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Babylonian Observations

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Abstract. Cuneiform tablets from Babylonia record lunar and solar eclipses, the presence and movement of comets, meteors and meteor showers. These have provided historical astronomers with much valuable data, but caution must be exercised when using such records, for accuracy of observation often ceded to astrological intent. In the future, texts from Assyria may also provide useful data for historical astronomers.

From the late 4th millennium BC, until shortly after the beginning of the Christian era, Mesopotamian scribes wrote in cuneiform on clay. The clay tablets are remarkably durable, though their surfaces may be severely damaged. Often duplicates of compositions are found, and lacunae may be filled many years later. The British Museum alone possesses some 130,000 tablets, but only a fraction have been catalogued, many fewer published. This applies as much to those documents that preserve astronomical data as to any other. New texts of a relevant nature are constantly been found in museums, and improvements in the readings of texts are being made all the time.

Large-scale excavations began in northern Iraq during the 19th century. From Nineveh, a substantial collection of texts was recovered that record, at least in part, celestial observations. Only a few are potentially of use to historical astronomers (see below). Later, the British, in particular, turned their attention to the south of Mesopotamia — Babylonia. Unprofessional excavations and large scale illicit digging by locals took place in Babylon, and at other major sites in the region, with the result that between 1876 and 1882 tens of thousands of tablets, including the vast majority of those texts recording astronomical observations, were shipped to London accompanied by little more than a note saying "Sippar", and even then many of those texts actually came from Babylon! Cuneiform had been deciphered by this time, so the discovery of the provenance of some of these texts was possible. Some 1600 documents in the BM concerned with the observation and prediction of celestial phenomena were copied in the 1890s, but not until the 1950s were these copies made widely available, and only recently has a substantial part of the collection been reliably translated.

The majority of the 2500 known post-750 BC astronomical texts from Babylonia come from the so-called "astronomical archive" of Babylon, but this term disguises more than it reveals. It has long been argued that most of these texts were found in the remains of the precincts of the great temple to the god Marduk, but it is also now believed that a substantial part of the collection was found in private houses outside the temple.

After 1912 the Germans began to excavate Uruk, another major site in the south. They discovered a further important collection of astronomical material.

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Of those published, most are predictive texts, but a few records of observations have emerged. Again, their find spots are a little unclear, but it is likely they came from the Reš sanctuary of the Anu temple. Recent Iraqi excavations at Sippar unearthed a library containing some still-unpublished texts of an astronomical–astrological nature, and it may transpire that the well-known claim made by Pliny (*Naturalis Historia* VI 121-93 and VII 193) that there were Babylonian schools of astronomy at Uruk, Babylon and *Hipparenum* (usually interpreted as Sippar) will in time be proved to be correct. It is very likely that future discoveries of astronomical texts will be made in Mesopotamia. The heady days of the unscientific scramble for "museum filling" have gone for good, but new light *will* be cast on the picture of Mesopotamian astronomy.

Probably from Uruk comes the oldest known reference to a heavenly body — to Venus in an early 3rd millennium BC text. Eclipses are occasionally noted in Babylonian chronicles of the second and first millennia BC, such as a solar eclipse in 763 BC, but it is not until the *mid*-8th century BC that systematic records of celestial phenomena were made. Many hundreds of texts from Babylon and Uruk are concerned with the prediction of particular, mostly ominous, celestial phenomena (see in particular Neugebauer 1955). About 1200 tablets and fragments of the vast astronomical collections, however, constitute the record of a programme of daily observation of the heavens and its phenomena, and this, above all, has provided historical astronomers with a rich source of data. The bulk of these tablets is in the BM, and is from Babylon. We refer to these tablets as Diaries, but to the Babylonians they were known as "regular watchings". We know that the Marduk temple employed observers to compile them. All the *datable* Diaries are now available in English translations (Hunger & Sachs 1988, 1989, 1996). They date from −651 to −60.

The Diaries were not written *in situ*. They were mostly compiled at the end of every year, or in later centuries every 6 months, from records that we in large part do not have. We do possess a few records of observations made over 1 or more nights, but oftentimes these were composed on perishable materials, such as wax writing boards. We have some duplicate records of the same night, and some records of the same observational period that disagree. Clearly, more than one observer was at work producing short Diaries from which the long Diaries were later compiled. We have little idea on what basis some records were favoured over others, but we have enough short Diaries to have a flavour, at least, of the industry lying behind the long ones.

In addition to the Diaries, we have other compositions, now known as Almanacs, Goal Year Texts (GYTs), and Eclipse and Planet Records. These too present astronomical data, probably for the purposes of prediction. The parlous state of *their* publication is rapidly improving, and with it our understanding of their relationship to the Diaries. In a few cases we can compare what is presented in an Almanac, say, with what is inscribed in a surviving Diary. Sometimes, the records agree, and we can be fairly sure that the Diaries were the source. Often, they do not agree, and all we can be sure of is that only a tiny fraction of the written output of the individuals engaged on this 800-year long enterprise has been recovered, and then only the material considered worthy of being written on clay tablets. Significantly, the Diaries were not solely the records of observations. They included many predictions, and these predictions sometimes fed into the Almanacs, GYTs, and so forth. The more we learn about the Diaries and the predictive texts the more we realize that the pressure to produce *complete* Diaries resulted in their inclusion of *predicted* data. For example, it has become apparent in the last few years that intervals such as those between sunset and moon rise were sometimes predicted rather than observed. This was not always marked in the Diaries, and any study that depends on these records must appreciate the limitations this brings.

