78) Dating the death of Xerxes — Traditionally, it is assumed that Xerxes died in the year 465 BC. Recently, Gérard Gertoux (2018) has argued for a 10 years higher date. As explained in his abstract, he bases that date primarily on the Babylonian eclipse text BM 32234. Unfortunately, as I shall show in the following, a more careful scrutiny of that text does not support the higher date. On the contrary, it flatly contradicts it!

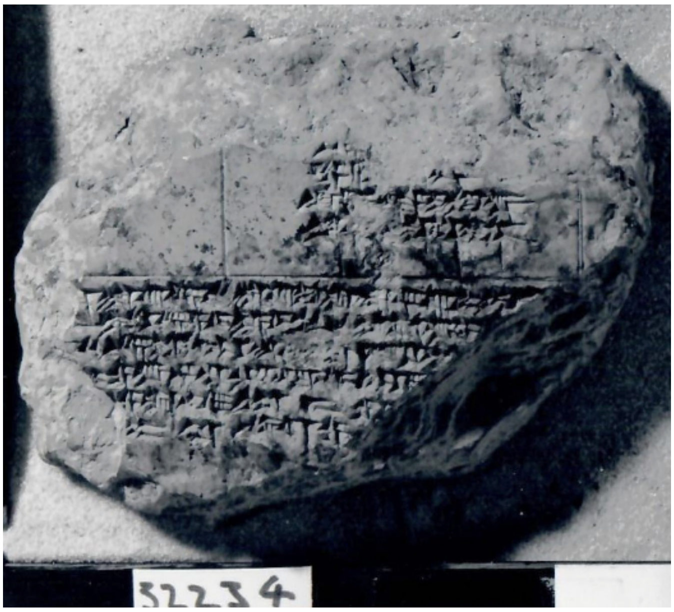

Figure 1. Reverse of BM 32234.

The text BM 32234 in question is a fragment of large collection of eclipse observations. That collection is organized as a kind of spreadsheet: each cell contains one eclipse description, and the cells follow a Saros arrangement: if you move one cell down, you reach the next eclipse possibility 5 or 6 months later, if you move one cell to the right, you reach an eclipse possibility 18 years later. For a photo of the text, see Fig.1; see also Hunger (2001) Vol V, Plate 2.

The reverse of BM 32234 covers parts of five columns and two rows of the spreadsheet. The report in col. IV top mentions the death of Xerxes. If we accept the traditional date, the reports cover the years

–518MAY04 5965 + +	–500MAY15 6188 – –	–482MAY26 6411 – –	–464JUN05 6634 + +	–446JUN17 6857 – –
–518OCT28 5971 – +	–500NOV07 6194 + +	–482NOV19 6417 + –	–464NOV29 6640 – +	–446DEC10 6863 + +

Each cell of this little table gives the date in the Julian calendar and the Goldstine (1973) syzygy number. The + and - signs indicate whether the beginning and end of the eclipse, respectively, were above (+) or below () the horizon; if those positions are left blank, there was no eclipse at all. These tables are extracted from Huber and DeMeis (2004: 4).

With Gertoux's higher date, they cover the years

–528MAY24 5842 – –	–510JUN04 6065 – –	–492JUN14 6288 + +	–474JUN26 6511 + –	–456JUL06 6734 – –
–528NOV17 5848 + +	–510NOV29 6071 + –	–492DEC09 6294 – –	–474DEC20 6517 + +	–456DEC31 6740 + –

Results of calculation for the 10 eclipses listed above
The results are excerpted from the eclipse canon of Huber and DeMeis (2004: 188-191).
First, for the traditional date:

Babyl.Date	Jul.Date	UT	LT-UT	LL	I	II	III	IV	Magn	E	A	MR	SS	SR	MS
DARI1 3U II	–518MAY04	21.90	3.06	217.2	23.21	.37	1.62	2.78	1.37	88	299	18.30	18.71	5.28	5.53
DARI1 3U VII	–518OCT28	12.50	3.16	29.5	13.66*	14.90*	16.39*	17.63	1.48	85	245	17.52	17.60	6.41	7.09
DARI1 21 II	–500MAY15	5.39	3.09	227.7	6.77*	8.02*	9.02*	10.26*	1.23	81	300	18.09	18.86	5.13	5.11
DARI1 21 VIII	–500NOV07	20.69	3.16	40.6	21.87	23.11	.59	1.83	1.47	88	247	17.12	17.44	6.57	6.96
XERXS 3 II	–482MAY26	12.85	3.10	238.1	14.31*	15.74*	16.28*	17.71*	1.09	74	301	19.04	19.00	4.99	5.62
XERXS 3 VIII	–482NOV19	4.96	3.14	51.8	6.12	7.36*	8.83*	10.07*	1.47	91	250	16.72	17.29	6.72	6.80
XERXS 21U III	–464JUN05	20.29	3.09	248.5	21.81	—	—	1.08	.95	65	302	18.80	19.10	4.90	5.23
XERXS 21U VIII	–464NOV29	13.27	3.09	63.0	14.39*	15.62*	17.09*	18.32	1.47	95	254	17.04	17.16	6.85	7.53
ARTX1 18 III	–446JUN17	3.73	3.06	259.0	5.32*	—	—	8.44*	.81	56	302	18.54	19.17	4.83	4.84
ARTX1 18 IX	–446DEC10	21.59	3.01	74.2	22.63	23.87	1.33	2.56	1.46	100	258	16.66	17.07	6.93	7.31

Now, for Gertoux's higher date.

