The Decline and Fall of Sothic Dating

El-Lahun Lunar Texts and Egyptian Astronomical Dates

Egyptian 12th Dynasty lunar dates derived from the Berlin papyri and used in support of the Orthodox Chronology are in poor agreement with the retro-calculated dates for the lunar phases of the period. These computations of the lunar dates are fixed by the Middle Kingdom Sothic date on Berlin papyrus 10012 which may therefore be suspect. The present study was carried out to see if the pattern of lunar months derived from the Berlin papyri could be used to date the 12th Dynasty with more precision and to assess whether the Orthodox Chronology (OC) or New Chronology (NC) best fits the data.

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In this study, the assumption was made that 12th Dynasty priests accurately recorded the lunar dates, and that the so-called Middle Kingdom Sothic date on Berlin papyrus 10012 may not have been a reference to the heliacal rising of the dog-star Sirius. The results from the first part of my analysis indicate that the Middle Kingdom began about 140 years later than the OC proposes and that the astronomical date is in close agreement with the NC. The data also indicated that at least one major calendar reform occurred between the Middle Kingdom and the Hellenistic period with the possibility of other major calendrical reforms. In addition, an alternative astronomical event involving Sirius can be associated with the prediction on Berlin papyrus 10012.

The second part of the analysis was performed to determine whether other astronomical evidence – consisting of various Sothic dates, lunar dates and solar eclipses – might also confirm the NC, given that the el-Lahun lunar texts were supportive. Other evidence was taken into account – namely the seasonal data afforded by the Nile flood texts of the Second Intermediate Period, New Kingdom and Third Intermediate Period.

This paper concludes that the combination of astronomical and seasonal data supports the NC with a minimum of three calendrical reforms implemented – two during the Second Intermediate Period and one during the Late/Persian Period. The agreement between the dates derived from astronomy and the dates derived from genealogies and other historical data by the NC is remarkable given the different approaches used.

Part 1

Analysis of the el-Lahun lunar texts

Berlin papyrus 10056, which was found at el-Lahun in the mortuary temple of Senuseret II, contains a series of 12 consecutive lunar observations over an 11-month period.[1] The cycle starts on II Shemu day 26 (X.26) – the dry season in the ancient Egyptian calendar – and is dated to the regnal Years 30 and 31. However, the name of the actual ruler is not found on the papyrus, leading to speculation about his identity. Eminent chronologist, Richard Parker[2] attributed this document D (and three other papyri A, B and C containing lunar texts) to the 12th Dynasty period whilst John Reid[3] favoured an 18th Dynasty date. A papyrus found nearby – 'Papyrus Lahun IV:1' – resolves the issue in favour of the 12th Dynasty king, Amenemhat III. Parker[4] points out in his reply to Reid that an official named on this second document, Nehktisoneb the son of Meket, is also mentioned on the Berlin Papyrus 10056 as being on duty from X.26 to XI.25 in Year 30. The Lahun IV:I papyrus is definitely dated to Year 1 of the second 13th Dynasty king, Sekhemkare, and mentions that a daughter was born in the regnal Year 40 to Senet, the daughter of Nehktisoneb. While one might concede that the Nehktisonebs named on the two documents are distinct individuals, circumstantial evidence supports the view that the same person is involved. This is because the documents were found in close proximity in a

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12th Dynasty structure and that they both mention events during the reign of a long-lived king. None of the early 13th Dynasty kings ruled for 40 years, therefore the texts must refer to the reign of an earlier king. Consultation of the Turin Canon tells us that Amenemhat III is the *only* ruler of the period to have reigned in excess of 40 years.

Early attempts to date D (such as that by Wood[5]) were doomed to failure because they used a translation of the calendar dates[6] which has subsequently been shown to be in error. In addition to the 12 dates for which he provides the 'correct' translation, Parker describes an additional 5 lunar dates found on papyri from el-Lahun.[7] The number of lunar observations attributed to the 12th Dynasty by Parker has been added to by Rolf Krauss[8] and by Ulrich Luft.[9] Attempts to answer the 'Edgerton Challenge'[10] – that the 12th Dynasty Sothic date and the el-Lahun lunar observations would enable the dates of Senuseret III to be fixed with precision to the early second millennium – are disappointing because a large number of the predicted dates in these analyses miss the retro-calculated dates derived from the lunar texts. Rose demonstrated that between a third and a half of the lunar dates were required to be wrong and, depending on the interpretation of the recorded cycle, one date on Berlin 10056A (verso) was also found to be in error because it inferred a month of 31 days.[11] There have been a number of attempts to explain the 31-day month, but the solutions have remained contentious.[12]

It has been proposed that Egyptians observed the moon in the morning and recorded the first date that it could no longer be seen (i.e. lunar disappearance) as the start of the month. The evidence Parker has amassed in favour of morning sightings is immense. He shows that lunar observations from the Greco-Roman period (when calendar dates for the Roman and Egyptian civil years can be matched) only make sense if the lunar observations were made in the morning.[13] Whilst there is nothing in the literature from the Middle or New Kingdoms which would contradict Parker's hypothesis, there is also nothing to support his view that this practice had been followed in these earlier eras.

Early texts alluding to lunar dates shed no light on how the Egyptians made their observations of the new moon. For example, the occurrence and date of a new moon is recorded during the first Asiatic campaign of Thutmose III, inscribed on the walls at Karnak:[14]

> Year 23, 1st month of the third season, day 21: the day of the feast of the true new moon. Appearance of the king at dawn.

We cannot be entirely sure what the Egyptians meant by 'the true new moon.' The Egyptians seem to have dated the start of a lunar month from first disappearance but they probably used this to determine the date of first crescent visibility as the date they held the new moon festival. This view is supported by a recent analysis by Rose,[15] who demonstrates that the dates of lunar festivals (published by Luft in 1992) appear to be governed by the date of first crescent visibility, not lunar disappearance.

Sothic dating

Most attempts to date el-Lahun lunar observations have relied on 'Sothic Dating'. The first heliacal rising of Sirius was important to the Egyptians because it heralded an annual event – the Nile flood or inundation. The ancient Egyptian solar calendar of 365 days was shorter than the Julian calendar (or Gregorian calendar) by approximately 1/4 day. When the heliacal rising of Sirius was observed on the first day of the Egyptian calendar (I.1), it would be seen to rise on this day for the next three years. Subsequently, it would be seen to rise heliacally 1 day later every 4 years. This means that Sirius would only rise again on the first day in the Egyptian calendar for a 4-year period every 1460 years. In his book entitled *De Die Natali*, Censorinus agreed with this calculation and fixed the beginning of a Sothic year to the 20th July AD 139 (Julian), when this date coincided with the first day of Thoth (I Akhet day 1 or I.1) in the Egyptian calendar. This enables us to fix the start of the preceding Sothic cycles (with the heliacal rising of Sirius observed from Memphis) to 20th July 1322 BC and 20th July 2782 BC.[16] However, in a recent analysis it has been shown that these Great Sothic Years would actually have started on 19th July 1314 and 2770 BC, respectively. This reduction is explained because the sidereal year is marginally longer than the Julian year and because of the precession of the equinox. Both allow the heliacal rising of Sirius to be seen days earlier than a straightforward Sothic calculation would imply.[17] At lower latitudes the heliacal rising of Sirius is also observable 1 day earlier for every degree further south the observer is based (4 days earlier at Thebes and 5 or 6 days earlier at Elephantine) and this effectively reduces the Sothic date. Thus these factors should be taken into consideration when calculating Sothic dates.[18]

However, the simple principal is that, if we know on which day of the Egyptian civil year Sirius rose heliacally, we can determine the year within an error of +/– 3 years. A day earlier or later would make a difference of 4 years (either way) in the chronological dating of the king in whose time the observation of the heliacal rising of Sirius was made.

Sothic dates

There are now 9 published Sothic dates, starting with Censorinus' AD 139. The Aswan inscription dates the heliacal rising of Sirius to 13th July 221 BC and the Canopus decree to 19th July 238 BC. The Sothic cycle proposed by Censorinus is supported by Theon and the Theon Annotator. The former discusses calendar reforms by Augustus in 26 BC, giving dates which are consistent with Sothic dating. The latter is responsible for placing the era of Menophres' Sothic date in 1322 BC. This date is often assigned to Menpehtire Ramesses I of the 19th Dynasty on rather flimsy grounds. However, there is evidence (in the form of scarabs bearing a royal cartouche) for the existence of an obscure ruler with the name Menneferre. In the NC, Rohl[19] follows a suggestion of Immanuel Velikovsky,[20] but suggests that Menneferre was one of the late-13th Dynasty kings and during the late 14th century BC. The names are the same, Menophres being a Greek vocalisation of Menneferre.

