Mediterranean Archaeology and Archaeometry, Vol. 8, No. 2, pp. 55-64

THE GAUGAMELA BATTLE ECLIPSE: AN ARCHAEOASTRONOMICAL ANALYSIS

V. F. Polcaro*[1], G.B. Valsecchi[1], L. Verderame[2]

[1]INAF, Istituto di Astrofisica Spaziale e Fisica Cosmica-Roma,V. del Fosso del Covaliere 100, 00133 Rome, Italy (vitofrancesco.polcaro@iasf-roma.inaf.it)

[2]Università di Palermo, Facoltà di Lettere e Filosofia, Palermo and University of Rome 'Sapienza', Italy

** to Whom all correspondence should be addressed*

Received: 9/6/2008
Accepted: 17/6/2008

ABSTRACT

A total lunar eclipse occurred during the night preceding the decisive Battle of Gaugamela (20th September 331 BCE), when the Macedonian army, led by Alexander the Great, finally defeated the Persian king Darius and his army. This astronomical event, well known to historians, had a relevant role on the battle outcome. The eclipse was described in detail by Babylonian astronomers, though, unfortunately, the text of their report has only partially been preserved. We have reconstructed the evolution of the phenomenon as it appeared to the observer in Babylonia, by using the positional astronomy code "Planetario V2.0". On the base of this reconstruction we suggest a number of integrations to the lost part of the text, allowing a finer astrological interpretation of the eclipse and of its influence on the mood of the armies that set against each other on the following morning.

KEYWORDS: Alexander the Great, Archaeoastronomy, Astronomical Diaries, Moon eclipses

INTRODUCTION

The sky and the movement of the celestial bodies have been observed since the very beginning of civilization, and the various attempts of interpretation of these phenomena have strongly contributed to the development of human knowledge (Walker, 1996; Verderame, 2008). Archaeoastronomy is the science devoted to the study of the astronomical observations before the invention of the telescope in the 16th Century. It is an interdisciplinary science, which requires the combined skills of astronomers, archaeologists, linguists, anthropologists and architects.

Archaeoastronomy can give strong contributions to all these disciplines. Notably, the documented coincidence with identified astonishing astronomical events (such as eclipses, transits of periodical comets, etc.) is a powerful way to date historical events[1]. On the other hand, the comparison between the physical reconstruction of such phenomena, based on modern positional astronomy codes, with their interpretation in a given cultural framework can give a deeper insight into the "world vision" of the observers.

THE BABYLONIAN "ASTRONOMICAL DIARIES"

In this context, an extremely important role is played by the Babylonian *Astronomical Diaries* (Sachs, 1948, 1974; Hunger & Sachs, 1988; Rochberg-Halton, 1991; Hunger & Pingree, 1999; Brown, 2000). These are cuneiform clay tablets, which record daily celestial observations and other exceptional events. These observations were performed by specialized personnel of the Esangila, the Marduk temple in Babylonia, whose duty was also that of draw up almanacs and astronomical tables (Hunger & Sachs, 1988: 11-12).

The Babylonian day starts at sunset (Verderame, 2008), therefore nightly phenomena (such as weather conditions, lunar and planetary phenomena) are reported first, then the diurnal atmospheric phenomena are registered. At the end, "prices" (i.e. the equivalent of a silver *siclum* for commonly used goods), the level of Tigris river, and local or historical events, if any, are reported.

The *Diaries* usually cover a six-month period but are based on shorter term (from a few days to a month) observations, called *Short Diaries*. In some cases, these one were noted down on wax tablets (Hunger & Pingree, 1999: 142; MacGinnis, 2002).

The most ancient known *Diary* is dated to 651 BCE; however, we know that similar observations were registered in more ancient periods too. Records dated to the 8th Century BCE confirm the information given by Ptolemy in the *Almagest* that all eclipses were regularly recorded starting from the reign of king Nabonassar (747-734 BCE). The most recent *Diary* is dated to 60 BCE (Sachs, 1976).