Judicious use of the data recorded in the Diaries and related texts *can* lead to some stunning results. Records of solar eclipses, and timed lunar eclipses have helped Stephenson and Morrison in particular, to extend the clock-error graph (the measure of the amount by which the rotation of the earth is slowing down) back to c. 650 BC. This, in turn, has permitted the recalculation of local eclipse times to take place, and helped in the confirmation of dating, or even in the redating, of some texts. It has allowed scholars to assess the absolute accuracy, as opposed to the apparent precision, with which observations were made, and to draw conclusions as to the timing devices used by the Babylonians, and whether their accuracy improved over time, or not, for example. In the 1980s it was recognised that Halley's comet had been noted in the Diaries of 164 and 87 BC, and the dates of its observation helped confirm the superiority of the model of its long-term orbit established by Yeomans and Kiang over those of others (see Stephenson, Yau, & Hunger 1985). Records of bolides, fireballs and shooting stars in the Diaries and related texts have yet to be analysed, as has the record of occultations. There are no records of novae, the aurora, or sunspots, but Diary records of the level of the Euphrates have proven useful in reconstructing weather patterns in the eastern Mediterranean between c. 300 and 70 BC, and has the potential for tying down the floating chronology provided by the Anatolian tree-ring record (Brown, forthcoming). If successful, this would help establish a firm date for the Old Babylonian period.

A collection of some 1000 letters and reports sent by scholars to their king in Nineveh recording celestial observations, mainly in the form of omens, are now in the BM and have been republished recently (Hunger 1992; Parpola 1993). Such records do contain some data of interest to historical astronomers, but they have not yet been used to refine the clock error graph, in comet studies, meteoritics and so forth. This report (Hunger 1992; No.104, retranslated by the author) sent by Akkullanu, an Assyrian in Assur, for example, reads:

> "On the 28th day at $2\frac{1}{2}$ *bē* [*ru* of the day...] in the west [...] it also cove[red...] 2 fingers [remained to completion], it made [an eclipse]... if there is an eclipse in Nisan (month I) on the 28th day..."

It can be dated convincingly to −656 April 15th, and states that 5 hours after daybreak a solar eclipse was seen in Assur. The solar eclipse tables published by Steele & Stephenson (1997/8) use a straight-line fit for the clock error from −50 to −650, extended back to −750, and imply that the maximal phase of this eclipse *seen in Babylon* occurred 3h and 52m after dawn. A rising partial solar eclipse was noted in another report (Hunger 1992; No.384) written by a Babylonian. The data given indicate that it must have occurred in −668, May 27th, but the new tables imply that this eclipse was just over by dawn. Thirdly, a lunar eclipse is reported (Parpola 1993, No.149) to have occurred while β-Cygni was culminating, i.e. the time of the eclipse is given. I have re-dated this letter to 679 BC. These new data points will serve to refine the value for clock error between 657 and 679 BC.

One particular comet occurring at the very end of 675 BC was remarked by a number of Assyrian and Babylonian scholars. It was not Halley's comet, since according to Yeomans and Kiang, that would have been at perihelion in July 616 BC and Jan 690 BC. As the periodicity of more and more comets are discovered we may yet discover which comet the Assyrians were observing so carefully in that year. The ancient records may then prove to be useful in refining our understanding of the behaviour of that comet. In time, an Assyrian record of Halley's comet may turn up, and the record of meteors from Assyria may also prove to be of astronomical value.

I would like to end on a note of caution, for what is, perhaps, most significant about the Assyrian texts is what they tell us about why records of celestial observations were made at all, and why particularly after 750 BC. My own research has concentrated on these questions above all (Brown 2000). In short, it was the desire on the part of diviners (competitively employed to protect the Assyrian king) to make accurate predictions that led to, or influenced, the programme of daily observations. It is clear that the programme *was* in its infancy around the mid-8th century, despite later claims that earlier records were destroyed in antiquity. What was ominous was recorded, and the record led to the discovery of periodicities. These characteristic periods were used both to make predictions of the dates and locations of future similar events, and to complete the daily record in the event of non-observation. We know predictions were already being made in the 7th century BC. I also noted above that we have only what was deemed worthy of survival — official records, and then only a fraction of what was produced. The Diaries and the related texts, these largely official records, were not observational records, as we would understand them. They were, in a sense, *doctored* — the work of some observers was preferred over that of others, and they included many predictions whose accuracy is questionable. These sources of systematic error will not always come out in the statistical wash, and we must be cautious about drawing counter-intuitive conclusions about, say, the accuracy with which observations were made in Mesopotamia on the basis of comparing retrocalculated data with "apparent" observations in the Diaries and related texts. Still, the future can only bring more data, and a greater understanding of its worth.

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