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The Venus Tablets of Ammizaduga

By
John D. Weir

Nederlands Instituut voor het Nabije Oosten
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UITGAVEN VAN HET
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THE VENUS TABLETS OF AMMIZADUGA

I. THE DATING OF THE HAMMURABI DYNASTY

1. *Introduction.* One of the treasured possessions of the British Museum is the Assyrian library of cuneiform clay tablets which once belonged to King Assurbanipal. This library, which was founded in the 7th century B.C., represented the learning of that age. Among its many branches was a section dealing with astrology. This section had at least 70 tablets, each with the title, "When the gods Anu and Enlil", forming an astrological series. Within that group, the 63rd tablet dealt with the planet Venus.

This 63rd tablet gives a sequence of setting and rising dates of Venus as observed over a period of 21-years, with the appropriate astrological omens added. Since no undamaged tablet containing that important document has so far been excavated, the text has had to be reconstructed from the various portions of different tablets which have been found. These fragments are known collectively as the Venus tablets.

2. *Father Kugler's Discovery of the Year Name.* Now, this Venus tablet astronomical record would have had no greater significance for dating purposes than the other astrological information in the series, had it not been itself dated by the Babylonian scribes. This fact was not immediately realised, however, because of the initial difficulties experienced by scholars in translating the newly discovered cuneiform symbols [1].

In 1912, Father Francis X. Kugler, who was a German professor of astronomy, correctly translated the phrase, "Year of the golden throne", which had been inserted between the data of the 8th and 9th years on the tablet. He pointed out that this is a year name belonging to the First Babylonian, or Hammurabi dynasty; being, in fact, the date-formula for the 8th year of King Ammizaduga [2].

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1 Langdon-Fotheringham-Schoch, *The Venus Tablets of Ammizaduga,* Oxford University Press, London 1928. Chapter V : J. K. Fotheringham, *Past Studies on the Subject.* Dr. Fotheringham deals with the early investigators in this chapter.

2 F. X. Kugler, *Sternkunde und Sternendienst in Babel,* Teil II, Heft I of the second book, Pages 257-311. (1912). Dr. Fotheringham summarises the contents of this portion of Kugler's book in Chapter V of *The Venus Tablets of Ammizaduga.*

Year names were in use by the Babylonians throughout the 300 years of the Hammurabi dynasty, but the custom dates from much earlier times. Each year was designated by some important event which had taken place, sometimes in the previous year, sometimes during the year itself. Thus the year name would record the occurence for posterity. When set out in their correct sequence, these year names provide a condensed history of the dynasty.

The story begins with an initial period of military expansion and consolidation, followed by 50-years of peaceful development. Then came the campaigns of Hammurabi, which gave the Babylonians temporary control of all Mesopotania. Six years after his death, however, a Kassite invasion paved the way for a successful revolt in the South. As a result, the Babylonians remained in control of only a very small area round their capital city. In due course, a Hittite incursion ended the dynasty, and in the resulting confusion the Kassites moved in and gained control of Babylonia.

The exact length of the Kassite period is very much more difficult to determine than that of the Hammurabi dynasty. Not only did they abolish the use of year names, but even the inscriptions which they left are less numerous than might be expected. Thus, when Dr. Kugler made his great discovery, the relationship of the rulers within the dynasty to each other was known, but not the relationship of the Hammurabi dynasty itself to the present day. The latter relationship was very uncertain.

However, Dr. Kugler's discovery meant that the choice of possible dates for the dynasty could be limited. Previously, only archeological evidence was available for this purpose. Now the astronomical conditions recorded by the Venus tablets had to be complied with. Thus, any date assigned to Ammizaduga must allow for a particular relationship between the planet Venus and the moon.

3. *The Early Chronologies.* Assyriologists of the period before the First World War were in general agreement that Hammurabi lived some time around 2,000 B.C. Thus, when Dr. Kugler in 1912, announced his discovery of the date-formula and proposed on astronomical grounds that Hammurabi should be dated 2123 B.C. to 2081 B.C., his arguments met with general acceptance. He based his chronology upon a solution of the Venus tablets which assiged the years 1977 B.C. to 1956 B.C. to Ammizaduga. The evidence must have seemed very convincing at first, till it began to be realised that other solutions to the astronomical problem were possible. Then doubts were expressed by some authorities.

First the Austrian archeologist, Professor E. F. Weidner, wrote in 1914, that in his opinion Dr. Kugler's restoration of the chronology was extremely problematical [3]. He himself thought, in 1917, that this chronology should be based on a solution dated 1809 B.C. to 1788 B.C. [4]

Dr. Kugler, while disagreeing with Professor Weidner's proposed dating, nevertheless began to accept the argument put forward for a late chronology. So in 1923, he abandoned his own earlier solution in favour of another dated 1801 B.C. to 1780 B.C. [5]

Meanwhile, Professor S. Langdon of Oxford university had requested the British astronomer, Dr. J. K. Fotheringham to analyse the Venus tablet data on astronomical grounds. This analysis revealed a solution dated 1921 B.C. to 1900 B.C. Professor Langdon put that solution forward in 1923 [6].

Finally, in 1927, Monsieur F. Thureau-Dangin, Chief Conservateur of Oriental Antiquities at the Louvre Museum, adopted the only remaining possible chronology within the accepted limits. His solution of the Venus tablets gave as Ammizaduga's reign, the dates 1857 B.C. to 1836 B.C. [7]

Thus there were now five rival solutions of the Venus tablets. The problem was to determine which was the correct one.

4. *The Langdon-Fotheringham-Schoch Investigation.* This task was undertaken by Professor Langdon and Dr. Fotheringham. They employed the German astronomer and mathematician, Herr Carl Schoch, to construct up-to-date astronomical tables. These tables yielded for each solution seemingly accurate setting and rising dates of Venus which were compared with the ancient record. The comparison disclosed that Ammizaduga could not have lived in either 1809 B.C. or 1801 B.C.; but the other three dates remained theoretically possible.

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[3] According to Dr. Fotheringham in Chapter V of *The Venus Tablets of Ammizaduga.*

[4] Berichte der Mathematisch-Physischen Klasse der Sachsischen Akademie der Wissenschaften zu Leipzig, 94. Band, Leipzig, 1943. Pages 23-56 : B.L. van der Waerden, *Die Berechnung der Ersten und Letzen Sichtbarkeit von Mond und Planeten und die Venustafeln des Ammisaduqa.* On page 24 is the following list of Venus Tablet solutions: Kugler 1912, –1976 to –1956; Fotheringham 1923, –1920 to –1900; Thureau-Dangin 1927, –1856 to –1836; Weidner 1917, –1808 to –1788; Kugler 1923, –1800 to –1780.

[5] See note 4.

[6] S. Langdon, Oxford Edition of Cuneiform Text (1923), Vol. II. Professor Langdon's conclusion is in the Preface to volume II. Dr. Fotheringham summarises his argument in Chapter V of *The Venus Tablets of Ammizaduga.*

[7] See note 4.

To narrow down the choice, the legal documents of the period were examined. Among them were found written agreements between landlord and tenent for the division of the date-harvest. The practice was for the unripe dates to be counted some time before the harvest, and a contract signed, by which the tenant undertook to supply to his Superior a given quantity of ripe dates by a given day in the month TESRIT, or by the first day of the next month, ARAHSAMNA. Judging by similar Neo-Babylonian documents, which can be related to the Gregorian calendar with certainty, and also on the basis of present-day harvest conditions, this Final Delivery Date would not normally come before October 14th. (Gregorian).

Now, the respective Contract and Delivery dates computed for the five solutions vary within a limit of two months. For the two solutions, 1977 B.C. and 1921 B.C., the landlord named in each contract would have duly received his quota after 14th October. According to the other three solutions, however, his share in the harvest would appear to have been delivered too early in the month. Thus, provided the crops ripened no earlier than at present, which seemed a reasonable assumption, the choice appeared to lie between the first two solutions. Other documents, connected with the wheat and barley harvests, confirmed this conclusion.

The final choice, however, had to depend upon a different type of evidence. Some of the documents were dated on the 30th day of the month. From this it was inferred that those particular months must have contained 30-days. Accordingly, these attested 30-day months were compared with the corresponding lunar months computed for each solution. The percentage agreement for the 1921 B.C. solution was 72; which was the highest percentage from all the solutions. By contrast, the 1977 B.C. solution had only 38 %. The logical conclusion seemed to be that Ammizaduga was king of Babylon from 1921 B.C. to 1900 B.C.

