O. NEUGEBAUER AND D. PINGREE

THE PAÑCASIDDHĀNTIKĀ OF VARĀHAMIHIRA

PART I

Det Kongelige Danske Videnskabernes Selskab
Historisk-Filosofiske Skrifter 6, 1

Kommissionær: Munksgaard
København 1970

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Selskabets sekretariat og postadresse: Dantes Plads 5, 1556 København V.

The address of the secretariate of the Academy is:

Det Kongelige Danske Videnskabernes Selskab,
Dantes Plads 5, 1556 København V, Denmark.

Selskabets kommissionær: MUNKSGAARD's Forlag, Prags Boulevard 47, 2300 København S.

The publications are sold by the agent of the Academy:

MUNKSGAARD, *Publishers,*
47 Prags Boulevard, 2300 København S, Denmark.

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PRINTED IN DENMARK
BIANCO LUNOS BOGTRYKKERI A/S

PREFACE

Written in the sixth century A.D., the Pañcasiddhāntikā of Varāhamihira is unquestionably one of the most important sources for the history of Indian astronomy and its relation to its Babylonian and Greek antecedents. The edition of the text with translation and commentary by Thibaut and Dvivedi, first published in 1889, has made the work generally available. But in the past decades not only have new manuscripts come to light, but also much new insight into Indian astronomy and into the astronomy of the Hellenistic period has been gained. It is hoped that the present publication will bear witness to the increase in our understanding of the Pañcasiddhāntikā thus obtained.

We are greatly indebted to the Kgl. Danske Videnskabernes Selskab, to the Institute for Advanced Study in Princeton, and to Brown University for their cooperation, which has made this publication possible.

O.N., D.P.

PART I

TEXT AND TRANSLATION
BY
D. PINGREE

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1. Introduction

A. Varāhamihira and his works

Varāhamihira, the son of Ādityadāsa, was a Maga Brāhmaṇa—that is, a descendent of one of those Persian Zoroastrians who entered India toward the beginning of the Christian era[1]. We learn from the penultimate verse of his Bṛhajjātaka (XXVIII, 9) that he was a native of Avantī or Western Mālwā (see also Pañcasiddhāntikā XVII,61) and resided in a village called Kāpattika. His date is delimited by his use of Lāṭadeva's epoch, A.D. 505, in the Pañcasiddhāntikā (see below p.8) and by the fact that Brahmagupta was familiar with his work when he wrote the Brāhmasphuṭasiddhānta in A.D. 628[2]. It has further been suggested that he was connected with the Aulikara court at Daśapura (modern Mandasor), and in particular with Yaśodharman who is known to have been ruling in Saṃvat 589 = A.D. 532[3], though no definite assertion can be made with regard to this hypothesis.

Varāhamihira was a prolific author in the three traditional skandhas of jyotiḥśāstra[4]. On gaṇita he composed only the Pañcasiddhāntikā; on horā he wrote the Bṛhajjātaka and the Laghujātaka; and on saṃhitā the Bṛhatsaṃhitā and the Samāsasaṃhitā. He also composed three works on military astrology—the Bṛhadyātrā, the Ṭikaṇikāyātrā, and the Yogayātrā—as well as a Vivāhapaṭala on the astrology of marriages. Several other works have been attributed to him, but their authenticity is doubtful.

Of the relative chronology of the works of Varāhamihira some notion may be derived from his cross-references. In Bṛhajjātaka XXVIII,4–6 he seems to indicate that his karaṇa, the Pañcasiddhāntikā, as well as treatises on interrogations[5], on

[1] See, e.g., D. K. Biswas, "The Maga Ancestry of Varāhamihira," *Indian Historical Quarterly* 25, 1949, 175–183. Traces of Persian influence on the Pañcasiddhāntikā are to be noticed in I, 23–25 and XV, 19. On the Maga Brāhmaṇas in general see now H. von Stieteneron, *Indische Sonnenpriester. Samba und die Sākadvīpīya-Brāhmaṇa, Schriftenreihe d. Südasiens-Instituts d. Universität Heidelberg* 3, Wiesbaden 1966.

[2] The date A.D. 505 is certainly not used in the Pañcasiddhāntikā because it is the date of his birth as is sometimes alleged. And there is no compelling reason to accept the tradition that he was one of the Nine Jewels at the court of Vikramāditya, no matter whom that shadowy figure is identified with.

[3] See D. Pingree, "The Empires of Rudradāman and Yaśodharman: Evidence from Two Astrological Geographies," *JAOS* 79, 1959, 267–270.

[4] A complete bibliography will appear in the appropriate volume of D. Pingree, *A Census of the Exact Sciences in Sanskrit*, to be published in the Memoires of the American Philosophical Society.

[5] We have no work on interrogations by Varāhamihira himself, but that of his son Pṛthuyaśas, the Ṣaṭpañcāśikā, does survive.

military astrology, on omens (saṃhitā), and on the time of marriage (the Vivāhapaṭala) had already been written. Moreover, Pañcasiddhāntikā I,22 seems to refer to the fact that he had not yet composed his books on horā, which include the Bṛhajjātaka. The Bṛhajjātaka, then, was written after the Pañcasiddhāntikā.

But Pañcasiddhāntikā XV,10 refers to Bṛhatsaṃhitā V,8–11, while the Bṛhatsaṃitā in several places (I,10; II (p. 22); V,18 (cf. Pañcasiddhāntikā VII–IX); XVII,1; and XXIV,5 (cf. Pañcasiddhāntikā XIV,34)) refers to the Pañcasiddhāntikā. Varāhamihira must have been working simultaneously on both texts. Furthermore, Bṛhatsaṃhitā II (p. 68) lists the subjects to be covered by a work on horoscopy, but this list is not a table of contents to either the Bṛhajjātaka or the Laghujātaka. Later (p. 71) there is a list of subjects for a work on military astrology, but again the list does not correspond to any of his three books on this subject; and, moreover, Varāhamihira only remarks that the subject has been written on by ācāryas when he would certainly have mentioned his own work if any such yet existed. It appears, then, that the Pañcasiddhāntikā and Bṛhatsaṃhitā were composed simultaneously towards the beginning of his writing career, the Bṛhajjātaka towards its end, and at least one work on military astrology and the Vivāhapaṭala in between.

Against this theory it may be objected that Bṛhasaṃhitā I,10 states that Varāhamihira had previously written extensively ("vistaratas") on genethlialogy, military astrology, and marriage. Either one must conclude from this that he wrote all of his major works simultaneously, or assume that I,10 was added to the Bṛhatsaṃhita by Varāhamihira after he had finished the Bṛhajjātaka. The latter seems to us the more probable solution.

B. The epochs of the Pañcasiddhāntikā

Varāhamihira in I,8–10 indicates that the ahargaṇa of the Romaka is counted from sunset at Yavanapura, which begins a Tuesday, at the beginning of the śuklapakṣa of Caitra in Śaka 428. We identify this date with 6 P.M. at Alexandria on Monday, 21 March 505 A.D., when the sunset day Tuesday began. The sunset at Yavanapura is reiterated in XV,18, where it is attributed to Lāṭācārya, the "commentator" of Varāhamihira's Romaka; and the Tuesday is confirmed by the rules for determining the week-days in I,17–21[6]. In VIII,1–5 we are given the Romaka's kṣepas for sunset at Avantī on 21 March 505, from which it is clear that a mean conjunction of the Sun and Moon will indeed occur (by the Romaka's calculations) shortly before sunset in Yavanapura.

In the ārdharātrika system, which is used by Lāṭadeva's (?) Sūryasiddhānta, a sidereal year ends at 0;3,9 days after midnight at Avantī of 20/21 March 505. It is for this time, or rather for the midnight exactly, that the kṣepas of the planets are

[6] The long discussions by Dikshit and others about whether this date is really Caitraśuklapratipad are irrelevant as their computations are based on the elements of the ārdharātrica system, not on those of the Romaka.

given in XVI,1–6. However, it appears that there was an earlier Sūryasiddhānta which employed a noon-epoch; the kṣepas of the Sun, Moon, lunar apogee, and lunar node are given according to it for noon at Avantī of Sunday, 20 March 505. These deviations from the epoch of I,8 are due to the facts that the parameters of the various siddhāntas do not yield identical times for conjunctions and that days are assumed to begin at various epochs.

But Varāhamihira not only does not use a single epoch throughout his work; he also fails to inform his reader accurately of the dates and sometimes even of the existence of the epochs he employs that are different from that given in I,8–10. His karaṇa thus becomes totally useless in many sections. If the reader remains ignorant of the epoch actually employed, he cannot obtain a correct result by following the rules in the text; and if he knows enough to be able to discover what the epoch was, he no longer will benefit (except as an historian) from the Pañcasiddhāntikā.

C. Varāhamihira's sources

In I,3 Varāhamihira states that there are five siddhāntas: the Pauliśa, the Romaka, the Vāsiṣṭha, the Sūrya, and the Paitāmaha, and that of these the first two were commented on by Lāṭadeva. It is precisely these five siddhāntas which he urges an astrologer to study in Bṛhatsaṃhitā II (p. 22). But his sources, as he himself indicates, are more numerous; for he names Arhat (i.e., Jaina tradition) in XIII,8; Āryabhaṭa in XV,20; Pradyumna in XVII,62; the Magas in I,23; the teacher of the Yavanas in XV,19; Lāṭadeva or Lāṭācārya in I,3 itself and in XV,18; himself in XVII,61,62, and 64; his Bṛhatsaṃhitā in XV,10; Vijayanandin in XVII,62; and Siṃhācārya in XV,19. We are not justified, then, in regarding all the material in the Pañcasiddhāntikā as having been derived from one of the five siddhāntas named in I,3. We can only distinguish certain sections as being from one source or another on the basis of Varāhamihira's explicit statements, and then attempt to gather associated material around these nuclei on the basis of their use of identical parameters. The colophons cannot be blindly followed, as is demonstrated by that for chapter III; this attributes the whole chapter to the Pauliśasiddhānta, though III,34–35 are certainly from the Romaka and III,4 and 9 belong with II (Vasiṣṭha).

Aside from the Pañcasiddhāntikā, one of our chief sources for a knowledge of Varāhamihira's sources is the Brāhmasphuṭasiddhānta which Brahmagupta wrote in Bhillamāla in 628. He is mainly concerned there, when he mentions his predecessors, either with praising his main source, the Brahmasiddhānta (i.e., the Paitāmahasiddhānta of the Viṣṇudharmottarapurāṇa)[7], or with attacking Āryabhaṭa[8]; but he also discusses certain aspects of some of the other works. A translation of all the relevant passages will be found in the Appendix (cf. F, p. 22).

[7] Cf., e.g., I,2; II,31; II,33; V,25; X,62; etc.
[8] Cf., e.g., I,12; I,32; I,61–62; II,19; II,33; II,46–47; VI,12; IX,11; X,13–14; XI,4–45; etc.

I. *The Paitāmahasiddhānta*

This work is summarized in chapter XII of the Pañcasiddhāntikā. Its epoch is 11 January 80 A.D. and its elements are derived from the Jyotiṣavedāṅga of Lagadha. Varāhamihira does not refer to the Paitāmahasiddhānta of the Viṣṇudharmottarapurāṇa, though that work is apparently mentioned by Āryabhaṭa (Golapāda 50) and certainly used by Brahmagupta as the basis of his Brāhmasphuṭasiddhānta.

II. *The Vasiṣṭhasiddhānta*

There existed a Vasiṣṭhasiddhānta already in A.D. 269/70 as Sphujidhvaja writes in his Yavanajātaka (LXXIX,3):

"By following the opinion of the sage Vaśiṣṭha some of those concerned with (astronomical) rules (believe that this great lunisolar yuga) is best; for those led by the Yavanas . . . (the lunisolar yuga) is 165 years."

Varāhamihira states in II,13 that the shadow-problem in II,12–13 is from the Vasiṣṭhasamāsasiddhānta (presumably an abridgement of a longer original Vasiṣṭhasiddhānta). We are inclined to believe that the rest of II is also from the Vasiṣṭha. If this assumption is true, we have Vasiṣṭha's solar theory (II,1), lunar theory (II,2–6; see also III,4 and 9), theory of nakṣatras and tithis (II,7), rules for computing the length of daylight (II,8), and gnomon-problems (II,9–13). The whole is based on Babylonian techniques filtered through Greek intermediaries. The epoch of the lunar theory is 3 December 499; this is perhaps the date at which the original Vasiṣṭhasiddhānta was turned into the Vasiṣṭhasamāsasiddhānta available to Varāhamihira. A kṣepa (presumably added by Varāhamihira) accounts for the difference between this epoch and 22 March 505.

All manuscripts insert after XVII,5 a note attributing the theory of Venus in XVII,1–5 to the Vāsiṣṭhasiddhānta; but these verses are an integral part of the whole section XVII,1–60 which presents a treatment of the motions of the five star-planets based on Babylonian methods. This also may well be properly assigned to the Vasiṣṭha- (or Vasiṣṭasamāsa-) siddhānta. The kṣepas indicate as epoch 22 March 505; they must have been added by Varāhamihira. An earlier Indian adaptation of Babylonian planetary theory is found in Sphujidhvaja (LXXIX,40–47).

By 628 Brahmagupta knows only of a Vasiṣṭhasiddhānta published by Viṣṇucandra (see Brāhmasphuṭasiddhānta I,62; II,46–47; X,13 and 62; XI,31,46–51, and 55; XVI,36; XXI,37–39 and XXII,2), who apparently combined ārdharātrika (Lāṭa) and audayika (Āryabhaṭīya) elements with some from Vijayanandin. He is constantly linked in the Brāhmasphuṭasiddhānta with Āryabhaṭa and Śrīṣeṇa. It might have been argued that his was the version of the Vasiṣṭhasiddhānta which is summarized in the Pañcasiddhāntikā and which uses as epoch 3 December 499 (the epoch of the Āryabhaṭīya is also 499). But Viṣṇucandra's use of a mahāyuga and of epicycles, which are unknown to Varāhamihira's Vasiṣṭhasiddhānta, precludes this identification. Viṣṇucandra, then, must be dated in the latter half of the sixth century.

Copies of Viṣṇucandra's Vasiṣṭhasiddhānta were still available in the ninth century as Pṛthūdakasvāmin, in his commentary on the Brāhmasphuṭasiddhānta, quotes from it three āryās. The first (on XXI,3; the first two pādas are also quoted on XXI,11a–b) is similar to Pauliśa frag. P 51:

Thus in the Vasiṣṭhasiddhānta[9].

"The earth, consisting of the five mahābhūtas (i.e., earth, fire, water, wind, and space) stands in the middle of the space of the cosmic egg (jagadaṇḍa) for the existence of all creatures; it is round (and) called a sphere."

This verse is also quoted by Utpala on Bṛhatsaṃhitā II (p. 58).

The next fragment is quoted on XXI,4:

Thus in the Vāsiṣṭha siddhānta[10].

"The sphere of the stars, which is covered with planets, nakṣatras, and constellations, constantly revolves from left to right in the sky."

And the third āryā is quoted on XI,54:

The yuga of precession (ayana) (is given) by Viṣṇucandra at the beginning of his chapter on yugas (yugaprakaraṇa)[11]:

"The yuga of the ayana is said to be 189411 (revolutions); this was formerly the opinion of Brahmā, the Sun (i.e., Sūrya), and so on."

Another āryā which is quoted as Vasiṣṭha's by Utpala on Bṛhatsaṃhitā II (p. 27) probably comes from Viṣṇucandra's work:

So the revolutions of the Moon (in a mahāyuga), when multiplied by 27, (become the days of) the nākṣatra measure in the opinion of Vasiṣṭha and others[12]:

"The nākṣatra (days) in a caturyuga are said by the ancients to be 1559340072."

Two other āryās of astrological content are quoted as Viṣṇucandra's by Utpala. The first is found in his commentary on Bṛhatsaṃhitā XIX,8 and in that on Bṛhajjātaka II,20[13]:

"The conjunction with the Sun of (the five star-planets) beginning with Mars together with the Moon is called their (heliacal) setting, that (of the five star-planets) with each other a (planetary) conflict."

The second occurs in his commentary on Yogayātrā IV,48–53[14]:

[9] jagadaṇḍakhamadhyasthā mahābhūtamayī kṣitiḥ /
bhavāya sarvasattvānāṃ vṛttā gola iti sthitā //

[10] tatrāgre grahanakṣatratārāgaṇasamāvṛtaḥ /
ajasraṃ bhramati vyomni jyotirgolaḥ pradakṣiṇam //

[11] tasya cātra cid rudrakṛtanandāṣṭakendavaḥ /
ayanasya yugaṃ proktaṃ brahmārkādimataṃ purā //

If the precession makes 189 411 revolutions in a Kalpa, the yearly motion is approximately 0;0,57° and the precession amounts to 1° in about 63 years.

[12] pakṣasaptakhaśūnyābdhiguṇagorthaśarendavaḥ /
caturyugārkṣāṇy etāni kathitāni purātanaiḥ //

The Vasiṣṭha's revolutions of the Moon in a mahāyuga, then, are those of the ārdharātrika system: 57 753 336. This is what one expects from Brahmagupta's description of Viṣṇucandra's work.

[13] divasakareṇāstamayaḥ samāgamaḥ śītaraśmisahitānām /
kusutādīnāṃ yuddhaṃ nigadyate 'nyonyayuktānām //

[14] balavatsaumyasamete pāpe kṛcchreṇa kendrage siddhiḥ /
balavatpāpasamete saumye siddhir na yātuḥ syāt //

"If there is a (weak) malefic planet in a cardine with a strong benefic, there is success for one who sets out (on a military campaign), though with difficulty; but if it is a (weak) benefic with a strong malefic, there is no success."

III. *The Romakasiddhānta*

The Romaka (one of the two siddhāntas which Varāhamihira claims to have been commented on by Lāṭa) is evidently, because of its name, of western origin. Sections of the Pañcasiddhāntikā which can unquestionably be ascribed to the Romakasiddhānta in Lāṭa's edition are I,8–10; I,15; III,34–35; and VIII. These passages discuss the computation of the ahargaṇa from the epoch—sunset at Yavanapura (= Alexandria) on 21 March 505; the elements of the Romaka's yuga; some speculation on a "world-year"; and solar eclipses. The use of sunset epoch, the Metonic cycle, the Hipparchan tropical year, and epicycles for the Sun and Moon indicate that the original Romakasiddhānta had an Hellenistic origin. One suspects that it arrived in India during the period of Śaka or Gupta rule in Western India. This Romaka is referred to by Brahmagupta in Brāhmasphuṭasiddhānta I,13.

But another Romakasiddhānta was known to Brahmagupta. This was composed by Śrīṣeṇa on the basis of elements from Lāṭa, Vasiṣṭha, Vijayanandin, and Āryabhaṭa (see Brāhmasphuṭasiddhānta I,62; II,46–47; X,13; XI,31,46–47,48–51, and 55; XVI,36 and 46; XXI,37–39; and XXII,2). Śrīṣeṇa was evidently contemporary with Viṣṇucandra.

IV. *The Pauliśasiddhānta*

To this work we can definitely assign I,11–13, in which Varāhamihira gives the rules for determining the ahargaṇa in the Pauliśasiddhānta as commented on by Lāṭadeva. The same parameter for the length of a year appears in III,1, so that at least in part the colophon of III is correct in ascribing that chapter to Pauliśa (it has been noted above that III,34–35 refer to the Romaka; Lāṭadeva, of course, may have inserted such a reference into his commentary). In this chapter again we find a mixture of Babylonian and Greek methods, though with a strong influence of Indian concepts (e.g., III,18–27). We see no secure way to sort out the material in this chapter which may go back to the original Pauliśa.

The Pauliśasiddhānta was apparently based on an Hellenistic source, and Pauliśa may represent the Greek Παῦλος; but he certainly had nothing to do with the astrologer Paulus Alexandrinus who wrote the Εἰσαγωγή in A.D. 378[15]. The identification depends on al-Bīrūnī's misreading in the India (see fragment P 1 of the later Pauliśasiddhānta) of T.n.y.s.r. in Arabic (for Sthāṇvīśvara, the locality at which the later Pauliśasiddhānta was written) as S.y.n.t.r; the only difference in Arabic script is in the positioning of the dots. Al-Bīrūnī corrects himself in a later Maqāla (see fragment P 41 of the later Pauliśasiddhānta). Moreover, Paulus Alexandrinus the astrologer is

[15] See D. Pingree, "The Later Pauliśasiddhānta", *Centaurus* 14, 1969, 172-241 and also *Isis* 54, 1963, 237 n. 63.

not known to have written on astronomy; and his limits of solar daily motions—1;2° and 0;57° (Εἰσαγωγή XXVIII)—disagree with those found in the table apparently from the Pauliśasiddhānta incorporated in Pañcasiddhāntikā III,17—1;1° and 0;57°.

The colophon of chapter VII, on solar eclipses, attributes it to the Pauliśa; chapter VI, on lunar eclipses, is closely connected with it and probably comes from the same source. This attribution may well be correct. There is more doubt about the colophon of chapter XVII, which ascribes the planetary theory of XVII,65–80 to the Pauliśasiddhānta though Varāhamihira in XVII,61–64 claims it for himself. In favor of the Pauliśa as the source of this section is the Babylonian character of the theory.

In the eighth century another Pauliśasiddhānta was written, which is essentially ārdharātrika. It is this work to which, e.g. Pṛthūdakasvāmin, Utpala, and al-Bīrūnī refer. Its fragments are gathered and discussed in the article mentioned in footnote 15.

V. *The Sūryasiddhānta*

Varāhamihira speaks of Lāṭadeva as a commentator on the Pauliśa and Romaka, but says nothing of the name of any original work of his. We believe that he wrote the Sūryasiddhānta summarized in the Pañcasiddhāntikā. Such a tradition was known to al-Bīrūnī (India, ed. p. 118, trans. vol. 1, p. 153). The parameters of this work belong to the ārdharātrika system which, as Brahmagupta tells us (Kaṇḍakhādyaka I,1), was promulgated by Āryabhaṭa; and Bhāskara, commenting on the Āryabhaṭīya (Kālakriyā 10) in 629, names Pāṇḍuraṅgasvāmin, Lāṭadeva, and Niḥśaṅku as pupils to whom Āryabhaṭa directly expounded astronomy.

On the assumption of Lāṭadeva's authorship of this Sūryasiddhānta, Pañcasiddhāntikā I,8–15 appears as a unit summarizing Lāṭadeva's rules for determining the ahargaṇa for a given calendar date with respect to his chosen epoch; I,14 gives the rules for the Sūryasiddhānta, based on the same parameters as are IX,1–2; IX (on solar eclipses) is attributed to the Sūryasiddhānta in both the first verse and in the colophon. It, however, gives the epoch as noon at Avantī rather than as midnight. Since this is not an error in the text, it is a reflection of an earlier version of the Sūryasiddhānta using noon epoch.

The identity of parameters shows that chapter X (on lunar eclipses) is also from the Sūryasiddhānta. And finally XVI (on the planets) is stated in verse 1 and after verse 11 to be from the Sūryasiddhānta; the statement is confirmed by this chapter's use of ārdharātrika parameters.

The epoch of this ārdharātrika version of the Sūryasiddhānta is midnight of 20/21 March 505 in XVI. But in IX there is evidence of an earlier Sūryasiddhānta using noon epoch and slightly different parameters for the mean motion of the Moon, lunar apogee, and ascending node. The kṣepas in IX,1–5 are computed for noon of 20 March 505. We assume that it was Lāṭadeva who computed these kṣepas, added the corrections in IX,4 and who authored the source of XVI. Another possible reflection of this earlier Sūryasiddhānta is the rule for computing the kakṣās and diameters of the Sun and Moon given in IX,15–16. The underlying assumptions of the other ārdharātrika texts for the solution of this problem (see, e.g., Mahābhāskarīya VII, 23–24 and fragment P 59 of the later Pauliśasiddhānta) are missing. And the method employs the true hypotenuse, which, according to IX,7–8, is not involved in the present text's computation of the manda equation as one would expect if it is to be used in the later passage.

One Śatānanda wrote a Bhāsvatī whose epoch is Śaka 1021 or A.D. 1099. This work he claims to be based on the Sūryasiddhānta taught by (Varāha)mihira (vs. 6). This work has not been utilized in our discussion of the Pañcasiddhāntikā; but the fact that it contains a section of the projection of eclipses indicates that Śatānanda probably considered Pañcasiddhāntikā XI to be from the Sūryasiddhānta.

VI. *Summary of attributions to the five Siddhāntas*

To the five siddhāntas, then, we can attribute the following chapters of the Pañcasiddhāntikā.

I,8–15	Romaka, Pauliśa, and Sūrya (Lāṭadeva's three)
II	Vasiṣṭha
III (most)	Pauliśa
III,34–35	Romaka
VI	Pauliśa (?)
VII	Pauliśa (?)
VIII	Romaka
IX	Sūrya
X	Sūrya
XI	Sūrya (?)
XII	Paitāmaha
XVI	Sūrya
XVII,1–60	Vasiṣṭha (?)
XVII,65–80	Pauliśa (?)

The other chapters are from various sources which we can only in part identify.

VII. *Varāhamihira's other sources*

a. Āryabhaṭa is referred to in XV,20 as having used as epoch both midnight at Lañkā (in the ārdharātrika system) and sunrise at Lañkā (in the Āryabhaṭīya). But he is not subjected to a vicious attack such as that launched against him by Brahmagupta.

b. Āryabhaṭa's pupil Lāṭadeva[16] appears in XV,18, where his epoch is stated to be sunset at Yavanapura (Alexandria); this is the Romaka's epoch (I,18). Within the Pañcasiddhāntikā we can also attribute to him some of the verses in XIII. Thus

[16] He is referred to by Brahmagupta in Brāhmasphuṭasiddhānta XI,46–51.

with XIII,1–2 compare these verses of Lāṭa cited by Pṛthūdakasvāmin on Brāhmasphuṭasiddhānta XI,3:

"The symmetrically round sphere of the earth stands in the heavens, free-standing (?) on all sides, held up by all the good and bad actions of creatures[17]."

"It is covered on all sides with mountains, rivers, and seas, with cities, kingdoms, trees, quadrupeds, and so on, and with kadamba, puṣpa, and granthi flowers[18]."

With XIII,9 compare a verse cited by Pṛthūdakasvāmin on Brāhmasphuṭasiddhānta XXI,6:

"The gods see the Sun proceeding from left to right on the equator, which is the horizon of their vision; the demons, those warriors in battle, see it moving to the left on their (horizon)[19]."

Another pair of āryās quoted from Lāṭa by Pṛthūdakasvāmin on the preceding verse finds no direct parallel in the Pañcasiddhāntikā (but cf. XIII,5):

"As from this region, so in all directions does the circle of the constellations rise up; it leaves a center of fixedness (i.e., the pole). This (axial) line splits the surface of the earth; like a cloud in an extensive plain a star stands above it[20]."

A half-verse of Lāṭa quoted by Pṛthūdakasvāmin on Brāhmasphuṭasiddhānta XXI,8a–b is comparable to Pañcasiddhāntikā XIII,27a–b:

"For a half of a year the Sun, having risen once, is seen by the Gods[21]."

Finally, Śaṅkara in his commentary on Bāṇa's Harṣacarita[22] quotes an āryā defining vyatīpāta as Lāṭa's:

"For when, in the heavens, the Sun and Moon are together in one mārga (i.e., semicircle between equinoxes) and when (the longitude of) the Sun and (that of) the Moon equal half of a revolution (i.e., 180°), then there occurs vyatīpāta[23]."

c. The influence of Varāhamihira's Iranian (Maga) ancestors, which perhaps reached him through his father and teacher Ādityadāsa, is found in I,23–25; the guru of the Yavanas in XV,19 is perhaps a Sasanian astronomer. Siṃha, who is also mentioned in XV,19, is referred to again only by Brahmagupta (Brāhmasphuṭasiddhānta XI,46–47). The same is true of Pradyumna and Vijayanandin whose names appear in XVII,62; for the first see Brāhmasphuṭasiddhānta XI,46–47 and 57–58, for the second XI,48–51 and 57–58. Varāhamihira's only other recognizable source is the Jaina tradition recorded in XIII,8; with this compare Brāhmasphuṭasiddhānta XI,3. To this same Jaina tradition may be due the term trailokya in the colophon of XIII.

[17] kṣitigolaḥ samavṛtto khe kila tiṣṭhati samantāt tv apadeśaḥ /
sāmānyaiḥ sattvānāṃ śubhāśubhaiḥ karmabhir upāttaḥ //

[18] parvatanadīsamudraiḥ purarāṣṭradrumacatuḥpadādyaiḥ /
pracitaḥ kadambapuṣpagranthibhiḥ samantataḥ kusumaiḥ //

[19] dṛgharije sve viṣuvati paśyanty amarāḥ pradakṣiṇagam arkam /
apasavyagatiṃ daityāḥ samare svāsthaṃ yudhā śramiṇaḥ //

[20] tasmāt kṣetroddeśād yathā yathā sarvato diśaṃ tathā /
unnamati bhagaṇacakraṃ dhruvatvamadhyaṃ parityajate //
bhittvā kṣititalam uttiṣṭhatīva meghaḥ prakṛṣṭadeśasthaḥ /
rekhāpy eṣā tiṣṭhaty upari jyotirgaṇo 'py evam //

[21] saṃvatsarārdham amaraiḥ sakṛd udgata eva dṛśyate sūryaḥ /

[22] Ed. A. A. Führer, Bombay 1909, p. 184 (I have emended his text).

[23] gagane hi himakarārkau yugapat syātāṃ yadaikamārgasthau /
bhagaṇārdham arkaś ca yadā śaśī tadā bhaved vyatīpātaḥ //

D. The Pañcasiddhāntikā in later literature

The first author to demonstrate a knowledge of the Pañcasiddhāntikā is Brahmagupta in his Brāhmasphuṭasiddhānta (I,13; XIV,46–49; and XXIV,2–3), which was written at Bhillamāla in A.D. 628. It is from the Brāhmasphuṭasiddhānta and its commentary-tradition that al-Bīrūnī (India, ed. pp. 118–119, trans. vol. 1, p. 153; this is Pauliśa frag. P 1) knows of the five siddhāntas. In Brahmagupta's Khaṇḍakhādyaka, written in A.D. 665, the fractions by which the ahargaṇa is to be multiplied to find the mean longitudes of several of the planets are identical with those in the Sūryasiddhānta of the Pañcasiddhāntikā; but both sets may be independently derived from their common ārdharātrika parameters.

In A.D. 718 an Indian, Chüt'an Hsita, produced a work entitled Chiuchih-li at the T'ang court. The Chiuchih-li, whose epoch is A.D. 714, is said to be based on methods devised by Brahma and inherited by Wut'ung Hsienjên, "the excellent scholar of full understanding of five." This seems to be a reference to the Pañcasiddhāntikā. A number of passages in the Chinese work can be paralleled in our text, though it is clear that Chüt'an Hsita's source was based on other texts besides the Pañcasiddhāntikā; he uses, e.g., $R = 3438$ rather than $R = 120$.

The parallel passages are as follows:

I. The computation of the ahargaṇa (pp. 499–502). The Chiuchih-li uses formulas which are the equivalents, with suitable substitutions for the new epoch, of the formulas in I,9–11 (Romaka).
II. The computation of the mean longitudes of the Sun, lunar apogee, and lunar anomaly (pp. 502–505). The rules in the Chiuchih-li are based on the parameters in IX,11–12 (Sūrya).
III. The computation of the solar and lunar equations (pp. 506–511). This passage is derived from IX,7 (Sūrya).
IV. The computation of the length of daylight (pp. 511–513). The Chiuchih-li depends on III,10 (Pauliśa).
V. The determination of the daily progress of the Moon (p. 514). See III,9 (Pauliśa).
VI. The determination of the daily progress of the Sun (p. 515). See III,17 (Pauliśa).
VII. The computation of the nakṣatra, nakṣatrasaṅkrānti, and tithi (pp. 515–518). See III,16 (Pauliśa).
VIII. The computation of the longitude of the lunar node (pp. 521–522). See III,28 (Pauliśa).
IX. The computation of lunar latitude (pp. 526–527). See IX,6 (Sūrya).
X. The computation of the duration of a lunar eclipse (pp. 528–529). See VI,3 (Pauliśa?).
XI. The computation of the magnitude of a lunar eclipse (pp. 529–530). See VIII,18 (Romaka).
XII. The computation of the duration of totality of a lunar eclipse (pp. 530–531). See VIII,16 (Romaka).

In A.D. 864 Pṛthūdakasvāmin of Sthāṇvīśvara wrote a commentary on Brahmagupta's Khaṇḍakhādyaka in which he refers to his already existing commentary on the Brāhmasphuṭasiddhānta. In this second commentary he quotes several verses from chapter XIII of the Pañcasiddhāntikā[24]. Utpala, apparently a Kāśmīrian, wrote a commentary on Varāhamihira's Bṛhatsaṃhitā in A.D. 966 in which he quotes 117 of the Pañcasiddhāntikā's 443 verses[25]. Al-Bīrūnī, when he composed the India in 1030, knew of the Pañcasiddhāntikā only from his Panjābī paṇḍitas, whose information was evidently derived from Bṛhatsaṃhitā II (p. 22) and from a commentary on the Brāhmasphuṭasiddhānta[26]; he had no manuscript of the text. Śatānanda in 1099, at an unknown locality[27], wrote the Bhāsvatī allegedly based on the parameters and methods of Varāhamihira's Sūryasiddhānta. And a Jaina author, Makkibhaṭṭa, wrote in Western India in the late fourteenth century a commentary on the Siddhāntaśekhara of Śrīpati in which he quotes several verses from the Pañcasiddhāntikā[28]. So far there is no indisputable evidence that the Pañcasiddhāntikā was known outside of an area roughly corresponding to the modern states of Madhya Pradesh, Gujarat, Rajasthan, the Panjab, Kashmir, and West Pakistan.

However, some verses from the text are quoted by fifteenth century Kerala astronomers of the dṛggaṇita school in their commentaries on the Āryabhaṭīya. Thus Parameśvara (c. 1380–1460) cites a verse[29], and Nīlakaṇṭha (b. 1443) several others[30]. It is noteworthy that all four verses that they quote are also found in Utpala's commentary on the Bṛhatsaṃhitā, which was known in Kerala; it is not proved, then, that they had a copy of the Pañcasiddhāntikā.

The manuscript tradition also supports the theory that the Pañcasiddhāntikā was never known outside of Western and Northern India. All known manuscripts are descended from two copies of the text, which in turn are derived from a common, lacunose manuscript. The older of the two was copied in Stambhatīrtha (Cambay) in 1616, while the other was in Sojītrā in Gujarat in the 1870's. Its then owner claimed that it was copied from a manuscript in Benares, where other manuscripts of the text and a commentary were available[31]. No such other manuscripts have ever turned up, however, despite the extensive work in cataloguing private and forming public manuscript collections that has been carried on in Benaras between 1873 and the present. We therefore doubt the story of a Benares provenience, and assume that the Sojītrā manuscript represents a Gujarātī tradition.

[24] They are XIII, 2–3, 5–6, 9,12,27, and 35.

[25] I,1,8–10, and 16–22; II,13; III,1,10,21, and 25; IV,20–23,27–28,30–33,35–36,38,41–44, and 48–49; V,1–10; VI,9–10 and 15; VIII,1 and 9–18; IX,1; XII,1–3; XIII,1–34 and 39–42; XIV,33 and 39–40; XV,15 and 18–29; and XVI,15–16.

[26] See Pauliśa frag. P 1.

[27] In the text he refers only to Avantideśa and Laṅkā; but such references do not help to fix his own place of residence. Some commentators place him at Puruṣottama in Orissa on the basis of his reference to the deity Puruṣottama in the last verse of his work.

[28] They are XIII,36 and XV,17–20.

[29] This is XIII,12.

[30] They are XIII,1 and XV,20 and 29.

[31] See G. Bühler quoted in A. E. Gough, *Papers Relating to the Collection and Preservation of the Records of Ancient Sanskrit Literature in India*, Calcutta 1878, pp. 116 and 132–133.

The first modern scholar to note the existence of the Pañcasiddhāntikā was G. Bühler, who noticed the Sojītrā manuscript in his tour in search of Sanskrit manuscripts undertaken on behalf of the Government of the Presidency of Bombay in 1873/74. The Cambay manuscript was procured in 1879/80, and copies of the two manuscripts (probably our D and E, now in the National Library in Calcutta) were sent to G. Thibaut in Benares, who collaborated with S. Dvivedin in attempting to interpret them.

The first results of their labors on the text were published in 1884[32], in which particular attention was paid to the Sūrya and Romaka siddhāntas. The following verses were edited, translated, and discussed: I,1–10 and 14–15; III,13; VIII,1,4–5, 7a–b and 8; IX,1–4; XV,19; and XVI,1–11. Also cited are Brāhmasphuṭasiddhānta I,13 and XI,47–50b. From all of this they correctly concluded that none of the five siddhāntas summarized by Varāhamihira is presently extant.

Their main publication with regard to the Pañcasiddhāntikā was an edition of the text with English translation and Sanskrit and English commentaries, which appeared at Benares in 1889[33], The inherent difficulties of a technical text without a commentary and the corruption of the manuscripts, while frequently overcome, at many points obstructed their understanding of the work. It would serve no purpose to discuss here in detail our disagreements with their interpretations.

In the year 1890 S. B. Dikshit[34], using a manuscript copied by Janardan Balaji Modak, Head Master of the Thāṇā High School, from the copy of the Sojītrā manuscript which we have denoted B[35], discusses the chronological implications of I,8 and 14; IX,1–4; XV,18 and 20; and XVI,10–11. Dikshit concludes that the epoch of Varāhamihira is Tuesday 22 March 505, but that, according to the Sūryasiddhānta, the kṣepakas in IX,1–4 are for noon of Sunday 20 March, and the kṣepakas in XVI, 10–11 are for midnight of 20/21 March in the same year.

In the same year Dikshit published a second article[36] devoted to the Romakasiddhānta, in which he discusses I,3 and 15; III,1; and VIII,1–5 and 8. He also discusses the Romakasiddhānta as known from Brāhmasphuṭasiddhānta I,13; XIV,46; and XXIV,2–3, and Śrīṣeṇa (and Viṣṇucandra) in Brāhmasphuṭasiddhānta I,62; II,46–47; X,13; XI,31,46–50, and 55; XVI,36; XXI,38–39; and XXII,2. He concludes that Śrīṣeṇa was not the author of the Romakasiddhānta summarized by Varāhamihira, that the kṣepakas in VIII,1,4–5, and 8 are computed for sunset of 20 March 505, and that this is not the epoch of the original Romakasiddhānta, which he claims was written between the time of Hipparchus and A.D. 150 as it uses the Hipparchan length of year and says nothing of the calculation of the longitudes of the planets,

[32] G. Thibaut, "Notes from Varāha Mihira's Panchasiddhāntikā," *Journal of the Asiatic Society of Bengal*, 53, 1, 1884, 259–293.

[33] Reprinted at Lahore in 1930 and at Varanasi (Benares) in 1968.

[34] S. B. Dikshit, "The Original Sūrya-siddhānta," *Indian Antiquary* 19, 1890, 45–54.

[35] Dikshit explicitly states (fn. 2) that Modak copied the manuscript from one of the two in the (then) Deccan College Collection, which are our A and B. And Modak's copy reads bhauma° in I,8d, ṣadyaneṃdri° in IX,2c and khakhavedavikalikāḥ in XVI,11c, all in agreement with β against α.

[36] "The Romaka Siddhantas," *Indian Antiquary* 19, 1890, 133–142.

which Dikshit believes to indicate that the Romaka was pre-Ptolemaic. Dikshit later in 1890 compared his conclusions with Thibaut and Dvivedin's edition[37].

Commenting on Dikshit's paper on the Romaka, J. Burgess[38] compares the Romaka's luni-solar parameters with those of Ptolemy and contends that Hipparchus had a planetary theory. In the following year he claimed[39] that the table of sines in IV,6–11 is closely related to the Ptolemaic table of chords and may have been derived from it.

In 1895 M. P. Kharegat of Bombay read a lengthy paper dealing with many difficult passages in the Pañcasiddhāntikā[40]: 1,8,10–13,17–20, and 23–25; II,1 and 3–6; III,4,20–21, and 29; IX,5 and 15–16; X,1; XII; and XIV,34–38. He has many valuable comments to make. He came near to explaining the computation of the ahargaṇa according to the Pauliśa in I,11–13; he realized the Persian background of the "lords of the degrees" in I,23–25; he correctly explained the theory of solar motion in II,1; he understood the character of the Vasiṣṭha's lunar theory in II,4–6 and III,4; he noticed the kṣepa of the ascending node in III,29; he correctly emended IX,15–16 on the distances and diameters of the Sun and Moon; he realized that the reading 286 is correct in X,1; and he computed the epoch of the Paitāmahasiddhānta in XII (though we do not understand his reference to the yogatārā of Dhaniṣṭhā).

Serious investigations[41] of the Pañcasiddhāntikā were only resumed in the 1950's. Neugebauer first recognized the Babylonian period relations in II,2[42] and in XVII,66–80[43]. K. S. Shukla corrected and explained IX,15–16 in much the same way as had Kharegat, and emended XVI,23[44]. T. S. Kuppanna Sastri interpreted II,1–6 and III,4 as had Kharegat, and further explained II,7–13[45]. Pingree noted the Babylonian character of XVII,1–60[46] and of III,4 and VIII,5[47].

The present edition of the Pañcasiddhāntikā does not solve all the remaining problems connected with this text. We suspect that much will never be understood unless better manuscript material becomes available. Until that may happen we hope that future historians of Indian astronomy will find this volume a useful tool in their researches.

[37] "The Panchasiddhantika," *Indian Antiquary* 19, 1890, 439–440.

[38] J. Burgess, "The Romaka Siddhantas," *Indian Antiquary* 19, 1890, 284–285.

[39] "The Sines of Arcs in the Pancha-Siddhantika," *Indian Antiquary* 20, 1891, 228.

[40] M. P. Kharegat, "On the Interpretation of certain passages in the Pancha Siddhántiká of Varáhamihira, an old Hindu Astronomical Work," *Journal of the Bombay Branch of the Royal Asiatic Society* 19, 1895/97, 109–141.

[41] We do not discuss here such articles as V. Thiruvenkatacharya, "Ayanamsa and Indian Chronology. The Age of Varahamihira, Kalidasa, Etc.," *Journal of Indian History* 28, 1950, 103–110, which has been satisfactorily refuted by T. S. Kuppanna Sastri and K. V. Sarma, "The Saka Era of Varahamihira—Salivahana Saka," *Journal of Indian History* 36, 1958, 343–367. An attempt to understand some passages was made by P. C. Sengupta in *JDL/UC* 18, 1929, art. 3.

[42] O. Neugebauer, *The Exact Sciences in Antiquity*, Princeton 1952, pp. 158–159, 2nd ed., Providence 1957, pp. 165–166.

[43] *Ibid.*, pp. 165–166; 2nd ed., pp. 172–173.

[44] K. S. Shukla, "On Three Stanzas from the Pañcasiddhāntikā," *Gaṇita* 5, 1954, 129–136.

[45] T. S. Kuppanna Sastri, "The Vāsiṣṭha Sun and Moon in Varāhamihira's Pañcasiddhāntikā," *Journal of Oriental Research, Madras* 25, 1955/56, 19–41.

[46] D. Pingree, "A Greek Linear Planetary Text in India," *Journal of the American Oriental Society* 79, 1959, 282–284.

[47] "Astronomy and Astrology in India and Iran," *Isis* 54, 1963, 229–246 (see 236–237).

E. The manuscript tradition of the Pañcasiddhāntikā

The surviving manuscripts of the Pañcasiddhāntikā fall naturally into 2 classes which I have designated α and β.

Class α

A. BORI 338 of 1879/80. 22 ff. After the colophon is written: saṃvat 1673 varṣa śāke 1538 pravartamāne dvitīyāśvinaśudi 2 budhe adyeha staṃbhatīrthavāstavyaṃ paṃditaśrīpītāṃbara tatsūnuḥ śrīśrīrañga tatputraḥ paṃditanānā tattanayo paṃditagoviṃdaḥ tasyātmajena śaṃkareṇeyaṃ paṃcasiddhāntikā likhitā / ātmapaṭhanārthaṃ tathā ⟨paro⟩pakṛtaye ca. The copying was finished, then, at Stambhatīrtha (Cambay) on Wednesday 2 October 1616 Julian by Śañkara, the son of Govinda, the son of Nānā, the son of Śrīrañga, the son of Pītāmbara. This manuscript (or D, a copy thereof?) was Thibaut and Dvivedin's main manuscript, which they reproduced in the left-hand column of their edition; we have quoted its readings from that reproduction.

D. NL Calcutta 39. 24 ff. This recent manuscript agrees almost entirely with **A**, of which it is most probably a copy—perhaps the copy utilized by Thibaut and Dvivedin. It now ends at XVII,79d. We have used a microfilm.

G. IO Bühler 268 (Keith 6288). 20 ff. This manuscript is a copy of **A** completed on Sunday Bhādrapada śuklapakṣa 1 of Sam. 1936, Śaka 1802 = 5 August 1879 Julian. We have not used it.

Class β

B. BORI 37 of 1874/75. 49 ff. This is a copy made in 1874/75 of a manuscript belonging to Sadārāma Joshī of Sojītrā, who claimed to have procured it in Benares. Thibaut and Dvivedin quote some of **B**'s readings (or those of **E**, its copy?) in the apparatus to their edition, whence we have taken them. Where they are silent, β in our apparatus does not necessarily include **B**.

C. OI Baroda 7165. 33 ff. After the colophon is written: saṃvat 1928 varṣe śake 1793 pravartamāne māghaśuklā I śukre // jyotirviduttamarāmadurlabharāmeṇa likhitā // amadāvādanivāsinā mubāībaṃdaramadhye idaṃ pustakaṃ likhitaṃ. The copying (from Sadārāma Joshī's manuscript?) was completed on Friday 28 January 1872 Julian by Uttamarāma Durlabharāma, a resident of Amadāvāda (Ahmadabad), at Mubāībandara (Bombay?). We have used a transcript prepared in 1958.

E. NL Calcutta 64. Pp. 7–114. This manuscript seems to be a copy of **B**—perhaps that used by Thibaut and Dvivedin. It now begins at I,22a. We have used a microfilm.

F. Bombay Univ. 288. 32 ff. After the colophon is written: saṃvat 1928 miti bhāda vadi pratipadā paṃcasiddhāntikākhyaṃ pustakaṃ jya likhataṃ nāthurāmapārikabrāhmaṇa. The copying was finished, then, on 17 September (?) 1871 Julian by Nāthurāma Pārika, a brāhmaṇa. This manuscript is a copy of the same manuscript that **C** was copied from—i.e., perhaps that which belonged to Sadārāma Joshī. We have used a microfilm.

Besides these seven manuscripts there existed in 1890 the manuscript belonging to J. B. Modak of Thāṇā which was copied from **B**, and we know of a manuscript (no. 6674) of the Pañcasiddhāntikā in the Ānandāśrama in Poona. The manuscripts recorded as the property of Sjt. Puspachandra Sarma Daloi of Helach in Assam and of the Arsha Library in Vijayanagara (no. 506) probably contain the Bhāsvatī of Śatānanda, which is sometimes confused with our text.

The archetypes of α and β (henceforth denoted simply α and β) were derived from a common original. This is shown by their sharing not only numerous errors, but also several lacunae (e.g., IV,43c–45b and VI,9). In general α is more correct, but neither gives any evidence that its scribe understood the material he was copying. Aside from their respective readings, each class is distinguished by lacunae peculiar to itself. Thus α omits XIII,3d–4d and β IV,18b–V,9c, XIII,11c–12d, and XVII,6c–7c. Moreover, β transposes XIV,33a–XV,7d (16 verses) so that they follow XV,24a[48].

Utpala had a fuller text than do we; he knew IV,43c–44d and VI,9. There are probably other verses which were in the original text and which were not in the archetype of α and β and were not quoted by Utpala. See, for instance, Brāhmasphuṭasiddhānta XIV,46–49 and note that Varāhamihira in Bṛhatsaṃhitā XVII,1 says that he has dealt with planetary conflicts (transits) according to the Sūryasiddhānta in his karaṇa. Unfortunately, as useful as Utpala's quotations are, they do not contribute now all that they might to our knowledge of the text. This is due to the fact that we do not yet have a critical edition of Utpala's commentary on the Bṛhatsaṃhitā, but only a text prepared by Thibaut's collaborator, Dvivedin. Dvivedin was certainly influenced by the readings adopted in his edition of the Pañcasiddhāntikā; thus, in his edition where Utpala quotes I,8, he prints somadivasādye which is the emendation he and Thibaut suggested for α's saumya° and β's bhaumya°; but Dikshit had a copy of Utpala in which bhauma° was read. In our apparatus, then, Utpala refers to Dvivedin's text and not necessarily to that tenth century scholiast.

[48] These 16 verses must have occupied 1 or 2 folios of β, which have obviously been misplaced. This proves that all β manuscripts go back to a single archetype, probably the Sojītrā manuscript.

F. Appendix. Verses from the Brāhmasphuṭasiddhānta

I,13. Yugas, manvantaras, and kalpas are said in smṛti to be the definers of time; as they do not occur in the Romaka, the Romaka is outside of smṛti.

I,62. Those who know Śrīṣeṇa, Āryabhaṭa, and Viṣṇucandra, when they see one who (really) knows mean motion, do not stand and face him publicly as horses, when they see a lion, do not stand and face him.

II,46–47. At the beginning of a yuga the true longitudes for Āryabhaṭa, Mars and so on (i.e., the star-planets) for Śrīṣeṇa, and all the planets for Viṣṇucandra do not start out from the beginning of Aries. Since the true (longitudes of) Mars and so on have fallen far away (from the truth) in (the treatises) of Śrīṣeṇa, Āryabhaṭa, and Viṣṇucandra, they are not respected by the wise.

X,13. For one observing (heliacal risings and settings) every day at sunrise or sunset and (making the calculations) described by Śrīṣeṇa, Āryabhaṭa, and Viṣṇucandra, there is no unity of observation and computation.

X,62. Even though one knows the tantras (written by) Āryabhaṭa, Viṣṇucandra, and so on, he is not a teacher; but he who knows the Brāhma's operations in the dust (i.e., computations) has attained the status of a teacher.

XI,3. The Jina says that there are 54 nakṣatras, two Suns, and two Moons and that days are caused by the revolution of the dhruvamatsya; this is false.

XI,31. Since Śrīṣeṇa and Viṣṇucandra compute solar eclipses with the five sines (the agrā, the madhyajyā, the raviśaṅku, the dṛggati, and the dṛkkṣepa), they share in the errors with respect to solar eclipses which have been enunciated by Āryabhaṭa.

XI,46–47. Ignorance is doubled every day by the disagreements of Śrīṣeṇa, Viṣṇucandra, Pradyumna, Āryabhaṭa, Lāṭa, and Siṃha regarding eclipses and so on. The mistakes singly pronounced by Āryabhaṭa are properly to be considered the faults of Śrīṣeṇa and the rest; I shall now mention some other faults.

XI,48–51. Śrīṣeṇa took the mean (motions of the) Moon and Sun and the Moon's apogee and node from Lāṭa; the mean (motions of) Mars, Mercury's śīghra, Jupiter, Venus' śīghra, and Saturn (and their) revolutions in the years that have passed of the yuga from the Vāsiṣṭha, (and?) from the chapter (pāda) composed by Vijayanandin; and the apogees, epicycles, computation of true longitudes, and so on from Āryabhaṭa. Thus he made the Romaka, which was a clothes-binding knot (?), into a patched garment. Viṣṇucandra, taking these same (elements), made the Vāsiṣṭha. In these two (works) there is never any agreement between observation and calculation with regard to eclipses and so on; whatever agreement there is is a happy chance. Therefore, what use are these two inaccurate (siddhāntas)?

XI,52. The center of the circle of perigee and apogee is called the "apogee" by the stranger to the sphere[49]; as the apogee is not there he does not know the apogee.

XI,53. Since (the planets) had various latitudes at the beginning of the Mahāyuga and their true longitudes were (their mean longitudes) increased by the equations due to the various positions of their apogees, therefore the (fixed) nodes and apogees (in some siddhāntas) are not correct.

XI,54. The most and fewest nāḍīs are respectively in daylight and in night-time (when the Sun is) at the end of Gemini (in the tropical zodiac); the ṛtus depend on the motion of the Sun (in the sidereal zodiac). There is no yuga for the ayana due to its (motion); but both ayanas are fixed[50].

XI,55. That which is called a mahāyuga by Śrīṣeṇa, Viṣṇucandra, and others, but which is outside of the (system of) yugas, is stupid because at the beginning of the mahāyuga there are minutes of dṛggati in the case of the planets (i.e., the planets are not at the beginning of Aries).

XI,56. It is said in the smṛtis that the creation of the planets and constellations occurs at the beginning of a day of Brahma, their dissolution at its end. As there are very many (of their mahāyugas) in this mahāyuga, this (system of theirs) is incomplete.

XI,57–58. Because of the daily diasgreement (with observation) (of the longitudes) of the planets, tithis, karaṇas, nakṣatras, days, and months in such things as eclipses and planetary conjunctions, who would touch a chapter (pāda) with his foot (pāda)? As the lowest (pāda) karaṇas are those of the stigmatized (aṅkaciti[51]), Vijayanandin, Pradyumna, and so on, their errors will not be written down here.

XIV,46–49. The calculation of the nakṣatras that is described in the Pauliśa, Romaka, Vāsiṣṭha, Saura, and Paitāmaha (siddhāntas)[52] is not mentioned by Āryabhaṭa; therefore it is described (here). Six nakṣatras are one and a half sized, six are half sized, and fifteen are equal sized; there is one bhoga of Abhijit. The (first) six are Keśa (i.e., Śravaṇa) Āditya (i.e., Punarvasu), Viśākhā, Proṣṭhapadā (i.e., Bhādrapadā), Āryamṇa (i.e., Uttaraphalgunī), and Vaiśvadeva (i.e., Uttarāṣāḍhā); the (second) six are Jyeṣṭhā, Bharaṇī, Svāti, Ārdrā, Vāruṇa (i.e., Śatabhiṣaj), and Āśleṣā. The fifteen are not named here, and the one other nakṣatrabhoga is called Abhijit, because this nakṣatra is difficult to learn for the slow-witted.

XVI,36. Since the eclipse falls far off (from the truth) in (the works of) Śrīṣeṇa, Āryabhaṭa, and Viṣṇucandra, because of the disagreement of calculation (with observation), (any) agreement is accidental.

[49] The "stranger to the sphere" is identified as Āryabhaṭa by Pṛthūdakasvāmin.

[50] Pṛthūdakasvāmin here quotes a verse from Viṣṇucandra's Vasiṣṭhasiddhānta regarding precession; see above p. 11.

[51] Literally, "he who has a multitude of stigmata"; Pṛthūdakasvāmin identifies him with Āryabhaṭa.

[52] The passage no longer survives in our Pañcasiddhāntikā.

XVI,46. (This) additional chapter on eclipses is not to be given away, even with curses for the destruction of someone's good fortune; the (original) section on eclipses, since (it follows the treatises of) Āryabhaṭa, Śrīṣeṇa, and so on, is not accurate.

XXI,37–39. "If Rāhu obscures the Moon from the east, why does he not obscure the Sun thus? Why is there not so long a duration of a solar eclipse as there is of a lunar eclipse? How can the Sun pervade (all) objects and Rāhu be something else? Since there is a difference of obscuration in a solar eclipse, solar and lunar eclipses are not caused by Rāhu." (This opinion expressed) by Varāhamihira, Śrīṣeṇa, Āryabhaṭa, Viṣṇucandra, and others is opposed to popular beliefs and is foreign to the Vedas, smṛtis, and saṃhitās.

XXII,2. Since the sphere was not understood by teachers such as Śrīṣeṇa, Āryabhaṭa, and Viṣṇucandra, the Brāhma's sphere was made accurate.

XXIV,2–3. The beginning of the yuga is simultaneously from sunrise in the south, from midnight in the west, from sunset in the north, and from noon in the east: just this was done by Sūrya, Indu (i.e., Soma), Puliśa, Romaka, Vasiṣṭha, Yavana, and so on. Therefore one siddhānta was written and no other.

SANSKRIT

2. Text

⟨श्रीवराहमिहिरविरचिता पंचसिद्धान्तिका प्रारभ्यते /⟩
श्रीरामच⟨न्द्रा⟩य नमः /

दिनकरवसिष्ठपूर्वान् विविधमुनीन्द्रान् प्रणम्य भक्त्यादौ /
जनकं गुरुं च शास्त्रे येनास्मिन्नः कृतो बोधः //१//
पूर्वाचार्यमतेभ्यो ⟨यद्⟩ यच्छ्रेष्ठं लघु स्फुटं बीजम् /
तत्तदिहाविकलमहं रहस्यमभ्युद्यतो वक्तुम् //२//
पौलिशरोमकवासिष्ठसौरपैतामहास्तु सिद्धान्ताः /
पंचभ्यो द्वावाद्यौ व्याख्यातौ लाटदेवेन //३//
पौलिशस्त्वथ स्फुटो ऽसौ तस्यासन्नस्तु रोमकप्रोक्तः /
स्पष्टतरः सावित्रः परिशेषौ दूरविभ्रष्टौ //४//
यत्तत्परं रहस्यं भ्रमति मतिर्यत्र तन्त्रकाराणाम् /
तदहमपहाय मत्सरमस्मिन् वक्ष्ये ग्रहं भानोः //५//
दिक्स्थितिविमर्दकर्णप्रमाणवेला ग्रहाग्रहाविन्दोः /
ताराग्रहसंयोगं देशान्तरसाधनं चास्मिन् //६//

1 quoted by Utpala on BS 2,2 (p. 67)
Title: om. aβ Invocation: श्रीगणेशाय नमः β 1b विबुधमुनीन् भावतः प्रणम्यादौ Utpala 2b यद् suppl. T.-D. यच्छ्रेष्ट a, यत् श्रेष्ट β, corr. T.-D. 2c तत्कृदिहाविकल° a, तत्त(त्र C, त्र F)दि(हि C, हि F)हा (रा C, हालिं F) विल° β, corr. T.-D. 3a °रोमयु° B, °रोमयू° F 3b पंच सिद्धान्ताः aβ 4a पौलिशतिथि a, पौलिशतिथः β 5a यत्तत्पैरं β 5c मच्चर° B, मप्सर° CF 5d वच्चे a, वक्ष्ये (च्ये C) β, corr. T.-D. 6a दिक्सं(म CF)स्थिति° β 6d °सावनं a

3. Translation

Chapter I

I,1. Revering in the beginning with devotion the various leaders of the sages, beginning with the Sun and Vasiṣṭha, and my father and teacher by whom I was instructed in this science;

I,2. whatever is the best, easy, accurate correction (bīja) according to the opinions of the former teachers, that secret in its entirety I shall attempt to tell here.

I,3. The siddhāntas are the Pauliśa, the Romaka, the Vāsiṣṭha, the Saura, and the Paitāmaha; of these five the first two were commented on by Lāṭadeva.

I,4. The Pauliśa is accurate; that which was pronounced by Romaka is near it; the Sāvitra (i.e. the Sūryasiddhānta) is more accurate; the remaining two have strayed far away (from the truth).

I,5. Whatever is the highest secret where the minds of the authors of tantras are perplexed, that—the eclipse of the Sun—I will explain in this (work), putting aside envy.

I,6. In it (in this work) are (the rules for computing) the direction, duration, totality, hypotenuse, magnitudes, and times (of solar eclipses), the occurrence or non-occurrence of lunar eclipses, the conjunctions of stars and planets, and the computation of longitudinal differences;

सममण्डलचन्द्रोदययन्त्रच्छेद्यानि शङ्कुवच्छाया /
उपकरणान्यक्षज्यावलम्बकापक्रमाद्यानि //७//
सप्ताश्विवेदसंख्यं शककालमपास्य चैत्रशुक्लादौ /
अर्धास्तमिते भानौ यवनपुरे भौमदिवसाद्ये //८//
मासीकृते समासे द्विष्ठे सप्ताहते ऽष्टयमपक्षैः /
लब्धैर्युतो ऽधिमासैस्त्रिंशद्घ्नस्तिथियुतो द्विष्ठः //९//
रुद्रघ्नः समनुशरो लब्धोनो गुणखसप्तभिर्द्युगणः /
रोमकसिद्धान्ते ऽयं नातिचिरे पौलिशे ऽप्येवम् //१०//
दिग्घ्नाः साष्टनवरसाः ⟨सौर⟩दिवसाः कृतुसप्तनवभक्ताः /
पौलिशमते ऽधिमासास्त्रिषड्दिनान्यवमसंक्षेपः //११//
तिथिदशांशमथ दद्यादधिमासार्थं स्वराम्बरैकाब्दैः /
अवमार्थं पंचतनुद्विद्विमितैस्तिथिशिवांशैश्च //१२//
अधिमासकेषु भूयो ऽप्येक ऋतुखपंचकेन्द्रियाब्देषु /
देयो ऽवमेषु हेयो नवसप्तद्वित्रिखयमेषु //१३//

8–10 quoted by Utpala on BS 2 (p. 31)

7b यंत्रछेद्यानि a, य(र्घ C F)त्र छेद्यानि β   तांड(ङ्ग D)वछाया aβ, corr. T.-D.
7c उपक(का B)रणाद्य° aβ   8d सौम्य° a, भौम्य° β, सोम° Utpala T.-D., भौम° Dikshit   9b द्विस्थे (स्थे F) β   9d °स्त्रिंशघ्न° a   द्विस्थः β, ऽघः:स्थः Utpala   10c °सिद्धान्तो a   यो β   11a दि (द्वि C) घ्ना: aβ, corr. Kharegat, Sengupta   साष्टा° aβ, corr. Sengupta   नवरस a   दिवसाः om. β
कृतु° (त्रु° D) a, रु (स C) तु° β, कृतत्तु° Sengupta, कृतु° Kharegat
11d °स्त्रिकृ(क F, ऋ D)तदि° aβ   12a °दशमथ (या above) दद्या° A, °दशम – दद्या° D, दश दद्या° β, corr. Kharegat, Sengupta   °दमांशदौ घमासार्थं β   स्वरांत्वरैः काब्दैः a   12c पंचकृ(ऋ D)ता aβ   द्विकुमितै° a, द्विसंस्थितै° β   13a °मासयेषु β
13b ऽप्येकीकर्तुं aβ, ऽप्येक एकर्तु° Kharegat   °यांशेषु aβ, corr. Kharegat

I,7. the prime vertical, the rising of the Moon, magical diagrams and geometrical constructions, the gnomon shadow, and useful matters such as the Sine of terrestrial latitude, the Sine of colatitude, and the declination.

I,8. Substract the Śaka year 427 (from the given Śaka year) at the beginning of the first half-month (śuklapakṣa) of Caitra, which begins a Tuesday, when the Sun has half-set at Yavanapura.

I,9. Convert (the number of lapsed years) into months, add the (number of lapsed solar) months (of the current year), and put it down in two places; multiply it (in one place) by 7 and (divide) by 228; increase it (in the second place) by the resulting intercalary months. Multiply (the sum) by 30, add (the number of lapsed) tithis (of the current month) and put it down in two places.

I,10. Multiply it (in one place) by 11, add 514, and (divide) by 703; subtract the result (from the other place; the remainder is) the ahargaṇa. This is in the Romaka-siddhānta; it is not very different in the Pauliśa.

I,11. In the opinion of Pauliśa, the solar days multipled by 10, increased by 698 and divided by 9761 are the intercalary months; there is an omitted tithi every 63 days.

I,12. One should give a tenth of a tithi every 107 days for the purpose of (computing) the intercalary months, (and one omitted tithi) every 25 135 tithis for the sake of (computing) the omitted tithis.

I,13. Add one more to the intercalary months every 5506 years; subtract 1 out of every 203 279 omitted tithis.

वर्षायुते धृतिघ्ने नववसुगुणरसरसाः स्युरधिमासाः /
सावित्रे शरनवकेन्द्रियार्णवाशास्तिथिप्रलयाः //१४//
रोमकयुगमर्केन्द्वोर्वर्षाण्याकाशपंचवसुपक्षाः /
सेन्द्रियदिशो ऽधिमासाः स्वरकृतविषयाष्टयः प्रलयाः //१५//
युगवर्षमाससपिण्डं रविमानं साधिमासकं चान्द्रम् /
अवमविहीनं सावनमैन्दवमब्दान्वितं पार्व्वम् //१६//
मुनियमयमद्वियुक्ते युगणे शून्यद्विपंचयमभक्ते /
प्रतिराशि स्वर्तुदहनैर्लब्धं वर्षाणि यातानि //१७//
तानि प्रपन्नसहितान्यग्निगुणान्यश्विवर्जितानि हरेत् /
सप्तभिरेवं शेषो वर्षाधिपतिः क्रमात् सूर्यात् //१८//
त्रिंशद्गुणे मासाः प्रपन्नसहिता द्विसङ्गुणाः कार्याः /
सप्तोद्धृतावशेषे मासाधिपतिस्तथैवार्कात् //१९//

16 quoted by Utpala on BS 2 (p. 30); 16a on BS 21,7; 17–18 on BS 2 (p. 31); 19 on BS 2 (p. 32).
14d °न्द्रिया— (र्यवा CF) शा° β 15b पंचयेस्तु (पस्तु C, मे सु F) पक्षाः β
15d स्वकृ (अE D) त° a, स्यात्कृ (स्यकृ CF) त β, corr. T.-D. 16a युगवर्षणं
सपिंडं β 16d तार्व्वं β, त्वार्व्वम् Utpala 17c प्रतिराश्च a, गतिरा (ए F) श्च β,
corr. T.-D. 17d पातानि (मि D) a 18b °न्यग्निगुणा° om. B
°न्यश्विवर्जिता a, °न्यद्रि (श्वि C) वर्जितानि β, °न्यश्विवर्जितानि Utpala
Kharegat 19b प्र (अ C) मवसहिताः β द्व्येकाः Utpala 19c °वशेषो Utpala
19d °स्तथैवार्घ्या (र्घ्ये F) त् BF

I,14. In the Sāvitra (i.e. Sūryasiddhānta), in 180 000 years there are 66 389 intercalary months and 1045 095 omitted tithis.

I,15. The yuga of the Sun and Moon according to the Romaka is 2850 years; the intercalary months are 1050; the omitted tithis 16547.

I,16. The sum of the (solar) months in the years of a yuga is the measure of the Sun; increased by the intercalary months, it is (the measure of) the lunar (months). (This total multiplied by 30 and) diminished by the omitted tithis is the number of civil days; the lunar (months) increased by the number of years are the sidereal months.

I,17. Increase the ahargaṇa by 2227 and divide (the sum) by 2520; with respect to the (remaining) amount, divide it by 360; the quotient is the number of lapsed years (in the current cycle of 7).

I,18. Increase these by the current year, multiply by 3, and subtract 2; divide by 7, and the remainder is the lord of the year, beginning with the Sun.

I,19. Divide (the augmented ahargaṇa) by 30; increase the (resulting) months by the current one and multiply by 2; the remainder after division by 7 is the lord of the month beginning with the Sun.

सप्तोद्धृते दिनेशास्त्रिगुणो व्येको युतश्च होराभिः /
पंचघ्नः सप्तहृतो विज्ञेयः कालहोरेशः //२०//
वर्षाधिपश्चतुर्थो मासाधिपतिस्तथा तृतीयोऽन्यः /
होराधिपश्च षष्ठो निरन्तरं दिवसनाथश्च //२१//
वर्षे यद्यस्य फलं मासे च मुनिप्रणीतमालोक्य /
तत्तद्वृत्तैर्वक्ष्ये होरातन्त्रोत्तरविधानैः //२२//
द्युगणे रूपाभ्यधिके पंचर्तुगुणोद्धृते मगाब्दाः स्युः /
त्रिंशद्धृतेऽर्के शेषं ज्ञेयं राश्यंशकेन्द्राणाम् //२३//
कमलोद्भवः प्रजेशः स्वर्गे(शो)शास्तृरुद्रमन्युवसवः /
कमलानलान्तरवयः शशीन्द्रगोनिर्ऋतयः क्रमशः //२४//
हरभवगुरुपितृवरुणा बलदेवसमीरणौ यमश्चैव /
वाक् श्रीधनदौ गिरयो धात्री वेधाः परः पुरुषः //२५//
करणावतारः //

20 quoted by Utpala on BS 2 (p. 35); 21 on BS 2 (p. 36); 22 on BS 19 intr.
20b °गुणे aBC ऽध्ये (ऽप्ये C) कश्च (क्ष C) होरादिः aβ, व्येको युतश्च होराभिः Utpala 20c पंचघ्ने aβ, पंचघ्नः Utpala °हृ (ह F) ते aβ, °हृतो Utpala विज्ञेया a काय (घ्य C, घ्म F) होरेशः β °होरेशाः a 21a °श्चतुर्थे aβ 21b नतोयो a, ततोयो β 21c होराधिपतिश्च β 21d दिवसनाथः स्यात् Utpala 22a E begins with वर्षे यद् om. β (suppl. E[2]) 22c तत्तद्वृत्तै° om. aβ, suppl. Utpala वच्चे aC 22d °विधाने Utpala 23a कगणे β 23b °गुणोध्धृते a, °गुणोध्व (ध्वा CF) जे β मगाब्दाः] ऽस्य मासाः aβ 23d राश्यंशवें (चें F, यं E) द्राणां aβ, corr. T.-D. 24a कमलोद्भवा a प्रजेसा a 24b स्वर्ग्ये शास्त्रं द्र (द्रु D) मान्यवासांसि a, स्व (स्व BE) र्गः (र्यः C) शास्त्रं रु (om. CF) द्रमा (न्ना E) न्यवासांसि β 24d °नियतयः aβ, corr. T.-D. 25a हरत्तव° β °गुह° a °चरुणा a, वरुण (णां C) β 25b °समीकरणौ a 25c श्रीधनवौ (वै C) β 25d पुरूषः a

I,20. When one divides (the augmented ahargaṇa) by 7, (the remainder) is the lord of the day. Multiply (this remainder) by 3, subtract 1 and add the (elapsed) hours; multiply (the result) by 5 and divide by 7; (the remainder) is to be known as the lord of the hour.

I,21. The lord of the next year is the fourth (in order of the week-days); the lord of the next month is the third; the lord of the next hour is the sixth; and the lord of the next day is the next.

I,22. Whatever is the (astrological) result of each (planet) in a year or in a month, that I shall explain with mastered rules of horoscopy in the future after examining the opinions of the sages.

I,23. Increase the ahargaṇa by 1 and divide by 365; (the quotient) is years of the Magas; when one divides (the ahargaṇa increased by 1) by 30, the remainder is to be known as belonging to the lords of the degrees of the signs.

I,24. Kamalodbhava, Prajeśa, Svargeśa, Śāstṛ, Rudra, Manyu, Vasu, Kamalā, Anala, Antara, Vayaḥ, Śaśi, Indra, Go, and Nirṛti in order;

I,25. Hara, Bhava, Guru, the Pitṛs, Varuṇa, Baladeva, Samīraṇa, Yama, Vāk, Śrī, Dhanada, the Giris, Dhātrī, Vedhāḥ, and Paraḥ Puruṣaḥ.

The Incarnation of the Karaṇa.

कृतगुणमृतुयुतमेकर्तुमनुहृतं षड्यमेन्दुभिर्वियुञ्जेत् /
शशिखखखयमकृतस्वरनवनववसुषट्कविषयोनैः ॥१॥
रसगुणनवेन्दुयुक्ते शशिगुणखगुणोद्धृते घना द्युगणे /
शेषे नवभिर्गुणिते गतयो ऽष्टजिनैः पदं शेषम् ॥२॥
घनषोडशाहृतशेषं प्रोज्झ्याधस्त्रिगुणितं चतुर्भक्तम् /
आदि कला द्विगुणघनाः शशिमुनिनवयमा राश्याद्याः ॥३॥
विषयधृतयो गतिघ्ना गतिषष्ठांशोनिताः कलाः प्रोक्ताः /
वेदार्काः पदसंख्या गत्यर्धं धनमृणं परतः ॥४॥
गत्यर्धे भगणार्धं देयं लिप्ताचतुष्कसंयुक्तम् /
शेषपदसमासांशास्तैश्च धनर्णात् फलं देयम् ॥५॥
व्येकपदमिन्द्रियघ्नं कृतनवदस्रसंयुतं वियुक्तं च /
मनुवेदयमेभ्यः पदगुणे त्रिषष्ट्युद्धृते लिप्ताः ॥६॥

1a कृतगुणष (य) (षय D) मृतुयुतमैकर्त्तु° a, कृतगुणषट्क (डु C, ट्ट E, ड्ड E², ड्ड F) तु-युतमैकर्तु (र्त्ते C) β, corr. Kuppana Sastri. 1b °र्विभजेत् aβ
1c °स्वरकृ (क्र a) त° aβ, corr. Kharegat, Kuppana Sastri. 2a °युक्त a, °युक्तं (क्तुं C) β, corr. T.-D. 2b घता a 2d प्रदं β 3a घ (घ EF) नषोडशा-हृ (हृ E, corr. E²) तं शेषं aβ 3b प्रोज्झ्याद्य° a, प्रोज्याध° β, corr. Kuppana Sastri. 3c कल β 3d °यमाश्च (श्च a BC) राश्या (शा a) द्याः aβ
4b गृ (ग A) ततिषष्टांशो° a, गृ (ग C) नतिघ्ना (घ्रा CF) षष्टांशो° β
4c पादसंख्या aβ, corr. Kuppana Sastri. 4d अ (अं CF) गत्यर्धं β
5b लिप्ताश्चतुष्क° aβ, corr. T.-D. 5d धनणा (रा F) त्फलं β
दे (दें A) त्यं (त्य β) aβ, corr. T.-D. 6b द्वियुक्तं β 6d त्रिषष्ट्योद्धृते aβ

Chapter II

II,1. (One should) multiply (the ahargaṇa) by 4, add 6, divide (the sum) by 1461, and subtract (successively) 126 diminished (respectively) by 1, 0, 0, 0, 2, 4, 7, 9, 9, 8, 6, and 5.

II,2. If one increases the ahargaṇa by 1936 and divides (the sum) by 3031, (the quotient) is (called) ghanas; if the remainder is multiplied by 9 and divided by 248, (the quotient) is (called) gatis and the remainder the pada.

II,3. Divide the ghanas by 16; put the remainder aside below; multiply it by 3 and divide it by 4; (the quotient) in signs and so on (is to be subtracted; add) minutes (equal to) twice the number of ghanas, (and) $2^s\ 9;7,1°$; (the result) is (the longitude of the Moon) in signs and so on.

II,4. The gatis multiplied by 185 and diminished by $^1/_6$ of the gatis are called the minutes. A half of a gati is 124 padas; it is positive (in the first half), negative in the other.

II,5. In the (first) half of a gati one must give 180° plus 4 minutes. Take degrees equal to the padas or to the remainder (after subtracting 124); add to these the contribution from the positive or negative (halves of the gati).

II,6. Multiply by 5 the padas diminished by 1; add 1094 to it (in the first half) and subtract it (in the second) from 2414; multiply (each sum) by the padas and divide by 63; the results are minutes (of the longitudinal increment).

शश्यर्धदलं त्रिकृतिघ्नमृक्षमंशस्थिता मुहूर्ताः स्युः ।
व्यर्केन्दुदलं विषयाहतं तिथिस्तद्वदेवोक्तः ॥७॥
मकरादौ गुणयुक्तो मेषादौ तिथियुतो रविर्दिवसः ।
कर्कटकादिषु षट्सु त्रयस्त्रिकाः शर्वरीमानम् ॥८॥
कर्कटकादिषु भुक्तं द्विगुणं मध्यन्दिनी भवेच्छाया ।
मकरादिषु चाप्येवं किं चास्मिन् मण्डलाच्छोध्यम् ॥९॥
मध्याह्नच्छायार्धं सत्रिभमर्को ऽयने भवेद्याम्ये ।
उदगयने संशोध्यं पंचदशभ्यो रविर्भवति ॥१०॥
द्वादशभिः सच्छायैर्मध्याह्नोनैर्भजेद्रसहुताशम् ।
अपराह्णे चक्रार्धाद्विशोध्य सार्कं भवति लग्नम् ॥११॥
व्यर्के लग्ने लिप्ताः प्राक् पश्चाच्छोधितास्तु चक्रार्धात् ।
कार्यश्छेदः शून्याम्बराष्टलवणोदषट्कानाम् ॥१२॥
लब्धं द्वादशहीनं मध्याह्नच्छायया समायुक्तम् ।
सा विज्ञेया छाया वासिष्ठसमाससिद्धान्ते ॥१३॥
नक्षत्रादिच्छेदः ॥

7a श (om. D) शादलं a, श (om. C) शस्वदमं β, corr. T.-D. 8b मेखादौ aBC 8c सतसु aβ, corr. T.-D. 9a भक्तं β 9c वाप्येवं a 9d यस्मिन् aCF, त्वस्मिन् Kuppana Sastri. मण्डलाछोध्यं a, मण्डलात् (त् om. F) शो (सो BE) ध्यां β, corr. T.-D. 11a द्वाशभिः AC 11b °द्रसजताशं a, °द्रसहृ (ह F) तांशाः β, corr. T.-D. 11c चन्द्रार्धा° aβ, corr. T.-D. 12b प्राक्यश्चाछोधितास्त्र a चक्राद्ध (त् द्ध E^2) तिः BEF 12c काय (यः C) छेदः aβ, corr. T.-D.

13c quoted by Utpala on BS 2 (p. 64).

13a लघ्वं a 13b समायुक्ता β

II,7. Multiply a fourth of the Moon's (longitude in signs) by 9; the product is the nakṣatra; the degrees (which remain) are muhūrtas. Half of the elongation between the Sun and the Moon (measured in signs) multiplied by 5 is the tithi; (the muhūrtas) are explained in the same way (as above).

II,8. At the beginning of Capricorn, (the longitude of) the Sun (in signs) plus 3 (muhūrtas) is the length of daylight; at the beginning of Aries, add 15 (muhūrtas); in the six signs beginning with Cancer, (add) 9 (muhūrtas to get) the measure of the night.

II,9. In the (six) signs beginning with Cancer, multiply the (number of signs from Cancer 0°) traversed (by the Sun) by 2; the result is the noon shadow. In the six signs beginning with Capricorn, do the same thing and subtract (the product) from 12.

II,10. Half the noon shadow plus three signs is the (longitude of the) Sun (in signs) in the southern ayana; in the northern ayana it is the same, subtracted from 15 (signs).

II,11. One should divide 36 by 12 increased by the shadow and diminished by the noon shadow; add the (longitude of the) Sun (in signs to the quotient); (the result) is the ascendent; in the afternoon, subtract (the quotient) from 6 signs (before adding the longitude of the Sun).

II,12. Subtract the (longitude of the) Sun from the ascendent; in the eastern (hemisphere), the (resulting) minutes are to be made the divisor of 64800; in the western, they must first be substracted from 10800.

II,13. The quotient (in signs) is to be diminished by 12 and increased by the noon shadow; (the result) is to be known as the shadow in the concise siddhānta of Vasiṣṭha.

Thus the Division of the Nakṣatras and so forth.

सार्केन्द्रे ऽग्निहृताशनमपास्य रूपाग्निवसुहृताशकृतैः /
हृत्वा क्रमाद्दिनेशो मध्यः केन्द्रं सविंशांशः //१//
एकादशाष्टषट्कं रूपोना सप्ततिः खयुक्ता च /
नवषट्कमब्धिकृतिश्च क्षयः कलाः केन्द्रराशिसमाः //२//
दशषट्काष्टकसप्ततिः सप्ततिरेकाधिका च नवषट्कम् /
पंचकृतिश्चोपचयो मध्यमसूर्यः स्फुटो भवति //३//
<वि>नवात् पदाद्द्विघ्नात् सप्तांशाः साग्निखस्वरो भुक्तिः /
गत्यर्धान्ताच्छोध्यो लिप्ताभ्यो नवमुनिवसुभ्यः //४//
पदमेकोनं पंचाष्टकघ्नमेकर्तुपञ्चविषयेभ्यः /
प्रोज्झ्य पदघ्नं छिन्द्यान्नवयममुनिभिः कला इन्दोः //५//
सार्काधिकं भवेच्चेत् परिशोध्यं ततः पुनः शतं विंशात् /
शशिनि धनं पूर्वार्धे गत्यर्धे ऽन्त्ये क्षयः कार्यः //६//

1 quoted by Utpala on BS 2 (p. 41).

1a ग्निहृताशन° aBC 1b °मपास्य aC 1c हृत्वा a, हृ (ह C) त्या (वा C) β, corr. T.-D. क्रमाद्दितेशो a, क्रमाद्दिनेशो β 1d धेंद्रं β सविंशांशं aβ 2b स्वयुक्ता β 2c °मुन्यकृतिश्च a, मु (सु C) म (त्य F, य C) कृतश्च β, corr. T.-D. 3a °सप्तति om. β 3b सप्ततिनैकाधिका aβ, corr. T.-D. 4a विनवात् Kuppanna Sastri पदाद (द्व CEF) शघ्नात् (घ्नात् F, घ्नात् C) β. 4b सप्तिखसांवरो aβ, corr. Kuppanna Sastri भु (भ CF) वतिक्ति: β 4c गत्यर्द्धता° BE, गत्यर्द्धौ (र्द्धं T°) CF 4d वसुमुनिनवभ्यः aβ, corr. Kuppanna Sastri 5a पदमेकानं β 5b °मेकंतु° aβ, corr. T.-D. 5c प्रोह्य a, प्रोह्वा (ध्या EF, ध्या C) β 6b परिशोध्या β तत् पुनः शताद्विं (द्विं EF) शात् aβ 6d त्ते (ते EF) aβ, corr. T.-D.

Chapter III

III,1. Multiply (the ahargaṇa) by 120, subtract 33, and divide by 43831; the result is the mean (longitude of the) Sun in order (of revolutions, etc.). This increased by 20° (and diminished by the apogee) is the anomaly.

III,2. The negative minutes corresponding to signs of anomaly are: 11, 48, 69, 70, 54, 25.

III,3. 10, 48, 70, 71, 54, 25 are the positive ones. The mean (longitude of the) Sun is corrected (by them).

III,4. For every ninth pada, multiply (the pada) by 10 and take a seventh part (of the product; the result) increased by 702 (minutes) is the (Moon's) daily motion (bhukti); after the end of a half of the anomalistic month (gati), one must subtract (that result) from 879 (minutes).

III,5. Multiply by 40 the padas decreased by 1, subtract (the product) from 5261, multiply (the result) by the padas and divide by 729; (the result) is the minutes (of the equation) of the Moon.

III,6. Whatever (pada) is more than 120, subtract 120 from it. It is additive to the Moon in the first half-gati, subtractive in the second.

न पदं त्रिषष्टिपरत: प्रथमपदं सप्ततिं त्वतिक्रम्य /
पदयुक्त: षट्पंचयुतश्च बिन्दुस्त्रिकृतिभक्त: //७//
षष्ट्यधिकं तु पदस्मिंस्तच्छोध्यं षष्टितो ऽवशिष्टं यत् /
तद्धानिं प्रथमपदे गतिदलपरत: शशिनि दद्यात् //८//
विनवपदे भुक्त्यून इन्दुश्च <च>न्द्रस्तदा हि चोत्तमे /
तद्विश्लेषाद्भुक्तिर्नीचे चैवं पदे सनवे //९//
विंशतिरष्टि: सार्धा पादोना: सप्त चाजपूर्वाणाम् /
विषुवच्छायागुणिता: क्रमोत्क्रमाच्चरविनाड्यो ऽर्धे //१०//
मेषादिषु तदुपचितै: कर्कट(क)ाद्येषु च तदपचयमितै: /
दिनवृद्धि: स्याद्येन क्षयस्तुलाद्येषु वैषुवतात् //११//
सागरहिमाद्रिपरिधौ स्पष्टमिदं चरविनाडिकाकर्म /
अन्यत्रापि यथैतत् स्पष्टं तच्छेद्यके वक्ष्ये //१२//

10 quoted by Utpala on BS 2 (p. 63).

7b च (om. B) तिक्रम्य Dβ 7c पद(र्व)युक्ता: aβ षट्पंचगुणाश्च BC, षट्कं च (च om. E²) गुणाश्च (णा: E²) aEF 7d °स्त्रिघन (ना aEF) भक्ते (त्तक्रे F) aβ 8a-b षष्ट्य (ष्ट्स F) धिकं तु यदवशिष्टं यत् β 8c तद्धानि: aβ 8d गतदल° aβ °पुरत: β शशि a दषा (ष B, शा C) द्यात् β 9a विनवपदै aβ. 9a-b °भु (भु a, भू C) क्त्यू (क्त्यु BE, त्सू F, सु C) नैर्विन्दुचन्द्र° aβ 9b चोत्मत्रै: a, चोत्पमप (भय C) दे β 9c गतदलपरतु तै: inserted from 3d β तद्विधिषा° β 9c-d °द्भुक्तिनीचे β, °द्भुक्तिनवे a 9d पदै: सनवै: (पै: EF) aβ 10a °रष्टै: a सार्द्ध° Utpala 10b पादोनैना: β चा (त्वा C) जपूर्वारि (पूर्वा C, पूर्वार F) गां (णां C) β 10d क्रोमोत्क्रमा° a र्द्धे a, ऽर्द्धे: Utpala 11a मेषादिषद्ु (द्ु E, द्ु F, द् C) पचितं aβ, corr. T.-D. 11b कर्कटाद्येषु aβ, corr. T.-D. °चयमिति β 11c साद्येन aβ, corr. T.-D.

III,7. There are no padas after the 63rd pada (in the second series). (But,) when one attains the 70th pada, that is (to be treated as) the first pada; increase the padas by 560/9.

III,8. When the padas are more than 60, they are to be subtracted from 60; whatever remains one should give to the Moon negatively in the first pada after the (second) half-gati(?).

III,9. The (longitude of the) Moon on every next ninth pada, decreased by its daily motion is the (longitude of the) Moon on that day; as the converse of this, the daily motion (is the difference between the Moon's longitude then and that) on the preceding ninth pada.

III,10. Multiply the (noon) equinoctial shadows for the (three) signs beginning with Aries by 20, $16^1/_2$, and $6^3/_4$ (respectively); these, taken in direct and reverse order, are the vināḍīs of the equation of daylight in the (first) half (of the zodiac).

III,11. In (the three signs) beginning with Aries, the increase in the (length of) daylight, (for each day) beginning with the equinoctial, is determined by adding these; in (the three signs) beginning with Cancer by subtracting them (successively); in (the six signs) beginning with Libra they are negative.

III,12. The operation (for finding) the vināḍikās of the equation of daylight is correct (for the region) bounded by the ocean and the Himālayas; how it is made accurate elsewhere I shall explain in the chapter on geometrical constructions.

यवनान्तरजा नाड्यः सप्तावन्त्यां त्रिभागसंयुक्ताः ।
वाराणस्यां त्रिकृतिः साधनमन्यत्र वक्ष्यामि ॥१३॥
त्रिकृतिघ्नात् खवसुहृताद्योजनपिण्डात् स्वताडिताज्जह्यात् ।
अक्षद्वयविवरकृतिं मूलं षट्कोद्धृतं नाड्यः ॥१४॥
देशान्तरनाडीभ्यश्चरनाड्यर्धोदयस्तु पूर्वार्धे ।
चक्रस्यार्धे चान्त्ये वृद्धिस्तद्भागमपि जह्यात् ॥१५॥
अच्चं लिप्ताश्चयती व्यर्काच्चन्द्रात्तिथिर्द्विषट्कांशैः ।
भुक्त्यनुपाताद्वेला रवीन्दुभुक्त्यन्तराच्च तिथेः ॥१६॥
गुणशिखिगुणाग्नियमशशिवियुता सैका सरूपरूपैका ।
सैकवियुता च भानोः षष्टिर्भुक्तिः क्रमादेवम् ॥१७॥
सितबहुलयोः क्षयधनं षड्भागाः शीतगोर्विरविभोगात् ।
लिप्ताः स्वर्तुहृतांशैर्लब्धं करणं तिथिवदन्यत् ॥१८॥

13a य (च C) वना (ना om. C) न्त (घ β) रजा (जा om. β) aβ 13b सप्तावंत्यास्त्रि° aβ, corr. T.-D. 14b °पिंडा (ड E) aβ, corr. T.-D. स्वताडिता° β
14c-d °क्र (कृ E) तिर्मूला: (ल्या: BE) aBEF 14d षट्कोद्धृता (त्ता aB) aBEF
15a °नाटीभ्य° a 15b °नाड्यर्धे aβ 15c विक्रस्यार्द्धे β
15d वृद्धिस्तद्भोग° a, वृद्धिस्तद्भो (द्भो E², द्भा F) रा β 16a रुच्चं (च्चे C) β
लिप्ताश (श्रीं C, थ a) ती aβ, corr. T.-D. 16b °च्चन्द्रात्तिथिर्द्वि° a,
°च्चन्द्रतिथि- द्वि° β, corr. T.-D. 16c भु (भू F, भ C) त्य (त्म E, त्स F, क्ष्य C)
नुपाता° β 18a सितवज्ज (ज BC, जु EF) लयो: (यो: β) aβ, corr. T.-D.
18b °भोगान् a, °त्तोगात् β, corr. T.-D.

III,13. There are $7^1/_3$ nāḍīs arising from the (longitudinal) distance between Yavana(pura) and Avanti; nine (between Yavanapura and) Vārāṇasī. I will explain the calculation for other places.

III,14. Multiply the sum of the yojanas (between the localities) by 9, divide (the product) by 80, and square (the result); subtract from this the square of the difference between the two latitudes (of the two localities); the square-root (of the remainder) divided by 6 are the nāḍīs (of the longitudinal difference).

III,15. Subtract half the nāḍīs of ascensional difference from the nāḍīs of longitudinal difference in the first half of the zodiac, add them in the second. One should ignore any fraction of them (?).

III,16. A nakṣatra is 800 minutes. A tithi (is known) from (the longitude of) the Moon diminished by (that of) the Sun (being divided) by 12°. The limit (of a nakṣatra) is a consequence of the daily progress (of the Moon). (The limit) of a tithi is derived from the difference between the daily progresses of the Sun and Moon.

III,17. The daily progress of the Sun (in each of the zodiacal signs) is in order 60 (minutes) minus 3, 3, 3, 3, 2, 1; plus 1, 1, 1, 1; and minus 0, 1.

III,18. In the śuklapakṣa 6° are subtracted, in the kṛṣṇapakṣa they are added. The minutes of the Moon (so modified and) diminished by the longitude of the Sun (are to be divided) by 360; the result is the karaṇa. The rest is like a tithi.

बहुलचतुर्दश्यर्धात् ध्रुवाणि शकुनिचतुष्पदं नागः ।
किंस्तुघ्नमिति चराण्यर्धं करणं तिथेः प्रवर्त्तते ॥१९॥
अर्केन्दुयोगचक्रे वैधृतमुक्तं दशर्क्षसहितस्तु ।
यदि चक्रो व्यतिपातो वेला मृग्यार्पितैर्भागैः ॥२०॥
आश्लेषार्धादासीद्यदा निवृत्तिः किलोष्णकिरणस्य ।
युक्तमयनं तदासीत् साम्प्रतमयनं पुनर्वसुतः ॥२१॥
विपरीतायनयातो यदार्ककाष्ठांशर(शे)शिरविक्षेपः ।
भवति तदा व्यतिपातो दिनकृच्छशियोगचक्रार्धे ॥२२॥
मेषतुलादौ विषुवत् षडशीतिमुखं तुलादिभागेषु ।
षडशीतिमुखेषु रवेः पितृदिवसा ये ऽवशेषाः स्युः ॥२३॥
षडशीतिमुखं कन्याचतुर्दशे ऽष्टादशे च मिथुनस्य ।
मीनस्य द्वाविंशे षड्विंशे कार्मुकस्यांशे ॥२४॥

21 quoted by Utpala on BS 2 (p. 41).

19a बहुलयतुर्द (द्द F) श्यंद्र BEF, बहुलचतुर्द्दि (र्दि C) श्यं (श्यं C) द्धा (तात् C) a C, corr. T.-D. 19b ध्रिवाणि BEF °निश्चनुष्पदं a 19c किंसु (स्तु C) घ्ना (घ्न) सित β, किंस्तुघ्नामिति a, corr. T.-D. 19c–d चरा (र BE) ण्यर्द्धं aβ 19d करणानि वत् प्रवर्त्तते aβ 20b दश्यर्क्ष° a °सहितेषु aβ 20d मृग्यापि (पि a) तैर्भागैः aβ 21a अश्लेषा° aβ 21b किलोष्क° D, किलोकृ° β 21c युक्तमयनं a 21d °मयनं a 22b °काष्ठांशशिसविक्षेपः aβ, corr. T.-D. 22d दिनकृच्छ° a 23a मेख° a बिषुव a 23b षडसीति° a 23d ये a, ये β, corr. T.-D. विशेषाः aβ, corr. T.-D. 24b ष्टादशे a 24d षड्विंशे a

III,19. From the middle of the fourteenth tithi of the kṛṣṇapakṣa the fixed (karaṇas) are Śakuni, Catuṣpada, Nāga, and Kiṃstughna; (the rest are) movable. A karaṇa is half of a tithi.

III,20. When the sum (of the longitudes) of the Sun and Moon is a revolution, it is called Vaidhṛta (yoga); but if it is a revolution plus 10 nakṣatras (133;20°), Vyatipāta. The time is to be ascertained by means of the degrees attained (by the luminaries).

III,21. When the return of the Sun was from the middle of Āśleṣā (at 113;20°), then the ayana (-correction) was positive; now the ayana is from Punarvasu (at 90°).

III,22. When the falling away (from the mean position) of the ayana is reversed, then the correction (kṣepa) for the Sun and Moon (equals) the degrees of the maximum declination (kāṣṭhā) of the Sun (23;20°). There is Vyatipāta if the sum (of the longitudes) of the Sun and the Moon is 180°.

III,23. The equator (viṣuvat) is at the beginnings of Aries and Libra. The ṣaḍaśītimukha ("eighty-six faced") is in the degrees beginning with Libra; in the ṣaḍaśītimukhas of the Sun, whatever (days) are left are days of the Pitṛs.

III,24. There is a ṣaḍaśītimukha at Virgo 14°, at Gemini 18°, at Pisces 22°, and at Sagittarius 26°.

उदगयनं मकराद्यावृतवः शिशिरादयश्च सूर्यवशात् ।
द्विभवनकालसमानं दक्षिणमयनं च कर्कटकात् ॥२५॥
षष्टिघ्ना भुक्तिहृता रविबिम्बकला भवन्ति नाड्यस्ताः ।
सङ्क्रान्तीनां कालः पुण्यो ऽतो ऽर्धेन चाद्यन्तात् ॥२६॥
तिथ्यन्तं यदि सूर्यः स्पृशन्नुदेत्येष्यं वासरं चापि ।
योगस्तदा त्र्यहःस्पृक् तिथित्रयस्पर्शनादह्नः ॥२७॥
अष्टगुणे दिनराशौ रूपेन्द्रियशीतरश्मिभिर्भक्ते ।
लब्धा राहोरंशा भगणसमाश्च क्षिपेल्लिप्ताः ॥२८॥
वृश्चिकभागा राहोः षड्विंशतिरेकलिप्तिकालुप्ता ।
आदिरतः प्रोज्झ्य मुखं षड्राशियुतं तु पुच्छमाख्यम् ॥२९॥
वक्त्रादधिकश्चन्द्रो हीनः पुच्छाच्च याति भगणोदक् ।
हीनो वदने पुच्छे ऽधिको ऽमुकाद्याति दक्षिणतः ॥३०॥

25 quoted by Utpala on BS 2 (p. 23).

25a–b मकरादौ वृषं (वृं om. a) त (त्त a) क aβ 25b शशिरा° β

25c °समाना Utpala 26a भु (भ्रु BE) क्ति (क्ति²भु¹ F) हृ (हृ E) ता β

26d चार्धा (र्धा F) न्ता (न्ता C) त् (कृतिः BE) β 27b स्पृशन्नुदेतोशा a, स्पृशोन्तु (तु F) देत्येशा β 27c योगस्तद (द om. B, दं CF) β त्र्यहस्पृक् a

28a दिनशात्रौ β 28b °रश्मिभिर्व्ये (व्य C) क्ते β 28c शहोरंशा β

29c आदित्यर (त्या C) त β प्रोह्य a, प्रोज्य β 30a चक्राद° β

30d मुराद्याति aβ

III,25. The northern ayana is at the beginning of Capricorn. The seasons beginning with Śiśira depend on the Sun; (each) is equal in time to (the Sun's passage through) two zodiacal signs. The southern ayana begins at Cancer.

III,26. The minutes in the (diameter of the) disc of the Sun multiplied by 60 and divided by the daily progress are nāḍīs; this is the auspicious time of the sañkrāntis, half before and (half) afterwards.

III,27. If the Sun rises touching the end of a tithi and also the coming day, then this is the yoga "touching three days"; (there is a yoga) for a day from its touching three tithis.

III,28. If the ahargaṇa is multiplied by 8 and divided by 151, the degrees of Rāhu are obtained; one should add (a number of) degrees equal to its revolutions.

III,29. The beginning (i.e. the longitude at epoch) for Rāhu is 26° of Scorpio diminished by one minute. Subtracting (its motion) from that (one obtains) the "head" (the ascending node); (this) plus six zodiacal signs is called the "tail".

III,30. When the Moon goes north of the zodiac, it increases (its latitude as it proceeds) from the head and decreases (it as it approaches) the tail; when it travels south from that, it decreases (its latitude) at the head and increases (it) at the tail.

भागनवत्या राहोश्चन्द्रो ऽन्तरितो ऽतिमहति विक्षेपे /
लिप्ताद्यतद्वय(मे)त्यशीतिमनुपातो ऽतो ऽन्यत्र //३१//
तिथिनक्षत्रच्छेदा प्रतिपत्तिर्यदि तथा ततः साधुः /
न तथा च भद्रविष्णोस्तथापि विनिवर्त्तते लोकः //३२//
न युगपदुदयो भानोरस्तमयो वापि भवति सर्वत्र /
कस्मिन् देशे ऽस्तमयः पादाद्दिनेन भुक्तं विदुः //३३//
मार्गादुपेतमेतत् काले लघुता न तावदतिदूरे /
स्वविषयभूताष्टरसैरक्षैः पश्चास्य विनिपातम् //३४//
रोमकमहर्गणं पादमर्कमिन्दुं च गणयतां ग्राह्य /
चैत्रस्य पौर्णमास्यां नवम्यां नक्षत्रमादित्यम् //३५//
कालापेक्षा विधयः श्रौताः स्मार्ताश्च तदपचारेण /
प्रायश्चित्ती भवति द्विजो यतो ऽतो ऽधिगम्येदम् //३६//

31b भिमहति β   31c–d °द्वयेत्यशीति (नβ)म° α, β   31d °पाततो α, °पातो ते (त C) β   32b °पत्ति यदि αβ, corr. T.-D.   32d °पि om. α   33a युगपद्रु (द्रु C, दु E²) दयो β   33a–b भानुर (र्नु E, नोर E²)स्तमयो αβ, corr. T.-D.   33d भुक्तिमिदं α, भक्तिमिन्दुः β   34b तावैदतिदू (दु C)रो (रो om. E, र add. E²) β   34c र (र om. B, रो E) विषय° β   35b ग्राह्या αβ   35d नवमी αβ

III,31. The Moon, being 90° distant from Rāhu, at its maximum latitude goes 280 minutes; elsewhere proportion (is to be used).

III,32. If the beginning (pratipatti) occurs when there is a separation of tithi and nakṣatra, then it is good. But it is not so in a bhadra tithi and Viṣṇu's nakṣatra (Śravaṇa); for thus does the world disappear.

III,33. There is not simultaneously everywhere a rising of the Sun or its setting. In what place is its setting? From that basis they know what has passed of the day.

III,34. This is arrived at from a method; there is no quickness in so very long a time. Look at its (the world's) destruction in 68550 years.

III,35. Taking the Romaka ahargaṇa as the basis, let one calculate (the longitudes of) the Sun and the Moon on the full-moon (tithi) of Caitra; on the ninth (tithi) the nakṣatra is Āditya (Punarvasu).

III,36. The śrauta and smārta regulations depend on time; because a twice-born through offending them is a prāyaścittī (i.e., he has to perform propitiatory rites), therefore he studies this (i.e., time).

कुकरणविदो द्विजा ये कथयन्त्यस्फुट<म>सत्यं <च गणितम्> ।
कुकरणकारसहि<ताश्च> ते घणं नरके कृतवासाः ॥३७॥
स्फुटगणितविदिह लब्ध्वा धर्मार्थयशांसि दिनकरादीनाम् ॥३८॥
इति पौलिशसिद्धान्तः ॥

37a अकरणविदो β   द्विन्यो a, द्वित्यो β   37b कथयन्त्यस्फुटं a, कथ(थं E)सत्यं β   37c अकरणकार° β   °सहते aβ   घनं A, अत्नं D, om. β
38a लब्धा (ध्रा F) aβ, corr. T.-D.   col. इति om. a

III,37. Whatever twice-born men, knowing a bad karaṇa, say that (astronomical) calculations are inaccurate and false, they, together with the makers of bad karaṇas, instantly make their homes in hell.

III,38. (But) one who knows accurate calculations of the Sun, and so on, obtains dharma, wealth, and praise in this world.

Thus the Pauliśasiddhānta.

षष्टिशतत्रयपरिधेर्वर्गदशांशात् पदं स विष्कम्भः ।
तद्दिहांशमतुष्कं संप्रकल्प्य राश्यष्टभागज्या ॥१॥
व्यासार्धकृतिर्ध्रुवसंज्ञिता कृतांशस्ततः स मेषस्य ।
ध्रुवकरणी मेषोना द्वयोस्तु राश्योः पदं ज्याः स्युः ॥२॥
शेषेष्विष्टेषु धनुर्द्विगुणपदाद्योगशेषगुणहीना ।
त्रिज्या तदर्धवर्गो द्विगुण<ार्ध>करणीसमायोज्यः ॥३॥
त<स्य> पदो ऽभिमतज्या ध्रुवा तदूनावशेषपिण्डस्य ।
ध्रुवकरणीदलमध्यर्धसंज्ञको ऽन्यो ऽत्र विधिरुक्तः ॥४॥
इष्टांशाद्द्विगुणोनत्रिभज्ययोना त्र्यस्य चापज्या ।
षष्टिगुणा सा करणी तया ध्रुवोनावशेषस्य ॥५॥
मेषज्याः स्वरतिथयो गुणशिवधृतिभिश्च विंशतिः सहिता ।
पंचनरकं शतार्धं त्रिसमेतं षष्टिरिति लिप्ताः ॥६॥

1a–b °परिधे वर्ग° $a\beta$, corr. T.–D. 1b विष्कुंभः a 1c तद्दिहां (हा β) शा
मतुष्कं $a\beta$, corr. T.–D. 1d संप्रकप्रल्प्य a, प्रकल्पं β, corr. T.–D.
राश्याष्ट° β 2a °कृते ध्रुव° $a\beta$ 2b कृतांशाः स्ततः a शेषस्य $a\beta$,
corr. T.–D. 2c मेषोना a, येषो (यो BE) ना (ना om. BC) β 2d द्वयोस्त्र a,
द्वयो (यो: C) सु β, corr. T.–D. 3a–b धनुर्द्वि° a 3b °गुणापदा° β
°योज्य° a, °ज्योज्य° β °गुणहिना $a\beta$, corr. T.–D. 3c तृज्या a, त्वज्या β,
corr. T.–D. सपा (प β) दार्द्धाद्वर्ग $a\beta$, corr. T.–D. 3d द्विगुणकारयो
(यो a) समा (ज्या a) यो (प्रो β) ज्यं $a\beta$ 4a तस्य T.–D. 4b तद्गुना° a
°शेषे β 4d °संज्ञामन्यो $a\beta$, corr. T.–D. विधिनुक्तः a 5a इष्टांश° a
°द्विगुणेन a 5b वाय (प E) ज्या $a\beta$, corr. T.–D. 5c स $a\beta$, corr. T.–D.
कारणी a 5d ध्रुवोनामशेषस्य $a\beta$, corr. T.–D. 6a शेषज्या $a\beta$, corr. T.–D.
स्वस्वर° β °तिथय: $a\beta$ 6b °भिश्चा $a\beta$, corr. T.–D. वि (भि B) ति: β

Chapter IV

IV,1. The square-root from the tenth part of the square (of a circle) whose circumference is 360 is the diameter. In this (circle), by one establishing four parts (i.e., quadrants), the Sine of an eighth part of a zodiacal sign (3;45°) (is to be determined).

IV,2. The square of the radius is called the dhruva. A fourth part of this is (the square of the Sine) of Aries (i.e., of 30°). The dhruva-square is diminished by (the square of the Sine) of Aries; the square-root is the Sine for two zodiacal signs (i.e., 60°).

IV,3. When the remaining (Sines) are desired, the radius is diminished by the Sine of the remainder of the subtraction of twice the arc from a quadrant; the square of half of that (remainder) is to be added to the square of half (the Sine) of double (the arc).

IV,4. The square-root of that is the desired Sine. The dhruvā diminished by that (square is the square) of the remaining sum. Half of the dhruva-square is called the adhyardha (i.e., (square of the Sine of) one and a half (signs, or 45°)). Here another rule is described.

IV,5. The Sine of the arc of three (signs) is diminished by the Sine of three signs diminished by twice the given degrees; (the remainder) multiplied by sixty is the square (of the Sine of the given arc). The dhruva diminished by that (square) is the square of the remainder (i.e., of the Cosine).

IV,6. The Sines in Aries are 7, 15, 20 plus 3 (= 23), plus 11 (= 31), and plus 18 (= 38), 45, 50 plus 3 (= 53), and 60 minutes;

सैकाब्जे पंचाशत् पंचाष्टकपंचवर्गवेदाश्च ।
त्रिंशच्चतुर्भिरधिका षट्पंचाशच्छराः शून्यम् ॥७॥
षट्कत्रयोदशैकोनविंशतिस्त्र्यष्टकौ ऽन्यतस्त्रिंशत् ।
युक्ताम्बरपंचनवत्रिजगतिभिर्लिप्तिका वृषभे ॥८॥
चत्वारिंशद्रामा मुनयो ऽर्धशतं च सैकं त्रि(ज)गतिः ।
द्वादश षष्टिर्हीना मनुभिर्विषयैर्वृषे विकलाः ॥९॥
गुणरसनवद्वादशविश्वा द्विस्त्रिभूतभूपान्तरज्ञाः ।
ज्यालिप्ताः पिण्डो ऽयं द्वितीयराशावतो विकलाः ॥१०॥
धृतिगुणधृतिपरिहीना षष्टिः शून्यं शतार्धमनलोनम् ।
वेदा व्येकार्धशतं पंचेति तदन्तरज्याः स्युः ॥११॥
मुनयो ऽब्जे व्येकान्ते रसत्रयं पंचकौ कृताग्निर्गवि ।
शिखिपक्षचन्द्रशून्या द्विर्द्विर्मिथुने कला ज्या<स्युः> ॥१२॥

7a सैकाब्ये β   7c °तुर्भिर (र om. B) येका β   7d षट्पंचाशच्छराः α
8a षट्त्रयो° β   °द (दे D) शैकात्र° αβ, corr. T.-D.   8b °विंशतिस्त्र्यष्ट° β
°कान्यत° αβ, corr. T.-D.   °स्त्रिंशत् (त्र D) α   8c शुक्लांबर° A
8c-d °नवा (वां AC) द्वि (द्वि AD², हि E) जागतिभि (भी α) र्लि (लि α) प्तिका
(काष्ट BEF) αβ   9a चत्वा (चा CF) रिंशद् (द्ध B) मा β   9b सैकमिति गति
αβ   9c षष्टिहीना αβ, corr. T.-D.   9d मनुभिविषयै° α
10a गुणनवरसद्वादश° αβ   10b भिश्च (श्च β) αβ, विश्वे T.-D.
द्विस्त्रिभूतभूतभुक्तं (क्तं α) तरसा αβ, corr. T.-D.   10c ज्यापिण्डा αβ
10d °राशायतो β   12a मुनयो α, गुन (ण CF, corr. F²) यो β   ज्ये αβ,
corr. T.-D.   12b पंचको β, को α   कृताब्धे गवि α, कृता – (वे C, घे F) गवि
β   12c शिखिपकृतचन्द्र° α   12d द्विर्द्वि मिथुने α

IV,7. in Aries 50 plus 1 (= 51), 5 times 8 (= 40), 5^2 (= 25), 4, 30 plus 4 (= 34), 56, 5, and 0 (seconds).

IV,8. In Taurus (they are) 6, 13, 19, 3 times 8 (= 24), and 30 plus 0 (= 30), plus 5 (= 35), plus 9 (= 39), and plus 13 (= 43) minutes;

IV,9. in Taurus 40, 3, 7, 50 plus 1 (= 51), 13, 12, and 60 minus 14 (= 46), and minus 5 (= 55) seconds.

IV,10. The minutes of the Sines for the intervals are 3, 6, 9, 12, 13, 3 times 5 (= 15), twice (= 10), and 16; this sum is (added to the Sine for) the second sign (i.e., 1,43;55). Then the seconds:

IV,11. 60 minus 18 (= 42), minus 3 (= 57). and minus 18 (= 42), 0, 50 minus 3 (= 47), 4, 50 minus 1 (= 49), and 5. These are the differences between the Sines:

IV,12. 7 in Aries, diminished by 1 in the last (Sine, thus 6); three sixes, two fives, and three fours in Taurus; twice each of three, two, one, and zero are the minutes in the Sines in Gemini.

मेषे विकलार्धशतं सैकं व्येकेन्द्रियेश्वरं त्रिंशत् /
द्वाविंशतिस्त्रिवर्गः <पंचाशच्च विषयसंयुक्तम्> //१३//
ख<समुद्र>गुण<द्विकृताः> ---------- /
कृतार्णव<द्वि>यमनवे<न्द्र>यसमुद्र शिखिस्वर्गे<शाः> //१४//
मनुविषयतिथिरसाः स्युस्त्रिगुणाः पंचाष्टकं स्वरोपेतम् /
सप्तदश नवपंचकं षोडश चेति क्रमान्मिथुने //१५//
जीवा व्यर्ध्यर्धशतांशाः साङ्गुलिप्ता दिनेशकाप्ताः /
चन्द्रस्य स विक्षेपस्तदपक्रमो राशिपादेभ्यः //१६//
लिप्ताशतमशीतिं दशत्रिसंयुक्ताभिन्द्रियमनूनाम् /
गवि मनुभवमुनिरूपैश्च <त्रि>गुणैः संयुतं च शतम् //१७//
नवतिस्त्रियुता षष्टिश्चत्वारिंशच्छिवाश्च मिथुनान्ते /
मेषादितो गत उदग्दक्षिणतो ऽदस्तुलादिषु च //१८//

13b सैक्यं (क्य F) β व्येकेन्द्रियस्व (स्व BE) रं aβ, corr. T.-D. 13c द्विविंश° aβ, corr. T.-D. 14c-d °यमनवकसमुद्रा aβ 14d शिखिवर्गैः (र्गै B) aβ 15c नवब (व om. B) पंचकं β 16a व्या⁻ (सा C) र्द्धसितांशाः β, ध्यार्द्धशतांशाः a 16b सैका षष्टि दिनेश° aβ 16d °स्तदपक्रम aβ 17b दशास्त्रिष (श BE)° aβ °युक्त (क्त A)° a 17c गविसेमनु° aβ 17d संयुतवशतं β
18b after °छिवाश्च a adds याम्योत्तरे कार्ये विषुवद्दिनसमध्य from 19c–20a; β adds याम्योत्तरे and then omits 18b मिथुनान्ते to V 9c तदुदयकाले प्रतिनूं (मति E) पत्र एक add. CEF, अग्रो नास्ति add. β मिथुनान्तरे a
18c मेषाद्गतागतमुद° a

IV,13. In Aries the seconds are 50 plus 1 (= 51), minus 1 (= 49), minus 5 (= 45), and minus 11 (= 39), 30, 22, 3^2 (= 9), ⟨and 55⟩.

IV,14. ⟨In Taurus they are 4⟩0, ⟨2⟩3, ⟨4⟩, 44, 2⟨2⟩, ⟨5⟩9, 34, and 1⟨1⟩.

IV,15. In Gemini they are, in order: 14 times 3 (= 42), 5 times 3 (= 15), 15 times 3 (= 45), 6 times 3 (= 18), 5 times 8 plus 7 (= 47), 17, 9 times 5 (= 45), and 16.

IV,16. The Sine of the maximum declination (kāṣṭhā) of the Sun is 50 minus 2 (= 48) parts and 9 minutes. (As) there is a latitude of the Moon, (so) is there a declination (of the Sun; it is) for fourths of a sign:

IV,17. 180 minutes plus 10 (= 190), plus 3 (= 183), minus 5 (= 175), and minus 14 (= 166); in Taurus 100 plus 14 times 3 (= 142), plus 11 times 3 (= 133), plus 7 times 3 (= 121), and plus 1 times 3 (= 103);

IV,18. 90, 60 plus 3 (= 63), 40 plus 3 (= 43), and 11 at the end of Gemini. As (the Sun) proceeds from the beginning of Aries, it is to the north; in the (six signs) beginning with Libra, to the south.

शङ्कुचतुर्विस्तारे वृत्ते छायाप्रवेशनिर्गमनात् ।
अपरैन्द्रीदिक्सिद्धिर्यवैश्च याम्योत्तरे कार्ये ॥१९॥
विषुवद्दिनसममध्यच्छायावर्गात् सवेदकृतरूपात् ।
मूलेन शतं विंशद्विषुवच्छायाहृतं छिन्द्यम् ॥२०॥
लब्धं विषुवज्जीवा याप(म)तो ऽक्षो ऽथवा यथेष्टदिने ।
मेषाद्यपक्रमयुतस्तुलादिषु विवर्जितः स्वाक्षः ॥२१॥
अयनोनयुताक्षज्या तत्त्रिज्याकृतिविशेषमूलेन ।
छित्त्वा द्वादशगुणिता लब्धा माध्याह्निकी छाया ॥२२॥
विषुवज्ज्यायामार्धवर्गविश्लेषमूलमवलम्बकः ।
क्रान्तिज्यात्रिज्याकृत्यन्तरात् पदं द्विदिनव्यासः ॥२३॥
अजवृषमिथुनापक्रमजीवाः षड्घ्नास्तु वेदमुनिवसवः ।
त्र्यष्टकतिथिषट्काष्ट(के)विकलाभ्यधिकाः परिज्ञेयाः ॥२४॥

20–21 quoted by Utpala on <u>BS</u> 2 (p. 62); 22 quoted by Utpala on <u>BS</u> 2 (p. 63); 23 quoted by Utpala on <u>BS</u> 2 (p. 62).

19a संकु (क्रु D) श्चतुर्विस्तारे a   19b–c °निर्गमनान्नपरैन्द्री° a, corr. T.–D.   19c–d °सिद्धियवाश्च a, corr. T.–D.   20a–b °सममधृष्टोया° a   20b °रूपान्न a   20c यते a   20d छिन्द्यात् Utpala   21b ऽथवैवमिष्टदिने Utpala   21d स्वोक्षः a   22a अपमोन° Utpala   °युताक्षज्यां a Utpala, corr. T.–D.   22b तात्रिज्याक्रति° a, त्रिज्यातत्कृति° Utpala, corr. T.–D.   °मूला a   22c छिन्द्याद्द्वादशगुणितां Utpala   22d माध्याह्नकी a   23a °छायामत्यार्द्ध° a   23b °मूलवलं[ब]लंबः A, °मूलभाणो लम्बः D   23c–d °ज्याक्रांत्यंतरात् a   क्रान्तित्रिज्याकृत्योरन्तरपदं द्विगुणं दिनव्यासः Utpala   24b षघ्ना (ष्ट्या D, corr. to घ्या D²) स्तु a, corr. T.–D.   24c–d °षट्काषड्विकला-ध्याधिका a, corr. T.–D.

IV,19. From the entrance and exit of a shadow into a circle whose diameter is four times (the length of) the gnomon is the attainment of the directions west and east; north and south are to be determined by means of barley-corn (figures).

IV,20. Multiply the equinoctial shadow by 120 and divide (the product) by the square-root of the square of the noon equinoctial shadow increased by 144.

IV,21. The result is the Sine at the equinox; its arc is the terrestrial latitude. Or else, on any given day, (the Sun's coaltitude at noon) increased by the declination (of the Sun when it is) in Aries and so on, and decreased (by the declination) in Libra and so on, is one's terrestrial latitude.

IV,22. The Sine of terrestrial latitude, increased or decreased by the declination (of the Sun), is to be divided by the square-root of the difference between the squares of that (Sine so increased or diminished) and of the radius; the quotient, multiplied by 12, is the noon shadow.

IV,23. The square-root of the difference between the squares of the Sine at the equinox (i.e., the Sine of terrestrial latitude) and of the radius is the Sine of terrestrial colatitude. The diameter of the day (-circle) is twice the square-root of the difference between the squares of the Sine of declination (of the Sun) and of the radius.

IV,24. The Sines of the declination (of the Sun at the ends) of Aries, Taurus, and Gemini are (respectively) 4 times 6 (= 24), 7 times 6 (= 42), and 8 times 6 (= 48); they are to be increased by 3 times 8 (= 24), 15, and 6 times 8 (= 48) minutes (respectively).

<पंचत्रिंशत्>त्र्यष्टकसरूपधृ<ि>त<संयुत>ा क्रमाद्द्विशती /
पंचाष्टकतिथिविकलाधिकौ वृषान्त्यौ दिनव्यास: //२५//
व्यासक्रान्तिज्याघ्नी विषुवज्ज्या लम्बकद्युदैर्घ्यहृता /
तच्चापकलात्र्यंशाश्चरखण्डविनाडिका: स्पष्टा: //२६//
चरखण्डकपञ्चांशज्याघ्नमहर्व्यासमुद्धरेत् खजिनै: /
द्विः कृत्वा तद्वर्गात् क्रान्तिज्याकृतियुतान्मूलम् //२७//
तेन विभजेत् क्षितिज्यां व्यासार्धगुणामवाप्तमवज्ज्या /
नवतेरक्षोनाया: क्रमशो ज्या लम्बको भवति //२८//
अपक्रमज्याकृतिविश्लेषमूल<गुणिताद्> विस्तारात् /
द्युव्यासहृताच्चापं द्विघ्नं राश्युद्गमविनाड्य: //२९//
वसुमुनिपञ्चा व्येकं शतत्रयं त्रिद्विकाग्नयश्चाजात् /
परतस्त एव वामा: षडुत्क्रमात्ते तुलाद्यर्धे //३०//

27–28 quoted by Utpala on BS 2 (p. 62); 30–31 quoted by Utpala on BS 2 (p. 63).
25a पंचत्रिंशत् suppl. T.-D. 25b °धृताक्रमाद्विशति a, corr. T.-D.
25c-d °विकलाधिकौ a, corr. T.-D. 25d वृषात्यौ a, corr. T.-D.
26b लं[ब]क° A, लक° D ([ब] add. D²) 27b °महसमुद्धरेत् a
27c व्यावृद्धि (द्वि D) कृत्वा तद्वत् a 27d °युतान्मुलं a 28a थितिज्यां a,
स्थितज्यां Utpala, corr. T.-D. 28b °वाप्त (प्त om. D, add. D²) पचज्या a
28c °रच्चोसोनाया a 29a अपक्रम° a 29a–b °ज्याक्रतिविश्लेषमुल-
विस्तरात् a, corr. T.-D. 29c द्युद्यासाहृताचाप a, corr. T.-D.
29d दिघ्नं a, corr. T.-D. 30b °ग्नयश्चाजान् (°व् D, corr. to न् D²) a,
°ग्नयश्चाङ्का: Utpala, corr. T.-D. 30d षड्क्रमास्ते तुताद्यर्द्धे a

IV,25. The diameters of the day-circles are in order 200 plus 35 (= 235), 200 plus 3 times 8 (= 224), and 200 plus 18 plus 1 (= 219); (those for the ends of) Taurus and the last sign (Gemini) are increased by 5 times 8 (= 40) and 15 minutes.

IV,26. Multiply the Sine at the equinox (i.e., the Sine of terrestrial latitude) by the diameter and by the Sine of the declination (of the Sun); divide (the product) by the Sine of terrestrial colatitude and by the diameter of the day (-circle); a third of the minutes of the arc of that (Sine) is the accurate vināḍikās of ascensional difference.

IV,27. Multiply the diameter of the day (-circle) by the Sine of half of the ascensional difference and divide (the product) by 240; put this (earth-Sine) down twice. (Take) the square-root of the squares of this increased by the square of the Sine of the declination (of the Sun).

IV,28. Multiply the earth-Sine by the radius and divide by this; the result is the Sine of terrestrial latitude. The Sine of 90° diminished by the terrestrial latitude is the Sine of terrestrial colatitude.

IV,29. Multiply the diameter by the square-root of the difference between the squares of the Sines of the declinations (of the Sun) and (of the Sines of the ends of the several) signs and divide (the products) by the (respective) diameters of the day (-circles). The arc from this, multiplied by 10, (equals) the vināḍīs of rising of (each) of the signs.

IV,30. From Aries they are 278; 300 minus 1 (= 299); and 323; afterwards they are the reverse. These six in reverse order are in the half (of the zodiac) beginning with Libra.

चरकालदलक्षीणास्त्रयस्त्रयः संयुताः प्रतीपैस्तैः /
उदयर्क्षतुल्यकालेन यान्ति तत्सप्तमाद्यास्तम् //३१//
इष्टोत्तरगोलापक्रमांशकज्यां स्वभास्करव्यस्ताम् /
हृत्वाक्षजीवया तच्चापादुदयेन तत्कालः //३२//
तस्मिन् दिनकृत् कुरुते सममण्डलसंश्रयं दिनाद्यर्धे /
तावच्छेषे परतो न तुलादिषु विद्यते चैतत् //३३//
स्वजिनघ्नी क्रान्तिज्या लम्बहृता ध्रुवगुणा द्युदैर्घ्यहृता /
तच्चापस्य रसांशः सकलः स्याद्दिन(नि)वृद्ध्यर्धः //३४//
उत्तरगोले ऽर्कज्या काष्ठान्तगुणा ध्रुवज्यया भक्ता /
ताः शङ्कुलिप्तिकास्स्युस्ताभिः सममण्डलच्छाया //३५//
सममण्डललेखासंप्रवेशवेलां करोति यो ऽर्कस्य /
तत्प्रत्ययं च जनयति जानाति स भास्करं सम्यक् //३६//

32–33 quoted by Utpala on BS 2 (p. 42); 35–36 quoted by Utpala on BS 2 (p. 43).

31a चरदलकाल° Utpala, चरकालदश° a, corr. T.–D. 31b प्रतीपैस्ते a 31d यंति तत्समाख्यास्तान् a 32b स्वतस्कराव्यस्तां a, स्वभास्कराव्यस्तां Utpala 32c हृतादक्षजीवज्ञा a 33b °संश्रया a दिनाद्ये वा Utpala 33d चैतन्न a 34a षजिनघ्नी a, corr. T.–D. 34a–b [क्रांतिज्या लंबघ्नी] A 34b द्युदैर्घ्या (र्घ्य D) हृतात् (त् om. D) a, corr. T.–D. 34c तच्चापंश a, corr. T.–D. 34d सकलसदिनवृध्यर्द्धः a 35b काष्ठांतरगुणा a 35d सममण्डले छाया Utpala 36a °मंडललेषा° a 36b °वेलाः a करोतिर्यो कस्य a

IV,31. (The right ascensions of) three (signs) are diminished by half the times of the (local) ascensional difference, (those of the next) three are increased by these in reverse; in a time equal to that of the sign which is rising the seventh (sign) from it sets.

IV,32. Multiply the Sine of the given degrees of declination in the northern gola by 120 and divide (the product) by the Sine of terrestrial latitude. From the arc of that (Sine is known) the time (since Sun-) rise;

IV,33. in this (time), which is in the first half of day (-light), the Sun reaches the prime vertical; so much (is the time) on the other side (to the west) in the remainder (of daylight). This is known not (to apply when the Sun is) in the (six signs) beginning with Libra.

IV,34. Multiply the Sine of declination by 240, divide (the product) by the Sine of colatitude, multiply (the quotient) by (the Sine of) the terrestrial latitude, and divide (the product) by the diameter of the day (-circle). A sixth of the arc from this (Sine) is all of a half of the increase of day (-light).

IV,35. (When the Sun is) in the northern gola, multiply the Sine of (the longitude of) the Sun by (the Sine of) its maximum declination (kāṣṭhānta) and divide (the product) by the Sine of terrestrial latitude. These are called "the minutes of the gnomon"; by means of them (is found) the shadow (when the Sun is) at the prime vertical.

IV,36. Whoever computes the time of the Sun's entrance into the prime vertical and produces confidence in that, he knows the Sun completely.

वर्षेण भगणमर्को यदि भुंक्ते किं ततो यथेष्टदिनैः ।
अन्यो ऽप्येवं गणयति किं न रविं लोष्टरेखाभिः ॥३७॥
कृतदिग्ग्रहणे वृत्ते रेखां पूर्वापरां यदा छाया ।
प्रविशति सम्यक् शङ्कोः सममण्डलगस्तदा सूर्यः ॥३८॥
इष्टक्रान्तिज्याघ्नं व्यास<श>कलं लम्बभागमुष्णांशुः ।
समपूर्वापररेखामतीत्य यात्यस्तमुदयं वा ॥३९॥
तेन हृता स्वार्कघ्नी क्रान्तिज्या लम्बको ऽस्य <य>च्चापम् ।
तेन नवतिर्विहीना यच्छेषं ते ऽक्षभागाः स्युः ॥४०॥
तत्कालचरविनाडीद्विदशांशं द्विषमजतुलाद्येषु ।
षड्घ्नीभ्यो नाडीभ्यो जह्यात् संयोजयेच्चापि ॥४१॥
तज्ज्या स्थितज्यया संयुता विसंयोजिता<ज तु>लाद्येषु ।
अविशोधनेन जीवा षड्घ्नीनामे<व> कर्तव्या ॥४२॥

38 quoted by Utpala on <u>BS</u> 2 (p. 43); 41–44 quoted by Utpala on <u>BS</u> 2 (pp. 63–64).

37a °मर्कौ a, corr. T.–D. 37b तयो a, corr. T.–D. 38a कृतदिग्ग्रहणे a 38c शंकुः a 38d सममंडलगतस्तदा a 39a °ज्याघ्ना a 39b व्यासकल° a, व्यासशकल° T.–D. लम्बकांशमु° a 39d °मती (ली D, corr. to ती D[2]) त्ययात्यस्त° a, corr. T.–D. 40a हृता a, corr. T.–D. स्वार्क (स्यु D) घ्नी a, corr. T.–D. 40b स्यच्चापं a, corr. T.–D. 40c–d °हीना छयेच्छत्ते क्षभागाः a, corr. T.–D. 41a–b °नाडीसदशांशां a 41c षष्ठाभ्यो a 42a तज्या a 42b विसंयोजितातात्येषु a 42c स्रीवा a 42d षघ्नी (घ्नां A) नामेकर्त्तव्या a

IV,37. If the Sun traverses the zodiac in a year, how much (does it traverse) in any given (number of) days? How does even an ignorant fellow not compute (the longitude of) the Sun thus by means of rows of markers?

IV,38. When the shadow of the gnomon completely enters into the east-west line in a circle wherein the directions have been indicated, then the Sun is on the prime vertical.

IV,39. Multiply the radius by the Sine of the given declination and divide (the product) by the Sine of terrestrial colatitude; (the result is the Sine of amplitude). The Sun, having passed the east-west line by an equal (amount) sets or rises.

IV,40. Multiply the Sine of the declination by 120 and divide (the product) by that (Sine of amplitude); whatever is the (corresponding) arc of that (result) is the terrestrial colatitude. Whatever is the remainder after that (terrestrial colatitude) has been subtracted from 90 is the degrees of terrestrial latitude.

IV,41. (Put down) in two places a twentieth part of the vināḍīs of ascensional difference for that time; (as the Sun is) in Aries and so on, or in Libra and so on, one should subtract (this) from, or add it to, the nāḍīs multiplied by 6.

IV,42. The Sine of that (amount) is to be increased or diminished by the Sine of what has been put aside (as the Sun is) in Aries and so on, or in Libra and so on. The Sine (of the nāḍīs) multiplied by 6 without any correction is to be found.

एवं कृत्वा हन्याद् द्युव्यासेनावलम्बकघ्नेन /
<छिन्द्यात् खखाष्टवस्वब्धिभिः फलं शङ्कुलिप्ताख्यम् //४३//
तत्कृतिविनाकृतानां खखवेदसमुद्रशीतरश्मीनाम् /
पदमर्कघ्नं शङ्क्वङ्गुलाख्यलिप्तोद्धृतं छाया //४४//
छायाद्वादशकृत्योर्योगान्मूलेन लम्बकघ्नेन> /
खखवस्वब्धिमुनीन्दून् विभज्य लब्धा प्रथमजीवा //४५//
तद्द्युक्रान्तिज्याघ्नी विषुवज्ज्या लम्बकोद्धृता स्याप्ता /
प्रथमज्या विश्लेष्या मेषाद्ये ऽन्यत्र संयुक्ता //४६//
तत्स्थितजीवे गुणिते खजिनैर्द्युव्यासभाजिते चापे /
युतवियुते ऽजतुलादिषु षडुद्धृता नाडिका लब्धाः //४७//
षड्घ्ने ऽथवा द्युमाने छिन्ने सद्वादशैर्विमाध्याह्नैः /
छायाङ्गुलैर्गतास्ता नाड्यः प्राक् पृष्ठतः शेषाः //४८//

48–49 quoted by Utpala on <u>BS</u> 2 (p. 64).

43a कृघा a   हन्या a   43c–45b om. a   45a–b suppl. T.–D.
45c खखबस्वस्रमु° a, corr. T.–D.   45c–d °नीन्द्राद्विभज्य a
46a तद्युज्या (– D, ज्या add. D²) क्रान्त्रीज्याघ्नी a, corr. T.–D.   46b विषुवज्ज्या a, corr. T.–D.   46c विस्लेषा a, corr. T.–D.   46d सेषाद्ये a, corr. T.–D.   नात्र a, corr. T.–D.   47a तस्थितिजीवे a, corr. T.–D.   47b खजिने द्युव्यास° a, corr. T.–D.   47c यतुलादिषु a, corr. T.–D.   47d षट्द्रुतो a, corr. T.–D.
48a षट्ह्ये a   ऽथ स्वद्युमिते Utpala   48b सद्वादशे विमध्याह्ने a
48c °गतास्छा a   48d नाच्यः a   प्रष्टतो a

IV,43. Having done thus, one should multiply (the Sine) by the diameter of the day (-circle) multiplied by the Sine of terrestrial colatitude, and divide (the product) by 28800; the result is called "the minutes of the gnomon" (i.e., the minutes of the Sun's altitude).

IV,44. Of 14400 diminished by the square of these (minutes) (take) the square-root; multiply (it) by 12 and divide (the product) by the minutes called "the digits of the gnomon" (i.e., by the minutes of the Sun's altitude); (the result is) the shadow.

IV,45. Take the square-root of the sum of the squares of the shadow and 12 and multiply it by the Sine of terrestrial colatitude; divide 172800 by the product; the quotient is the "first Sine".

IV,46. Multiply the Sine at the equinox (i.e., the Sine of terrestrial latitude) by the Sine of declination on that day, and divide (the product) by the Sine of terrestrial colatitude; put (the quotient) down (in two places). The "first Sine" is to be diminished (by this, if the Sun is) in Aries and so on, otherwise it is to be increased (by it).

IV,47. Multiply both, that (Sine) and the Sine which was put aside, by 240 and divide both (products) by the diameter of the day (-circle); the two (corresponding) arcs are to be added together or subtracted one from the other (as the Sun is) in Aries and so on, or in Libra and so on. The resulting (degrees) divided by 6 are nāḍikās.

IV,48. Or else multiply the length of daylight by 6, and divide (the product) by the digits of the shadow increased by 12 and diminished by (the digits) of the noon (shadow). (The result is), in the east, the nāḍīs that have passed, in the west the remaining ones (that are to come).

छायार्को नाडीभिर्दिनमानं षड्घ्नमुद्धरेत्तत्र /
लब्धं द्वादशहीनं मध्याह्नच्छायया सहितम् //४९//
दृष्टा नाड्यो द्युनिशे चन्द्रोदयनाडि<का>युतविहीनाः /
ताभिस्तत्कालेन्दोर्भानोरिव चिन्तयेच्छायाम् //५०//
चरनाड्य<प>क्रम<ादि>विधिना द्युव्यासापक्रमविक्षेपम् /
अस्तमये पूर्वविधिः शेषाणां युक्तितश्चिन्त्यम् //५१//
छायार्कवर्गयोगा<त्> पदविभाज्यार्कसङ्गु<ि>ण<त>ा त्रिज्या /
विषुवज्जीवागुणिता ल<म्ब>कभक्ता तु सूर्याग्रा //५२//
काष्ठा<हृ>तार्कमौर्व्या लम्बकहृतया विहीनसंयुक्ता /
सूर्याग्राजतुलादौ कर्णघ्नी त्रिज्ययापहृता //५३//
लब्धाङ्गुलानि कोटिस्तच्छायावर्गविवरमूलं <यत्> /
स च बाहुर्दिग्ग्रहणे सममिति कोट्या तु देयमृणम् //५४//

49a नाडिभि° a 49b षड्समु° a 50a द्युनिशं a, corr. T.-D.
50b °नाडियुतविहिना a, corr. T.-D. 50c °स्तत्कालंदो° a, corr. T.-D.
51a चरनाडीक्रम° a 51b द्युव्यासान्यथमतिविक्षेपं a
51c अस्तमयो a, corr. T.-D. प्यद्ववविधिः a 52a °योगा a, corr. T.-D.
52b पदे a °सङ्गुणा a 52d लंकाभक्ता a, corr. T.-D. 53a काष्ठे यार्क° a, corr. T.-D. 53b विहितसंयुक्ता a, corr. T.-D. 53c सूर्याग्राचतुलादौ a, corr. T.-D. 54a काटि° a, corr. T.-D. 54b यत् suppl. T.-D.
54c बाहु (हु D)दिग्ग्रहणे a, corr. T.-D. 54d कोट्या a, corr. T.-D.
देयमृणं a, corr. T.-D.

IV,49. Multiply the length of daylight by 6, and divide (the product) by the nāḍīs (which have passed); diminish the quotient by 12 and increase it by the (digits of the) noon shadow. (The result is) the shadow of the Sun.

IV,50. The observed nāḍīs are to be increased or decreased by the nāḍikās of the rising of the Moon as it is day or night; by means of these one should find out the shadow of the Moon at that time as (one finds out that) of the Sun.

IV,51. By means of the rules (for computing) the nāḍīs of ascensional difference and the declination (of the Sun, one should compute) the diameter of the day (-circle), the declination, and the latitude (of the Moon). The previous rules (apply also) for setting. For the rest (of the planets) it is to be thought out by reasoning.

IV,52. The radius multiplied by 12 is to be divided by the square-root of the sum of the squares of the shadow and of 12; (the quotient) is to be multiplied by the Sine at the equinox (i.e., the Sine of terrestrial latitude), and (the product) divided by the Sine of terrestrial colatitude; (the result) is the Sine of the amplitude of the Sun.

IV,53. Multiply (the Sine of) the maximum declination (of the Sun) by the Sine of the Sun's (longitude), and divide (the product) by the Sine of terrestrial colatitude; the Sine of the amplitude of the Sun is to be decreased or increased (by that amount, as the Sun is) in Aries and so on, or in Libra and so on. Multiply (the result) by the hypotenuse, and divide (the product) by the radius.

IV,54. The digits (thus) obtained are the koṭi; whatever is the square-root of the difference between the squares of that and of the shadow is the bāhu. In determining the directions, (the bāhu) is level (on the east-west line) and is to be given as forming a right angle with the koṭi.

छायासमरेखान्तरगुणिता त्रिज्या स्वकर्णभक्तास्याः ।
एकत्वेऽन्तरितैष्या सूर्याग्रा संयुतान्यत्वे ॥५५॥
लम्ब(को)गुणिता सा ज्या काष्ठामौर्व्या हृतार्कः स्यात् ।
सूर्योद्भवेन विधिना ग्रहास्ततोऽन्येऽपि कर्तव्याः ॥५६॥
इति करणाध्यायश्चतुर्थः ॥

55c तिर (र om. A) तेष्या a 55d सूर्यग्रा a, corr. T.-D. 56a लंबगुणिता a, corr. T.-D. 56b मनोर्कः a 56d ग्रहास्यतो a, corr. T.-D.

IV,55. Multiply the radius by the distance between the shadow and the east-west line, and divide (the product) by its (i.e., the shadow's) hypotenuse. If (this and the koṭi are) in the same direction, their difference is to be taken; if in opposite directions, their sum. (The result) is the Sine of the amplitude of the Sun.

IV,56. Multiply this Sine by the Sine of the terrestrial colatitude, and divide (the product) by the Sine of maximum declination; (the quotient) is the Sun's (longitude). By the rules applying to the Sun the other planets are to be calculated.

Thus the fourth chapter, the Karaṇa.

अयनान्तरसंयुक्तात्तदूनगु(णि)ताच्छशाङ्करविविवरात् /
मूलेनायनविवरे छिन्ने विक्षेपसंगुणिते //१//
फलमिन्द्वर्कविशेषाच्छोध्यं त्वयनानुकूलविक्षिप्ते /
तद्व्यत्यासे देयं विपरीतं पूर्वसन्ध्यायाम् //२//
दिनकृत्सप्तमभवनात्तेनोदयनाडिकाद्वयं यदि वा /
वियति विमले तदेन्दोर्लोकस्यालोकमायाति //३//
द्विगुणाच्छे तिथ्यंशाः युङ्मुदक्कु(ङ्)मुडुगणाधिपतेः /
देयं च भुजादेतच्छौक्ल्यं कर्णद्विषट्कांशः //४//
अ(प)नान्तरविक्षेपावैकान्यत्वे युतोनितौ कोटिः /
कर्णो रवीन्दुविवरं तत्कृतिविवरात् पदं बाहुः //५//
सविता यतः शशाङ्कात् कोट्या परिकल्पित(स्ततः) कोटिः /
देयांशकाङ्गुलसमा भुजकर्णौ चाङ्गुलैरेव //६//

1–10 quoted by Utpala on BS 4,15

1a अयनंतर° a, अपमान्तर° Utpala 1b °तदूनयुक्ताच्छशांक° a °विवरात् a, °विवरे Utpala, corr. T.-D. 1c मूलेनापमविवरे Utpala 2a फलसिंध्वर्के° a 2b चयनानु° a, त्वपमानु° Utpala °विक्षिप्तो a 3b °त्तेनोदयानाडिका° a 3c तदिंदो° a 4a द्विगुणेच्छे a, द्विगुणेच्छा Utpala तिथ्यंशाः a Utpala 4b °मुदक्कुमुडुगुणाधिपतिः a 4d कर्णाद्वि° a, कर्णाद्वि° Utpala °षट्कांशम् Utpala 5a अनांतर° a, अपमान्तर° Utpala 5b °वैकानत्वे a, °वैकान्यत्वे Utpala, corr. T.-D. यातोनिता a 5d तत्कृति° a बाहोः a 6b कोज्या परिकल्पितकोटिः a

Chapter V

V,1. Multiply the difference of (the longitudes of) the Sun and Moon increased by the difference of their declinations (corresponding to this elongation), by the (first difference) diminished by that (second difference); by the square-root (of the product) divide the difference of their declinations, multiplied by (the Moon's) latitude.