There are three more New Kingdom Sothic dates. The Medinet Habu inscription is attributable to either Ramesses II or III, but the year and the day of the month in I Akhet are both missing. An Elephantine 'Sothic' document from the 18th Dynasty, usually attributed to the reign of Thutmose III, is also of less value chronologically because the regnal year is no longer readable. Papyrus Ebers, found at Thebes, apparently fixes a heliacal rising of Sirius in Year 9 of the 18th Dynasty pharaoh, Amenhotep I. One interpretation of this document is that Sirius rose heliacally on III Shemu day 9 (XI.9). Dating from the preceding Great Sothic Year of 2770 BC, with a heliacal rising of Sirius at Thebes, the event is datable to between 1523 and 1517 BC. Thus, with reference to the Turin Canon, the beginning of New Kingdom 18th Dynasty rule is dated to *circa* 1550 BC. A 17th Dynasty Sothic date II Shemu day 20 was found on a piece of graffiti at Gebel Tjauti (X.20) and has been dated to 13th July 1598 BC.[21] Probably of more relevance to my analysis is Papyrus Berlin 10012 found in the pyramid town of el-Lahun (Kahun). The papyrus appears to give a prophecy that the heliacal rising of Sirius would occur on Year 7, VIII.16 which has been retro-calculated to 1870 BC[22] for observations made from Memphis (or 1850 BC for those from Thebes).[23] In any case, as with many of the 12th Dynasty texts, the name of the king is not mentioned on the papyrus. Current opinion is that the document should be attributed to Senuseret III or perhaps Senuseret II.

Lunar dates

Parker suggests two different interpretations of Berlin 10056 (D). The words 'down to' could be interpreted as 'down to and including' or 'down to and not including'. This means that the first dates on each line should be interpreted as the first day of the lunar month, whilst the second date could refer to either the last day of the same month (Possibility I) or the start of the next month (Possibility II). Parker argues that both are viable alternatives. Initially he preferred the interpretation 'down to and including', but found that Possibility II fitted better after carrying out his analysis.[24]

The IV.19 date is badly damaged on the right-hand side of the papyrus, but this number is just about distinguishable on Luft's recent photograph of the papyrus.[25] For the sake of the analysis the reconstructed date on D should be considered to be either VI.18 or VI.19.

Based on the 12th Dynasty Sothic date and the Sothic cycle, Parker used el-Lahun lunar observations to place Year 30 of Amenemhat III (the year-date on D) in 1813 BC. The cycle he matched was based on morning observations of the waning crescent moon. Parker's analysis of D can be criticised because, at best, only 8 out of 14 lunar disappearance dates actually hit the predicted dates[26] – marginally better than Borchardt's 7 out of 14 when placing D in 1852-1851 BC. The consensus amongst OC scholars places Amenemhat III in 1817-1772 BC. However, all attempts to reconcile this date with el-Lahun lunar texts have failed.

Civil Year Date	Intermediate Wording	Civil Year Date
X.26	down to	XI.25
XII.25	down to regnal year 31	I.19
	Regnal year 31	
II.20	down to	III.19
IV.19 * (IV.18)	down to	V.18
VI.18	down to	VII.17
VIII.17	down to	IX.16

*Table 1: El-Lahun Document 'D'. The hieratic runs right to left. * = restored from the original. After R. A. Parker (1950), p. 63.*

In 1970, Reid proposed that the lunar cycle starting on 5th July 1549 BC was the best match for Berlin 10056A *verso* (D).[27] He claimed that the match was virtually 100%. Reid suggested that the right-hand portion of the papyrus recorded the morning after first crescent visibility, and that the left-hand portion recorded the actual day of observation.[28] Reid explains that the recording was made in this manner because this was the date on which a new priest took up office for the next month. The same priest then recorded the first sighting of the next lunation to mark the end of his tenure. This gives the same sequence as Parker's 'Possibility I'.[29] (Incidentally, Parker's explanation for the 31-day month is that II.20 was recorded instead of II.19 – an obvious solution if the sightings were made of the waxing crescent moon similar to the practice in Mesopotamia.) The major criticism of Reid's work is that he attributes the documents to Ahmose I of the 18th Dynasty and credits him with a reign in excess of 40 years. This surely cannot be correct. First, there is absolutely no evidence for a reign exceeding 25 years for Ahmose. Second, the evidence, cited above, regarding the Middle Kingdom origins of the papyrus clearly refutes Reid's 18th Dynasty date. Furthermore, Reid was unaware of the other lunar texts and consequently made no attempt to match any of these on the strength of his 1549 BC cycle. I have done this for him and found that his match is very poor indeed and achieves only 23 hits out of 39 dates.

Weggelaar and Kort[30] suggested that the 12th Dynasty used a 364-day calendar. This enabled them to match 14 out of 15 lunar dates known to Parker, as well as the 12th Dynasty Sothic date. They placed D in 1557-1556 BC and the Sothic date to 17th July 1601 BC. At first inspection this seems like an excellent suggestion, but the subsequent publication of an additional 24 lunar dates allows their hypothesis to be further tested. When I carried out that analysis I found that I could match only 19 out of 39 lunar dates. All of the misses are several days wide of the mark, making invalid their assumption that a 364-day calendar was in use during the reign of Amenemhat III.

Krauss suggested an Elephantine observation point for the Sothic date and attributed the document to Senuseret II. He then attempted to place D in 1788-1787 BC. Unfortunately only 10 of his lunar disappearance dates fall on the predicted dates.[31] In 1992 Luft published the most complete set of lunar observations from el-Lahun. His best match with the lunar dates advocated a Memphis observation in Year 7 of Senuseret III and dated D to 1824-1823 BC. However, he succeeded in matching only 23 of the 39 dates.[32] In his 1994 study and re-analysis of Parker, Krauss and Luft, Rose concluded that:

> No-one seems to have been able to establish an early second millennium chronology for the 12th Dynasty by calculating precise placements both for the Sothic date and el-Lahun lunar documents.[33]

Rose has subsequently shown that there is a first millennium solution for the Edgerton Challenge![34] He has succeeded in matching 34 of the 39 lunar dates to lunar disappearances, placing D in 353-352 BC and the 12th Dynasty Sothic date on 17th July 395 BC. Rose assumed that the dates on D were lunar day 3 dates in his final analysis. I also thought that this was an acceptable interpretation and should be considered in the analysis.

Rose felt that 5 of the dates were suspect and excluded 4 of them from his final analysis. He found that if one text was dated to Senuseret II, he could increase his tally to 35 hits. I agree that 1 and perhaps 2 el-Lahun dates are suspect and cannot be relied upon. However, running analyses on computer programmes Redshift and Starry Night showed that two of his dates were early by one day (D2 from Berlin 10056A and the date on Berlin 10165). Rose therefore obtained a maximum score of 35 hits out of 37 dates and a minimum score of 32 hits out of 38. On this basis, Rose proposed that the 12th Dynasty should be shifted a whole Sothic period so that the Middle Kingdom ended in 332 BC when Alexander the Great invaded Egypt![35]

Needless to say, Rose's radical solution has many problems. There are, for example, 19th Dynasty references to the 12th Dynasty, as well as the Memphite Genealogy from the Third Intermediate Period (centuries before Alexander) listing kings of the 12th Dynasty. The textual evidence alone is sufficient to dismiss his hypothesis.

The inability to find a satisfactory chronological match with the heliacal rising of Sirius and the el-Lahun texts might imply that these two sets of observations are not linked by a predictable chronological sequence such as the Sothic cycle. In that case perhaps the chronology is wrong. *Centuries of Darkness* authored by Peter James *et al.*,[36] and David Rohl's *A Test of Time* series[37] supplied many adroit arguments in support of a reduced chronology. For example, Peter James raised this objection to Sothic-based chronology:[38]

> There are good reasons for rejecting the whole concept of Sothic dating as it was applied by the earlier Egyptologists, simply on the grounds that it did not make allowances for any calendrical adjustments. It is assumed that the Egyptians allowed the Civil Calendar and seasonal cycle, to which the lunar-religious calendar was tied, to progress further and further out of adjustment.

Of course, Sothic chronology relies on the concept that the Egyptians refused to modify their calendar – despite the anomalies which occurred because of the absence of a leap year. James suggested the possibility that Reid's solution for document D might actually date the 12th Dynasty to the 16th century BC. He also suggested that Torr's date of 1271 BC[39] for the 18th Dynasty might be close to the mark.[40]

Rohl went further by pinpointing specific problems with the interpretation of Egyptian archaeology, supporting his findings with evidence from Josephus, Artapanus[41] and the Old Testament to postulate what has become known as the 'New Chronology'. He provided alternative explanations for the texts on Papyrus Ebers[42] and Papyrus Berlin 10012[43] in a demolition of Sothic-based chronology. However, he did not actually dismiss the concepts involved but rather offered alternative explanations of the texts.

With the el-Lahun lunar texts and other astronomical dates from the 18th and 19th Dynasties, astronomers have an ideal opportunity to test these alternative chronologies for the Middle Kingdom and New Kingdom.

Method

To carry out the analysis of the lunar dates, I used both Reid's approach[44] (which involved evening sightings of the waxing crescent) and Parker's criteria[45] (which is of morning observations). In performing the analysis of single lunar sightings – that is those dated to the reigns of Thutmose III and Ramesses II – I allowed for a possible error of +/– 1 day to account for missed sightings and checked these against the previous month's new moon. This allows a check on the veracity of the date cited. These calculations were performed only after the criteria were set for el-Lahun sightings, which I will now describe.

