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Review Article:

Texts and Fragments:

RITUALS FOR AN ECLIPSE POSSIBILITY IN THE 8TH YEAR OF CYRUS[1]

Paul-Alain Beaulieu and John P. Britton
Yale University

In *RA* 23 (1926) 13–17 there appeared a short article, authored by A. Boissier, and entitled "Extrait de la chronique locale d'Uruk." In that article Boissier published, with autograph copy, transliteration, translation, and a commentary, a Neo-Babylonian text from Uruk dated in the 8th year of Cyrus. The text records a deposition made by three individuals, named but not otherwise identified, before the assembly of the *qīpāni* and the *mār-banî* of the Eanna temple. The subject matter of the deposition is the ritual playing of the kettledrum at the gate of the Ebabbar temple. According to the deposition, the kettledrum was played in connection with a lunar eclipse (*attalû*), and the inhabitants of the city witnessed the performance. Although Boissier clearly copied the name of the city where the ritual was performed as UD.UNUG$^{\text{ki}}$ (= Larsa), he read the name as Uruk (UNUG$^{\text{ki}}$) in his transliteration and translation (line 21). Boissier's oversight was never challenged, with the result that in all subsequent references to this text it has been assumed that the events reported in the deposition took place at Uruk rather than Larsa.[2] The title of Boissier's article was therefore somewhat a misnomer. However, the deposition itself was made at Uruk, and it is there that the text was drafted. The affairs of the city of Larsa[3] were often referred to the administration of Uruk in the Neo-Babylonian period, since Uruk held a status akin to that of a regional capital. The circumstances which prompted the recording of the deposition there rather than at Larsa are therefore not exceptional. The text published by Boissier reads as follows:

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1. I *im-bi-ia* $^{\text{lú}}$GAR.UŠ$_4$ UNUG$^{\text{ki}}$ DUMU-*šú šá* I $^{\text{d}}$*na-na-a*-KAM
2. DUMU I *ki-din*-$^{\text{d}}$AMAR.UD I $^{\text{d}}$NÀ-DU-IBILA $^{\text{lú}}$ŠÀ.TAM É.AN.NA
3. DUMU-*šú šá* I *na-di-nu* DUMU I *da-bi-bi* I $^{\text{d}}$NÀ-ŠEŠ-MU LÚ SAG LUGAL
4. $^{\text{lú}}$EN *pi-qit-tu*$_4$ É.AN.NA I *šá*-$^{\text{d}}$NÀ-*ṭa-a-bi* $^{\text{lú}}$*qí-i-pi*

1–12 Imbiya, the governor of Uruk, son of Nanaya-ēreš, descendant of Kidin-Marduk; Nabû-mukīn-apli, the *šatammu* of Eanna, son of Nādinu, descendant of Dābibi; Nabû-ah-iddin, a royal servant, the commissioner of Eanna; Ša-Nabû-ṭāb, the *qīpu* of the city Šalamu; Arad-Marduk, son of Zēriya, descendant of Egibi; Arad-Bēl, son of Ṣillâ, descendant of Iddin-Papsukkal;

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[1] A preliminary version of this article was presented at the 202nd Annual Meeting of the American Oriental Society, held in Cambridge, Massachusetts, March 29–April 1, 1992.

[2] See, for instance, *CAD* L, s.v. *lilissu*, where the deposition is quoted in its entirety (p. 187a), and Zadok [1985, 33], who, on the basis of the misreading, assumes the existence of a temple named Ebabbar at Uruk, distinct from the one located in Larsa. This reference to Larsa should be added to the ones listed in *RGTC* 8, 210–11, s.v. Larsa.

[3] On the relationship between the two cities in the Neo-Babylonian period see Beaulieu [1991, 58–60], where the previous literature on the question is listed.

ending when the eclipse ended. Thus, from the reports in the two depositions from Uruk, we should expect to find that an eclipse took place sometime near sunset on the 13th of Simānu in the 8th year of Cyrus, in which case the ritual performances reported in our texts would appear simply as variants of a general tradition of playing the kettledrum to ward off the evil consequences of an eclipse of the moon. In fact, however, no lunar eclipse took place that month (nor the following month), and full moon did not occur until 1:13 PM the following afternoon, roughly eighteen hours after the events reported.

