Observations of the Moon, Sirius and Solar Eclipses, Dating the Middle Kingdom and New Kingdom in Egypt (Part 2)

David F Lappin, Independent Researcher, Glasgow
lappindf@gmail.com

Part 2: Dating the New Kingdom: Sothic dates, lunar dates and solar eclipse

Controversy has raged ever since the so-called Sothic date on the Ebers medical papyrus was discovered. The difficulties have been many. 1) Is the reading authentic? 2) The era and thus the identity of the pharaoh? 3) The day date; was it day 3, 6, 9, 30 or the day of the new moon? 4) Is it a copy of the civil calendar in use and why does it not mention the epagomenal days or is it a lunar calendar? 5) Is it really a Sothic date? 6) What was the first month of the year when the script was written? 7) Is it proof of a calendar reform? 8) Where was the observation of the heliacal rising of Sirius made? Could reference be to the disappearance or last sighting of Sirius in the evening? For the following discussion and simplicity reference will be to the Heliacal rising of the star, but in reality, this can be replaced with other possibilities and in particular the star's disappearance in May two months earlier in the year which would if the Egyptian calendar remain unaltered place the Sothic dates more than two centuries later than currently accepted. This assessment is geared to look at possible astronomical solutions to locate later dates for the New Kingdom and subsequent Third Intermediate Period. Earlier placements have not been scrutinized and remain possible.

18th Dynasty Sothic and lunar dates

1) Some doubt must be reserved for the authenticity of the reading of the Ebers papyrus, but the reading is now generally accepted that the text should be translated as follows:

"Year-9 under King Deserkare [throne name of Amenhotep I]: Feast of the New [astronomical] Year- = ninth day of the eleventh month [of the civil year] = heliacal rising of Sirius."[1]

2) Difficulties in the reading of the throne name have resulted in assigning of the Papyrus to the 6th Dynasty, but this is not supported by other evidence, such as the 17th Dynasty Sothic date (see above) and the Elephantine Sothic date attributed to Thutmoses III or his successors, because both these references to an event involving Sirius bracket the Ebers papyrus Sothic date.

3) The day date is most likely to be day 9, but Borchardt's claim that it is the day of the new moon is worth investigating[2]. The '*psd*', could it be an abbreviation of '*psdntyw*'. It would be easier to understand the nature of the document if it were a lunar calendar; every month entry could then be interpreted as indicating a new moon festival.

4) The gap between each new moon would vary, being either 29 or 30 days, and it could explain why the epagomenal days are missing from the calendar. It would just mean in such a context that in Year-9 of Amenhotep I the new moon and the rising of, setting

of (or another event (e.g, festival) involving Sirius coincided in III *smw*

5) If the heliacal rising of Sirius had been on day 9 then it would be a useful Sothic date. If it were on the day of the new moon it would be more difficult to use chronologically. However, it can be narrowed down, for every new moon has to fall in an Egyptian civil month, but not on an epagomenal day and in the first half of III *smw* because the heliacal rising of Sirius at Elephantine has to be at least 48 years later and occurred on the 28th day of III *smw* Years 1-10 are excluded because the lunar disappearance cannot occur every month otherwise. In many cases day 11 can also be excluded for the same reason. So, that means the New moon could have been only occasionally on day 11 and on days 12 through 18 depending on the location of the observation of Sirius. That also means that the Elephantine Sothic date (the 10-Jul or 11-Jul) is restricted to between 48 and 88 years after Amenemhat I Sothic date. The helical rising is most likely to have been on the 12-Jul at Thebes, a helical rising at Memphis probably can be excluded. We can search for matching dates for Thutmoses III using three criteria: 1) heliacal rising of Sirius on day 9 month 11, 2) Krauss has suggested that the Ebers calendar can be described as a schematic 'moon-Sothis year' of 12 months, whose New Year's Day fell in the 9th year of Amenhotep I on III *smw* 9 and was especially characterized by the coincidence of the first day of the first moon month (*wpt-rnpt*) and rising of Sirius and 3) the Ebers calendar is a true lunar calendar and the helical rising of Sirius might have coincided with a new moon on the following days (and locations) of month eleven: day 11, through 16 at Elephantine day 11 through 18 at Thebes and would be between day 11 through 25 at Memphis if it were a viable candidate. The first disappearance of the moon could occur on the same morning as the seeing of Sirius or approximately 24 hours before the seeing of the star. Thus, new moons on the 10-Jul are compatible with seeing of Sirius at Elephantine on 10-Jul or on 11-Jul, etc.

6) There is some controversy whether Thoth was the first civil month of the year during the reign of Amenhotep I. Traditional Sothic dating requires it. Menkhet (Phaophi) is the first month on the Ebers papyrus according to some readings[4], if this were the first civil month then it is one month later than one might expect and it would place the Sothic date of Amenhotep I, 120 years later than usually cited. By the 20th Dynasty period Mesore might have been the first month as Hathor appears to be the fourth month[5], but by the late 8th century BC Tekhy (Thoth) was the first month in the civil calendar[6]. The temple of Khnum at Elephantine Sothic date is reported as: "Epiphi, day 28, the day of the festival of the rising of Sothis." Such a shift would allow earlier solutions to be accommodated. One such is a recent solution published by M. Christine Tetley dating Ramesses II to the early 14th Century BC. While this is an invaluable resource for Egyptian Astronomical texts (including details of most included in this article) there are some errors in the calculation of some lunar dates attributed to Ramesses II (in particular the Ptah-south of the wall dates—see below for details). If the Helical rising during the reign of Amenemhat I was in Mesore, unless there was a 30 day calendar reform prior to the Elephantine Epiphi day 28 rising of Sirius the Ebers calendar date would apparently post-date the Elephantine Stele date that is unless as suggested by Krauss[8] that the month name on the Ebers calendar is attached to the lunar month.

7) The Ebers papyrus calendar has been reported to be evidence of a calendar reform[9] the recent finding of a 17th Dynasty Sothic date makes this less certain[10].

The following results are dependent on first line of the Ebers papyrus calendar reading:

"Year-9 under King Amenhotep I: Feast of the New astronomical Year-= ninth day of the eleventh month of the civil year = heliacal rising of Sirius."

8) Memphis[11], Thebes[12], and Elephantine[13] have all been suggested to be place where the heliacal rising of Sirius was observed during the 12th Dynasty. Thebes and Elephantine appear to be the most likely candidates during the 18th Dynasty.

9) Variation in the length of Thutmoses II reign; alternate reign lengths have been proposed for Thutmoses II. Two sets of alternatives have been proposed: 1) a 3-year reign and 2) a 14-year reign, largely because the candidates are consistent with lunar disappearance dates for Thutmoses III in Year-23 and Year-24 and the helical rising of Sirius on Year-9 III *smw* 9 of Amenhotep I. There is no certainty that either is correct. If Borchardt was correct all along that the Beer's calendar was a lunar calendar and each entry referred to the day of the new moon and not day 9 then reign lengths of 1, 4, 6, 7, 9 or 12 years are also possible for Thutmoses II. These lunar date candidates will have to be investigated separately.

Candidate lunar dates for Thutmoses III between 1500 and 1100 BC are based on: A) the helical rising of Sirius at i) Elephantine or ii) Thebes, on day 9 of Month 11 in Year-9 (Year-9.III *smw* 9) of Amenhotep I, with the first Thutmoses III lunar date following I) 49 years or II) a 60 years later (there are a few occasions when the heliacal rising of the star) happens on the same day as lunar disappearance or on the day of the last visible crescent moon); B) the heliacal rising occurs on the same date as the heliacal rising of Sirius at i) Elephantine or ii) Thebes and is followed by the first Thutmoses lunar date after III) 47, IV) 50, V) 52, VI) 55 and VII) 58 years, respectively. This analysis allows for calendrical modification, that is, we cannot precisely fix the calendar by Sothic dating techniques and relies purely on the date of the heliacal rising of Sirius. An important consideration here that might exclude Memphis is that if the Beer's papyrus date is a Memphite observation of the heliacal rising of Sirius the Elephantine Stele Sothic date could not be from the reign of Thutmoses III if it occurred on day 9 of III *smw* as there would have to be a period of about 104 ± 3 years between both observations rather than the 84 ± 3 years required for the Theban observations or the 76 ± 3 years for Elephantine observations. With the short reign possibilities for Thutmoses II a Theban Sothic date would fall in the final years of Thutmoses III.

Lunar disappearance coincides with the heliacal rising of Sirius on about 110 occasions between the 1500 BC and 1100 BC, but they only match lunar dates for Thutmoses III on 46 occasions when the new moon and the rising of Sirius are on day 9 of III *smw* in Year-9 of Amenhotep I. On 21 occasions, the combined observation is possible at Memphis, 13 occasions at Thebes and 12 from Elephantine. If Thutmoses II had a 14-year reign, it was found that the data does not support Krauss suggested date for the coincidence of the new moon and the rising of Sirius at Elephantine in 1506 BC since only one Thutmoses III lunar dates matches. The Year-23 I *smw* 21 date falls on the correct date, but Year-24 II *prt* 30 is two days too early; lunar disappearance is not until III *prt* 2, had it been on III *prt* 1 it would have been acceptable. However, Krauss' candidate does match when Thutmoses II is allocated a 3-year reign. This study largely supports Krauss' analysis of the New kingdom lunar dates[14] while the first of Thutmoses dates the Megiddo date I *smw* 20 not I *smw* 21 to 8-May 1457 BC). Furthermore, the second lunar date is II *prt* 30 (17-Feb 1455 BC) and not III *prt* 1 at Karnak.