V,2. The result is to be deducted from the difference between the Sun and Moon if the (Moon's) latitude is in the same sense as its declination; if it is in the opposite sense, it is to be added. In the case of the eastern twilight, (the procedure) is reversed.

V,3. If that (result) has two nāḍikās of rising—(to be taken) from the sign that is seventh from the Sun—then, if the sky is clear, visibility of the Moon comes to the world (of men).

V,4. In the diameter of the Moon are 15 parts; its horn is elevated. A twelfth of the hypotenuse is the illuminated portion; it is laid off from the bhuja.

V,5. The difference of the declinations it to be added to or subtracted from the (Moon's) latitude as they are in the same or in the opposite directions; (the result is) the koṭi. The hypotenuse is the difference of (the longitudes of) the Sun and Moon. The square-root of the difference between the squares of these (i.e., of the koṭi and of the hypotenuse) is the bāhu.

V,6. On whatever side the Sun is from the Moon, on that side lies the koṭi. The koṭi is laid off with parts equal to digits; the bhuja and the hypotenuse are also (laid off) with digits.

शशिमध्यात् प्राक् कर्णः कोटिरतो ऽतो भुजः शशाङ्कगतः ।
परिधावतो नाम शौक्ल्यमध्यात्तदनु <च> सूत्रम् ॥७॥
याम्योदग्विक्षेपाद्विषुवच्छा<या>घ्नाद्विभक्तांशाः ।
उदये शशिनो वृद्धिः क्षयो विपर्यस्तमस्तमये ॥८॥
एवं व्यर्काग्र<न्द्र>ाद्येनोना राशयः षडधिका वा ।
तदुदयकालेन दिवा निशि च शशाङ्कोदयो वाच्यः ॥९॥
कृत्वैवं क्षयवृद्धिं व्यर्कं चन्द्रं विशोध्य चक्रार्धात् ।
शेषोदयकालसमे निशि दिवसे ऽस्तं शशी याति ॥१०॥
इति शशिदर्शनम् ॥

7a प्राक्कर्णः a   7c नामः a   7d शौक्ल्यं a Utpala   मध्यातदनुसूत्रं a, मध्याद्धनुस्तत्र Utpala   8b °द्विषुवज्याघ्नाद्विस्तरावांशाः a, °द्विषुवत्याघ्नाद्विभिरवासांशः Utpala   8d विपर्यस्तमय एवम् Utpala   9a–b व्यर्काग्राद्येनोना a, व्यर्काग्रन्द्राद्यद्यूना Utpala   9b षडधिकाया a   9c तदुदयाकालेन a   β begins °न दिवा   10a तत्रै (चै F, त्रै C)वं β   क्षयवृद्धी Utpala   10c मेखो (षा C)दय° aβ   10d शा(षा E)शिदिवसा(स्या F)र्द्धे शशि (शी a Utpala) मध्ये aβ Utpala, corr. T.-D.   col. इति om. a

V,7. First (is drawn) the hypotenuse from the center of the Moon, then the koti; then the bhuja goes toward the (center of the) Moon. On the circumference (of the Moon) is the akṣa; after that, from the midpoint of the illuminated portion (i.e., from the akṣa) (is laid off) the sūtra.

V,8. Multiply the equinoctial shadow by the latitude to the south or north; divide the resulting degrees by 12. (The result) is positive or negative at the rising of the Moon, the opposite at its setting.

V,9. The signs (resulting) from the subtraction of the Sun from the Moon (or these) increased by 6 (signs) are to be diminished by this. The rising of the Moon by day or at night is to be described (as occurring) in the rising-time of these (signs).

V,10. Making it thus negative or positive, subtract the Sun from the Moon and subtract (the remainder) from 180°; the Moon sets at night or by day in a time equal to the rising-time of the remainder.

Thus the Visibility of the Moon.

नैष्यास्तिथिनाड्यो ऽर्कोदयाग्रकाद्यैर्नेन्दुरवि(वि)वरात् /
पाण्डवघ्नाश्च शोध्याः स भवति तत्कालशशी लिप्तः //१//
राहोः सषट्कृतिकलां हित्वांशं तच्छशाङ्कविवरांशैः /
ग्रहणं त्रयोदशान्तः पंचदशान्तस्तमस्तस्य //२//
विक्षेपकलाकृतिवर्जितस्य पंचोनषष्टिवर्गस्य /
मूलं द्विगुणं तिथिवद्विभज्य कालः स्थितेर्भवति //३//
शशितिमिरविवरभागैस्त्रयोदशोनाः शराहताः क्षेप्याः /
स्थित्या विनाडिकास्ता राहावधिके ऽन्यथा हानिः //४//
किं त्वन्तरांशहीनैः पंचभिरूनाहता दश कृतघ्नाः /
तत्पदमेकाब्धिघ्नं पंचांशो ऽस्माद्विमर्दकलाः //५//
स्थितिदलविमर्ददलयोर्विशेषकाले ऽसकलं तमो ऽत्तीन्दुम् /
प्रग्रहमोक्षे शशिराहुविवरभागैश्च दिग्वाच्या //६//

1b ऽर्को (ऽर्कै β) द (दे β) याग्रंदु (दु BE) स (य BE, य F) मेन्दु (दु aF, दू C) रविवरात् (तृ a) aβ   1c व (पं D) शुद्धवाश्च a, स्यु (स्यु CE) द्रु (-द्रु BE) वाद्भव: (ब्धा: E, om. B) β   1d °शशि aβ, corr. T.-D.   after °शशी a adds दिवसार्द्धै
2a सषट्तति° β   2b हित्वा (त्या CF) शं β   तच्छशाङ्क° β
2d पंचदशान्तसमस्तस्य β   3a °कलाक्रति° a   3c मूल्तो aβ, corr. T.-D.
5a चं (च C) तरांशहीनैः β   5b पंचाभी (भि C) रू (रु CE) ना° β
दश a, द β   क्रतघ्नाः a   5cd °मेकाब्धि (ब्धि BE) – (– om. C) पंचांशो β
6a स्थितदल° a   6b °विशेषको (का β) मे aβ   सकलीमतीत्तीं (त्तीं om. β)
दुं (दुः BE, दं F) aβ   6c प्रग्रहण (ण om. F)° β   °मोक्ष a, माक्ष β, corr. T.-D.

Chapter VI

VI,1. The lapsed nāḍīs of the (current) tithi at sunrise are to be subtracted from (i.e., diminished by) five times the difference between (the longitude of) the Sun and (that of) the Moon diminished by 180°; the Moon at that time is obscured.

VI,2. Put down the degree of the ascending node increased by 36 (or by 26?) minutes. (Operate) with the degrees of the difference between this and (the longitude of) the Moon; if they are within 13°, there is an eclipse, and if within 15°, a darkening of it (the Moon).

VI,3. Subtract the square of the minutes of (the Moon's) latitude from the square of 55; double the square-root (of the remainder). From dividing this up as (is done) with a tithi there results the time of the duration (of the eclipse).

VI,4. Subtract the degrees of the difference between (the longitudes of) the Moon and the node from 13° and multiply (the result) by 5. The (resulting) nāḍikās are to be added to the duration of the eclipse if the ascending node is greater (in longitude), otherwise subtracted.

VI,5. Multiply 10 diminished by (the remainder from) 5 diminished by the degrees of difference (between the Moon and the node) by that remainder, and multiply (the product) by 4; multiply the square-root of that (product) by 21. A fifth part of that (product) is the minutes of the totality of the eclipse.

VI,6. In a time equal to the difference between half the duration and half the totality the darkness eats the Moon, but not entirely. The directions of first contact and last contact are to be determined by means of the degrees of difference between (the longitudes) of the Moon and the node.

विक्षेपविपर्यासस्तुरीयभागे हृते त्रयोदशधा /
परिधौ प्राक्प्रभृतीन्दोर्ग्रहणाशा<तद्>वदेत् पर्व //७//
शशिपरिधिदलार्धघ्ने खेन्द्वन्तरभागसङ्गुणे चाप्ते /
खखरूपाष्टहृते प्राग्वलनं वामं परे सव्यम् //८//
<तिथ्यन्ते ग्रहमध्यं प्राक् परतः स्थितिदलेन चाद्यन्तौ /
रक्तकपिलौ च वर्णावुद्धाधःस्थे परे नितराम्> //९//
सर्वग्रासिन्येवं वर्णविशेषं वदेन्निशानाथे /
उदयास्तमये धूम्रं खण्डग्रहणे सलिल<दा>भम् //१०//
राहुं मुखोनचक्रं त्रियमद्विगुणं शशि<हीन>संयुक्तम् /
अभिक्लेशो ऽयमुच्चः क्रियादिः कन्यान्तगो नीचः //११//
सप्तदशाष्टत्रिंशत्तद्व्यलिप्तामितेन सूत्रेण /
शशिराहुस्थितिवृत्तान्येकस्थानि वा संलेख्य //१२//

9–10 quoted by Utpala on BS 5,18.

7a–b °विपर्यासां (°नं D)तरीयभागे aβ 7b क्रते a, तते β च (om. F)योदशधा (धम D) aβ, corr. T.-D. 7c परिधमै a प्राक्प्रभृतीन्दो °aBC 7d °ग्रैहणास्तांशे a, °ग्रहणास्वां (°स्रां B) शे β 8a °दलाद्वि (द्वी F, द्विं C) घ्ने aβ, corr. T.-D. 8b वाच्चे aβ, corr. T.-D. 8c खखरूपाष्टद्रुते β प्राग्वलना aβ, corr. T.-D. 8d युते a, च्युते β, corr. T.-D. 9 om. aβ 10a पर्वग्रासिव्ये (न्ये C) वं β 10b वेदन्निशानाथे β 10c उदयास्तगांसधूम्रं aβ 10d after खण्डग्रहणे a adds च सलिलाभं aβ 11a राहुमुखोनं चक्रं aβ 11b शशाङ्कसंयुक्तं (°क्तन् a) aβ 11c एमि (यि C) क्लेशो aβ यमुच्च aβ 11d नीचः β 12a सप्तदशाष्टा° aβ, corr. T.-D. 12a–b त्रिंशात (त om. C) द्व्य° β 12b °लिप्तामतेन a 12c शशिना (न F) वहुस्थिति° aβ, corr. T.-D. 12c–d °वृत्ता (ता F) नि एकष्ठ (ष्ठ a C) न्नो (नो a C) नि aβ 12d वालेख्य a

VI,7. The direction of (first contact in) the eclipse is opposite to (the direction of) the (Moon's) latitude, on a quadrant of the circumference of the Moon, beginning from the east (-point), divided 13 times. One should say that this is the parvan (i.e., the point of contact).

VI,8. Multiply a quadrant of the Moon (i.e., 90°) by the terrestrial latitude and multiply (the product) by the degrees of difference between (the longitudes of) the (mid)-heaven and the Moon; divide (the product) by 8100. The (resulting) deflection is to the north (if the Moon is) in the east, to the south (if the Moon is) in the west.

VI,9. The middle of the eclipse is at the end of the tithi; (the times of) its beginning and end, to the east and to the west, (are determined) by half its duration. Blood-red (rakta) and reddish-brown (monkey-colored: kapilla) are the colors when (the impact is) respectively up and down, especially in the west.

VI,10. One should say that there is a distinctive color (or: a diversity of colors) in the Moon when it is totally eclipsed. It is smoke-colored (dhūmra) (when the eclipse occurs while the Moon is) at the ascendent or at the descendent; it is cloud-colored if the eclipse is partial.

VI,11. (The longitude of) the ascending node, (or) 360° diminished by (the longitude of) the ascending node, [multiplied by 223,] is diminished or increased by (the longitude of) the Moon; the result is (the direction of) impact (of the eclipse). It is high (if the Moon is) at the beginning of Aries, low if it is at the end of Virgo.

VI,12. Draw the circles (representing) the Moon, the shadow, and the (maximum) duration of the eclipse, (all) having one center, by means of a string measuring (respectively) 17, 38, and their sum (55) in minutes.

प्रोतायार(मं)शकलका(त्)पूर्वापरयोश्च पार्श्वयोश्चापि /
आयामिन्यो रेखास्त्रयोदश समान्तराः कार्याः //१३//
चन्द्रच्छेद्यकमेतच्छास्त्यागम्यं समासतो ऽभिहितम् /
ग्रासविमर्दस्थितयः संस्थानेनात्र दृश्यन्ते //१४//
स्वे भूछायामिन्दुः स्पृश(त्य)तः स्पृश्यते न पश्चार्धः /
भानुग्रहे ऽर्कमिन्दोः प्राक्प्रग्रहणं रवेर्नातः //१५//
चन्द्रग्रहणं षष्ठो ऽध्यायः //

15 quoted by Utpala on BS 5,12.

13a प्रोतायांसकलंका a, प्रोतायोंसबूलंका β 13b पूर्वापयोश्च a

13d समात्तराः a, समांताराः β कार्यः β 14a चन्द्रछेदक° a, चन्द्रष्टेदक° β, corr. T.-D. 15a भूय(य om. C)छायामिंदु β 15b स्पृशतः a, स्पृश्य(श C)तः β

पश्चार्द्धः Utpala 15c भागनुग्रहे aβ

VI,13. In the two sides to the east and west of the afore-mentioned radii are to be drawn thirteen long lines having equal intervals (between them).

VI,14. This projection of the Moon, which is to be approached with a commentary, has been summarily set forth; in it are seen, by means of the representation, the first contact, totality, and duration of the eclipse.

VI,15. In its own (eclipse) the moon touches the shadow of the earth; therefore its western half is not touched. In an eclipse of the Sun, (the Moon touches) the Sun; (therefore) the first contact of the Moon is in the east, but not that for the Sun.

The sixth chapter: the Eclipse of the Moon.

दिनमध्यमसंप्राप्ता यावत्यो नाडिका व्यतीता वा /
ताभ्यः षड्गुणिताभ्यो ज्या त्रिंशांशस्तिथेर्नामः //१//
पंचघ्नास्त्रयमासा <क्षेपो> ऽक्षे मुखपुच्छयोर्धनर्णः /
तद्राशिचरणायनगुणं धनमृणं नाड्यो द्विकविभक्ताः //२//
उदगयने पूर्वार्धे धनमृणं दक्षिणे प्राच्याम् /
पश्चाद्धनं तु याम्य उदगृणं वामतः पुच्छे //३//
दिनयातशेषनाड्यश्चन्द्रायनसङ्गुणास्त्वशीतिहृताः /
मेषतुलाद्यृणं धनं विपरीतं वामतः पुच्छे //४//
राहोः सषट्कृतिकलां हित्वांशं तच्छशाङ्कविवरांशैः /
ग्रहणं त्रयोदशान्तः शशिनो भानोस्तथाष्टान्तः //५//
तद्वर्गमपास्येन्दोर्नवर्तुरूपाद्रवेः कृतरसाभ्र /
तन्मूलं पादोनं स्थितिकालश्चन्द्रभान्वोश्च //६//
पौलिशसिद्धान्ते रविग्रहणं सप्तमो ऽध्यायः //

1 equals VIII 9. 5a–c equal VI 2 a–c.

1b यावन्त्यो β वत (त् B, त्त E, त्तत् C) aβ, corr. T.–D. 1b ज्यास्त्रिंशांशस्तिथि (थि F) नी (नीं D, corr. to ना D²) म aβ, corr. T.–D. 2a–b पंचघ्नास्त्रयमासा- दक्षान्मुख° aβ 2b °पुछयोर्द्धनर्णे a, °पुष्टयोर्द्धनर्णे β 2c तत्र राशि° a, तत् राशि° β 2d धनमृणना (ता β) ड्यो aβ 3b धनं ऋणं aCF दिणे a, दक्षिणं β, corr. T.–D. 3c–d याम्ये दगृणं a, याम्ये दृ (द C) गुगृणं β 3d पुष्टे β 4a–b °शेषं नाड्यश्चन्द्रानय (व C) न° β 4b °सङ्गुणास्त्वशीति° a, °सङ्गुणाश्चा (स्व CF) शीति° β, corr. T.–D. °कृताः C, °ह्वताः E, °–ताः F 4c शेषतुलादि ऋणधनं aβ 5a °कृतिकिलां a, °कृतिकला β 5b हित्वासं a, हित्यास β, corr. T.–D. 5d °स्तथाष्टीतः β 6a–b तद्वर्गसमासेन्दोत्तव (घ β) र्तुरूपात्रवे aβ, corr. T.–D. 6b छतरसा (स EF) भ्रु aβ 6d °भानोश्च aBE, °भान्योश्च C

Chapter VII

VII,1. As many as are the nāḍikās till noon is attained or that have passed (since noon), multiply them by 6 and (take) the Sine (of the product); a thirtieth part (of the Sine) is called the "displacement of the tithi" (parallax in longitude).

VII,2. Multiply the nāḍīs by 5 and divide (the product) by 23; divide (again) by 2. The lunar latitude is added to the terrestrial latitude at the ascending node (i.e., if the latitude is northern), subtracted from it at the descending node (i.e., if the latitude is southern). Add or subtract this (sum or difference) to the declination of a fourth of the zodiacal signs (i.e., of the nonagesimal). (Take the Sine of this and) multiply it (by the amount found at the beginning of the verse).

VII,3. In the northern ayana it is positive in the east, in the southern (ayana) negative in the east; in the southern ayana it is positive in the west, in the northern negative. (The signs are) reversed at the descending node.

VII,4. Multiply the nāḍīs that have passed or that yet remain in the day by the declination of the Moon and divide (the product) by 80; (the result) is negative in Aries and so on, positive in Libra and so on. (The signs are) reversed at the descending node.

VII,5. Put down the degree of the ascending node increased by 36 (or by 26?) minutes. (Operate) with the degrees of difference between this and (the longitude of) the Moon; if they are within 13°, there is an eclipse of the Moon, and if within 8°, an eclipse of the Sun.

VII,6. For the Moon, deduct the square of its (distance from the node) from 169; for the Sun, deduct the square of its (distance from the node) from 64. The square-roots of these (differences), diminished by their fourths, are the times of duration of their eclipses for the Moon and Sun.

The seventh chapter: the Eclipse of the Sun in the Pauliśasiddhānta.

रोमकसूर्यो द्युगणात् खतिथिघ्नात् पंचकर्तुपरिहीणात् /
सप्ताष्टकसप्तकृतेन्द्रियोद्धृतान्मध्यमः क्रमशः //१//
रविशशिनोः स्फुटकरणं स्वकेन्द्रभवनार्धसंमितैः खण्डैः /
तत्क्रमशश्च पुनस्तैर्मिथुनदलं शोध्यते ऽर्कस्य //२//
तिथिमनुदशाकृतसहिता रसमनु(वि)हीना च विंशतिर्हिता /
धृतिविषयोना द्विदशाष्टिधृतिषु वृद्धिः कला विकलाः //३//
खखरूपाष्टगुणघ्नात् कृताष्टनवकैकवर्जिताद् द्युगणात् /
त्रिविषयाङ्कखकृताशापरिलब्धान्मध्यशीतांशुः //४//
शून्यैकैकाभ्यस्तान्नवशून्यरसान्विताद्दिनसमूहात् /
रूपत्रिखगुणभक्तात् केन्द्रं शशिनो ऽस्तगमवन्त्याम् //५//
मनुभवयमसहितोंऽशो वसुहोत्रा वर्जितो धृतिकृतश्च /
विषयकृतिरष्टिषट्कं नवतिहीनं <हि>तं चन्द्रेण //६//

1 quoted by Utpala on BS 2 (p. 41).

1a रोमसूया (र्यो D) α 1b °परिही (हि C) णान्न (त् न E) αβ, corr. T.–D. 1c सप्ताष्टकया (णा C, आ E) स (न्य C) तते° β 1d °न्द्रि (न्द्र β) योधृ (द्धृ α) तान्मध्यमाः αβ, corr. T.–D. क्रमशः αβ, सूर्यः Utpala 2a स्फुरठकरणं β 2b स्वकेन्द्र° αβ, खखेन्द्र° Dikshit, corr. T.–D. 2d क (क्र C) स्य (स्य C) β 3b रसमनुहीनाभ्यविंशतिर्ही (ही β) ना αβ 3d °धृतिष्ट β कला द्विरकि (क E) ला αβ, कलाद्विरकिला Dikshit, corr. T.–D. 4a° रूपाष्टगुणाष्टघ्नात् (त् om. C) αβ, corr. T.–D. 4b क (क्रा F) ताष्ट° αβ, corr. T.–D. °वर्जिता (ता om. β) द्युगणात् αβ, corr. T.–D. 4c त्रिविषये च खकृताशा° αβ, corr. Dikshit 4d °परिशुद्धान्मध्य° αβ °शीतांशोः αβ, corr. T.–D. 5a शून्यैकैकान्यस्ता° αβ, corr. T.–D. 5d स्तगमवध्यां α, स्तगमवट (द्व EF) गाम् β, corr. T.–D. 6a-b °सहितांशौ वसुहोता वर्जितौ धृतिकृतौ च αβ, corr. T.–D. 6c विषयक्रति° α °रष्टव (य C, क E) षट्कं (द्ध C, द्व EF) αβ 6d नवतिर्हितौ न चंद्रेना αβ

Chapter VIII

VIII,1. Multiply the ahargaṇa by 150, subtract 65 (from the product), and divide (the remainder) by 54 787 in order; from this (is obtained) the mean (longitude of the) Sun (according to) the Romaka.

VIII,2. The calculation of the true longitudes of the Sun and the Moon are by means of segments measured in halves of zodiacal signs of their anomalies, (both) in direct order of these and in reverse. A half of Gemini (i.e., 75°) is subtracted from (the mean longitude of) the Sun.

VIII,3. The minutes are 20 plus 15 (= 35), plus 14 (= 34), plus 10 (= 30), plus 4 (= 24), minus 6 (= 14), and minus 14 (= 6); the seconds are minus 18, minus 5, plus 2, plus 10, plus 16, and plus 18.

VIII,4. Multiply the ahargaṇa by 38 100, subtract 1984 (from the product), and divide (the result) by 1 040 953; from this (is obtained) the mean (longitude of the) Moon.

VIII,5. Multiply the ahargaṇa by 110, add 609 (to the product), and divide (the sum) by 3031; from this (is obtained) the anomaly of the Moon at sunset at Avantī.

VIII,6. A degree plus 14 (= 1;14°), 11 (= 1;11°), and 2 (= 1;2°); 4 times 18 minus 8 times 3 (= 0;48°); 5^2 (= 0;25°); and 6 times 16 minus 90 (= 0;6°); (these are) used with the Moon.

स्वनवनगाः शशिभुक्तिः कृतवसुमुनयः शशाङ्ककेन्द्रस्य /
यातस्फुटान्तरे दिवसभुक्तिरागामिकी नैशी //७//
त्र्यष्टकगुणिते दद्याद्रसर्तुयमषट्कपंचकान् राहोः /
भवरूपाग्न्यष्टिहृते क्रमाज्झषात् सोच्यते वक्त्रम् //८//
दिनमध्यमसंप्राप्ता यावत्यो नाडिका व्यतीता वा /
ताभ्यः षड्गुणिताभ्यो ज्या त्रिंशांशस्तिथेर्नाम: //९//
उदयात् प्रभृति च नाड्यो याः स्युः प्राग्लग्नमानयेत्ताभिः /
तस्मात्तु नवसमेतादपक्रमांशा विनिश्चिन्त्याः //१०//
लग्नासुरविर(व)रज्यां द्विगुणां स्वरसाप्तामपक्रमांशात् /
जह्याद्दिग्व्यत्यासे विश्लेषैक्ये तयोर्योगः //११//
उत्तरमक्षाच्छुद्धं याम्यं साक्षं च दक्षिणं विद्यात् /
उत्तरमक्षाद्यदधिकमुत्तरमेवं विजानीयात् //१२//

9–18 quoted by Utpala on BS 5,18; 9 equals VII 1.
7b क्रत° a, तत्त (त om. C) त्त (तृ C) β, corr. T.-D. 7d °भुक्ति आगामिकी aβ, corr. T.-D. 8a त्र्य (त्र्य om. E, add E²) ष्टगुणिते (भो BE) β 8b °पंचकान्राहो: a 8d क्रमा (मात् CF) aβ, corr. T.-D. झखांत्तोच्यते a, दु (ड CF) खां (खो F) तोच्यते β वक्त्रां a 9b या (त्या C) यत्या β दिनादिका a
9c षड्गुणितायो aβ 9d °स्तिथिर्ना (र्नी D, ना D²) म aβ 10a व a
10b पु: प्रा (फा C) लग्नमानये (वे C) ताभि: β 10c नवम (म om. E, add. E²) मेता° aβ 10d °क्रमांशान् Utpala विनिश्चित्या a, द्विनिश्चित्य β, विनिश्चित्य Utpala, corr. T.-D. 11a वग्नासुरविरज्यां a, लग्नासु (स्त C) रविरन्यां β, लग्नत्र्यगु-विवरज्यां Utpala 11b सवसांससंयुतयममरान् a, या (यर F, मर C) सांस (रु C) सं-पुतय (य om. C) ममरान् β, स्वरसांशसंमितामपमात् Utpala 11c जह्यादिग्व्य (ग्व C) त्यासौ aβ 11d विश्लेयैके aβ 12b यदक्षि (दीक्ष C) णं β 12c उत्तमक्षा° β

VIII,7. The daily progress (bhukti) of the Moon is 790 (minutes), (that) of the Moon's anomaly 784. In the difference between the past (and present) true longitudes (are found) the day's bhukti (and that) for the coming night.

VIII,8. Multiply (the ahargaṇa) by 24, add (to the product) 56 266, and divide (the sum) by 163 111; the (result, counted) in (reverse) order from Pisces, is called "the face of Rāhu" (i.e., the ascending node).

VIII,9. As many as are the nāḍikās till noon is attained or that have passed (since noon), multiply them by 6 and (take) the Sine (of the product); a thirtieth part (of the Sine) is the deplacement of the tithi (i.e., the parallax in longitude).

VIII,10. By means of those nāḍīs which (have elapsed) since sunrise one should calculate the ascendant; from this increased by 9 (zodiacal signs) the degrees of declination are to be determined.

VIII,11. Multiply the Sine of the difference between the (madhya)lagna (the nonagesimal) and the node by 2 and divide (the product) by 60; one should subtract (the result) from the degrees of declination if the directions are opposite, add them together if the latitude (and declination) are in one direction.

VIII,12. If (the result) is northern and is subtracted from the terrestrial latitude or if it is southern and is added to it, one should know that (the result) is southern; if it is northern and is greater than the terrestrial latitude, one should know (the result) is northern.

तज्ज्याघ्नीं शशिभुक्तिं हृत्वा धृतिभिः शतैः स्फुटाबनतिः /
मध्यममानं त्रिंशद्भानोः शशिनश्चतुस्त्रिंशत् //१३//
समलिप्तराहुबिबरज्याभ्यस्ता मूर्ध्ना नवहृता च /
अबनत्या युतविश्लेषिता च दिक्साम्यवैलोम्ये //१४//
मध्यममानाभ्यस्ता स्फुटभुक्तिर्मध्यभुक्तिभक्ता च /
भबति कलापरिमाणं तत्कालीनं रविहिमांश्वोः //१५//
अबनतिबर्गं जह्याद्रवीन्दुपरिमाणयोगदलबर्गात् /
तन्मूलात्तु द्विगुणात्तिथिभुक्तबदादिशेत् कालम् //१६//
रबिशशिमानयुतिदलादबनतिहीनाद्भवन्ति या लिप्ताः /
तान्यङ्गुलानि बिन्द्याद्भानोश्छन्नानि चन्द्रमसा //१७//
अर्धेनालिख्य रबिं दत्वाबनतिं यथादिशं मध्यात् /
अवनत्यन्ताच्चन्द्रं बिलिखेद्ग्रासार्थमर्धेन //१८//
इति रोमकसिद्धान्ते ऽर्कग्रहणमष्टमो ऽध्यायः //

13a तज्याघ्नीं (घ्नी β) αβ 13b हृत्वा (घा F) β स्मृतानवभि: αβ
13c–d त्रिशन्भानोः β 13d °स्त्रिंशन्न α 14a–b समलिप्ताद्गविबरज्यान्यस्ता α,
समलिप्त (प्त E, प्ति E²) ता (ता om. E, add. E²) द्रविवरज्यान्यस्ता β 14b नवहृ (हृ EF)
ताश्च αβ Utpala 14c अनबध्या α, अ (प्र F) वन (म C) ध्या (घ C) β 14c–d युतविश्ले-
षिबाश्च β, युतविश्लेषिताश्च α 14d दिक्साम्ये αβ 15a मध्यमभा (मा EF) ना (ता E)
न्यस्ता αβ 15b स्फुट (टे E) भुक्ति (भुक्ति om. BE) मध्यमभुक्तिभक्ता αβ
15c कलापपरिमाणं αβ 15d हिमांशो (शो om. BC) शोः β 16a °वर्ग्गं α
16b °द्रविन्दु° αCF °वग्गति β 16c तन्मुलात्तु α 16c–d द्विगुणा तिथि° β
17b °द्रवति αβ 17d °द्भानोश्छन्नानि αC चंद्रमद्र (द्र om. A; "illegible" written above
it by D²) मसा (स्म D, स्स and then प्स D²) α 18b दत्वा (त्रा C, घा F) नवतिं αβ
18c अवनत्यां (त्या β) तश्चंद्रं αβ 18d विलिखेत् (त F, त्तु E) ग्रासा° β col. इति
om. α रोमफसिद्धान्ते α

VIII,13. Multiply the velocity (bhukti) of the Moon by the Sine of that (result) and divide (the product) by 1800; (there results) the accurate avanati. The mean measure (of the diameter) of the Sun is 30 (minutes), (that) of the Moon 34.

VIII,14. Multiply the Sine of the difference between the longitude of the Moon at conjunction (samalipta) and the node by 21 and divide (the product) by 9; (the result) is added to or subtracted from the avanati as their directions are the same or opposite.

VIII,15. Multiply the accurate velocity by the mean measure (of the diameter) and divide (the product) by the mean velocity; (the result) is the accurate measure in minutes of (the diameter of) the Sun or Moon at that time.

VIII,16. One should subtract the square of the avanati from the square of half the sum of the measures of the Sun and Moon; multiply the square-root of that (remainder) by 2. From this one should indicate the time (of the eclipse) as (is done) in the case of the lapsed portion of a tithi.

VIII,17. Subtract the avanati from half the sum of the measures of the Sun and Moon; one should find that the minutes that result are the digits of the Sun that are covered by the Moon.

VIII,18. Draw the Sun with (a radius equal to) half (of its measure) and lay off the avanati from its center in the proper direction; one should draw the Moon with (a radius equal to) half (of its measure) from the end of the avanati for the sake of (determining) the magnitude (of the eclipse).

Thus the Solar Eclipse in the Romakasiddhānta: the eighth chapter.

द्युगणे ऽर्को ऽष्टशतघ्ने विपञ्चवेदार्णवे ऽर्कसिद्धान्ते /
स्वरखाश्विद्विनवयमोद्धृते क्रमाद्दिनदले ऽवन्त्याम् //१//
नवशतसहस्रगुणिते स्वरैकपञ्चाम्बरस्वरर्तूने /
षड्व्योमेन्द्रियनववसुविषयजिनैर्भाजिते चन्द्रः //२//
नवशतगुणिते दद्याद्रसविषयगुणाम्बरर्तुयमपञ्चान् /
नववसुसप्ताष्टाम्बरनवाब्धिभक्ते शशाङ्कोच्चम् //३//
शशिविषयघ्नानीन्दोः सार्काग्निहृतानि मण्डलानि त्वृणम् /
स्वोच्चे दिग्घ्नानि धनं स्वररन्ध्रयमहृता<नि> विकलाः //४//
त्रिघ्नशतघ्ने नवकैकपञ्चरामेन्दुदहनषट्सहिते /
करयमवसुभूतार्णवगुणधृतिभक्ते <क्र>माद्राहुः //५//
चक्रात् पतितं वक्त्रं षड्राशियुतं च पुच्छाख्यम् /
तिमिरविवरस्य लिप्ता विक्षेपः सप्ततिर्द्विशती //६//

1 quoted by Utpala on BS 2 (pp. 41 and 67).
1a द्युगुणे a   र्कैं aβ   1c-d स्वरस्वा (स्वा F) द्विद्वि (द्विद्वि om. F) नवयमोद्धृ (द्धृ β) ते aβ   1d वत्यां a, व (य C) त्या β   2b °पञ्चावर° a   °स्वरर्तु (र्त्त a) ने (ने om. C) aβ, corr. T.-D.   2c षडूनेंद्रिय° a, षद्य (ड्व्य C) नेंद्रिय° β, corr. Dikshit   3a °गुणितं aCF   3b °गुणावर° a   °पञ्चात् β   3c-d °सप्ताष्टास्वरनवाब्धिभक्ते a   4a °विषयघ्नीनींदोः β   4b स्वर्काग्निहृतानि aβ, corr. T.-D.   ऋद (ऋ F) णं aβ   4c स्वोच्चे a   टिग्घ्नानि aβ, corr. T.-D.   4d स्वरदस्त्रयमोद्धृ (द्धृ β) ते aβ, स्वररन्ध्रयमोद्धृते Dikshit
5a द्विघ्ननगजघ्ने aβ, corr. Kuppanna Sastri and Sarma   स्व (न् च CF) कै° β
5b °दहन (न om. a) शब्दाः स (प्र BE) हिते aβ, corr. Kuppanna Sastri and Sarma
5c चरयमवसुधृतार्णव° a, वरयमवसुभूतार्णव° β   5d °गुधृतिभक्त a, गुणाधृति रनू (रनु F, मू C) ता β, corr. Kuppanna Sastri and Sarma   रना (मा βD, corr. to रना D^2) द्राहोः aβ   6a वक्त्रं] चक्रं aβ, corr. T.-D.   6b व a, तु β, corr. T.-D.   6c तिमिर°] सहित° a, ग्रहति° β   6d सप्तताद्विशती aβ

Chapter IX

IX,1. In the Sūryasiddhānta, if the ahargaṇa is multiplied by 800, if 442 is subtracted (from the product), and if (the remainder) is divided by 292 207 in order, (the result) is (the mean longitude of) the Sun at noon at Avantī.

IX,2. (If the ahargaṇa) is multiplied by 900 000, if (the product) is diminished by 670 217, and if (the remainder) is divided by 24 589 506, (the result is the mean longitude of) the Moon.

IX,3. (If the ahargaṇa) is multiplied by 900, (if) one adds (to the product) 2 260 356, and if (the sum) is divided by 2 908 789, (the result) is the apogee of the Moon.

IX,4. Multiply the revolutions of the Moon by 51 and divide (the product) by 3120; (the result, in seconds,) is negative. In the case of its apogee, multiply (the revolutions) by 10 and divide (the product) by 297; (the result), in seconds, is positive.

IX,5. (If the ahargaṇa) is multiplied by 2700, if 6 313 219 is added (to the product), and if (the sum) is divided by 18 345 822 in order, (the result determines the position of) the ascending node.

IX,6. This subtracted from a circle (i.e., 360°) is the (longitude of the) ascending node, and that increased by 6 signs is the "planet" called the descending node. The minutes of (the Moon's) distance from its node (determines its latitude; the maximum) latitude is 270 minutes.

अंशाशीत्या हीनो ऽर्कः केन्द्रं स्वोच्चवर्जितश्चन्द्रः ।
तज्ज्यार्कस्य मनुघ्नी रूपाग्निगुणा शशाङ्कस्य ॥७॥
व्योमरसानलभक्ते तच्चापं द्विस्थितं शशाङ्करवौ ।
प्रथमे चक्रस्यार्धे व्ययश्चयः पश्चिमे भागे ॥८॥
सौर्यं स्थापितचापं तद्भुक्तिघ्नं सखाष्टियमभक्तम् ।
प्रथमवदर्के कार्यं चन्द्रे च दिवाकरवशेन ॥९॥
पंचाशता त्रिभिस्त्र्यंशसंयुतैर्योजनैश्च नाड्येका ।
समपूर्वपश्चिमस्थैर्नित्यं शोध्या च देया च ॥१०॥
नवतिः सप्तशतीन्दोः सचतुस्त्रिंशद्विलिप्तिका भुक्तिः ।
षष्टिर्व्येका विकलाष्टकं च मध्या सहस्रांशोः ॥११॥
सप्तकला त्र्यंशाश्चन्द्रोच्चस्येन्दुभुक्तिरनयोना ।
केन्द्रस्य परिच्छेया स्फुटभुक्तिश्चानया कार्या ॥१२॥

7a अंशाशीत्यो a, अ (प्र F) शाशत्यो (त्वो B) β, corr. T.-D.   द्वि (दि C) नो aβ, corr. T.-D.   7b र्कं (र्कर्कं C) द्रश्चः aβ, corr. T.-D.   7c तज्ज्यार्कस्य aβ, corr. T.-D.
7d °गुणि (ण D) ता a   8b शशाङ्कवशात् aβ   8c प्रथमे om. β   9b सखाष्टिव ([illegible] CE) यमभक्तं aβ, corr. T.-D.   10a पंचा (चां aBF) शतास्त्रिभि° aβ, corr. T.-D.
11a नव (च a) तु aβ, corr. T.-D.   सप्तस (स om. C) तींद्वोः aβ, corr. T.-D.
11b सुभुक्तिः β   12a विंच (वि C) त्र्यं (अं C) शा° β   12b °रतयोना a
12d स्फुटभुक्ति° (क्ति C) β   °श्चात (त् BEF) या aβ, corr. T.-D.

IX,7. Diminish (the mean longitude of) the Sun by 80°, (that of) the Moon by its apogee; the results are their arguments. The Sine of this for the Sun is multiplied by 14, that for the Moon by 31.

IX,8. Divide (the products) by 360; put the arcs (corresponding to) these (Sines) down in two places. They are subtractive for (the mean longitudes of) the Sun and Moon in the first half of the circle, additive in the latter part.

IX,9. Multiply the arc determined for the Sun by its velocity (bhukti) and divide (the product) by 21 600; this is to be applied to the Sun as was done previously. (Operate) for the Moon according to (the rule for) the Sun.

IX,10. One nāḍī is always to be subtracted or to be added for every $53^1/_3$ yojanas to the east or west of the prime meridian.

IX,11. The mean velocity (bhukti) of the Moon is 790 (minutes) and 34 seconds; (that) of the Sun is 59 (minutes) and 8 seconds;

IX,12. (that) of the Moon's apogee is 7 minutes diminished by $^1/_3$ (= 0;6,40°); the (mean) velocity of the Moon diminished by that (same amount) is to be known as the (mean) velocity of the anomaly. These are to be made into the true velocities.

केन्द्रान्तरज्यागुणिता तिथिवर्गेणोद्धृता च परिणाम्य ।
तत्कार्मुकं व्ययचयौ भुक्तौ मृगकर्कटाद्येषु ॥१३॥
तत्कालभुक्तिरेषा ज्ञेयाहोरात्रिकी शशिविशेषात् ।
व्यासार्धहृता भुक्तिः स्फुटभुक्तिहृता स्फुटः कर्णः ॥१४॥
मुनिकृतगुणेन्द्रियघ्नः स्फुटकर्णः स्वकृतभाजितोऽर्कस्य ।
कक्षेति चन्द्रकर्णो द्विघ्नः कक्षा शशाङ्कस्य ॥१५॥
खवसुखमुनीन्दुविषया भानोः स्वकृतर्तु⟨व⟩सुगुणाः शशिनः ।
तात्कालिकमानार्थं स्फुटकक्षाभ्यां पृथग्विभजेत् ॥१६॥
मध्याह्नलम्बिततिथेरन्तर⟨र⟩राश्युद्गमैः प्रतीपांशाः ।
प्राक्समलिप्ताहानिः क्रमेण पश्चाद्धनं कार्यम् ॥१७॥
तन्मध्यविलग्नाख्यं तस्माच्चापक्रमांशकाः क्रमशः ।
तैरक्षवियुतयुतैर्या ज्या मध्याभिधाना सा ॥१८॥

13b °वर्गेणोद्ध (ध्रृ β)ता aβ, corr. T.-D. 13d भुक्तो β 14b ज्ञेयाहोर्भेन्द्रकी a, ज्ञेया – होर्भेन्द्रकी β, corr. T.-D. 14d °हृ (फृ C, ऋ E)ता aβ, corr. T.-D.
15b [illegible]भाजितो a, स्वकृतभाजितो β, corr. Kharegat, Shukla
15c-d चंद्रकरणोंद्विघ्नः a, चन्द्रकर्णो° (र्णें° EF, रर्णें C) द्विघ्नः β, corr. Kharegat, Shukla 16a खखवसुख° aβ, corr. T.-D. °मुनीन्द्रविषया aβ, corr. Kharegat, Shukla 16b स्वत्त (त्त EF, त्र C)तर्तु° β °वसुगुणाः Kharegat, Shukla
17a मध्या (ध्य F) के° aβ 17a-b °तिथेरनराश्युद्गमैः a, °ती (ति F) थेरत्तरा-श्यु (ह्यु B) द्गु (द्रु C) मैः (ग्रैः B, गैः F) aβ 17b प्रीतिपांशाः β 17d पश्चाध्न (द्रु C) न aβ, corr. T.-D. 18d ज्या कृतिं (कृतिं om β) सध्या (धा E, ध्या C) भिधाना aβ corr. T.-D.

IX,13. Multiply (the mean velocity of the anomaly) by the tabular difference between the Sines of the anomaly and divide (the product) by the square of 15 (= 225); reduce (the result) and take that arc. (The latter) is subtractive or additive to the velocity as it is in Capricorn and so on, or in Cancer and so on.

IX,14. The progress during a nychthemeron for the (given) time is to be known by means of the difference between (two true longitudes of) the Moon. Multiply the (mean) velocity by the radius and divide (the product) by the true velocity; (the result is) the true hypotenuse.

IX,15. Multiply the true hypotenuse of the Sun by 5347 and divide (the product) by 40; (the result) is called the orbital radius (kakṣā). The hypotenuse of the Moon multiplied by 10 is the orbital radius of the Moon.

IX,16. One should divide separately by their true orbital radii 517 080 for the Sun and 38 640 for the Moon in order to obtain the measures (of their diameters) at any given time.

IX,17. The degrees (on the ecliptic) corresponding to the rising-times of the zodiacal signs (at sphaera recta) between the depressed (end of the) tithi (i.e., the time of the conjunction) and noon are subtracted from the longitude of the conjunction (samalipta) if it is in the east, but added in the west.

IX,18. That (result) is called the madhyavilagna; (take) the degrees of its declination and add to or subtract from them the terrestrial latitude; the Sine of the result is called the madhyā (jyā).

तिथ्यन्तविलग्नज्या काष्ठान्तज्याहता स्वलम्बहृता /
मध्यज्याघ्नी व्यासार्धभाजिता वर्गिता सा च //१९//
मध्यज्याकृतिविशेषिता पृथक्स्थाप्या मूलमेकस्याः /
सवितुर्दृक्क्षेपाख्यं संस्मृत्यर्थं पृथक्स्थाप्यम् //२०//
दृक्क्षेपकृतिं जह्यात् त्रिज्यावर्गात्ततो ऽस्य यन्मूलम् /
लग्नार्कविवरमौर्व्या गुणितं त्रिज्योद्धृतं शङ्कुः //२१//
शङ्क्वङ्गुलाख्यविंशतिशतकृत्योरन्तरेण विशेषि<त>ात् /
स्थितवर्गान्मूलं द्विनवकाहतं तद्विभज्य कक्षाभ्याम् //२२//
भागविशेषात्तिथिवत्तिथ्यन्तो ऽतः पुनः पुनस्तत् स्यात् /
एवं मृग्यः कालस्तूत्पन्नो यावदविशेषः //२३//
अविशेषाद्दृक्क्षेपं वस्वेकघ्नं विभज्य कक्षाभ्याम् /
लब्धान्तरचापांशा मध्यज्यादिग्वशेन नतिः //२४//

19a °विलग्ना ज्या aβ, corr. T.-D.   19b स्वलम्बह (ह C) ता β
20a मध्यज्यान्त (त C) ति° β   °विश्लेषि (ष β) तां aβ   20c °दृ (द्दृ β) क्षेपाख्यं aβ corr. T.-D.   21a दृ (दृ β) क्षेप° aβ, corr. T.-D.   21b °वर्ग (र्गा EF) त्त (त्त EF, त C) तो (त्तो EF) aβ, corr. T.-D.   स्य वन्मूलं a   21c °विवेर (वरे C) β
21d त्रिज्योद्धृ (द्धृ C, धृ EF) तं aβ, corr. T.-D.   22a शंकंगुलाख्यं β
22b °कृशोनंतरेण a, °त (त om. C) शोनंतरेण β, corr. T.-D.   विश्लेषात् aβ
22c स्थितिवर्गा° aβ, corr. T.-D.   22d सद्विभाज्य aβ, corr. T.-D.   कक्ष्याभ्यां a
23a °विशेषास्ति (स्ति a) थि° aβ   23b °त्तिथ्यर्धो (द्धो β) त्ता (ता β) मतः (नः β) aβ
23d °स्तूत्पन्नो a, स्तत्पन्नो β, corr. T.-D.   24a °दृ (दृ C) क्षेपं aβ, corr. T.-D.
24b यस्वेकघ्नं β

IX,19. Multiply the Sine of the (madhya)vilagna at the end of the tithi by the Sine of the maximum declination (of the Sun) and divide (the product) by the Sine of terrestrial colatitude. Multiply (the result) by the madhyajyā and divide (the product) by the radius; square (the result).

IX,20. Subtract (this) from the square of the madhyajyā, put (the result) down separately (in two places), and (take) the square-root of one (of them); this is called (the Sine of) the zenith distance (dṛkkṣepa) of the Sun. Put it down separately in order to remember it.

IX,21. One should subtract the square of the dṛkkṣepa from the square of the radius, and (take) the square-root (of the remainder). Multiply this by the Sine of the difference between (the longitudes of) the ascendant-point and the Sun, and divide (the product) by the radius; (the result is) the Sine of (the Sun's) altitude.

IX,22. Subtract the square which has been put aside (i.e., the square of the dṛkkṣepa) from the difference between the squares of the so-called śan̄kvan̄gula (i.e., Sine of the Sun's altitude) and of 120; multiply the square-root (of the remainder) by 18 and divide (the product) by the two orbital radii (i.e., by that of the Sun and by that of the Moon).

IX,23. From the difference in the degrees (of these two arcs is found) the end of the tithi, in the same way as (is found what has passed, or is to come, of) a tithi; from that (the procedure) is (to be iterated) again and again. The resulting time is to be investigated thus, until there is no remainder.

IX,24. Multiply the dṛkkṣepa (for that time) which has no remainder by 18 and divide (the product) by the two orbital radii; the degrees in the arc between the (two) results is the parallax in latitude, whose direction is that of the madhyajyā.

ज्याविधिना विक्षेपं तत्कालं प्राप्य तेन सहितोना /
स्पष्टा नतिः प्रमाणैः स्वैः स्वैर्ग्रासं स्थितिं च वदेत् //२५//
अवनतिवर्गं जह्याद्रवीन्दुपरिमाणयोगदलवर्गात् /
तन्मूलात्तु द्विगुणात्तिथिभुक्तवट्टादिशेत् कालम् //२६//
तिथ्यवनामो ग्रहणादिना च विश्लेषितः स्थित्या /
गोलान्यत्वे टेऽयस्त्ववनामो ⟨मौ⟩चिकस्यैवम् //२७//
इति सूर्यसिद्धान्ते ऽर्कग्रहणं नवमो ऽध्यायः //

25b प्राप्त α   25c स्पष्टनतिः αβ, corr. T.-D.   25d स्वैर्ग्रसं α, स्वैर्ग्रामं (मं om. CF) β, corr. T.-D.   स्थितं αβ   26a-b जह्यात् र° αβ, corr. T.-D.   26b °परिपरिमाण° β   26c तन्मूलात्त αβ, corr. T.-D.   26d °तिथिभुक्तिव° αβ, corr. T.-D.   °ट्टादिके (केत् E) β   27a तिथ्यवनाम αβ, corr. T.-D.   27b स्थित्यां αβ, corr. T.-D.   27c गोलान्य (न C) ये β   27d °नामोचिकोस्यैवं αβ, corr. T.-D.   col. इति om. EF

IX,25. Obtain the latitude (of the Moon) at that time by means of the Sines; the parallax in latitude increased or decreased by this is correct. By means of their proper measurements one should describe the magnitude and the duration (of the eclipse).

IX,26. One should subtract the square of the avanati from the square of half the sum of the measures (of the diameters) of the Sun and Moon; multiply the square-root of that (remainder) by 2. One should predict the time from this as in the case of what has passed of a tithi.

IX,27. Take the difference between the displacement of the tithi (i.e., the parallax in longitude) and the duration at the beginning of the eclipse; if (the eclipse) is in the other (i.e., western) hemisphere, the displacement is to be added. (Do) likewise for the (time of) release.

Thus the ninth chapter: the Eclipse of the Sun in the Sūryasiddhānta.

रविकक्षा नवतिगुणा षडष्टदस्रोद्धृतेन्दुकक्षायाः /
छेदः षट्त्रिघ्नायाया लब्धेनोनस्य षड्वर्गः ॥१॥
वियदर्कगुणे शशिकक्षया हृते कार्मुकं तमोव्यासः /
चन्द्रतमोव्यासयुतिं द्वाभ्यां हृत्वा ततो वर्गात् ॥२॥
विक्षेपवर्गहीनादासन्नपदे वियद्धिचन्द्रघ्ने /
सूर्येन्दुभुक्तिविवरोद्धृते स्थिते नाडिका लब्धाः ॥३॥
प्रग्रहणेन्दोः कृत्वा विक्षेप(स्)ततो ऽनया स्थितिर्भवति /
एवं भूयो भूयः स्थित्यविशेषः कृतो यावत् ॥४॥
अर्केन्दुभुक्तिविवरं वाञ्छितनाडीहतं तु षष्टिहृतम् /
स्थितिलिप्तास्ताभ्यस्तु तात्कालेन्दोश्च विक्षेपात् ॥५॥
कृतियोगपदं शोध्यं शशिराहुकलाद्यमानयोगदलात् /
यच्छेषं तद्ग्रस्तं ज्ञेयं तत्कालमर्केन्द्वोः ॥६॥

1a रविकक्ष्या a   नव(वा C)तीगुणा β   1b °दस्रोद्धृ(धृ β)ते° aβ, corr. T.-D. °कक्ष्यायाः aβ, corr. T.-D.   1c षड्त्रिघ्नाया a, षट्त्रि(त्रि C)घ्नाया β, corr. T.-D. 1d लब्धोनो(ना β)न(त β)स्य aβ, corr. T.-D.   2a वियदर्वेगुणे β   2a-b °कक्ष्याया aβ, corr. T.-D.   2b हृ(हू C, ह्र F)ते β   तयोर्व्यासः(स्रः β) aβ, corr. T.-D. 2c-d °यतिर्द्वाभ्यां aβ, corr. T.-D.   2d हृ(कृ C, ह F)त्वा(त्या C, श्वा E, या F) aβ, corr. T.-D.   3b वियद्धि° aβ, corr. T.-D.   3c-d °विवरोधृते aβ, corr. T.-D. 4a प्रग्रहणेन्दुः aβ, corr. T.-D.   4b विक्षेपतो aβ, corr. T.-D.   स्थितेर्भवति aβ, corr. T.-D.   4d स्थित्यवशेषः aβ, corr. T.-D.   5c-d °स्ताभ्यस्ताता(त्ता a)त्काले° aβ   5d विशेषात् aβ, corr. T.-D.   6a-b om. C   6b °कलाद्यमा(म β)ण° aβ, corr. T.-D.   6c यच्चेषं aβ, corr. T.-D.   6d °मर्केन्दोः β

Chapter X

X,1. Multiply the orbital radius (kakṣā) of the Sun by 90 and divide (the product) by 286; (the result) is the divisor of the orbital radius of the Moon after it has been multiplied by 36. Diminish the square of 6 (i.e., 36) by the quotient.

X,2. Multiply (the remainder) by 120 and divide (the product) by the orbital radius of the Moon; the (corresponding) arc is the diameter of the shadow. Divide the sum of the diameters of the Moon and of the shadow by 2 and square the result.

X,3. Take the approximate square-root (of this square) diminished by the square of the (Moon's) latitude and multiply it by 120; divide (the product) by the difference between the velocities (bhuktis) of the Sun and Moon; the quotient is in nāḍikās.

X,4. Calculate the latitude of the Moon at the (time of) first contact; then, by this (procedure), there results the (half-) duration (of the eclipse). Thus the (half-) duration is calculated again and again until there is no remainder.

X,5. Multiply the difference between the velocities of the Sun and Moon by the stated nāḍīs (of the half-duration) and divide (the product) by 60; (the result) is the minutes (of arc) of the (half-) duration. (Take the square) of these (minutes) and of the latitude of the Moon at any given time.

X,6. Subtract the square-root of the sum of these squares from half the sum of the measures (of the diameters) of the Moon and the shadow taken in minutes (of arc) and so on; whatever is left is to be known as the obscured (portion) of the Sun or the Moon at that time.

अन्त्याद्ययोर्विश्लेषार्धावनतिविक्षेपवर्गविवरपदम् ।
द्विगुणं तिथिवत् कृत्वा विमर्दकालो ऽर्कचन्द्रमसोः ॥७॥
चन्द्रग्रहणं दशमो ऽध्यायः ॥

7a अताद्ययार्वि° β   7a-b °श्लेषाववव (व om. β) नतिविक्षेप° αβ
7d ऽर्क° om. β

X,7. Multiply by 2 the square-root of the difference between the square of half the difference between the diameter of the eclipsed body (antya) and the diameter of the eclipsing body (ādya) and the square of the Moon's latitude; compute (with the result) as in the case of a tithi. (The result) is the duration of total obscuration of the Sun or Moon.

The tenth chapter: the Eclipse of the Moon.

यष्ट्या विध्यङ्गुलया वृत्तं परिलिख्य संप्रसार्य दिशः /
अन्त्याद्यदलैक्येनाद्यमपरमर्धेन चाद्यस्य //१//
चन्द्राम्बरान्तरांशात् क्रमज्यया ज्यां निहत्य वैषुवतीम् /
सार्कांशानुदयास्तमयात्तूदग्याम्यतो दद्यात् //२//
सत्रिगृहस्य हिमांशोरपक्रमांशान् यथादिशं कुर्यात् /
प्रागपरसिद्धिरेवं बकाद्याम्योत्तरे ज्ञेये <च> //३//
दिग्व्यत्ययेन शशिनो विक्षेपस्तद्दिगन्तकं सूत्रम् /
स्पृशेद्द्वितीयं वृत्तं तस्मादन्यं <लि>खेन्मध्यात् //४//
तत्संपाते स्पर्शो मोक्षो ऽप्येवं विपर्ययात् साध्यः /
तात्कालिका स्वकृत्या मोक्षादिक् संविधातव्या //५//
लिप्ताद्वयेन हरिज्जे त्रयेण मेषूरणे ऽङ्गुलं भवति /
अनुपातो ऽन्तर(सं)ख्ये कर्तव्यो दृष्टिसुखार्थम् //६//
अ(नु)वर्णनमेकादशो ऽध्यायः //

1a षष्ट्या aβ, corr. T.-D. विधित्र्यंगुलया aβ, corr. T.-D. 1b दिशं (शां C) aβ, corr. T.-D. 1c अंताद्य (धृ β) दलैक्योना° aβ, corr. T.-D. 1d °द्यदपरम° a, तद् पदपरम° β, corr. T.-D. 2a चंद्रावतरां° β 2a-b °शोत्क्रम° aβ 2b °ज्या (ज्य CF) धा (धा F) β विहत्य aβ, corr. T.-D. 2c-d सार्कांशांशावुदयादस्तमयोतुदग्याम्यतो a, सर्कांशांशांबुरदयास्तमयोनुदग्याम्यतो β 3b °मांशाद् (त् CF) β 3c °सिधिरेवं a 3d वकाद्याम्योत्तरे a 4b विक्षेपां तद्दि° aβ 4c स्पृशद्वि° a, स्पर्शोद्वि° β 4d °दन्यश्येन्मध्यं a, °दन्यक्षे (त् चे CF) न्मध्या β 5a त्त (त्य C) संपाते (तं B) β 5b विपर्ययशोध्यः β 5c °त्स्वकृध्या a, स्वकृत (त om. CF) वृध्या β 5d मोक्षत्वादिक् (कू EF) aβ 6b मेषुरणं aβ, corr. T.-D. 6c न्तरः (र CEF) स्ये aβ, corr. T.-D. col. अवर्णनात्येकादशो aβ

Chapter XI

XI,1. Draw a circle by means of a staff measured in digits with (a radius equal to) the sum of the halves of the diameter of the eclipsed and of the eclipsing body; distinguish the directions. Now (draw) another (circle) with (a radius equal to) half of the diameter of the eclipsing body.

XI,2. Multiply the Sine of terrestrial latitude by the Sine of the degrees between the Moon and midheaven; (take) an 120th part (of the product). One should apply (the result) to the north or south as (the Moon) is towards its rising or setting.

XI,3. One should compute the degrees of declination of (the longitude of) the Moon increased by 3 zodiacal signs (and use it) in the proper direction; thus is obtained the east and west (points). The north and south (points) are to be known from a fish (-figure).

XI,4. A string—the latitude of the Moon—going in the opposite direction (to the latitude) and ending at that direction (of deflection) should touch the second circle; from the center one should draw another (line to that point on the second circle).

XI,5. At that point of intersection (with the first circle) first contact (takes place); release (i.e., last contact) is thus to be ascertained from the reversal (of this). The direction at any particular time is to be determined by one's calculation from the release.

XI,6. A digit equals two minutes on the horizon, three at midheaven; proportion is to be used (when a body) is in between, in order for (calculation) to coincide with observation.

The eleventh chapter: (Graphical) Description (of a Lunar Eclipse).

रविशशिनोः पंच युगं वर्षाणि पितामहोपदिष्टानि /
अधिमासास्त्रिंशद्भिर्मासैरवमो द्विषष्ट्याह्नाम् //१//
द्व्यूनं शकेन्द्रकालं पंचभिरुद्धृत्य शेषवर्षाणाम् /
द्युगणं माघसिताद्यं कुर्याद् द्युगणं तदह्न्युदयात् //२//
सैकषडंशे द्युगणे तिथिर्भमार्कं नवाहते ऽद्व्यर्कैः /
दिग्रसभक्तैः सप्तभिरूनं शशिभं धनिष्ठाद्यम् //३//
प्रागर्धे पर्व यदा तदोत्तरातो ऽन्यथा तिथिः पूर्वा /
अर्कघ्ने व्यतिपातो द्युगणे पंचाम्बरहुताशैः //४//
<सवि>धृति<य>रणद्यु<मु>त्तरगे त्वगतद्युमपि च याम्यस्थे /
द्विघ्नं शशिरसभक्तं द्वादशहीनं दिवसमानम् //५//
इति पैतामहसिद्धान्तो द्वादशो ऽध्यायः //

1–3 quoted by Utpala on BS 8, 22.
1c अधिमासास्त्रिं° (त्रि C) aβ Utpala 1d °र्मासिर° β °वमस्त्रिषष्यामुं a, °वमास्त्रिषष्ट्यार्का (हां F, यं C) β 2a द्यु (द्यू F Utpala) नं aβ Utpala, corr. T.-D. 2b पंचविशुधृत्य a, पंचविशुद्दृ (द्दृ E, द्धु C) त्य β 2c माघ (स C) सिताद्यं aβ 2d कुर्याद्युगणं a, कुर्याद्ध्यु (त् द्ध्यु F, त् द्यु C) द्युग (गु E) णं β, कुर्याद्युगणानि Utpala, corr. T.-D. तदद्वै (द्धु F) दयात् (न् E) β, बह्न्युदयात् Utpala 3a त्र्यं (अं C E) श (शा F) त्वं (न्वं β) चे aβ, सैकत्रिंशे Utpala 3b नवा (चा a) हस्ते (स्ने a) aβ, नवाहतो Utpala द्र्कैः a, द्रकैः β 3c दिग्गहभागैः aβ, दिग्रसभागैः Utpala 3c–d सप्तभिनूनं a 4b तदोतरात्तो a, तदात्त (त C F) ए (रां C) सो (तो C, स्तो F, षो E[2]) β, corr. T.-D. 4c व्यापिपाता aβ 4d पंचांबरंदु (दू E) ताशैः β 5a–b धृतिरनयाद्युत्तरयो स्व (सू β) मृणं ग (ग om. a) तद्यमपि च याम्यास्म aβ 5c द्विग्नं aβ, corr. T.-D. col. इति om. a पि (पी F) तामह° β °सिद्धान्ते aβ

Chapter XII

XII,1. Five years are taught by Pitāmaha to be a yuga of the Sun and Moon. (There is) an intercalary month (adhimāsa) every 30 months, an omitted tithi (avama) every 62 days.

XII,2. Diminish the time of the Śaka king by 2 and divide (the remainder) by 5. One should calculate the ahargaṇa of the remaining years, beginning with the first half (śuklapakṣa) of (the month) Māgha; this ahargaṇa begins in the day from sunrise.

XII,3. If the ahargaṇa is increased by a 61st part, (the result) is the tithis; if it is multiplied by 9 (and the product divided) by 122, (the result) is the nakṣatra of the Sun; (if the ahargaṇa) is diminished (by itself multiplied) by 7 and divided by 610, (the result) is the nakṣatra of the Moon beginning with Dhaniṣṭhā.

XII,4. When the last tithi in the first half (of the month) is a syzygy (parvan), after it is the first (tithi) in the other (half of the month). If the ahargaṇa is multiplied by 12 and (the product divided) by 305, (the result) is the vyatipāta.

XII,5. (When the Sun) is in the northern (ayana), increase the days by 183 times 4 (= 732); (when it is) in the southern (ayana), increase the future days (by 732). Multiply (the sum) by 2, divide (the product) by 61, and diminish (the quotient) by 12; (the result) is the measure of the day(-light in muhūrtas).

Thus the twelfth chapter: The Paitāmahasiddhānta.

पंचमहाभूतमयस्तारागणपंजरे महीगोलः /
खे ऽयस्कान्तान्तस्थो लोह इवावस्थितो वृत्तः //१//
तरुनगनगरारामसरित्समुद्रादिभिश्चितः सर्वः /
विबुधानिलयः सुमेरुस्तन्मध्ये ऽधःस्थिता दैत्याः //२//
सलिलतटासन्नानामवाङ्मुखी दृश्यते यथा छाया /
तद्वद्गतिरसुराणां मन्यन्ते ते ऽप्यधो विबुधान् //३//
गगनमुपैति शिखिशिखा <क्षिप्तमपि> क्षितिमुपैति गुरु किंचित् /
यद्वदिह मानवानामसुराणां तद्वदेवाधः //४//
मेरोः सममुपरि वियत्यक्षो व्योमस्थितो ध्रुवो ऽधो ऽन्यः /
तत्र निबद्धो मरुता प्रवहेण भ्राम्यते भगणः //५//
भ्रमति भ्रमस्थितेव क्षितिरित्यपरे वदन्ति नोडुगणः /
यद्येवं श्येनाद्या न खात् पुनः स्वनिलयमुपेयुः //६//

1–4 quoted by Utpala on BS 2 (p. 57); 1 quoted by Nīlakaṇṭha on Golapāda 6; 2–3 quoted by Pṛthūdaka on BSS 21,3; 5 quoted by Utpala on BS 2 (p. 58) and by Pṛthūdaka on BSS 21,4; 6–8 quoted by Utpala on BS 2 (pp. 58–59); and 6c–d quoted by Pṛthūdaka on BSS 21,4.

1c यस्कां (स्का β) तां (तों α) त (तर EF) स्थो αβ, यस्कान्तान्तःस्थो Utpala, Nīlakaṇṭha, T.-D.   2a तरुनगरनन (न om. α) रामर αβ   3a °तन्नासं (से C) ताना° αβ   3c तद्वग (च D, ग written above D^2) ति° α, तद्वर्वं (वं C) गति° β   3d–4d मन्यन्ते to °सुराणां om. α   3d विबुधानां β   4b क्षिप्तमपि om. β, suppl. Utpala   4c तद्वदि (द्वि C) ह β   5a समुप β, समोपरि Pṛthūdaka   5b व्योम्नि स्थितो Pṛthūdaka, Utpala   धान्यः (ध्यः D) αβ   5c निबद्धो α   मतुला α, महता β   5d प्राहवे (वहे CF) न β   6a °स्थिते च β   6b स्थितिरि° Utpala   °त्यपरे α   6c शेनाद्या αβ

Chapter XIII

XIII,1. The sphere of the earth, which consists of the five elements, stands in the cage of the constellations in the sky like a round piece of iron standing at the end of a loadstone;

XIII,2. it is all covered by trees, mountains, towns, parks, rivers, oceans, and so on. In the middle of it is Sumeru, the abode of the wise (gods); the Daityas stand below.

XIII,3. As the reflection of those who sit on the shore of (a body of) water is seen to be facing downwards, so the motion of the Asuras (appears to the gods); and they (the Asuras) think that the wise (gods) are below.

XIII,4. As here among men the flame of a fire ascends to the sky and something heavy when thrown descends to the earth, so (does it happen) below among the Asuras.

XIII,5. Directly above Meru in the sky is (one) fixed pole, below in the sky is another; bound to these the constellations are turned around by the pravaha wind.

XIII,6. Others say: "The earth, as if situated on a potter's wheel (bhrama), revolves, not the constellations." If that were so, hawks and so on would not come back again to their abodes from the sky.

अन्यच्च भवेद्भ्रमेरह्ना भ्रमरहंसध्वजादीनाम् /
नित्यं पश्चात् प्रेरणमथाल्पगा स्यात् कथं भ्रमति //७//
अर्हत्प्रोक्ते ऽर्कैन्दू द्वौ द्वावेकान्तरोदयौ किल तौ /
यद्येवमर्कसूत्रात् किं ध्रुवचिह्नं भ्रमत्यह्ना //८//
प्रोद्यद्रविरमराणां भ्रमत्यजादौ कुवृत्तगः सव्यम् /
उपरिष्टाल्लङ्कायां प्रतिलोमश्चामरारीणाम् //९//
मिथुनान्ते च कुवृत्तादंशचतुर्विंशतिं (विं)हायोच्चैः /
भ्रमति हि रविरमराणां समोपरिष्टात्तदावन्त्याम् //१०//
नष्टच्छायाप्येवं छायोदक् तत्रभृत्युदक्स्थानाम् /
तद्दक्षिणदेश(शा)नां मध्याह्ने दक्षिणा छाया //११//
मेषवृषमिथुनसंस्थे दिवसो ऽर्के कर्कटादिगे रात्रिः /
यैरुक्ता विबुधानां मेरुस्थानां नमस्तेभ्यः //१२//

9–34 quoted by Utpala on BS 2 (pp. 59–61); 9 quoted by Pṛthūdaka on BSS 21, 6; 12 quoted by Pṛthūdaka on BSS 21, 7 and by Parameśvara on Golapāda 14.

7b °रन्य (न्व B) द्रुद्रूमणोद्र (द्रू C, त्रु F) माध्वजा° β, °रह्नाद्भ्रमणोद्भ्रमाध्वजा° a
7c पश्चाद्ये (च्ये C, ध्ये EF) रण° β 8a र्कैंदु (द्रु CE) aβ 8b तै a 8c °मर्कस्तत्र β
8d ध्रुवबिद्रु (द्रु CF) ह्नां (हां C) β, ध्रुवसूत्रं Utpala भवत्यह्ना a, भवत्यन्हा (– F)
द्रु (न्दु E) न्हा β 9b °त्यजागो aβ कुवृत्तगः a, कुन्दू (मू C) वृ (नृ C) तगः β
9d °मराराणां β 10a कुवृत्ता° (त्त्वा C, च्चा EF) aβ 10b° चतुर्थिराति a
हायोच्चैः a, हापोच्चैः β 10d समोपष्टात्त° a °दावत्यं β 11b °दक् च भृत्युस्थाना
a, °दक्ष्यभृत्युदस्थानां β 11c–12d तद्दक्षिण° to मेरुस्थानां om. β 11c तदक्षिणादेलां
a, तद्दद्दक्षिणगानां Utpala, corr. T.-D. 12a °मियुन° a 12b दिनं रवौ Utpala,
दिनमर्के Parameśvara कर्कटादिके Pṛthūdaka 12c–d मेरुस्थितदेवतानामिति
यैरुक्तं नमस्तेभ्यः Parameśvara

XIII,7. Another thing: if there were (a revolution) of the earth (every) day, bees, geese, flags, and so on would always be driven to the west; if it were moving slowly, how would it revolve (once a day)?

XIII,8. According to what is said by the Arhats, there are two Suns and two Moons which rise one after the other; if this were so, why does a fixed mark from the sūtra of the Sun revolve in a day?

XIII,9. For the gods, the rising Sun at the beginning of Aries, moving on the terrestrial equator, revolves to the right; (for those) at Laṅkā it revolves overhead; and for the foes of the gods in the opposite direction.

XIII,10. At the end of Gemini the Sun revolves, going up 24° from the terrestrial equator for the gods, (while) it is directly overhead (for those) at Avantī.

XIII,11. Thus the (noon) shadow is destroyed (there); the (noon) shadow is to the north for those dwelling in the north of that (place); for those places which are to the south of it the shadow at noon is southern.

XIII,12. Reverence be to those who say: "For the wise (gods) who dwell on Meru it is day when the Sun is in Aries, Taurus, and Gemini, night when it is in Cancer and so on."

येष्वेवोदग्देशाद्याति स्थानेषु संनिवृत्तो ऽपि /
तेष्वेव कथं दृश्यः पुनर्न दृश्यश्च तत्रस्थः //१३//
दृश्ये चक्रस्यार्धे त्रयः खमध्यात्तु राशयस्तें ऽशाः /
नवतिस्तानि च खण्डान्युदयात् परिकल्पनीयानि //१४//
एकैकों ऽशो नवभिर्नवभागोनैश्च योजनैर्भवति /
समदक्षिणोत्तराणां प्रत्यक्षे ध्येयः खमध्यात् //१५//
एवं च नवत्यंशैरष्टौ दृष्टानि योजनशतानि /
तत्प्रामाणाद्देशे मध्याह्ने दृष्टुरुदयो यः //१६//
उज्जयिनी लङ्कायाः संनिहिता योत्तरेण समसूत्रे /
तन्मध्याह्नो युगपद्विषमो दिवसो विषुवतो ऽन्यः //१७//
योजनशतानि भूमेः परिमाणं षोडश द्विगुणितानि /
तापयति मेरुमध्याद्विषुवस्थो ऽर्कः क्षितिमेवम् //१८//

14a quoted by Utpala on BS 2 (p. 56)

13b °द्यादि aβ   संनिवृत्ते a, सन्निवृवृशे β   13d दस्यश्च β   14a वक्रस्या (स्था C) र्द्धे β   14b खमध्यात a, खमध्यते β   राशयस्तेषां Utpala (some manuscripts)   14c-d ख (ष BE) डंगानि उ (न्यु BE) दयात् (त CF, त्त BE) aβ   15a एकैकांशो Utpala   नवतिर्न° aβ   15b योजनैर्यान्ति (ति EF) aβ   15c स च दक्षिणो° Utpala   °त्तराय (प β) णं aβ   15d प्रत्यक्षः Utpala   ध्यै (ध्ये BE) य (प्य β) यं मध्यात् aβ, खे ऽप्ययं मध्यात् Utpala   16a च a, om. β   नवृत्यांशै° a, नववृत्यांशै° β   16b °रष्टौ दष्टौ दृष्टानि β   16c सहितत्प्रमाणदेशे aβ, तत्प्रामाण्याद्देशे Utpala   16d दृष्टरु° a   17a उ (ड C) ज्नी (ज्ज C, नू F) यि (पि F) नी β   17b सतिहिता β   समस्तत्र (त्रो CF) β   17c तन्मध्याह्ने aβ   17d दिव (य F) से (सो E) aβ   18c तायपति a   °मध्य° aCF   18d र्कौ aβ   क्षितिरेवं aβ, क्षितिं चैवम् Utpala

XIII,13. In those places in which (the Sun) goes to the north from Aries it also returns (from Cancer); how is it both visible and again not visible while it is there?

XIII,14. In the visible half of the (zodiacal) circle, from midheaven, there are three zodiacal signs, that is 90°; these divisions are also to be reckoned from the rising (-point).

XIII,15. Each 1° equals 9 diminished by a ninth (i.e., $8^8/_9$) yojanas; for those who are to the north and south (of each other) on (the same) meridian it (the distance in yojanas) is to be considered from midheaven (i.e., zenith) in direct perception.

XIII,16. Thus 800 yojanas are seen to equal 90°; whatever is sunrise for (one) observer is at noon in a place (whose distance is) measured by that (amount).

XIII,17. Ujjayinī, which is close to Laṅkā, is on the line of (the same) meridian to the north; their noons are simultaneous, but their days (i.e., lengths of daylight) other than the equinoctial (days) differ.

XIII,18. The measure (of the circumference) of the earth is 1600 times 2 (= 3200) yojanas; the Sun, at the equinox, thus heats the earth from (a circle) whose center is Meru.

षडशीतिं पंचशतीं त्रिभागहीनं च योजनं गत्वा /
क्षितिमध्यमुदगवन्त्या लङ्काया योजनाष्टशतीम् //१९//
प्रतिविषयमुदक् तुङ्गो हरिजाद्यावद्ध्रुवः समध्यात्तु /
दिनकृदपि नमति विषुवति दक्षिणतस्तावदेवांशैः //२०//
त्रिशतीं त्रिसप्ततियुतां गत्वोदग्योजनत्रिभागं च /
उज्जयिनीतो विरमति पर्यस्तोऽयं भगणगोलः //२१//
षष्टिं नाडीस्तस्मिन् सकृदुदितो दृश्यते दिवसनाथः /
परतः परतो बहुतरमाषण्मासादिति सुमेरौ //२२//
योजनपंचनवांशांस्त्र्यधिकां सचतुःशतीमुदगवन्त्याः /
गत्वा न धनुर्मकरौ कदाचिदपि दर्शनं व्रजतः //२३//
तस्मादेव स्थानाद् द्व्यशीतियुक्तां चतुःशतीं त्याग्य /
नोदयमिह यान्त्यलिमृगघटचापधराः कदाचिदपि //२४//

19b योजनमित्वा Utpala 19d लंकायां aβ 20a प्रतिविष (य CF) मुदक्तुंगो β 20b हरियाद्याद्याध्रुवः a, हि (ह CF) रियाद्यान्वाध्रुवः β 20c दिनक्र (क्रि C) दपि β ममति β विषुववि a, रिषु (पु BE) वति β 20d °तस्नावदे° a 21a त्रिं (त्रि CE) शतिं (ति β) aβ 21b गचोद° β °जनविभागं a 21c ऊ (उ β) ज्जयि (य C) नी (नि E) तो aβ विघटति Utpala 21d पर्यासो Utpala 22a षष्टीर्नाडितस्मिन् a, षष्टीं (ष्टी C, ष्टीं F) नाडिं (डी CF) तस्मिन् β, षष्टिर्नाड्यस्तस्मिन् Utpala, corr. T.-D. 22b ससदुदितो β 22c बहुतर° aβ 23a योनपंच° β 23a-b °नवांशाः स्त्र्याधिक्यं सवतुःसतिमुदग (गा D) वंत्याः a, °नवांशाः स्त्र्यधिका स (स्न F) व (च EF) तुःसतिमुदगवंत्याः β, °नवांशानधिकां च चतुःशतीमुदगवन्त्याम् Utpala 23c गया β धनुर्मकरं a, धनुर्मकरा β 24a-b स्थानाद्धशीति° a, स्थानाद्य (इय C) शीति° β 24b साग्रं a, त्या (स्ना C) गं β, गत्वा Utpala 24c नोदयमु (म a, सु BE) द aβ, दृष्टिपथं नो Utpala, corr. T.-D. यां सलि° BE 24d कदाचित् Utpala

XIII,19. Going 586 (yojanas) and a yojana diminished by $^1/_3$ (= $586^2/_3$) north of Avantī (one reaches) the middle of the earth, or 800 yojanas (north) of Laṅkā.

XIII,20. In any region, as much as the north pole star is raised to the north from the horizon, by so many degrees is the Sun depressed to the south from midheaven when it is at the equinox.

XIII,21. (For one) going $373^1/_3$ yojanas north from Ujjayinī this sphere of constellations which is cast about (the earth) ceases (to exist).

XIII,22. In this (place) the Sun, having risen once, is seen for 60 nāḍīs. (As one proceeds) further and further (to the north, the length of daylight) becomes greater until it is six months at Sumeru.

XIII,23. (For one) going $403^5/_9$ yojanas to the north of Avantī Sagittarius and Capricorn never come into sight.

XIII,24. (For one) going 482 (yojanas) from that place Scorpio, Sagittarius, Capricorn, and Aquarius never rise.

षडशीतिं पंचशतीं त्र्यंशोनं योजनं च तत एव /
गत्वान्त्यं चक्रार्धे नोदेत्याद्यं न यात्यस्तम् //२५//
लङ्कास्था भूलग्नां नभसो मध्यस्थितां च मेरुगताः /
ध्रुवतारामीक्षन्ते तदन्तराले ऽन्तरोपगताः //२६//
सकृदुदितः षण्मासान् दृश्यो ऽर्को मेरुपृष्ठसंस्थानाम् /
मेषादिषु षट्सु चरन् परतो दृश्यः स दैत्यानाम् //२७//
मेषस्तेषां नित्यं लग्ने त्र्यंशश्च भूमिपुत्रस्य /
त्रिंशद्भागनवांशद्वादशभागाश्च तस्यैव //२८//
विषुवल्लेखाधस्ताल्लङ्का तस्यां समो भगणगोलः /
त्रिंशन्नाड्यो दिवसस्त्रिंशत्तस्यां च सदा निशा //२९//
सलिलेन समं कृत्वा तुङ्गं फलकं यथादिशं दृष्ट्वा /
दक्षिणकोट्यां शङ्कुं फलकप्रतिमं व्यवस्थाप्य //३०//

27 quoted by Pṛthūdaka on BSS 21,8a–b.

25a षडशीतां (तीं E) षडशतीं aβ   25c चक्रार्धे (र्धं CF) β   25d नोत्याद्यं a, नोस्मा (त्या CF) द्यं (घं C) β   26b मध्यां स्थितां च a, मध्याय β
26c ध्रुवतारामी (भी CF) क्षं (– E) ते β   26d तरेम (व C) गताः aβ
27b मे (भे F) कपृष्ठ° β   27c षट्भु (ड्भु CE, ट्टु F) β   27c–d चरन्यस्तो (तो C) β
28b लगो β   त्यंशश्च aβ   भूमिपुत्र (त्रः E) स्यात् (स्या CF) β   28d तस्मैव (च F) β   29a °ल्लेखाधः स्ता° Utpala   29c त्रिंशनाड्यो β   29c–d दिवसत्रिं° aβ
च सदा a, च स (श EF) दा β, सदा च Utpala   30a सम (म C, मं F) कृता (का CF) β   30c दक्षिणकोध्यां (ध्यां β) aβ   30d व्ययं (यं F) व्य (om CF) व (च F) स्थाप्य β

XIII,25. (For one) going 586 (yojanas) and a yojana diminished by $^1/_3$ (= $586^2/_3$) from there the last half of the (zodiacal) circle does not rise and the first (half) does not set.

XIII,26. Those who dwell at Laṅkā see the north pole star touching the earth, those who go to Meru see it standing in midheaven (i.e., zenith), and those who go between (these two places) see it in between.

XIII,27. For those who dwell on the top of Meru the Sun, having risen once, is visible for 6 months in the six (signs) beginning with Aries; when it proceeds further, it is visible for the Daityas.

XIII,28. For them Aries is always at the ascendant. Its (Aries') (first) third part (i.e., decan), triṃśadbhāga (i.e., fines), navāṃśa, and dvādaśabhāga (i.e., dodecatemorion) belong to Mars.

XIII,29. Laṅkā is under the (celestial) equator; there the sphere of the constellations is even (sphaera recta). A day is 30 nāḍīs there, and a night always is also 30 (nāḍīs).

XIII,30. Having made level with water a raised surface, having seen where the directions are, and having set up at the southern tip a gnomon (whose length) is measured by (the extension of) the (prepared) surface,

ऋज्जुशङ्कुबुध्नविन्यस्तलोचनो नामयेत्तथा शङ्कुम् /
भवति यथा शङ्क्वग्रं ध्रुवताराद्दृष्टिमध्यस्थम् //३१//
पतितेन भवति वेधो लङ्कायामूर्ध्वगेन तु सुमेरौ /
विनतेन चान्तराले फलके व्यासार्धसूत्रसमे //३२//
तत्रावलम्बको यः सोऽक्षज्या तस्य शङ्कुविवरं यत् /
विषुवदवलम्बकोऽसौ याम्योत्तरदिक्प्रसिद्धिकरः //३३//
स्वप्रत्ययेन सन्तो विचार्यैवं वदन्ति भूमध्यम् /
सकलमहीमानं वा रसमिव लवणाम्भसोऽल्पेन //३४//
नित्यमधःस्थस्येन्दोर्भाभिर्भानोः सितं भवत्यर्धम् /
स्वच्छाययान्यदसितं कुम्भस्येवातपस्थस्य //३५//
सलिलमये शशिनि रवेर्दीधितयो मूर्छितास्तमो नैशम् /
क्षपयन्ति दर्पणोदरनिहिता इव मन्दिरस्यान्तः //३६//

35a quoted by Pṛthūdaka on BSS 21,8c–d; 36 quoted by Makkibhaṭṭa on SŚ 1,1.
31a ऋजु° β °शंकुबु (कुबु om. C) ध्न्य° aβ 32b लम्बतध्या°(ध्या° E) β
°मूर्ध्व (र्द्ध β) गेन aβ 32c चांतराल aβ 32d व्येष्याद्ध° a, छ्योध्यर्द्ध β
सूत्रसमो (मा: E) β 33a तत्रावलंबो को a 33b सो सज्या aβ यत्तं (ते C) β
33c विषुबदवलंडको β 34d रसमि – a, रसमित β लवणास्वसो ल्पेन aβ
35a नि (नि D, corr. to नि D²) त्यमध्य (ध्य C) स्थस्येंदो° aβ 35b °र्भवति भानोः
aβ, corr. T.-D. 35c स्वछायान्यदसितं aF 36a सलिलमये च शशिनि a
36b °र्दी (दी D) ध्यो a, –ध्य (धृ C) तयो β 36d इमं व मं (हं F) हरिस्यांतः β

XIII,31. with his eye directed to the base of this straight gnomon, one should depress the gnomon until the tip of the gnomon is at the middle of one's sight of the north pole star.

XIII,32. At Laṅkā the observation is with (the gnomon) fallen down, at Sumeru with it upright, and in an intermediary place with it depressed. If the (extension of the) surface is equal to a string representing the radius,

XIII,33. whatever is the perpendicular (from the tip of the gnomon to the horizontal surface) there is the Sine of terrestrial latitude, and whatever is the distance between (the base of the perpendicular and the base of) the gnomon—(a line) which determines the north and south directions—is the Sine of the terrestrial colatitude.

XIII,34. By their own intelligence good men, investigating thus, proclaim what is the center of the earth or the measure (of the diameter) of the whole earth just as (they proclaim) what is taste by means of a little salty water.

XIII,35. One half of the Moon, which is always below (the Sun), is bright because of the Sun's light, the other half is dark because of its own shadow, just like a pot standing in the sunshine.

XIII,36. The rays of the Sun, reflected on the Moon which consists of water, destroy the darkness of the night just as, falling on the surface of a mirror, (they destroy the darkness) within a house.

प्रतिदिवसमेवमर्कात् स्थानविशेषेण शौक्ल्यपरिवृद्धिः /
भवति शशिनोऽपराह्णे पश्चाद्भागे घटस्येव //३७//
असितात् सिताश्च पक्षादसितं पक्षार्धमर्कमीक्षन्ते /
शशिक्षयाद्भयतो न भान्य⟨था⟩ तु शीतकरसंस्थाः //३८//
चन्द्रादूर्ध्वं बुधसितरविकुजजीवार्कजास्ततो भानि /
प्राग्गतयस्तुल्यजवा ग्रहास्तु सर्वे स्वमण्डलगाः //३९//
तैलिकचक्रस्य यथा विवरमराणां घनं भवति नाभ्याम् /
नेम्यां स्यान्महदेवं स्थितानि राश्यन्तराण्यूर्ध्वम् //४०//
पर्येति शशी शीघ्रं स्वल्पं नक्षत्रमण्डलाधःस्थः /
ऊर्ध्वस्थस्तुल्यजवो विचरति न⟨सो⟩ महदर्कसुतः //४१//
मासाधिपा यथोर्ध्वं चन्द्रात् सौराद्धश्च होरेशाः /
ऊर्ध्वं क्रमेण दिनपाश्च पंचमा वर्षपाः स्पष्टाः //४२//
त्रैलोक्यसंस्थानं नाम त्रयोदशोऽध्यायः //

39 quoted by Utpala on BS 2 (p. 44); 40–41 quoted by Utpala on BS 2 (p. 44); 42 quoted by Utpala on BS 2 (p. 35).

37a °मेवमर्बा (र्बो F) क् (कू F) β 37b °विदोषेण शौ (शो C) क्षय (क्र C, त्म F)° β 38a असिता β 38b °मी (मि C) क्षंते β 38c राशिक्षया° a, शशिक्षया° β °द्भ्रमयतो म a 38d भो यत (येत्त C, but crossed out) aβ गे (गेति C, but crossed out) तीतकर° β 39a चन्द्रादू (द्रु C) र्ध्व (ध्व C, र्द्धं E, र्ध्व F) aβ, corr. T.-D. वु (पु E, बु F) धास्वि (स्वी C) त° β 39c प्राग्ग (गा β) तय (रा β) स्तु (– β) ल्यजवा (या F) aβ 40b विपर° β नाध्रूभ्या β 40c मे (म्ये C) म्यं β स्यान् om. Utpala 40d संस्थितानि Utpala °राण्यूर्ध्व a, °राण्यूर्द्धं (र्ध्वा C, र्द्धा F) β 41a रात्री (त्रि E) β 41b नक्षममंडलमधः:स्थः a, नक्षत्रमंडलमध्य (मंध्यमंडल C) स्थः β 41c ऊर्ध्व° a, ऊर्द्ध° β 41d ऽपि संस्थितस्तथा न महद° Utpala विवरति β न महद° aβ, corr. T.-D. 42c दिनपा च a, दि (छम B, दि E, णि F) पा य β पंचमास्याः aβ col. नाम om. a

XIII,37. Every day, because of the change in its position from the Sun (since conjunction), there is an increase in the illuminated portion of the Moon just as there is on the western part of the pot in the afternoon;

XIII,38. (this is) from after the kṛṣṇapakṣa, but the dark (portion increases) from after the śuklapakṣa. Those who dwell on the Moon see the Sun for half a pakṣa on either side of the disappearance of the Moon; otherwise there is no light.

XIII,39. Above the Moon are Mercury, Venus, the Sun, Mars, Jupiter, Saturn, and then the nakṣatras. All the planets, moving in their own orbits, travel to the east with the same velocity.

XIII,40. As the interstices of the spokes of the wheel of an oil-press are small at the hub but large at the rim, so are the interstices of the zodiacal signs (as one goes) higher.

XIII,41. The Moon, which is (furthest) below the orbit of the nakṣatras, revolves fast about its small (orbit); Saturn, which is high(est), travels with an equal velocity arround its large (orbit).

XIII,42. (Ascending) up from the Moon (each successive planet) is lord of the month, (descending) down from Saturn lord of the hour. (Ascending) up in order (every) fifth (planet) is lord of the day; the lords of the year are clear.

The thirteenth chapter named: the Form (of the Universe) Consisting of the Three Worlds (of Gods, Men, and Demons).

साशीतिकाङ्गुलशतं विस्तीर्णवृत्तमविषमं धरित्र्याम् /
समराश्यंशकचिह्नं परिधौ सापक्रमं कुर्यात् //१//
याम्योदक्समसूत्रादपक्रमांशावगाहिभिः सूत्रैः /
प्रथमवदङ्कच्छिन्नं वृत्तत्रयमालिखेन्मध्यात् //२//
अह्ने छिन्नां लेखां प्रकुर्याच्च भगणचिह्नपर्यन्ताम् /
अह्नोत्तरलेखान्तरमपक्रमांशोत्थमादाय //३//
द्विगुणं प्रसार्य वृत्ते स्वे दिक् तच्चापांशदलाभ्यस्ताः /
प्रथमचरविनाड्यो ज्ञेयाः परिशेषयोर्मिश्राः //४//
नाड्यः षड्भ्यो भागास्तज्ज्या व्यासार्धशोधिता छाया /
माध्यन्दिनीसमेता नाड्यर्धे सा तया हीना //५//
छायाहरिजाभ्यन्तरजीवाचापांशषष्ठभागो यः /
ता नाड्यः प्राग् याताः पश्चाच्छेषास्तथा प्राप्ताः //६//

1c समराश्यंकं चिह्नं α 1d मापक्रमं α, मायक्रमः β, corr. T.-D. 2a-b °सूत्रापदक्रमा° β 2c प्रथमव (-β) टंकाच्चिह्नं αβ 2d वृत्ततुत्रयमा° β 3b कुर्याच्च α, प्रक (कु C) र्या (या E, र्वे B) के (के C, क F) β ल्लंगण° β °पर्यंतात् (न β) αβ, corr. T.-D. 3d °मांशोच्छ (छ CF) माटाय αβ, corr. T.-D. 4a-b प्रसा (स्ता C) र्ये (र्वे C, र्पे EF) वृर्शेन (व CF) वा (बा CF) पांशका दलाभ्यस्ताः β 4c °विनाड्ये α, °विनात्रे β 5a षड्या α, ष (भ्र C) मक्षया β, corr. T.-D. 5a-b भागास्तज्ज्या α, मा (सा C, भा F) गारु (टु .F, स C, but crossed out) β, corr. T.-D. 5b छ्या (ध्वा C) सा° β 5c माध्यंदिनी α 6a °हरिज्या° α °भ्यं (भ्यां C) तरजा जीवा β 6c यतः α, युता β, corr. T.-D. 6d पश्चा (श्वा C) छेषास्त (स्न α) था प्राप्त (प्तो α) αβ

Chapter XIV

XIV,1. One should make on the ground a level circle having a diameter of 180 digits, with marks indicating the prime vertical, the zodiacal signs, and the degrees on the circumference, and with the degrees of the declinations (of the signs) (marked).

XIV,2. From the center (of this circle), with strings which are perpendiculars from the string marking the north-south prime vertical to the (marked) degrees of the declinations (of the signs), one should draw three circles marked as was the first.

XIV,3. One should make a line cast (from the center) towards the terrestrial latitude to the mark (for it on the circle graded like) the zodiac; take (that chord) in (the circle whose radius depends on) the degrees of declination (of the first sign) which lies between the line of terrestrial latitude and the north(-south) line (where they intersect the circumference);

XIV,4. multiply it by 2 and extend it on its own circle, and multiply half the degrees of the arc corresponding to that (chord) by 10. (The result) is to be known as the vināḍīs of ascensional difference for the first sign; (those) for the other two are composite.

XIV,5. The nāḍīs (since sunrise) multiplied by 6 are degrees; the Sine of these subtracted from the radius is the shadow (at any time) increased by the noon-shadow; in order to find the nāḍīs it (i.e., the shadow at any time) is diminished by that (i.e., the noon-shadow).

XIV,6. Whatever is the sixth part of the degrees of the arc corresponding to the Sine which lies between (the end of) the shadow (so diminished) and the horizon, these are nāḍīs; to the east those which have passed are obtained, to the west those that remain.

तिर्यग्रेखा समदक्षिणोत्तरापक्रमांशरेखायाम् /
तच्चापांशा दिग्घ्ना राश्युदयविनाडिकाः क्रमशः //७//
मध्याह्ने प्राक् तथा छायायामन्यतो गते शङ्कौ /
शङ्क्वग्रयातसूत्राद्विषुवान्तरं यच्चक्राङ्कितम् //८//
विन्यस्योदक् छायां छायाग्राच्छङ्कुरपरतः पात्यः /
तत्कर्णसमं मध्यात् प्रसारयेत् सूत्रमापरिधेः //९//
तद्विषुवान्तरमक्षो ऽतो ऽक्षाच्चैवं प्रकल्पयेच्छायाम् /
इष्टे ऽहनि बुद्ध्वायनमक्षादधिकं यदूनं वा //१०//
तज्ज्या तिर्यग्रेखाविषुवद्रेखास्थिता स्पृशति यस्मिन् /
तच्चापांशसमानो ज्ञेयो ऽर्को गोलभागेन //११//
छेद्यार्धयष्टिवेधादर्केन्द्वोरन्तरांशकार्कांशः /
स्फुटनष्टतिथिर्ज्ञेया तस्मात् कार्या तथा चान्या //१२//

7b °राव (य β) क्र (क्रं β) मां (मा β) श° (शा° β) aβ, corr. T.-D. 7c दिघ्ना: a, दि – β, corr. T.-D. 7d क्रमंशः a, क्रमशा β, corr. T.-D. 8a मध्यानां प्रांतथा a, मध्यान्यां ध्यातपा (या C(F)) β 8b छायायामस्वतो a, छायाया (या om. C F) मन्यतो β गते ततः शंकौ (को: a) aβ 8c °या (पा C) तं (त β) त्सू (सू β) त्रा° aβ 8d विषुवांतरयाच्चकांद्य (दि B, द्रि E) दिता: aβ 9a विन्यश्योदक् a, विष्ट (न्य C, मृ F) २य (२ये C) श्योद (द्र EF) क् β, corr. T.-D. 9b पाताः β 9d °परिधौ (धो EF) β 10a तद्विष्वं (षं BE, ष्कं C) तर° aβ, corr. T.-D. 10c बुध्यायनम° a, बुध्ययन° β 11a-b तिर्यग्रेखाद्विषुव° β 11c °समान aβ, corr. T.-D. 11d को β 12a छेद्यर्ध° a, छेद्यद्य° β 12b °द (दा E) केंद्वो (द्वो C) रंत्व (त्य C) शशावतकशि: β 12c °तिथिज्ञेया a

XIV,7. The ecliptic is on a line (running through) the degrees of declination (marked) on parallel north-south lines (beginning at the beginnings of the signs); the degrees of arc corresponding to these (segments), when multiplied by 10, are, in order, the vināḍikās of rising of (each of) the signs.

XIV,8. (About the end of) the shadow (obtained) at noon (on the equinoctial day describe a circle); move the gnomon elsewhere, to the east (so that it lies on the east-west line); whatever is marked on (the circumference of) the circle by a string proceeding (from its center) through the tip of the gnomon is the distance from the equator (i.e., the colatitude).

XIV,9. Lay out the (noon equinoctial) shadow to the north; the gnomon is to be caused to fall to the west from the tip of the shadow. One should extend a string parallel to its hypotenuse from the center of the circumference.

XIV,10. The distance of that from the equator is the terrestrial latitude. In this way one should determine the (noon) shadow from the terrestrial latitude. Knowing on any particular day the declination (of the Sun), which is either greater or less than the terrestrial latitude,

XIV,11. place its Sine (between) the ecliptic and the equator; wherever it touches (both), (the longitude of) the Sun, depending on its portion of the sphere, is to be known as being equal to the degrees of that arc.

XIV,12. By means of an observation with the rod on half of the construction (i.e., a diopter on a semicircle) (find) the degrees between the Sun and Moon (and take) a twelfth part (of them); (the result) is to be known as the true lapsed tithis. From this is to be computed the next (tithi).

दत्त्वांशकेषु तेष्वेव भास्करं छेद्यकेन विज्ञातम् /
स भवति तस्मिन् काले निशाकरश्छेद्यकेनैव //१३//
नाभ्यासन्नच्छायाग्रमङ्कयेत्⟨त्⟩त्रिस्ततो लिखेन्मत्स्यौ /
तन्मत्स्यवदननिःसृतसूत्रद्वयपाततुल्येन //१४//
सूत्रेण बिन्दुकत्रयसंस्पर्शसमेन मण्डलं यत् स्यात् /
तेन तदाहि छाया शङ्कोर्गच्छत्यमुंचन्ती //१५//
तन्मण्डलमध्या⟨त्⟩च्छङ्कुतश्च दक्षिणोत्तरं भवति /
तच्छङ्कुविवरमुदगास्थितं च माध्यन्दिनी छाया //१६//
हरिजमिति गगनमवनौ प्रसक्तमिव यत् प्रदृश्यते ऽन्तेषु /
सममिति पूर्वापररेखैवं च दक्षिणोत्तरगता //१७//
ध्रुवहरिजविवरमक्षो ऽवनतिविवरं च लम्बको ऽभिहितः /
लग्नोनमिति खमध्यं द्युव्यासो ऽस्तोदय⟨चक्रस्य⟩ //१८//

13a दशंशकेषु अंचंश (श om. B) केषु (अंचंशकेषु om. CF) तेष्वेन β 13b भास्कर छेध्यकेन (न om. C) β 13c भवति हि तस्मिन् aβ, corr. T.-D. 13d निशाकरात् छिद्य° a, निशाकर — द्य° β, corr. T.-D. 14a नाभ्यासंनछाय्या° (या° β) aβ 14b °ग्रमंकये a, ग्र (ग्रं BE) नं (न BE) कपे (वे C) β, corr. T.-D. त्रिसुतो β
14c तन्मत्स्य (स्य C) व -- निसृत° β 14d °पाततुल्यन β 15a सूर्येण a, स्तार्येण β, corr. T.-D. 15c तिन (त F) तदाद्रि β 16b छंकु (क EF, क C) तः (त β) श्च aβ दक्षिणोत्तरे β 16c तछज (जवि C) षविवर° β 16d °स्थितश्च (:च F) β
17a हरियमिति aβ, corr. T.-D. गमन° a, गम (मि C) ते β, corr. T.-D. 17b प्रदृश्यंते तेषु a, प्र (पू C) दिश्यंते (त C) षु (बु C) β, corr. T.-D. 17c-d पूर्वापरतो (ते C) छो (ये EF, यि C) व (च E) मृणं aβ दक्षिणोत्तरग (ग om C, त F) त (ग F) β 18a ध्रुवहरीरज° β
18a-b °मक्षः क्षिति (भि β) रवदि (वि β) बि (किं β) वरं aβ, corr. T.-D. 18c मणोन° β
18d धुव्यासो β स्तोदय a, स्तो β

XIV,13. (For one) adding (the longitude of) the Sun which is known by means of the (geometrical) construction to these degrees (of elongation) there results (the longitude of) the Moon at that time by means of just the construction.

XIV,14. One should thrice mark the tip of the shadow near the center (of that construction); from these (three points) one should draw two fish (-figures). (With a center) equal to the intersection of the two strings issuing from the mouths of these fish (-figures),

XIV,15. and with a string (as radius) equal to (the length necessary for) touching the three points (draw) a circle; on that day the shadow of the gnomon moves on this (circle) without leaving it.

XIV,16. The line from the center of that circle to the gnomon is the north-south line; its (the circle's) distance (from the gnomon) to the north is the noon shadow.

XIV,17. That (circle) which seems to join the sky to the earth at their ends is called the horizon; the east-west line and the north-south line are called the prime verticals.

XIV,18. The distance between the north pole star and the horizon is the terrestrial latitude; the difference between 90° and the terrestrial latitude is called the terrestrial colatitude. Midheaven is called the lagnona (nonagesimal); and the diameter of the day (-circle) is that of the circle (which passes through) the setting (-point) and the rising (-point) (of the Sun).

छेद्यवदर्घ्यैकपालं सचिह्नमर्धोन्नतं सदिक्चक्रम् ।
सुसमावटविन्यस्तं कुर्याच्छङ्कुं सनाभ्यङ्कम् ॥१९॥
सूत्रद्वयसंपात(ा)च्छायाभुक्तांशका रवौ देयाः ।
स भवत्युदये रात्रिर्दिनस्य नाड्यश्च ता याताः ॥२०॥
समभागणाङ्कचक्रमर्धाङ्गुलबहलमायतं हस्तम् ।
विस्तारमध्यभागे छिद्रं तद्भ्रामि तिर्यक् च ॥२१॥
मध्याह्नार्कमयूखं प्रवेश्य सूक्ष्मेण परिधिविचरणे(न) ।
मध्यावलम्बिसूत्रात्समान्तरांशास्तदन्याह्नः ॥२२॥
समवृत्तपृष्ठमानं सूक्ष्मं गोलं प्रसाध्य दारुमयम् ।
स्थगितार्क(स)मङ्कितकालभोगरेखाद्वये परिधौ ॥२३॥
याम्योदग्रेखाया झषाजसन्ध्युभयतो न्यसेद्वेधात् ।
अयनांशकाङ्कतुल्यांस्तिर्यग्वेधप्रकाशकरान् ॥२४॥

19a °दर्धैकपालं a, °दर्घैकपालं β 19b सचि (वि C) ह्नु (ह्नु C, ह्नु EF) मद्धौ (द्धो B) त्र (त्त B) च β 19c सु (स C) य (प C) मावढ° (रू° C) β 19d कुर्यादिक्क: (ध्यु: D, क: β) aβ
20b °छायासु (सु om. C) क्ता (का C) शका aβ, corr. T.-D. 20c भवति उदयो aβ
20c-d रात्रि (त्रि CF) र्दिना (ता C) ड्य (ध्य C) श्च β 20d यात: β 21a समभागणांफक-वक्र° β 21b °मर्धांगुलवदजम - तहस्ता β 21d तद्भ्रामि a, - - - β
तिर्यक्का aβ, corr. T.-D. 22a मध्याह्ना (ग्रा C) र्क° β °मयूषं a, °मसू (सु C) षं β, corr. T.-D. 22b °विवरेण a, विचरेण β 22c-d °सूत्रां तला (ल्पा BE, ल्मं F, लपं C) तरांशा° aβ 22d °दन्पद्व: a, °दन्यद्वं β, corr. T.-D. 23b प्रसाध्य β धातुमयं a
23c स्थगितार्कमंकित° a, स्थगिचावमिंकित° β 24b झखाजसंध्या (ध्य F) भयतो β
24b °स्तिर्यग्वैध्य° (धे° C) β °प्रकाशकरात् a

XIV,19. One should make a water-basin like the (plane geometrical) construction with the marks (of the degrees) and with the circle of directions, and tilt it by (the amount of) the terrestrial latitude; insert in it a very symmetrical cavity and place a gnomon to mark its center.

XIV,20. The degrees that have been passed by the shadow from the intersection of two lines (i.e., that of the circumference of the basin and the shadow at dawn) (along the day circle) are to be added to (the longitude of) the Sun; the result is the sign at the rising (-point), and (the degrees passed by the shadow, divided by 6) are the lapsed nāḍīs of the day.

XIV,21. (Make) a circle half a digit wide and a hand in diameter and mark it evenly with (the signs of) the zodiac; (make) a hole in the middle of its width. Coming through this obliquely

XIV,22. cause a ray of the Sun at noon to enter (the circle) with a small motion of the circumference. The degrees between (the spot) that is heated (by the Sun's ray) and the string hanging from the middle (of the circle) is its (the Sun's) zenith distance.

XIV,23. Construct a small sphere of wood having the measure of its surface evenly round; on its circumference (i.e., surface?) (draw) two lines (indicating) the passage of time, which are bent where the Sun stops (i.e., at the two solstices).

XIV,24. On either side of the juncture of Pisces and Aries, by means of observation, one should lay off north-south lines (perpendicular to the equator, whose lengths) equal the marks of the degrees of declination (for appropriate zodiacal longitudes); these determine (the positions of) the "illuminators of the oblique observation."

अच्चोत्क्षिप्तस्योदक् तिर्यग्वेधप्रकाशहरिजस्थाः /
या नाड्यस्ता याताः षड्ंशकसमन्विता मध्ये //२५//
यद्वदुदयति कालचक्रे मृगादिकमुद(ग)यने द्युवृद्धिः स्यात् /
व्यत्यासे तद्धानिर्व्याख्याताच्छेषमिति <ग>म्यम् //२६//
गुणसलिलपांशुभिर्योजितानि बीजानि सर्वयन्त्राणाम् /
तैः फलके कूर्ममानवयथेष्टरूपाणि कार्याणि //२७//
गुरुरचपलाय दद्याच्छिष्यायैतान्यवाप्य शिष्यो ऽपि /
पुत्रेणाप्यज्ञातं बीजं संयोजयेद्यन्त्रे //२८//
अभिमतदेशाक्षवशात् कृतवेधेनोडु(प)पूर्णिमाकर्म /
दृष्टिघटिकोदयांश तुल्यान्यत्वे वियुतयुक्तम् //२९//
तिथिवद्धिकृत्य लब्धं चरकालेनान्वितं क्रियाद्येषु /
जूकादिष्वपि हीनं विषुवति देशान्तरं स्पष्टम् //३०//

25a अच्चोत्क्षिप्तस्योदक् a, अच्चौ (च्चो CF) क्षिपूस्यो (ष्यो B, प्यो E, यिनोशकाकन्येस्यो C) दक् (व् F) β, corr. T.-D. 25b तिर्यग्वेद° β °हरिजास्थाः aβ, corr. T.-D. 25c या याड्यस्ता a वाताः a 25c नाड्यस्ता to 27a गुण° om. C 26a यद्रुपेति β 26b भागादिक° a, भादिक° β °मुदयातेषु वृद्धिः β, °मुदयते द्युवृद्धिः a सा aβ, corr. T.-D. 26c तद्धाति° a 26d °मिति –म्यं a, °मिति β, corr. T.-D. 27a गुणं aβ, corr. T.-D. 27a-b °र्योजा (जी F) तानि β 28a गुरुरचपालाय a, गुरुरच्यप (प– E) ल– β, corr. T.-D. 28c °ज्ञानं a 28d संयोजये– तो (नो BE) β 29b कृतवधेनोडुपूर्णमाकर्म a, चतम (य C) धेनोदुमरामिकर्मा (र्म F) β 29c देष्टि° β 29c-d °घटिकोदयांसं दुत्यान्यत्वे a, °घटिकोदयांसं तुल्यान्यत्वे β 29d विद्यु (द्यु F, घ C) त° β 30a तिथिवद्धि– (भा β) त्य (त्यं β) aβ 30b चकालादि (द β) नान्वितं aβ, corr. T.-D. क्रियाद्येषु β 30c जूकादिषु पतिही (हि C) नं aβ, corr. T.-D.

XIV,25. Tilt (the sphere) to the north by the amount of the terrestrial latitude (and measure the degrees between) the "illuminator of the oblique observation" (i.e., the point on the ecliptic occupied by the Sun) and (the point where) the horizon (and the day-circle) meet; the lapsed nāḍīs correspond to a sixth part (of the degrees) in between.

XIV,26. If, among the time-circles, one of those beginning with (that of) Capricorn rises, (then the Sun is) in the northern ayana and the length of daylight increases; in the reverse situation the length of daylight decreases. The rest is to be approached on the basis of what has already been explained.

XIV,27. The seeds of all magical diagrams are furnished by string, water, and sand; with these the forms as desired, of tortoises or men, are to be made on a surface.

XIV,28. The teacher should give these things only to a steadfast pupil; the pupil, having received the seed which is known not even by his (i.e., the teacher's) son, should use it in a magical diagram.

XIV,29. With an instrument adjusted to the terrestrial latitude of the given locality observe the fulness of the Moon; (the observed longitude) is diminished or increased by another (longitude computed for a time) equal to the ghaṭikās (after sunset) of the observation (which are computed) by means of the rising-time (of the longitude of the Moon);

XIV,30. convert (the result) as in the case of a tithi (into time). Add the quotient to the time of half of the equation of daylight in (the six signs) beginning with Aries, subtract (the half-equation of daylight) in (the six signs) beginning with Libra; (the result is) the accurate longitudinal distance (of the given locality from the prime meridian) along the equator.

द्युनिशि विनिःसृततोयादिष्टच्छिद्रेण षष्टिभागो यः /
सा नाडी स्वमता वा श्वासाशीतिः शतं पुंसः //३१//
कुम्भार्धाकारं ताम्रं पात्रं कार्यं मूले छिद्रं
स्वच्छे तोये कुण्डे न्यस्तं तस्मिन् पूर्णे नाडी स्यात् /
मूलापाताद्वेधो वा षष्टिर्योज्या चाह्ना रात्र्या
वर्णाः षष्टिर्वक्राः श्लोको यत्तत् षष्ट्या वा सा स्यात् //३२//
बुध्वा शशिविक्षेपं दृष्ट्वा ताराशशाङ्कविवरं च /
संसाध्यैवं वाच्यः पश्चात्तारासमायोगः //३३//
बहुलाः षष्ठांशान्ते सार्धे हस्तत्रये च भगणोदक् /
रोहिण्यष्टदलान्ते दक्षिणतश्चार्धषष्ठेषु //३४//
हस्ते ऽष्टमे ऽष्टमें ऽशे पुनर्वसौ दक्षिणोत्तरे तारे /
अर्धचतुर्थे हस्ते पुष्यस्योदक् चतुर्थें ऽशे //३५//

33 quoted by Utpala on BS 24,4-5.

31a-b विनि (ति C) सृत (तं a) तोयादिष्ट (ष्र C) छि (च्छि E) द्रेण aβ, corr. T.-D. 31c स्वमतो a, स्व (स C, स्व F) मभो (त्रो E) β 31d स्वासाशीतसतं aβ, corr. T.-D. धुसः β 32b क्रुडे β 32c मूलाल्पत्वाद्वेधो aβ षष्टिज्ञोज्या aβ, corr. T.-D. मह्ना a, मद्रा β, corr. T.-D. 32d वर्णा (स्पा D) षष्टिवक्त्राः a, वर्णाः षष्टिवक्राः (क्त्राः EF, त्राः C) β, corr. T.-D. स्यात् a XIV 33a शशिविक्षेपं to XV 7d धनवद्रानोर्धव° placed after XV 24a अ° β 33a राशिविक्षेपं β 33b कृत्वा Utpala नारा° β 33c सस्ता (स्त F) ध्यैव β, संसाध्यैव a, संसाध्य च Utpala, corr. T.-D. वक्तव्यः Utpala 34a बहुला a, चद्रला β षष्ठांशान्ते (न्ते F, न्ति CE) aβ, corr. T.-D. 34b भगणोदक (कः E) aβ, corr. T.-D. 34d दक्षिणस्तश्चस्वार्ध° aβ, corr. T.-D. 35c-d हस्तेषु पुष्य (ष्यो C) स्योदक् β

XIV,31. A sixtieth of the water that escapes by means of a particular hole during a nychthemeron is considered to be a nāḍī, or else 180 breaths of a man.

XIV,32. A copper vessel shaped like half a pot (i.e., a hemisphere) is to be made; (pierce) a hole in its bottom and put it in clear water in a basin; when this is full, that is a nāḍī—or else the observation (is made) by means of (the striking of) the sunken bottom. For a day and a night 60 (of these) are to occur. Or else (a nāḍī is the time it takes to recite) 60 of these verses (each of which consists of 60 long syllables).

XIV,33. Knowing the latitude of the Moon and observing the distance of the Moon from a star, by calculating one should predict its conjunction with the star in the future.

XIV,34. (The yogatārā of) Kṛttikā is at the end of the sixth degree and $3^1/_2$ hands to the north of the zodiac; (the yogatārā of) Rohiṇī is at the end of $8^1/_2$ (degrees) and $6^1/_2$ (hands) to the south;

XIV,35. the two (yoga-) tārās in Punarvasu are in the eighth degree and at the eighth hand north and south; (the yogatārā) of Puṣya is in the fourth degree and $4^1/_2$ hands to the north;

दक्षिणतारा हस्ते सार्पस्यांशे तथोत्तरा तारा /
पित्र्यस्य स्वक्षेत्रे षष्ठे चांशे समायोगः //३६//
चित्रार्धाष्टमभागे दक्षिणतः संस्थिते त्रिभिर्हस्तैः /
विक्षेपकलान्तादङ्गुलानि मध्याच्छशाङ्कस्य //३७//
विक्षेपात् सप्तदशापनीय तिथिसङ्गुणा⟨त्⟩ कृताग्न्यंशः /
विद्यादङ्गुलमानं कालं दिनभोगविर⟨व⟩रेण //३८//
विषुवच्छायार्धगुणा पंचकृतिस्तत्कलास्ततश्चापम् /
छायात्रिसप्तकयुतं दशभिर्गुणितं विनाड्यस्ताः //३९//
ताभिः कर्कटकाद्याद्यल्लग्नं तादृशे सहस्रांशौ /
याम्यातो वनितामुखविशेषतिलको मुनिरगस्त्यः //४०//
गणितविषयोपलब्धच्छेद्यकयन्त्रैः प्रकाशतां याति /
सुखयति मनांसि पुंसां दिव्यं कालाश्रयं ज्ञानम् //४१//
इति छेद्यकयन्त्राणि चतुर्दशो ऽध्यायः //

39–40 quoted by Utpala on BS 13,21

36b सार्पस्यांसे a   तथोत्तरात्तारा a   36c स्वक्षेत्रे a, स्व (स्प C) क्षेचत्रे β, corr. T.-D.   36d वां (वा β) शे aβ, corr. T.-D.   37a चित्रार्धाश्रमभाभागे a, चित्रार्धा (र्द्धु CF) ष्टभागे β, corr. T.-D.   37b त्रिहस्तैः β   37c °कलान्तादं° a, कलाता (ध्यता C) दृ° (द° F) β, corr. T.-D.   37d मध्याशाछशाकस्य β
38a-b सप्तदशायनीय β   38b °संगुणा aβ, corr. T.-D.   क्षताग्न्यंशः β   38c °माणं a
38d दिनभोगे वि (चि β) रेण aβ, corr. T.-D.   39a °छायाद्विगुणा (णणा F) β
39b पंचकृतेस्त° aβ   39c छायानृसप्तक° a, छायातृसक° β, corr. T.-D.
39d °र्गुणिता aβ, corr. T.-D.   40a-b °काद्याय (प C) लग्नं aβ, corr. T.-D.
40b तदशे (तदशे तदृशे C) β   सहस्तां (स्तं C) शो (या C) β   40c याम्याता (स्ता a) aβ   वनितास्तु (स्त्रु a) ख° aβ, corr. T.-D.   40d °विषतिलको β   मुनिणस्त्यः a
41b प्रकाशता β   यातं aβ, corr. T.-D.   41c र (2 F, om. E) धसुखयति β   col. इति om. a

XIV,36. the southern (yoga-) tārā of Āśleṣā is in the (first) degree and a hand (to the south), the northern (yoga-) tārā is also (in the first degree and a hand to the north); the conjunction (with the yogatārā) of Maghā (takes place) in the sixth degree in its own field (i.e., in Maghā);

XIV,37. (the yogatārā of) Citrā is at $8^1/_2$ degrees and 3 hands to the south. The digits (are counted) from the center of the Moon where the minutes of latitude end.

XIV,38. Subtract 17 from the latitude (of the yogatārā with respect to the Moon), multiply (the remainder) by 15, and (take) a thirty-fourth (of the product); one should know (that this is) the measure of the digits. (Compute) the time (of the conjunction) by means of the difference in the daily progresses (of the Moon).

XIV,39. Multiply half the (noon) equinoctial shadow by 5^2 (= 25); the result is in minutes. Add 21 times (half of) the shadow to the arc from this and multiply (the sum) by 10; the result is vināḍīs.

XIV,40. By means of these (compute) the ascendant from the beginning of Cancer; when the Sun stands there, to the south the sage Agastya, (like) a forehead-mark distinguishing the face of a lady,

XIV,41. shines forth because of the magical diagrams on the (graphical) constructions which are understood by means of the principles of mathematics. The divine knowledge which pertains to time delights the minds of men.

Thus the fourteenth chapter: the Magical Diagrams of the (Graphical) Constructions.

सूर्येन्दुभगणधात्रीसंस्थानविदो ऽधिकृत्य कथयामि /
ग्रहणं सदैव भानोः स्थानविशेषात् क्वचिद्दृश्यम् //१//
अविदितसंस्थानानां बोधो ऽपि हि जायते यथा ध्यानात् /
क्षीरं शंखोपहितं दशनविनाशक्षमं भवति //२//
संक्षेपसूत्राविशेषेण तीर्यते दिवाकरो येषाम् /
तेषां सूर्यग्रहणं स च देशः प्रतिदिनं क्वापि //३//
सकृदेव रविं ग्रस्तं पक्षं पश्यन्ति शशिगताः पितरः /
अग्रस्तमपि च पक्षं ग्रहमध्यं पौर्णमास्यां तु //४//
न कदाचिदपि ग्रहणं मेरुगता मेरुसंनिकृष्टा वा /
पश्यन्ति तिग्मरश्मेरनुद्भावाद्विहिमांशोः //५//
अर्केन्दुदृष्टिवेधा न मेरुगाः कदाचिदपि पार्श्वस्थाः /
ते <सर्वे खलु> विवरं पश्यन्ति सदैव सूर्येन्द्वोः //६//

1a °भगणाधात्री° a 1c ग्रहाणां a 1d °विशे (शो C) षात (त्त E, om. C)- (- om. C) β क्वचिद्दृस्यं a, धु (ध्रु C, क E) चिद्दृस्यं β, corr. T.-D. 2a आअविदितसस्ताना-नां β 2b वेध्यो (ध्यौ C) β ध्यान्यां a, ध्यान्यां (नां C) β 2d दशान (न om. C) न (न om. aCF) विनाश° aβ, corr. T.-D. 3a संक्षेपसूत्राव (वं β) श (शश E) शिना aβ 3b त्रियते aβ 3c तेषां om. β 3d सवदेशः a 4c अग्रस्थमपि a, अग्रस्तमवि β, corr. T.-D. 4d ग्रस्तं मध्या β 5d °रनुद्भावाद्विहिमांशोः (श्रोः F) β 6a °वेधो aβ 6c स्ते विवरं aβ, corr. T.-D. 6d सूर्येंदोः β

Chapter XV

XV,1. Placing those who know the relative positions of the Sun, Moon, zodiac and earth ahead I speak. There is always an eclipse of the Sun; somewhere it is visible because of the difference of localities.

XV,2. For those who are ignorant of the relative positions, understanding arises from meditation just as milk deposited in a conch-shell is able to withstand the destruction caused by teeth.

XV,3. For those for whom the Sun is crossed by an identity of all (the requisite) lines there is an eclipse of the Sun; this locality is somewhere every day.

XV,4. The Pitṛs on the Moon see the Sun eclipsed once for (a whole) half-month (pakṣa), and not eclipsed for (a whole) half-month; the middle of the eclipse is on the full-moon tithi.

XV,5. Those who live on Meru or near to Meru never see an eclipse of the Sun since the Sun and the Moon are not high (enough) up (above their horizon).

XV,6. Those on Meru (and) on its side, never make an observation of the Sun and Moon (together); they always see a distance between the Sun and Moon.

यद्यप्युदये ऽस्ते वा नीचस्थो ऽस्माकमंशुमान् भवति /
चन्द्रोपर(सो)मवस्थो घनर(वो)द्भानोर्भवति हेतुः //७//
अस्माकमुदयसमये येषामल्पास्तगो दिवसनाथः /
मध्याह्नो वा येषां तेषामपि न युगपद्ग्रहणम् //८//
तदतीतमुदयगानां क्षणद्वयेनैष्यदस्तदेशानाम् /
मध्याह्नदेशगानामनवरतं वर्त्तमानेन //९//
उक्तं च संहितायां मया प्रपंचे ऽस्य राहुचारादौ /
ग्रहणस्य यन्निमित्तं विनैव राहुं रविहिमांश्वोः //१०//
मेरोर्न दिग्विभागो यस्मात् प्राची न भास्करात्तस्मिन् /
उदयति यावद्दिनपः पर्येति वसुन्धरीं तावत् //११//
अणुमात्रदर्शनात् प्राग्विभाग इति चेत् समार्धमित्वा तु /
तस्मिन्नेवास्तमये किं वा प्राची भवेत् त्वपरा //१२//

7a यद्य (यं aC, यु F) प्युदये aβ   वा om. β   7b नियस्थो β   °मंशुमा a
7d घनद्भानो° a, घनद्भा (घ्रा C, न्हा F) नो (तो BE) β, corr. T.-D.
7d °ति हेतुः to 23d सः inserted after XIV 33a बुद्ध्वा β   8b दिवनाथः β
8d तेषां मे (मे om. B) यिनमुग्रापतग्रहणं β   9a त (रत C) दानी (ती F, नी C)
तमु-यश्रंगानां β   9b क्षणद्वयेनेष्यद° a, क्षणद्वयेने (मे C) ष्यद° β, corr. T.-D.
°स्तदोषाणां (नां EF) aβ, corr. T.-D.   9c °देश्रो गाना° a   9d °मनप (ग C) रत β
वर्तमान β   10a न (रन C) क्तं β   संताया β   10b मवा β   प्रपंचो aβ   स्म a
10c यनिमितं β   10d विनैराहुं β   पर (रि C) पिहिमांश्च (श्रस E) β
11b भास्करामस्मिन् β   11c नदयति β   11c–d यावद्दि (र्दि D, द्वि C) वं (वं om. β)
पर्येती aβ, corr. T.-D.   11d वसुंदरी aβ   12a अनुमात्र° aβ, corr. T.-D.
12b °मिया नु a, °मित्वान्तु β, corr. T.-D.   12c तस्मिवास्तमये β

XV,7. For us, even if the Sun is low down (towards the horizon) at sunrise or sunset, the Sun's being under the Moon as (under) a cloud is the cause (of the eclipse).

XV,8. (If) for us there is an eclipse at the time of sunrise, there is not one simultaneously for those for whom the Sun is almost set or for those for whom it is noon.

XV,9. It is past for those at (a place where it is) sunrise (and) in the future by (as much as) two kṣaṇas for those at a place (where it is) sunset (when it is) incessantly with the present for those at a place (where it is) noon.

XV,10. I have in detail discussed in the (Bṛhat-)saṃhitā, at the beginning of (the chapter on) the motion of the ascending node, what is the cause of an eclipse of the Sun and Moon aside from the ascending node.

XV,11. Because there is no distinction of directions on Meru, the eastern (direction) is not (indicated) by the (rising) Sun; as long as the Sun is risen, so long does it revolve about the earth.

XV,12. If (it is said): "The eastern (direction) is distinguished by the visibility (of the Sun) when it is the size of an atom", (it may be answered that) after it has travelled for half of the (ecliptic) great circle it sets at just that (point); what then is east or what west?

तेषामपक्रमवशाद्दिवसो न खलु भ्रमाद्यथास्माकम् /
षष्टिर्नाड्यो ऽस्माकं वर्षमहोरात्रममराणाम् //१३//
वर्षे वर्षे द्युनिशं सुरासुराणां विपर्ययेणाहः /
मासं तु तत्पितॄणां मनुजानां नाडिकाषष्टिः //१४//
यन्मात्रं भूवृत्तात् क्षणद्वयेनोन्नतिं व्रजत्यर्कः /
तन्मात्रान्तरचारिणममराः पश्यन्ति नोर्ध्वमधः //१५//
होराधिपतिदिनेश्वरपरम्परा न स्यात्तु यथास्माकम् /
षष्टिर्नाड्यस्तस्मिन्नाहोरात्रो भवति यस्मात् //१६//
दिनवारप्रतिपत्तिर्न समा सर्वत्र कारणं कथितम् /
नेहापि भवति यस्माद्द्विप्रवदन्ते ऽत्र दैवज्ञाः //१७//
द्युगणाद्दिनवारानिर्द्युगणो ऽपि हि देशकालसम्बन्धः /
लाटाचार्येणोक्तो यवनपुरे ऽर्धास्तगे सूर्ये //१८//

15 quoted by Utpala on BS 17,4–5; 17–20 quoted by Makkibhaṭṭa on ŚS 2,10; 18–29 quoted by Utpala on BS 2 (pp. 32–33).

13a तेवा (या C) म (म om. E) प° β 13c षष्टिर्नोड्यो (ड्यौ C) स्माकं β 14a द्युनिशं (शां F) β 14c तत्पितॄणां aβ, corr. T.-D. 15a भ्रमव (व om. CF) त्ता (ता CF) β 15b क्षणदा (वृ EF) येनोन्नति β 15c °त्रांतरवारिण° a, °त्रांत (स CE) रचारि° β 15d नोर्ध्वं (र्ध्वं β) मधः (धः CF) aβ 16b नयन्ते a, नट (T C) ते β 16d °न्नहोरात्रो β 17a-b °प्रतिपत्ति न aβ 17b कारणे कथिता Makkibhaṭṭa 18b द्विगुणो aβ ऽपि च Makkibhaṭṭa °संबन्धा a 18c लाजा° a, लाता° β 18d वास्तगे a, यास्तगे β, चास्तगे Makkibhaṭṭa, Dikshit

XV,13. For them (i.e., those on Meru) the day (is determined) by (the Sun's) declination, not, as for us, by its motion; our year is a nychthemeron (consisting of) 60 nāḍīs for the Gods.

XV,14. Every year is a day and a night for the Gods and Demons, with a reversal (of the position) of the day; (a day and a night) is a month for the Pitṛs, 60 nāḍīs for men.

XV,15. To whatever elevation from the horizon the Sun moves in two kṣaṇas, at that distance do the Gods see him moving, neither higher nor lower.

XV,16. The succession of lords of the hour and of lords of the day is not the same as ours because the nychthemeron there is not 60 nāḍīs.

XV,17. The (means of) ascertaining the week-days is not the same everywhere; since no cause is spoken of in this matter, the astrologers disagree about it.

XV,18. The week-day is obtained from the ahargaṇa; but the ahargaṇa is a combination of time and place. It is said by Lāṭācārya (to begin) when the Sun is half-set at Yavanapura;

रव्युदये लङ्कायां सिंहाचार्येण दिनगणोऽभिहितः /
यवनानां निशि दशभिर्गतैर्मुहूर्तैश्च तद्गुरुणा //१९//
लङ्कार्धरात्रसमये दिनप्रवृत्तिं जगाद चार्यभटः /
भूयः स एव सूर्योदयात् प्रभृत्याह लङ्कायाम् //२०//
देशान्तरसंशुद्धिं कृत्वा चेन्न घटते तथा तस्मिन् /
कालस्यास्मिन् साम्यं तैरेवोक्तं यथाशास्त्रम् //२१//
मध्याह्नं भद्राश्वेष्वस्तमयं कुरुषु केतुमालानाम् /
कुरुते ऽर्धरात्रमुद्यन् भारतवर्षे युगपदर्कः //२२//
उदयो यो लङ्कायां सो ऽस्तमयः सवितुरेव सिद्धपुरे /
मध्याह्नो यमकोट्यां रोमकविषये ऽर्धरात्रः सः //२३//
अधिमासकोनरात्रग्रहदिनतिथिदिवसमेषचन्द्रार्काः /
अयनर्तुगतिनिशाः समं प्रवृत्ता युगस्यादौ //२४//

20 quoted by Nīlakaṇṭha on Kālakriyā 16

19c यवनानां शिनिशिभि° β, यवना निशीह दशभि° Makkibhaṭṭa
19d °मुहूर्तैश्च aBC   20a °समयात् Nīlakaṇṭha   20b चार्यभट्टः a
20c-d चार्कोदयात् Utpala, Makkibhaṭṭa, Nīlakaṇṭha   21b क्र (त्तं C, त्त E, त्व F) चत्र (त्र C) β   21c कालस्यात् (त् om. C) साम्यं (स्यां C) β   21d नैरेवोक्तं a
21d यथाशास्त्रं to 22b °ष्वस्तमयं om. β   22b कुरुषूत्तरेषु केतुमालानां a, तरेषु काले तुलानां β   22c °मुद्यद् a, °मुद्यन् β   23a दिनग्रो β
यो om. a   23c यमकोट्यां मध्याह्नं Utpala   यमकोय्यां (ध्यां C) aβ
23d रोकवि (फ्रि B)ये β   ऽर्धरात्रं म Utpala   24a °कोनरात्रि° β
24b °दिवसमयूषचंद्रार्काः (र्काः C) β   24c अयन - र्द्वे° a, अयनत्वर्द्वे° β
24d युगस्यादौ a

XV,19. the ahargaṇa is said by Siṃhācārya (to begin) at sunrise at Laṅkā; for the Yavanas (it is said) by their guru (to begin) at night when 10 muhūrtas have passed;

XV,20. Āryabhaṭa has said that the day begins at midnight at Laṅkā; moreover he has said that it begins at sunrise at Laṅkā.

XV,21. If, after one has made the correction for longitudinal difference, no agreement concerning the time arises in this, it is said by them in agreement with the śāstras:

XV,22. The Sun rising in Bhāratavarṣa simultaneously causes noon among the Bhadrāśvas, sunset among the Kurus, and midnight for the Ketumālas.

XV,23. Sunrise at Laṅkā is sunset at Siddhapura, noon at Yamakoṭi, and midnight in the territory of the Romakas.

XV,24. The intercalary months, omitted tithis, (mean longitudes of) the planets, the days, tithis, (lords of) the days, Aries, the Moon, the Sun, the ayanas, ṛtus, motions of the constellations, and the nights begin equally at the beginning of the yuga.

अन्यद्रोमकविषयाद्देशान्तरमन्यदेव यवनपुरात् /
लङ्कार्धरात्रसमयादन्यत् सूर्योदयाच्चैव //२५//
सूर्यस्यार्धास्तमयात् प्रतिदिवसं यदि दिनाधिपं ब्रूमः /
तत्रापि नाप्तवाक्यं न च युक्तिः काचिदन्यास्ति //२६//
सन्ध्या क्वचित् क्वचिदहः क्वचिन्निशा दिव(स)पतेः क्वचित् क्वचित् /
स्वल्पे स्वल्पे स्थाने व्याकुलमेव दिनपतित्वम् //२७//
होरावार्त्ताप्येवं यस्माद्धोरा दिनाधिपस्याद्या /
तस्यापरिनिष्ठाने होराधिपतिः कथं भवति //२८//
अविचार्यैवं प्रायो दिनवारे जनपदः प्रवृत्तो ऽयम् /
स्फुटतिथिविच्छेदसमं युक्तमिदं प्राहुराचार्याः //२९//
ज्योतिषोपनिषत् पंचदशो ऽध्यायः //

29c–d quoted by Nīlakaṇṭha on Kālakriyā 16.

25d °दन्य (न्यः β) aβ 26a सूर्यस्यार्धास्तमयात् β 26b प्रतिविषयं Utpala दिनाधिप (ष B) त्यं β 26c नाप्तं वाक्यं β 26d नवयुक्तिः a काचिदप्यस्ति Utpala 27b दिनपतिः aβ 27c स्था (प्रस्था C) नं aβ 27d व्याकुलमेवं aβ 28a होरावार्त्तायेवं a 28b दिनाधिपस्याद्याः (दयाः B) β 28c °निष्ठाने a 29a अविदित्वैवं Utpala (some manuscripts) 29b दिनवारौ a, दिनवारै (रौ C) β 29c स्फुरतिथि° β col. पंचदशमो β

XV,25. There is one longitudinal difference from the territory of the Romakas, another from Yavanapura; there is one (time) from midnight at Laṅkā, (another) from sunrise.

XV,26. If we say (what is) the lord of the day (by counting) every day from the setting of half the Sun, there is no accepted statement in this nor any other reasoning at all.

XV,27. Because of the Sun's being in various places, it is twilight in one place, daylight in another, and night in another; at every little (shift in) locality the lordship of the day is confused.

XV,28. Thus also is the information about the hours since the first hour belongs to the lord of the day; since that is not completely fixed, how is the lord of the hour?

XV,29. The common people for the most part deal with the (accepted) week-day without reflection; the ācāryas say that that is right which coincides with the accurate divisions between tithis.

The fifteenth chapter: the Upaniṣad of Astronomy.

एष निशार्धे ऽवन्त्यां ताराग्रहनिर्ण(यो)ऽर्कसिद्धान्ते /
तत्रेन्दुपुत्रशुक्रौ तुल्यगतौ मध्यमार्केण //१//
जीवस्य शताभ्यस्तं द्वित्रियमाग्नित्रिसागरैर्विभजेत् /
द्युगणं कुजस्य चन्द्राहतं तु सप्ताष्टषड्भकम् //२//
सौरस्य सहस्रगुणमृतुरसशून्यर्तुषट्कमुनिखैकैः /
यल्लब्धं ते भगणाः शेषा मध्या ग्रहाः क्रमेणैव //३//
दश दश भगणे भगणे संशोध्यास्तत्पराः सुरेज्यस्य /
मनवः कुजस्य देयाः शनेश्च बाणा विशोध्यास्तु //४//
राशिचतुष्टयमंशद्वयं कलाविंशतिर्वसुसमेता /
नववेदाश्च विलिप्ताः शनेर्धनं मध्यमस्यैव //५//
अष्टौ भागा लिप्तार्तवः खपक्षौ गुरोर्विलिप्ताश्च /
क्षेपः कुजस्य यमतिथिपंचत्रिंशश्च राश्याद्याः //६//

1a वत्यां aβ, corr. T.-D. 1b °ग्रहनिर्णो a, °ग्रहण β, corr. T.-D. कसिद्धांते β
1d महमार्केण a, म (क्रौ म C)ध्यमार्के (र्क्रे E, र्के CF)मा β, corr. T.-D. 2a निवस्य β
2d सप्ताष्टद्रुकं a 3a सौम्यस्य सताभ्यस्तंद्वित्रियमाग्नित्रिसागरै (from 2a-b)
सहस्र° β 3a-b °गुणादतुरस° a, गुणारु (ह F, om. C)तुरस° β 3b °सून्य° a
°मुनिखेकैः β 4a दशांशभगणे β भगणे om. β 4c नवमः β कुकुद्व (द्व C)
β 4d विशोध्यास्त्र a, विशोध्याः (ध्य F) स्तुः β, corr. T.-D. 5a राशिचतुष्टयमंशं β
5c नवदेवाश्च (श्च EF) β 5d शनेर्धने a, शने β, corr. T.-D. मध्यमास्येव a,
मध्यमस्त्वेयं β, corr. T.-D. 6a भामा a लिप्तर्तवः a, लिप्ततवः (क C) β
6b खमक्षौ a, शेषसौ β गुरौ a, गुरु β 6c क्षे (द्व C) वः (यः C) β
जमतिथि° a, यमतितिथि° β, corr. T.-D. 6d °त्रि (त्रिं E) शश्च β

Chapter XVI

XVI,1. This is the determination of the star-planets in the Arkasiddhānta for midnight at Avantī; in this Mercury and Venus have a (mean) motion equal to that of the mean Sun.

XVI,2. For Jupiter multiply the ahargaṇa by 100 and divide (the product) by 433 232; for Mars multiply it by 1 and divide by 687;

XVI,3. for Saturn multiply it by 1000 and divide by 10 766 066. The quotients are revolutions, the remainders the mean (longitudes of the) planets in order.

XVI,4. For every revolution of Jupiter 0;0,0,10° are to be subtracted; of Mars 0;0,0,14° are to be added; of Saturn 0;0,0,5° are to be subtracted.

XVI,5. To the mean (longitude of) Saturn is added 4 signs and 2;28,49° (= 122; 28,49°);

XVI,6. to Jupiter 8;6,20°; to Mars the kṣepa is 2, 15, and 35 in signs and so on (= 75;35°).

शतगुणिते बुधशीघ्रं स्वरनवसप्ताष्टभाजिते क्रमशः ।
अत्रार्धपंचमास्तत्पराश्च भगणाहताः क्षेप्याः ॥७॥
सितशीघ्रं दशगुणिते द्युगणे भक्ते स्वरार्णवाब्धियमैः ।
अर्धैकादश देया विलिप्तिका भगणसङ्गुणिताः ॥८॥
सिंहस्य वसुयमांशाः स्वरेन्दवो लिप्तिका च शीघ्रधनम् ।
शो<ध्याः> सितस्य विकलाः शशिरसनवपञ्चगुणदहनाः ॥९॥
क्षेप्याः स्वरेन्दुविकलाः प्रतिवर्षं मध्यमक्षितिजे ।
दश दश गुरोर्विशोध्याः शनैश्चरे सार्धसप्त युताः ॥१०॥
पंचाब्धयो विशोध्याः सिते बुधे साब्धिचन्द्रयुताः ।
खखवेदेन्दुविकलिकाः शोध्याः सुरपूजितस्य मध्यात् स्युः ॥११॥
सूर्यसिद्धान्ते मध्यगतिः ॥
शीघ्राख्यो ऽर्कौ ऽन्येषां भौमादीनां तु <मन्द>परिधयः <स्युः> ।
द्विगुणाः पंचत्रिंशन्मनवो ऽष्टयः स्वरास्त्रिंशा<श्च> ॥१२॥

7a शतगुणितं β   7c-d °पंचमौ स्तस(त्प E)राश्च β   7d °हतः क्षेपः α, °हतक्षिपा β, corr. T.-D.   8b द्विगुणे (णो F) αβ, corr. T.-D.   स्वरार्णवाब्धियमैः α   8c अर्कैकादश α   8d विलिप्ता α   9a सिंहस्प α   9b स्वरोदवो α   विलिप्तिका β   9c शो αβ, corr. T.-D.   9d °पञ्चगुणादहनाः (ताः α) αβ, corr. T.-D.   10a शरेन्दु° β Dikshit   10b प्रतिवर्षमाध्यमक्षितिजो αβ, corr. T.-D.   10d युक्ताः β   11a पंचाद्वयो α, पंचद्वयो β, पंचद्वया Dikshit, corr. T.-D.   11b स्ताब्धिचन्द्र° α °युक्ताः β   11c खखवेदेन्दुविकालिकाः α, खखवेदविकलिकाः β, corr. T.-D.   11d मध्याः β   मध्यशनिः β   12a र्कौ β   12c °त्रिंशत्सनवो α   12d सुरास्त्रिंशाः αβ

XVI,7. (If the ahargaṇa) is multiplied by 100 and divided by 8797 in order, (the result is) the conjunction of Mercury; to this 0;0,0,4,30° multiplied by (the number of) revolutions is to be added.