This raises the question: what occasioned the rituals reported in our texts—rituals which were performed in similar, if not identical, circumstances in Uruk and Larsa—and which subsequently became the object of an administrative proceeding before the highest officials of Uruk?[9]

The simplest answer is, of course, that an eclipse was expected and the *kalû* priests began to perform the appropriate rituals after sunset, but the eclipse did not happen after all, thereby precipitating some controversy of sufficient gravity to prompt the recorded proceedings. What in fact seems to have happened is more complex. As we shall see the rituals were performed on the eve[10] of full moon in a month in which an eclipse would have been expected from the use of the Saros eclipse cycle (discussed below) as a predictive scheme for lunar eclipses. However, while eclipses observed in the 8th and 7th centuries fit the Saros cycle well, the actual eclipse record showed an increasing incidence of discrepancies with that cycle in the late 7th and 6th centuries, and this should have cast doubt on whether an eclipse might actually occur on the date recorded in our two depositions. Furthermore, the rituals were apparently performed at a time of day which seems unrelated to the time of full moon, which by itself should have implied that any eclipse would occur during daytime and thus appear to "pass by." Thus we are presented with a partially explicable event, whose full interpretation, however, is hampered by our ignorance of the complete ritual practice associated with eclipses. Nevertheless, the rituals themselves are evidence of the techniques used by 6th century B.C. scholars to predict eclipses, while the fact that they became the subject of depositions suggests that the limitations of these techniques were already becoming apparent by this time.

One of the most famous discoveries of ancient astronomers is the eclipse cycle known to us as the "Saros."[11] This cycle assumes that the moon returns to its original position relative to the nodes (the condition which governs eclipses) every 223 months. As it happens 223 months is also very nearly a whole number (239) of anomalistic months (in which the moon returns to its initial velocity), and roughly 11 days more than 18 years.[12] Consequently, one Saros cycle reflects approximate returns in lunar velocity and longitude as well as nodal elongation, a fact which made the Saros a convenient interval for investigating lunar visibility phenomena as well as eclipses, and which ultimately gave the Saros a central role in the development of the mathematical lunar theory known as System A.

These extended relationships—while important to the subsequent development of mathematical astronomy—have no bearing on the usefulness of the Saros as a simple period relationship for predicting eclipses, and need not have been known for this purpose. As an eclipse cycle the Saros implies simply that eclipses with the same magnitude and direction—qualities

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[9] Boissier was fully aware that no lunar or solar eclipse took place on the date in question, and he proposed therefore that the word *attalû* referred in this case to another astronomical or meteorological phenomenon. This seems unlikely, as the semantic range of *attalû* is limited mostly to eclipses of the moon and the sun. The implications of the two depositions for the history of astronomy have never been investigated since Boissier's publication of his text.

[10] Strictly speaking, at the beginning of the day of full moon, since the Babylonian day began at sunset.

[11] The use of the term "Saros" to denote the eclipse cycle of 223 months is a modern anachronism which originated with Edmund Halley [*Phil. Trans.* (1691) 535–40] and was propagated by Simon Newcomb, despite efforts to correct it. For an account of its history see O. Neugebauer [1957, 141–43] and *HAMA*, 497 n 2. The Babylonian name for this interval was simply "18 years."

[12] Accurately: $10.70^d = 10.42^d$ more than 18 sidereal years.

	(1)			(2)			(3)	(4)	(5)
							Time of	*Visibility*	
Saros	*Babylonian Date*			*Julian*			*Full Moon*	*in Babylon*	
Cycle	*King*	*Year*	*Month*	*Date*			*(BCT)*	*(BCT)*	*Magnitude*
0	Nabu-nasir	0	XII	-746	Feb	6	4;23	2.3 - 5.8	11.4
1	Ukin-zer (Pulu)	2	XII	-728	Feb	17	11;46	Daytime	(10.0)
2	Marduk-apla-iddin	10	XII	-710	Feb	27	19;00	17.1 - 20.3	8.9
3	Assur-nadin-sumi	6	XII	-692	Mar	10	2;04	0.2 - 3.3	8.3
4	Assur-aha-iddina	5	XII2	-674	Mar	21	8;58	Daytime	(6.7)
5	Samas-suma-ukin	11	I	-656	Mar	31	15;45	Daytime	(5.0)
6	Kandalanu	9	I	-638	Apr	11	22;24	21.4 - 23.5	3.7
7	Nabu-apla-usur	5	II	-620	Apr	22	4;57	4.4 - 6.1	2.1
8	Nabu-kudurra-usur	2	II	-602	May	3	11;26	None	-
9	" " "	20	II	-584	May	13	17;52	None	-
10	" " "	38	II	-566	May	25	0;18	None	-
11	Nabu-na'id	7	II	-548	Jun	4	6;44	None	-
12	Cyrus	8	III	-530	Jun	15	13;13	None	-