The *Diaries,* in association with historical and astronomical data, are

[1] For an outline of the Mesopotamian chronology and astronomy see the bibliography at the site *http://www.phys.uu.nl/~vgent/babylon /babybibl.htm*

primary sources for dating precisely crucial events as well as reconstructing chronologies, specially for the Seleucid period (Sachs, 1948; Stolper, 1988; Geller, 1990, 1991; Gera & Horowitz, 1997; Wheatley, 2002), not limited at the Mesopotamian area (Foster & Ritner, 1996). The importance of these sources was perceived at the beginning of the assyriological discipline, when first scholars devoted part of their efforts to the study of these documents (Hunger & Pingree, 1999: 140-141). However, the same Babylonians used already these documents for their historical value, if we assume the hypothesis that the *Diaries* are also the main source of the Neo-Babylonian Chronicles, as it has been proposed recently (Gerber, 2000).

THE ECLIPSE OF THE 20TH SEPTEMBER 331 BCE

The *Astronomical Diary* under investigation in the present paper is composed by two fragments kept in the British Museum (BM 36761 + 36390). In the preserved parts of the text are registered the astronomical and meteorological phenomena of the months VI (Ulūl) and VII (Tašrīt) of the Babylonian calendar (corresponding to August-September and September-October)[2]; at the end of each section the prices of different goods, the position of the planets, and historical facts are recorded.

The text has been known for a long time due[3] mainly to the description of the Moon eclipse of the 20th September 331 BCE night (13/VI of the Babylonian calendar):

1') [....] 2') [....] The 13th, moonset to sunrise : 8° [....] 3') [.... lunar] eclipse, in its totality covered. 10° night [totality? ...] (broken) Jupiter set; Saturn [....] 4') [....] during totality the west wind blew, during clearing the east wind [....] fourth? .... ; during the eclipse, deaths and plague? [occurred?] in [....] (Hunger & Sachs, 1988: 177)

We are obviously dealing with the famous total Moon eclipse of the night between the 20th and the 21st September 331 BCE, reported by classic authors in a number of texts (Curtius Rufus, Arrianus), and that preceded[4] the decisive battle between the army of Alexander the Great and that of Darius at Gaugamela, ratifying the end of the Persian Empire and the beginning of the Hellenistic period.

Assuming the geographical coordinates of the observing site (Babylonia) as 44:30 E, 32:30 N and using the Positional Astronomy Code "Planetario" V2.0 (Massimino, 1999), the duration of the total phase of this eclipse turns out to be 1 h 03 m: it is

[2] The names of the months are never preserved in the text, and the date is reconstructed thanks to the historical and astronomical data, for which see F.R. Stephenson *apud* Hunger & Sachs (1988: 179).

[3] The earliest reference to this text is found in a review article by Lehmann in *Zeitschrift für Assyriologie* (1900), p. 128 fn. 1; subsequently Sachs (1955: xiii no. 196), Wiseman (1985: 117-121), Brinkman (1987: 34), Hunger & Sachs (1988: 176-179 no. -330 tav. 29), Del Monte (1976: 1-6).

[4] For the problem of the eclipse date in relation to the battle in the different sources, see below.

thus considerably longer than the one reported by the tablet (10 degrees = 40 minutes). On the other hand, the data reported for this eclipse on the Goddard Space Flight Center data base[5] is essentially coincident with the one we have computed. A time difference in the order of magnitude found, if interpreted as a real one, would imply a difference between the actual Earth – Moon distance and the one evaluated by current models, which is difficult to believe considering the present day status of our knowledge of the Earth – Moon system dynamics.

It is well known that time intervals reported by the *Diaries* are often affected by large approximations, due to the low precision of time measurement devices (Verderame, 2008: fn. 85), and to the low relevance precision had for astrological forecasting, the basic purpose of the observations (Neugebauer, 1975: 545; Hunger & Sachs, 1988: 16). However, these approximations are greater close to sunrise and sunset, when only a few brilliant stars are available for time interval determination by means of astronomical measurements (Neugebauer, 1975: 545), while, in this case, the eclipse happened nearly two hours after the sunset and thus in full astronomical darkness.

The difference between the recorded length of the total phase and the one computed by using present day models should not thus be neglected or simply attributed to an "error". Perhaps, it could be explained by the criteria used by Babylonian astronomers to define the "total phase", that can be different by the one used by modern Astronomy.