Matching Berlin 10056A (D)

We now possess a number of additional lunar observations from the temple at el-Lahun. Initially, I used only Berlin 10056A (D) since my intention was to find the best match for this and, based on the result, determine if any of the other lunar dates (which may or may not date from the reign of Amenemhat) could be used to support the match. In D only one scribal error or missed observation (on II.20 rather than on II.19) is required to convert the recorded month-length sequence to the retro-calculated lunar-month sequence. My initial analysis was performed with the dates on the left in Parker's transcription of D. This sequence of 59,60,59,59,59 days matches the lunar month sequence twice every 3 years. When the dates on the right are included in the analysis, a match occurs once in a period of 10 years (on average) with first crescent visibilities, and once every 16 years with lunar disappearances.

The sequences (in the box at the top of the next column) are: (1) the recorded month lengths using Possibility II; (2 & 3) the adjusted month lengths assuming a scribal error, etc. for morning and evening sightings, respectively; and (4) the month lengths according to Reid or Possibility I.

1.	29, 30, 29, 31, 29, 30, 29, 30, 29, 30, 29 days
2.	29, 30, 30, 30, 29, 30, 29, 30, 29, 30, 29 days
3.	29, 30, 29, 30, 30, 30, 29, 30, 29, 30, 29 days
4.	30, 29, 30, 30, 30, 29, 30, 29, 30, 29, 30 days

I accept Parker's argument that the scribe might have made an 'error' in recording the cycle. This 'mistake' would have been in recording the event on II.20, when theoretically it would have occurred one day earlier on II.19.

I have completed over 6000 calculations of the new moon by using Carl Schoch's tables[46] and from this determined both first crescent visibility and lunar disappearance. The results derived from Schoch's tables are based on the new moon in Babylonia but, using the correction factor of minus 53 minutes proposed by Schoch for sightings from Memphis or at el-Lahun (for simplicity I used, 31°15' East, 30°00' North), the new moon can be calculated for that location also.

According to calculations performed using Schoch's tables, sightings of the new crescent moon from Memphis should usually be observable one day or two days after a lunar conjunction. In most cases the last crescent would still be visible the day before the new moon. This is true so long as the intervening period between new moon and visible crescent was greater than the 16 to 44 hours usually required for the separation of sun and moon in the sky in order to allow the crescent to be visible in the evenings (on or prior to 6 pm) or the mornings (on or after 6 am), respectively. This period depends not only on the latitude of the moon and of the observer, but also upon the season. In addition to Schoch's tables, I used two computer programs – Redshift and Starry Night. However, there were some important discrepancies between Schoch's tables and these computer programs. The manual calculations were reaching first crescent visibility about 2 to 3 hours later than Redshift or Starry Night and occasionally indicated longer periods of lunar disappearance than the computer programs.

Preliminary results

An extensive investigation of Berlin 10056 (D) failed to give a match, either with lunar disappearance or first crescent visibility dates and the 12th Dynasty Sothic date in the early- to mid-second millennium – regardless of the location of the heliacal rising of Sirius. Recent chronological considerations have tended to ignore the 12th and, very occasionally, the 18th Dynasty Sothic dates.[47] I accepted at an early point in my study that the 12th Dynasty Sothic date should be disregarded when trying to determine Middle Kingdom chronology.[48] That does not mean that I had to abandon the concept of Sothic dating – just that the prediction on Berlin papyrus 10012 probably did not contain a true Sothic date. When I carried out an analysis using the Sothic calendar, I found that a number of lunar cycles between 1900 and 1400 BC match the data-set of Parker[49] almost as well as the 1813 date he had previously determined. But most miss on 33% of the lunar dates.

Abandoning Sothic-based chronology

I then abandoned the Sothic calendar in order to carry out the rest of my analysis. It is important to stress that, even when there are no matches with Sothic-based chronology in the second millennium BC,[50] we can still consider matching the lunar cycle to actual lunar month lengths, because (as stated previously) we cannot be sure that the Egyptians did not make adjustments to their calendar. There are a number of ways they could have done this. If one assumes that they did make corrections, then accurate dating can only be carried out if we can identify when those adjustments were made. They could have made periodic changes to the calendar to no particular pattern. Calendrical resetting could have been subject to the whim of a particular ruler or priestly council. Unless we can define a pattern, it seems that we are at a loss. Yet it might be possible to link a series of astronomical observations to a series of dates in a particular epoch, because the sequence in question would be fairly uncommon and, over a time-span of several centuries, unique. However, such an analysis of a short sequence of month lengths, without any imposed restriction, does result in a large number of acceptable matches when allowances are made for poor weather and missed sightings.

The vast majority of matches are consistent with Parker's Possibility II. Assuming a late sighting error on II.20 permits a 100% match because we can assume that a sighting was missed on II.19. The 12-date sequence on document D repeats on 30 occasions using lunar disappearance and on 50 occasions using first crescent visibility in the 500-year period from the late 20th to 15th centuries BC.[51]

Other lunar dates on the Berlin papyri

After identifying this large number of acceptable cycles which match the lunar sequence of D (Berlin 10056A), a process of elimination was required to weed out those which did not give acceptable results when the additional el-Lahun documents were analysed. This elimination process was carried out by matching the lunar dates against the predicted lunar sequence determined by Schoch's tables and then confirmed by Redshift.

As well as Berlin 10056A (D) three other documents (A-C) were described by Borchardt[52] and Parker:[53]

A.	10090:	Year 3	XI.16
B.	10062:	Year 29	IX.8
C.	10006:	Year 32	III.6 (or 7)

B is actually a reduction from a day-9 date reconstructed by Borchardt. The original entry on the edge of the papyrus was damaged, but is associated with another date – IX.15. Borchardt's reconstruction of the damaged date was IX.16, however, it is just as likely that the damaged date was IX.15, thus giving a reduced IX.7 for B. A hit with either IX.7 or IX.8 would therefore be acceptable.

None of these documents names the king, so they could date to the reign of any of the late 12th Dynasty kings – that is Senuseret III, Amenemhat III or Amenemhat IV. Parker assigns both the Year 3 and Year 32 sightings to Senuseret III since they do not match his chronology for Amenemhat III. However, most Egyptologists give Senuseret no more than 19 years and I have made the assumption that the Years 29 and 32, at least, must belong to Amenemhat.[54] Further scrutiny of document C has resulted in the identification of another lunar date and Krauss informs us that the two day-1 dates must be II Akhet day 9 (C1) and III Akhet day 8 (C2) in Year 32 (II.9 & III.8 respectively).

Knowing on what day in the Julian calendar Year 30, X.26 fell, determines the date for each observation in the reign of Amenemhat III. The predicted Julian date for A (Year 3, XI.16) fell at least one day early in the vast majority of the cycles which I had identified in my analysis of D. And so this date may well belong to another reign – unless we suggest a poor weather observation. However, Krauss modified this date to XI.17 in his analysis. When this date is used there is an exact match in the majority of the lunar sequences. In almost all of the lunar cycles where sequence 3 (on p. 75) matched D, the lunar phase occurred on the predicted Julian dates for B (Year 29, IX.8 or IX.7). All cycles achieved hits with C2 (Year 32, III.8) and that could be used to discriminate between them. Using Krauss' interpretation, the earlier C1 date misses on most of the matches with D, but we can explain C1 as a late observation which resulted in a 29-day instead of a 30-day month.[55]

In his recent analysis, Luft lists a further 19 lunar dates – 11 of which he attributes to Senuseret III and 8 to Amenemhat III. I am convinced he is right in this assumption.[56] Many of these additional dates were of feasts which are presumed to have happened on a particular day in the lunar month. Luft then reduces these dates to determine the equivalent Egyptian date for lunar day 1. However, Luft's interpretation is disputed by Krauss who argues that many of Luft's reductions are incorrect.[57] For example, Luft reasons that the Egyptian lunar day 15 actually fell on the 16th day of the lunar month, but Krauss insists that it must have fallen on the 15th day of the month. Luft defends his view, citing as evidence the date of the fixed annual *Wag*-feast which occurred on I Akhet day 18 (I.18).[58] But, calculating the reduced date for lunar disappearance from the date of a feast may be unreliable because it is possible that another lunar phase was used to determine this date (perhaps the first crescent visibility or full moon). Rose has recently clarified the situation by showing that first crescent visibility was indeed used to set the dates of the lunar feasts. Rose then reduced all the dates to lunar disappearances in his analysis.[59] Luft – who also advocates lunar disappearance – deducts one day from the Year 30-31 dates in his analysis because he assumes that each date in D refers to lunar day 2.[60] I have assumed that the dates on D could either be lunar disappearances or first crescent visibilities and that any reductions should be made accordingly.

First crescent visibility is frequently observed in the evening on the day after lunar disappearance occurs. However, there are circumstances when it is the second or even third day before the moon becomes visible again. If lunar disappearance was actually used to predict the date of first visibility, poor weather on the second lunar day and in some cases the third lunar day would have resulted in an early or late date being given.