XVI,8. If the ahargaṇa is multiplied by 10 and (the product) divided by 2247, (the result is) the conjunction of Venus; to this 0;0,10,30° multiplied by (the number of) revolutions are to be added.

XVI,9. Of Leo 28° and 17 minutes (= 148;17°) are added to the conjunction of Mercury; 332 961 seconds (= 92;29,21°) are to be subtracted (from that) of Venus.

XVI,10. Every year 17 seconds are to be added to mean Mars, 10 (seconds) are to be subtracted from (mean) Jupiter, and $6^1/_2$ (seconds) are added to (mean) Saturn;

XVI,11. for (the mean conjunction of) Venus 45 (seconds) are to be subtracted, and for (the mean conjunction of) Mercury 120 (seconds) are added. From the mean (longitude) of Jupiter 1400 seconds (= 0;23,20°) are to be subtracted.

Mean motion in the Sūryasiddhānta.

XVI,12. The Sun is called the conjunction of the other (planets). The manda-circumferences of Mars and so on are 35, 14, 16, 7, and 30 multiplied by 2 (i.e., Mars 70°, Mercury 28°, Jupiter 32°, Venus 14°, and Saturn 60°).

रसभवसुवेदार्का विंशतिगुणिता: कुजस्य दशकोना: ।
मन्दगतीनां भागा: कुजबुधगुरुशुक्रसौराणाम् ॥१३॥
शीघ्रपरिधावथांशा: कृतगुणपक्षा द्विवह्निशीतकरा: ।
पक्षस्वरा: सषड्यमा: सकृता: स्यु: कुजादीनाम् ॥१४॥
शीघ्रान्मध्यमहीनाद्राशित्रितये गतैष्यदंशज्ये ।
भुजकोटी तत्परत: षड्भ्य: पतिते स एव विधि: ॥१५॥
स्वपरिधिगुणिते भाज्ये स्वर्तुगुणैर्विप<रि>णते <ते त>तच्च ।
कोटिफलं व्यासार्धे मृगकर्क्यादौ चयापचयम् ॥१६॥
तद्भुजकृतियोगपदैर्भाजयेत्तत<री> भुजं ससूर्यघ्नम् ।
तच्चापार्धं मन्दे हानिधनं शीघ्रकेन्द्रवशात् ॥१७॥
स्फुटयित्वैवं मन्दं मध्याच्च विशोध्यं तस्य भुजम् ।
परिणाम्य कार्मुकार्धं तन्मन्देनैव धनहानि ॥१८॥

15-16 quoted by Utpala on BS 2 (p. 46)

13a रससंवत्सुवेदार्कौ β 13b कुजस्य a दशकोणा: a, दशकोणस्यणा: (दणा: C) β, com. T.-D. 13c मंदगतिनाम° aβ °लाघवं β 13d °सोराणां a

14a-b शीघ्रपरिधा (धा om. C) यथाशात्तत्त (त CF) द्गु (गु CF) णपचा β

14c पचस्वरा: om. β स (सं a) षष्य (ट्य CF) मा aβ, com. T.-D. 14d स्यु: om. β

15a शीघ्रान्मध्यविहीना° Utpala 15b °द्राशि° a गतैष्य (ष्य a) दं (दे C) शोज्ये aβ, गतैष्यदंशज्या Utpala, com. T.-D. 15c भुजको (क C) टि β 15d पतते aβ

16b स्वर्तुगुणैर्विपगते तच्च a, स्वर्तुगुणे विसुगतच्च β, स्वर्तुगुणैस्ते विपरिणते तच्च Utpala

16d चयापचया: aβ, चयापचय: Utpala, com. T.-D. 17a °कृति° om. β

17b °र्भा (भा β) जयेत्र (त्र a) तभू (भु D, द्गु D²) जस्वसर्य (य C) घ्नं (घ्न: CF, घ्न: E) aβ

17c तच्चापा (या β) र्धं aβ, com. T.-D. 17d शीघ्रं केंद्रवश (शा E) तात् β

18a स्फुटत्ववं मंदं β 18b तस्य जुभुजां β 18d धनहानी a, धनहानि: β, com. T.-D. after 18d, 17d धनं to 18d धनहानि: repeated β

XVI,13. The degrees of the slowest motion (i.e., the mandoccas) of Mars, Mercury, Jupiter, Venus, and Saturn are 6, 11, 8, 4, and 12 multiplied by 20; (that) of Mars is diminished by 10 (i.e., Mars 110°, Mercury 220°, Jupiter 160°, Venus 80°, Saturn 240°).

XVI,14. In the śīghra-circumferences of Mars and so on are 234°, 132°, 72°, 260°, and 40°.

XVI,15. If (the remainder from) the conjunction (i.e., the longitude of the Sun) diminished by the mean (longitude of the planet) is within three signs, then the Sines of the traversed and untraversed degrees are the bhuja and koṭi (respectively); if it is more than that, then it is subtracted from six (signs) and the same rule (applies).

XVI,16. Multiply (the bhuja and koṭi) by their (proper) circumferences and divide (the products) by 360; thereby are they reduced (to the bhujaphala and the koṭiphala). The koṭiphala is added to the radius in Capricorn and so on, subtracted from it in Cancer and so on.

XVI,17. Then one should multiply the bhuja(phala) by 120 and divide (the product) by the square-root of the sum of the squares of that (i.e., $R \pm$ koṭiphala) and of the bhuja(phala). Depending on the anomaly of the conjunction, half of the corresponding arc is to be subtracted from or added to (the longitude of) the apogee.

XVI,18. Having corrected the apogee thus, subtract (it) from the mean (longitude of the planet); reduce its bhuja (to the bhujaphala). Half (of the corresponding arc) is added to, or subtracted from, just that (corrected longitude of the) apogee.

मध्यात् पुनर्विशोध्यस्तस्माद्बाहुं नतस्य यच्चापम् /
तन्मध्यमे चयधानं कर्तव्यं मन्दकेन्द्रवशात् //१९//
एवं स्फुटमध्याख्यं शीघ्रात् संशोध्यं पूर्वविधिनैव /
आदिवदाप्तं चापं स्फुटमध्याख्ये चयापचयम् //२०//
सर्वे स्फुटाः स्युरेवं ज्ञेड्येषु शीघ्राद्विहाय रविमन्दम् /
रविपरिधिनतं बाहुं बुधे <को>बरौ> चयधानं कुर्यात् //२१//
शुक्रस्य सप्तषष्टिर्लिप्ताः शोध्याः स्फुटीकृतस्यैव /
वक्रानुवक्रकालो भुक्तिविशेषेण विज्ञेयः //२२//
स्फुटदिनकरान्तरांशाश्चन्द्रादीनां च दर्शने ज्ञेयाः /
विंशतिरूना वसुशिखिमुनिनवरुद्रेन्द्रियैः क्रमशः //२३//
मन्दग्रहान्तरज्या स्वाष्टांशयुतार्किजीवशुक्राणाम् /
सौम्यारयोः पदोना विक्षेपो ऽन्यच्च शीघ्रविधौ //२४//

19a मध्या β   पुरो विशोध्य° α, सुरो विशोध्य° β, corr. T.-D.   20a °मध्याख्यां α
20c आदिवदाप्ते (प्ये C) αβ, corr. T.-D.   20d °मध्याख्योप (प om. β) चयापचयः αβ, corr. T.-D.   21a स्फुटाः स्फु (स्पु A)रेवं α, कारेवं (वं om. C) β, corr. T.-D.
21b ज्ञस्य तु (पु) α, ज्ञेक्यंघ्नु β   21c वाम्दं (ग्दं CE, दुं F) β   21d बुधावत्रयधाने αβ
22a सप्तव्याष्टि° αβ, corr. T.-D.   22b लिप्ता β   स्फुटिकृतस्यैव α, स्फुटितत्त (त्त om. B) स्यैव β, corr. T.-D.   22c वक्रानुवक्र° α   23a-b om. C   23a स्फुरदिन° β
°करांतरां (सं β) तरां (रा BE, सं F) शा° αβ, corr. T.-D.   23b व β   दर्शनी α, द (र्द F) र्श β, corr. T.-D.   23c विशति° αβ, corr. T.-D.   °रूना α   23c-d वसुशशि-शिखि° αβ, corr. Shukla   23d °नवरुद्रेद्रि (द्रि α) यैः (यैः β) αβ
24b स्वा (स्व B) ष्टांशसुर्किजीवशुक्राणां β   24c सौम्यान्य (न्य α) यो: αβ
पदोनां α, पदनां β   24d न्यच्च α

XVI,19. Again (the second corrected apogee) is to be subtracted from the mean (longitude of the planet); (find) the bāhu from that. The arc corresponding to this after it has been reduced (to the bhujaphala) is to be subtracted from, or added to, the mean (longitude of the planet) depending on the argument of the apogee.

XVI,20. Subtract the mean (longitude of the planet) thus corrected from the conjunction (i.e., the longitude of the Sun) according to the previous rule; the arc that is obtained as was the first (śīghra correction) is to be added to, or subtracted from, the corrected mean (longitude of the planet).

XVI,21. All (the planets) thus are corrected. But in the case of Mercury and Venus subtract the Sun's apogee from the conjunction (i.e., the Sun's longitude); reduce the bāhu to the circumference of (the epicycle of) the Sun and subtract (the corresponding arc) from, or add (it) to, (the corrected longitude of) Mercury or Venus.

XVI,22. From Venus, after it has been corrected, 67 minutes are to be subtracted. The time of the first station or of the second station is to be known by means of the difference between velocities.

XVI,23. The degrees of distance between the true (planet) and the Sun (required) for the visibility of the Moon and so on are to be known as 20 diminished in order by 8, 3, 7, 9, 11, and 5 (i.e., Moon 12°, Mars 17°, Mercury 13°, Jupiter 11°, Venus 9°, and Saturn 15°).

XVI,24. For Saturn, Jupiter, and Venus add an eighth to the Sine of the interval between the apogee and the planet; for Mercury and Mars subtract a fourth. There is another latitude in the rule of the conjunction:

गुरुभूतनयास्फुजितां पाटोना ज्ञयमयोस्तु साष्टांशा /
त्रिज्याघ्नी कर्णाप्ता वियोगयोगः स विक्षेपः //२५//
ताराग्रहस्फुटीकरणं षोडशोऽध्यायः //

25a गुह (रु F) भूतन (न C) याः β   25b पटोना β   ज्ञयममयोर्मुशांष्टांशाः α, ज्ञय (प F) मयोर्मुष्ट्यं (ष्टयं C, ष्व्यं F) शां β   25d नियोगयो (यो om. E) श αβ

XVI,25. for Jupiter, Mars, and Venus subtract a fourth, and for Mercury and Saturn add an eighth. Multiply (the result) by the radius and divide (the product) by the hypotenuse; the latitude is the difference or sum (of the apogee and conjunction latitudes?).

The sixteenth chapter: the Correction of the Star-planets.

हित्वा मुनिजलचन्द्रा⟨न्⟩ द्युगणाद्विदाष्टभूतहृतलब्धाः ।
शुक्रोदया गुणांशाः सार्धाः पंचालिनो भोगः ॥१॥
कन्यांशाः षड्विंशतिमित्वा शुक्रोऽपरेण यात्युदयम् ।
उदयैकादशभागं दिनेषु दत्वा ततश्चारः ॥२॥
षष्टित्रयेण वेदाग्नियमयुतामंशसप्ततिं भुंक्ते ।
अर्धाष्टकविंशत्या विंशत्यं⟨शका⟩स्त्रिभिः सपादांशम् ॥३॥
वक्रमतस्तिथिभिर्द्वौ पंचभिरेवं ततोऽपरास्तमितः ।
दशभिः प्रागुदितः स्यात्तस्वैश्च जलधीन् सितो गत्वा ॥४॥
अनुवक्री परिगत्वा विपरीतं चास्तमेत्यैन्द्र्याम् ।
षष्ट्यांशपंचसप्ततिमित्वापरतो भृगुर्दृश्यः ॥५॥
वासिष्ठसिद्धान्ते शुक्रः ॥
विचतुस्त्रिंशद् द्युगणं नाडीभिस्तावतीभिरपि च गुरोः ।
हृत्वा नवनवदहनैरुदया लब्धाः स्थिर⟨ता⟩ दिवसाः ॥६॥

1a मुनिजला° β °चन्द्रा aβ, corr. T.-D. 1b °भूतहृत° β 1c शुक्रेदया a गु(ग C)णाशैः aβ 1d सार्द्धां a भोगाः aβ 2a षड्विति° β 2c उदैकादश° β °भागान् aβ, corr. T.-D. 2d ततस्तारा: a 3a–b सेसाग्नियम° β
3c अर्धाष्टके (केन a) विंशतां (तिं a, तिः E) aβ 3d विंशत्यैस्त्रिभिः aβ
4a वक्रमतंस्तितिभि° β 4d मिता aβ गता β 5 and वासिष्ठसिद्धान्ते om. β
5b विपरीतमस्तमत्यैड्यां (ड्यं D) a 6a विवतुस्त्रिंश द्विगुणं aβ, corr. T.-D.
6b गुरुः aβ, corr. T.-D. 6c हृ(हू C)त्वा aβ, corr. T.-D. 6c–7c °वनवदहनै to °हिन्ने om. β 6c °तुदया लब्धारिश्च a, corr. T.-D.

Chapter XVII

XVII,1. Subtract 147 from the ahargaṇa and divide (the remainder) by 584; the quotient is the (number of) risings of Venus. Its progress in longitude (during that time) is $5^1/_2$ and $^1/_3$ (degrees) of Scorpio (= 215;50°).

XVII,2. When Venus has travelled to 26° of Virgo it rises in the west. Add $^1/_{11}$th (of a day for every) rising to the days; from this (compute) its motion.

XVII,3. In three (periods) of sixty (days) it travels 70° increased by 4, 3, and 2 (i.e., 74°, 73°, and 72° respectively); in $27^1/_2$ (days) 20°; and in 3 (days) $1^1/_4$°.

XVII,4. Then it retrogrades 2 (degrees) in 15 (days); then it sets in the west in 5 (days) and rises in the east in 10 (days); Venus goes 4 (degrees) in 20 (days).

XVII,5. Proceeding in direct motion, it travels in the opposite direction to setting in the east; proceeding 75° in 60 (days) Venus is (again) visible in the west.
Venus in the Vāsiṣṭhasiddhānta.

XVII,6. For Jupiter subtract from the ahargaṇa 34 (days) and as many nāḍīs and divide (the remainder) by 399; the quotient is (the number of) its risings. The (remaining) days are put down.

उदयनवांशान् दत्वा दिनेषु षड्वर्गसङ्गुणे ह्युदये /
एकनवाग्निच्छिन्ने पदमिति साष्टादशं शेषम् //७//
द्वि<हीनः> क्रमशो मध्यः स्फुटस्य खण्डस्तयोश्च विश्लेषात् /
स्फुटहानौ द्युषु दद्यात्त<न्म>ध्यखण्डे ऽन्यथा हानिः //८//
रसविषयकृतशशाङ्काः द्यसखण्डे खधृतयः पदं यावत् /
विषयरसेना वृद्धौ जीवः स्यात् पंचनवतिशतात् //९//
षड्सुमनवो हानौ तृतीयखण्डे गुरुस्तु षोडशके /
पंचगुणिते त्वष्टभाजिते कलाः पूर्वतो ऽभ्युदेति //१०//
नव सार्धाः कन्यांशाः प्रथमे खण्डे द्वितीयखण्डे स्युः /
चक्रार्धं द्विगुणांशा दश सदला देवपूज्यस्य //११//
दिनषष्ट्यांशा द्वादश खकृतैर्वेदाः कृताब्धिभिर्द्वौ च /
सप्ताष्टकेन वक्री षड्भागाः षष्टितः षट् च //१२//

7a उदयरवांश a, corr. T.-D. 7b °संगुणैरुदयः a, corr. T.-D. 7d बदमिति (तिः β) aβ, corr. T.-D. 8a–c द्वि° to स्यु om. C 8a द्वि° om. B मध्य° a 8b खण्डे° aβ °स्तयोश्च a विशेषात् aβ, corr. T.-D. 8c–d दद्यातध्य (ध्य om. β) खसौरे aβ 9a रसाविषय° aβ, corr. T.-D. °शशांकाः a 9b–10b खधृतयः to तृतीयखण्डे om. β 9b विधृतयः a, corr. T.-D. 9c विषयरसोना a, corr. T.-D. 10c–d त्य (अ E) ष्टकभाजिते aβ 10d ऽभ्युदिते a 11b स्फुः a 11c चक्रार्धे β वगुणांशाः a, च गुणांशाः β 11d दश शकला aβ 12a दिनषष्ट्यंशा aβ, corr. T.-D. 12d षड्वर्गाः aβ, corr. T.-D. षष्टि β षड् च a, षड्ढ (च C) β, corr. T.-D.

XVII,7. Add to (these) days $^1/_9$th (of a day for every) rising. Multiply the (number of) risings by 6^2 (= 36) and divide (the product) by 391; (the remainder) is called the pada. Add 18 to the remainder.

XVII,8. Put down the mean and the true segments, in order, in two places. (Decide) from the difference between them. If the true is less, one should add it to the days; otherwise, if the mean segment (is less), subtract it.

XVII,9. Until the pada (equals) 180, (Jupiter) is in the negative segment 1456; until (it increases by) 195, Jupiter is in the positive (segment) 1265 (or 1456 − 65 = 1391);

XVII,10. for 16 Jupiter is in the third, negative segment 1486. Multiply by 5 and divide by 8 (or 83); it rises to the east in so many minutes (of arc).

XVII,11. In the first segment of Jupiter they are $9^1/_2°$ of Virgo (= 159;30°); in the second segment half a circle (= 180°); (and in the third) $20^1/_2°$.

XVII,12. In 60 days (Jupiter) traverses 12°, in 40 (days) 4 (degrees), and in 24 (days) 2 (degrees); (it moves) retrograde 6° in 56 (days) and 6 (degrees) in 60 (days);

अनुवक्रो ऽशीत्यार्का<न्> दिनार्धशतेन नव <च> ततो ऽस्तमितः /
स्थित्वा<थ>मेकमासं स्फुटोदयो ऽष्टान्त्ये मासस्य ॥१३॥

बृहस्पतिः ॥

अध्यर्धशतं सत्र्यंशमपनयेत् सूर्यजस्य दिवसेभ्यः /
वसुमुनिगुणोद्धृतेभ्यः स्थिता दिनाद्यास्तमभ्युदयात् ॥१४॥
जह्यादुदयदशांशं द्युभ्यो नवसङ्गुणान् भजेदुदयान् /
षड्विषययमैः शेषं पदं युतं तन्नवाशीत्या ॥१५॥
षड्रूपवेदपक्षा वृद्धिस्त्रिंशत् पदानि सौरस्य /
नवरूपविषययमला ह्रासः स्वरभास्करपदाख्यः ॥१६॥
प्रचयः स्वराग्निकयमा नवनवतिस्त्रिघनभागलिप्तानाम् /
चयवृद्धिर्द्विगुणहृतश्चैकगुणघ्नः शनेरुदयः ॥१७॥
षोडश वृषभस्यांशा नवलिप्तावर्जिताः प्रथमखण्डे /
विषयास्त्रिघनस्त्रिंशाश्चतुर्युता मध्यमे खण्डे ॥१८॥

13a अ (य BE, प्र F) नुवक्री aβ, corr. T.-D. शीत्यर्का (र्क्रा EF) aβ, corr. T.-D. 13b टी (ही a) नार्धमतेन aβ 13c स्थित्वा सैकं मासं aβ 13d स्फुटोदयाष्टा (ष्टां C) त (त्त a, ता BE) रं मास (सं a) मी (मी om. a) aβ 14a-b शत्र्यंशमपनयेत् a, णमपानये β, corr. T.-D. 14c °गुणोधृतेभ्यः aβ, corr. T.-D. 14d स्थितं aβ, corr. T.-D. दिनाद्यास्तम° aβ 15a जह्याद्युदय° aβ, corr. T.-D. °दशांशं β 15b न (नं β) वसंगुणाद्भजे° aβ 15d पदैर्युतं तत्तवा° a, पदैः युतं म (भ C) त्त (त CF) वा β, corr. T.-D. 16a षड्रू (ड्रु C) पवेद° β 16a-b °पक्षाद्वृ (द्वृ F, द C, बृ D) द्धि° aβ 16c °यमलो β 17b नवननवतस्त्रि° β 17c चयवृद्धिद्विगुण° aβ, corr. T.-D. 17c-d °यदैरेक° a, °पदैरेक° β, corr. T.-D. 17d शनैरुदयः a, शनैरुदयः β, corr. T.-D. 18a वृष (श C) भांशा β 18b प्रथमखंडाः aβ, corr. T.-D. 18c-d °स्त्रिंश चतुर्युता aCF

XVII,13. in direct motion (it goes) 12 (degrees) in 80 (days); 9 (degrees) in 50 days; then it sets; staying (set it travels) 7 (degrees) in one month (i.e., 30 days); its accurate rising is on the last day of the month (i.e., on the 29th).

Jupiter.

XVII,14. One should subtract $150^1/_3$ from the days of Saturn (and) divide (the remainder) by 378; put down the days and so on; the quotient is its (number of) risings (i.e., synodic periods).

XVII,15. One should subtract $^1/_{10}$th (of a day for every) rising from the days. Multiply the (number) of risings by 9 and divide (the product) by 256; the remainder is the pada. Add to it 89(?).

XVII,16. Saturn's (first) 30 padas are positive 2416; 127 padas are negative 2519;

XVII,17. (and) 99 (padas) are positive 2037. There is a subtraction or addition of 12 degrees and minutes (i.e., 12;12°). Multiply by 31 and divide (the product) by 32 (or: by 32 padas); (the result is) Saturn's rising.

XVII,18. In the first segment are 16° of Taurus diminished by 9 minutes (= 45;51°); in the middle segment are 5 (signs) 27 (degrees) and 34 (minutes) (= 177;34°);

परिहीनाः स्त्रीस्वांशा मनुभिर्लिप्तास्त्रिगुणाः सप्त /
षोडशभिश्चाशीतिं कृतोनषष्ट्या द्विगुणपञ्चान् //१९//
वक्री विभुक्तषष्ट्या त्रीनंशान् षष्टितः कृतान् सौरः /
अनुगो ऽर्कशतेनाष्टौ षट्कृत्या चास्तगो दहनम् //२०//
शनैश्चरः //
द्युगणात् षड्केकयमान् विहाय पञ्चाष्टकं च नाडीनाम् /
गगनाष्टमुनिभिरुद्ध्या लभ्यन्ते प्राक्प्रहीनस्य //२१//
उदयगुणिता विनाड्यः स्वरतिथयो ऽब्ध्यन्विता दिनक्षेपः /
धृतिगुणितान् त्र्यग्नीन्दुभिरुद्ध्यान् हृत्वा स्थितो ऽतो ऽस्मात् //२२//
पंचाशीतिं कृत्वा सत्रिराशिं मध्यमः क्रमशः /
राशिप्रमाणतो ऽस्य स्फुटिताचारं क्रम⟨ात्⟩ कुर्यात् //२३//
स्फुटमध्यमविक्षेपांशकान् क्षिपेन्मध्यमे द्युभ्यः /
मध्यमहानौ जह्याद्गतितो ऽप्याचारमभिधास्ये //२४//

19a षट् (ड् C, ड EF) ह (हु C) ताक्त्रीणांशान् aβ 19b मनुभिर्लिप्तास्तर्गुणाः aβ
19d कृतोनषष्ट्वात् (श D, corr. to त् D²) a, कृतोनपञ्चा (श्चा om. C) श β, corr. T.-D.
20a विभुक्त° β 20b त्रिनं (न β) शान् aβ कृतात् a, कृतत् β, corr. T.-D.
20c रुनु (तु F, लु BE) गो β कैशतैर्ना (ना β) ष्टौ (ष्टों β) aβ 20d षद्ध (द्धृ E) त्या (सा E) β चास्तगे a, वास्तमे β, corr. T.-D. 21a द्युगुणे aβ, corr. T.-D. षट्कंवयमान् aβ
21b नाडी (डि BE) त्वं β 21d प्राक् महीजस्य β 22b ब्ध्यान्विता a, ब्द्यान्विता β, corr. T.-D. 22c °गुणितास्त्र्याग्री (त्री β) दुभि° (भि om. β) aβ 22d हृ (हृ om. C) त्वा aβ, corr. T.-D. स्मा: aβ, corr. T.-D. 23b त्रतिराश्यं aβ मध्यत: β
23c स aβ, corr. T.-D. 23d °चारक्रमं a, °चारक्र (क्रु F) β 24a-b °विक्षेपांशका (का om. a) न् aβ, corr. T.-D. 24d याचाराम° a, प्याचारा (र E) म° β

XVII,19. (and in the last segment) 0° of Virgo diminished by 14 (degrees) (plus) 7 times 5 minutes (= 136;35°). In 16 (days Saturn traverses) 80 (minutes); in 60 minus 4 (= 56) (days) 232 (minutes);

XVII,20. Saturn (moves) retrograde 3° in 60 minus 5 (= 55) (days) and 4 (degrees) in 60 (days); in direct motion (it proceeds) 8 (degrees) in 112 (days); (and, having gone) 3 (degrees) in 6^2 (= 36) (days), it sets.

Saturn.

XVII,21. Subtract 216 (days) and 40 nāḍīs from the ahargaṇa (and divide the remainder) by 780; the risings of Mars in the east are obtained.

XVII,22. Add to the days 157 plus 4 (= 161) vināḍīs for every rising (i.e., synodic period). Multiply the (number of) risings by 18 and divide (the product) by 133; put down (the remainder) from that.

XVII,23. Calculate 85 (degrees) plus three zodiacal signs (= 175°); (this is), in order, the mean (longitude of Mars); one should compute in order its true motion by means of the measures of the signs (?).

XVII,24. If the mean (is greater), one should add the degrees of difference between the true and mean (segments) to the days; if the mean is less, one should subtract them from the gati. I will describe its motion.

प्रागुदये षट्काष्टैकमष्टादश वक्रगस्ततो वक्रः ।
गत्यर्धं च ततः शीघ्रात्त्रिघ्नषष्टिं ततोऽस्तमितः ॥२५॥
समतीत्य दश त्रिहता⟨न्⟩ निरंशगस्त्रिंशतिं व्यतीत्य कुजः ।
उदयमुपयाति वक्रे गतिचारदिना⟨स्⟩ क्रम⟨ाम्⟩ चातः ॥२६॥
चत्वारिंशशतद्वयमष्टयमान्वितं विपद्यांशाम् ।
प्रथमगतौ कुर्याद्दिवसा⟨न्⟩ मीनाद्राशिद्वयसमान् ॥२७॥
विषयस्वरसप्त⟨र्तू⟩तुपंचका⟨न्⟩ दशगुणान् द्वि⟨ती⟩यगतौ ।
सहिताः स्वरैकपञ्चर्तुचन्द्रशीतांशुभिः क्रमशः ॥२८॥
झषवृश्चिकाजचापे वक्रे षट्सप्तकेन षड्भागा⟨न्⟩ ।
द्विकृतेन दिगतिवक्रे दिनषष्ट्या षोडशानुगतिः ॥२९॥
गोमिथुनतौलिकन्यासु दश⟨ह⟩तैः समुद्रैः स्वरानंशान् ।
सकृतैर्दश त्रिषष्ट्या सप्तदश यथाक्रमं वक्री ॥३०॥

25ab षट्च (द्व EF, ड्व C) सप्तेकमष्टादश αβ 25b मस्तगस्ततो αβ व (च β) क्रं αβ 25c अत्यर्धं αβ 25c–d शीघ्राच्युना° α, शीघ्राघ्नना° β 25d °षष्टिस्ततो αβ 26a समर्तत्य β 26a–b त्रियुता निरंशतो विंशतिं αβ 26d गतिचा (च F) रा° β °दिनाक्रमं αβ 27a चत्वारिंशशिनमध्य° α, चत्वारिशशिनम° β 27b °ष्टयमान्विता विपद्या च αβ 27c प्रथममतौ α 27c–d कुर्यादिवसा αβ 27d मीनद्रो (द्रा B, द्रो C) शि° β °समाना: αβ 28a–b °सप्ततुंपंचकादशगुणान् αβ 28b द्विबगतौ α, द्वियतगौ β 29a झ (त्र C, ड F) ष° β 29a–b °झवापेषु वक्रेषु α, जपा (या C) चे (जे B, न्वे C) षु वक्रेषु β 29b षट् (ड्स A, ड्स C, ड्र B) स (क D) केन αβ, corr. T.-D. ववभागं α, नवभागा β, corr. T.-D. 29c विकृतेन αβ, corr. T.-D. दिनगतिवक्री αβ 30a–b °क (कं β) न्यानुवा (व C) सनैः αβ 30b स्त (स C) रानांशान् αβ, corr. T.-D. 30c सकृते दश β त्रिषष्टी αβ, corr. T.-D.
30d वक्राशा α, चक्रात् β

XVII,25. At rising in the east Mars (traverses) 186 (degrees); then (having traversed) 18 (degrees) in retrogression (it has travelled) half of its course since conjunction; then (traversing) 60 times 3 (= 180) (degrees), it sets;

XVII,26. traversing 10 times 3 (= 30) (degrees) Mars is in conjunction (with the Sun); traversing 30 (degrees) it rises. Now I shall tell the days for the motion of (Mars') gatis in order.

XVII,27. In the first gati 240 plus 28 minus $^1/_2$ (= $267^1/_2$) (days). One should calculate days for every two signs from Pisces:

XVII,28. in the second gati 5, 7, 7, 6, 6, and 5, multiplied by 10 and increased by 7, 1, 2, 6, 1, and 1 in order (i.e., 57, 71, 72, 66, 61, and 51 respectively).

XVII,29. In retrogression ($\Phi \rightarrow \Theta$) in Pisces, Scorpio, Aries, and Sagittarius (Mars goes) 6 degrees in 6 times 7 (= 42) (days), and in extreme retrogression ($\Theta \rightarrow \Psi$) 10 (degrees) in 42 (days). It goes 16 (degrees) in 60 days.

XVII,30. In Taurus, Gemini, Libra, and Virgo (it goes) 7 degrees in 4 times 10 (= 40) (days), and 10 (degrees) in 40 (days). It is retrograde in order 17 (degrees) in 63 (days).

कर्कटसिंहयोर्वेदसागरैः सप्त भवान् सार्णवैश्च ।
दिवसैः षट्षष्ट्याष्टादश च क्रमात् कुजो वक्रसर्वे तु ॥३१॥
घटमृगयोर्यमदहनैः षड् भागान् नवहुताशनैर्(श्च) नव ।
मुनिविषयैः पंचदशांशकांश्च तद्व(त्)त्रये ऽप्यारः ॥३२॥
वक्रे दिनत्रिभागैर्नवांशयुतैस्तुल्यजिह्मैर्भुक्तैः ।
अतिवक्रे विपरीतं वक्रमतिवक्रं सत्र्यंशम् ॥३३॥
एकेन्द्रियवसुशिवमनुभवत्रिवर्गर्तुपञ्चसंयुक्तम् ।
शीघ्रगतौ पंच षष्टिमूनं च शशाङ्ककृतवेदैः ॥३४॥
षष्टि(र्भि)भिश्च संयुक्ता अनिलाद्र्यर्कत्रिवर्गगुणशून्याः ।
दिवसाः सप्तमगत्यां चारो यस्तद्वदष्टम्याम् ॥३५॥
भौमः ॥
दद्यात् सप्तचतुष्कान् युगणे त्र्यंशं च वसुगुणो भाज्यः ।
मुनियमनवकैरपि रोचिताः स्युः शोध्यो दिनाष्टांशः ॥३६॥

31b भवान्] सप्त aβ 31c दिवसान् aβ षट्षा (वा D) ष्ट्या° a, षड्षष्ट्या° β 31d क्रमा a, क्रमान (न् E, म C) β वक्रपू (स CE) र्वास्तु (प्सु EF) aβ 32b भागानवव (वृβ) द्रुताशनैरे (र EF) व च aβ 32d तद्व aβ, corr. T.-D. 33b °युततुल्यजिनैर्भुक्तैः a, °युततुल्यजिह्मे (ह्मे C) र्भुक्ते β 33c अतिचक्रे β 33d वक्रमनुवक्रगस्त्र्यंशं a, वक्रु (द्रु B, न्द्रु E) मनुगस्त्र्यंशं β 34b °भवत्रिगर्ग° (ग्रं C, ग्रै E) β °तु (नु BE) पञ्च° aβ °शंयुक्तं a 34c पंचाष्टकमूनं aβ 34d शशांकतत्त्ववेदैः β 35a षड्त्रिं (ड्रिं D, ड्रिं E, ट्रि F) शस्तंयुक्ता aβ 35b द्विकलाद्र्यार्कात्रि° a, द्वि (द्वि C) फलाद्र्या (द्या C) र्कात्रि° β °वर्गगणशून्यैः aβ 35d चावो a यत्रद्वद° a, यत (न C) द्व (द्व C) द° β, corr. T.-D. 36a दद्या a सप्तनु (तु C) ष्कान् β 36b स्यु (य EF) गणो β त्र्य (त्र्यं F) शश्च aβ वसुगुणा (ण– B, ण E) β भागः aβ 36c–d रोचितस्य मेध्या दिनाष्टांशाः aβ

XVII,31. In Cancer and Leo (it goes) 7 (degrees) in 44 (days), and 11 (degrees) in 40 (days). Mars in all its retrogression in order (goes) 18 (degrees) in 66 days.

XVII,32. In Aquarius and Capricorn (it goes) 6 degrees in 32 (days), and 9 (degrees) in 39 (days). (It goes) 15 degrees in 57 (days). So Mars is in three (sections).

XVII,33. In retrogression (it goes) for $^1/_3$ with $^1/_9$ (= $^4/_9$) of the days, with the even and odd traversed (?); in extreme retrogression the reverse. The retrogression with $^1/_3$ (i.e., $^4/_3$) is the extreme retrogression.

XVII,34. In the fast gati 5 times 60 (= 300) increased by 1, 5, 8, 11, 14, 11, 3^2 (= 9), 6, and 2, and diminished by 1, 4, and 4 (i.e., 301, 305, 308, 311, 314, 311, 309, 306, 302, 299, 296, and 296 days respectively for the 12 zodiacal signs).

XVII,35. In the seventh gati there are 60 increased by 2, 9, 12, 9, 3, and 0 (i.e., 62, 69, 72, 69, 63, and 60) days; there is the same motion in the eighth (gati).

Mars.

XVII,36. One should add 7 times 4 and $^1/_3$ (= 28;20) to the ahargaṇa; multiply (the sum) by 8 and divide (the product) by 927; (the quotient is the number of) the first visibilities (synodic periods) (of Mercury). Subtract an eighth part of a day (for every synodic period);

हृत्वा चतुर्भिरुदयान् नाड्यः शोध्या बुधस्य दिवसेभ्यः /
<अ>ष्टिदशयमघ्नानुदयान् पाण्डववर्जितैश्छिन्द्यात् //३७//
नववसुरसैर्मध्यमतो बुधो <ऽष्टां>शा<न्&gt् क्रमा<द्>हृदैस्त्रैश्च /
पंचयुतैस्त्रिंशद्भिस्त्रिंशद्भके स्फुटानंशान् //३८//
नवकृत्या षष्टिं वसुयुतयाशीत्या शतं स तीक्ष्णांशुम् /
शर्वैस्त्रिभिरभ्यधिकैस्त्रिंशद्भिस्त्रिंशदेवांशान् //३९//
चतुरधिकेन शतेन त्रिभिरूनं शतमतो ऽर्धसंयुतया /
षड्विंशत्या त्र्यधिकां विंशतिमेवं स्फुटः सौम्यः //४०//
अनयोर्विश्लेषांशा<न्> दिवसेभ्यः शोधयेत् स्फुटाभ्यधिके /
अधिके तु मध्यमें ऽशान् दद्याच्चारः स्फुटबुधाच्च //४१//
मेषे दिनषट्कृत्या सभवस्वरसप्तहीनया भागान् /
पंचत्रिंश<द्> द्विकृतिं त्रिसप्तकं षडङ्कगुणितम् //४२//

37a कृत्वा aβ, corr. T.-D. 37b दुधस्य a, बुधस्या β, corr. T.-D. 37c त्रिद (द om. C) शयम° aβ 37d °यान् रामार्णव° a, °यारुदयां (शां B) रामाणव° β °वर्जितां छिंद्यात् aβ 38a-b नववसुयममध्यमधो: साक्रमांनुदत्रैश्च a, नववसुमध्ययम-मध्य (यममध्य om. C) मधो: सा (शा BE) क्रमाह (रु F) टत्रैश्च β 38d °द्रुके aβ, corr. T.-D. 39a नव (व om. C) कृत्यात् aβ, corr. T.-D. षष्टिर्वसु° aβ, corr. T.-D. 39b °युतावशीत्या aβ, corr. T.-D. तीक्ष्णांशो: aβ 39c सर्वैस्त्रिभि° aβ, corr. T.-D. °रभ्यकधिकै° a 39d °देवार्का (र्का C, र्का F) त् (न् E) aβ, corr. T.-D. 40a चतुरधिकेन् a 40b त्रिभिरुनं aβ, corr. T.-D. र्धसंयुतया aβ, corr. T.-D. 40c षड्त्रिंशत्या a अधिकां aBE 41a °र्विश्लेषांशा aβ, corr. T.-D. 41b शोधये a after 41b repeat 40a–d aβ 41c-d मध्यमे स्यादधाच्चार aβ, corr. T.-D. 42a-b षट्कृ (ड्कृ a, ड्कृ B, ट्कृ E) त्यां (सा B) शं भवस्वर° aβ 42b भाग: aβ, corr. T.-D. 42c पंचत्रिंश aβ, corr. T.-D. 42d षड्व (ड्वय D) गैवगणितं a, षड्व (ड्व F) व (च B) गणित β

XVII,37. divide the (number of) risings by 4 and subtract (so many) nāḍīs from the days of Mercury (i.e., 15 vināḍīs for every synodic period). Multiply the risings by 217 and divide (the product)

XVII,38. by 689 diminished by 5 (= 684); (the result concerns) the mean Mercury. (It) travels in order: 8° in 2 plus 5 (= 7) days, 30 accurate degrees in 30,

XVII,39. 60 (degrees) in 9^2 (= 81), 100 (degrees) in 80 plus 8 (= 88), 12 (degrees) in 14, 30° in 30 plus 3 (= 33),

XVII,40. 100 minus 3 (= 97) (degrees) in 100 plus 4 (= 104), and 20 plus 3 (= 23) (degrees) in 26 plus 5 (= 31); thus (travels) true Mercury.

XVII,41. One should subtract from the days the degrees of difference between these two (i.e., mean and true segments) if the true is greater; but if the mean is greater, one should add the degrees. The motion is known from true Mercury.

XVII,42. In Aries, in 6^2 (= 36) days diminished by 0, 11, 7, and 7 (i.e., 36, 25, 29, and 29) (Mercury travels) 35, 22, 3 times 7 (= 21), and 6 times 9 (= 54) degrees.

गवि वेदयमद्विकृतैर्दिग्घ्नैर्विषयाग्निगुणनवाभ्यधिकैः /
बिरसं शतार्धममरैरुडूनं च सप्ततिं व्येकाम् //४३//
द्विदशं सपंचवर्गं स्वरसत्रिघ्नान्वितं च मिथुने च /
भागार्धशतं द्व्यूनं मनवस्त्रिघ्नं च पंचसप्त //४४//
कर्किणि दिग्घ्नैः कृतशशिगुणवेदैः सद्विकाष्टशून्यरसैः /
सैकान् दलितान् सेन्दून् पंचकवर्गान्वितांश्चांशान् //४५//
सिंहे गुणेन्दुरामार्णवैर्दिग्घ्नैस्तथा सार्णवर्तुयमविषयैः /
तुल्यां सप्तविहीनां सदृशामधिकां विषयकृत्या //४६//
कन्यायास्तुकृत्याष्ट(दशत्रि)त्रिंशत्त्रिकृतैर्न भूयः /
त्रिघ्ननवपंचसप्तकमष्टशतार्धं च रवियुक्तम् //४७//
विंशतिरेकेन युता जूके सशून्यतिथिर्द्विसद्गुणाश्च /
अंशास्त्रिवसुविहीना ह्येकत्रिंशद्युताश्चैव //४८//

43a गाव α, माव β, corr. T.-D. वेदे α °द्विकृतो α, द्वितता β, corr. T.-D. 43b द्विघ्नै° αβ, corr. T.-D. °र्विषयग्नि° α °गण° αβ, corr. T.-D. 43c शताद्धमम (न β) लो αβ 43d रुद्रावद्य (य C) सप्तभिर्व्येकां (क α) αβ 44b मिथुनं αβ, corr. T.-D. 44c द्व्यून α 44d प (प om. C) च (व α CF) सुतश्च (तश्च om. β) αβ 45a–47c कर्किणि to त्रिघ्ननवपंच° om. β 45a कीर्किनि α, corr. T.-D. दिघ्नै: α, corr. T.-D. 45b °सून्यरसै: α, corr. T.-D. 45c सैकां दलितां सेंदु α, corr. T.-D. 46b °विषया: α, corr. T.-D. 46c तुल्या α, corr. T.-D. 47a–b °सुकृत्याष्टत्रिंशत्तया तया न भूयः α 47c–d °सप्ताष्टकद्य (श C) ताद्धे (र्धं α) αβ 47d च om. β 48a °रेकेण αβ, corr. T.-D. 48b व्यन स्वांसांतिथिर्द्वि (द्वि α C) सं (स β) गुणैश्च αβ 48d द्येक° α, य (द्य CF) क β, corr. T.-D. °स्त्रिंशद्यु (फ C) ताश्चैव β

XVII,43. In Taurus, in 10 multiplied by 4, 2, 2, and 4 and increased by 5, 3, 3, and 9 (i.e., 45, 23, 23, and 49) (days it travels) 50 diminished by 6, 33, and 27 (i.e., 44, 17, and 23) (degrees) and 70 diminished by 1 (= 69).

XVII,44. In Gemini, in 20, increased by 5^2 (= 25), 0, 6, and 3^3 (= 27) (i.e., 45, 20, 26, and 47) (days it travels) 50 diminished by 2 (= 48), 14, 3^3 (= 27), and 75 degrees.

XVII,45. In Cancer, in 10 multiplied by 4, 1, 3, and 4 and increased by 2, 8, 0, and 6 (i.e., 42, 18, 30, and 46) (days it travels these numbers of) degrees increased by 1, halved, and increased by 1 and 5^2 (= 25) (i.e., 43, 9, 31, and 71).

XVII,46. In Leo, in 10 multiplied by 3, 1, 3, and 4 and increased by 4, 6, 2, and 5 (i.e., 34, 16, 32, and 45) (days it travels) an equal (number of degrees), diminished by 7, the same, and increased by 25 (i.e., 34, 9, 32, and 70).

XVII,47. In Virgo, in 26, 18, 33, and 43 (days)—no more—(it travels) 3^3 (= 27), 9, 5 times 7 (= 35), and 58 increased by 12 (= 70) (degrees).

XVII,48. In Libra, (in) 20 increased by 1, 0, and 15, and multiplied by 2 (i.e., 21, 20, 35, and 40) (days it travels these numbers of) degrees diminished by 3 and 8 and increased by 1 and 30 (i.e., 18, 12, 36, and 70).

अलिनि दशाद्याः शशि(द्वि)कृतदहनाः षट्शरार्णवाष्टयुताः /
तेंऽशा यममुनीशोना षड्विंशत्या समेताश्च //४९//
धन्विनि दिवसानीह षट्कृतिं षट्सप्तकं दशोनं च /
ते स्युः शशिविषयोनाः सैकास्त्रिंशान्विता भागाः //५०//
मकरे द्विदशं स्वयुतं मुनियुक्तं धृतिदिवाकराभ्यधिकम् /
अंशा रूपेणोनाः सैकैकाश्चोत्कृतियुताश्च //५१//
कुम्भेऽह्नां त्रिकृत्या युतया हुतभुग्दिनेशदिननाथैः /
द्वाविंशतिरंशाः पंचवर्गं सुराधिपाः षष्टिः //५२//
मीने त्र्यष्टकमह्नां शशिविषययुतं हुताशसंयुक्तम् /
त्र्यष्टककृतविंशत्याः शतार्धमेकोनमंशाः स्युः //५३//
अथोदयान्तरांशा बुधस्य कालांशकास्त्रिगतीनाम् /
दिवसाश्चतुर्थगत्या अनुवक्रमजमीनयोर्मन्दम् //५४//

49a दशाद्यी a 49a-b शशिकृत (त om. β) दहनाः aβ 49b षड्स्वशर्णवाष्ट° a, षट्स्वरार्णवाष्ट° β 49c तेंशा a, तेशां (षों C) β, corr. T.-D. 49d समेता (ना aBF) च (व a) aβ, corr. T.-D. 50a दियसाद्या (या β) ष्टौ aβ 50b षोडश (स a) aβ षड् (ट् D) सप्तकं a 50c स्फुः a °विषयोनैः aβ, corr. T.-D. 50d सैका त्र्यंशा° a, सैका त्रिंशा° β 51a स्युदशं aβ, corr. T.-D. 51b मुनिहीनं aβ 51c आशा (षा C) β रूपेणोनाः aβ, corr. T.-D. 51d °सोत्कृ (क्रु C) ति° β 52a ह्ना a त्रिंशत्या aβ 52b हु (ग C) तभुग्द (दि C) वेददिननाथैः aβ 52c °वर्गमथाधिका aβ 53a अष्टक° β 53b हुताशसशरं a, हुताशस (स om. BE) शीरं β, corr. T.-D. 53c त्र्यष्टककृति° a, अष्टककृ (क्र E) ति° β 53d °मेकोनमष्टां aβ, corr. T.-D. 54a अष्टोदयां° aβ °तरांशान् a 54b कलांशकां° aβ °स्त्रिगत्सुनात् a, °स्त्रिगन्यूनान् β 54c दिवसा चतुर्थ° β 54d °मीनयोंदं a

XVII,49. In Scorpio, (in) 10 multiplied by 1, 2, 4, and 3 and increased by 6, 5, 4, and 8 (i.e., 16, 25, 44, and 38) (days it travels these numbers of) degrees diminished by 2, 7, and 1 and increased by 26 (i.e., 14, 18, 43, and 64).

XVII,50. In Sagittarius, in 16, 26, 6 times 7 (= 42), and (this) diminished by 10 (= 32) days (it travels these numbers of) degrees diminished by 1 and 5 and increased by 1 and 30 (i.e., 15, 21, 43, and 62).

XVII,51. In Capricorn, in 20 increased by 0, 7, 18, and 12 (i.e., 20, 27, 38, and 32) (days it travels these numbers of) degrees diminished by 1 and increased by 1, 1, and 26 (i.e., 19, 28, 39, and 58).

XVII,52. In Aquarius, in 23 increased by 3, 12, and 12 (i.e., 23, 26, 35, and 35) days (it travels) 22, 5^2 (= 25), 33 and 60 degrees.

XVII,53. In Pisces, in 3 times 8 (= 24) increased by 1, 5, and 3 (i.e., 24, 25, 29, and 27) days (it travels) 3 times 8 (= 24), 24, ⟨24⟩, and 50 diminished by 1 (= 49) degrees.

XVII,54. For the (first) three gatis of Mercury the time-degrees are degrees of ascensional differences (?); for the fourth (gati) days (?). In Aries and Pisces the direct motion is slow.

गतिविश्लेषकृतिघ्नैरंशैर्गतवर्गभाजितैर्लब्धम् /
हित्वा राशिभ्यो भुक्तं प्रथमगतौ वक्रपश्चात् //५५//
वक्रगतौ पूर्वार्धे तृतीयगत्याश्च यातकृतिगुणितैः /
भागैर्गतकृतिभक्तैः फलमनुपाताच्चतुर्थगतौ //५६//
ज्याविधिनाविक्षेपघ्नाच्चरकालादम्बराष्टवेदांशम् /
जह्यात् क्षिपेच्च याम्योत्तरे ग्रहे स्वं यथा कल्पम् //५७//
एवं कृते ग्रहार्कान्तरांशकैरस्तदर्शनं तेषाम् /
चन्द्रादीनां द्वादशमनुरवितिथ्यष्टतिथिसंज्ञैः //५८//
त्रिशतविनाडीगुणितैरुदय(वि)नाडीप्रमाणहृतैः /
लब्धांशकप्रमाणादुदयो ऽस्तं वा स्फुटं वाच्यम् //५९//
ज्ञसितारेज्यार्क्यूनाः शशिनः प्रत्युत्तरं रव्यंशाश्च /
ज्ञात्वैवं विक्षेपाद्दादेशमनागतं कुर्यात् //६०//

55c–d भुक्तं β 55d प्रथमगातौ a वक्रषश्चाश्चा a, वक्रपश्चाश्चा β 56a वर्गैक्रगतौ a, चक्रगतौ β 56b °गत्या च aβ यात्कृतं a, याच (च om. CF) तच्चत° β 56c भागैर्गीति° aβ, corr. T.–D. °कृतिभृत्यै β 56d °पाताच्चतुर्थभागागनौ a, °पाच्च चतुर्थभागग (ग om. C) तौ β, corr. T.–D. 57a–b °विक्षेपघ्ना चर° aβ, corr. T.–D. 57b °काला (ला om. BE) दिम्बराष्ट° β 57c जह्या a 57c–d यान्मोत्तरं a, याम्यों (भ्यों C) तरे β, corr. T.–D. 57d यथा कच्चं a 58d °रविति (तिथ C) ष्टतिथि-संज्ञैः β 59a त्रिंशत° a, त्रिंशति° β, corr. T.–D. 59a–b °गुणितैघ्न (corr. to ह्व D²) दशनाडी° a, °गुणितैश्च दशनाडी° β, corr. T.–D. 59b °प्रमाणहृतेः aβ, corr. T.–D. 60a °ज्यार्कोनाः a, °ज्यार्क्कौ (र्क्कौ C) ना β 60b स्वरांशोना aβ 60d °मनागमत (तत C) त्कुर्यात् β

XVII,55. Multiply the degrees by the square of the difference between the gatis and divide (the product) by the square of what has passed; subtract the quotient from the zodiacal signs; the result is what has been traversed after the first station in the first gati.

XVII,56. In the retrograde gati, in the first half, multiply the degrees by the square of what has passed of the third gati and divide (the product) by the square of what has passed; the result is, by proportion, (what has been traversed) in the fourth gati.

XVII,57. Multiply the time of the ascensional difference by the latitude (of the planet) in the form of a Sine; take a 480th part (of the product); one should subtract or add (the result) according to its orbit as the planet is south or north (of the east-point).

XVII,58. Having done thus, the visibility at setting of the Moon and so on is with 12, 14, 12, 15, 8, and 15 degrees between the planet and the Sun (i.e., Moon 12°, Mars 14°, Mercury 12°, Jupiter 15°, Venus 8°, and Saturn 15°).

XVII,59. Multiply (these degrees) by 300 vināḍīs and divide (the product) by the measure of rising in vināḍīs; from the measure of the obtained degrees the accurate rising or setting (of the planet) is to be declared.

XVII,60. The degrees of the Sun are to be diminished by (the longitude of) Mercury, Venus, Mars, Jupiter, and Saturn; the opposite in the case of the Moon. Thus knowing (the elongation necessary for first visibility) from the latitude, one should compute the future prediction.

आवन्त्यकः समासाच्छिष्यहितार्थं वियद्गस्फुटांशम् /
चक्रे वराहमिहिरस्ताराग्रहकारिकातन्त्रम् ॥६१॥
प्रद्युम्नभूमितनये जीवे सौरे ऽथवा विजयनन्दिकृते /
बुधो भग्नः स्फुटमिदं करणं भजति दृष्टं वराहमिहिरेण ॥६२॥
प्रस्तावे ऽपि न दोषा(न्)जानन्नपि वक्ति यः परोक्षस्य /
प्रथयति गुणांश्च तस्मै सुजनाय नमः परहिताय ॥६३॥
अष्टादशभिर्बान्यत्ताराग्रहतन्त्रमेतदार्याभिः /
वरमिति वराहमिहिरो ददाति निर्मत्सरः करणम् ॥६४॥
आकरणाद्विभागा दिवसाश्चारांशका रवौ कार्याः /
अधिका यदा दिनेभ्यो भागा ज्ञेयास्तदा चक्रात् ॥६५॥
नवयमगुणर्तुहीने कृताहते विषयसप्तखाग्निहृते /
भूयो हृते चतुर्भिर्निरंशदिवसा महीजस्य ॥६६॥

61a आयंतकः β 61a-b समासछिष्य° a, समसाः छिसंष्यं β, corr. T.-D. 61b तमद्गस्फुटांशं aβ 61c वराहमिहर° aβ, corr. T.-D. 62a प्रद्युम्न° a °सुमिß 62b जी (जि C) वै (वे C) aβ, corr. T.-D. शौर a वीजयनंदि° a कृतो β 62c बुधेव a, छुधे (धा C) च β नग्ना a, भग्ना – β 62d भजतां aβ वरा (र C) हमिहरेण aβ, corr. T.-D. after this verse add सुखप्रबोधां (धां β) aβ 63a दोषा aβ, corr. T.-D. 63b जानन्नापि न a, ज्ञानाना (न C) पि न β, corr. T.-D. पटोक्षस्य a 63c प्रथयाति β गुणाश्च a, गुणा° β, corr. T.-D. °स्तस्मै β 63d सु (स्तु F, स्त C) जनया aβ, corr. T.-D. नम a, तमः β, corr. T.-D. पर (रि C) हिताया β 64a-b °दशभिर्बद्धान्यातारा° a, °दशभिर्बे (ब CF) धान्यातारा° β 64c वराहमिह (हर E) aβ, corr. T.-D. वराहमिहरो β 64d निमत्स (त्सम C) रः β 65b दिवसा (मा D, corr. to सा D²) श्चारांशका a, दिवसाश्चांश (स C) का β, corr. T.-D. 65c अधिकार्यदा दितेभ्यो aβ, corr. T.-D. 65d वक्रात् β 66a °यमगृणार्नु° a, °यमगुणार्तु° β, corr. T.-D. 66b कृ (क्रु β) ताहृते aβ, corr. T.-D. °सप्तग्निहृते β 66c हतो aβ, corr. T.-D. 66d °विरंस° a, °भि (श्च BE) रंस° β, corr. T.-D.

XVII,61. In order to benefit his pupils, Varāhamihira of Avantī has made concisely this tantra of kārikās concerning the star-planets which (gives) the degree of true longitude of the planets.

XVII,62. The wise man who is disturbed at Pradyumna's Mars or at Jupiter or Saturn as computed by Vijayanandin resorts to this accurate karaṇa which has been "seen" by Varāhamihira.

XVII,63. He who, though knowing the faults of one who is absent, does not tell them even when the occasion (presents itself), but recites his good qualities—to that noble benefactor of others, reverence!

XVII,64. Varāhamihira, being free from jealousy, gives this other tantra for the star-planets in 18 āryā (-verses) (thinking): "This is the best karaṇa."

XVII,65. (Take) the degrees of (the longitude of) the Sun at the (last) calculation; convert the days (since then) into degrees of motion for the Sun. When (the degrees) are added to the days, then the degrees (of the Sun's longitude) within the circle (of the zodiac) are to be known.

XVII,66. Diminish (the ahargaṇa) by 6329; multiply (the remainder) by 4, divide (the product) by 3075, and divide (the remainder) again by 4; (the result) is the days of conjunction (with the Sun) of Mars.

षट्त्रिंशैस्तिथ्यंशा दृष्टो वसुधृति(भि)रंशकाः षष्टिः /
अष्टशतेन च षष्टिः सप्तत्या ध्यधिकया नवतिः //६७//
षष्ट्याष्टयुक्तया शतदलं च साब्ध्यद्रिकैः स्वरा दिग्घ्नाः /
अस्तमितो ऽतः सप्ताष्टकेन तिथयो निरंशगतिः //६८//
कुजः //

विश्वशिवसुरसेन्दौ नवयमगुणिते ऽर्करा(सो)गुणाब्धके /
गुणकारहृते लब्धान्यहानि शीतांशुपुत्रस्य //६९//
दशभिर्द्वादशहीनः प्रागुदितो मनुभिर्विषयाष्टांशाः /
धृतिभिर्मनवो ऽस्तमितस्त्रिंशद्भिरुदेति स रसांशाः //७०//
अष्टादशभि(सि)र्नवः षोडशभिस्साष्टवर्जितो ऽस्तमितः /
पश्चाद्वसुभिर्नववर्जितो निरंशं बुधो ऽपि याति //७१//
बुधः //

67a षड्त्रिंत्सबैस्तिथ्युनो a, षड्विबैस्तिथ्यतो β 67b दृष्टो β °धृतिरंशका ष (च्छ A, छ D)ष्टि: aβ, corr. T.-D. 67c व a 67d सप्तध्यधिकया β 68a षष्ट्यो (ष्टो β) ष्ट° aβ, corr. T.-D. 68a-b संतदलं a, सप्तदलं β, corr. T.-D. 68b साब्ध्यधिकै: β टिघ्ना: aβ, corr. T.-D. 68c-d साष्टकेन β 68d निरंगशनि: (नि β) aβ, corr. T.-D. 69a बिंशशि° a °रसेंद्रे (द्रा EF) aβ 69a-b नवनवगुणिते aβ, corr. T.-D. 69b कैरागुणाब्धके (के: CF) aβ, corr. T.-D. 69c °हृते a, °हते β 69c-d लब्धा (ब्धु C) न्य – (नाश्वि.. C) तांशुपुत्रस्य β 70a दशभि द्वा° a °दशहीना: aβ, corr. T.-D. 70b मनिभीरुनभ्यष्टांशा: a, मैनाभीरुनत (न्त B) ष्टांशा: β 70c °शनवो a, °नवो (वौ C) β स्तमित: त्रिं (क्रिं F) श° aβ, corr. T.-D. 70d स रसाष्ट: a, स (स om. C) रसाष्टा: β 71a अष्टादभि: a, अष्टादशाभि: β 71b षोडभिस्साष्ट° a 71c पश्चात् वसु° aβ, corr. T.-D. 71d निरंस (स a) aβ, corr. T.-D. पि (पि om. D, "here a प" in marg. D[2]) याति a, याति β

XVII,67. In 36 (days) (it comes to the Sun) diminished by 15 (degrees) and becomes visible; in 188 (days) (it travels) 60°; in 108 (days) 60 (degrees); in 70 plus 2 (= 72) (days) 90 (degrees);

XVII,68. in 60 plus 8 (= 68) (days) 50 (degrees); in 240 (days) 7 times 10 (= 70) (degrees); then it sets; in 7 times 8 (= 56) (days) 15 (degrees); then it comes into conjunction (with the Sun).
Mars.

XVII,69. Diminish (the ahargaṇa) by 1681; multiply (the remainder) by 29 and divide (the product) by 3312; divide (the quotient) by the multiplier (29); the result is the days of Mercury.

XVII,70. In 10 (days) it is diminished by 12 (degrees) and rises in the east; in 14 (days) (it is diminished by) 5°; in 18 (days) 14 (degrees); then it sets; in 30 (days) 6° and it rises;

XVII,71. in 18 (days) 14 (degrees); in 16 (days) it is diminished by 8 (degrees) and sets in the west; in 8 (days) Mercury is diminished by 9 (degrees) and comes into conjunction.
Mercury.

रहिते यमशराष्टिभिर्नगाहते द्विविषयस्वराब्धिहृते /
सप्तहृते देवगुरोर्भवन्ति दिवसा निरंशगस्य //७२//
सर्वे ऽर्कात् संशोध्याः षोडशभिर्द्वादशोदितः प्राच्य<म्>//
कृतविषयैः कृतवेदाः सप्तत्या सार्णवा षष्टिः //७३//
नवतिभिः शून्याकाष्टाशीत्या रसस्वरा स्तुभिः /
शून्यकृतैर्द्वात्रिंशत्ततो ऽस्तगः षोडशभिरर्कान् //७४//

जीवः //

नयनार्कमहीन्दूने द्विगुणे रूपेन्द्रियेश्वरैर्भक्ते /
शेषं यत्तद्दलितं भृगुतनयनिरंशदिवसाः स्युः //७५//
विषयैर्नवकविहीनः प्रागुदितस्तिथि<भि>रेकयमहीनः /
वसुकृत्या तिथ्यूनः कृत<घ्नै>स्त्रिभिः स <पंचास्तगः> //७६//

72a रहिते ष्टिद्वि (ष्टि C, द्विती F) यम° $\alpha\beta$ 72b °नागह (हि E) ते $\alpha\beta$, corr. T.-D.
द्विविषयस्वराब्धिहृते α, द्विविषय (यं F) स्व (म्स्व E, म्स्व B, स्व C) राब्धिहृते β, corr. T.-D.
72c-d देवगुरौ भवन्ति $\alpha\beta$, corr. T.-D.   72d तिरांसं गम्याः α, निरंश (शं F) गम्याः β
73a कात् (त् F) $\alpha\beta$, corr. T.-D.   73b प्राक्र α, प्राक् β, corr. T.-D.   73c कृतविषयैः om. β
क्रतुबेदाः β 74a नवातिभिः β 74c शून्यकृतिर्द्वात्रिंश α, शू (शु C) न्यक्रु (क्र E)
तिर्द्वात्रिंश β, corr. T.-D.   74d तोतु (रु β) मस्तगा (गात् β) $\alpha\beta$, corr. T.-D.   °रर्का (र्का G,
र्घा F) त (त्र E) $\alpha\beta$, corr. T.-D.   75a नयनार्के (र्के E, र्धु F) मितिद्रुने $\alpha\beta$, corr. T.-D.
75b रूपेंद्रियैः स्वरैर्भ (भ C F) के $\alpha\beta$, corr. T.-D.   75c यत्त (कृ β) दलितं $\alpha\beta$, corr. T.-D.
76b °स्तिथिरेकय (प α) म° $\alpha\beta$, corr. T.-D.   76c बसुकृत्या α तिथ्युन α
76d कृ (क्रु EF, क्र B) ताष्ट (ष्टा β) भिः स $\alpha\beta$

XVII,72. Diminish (the ahargaṇa) by 1652; multiply (the remainder) by 7 and divide (the product) by 2752; divide (the quotient) by 7; they are the days of Jupiter coming into conjunction (with the Sun).

XVII,73. All are to be subtracted from the Sun. In 16 (days) (it travels) 12 (degrees) and rises in the east; in 54 (days) 44 (degrees); in 70 (days) 60 plus 4 (= 64) (degrees);

XVII,74. in 109 (days) 120 (degrees); in 88 days 76 (degrees); in 40 (days) 32 (degrees); then it sets; and in 16 (days) 12 (degrees).

Jupiter.

XVII,75. Diminish the ahargaṇa by 11 122; divide (the remainder) by 1151; take half of the remainder; these are the days of Venus' conjunctions (with the Sun).

XVII,76. In 5 (days) it is diminished by 9 (degrees) and rises in the east; in 15 (days) diminished by 21 (degrees); in 208 (days) diminished by 15 (degrees); in 3 times 4 (= 12) (days) 5 (degrees) and it sets;

षष्ट्याष्टकेन स दृश्यो निरंशगोऽतो विलोमगः पश्चात् /
उदयति निरंशकालान्न याति वास्तं दि⟨न⟩नाथगतिः //७७//
शुक्रः //
विधृतिशररसशशाङ्के त्रिघ्ने धृतिरुद्रभाजिते ऽग्निहृते /
सौरस्य धृतिभिरष्टैः सार्धार्काद्भानिरुदितः प्राक् //७८//
अष्टनवतिभिर्नवतिर्दृष्टं च मनुभिस्त्रयोदशविहीनः /
गुणरुद्रैः शून्यार्का ऊनेन शतेन शशिनवकम् //७९//
अतिजगतिभिरर्का⟨न्⟩ सार्धा⟨न्⟩नस्तमेति नव⟨दश⟩भिर्निरंशम् /
षोडश सार्धान् सौरश्चरति रवेः सर्वदा हीनः //८०//
शनैश्चरः //
पौलिशसिद्धान्ते ताराग्रहाः //
इत्याचार्यवराहमिहिरकृता पंचसिद्धान्तिका समाप्ता //

77b निरंसतो तो α, निरंश (स CF) ताततो β, corr. T.–D. 77c-d उदयति ति(ति om. CF) थिनिरंशकालोन (श β) य (व β) ति αβ 77d विनाथगतिः αβ 78a °रसषड्कवर्के (कैं β) शशांके αβ 78b °भाजिता (त CF) β ग्नि (ध्नि C) हृ (हू A) ते αβ 78c सौरस्प α धृतिभि (भि om. E) रष्टा (ष्ट C) भि αβ, corr. T.–D. 78d सार्धार्केहानि° α, सार्धार्कें हानि° β 79a अष्टनवतिर्म्यो (र्म्ये C) नवति° αβ, corr. T.–D. 79b च om. β 79d ध्रुनेन α, ध्रु (ध्रू F) नेन β, corr. T.–D. here ends D शशिनवकं A 80a-b अतिजग - - र्कारस्तमेत्यंतो A, अतिजगति (ती F) भिर (र om. B) र्का (र्क्का F) रस्ते मे (मे om. C) त्य (सं CF) त्तो (त्रो E, तो CF) β 8b न (श C) वतिभि- र्वि (वि F) रंशं (शंशं C) αβ 80c सार्धात् A, सार्धा β, corr. T.–D. 80d रचे: A col. एवमित्याचार्य° β °वराहमिहर° Aβ, corr. T.–D.

XVII,77. in 6 times 8 (= 48) (days) 10 (degrees) and it comes in conjunction (with the Sun); then it goes in the reverse order in the west. After the time of conjunction it rises, it stands still, it sets, and it comes (in conjunction with) the Sun.

Venus.

XVII,78. Diminish (the ahargaṇa) by 16 518; multiply (the remainder) by 3 and divide (the product) by 1118; divide (the quotient) by 3; (the result is the days) of Saturn. In 18 (days) it is diminished from the Sun $16^1/_2$ (degrees) and rises to the east;

XVII,79. in 98 (days) $90^1/_2$ (degrees); in 14 (days) it is diminished by 13 (degrees); in 113 (days) 120 (degrees); in 100 minus 2 (= 98) (days) 91 (degrees);

XVII,80. in 13 (days) $12^1/_2$ (degrees) and it sets; in 19 (days) Saturn travels $16^1/_2$ (degrees) to conjunction (with the Sun). It is everywhere subtracted from the Sun.

Saturn.

The Star-planets in the Pauliśasiddhānta.

Thus the Pañcasiddhāntikā composed by ācārya Varāhamihira is completed.

4. The Bhūtasaṅkhyā System in the Pañcasiddhāntikā

0. ambara, ākāśa, kha, gagana, bindu, viyat, vyoman, śūnya
1. indu, īśa, ku, candra, jagati, bhū, mahī, rūpa, śaśāṅka, śaśi, śītakara, śītaraśmi, śītāṃśu, himāṃśu
2. akṣi, aśvi, kara, dasra, nayana, pakṣa, yama, yamala
3. agni, anala, guṇa, dahana, rāma, vahni, śikhin, hutabhuj, hutāśa, hutāśana, hotṛ
4. abdhi, arṇava, kṛta, ghana (= ghanada), caraṇa, jala, jaladhi, yuga, lavaṇoda, veda, samudra, sāgara
5. akṣa, artha, indriya, iṣu, pāṇḍava, bāṇa, bhūta, viṣaya, śara
6. ṛtu, rasa
7. adri, aśva, naga, muni, svara
8. tanu, vasu
9. aṅka, anilāhva, randhra
10. āśā, diś
11. īśvara, bhava, rudra, śiva, svargeśa
12. arka, ina, tīkṣṇāṃśu, dinanātha, dinapa, divākara, bhāskara, maṇḍala, ravi
13. atijagati, viśva
14. manu, śarva
15. tithi
16. aṣṭi
18. dhṛti
20. kṛti, nakha
21. mūrchanā
24. jina
26. utkṛti
33. amara, surādhipa
40. naraka
10 000. ayuta

5. Metrological Units in the Pañcasiddhāntikā

Time:

yuga—period in which integer numbers of revolutions of (a) the Sun and Moon or of (b) all the planets occur.

saura measure:

saura year—period in which the Sun travels 360° (normally measured with respect to the fixed stars, i.e., a sidereal year; but cf. the Romakasiddhānta).

saura month—period in which the mean Sun travels 30°.

saura day—period in which the mean Sun travels 1°.

lunar measure:

lunar year—twelve mean synodic months.

lunar month—(a) the mean or (b) the true period between two successive conjunctions (or oppositions) of the Sun and Moon.

lunar day = tithi—a thirtieth of a lunar month. Three varieties of tithi are known: (a) the mean period in which

the elongation of the Sun and Moon increases by 12°; (b) the true period in which the elongation of the Sun and Moon increases by 12°; and (c) the sāvana day which begins during a given tithi.
karaṇa—half a tithi.
omitted tithi = avama or ūnarātra—a tithi which does not contain the beginning of a sāvana day.

sāvana measure:
sāvana year—saura year.
sāvana month—true lunar month.
intercalary month = adhimāsa—the accumulation of 30 tithis from the difference between a saura and a lunar year.
sāvana day—ordinarily the period between two successive sunrises (audayaka), but the period between two successive midnights (ārdharātrika) in the Sūryasiddhānta.
muhūrta—a thirtieth of a sāvana day.
24-hour day—the mean period between two successive midnights or two successive noons.
kṣaṇa—an eighth of a 24-hour day; 3 hours.
nāḍī (nāḍikā) = ghaṭī (ghaṭikā)—a sixtieth of a 24-hour day.
vināḍī (vināḍikā)—a sixtieth of a nāḍī.

Relations in a yuga:
saura years = saura months: 12 = saura days: 360.
lunar years = lunar months: 12 = tithis: 360.
lunar months = saura months + intercalary months.
tithis = sāvana days + omitted tithis.
ahargaṇa—lapsed sāvana days from a given epoch.

Circle:

cakra = bhagaṇa—360°.
cakrārdha = cakradala—180°.
rāśi (rāśika) = bha—30° arcs laid off consecutively from Aries 0°.
nakṣatra = bha—13;20° arcs laid off consecutively from Aries 0°.
aṃśa = bhāga—1°.
kalā = liptā (liptikā) (from λεπτόν)—0;1°.
vikalā = viliptā (viliptikā)—0;0,1°.
tatpara—0;0,0,1°.

Space:

aṅgula—digit.
hasta—hand; 24 aṅgulas.
krośa—4000 hastas.
yojana—4 krośas.

	Nakṣatras	Beginnings		Nakṣatras	Beginnings
1	Aśvinī	0°	15	Svāti	186;40°
2	Bharaṇī	13;20	16	Viśākhā	200
3	Kṛttikā	26;40	17	Anurādhā	213;20
4	Rohiṇī	40	18	Jyeṣṭhā	226;40
5	Mṛgaśiras	53;20	19	Mūla	240
6	Ārdrā	66;40	20	Pūrvāṣāḍhā	253;20
7	Punarvasu	80	21	Uttarāṣāḍhā	266;40
8	Puṣya	93;20	22	Śravaṇa	280
9	Āśleṣā	106;40	23	Dhaniṣṭhā	293;20
10	Maghā	120	24	Śatabhiṣaj	306;40
11	Pūrvaphālgunī	133;20	25	Pūrvabhādrapadā	320
12	Uttaraphālgunī	146;40	26	Uttarabhādrapadā	333;20
13	Hasta	160	27	Revatī	346;40
14	Citrā	173;20			

	Months	Seasons		Months	Seasons
1	Caitra	Vasanta	7	Āśvina	Śarad
2	Vaiśākha		8	Kārttika	
3	Jyaiṣṭha	Grīṣma	9	Mārgaśira	Hemanta
4	Āṣāḍha		10	Pauṣya	
5	Śrāvaṇa	Vārṣa	11	Māgha	Śiśira
6	Bhādrapada		12	Phālguna	

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Færdig fra trykkeriet den 1. december 1970.

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Printed in Denmark
Bianco Lunos Bogtrykkeri A/S

O. NEUGEBAUER AND D. PINGREE

THE PAÑCASIDDHĀNTIKĀ OF VARĀHAMIHIRA

PART II

Det Kongelige Danske Videnskabernes Selskab
Historisk-Filosofiske Skrifter 6, 1, Part II

Kommissionær: Munksgaard
København 1971

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Selskabets sekretariat og postadresse: Dantes Plads 5, 1556 København V.

The address of the secretariate of the Academy is:

Det Kongelige Danske Videnskabernes Selskab,
Dantes Plads 5, 1556 København V, Denmark.

Selskabets kommissionær: Munksgaard's Forlag, Prags Boulevard 47, 2300 København S.

The publications are sold by the agent of the Academy:

Munksgaard, *Publishers,*
47 Prags Boulevard, 2300 København S, Denmark.

O. NEUGEBAUER AND D. PINGREE

THE PAÑCASIDDHĀNTIKĀ OF VARĀHAMIHIRA

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Det Kongelige Danske Videnskabernes Selskab
Historisk-Filosofiske Skrifter **6, 1**, Part II

Kommissionær: Munksgaard
København 1971

PRINTED IN DENMARK
BIANCO LUNOS BOGTRYKKERI A/S

PREFACE

In our commentary to the first sixteen chapters we follow the order of the verses of the text, though often combined to form larger groups according to contents. In Chapter XVII, however, which is concerned with planetary theory based on Babylonian methods, we found it necessary to rearrange the material. The following Table of Contents will show the details.

For a number of technical terms for which no short equivalent exists in western astronomy (e.g., ahargaṇa or tithi) we give an alphabetical index on p. 129. An extensive index verborum will be found in Part I, p. 188 ff. The notation which we generally adopted in formulae is shown in the list on p. 130, arranged according to topics. Since numerical parameters provide one of the most powerful tools in the investigation of the interconnection between different sources, we have compiled a detailed index of parameters (p. 131 ff.).

A discussion of the general historical position of the Pañcasiddhāntikā in Indian astronomy is given in Part I.

O.N., D.P.

PART II

COMMENTARY
BY
O. NEUGEBAUER AND D. PINGREE

TABLE OF CONTENTS TO PART II

Chapter I

I,1. Varāhamihira's invocatory verses normally mention the Sun; cf. e.g. Bṛhatsaṃhitā I,1. This is appropriate because of his position as a Maga Brāhmaṇa. But here the Sun is also representative of the divine authors of siddhāntas (joined in the Pañcasiddhāntikā by Pitāmaha = Brahma), while Vasiṣṭha, who is one of the seven Vedic ṛṣis who form the constellation Saptarṣi (Ursa maior), represents the human authors (joined here by Pauliśa and Romaka). Varāhamihira's father, as stated Part I p. 7, was named Ādityadāsa ("Slave of the Sun").

I,2. The term bīja normally is applied only to a correction to a planet's mean longitude. It is not clear what in this verse is ascribed to "former teachers," or what is regarded as secret.

I,3. For the five siddhāntas and Lāṭadeva see Part I pp. 9–15.

I,4. The ranking in accuracy of the five siddhāntas given in this verse is appropriate: Sūrya, Pauliśa and Romaka, Vāsiṣṭha and Paitāmaha.

In the late seventh or during the eighth century (between 628, the date of the Brāhmasphuṭasiddhānta, and ca. 850, the date of the Prakaṭārthadīpikā), another verse based on this one became popular. It is quoted by Govindasvāmin in his Prakaṭārthadīpikā on II,8 of the Uttarabhāga of the Bṛhatpārāśarahorāśāstra:

spaṣṭo brāhmas tu siddhāntas tasyāsannas tu romakaḥ/
sauraḥ spaṣṭataro spaṣṭau vāsiṣṭhaḥ pauliśaś ca tau//

"The Brāhma (sphuṭasiddhānta) is accurate; the Romaka is close to it; the Sūrya (saura) is more accurate; and the Vāsiṣṭha and Pauliśa are inaccurate."

I,5–7. Varāhamihira here lists the contents of the Pañcasiddhāntikā, though in a fashion that is uncharacteristically unsystematic.

a) solar eclipses: VII; VIII; IX; XV,1–10.
b) lunar eclipses: VI; X; XI
c) conjunctions of stars and planets: XIV,33–38
d) longitudinal differences (of cities): III,13–15; XV,21–23; 25

e) prime vertical: IV,32–33; 36; 38
f) rising of the moon: V
g) magical diagrams: XIV,27–28; 41
h) graphical constructions: XIV,1–18; 41
i) gnomon shadow: II,9–13; III,10; IV,19–22; 35; 37–38; 41–56; XIII,11; 30–33; XIV,5; 10; 14–15
j) sine of terrestrial latitude: IV,20–21; IV,27–28; 40; XIV,9–10; 18
k) sine of colatitude: IV,23; 28; 40; XIV,8; 18
l) declination: IV,16–18; 24; XIII,10.

It is curious that this list of contents does not mention the rules for calculating planetary positions as given in XVI and XVII.

I,8–15. In these verses Varāhamihira summarizes the rules for computing the ahargaṇa (i.e. the number of days elapsed since epoch) in the three texts associated with Lāṭadeva, i.e., the Romakasiddhānta (I,8–10 and 15), the Pauliśasiddhānta (I,11–13), and the Sūryasiddhānta (I,14).

I,8. The epoch of Lāṭadeva's Romaka is the first tithi after conjunction in the month Caitra at the beginning of the year Śaka 428, i.e., the time of conjunction of Sun and Moon at approximately Aries 0°. This date is A.D. 505 March 22, Tuesday; see Part I p. 8 in the introduction. The time is sunset at Yavanapura (cf. XV,18), i.e., about 6 P.M. of March 21, local time at Yavanapura. According to III,13 the time difference between Yavanapura and Avantī is $7^1/_3$ nāḍīs or 2 hours 56 minutes; therefore the local time at Avantī is ca. 8;56 P.M. Cf., however, VIII,5 and XV,18.

I,9–10. The purpose of this section is the determination of the number D of days elapsed since epoch at a moment characterized as N completed years of the Śaka era, plus m completed (mean) synodic months, plus τ completed tithis.

This problem is solved by computing first two terms A and B:

$$A = (12(N-427)+m)\frac{7}{228} \tag{1}$$

$$B = (A+12(N-427)+m)\,30+\tau. \tag{2}$$

In these expressions the factor $12(N-427)+m$ represents the number of lunar months completed since epoch (Ś.E. 428) under the preliminary assumption that only 12 months correspond to each year. According to the "Metonic" 19-year cycle, however, 7 intercalary months must be added to each set of $19 \cdot 12 = 228$ months. Consequently the term A gives the number of intercalary months since epoch, B the total of tithis since epoch.

It is furthermore assumed that

$$703^{\tau} = 692^{\mathrm{d}} = (703-11)^{\mathrm{d}}. \tag{3}$$

The number C of days corresponding to B tithis is therefore

$$C = B - \frac{11}{703} B. \tag{4}$$

From this amount is subtracted a constant

$$c = \frac{514}{703} \tag{5}$$

which leads to the final result

$$D = C - c = B - \frac{11B + 514}{703} = B - \frac{11\,B + 8{,}34}{11{,}43} \tag{6}$$

for the number of days since epoch.

Measured in sexagesimal fractions of a day the constant c corresponds to

$$c \approx 0;43,\,52, \ldots^{\mathrm{d}}. \tag{7}$$

Since $C = D + c$ this means that the interval C begins about $^3/_4$ of one day before epoch. The latter falling at sunset (cf. I,8) C begins at the preceding midnight. The time of epoch being the vernal equinox one should expect $c = {^3/_4}^{\mathrm{d}} = 0;45^{\mathrm{d}}$ exactly instead of (7). This would have been obtained by replacing 514 in the numerator of (5) by 527. We cannot explain this small discrepancy.

It follows from (3) that

$$1 \text{ tithi} = 0;59,3,40,11,56,\ldots \text{ days} \tag{8}$$

hence

$$1 \text{ lunar month} = 29;31,50,5,58,\ldots \text{ days} \tag{9}$$

and from the 19-year cycle

$$1 \text{ year} = 365;14,48,4,\ldots \text{ days} \tag{10}$$

Note that in I,15 a tropical year contains 365;14,48 days exactly.

I,11–13. The text gives the following rule for the determination of the number m_{a} of intercalary months:

$$m_{\mathrm{a}} = \frac{10d_{\mathrm{s}} + 698}{9761} + \frac{y}{300 \cdot 107} + \frac{y}{5506} \tag{1}$$

where d_{s} means the number of saura days contained in the interval under consideration, y the number of complete years in the same interval of time. The term $698/9761 = 11{,}38/2{,}42{,}41 \approx 0;4{,}17$ is obviously an epoch correction which must be due to the fact that an integer number of intercalary months plus this fraction had elapsed between the original epoch of the Pauliśasiddhānta and the epoch of Lāṭadeva.

If we wish to apply (1) for exactly one year we have to substitute $d_s = 360$ and $y = 1$. Computing sexagesimally this gives

$$m_a(1) = \frac{1,0,0}{2,42,41} + \frac{1}{8,55,0} + \frac{1}{1,31,46}$$
$$\approx 0;22,7,43,58,7 + 0;0,0,6,43,44 + 0;0,0,39,13,48$$
$$\approx 0;22,8,29,54.$$

Hence one year contains

$$1^{y} = 12;22,8,29,54^{m} \tag{2}$$

synodic months. From III,1 we know that one sidereal year is exactly defined by

$$1^{y} = 6,5;15,30^{d} \tag{3}$$

hence from (2)

$$1^{m} \approx 29;31,48,16,37^{d}. \tag{4}$$

For the number u of omitted tithis the text gives the rule

$$\left.\begin{aligned} u &= \left(\frac{d}{63} + \frac{\tau}{25\,135}\right)\left(1 - \frac{1}{203\,279}\right) \\ &= \left(\frac{d}{1,3} + \frac{\tau}{6,58,55}\right)\left(1 - \frac{1}{56,27,59}\right) \approx \left(\frac{d}{1,3} + \frac{\tau}{6,58,55}\right)\cdot 0;59,59,58,56 \end{aligned}\right\} \tag{5}$$

d being the number of calendar days, τ the number of tithis contained in the interval under consideration. If we again apply this rule to 1 year we must for d use (3) and for τ, because of (2),

$$1^{y} = 6,11;4,14,57^{\tau}. \tag{6}$$

Hence for one year

$$u = \left(\frac{6,5;15,30}{1,3} + \frac{6,11;4,14,57}{6,58,55}\right)\cdot 0;59,59,58,56$$
$$\approx (5;47,51,54,17 + 0;0,53,8,50)\cdot 0;59,59,58,56$$
$$\approx 5;48,44,56,55$$

as the number of omitted tithis.

This result can also be obtained directly from (6) and (3) because

$$6,11;4,14,57 - 6,5;15,30 = 5;48,44,57 \tag{7}$$

again represents the number of omitted tithis.

Also from (2) and (3) can be derived the sidereal mean motion of the moon. One finds $13;10,35,37,\ldots^{\circ/d}$.

I,14. Since 180 000^{y} = 50,0,0^{y} contain 66 389 = 18,26,29 intercalary months, hence 50,0,0 · 12 + 18,26,29 = 10,18,26,29 lunar months, one finds that

$$1^{y} = 12;22,7,46,48^{m} = 6,11;3,53,24^{\tau}. \qquad (1)$$

Since 50,0,0^{y} contains 1 045 095 = 4,50,18,15 omitted tithis their number per year is 5;48,21,54 and therefore with (1)

$$1^{y} = (6,11;3,53,24 - 5;48,21,54)^{d} = 6,5;15,31,30^{d} \qquad (2)$$

as the exact length of the sidereal year; cf. also IX,1.

It follows from (1) and (2) that

$$1^{m} \approx 29;31,50,6,52,59,\ldots^{d} \qquad (3)$$

and

$$\bar{v} \approx 13;10,34,52,6,\ldots^{o/d} \qquad (4)$$

for the sidereal mean motion of the moon.

Lāṭadeva's Sūryasiddhānta, as we know from chapter XVI, employed a Mahāyuga of 4 320 000 = 20,0,0,0 = 24 · 50,0,0 years. If we multiply the parameters in this verse by 24 we find that there are

53 433 336	=	4,7,22,35,36	lunar months
1 593 336	=	7,22,35,36	intercalary months
1 603 000 080	=	2,3,41,17,48,0	tithis
1 577 917 800	=	2,1,45,10,30,0	sāvana days

in one Mahāyuga; these are precisely the parameters of the ārdharātrika (i.e., midnight) system.[1])

I,15. Here it is assumed that 2850 = 47,30 = 2,30 · 19 years contain 1050 = 17,30 = 2,30 · 7 intercalary months. This is the well known scheme of the "Metonic cycle", consistently used in the Babylonian ephemerides. The number of omitted tithis is 16 547 = 4,35,47, therefore the number of days in one year

$$\left(12 + \frac{7}{19}\right)30 - \frac{4,35,47}{2,30 \cdot 19} = \frac{4,49,9,13}{19 \cdot 2,30} = \frac{15,13,7}{2,30} = 6,5;14,48^{d}. \qquad (1)$$

This is exactly the length of the tropical year according to the Hipparchian-Ptolemaic theory (Almagest III,1 p. 208,12 Heiberg). The same value appears again in VIII,1.

The relation (1) can also be formulated as

$$47,30^{y} = 2,30 \cdot 19^{y} = (47,30 \cdot 12 + 17,30)^{m} = 9,47,30^{m} = 2,30 \cdot 3,55^{m} \qquad (2a)$$

i.e.

$$19^{y} = 3,55 \text{ synodic months.} \qquad (2b)$$

[1]) The parameters of the ārdharātrika system are found in Mahābhāskarīya VII,21–35, and in Khaṇḍakhādyaka I, II, and VI. Table 1 shows the number N of sidereal revolutions in a Mahāyuga which consists of 4 320 000 = 20,0,0,0 sidereal years = 1 577 917 800 = 2,1,45,10,30,0 days. For additional planetary parameters see the commentary on XVI,12–14, Table 22.

Table 1.

	N
Sun	4 320 000 = 20, 0, 0, 0
Moon	57 753 336 = 4,27,22,35,36
Lunar apogee	488 219 = 2,15,36,59
Lunar nodes	232 226 = 1, 4,30,26
Saturn	146 564 = 40,42,44
Jupiter	364 220 = 1,41,10,20
Mars	2 296 824 = 10,38, 0,24
Venus, śīghra	7 022 388 = 32,30,39,48
Mercury, śīghra	17 937 000 = 1,23, 2,30, 0

Furthermore

$$47{,}30^{y} = 9{,}47{,}30^{m} = 4{,}53{,}45{,}0^{\tau} = (4{,}53{,}45{,}0 - 4{,}35{,}47)^{d} = 4{,}49{,}9{,}13^{d}. \qquad (3)$$

In VIII,1 this same number of days is equated to 10,35,0 sidereal months:

$$4{,}49{,}9{,}13^{d} = 10{,}35{,}0 = 2{,}30 \cdot 4{,}14 \text{ sidereal months} \qquad (4a)$$

hence with (2a)

$$19^{y} = 4{,}14 \text{ sidereal months} \qquad (4b)$$

and finally

$$3{,}55 = 235 \text{ synodic months} = 4{,}14 = 254 \text{ sidereal months} \qquad (5)$$

as basic relation between synodic and sidereal revolutions of the moon, well known in Babylonian astronomy.

Because 7:19 = 0;22,6,18,56,50,... one finds for the Metonic cycle that

$$1^{y} = 12;22{,}6{,}18{,}56{,}50,\ldots^{m} \qquad (6)$$

and thus with (1)

$$1^{m} = 29;31{,}50{,}5{,}37,\ldots^{d}. \qquad (7)$$

Finally the mean motion of the moon is

$$\bar{v} = 13;10{,}34{,}59{,}50,\ldots^{\circ/d}. \qquad (8)$$

I,16. Summary of the general rules on which the relations are based which were utilized in the preceding verses. For the term "solar measure" cf. pt. I, p. 185.

I,17–21. Let

$$a' = a + 2227 = a + 37{,}7 \qquad (1)$$

be the (augmented) ahargaṇa where a represents the number of days since epoch. Then the following set of rules is given in the text:

$$a' = q \cdot 2520 + r \qquad 0 \leqq r < 2520 = 7 \cdot 360 = 42{,}0 \tag{2}$$

$$r = c_1 \cdot 360 + c_2 \qquad \text{thus } 0 \leqq c_1 < 7, \qquad 0 \leqq c_2 < 360 \tag{3}$$

where c_1 represents the number of completed years. From it

$$(c_1 + 1) \cdot 3 - 2 = c_3 \cdot 7 + c_4 \qquad 0 \leqq c_4 < 7 \tag{4}$$

gives the "lord of the year" c_4. Furthermore

$$\left(\frac{a'}{30} + 1\right) \cdot 2 = c_5 \cdot 7 + c_6 \qquad 0 \leqq c_6 < 7 \tag{5}$$

where c_6 is the "lord of the month", counting from Sunday.[1] Then

$$a' = c_7 \cdot 7 + c_8 \qquad 0 \leqq c_8 < 7 \tag{6}$$

gives the "lord of the day" c_8 and

$$(c_8 \cdot 3 - 1 + h) \cdot 5 = c_9 \cdot 7 + c_{10} \qquad 0 \leqq c_{10} < 7 \tag{7}$$

the "lord of the h-th hour".

Let

$$\text{A B C D E F G} \tag{8a}$$

be the order of days in the week, ruled by the planets

$$\odot \quad ☾ \quad ♂ \quad ☿ \quad ♃ \quad ♀ \quad ♄ \tag{8b}$$

respectively. Then the rule (7) results for the first hour ($h = 1$) in

$$c_8 \cdot 15 = 2c_8 \cdot 7 + c_8$$

hence in

$$c_{10} = c_8$$

i.e. the lord of the first hour is also the lord of the day.

For $h = 25$ one obtains

$$c_8 \cdot 15 + 120 = (2c_8 + 17)7 + c_8 + 1$$

i.e. the first hour of the next day has the lord $c_8 + 1$ as it should be. For $h = 2$ one has

$$c_8 \cdot 15 + 5 = 2c_8 \cdot 7 + c_8 + 5.$$

This means: if we begin for $h = 1$ with A then $h = 2$ has the lord F, $h = 3$ the lord D, etc. In this way one obtains for consecutive hours the following order of the planets

$$\odot \quad ♀ \quad ☿ \quad ☾ \quad ♄ \quad ♃ \quad ♂ \quad \text{etc.}$$

[1]) The rule given in (5) is wrong. The text's (I,19) "increase the (resulting) months by the current one" should be replaced by "discard the fractional part of the current (month)".

i.e. the Greek order of the planets from which the order (8b) for the days of the week originated.

From (5) it follows that an increase of a' (or of a) by 30 increases the lord of the month by 2, as it should be since $30 \equiv 2$ mod. 7. Of course "month" means here a fixed interval of 30 days and not a lunar month.

For the first day of the ahargaṇa one has $a' = 2227 + 1$ hence from (6)

$$2228 \equiv 318 \cdot 7 + 2$$

hence $c_6 = 2$ i.e. Tuesday.

The rule (4) can also be written as

$$3c_1 \equiv c_4 - 1 \text{ mod. } 7.$$

Each unit of c_1 represents according to (2) a schematic "year" of 360 days. Hence c_4 increases by 3 if c_1 increases by 1 as is to be expected since $360 \equiv 3$ mod. 7. For $a' = 1$ one has $c_1 = 0$ thus $c_4 = 1$ i.e. Sunday.

I,22. Varāhamihira explains the astrological influences of the lords of the year, the lords of the month, and the lords of the day in Bṛhatsaṃhitā XIX.

I,23–25. Varāhamihira here discusses the Persian year of the Maga Brāhmaṇas.

I,23. If we now consider a "year" as containing 365 days, the quotient

$$a + 1 \equiv c_5 \text{ mod. } 365 \qquad 0 \leqq c_5 < 365$$

gives the fraction c_5 of one year elapsed at the given moment a. Furthermore

$$c_5 \equiv c_6 \text{ mod. } 30 \qquad 0 \leqq c_6 < 30$$

refers to the number of days within the current schematic month of 30 days. This last residue c_6 defines the "lord of the degree".

I,24–25. Here are listed the Sanskrit "equivalents" of the thirty angels who rule the days of a Persian month. Column I below gives their names according to the Bundahishn (cf. A. Christensen, L'Iran sous les Sassanides, 2nd ed. Copenhague 1944 p. 158), and column II Varāhamihira's list.

	I	II
1.	Ōhrmazd	Kamalodbhava = Brahman
2.	Vahman = "Good Thought"	Prajeśa = Prajāpati
3.	Urdvahisht = "Best Truth"	Svargeśa = "Lord of Heaven"
4.	Shahrēvar = "Desirable Domination"	Śāstṛ = "Ruler"

5. Spandarmadh = "Spiritual Purity"	Rudra
6. Khvardādh = "Integrity"	Manyu = "Mind"
7. Amurdādh = "Immortality"	Vasu = "Wealth"
8. Dadhv = "Creator"	Kamalā = Lakṣmī
9. Ādhur = "Fire"	Anala = "Fire"
10. Ābhān = "Water"	Antara = "Death"
11. Khvar = "Sun"	Vayaḥ = "Sun"
12. Māh = "Moon"	Śaśi = "Moon"
13. Tīr = "Mercury"	Indra
14. Gōsh = "Bull"	Go = "Bull"
15. Dadhv = "Creator"	Nirṛti = "Destruction"
16. Mihr = "Sun"	Hara = Śiva
17. Srōsh = "Obedience"	Bhava = "Being"
18. Rashn = "Truth"	Guru = "Teacher"
19. Fravardīn = "Genii"	The Pitṛs = "The Fathers"
20. Varhrān	Varuṇa
21. Rām = "Joy"	Baladeva
22. Vādh = "Wind"	Samīraṇa = "Wind"
23. Dadhv = "Creator"	Yama = "Death"
24. Dēn = "Religion"	Vāk = "Word"
25. Ard = "Retribution"	Śrī = "Prosperity"
26. Ashtādh = "Rectitude"	Dhanada = Kubera
27. Asmān = "Sky"	The Giris = "The Mountains"
28. Zāmdādh = "Earth"	Dhātrī = "Earth"
29. Mahrspand = "God's Word"	Vedhāḥ = "Pious"
30. Anaghrān = "Infinite Lights"	Paraḥ Puruṣa = Viṣṇu

The angels of lists I and II are reasonably similar for days 1, 2, 3, 4, 5(?), 7, 9, 11, 12, 14, 18(?), 19, 22, 24, 28, and 29, and perhaps for some others. The variations may be due in part to the fact that Varāhamihira's is a Maga Brāhmaṇa list, the Bundahishn's probably a Zurvanite document.

Chapter II

II,1. The rule of the text implies the use of a julian year since

$$\frac{a \cdot 4 + 6}{1461} = \frac{a + 1;30}{365;15}. \tag{1}$$

The division of the ahargaṇa a by 365;15^{d} will leave a remainder which gives the number of quarter-days after the vernal equinox. The twelve coefficients enumerated at the end of the verse, 126 − 1 = 125, 126 − 0 = 126, etc., give the number of quarter

Table 2.

	d/4	d	Season	Velocity
♈	125	31;15		0;57,16,48°/d
♉	126	31;30		0;57, 8,34,...
♊	126	31;30	94;15	0;57, 8,34,...
♋	126	31;30		0;57, 8,34,...
♌	124	31; 0		0;58, 3,52,...
♍	122	30;30	93; 0	0;59, 0,59,...
♎	119	29;45		1; 0,30,15,...
♏	117	29;15		1; 1,32,18,...
♐	117	29;15	88;15	1; 1,32,18,...
♑	118	29;30		1; 1, 1, 1,...
♒	120	30; 0		1
♓	121	30;15	89;45	0;59,30,14,...
Total	1461	365;15		

days for the travel of the Sun in the consecutive zodiacal signs. This leads for the solar motion to the pattern shown in Table 2.

The additive constant (kṣepa) 6 in the numerator (i.e. $^6/_4 = 1^1/_2$ days) indicates that the author supposed the vernal equinox to occur not at the epoch, but $1^1/_2$ days earlier.

The graph for the corresponding velocities (cf. Fig. 1) shows that the values for Pisces and Aries cannot be correct. A simple emendation would be 124 for Aries and correspondingly 122 for Pisces. The text, however, does not permit such a correction.

II,2–6. We have here rules for the determination of the longitude of the Moon, rules which are of great historical interest because their Hellenistic, ultimately Babylonian, prototypes are known.[1])

Let a be the ahargaṇa, then one takes as number of days

$$n = a + 1936 = a + 32,16 \qquad (1)$$

i.e. one introduces a point of departure about $5^1/_3$ years back from the accepted epoch date. We shall return to this modified epoch date later and show that it represents a position of the Moon at its apogee (cf. p. 22).

From n one derives numbers α and β:

$$n = \alpha \cdot 3031 + \beta \qquad 0 \leqq \beta < 3031 \qquad (2)$$

where α (called "ghana") counts the number of periods of 3031 = 50,31 days length. This number 3031 represents the length of 110 anomalistic months as we know, e.g., from VIII,5.

[1]) Cf., e.g., the Greek papyri P. Lund 35a and P. Ryl. 27 (cf. below p. 152, Bibliography 1,D) and ACT I passim.

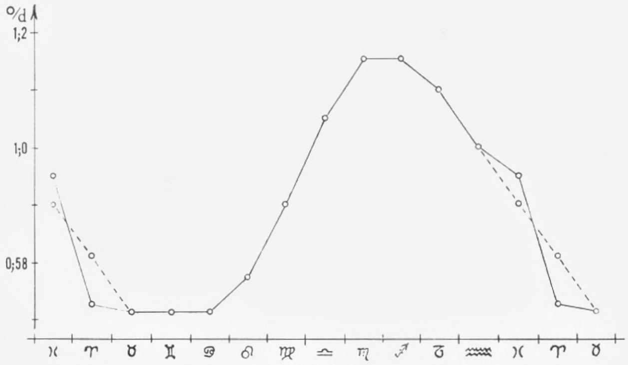

Fig. 1.

With the remainder β one forms

$$\frac{9\beta}{248} = m + \frac{9t}{248} \qquad 0 \leqq t < \frac{248}{9}. \tag{3}$$

Since

$$\tfrac{248}{9} = 27;33,20^{d} \tag{4}$$

is the length of one anomalistic month, one can replace (3) by

$$\beta = m \cdot 27;33,20 + t \qquad 0 \leqq t < 27;33,20 \tag{5}$$

where m (called "gatis") gives the number of anomalistic months contained in β. The text counts the residue t in "padas" where (cf. (4))

$$1 \text{ pada} = \tfrac{1}{248} \text{ anomal. month} = \tfrac{1}{9} \text{day}. \tag{6}$$

Having determined the integers α, m, and t the corresponding increments of longitude λ_1, λ_2, λ_3 respectively will be computed.

First, with α from (2):

$$\alpha = 16u + v \qquad 0 \leqq v < 16 \tag{7}$$

and from it

$$\lambda_1 = 69;7,1^\circ - \tfrac{3}{4}v \cdot 30^\circ + 0;2\alpha. \tag{8}$$

This means that for $n = 0$ the Moon had the longitude

$$\lambda_0 = 69;7,1^\circ. \tag{9}$$

For this parameter cf. below p. 22. Otherwise (7) and (8) are based on the assumption that the longitude of the Moon increases during one ghana by $337\frac{1}{2}^\circ + 0;2^\circ = 5,37;32^\circ$ — corresponding to a mean motion of $13;10,34,52,46,\ldots {}^{o/d}$.

Indeed, since

$$5,37;30 \equiv -22;30 = -\tfrac{3}{4}30 \qquad \text{mod. } 6,0$$

one has for α ghanas, with (7):

$$-\alpha\tfrac{3}{4}30 = -(16u+v)\tfrac{3}{4}30 = -12\cdot 30u - \tfrac{3}{4}v\cdot 30 \equiv -\tfrac{3}{4}v\cdot 30 \qquad \text{mod. } 6,0$$

which explains the increment depending on v in (8).

The contribution to the longitude during m gatis is assumed to be

$$\lambda_2 = m(185 - \tfrac{1}{6}) \text{ minutes} = m\cdot 3;4,50^\circ. \tag{10}$$

That is to say the Moon moves in one anomalistic month 6,3;4,50°, or, using (4), the Moon's mean velocity is taken to be 13;10,34,43,3,...$^{o/d}$. This is slightly less than the value obtained from (7) and (8).[1])

The increments λ_1 and λ_2 take care of complete anomalistic periods of the Moon. What remains is only the fraction t in (5) of the current anomalistic period. For this last contribution a definite velocity pattern is assumed, beginning with minimum velocity. This implies that the Moon had minimum velocity at $n = 0$.

In order to compute the increase in longitude of the Moon during a fraction of an anomalistic month one has to distinguish between the two halves of a month. During the first half the motion is accelerating, during the second half the velocity decreases again toward its minimum. The two halves are characterized in the text by the number of "padas" (cf. (6)) within the month: the first half of 124 padas contributes (according to II,5) 180;4° of longitudinal progress, the second half should complete the anomalistic period. According to (10) one should expect a total of about 363° in longitudinal gain but for the sake of greater computational convenience the motion during the last part of the month is slightly modified.

In describing the rules of the text we denote the longitudinal increment during the first half of the month by λ^+, during the second half by λ^-. Reckoning the residue t found in (3) or (5) as p "padas" the rules of the text are

$$\left.\begin{array}{c}\text{first half: } \lambda^+ = p^\circ + (1094 + 5(p-1))\dfrac{p}{63} \text{ minutes} \\ 0 \leqq p \leqq 124\end{array}\right\} \tag{11}$$

$$\left.\begin{array}{c}\text{second half: } \lambda^- = (p-124)^\circ + (2414 - 5(p-124-1))\dfrac{p}{63} \\ +\ \lambda^+(124) \text{ minutes} \qquad 125 \leqq p \leqq 248\end{array}\right\} \tag{12}$$

where $\lambda^+(124)$ represents the value obtained from (11) if one substitutes $p = 124$, or, as said in the text

$$\lambda^+(124) \approx 180;4^\circ. \tag{12a}$$

[1]) If one were to emend in (10) the 1/6 to 0;6 = 1/10 one would have a motion of 3;4,54° (+360°) in one anomalistic month and hence a mean motion of 13;10,34,52,...$^{o/d}$, i.e., practically the same value as in (7) and (8). On the other hand, the parameters in P. Ryl. 27 lead to 3;4,49,26,...° as progress per anomalistic month.

Indeed, for $p = 124$ one obtains from (11) the value $124^\circ + (3363 + \frac{47}{63})$ minutes $= 180^\circ + (3 + \frac{47}{63})$ minutes $\approx 180;4^\circ$.

In order to discuss the astronomical signifcance of these rules it is convenient to reconvert the padas to days t and to write the numbers sexagesimally with degrees as units.

For the accelerating, i.e. first, half of the month one can replace (11) by

$$\lambda^+ = 11;42\, t + \frac{0;45}{7}\, t(t-1) = mt + \frac{d}{2}\, t(t-1). \tag{13}$$

The velocity (in degrees per day) which produces such a motion is found by forming the differences

$$v^+ = \Delta\lambda^+ = \lambda^+(t+1) - \lambda^+(t) = m + dt. \tag{14}$$

Hence v^+ is a linearly increasing function of time with the minimum

$$m = 11;42^{\circ/\mathrm{d}} \tag{15a}$$

and the difference

$$d = \frac{1;30}{7}. \tag{15b}$$

For the second half of the month we count the days t' beginning with the midpoint $p = 124$, i.e. we define

$$t' = \tfrac{1}{9}(p - 124). \tag{16}$$

Then (12) transforms itself into

$$\lambda^- = 3,0;3 + \frac{0;47}{1,3} + \left(14;39 + \frac{1}{7,0}\right)t' - \frac{0;45}{7}\, t'(t'-1) = c + Mt' - \frac{d}{2} t'(t'-1) \tag{17}$$

with

$$c = 3,0;3 + \frac{0;47}{1,3} \approx 3,0;4^\circ \tag{18a}$$

$$M = 14;39 + \frac{1}{7,0} = 14;39,8,34,17,\ldots^{\circ/\mathrm{d}} \tag{18b}$$

and $d = \dfrac{1;30}{7}$ as before in (15b). The velocity in the second half is therefore given by

$$v^- = \Delta\lambda^- = M - dt'. \tag{19}$$

The fact that d has the same value in (14) and (19) shows that the velocity underlying (11) and (12) is a linear zigzag function with extrema given by (15a) and (18b) and difference (15b). Consequently we find for the period of this function

$$P = \frac{2(M - m)}{d} = \frac{20,40}{7} \cdot \frac{7}{45} = \frac{248}{9} = 27;33,20^{\mathrm{d}} \tag{20}$$

as it should be according to (4). For the mean value one finds

$$\mu = \tfrac{1}{2}(m+M) = 13;10+\frac{4}{7,0} \approx 13;10,34,17,\ldots{}^{\mathrm{o/d}}. \tag{21}$$

Essentially the same linear zigzag function for the lunar velocity is described in III,4, the only difference being that the value (18b) for M is rounded to $14;39^{\mathrm{o/d}}$ which would mean $\mu = 13;10,30^{\mathrm{o/d}}$ instead of (21).

We must still explain the value (18a) of the constant c in (17). Obviously the longitudinal gain over one complete anomalistic period should be μP. Hence, one should have at the end, i.e. for $t' = \frac{P}{2}$ from (17):

$$\mu P = c+M\cdot\frac{P}{2}-\frac{d}{2}\cdot\frac{P}{2}\cdot\left(\frac{P}{2}-1\right) \tag{22}$$

or

$$\mu = \frac{c}{P}+\frac{M}{2}-\frac{d}{4}\left(\frac{P}{2}-1\right)$$

$$= \frac{9}{4,8}\left(3,0;3+\frac{47}{1,3}\right)+\tfrac{1}{2}(14,39+\tfrac{1}{7})-\frac{45}{14}\cdot\frac{1,55}{9} = 13,11$$

exactly. This shows that c was computed from the necessary relation (22) by using for the mean motion the rounded value

$$\mu \approx 13;11^{\mathrm{o/d}}. \tag{23}$$

It is of interest to investigate the lunar equation which results from the pattern of the true longitude λ^+, computed according to the above scheme. For this end one has to compute λ^+ from (13) for $t = 1, 2, \ldots$ and similarly the corresponding mean positions $\bar{\lambda}$ from day to day, beginning with the apogee, and to form the differences

$$\theta = \lambda^+ - \bar{\lambda}. \tag{24}$$

Table 3 and its graphical representation in Fig. 2 show the result. From it it is clear that the maximum equation is

$$\theta_{\max} = 5;5^{\circ} \tag{25}$$

which occurs at $t = 7$, i.e., as expected, near $t = \frac{P}{4} = 6;53,20$.

It should be emphasized that this is a necessary consequence of the velocity function determined by (14) and (19). In other words (25) is not a parameter which can be chosen freely after v has been fixed; cf. below the discussion to III,4 and III,5–8.

The origin of the other parameters can only be reconstructed with a fair degree of plausibility. In the construction of a linear zigzag function the only parameter

TABLE 3.

t	$\bar{\lambda}$	λ^{+}	$-\theta$	
1	784.14	702.00	82.1′ =	1;22°
2	1568.28	1416.86	152.4	2;32
3	2352.42	2144.57	207.8	3;28
4	3136.57	2885.14	251.4	4;11
5	3920.71	3638.57	282.1	4;42
6	4704.85	4404.86	300.0	5; 0
7	5489.00	5184.00	305.0	5; 5
8	6273.14	5976.00	297.1	4;57
9	7057.28	6780.86	276.3	4;36
10	7841.42	7598.57	242.8	4; 3
11	8625.57	8429.14	196.4	3;16
12	9409.71	9272.57	137.1	2;17
13	10193.85	10128.86	65.0	1; 5
13;47	10803.74	10803.75	0.0	0

which must be strictly preserved is the period P, here represented by the classical Babylonian parameter (20). For the convenience of actual computation it is essential that d be a small number. A crude estimate of the anomalistic lunar motion, $P \approx 28^{d}$, $M - m \approx 3°$ would give for d

$$d = \frac{M - m}{P} = \frac{1;30}{7}$$

as in (15b). Again a crude estimate for the velocities would be $\mu \approx 13;11$, hence $m \approx 11;41$, $M \approx 14;41$. Starting with these estimates one must improve μ by coming nearer to the well known mean value 13;10,35. If one wishes to preserve d which contains the fraction 1/7 it is convenient to take also for μ the nearest approximation with this fraction, i.e. $\mu = 13{,}10 + \frac{4}{7}$ which is (21). Finally, one must use the accurate value (20) for P and this, with (21), leads to (15a) and (18b) for the extrema. At any rate, arithmetical considerations more or less following the here described lines

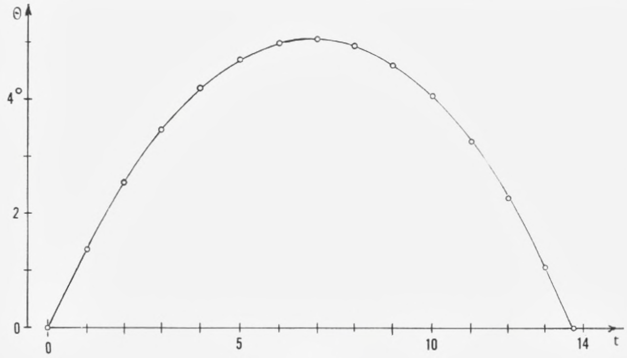

Fig. 2.

must lie at the basis of the rules given in the text and certainly not any detailed observations beyond the well known Babylonia parameters.

As a result of the prescribed operations one has found the contributions to the motion in longitude λ_1, λ_2, and $\lambda_3 = \lambda^+$ or λ^- respectively. Hence one obtains for the longitude λ of the Moon at the moment t

$$\lambda = \lambda_0 + \lambda_1 + \lambda_2 + \lambda_3 \tag{26}$$

where λ_0 is the lunar longitude 1936 days before epoch, i.e. before 505 March 22 (cf. above p. 16 (1)), given in II,3:

$$\lambda_0 = ♊\ 9;7,1. \tag{27}$$

The correctness of this element can be easily checked with modern tables. Computing for 499 Dec. 3, 5 P.M. (a) for the meridian of Ujjayinī (b) for the meridian of Alexandria, one finds[1])

Ujjayinī: $\lambda = 69.33 =$ ♊ 9;20 anomaly 186°

Alexandria: $\lambda = 70.82 =$ ♊ 10;49 anomaly 187;30°

as compared with $\lambda_0 =$ ♊ 9;7 and anomaly 180° assumed in the text. The computed data obviously confirm in principle the data of the text but do not provide a clear enough distinction between Ujjayinī and Alexandria.

It is not clear why just this particular apogee position had been chosen instead of the nearest one to the epoch A.D. 505 of the ahargaṇa, unless the Vasiṣṭhasiddhānta was revised in 499 as the Romaka, Pauliśa (and Sūrya) were revised by Lāṭadeva in 505.

II,7. We adopt here the following notation for longitudinal arcs:

s . . . sign: $1^s = 30°$

na . . . nakṣatra: $1^{na} = 13;20° = \frac{4^s}{9}$

μ . . . muhūrta: $1^{\mu} = \frac{1^{na}}{30} = 0;26,40° = \frac{4°}{9}$.

This explains the rule of the text:

$$\lambda° = a^s + b° = \tfrac{4}{9}a^{na} + \tfrac{1}{9}b^{\mu}.$$

Let $\Delta\lambda$ be the elongation of the Moon from the Sun. In one lunar month, which, by definition, contains 30 tithis (τ), the elongation increases by 360°, hence 12° per tithi. Consequently for an elongation of 1^s is required the time $\frac{30}{12} = \frac{5^{\tau}}{2}$, hence $\frac{5}{2}\Delta\lambda^{\tau}$ for an elongation of $\Delta\lambda^s$. Cf. also III,16.

[1]) Using the tables of P. V. Neugebauer, Tafeln zur astronomischen Chronologie II (1914) and his Chronologie II (1929) Tafel E 1.

II,8. One muhūrta is $^1/_{30}$ of a nychthemeron, i.e. $0;48^h$. When the Sun is at the beginning of Capricorn the length of daylight is assumed to be $9+3 = 12$ muhūrtas, i.e. $9;36^h$. For each subsequent sign 1 muhūrta is added until Aries. From there on the number of signs has to be added to 15 until Cancer and similarly for the length of night which increases after Cancer. The result is a linear zigzag function for the length of daylight with a ratio 2:3 for shortest to longest daylight (cf. Table 4). For this originally Babylonian ratio see Sphujidhvaja's Yavanajātaka 1,68 and 79,31; cf. also Varāhamihira's Bṛhajjātaka I,19, and XII,5 below.

TABLE 4.

0°	Daylight		0°
♑	12^{muh} =	$9;36^h$	♑
♒	13	10;24	♐
♓	14	11;12	♏
♈	15	12	♎
♉	16	12;48	♍
♊	17	13;36	♌
♋	18	14;24	♋

II,9–10. Rules for the length s_n of the noon shadow of a vertical gnomon at a locality for which the geographical latitude φ equals the obliquity ϵ of the ecliptic. Consequently $s_n = 0$ at the summer solstice, i.e. at a solar longitude $\lambda = 3^s$. It is furthermore assumed that s_n increases linearly with 2 units per sign:

$$\left.\begin{array}{ll} s_n = 2a & \text{for } \lambda = (3+a)^s \\ s_n = 12-2a & \text{for } \lambda = (9+a)^s \end{array}\right\} \quad a = 0, 1, \ldots, 6$$

Conversely one can find the solar longitude from the length s_n of the noon shadow:

$$\lambda = \left(\frac{s_n}{2}+3\right)^s \quad \text{for} \quad ♋0 \leqq \lambda \leqq ♑0$$

$$\lambda = \left(15-\frac{s_n}{2}\right)^s \quad\quad ♑0 \leqq \lambda \leqq ♋0.$$

For the equinoctial noon shadow ($a = 3$) and with $\varphi = \epsilon$ one would have a gnomon

$$g = 6 \cot \epsilon \approx 6 \cdot 2;15 = 13;30.$$

Because of the crudeness of the scheme a gnomon of length 12 is not quite excluded by this estimate.

II,11–13. Let $\lambda(H)$ be the longitude of the rising point of the ecliptic, λ the longitude of the Sun, s_n the noon shadow, s the shadow at any time of the day. Then the text states that

$$\left.\begin{aligned} \lambda(\mathrm{H}) &= \lambda + \frac{36}{12+s-s_n} && \text{before noon} \\ \lambda(\mathrm{H}) &= \lambda + \left(6 - \frac{36}{12+s-s_n}\right) && \text{after noon} \end{aligned}\right\} \quad (1)$$

and conversely

$$\left.\begin{aligned} s &= s_n - 12 + \frac{64800}{\lambda(\mathrm{H}) - \lambda} && \text{before noon} \\ s &= s_n - 12 + \frac{64800}{10800 - (\lambda(\mathrm{H}) - \lambda)} && \text{after noon} \end{aligned}\right\} \quad (2)$$

where $\lambda(\mathrm{H}) - \lambda$ should be reckoned in minutes of arc.

Since (2) results from (1) by solving for s we need only to discuss (1). Substituting in (1) $s = s_n = 0$ one obtains $\lambda(\mathrm{H}) = \lambda + 3$ signs which is correct for $\lambda =$ ♋0° under the assumption that the sun is in the zenith as would be the case for $\varphi = \epsilon$ (cf. II,9–10). Substituting $s = \infty$ one finds $\lambda = \lambda(\mathrm{H})$ or $\lambda = \lambda(\mathrm{H}) + 6$ signs as is correct for sunrise or sunset respectively.

If one generally substitutes $s = s_n$ one obtains $\lambda(\mathrm{H}) = \lambda + 3$ signs which is, however, not generally true because the culminating point of the ecliptic and the nonagesimal need not to coincide.

Chapter III

III,1. The rule that the number of revolutions of the Sun is obtained from the ahargaṇa a by multiplying it by 120/43831 = 2,0/12,10,31 = 1/6,5;15,30 shows that one sidereal year is assumed to be 365;15,30 days long. This value is well known during the Middle Ages. Battānī, e.g., calls it "Babylonian".[1])

III,2–3. The equation of center for the Sun is given for 30° sections of anomaly. Since one is directed to add 20° to the longitude of the Sun it is clear that these sections begin at 20° of each sign. Hence the solar apogee is located at ♊20°, as in the ārdharātrika system.

Fig. 3 shows as a continuous curve the function 1;12 sin α. The points marked by × give the values of the equation found in the text at arguments 10°, 40°, 70°, etc. (cf. Table 5). Since ♊20 corresponds to $\alpha = 0$ we may also say that the points × correspond to ♋0°, ♌0°,... etc. The very close agreement of the points × with 1;12 sin α shows that the maximum equation for the Sun was assumed to be 1;12°, almost exactly one half of the value in the Almagest (2;23°).

III,4 and 9. The lunar velocity v is here described as a linear zigzag function with the following parameters

[1]) Cf. Nallino, Battānī I p. 40 and p. 127 (4).

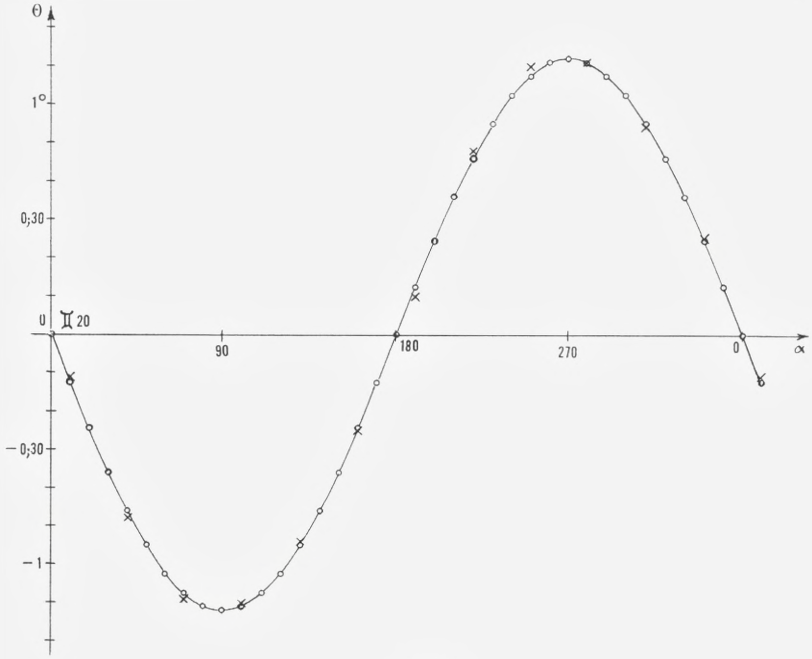

Fig. 3.

$$\left.\begin{aligned} m &= 702 \text{ minutes in 9 padas, i.e. } 11;42^{o/d} \\ M &= 879 \text{ minutes in 9 padas, i.e. } 14;39^{o/d} \\ d &= \frac{9 \cdot 10}{7} \text{ in 9 padas, i.e. } \frac{1;30^{o/d}}{7} \text{ per day.} \end{aligned}\right\} \quad (1)$$

This is the same function which we derived from II,2 to 6, excepting M which had previously the value $14;39 + \frac{1}{7,0}$ as is necessary if one wishes to obtain the exact

TABLE 5.

α		$\lvert 1;12 \sin\alpha \rvert$	Text				α	
0		0					360	
10	170	0;12,30	−0;11		+0;10		190	350
20	160	0;24,39		−0;25		+0;25	200	340
30	150	0;36					210	330
40	140	0;46,17	−0;48		+0;48		220	320
50	130	0;55, 9		−0;54		+0;54	230	310
60	120	1; 2,21					240	300
70	110	1; 7,39	−1; 9		+1;10		250	290
80	100	1;10,54		−1;10		+1;11	260	280
90		1;12					270	

period of 248/9 days for the anomalistic month. Obviously the value of M in (1) is only a convenient rounding for the value in II,2–6.

Separated from III,4 by different rules for the lunar equation (III,5–8) is III,9 where it is said that the longitude of the Moon $\lambda(t+1)$ at the moment $t+1$ is found from $\lambda(t)$ by adding to it $v(t+1)$ as determined from (1).

III,5–8. These verses deal with the determination of the lunar equation, i.e. with the correction θ which must be added to, or subtracted from, the mean longitude to give the true longitude. This function θ has the value zero at the apogee and the perigee of the lunar orbit. Otherwise it is here assumed that the differences $\Delta\theta$ form a linear zigzag function of period $P/2$, $P = 27;33,20^d$ being the anomalistic month. Consequently θ is represented by a difference sequence of second order.

The rules of the text distinguish between the first and the second half of the anomalistic month, beginning at the apogee. As in II,2–6 the anomalistic month is again divided into 248 "padas" (cf. p. 17) such that $1p = \frac{1^d}{9}$.

For the first half, or more specifically, for

$$0 \leqq p \leqq 120 \quad \text{or} \quad 0 \leqq t \leqq 13;20^d \tag{1a}$$

one finds θ (i.e. the negative equation) from

$$\theta = (5261 - 40(p-1))\frac{p}{729} \tag{1b}$$

reckoned in minutes. Proceeding again as in II,2–6 one can replace (1b) by the equivalent rule

$$\theta = 1;1 \cdot t - \left(0;4 + \frac{0;4}{9}\right)t(t-1) \tag{2}$$

which shows that

$$\Delta\theta = 1;1 - \left(0;8 + \frac{0;8}{9}\right)t = 1;1^\circ - 0;8,53,20 \cdot t. \tag{3}$$

The maximum equation should occur at $t = \frac{1}{4}P = 6;53,20^d$. Substituting this value in (2) one obtains

$$\theta_{\max} = 3;59,55,\ldots{}^\circ \approx 4^\circ \tag{4}$$

while (3) gives $\Delta\theta = -0;0,14,\ldots \approx 0$ as it should be. The equation (4) would correspond to an eccentricity of 3;49 for $R = 60$.

In the discussion of II,2–6 we have seen (p. 20) that the velocity function (1) of III,4 leads to a maximum equation of 5;5°. Consequently it is certain that III,5–8 is unrelated to III,4 and III,9 which are the equivalent to II,2–6.

One can again ask how the parameters could have been determined which underly the rules (2) and (3). Obviously one intended to construct a function θ of the type shown in Fig. 2 p. 21 i.e. a sequence of second order such that

$$\Delta\theta = a - dt \tag{5}$$

and therefore

$$\theta = at - \tfrac{1}{2}dt(t-1). \tag{6}$$

Hence our question boils down to the problem of determining the two parameters a and d.

Here one has to start with

$$\theta_{\max} = 4° \quad \text{at} \quad t = \frac{P}{4} = \frac{1{,}2}{9}. \tag{7}$$

At that point $\Delta\theta$ must be zero; thus from (5)

$$a = d \cdot \frac{P}{4}. \tag{8}$$

Substituting this relation in (6) one finds

$$\theta_{\max} = \tfrac{1}{32}\, dP(P+4)$$

hence

$$d = \frac{32}{P(P+4)}\theta_{\max}. \tag{9}$$

Using the values from (7) this gives

$$d = \frac{5{,}24}{36{,}41} = 0;8{,}49{,}56,\ldots \approx 0;8{,}50 \approx 0;8 + \frac{0;8}{9} = \frac{1;20}{9} \tag{10a}$$

$$a = \frac{1;20 \cdot 1{,}2}{1{,}21} = 1;1{,}18,\ldots \approx 1;1. \tag{10b}$$

One would have obtained exactly $d = 1;20/9$ if $P \approx 27;27,30$ and from it exactly $a = 1;1$ if $P \approx 27;27$. The effect of these inaccuracies is clearly visible in Fig. 4.

As a result of these operations one can determine the equation θ which concerns the time between 0 and $\frac{P}{2}$ (and should be subtracted from the mean positions). For the second half of the interval the equation could have been found simply on the basis of symmetry, counting backwards from the endpoint of the anomalistic month. In fact, however, the text instructs us (in III,6) to use for $p > 120$ the amounts

$$p' = p - 120 \tag{11}$$

and to find the equation θ' from the same expression as θ in (1b)

$$\theta' = (5261 - 40(p'-1))\frac{p'}{729} \tag{12}$$

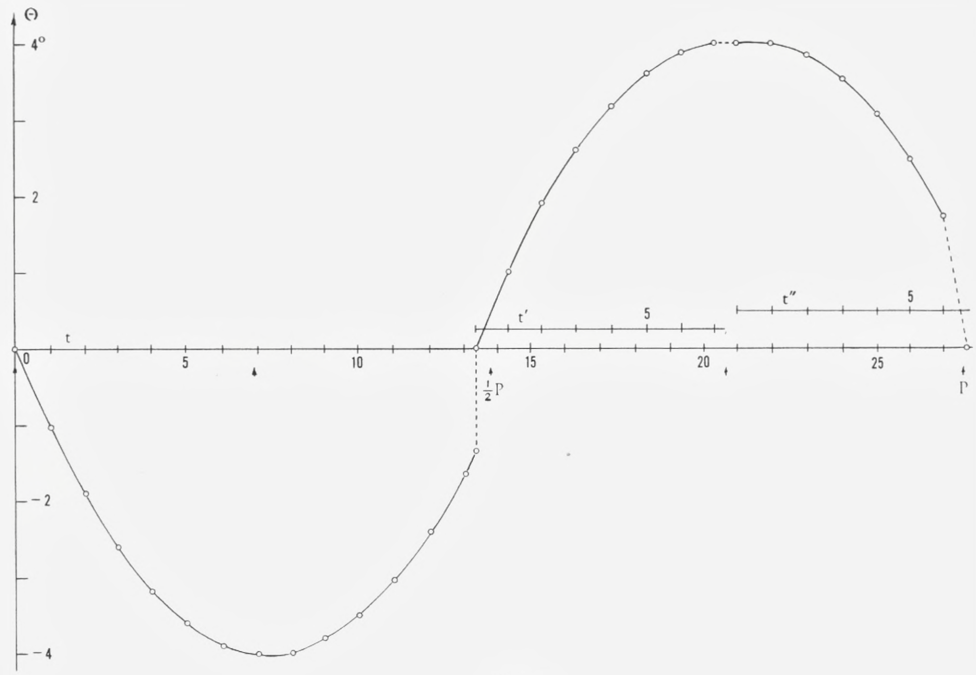

Fig. 4.

but only as long as

$$0 < p' \leqq 63. \tag{13}$$

What happens from here on is difficult to motivate. If we interpret the text correctly (as is by no means certain) the value found for $p' = 63$ is kept valid until $p' = 70$. At $p' = 70$, however, a value is assumed as found from (12) for $p = \frac{560}{9} = 62^2/_9$, i.e. a value which is practically θ_{max}. But by moving it to $p' = 70$ the maximum area is extended instead of shortened (as θ should have shown; cf. Fig. 4). In other words from $p' = 70$ on one introduces a new variable

$$p'' = p' - 69 \tag{14}$$

and computes

$$\theta' = (5261 - 40(p'' - 1))\frac{p''}{729}. \tag{15}$$

This leads for $p'' = 55$ to an equation of about 1;54° instead of to a value nearly zero. The text seems to say that $\theta = 0$ for $p' = 60$; actually $p' = 59$ would correspond to P. It would have been much better to use (12) for the whole second half of an anomalistic month.

III,9 see III,4.

TABLE 6.

t	θ	t	t′	θ'
1^{d}	1; 1	$13;20^{\mathrm{d}}$	0	0
2	1;53, 6,40	14;20	1	1; 1
3	2;36,20	15;20	2	1;53, 6,40
4	3;10,40	16;20	3	2;36,20
5	3;36, 6,40	17;20	4	3;10,40
6	3;52,40	18;20	5	3;36, 6,40
7	4; 0,20	19;20	6	3;52,40
8	3;59, 6,40	20;20	7	4; 0,20
9	3;49	t	t″	
10	3;30			
11	3; 2, 6,40	21	0	4; 0, 1,...
12	2;25,20	22	1	3;59,34,...
13	1;39,40	23	2	3;50,13,...
p =		24	3	3;31,59,...
120 13;20	1;22,26,...			
		25	4	3; 4,52,...
14	0;45, 6,40	26	5	2;28,51,...
		27	6	1;43,57,...
		27;40		0

III,10–11. We associate the indices $i = 0, 1, 2, 3$ with the longitudes 0, 30, 60, 90 respectively. The remaining quadrants of the ecliptic need no special discussion since all steps can be repeated with proper symmetries.

The text gives rules for finding the length of daylight C_i counted in vināḍīs where $360° = 3600^{\mathrm{vin}}$. At equinox $C_0 = 1800^{\mathrm{vin}}$ and in general

$$C_i = 1800 + 2\omega_i \tag{1}$$

where ω_i is the arc ω shown in Fig. 5, for $\lambda = i \cdot 30$. The geographical latitude φ is characterized by the equinoctial noon shadow s_0 of a vertical gnomon of length $g = 12$. The text gives coefficients γ_i such that

$$s_0 \gamma_i = 2(\omega_i - \omega_{i-1}). \tag{2}$$

Since obviously $\omega_0 = 0$ the formula (2) suffices to find all ω_i and thus all C_i. The values given for the γ_i are

$$\gamma_1 = 20^{\mathrm{vin}} \quad \gamma_2 = 16;30^{\mathrm{vin}} \quad \gamma_3 = 6;45^{\mathrm{vin}}. \tag{3}$$

It is not difficult to derive, at least approximately, these values from other known data. Let δ_i be the declination of the Sun. Then Fig. 5 shows that

$$\cot\varphi = \frac{\tan\delta}{\sin\omega}. \tag{4}$$

Now

$$\cot\varphi = g/s_0 \tag{5}$$

and

$$\tan\delta = R\sin\delta/r = \operatorname{Sin}\delta/r \tag{6}$$

where r is the "day radius" (cf. Fig. 6) of the Sun. Thus

$$\operatorname{Sin}\omega = \frac{R\operatorname{Sin}\delta}{r}\cdot\frac{s_0}{g}. \tag{7}$$

For geographical latitudes near 24° the quantities ω can be considered to be small angles for which the approximation

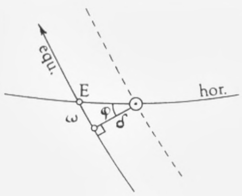

Fig. 5.

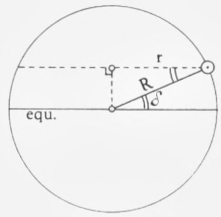

Fig. 6.

$$\operatorname{Sin}\omega \approx 2\omega^{\circ} \tag{8}$$

is permissible.[1]) Thus from (7)

$$2\omega^{\circ} \approx \frac{R\operatorname{Sin}\delta}{r}\cdot\frac{s_0}{g}$$

with $R = 120$ and $g = 12$, $d = 2r$:

$$2\,\omega^{\circ} = \frac{20\operatorname{Sin}\delta}{d}\cdot s_0 \quad \text{hence} \quad 2\omega^{\text{vin}} = \frac{200\operatorname{Sin}\delta}{d}\cdot s_0. \tag{9}$$

We do not know the exact values used for the declination δ and for d but the proper order of magnitude is found when using the parameters given in IV,23–25 (cf. Table 7). The values of the coefficients γ_i in (3) agree well enough with the result of our computation to leave little doubt as to the correctness of our reconstruction.

III,12. The region between the Himālayas and the ocean is Bhāratavarṣa, the Indian sub-continent, corresponding to latitudes φ roughly between 10° and 30°. For this

[1]) This approximation implies two more assumptions:

(a) $\pi \approx 3$ (b) $R = 120$.

For small α, counted in radians, we have $\sin\alpha \approx \alpha$, thus $\operatorname{Sin}\alpha \approx R\alpha$ and consequently $(\alpha R)^{\circ} \approx \frac{180}{\pi}\operatorname{Sin}\alpha \approx 60\operatorname{Sin}\alpha$ because of (a) and finally $2\alpha^{\circ} \approx \operatorname{Sin}\alpha$ because of (b).

area φ is sufficiently near to $\epsilon \approx 24°$ to justify the approximation (8) in III,10–11. The reference for the further explanations is to XIV,1–4.

III,13. The true distances of Avantī (= Ujjayinī) and Vārāṇasī (= Benares) from Yavanapura, assuming that the last is Alexandria in Egypt, are 45;50° and 53;7°. The distances given in the text are $0;7,20^d = 44°$ and $0;9^d = 54°$ respectively.

A result of this type, if not purely accidental, could only have been obtained from the observation of lunar eclipses. The procedure described in the next verse is not applicable for larger distances.

TABLE 7.

i	$\text{Sin}\,\delta_i$	d_i	$\frac{200\,\text{Sin}\,\delta_i}{d_i}$	$\frac{2(\omega_i - \omega_{i-1})}{s_0}$	γ_i
0	0	$4,0 = 2R$	0	0	
1	24;24	3,55	20;46	$20;46^{\text{vin}}$	20^{vin}
2	42;15	3,44;40	37;37	16;51	16;30
3	48;48	3,39;15	44;31	6;54	6;45

III,14. If d is the shortest distance between two localities, measured in yojanas, while their geographical latitudes differ by Δb degrees, the longitudinal difference, in degrees, is found from

$$\Delta l = \sqrt{(9\,d/80)^2 - \Delta b^2}$$

and hence the difference of local time $\Delta l/6$ nāḍikās.

The factor 9/80 is based on assuming 3200 yojanas for the equatorial circumference of the earth, hence

$$\frac{360°}{3200} = \frac{9°}{80}.$$

The same parameter is found in IX,10 and in XIII,15–16.

III,15. A fragmentary passage which in the present form makes no sense, e.g., because one cannot add longitudinal differences and ascensional differences.

III,16. Cf. II,7 and p. 22.

III,17. The daily velocity of the Sun as function of its longitude is assumed to be $1^{\circ/d}$ plus a small correction, constant in each sign (cf. the graph Fig. 7). The apogee lies correctly in Gemini if we assume that the enumeration begins with Aries. The arithmetical mean of the twelve given values is $0;59^{\circ/d}$, the same as the mean value between the minimum $0;57^{\circ/d}$ and the maximum $1;1^{\circ/d}$.

Obviously there is no astronomical reason for the asymmetry of the given values nor can such data be the result of direct observations. On the other hand, the text does not allow for plausible emendations. Hence it is probably a distorted tradition on which the extant text is based. It is, of course, not difficult to reconstruct a symmetric distribution, without changing either the extrema or the mean value. The dotted graph in Fig. 7, changing only two numbers by 0;1 respectively leads, e.g., to a typical "System B" type[1]) of distribution.

III,18–19. A karaṇa is half of a tithi or the period in which the elongation of the Moon from the Sun increases by $6° = 360'$.

Four of the 60 karaṇas thus contained in one synodic month are called "fixed" because the same name is always associated with them: the first karaṇa after conjunction, $n = 1$, is Kiṃstughna, and at the end $n = 58$ is Śakuni, $n = 59$ is Catuṣpada, $n = 60$ is Nāga. The remaining 56 karaṇas are called "movable" and are divided

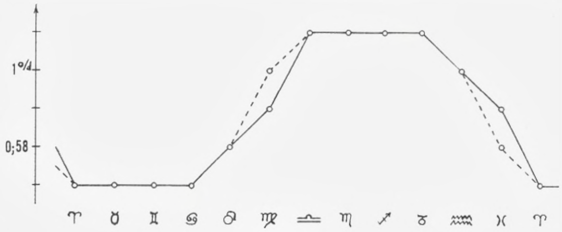

Fig. 7.

into 8 series of 7 each, named in order Bava, Bālava, Kaulava, Taitila, Gara, Vaṇij, and Viṣṭi (see Bṛhatsaṃhitā 99,4–5).

Consequently, in the first half of the month, in the śuklapakṣa, the second karaṇa has the name Bava, i.e., the number $k = 1$ among the movable karaṇas and in general

$$k \equiv n - 1 \mod 7 \tag{1}$$

where n is the consecutively counted number of the karaṇa (i.e., $n = 1, 2, \ldots, 60$) and k the order number of the names of the movable karaṇas (i.e., beginning with Bava, $k = 1$ and ending with Viṣṭi, $k = 7$).

In the second half of the month, i.e., in the kṛṣṇapakṣa, the first karaṇa has the number $n = 31$ but $k = 2$. Hence, if we count the karaṇas of the kṛṣṇapakṣa from $n' = 1$ to 30 we have now

$$k \equiv n' + 1 \mod 7. \tag{2}$$

In order to find n in the śuklapakṣa one takes the elongation $\lambda_m - \lambda_s = \Delta\lambda°$ where λ_m and λ_s are the longitudes of Moon and Sun respectively, reckoned in minutes, $\Delta\lambda°$ the corresponding elongation in degrees. We furthermore assume that these elongations refer to the upper end of a karaṇa such that, e.g., $\Delta\lambda° = 6°$ for the first karaṇa ($n = 1$). With these assumptions one can express (1) in the form

$$k = \frac{\Delta\lambda°}{6} - 1 = \frac{(\lambda_m - \lambda_s) - 360'}{360}. \tag{1a}$$

[1]) Cf., e.g., Neugebauer, Exact Sci.(2) p. 159.

For n' in the kṛṣṇapakṣa we have only to replace $\Delta\lambda°$ by $\Delta\lambda'° = \Delta\lambda° + 180°$ and obtain from (2)

$$k = \frac{\Delta\lambda'°}{6} + 1 = \frac{(\lambda_m + 180° - \lambda_s) + 360'}{360}. \qquad (2a)$$

III,20–22. The vaidhṛta occurs when the Sun and the Moon are equidistant from and on opposite sides of an equinox; then

$$\lambda_s + \lambda_m = 360°. \qquad (1)$$

The vyatipāta occurs when the Sun and Moon are equidistant from and on opposite sides of a solstice; then

$$\lambda_s + \lambda_m = 180°. \qquad (2)$$

This simple scheme is modified by the assumption of a trepidation of the solstices and equinoxes over an arc of 46;40°. The summer solstice is assumed by Varāhamihira to be at Cancer 0° in his own time, in the middle of the arc of trepidation.[1]) But the summer solstice was once in the middle of Āśleṣā (i.e. Cancer 23;20°), and again it will be at Gemini 6;40°. At this latter extreme the vyatipāta produces, instead of (2), the sum

$$\lambda_s + \lambda_m = 180° - 46;40° = 133;20°.$$

This implies that the base vyatipāta occurred when the summer solstice was at Cancer 23;20°.

The choice of an arc of 23;20° is here associated with the obliquity of the ecliptic, though elsewhere that is stated to be 23;40° (IV,16–18) or 24° (IV,24). In fact the choice of the arc must be motivated by the statement in the Jyotiṣavedāṅga (Ṛk 6 = Yajus 7) that the northern ayana of the Sun begins at Dhaniṣṭhā, i.e., at Capricorn 23;20°.

Varāhamihira states in the Bṛhatsaṃhitā (2,1):

> āśleṣārdhād dakṣiṇam uttaram ayanaṃ raver dhaniṣṭhādyam/
> nūnaṃ kadācid āsīd yenoktaṃ pūrvaśāstreṣu//

"Once, according to what is said in ancient treatises, the southern ayana of the Sun was from the middle of Āśleṣā, and the northern began with Dhaniṣṭhā."