Babyl.Date	Jul.Date	UT	LT-UT	LL	I	II	III	IV	Magn	E	A	MR	SS	SR	MS
CAMBS 1 II	–528MAY24	4.68	3.10	236.0	5.90*	7.06*	8.37*	9.54*	1.39	95	304	18.21	18.97	5.03	5.05
CAMBS 1 VIII	–528NOV17	18.65	3.14	50.6	20.08	—	—	23.19	.58	109	208	17.03	17.30	6.71	7.21
DARI1 11U III	–510JUN04	12.04	3.09	246.4	13.23*	14.34*	15.80*	16.92*	1.54	96	296	19.16	19.09	4.91	5.50
DARI1 11U VIII	–510NOV29	2.79	3.09	61.8	4.17	—	—	7.29*	.59	113	212	16.70	17.18	6.83	7.03
DARI1 29A III	–492JUN14	19.42	3.07	256.8	20.59	21.68	23.23	.31	1.68	95	287	18.87	19.16	4.84	5.20
DARI1 29A IX	–492DEC09	10.90	3.02	72.9	12.21*	—	—	15.34*	.60	117	217	16.99	17.08	6.93	7.75
XERXS 11 III	–474JUN26	2.87	3.03	267.3	4.01	5.07*	6.67*	7.74*	1.81	95	279	18.54	19.19	4.81	4.89
XERXS 11 IX	–474DEC20	18.98	2.93	84.1	20.20	—	—	23.36	.61	121	222	16.71	17.03	6.97	7.48
ARTX1 8A IV	–456JUL06	10.39	2.99	277.8	11.51*	12.57*	14.17*	15.23*	1.84	94	271	19.31	19.18	4.82	5.63
ARTX1 8A X	–456DEC31	2.98	2.85	95.3	4.08	—	—	7.27*	.63	125	228	16.45	17.02	6.97	7.19

The Julian Date and Universal Time (UT) are given for mid-eclipse. LT-UT is the difference between true local time LT and UT. LL is the geocentric lunar longitude at mid-eclipse. The true local times of the four contacts are starred if below the mathematical horizon (for accurate visibility conditions, use MR and MS). E and A: entrance and exit angles in degrees (0° north, 90° east, 180° south, 270° west), calculated in the equatorial coordinate system. MR, SS, SR, MS: true local times of moonrise, sunset, sunrise, and moonset. They have been calculated for the upper rim of Sun and Moon, i.e. using a zenith distance of 91°12′ for the Sun, plus parallax for the Moon.

Comparison of the observations with calculation
The transliterations and translations have been culled from Huber and DeMeis (2004); occasionally I have substituted somewhat clearer translations by Hunger (2001) Vol. V. See there for details. Note that observed Babylonian time intervals are not very accurate, they may have errors of 20% or so.

The calculated beginnings and endings of the eclipses have a standard error of about 3 minutes due to the uncertainty in ΔT, see Huber and DeMeis (2004: 26). This is in addition to a systematic error of a similar size due to uncertainties in our modeling of the Babylonian visual observations, see Huber and DeMeis (2004: 23).

Rev I top
Only traces of the tablet surface and nothing of the text are preserved.

Rev I bottom

1′. [... ... g]e₆? *ana*?	[... ...] ...
2′. [... ...] pap?	[... ...] watched (?)
3′. [... ana š]ú? *šamáš*	[... before] sunset (?)
4′. [*ki* pap nu] igi?	[when watched, not] seen (?)
5′. [... ...]	[... ...]

Apparently, the Babylonian watched out for the eclipse, but it is not clear what, or whether anything at all, he was able to see.

Calculation for low chronology (–518OCT28):
The upper rim of the moon began to rise 17.52 LT, 0.11h = 7 min before the end of the eclipse (17.63 LT).

Calculation for high chronology (–528NOV17):
Partial eclipse, above the horizon from beginning to end.

The eclipse record suggests marginal visibility conditions. This agrees better with the low chronology.

Rev II top
Blank cell; the first few lines are broken off. Presumably, the missing lines contained merely the date and a brief remark that the eclipse "passed".

Calculation gives for both the low (–500MAY15) and the high chronology (–510JUN04) an invisible eclipse below the horizon.