Figure 1.

which determined the astrological portent of an eclipse in Antiquity—should recur every 223 months, although at a given place some will occur during the day and thus not be visible. In fact, the position of the full moon recedes on average by roughly half a degree in 223 months, so the relationship implied in the Saros eclipse cycle is not quite exact.

The effect of this can be seen in Figure 1, which shows the application of the Saros cycle to the first lunar eclipse in the reign of Nabonassar (Nabû-nāṣir). The eclipse was observed in Babylon in month XII of the accession year of Nabonassar (-746 Feb 6), and its report, preserved in a text published as *LBAT* 1413 (= BM 41985), is the earliest observational record of a lunar eclipse that we possess. Beginning with this eclipse the table displays the following information. In column (1) are dates (years and months) in the Babylonian calendar at intervals of 223 months. In column (2) are the same dates in the Julian calendar. In column (3) are the times of full moon in hours and minutes reckoned from Babylonian midnight according to modern theory.[13] In column (4) are the durations of the lunar eclipses visible in Babylon, again in hours reckoned from Babylonian midnight.[14] Finally in column (5) are the (modern) magnitudes of each eclipse, those which were invisible in Babylon being shown between parentheses.

As can be seen from columns (4) and (5), the cycle works fine for a while, with daytime invisible eclipses alternating with observable eclipses as would be expected. Reflecting the inaccuracy of the eclipse cycle, however, the magnitudes drop steadily with each Saros, and eclipses disappear altogether after seven Saros cycles. For two, possibly three, cycles, this disappearance could have been ascribed to daytime eclipses, but by the next to last date in the table—month II in year 7 of Nabonidus—it would have been clear to ancient scholars that something was amiss.

The last date in the table is, of course, the subject of our depositions, and demonstrates what

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[13] From Goldstine [1973].

[14] The times of eclipse beginnings and endings and the magnitudes shown in column (5) are from P. V. Neugebauer [1934]. These are based on the same elements as are Goldstine's computations of the time of syzygies. The latter, however, omit certain terms in the moon's motion which can have a sensible effect on the times of syzygy. Thus, despite greater precision, Goldstine's tables are less accurate than P. V. Neugebauer's.

we have already described as their context. This is that the date in question was simply that of a possible eclipse derived from both the Saros cycle and the cumulative evidence, from the 8th and early 7th centuries, of a sequence of historical eclipses, which eclipses had, however, ceased to recur nearly a century earlier.

While it is not impossible that some other method was used to establish this date as a possible eclipse date, it is hard to imagine how this might have been done. The immediately preceding eclipse was 11 months earlier, which rules out the use of 6-month intervals to arrive at this date. Periods of 47 and 135 months, discussed below, can also be ruled out, since no visible eclipse at multiples of these intervals appears in the proximate historical record. Thus we can be reasonably certain that the date in question was derived from the Saros cycle.

To place this event in a broader context, it will be helpful to consider how lunar eclipses occur, and specifically the pattern of all lunar eclipses in the centuries from Nabonassar to the date in question.

Lunar eclipses occur at full moon whenever the moon is close enough to the sun's path to pass through the earth's shadow. Because the moon's orbit is inclined to the sun's, lunar eclipses only occur when the earth's shadow at full moon is within roughly 11° of one of the intersections of the orbits of the sun and moon.[15] We call these intersections "nodes"; the Babylonians called them *kiṣru*, a term whose meanings included the sense "eclipse possibility".[16]

On average the earth's shadow moves 30;40° per month relative to the nodes and therefore passes by a node every 5.87 months.[17] Since the monthly progress of the shadow relative to the nodes (30;40°) exceeds the interval around the nodes in which eclipses can occur (ca. 22°), lunar eclipses do not occur in successive months. Furthermore, if at full moon preceding the shadow's passage by a node, the shadow's distance from the node is between −11° and −19°, this distance will be between +19° and +11° at the next full moon, and no eclipse will take place at that nodal passage by the shadow. Thus it happens that only one lunar eclipse at most can occur each time the shadow passes by a node, while no eclipse can take place at some nodal passages.