When investigating the dates cited in Luft's publication, I have increased all his equivalent Egyptian dates by one day – with three exceptions. First, I follow Parker's date for B (IX.6 for lunar disappearance, equivalent to IX.7 for first crescent visibility) and, second, with Berlin 10056A *recto*, I choose to explain Year 8 IV.25 as the date of lunar disappearance and Year 8 IV.26 as the date of first crescent visibility.[61] Thus I have adopted the higher dates cited by Krauss and Parker – but purely for continuity and not for any other reason. Besides, if we carry out the analysis with the dates cited by Luft, we end up with the same match. It is the computed periods between each of the lunations which becomes the determining factor for matching a sequence of dates because we no longer consider the 12th Dynasty Sothic date as an anchor for Egyptian calendar dates.

Results for Amenemhat III

As the length of the reign of Senuseret III was an uncertain factor, the analysis was first performed with the 25 lunar dates which could be attributed to Amenemhat III. In carrying out this analysis several candidates achieved higher scores than all the others.

When using first crescent visibility, at least 23 out of 25 dates match the predicted lunar sequence when Year 30 X.26 of D = 3rd May 1649 BC. Alternatively, 21 first crescent visibility dates match the predicted dates when Year 30 X.26 = 5th August 1796 BC, 22nd May 1781 BC, 24th April 1773 BC, 19th August 1743, or 18th May 1710 BC.

When using lunar disappearance, 24 out of 25 dates match the predicted lunar sequence when Year 30 X.26 = 2nd May 1649 BC; 22 dates match when Year 30 X.26 = 23rd March 1686 BC; and 21 dates match when Year 30 X.26 = 2nd July 1755 BC or 3rd August 1701 BC.

In this analysis the vast majority of these potential candidates for D fell by the wayside. This is because they missed on many of the additional lunar dates cited by Parker, Krauss and Luft. Whilst most of the misses were by one day, some required late observations and others, within the same sequence, early observations. Some missed by as much as two days.

The very best match with Amenemhat's lunar dates is when Year 30 X.26 fell on 2nd May 1649 BC in a sequence of lunar disappearance dates. This match assumes that the sequence on D follows Parker's Possibility I and that the dates on the right side of the papyrus (i.e. the left column in Table 1) of document D and those of document C are lunar day-2 dates. Using the Year 30-31 data to determine the Julian calendar dates, all 8 of Luft's additional dates were seen to match exactly when D is dated to 1649-1648 BC or 1773-1772 BC, while the other candidates missed by at least 2 to 3 dates. The results of the retro-calculations with Redshift for Amenemhat Year 30 = 1650-1649 BC are shown in Table 2.

The dates for Amenemhat III

So, regardless of the lunar phase used in computations, the best fit with Amenemhat's lunar data is when his Year-30 spanned the period from 13th July 1650 to 11th July 1649 BC. This would date a heliacal rising of Sirius observed at Elephantine to the first day of Akhet on 12th July 1649 BC.

Whilst an 18th-century match for the late 12th Dynasty would be expected in the OC, the 17th-century-BC match discovered here is entirely consistent with the NC proposed by David Rohl. There is a discrepancy of just 3 years from the dates for Amenemhat III published in *A Test of Time.*[62] It should be stressed that this result does not depend upon the NC but instead lends it strong independent support.

Results for Senuseret III

Senuseret's reign is considered to have lasted no more than 19 years before his son became king. However, I had to consider the possibility that a longer reign might be supported by the lunar data. Dates based on reign lengths from Years 19 to 44 were therefore tested in my analysis, but they failed to support an independent reign beyond Year 19 for Senuseret III. My method was as follows: I calculated the periods (in days) between the recorded new moons and compared them with the actual lunar sequence, starting in the early 19th century down to the 15th century BC.[63] Berlin 10090, 10062, 10006 and 10056 (A, B, C & D) were analysed against this lunar sequence (assuming that they belonged to the reign of Senuseret and not Amenemhat) – but many of the dates were found to miss. Since the periods between the lunar dates on these documents do not fit for Senuseret, I therefore concluded that they had to be from Amenemhat III's reign. When tested against Amenemhat's Year 30 = 1650-1649 BC, only two of the full set of dates miss – and then only if we adhere strictly to Luft's reductions.

Of the remaining dates assigned to Senuseret III, Redshift allows a match with 13 out of 14 lunar disappearance dates if the king's Year 1 = 1698 BC. The calculations using Schoch's tables, on the other hand, give 11 out of 14. This, as we have noted, is because the tables predict longer periods of lunar disappearance than the computer programs.

Reign of Amenemhat III (now set at 1679-1633 BC)								
Papyrus Document	Regnal Year	Luft (1992)	Calendar Date	Interval in Days	Julian Date		Lunar Disappearance (astronomical date BC)	
10090 (A)	3	XI.16	XI.17	1624	30th May	=	30th May	1676
10056 (1)	8	IV.26	IV.26	296	9th November	=	9th November	1672
10166 (2)	9	II.16	II.17	236	1st September	=	1st September	1671
c58065 (H)	9	X.12	X.13	118	25th April	=	25th April	1670
10018 (3)	10	II.5	II.6	30	21st August	=	21st August	1670
10079 (4)	10	III.5	III.6	384	20th September	=	20th September	1670
10344 (5)	11	III.24	III.25	4665	8th October		8th October	1669
10052 (6)	24	I.4	I.5	178	17th July	=	17th July	1656
10104 (70	24	VII.2	VII.3	1889	11th January	=	11th January	1655
10062 (B)	29	IX.6	IX.7	414	15th March	=	15th March	1650
10056 (D)	30	X.25	X.25	30	1st May	=	1st May	1649
10056 (D)	30	XI.24	XI.25	29	31st May	=	31st May	1649
10056 (D)	30	XII.24	XII.24	30	29th June	=	29th June	1649
10056 (D)	31	I.18	I.19	30	29th July	=	29th July	1649
10056 (D)	31	II.19	II.19	30	28th August	=	28th August	1649
10056 (D)	31	III.18	III.19	29	27th September	≠	26th September	1649
10056 (D)	31	IV.18	IV.18	30	26th October	=	26th October	1649
10056 (D)	31	V.17	V.18	29	25th November	=	25th November	1649
10056 (D)	31	VI.17	VI.17	30	24th December	=	24th December	1649
10056 (D)	31	VII.16	VII.17	29	23rd January	=	23rd January	1648
10056 (D)	31	VIII.16	VIII.16	30	21st February	=	21st February	1648
10056 (D)	31	IX.15	IX.16	148	23rd March	=	23rd March	1648
10006 (C)	32	II.8	II.8	29	17th August	=	17th August	1648
10006 (C)	32	III.7	III.7	1447	15th September	=	15th September	1648
10206 (8)	36	II.24	II.25		2nd September	=	2nd September	1644

Table 2: The Amenemhat III lunar texts. The shaded entry marks the single miss in the 1676-1644 sequence.

Reign of Senuseret III (now set at 1698-1679 BC)								
Papyrus Document	Regnal Year	Luft (1992)	Calendar Date	Interval in Days	Julian Date		Lunar Disapperance (astronomical dates BC)	
10092	5	II.24*	II.26$^{\$}$	118	17th September	=	17th September	1694
10009	5	VI.22	VI.23	206	12th January	≠	13th January	1693^{+}
10282	6	I.14	I.15	30	6th August	=	6th August	1693
10282	6	II.13	II.15$^{\$}$	30	5th September	=	5th September	1693
10282	6	III.13	III.15$^{\$}$	708	5th October	=	5th October	1693
10130	8	II.21	II.23$^{\$}$	29	13th September	=	13th September	1691
10130	8	III.21	III.22	473	12th October	=	12th October	1691
10003 (E)	9	VII.9	VII.10	295	28th January	=	28th January	1689
10112	10	IV.29	IV.30	266	18th November	=	18th November	1689^{+}
10412	11	I.20	I.21	620	11th August	=	11th August	1688
10165	12	X.5	X.6	502	23rd April	=	23rd April	1686
10248 (F)	14	II.17	II.18	857	6th September	=	6th September	1685
10011	16	VI.23	VI.24	827	11th January	=	11th January	1682
10016 (G)	18	IX.30	X.1/X.2	1505	16/17th April	=	17th April	1680^{+}

*Table 3: The Senuseret III lunar texts. The shaded entry marks the single miss in the 1694-1680 sequence. *Luft originally cited II.25. $^{\$}$FCV lunar Day 4. $^{+}$ Using Redshift: 12th Jan = 12th Jan 1693 BC; 18th Nov ≠ 17th Nov 1689 BC; X.1 = 16th Apr 1680 BC.*

The dates for Senuseret III

The results of this lunar dating analysis show that Year 19 of Senuseret III and Year 1 of Amenemhat III were indeed consecutive – as many Egyptologists have come to accept. If Year 30 of Amenemhat III is fixed to 1650-1649 BC (in accordance with the best lunar month-length fit), Year 1 of Senuseret is then dated to 1699-1698 BC (see Table 3). The 1505-day interval between Year 18 X.1 (or X.2) of Senuseret and Year 3 XI.17 of Amenemhat confirms this sequence.