[5] *http://planets.gsfc.nasa.gov/eclipses/eclipses.htm*

THE MESOPOTAMIAN OBSERVATION OF THE MOON

According to the Mesopotamian astrological theory, a series of variables influencing the interpretation of the eclipse were observed, registered, and analyzed. These were the date (day, month), the eclipsed area of the Moon and direction of the shadow according to the four cardinal points, the wind blowing or the presence of a planet during the eclipse (Parpola, 1982: 406-408; Rochberg-Halton, 1988: Chap. 4).

The Moon was divided into four quadrants each identified with one of the four quarters of the world, in correspondence with heaven and earth (Parpola, 1982: 406):[6]

-South = Gutium/Subartu (Northern Iraq, Kurdistan and Zagros). .

[6] The one exposed was the basic identification: the interpretative schemas relating all the variables listed above were, indeed, really complex. Furthermore, regularity, and what we could call "logic" as the relation between the variables, is not always satisfying as we might expect (Verderame, 2002 and 2004). Besides, the theory relates geo-political entities that vary in time; this means a continuous updating of the correspondence between the changing earthly and the costant heaven regions, vd. Rochberg-Halton (1983: 53-54): in the case here discussed the term "Gutium", a Third Millennium political entity, is used to denominate the north-east region of Mesopotamia.

-North = Amurru (Syrian Desert).
-East = Akkad/Babilonia (Southern Iraq).
- West = Elam (Susiana/Iran)

This theory gives us a first hint to explain the concept of totality of the eclipse, as confirmed by Munnabitu, author of the astrological report to the Neo-Assirian king Assurbanipal, where the meaning of the 22nd May 678 BCE total eclipse is explained (Parpola, 1982: 406; Hunger, 1992: 178 no. 316):

"The evil of an eclipse affects the one identified by the month, the one identified by the day, the one identified by the watch, the one identified by the beginning, where (the eclipse) begins and where the moon pulls off its eclipse and drops it; the (people) receive its evil. Sivan (III) means Westland, and a decision for Ur. The evil of the 14th day, as is said, the 14th means Elam. The beginning, where (the eclipse) began, we do not know. (The moon) pulled the amount of its eclipse to the south and west; that is evil for Elam and the Westland. That it became clear from the east and north, is good for Subartu and Akkad. That it covered all of (the moon), is a sign for all lands. The right side of the moon means Akkad, the left side of the moon means Elam, the upper part of the [moon means the Westl]and, the lower part of the moon means Subartu ... In the eclipse [of the moon] Jupiter stood there: well-being for the king".

POSSIBLE INTEGRATION

We are presently analyzing the other total Moon eclipses reported by the *Diaries*, in order to evaluate possible further discrepancies between the recorded and computed durations of the total phase and their possible meaning.

Last, it is interesting to notice that the "Planetario" V2.0 code allows us to complete in two points the missing part of the text. Actually, as it can be seen in the related reconstruction reported in Fig.1 (where the white disk represents the full Moon and planets are sketched as they appear in a small telescope), corresponding to the time of starting of the eclipse total phase

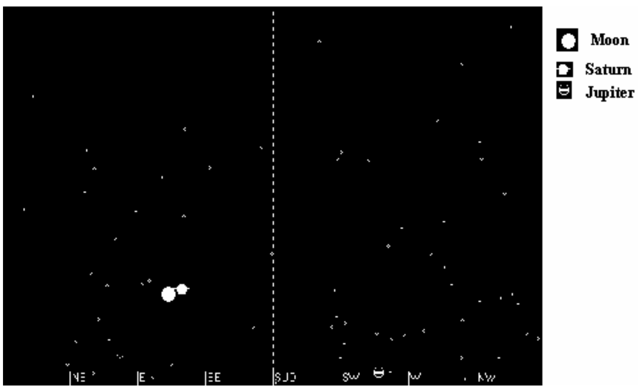

Fig. 1: The sky over Babylonia at the beginning of the total phase of the eclipse of 20th September 331 BCE.

Saturn [...]

should be read as:

Saturn [was in conjunction with the Moon] (or [was very near to the Moon] or any equivalent expression).

and

[...] Jupiter was set

should be read as

[The total phase started immediately after] Jupiter was set

DISCUSSION

The last point is of the highest historical interest, since it allows better understanding of the behavior of the two main characters of the Gaugamela battle.

