Towards an Absolute Chronology for Ancient Egypt

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I. Absolute Chronology for the Reigns of Seti I and Ramesses II

In his thesis, Brand [1] includes six complete dates recorded on monuments of Seti I, and Kitchen [2] mentions two more in his book. Following the method of matching such inscribed Egyptian dates to Julian dates of new or full moon [3], I find that five of the eight can be so matched, to within a day. Two more fit if the regnal year is one year in error, either by ancient miswriting or modern misreading. The eighth date records troop movements, and it should not be expected that they would conform to phases of the moon. Brand also describes eight more monuments for which he mentions only the regnal year of Seti I, presumably because the month and day are not present or unreadable. For the reign of Ramesses II, Brand includes one complete date that matches, while Kitchen includes two matches, among many that do not match.

Each lunar month contains two main 'marker' days: new moon and full moon, which are essentially night-time phenomena. If the day after each is also viewed as significant for ceremonial purposes, then there are four 'marker' days for each synodic month of 29.53 days. The probability that any randomly selected day be one of these four is 4/29.53 = 0.135. Of the eight dates found for Seti I, about one should be expected to fall on a 'marker' day; but at least five do so. Thus, it appears that the Egyptians did not date their monuments randomly. Thoth, the god of writing, was also a moon god, so it might be that they regarded new and full moon as auspicious occasions for dedicating inscriptions on stelae and other monuments, and even writing graffiti. Possibly, Pharaoh scheduled his public audiences according to a lunar calendar: making announcements such as new building projects, endowments for temples, appointing or rewarding officials, for example.

It may be asked why, with no specific direct evidence, I have assumed that many of the dated inscriptions have such 'marker day' significance; after all, in other years, the month and day would correspond to no particular phase of the moon. However, within a given reign such as Seti I, it is indisputable that the intervals between those inscribed dates are multiples of half a synodic month, so that all of the dates would be displaced from a 'marker day' by the same amount if the reign were advanced or retarded by a number of years. My 'marker day' theory suggests that Seti I reigned 1290-1279 BC, which conforms to the 'low chronology' proposed by many Egyptologists.

However, the 25-year cycle between lunar phases and the Egyptian civil calendar [3] allows alternative dating: the same lunar phases could support a chronology of 25 years earlier or later (1315-1304 or 1265-1254) for Seti I. There would be one or two days error for a chronology 11 or 14 years earlier or later. Reversed lunar phases (new and full moons interchanged) would support a chronology 7 or 18 years earlier or later (e.g. 1297-1286 or 1283-1272). If it were supposed that the Egyptians favored first or last quarter days for inscriptions, then a chronology 9 or 16 years earlier or later would fit.

Dated Monuments from Reign of Seti I

Brand and others propose that the accession date of Seti I was Year 1, III Shemu 24. If so, I believe this was 31 May 1290 BC, which fits the monument dates listed below, and would have two significant lunar anniversaries:
Anniversary: Year 3, III Shemu 24 – New moon, 30 May 1288 BC
Anniversary: Year 10, III Shemu 23 – Full moon, 27 May 1281 BC

In referring to Brand's thesis, the section numbers are given at the beginning of the lines, and the page numbers at the end. The thesis has xxvii pages at the start, so the pages of the Adobe Reader PDF version are numbered 27 pages later, as noted in italic parentheses.

Brand: 3.139 Larger Stela of Seti I, Year 1 (British Museum EA 1189), p. 326 *(353)*
Brand: 3.140 Smaller Stela of Seti I, Year 1 (Pennsylvania Univ. Museum E. 10988), p. 327 *(354)*
Both record the king's order that a new endowment of various items be granted to the temple of Ptah in the fortress of Buhen in Nubia.
Year 1, IV Shemu 30
Full moon, 6 Jul 1290 BC

Brand: 3.70 Alabaster Stela of Seti I, Year 1 (Cairo CG 34501), p. 249 *(276)*
Thebes, Karnak Precinct of Amen-Re: Erected "opposite the Mansion of the Prince, at the Place of Appearances of the Incarnation of Re," a rooftop shrine that served as the principle sanctuary of Re in Karnak where the morning form of the sun god appeared.
Year 1, II Akhet 1
If Year 2 instead of 1: New moon, 8 Aug 1289 BC (I Akhet 29)?