These findings were made public in 1928, when they appeared in book form, under the title, *The Venus Tablets of Ammizaduga*. In general, that proposed chronology was accepted up to the begining of the Second World War [8].

5. *Macnaughton's Chronology*. One other alternative system of dating did, however, appear in 1930. This was Mr. Macnaughton's book, *A Scheme of Babylonian Chronology*. Mr. Macnaughton, who is a member of the legal profession, had made a study of ancient astronomy. He discovered that certain year names of the Hammurabi period, which record the enthronement of Babylonian gods, fall on dates which are apparently related in some way to the synodic periods of the

[8] See p. 1, note 1.

planets. The inference was that an enthronement of one of the "planetary gods" occurred whenever the associated planet was at a certain position during the month of Nisan [9]. Unfortunately, there is no evidence among the surviving records to establish whether that was indeed the case; and, if so, what particular aspect of the planetary phenomena the Babylonians were interested in. However, if the theory was correct, it offered an avenue of approach which might lead to the date of the Hammurabi dynasty.

It is, perhaps, unfortunate that when this enquiry was carried out, solutions later than 1801 B.C. were not thought possible. Within the then historical limits, Mr. Macnaughton established that for a solution dated 2260 B.C. to 2239 B.C., the enthronement of the planetary gods was apparently being carried out when the heliacal rising of their respective planets took place during Nisan [9]. In fact, it was not the heliacal rising, but the maximum brightness which was the deciding factor [10]. However, that information could not have been deduced from a study confined to the early solutions. Thus, on the basis of the knowledge available at the time, Mr. Macnaughton decided quite logically, that Ammizaduga must have reigned from 2260 B.C. to 2239 B.C., and worked out his chronology accordingly.

Macnaughton's Chronology was the last to be based on a very early date. Fresh evidence was about to be published, which pointed in the opposite direction.

6. *Smith and Ungnad's Solution.* The palace archives of the Royal City of Mari had been discovered by the French archeological expedition led by Professor Parrot. Mari was looted and destroyed by the troops of Hammurabi, during the latter part of that monarch's reign. Accordingly, the archives contained interesting information about happenings around the early part of his reign. This information was now becoming available to Assyriologists as translation of the tablets progressed.

One of the contemporaries of Hammurabi, according to the archives, was almost certainly Yarim-Lim, king of Alalak. Alalak was then a town near the Mediterranean coast, strategically sited on the trade route from the upper part of the Euphrates valley. The ruins were still being excavated by the British expedition

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9 Duncan Macnaughton, *A Scheme of Babylonian Chronology.* London, Luzac & Co. 1930. Pages 88-92. Note 28 : *The Thrones of the Planetary Gods.*

10 I have found, for Smith and Ungnad's solution only, a relationship between the religious events recorded by the year-names of the Hammurabi period and the planets visible, usually at their maximum brilliance, in the months Nisan, Tammuz, Tesrit and Tebit.

under Sir Leonard Wooley, but cuneiform tablets from Yarim-Lim's own archives had by now been found. Thus his Period could be safely assigned to a particular level of the excavation.

Apart from these tablets, objects of Egyptian origin had been unearthed at various levels of the site. These discoveries made it possible to synchronise the development of the town of Alalak with the main periods of Egyptian history. So Egyptian chronology could now be used as a guide to Babylonian dating. The result of this link-up was a provisional date of $\pm$ 1600 for the end of the First Babylonian dynasty.

Professor Sydney Smith, who was at that time Keeper of the Department of Western Asiatic Antiquities at the British Museum, had realised the significance of the referance to Yarim-Lim in the Mari records. In 1940, he published a brochure entitled *Alalak and Chronology,* in which he set out the archeological and documentary arguments for a revision of the dating of the Hammurabi dynasty. The shortened chronology which he suggested was based on the Venus tablet solution, 1646 B.C. to 1625 B.C. That solution was computed by Brigadier-General J. W. Sewell [11].

Professor Sydney Smith was not, however, the only person trying to establish a new chronology. The German expert, Professor Arthur Ungnad had been working quite independant of the British investigation, and following a different method. Yet he reached the same conclusion as Professor Sydney Smith, and published his results in the same year [12].

7. *Sidersky's Solution.* Meanwhile, another investigator had been working on the problem. This was Monsieur David Sidersky. Monsieur Sidersky was by profession a Chemical Scientist, but his hobby was ancient Oriental astronomy, mathematics, and chronology. He had already written a number of books on these subjects, and was also a member of the "Société Asiatique".

In 1940, the same year in which Professor Sydney Smith's brochure apeared, Monsieur Sidersky published findings which were somewhat different. He based

11 Sidney Smith, *Alalakh and Chronology,* London, 1940. Brigadier-General J. W. S. Sewell, C.B., *The Observations of Venus,* on Page 27.

12 Mitt. altorient. Ges. XIII, Heft 3, 1940. A. Ungnad, *Die Venustafeln und das Neunte Jahr Samsuilunas.*

his chronology on an earlier solution of the Venus tablets. Ammizaduga, according to that solution, reigned from 1702 B.C. to 1681 B.C. [13]

A Turkish scholar, Kemel Turfan, reached a similar conclusion independently in the following year. However, his date for Hammurabi was approximate, whereas Monsieur Sidersky based his chronology on a more precise astronomical date [14].

Monsieur Thureau-Dangin examined very closely the arguments for the two rival chronologies. He thought the link with Egyptian history was not yet definite enough to rule out either system of dating. Certainly, both seemed to be within the bounds of historical possibility [15].

However, Professor Sydney Smith's chronology had by now been adopted by the American archeologist, Professor W. F. Albright. It seemed likely to gain universal acceptance, but the situation was again altered by the publication of a new approach to the problem [16].

8. *The Cornelius Solution.* In 1942, Dr. F. Cornelius proposed an even later date for Hammurabi than had hitherto been thought possible [17]. Dr. Cornelius, who is a member of the Federation of German Historians, deduced the date of Hammurabi, not from archeological evidence, but from a historical source.

During the Seleucid Period, a history of Mesopotania had been written by Berossos, who was a priest from the Marduk temple at Babylon. It dealt with the period from the Deluge to Alexander the Great. The book itself, which was known as the "Babyloniaca", has unfortunately, not survived; but extracts are quoted by various Classical writers. Among those quotations is a list of kings from the Flood to Tiglath-Pileser III [18]. This list was regarded by scholars as being somewhat unrealistic, but Dr. Cornelius now showed that it could be interpreted to agree with Babylonian tradition. It runs as follows : –

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13 Rev. Assyr. 37, 1940. Page 45. D. Sidersky, *Nouvelle étude sur la chronologie de la dynastie Hammurapienne.*

14 Ex Oriente Lux. Jaarbericht N° 10. 1945-1948. Pages 481-490. C. Kern, *Primum Monumenta, Deinde Chronologia.* Alalakh (Thans Tell Atsjana), Hammurabi 1792-1750. Kemel Turfan is mentioned at the end of the middle paragraph on page 487.

15 C. Kern, *Primum Monumenta, Deinde Chronologia.* (See footnote 10). Page 487.

16 *Loc. cit.*

17 KLIO 35, 1942, Page 1. F. Cornelius, *Berossus und die Altorientalische Chronologie.*

18 Ex Oriente Lux. Jaarbericht N° 10. 1945-1948. Pages 414-424. B. L. van der Waerden, *On Babylonian Astronomy I., The Venus Tablets of Ammizaduga.* VI. Berossos' List of Kings. (Pages 419-420).

BEROSSOS' LIST OF KINGS

1st dynasty	86 kings,	reigning	34,090	years.
2nd	” 8 or 21 Marians	”	224	”
3rd	” 11 kings	”	48	”
4th	” 49 Chaldaeans	”	458	”
5th	” 9 Arabs	”	245	”
6th	” 1 Assyrian and 45 kings	”	526	”

Berossos' list as it stands, is incomplete. Since his history stopped at Alexander the Great, his list presumably continued in its original form to that historical landmark. Accordingly, Dr. Cornelius added a further 409 years to fill the gap from Tiglath-Pileser III to Alexander. This gave a total of 36,000 years for the period covered by the list. Since the starting date of the 1st dynasty is, obviously, conjectural, the over-all total must be an approximation. Thus the assumed figure of 36,000 years is very probably correct. Accordingly, it should not be affected by any copyists' errors.