If the Beer's calendar were a true lunar calendar of alternating 30-day and 29-day lunar months the lunar disappearance and rising of Sirius would have to coincide with dates between day 11 and day 18 of III *smw* As stated earlier heliacal rising on days 11-through 16 are compatible with Elephantine observations. Later month dates require shorter reign length for Thutmoses II for example day 11 means that the Elephantine Sothic date was 64-71 years later than the Ebers calendar Sothic date; day 16 implies an Elephantine date about 44-51 years later.

Matching lunar dates with the evening disappearance of Sirius

The solution could be so much easier if for example the 18th Dynasty Sothic dates did not identify the heliacal rising of Sirius in July, but the setting of the star in May. This solution may have been suggested by Cecil Torr, but had fallen out of favour. Indeed, papyri, ceiling calendars and water clocks from the New Kingdom and late period[15] appear to contradict such a proposal, but this remains a contentious issue. They are thought tentatively to be lunar calendars linked to the seasons and only loosely connected to the civil calendar. While a lunar calendar with an appropriate number of intercalary months resets to the seasons, the Egyptian civil year moved inexorably out of touch. The required calendar shift would be two lunar months. The Ebers papyrus date would place the date in the early 13th century BC. A Sirius setting date if observed during the reign of Thutmoses III would have been recorded about 50-60 years later. Potential solutions do not require a dramatic change in the Sothic calendar. This is a major focus in a series of investigations. Because of the ease of determining a series of candidates is reduced and will be presented before the generally accepted interpretation.

In contrast with the heliacal rising dates more northerly observations of the star's setting date earlier in the month that is the length of the disappearance is longer ranging from 55 days in the south to 70 days in the north. The number of setting dates occurring on the lunar disappearance date or prior to the first crescent visibility date between 1300 BC and 1270 BC numbers three and are Lunar disappearance on 17th May 1287 BC, 13th -14th May 1281 BC and 12th May 1270 BC with observations at Elephantine, Thebes and Memphis respectively.

18th Dynasty Chronology

The aim was to determine the minimum and maximum period that elapsed between Year-23 of Thutmoses III and Year-52 of Ramesses II for which there is a lunar date. Unfortunately, the Medinet Habu Sothic date is too vague regarding the day of the month and the king in power when the observation was recorded. Two approaches have been taken the first to accept that the heliacal rising of Sirius was intended and the second that it was the setting of the star that was recorded, by far an easier prospect since the Eber's calendar would not date earlier than the very early 13th century BC if observations had been made at Elephantine, see above.

As with Thutmoses III lunar dates the analysis is split into three, based on the interpretation of '*psd*' on the Beer's papyrus calendar and the Sirius observation site.

In Table 2-1 is shown the reign length in years. Periods of co-regency or possible periods of co-regency are also indicated. A tally of the shortest possible reign lengths is given, as is a tally of the dates following Year-9 of Amenhotep I.

The reign lengths of the early 18th Dynasty rulers are documented on 19th Dynasty period texts *e.g.*, the Turin canon, etc., they are fairly well understood, but serve only as a guide and these are shown in Table 2-1 & Table 2-2; as certain of the later monarchs, *i.e.*, those associated with the Amarna period: Akhenaten, Neferuneferuaten (Nefertiti?), Smenkhkare Tutankhamen and Ay were not included on the official canon by their 19th Dynasty successors. There is still some controversy surrounding the reign of Thutmoses II he is generally given 14 years[16] but the highest year on any texts is Year-1. He may have reigned little more and 3 years is often given him[17].

There is a possibility that Amenhotep III might have had Akhenaten, his son, as a co-regent for as many as 12 years, but the evidence for this is unclear. In which case there could be 12 additional years to be accounted for. A shorter co-regency period has also been suggested lasting one or two years. The length of time Neferuneferuaten and/Smenkhkare reigned is also in doubt but is thought generally that they reigned no more than a year after the death of Akhenaten. Tutankhamen certainly ascended the throne as a child and until recently was thought to be still in his teens when he died. More recent analysis of his dentition, etc., suggests that he lived until his early twenties.

18 Dynasty Ruler	**Years**	**Cum. Total**	**Additional? & Co-regency**		From yr-9 Amenhotep I	
Ahmose I	**25**	25			-34	
Amenhotep I	**21**	46	**-2**		10	12
Thutmoses I	**12**	58	**+1**		22	24
Thutmoses II	**14**	72	**-13 to -2€**		23	38
Hatshepsut$	**22**	94			45	60
Thutmoses III	**32**	126		**22**	77	92
Amenhotep II	**33**	159		**2**	110	125
Thutmoses IV	**10**	169			120	135
Amenhotep III#	**38**	207			158	173
Akhenaten	**5**	212		**12**	163	188
Neferuneferuaten (Nefertiti ?)	**<1**	213	**-1**	**5**	163	189
Smenkhkare	**>1**	214		**2**	164	190
Tutankhamen	**9**	223			173	199
Ay	**4**	227			177	203
Horemheb*	**14**	236	**+15?**	**30**	191	232
Ramesses I	**2**	238		**1**	193	234
Seti I	**11**	249	**+4**	**0**	204	249
Ramesses II to Year-52	**51**	300			255	300
			Total 74			
Amenhotep to Ramesses	Ebers pap. Sothic to Year-52 lunar date				**255 -**	**300**
Thutmoses to Ramesses	Year-23-Year-52 Lunar date				**200 -**	**261**

Table 2-1: 18th and early 19th Dynasty

@ Plus or minus 1 year
€ Thutmoses II may have ruled 1, 3,4, 6, 9,10, 12 years or (as often given) 14 years.
$ Hapshepsut was regent for Thutmoses III for about seven years before she assumed full royal powers.
# Amenhotep III might have had Akhenaten as co-regent for 1,2 ,6, 8 or 12 years and the latter Smenkhkare or Neferuneferuaten (Nefertiti?) for 2-5 years.
* Horemheb might have reigned as long as 29 years after Ay & may have laid claim to rule the period from Akhenaten' coregency period to Ramesses I that is 59 or 60 years.

There is uncertainty about the length of reign of Horemheb. The 'Mes inscription' attributes a reign of at least 59 years to Horemheb. It is not supported by other documents, which seem to support a shorter reign less than 30 years and about 14 is generally accepted. However, in his reign he took it upon himself to destroy all previous references to the Amarna period, and the immediate successors of Akhenaten, with the consequence that their reigns were allocated to Horemheb. This could explain the high total[18]. Ramesses I, his successor reigned for almost 2 years but the last year was in co-regency with Seti I. There is also a degree of uncertainty about the reign of Seti I, 11 years at least. It could have been longer. I have included an additional 4 years where it seems necessary. Ramesses II then reigned for 66 years. The period in the table (Table 2-1) shown for Ramesses II is until Year-52.

Ramesses II lunar date Year-52 II prt 27

However, in accord with references to the Medinet Habu (19th or 20th Dynasty) Sothic date *II 3ht*, it appears that the calendar was not modified between the 17th and 19th Dynasty. The Year-52 II *prt* 27 lunar date appeared on a ship log at Piramesse and circumstances might dictate that the observation was premature. Certainly, this appears to be what the traditional 1228 BC dating suggests since lunar disappearance in 1228 BC was on II *prt* 28. However, this has no real basis in fact.

The Ramesses II Piramesse lunar date in Year-52 should fall not much later than about 300 years after AmenhotepI; allowing 12 additional years to Akhenaten, an additional 20-50 years to Horemheb with the possibility that Seti I ruled independently for 15 years and must by reckoning fallen in middle to late December. This concept is supported by the Nilotic graffiti, which probably precludes a shift in the calendar of more than 30 days. One assumes graffito G.1158 dates from year 2 *II 3ht* 5 Ramesses II and dates to early August (Julian). Two graffiti G.882 & G.856 from year-1 *III 3ht* 3 (possibly year-2 *II 3ht* 3) and year-7 *III 3ht* 5 Merenptah would be mid to late August (*II 3ht* 3 = mid to late July) and the ostracon (O.) 25801 and graffito G.881d both record *III 3ht* 4 in year-4 and year-18, respectively, presumably of Ramesses III equivalent to dates early to mid-August. As these are seasonal dates relating to the flooding of the Nile they tend to argue against a major reduction of the dates of the 19th and 20th Dynasty without disrupting Sothic dating.

There are potentially 3 additional lunar dates for Ramesses II. The first is a graffito from Deir el Bahri (II *smw* 22) day of the lunar month uncertain, but Krauss thinks it might be lunar day 1 or 2 but finds it is lunar day 3. The second (*IIII smw* 24) and third (II *prt* 25) are from Saqarra appear to be dates of the feast of Ptah-south of the wall and are lunar day 4 dates according to Krauss[19] or day-14/15 (full moon) according to Borchardt[20]. However, Borchardt was not aware of the III *smw* 27 Accession date for Ramesses II which makes the suggestion untenable unless there is an error in the year of the Piramesse (year-52) lunar date.