Brand: 3.128 Boundary Stela, Year 4, p. 319 *(346)*
Near Kurkur Oasis: Carved in sunk relief on a sandstone slab; portrays Seti I bowing before god Khnum: "On this day, now His Majesty he is joyful at establishing the boundaries of Ta-Sety."
Year 4, III Peret 20
Full moon, 26 Jan 1286 BC

Brand: 3.109 Rock Stela, Year 6, p. 296 *(323)*
Gebel Silsila East: Commemorates an expedition to quarry sandstone for building projects. Text known only from 19th century copies, current location unknown.
Year 6, IV Akhet 1
Full moon, 7 Oct 1285 BC (III Akhet 30)

Brand: 3.6 Stela of Ashahebused, Year 8 (No. 249), p. 135 *(162)*
Sinai, Serabit el-Khadim: Large, free standing stela set up on approach to Hathor shrine, made by an official named Ashahebused, who made several expeditions to turquoise mines in the Sinai.
Year 8, I Peret 2
If Year 7 instead of 8: New moon, 9 Nov 1284 BC (I Peret 3)?

Kitchen: Revolt in the Deep South, pp. 30-31
Army arrived at Fortress 'Pacifier of the Two Lands' to suppress a Nubian revolt in Irem.
Year 8, III Peret 13 - No lunar match, as should be expected for military movements.

Kitchen: Deserts and Quarries, p. 31
Dug well and built temple at Kanais for gold-miners in the Edfu desert.
Year 9, III Shemu 20
New moon, 25 May 1282 BC

Brand: 3.151 Fragmentary Stela of Seti I, Year 11 (Khartoum 1856), p. 335 *(362)*
Describes some building projects the king initiated for various gods in the temple of Amen at Gebel Barkal in Nubia, and in the temple of the Benben-stone in Heliopolis. (Highest known date of Seti I)
Year 11, IV Shemu 12/13
Full moon, 15 Jun 1280 BC (IV Shemu 12)

Dated Monuments from Reign of Ramesses II

Brand and others propose III Shemu 27 (31 May 1279 BC) as the accession date of Ramesses II. However, I believe his accession month is probably I Akhet (July 1279 BC), to fit the Year 34 date below. In either case, this implies that Seti I died early in his 12th regnal year.

Kitchen: 'Gold in those far Hills', p. 49
Well dug for gold-miners in the Eastern desert at Akuyati in Nubia.
Year 3, I Peret 4
Full moon, 7 Nov 1277 BC (I Peret 3)

Brand: 4.2.3 Manshiet es-Sadr Stela regarding work on colossal statue, p. 341-2 *(368-9)*
Year 8, II Peret 8
Full moon, 12 Dec 1272 BC (II Peret 9)

Kitchen: Tales and Tourism in Ramesside Egypt, pp. 147-8
Inscription at the pyramid of king Khendjer (~1740 BC) by scribe Nashuyu.
Year 34, IV Shemu 24, day of the festival of Ptah
Full moon, 18 Jun 1245 BC

II. Joining the Chronologies of Dynasties 18 and 19

My previous study [3] combined solar eclipse calculations and inscriptions matched to lunar phase dates to develop an absolute chronology for the Amarna period (reigns of Amenhotep III to Tutankhamen). When writing that paper, I was puzzled that the 'repetition of discovery' on 13 Peret IV in Year 6 noted on the boundary stelae of Akhet-Aten could be matched to a new/full moon occasion, but the 'original discovery' on 13 Peret IV in Year 5 could not, the opposite of what might be expected. I assumed that the Year 5 date was only approximate, but inscribed later to make it appear that the anniversary was exact.

However, I now realize that there is a logical explanation if the chronology in my Table VI, updated in Table I here, is correct. This dates the total eclipse on 14 May 1338 BC to 25 Shemu II in Year 2 of Akhenaten, leading him to celebrate a heb-sed at Karnak, and dates the annular eclipse on 13 March 1335 BC to 24 Peret IV in Year 5. Now, 13 Peret IV in Year 6 is the 12-lunar month anniversary of the annular eclipse. The dates on the 'Earlier Proclamation' boundary stelae must have been inscribed after the Year 6 event, and subject to a mix-up between civil and lunar calendar anniversaries. The Aten did indeed tell Akhenaten where and when to found the city of Akhet-Aten!