The Jyotiṣavedāṅga placed the beginning of the Sun's northern ayana in Dhaniṣṭhā because its list of nakṣatras began with Kṛttikā (as do those in the Atharvaveda and in the Samhitās) rather than with Aśvinī. The true difference between the two starting points is 26;40° not 23;20°.

[1]) As is usual in this and in other texts of Indian astronomy, all longitudes are sidereal, save in cases in which the declination of the Sun plays a role. For the sidereal coordinates the beginning of Aries is identical with the beginning of the nakṣatra Aśvinī.

III,23–24. The ṣaḍaśītimukhas divide the ecliptic into four equal arcs of 86° each and one remaining arc of 16°. The four equal arcs are:

Libra 0° to Sagittarius 26°, Sagittarius 26° to Pisces 22°,
Pisces 22° to Gemini 18°, Gemini 18° to Virgo 14°.

The remaining arc from Virgo 14° to Libra 0° completes the circle. The modern Sūryasiddhānta (XIV,6) states that one must sacrifice to the Pitṛs on the 16 days that do not fall in a ṣaḍaśītimukha; the reason for this practice is not mentioned.

III,25. For the seasons or ṛtus see Part I p. 187. The expression is reminiscent of the passage in the Parāśaratantra cited by Utpala (on Bṛhatsaṃhitā 2,1): "While the Sun travels from the beginning of Śraviṣṭhā (= Dhaniṣṭhā) to the end of Pauṣṇa (= Revatī) it is Śiśira; from the end of Pauṣṇa to the end of Rohiṇī, Vasanta; from the beginning of Saumya (= Mṛgaśiras) to the middle of Sārpa (= Āśleṣā), Grīṣma; from the middle of Sārpa to the end of Hasta, Prāvṛṭ (= Vārṣa); from the beginning of Citrā to the middle of Indra (= Jyeṣṭhā), Śarat; and from the middle of Jyeṣṭhā to the end of Vaiṣṇava (= Śravaṇa), Hemanta."

Parāśara adheres to the old scheme of the Jyotiṣavedāṅga. Varāhamihira's verse is intended to bring the calendar in line with his solstice position.

III,26. The problem is to find the time in nāḍīs that it takes the disc of the Sun to traverse a point on the ecliptic. If v_s is the daily progress of the Sun in minutes, then $v_s/60$ is the motion during one nāḍī. Consequently it takes $60\, d_s/v_s$ nāḍīs for the Sun to move the d_s minutes of its apparent diameter. The mean diameter of the Sun is stated in VIII,13 to be 0;30°.

This solution is specifically applied to the saṅkrāntis or entries of the Sun into a zodiacal sign, which are auspicious. By computation of the Sun's longitude the moment of the entry of its center into a sign is determined; the period of auspiciousness is assumed to extend over the length of time determined in this verse, half taken before, half after the computed moment.

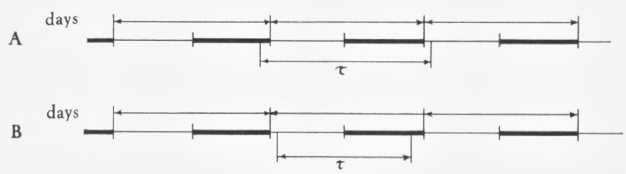

Fig. 8A–B.

III,27. Three possibilities exist: that a true tithi (τ) be longer than the sāvana (sunrise) day, that it be equal to it, or that it be shorter than it. For the first case Fig. 8A illustrates the situation when the tithi participates in three days while Fig. 8B shows for a short tithi the case in which one day participates in three tithis.

III,28–29. These verses concern the retrograde motion of the lunar nodes. Since the ahargaṇa a is to be multiplied by 8/151 we have in first approximation a daily motion of the nodes by

$$8/151 = 8/2,31 \approx 0;3,10,43,42,31,\ldots{}^{\circ/d}.$$

At this rate one revolution requires exactly

$$2,31 \cdot 6,0/8 = 1,53,15^{d}.$$

Consequently the number of revolutions of the nodes during a days is a/1,53,15. For each revolution a correction of +1′ of retrograde motion is required. Thus the daily motion is given by[1])

$$\frac{8}{2,31} + \frac{1}{1,53,15,0} \approx 0;3,10,43,42,31 + 0;0,0,0,31,47 \approx 0;3,10,44,14,18,\ldots{}^{\circ/d}.$$

In III,29 the ascending node at epoch is placed at Scorpio 25;59° (λ = 235;59°). Modern tables[2]) give for 505 March 22 for the ascending node about Scorpio 25;54°. Varāhamihira's Sūryasiddhānta would place it at Scorpio 26;6,57°; see below IX,5.

III,30–31. The variation of the lunar latitude is treated as a simple linear zigzag function with 4;40° as maximum, a value which seems to be attested nowhere else. The value in IX,6 is the more common one 4;30°.

III,32–35. These verses are evidently based on some obscure speculation in the Romakasiddhānta about the duration of creation. III,33 seems to belong naturally with XV,17–27.

The separation of tithi and nakṣatra presumably means that at the first tithi of the month the Moon is not in the first nakṣatra, Aśvinī; this separation is supposed to be an auspicious muhūrta for the pratipatti, i.e. the beginning of any action (or the beginning of creation?). However, if on a bhadrā tithi (the 2nd, 7th, or 12th in any pakṣa[3])) the Moon is in Śravaṇa (Sagittarius 10° to 23;20°), the muhūrta is inauspicious. The inauspiciousness arises from the fact that the creation ceases at such a yuga, i.e. when the conjunction of the Sun and Moon (the first tithi) occurs in Uttarāṣāḍhā, i.e. at the winter solstice. This is reminiscent of Hellenistic speculations regarding a "world-year."[4])

The 68 550 years in III,34 is derived from the Romakasiddhānta; it is equal to 24·19·150 + 150 = 19,2,30, where 19·150 = 2850 years is the Romaka's yuga (cf. I,15). The significance of this computation is obscure.

[1]) Cf. also IX,5.
[2]) Ernest W. Brown, Tables of the Motion of the Moon (New Haven 1919) Section II.
[3]) The 15 tithis of every half-month are divided into three equal series whose members are consecutively called mandā, bhadrā, vijayā, riktā, and pūrṇā; see Bṛhatsaṃhitā 99,2.
[4]) See e.g., B. L. van der Waerden, Hermes 80 (1952) p. 129–155.

The meaning of III,35 also defies comprehension. Dikshit [1890 a] has indeed demonstrated that, by the elements of Varāhamihira's Sūryasiddhānta, the Caitra whose pratipad is used as epoch in this karaṇa is pūrṇimānta; but there is no reason to compute the longitudes of the Sun and Moon for the pūrṇimā of that month. Moreover, at Caitrapūrṇimā the Moon must be close to Libra 0° so that the Moon on the ninth tithi is far from Punarvasu (Gemini 20° to Cancer 3;20°). The reference to Punarvasu rather suggests an ecpyrosis at the summer solstice as we had a cataclysm at the winter solstice (III,32), but the text as it stands does not allow us to arrive at this interpretation.

III,36–38. The need to select the proper times (muhūrta) for the twice-born (Brāhmaṇa, Kṣatriya, or Vaiśya) to perform the various śrauta (Vedic) and smārta (customary) rituals is one of the principal motivations for the study of astronomy in India. Therefore those who despise astronomy as being inaccurate as well as those who incorrectly practice it are suitably punished, while experts in the field are rewarded in the traditional manner. Compare IX,8 in the Paitāmahasiddhānta of the Viṣṇudharmottarapurāṇa.

Chapter IV

IV,1–5. Let c be the circumference of a circle of radius R, d its diameter. It is assumed that

$$d = \sqrt{c^2/10} \tag{1}$$

hence

$$\pi = \sqrt{10} \approx 3.162 \quad \text{instead of} \approx 3.141. \tag{1a}$$

Furthermore

$$\left.\begin{aligned} \operatorname{Sin} 30^\circ &= \sqrt{R^2/4} = R/2 \\ \operatorname{Sin} 60^\circ &= \sqrt{R^2 - R^2/4} = R\sqrt{3/2}. \end{aligned}\right\} \tag{2}$$

Finally a formula is given to obtain $\operatorname{Sin}\alpha$ from $\operatorname{Sin} 2\alpha$, i.e., to go from Sin 30° to Sin 15°, Sin 7;30°, Sin 3;45°:

$$\operatorname{Sin}^2\alpha = \left(\frac{R - \operatorname{Sin}(90-2\alpha)}{2}\right)^2 + \left(\frac{\operatorname{Sin} 2\alpha}{2}\right)^2. \tag{3}$$

This formula can easily be obtained from the relation between chord- and sine-function (cf. Fig. 9):

$$\operatorname{Crd}^2\theta = \operatorname{Vers}^2\theta + \operatorname{Sin}^2\theta$$

and

$$\operatorname{Crd}\theta = 2\operatorname{Sin}\frac{\theta}{2}$$

give indeed

$$4\operatorname{Sin}^2\frac{\theta}{2} = (R - \operatorname{Cos}\theta)^2 + \operatorname{Sin}^2\theta.$$

The relation (3) is the equivalent of

$$4 \sin^2\alpha = (1 - 2\cos 2\alpha + \cos^2 2\alpha) + \sin^2 2\alpha = 2 - 2\cos 2\alpha$$

hence

$$2 \sin^2\alpha = 1 - \cos 2\alpha. \quad (4)$$

Also this form is found in our text (IV,5):

$$\text{Sin}^2\alpha = 60(R - \text{Sin}(90 - 2\alpha)) \quad (5)$$

which follows from (4) if $R = 120$.

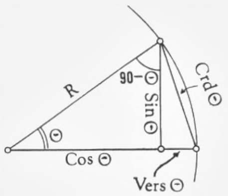

Fig. 9.

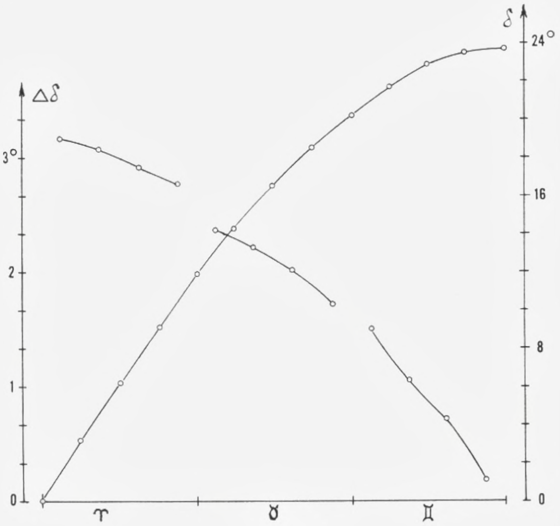

Fig. 10.

IV,6–15. Table 8 shows the numerical equivalents of the numbers described in these verses. The units are called "minutes" and "seconds" but in fact the "minutes" are the same units in which R counts as 120. The terminology is derived from the earlier Sine-table in the Paitāmahasiddhānta of the Viṣṇudharmottarapurāṇa (III,12) in which the radius as well as the circumference are reckoned in minutes ($R = 3438 = 57{,}18$, $c = 21\,600 = 6{,}0{,}0$).

IV,16–18. These verses concern the solar declinations (δ) for which the text gives the differences ($\Delta\delta$) in steps of 7;30° of longitude (cf. Table 9). The trend of these differences is rather irregular (cf. Fig. 10) but the effect on the declinations themselves is not very visible. The total for 90° is

$$\varepsilon = 23;40°. \quad (1)$$

and that this was intentional is shown by the statement in IV,16 that

$$\text{Sin}\,\varepsilon = 48;9 \quad (2)$$

which is indeed correct for $\varepsilon = 23;40°$.

From IV,23–25 one derives the round value $\varepsilon = 24°$.

TABLE 8.

α	sin α	$Sin_{120}\,α$	Text $Sin_{120}\,α$	Δ	Text Δ
3;45°	0; 3,55,27	7;50,54	7;51	7;50,54	7;51
7;30	7,49,54	15;39,48	15;40	7;48,54	7;49
11;15	11,42,20	23;24,40	23;25	7;44,52	7;45
15	15,31,45	31; 3,30	31; 4(+)	7;38,50	7;39
18;45	19,17,11	38;34,22	38;34	7;30,52	7;30(−)
22;30	22,57,40	45;55,20	45;56(+)	7;20,58	7,22(+)
26;15	26,32,14	53; 4,28	53; 5(+)	7; 9, 8	7; 9
30	30	1, 0	1, 0	6;55,32	6;55(−)
33;45	33,20, 3	1, 6;40, 6	1, 6;40	6;40, 6	6;40
37;30	36,31,32	1,13; 3, 4	1,13; 3	6;22,58	6;23
41;15	39,33,39	1,19; 7,18	1,19; 7	6; 4,14	6; 4
45	42,25,35	1,24;51,10	1,24;51	5;43,52	5;44
48;45	45, 6,37	1,30;13,14	1,30;13	5;22, 4	5;22
52;30	47,36, 4	1,35;12, 8	1,35;12	4;58,54	4;59
56;15	49,53,17	1,39;46,34	1,39;46(−)	4;34,26	4;34
60	51,57,41	1,43;55,22	1,43;55	4; 8,48	4;11(+)
63;45	53,48,45	1,47;37,30	1,47;37(−)	3;42, 8	3;42
67;30	55,25,58	1,50;51,56	1,50;52	3;14,26	3;15(+)
71;15	56,48,57	1,53;37,54	1,53;37(−)	2;45,58	2;45(−)
75	57,57,20	1,55;54,40	1,55;55	2;16,46	2;18(+)
78;45	58,50,50	1,57;41,40	1,57;42	1;47, 0	1;47
82;30	59,29,12	1,58;58,24	1,58;59(+)	1;16,44	1;17
86;15	59,52,18	1,59;44,36	1,59;44(−)	0;46,12	0;45(−)
90	1; 0, 0, 0	2, 0; 0, 0	2, 0; 0	0;15,24	0;16(+)

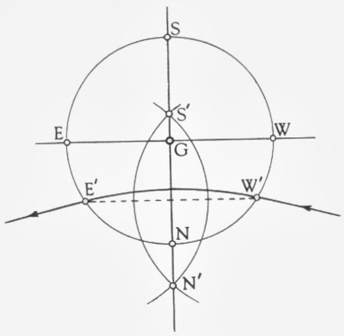

Fig. 11.

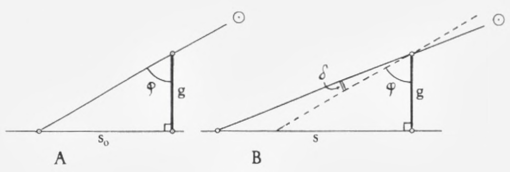

Fig. 12.

TABLE 9.

λ	$\Delta\lambda$		δ
7;30°	190′ =	3;10°	3;10°
15	183	3; 3	6;13
22;30	175	2;55	9; 8
30	166	2;46	11;54
37;30	142′ =	2;22°	14;16
45	133	2;13	16;29
52;30	121	2; 1	18;30
60	103	1;43	20;13
67;30	90 =	1;30°	21;43
75	63	1; 3	22;46
82;30	43	0;43	23;29
90	11	0;11	23;40

IV,19. Construction of the cardinal directions in a horizontal plane (cf. Fig. 11) If G is the foot of a gnomon, E′, W′ the intersections of a shadow-curve with a circle of center G (why of radius $4g$?); perpendicular to E′W′ (based on a "barley-corn figure" N′S′) is the N–S direction.

IV,20–23. The following formulae are direct consequences of Fig. 12A and B, assuming $R = 120$ and $g = 12$:

$$\mathrm{Sin}\,\varphi = 120\, s_0 / \sqrt{s_0^2 + 144} \tag{1}$$

$$s = 12\ \mathrm{Sin}(\varphi \pm \delta) / \sqrt{R^2 - \mathrm{Sin}^2(\varphi \pm \delta)} \tag{2}$$

$$\mathrm{Sin}\,\bar{\varphi} = \sqrt{R^2 - \mathrm{Sin}^2 \varphi}. \tag{3}$$

The second part of IV,21 implies that, when one replaces the equinoctial noon shadow s_0 in (1) by s, the noon shadow at any day, one obtains the Sine of the Sun's coaltitude $\bar{h}$:

$$\mathrm{Sin}\,\bar{h} = Rs / \sqrt{s^2 + g^2} \tag{1a}$$

and again φ from $\bar{h}$ by adding (algebraically) the declination:

$$\varphi = \bar{h} + \delta. \tag{1b}$$

IV,23–25. It follows from Fig. 6 (p. 30) that the radius r of the Sun's daycircle at a declination δ is given by

$$r = \sqrt{R^2 - \mathrm{Sin}^2 \delta} \tag{1}$$

measured in units in which $R = 120$. In the text we have the following numerical relations

$$\left.\begin{array}{llll} \lambda_s: & 30^\circ & 60^\circ & 90^\circ \\ \mathrm{Sin}\,\delta: & 24;24 & 42;15 & 48;48 \\ 2r: & 3,55 & 3,44;40 & 3,39;15. \end{array}\right\} \quad (2)$$

It follows from (1) that one should have $\mathrm{Sin}^2\delta + r^2 = R^2 = 4,0,0$. In fact one obtains from (2) for $\mathrm{Sin}^2\delta + r^2$ the values

$$3,54,51;\ldots \quad 4,0,3;\ldots \quad 3,59,58;\ldots$$

respectively. Since the last number agrees best we may use correspondingly

$$48;48 = \mathrm{Sin}\,\varepsilon \quad (3)$$

for the determination of the obliquity ε of the ecliptic and find by linear interpolation in Table 8 (p. 38) of IV,6–15[1])

$$\varepsilon = 24;0,12,\ldots \approx 24^\circ \quad (4)$$

a much used round value, but different from the value used in IV,16–18.

IV,26. The following rule is given for the determination of the ascensional differences ω (cf. Fig. 5 p. 30):

$$2\omega^{\mathrm{vin}} = 60\,\frac{\mathrm{Sin}\,\varphi \cdot R \cdot \mathrm{Sin}\,\delta}{\mathrm{Sin}\,\bar{\varphi} \cdot d \cdot 3}. \quad (1)$$

Its correctness follows from (6) in III,10–12 (with $R = 120$, $g = 12$, $d = 2r$):

$$2\omega^{\mathrm{vin}} = \frac{200\ \mathrm{Sin}\,\delta}{d}\,s_0 = 10 \cdot 12\ \tan\varphi \cdot \frac{60\ \mathrm{Sin}\,\delta}{3d} = R\tan\varphi \cdot \frac{60\,\mathrm{Sin}\,\delta}{3d}$$

q.e.d. Cf. also IV,34.

If we reckon ω in degrees instead of in vināḍikās we obtain from (1) simply

$$\omega = \frac{R}{r}\mathrm{Sin}\,\delta\tan\varphi. \quad (2)$$

IV,27–28. Computing first the "earth-Sin" e from

$$e = d\ \mathrm{Sin}\,\omega/240 \quad (1)$$

one finds φ from

$$\mathrm{Sin}\,\varphi = eR/\sqrt{e^2 + \mathrm{Sin}^2\delta}. \quad (2)$$

The proof follows readily from Fig. 13:

$$e = \mathrm{Sin}\,\delta\tan\varphi$$

and (cf. III,10–12 (7) and (5))

[1]) Accurate would be $\mathrm{arc\,Sin}\ 48;48 = 23;59,45^\circ$.

$$\mathrm{Sin}\,\omega = \frac{R}{r}\,\mathrm{Sin}\,\delta\,\tan\varphi$$

which gives (1) if $R = 120$. Fig. 13 shows furthermore that

$$\sin\varphi = e/\mathrm{AO} \qquad \mathrm{AO}^2 = e^2 + \mathrm{Sin}^2\delta$$

which proves (2).

IV,29–30. Let us assume that λ is a longitude within the first quadrant of the ecliptic; for the remaining quadrants obvious symmetries hold. Then the right ascensions $\alpha(\lambda)$ are determined by

$$\mathrm{Sin}\,\alpha = \frac{2R}{d}\sqrt{\mathrm{Sin}^2\lambda - \mathrm{Sin}^2\delta}. \tag{1}$$

If, in particular, α obtained from (1) is measured in degrees, then 10α is the right ascension measured in vināḍīs.

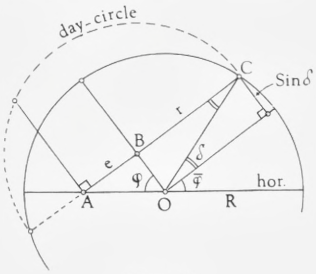

Fig. 13.

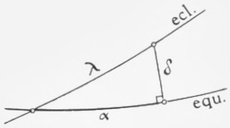

Fig. 14.

For the endpoints of the first three signs the text gives data which agree very well with the values found in the Almagest:

♈:	278^{vin} =	27;48°	Alm. II,8:	27;50°
♉:	299	29;54		29;54
♊:	323	32;18		32;16.

Proof of (1): It follows from Fig. 14 that[1])

$$\sin\varepsilon = \sin\delta/\sin\lambda \qquad \tan\varepsilon = \tan\delta/\sin\alpha \tag{2}$$

thus

$$\frac{\sin\alpha}{\sin\lambda} = \frac{\tan\delta}{\tan\varepsilon}\cdot\frac{\sin\varepsilon}{\sin\delta} = \frac{\cos\varepsilon}{\cos\delta} = \frac{r_0}{r} \tag{3}$$

where r_0 is the day-radius for $\lambda = 90°$ i.e. for $\delta = \varepsilon$ (cf. Fig. 13); thus

$$r_0 = R\cos\varepsilon. \tag{4}$$

[1]) It is not necessary to assume here the use of spherical trigonometry (Fig. 14) since the same relation can be readily obtained from an "analemma" (Fig. 15).

Hence from (3) and (2)

$$\operatorname{Sin}\alpha = \frac{r_0}{r}\operatorname{Sin}\lambda = \frac{R}{r}\operatorname{Sin}\lambda\cos\varepsilon = \frac{R}{r}\operatorname{Sin}\lambda\sqrt{1-\sin^2\varepsilon}$$

$$= \frac{R}{r}\operatorname{Sin}\lambda\sqrt{1-(\operatorname{Sin}^2\delta/\operatorname{Sin}^2\lambda)}$$

q.e.d.

IV,31. The difference between the right ascension $\alpha(\lambda)$ of a point of the ecliptic of longitude λ and the corresponding oblique ascension $\varrho(\lambda)$ is the quantity $\omega(\lambda)$ (cf. Fig. 5 p. 30):

$$\omega(\lambda) = \alpha(\lambda) - \varrho(\lambda) \tag{1}$$

which, in the terminology of the text, is half of the "ascensional difference" 2ω.

Since there is always one semicircle of the ecliptic above the horizon the rising time of λ equals the setting time of $\lambda + 180$.

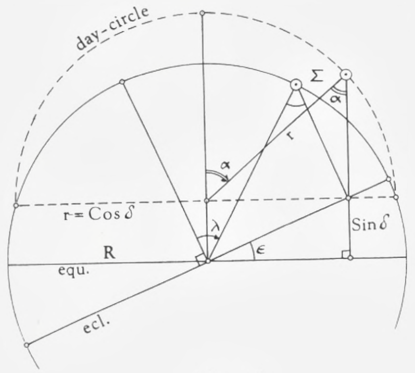

Fig. 15.

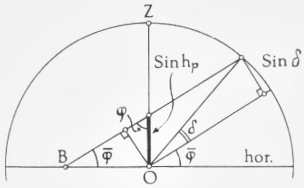

Fig. 16.

IV,32–33. When the Sun is on the northern semicircle (gola) of the ecliptic the declination δ is positive and one can compute the altitude h_p of the Sun in the prime vertical (cf. the projection on the meridian in Fig. 16) from

$$\operatorname{Sin} h_p = R\operatorname{Sin}\delta/\operatorname{Sin}\varphi. \tag{1}$$

Having found the altitude h_p of the Sun, the time (after sunrise or before sunset) when the Sun crosses the prime vertical can be computed, but the text does not tell us how this should be done.

IV,34. The increase of the length of daylight over 12 hours = 30 nāḍikās is given by

$$2\omega^n = \frac{2R\cdot\operatorname{Sin}\delta}{6d}\cdot\frac{\operatorname{Sin}\varphi}{\operatorname{Sin}\bar{\varphi}}. \tag{1}$$

This, in fact, is only a repetition of IV,26. It is here out of place since IV,35, 36, 38 return to the problems connected with the crossing of the prime vertical by the Sun.

IV,35–36. As in IV,32–33 we assume $\delta > 0$. Then

$$\operatorname{Sin} h_{\mathrm{p}} = \frac{\operatorname{Sin}\lambda \cdot \operatorname{Sin}\varepsilon}{\operatorname{Sin}\varphi}. \qquad (1)$$

This follows immediately from (1) in IV,32–33 since with (2) in IV,29–30

$$R \operatorname{Sin}\delta = \operatorname{Sin}\lambda \operatorname{Sin}\varepsilon. \qquad (2)$$

IV,37. By marking on the circle, whose center is the foot of the gnomon, the point that the gnomon-shadow at dawn intersects, one obtains the ortive amplitude by observation; from this can be computed δ by IV,39 and hence the longitude λ of the Sun.

IV,38. The Sun is in the prime vertical when the shadow of a vertical gnomon falls in the east-west line.

IV,39–40. The ortive- or setting-amplitude η of the Sun at declination δ can be found from

$$\operatorname{Sin}\eta = R \operatorname{Sin}\delta / \operatorname{Sin}\overline{\varphi}. \qquad (1)$$

This follows from Fig. 16 because BO = $\operatorname{Sin}\eta$ and $\sin\overline{\varphi} = \operatorname{Sin}\delta/\mathrm{BO}$. Conversely (1) can be used to find $\overline{\varphi}$ and φ from

$$\operatorname{Sin}\overline{\varphi} = R \operatorname{Sin}\delta / \operatorname{Sin}\eta. \qquad (2)$$

IV,41–44. Determination of the length of the shadow of a vertical gnomon at a given time t^{n} (in nāḍikās) after sunrise. From the given time

$$t^{\circ} = 6t^{\mathrm{n}} \qquad (1)$$

and the ascensional difference found from IV,26 or IV,34

$$\omega^{\circ} = \tfrac{1}{20}\, 2\omega^{\mathrm{vin}} \qquad (2)$$

one finds a time interval

$$t' = t^{\circ} \mp \omega^{\circ} \quad \text{if } \delta \gtrless 0. \qquad (3)$$

From IV,23–25 the diameter of the day-circle is known, hence one can compute the altitude h of the sun from

$$\operatorname{Sin} h = \frac{d \operatorname{Sin}\overline{\varphi}}{2R^2}(\operatorname{Sin} t' \pm \operatorname{Sin}\omega) \qquad (4)$$

and thus the length of the shadow

$$s = \frac{g}{\operatorname{Sin} h}\sqrt{R^2 - \operatorname{Sin}^2 h} \qquad (5)$$

where for $R = 120$

$$2R^2 = 28\,800 \qquad R^2 = 14\,400.$$

The proof follows from Fig. 17 which represents the plane of the meridian with half of the day-circle turned into it, the Sun being at Σ. Then

$$\Sigma' B = \Sigma'\mathrm{C} \pm \mathrm{CB} = r \sin t' \pm r \sin \omega = \frac{r}{R}(\mathrm{Sin}\, t' \pm \mathrm{Sin}\, \omega) \qquad \delta \gtrless 0. \tag{6}$$

Furthermore

$$\mathrm{Sin}\, h / \Sigma'\mathrm{B} = \mathrm{Sin}\, \bar{\varphi} / R \tag{7}$$

which gives (4) using (6). Formula (5) means simply (cf. Fig. 18):

$$\cot h = s/g = \sqrt{R^2 - \mathrm{Sin}^2 h} / \mathrm{Sin}\, h. \tag{8}$$

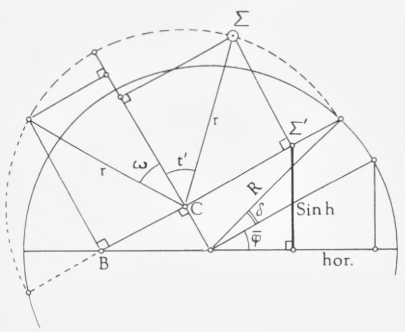

Fig. 17.

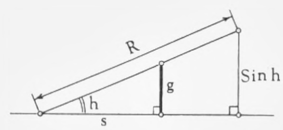

Fig. 18.

IV,45–47. This is the inverse problem to IV,41–44: find from the length s of the shadow the time t^n after sunrise. One is directed to compute to given s a "first Sine" S_1:

$$S_1 = \frac{gR^2}{\mathrm{Sin}\, \bar{\varphi} \sqrt{s^2 + g^2}} \qquad gR^2 = 12 \cdot 120^2 = 172\,800 \tag{9}$$

and from it

$$S_2 = S_1 \mp \frac{\mathrm{Sin}\, \varphi}{\mathrm{Sin}\, \bar{\varphi}} \mathrm{Sin}\, \delta. \tag{10}$$

Then

$$t' = \mathrm{arc\ Sin}\left(S_2 \cdot \frac{2R}{d}\right) \tag{11}$$

and

$$\omega = \mathrm{arc\,Sin}\left(\frac{\mathrm{Sin}\, \varphi}{\mathrm{Sin}\, \bar{\varphi}} \mathrm{Sin}\, \delta \cdot \frac{2R}{d}\right) \tag{12}$$

from which the time after sunrise in nāḍikās

$$t^n = \tfrac{1}{6}(t' + \omega). \tag{13}$$

Indeed, from (7) and Fig. 18 (or IV,52)

$$S_1 = \frac{R}{\operatorname{Sin}\overline{\varphi}} \cdot \frac{gR}{\sqrt{s^2+g^2}} = \frac{R}{\operatorname{Sin}\overline{\varphi}} \operatorname{Sin} h = \Sigma' \mathrm{B} \tag{14}$$

which explains (9). Consequently (cf. Fig. 17) for $\delta \gtrless 0$

$$S_2 = \Sigma' \mathrm{B} \mp \tan\varphi \operatorname{Sin}\delta = \Sigma' \mathrm{B} \mp e = \Sigma' \mathrm{C} = r \sin t' = \frac{r}{R} \operatorname{Sin} t'$$

therefore (11):

$$\operatorname{Sin} t' = S_2 \frac{2R}{d}.$$

Finally (Fig. 17)

$$r \sin\omega = \frac{r}{R} \operatorname{Sin}\omega = e = \tan\varphi \operatorname{Sin}\delta$$

therefore

$$\operatorname{Sin}\omega = \tan\varphi \operatorname{Sin}\delta \cdot \frac{2R}{d}$$

q.e.d.

IV,48–49. The relations developed in IV,41–47 for finding the time after sunrise (before noon) from the length of the shadow, and vice versa, are astronomically exact. What now follows is a crude approximation for the same problem, based on the simple assumption that the length s of the shadow at the time t after sunrise is given by

$$s = \frac{a}{t} + b \tag{1}$$

with arbitrary constants a and b. This relation satisfies at least the condition $s = \infty$ for $t = 0$ and a/t is the simplest function to give this result.

If C is the length of daylight, measured in the same units as t, then it follows from (1) that the noon shadow s_0 is given by

$$s_0 = \frac{2a}{C} + b.$$

Hence we have now instead of (1)

$$s = \frac{a}{t} + s_0 - \frac{2a}{C} \tag{2}$$

where a is still an arbitrary constant. For no special reason the text chooses

$$a = 6C, \tag{3}$$

hence IV,49:

$$s = \frac{6C}{t} + s_0 - 12 \tag{4}$$

and solving for t, IV,48:

$$t = \frac{6C}{s - s_0 + 12}. \tag{5}$$

IV,50–51. General remarks concerning the adaptation of the preceding rules to the Moon and the planets. In fact without value and out of place.

IV,52–54. It is supposed to be known: the solar longitude λ, the solar declination δ, the geographical latitude φ, the length s of the shadow ($g = 12$), and the E-W-line in the plane of the horizon. One wishes to find the distance s' of the endpoint A of the shadow from the E-W-line (cf. Fig. 19B).

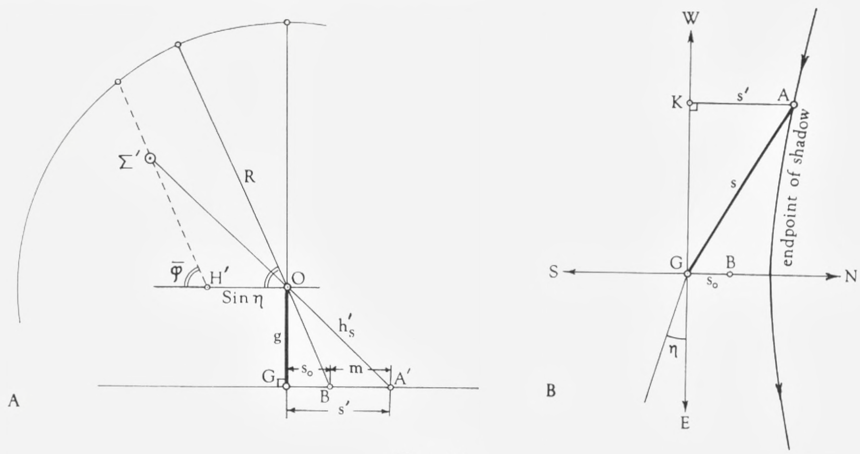

Fig. 19.

This problem is solved through the following steps. First one finds the altitude h of the Sun from

$$\operatorname{Sin} h = gR/\sqrt{s^2 + g^2} \tag{1}$$

(cf. Fig. 18 p. 44) and defines

$$\operatorname{Sin}\theta = \operatorname{Sin} h \frac{\operatorname{Sin}\varphi}{\operatorname{Sin}\bar{\varphi}}. \tag{2}$$

This angle θ is conventionally called the "Sun's amplitude" (sūryāgrā). Furthermore the ortive amplitude η of the Sun is given by

$$\operatorname{Sin}\eta = R \operatorname{Sin}\delta/\operatorname{Sin}\bar{\varphi} \tag{3a}$$

or

$$\mathrm{Sin}\,\eta = \mathrm{Sin}\,\varepsilon \cdot \mathrm{Sin}\,\lambda / \mathrm{Sin}\,\bar{\varphi} \tag{3b}$$

(cf. IV,39–40 (3) and IV,35–36 (2)). Then the "koṭi" s' is given by

$$s' = (\mathrm{Sin}\,\eta \mp \mathrm{Sin}\,\theta) h_s / R \quad \delta \gtrless 0 \tag{4}$$

where h_s is the "hypotenuse" of the shadow, i.e.,

$$h_s = \sqrt{s^2 + g^2}. \tag{5}$$

The distance GK on the east-west-line is called the "bāhu".

In order to prove (4) we consider in Fig. 19A the top O of the gnomon as the center of the celestial sphere and project the sun Σ onto Σ' in the meridian plane. Similarly $A'G = s'$ is the projection of the shadow s, $h_s' = OA'$ the projection of the hypotenuse OA. Let $s_0 = GB$ be the equinoctial noon shadow, then

$$A'B = s' - s_0 = m \qquad OH' = \mathrm{Sin}\,\eta$$

and because

$$\frac{m}{h'} = \frac{\mathrm{Sin}\,\eta}{O\Sigma'} \quad \frac{h'_s}{O\Sigma'} = \frac{h_s}{O\Sigma} = \frac{h_s}{R}$$

we have

$$m = \mathrm{Sin}\,\eta \cdot h_s / R. \tag{6}$$

Furthermore with (2), (1), and (5):

$$\mathrm{Sin}\,\theta \cdot h_s/R = \mathrm{Sin}\,h \cdot \tan\varphi \cdot h_s/R = \frac{gR}{h_s} \cdot \tan\varphi \cdot \frac{h_s}{R} = g \tan\varphi = s_0$$

hence

$$s' = m \mp s_0 \quad \delta \gtrless 0$$

as is correct according to Fig. 19A (drawn for $\delta < 0$).

IV,55–56. Here the inverse problem to IV,52–54 is solved: find the solar longitude λ from observed s and s', φ and ε being known, $g = 12$. With

$$h_s = \sqrt{s^2 + g^2}$$

one finds from (4)

$$\mathrm{Sin}\,\eta \mp \mathrm{Sin}\,\theta = Rs'/h_s. \tag{6}$$

From (1) and (2) one finds $\mathrm{Sin}\,\theta$, hence $\mathrm{Sin}\,\eta$ from (6) and $\mathrm{Sin}\,\lambda$ from (3b).

Chapter V

V,1–3. If $\Delta\lambda$ is the elongation of the Moon from the Sun, $\Delta\delta$ the difference of the respective declinations, β the lunar latitude, then we are told to compute

$$A = \sqrt{(\Delta\lambda + \Delta\delta)(\Delta\lambda - \Delta\delta)} = \sqrt{\Delta\lambda^2 - \Delta\delta^2} \tag{1}$$

and from it

$$B = \beta\Delta\delta/A. \tag{2}$$

Finally one forms

$$C = \Delta\lambda \mp B \quad \text{at first visibility} \tag{3a}$$

and

$$C = \Delta\lambda \pm B \quad \text{at last visibility} \tag{3b}$$

where the upper sign is to be used when the latitude β has the same sign as $\Delta\delta = \delta_m - \delta_s$, the lower sign in the opposite case.

For first visibility it is required that

$$\bar{\varrho}(C) \geq 2 \text{ nāḍikās} = 12° \tag{4}$$

where $\bar{\varrho}(C)$ is the setting time of the arc C, i.e., the rising time of $C + 180°$.

In order to explain these rules we consider the situation near sunset at first visibility (cf. Fig. 20), the Sun being at Σ, the Moon at M, in the case that

$$\left.\begin{aligned} \mathrm{U}\Sigma &= \Delta\lambda = \lambda(\mathrm{M}) - \lambda(\Sigma) > 0 \\ \mathrm{UV} &= \Delta\delta = \delta(\mathrm{U}) - \delta(\Sigma) > 0. \end{aligned}\right\} \tag{5}$$

Treating all triangles as plane we see that A in (1) represents the right ascensional difference

$$A = \Delta\alpha = \alpha(\mathrm{V}) - \alpha(\Sigma) = \mathrm{V}\Sigma. \tag{6}$$

Furthermore

$$\Delta\delta/A = \mathrm{UV}/\mathrm{U}\Sigma = \cot\theta = \mathrm{c}/\beta.$$

Therefore, from (2):

$$B = \beta\cot\theta = c = \mathrm{UT} \tag{7}$$

and from (3a):

$$C = \Delta\lambda - c = \mathrm{U}\Sigma - \mathrm{UT} = \mathrm{T}\Sigma = \Delta\lambda^* \tag{8}$$

(which, incidentally, is the "polar longitude" of the Moon). The corresponding right ascensional difference is the setting time, i.e., the delay of moonset over sunset

$$\bar{\varrho}(C) = \mathrm{R}\Sigma \tag{9}$$

which must exceed 12° in order to make the first crescent visible.

V,4–7. These verses concern the determination of the width σ (sūtra) of the illuminated sickle of the new crescent (cf. Fig. 21). We first give an astronomically plausible solution of the problem (cf. Fig. 22) and discuss only at the end how the erroneous formulation in the text may have originated.

Under all circumstances we may consider to be known the longitudes of Sun and Moon, hence also their elongation $\Delta\lambda$. Fig. 21 illustrates how the width of the sickle increases with $\Delta\lambda$ such that σ can be found from

$$\sigma = r_{\mathrm{m}}(1 - \cos\Delta\lambda) \tag{1}$$

where r_{m} is the apparent radius of the Moon. According to V,4 the apparent diameter of the Moon contains 15 "parts"; the origin of this division is unknown but it seems also to be used in XIV,38.

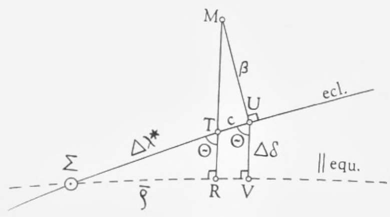

Fig. 20.

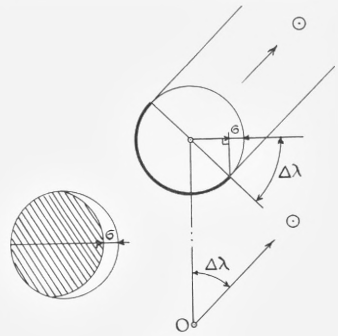

Fig. 21.

If one assumes that $\cos\Delta\lambda$ decreases linearly from 1 to 0 as $\Delta\lambda$ increases from 0° to 90° one can replace (1) by

$$\sigma = \frac{\Delta\lambda}{180} \cdot 15 = \frac{\Delta\lambda}{12} \tag{2}$$

measured in "parts". For $\Delta\lambda = 90°$, i.e. for quadrature, one obtains correctly $\sigma = 7;30 = r_{\mathrm{m}}$.

In (1) we have tacitly assumed that the Moon lies in the ecliptic. If, however, the Moon is at a latitude β, as shown in Fig. 22, then $\Delta\lambda$ has to be replaced in (1) and (2) by

$$h = \sqrt{\Delta\lambda^2 + \beta^2}. \tag{3}$$

This would solve our problem. The text, however, continues (cf. V,5) by forming the "koṭi" by combining β and the arc of declination $\Delta\delta$

$$k = \beta + \Delta\delta \tag{4}$$

(with proper signs) as shown in Fig. 22; finally the bāhu (or bhuja) is found from

$$b = \sqrt{h^2 - k^2}. \tag{5}$$

The reason for computing $b = \Delta\alpha$ would be that $\Delta\alpha \geqq 12°$ is the criterion for the visibility of the new crescent (cf. XVI,23 and XVII,58).

The formulation of the text (cf. Fig. 23) does not agree with this interpretation since it is said that the quantity σ (the sūtra) is to be laid off on the bhuja b (V,4) "which goes toward (the center of) the Moon" (V,7). It seems that h and b were interchanged, an error perhaps caused by the description of h as "the difference of Sun and Moon" (V,5) which would normally mean the longitudinal difference $\Delta\lambda$ and not the actual distance of the luminaries that is needed in our interpretation.

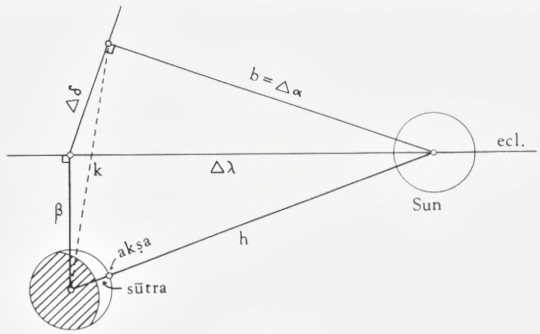

Fig. 22.

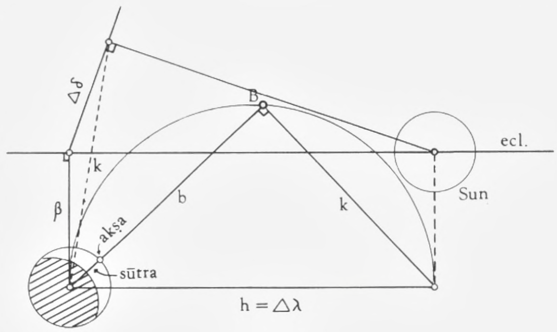

Fig. 23.

V,8–10. Let U be the point of the ecliptic for which $\lambda(U) = \lambda(M)$, hence $U\Sigma = \Delta\lambda$ (cf. Fig. 20). The rising time of this arc (or the setting time) gives the delay of sunrise over moonrise, or of moonset over sunset, in V,9 or V,10 respectively.

In V,8 is computed a quantity d from

$$d = \beta \frac{s_0}{12} = \beta \tan\varphi \qquad (1)$$

where s_0 is the equinoctial noon shadow, $g = 12$ the length of the gnomon. It seems as if d should represent a correction of the rising times, needed for lunar latitudes $\beta \neq 0$. In fact such a correction should depend on λ as is correctly implied in V,1–3.

The influence of the lunar latitude will be expressed by (1) only if one identifies the ecliptic with the equator. In other words one may say that (1) is "in the mean" correct and gives at least the proper sign for the influence of the latitude. But it seems strange that so crude a rule is given after a correct solution of the problem had been found in V,1–3.

Chapter VI

VI,1. In order to find the moment of opposition of Sun and Moon it is assumed that the longitudes of the two luminaries are known (found by some standard method of computation) for the sunrise after opposition (assuming that the eclipse occurs during night time). Let λ_{mr} and λ_{sr} denote the longitudes of the Moon and the Sun respectively for the moment of sunrise and thus

$$\varDelta\lambda = \lambda_{mr} - 180° - \lambda_{sr} \qquad (1)$$

the elongation of the Moon from the shadow center at sunrise. Assuming that $\varDelta\lambda$ increases 12° per day, i.e. 0;12° per nāḍī, the time $\varDelta t$ from opposition to sunrise will be given by

$$\varDelta t = \frac{\varDelta\lambda}{0;12} = 5\varDelta\lambda \qquad (2)$$

nāḍīs. The longitude λ_m of the Moon at opposition can then be computed for the moment $\varDelta t$ nāḍīs before sunrise.

VI,2. A lunar eclipse will take place if

$$|\lambda_m - \lambda_c'| < 13° \qquad (1)$$

where λ_m is the longitude of the Moon at opposition, and

$$\lambda_c' = \lambda_c + 0;36° \qquad (2)$$

λ_c being the longitude of the node near λ_m. The modification (2) of λ_c to λ_c' is probably introduced in order to formulate (1) in terms of integer degrees (again used in VII,5).

If

$$13° < |\lambda_m - \lambda_c'| < 15° \qquad (3)$$

only a "darkening" takes place. It follows from VI,3 (cf. Fig. 24) that for the interval (3) the Moon does not at all come into contact with the earth's shadow. Hence it seems an inescapable conclusion that (3) refers to the penumbra though this concept seems to be otherwise unknown in ancient and mediaeval astronomy.

There is no trace of a recognition of the dependence of the eclipse limits on the lunar (and solar) anomaly.

VI,3. In this whole chapter the following dimensions are assumed for the apparent radii of the disk of the Moon and the earth's shadow:

$$r_m = 0;17° \qquad r_u = 0;38° \tag{1}$$

thus

$$r_m + r_u = 0;55° \qquad r_u - r_m = 0;21°. \tag{1a}$$

In the vicinity of the nodes all triangles are assumed to be plane and the lunar latitude β is reckoned as if perpendicular to the Moon's orbit (cf. Fig. 24) instead of to the ecliptic.

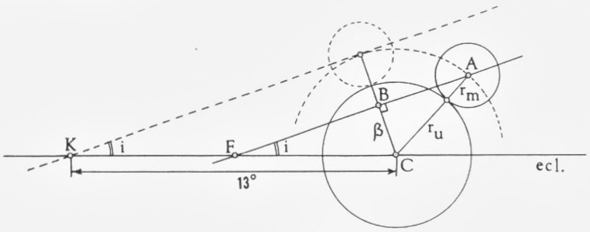

Fig. 24.

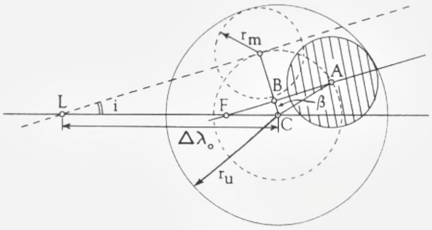

Fig. 25.

It follows from Fig. 24 that the duration Δt of a lunar eclipse is given by $2AB/(v_m - v_s)$ if $v_m - v_s$ represents the relative velocity of the Moon with respect to the Sun. Thus

$$\Delta t = \frac{2}{v_m - v_s}\sqrt{(r_u + r_m)^2 - \beta^2}. \tag{2}$$

From the boundary 13;36° in VI,2 (1) and (2) it follows for the inclination i of the lunar orbit that

$$\sin i = 0;55/13;36 \approx 0;4,2,40,\ldots \tag{3}$$

Since $\sin 4° \approx 0;4,11$ it is clear that

$$i = 4° \tag{4}$$

was intended.[1]) This value would have to be lowered to 3;30° if the boundary of 15° in VI,2 (3) were still to produce an eclipse in the proper sense of the term; nor would it then be meaningful to give a second limit of 13° to which no characteristic phase would correspond.

VI,4. The arc $\Delta\lambda = 13° - (\lambda_m - \lambda_c)$ is multiplied by 5. Exactly as in VI,1 (2) the result represents a time interval Δt, reckoned in nāḍīs, and Fig. 24 shows that it is the time required for the elongation to increase by the arc FK. This Δt should be added to or subtracted from a "duration of the eclipse", depending on the position of the node before or behind the center of the shadow. What is meant by "duration" of the eclipse and what the result should represent is not clear to us.

[1]) Arcsin 0;4,2,40 = 3;52°. Also in VI,5 $i = 4°$ is assumed.

VI,5. It follows from Fig. 25 that for $i = 4°$ (cf. VI,3 (4))

$$\sin i = 0;4,11 = (r_u - r_m)/\Delta\lambda_0 = 0;21/\Delta\lambda_0 \tag{1}$$

thus

$$\Delta\lambda_0 = (r_u - r_m)/\sin i = 21/4;11 \approx 5;1 \approx 5°. \tag{2}$$

Furthermore

$$\beta = (\lambda_m - \lambda_c') \sin i = \Delta\lambda \sin i$$

and

$$AB^2 = (r_u - r_m)^2 - \beta^2 = (\Delta\lambda_0^2 - \Delta\lambda^2) \sin^2 i.$$

If we express the duration 2AB° of totality in minutes of arc we have for it

$$\tau = 2{,}0\ AB = \mathrm{Sin}\, i \sqrt{\Delta\lambda_0^2 - \Delta\lambda^2} \qquad R = 120.$$

From (1) and (2) we find

$$\mathrm{Sin}\, i = 2 \cdot 21/5$$

hence

$$\tau = \frac{2 \cdot 21}{5} \sqrt{5^2 - \Delta\lambda^2}. \tag{3}$$

The text gives this relation in the form

$$\tau = \tfrac{21}{5} \sqrt{4(5 - \Delta\lambda)(10 - (5 - \Delta\lambda))}$$

which is indeed the equivalent of (3).

VI,6. The duration of the partial phase of a lunar eclipse is the difference between the duration found in VI,3 and the duration of totality (VI,5).

VI,7. Cf. VI,12–15.

VI,8. The "deflection" γ referring to a given position of the Sun or the Moon (at a solar- or lunar-eclipse respectively) is the angle at the given point between the ecliptic and the "east-west-line" E′W′ (cf. Fig. 26) which is perpendicular to the great circle N′S′ through the eclipsed body and the north- and south-point on the horizon. This definition is not explicitly found in the present text but there seems to be no reason to doubt the identity of terminology with later texts, e.g. Raṅganātha's commentary on Sūryasiddhānta IV,24–25.

If we for the moment identify ecliptic and equator, denoting the culminating point as C (cf. Fig. 27), the lunar (or solar) longitude as λ, we can represent the rule given in the present verse for finding the deflection γ by

$$\gamma = 90°(C - \lambda)\varphi/1800'. \tag{1}$$

If we cancel the factor 90°/90 and call the distance between C and λ the hour angle t then we have instead of (1) the rule

$$\gamma = t\varphi/90. \tag{2}$$

The factor $t/90$ has the value 0 at the meridian and 1 at the horizon. Hence (2) implies that $\gamma = 0$ in the meridian and $\gamma = \varphi$ in the horizon as is indeed the case for the angle between east-west-line and equator at these extremal points. The rule (2) represents simply a linear interpolation between these limits.

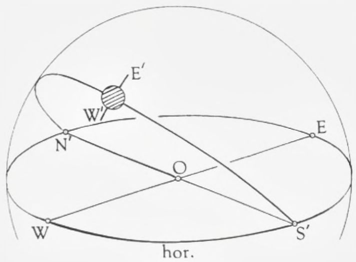

Fig. 26.

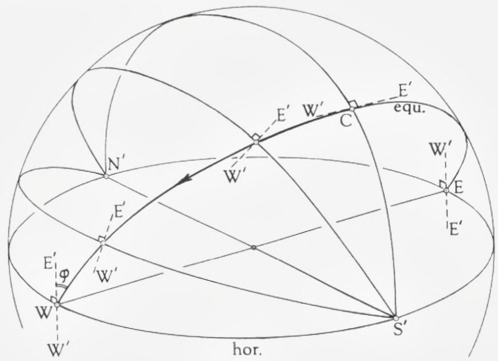

Fig. 27.

The values $\gamma = 0$ and $\gamma = \varphi$ are also obtained if we write

$$\gamma = \varphi \sin t \tag{3}$$

or even

$$\mathrm{Sin}\,\gamma = \mathrm{Sin}\,\varphi \ \mathrm{Sin}\,t/R \tag{4}$$

where a trigonometric interpolation replaces the linear relation (2). The rule (4) is found in XI,2. It is also given in the Āryabhaṭīya (Gola 45) and in the Khaṇḍakhādyaka (IV,7).

The preceding rule concerns only the computation of one component of the deflection, the "akṣavalana" which depends on φ of the locality and the t of the particular eclipse; it should further be modified by a second component, the "ayanavalana", in the amount of $\pm\delta(\lambda + 90°)$ as stated in XI,3. That at least one verse is missing after VI,8 is indicated by the fact that VI,9 is not found in our manuscripts, but is quoted with VI,10 by Utpala. In the same direction points also the fact that VI,9 introduces a new topic.

VI,9–10. The use of eclipse-colors as omens, which is found, e.g., in Bṛhatsaṃhitā 5,53–59, can be traced back to the Babylonian series Enūma Anu Enlil, tablets 15–18.[1]) The goal of the present verses is to establish criteria for predicting the colors. Varāhamihira's criteria are the altitude of the eclipsed body, its relation to ascendent or descendent, and the magnitude of the eclipse; normally Indians relate the colors to the phases of the eclipse (cf. Āryabhaṭīya, Gola 46, and Brāhmasphuṭasiddhānta 4,19).

[1]) Weidner, Archiv für Orientforschung 17 (1954) p. 71 ff.

VI,11. The direction of impact is determined by this rule. Four cases are to be considered (cf. Fig. 28), depending on the position of the Moon relative to the node and the character of the node (ascending or descending). Assuming that the Moon is ahead of the ascending node, thus $\lambda_c - \lambda_m > 0$, then the impact (i.e., the point of contact with the shadow) occurs on the upper (northern) half of the Moon; conversely,

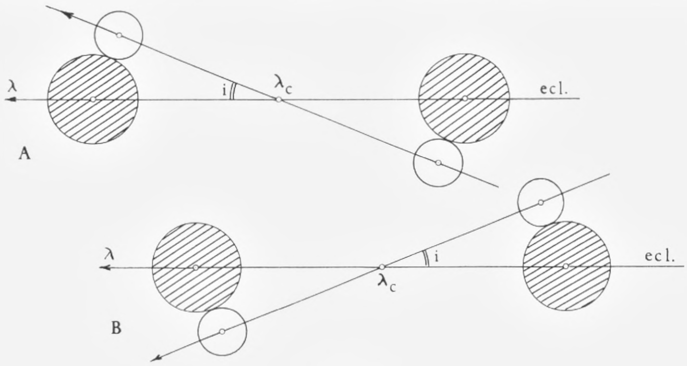

Fig. 28.

when the Moon has passed the node, thus $360 - \lambda_c + \lambda_m = \lambda_m - \lambda_c > 0$, the impact is on the lower (southern) half. The situation is reversed at the descending node.

"The beginning of Aries" ($\lambda = 0°$) seems to mean the ascending node, "the end of Virgo" ($\lambda = 180°$) the descending node. The number of synodic months in an 18-year eclipse cycle is 223, but the role of this number in the present context remains obscure to us.

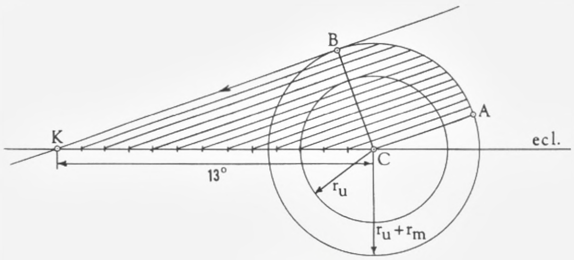

Fig. 29.

VI,12–15. In VI,12 we are given explicitly the apparent diameters

$$r_m = 0;17° \qquad r_u = 0;38° \tag{1}$$

already used in VI,3 and VI,5. For the graphic representation of an eclipse concentric circles have to be drawn of radius r_u, r_m, $r_u + r_m$ (cf. Fig. 30).

The 13 parallel lines mentioned in VI,13 are most likely related to the 13° given in VI,2 as eclipse limits. If this is the case the parallel lines would be drawn parallel to the lunar orbit, subdividing the radius $CB = r_u + r_m$ (cf. Fig. 29) into 13 equal intervals which would be a measure of the eclipse magnitudes between zero and maximum duration as function of β.

This construction can now be related to VI,7 where a 13-division of a quadrant of the Moon's circumference is mentioned, such that one can read off the distance of the point of first (and last) contact with respect to the line EW (cf. Fig. 30). We construct the point H′ of the first contact when the moon is at G, where FG is one of the 13 parallels from Fig. 29. According to VI,12 one has at the common midpoint C also a circle of radius r_m. Hence H at this fixed circle shows the same position with respect to the Moon's center as H′ with respect to G. For all lunar positions on the

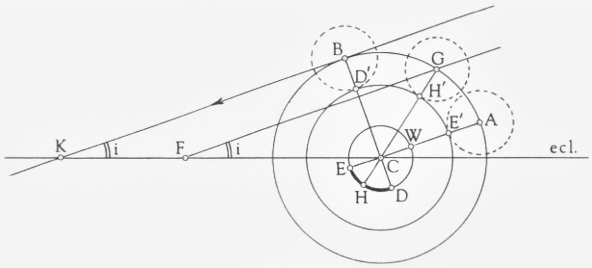

Fig. 30.

quadrant between no eclipse at B and greatest duration at A we thus obtain on the quadrant ED of the Moon's image with center C the images of the points of first contact. And since we have 13 parallels FG we have also 13 sections (of unequal length) on the quadrant ED.

The verse VI,15 gives obvious rules for the sides at which first contact will be seen at lunar- and solar-eclipses. The middle of the eclipse coincides with the syzygy, i.e., with the end of a tithi.

The "projection" of an eclipse (VI,14) is discussed later in XI,1–5. It consists of a graphical method by means of which the phases of an eclipse can be illustrated with respect to the eclipsed body which is represented by a fixed circle in the center of the diagram. Our present chapter refrains from giving specific rules.

Chapter VII

VII,1. This verse (which is repeated in VIII,9) gives a rule for the approximate determination of the longitudinal components p_λ of the (difference between) lunar (and solar) parallax, expressed in nāḍīs, i.e., essentially the time interval between true and apparent conjunction. It is assumed that $p_\lambda = 0$ in the meridian (here, as is often the case, substituted for the nonagesimal) and that the maximum $p_{\lambda\,\mathrm{max}}$ of p_λ occurs at an hour angle of $\pm 90°$, meant to represent a position in the horizon. This "horizontal parallax" $p_{\lambda\,\mathrm{max}} = p_0$ is estimated as 4 nāḍīs. A delay of this amount between true and apparent conjunction represents a reasonable estimate for the horizontal (relative) parallax since $0;4^{d} \cdot 12;10^{o/d} \approx 0;49°$ is the corresponding longitudinal displacement.

Finally it is assumed that p_λ varies sinusoidally between the value of 4^n in the horizon and 0 at the meridian, hence (reckoned in nāḍīs)

$$p_\lambda = 4 \sin \Delta t° = \frac{\text{Sin}\, \Delta t°}{30} = \frac{\text{Sin}(6 \Delta t^n)}{30} \tag{1}$$

where $\Delta t°$ is reckoned in degrees, Δt^n in nāḍīs.

VII,2. This verse is corrupt, but seems to contain the elements necessary for the computation of the latitudinal parallax. The translation, then, here more than elsewhere, depends on astronomy rather than grammar. Cf. also VIII,10–14.

The computation of the latitudinal component p_β of the parallax is based on the relation

$$p_\beta = p_0 \sin z \tag{2}$$

where p_0 is the horizontal parallax, z the zenith distance of the nonagesimal; p_β is now measured in degrees and has a constant value along the ecliptic (or, in practice, along the lunar orbit) for a fixed zenith distance. The latter is found from $\varphi \pm \delta \pm \beta$ with proper rules for the signs of the declination δ and the latitude β.

If one assumes for the horizontal parallax the same estimate of 4 nāḍīs as in the preceding verse, and $13^{o/d}$ for the lunar velocity[1]) one has

$$p_0 \approx 0;4^{d} \cdot 13^{o/d} = 0;52°. \tag{3}$$

The text obtains the same result by saying

$$p_0 = 4 \cdot \tfrac{5}{23} \approx 4 \cdot 0;13 = 0;52 \tag{3a}$$

or finally, by introducing nāḍīs:

$$p_\beta = 4^n \frac{5}{23} \cdot \frac{\text{Sin}\, z}{2} \approx 0;4^{d} \cdot 0;13 \frac{\text{Sin}\, z}{2} = 4 \cdot 0;13 \frac{\text{Sin}\, z}{120} = p_0 \sin z \tag{4}$$

as it should be according to (2).

VII,3. Here we find rules for the signs of the corrections due to parallax. The text as it stands seems to have confused the different cases. In fact the longitudinal component is subtractive to the west of the nonagesimal, additive to the east. The latitudinal component, however, is always negative.

VII,4. Let Δt be the time (of the syzygy?) after sunrise or before sunset, reckoned in nāḍīs, δ_m the declination of the Moon. The text seems to instruct us to compute $\Delta t \cdot \delta_m / 80$ (or, perhaps, $\text{Sin}\, \Delta t \cdot \delta_m / 80$).

[1]) Actually one should take also here the relative velocity, i.e., $\approx 12^{o/d}$.

At any rate this quotient is zero at the horizon ($\varDelta t = 0$) and this seems to exclude any interpretation as parallax. We have no explanation to offer.

VII,5. As in VI,2 one introduces a modified nodal position

$$\lambda_c' = \lambda_c + 0;36° \quad (1)$$

λ_c being the longitude of the node. Then the limits for lunar eclipses are

$$|\lambda_m - \lambda_c'| < 13° \quad (2)$$

(as in VI,2) and

$$|\lambda_m - \lambda_c'| < 8° \quad (3)$$

for solar eclipses, λ_m being the longitude of the Moon.

If we assume, as in VI,3, $r_m = 0;17°$, $i = 4°$, one has

$$\sin i \approx 0;4,11$$

and thus with (3)

$$r_s = 0;4,11 \cdot 8 - 0;17 = 0;16,28$$

hence probably originally

$$r_s = r_m = 0;17° \quad (4)$$

whereas the Romakasiddhānta assumes (cf. VIII,13) the slightly different values

$$r_s = 0;15° \quad r_m = 0;17° \quad (5)$$

for the apparent radii of the luminaries.

VII,6. The duration of an eclipse is given by

$$\tfrac{3}{4}\sqrt{\varDelta^2 - \varDelta\lambda^2} \quad (1)$$

where, according to VII,5

$$\varDelta = \begin{cases} 13° \text{ for lunar eclipses} \\ \;\;8° \text{ for solar eclipses.} \end{cases} \quad (2)$$

In order to check this rule we use again Fig. 24 (p. 52) calling CK = $\varDelta$, CF = $\varDelta\lambda$ and

$$r = \begin{cases} r_u + r_m & \text{for lunar eclipses} \\ r_s + r_m & \text{for solar eclipses.} \end{cases}$$

Then $r = \varDelta \sin i$ and $\beta = \varDelta\lambda \sin i$ and thus the distance AB which measures the half duration

$$AB = \sin i \sqrt{\varDelta^2 - \varDelta\lambda^2} \approx 0;4\sqrt{\varDelta^2 - \varDelta\lambda^2} \quad (3)$$

The distance AB is here measured in degrees.

Assuming as the daily increase of elongation 12° we obtain for the total duration of the eclipse

$$t = \frac{0;4}{12}\sqrt{\Delta^2 - \Delta\lambda^2} = 0;0,40^{d}\sqrt{\Delta^2 - \Delta\lambda^2}$$

$$= \frac{2^{n}}{3}\sqrt{\Delta^2 - \Delta\lambda^2}$$

instead of (1), reckoned in nāḍīs. We cannot explain the origin of this discrepancy.

Chapter VIII

VIII,1. The mean longitude $\bar{\lambda}$ of the Sun, reckoned in rotations, is obtained from the ahargaṇa a by means of

$$\bar{\lambda} = \frac{a \cdot 150 - 65}{54\,787} = \frac{a \cdot 2,30 - 1,5}{15,13,7}\,\text{rot.} \qquad (1)$$

Since

$$\frac{2,30}{15,13,7} = \frac{1,0,0}{6,5,14,48}$$

one sees that (1) is based on the assumption that

$$1 \text{ year} = 365;14,48^{d} \qquad (2)$$

i.e. on the value adopted for the tropical year by Hipparchus and Ptolemy; cf. also I,15 (1).

For the constant −65/54 787 cf. below at VIII,5.

VIII,2–3. The solar apogee is placed at ♊ 15°. If α denotes the anomaly reckoned from this point the following equations of center θ are assumed (cf. Fig. 31):

α	$\Delta\theta$	θ
0°		0
15	0;20 + 0;15 − 0;0,18 = 0;34,42°	0;34,42°
30	+ 0;14 − 0;0, 5	1; 8,37
45	+ 0;10 + 0;0, 2	1;38,39
60	+ 0; 4 + 0;0,10	2; 2,49
75	− 0; 6 + 0;0,16	2;17, 5
90	− 0;14 + 0;0,18	2;23,23

The maximum equation of 2;23,23 would correspond, for $R = 60$, to an eccentricity of 2;17. Cf. also IX,7–8.

VIII,4. The sidereal mean longitude of the Moon, reckoned in rotations, is given by

$$\bar{\lambda} = \frac{a \cdot 38\,100 - 1984}{1\,040\,953} = \frac{a \cdot 10{,}35{,}0 - 33{,}4}{4{,}49{,}9{,}13}\,\text{rot.} \tag{1}$$

From

$$\frac{4{,}49{,}9{,}13}{10{,}35{,}0} \approx 27;19{,}17{,}45{,}50,\ldots^{d} \tag{2}$$

one knows the length of the sidereal month. In I,15 (5) we have shown that (2) is based on the relation

$$4{,}14 \text{ sid.m.} = 3{,}55 \text{ syn.m.} = 19^{y}. \tag{3}$$

For the epoch constant (kṣepa), obtained for $\alpha = 0$, cf. the commentary on VIII,5.

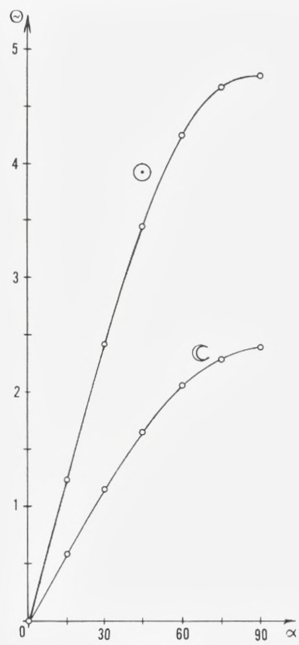

Fig 31.

VIII,5. The longitude of the lunar anomaly is give by

$$\bar{\alpha} = \frac{a \cdot 110 + 609}{3031} = \frac{a \cdot 1{,}50 + 10{,}9}{50{,}31}. \tag{1}$$

This rule is based on an anomalistic month of

$$\frac{50{,}31}{1{,}50} \approx 27;33{,}16{,}21{,}49,\ldots^{d} \tag{2}$$

Cf. for this relation above II,2–6.

The epoch constants in VIII,1,4, and 5 indicate that the initial positions for the Sun, the Moon, and the lunar anomaly at epoch were respectively

$$\text{for the Sun: } -\frac{1,5}{15,13,7}\text{ revol.} = -\frac{6,30,0^\circ}{15,13,7} \approx -0;25,38^\circ = 359;34,22^\circ \qquad (3)$$

$$\text{for the Moon: } -\frac{33,4}{4,49,9,13}\text{ revol.} = -\frac{3,18,24,0^\circ}{4,49,9,13} \approx -0;41,10^\circ = 359;18,50^\circ \qquad (4)$$

$$\text{for the lunar anomaly: } \frac{10,9}{50,31}\text{ revol.} = -\frac{1,0,54,0^\circ}{50,31} \approx 72;19,57^\circ. \qquad (5)$$

The longitude of the lunar apogee, λ_A, can be found (cf. Fig. 58 p. 101) from

$$\lambda_A = \bar{\lambda} - \bar{\alpha}. \qquad (6)$$

Consequently (4) and (5) give

$$\lambda_A = 359;18,50^\circ - 72;19,57^\circ = 286;58,53^\circ \qquad (7)$$

as position of the apogee at epoch.

These here determined epoch constants refer, according to VIII,1, to sunset at Avantī. In I,8 the epoch of the Romakasiddhānta and in XV,18 the epoch of Lāṭācārya is said to be sunset at Yavanapura.

VIII,6. As function of the anomaly α the following equations θ are prescribed for the motion of the Moon (cf. Fig. 31)

α	$\Delta\theta$	θ
0°		0
15	1° + 0;14 = 1;14°	1;14°
30	+ 0;11 = 1;11	2;25
45	+ 0; 2 = 1; 2	3;27
60	4·0;18 − 8·0;3 = 0;48	4;15
75	5·0;5 = 0;25	4;40
90	6·0;16 − 1;30 = 0; 6	4;46

The maximum equation of 4;46° would correspond to an eccentricity of 4;33 for $R = 60$. The above given numbers are, however, not very secure; one would prefer a maximum equation of 4;56° as found in the ārdharātrika system (cf. IX,7).

VIII,7. Crude approximations for the daily motion in longitude (13;10°) and in anomaly (13;4°). Cf. also IX,11–12.

VIII,8. For the ahargaṇa a the ascending lunar node has the longitude

$$\lambda_c = \frac{a \cdot 24 + 56\ 266}{163\ 111} = \frac{a \cdot 24 + 15{,}37{,}46}{45{,}18{,}31}. \qquad (1)$$

Since

$$\frac{45{,}18{,}31}{24} = 1{,}53{,}16;17{,}30^d \qquad (2)$$

we have in (2) the number of days required for one revolution of the lunar nodes (about $18^1/_2$ years). From it one finds for the retrograde daily motion

$$\frac{6{,}0}{1{,}53{,}16;17{,}30} \approx 0;3{,}10{,}41{,}32,\ldots^{\circ/d}. \qquad (3)$$

The kṣepa in (1) indicates that the longitude of the ascending node at epoch was

$$-\frac{15{,}37{,}46}{45{,}18{,}31} \text{ revolutions} \approx -124;11{,}2^\circ = 235;48{,}58^\circ \qquad (4)$$

in close agreement with III,29.

VIII,9. The same rule for the determination of the longitudinal parallax as given in VII,1 (q.v.).

VIII,10–14. The goal of this section is the determination of the latitudinal parallax p_β of the moon, or of the apparent latitude β_a of the Moon at a solar eclipse.

First one has to find the nonagesimal V of the ecliptic, i.e. the midpoint of the semicircle of the ecliptic that is above the horizon. Having determined for the given moment the ascendent H one has

$$\lambda(\mathrm{V}) = \lambda(\mathrm{H}) + 270^\circ = \lambda(\mathrm{H}) - 90^\circ. \qquad (1)$$

Hence one can also find the declination $\delta(\mathrm{V})$ which belongs to $\lambda(\mathrm{V})$.

Let U be the point of the lunar orbit for which (cf. Fig. 32)

$$\lambda(\mathrm{U}) = \lambda(\mathrm{V}),$$

β its latitude, ω its distance from the ascending node. Then it is assumed that approximately

$$\delta(\mathrm{U}) = \delta(\mathrm{V}) \mp \beta, \qquad (2)$$

i.e., the directions of latitudes and of declinations at V are identified. Since for a given moment the longitude λ_c of the ascending node can be considered to be known one can also find $\beta(\mathrm{U})$ from

$$\beta = \tfrac{2}{60} \operatorname{Sin}(\lambda(\mathrm{H}) - (\lambda_c + 90)). \qquad (3)$$

Indeed, it follows from (1) that (with $R = 120$)

$$\beta^\circ = \tfrac{2}{60}\,\mathrm{Sin}(\lambda(V) - \lambda_c) \approx \tfrac{2}{60}\,\mathrm{Sin}\,\omega = 4\,\sin\omega. \tag{3a}$$

Accurately one should have

$$\sin\beta = \sin i\,\sin\omega$$

but for small angles

$$\sin\beta \approx \beta = \beta^\circ \frac{\pi}{180} \approx \frac{\beta^\circ}{60} \quad (\pi \approx 3)$$

hence

$$\beta^\circ \approx 60\,\sin\beta = 60\,\sin i\,\sin\omega \tag{3b}$$

thus from (3a)

$$\sin i \approx 0;4 \approx 0;4,11 \quad \text{thus } i \approx 4^\circ. \tag{3c}$$

It is assumed next that the zenith distance of U can be found from

$$z(V) = \varphi \pm \delta(U) \tag{4}$$

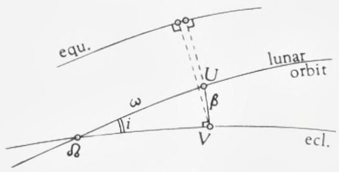

Fig. 32.

which is the same as to say that (approximately) V, U, and Midheaven lie in the same meridian. With z thus determined the latitudinal parallax is computed from

$$p_\beta = \frac{v_m\,\mathrm{Sin}\,z}{1800} \tag{5}$$

where v_m is the lunar velocity.

Since p_β can be considered constant along the ecliptic[1]) (or along the lunar orbit) with the value

$$p_\beta = p_0\,\sin z \tag{6}$$

we can obtain an estimate for the "horizontal parallax" p_0 by using (5) in the form

$$p_\beta = \frac{v_m}{15}\sin z.$$

Consequently

$$p_0 = 0;4\,v_m \approx 0;53^\circ \tag{7}$$

since $v_m \approx 13;10,35^\circ/^d$.

With p_β known from (5) one finds the apparent latitude of the Moon

$$\beta_a = \beta \pm p_\beta \tag{8}$$

[1]) Cf. Neugebauer, Al-Khwārizmī, p. 122 f.; also below IX,24–25.

where the true latitude β is found in minutes of arc from

$$\beta = \tfrac{21}{9}\,\mathrm{Sin}\,\omega. \tag{9}$$

For small β we use again (3b)

$$\beta^\circ \approx \tfrac{1}{2}\sin i\,\mathrm{Sin}\,\omega.$$

Hence from (9), since $\beta^\circ \approx 60\beta$

$$\sin i \approx \frac{2\cdot 21}{9\cdot 60} = 0;4,40$$

thus

$$i \approx 4;30^\circ \tag{10}$$

in contrast to (3c); cf. also IX,6.

VIII,15. In VIII,13 the following mean values for the apparent diameters of Sun and Moon were given

$$\bar{d}_s = 0;30^\circ \quad \bar{d}_m = 0;34^\circ. \tag{1}$$

For the true apparent diameters it is assumed that the ratio of diameter to velocity remains constant. Consequently

$$d_s = \frac{\bar{d}_s}{\bar{v}_s}\,v_s \qquad d_m = \frac{\bar{d}_m}{\bar{v}_m}\,v_m. \tag{2}$$

VIII,16. Let β_a be the apparent latitude of the moon, found in VIII,10–14 (8). Then it follows from Fig. 33 that the duration of a solar eclipse between first and last contact is given by

$$2\mathrm{AB} = \sqrt{(r_s + r_m)^2 - \beta_a^2}. \tag{1}$$

The same rule is given in IX,26.

Note that the text here and in VIII,17 uses avanati, i.e. p_β, in the sense of "corrected latitude" i.e. $\beta - p_\beta = \beta_a$.

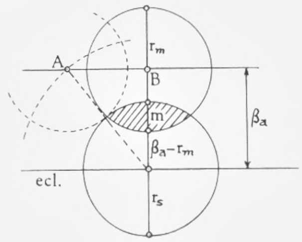

Fig. 33.

VIII,17–18. Fig. 33 shows that the obscured part of the Sun at the middle of the eclipse has the width

$$m = r_s - (\beta_a - r_m) = r_s + r_m - \beta_a. \qquad (1)$$

All quantities should be measured in minutes of arc, hence also m. Nevertheless the text calls the result "digits". Cf. also X,5–6.

Chapter IX

IX,1. The mean longitude $\bar{\lambda}_s$ of the Sun, reckoned in sidereal rotations, is found for the ahargaṇa a by means of

$$\bar{\lambda}_s = \frac{a \cdot 800 - 442}{292\,207} = \frac{a \cdot 13{,}20 - 7{,}22}{1{,}21{,}10{,}7} \text{ rot.} \qquad (1)$$

Since

$$\frac{1{,}21{,}10{,}7}{13{,}20} = 6{,}5;15{,}31{,}30 \qquad (2)$$

we see that (1) is based on a sidereal year of 365;15,31,30^d (exactly).

The daily mean motion of the Sun amounts accordingly to

$$\frac{6{,}0}{6{,}5;15{,}31{,}30} \approx 0;59{,}8{,}10{,}10{,}37, \ldots {}^{\circ/d}. \qquad (3)$$

The exact equivalent of (2) is the statement of the ārdharātrika system (cf. I,14) that

$$4\,320\,000\ (= 20{,}0{,}0{,}0) \text{ sid. years} = 1\,577\,917\,800\ (= 2{,}1{,}45{,}10{,}30{,}0) \text{ days} \qquad (4)$$

as is evident in the sexagesimal version since the number of days in (4), multiplied by a factor 3 gives the right hand side in (2).

For the epoch-correction (kṣepa)

$$-\frac{7{,}22 \cdot 6{,}0^\circ}{1{,}21{,}10{,}7} \approx -0;32{,}40^\circ \qquad (5)$$

cf. the commentary to XVI,1–9.

IX,2. The mean longitude of the Moon, reckoned in sidereal rotations, is obtained from

$$\bar{\lambda}_m = \frac{a \cdot 900\,000 - 670\,217}{24\,589\,506} = \frac{a \cdot 4{,}10{,}0{,}0 - 3{,}6{,}10{,}17}{1{,}53{,}50{,}25{,}6} \text{ rot.} \qquad (1)$$

The quotient

$$\frac{1{,}53{,}50{,}25{,}6}{4{,}10{,}0{,}0} = 27;19{,}18{,}1{,}26{,}24 \text{ days} \qquad (2)$$

gives the length of the sidereal month (exactly). From (2) one finds for the daily mean motion of the Moon

$$\frac{4,10,0,0\cdot 6,0}{1,53,50,25,6} = \frac{25}{1;53,50,25,6} = 13;10,34,52,9\ldots{}^{\circ/d}. \qquad (3)$$

For the epoch correction

$$-\frac{3,6,10,17\cdot 6,0^\circ}{1,53,50,25,6} \approx -9;48,44^\circ \qquad (4)$$

cf. the commentary to XVI,1–9.

IX,3. The number of sidereal rotations of the Moon's apogee at the ahargaṇa a is given by

$$\frac{a\cdot 900 + 2\ 260\ 356}{2\ 908\ 789} = \frac{a\cdot 15,0 + 10,27,52,36}{13,27,59,49}\ \text{rot.} \qquad (1)$$

Consequently one rotation takes

$$\frac{13,27,59,49}{15,0} = 53,51;59,16 \text{ days} \qquad (2)$$

(exactly). The daily motion of the Moon's apsidal line amounts therefore to

$$\frac{6,0}{53,51;59,16} \approx 0;6,40,59,29,\ldots{}^{\circ/d}. \qquad (3)$$

rounded to $0;6,40 = 1/9^{\circ/d}$ in IX,12 (3).

For the epoch-correction

$$\frac{10,27,52,36\cdot 6,0^\circ}{13,27,59,49} \approx 279;44,53^\circ \qquad (4)$$

cf. the commentary to XVI,1–9.

IX,4. It is of interest to note that the basic intervals which correspond to the rules formulated in IX,1–3 (and IX,5) are all expressed exactly by finite sexagesimal fractions, no doubt intentionally. In IX,4 small corrections of the lunar parameters are introduced the purpose of which is an adjustment to the parameters of the ārdharātrika system which in turn is based on simple sexagesimal relations without approximations but now referring to the huge interval of 20,0,0,0 years. The corrections in IX,4 serve to bridge the inevitable gap between the exact identities of the individual basic periods and similar identities for the cosmic intervals.

The rules given in IX,4 are as follows:

For each sidereal revolution of the mean Moon $\bar{\lambda}_m$ should be modified by

$$-\frac{51}{3120} = -\frac{51}{52,0}\text{ seconds} \approx -0;0,0,0,58,50,46,\ldots{}^\circ \qquad (1)$$

and

For each sidereal revolution of the Moon's apogee one should add

$$\frac{10}{297} = \frac{10}{4,57}\text{ seconds} \approx 0;0,0,2,1,\ldots{}^\circ \qquad (2)$$

In order to relate these rules to the ārdharātrika system we proceed as follows. First we combine IX,1 (2)

$$1 \text{ year} = 6,5;15,31,30^d = \frac{1,21,10,7}{16\cdot 50}$$

with IX,2 (2)

$$1 \text{ sid. month} = 27;19,18,1,26,24^d = \frac{1,53,50;25,6}{5\cdot 50}$$

and thus find

$$1 \text{ year} = \frac{1,21,10,7\cdot 5}{1,53,50;25,6\cdot 16} = \frac{6,45,50,35}{30,21,26;41,36} = 13;22,7,46,50,11,5,24,\ldots \text{ sid. months.} \qquad (3)$$

In the ārdharātrika system, however, it is assumed that

$$4\,320\,000\ (=20,0,0,0)\text{ sid. y.} = 57\,753\,336\ (=4,27,22,35,36)\text{ sid. m.} \qquad (4a)$$

Multiplication by the factor 3 gives this assumption the form

$$1 \text{ year} = 13;22,7,46,48 \text{ sid. months.} \qquad (4b)$$

Comparison of (4b) with (3) shows that the rule of IX,2 produces a result which is 0;0,0,0,2,11,5,24 sidereal months in excess over the result obtained by the ārdharātrika norm. Since each sidereal month corresponds to a complete rotation the above found excess amounts to

$$0;0,0,0,2,11,5,24\cdot 6,0^\circ = 0;0,0,13,6,32,24^\circ$$

per year, i.e., because of (4b)

$$\frac{0;13,6,32,24\text{ seconds}}{13;22,7,46,48} \approx \frac{51}{52,0}\text{ seconds}^{1)}$$

as subtractive correction. This is the above given rule (1).

[1]) Indeed $13,6,32,24\cdot 52 \approx 11,21,40$ and $13,22,7,46,48\cdot 51 \approx 11,21,48$.

Similarly IX,3 (2) in combination with IX,1 (2) shows that

$$1 \text{ year} = \frac{1,21,10,7\cdot 9}{13,27,59,49\cdot 8} = \frac{12,10,31,3}{1,47,43,58,32} = 0;6,46,50,56,57,43,23,\ \ldots \text{ rot.} \quad (5)$$

of the lunar apogee. The ārdharātrika system, however, postulates

$$4\,320\,000\ (= 20,0,0,0) \text{ years} = 488\,219\ (= 2,15,36,59) \text{ rotations} \quad (6a)$$

or the equivalent

$$1 \text{ year} = 0;6,46,50,57 \text{ rotations} \quad (6b)$$

i.e. 0;0,0,0,0,2,16,37 rotations = 0;0,0,2,16,37 · 6,0 seconds = 0;0,13,39,42 seconds more than in (5) in each year. Since, according to (5) each year contains 0;6,46,... rotations the correction per rotation amounts to

$$\frac{0;13,39,42}{6;46,50,57} \approx \frac{10}{4,57} \text{ seconds}^{1)}$$

as required in (2).

No correction is needed for the mean Sun since IX,1 (2) and IX,1 (4) are exactly equivalent, both being based on ārdharātrika parameters.

IX,5. The longitude of the ascending node of the Moon at the ahargaṇa a, reckoned in sidereal rotations, is found from

$$\lambda_{\text{n}} = \frac{a\cdot 2700 + 6\,313\,219}{18\,345\,822} = \frac{a\cdot 45,0 + 29,13,40,19}{1,24,56,3,42} \text{ rotations.} \quad (1)$$

The time required for one sidereal rotation is therefore (exactly) given by

$$\frac{1,24,56,3,42}{45,0} = 1,53,14;44,56^{\text{d}}. \quad (2)$$

From (2) and from the number 2,1,45,10,30,0 assumed in the ārdharātrika system for the days contained in the Mahāyuga (cf. (4) in IX,1) one finds for the number of sidereal rotations of the nodes in that period

$$\frac{2,1,45,10,30,0}{1,53,14;44,56} = 1,4,30,26;3,\ \ldots \text{ rot.} \quad (3)$$

hence not exactly an integer number. In fact, however, the ārdharātrika system postulates exactly 232 226 = 1,4,30,26 rotations of the nodes[2]) in a Mahāyuga. One

[1]) Indeed 13,39,42 · 4,57 ≈ 1,7,40 and 6,46,50,57 · 10 ≈ 1,7,48.
[2]) Cf. note 1 to I,14 Table 1.

expects, then, a correction to be applied to the longitude of the ascending lunar node such as was applied to the mean longitude and the apogee of the Moon in IX,4. Perhaps such a correction has accidentally been dropped from the text.

Again from (2) one can derive the corresponding daily motion of the nodes:

$$-\frac{6,0}{1,53,14;44,56} = -0;3,10,44,7,53, \ldots{}^{o/d}. \tag{4}$$

Cf. also III,28–29.

The epoch correction contained in (1) has to be reckoned negative since the rotation of the nodes proceeds in retrograde direction. Converted to degrees it amounts to

$$-\frac{29,13,40,19 \cdot 6,0^\circ}{1,24,56,3,42} \approx -123;53,3 = 236;6,57^\circ. \tag{5}$$

Cf. for it the commentary to XVI,1–9 (p. 100).

IX,6. The value

$$i \approx 4;30^\circ$$

for the inclination of the lunar orbit agrees with VIII,10–14 (10).

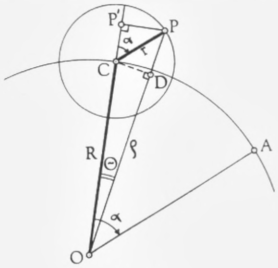

Fig. 34.

IX,7–8. Here we have rules for the determination of the equation of center for Sun and Moon as function of the anomaly α, based on a simple epicyclic model (cf. Fig. 34). The anomaly α is found from

$$\alpha = \bar{\lambda} - \lambda_A \tag{1}$$

$\bar{\lambda}$ being the mean longitude at the given moment, λ_A the longitude of the apogee.

For the Sun, in the ārdharātrika system, one has always

$$\lambda_A = 80^\circ \tag{2}$$

as fixed sidereal longitude. For the Moon λ_A has to be found with IX,3 and IX,4.

Let c be the length of the circumference of the epicycle, measured in the same units (misleadingly called "degrees") in which the circumference of the deferent measures 360. Then it is assumed that

$$c = \begin{cases} 14 \text{ for the Sun} \\ 31 \text{ for the Moon.} \end{cases} \tag{3}$$

Using c and α from (3) and (1) respectively the equation θ is found from

$$\operatorname{Sin}\theta = \frac{c \operatorname{Sin}\alpha}{360}. \tag{4}$$

It is easy to see that (4) is the result of a plausible approximation (cf. Fig. 34). Obviously

$$\frac{c}{360} = \frac{r}{R} = \frac{r \sin\alpha}{R \sin\alpha} = \frac{PP'}{\operatorname{Sin}\alpha}.$$

Since r is small in comparison to R[1]) we may assume that $PP' \approx CD$, hence

$$\frac{c}{360} \approx \frac{CD}{\operatorname{Sin}\alpha} = \frac{R \sin\theta}{\operatorname{Sin}\alpha} = \frac{\operatorname{Sin}\theta}{\operatorname{Sin}\alpha}$$

which proves (4).

It follows from (3) and (4) that

$$r = \begin{cases} 0;2,20 \text{ for the Sun} \\ 0;5,10 \text{ for the Moon} \end{cases} \tag{5}$$

which leads to a maximum equation of

$$\theta_{\max} = \begin{cases} 2;14^\circ \text{ for the Sun} \\ 4;56^\circ \text{ for the Moon.} \end{cases} \tag{6}$$

Cf. also VIII,2–3 and VIII,6. In terms of Greek astronomy the eccentricities corresponding to (5) would be 2;20 and 5;10 respectively ($R = 60$); cf. also XVI,12–14 Table 22 (p. 102).

IX,9. This is a rule for finding the daily increase in the solar and lunar equations. Since the increase of both θ and α in a day will be very small we replace (3) in IX,7–8 by $\theta = c\alpha/360$ and thus obtain

$$\theta' = \frac{c}{360}\alpha'$$

where θ' and α' denote the daily increments of θ and α respectively. For the Sun the daily increase in anomaly is the same as its daily increase v_S in longitude, reckoned in degrees per day. If b denotes the same velocity (bhukti) expressed in minutes we have therefore

[1]) Fig. 34 is not drawn to scale; for the Moon r should be about 1/12 of R, for the Sun only 1/30 of R (cf. (2)).

$$\theta' = \frac{c}{21\,600} b = \frac{cb}{6,0,0}.$$

For the Moon one should use the bhukti of the anomaly given in IX,12; cf. also IX,13.

IX,10. For 53;20 yojanas of distance (measured on the terrestrial equator) a time correction of ±1 nāḍī is to be applied. With this time correction one can compute the correction to the longitudes of the planets due to the fact that one's locality is a known number of yojanas (on the equator) to the east or west of the prime meridian.

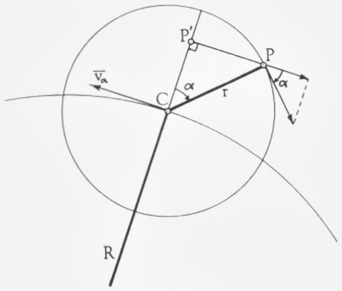

Fig. 35.

It follows from the above given numbers that

$$1^d = 53,20 \text{ yojanas} = 3200 \text{ yojanas}$$

on the equator; cf. also III,14 and XIII,15–19. The radius of the earth is therefore about 510 yojanas.

IX,11–14. The mean motions are (cf. also VIII,7)

$$\bar{v} = \begin{cases} 0;59,8^\circ/^d & \text{for the Sun} \\ 13;10,34 & \text{for the Moon.} \end{cases} \tag{1}$$

The true motion of the Moon is given by

$$v = \bar{v} \pm \bar{v}_\alpha \frac{\Delta \operatorname{Sin} \alpha}{225} \cdot \frac{c}{360} \tag{2}$$

where

$$\bar{v}_\alpha = \bar{v} - \bar{v}_A \tag{3}$$

with

$$\bar{v}_A \approx 0;6,40^{\circ/d} \tag{4}$$

(cf. also IX,3) and c being defined as in IX,7–8. As shown in Fig. 35 $\bar{v}_\alpha$ represents therefore the velocity of the center C of the epicycle with respect to the apsidal line.

Since the function $\operatorname{Sin}\alpha$ is tabulated in steps of 3;45° = 225′ (cf. IV,6–15, Table 8) we see that $\Delta \operatorname{Sin}\alpha/225$ is approximately the derivative of the Sine-function. Thus we have

$$\bar{v}_\alpha \frac{\Delta \operatorname{Sin}\alpha}{225} = \bar{v}_\alpha \frac{\Delta \operatorname{Sin}\alpha}{\Delta\alpha} \approx \bar{v}_\alpha \cos\alpha.$$

Because of the "reducing" factor $c/360 = r/R$ we have in $\bar{v}_\alpha c/360$ the velocity of the Moon P on the circumference of the epicycle. Consequently the multiplication with $\cos\alpha$ gives the component in the direction of $\bar{v}_\alpha$ representing (algebraically) the effect of the motion of P on the epicycle, while C moves with the constant mean velocity $\bar{v}$.

The instantaneous velocity v of P with respect to O (cf. Fig. 34) can also be described by means of the "true hypotenuse" ϱ = OP in relation to R:

$$\bar{v}/v = R/\varrho. \tag{5}$$

IX,15–16. It is the purpose of these verses to introduce the actual geocentric distances (kakṣā) of Sun and Moon instead of operating uniformly with the norm $R = 120$ for the radii of the deferents. If ϱ_s and ϱ_m represent the true hypotenuse of Sun and Moon respectively the kakṣā is defined by

$$k_s = \frac{5347}{40}\varrho_s = \frac{1,29,7}{40}\varrho_s \quad k_m = 10\varrho_m. \tag{1}$$

By means of two more parameters

$$b_s = 517\,080 \ (= 2,23,38,0) \quad b_m = 38\,640 \ (= 10,44,0) \tag{2}$$

are found the apparent diameters of Sun and Moon

$$d_s = \frac{b_s}{k_s} = 1,4,28;11,\ldots \cdot \frac{1}{\varrho_s} \qquad d_m = \frac{b_m}{k_m} = 1,4,24\frac{1}{\varrho_m}. \tag{3}$$

For the mean distances of the luminaries, i.e. for

$$\varrho_s = \varrho_m = R = 120$$

one obtains from (1) the geocentric distances

$$k_s = 4,27,21 \quad k_m = 20,0 \tag{4}$$

and from (3) the apparent diameters

$$d_s = 32;14,6,\ldots \quad d_m = 32;12 \tag{5}$$

obviously measured in minutes of arc.

One can now determine the absolute dimensions of the diameters $2s$ and $2m$ of Sun and Moon respectively, measured in the units of k_s and k_m. Dividing d_s and d_m by the ratio

$$3{,}0{,}0'/\pi = 10\ 800'/\pi \approx 3438' = 57{,}18'$$

one changes minutes of arc to radians. Multiplication by k_s and k_m then produces $2s$ and $2m$:

$$\left.\begin{aligned} 2s &= \frac{d_s}{57{,}18}\,k_s = \frac{b_s}{57{,}18} = 2{,}30;24{,}5,\ldots \\ 2m &= \frac{d_m}{57{,}18}\,k_m = \frac{b_m}{57{,}18} = 11;14{,}20,\ldots \end{aligned}\right\} \quad (6)$$

i.e. the radii

$$s \approx 1{,}15;12 \quad m \approx 5;37 \quad (7)$$

respectively.

In IX,19–23 we shall find (cf. below p. 76) that the determination of the lunar parallax is based on the assumption that

$$e = 18 \quad (8)$$

is the radius of the earth, measured in otherwise unknown units. If we assume that these units are the same as in s and m, hence also as in k_s and k_m, we can convert all these quantities to earth radii; from (4) one obtains:

$$\left.\begin{aligned} k_s &= \frac{4{,}27{,}21}{18}\,e = 14{,}51;10e = 891^1/_6\,e \\ k_m &= \frac{20{,}0}{18}\,e = 1{,}6;40\,e = 66^2/_3\,e. \end{aligned}\right\} \quad (9)$$

The value for the lunar distance is essentially correct and in general agreement with the results obtained in ancient astronomy. This confirms the uniformity of all units of distance.

Finally one obtains the absolute sizes for Sun and Moon from (7):

$$s \approx \frac{1{,}15;12}{18}\,e = 4;10{,}40\,e \quad m \approx \frac{5;37}{18}\,e = 0;18{,}43{,}20\,e. \quad (10)$$

Hence, the radius of the Sun is about four times the radius of the earth, the radius of the Moon about one third.

IX,17–18. We are given the time difference $\Delta\alpha$ between the moment of conjunction and noon, i.e. the arc $\Sigma'C$ in Fig. 36. The corresponding ecliptic arc $\Delta\lambda = \Sigma M$ can be found from a table of right ascensions since $\Delta\alpha$ is the rising time of $\Delta\lambda$ at sphaera recta.

Since we know for the given moment the longitude λ of the conjunction we have in $\lambda + \Delta\lambda$ the longitude of M. Hence one can find from a table the declination δ_M of M and finally the zenith distance of M:

$$z_M = \varphi \mp \delta_M. \tag{1}$$

IX,19–23. These verses concern the determination of the longitudinal parallax of sun and moon at a conjunction, i.e. for a solar eclipse. The procedure is best broken up in single steps for which we give the proofs as we go along.

Let M be the culminating point of the ecliptic (cf. Fig. 37), V the nonagesimal, Z the zenith, λ_M and δ_M longitude and declination of M respectively, η the azimuth

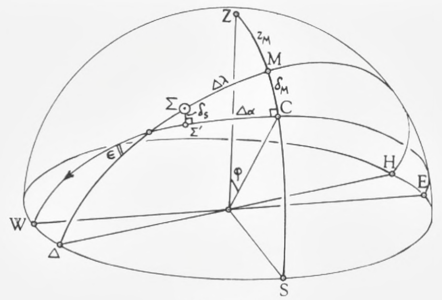

Fig. 36.

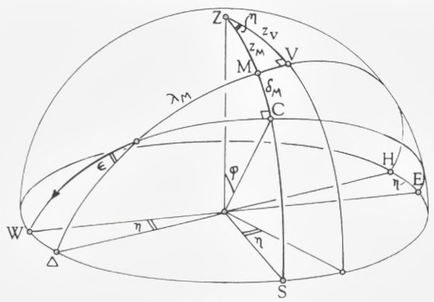

Fig. 37.

of the ascendent H, ε the obliquity of the ecliptic, φ the geographical latitude. Then, with λ_M known from IX,17

$$\operatorname{Sin}\eta = \frac{\operatorname{Sin}\varepsilon \cdot \operatorname{Sin}\lambda_M}{\operatorname{Sin}\bar{\varphi}}. \tag{1}$$

Proof: $\sin\varphi = \operatorname{Sin}\delta_M/\operatorname{Sin}\eta$ (cf. IV,39–40 (2)) and $\sin\varepsilon = \operatorname{Sin}\delta_M/\operatorname{Sin}\lambda_M$ (cf. IV,35–36 (2)); q.e.d.

Let z_M and z_V represent the zenith distances of M and V respectively. Then

$$\operatorname{Sin} VM = \operatorname{Sin}\eta \cdot \operatorname{Sin} z_M / R \tag{2}$$

where $\operatorname{Sin}\eta$ is known from (1) and z_M from IX,17–18 (1).

Proof: In the right spherical triangle ZVM holds

$$\sin\eta = \sin VM / \sin z_M$$

q.e.d.

The next step implies a very crude approximation because it assumes that the right spherical triangle ZVM can be considered as a plane triangle. Hence

$$\operatorname{Sin} z_V = \sqrt{\operatorname{Sid}^2 z_M - \operatorname{Sin}^2 VM} \tag{3}$$

can be computed, using z_M from IX,17–18 (1) and VM from (2).

With z_V known from (3) one has for the altitude a_V of V

$$a_V + z_V = 90° \quad (4a)$$

thus

$$\text{Sin}\, a_V = \sqrt{R^2 - \text{Sin}^2 z_V}. \quad (4b)$$

Let a_s be the altitude, z_s the zenith distance of the Sun for a given moment when the Sun has a longitudinal distance $\Delta\lambda$ ($< 90°$) from the rising or setting point of the ecliptic. Then

$$\text{Sin}\, a_s = \text{Sin}\, \Delta\lambda \cdot \text{Sin} a_V / R. \quad (5)$$

Since

$$a_s + z_s = 90° \quad (6a)$$

one has

$$\text{Sin}\, z_s = \sqrt{R^2 - \text{Sin}^2 a_s}. \quad (6b)$$

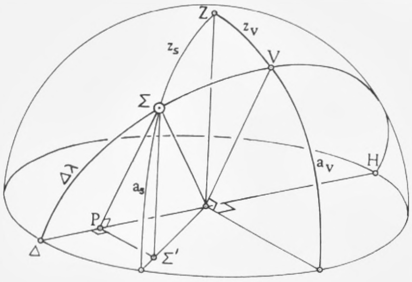

Fig. 38.

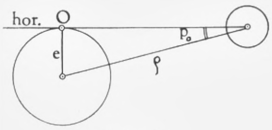

Fig. 39.

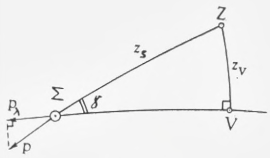

Fig. 40.

Proof of (5): it follows from Fig. 38

$$\Sigma\Sigma' = R \sin a_s = \text{P}\Sigma \sin a_V$$

and

$$\text{P}\Sigma = R \sin \Delta\lambda$$

q.e.d.

We have now all elements that are required for the computation of the longitudinal parallax

$$p_\lambda = \frac{18}{\varrho R} \sqrt{\text{Sin}^2 z_s - \text{Sin}^2 z_V} \quad (7)$$

where ϱ is the distance of the Sun or Moon (cf. Fig. 39) from the earth. If we substitute in (7) for ϱ the value ϱ_s we obtain the longitudinal solar parallax $p_{\lambda s}$, otherwise with ϱ_m the lunar parallax $p_{\lambda m}$ and, for an eclipse, when $\lambda_s = \lambda_m$, the "adjusted" longitudinal parallax

$$p'_\lambda = p_{\lambda m} - p_{\lambda s}. \quad (8)$$

Proof of (7): In the right spherical triangle ZVΣ (cf. Fig. 40), Σ being the Sun, we have

$$\sin\gamma = \sin z_V / \sin z_S.$$

If p is the total parallax at Σ then

$$p_\lambda = p\cos\gamma = p\sqrt{1 - \mathrm{Sin}^2 z_V/\mathrm{Sin}^2 z_S}$$

$$= \frac{p}{\mathrm{Sin}\, z_S}\sqrt{\mathrm{Sin}^2 z_S - \mathrm{Sin}^2 z_V}.$$

Comparison with (7) shows that one should have the following relation

$$p/\mathrm{Sin}\, z_S = 18/\varrho R \tag{9}$$

or

$$p = \frac{18}{\varrho}\sin z_S = p_0 \sin z_S \tag{10}$$

with

$$p_0 = \frac{18}{\varrho}. \tag{11}$$

Since $z_S = 90°$ at the hirizon we see from (10) that p_0 is the horizontal parallax. But the lunar horizontal parallax is the angle under which the radius e of the earth appears from the moon when in the horizon. Thus (11) implies a value

$$e = 18 \tag{12}$$

for the radius of the earth, a value confirmed by its use in X,1–2.

In VII,2 we found that $p_0 \approx 0;52°$, in VIII,10–14 we arrived at the estimate $p_0 \approx 0;53°$. In order to express p_0 also here in degrees we have to replace (11) by

$$p_0 = \frac{18}{\varrho}\cdot\frac{3,0}{\pi} = \frac{54,0}{\varrho\pi}. \tag{13}$$

In IX,15–16 (1b) the distance of the Moon is assumed to be measured by

$$\varrho = k_m = 20,0.$$

If we accept for π the approximation $\pi \approx 3$ we have $\varrho\pi = 1,0,0$ and thus

$$p_0 = 0;54° \tag{14}$$

which agrees sufficiently well with the previously obtained estimates.

IX,24–25. For a given zenith distance z of the nonagesimal V the latitudinal component p_β of the parallax is assumed to be constant with the value

$$p_\beta = p_0 \sin z_V$$

where p_0 represents the horizontal parallax (cf. VIII,10–14 (6)).

IX,26. The same rule for the duration of an eclipse is found in VIII,16.

IX,27. Effect of the longitudinal component of the adjusted parallax on the duration of a solar eclipse.

Chapter X

X,1–2. Let k_s and k_m denote (as in IX,15–16) the geocentric distances of Sun and Moon respectively, s, e, and u the radii of Sun, earth, and shadow at the Moon's (mean) distance, all these quantities measured in the same units. Then the diameter $2u$ of the shadow cone at the Moon's (mean) distance is found from

$$2u = \left(36 - \frac{36k_m}{90k_s/286}\right)\frac{120}{k_m}. \tag{1}$$

A more convenient form of the rule (1) would be

$$u = 36{,}0\left(\frac{1}{k_m} - \frac{3;10{,}40}{k_s}\right). \tag{1a}$$

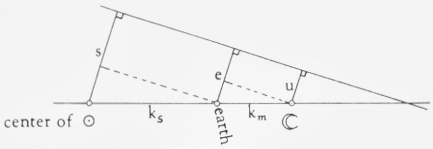

Fig. 41.

Fig. 41 illustrates the underlying argument. Obviously

$$\frac{s-e}{k_s} = \frac{e-u}{k_m} \tag{2}$$

and therefore

$$u = e\left(1 + \frac{k_m}{k_s}\right) - s\frac{k_m}{k_s}. \tag{3}$$

We now assume, as in IX,19–23 (12)

$$e = 18 \tag{4a}$$

and

$$s = 75;12 \tag{4b}$$

as derived in IX,15–16 (7). Then one obtains from (3)

$$u = 18 - 57;12\frac{k_m}{k_s} = 18\, k_m\left(\frac{1}{k_m} - \frac{3;10{,}40}{k_s}\right)$$

which agrees with (1a) if

$$k_m = 2{,}0 = R \tag{5}$$

i.e. for the normed mean distance of the Moon.

X,2–4. Let r_u and r_m be the apparent radii of shadow and Moon, both expressed in degrees, β_0 the latitude of the Moon at the moment t_0 of the true opposition, $v_m - v_s$ the relative angular velocity of the Moon with respect to the Sun, expressed in degrees per day, then

$$\Delta_1 t = \sqrt{(r_u + r_m)^2 - \beta_0^2} \cdot \frac{120}{v_m - v_s} \tag{1}$$

is in first approximation the half-duration of the eclipse (cf. Fig. 42). The underlying assumption that the latitude of the Moon at first contact is the same as at the midpoint of the eclipse, is, however, not quite correct. If one computes the latitude

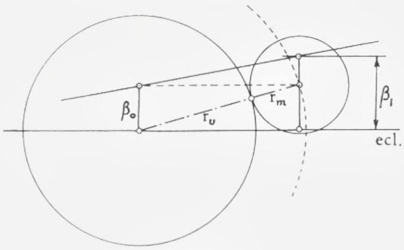

Fig. 42.

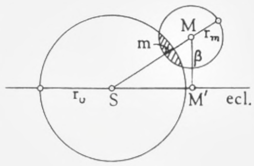

Fig. 43.

for the moment $t_0 - \Delta_1 t$ one will find a value β, slightly different from β_0. If we replace β_0 in (1) by β_1 a more accurate value $\Delta_2 t$ of the half-duration will result. Computing the latitude for $t_0 - \Delta_2 t$, etc., leads to β_2, β_3 etc. The process ends when $\Delta_{n+1} t = \Delta_n t$.

X,5–6. If t is an arbitrary moment near the moment t_0 of the true syzygy, β the corresponding latitude of the Moon, then the size m of the obscured part is found, for a lunar eclipse, from

$$m = (r_u + r_m) - \mathrm{MS} \tag{1}$$

where

$$\mathrm{MS} = \sqrt{M'\mathrm{S}^2 + \beta^2} \tag{2}$$

and

$$\mathrm{M'S} = \frac{v_m - v_s}{60}(t_0 - t). \tag{3}$$

The correctness of this rule follows immediately from Fig. 43. For a solar eclipse (1) is to be replaced by

$$m = (r_s + r_m) - \mathrm{MS}.$$

Cf. also VIII,17–18.

X,7. The half-duration of totality is computed by determining the distance AB (cf. Fig. 44) between first contact and eclipse middle:

$$AB = \sqrt{(r_u - r_m)^2 - \beta^2}.$$

The duration of totality can be found from the distance 2AB by dividing it by the relative velocity of the two luminaries, a step which is hinted at by referring to "the case of the tithi".

Chapter XI

XI,1–5. These verses concern the "projection" of eclipses, i.e., a graphical method for finding the points of first and last contact on the eclipsed body in relation to certain orthogonal diameters N′S′ and E′W′ as defined previously in VI,8 (cf. Fig. 26 p. 54).

For any given moment the direction of the ecliptic must be determined by means of an angle γ (called "deflection") with respect to the "east-west-line" E′W′ (cf. Fig.

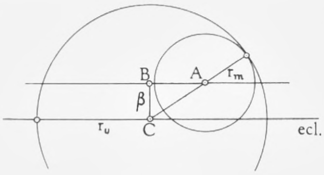

Fig. 44.

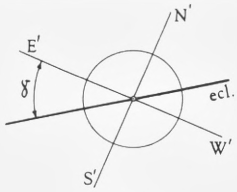

Fig. 45.

45). This angle is found from two components. The first, depending on the geographical latitude φ, is found in XI,2 from

$$\text{Sin}\,\gamma_1 = \text{Sin}\,\varphi\ \text{Sin}\,t/R \qquad (1)$$

where t is the hour angle. We have explained the reasoning underlying this rule in connection with VI,8. As was then shown the resulting angle gives actually the direction of the equator with respect to the east-west-line. One can formulate this situation also in the following form: γ_1 assumes that the eclipsed body is in the equator, i.e., $\lambda = 0°$ or $180°$. The angle of the ecliptic with the east-west-line is then $\gamma_1 \pm \varepsilon = \gamma_1 \pm \delta(\lambda + 90°)$ where $\delta(\lambda + 90°)$ is the declination at $\lambda + 90°$. For $\lambda = \pm 90°$, i.e. at the solstices, the ecliptic is parallel to the equator; then $\gamma \approx \gamma_1 = \gamma_1 + 0$, i.e. again $\gamma_1 + \delta(\lambda + 90°)$ since now $\lambda + 90° = 0°$ or $180°$, and hence $\delta = 0$. Hence, in all four cases we have found that $\gamma = \gamma_1 + \delta(\lambda + 90°)$ and XI,3 shows that this rule was considered valid not only for the equinoxes and solstices but generally:

$$\gamma = \gamma_1 + \gamma_2 = \gamma_1 \pm \delta(\lambda + 90°).$$

This, then, represents the angle between ecliptic and east-west-line at a moment when the eclipsed body has the longitude λ. Hence we can consider γ to be known for any phase of the eclipse since the times for the phases can be computed, starting from the true syzygy.

We now can turn to the graphic construction. In XI,1 we are directed to draw two concentric circles, one with radius r of the eclipsed body, the other with radius r' which is the total of the radii of eclipsed and eclipsing body, i.e.

$$\left.\begin{array}{lll} r = r_m & r' = r_m + r_u & \text{for lunar eclipses} \\ r = r_s & r' = r_s + r_m & \text{for solar eclipses.} \end{array}\right\} \quad (3)$$

Through the center A of these circles one draws a fixed direction which represents the ecliptic (Fig. 46) and, knowing γ from (2), one also can draw the east-west-line E′W′ through A. Perpendicular to it is N′S′ (XI,3). For each phase a diagram of this type has to be constructed because γ can vary considerably, e.g., between beginning and end of a lunar eclipse.

Suppose that Fig. 46 is constructed for the moment of first contact at a lunar eclipse. We then assume parallelism between the lunar orbit and the ecliptic. If, there-

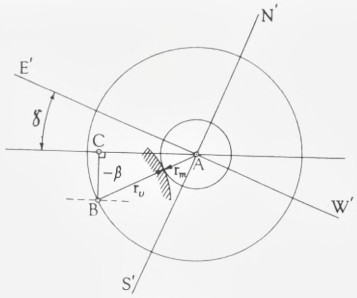

Fig. 46.

fore, A is the center of the Moon, the point B at $-\beta$ is the center of the shadow and AB intersects the rim of the Moon where the first contact will occur.

XI,6. This verse seems to deal with the optical illusion that the disk of the Moon or the Sun near the horizon seems larger than when high in the sky. An arc of one minute would then subtend (on some instrument?) $^1/_2$ digit when near the horizon but only $^1/_3$ digit at high altitude. The rule occurring here must be intended to determine the actual physical dimensions of the "projection" described in XI,1–5.

Chapter XII

XII,1. The yuga is here a cycle of 5 years, containing $12 \cdot 5 + 2 = 62$ months. It is furthermore stated after every 62 days one tithi has to be omitted, i.e.

$$62^\tau = 61 \text{ sid. days.} \quad (1)$$

and hence the length of one tithi

$$1^{\tau} = 61/62 \text{ sid. d.} = 0;59,1,56, \ldots \text{ sid. d.} \quad (2a)$$

and conversely

$$1 \text{ sid. d.} = 62/61 \text{ tithi} = 1;0,59,0,59, \ldots^{\tau}. \quad (2b)$$

The same relation follows from XII,3.

From (1) one obtains

$$1 \text{ yuga} = 5 \text{ years} = 62 \text{ months} = 62 \cdot 30^{\tau} = \tfrac{62}{61} \cdot 1830^{\tau} = 1830 \text{ sid. d.} \quad (3)$$

and consequently

$$1 \text{ year} = 366 \text{ sid. d.} = 365 \text{ days.} \quad (4)$$

The "years" are here the Egyptian-Persian years without intercalation.

These relationships in the Paitāmahasiddhānta of the Pañcasiddhāntikā are taken from the Jyotiṣavedāñga of Lagadha (fifth century B.C.?), and are found also in the earliest recension of the Gargasaṃhitā (first century B.C. or A.D.?). Varāhamihira's use of the technical term avama here and in I,11–16 and his statement in XII,2 that the ahargaṇa begins with sunrise indicates that he assumes that the Paitāmahasiddhānta operated with sāvana (sunrise) rather than with nākṣatra (sidereal) days. Nevertheless the only reasonable interpretation of (3)

$$5 \text{ years} = 1830 \text{ ``days''}$$

is the relation (4).

XII,2. If S represents the number of completed years in the Śaka Era then

$$N = \frac{S-2}{5} \quad (1)$$

gives the number of completed yugas, i.e. the counting of the yugas begins with Śaka Era 3.

The year Śaka 3, i.e. A.D. 80, being fixed by the text as the year of epoch for Varāhamihira's Paitāmahasiddhānta, the date can be determined more closely as January 11 of this year.[1]) At this date occurred a conjunction of Sun and Moon at a tropical longitude $\lambda \approx 290°$. Consequently the Sun would enter Aries in the third month after this conjunction. Now Māgha is the second month before Caitra. Under the plausible assumption that Caitra was already in the first century the month in which the Sun enters Aries, as is the case in the fifth century, the above given date would fit all conditions of the text.

XII,3. If a is the ahargaṇa (here to be understood in sidereal days) then the number of corresponding tithis is given by

$$\tau = a(1 + \tfrac{1}{61}). \quad (1)$$

[1]) This was suggested by Kharegat [1895/7] p. 134 f. (cf. below p. 154).

The Sun traverses 27 nakṣatras in one year of 366 sidereal days (cf. XII,1 (4)), hence in a sidereal days

$$\frac{a}{366}\cdot 27 = a\cdot\frac{9}{122} \text{ nakṣatras.} \tag{2}$$

The Moon completes in 5 years of 62 months

$$62+5 = 67 \text{ sid. rotations} = 67\cdot 27 \text{ nakṣatras.} \tag{3}$$

Since 5 years = 1830 sid. days (cf. XII,1(3)) the Moon progresses in a sidereal days

$$a\cdot\frac{67\cdot 27}{1830} = a\cdot\frac{603}{610} = a\left(1-\frac{7}{610}\right) \text{ nakṣatras.} \tag{4}$$

These rules make sense only if one is dealing with "equal" nakṣatras, i.e. with sections of uniformly 13;20° in length. If the conjunction, mentioned in XII,2, was in fact the conjunction of A.D. 80 Jan. 11 at the beginning of the nakṣatra Dhaniṣṭhā we would know that this point had in the first century a tropical longitude of about $\lambda = 290°$. Since there are 5 nakṣatras from Dhaniṣṭhā to Aśvinī, the beginning of the nakṣatra-zodiac, we find for this point $290+5\cdot 13;20 = 356;40°$, i.e., Pisces 26;40°, in the first century A.D.

XII,4. The parvan is either the conjunction or the opposition of Sun and Moon. The first half of this verse, then, correctly states that the parvan is the boundary between the first and second halves (pakṣas) of a month.

The second part of this verse refers to the 17th yoga, called vyatipāta, in a series of 27 yogas. These yogas count arcs of 13;20° each, contained in the sum of solar and lunar longitude (cf. also III,20–22). According to XII,3 a conjunction occurred at epoch, in A.D. 80, at the beginning of Dhaniṣṭhā, i.e. at Capricorn 23;20° or $\lambda = 293;20°$. Consequently the yoga has the number

$$\frac{2\cdot 293;20}{13;20} \equiv \frac{226;40}{13;20} = 17 \tag{1}$$

i.e. vyatipāta.

Furthermore, the combined travel of Sun and Moon in a yuga of 5 years is $5+67 = 72$ complete rotations, i.e. $72\cdot 360°$. But each series of 27 yogas of 13;20° each amounts also to 360°. Thus the above travel contains 72 series of yogas, accumulated during 1830 days (cf. XII,1 (3)). Hence the number of series elapsed since epoch at ahargaṇa a is given by

$$\frac{72}{1830}a = \frac{12}{305}a. \tag{2}$$

XII,5. For the interval from the winter solstice to the summer solstice (the "nothern ayana") the length of daylight C, measured in muhūrtas:

$$30 \text{ muhūrtas} = 1 \text{ day}, \tag{1}$$

is given by

$$C = \tfrac{2}{61}(n+732) - 12 \text{ muhūrtas} \tag{2}$$

where n is the number of days since the winter solstice. For $n = 0$ this formula gives $C = 12$, for $n = \frac{366}{2} = 183$ one obtains $C = 18$. Hence (2) is based on the assumption that the length of daylight varies according to a linear zigzag function between the extrema

$$m = 12 \qquad M = 18$$

i.e. it is assumed that

$$\frac{m}{M} = \frac{2}{3} \tag{3}$$

and that the year is exactly halved by the solstices. The ratio (3) is a basic parameter in Babylonian astronomy; cf. II,8 above.

Chapter XIII

XIII,1–5, 9–14. This is the conventional cosmography of the astronomers who have adapted the Purānic (and Jaina) conception of a flat oikoumene surrounding Mount Meru to the necessities of spherical astronomy by retaining Meru as the North Pole where the gods dwell, and calling the South Pole Vaḍavāmukha, the dwelling place of the demons. The phraseology echoes verses of Lāṭadeva (see above Pt. I p. 14f.).

XIII,6–7. The "others" are Āryabhaṭa (Āryabhaṭīya, Daśagītikā 4 and Gola 9).

XIII,8. The Arhats or Jainas believe that there are two Suns, two Moons, and two sets of nakṣatras which rise alternately, so that a complete revolution of one of these bodies about the center of the flat earth, Mount Meru, takes 2 nychthemera. This system is also referred to by Brahmagupta (Brāhmasphuṭasiddhānta XI,3) who perhaps had this verse of the Pañcasiddhāntikā in mind; for a detailed description of this peculiar conception see Kirfel [1920] pp. 285–291 and plate 16.

Varāhamihira's criticism seems to imply that the Jaina theory must be false because a determined point associated with the Sun appears on two successive nychthemera. This is not a valid criticism as the Jainas could assert an absolute identity in appearance between the two opposite halves of heaven occupied by the two Suns. More cogent would have been the argument that the Jaina theory accounts for only 90° of motion of heaven between sunrise and sunset whereas observations with a gnomon would quickly establish that the motion amounts to about 180°. We do not see, however, how such an interpretation could be made of this verse.

XIII,9–10. These verses show that Laṅkā is located on the terrestrial equator, $\varphi = 0°$, and Avanti at $\varphi = \varepsilon = 24°$. Cf. also XIII,19.

XIII,15–19. The following relations are assumed for a terrestrial great circle:

$$1° = 8;53,20 \text{ yojanas} \tag{1}$$

$$1 \text{ yojana} = 0;6,45°. \tag{2}$$

Consequently one quadrant measures 800 yojanas (in agreement with III,14 and IX,10).

On the basis of the relation (1) the distance in yojanas can be found between two places on the same meridian after the geographical latitudes were determined by direct astronomical observation.

The distance from Mount Meru to Avantī (= Ujjayinī) is $586^2/_3$ yojanas, hence, according to (1), exactly 66° as it should be if $\varphi = 24°$ at Avantī (cf. XIII,10).

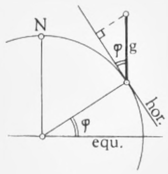

Fig. 47.

XIII,20–25. Here are consequences developed, based on the assumption made in XIII,15–19:

$$42° = 373^1/_3 \text{ yojanas north of Avantī}$$

i.e., at a latitude

$$\varphi = 66° = 90° - \varepsilon$$

the longest daylight is 60 nāḍikās = 24 hours.

Furthermore

$403^5/_9$ yojanas ≈ 45;24° north of Avantī ♐ and ♑ remain invisible
482 yoj. ≈ 54;14° north of Avantī ♏ to ♒ remain invisible
$586^2/_3$ yoj. = 66° north of Avantī ♎ to ♓ never rise, ♈ to ♍ never set.

If one schematically identifies months and zodiacal signs, the above statements imply that

at $\varphi \approx 69;24°$ longest daylight = 2 months
at $\varphi \approx 78;14°$ longest daylight = 4 months
at $\varphi = 90°$ longest daylight = 6 months.

In Almagest II,6 the same data are associated with $\varphi \approx 69;30°$, $\varphi \approx 78;20°$, $\varphi = 90°$ respectively.

XIII,26–29. Cf. the commentary to XIII,1–5, 9–14.

The astrological rules in XIII,28 are common to all Sanskrit texts on the subject since they were introduced by the Yavanajātaka of Yavaneśvara in 149/150 A.D.

XIII,30–34. The tip of a gnomon which is parallel to the earth's axis is $g\ \sin\varphi$ above the horizontal plane (cf. Fig. 47) at a locality of latitude φ.

XIII,35–38. On the phases of the Moon. For the pakṣas cf. the commentary on III,18–19.

XIII,39–42. The order of the planets is the familiar Greek one. From it follows the order of the rulers of the months, hours, days, and years (for which cf. I,17–21).

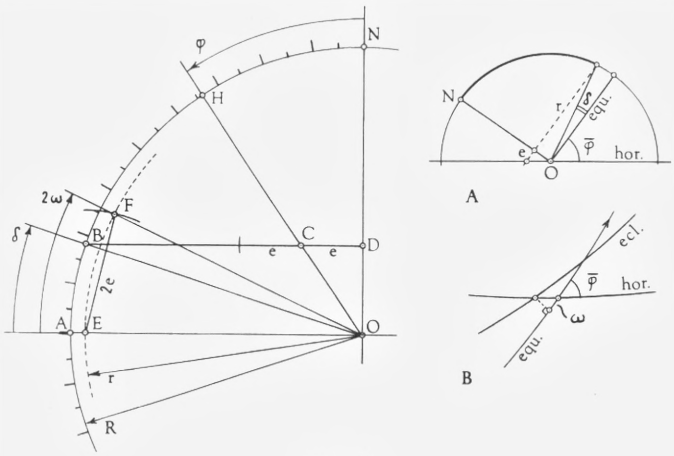

Fig. 48.

Chapter XIV

XIV,1–4. We have here a graphical method for the determination of the ascensional difference ω (cf. Fig. 48B) to given declination δ—though the formulation of the text is less general since it considers only the endpoints of zodiacal signs.[1])

The basis of construction is a graduated circle AN with center O (cf. Fig. 48), only one quadrant being actually needed. On its circumference one marks the point H such that the arc NH represents the given geographical latitude φ and AO the equator. Consequently HO represents the horizon if N is the north pole. A second arc is determined such that AB is the declination. Since AO is the equator the parallel DB is in the plane of the day-circle which belongs to δ, hence DB $= r$ the "day-radius", DC $= e$ the "earth-Sine" (cf. Fig. 48A) and

$$e = \operatorname{Sin}\delta \tan\varphi. \qquad (1)$$

[1]) The ascensional difference is called "composite" (XIV,4) when the arc beginning at the vernal point extends over more than one sign.

One now uses the same diagram as representation of the plane of the day-circle by making OE = OF = DB = r. We then determine on the day-circle a point F such that the chord EF = $2e$. If we call the resulting angle

$$\mathrm{EOF} = 2\omega$$

one has

$$\sin\omega = e/r$$

thus with (1)

$$\mathrm{Sin}\,\omega = \frac{R}{r}\,\mathrm{Sin}\,\delta\,\tan\varphi \tag{2}$$

which is, according to IV,26 (2), the defining relation for the ascensional difference ω which belongs to δ.

The present method is, of course, independent of the units in which the radius R of the diagram is drawn. Why the text requires to make OA = 90 digits is not clear since $R = 90$ is nowhere else a norm for trigonometric functions. Only if our first interpretation of XIV,7 is correct the number 90 could perhaps represent the number of degrees from the pole to the equator.

XIV,5–6. If t is a time interval (since sunrise or before sunset), measured in nāḍīs, then $6t$ is the equivalent angle in degrees. If furthermore s_0 is the length of the shadow cast by a vertical gnomon of length g at noon, s at any time t, the text seems to tell us how to find the increment of s over s_0. Apparently this should be found from

$$s = s_0 + R - \mathrm{Sin}\,t. \tag{1}$$

Unfortunately such a relation cannot be correct since it gives for $t = 0$ not $s = \infty$ but $s = s_0 + R$ (though for $t = 90°$ one obtains $s = s_0$ as expected).

Furthermore any such formula must involve g, the geographical latitude φ, and the solar declination on the day in question. The only possibility of avoiding these data would imply that (1) concerns only the equinoxes and that s_0, the equinoctial noon shadow, is considered to be a given parameter. But even so s would have to be found from $s = s_0/\cos\alpha$ with α found from $\tan\alpha = \cot r/\sin\varphi$.

XIV,7. A possible interpretation of this verse is illustrated by Fig. 49. Let AN represent a quadrant of the equator with OA = 90 (cf. XIV,1–4). On this quadrant make AP = 30°, AQ = 60°. Parallel to NO are drawn the declinations NB = ε, QQ′ = $\delta(60°) \approx 20;30°$, PP′ = $\delta(30°) \approx 11;40°$, measured in the same units as the radius NO—and, if desired, analogously for any other arc from A toward N. The resulting curve AP′Q′B is then considered as representing the ecliptic. One now draws the radii OP′P″, OQ′Q″ which intersect the given quadrant at points P″, Q″ which define arcs AP″ = $\alpha(30°)$, AQ″ = $\alpha(60°)$ which are supposedly the right ascensions for $\lambda = 30°$ and $\lambda = 60°$ respectively.

That this procedure is not correct (except for A and N) is obvious. This can be seen also by direct measurement which gives AP″ ≈ 23° (instead of ≈ 27:50°) and AQ″ ≈ 52 °(instead of ≈ 57;55°). Only the general trend of the right ascensions as function of λ is more or less preserved. Cf. also XIV,10–11.

The advantage of this interpretation of the text lies in the fact that it relates the problem at hand to the general type of numerical and graphical methods which are presented in this chapter. Otherwise an alternative translation could be proposed which implies no more than a simple description of the concept "right ascension":

"The ecliptic (lies) on a line (running through) the degrees of declination north and south of the equator; the degrees of the (corresponding) arcs of that (i.e., of the

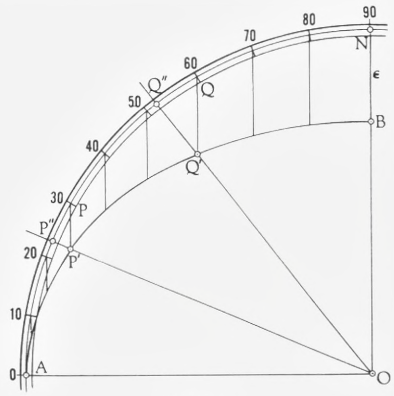

Fig. 49

equator) multiplied by 10 are, in order, the vināḍikās if rising (the right ascensions) of the zodiacal signs".

XIV,8–10. Let G be the foot of the gnomon of length g (Fig. 50), the point C of the north-south line the endpoint of the equinoctial noon shadow. A point F is obtained by turning the gnomon down into the east-west line, hence making FG = g. Then FC intersects the circle at an angle $\bar{\varphi}$ from CG such that $\bar{\varphi}$ is the colatitude.

The construction in XIV,9–10 (cf. Fig. 51) is only a trivial variant of the same idea.

XIV,10–11. Based on the graphical method assumed in Fig. 49 as interpretation of XIV,7 the longitude λ which belongs to a given declination δ could be found by fitting δ (parallel to NBO) between the two curves (cf. Fig. 52). The principle of such a procedure is, of course, incorrect, e.g., because the quadrant AN is now used as representing longitudes though originally serving as the equator.

XIV,12–13. The elongation $\Delta\lambda$ between Sun and Moon is found by direct observation. Since the velocity of the Moon relative to the Sun is about 12° per tithi the quotient $\Delta\lambda/12$ is an estimate of the number of elapsed tithis since conjunction.

XIV,14–16. The following construction supposedly provides a method for finding the path of the shadow end of a vertical gnomon and the position of the meridian line from three arbitrarily selected positions of the shadow (cf. Fig. 53). If G is the foot of the gnomon, A, B, C the endpoints of three shadows s_1, s_2, s_3 then M is constructed as midpoint of the circle which circumscribes the triangle ABC; this circle is assumed to be the path of the shadow, i.e. a hyperbola is approximated by a circular arc as may be reasonably adequate for the section from A to C.

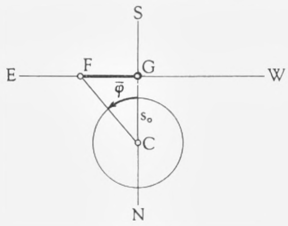

Fig. 50.

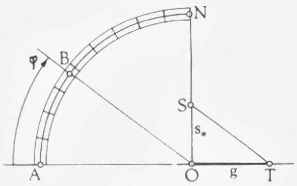

Fig. 51.

It is obviously wrong, however, that MG defines the meridian line since the same points A, B, C, and M can be the result of totally different positions of G. Or formulated differently: three points define a circle but not a hyperbola.

XIV,17–18. Definition of concepts which have been used many times before.

XIV,19–20. Construction of a hemispherical sun dial (cf. Fig. 54), the plane of its rim being made to coincide with the plane determined by the east-west line and the direction to the north pole. The gnomon in the center will point in the direction of midheaven, its tip being at the center of the sphere. The endpoint of the shadow then describes the part above the horizon of the respective day-circle. From this can di-

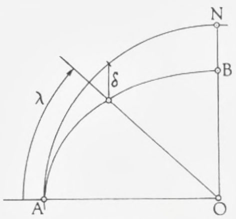

Fig. 52.

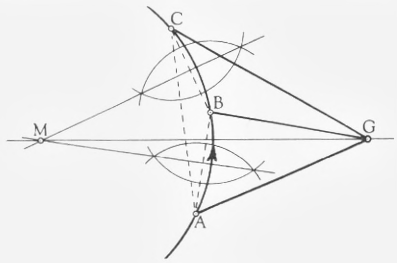

Fig. 53.

rectly be known the nāḍīs that have elapsed since sunrise. However, one cannot find the ascendent point of the ecliptic by adding an arc on the day-circle to the longitude of the Sun.

XIV,21–22. Fig. 55 illustrates the principle of the instrument in question. Using for the "hand" (hasta) and the "finger" a norm as found in the Āryabhaṭīya (Daśagītikā

6) we get a ratio 1 : 48 for the width of the ring to its diameter and width of the ring of about $^1/_3$ of an inch. To keep such a ring accurately circular and in the same plane will not be easy. A practical execution of the instrument was probably never attempted.

XIV,23–26. The text seems to suggest a solid sphere with the principal circles drawn on its surface. Equidistant perforations made on the ecliptic should then be used to single out two diametrically opposite holes which define the position of the Sun in longitude.

The practical difficulties in constructing such a sphere would be extremely great and an armillary sphere, consisting of a system of rings, would serve the purpose

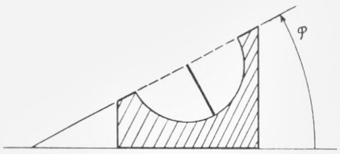

Fig. 54.

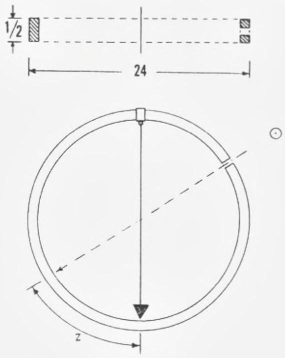

Fig. 55.

much better. The wording of the text, however, seems not to allow such an interpretation.

XIV,27–28. Strings are used for drawing circles, water for leveling surfaces, sand either for constructing diagrams on the ground or for computing on the sand-board.

The references to the forms of tortoises and men look more like tantra than gaṇita.

XIV,29–30. The only accurate time signals available in ancient astronomy for the determination of relative geographical longitudes were lunar eclipses.[1]) The present verses speak of full-moons in general which would, in practice, deprive the method of all its value since the accurate moment of opposition cannot be established by observation.[2]) Nevertheless the underlying idea is in principle correct, being based on a reversal of the rule for the application of the correction for geographical longitude-differences, e.g., in IX, 10.

The longitudes of Sun and Moon at opposition, i.e., λ_s and $\lambda_m = \lambda_s + 180°$ may be assumed to be known by computation. Hence one can in principle establish by

[1]) This method can be made independent from man-made clocks by relating the characteristic phases of the eclipse to transit observations of stars.

[2]) An error of only 10 minutes in longitude (considered permissible even at the height of Greek astronomy) would result in an error of 5° in geographical longitude and parallax alone could increase the error to five times this amount.

observation the moment at which the moon reaches this longitude λ_m. At that moment one also should observe which point of the ecliptic is rising, giving us, at least ideally, a longitude λ_H and hence an ecliptic arc $\lambda_H - \lambda_m$ which is equal to the arc $\lambda_s - (\lambda_H + 180°)$ The oblique ascension of the arc $\lambda_H - \lambda_m$ is therefore equal to the time t' (expressible in ghaṭikās) since local sunset.

The simplest method of proceeding would be to apply the equation of daylight to t' and thus to find the time t of the observation after 6 p.m. (in equinoctial hours). On the other hand, one can find by the standard computational methods of the karaṇa the time t_0 of the opposition with respect to 6 p.m. Lañkā. Hence the time difference $\Delta t = t_0 - t$ between the given locality and the prime meridian would be known, which solves our problem.

The text is by no means clear but seems to ask for a more intricate procedure. Although mentioned in the text at the wrong place we may assume the transformation of t' into t carried out correctly, i.e., we consider to be known the time t in equinoctial hours after 6 p.m. local time at which the opposition took place. One now computes for the same number t of hours after 6 p.m. Lañkā time the longitude λ_0 of the Moon. Then $\Delta\lambda = \lambda_m - \lambda_0$ represents the lunar motion during the time interval $\Delta\lambda$ between the local meridian and the prime meridian through Lañkā. Hence Δt can be found from $\Delta\lambda$ by dividing the latter by the lunar velocity-reminiscent of the conversion of a longitudinal difference into tithis.

This circuitous way is not only needlessly complicated but increases considerably the number of inaccurately known elements. The whole method probably had never been tried in practice.

XIV,31–32. Both the inpouring and the outpouring types of waterclocks are here described. For other references in early Sanskrit literature see Isis 54 (1963) p. 232 to which add Sphujidhvaja, Yavanajātaka 79,27.

The text states that there are 180 breaths (śvāsa) in a nāḍī. Each śvāsa consists of two prāṇas—an ingoing and an outgoing. The prāṇa, in fact, is traditionally a sixth of a vināḍī (i.e. $^1/_{360}$ of a day) or the time necessary to recite 10 long syllables. XIV,32 contains 60 long syllables, and should therefore require 1 vināḍī to be recited.

TABLE 10.

Yogatārā	Longitude		Latitude		No.
	Varāhamihira	Paitāmaha	Varāhamihira	Paitāmaha	
Kṛttikā	32;40°	37;28°	+3;9°	+5°	1
Rohiṇī	48;30	49;28	−5;51	−5	2
Punarvasu	88	93	+7;12 and −7;12	+6	3
Puṣya	97;20	106	+4;3	0	4
Āśleṣā	107;40	108	+0;54 and −0;54	−7	5
Maghā	126	129	–	0	6
Citrā	181;50	183	−2;42	−2	7

Table 11.

Regulus	
A.D.	λ
0	122; 9°
100	123;32
200	124;54
300	126;17
400	127;40
500	129; 3
600	130;26

Table 12.

No.	Longitude		Latitude	
	Var.	Pait.	Var.	Pait.
1	−93;20°	−91;32	+3; 9°	+5°
2	−77;30	−78;32	−5;51	−5
3	−38	−36	±7;12	+6
4	−28;40	−23	+4; 3	0
5	−18;20	−21	±0;54	−7
6	0	0	−	0
7	+55;50	+54	−2;42	−2

XIV,33–37. These verses are to be used in predicting the conjunctions of the Moon with certain fixed stars whose longitudes are given as degrees within the nakṣatras for which they serve as reference stars ("yogatārās"); the latitudes are given in "hands" (hastas), of which each should be approximately 0;54°.

We can easily compare (cf. Table 10) the figures in our text with those of the Paitāmahasiddhānta of the Viṣṇudharmottarapurāna (III,30) from which all later Indian star catalogues seem to be derived—with various modifications, of course. The discrepancies in latitude seem to indicate that the yogatārās of Kṛttikā, Puṣya, and Āśleṣā according to Varāhamihira are different from those according to Paitāmaha.

The safest identification seems Maghā and Regulus (α Leo) since the longitudes of Regulus between A.D. 0 and 600 agree with such an identification (cf. Table 11). The latitude of Regulus during this period is practically constant +0;24° in fair agreement with the Indian norm.

For the further investigation it is advantageous to operate with relative longitudes, e.g., with respect to Maghā, since one eliminates in this way all chronological questions. Thus Table 12 can replace Table 10. Similarly Table 13 gives the coordinates of six stars which may be identified with some degree of plausibility with the yogatārās Nos. 1 to 3 and 5 to 7 of Table 12. For No. 4 one would like to suggest some star in Cancer but no convincing identification presents itself.

Table 13.

	Magn.	Long.	Lat.	No.
η Tau (Hyades)	5	−89;57°	+3;52°	1
α Tau (Aldebaran)	1	−80;11	−5;35	2
β Gem (Pollux)	2	−36;27	+6;33	3
ε Can (Crib)	neb.	−22;32	+1; 0	5
α Leo (Regulus)	1	0	+0;24	6
α Vir (Spica)	1	+53;55	−1;56	7

XIV,38. If the Moon at latitude β_m comes in conjunction with a star of latitude β, i.e., if the Moon and the star are of same longitude, then the distance b of the northern rim of the Moon from the star (cf. Fig. 56) is given by

$$b = (\beta - \beta_m) - 0;17^\circ \tag{1}$$

since (VI,3) we have for the apparent diameter of the Moon

$$d_m = 0;34^\circ. \tag{2}$$

If one measures, however, the distance b in "digits" such that

$$d_m = 15 \text{ digits} \tag{3}$$

then one has to replace (1) by

$$b = \tfrac{15}{34}((\beta - \beta_m)' - 17') \text{ digits} \tag{4}$$

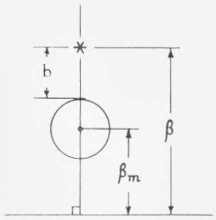

Fig. 56.

measuring β and β_m in minutes of arc. According to XIV,33 the distance $\beta - \beta_m$ has been found by observation. Of course it would be more reasonable to determine β_m from the directly observable distances β and b.