Changes in the Earth's acceleration rate

The discrepancies between Redshift's first crescent visibility dates and those manually calculated from Schoch's tables disappears when a decrease in the Earth's rate of rotation is allowed for. Recent astronomy – including Redshift – uses a greater value for the Earth's deceleration than originally utilised by Schoch in formulating his lunar tables. This is easily remedied by deducting from the manual calculations the difference in the delta-T values (the estimated time lost by the slowing of the Earth's spin speed) between Redshift and Schoch's tables. This is reckoned to be between 137 and 142 minutes in the early 17th century BC.[64]

In total 37 out of 39 lunar dates hit with the predicted lunar disappearance dates when D is dated to 1649-1648 BC. The dates which miss consist of one date of Amenemhat (the 6th date of D reduced to Year 31 III.19) and one date of Senuseret III (Year 5 VI.23) – either of which could be accounted for by poor visibility (cloud cover). Both missed observations would have resulted in the preceding 29-day month being lengthened to 30 days and, as a consequence, this would have shortened the following month to 29 days.

Summary of lunar dating attempts

With the exception of Reid's analysis, all the studies attribute the Berlin papyri to the 12th Dynasty and (with the exception of Rose) a date in early to mid-second millennium BC has been sought for the el-Lahun texts. By far the best matches between the predicted lunar dates and the retro-calculated dates of lunar disappearance (LD) are provided by the analysis of Rose (1999) and this present study. Since Rose's 4th-century BC dates are simply not feasible for the reasons cited earlier, this leaves the two candidates discovered in this study. The Amenemhat III Year 30/31 = 1649-1648 BC lunar disappearance dates (LD) match the sequence better than the Year 30/31 = 1686-1685 BC LD dates. When other astronomical and chronological factors are taken into account the lower dates are to be preferred – particularly when I apply the greater delta-T values currently used by recent astronomy programs.

Statistical analysis

The lunar cycle is an arithmetical sequence which contains repetitive elements. Therefore, given a sufficient number of sequences over time, a match which hits a high proportion of the dates will occur. In the Egyptian calendar, the lunar cycle repeats (with internal variations) every 25 years. In a 25-year period (including determinations of first crescent visibility and lunar disappearance) there would have been 4 close matches to the sequences derived from Berlin 10056A (D). Over a 500-year period (6031 moons), this produces 80 matches with the D sequence.

A statistical analysis was performed on the sequence of lunar disappearances and first crescent visibilities to calculate the likelihood of obtaining a match purely by chance. First crescent visibility and lunar disappearance dates obtained one match each in the 500 years when a hit rate of 85% was simulated. The actual observational hit rate frequency never exceeded this figure with the OC dating and, in fact, the two best results managed only 59% (see Table 4).

Excluding some dates from the analysis increased the likelihood of obtaining a match. One or two dates can be omitted for a good reason – because the texts are damaged – and more dates can possibly be excluded on the basis of poor weather observations.

The OC requires errors in at least 40% of the dates from the lunar texts. This is a high proportion with the obvious implication that the Egyptian astronomer-priests were somewhat incompetent. Surely we should rather consider that the priests were skilled observers and that few errors are actually contained in the texts. A more realistic figure, affecting 20% of the dates, might be closer to reality. If we accept this sort of estimate, we can expect 5 matches within a 500-year period and 15 matches in one complete Sothic cycle. Therefore, it is not surprising that other matches (with 80%-90% of the data) will have occurred over a sufficiently long period of time. It would appear that the 4th-century-BC match discovered by Rose (at 82-95%) is one such example. It is also clear from my analysis that any sequence found with all 39 date matches will be extremely rare, if not unique.[65]

Study	Result A	Result B	Year 30/31	Percentage
Borchardt	FC 7/14	ND+	1852-1851 BC	50%
Parker	LD 8/14	20/39	1813-1812 BC	51%
Reid	FC 11+/12	23/39	1549-1548 BC	59%
Weggelaar *et al.*	LD 14/15	19/39	1557-1556 BC	49%
Krauss	LD 10/20	22/39	1788-1787 BC	56%
Luft	LD 23/39	23/39	1824-1823 BC	59%
Rose	LD 35/37	32/39*	353-352 BC	82-95%
Lappin	LD 35/39	31/39*	1686-1685 BC	80-90%
Lappin	FC 37/39	38/39*	1649-1648 BC	95-97%
Lappin	LD 32/39	36/39*	1649-1648 BC	82-92%

*Table 4: Comparison of lunar dating attempts. Result A = the original study; Result B = my reassessment; * = Redshift results; + = D dated to Senuseret III.*

Conclusion

The dating of Senuseret III and Amenemhat III to the 17th century BC – rather than to the 19th century BC as in the Orthodox Chronology – is the surprising outcome of this research. Some 95% of the predicted lunar dates derived from the papyri documents match the retro-calculated dates for a 17th century late Middle Kingdom, placing Year 1 of Amenemhat III in 1679 BC (OC – 1817 BC) and Year 1 of Senuseret III in 1698 BC (OC – 1836 BC). The dates also confirm that Amenemhat III became king in Year 20 of Senuseret III (1679 BC). Furthermore, this result agrees with the historically-based NC dates for the 12th Dynasty.

Part 2

Testing the New Chronology

The degree of support which this analysis of the 12th Dynasty lunar texts lends to Rohl's historically determined dates for the Middle Kingdom is not to be underestimated. However, it should be emphasised that the NC already relies, in part, upon other astronomical retro-calculations, which I shall briefly review.

The Ugarit eclipse

Early in the last century a small fire-damaged cuneiform tablet – KTU 1.78 – was found in the ruins of a Late Bronze Age palace at Ras Shamra (ancient Ugarit). Much depends on whether one can accept the argument that KTU 1.78 contains the record of a solar eclipse at sunset as seen from Ugarit by Nikmaddu II.[66] But some astronomical event is mentioned and it is difficult to see it as something mundane. In the Amarna letter EA151 Abimilku, king of Tyre, informs Akhenaten that part of the royal palace at Ugarit has been destroyed by fire. Abimilku's letter seems to have been sent in Year 12 of Akhenaten. Mitchell, who interpreted the KTU 1.78 text to mean that the eclipse occurred at sunset, found that there was really only one candidate – the eclipse observed from Ugarit at 6:17 pm on 9th May 1012 BC.[67]

The Tawananna eclipse

There seems to be evidence for a second solar eclipse in close proximity to the Amarna period eclipse. Tablet Bo-4802 – datable to the reign of the Hittite King Murshili II – appears to contain a reference to a solar eclipse known as the 'Tawananna Eclipse'.[68] This eclipse should date about 30 to 40 years after the KTU 1.78 event. Mitchell calculated that just such an eclipse occurred on 30th April 984 BC.[69]

The significance of these dates is that they support Rohl *et al.*'s hypothesis that the Amarna tablets contained contemporary reports of the Hebrew revolt in the time of Saul and the establishment of the United Monarchy of Israel by Saul and David. These events were played out during the Late Bronze II-A rather than Iron Age II-A but, with the new chronological revision applied, this remained consistent with biblical chronology.[70]

The Neferhotep – Hammurabi synchronism

The other astronomical pillar of the NC is Mitchell's Venus Solution for the tablets of Ammisaduga – an Assyrian copy of lunar and planetary observations made by Babylonian scribes during the reign of the penultimate Amorite king of Babylon I. Mitchell's Venus Solution places Ammisaduga's accession to 1419 BC – several centuries later than in the conventional scheme.[71] This date for Ammisaduga allows a cross-reference to the 13th Dynasty pharaoh, Neferhotep in Egypt via Yantin, king of Byblos, and Zimrilim, king of Mari (a contemporary of Hammurabi whose reign began in 1565 BC). With reference to the Turin Canon, Rohl calculates that the end of the 12th Dynasty would then have been sometime in the mid-to-late-17th century BC.[72] Conventional chronology allows at least 78 years between the death of Amenemhat III and the reign of Neferhotep.[73]

Calendar reform

The Sothic dates themselves are also based on an astronomical event (i.e. the heliacal rising of Sirius in mid-July) and should make some sense if the original texts have been interpreted correctly. We should also be able to corroborate our match with those astronomical observations made by other cultures of the Near East. Seasonal data – such as Nile flood dates – should also fit into the scheme and assist the formation of a chronology for Middle Kingdom and New Kingdom Egypt. Although most of these data have usually been used within an unreformed calendar in order to bolster the conventional chronology (with limited success), these observations should make some sense in the NC where a reformed calendar is inevitable. Calendar reform is mandated by all the good matches of the lunar dates from el-Lahun.

Theon is credited with stating that a Sothic period was 1460 years, but he also stated that the last Great Sothic Year was dated back from 26 BC (in Augustus' Year 5), thus apparently contradicting Censorinus. Albiruni, an Arabian chronologist (AD 973-1048), supported Theon. He says that Augustus delayed his reform of the Egyptian calendar for five years until the completion of the Sothic cycle in 26 BC. With the beginning of a new cycle, Augustus took advantage of the situation by instituting the new 365+1/4-day year. If the new Great Sothic Year started with the heliacal rising of Sirius in 26 BC, then the old Sothic cycle presumed by Censorinus to have ended in AD 139 is apparently anchored to the wrong date because, with the 1/4-day correction, Sirius would have risen on 20th July every year from 26 BC to AD 139. However, this was not the reality, for it seems that the Egyptian and Alexandrian calendars ran concurrently with the new Augustan calendar, continuing to move out of step with the latter by 1 day every 4 years.