The eclipse paths shown in Figure 3 of my paper [3] place Akhet-Aten on the central path of totality for the 1338 BC eclipse, by selection of Delta T to do so. Also, the city is close to the southern boundary of the path of annularity for the 1335 BC eclipse. If Delta T is reduced by 6 minutes, all the eclipse paths are shifted East by 1.5 degrees, and Akhet-Aten is placed close to the center of the region in which both eclipses were seen as total or annular, respectively. A 1.5 degree Eastward shift is about the limit for which the 1375 BC and the 1223 BC eclipses would be seen total at Ugarit.

To close the gap between the Amarna period and the reign of Seti I, the reigns of Ay, Horemheb, and Ramesses I need to be dated. The following sections attempt to do so, but are inconclusive.

Dated Monument from Reign of Ramesses I

The accession date of Ramesses I is unknown, but many believe Year 2 is his last; his highest known date is recorded on the following stela:
Brand: 4.2.1 Stela decreeing new endowments for temple at Buhen in Nubia, p.338 *(365)*
Year 2, II Peret 20: New moon, 26 Dec 1291 BC (II Peret 18)? Best fit to conventional chronology.

Dated Monuments from Reign of Ay

Usually, Tutankhamen is thought to have died in his 9th or 10th regnal year, followed by Ay who reigned for about four years. However, this does not fit possible lunar matches to the two complete dates for Ay given by Murnane [5].

Murnane: 103-C. Donation Stela from Giza, p. 225
Year 3, III Shemu 1
New moon, 12 May 1308 BC?
This would imply that Tutankhamen reigned 11-12 years. If he died at age 18, as generally found by examination of his mummy, he would have been born about Year 12 of Akhenaten, and might well be the infant whose mother (Kiya?) appears to have died in childbirth, depicted in the Royal Tomb at Amarna.

Murnane: 103-D. Dateline on Berlin Museum Stela No. 2074, p. 226
Year 4, IV Akhet 1 (the highest known date for Ay)
No match unless Year 5 instead of 4: New moon, 15 Oct 1306 BC (Year 5, IV Akhet 2)?

Dated Monuments from Reign of Horemheb

Murnane [5] 107-C. pp. 234-5, includes three dated inscriptions attributed to Horemheb:
1. Ostracon dated to Regnal Year 7, no month or day stated.
2. Wine jar docket from Saqqara tomb of Horemheb: Year 13, III Akhet (September), widely regarded as Horemheb's highest contemporary year date. Since it was found in his tomb, might it be an offering placed there soon after his death?
3. Graffito written in ink on statue from mortuary temple of Horemheb in West Thebes:
Year 27, I Shemu 9; many suggest the possibility that the year is in the reign of Ramesses II.

A photograph and translation of a wall docket found in KV 43 (Tuthmosis IV) is posted online [6]:
Year 8, III Akhet 1 (of Horemheb). An official, Maya, is charged to renew the burial of Tuthmosis IV.
A lunar match to this date is:
Full moon, 12 Sep 1299 BC.
This is consistent with Year 4 of Ay in 1307 BC, Year 13 of Horemheb in 1294 BC, and Year 1 of Ramesses I in 1292 BC. It would be highly desirable to have more full dates from the reigns of these kings to establish an accurate chronology.

III. Synchronization with Hittite Chronology

In this period, Egyptian-Hittite relations require that Suppiluliuma I correspond with Akhenaten in some of the Amarna letters and then with the widow of an Egyptian king, who requested one of his sons (Zannanza) to marry, near the end of his own life. By most scholars, the queen is believed to be Ankhsenamen as widow of Tutankhamen, but Nefertiti as widow of Akhenaten, or Meritaten as widow of Smenkhkare, have also been suggested. The question might be resolved if we can find an astronomical basis for the Solar Omen of Mursili II. My thanks to Prof. H. Craig Melchert of UNC for sending me a copy of Huber's recent article on this topic [7].

In a fragmentary tablet (KUB 14.4), a prayer of Hittite king Mursili II recounts intrigues by the queen Tawannanna, his stepmother and Babylonian-born widow of Suppiluliuma I. It appears that while Mursili was marching his army to Azzi-Hayasa at the end of his year 9 or the start of year 10, the Sun-god gave an omen that the queen interpreted and used to plot against the king. Huber summarizes his analysis by concluding that the omen was an eclipse, seen total or near-total at the capital Hattusa where the queen resided. I have calculated the paths of the six eclipses mentioned by Huber, plus three from the early 13th century, which are plotted in Figure 1 (the 1315 and 1308 BC eclipses are off the map). The 8 January 1340 BC total eclipse, which Huber prefers as the candidate 'solar omen',

crossed southern Anatolia and would have been seen by anyone campaigning in that region, but would not have been total at Hattusa. In the chronology I propose, it would be much too early – the accession year of Akhenaten.