It is convenient to identify each passage of the shadow by a node with a single month, and to consider such months "eclipse possibilities," even though eclipses do not occur at all of them. Such "eclipse possibilities" (properly chosen) will include all months in which lunar eclipses occur together with a small number (ca. 27%) at which no eclipse occurs.

Since the shadow passes a node every 5.87 months, most eclipse possibilities are separated by 6 months, but a small fraction (roughly 13%) are separated by 5 months. Thus every 7 or 8 eclipse possibilities, a 5-month interval replaces the normal 6-month interval. Typically, eclipses occur every 6 months for five or six eclipse possibilities followed by two eclipse possibilities at which no eclipse occurs. Thereafter, a new group begins with an eclipse which follows the preceding eclipse by one month less than a multiple of 6 months, thus requiring that the 5-month interval be placed among the empty eclipse possibilities.[18] The regularity of this pattern is apparently distorted by the fact that at any given place one third of all eclipses occur entirely during the day and thus are not seen. Nevertheless, to determine the dates of future eclipse possibilities it is in principle only necessary to find a repetitive

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[15] Specifically, within 11;10° ± 1° of a node, where the variation depends primarily on the moon's distance from the earth and thus is a function of lunar anomaly.

[16] Cf. BM 36754, a table of dates of solar eclipse possibilities arranged in 18 year cycles from at least -347 to -258, whose colophon reads *ki-ṣa-ri šá* [. . .] (Aaboe, Britton, Henderson, Neugebauer and Sachs, 1991, Text D, 25ff.). See also *ACT*, 479.

[17] More precisely (−600), every 5.868818. . = 5;52,7,44,45. . months, corresponding to an average motion of the sun and shadow relative to the nodes of 30;40,14,1, . .°/month.

[18] In theory, lunar eclipses separated by 5 months are possible, as demonstrated by Ptolemy (*Almagest*, VI, 6; cf. *HAMA*, 130ff.), who does not cite any examples. In fact there may well have been no lunar eclipses separated by 5 months visible at Babylon from the time of Nabonassar (−750) to Ptolemy (+150). A possible exception is the pair of eclipses: −375 Sep 8 and −374 Feb 3, but the visibility of both is doubtful.

scheme which distributes the 5-months intervals in conformity with the actual eclipse record.[19]

In practice there are only a few simple schemes for accomplishing this. The very simplest has one 5-month interval every 8 eclipse possibilities, resulting in a crude eclipse cycle comprising 47 months. In each cycle the earth's shadow advances, on average, 1;30° relative to the nodes, with the result that after only 3 cycles an eclipse occurs one month earlier than expected, and a 5-month interval appears after only 7 eclipse possibilities. A better cycle, which is also attested in later texts,[20] has three 5-month intervals distributed over 135 months comprising 23 eclipse possibilities. This cycle has an error of only 0;32° per cycle, so that an eclipse appears one month earlier than expected only after 8 cycles or roughly 90 years.

The next distinctive cycle is the Saros, which comprises 38 eclipse possibilities and five 5-month intervals. Its error of −0;28° per cycle is not appreciably less than that of the 135-month cycle, but accumulates over a longer period, so that the cycle begins to decay after roughly 150 rather than 90 years. More importantly, the direction of its error is such that eclipses "disappear" instead of occurring one month earlier than expected. As a result, it takes nearly 20 cycles or 350 years before eclipses begin to appear one month later than expected and the cycle thus visibly breaks down.

Although combining the Saros and the 135-month cycle yields a far better eclipse cycle with eight 5-month intervals,[21] we find no textual evidence for short-period eclipse cycles other than the three described above. Thus the Saros is the best of the simple schemes known to have been used in Babylon to predict eclipses.

If we distribute the 5-month intervals in a Saros as uniformly as possible, we obtain groups of 7 or 8 eclipse possibilities separated by 5-month intervals, where eclipse possibilities within each group occur at 6-month intervals.[22] If we then fix the pattern of these groups within a cycle and fit the resulting cycles to the historical eclipse record so that the 5-month intervals immediately precede the first eclipse of each group in some cycle, we obtain a distribution of eclipses and eclipse possibilities similar to Figure 2.