The identification of the six dynasties is a necessary preliminary to establishing the year of Ammizaduga. The first one, of course, is largely made up of mythical kings; but it agrees well with Babylonian tradition. The second must comprise 21 kings of Gutium in Media. So the word "Marian" should be altered to read "Median".

Three Sumerian dynasties are grouped together to form the 3rd dynasty. They are the 4th and 5th dynasties of Urak and the 3rd dynasty of Ur, which together total 11 reigns covering a period of 148 years. The list, of course, only gives 48 years, but the time allowed for the previous dynasty is much too long. The Medes only reigned for 124 years. So 100 years can be deducted from the 2nd dynasty total and added to that of the 3rd dynasty. This adjustment leaves the over-all total unaltered.

The Hammurabi dynasty is included in Berossos' 4th dynasty. It is grouped with the dynasties of Larsa, Isan, and the Sea Country. The Kassite rulers are represented by the 9 Arabs of the 5th dynasty, though, presumably, the figure 9 is corrupt. Finally, the 1 Assyrian is Tukulti-Ninurta I, who conquered Southern Mesopotamia and destroyed Babylon.

The dating of Ammizaduga follows logically once these identifications have been made. Alexander the Great died in 323 B.C. Adding 409 years to this date gives 732 B.C. for Tiglath-Pileser III. Moving back from there a further 1229 years, which is the total of the last three dynasties, leads to 1961 B.C. for the founding of the Larsa dynasty. Then, working down through each reign, and knowing the relationship between the Larsa and the Hammurabi dynasties, the year 1582 B.C. for Ammizaduga's accession to the throne, is finally arrived at. This date might vary within narrow limits, since in a few cases, the exact length of a reign may be in doubt.

However, whether by coincidence or otherwise, a possible solution of the Venus tablets happens to be 1582 B.C. to 1561 B.C. Since this could so easily not have been the case, that fact seemed to be a very strong argument in favour of acceptance of this new Chronology. Moreover, the Cornelius chronology appeared at a very opportune time.

During the season 1932/33, when excavations were being conducted by the Oriental Institute of the University of Chicago, an Assyrian Kinglist- was found at Khorsobad [19]. This list covered the period from Shamsi-Adad I to Ashur-Nirari V.

The name of the Assyrian king Shamsi-Adad I had been found on letters from the archives of Mari. He wrote to his son, Yashmakh-Adad, who was king of Mari. Shamsi-Adad had, in fact, conquered that city and put his son on the throne. Since some of the letters refer to Hammurabi, it follows that Hammurabi and Shamsi-Adad I must have been contemporaries.

Previously, it had been thought that Hammurabi lived two generations before Shamsi-Adad. Then, some time before 1930, a recorded oath was discovered, dated the 10th year of Hammurabi. It had been sworn "by the god Marduk, and the kings Hammurabi and Shamsi-Adad". The Mari letters now confirmed the evidence of the oath. Since Shamsi-Adad lived certainly later than 1900 B.C., all the early chronologies were ruled out by this discovery, apart from any other reason.

Unfortunately, the Khorsobad king list cannot give an exact date for Shamsi-Adad. The tablet on which it was written was preserved in almost perfect condition till the moment of its discovery. It is thought that the spade of the excavator must have damaged the surface before its presence could be detected. As a result of this mishap, the length of five reigns has been lost. So Shamsi-Adad can only

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[19] JNES 1, 1942, pages 247-306 and 460-492. JNES 2, 1943, pages 56-90. A. Poebel, *The Assyrian King-list from Khorsabad.*

be dated to within ten years before, or after 1734 B.C. It follows that Hammurabi also must have lived about that year.

Hammurabi, according to Dr. Cornelius, reigned from 1728 B.C. to 1686 B.C. This period is certainly within the historical limits required by the Khorsobad king-list. The list itself was being prepared for publication by Professor Arno Phoebel of the University of Chicago, when Dr. Cornelius' findings were published. He seemed to confirm those findings by announcing that, according to the list, Shamsi-Adad's reign was from 1726 B.C. to 1694 B.C. Professor Albright then revised his chronology so as to conform to the Cornelius dating of the Hammurabi dynasty [20].

9. *Professor van der Waerden's Investigation.* Support for the Cornelius dating came next from Professor van der Waerden of Leipzig. In December 1942, he presented a mathematical treatise at a Sitting of the Leipzig Academy [21]. In this he included a comparison of Venus data computed for the three latest solutions.

The astronomical tables which he used were not those of Herr Schoch. They were, in fact, earlier tables compiled by the German astronomer Professor Paul V. Neugebauer, and first published in 1914 [22]. Schoch's planetary tables were becoming obsolete, whereas those of Neugebauer yielded more accurate results.

Exact agreement between record and computation was not, of course, to be expected. It was well known that when the Scribes copied from earlier documents they sometimes made mistakes. Also, the weather conditions under which the observations were taken are not recorded. Apart from that, slight variations occur in the results from different mathematical tables. Accordingly, a reasonable margin of error should be permitted when comparing those computed results with the recorded astronomical dates. Professor van der Waerden allowed two or three days difference at Inferior conjunctions, where the apparent brightness of the planet changes rapidly; and eight days at Superior conjunctions, where the change is more gradual. Within those limits he classified agreement as "good".

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20 C. Kern, *Primum Monumenta, Deinde Chronologia.* (See footnote 14.) Page 488.

21 B. L. van der Waerden, *Die Berechnung der Ersten und Letzten Sichtbarkeit von Mond und Planeten und die Venustafeln des Ammisasuqa.* (See footnote 4.)

22 P. V. Neugebauer, *Tafeln zur Astronomischen Chronologie,* Leipzig, 1914.

The results of his comparison he listed as follows : –

SOLUTION	DATE (JULIAN)	"GOOD" EXAMPLES	GOOD AGREEMENT
Sideresky	–1701 to –1681	26 out of 50	that is 52 %
Ungnad	–1645 to –1625	27 out of 50	that is 54 %
Cornelius	–1581 to –1561	29 out of 50	that is 58 %

So the Cornelius data was found to be giving the best agreement. Naturally, this helped the argument in favour of accepting that solution.

Not everyone, however, was convinced of the merits of the Cornelius chronology. Professor van der Meer of the University of Amsterdam had examined the evidence, and his findings were published in 1944 [23]. His date for Hammurabi was almost identical with that of Smith and Ungnad.

In the following year Professor Sydney Smith himself was dating Hammurabi's reign as from 1792 B.C. to 1750 B.C.; whereas Professor Albright was pointing out links between the histories of Egypt and Mesopotania which he considered strengthened the case for the Cornelius chronology.

Then in 1946, Professor van der Waerden republished his arguments in a more developed form [24]. He now focussed his attention on the alternative solutions proposed by Ungnad and by Cornelius. That of Sidersky would appear to be ruled out by his previous findings. He decided also not to use text data which gives information obviously incorrect. As a result, overall agreement based on the remainder of the text is much improved.

Now, the Cornelius solution gives slightly better agreement than its rival between text and calculation. Unfortunately, the difference is not enough to decide which of the two is the correct one.

However, one very significent factor was revealed by the new comparison. The Cornelius solution has a balanced distribution of positive and negative differences between the record and the computation. There are thirteen positive variations, eight negative and five zero. This is roughly what might be expected from a random distribution.

[23] JEOL 9, 1944, pages 137-145 and page 192. P. van der Meer, *Chronologie des Assyrisch-Babylonischen Köninge*. C. Kern, *Primum Monumenta, Deinde Chronologie*. (See footnote 14.) Page 488.
[24] See p. 7 note 18.

The alternative solution has nine positive differences, twenty-five negative, and two zero. On the theory of probability, the changes are 1/100 of finding such a preponderance of negative values.

Moreover, the chances are less than 1/2 that the Cornelius set of differences should be smaller than those of Ungnad for the setting and rising dates at Superior conjunction. Similarly, the chances of the same effect being found at the Inferior conjunction intervals is also less than 1/2.