The central path of the annular eclipse on 14 April 1281 BC passed close to Hattusa, but it was much too late to have been the omen in question. This leaves the 24 June 1312 BC total eclipse, which crossed from central to northern Anatolia. Hattusa was just within the northern boundary of the path of totality, and the sun would have been totally eclipsed for about 1½ minutes there. If the solar omen of Mursili was an eclipse, this must have been the one. Huber's preference would be a date earlier in the military campaign season, but note that 24 June Julian would have been 12 June Gregorian. Ibrahem [8] argues that the long, cold winter in Anatolia delayed the start of Hittite campaigns until late April, so that June would still be near the beginning.

However, the 1312 BC eclipse date has decisive implications for identifying the Egyptian participants in the earlier 'Zannanza Affair' and its aftermath. The just-deceased king is most likely Akhenaten, rather than Smenkhkare, since the chronological fit is better. While some might suppose the Egyptian queen must have been Nefertiti, I believe she predeceased Akhenaten, and the widow who wrote to Suppiluliuma was Meritaten who had then married her father (or at least used the title 'Dakhamunzu'). After his death, she ruled independently as **(**Ankhkheprure**)[-(**Nefernefruaten**)[**, counting her regnal years beginning with a de-facto co-regency with her father, perhaps during his terminal illness. Note the references to 'Mayati' in EA-10, 11 and especially EA-155 [9]. Her consort Smenkhkare might have been the Egyptian name of Zannanza or, more likely, the 'servant' who she was forced to marry, probably Akhenaten's son by a minor queen (Kiya?), since the mummy in KV-55 seems related to Tutankhamen. Anyway, it seems that both Egyptian and Hittite royalty were dying one after the other about this time, perhaps succumbing to a plague. This, of course, is my speculative scenario.

IV. The Chinese Connection

Further evidence supporting my proposed chronology based on observations of lunar phases and solar eclipses comes from far-off China, where other astrologers watched the sun and moon in the heavens. Chinese Shang Dynasty seers in the 14th century BC used 'oracle bones' (pieces of tortoise shell) for forecasting everyday events, such as the weather. One such bone attracted the attention of researchers at NASA-JPL in Pasadena, CA. The next two paragraphs are extracted from their report [10].

The bone's inscription says, "Diviner Ko asks if the following day would be sunny or not." It was dated the 51st day of the cycle then in progress in the calendar system used continuously in China from time immemorial. The bone is useful to astronomical researchers because it records not only the diviner's question but also the eventual outcome of the next day's weather. On the reverse side the inscription continues, " ... 52nd day, fog until next dawn. Three flames ate the Sun, and big stars were seen." This was interpreted to be a description of a total eclipse of the Sun. The "three flames" would be coronal streamers licking out from the Sun's surface, visible only during total eclipses. Also, the masking of the Sun by the Moon would allow Earth observers to see stars during the daytime.

The historical records were not complete enough to tell precisely from what year the oracle bones dated, so the researchers turned to records of eclipses of the Moon in Shang Dynasty China. The seers who reported the lunar eclipses were known to work for King Wu Ding, who also was the patron of the seer who recorded the solar eclipse on the oracle bone. The lunar eclipses were known to span the years 1322 to 1278 B.C.

On this basis, the researchers concluded that the total eclipse of 5 June, 1302 BCE was the one observed. However, using values of Delta T consistent with my previous study [3], I find that this eclipse passed too far East, but the eclipse of 30 January, 1304 BCE was total at Anyang, capital of Shang Dynasty China, according to the paths of totality plotted in Figure 2.

V. Notes on Astronomical Calculations

The computer software employed today for predicting phases of the moon and eclipses of the sun and moon include algorithms to solve the equations of celestial dynamics, using parameters that have been accurately determined by modern observations. Certain parameters vary over time periods of centuries by uncertain amounts and astronomers have developed a number of mathematical methods to estimate those amounts, based on ancient eclipse observations. The locations on earth where eclipses are seen depend on two main parameters: “Delta T” which is a measure of the slowing of the earth’s rotation, and the "Lunar Acceleration Parameter", 'n dot'. The two are related by the laws of conservation of angular momentum in the earth-moon system. Some of the proposed equations can be found on-line [11], but most do not include any observations earlier than those from Babylon in 700 BC.