It is possible that the Beer's calendar contained a description of an Elephantine observation date (heliacal rising date 10-Jul or 11-Jul) and whereas a Memphis observation (17-Jul or 18-Jul) seems unlikely, an observation made at Thebes (12-Jul or 13-Jul) is the most likely. This would equate to dates in May for Sirius setting dates and reverse the order. The possible matches for Ramesses II Year-52 II *prt* 27 are between 13-Dec to the 3-Jan. The data suggest a period of about 200 years between Year-23 of Thutmoses III and Year-52 of Ramesses II.

Allowing for flexibility, of one additional day, for the recording of the heliacal rising of Sirius at either Elephantine or Thebes and even Memphis we can estimate the number of potential candidates for the Thutmoses III lunar Year-23 lunar date. By increasing the analysis to heliacal rising date + 1 day means that one might also consider Krauss' suggested interpretation of Thutmoses III lunar dates[21]. As well as the 24.II *prt* 30 date one might consider III *prt* 1 as lunar day 1[22] in combination with 23 I *smw* 21 the Megiddo lunar date. In the analysis these then should match Ramesses II lunar disappearance date on 52 II *prt* 27. However, while 23. I *smw* 21 is a viable candidate 24.III *prt* 1 seems less likely as the festival associated with the foundation date appears to be celebrated on the same day and that is Lunar day 1[23].

Since two potential dates are feasible depending on acceptance or rejection of Faulkner's hypothesis there are on average 8 (4-12) potential candidates per century over 380 years, *i.e.*, about 30 and 4, 6 or 8 possible candidates between Amenhotep I and Thutmoses III for each of three observation positions and the reign length of Thutmoses II (totaling 18). The different candidate year length is actually calculated from the lunar cycle. Later III *smw* dates for coincidence of lunar disappearance and the heliacal rising of Sirius are only possible from Memphis. Observations from Elephantine, Thebes and Memphis are compatible with a reign length of 3, 6, 9 or 14 years for Thutmoses II; a reign of 1 year and 12 years are also feasible for data derived from Theban and Memphis observations and a reign length of 4 years and 10 years for Thutmoses II might be possible for Memphis observations. Each parameter increases the number of candidates to give an estimate of around 550. Fortunately, the other lunar date candidates for Thutmoses III in Year-24 is more precise and allows us to whittle down the number to about 40% of this total. Once the Year-52 Ramesses II lunar date is factored into the analysis the number drops slightly and about 180 sets of dates emerge. The reason there is not a greater dropout is due to the uncertainty concerning the length of the period covering the late 18th Dynasty and the early 19th Dynasty (see Table 2-1) and the acceptance of near misses. The lunar data allow for periods of 200 years (short) 215-225 years (Medium) and 240 years or greater (long) between Year-23 of Thutmoses III and Year-52 of Ramesses II.

As more evidence as to the absolute period between the end of the 18th Dynasty and the reign of Ramesses II becomes clear the number of candidates will be reduced considerably.

Not all possibilities are shown and minor variations of each of the models might more closely match reality. Overall, with the chronological information that is available, the candidates that support a period of about 200 years between Thutmoses Year-23 and Ramesses Year-52 appear most likely unless that is if the Mes inscription can be taken as authentic, *i.e.*, when it refers to Year-59 of Horemheb which would extend the period.

Dealing with chronology based on the alternate hypothesis that Sothic references are to the setting of Sirius is a much easier concept as the event has to be later than 1292 BC and that leaves a fairly narrow window in which to place the 18th and 19th Dynasties. Also, because it is likely that the Egyptian calendar would still be in operation with or without calendar reform makes it easier to tease out a set of potential contenders for the likely accession dates for Amenhotep I, Thutmoses III and Ramesses III among others[24]. While it seems likely that the Sothic date will be associated with a lunar phenomenon it is unclear what that was. It is likely either to be the full moon or a date associated with the new moon either the lunar disappearance or the first crescent visibility.

To fine-tune the possible candidates one can use the reference to a potential Solar eclipse on Tablet Bo-4802 usually dated to Year-10[25], with the distinct possibility that the eclipse occurred around Year-8[26] of Murshili II king of the Hittites. Given that Murshili lived some 140-150 years later than Thutmoses III; Murshili was a contemporary of Horemheb and a near contemporary of Ramesses II and Seti I. There are 25 solar eclipses over Anatolia, 16 are potentially visible between 1350 BC and 950 BC, which are shown in Table 2-3. The following low magnitude eclipses on 20 May The start of Murshili's reign more probably coincides with that of 1) Ay and Horemheb and less likely also with 2) Tutankhamen. In the first case, If Horemheb's reign was short then Murshili and Seti I were also contemporary in the second case Murshili would be contemporary with Tutankhamen, Ay and Horemheb. As the highest attested year for Murshili was Year-26. The eclipse was observed from Central Northern Anatolia when Murshili was on campaign against Azzi and Hayasa which he did in Year-7, Year-8 and Year-10 according to the Annals. 1078 BC, 30 Sep 1131 BC, 26 Aug 1315 BC, 17 Oct 1328 BC, 13 Mar 1335 BC, and 15 Jul 1360 BC, according to my calculations occur when the altitude of the sun is too high for atmospheric refraction or thin cloud or hazy conditions to assist in the visualization of the eclipse. Of the 16 best eclipse candidates, only seven are very likely to have been seen and of these, three would be extremely unlikely to have been missed. The probability of observation is indicated in Table 2-3 by the showing the more easily observable candidates in the larger bolder text.

One other consideration is the dating of the eclipse. It is associated with a military campaign to the north east of the Hittite heartland in the vicinity of Trabzon. This has two impacts on the dating of the event. The time of the year in which the eclipse should have occurred and the year in which it happened during the reign of Murshili II.

Although it has been suggested by Huber[27] and others that the eclipse occurred in Year-10, It has been assumed that Newgrosh's reasoning placing the eclipse in Year-8 also make sense. Perhaps the eclipse was as early as late Year-7, which would be compatible with an eclipse in autumn. However, only a few of the dates (these are underlined in the tables) would actually be upset if a return to a Year-10 dating were found to be correct after all. At this point no conclusion about the time of the year in which the eclipse occurred can be drawn. Military activity in this area was generally restricted to the late spring through late summer, but not exclusively. The Year-7 account refers to a campaign starting in late summer against Azzi when Murshili records that he reached the border at the city of Ura possibly sacking the city. The rest of the account is missing, but a major attack on Azzi does not appear to have proceeded, why is unknown. If the eclipse occurred late in the year and did coincide with a Year-7 date, was an eclipse seen as a bad omen? Would it provide an explanation for the halt in the campaign that year? Only later after divination, was the eclipse associated with the fate of the queen. A further campaign against Azzi probably occurred in Year-8, however the annals for that year are too damaged and fragmentary to draw any definite conclusion. Inferring that the campaign in Year-8 was restricted to the summer cannot be proven, but seems likely, but whenever it took place it also seems to have been aborted because Anniya king of Azzi promised concessions, *i.e.*, to return Hittite subjects to Hattusas; a position he was opposed to in Year-7. Were these concessions made because Murshili again made a move towards Azzi? One can only speculate. The concessions made by Anniya were not kept and a further campaign was required. This did not occur until Year-10, since in Year-9 Mushili was otherwise preoccupied by a number of personal misfortunes including the death of his wife and his brother. According to the Year-10 account, Murshili's campaign started in spring and lasted most of that year. The Azzians did not meet Murshili in on the battlefield, they retreated to their citadels and although the Hittites attacked only two, after they successfully captured Aripasa, which was on a rocky promontory on the Black Sea, the other city under siege, Duskamma, surrendered to Murshili. Murshili then appears to have returned to Hattusa for the Festival of the Year, which was held in the winter months at Hattusa.

Ramesses II was contemporary with the sons and grandsons of Murshili II namely Muwattali II, Hattusili III & Murshili III and Tudhaliya IV. Therefore, the eclipse must have occurred: 1) between 17 to 47 years before the reign of Ramesses II or 2) between 25 and

55 years before Ramesses II as the reign of Murshili II is unlikely to commence 1) before Year-3 of Ay or 2) before Year-3 of Tutankhamen assuming letters to and from Suppiluluma (his father) 1) post-date Tutankhamen or 2) predate Tutankhamen, respectively as his brother Arnuwanda appears to have reigned almost 2 years.

Once the constructs in Table 2-2 are transcribed into dates and compared with the Murshili eclipse candidates (Table 2-3) in more detail some things become much clearer. Some sets of matching Thutmoses III and Ramesses II lunar dates cannot be matched with a Solar eclipse; others will only match the less likely to be observed Solar eclipse candidates. In total about 95 Thutmoses III /Ramesses II lunar date sets are compatible with a solar eclipse candidate. Of these 40 would rely on a Memphis observation of the heliacal rising of Sirius during the reign of Amenhotep I and for that reason might be excluded as unlikely since the early 18th Dynasty capital was at Thebes. Others are excluded because poor seeing of much of the lunar cycle would be required.