One could propose that the Egyptians reset their civil calendar to ensure the heliacal rising of Sirius would always precede the start of Akhet. In his book *Calendars of Ancient Egypt* Parker suggests that the Egyptians might have intercalated a lunar month if, and only if, the lunar month ended eleven or less days after the heliacal rising of Sirius. The intention would be to maintain the heliacal rising of Sirius in lunar month 12. Did the Egyptians adjust the civil year in order to keep the seasons in order? And was the calendar sometimes reset to align the New Year with an actual inundation event? How can we reconcile this information? What it might mean is that the Egyptians accepted that their calendar started some 41 days after the heliacal rising of Sirius, which equates to 164 years before AD 139. Parker also thought that the calendar was first instituted about 160 years earlier than the date on which I.1 coincided with the heliacal rising of Sirius. This equates to a date at the end of August in the Julian calendar, about the same date on which the inundation would start. I would argue that the Egyptian calendar was reset to a date later in the tropical year, i.e. a date that coincided with the high point of the inundation.[74] My reasoning will become apparent shortly.

The inundation stela of Sobekhotep VIII

If we had evidence for the celebration of a new civil year at an actual inundation, we might be able to determine the frequency and periodicity of calendrical readjustments. We have one such report on the 'Inundation Stela' of Sobekhotep VIII,[75] recording the flooding of Karnak during the epagomenal days of Year 4. This king is likely to have been included in the part of the Turin Canon where names of 4 kings have been lost between Sobekhotep VII and Dudimose. Rohl thus places Sobekhotep VIII in *c.* 1458.[76] The predicted Julian date for I.1 would be 24th August, counting back from the start of the next Great Sothic Year in 1314 BC. Although the validity of the 1314 BC-Sothic cycle must now be in question, the above Julian date for Sobekhotep's visit to Karnak cannot be far out. What is the significance of this date? According to Willcocks and Craig, 12th August (Gregorian) was the average date for opening the canals in the 19th century AD, which is equivalent to 25th August (Julian) in the 15th century BC.[77] So, this date marked the inundation of the land – and therefore the temples. Based on the lunar dating of the 12th Dynasty, the flooding of Karnak witnessed by Sobekhotep would have occurred in June rather than late August – without a calendar reform. An adjustment of about 90 days is thus required to move the epagomenal days of Sobekhotep VIII's Year 4 to the documented event in the inundation period.

The 1419 BC Venus Solution

The placement of Sobekhotep VIII in the mid-15th century is supported by Mitchell's Venus Solution. Assyrian tablets K-160, K-2321 to K-3032 are copies of Old Babylonian texts, which contain lunar and Venus observations over a 16-year period. On K-160 the 'year of the golden throne' is mentioned – known to have been Year 8 of Ammisaduga (the penultimate ruler of Babylon I). Mitchell's analysis of 30-day lunar months on these documents gave the best match when Year 1 = 1419 BC. Other less acceptable matches were obtained for 1483, 1526 and 1702 BC. Since we have a detailed chronology for the Amorite dynasty of Babylonia (Babylon I), we can apply Mitchell's best fit to obtain an independent method for dating Neferhotep I to the mid-16th century BC, because he was a close contemporary of Ammisaduga's ancestor Hammurabi.

In determining the possibility of calendar reform later than Sobekhotep VIII, the problem arises that the calendar may have been abandoned for a period. The 13th and 14th Dynasties were conquered by Asiatics (Hyksos), who may have continued to use a lunar calendar. So was the Egyptian solar calendar abandoned? Redactors of Manetho relate that the Hyksos king Saites added 6 days to the year. Was this to convert a 354-day lunar year to 360-day year? It is also stated that Aseth added a further 5 days. Did this restore the 365-day year by addition of the epagomenal days? Did the contemporary 14th and 17th Dynasty native Egyptian kings continue to use the 365-day calendar?

A 13th Dynasty Sothic date

Darnell and Darnell found a Sothic date of II Shemu day 20 (X.20) on a graffito from Gebel Tjauti.[78] With a 90-day calendrical modification on or before 1245 BC we can have a 17th Dynasty match for X.20 on 13th July 1245-1241 BC. A 90-day shift in the calendar is equivalent to a 360-year deletion from the Sothic cycle. This calendar reform would have occurred after the era of Menophres Sothic date on I.1 which would have fallen on 18th July 1314 BC.

Dating the New Kingdom

A 13th-century calendar reform of 90 days will allow the dates of Amenhotep I to be determined from the putative Sothic date on Papyrus Ebers (i.e. Year 9, XI. 9). The heliacal rising of Sirius would then have fallen on 13th July 1161 BC at Thebes. With Amenhotep I's Year 9 set at 1161-1160 BC, his Year 1 would have been 1169-1168 BC – remarkably close to the date determined by the NC (Year 1 = 1170 BC).

Using these criteria we can search out solutions for the other Sothic dates and the three lunar observations of the New Kingdom period.

As mentioned above, the reign of Akhenaten is dated in the NC to the late 11th century BC by a solar eclipse seen at Ugarit in 1012 BC. This is confirmed, in part, by the dating of the solar eclipse in the reign of Murshili II dated to 984 BC. By implication, Thutmose III – who reigned about 120 years before Akhenaten – would have ruled from about 1130 BC, whilst Ramesses II – who came to the throne some 60 years after Akhenaten – would have reigned about 945 BC.

Dating Thutmose III

There are two lunar dates and possibly one Sothic date for Thutmose III. The Sothic date was observed from Elephantine – year unknown XI.28 – and will now date to 12th July 1081-1077 BC. The first lunar date is associated with the battle of Megiddo in Year 23, whilst the second has to do with the laying of foundations for a temple in Year 24. The first lunar date is Year 23, I Shemu day 21 (IX.21) and the second is Year 24, II Peret day 30 (VI.30). The latter occurs exactly 651 days after the former because the year reckoning is determined by the 24th anniversary of King Thutmose's coronation on IX.4, which falls inbetween the two lunar observations.

According to calculations using Schoch's tables,[79] Redshift and Starry Night, there is one solution for lunar disappearance on Thutmose's Year 23 date (IX.20) – that is 14th May 1121 BC. The second lunar observation of Year 24, VI.30 in the Egyptian calendar was almost 22 months after the previous recording and this lunar disappearance is computed to have been on 23rd February 1119 BC.

The Elephantine Sothic date thus appears to miss the reign of Thutmose III if his Year 1 = 1143 BC. However, if both of the lunar dates were first crescent visibility dates (as Year 23 IX.21 almost certainly was) rather than lunar disappearances, then Thutmose III Year 23 XI.21 = 11th May 1107, and Year 24 VI.30 = 20th February 1105 BC. Year 1 of Thutmose would then have been in 1129 BC – consistent with the Elephantine Sothic date. Thutmose can thus be dated to within 5 years of the NC dates predicted by Rohl.[80]

Dating Ramesses II

The lunar date that pertains to Ramesses II is to be found on Papyrus Leiden where a new moon is dated to Year 52, II Peret, day 27 (VI.27). According to the NC, we should assume that Ramesses' reign started in the mid-10th century BC (as suggested by the 1012 BC date for Year 11 or 12 of Akhenaten).[81] There is then one solution for the Ramesses II lunar date Year 52, VI.27 – the lunar disappearance on 25th December 892 BC, thus dating Ramesses II Year 1 to 943 BC.

Nilotic texts

The calendar reforms suggested above occur at 360-year intervals. The next reform would then have been due in the late-10th to early-9th centuries BC. A series of Nile flood records in graffiti found close to the Valley of the Kings help to suggest when, historically, it may have taken place. There are 5 principal Nilotic texts as shown in Table 5.