My software is EclipseMaster Plus [12], which appears to use the old IAU (1952) formula with 'n dot' = -22.44 arcsec/century/century. However, it allows the user to input another value of Delta T to replace the value automatically calculated by the built-in formula. For the year 1338 BC, the program gives Delta T = 484.42 minutes. Changing this to Delta T = 503.35 minutes puts the central path of the eclipse through the site of Akhet-Aten. For total and annular solar eclipses, the 'bottom line' of prediction can be summarized by the longitude on earth where the 'Greatest Eclipse' is seen, which is one of the critical results listed in Espenak's Solar Eclipse tables [13].

Espenak's calculations employ 'n dot' = -26.00 arcsec/century/century. The 2003 July 14 revision of his tables contains a significant change in Delta T from his previous version, from empirical expressions fit to historical records by Stephenson and Houlden (1986) to a new analysis by Stephenson (1997) and a spline fit to observations. This change implies a 75 minute increase in the estimate of Delta T for 1338 BC, resulting in an 18.7 degree Westward shift in the path of that eclipse and similar shifts for other years. My estimates fall between these extremes, as seen in Table II.

Note that every point on each eclipse path is shifted in longitude by the same amount as the point of 'Greatest Eclipse'. All the paths in Figure3 of [3] and Figures 1-2 here are plotted from calculations by my software with my estimated Delta T input. The effect of shifting the eclipse paths to satisfy the earlier and later tables of Espenak is shown in Table III. Taking the –1374 May 03 eclipse, for example, the Espenak (1986) path is shifted (97.7 – 91.0) = 6.7 degrees East, and the Espenak (1997) path is shifted (91.0 – 78.1) = 12.9 degrees West of the path drawn in Figure 3 of [3], and in both cases the eclipse would not have been seen total at Ugarit. Likewise, the –1222 Mar 05 eclipse would not have been seen total at Ugarit for either case.

However, for the –1337 May 14 eclipse, Akhet-Aten would remain between the Northern and Southern boundaries of totality. I conclude that if the Ugarit tablet is accepted as a record of a total eclipse seen in that city on either of the proposed alternative occasions, then Akhet-Aten would be close to the central path of the –1337 eclipse. While any one possible ancient eclipse observation in isolation may be subject to serious question, I believe that the cluster of five eclipses listed in Tables II and III, in combination diminish the doubt, and the paths plotted in my figures are the best fit to the observational evidence, although it is admittedly vague in some cases.

If enough fully dated monuments exist, and assuming that new or full moon occasions were favored for inscriptions from an early time, it should be possible to extend the absolute chronology of Egypt further back in history. To expedite the search for date matches, it would be helpful to have tables of lunar phases, such as published online by NASA [4], limited to new and full moon, but with Julian dates and their corresponding Egyptian civil calendar dates included. These should be adjusted to follow the Egyptian method of measuring time: days begin at sunrise and end at the next, and ‘new moon’ (lunar day 1), is the day when the crescent moon is no longer seen in the eastern horizon before sunrise. By a method similar to that used to calculate the heliacal rising of Sirius [14], the conditions

for observing such a 'new moon' should be determinable. There may be a small effect depending upon the season and the location of the observer; Egypt-Nubia covers about 30-33ºE and 20-31ºN. Inevitably, there will be some times when the conditions are marginal and the crescent may or may not be seen.

Astronomically, 'new moon' is its conjunction with the sun, which is usually tabulated in 'Universal Time' (UT) or GMT with respect to noon at the Prime Meridian. If the conjunction occurs close to the ±180º 'date line', the date may jump by a day for a few minutes change in a parameter such as Delta T. Luckily, in most cases, the inscribed dates I assume are 'new moon' seem to match the tables [4] or are one day off. Possibly, if many Egyptian inscriptions are implicit records of lunar phases, they might be useful in estimating Delta T when eclipse records are sparse.