Finally, there is the unlikely chance of agreement between the Berossos list and the Venus tablets. This could only occur four times in two hundred years, a probability of 1/50.

So combining these probabilities, it would appear that the chances of them all accidentally occuring together are less than : –

$1/50 \,.\, 1/2 \,.\, 1/2 \,.\, 1/100 = 1/20{,}000.$

Faced with this probability fraction, who could doubt that Dr. Cornelius had found the correct solution? Yet there was one serious obstacle to be overcome before the Cornelius chronology could be accepted.

When the harvest contract documents compiled by Dr. Fotheringham are dated by this solution, the labourers coming to reap the harvest appear to be arriving from two to three weeks too early. If the documents are dated correctly, a change in climatic conditions must be inferred to allow barley and dates to ripen three weeks earlier in old-Babylonian times than during the Persian period and today. Could such a change of climate be possible?

Dr. Cornelius himself, writing two years earlier, considered that insufficient information was available about past climatic conditions. The correct procedure, he argued, should be to establish reliable calendar dates, and from them to determine the climatic conditions; not the other way round [25].

When Professor van der Waerden reviewed the evidence, he was unable to establish directly any change of climate affecting the Hammurabi period. Nevertheless, it seemed "highly probable, that before 1,000 B.C. the climate was warmer than

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[25] Zeitschrift fur Assyriologie, N.F. XIV, pages 146 to 151. F. Cornelius, *Die Venusdaten des Ammisaduqa.* See final paragraph, pages 150-151.

now, not only in Europe, where it is certain, but also in Near Asia". He concluded that there appeared to be nothing impossible in the assumption that during the period of the First Babylonian dynasty, barley and date crops were ripening three weeks earlier than at the present time.

Further investigation, however, has not confirmed this climatic change. It seems more likely that the climate has not changed significantly since the 5th millenium B.C. Thus, Professor M. A. Beek of the University of Amsterdam, in a book published in 1962, states that from 5,000 B.C. onwards "the inhabitants of Mesopotania lived in climatic conditions which probably differed little from those existing at present" [26].

So the anomaly remains unresolved. While the Cornelius chronology certainly links up with a Venus tablet solution, the seasons related to that solution appear to be incorrect.

10. *Other Solutions.* The reason why it has proved so difficult to establish a precise astronomical date from the Venus tablets is, of course, the lack of really close agreement between the astronomical record and the computed data of the various solutions. Had the scribes set out deliberately to confuse posterity, they could hardly have chosen a better distribution of copyists' mistakes. The unfortunate effect has been, that with each of the three solutions already considered there is another similar solution separated from it by an eight year interval.

However, the alternative dating of Sidersky's solution can be safely ignored. It would make his date sequence occur eight years earlier; whereas Sidersky's chronology is thought to be quite early enough. By contrast, the other two solutions have their alternative dates fixed by the succeeding 8-year Venus cycle. Thus all the arguments in favour of Smith and Ungnad's solution apply equally to a solution dated 1638 B.C. to 1617 B.C. Moreover, the alternative dates, 1574 B.C. to 1553 B.C., have been suggested for the Cornelius solution. The exact period of time between the begining of the Larsa dynasty and Ammizaduga's reign, which determines the choice of Venus tablet solution, was uncertain; but possibly not to the extent of eight years.

Perhaps because of this duality of the astronomical findings, Professor van der Meer, when he abandoned his earlier conclusions in favour of a solution designed

[26] M. A. Beek, *Atlas of Mesopotamia.* Translated by D.R. Welsh, M.A. Edited by H. H. Rowley, M.A., B. Litt., D.D., LL.D., F.B.A. Nelson, 1962. Page 9. *The Land and Climate of Mesopotamia.* See paragraph 5.

to fit in with the known sequence of events in the countries around Mesopotania, selected the date 1578 B.C. for the first year of Ammizaduga [27]. Placed half-way between the two possible solutions, it should only be four years out, assuming one of these solutions to be correct; whereas, an astronomical date might prove to be eight years out.

However, the tendancy seems now to have been to rely on archeological and historical, rather than astronomical evidence. A chronology with Hammurabi dated twenty-four years after the date given by Dr. Cornelius, was adopted by Professor E. F. Weidner [28]. On the basis of the Venus tablet evidence that system of dating would be impossible; though, apart from that, there were no doubt, good reasons for selecting it.

11. *The "Middle" Chronology.* The cause of these wide variations in the dates proposed by various experts is, of course, uncertainties in the interpretation of the available historical evidence. Thus dynasties which may have ruled simultaneously were listed sequentially by the Babylonians. Also, gaps in the sequences, due to damaged tablets, cause further uncertainty.

Then there was doubt, also, about when the Kassite period began. It might have followed immediately after the end of the Hammurabi dynasty; or the Kassites could have been already established in some other part of the country before that event took place.

It would now seem, on the evidence of one of the king lists, that the first king of the Kassite dynasty should be dated about 1740 B.C. On the assumption that the Kassites established themselves somewhere in Mesopotania on that date, they should have entered the country, according to Sidersky's chronology, in the reign of Ammiditana. That might well be possible; bearing in mind that the first Kassite king, at least, probably never reigned from Babylon. On the other hand, according to Smith and Ungnad's chronology, the Kassites should have appeared during the reign of Samsuiluna; and the year names of Samsuiluna certainly record a Kassite invasion. On the basis of the Cornelius chronology, however, the Kassites ought to have been already somewhere in the country before the reign of Hammurabi. Since there is no mention of them in the Mari archives,

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[27] M. A. Beek, *Atlas of Mesopotamia.* (See footnote 26). Professor van der Meer's Chronologie for the Hammurabi Dynasty is given on page 83.

[28] M. A. Beek, *Atlas of Mesopotamia.* (See footnote 26). Page 87. *Problems of Chronology.* Dating Hammurabi. Paragraph 2. "de Liagre Böhl 1704-1662 (and so Weidner)".

this is not very likely. So, on that evidence alone, the Cornelius chronology seems less likely to be correct than the other two.

The Sidersky chronology, however, requires a very high average for certain reigns in Assyria and Babylonia. While that fact suggests that the chronology may well be incorrect, it is not conclusive. The most that can be said on the evidence available, is that the "middle" chronology, based either on Smith and Ungnad's solution, or on the solution dated eight years later, is the most probable [29].

[29] The Cambridge Ancient History. Revised Edition of Volumes I & II. Cambridge University Press. 1964. M. B. Rowton, *Ancient Western Asia.* The Main Problem. (c) The date of the First Dynasty of Babylon (Babylon I). Pages 61-63. See last paragraph on page 63.

II. THE ASTRONOMICAL TABLES

1. *Introduction.* About a thousand years after the reign of King Ammizaduga, when the centre of power had shifted from Babylon to Seleucia, Chaldean astronomers were using simple astronomical calculation tables to forecast the movements of the moon and the planets. They knew, of course, from their observations of these bodies, that similar celestial phenomena would always recur after a fixed time interval. Yet within this period the movement taking place across the sky varied from day to day. However, by now the idea had occurred to someone of assuming for calculation purposes a constant velocity throughout this Synodic Period. On that assumption, theoretical mean positions for the moon and planets could easily be calculated for any day of the year. Then a comparison with the corresponding recorded positions yielded seasonal variations which could be tabulated and used later as corrections applied to the calculated mean to give the correct position. So calculation tables were produced giving the astronomer approximate future positions based on this type of calculation.

Modern astronomical tables follow the same principle as their Chaldean predecessors [30]. They incorporate various adjustments which become added to, or subtracted from the mean value as part of the calculation leading the to final result. These adjustments are related to certain quantities, known as "Elements", which define the size and shape of an orbit, and its plane is relation to the earth's orbit. Mathematical equations, expressing gradual changes which take place in the values of these quantities throughout the centuries, are likewise termed "The Elements".

The Elements, as equations, have been altered very little since the begining of this century. Those of Venus were constructed by Professor Simon Newcomb, who died in 1909. He was head of the American Nautical Almanac Office, and became professor of mathematics and astronomy at the Johns Hopkins University in 1884. His great work was on the mathematical astronomy of the Solar System.