No.	Date	(BC)	Eclipse details $ *	Ramesses II Yr-52 range (BC)
1	8-Jan	1340	Total **	1273 to 1243
2	24-Jun	1312	Total	1245 to 1215
3	13-Apr	1308	Magnitude 0.66 at sunrise	1241 to 1211
4	5-Mar	1223	**Magnitude 0.94, Hattusa;** 0.99, Trabzon	1156 to 1126
5	**16-May**	**1208**	**Magnitude 0.97 annular**	**1141to 1111**
6	7-Jul	1146	Magnitude 0.50 at sunset	1079 to1049
7	23-Feb	1138	Magnitude 0.98 **(annular)** at Hattusa	1071 to 1041
8	29-May	1106	Magnitude 0.30 at sunset	1039 to 1009
9	18-May	1105	Magnitude 0.27 at sunrise	1038 to 1008
10	**18-Mar**	**1075**	**Magnitude 0.88 at Hattusa**	**1008 to 978**
11	**23-Oct**	**1068**	**Total**	**1001 to 971**
12	**30-May**	**1060**	**Magnitude 0.95 annular**	**993 to 963**
13	31-Aug	1055	Magnitude 0.20 at sunrise	988 to 958
14	**21-Jun**	**1024**	**Magnitude 0.89 at sunrise**	**957 to 927**
15	30-Apr	984	Magnitude **0.93,Hattusa;** 0.97,Trabzon[s]	917 to 887
16	2-Aug	979	Magnitude 0.35 at sunrise	912 to 882

Table 2-3: Candidates for (Tablet Bo-4802) Murshili Year-10 solar eclipse

$ Eclipses conform to the ST95 = Stephenson & Morrison (1995) Spline curve for an estimate of the Earth's apparent acceleration

* Not all of the eclipses are total or near total, but it is felt that large partial eclipses at sunrise and sunset are potentially observable.

s Also a near sunset solar eclipse.

** The more likely the eclipse is to have been observed or fit with the timing of the military campaigns of Murshili II the bolder the text.

Comparison of lunar dates with the Hittite solar eclipse candidates Heliacal Rising of Sirius 'Sothic' dates

The Illahun lunar dates (Table 1-2, and Table 1-3) appears to preclude matching Thutmoses lunar dates earlier than the 14th Century BC and Ramesses II dates earlier than the 12th Century BC. Otherwise, the 13th and 14th century dates for Ramesses II and Thutmoses III, respectively can be supported by the analysis of the New Kingdom astronomical data. The main assumptions in forming Table 2-4 are that the Ebers medical papyrus contained a schematic calendar and that the heliacal rising of Sirius was not necessarily on day-9 in III *smw* and that the Egyptian calendar had been reset to follow the seasons causing a dislocation from the traditional view that it was not modified.

To be compatible with the reduced dates suggested for the 12th Dynasty the earliest dates should be compatible with the Solar eclipse of 5-Mar 1223 BC. A further 15 potential candidates for Year 1 of Ramesses II from the early 13th to the late 12th centuries can be excluded. There remain only 18 dates between the late 12th and late 10th centuries; ten are governed by an observation of the heliacal rising of Sirius at Elephantine and eight from Thebes (Table 2-4). The finding of the Ebers papyrus at Thebes might favour this location as the place from which Sirius was observed, but the result is not conclusive and less favoured in more recent calculations.

It is accepted that interpretation that Tablet Bo-4802 described a Solar eclipse could be disputed and that this would render the selection of the data to match such a phenomenon moot. Therefore, promising solutions were not rejected on this selection only.

The matches on Table 2-4 are lunar disappearance dates.

The results show that year-1 dates cluster in the 13th Century for Thutmoses III and in the 11th century BC for Ramesses II with a reduction of more than 200 years from traditional dates. A reduction of this magnitude could be justified if the Sothic Dates referred to the disappearance of the star in May. Sirius disappears for about 70 days in the north of Egypt and at least for 55 days in the very south. In the Egyptian calendar this would equate to a period of between 220 and 280 years.

If we adopt the notion that the 17th -18th Dynasty Sothic dates were related to the disappearance of Sirius and assume the Egyptian calendar ran true this would place Amenhotep I Sothic date in the early 13th century BC, Thutmoses III in the second half of the same century and Ramesses II somewhere in the middle of the 11th century BC. As described above this analysis is a far easier prospect as it restricts the range of possible solutions before further refinement would be required. On the downside the relationship with ceiling calendars and water clocks may present an obstacle, if they are civil calendars rather than lunar or seasonal calendars.

Key to Table 2-4:

OS = Observation site of the rising of Sirius: T=Thebes; E= Elephantine.

HR & LD = Egyptian dates on which heliacal rising of Sirius and lunar disappearance coincide otherwise the heliacal rising date is III *smw* 9

Am = Amenhotep I,

Th = Thutmoses III

Th E = Elephantine 'Sothic date' attributed to Thutmose III

Rm = Ramesses II

Ms SE year = Solar eclipse year attributed to Murshili II Year-7, 8 or 10

† Dates are all BC.

$ The earliest compatible Elephantine 'Sothic' date
*Italicized dates require rejection of Faulkner's hypothesis that the lunar disappearance in Year-23 Thutmoses III was I *smw* 20 that means I *smw* 21 was selected.

When the Thutmose III year-24 date falls on the less favoured alternative day, is indicated.
Underlined dates will only match a Year-7 or 8 eclipse; the others will match an eclipse in Year-8 or -10 for eclipses in the first half of the Year-7 or -10 for eclipses late in the year.

OS	Hr & LD	Am Year-9	*III smw* 9	Years	Th Year-23	*I smw* 20	Th Year-24	*II prt* 30*	Th E	Rm Year-52	*II prt* 27	Ms SE Year
E	*III smw 10*	1414	11 Jul	63	1351	7 May	1349	15 Feb[X]	1330	1133	19 Dec	1223
E	*III smw 9*	1354	10-Jul[h]	60	1294	7-May	1292	15-Feb	1278	1065	17-Dec[-1]	1138
T	*III smw 9*	1349	13-Jul [h]	49	1300	13-May	1298	22-Feb	1262	1060	21-Dec	1138
T	***III smw 16***	**1262**	**5-Jul**	**58**	**1204**	**2-May**	**1202**	**11-Feb[X]**	**1202**	**989**	**16-Dec[-1]**	**1068**
E	***III smw 18***	**1251**	**2-Jul**	**47**	**1204**	**2-May**	**1202**	**11-Feb[X]**	**1202**	**989**	**16-Dec[-1]**	**1068**
E	***III smw 12***	**1251**	**7-Jul**	**52**	**1199**	**6-May**	**1197**	**15-Feb**	**1186**	**981**	**19-Dec**	**1068**
T	*III smw 9*	1186	12-Jul[h]	60	1126	9-May	1124	17-Feb	1102	897[±]	20-Dec	984
E	*III smw 14*	1175	5-Jul	55	1120	3-May	1118	12-Feb	1118	891[§]	14-Dec	984
T	*III smw 18*	1167	3-Jul	47	1120	3-May	1118	12-Feb	1118	891[§]	14-Dec	984
T	*III smw 9*	1167	12-Jul[h]	49	1118	12-May	1116	20-Feb	1086	903	26-Dec	984
OS	**Hr & LD**	**Am Year-9**	***III smw* 9**	**Years**	**Th Year-23**	***I smw* 21**	**Th Year-24**	***II prt* 30**	**Th E**	**Rm Year-52**	***II prt* 27**	**Ms SE Year**
T	*III smw 9*	*1422*	*12-Jul* [h]	*60*	*1362*	*10-May*	*1360*	*17-Feb*	*1330*	*1158* [¥]	*26-Dec*	*1223*
E	*III smw 9*	*1403*	*10-Jul*	*49*	*1354*	*11-May*	*1352*	*18-Feb*	*1330* [$]	*1136* [#]	*23-Dec*	*1223*
E	*III smw 12*	*1327*	*7-Jul*	*52*	*1275*	*7-May*	*1273*	*15-Feb*	*1260*	*1057*	*20-Dec*	*1138*
E	***III smw 14***	***1270***	***5-Jul***	***55***	***1215***	***4-May***	***1213***	***12-Feb***	***1214***	***997***	***16-Dec***	***1068***
E	***III smw 9***	***1270***	***10-Jul***	***49***	***1221***	***10-May***	***1219***	***18-Feb***	***1194***	***992*** [†]	***20-Dec***	***1068***
T	***III smw 9***	***1262***	***12-Jul***	***49***	***1213***	***12-May***	***1211***	***20-Feb***	***1178***	***984****[@]	***22-Dec***	***1068***
T	***III smw 9***	***1262***	***12-Jul***	***60***	***1202***	***10-May***	***1200***	***17-Feb***	***1178***	***984****[@]	***22-Dec***	***1068***
E	***III smw 9***	***1251***	***10-Jul***	***49***	***1202***	***10-May***	***1200***	***17-Feb***	***1174***	***984****[@]	***22-Dec***	***1068***
E	*III smw 9*	*1194*	*11-Jul* [h]	*60*	*1134*	*9-May*	*1132*	*16-Feb*	*1114*	*905* [$]	*19-Dec*	*984*

Table 2-4 New kingdom candidates for dates (BC) of the heliacal rising of Sirius on the Ebers calendar, Thutmoses III lunar dates & 'Sothic' date and the Ramesses II lunar date matched with high magnitude solar eclipses visible from central or northern Anatolia

Underlined dates require a Year-7 or Year-8 Solar eclipse.

h Heliacal rising of Sirius at the end of lunar day 1 on the other occasions the rising of Sirius would coincide with lunar disappearance.

X This may be positively incorrect observation and the lunar disappearance date possibly was II *prt* 29. However, the thin crescent is almost at sufficient elevation to have been observed. Otherwise one could attribute poor seeing and a 29 day month starting II *prt* 1 recorded as 30 days.

-1Alternative Ramesses II 52 II *prt* 27 lunar disappearance (LD) dates or LD-1 (-1) dates.