Here the dates of all eclipse possibilities from the beginning of the reign of Nabonassar are arranged in columns of 38, so that each column covers a single Saros, and dates in the same row (except in the last column) are always separated by some multiple of 223 months. Dates on which an eclipse was visible at Babylon are unshaded, while heavy shading indicates that no eclipse was visible at Babylon on that date. No distinction is made between eclipses which were invisible at Babylon and eclipse possibilities at which no eclipse took place. The location of 5-month intervals is indicated by horizontal rulings; elsewhere eclipse possibilities are separated by 6 months. The eclipse possibility which is the subject of our two depositions is highlighted in the square near the bottom right corner of the figure in SC 12 (SC = Saros cycle).

Figure 2 illustrates the shift in the bands of empty eclipse possibilities which results from the error in the Saros cycle. Typically, these consist of two eclipse possibilities where no eclipse occurs,[23] initially at the end of each group and thus ending with a 5-month interval. Slowly, however, these bands of empty eclipse possibilities drift "downwards," with the result that eclipses begin to disappear in the first eclipse possibility of some groups where formerly they

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[19] For discussions of empirical and arithmetical approaches to this problem see Britton [1989, 4–20] and Aaboe [1972].

[20] Aaboe [1972, 110–13], cites three instances of saw functions with a number period of 135 months, one of which is Babylonian (*ACT* 93 = BM 34075+). Britton [1989, 25ff.] shows that a function with this period underlies the earliest known function for eclipse magnitudes as well as the units for eclipse magnitudes which continued to be used in lunar System A. A related function is discussed in Aaboe, Britton, Henderson, Neugebauer, and Sachs [1991, 43–62 (Text L)].

[21] See Britton [1989, 4–13] for a general discussion of short- and long-period eclipse cycles and their possible derivations.

[22] Cf. Aaboe [1972, 114–15] and Britton [1989, 14–21].

[23] In figure 2 there are only two instances of visible eclipses separated by 11 months (and thus by only one empty eclipse possibility): SC 4, EP# 21 and 23; and SC 12, EP# 14 and 16.