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30 Stephen Toulmin and June Goodfield, *The Fabric of the Heavens*. Penguin Books Ltd, Harmondsworth, Middlesex. Published in Pelican Books 1963. Part I. *The Sources of the Old Order*. I. *Celestial Forecasting*. Pages 27-57. This is the chapter which deals with Babylonian astronomy. On page 29 the authors state : "Deciphering those tablets has called for extreme ingenuity, but it has eventually become clear that they correspond very closely to the records of our own Nautical Almanac Office".

This involved the preparation of very exact tables for the motions of the planets, but these were naturally intended for the use of astronomers only.

2. *The Astronomical Chronology of Dr. Wislicenus.* However, in 1895, an *Astronomical Chronology,* summarising the various astronomical calculation tables then available was published at Leipzig. It was compiled by Dr. Walter Wislicinus, Professor of Astronomy at the Kaiser Wilhelm University of Strasbourg [31]. Not only did he explain the method of using different tables, but he also pointed out the purposes to which certain tables were particularly suited. Thus it became possible for the non-astronomer to gain some knowledge of tablework methods.

When the first astronomical data was translated from the cuneiform clay tablets excavated at Nineveh and elsewhere, naturally only astronomers were qualified to deal with it. Now that more material was becoming available, however, historians and others interested began to consider the possibility of making their own astronomical calculations. Unfortunately, the tables available were not very suitable for their purposes. However, astronomical tables with an explanatory preface were now being published. They were of use to the amateur astronomer, if not the historian.

3. *Neugebauer's Tables.* One astronomer who sought to meet the requirements of the historian was Professor P. V. Neugebauer. Professor Neugebauer was astronomer to the Royal Astronomical Computing Office (Rechen-Institute) in Berlin. He began by publishing abridged astronomical tables in 1904 and 1905, but they subsequently became obsolete and were superseded by his later works. In 1912 he published his stellar tables, and in 1914, tables for the sun, planets, and moon; together with the lunar phases. They were designed to cover the period from 4,000 B.C. to 3,000 A.D. [32]

Unfortunately, the specialised information required for ancient astronomical purposes, could only be derived from the tables by means of a very long calculation. However, none of the other tables in use at that time were any better in that respect.

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31 W. Wislicenus, *Astronomische Chronologie,* Leipzig, 1895. See also : P. V. Neugebauer, *Astronomische Chronologie,* Vols I and II. Berlin-Leipzig 1929. Vol. I. *The Preface.* Professor Neugebauer draws attention to Dr. Wislicenus' book in the second paragraph. Vol. I. *The Literature of Astronomical Chronology.* Pages 22 and 23. This is a list of books on astronomical calculation methods from the 1850's to 1923.

32 P. V. Neugebauer, *Tafeln zur Astronomischen Chronologie.* Leipzig, Hinrichs, 1912, 1914, 1922, 1925.

To calculate a first, or last visibility date of Venus, it was necessary to choose an approximate date as a starting point. Then the latitude and longitude of the planet at sunset was calculated for that particular day. This information had next to be converted into Right Ascension and Declination, and a further calculation followed to covert that quite irrelavent data into Altitude and Azimuth. Provided the altitude of Venus at sunset was above a specific angular distance, the planet would become visible when the sun had sunk to that distance below the horizon. To establish the crucial date when the planet was last visible before a conjunction, or just visible after a conjunction, the same calculation had to be repeated for a sequence of perhaps three, or more days.

Thus, the setting and rising dates of Venus could only be determined by means of the maximum amount of labourious calculation [33]. Yet, in spite of this handicap, the early solutions of the Venus tablets were somehow computed. A fair comparison between them was impossible, however, since their authors were presumably using different calculation tables to arrive at their results.

4. *The Oxford Tables.* Accordingly, when Professor Langdon and Dr. Fotheringham decided to investigate the Venus tablet problem, the alternative solutions available for study had first to be recomputed on the same basis. For this purpose, they employed the German astronomer, Herr Carl Schoch. Herr Schoch constructed, therefore, and used an entirely new set of astronomical tables. Unlike an earlier tablework which he had designed for all purposes, not exluding the specialised field of Babylonian Astronomy, these new tables for Babylonian Astronomy are only valid for the latitude of Babylon. For that latitude they give setting and rising dates for the moon and planets. Since they were included in the book, *The Venus Tablets of Ammizaduga,* which was published at Oxford, they are known as the Oxford Tables [34].

The Oxford Tables make use of a seasonal relationship which exists between the setting and rising dates of any planet and the date of the intervening conjunction. For practical purposes, this relationship is repeated annually, being independant of any particular year. Thus a table can be constructed for any latitude selected, which relates the sun's longitude when the planet is at conjunction to the setting

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[33] Berichte der Mathematisch-Physischen Klasse der Sachsischen Akademie der Wissenschaften zu Leipzig, 94 Band, Leipzig, 1943. Pages 23-56. B. L. van der Waerden, *Die Berechnung der ersten und letzen Sichbarkeit von Mond und Planeten und die Venustafeln des Ammisaduqa.* Pages 28-30. 2. *Die Modernen Verfahren zur Berechnung der ersten und letzten Sichtbarkeit von Mond und Planeten.*

[34] Langdon-Fotheringham-Schoch, *The Venus Tablets of Ammizaduga.* Oxford University Press, London 1928. The Oxford Tables are at the end of the book.

date which precedes the conjunction, and the rising date following. So one has only to calculate the time and longitude of the conjunction, and add or subtract the intervening days, to determine the setting or rising date. Since the calculation can be worked out in a few minutes, the Oxford Tables appealed very naturally to Oriental scholars, who might have occasion to check some matter connected with Ancient Astronomy.

5. *Van der Waerden's Amendments to the Oxford Tables.* The Oxford Tables, however, can only yield approximate dates for planetary phenomena. Occasionally, they even give results which are entirely unreliable. This was not generally realised when they were first published in 1928. However, that has been made clear since, as a result of the work of Professor B. L. van der Waerden. In 1943, Professor van der Waerden published a revision of Herr Schoch's Setting and Rising Date Table, based on his own researches. As amended, and compared with the more accurate results obtained by using Neugebauer's Tables, the Oxford Table results are usually either in agreement with the other values, or differing from them by one day. Occasionally, however, they can be two days out, and more rarely the variation is three days. In their original form, however, an error of five, or more days was possible.

These discrepancies were not, of course, the fault of Herr Schoch. They arose because of uncertainty regarding the precise moment at which a planet became visible. The visibility of any planet, however, depends on the atmospheric absorption of sunlight reflected from its surface. At some point during twilight, when the sun is at the correct distance below the horizon, the sky is just dark enough to allow the reflected light to penetrate.

Since in the Northern hemisphere, the effect of the tilt of the earth's axis of rotation is to make the night sky brighter during the summer months than in the winter, it was naturally thought that Venus, or any other planet, would be more difficult to observe against the brighter summer sky; and, therefore, periods of invisibility would be longer during summer than during winter. However, this theory is not quite correct when applied to the Superior conjunction intervals of Venus. The longest invisibility periods for the latitude of Babylon last about 2-months 11-days, with their conjunctions taking place during the first fortnight of May. (Gregorian). Conjunctions occurring in mid-July yield periods of about 2-months duration. Yet conjunctions which occur at the beginning of September have invisibility periods of 2-months 7-days. While this phenomenon is duly recorded by the Venus tablet observations, it was not expected to happen. Accordingly, since there was no background material available to check that particular data, it was naturally assumed to be corrupt. So Herr Schoch's tables assign the longest Venus intervals to the June conjunctions, and make no allowance for a reversal of the general trend in the Autumn. Professor van der Waerden's revision of these tables correct that fault [35].

6. *Van der Waerden's Amendments to Neugebauer's Tables.* Since Classical times, the Angular Distance of the sun below the horizon at the moment when a planet just becomes visible, has been known as the "Arc of Vision". The Arc of Vision, however, is of no particular interest to modern astronomers. The exact days on which planets set or rise, are not now recorded. So there were no recent observations available, which could have been used to assign accurate values to the various Arcs of Vision. Neo-Babylonian records had to be used for that purpose, and attempts were made to observe the actual planets. As more information became available, the values agreed upon became more accurate. Those of Herr Schoch are considerably better than earlier generally accepted figures. Yet, according to Professor van der Waerden, they are "not quite exact, and not able to be". So the Arc of Vision by no means allows for precise computing of setting and rising dates. However, the position is not really so bad as all that.