The origin of the norm (3) is unknown but in V,4 we have a similar division of the lunar diameter in 15 "parts".

XIV,39–41. It is the purpose of the text to compute for a given geographical latitude φ the longitude λ_s of the Sun at the heliacal rising of the star Canopus (which has a longitude near, or equal to Cancer 0° i.e. 90°). The text relates the rising time ϱ of the arc $\lambda_s - 90°$ to an expression reckoned in degrees and then multiplied by 10 in order to obtain time units (vināḍīs). We can avoid this factor by counting also oblique ascensions in degrees. Then the text seems to say

$$\tfrac{1}{2}(s_0 \cdot 0;25^\circ + 21^\circ \cdot s_0) = \varrho(\lambda_s - 90^\circ) \tag{1}$$

where s_0 is the equinoctial noon shadow.

$$s_0 = 12 \tan\varphi \tag{2}$$

and thus for (1)

$$2,8;30 \tan\varphi = \varrho(\lambda_s - 90^\circ). \tag{3}$$

This relation cannot be strictly correct since we know that the Sun must be somewhere in the last third of Leo[1]) which makes $\lambda_s - 90°$ about 50° or 60°, hence the oblique ascension greater than 50 and increasing with φ. The left-hand side, however, is zero at the equator and increases toward 120 as φ moves toward 45°. Hence (3) can be only approximately correct within certain limits of φ. It is plausible to investigate the situation for $\varphi = 24°$, which is the latitude of Ujjayinī, hence for $\tan\varphi \approx 0;27$. This gives

$$\varrho(\lambda_s - 90°) \approx 58$$

which is satisfied at $\varphi \approx 24°$ by $\lambda_s \approx$ Leo 21. Hence (1) would be applicable for an area which contains Ujjayinī.

Chapter XV

XV,1–4. The Sun is "eclipsed" for any observer located within the shadow of the Moon. In this sense there is always a solar eclipse somewhere in the universe; he who correctly knows the relative position of the two luminaries can predict where

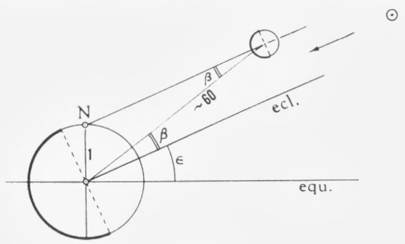

Fig. 57.

and when a solar eclipse will be visible. The Pitṛs, who dwell on the side of the Moon opposite the earth, cannot see the Sun for half a synodic month; the middle of this type of "solar eclipse" occurs at full moon.

XV,5–6. On the north pole solar eclipses are considered impossible. The argument seems to be that the ecliptic is not far enough from the equator to cause the Moon's shadow to reach the north pole. This would be, however, the case only if the Moon would be restricted to a position in the ecliptic. But it is easy to see (cf. Fig. 57) that for a conjunction near the summer solstice a lunar latitude of about 1° suffices to produce a solar eclipse on the north pole.

XV,7–9. Dependence of a solar eclipse on local time, whereas XV,9 refers to the influence of longitudinal parallax, here estimated as reaching as much as 2 kṣaṇas = 4 nāḍīs. This agrees with the estimate for the horizontal parallax in VII,1 and VIII,9.

XV,10. The reference is to Bṛhatsaṃhitā 5, 8–11.

[1]) Bṛhatsaṃhitā XII,14 gives Leo 23° as solar longitude when Canopus rises.

XV,11–14. If one calls a "nychthemeron" the succession of one period of light and one of darkness, then 60 nāḍīs is a nychthemeron for men, a synodic month for the Pitṛs on the Moon, and one year for the Gods on the north pole.

XV,15. The maximum altitude at which the Gods on the north pole can see the Sun is $\varepsilon = 24°$. In contrast, the same altitude is attained in 2 kṣaṇas = $^1/_{15}$ day when the Sun crosses a horizon perpendicularly, as is possible for geographical latitudes $|\varphi| \leqq \varepsilon$, thus, e.g., anywhere between Ujjayinī and Laṅkā.

XV,16–21. This discussion is clear enough; it will suffice to indicate here some parallel references to statements about the epochs of the various authorities listed by Varāhamihira.

XV,18. The epoch here ascribed to Lāṭācārya is found again in I,8 as that of the Romakasiddhānta; the epoch-date 22 March 505 A.D., then, must be Lāṭa's. But note that in VIII,5 sunset at Avantī is ascribed to the Romakasiddhānta.

XV,19. Siṃhācārya is not otherwise known, but his epoch is the standard epoch of most Indian astronomers—e.g., for both the āryapakṣa and the brāhmapakṣa.

The guru of the Yavanas gives as epoch 10 muhūrtas i.e., 8 hours past sunset, hence about 2 hours $\approx 30°$ to the west of the prime meridian Laṅkā-Ujjayinī. We have seen in III,13 that Yavanapura (Alexandria) is assumed to lie 44° to the west of Ujjayinī, as is very nearly correct. Baghdad-Babylon, however, lies 31;25° west of Ujjayinī; so the epoch of the guru of the Yavanas is midnight at Babylon as it was, e.g., in the Sasanian Zīj ash-Shāh (according to al-Bīrūnī, cited by E. S. Kennedy, JAOS 78, 1958, p. 260–261).

XV,20. Āryabhaṭa's first epoch is that of the ārdharātrika system, for which see Part I p. 14; his second is that of the Āryabhaṭīya, Daśagītikā 2 and Kālakriyā 16.

XV,22–23. In Purāṇic cosmology the inner continent, Jambūdvīpa, of which Mount Meru is the center, has at its four cardinal points the four territories listed here: Bhāratavarṣa (i.e., India) to the south, the Bhadrāśvas to the east, the Kurus to the north and the Ketumālas to the west. Similarly the astronomers (e.g. Āryabhaṭīya, Gola 13) posit on the equator four cities distant 90° from each other; starting from Laṅkā and proceeding westward they are Laṅkā, Romakaviṣaya, Siddhapura, and Yamakoṭi.[1])

XV,24. This verse states that the various series of chronological units begin at the beginning of the yuga, at which time all of the planets were at Aries 0°. There is some ambiguity in the text as it is stated that both the series of days and that of nights begin at this time. The apparent contradiction disappears if we assume a sunset epoch and interpret the word "day" (dina) in the sense of "nychthemeron". But Varāhamihira may also have been expressing himself in a very loose manner.

[1]) Cf. D. Pingree, The Thousands of Abū Maʿshar, p. 45.

The ayanas are usually the semicircles of the solar orbit from solstice to solstice but in the present context a beginning at the equinoxes is required. The ṛtus define a kind of seasonal division of the year. The "motion of the constellations" counts the number of sidereal days in a yuga.

XV,25. Romakaviṣaya is per definition 90° west of Lan̄kā, and Yavanapura is by III,13 44° west of Lan̄kā. The variation referred to in the second half of the verse is a direct effect of the variation in the length of daylight; such a variation does not exist, however, at Lan̄kā itself but at any other locality on the prime meridian through Lan̄kā.

XV,26–29. Criticism of the ordinary concept "Lord of the day" because of its dependence on geographical location.

Chapter XVI

XVI,1–9. In order to find from the ahargaṇa a for the outer planets their mean (sidereal) longitude $\bar{\lambda}$, for Venus and Mercury the śīghra (i.e. the sum of the mean sidereal longitude of the Sun plus the planet's mean anomaly), rules of the following form are given

$$\bar{\lambda} = 360 \frac{a}{p_0} + \frac{a}{p_0} \delta + c. \tag{1}$$

Here p_0 is the approximate duration (in days) of one sidereal rotation, δ a correction due to the inaccuracy of p_0, and c (in degrees) the epoch constant (kṣepa).

The given data for $1/p_0$ and the resulting values for p_0 are shown in Table 14. Note that the values of p_0 are the exact equivalents of the ratios given for $1/p_0$, no roundings being involved. The identical values for $1/p_0$ for Mars, Venus, and Mer-

Table 14.

	$1/p_0$	p_0
Saturn	$\frac{1000}{10766066} = \frac{16,40}{49,50,34,26} = \frac{1,0,0,0}{2,59,26,3,57,36}$	$2,59,26;3,57,36^d$
Jupiter	$\frac{100}{433232} = \frac{1,40}{2,0,20,32} = \frac{1,0,0}{1,12,12,19,12}$	$1,12,12;19,12^d$
Mars	$\frac{1}{687} = \frac{1}{11,27}$	$11,27^d$
Venus śīghra	$\frac{10}{2247} = \frac{10}{37,27} = \frac{1,0}{3,44,42}$	$3,44;42^d$
Mercury śīghra	$\frac{100}{8797} = \frac{1,40}{2,26,37} = \frac{1,0,0}{1,27,58,12}$	$1,27;58,12^d$

TABLE 15.

	N	Np_0	$\Delta = Np_0 - A$
Saturn	146 564 = 40,42,44	$2,1,45,10,28,17;13,26,24^d$	$-$ $1,42;46,33,26^d$
Jupiter ...	364 220 = 1,41,10,20	2,1,45,10,26,30;24	$-$ 3,29;36
Mars	2 296 824 = 10,38, 0,24	2,1,45,10,34,48	+ 4,48
Venus	7 022 388 = 32,30,39,48	2,1,45,14, 3, 3;36	+3,33,3;36
śīghra Mercury ..	17 937 000 = 1,23, 2,30, 0	2,1,45,10,31,30	+ 1,30
		2,1,45,10,30,0 = A	

cury and equivalent expressions for Saturn and Jupiter are found in Khaṇḍakhādyaka II,1–5.

In order to determine the correction δ one has to introduce the numbers p of days which represent the accurate lengths of the sidereal periods of the planets. Traditionally these numbers p are defined by saying that exactly N sidereal revolutions of the planet take place during A days, i.e.,

$$p = \frac{A}{N}. \tag{2}$$

For the number A can be taken the number of days in a Mahāyuga, i.e., in 20,0,0,0 sidereal years. In the ārdharātrika system it is assumed (cf. IX,1) that

$$A = 1\ 577\ 917\ 800^d = 2,1,45,10,30,0^d \tag{3}$$

which is the exact equivalent of the statement that

$$1 \text{ sidereal year} = 365;15,31,30^d. \tag{3a}$$

In the following we shall use the parameter (3) and the values N listed in Table 15.

It follows from the definition of p as exact sidereal period that one should have

$$\bar{\lambda} - c = 360 \frac{a}{p}$$

whereas (1) gives

$$\bar{\lambda} - c = 360 \frac{a}{p_0} + \frac{a}{p_0} \cdot \delta.$$

Consequently

$$\frac{a}{p_0}(360 + \delta) = \frac{a}{p} 360 \text{ and thus } \delta = 360\left(\frac{p_0}{p} - 1\right).$$

Finally, using (2), we find for δ, measured in degrees

Table 16.

	$6,0 \cdot \Delta/A$	Text: δ
Saturn	−0; 0, 0, 5, 3,...°	−0; 0, 0, 5°
Jupiter	−0; 0, 0,10,19,...	−0; 0, 0, 10
Mars	+0; 0, 0,14,11,...	+0; 0, 0,14
Venus	+0; 0,10,29,58,...	+0; 0,10,30
śīghra		
Mercury ...	+0; 0, 0, 4,26, 6,...	+0; 0, 0, 4, 30

$$\delta = 360 \frac{Np_0 - A}{A} \tag{4}$$

in excellent agreement with the values found in the text (cf. Tables 15 and 16).

The problem of determining the accurate moment of the epoch is naturally related to the explanation of the values given in the text for the epoch constants, the kṣepas. We shall show in the following that the epoch positions for the Sun and the Moon are referred to noon (Ujjayinī) of March 20 A.D. 505 whereas the positions for the planets are based on midnight March 20/21 of that year. One can consider this inconsistency as evidence for an earlier version of the Sūryasiddhānta (cf. above Pt. 1 p. 13 f.)

For the date of the epoch we can conclude from the rule given in I,8 for the computation of the ahargaṇa that 427 years in the Śaka era were completed at the epoch. Adding 427 to the number 3179 af years conventionally assumed as the date for the beginning of the Śaka era with respect to the Kaliyuga[1]) we obtain for our epoch a distance of exactly 3606 (= 1,0,6) years from the beginning of the Kaliyuga.

We know furthermore (cf. (3a)) that

$$1 \text{ sidereal year} = 6,5;15,31,30^{d}.$$

Consequently the 1,0,6 years elapsed since the beginning of the Kaliyuga contain

$$6,5;15,31,30 \cdot 1,0,6 = 6,5,52,3;3,9^{d} \approx 1\,317\,123^{d}. \tag{5}$$

If we add these days to the beginning of the Kaliyuga, i.e. to midnight of February 17/18 −3101 we obtain (ignoring the fraction $0;3,9^{d}$) midnight March 20/21 A.D. 505.

Computing for this moment and with the parameters of the ārdharātrika system the planetary (mean) positions one finds exactly, or almost exactly, the epoch constants given in the present chapter (cf. Table 17). For Sun and Moon, however, one finds discrepancies of about one half day's motion too short; this shows that for these bodies noon of March 20 had been used as epoch, thus confirming the statement in IX,1 that noon in Avantī is the point of reference for the solar longitudes. In the following we shall first deal with the epoch constants for Sun and Moon as given in

[1]) Brāhmasphuṭasiddhānta I,26 or Laghubhāskarīya I,4.

Table 17.

	N	0;18,1,48 · N = c_1	$\bar{v}$	− 0;3,9 · $\bar{v}$ = c_2	$c_1 + c_2 = c'$	c	XVI	c − c′
Saturn..	40,42,44	122;28,55,12°	0; 2, 0,23°/d	−0; 0, 6,19°	122;28,48,53°	122;28,49°	5	0
Jupiter .	1,41,10,20	8; 6,36, 0	0; 4,59, 9	−0; 0,15,42	8; 6,20,18	8; 6,20	6	0
Mars ...	10,38, 0,24	75;36,43,12	0;31,26,27	−0; 1,39, 2	75;35, 4,10	75;35	6	−0;0,4°
Venus ..	32,30,39,48	267;35,38,24	1;36, 7,44	−0; 5, 2,48	267;30,35,36	267;30,39	9	+0;0,3
Mercury	1,23, 2,30, 0	148;30, 0, 0	4; 5,32,17	−0;12,53,27	148;17, 6,33	148;17	9	−0;0,7

IX,4 and 5 (cf. Table 18 and 19) before turning to the planetary kṣepas from XVI,5, 6, and 9 (Table 17).

Let N again represent the number of sidereal rotations of a celestial body (or apogees, or nodes) in 20,0,0,0 sidereal years, thus N/20,0,0,0 the number of revolutions per year and therefore

$$1,0,6 \cdot \frac{N}{20,0,0,0} \cdot 6,0^\circ = 0;18,1,48 \cdot N \tag{6}$$

the mean motion during 1,0,6 sidereal years since the beginning of the Kaliyuga. At the beginning of the Mahāyuga, i.e. 15,0,0,0 years before the beginning of the Kaliyuga, all mean longitudes are assumed to be zero. The number of sidereal revolutions during 15,0,0,0 years is given by

$$15,0,0,0 \cdot \frac{N}{20,0,0,0} = 0;45 \cdot N. \tag{7}$$

Hence, whenever the last digit of N, multiplied by 0;45, produces a number ending in zero—that is to say, whenever the last digit of N is divisible by 4—then the number of rotations during 15,0,0,0 years is an integer and therefore the corresponding longitude will again be zero, also at the beginning of the Kaliyuga.

The values of N for the rotations of Sun and Moon in a Mahāyuga are[1])

Sun, mean longitude:	20,0,0,0
Moon, mean longitude:	4,27,22,35,36
Moon, apogee:	2,15,36,59
Moon, nodes (retrograde):	1,4,30,26.

The first two numbers are divisible by 4; thus the mean longitude of Sun and Moon is zero at the beginning of the Kaliyuga. But 59·0;45 = 44;15 and 26·0;45 = 19;30. Consequently the lunar apogee had a longitude of 90° at the beginning of the Kaliyuga while the longitude of the ascending node was ±180°.

[1]) Cf. note 1 to I,14, Table 1.

TABLE 18.

	$c_0 + 0;18,1,48 \cdot N = c_1$
Sun, Mean Long.	$0° + \quad 0° = 0°$
Moon, Mean Long.	$0 + 357;28,\ 4,48 = -2;31,55,12°$
Moon, Apogee	$90 + 189;48,34,12 = 279;48,34,12$
Moon, Asc. Node	$180 - 303;54,46,48 = -123;54,46,48$

Having thus found the initial longitudes c_0 for the beginning of the Kaliyuga we can now go 1,0,6 years forward to the epoch in A.D. 505 by adding, according to (6), the amount of $0;18,1,48 \cdot N$. The resulting longitudes c_1 are shown in Table 18. We must now observe that (5) tells us that 1,0,6 sidereal years, beginning at midnight of −3101 Febr. 17/18 lead $0;3,9^d$ beyond midnight of A.D. 505 March 20/21. Thus noon of March 20, the epoch for Sun and Moon, precedes by $0;33,9^d$ the endpoint of 1,0,6 years.

Let $\bar{v}$ be the daily mean motions as determined from the parameters of the ārdharātrika system in IX,1–5. Then

$$c_2 = -0;33,9 \cdot \bar{v} \tag{8}$$

furnishes the motion away from c_1 found before. Thus

$$c' = c_1 + c_2 \tag{9}$$

are the longitudes to be expected for the epoch, i.e., for noon of March 20 A.D. 505. Table 19 shows that the agreement with the kṣepas given in IX,4 and 5 is excellent.

A similar consideration leads us to the kṣepas for the planets in XVI,5–9. All numbers N are divisible by 4, thus all longitudes are zero at the beginning of the Kaliyuga and (6) gives directly c_1 (cf. Table 17). Since midnight epoch is used for the planets the excess of c_1 is only $0;3,9 \cdot \bar{v}$ where $\bar{v}$ is again the daily mean motion based on ārdharātrika parameters. Thus the expected epoch-longitudes are $c' = c_1 - 0;3,9 \cdot \bar{v}$, again in excellent agreement with the kṣepas in the text.

Table 20 gives in column I the modern data for the planetary positions in A.D. 505 March 20 (7 p.m. Babylon).[1]) Column II is computed with Theon's "Handy

TABLE 19.

	IX	$\bar{v}$	$-0;33,9 \cdot \bar{v} = c_2$	$c_1 + c_2 = c'$	c	IX	$c - c'$
Sun, Mean Long.	1 (3)	$0;59,8,10^{o/d}$	$-0;32,40,22°$	$-0;32,40,22°$	$-0;32,40°$	1 (5)	0
Moon, Mean Lng.	2 (3)	13;10,34,52	−7;16,47,46	−9;48,42,58	−9;48,44	2 (4)	−0;0,1°
Moon, Apogee	3 (3)	0;6,40,59	−0;3,41,33	279;44,52,39	279;44,53	3 (4)	0
Moon, Asc. Node	5 (3)	−0;3,10,44	+0;1,45,23	−123;53,1,25	−123,53,3	5 (4)	−0;0,2

[1]) From Tuckerman, Tables. The time difference to midnight Ujjayinī is only 3^h.

TABLE 20.

Planet		I	II	c	c − II
Saturn	λ	123.19°	120;13°		
	$\bar{\lambda}$		125;19	122;28,49°	− 2;50°
Jupiter	λ	9.41	7;45		
	$\bar{\lambda}$		9;41	8; 6,20	− 1;35
Mars	λ	53.78	47;31		
	$\bar{\lambda}$		80;34	75;35	− 4;59
Venus	λ	324.28	320;53		
	$\bar{\lambda}$		359;17		
	$\bar{\alpha}$		265; 2	267;30,39	+ 2;29
Mercury	λ	6.89	13; 1		
	$\bar{\lambda}$		359;17		
	$\bar{\alpha}$		149;12	148;17	− 0;55

Tables" [1]) (for midnight Ujjayinī, March 20/21). The true longitudes in column II differ so little from the modern values that we may consider the mean longitudes and anomalies as fair estimates for these parameters (which have no simple parallel in modern tables). The agreement with the kṣepas *c* is close enough to show their correctness for the date of the epoch.

For the Moon all relevant parameters can conveniently be computed with P. V. Neugebauer's tables (cf. Table 21, column II) and, for the sake of comparison, also from the "Handy Tables" (Table 21, column I). The longitude λ_A of the apogee of the lunar orbit can be found, according to Fig. 58, from

$$\lambda_A = \bar{\lambda} - \bar{\alpha}. \qquad (10)$$

The agreement of the kṣepas is very good indeed.

TABLE 21.

Moon	505 March 20 noon Ujj.		c	c − II
	I	II		
$\bar{\lambda}$	− 9;24°	− 9.84°	− 9;48,44	+ 0;1,40°
λ	345;50	345.13		
$\bar{\alpha}$	74; 5	70.6	70;26,23	− 0;9,37
λ_A	276;31	279. 6	279;44,53	+ 0;9
$-\lambda_n$	126;57	123.8	123;53,3	+ 0;5
β	+ 4;36	+ 4;45		

[1]) Using (after correcting many errors) the edition by Halma "Commentaire de Théon d'Alexandrie...; Tables manuelles des mouvemens des astres" Paris 1822, 1823.

XVI,10–11. The yearly corrections (bīja) required according to these verses are

Saturn	mean long.	+0;0,6,30°	Venus	śīghra	−0;0,45°
Jupiter	mean long.	−0;0,10	Mercury	śīghra	+0;2
Mars	mean long.	+0;0,17			

For Jupiter an additional correction of −0;23,20° (at epoch?) is to be applied.

If one computes the number of revolutions which accumulate by these corrections during 20,0,0,0 years and then adds the results (algebraically) to the numbers N known from the ārdharātrika system one obtains numbers (involving fractions for the outer planets) which are recorded nowhere else. We have no explanation to offer.

XVI,12–14. The underlying model of planetary motion assumed by the Sūrya-siddhānta, as by other early Indian texts, is a deferent concentric with the center O

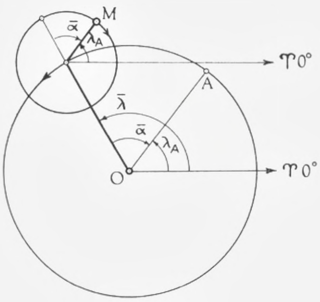

Fig. 58.

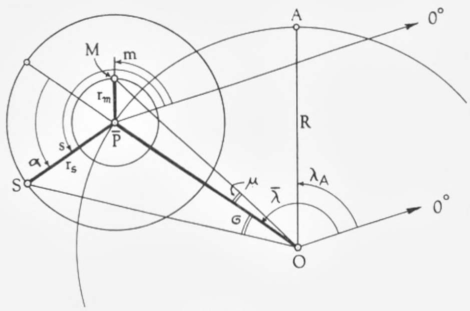

Fig. 59.

of the earth (cf. Fig. 59), carrying the mean planet $\bar{\mathrm{P}}$. The latter is the center of two epicycles, the "manda-epicycle" and the "śīghra-epicycle". On the former is situated the "mandocca" M such that the radius $r_m = \bar{\mathrm{P}}\mathrm{M}$ has a fixed sidereal direction, parallel to the direction from O to the apogee A; on the latter epicycle is moving the "śīghrocca" S such that, for an outer planet, $\bar{\mathrm{P}}\mathrm{S} = r_s$ is always parallel to the direction from O to the Sun (which, then, the text calls śīghra, i.e., "conjunction") whereas for an inner planet $\bar{\mathrm{P}}$ coincides with the mean Sun while $\bar{\mathrm{P}}\mathrm{S}$ makes with the direction $\mathrm{O}\bar{\mathrm{P}}$ the angle α which represents the anomaly of the planet.

Obviously the displacement caused by the manda-epicycle is the cinematic equivalent of an eccentric deferent in the Greek planetary theory (with $\bar{\mathrm{P}}\mathrm{M}$ as eccentricity) whereas the śīghra epicycle plays essentially the same role as the epicycle which carries the planet.

As independent variables serve in the Indian arrangement the angles m (manda) and s (śīghra) shown in Fig. 59,

$$m = \lambda_A \tag{1}$$

being the (sidereal) longitude of the apogee A, and

$$s = \bar{\lambda} + \alpha, \tag{2}$$

the sum of the mean longitude of the planet and its anomaly. Both m and s produce corrections, μ and σ respectively, which, combined and modified in a fashion to be described presently, lead from the mean longitude $\bar{\lambda}$ of the planet to its true longitude λ.

The basic parameters for both inequalities are expressed in the text as circumferences of the epicycles, c_m and c_s respectively, measured in units of which the circumference c of the deferent of radius R contains 360.[1]) Since

$$\frac{r_m}{R} = \frac{c_m}{360} \qquad \frac{r_s}{R} = \frac{c_s}{360} \tag{3}$$

and since we have in the Pañcasiddhāntikā the norm $R = 120$, it follows from (3) that

$$r_m = \frac{c_m}{3} \qquad r_s = \frac{c_s}{3}; \tag{4}$$

for the norm $R = 60$ adopted in Greek astronomy, however, one has

$$e = \frac{c_m}{6} \qquad r = \frac{c_s}{6}. \tag{5}$$

Table 22 shows the specific values (following the ārdharātrika system) for the individual planets.[2]) All longitudes λ_A of the apogees are sidereally fixed. It should be noted that the manda-parameters of Venus are the same as the solar parameters, taken from IX,7–8 (above p. 69 f.). This means, expressed in modern terms, that the solar orbit can serve as deferent for Venus.

TABLE 22.

	manda				śīghra			asc. node
	c_m	r_m	e	λ_A	c_s	r_s	r	λ_n
Saturn	60	20; 0	10; 0	240°	40	13;20	6;40	100°
Jupiter	32	10;40	5;20	160	72	24	12	80
Mars	70	23;20	11;40	110	234	78	39	40
Venus	14	4;40	2;20	80	260	86;40	43;20	60
Mercury	28	9;20	4;40	220	132	44	22	20
Sun	14	4;40	2;20	80				

[1]) These units are, of course, not "degrees" since every circle, independent of size, contains 360°. Here, however, we are dealing with arc-lengths measured in units of length $\frac{\pi}{180}R$ such that the circumference of a circle of radius smaller than R contains less than 360 units.

[2]) For the Sun cf. IX,7–8 (above p. 69 f.).

XVI,15–22. These verses give the rules for finding the true longitude λ of a planet from its mean longitude $\bar{\lambda}$, the latter assumed to be known, together with the mean longitude $\bar{\lambda}_0$ of the Sun and the parameters from Table 22.

The first step (XVI,15) consists in the determination of the equation σ caused by the epicyclic anomaly α (cf. Fig. 60). For an outer planet one has always

$$\alpha = \bar{\lambda}_0 - \bar{\lambda} \tag{1}$$

hence one can form with α as argument the trigonometric functions

$$\left.\begin{aligned} \text{bhuja (or bāhu)} &= \operatorname{Sin}\alpha = R\sin\alpha \\ \text{koṭi} &= \operatorname{Cos}\alpha = R\cos\alpha \end{aligned}\right\} \tag{2}$$

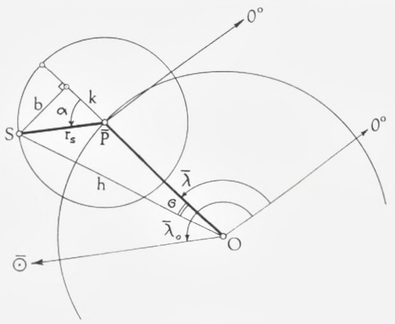

Fig. 60.

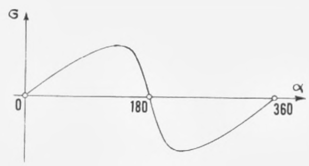

Fig. 61.

R being the radius of the deferent. Making use of the relation (1) of the preceding section one obtains (XVI,16)

$$\left.\begin{aligned} b &= \text{bhujaphala} = \frac{c_s}{360}\operatorname{Sin}\alpha = r_s\sin\alpha \\ k &= \text{koṭiphala} = \frac{c_s}{360}\operatorname{Cos}\alpha = r_s\cos\alpha \end{aligned}\right\} \tag{3}$$

(cf. Fig. 60).[1]) Computing the "(śīghra-) hypotenuse"

$$OS = h = \sqrt{(R+r_s\cos\alpha)^2+(r_s\sin\alpha)^2} \tag{4}$$

one finds (XVI,17)

$$\operatorname{Sin}\sigma = R\cdot\frac{b}{h}. \tag{5}$$

This gives the "śīghra-correction" σ; it is positive for $0 < \alpha < 180°$ and negative in the remaining semicircle. Fig. 61 shows the general type of the function $\sigma(\alpha)$.

[1]) The rules of signs in XVI,16 follow a terminology according to which "Aries 0°" means $\alpha = 0$. Consequently $k \geqq 0$ for the arc "Capricorn 0° to Gemini 30°" and similarly for $k \leqq 0$. Our notation $k = r_s \cos\alpha$ automatically takes care of these rules.

The next steps consist in a modification of the direction of the apsidal line, first under the influence of the śīghra correction, then by a manda correction (cf. Fig. 62).

The first displacement moves the apogee from A to A_1, and correspondingly the endpoint M of the manda-radius to M_1, by the amount of the angle $\frac{\sigma}{2}$ where σ is the śīghra correction found in (5). Having thus formed the "corrected longitude of the apogee" (XVI,18)

$$m_1 = m \mp \tfrac{1}{2}\sigma \tag{6}$$

one computes

$$\varkappa_1 = \bar{\lambda} - m_1 \tag{7}$$

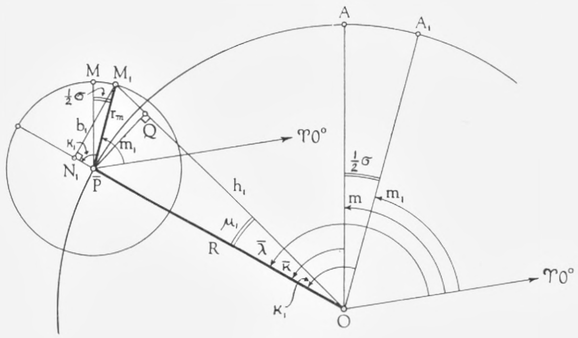

Fig. 62.

i.e., the angle made by the radius $r_m = M_1\bar{P}$ with the direction $O\bar{P}$. From k_1 one obtains, as in (3), the perpendicular $b_1 = M_1N_1$ from

$$\frac{c_m}{360}\,\mathrm{Sin}\,\varkappa_1 = r_m \sin\varkappa_1 = b_1 \tag{8}$$

which is seen from O under the angle μ_1.

In order to determine this angle μ_1 the same type of approximation is used as in IX,7–8 (above p. 69 f.) that is to say it is assumed (cf. Fig. 62) that

$$M_1N_1 = b_1 \approx \bar{P}Q = R\sin\mu_1$$

or

$$\mathrm{Sin}\,\mu_1 = b_1. \tag{9}$$

This manda correction is now used to correct once more the apsidal line by moving A_1 to A_2 (hence M_1 to M_2) by the angle $\frac{1}{2}\mu_1$ (cf. Fig. 63). Thus one forms

$$m_2 = m_1 \pm \mu_1 \tag{10}$$

and find from it (XVI,19)

$$\varkappa_2 = \bar{\lambda} - m_2. \tag{11}$$

Hence one can find the perpendicular $b_2 = M_2N_2$ from

$$\frac{c_m}{360} \operatorname{Sin} \varkappa_2 = r_m \sin \varkappa_2 = b_2 \tag{12}$$

to which corresponds a manda correction μ_2, again determined from

$$\operatorname{Sin} \mu_2 \approx b_2. \tag{13}$$

This correction μ_2 is now used to change the position of the center of the śīghra epicycle from the original mean position $\bar{P}$ to a point $\bar{P}_1$ of longitude $\bar{\lambda}_1$ such that (XVI,19)

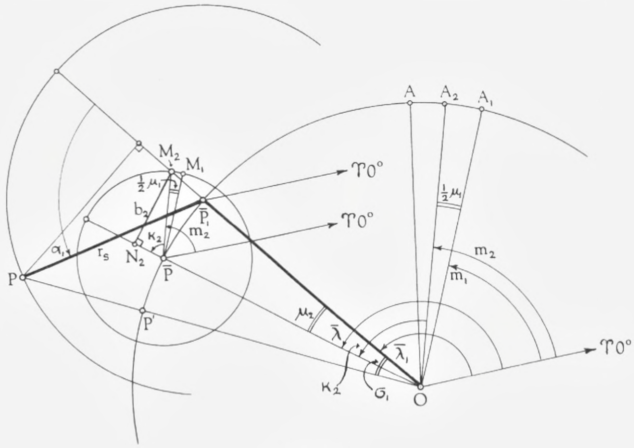

Fig. 63.

$$\bar{\lambda}_1 = \bar{\lambda} \mp \mu_2. \tag{14}$$

With $\bar{P}_1$ as center one finds the śīghra correction σ_1 (of course by the same process as before σ from (1) to (5)) for the anomaly (XVI,20)

$$\alpha_1 = \bar{\lambda}_0 - \bar{\lambda}_1. \tag{15}$$

The resulting śīghra correction σ_1 then defines the true longitude of the planet from

$$\lambda = \bar{\lambda}_1 \pm \sigma_1 \tag{16}$$

which is in Fig. 63 the longitude of the point P′ on the deferent. This completes the computation of the true position of an outer planet.

For Venus and Mercury (XVI,21) the equation of center of the Sun is still to be taken into consideration. Let λ_{A0} be the (sidereally fixed) longitude of the solar apogee, c_0 the circumference of the manda epicycle of the Sun of radius r_0 (which is the equivalent of the solar eccentricity), $\bar{\lambda}_0$ the longitude of the mean Sun at the given moment and

$$\bar{\varkappa}_0 = \bar{\lambda}_0 - \lambda_{A0}. \tag{17}$$

Then

$$\frac{c_0}{360}\,\mathrm{Sin}\,\bar{\varkappa}_0 = r_0 \sin\bar{\varkappa}_0 \tag{18}$$

leads as before (e.g. (3) to (5)) to the manda correction μ_0 of the Sun. It gives us the amount by which the true Sun differs in longitude from the mean Sun; by the same amount the whole epicycle of an inner planet must be displaced with respect to the

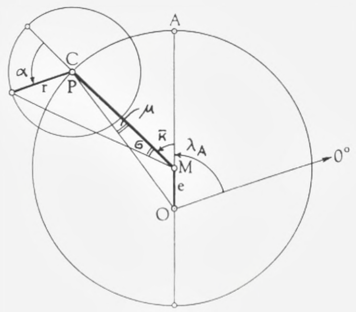

Fig. 64.

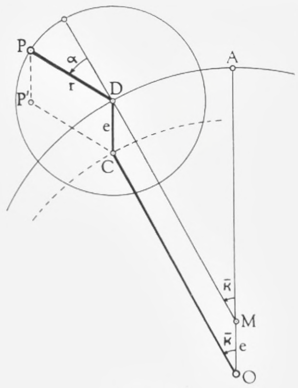

Fig. 65.

corrected mean position $\bar{\lambda}_1$ obtained in (14). Thus μ_0 has to be added to the value λ given by (16).

This solar correction μ_0 appears to be unique to the Pañcasiddhāntikā.[1]) An additional correction of $-1;7^\circ$ is prescribed in XVI,22 for the longitude of Venus. This is probably an empirical correction, perhaps introduced by Varāhamihira.

With (16) we have finally the following rules for the determination of the true longitudes of the inner planets:

$$\left.\begin{aligned} \lambda &= \bar{\lambda}_1 + \sigma_1 + \mu_0 - 1;7^\circ && \text{for Venus} \\ \lambda &= \bar{\lambda}_1 + \sigma_1 + \mu_0 && \text{for Mercury.} \end{aligned}\right\} \tag{19}$$

We now can turn to the problem of motivating the peculiar way in which the two equations, σ depending on α and μ depending on $\bar{\varkappa}$ (cf. Fig. 64), are combined in the rules from (6) to (16). Obviously the core of the difficulty of computing planetary positions lies in the fact that two inequalities are superimposed and that all combinations of the two effects are in principle possible. In other words we are dealing actually for a function of two independent variables which one tries to control, for

[1]) An attempt to correct for solar equation was made in Khaṇḍakhādyaka IX,9.

practical reasons, through a combination of values depending on each variable separately.

In order to explain the astronomical meaning of the compromise adopted by out text we replace the effect of the manda-epicycle by the equivalent eccentricity of the deferent and change our notation accordingly. Thus r_m becomes the eccentricity e of the deferent (cf. Fig. 64 and Fig. 65), while r_s is placed by r, the radius of the epicycle which carries the planet P. Without the effect of the eccentricity the mean planet would be at C and the true planet at P′ when subject to the anomaly α alone.

To combine the two displacements, one in the fixed direction CD in the amount e, the other CP′ depending on α, we assume that both are small in comparison to the

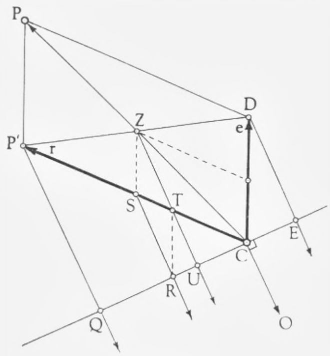

Fig. 66.

radius R of the deferent, such that the arc EQ of the deferent (cf. Fig. 66) may be considered a straight line, of course perpendicular to the direction OC. Under this assumption the observer at O would ascribe to the planet the longitude of Q when affected only by the śīghra correction $\sigma(\alpha) = $ CQ. Conversely the eccentricity e would move the center of the epicycle from C (which is at a distance $\bar{\varkappa}$ from the apogee of the deferent) to D, i.e., to the longitude of the point E. Hence CE is the manda correction $\mu(\bar{\varkappa})$.

According to the rules of the text neither $\sigma(\alpha)$ nor $\mu(\bar{\varkappa})$ are used directly. The point with the distance $\varkappa_1$ from the apogee, where

$$\varkappa_1 = \bar{\lambda} - m_1 = \bar{\varkappa} + \tfrac{1}{2}\sigma$$

(according to (6) and (7)) is represented by the midpoint R of CQ (cf. Fig. 66). The manda equation μ_1 which belongs to the point R would be obtained by projecting onto the deferent a vector from R parallel to CD and of length $e = $ CD. Formula (10), however, shows that only $\frac{1}{2}\mu$, is used, i.e., the projection RU of RT $= \frac{1}{2}e$. The parallelograms drawn in Fig. 66 show that T is a point of CP′ and that U also can be obtained by projecting the midpoint Z of the parallelogram PP′CD onto the deferent. Thus the use of $\frac{1}{2}\sigma$ and $\frac{1}{2}\mu_1$ is shown to be the equivalent of introducing the midpoint of the resultant displacement of both inequalities, represented on the deferent by the point U.

One now considers U as the point for which the manda correction μ_2 should be obtained, then applied to C according to (14). This, in turn, results in some change in the epicyclic anomaly according to (15) and hence to a new śīghra correction σ_1, to be used as the final correction in (16).

The statement made above that U is the representative of the midpoint Z of the resultant inequality is no longer exact when QE is curved. Nevertheless the general idea remains valid that a point near the point Z on the resultant may produce a better correction than a correction provided by either D or P′ alone.

XVI,22. In the Paitāmahasiddhānta of the Viṣṇudharmottarapurāṇa IV,15 one finds the following rule which can explain what Varāhamihira had in mind:

"One should divide the difference between the corrected argument for the final śīghra operation and the argument for the first station by the difference of the (planet's) true velocity and the true velocity of the śīghra; the result is the time, in days and their parts, of the first station."

The idea underlying this rule can be summarized as follows. From III,31 in the same text is known the anomaly α_0 at which the first station should occur (and, symmetrically to 180°, the second station). Let α be the true anomaly found by computation for a moment t not too far ahead of the time for which the station may be expected. Hence $\alpha_0 - \alpha$ is the arc still to be travelled by the planet. Its velocity v on the epicycle is the difference between the velocity of the śīghra s and the mean velocity of the planet. The quotient $(\alpha_0 - \alpha)/v$ gives the time between t and the moment when the planet becomes stationary.

XVI,23. The following angular differences between Sun and planet are required for visibility:

Moon 12°	Jupiter 11°
Mars 17	Venus 9
Mercury 13	Saturn 15.

The same numbers are found in the Paitāmahasiddhānta of the Viṣṇudharmottarapurāṇa (III,9) and, e.g., in the Laghubhāskarīya (VII,1–2). In the latter text the degrees are transformed into vināḍikās by multiplication with 10, a procedure which shows that we are dealing with equatorial degrees, i.e., with arcs of oblique ascensions.

Similar, but slightly different data are given in XVII,58, excepting those for the Moon and Saturn that are unchanged.

XVI,24–25. These verses deal with the computation of the latitudes of the planets, but we do not understand how the given rules can lead to reasonable results. Latitudes should depend on three elements: the inclination of the planet's orbit (i.e. inclination of deferent and epicycle with respect to the ecliptic), the location of the nodes, and the distance of the planet from the earth (i.e., essentially, on the anomaly α). The last element is taken care of by the rule in XVI,25 to multiply a preliminary result by R/h where h is the corrected śīghra hypotenuse, i.e. the distance of the planet from the observer corrected for both inequalities (in first approximation shown by OS in Fig. 60 p. 103).

The two first mentioned effects should somehow appear in the rules which seem to involve the two planetary inequalities but the details remain obscure. The pairs of coefficients

Saturn	9/8	9/8
Jupiter	9/8	3/4
Mars	3/4	3/4
Venus	9/8	3/4
Mercury	3/4	9/8

could perhaps suggest a tilting of the epicycles about two orthogonal diameters but the restriction to only two numerical values, 3/4 = 0;45 and 9/8 = 1;7,30, makes any coordination with the individual conditions still more difficult to understand.

Chapter XVII

XVII,1–60. These sixty verses of the last chapter of the Pañcasiddhāntikā form a unit, clearly distinct from the preceding chapters. We find here a theory of the planetary motions and of the planetary phases in a form which is directly related to Babylonian methods, in marked contrast to the geometric models in the classical Greek fashion as found, e.g., in chapter XVI.

In the present text the planets are discussed one by one in the order

Venus Jupiter Saturn Mars Mercury.

This arrangement is very unusual since it differs from the ordinary sequence in Indian astronomy (e.g. in XVII,65–80)

Mars Mercury Jupiter Venus Saturn

which is the sequence of the days of the week and thus ultimately based on the Hellenistic order

Saturn Jupiter Mars Venus Mercury.

It also differs from the Babylonian order

Jupiter Venus Mercury Saturn Mars.

Astrologically it groups together the benefic planets (Venus and Jupiter) and the malefic (Saturn and Mars), leaving the neutral Mercury for last; but this may be a completely fortuitous circumstance.

In order to avoid repetitions we shall not follow in our discussion the text verse by verse. First we will combine all data about the synodic periods from which the mean motions are derived. Then we will take up, planet by planet (from Saturn to Mercury), problems concerning the planetary phases, their distribution and natural order. Finally epoch constants and visibility conditions will be treated, again in separate sections.

1. Synodic Periods

As "synodic period" or "synodic time" one denotes the time interval between one heliacal rising of a planet and the next, or, in general, from one phase to the next of the same kind. If one wants to establish the date of a certain phase one must know the number of synodic periods elapsed since the given epoch. The following procedure is designed to furnish this information.

Let a be the given ahargaṇa and a_0 a positive or negative correction of a which leads from the epoch date to the nearest phase—for which we use ordinarily the first visibility after conjunction (for an inner planet: after inferior conjunction) and which we denote by Γ. We wish to know the number s of synodic periods of a given length $\bar{p}$ contained in

$$a' = a + a_0 \tag{1}$$

days. In our text the obvious answer

$$\bar{s} = a'/\bar{p} \tag{2}$$

is not reached directly but only as a result of modifications of approximate values p and s where

$$s = a'/p. \tag{3}$$

If ζ is a correction which changes the approximate period p to the accurate period $\bar{p}$ by

$$p + \zeta = \bar{p} \tag{4}$$

one has

$$\bar{s} = \frac{a'}{\bar{p}} = \frac{a'}{p+\zeta} = \frac{s}{1+\zeta/p} \approx s\left(1 - \frac{\zeta}{p}\right) = \frac{a' - \zeta s}{p}. \tag{5}$$

Table 23 shows the values taken from the text for a_0, p, and ζ.

Let us assume that a certain phase (e.g. Γ) occurs at a point of longitude λ. The next occurrences will take place at about $\lambda + \overline{\Delta\lambda}$, $\lambda + 2\overline{\Delta\lambda}$, etc., where $\overline{\Delta\lambda}$ represents the "mean synodic arc". As the planet traverses the ecliptic the phases will be more or less equidistantly spaced, but one sidereal rotation will not result in an occurrence of the phase in question at the starting point λ. In general it will take Z rotations (or $Z + \Pi$ rotations for Venus and Mars) before an accurate return of the phases to the same longitudes takes place, i.e., only after Π occurrences during Z (or $Z + \Pi$) revo-

TABLE 23.

	a_0	p	ζ	$\bar{p}$	ch. XVII
♄	$-150\frac{1}{3}^d$	378 = 6,18^d	+1/10	6,18; 6^d	14–15
♃	– 34;34	399 = 6,39	–1/9	6,38;53,20	6– 7
♂	–216;40	780 = 13, 0	–0;2,41	12,59;57,19	21–22
♀	–147	584 = 9,44	–1/11	9,43;54,32...	1– 2
☿	+28;20	927/8 = 1,55;52,30	+0; 0,15	1,55;52,45	36–37

lutions the phases will be periodically repeated. Since neither a planet nor the Sun move with constant angular velocity the "true synodic arcs" will more or less differ from the mean $\overline{\Delta\lambda}$. Nevertheless Π occurrences will result in a periodic repetition of all phases since the apsidal lines can be considered fixed for comparatively long intervals of time.

For an outer planet the sum of Π and of the corresponding number Z of sidereal revolutions of the planet gives the length of the basic period expressed in years; for an inner planet the number of sidereal rotations itself represents the number of years. Specifically one has the following relations:

$$\begin{array}{l} \text{Saturn, Jupiter} \\ \quad\text{Mars} \\ \quad\text{Venus} \\ \quad\text{Mercury} \end{array} \qquad \Pi \text{ occur.} = \left\{ \begin{array}{l} Z \text{ sid. rot.} = (\Pi+Z) \text{ sid. years} \\ (\Pi+Z) \text{ sid. rot.} = (2\Pi+Z) \text{ sid. years} \\ (\Pi+Z) \text{ sid. rot.} = (\Pi+Z) \text{ sid. years} \\ Z \text{ sid. rot.} = Z \text{ sid. years} \end{array} \right\} \tag{6}$$

The quotient

$$P = \Pi/Z \tag{7}$$

indicates the number of synodic intervals which correspond in the mean to one sidereal revolution of the planet. Consequently

$$\overline{\Delta\lambda} = \frac{360^\circ}{P} = \frac{360^\circ \cdot Z}{\Pi} \tag{8}$$

gives the length of the mean synodic arc. In general P is, of course, not an integer.

Furthermore: if one divides the number $\bar{s}$ of synodic intervals contained in the given ahargaṇa a', found in (5), by the number P

$$\frac{\bar{s}}{P} = N \tag{9}$$

then the result N tells us how many revolutions of the planetary phase under consideration (e.g., Γ) took place during a' days. Therefore the integer part of N can be ignored while the remainder gives the fraction of a revolution gained in longitude over the position at a_0. Hence (9) allows us to determine the mean longitude of the planet at the given moment.

TABLE 24.

	Babylonian			Pañcasiddhāntikā			
	Π	Z	$\overline{\Delta\lambda}$	P = Π/Z	$\overline{\Delta\lambda}$	ch. XVII	
♄	4,16	9	≈12;39°	256/ 9 = 4,16/ 9 = 28;26,40		15	♄
♃	6,31	36	≈33; 9	391/36 = 6,31/36 = 10;51,40		7 – 8	♃
♂	2,13	18	≈48;43	133/18 = 2,13/18 = 7;23,20		22 – 24	♂
♀	12, 0	7,11	3,35;30		3,35;50°	1	♀
☿	11,24	3,37	≈1,54;13	684/217 = 11,24/3,37 = 3;9,7,32,...		37 – 38	☿

The parameters (7) and (8) are at the foundation of Babylonian planetary theory. The close resemblance of the data recorded in XVII,1–60 to Babylonian procedures suggests a comparison with the above mentioned basic parameters. Table 24 reveals exact numerical agreement for the outer planets and Mercury.[1]) For Venus one finds a minor deviation but this is not to be taken too seriously since our knowledge of Babylonian data is particularly incomplete for this planet.

2. Patterns of Distribution for the Phases on the Ecliptic

If consecutive occurrences of a given phase were always spaced at a distance $\overline{\Delta\lambda}$ from each other the Π points on the ecliptic where our phase occurs would be also equidistantly arranged at a distance of

$$360°/\Pi = 360°/PZ = \overline{\Delta\lambda}/Z.$$

In fact, however, the length of the synodic arcs is greater in some sections of the ecliptic and therefore smaller in others, due to the anomaly of Sun and planet and other causes, such that the density of the Π points at which a certain phase will be observed depends on the region of the ecliptic.

To take care of this empirical fact Babylonian astronomy has invented several devices among which "System A" is of interest in the present context. The ecliptic is divided in a number of sections (from two to six are attested), generally of unequal length; within each of these sections the phases are equidistantly spaced, in some sections narrower, in others wider, than the mean distance $\overline{\Delta\lambda}/Z$. It is exactly this idea which we find applied in the present chapter.

Saturn (**XVII,16–19**)

The ecliptic is divided into three sections

(1)	length: $\alpha_1 =$ 45;51°	containing	30 occurrences
(2)	$\alpha_2 =$ 177;34		127
(3)	$\alpha_3 =$ 136;35		99
Total	360;0		Π = 256

[1]) For the Babylonian parameters cf. ACT II p. 283.

We are not told, however, where these three arcs should be located on the ecliptic.

The lengths of these three sections α_1, α_2, α_3, are only little different from the mean lengths $\overline{\alpha}_1$, $\overline{\alpha}_2$, $\overline{\alpha}_3$, which one obtains from the mean distance

$$360°/\Pi = 6{,}0°/4{,}16 = 1;24{,}22{,}30°$$

by multiplication with the number of occurrences each arc contains. In this way one finds

$$\overline{\alpha}_1 = 42;11{,}15° = \alpha_1 - 3;39{,}45°$$
$$\overline{\alpha}_2 = 178;35{,}37{,}30 = \alpha_2 + 1;1{,}37{,}30$$
$$\overline{\alpha}_3 = 139;13{,}7{,}30 = \alpha_3 + 2;38{,}7{,}30.$$

This shows that the "true" distribution of the phases is only insignificantly different from the "mean" distribution and it is difficult to see why at all one should have introduced separate zones for such minute deviations.

Jupiter **(XVII,9–11)**

The ecliptic is divided into three sections

(1) length:	$\alpha_1 = 159;30°$	containing	180 occurrences
(2)	$\alpha_2 = 180;0$		195
(3)	$\alpha_3 = 20;30$		16
Total	360;0		$\Pi = 391$

The location of these sections on the ecliptic is not specified.

The length of the mean distance on the ecliptic between phases of the same kind is given by

$$360°/\Pi = 6{,}0°/6{,}31 \approx 0;55{,}14{,}34{,}40{,}49,\ldots°$$

Multiplication of this arc by the above given number of events gives mean arcs which are hardly different from the given arcs:

$$\overline{\alpha}_1 = 165;43{,}44,\ldots° = \alpha_1 + 6;13{,}44,\ldots°$$
$$\overline{\alpha}_2 = 179;32{,}22,\ldots = \alpha_2 - 0;27{,}37,\ldots$$
$$\overline{\alpha}_3 = 14;43{,}53,\ldots = \alpha_3 - 5;46{,}7,\ldots$$

As in the case of Saturn the true density of the occurrences is only little different from the mean one.

Mars

For a sixfold division of the ecliptic cf. below p. 119.

Venus (**XVII,1–2**)

The uniformity in the motion of Venus makes it unnecessary to introduce a sectioning of the ecliptic, a conclusion also known from Babylonian astronomy.

In XVII,1 the mean synodic arc is given as

$$\overline{\Delta\lambda} = 215;50^\circ$$

(cf. Table 24), the mean synodic time as

$$\overline{\Delta t} = 583;54,32,\ldots^{d}$$

(cf. Table 23), i.e. about 593;11,... tithis. The corresponding Babylonian parameters are $\overline{\Delta\lambda} = 215;30^\circ$ and $\overline{\Delta\tau} = 593;10^\tau$ respectively. Exactly the Babylonian value $\overline{\Delta\lambda} = 215;30^\circ$ is also attested in our present text (XVII,75; cf. Table 33, below p. 126).

For the subdivision of the synodic arc cf. below p. 120 f.

Mercury (**XVII,38–40**)

For this planet we find here an eightfold division of the ecliptic. The individual arcs are

$$\begin{array}{llll} \alpha_1 = & 8^\circ & \alpha_5 = & 12^\circ \\ \alpha_2 = & 30 & \alpha_6 = & 30 \\ \alpha_3 = & 60 & \alpha_7 = & 97 \\ \alpha_4 = & 100 & \alpha_8 = & 23, \end{array}$$

correctly totalling 360°.

Associated with these segments are eight numbers as follows:

$$\begin{array}{llll} n_1 = & 7 & n_5 = & 14 \\ n_2 = & 30 & n_6 = & 33 \\ n_3 = & 81 & n_7 = & 104 \\ n_4 = & 88 & n_8 = & 31. \end{array}$$

One would expect these numbers to represent occurrences of a certain phase, presumably Ξ, within each segment, the total being Π. In fact, however, the total 388 = 6,28 is not attested as a number Π (and the corresponding $Z = \Pi/P$ with $P \approx 3;9,7$ would not be an integer) but as the number Z of years which contain Π = 20,23 occurrences.[1])

The fact that the numbers n_i do not represent occurrences but their number divided by P may have to do with the determination of true and mean longitudes of the phases described in the next section. The text calls the numbers n_i "days" which is in any case meaningless.

The mean distance between occurrences is given by $6,0^\circ/\Pi$ ($\approx 0;17,39,\ldots$). An arc of length α_i should therefore contain in the mean $m_i = \alpha_i\Pi/6,0$ occurrences. If the n_i whose total is $Z = \Pi/P$ would correspond to a mean density their number

[1]) Cf. ACT II, p. 283.

on α_i should be $\bar{n}_i = \alpha_i Z/6,0$, hence $m_i/\bar{n}_i = \Pi/Z = P$. In fact the quotients $p_i = m_i/n_i$ are not constant. One finds

$p_1 = 3;52,57,\ldots$	$p_5 = 2;54,42,\ldots$
$p_2 = 3;23,50$	$p_6 = 3;5,18,\ldots$
$p_3 = 2;30,59,\ldots$	$p_7 = 3;10,6,\ldots$
$p_4 = 3;51,40$	$p_8 = 2;31,13,\ldots$

But the variation from the mean value $P \approx 3;9,7$ are not very great, a fact reminiscent of the experience with Saturn and Jupiter.

3. Mean and True Positions

For Venus no distinction seems to be made between mean and true positions (cf. above p. 114). For the other planets the number N of its "risings" is to be multiplied by a certain number Z and the product divided by another number Π. These numbers Z and Π are the well known Babylonian parameters which determine the ratio $P = \Pi/Z$ (cf. above p. 111 and Table 24) that counts the number of mean synodic arcs (and their fractions) which cover exactly 360° in longitude. Hence we can give the above rule the form: the number of risings should be divided by P.

It is not difficult to find the reason for this operation. Let N be the number of "risings" i.e. the number of occurrences of the phase Γ of a planet since a first Γ after epoch. Suppose N is an integer multiple of P. Then we know that N synodic arcs cover an integer multiple of 360°; hence the first and the last rising have the same longitude. Consequently it is only the remainder in the quotient N/P which is of interest and which tells us which fraction $n < 1$ of P synodic arcs goes beyond the longitude of the first rising. The corresponding gain in mean longitude will be $nP\overline{\Delta\lambda}$.

The longitudinal progress will be greater than this amount in case the true synodic arcs $\Delta\lambda$ are greater than $\overline{\Delta\lambda}$, smaller for $\Delta\lambda < \overline{\Delta\lambda}$. This seems to be the meaning of the statements found in XVII,8, XVII,24, and XVII,41. That the correction is applied to "days" instead of to longitudes is a common mistake in this chapter (cf. p. 126 and p. 128). The transformation to corresponding time intervals would not be difficult since the mean synodic times are known ($\bar{p}$ in Table 23 p. 111). The information concerning the true synodic arcs would have to come from the schemes for the distribution of the occurrences of the phases in different sections of the ecliptic (cf. above p. 112).

So far the principle of the procedure seems clear. There are, however, additional steps mentioned in the text which we cannot properly explain.

Saturn (XVII,15–17) *and Jupiter* (XVII,7,9–10)

For both planets additive constants, +89 (in XVII,15) and +18 (in XVII,7) respectively, are mentioned which seem to be epoch constants. Their discussion is therefore postponed to a later section (p. 123–125).

Other positive and negative corrections are related to the remainders n (called "padas") of the quotients N/P. These corrections are

for Saturn	in	(1) 30 padas	$+2416' = +40;16°$	
(XVII,16–17)		(2) 127	$-2519' = -41;59°$	
		(3) 99	$+2037' = +33;57°$	
		total: $\Pi = 256$		

and similarly

for Jupiter	in	(1) 180 padas	$-1456' = -24;16°$
(XVII,9–10)		(2) 195	$+1265' = +21;5°$
		(3) 16	$-1391' = -24;46°$
		total: $\Pi = 391$.	

If one takes the number of padas in which positive corrections are prescribed and compares it with the number of padas of opposite sign one finds

for Saturn: 129 positive, 127 negative
for Jupiter: 195 positive, 196 negative.

In the case of Jupiter 195 and 196 are the integers nearest to $\frac{1}{2}\Pi$.
In the case of Saturn one has $\frac{1}{2}\Pi \pm 1$ instead of simply $\frac{1}{2}\Pi = 128$.

The reason for this arrangement we do not know. On the values of the corrections it seems without influence.

The above given corrections are not final, either for Saturn or for Jupiter. For Saturn XVII,17 prescribes "a subtraction or addition" of 12;12° which perhaps should be applied as follows:

in (1) $+40;16° - 12;12° = +28;4°$
(2) $-41;59 + 12;12 = -29;47$
(3) $+33;57 - 12;12 = +21;45$.

Finally all numbers (i.e. 28;4 etc.) should be multiplied by a factor $31/32 = 0;58,7,30$.

For Jupiter no further corrections are prescribed save a reduction (in XVII,10) of all numbers by $5/8 = 0;37,40$. We have no explanation to offer for any of these numbers. Also the concluding remark that Jupiter "rises in the east (Γ) in so many minutes (of arc)" makes no sense to us.

Mercury **(XVII,36–37)**

Between the operations which fit the pattern of Table 23 and 24 we find in XVII,36 a subtraction of 1/8 of a day and a division of the number of risings by 4. We cannot explain these steps which seem in excess of the normal procedure.

4. Subdivision of the Synodic Arc

We denote the planetary phases by Greek letters. For an outer planet we have the following sequence:

Γ heliacal rising
Φ first station
Θ opposition
Ψ second station
Ω acronychal setting.

From Ω to Γ the planet is invisible. The longitudinal progress from one Γ to the next is the "synodic arc", the time elapsed during this motion is the "synodic time". In principle the same applies to the motion from Ω to Ω or to any other phase but the corresponding intervals need not to be the same for all phases. Only for the mean synodic arc $\overline{\Delta\lambda}$ could any pair of Greek letters be used.

For an inner planet we define

Γ	morning rising	morning star
Φ	first station	
Σ	morning setting	
		invisible at superior conjunction
Ξ	evening rising	evening star
Ψ	second station	
Ω	evening setting	
		invisible at inferior conjunction
Γ	morning rising	

In the preceding sections we collected the information concerning (a) the mean values obtainable from the periodicity of the phases and (b) the variations in density of a given phase (Γ) on the ecliptic within the total of Π occurrences. In both cases one is dealing only with one specific phase, independent of its relation to the other phases. What remains are data which describe the sequence of all phases within one synodic arc (e.g. from Γ to Γ), both with respect to motion in longitude and to time intervals. Since no mention is made of differences in length of the synodic arcs depending on different sections of the ecliptic the total of intervals between consecutive phases should be the mean value of the synodic arc and the synodic time. Such a pattern will be fairly close to the actually observable intervals and discrepancies can be absorbed by the stretch of invisibility from Ω to Γ. Consequently such a scheme is not meant to be extended beyond one synodic period, or rather it begins with Γ and ends at Ω.

Larger intervals between consecutive phases (e.g., between Γ and Φ) are sometimes subdivided into shorter sections. We denote the dividing points—which do not correspond to real planetary phases—by Greek letters with accents.

The striking parallelism with Babylonian data established in the preceding sections extends also into the present problems. Without going into greater detail we shall therefore add to the Indian analysis of the sequence of the planetary phases also a description of similar schemes found in Babylonian sources. That such a comparison is at all fruitful in spite of the only fragmentary character of our knowledge of Babylonian astronomy demonstrates how intimate the relation of early Indian astronomy and its Babylonian predecessor must have been.

Saturn **(XVII,19–20)**

Table 25 shows the given data. For the Babylonian theory we have only a pattern with two velocity zones[1]) which divide the direct motion in a different fashion. Hence we have here no means for a closer comparison.

TABLE 25.

Saturn	ch. XVII,19–20		Babylonian	
$\Gamma \to \Gamma'$	16^d	1;20°		
$\Gamma' \to \Phi$	56	3;52		
$\Phi \to \Theta$	55	−3	$52;30^d$	} −8° or −6;40°
$\Theta \to \Psi$	60	−4	60	
$\Psi \to \Omega'$	112	8		
$\Omega' \to \Omega$	36	3		
$\Gamma \to \Omega$	335^d	9;12°		

Since XVII,14–15 give for the mean synodic time $\bar{p} \approx 378^d$ (cf. Table 23 p. 111) one may estimate the time of invisibility $\Omega \to \Gamma$ as about 43^d with about 3;30° of direct motion since the mean synodic arc should be about 12;40° (cf. Table 24 p. 112).

Jupiter **(XVII,12–13)**

For this planet one finds (cf. Table 26) good agreement with the previously determined parameters (cf. Table 23 p. 111): $\bar{p} = 398;53,20^d \approx 399^d$ and $\overline{\Delta\lambda} = 33;9° \approx 34°$ (cf. Table 24). A corresponding Babylonian pattern is also shown in Table 26.

TABLE 26.

Jupiter	ch. XVII,12–13		Babylonian		
$\Gamma \to \Gamma'$	60^d	12°	$\Gamma \to \Gamma'$	30^d	7; 2°
$\Gamma' \to \Gamma''$.....	40	4	Γ'		
$\Gamma'' \to \Phi$	24	2	Φ	90	11;15
$\Phi \to \Theta$	56	−6	Φ		
$\Theta \to \Psi$	60	−6	Ψ	120	−9;23
$\Psi \to \Omega'$	80	12	$\Psi \to \Omega'$	90	10;47
$\Omega' \to \Omega$	50	9	$\Omega' \to \Omega$	30	7; 2
$\Omega \to \Gamma$	29	7	$[\Omega \to \Gamma]$	[30]	7; 2
$\Gamma \to \Gamma$	399^d	34°	$\Gamma \to \Gamma$	390^d	33;45°

[1]) Cf. ACT II p. 315.

Mars **(XVII,25–35)**

These eleven verses are meant to give a description of the subdivision of the synodic arc of Mars into five sections (gatis), thrown into confusion by the insertion of a detailed description of the retrograde motion.

At the beginning (XVII,25–26) we have the following arcs between the consecutive phases (C denoting the conjunction with the Sun):

(I)	$\Gamma\to\Phi$	186°
(II)	$\Phi\to\Psi$	−18
(III)	$\Psi\to\Omega$	180
(IV)	$\Omega\to$C	30
(V)	C$\to\Gamma$	30
Total:	$\Gamma\to\Gamma$	408° ≡ 48° (mod. 360°).

A final synodic motion of 48° agrees well with the data found in XVII,22 (cf. Table 24). The text obviously considers as point of separation between gatis (II) and (III) the opposition Θ by describing it as "half of its course since conjunction" (XVII,25). This, however, must be a mistake since 18° can only be the total arc of retrogradation. Furthermore, by adding (V), (I), and (II) one finds 198° instead of 204° whereas $\Phi\to\Theta = -9°$ would lead to $C\to\Theta = 207°$.

The intrusion which concerns retrogradation consists of the verses XVII,29–33. Since this material is divided into three sections Varāhamihira (or his source) took this as representing 3 gatis; since XVII,27 and 28 deal with the gatis (I) $\Gamma\to\Phi$ and (II) $\Phi\to\Theta$ he counted XVII,34 as the 6th gati, concerning $\Psi\to\Omega$, the "fast gati" after retrogradation, while XVII,35 for $\Omega\to$C and C$\to\Gamma$ become gatis "7" and "8".

Excluding the foreign material XVII,29–33 we obtain the following pattern for the time intervals:

XVII,27:	(I)	$\Gamma\to\Phi$	267;30^d
XVII,28:	(II)	$\Phi\to\Psi$	between 51^d and 72^d
XVII,34:	(III)	$\Psi\to\Omega$	between 296^d and 314^d
XVII,35:	(IV)	$\Omega\to$C	between 60^d and 72^d
	(V)	C$\to\Gamma$	between 60^d and 72^d.

The total which may vary between 735^d and 798^d (mean value 767^d) agrees reasonably well with the mean synodic time of about 780^d. Table 27 shows the distribution of the intervals within the zodiacal signs. The pairing Pisces and Aries, Taurus and Gemini, etc., is a characteristic feature of the Babylonian theory of Mars[1]) and assures us of a Babylonian archetype of the present material.

We now turn to the verses XVII,29–33 which concern the retrogradations of Mars, again arranged for pairs of zodiacal signs. In order to bring some sense in these data we have to assume another mistake. For each pair of signs we find three arcs

[1]) Cf. ACT II p. 302–306.

Table 27.

Mars	♓ ♈	♉ ♊	♋ ♌	♍ ♎	♏ ♐	♑ ♒	XVII
I . . .	267;30^{d}						27
II . . .	57^{d}	71^{d}	72^{d}	66^{d}	61^{d}	51^{d}	28
III . . .	301 305	308 311	314 311	309 306	302 299	296	34
IV . . .	62	69	72	69	63	60	35
V . . .	62	69	72	69	63	60	
Total .	750 754	785 788	798 795	781 778	757 754	735	

and three corresponding time intervals. We assume that the first two concern $\Phi \to \Theta$ and $\Theta \to \Psi$ respectively (cf. Table 28) whereas the third belongs to an independent scheme for $\Phi \to \Psi$ (cf. Table 29), erroneously combined with the first two. This latter scheme not only forms a typical linear zigzag function for arcs as well as for days but the arcs agree exactly with the Babylonian "Scheme R" for the retrogradations of Mars.[1]) The data shown in Table 28 show the same pattern for the arcs $\Phi \to \Psi$. The time intervals, however, look rather garbled and we do not dare to offer any emendations.

What XVII,33 is intended to express escapes us, except for the final statement which seems to indicate that the second part of the retrograde arc, i.e., $\Theta \to \Psi$, should be 4/3 of the first part ($\Phi \to \Theta$). In the Babylonian theory the corresponding factor is 3/2.

Venus (XVII,3–5)

The only clear section concerns the direct motion of Venus as evening star from Ξ to Ψ with slowly decreasing velocity as one approaches the stationary point:

Table 28.

Mars	♑, ♒	♓, ♈ and ♏, ♐	♉, ♊ and ♍, ♎	♋, ♌
$\Phi \to \Theta$	$-$ 6° 32^{d}	$-$ 6° 42^{d}	$-$ 7° 40^{d}	$-$ 7° 44^{d}
$\Theta \to \Psi$	$-$ 9° 39^{d}	$-$10° 42^{d}	$-$10° 40^{d}	$-$11° 40^{d}
$\Phi \to \Psi$	$-$15° 71^{d}	$-$16° 84^{d}	$-$17° 80^{d}	$-$18° 84^{d}

Table 29.

Mars $\Phi \to \Psi$	♑, ♒	♓, ♈ and ♏, ♐	♉, ♊ and ♍, ♎	♋, ♌
XVII,29–32	$-$15° 57^{d}	$-$16° 60^{d}	$-$17° 63^{d}	$-$18° 66^{d}
Babyl. "R"	$-$15°	$-$16°	$-$17°	$-$18°

[1]) Cf. ACT II p. 305 f. and Fig. 58 a.

Ξ	60^d	$74°$
↓	60	73
	60	72
	27;30	20
Ψ	3	1;15

giving a total of 210;30^d and 240;15° in direct motion.

The retrograde motion near inferior conjunction is divided as follows:

Ψ	15^d	$-2°$
Ω	5	$-2(?)$
$\Omega \to \Gamma$	10	$-4(?)$
$\Gamma \to \Phi$	20	-4

i.e. lasting 50^d, perhaps with a total of 12° in retrograde motion.

One might assume that the direct motion as morning star (i.e. $\Phi \to \Sigma$) is of the same amount as the direct motion as evening star (i.e. $\Xi \to \Psi$). This would result in a total

$$\Xi \to \Sigma \qquad 471^d \qquad 468;30°.$$

According to Table 23 p. 111 the synodic period amounts to about 584^d with a longitudinal motion of 575;50° (cf. Table 24 p. 112). This would give for the period of invisibility at superior conjunction

$$[\Sigma \to \Xi] \qquad 113^d \qquad 107°.$$

This relation cannot be correct, however, since during this period the planet must move with more than solar velocity (cf. also the above given pattern for $\Xi \to \Psi$). This seems also to be expressed in the last sentence of XVII,5:

$$\Sigma \to \Xi \qquad 60^d \qquad 75°$$

which is exactly what one should expect. Consequently this would lead to

$$[\Phi \to \Sigma] \qquad 264;30^d \qquad 272;15°$$

or 54^d and 32° more than for $\Xi \to \Psi$, a rather implausible conclusion.[1]) At any event the description of the motion of Venus as given in our text seems incomplete.

Mercury **(XVII,42–56)**

We have here a group of verses which deal with four separate cases in a perfectly parallel fashion (cf. Table 30 and Figs. 67 and 68). In each case we are given for the single zodiacal signs from Aries to Pisces an amount T of days and an amount

[1]) We have an early Babylonian text (5th century B.C.) which assumes for $\Phi \to \Sigma$ a motion of about 248° in 227$^\tau$ in good agreement with $\Xi \to \Psi$ in the present text; cf. Neugebauer-Sachs [1967] p. 197 (cf. below p. 128).

TABLE 30.

☿	$\Xi \to \Omega$		$\Omega \to \Gamma$		$\Gamma \to \Sigma$		$\Sigma \to \Xi$		Totals		☿
	T	B	T	B	T	B	T	B	T	B	
♈	36d	35°	25d	22°	29d	21°	29d	54°	119d	88°	♈
♉	45	44	23	17	23	23	49	69	140	119	♉
♊	45	48	20	14	26	27	47	75	138	136	♊
♋	42	43	18	9	30	31	46	71	136	136	♋
♌	34	34	16	9	32	32	45	70	127	127	♌
♍	26	27	18	9	33	35	43	70	120	123	♍
♎	21	18	20	12	35	36	40	70	116	112	♎
♏	16	14	25	18	44	43	38	64	123	103	♏
♐	16	15	26	21	42	43	32	62	120	99	♐
♑	20	19	27	28	38	39	32	58	117	88	♑
♒	23	22	26	25	35	33	35	60	119	90	♒
♓	24	24	25	24	29	24	27	49	105	73	♓

B of degrees (which we call "pushes" in time and longitude respectively), leading from one phase to the next:

I: $\Xi \to \Omega$
II: $\Omega \to \Gamma$
III: $\Gamma \to \Sigma$
IV: $\Sigma \to \Xi$

The whole pattern has close relations to the Babylonian theory of Mercury[1]) which operates with similar "pushes", although in the texts known to us only for the

TABLE 31.

☿	$\Xi \to \Omega$		$\Gamma \to \Sigma$		☿
	T	B	T	B	
♈	36d	36°	14d	12°	♈
♉	42	42	16	14	♉
♊	48	46	19	18	♊
♋	44	42	24	22	♋
♌	38	36	27	26	♌
♍	22	22	30	30	♍
♎	15	14	36	34	♎
♏	15	14	46	44	♏
♐	16	16	46	44	♐
♑	22	20	44	42	♑
♒	24	22	34	34	♒
♓	24	22	24	24	♓

[1]) Cf. ACT II p. 293–295.

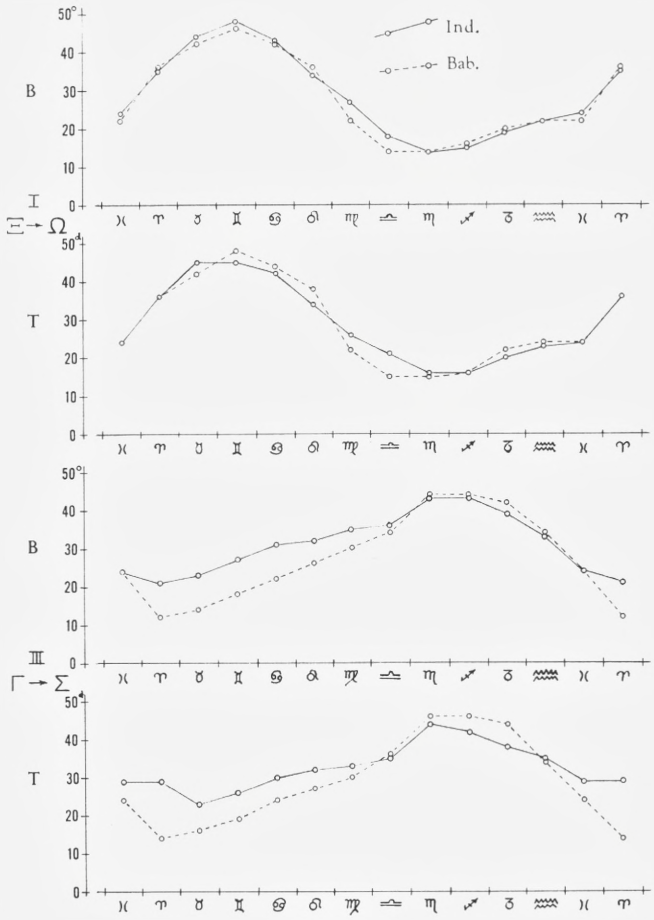

Fig. 67.

visible sections of the orbit, i.e., for $\Xi \rightarrow \Omega$ (here case I) and $\Gamma \rightarrow \Sigma$ (case III) as shown in Table 31 and Fig. 67. The numerical agreement is not perfect but the parallelism in the general trend and in the method itself is obvious.

We cannot connect any rational procedure with the verses XVII,54–56.

5. Epoch Values

In Table 23 (p. 111) we have a list of numbers a_0, representing days, which are elapsed between the epoch date and the nearby date of a specific planetary phase, i.e. heliacal rising (Γ) for the outer planets, first appearance as evening star (Ξ) for Venus and Mercury.

Assuming A.D. 505 March 22 as the date of the epoch (cf. pt. I, p. 8) a date a_0 days later (algebraically) should give us the date of the phase. Modern tables provide us with the corresponding elongations from the Sun. As Table 32 shows these elon-

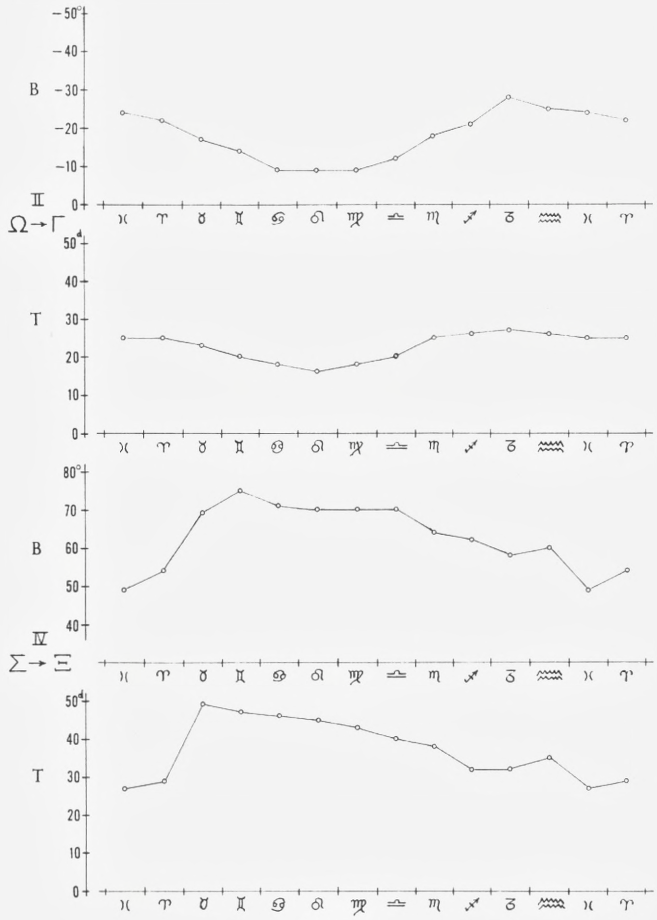

Fig. 68.

gations agree reasonably well with the visibility limits $\Delta\alpha$ given in XVII,58–60 (cf. below, p. 125). The only exception is Venus where a_0 leads only to the conjunction with the Sun. In XVII,2, however, we are given Virgo 26° as longitude of Ξ. This is indeed in agreement with the expected elongation since Venus reaches this position in A.D. 505 Sept. 10 when the Sun is about at Virgo 19°.

For Mercury we have no epoch constant giving us directly a longitude. For the outer planets we have in XVII,7 an additive constant of 18 (degrees) for Jupiter. Interpreting this as the planet's longitude at its first Γ after epoch we would have exact agreement with the position found for the date derived from XVII,6 (cf. Table 32). Consequently one should also interpret the corresponding constants for Saturn (in XVII,15) and for Mars (in XVII,23) as longitudes of the respective phases. For Mars this would mean a longitude of 175° (instead of 194° derived on the basis of a_0 in Table 32). This longitude would correspond to Sept. 27 and a solar position at 186°, hence to an elongation of 11°. For Saturn, however, no such agreement seems obtainable for the given numbers.

TABLE 32.

XVII		$-a_0$	505 March 22 $-a_0$	Planet λ	Sun λ_S	$\Delta\lambda = \lambda_S - \lambda$	$\Delta\alpha$ (XVII,58–60)
14	Saturn	+150;20[d]	505 Aug. 19	135°	148°	13° Γ	15°
6	Jupiter	+ 34;34	Apr. 26	18	38	20 Γ	15
21	Mars	+216;40	Oct. 25	194	214	20 Γ	14
1	Venus	+147	Aug. 16	145	145	0	(−)8
36	Mercury	− 28;20	Febr. 22	350	336	−14 Ξ	(−)12

6. First Visibility (XVII,57–60)

Of these four verses the second one (XVII,58) presents the most essential data, i.e. elongations from the Sun for each planet (and the Moon) required for visibility:

Saturn:	15°	in XVI,23:	15°
Jupiter:	15		11
Mars:	14		17
Venus:	8		9
Mercury:	12		13
Moon:	12		12.

(1)

Arranged according to permissible approach to the Sun, i.e. brightness, we would have here the order: Venus, Moon = Mercury, Mars, Saturn = Jupiter. In XVI,23 the arrangement would be: Venus, Jupiter, Moon, Mercury, Saturn, Mars.

In XVII,60 we are told that the arcs in question should be subtracted from the longitude of the Sun in the case of the planets but added for the Moon. This shows that the planets are assumed to be near the eastern horizon, i.e. the phase in question is always Γ, i.e. heliacal rising for the outer planets, first appearance as morning star for the inner planets. In the preceding sections it was always Ξ, i.e. first appearance as evening star, which played the leading role for Venus and Mercury.

The remaining verses, XVII,59 and XVII,57, seem to concern corrections to (1) depending on variable positions of the ecliptic with respect to the horizon. In XVII,59 it is said that the values in (1) should be multiplied by a corrective factor $c = \frac{30°}{\varrho}$ where ϱ seems to mean the rising time of the zodiacal sign in question. If the ecliptic rises to the south of the eastpoint it is steeper to the horizon than the equator, hence $\varrho > 30°$ and $c < 1$. Similarly $c > 1$ when the ecliptic rises to the north of the east-point. This implies that the values in (1) refer to arcs on the equator, as one would indeed expect in Indian astronomy (cf. also XVI,23). That $c < 1$ to the south of the east-point, $c > 1$ to the north is reasonable since the visibility of a planet depends essentially on the vertical distance of the Sun below the horizon (the so-called arcus visionis).

We meet again references to south and north (presumably from the east-point) in XVII,57, south having a subtractive, north an additive effect. If this correction would again apply to the values in (1) one would have here only another method for solving the same problem as in XVII,59. But all details escape us.

The number 480 could be 10 $\mathrm{Sin}\,\varepsilon$ with $\varepsilon \approx 24°$ and $R = 120$, modified by an unexplained factor 10. The term "latitude" could also mean declination but we see no reason for computing $\mathrm{Sin}\,\delta/10\ \mathrm{Sin}\,\varepsilon$.

XVII,64–80. In conclusion Varāhamihira has recorded a set of parameters, apparently from the Pauliśasiddhānta, concerning the mean synodic arcs of the planets and their subdivision by the planetary phases. The formulation in the text is marred by a misunderstanding. Varāhamihira calls ahargaṇa what is actually the planet's longitude (at a given date) and consequently takes the results obtained as "days" instead of degrees. The error originated probably in XVII,65 where degrees of solar motion and days are considered to be equivalent. Another consequence of this misunderstanding is probably the repeated division by the quantity which we here call b (e.g. $b = 4$ in XVII,66). We disregard these mistakes from now on in our commentary.

In order to avoid repetitions we regroup the different verses for our summary according to parallel subject matters. Since we are dealing again with methods which are closely related to ultimately Babylonian procedures we also give the relevant data from the cuneiform sources.

We begin with a group of rules asking for the computation of expressions of the form

$$\frac{(\lambda - \lambda_0)\, b}{a} = \frac{\lambda - \lambda_0}{\overline{\Delta\lambda}} \tag{1}$$

with given parameters λ_0,[1]) a, and b, listed in our Table 33 (which also should be compared with Table 24 (p. 112). That

$$b/a = \overline{\Delta\lambda} \tag{2}$$

represents the mean synodic arc of the planet in question is evident from the numerical values. It is also clear that λ_0 represents degrees and minutes of arc; consequently

Table 33.

	ch. XVII	λ_0	a	b	$\overline{\Delta\lambda}$ = a/b	$\overline{\Delta\lambda}$ Babylonian	ACT p.
♄	78	16518′ = 275;18°	1118 = 18,38	3	6,12;40°	(6,0+)12;39,22,30	313
♃	72	1652′ = 27;32	2752 = 45,52	7	6,33; 8,34, . . .	(6,0+)33; 8,44,48, . . .	307
♂	66	6329′ = 105;29	3075 = 51,15	4	12,48;45	(6,0+)6,48;43,18,29,.	302
♀	75	11122′ = 185;22	1151 = 19,11	2	9,35;30	9,35;30	283
☿	69	1681′ = 28; 1	3312 = 52,12	29	1,54;12,24, . .	1,54;12, . . .	283

[1]) In XVII,75 the term $\lambda - \lambda_0$ is described as a subtraction from "the ahargaṇa" instead of from "the longitude of the planet." The parallelism of the corresponding sentences in XVII,66, 69, 72, and 78 leaves no doubt that the same mistake has to be assumed in all cases.

$\lambda - \lambda_0$ must be a longitudinal arc, reckoned from some initial position λ_0. If the division by $\overline{\Delta\lambda}$ results in an integer we know that the arc in question begins and ends with the same planetary phase (operating here with the mean distribution). If, however, (1) produces a fractional remainder then we know from it how far the planet is removed from the phase at the beginning of the synodic arc. As beginning may serve, of course, not only a phase like Γ but also, e.g., a (mean) conjunction with the Sun. We do not know, however, how the initial positions λ_0 were chosen. All planets, excepting Saturn, reach the longitude λ_0 during A.D. 505 but only Venus would then be near a characteristic phase (Ξ, about September 17; cf. also above p. 124).

The subdivision of the synodic arcs follows a common pattern as seen in our Table 34. Three steps lead from the conjunction (C) over heliacal rising (Γ) to the first station (Φ), then follows the retrograde arc (from Φ to Ψ) and finally again three steps from Ψ to setting (Ω) back to C. For these steps the motion of the Sun (in degrees or "days") is given and the corresponding increase of elongation of the planet. The total of these steps must be $\overline{\Delta\lambda}$ for the Sun and 360° for the elongations. Both conditions are very well satisfied for all three superior planets.

During the planet's direct motion the Sun moves faster than the elongation increases. For the retrograde arcs, however, the elongation exceeds the solar progress and the difference represents the length of the retrograde arc. Thus we find the following retrogradations

Saturn:	113° − 120° = − 7°	ACT p. 315 :	−6;40° and −8°
Jupiter:	109 − 120 = −11	p. 312 f.:	−8 to −10;12
Mars:	72 − 90 = −18	p. 305 f.:	−15 to −18;45

in good agreement with the Babylonian data. One should note that the midpoint of the retrograde arc leads in all cases to an elongation of exactly 180° which shows

Table 34.

	Saturn ch. XVII,78–80				Jupiter ch. XVII,73–74				Mars ch. XVII,67–68			
	solar motion		elongation		solar motion		elongation		solar motion		elongation	
C → Γ	18°		16;30°		16°		12°		36°		15°	
Γ	98		90;30		54		44		188		60	
Φ	14	130	13	120	70	140	64	120	108	332	60	135
$\Phi \to \Psi$	113		120		109		120		72		90	
Ψ	98		91		88		76		68		50	
Ω	13		12;30		40		32		240		70	
$\Omega \to$ C	19	130	16;30	120	16	144	12	120	56	364	15	135
Totals	373 = 6,13° $\overline{\Delta\lambda}$ = 6,12;40		360°		393 = 6,33° $\overline{\Delta\lambda}$ = 6,33;8,..		360°		768 = 12,48° $\overline{\Delta\lambda}$ = 12,48;45		360°	

Table 35.

ch. XVII 76 – 77	Venus			
	solar motion		elongation	
C → Γ	5°		9°	
Γ → Φ	15	20°	21	−30
Φ	208		15	
Σ	12		5	
Σ → S	48	268	10	+30
Totals	288° = 4,48° $\overline{\Delta\lambda}$ = 9,35;30°		0°	

that the opposition Θ is here assumed to divide the retrograde arc symmetrically —in contrast to the known Babylonian schemes for Mars (cf. above p. 120).

For Venus we have a slightly different pattern. The regularity of the motion of this planet makes it possible to consider only the motion from the inferior conjunction (C) to the superior conjunction (S), assuming that the other half of the motion, from S to C, is symmetric to the first half. Thus one obtains Table 35 which would give a total synodic arc of $2 \cdot 4{,}48° = 9{,}36°$ in excellent agreement with the required $\overline{\Delta\lambda}$ = $6{,}0° + 3{,}35;30°$.

For Mercury one finds Table 36, again with a correct total for the synodic motion. In the text the degrees of solar motion are schematically replaced by "days".

We do not possess for the inner planets similar Babylonian patterns for the subdivision of the synodic arcs but this is undoubtedly caused by the accidents of preservation.

Table 36.

ch. XVII 70 – 71	Mercury			
	solar motion		elongation	
C → Γ	10°		12°	
Γ → Φ	14	24°	5	−17°
Φ → Σ	18		14	
Σ → Ξ	30		6	
Ξ → Ψ	18	66	14	34
Ψ → Ω	16		8	
Ω → C	8	24	9	−17
Totals	114° = 1,54° $\overline{\Delta\lambda}$ = 1,54;12,...		0°	

2. Short Terminological Glossary

For a complete index see Part I p. 187 ff.

ahargaṇa	number of days since epoch
ārdharātrika	system "midnight-system". for the characteristic parameters cf. I, 14 Table 1 (p. 12).
Avantī	see Ujjayinī
ayana	semicircle of the ecliptic, usually bounded by the solstices
bāhu	one side of a right triangle: $b = c \cos \alpha$
bhuja	same as bāhu
Caitra	name of a month (cf. Part I p. 187)
gati	arc between consecutive Greek-letter phenomena (i.e phases) of a planet
gola	semicircle of the ecliptic, bounded by the equinoxes
kakṣā	geocentric distance of a point on the orbit of a planet, etc.
karaṇa	1/2 tithi (cf. III, 19)
koṭi	one side of a right triangle: $a = c \sin \alpha$
kṛṣṇapakṣa	second half of the synodic month, following opposition (cf. III, 18)
kṣepa	epoch constant
mahāyuga	interval of 20,0,0,0 years
muhūrta	time interval of 1/30 day, i.e., 48 minutes
nāḍī	time interval of 1/60 day, i.e., 24 minutes
nakṣatra	"equal nakṣatra": arc of 13;20° of longitude, i.e., 360°/27 (cf. Part I p. 187)
rāhu	the ascending lunar node
Śaka	Śaka-era: year 1 beginning in A.D. 78
śuklapakṣa	first half of the synodic month (cf. III, 18)
tithi	1/30 of one synodic month
Ujjayinī	also called Avantī; locality at 75;50° east of Greenwich, $\varphi = 23;11°$
vināḍī	time interval of 1/60 nāḍī, thus 0;0,1 day = 24 seconds
Yavanapura	Alexandria in Egypt
yojana	unit of length such that 3200 yojanas = terrestrial equator
yuga	number of years, being a common period of several phenomena

3. Notation

It is, of course, impossible to associate letters and concepts in a strictly unique fashion. We nevertheless tried to adhere, within reasonable limits, to a consistent notation.

Trigonometry

R... radius of the basic circle and of the celestial sphere, usually $R = 120$, if not stated otherwise

$\mathrm{Sin}\,\alpha = R \sin\alpha, \quad \mathrm{Cos}\,\alpha = R\cos\alpha$

$\mathrm{Vers}\,\alpha = R - \mathrm{Cos}\,\alpha \quad \mathrm{Crd}\,\alpha = 2\,\mathrm{Sin}\frac{\alpha}{2}$

Gnomon

g... length of vertical gnomon, usually $g = 12$

s... length of shadow of g, s_0... equinoctial noon shadow

$h_s = \sqrt{s^2 + g^2}$ ..."hypotenuse" to s

Spherical Astronomy

λ... longitude, usually sidereal, but also tropical, depending on context

β... latitude

m... "*mediatio*" (or "polar longitude"),

b... polar latitude

α... right ascension, δ... declination

ε... obliquity of ecliptic

Z... zenith, V... nonagesimal

z... zenith distance h... altitude, $\bar{h} = 90 - h$

φ... terrestrial (= geographical) latitude, $\bar{\varphi} = 90 - \varphi$... colatitude

η... ortive amplitude (also for setting amplitude)

ω... ascensional difference

e... "earth Sine" r... "day radius" in sphere of radius R (cf. Fig. 13 p. 41)

Sun, Moon, Eclipses; Planets

Subscripts:

s... concerning the Sun, m... Moon,
u... shadow e.g. r_u... apparent radius of the shadow at the Moon's distance

a... ahargaṇa, i.e. days elapsed since epoch

$\bar{\lambda}$... mean longitude, $\overline{\Delta\lambda}$... mean synodic arc

$\theta = \lambda - \bar{\lambda}$... equation of center

v... velocity (usually in degrees per day)

$\lambda_{\text{☊}}$... longitude of the Moon's ascending node

i... inclination of the lunar orbit with respect to the ecliptic

β... lunar latitude

p_0... horizontal parallax, p... total parallax

p_λ, p_β... components of parallax (also lunar – solar)

Units of Time and Distance

Letters in raised position:

d... days τ... tithis

n... nāḍīs vin... vināḍīs μ... muhūrtas

y... years, sidereal or tropical, depending on context

m... months, usually mean synodic months

z... zodiacal signs, 30° each

na... nakṣatras 13;20° each

Linear Zigzag Functions

m... minimum M... maximum

d... constant difference (absolute value)

$\Delta = M - m$... amplitude,

$\mu = 1/2\,(m + M)$... mean value

$P = 2\Delta/d$... period $P = \Pi/Z$

4. Index of Parameters

Decimal

Lexicographically arranged; the integers from 1 to 59 are only listed in the sexagesimal index. For references see under the sexagesimal equivalent.

100 = 1,40
104 = 1,44
1 040 953 = 4,49,9,13
1 045 095 = 4,50,18,15
1050 = 17,30
10 766 066 = 49,50,34,26
110 = 1,50
11 122 = 3,5,22
114 = 1,54
1200 = 20,0
122 = 2,2
123 = 2,3
127 = 2,7
128 = 2,8
132 = 2,12
136 = 2,16
143 = 2,23
144 = 2,24
1461 = 24,21
146 564 = 40,42,44
148 = 2,28
150 = 2,30
1 577 917 800 = 2,1,45,10,30,0
1 593 336 = 7,22,35,36
159 = 2,39
160 = 2,40
1 603 000 080 = 2,3,41,17,48,0
16 041 = 4,27,21
163 111 = 45,18,31
16 518 = 4,35,18
1652 = 27,32
16 547 = 4,35,47
1681 = 28,1
177 = 2,57
17 937 000 = 1,23,2,30,0
180 = 3,0
1830 = 30,30
18 345 822 = 1,24,56,3,42
186 = 3,6
1936 = 32,16
195 = 3,15
1984 = 33,4

210 = 3,30
215 = 3,35
21 600 = 6,0,0
220 = 3,40
2227 = 37,7
223 = 3,43
2247 = 37,27
225 = 3,45
2 260 356 = 10,27,52,36
228 = 3,48
2 296 824 = 10,38,0,24
232 226 = 1,4,30,26
234 = 3,54
235 = 3,55
240 = 4,0
24 589 506 = 1,53,50,25,6
248 = 4,8
2520 = 42,0
254 = 4,14
260 = 4,20
267 = 4,27
2700 = 45,0
279 = 4,39
2850 = 47,30
286 = 4,46
288 = 4,48
2 908 789 = 13,27,59,49
292 207 = 1,21,10,7
297 = 4,57

3031 = 50,31
3120 = 52,0

Sexagesimal

Lexicographically arranged, initial zeros being ignored. References are to chapter and verse in the commentary. The topics mentioned are not intended to give more than the general area to which a parameter belongs.

1,0	Venus, node XVI,12–14 (Table 22)
1,0	Mercury, ecliptic arc XVII,38–40
1,0	Saturn, manda epicycle XVI,12–14 (Table 22)
1;0,59,0,59	tithi XII,1 (p. 81 (2b))
1,1	tithi XII,1 (p. 80 (1))
1,2	months in 5 years XII,1
1,4,24	lunar diameter IX,15–16 (p. 72 (3))
1,4,28;11	solar diameter IX,15–16 (p. 72 (3))
1,4,30,26	lunar nodes, number of rotations in Mahāyuga I,14 (Table 1) XVI,1–9
1,4,30,26;3	lunar nodes IX,5 (p. 68 (3))
1,5	Sun, kṣepa VIII,1 (p. 59 (1)) VIII,5 (p. 61 (3))
1,6;40	distance of Moon IX,15–16 (p. 73 (9))
1,9;7,1	moon, longitude at epoch II,2–6 (p. 17 (9))
1,10	Mars, manda epicycle XVI,12–14 (Table 22)
1,10;26,23	lunar anomaly, kṣepa XVI,1–9 (Table 21)
1,12	Jupiter, śīghra epicycle XVI,12–14 (Table 22)
1,12,12,19,12	Jupiter XVI,1–9 (Table 14)
1,15	solar apogee (Gemini 15) VIII,2–3
1,15;12	semidiameter of Sun X,1–2 (p. 77 (4b))
1,15;35	Mars, kṣepa XVI,1–9 (Table 17, Table 20)
1,20	Jupiter, node XVI,12–14 (Table 22)
1,20	solar apogee (Gemini 20) III,2–3 IX,7–8 (p. 69 (2)) XVI,12–14 (Table 22)
1,20	Venus, apogee XVI,12–14 (Table 22)
1,21	Mercury XVII,38–40
1,21,10,7	solar mean longitude IX,1 (p. 65 (2))
1,23,2,30,0	Mercury, śīghra, number of rotations in Mahāyuga I,14 (Table 1) XVI,1–9 (Table 15 and 17)
1;24,22,30	Saturn, density of occurrences XVII,16–19
1,24,56,3,42	lunar nodes IX,5 (p. 68 (2))
1,27;58,12	Mercury, śīghra XVI,1–9 (Table 14)
1,28	Mercury XVII,38–40
1,29,7	solar distance IX,15–16 (p. 72 (1))

5. Subject Index to the Commentary

References are to chapter and verse in the commentary

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Indleveret til Selskabet den 25. september 1969.
Færdig fra trykkeriet den 18. marts 1971.

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The Aegean, Corinthian and Eastern Greek Pottery and Terracottas

Det Kongelige Danske Videnskabernes Selskab
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Selskabets kommissionær: MUNKSGAARD's Forlag, Nørre Søgade 35,
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PRINTED IN DENMARK
BIANCO LUNOS BOGTRYKKERI A/S
ISBN 87 7304 012 6

Abbreviations

In addition to those indicated in the Archäologische Bibliographie, Beilage zum Jahrbuch des deutschen archäologischen Instituts and Sūkās I, 3–4, the following abbreviations are used:

Agora XII — B. A. Sparks & L. Talcott, Black and Plain Pottery of the 6th, 5th and 4th Century B.C. Agora XII.1–2. Princeton 1970.

ClRh III–VIII — G. Jacopi, Clara Rhodos III–VIII. Bergamo 1929–1936.

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Samos V — H. Walter, Frühe samische Gefässe. Samos V. Bonn 1968.

Schiering — W. Schiering, Werkstätten orientalisierender Keramik auf Rhodos. Berlin 1957.

SovArch — Советская Археология.

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Tocra — J. Boardman & J. Hayes, Excavations at Tocra 1963–1965. The Archaic Deposits I. Oxford 1966.

Villard, Marseille — F. Villard, La céramique greque de Marseille. Paris 1960.

MH—Middle Helladic.
MM—Middle Minoan.
LM—Late Minoan.
Myc—Late Mycenaean.
MG—Middle Geometric.
LG—Late Geometric.
PC—Protocorinthian (EPC and LPC—Early and Late PC).
TR—Transitional.
C—Corinthian (EC, MC and LC—Early, Middle and Late C).
CypArc—Cypro Archaic.
CypClas—Cypro Classical.

Besides the above-mentioned terms, only easily understood abbreviations occur.

I

Introduction

For information on the progress of the excavations undertaken throughout five seasons on Tall Sūkās in Syria, see the introduction by P. J. Riis, Sūkās I, 7–20. The material treated in Sūkās II is the Aegean and Greek pottery of the Late Bronze Age, the Geometric and Archaic periods, with the exception of the Attic exports, which are to be dealt with in a forthcoming volume. Only very few non-Attic Archaic terracottas appeared on Tall Sūkās—they too are included in the catalogue. All Greek sherds were registered during the excavation, but only about one third, roughly a thousand fragments, were registered in detail (TS-numbers) and photographed. The objects in the present catalogue were selected from this category, whereas some sherds without TS-number and enumerated by inventory number only are mentioned in Sūkās I on account of their particular importance for the interpretation of the contexts. Of the sherds with TS-numbers, about eight hundred figure in the catalogue, but descriptions are given for half of them only; the other half consisting of repeats arranged in respective, similar groups, included in order to give a more complete representation of datable Greek finds on the tall. A list of provenances for all the sherds in the catalogue is given in the Appendix. The writer took part in two of the campaigns, but did not have the opportunity to make a systematic and thorough examination of all the fabrics of the pottery dealt with in this volume. Thus it was found preferable to publish the descriptions of clay and paint reported by the registrars working in the field (cf. Sūkās I, 14–15). On this background it has been impossible to contribute to distinctions of workshops when an ascription is based mainly on the nature of the clay, as for instance with the Ionian cups and the Waveline Ware. The bulk of Greek Archaic pottery from Tall Sūkās is East Greek and only two mainland categories, Corinthian and Attic, occurred, a situation very similar to that known from the Greek sites in the Pontic area, whereas the Laconian pottery, so frequent in the Greek cities of North Africa, is totally absent. In 1972 the Syrian Directorate General of Antiquities, according to existing regulations, offered to the Danish National Museum a certain number of objects found by the Carlsberg Expedition during the campaigns of 1958–63. The Museum is gratefully looking forward to receiving the said objects.

The writer wishes to express her deep gratitude to Mr. P. Christensen, who made the final drawings and arranged the photographic material. Furthermore, I am indebted to the architects, photographers, and draughtswomen of the Expedition, see Sūkās I, 14–15 and to Mrs. J. Dupuis Starcke who patiently revised the English text. To Professor P. J. Riis, the director of the Expedition, I extend my sincere thanks for help and encouragement both during the excavations and during the preparation of this volume.

II
Minoan (?) and Mycenaean Vases and Plastic Figures

The Greek Bronze Age pottery from Tall Sūkās is not abundant, little more than fifty fragments having been registered; a few of the sherds are of special interest as they exhibit features both earlier and later than the greater mass of Greek pottery from the LEVANT[1]. The earliest example is **6**; in the preliminary report it is mentioned as Myc I, and it should thus be the earliest Mycenaean fragment from the LEVANT.[2] It is decorated with a white spiral laid on brownish or blackish paint, but in Myc I no superimposed spirals seem to occur on pottery, white is used only as an accessory colour on the dark spirals.[3] White spirals on dark ground were very popular in Crete during all phases of MM[4], and the technique was still in use in LM I but was to some degree overtaken by the "reserved" technique.[5] Superimposed white spirals were frequent on MH pottery too,[6] but it is very unlikely that MH was exported to the Middle East.[7] Furthermore, though the painting of **6** is indistinct, the spiral is said by the registrar to be "rather rashly painted", a fact which should point to a Cretan origin.[8] MM II–III pottery is known from Syria,[9] whereas there is no evidence up till now of Cretan connections with Syria in LM.[10] **6** may be MM, but an origin of the vase in the succeeding period cannot be excluded.[11]

The bulk of Mycenaean material from Tall Sūkās can be assigned to Myc III A;[12]

[1] F. H. Stubbings, Mycenaean Pottery from the Levant, Cambridge 1951, V. Hankey, Mycenaean Pottery in the Middle East: Notes on Finds since 1951, BSA 62 1967, 107–147.

[2] BSA 62 1967, 113.1.

[3] C. W. Blegen, Prosymna, Cambridge 1937, pl. 166.658 no. 216, 659 no. 57. The spirals published by A. Furumark, The Mycenaean Pottery, Analysis and Classification, Stockholm 1941, mot. 46 fig. 59.2–4,6, do not represent the superimposed technique, but the special "reserved" technique invented on Crete during LM I, see E. Reisinger, Kretische Vasenmalerei vom Kamares- bis zum Palast-Stil, Berlin 1912, 24 and A. Evans, The Palace of Minos IV.1, London 1935, 267–269 fig. 198a–b (for the Nubian vase, see further H. J. Kantor, The Aegean and the Orient in the Second Millenium B.C, AJA Mongr. 1 1947, 35 note 28 and OpArch 6 1950, 207 fig. 17) and later seen on the Mainland, see A. W. Persson, The Royal Tombs at Dendra near Midea, Lund 1931, 66 fig. 46 (Myc IIIA). For the use of white on Myc II pottery, see C. W. Blegen & M. Rawson, The Palace of Nestor at Pylos in Western Messenia, Princeton 1966, 390–392.54a figs. 379.600,606, on Myc III pottery, see BSA 42 1947, 11–12. It should be noted that the white spirals on the stirrup-jar from Mīnat al-Baida are painted on reddish ground, see Evans, PM IV.2, London 1935, 777 fig. 756c, not blackish; the jar has been recognized by A. Furumark as an imitation of a Myc IIIA1 type, see OpArch 6 1950, 207 note 9, not of a Minoan type, as was suggested earlier, see C. F. A. Schaeffer, Ugaritica I, Paris 1939, 72 fig. 68 and Kantor, Aegean and Orient, 19, 76–77.

[4] For the latest examples, see Evans, PM I, London 1921, 556–57 fig. 404 f, 578–579 figs. 420, 422: MM III, L. Pernier, L. Banti, Il Palazzo Minoico di Festos II, Pavia 1951, 403–404 fig. 267 right: late MM III, R. B. Seager, The Cemetery of Pachyammos, Crete, the University Museum Anthropological Publications, Pennsylvania 7.1 1916, 18 pl. 2 middle left: late MM III/LM I, BSA 62 1967, 337–339 pl. 78.a: LM IA.

[5] See note 3.

[6] C. W. Blegen, Korakou, New York 1921, pl. 2.2,4,8.

[7] However, see OpArch 6 1950, 204 fig. 14.A–B: "sub-I" style in Egypt.

[8] OpArch 6 1950, 162.

[9] For references to Ras Šamra, see Kantor, Aegean and Orient, 18 note 15, 19 notes 18–19, to Byblos ibid. 20 notes 27–29, to Alalakh see L. Woolley, Alalakh, Oxford 1955, 370 (ATP/48/16) pl. 129.

[10] Kantor, Aegean and Orient, 74.

[11] During the Mycenaean Symposium in Nicosia in 1972 Dr. G. Cadogan expressed the view to Professor P. J. Riis that a LM date of the sherd may be possible.

[12] Unlike Ras Šamra, where Myc III B prevails, Stubbings, Levant, 71.

the following are ascertained to belong to III A 2: **1**;[13] **2**: might come from a vase similar to **1**,[14] but perhaps just as well from a pyxis;[15] **5**: the diameter of the flat disk is so small that it must belong to the earliest of the Myc III stirrup-jars;[16] the small piriform jar with three handles, the stirrup-jar and the pyxis are the shapes most frequently found in the Levant;[17] **7**;[18] **8**:[19] the upright position of the flowers in the shoulder field exclude the stirrup-jars as the possible origin of 8,[20] it is rather from a larger vase with a more complicated composition;[21] **24**: one of the flowers on the krater sherds has an appearance in which Minoan influence is detected[22]—the sherds might have come from an amphoroid krater with a chariot scene;[23] **26**: from a cup either with a running spiral[24] or a curtailed form.[25] **9**[26] and **13**[27] can only be understood as Myc III A, **9**: curved flower stems are frequent on alabastra.[28] Only one potsherd can with some certainty be regarded as Myc III B (for the figurines, see later), this is **23** presumably Cypriote and from a bell krater, the most common krater shape of III B. The exact stylization of the bull as on **23** does not occur among any of the known pictorial representations, but the scene which is illustrated may be the same as on the Enkomi bull krater, on which a cattle egret perches on a bull.[29] Though the head of **23** is in contour, the fragment is perhaps to be ascribed to the same master, i.e. the "Enkomi Bull Painter": inside the silhouette of the Enkomi bull's head are traces, which suggest that originally only the contours of the head were indicated, including the double lines between head and neck, which occur too on the Sūkās bull.[30] Another fragment is the only one which can be assigned to the latest phase, III C, not often represented in the Levant:[31] **16** decorated with a pair of "tongue-

[13] Furumark, Analysis, mot. 45 fig. 58.1, P. Dikaios, Enkomi I, Mainz am Rhein 1969, 376.233 Tomb 10 pl. 208.11.

[14] Dikaios, Enkomi, 378.271 Tomb 10 pl. 208.14.

[15] CVA Heidelberg fasc 3, pl. 99.3 with text, BCH 93 1969, 582 Tomb II.9 fig. 11, Dikaios, Enkomi, 371.122 Tomb 10 pl. 211.21.

[16] Furumark, Analysis, 85–86.

[17] Stubbings, Levant, 68–69, BSA 62 1967, 145. The writer takes the opportunity to thank Professor P. Åström for sending her a proof of his forthcoming study on the Mycenaean pottery in Cyprus.

[18] Furumark, Analysis, mot. 18 fig. 42.17.

[19] Furumark, Analysis, mot. 18 fig. 42.3–4,6.

[20] BSA 42 1947, 15–20 figs. 4–5, CVA Cyprus fasc 1, pl. 21.7–9.

[21] CVA Brit. Mus. fasc 1, II Cb, pl. 8.6, Stubbings, Levant, pl. 2.4, CVA Brit. Mus. fasc 5, III a, pl. 2.8, OpAth 3 1960, 151 Tomb 7/VII pl. 13; for the flower, see BSA 42 1947, 57 fig. 26.

[22] Furumark, Analysis, 286 mot. 18 figs. 42.9, 41.D, BSA 62 1967, 114.2, with reference to the early Amman krater, for the latter, see further Mélanges de l'Université Saint Joseph 46 1970/71, 19–20 fig. 3.

[23] CVA Cyprus fasc 1, pl. 6.3, fasc 2 pl. 1: both with transversal stripes on rim; for the Ras Šamra krater, see AJA 65 1961, 344.9 no. 3 pl. 109.45–46; all Myc III A.

[24] E. Gjerstad, Studies on Prehistoric Cyprus, Uppsala 1926, 211.8, 213.8.

[25] Furumark, Analysis, mot. 46 fig. 59.22–23, C. F. A. Schaeffer, Enkomi-Alasia, Paris 1952, 126 fig. 55.1095.

[26] Furumark, Analysis, mot. 9 fig. 32.16–17: lily, mot. 11 fig. 34.47–48: papyrus, mot. 12 fig. 36.13: sacral ivy.

[27] Furumark, Analysis, mot. 53 fig. 65.7, CVA Cyprus fasc 2, pl. 15.2, BSA 62 1967, 141.1 pl. 34.a1.

[28] CVA Cyprus fasc 1, pl. 23.7–8.

[29] AJA 60 1956, 144 pl. 56.3–4, JHS 81 1961, 44–48.

[30] The writer thanks Professor P. J. Riis for calling her attention to this relationship.

[31] BSA 62 1967, 114.4: Tall Sūkās is the first coastal site in Syria with Myc III C.

shaped antitheticals".[32] Only approximate datings can be given for the rest of the material. The disk of **4** is larger than that of **5** and thus probably later;[33] **10** and **15** might belong to pilgrim flasks;[34] the casually drawn stripes of **11** could be part of a simple line spiral, i.e. without the usual horizontal connecting lines;[35] the stemmed lozenge of **14** cannot be earlier than III B—the interior of the sherd is not described, so it is included in the group of closed vases in the catalogue, but the motive is very often connected with pictorial representations on kraters, and **14** might perhaps have belonged to an open vase.[36] The very close-set band groups of **19** might indicate an early dating;[37] the sloping curved line of **20** has perhaps encircled the side spout of a "tea pot".[38] **25**, **27–29** are all fragments of cups: the earliest one is **25** with part of what is possibly a lily with curved stem;[39] the empty area above the band group of **27** is fairly large and the cup might have been undecorated on the upper half.[40] The cup to which **29** belonged was most likely decorated with bands only;[41] in the description of **28** the concentric circles are said to be on the exterior, but there are no traces of a foot, which should be expected.[42] The "group" looks earlier than III C, and among the determinable sherds there are no obvious counter-parts to the vases in the so-called Rude Style of Cyprus or to the wares reported from Tall Ashdod and Beth Shan. However a stirrup-jar was found in the South Harbour of Tall Sūkās, the decoration much corroded, but in shape very similar to the one from Beth Shan.[43] As on nearly all sites where Mycenaean pottery has appeared, Mycenaean figurines occur too on Tall Sūkās.[44] All the fragments of female figurines, **31–33 b** presumably represent the Ψ-type, which is usually assigned to Myc III B.[45] On **31** the waistline of the torso is placed very high, a feature showing that the figure is one of the earliest of the Ψ-type.[46] The animal fragments all belong to Blegen's type "c", and both varieties of type "c"

[32] Furumark, Analysis, mot. 19 fig. 47.48, OpArch III 1944, 201, 208 note 1 fig. 1.1.

[33] Furumark, Analysis, 85–86, Stubbings, Levant, 95 fig. 35: Myc III B.

[34] CVA Copenhague fasc 1, pl. 48.3–5: Myc III A2 (Stubbings, Levant, 16), pl. 48.1–2: Myc III B (Stubbings, Levant, 19–20), CVA Cyprus fasc 2, pl. 14.5–6: Myc III A2.

[35] Furumark, Analysis, mot. 46 fig. 60.52–59: Myc III A–C, CVA Cyprus fasc 1, pl. 18, specially no. 7: III A2, CVA Cyprus fasc 2, pl. 26.4: III A2, É. Coche de la Ferté, Essai de classification de la céramique mycénienne d'Enkomi, Paris 1951, pl. 2.6: III B.

[36] Furumark, Analysis, mot. 73 fig. 71: stemmed no. 8, Stubbings, Levant, 37 pl. 9.7, JHS 81 1961, pl. 1.5–6: III B.

[37] Stubbings, Levant, pl. 1.9, 11: Myc III A1, Blegen, Prosymna, pl. 186 fig. 716.764: Myc III A.

[38] OpArch III 1944, 235 fig. 10.23, BSA 42 1947, 53–54 pl. 17.3, BCH 93 1969, 582 Tomb II.13 fig. 19.

[39] Furumark, Analysis, mot. 9 fig. 32.16, CVA Brit. Mus. fasc 1, II C b, pl. 12.12: Myc III A1.

[40] CVA Cyprus fasc 1, pl. 26.8: Myc III A2, Dikaios, Enkomi, 284 pl. 80.19: Myc III B, Stubbings, Levant, 38 pl. 12.15: Myc III B.

[41] BSA 64 1969, 276.68 note 32 fig. 7: Myc III B.

[42] For a decorative system like that of **28**, except for the interior, see Dikaios, Enkomi, 246 pl. 66.5.

[43] Rude Style: Mélanges de l'Université Saint Joseph 46 1970/71, 21–22; on Ashdod see BSA 62 1967, 143, Archaeometry 13.2 1971, 169–175 pl. 1 and T. Dothan in a lecture given in Nicosia 1972 during the Mycenaean Symposium: Philistine Material Culture and its Mycenaean Affinities, where attention was called to the ware from Beth Shan, for the latter see BSA 62 1967, 127–128 pls. 28–29. The stirrup-jar from the South Harbour, Sh 78, is to be published later.

[44] OpAth 5 1964, 46–57. The review by E. French in BSA 66 1971, 101–87, appeared too late.

[45] A. Furumark, The Chronology of Mycenaean Pottery, Stockholm 1941, 86–88 fig. 1, BSA 62 1967, 114.3.

[46] In Deiras figurines of this sort were found with late Myc III A2 pottery, see J. Deshayes, Argos, Les fouilles de la Deiras, Paris 1966, 198, 200 DM 19 pl. 54.2. See BSA 66 1971, 109 fig. 1, 131–133.

are represented.[47] The Sūkās fragments are suggested to be Myc III B[48] and the type represented by **34–35 b**,[49] i.e. Blegen's first variety, is now dated to the beginning of III B;[50] the second variety, with transversal stripes on the body, is known from the Argive Heraion in a Myc III A 2/III B context.[51]

Small piriform jar.

1. TS 5601. Sūkās I 29 no. 33, 31 fig. 8 b pl. 2. Neck/shoulder sherds with root of handle. G 15 NE. 10.0×7.5 cm, diam. of rim 9.5 cm. Fine grey brown clay, greenish grey slip, brown glaze. Broad cylindrical neck with horizontal offset rim; small horizontal loop-handle, on shoulder frieze of U-patterns enframed by narrow bands. *Pl. I.*

Pyxis?

2. TS 569. BSA 62 1967, 114.2. Neck/shoulder sherd, handle. G 11 SW. 5.1×3.7 cm. Light buff clay, pink in core, yellowish slip, reddish brown to chocolate glaze. Small horizontal loop-handle. Neck glazed, in handle zone frieze of small vertical stripes enframed by narrow bands. Handle glazed. *Pl. I.*

Stirrup-jars.

3. TS 4657. Shoulder sherd with spout. G 10 NE. H. of spout 3.2 cm, diam. of rim 2.5 cm, w. 5.0 cm. Light yellowish clay, darker core, brownish glaze. Band on interior of rim and another round root of neck; on shoulder, one broad and two or three narrow horizontal bands. *Pl. I. Similar*: TS 1676 P 11 SW.

4. TS 2055. Disk and part of handle of false-neck. J 8 SE. 4.6×2.9 cm. Yellow clay, dark brown to olive glaze. Disk: large central dot and concentric circles. Handle: glazed except for triangle at top. *Pl. I. Similar*: TS 4792 G 10 NE, TS 3572 G 13.

5. TS 600. Disk and part of handles of false-neck. G 11 SW. 5.9×2.7 cm. Light buff gritty and micaceous clay, greenish in core, light reddish brown glaze. Flat disk with central dot and concentric circle. Handles glazed, except for irregular, reserved field at top. *Pl. I.*

Other closed vases.

6. TS 663. AASyr 8/9 1958/59, 131–32, BSA 62 1967, 113.1. Neck/shoulder sherd. G 11 SW. 7.2×10.1 cm. Light drab, very gritty and slightly micaceous clay, brownish to black glaze. Shoulder not distinctly offset from neck. Glazed all over; on neck, running spiral between two horizontal bands all added in white which is very worn. *Pl. I.*

7. TS 5515. Side sherd. G 15. 3.0×4.0 cm. Light brownish clay, light brownish glaze. Part of voluted flowers. *Pl. I.*

8. TS 4752. Neck/shoulder sherd. Surface, Eastern Spur. 4.5×2.9 cm. Light brown clay, creamy slip, brown glaze. Neck glazed; on shoulder, part of voluted flowers. *Pl. I.*

9. TS 2721. Neck/shoulder sherd. L 8 SE. 3.0×3.0 cm. Very fine light clay, greenish slip, brown lustrous glaze. Horizontal rib between neck and shoulder. Neck glazed; on shoulder, curved narrow stripe and two parallel zigzag lines. *Pl. I.*

10. TS 3716. Side sherd. G 14. 3.5×3.3 cm. Light buff clay, yellowish slip, brown to black glaze. Part of three concentric bands. *Pl. I.*

11. TS 5585. Side sherd. G 16 NW. 3.0×2.0 cm. Fine light brownish clay and slip, red glaze. Part of irregular spiral overlapping broad band. *Pl. I.*

[47] Blegen, Prosymna, 363–364, BSA 66 1971, 151–153 fig. 11.
[48] BSA 62 1967, 114.3.
[49] Similar in Ras Šamra, C. F. A. Schaeffer, Ugaritica II, Paris 1949, 230 fig. 97.9, 20.
[50] Deshayes, Deiras, 201 DM 73 pl. 82.5, the bull from Deiras does not have exactly the same decoration as the Sūkās fragments, but see ibid, note 2, for a bull like those from Sūkās. BSA 66 1971, 155–56.
[51] Deshayes, Deiras, 201 note 4 DM 86 pl. 92.2. See further BSA 66 1971, 156–57.

12. TS 1734. Side sherd. P 11 NW. 2.5×2.0 cm. Fine buff clay, yellow buff slip, brownish to black glaze. Composition of dots and stripes. *Pl. I.*

13. TS 3038. Side sherd. G 15. 3.0×3.7 cm. Buff clay, buff slip, red lustrous glaze. Frieze of broken wavy line; at bottom, band and indefinable rounded design. *Pl. I.*

14. TS 4522. Side sherd. G 10 SE. 5.7×3.3 cm. Buff clay, reddish brown glaze. Stemmed lozenge with groups of semicircles. *Pl. I.*

15. TS 1385. Side sherd. G 11 SW. 4.5×2.5 cm. Light reddish buff clay, creamy slip, red glaze. Banded. *Pl. I. Similar*: TS 1537 E 8 SE, TS 3481 G 15.

16. TS 812. AASyr 8/9 1958/59, 131. Shoulder sherd. G 11 SW. 6.9×4.5 cm. Fine light buff clay with white and dark grits, red to brown glaze. Pair of hatched tongue-shaped antitheticals, below broad and narrow bands. *Pl. I.*

17. TS 1390, 1391. Shoulder/side sherds. G 11 SW. 4.5×4.0 cm. Light buff somewhat porous clay, red glaze. Narrow and broad bands, "sling" in field. *Pl. I.*

18. TS 641. Side sherd. G 11 SW. 2.1×1.6 cm. Light greenish clay with some grits and mica, brown glaze. Four narrow bands enframed by two broad ones. *Pl. I. Similar* (three to nine narrow bands): TS 364 Surface, TS 365 Surface, TS 1198 G 11 SW, TS 1893 H 11 NW, TS 1957 G 7 SE.

19. TS 3489. Side sherd. G 15. 2.0×3.5 cm. Red to buff clay, buff in core, buff slip, red glaze. Broad and narrow bands. *Pl. I. Similar*: TS 4910 G 14 NE, TS 5553 H 11 NE.

20. TS 5658. Shoulder sherd with root of spout(?). G 15 NE. C. 5.0×5.0 cm. Light greyish clay, black glaze. Band round root of spout(?), at bottom horizontal band. *Pl. I.*

21. TS 5586. Side sherd. G 16 NW. 2.5×3.0 cm. Fine reddish clay, yellowish slip, brownish glaze. Vertical, irregular, slim stripe; below, horizontal band with small pendant stripe. *Pl I.*

22. TS 3826. Handle fragment. H 11 NW. 3.6×1.2 cm. Reddish somewhat micaceous clay, yellowish slip, red brown glaze. Transversal stripes. *Pl. I.*

Kraters.

23. TS 2314. AASyr 10 1960, 128 fig. 18, AA 1962, 374 fig. 90. Shoulder sherd with root of neck. G 16 NW. 4.3×5.7 cm. Buff clay with few grits, greyish buff slip, red glaze. Exterior: neck glazed; on body, part of neck and head with probably the long toes of a bird perched on the neck of the bull. Interior: no description. *Pl. I.*

24. TS 483, 484, 497. AASyr 8/9 1958/59, 131 fig. 18. Rim/neck/shoulder/side sherds with strap-handle. E 8 SW, SE and NW. L. 2.8–9.4 cm, w. 1.8–5.5 cm. Fine light yellowish buff clay with small grits and mica, black to brown glaze. Flat rim, broad vertical strap-handle, three holes through top of handle. Rim: groups of transversal stripes limited along the inward edge by horizontal band. Handle: glazed, except for vertical stripe. Exterior: voluted and unvoluted flowers, vertical row of quirks. Interior: glazed. *Pl. I.*

Other open vases.

25. TS 988. Side sherd of cup(?). G 15 SE. 3.1×1.9 cm. Yellow clay with some white grits, red mat paint, burnished! Exterior: part of lily(?). Interior: horizontal bands. *Pl. I.*

26. TS 3078. Rim/side sherd of cup(?). G 14. 2.8×2.1 cm. Light brown clay, yellow slip, red glaze. Slightly everted rim. Exterior: rim glazed, below three curved lines. Interior: slipped, rim glazed. *Pl. I. Similar*: TS 2606 H 11 NW.

27. TS 1773. Bottom sherd of cup(?). F 8 NW. 4.0×3.5 cm. Red clay with white grits, red glaze. Exterior: group of broad and narrow concentric circles. Interior: two concentric bands. *Pl. I.*

28. TS 1735. Bottom sherd. P 11 NW. 1.5×2.0 cm. Light buff clay, red slip, brown glaze. Exterior: three concentric circles. Interior: slipped. *Pl. I.*

29. TS 1355. Side sherd of cup(?). G 8 SE. 3.0×2.0 cm. Fine yellow clay, yellow slip, red glaze. Exterior: banded. Interior: glazed. *Pl. I.*

30. TS 5621. Fragmentary stem. H 12. 4.7×3.7 cm. Fine light brownish clay, darker in core, yellow slip, red glaze. Broad and narrow horizontal bands. *Pl. I.*

Ψ-figurines.

31. TS 5561. Sūkās I 36 no. 51 fig. 8 d pl. 2. Columnar stem with part of torso. G 16 NW. W. 3.2 cm, h. 5.7 cm, diam. below 3.0 cm. Fine light red-brown clay, yellowish slip, red-brown glaze. Above waistline short vertical stripes, on stem three vertical stripes. *Pl. II.*

32. TS 563. AASyr 8/9 1958/59, 131 fig. 17, NMArb 1961, 123–24 fig. 5, AA 1962, 374–75 fig. 89, BSA 62 1967, 114.3. Fragmentary columnar stem. G 11 SW. 2.6×4.7 cm. Light buff clay with white and dark grits, brownish red glaze. Three vertical stripes. *Pl. II.*

33a. TS 4516. Sūkās I 34 no. 49 fig. 8 f pl. 2. Arm. G 16 SW. 2.4×2.0 cm. Buff clay, buff slip, reddish glaze. Band along edge, on both sides vertical stripes. *Pl. II. Similar*: TS 4679 G 16 SW.

33b. TS 4533. Sūkās I 29 no. 36 fig. 8 e pl. 2. Arm. G 15 SE. 2.3×1.5 cm. Buff clay, buff slip, brownish glaze. Band along edge, vertical stripes on both sides. *Pl. II.*

Animal figurines.

34. TS 561. AASyr 8/9 1958/59, 131 fig. 17, NMArb 1961, 123–34 fig. 5, AA 1962, 374–75 fig. 89. Fragmentary bull. G 11 SW. L. 10.8 cm, h. 6.9 cm. Light yellowish to reddish clay with some white and dark grits, brownish to black glaze. Forelegs and outer part of horns are missing. Banded longitudinally, end of muzzle glazed; small transversal stripes on top of muzzle and front of horns. *Pl. II. Similar head*: TS 4484 G 15 SW. *Similar bodies*: TS 4080 G 15 SE, TS 5542 G 15 NE.

35a. TS 562. AASyr 8/9 1958/59, 131 fig. 17, NMArb 1961, 123–24 fig. 5, AA 1962, 374–75 fig. 89. Fore- and hind-part of bull. G 11 SW. 4.2×9.1 cm, 2.0×4.9 cm. Light yellowish to reddish clay, with some white and dark grits, brownish to reddish glaze. Banded longitudinally, end of muzzle glazed, small transversal stripes on top of muzzle. *Pl. II. Similar horn*: TS 4680 b G 16 SW. *Similar legs*: TS 3858 G 12 NE, TS 4604 H 11 NE, TS 4680 a G 16 SW, TS 5584 G 16 NW.

35b. TS 4532. Sūkās I 29 no. 35 fig. 8 c pl. 2. Fragmentary fore-part of bull. G 15 SE. 4.1×6.1 cm. Buff clay with grey grits, yellowish slip, dark brownish lustrous glaze. Banded longitudinally, transversal stripes on horns. *Pl. II.*

36. TS 2295. Fragmentary trunk. G 16 NW. 6.2×2.8 cm. Red brown clay with few white grits, yellowish slip, red glaze. Close-set vertical stripes crossed by a horizontal stripe along back. *Pl. II.*

III
Cycladic Geometric Vases

Only five sherds have been determined as Geometric, **37–41**, all presumably Cycladic. Though the description of the clay is sparse, it does not disagree with that of Cycladic fabrics. **37** and **38** are from skyphoi with pendent-semicircles.[52] The exact

[52] This group of cups are conventionally called "skyphoi" and for convenience that name has been employed in the catalogue, but the shape is that of a kylix, a term known from an inscription on a cup from the 8th century (see Sūkās I 174–175). For lists see H. G. Buchholz, Berliner Jb 5 1965, 224–229 and Emporio, 117 note 2; add: Emporio, no. 157 fig. 72 pl. 30, M. R. Popham & L. H. Sackett, Excavations at Lefkandi, Euboea 1964–66, London 1968, 26–27 figs. 59, 65 and BCH 89 1965, 845 fig. 3, Archaeology 1967, 67 fig. above (Sardis), R. Saidah, Découvertes d'objets grecs d'époque protogéométrique et géométrique sur le littoral libanais, IXe congrès international d'archéologie classique, Damas 1969, 66–67 (Ḫalda), Sūkās I 144 note 574 (Niniveh). See furthermore note 543.

profile of **38**[53] is not known, and so little is left of the sherd that there are no traces of another intersecting circle group; the decoration is unusual, the semicircles describe more than half a circle, and innermost is a full circle.[54] The body of **37** is rather deep, the rim distinctly offset from the shoulder and clearly swept back. Among the skyphoi found in Syria the greatest similarity in profile to **37** is found in the fragmentary cup from Tall Taʿyināt, on which the number of semicircles is considerable too, i.e. ten,[55] and in the Tall Halāf skyphos which has eleven semicircles[56] like **37**. Recently J. N. Coldstream has thoroughly dealt with the pendent-semicircle skyphoi, including the category to which the sherds from Tall Sūkās belong.[57] According to Coldstream the skyphoi from Tall Taʿyināt and Tall Ḥalāf date to the second half of the 9th century, i.e. MG I, and the Ḥama cups are assigned to the early 8th century, i.e. MG II.[58] The Ḥama cups, which have never been fully published, are now dealt with by P. J. Riis.[59] For two of the cups a date is proposed earlier than that of MG II: 8 A 189,[60] found in a cinerary urn, is safely dated to the late 9th century or around 800 B.C.,[61] while L 941[62] is suggested to be even earlier, it is compared with EG cups.[63] The two remaining cups are held to be later:[64] on account of its occurrence in deposits of the 4th period of the cremation necropolis, one of them, 6 A 290, is dated within 800–720 B.C.[65] According to P. J. Riis, the latest of the Ḥama cups should be contemporary with the cups from Tall Taʿyināt, Tall Ḥalāf, Tall Sūkās and some of the Al-Mīna cups.[66] However, the profiles of the later Ḥama cups show features rather different from those of the cups from Tall Taʿyināt, Tall Ḥalāf and Tall Sūkās: the concavity of the rim is more pronounced on the Ḥama cups, the bodies are shallower and with straighter sides, whereas the profile of the earlier Ḥama cup, dated by P. J. Riis not later than 800 B.C., i.e. MG I,[67] comes closer to the three cups in question.

[53] NMArb 1961, 124–125 fig. 6.

[54] So far a skyphos found on Cyprus seems to be the only specimen with a full central circle, Desborough, Protogeometric, 181 pl. 25.C left (Keraphani).

[55] Desborough, Protogeometric, 328 pl. 26.5.

[56] B. Hrouda, Tell Halaf IV, Die Kleinfunde aus historischer Zeit, Berlin 1962, 84, 101.188 pl. 69.

[57] Coldstream, Geometric, 156–157. In connecting the material with the evolution of Attic Geometric and in stressing the significance of Attic influence on the Cyclades, J. N. Coldstream has reached a reasonable relative chronology for these skyphoi. The type has no Attic counterpart, it is a descendant from the Cycladic Sub-Protogeometric version of the local skyphos. It must have developed "somewhere near the transition from Early to Middle Geometric in Attica". The skyphoi from the Rheneia graves, regarded as the culmination of the class, were found with Atticizing MG I vases; for the skyphoi from the Purification Trench there are no valuable contexts, but Coldstream suggests that none of them were made much later than the end of MG II; first, because the shape seems to be the predecessor of Atticizing MG II skyphoi also found in the Trench, and second because there is no reflection on the ceramics found in the western colonies, neither in shape nor in decoration; on the latter see Sūkās I 156.

[58] Coldstream, Geometric, 312–313.

[59] Sūkās I 150–152 fig. 51 a–d.

[60] Sūkās I fig. 51 d.

[61] It was found in a cinerary urn of the bottom layer in the 8th century necropolis, Sūkās I 150 note 613, fig. 52 (no. 38). Coldstream, Geometric, 311 note 6.

[62] Sūkās I fig. 51 b.

[63] Sūkās I 150–152 notes 614–615.

[64] Sūkās I figs. 51 a, c. Coldstream, Geometric, 311 note 7.

[65] Sūkās I 150 note 612.

[66] Sūkās I 152 notes 616–618, for Al-Mīna, see below note 72.

[67] See note 61.

The similarity of the cups from Tall Taʿyināt and Tall Ḥalāf to the MG I cup from Ḥama seems to confirm J. N. COLDSTREAM's ascription of the Taʿyināt and Halāf cups to the 2nd half of the 9th Cent. B.C.[68] It is not possible to judge if **38** can be assigned to the 9th Cent. B.C. like **37**. **38** is too small and the course of its profile is not known. No profile drawings have been published of the sherds from Al-Mīna, and the range within the sherds is still confusing, but the early MG type is represented among them.[69] The skyphos is described as unusually deep,[70] probably not unlike the ones from Tall Taʿyināt, Tall Halāf, Tall Sūkās and the early one from Ḥama. Three other fragments are distinguished by COLDSTREAM as belonging to late and degenerate skyphoi with extremely shallow bodies and only few semicircles which often overlap the glaze;[71] they are understood as Late Geometric. Two of these fragments are mentioned by P. J. RIIS as contemporary with the skyphoi from Tall Taʿyināt, Tall Halāf and Tall Sūkās together with the two latest Ḥama cups.[72] As shown above, we cannot talk about stylistic contemporarity in connection with the three former cups—and even *in connection* with the two latest Ḥama cups it is questionable. The latter are of a decidedly better quality than the Al-Mīna sherds and the Late Geometric skyphoi from Cyprus,[73] and might have been produced earlier, i.e. in MG II,[74] but they may of course have been in use as late as 720 B.C.[75] Only a corner of a hatched meander is left on **39**. Though the description of the clay does not reveal it, the sherd is most likely Cycladic as at least some of the early ceramics from Al-Mīna; the sherd might belong to a skyphos with window panel, which is a normal Atticizing MG type in the Cyclades.[76] Though the clay is not termed micaceous, the slip betrays the Cycladic origin of the sherds **40–41**;[77] kraters of this sort are already known in the LEVANT.[78] The type is LG.[79]

Skyphoi.

37. TS 2018. Sūkās I 50 with note 143, pp. 142, 152 figs. 53 b, 54 a. Rim/shoulder/side sherd. F 8 NW. 7.0×5.2 cm. Fine pale buff clay with tiny white grits and a little mica, black to light brown glaze. Exterior: rim glazed, eleven pendent-semicircles, centre marked by dot and compass-point, faint traces of six other pendent-semicircles intersecting the outer nine ones of the former group. Interior: glazed, except for band at top of rim. *Pl. II. Fig. a.*

[68] Concerning Tall Taʿyināt, J. N. Coldstream notes that "the evidence for this date is not stated" Geometric, 311 note 3.

[69] JHS 60 1940, 3 figs. 1 d, j and another fig. 1 b is suggested to be early by P. J. Riis, Sūkās I 152 note 619.

[70] Coldstream, Geometric, 312.

[71] Coldstream, Geometric, 312, 157 note 6.

[72] Sūkās I 152 figs. 48 a, d.

[73] Coldstream, Geometric, 157 notes 4–5.

[74] 6 A 290 is very similar in shape to a Cypriote skyphos from: A "Royal" tomb at Salamis, AA 78 1963, 177 fig. 35.46, found with MG II, see Coldstream, Geometric, 157 note 3.

[75] However, even this is doubted by J. N. Coldstream, Geometric, 311; see further Sūkās I 148–150. For the group see Sūkās I 156, Emporio, 117, Gnomon 42 1970, 497.

[76] JHS 60 1940, 2–3 fig. 1.1, Sūkās I 146 fig. 47 l–j, Coldstream, Geometric, 312 B1 (MG I), see pl. 34 k.

[77] Coldstream, Geometric, 172.

[78] Sūkās I 148 notes 598–599, 154 notes 629, 631 (with references); for the Delos Krater Bc 8, see Coldstream, Geometric, 172–174 no. 3 (the Cesnola Painter).

[79] See preceding note: Coldstream.

38. TS 1012. AASyr 10 1960, 123 fig. 13, Sūkās I 50 with note 143, pp. 142, 152 figs. 53 c, 54 b. Shoulder/side sherd with root of rim. H 5 SE. 2.5×2.1 cm. Fine buff clay, black to light brown glaze. Exterior: root of rim glazed, four pendent-semicircles and one small full circle, centre marked by dot and compass-point. Interior: glazed. *Pl. II.*

39. TS 3520. Side sherd. G 5 NE. 1.8×2.3 cm. Grey brown clay, brown to black glaze. Exterior: part of meander with diagonal hatching. Interior: one broad and two narrow bands. *Pl. II.*

Kraters.

40. TS 1394. Rim sherd. G 15 NE. 3.0×3.0 cm. Rather fine light reddish clay with few white grits, creamy slip, black to reddish glaze. Flat rim. Exterior and interior: glazed. Topside: group of four transversal stripes, broad band along edge. *Pl. II.*

41. TS 969. Rim sherd. F 6 NW. 1.6×2.7 cm. Dark reddish clay, greenish slip, black glaze. Groove on underside. Exterior, interior and underside: glazed. Topside: two groups of transversal stripes, broad band along edge. *Pl. II.*

IV
Cycladic Orientalizing Vases

Only two Cycladic sherds belong to this phase. **42** is from "a big jar", and the metope-circle decoration points to the still not located Linear Island group,[80] which consists mainly, of large amphorae, frequently with a funeral purpose. So far these vases have appeared only within Greece itself, and of the pieces without known finding places, only one has an Eastern provenance, i.e. the one in Leyden which was acquired in Smyrna.[81] On this basis it is strange to find a fragment in a remote Syrian location, thus P. J. Riis has attempted to connect **42** with other and more widespread Cycladic vase shapes, as kraters and krateriskoi. In addition to Eastern Greece these have been found further afield in Asia Minor.[82] However **42** presumably does not belong to an open vase, as the interior of the sherd was apparently unglazed. Though none of the circle schemes of the known Linear Island amphorae are absolutely identical to **42**, nor the later ones,[83] it cannot be denied that the group in general is that with which **42** has the greatest affinity. **43** is totally without slip, thus connecting it with Dugas's A-groups,[84] where friezes of "running dog" are usually found on the Ad vases.[85] The latter look geometric, and are suggested to date to the 1st quarter of the 7th century;[86] it has recently been argued that they may last into the second quarter of the 7th Cent. B.C.[87] Three sherds of this category are reported from Al-Mīna.[88]

[80] The different points of view summed up by I. Strøm, ActaArch 33 1962, 243–246; add P. Bocci, Ricerche sulla ceramica cicladica, Rome 1962, 5–8 and Fondation Hardt pour l'étude de l'antiquité classique, entretiens X 1964, 57–58 (N. M. Kontoleon). P. J. Riis, Sūkās I 50 note 145 Pl. III no. 37 fig. 16 g, described the sherd as unslipped, i.e. without the thick yellowish slip; the slip of the Linear Island vases is extremely thin and sometimes yellowish brown, see ActaArch 33 1962, 224 note 8, and this sort of slip may correspond to the slip registered as yellowish to brown.