Janssen interprets the dates to represent the day on which the waters first flooded the land – usually in mid-to-late-August in the Julian calendar during the late second millennium (Hypothesis 1). David Rohl, on the other hand, suggests that on graffito 882 the verb *hay* usually means 'to go down' and offers the alternative explanation that the dates on the graffiti are when the inundation had started to recede from the high watermark – usually in mid-September to late-October (Hypothesis 2).[82]

The second interpretation would be problematic for the OC because the high point of the inundation would have consistently arrived too early. The Hypothesis 1 dates are mainly in mid-to-late-August with the exception of the alternative reading of graffito 882 – Year 2, II.3 – which would then date to 1st August 883 BC. The fact that these dates encompass the reigns of Ramesses II to Ramesses III would suggest that no such calendar reform could have taken place in this period. On the other hand, if a calendar

		No calendar reform: flood start dates			Calendar reform: flood recedes dates		
Nilotic Text	Egyptian Date	Reign	Julian Date	Year (NC)	Reign	Julian Date	Year (NC)
G.882	Year 1, III.3	Merenptah	31st August	884 BC	Merenptah	29th November +	884 BC
	or Year 2, II.3	Merenptah	1st August*	883 BC	Merenptah	30th October	883 BC
G.856	Year 7, III.5	Merenptah	1st September	877 BC	Ramesses II	16th September	937 BC
G.881d	Year 22, II.5	Ramesses II	14th August	922 BC	Ramesses III	20th October	832 BC
G.1158	Year 18, III.4	Ramesses III	21st August	836 BC	Ramesses II	13th September	925 BC
O.25801	Year 4, III.4	Ramesses III	24th August	850 BC	Ramesses II	16th September	940 BC
		Merenptah	1st September	881 BC			

*Table 5: NC dates derived from Nilotic texts. * = This date is probably too early. + = This date would require a long or late flood.*

reform of 90 days *had* occurred during the 19th Dynasty, the flood dates would *only* make sense within the Hypothesis 2 scheme. In this case, all the dates fall mid-September to late-October as expected.[83]

Third Intermediate Period floods

References to Nile floods during the Third Intermediate Period may provide a method to test the existence of a 19th Dynasty calendar reform. If we work on the assumption that the last calendrical reform took place in the 13th century BC (Hyksos era), the Osorkon II high flood in Year 3 Tybi 12 (V.12) would be recorded in mid-October instead of early August because the NC would reduce the dates of Osorkon by approximately a century (from OC 874 BC down to NC 784 BC). Such a late flood peak would be unusual but not impossible.[84] However, if a subsequent 19th Dynasty calendar reform had taken place after the Hyksos adjustments, then this would place the Osorkon inundation event as late as mid-January – almost certainly impossible. This obviously argues against a 19th Dynasty reform.

However, we might have a problem with the Osorkon III high flood dated to III Peret 22 (VII.22). In the OC (Osorkon III = 787-759 BC) this appears to fall in mid-to-late-September as one would expect. The NC, on the other hand, lowers this Osorkon's dates by about 65 years (down to 720-692 BC) and, as a result, the inundation would have been so long that it persisted until at least late November. Again, floods persisting this long are known but unusual. A calendrical reform in the 19th Dynasty period would place this flood in late February to early March which is, of course, unacceptably late.

The Piankhi flood of the 25th Dynasty, which dates to April in the OC now dates to late July in the NC – early but preferable to the April date of the OC. With a 19th Dynasty calendar reform the Piankhi flood peak would have occurred in late October.

So, on balance of evidence the Third Intermediate Period floods tend to support a 13th century BC Hyksos calendar reform, and argue against an additional 19th Dynasty reform in the late-10th-to-early-9th centuries BC – but the data is not conclusive on this point. It is entirely possible that subsequent kings (perhaps during the late-20th Dynasty) also manipulated the calendar which might then allow for a 19th Dynasty calendrical reform. However, this leads to circular reasoning, and at present I have not uncovered sufficient astronomical or seasonal data from the Third Intermediate Period and Late Period on which to base a further analysis into this aspect of the chronology.

Late calendar reform

If there was no calendar reform at the end of the 10th century, then only one more reform is required – a deletion of 90 days from the calendar at a date earlier than the Canopus decree of 238 BC. Whether this could have occurred during the Assyrian, Persian or Macedonian periods is difficult to tell. It is also obvious that a return to a 354-day lunar calendar (used in Mesopotamia) for as little as 8 to 9 years would have the same net effect. There can be little doubt that the situation with Macedonian (i.e. Ptolemaic) and Egyptian double dates existing concurrently during the third century BC is confusing. Nevertheless, the deletion of 3 months of Shemu or of one month from each season would allow the heliacal rising of Sirius on Payni 1 (X.1) in 238 BC as recorded in the Canopus decree.

With a minimum of 3 calendar reforms – in the 17th, 13th, and between the 8th and 3rd centuries BC – it is possible to match at least 8 out of the 9 putative Sothic dates. The dates on the New Kingdom Nilotic texts, the other inundation dates from the Second and Third Intermediate Periods, and the lunar dates from the New and Middle Kingdoms all fit with an NC model based on calendrical reforms. Thus the hypothesis of a 90-day readjustment to the Egyptian calendar proposed here does support Rohl's New Chronology and enhances its credibility (see Table 6).

Conclusions

(1) Whilst it is possible to look for alternative chronologies, based on the dates I have been able to determine for the 12th Dynasty from the el-Lahun lunar texts, it is quite clear that the high dates offered by the standard Egyptological works are not compatible with the data (see Table 4).

Rohl's New Chronology		Astronomical Dating	
Senuseret III	1701-1683 BC	Senuseret III	1699-1680 BC
Amenemhat III	1682-1636 BC	Amenemhat III	1679-1633 BC
End of 12th Dynasty	1633 BC	End of 12th Dynasty	1630 BC
Sobekhotep VIII	*c.* 1450 BC	Sobekhotep VIII	*c.* 1450 BC
Amenhotep I	1170-1150 BC	Amenhotep I	1169-1149 BC
Thutmose III	1138-1085 BC	Thutmose III	1143-1089 BC
			1129-1075 BC
Akhenaten	1023-1006 BC	Akhenaten	1023-1006 BC
Ramesses II	940-874 BC	Ramesses II	943-877 BC

Table 6: The NC compared to astronomically derived dates.

(2) In contrast, the New Chronology is entirely consistent with the findings of this paper – as can be seen in the overview of comparisons between historical and astronomical dates provided in Table 6. It is important to point out that the majority of the dates in this comparison were derived by entirely different methods.

(3) Whilst this is not definitive proof that the NC is correct, any argument that the astronomical data unequivocally disproves the NC can be rejected.

(4) Of equal importance is the fact that astronomy does not support the OC as many have attempted to maintain.

In summation, most of the astronomical data – particularly the 12th Dynasty lunar dates – simply do not fit with the Orthodox Chronology, whilst the support it gives to David Rohl's New Chronology is nothing less than startling. □

Appendix

Calendrical adjustment and the lunar cycle

The analysis of el-Lahun lunar texts undertaken here implies that a calendrical adjustment was made at some point between the late Middle Kingdom and the middle of the Second Intermediate Period. The results suggest that the Egyptian calendar was recalibrated to the inundation period. This process may have been repeated at approximately 360-year intervals. The Turin Canon, column II (lines 1-5), seems to suggest that the Egyptian lunar year – which was shorter than the civil year by about 11 days – was reset to the civil year by the intercalation of a short 'holy year' of 330 days every 30 years. The result of this resetting is that 30 civil years amounted to 31 holy years. Even so, the system was far from precise since the lunar year alternates between 354 and 355 days. However, it is easy to see that 12 such intercalations would have occurred over a period of 360 years – close to the sort of period after which calendrical readjustment of 90 days would allow the resetting of the civil year to the agricultural calendar.

My suggestion is that any readjustment of the solar calendar relied upon the lunar calendar. Every 19 years, first crescent visibility would fall on the average date of the inundation. The Egyptians must have been well aware of the Metonic cycle because the heliacal rising of Sirius would coincide with a new moon every 19 years. After 19 cycles of 19 years (that is 361 years) the Egyptian calendar would have slipped back some 90 days against this event. To reset the calendar would require the intercalation of 3 calendar months. There are a number of ways that this could have been accomplished – the straight forward addition of 3 extra months onto Shemu; the insertion of 3 extra months into Akhet; a lengthened Peret; or the addition of one extra month onto each season, giving 5 months each to Akhet, Peret and Shemu. While I propose a second 90-day modification of the calendar in the 13th century BC, I can see an alternative mechanism for a 90-day addition to occur. The introduction of a lunar calendar by the Hyksos could have brought about just such a shift. For example 26 x 354.367-day lunar years is approximate to 25 Egyptian years + 90 days, and 129 x 354.36-day lunar years would match 125 Egyptian years + 90 days. The introduction of a 360-day calendar would add complexity, but it would also allow other time spans to be possible – for example 56 lunar years + 9 x 360-day years is equivalent to 63 Egyptian years + 90 days.

Notes and References

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11. L. E. Rose, *JNES* 53 (1994), pp. 237-261.
12. E. Mahler, *ZAS* 40 (1902), p. 79.
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14. J. B. Pritchard: *The Ancient Near East. Vol. I. An Anthology of Texts and Pictures* (Princeton, 1958), p. 179.
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19. D. M. Rohl: *Legend: The Genesis of Civilisation* (*A Test of Time*, vol. 2) (London, 1998) p.23.
20. I. Velikovsky: *Peoples of the Sea* (New York, 1977), p. 227.
21. J. D. Darnell & J. J. Darnell: *Oriental Institute Annual Report 1994-1995.*
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23. E. Hornung: Discussion in *HML?* 3 (1987), pp. 34-6.
24. R. A. Parker, *op cit.* [2], p. 80.
25. U. Luft, *op cit.* [9], p. 76.
26. R. A. Parker, *op cit.* [2].
27. J. G. Reid, *op cit.* [3].
28. In the English transcription these directions are reversed.
29. R. A. Parker, *op cit.* [2].
30. N. Weggelaar & C. Kort: *Discussions in Egyptology* 13 (1989), pp. 79-89.