The classical historical texts refer that the Macedonian army was quite impressed by the eclipse, considered in all cultures as an upset of the natural order, while Alexander deeply slept all the night preceding the battle. It is highly probable that the same Macedonian king had circulated this anecdote, in order to make his army confident that he was not concerned at all by the nightly astronomical event.

However, the mood of Darius must have been quite different. We actually saw how Munnabitu reassured his king specifying that, during the eclipse, Jupiter was clearly visible. The reason can be deduced from table XVII of the astrological series *Enūma Anu Enlil*, whose last editing is dated to the beginning of the First Millennium, though the first version was probably written down in the 18th Century BCE (Rochberg-Halton, 1988: 19). This text reports the following omen:

DIŠ *ina* ITI.KIN UD.14.KÁM AN.MI GAR HI.GAR *ana* LUGAL GÁL ÉRIN DAGAL ŠUB

"If, in the month of Ulūl (August-September), on the day 14, an eclipse happens: rebellion against the king, a great army will fall" (Rochberg-Halton, 1988: 133 §VI.6)

Even clearer is a Seleucid tablet coming from Uruk (Rochberg-Halton, 1987), sharply stating:

"The Moon or the Sun are eclipsed (and) Jupiter is faint: end of a kingdom. The Moon or the Sun are eclipsed and Jupiter is not present: end of a kingdom"

It was impossible for Darius not to be aware of this astrological meaning of the eclipse that preceded the battle: when Alexander's javelin hit and overthrew the driver of his chariot, the Persian king felt that his kingdom was ended and escaped, creating confusion, so the defeat of his army turned into real the destiny he was fearing most. The *Astronomical Diary* here discussed describes in the following manner the effects of the eclipse over Darius' army:

14') That month, on the 11th, panic occurred in the camp before the king [....] 15') lay? opposite the king. On the 24th, in the morning, the king of the world [....] the standard? [....] 16') [.... lunar] eclipse, in its totality covered. 10° night [totality? ...] (broken) Jupiter set; Saturn [....] 4' [....] during totality the west wind blew, during clearing the east wind [....] fourth? .... ; during the eclipse, deaths and plague? [occurred?] in [....]

(Hunger & Sachs, 1988: 179)

We must notice the discrepancy between the date of the eclipse (13) and that of the battle (24) provided by the *Diary* and the classical sources. The question is out of our competence area (Bernard, 1990; Del Monte, 1997: 1-6), but we can underline that the *Astronomical Diary* here analyzed has been written after the events, as the expression "broken" (*hepi*) in l. 3' (see above) suggests: the scribe redacted the monthly *Diary* collecting the data from older tablets which in some passages were no longer readable. Because of this, we could assume that a period of time existed between the observation and registration of the astronomical data (daily) and the successive historical resume, written after the entrance of Alexander in Babylonia and the conciliatory policy of the Macedonian king toward the southern Mesopotamian cities and temples, as the same *Diary* registers:

Rev. 3') That month from the 1st to [....] 4') came to Babylon saying: "Esangila [...."] 5') and the Babylonians for the property of Esangila [....] 6') On the 11th, in Sippar an order of Al[exander ....] 7') ["....] I shall not enter your houses". On the 13th, [....]

....

11') [....] Alexander, king of the world, [came in]to Babylon [....]

(Hunger & Sachs, 1988: 179)

We are dealing, of course, with a description of the events *a posteriori*[7]. The same *omen* - and the events it causes, that seal the victory of Alexander, seems to be used to fashion the image of the hero[8]. The classic literature is full of literary τόποι connected to omens announcing the arrival of the "new man", an usurper (such as Sargon of Akkad, Cyrus the Great, etc): these are expedients in order to endorse the authority of these men, by means of signs of gods' favour. Curtius Rufus' history of Alexander the Great campaign abounds of ominous events and another Darius (the First) was elected thanks to one of these presages (Herodotus), though in this case it was a mere pretension. However, in our case, we are not dealing with dreams or birds flights announcing the rise of the new hero, but with an astronomical event, "scientifically" observed and recorded by Babylonian astronomers, that we are able to reasonably reconstruct.