Rev II bottom

1.	apin 13 *ina* 15 *ina* kur	Month VIII, 13. In 15° (from) in the east,
2.	*gab* šú 25 ír	totally covered. 25° duration of the maximal phase.
3.	*ina* 25 ta kur *ana* mar	In 25° from east to west
4.	zalág dir *ina* gar si	it became bright. Clouded (or red?). During onset, north (wind),
5.	[*ina*] zalág ulù <gin> *ina* 1$^{?}$,17	during clearing south(wind) blew. At 1(?),17°
6.	ge$_6$ gin	after sunset.

Calculation for low chronology (–500NOV07):
The eclipse was total, and above the horizon from beginning to end. The timings agree reasonably well with calculation (observed 15°+25°+25°=65°, calculated 19°+22°+19°=60°). The Babylonian timings are given in time degrees: 1° = 4 minutes. Also the time of the beginning (77°?=5.13h? **after sunset**) is compatible with calculation (4.43h=66°).

Calculation for high chronology (–510NOV29):
The eclipse was partial, beginning 2.66h=40° **before sunrise**, and the moon set eclipsed.

The high chronology is incompatible with the observation.

Rev III top
Blank cell; the first few lines are broken off. Presumably, the missing lines contained merely the date and a brief remark that the eclipse "passed".

Calculation for low chronology (–482MAY26):
The eclipse was below the horizon and invisible.

Calculation for high chronology (–492JUN14):
The eclipse was total and above the horizon of Babylon from beginning to end.

The high chronology is incompatible with the observation.

Rev III bottom

1.	apin 13 *id* ulù	Month VIII 13. Beginning on the south (error for east) side.
2.	tab ír nu pap$^{?}$ *ád*	Maximal phase not observed, it set
3.	šú *ina* an-mi ⸢*dele-bat*⸣ gub	eclipsed. During the eclipse, Venus stood (there),
4.	tag$_4$ ^{d}udu-idim-me	the other planets
5.	nu gub-me	did not stand (there).
6.	*ina* 10 uš *ana* zalág	At 10° before sunrise

Calculation for low chronology (–482NOV19):
The eclipse began 0.60h = 9° before sunrise and 0.68h = 10° before moonset, and the moon set before the beginning of totality. Venus was the only planet above the horizon.

Calculation for high chronology (–492DEC09):
The eclipse was below the horizon and invisible.

The high chronology is incompatible with the observation.

Rev IV top

1′.	[... ...]	[... ...]
2′.	*ina* 18$^?$ [... ...]	In 18°(?) [it became bright.]
3′.	40 gar í[r *u* zalág ...] túg an gar	40° onset, m[aximal phase and clearing.] The ‘garment of the sky’ was in place.
4′.	*ina* ki 4-àm *ár šá* pa *ád* kin dir	In the region of the 4 rear stars of Sagittarius it was eclipsed. Month VI$_2$.
5′.	izi 14[+x] *hi*$^?$*-ši*$^?$*-ár-šú* dumu-*šú* gaz-*šú*	Month V 14[+x] Xerxes was murdered by his son.

The text spills over into the blank parts of Rev III top and Rev V top. The eclipse is described as lasting 40° = 2.67h from beginning to end.

Calculation for low chronology (–464JUN05):
Large partial eclipse, above the horizon from beginning to end, lasting 3.27h = 49°. According to Roughton and Canzoneri (1992), the “4 rear stars” are ν1, ν2, ξ1, ξ2 Sagittarii; for –464 the coordinates of ν2 were long: 248.41, lat: 0.48. The lunar longitude at mid-eclipse was LL=248.5.

Calculation for high chronology (–474JUN26):
The moon set 0.88h = 13° after the first contact, before the beginning of totality. A duration of 40° does not fit, nor does the position of the moon (LL=267.3).

The high chronology is incompatible with the observation.

Rev IV bottom

1.	apin 14 13 ge$_6$	Month VIII 14. (After) 13° night
2.	gin ta dir e	it came out from a cloud.
3.	4-*ú* hab-*rat i*[*d* si$^?$]	A quarter of the disk [on the north(?)]
4.	*u* mar šú 7 (? or 8?) [...]	and west side was covered. 7°(? or 8°?) [until it became]
5.	zalág [... ...]	bright. [... ...]
6.	[... ...]	[... ...]

Only the final phase of this eclipse could be observed; apparently, it ended about 20° or 21° after sunset.

Calculation for low chronology (–464NOV29):
The moon rose shortly before the end of totality, and the eclipse ended 1.16h = 17° after sunset.

Calculation for high chronology (–474JUN26):
The eclipse began more than 3 hours after sunset and ended more than 5 hours after sunset.

The high chronology is incompatible with the observation.

Rev V top
No text preserved, probably blank. An eclipse that “passes”?

Calculation gives for both the low (–446JUN17) and the high chronology (–456JUL06) an invisible eclipse below the horizon.

Rev V bottom

1.	gan 13(+x) [...]	Month IX 13(+x) [...]
2.	[... ...]	[... ...]

Not enough text for interpretation.

Conclusions
All eclipse observations of BM 32234 Rev. are compatible with calculations for the low chronology (death of Xerxes in 465 BC). But at least five of them flatly contradict the calculations for Gertoux’s higher chronology.

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