References

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TABLE I: Lunar Events Matching Inscriptions – Amarna Period

Date of inscription is in *italics* if it differs from lunar event

Event	Julian date	Egyptian date	Inscription
New moon	29 Sep 1367 BC	1 Akhet III Year 11	Lake Scarab – Work begun
Full moon	13 Oct 1367 BC	15 Akhet III Year 11 *16 Akhet III*	Lake Scarab – Opening the Lake
Total eclipse, Nubia	**15 Aug 1352 BC**	**20 Akhet I Year 26**	
Full moon	19 May 1348 BC	28 Shemu II Year 30 *27 Shemu II*	First Jubilee – Tomb of Kheruef
New moon	22 Mar 1344 BC	1 Shemu I (Year 34)	Second Jubilee – Soleb Temple
New moon	21 Nov 1342 BC	30 Akhet IV Year 37	Third Jubilee – Tomb of Kheruef
	1340 BC 21-28 Nov	Year 39 / **Year 1** 1-8 Peret I	Amenhotep III / **Akhenaten**
Total eclipse, Akhet-Aten	**14 May 1338 BC**	**25 Shemu II Year 2**	**Inspired Akhenaten to celebrate heb-sed at Karnak**
Annular eclipse, northern Egypt	**13 Mar 1335 BC**	**24 Peret IV Year 5**	**Inspired Akhenaten to found city of Akhet-Aten**
New moon	2 Mar 1334 BC	13 Peret IV **Year 6**	Boundary Stelae of Akhet-Aten First lunar anniversary of eclipse
Full moon	26 Nov 1333 BC	8 Peret I **Year 8**	Boundary Stelae of Akhet-Aten Repetition of Oath
Total eclipse, Nubia	**30 Dec 1332 BC**	**12 Peret II Year 9**	
New moon *	20 Nov 1331 BC	2 Peret I **Year 9** (*30 Akhet IV **Year 8***?)	Boundary Stelae of Akhet-Aten Another Oath (The Colophon)
New moon	26 Dec 1329 BC	9 Peret II **Year 12** *8 Peret II*	Reception of Foreign Tribute Tombs of Meryre II and Huya
	1324 BC	**Year 16** / Year 1	**Akhenaten** / Ankhkheprure Co-regency begins
	1323 BC	**Year 17** / Year 2	**Akhenaten** dies
Full moon	27 Sep 1322 BC	10 Akhet III Year 3	Graffito in Tomb of Pere
	4 Nov 1322 BC - 5 Feb 1321 BC	Year 3 or 4 / **Year 1** 20 Akt IV - 23 Prt III	Ankhkheprure / **Tutankhamen**
New moon	3 Nov 1316 BC	19 Akhet IV **(Year 6)**	Tutankhamen Restoration Stela
New moon	29 May 1315 BC	16 Shemu III **(Year 7)**	Stela of Merymery
Full moon, * eclipsed	5 Feb 1314 BC	23 Peret III **Year 8** *21 Peret III*	Royal charge for chancellor Maya
Total eclipse, Hattusa	**24 Jun 1312 BC**	**13 Shemu IV Year 10**	**Hittite King Mursili II, Year 9/10 Solar Omen of Tawannanna**

* Would have been credited to the day before by the ancient Egyptians.

Table II: Longitudes of Greatest Eclipse

Contemporary Evidence of Eclipse	**Julian Date** (astronomical)	**Espenak (1986)**	**McMurray**	**Espenak (1997)**
Ugarit 1 Tablet KTU 1.78 ?	-1374 May 03	97.7 E	91.0 E	78.1 E
Akhet-Aten, central path: interrupted sunrays in Tomb of Meryre I	-1337 May 14	23.4 E	17.6 E	4.7 E
Akhet-Aten, 12-month anniversary date on Year 6 Boundary Stelae	-1334 Mar 13 (annular)	33.5 E	27.9 E	14.8 E
Hattusa, Tablet KUB 14.4 Solar Omen of Mursili II	-1311 Jun 24	31.9 E	26.5 E	13.7 E
Anyang, Shang Dynasty Chinese Oracle Bone	-1303 Jan 30	146.2 E	141.1 E	128.3 E
Ugarit 2 Tablet KTU 1.78 ?	-1222 Mar 05	26.3 E	21.9 E	10.2 E