CONCLUSION

We can summarize our conclusions as follows:

i) Babylonian report of the duration of total phase for Moon eclipse of the night between the 20th and the 21st September 331 BCE does not fit with the figure computed by using present day mathematical models: the

[7] Also an ambiguous use of the term "king" and "king of the world" in the different parts of the texts testifies a redaction *a posteriori* of the historical facts.

[8] The stories of Alexander are full of omens, so it comes to mind if there was a conscious and tactical policy "of signs" adopted by the Macedonian king, as Alexander's mood the night of the eclipse together with this last assumption about the *Astronomical Diary* suggest.

difference should not be neglected or simply attributed to an "error". This discrepancy is thus worth of further studies.

ii) Our reconstruction of this astronomical event suggests a number of integrations to the lost part of the text, allowing a finer astrological interpretation of the eclipse and of its influence on the mood of the armies that set against each other on the following morning.

Therefore, our analysis, though still preliminary, clearly shows the capability of Archaeoastronomical methods for text interpretation as well as the verification and improvement of our astronomical knowledge.

ACKNOWLEDGEMENTS

VFP acknowledge Dott. Patrizia von Eles (Soprintendenza per i Beni Archeologici dell'Emilia-Romagna, Director of the Museo Civico Archeologico di Verrucchio) and Prof. Mario Torelli (Università di Perugia) for critical reading and useful suggestions

REFERENCES

Baity, E.C., (1973) Archaeoastronomy and Ethnoastronomy So Far. *Current Anthropology* 14/4, 389-449.

Bernard, P., (1990) Nouvelle contribution de l'épigraphie cunéiforme à l'histoire hellénistique. *Bulletin de Correspondance Hellénique* 114, 515-528

Boiy, T., (2001) Dating Problems in Cuneiform Tablets concerning the Reign of Antigonus Monophthalmus. *Journal of the American Oriental Society* 121/4, 645-649

Brinkman, J.A. (1987) BM 36761, the Astronomical Diary for 331 B.C. *Nouvelles Assyriologiques Brèves et Utilitaires* 1987 No. 63, 34

Brown, D. (2000) *Mesopotamian Planetary Astronomy-Astrology* (Cuneiform Monographs 18), Styx, Groningen

De Meis, S., (2002) *Eclipses. An Astronomical Introduction for Humanists* (Serie Orientale Roma XCVI), Istituto Italiano per l'Africa e l'Oriente, Roma

Del Monte, G., 1997, *Testi della Babilonia Ellenistica I. Testi cronografici*, Istituti Editoriali Poligrafici Internazionali, Pisa - Roma

Foster, K.P., Ritner, R.K. (1996) Texts, Storms, and the Thera Eruption. *Journal of Near Eastern Studies* 55/1, 1-4

Geller, M.J. (1990) Babylonian Astronomical Diaries and Corrections of Diodorus. *Bulletin of the School of Oriental and African Studies* 53/1, 1-7

Geller, M.J. (1991) New Information on Antiochus IV from Babylonian Astronomical Diaries. *Bulletin of the School of Oriental and African Studies,* 54/1, 1-4

Gera, D., Horowitz, W. (1997) Antiochus IV in Life and Death: Evidence from the Babylonian Astronomical Diaries. *Journal of the American Oriental Society* 117/2, 240-252

Gerber, M. (2000) A Common Source for the Late Babylonian Chronicles Dealing with the Eighth and Seventh Centuries. *Journal of the American Oriental Society* 120/4, 553-569

Huber, P.J., de Meis, S. (2004) *Babylonian Eclipse Observations from 750 BC to 1 BC*, IsIAO – Mimesis, Milano

Hunger, H. (1992) *Astrological Reports to the Assyrian Kings* (State Archives of Assyria VIII), Helsinki University Press, Helsinki

Hunger, H., Dvorak, R. (1981) *Ephemeriden von Sonne, Mond und helle Planeten von -1000 bis -601*, Österreichischen Akademie der Wissenschaften, Wien