LUNAR ECLIPSE POSSIBILITIES: -746 TO -508

	SC = 0 EP# 31 = 0 NBNSR -746:2/6		SC = 1 EP# 1 = 4 NBNSR -743:11/25		SC = 2 EP# 1 = 1 ULULA -725:12/6		SC = 3 EP# 1 = 2 SARG2 -707:12/16		SC = 4 EP# 1 = 3 MUSMK -689:12/28		SC = 5 EP# 1 = 9 ASHRD -670: 1/7		SC = 6 EP# 1 = 14 SSSUK -652: 1/18		SC = 7 EP# 1 = 12 KANDL -634: 1/29		SC = 8 EP# 1 = 8NBPLS -616: 2/19		SC = 9 EP# 1 = 5 NBKDR -598: 2/19		SC = 10 EP# 1 = 23 NBKDR -580: 3/ 2		SC = 11 EP# 1 = 41 NBKDR -562: 3/13		SC = 12 EP# 1 = 10 NBNID -544: 3/23		SC = 13 EP# 1 = 3 CAMBS -526: 4/4	
EP#	Yr	Mo	Yr	Mo	Yr	Mo	Yr	Mo	Yr	Mo	Yr	Mo	Yr	Mo	Yr	Mo	Yr	Mo	Yr	Mo	Yr	Mo	Yr	Mo	Yr	Mo	Yr	Mo
1			4	IX		IX		X		X		X		X		XI		XI		XI		XII		XII		XII	3**	I
2			5	III	2	III	3	III	4*?	IV	10	IV	15	IV	13*?	V	9	V	6	V	24	V	42*	VI	11	VI		VI2
3				IX		IX		IX	SANH2	X ?		X		X		XI		XI		XI		XI		XII		XII		XII
4			6**	III	3**	III	4	III	1	III	11**	IV	16	IV	14	IV	10**	V	7**	V	25	V	43	V	12*	VI	4	VI
5				VIII?		VIII?		IX		IX		IX		X		X		X		X		XI	AMLMK	XI		XII		XII
6			7	II	4	II	5*?	III	2	III	12	III	17**	IV	15	IV	11	IV	8	IV	26*	V	1	V	13	V	5*	VI
7				VIII		VIII	SANH1	IX ?		IX		IX		IX		X		X		X		XI		XI		XI		XII
8			8**	I	5	I	1	I	3**	II	13*	II	18	II	16**	III	12*	III	9**	III	27	III	2*	IV	14	IV	6	V
9				VI2?	MKAID	VII		VII		VII	SSSUK	VIII		VIII		VIII?		IX		VIII		IX	NLSUS	X		X		X
10				XII?	1**	I	2	I	4	I	1**	II	19	II	17	II	13	II	10	II	28*	III	1	III	15*	IV	7	IV
11			9	VI		VI2?	BELIB	VII		VII		VII		VIII		VIII		VIII		VIII		IX		IX		X		X
12				XII		XII	1**	I	5*	I	2 !?	I	20**	II	18	II	14	II	11*	II	29	II	2	III	16	III	8*	IV
13			10	VI	2	VI		VI2?		VII		VII	KANDL	VII		VIII		VIII		VIII		VIII		IX		IX		X
14				XII		XII		XII		XII2	3*	I	1	I	19**	II	15**	II	12	I	30	II	3*	III	17	III	1	III
15			11**	VI	3*?	VI	2	VI	6	VI		VII		VII		VII		VII		VII		VIII		IX	CYRUS	IX		IX
16				X ?		XI?		XI		XI		XII		XII		XII		XII		XII	31**	I	4	I	1	II	2	III
17			12	IV	4	IV	3*?	V	7	V	4	V	2*	VI	20	VI	16	VI	13	VI		VI2	NBNID	VII		VIII		VIII
18				X		X	ASNSM	XI		XI		XI		XII		XII		XII		XII		XII	1*	I	2**	II	3**	II
19			13**	IV	5	IV	1	IV	8**	V	5	V	3	V	21	VI	17	VI	14*	VI	32	VI		VII		VII		VII
20				IX ?		X		X	ASHRD	X		XI		XI		XII		XII		XII		XII		XII2	3*	I	4	I
21			14	III?	6*?	IV	2	IV	1	IV	6*	V	4	V	22**	VI	18**	VI	15	V	33*	VI	2	VI		VII		VII
22			NBNDZ	IX ?		X ?		X		X		XI		XI	NBPLS	XI		XI		XI		XII		XII		XII2	5*	I
23			1	II	7	II	3*?	III	2	III	7	III	5**	III	1	IV	19 !	IV	16	IV	34	IV	3*	V	4	V		VII
24				VIII		VIII		IX ?		IX		IX		IX		X		X		X		X		XI		XI		XII
25			2*?	II	8	II	4	II	3*	III	8	III	6	III	2*	IV	20*	IV	17*	IV	35	IV	4	IV	5	V	6	V
26			UKNZR	VIII?		VIII		VIII		IX		IX		IX		X		X		X		X		X		XI		XI
27			1	I	9*?	II	5	II	4	II	9**	III	7	III	3	III	21	III	18	III	36*	IV	5	IV	6*	V	7	V
28				VII		VIII?		VIII		VIII		VIII		IX		IX	NBKDR	IX		IX		X		X		XI		XI
29			2	I	10	I	6*?	II	5*	II	10	II	8*	III	4	III	1	III	19	III	37	III	6*	IV	7	IV	8*	V
30	NBNSR			VII		VII		VIII?		VIII		VIII		IX		IX		IX		IX		IX		X		X		XI
31	0	XII	2	XII		XII	NLUSZ	XII		XII2	11*	I	9	I	5**	II	2**	II	20	II	38	II	7	II	$\boxed{8}$	III	9	IV
32	1**	VI	3**	VI	11	VI	1	VI	6	VI		VII		VII		VII		VII		VIII		VIII		VIII		IX		IX
33		IX	PULU	XI ?		XII	MUSMK	XII		XII		XII2	10*	I	6	I	3	I	21**	II	39	II	8	II	9**	III	10	III
34	2	V	1	V	12**	VI	1	VI	7	VI	12	VI		VII		VII		VII		VII		VIII		VIII	CAMBS	VIII		IX
35		XI		XI	SARG2	XI ?		XII		XII		XII		XII2	7*	I	4	I	22	I	40	II	9	II	1	II	11**	III
36	3**	V	2*?	V	1	V	2**	VI	8*	VI	13	VI	11	VI		VII		VII		VII		VIII		VIII		VIII		IX
37		X	ULULA	XI ?		XI		XI ?		XII		XII		XII		XII2	5**	I	23*	I	41**	II	10**	II	2	II	12	II
38	4	IV	1	IV	2*?	V	3	V	9	V	14*	VI	12	VI	8	VI		VI2		VII		VII		VII		VIII		VIII

☐ Eclipse visible at Babylon

▨ No Eclipse visible at Babylon

☐ Eclipse possibly visible at Babylon

Figure 2

had appeared with only intermittent interruptions for daytime eclipses. This first occurs in the fourth group in our table, where eclipses disappear in line (EP#) 23 beginning in SC 5. Subsequently, eclipses disappear at the beginnings of the second and fifth groups (EP# 8 and 31) beginning in SC 8.