For mathematical purposes, the visibility of a planet in the proximity of the sun can only be determined by the angular distance of the sun below the horizon at the moment when the planet exactly sets, or rises. The time when this phenomenon takes place can be computed with considerable accuracy. Moreover, when the planet is in that position, the inclination of the ecliptic to the horizon line can be expressed as a function of the longitude of the point where they intersect and the géographical latitude of the place where the observations were made. This means that Altitude can be calculated direct from Latitude and Longitude. So the detour, previously necessary, which involved fixing the planet's position on the Celestial Sphere, can be dispensed with. Accordingly, the time now required to compute an accurate setting or rising date is somewhat reduced, compared with the older method.

The tables requied for following the new method were calculated by Professor B. L. van der Waerden, and incorporated in a treatise for the Leipzig Acadamy in 1942 [36]. They merely supplement the older planetary tables of Professor P. V. Neugebauer. By referring to both sets of tables and a book of logarithms, it is possible to determine whether, or not, Venus was theoretically visible on a selected

[35] B. L. van der Waerden, *Die Berechnung der ersten und letzen Sichbarkeit von Mond und Planeten und die Venustafeln des Ammisaduqa.* (See Foot-note 33) Page 50. Tafel 4.

[36] The Leipzig Academy assembled on 14th December, 1942. Professor van der Waerden presented his treatise at that sitting, but the work was not published till the following year.

day. The calculation takes at least three quarters of an hour to complete. As often as not, it has to be repeated for the following day before one can be absolutely certain on which day the planet was just visible. However, the results ought to be reasonably accurate. They are certainly much better than any dates previously computed for the Venus tablets [37].

7. *The Babylonian Lunar Calendar.* Having thus computed all the Venus dates required by the Julian calendar, the next requirement is to transfer them to the Babylonian calendar for comparison with the Babylonian dates recorded by the Venus tablets. This involves lunar calculations.

The Babylonian calendar is a lunar calendar, with the day beginning at sunset. The Babylonians, it can be inferred, kept a watch on the 29th day of the month for the first appearance of the New Moon. If the crescent failed to appear, the day beginning at sunset was regarded as the 30th day of the old month. Otherwise, it became the first day of the new month. If the moon was hidden by clouds, however, its probable phase would have to be computed [38].

Since the Synodic lunar month is a little over 29 $^1/_2$ days, Babylonian months tended to alternate between 29 and 30-days duration; but two 29-day months in sucession are not uncommon, and occasionally a group of three such months occurs. If, as a result of cloudy weather, the first of two successive 29-day months was incorrectly given the full 30-days, the second would be made a 28-day month to compensate.

Months of 30-days also form themselves into groups. Two, three, four, five and even six such months in succession are possible, but the larger groups are less common. Grouping takes place at intervals of 18, or 19-years. Thus it appears to be related to the retrograde revolution of the nodes, which takes 18 $^2/_3$ years to complete. The pattern of lunar months within that period varies with each successive cycle.

Now, twelve lunar months total about eleven days less than the full 365-days of the year. Hence, months related to the moon begin eleven days earlier each successive year. Thus they tend to move out of their proper season. To prevent

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37 B. L. van der Waerden, *Die Berechnung der ersten und letzen Sichbarkeit von Mond und Planeten und die Venustafeln des Ammisaduqa.* (See foot-note 33). Pages 30-39. II. Theoretischer (geometrischer) Teil.

38 Langdon-Fotheringham-Schoch, *The Venus Tablets of Ammizaduga.* (See foot-note 34). Chapter V. J. K. Fotheringham, *The Visibility of the Lunar Crescent.*

this happening, the Babylonians introduced an extra month every few years. This month was known as an "Intercalary Month".

Intercalary months usually appear either at the middle, or at the end of the year. Thus, the sixth month "Ulul" might be followed by a "Second (or intercalary,) Ulul", and the twelfth month "Adar" by a "Second Adar". Very occasionally, a "Second Nisan" might be used.

During the Venus tablet period , "second Ulul" and "second Adar" months were both used. Moreover, every intercalary month in the reign of Ammizaduga has been found on some or other contract of the period. Since these months can also be inferred from the astronomical record, the record itself could only have originated during his reign.

Babylonian months are usually denoted by Roman numerals. A number follows to denote the day of the month. Thus, the 8th of Ulul is contracted to VI 8. VIb 8 denotes the 8th of intercalary Ulul.

8. *Lunar Tables.* The Oxford Tables are normally used to compute the first day of a Babylonian month. Unlike his planetary table-work. Herr Schoch's Lunar Tables have stood the test of time [39]. He constructed them after he had examined 400 known beginnings on months in the neo-Babylonian Period, and they satisfy 380 of these dates of First Visible Moonlight. Of the 20 discrepancies, he thought 10 could be attributed to bad weather, while the remaining 10 are enigmatical [40].

The tables give data for calculating the times of the New Moon and the first appearence of the Lunar Crescent as seen from Babylon. For calculation purposes, 6 P.M. is taken as the time of Sunset throughout the year. The time which should elapse from the New Moon, or lunar conjunction, to 6 P.M. on the following day for the Crescent to be visible is tabulated. By comparing this with the calculated time, the date of First Visible Moonlight can be arrived at. The day after is, of course, the begining of the month.

Since the Oxford Tables apply only to the latitude of Babylon, other tables have

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[39] B. L. van der Waerden, *Die Berechnung der ersten und letzten Sichtbarkeit von Mond und Planeten und die Venustafeln des Ammisaduqa.* (See foot-note 33). Page 24. "Von diesen (i.e. The Oxford Tables) haben sich die Neulicht-tafeln sehr gut bewährt, aber die Planetentafeln sind leider ganz unzuverlässig".

[40] Landon-Fotheringham-Schoch, *The Venus Tablets of Ammizaduga.* (See footnote 34). Schoch gives this information in the introduction to his Lunar Tables.

to be used for other latitudes. Professor P. V. Neugebauer's Lunar Tables can be used for this purpose. They involve calculating the positions of the sun and moon at the moment when the sun exactly sets. Under those conditions, the altitude of the moon is compared with the minimum altitude at which the crescent could be visible.

For the latitude of Babylon, however, the two methods give about 85 % agreement, and never differ by more than one day. So the Oxford Tables are used where applicable, especially as the other tables require considerably more time to operate.

The Oxford planetary tables are valid only for about one degree North and South of Babylon, but the lunar tables must apply to a much wider belt. Certainly, two degrees North or South should not make much difference. Only a border-line case, with the crescent just becoming visible at 6 P.M., might require to be checked with the other tables to determine the effect of a slight change in the latitude.

Having established the Julian date which corresponds to the first day of the Babylonian month, the day of the month on which the planet Venus was observed is easily determined. The only difficulty arises because the Babylonian day began at sunset, whereas the Julian day begins at midnight. Thus, Venus observations which were taken during the evening of a Julian day, refer to the following day on the Babylonian calendar. Morning observations keep to the same day on both calendars.

Finally, it should be noted that between March –1700 and March –1500 the Julian calendar months begin fourteen days later than the months of the Gregorian calendar. Thus, for the three later solutions, the Vernal Equinox day is March 21st on the Gregorian calendar, and April 4th on the Julian calendar. Similarly, the first Venus tablet date, March 8th (Julian) –1644, is equivalent to March 22nd (Gregorian) 1655 B.C.

III. VENUS TABLET SOURCES AND CORRECTIONS TO THE TEXT

1. *Introduction.* When Sir Austin Henry Layard discovered the first section of King Assurbanipal's library in the ruined palace of King Sennacherib at Nineveh, its clay tablets were covering the whole floor area of two large rooms to a depth of a foot or more. It is thought that these tablets were originally set out at a higher level of the building, where they would be grouped together in baskets with labels to indicate their contents. Since the victorious Medes and Babylonians set fire to the plundered residence before departing, the supporting floor beams would be consumed by the flames, and hundred of clay tablets must have cascaded downwards to the level where they were subsequently excavated [41].

It is not surprising, therefore, that the individual tablets, known as the Venus tablets, some of which were among the surviving 26,000 baked clay tablets which finally reached the British Museum, are broken and defaced with parts missing. Only by combining the information which eauch tablet gives, can the original text be arrived at. It is mainly reconstructed from three important documents.