¥ One lunar cycle later on 19-Dec 1133 BC, # 11 years later on 21-Dec 1125 BC and 25 years later on 17 Dec 1111 BC, @11 years later on 20 Dec 973 BC $ 11 years later on 17 Dec 894 BC, ± one lunar cycle later on 13 Dec 872 BC (LD-1), †14 years later on 17 Dec 978 BC, 1 lunar cycle later on § 8 Dec 866 BC.

First the solar eclipse candidates between 1138 BC and 1024 BC are potentially compatible with the reduced dates in this data set with eclipses in the 11 century BC being more likely.

With reference to previous arguments, it was assumed that the three 18th Dynasty Sothic dates describe Sirius' western setting closely associated with a lunar phase such as lunar disappearance, etc. While the Star may have disappeared on other than III *smw* day-9 it was observed readily that there was set of obvious candidates on that date. No matter, it confines Amenhotep I to no earlier than 1292 BC.

The lunar disappearance (LD1) would be noted in the morning just before dawn just prior to the Egyptian calendar date, which was called lunar day 1, whereas Sirius could have vanished the evening before or on the evening of LD1, LD2, etc. At Elephantine, the star would have disappeared in the evening about the 14 May. Exceptional clear atmospheric conditions may have allowed sightings for a further day or two, but it is probably unlikely. Earlier Accession dates for Amenhotep I, etc., would require a calendar change as described for the constructs in Table 2.4.

Setting of Sirius 13C	**Elephantine** 14-15-May, **Thebes** 12-13-May & **Memphis** 8-9-May. **(Dates BC)**		
Amenhotep I 9 III *smw* 9	1278-1258 **11-May 1270 (LD-1)*** **or 12-May 1274 (FM)**	1285-1265 **14 May 1277 (FM)**	**1275-1255#** **8-May 1267 (LD-1)**
Thutmoses III 23 *I smw* 20/*21* 24 *II prt* 30	**1229-1175** **7/*8*-Mar 1207 (LD1)†** **17-Dec 1206 (LD1)**	**1243 1189** ***11-Mar 1221*(LD-1)** **21- Dec 1220 (LD1)**	**1226-1172** **4-Mar 1204 (LD1)** **14-Dec 1203 (LD2)**
Sothic date *III smw* 28 *Lost-* *Sothic date 33 IIII smw 2*	**14-May 1208 (LD-1)** y 22 **15-May 1197 (LD2)**	**14-May 1208 (LD-1)** y 36 **19-May 1211‡**	**14-May 1216 (LD1)** y 11 **13 May 1194 (LD2)**
Ramesses II 52 *II prt* 27	**1043-987** **21-Oct 992 (LD-1)**	**1079-1013** **30-Oct 1028 (LD)** **1068-1002** **27-Oct 1017 (LD-1)**	**1040-984#** **18-Oct 989 (LD-1)**
Bo-4802	**1068 Solar E**	1106/5 Solar E	**1068 Solar E**

Table 2-5 18th Dynasty Sothic dates based on the evening disappearance of Sirius, the Thutmoses III year-23 and Piramesse (Ramesses II year-52) lunar dates

*LD =lunar disappearance, LD-1= last visible crescent, FCV = First crescent visibility, FM =full moon

† Very near hit as the crescent within the upper error zone might suggest a potential sighting on 23 *I smw* 20 but otherwise count (7 -Mar 1207 BC) as LD1 nevertheless the moon is definitely invisible on 23 *I smw* 21 (8-Mar) the acceptable alternate and both suggest that = Sirius setting date on 15-May 1197 BC could be the lost Sothic date 33 *IIII smw* 2.

This set requires a +2-day calendar shift.

‡ Hypothetical Sothic date - not acceptable!

Table 2.5 Shows of possible solutions with 'Sothic dating' based on the setting of Sirius in May rather than the heliacal rising of the star in July. Dates that coincide with lunar disappearance, first crescent visibility or the full moon are shown but it is acknowledged that the date of Sirius' absence from the evening sky in May would have been observed between the 8th May at Memphis about 4 or 5 days later at Thebes and 6 or 7 days later at Elephantine give or take a day. The 1068 BC solution for Ramesses II is exact on only 1 of 3 lunar dates, but acceptably early on two of the disappearance dates, the 1043 BC solution is a day early on Ramesses II year-52 date but exact on the other two dates. The 1040 BC solution which also early on the Piramesse lunar date also appears to miss out on Thutmoses III year-24 II *prt* 30. It is a near miss, but it would have required exceptional vision for the observation to be made of a thin crescent moon on II *prt* 29. This lunar month was 29 days long and extreme good vision or a sighting error extending it to 30 days is conceivable.

Matching sets of Ebers papyrus 9 III *smw* 9, Elephantine III *smw* 28, the 'lost Sothic date' 33 *IIII smw* 2 the lunar dates of Thutmoses III year-23 & year-24 and Ramesses II year-52 lunar dates are shown in Table 2-5. Higher dates for Thumoses III (year-1 1279) are theoretically possible to match with the 1068 BC Ramesses II solution but only if the Ebers papyrus is not a true Sothic date. They do fit with the 17th Dynasty Sothic date (II *smw* 20, c1374-1367 BC) but would relegate the III *smw* 28 Sothic date to Amenhotep II and the 33 *IIII smw* 2 date, cannot follow but as it is no-longer verifiable, could be ignored.

Other Lunar Dates

In addition to the Illahun lunar texts and the lunar dates of Thutmoses III and Ramesses II many other lunar dates are published in the literature, which are attributable to the period between the 5th Dynasty and the 22nd Dynasty. Many of these have been reviewed and discussed at length by Krauss[28]. Other than those described above, there are several others that may be useful to define the chronology of the Middle and New Kingdoms. Third Intermediate Period (TIP) lunar dates are also available, but are outside the scope of this analysis.

	Year-34 *IIII smw* 24	Year-47 *II prt* 25		Year-34 *IIII smw* 24	Year-47 *II prt* 25		Year-34 *IIII smw* 24	Year-47 *II prt* 25
Year-1	Lunar day	Lunar day	Year-1	Lunar day	Lunar day	Year-1	Lunar day	Lunar day
			1279	4 0*	4 0			
			1209	5 +1	4 0			
1187	7 +3*	7 +3				*1184*	*5 +1*	*4 0*
						1162	*6 +2*	*7 +3*
			1116	5 +1	5 +1			
			1111	*4 0*	3 -1			
1079	5 +1	4….0						
1068	4 0	3 -1						
1048	6 +2	5 +1						
1043	**4 0**	**4 0**						
1040	**4 0**	**4 0**						
1040	**4 0**	**4 0**	**1040†**	**4 0**	**4 0**			
1035	*6 +2*	*5 +1*	*1024*	*3 -1*	*4 0*	*1010*	*7 +3*	*6 +2*
1035	*6 +2*	*5 +1*	*1024*	*3 -1*	*4 0*	*1010*	*7 +3*	*6 +2*
1035	*6 +2*	*5 +1*	*1024*	*3 -1*	*4 0*	*1010*	*7 +3*	*6 +2*
1032	**6 +2**	**4 0**						
956	7 +3	6 +2	*945*	*6 +2*	*5 +1*			
954	5 +1	4 0	940	7 +3	5 +1			
948	6 *+2*	4 0	931	6 *+2*	6 *+2*			
942	5 *+1*	7 *+3*	931	6 *+2*	6 *+2*			
942	5 *+1*	7 *+3*				923	6 +2	5 +1

Table 2-6 Analysis of the Saqqara Ptah-south of his wall festival dates days in the lunar month matched with Year-1 dates for Ramesses II (BC)

Dates in black are based on Sirius' heliacal rising dates.
Dates in blue are based on the star's disappearance dates.
*Lunar day error difference from the required lunar day 4 for the festival.
† Two days out of step with the traditional Sothic calendar. This would occur if there were 2 leap years added before or during the Hellenistic period.

One example that may be of use is on Papyrus Saint Petersburg 1116A. It records that the grain harvested from Amenhotep II Year-18 was allocated to be brewed on II *smw* 6 in Year-19 or Year-20 for consumption on lunar day 1, a few days later. That means that the particular lunar day 1 in II *smw* was near day 10 of the civil month in Year-19 or Year-20 and about 45 to 50 years after Thutmoses III Year-24 lunar date. Two patterns emerge: 1) the beer was prepared in Year-19 and lunar disappearance was on II *smw* 11 (44%), II *smw* 12 (54%) or II *smw* 13 (2%) and there was a 2 Year-4 month co-regency between Thutmoses III and Amenhotep II; 2) the beer was prepared in Year-20, lunar disappearance was on II *smw* 8 (12%), II *smw* 9 (45%) or II *smw* 10 (33%) and there was no co-regency between Thutmoses III and Amenhotep II.Possibly of more use chronologically in this analysis is the Small Amarna Temple dedication dated to Year-5. *IIII prt* 13 of Akhenaten, which might have coincided with or preceded a foundation ceremony on lunar day 1. It could have been on the same day, that is on 5 *IIII prt* 13 or the next day on 5. *IIII prt* 14[29]. If this is indeed a lunar date, then Year-1 of Akhenaten is between 126 to 137 years after Thutmoses III Year-1. With the period of 127 years, co-regencies between Thutmoses III and Amenhotep II &/or Amenhotep III and Akhenaten require to be considered. If there were no co-regencies during the period, then the 137 year span might be more appropriate.