Table III: Effect of Shifting Longitudes of Eclipse Paths Drawn in Figures

Julian Date (astronomical)	**Espenak S&H(1986)**		**Espenak S(1997)**	
	Shift	**Change in Visibility**	**Shift**	**Change in Visibility**
-1374 May 03	6.7 E	Not total at Ugarit	12.9 W	Not total at Ugarit
-1337 May 14	5.8 E	Akhet-Aten at N. boundary	12.9 W	Akhet-Aten at S. boundary
-1334 Mar 13 (annular)	5.6 E	Akhet-Aten at N. boundary instead of near S. boundary	13.1 W	Not annular anywhere in Nile valley
-1311 Jun 24	5.4 E	Not total at Hattusa*	12.8 W	Still total at Hattusa**
-1303 Jan 30	5.1 E	Not total at Anyang	12.8 W	Anyang near N. boundary
-1222 Mar 05	4.4 E	Not total at Ugarit	11.7 W	Not total at Ugarit

* Eclipse of –1327 Oct 17 would be annular at Hattusa

** Eclipse of –1334 Mar 13 likely annular, and eclipse of –1339 Jan 8 likely total, at Hattusa, but these three eclipses are too early to be the solar omen of Mursili II.

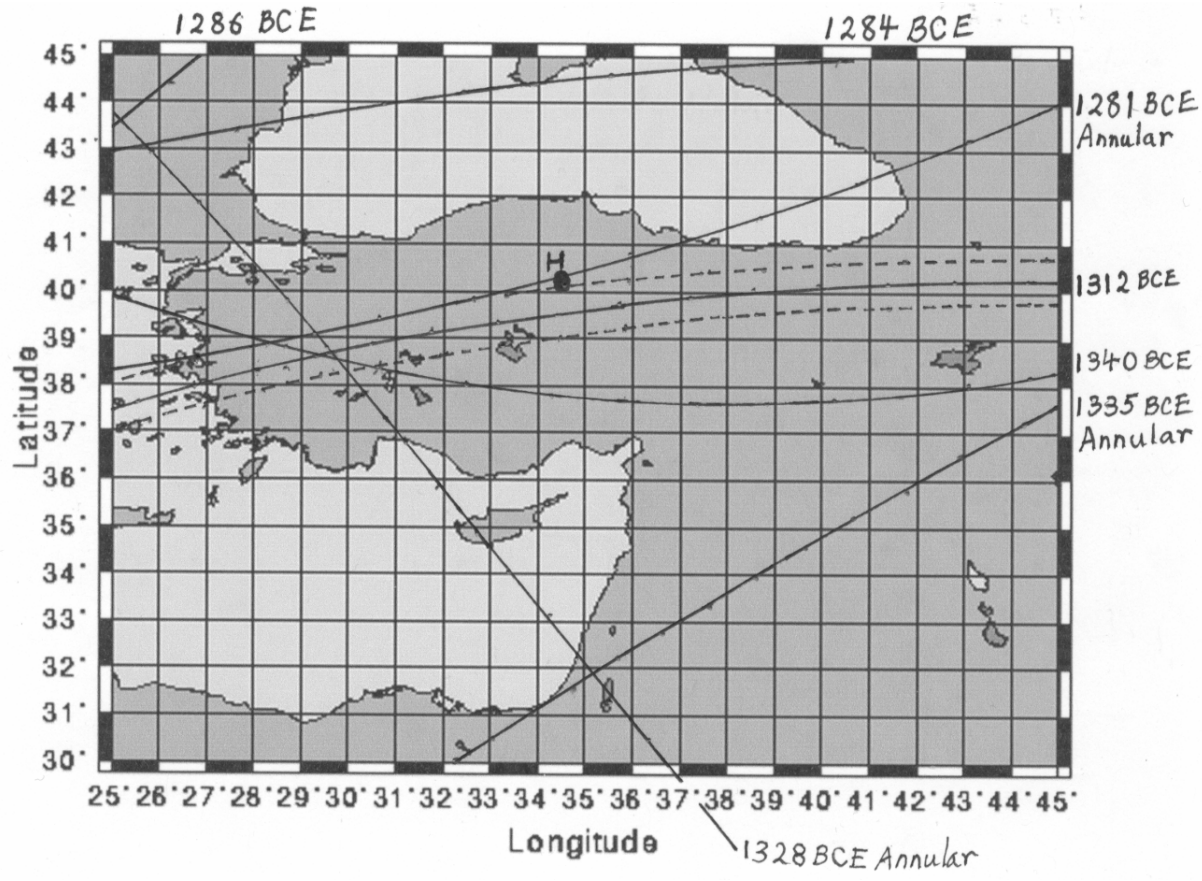

Figure 1 Candidate Eclipses for Solar Omen of Mursili II

H = Hittite capital Hattusa (Bogazkale), 40.0ºN, 34.6ºE
Dashed lines show bounds of totality for eclipse of 1312 BC