[81] ActaArch 33 1962, 222–223.

[82] Sūkās I 50 note 145. On **42** see further Sūkās II 94.

[83] Sūkās I 50.

[84] ActaArch 33 1962, 271.

[85] Délos XV 39–48 pls. 20–25, ActaArch 33 1962, 267–278, Bocci, Ricerche cicladica, 8–10 pl. 5.

[86] ActaArch 33 1962, 269.

[87] See preceding note.

[88] BSA 52 1957, 6 note 25 a.


1:2
37
60
64
67a
85
98 (1:4)
95 (1:4)
93 (1:4)
100
103
104
105
105.2
103.1
106.1
105.1

Fig. a.

Closed vases.

42. TS 4183. Sūkās I 50 no. 37 fig. 16 g pl. 3. Shoulder sherd. H 14. 7.6×7.8 cm. Light yellowish to brown clay with numerous dark and white grits and a few mica, yellowish to brown slip, orange glaze. In metope field, one half of concentric group of four circles, faint traces of four triglyphs. *Pl. II.*

43. TS 1027. Side sherd. G 5 SE. 2.7×2.1 cm. Buff clay with some white grits and a few mica, red glaze. Frieze of "running dog" (no band above/below). *Pl. II.*

V
Al-Mīna Ware

The ware demonstrated by J. Boardman as possibly manufactured by Greek potters in Syria[89] is represented on Tall Sūkās by five sherds, **44–47**. Only one of the sherds, **44**, is in the bichrome technique, one of the hallmarks of the group, which is most fully represented in Al-Mīna, the suggested centre for the production. **44** perfectly matches one of the Al-Mīna sherds except for a greater number of triglyphs on the Sūkās sherd.[90] Though the description of the interior of **44** is not clear, the sherd must belong to Boardman's first class, because of the elaborate decoration on the exterior,[91] whereas **45** with its simple linear decoration belongs to the second class.[92] The other sherds **46–47** are small and not very characteristic.[93] In addition to Al-Mīna, Tall Sūkās and Cyprus,[94] the ware is now reported from farther south at Byblos[95] and in the Ḫhalda necropolis at the Beirut airport.[96] Some fragments from Tarsus have a very similar decoration, but G. M. A. Hanfmann points out that the technique is different, and he suggests an Ionian origin for the Tarsian pieces.[97] The type and decoration which the Al-Mīna cups copy is that of LG skyphoi, Euboean(?)[98] and the ware is supposed still to have been made in the 8th century B.C.[99] For the stratification of **47** see conclusion p. 93.

Skyphoi.

44. TS 4044. Sūkās I 50 no. 36 fig. 15 c pl. 3. Shoulder/side sherd with root of rim. H 14. No measurements. Pink clay with numerous black and white grits and mica, creamy slip. Exterior: on rim, lower part of vertical zigzags in orange matt paint, below two black glazed bands with black (or dark grey) matt painted stripes added; on shoulder/side: five triglyphs, the outer four in black (or dark grey) matt paint, the innermost in red matt paint; in metope field: four-leaved flower with contours and hatches in black (or dark grey) matt

[89] AnatSt 9 1959, 163–169, Coldstream, Geometric, 193, 310 note 6, 384.
[90] AnatSt 9 1959, 168.4 pl. 24 fig. 1.
[91] AnatSt 9 1959, 164. For the multiple brush, see Antiquity 34 1960, 85–89.
[92] AnatSt 9 1959, 169.22 pl. 25.
[93] **46** might be of Boardman's 1st class.
[94] AnatSt 9 1959, 166 notes 11–14.
[95] Sūkās I 158 note 640.
[96] Sūkās I 158 note 641, R. Saidah, Découvertes d'objects grecs d'époque protogéométrique et géométrique sur le littoral libanais, IXe congrès internationale d'archéologie classique, Damas 1969, 66–67.
[97] Tarsus III 280–281.1375–1377 fig. 95.
[98] Coldstream, Geometric, 193.
[99] AnatSt 9 1959, 167.

paint and interior of central dot in red matt paint, two tongues with contours in black (or dark grey) matt paint and interiors in red matt paint, dot-fillers in black (or dark grey) matt paint. Interior: "brown paint on creamy slip". *Pl. II.*

45. TS 1387. Rim/shoulder sherd. G 11 SE. 3.0×2.5 cm. Fine dark buff clay, light buff slip, brown matt paint. Exterior: banded rim, vertical wavelines made by at least a sextuple brush on shoulder. Interior: two broad bands on rim. *Pl. II.*

46. TS 3828. Rim/shoulder sherd with root of handle. G 15. 2.4×2.3 cm. Light buff clay, creamy slip, light red brown matt paint. Exterior: glazed rim, narrow band and two vertical stripes on shoulder. Interior: glazed, except for band at top of shoulder. *Pl. II. Similar ?* TS 3834 G 15 SW.

47. TS 4438. Sūkās I 48 no. 29 fig. 15 e pl. 3, 49–50. Side sherd. G 16 SW. 1.8×1.3 cm. Reddish clay with grey grits, creamy slip, orange matt paint. Exterior: vertical stripes. Interior: no description. *Pl. II.*

VI
Protocorinthian and Corinthian Vases

The amount of pottery from Corinth is not overwhelming on Tall Sūkās, altogether about fifty sherds have been registered, mostly Middle and Late Corinthian. Only four of the sherds can be regarded as Protocorinthian **49**, **62**, **64** and **70**. **49** is from a kotyle; in the handle zone only a few vertical stripes are left and above the handle only one band. At this particular place EPC kotylai usually have two bands, only very few have one.[100] The latter are all rather early, but the indistinct and restricted decoration of **49** does not permit a date closer than the later part of the 8th Cent. B.C. or the beginning of the 7th Cent. B.C. Numerous concentric circles, the uppermost ones with very small diameters, indicate that **62** cannot belong to an aryballos or another small closed vase;[101] the fragment is more likely to originate from a pyxis-lid. The registrar termed the sherd a shoulder sherd, a fact which might point to a domed lid rather than to a flat one; especially on the tall domed lids the uppermost circles have small diameters.[102] PC pyxides with tall lids are descendants of a Late Geometric shape,[103] the former are rare and seem to disappear in the EPC period.[104] The writer only knows the fragment catalogued as similar to **62** (TS 4717) from a photograph and cannot determine if it is from a domed or flat lid. The bottom sherd, **64**, is decorated in the EPC linear fashion[105] and the sherd is from a closed vase with small foot diameter.[106] **70** is from a vertical neck with distinctly offset rim triangular in section; it

[100] CVA Louvre fasc 13, pl. 35.1,4 (740–30), BSA 48 1953, 283.685 fig. 10 (c. 700), BSA 53/54 1958/59, 139 pl. 21.15 (730), CVA Heidelberg fasc 1, pl. 7.10 (early 7th century).

[101] The stripe decoration on smaller closed vases never covers the shoulder.

[102] K. Friis Johansen, Les vases sicyonien, Copenhague 1923, 32 pl. 11.3 (Thera), BSA 43 1948, 28 pl. 6.77 (Ithaka).

[103] From the so-called Thapsos class, see Coldstream, Geometric, 102–104, pl. 20 e (Ithaka).

[104] Perachora II 119; the domed lids from Perachora are all significantly lower, i.e. the circles have larger diameters, ibid. 119–122.1201–1226 pl. 54, they range from EPC to LPC/TR; on the Thera pyxis, see further Coldstream, Geometric, 107 note 2 pl. 21 g.

[105] For the same decorative system, see BSA 48 1953, 296.793 pl. 48 (krater); 300.827 fig. 21 (pyxis); Corinth XIII 38 S–1, S–2 pl. 10, 43–47 (kraters).

[106] AJA 62 1958, 270 pl. 69 fig. 35.5: Cretan aryballos.

might have belonged to an amphoriskos, a shape not usual in the PC series, but well known in LG.[107]

The Corinthian pottery from Tall Sūkās represents shapes of the probably mass-produced wares usually exported eastwards,[108] and perhaps more or less accidentally carried overseas.[109] Among the exported vases kotylai and aryballoi are very frequent and on Tall Sūkās they constitute the largest Corinthian group. **48** is from a smaller open vase, which might be a kotyle, and if so it is outstanding among the other more ordinary kotylai from Tall Sūkās. The shield could be part of an elaborate decoration resembling that on the MC kotyle in Boston,[110] and the vase might have been carried to Syria as an "objet d'art". Perhaps with the exception of **52**, none of the other kotylai seem to be earlier than MC, several are LC. True black-figure technique is employed only on two of the sherds, **50–51**; the bodies of the beasts are elongated with rather neat incisions and this—together with the close-set, large, deformed filling-ornaments and the small dot-fillers—shows that the sherds still belong to MC.[111] Of the bottom fragments, **52–54**, **52** with the broader rays might be EC,[112] while **53–54** cannot be earlier than MC; they may have belonged to kotylai like **50–51**.[113] Silhouette technique alone is used on **55–56**; the animals are the so-called stick-legged ones, on **55** probably a goat, surrounded by plenty of dot-fillers—"hailstorm". They date from the beginning of LC.[114] Like **49**, the rimsherds **57** and **59** have only one band above the handle, but neither of them are as early as **49**; the wavelines of **57** might indicate a PC date, but the wavelines are shorter on PC kotylai.[115] The short, broad strokes of **58** are found on small kotylai of rather poor quality.[116] On **59** there is a narrow and a broad band below the tiny wavelines, this combination is known from both MC and LC.[117] Kotylai with stripes round the foot

[107] BSA 48 1953, 303.862 pl. 53. On the EPC group, see further Sūkās II 92–93.

[108] Délos X 67–152 pls. 22–37, Délos XVII 87–112 pls. 54–62, AM 74 1959, 64–68 Beilage 108–112 (Samos), ClRh III, Jalysos passim, see sp. pls. 6–7, ClRh IV, Makro Langoni passim, Checraci passim, ClRh VI/VII, Papatislures passim, Checraci passim, ClRh VIII, Jalysos passim, ÉThas 7, 49–50 pl. 18, BSA 53/54 1958/59, 144–151 pls. 24–30 (Old Smyrna), Histria 2, 117–119 pl. 37, Tocra, 21–40 pls. 4–27, Mégara Hyblaea 2, 57–70 pls. 40–58.

[109] Boardman, GO, 31–34, Sūkās I 163 note 656.

[110] Payne, Necrocorinthia, 309.951 pl. 33.11. For a more carelessly painted shield, see two MC cups with armed riders ASAtene 21/22 1959/60, 146–148.68.4 fig. 124, 148–151.69 fig. 127. It is not likely that the sherd belongs to a kothon, of which the interior is generally reserved, see CVA Heidelberg fasc 1, pl. 19.5–6 or decorated for instance by a rosette, see Délos X 152.528 pl. 37.

[111] BSA 44 1949, 218–223.3, 17, Corinth VII.1 78.337–338 pl. 42, Corinth XIII 104–105 grave 147.1–2 pl. 83, Perachora II 255.2475 pl. 101, Mégara Hyblaea 2, 65 pl. 52.5–6,9, Tocra, 25.325, 329–330 note 3 pl. 23.

[112] Corinth VII.1 65.251 pl. 34.

[113] For the decoration inside the foot see Corinth XIII 104–105.162.3 pl. 83, late MC or transition to LC, Tocra, 25.334 pl. 24, Corinth XIII 192 grave 174.1–2 pl. 28.

[114] Tocra, 25.370–81 notes 10–11 pl. 26.

[115] PC: Perachora II 51–53.374–382 pl. 19, Mégara Hyblaea 2, 38 pl. 20.6. MC: Mégara Hyblaea 2, 68 pl. 55.13, Corinth VII.1 78.337–338, 341 pl. 42, Tocra, 25.314–316 pl. 23.

[116] **58** has no band above, a feature more common on smaller kotylai from LC, Mégara Hyblaea 2, 70 pl. 57.7, BCH 94 1970, 401.10–11 fig. 48, than on the equally bad LPC kotylai; they usually have a band along the edge, BSA 44 1949, 51.6–7 pl. 18. 11–12.

[117] **59** seems to have a slip on the exterior and may be an imitation. For the type see Tocra, 25.352–94 pls. 25–26. The broad band looks brighter than the rest of the decoration, but it is not mentioned by the registrar as a red band; for red bands on kotylai, see further Corinth XIII 105, graves 142-b, 163-a, 170-1, 172-b-e, 221-1.

instead of rays are not supposed by H. G. G. Payne to be common until LC.[118] The only krater fragment is the rim sherd **61**; the diagonal zigzags assign the krater to MC or LC.[119] Of the closed vases the fragments of the aryballoi are the best recognizable. **65–66** belong to a common and very widespread class, aryballoi with marching warriors;[120] they are mainly MC and early LC.[121] The inserted dot-rosettes assign **65** to the early phase of MC, the rosettes are known on aryballoi from P. N. Ure's group "b graves".[122] **66** has no filling-ornaments and the "helmet-like" faces are characteristic of the latest phase in the degeneration of the motive.[123] Floral motives decorate the two aryballoi, **67** a–b, but they are not contemporary. On **67** a the slender arch which is connected with the leaf by two transversal stripes is a lotus leaf of the debased form of the horizontal pair of cross-hatched lotuses represented on aryballoi regarded as forerunners of the later and very popular quatrefoil aryballoi.[124] Though the decoration of **67 b** is very sparse, it is obvious that it is not slender and refined as on **67** a; the sherd must belong to a typical quatrefoil aryballos.[125] The latter are late MC or early LC,[126] while the forerunners are considered EC.[127] The description given of the clay of **69** does not seem to approximate to Corinthian clay, and the fragment might be an East Greek imitation of a MC amphoriskos.[128] Vases with dotted friezes like **71** are known already early in the PC series,[129] but were not common until the later phase, were very frequent in EC, and MC vases with similar linear decoration do occur.[130] The sparsely decorated sherd, **72**, is rather C than PC; below the band groups is a wide empty area, which occurs especially on the later Corinthian vases,[131]

[118] Payne, Necrocorinthia, 334, for decoration like that on **60** see ibid. fig. 181 B, but H. G. G. Payne notes that a few are known in MC; add a piece in a MC grave at Corinth, Corinth XIII grave 163 a pl. 25, for totally similar decoration see CVA Reading fasc 1, III C, pl. 2.5 (LC).

[119] Perachora II 231–232.2253 pl. 78 (MC), Mégara Hyblaea 2, 64 pl. 49, 67 pl. 55.2 (MC), Corinth XIII 118 X–134 pl. 89 (LC).

[120] BSA 44 1949, 200 e, 202–204.1,5,11,24,25, Perachora II 150.1579 pl. 63, Corinth XIII 113 with references, Mégara Hyblaea 2, 69 pl. 56.6, Tocra, 29.52–53 pl. 9, Berytus 11 1955, 102.26 pl. 21.6, AA 74 1959, 9–10, 18–19.1–3 figs. 1–2, CVA Reading fasc 1, III C, pl. 4.7–11 with text, CVA Frankfurt am Main fasc 1, pl. 15.10–12 with text.

[121] See preceding note: CVA Reading with references.

[122] P. N. Ure, Aryballoi and figurines from Rhitsona in Boetia, Cambridge 1934, 38–39 IV.vi.b 87.15 pl. 8.

[123] Ure, Aryballoi, 39–41 IV.vi.c 86.72–73 pl. 8. On **66** there might be traces of white dots on the shield; for a late example with white dots, see CVA Reading fasc 1, IIIC, pl. 4.10 with text.

[124] Payne, Necrocorinthia, 146–148 fig. 54 D, 287.485 A, BSA 44 1949, 201, 202.6, CVA Heidelberg fasc 1, pl. 12.1–3 with text.

[125] The dots indicate that the sherd should be ascribed to Hayes Type II see Tocra, 22.79–95 note 10 pl. 9, see further Délos X 91.205 pl. 22, Corinth XIII 114 graves 157–k, 163–c, BCH 94 1970, 399.8–9 fig. 47, CVA Pays Bas fasc 1, III C, pl. 5.13, CVA Heidelberg fasc 1, pl. 13.1–2 with text, CVA Leipzig fasc 1, pl. 32.1–9 with text, CVA Frankfurt am Main fasc 1, pl. 16.1–12.

[126] Corinth XIII 114 with references.

[127] See note 124.

[128] Payne, Necrocorinthia, 314.1073–1089, Délos X 140–141.470–474 pls. 34–35, Tocra, 22.13–14 pl. 6, CVA Reading fasc 1, III C, pl. 7.4 with text. No. **68** is mentioned as having a slip and this sherd might too be from a vase imitating Corinthian.

[129] Perachora II 15.25 pl. 2.

[130] Perachora II 144 (with references to the discussions by Payne and Ure) nos. 1547–1548 pl. 87 (alabastra TR/EC), BSA 53/54 1958/59, 144–145.83, 89, 91 pl. 24 (alabastra EC), Mégara Hyblaea 2, 57 pl. 39.4–5 (alabastra TR), AM 74 1959, 64–65 Beilage 109.2–3 (alabastron and aryballos EC), Mégara Hyblaea 2, 66 pl. 54. 5 (aryballos MC), CVA Heidelberg fasc 1, pl. 9.11 (alabastron E or MC).

[131] Perachora II 210 with references, 214 C; in LC graves: Corinth XIII graves 180–4, 188–4.

whereas the PC linear decoration is scattered regularly all over the belly.[132] Fragments of closed vases with black-figure decoration are only few; **73–77** are decorated with nothing but uncharacteristic parts of animals and filling-ornaments; still on **75** and **76** the latter point to a MC date. Double vertical incisions framing polychrome panels are known on both larger and smaller vases from LPC until LC.[133] It is most likely that **78** belongs to the latter category, perhaps to a flat-based aryballos.[134] Of the two plate fragments **81–82**, **81** is certainly MC, and according to the study of D. Callipolitis-Feytmans it belongs to the middle of the period,[135] but whether **82** is MC or LC cannot be decided.

Indeterminate open vase.

48. TS 232. AASyr 8/9 1958/59, 129 fig. 13. Side sherd. G 11 SE. 3.1×2.5 cm. Pale yellowish clay, black glaze. Exterior: whirligig on circular shield with alternating black and added red spikes, and bordering band framed by incisions. Interior: glazed. *Pl. II.*

Kotylai.

49. TS 517. Sūkās I 50 with note 144. Rim sherd with handle. P 11 SW. 5.5×2.8 cm. White clay with greenish tinge, yellow to brown glaze. Exterior: one band at rim; in handle zone, groups of c. five vertical stripes set close to the handle, below banded, traces of glaze on handle. Interior: glazed. *Pl. II.*

50. TS 2151. Side sherd. P 11 NW. 5.5×3.7 cm. Light yellow clay, black glaze. Exterior: hindpart of marching beast, with red stripes added, straight tail and faint traces of horizontal band above. Interior: glazed. *Pl. II.*

51. TS 2498. Side sherd. P 11 NW. 3.5×3.7 cm. Fine light buff clay, light creamy slip(!), black glaze. Exterior: hindpart of marching beast with red stripes added, faint traces of horizontal band above. Interior: glazed. *Pl. II.*

52. TS 1513. Bottom sherd with ring foot. G 5 SE. H. 6.0 cm, diam. of foot c. 11.0 cm. Fine light buff clay with few mica, red to black glaze. Exterior: rays, at top of sherd glazed field with two added red bands, foot glazed, inside of foot banded. Interior: glazed. *Pl. II.* *Similar*: TS 1024 G 5 SE, TS 1068 G 8 SW, TS 1100 G 8 SW.

53. TS 1042. Bottom sherd with ring foot. G 7 SE. 5.8×2.3 cm, diam. of foot 4.6 cm. Fine light greenish clay, brownish glaze. Exterior: at top, two or three bands, numerous rays; foot glazed, inside of foot banded. Interior: glazed. *Pl. II.*

54. TS 1088. Bottom sherd with ring foot. G 8 SE. 7.3×3.2 cm, diam. of foot 6.3 cm. Fine light reddish to buff clay with some mica, black, brown and red glaze. Exterior: numerous rays, foot glazed, inside of foot: black-red-brown-black-brown bands. Interior: glazed. *Pl. II.*

55. TS 644. Side sherd. G 5 NE. 2.4×1.7 cm. Light brownish clay with mica, black to red glaze. Exterior: forepart of stick-legged goat, "hailstorm", red bands superimposed on the dots which frame the frieze. Interior: glazed. *Pl. II.*

56. TS 2746. Side sherd. J 8 SE. 4.5×3.0 cm. Fine light clay, brown glaze. Exterior: body of elongated animal with hindleg and nearly horizontal tail; at bottom, two narrow bands crossed by stripes radiating from the foot. Interior: glazed. *Pl. III.*

[132] See for instance Perachora II pl. 2.18 passim.

[133] Perachora II 80–81.713 pl. 31 (LPC), Mégara Hyblaea 2, 51 pl. 33.2–3 (TR), 55 pl. 38.9, 12 (TR), 63 pl. 48.6 (EC), D. A. Amyx, Corinthian Vases in the Hearst Collection at San Simeon, University of California Publications in Classical Archaeology I no. 9 1943, 221–223 pl. 30 a–c (MC), Payne, Necrocorinthia, 321–322 C 1294 fig. 162 (LC).

[134] Délos X 114.335–336 pl. 27, CVA Frankfurt am Main fasc 1, pl. 17.2 with text; on the EC football aryballoi single incisions seem to be the rule, see CVA Frankfurt am Main fasc 1, pl. 15.1–2 with text.

[135] BCH 86 1962, 132–133 fig. 8, 152.28 fig. 16.28.

57. TS 1059. Rim sherd. G 8 SE. 3.8×1.9 cm. Light greenish clay, brown to black glaze. Exterior: band at rim, several vertical wavelines, two(?) bands below. Interior: plain, except for broad band at rim. *Pl. III. Similar* (interior glazed): TS 2728 J 8 SE.

58. TS 3436. Rim sherd. H 11 NW. 1.5×1.2 cm. Yellowish clay, brown glaze. Exterior: vertical stripes, two(?) bands below. Interior: glazed, except for band at top. *Pl. III.*

59. TS 3614. Rim sherd. G 13. 2.4×2.5 cm. Yellow clay, brown glaze. Exterior: band at rim, vertical stripes, narrow and broad band below. Interior: glazed, except for band at top. *Pl. III. Similar*: TS 1064 G 8 SW, TS 1442 P 11 SW, TS 3615 G 13.

60. TS 3505. Bottom sherd with ring foot. G 5 NE. Pr.h. 2.1 cm, diam. of foot 3.5 cm. Buff clay, brown to black glaze. Exterior: banded, foot glazed, inside of foot banded. Interior: glazed. *Pl. III. Fig. a.*

Krater.

61. TS 1131. Rim sherd. G 11 SW. 4.2×2.5 cm. Smooth, light yellow to green clay, darker in core, lustrous black glaze. Diagonal zigzags on topside and outer edge. Interior: glazed. *Pl. III.*

Pyxis-lid.

62. TS 520. AASyr 8/9 1958/59, 129 fig. 13. Fragment from upper part. E 8 SW. 4.0×3.0 cm. Fine greyish to buff clay with many grits but few mica, black to brown glaze. Numerous concentric "circles". *Pl. III. Similar*: TS 4717 G 15 SE.

Lekane.

63. TS 1346. Rim fragment with root of handle. G 8 SE. 4.5×2.0 cm. Smooth light buff clay, black glaze. Glazed all over. *Pl. III.* See Tocra, 24 note 5.

"Globular" aryballos?

64. TS 4416. Sūkās I 49–50 no. 35 fig. 15 h pl. 3. Bottom sherd with ring foot. G 15 SW. 6.7×1.6 cm, diam. of foot 3.8 cm. Light brownish clay, reddish glaze. Five narrow bands enclosed by two broad bands, one above the foot and one at the top of the sherd, foot glazed. *Pl. III. Fig. a.*

Spherical aryballoi.

65. TS 623. AASyr 8/9 1958/59, 129 fig. 13. Side sherd. H 5 NW. C. 7.4×c. 1.7 cm. Light red-grey clay with some grits, black to brown glaze. Three marching warriors, fragmentary, inserted dot-rosettes. *Pl. III.*

66. TS 3545. Shoulder/side sherds. G 5 NE. H. c. 5.0 cm, diam. of shoulder c. 6.0 cm. Buff clay, black to brown glaze. On shoulder, radiating leaves and three bands, marching warriors below, incisions used for the helmet-like faces, added red central dot encircled by incision on the shields, and perhaps faint traces of white dots along the border of the shields, at the bottom, two bands. *Pl. III.*

67a. TS 4786. Side sherd. J 13 NE. 2.6×1.7 cm. Fine light yellowish clay, light brownish glaze. Lotus leaf with added red on interior and glazed outlines, attached by two slim bands to curved line. *Pl. III. Fig. a.*

67b. TS 5665. Side sherd. H 12. 3.0×1.8 cm. Fine light brownish clay, dark brown glaze. Dots and part of leaf. *Pl. III.*

68. TS 1317. Vertical handle. Surface. 2.5×2.5 cm. Reddish to buff clay, light slip, red glaze. Vertical zigzag. *Pl. III. Similar*: TS 2841 L 8 SE (rim collar, no handle), TS 3393 H 11 NW, TS 3540 G 5 NW.

Amphoriskos.

69. TS 1038. Neck with roots of handles. G 7 SE. H 4.1 cm, diam. of rim 3.1 cm. Light greyish to buff clay, dark reddish glaze. Bands and wave-line. *Pl. III.*

Other closed vases.

70. TS 5551. Sūkās I 46 no. 26 fig. 15 f pl. 3, 49–50. Rim/neck sherd. G 15 SW. 2.3×1.9 cm, org. diam. c. 8.0 cm. Fine very light brownish clay, black glaze. Exterior: on rim, one broad and two narrow bands; on neck, broad and narrow band. Interior: broad band. *Pl. III.*

71. TS 631. Side sherd. P 11 NW. C. 2.5×2.4 cm. Light greyish to green clay with few mica, black glaze. Three bands dividing two zones with "hailstorm". *Pl. III. Similar*: TS 624 P 11 SW, TS 3006 G 19.

72. TS 612. Side sherd. G 5 SE. 1.9×2.7 cm. Greyish clay with few mica, black to brown glaze. At top glazed zone or bands, below three bands. *Pl. III. Similar*: TS 1077 G 8 SW.

73. TS 1382. Shoulder/side sherd. G 7 SE. 3.5×3.7 cm. Light creamy-greenish clay, very worn black glaze. On shoulder, radiating stripes, four bands below; at bottom, traces of obscure figure. *Pl. III.*

74. TS 306. AASyr 8/9 1958/59, 129 fig. 13. Shoulder/side sherd. F 5 SE. 3.0×1.8 cm. Yellowish to grey clay, black glaze. At top, three or four bands; below, several incisions belonging to a single figure. *Pl. III.*

75. TS 1078. Side sherd. G 8 SW. 4.9×3.1 cm. Greenish clay, black glaze. At bottom, broad band; above, tail of animal(?) next to it irregularly shaped filling-ornament. *Pl. III.*

76. TS 359. AASyr 8/9 1958/59, 129 fig. 13. Side sherd. Surface. 4.1×2.2 cm. Greenish to grey clay, black glaze. Dot-rosette in interstice between neck and wing of bird(?), parallel incisions on "wing". *Pl. III.*

77. TS 1376. Side sherd. G 5 SE. 3.0×3.0 cm. Light buff to greyish clay, black glaze. Hindpart of sitting(?) beast with added red stripes. *Pl. III.*

78. TS 3829. Side sherd. G 5 NE. 2.2×2.1 cm. Light buff clay, dark brown shining glaze. Two groups of vertical double incisions enframing two added red dots. *Pl. III.*

79. TS 2842. Shoulder?/side sherd. L 8 SE. 3.8×3.0 cm. Fine light clay, brown glaze. Banded, with white stripes added. *Pl. III. Similar*: TS 3613 G 13 (no white stripes).

80. TS 4434. Side sherd. G 12 NW. 5.4×4.2 cm. Pale greenish clay, brownish glaze. Three narrow, one broad and four narrow bands. *Pl. III.*

Plates.

81. TS 1. Rim/side sherd. Surface. 12.2×6.0 cm. Pale greenish clay, brownish glaze. Suspension-hole through rim. Exterior: plain rim, except for narrow band on outer and inner edge, leg of feline on floor. Interior: rim plain except for bands on outer and inner edge, hindleg of feline on floor, dot-fillers, and rosettes with incisions. *Pl. III.*

82. TS 1868. Rim/side sherd. G 5 NE. 4.0×3.5 cm. Light buff, somewhat porous clay, red to black glaze. Rim: everted with rib on exterior and groove on interior. Both sides plain except for the edge. *Pl. III.*

VII
Imitations of Protocorinthian and Corinthian Vases

A few sherds can perhaps be distinguished from the true Protocorinthian and Corinthian imports as imitations maybe made somewhere in Eastern Greece. The decoration of the kotylai, **83–85**, is good—not clumsy—and the exclusion is mainly based on the clay which, according to the registrar's description, seems foreign to the clay from Corinth. On **83**, moreover, a creamy slip is applied.[136] **86** is from a fairly

[136] The Corinthian section of the catalogue includes two pieces which might also be imitations, **68** (which appears to have a light slip) and **69**.

large vase on which the scales are rendered by single incisions. In PC and C[137] it is unusual to find this sort of scales, there double incisions seem to have been the rule; but on the most well known imitations, the Italo-Corinthian ware, single ones are very frequent.[138]

Kotylai.

83. TS 2882. Bottom sherd with low foot. J 8 SE. 5.0×1.0 cm, diam. of foot 4.2 cm. Fine buff clay, creamy slip, red glaze. Exterior: numerous radiating rays, foot glazed, band and central dot under foot. Interior: glazed. *Pl. III.*

84. TS 4565. Sūkās I 82 no. 91 fig. 25 h pl. 4. Bottom sherd with low foot. H 13 SW. H. 1.8 cm, diam. of foot c. 7.0×8.0 cm. Rather fine brown micaceous clay, black to brown glaze. Exterior: short radiating rays, glazed field with added red stripe above. Interior: glazed. Foot: glazed on both sides, two bands under foot. *Pl. III.*

85. TS 4701. Bottom sherd with low foot. H 13 SW. 2.7×1.2 cm, diam. of foot 7.0 cm. Brownish clay with some grits, black glaze. Exterior: radiating, probably short rays. Interior: glazed. Foot: glazed on both sides, red band under foot. *Fig. a.*

Closed vase.

86. TS 3416. Side sherd. H 11. 7.0×5.2 cm. Grey clay, black glaze. Glazed field with four rows of incised scales, bottom of sherd plain. *Pl. III.*

VIII
East Greek Wares with Wave/Band Decoration[139]

These wares, which include several shapes of vase, had a wide distribution in Eastern Greece and the colonies from the late 8th century until well into the 5th.[140] The fabric varies considerably, and it is obvious that the wares were produced in many places, but so far only few workshops have been distinguished: on Samos and Rhodes, probably in Cilicia, in Old Smyrna, and Nymphaion in the Crimea.[141] On Tall Sūkās these wares are few, the greatest group constitute the fragments of closed vases, most of them probably belonging to waveline amphorae and hydriae, while a smaller group represents the red glaze and other related kraters and krateriskoi. Because of the homogeneity of the decorative system on waveline vases, the nature of clay and slip is the only indicator for an attribution to a possible workshop. As men-

[137] The motif is most common from LPC to EC.

[138] Mainly on the piriform aryballoi, see for instance CVA Leipzig fasc 1, pl. 20.5–6, more seldom on larger vases, but see NSc 1955, 56.13 fig. 13.

[139] On white slip amphorae, see Chian.

[140] Hanfmann, Aegean, 176–182 figs. 17–25, Tarsus III 316–318.1564–1580, 324–327.1608–1630 figs. 105–108, 148, 150, see further J. Boardman's note on waveline from Tarsus, JHS 85 1965, 9, AM 74 1959, 12–27 (Well F and G passim), 83 1968, 266–268.46–47 fig. 17 pl. 103.1–2 (Samian), Tocra, 42.587 note 3 pl. 29 (Rhodian), 66.843 note 5 pl. 48, Select Exhibition of Sir John and Lady Beazley's Gifts to the Ashmolean Museum 1912–1966, London 1967, 33.85 pl. 7 (Rhodian), Emporio, 137.508 fig. 88, ÉThas 7, 33–34.44–48 pl. 11, BSA 53/54 1958/59, 29 pl. 4 (Smyrnaean), CVA München fasc 6, pl. 305.1–2 (North Ionian), 3 (South Ionian), JdI, Ergh. 23 1967, 144 note 423, BCH 88 1964, 138 note 14, Agora XII 347.1580, 1583 pl. 70 fig. 13, Histria 2, 104–109.536–616 pls. 30–33, 55–57, Fabricius, Arch Karta 1, pl. 8.1,4, Materiali 25 1952, 241 fig. 9.4–5, 50 1956, 232 fig. 11.2, 69 1959, 167 fig. 15.1, 103 1962, 46 fig. 31.1, 143 fig. 18, 144 fig. 19.1–3, BCH 92 1968, 281 fig. 42, JHS 58 1938, 146 fig. 28.24, AASyr 8/9 1958/59, 129, IEJ 12 1962, 106.14, 16 fig. 7. H. Metzger, Xanthos IV. Paris 1972, 47–51.50, 57–66, pp. 54–56 pls. 12, 15–16, 19.

[141] See preceding note.

tioned previously,[142] the writer is not able to comment on the description of the clay given in the catalogue, but the clay is not Syrian, so there was no local production—as for instance in the colony of Nymphaion.[143] In 1956 G. M. A. Hanfmann wrote[144] that one of the three waveline varieties in Tarsus and Al-Mīna was Samian, and later on[145] that the pieces found in Tarsus, Mersin and the Antioch region were made by immediate pupils of the Samian potters, but that one or the other fragment might be Samian. In all probability the sherds from Tall Sūkās should be grouped with the other fragments from North Syria and the Antioch region.[146] To judge by the treatment of the surface of the sherds, at least two different wares were represented on Tall Sūkās. The largest group, **87–92**, is unslipped; two of these sherds are said to have a self-slip, and it cannot be excluded that the others have had a similar "slip" which was overlooked.[147] On two sherds, **93–94**, is found the real slip, which is described as creamy and white.[148] On the unslipped fragments the glaze is usually brownish to black and very often matt;[149] the manner of painting is not clumsy, but slender and precise, and the frequently streaky, diluted glaze does not undermine the effect of competence. The same resolute style is used on a Samian hydria from a bothros south of Hekatompedon II, dated 625–600 B.C.;[150] the band combination on the belly is similar to that of 88, but there is no S-loop on the shoulder. This particular shoulder design is found only on the "later" vases,[151] i.e. on vases from the later part of the 7th century until well into the 5th century.[152] 88 has a comparatively large empty field below the

[142] See introduction.

[143] Hanfmann, Aegean, 179–180 note 43.

[144] Hanfmann, Aegean, 180.

[145] Tarsus III 324.

[146] The hydriae from Al-Mīna are unpublished. Hanfmann, Aegean, 178 (Antioch), Tocra, 66 note 5 (Oxford).

[147] Most of the waveline from Tarsus are slipped (orange/orange-peach or light yellow), and the "local" ware, thought to have been manufactured around the Bay of Iskenderun, has a "poor slip", Tarsus III 326–327; but a few are said to have only self-slip, Tarsus III 324 note 4, 326.1618 fig. 150: ". . . a factory . . . . perhaps in one of the Greek colonies of Cilicia Tracheia or North Syria. Similar or same ware was found in Al-Mīna-Posideon", 326.1623 fig. 108 (Regional Greek). The waveline vases supposed to be Rhodian, see Hanfmann, Aegean, 176–178, never seem to have a real slip; see further a Rhodian waveline amphora from Tocra no. 587 (see above note 140), which is specifically noted to be unslipped. Some of the sherds from Istros are listed as unslipped, Histria 2, 104–105.536–557, 106.569–573.

[148] The Samian slip is sometimes described as yellowish or yellow-white, but more often as "weisslicher", AM 83 1968, 266–268.46–47, usually with a greyish tone, Tarsus III 326 V "local" and Samos V. passim. A yellow slip is noted on some fragments from Tarsus, Tarsus III 319.1585 figs. 106, 149 (perhaps from a Greek colony near Tarsus), 326.1620–21 fig. 108 (Regional Greek).

[149] Without having had the opportunity of comparing all the sherds, the writer distinctly recalls the predominance of this sort of glaze and usually on a resounding and very hard burnt fabric.

[150] AM 74 1959 28, Beilage 48.2.

[151] Hanfmann, Aegean, 180 note 48; for the origin of the motif see note 152: Emporio.

[152] The motif is used already as shoulder decoration on Late Mycenaean vases, see Popham & Sachett, Excavations at Lefkandi, Euboea 1964–66, 16 fig. 29; for a possible relation of Mycenaean with the "later" vases see Emporio, 105 note 2. S-loops on shoulders are not met with on any of the published Samian waveline vases from the 7th century. The earliest Archaic waveline vases with S-loops are: the Tocra amphora/hydria Tocra, 66.843 pl. 48, which has affinities with 7th century Samian waveline, the Al Mīna hydria in Oxford, see above note 146, a hydria from Chios, Emporio, 137.508 fig. 88, which is assigned to the 7th century (it is listed as unslipped). On the white slip wine amphorae the S-loop appears too in the later part of the 7th century, see BSA 49 1954, 168–170, BCH 68 1964, 137–140. The S-loop decoration is almost lacking among the waveline ware from Tarsus, where the bulk of the Greek material is from the 7th century; only one of the published fragments, Tarsus III 317.1568 fig. 105, has a design interpreted as a S-loop; it is found exclusively with 6th century material, and it is probably this sort of waveline G. M. A. Hanfmann refers to as similar to the Al-Mīna hydria in Antioch, see above note 146.

band group; this is unusual on the 7th century waveline, which is decorated in a subgeometric manner with more and closer-set band groups;[153] the exception is the hydria from the bothros.[154] In the 6th century there are several varieties of band groups; among them the system on the hydria from Tell Defenneh, dated to the third quarter of the 6th century,[155] is very similar to 88. Nevertheless the Sūkās fragment is certainly not so late, it is too stylistically related to the bothros hydria. The shoulder field of 88 gives the impression of being more extensive than on vases of the 7th century and perhaps a date in the early 6th century is preferable to a date in the late 7th century. The other sherds are very small and exhibit no datable features. However, as previously mentioned all the unslipped fragments are united technically and should probably be of the same date as 88. The only exception could be **91**, which differs from the rest in having a waveline of considerable thickness. The opposed hooks of **89** are either parts of two S-loops[156] or endings of two horizontal wavelines.[157] The shoulder sherd **93** does not belong to the waveline ware distinguished by G. M. A. Hanfmann,[158] but the same simple decorative system is found on several other vases during the 6th century B. C., for instance on certain other amphorae and hydriae,[159] and perhaps more frequently on jugs.[160] Some fragments from Smyrna are found in levels of the second half of the 6th century,[161] but the shape of **93** is more similar to vases from the first half of the 6th century.[162] The class of red glaze kraters and krateriskoi, the decoration of which is shared by **95–98**, is not as widespread as the waveline ware. So far it is represented on Samos, in Asia Minor, Syria and Palestine; only the pieces from Tarsus,[163] Mersin,[164] Samos,[165] and Palestine[166] have been published, but the ware is reported, too, from Ephesus, Old Smyrna and Al-Mīna.[167] G. M. A. Hanfmann distinguished at least two workshops; he declares the pieces from Tarsus, Mersin and Al-Mīna to be produced in a workshop different from the Samian one.[168] The shape and decoration certainly connect all the fragments from Sūkās with the kraters and krateriskoi in question, but only two, **95–96**, have the red glaze supposed to be the hallmark of the class. **97–98** have a brownish matt glaze most

[153] See the 7th century vases cited in note 152, and Samian waveline AM 74 1959, 21 Beilage 46–48 (Well G), 83 1968, 266–268.47–48 fig. 17 Beilage 103.1–2.
[154] See above note 150.
[155] CVA Brit. Mus. fasc 8, II D p, pl. 4.1.
[156] ClRh IV 361 fig. 408.
[157] ClRh IV 240 fig. 271.
[158] However, the category is perhaps included in the red glaze ware see, Tarsus III 316 note 3.
[159] BSA 53/54 1958/59, 29 pl. 4 c.
[160] BSA 53/54 1958/59, 29 pl. 4 b, J. Sieveking, R. Hackl, Die Königliche Vasensammlung zu München, München 1912, 47.471–472 pl. 17, CVA Leipzig fasc 1, pl. 51.5–6, CVA München fasc 6, pl. 305.4 with text.
[161] See above note 159.
[162] ClRh IV 46.5 fig. 13, an amphora dated 600–580 B.C. by G. M. A. Hanfmann, Aegean, 176.
[163] Tarsus III 316–18.1569–1579 figs. 105–106, 148.
[164] LAAA 26 1940, 123–124 pls. 51.5, 76.1–2, J. Garstang, Prehistoric Mersin, Oxford 1953, 258.10 fig. 161.
[165] AM 54 1929, 33 fig. 24.4. On the Samian red glaze krater the waveline on the neck is incised and not painted; an incised waveline is found too on a Samian krater type, which was introduced in LG and continued all through the 7th century, Samos V 33–35 fig. 17 d pls. 21–25; 52 pls. 62.363, 63.366, 64.369, 74.406 fig. 33 a; 70 pl. 110.565–567.
[166] IEJ 12 1962, 106.14, 16 fig. 7.
[167] Hanfmann, Aegean, 182.
[168] Tarsus III 316.

similar to the glaze on the unslipped sherds, **87–92**, belonging to the waveline amphorae and hydriae. The group including the red glaze ware from Tarsus has a distinctive slip, whereas there is no report of slip on any of the Sūkās sherds. Though we cannot regard the registrar's description of the fragments, **95–98**, as exhaustive, the writer is not disinclined to regard **97–98** as unslipped (but perhaps with self-slip) on account of the resemblance of the glaze to that of **87–92**.[169] Therefore **97–98** should not strictly belong to the class of red glaze kraters and krateriskoi, but might represent a variety, perhaps manufactured in the same region as the unslipped waveline vases referred to above.[170] **95** is reconstructed as a fairly deep krater not unlike the Samian krater which, together with a krater from Smyrna,[171] has tilted loop-handles like **95**. However, the decoration as on **95** does not occur among any of the published pieces of the red glaze kraters. Most of the Tarsian kraters and krateriskoi are round-bottomed and were put on stands, but the krater from Smyrna has a low foot[172] which occurs, too, on the very deep krateriskos, **98**. The same restricted decoration consisting of bands only and a slim slow waveline, as on **97**, is found on some of the krateriskoi from Tarsus and on one of the Palestinean pieces.[173] Unfortunately the stratification for the red glaze ware in Tarsus is not good, it is dated only within the second half of the 7th century and the early part of the 6th century. The Palestinean fragments are dated more closely to the fourth quarter of the 7th century, but the everted neck profile of the two Palestinean kraters differs from the tall, steep neck of the Sūkās fragments. The latter are more related to two Tarsian kraters, one of them from a level of the earliest 6th century.[174] The Sūkās kraters and krateriskoi themselves are found in later contexts. The hemispherical cup, **99**, is, as far as size, shape and interior decoration is concerned, very similar to **137**, which has however thicker walls.[175] Only one vertical strap-handle is preserved, and the type might have been a one-handler; the red glaze and the waveline decoration might connect **99** with the red glaze ware.[176]

Indeterminate closed vases.
Without slip.

87. TS 1173. Side sherd with root of handle, hydria. G 11 SW. 7.0 × 10.0 cm. Fine brown clay with few black grits, brownish to black, rather matt glaze. Above, broad and narrow band; below, broad band, end of waveline and sloping handle-band in handle zone. *Pl. IV.*

88. TS 1279. Shoulder/side sherds with root of neck. P 11 SW. 16.0 × c. 18.0 cm. Red, gritty clay, black in core, some mica, brownish glaze. Root of neck glazed, S-loop on shoulder, group of bands below. *Pl. IV. Similar*: TS 1109 G 8 SW (no S-loop), TS 1797 F 16 SW.

[169] See note 149.
[170] See G. M. A. Hanfmann's observations on red glaze kraters and krateriskoi, Tarsus III 316 notes 3–4; note too one of the Palestinian kraters which has no slip and only brown decoration, IEJ 12 1962, 106.16 fig. 7.
[171] For references see Tarsus III 317 and no. 1569 fig. 105.
[172] Hanfmann, Aegean, 182; on the Samian krater the foot is a reconstruction, which follows an identical but undecorated krater.
[173] Tarsus III 318.1574–1576 figs. 106, 148, IEJ 12 1962, 106.16 fig. 7.
[174] Hanfmann, Aegean, 182, IEJ 12 1962, 97–99. The Tarsian kraters with necks similar to our **95** and **98** are: Tarsus III 317.1569 (1570), 1571 figs. 105, 148.
[175] See p. 38–41.
[176] Hanfmann, Aegean, 173, Tarsus III 316.

89. TS 356. Shoulder sherd. Surface. 3.9×8.2 cm. Buff clay with white grits, light buff self-slip, black glaze. Opposed hooks. *Pl. IV. Similar*: TS 1515 G 5 SE.

90. TS 1481. Neck sherd with root of rim and shoulder. G 11 SW. 5.2×6.0 cm. Red to buff, very micaceous clay, light buff self-slip, brown glaze. Probably offset rim, piercing-hole at upper part of neck. Narrow band immediately below rim; quick waveline on neck. *Pl. IV.*

91. TS 1177. Shoulder sherd with root of neck. G 11 SE. 5.0×4.2 cm. Dark buff clay with some grits, black glaze. Root of neck glazed, thick waveline on shoulder. *Pl. IV.*

92. TS 1066. Bottom sherds with ring foot. G 8 SW. 15.2×6.6 cm. Reddish to buff clay with some white and black grits, black glaze. Band at lower part of belly as well as on foot and at junction with foot. *Pl. IV. Similar*: TS 1292 P 11 NW, TS 1300 P 11 NW.

Slipped.

93. TS 4843. Shoulder/side sherd. H 11 SE. C. 14.5×c. 10.0 cm. Fine, somewhat porous brownish clay, creamy slip, brownish lustrous glaze. Horizontal frieze of close-set U's, broad band enframed by narrow ones below. *Fig. a.*

94. TS 332. Side sherd, probably from hydria. G 8 SW. 5.4×5.2 cm. Red clay with white grits and mica, white slip, brownish rather matt glaze. Slow waveline, enframed by narrow band and glazed field. *Pl. IV. Similar*: TS 12 E 8 NW.

Krater.

95. TS 4847. Rim/neck/shoulder/side sherds, loop-handle. H 11 SE. Diam. of rim c. 30.5 cm. Horizontal groove on the vertical edge of the rim. Fine brownish clay with som grits, reddish glaze. Exterior: rim and handle glazed, remnants of perhaps two wavelines on neck and one on shoulder; at junction with neck, narrow band; banded belly. Interior(?). *Pl. IV. Fig. a.*

Krateriskoi.

96. TS 1065. Shoulder sherd with root of neck and horizontal handle. G 8 SW. 8.0×6.5 cm. Red, very gritty clay with few mica, red glaze. Exterior: narrow band at junction with neck, end of waveline on shoulder, below handle level broad band; root of handle glazed. Interior(?). *Pl. IV.*

97. TS 1075. Rim/neck/shoulder/side sherds. G 8 SW. 10.2×9.0 cm, 8.5×12.8 cm. Reddish to buff clay with white and black grits, brownish glaze. Ledge rim, low cylindrical neck. Exterior: rim glazed, broad band enframed by narrow ones on neck, slow, thin waveline on shoulder; below band. Interior(?). *Pl. IV.*

98. TS 4846. Neck/shoulder/side sherds, low foot. H 11 NE. 17.0×20.5 cm, diam. of foot c. 10.0 cm. Low cylindrical neck. Fine brownish clay with some grits, red to brown, rather matt glaze. Exterior: banded, on neck two bands, on shoulder, two others, belly banded and foot partly glazed. Interior(?). *Pl. IV. Fig. a.*

One-handled(?) cup.

99. TS 97, 531, 534, 568, 930. Rim/side/bottom sherds, vertical strap-handle, low foot. P 11 SW, E 8 NE. Diam. 16.0 cm, h. 7.0 cm. Reddish clay with white grits, red glaze. Exterior: banded; below rim, quick waveline, glazed handle, unglazed foot. Interior: at top, broad and narrow band, small and large concentric circle in central field. *Pl. IV.*

IX
Ionian cups

Black-glazed, two-handled drinking cups usually with a prominent rim are represented on nearly all Eastern Greek and overseas sites from Geometric until

Classical times.[177] Of the Archaic cups the greater part are of East Greek origin,[178] only few examples of the very similar cup-series from the mainland are found eastward.[179] In spite of the multitude of cups, the bulk of the material seems to originate in only two places, Rhodes,[180] where probably several workshops were employed,[181] and Samos;[182] minor and not yet differentiated workshops might occur.[183] Though many of the cups from Tall Sūkās match several of the Rhodian types classified among the Tocra finds, the original and vague name "Ionian" should be preferred for all the Sūkās cups[184] as nothing definite can be said about the place of manufacture. A conclusive determination depends on the nature of the clay, and it has not been possible to examinate it systematically.[185] Beside the sherds of Wild Goat style, the cup sherds constitute the greatest amount of the Greek import on Tall Sūkās. About 250 sherds were fully registered, mostly rim and shoulder sherds, and at least twice as many side sherds were perfunctorily registered during the excavation. The material represents most of the ordinary types; they have been thoroughly dealt with by G. M. A. Hanfmann, G. Vallet–F. Villard and J. Hayes,[186] and the Sūkās cups are as often as possible adapted to the typology arranged by these scholars.

Group 1. *Exterior and interior glazed*

The type represented by **100** is shallow, thick-walled, with short, steep rim and offset shoulder. It has affinities with a cup assigned to the 1st half of the 8th century[187] but the shallowness of **100** connects it closer with LG vases, for instance a Samian skyphos with waveline on the rim;[188] the lower limit is established by another Samian

[177] Hanfmann, Aegean, 167–173 figs. 1–15. G. M. A. Hanfmann demonstrates the relation of the Archaic cups to the MG black-glazed skyphos from the Greek Mainland.

[178] Samian: see note 182, Rhodian: see note 180; Emporio, 135.456–459, 171.860–868 figs. 83, 118, pl. 65, ÉThas 7, 28–30.6–15 pls. 8, B, Hommel, Panionion und Melie, 149–153.1–37 pls. III–V, 2–3, Tarsus III 282–291.1385–1414 figs. 95–97, 144, C. H. E. Haspels, Phrygie III, La cité de Midas, céramique et trouvailles diverses, Paris 1951, 31–32 pl. 8 c.1–5, Histria 2, 78–85.245–260, 262–307 pls. 15–17, Fabricius, Arch Karta 1, pl. 7.5, Materiali 25 1952, 239 fig. 8.1, 50 1956, 227 fig. 5.6, 56 1957, 185 fig. 2 B.7, 69 1959, 161 fig. 6 a–b, 167 fig. 16, 170 figs. 23, 25, Berytus 11 1955, 107–108.87–95 pl. 22.1–7, IEJ 12 1962, 106.1–12 fig. 7, Villard, Marseille, 43–44 pls. 21–23, 45.6–9, 46.1–3, R. Naumann & F. Hiller & E. Naumann, Palinuro I, Topographie und Architektur, RM, Ergh III 1958, 36–38 figs. 1–2. R. Naumann & B. Neutsch, Palinuro II, Nekropole, Terrassenzone und Einzelfunde, RM, Ergh IV 1960, 106–109 note 2 (with references to the finds from Tarent and Sicily) fig. 65 Beilage 2 pls. 32–33, Xanthos IV 43–46 pls. 9–11 fig. 3.

[179] Tocra, 119 notes 1, 4.

[180] Mél 67 1955, 14–34, Tocra, 111–115.1192–1297 figs. 55–57 pl. 87, AM 59 1934, 89 note 2, Hanfmann, Aegean, 173: "I consider it likely that the largest group of "Ionian" cups found in Tarsus, those made of brown clay with matt glaze, came from Rhodes", see further Tarsus III 283.

[181] Hanfmann, Aegean, 172.

[182] Tocra, 115–116.1298–1300 fig. 55, add: AM 72 1957, 41–42, 46, 48–50 figs. 4–5, Beilage 54.3–4, 67.3–4, 69.3, 72.1, 3–4, 74.4, 74 1959, 19, 28 Beilage 33.3–4, 38.1–3 (Well G), 61.4–5, 62.1–2 (Bothros), 83 1968, 257.18–23, 275–279.72–74 figs. 8–9, 27 pls. 95.3–6, 107.3,5.

[183] Tocra, 116.1301–1306 fig. 58 pl. 88. Some of those found in Smyrna are suggested to be local, see Hanfmann, Aegean, 171 note 21, 172. A few cups found in Tarsus are thought to come from the so-called "red glaze area" in Western Asia Minor, see Hanfmann, Aegean, 173, Tarsus III 283.

[184] The term is certainly wrong, the cups are not only produced in Eastern Greece, as was supposed earlier, see Chr. Blinkenberg, Lindos I, Les petits objects, Berlin 1931, 289; for mainland centres see Tocra, 111, 116–120; for the Attic cups see Agora XII 88–90 fig. 4 pl. 18.

[185] See introduction.

[186] See notes 178, 180.

[187] Sūkās I 175 fig. 64.

[188] AM 72 1957, 41 Beilage 53.3: "späteres achtes Jahrhundert".

cup said to be Subgeometric.[189] The profile of **101** is not known but the rim is described as low, slightly everted and offset; the registrar suggested 2nd or 3rd quarter of the 7th century.[190]

Group 2. *Red and white bands added on both sides*

(Hanfmann, Type I, Vallet & Villard, Type A_1, Tocra, Type III).[191]

The minute sherd, **102**, is the only one definitely representing the well known type of cup with polychrome bands from the last third of the 7th century; it is considered Rhodian by some,[192] but other centres are suggested too.[193]

Group 3. *Exterior glazed, except band at handle level*

(Tocra, Type II).[194]

Apparently the rim of **103** is a little steeper than that of the Tocra cup, which is assigned to the late 7th century. Some Samian cups belong to the same period,[195] whereas a Tarsian piece is found with late 7th and 6th century material.[196]

Group 4. *Exterior glazed, red bands added*

The type of **104** is a fairly deep cup with nearly steep rim; it is totally glazed, and the misfired glaze is metallic in appearance; the profile looks early. The type does not occur among the Tocra finds, nor are similar cups published from Samos. A cup of perhaps the same sort is known from Tarsus;[197] the 7th century is suggested by G. M. A. Hanfmann.

Group 5. *Exterior glazed, except rim and band at handle level*; *low foot*

(Hanfmann, Type IV, Vallet & Villard, Types A_2 and B_2, Tocra, Types VIII–IX).[198]

Not unexpectedly the "standard cup" is the sort of cup most fully represented on Tall Sūkās. All the material covering the first half of the 6th century has been divided into three main types, exemplified by **105–107** and the feet **108–109**. The fragments listed as **107** are the most numerous and show the most diversified profiles. Generally the "standard cup" is glazed all over on the interior, with the exception of a narrow band reserved at the top of the rim, but soon after the development of the shape a

[189] AM 54 1929, 34 fig. 28.2.

[190] AM 72 1957, 46 Beilage 67.3–4: 2nd quarter of the 7th century, 48 Beilage 70.1: 3rd quarter of the 7th century, 49 Beilage 72.1, 3: 4th quarter of the 7th century, 74 1959, 19 Beilage 38.1, 3: Well G, 28 Beilage 61.5: Bothros.

[191] Hanfmann, Aegean, 168, Tarsus III 284–285, Mél 67 1955, 15–18, 29, Tocra, 112, 114.

[192] See preceding note: Mél and Tocra, further AM 59 1934, 89 note 2 and Boardman, GO, 72 fig. 10 d.

[193] CVA Frankfurt a.M. fasc 1, pl. 11.1 with text. They are frequent on Samos, see AM 74 1959, 28 Beilage 62.1–2. For the type, see further Berytus 11 1955, 108.88–90 pl. 22.1, 3–4, NSc 1960, 152 fig. 2 b, BCH 86 1962, 384 fig. 79 and CVA München fasc 6, pl. 293.1 with text.

[194] Tocra, 112, 114.

[195] AM 72 1957, 49 Beilage 72.1, 3.

[196] Tarsus III 289.1403 figs. 96, 144.

[197] Tarsus III 288.1394 fig. 96, unfortunately without profile drawing.

[198] Hanfmann, Aegean 170, Tarsus III, 285–286, Mél 67 1955, 18–19, 21–23 figs. 3 a–b, 29, Tocra, 113–115.

variety with a banded interior appeared.[199] This variety is represented on Tall Sūkās by **106**, of which no profile drawing is available; but one of the fragments, catalogued as similar to **106**, is from a deep cup with a rather steep rim, i.e. **106.1**. This fragment most likely belongs to an early version of the type,[200] whereas **106**, with as it seems a more everted rim, should fall later in the first half of the century.[201] **105** and **107** represent the true "standard cup", and the most obvious reason for a distinction between them is that **107** and the fragments similar to it have a taller and more overhanging rim than **105**. The latter is a rather shallow type, and like one of the fragments of its similar group, **105.2**, it is thick-walled, the rim only moderately everted, and the foot, which is incomplete, low and conical—still not much flaring at the bottom. **105** and **105.2** might range among the early "standard cups" from the first quarter of the 6th century.[202] Early versions with thin walls like **105.1** are known too,[203] but the writer is not quite certain if **105.1** is to be included among them. **107** and its similar group together with the feet **108–109** are all of the same sort as Tocra, Type IX, dated to the first half of the 6th century. The greater part of the Sūkās cups are probably from the later phase, i.e. contemporary with Vallet & Villard, Type B_2;[204] for instance **107**, **107.4,7** which belong to smaller cups like some of the Tocra cups dated in the second quarter of the 6th century.[205] **107.3** and **107.5** are from fairly large cups with shallow bodies, the latter very much like a Tocra cup.[206] **107.6** has a very overhanging rim and should be related to the early lip-cups.[207] **107.1** is apparently of bad potting, but with the very flaring rim the shape does not seem early.[208]

Group 6. Exterior glazed, except rim (sometimes with leaf-wreath), band at handle level and band on lower part of side; stemmed foot

(Hanfmann, Type III, Vallet & Villard, Type B_3, Tocra, Types X–XI).[209]

The group is nearly as numerous on Tall Sūkās as the preceding one. The East

[199] Tocra, Type VIII, 113; according to J. Hayes the evolution of this type runs parallel with Type IX of which an early example, 1226, is found in Deposit I, so the type was certainly not established later than 600 B.C.

[200] There is a certain resemblance with Samian cups from the latest 7th century, AM 72 1957, 49 Beilage 72.1, 3.

[201] For the type see BCH 90 1966, 309 fig. 24. Xanthos IV 43–44.43, 44–47 pls. 10, 11 fig. 3.

[202] **105** shows affinities with a Samian cup from c. 600 B.C. AM 72 1957, 49–50 fig. 5, whereas the Sūkās cup does not seem as late as another Samian cup, dated c. 570 B.C. AM 83 1968, 275.72 fig. 27 pl. 107.1. A cup in Munich displays similarity with our cup, CVA München fasc 6, pl. 293.2 fig. 21, dated early in the 6th century.

[203] Villard, Marseille, 43 pls. 23.4–5, 45.7, 8–9, Tocra, 120.1218 fig. 55.

[204] Two feet similar to **108** are assigned to Period G^2 (588–552 B.C.). TS 3804 is found with a Late Wild Goat sherd, Sūkās I 83 note 274 pl. IV no. 107, in the present catalogue similar to **189**. Two other fragments of the similar group have a graffito and a red dipinto under the foot, i.e. TS 2603 and TS 4924, compare, Kardara, A, pl. A, Tocra, 46 fig. 22, Lambrino, Vases, 211–229, Histria 2, pl. 64. The excavators of Palinuro convincingly argue for a durability of the East Greek "standard cup" into the last quarter of the 6th century, see Naumann-Neutsch, Palinuro II, 107–109; this has not been proved from other sites. J. Hayes suggests that most of the cups found in Italy are imitations of probably Rhodian cups, see Tocra, 111 notes 1,3; on Palinuro, see further Hommel, Panionion und Melie, 150–151.

[205] Tocra, 124.1228, 1263 fig. 56. 1228 and 1263 are similar to 1261 which is found in Deposit III, dated 565–530 B.C.

[206] Tocra, 120.1219 fig. 56.

[207] CVA Torino fasc 2, pl. 4.1 dated in the second quarter of the 6th century.

[208] For "standard cups" recently published, see BCH 88 1964, 301 fig. 16, 93 1969, 449 fig. 26, Πρακτ. 1966, 138 Πιν. 122γ, CVA Stuttgart fasc 1, pl. 16.11.

[209] Hanfmann, Aegean, 169–170, Tarsus III 285, Mél 67 1955, 27–29, Tocra, 114–115.

Greek lip-cup is usually assumed to start about the middle of the 6th century and to culminate in the third quarter of the century,[210] but J. HAYES suggests an earlier date for the East Greek "probably Rhodian" cups found in Tocra.[211] The profile can be ascertained only for few of the Sūkās cups; one, that of **121**, is not unlike TOCRA, Type X[212] which is connected with other groups of East Greek vases, including cups with thin lines on the interior of the rim, like our **111–112**[213]–these groups are thought by J. HAYES to belong to the second quarter of the 6th century. The only other recognizable profiles are those of **113–114**[214] and **124**, which all have a distinct, carinated shoulder; none of these cups are as deep as any of the East Greek cups from TOCRA,[215] but a cup from the necropolis of Orvieto has a shallow body very similar to **113**.[216] The Orvieto cup is dated c. 560 B. C. Cups with leaf-wreaths bearing white dots like **122–23** are included too in the early cup series;[217] apart from Tocra this category of cups is not frequent on the sites where it has been found.[218] The cups are thought to have been manufactured in different places, and Samos might have been a very significant one.[219] The Tocra cups are supposed to be Rhodian, they are mostly miniatures, like the only two published specimens from Rhodes.[220] Most of the lip cups from Tall Sūkās are glazed on the interior, except for smaller or larger central tondi, for instance **110**, **116** and **119**, while only two fragments, **125–126**, have the more refined decoration, usually connected with Ionian Little Master cups. On **125** the major part is decorated with thin lines,[221] on **126** these are separated by broader bands.[222]

Group 7. Exterior glazed, except broad band at handle level

The shape of **127 b** is that of a band cup, with slightly everted rim. From the

[210] The group is dated by Vallet & Villard 560/50–30 B.C., see preceding note: Mél.

[211] Tocra, 115. Two fragments of the similar groups belonging to **118**, TS 2345, and to **120**, TS 2129, are assigned to Period G^2 (588–552 B.C.).

[212] Tocra, 124.1288 fig. 57.

[213] Tocra, 124. 1277 fig. 57. Beside the two rim sherds of **112**, a bottom sherd with a foot described as a ring foot is thought by the registrar to belong to the same cup. The ring foot is probably a low conical foot, like on a reconstruction of a cup with thin lines on the interior, Lambrino, Vases, 84 fig. 54. For the type with thin lines, see AM 59 1934, 89–91 Beilage 6.13. Very refined examples recently published are: CVA Mus. Capitolino fasc 2, pl. 2.5, CVA Orvieto fasc 1, pls. 1–2.2, AA 77 1962, 612 fig. 14, CVA München fasc 6, pl. 293.6–7, 294. 4–5 figs. 25–26, dated in the second quarter of the 6th century.

[214] One fragment belonging to the similar group of **114** is found in layers of G^2 (588–552 B.C.).

[215] They more resemble some of the Attic Tocra cups, which are suggested to copy Eastern lip-cups; the date of the Attic type, too, should be before 550 B.C. The Attic Type III, Tocra 115, 118–120, see specifically 129.1353 fig. 64.

[216] CVA Orvieto fasc 1, pl. 1.7 with text: for the same type, see AM 54 1929, 36–37 fig. 28.7.

[217] Tocra, Type XI 114–115.

[218] For Samos, Rhodes, Naukratis and Aegina, see AM 59 1934, 90–99 Beilage 6.4–5, 7.1–2, 5, add: *Istros*: Lambrino, Vases, 85 fig. 56, *Chios*: Emporio, 171.861–863 with note 1 pl. 65, *Smyrna*: BSA 60 1965, 118.25 pl. 26 (atticizing), *Italy*: CVA Mus. Capitolino fasc 2, pl. 2, *Tocra*: see preceding note, Xanthos IV 43.45 pl. 11, p. 46, *no provenance*: CVA München fasc 6, pl. 294.1–2.

[219] Emporio, 171.

[220] ClRh IV 351.6 fig. 296.

[221] AM 59 1934, 90 Beilage 6.15, CVA Louvre fasc 6, II D, pl. 1.12–17, CVA Orvieto fasc 1, pls. 1–2.2 dated 560–50 B.C., CVA München fasc 6, pls. 293.5, 294.3 fig. 24.

[222] CVA Oxford fasc 2, II D, pl. 10.28–29, CVA Louvre fasc 9, II D, pl. 2.7–10, CVA Mannheim fasc 1, pl. 9.5–6, none of them have more than two broader bands; for greater similarity, see Siveking-Hackl, Vasensammlung, 52.525 pl. 18.

description of the clay it is not possible to say whether the fragment is Attic or East Greek, the glaze is not termed metallic, but said to have "a greenish tinge".[223]

Group 8. *Exterior(?); low foot*

A classification of **127** a is uncertain. The registrar describes it as a "bowl or cup"; the decoration on the interior is not consistent with any of the species usually regarded as bowls and **127** a is more likely from a cup. A low foot and a large reserved tondo is known on 6th century cups, see for instance below, **129–131**, group 9.

Group 9. *Exterior unglazed, except rim and shoulder (sometimes band below handle level); low foot*

With the exception of **129–131**, the fragments included in group 9 are very small, all rim sherds. Two sorts of profiles can be distinguished 1) low, everted rather flaring rim, rounded shoulder: **128** a–c, **128** c.**2**, **129–131**, **131**.**1–3**, 2) low, upright rim, angular shoulder: **128** c.**1**, **4–8**. Below the glazed shoulder all the small rim sherds have a fairly large undecorated field, larger than the usual reserved band found on cups of which the exterior is otherwise glazed.[224] Because of the similarity in profile of the first group of rim sherds to the well preserved cups **129–131**, it is proposed that the rim sherds might have belonged to similar cups, i.e. with an unglazed exterior. **129–131** have a reserved tondo on the interior and this is usually a 6th century feature, seen first on the variety of the standard cup and the early lip-cups;[225] **130–131** have the largest tondi and their feet are very similar to those of the latest bird and rosette-bowls, which were not made earlier than 580 B.C.[226] Some of the small rim sherds **128** a–c have been suggested to be early (see catalogue), i.e. from the late 7th century, and one of them, **128** a, may be as early. This specimen differs from the others in having a band below the handle level and in being glazed all over on the interior, a decorative system very much like that found on some early cups from Vroulia.[227] On the interior the other rim sherds and the cups, **129–31**, have a reserved band at the top of the rim, a feature which together with their profiles and unglazed exteriors makes this group resemble a class of cups dated usually 620–580 B.C., but the type presumably continued a little longer—these are the low-footed cups with red and white bands added on both sides.[228] However, none of the rim sherds have any added bands

[223] For East Greek band cups, see AM 59 1934, 89 note 3, AA 29 1914, 222–223 fig. 30, CVA Louvre fasc 9, II D, pl. 2.1–5, CVA Braunschweig fasc 1, pl. 1.3–4 and S. G. Zervos, Rhodes capitale du Dodécanèse, Paris 1920, 297 fig. 559. In Tocra, only Attic band cups occur, they are dated after c. 550 B.C., Tocra, Types VI–VII 118–120.

[224] AM 72 1957, 46 Beilage 67.4, 69.3, 49 Beilage 72, 74 1959, 19 Beilage 38: Well G, 28 Beilage 62: Bothros, 83 1968, 257.22 fig. 9 pl. 95.5.

[225] See above groups 5–6. A reserved interior with a painted tondo occurs on a cup from Cyprus in a CypArc II grave, BCH 92 1968, 281 fig. 43.

[226] Tocra, 45, 55.734 fig. 28.

[227] Kinch, Vroulia, 26 pl. 18.9, 70 pl. 39. 10, 79 pl. 45.20, 78, the latter found with PC lekythos.

[228] Hanfmann, Type II (Aegean, 169, Tarsus III 285), Vallet & Villard, Type B_1 (Mél 67 1955, 23–27, 29 fig. 4 a–j), Tocra, Type V (Tocra, 112–113). In Tocra the cups occur in Deposit II, so the manufacture of the type may have continued later than 580 B.C. A cup from Tarsus is dated 570–60 B.C. Tarsus III 291.1414 figs. 96, 144. For a cup with red bands from the Athenian Agora, see E. T. H. Brann, Late Geometric and Protoattic Pottery, Agora VIII, Princeton 1962, 49.148 pl. 8, with references to the cups from Corinth.

slanting on **157**; the latter represents the typical illustrating of the fast running goat on the late vases.[296] The goats on **158–159** might have been of this type too.[297] Small and not very characteristic fragments of grazing goats occur on **160–164**; on **163** the filling-ornaments are very crowded as is usual on vases from the first quarter of the 6th century,[298] whereas there is no sign of ornaments between the goat-legs on **161**, and the fragment may be late like the oinochoe **154**.[299] On **160** there are remnants of what may be a St. Andrew cross,[300] and on **164** there is a four-leaf flower.[301] **155**, and **165–167** have pure black-figured decoration. On the shoulder sherd, **155**, is part of a sphinx[302] or a siren;[303] the incised line which curls into a spiral indicates the border of the hair, the ear or an ear disk.[304] A stripe may be incised on the deer's ear on **165**, but V-shaped horns are not the usual black-figured type;[305] the closest parallel is found

[296] BCH 86 1962, 407 fig. 100 a, Blinkenberg, Lindos I 282.985 pl. 46 (Kardara, A, 208.7, Schiering, notes 267, 268, 276, Rumpf, 78 II k 10), CVA Oxford fasc 2, II D, pl. 2.5 (Kardara, A, 208.1 (see above 282), CVA Rodi fasc 2, II Dh, pl. 7.1 (Kardara, A, 208.2 (see above note 281), CVA Copenhague fasc 2, II D, pl. 77.3 (Kardara, A, 208.3 (see above note 279), Lambrino, Vases, 256.12 figs. 218–221 (Kardara, A, 210.1, Schiering, notes 318, 319, 322, 617), JdI 1 1886, 139–140.2939 (Kardara, A, 208.4 (see above note 282), Homann-Wedeking, Vasenornamentik, 17.7: Gruppe R).

[297] For the pendent hook, see AJA 59 1955, 51H–J, Kardara, A, 269 fig. 257 below, CVA Oxford fasc 2, II D, pl. 4.9 (Kardara, A, 216.5 (see above note 285) and AA 32 1917, 101.25 fig. 25 (Kardara, A, 181.4, Schiering, notes 151, 152, 373, 408, 668, 716, 773, Rumpf, 78 II f 2).

[298] CVA Oxford fasc 2, II D, pl. 4.31 (Kardara, A, 231.12, Schiering, note 151, Rumpf, 80 III a 22), ActaArch 6 1935, 191 fig. 15 (Schiering, notes 115, 336, 344, 361, 383, 472, 479, 536, 624, 687, 734, 739, 778, Rumpf, 80 III b 1), Kinch, Vroulia, pl. 15 (Kardara, A, 217.2 (see above note 280).

[299] See above, notes 284, 291.

[300] BCH 86 1962, 407 fig. 100 a, 88 1964, 329 fig. 60. For varieties on Fikellura vases and "Clazomenian" sarcophagi, see ActaArch 13 1942, 30 note 55.

[301] CVA Copenhague fasc 2, II D, pl. 77.3 (Kardara, A 208.3 (see above note 279).

[302] CVA Oxford fasc 2, II D, pl. 4.32 (Kardara, A, 226.2, Schiering, note 151, Rumpf, 80 III a 23), JHS 44 1924, pl. 8.16 (Kardara, A, 230.1, Schiering, notes 151, 756, Rumpf, 80 III a 31), BCH 86 1962, 406 fig. 100 b.

[303] Naukratis II pl. 11.3 (Kardara, A, 235.1, Schiering, notes 308, 309, 316, 317, 455, 472, 778, Rumpf, 80 III d 1).

[304] Females on Corinthian vases seldom wear jewellery in their ears, the ear itself is usually distinctly rendered, see AJA 65 1961, 3 pl. 4 c, 5 pl. 5, but on less carefully drawn Corinthian figures a stylization of the ear similar to that of **155** occurs, CVA Frankfurt am Main fasc 1, pl. 16.13–15. The sphinx on a Late Rhodian plate wears a disk in her ear, Naukratis II pl. 12 (Kardara, A, 236.1, Schiering, notes 246, 451, Rumpf, 82 IV a 5), and on a fragment of an oinochoe, likewise from Naukratis, the stylization may indicate an ear as well as an ear disk, CVA Oxford fasc 2, II D, pl. 4.51 (Kardara, A, 226.4, Schiering, note 151, Rumpf 80 III a 29); otherwise ear disks are not used on sphinxes etc., in the earlier or in the later Wild Goat Style. They appear from time to time on Chian; on Animal Style chalices, CVA Heidelberg fasc 1, pl. 3.12, and on Simple Figure Style chalices, BSA 60 1965, 141.10 pls. 42, 44; not usually on Chian Black-Figure, but see JHS 44 1924, pl. 12.16; sometimes the stylization is so pronounced that it is difficult to decide if it is all ear or if a disk is attempted, ibid. pl. 12.8; in the "Grand Style" the ear itself is carefully rendered, and ear disks occur, ibid, pl. 6.1. See furthermore the remarks of R. M. Cook on the ear types on "Clazomenian", CVA Brit. Mus. fasc 8, 28 Postscript.

[305] Black-figured: AA 29 1914, 228–231 fig. 43 (Kardara, A, 210.1 (see above note 286). The Corinthian version of horns is different from **165**, CVA Bruxelles fasc 1, III C, pl. 3.4 a. On a bowl from Naukratis the deer might have had a pair of horns similar to **165**, but in the drawing published by Chr. Kardara the horns look reconstructed, Kardara, A, 245. 4 fig. 198 (Schiering, notes 267, 277, 365, 776, Rumpf, 81 III f 2), see further JHS 8 1887, 121 pl. 79 above (the sketch here is probably not reliable); J. M. Cook compares the bowl to the Miscellaneous East Greek Black-Figure from the second quarter of the 6th century, BSA 60 1965, 120, and our fragment may belong to these, the latest of the Orientalizing East Greek vases; on the group, see below p. 74. In the Wild Goat Style deer rendered in silhouette and outline often have the double horns, ClRh VI/VII 85.1 figs. 91–93, 95 (Kardara, A, 101.1, Schiering, notes 120, 125, 127, 371, Rumpf, 71 III D 13), Samos V 75–76.616 pl. 125 (Kardara, A, 68.13, Schiering, note 200, pp. 10, 45, 50), Schiering, Werkstätten, 49 note 371, and the black-figured deer in question may be of the same type as the one illustrated on these 7th century Wild Goat vases rather than the one favoured on the Corinthianizing Wild Goat vases.

in the fragments of a dinos in Cambridge, possibly related to "Clazomenian".[306] On **166** the raised leg looks like a paw of a beast, and the upright position of the animal, the lack of differentiation between head and neck, and the stylization of the head are features usually connected with a lion with frontal head.[307] The leg is raised to an uncertain angular design, which may perhaps be interpreted as a meander, or a most unusual version of a tail of a bull.[308] The slim and somewhat elongated body on **167** belongs either to a crouching griffin[309] or to a sphinx.[310] **168–169** are rim and neck fragments; **168** has a white rosette on the interior,[311] **169** a white painted eye on the exterior; eyes with slender contours like those of **169** are found mainly on Late Wild Goat vases, frequently on those in mixed technique.[312] The handle-rotelle, **170**a, probably belonged to a vase from the last quarter of the 7th century.[313] **171–191** are ascribed to amphorae, a shape not met with among the Wild Goat vases until the late phase.[314] Of **171** nearly one half is preserved; the large goats which occupy the shoulder field of a great many of the amphorae are not usually rendered with their heads pointing straight forwards and in marching posture as on **171**.[315] In other respects too **171** differs from the other amphorae: it has several filling-ornaments,[316] vertical panels with meanders[317] and four narrow bands below the shoulder

[306] CVA Cambridge fasc 2, II D, pl. 19.1–5, BSA 47 1952, 138. F1 a–c, 139 note 64 (139: "They are, I think, to be dated a little before the middle of the sixth century, earlier than any of the pieces listed above. If so, they mark an early — probably experimental stage in the Clazomenian b.f. style"), BSA 60 1965, 131.

[307] For a lion with frontal head, see BSA 60 1965, 120.32 pl. 26. The latter has whiskers like our lion —the frontal lions without mane are still conventionally called panthers, but see below note 378.

[308] For a lion "attacking" a bull from behind, see CVA Cambridge fasc 2, II D, pl. 18.38 (Kardara, A, 223.2), ActaArch 13 1942, 26 fig. 15 (Kardara, A, 211.1 (see above note 286).

[309] Like CVA Oxford fasc 2, II D, pl. 4.30 (Kardara, A, 227.10, Schiering, note 151, Rumpf, 80 III a 21), CVA Cambridge fasc 2, II D, pl. 18.32 (Kardara, A, 224.17, Schiering, notes 420, 439).

[310] Like Délos X 38–39.59 pl. 12 (Kardara, A, 208.5 (see above note 282), Homann-Wedeking, Vasenornamentik, 17.5).

[311] Otherwise white rosettes are found on the exterior of the rim of Wild Goat oinochoai; but see a Fikellura oinochoe in Paris which has white lotus flowers and buds painted on the interior of the trilobe rim, CVA Louvre fasc 1, II Dc, pl. 5.12, Zervos, Rhodes, 143 fig. 336, BSA 34 1933/34, 39.S1, 41: "continue the Rhodian tradition", dated c. 550 B.C.

[312] ClRh III 76–77.14 fig. 67 pl. A (Kardara, A, 208.2 (see above note 281, Homann-Wedeking, Vasenornamentik, 14, 17.4: Gruppe R), CVA Copenhague fasc 2, II D, pl. 77.3 (Kardara, A, 208.3 (see above note 279); on late vases in silhouette and contour technique, see CVA Torino fasc 2, II D, pl. 3.2, Kardara, A, 182.6 fig. 149 (Schiering, notes 152, 155, 174, 472, 608, 654, 774, Rumpf, 78 II f 5), 236.1 fig. 196 (see Schiering, pl. 6.4), 237.2 fig. 197. Late oinochoai with only floral decoration have the same sort of eye, Tocra, 42.591 pl. 30. On Classical Camiran vases the contours are usually broader, CVA Louvre fasc 1, II D, pl. 5.1 (= Zervos, Rhodes, 32 fig. 45, 133 fig. 304, pl. 26 fig. 500 (Kardara, A, 104.1, Schiering, notes 120, 130, 133, 135, 428, 433, 445 a, 461, 724, 733, 743 a, Rumpf, 70 III A 4), CVA München fasc 6, pl. 275 "Sub-Camiran" (Kardara, A, 190.2, Schiering, notes 126, 133, 136, 147, 460, 571, Rumpf, 72 III D 43).

[313] ArchRep 1962/63, 41 fig. 17; for the same motif used as filling-ornament, see ClRh VI/VII 218–219 pls. 6–7 (Kardara, A, 104.2, Schiering, notes 6, 120, 123, 133, 349, 367, 424, 433, 499, 635, 637, 724, 736, 744, 746, Rumpf, 70 III A 2), BSA 61 1966, 153.1 pl. 31.

[314] BSA 34 1933/34, 55, Schiering, Werkstätten, 27–28.

[315] Only the sphinx on the amphora in the Louvre has the same appearance, Zervos, Rhodes, 52 fig. 94 (Kardara, A, 189.1, Schiering, notes 182, 424, 433, 616, 630, 644, Rumpf, 72 III d 1).

[316] On the Louvre amphora (see preceding note) filling-ornaments occur in similar numbers, but they seem related to the Classical Camiran Style, whereas the filling-ornaments on **171** are similar to those employed on vases in mixed technique; the latter type of filling-ornament occurs on most of the other amphorae, but here the trend is towards larger and fewer ornaments, see for instance Délos XVII 58–59.4–7 pl. 39. Note some fragments from Istros on which the filling-ornaments are still small and rather crowded, Histria 2, 59.29 pl. 3, the vase is listed as an oinochoe, but might be an amphora.

[317] The panels are usually filled with dots: JdI I 1886, 140. 2944 (Kardara, A, 209.2, Schiering, note 185, Rumpf, 78 II g 3), AA 7 1892, 170.175 (Kardara, A, 210.3, Schiering, notes 185, 525, Rumpf, 78 II g 2), Délos XVII 60.14 pl. 41 (Schiering, note 537).

field.[318] These features suggest an origin early in the first quarter of the 6th century.[319] The filling-ornaments on **172–173** look identical, and the fragments may belong to shoulder fields, A and B, of the same vase. On **172** one of the forelegs is stretched forwards, the other one is nearly kneeling[320] — on **173** the goat is marching, its legs perhaps rendered like those of the goat on **171**. There are no traces of pendent tongues above the goat on **172**, and the filling-ornaments were probably sparse, so the vase should be classed among the latest amphorae from c. 580–60 B.C.[321] The same may hold good for **175–177** on which the goat type canonic for the amphorae is shown.[322] The goat's head on **174** is not turned backwards, and, as mentioned above, this is strange on amphorae;[323] the fragment may be connected with the earliest of the amphorae from Delos/Rheneia.[324] **178–184** belong to amphorae with exclusively large floral motives in the shoulder fields, a group not strictly regarded as belonging to the Wild Goat style, but to be derived from the latest Wild Goat vases.[325] On **178** the inner part of a pair of large volutes occurs,[326] on **181** the root of the neck is preserved, and the small leaf should thus illustrate the upper leaf of a similar pair of volutes;[327] remnants of large, nearly horizontal handle-palmettes occur on **179–180**, and they too can be combined with large volutes.[328] **183** is obscure; the motive resembles that of the handle-palmettes, but the wheel-marks seem to make the usual placement in the shoulder field impossible. Sherds with part of a vegetable motif nearly identical to **182** have been found in Istros[329]—linked circles with buds between as on **184** occur on the shoulder of an amphora from Tocra.[330] On **185–186** are remains of probably short neck-cables like those usually found on amphorae. The leaf of **186** is rounded—on

[318] On the Louvre amphora (see note 315) there are three bands, but usually the number is one or two: AA 29 1914, 222–223 fig. 29 (Kardara, A, 251.1 (see above note 284), Tocra, 41–42.580 pl. 28, Délos XVII 59–60.8–11 pl. 40 (Schiering, note 185).

[319] The Louvre amphora is dated 610–590 B.C., Kardara, A, 189, whereas the amphorae with very few filling-ornaments, no vertical panels, and only few horizontal bands on the belly are suggested to have a later date, c. 580–60 B.C., see Tocra, 41–42.580–581 pl. 28.

[320] The posture is known already on the later Classical Camiran vases, Kardara, A, 100.13 Paris = Zervos, Rhodes, 59 fig. 108, Schiering, notes 120, 356, Rumpf 71 III D 24), it recurs on a later but related vase, CVA München fasc 6, pl. 275.450 (Kardara, A, 93.7, Schiering notes 6, 56, 120, 424, 433, 507, 612, 743 a, Rumpf, 70 III B 2), and on one of the amphorae from Rheneia, Délos XVII 58–59.6 pl. 39 (Schiering, note 185). A similar posture occurs on some of the Fikellura vases, CVA Brit. Mus. fasc 8, II Dl, pl. 3.2, BSA 34 1933/34, 63.

[321] Tocra, 41–42.

[322] Add to the examples enumerated by J. Hayes (see preceding note): Histria 2, 59.25–26, 29 pls. 2–3 (early type), 59.27 pl. 2 (later type), 59.28, 60.31–32, 34 pl. 3.

[323] See note 315. Goats placed in the shoulder fields of oinochoai seldom have such slanting bodies, see for instance Kardara, A, 100.4 fig. 65 (cf. Zervos, Rhodes, 59 fig. 108 (see above note 320), CVA München fasc 6, pl. 275.450 (Kardara, A, 190.2 (see above note 312); the very slanting body occurs only on the belly friezes, CVA Oxford fasc 2, II D, pl. 2.4–5 (Kardara, A, 208.1 (see above note 282).

[324] From the early 6th century, Délos XVII 58–59.6, 8, 10 pls. 39–40 and Vroulia, 228 fig. 116 (Kardara, A, 210.5, Rumpf, 78 II g 4).

[325] Gnomon 1965, 506, Tocra, 41–42.

[326] Like Délos XVII 58.2 pl. 38 (Schiering, notes 185, 187, 535, 608).

[327] Another variety, see Tocra, 41–42.583 pl. 28.

[328] Besides on amphorae, this type of handle-palmette is very frequent on oinochoai, Délos X 38–39.59–60 pl. 12 (see above notes 273, 282), Homann-Wedeking, Vasenornamentik, 17.5–6: Gruppe R), and we cannot be sure if **179–180** really belong to one of the late amphorae — or to an oinochoe.

[329] Histria 2, 59.23–24 pl. 2.

[330] Tocra, 41–42. 583 pl. 28.

185 it is pointed like the one on **172**;[331] open cables as on **187** are connected with the latest Wild Goat vases and the amphorae with exclusively floral ornaments.[332] Red and white stripes added on dividing bands were introduced on the Late Wild Goat oinochoai[333] and they still occur on the broad bands of a great many of the late amphorae, like the ones to which **188–189** belonged[334]—but accessory colours are surely excluded on some, perhaps the later ones.[335] Our **191** belongs to the latter category. A large group of sherds, **192–253**, has been catalogued as belonging to indeterminate closed vases; most of them are tiny side sherds which mainly belong to the Late Wild Goat style. The goats on **192–197** probably all represent the late type with its head turned backwards.[336] It is not possible to talk about a uniform style of drawing in the goats represented on the fragments from Tall Sūkās, but generally a certain similarity to the material from Istros may be noted.[337] The ear of **198** is apparently drawn exclusively in silhouette and the goat might have been in black-figured technique. **199** perhaps has a broad neck collar and the fragment might thus be connected with a one-piece amphora.[338] For the S-loop on **200**, see above.[339] **202** may have belonged to one of the latest Wild Goat amphorae on which the original panels are provided by only one or two vertical stripes.[340] On **204–206** three different versions of black-figured birds are represented: **204** probably with raised wings,[341] **205–206** apparently marching;[342] other black-figured animals occur on **207–210**.[343] Most of the filling-ornaments on **212–226** are to be included among the stock of ornaments em-

[331] Both varieties occur on the latest amphorae, see Tocra, pl. 28.580–581.

[332] Délos XVII 58.2–4 pls. 38–39 (amphorae, see above note 326), 60.15 pl. 42 (flat-bottomed oinochoe, Schiering, note 171).

[333] BSA 34 1933/34, 71 fig. 10, Vroulia, 228. R. M. Cook, Greek Painted Pottery, London 1966, 122.

[334] Délos XVII 58–60.2–3, 5–8, 10–11 pls. 38–40 (see above notes 320, 326).

[335] Délos XVII 58.4, 59.9 pls. 39–40, (see above note 326), Tocra, 46.580 pl. 28.

[336] This posture is to be accepted, too, for **192**, **196–197**, as the heads of the goats seem to be raised.

[337] Compare **176** for instance, with Lambrino, Vases, 256.12 figs. 218–221 (Kardara, A, 210.1 (Schiering, notes 318–22). Eyebrows and nose-wrinkles never seem to occur on our goats, whereas these features are very frequent in the material from Naukratis, CVA Oxford fasc 2, II D, pl. 4 passim, CVA Cambridge fasc 2, II D, pl. 18.12 and passim; the same features are found only on few of the goats from Istros, Lambrino, Vases, 251.11 fig. 217 (Kardara, A, 109.1), 256.13 fig. 222 (Kardara, A, 274.2), Histria 2, 57.4 pl. 1.

[338] Tocra, 41–42.588 pl. 29 (goat), Lambrino, Vases, 243–244.2 figs. 205–207 (floral motif, Schiering notes 185, 544, 547).

[339] See note 285.

[340] Tocra, 41–42.581 pl. 28. **371** catalogued as "Unclassified East Greek" may have belonged to a similar amphora.

[341] Compare CVA Oxford fasc 2, II D, pl. 4.33 (Kardara, A, 230.2, Schiering, note 151, Rumpf, 80 III a 24). The type occurs in Corinthian, Corinth VII.1, 65.251 pl. 34, but usually the Corinthian birds do not have raised wings, NSc 1960, 144 fig. 9; the latter type prevails too on the Late Wild Goat vases on which black-figured technique was employed, JHS 44 1924, pl. 8.13 (Schiering, notes 267, 268, 277, 343, Rumpf, 81 III f 15), CVA Oxford fasc 2, II D, pl. 4.37A, 47 (Kardara, A, 234.25, Schiering, notes 267, 277, Rumpf, 81 III f 9, Kardara, A, 248.9, Schiering, note 200, Rumpf, 81 III h 11).

[342] **205:** CVA Oxford, fasc 2, II D, pl. 4.47 (Kardara, A, 248.9 (see above note 341); **206:** the fragment is rather large and the stylization is not equal to that of the usual Wild Goat birds or sirens; the polychromy might point to "Clazomenian" pottery, but the slip of **206** seems to contradict this–the sherd is perhaps to be connected with the so-called "Indeterminate East Greek Black-Figure", BSA 60 1965, 120, Gnomon 1965, 506, see below p. 74.

[343] **207:** possibly a boar, compare Naukratis I pl. 6.3 (see above note 281); **208:** see Naukratis I pl. 13.2 (Schiering notes 267–8, Rumpf 81 f 29); **209:** for the filling-ornament, see NSc 1960, 148 fig. 13 b, ActaArch 13 1942, 49 fig. 30 (Kardara, A, 233.11, Schiering, notes 409, 778, Rumpf, 83 IV e 1), BCH 86 1962, 407 fig. 100 b; **210:** the white-spotted animal might have an incised belly-line and below the abdomen part of a filling-ornament. For this type, see a lid from Smyrna not of the ordinary Late Wild Goat Style, but assigned to the "Indeterminate East Greek Black-Figure", BSA 60 1965, 120.32 pl. 26.

ployed on vases in mixed technique, only one fragment, **216**, might belong to the last quarter of the 7th century.[344] **227–234** have only linear decoration which occasionally represents floral motives;[345] **235**, **237–239** have meanders as dividing bands,[346] **240** a waveline.[347] Chequers, which occur on **242**, are only seldom found on Wild Goat vases[348] and the writer only knows of one example where the chequers are placed immediately above the rays radiating from the foot.[349] The motif is more frequent on later vases as "Clazomenian"[350] and other East Greek Black Figure.[351] The neck-cable, **244**, may have belonged to an amphora or to an oinochoe.[352] **243**, **245–250** are bottom sherds and fragments of the lower part of the belly, on which only bands and rays appear;[353] **251** is perhaps an amphora handle.[354] **252–253** are from vases either

[344] **212:** compare BCH 88 1964, 329 fig. 60; **213:** might be from a late amphora, see note 340; **214:** see CVA Oxford fasc 2, II D, pl. 2.5 (Kardara, A, 208.1 (see above note 282), but probably **214** did not belong to a vase on which the filling-ornaments were so crowded. It is rather from a more sparsely decorated specimen, as for instance, Tocra, 41–42.580 pl. 28; **215:** ClRh III 76–77.14 fig. 67 pl. A (Kardara, A, 208.2 (see above note 281); **216:** the ornament is well known on 6th century vases with very crowded filling-ornaments, Naukratis II pl. 8.1 (Kardara, A, 244.3, Schiering, notes 267, 268, 277, 279, 343, 395, 546, 547, 592, 594, 605, 608, 776, 778, Rumpf, 81 III f 1), AJA 63 1959, 183.5 pl. 48 fig. 8 (Kardara, A, 247.1). However on **216** the ornament seems to be the only one between the legs, as found frequently on vases of the later Classical Camiran Style, ClRh VI/VII 85.1 figs. 91–93, 95 (Kardara, A, 101.1 (see above note 305), on which the bodies of the goats are horizontal like that of **216**. The remnant of the leg on **216** indicates that our goat was not marching, but running fast like the goats on an oinochoe from Camiros, see Zervos, Rhodes, 44 fig. 77 (Kardara, A, 95.5, Schiering, notes 120, 134, 349, 397, 472, 474, 580, 704, 708, 736, Rumpf, 70 III C 4); compare the typical running position of the 6th century goat, Blinkenberg, Lindos I 282.985 pl. 46 (Kardara, A, 208.7 (see above, note 296) - our fragment may have belonged to a vase from the 7th century; **217:** CVA Oxford fasc 2, II D, pl. 2.5 (Kardara, A, 208.1, (see above note 282); **218:** the fragment is described as a side sherd, but might rather have been from the shoulder of an amphora, compare Délos XVII 60.14 pl. 41 (see above note 317); **219–220:** see Histria 2, 59.26 pl. 2 and Tocra, 41–42.580 pl. 28; **221:** see CVA Oxford fasc 2, II D, pl. 2.4–6 (Kardara, A, 208.1 (see above note 282), but our sherd belonged to a vase with more sparse filling-ornaments; **222:** Tocra, 41–42.588 pl. 29; **225:** BCH 86 1962, 407 fig. 100 a; **226:** the rosette is very large, compare Naukratis I pl. 6.5 (Schiering, notes 267, 268, 277, Rumpf, 81 III f 26), Kinch, Vroulia pl. 15 (Kardara, A, 217.2 (see above note 280); **224:** the fragment is strange, but compare the late amphorae with horizontal handles on the shoulder, Schiering, Werkstätten, 28 with references.

[345] **227–229:** probably all shoulder sherds, compare Kardara, A, 237.2 fig. 197, ArchRep 1962/63, 46 fig. 26, Délos XVII 58.3 pl. 38 (see above note 326), ClRh VI/VII 508 figs. 33, 35 (Schiering, notes 69, 188, 525, Rumpf, 78 II h 7–8), AA 7 1892, 170.174 (Schiering, notes 69, 142, 143, 377, 422, 441, 568, 572, 585, 624, 633), 170.175 (see above note 317); **231:** perhaps part of a large pair of volutes, like Délos XVII 58.2 pl. 38, but the fragment might possibly be Chian, see Lambrino, Vases, 126.7 fig. 68 c; **233:** graffito, see Kardara, A, pl. A, Lambrino, Vases, 211–229 figs. 168–202 and Histria 2, pl. 64.

[346] **235, 237–238:** broken meanders like Délos XVII 58–59.5–7 pl. 39 (see above note 334); **239:** hook meanders very often on oinochoiai in mixed technique CVA Copenhague fasc 2, II D, pl. 77.3 (Kardara, A, 208.3 (see above note 279), Délos X 38–39.59–60 pl. 12 (Kardara, A, 216.1 (see above note 273), 208.5 (see above note 282).

[347] **240:** ClRh VI/VII 495–496.1 fig. 22 (Kardara, A, 283.5, Schiering, notes 69, 142, 387, 573, 619, 645, Rumpf, 75 I c 3), D. M. Robinson, Catalogue of Greek Vases, Toronto 1930, 66–67.205–C259 pl. 18 (Kardara, A, 100.5); **241:** compare the late amphorae, Tocra, 41–42.580, 588 pls. 28–29.

[348] Kardara, A, 67.3 (Schiering, note 188); on a stand, see Vroulia, 191–192 fig. 73 (Kardara, A, 274.1, Schiering notes 93, 282, 291, 348, 731, Rumpf, 79 II 1.1), see too Naukratis II pl. 11.3 (Kardara, A, 235.1 (see above note 303).

[349] Fairbanks, Catalogue, 105.315 pl. 33 (Schiering, notes 267, 268, 277, 278, 534, 621, Rumpf, 81 III f 20).

[350] BSA 47 1952, 144, BSA 60 1965, 128–132.64–84 pls. 34–36.

[351] BSA 60 1965, 121.37 pl. 28.

[352] Délos XVII 59.10 pl. 40 (see above note 334), Kardara, A, 237.2 fig. 197.

[353] Distinguishing between the bottom fragments on the basis of the number of the rays is not quite safe–but in general the early amphorae seem to have rather close-set rays, AA 7 1892, 170.175 (Kardara, A, 210.3 (see above note 317), and there is a tendency towards fewer rays on the later amphorae, Délos XVII 58.2 pl. 38 (see above note 326) and Tocra, 41–42.588 pl. 29. For the red dipinto under the foot of **247**, see Tocra, 46 fig. 22.

[354] AA 7 1892, 170.175 (Kardara, A, 210.3 (see above note 317).

totally glazed or with glazed friezes on which the decoration is incised.[355] Several fragments, **254–282**, have been ascribed to larger open vases, i.e. kraters or dinoi. The krater shape most frequently represented is the MC low-necked column krater;[356] black-figured technique prevails, only **254** could perhaps be assigned to a krater on which the old Ionian technique is employed.[357] On **255** the meander band is placed immediately below the metope.[358] **256–258** and perhaps **264** have a frieze of pendent tongues above the metope,[359] on **259** it is abandoned.[360] **257–258** have only Corinthian filling-ornaments;[361] the griffin, **257**, has an extraordinarily tall neck, and it might be that only a protome was intended,[362] the rounded design below the corner-palmette is placed much too low to be interpreted as a wing.[363] Representations of large water-birds are very popular in the metope of Corinthian kraters,[364] and likewise on the Eastern versions of the column krater: **260–261** are to be ascribed to kraters with such scenes.[365] The double incisions, the stylization of the mane, the heart-shaped ear and the nearly circular eye are features which connect the lion on **262** with the Wild Goat tradition.[366] The animal on **263** might be a bull.[367] The letters on **265** are assigned to the 1st half of the 6th century.[368] Rim fragments decorated with meanders, continuous like **266** or broken like **267**, may come from column kraters as well as

[355] Lambrino, Vases, 275–278.46–51 (assigned to oinochoai). Dark friezes with incised floral motifs, lotuses (like **252**) are frequent on dinoi and kraters in mixed technique, CVA Oxford fasc 2, II D, pl. 4.29 (Kardara, A, 225.30, Schiering, notes 287, 297, 409, 484, 587, 594, 778, Rumpf, 80 III c 21), Kinch, Vroulia, pl. 15 (Kardara, A, 217.2 (see above note 280). A group of amphorae and situlae together with the Vroulia cups display the same technique, CVA Karlsruhe fasc 2, pl. 47.5 with text, CVA Brit. Mus. fasc 8, II Dm, pls. 2–8 Appendix A VIII, Kinch, Vroulia, 174–194 figs. 58–72 pls. 10–12, 46.

[356] Schiering, Werkstätten, 40–41. See furthermore BSA 60 1965, 122–123 and Payne, Necrocorinthia, 300–301. Some of our fragments have no description of their interiors, and the writer is aware of the fact that they might have belonged to closed vases. When catalogued as belonging to kraters, it is mainly because of the large dimensions of the figures represented and the vertical, glazed panels, which seem broader than is usual on oinochoai.

[357] Like that of a krater in Leningrad, Kardara, A, 250.1 fig. 199. For the corner-palmette on **254** compare Histria 2, 62.64 pl. 5.

[358] This is seldom seen, but occurs on an Aeolic krater from Pitane, ArchRep 1964/65, 36 fig. 5.

[359] The same sort of tongues appear on some of the North Ionian kraters, too, for instance BSA 60 1965, 121.34 pl. 27.

[360] This is strange on Wild Goat kraters; nevertheless see a fragment in the Hague assigned by W. Schiering to the Vlastos group, Werkstätten, 40 note 308.

[361] For a corner-palmette similar to that of **257**, see the krater in Bonn, ActaArch 13 1942, 24 fig. 12 (Schiering, notes 308, 314, 317, 409, 468, 588, Rumpf, 83 IV d 1); the other side of the same krater is published in AA 51 1936, 378–379.27 fig. 30.

[362] Protomes of griffins on Late Wild Goal vases usually have very long and rather powerful necks: JHS 44 1924, 200 fig. 31 (Kardara, A, 228.4 fig. 237, Schiering, notes 437, 439, Rumpf, 80 III e 9), CVA Oxford fasc 2, II D, pl. 4.36 (Kardara, A, 224.20 fig. 238, Schiering, notes 287, 437, 542, 755, Rumpf, 80 III e 4), Tocra, 41.590 fig. 23 pl. 30, Kardara, A, 235.4, 237.2 fig. 197 and Schiering, Werkstätten note 437 with further references. See furthermore CVA München fasc 6, p. 20 text to no. 3.

[363] For regular wings, see AM 54 1929, 20, 22, fig. 15.3, Beilage 10.2 (Kardara, A, 218.6, Schiering, note 294, Rumpf, 80 III e 1), R. Lullies, Griechische Kunstwerke Sammlung Ludwig, Aachen, Aachen Kunstblätter 37 1968, 21–22.8, Kinch, Vroulia, pl. 15 (Kardara, A, 217.2 (see above note 280).

[364] CVA Altenburg fasc 1, pls. 2–3, Corinth XIII 172 grave 135.3 pls. 18, 89.

[365] AA 51 1936, 378–379.27 fig. 30, ActaArch 13 1942, 24 fig. 12 (see above note 361).

[366] Kardara, A, 232.2 fig. 229; ActaArch 13 1942, 24 fig. 12 (see above note 361).

[367] Kardara, A, 211.1 fig. 225 (see above note 286), AA 27 1912, 334 fig. 20 (Schiering, notes 185, 186, Rumpf, 82 IV b 1).

[368] See the catalogue. For inscriptions on vases in Rhodian Wild Goat Style, see Kardara, A, pl. A.

from kraters with ring-handles.[369] The fragmentary handle plates, **268–274**, display both geometrical and "floral" decoration.[370] **275–283** can be ascribed to kraters or to dinoi. The profile of **275** is not known, but the fragment possibly comes from a dinos.[371] On the rim fragment, **276**, a quatrefoil is inserted in the meander.[372] The shoulder sherd **277** is from a dinos or a krater which is slipped on the exterior except for a glazed zone on the shoulder decorated with an incised floral frieze.[373] The bottom fragment, **278**, is very similar to a fragment from Lindos.[374] Wavelines as on **279** are seldom on kraters/dinoi[375] — more frequent on bowls[376]. Open vases with pendent tongues and very degenerated filling-ornaments as on **280** occur in Kardara's Late Rhodian I, which apparently includes some of the vases later excluded as Aeolic by E. Walter-Karydi.[377] The stylization of the lion with frontal head **282**[378] looks similar to MC lions.[379] **283–284** have been catalogued as belonging to bowls: the rounded design behind the marching beast on **283** is perhaps the point of the leaf from a handle palmette;[380] the drawing of the bull on **284** faithfully copies the Corinthian tradition.[381] **285–309** are fragments of fruit-stands or dishes, and many of them are paralleled by the Rhodian types from Tocra, where they are found mainly in Deposits II–III which cover the second and third quarters of the 6th century.[382] The fragmentary foot-stems identify **285–288** as fruit-stands. **285** and **286** display the same sort of inner, central decoration;[383] on **287** the buds alternate with tongues instead of leaves;[384] wavelines often occur on fruit-stands with a low vertical rim as on **288**.[385] **289–293**

[369] Column kraters: Boehlau, Nekropolen, 50, 82 pl. 12.5 (Vlastos group: Schiering, notes 287, 295, 298, Rumpf, 80 III c 7), ActaArch 13 1942, 24 fig. 12 (see above note 361), ArchRep 1964/65, 36 fig. 5, krater with ring handles: Sammlung Ludwig, Aachen, 21–22.8.

[370] **271–272:** rays are well known on handle-plates of the Late Wild Goat Style, ArchRep 1964/65, 36 fig. 5, Histria 2, 62.63 pl. 5, and continue on some of the East Greek, unslipped black-figure kraters, BSA 60 1965, 125.52 pl. 32 a; **273:** for similar, but not identical fragments, see CVA Reading fasc 1, II D, pl. 22.25 (Kardara, A, 239.2), Fairbanks, Catalogue, 107.318.2 pl. 34; **274:** CVA Oxford fasc 2, II D, pl. 4.24 (Schiering, notes 287, 298, Rumpf, 78 II i 5).

[371] For the profile of a Rhodian dinos, see AM 54 1929, 21 fig. 15 (Kardara, A, 218.6 (see above note 363); complete or nearly complete dinoi are hitherto best known among the Aeolic material, Larisa III pls. 16–17, Antike Kunst 7. Beiheft 1970, pls. 1–4.

[372] Fairbanks, Catalogue, 106.317 pl. 33 (Kardara, A, 235.1 (see above note 303); but **276** is perhaps rather to be connected with a dish, AM 54 1929, Beilage 12.1 (Schiering, notes 200, 648, Rumpf, 74 III i 61).

[373] JHS 44 1924, 200 fig. 32 (Schiering, notes 287, 297, 594, Rumpf, 80 III c 23), CVA Oxford fasc 2, II D, pl. 4.29 (Kardara, A, 225.30 (see above note 355), ActaArch 13 1942, 24–25 figs. 13–14 (Kardara, A, 217.2 (see above note 280). See above note 355.

[374] Blinkenberg, Lindos I 282.985 pl. 46 (Kardara, A, 208.7 (see above note 296).

[375] ClRh VI/VII 523–524 figs. 54–57 (Schiering, notes 69, 72, 308, 317).

[376] Naukratis II pl. 8.1 (Kardara, A, 244.3 (see above note 344).

[377] Kardara, A, 271–294; Antike Kunst 7. Beiheft 1970, 1–18 pls. 1–10.

[378] On the abandoning of the name "panther" see J. Boardman, Antike Kunst 13 1970, 94.

[379] CVA California fasc 1, pl. 6.2, CVA Mannheim fasc. 1, pl. 7.7–9.

[380] Naukratis II pl. 7.5 (Kardara, A, 235.2, Schiering, notes 267, 277, 278, 455, 534, 591, 597, 646, 756, Rumpf, 81 III f 19), for the stylization of the breast, see ActaArch 13 1942, 27 fig. 16 (Kardara, A, 208.3 (see above note 279).

[381] EC: CVA Louvre fasc 6, III C a, pl. 11.4, 7; see other Wild Goat versions from Naukratis: a Rhodian bowl, ActaArch 13 1942, 26 fig. 15 (Kardara, A, 211.1 (see above note 286), and a Rhodian dinos in Boston, Fairbanks, Catalogue, 106.317 pl. 33 (Kardara, A, 235.1 (see above note 303).

[382] Tocra, 43–44.614–700 figs. 24, 26, pls. 33–37.

[383] Tocra, pl. 34.618, 621, 625.

[384] Délos XVII 63.28 pl. 44 (Schiering, notes 200, 226).

[385] Délos X 40.66 pl. 13 (Schiering, note 200, Rumpf, 81 III h 32).

are side sherds of which **289–291** are to be connected with fruit-stands, the others may equally well have belonged to dishes. Examples with outer friezes like those on **289** do not occur among the material from Tocra, but among that from Naukratis.[386] Friezes with "geometrical" decoration used as dividing bands between the central decoration and the outer frieze, like on **290–291**, still occur early in the 6th century.[387] **294** is the earliest Wild Goat fragment found on Tall Sūkās. According to the registrar it is from a plate which has a low ring-foot divided by a deep furrow; this is not the ordinary shape for plates in Wild Goat Style.[388] Only in the first half of the 7th century

[386] Fairbanks, Catalogue, 112–113.323.2–3, 13 pl. 35, F. Robert, Trois sanctuaires sur le rivage occidental, Délos XX, Paris 1952, 39 fig. 34.3.

[387] See, for instance, Kardara, A, 191.1–5 (Rumpf, 73 III g 12 (Schiering, 200, 231), Rumpf, 74 III i 24 (Schiering, notes 200, 648), i 45 (Schiering, notes 200, 618, 648), i 59 (Schiering, notes 200, 214, 568, 648), i 56 (Schiering, notes 200, 213, 568, 648) and Tocra, 43 note 7; but they are far from being as frequent as in the 7th century, see Kardara, A, 121–124 (121.3 (Schiering, note 200, Rumpf, 74 i 43), 121.4 (Schiering, note 200, Rumpf, 74 III i 38), 121.5 (Schiering, note 200), 122.1 (Schiering, notes 200, 205, 460, 627, Rumpf, 74 III i 35), 123.7 (Schiering, notes 200, 211, 566, 648, Rumpf, 75 III i 68), 123.10 (Schiering, notes 200, 648, Rumpf, 75 III i 75–77), 123.6 (Schiering, notes 200, 552, 648, Rumpf, 74 III i 42), 124.12 (Schiering, note 200), 124.16 (Schiering, notes 200, 648, 780, Rumpf, 75 III i 71); usually on the later 6th century dishes and fruit-stands the tondo is enlarged, the outer frieze abandoned and supplied by broad bands, Tocra, pls. 34–36. For motives similar to our **290–291**, but for the outer frieze, see Délos X 39.62 pl. 13 (Kardara, A, 241.8, Schiering, notes 200, 224, 227, Rumpf, 81 III h 31), Naukratis I pl. 7.1 (Schiering, note 200, Rumpf, 82 III h 74); for the squares, see CVA Cambridge fasc 2, II D, pl. 18.28, Fairbanks, Catalogue, 114.324.10 pl. 35.

[388] This is the totally flat-bottomed type provided with different numbers of furrows, established already from the middle of the 7th century and living on into the 6th century: for the early group, see Kardara, A, 81–85 (83.1 (Schiering, notes 244, 256), 83.2 (Schiering, notes 244, 441, Rumpf, 76 II d 21), 84.3 (Schiering, notes 74, 80, 244, 252, 255, 494, 799, Rumpf, 76 II d 2), 84.4 (Schiering, notes 75, 244, 472, Rumpf, 77 II d 40), 84.5 (Fairbanks, 35.323.7, Rumpf, 77 II e 4), 84.6 (Schiering, notes 244, 251, 353, 433, 749 b, Rumpf, 77 II d 36), 84.1 (Schiering, notes 47, 106, 652, Rumpf, 69 I a 6), 85.2 (Schiering, notes 107, 652, Rumpf, 69 I a 7), 85.3 (Schiering, note 318, Rumpf, 79 II m 7), for the profile, see Kinch, Vroulia, pl. 35 (Kardara, A, 83.1, Schiering, notes 244, 256), the Gorgon group, see Kardara, A, 204–207 (207.1 (Schiering, notes 71, 244, 252, 253, 467, 607, 622, 786, 787, Rumpf, 76 II d 18), 207.2 (Schiering, notes 69, 71, 79, 244, 254, 564, 624, 633, 792, 794, 795, 796, 797, 799, Rumpf, 76 II d 1), 207.3 (Schiering, notes 71, 75, 244, 262, 451, 792, Rumpf, 76 II d 5), the Thasian group, see BCH 85 1961, 98–122 figs. 2, 5–7, 13–14; 6th century plates: Kardara, A, 284–289 (284.1 (Schiering, notes 244, 257, 259, 377, Rumpf, 76 II d 9), 284.2 (Schiering, notes 257, 259, 337, 354, 710), 284.1 (Schiering, notes 244, 245, 251, Rumpf, 77 II d 46), 284.2 (Schiering, note 244, Rumpf, 77 II d 48), 284.3 (Schiering, note 244, Rumpf, 77 II d 47), 284.4 (Schiering, notes 244, 387, 568, Rumpf, 77 II d 49), 284.5 (Schiering, note 244, Rumpf, 77 II d 54), 285.6 (Schiering, note 244, Rumpf, 77 II d 50), 285.7 (Schiering, note 244, Rumpf 77 II d 51), 285.8, 285.9, 288.12, 288.2, 289.1 (Schiering, notes 150, 244, 422, 525, 567, Rumpf 77 II d 29, 37, 52, 53, 67), 286.10 (Schiering, notes 244, 251, 386, Rumpf 77 II d 45), 286.11 (Schiering, notes 244, 386, Rumpf 77 d 55), 286.12 (Schiering, notes 73, 76), 286.1 (Schiering, notes 244, 257, 411, 422, 585, Rumpf, 76 II d 12), 286.3 (Schiering, notes 244, 394, Rumpf, 76 II d 20), 287.4 (Schiering, notes 244, 415, Rumpf 76 II d 19), 287.5 (Schiering, notes 244, 415), 287.1 (Schiering, notes 244, 251, 422, Rumpf, 76 II d 24), 287.2 (Schiering, notes 244, 251, 254, 422, Rumpf, 76 II d 23), 287.3 (Schiering, notes 76, 244, 251, 254, 422, Rumpf, 77 II d 32), 287.4 (Schiering, notes 244, 251, 422, 662, Rumpf, 77 II d 30), 287.5 (Schiering, note 244, Rumpf, 77 II d 31), 287.6 (Schiering, notes 78, 244, 422, Rumpf, 76 II d 22), 287.7 (Schiering, notes 76, 244, 422, Rumpf, 77 II d 34), 287.8 (Schiering, notes 244, 422, Rumpf, 77 II d 26), 287.9 (Schiering, notes 244, 422, Rumpf 77 III i 33), 287.10 (Schiering, notes 244, 411, 422, Rumpf 77 II d 27), 288.11 (Schiering, notes 244, 411, 422, Rumpf, 77 II d 28), 288.12 see above, 288.13 (Schiering, notes 244, 257, 411, 422, 585, 618, Rumpf, 76 II d 13), 288.14 (Schiering, notes 244, 257, 411, 422, 585, 618, Rumpf, 76 II d 14), 288.2 (Schiering, notes 244, 485, Rumpf, 77 d 43), 288.3 (Schiering, pp. 35, 73, 74, Beil. 9.7), 288.1 (Schiering, notes 244, 257, 338, 585, Rumpf, 76 II d 15), 288.2 see above, 288.1 (Schiering, notes 244, 487, 802, Rumpf, 77 II d 57), 288.2 (Schiering, notes 244, 487, Rumpf, 77 II d 56), 289.1 (Schiering, note 490), 289.1 see above, 289.2 (Schiering, notes 244, 252, 258, 548, 585, Rumpf, 76 II d 17), 289.3 (Schiering, notes 244, 252, 258, 548, 585, Rumpf, 76 II d 16), 289.1 (Schiering, note 200, Rumpf, 82 III h 80), for the profile, see Kinch, Vroulia, 221 fig. 109 (Kardara, A, 284.1, Schiering, notes 244, 245, 251, Rumpf, 77 II d 46). Only the shallow dishes with floral decoration from the late 7th and the 6th century have a ring foot: Kardara, A, 128–129 (128.2 (Schiering, notes 231, 232, 237, 548, 623, Rumpf, 73 III g 5), 128.1 (Schiering, notes 231,

does a type with low ring foot divided by a furrow occur;[389] its sparse decoration is geometric in character—and our fragment is clearly connected with the Wild Goat tradition, though the decoration of it has an early look. Palmettes with double contours are known all through the second half of the 7th century,[390] but the irregularity of the palmette on **294** may be accepted as a sign of early experimentation. It is not obvious which sort of bird is represented on **294**; there is no real similarity to the famous Wild Goat swallows—not even the earliest ones, or the waterbirds.[391] Whatever species the very geometrical birds of the first half of the 7th century represent,[292] our bird seems related to them, not only by the painting, but also by the these birds' rather casual position in the field, quite different from the very deliberate and charming way in which the Wild Goat birds are placed. **294** may possibly belong to the early Wild Goat style, emerging during the end of the first half of the 7th century.[393] **295–304** are all fragments of dishes with floral decoration, **305–309** of plain ones. The earliest fragment is **295** which probably belongs to a late 7th century dish with cutaway rim.[394] **296–304**[395] and the banded dishes, **305–308**, are late, matched by the Rhodian dishes from Tocra, dated c. 580–60 B.C.[396]

Oinochoai.

150. TS 1170. Shoulder/side sherds with root of neck. G 11 SW. No measurements. Fine reddish clay with few grits, creamy slip, red to black glaze. Small codron at junction of shoulder and neck. Frieze of pendent tongues, goat with head turned backwards. *Pl. VII.*

151. TS 1193. Shoulder/side sherds with root of neck. G 11 SW. No measurements. Red to buff clay with some grits and mica, creamy slip, red glaze. Small codron at junction of neck and shoulder. Part of two friezes, upper one: pendent tongues, grazing goat(s?), lower one: buttocks (of goat?); white-red-white stripes added on the broad band between the friezes; in field furthermore rosette with several petals, alternatingly glazed(?). *Pl. VII.*

152. TS 4467. Shoulder sherd with root of vertical handle. H 11 NE. 8.1×10.1 cm. Light brownish clay with grits, white slip, brownish to black glaze. In field to the right of handle, head of grazing goat, in the opposite field group of short strokes. Handle enframed by two

237, 551, 582, Rumpf, 73 III g 7), 129.5 (Schiering, notes 231, 232, 234, 237, 558), 129.4 (Schiering, notes 231, 232, 237, 558), 129.6 (Schiering, notes 231, 233, 237, 582, 623, Rumpf, 73 III g 6), 129.7 (Schiering, notes 231, 232, 237, 558, 582, 623), 129.9 (Schiering, notes 231, 237, 515, 558, 560, 582), 129.8 (Schiering, notes 231, 237, 515, 560, 623, Rumpf, 73 III g 2), Tocra, 50–52.631–680 fig. 26 pls. 34–36. A small and isolated group of plates from Tocra alone displays a low ring foot (without grooves), Tocra 43, 49.607–611, fig. 24, pls. 31–33: late seventh to early sixth century. On the Tocra group see further, BSA 61 1966, 153–154.

[389] Samos V 57.440–441 pl. 80, AM 57 1933, 111 fig. 54 c.

[390] Schiering, Werkstätten, Beilage 6, Samos V 68 fig. 42 pl. 107.560.

[391] Swallows: Samos V pls. 105, 123.609, 610 (Kardara, A, 68.8–9, 93.5, Schiering, notes 399, 745, Rumpf, 70 III B 6). Waterbirds: BCH 89 1965, 971 fig. 5, Kinch, Vroulia, pl. 35 (Kardara, A, 83.1, Schiering, notes 244, 256), JHS 60 1944, pl. 1.1 (Kardara, A, 70.2), m–n (Kardara, A, 73.15–16), p (Kardara, A, 70.1), r (Kardara, A, 70.3).

[392] Samos V 62.483 pl. 85.

[393] Gnomon 1965, 506, Samos V 63.

[394] Kardara, A, 128–129 pl. 11 (see above note 388), Tocra, 43 note 13.

[395] From the picture it is difficult to decide if the hook meander of **298** is placed on a broad flat rim like on **296–297** and **301–303**. However, if located on the side, then **298** is rather from a fruit-stand; the same may be the case for two of the fragments from the similar group of **297** i.e. TS 304 and TS 3465.

[396] Tocra, 43–44.633–672, 681–709 pls. 35–37. For the differing decoration of **301**, see Histria 2, 63.71 pl. 6. The decoration of **304** is paralleled by Tocra no. 654, except for the fact that our dish has bands on the rim, not a hook meander. **381** catalogued as "Unclassified East Greek" may possibly be from a dish.

vertical lines, one nearly straight and one slightly waved; root of handle glazed, vertical band hanging from handle. *Pl. IX.*

153. TS 1378. Shoulder/side sherd. G 5 SE. 7.0×6.0 cm. Dark brown clay with some grits, white slip, brownish to black glaze. Exclusively silhouette technique. Faint traces of pendent leaf above, marching animal with head turned backwards (ram?), rosette. *Pl. IX.*

154. TS 274. AASyr 8/9 1958/59, 129 fig. 12. Fragmentary half of oinochoe. G 8 SW. H. c. 28.0 cm. Pink clay, creamy slip, golden brown to black glaze. Upper frieze, black-figured: two groups of confronted sphinxes, between them, 1) owl, 2) large palmette, furthermore tail possibly belonging to a similar confronted group; red added on sphinxes' hair, bands on wings and owl's breast; lower frieze, outline and silhouette technique: running goats with heads turned backwards, red added on shoulders and buttocks, filling-ornaments; broad bands with red-white-red stripes added, enframed meander in which boxes and quatrefoil are inserted, frieze of pendent tongues on shoulder, rays radiating from the foot. *Pl. VIII.*

155. TS 4641. Shoulder sherd with root of neck. H 10 NE. 3.7×4.3 cm. Grey clay with some grits, greyish slip (slip and clay blackened by fire), brownish glaze. Black-figure. Traces of pendent tongues at top and below back of head with border of hair(?) curling into a spiral with central dot, part of wing; sphinx or siren(?), rosette. *Pl. IX.*

156. TS 4642. Side sherd. G 10 SE. 5.8×6.0 cm. Light red-brown clay with some grits, yellowish slip, dark brown glaze. Running goat with head turned backwards. *Pl. IX. Similar*: TS 1494 G 11 SW.

157. TS 1087. Side sherd. G 8 SW. 4.3×5.1 cm. Buff clay with grits and mica, white slip, brown to red glaze. Goat, head turned backwards, trace of filling-ornament, white stripe added on broad band above. *Pl. IX.*

158. TS 640. Side sherd. G 8 SW. 4.4×3.5 cm. Reddish clay with mica, creamy slip, black to red glaze. Goat's head lifted and turned backwards(?), pendent hook in front of nose, part of meander(?) above band. *Pl. IX.*

159. TS 1520. Side sherd. G 7 SE. 3.5×2.8 cm. Light brown clay, creamy slip, brown glaze. Part of goat's head with pendent hook(?) in front, red stripe added on the broad band above. *Pl. IX.*

160. TS 4648. Side sherd. G 10 SE. 8.2×5.6 cm. Brown gritty and micaceous clay, (slip not mentioned), brownish glaze. Forepart of grazing goat, between legs perhaps St. Andrew cross, red added on goat's neck. *Pl. IX.*

161. TS 541. Side sherd. F 5 SE. 7.1×8.1 cm. Light brown to pinkish clay with dark core, white slip, dark brown glaze. Part of two grazing goats, red-white-red stripes added on band above meander. *Pl. IX.*

162. TS 1099. Side sherd. G 8 SW. 3.1×4.1 cm. Reddish clay with some grits, (slip not mentioned), red glaze. Two friezes: upper, part of neck or leg of grazing goat; lower, end of indefinable design, white stripe added on the broad dividing band. *Pl. IX.*

163. TS 671. Side sherd. G 16 SW. 9.0×4.1 cm. Reddish, gritty clay, grey in core, white slip, black to brown glaze. Fore- and hindlegs of goat marching left, very close-set filling-ornaments, white-red-white stripes added on the broad band below. *Pl. IX.*

164. TS 651. Side sherd. G 11 SW. 7.2×6.2 cm. Reddish clay with few grits and mica, white slip, black to brown glaze. Hind-part of marching animal (goat?); part of four-leaf flower between legs. *Pl. IX.*

165. TS 3845. Side sherd. G 15 SW. 8.8×7.2 cm. Light brownish clay, yellowish slip, red brown glaze. Above, trace of narrow horizontal band; below, horns of deer, perhaps an incised stripe in the middle of its ear. *Pl. IX. Similar*: TS 4635 H 10 NE.

166. TS 677. Side sherd. F 5 SE. C. 5.0×3.0 cm. Reddish clay with grits and mica, creamy slip, black glaze. Black-figure. Forepart of lion with frontal head and whiskers, its leg raised to angular design, trace of narrow band above. *Pl. IX.*

167. TS 658. Side sherd. P 11 SW. 7.2×7.3 cm. Light buff clay with grits and mica, white slip, black glaze. Black-figure. Two friezes: upper, abdomen and wing of crouching griffin or sphinx with red added alternately on the wing-feathers, rosette and below the narrow horizontal band part of the empty field of the second frieze. *Pl. IX.*

168. TS 1449. Rim sherd, i.e. fragmentary lobe. P 11 NW. 2.5×2.5 cm. Reddish to buff clay, red glaze. Exterior: no description, interior: glazed with part of added white dot-rosette. *Pl. IX.*

169. TS 2652. Neck sherd. L 8 SE. 3.3×2.0 cm. Fine red clay, red glaze. Small codron at bottom. Exterior: glazed with one half of added white eye, interior: no description. *Pl. IX.*

170a. TS 2270. Handle-rotelle with neck sherd. G 7 SE. Diam. 3.5 cm, w. 2.5 cm. Dark buff clay with some grits, whitish slip, black glaze. One side of neck sherd glazed, the other slipped(?). Edge of rotelle glazed, rosette on topside. *Pl. IX.*

170b. TS 1959. Shoulder/side sherds with root of neck. G 7 SE. No measurements. Light red clay, reddish to black glaze. Totally glazed. *Pl. IX. Similar*: TS 1202 G 11 SW, TS 1974 G 7 SE, TS 2099 P 11 NW.

Amphorae.

171. TS 2247. AASyr 10 1960, 119 fig. 7, NMArb 1961, 126, 128 fig. 9, Archaeology 14 1961, 215. Fragmentary half of amphora. G 15 NW, G 15 SE, G 15 NE. H. 21.2 cm, w. 19.8 cm. Light reddish clay with grits and few mica, light brown somewhat greenish slip, brown to black glaze. Small codron at junction of neck and shoulder. Frieze of pendent tongues. Marching goat, vertical panels with meanders, several filling-ornaments, red-white-red-white-red stripes added on the broad band of the belly, rays radiating from the foot. *Pl. IX.*

172. TS 2880. Rim/neck/shoulder/side sherds. J 8 SE. 11.5×11.0 cm, w. of rim 10.3 cm. Fine light brown clay, thin white slip, black glaze. Small codron at junction of neck and shoulder. Neck: part of cable, shoulder: fast running goat (one of the forelegs nearly kneeling), rosette in front, two narrow and one(?) broad band below. *Pl. X.* Cf. no. **173.**

173. TS 2879. Shoulder/side sherd. J 8 SE. 12.5×c. 6.0 cm. Fine brown clay with some grits, (slip not mentioned), red to brown glaze. Hindpart and one of the forelegs of marching goat, rosette. *Pl. X.* Might possibly belong to no. **172.**

174. TS 3632. Shoulder sherd. G 13. 6.2×6.6 cm. Red clay with grits, whitish slip, brown to black glaze. Small codron at junction of neck and shoulder. Goat with raised head and very slanting body, red added on chest and back. *Pl. X.*

175. TS 1836. Shoulder sherds. G 15 SE. 7.0×7.0 cm, 8.5×7.0 cm. Fine reddish brown clay, white slip, black glaze. Running goat with its head turned backwards, very slanting body, dot-rosette in front, half-rosette on ground line, white stripes added on band at bottom of sherd. *Pl. X.*

176. TS 954. Neck/shoulder sherd. G 12 SW. 8.2×c. 6.5 cm. Buff clay with few grits, creamy slip, brown to red glaze. Small codron at junction of neck and shoulder. Goat with its head turned backwards and very slanting body. *Pl. X.*

177. TS 2297. Shoulder sherd with root of neck. G 16 NW. 5.0×2.7 cm. Brownish clay with few white grits, yellowish slip, red to brown glaze. Goat with its head turned backwards and very slanting body, group of pendent strokes above. *Pl. X.*

178. TS 512. Shoulder sherd. Surface. F 5 w-slope. 5.1×5.0 cm. Light brown pinkish clay, core grey, white slip, dark brown glaze. Central part of large volute pair with inserted dot above and below. *Pl. X.*

179. TS 1514. Shoulder/side sherd. G 5 SE. 2.0×4.5 cm. Light buff clay, creamy slip, brown glaze. Lower part of volute with stalks of two palmette leaves curling upwards, white stripes added on the horizontal band below. *Pl. X.*

180. TS 1523. Shoulder/side sherd. G 8 SW. 6.0×4.5 cm. Reddish clay, creamy slip, black to red glaze. Lower part of volute with stalks of two palmette leaves curling upwards, two narrow and one broad band below. *Pl. X.*

181. TS 3405. Shoulder sherd. H 11 NW. 3.5×2.8 cm. Light brown clay, whitish slip, brown glaze. Small glazed codron at junction of neck and shoulder. Part of big volute pair with inserted leaf. *Pl. X.*

182. TS 1516. Shoulder/side sherd. G 5 NE. 5.4×6.0 cm. Dark buff clay with some grits, white slip, black glaze. Central part of large volute pair(?) rising from ground line, inserted leaf. *Pl. X.*

183. TS 1448. Shoulder or side sherd. P 11 NW. 5.0×4.3 cm. Light buff clay with numerous grits, whitish slip, red glaze. Part of probably asymmetric volute pair with inserted leaf, traces of horizontal band. *Pl. X.*

184. TS 5622. Shoulder or side sherd. H 12. 3.5×4.0 cm. Dark brownish clay, dark brown glaze. Linked circles with inserted buds. *Pl. X.*

185. TS 1058. Rim/neck/side sherds. G 8 SE. 7.7×2.4 cm, 11.3×7.0 cm, c. 8.5×5.5 cm. Buff clay, with white and black grits, white slip, brown glaze. Rim glazed, on neck upper part of cable, at side two broad and one narrow band, below rays radiating from the foot, between them blob-rosette. *Pl. X.*

186. TS 1997. Rim/neck sherd. G 13 SE. 4.5×5.0 cm. Red clay with white grits, white slip, black glaze. Rim glazed, part of cable. *Pl. X. Similar*: TS 3709 G 14, TS 1343 G 11 SW.

187. TS 4912. Rim/neck sherd. G 14 NE. 4.5×5.4 cm, org. diam. of rim c. 12.0 cm. Reddish clay with some grits, whitish slip, red glaze. Rim glazed, part of open cable. *Pl. X. Similar*: TS 1286 P 11 SW.

188. TS 289. Side sherd. G 8 SW. 14.0×9.6 cm. Light brown clay, greyish-white slip, black glaze. Broad band with white-red-white stripes added; above, traces of two narrow bands; below, one narrow band and point of ray. *Pl. X. Similar*: TS 647 G 11 SE.

189. TS 1122. Side sherd. G 8 NW. 6.4×8.8 cm. Dark brownish clay with some white grits, white slip with pinkish tinge, brown to red glaze. Group of small dots in field, below narrow bands and one broad band with red and white stripes added. *Pl. X. Similar*: TS 829 G 11 SE, TS 1084 G 8 SW, TS 1138 G 11 SE, TS 2594 H 11 NW, TS 2884 J 8 SE, TS 3237 J 15 (Sūkās I, 83 no. 107 pl. 4).

190. TS 3523. Side sherd. G 5. 9.0×8.9 cm. Brown clay, creamy slip, brown to black glaze. Foot of goat in field; below, narrow and two broad bands. *Pl. X. Similar*: TS 2608 H 11 NW.

191. TS 1210. Shoulder/side/bottom sherds with ring foot. G 11 NW. Diam. of foot c. 13.0 cm. Reddish to buff clay, white slip, black glaze. Group of small dots in field; below, one narrow and two broad bands, rays radiating from the foot. *Pl. XI. Similar*: TS 648 G 11 SE, TS 834 G 11 SW, TS 1327 G 11 SW.

Indeterminate closed vases.

192. TS 3015. Side sherd. H 13. 4.0×2.2 cm. Red clay with grits, yellowish slip, brown glaze. Fragmentary head of goat. *Pl. XI.*

193. TS 4619. Shoulder sherd. H 10 NE. 1.7×6.0 cm. Fine brownish clay, creamy slip, brown glaze. Forepart of running goat, head turned backwards, frieze of pendent tongues above. *Pl. XI.*

194. TS 2692. Shoulder sherd with root of neck. L 8 SE. 4.2×8.5 cm. Reddish to brown clay with some grits, (slip not mentioned), black glaze. Band along root of neck, below forepart of running goat, head turned backwards, small dot above leg. *Pl. XI.*

195. TS 315. Shoulder sherd with root of neck. F 5 SE. 3.6 cm×6.4 cm. Red to brownish clay with few grits and mica, creamy slip, light brownish glaze. Band along root of neck, group of pendent dots below forepart of goat, head turned backwards. *Pl. XI.*

196. TS 830. Side sherd. G 11 SE. 3.9×2.9 cm. Reddish clay with mica, white slip, red glaze. Fragmentary head of goat. *Pl. XI.*

197. TS 1675. Neck/shoulder sherd. P 11 NW. 5.6×4.0 cm. Fine light brown clay, light yellowish slip, black glaze. Small codron at junction of neck and shoulder, group of pendent strokes, snout of goat. *Pl. XI.*

198. TS 1151–53. Shoulder/side sherds. G 11 SW. No measurements. Reddish clay, white slip, black to red glaze. Frieze of pendent tongues; below, horn and ear of goat, red and white stripes added on broad band of belly. *Pl. XI.*

199. TS 638. Rim/neck/shoulder sherd. G 11 SW. C. 8.7×c. 7.7 cm. Light, reddish clay with grits and mica, creamy slip, black glaze. Rim-collar slightly everted and glazed, white stripe added on interior. Frieze of pendent tongues, horn and ear of goat in field. *Pl. XI. Similar* (neck sherd): TS 1266 P 11 SW, TS 3685 G 14.

200. TS 3282. Side sherd. G 13. 9.1×6.4 cm. Reddish, gritty clay, core grey brown, with few mica, creamy slip, red glaze. Slanting abdomen of goat, probably with head turned backwards (two small vertical stripes above the back might be part of the beard); below, S-loop. *Pl. XI.*

201. TS 78. Side sherd. G 5 SE. 3.8×2.5 cm. Light brown clay, yellowish slip, black to brown glaze. Breast and foreleg of running goat; red added on breast. *Pl. XI.*

202. TS 2094. Neck/shoulder sherd. P 11 NW. 7.0×5.5 cm. Light brown to greyish clay with grits and mica, white slip, black glaze. Small codron at junction of neck and shoulder, codron partly glazed. Two vertical stripes, rump of goat. *Pl. XI.*

203. TS 1149. Side sherd. G 11 SW. 3.6×4.7 cm. Reddish clay with grits, whitish slip, black to red glaze. Waterbird(?). *Pl. XI.*

204. TS 676. Side sherd. P 11 SW. C. 2.8×3.4 cm. Reddish clay with grits, white slip, brownish glaze. Black-figure. Forepart of waterbird with its head bent forwards and pressed against its neck, probably raised wing; white added on neck, breast and wing. *Pl. XI.*

205. TS 672. Side sherd. P 11 NW. 4.4×3.4 cm. Light buff clay with mica, white slip, black glaze. Black-figure. Hindpart of marching bird with pendent tail; red added on foot and wing, and for stripe on band below. *Pl. XI.*

206. TS 5635. Side sherd. H 12. 5.3×5.0 cm. Brownish clay with some grits, yellowish slip, brownish glaze. Black-figure. Lower part of marching bird; red and white added on wing. *Pl. XI.*

207. TS 3426. Side sherd. H 11 NW. 3.4×4.1 cm. Grey brown clay, whitish slip, black glaze. Black-figure. Neck of boar(?); red added. *Pl. XI.*

208. TS 549. Side sherd. G 5 NE. 6.3×4.7 cm. Buff clay, with grits and mica, creamy slip, black glaze. Black-figure. Buttocks and tail of sitting beast. *Pl. XI. Similar*: TS 675 P 11 SW.

209. TS 3565. Side sherd. G 5 NE. 5.0×5.1 cm. Grey-brown clay with mica and small black grits, whitish slip, brown to black glaze. Black-figure. Foot of sitting beast, large, solid rosette; red and white added for stripes on band below. *Pl. XI. Similar*: TS 673 P 11 SW.

210. TS 178. Side sherd. F 5 SE. 3.2×4.1 cm. Light brown clay, creamy slip, black glaze. Black-figure. Fragmentary abdomen of white dotted animal; below the horizontal belly line, which ends in a hook, there was probably a white stripe rather than dots; adjoining abdomen, part of filling-ornament(?). *Pl. XI. Similar*: TS 2726 L 8 SE.

211. TS 2374. Side sherd. G 16 NW. 4.5×4.0 cm. Light red clay, white slip, brown glaze. Marching animal(?). *Pl. XI.*

212. TS 2645. Shoulder sherd. L 8 SE. 4.0×4.7 cm. Light brown clay, white slip, brown glaze. Frieze of pendent tongues; below, pendent half-rosette with festoon border, dot and part of two larger filling-ornaments(?) in field. *Pl. XI.*

213. TS 1356. Shoulder sherd. G 11 SW. 5.5×5.0 cm. Buff clay, with white grits, tan slip, red glaze. Frieze of pendent tongues, two vertical stripes and double angular corner ornament in field, root of handle glazed(?). *Pl. XI.*

214. TS 937. Shoulder sherd with root of handle. P 11 NW. 6.7×c. 4.0 cm. Brick-red clay with grits, white slip, black glaze. Rosette in field, in front of it sloping slim stripe, on root of handle two horizontal stripes, below them a sloping one, a dot and faint traces of glaze. *Pl. XI.*

215. TS 294. Side sherd. G 5 SE. 7.3×4.5 cm. Grey clay, white slip with greenish tinge, brown to black glaze. Slanting abdomen of goat, rosette below. *Pl. XI.*

216. TS 668. Side sherd. G 7 SE. 5.5×6.3 cm. Reddish clay with grits and mica, creamy slip, light brownish glaze. Horizontal abdomen of goat, rosette below. *Pl. XII. Similar* (rosettes): TS 1053 G 8 SW, TS 3002 L 8 SE.

217. TS 804. Side sherd. G 8 SE. 2.6×2.3 cm. Red clay with few grits and mica, creamy slip, brown to red glaze. Rosette. *Pl. XII.*

218. TS 1168. Side sherds. G 11 SW. 11.0×7.0 cm. Reddish to buff clay, creamy slip, black glaze. Hind legs of goat, between them dot and in front rosette and slim stripe, leg(?). *Pl. XII.*

219. TS 2097. Side sherd. P 11 NW. 3.4×5.0 cm. Pink clay, white slip, reddish to dark brown glaze. Rosette and foot of goat. *Pl. XII. Similar*: TS 321 G 5 SE.

220. TS 1482. Side sherd. G 11 SW. 4.5×3.5 cm. Reddish clay, whitish slip, red glaze. Rosette and slim vertical stripe. *Pl. XII. Similar* (rosette): TS 1500 P 11 NW.

221. TS 1443. Side sherd. P 11 NW. 6.5×6.0 cm. Red to buff clay, white slip, brown glaze. Hind leg of goat and slim vertical stripe, between them a small cross. *Pl. XII.*

222. TS 1485. Side sherd. G 11 SE. 2.5×4.5 cm. Reddish to buff clay, creamy slip, brown glaze. Hind foot of goat, angular ornament. *Pl. XII.*

223. TS 1451. Side sherd. G 11 SW. 5.5×7.5 cm. Reddish to buff clay, white slip, black glaze. Hook shaped design, dots. *Pl. XII. Similar*: TS 1714 G 15 NE, TS 2661 L 8 SE.