When the data are analysed, 39% of the lunar disappearances occur on *IIII prt* 13, 59% on *IIII prt* 14 and 2% on *IIII prt* 15 (a near miss). If we give credence to one rather than the other interpretation, then some the data sets can be excluded.

Ramesside lunar dates

Of importance in this investigation are a set of Nilotic graffiti that are compatible with the candidates for Ramesses II listed in Table 2-4. They have to be interpreted differently with those in Table 2-5. because there approximately a two-month shift in the events that we think were recorded by the graffiti[30]. The only explanation is that they record something else. The suggestion is the start of the flood rather than when it was beginning to retreat.

Of more practical use are sets of Ramesside lunar dates, principally those from Saqqara and dated to the reign of Ramesses II and other late 19th Dynasty and 20th Dynasty lunar dates from Deir el-Bahri that are useful for testing the remaining candidates. Until more is known of the fine chronology of the period there is little to recommend one solution over another with this limited analysis. This is not surprising given the uncertainty as to the absolute reigns and relative relationship of many of the late New Kingdom Kings. However, as stated above the most useful of the additional dates given by Krauss are the 'Feast of Ptah-south of the wall' dates from Saqqara. He has argued convincingly that the feast of fell on lunar day 4[31], although this might appear to be an assertion based on the match with the 1228 BC Piramesse lunar date. The first, dated 34 *IIII smw* 24 and the second 47 II *prt* 25 were as Krauss stated, lunar day 4.

However, a 1228 BC Piramesse lunar date is a negatively incorrect error; an apparent early recording of the lunar disappearance of the moon on II *prt* 27 (19 Dec 1228 = lunar day 30). Extensive analysis of the lunar cycle shows that if II *prt* 27 was lunar day 1 on 20 Dec 1228 BC, and then the lunar dates from Saqqara dated to Ramesses II Year-34 and Year-47 would both be lunar day 5. Even if Krauss has it wrong, what is likely is that they should be the same day of the lunar month and that it should be near lunar day 4, so could be day 3, day 4, day 5 if we allow for negative or positive seeing error. If we assume they cannot possibly be lunar day 1-2 or lunar day 6-30 we can use the information to reduce the number of potential candidates.

If the Saqqara lunar dates are truly day 4, there are only three strong contenders remaining for Year-1 Ramesses II. However observational errors or erroneous assumptions expand the number of contenders for year 1 Ramesses II: 1209 BC, 1184 BC, 1116 BC, 1111BC, 1079 BC, 1068 BC 1040 BC, 1026 BC and 954 BC.

Other data sets

Although there are several alternatives for Thutmoses III and the Piramesse lunar dates that match the lower magnitude eclipse candidates for the Tablet Bo-4802 solar eclipse these have been eliminated following attempts to match with the lunar dates for Ramesses II (from Saqqara) and the late 19th Dynasty and 20th Dynasty lunar dates from Deir el Bahri (Data not shown, but none of these putative alternatives appear to give satisfactory results for the Saqqara or Deir el Bahri data). However, the method used is described below.

Three possible chronologies can be found to fit with the Ebers papyrus 'Sirius setting' Sothic date (Table 2-5). It is virtually impossible to place an earlier candidate for year-23 Thutmoses III in 1257 BC, which would also be compatible with a year-1 Ramesses II in 1068 BC but not with a possible contender for Ramesses year-1, 11 years earlier in 1079 BC., in context with a Ebers papyrus Sothic date without a severe contraction of the early part of the 18th Dynasty. There is an alternative for the 1068 BC year-1 Ramesses II solution and that is a match with a later set of Thutmoses dates in the same cycle as the 1043 BC solution with a contraction of the later part of the 18th and early 19th Dynasties to match year-1 of Ramesses II in 1068 BC. This is at the expense of Horemheb and Seti I. With the 1043 BC and 1040 BC year-1 Ramesses solutions this is not required, and both fit comfortably with the longer versions of both king's reigns. Note that the 1040 BC solution requires a two-day shift in the Egyptian calendar. Addition of two leap years prior to the common era would bring about such a result.

The fact that one of the 1040 BC solutions is two days out of step with the traditional Sothic based Egyptian calendar prompted me to look at a match with first crescent dates also. The Pirammese FCV would be incorrect. The Thutmoses III year-23 date matches the predicted FCV, but the year 24 date would be one day later than FCV. Both Ramesses II year-34 and year-47 Saqqara day-4 dates only fit if counted from first crescents.

If it is assumed that there was no change in the Egyptian calendar between the Ebers Sothic date and the last of the Ramesside kings of the 20th Dynasty, it is possible to identify a sequence of dates based on several graffiti in the Djeser-akhet temple at Deir el Bahri: DB 3, DB 9, DB 10, DB 32 & DB 31. According to Krauss the dates should be attributed as follows: DB 3 is Year-7 Twosre, II *smw* 28; DB 9 is Year-6 Siptah, III *smw* 9; DB 10 is Year-7 Ramesses III or Year-7 Ramesses VII, III *smw* 9; DB 32 is Year-3 Ramesses IV, II *smw* 20 and DB 31 is either Year-22 Ramesses II or Year-22 Ramesses XI and dated to II *smw* 22.

There are certain limitations in using these dates since the dates cannot be tied specifically to some of the individual kings, but it should be possible to show what structures are possible astronomically. Krauss submits that these dates were either lunar day 1 or lunar day 2 but demonstrated that they are mainly lunar day 2. There is no-reason they could not be lunar day 3 instead, but they should all be on the same lunar day. The Year-I candidates that did not match the sequence were excluded.

Part 1 Based on Helical rising dates and a reset of the Egyptian calendar to fit the seasonal changes. The day of lunar disappearance =lunar day 1.

Year-1 =1209 BC

DB 9 = Year-6 Siptah, *III smw* 9 = 28-Apr 1122 BC = lunar day 3.
DB 3 = Year-7 Twosre, *II smw* 28 =16-Apr 1121 BC = lunar day 3.
DB 10 = Year-7 Ramesses III, *III smw* 9 = 25-Apr 1111BC = lunar day 3.
DB 32 = Year-3 Ramesses VI, *II smw* 20 = 27-Mar 1073 BC = lunar day 3.
DB 31 = Year-22 Ramesses II, *II smw* 22 = 27-Apr 1187 BC = lunar day 3 or
DB 31 = Year-22 Ramesses XI, *II smw* 22 =15-Mar 1015 BC = lunar day 2.
<u>5 hits or 1 hit, 4 misses.</u>

Year-1 =1184 BC
DB 9 = Year-6 Siptah, *III smw* 9 = 21-Apr 1097 BC = lunar day 2/3. This is a near miss on 19-Apr and more likely to be lunar day 3 than day 2.
DB 3 = Year-7 Twosre, *II smw* 28 =10-Apr 1096 BC = lunar day 2.
DB 10 = Year-7 Ramesses III, *III smw* 9 = 19-Apr 1086 BC = lunar day 2.
DB 32 = Year-3 Ramesses VI, *II smw* 20 =21-Mar 1048 BC = lunar day 3.
DB 31 = Year-22 Ramesses II, *II smw* 22 = 21-Apr 1162 BC = lunar day 4 or
DB 31 = Year-22 Ramesses XI, *II smw* 22 = 9-Mar 990 BC = lunar day 2.
<u>3 hits, 2 misses</u>

Year-1 =1116 BC
DB 9 = Year-6 Siptah, III smw 9 = 19-Apr 1029 BC = lunar day 3.
DB 3 = Year-7 Twosre, II smw 28 = 8-Apr 1028BC = lunar day 2
DB 10 = Year-7 Ramesses III, III smw 9 = 17-Apr 1018 BC = lunar day 2.
DB 32 = Year-3 Ramesses VI, II smw 20 = 19-Mar 980 BC = lunar day 3.
DB 31 = Year-22 Ramesses II, II smw 22 = 19-Apr 1094 BC = lunar day 4 or
DB 31 = Year-22 Ramesses XI, II smw 22 = 7-Mar 922 BC = lunar day 1.
2 hits, 3 misses

Year-1 =1111 BC
DB 9 = Year-6 Siptah, *III smw* 9 = 22-Apr 1024 BC = lunar day 1.
DB 3 = Year-7 Twosre, *II smw* 28 = 12-Apr 1023 BC = lunar day 2
DB 10 = Year-7 Ramesses III, *III smw* 9 = 20-Apr 1013 BC = lunar day 2.
DB 32 = Year-3 Ramesses VI, *II smw* 20 = 22-Mar 975 BC = lunar day 2.
DB 31 = Year-22 Ramesses II, *II smw* 22 = 22-Apr 1089 BC = lunar day 3 or
DB 31 = Year-22 Ramesses XI, *II smw* 22 = 10-Mar 917 BC = lunar day 1. The moon on 9-Mar 917 BC had an altitude of 9.7 deg and difference in azimuth to the sun of 19 deg at sunrise and should have been visible. A missed observation would result in II *smw* 22 being recorded as lunar day 2.
<u>3 hits, 2 misses</u>

Year-1 = 1040 BC (+2 lunar month fit)
DB 9 = Year-6 Siptah, *III smw* 9 = 18-Apr 953 BC = lunar day 2.
DB 3 = Year-7 Twosre, *II smw* 28 = 7-Apr 952 BC = lunar day 2.
DB 10 = Year-7 Ramesses III, *III smw* 9 = 16-Apr 942 BC = lunar day 2.
DB 32 = Year-3 Ramesses VI, *II smw* 20 = 18-Mar 904 BC = lunar day 2.
DB 31 = Year-22 Ramesses II, *II smw* 22 = 18-Apr 1018 BC = lunar day 2 or
DB 31 = Year-22 Ramesses XI, *II smw* 22 = 6-Mar 846 BC = lunar day 1/2. The moon on 5-Mar 846 BC had an altitude of 9.1 deg and difference in azimuth to the sun of 20 deg at sunrise and could have been visible. An easily missed observation would result in II *smw* 22 being recorded as lunar day 2.
<u>5 hits.</u>

Year-1 = 1024 BC

DB 9 = Year-6 Siptah, *III smw* 9 = 21-Apr 937 BC = lunar day 2.