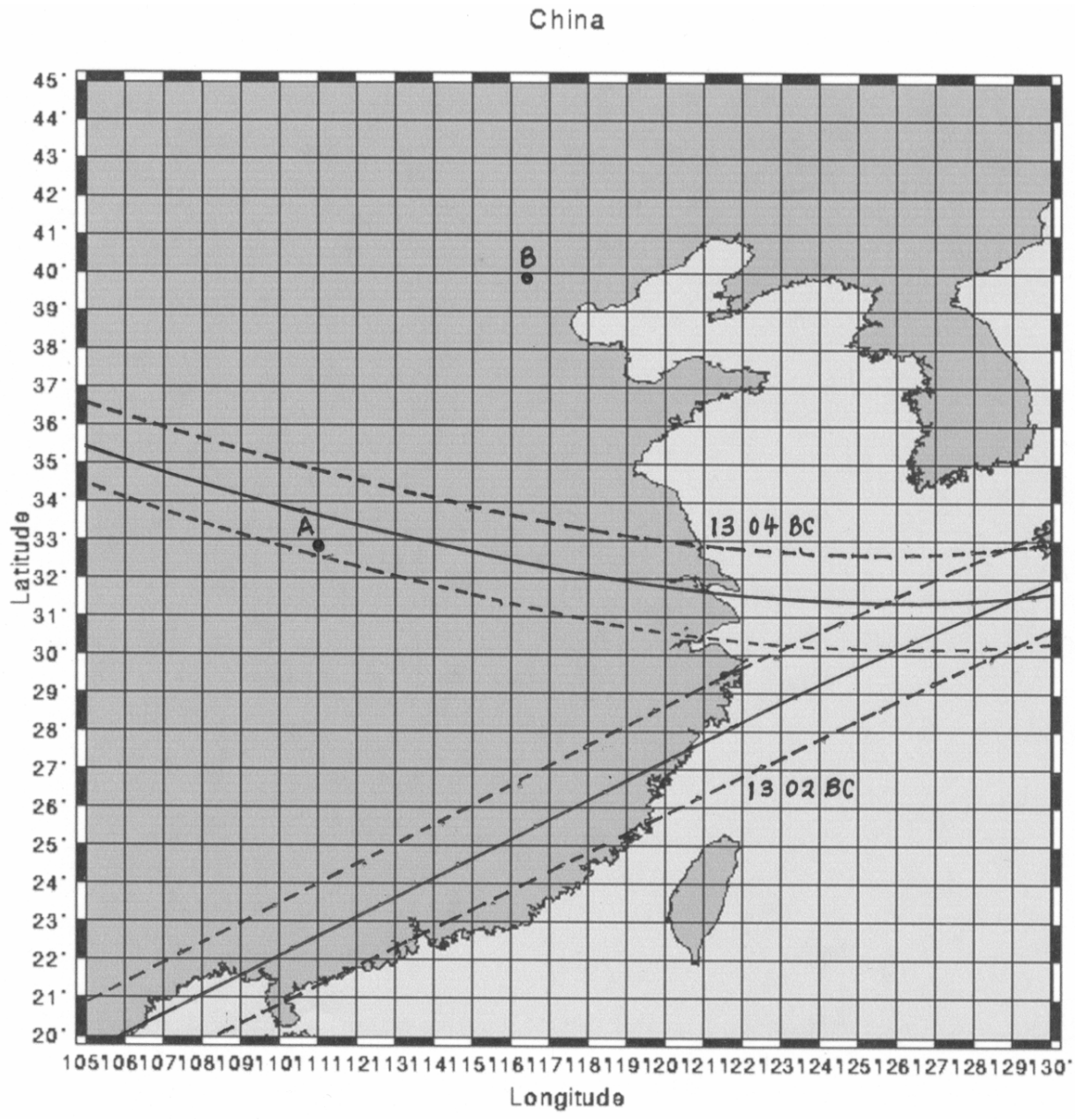

Figure 2 Two Ancient Chinese Eclipses

A = Anyang, capital during Shang Dynasty, 32.8ºN, 111.0ºE
B = Beijing
Dashed lines show bounds of totality for eclipses of 1302 and 1304 BC