224. TS 5628. Two side sherds, glued. H 11 NE. 14.0×9.0 cm. Dark brownish clay, white smooth slip, brown glaze. Sloping stripe crossed by small stripes in field; red added on two of the five horizontal bands below. *Pl. XII.*

225. TS 3575. Side sherd. G 13. 7.0×4.0 cm. Light brown clay, grey in core, yellowish slip, black glaze. Black-figured. Fragmentary hind part and abdomen of animal, faint traces of incisions on abdomen; red added on body as well as on the solid rosette. *Pl. XII. Similar*: TS 30 G 5 NE (abdomen), TS 1150 G 11 SW (rosette).

226. TS 1162. Side sherd. G 11 SE. 4.0×2.0 cm. Reddish clay with some mica, whitish slip, red to brown glaze. Black-figure. Rosette with incisions radiating from incised circle. *Pl. XII.*

227. TS 1341. Shoulder sherd. G 8 SE. 5.6×4.0 cm. Reddish clay, creamy slip, red glaze. On shoulder, curved stripe and two pointed ones, white stripes added on the broad horizontal band, below meander. *Pl. XII.*

228. TS 2883. Shoulder/side or bottom sherd. J 8 SE. 5.2×3.5 cm. Fine light brown clay, greyish slip, red glaze. Point of single ray and two close-set ones, curved band crossing some of the narrow horizontal bands below. *Pl. XII.*

229. TS 1832. Shoulder sherd. G 15 NE. 6.5×5.0 cm. Fine light brown clay, white slip, black glaze. Two rays of different width. *Pl. XII.*

230. TS 2096. Shoulder/side sherd. P 11 NW. 4.0×4.2 cm. Light buff clay, white slip with greenish tinge, black to brown glaze. Part of floral design(?); white added for stripes on band below. *Pl. XII.*

231. TS 3396. Shoulder sherd. H 11 NW. 4.8×4.5 cm. Dark red, coarse, gritty clay, creamy slip, brown glaze. Two opposed, curved stripes. *Pl. XII.*

232. TS 2725. Shoulder sherd(?). L 8 SE. 3.3×3.0 cm. Red clay, whitish-greyish slip, black glaze. Part of floral design(?). *Pl. XII.*

233. TS 1386. Side sherd. G 11 SW. 4.5×5.0 cm. Reddish buff clay, yellowish slip, black glaze. Irregular design, graffito in field. *Pl. XII. Fig. g.*

234. TS 3652. Side sherd. G 13. 13.0×11.0 cm. Light brown clay, greyish white slip, brown to black glaze. At top, glazed field (panel ?); below, two bands of different width separated by narrow ones, white stripe added on the broadest of the bands, point of ray at bottom. *Pl. XII.*

235. TS 3513. Side sherd. G 5 NE. 3.6×3.1 cm. Buff sandy clay, whitish slip, brown glaze. Group of three dots in field, below broad band with white-red-white stripes added, meander at bottom. *Pl. XII. Similar*: TS 3579 G 13 NW.

236. TS 921. Side sherd with root of handle. P 11 NW. 3.9×2.9 cm. Reddish clay, yellow slip, red glaze. Root of handle glazed; two white stripes added on the glazed field below. *Pl. XII.*

237. TS 2712. Side sherd. L 8 SE. 4.0×5.0 cm. Red clay, white slip, red glaze. At top meander, narrow and broad band below, white stripes added on the latter, ray at bottom. *Pl. XII.*

238. TS 207. Side sherd. G 5 NW. 10.2×8.2 cm. Fine, light brown clay, creamy slip, black to brown glaze. At top meander, one broad band with red-white-red stripes added below, traces of glazed field at bottom. *Pl. XII. Similar*: TS 529 H 5 SE, TS 1344 H 5 NE, TS 1446 P 11 NW, TS 1940 F 16 SW, TS 2564 H 11 NW, TS 3534 G 5 NW, TS 3744 G 14.

239. TS 669. Side sherd. G 8 SE. 3.4×3.6 cm. Reddish clay with few grits and mica, creamy slip, black to red glaze. Hook meander, glaze below. *Pl. XII.*

240. TS 1683. Side sherd. G 8 SW. 7.5×4.8 cm. Light red to brown clay with some white grits, light buff slip, red glaze. Quick waveline enframed by narrow and broad bands, on latter an added white stripe. *Pl. XII. Similar* (white slip): TS 1080 G 8 SW, TS 1989 G 8 NW.

241. TS 1180. Side sherd. G 11 SW. 5.0×6.0 cm. Fine buff clay, white slip, brown glaze. Two broad bands. *Pl. XII. Similar*: TS 1800 G 7 SE, TS 1877 G 19, TS 2639 L 8 SE, TS 4408 G 10 NE.

242. TS 1278. Side/bottom sherds. P 11 SW. 7.0×6.5 cm. Light reddish to buff clay with few grits, light buff slip, black glaze. Chequers, rays below. *Pl. XII. Similar* (white slip): TS 1342 G 8 SE, TS 4409 G 10 NE.

243. TS 1186. Side sherd. G 11 SW. 8.0×9.0 cm. Reddish, somewhat micaceous clay, black core, creamy slip, red glaze. Two broad bands with added white stripes, point of ray below. *Pl. XII. Similar*: TS 1108 G 8 SW, TS 2878 J 8 SE.

244. TS 611. Neck sherd. G 5 SE. 4.5×4.5 cm. Reddish clay with few grits, white slip, red glaze. Cable with inserted leaves. *Pl. XII. Similar*: TS 854 G 11 SE, TS 3611 G 13, TS 4714 Surface.

245. TS 1086. Side/bottom sherd. G 8 SW. 9.6×6.6 cm. Red, somewhat porous clay, whitish slip, brown to black glaze. One broad and two narrow bands, radiating rays below. *Pl. XIII. Similar*: TS 536 F 5 SE, TS 1679 F 5 SE.

246. TS 1681. Side/bottom sherd. G 11 SW. 9.5×7.5 cm. Brick-red clay with white grits, white slip, brown glaze. Broad and narrow band, point of ray below. *Pl. XIII. Similar*: TS 379 G 8 SE, TS 1085 G 8 SW, TS 1194 G 11 SW, TS 1696 G 5 SW.

247. TS 2251. Bottom sherd with ring foot. J 8 SE. 12.2×3.9 cm. Brown clay, white slip, brown glaze. Rays radiating from the glazed foot. Red dipinto under foot. *Pl. XIII. Fig. g.*

248. TS 849. Bottom sherd with ring foot. G 11 NW. H. c. 4.0 cm. Hard, gritty red clay, reddish slip, black glaze. Two rays radiating from the glazed foot. *Pl. XIII.*

249. TS 3508. Bottom sherd with ring foot. G 5 NE. Org. diam. of foot c. 10.0 cm. Reddish clay, whitish slip, black to brown glaze. Three rays of different width radiating from the glazed foot. *Pl. XIII.*

250. TS 1169. Bottom sherd with ring foot. G 11 SW. 4.5×7.5 cm. Dark buff clay with white grits, core black, white slip, brown glaze. Foot and lower part of side glazed. *Pl. XIII. Similar*: TS 1192 G 11 SW, TS 1195 G 11 SW, TS 2688 L 8 SE.

251. TS 1357. Double-roll handle. F 5 SE. 10.5×2.0 cm. Red clay with grits, creamy slip, red glaze. Two rows of dots, glazed band at handle-root, slim vertical band in shoulder field. *Pl. XIII. Similar*: TS 33 G 5 SE, TS 1174 G 11 SE, TS 1492 P 11 NW.

252. TS 1730. Side sherd. H 5 NE. 4.0×5.0 cm. Reddish to buff clay, black glaze. Glazed all over, incised decoration: probably inner part of lotus-flower, "above" narrow white band added. *Pl. XIII. Similar*: TS 96 E 8 NE.

253. TS 3824. Side sherd. H 11 NW. 3.6×2.8 cm. Yellowish, somewhat gritty clay, brownish to violet glaze. Glazed all over, incised decoration: floral(?). *Pl. XIII.*

Kraters.

254. TS 1339. Shoulder sherd. G 8 SE. 6.5×9.0 cm. Light buff clay, creamy slip, brown glaze. Exterior: vertical panel, corner palmette in field, rosette with festoon border and four-leaf flower with inserted dots. Interior:(?). *Pl. XIII.*

255. TS 597. Shoulder/side sherds. G 11 SW. C. 12.4×c. 8.7 cm. Reddish clay with grits and mica, creamy slip, light brown glaze. Exterior: vertical panel, hind leg of animal in field, behind it vertical slim ray; below, broad band and meander. Interior:(?). *Pl. XIII.*

256. TS 1452. Neck/shoulder sherd. G 11 SW. 7.0×5.5 cm. Red clay with some grits and mica, whitish slip, black glaze. Exterior: neck glazed, vertical panel, frieze of pendent tongues; below, group of pendent dots. Interior: neck glazed with white and red bands added. *Pl. XIII.*

257. TS 2098. Shoulder sherd. P 11 NW. 9.2×7.0 cm. Light brown clay, chalky white slip, black glaze. Black-figure. Exterior: frieze of pendent tongues, vertical panel, griffin with tall neck in field, rounded design at bottom, corner-palmette, irregular designs in front of griffin. Interior: plain. *Pl. XIII. Similar* (no griffin): TS 302 F 5 SE, TS 2625 J 8 SE.

258. TS 2269. Shoulder sherd. G 7 SE. 5.1×5.2 cm. Dark brown gritty clay, yellowish slip, light to dark brown glaze. Vertical panel, filling-ornament with added red in field. Interior: plain. *Pl. XIII.*

259. TS 2324. Neck/shoulder sherd. L 8 SE. 9.3×6.4 cm. Brick-red, very gritty clay, whitish slip, brown glaze. Black-figure. Exterior: neck glazed, vertical panel, in field hindpart of animal. Interior: glazed, white band added on neck. *Pl. XIII.*

260. TS 3057. Shoulder/side sherd. G 14. 7.0×4.4 cm. Grey-brown, micaceous clay, white slip, black glaze. Black-figure. Vertical panel, in field wing(?) with added red, solid star-rosette, small group of tips below. Interior:(?). *Pl. XIII.*

261. TS 662. Shoulder/side sherd. G 8 SE. 9.3×10.5 cm. Light brownish clay with mica, creamy slip, black glaze. Black-figure. Vertical panel, tail of bird in field, corner palmette; red and white added for stripes on the two bands below. *Pl. XIII.*

262. TS 667. Neck/shoulder sherd. G 8 SW. 5.6×4.7 cm. Reddish clay with grits and mica, creamy slip, red glaze. Black-figure. Vertical panel, head of lion in field. Interior:(?). *Pl. XIII.*

263. TS 2150. Shoulder sherds. P 11 NW. 13.7×7.7 cm. Light grey clay, thin greyish slip, black glaze. Black-figure. Vertical panel; in field, blob-rosette and hindpart of bull with added red on belly. Interior: plain. *Pl. XIII.*

264. TS 2323. Shoulder sherd. L 8 SE. 3.9×5.1 cm. Reddish, very gritty clay, creamy slip, black to brown glaze. Vertical panel; in field, group of four small stripes, above frieze of pendent tongues. Interior:(?). *Pl. XIII.*

265. TS 4514. Sūkās I 60 no. 1 fig. 25 d pl. 4. Shoulder sherd. G 13 NW. 4.5×4.0 cm. Buff clay, creamy slip, brownish glaze. Vertical panel with graffito: δα. *Pl. XIV. Fig. g. Similar* (no graffiti): TS 659 P 11 NW, TS 828 G 11 SE.

slanting on **157**; the latter represents the typical illustrating of the fast running goat on the late vases.[296] The goats on **158–159** might have been of this type too.[297] Small and not very characteristic fragments of grazing goats occur on **160–164**; on **163** the filling-ornaments are very crowded as is usual on vases from the first quarter of the 6th century,[298] whereas there is no sign of ornaments between the goat-legs on **161**, and the fragment may be late like the oinochoe **154**.[299] On **160** there are remnants of what may be a St. Andrew cross,[300] and on **164** there is a four-leaf flower.[301] **155**, and **165–167** have pure black-figured decoration. On the shoulder sherd, **155**, is part of a sphinx[302] or a siren;[303] the incised line which curls into a spiral indicates the border of the hair, the ear or an ear disk.[304] A stripe may be incised on the deer's ear on **165**, but V-shaped horns are not the usual black-figured type;[305] the closest parallel is found

[296] BCH 86 1962, 407 fig. 100 a, Blinkenberg, Lindos I 282.985 pl. 46 (Kardara, A, 208.7, Schiering, notes 267, 268, 276, Rumpf, 78 II k 10), CVA Oxford fasc 2, II D, pl. 2.5 (Kardara, A, 208.1 (see above 282), CVA Rodi fasc 2, II Dh, pl. 7.1 (Kardara, A, 208.2 (see above note 281), CVA Copenhague fasc 2, II D, pl. 77.3 (Kardara, A, 208.3 (see above note 279), Lambrino, Vases, 256.12 figs. 218–221 (Kardara, A, 210.1, Schiering, notes 318, 319, 322, 617), JdI 1 1886, 139–140.2939 (Kardara, A, 208.4 (see above note 282), Homann-Wedeking, Vasenornamentik, 17.7: Gruppe R).

[297] For the pendent hook, see AJA 59 1955, 51H–J, Kardara, A, 269 fig. 257 below, CVA Oxford fasc 2, II D, pl. 4.9 (Kardara, A, 216.5 (see above note 285) and AA 32 1917, 101.25 fig. 25 (Kardara, A, 181.4, Schiering, notes 151, 152, 373, 408, 668, 716, 773, Rumpf, 78 II f 2).

[298] CVA Oxford fasc 2, II D, pl. 4.31 (Kardara, A, 231.12, Schiering, note 151, Rumpf, 80 III a 22), ActaArch 6 1935, 191 fig. 15 (Schiering, notes 115, 336, 344, 361, 383, 472, 479, 536, 624, 687, 734, 739, 778, Rumpf, 80 III b 1), Kinch, Vroulia, pl. 15 (Kardara, A, 217.2 (see above note 280).

[299] See above, notes 284, 291.

[300] BCH 86 1962, 407 fig. 100 a, 88 1964, 329 fig. 60. For varieties on Fikellura vases and "Clazomenian" sarcophagi, see ActaArch 13 1942, 30 note 55.

[301] CVA Copenhague fasc 2, II D, pl. 77.3 (Kardara, A 208.3 (see above note 279).

[302] CVA Oxford fasc 2, II D, pl. 4.32 (Kardara, A, 226.2, Schiering, note 151, Rumpf, 80 III a 23), JHS 44 1924, pl. 8.16 (Kardara, A, 230.1, Schiering, notes 151, 756, Rumpf, 80 III a 31), BCH 86 1962, 406 fig. 100 b.

[303] Naukratis II pl. 11.3 (Kardara, A, 235.1, Schiering, notes 308, 309, 316, 317, 455, 472, 778, Rumpf, 80 III d 1).

[304] Females on Corinthian vases seldom wear jewellery in their ears, the ear itself is usually distinctly rendered, see AJA 65 1961, 3 pl. 4 c, 5 pl. 5, but on less carefully drawn Corinthian figures a stylization of the ear similar to that of **155** occurs, CVA Frankfurt am Main fasc 1, pl. 16.13–15. The sphinx on a Late Rhodian plate wears a disk in her ear, Naukratis II pl. 12 (Kardara, A, 236.1, Schiering, notes 246, 451, Rumpf, 82 IV a 5), and on a fragment of an oinochoe, likewise from Naukratis, the stylization may indicate an ear as well as an ear disk, CVA Oxford fasc 2, II D, pl. 4.51 (Kardara, A, 226.4, Schiering, note 151, Rumpf 80 III a 29); otherwise ear disks are not used on sphinxes etc., in the earlier or in the later Wild Goat Style. They appear from time to time on Chian; on Animal Style chalices, CVA Heidelberg fasc 1, pl. 3.12, and on Simple Figure Style chalices, BSA 60 1965, 141.10 pls. 42, 44; not usually on Chian Black-Figure, but see JHS 44 1924, pl. 12.16; sometimes the stylization is so pronounced that it is difficult to decide if it is all ear or if a disk is attempted, ibid. pl. 12.8; in the "Grand Style" the ear itself is carefully rendered, and ear disks occur, ibid, pl. 6.1. See furthermore the remarks of R. M. Cook on the ear types on "Clazomenian", CVA Brit. Mus. fasc 8, 28 Postscript.

[305] Black-figured: AA 29 1914, 228–231 fig. 43 (Kardara, A, 210.1 (see above note 286). The Corinthian version of horns is different from **165**, CVA Bruxelles fasc 1, III C, pl. 3.4 a. On a bowl from Naukratis the deer might have had a pair of horns similar to **165**, but in the drawing published by Chr. Kardara the horns look reconstructed, Kardara, A, 245. 4 fig. 198 (Schiering, notes 267, 277, 365, 776, Rumpf, 81 III f 2), see further JHS 8 1887, 121 pl. 79 above (the sketch here is probably not reliable); J. M. Cook compares the bowl to the Miscellaneous East Greek Black-Figure from the second quarter of the 6th century, BSA 60 1965, 120, and our fragment may belong to these, the latest of the Orientalizing East Greek vases; on the group, see below p. 74. In the Wild Goat Style deer rendered in silhouette and outline often have the double horns, ClRh VI/VII 85.1 figs. 91–93, 95 (Kardara, A, 101.1, Schiering, notes 120, 125, 127, 371, Rumpf, 71 III D 13), Samos V 75–76.616 pl. 125 (Kardara, A, 68.13, Schiering, note 200, pp. 10, 45, 50), Schiering, Werkstätten, 49 note 371, and the black-figured deer in question may be of the same type as the one illustrated on these 7th century Wild Goat vases rather than the one favoured on the Corinthianizing Wild Goat vases.

in the fragments of a dinos in Cambridge, possibly related to "Clazomenian".[306] On **166** the raised leg looks like a paw of a beast, and the upright position of the animal, the lack of differentiation between head and neck, and the stylization of the head are features usually connected with a lion with frontal head.[307] The leg is raised to an uncertain angular design, which may perhaps be interpreted as a meander, or a most unusual version of a tail of a bull.[308] The slim and somewhat elongated body on **167** belongs either to a crouching griffin[309] or to a sphinx.[310] **168–169** are rim and neck fragments; **168** has a white rosette on the interior,[311] **169** a white painted eye on the exterior; eyes with slender contours like those of **169** are found mainly on Late Wild Goat vases, frequently on those in mixed technique.[312] The handle-rotelle, **170**a, probably belonged to a vase from the last quarter of the 7th century.[313] **171–191** are ascribed to amphorae, a shape not met with among the Wild Goat vases until the late phase.[314] Of **171** nearly one half is preserved; the large goats which occupy the shoulder field of a great many of the amphorae are not usually rendered with their heads pointing straight forwards and in marching posture as on **171**.[315] In other respects too **171** differs from the other amphorae: it has several filling-ornaments,[316] vertical panels with meanders[317] and four narrow bands below the shoulder

[306] CVA Cambridge fasc 2, II D, pl. 19.1–5, BSA 47 1952, 138. F1 a–c, 139 note 64 (139: "They are, I think, to be dated a little before the middle of the sixth century, earlier than any of the pieces listed above. If so, they mark an early — probably experimental stage in the Clazomenian b.f. style"), BSA 60 1965, 131.

[307] For a lion with frontal head, see BSA 60 1965, 120.32 pl. 26. The latter has whiskers like our lion —the frontal lions without mane are still conventionally called panthers, but see below note 378.

[308] For a lion "attacking" a bull from behind, see CVA Cambridge fasc 2, II D, pl. 18.38 (Kardara, A, 223.2), ActaArch 13 1942, 26 fig. 15 (Kardara, A, 211.1 (see above note 286).

[309] Like CVA Oxford fasc 2, II D, pl. 4.30 (Kardara, A, 227.10, Schiering, note 151, Rumpf, 80 III a 21), CVA Cambridge fasc 2, II D, pl. 18.32 (Kardara, A, 224.17, Schiering, notes 420, 439).

[310] Like Délos X 38–39.59 pl. 12 (Kardara, A, 208.5 (see above note 282), Homann-Wedeking, Vasenornamentik, 17.5).

[311] Otherwise white rosettes are found on the exterior of the rim of Wild Goat oinochoai; but see a Fikellura oinochoe in Paris which has white lotus flowers and buds painted on the interior of the trilobe rim, CVA Louvre fasc 1, II Dc, pl. 5.12, Zervos, Rhodes, 143 fig. 336, BSA 34 1933/34, 39.S1, 41: "continue the Rhodian tradition", dated c. 550 B.C.

[312] ClRh III 76–77.14 fig. 67 pl. A (Kardara, A, 208.2 (see above note 281, Homann-Wedeking, Vasenornamentik, 14, 17.4: Gruppe R), CVA Copenhague fasc 2, II D, pl. 77.3 (Kardara, A, 208.3 (see above note 279); on late vases in silhouette and contour technique, see CVA Torino fasc 2, II D, pl. 3.2, Kardara, A, 182.6 fig. 149 (Schiering, notes 152, 155, 174, 472, 608, 654, 774, Rumpf, 78 II f 5), 236.1 fig. 196 (see Schiering, pl. 6.4), 237.2 fig. 197. Late oinochoai with only floral decoration have the same sort of eye, Tocra, 42.591 pl. 30. On Classical Camiran vases the contours are usually broader, CVA Louvre fasc 1, II D, pl. 5.1 (= Zervos, Rhodes, 32 fig. 45, 133 fig. 304, pl. 26 fig. 500 (Kardara, A, 104.1, Schiering, notes 120, 130, 133, 135, 428, 433, 445 a, 461, 724, 733, 743 a, Rumpf, 70 III A 4), CVA München fasc 6, pl. 275 "Sub-Camiran" (Kardara, A, 190.2, Schiering, notes 126, 133, 136, 147, 460, 571, Rumpf, 72 III D 43).

[313] ArchRep 1962/63, 41 fig. 17; for the same motif used as filling-ornament, see ClRh VI/VII 218–219 pls. 6–7 (Kardara, A, 104.2, Schiering, notes 6, 120, 123, 133, 349, 367, 424, 433, 499, 635, 637, 724, 736, 744, 746, Rumpf, 70 III A 2), BSA 61 1966, 153.1 pl. 31.

[314] BSA 34 1933/34, 55, Schiering, Werkstätten, 27–28.

[315] Only the sphinx on the amphora in the Louvre has the same appearance, Zervos, Rhodes, 52 fig. 94 (Kardara, A, 189.1, Schiering, notes 182, 424, 433, 616, 630, 644, Rumpf, 72 III d 1).

[316] On the Louvre amphora (see preceding note) filling-ornaments occur in similar numbers, but they seem related to the Classical Camiran Style, whereas the filling-ornaments on **171** are similar to those employed on vases in mixed technique; the latter type of filling-ornament occurs on most of the other amphorae, but here the trend is towards larger and fewer ornaments, see for instance Délos XVII 58–59.4–7 pl. 39. Note some fragments from Istros on which the filling-ornaments are still small and rather crowded, Histria 2, 59.29 pl. 3, the vase is listed as an oinochoe, but might be an amphora.

[317] The panels are usually filled with dots: JdI I 1886, 140. 2944 (Kardara, A, 209.2, Schiering, note 185, Rumpf, 78 II g 3), AA 7 1892, 170.175 (Kardara, A, 210.3, Schiering, notes 185, 525, Rumpf, 78 II g 2), Délos XVII 60.14 pl. 41 (Schiering, note 537).

field.[318] These features suggest an origin early in the first quarter of the 6th century.[319] The filling-ornaments on **172–173** look identical, and the fragments may belong to shoulder fields, A and B, of the same vase. On **172** one of the forelegs is stretched forwards, the other one is nearly kneeling[320] — on **173** the goat is marching, its legs perhaps rendered like those of the goat on **171**. There are no traces of pendent tongues above the goat on **172**, and the filling-ornaments were probably sparse, so the vase should be classed among the latest amphorae from c. 580–60 B.C.[321] The same may hold good for **175–177** on which the goat type canonic for the amphorae is shown.[322] The goat's head on **174** is not turned backwards, and, as mentioned above, this is strange on amphorae;[323] the fragment may be connected with the earliest of the amphorae from Delos/Rheneia.[324] **178–184** belong to amphorae with exclusively large floral motives in the shoulder fields, a group not strictly regarded as belonging to the Wild Goat style, but to be derived from the latest Wild Goat vases.[325] On **178** the inner part of a pair of large volutes occurs,[326] on **181** the root of the neck is preserved, and the small leaf should thus illustrate the upper leaf of a similar pair of volutes;[327] remnants of large, nearly horizontal handle-palmettes occur on **179–180**, and they too can be combined with large volutes.[328] **183** is obscure; the motive resembles that of the handle-palmettes, but the wheel-marks seem to make the usual placement in the shoulder field impossible. Sherds with part of a vegetable motif nearly identical to **182** have been found in Istros[329]—linked circles with buds between as on **184** occur on the shoulder of an amphora from Tocra.[330] On **185–186** are remains of probably short neck-cables like those usually found on amphorae. The leaf of **186** is rounded—on

[318] On the Louvre amphora (see note 315) there are three bands, but usually the number is one or two: AA 29 1914, 222–223 fig. 29 (Kardara, A, 251.1 (see above note 284), Tocra, 41–42.580 pl. 28, Délos XVII 59–60.8–11 pl. 40 (Schiering, note 185).

[319] The Louvre amphora is dated 610–590 B.C., Kardara, A, 189, whereas the amphorae with very few filling-ornaments, no vertical panels, and only few horizontal bands on the belly are suggested to have a later date, c. 580–60 B.C., see Tocra, 41–42.580–581 pl. 28.

[320] The posture is known already on the later Classical Camiran vases, Kardara, A, 100.13 Paris = Zervos, Rhodes, 59 fig. 108, Schiering, notes 120, 356, Rumpf 71 III D 24), it recurs on a later but related vase, CVA München fasc 6, pl. 275.450 (Kardara, A, 93.7, Schiering notes 6, 56, 120, 424, 433, 507, 612, 743 a, Rumpf, 70 III B 2), and on one of the amphorae from Rheneia, Délos XVII 58–59.6 pl. 39 (Schiering, note 185). A similar posture occurs on some of the Fikellura vases, CVA Brit. Mus. fasc 8, II Dl, pl. 3.2, BSA 34 1933/34, 63.

[321] Tocra, 41–42.

[322] Add to the examples enumerated by J. Hayes (see preceding note): Histria 2, 59.25–26, 29 pls. 2–3 (early type), 59.27 pl. 2 (later type), 59.28, 60.31–32, 34 pl. 3.

[323] See note 315. Goats placed in the shoulder fields of oinochoai seldom have such slanting bodies, see for instance Kardara, A, 100.4 fig. 65 (cf. Zervos, Rhodes, 59 fig. 108 (see above note 320), CVA München fasc 6, pl. 275.450 (Kardara, A, 190.2 (see above note 312); the very slanting body occurs only on the belly friezes, CVA Oxford fasc 2, II D, pl. 2.4–5 (Kardara, A, 208.1 (see above note 282).

[324] From the early 6th century, Délos XVII 58–59.6, 8, 10 pls. 39–40 and Vroulia, 228 fig. 116 (Kardara, A, 210.5, Rumpf, 78 II g 4).

[325] Gnomon 1965, 506, Tocra, 41–42.

[326] Like Délos XVII 58.2 pl. 38 (Schiering, notes 185, 187, 535, 608).

[327] Another variety, see Tocra, 41–42.583 pl. 28.

[328] Besides on amphorae, this type of handle-palmette is very frequent on oinochoai, Délos X 38–39.59–60 pl. 12 (see above notes 273, 282), Homann-Wedeking, Vasenornamentik, 17.5–6: Gruppe R), and we cannot be sure if **179–180** really belong to one of the late amphorae — or to an oinochoe.

[329] Histria 2, 59.23–24 pl. 2.

[330] Tocra, 41–42. 583 pl. 28.

185 it is pointed like the one on **172**;[331] open cables as on **187** are connected with the latest Wild Goat vases and the amphorae with exclusively floral ornaments.[332] Red and white stripes added on dividing bands were introduced on the Late Wild Goat oinochoai[333] and they still occur on the broad bands of a great many of the late amphorae, like the ones to which **188–189** belonged[334]—but accessory colours are surely excluded on some, perhaps the later ones.[335] Our **191** belongs to the latter category. A large group of sherds, **192–253**, has been catalogued as belonging to indeterminate closed vases; most of them are tiny side sherds which mainly belong to the Late Wild Goat style. The goats on **192–197** probably all represent the late type with its head turned backwards.[336] It is not possible to talk about a uniform style of drawing in the goats represented on the fragments from Tall Sūkās, but generally a certain similarity to the material from Istros may be noted.[337] The ear of **198** is apparently drawn exclusively in silhouette and the goat might have been in black-figured technique. **199** perhaps has a broad neck collar and the fragment might thus be connected with a one-piece amphora.[338] For the S-loop on **200**, see above.[339] **202** may have belonged to one of the latest Wild Goat amphorae on which the original panels are provided by only one or two vertical stripes.[340] On **204–206** three different versions of black-figured birds are represented: **204** probably with raised wings,[341] **205–206** apparently marching;[342] other black-figured animals occur on **207–210**.[343] Most of the filling-ornaments on **212–226** are to be included among the stock of ornaments em-

[331] Both varieties occur on the latest amphorae, see Tocra, pl. 28.580–581.

[332] Délos XVII 58.2–4 pls. 38–39 (amphorae, see above note 326), 60.15 pl. 42 (flat-bottomed oinochoe, Schiering, note 171).

[333] BSA 34 1933/34, 71 fig. 10, Vroulia, 228. R. M. Cook, Greek Painted Pottery, London 1966, 122.

[334] Délos XVII 58–60.2–3, 5–8, 10–11 pls. 38–40 (see above notes 320, 326).

[335] Délos XVII 58.4, 59.9 pls. 39–40, (see above note 326), Tocra, 46.580 pl. 28.

[336] This posture is to be accepted, too, for **192, 196–197**, as the heads of the goats seem to be raised.

[337] Compare **176** for instance, with Lambrino, Vases, 256.12 figs. 218–221 (Kardara, A, 210.1 (Schiering, notes 318–22). Eyebrows and nose-wrinkles never seem to occur on our goats, whereas these features are very frequent in the material from Naukratis, CVA Oxford fasc 2, II D, pl. 4 passim, CVA Cambridge fasc 2, II D, pl. 18.12 and passim; the same features are found only on few of the goats from Istros, Lambrino, Vases, 251.11 fig. 217 (Kardara, A, 109.1), 256.13 fig. 222 (Kardara, A, 274.2), Histria 2, 57.4 pl. 1.

[338] Tocra, 41–42.588 pl. 29 (goat), Lambrino, Vases, 243–244.2 figs. 205–207 (floral motif, Schiering notes 185, 544, 547).

[339] See note 285.

[340] Tocra, 41–42.581 pl. 28. **371** catalogued as "Unclassified East Greek" may have belonged to a similar amphora.

[341] Compare CVA Oxford fasc 2, II D, pl. 4.33 (Kardara, A, 230.2, Schiering, note 151, Rumpf, 80 III a 24). The type occurs in Corinthian, Corinth VII.1, 65.251 pl. 34, but usually the Corinthian birds do not have raised wings, NSc 1960, 144 fig. 9; the latter type prevails too on the Late Wild Goat vases on which black-figured technique was employed, JHS 44 1924, pl. 8.13 (Schiering, notes 267, 268, 277, 343, Rumpf, 81 III f 15), CVA Oxford fasc 2, II D, pl. 4.37A, 47 (Kardara, A, 234.25, Schiering, notes 267, 277, Rumpf, 81 III f 9, Kardara, A, 248.9, Schiering, note 200, Rumpf, 81 III h 11).

[342] **205:** CVA Oxford, fasc 2, II D, pl. 4.47 (Kardara, A, 248.9 (see above note 341); **206:** the fragment is rather large and the stylization is not equal to that of the usual Wild Goat birds or sirens; the polychromy might point to "Clazomenian" pottery, but the slip of **206** seems to contradict this–the sherd is perhaps to be connected with the so-called "Indeterminate East Greek Black-Figure", BSA 60 1965, 120, Gnomon 1965, 506, see below p. 74.

[343] **207:** possibly a boar, compare Naukratis I pl. 6.3 (see above note 281); **208:** see Naukratis I pl. 13.2 (Schiering notes 267–8, Rumpf 81 f 29); **209:** for the filling-ornament, see NSc 1960, 148 fig. 13 b, ActaArch 13 1942, 49 fig. 30 (Kardara, A, 233.11, Schiering, notes 409, 778, Rumpf, 83 IV e 1), BCH 86 1962, 407 fig. 100 b; **210:** the white-spotted animal might have an incised belly-line and below the abdomen part of a filling-ornament. For this type, see a lid from Smyrna not of the ordinary Late Wild Goat Style, but assigned to the "Indeterminate East Greek Black-Figure", BSA 60 1965, 120.32 pl. 26.

ployed on vases in mixed technique, only one fragment, **216**, might belong to the last quarter of the 7th century.[344] **227–234** have only linear decoration which occasionally represents floral motives;[345] **235**, **237–239** have meanders as dividing bands,[346] **240** a waveline.[347] Chequers, which occur on **242**, are only seldom found on Wild Goat vases[348] and the writer only knows of one example where the chequers are placed immediately above the rays radiating from the foot.[349] The motif is more frequent on later vases as "Clazomenian"[350] and other East Greek Black Figure.[351] The neck-cable, **244**, may have belonged to an amphora or to an oinochoe.[352] **243**, **245–250** are bottom sherds and fragments of the lower part of the belly, on which only bands and rays appear;[353] **251** is perhaps an amphora handle.[354] **252–253** are from vases either

[344] **212:** compare BCH 88 1964, 329 fig. 60; **213:** might be from a late amphora, see note 340; **214:** see CVA Oxford fasc 2, II D, pl. 2.5 (Kardara, A, 208.1 (see above note 282), but probably **214** did not belong to a vase on which the filling-ornaments were so crowded. It is rather from a more sparsely decorated specimen, as for instance, Tocra, 41–42.580 pl. 28; **215:** ClRh III 76–77.14 fig. 67 pl. A (Kardara, A, 208.2 (see above note 281); **216:** the ornament is well known on 6th century vases with very crowded filling-ornaments, Naukratis II pl. 8.1 (Kardara, A, 244.3, Schiering, notes 267, 268, 277, 279, 343, 395, 546, 547, 592, 594, 605, 608, 776, 778, Rumpf, 81 III f 1), AJA 63 1959, 183.5 pl. 48 fig. 8 (Kardara, A, 247.1). However on **216** the ornament seems to be the only one between the legs, as found frequently on vases of the later Classical Camiran Style, ClRh VI/VII 85.1 figs. 91–93, 95 (Kardara, A, 101.1 (see above note 305), on which the bodies of the goats are horizontal like that of **216**. The remnant of the leg on **216** indicates that our goat was not marching, but running fast like the goats on an oinochoe from Camiros, see Zervos, Rhodes, 44 fig. 77 (Kardara, A, 95.5, Schiering, notes 120, 134, 349, 397, 472, 474, 580, 704, 708, 736, Rumpf, 70 III C 4); compare the typical running position of the 6th century goat, Blinkenberg, Lindos I 282.985 pl. 46 (Kardara, A, 208.7 (see above, note 296) - our fragment may have belonged to a vase from the 7th century; **217:** CVA Oxford fasc 2, II D, pl. 2.5 (Kardara, A, 208.1, (see above note 282); **218:** the fragment is described as a side sherd, but might rather have been from the shoulder of an amphora, compare Délos XVII 60.14 pl. 41 (see above note 317); **219–220:** see Histria 2, 59.26 pl. 2 and Tocra, 41–42.580 pl. 28; **221:** see CVA Oxford fasc 2, II D, pl. 2.4–6 (Kardara, A, 208.1 (see above note 282), but our sherd belonged to a vase with more sparse filling-ornaments; **222:** Tocra, 41–42.588 pl. 29; **225:** BCH 86 1962, 407 fig. 100 a; **226:** the rosette is very large, compare Naukratis I pl. 6.5 (Schiering, notes 267, 268, 277, Rumpf, 81 III f 26), Kinch, Vroulia pl. 15 (Kardara, A, 217.2 (see above note 280); **224:** the fragment is strange, but compare the late amphorae with horizontal handles on the shoulder, Schiering, Werkstätten, 28 with references.

[345] **227–229:** probably all shoulder sherds, compare Kardara, A, 237.2 fig. 197, ArchRep 1962/63, 46 fig. 26, Délos XVII 58.3 pl. 38 (see above note 326), ClRh VI/VII 508 figs. 33, 35 (Schiering, notes 69, 188, 525, Rumpf, 78 II h 7–8), AA 7 1892, 170.174 (Schiering, notes 69, 142, 143, 377, 422, 441, 568, 572, 585, 624, 633), 170.175 (see above note 317); **231:** perhaps part of a large pair of volutes, like Délos XVII 58.2 pl. 38, but the fragment might possibly be Chian, see Lambrino, Vases, 126.7 fig. 68 c; **233:** graffito, see Kardara, A, pl. A, Lambrino, Vases, 211–229 figs. 168–202 and Histria 2, pl. 64.

[346] **235, 237–238:** broken meanders like Délos XVII 58–59.5–7 pl. 39 (see above note 334); **239:** hook meanders very often on oinochoiai in mixed technique CVA Copenhague fasc 2, II D, pl. 77.3 (Kardara, A, 208.3 (see above note 279), Délos X 38–39.59–60 pl. 12 (Kardara, A, 216.1 (see above note 273), 208.5 (see above note 282).

[347] **240:** ClRh VI/VII 495–496.1 fig. 22 (Kardara, A, 283.5, Schiering, notes 69, 142, 387, 573, 619, 645, Rumpf, 75 I c 3), D. M. Robinson, Catalogue of Greek Vases, Toronto 1930, 66–67.205–C259 pl. 18 (Kardara, A, 100.5); **241:** compare the late amphorae, Tocra, 41–42.580, 588 pls. 28–29.

[348] Kardara, A, 67.3 (Schiering, note 188); on a stand, see Vroulia, 191–192 fig. 73 (Kardara, A, 274.1, Schiering notes 93, 282, 291, 348, 731, Rumpf, 79 II 1.1), see too Naukratis II pl. 11.3 (Kardara, A, 235.1 (see above note 303).

[349] Fairbanks, Catalogue, 105.315 pl. 33 (Schiering, notes 267, 268, 277, 278, 534, 621, Rumpf, 81 III f 20).

[350] BSA 47 1952, 144, BSA 60 1965, 128–132.64–84 pls. 34–36.

[351] BSA 60 1965, 121.37 pl. 28.

[352] Délos XVII 59.10 pl. 40 (see above note 334), Kardara, A, 237.2 fig. 197.

[353] Distinguishing between the bottom fragments on the basis of the number of the rays is not quite safe–but in general the early amphorae seem to have rather close-set rays, AA 7 1892, 170.175 (Kardara, A, 210.3 (see above note 317), and there is a tendency towards fewer rays on the later amphorae, Délos XVII 58.2 pl. 38 (see above note 326) and Tocra, 41–42.588 pl. 29. For the red dipinto under the foot of **247**, see Tocra, 46 fig. 22.

[354] AA 7 1892, 170.175 (Kardara, A, 210.3 (see above note 317).

totally glazed or with glazed friezes on which the decoration is incised.[355] Several fragments, **254–282**, have been ascribed to larger open vases, i.e. kraters or dinoi. The krater shape most frequently represented is the MC low-necked column krater;[356] black-figured technique prevails, only **254** could perhaps be assigned to a krater on which the old Ionian technique is employed.[357] On **255** the meander band is placed immediately below the metope.[358] **256–258** and perhaps **264** have a frieze of pendent tongues above the metope,[359] on **259** it is abandoned.[360] **257–258** have only Corinthian filling-ornaments;[361] the griffin, **257**, has an extraordinarily tall neck, and it might be that only a protome was intended,[362] the rounded design below the corner-palmette is placed much too low to be interpreted as a wing.[363] Representations of large water-birds are very popular in the metope of Corinthian kraters,[364] and likewise on the Eastern versions of the column krater: **260–261** are to be ascribed to kraters with such scenes.[365] The double incisions, the stylization of the mane, the heart-shaped ear and the nearly circular eye are features which connect the lion on **262** with the Wild Goat tradition.[366] The animal on **263** might be a bull.[367] The letters on **265** are assigned to the 1st half of the 6th century.[368] Rim fragments decorated with meanders, continuous like **266** or broken like **267**, may come from column kraters as well as

[355] Lambrino, Vases, 275–278.46–51 (assigned to oinochoai). Dark friezes with incised floral motifs, lotuses (like **252**) are frequent on dinoi and kraters in mixed technique, CVA Oxford fasc 2, II D, pl. 4.29 (Kardara, A, 225.30, Schiering, notes 287, 297, 409, 484, 587, 594, 778, Rumpf, 80 III c 21), Kinch, Vroulia, pl. 15 (Kardara, A, 217.2 (see above note 280). A group of amphorae and situlae together with the Vroulia cups display the same technique, CVA Karlsruhe fasc 2, pl. 47.5 with text, CVA Brit. Mus. fasc 8, II Dm, pls. 2–8 Appendix A VIII, Kinch, Vroulia, 174–194 figs. 58–72 pls. 10–12, 46.

[356] Schiering, Werkstätten, 40–41. See furthermore BSA 60 1965, 122–123 and Payne, Necrocorinthia, 300–301. Some of our fragments have no description of their interiors, and the writer is aware of the fact that they might have belonged to closed vases. When catalogued as belonging to kraters, it is mainly because of the large dimensions of the figures represented and the vertical, glazed panels, which seem broader than is usual on oinochoai.

[357] Like that of a krater in Leningrad, Kardara, A, 250.1 fig. 199. For the corner-palmette on **254** compare Histria 2, 62.64 pl. 5.

[358] This is seldom seen, but occurs on an Aeolic krater from Pitane, ArchRep 1964/65, 36 fig. 5.

[359] The same sort of tongues appear on some of the North Ionian kraters, too, for instance BSA 60 1965, 121.34 pl. 27.

[360] This is strange on Wild Goat kraters; nevertheless see a fragment in the Hague assigned by W. Schiering to the Vlastos group, Werkstätten, 40 note 308.

[361] For a corner-palmette similar to that of **257**, see the krater in Bonn, ActaArch 13 1942, 24 fig. 12 (Schiering, notes 308, 314, 317, 409, 468, 588, Rumpf, 83 IV d 1); the other side of the same krater is published in AA 51 1936, 378–379.27 fig. 30.

[362] Protomes of griffins on Late Wild Goal vases usually have very long and rather powerful necks: JHS 44 1924, 200 fig. 31 (Kardara, A, 228.4 fig. 237, Schiering, notes 437, 439, Rumpf, 80 III e 9), CVA Oxford fasc 2, II D, pl. 4.36 (Kardara, A, 224.20 fig. 238, Schiering, notes 287, 437, 542, 755, Rumpf, 80 III e 4), Tocra, 41.590 fig. 23 pl. 30, Kardara, A, 235.4, 237.2 fig. 197 and Schiering, Werkstätten note 437 with further references. See furthermore CVA München fasc 6, p. 20 text to no. 3.

[363] For regular wings, see AM 54 1929, 20, 22, fig. 15.3, Beilage 10.2 (Kardara, A, 218.6, Schiering, note 294, Rumpf, 80 III e 1), R. Lullies, Griechische Kunstwerke Sammlung Ludwig, Aachen, Aachen Kunstblätter 37 1968, 21–22.8, Kinch, Vroulia, pl. 15 (Kardara, A, 217.2 (see above note 280).

[364] CVA Altenburg fasc 1, pls. 2–3, Corinth XIII 172 grave 135.3 pls. 18, 89.

[365] AA 51 1936, 378–379.27 fig. 30, ActaArch 13 1942, 24 fig. 12 (see above note 361).

[366] Kardara, A, 232.2 fig. 229; ActaArch 13 1942, 24 fig. 12 (see above note 361).

[367] Kardara, A, 211.1 fig. 225 (see above note 286), AA 27 1912, 334 fig. 20 (Schiering, notes 185, 186, Rumpf, 82 IV b 1).

[368] See the catalogue. For inscriptions on vases in Rhodian Wild Goat Style, see Kardara, A, pl. A.

from kraters with ring-handles.[369] The fragmentary handle plates, **268–274**, display both geometrical and "floral" decoration.[370] **275–283** can be ascribed to kraters or to dinoi. The profile of **275** is not known, but the fragment possibly comes from a dinos.[371] On the rim fragment, **276**, a quatrefoil is inserted in the meander.[372] The shoulder sherd **277** is from a dinos or a krater which is slipped on the exterior except for a glazed zone on the shoulder decorated with an incised floral frieze.[373] The bottom fragment, **278**, is very similar to a fragment from Lindos.[374] Wavelines as on **279** are seldom on kraters/dinoi[375] — more frequent on bowls[376]. Open vases with pendent tongues and very degenerated filling-ornaments as on **280** occur in Kardara's Late Rhodian I, which apparently includes some of the vases later excluded as Aeolic by E. Walter-Karydi.[377] The stylization of the lion with frontal head **282**[378] looks similar to MC lions.[379] **283–284** have been catalogued as belonging to bowls: the rounded design behind the marching beast on **283** is perhaps the point of the leaf from a handle palmette;[380] the drawing of the bull on **284** faithfully copies the Corinthian tradition.[381] **285–309** are fragments of fruit-stands or dishes, and many of them are paralleled by the Rhodian types from Tocra, where they are found mainly in Deposits II–III which cover the second and third quarters of the 6th century.[382] The fragmentary foot-stems identify **285–288** as fruit-stands. **285** and **286** display the same sort of inner, central decoration;[383] on **287** the buds alternate with tongues instead of leaves;[384] wavelines often occur on fruit-stands with a low vertical rim as on **288**.[385] **289–293**

[369] Column kraters: Boehlau, Nekropolen, 50, 82 pl. 12.5 (Vlastos group: Schiering, notes 287, 295, 298, Rumpf, 80 III c 7), ActaArch 13 1942, 24 fig. 12 (see above note 361), ArchRep 1964/65, 36 fig. 5, krater with ring handles: Sammlung Ludwig, Aachen, 21–22.8.

[370] **271–272:** rays are well known on handle-plates of the Late Wild Goat Style, ArchRep 1964/65, 36 fig. 5, Histria 2, 62.63 pl. 5, and continue on some of the East Greek, unslipped black-figure kraters, BSA 60 1965, 125.52 pl. 32 a; **273:** for similar, but not identical fragments, see CVA Reading fasc 1, II D, pl. 22.25 (Kardara, A, 239.2), Fairbanks, Catalogue, 107.318.2 pl. 34; **274:** CVA Oxford fasc 2, II D, pl. 4.24 (Schiering, notes 287, 298, Rumpf, 78 II i 5).

[371] For the profile of a Rhodian dinos, see AM 54 1929, 21 fig. 15 (Kardara, A, 218.6 (see above note 363); complete or nearly complete dinoi are hitherto best known among the Aeolic material, Larisa III pls. 16–17, Antike Kunst 7. Beiheft 1970, pls. 1–4.

[372] Fairbanks, Catalogue, 106.317 pl. 33 (Kardara, A, 235.1 (see above note 303); but **276** is perhaps rather to be connected with a dish, AM 54 1929, Beilage 12.1 (Schiering, notes 200, 648, Rumpf, 74 III i 61).

[373] JHS 44 1924, 200 fig. 32 (Schiering, notes 287, 297, 594, Rumpf, 80 III c 23), CVA Oxford fasc 2, II D, pl. 4.29 (Kardara, A, 225.30 (see above note 355), ActaArch 13 1942, 24–25 figs. 13–14 (Kardara, A, 217.2 (see above note 280). See above note 355.

[374] Blinkenberg, Lindos I 282.985 pl. 46 (Kardara, A, 208.7 (see above note 296).

[375] ClRh VI/VII 523–524 figs. 54–57 (Schiering, notes 69, 72, 308, 317).

[376] Naukratis II pl. 8.1 (Kardara, A, 244.3 (see above note 344).

[377] Kardara, A, 271–294; Antike Kunst 7. Beiheft 1970, 1–18 pls. 1–10.

[378] On the abandoning of the name "panther" see J. Boardman, Antike Kunst 13 1970, 94.

[379] CVA California fasc 1, pl. 6.2, CVA Mannheim fasc. 1, pl. 7.7–9.

[380] Naukratis II pl. 7.5 (Kardara, A, 235.2, Schiering, notes 267, 277, 278, 455, 534, 591, 597, 646, 756, Rumpf, 81 III f 19), for the stylization of the breast, see ActaArch 13 1942, 27 fig. 16 (Kardara, A, 208.3 (see above note 279).

[381] EC: CVA Louvre fasc 6, III C a, pl. 11.4, 7; see other Wild Goat versions from Naukratis: a Rhodian bowl, ActaArch 13 1942, 26 fig. 15 (Kardara, A, 211.1 (see above note 286), and a Rhodian dinos in Boston, Fairbanks, Catalogue, 106.317 pl. 33 (Kardara, A, 235.1 (see above note 303).

[382] Tocra, 43–44.614–700 figs. 24, 26, pls. 33–37.

[383] Tocra, pl. 34.618, 621, 625.

[384] Délos XVII 63.28 pl. 44 (Schiering, notes 200, 226).

[385] Délos X 40.66 pl. 13 (Schiering, note 200, Rumpf, 81 III h 32).

are side sherds of which **289–291** are to be connected with fruit-stands, the others may equally well have belonged to dishes. Examples with outer friezes like those on **289** do not occur among the material from Tocra, but among that from Naukratis.[386] Friezes with "geometrical" decoration used as dividing bands between the central decoration and the outer frieze, like on **290–291**, still occur early in the 6th century.[387] **294** is the earliest Wild Goat fragment found on Tall Sūkās. According to the registrar it is from a plate which has a low ring-foot divided by a deep furrow; this is not the ordinary shape for plates in Wild Goat Style.[388] Only in the first half of the 7th century

[386] Fairbanks, Catalogue, 112–113.323.2–3, 13 pl. 35, F. Robert, Trois sanctuaires sur le rivage occidental, Délos XX, Paris 1952, 39 fig. 34.3.

[387] See, for instance, Kardara, A, 191.1–5 (Rumpf, 73 III g 12 (Schiering, 200, 231), Rumpf, 74 III i 24 (Schiering, notes 200, 648), i 45 (Schiering, notes 200, 618, 648), i 59 (Schiering, notes 200, 214, 568, 648), i 56 (Schiering, notes 200, 213, 568, 648) and Tocra, 43 note 7; but they are far from being as frequent as in the 7th century, see Kardara, A, 121–124 (121.3 (Schiering, note 200, Rumpf, 74 i 43), 121.4 (Schiering, note 200, Rumpf, 74 III i 38), 121.5 (Schiering, note 200), 122.1 (Schiering, notes 200, 205, 460, 627, Rumpf, 74 III i 35), 123.7 (Schiering, notes 200, 211, 566, 648, Rumpf, 75 III i 68), 123.10 (Schiering, notes 200, 648, Rumpf, 75 III i 75–77), 123.6 (Schiering, notes 200, 552, 648, Rumpf, 74 III i 42), 124.12 (Schiering, note 200), 124.16 (Schiering, notes 200, 648, 780, Rumpf, 75 III i 71); usually on the later 6th century dishes and fruit-stands the tondo is enlarged, the outer frieze abandoned and supplied by broad bands, Tocra, pls. 34–36. For motives similar to our **290–291**, but for the outer frieze, see Délos X 39.62 **pl.** 13 (Kardara, A, 241.8, Schiering, notes 200, 224, 227, Rumpf, 81 III h 31), Naukratis I pl. 7.1 (Schiering, note 200, Rumpf, 82 III h 74); for the squares, see CVA Cambridge fasc 2, II D, pl. 18.28, Fairbanks, Catalogue, 114.324.10 pl. 35.

[388] This is the totally flat-bottomed type provided with different numbers of furrows, established already from the middle of the 7th century and living on into the 6th century: for the early group, see Kardara, A, 81–85 (83.1 (Schiering, notes 244, 256), 83.2 (Schiering, notes 244, 441, Rumpf, 76 II d 21), 84.3 (Schiering, notes 74, 80, 244, 252, 255, 494, 799, Rumpf, 76 II d 2), 84.4 (Schiering, notes 75, 244, 472, Rumpf, 77 II d 40), 84.5 (Fairbanks, 35.323.7, Rumpf, 77 II e 4), 84.6 (Schiering, notes 244, 251, 353, 433, 749 b, Rumpf, 77 II d 36), 84.1 (Schiering, notes 47, 106, 652, Rumpf, 69 I a 6), 85.2 (Schiering, notes 107, 652, Rumpf, 69 I a 7), 85.3 (Schiering, note 318, Rumpf, 79 II m 7), for the profile, see Kinch, Vroulia, pl. 35 (Kardara, A, 83.1, Schiering, notes 244, 256), the Gorgon group, see Kardara, A, 204–207 (207.1 (Schiering, notes 71, 244, 252, 253, 467, 607, 622, 786, 787, Rumpf, 76 II d 18), 207.2 (Schiering, notes 69, 71, 79, 244, 254, 564, 624, 633, 792, 794, 795, 796, 797, 799, Rumpf, 76 II d 1), 207.3 (Schiering, notes 71, 75, 244, 262, 451, 792, Rumpf, 76 II d 5), the Thasian group, see BCH 85 1961, 98–122 figs. 2, 5–7, 13–14; 6th century plates: Kardara, A, 284–289 (284.1 (Schiering, notes 244, 257, 259, 377, Rumpf, 76 II d 9), 284.2 (Schiering, notes 257, 259, 337, 354, 710), 284.1 (Schiering, notes 244, 245, 251, Rumpf, 77 II d 46), 284.2 (Schiering, note 244, Rumpf, 77 II d 48), 284.3 (Schiering, note 244, Rumpf, 77 II d 47), 284.4 (Schiering, notes 244, 387, 568, Rumpf, 77 II d 49), 284.5 (Schiering, note 244, Rumpf, 77 II d 54), 285.6 (Schiering, note 244, Rumpf, 77 II d 50), 285.7 (Schiering, note 244, Rumpf 77 II d 51), 285.8, 285.9, 288.12, 288.2, 289.1 (Schiering, notes 150, 244, 422, 525, 567, Rumpf 77 II d 29, 37, 52, 53, 67), 286.10 (Schiering, notes 244, 251, 386, Rumpf 77 II d 45), 286.11 (Schiering, notes 244, 386, Rumpf 77 d 55), 286.12 (Schiering, notes 73, 76), 286.1 (Schiering, notes 244, 257, 411, 422, 585, Rumpf, 76 II d 12), 286.3 (Schiering, notes 244, 394, Rumpf, 76 II d 20), 287.4 (Schiering, notes 244, 415, Rumpf 76 II d 19), 287.5 (Schiering, notes 244, 415), 287.1 (Schiering, notes 244, 251, 422, Rumpf, 76 II d 24), 287.2 (Schiering, notes 244, 251, 254, 422, Rumpf, 76 II d 23), 287.3 (Schiering, notes 76, 244, 251, 254, 422, Rumpf, 77 II d 32), 287.4 (Schiering, notes 244, 251, 422, 662, Rumpf, 77 II d 30), 287.5 (Schiering, note 244, Rumpf, 77 II d 31), 287.6 (Schiering, notes 78, 244, 422, Rumpf, 76 II d 22), 287.7 (Schiering, notes 76, 244, 422, Rumpf, 77 II d 34), 287.8 (Schiering, notes 244, 422, Rumpf, 77 II d 26), 287.9 (Schiering, notes 244, 422, Rumpf 77 III i 33), 287.10 (Schiering, notes 244, 411, 422, Rumpf 77 II d 27), 288.11 (Schiering, notes 244, 411, 422, Rumpf, 77 II d 28), 288.12 see above, 288.13 (Schiering, notes 244, 257, 411, 422, 585, 618, Rumpf, 76 II d 13), 288.14 (Schiering, notes 244, 257, 411, 422, 585, 618, Rumpf, 76 II d 14), 288.2 (Schiering, notes 244, 485, Rumpf, 77 d 43), 288.3 (Schiering, pp. 35, 73, 74, Beil. 9.7), 288.1 (Schiering, notes 244, 257, 338, 585, Rumpf, 76 II d 15), 288.2 see above, 288.1 (Schiering, notes 244, 487, 802, Rumpf, 77 II d 57), 288.2 (Schiering, notes 244, 487, Rumpf, 77 II d 56), 289.1 (Schiering, note 490), 289.1 see above, 289.2 (Schiering, notes 244, 252, 258, 548, 585, Rumpf, 76 II d 17), 289.3 (Schiering, notes 244, 252, 258, 548, 585, Rumpf, 76 II d 16), 289.1 (Schiering, note 200, Rumpf, 82 III h 80), for the profile, see Kinch, Vroulia, 221 fig. 109 (Kardara, A, 284.1, Schiering, notes 244, 245, 251, Rumpf, 77 II d 46). Only the shallow dishes with floral decoration from the late 7th and the 6th century have a ring foot: Kardara, A, 128–129 (128.2 (Schiering, notes 231, 232, 237, 548, 623, Rumpf, 73 III g 5), 128.1 (Schiering, notes 231,

does a type with low ring foot divided by a furrow occur;[389] its sparse decoration is geometric in character—and our fragment is clearly connected with the Wild Goat tradition, though the decoration of it has an early look. Palmettes with double contours are known all through the second half of the 7th century,[390] but the irregularity of the palmette on **294** may be accepted as a sign of early experimentation. It is not obvious which sort of bird is represented on **294**; there is no real similarity to the famous Wild Goat swallows—not even the earliest ones, or the waterbirds.[391] Whatever species the very geometrical birds of the first half of the 7th century represent,[292] our bird seems related to them, not only by the painting, but also by the these birds' rather casual position in the field, quite different from the very deliberate and charming way in which the Wild Goat birds are placed. **294** may possibly belong to the early Wild Goat style, emerging during the end of the first half of the 7th century.[393] **295–304** are all fragments of dishes with floral decoration, **305–309** of plain ones. The earliest fragment is **295** which probably belongs to a late 7th century dish with cutaway rim.[394] **296–304**[395] and the banded dishes, **305–308**, are late, matched by the Rhodian dishes from Tocra, dated c. 580–60 B.C.[396]

Oinochoai.

150. TS 1170. Shoulder/side sherds with root of neck. G 11 SW. No measurements. Fine reddish clay with few grits, creamy slip, red to black glaze. Small codron at junction of shoulder and neck. Frieze of pendent tongues, goat with head turned backwards. *Pl. VII.*

151. TS 1193. Shoulder/side sherds with root of neck. G 11 SW. No measurements. Red to buff clay with some grits and mica, creamy slip, red glaze. Small codron at junction of neck and shoulder. Part of two friezes, upper one: pendent tongues, grazing goat(s?), lower one: buttocks (of goat?); white-red-white stripes added on the broad band between the friezes; in field furthermore rosette with several petals, alternatingly glazed(?). *Pl. VII.*

152. TS 4467. Shoulder sherd with root of vertical handle. H 11 NE. 8.1×10.1 cm. Light brownish clay with grits, white slip, brownish to black glaze. In field to the right of handle, head of grazing goat, in the opposite field group of short strokes. Handle enframed by two

237, 551, 582, Rumpf, 73 III g 7), 129.5 (Schiering, notes 231, 232, 234, 237, 558), 129.4 (Schiering, notes 231, 232, 237, 558), 129.6 (Schiering, notes 231, 233, 237, 582, 623, Rumpf, 73 III g 6), 129.7 (Schiering, notes 231, 232, 237, 558, 582, 623), 129.9 (Schiering, notes 231, 237, 515, 558, 560, 582), 129.8 (Schiering, notes 231, 237, 515, 560, 623, Rumpf, 73 III g 2), Tocra, 50–52.631–680 fig. 26 pls. 34–36. A small and isolated group of plates from Tocra alone displays a low ring foot (without grooves), Tocra 43, 49.607–611, fig. 24, pls. 31–33: late seventh to early sixth century. On the Tocra group see further, BSA 61 1966, 153–154.

[389] Samos V 57.440–441 pl. 80, AM 57 1933, 111 fig. 54 c.

[390] Schiering, Werkstätten, Beilage 6, Samos V 68 fig. 42 pl. 107.560.

[391] Swallows: Samos V pls. 105, 123.609, 610 (Kardara, A, 68.8–9, 93.5, Schiering, notes 399, 745, Rumpf, 70 III B 6). Waterbirds: BCH 89 1965, 971 fig. 5, Kinch, Vroulia, pl. 35 (Kardara, A, 83.1, Schiering, notes 244, 256), JHS 60 1944, pl. 1.1 (Kardara, A, 70.2), m–n (Kardara, A, 73.15–16), p (Kardara, A, 70.1), r (Kardara, A, 70.3).

[392] Samos V 62.483 pl. 85.

[393] Gnomon 1965, 506, Samos V 63.

[394] Kardara, A, 128–129 pl. 11 (see above note 388), Tocra, 43 note 13.

[395] From the picture it is difficult to decide if the hook meander of **298** is placed on a broad flat rim like on **296–297** and **301–303**. However, if located on the side, then **298** is rather from a fruit-stand; the same may be the case for two of the fragments from the similar group of **297** i.e. TS 304 and TS 3465.

[396] Tocra, 43–44.633–672, 681–709 pls. 35–37. For the differing decoration of **301**, see Histria 2, 63.71 pl. 6. The decoration of **304** is paralleled by Tocra no. 654, except for the fact that our dish has bands on the rim, not a hook meander. **381** catalogued as "Unclassified East Greek" may possibly be from a dish.

vertical lines, one nearly straight and one slightly waved; root of handle glazed, vertical band hanging from handle. *Pl. IX.*

153. TS 1378. Shoulder/side sherd. G 5 SE. 7.0×6.0 cm. Dark brown clay with some grits, white slip, brownish to black glaze. Exclusively silhouette technique. Faint traces of pendent leaf above, marching animal with head turned backwards (ram?), rosette. *Pl. IX.*

154. TS 274. AASyr 8/9 1958/59, 129 fig. 12. Fragmentary half of oinochoe. G 8 SW. H. c. 28.0 cm. Pink clay, creamy slip, golden brown to black glaze. Upper frieze, black-figured: two groups of confronted sphinxes, between them, 1) owl, 2) large palmette, furthermore tail possibly belonging to a similar confronted group; red added on sphinxes' hair, bands on wings and owl's breast; lower frieze, outline and silhouette technique: running goats with heads turned backwards, red added on shoulders and buttocks, filling-ornaments; broad bands with red-white-red stripes added, enframed meander in which boxes and quatrefoil are inserted, frieze of pendent tongues on shoulder, rays radiating from the foot. *Pl. VIII.*

155. TS 4641. Shoulder sherd with root of neck. H 10 NE. 3.7×4.3 cm. Grey clay with some grits, greyish slip (slip and clay blackened by fire), brownish glaze. Black-figure. Traces of pendent tongues at top and below back of head with border of hair(?) curling into a spiral with central dot, part of wing; sphinx or siren(?), rosette. *Pl. IX.*

156. TS 4642. Side sherd. G 10 SE. 5.8×6.0 cm. Light red-brown clay with some grits, yellowish slip, dark brown glaze. Running goat with head turned backwards. *Pl. IX. Similar*: TS 1494 G 11 SW.

157. TS 1087. Side sherd. G 8 SW. 4.3×5.1 cm. Buff clay with grits and mica, white slip, brown to red glaze. Goat, head turned backwards, trace of filling-ornament, white stripe added on broad band above. *Pl. IX.*

158. TS 640. Side sherd. G 8 SW. 4.4×3.5 cm. Reddish clay with mica, creamy slip, black to red glaze. Goat's head lifted and turned backwards(?), pendent hook in front of nose, part of meander(?) above band. *Pl. IX.*

159. TS 1520. Side sherd. G 7 SE. 3.5×2.8 cm. Light brown clay, creamy slip, brown glaze. Part of goat's head with pendent hook(?) in front, red stripe added on the broad band above. *Pl. IX.*

160. TS 4648. Side sherd. G 10 SE. 8.2×5.6 cm. Brown gritty and micaceous clay, (slip not mentioned), brownish glaze. Forepart of grazing goat, between legs perhaps St. Andrew cross, red added on goat's neck. *Pl. IX.*

161. TS 541. Side sherd. F 5 SE. 7.1×8.1 cm. Light brown to pinkish clay with dark core, white slip, dark brown glaze. Part of two grazing goats, red-white-red stripes added on band above meander. *Pl. IX.*

162. TS 1099. Side sherd. G 8 SW. 3.1×4.1 cm. Reddish clay with some grits, (slip not mentioned), red glaze. Two friezes: upper, part of neck or leg of grazing goat; lower, end of indefinable design, white stripe added on the broad dividing band. *Pl. IX.*

163. TS 671. Side sherd. G 16 SW. 9.0×4.1 cm. Reddish, gritty clay, grey in core, white slip, black to brown glaze. Fore- and hindlegs of goat marching left, very close-set filling-ornaments, white-red-white stripes added on the broad band below. *Pl. IX.*

164. TS 651. Side sherd. G 11 SW. 7.2×6.2 cm. Reddish clay with few grits and mica, white slip, black to brown glaze. Hind-part of marching animal (goat?); part of four-leaf flower between legs. *Pl. IX.*

165. TS 3845. Side sherd. G 15 SW. 8.8×7.2 cm. Light brownish clay, yellowish slip, red brown glaze. Above, trace of narrow horizontal band; below, horns of deer, perhaps an incised stripe in the middle of its ear. *Pl. IX. Similar*: TS 4635 H 10 NE.

166. TS 677. Side sherd. F 5 SE. C. 5.0×3.0 cm. Reddish clay with grits and mica, creamy slip, black glaze. Black-figure. Forepart of lion with frontal head and whiskers, its leg raised to angular design, trace of narrow band above. *Pl. IX.*

167. TS 658. Side sherd. P 11 SW. 7.2×7.3 cm. Light buff clay with grits and mica, white slip, black glaze. Black-figure. Two friezes: upper, abdomen and wing of crouching griffin or sphinx with red added alternately on the wing-feathers, rosette and below the narrow horizontal band part of the empty field of the second frieze. *Pl. IX.*

168. TS 1449. Rim sherd, i.e. fragmentary lobe. P 11 NW. 2.5×2.5 cm. Reddish to buff clay, red glaze. Exterior: no description, interior: glazed with part of added white dot-rosette. *Pl. IX.*

169. TS 2652. Neck sherd. L 8 SE. 3.3×2.0 cm. Fine red clay, red glaze. Small codron at bottom. Exterior: glazed with one half of added white eye, interior: no description. *Pl. IX.*

170a. TS 2270. Handle-rotelle with neck sherd. G 7 SE. Diam. 3.5 cm, w. 2.5 cm. Dark buff clay with some grits, whitish slip, black glaze. One side of neck sherd glazed, the other slipped(?). Edge of rotelle glazed, rosette on topside. *Pl. IX.*

170b. TS 1959. Shoulder/side sherds with root of neck. G 7 SE. No measurements. Light red clay, reddish to black glaze. Totally glazed. *Pl. IX. Similar*: TS 1202 G 11 SW, TS 1974 G 7 SE, TS 2099 P 11 NW.

Amphorae.

171. TS 2247. AASyr 10 1960, 119 fig. 7, NMArb 1961, 126, 128 fig. 9, Archaeology 14 1961, 215. Fragmentary half of amphora. G 15 NW, G 15 SE, G 15 NE. H. 21.2 cm, w. 19.8 cm. Light reddish clay with grits and few mica, light brown somewhat greenish slip, brown to black glaze. Small codron at junction of neck and shoulder. Frieze of pendent tongues. Marching goat, vertical panels with meanders, several filling-ornaments, red-white-red-white-red stripes added on the broad band of the belly, rays radiating from the foot. *Pl. IX.*

172. TS 2880. Rim/neck/shoulder/side sherds. J 8 SE. 11.5×11.0 cm, w. of rim 10.3 cm. Fine light brown clay, thin white slip, black glaze. Small codron at junction of neck and shoulder. Neck: part of cable, shoulder: fast running goat (one of the forelegs nearly kneeling), rosette in front, two narrow and one(?) broad band below. *Pl. X.* Cf. no. **173.**

173. TS 2879. Shoulder/side sherd. J 8 SE. 12.5×c. 6.0 cm. Fine brown clay with some grits, (slip not mentioned), red to brown glaze. Hindpart and one of the forelegs of marching goat, rosette. *Pl. X.* Might possibly belong to no. **172.**

174. TS 3632. Shoulder sherd. G 13. 6.2×6.6 cm. Red clay with grits, whitish slip, brown to black glaze. Small codron at junction of neck and shoulder. Goat with raised head and very slanting body, red added on chest and back. *Pl. X.*

175. TS 1836. Shoulder sherds. G 15 SE. 7.0×7.0 cm, 8.5×7.0 cm. Fine reddish brown clay, white slip, black glaze. Running goat with its head turned backwards, very slanting body, dot-rosette in front, half-rosette on ground line, white stripes added on band at bottom of sherd. *Pl. X.*

176. TS 954. Neck/shoulder sherd. G 12 SW. 8.2×c. 6.5 cm. Buff clay with few grits, creamy slip, brown to red glaze. Small codron at junction of neck and shoulder. Goat with its head turned backwards and very slanting body. *Pl. X.*

177. TS 2297. Shoulder sherd with root of neck. G 16 NW. 5.0×2.7 cm. Brownish clay with few white grits, yellowish slip, red to brown glaze. Goat with its head turned backwards and very slanting body, group of pendent strokes above. *Pl. X.*

178. TS 512. Shoulder sherd. Surface. F 5 w-slope. 5.1×5.0 cm. Light brown pinkish clay, core grey, white slip, dark brown glaze. Central part of large volute pair with inserted dot above and below. *Pl. X.*

179. TS 1514. Shoulder/side sherd. G 5 SE. 2.0×4.5 cm. Light buff clay, creamy slip, brown glaze. Lower part of volute with stalks of two palmette leaves curling upwards, white stripes added on the horizontal band below. *Pl. X.*

180. TS 1523. Shoulder/side sherd. G 8 SW. 6.0×4.5 cm. Reddish clay, creamy slip, black to red glaze. Lower part of volute with stalks of two palmette leaves curling upwards, two narrow and one broad band below. *Pl. X.*

181. TS 3405. Shoulder sherd. H 11 NW. 3.5×2.8 cm. Light brown clay, whitish slip, brown glaze. Small glazed codron at junction of neck and shoulder. Part of big volute pair with inserted leaf. *Pl. X.*

182. TS 1516. Shoulder/side sherd. G 5 NE. 5.4×6.0 cm. Dark buff clay with some grits, white slip, black glaze. Central part of large volute pair(?) rising from ground line, inserted leaf. *Pl. X.*

183. TS 1448. Shoulder or side sherd. P 11 NW. 5.0×4.3 cm. Light buff clay with numerous grits, whitish slip, red glaze. Part of probably asymmetric volute pair with inserted leaf, traces of horizontal band. *Pl. X.*

184. TS 5622. Shoulder or side sherd. H 12. 3.5×4.0 cm. Dark brownish clay, dark brown glaze. Linked circles with inserted buds. *Pl. X.*

185. TS 1058. Rim/neck/side sherds. G 8 SE. 7.7×2.4 cm, 11.3×7.0 cm, c. 8.5×5.5 cm. Buff clay, with white and black grits, white slip, brown glaze. Rim glazed, on neck upper part of cable, at side two broad and one narrow band, below rays radiating from the foot, between them blob-rosette. *Pl. X.*

186. TS 1997. Rim/neck sherd. G 13 SE. 4.5×5.0 cm. Red clay with white grits, white slip, black glaze. Rim glazed, part of cable. *Pl. X. Similar*: TS 3709 G 14, TS 1343 G 11 SW.

187. TS 4912. Rim/neck sherd. G 14 NE. 4.5×5.4 cm, org. diam. of rim c. 12.0 cm. Reddish clay with some grits, whitish slip, red glaze. Rim glazed, part of open cable. *Pl. X. Similar*: TS 1286 P 11 SW.

188. TS 289. Side sherd. G 8 SW. 14.0×9.6 cm. Light brown clay, greyish-white slip, black glaze. Broad band with white-red-white stripes added; above, traces of two narrow bands; below, one narrow band and point of ray. *Pl. X. Similar*: TS 647 G 11 SE.

189. TS 1122. Side sherd. G 8 NW. 6.4×8.8 cm. Dark brownish clay with some white grits, white slip with pinkish tinge, brown to red glaze. Group of small dots in field, below narrow bands and one broad band with red and white stripes added. *Pl. X. Similar*: TS 829 G 11 SE, TS 1084 G 8 SW, TS 1138 G 11 SE, TS 2594 H 11 NW, TS 2884 J 8 SE, TS 3237 J 15 (Sūkās I, 83 no. 107 pl. 4).

190. TS 3523. Side sherd. G 5. 9.0×8.9 cm. Brown clay, creamy slip, brown to black glaze. Foot of goat in field; below, narrow and two broad bands. *Pl. X. Similar*: TS 2608 H 11 NW.

191. TS 1210. Shoulder/side/bottom sherds with ring foot. G 11 NW. Diam. of foot c. 13.0 cm. Reddish to buff clay, white slip, black glaze. Group of small dots in field; below, one narrow and two broad bands, rays radiating from the foot. *Pl. XI. Similar*: TS 648 G 11 SE, TS 834 G 11 SW, TS 1327 G 11 SW.

Indeterminate closed vases.

192. TS 3015. Side sherd. H 13. 4.0×2.2 cm. Red clay with grits, yellowish slip, brown glaze. Fragmentary head of goat. *Pl. XI.*

193. TS 4619. Shoulder sherd. H 10 NE. 1.7×6.0 cm. Fine brownish clay, creamy slip, brown glaze. Forepart of running goat, head turned backwards, frieze of pendent tongues above. *Pl. XI.*

194. TS 2692. Shoulder sherd with root of neck. L 8 SE. 4.2×8.5 cm. Reddish to brown clay with some grits, (slip not mentioned), black glaze. Band along root of neck, below forepart of running goat, head turned backwards, small dot above leg. *Pl. XI.*

195. TS 315. Shoulder sherd with root of neck. F 5 SE. 3.6 cm×6.4 cm. Red to brownish clay with few grits and mica, creamy slip, light brownish glaze. Band along root of neck, group of pendent dots below forepart of goat, head turned backwards. *Pl. XI.*

196. TS 830. Side sherd. G 11 SE. 3.9×2.9 cm. Reddish clay with mica, white slip, red glaze. Fragmentary head of goat. *Pl. XI*.

197. TS 1675. Neck/shoulder sherd. P 11 NW. 5.6×4.0 cm. Fine light brown clay, light yellowish slip, black glaze. Small codron at junction of neck and shoulder, group of pendent strokes, snout of goat. *Pl. XI*.

198. TS 1151–53. Shoulder/side sherds. G 11 SW. No measurements. Reddish clay, white slip, black to red glaze. Frieze of pendent tongues; below, horn and ear of goat, red and white stripes added on broad band of belly. *Pl. XI*.

199. TS 638. Rim/neck/shoulder sherd. G 11 SW. C. 8.7×c. 7.7 cm. Light, reddish clay with grits and mica, creamy slip, black glaze. Rim-collar slightly everted and glazed, white stripe added on interior. Frieze of pendent tongues, horn and ear of goat in field. *Pl. XI*. *Similar* (neck sherd): TS 1266 P 11 SW, TS 3685 G 14.

200. TS 3282. Side sherd. G 13. 9.1×6.4 cm. Reddish, gritty clay, core grey brown, with few mica, creamy slip, red glaze. Slanting abdomen of goat, probably with head turned backwards (two small vertical stripes above the back might be part of the beard); below, S-loop. *Pl. XI*.

201. TS 78. Side sherd. G 5 SE. 3.8×2.5 cm. Light brown clay, yellowish slip, black to brown glaze. Breast and foreleg of running goat; red added on breast. *Pl. XI*.

202. TS 2094. Neck/shoulder sherd. P 11 NW. 7.0×5.5 cm. Light brown to greyish clay with grits and mica, white slip, black glaze. Small codron at junction of neck and shoulder, codron partly glazed. Two vertical stripes, rump of goat. *Pl. XI*.

203. TS 1149. Side sherd. G 11 SW. 3.6×4.7 cm. Reddish clay with grits, whitish slip, black to red glaze. Waterbird(?). *Pl. XI*.

204. TS 676. Side sherd. P 11 SW. C. 2.8×3.4 cm. Reddish clay with grits, white slip, brownish glaze. Black-figure. Forepart of waterbird with its head bent forwards and pressed against its neck, probably raised wing; white added on neck, breast and wing. *Pl. XI*.

205. TS 672. Side sherd. P 11 NW. 4.4×3.4 cm. Light buff clay with mica, white slip, black glaze. Black-figure. Hindpart of marching bird with pendent tail; red added on foot and wing, and for stripe on band below. *Pl. XI*.

206. TS 5635. Side sherd. H 12. 5.3×5.0 cm. Brownish clay with some grits, yellowish slip, brownish glaze. Black-figure. Lower part of marching bird; red and white added on wing. *Pl. XI*.

207. TS 3426. Side sherd. H 11 NW. 3.4×4.1 cm. Grey brown clay, whitish slip, black glaze. Black-figure. Neck of boar(?); red added. *Pl. XI*.

208. TS 549. Side sherd. G 5 NE. 6.3×4.7 cm. Buff clay, with grits and mica, creamy slip, black glaze. Black-figure. Buttocks and tail of sitting beast. *Pl. XI*. *Similar*: TS 675 P 11 SW.

209. TS 3565. Side sherd. G 5 NE. 5.0×5.1 cm. Grey-brown clay with mica and small black grits, whitish slip, brown to black glaze. Black-figure. Foot of sitting beast, large, solid rosette; red and white added for stripes on band below. *Pl. XI*. *Similar*: TS 673 P 11 SW.

210. TS 178. Side sherd. F 5 SE. 3.2×4.1 cm. Light brown clay, creamy slip, black glaze. Black-figure. Fragmentary abdomen of white dotted animal; below the horizontal belly line, which ends in a hook, there was probably a white stripe rather than dots; adjoining abdomen, part of filling-ornament(?). *Pl. XI*. *Similar*: TS 2726 L 8 SE.

211. TS 2374. Side sherd. G 16 NW. 4.5×4.0 cm. Light red clay, white slip, brown glaze. Marching animal(?). *Pl. XI*.

212. TS 2645. Shoulder sherd. L 8 SE. 4.0×4.7 cm. Light brown clay, white slip, brown glaze. Frieze of pendent tongues; below, pendent half-rosette with festoon border, dot and part of two larger filling-ornaments(?) in field. *Pl. XI*.

213. TS 1356. Shoulder sherd. G 11 SW. 5.5 × 5.0 cm. Buff clay, with white grits, tan slip, red glaze. Frieze of pendent tongues, two vertical stripes and double angular corner ornament in field, root of handle glazed(?). *Pl. XI.*

214. TS 937. Shoulder sherd with root of handle. P 11 NW. 6.7 × c. 4.0 cm. Brick-red clay with grits, white slip, black glaze. Rosette in field, in front of it sloping slim stripe, on root of handle two horizontal stripes, below them a sloping one, a dot and faint traces of glaze. *Pl. XI.*

215. TS 294. Side sherd. G 5 SE. 7.3 × 4.5 cm. Grey clay, white slip with greenish tinge, brown to black glaze. Slanting abdomen of goat, rosette below. *Pl. XI.*

216. TS 668. Side sherd. G 7 SE. 5.5 × 6.3 cm. Reddish clay with grits and mica, creamy slip, light brownish glaze. Horizontal abdomen of goat, rosette below. *Pl. XII. Similar* (rosettes): TS 1053 G 8 SW, TS 3002 L 8 SE.

217. TS 804. Side sherd. G 8 SE. 2.6 × 2.3 cm. Red clay with few grits and mica, creamy slip, brown to red glaze. Rosette. *Pl. XII.*

218. TS 1168. Side sherds. G 11 SW. 11.0 × 7.0 cm. Reddish to buff clay, creamy slip, black glaze. Hind legs of goat, between them dot and in front rosette and slim stripe, leg(?). *Pl. XII.*

219. TS 2097. Side sherd. P 11 NW. 3.4 × 5.0 cm. Pink clay, white slip, reddish to dark brown glaze. Rosette and foot of goat. *Pl. XII. Similar*: TS 321 G 5 SE.

220. TS 1482. Side sherd. G 11 SW. 4.5 × 3.5 cm. Reddish clay, whitish slip, red glaze. Rosette and slim vertical stripe. *Pl. XII. Similar* (rosette): TS 1500 P 11 NW.

221. TS 1443. Side sherd. P 11 NW. 6.5 × 6.0 cm. Red to buff clay, white slip, brown glaze. Hind leg of goat and slim vertical stripe, between them a small cross. *Pl. XII.*

222. TS 1485. Side sherd. G 11 SE. 2.5 × 4.5 cm. Reddish to buff clay, creamy slip, brown glaze. Hind foot of goat, angular ornament. *Pl. XII.*

223. TS 1451. Side sherd. G 11 SW. 5.5 × 7.5 cm. Reddish to buff clay, white slip, black glaze. Hook shaped design, dots. *Pl. XII. Similar*: TS 1714 G 15 NE, TS 2661 L 8 SE.

224. TS 5628. Two side sherds, glued. H 11 NE. 14.0 × 9.0 cm. Dark brownish clay, white smooth slip, brown glaze. Sloping stripe crossed by small stripes in field; red added on two of the five horizontal bands below. *Pl. XII.*

225. TS 3575. Side sherd. G 13. 7.0 × 4.0 cm. Light brown clay, grey in core, yellowish slip, black glaze. Black-figured. Fragmentary hind part and abdomen of animal, faint traces of incisions on abdomen; red added on body as well as on the solid rosette. *Pl. XII. Similar*: TS 30 G 5 NE (abdomen), TS 1150 G 11 SW (rosette).

226. TS 1162. Side sherd. G 11 SE. 4.0 × 2.0 cm. Reddish clay with some mica, whitish slip, red to brown glaze. Black-figure. Rosette with incisions radiating from incised circle. *Pl. XII.*

227. TS 1341. Shoulder sherd. G 8 SE. 5.6 × 4.0 cm. Reddish clay, creamy slip, red glaze. On shoulder, curved stripe and two pointed ones, white stripes added on the broad horizontal band, below meander. *Pl. XII.*

228. TS 2883. Shoulder/side or bottom sherd. J 8 SE. 5.2 × 3.5 cm. Fine light brown clay, greyish slip, red glaze. Point of single ray and two close-set ones, curved band crossing some of the narrow horizontal bands below. *Pl. XII.*

229. TS 1832. Shoulder sherd. G 15 NE. 6.5 × 5.0 cm. Fine light brown clay, white slip, black glaze. Two rays of different width. *Pl. XII.*

230. TS 2096. Shoulder/side sherd. P 11 NW. 4.0 × 4.2 cm. Light buff clay, white slip with greenish tinge, black to brown glaze. Part of floral design(?); white added for stripes on band below. *Pl. XII.*

231. TS 3396. Shoulder sherd. H 11 NW. 4.8 × 4.5 cm. Dark red, coarse, gritty clay, creamy slip, brown glaze. Two opposed, curved stripes. *Pl. XII.*

232. TS 2725. Shoulder sherd(?). L 8 SE. 3.3×3.0 cm. Red clay, whitish-greyish slip, black glaze. Part of floral design(?). *Pl. XII.*

233. TS 1386. Side sherd. G 11 SW. 4.5×5.0 cm. Reddish buff clay, yellowish slip, black glaze. Irregular design, graffito in field. *Pl. XII. Fig. g.*

234. TS 3652. Side sherd. G 13. 13.0×11.0 cm. Light brown clay, greyish white slip, brown to black glaze. At top, glazed field (panel ?); below, two bands of different width separated by narrow ones, white stripe added on the broadest of the bands, point of ray at bottom. *Pl. XII.*

235. TS 3513. Side sherd. G 5 NE. 3.6×3.1 cm. Buff sandy clay, whitish slip, brown glaze. Group of three dots in field, below broad band with white-red-white stripes added, meander at bottom. *Pl. XII. Similar*: TS 3579 G 13 NW.

236. TS 921. Side sherd with root of handle. P 11 NW. 3.9×2.9 cm. Reddish clay, yellow slip, red glaze. Root of handle glazed; two white stripes added on the glazed field below. *Pl. XII.*

237. TS 2712. Side sherd. L 8 SE. 4.0×5.0 cm. Red clay, white slip, red glaze. At top meander, narrow and broad band below, white stripes added on the latter, ray at bottom. *Pl. XII.*

238. TS 207. Side sherd. G 5 NW. 10.2×8.2 cm. Fine, light brown clay, creamy slip, black to brown glaze. At top meander, one broad band with red-white-red stripes added below, traces of glazed field at bottom. *Pl. XII. Similar*: TS 529 H 5 SE, TS 1344 H 5 NE, TS 1446 P 11 NW, TS 1940 F 16 SW, TS 2564 H 11 NW, TS 3534 G 5 NW, TS 3744 G 14.

239. TS 669. Side sherd. G 8 SE. 3.4×3.6 cm. Reddish clay with few grits and mica, creamy slip, black to red glaze. Hook meander, glaze below. *Pl. XII.*

240. TS 1683. Side sherd. G 8 SW. 7.5×4.8 cm. Light red to brown clay with some white grits, light buff slip, red glaze. Quick waveline enframed by narrow and broad bands, on latter an added white stripe. *Pl. XII. Similar* (white slip): TS 1080 G 8 SW, TS 1989 G 8 NW.

241. TS 1180. Side sherd. G 11 SW. 5.0×6.0 cm. Fine buff clay, white slip, brown glaze. Two broad bands. *Pl. XII. Similar*: TS 1800 G 7 SE, TS 1877 G 19, TS 2639 L 8 SE, TS 4408 G 10 NE.

242. TS 1278. Side/bottom sherds. P 11 SW. 7.0×6.5 cm. Light reddish to buff clay with few grits, light buff slip, black glaze. Chequers, rays below. *Pl. XII. Similar* (white slip): TS 1342 G 8 SE, TS 4409 G 10 NE.

243. TS 1186. Side sherd. G 11 SW. 8.0×9.0 cm. Reddish, somewhat micaceous clay, black core, creamy slip, red glaze. Two broad bands with added white stripes, point of ray below. *Pl. XII. Similar*: TS 1108 G 8 SW, TS 2878 J 8 SE.

244. TS 611. Neck sherd. G 5 SE. 4.5×4.5 cm. Reddish clay with few grits, white slip, red glaze. Cable with inserted leaves. *Pl. XII. Similar*: TS 854 G 11 SE, TS 3611 G 13, TS 4714 Surface.

245. TS 1086. Side/bottom sherd. G 8 SW. 9.6×6.6 cm. Red, somewhat porous clay, whitish slip, brown to black glaze. One broad and two narrow bands, radiating rays below. *Pl. XIII. Similar*: TS 536 F 5 SE, TS 1679 F 5 SE.

246. TS 1681. Side/bottom sherd. G 11 SW. 9.5×7.5 cm. Brick-red clay with white grits, white slip, brown glaze. Broad and narrow band, point of ray below. *Pl. XIII. Similar*: TS 379 G 8 SE, TS 1085 G 8 SW, TS 1194 G 11 SW, TS 1696 G 5 SW.

247. TS 2251. Bottom sherd with ring foot. J 8 SE. 12.2×3.9 cm. Brown clay, white slip, brown glaze. Rays radiating from the glazed foot. Red dipinto under foot. *Pl. XIII. Fig. g.*

248. TS 849. Bottom sherd with ring foot. G 11 NW. H. c. 4.0 cm. Hard, gritty red clay, reddish slip, black glaze. Two rays radiating from the glazed foot. *Pl. XIII.*

249. TS 3508. Bottom sherd with ring foot. G 5 NE. Org. diam. of foot c. 10.0 cm. Reddish clay, whitish slip, black to brown glaze. Three rays of different width radiating from the glazed foot. *Pl. XIII.*

250. TS 1169. Bottom sherd with ring foot. G 11 SW. 4.5×7.5 cm. Dark buff clay with white grits, core black, white slip, brown glaze. Foot and lower part of side glazed. *Pl. XIII. Similar*: TS 1192 G 11 SW, TS 1195 G 11 SW, TS 2688 L 8 SE.

251. TS 1357. Double-roll handle. F 5 SE. 10.5×2.0 cm. Red clay with grits, creamy slip, red glaze. Two rows of dots, glazed band at handle-root, slim vertical band in shoulder field. *Pl. XIII. Similar*: TS 33 G 5 SE, TS 1174 G 11 SE, TS 1492 P 11 NW.

252. TS 1730. Side sherd. H 5 NE. 4.0×5.0 cm. Reddish to buff clay, black glaze. Glazed all over, incised decoration: probably inner part of lotus-flower, "above" narrow white band added. *Pl. XIII. Similar*: TS 96 E 8 NE.

253. TS 3824. Side sherd. H 11 NW. 3.6×2.8 cm. Yellowish, somewhat gritty clay, brownish to violet glaze. Glazed all over, incised decoration: floral(?). *Pl. XIII.*

Kraters.

254. TS 1339. Shoulder sherd. G 8 SE. 6.5×9.0 cm. Light buff clay, creamy slip, brown glaze. Exterior: vertical panel, corner palmette in field, rosette with festoon border and four-leaf flower with inserted dots. Interior:(?). *Pl. XIII.*

255. TS 597. Shoulder/side sherds. G 11 SW. C. 12.4×c. 8.7 cm. Reddish clay with grits and mica, creamy slip, light brown glaze. Exterior: vertical panel, hind leg of animal in field, behind it vertical slim ray; below, broad band and meander. Interior:(?). *Pl. XIII.*

256. TS 1452. Neck/shoulder sherd. G 11 SW. 7.0×5.5 cm. Red clay with some grits and mica, whitish slip, black glaze. Exterior: neck glazed, vertical panel, frieze of pendent tongues; below, group of pendent dots. Interior: neck glazed with white and red bands added. *Pl. XIII.*

257. TS 2098. Shoulder sherd. P 11 NW. 9.2×7.0 cm. Light brown clay, chalky white slip, black glaze. Black-figure. Exterior: frieze of pendent tongues, vertical panel, griffin with tall neck in field, rounded design at bottom, corner-palmette, irregular designs in front of griffin. Interior: plain. *Pl. XIII. Similar* (no griffin): TS 302 F 5 SE, TS 2625 J 8 SE.

258. TS 2269. Shoulder sherd. G 7 SE. 5.1×5.2 cm. Dark brown gritty clay, yellowish slip, light to dark brown glaze. Vertical panel, filling-ornament with added red in field. Interior: plain. *Pl. XIII.*

259. TS 2324. Neck/shoulder sherd. L 8 SE. 9.3×6.4 cm. Brick-red, very gritty clay, whitish slip, brown glaze. Black-figure. Exterior: neck glazed, vertical panel, in field hindpart of animal. Interior: glazed, white band added on neck. *Pl. XIII.*

260. TS 3057. Shoulder/side sherd. G 14. 7.0×4.4 cm. Grey-brown, micaceous clay, white slip, black glaze. Black-figure. Vertical panel, in field wing(?) with added red, solid star-rosette, small group of tips below. Interior:(?). *Pl. XIII.*

261. TS 662. Shoulder/side sherd. G 8 SE. 9.3×10.5 cm. Light brownish clay with mica, creamy slip, black glaze. Black-figure. Vertical panel, tail of bird in field, corner palmette; red and white added for stripes on the two bands below. *Pl. XIII.*

262. TS 667. Neck/shoulder sherd. G 8 SW. 5.6×4.7 cm. Reddish clay with grits and mica, creamy slip, red glaze. Black-figure. Vertical panel, head of lion in field. Interior:(?). *Pl. XIII.*

263. TS 2150. Shoulder sherds. P 11 NW. 13.7×7.7 cm. Light grey clay, thin greyish slip, black glaze. Black-figure. Vertical panel; in field, blob-rosette and hindpart of bull with added red on belly. Interior: plain. *Pl. XIII.*

264. TS 2323. Shoulder sherd. L 8 SE. 3.9×5.1 cm. Reddish, very gritty clay, creamy slip, black to brown glaze. Vertical panel; in field, group of four small stripes, above frieze of pendent tongues. Interior:(?). *Pl. XIII.*

265. TS 4514. Sūkās I 60 no. 1 fig. 25 d pl. 4. Shoulder sherd. G 13 NW. 4.5×4.0 cm. Buff clay, creamy slip, brownish glaze. Vertical panel with graffito: δα. *Pl. XIV. Fig. g. Similar* (no graffiti): TS 659 P 11 NW, TS 828 G 11 SE.

266. TS 1284. Rim/neck/shoulder sherd. P 11 SW. 10.0×2.5 cm, h. c. 4.0 cm, org. diam. c. 21.5 cm. Reddish clay with white grits, whitish slip, black glaze. Rim: continuous meander on topside, vertical stripes on edge. Exterior: neck glazed, frieze of pendent tongues on shoulder. Interior: glazed; at top, three white bands added. *Pl. XIV. Fig. d. Similar*: TS 29 G 5 NE, TS 269 G 11 SE, TS 2095 P 11 NW.

267. TS 1213. Rim/neck/shoulder sherd. G 11 SE. 3.0×5.0 cm, org. diam. c. 22.0 cm. Light reddish clay with white grits, white slip, red glaze. Rim: meander on topside, vertical stripes on edge. Exterior: neck glazed, frieze of pendent tongues on shoulder. Interior: glazed, white band added at top. *Pl. XIV. Fig. d. Similar* (red sometimes added on the interior): TS 3 Surface, TS 92 E 8 NE, TS 265 G 5 SE, TS 313 G 8 SW, TS 318 G 5 SE, TS 609 G 5 SW, TS 678 G 11 SE, TS 774 G 7 SE, TS 821 G 11 SW, TS 1110 G 8 SW, TS 1285 P 11 SW, TS 1298 P 11 NW, TS 1798 F 16 SW, TS 2144 L 8 SE, TS 2571 H 11 NW, TS 2575 H 11 NW, TS 2619 J 8 SE, TS 2723 L 8 SE, TS 3383 H 11 NW, TS 3512 G 5 NE, TS 3546 G 5 NE, TS 3610 G 13, TS 3666 G 14, TS 3736 G 14, TS 4404 G 14 NW, TS 4802 G 10 SE.

268. TS 1790. Handle-plate with rim sherd. F 15 SE. C. 7.0×3.5 cm, h. of handle 3.0 cm. Red brown clay with grits, (slip not mentioned), brown glaze. Plate: meander on topside, edges glazed, rim: traces of meander. *Pl. XIV. Similar*: TS 2538 Surface, TS 2586 H 11 NW.

269. TS 83. Handle-plate with rim sherd and root of handle. G 15 SE. 7.7×2.5 cm. Light brown clay, white slip with greenish tinge, black glaze. Plate: four clubs on topside, edges and handle-root: glazed, rim: meander. *Pl. XIV.*

270. TS 351. Handle-plate with rim sherd and root of loop-handle. Surface. 8.0×5.5 cm. Light brown clay, creamy white slip, light reddish-brown glaze. Decoration similar to no. 269. *Fig. d.*

271. TS 3844. Handle-plate with rim sherd and root of handle. Surface, W-slope. 9.2×6.0 cm, h. of handle 2.7 cm. Reddish clay with few grits, creamy slip, black to brown glaze. Plate: three rays on topside, edges glazed, rim: meander. *Pl. XIV. Similar*: TS 3428 H 11, TS 3466 H 11 NE.

272. TS 4401. Handle-plate with rim sherd and root of handle. G 10 NE. 4.8×1.5 cm. Light brownish clay, with dark and light grits, mica, yellowish slip, black glaze. Plate: six rays on topside, edges glazed, rim: meander. *Pl. XIV. Similar*: TS 779 G 7 SE.

273. TS 4913. Handle-plate with fragment of loop-handle. G/H 14. 7.0×7.0 cm, h. of handle 3.0 cm. Light brownish clay, yellowish slip, brownish glaze. Plate: on topside, volute pair with inserted leaf, volutes connected to the edge by small stripes, underside and edges glazed. *Pl. XIV. Fig. d.*

274. TS 2311. Handle-plate with rim sherd and root of handle. F 16 SW. 8.5×5.0 cm. Brown, very gritty clay, whitish slip, brown glaze. Plate: three linked circles with buds between, rim: meander, root of handle: glazed. *Pl. XIV.*

Kraters or dinoi.

275. TS 2093. Rim/shoulder sherd. P 11 NW. 4.5×7.9 cm. Pink clay, creamy white slip, brown and orange glaze. Collar of rim sloping on the exterior. Rim: meander, exterior: frieze of pendent tongues, below broad band with white-red-white stripes added, in field two small pendent strokes and a curved one (slanting back of animal?). Interior: plain. *Pl. XIV.*

276. TS 1444. Rim sherd. P 11 NW. 2.5×2.0 cm. Light buff clay, creamy slip, brown glaze. Square with quatrefoil inserted in meander. *Pl. XIV.*

277. TS 4528. Shoulder sherd. H 11 SE. 4.6×9.8 cm. Reddish clay, core grey, creamy slip, red glaze. Black-figure. At top, small codron covered by slip. Exterior: glazed, incised decoration: upper part of three pendent lotus flowers linked by double incisions, inserted leaves. Interior: slipped. *Pl. XIV.*

278. TS 2238. Bottom/side sherd. G 15 SE. 17.9×12.0 cm. Red, very gritty clay, yellow slip, red glaze. Exterior: at top, rosette with festoon border, solid star-rosette and group of strokes at ground line, below hook meander enframed by broad bands with added white stripes, at bottom several rays with dot-rosettes between. Interior: glazed; two red and four white bands added. *Pl. XIV.*

279. TS 1044. Side sherd. G 7 SE. 6.0×5.3 cm. Red clay, white grits, white slip, black to brown glaze. Exterior: half-rosette at ground line, below quick waveline enframed by broad bands, narrow one at bottom. Interior: glazed, red and white bands added. *Pl. XIV.*

280. TS 4630. Shoulder sherd. H 10 NE. 4.0×5.5 cm. Light yellow-brown clay, creamy slip, brownish glaze. Exterior: frieze of pendent tongues, small and larger dots in field. Interior: slipped. *Pl. XIV.*

281. TS 292. Shoulder sherd with root of neck. Surface, F 5 W-slope. 10.1×5.5 cm. Pink clay, creamy white slip, orange glaze. Exterior: root of neck glazed, frieze of pendent tongues, back of animal below. Interior: neck glazed. *Pl. XIV. Similar*: TS 3831 G 13.

282. TS 4620. Side sherd. H 10 NE. 4.0×2.5 cm. Brownish clay, creamy slip, brown glaze. Black-figure. Exterior: forepart of lion with frontal head, red added on neck. Interior: glazed. *Pl. XIV.*

Bowls.

283. TS 636. Side sherd. G 16 SW. 6.7×c. 5.0 cm. Reddish clay with grits, creamy slip, red glaze. Black-figure. Exterior: hindpart of beast and rounded design (point of leaf of handle palmette?), solid star-rosette and group of strokes at ground line, red and white added for stripes on band below. Interior: glazed. *Pl. XIV.*

284. TS 2152. Side sherd. P 11 NW. 4.3×4.6 cm. Red clay, white creamy slip, red to brown glaze. Black-figure. Exterior: marching bull, added red on belly and hind flank, below waveline enframed by two bands. Interior: glazed, white-red-white stripes added. *Pl. XIV.*

Fruit-stands.

285. TS 1125. Bottom sherd with upper part of stem. G 11 SE. 6.0×2.7 cm. Dull, red-brown clay with grits, light buff slip, black glaze. Exterior: two narrow bands, stem glazed. Interior: four buds, four leaves, central dot and two circles, tondo enframed by narrow and broad band. *Pl. XIV.*

286. TS 2928. Bottom sherd with stem and root of splaying foot. J 8 SE. 5.2×5.5 cm. Light brown, very gritty clay, white slip, black glaze. Exterior: no description. Interior: stalks and bottoms of four leaves and four buds, central dot and two circles. *Pl. XIV.*

287. TS 3067. Bottom sherd with root of stem. G 14. W. 8.7 cm. Brownish clay, grey in core, (slip not mentioned), red glaze. Exterior: four narrow bands, stem plain. Interior: two buds and tongue, central dot and two circles, tondo enframed by broad band. *Pl. XIV.*

288. TS 595. Rim/side sherds. G 11 SE. W. c. 8.9 cm, org. diam. c. 20.6 cm. Reddish gritty clay with mica, white slip, black glaze. Exterior: three narrow bands, the low vertical rim glazed. Interior: waveline, three bands (glaze-red-glaze) and two narrow ones, point of radiating bud or leaf. *Pl. XV. Similar*: TS 1179 G 11 SW, TS 2996 H 11 NW, TS 3377 H 11 NW.

289. TS 4645. Side sherd. G 10 SE. 5.5×5.9 cm. Brownish, somewhat gritty and micaceous clay, (slip not mentioned), brown glaze. Exterior: three narrow bands, interior: outmost hook meander and narrow band with white and red stripes added, inner frieze group of five tongues and part of large rosette. *Pl. XV.*

290. TS 4689. Side sherd. H 10 SE. 2.7×4.0 cm. Light brownish, somewhat gritty clay, creamy slip, brownish glaze. Exterior: two narrow bands. Interior: outmost squares with quatrefoil and dots, broad band with white and red stripes added, inner frieze four or five tongues and part of bud, central dot and two circles. *Pl. XV.*

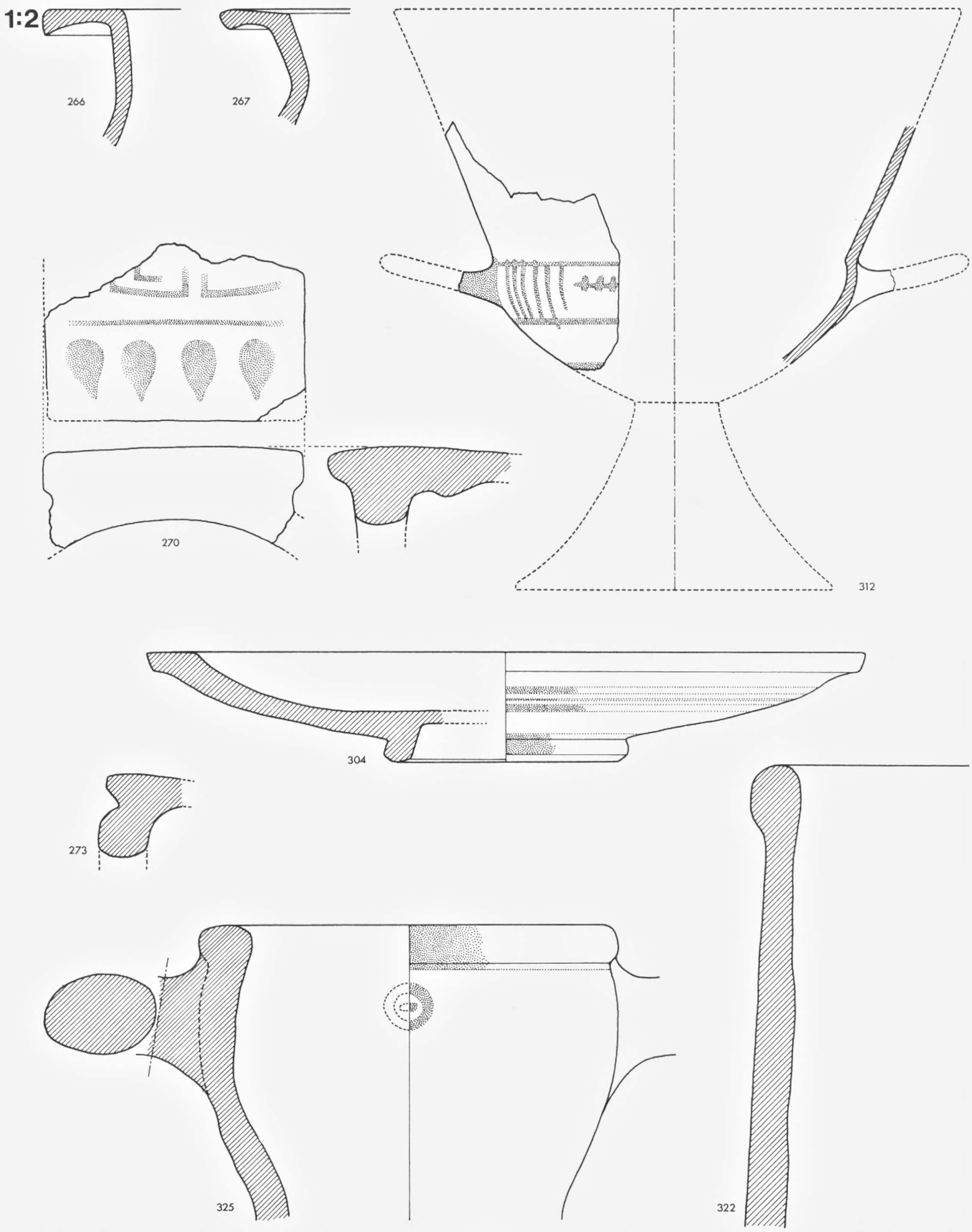


Fig. d.

291. TS 610. Side sherd. G 11 SW. 4.2×4.2 cm. Pink gritty and micaceous clay, creamy slip, black to brownish glaze. Exterior: two narrow bands and grafitto. Interior: in outer frieze, bud linked to flower(?) red added, broad band with white and red stripes added, in inner frieze, squares with quatrefoil and dots, innermost band with white and red stripes added. *Pl. XV. Fig. g.*

Fruit-stands or dishes.

292. TS 4837. Side sherd. H 11 NE. 3.7×2.3 cm. Rather fine brownish clay, creamy slip, red brown glaze. Exterior: one narrow band. Interior: bottom of flower linked to bud. *Pl. XV.*

293. TS 1052. Side sherd. G 8 SW. 4.8×4.7 cm. Dark brown, very gritty clay, whitish slip, black glaze. Exterior: one narrow band. Interior: group of tongues, band above. *Pl. XV.*

Plate.

294. TS 608. Side/bottom sherd, ring foot with groove. G 5 SW. 4.9×4.8 cm. Reddish, gritty and micaceous clay, creamy slip, black to brown glaze. Exterior: plain. Interior: bird and floral ornament, glaze(?) at border above. *Pl. XV.*

Dishes.

295. TS 352. Rim sherd with suspension-hole through outer part of side. Surface. 6.7×6.0 cm. Light brown to pinkish clay, light grey in core, white slip, black glaze. Exterior: edge of rim glazed. Interior: chain of lotus flowers and buds on rim. *Pl. XV.*

296. TS 1015. Rim/side/bottom sherd with ring foot. H 5 NE. 6.0×4.4 cm. Dark buff clay with some grits, creamy slip, black glaze. Three suspension-holes through rim. Exterior: group of two narrow bands and one around foot. Interior: hook meander on rim; on side, three bands (glaze-red-glaze) and two narrow ones, point of bud and leaf. *Pl. XV.*

297. TS 1147. Rim/side sherd. G 11 SW. 5.0×10.1 cm. Dark red clay with grits and mica, creamy slip, brown glaze. Exterior: three narrow bands. Interior: hook meander on rim, two broad bands and central bud and leaf on side. No added colour. *Pl. XV. Similar*: TS 48 Surface, TS 85 E 8 NE, TS 296 G 5 SE, TS 304 F 5 SE, TS 347 G 7 SE/G 8 SW, TS 1079 G 8 SW, TS 1081 G 8 SW, TS 1103 G 8 SW, TS 1141 G 11 SW, TS 1397 P 11 NW, TS 2687 L 8 SE, TS 3048 G 16, TS 3378 H 11 NW, TS 3465 H 11 NE, TS 3603 G 13, TS 3714 G 14, TS 4402 G 10 NE.

298. TS 1340. Rim/side sherd. H 5 NE. 8.5×7.0 cm. Dark buff gritty clay, whitish slip, black glaze. Exterior: four narrow bands. Interior: hook meander on rim(?), two broad and two narrow bands, central leaf on side. *Pl. XV.*

299. TS 2110. Side/bottom sherd with ring foot. P 11 NW. 5.1×6.0 cm. Pink clay, creamy slip, reddish brown glaze. Exterior: narrow band on foot. Interior: two(?) buds and one leaf, one of the buds(?) turned down. *Pl. XV.*

300. TS 1517. Rim/side/bottom sherd with ring foot. G 5 SE. 10.0×5.0 cm, h. 4.0 cm. Reddish gritty clay, creamy slip, red glaze. Exterior: four narrow bands, foot glazed. Interior: transversal stripe on rim; on side, three bands (glaze-red-glaze) and one narrow one, cross and remnant of bud or leaf. *Pl. XV.*

301. TS 2620. Rim/side/bottom sherds with ring foot. J 8 SE. 10.5×11.0 cm. Brown clay with white grits, white slip, black glaze. Exterior: two narrow bands. Interior: hook meander on rim; on side, three bands (glaze-red-glaze) and two narrow ones, lotus flower and bud. *Pl. XV.*

302. TS 238. Rim/side sherds. P 11 SW. 10.7×8.5 cm. Pink clay, creamy slip, brownish glaze. Exterior: narrow bands, dots on edge of rim. Interior: hook meander on rim; on side, two broad bands with added red stripes, three narrow bands, point of central bud or leaf. *Pl. XV. Similar*: TS 26 E 8 SE, TS 330 G 5 SE, TS 338 H 5 NE, TS 810 G 8 SE, TS 2497 P 11 NW.

303. TS 1105. Rim/side/bottom sherd with ring foot. G 8 SE. 7.0×5.0 cm. Dark brownish very micaceous clay, whitish slip, red glaze. Exterior: no description. Interior: hook meander on rim; on side, two broad bands, point of bud or leaf and radiating waveline. *Pl. XV.*

304. TS 5632. Rim/side/bottom sherds with ring foot. H 12. Org. diam. c. 20.0 cm, h. 4.5 cm. Dark brownish clay, thin light slip, brown glaze. Exterior: upper part, three bands, broad band at junction with foot and on foot. Interior: on rim and side, broad and narrow bands (glaze-red-glaze), buds alternating with groups of two tongues. *Pl. XV. Fig. d.*

305. TS 1271. Rim/side sherds. P 11 SW. 4.0×8.0 cm, 5.4×8.5 cm. Reddish buff clay with few mica, whitish slip, red glaze. Suspension-hole below rim. Exterior: no description. Interior: broad band on rim; on side, broad and narrow band, point of tongue. *Pl. XV.*

Banded dishes.

306. TS 1076. Rim sherds. G 8 SW. 6.1×2.4 cm, 4.0×2.0 cm. Red, very gritty clay, black glaze. Exterior: no description. Interior: rim glazed, groups of four white transversal stripes added. *Pl. XV. Similar*: TS 1111 G 8 SE.

307. TS 1037. Rim/side/bottom sherds with ring foot. G 7 SE. 14.4×3.4 cm. Very micaceous red clay with some grits, black glaze. Two suspension-holes through rim. Exterior: no description. Interior: glaze on rim, two groups of white transversal stripes added, one band on side. *Pl. XV.*

308. TS 1988. Rim/side sherd. G 8 NW. 4.0×2.5 cm. Fine brown clay, black glaze. Exterior: graffito. Interior: band on rim and at junction of side. *Pl. XV. Fig. g. Similar*: TS 3577 G 13 NW (no graffito).

309. TS 533. Rim sherd. P 11 SW. Org. diam. c. 10.0 cm, h. c. 2.2 cm. Reddish clay with white grits, red glaze. Exterior: band on rim. Interior: band on rim and immediately below rim. *Pl. XV.*

XIII
Chian Vases

The ceramic series from Chios are poorly represented among the finds from Tall Sūkās; most of the pieces are late, only the two jugs, **320–321**, seem to be from the 7th century. The chalice fragments, **310–318**, display examples of three types of decoration of the first half of the 6th century: Animal Style chalices, Simple Figure chalices and Plain chalices.[397] **310**, and possibly **311**, **313** and **317**, have belonged to Animal Style chalices. On the interior of **310** part of an elaborate lotus flower occurs,[398] whereas **311** has a row of buds radiating from two narrow bands—instead of a flower. The decoration of the latter looks similar to that of phialai,[399] but **311** is decorated on the exterior like the chalices in question.[400] The dots flanked by two narrow bands on **313** might be part of a large volute composition like that on some of the Chian Wild Goat chalices of the late 7th century,[401] only a rim ornament as on **313** is not found on

[397] For references, see Emporio, 157 notes 2–5, 158 notes 1–2.

[398] Emporio, 157.732 pl. 59, Tocra, 58.774 pl. 40.

[399] Lambrino, Vases, 305–306.12–13 figs. 295–297 pl. 3 and perhaps Naukratis I pl. 5.1–2.

[400] The decoration of the phialai is very restricted, usually consisting only of horizontal, narrow stripes, see note 397 and BSA 60 1965, 141.13–15 pls. 43–44.

[401] E. Langlotz, Griechische Vasen, Martin von Wagner-Museum der Universität Würzburg, München 1932, pl. 13 below.

chalices earlier than those of the Animal Style; the latter generally continues the Wild Goat tradition.[402] The other fragment, **317**, might possibly belong to an Animal Style chalice too; a roundel without transversal stripes is not usual in Chian, but occurs on a fragment from Naukratis.[403] **312** is from a plain chalice with tall, slightly offset walls and shallow body; the probably tall, conical foot is not preserved. The shape is quite similar to that of the Simple Figure chalices, of which some have been found in Deposit II in Tocra.[404] Two tiny sherds, **314–315**, may be connected with Simple Figure chalices, on account of their rim ornaments.[405] The rim fragment **316** has only a narrow band on the edge, and though some of the latest of the chalices are without any particular rim ornament,[406] **316** may just as well have belonged to other shapes.[407] Because of its finding place **318** is assigned to Period G². The only fragment with figure representation is **319**; the seated sphinx is rendered in silhouette with reserved details. The fragment is plain on the interior and should thus belong to a closed vase; but the frieze of boxes below makes **319** resemble the domed Chian lids which usually have black-figure decoration.[408] Seated sphinxes are very popular on the latter,[409] and one of the early black-figure fragments from Thasos indeed displays similarity with the figure of our sphinx,[410] but the same holds good for a sphinx on an Animal Style chalice where the technique employed is the same as on **319**.[411] Therefore our fragment, though clearly showing Fikellura affinities, is tentatively classified as Chian, i.e. from a bowl with domed lid rendered not as usual in black-figure technique, but in that of the Animal Style chalices.[412] Only one of the two jugs **320–321** has a white slip, i.e. **320**, but the surface of **321** is so worn that we cannot tell if it has not been slipped,[413] and the band system of the latter makes an ascription to Chios reasonable. **320** might belong to the last quarter of the 7th century, like most of

[402] Compare the fragment in Oxford, CVA Oxford fasc 2, II D, pl. 5.6. Rim ornaments similar to that of **313** are often connected with the "Z.2 writer", BSA 47 1952, 161, 166–167.45, 62, 64 pl. 34.13–16, BSA 51 1956, 57 note 1, 58.

[403] Naukratis I pl. 5.25.

[404] Tocra, 58–60, Type III; the latest pottery in Deposit II is about 565 B.C.

[405] Like Tocra, 59.783–785 pl. 42; but we cannot be definite about the vase shape, kantharoi have similar rims, see below note 407. It is on fragments of this sort that inscriptions, dedications to Chian and to Naukratite deities, occur, see BSA 47 1952, 159–170 and BSA 51 1956, 56–59. J. Boardman has suggested that the factory for the latter was at Naukratis" . . . near the places of dedication", and it cannot be excluded that the vases to which our fragments belonged may have been manufactured at Naukratis.

[406] Simple Figure chalices: Tocra, 59.792–794 pls. 44–45, black-figured chalices : ibid. 59.787 pl. 44, plain chalices: ibid. 59–60.797 pl. 45; most of them are small chalices.

[407] Like, for instance, kantharoi or phialai, BSA 47 1952, 159, Emporio, 157.

[408] The Chian lids are usually slipped on the interior and occasionally decorated with friezes, BSA 51 1956, 58 note 1, Emporio, 166 note 2; as mentioned, our fragment is plain on the interior.

[409] Emporio, 166.824 fig. 115 pl. 62.

[410] ÉThas 7, 40.24 pl. 13.

[411] Emporio, 157.724 fig. 106 pl. 58.

[412] The tails of the sphinx on our fragment, and on the one from Thasos (see note 410) and the one from Emporio (see note 411), are clearly related to the Wild Goat tradition, see Samos V pl. 124, whereas the tails of the figures on the Simple Figure chalices and on vases in black-figure are usually placed higher up the buttocks, see Tocra, 59.781, 784 pls. 41–42, Emporio, 166.824 pl. 62, JHS 44 1924, pl. 12. For a seated sphinx on a Fikellura amphora, see CVA Oxford fasc 2, II D, pl. 6.4 (BSA 34 1933/34, 10.E1).

[413] The latest of the Chian jugs are often unslipped, see Emporio, 144; but, as mentioned, the lack of slip on **321** is not sufficient to term the jug late.

the jugs from Emporio.[414] Most similar to **321** both in proportions and decoration is a jug from Kofina found in Deposit II, where nothing earlier than the 6th century occurs,[415] nevertheless, the squatness of our jug is more pronounced than of the ones usually ascribed to the 6th century.[416] A few fragments, **322–325**, of the wide-spread Chian wine-amphorae appeared too on Tall Sūkās.[417] **322–324** are slipped like the earliest wine-amphorae from the late 7th and the early part of the 6th century.[418] **322** is from a rather tall neck, the profile is straight and the lip only moderately thickened; these are features which distinguish our fragment from the 7th century amphorae,[419] and connect it with the more pronounced spindle-shaped type.[420] The latter may have developed around 600 B.C.; some occur in CypArc II graves,[421] and a fragmentary, re-used amphora from Tell Defenneh was sealed with carthouches of King Amasis.[422] The casual drawing of **323** assigns the fragments to the same type as **322** and the same holds good for **324**.[423] **325**[424] is unslipped, a tendency which appeared already in the first half of the 6th century.[425] The swelling neck and the dotted theta place this fragment late in the Chian series, perhaps as late as the beginning of the 5th century.[426]

Chalices.

310. TS 234. Side sherd. G 8 SE. 2.4 × 1.3 cm. Reddish grey clay, milky-white slip, black glaze. Exterior: slipped. Interior: glazed, part of lotus flower with white outlines and red interiors. *Pl. XVI.*

311. TS 2338. Side sherd. P 11 NW. 4.6 × 2.0 cm. Light red clay with dark grits, yellow slip, black to brown glaze. Exterior: slipped, frieze of Z's enframed by three bands; at top, single dot; at bottom, slim sloping band. Interior: four buds with white outlines and red interiors radiating from two curved stripes, below white point. *Pl. XVI.*

[414] Emporio, 144–145.592–595 fig. 93 pl. 51 belonging to Period IV. For references to the similar Samian series, on which the bands never seem to be grouped as on the Chian jugs, see Emporio, 144 note 1 and Agora XII.1, 78 note 11.

[415] BSA 49 1954, 138.44 pl. 7. The band round the bottom is suggested to imitate a foot, see Agora XII.1 78.

[416] Emporio, 145.596 pl. 51. The jugs from the Samian Bothros, closed c. 600 B.C., are definitely slimmer, see AM 74 1959, 27–32 Beilage 59, 73.1; the jug from the "Grand Dépot" in Lindos has the same slim dimensions, Lindos I 618.2565 pl. 123.

[417] Emporio, 178–180 with references; for antecedents, ibid, 137–138. See further Lambrino, Vases, 95–132 figs. 62–90, Histria 2, 89–91.348–372 pls. 21–22, Materiali 103 1962, 11 fig. 4, BSA 60 1965, 139, ArchRep 1965/66, 34 fig. 12, BCH 93 1969, 448–449 fig. 25, Mégara Hyblaea 2, 83–84 pl. 70.1–2, 6, Xanthos IV 69–70.111 pl. 25, Agora XII.1, 200 note 4.

[418] BSA 49 1954, 169, Emporio, 179 note 1.

[419] BSA 53/54 1958/59, 16 fig. 4, BCH 88 1964, 137–140.218 fig. 50.

[420] ArchRep 1965/66, 34 fig. 12.

[421] BCH 88 1964, 138 note 7, 140.

[422] W. M. Flinders Petrie and others, Tanis II. London 1888, 72 pl. 36.5: "white faced Greek amphora with red lines", BSA 51 1956, 62 note 4, Boardman, GO, 32, 147 fig. 38.

[423] Emporio, 137: "the upright handle regularly carries a vertical stripe, as do the sixth-century wine-amphorae".

[424] **325** is found with a Phoenician jar (TS 4927), dated 600–475 B.C. Sūkās I 90 note 301.

[425] BSA 49 1954, 169.

[426] An identical neck is known from Kofina, BSA 49 1954, 139.51 fig. 8, 169, found in Deposit III which contains material from the end of the Archaic period. See further, Amphoras and the Ancient Wine Trade, Excavations of the Athenian Agora, Picture Book No. 6 1961, fig. 44.2 (P 24873). The dotted theta is known from the last quarter of the 6th century, but is not regular until the 5th, see L. H. Jeffery, The Local Scripts of Archaic Greece, Oxford 1961, 325, 335, 338 no. 48 pl. 65.

312. TS 4386. AASyr 13 1963, 220 fig. 23, Emporio, 158 note 2. Side/bottom sherds with handle root. G 12 SW. 8.9 × 7.9 cm (one sherd). Brownish very gritty clay, with mica, yellowish slip, black to brown glaze. Exterior: handle-zone enframed by two narrow bands, six vertical stripes, row of V's executed with multiple brush, root of handle glazed. Interior: glazed. *Pl. XVI. Fig. d.*

313. TS 2155. AASyr 10 1960, 127–28 fig. 16. Rim sherd. P 11 NW. 2.1 × 2.2 cm. Light brown clay with small white grits, creamy slip, black to brown glaze. Exterior: frieze of S's enframed by four bands, dots superimposed on the uppermost one; in field, slightly curved row of dots flanked above by narrow band and below by glazed field. Interior: single leaf with white outlines and red interior. *Pl. XVI. Similar* (no decoration except that on the rim): TS 2199 J 8 SE.

314. TS 2663. Rim sherd. L 8 SE. 2.2 × 1.5 cm. Light brownish clay, white slip, brown to black glaze. Exterior: frieze of small, slanting strokes enframed by four bands. Interior: glazed. *Pl. XVI.*

315. TS 4562. AASyr 13 1963, 220 fig. 25, Emporio, 157 note 5. Rim sherd. H 10 NE. 2.5 × 1.5 cm. Greyish brown clay, creamy slip, light brown and black glaze. Exterior: frieze of dots enframed by two bands. Interior: glazed, two bands and dot in added white. *Pl. XVI. Similar*: TS 2664 L 8 SE.

316. TS 3581. Rim sherd. G 13 NW. 2.1 × 3.1 cm. Grey-brown, sandy clay, white slip, brown glaze. Exterior: slipped, band on edge. Interior: glazed, except for band at top. *Pl. XVI.*

317. TS 4801. Side sherd. G 10 SE. 1.8 × 1.2 cm. Dark brownish clay, thick, smooth yellow slip, brown to black glaze. Exterior: roundel with double contours and solid interior. Interior: part of lotus flower with white outlines and red interiors. *Pl. XVI.*

318. TS 4699. Side sherd. H 13 NW. 1.5 × 2.4 cm. Brownish somewhat gritty clay, thick white slip, black to brown glaze. Exterior: slipped, narrow and broad glazed band superimposed. Interior: glazed, two white bands added. *Pl. XVI.*

Lid?

319. TS 2281. Fragment from upper part. F 16 SW. 2.7 × 4.0 cm. Red clay with a little mica, creamy slip, light brown to black glaze. Exterior: possibly four-leaf rosette, seated sphinx(?) with red added on thigh and belly, curved, reserved stripes at hip and another in the forepart of the wing; below, two narrow bands and frieze of boxes. Interior: plain. *Pl. XVI.*

Jugs.

320. TS 4440. AASyr 13 1963, 220 fig. 24. Nearly intact. G 12 SE. H. 8.0 cm. Reddish brown clay, white slip, brownish glaze. Exterior: two bands below handle, on handle transversal stripes. Interior: band on rim. *Pl. XVI.*

321. TS 235. Handle missing, otherwise nearly complete. H 5 NE. H. 9.9 cm, diam. of foot 6.9 cm. Fine light brownish clay with some grits and mica, reddish brown glaze. Exterior: band on rim, two bands below handle. Interior: band on rim. *Pl. XVI.*

Amphorae.

322. TS 5637. Rim/neck sherd. H 12. 5.3 × 14.5 cm. Dark red, gritty clay, whitish slip, brown matt glaze. Rim glazed; on neck, pendent, slim, slightly curved stripe; at bottom, narrow horizontal band. *Pl. XVI. Fig. d.*

323. TS 1158–59. Neck/side sherds. G 11 SW. 8.0 × 12.0 cm, 12.0 × 12.0 cm, 11.0 × 13.0 cm. Red gritty clay with few mica, white slip, red matt glaze. On neck, slim curved band, and below narrow horizontal band; on belly, another narrow band. *Pl. XVI. Similar*: TS 1224 G 11 NW, TS 2616 H 11 NW, TS 5650 H 12.

324. TS 1475. Handle. G 11 SW. 9.0 × 3.5 cm. Dark brown gritty clay, white slip, red matt glaze. Vertical band. *Pl. XVI.*

325. TS 4928. Sūkās I 90 no. 6 fig. 32 c pl. 5. Fragmentary neck with handle roots. H 15. H. 10.0 cm, diam. 12.0 cm. Light reddish brown, very gritty clay, black glaze. Rim glazed, on both sides painted: *θ. Pl. XVI. Fig. d.*

XIV
Vroulian Cup

Surprisingly, a fragment of a Vroulian cup has appeared. This category is found only rarely outside Rhodes;[427] overseas the cups are represented in Naukratis[428] and in Mersin, where two fragments have appeared.[429a] On account of the contexts in Vroulia the cups are dated to the first third of the 6th century.[429b]

326. TS 4693. Side sherd. H 11 SE. 3.0×2.5 cm. Red-brownish, somewhat gritty clay, black glaze. Exterior: incised leaves alternately in glaze and added red radiating from two incised curved stripes. Interior: similar leaves. *Pl. XVI.*

XV
Vases in Fikellura Style

Another of the possible Rhodian groups, the Fikellura vases,[430] are sparsely represented too: less than ten sherds were found and registered, **327–331**.[431] Usually friezes of short vertical strokes enframe the meander as on **327**, only the earliest of the vases with meanders on the neck are without these friezes;[432] on the later vases they are canonic.[433] The Altenburg Group, dated 550–540 B.C., seems to provide the

[427] Kinch, Vroulia, 174–185 pls. 10–12, ClRh III 28–29.2 figs. 11–12 (= CVA Rodi fasc 2, II Dm, pl. 4) ClRh VI/VII 25–26.4 figs. 26–27, CVA Rodi fasc 2, II Dm, pl. 3.1–2, Cook, Greek Painted Pottery, 140–141.

[428] JHS 44 1924, 188–189 figs. 14–17.

[429a] LAAA 26 1940, 117.IV pl. 49.3–4, Garstang, Mersin, 258.3–4 fig. 161.

[429b] See CVA Brit. Mus. fasc. 8, 31 note 7.

[430] BSA 34 1933/34, 1–98 pls. 1–19, CVA Brit. Mus. fasc 8, II D l, pls. 1–14. For the overseas sites, see further ArchRep 1961/62, 37 fig. 10 (= AJA 71 1967, 500 pl. 115.12), Berytus 11 1955, 106.64–74 (74 = CVA Brit. Mus. fasc 8, Appendix B), Tocra, 42.586 pl. 29, Calif St Clas Arch 3 1970, 56–57 note 3, Tarsus III 322–323.1603 pls. 107, 149 (compare Tarsus III 303.1483 pl. 100), Lambrino, Vases, 310–344 figs. 302–341 pls. 4–6, Histria 2, 92–95.388–415 pls. 23–26, Fabricius, Arch Karta 1, 59 fig. 18, pls. 7.1, 9.5, 11.5, Sov Arch 16 1952, 250 fig. 12.1, Materiali 50 1956, 43 fig. 8, 56 1957, 183 fig. 1.1, 185 fig. 2 b.1, 103 1962, 125 fig. 9.1–2, 128 fig. 10 A1–8, 129 fig. 10 B9–13, ArchRep 1962/63, 45 note 30. Xanthos IV 29–30, 36 pls. 4–5.

[431] The expedition is most grateful to Professor M. E. Mellink who kindly made available photographs of sherds kept at Bryn Mawr College from Forrer's Soundings on Sūkās. Among these were several East Greek sherds, most of them replices of pieces included in the present catalogue, except one, a tripartite handle, which is probably from a Fikellura vase (see BSA 34 1933/34, 15 J 1 pl. 6, CVA Brit. Mus. fasc 8, II D l, pl. 3.3 = BSA 34 1933/34, 5 B 1) rather than from a vase in Wild Goat Style (see late 7th century: CVA Bibl. Nat. fasc 1, pl. 4.5–6 (Kardara, A, 107.9), 6th Cent.: CVA Rodi fasc 2, II Dh, pl. 7 (Kardara, 208.2). See further, Villard, Marseille, 39 note 4. II 73.7

[432] CVA Brit. Mus. fasc 8, II D l, pl. 13.1 (= BSA 34 1933/34, 5 B 4 Lion Group), Délos XV on the pl. 51 (= BSA 34 1933/34, 8 C 2 Group of BM B 117), whereas the cable ornament, more common SA 34 earlier Fikellura vases (BSA 34 1933/34, 71–73) was enframed by short strokes from the beginning, B 1933/34, 5–8 B Lion Group.

[433] CVA Oxford fasc 2, II D, pl. 6.1 (= BSA 34 1933/34, 22 L 14 Running Man Group); no. 14 is dated to the end of the third quarter of the 6th century.

earliest examples,[434] and this dating should thus be the earliest possible for **327**. **328** is without enframing friezes, so theoretically it might be earlier than **327**—the very delicate and careful drawing of the meander and the square connect the fragment with early vases like the Mykonos Group.[435] Pendent lotus flowers, as the one on the shoulder sherd **329**, occur on vases dated between c. 550 and 535 B.C.[436]

Indeterminate closed vases.

327. TS 2312. Neck sherd. F 16 SW. 3.2×2.4 cm. Reddish somewhat porous clay, with some mica, yellow slip, red brown glaze. At top small glazed codron. Frieze of short vertical strokes enframed by narrow bands, below remnants of meander. *Pl. XVI.*

328. TS 4419. Sūkās I 63 no. 18, 88 fig. 25 g pl. 4. Neck sherd. G 14 SE. 6.5×8.9 cm. Light, reddish very micaceous clay, yellow slip, brownish glaze. Reserved metope with meander and squares with quatrefoil and inserted dots. *Pl. XVI.*

329. TS 2629. Shoulder sherd. F 15 SW. 4.0×3.3 cm. Red, very micaceous clay, white slip, red glaze. Pendent lotus flower, narrow bands. *Pl. XVI.*

330. TS 625. Side sherd. G 11 SE. C. 3.5×3.3 cm. Reddish clay with mica, yellow-white slip, red glaze. Two friezes of crescents, separated by two narrow bands. *Pl. XVI.*

331. TS 575. Side sherd. G 11 SW. 2.5×2.3 cm. Red clay with mica, white slip, red glaze. Frieze of crescents, below/above frieze of short vertical strokes. *Pl. XVI. Similar*: TS 598 G 11 SW, TS 1102 G 8 SW, TS 1740 P 11 NW, TS 3077 G 14.

XVI
Other East Greek Black-Figured Vases

The fragments classified under this heading form no homogeneous group; stylistically as well as chronologically they are very different. **332–347** all belong to closed vases. **332–336** are slipped and thus related to the latest Orientalizing wares, i.e. Late Wild Goat, Chian and Naucratite (?), but in the colour effect and the incised details they lead forward to the Black-Figure schools of the second half of the 6th century in Eastern Greece. Only little material belonging to this transitional phase, mainly covering the second quarter of the 6th century, has been published.[437] Usually the items are listed under Miscellaneous or Indeterminate Black-Figure.[438] Thick and broad white bands, like on **332**, are frequent in this period;[439] on the body of the lions the use of small vertical incisions is still restricted to the mane, the forepart of the back and the buttocks.[440] **333** might represent this type, but on **332** the incisions apparently appear too on the breast of the animal, a feature which is met with in "Clazomenian"–

[434] BSA 34 1933/34, 16–17 J 12 pl. 7 b.

[435] For the same sort of meander and square, see Délos XVII 72–73.5 pl. 50 (= BSA 34 1933/34, 13 G 10 Mykonos Group, "No. 1 . . . . . . may be about 550, the others not much later").

[436] CVA Brit. Mus. fasc 8, II D 1, pl. 2.3 (= BSA 34 1933/34, 8 C 1 Group of BM B 117), BSA 34 1933/34, 15 J 1 pl. 5 Altenburg Group, BSA 34 1933/34, 48 Y 13 pl. 15 b Amphoriskos.

[437] The fullest account hitherto given is by J. M. Cook in BSA 60 1965, 114–137; see further the remarks by J. Boardman in JHS 78 1958, 12 and J. Hayes, Tocra, 64.

[438] See note 437: Cook; add Gnomon 1965, 506–507. See further above notes 305, 342–343.

[439] BSA 60 1965, 120.32 fig. 4 pl. 26, JHS 8 1887, 121 pl. 79 above; according to Chr. Kardara the latter is Late Rhodian, Kardara, A, 245.4 fig. 198.

[440] JHS 8 1887, 121 pl. 79 above.

already on the earliest of these vases.[441] The closest parallel to the waved silhouette of the indeterminate figure of **336** seems to be the stylization of the belly of a centaur on a "Clazomenian" fragment dated c. 550–540 B.C.[442] The tail on **334** probably belonged to a horse,[443] as none of the early "Clazomenian" satyrs appear to have tails stylized in the same manner.[444] White crosses are favourite ornaments especially on female dresses of the "Clazomenian" vases; they occur too on our fragment **335**, where the border is indicated by three incised and perhaps two red vertical wavelines, but the appearance looks less stiff than on the "Clazomenian" vases. Like the preceding four sherds, this fragment is slipped and may thus antecede the "Clazomenian" proper, or perhaps be a late, Chian/Naucratite representation influenced by "Clazomenian".[445] The rest of the fragments belonging to closed vases, **337–347**, are not slipped; most of them are from the second half of the 6th century, and thus probably to be connected with vases from the "Clazomenian" koiné. Red and white are used lavishly on **337–338**, **341–343**; the most ornamental fragment, **337**, might be rather late, the stylization of the mane is closest to the pieces grouped together in the Knipovitch Class,[446] where the horses, as usual in "Clazomenian", are bridled, but on none of them is the neck ornament stylized in the same primitive manner as on **337**.[447] Broad white bands as on **338** and on the chest of **337** are seen still on the "Clazomenian" pottery from the late 6th century.[448] S-shaped incisions flanking added stripes, like on **342–343**, occur on a horse of a hydria assigned to the Urla Group.[449] **339**[450] might be rather early; the manner seems to copy the Gorgo Painter.[451] The details of the sturdy bird on **344**a are not very informative.[452] Fussy incisions like those on **345** often appear on the horses of the Urla Group.[453]

[441] AD II.5, Berlin 1908, pl. 55 (= BSA 47 1952, 124 A 3 Tübingen Group).

[442] AD II.5, pl. 56.5 (= BSA 47 1952, 139 F 15 Miscellanea). For similar stylization on the later vases belonging to the Clazomenian koiné, see for instance CVA Brit. Mus. fasc 8, II Dn, pls. 7.9, 11.2 (= BSA 47 1952, 131 C II 22, C II 18 Urla Group), BSA 47 1952, 140 F a pl. 32 Miscellanea.

[443] CVA Cambridge fasc 2, II D, pl. 18.4 (= BSA 47 1952, 138–139 F 1 a–c Miscellanea, dated "... a little before the middle of the 6th century .... an early — probably experimental stage in the Clazomenian b.f. style"), see further BSA 60 1965, 131, AD II.5, pl. 55.2 a (= BSA 47 1952, 124 A 3 Tübingen Group).

[444] CVA Brit. Mus. fasc 8, II Dn, pl. 7.9 (= BSA 47 1952, 131 C II 22 Urla Group); late example: BSA 47 1952, 140 Fa Miscellanea, last quarter of the 6th century.

[445] The chain of woman dancers on the "Clazomenian" vases may have influenced Chain representations, see BSA 51 1956, 61 note 10 and JHS 44 1924, 204, 217–218; for the opposite point of view, see BSA 47 1952, 127 note 20. Ornamental crosses are found too on Naucratite dresses, JHS 44 1924, pl. 6.8,25 but bordering wavelines like on **335** are apparently not to be connected with the latter category. On "Clazomenian" the chiton-clad women are fullest represented in the Tübingen Group: C. Watzinger, Griechische Vasen in Tübingen, Reutlingen 1924, 15.9 pl. 2 C 8 (according to R. M. Cook an "unreliable sketch", BSA 47 1952, 125 A 10), CVA Brit. Mus. fasc 8, II Dn, pl. 13.3 (= BSA 47 1952, 125 A 11), BSA 60 1965, 130.68 fig. 12 pl. 34.

[446] BSA 47 1952, 136–138, for the mane, see especially E II 3. The class is dated 540–10 B.C.

[447] The five narrow bands on the neck of **337** more likely illustrate the delicate necklace found on "Clazomenian" horses, CVA Brit. Mus. fasc 8, II Dn, pl. 12.1 (= BSA 47 1952, 132 C II 25 Urla Group) than a harness, see BSA 47 1952, 136 E III 2 Knipovitch Class.

[448] BSA 60 1965, 130–131.71–73 pl. 35.

[449] CVA Brit. Mus. fasc 8, II Dn, pl. 13.1 (= BSA 47 1952, 131 C I 14), dated c. 530 B.C.

[450] **339** is found with a fragment of possibly an Ionian Little Master cup, Sūkās I 60 note 176 pl. IV no. 4 (not included in the present catalogue).

[451] Sūkās I 60 note 175, add: JdI 76 1961, 1–47 figs. passim.

[452] For an Atticizing fragment, see BSA 60 1965, 115.3 pl. 23.3 g.

[453] BSA 47 1952, 133; see CVA Brit. Mus. fasc 8, II Dn, pls. 12.1, 3–4, 13.2 (= BSA 47 1952, 132 C II 25, 131 C II 14, 132 C II 27).