DB 3 = Year-7 Twosre, *II smw* 28 = 10-Apr 936 BC = lunar day 2

DB 10 = Year-7 Ramesses III, *III smw* 9 = 19-Apr 926 BC = lunar day 1/2. On the 18-Apr 926 BC the moon had an altitude of 10.1 deg and difference in azimuth to the sun of 15 deg at sunrise and should have been visible. A missed observation would result in III *smw* 9 being recorded as lunar day 2

DB 32 = Year-3 Ramesses VI, *II smw* 20 = 21-Mar 888 BC = lunar day 2.

DB 31 = Year-22 Ramesses II, *II smw* 22 = 21-Apr 1002 BC = lunar day 2 or

4 hits, 1 miss.

Year-1 = 954 BC

DB 9 **=** Year-6 Siptah, *III smw* 9 = 28-Apr 867 BC = lunar day 3, a near miss for lunar day 2. The moon was in lower extinction zone on 26-Apr 867 BC.

DB 3 = Year-7 Twosre, *II smw* 28 = 16-Apr 866 BC = lunar day 1

DB 10 = Year-7 Ramesses III, *III smw* 9 = 25-Apr 856 BC = lunar day 1.

DB 32 = Year-3 Ramesses VI, *II smw* 20 = 27-Mar 818 BC = lunar day 2.

DB 31 = Year-22 Ramesses II, *II smw* 22 = 26-Apr 933 BC = lunar day2.

2 hits, 3 misses.

Part 2 Sothic dating where the reference is to the May disappearance of Sirius from the evening sky. The day of lunar disappearance =LD1

Year-1 =1079

DB 9 **=** Year-6 Siptah, *III smw* 9 = 2-Mar 992 = lunar day 3

DB 3 = Year-7 Twosre, *II smw* 28 = 19-Feb 991= lunar day 2

DB 10 = Year-7 Ramesses III, *III smw* 9 = 28-Feb 981 = lunar day 1

DB 32 = Year-3 Ramesses VI, *II smw* 20 = 30-Jan 943 = lunar day 3.

DB 31 = Year-22 Ramesses II, *II smw* 22 = 1-Mar 1057 = lunar day 3.

1 hit, 4 misses or 3 hits & 2 misses.

Year-1 =1068

DB 9 = Year-6 Siptah, *III smw* 9 = 28-Feb 981 = lunar day 2.

DB 3 = Year-7 Twosre, *II smw* 28 = 16-Feb 980 = lunar day 2

DB 10 = Year-7 Ramesses III, *III smw* 9 = 25-Feb 970 = lunar day 1.

DB 32 = Year-3 Ramesses VI, *II smw* 20 = 27-Jan 932 = lunar day 1.

DB 31 = Year-22 Ramesses II, *II smw* 22 = 27-Feb 1046 = lunar day 2.

3 hits, 2 misses.

Year-1 = 1043

DB 9 = Year-6 Siptah, *III smw* 9 = 21-Feb 956 = lunar day 2.

DB 3 = Year-7 Twosre, *II smw* 28 = 10-Feb 955 = lunar day 2

DB 10 = Year-7 Ramesses III, *III smw* 9 = 19-Feb 945 = lunar day 2

DB 32 = Year-3 Ramesses VI, *II smw* 20 = 21 Jan 907 = lunar day 2.

DB 31 = Year-22 Ramesses II, *II smw* 22 = 21 Feb 1021 = lunar day 2.

5 hits.

Year-1 = 1040 (2 day calendar shift)

DB 9 = Year-6 Siptah, *III smw* 9 = 18 Feb 953 = lunar day 3.

DB 3 = Year-7 Twosre, *II smw* 28 = 6-Feb 952 = lunar day 2

DB 10 = Year-7 Ramesses III, *III smw* 9 = 16-Feb 942 = lunar day 1

DB 32 = Year-3 Ramesses VI, *II smw* 20 = 18 Jan 904 = lunar day 2.

DB 31 = Year-22 Ramesses II, *II smw* 22 = 18-Feb 1018 = lunar day 2.
3 hits, 2 misses.

Of the late contenders for year-1 of Ramesses II, overall, the 1040 BC (+2 lunar month shift) and 1043 BC (Sirius setting Sothic date) = Ramesses II year-1 are the best solutions with 9 out of 10 dates matching the predicted lunar observations with suitable dates for the Heliacal rising or Evening setting of Sirius, respectively, that match the predicted Egyptian calendar dates within a modified Sothic dating scheme.

Comparing different chronologies

The lunar dates used in support of Ramesses II and Thutmoses III in the Orthodox Chronology are as expected to be in agreement, but they appear to be too early in light of the 12th Dynasty dates based on matching the Illahun texts with the retrocalculated lunar disappearance dates to the early 17th Century BC. This is supported by the lunar dating and Venus cycle (VS 1483 –1462) data that place the end of the 1st Dynasty of Babylon in the late 15th Century BC. So, it would appear that dates for Amenehotep I before 1430 BC are unlikely.

If we refer to the information in Table 2-4 the earliest candidates that suggest that the 18th Dynasty and 19th Dynasty can be dated between 70 and 15 years later than the Orthodox dates. These are both 'Elephantine and Theban' data sets. They differ on the length of reign one can attribute to Thutmoses II: 3 years 6 or 14 years (Table 2-4). However, the data generally show that there would have been co-regency between Amenhotep III and Akhenaten. However, these dates do not sit well with the Saqqara lunar dates of Ramesses II (Table 2-6) or the Deir el Bahri lunar dates and can thus be disregarded. The data sets that reduce the chronology by 200-240 years appear to match the lunar observations better.

In line with James et al. (1991)[32] suggested reduction in the chronology there are no fewer than seven possible accession dates for Ramesses II ranging from 1068 BC to 1010 BC. However only three are acceptable when the Saqqara "Feast of Ptah-south of the wall" dates are considered,1068 BC, 1043 BC and 1040 BC, which match two or three, respectively, sets of Amenhotep I and or Thutmoses II and Thutmoses III accession dates. However only three are acceptable when the Saqqara "Feast of Ptah-south of the wall" dates are considered,1068 BC, 1043 BC and 1040 BC, which match two or three, respectively, sets of Amenhotep I and or Thutmoses II and Thutmoses III accession dates. Of the three sets the 1043 BC one of the better sets provide with the data assuming the Egyptian calendar was correct, and no leap years inserted this can be replaced with the 1068 BC year-1 date by assigning Horemheb and Seti I their shortest possible reigns. The 1068 BC sequence does poorly on the Deir el Bahri lunar dates. It also fails to match a High magnitude Hittite (Mursilis II) eclipse. Although I have preferred this to match the data it does not justify rejecting the 1068 BC accession date for Ramesses II. As stated above the 1043 BC sequence works with the 1068 BC eclipse candidate so long as it occurred in year-10 of Murshilis II.

The 1040 BC date as a potential candidate was arrived at in two ways 1) a two Egyptian month shift (actually 58 days slightly less than two Egyptian calendar and two lunar months) to match the helical rising of Sirius or by the insertion of two days (leap years into the Egyptian calendar) to match with the Sirius setting dates. The 1040 BC year-1 date solutions matched the lunar sequence particularly well when the calendar date shifted by the insertion of a radical calendar 58 day shift to allow the aligning of the seasons and allow the heliacal rising of Sirius to be observed. All the dates can be correct (except the Year-52 date). The alternate 1040 BC candidate required insertion of two leap years into the Egyptian calendar this was placed in the 3rd Century BC.

Year-1 (BC)	1068	1043*	1040*				Hittite A	Hittite B
Pharaoh/model	1068	1043	1040a	40b	40c	King	1043, 40a	1040 b,c
Amenhotep I	1285	1277	1279	1274	1275			
Thutmoses I	1264	1256	1259	1253	1254			
Thutmoses II	1252	1244	1247	1241	1242			
Hatshepsut	1243	1230	1237	1227	1227			
Thutmoses III	1221	1208	1215	1205	1204			
Amenhotep II	1189	1176	1183	1173	1172			
Thutmoses IV	1156	1143	1150	1140	1139			
Amenhotep III	1146	1133	1140	1130	1129			
Akhenaten	1108	1095	1102	1092	1091			
Neferuneferuaten	1103	1090	1090	1087	1086			
Smenkhkare	1102	1089	1089	1086	1086	Suppiluluma I	1101	1098
Tutankhamen	1101	1088	1088	1085	1085	Arnuwanda II	1079	1076
Ay	1092	1079	1079	1076	1076	Murshili II*	1077	1074
Horemheb	1088	1075	1075	1072	1072	Muwatalli II	1051	1048
Ramesses I	1073	1060	1057	1057	1057	Murshili III	1028	1025
Seti I	1071	1058	1055	1055	1055	Hatusili III	1021	1018
Ramesses II	1060	1043	1040	1040	1040	Tudhaliya IV	991	988

Table 2-7 Provisional Chronology: Year-1 dates for Amenhotep I to Ramesses II with a compatible Hittite chronologies for Suppiluluma to Tudhaliya IV based on 1068 BC eclipse.