2. *The Original Sources.* The first of these is Tablet K 160. This is a damaged Assyrian version of the text from Assurbanipal's library. It was first translated and published in 1874 by Professor A. H. Sayce of Oxford University [42]. As the knowledge of cuneiform writing was still being acquired at that time, his translation was somewhat stilted compared with the later translation by Professor Langdon.

The second source is known as K 2321 + K 3032. It comprises two portions of a single Babylonian tablet. This document was available in 1906 to the Italian astronomer, Giovanni Virginio Schiaparelli [43]. He compared it with the Assyrian K 160, and deduced that their common origin must have been Babylonian.

Finally, the most ancient of the three sources is Tablet W 802. This is a tablet which dates from the reign of Sargon of Assyria. It was excavated at Kish in 1924.

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41 M. Joachin Menant, *La Bibliothèque du Palais de Ninive.* Paris, 1880. Chapter II. *Les Livres.*

42 Monthly Notices of the Royal Astronomical Society. Vol. XL. No. 9. (1879-1880).

43 Langdom-Fotheringham-Schoch, *The Venus Tablets of Ammizaduga.* Oxford University Press, London. 1928. For the Venus Tablet sources see : Chapter I. S. Langdon, *Analysis of the Cuneiform Texts.* Chapter II. S. Langdon, *Transcription and Translation.* For Schiaparelli's investigation see : Chapter V. J. K. Fotheringham, *Past Studies on Subject.*

Unfortunately, only the top portion of W 802 has survived, but at least it gives the text for the first six years in legible form. The text for the first eleven years ought to appear on Tablet K 2321 + K. 3032, but much of the astronomical data of the earlier years is now illegible. However, the text can be clearly read on that tablet from Year 7 onwards. So between them, W 802 and K 2321 + K 3032 supply the first half of the astronomical data.

The remainder comes mainly from K 160. This tablet has its top portion missing, and its surface has become defaced. The sequence begins with the 8th year, and would be complete otherwise, if it could all be read. The omens can be identified, but some of the astronomical data is illegible.

However, the back of K 2321 + K 3032 gives additional information. The scribe has arranged the same data here, not in its natural sequence, but in the order of the months of setting. Since the omens for each year are recognisable on K 160, even when the astronomical record itself is obliterated, the particular years can be identified on the other tablet and used, either as a check on data already available, or to fill in the gaps in K 160.

Finally, some small fragments of other Venus tablets are also available for checking where applicable, but they are not very important.

3. *The Two Insertions.* The genuine astronomical sequence which is thus reconstructed, has been disrupted in two places. First, there is the insertion of the date-formula, "Year of the Golden Throne", at the beginning of the 9th Year. The Western rising of Year 9 was, presumably, erased when this was done. However, the relavent data is recorded on the reverse side of K 2321 + K 3032, though not necessarily correctly.

The other break is caused by the insertion of an astronomical table, which is composed of artificial Venus data with the appropriate omens. This table makes use of a standard period of 8 months 5 days from the first day of visibility to the first day of invisibility. Its invisibility periods are respectively, 3 months at Superior conjunction, and 7 days at Inferior conjunction.

The begining of the interval during which Venus was absent from the sky was probably of secondary importance to the Babylonians. 8 months 5 days was not the shortest possible period of visibility, judging by the Venus tablet data; but it would, no doubt, give a reasonable indication of when Venus might be expected to set. Astronomical observation nearer the time would, of course, yield a more accurate estimate of the probable date.

The date when Venus would again become visible was much more important than the setting date. The table gives two values for that date in relation to the previous setting date. They are 11 months 5 days from Eastern rising to Western rising, and 8 months 12 days from Western rising to Eastern rising.

Now, these two periods of time compare quite well with the corresponding data given by the Venus tablets. It is, of course, necessary to ignore the two periods associated with Year 12, since the setting and rising dates of that year are abnormal. So the shortest normal Venus tablet interval between two successive rising dates is 8 months 15 days, and the longest similar period is 11 months 7 days. The first value represents the time which elapsed from the Western rising of Year 15 to the Eastern rising of Year 16; and the second value, the period between the Eastern rising of Year 14 and the Western rising of Year 16. Those two Venus tablet intervals are respectively 3 days, and 2 days greater than the periods of time given by the table.

However, it seems clear enough that the main purpose of the table was to indicate the limits within which the next rising date might be expected. Moreover, there is further agreement with the Venus tablet data. According to the tablets, the longest period between a Western rising and an Eastern rising was 9 months 15 days. This is roughly one month greater than the shortest period of 8 months 12 days given by the table. Similarly, if one month is deducted from the table's highest value to give 10 months 7 days, that interval is only 3 days less than the shortest Venus tablet period between an Eastern rising and a Western rising. No doubt this margin of one month was allowed for when the table was in use, though no instructions regarding that provision are recorded.

While there is certainly agreement between the table and the Venus tablet data, that agreement does not apply to the Venus tablet solutions. For the Solution 1646 B.C. to 1625 B.C., the shortest interval between two rising dates is not 8 months 15 days, but 8 months 23 days; and the longest is 11 months 3 days. Thus, if the astronomical data recorded by the Venus tablets is correct, and if the "Medium chronology" is, in fact, the correct chronology for the Hammurabi period, the relationship of Venus to the earth must have changed since Old-Babylonian times, so that the table subsequently became obsolete. It has probably survived only because it happened to provide a convenient peg for the omens. The omens are associated with the month of rising, and were quite possibly added during the Kassite period. Perhaps, in its original form, the table would only consist of columns of month names and day numerals [44].

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[44] Schiaparelli considered this insertion to be a table by means of which, given the time of any reap-

The insertion of this Venus Rising Date table has, unfortunately, resulted in the recorded data for the 18th Year being omitted from the sequence. As it happens, however, the face or obverse side, of K 2321 + K 3032 records for the 5th Year Superior conjunction, setting and rising dates which are totally different from the information given on the reverse side, and also by W 802. That data, while clearly incorrect for Year 5, would appear to fit in quite well with the alternative computed data for Year 18. Accordingly, it seems reasonable to accept it as such [45].

4. *The Scribal Errors.* Now, a comparison of these alternative sources where they interlap, shows that they are not always in exact agreement. A decision to copy an earlier tablet would probably be taken when it was beginning to show signs of damage through use. Thus, some of the cuneiform symbols might by then have become difficult to identify. Perhaps to minimise uncertainty due to this cause, the duration of the invisibility intervals came to be included with the setting and rising dates. Unfortunately, the text seems already to have become altered in places before this was done. Further mistakes arose over the centuries in spite of the check provided by thus recording the invisibility periods.

The most common discrepancy is a variation of one day only between alternative versions. This is not a serious matter. W 802, the oldest tablet, seems to give the correct version. Where this source is not available, the reverse side of K 3321 + K 3032 is more dependable than the obverse side, and also more dependable than K 160. Tablet K 160, however, takes precedence over the small fragments of other tablets.

Another common mistake which the scribes tended to make, was adding or subtracting a "ten". This is not so bad where the alternative versions are known, because the correct version can be identified by comparison with the computations of different solutions. With only one version available, however, it is not always so easy to decide whether this type of error has occurred. One solution may benefit if a "ten" is added to the text, whereas another requires no such adjustment.

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pearance of Venus, the time of the next disappearance and reappearance could be computed, assuming mean intervals between the different phenomena. Using a mean lunation of 29.5 days, he found the intervals used implied a synodic period of 557.5 days. That is about 6-days less than the true period of 583.9 days.

Kugler, on the other hand, thought the Babylonian table was based on conventional months of 30-days and a conventional year of 360-days. On that assumption, he deduced a conventional synodic period of 587 days.

The true synodic period of Venus in old-Babylonian times could not, of course, have been very much different from its present value.

45 My own suggestion.

Ambiguity in the text is not, of course, confined to the addition or omission of a "ten". The Western rising of Year 20 has two versions which are totally different from each other. According to K 2321 + K 3032, the rising took place on 1st Tesrit, and K 160 gives an invisibility period which is consistant with that date. Yet K 160 also records the rising date as 24th Tesrit. The former version is more likely to be correct, since it is closer to the various computed values. Yet it is the latter version, 24th Tesrit, which has always been accepted.