Two rows of rays radiating from the foot are not usual on East Greek pottery, though the contrary has been claimed.[454] **348–364** may seem Attic, but the fabric indicates an Eastern origin. **348–352** are from open vases; the fragments all bear figure representations which more or less are influenced by the traditions of the mainland. The most outstanding one is that on **348**: a man(?) is leaning forward, and the raised hand is rather his own than that of another person. The gesture and the stylization of some of the details, which are rendered rather awkwardly, are not familiar in Eastern Greece. The posture of the hand is matched on an Attic amphora assigned to the Amasis Painter;[455] the Attic scene is Dionysaic and our figure, whom two red stripes on the shoulder may indicate as dressed, may be a participant in a similar party rather than in a sporting contest.[456] The stylization of the hair hanging down the back seems to copy the Attic fashion employed by the Amasis Painter and his contemporaries;[457] because of the raised hand the position of the fillet looks strange.[458] The profile and the large nearly circular eye suggest a date not later than c. 540 B.C. for our fragment. Large solid filling-ornaments occur on two fragments **349** and **351**, and the decoration of at least the latter fragment seems due to Attic influence: the use of several incisions is characteristic especially for the Polos Painter,[459] whose works were widely exported.[460] A stylization of leg and chest similar to that on **350** is found on Attic as well as Corinthian.[461] The type of lion painted on **352**, where the whole mane except the narrow, incised fore part is painted red, may equal the Corinthian lion[462] — but the model may rather be the Attic one.[463] **353–357** are rim fragments of kraters or dinoi. The flower chain on **353**a may be understood as a simplification of the elaborate Attic and Corinthian rim ornament.[464] The very slovenly

[454] See JHS 19 1889, 163–164. They occur on the vases of the Northampton-group; for references to the latter, see CVA München fasc 6, text to pls. 297–299, and further BSA 60 1965, 121. They are some times on the Campanadinoi, for an example, see K. Masner, Die Sammlung antiker Vasen und Terrakotten im K. K. Österreichischen Museum. Wien 1892, 20.215 pl. 5. In Attika they are found only on some of the vases assigned to the Amasis Painter and to the Affecter, on both see G. Karo in JHS 19 1889 and further J. D. Beazley, Attic Black-Figure Vase Painters. Oxford 1956, 150–152, 238–247. They are frequent in Corinthian and Laconian, see Karo, loc. cit. The fabric of **346–347** is not Attic.

[455] S. Karouzou, The Amasis Painter, Oxford 1956, 13–14 pl. 24 below. On a band-cup in the Louvre a man is leaning forward and holding his hand up to the back of his head, but here this is to carry a burden (which is not preserved), CVA Louvre fasc 9, III He, pl. 82.4, 7. On the Amasis Painter, see further J. Boardmann in JHS 78 1958,1–3.

[456] Men leaning forward are seen on a Siana cup representing a sporting contest, but they are onlookers and their arms are not raised to the back of their heads, CVA Louvre fasc 8, III He, pl. 78.1.

[457] See Karouzou passim, and for instance Exekias, W. Technau, Exekias, Leipzig 1936, passim. See further an odd Attic skyphos from Ialysos, painted in the manner of Amasis, ClRh 8 120–125.11 fig. 108–111.

[458] The border of the hair is crossed by the fillet, which was surely meant to be placed above the ear, as usual in Attic, where the fillet is only seldom broken by the ear, see notes 455 and 457. On East Greek Black-Figure the fillet is not usually set above the ear, BSA 60 1965, 123.43 pl. 29, CVA Brit. Mus. fasc 8, II Dn, pls. 1–13; exceptions: BSA 60 1965, 130.68 fig. 12 pl. 34, AD II.5, pls. 54.3, 55.1a.

[459] AM 56 1931, Beilage 46.1, Délos X 177.589 pl. 44, E. Fölzer, Die Hydria, Leipzig 1906, pl. 4.49–50.

[460] Tocra, 96.

[461] Attic: JdI 76 1961, 12 fig. 14, Corinthian: AJA 73 1969, pl. 35.5.

[462] Payne, Necrocorinthia, pl. 37.3.

[463] If **352** is not Attic itself. Early: CVA Louvre fasc 2, III Hd, pl. 14.2 upper frieze left, CVA Louvre fasc 12, III He, pl. 158.4, later examples: A. Rumpf, Sakonides, Leipzig 1937, pl. 23.

[464] Attic: CVA Louvre fasc 2, III Hd, pl. 20.2, Corinthian: CVA Orvieto fasc 1, III C, pl. 3.1.

rendering of the animal on the handle-plate **353**b may perhaps too imply influence from the manner of the Polos Painter. The motifs on **354–357** are the current East Greek rim ornaments.[465] **358–364** are rim fragments of cups suggested to be East Greek because of the clay which is described as brownish, sometimes with white particles. **358–359** have the same rim ornament and on account of their finding places they might have belonged to the same cup. The type to which **358–359** have belonged is that of a Siana-cup, a double-decker, but usually on the Attic cups the lotuses are linked to lotuses and the buds to buds,[466] while on our fragments the lotus is linked to a bud, i.e. the arches do not cross each other. Only on a few of the Sianas painted in the manner of the Griffin Bird Painter an arrangement as on **358–359** occurs.[467] If the fabric, as described, can qualify for an Attic origin, our cup may well be Attic.[468] The bird has affinities with those from Tocra[469] rather than with those on a suggested East Greek, but Attic influenced cup, which M. Robertson[470] regards as a possible precursor of the Ionian Little Masters.[471] Human figures and animals appear on **360–363** which have belonged to band-cups;[472] they have been discarded as Attic on account of their fabric, but the drawing of **360** is perhaps clumsier too than on Attic cups. This fragment should be dated c. 530 B.C. What sort of cup **364** belonged to is uncertain.[473] The fragment **365** is flat and with a plain exterior; most likely it belongs to a plate, a shape not usual in the "Clazomenian" series.[474] The representation shows affinities with "Clazomenian", but also divergencies: white is used for the ornamental details, but the flesh of the figure is black, not white as usual for women in "Clazomenian".[475] Nevertheless it is preferable to consider our figure as female: jewels indeed seem to be absent on **365**, but in this sketchy drawing the hairline curling into a spiral might indicate an ear-disk.[476] Because of the plate shape our figure was most likely the only one represented on the plate; the incisions on the breast indicate a wing, i.e. of a sphinx[477] or a siren[478]—with head turned back. The profile and the oblong eye date our fragment to the decade 530–20 B.C., and **365**

[465] **354:** BSA 60 1965, pl. 32.52 e, Attic: CVA Louvre fasc 12, pl. 164.3; **355:** Attic: CVA Louvre fasc 12, pl. 160.1; **356:** the profile looks similar to Attic kraters dated c. 540–30 B.C., CVA Louvre fasc 12, pl. 164; **357:** BSA 60 1965, pl. 28.37.

[466] Tocra, 96.1042–5 note 5 pl. 75.

[467] See specially CVA Capua fasc 2, III H, pl. 11.5 (J. D. Beazley, Attic Black-Figure Vase-Painters. Oxford 1956, 74.8). Our fragments have no visible traces of added white.

[468] Εφημ Αρχ 1953/54 II, 147: the Attic fabric is doubtful.

[469] See note 466.

[470] Εφημ Αρχ 1953/54 II, 147–148 pl. 1.3.

[471] AM 59 1934, 81–122 pls. 6–9, Beilage 6–11.

[472] JHS 52 1932, 187–191 pl. 9, further CVA Orvieto fasc 1, III H, pls. 3–5, Tocra, 96.1062 pl. 79.

[473] The ground line is indicated by horizontal bands, a feature which occurs on the Attic Siana cups, see note 466, but the fabric of **364** is certainly not Attic.

[474] BSA 47 1952, 139 F 8, 142.

[475] Even on the latest vases, BSA 60 1965, 130.68 fig. 12 pl. 34: c. 540 B.C., 130.71 pl. 35: c. 525 B.C. On white for male flesh, see BSA 47 1952, 128 note 30, 141 note 78.

[476] See R. M. Cook on "Clazomenian" ears and ear-rings, CVA Brit. Mus. fasc 8, 28 Postscript.

[477] For a sphinx with head turned back, see a fragment of a Clazomenian sarcophagus in Copenhagen, ActaArch 6 1935, 175–178 fig. 7 pl. 2, dated in the first quarter of the 5th century. For a sphinx on a late Wild Goat plate, see Naukratis II pl. 12 (Kardara, A, 236.1, Schiering, notes 246, 451, Rumpf, 82 IVa 5).

[478] For a "Clazomenian" siren with head turned back, see CVA Brit. Mus. fasc 8, II Dn, pl. 6.1, dated in the third quarter of the 6th century.

might perhaps be grouped with the vases listed by R. M. Cook as "sometimes mentioned with Clazomenian";[479] a woman on a very late amphora from Rhodes has dark flesh like **365**.[480]

Indeterminate closed vases.

Slipped.

332. TS 1380. Side sherd. G 7 SE. 7.0×4.0 cm. Fine dark buff clay with few mica, creamy slip, black glaze. Forepart of beast, outline of chest marked by small incisions, incisions and added red and white on body. *Pl. XVII.*

333. TS 1738. Side sherd. P 11 SW. 4.5×6.5 cm. Reddish buff clay, white slip, red very worn glaze. Forepart of beast, outline of neck and back marked by small incisions, red added on abdomen. *Pl. XVII.*

334. TS 4063. Side sherd. H 11 NW. 5.0×5.3 cm. Red brown, very gritty clay, white slip, black glaze. Panel, tail of horse in field, careful incisions. *Pl. XVII.*

335. TS 578. Side sherd. G 11 SE. 3.7×3.4 cm. Light buff clay with grits and mica, white slip, black glaze. Border of costume: three incised and one red vertical waveline, two white crosses added besides. *Pl. XVII.*

336. TS 1379. Side sherd. G 5 NE. 5.0×3.5 cm. Light buff clay, whitish slip, black and red glaze. Body of centaur(?), outline waved and marked by incisions. *Pl. XVII.*

Without slip.

337. TS 635. Side sherd. G 11 SE. 4.5×6.9 cm. Reddish clay with white grits, black glaze. Forepart of horse with added red on mane; at top, white dot belonging to head-harness, below five white bands indicating necklace, curvilinear red and white bands added on body. *Pl. XVII.*

338. TS 1447. Side sherd. P 11 NW. 5.5×4.5 cm. Red clay with white grits, red brown glaze. Glazed all over, added white curvilinear stripe and parallel incised stripe. *Pl. XVII.*

339. TS 4574. Sūkās I 60 no. 3 fig. 25 f pl. 4. Side sherd. G 13 SE. 4.2×3.2 cm. Buff micaceous clay, brownish glaze. Forepart of lion, incisions on body, two groups of sloping parallel incisions on leg, red added on abdomen and mane. *Pl. XVII.*

340. TS 1986. Side sherd. G 7 SE. 3.7×2.5 cm. Fine light reddish clay, black glaze. Hind part of animal(?), red and white bands added. *Pl. XVII.*

341. TS 634. Side sherd. G 11 NW. C. 3.5×3.0 cm. Reddish clay with white grits and mica, black to red glaze. Glazed field at top; below, hind part of animal(?), red and white stripes added. *Pl. XVII. Similar*: TS 1839 G 15 NE.

342. TS 2226. Side sherd. L 8 SE. 3.9×3.0 cm. Red clay, brownish-black glaze. Forepart of beast, incisions, red-white-red curvilinear bands added. *Pl. XVII.*

343. TS 2442. Side sherd. L 8 SE. 5.0×3.0 cm. Reddish clay, lustrous dark red glaze. Body of beast, incisions, white S's added. *Pl. XVII.*

344a. TS 4489. Side sherd. H 11 NE. 2.6×2.8 cm. Buff clay, black glaze. Lower part of bird, feathers indicated. *Pl. XVII.*

344b. TS 2838. Side sherd. F 8 NW. 4.0×4.2 cm. Red clay with white grits, red glaze. Part of wing(?), incisions radiating from curved incised line. *Pl. XVII.*

345. TS 2677. Side sherd. L 8 SE. 3.5×2.8 cm. Fine red clay, black glaze. Forelegs of horse, several incisions. *Pl. XVII.*

346. TS 1764. Echinoid foot with bottom sherd. Surface, J 5 NW. Diam. 13.5 cm, h. pr. 6.0 cm. Fine red to buff clay with mica, red to black glaze. Foot glazed, red band added on the

[479] BSA 47 1952, 140–141 pl. 32, JHS 78 1958, 11–12.
[480] BSA 47 1952, 140 e.

vertical edge, two rows of rays radiating from the foot. Graffito under foot. *Pl. XVII. Fig. g. Similar* (no graffito): TS 4835 G 12 SE.

347. TS 1009. Bottom sherd. H 5 SE. 10.3×5.7 cm. Fine reddish, very micaceous clay, black to brown glaze. Two rows of rays radiating from the foot. *Pl. XVII.*

Indeterminate open vases.

348. TS 742. Shoulder/side sherd. F 11 NW. 4.7×3.7 cm. Reddish, very micaceous clay, black to red glaze. Exterior: human figure with long hair leaning forward, hand raised to back of head, the border of the front hair crossed by a fillet, two added vertical red bands on shoulder, in front narrow sloping band, narrow band and glazed field at top. Interior: glazed. *Pl. XVII.*

349. TS 633. Rim/side sherd. H 5 SW. C. 4.4×c. 2.6 cm. Reddish clay with black grits and mica, black to brown glaze. Rim flat and offset on the exterior. Exterior: on topside of rim "two bands with dots"; below rim, broad band, large filling ornament and rounded design with numerous incisions. Interior: glazed, red band added. *Pl. XVII.*

350. TS 628. Side sherd. G 8 SE. C. 5.4×c. 4.4 cm. Light buff clay with mica, black to brown glaze. Exterior: forepart of marching beast, incisions, red band added on breast. Interior: glazed. *Pl. XVII.*

351. TS 4615. Side sherd. H 10 SE. 4.0×4.7 cm. Dark brownish clay with some grits, black to brown glaze. Exterior: back of beast, several incisions, red dots added along edge of back, above sling-shaped tail, large filling-ornament. Interior: glazed, red band added. *Pl. XVII.*

352. TS 4644. Side sherd. G 10 SE. 3.6×4.4 cm. Light brownish clay, red-brown glaze. Exterior: forepart of beast, red added on neck and shoulder, foremost narrow "band" with incisions. Interior: glazed. *Pl. XVII.*

Kraters.

353a. TS 4658. Rim. G 10 SE. 7.5×3.2×1.6 cm. Buff, very gritty clay, black to brown glaze. Topside: chain of alternating lotus flowers and palmettes, red added on outer lotus leaves and inner part of palmettes; underside and vertical edge glazed, red band added on edge. *Pl. XVII. Fig. e.*

353b. TS 4572. Handle plate. G 13 NW. 4.0×3.0 cm. Brownish somewhat gritty and micaceous clay, brown to black glaze. Topside: buttocks of beast with incisions and added red, underside and vertical edges glazed. *Pl. XVII.*

354. TS 3524. Handle plate with rim sherd. G 5. 4.7×5.3 cm. Reddish clay with white grits, yellowish slip, red brown glaze. Suspension-hole through rim. Plate: two rays, vertical edges glazed, rim: transversal zigzags. *Pl. XVII.*

355. TS 929. Rim/side sherd. P 11 SW. C. 8.4×2.5 cm. Red clay with some grits and mica, black to brown glaze. Groove in underside of rim. Rim: on topside transversal rays, vertical edge and underside glazed. Interior: glazed, red band added. *Pl. XVII.*

356. TS 1296. Rim/side sherd. P 11 NW. 12.5×3.5 cm. Red clay with some white grits, black glaze. Rim: topside and underside glazed, on vertical edge rays. Interior: glazed. *Pl. XVII. Fig. e.*

357. TS 665. Rim/side sherd. G 11 SW. C. 7.5×4.6 cm. Light reddish clay with white grits and mica, creamy slip, red glaze. Rim: on topside chequers, on vertical edge three vertical stripes, glazed underside. Interior: broad band at top. *Pl. XVII.*

Cups.

358. TS 4437. Rim/side sherds. H 11 NE. 1.1×1.7 cm, 3.0×3.9 cm. Reddish brown clay with white grits, black to brown glaze. Suspension-hole through rim. Exterior: lotus-and-bud on rim, forepart of confronted pair of birds and grazing deer on side. Interior: glazed, except for band at top of rim. *Pl. XVIII.*

359. TS 4611. Rim sherds. H 11 NE. 3.0×2.1 cm, 2.8×2.0 cm. Light brownish clay, black to brown glaze. Exterior: lotus-and-bud, red added on lotuses. Interior: glazed. *Pl. XVIII. Similar*: TS 576 G 11 SW.

360. TS 5645. Side sherd. H 12. 2.4×2.2 cm. Brownish clay, black glaze. Exterior: lower part of human figure in himation, red and white added. Interior: glazed. *Pl. XVIII.*

361. TS 3827. Side sherd. H 11 NW. 3.0×1.8 cm. Brownish clay, light buff slip, black glaze. Exterior: club-shaped design with added white dot, glazed field below. Interior: glazed. *Pl. XVIII.*

362. TS 5647. Side sherd. H 12. 3.7×3.5 cm. Fine brownish clay, shining black glaze. Exterior: foot and lower part of human figure clad in long dress, red added, in front two tiny legs of an animal. Interior: glazed. *Pl. XVIII.*

363. TS 5646. Side sherd. H 12. 2.9×1.6 cm. Brownish clay, shining black glaze. Exterior: hindlegs of animal, glazed design at top. Interior: glazed. *Pl. XVIII.*

364. TS 2336. Side sherd. G 13 SE. 4.1×6.3 cm. Light yellow clay with white grits and mica, black glaze. Exterior: hind leg af animal and bird's tail and wing(?), at bottom of sherd two narrow bands and glazed field. Interior: glazed. *Pl. XVIII.*

Plate.

365. TS 427. Rim/side sherd. Surface, south of tall. 11.6×8.0 cm. Reddish-brown clay, grey in core, black glaze. Exterior: plain. Interior: at border, broad band with white added stripe, row of dots, narrow band with white dots added; in field, head and upper part of sphinx or siren with head turned back, red added on hair, red and white on feathers. *Pl. XVIII.*

XVII
Unclassified East Greek Vases

About forty fragments can only be regarded as belonging to the stock of vases common all over Eastern Greece. Only in two cases, **366–367**, was the vase recognisable, the remainder of the fragments being catalogued under the heading "closed and open vases". The aryballos, **366**, looks very similar to a Rhodian type from Tocra, where it is dated to the second and third quarters of the 6th century.[481] The shape of the lekythos, **367**, is not common in Eastern Greece and the description of the clay may in fact hint at a foreign origin.[482] The neck fragment, **368**, looks asymmetrical and may have belonged to the popular East Greek shape of the askos, not hitherto found in a reliable context in Eastern Greece itself.[483] The shape of the thin-walled, squat and flat-based vase, **370**a, diverges from the current plain East Greek Archaic vases and might be later.[484] It has furrows and ribs on the belly, furthermore the curve of

[481] Tocra, 46.766–768 notes 4–5 pl. 39.

[482] The long neck and the fastening of the handle equal that of the latest black-figured lekythoi in Attica, C. H. E. Haspels, Attic Black-Figured Lekythoi, Paris 1936, 181, 191 pl. 54.4 a–b, assigned to the workshop of the Beldam Painter.

[483] A complete example is known from the Athenian Agora in a context dated c. 520–490 B.C., see Agora XII 210.1725 note 4, 358 pl. 80 with references to the Eastern finds, add: Perachora II 374.4054 pl. 156, Robinson, Catalogue of Greek Vases, 71.215–C418 pl. 15, CVA München fasc 6, pl. 303.6, Schiering, Werkstätten, note 180, Fabricius, Arch Karta 1, pl. 9.4, Materiali 25 1952, fig. 9.1, 69 1959, 170 fig. 24, 180 fig. 44.1.

[484] For the common, flat-based and squat jugs, see above note 414.

the belly does not run unbroken into the neck; at the junction is a rib. On account of its finding place the handle fragment, **370** b, is assigned to period G^2, 588–552 B.C.[485] The fragment, **371**, with only linear decoration may perhaps be interpreted as a schematic version of a Late Wild Goat amphora,[486] the only divergency from the latter is the slip, which is light buff on **371**. **372–374** all bear pendent tongues on the shoulder; the slip of **372**, the pairs of tongues separated by vertical stripes, and the dots at the ground line seem to relate our fragment to some of the Fikellura vases,[487]—the decoration on the belly resembles that on the various groups of banded wares from the second half of the 6th century.[488] The two other fragments are unslipped, and this is common for a large, but not homogeneous group of vases, probably from the second half of the 6th century and the first third of the 5th century.[489] **375–377** represent other varieties which certainly are to be connected with the latter group.[490] The bottom fragment, **378** a, belongs to a large vase, an amphora, hydria or a pithos with band decoration on the belly, perhaps like the Rhodian ones, which served funeral purposes.[491] **378** b is from a large closed vase, probably totally glazed; the profile of the foot is not unlike that of an Attic storage amphora from a context of 520–500 B.C.[492] The side sherd **379** displays scratched Greek letters, which resemble those of inscriptions of the first half of the 6th century.[493] On **381** there are faint traces of probably lotus flowers alternating with buds; the same sort of schematic drawing appears on a Rhodian dish,[494] and the low ring foot of **381** makes it likely that our fragment belonged to a similar dish. The fragment, **382**, is obscure: the rendering of the circles is "geometric" in character, but none of the existing circle-schemes are placed as isolated in the field as that of **382**,[495] neither are there visible traces of further decoration. The bottom fragment, **383**, has a foot similar to that of the late bird- and rosette-bowls.[496] The inscription on **385** is written in the manner of the first half of the 6th century,[497] whereas the rho on **386** looks later.[498]

[485] **370** b was found with six fragments of bowls, Sūkās I 83 note 267 pl. IV nos. 93–98 (in the present catalogue **133** b, **136** b, one fragment belonging to the similar group of **133**a (i.e. TS 3271), and three fragments belonging to the similar group of **137** (i.e. TS 3205, TS 3206, TS 3209).

[486] See **320** and note 340 (**371**).

[487] BSA 34 1933/34, 12 G 1 pl. 15 a Mykonos Group.

[488] CVA München fasc 6, pls. 303–305, BSA 53/54, 1958/59, 29 pl. 4 b–c.

[489] In Olynthus vases of this sort are Pre-Persian, D. M. Robinson, Excavations at Olynthus V, Baltimore 1933, 33 P 47 pl. 30, and in Nymphaion the earliest pottery is from the middle of the 6th century, ArchRep 1962/63, 48 fig. 33. Other examples: Larisa III pl. 54.13, Villard, Marseille, 48 note 2 pl. 24.11–12, BCH 87 1963, 330–333 fig. 11, 90 1966, 309 fig. 23. Xanthos IV 47–48.52–55, p. 54–55 pls. 13–14.

[490] Compare the one-piece amphora with, BCH 87 1963, 330–33 fig. 11. For the decoration, see Lambrino, Vases, 129.5 figs. 78–79, D. M. Robinson, Excavations at Olynthus XIII, Baltimore 1950, 47 P 3 pl. 3 below.

[491] ClRh III 130 grave C pl. 4, 145 grave CXXXVI pl. 4, 149 grave CXLV pl. 4.

[492] Agora XII 192–93.1503, 341 pl. 64; compare, too, the amphora from Rhodes, ClRh III 81–82 fig. 72 determined by J. Hayes as Lakonian, Tocra, 88 note 1: Second to third quarter of the 6th century.

[493] Compare Sūkās I 78 note 251 Pl. IV no. 74 fig. 26 e.

[494] Tocra, 52.653 pl. 36. See above note 396.

[495] Tarsus III 312–313.1545–1548 figs. 104, 147, ActaArch 33 1962, 222–243 pl. I a.

[496] Tocra, 44–45.734 fig. 28 pl. 38.

[497] L. H. Jeffery, The Local Scripts of Archaic Greece, Oxford 1961, 345–346, 348, 356.4, 6 pl. 67.

[498] Jeffery, Scripts, 346: third and fourth quarters of the 6th century.

Aryballos.

366. TS 1190. Rim/neck/shoulder sherd with handle. G 11 SE. H. 2.5 cm, diam. of rim 4.4 cm. Dark red clay with white grits and few mica, red glaze. Rib on neck. Topside of rim glazed, otherwise plain except for horizontal band below handle. *Pl. XVIII.*

Lekythos.

367. TS 2123. Rim/neck/shoulder sherd with handle. L 8 SE. H. 5.8 cm. Pink clay, black glaze. Both sides of rim glazed; on handle, vertical stripe, "traces of ornaments on shoulder". *Pl. XVIII.*

Indeterminate closed vases.

368. TS 1395. Rim/neck/shoulder sherd. H 5 NE. H. 5.0 cm, diam. of neck 1.0 cm. Dark red, gritty clay, red glaze. Rim flat, broad and sloping on the interior. Transversal stripes on topside of rim, narrow band along root of neck, glaze on shoulder. *Pl. XVIII. Similar*: TS 1736 P 11 SW.

369. TS 3454. Neck sherd with root of rim. H 11 NW. 1.9×2.7 cm. Grey-brown clay, in core grey, brown glaze. Rim glazed, two bands on neck, glaze along root of rim and neck. *Pl. XVIII.*

370a. TS 191. Neck/side/bottom sherds, flat base. G 5 NE. H. 12.5 cm, w. 10.7 cm. Light yellow clay with black and white grits. Rib at junction of belly and neck, horizontal ribs and furrows on belly. *Pl. XVIII.*

370b. TS 3208. Sūkās I 83 no. 102 pl. 4. Shoulder sherd with fragment of vertical handle. J 13 NE. 5.4×4.5 cm. Red gritty clay, black glaze. Plain, but traces of glazed field below handle. *Pl. XVIII.*

371. TS 1737. Neck/shoulder sherd. P 11 SW. 9.0×5.0 cm. Clay: no description; light buff slip, brown glaze. Small codron at junction of neck and shoulder. On neck curvilinear design, part of cable(?), on shoulder two panels(?), in one of them trunk of animal(?). *Pl. XVIII.*

372. TS 2690. Shoulder/side sherds with root of horizontal handle. L 8 SE. 10.5×6.0 cm, 14.0×9.0 cm. Fine red clay, white slip, red glaze. On shoulder pendent tongues separated from each other by vertical stripes, dots at ground line, broad and narrow bands on belly. *Pl. XVIII.*

373. TS 2649. Shoulder/side sherds. L 8 SE. 15.0×12.0 cm, 6.5×5.5 cm. Red clay with few grits, light brown slip, brown, rather matt glaze. Belly banded, pendent tongues at upper part of shoulder. *Pl. XVIII.*

374. TS 3326. Shoulder sherd with root of neck. F 7 E. 5.4×6.4 cm. Brown clay, dark brown glaze. Pendent tongues, narrow band and glazed field at bottom, narrow band and glazed field along root of neck. *Pl. XVIII.*

375. TS 4819. Rim/neck sherd. H 11 NE. 6.7×8.7 cm. Rather fine light brown clay, grey in core, light brownish slip, black to brown matt glaze. Slightly everted, carinated rim. Rim glazed on both sides, three stalked buds on neck. *Pl. XVIII. Fig. e.*

376. TS 5613. Neck/shoulder/side sherds with handle. H 12. H. 13.5 cm, w. c. 14.0 cm. Brownish, somewhat gritty and porous clay, red matt glaze. Tall cylindrical neck, handle oblong in section. Shoulder/side banded, on neck/shoulder group of three stalked buds, handle surrounded by band, vertical band on handle. *Pl. XVIII. Fig. e.*

377. TS 1360. Shoulder/side sherd with roots of horizontal handle. G 7 SW. 7.5×5.0 cm. Red-buff clay with white grits, red glaze. Handle-roots glazed, between them bud(?) below narrow horizontal band. *Pl. XIX.*

378a. TS 3479. Side/bottom sherd with pointed, flat base. F/G 15. 11.0×15.0 cm. Red to brown micaceous clay, greyish in core, brown glaze. Two bands on belly, traces of glaze on base. *Pl. XIX.*

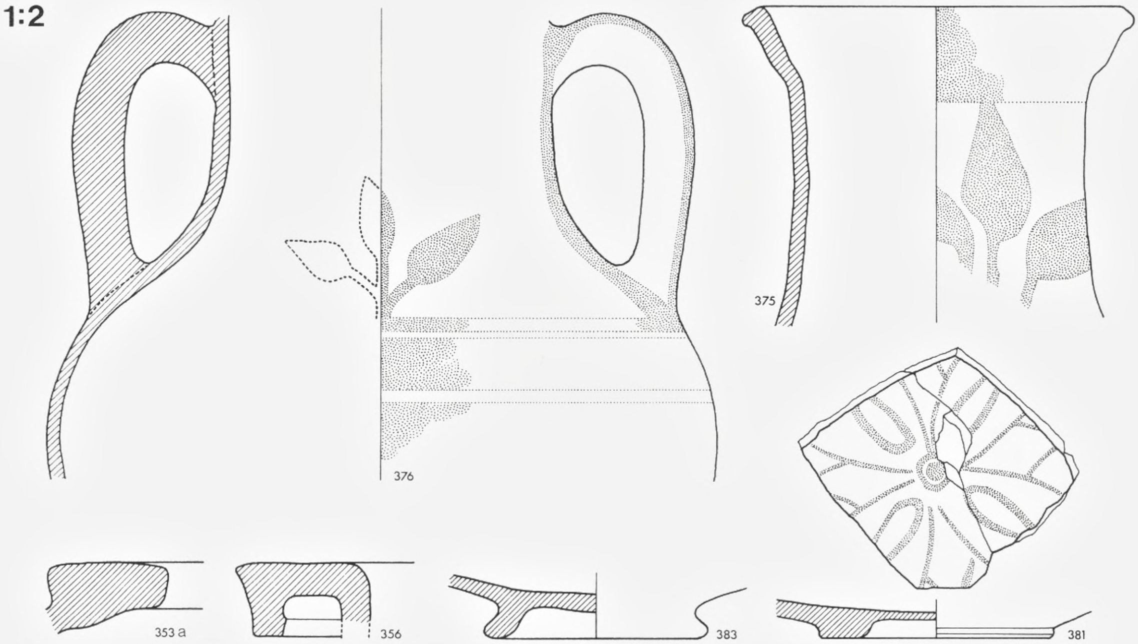


Fig. e.

378b. TS 2621. Bottom sherds with biconical foot. J 8 SE. H. 11.0 cm, diam. of foot 15.5 cm. Fine reddish-buff clay with white grits, red glaze. Glazed except for lower part of foot. *Pl. XIX.*

379. TS 3056. Side sherd. G 14. 2.9×3.1 cm. Buff, gritty and micaceous clay, brown glaze. Horizontal band with scratched letters: στα? below glazed field. *Pl. XIX. Fig. g.*

Indeterminate open vases.

380. TS 922. Side/bottom sherds with ring foot. P 11 SW. H. c. 4.2 cm, w. 11.2 cm. Rather fine clay (colour not mentioned) with some grits, black glaze. Exterior: plain. Interior: part of irregular, concentric circle, dot above. *Pl. XIX.*

381. TS 5663 and 4911. Bottom sherds with ring foot. H 12. H. 1.2 cm, w. 6.0 cm, diam. of foot 5.5 cm. Fine, but somewhat gritty, light brownish clay, grey in core, red to brown glaze. Exterior: no description. Interior: central dot and circle, four radiating buds, between them faint traces of lotus flowers, central dot with small circle. *Pl. XIX. Fig. e.*

382. TS 2471. Side sherd. L 13 SE. 2.5×3.7 cm. Fine reddish clay, smooth reddish slip, black glaze. Exterior: small concentric circle group. Interior: glazed. *Pl. XIX.*

383. TS 3583. Bottom sherd with low foot. G 13. H. of foot 0.8 cm, diam. 5.8 cm. Light brown clay, red glaze. Exterior: foot and lower part of side glazed. Interior: glazed, central circle in added red. *Pl. XIX. Fig. e.*

384. TS 1073. Side/bottom sherds with ring foot. G 8 SW. 8.1×2.6 cm. Dark buff clay with white and black grits, black glaze. Exterior: band on foot. Interior: glazed tondo(?) surrounded by broad band and thin stripes in dilute glaze(?), glaze at top of sherd. *Pl. XIX.*

385. TS 2644. Side sherd. L 8 SE. 3.2×3.5 cm. Red clay with grits, dark brown glaze. Exterior: glazed, scratched letters: μελα. Interior: glazed. *Pl. XIX. Fig. g.*

386. TS 4694. Side sherd. H 11 SW. 2.8×1.9 cm. Brownish clay, black to red glaze. Exterior: glazed, scratched letters: αδα. Interior: band. *Pl. XIX. Fig. g.*

XVIII
Local Ware

The local manufacture of Greek vases mainly represents the shapes current in the 6th century. The clay is either light brownish or reddish with several particles and usually very micaceous. **387–391** are fragments of various types of amphorae. Both fragments, **387** and **389**, have a rather low neck, like those of the Samian amphorae dated c. 600 B.C.,[499] but our fragments are later. The torus rim of **389** swells less than those of the Samian ones, and together with **387**, which has an echinoid rim,[500] it should be dated to the first half of the 6th century. The profile of **388** is not known, but it too seems to have had an echinoid rim.[501] **390** has a tall and totally straight neck and might be as late as the end of the 6th century or the early 5th century.[502] The carinated rim fragment, **392**, might belong to a krater or large basin like those from Kofina, where they were found in an Archaic deposit.[503] The bottom fragment **393** is white slipped, but the heavy type of vase with a biconical foot is apparently not Chian;[504] the shape is close to that of CypArc II amphorae.[505] Though we know nothing of the upper part of **394**, the appearance of the body is straighter than on the CypClas type, and perhaps **394** should too be regarded as Archaic.[506] There is a glazed field at the bottom of the unslipped pointed foot of **395**, this feature seems to occur on a 6th century Chian white slip amphora from Cyprus,[507] but the walls of our fragment look steeper. Lekythoi with carinations like **396** are found on Rhodes in contexts from the second quarter of the 6th century.[508] The very thick-walled fragment, **397**, with the echinoid foot may have belonged to a large vase, a pithos(?) with rather straight sides.[509] The profile of the small bottom fragment **398** is most similar to that of the so-called salt cellars with echinus wall and recessed underside; the type is best known from Attica and the existing pieces from this area are usually glazed.[510] The series begins before 480 B.C., but the shape is "popular earlier and lasts little, if at all, beyond 450 B.C.".[511] Triple- and double-roll handles are used commonly in the Orientalizing wares of the 7th and the 6th centuries in Eastern Greece, but plain ones

[499] AM 83 1968, 268.48–49 fig. 18 pl. 103.3–4.

[500] A type known from the first half of the 6th century, G. M. A. Richter & K. J. Milne, Shapes and Names of Athenian Vases, New York 1935, fig. 12; **387** is certainly earlier than an amphora in Munich, dated to the third quarter of the 6th century, CVA München fasc 6, pl. 304.1. Compare an amphora from Melie, Hommel, Panionion und Melie, 144 Typ. 1.7 fig. 82 a–b.

[501] The neck of **388** is longer than that of **387**, and **388** might perhaps be contemporary with the amphora in Munich (see preceding note).

[502] Excavations of the Athenian Agora, Picture Book No. 6 1961, fig. 35 middle behind: found in the debris of the Persian destruction 480–79 B.C. Compare Lambrino, Vases, 114–115 figs. 76–77.

[503] BSA 49 1954, 134, 136–137.27–28 fig. 5.

[504] Compare BSA 49 1954, 155.274 fig. 10 n: said to be a "foreign amphora".

[505] OpAth III 1960, 121 fig. 16.1 Type V: 600–475 B.C.

[506] OpAth. III 1960, 121 fig. 16.2 Type VI: CypClas I 475–400 B.C., for the Archaic type see preceding note.

[507] ArchRep 1965/66, 34 fig. 12.

[508] ClRh III 82–83 fig. 73, similar: Boehlau, Nekropolen, 147–148 pl. 7.3–4, 6.

[509] ClRh III 146 grave CXXXIX pl. IV, probably 6th century context, see ibid., pl. I.

[510] Agora XII 136.899–908 fig. 9 pl. 34.

[511] Similar Samian salt cellars were dated later, i.e. the 4th century, see AM 54 1929, 43 fig. 30.2.

like **399–400** occur too.[512] **401–408** bear scratched letters or other signs. Those on **401** are not intelligible.[513] **402** may possibly be interpreted as a lambda and a pi. **403**, **405**, and **408** are fragmentary Greek inscriptions datable to the first half of the 6th century.[514] The kappa under the foot of **407** is perhaps either a potter's mark or a numeral;[515] the confusing scratchings on **406** are perhaps a gamma and an alpha.[516] The fabric of **404** is not necessarily local, the sherd may be from a Greek pot; of the scratched letters, at least the one to the right is non-Greek, rather it looks Semitic and resembles a taw and a reš.[517] The proportions of the nearly complete column krater, **409**, seem to resemble those of Attic kraters dating from the end of the 6th century and the first quarter of the 5th century;[518] no Attic krater has roundels applied at the handle roots, this may be exclusively East Greek; they appear too on **410**, on which the colonnettes are nearly straight, the neck looks as tall as that of **409**. Only three fragments, **411** and **412–413**, of local cups copying Ionian cups have been recognised. Though the shape of the thick-walled cup, **411**, imitates that of cups of the first half of the 6th century the same decorative scheme as on **411** is not met with among the true Greek cups. The banded interior may perhaps match that of the Rhodian Type VIII in Tocra.[519] The bottom fragment **412** has probably a very pronounced conical foot;[520] the letters incised under the foot assign the fragment to the first half of the 6th century.[521] The rim sherd **413** may imitate hemispherical bowls like nos. **138–149**.

Amphorae.

387. TS 1020. Rim/neck/shoulder sherds with part of handle. G 5 NE. H. 9.8 cm, diam. of rim 14.5 cm. Light brownish, very micaceous clay with white and dark grits. Echinoid rim, codron at junction of neck and shoulder. Plain. *Pl. XX. Fig. f.*

388. TS 1768. Rim/neck/shoulder sherd with part of one handle. F 8 NW. H. of neck 9.0 cm, diam. of rim 14.0 cm. Brown very gritty clay, black in core. Thickened and everted rim, nearly cylindrical neck, flat handle. Plain. *Pl. XX.*

389. TS 1018. Rim/neck sherd with part of handle. G 5 SE. H. 8.7 cm. Light brownish, very micaceous clay with white and dark grits. Torus rim, cylindrical neck, flat handle below root of codron. Plain. *Pl. XX. Similar*: TS 110 E 8 NE, TS 1276 P 11 SW, TS 1277 P 11 SW, TS 3820 H 11 NW.

390. TS 1325. Rim/neck sherds with root of shoulder and handle. F 5 NE. H. 10.0 cm, diam. 12.3 cm. Light brownish clay with white grits, light buff slip. Torus rim, cylindrical neck, flat handle. *Pl. XX. Similar*: TS 2501 P 11 NW (*Fig. g:* 190.1, scratched axe–like design).

[512] Hommel, Panionion und Melie, 158.1–4 pl. 6 a.
[513] Not identical, but compare Lambrino, Vases, 223–24.26, 28 figs. 188–189.
[514] AASyr 11 1961, 139 fig. 11 B.
[515] Compare Kardara, A, pl. A, M. Guarducci, Epigrafia greca, Roma 1967, 422–423: K = 20.
[516] That version of the alfa occurs in the first half of the 6th century, Jeffery, Scripts, 356.6 pl. 67.
[517] The writer wants to thank Professor E. Hammershaimb for the interpretation of the letters; see further H. Donner, W. Röllig, Kanaanäische und aramäische Inschriften, Wiesbaden 1969, nos. 11, 261 vol. III pls. 3, 21.
[518] CVA Louvre fasc 12, pl. 174.1–2 (c. 510 B.C.), pl. 189.2 (c. 490–80 B.C.). See furthermore a krater on a red-figured kylix, dated c. 510, A. Greifenhagen, Antike Kunstwerke, Berlin 1960, 40 pl. 51 below.
[519] Tocra, 113 fig. 56.1204. 6th century, thick-walled cups are known, too, from Samos AM 72 1957, 50 Beilage 74.3–4, 83 1968, 275–279.72–74 fig. 27 pl. 107.1, 3, 5.
[520] See above, foot belonging to the similar group of **109** i.e. TS 3543.
[521] Jeffery, Scripts, 345–46.358.48 a–c pl. 69.

391. TS 2613. Handle with rim and shoulder sherd. H 11 NW. H. c. 17.0 cm. Red very gritty clay. Handle flat, rim "slightly thickened". Plain. *Pl. XX.*

392. TS 1493. Rim sherd. G 11 SW. 5.0×5.0 cm. Buff to red clay with mica, black glaze. Thickened rim, rounded on the exterior, carination below. Rim glazed on both sides. *Pl. XX.*

393. TS 2762. Bottom sherd with biconical foot. L 13 SE. 10.5×3.0 cm. Red, very micaceous clay, white slip. Exterior: slipped all over. *Pl. XX. Fig. f.*

394. TS 2748. Fragmentary amphora with pointed bottom. G 15 NW. Max. w. 38.5 cm, h. 44.5 cm. Red, very micaceous clay, black in core. Flat base. Plain. *Pl. XX.*

395. TS 4762. Bottom sherd with pointed foot. H 11 NW. 3.5×6.0 cm. Reddish, very micaceous clay, grey in core, light brownish glaze. Horizontal band on the pointed foot. *Pl. XX. Fig. f.*

Lekythos.

396. TS 1293. Fragmentary neck with root of one handle. P 11 NW. H. 5.5 cm, diam. of rim 5.3 cm. Light buff, very micaceous clay. Conical rim, carination at handle level. Plain. *Pl. XX.*

Indeterminate closed vases.

397. TS 1420. Pointed bottom with disk foot. G 11 SE. 8.6×6.2 cm, diam. of foot 8.4 cm. Light brown, very micaceous clay with white and dark grits. Conical, nearly echinoid foot. Plain. *Pl. XX.*

398. TS 1884. Bottom of jar with low foot. H 11 NW. 7.0×3.4 cm. Fine red, very micaceous clay. Plain. *Pl. XX. Fig. f.*

399. TS 4578. Triple-roll handle. G 12 SE. 2.8×9.5 cm. Light brownish clay with few grits and few mica. Plain. *Pl. XX.*

400. TS 1428. Double-roll handle. G 12 SW. 3.4×10.5 cm. Light brownish, very micaceous clay with dark and white grits. Plain. *Pl. XX.*

401. TS 4456. Bottom sherds with ring foot. H 11 NE. 7.0×2.1 cm. Reddish clay with grey and white grits, red glaze. Faint traces of glaze on side and on foot(?), under foot unintelligible graffito. *Pl. XX. Fig. g.*

402. TS 619. AASyr 8/9 1958/59, 130 fig. 15. Neck/shoulder sherd. G 8 SE. 7.0×4.8 cm. Brownish clay with numerous white and dark grits and some mica. On shoulder scratched Greek letters: λ̣ π̣. *Pl. XX. Fig. g.*

403. TS 4180. AASyr 11 1961, 139 fig. 11 B. Shoulder sherd with root of neck(?). G 14. 7.4×6.3 cm. Light brownish clay, black in core, dark grits. On shoulder scratched Greek letters: α̣ λ̣ (or μ). *Pl. XX. Fig. g.*

404. TS 4670. Shoulder sherd. G 13 SE. 4.0×3.7 cm. Brownish, gritty and micaceous clay, yellow slip. Scratched letters: Semitic. *Pl. XX. Fig. g.*

405. TS 4315. AASyr 11 1961, 139 fig. 11 C, NMArb 1961, 131, 133 fig. 14, Supplementum Epigraphicum Graecum 19 1963, no. 879, Archaeology 19 1961, 214–16, Revue Numismatique 6 1964, 23, Sūkās I 78 no. 74, 85 fig. 26 e pl. 4. Shoulder sherd of big jar. H 14. 7.4×6.1 cm, th. 1.3 cm. Light grey clay, pinkish in core, white and dark grits. Scratched Greek letters: α̣λιοημ. *Pl. XX. Fig. g.*

406. TS 4181. AASyr 11 1961, 139 fig. 11 A. Side sherd. G 14. 12.0×9.7 cm. Reddish clay, black in core, white and dark grits. Graffito, Greek letters(?) γ α̣. *Pl. XX. Fig. g.*

407. TS 601. AASyr 8/9 1958/59, 130 fig. 15. Bottom with disk foot. G 11 SW. 7.8×7.0 cm, h. 2.0 cm, diam. of base 4.1 cm. Light brownish, very gritty clay, red slip. Exterior slipped all over. Scratched Greek letter: K under foot. *Pl. XX. Fig. g.*

Bowl.

408. TS 621. AASyr 8/9 1958/59, 130 fig. 15, NMArb 1961, 131, 133 fig. 14, Supplementum Epigraphicum Graecum 20 1964, no. 382. Rim sherd. P 11 NW. 7.3×3.2 cm, th. 1.0 – 1.6 cm.

Light yellowish-grey, very gritty clay, slightly pinkish in core. Thickened and rounded rim. Scratched Greek letters on rim, retrograd: η̣μ̣ι̣ *Pl. XX. Fig. g.*

Column kraters.

409. TS 4317. AASyr 11 1961, 139 fig. 10, NMArb 1961, 130, 132 fig. 13. Half of foot missing, otherwise nearly complete. H 11 NW. 56.0×59.0 cm, diam. of rim 51.5 cm. Light reddish-brown to orange clay with some white and many dark grits. Nearly cylindrical neck tapering slightly upwards, codron between neck and shoulder, looped handles with rotels at outer side of root, echinoid foot. *Pl. XX. Fig. f.*

410. TS 2767. Neck sherd and handle plate with nearly straight colonnettes, large krater. L 13 SE. 20.5×21.5 cm. Red, very gritty clay. Remnants of rotels at outer side of handle-root(?). *Pl. XX.*

Cups.

411. TS 1036. AASyr 10 1960, 127 fig. 14 A–B, Mélanges de l'Université Saint Joseph 37 1961, 194 pl. 1.3. Rim/shoulder/side sherds. G 7 SE. 13.0×6.4 cm. Rather coarse, light brownish to reddish and greyish clay, very micaceous, light and dark grits, greyish to brownish-black glaze, in places nearly matt. Exterior: rim and shoulder glazed except for edge of rim, root of handle glazed, below two narrow bands. Interior: banded, rim and shoulder glazed, except for edge of rim. *Pl. XX. Fig. f.*

412. TS 4894. Bottom sherd with fragmentary low foot. H 12. 6.5×6.2 cm, h. 2.8 cm, diam. of foot 6.1 cm. Rather fine, pale, yellowish-grey or drab clay with some grits. Dull dark brown glaze. Exterior: glazed. Interior: large central dot and concentric circle. Scratched Greek letters: χ ε under foot. *Pl. XX. Fig. g.*

413. TS 3822. Rim sherd, slightly contracted rim. H 11 NW. 3.6×4.0 cm. Buff, gritty and very micaceous clay, dark in core, light buff slip, dark brown matt paint. Slipped on both sides, on the exterior three bands added immediately below rim. *Pl. XX.*

XIX
Lamps

No complete East Greek lamps were found; the fragments are very small, in some cases so small and uncharacteristic that they are not datable. **414** is an open type, with a profile totally without curves, flat rim and probably likewise flat base. Without being a close parallel, **414** shares these features with lamps which are mainly later Archaic.[522] **415**, too, is from an open lamp; it has a flat rim with painted band decoration, and on account of this sparse information it is only possible to date the fragment as not later than the 5th century.[523] The short nozzle of **416** makes a similar date possible for this piece.[524] The tiny fragment, **418**, is from a lamp of the well known 6th century type with the rim offset on the exterior and a groove in the topside of the rim.[525] **417** is the latest one; a large nozzle with small circular opening and grooves on the rim occur from the later part of the 5th century in Attica.[526]

[522] O. Broneer, Terracotta Lamps, Corinth IV.2, Cambridge Massachusetts 1930, Type I, 31–33.5 fig. 14, Type III, 38–39.14 fig. 16, Tocra, 140.1438 fig. 68 pl. 90.

[523] See for instance, AM 54 1929, 54 fig. 45.

[524] AM 54 1929, 53–54 figs. 44–45, Tocra, 139–140.1424–1438 fig. 68 pl. 90.

[525] AM 72 1957, 50–51 Beilage 76.3, 83 1968, 274–275.68 h, i, k, l fig. 23 pl. 105.

[526] R. H. Howland, Greek Lamps and Their Survivals, Agora IV, Princeton 1958, Type 24 A 63.243 pls. 8, 37. The Samian fragments assigned from the 4th to the 3rd century have central openings which are apparently smaller than the one on our fragment, AM 54 1929, 54–55 fig. 46.1.

414. TS 3437. Rim/side/bottom sherd. H 11 NW. W. 4.2 cm, h. 2.4 cm. Red, very micaceous clay, red glaze. Exterior: edge of rim glazed, horizontal band on transition from rim to side. Interior: bottom glazed. *Pl. XIX. Fig. f.*

415. TS 3589. Rim/side/bottom sherd with root of spout. G 13. W. 3.7 cm, h. 1.8 cm. Grey-brown clay, dark brown glaze. Exterior: edge of rim glazed, horizontal band at junction of rim and side. *Pl. XIX. Fig. f.*

416. TS 368. Spout. Surface. L. 3.7 cm, w. 2.7 cm, h. 3.2 cm. Red clay. Very worn. *Pl. XIX. Similar*: TS 369 Surface.

417. TS 4661. Rim/side sherd with spout. G 10 SE. W. c. 5.0 cm, h. 3.5 cm. Brownish, somewhat gritty and micaceous clay, black glaze. Concentric groove on topside. Interior: faint traces of glaze. *Fig. f.*

418. TS 142. Rim/side sherd. H 5 NE. L. 5.7 cm, w. 2.0 cm, h. 2.3 cm. Light reddish clay with dark grits and some mica. Thin greenish or yellowish white slip. Thickened offset rim with deep groove. *Pl. XIX.*

419. TS 2714. Side sherd. L 8 SE. 4.2×4.5 cm. Red micaceous clay, red glaze. Exterior: three horizontal bands. *Pl. XIX.*

XX
Archaic Plastic Figures

Four fragments occurred, all mediocre and badly preserved. Female protomes, like the worn and fragmentary specimen **420**, are known from other overseas sites.[527] Our fragment probably belongs to the series represented on Rhodes, where they date from the second half of the 6th century until c. 450 B.C.[528] **420** is still very Archaic and the closest Rhodian parallel is found in a context from the second half of the 6th century,[529] and thus indicates a dating of our fragment to the fourth quarter of the 6th century.[530] The wide-spread legs of **421** determine the fragment as belonging to a rider. The well known series of horse-riders from Samos are mainly assigned to the 7th century,[531] but our fragment has a short torso with broad shoulders and a waistline which resembles works of the 6th century more than the plastic of the earlier phase.[532] The placing of the feet belonging to the moulded figurine, **422**, and the two-stepped base seem to exclude an origin in the latest stage of the Archaic period.[533] **423** is noted

[527] Blinkenberg, Lindos I 589; on account of the concave back a female head from Byblos is to be interpreted as a protome, M. Dunand, Fouilles de Byblos II, Paris 1954, 85.7291 fig. 65; SovArch 16 1952, 263 fig. 22 protome from Nymphaion.

[528] ClRh IV 173.7 fig. 86 grave LXXV, 188.1 fig. 203 grave LXXXVII, 222.18 fig. 246 grave CVIII, all from Makro Langoni, the contexts are the second half of the 6th century; ClRh VIII 191.18 fig. 181 Sep.no. 78 Ialysos c. 525–450 B.C. See further R. A. Higgins, BMC Terracottas, London 1954, 67–70 and Délos XXIII 73–80.103–158 pls. 9–18.

[529] ClRh IV 188.1 fig. 203 (see preceding note).

[530] Compare a Samian head assigned to the last quarter of the 6th century, E. Buschor, Samische Standbilder III, Berlin 1934, 35 fig. 133.

[531] Emporio, 189.72, 191 note 10, with references to the Samian fragments.

[532] E. Buschor, Standbilder III, fig. 191. Most of the figurines from Lindos are probably early, see AA 79 1964, 506–507.3; only one Lindian rider looks more modulated, Blinkenberg, Lindos I 481.1976 pl. 88.

[533] AA 79 1964, 531–534.20 fig. 16, a female statuette or a female alabastron, dated to the third quarter of the 6th century.

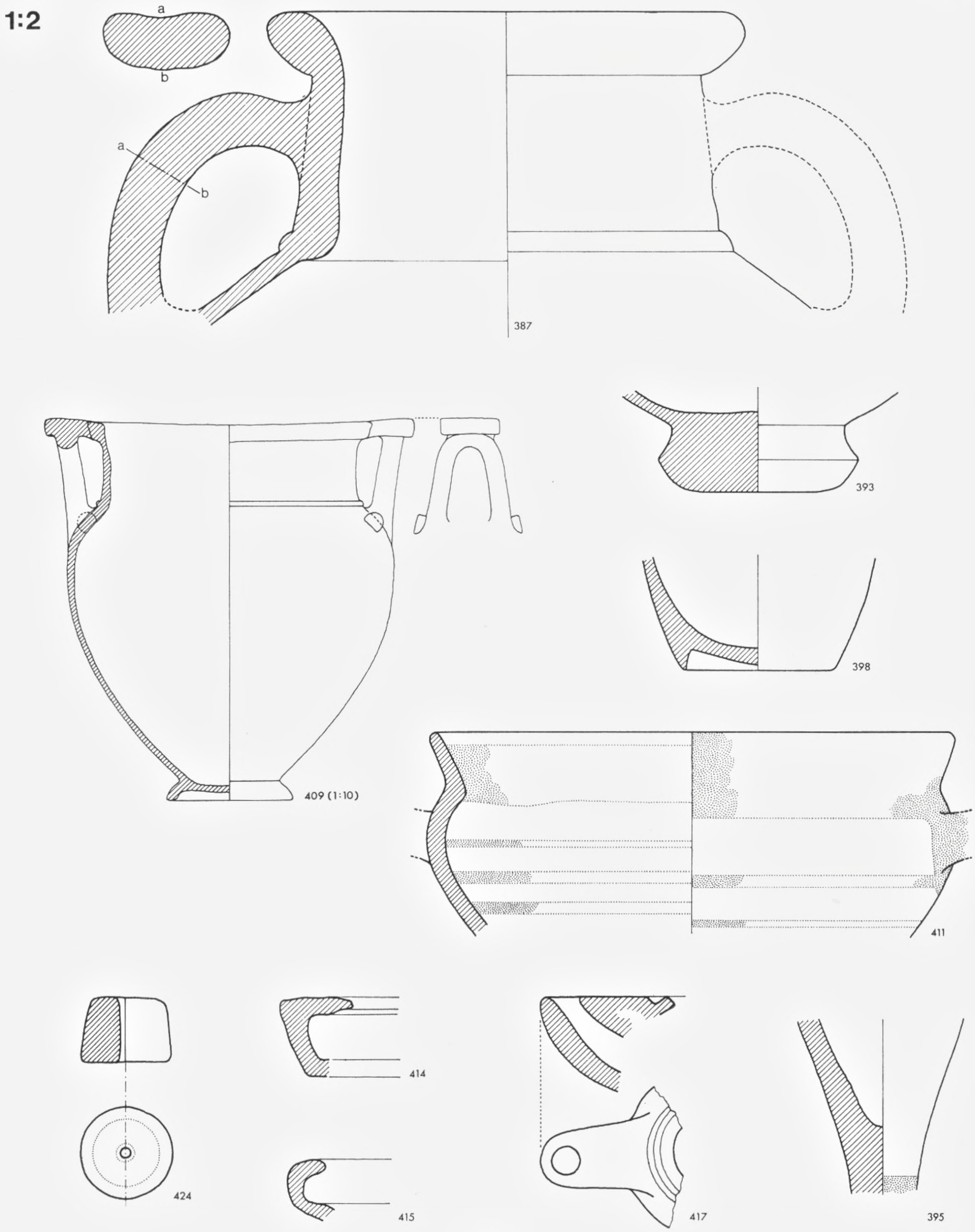


Fig. f.

by the registrar to be hand-made; but the posture represented is that of a current moulded type, where one arm is held tight to the body.[534]

420. TS 4319. AASyr 11 1961, 138, NMArb 1961, 128, 131 fig. 12. Fragmentary female protome. G 10 SE. Two fragments: 5.5×9.3 cm, 7.5×6.0 cm. Light reddish-grey clay, dark grey in core, with some white and many dark particles. Rim of protome with piercing-hole preserved in the smallest fragment. The matrix used was very worn and the details are indistinct. Oval face with pointed chin, short, full and very smiling lips, bulk of hair above forehead, highly placed ears, disk ear-rings, stephane. *Pl. XIX.*

421. TS 909. Torso of rider. P 11 SW. H. 6.4 cm, th. c. 1.8 cm. Coarse, dark brown, gritty and somewhat micaceous clay. Hand-made. Remnants of curls(?) hanging from the shoulder impressed on the breast. *Pl. XIX.*

422. TS 4364. Pair of fragmentary feet on two-stepped base. G 10 NE. L. 4.4 cm, w. 5.0 cm, h. 2.8 cm. Light reddish-brownish micaceous clay with dark and light grits. Moulded. *Pl. XIX.*

423. TS 2595. Fragment of female figurine. H 11 NW. 4.9×4.7 cm. Red clay. Hand-made (but see text). Hand lying close to body, indistinct traces of drapery. *Pl. XIX.*

XXI
Other Objects

The spindle whorl, **424**, is made of local clay, but bears a Greek inscription incised around 600 B.C.; the shape of the spindle whorl itself is probably earlier.[535] The spindle whorl, **425**, is cut out of a potsherd, which may have been from a local vase just as from an Ionian one.

Spindle whorls.

424. TS 5528. Sūkās I 158, 174 fig. 53 d. Slightly conical. H 12. H. 1.9 cm, diam. top: 2.2 cm, bottom: 2.9 cm. Light brownish, somewhat gritty clay, grey in core. Scratched Greek inscription: Πεσαϙορες εμι. *Pl. XIX. Figs. f, g.*

425. TS 3653. Cut out of a potsherd. G 13 SW. 6.2 cm, th. 0.7 cm. Red micaceous clay, red glaze. Exterior: glazed, but for reserved band. *Pl. XIX.*

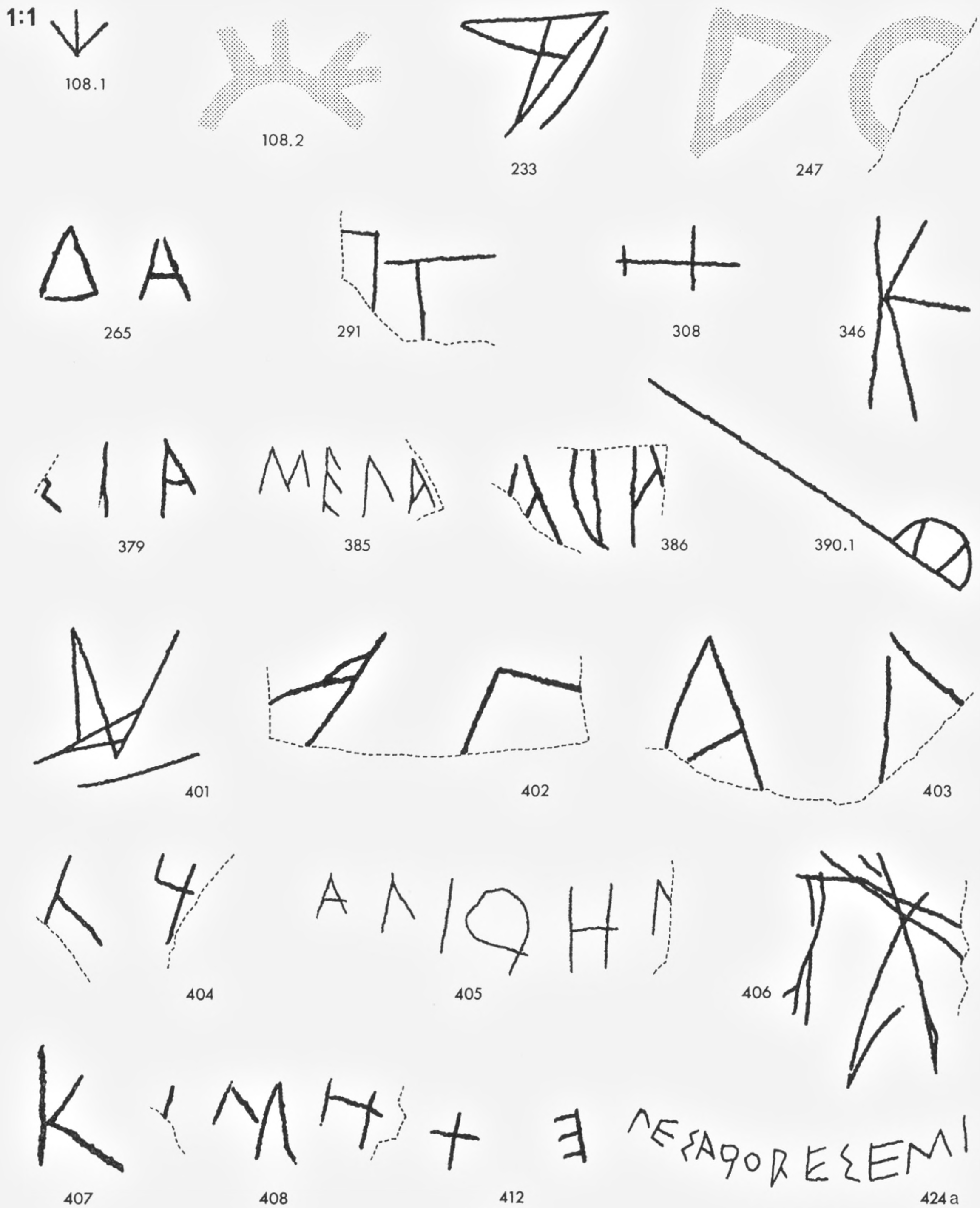
XXII
Conclusion

The earliest fragment included in the catalogue is **6**, which has been claimed to be Cretan rather than Mycenaean. Minoan contacts with these eastern regions already in the Middle Bronze Age are attested by finds from Ras Sămra and Byblos.[536] The single sherd from Sūkās signifies an accidental and probably not direct contact with the Aegean. It is not until the Late Bronze Age that there are signs of more essential

[534] Délos XXIII 64–66.52, 57 pl. 4, O. Rubensohn, Das Delion von Paros, Wiesbaden 1962, 140.T32–33 pl. 25, Tocra, 152.17–19 pl. 96, second half of the 6th century.

[535] Corinth XII 172, 175.1216 pl. 77 (definitely PC), 1218 pl. 78 (7th–6th century), Corinth XV 271, 279.49 (late 7th or early 6th century), Lindos I 133–134, 138.361 pl. 14 left, 139.366 pl. 13, 140.375 pl. 14 (8th to 6th century).

[536] See above note 9.


1:1
108.1
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233
247
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408
412
424a

Fig. g.

relations to the West. Of the 46 Mycenaean fragments found on Tall Sūkās only ten are not included in the present catalogue. About ten have been definitely distinguished as Myc IIIA2, **1**, **2**, **5**, **7–9**, **13**, **24**, **26**, a single sherd as IIIB, **23**, and another as IIIC, **16**. Furthermore, a number of IIIB figurines, **31–33b**, occur. On the remaining sherds the linear decoration is so simple that it did not seem reasonable to distinguish between them, but a great many are probably Myc IIIB. This would correspond to the conditions in Ras Sămra, where IIIB prevails.[537] On account of the bulk of Mycenaean pottery it has earlier been argued that there was a Peloponnesian or Rhodian settlement of the IIIB phase in Ras Sămra.[538]. However, P. J. Riis has recently suggested that the Mycenaean settlement in Ras Sămra was rather established by half-Mycenaeanized Cypriots.[539] The Mycenaean objects from Sūkās may have had the same origin.

The first genuine Greek pottery occurring on Tall Sūkās is Geometric. The Sūkās fragments belonging to such early vases, brought from Greece to Syria, confine themselves to two shapes: drinking cups and kraters, **37–41** and **100**. Similar vases appeared in the earliest levels (i.e. IX–VIII) at the near-by port of Al-Mīna, where the Greek pottery occurring bears witness that Greeks probably settled there already during the 9th century.[540] According to the pottery, the first Greeks arriving at Al-Mīna were Cypriot Greeks and other Greek islanders, and among the Geometric sherds from Tall Sūkās the three LG sherds, **39–41** are Cycladic, the latter two presumably manufactured in Naxos.[541] **37–38** belong to skyphoi with pendent semicircles; the latter category is very frequent in the Cyclades,[542] but an Euboean origin has often been claimed.[543] Late in the 8th century the Greeks living in Phoenicia, perhaps in Al-Mīna, started producing ceramics, mostly drinking cups. Using the local clay they copied the shape and decoration of a cup type current in Late Geometric Greece;[544] five sherds of this category, **44–47**, the so-called Al-Mīna ware, also appeared at Sūkās. Closely connected chronologically with the Geometric sherds from Sūkās are the only four PC sherds which were found: **49**, **62**, **64**a and **70**. They all have a Geometric character[545] and are to be regarded as EPC. Together with these fragments should be noted a single, Cycladic sherd, **43**, which may belong to an Ad vase, a group mainly dated to the first quarter of the 7th century.[546] These fifteen sherds form an early "group" and

[537] Stubbings, Levant, 61–62.
[538] Stubbings, Levant, 71–72.
[539] Sūkās I 129–132. See the spectral analysis, Sūkās I Appendix: one sherd from Sūkās, a surface find made before the excavations begun, seems to belong to the Thessalian or Euboean group.
[540] Boardman, GO, 61–70, Sūkās I 159–162.
[541] See above notes 77–78.
[542] See above notes 52 and 57.
[543] BSA 52 1957, 5–6, Boardman, GO, 63–66, ActaArch 33 1962, 255 note 117, JHS 85 1965, 12 note 27, Gnomon 42 1970, 500.
[544] See above note 89.
[545] Coldstream, Geometric, 105: "the first phase of the Orientalizing style, manifested in the oinochoai of the Cumae Group, and in the globular aryballoi with outline figures . . . . . . Less well known, but more relevant to our quest is the enormous mass of EPC material whose decoration is still linear; for these vases represent the last truly creative stage in the Geometric tradition of Corinth."
[546] See above note 86.

with the exception of three sherds **42**, **101** and **294**, which are to be dated in the 2nd quarter of the 7th century, **101** perhaps in the 3rd quarter, there was no evidence of Greek pottery in the excavated areas of the mound until the last quarter of the 7th century. Greeks, presumably, brought this early "group" of vases to Tall Sūkās;[547] but we cannot be sure at which time they visited the tall, as the sherds were found in contexts much later than those to which they should have belonged.[548] Only two were found in more appropriate connections. One was one of the EPC sherds, **70**, which was found in the terrace in front of the so-called rectangular building;[549] the predecessor of this building was Complex III,[550] a Phoenician private house, ascribed to Period H^1, which is thought to have come to an end about 675 B.C., perhaps in connection with one of Assarhaddon's compaigns, in 677 or in 671 B.C.[551]—the other fragment, one of the Al-Mīna sherds, **47**, was found not in the building fill, but in the open area east of the rectangular building,[552] so for **47** the context is the period succeeding H^1, i.e. G^3 (675–588 B.C.). Therefore — on account of the chronological unity within the early "group" and the almost total abscence of other Greek ceramics datable earlier than the end of the 7th century, it seems to me, that the Greeks visited the tall rather early, and that, about 675 B.C., the afore-mentioned destruction may have put an end to their existence there. So far it has been impossible to distinguish architectural remains, which could be connected with the early Greeks,[553]—there is no safe evidence of Greek building activity on the tall until c. 600 B.C.

In the neighbourhood of the rectangular building pieces of broken tiles occurred, elements not usually included in Oriental architecture.[554] Tiles are a Greek invention, originating in the second half of the 7th century on the Greek mainland.[555] Two of the tile fragments were found in connection with the rectangular building, i.e. in the fill of the north wall of that structure, which belongs to Period G^2 (588–552 B.C.).[556] These fragments are thought to have belonged to the rectangular building itself in its earlier form, i.e. that standing in Period G^3.[557] It was furthermore possible to detect other features which made an interpretation of the structure as a Greek building, a temple, possible.[558] Nearby there were remnants too of an altar and of a peribolos, i.e. presumably a whole area of a sacral character.[559] None of the tiles from the Greek

[547] Orientals did not care for Greek pottery, see Sūkās I 129 note 481.

[548] For references see the catalogue.

[549] Sūkās I 46, for the rectangular building, see notes 556–559.

[550] Sūkās I 34–36 pl. II.

[551] Sūkās I 58. Traces of fire were observed on the floors of Complex III, see ibid, 52.

[552] Sūkās I 47–48.

[553] However, see P. J. Riis's suggestion, Sūkās I 129, about a connection between the early Greeks and Complex III. The latter included a hearth, and the cella of the later Greek temple was laid immediately above the hearth; it is assumed that cults in connection with this hearth were perhaps already performed by the early Greeks, and that they were living in Complex III itself.

[554] Sūkās I 52.

[555] See preceding note.

[556] For the G^2 building, see Sūkās I 60–71 pl. IV, and for the tiles, nos. 38–39, see ibid., 52, 63 and 68–69.

[557] Sūkās I 44–59 pl. III.

[558] Sūkās I 52–59.

[559] Sūkās I 42–44, 47–49 pl. III.

mainland is earlier than the second half of the 7th century; so there cannot have been buildings with a Greek tile roof on Tall Sūkās until the end of the 7th century or about 600 B.C.[560] From this time there is more Greek pottery again on the tall, but the earliest of these finds are not numerous: two Corinthian sherds may be EC, **52**(?), **67**a, and some of the Ionian cups possibly still belong to the 7th century, **102**, **103**(?), **104**, **128**a(?), **128**c.**1**, **128**c.**4**. Three fragments of the Wild Goat Style are from the 4th quarter of the 7th century, **170**a, **216**, **295**, as probably two Chian jugs, **320**, **321**. Still, together with the tile fragments, these few sherds certainly support the theory of a smaller Greek settlement established on the tall already at the end of the 7th century. P. J. Riis has suggested that the building of the late 7th century with the Greek tile roof, i.e. the G^3 building, may originally have had a "high-pitched ridgeroof consisting of wattle and daub covered with mud and thatch" and that ". . . . this roof towards the end of the century was replaced by an up-to-date one of tiles with a lower pitch",[561] thus indicating the possibility of a continuous Greek habitation all through the 7th century. As mentioned above, three sherds, **42**, **101** and **294**, which can be dated to the second and third quarters of the 7th century have been found: **101** is from an Ionian cup, **294** from a plate in Wild Goat Style, and **42** is from a large jar, perhaps a Cycladic amphora of the Linear Island group. If Greeks were living on the tall during the second and the third quarters of the 7th century, these three sherds are the only ceramic evidence we have of their existence. As mentioned by P. J. Riis the reason why the number of sherds is so small could be that no destruction took place during this period and that broken vases were regularly removed.[562] But the presence of the three vases may too be due to a conservative taste or to an export of old stock material, so that the vases were imported at a time when they were outdated, i.e. in the fourth quarter of the 7th century. It should be noted too that no vase of the Linear Island group appeared in Al-Mīna, nor has any specimen hitherto been found at other sites in the Near or Middle East.[563] The finding of a spindle-whorl, **424**, may have special interest in connection with the latter sherd; it was made of local clay, but carried an inscription scratched about 600 B.C. and undoubtedly insular in character, i.e. the origin of the owneress may have been Cycladic just as well as East Greek.[564] It cannot be excluded that among the late 7th century inhabitants there may have been a Cycladic element, though we have no finds of their contemporary pottery. However, to judge from the pottery in general, mainly people from Eastern Greece lived on the tall in the late 7th century. Among the Ionian cups there are no stripe-decorated Samian cups, which are so frequent in Al-Mīna,[565] nor has any other Samian

[560] If the tiles belong to the G^3 building, probably standing on the tall at the end of the 7th century or about 600 B.C., they are the earliest ones so far known outside the Greek Mainland and Magna Graecia. In Eastern Greece tiles do not occur until the second quarter of the 6th century, see Å. Åkerstrøm, Die architectonischen Terrakotten Kleinasiens, Lund 1966, 110–114 (Didyma).

[561] Sūkās I 58 note 168. See above note 553.

[562] Sūkās I 159, a catastrophe usually accounts for an accumulation of sherds.

[563] See above note 81.

[564] AASyr 15.2 1965, 59–61 fig. 1, Sūkās I 158 note 642.

[565] Tocra, 115 note 5.

type of cup been safely distinguished. There is one fragment of an early Rhodian cup, **102**, but among the early 6th century standard cups, which in fact are few, **105**, **105.2**, **106.1**, any one may be Rhodian just as well as Samian. Besides the early Wild Goat sherd, **294**, only three other sherds of vases in Wild Goat Style belonged to the 7th century, i.e. to the fourth quarter: **170**a, **216**, **295**. These fragments might well be Rhodian, but Wild Goat vases were produced in other centres too. Up till now 7th century workshops have been recognized in addition in Samos, Chios, Smyrna, Ephesus, Miletus and Larisa.[566] Two Chian jugs, **320–321**, were determined as belonging to the 7th century. The pottery from the first quarter of the 6th century is only slightly more prolific: the Ionian cups are not many (see above), and of fragments in Wild Goat Style belonging to the first third a few more than ten have been identified: **153**, **155**, **163**, **166**, **167**, **171**, **204**, **212**, **278**, **283**, **289**, **290**, **291**. A single sherd should be noted, that of a Vroulian cup, **326**, a definite Rhodian type.[567] The Chian element, observed already in the late 7th century, still existed during the first quarter. It was never large, but culminated during this period, altogether nine sherds were identified: **310**, **311**, **313**, **314**, **315**, **317**, **319**. It should be noted that two of the fragments, **314–315**, may have come from Naukratis, see above note 405. From the second quarter only a couple of Chian fragments appeared: **312**, **316**, **318**; the wine amphorae, **322–324**, may belong anywhere in the first half of the 6th century.

The G^3 building was destroyed by fire, of which traces were seen on the terrace.[568] A local catastrophe may have taken place, but the disaster is thought rather to have been caused by an attack, for instance by the Egyptian pharaoh Apries in 588 B.C. during his confrontations with the Babylonians and their allies.[569] Tile fragments of the same general type as the early ones ascribed to the G^3 building were found in the area around the succeeding building, i.e. the G^2 building. One of the fragments has three incised letters of the early 6th century,[570] a fact which has been accepted as an indication that rebuilding took place already soon after the destruction. If the year 588 B.C. is understood as the time for the destruction of the G^3 building, then the rebuilding should be about or even before 580 B.C.[571] At this time the Greeks seem to have gained greater influence on the tall: the rebuilding of the temple is on a larger scale[572] and Greek pottery occurs in the largest quantities ever found on the tall. About 4425 East Greek sherds dating from the 6th century were registered during the excavation, i.e. about two sherds pr. m^2 excavated area. It is not wise to make calculations of the number of complete vases, but sherds occurred of most of the wares current in Eastern Greece during the first half of the 6th century. Among the determinable East Greek sherds from Period G^2, 55.6 % were grouped as Ionian cups,

566 Samos V 63–81; on Ephesus, see further ArchRep 1964/65, 43 and CalifStClasArch 3 1970, 57 note 3.
567 But rarely found outside Rhodes, see note 427.
568 Sūkās I 46, 56.
569 Sūkās I 58–59.
570 Sūkās I 68–69.37 pl. 4 fig. 28 a, 86.
571 Sūkās I 86.
572 Sūkās I 62–71.

30.6 % as vases of Wild Goat or Derivative Styles and 13.8 % were other wares. If compared to the whole amount of East Greek pottery (the greater part from the second quarter) 59.3 % signifies the group determined as East Greek during the excavation, but not examined in detail, 22.6 % the Ionian cups, 12.4 % the vases of Wild Goat or Derivative Styles and 5.7 % other wares. The genuine Wild Goat Style comes to an end early in the second quarter of the 6th century, but simplified versions together with a floral style live on till shortly before the middle of the century. These late groups of which the shapes are mostly limited to amphorae, hydriae, dishes and fruit-stands are well represented on Sūkās: **171–191** are from amphorae; among the sherds catalogued as belonging to indeterminate closed vases, **192–253**, the largest number may be from similar vases; **295–309** are from shallow dishes, while **285–293** are from fruit-stands. Rhodes is suggested as supplier of most of these late groups;[573] of the Ionian cups from Sūkās a large amount may possibly be Rhodian, too,[574] mostly from among the standard cups, group 5, and the lip cups, group 6. The rosette decorated and other related hemispherical bowls, which in Greece have only appeared in quantities in Vroulia,[575] are represented on Sūkās in small numbers, **138–149**. The origin of the two remaining categories from the first half of the 6th century, the wares with wave patterns and the one-handled bowls, is still obscure. Beside their own pottery, the Eastern Greeks living on Tall Sūkās had a taste for Corinthian vases, which they probably acquired through their home cities.[576] The Corinthian import is not plentiful, nearly every Corinthian sherd registered during the excavation is included in the present catalogue, but the continuity from EC to LC is obvious.

The G² building is thought to have been destroyed about the middle of the 6th century. A Fikellura sherd, **328**, which was found "on top of the ruined west wall"[577] might be dated about 550 B.C. or 550–540 B.C.[578] A blackish layer covered parts of the north-eastern angle of the building and there were traces of charcoal and ashes all over the surrounding area; thus it is argued that a hostile devastation may have taken place, and this has been connected with Nabonidus's campaign in 553–552 B.C.[579] The temple was not rebuilt during the second half of the 6th century and only the eastern part of the building was in use.[580] The altar was probably still in function, and the peribolos does not seem to have been demolished until the end of the century.[581] The ceramic evidence fully stresses the impression of decline gained from the architectural remains of the G¹ period (552–498 B.C.). The East Greek imports

[573] Tocra, 41–42 notes 6–7, 43–44, Boardman, GO, 72 c.
[574] See above notes 180–181.
[575] See above note 250.
[576] See the remarks by J. Boardman, GO, 73, on Corinthian pottery, which occurs all over Greece, and on nearly every overseas site where the Greeks were involved. See further JHS 66 1946, 84.
[577] Sūkās I 86, 88.
[578] See above note 435.
[579] Sūkās I 86–87.
[580] Sūkās I 89–90 pl. V.
[581] Sūkās I 88–89.

are scarce; the greater part belong to the third quarter: several sherds of vases from the Ionian black-figured schools, **337–365**, but only nine sherds of Fikellura vases **327–331**; the band cup, **127b**, may too be as late. Of the plastic figures, **422** is probably from the third quarter, whereas the protome, **420**, is from the last quarter of the 6th century. Surprisingly there is a fragment of a Chian amphora, **325**, from the late 6th or the early 5th century; at this late period there was still a local production of vases imitating Greek shapes, for instance **390**.

The evidence from Sūkās is strongly in contrast to that from the neighbouring Al-Mīna, where the Greek pottery frequency culminates during the 7th century, but decreases in the 6th.[582] J. Boardman holds the explanation that during the period of Babylonian supremacy the Greeks in North Syria may have been allowed only to live on Sūkās.[583] The Babylonians were defeated by the Persians in 539 B.C.,[584] and in the fourth quarter of the 6th century the frequency of Greek ceramics increases in Al-Mīna. At this time some of the Greeks from Sūkās may have moved to Al-Mīna, which was then rebuilt on a larger scale and the new city is supposed to be purely Greek.[585] A warlike event in connection with the Ionian revolt in 498 B.C. is suggested to have put an end to the remainder of the Greek settlement on Tall Sūkās.[586]

As mentioned, most of the pottery from the end of the 7th and the first half of the 6th century occurring on Sūkās belongs to groups which conventionally, but sometimes surely correctly, are connected with Rhodes. The same groups are found in considerable amounts too on other sites overseas: Naukratis, Tocra and Istros,[587] and single pieces in most of the other Greek cities on the shores of the Black Sea.[588] Pottery may be a reliable indicator of the origin of the people who carried and used it; but the wide distribution of Rhodian ceramics does not agree with the modest rôle played by Rhodes in the overseas ventures.[589] Historically the city of Miletus was the most enterprising colonizer,[590] operating especially in the Pontic area; here Istros was founded in 657/6 B.C. according to Eusebius, but according to pseudo-Skymnos not until later in the century;[591] the earliest pottery is from the last third of the 7th century. Among the Milesian cities on the Black Sea, Istros has hitherto been most fully explored

582 Boardman, GO, 70–76.

583 Boardman, GO, 76.

584 Boardman, GO, 77.

585 JHS 58 1938, 20–30: Levels IV–II, Boardman, GO, 77.

586 Sūkās I 91.

587 Naukratis I pls. 4–7, 10, 13, II pls. 5–9, 11–13, Tocra, pls. 28–39, 87, Lambrino, Vases, passim, Histria 2, pls. 1–19.

588 Fabricius, Arch Karta 1, pls. 7–11, Materiali 50 1956, 223–230 figs. 1–2, 4, 8–9, 56 1957, 183–185 figs. 1, 2 a–b, 103 1962, 10–129 figs. 1–6 B, 9–10 B.

589 According to tradition it founded only two colonies eastwards, Phaselis, see P. M. Fraser, G. E. Bean, The Rhodian Peraea and Islands, Oxford 1954, 54 note 1, J. Bérard, L'Expansion et la colonisation grecques jusqu'aux guerres médiques, Paris 1960, 79 and Soloi, see REA 2.5 1927, 935–938, JHS 85 1965, 15 and took part in the foundation of Apollonia, see C. Roebuck, Ionian Trade and Colonization, New York 1959, 122 note 37.

590 Roebuck, Ionian Trade, 119–123, Bérard, L'Expansion, 103–105.

591 JHS 55 1935, 133–134, JHS 66 1946, 77, G. L. Huxley, The Early Ionians, London 1966, 68–69.

and the pottery groups found there closely correspond to those from Sūkās; only one group, the bird bowls which appeared in considerable numbers in Istros[592] as in Al-Mīna,[593] is totally lacking among our finds. Miletus was not only active on the shores of the Black Sea, but furthermore took part in the foundation of Naukratis in Egypt. Here a sanctury to the Milesian deity, Apollo, was erected,[594] and it was to the Milesian Apollo, at Didyma, that the Egyptian pharaoh Necho dedicated his armour after his Syrian campaign in 608 B.C. against the Babylonians.[595] J. Boardman has suggested that Milesian activity should be expected too in Al-Mīna,[596] and the notable similarity between the pottery groups from Istros and Sūkās may perhaps further imply such a relation. Not much Milesian pottery has yet been identified,[597] and the city perhaps did not have a local production of finer vases itself. If so, it may have imported vases from other cities and this could explain why Rhodian pottery, for instance the shallow dishes, has travelled so far.[598] Wild Goat vases in black-figure technique are found on nearly all sites overseas,[599] including Sūkās, see **154–155**, **166–167**, **204–210**, **257–263**, **282–284**. A Rhodian origin for this style is no longer regarded as a sound idea; a more northern origin is now preferred.[600] If the suggestion is valid, the northern region supplied quite an amount of exports to Milesian colonies; Mr. Boardman has already noted that vases from the North Ionian island, Chios, always seem to occur in Milesian cities.[601] Besides the black-figured Wild Goat vases, other East Greek Black Figure wares from the first half of the 6th century, **332–336**, are represented on Sūkās, and the North Ionian element still exists there in the third quarter, when vases of the so-called "Clazomenian" koiné occur. Nevertheless, in spite of the similarity between the pottery groups from Istros and Sūkās we cannot be definite about a Milesian origin of the settlers on the tall, because we have no possibility of comparisons with the pottery used in Eastern Greek colonies *not* founded by Miletus. Only Massalia, founded by Phocaeans, c. 600 B.C.,[602] has yielded material, but this may not be entirely representative since it has been impossible to carry out extensive excavations here. Chian vases and Ionian cups were present, and some of the non-localized East Greek groups, the wares with wave patterns, the stripe-decorated wares, and some of the hemispherical bowls too,[603] but vases in Wild Goat Style were almost absent. At all events Sūkās was not a Milesian colony, as it was no real Greek colony, but a Phoenician town, in which Greek merchants, Milesians(?),

[592] Lambrino, Vases, 39–46.
[593] JHS 60 1940, 14 fig. 8 f–k.
[594] Her. II 178.3.
[595] Her. II 159.3.
[596] Boardman, GO, 74.
[597] Samos V 75–76.
[598] However, the possible Rhodian participation in the foundation of Cyrene may explain why so much Rhodian pottery is found in Tocra, see Tocra, 14–15.
[599] See notes 587–588.
[600] Tocra, 64, JHS 86 1966, 286.
[601] Boardman, GO, 250–251.
[602] Huxley, Early Ionians, 71 notes 79–80. See further E. Langlotz, Die kulturelle und künstlerische Hellenisierung der Küsten des Mittelmeers durch die Stadt Phokæa. Köln 1966, 10 note 1, 14–19.
[603] Villard, Marseille, 36–50, 54–57 pls. 19–28.

Chians(?) or other Eastern Greeks(?), were permitted to live among Orientals, i.e. some sort of ἐνοικισμός.[604] However in the first half of the 6th century there is safe evidence of direct Greek contact with Northern Phoenicia, and the influence known from these regions, for instance in the early East Greek architecture, is not only to be explained by contact through 7th century Al-Mīna.[605]

[604] Sūkās I 129.

[605] The oriental influence, i.e. Syro-Hittite is seen for instance in the tradition of decorating the lower column drums with sculpture, see F. Krischen, Weltwunder der Baukunst in Babylonien und Jonien, Tübingen 1956, 64–66. For the columna caelata from Ephesus, Didyma and Kyzikos, see D. G. Hogarth, Excavations at Ephesus, British Museum, London 1908, 293–312, JdI 78 1963, 102–112, K. Tuchelt, Die archaischen Skulpturen von Didyma, Ist. Forsch. 27 1970, 99–103, Antike Kunst 8 1965, 99–102. On the suggestion by B. Ridgeway—that the carved drums from Didymaion may imitate metal appliqué—see Hesp 35 1966, 191 note 16. See further B. Wesenberg, Kapitelle und Basen. Düsseldorf 1971, 87–89, on the North Syrian leaf-base, which may have influenced East Greek bases, ibid. 111–116.

Appendix

List of Provenances of the Aegean, Corinthian and Eastern Greek Pottery and Terracottas from Tall Sūkās

The squares are those indicated on the plan, Sūkās I 13 fig. 4. Regarding the location within the squares, see ibid. 20, cf. 18–19.

The numbering of layers is that used during the excavation, cf. the preliminary reports in AASyr VIII/IX–XV 2, 1958/59–1965. Where possible the final designation of strata given in Sūkās I and forthcoming publications of the architectural finds, cf. Sūkās I 11–12 and 127, has been employed. *A concordance will be printed on completion of the entire series of publications on the Carlsberg Expedition to Phoenicia.*

Square		*Location*	*TS.no.*	*Cat.no.*
E 8	NW	located object		
		IX	12	ad **94**
	NE	not precisely located objects		
		layer 1	85	ad **277**
		–	92	ad **267**
		–	96	ad **252**
		layer 2	110	ad **389**
	SW	located objects		
		XXXVI	483	
		XXXVIII	484	**24**
		XLVI	497	
		and E 8 SE layer 4, E 8 NW layer 3		
		not precisely located objects		
		layer 2	18	ad **115**
		–	127	ad **128 a**
		layer 4	520	**62**
	SE	not precisely located objects		
		layer 3	26	ad **302**
		layer 4	1537	ad **15**
F 5	NE	located object		
		XXVI	1325	**390**
	SE	located objects		
		XI	541	**161**
		XII	536	ad **245**
		XII	537	ad **118**
		XIV		
		XV	961	ad **134**
		XXI	522	ad **118**
		XXIII	524	**114**
		not precisely located objects		
		layer 1	178	**210**
		–	180	ad **122**
		–	181	ad **115**
		layer 3	677	**166**
		11/9 1958	302	ad **257**
		– –	304	ad **297**
		– –	306	**74**
		13/9 –	315	**195**
		14/9 –	971	**144**
		20/9 –	1357	**251**
		5/10 –	1549	ad **123**
		6/10 –	1679	ad **245**
F 6	NW	not precisely located object		
		layer 1 in front of N-wall	969	**41**
F 7	E	located objects		
		II	3326	**374**

Square		*Location*	*References*	*TS.no.*	*Cat.no.*
F 8	NW	located objects			
		I		1768	**388**
		XVIII		1773	**27**
		XXXVI		1923	ad **111**
		not precisely located objects			
		layer 2	Sūkās I 50, 142, 152 figs. 53 b–c, 54 a–b.	2018	**37**
		layer 5 baulk towards E 8		2838	**344 b**
F 11	NW	located object			
		III		742	**348**
F 15	SW	not precisely located objects			
		layer 6 (?) W. of tower		2629	**329**
	SE	located objects			
		XXIV		1929	ad **115**
		XXV		2290	**111**
		not precisely located object town wall in same height as layer 9		1790	**268**
F 15/G 15		not precisely located object			
		layer 4		3479	**378 a**
F 16	SW	located objects			
		XIV		2281	**319**
		XIX		1939	ad **107**
		XXIV		1940	ad **238**
		XXV		2311	**274**
		XXVI		2312	**327**
		not precisely located objects			
		layer 10		1797	ad **88**
		B		1798	ad **267**
G 5	NW	not precisely located objects			
		layer 2 baulk		3540	ad **68**
		cleaning of facade of W-wall		207	**238**
		between stones in town wall		3529	ad **118**
		–		3530	ad **107**
		–		3531	ad **107**
		–		3532	ad **107**
		–		3533	ad **121**
		–		3534	ad **238**
	NE	located objects			
		V		542	ad **137**
		V		543	ad **132 b**
		V		544	ad **115**
		XVI		1020	**387**
		XVI		1021	**116**
		XVII		549	**208**
		XXII		557	ad **108**
		XXX		1030	ad **128 c**

Square	*Location*	*TS.no.*	*Cat.no.*
G 5	not precisely located objects		
	layer 1	28	ad **143**
	–	29	ad **266**
	–	30	ad **225**
	–	188	ad **116**
	–	189	ad **132 a**
	–	190	ad **140**
	–	191	**370 a**
	layer 2 baulk	3521	ad **129**
	– –	3522	ad **131**
	– –	3525	ad **108**
	– –	3527	ad **107**
	layer 3	551, 765	ad **134**
	–	3500	ad **132 a**
	–	3501	ad **122**
	–	3541	ad **118**
	–	3542	**149**
	–	3543	ad **109**
	–	3546	ad **267**
	–	3552	**108**
	–	3553	ad **128 c**
	–	3554	ad **107**
	–	3555	ad **123**
	–	3556	ad **122**
	–	3557	ad **142**
	layers 3–4	3545	**66**
	layer 4	3504	**121**
	–	3505	**60**
	–	3508	**249**
	–	3512	ad **267**
	–	3513	**235**
	– baulk	3516	ad **107**
	– –	3518	ad **128 c**
	– –	3519	ad **132 a**
	– –	3520	**39**
	– –	3560	ad **123**
	– –	3561	**127 b**
	– –	3562	ad **107**
	– –	3563	ad **128 c**
	– –	3564	ad **103**
	– –	3565	**209**
	– –	3567	ad **143**
	– –	3811	ad **122**
	– –	3829	**78**
	20/9 1958	644	**55**
	– –	1379	**336**

Square		*Location*	*TS.no.*	*Cat.no.*
G 5		14/9 1958	1512	**134**
		25/9 –	1516	**182**
		6/10 –	1868	**82**
	SW	not precisely located objects		
		layer 1 baulk towards W	185	ad **132 a**
		cleaning of W-wall	608	**294**
		cleaning of W-wall	609	ad **267**
		in front of W-wall	1696	ad **246**
	SE	located objects		
		I	71	ad **118**
		III	72	ad **107**
		VI	1018	**389**
		XXV	1022	ad **107**
		XXV	1024	ad **52**
		XXV	1027	**43**
		XXVI	1028	ad **128 c**
		XXXV	758	ad **132 a**
		XXXVIII	710	ad **107**
		not precisely located objects		
		layer 1	31	ad **108**
		–	33	ad **251**
		–	34	ad **111**
		–	55	ad **141 a**
		–	78	**201**
		–	81	ad **118**
		–	330	ad **302**
		layer 2 baulk	3523	**190**
		– –	3524	**354**
		layer 3	552	ad **107**
		–	553	ad **122**
		–	554	ad **125**
		–	555	ad **132 a**
		17/9 1958	265	ad **267**
		13/9 –	284	ad **132 a**
		– –	285	ad **132 a**
		– –	294	**215**
		– –	295	ad **148**
		– –	296	ad **297**
		– –	318	ad **267**
		– –	320	ad **107**
		– –	321	ad **219**
		28/9 –	611	**244**
		– –	612	**72**
		baulk towards W	1117	**113**
		8/10 1958	1376	**77**
		14/9 –	1378	**153**
		17/9 –	1513	**52**

Square		*Location*	*TS.no.*	*Cat.no.*
G 5		17/9 1958	1514	**179**
		24/9 –	1515	ad **89**
		27/9 –	1517	**300**
G 7	SW	not precisely located objects		
		layer 3	1345	ad **142**
		16/9 1958	1360	**377**
	SE	located objects		
		IV	1035	ad **109**
		V and layer 3	1036	**411**
		VI	779	ad **272**
		VI	780	ad **142**
		VII	775	ad **128 c**
		VII	776	ad **107**
		VII	777	ad **116**
		VIII	774	ad **267**
		X	1037	**307**
		XIII	1038	**69**
		XIX	668	**216**
		XX	1042	**53**
		XX	1043	ad **108**
		XXII	2037	ad **107**
		XXIV	1800	ad **241**
		XLI	2135	ad **141 a**
		XLII	1954	ad **107**
		XLV	1957	ad **18**
		XLVI } XLII }	1959	**170 b**
		LXXIV	2269	**258**
		LXXVI	1972	**141 b**
		LXXVII	1973	ad **108**
		LXXVIII	1974	ad **170 b**
		LXXXVIII	2270	**170 a**
		LXXXVIII	2271	ad **132 a**
		not precisely located objects		
		layer 1	1520	**159**
		layer 2 on floors	1044	**279**
		–	1380	**332**
		–	1382	**73**
		layer 3	1383	**146**
		layer 9 ashes in N–W part	1947	ad **106**
		layer 16 SE angle	1986	**340**
G 7 SE/**G 8** SW		not precisely located object		
		layer 2	347	ad **297**
G 8	NW	not precisely located objects		
		layers 1–2	1122	**189**
		layers 1–6 descent to G 8 SW	1810	ad **120**
		layers 1–6 descent to G 8 SW	1811	ad **128 c**

Square		*Location*	*TS.no.*	*Cat.no.*
G 8		layers 1–7 descent to G 8 SW	1988	**308**
		layers 1–7 descent to G 8 SW	1989	ad **240**
	SW	located objects		
		III	276	ad **147**
		III	289	**188**
		IV	1052	**293**
		VII	1053	ad **216**
		XII	1064	ad **59**
		XIV	1065	**96**
		XIV	1066	**92**
		XIX	667	**262**
		III }		
		XIII }		
		XX }	274	**154**
		XXVI }		
		XLI }		
		XX	1067	**138**
		XXV	1073	**384**
		XXV	1075	**97**
		XXV	1076	**306**
		XXV	1077	ad **72**
		XXV	1078	**75**
		XXV	1079	ad **297**
		XXV	1080	ad **240**
		XXV	1081	ad **297**
		XXV	1083	ad **143**
		XXV	1084	ad **189**
		XXV	1085	ad **246**
		XXV	1086	**245**
		XXV	1099	**162**
		XXV	1100	ad **52**
		XXV	1689	ad **107**
		XXXVIII	1096	ad **107**
		XLI	803	ad **138**
		XLVIII	1102	ad **331**
		XLIX	1103	ad **297**
		L	794	ad **105**
		LV	790	**115**
		not precisely located objects		
		layer 1	332	**94**
		layer 2	640	**158**
		–	1068	ad **52**
		–	1108	ad **243**
		–	1109	ad **88**
		–	1110	ad **267**
		–	1523	**180**
		–	4924	ad **108**

Square		*Location*	*TS.no.*	*Cat.no.*
G 8		layer 3	1521	ad **123**
		layer 4	793	ad **115**
		11/9 1958	313	ad **267**
		1958	1087	**157**
		24/9 1958	1683	**240**
	SE	located objects		
		IX	1058	**185**
		X	1059	**57**
		XV	810	ad **302**
		XXIV	379	ad **246**
		XXVIII	1088	**54**
		XXX	628	**350**
		XL	804	**217**
		XLIII	798	ad **108**
		LIV	1692	ad **108**
		LVII	1105	**303**
		LVII	1106	ad **132 a**
		LX	785	ad **107**
		LXII	669	**239**
		not precisely located objects		
		layer 2	1341	**227**
		–	1342	ad **242**
		–	1384	ad **122**
		layer 3	1355	**29**
		layer 6	234	**310**
		– SE/SW baulk	662	**261**
		layer 6	1111	ad **306**
		–	1339	**254**
		layer 8	619	**402**
		/SW 26/10 1958	1346	**63**
G 10	NE	located objects		
		XVIII	4811	ad **118**
		XIX	4401	**272**
		XIX	4402	ad **297**
		XXII	4408	ad **241**
		XXIII	4409	ad **242**
		LXVII	4792	ad **4**
		not precisely located objects		
		layer 2	4364	**422**
		layer 5	4657	**3**
	SE	located objects		
		XLI	4648	**160**
		XLIX	4645	**289**
		LIV	4644	**352**
		LVII	4789	ad **109**
		LIX	4522	**14**
		LXXIX } LXXX }	4802	ad **267**

Square		*Location*	*TS.no.*	*Cat.no.*
G 10		LXXX	4801	**317**
		LXXXI	4642	**156**
		not precisely located objects		
		layer 6	4658	**353 a**
		layer 7	4659	ad **105**
		layer 8 or 2	4661	**417**
		depth 1.5 m i.e. layer 11 in G 11 SW	4319	**420**
G 11	NW	located objects		
		LXXIII	1210	**191**
		XCV	849	**248**
		CXIII	1224	ad **323**
		not precisely located object		
		layer 2	634	**341**
	SW	located objects		
		X	1131	**61**
		XXV	1141	ad **297**
		XXV	1150	ad **225**
		XXIX	1158 }	**323**
		L	1159 }	
		XXXIV	1149	**203**
		XXXIV	{1151 / 1153}	**198**
		XXXIV	1157	ad **142**
		XXXIV	1327	ad **191**
		XXXVII	1148	ad **107**
		XXXVIII	1147	**297**
		XXXIX	1169	**250**
		XL	1168	**218**
		XLVIII	1173	**87**
		XLIX	834	ad **191**
		L	1170	**150**
		L	1171	ad **107**
		L	1172	ad **137**
		LIII	1189	ad **108**
		LVI	1186	**243**
		LVIII	610	**291**
		LXIII	827	ad **128 c**
		LXIII	855	ad **106**
		LXIV	1179	ad **288**
		LXIV	1180	**241**
		LXIX	820	ad **107**
		LXX	821	ad **267**
		LXXIV	1193	**151**
		LXXIV	1194	ad **246**
		LXXIV	1198	ad **18**
		LXXIV	1200	**148**
		LXXIV	1202	ad **170 b**
		LXXIV	1195	ad **250**

Square	*Location*	*TS.no.*	*Cat.no.*
G 11	LXXV	1192	ad **250**
	XCIII	638	**199**
	CX CXVII CXXI CXXX	562	**35 a**
	CXX CXXII	561	**34**
	CXXIII	563	**32**
	not precisely located objects		
	layer 1	663	**6**
	layer 2	1475	**324**
	–	1481	**90**
	layer 3	665	**357**
	–	1482	**220**
	–	1483	ad **102**
	layer 4	597	**255**
	–	651	**164**
	–	1493	**392**
	–	1494	ad **156**
	–	1681	**246**
	layer 5	575	**331**
	–	576	ad **359**
	– /NE baulk	812	**16**
	layer 6	1356	**213**
	layer 7	601	**407**
	–	852	ad **137**
	layer 8 yellow clay below stone wall	598	ad **331**
	–	1343	ad **186**
	– beneath wall SE/NW	1451	**223**
	– beneath wall SE/NW	1452	**256**
	layer 9	1385	**15**
	–	1386	**233**
	layer 10	600	**5**
	layer 11	641	**18**
	–	1390 1391	**17**
	layer 11²	569	**2**
SE	located objects		
	VI	1125	**285**
	XXVI	1137	ad **134**
	XXVI	1138	ad **189**
	XXVI	1144	**135**
	XXVI	1145	ad **137**
	XLI	836	ad **108**
	XLIII	1164	**109**
	XLIV	1162	**226**

Square		*Location*	*TS.no.*	*Cat.no.*
G 11		XLVI	1174	ad **251**
		XLVI	1177	**91**
		LII	1190	**366**
		LIX	830	**196**
		LIX	1182	ad **137**
		LX	831	ad **118**
		LXI	828	ad **265**
		LXI	829	ad **189**
		LXVII	1687	ad **108**
		LXXXV	1115	ad **118**
		LXXXVIII	678	ad **267**
		LXXXVIII	854	ad **244**
		LXXXVIII	1420	**397**
		XCI	851	ad **115**
		XCVIII	1213	**267**
		CII	595	**288**
		CVI	269	ad **266**
		not precisely located objects		
		layer 1	647	ad **188**
		–	648	ad **191**
		layer 2 baulk	578	**335**
		layer 3 SW-corner	635	**337**
		layer 4	625	**330**
		layer 6	232	**48**
		–	1387	**45**
		–	1388	**141 a**
		–	1485	**222**
		layer 8 ?	1389	ad **146**
G 12	NW	not precisely located object		
		layer 3	4434	**80**
	NE	not precisely located object		
		layer 13	3858	ad **35 a**
	SW	located objects		
		I = G 11 SE LXXXVIII	954	**176**
		I = G 11 SE LXXXVIII	955	ad **134**
		I = G 11 SE LXXXVIII	1428	**400**
		XX	4861	**117**
		not precisely located object		
		layer 2	4386	**312**
	SE	located objects		
		XVII	4578	**399**
		XXXIII	4577	**100**
		XLV	4835	ad **346**
		LV	4440	**320**

Square		Location	References	Final indication of stratum	TS.no.	Cat.no.
G 12		LIX			3282	**200**
		XCVI			4506	**104**
G 13	NW	located objects				
		XCVIII	Sūkās I 60 pl. IV no. 1 fig. 25 d	J	4514	**265**
		LXXII	Sūkās I 60 pl. IV no. 2 fig. 25 e	G^2	4572	**353 b**
		not precisely located objects				
		layer 2				
		–			3291	ad **108**
		–			3576	ad **107**
		–			3577	ad **308**
		–			3578	ad **123**
		–			3579	ad **235**
		–			3581	**316**
	SE	located objects				
		III			1995	ad **107**
		VII		E	1997	**186**
		VIII		E	1998	ad **107**
		VIII		E	1999	**132 b**
		XIV	Sūkās I 61 pl. IV no. 11	G^2	2129	ad **120**
		XXIII		G^2	2345	ad **118**
		XXV	Sūkās I 60 pl. IV no. 6.	G^2	2347	ad **108**
		XXIX	Sūkās I 60–61 pl. IV no. 7.	G^2	2350	ad **141 a**
		LXVII	Sūkās I 60 pl. IV no. 3 fig. 25 f.	G^3	4574	**339**
		LXXXVII	Sūkās I 44 pl. III no. 12 fig. 16 a	H^1	4478	**145**
		not precisely located objects				
		layer 6		G^2	2336	**364**
		layer 7		G^3	4670	**404**
	SW	located objects				
		XLVI			3652	**234**
		XLVI			3653	**425**
		not precisely located objects				
		layer 1			3569	ad **107**
		–			3571	ad **133 a**
		–			3572	ad **4**
		–			3583	**383**
		–			3632	**174**
		–			3638	ad **146**
		layer 2			3575	**225**
		–			3584	ad **118**
		–			3585	ad **128 c**

Square		*Location*	*References*	*Final indication of stratum*	*T.S.no.*	*Cat.no.*
G 13		layer 2			3588	ad **122**
		–			3589	**415**
		–			3830	ad **146**
		layer 3			3593	ad **148**
		–	Sūkās I 50 note 146 fig. 16 c		3594	**128 b**
		–			3595	ad **107**
		–	Sūkās I 50 note 146 fig. 16 d		3596	**128 a**
		layer 4			3603	ad **297**
		–			3610	ad **267**
		–			3611	ad **244**
		–			3613	ad **79**
		–			3614	**59**
		–			3615	ad **59**
		–			3616	ad **123**
		–			3831	ad **281**
G 14	NW	located objects				
		LXXIX			4404	ad **267**
		LXII			3064	ad **109**
	NE	not precisely located objects				
		baulk layers 1–2 = G 15 N layers 5–7 c		B–A	4910	ad **19**
		baulk layers 1–2 = G 15 N layers 5–7 c		B–A	4912	**187**
	SE	located objects				
		LXX	Sūkās I 65 pl. IV no. 25.	G^2	3153	ad **114**
		LXXXIV	Sūkās I 63, 88 pl. IV no. 18 fig. 25 g.	G^3	4419	**328**
	SW	located objects				
		XVI			3657	ad **134**
		XVII			3067	**287**
		LIV			3066	**126**
		LIX			3065	ad **118**
		not precisely located objects				
		layer 1			3666	ad **267**
		–			4180	**403**
		layer 2			3056	**379**
		–			3057	**260**
		–			3058	ad **118**
		–			3077	ad **331**
		–			3078	**26**
		–			3685	ad **199**

Square		*Location*	*References*	*Final indication of stratum*	*TS. no.*	*Cat. no.*
G 14		layer 2			3695	ad **106**
		–			3709	ad **186**
		–	Sūkās I 50 note 146 fig. 16 e.		3710	**128 c**
		–			3712	ad **128 c**
		–			3714	ad **297**
		–			3716	**10**
		–			3736	ad **267**
		–			3752	**127 a**
		–			4181	**406**
		layer 2 b			3744	ad **238**
G 14/H 14		not precisely located object				
		baulk			4913	**273**
G 15	NW	located objects				
		LXXXIX and SE LXXXVIII, NE XCIV and CI			2247	**171**
		LXXXIX			2748	**394**
		CLXVII	Sūkās I 65 pl. IV no. 30.	G²	5567	ad **128 c**
	NE	located objects				
		CXV			3038	**13**
		CLXII		G¹	5542	ad **34**
		CLXXXVIII	Sūkās I 29 pl. II no. 33 fig. 8 b.	J	5601	**1**
		not precisely located objects				
		layer 2 baulk towards NW			1839	ad **341**
		layer 2 baulk towards NW			1840	ad **135**
		layer 3 baulk			1843	ad **116**
		layer 3 a	Sūkās I 154 note 631.		1394	**40**
		layer 4 baulk towards NW			1832	**229**
		layer 6			1714	ad **223**
		layer 18		H²	5658	**20**
	SW	located objects				
		CXLII	Sūkās I 49–50 pl. III no. 35 fig. 15 h.	F	4416	**64**
		CXLIX		G¹	4484	ad **34**
		CLXVI A	Sūkās I 46 pl. III no. 26 fig. 15 f.	G³	5551	**70**
		not precisely located objects				
		layer 14		G³	3834	ad **46**
		–		G³	3837	ad **128 c**
		–		G³	3845	**165**
	SE	located objects				
		XXXVIII			988	**25**
		LXXXI and layer 3 baulk towards SW			1836	**175**

Square		*Location*	*References*	*Final indication of stratum*	*TS. no.*	*Cat. no.*
G 15		LXXXVIII			2238	**278**
		CX		F–E	4080	ad **34**
		CLIX	Sūkās I 29 pl. II no. 36 fig. 8 e.	J	4533	**33 b**
		CLX	Sūkās I 29 pl. II no. 35 fig. 8 c.	J	4532	**35 b**
		not precisely located objects				
		layer 2			83	**269**
		layer 2 baulk towards SW			1834	ad **128 c**
		layer 13		H	4717	ad **62**
		not precisely located objects				
		layer 7			3828	**46**
		layer 8			3481	ad **15**
		–			3489	**19**
		cleaning			5515	**7**
G 16	NW	located objects				
		XLIII			2374	**211**
		XLIV			2258	ad **121**
		LXII			2295	**36**
		LXV			2297	**177**
		LXXXI			2314	**23**
		CXVII } CXXII }	Sūkās I 36 pl. II no. 51 fig. 8 d.	G^1	5561	**31**
		not precisely located objects				
		layer 7 in floor			1865	ad **136 a**
		layer 12 b filling in tower		F	5585	**11**
		layer 12 filling in tower		F	5586	**21**
		layer 14 filling in tower		G^1	5584	ad **35 a**
	SW	located objects				
		XXV		A–D	671	**163**
		XXXIII		F	636	**283**
		LXXXIII		G^2	2320	ad **142**
		LXXXVIII			3048	ad **297**
		CII	Sūkās I 48 pl. III no. 29 fig. 15 e.	G^3	4438	**47**
		CVII	Sūkās I 34 pl. II no. 49 fig. 8 f.	J–K	4516	**33 a**
		not precisely located objects				
		layer 10		G^2	4679	ad **33 a**
		layer 11		G^3	4680 a	ad **35 a**
		layer 12		H	4680 b	ad **35 a**
	SE	located object				
		XCV		F	3053	**103**
G 19	SW	located object				
		XI			2330	ad **136**
		not precisely located objects				
		layer 4			3006	ad **71**

Square		*Location*	*TS. no.*	*Cat. no.*
G 19		W. of wall	1877	ad **241**
H 5	NW	not precisely located objects		
		17/9 1958	623	**65**
		cleaning of facade of wall	1255	ad **107**
	NE	located objects		
		XXVIII	895	ad **108**
		XXX	235	**321**
		XLIII	1008	**131**
		XLIII	1015	**296**
		XLIII	1016	**129**
		XLIII	1017	**112**
		not precisely located objects		
		layer 1	142	**418**
		layer 3	211	**105**
		13/9 1958 baulk	338	ad **302**
		5/10 –	653	ad **131**
		20/9 –	1340	**298**
		20/9 –	1344	ad **238**
		28/9 –	1395	**368**
		17/9 –	1721	ad **107**
		17/9 –	1722	ad **107**
		17/9 –	1730	**252**
	SW	not precisely located object		
		25/9 1958	633	**349**
	SE	located objects		
		XII	118	ad **109**
		XXIX	1009	**347**
		XXIX	1010	**110**
		XXIX	1012	**38**
		XXXIII	212	**130**
		XXXIII	213 558	**120**
		not precisely located objects		
		layer 1	171	ad **116**
		layer 3(?)	657	ad **131**
		17/9 1958	525 527	**107**
		– –	526	ad **107**
		– –	528	ad **128** c
		– –	529	ad **238**
		9/10 –	1723	**102**
		17/9 –	1729	ad **111**
H 10	NE	located objects		
		LVIII	4641	**155**
		LXV	4635	ad **165**
		XCIX	4630	**280**
		CII	4562	**315**

Square		*Location*	*TS. no.*	*Cat. no.*
H 10		CV	4619	**193**
		CV	4620	**282**
	SE	located object		
		XXXIX	4615	**351**
		not precisely located object		
		layer 9	4689	**290**
H 11	NW	located objects		
		XVI	1884	**398**
		XXVII	1893	ad **18**
		LXXIII	4063	**334**
		LXXXVI	3822	**413**
		XCVII	2561	**119**
		C	2564	ad **238**
		CV	2567	ad **132 a**
		CXVIII	2571	ad **267**
		CXXIX, CXXXIII, CL	4317	**409**
		CXXIX, CLI	4758	**133 a**
		CXXIX	4762	**395**
		CXXXI	2575	ad **267**
		CXL	2577	**122**
		CXLVIII	2586	ad **268**
		CLIV	2594	ad **189**
		not precisely located objects		
		layer 2 baulk towards G 11	2616	ad **323**
		layer 3 baulk	2608	ad **190**
		layers 3–4 baulk towards G 11	2613	**391**
		layer 4 baulk	2603	ad **108**
		– –	2606	ad **26**
		– –	2996	ad **288**
		layer 7	3418	ad **111**
		–	3422	ad **107**
		–	3426	**207**
		–	3827	**361**
		layer 8	3440	ad **107**
		–	3826	**22**
		layer 9	3448	ad **128 c**
		layer 10	3432	ad **106**
		–	3433	ad **111**
		–	3824	**253**
		–	3825	ad **143**
		layer 11		
		–	3453	ad **145**
		–	3454	**369**
		layer 12	3408	ad **107**

Square		Location	TS. no.	Cat. no.
H 11		layer 12	3409	ad **107**
		–	3436	**58**
		–	3458	ad **109**
		layer 13	3365	ad **107**
		layer 14	3823	**147**
		layer 15	3377	ad **288**
		–	3378	ad **297**
		–	3820	ad **389**
		layer 16	3383	ad **267**
		–	3384	ad **107**
		–	3385	ad **132 a**
		–	3393	ad **68**
		layer 17	2595	**423**
		–	3396	**231**
		–	3405	**181**
		20/10 1960	3437	**414**
	NE	located objects		
		CCIV	4437	**358**
		CCXIII	4611	**359**
		CCXIX	4480	ad **143**
		CCXXIX	4467	**152**
		CCXXXVII	4489	**344 a**
		CCLV	4819	**375**
		CCCI	4846	**98**
		CCCII	4837	**292**
		CCCXIII	4604	ad **35 a**
		CCCXXXVI	5553	ad **19**
		not precisely located objects		
		layer 2	3465	ad **297**
		layer 3	3464	ad **148**
		layer 4		
		–	3466	ad **271**
		layer 6	4456	**401**
		–	4460	ad **128 c**
		layer 12	5628	**224**
		layer 24	5652	**101**
	SW	not precisely located object		
		layer 12	4694	**386**
	SE	located objects		
		CCLXIV	4528	**277**
		CCXCIV	4838	**136 a**
		CCXCVII	4847	**95**
		CCCX	4843	**93**
		not precisely located object		
		layer 11	4693	**326**

Square		*Location*	*References*	*Final indication of stratum*	*TS. no.*	*Cat. no.*
H 11		not precisely located objects				
		layer 6			3416	**86**
		–			3428	ad **271**
H 12	NW	located object				
		XV			5528	**424**
		not precisely located objects				
		layer 1			5621	**30**
		–			5622	**184**
		layer 4			4894	**412**
		–			5613	**376**
		layer 5			5632	**304**
		–			5634	ad **273**
		–			5635	**206**
		–			5637	**322**
		–			5663 4911	**381**
		–			5664	**142**
		–			5665	**67 b**
		layer 6				
		–				
		–			5645	**360**
		–			5646	**363**
		–			5647	**362**
		–			5650	ad **323**
H 13	NW	not precisely located object				
		layer 6		G^2	4699	**318**
	SW	located object				
		LXXVII	Sūkās I 82 pl. IV no. 91 fig. 25 h	F	4565	**84**
		not precisely located object				
		layer 7		G^{2-1}	4701	**85**
	SE	located object				
		LI			3777	**137**
		not precisely located object				
		layer 2 a			3015	**192**
H 14	NE	located object				
		VII	Sūkās I 50 pl. III no. 37 fig. 16 g.		4183	**42**
		not precisely located objects				
		layer 1			4315	**405**
		layer 2	Sūkās I 50 pl. III no. 36 fig. 15 c.		4044	**44**
H 15	NW	located object				
		XXXI			4928	**325**
H 16	SE	not precisely located object				
		layer 1			3761	ad **146**

Square		*Location*		*References*	*Final indication of stratum*	*TS. no.*	*Cat. no.*
J 8	SE	located objects					
			X			2055	**4**
			XV			2199	ad **313**
			XXIII			2619	ad **267**
			XXV			2621	**378 b**
			ad XXV			2928	**286**
			XXVI			2620	**301**
		not precisely located objects					
			layer 4			2251	**247**
			–			2728	ad **57**
			–			2733	ad **107**
			–			2734	ad **107**
			–			2735	**139**
			–			2737	ad **107**
			–			2739	ad **107**
			–			2740	ad **108**
			–			2741	ad **107**
			–			2742	ad **109**
			–			2744	ad **121**
			–			2746	**56**
			layer 5			2878	ad **243**
			–			2879	**173**
			–			2880	**172**
			–			2882	**83**
			–			2883	**228**
			–			2884	ad **189**
			SE quadrant			2625	ad **257**
J 13	NE	located objects					
			LV		G^2	3797	ad **134**
			LXVI	Sūkās I 83 pl. IV no. 96.	G^2	3205	ad **137**
			LXVII	Sūkās I 83 pl. IV no. 98.	G^2	3206	ad **137**
			LXVIII	Sūkās I 83 pl. IV no. 102.	G^2	3208	**370 b**
			LXX	Sūkās I 83 pl. IV no. 95.	G^2	3209	ad **137**
			LXXI	Sūkās I 83 pl. IV no. 94 fig. 25 a.	G^2	3271	ad **133 a**
			LXXII	Sūkās I 83 pl. IV no. 93.	G^2	3272	**133 b**
			LXXIII	Sūkās I 83 pl. IV no. 97 fig. 25 c.	G^2	3273	**136 b**
		not precisely located object					
			layer 4		F	4786	**67 a**
	SE	located object					
			XXVII			3805	ad **133 a**
J 15	NW	located object					
			LI	Sūkās I 83 pl. IV no. 107.		3237	ad **189**
	SW	located object					
			L	Sūkās I 83 pl. IV no. 109.	G^2	3804	ad **108**

Square		*Location*	*FS. no.*	*Cat. no.*
L 8	SE	located objects		
		XIII	2123	**367**
		XVII	2144	ad **267**
		XXIII	2442	**343**
		XXIX	2647	ad **134**
		XXXI	2648	ad **134**
		XXXII	2226	**342**
		XXXII	2649	**373**
		LIII	2690	**372**
		LIII	2723	ad **267**
		LV	2323	**264**
		LVII	2324	**259**
		LIX	2445	**124**
		not precisely located objects		
		layer 2	3002	ad **216**
		layer 5 Room XXII	2638	**140**
		– – –	2639	ad **241**
		– – XXIII	2644	**385**
		– – –	2645	**212**
		– – –	2646	**143**
		– – XXII	2651	ad **111**
		– – –	2652	**169**
		– – –	2653	ad **128 c**
		– pocket in Room XXII	2677	**345**
		– Room XXIII	2841	ad **68**
		– – XXII	2842	**79**
		layer 6 Room XXIII	2658	ad **111**
		– – XXII	2661	ad **223**
		– – –	2663	**314**
		– – –	2664	ad **315**
		– fill under break, stone wall w. of ashlar pillar	2712	**237**
		– fill under break, stone wall w. of ashlar pillar	2713	ad **141 a**
		layer 6 b Room XXII	2687	ad **297**
		– – –	2688	ad **250**
		– – –	2692	**194**
		– – XXIII	2694	ad **136 a**
		– – –	2700	ad **106**
		layer 7 Room XXII	2714	**419**
		– – –	2721	**9**
		– – –	2725	**232**
		– – –	2726	ad **210**
L 11	SW	not precisely located objects		
		layer 7 Room XI	2843	ad **108**
		layer 8 – X	2858	ad **145**

Square		*Location*	*TS. no.*	*Cat. no.*
L 13	SE	located objects		
		XL	2471	**382**
		LI	2767	**410**
		not precisely located objects		
		layer 4 fill below wall	2762	**393**
		layer 5 Room XXII	2465	ad **144**
P 11	NW	located objects		
		XXXVII	906	ad **132 b**
		LV	1296	**356**
		LVII	1292	ad **92**
		LVIII	1291	ad **137**
		LX	672	**205**
		LXII	1299	ad **107**
		LXII	1300	ad **92**
		LXIII	1298	ad **267**
		LXIV	913	**118**
		LXV	937	**214**
		LXVII	925	ad **106**
		LXX	921	**236**
		LXXIV	2093	**275**
		LXXVIII	2099	ad **170 b**
		LXXXII	2095	ad **266**
		LXXXIV	2101	ad **107**
		LXXXV	2096	**230**
		LXXXV	2097	**219**
		LXXXVI	2480	ad **132 a**
		LXXXVI	2481	ad **108**
		LXXXVII	2098	**257**
		LXXXIX	2109	ad **120**
		XC	2110	**299**
		XCVI	2485	ad **109**
		XCIX	2150	**263**
		C	2151	**50**
		CI	2155	**313**
		not precisely located objects		
		layer 2 in filling of wall	1293	**396**
		layer 3	1446	ad **238**
		–	1447	**338**
		–	1448	**183**
		–	1449	**168**
		layer 4	621	**408**
		layer 5	2094	**202**
		–	2497	ad **302**
		–	2498	**51**
		layer 6	2152	**284**
		– filling in wall	2338	**311**
		layer 7	2501	ad **390**

Square		*Location*	*References*	*TS. no.*	*Cat. no.*
P 11		25/10 1958		631	**71**
		– –		659	ad **265**
		2/10 –		1397	ad **297**
		28/10 –		1443	**221**
		28/10 –		1444	**276**
		25/10 –		1492	ad **251**
		2/10 –		1500	ad **220**
		25/10 –		1675	**197**
		26/10 –		1734	**12**
		– –		1735	**28**
		25/10 –		1740	ad **331**
	SW	located objects			
		III		673	ad **209**
		XVIII		1271	**305**
		XX		1278	**242**
		XX		1279	**88**
		XXIII		1276	ad **389**
		XXIII b		1277	ad **389**
		XXVI		675	ad **208**
		XXVI		676	**204**
		XXVII		919	ad **115**
		XXIX		916	ad **108**
		XXIX		917	ad **116**
		XXX		920	**125**
		XLIII layer 4 and E 8 NE layer 1		97, 513, 534, 568, 930	**99**
		XLIII		1287	ad **107**
		XLV		918	ad **115**
		XLIX		1284	**266**
		XLIX		1285	ad **267**
		XLIX		1286	ad **187**
		L		929	**355**
		LI		926	**132** a
		not precisely located objects			
		layer 2		218	**106**
		–	Sūkās I 50 note 144.	517	**49**
		– W-pit		1266	ad **199**
		layer 3 NW baulk		1736	ad **368**
		layer 4		530	ad **107**
		–		532	ad **131**
		–		533	**309**
		2/10 1958		238	**302**
		19/10 –		624	ad **71**
		1/10 –		658	**167**

Square	*Location*	*TS. no.*	*Cat. no.*
P 11	25/10 1958	909	**421**
	30/9 –	922	**380**
	4/10 –	1399	ad **139**
	– –	1441	ad **146**
	19/10 –	1442	ad **59**
	1/10 –	1676	ad **3**
	– –	1737	**371**
	– –	1738	**333**
Surface			
	22 and 29/8 1958	1	**81**
	– – –	2	**123**
	6/9 1958	3	ad **267**
	7/9 –	48	ad **297**
	F 5 W-slope	292	**281**
	19/10 1958	351	**270**
	– –	352	**295**
	– –	356	**89**
	– –	357	ad **123**
	– –	359	**76**
	– –	364	ad **18**
	– –	365	ad **18**
	– –	368	**416**
	– –	369	ad **416**
	S of tall 3/11 1958	427	**365**
	F 5 W-slope 11/9 1958	512	**178**
	1958	1314	ad **128c**
	–	1317	**68**
	J 5 NW in fill outside crousade-wall	1764	**346**
	1960	2538	ad **268**
	W-slope on terrace half-way down	3844	**271**
	24/10 1961	4714	ad **244**
	Eastern spur 4/9 1961	4752	8

Indleveret til Selskabet den 16. sept. 1971.
Færdig fra trykkeriet den 10. oktober 1973.

PLATES

(Small numbers refer to the catalogue)


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PLATE II

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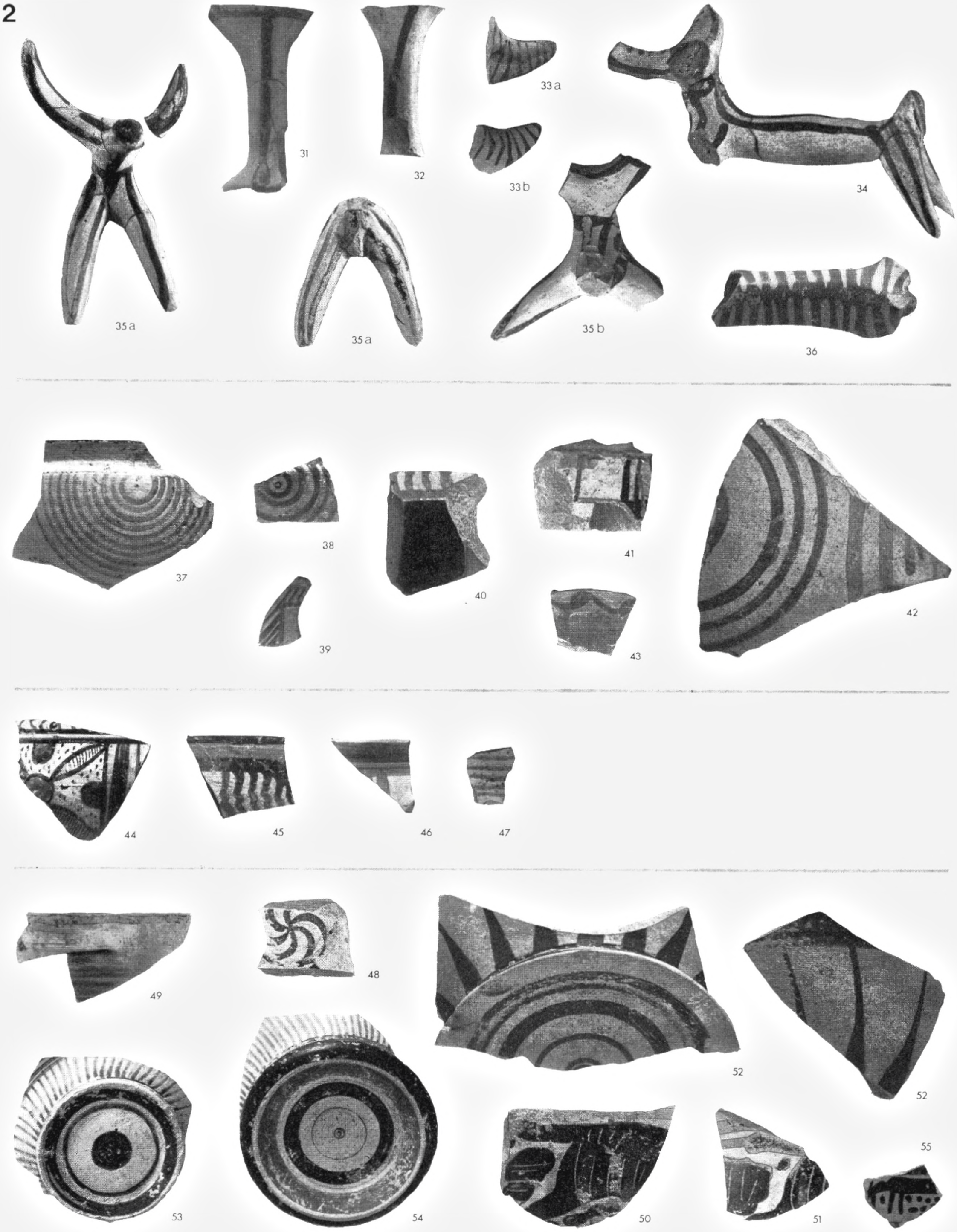

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PLATE IV

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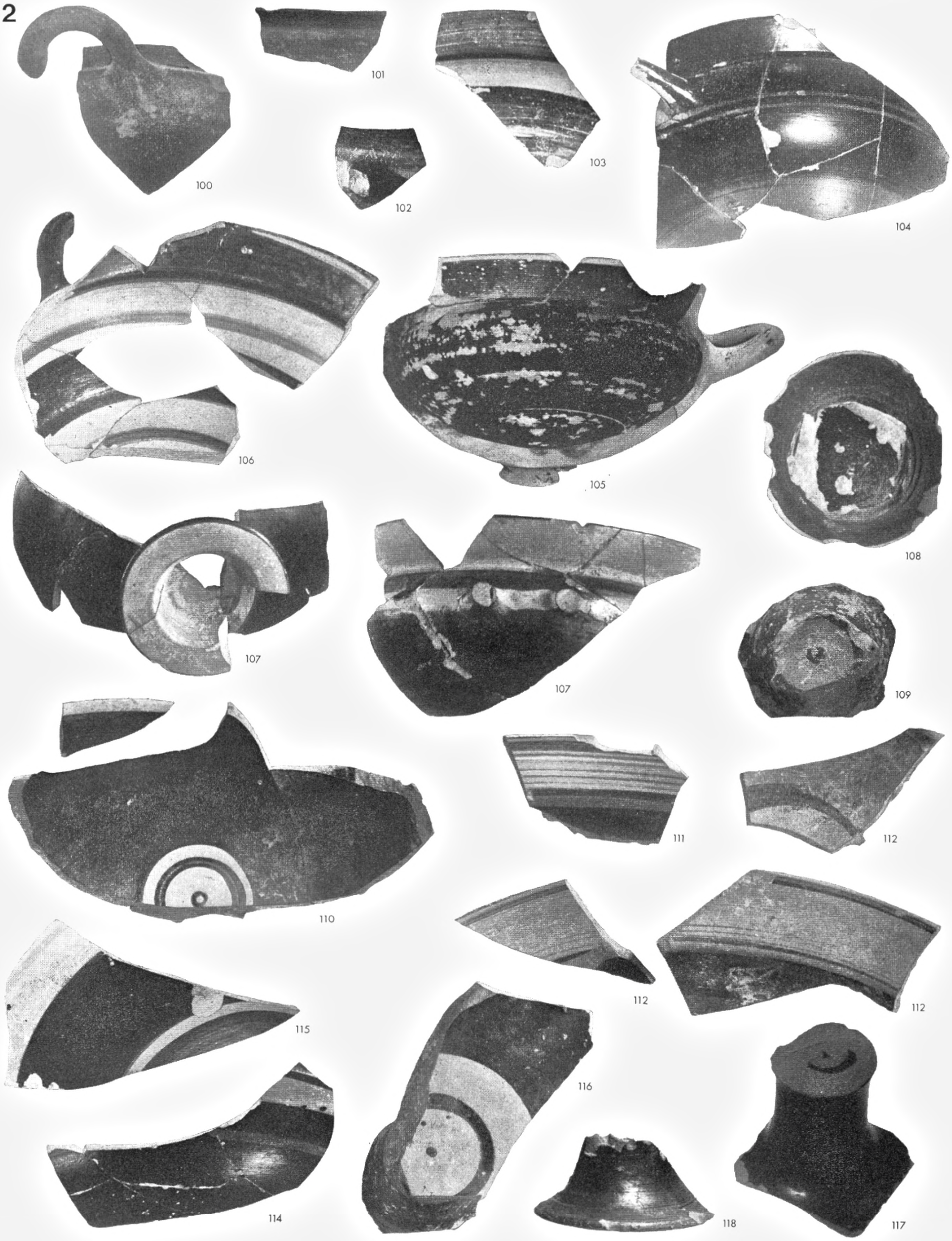
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PLATE VI

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Plate XII


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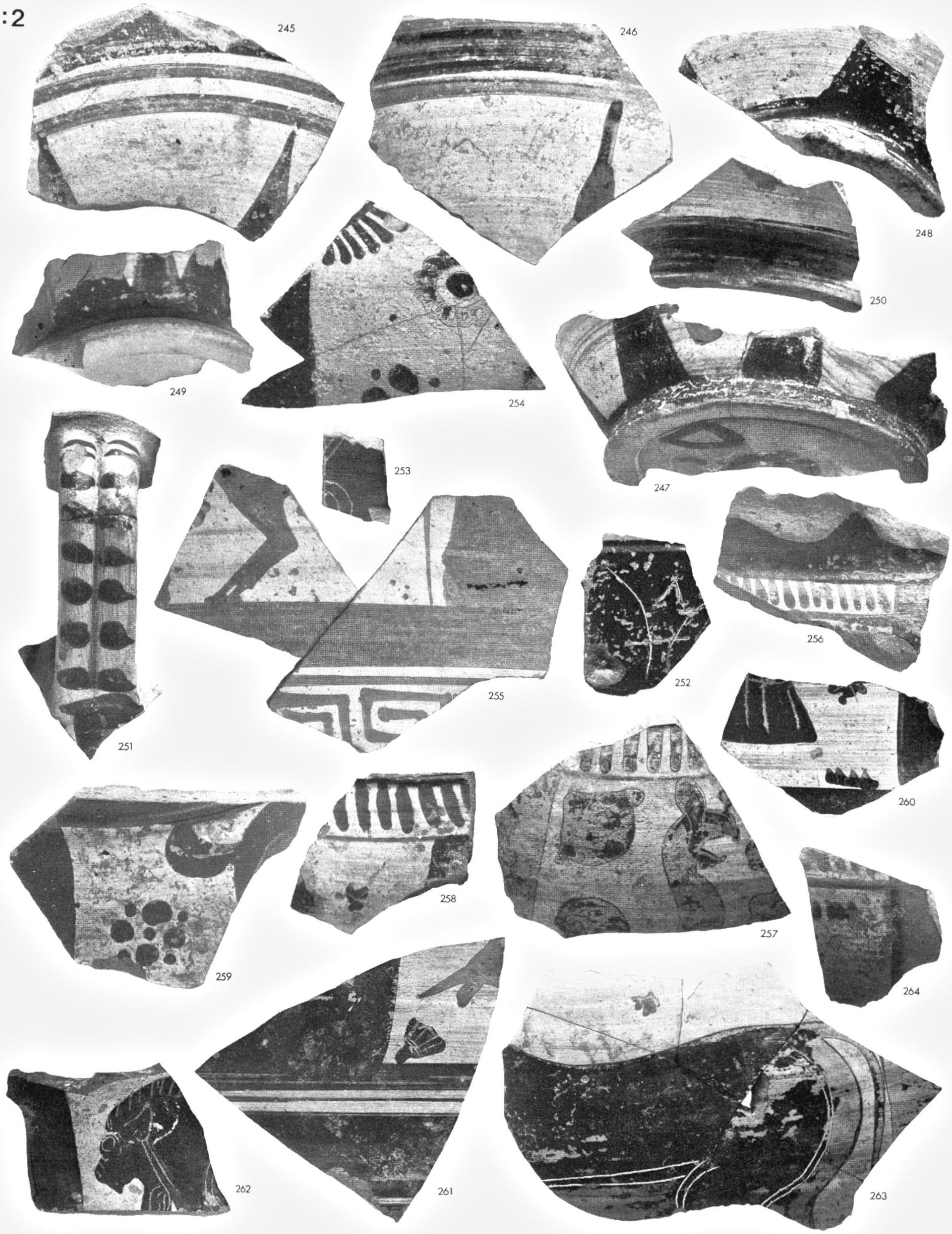
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Plate XIV

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PLATE XVI


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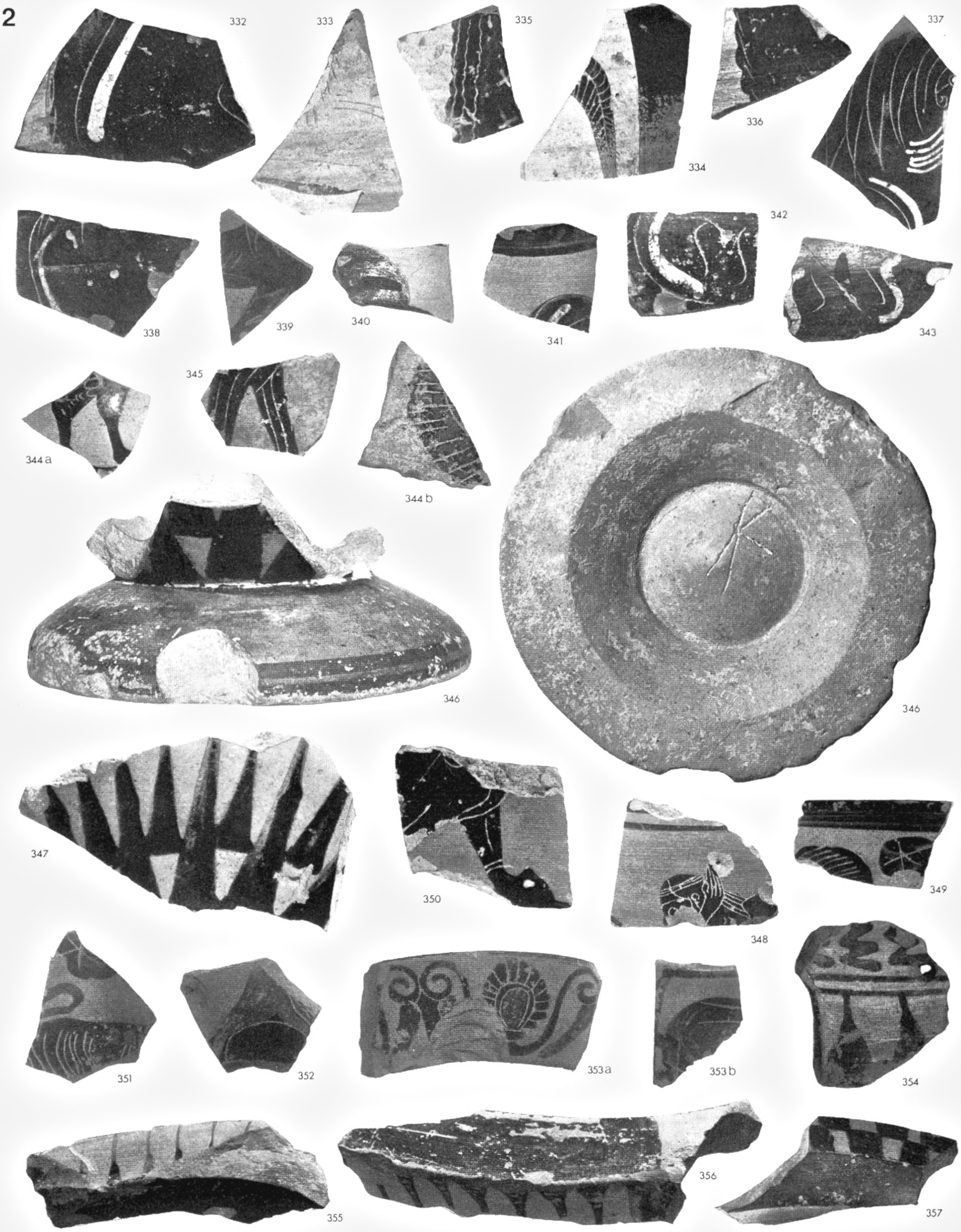
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Det Kongelige Danske Videnskabernes Selskab

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Printed in Denmark
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ISBN 87 7304 012 6