*Compatible with a 1068 BC Eclipse in year-10

New Kingdom calendar reform

It seems unlikely that there were major calendrical reforms throughout most of the New Kingdom period *i.e.*, late 17th Dynasty, 18th Dynasty, 19th Dynasty and possibly not until the end of the 20th Dynasty. Dating of Ramesses II Year-52 II *prt* 27 to 19-Dec 1228 BC, although it is a negatively incorrect date, is compatible with Sothic dating and a 13th Dynasty 88-day calendar readjustment, but not with 17th century -12th Dynasty dates. A Year-52 lunar date in the late 12th century would be compatible with a difference in the Sothic calendar of approximately + 30 days and would have required an adjustment of approximately 120-days between the 12th Dynasty and 17th Dynasty. A shift of + 30 days might have some support in the literature because, as suggested above it appears that during the 18th Dynasty that Menkhet might have been the first month of the civil year rather than the name of the lunar month, only being changed to Thoth at some later date[33]. The reason for rejecting this suggestion was discussed earlier.

For example, among the alternative modifications of the calendar: the 13th and 14th Dynasties were conquered by Asiatics (Hyksos). So, was the Egyptian Solar Calendar abandoned? It is possible. The introduction of a lunar calendar into Egypt by the Hyksos can bring about just such a shift of about 90 days very easily. 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 civil year? It is also stated in Manetho that Aseth added 5 days[34]; did this restore the 365-day year? This all happen prior to the 17th Dynasty. Whether this affected the Egyptian civil calendar is moot. Obviously for some of my deductions above to work calendar reform or changes would be required. A calendar shift of approximately two months allows for the middle to late 11th century solutions for Ramesses II to follow the traditional Egyptian calendar. In the case of 1040 BC, to be precise, the difference is 58 days almost two lunar months. This might explain the poorer lunar match obtained with traditional dates because seasonal differences do affect the lunar sequence slightly. The simplest to explain would be the temporary introduction of a leap year on at least two occasions as necessitated for one of the 1040 BC Ramesses year-1 solutions. It has been argued by Lynne Rose that the Canopus decree may be at least one attempt to add at least one leap year[35]. However, this is not required if first crescents were the preferred lunar phase for timing various festivals during the New Kingdom. It appears at least to be true for the 12th Dynasty. Such considerations can be ignored for the 1068 BC or the 1043 BC Ramesses II year-1 solutions as this match the traditionally derived Egyptian dates, but only the second of these two solutions will fit with Thutmoses III lunar dates.

Notes:

1. Long 1974: 266.
2. Borchardt 1935: 19.
3. Krauss 1992.
4. Courville 1971: 60-62.
5. Courville 1971.
6. MacNaughton 1932: 249.
7. Tetley.
8. Krauss 1992.
9. Goodwin 1873: 107.
10. Darnell and Darnell 1996.
11. Borchardt 1899.
12. Parker 1977.
13. Luft 1992.
14. Krauss 2007: 401–402.
15. Clagett 1995; 193-200; Depuydt 1996.
16. Shaw and Nicholson. 1995.
17. von Beckerath 1997.
18. Rowton 1946.
19. Krauss 2007.
20. Borchardt 1934: 97–98, 100 n. 9. But these do not match accession date of III *Smw* 27 for Ramesses II.
21. Krauss 2007: 420–421.
22. Wente 1975: 265–272.
23. von Beckerath 1986: 146-148; Krauss 2007: 420-421.
24. Conversations with Ad Thijs have been invaluable and assisted in pinpointing 1068 BC as a potential candidate year for the accession of Ramesses III.
25. Forrer 1930: 1–2; Mitchell 1990.
26. In discussions with Bernard Newgrosh. A full account of Newgrosh's reasoning is now published in Newgrosh 2007.
27. Huber 2001: 640–644.
28. Krauss 2007.
29. Wells 1987: 313–333.
30. Janssen 1987 : 129–136.

Nilotic grafitti & ostracon

G.1158	Ramesses II	year-22	II *3ht* 5
G.882	Merenptah	year-1	III *3ht* 3
G.882	Merenptah	year-2	II *3ht* 3
G.856	Merenptah	year-7	III *3ht* 5
O.25801	Ramesses III	year-4	III *3ht* 4
G.881d	Ramesses III	year-18	III *3ht* 4

31. Krauss 2007: 418–419.
32. James *et al.* 1991.
33. Courville 1971.
34. Waddell.
35. Rose 1999: 129–130.

Bibliography:

VON BECKERATH, J. 1997. "Chronologie des Pharaonischen Ägypten." In: *Münchner ägyptologische Studien* 46, pp. 201–202.

BORCHARDT, L. 1899. "Der zweite Papyrusfund von Kahun und die zeitliche Festlegung des mittleren Reiches der agyptischen Geschichte." In: *Zeitschrift fur Agyptische Sprache und Alterthumskund*e XXXVII, pp 99–101.

BORCHARDT, L. 1934 "Einige astronomisch festgelegte Punkte zweiter Ordnung im Neuen Reiche." In: *Zeitschrift für Ägyptische Sprache und Alterthumskunde* LXX, pp. 97–103.

BORCHARDT, L. 1935. *Quellen und Forschungen zur Zeitbestimmung der Agyptischen Geschichte. B and 2: Die Mittel zur Zeitlichen Festlegug von Punkten der ägyptischen Geschicte und Ihre Anwenilung.* Kairo, Selbstverlag.

CLAGETT, M. 1995. *Ancient Egyptian Science Vol 2: Calendars, Clocks, and Astronomy*. Philadelphia, American Philosophical Society.

COURVILLE, D. 1971. *The Exodus Problem and Its Ramifications*. Vol. II. Loma Linda, Crest-Challenge Books.

DARNELL J.D. and DARNELL, J.J. 1996. *Oriental Institute 1993–1994 Annual Report.* Chicago, University of Chicago.

DEPUYDT L. 1996. "The Function of the Ebers Calendar Concordance." In: *Orientalia* 65, pp. 74–77.

FORRER, E. 1930. *Die astronomishe festlegung des Soppilulujomas, Morsilis und Amenophis IV, Foorschungen* II/I. Band, 1. Heft. Berlin, Eigenverlag

GOODWIN, C. 1873. "Notes on the calendar in Mr. Smith's papyrus." In: *Zeitschrift für Ägyptische* 11, 107–109

HUBER, P.J. 2001. "The Solar Omen of Mursilis II." In: *Journal of the American Oriental Society* 121: 640-644.

JANSSEN, J. 1987. "The Day the Inundation Began." In: *Journal of Near Eastern Studies* 46, pp. 129–136.

KRAUSS, R. 1992. "Das Kalendarium des Papyrus Ebers und seine chronologische Verwertbarkeit." In: *Ägypten und Levante* 3, pp. 75–96.

KRAUSS, R. 2007. "Lunar Dates." In: HORNUNG, E., KRAUSS, R. and WARBURTON, D. (eds.). *Ancient Egyptian Chronology*. Handbook of Oriental Studies. Section 1. The Near and Middle East, Volume 83. Leiden/Boston, Brill, pp. 401-402

LONG, R. 1974. "A Re-examination of the Sothic Chronology of Egypt." In: *Orientalia* 43, pp. 261–274.

LUFT, U. 1992. *Die Chronologishe fixierung des aegyptischen Mittleren Reiches nach dem Tempelarchiv von Illahun.* Vienna, Austrian Academy of Sciences.

MACNAUGHTON, D. 1932. *A Scheme of Egyptian Chronology*. London, Luzac & Company.

MITCHELL, W.A. 1990. "Ancient Astronomical observations and near eastern chronology-The case for Venus solution 1419 BC." In: *Journal of the Ancient chronology Forum* 3, pp. 7–26.

NEWGROSH, B. 2007. *Chronology at the Crossroads, the Late Bronze Age in Western Asia,* Leicester, Matador.

TETLEY, M.C. *The Reconstructed Chronology of the Egyptian Kings*. Onerahi, Whangarei, New Zealand, Barry W. Tetley.

JAMES, P., THORPE I.J., KOKKINOS N., MORKOT R. & Frankish J. 1991. *Centuries of Darkness*, London, Jonathan Cape Ltd.

ROSE, L.E. 1999. *Sun, Moon and Sothis*. Deer Field Beach, Kronos.

ROWTON, M. 1946. "Mesopotamian Chronology and the 'Era of Menophres'." In: *IRAQ* 8, pp. 94–110.

SHAW I. and NICHOLSON P. 1995. *The Dictionary of Ancient Egypt*. London, The British Museum Press.

WELLS, R.A. 1987. "The Amarna M, X, K Boundary Stelae Date: A Modern Calendar Equivalent." In: *Studien zur Altägyptischen Kultur* 14, pp. 313–333.

WENTE E.F. 1975. "Thutmose III's accession and the beginning of the New Kingdom." In: *Journal of Near Eastern Studies* 34, pp. 265–272.