Similarly, eclipses also begin to appear towards the end of groups at eclipse possibilities which hitherto had been empty. This happens in the third group (EP# 21) in SC 4, in the first group (EP# 6) in SC 5, in the fourth group (EP# 29) in SC 11, and in the second and fifth groups in SC 12. Thus by the date of our texts, considerable evidence would have accumulated that the pattern of eclipses expected from the Saros cycle was changing in the vicinity of all group boundaries except that shown with double scoring which defines the cycles in Figure 2.

The scheme shown in Figure 2 is very nearly identical to a scheme, found in later texts and most prominently in the so-called "Saros Canon," which is attested for at least 14 Saros cycles beginning in −490 (SC 15) and ending in −238 (SC 28).[24] This scheme begins and ends with the same eclipse possibilities as that shown in Figure 2, but the other 5-month intervals are all shifted downwards by one row. This structure is shown in SC 13 in Figure 2, which is the earliest cycle for which it fits the actual eclipse record.[25] It is reflected in at least one astronomical text composed probably in the second half of the 5th century,[26] which suggests that it was introduced at some time in the century following the date of our depositions.

In sum it seems certain that the Saros cycle was known to the Babylonians and used to predict the dates of possible eclipses by at least the middle of the 6th century B.C. and most probably long before that.[27] Indeed, it seems quite possible that a scheme similar to that shown in Figure 2 was already used for that purpose, although perhaps starting with the group we have placed last in Figure 2 to facilitate comparison with the "reformed Saros" from later texts.[28]

Whatever the case, it is evident that the rituals described in our depositions were performed on a day designated as an eclipse possibility by the Saros cycle and the accumulated evidence from several earlier eclipses. At the same time the "disappearance" of this line of eclipses several cycles earlier must have raised doubts as to whether an eclipse would actually occur. Since full moon took place at midday nearly 18 hours after the events described, it also seems unlikely that the rituals were performed at the time of an expected eclipse,[29] which supports the assumption that an eclipse was considered possible, yet improbable.

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[24] These texts are published and discussed in Aaboe, Britton, Henderson, Neugebauer, and Sachs [1991, 4–33], where it is noted (p. 14) that this scheme may have extended two cycles earlier to −526.

[25] The later scheme is inconsistent with the eclipse in month II of the 1st year of Cyrus as well as earlier eclipses in EP# 6.

[26] "Text S" (BM 36599+ and 36737+): originally published by Aaboe and Sachs [1969]. An additional fragment (BM 36580) is published in Aaboe, Britton, Henderson, Neugebauer, and Sachs [1991], and the entire text with revisions is discussed in Britton [1989, (esp. 29ff.)].

[27] Parpola [*LAS* 2, 51] notes that Assyrian scholars of the early 7th century B.C. "certainly had recognized the 47-month eclipse period and probably also the 18-year 'Saros'." In general Assyrian scholars appear to have predicted large lunar eclipses with confidence; partial lunar eclipses as possibilities to be watched for; and solar eclipses as possibilities at the beginning or end of a month in which a lunar eclipse was possible.

[28] This possibility is (mildly) supported by evidence from both earlier and later observational reports, which reflect a distribution of 5-month intervals which is identical to that shown in Figure 2 for cycles SC 0 to SC 12. Cf. Aaboe, Britton, Henderson, Neugebauer, and Sachs [1991, 20].

[29] While we do not know the precision with which the times of syzygies could be calculated at this time, evidence from 7th century Assyria reflects confident predictions that eclipses would pass by (*LAS* 42), as well as predictions of the watch in which an eclipse would occur (*LAS* 63). Thus it is reasonable to assume that Babylonian scholars of the 6th century should have been able to determine that full moon would occur during the daytime in this instance.