Hunger, H., Pingree, D. (1999) *Astral sciences in Mesopotamia* (Handbuch der Orientalistik. 1. Der nahe und mittlere Osten 44), Brill, Leiden

Hunger, H., Sachs, A.J. (1988) *Astronomical diaries and related texts from Babylonia I*, Österreichischen Akademie der Wissenschaften, Wien

Hunger, H., Sachs, A.J. (1996) *Astronomical diaries and related texts from Babylonia III*, Österreichischen Akademie der Wissenschaften, Wien

MacGinnis, J. (2002) The Use of the Writing Boards in the Neo-Babylonian Temple Administration at Sippar. *Iraq* 64, 217-236

Massimino, P. (1999) *Planetario V2.0*, http://ntserver.ct.astro.it/cgiplan/ (consulted on 20th February 2006)

Neugebauer, O. (1975) *A History of Ancient Mathematical Astronomy. Part One, Studies in the History of Mathematical and Physical Sciences 1*, Springer-Verlag, Berlin - Heidelberg - New York

Olmstead, A.T. (1937) Cuneiform Texts and Hellenistic Chronology. *Classical Philology* 32/1, 1-14

Parpola, S. (1982) *Letters from Assyrian Scholars to the Kings Esarhaddon and Assurbanipal. Part II: Commentary and Appendices* (Alter Orient und Altes Testament 5/2), Butzon & Bercker – Neukirchener, Kevelaer – Neukirchen-Vluyn

Rochberg-Halton, F. (1987) TCL 6 13: Mixed Traditions in Late Babylonian Astrology. *Zeitschrift für Assyriologie* 77, 207-228

Rochberg-Halton, F. (1988) *Aspects of Babylonian Celestial Divination: The Lunar Eclipse Tablets of Enūma Anu Enlil* (Archiv für Orientforschung, Beiheft 22), Ferdinand Berger & Sohne, Horn

Rochberg-Halton, F. (1991) The Babylonian Astronomical Diaries. *Journal of the American Oriental Society* 111/2, 323-332

Sachs, A.J. (1948) A Classification of the Babylonian Astronomical Tablets of the Seleucid Period. *Journal of Cuneiform Studies* 2, 271-290

Sachs, A.J. (1955) *Late Babylonian Astronomical and Related Texts* (Brown University Studies 18), Brown University Press, Providence

Sachs, A.J. (1974) Babylonian Observational Astronomy. *Philosophical Transactions of the Royal Society* 276, pp. 43-50

Sachs, A.J. (1976) The Latest Datable Cuneiform Tablets. In B.L. Eichler, *Kramer Anniversary Volume: Cuneiform Studies in Honor of Samuel Noah Kramer*

(Alter Orient und Altes Testament 25), Butzon & Bercker, Kevelaer, 379-398

Slotsky, A.L. (1997) *The Bourse of Babylon : Market Quotations in the Astronomical Diaries of Babylonia*, CDL Press, Bethesda

Stolper, M.W. (1988) Some Ghost Facts from Achaemenid Babylonian Texts. *The Journal of Hellenic Studies* 108, 196-198

Swerdlow, N.M. (1998) *The Babylonian Theory of the Planets*, Princeton University Press, Princeton

Verderame, L. (2002) *Le tavole I-VI della serie astrologica* Enūma Anu Enlil (NISABA 2), DiScAM, Messina

Verderame, L. (2004) I colori nell'astrologia mesopotamica. In H. Waetzoldt, *Von Sumer nach Ebla und zurück. Festschrift Giovanni Pettinato zum 27 September 1999 gewidmet von Freunden, Kollegen und Schülern* (Heidelberger Studien zum Alten Orient 9), Heidelberg, pp. 327-332

Verderame, L. (2008) Le calendrier et le compte du temps dans la pensée mythique suméro-akkadienne. *De Kêmi à Birit Nâri, Revue Internationale de l'Orient Ancien* 3 (in print)

Walker, C.B.F. (1996) *Astronomy Before the Telescope*, The British Museum, London

Wheatley, P. (2002) Antigonus Monophthalmus in Babylonia, 310-308 B. C. *Journal of Near Eastern Studies* 61/1, 39-47

Wiseman, D.J. (1985) *Nebuchadrezzar and Babylon*, British Academy, London