31. R. Krauss, *op cit.* [8].
32. U. Luft, *op cit.* [9].
33. L. E. Rose, *op cit.* [11].
34. L. E. Rose, *op cit.* [15].
35. L. E. Rose, *op cit.* [15], pp. 245-56.
36. P. James, I. J. Thorpe, N. Kokkinos, R. Morkot & J. Frankish: *Centuries of Darkness* (London, 1991).
37. D. M. Rohl: *A Test of Time: The Bible – From Myth to History*, (London, 1994) & D. M. Rohl, *op cit.* [19].
38. P. James *et al., op cit.* [36], p. 227.
39. C. Torr: *Memphis and Mycenae* (Cambridge, 1896, re-published 1988).
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41. J. J. Collins in T. M. Charlseworth (eds.): *The Old Testament Pseudo-epigraphia*, Vol. II (London, 1985), pp. 889-903.
42. D. M. Rohl, *op cit.* [37], p. 130.
43. D. M. Rohl, *op cit.* [37], p. 371.
44. J. G. Reid, *op cit.* [3].
45. R. A. Parker, *op cit.* [2].
46. C. M. Schoch: *In 'Venus Tablets of Ammizaduga'* (London, 1928), pp. i-xvi.
47. E. Hornung, *op cit.* [23].
48. I heeded the observation made by L. E. Rose, *op cit.* [11], p. 254, 'Only the Sothic date itself would put any kind of damper on our prospects'.
49. R. A. Parker, *op cit.* [2].
50. Lynn E. Rose's also disputes a second millennium Sothic solution for the lunar texts and advocates a first millennium Sothic solution, *op cit.* [15].
51. There is always the possibility that poor seeing has affected some of the dates on D and if we allow for such an occurrence of bad sighting on at least one or two other occasions, we find an increase in the number of possible matches for D. With first crescent visibility this increases the tally from 50 to about 100 potential matches, and with lunar disappearance from 30 to about 70.
52. L. Borchardt, *op cit.* [1]. Date B is derived from a reconstruction and no longer visible on the papyrus.
53. R. A. Parker, *op cit.* [2].
54. I have considered that they belong to Senuseret's reign, but my analysis below shows that they miss.
55. Krauss also gave reductions on 4 other documents – E, F, G and H. The dates on E (Year 9 VII.10) and F (Year 14 II.18) seem to belong to Senuseret III and the dates on G and H are of the fixed *Wag*-feast. These dates require reduction to find the date of first crescent visibility or lunar disappearance. Parker, Krauss and Luft all disagree on the extent of reduction required. It just happens that two movable *Wag*-feast dates were known to Borchardt and Parker and were analysed by the latter. Cairo 58065 (H) from Year 9 of an unknown king records a *Wag*-feast which, according to Parker, always occurred on the 13th day of the lunar month and is dated to day 29 of II Shemu (X.29). Krauss argued that these feasts always happened on day 17 of the month, whilst Luft prefers day 18. I put aside the proposed reductions by Parker, Krauss and Luft and decided to examine these dates separately. Cairo 58065 indicates that the date of the *Wag*-feast actually fell on day 16 in month X. Both of the *Wag*-feasts in that document were dated to the reign of Senuseret III. The feast on X.29 in Year 9 would have occurred on 16th May 1689 BC – 5 days after the full moon. However, the feast on X.17 in Year 18 would be dated to 2nd May 1680 BC – almost 2 days after the full moon. I therefore argue that the Year 18 feast (G) dates from the reign of Senuseret, but that the Year 9 feast (H) is 10 years later in the reign of Amenemhat. This suggests that it was the first crescent visibility which determined the date of the fixed *Wag*-feast and that the feast occured 15 days after the first crescent observation in the lunar month. According to Redshift and Starry Night, the *Wag*-feasts would have fallen 17 or 18 days after lunar disappearance. This hypothesis is also supported by a third *Wag*-feast on Berlin 10065 dated to Year 12 of Senuseret III which is reduced to first crescent visibility on X.7 and lunar disappearance on X.5.
56. U. Luft, *op cit.* [9].
57. R. Krauss: 'Fällt im Illahun-Archiv der 15. Mondmonatstag auf den 16. Mondmonatstag?' in *GM* 138 (1994), pp. 81-92.
58. U. Luft: '"Weil nicht sein kann, was nicht sein darf." Replik einer Kritik' in *GM* 141 (1994), pp. 109-11.
59. L. E. Rose, *op cit.* [15].
60. In a sense I agree with Luft because first crescent visibility would most often occur on lunar day-2.
61. We cannot put much reliance on Berlin 10056A since several dates are mentioned on the papyrus including Year 8 IV.25 and Year 8 IV.26. Luft's suggestion that IV.26 is the date of lunar disappearance cannot be confirmed by the evidence. I put forward the possibility that IV.25 is lunar disappearance and IV.26 is first crescent visibility. I note that had Luft chosen IV.25 as lunar disappearance it would have increased his score by one, U. Luft, *op cit.* [9].
62. D. M. Rohl, *op cit.* [37], p. 339.
63. This proved to be a relatively simple procedure on a Microsoft Excel spreadsheet.
64. Corrections to Schoch calculations from 0 to 480 minutes were investigated in detail. The 1649 BC match was resistant to moderate changes in the Earth's acceleration and actually did better with most current estimates. In contrast, the 1686 BC match was less robust. Increased differences in delta-T beyond 360 minutes have a detrimental effect on the sequence of first crescent visibility dates, but changes of this magnitude are not supported by current theory regarding the deceleration of the Earth's rotation rate. Overall the 1649 match improved when the acceleration rate was increased. Senuseret III Year 5 VI.23 reached first crescent visibility on 12 January 1693 BC, but the date on Berlin 10112 attained first crescent visibility 1 day early. Although Year 30 VI.19 achieved first crescent visibility on 27 October 1649 BC (VI.18) the date is a reconstruction, and VI.18 is an acceptable alternative reading from Berlin papyrus 10056A verso (D). Both dates on text C achieved hits, when a higher acceleration was used giving a maximum tally of 38 hits out of at total of 39 dates. Furthermore, there is consistency with the 'Wag' feasts, which occur 15 days after first crescent visibility.
65. There is one further ramification for the 1649 BC match for Year 31 Amenemhat III. The so-called Sothic date in Year 7 of Senuseret III (?), VIII.16 would now date to 4th March 1691 BC and can no longer be a Sothic date in the traditional sense. but what if it signified some other astronomical event involving the star? One can predict where Sirius would become visible in the sky on the 4th March 1691 BC. This actually occurs at the star's highest point in the sky, i.e., due south as the sunset. On subsequent evenings Sirius would become visible progressively lower and further west in the sky until it vanished from sight in early May. One might speculate that this event involving Sirius, and predicted on Berlin papyrus 10012, also referred to a religious festival that was being planned to celebrate this phenomenon. There can be little doubt that the prediction of this astronomical event by the priests would be an easier undertaking than predicting the heliacal rising of Sirius because they would have had weeks of observations of Sirius and they would have observed that the position where the star first appeared in the evening moves progressively from the east towards the south.
66. J. F. A. Sawyer & F. R. Stephenson, *BSOAS* 33 (1970), pp.467-89.
67. W. A. Mitchell: 'Ancient Astronomical Observations and Near Eastern Chronology' in *JACF* 3 (1990), pp. 18-20.
68. This is generally dated to Year 10, but the eclipse could be earlier i.e. Year 8 of Mursili, discussions with Bernard Newgrosh, Spring 2001.
69. There are other eclipse pairs in the second millennium BC; several are described by W. A. Mitchell, *op cit.* [65], pp. 21-2, but only the 1012 BC eclipse occurs at sunset.
70. D. M. Rohl, *op cit.* [37], Ch. 9.
71. W. A. Mitchell , *op cit.* [66].
72. D. M. Rohl, *op cit.* [37], Ch. 15.
73. K. A. Kitchen: 'The Basics of Egyptian Chronology in Relation to the Bronze Age' in *HML?* 1(1987), pp. 37-55.
74. I acknowledge L. E. Rose's book: *Sun, Moon and Sothis*, conversations with Chris Bennett and some ideas posted by Jon Smyth on the NC web site for prompting me to investigate this possibility further.
75. J. Baines, *Acta Orientalia* 36 (1974), pp. 39-54; D. M. Rohl, *op cit.* [37], pp. 391-92.
76. D. M. Rohl, *op. cit.* [37], pp. 391-92 shows that he can date anywhere between 1572 & 1435 BC.
77. W. Willcocks & J. I. Craig: *Egyptian Irrigation* (London, 1913), p303.
78. J. D. Darnell and J. J. Darnell, *op cit.* [21].
79. S. Langdon, M. A. Fotheringham & C. Schoch, *op cit.* [46].
80. D. M. Rohl, *op cit.* [37], p. 241.
81. W. A. Mitchell , *op cit.* [66].
82. D. M. Rohl response to Kenneth Kitchen, extant on Nunki.net/PerRenput/Reaction/ReplyKitchen.html.
83. Except for the Year 1 reading of graffito 882, which would date to the end of November – late, but long floods were recorded in the 19th century which lasted into December. See W. Willcocks & J. I. Craig, *op cit.* [74].
84. W. Willcocks & J. I. Craig, *op cit.* [74].