There is one correction to the Venus tablet text which is never disputed. It affects the Western setting month of Year 9. Venus, when at inferior conjunction during that year, might have been expected to be absent from the sky for about 4 days. Yet, 9 months 4 days is the interval which the tablets record. It is thought that a scribe, when copying from an earlier tablet, misread the previous month of rising as the setting month; and thus wrote the wrong month down. This mistake would be possible if the periods of invisibility, which the Venus tablets record in "months" and "days", were not then incorporated in the text. Since the month of setting is very unlikely to have been Sivan, it is always altered to Adar. That correction reduces the duration of the invisibility period to the more acceptable value of 4 days.

The Western rising of Year 9, which the scribe presumably misread, is itself incorrect. As given by the Venus tablets, that rising apparantly took place on 2nd Sivan; whereas 12th Sivan would be a more likely date. Alternatively, the numeral could have been "11". Confusion between the figures "2" and "11" was possible because of the limitations of the cuneiform writing. The scribes were using sharpened reeds to make wedge-shaped incisions on a wet clay surface. The figure "ten" was denoted by a wedge sloping down from left to right at an angle of 45 degrees, and the figure "one" by a vertical wedge. When grouped together they represented the numeral "eleven". Similarly, two verticals side by side gave the number "two". If the first wedge became illegible, however, or had been badly incised, there would subsequently be doubt as to whether the number recorded was an "eleven" or a "two". However, 11th Sivan is the date of the incorrect Western setting of Year 9. If a scribe did, in fact, mistake the Western rising date for the setting date, the rising date itself was probably 11th Sivan.

Another source of confusion to the scribes was the cuneiform numbers "six" and "eight". The former numeral was denoted by two groups of three vertical wedges, one group above the other; the latter by two similarly placed groups of four wedges. With either sign, the units would tend to merge into rectangular shapes, which probably looked very similar when the eye was tired, or the vision perhaps a little blurred. The result for the Venus tablets was the Eastern rising date of Year 14, which is given as 26th, 27th, or 28th Arahsamna. The correct numeral was probably "28".

Apart from confusing the numerals, the scribes sometimes mixed up the months. The Western rising of Year 13 is an example of this type of error. Accoring to the Venus tablets, the planet became visible during the month of Sabat. Since that is impossible by any solution, the following month, Adar, is usually substituted for Sabat. While that reconstruction is possible, the revised date, 21st Adar, is still too early in relation to the various computed values. This is especially the case if an alternative version, which gives the numeral as "11", is accepted. So the next again month, which is Nisan, may be the correct one. Now, the cuneiform signs for both Nisan and Sabat begin with three horizontal wedges. Otherwise, of course, they are totally different. Assuming an earlier tablet was defaced, so that only the begining of the month's name was legible, the scribe may have been in doubt as to which month was intended. Not being an astronomical expert, he selected the wrong one. The rising date, as 11th Nisan, is rather late in relation to the computations, but that could be attributed to unfavourable weather. Alternatively, of course, the "11" may have once been a "2".

A more complicated example of mixed months is the impossible data given for Year 19. Venus is supposed to have set on the 1st of intercalary Ulul, and to have risen again on the 17th on that month. The invisibility period is given as 15 days, but it must originally have been 16 days to fit these setting and rising dates. If the numeral "one" of the setting date is part of the original numeral, Venus probably reached its last visibility on the 21st of intercalary Ulul. Sixteen days from that date is 7th Tesrit, which is a possible rising date. So not only has the scribe selected the wrong month, but also he appears to have added a "ten" to the day numeral. Otherwise, the original version was VIb 11/VII 7.

5. *Unfavourable Weather*. One of the difficulties which arise when a comparison is made between the text of the Venus tablets and the computed data of the various solutions, is deciding when adverse weather conditions occurred during the reign of Ammizaduga. The computation can only give setting and rising dates of Venus on the assumption that visibility was always perfect. If, in reality, a bank of cloud near the horizon prevented observation of the planet at the crucial date, the effect will be divergence between record and computation. Unfortunately, minor variations due to weather can only be detected when the correct solution is known. However, two of the abnormally long periods of invisibility could be connected with unfavourable weather conditions.

One of those periods comes from Year 14. Venus, at inferior conjunction, is recorded as having been absent from the sky over a period of 1 month 16 days. Normally, the duration of the interval would be about 3 days. However, during Year 14, the Western setting apparently took place on 10th Tesrit. As this date is over a month too early, it might be assumed that the scribes have made yet another mistake. On the other hand, the conjunction took place round about December, when stormy weather is to be expected. Thus it is possible that a cloudy wet month prior to the new moon prevented normal observation of the planet.

The other abnormal period of invisibility took place when Venus was at Superior conjunction during Year 12. Normally during the summer months the planet would be absent from the sky for about 2 months 5 days if a conjunction took place, but during this year Venus was invisible over a period of 5 months 16 days. So either the text is corrupt, or Ammizaduga's 12th year had a freak summer.

The text gives the respective setting and rising dates of Venus as 9th Nisan and 25th Tesrit, or in their contracted form, I 9/VI 25. Herr Schoch has suggested that these dates were originally II 29/V 5. According to this theory, when the astronomers recorded their astronomical observations, they denoted the months, as well as the days of the month, by numerals. The scribe who copied the record inadvertently deducted a vertical wedge representing "one" from the numeral of the month of setting, and added it to the rising month numeral. Similarly, he ommited the two sloping wedges representing "twenty" from the day numeral of the date of setting, and added them to the corresponding numeral of the rising date. Finally, he calculated the interval, and duly wrote down the incorrect invisibility period. Though hardly complimentary to the intelligence of the scribe, the reconstructed dates are very close to the computed values.

Alternatively, the recorded setting and rising dates of Year 12 can be regarded as genuine. They are, at least, correctly spaced in relation to the conjunction date. Thus they would be consistent with some form of atmospheric obscuration, though a year having continuous cloud from May to July and from August to October would certainly be abnormal.

Years having abnormal summers are sometimes connected with volcanic activity. In 1912, after the eruption of Katmai in Alaska, the volcanic ash ejected into the atmosphere reduced solar radiation by about 20 %, and a very cold year followed. Similarly, following the eruption of Tomboro in 1815, the year 1816 was known as "The Year without a Summer". [46] Thus, if volcanic activity took

[46] Martin Schwarzbach, *Climates of the Past — an Introduction to Paleoclimatology*, translated and

place during Ammizaduga's reign, the astronomical observations of Year 12 would appear to be more reasonable.

Now, it is known that some great natural catastrophe did occur in Crete about 1600 B.C. That was when the Middle Minoan Period ended, probably as a result of an earthquake. There may also have been volcanic activity somewhere about. As the "Medium Chronology" gives the date of Year 12 as –1634, the astronomical record may be related to that disaster. If the atmosphere was saturated with volcanic dust, the dust would probably interfere with observation of the planets near the horizon, rather than overhead. Venus is naturally very close to the horizon at first and last visibility. Apart from that, the conditions which sometimes result in a freak summer might well have been present. So there is some justification for accepting, at least provisionally, the Venus tablet data for Year 12, and giving the scribes the benefit of the doubt.

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edited by Richard O. Muir. D. van Nostrand Company Ltd., 358 Kensington High Street, London, W 14. Pages 236-238. *Volcanic Ash.*

THE VENUS TABLET SOURCES [47]

YEAR	CORRECT ASTRONOMICAL SEQUENCE.				ARRANGED IN ORDER OF RISING MONTH.			
	W 802	K 2321+ K 3032 Observe	K 160	R.M. II 531	K 2321+ K 3032 Reverse	R.M. 134	K 7072	S 174
1.	W.S.	W.S.			W.S.			
	XI 15				XI 25			
	3d.	3d.			3d.			
	E.R.	E.R.			E.R.			
	XI 18				XI 28			
2.	E.S.	E.S.			E.S.			
	VIII 11				VIII 11			
	2m 7d.	2m 7d.			2m 8d.			
	W.R.	W.R.			W.R.			
	X 19				X 19			
3.	W.S.	W.S.			W.S.			
	VI 23				VI 23			
	20d.	20d.			20d.			
	E.R.	E.R.			E.R.			
	? IV 13				VII 13			
4.	E.S.	E.S.						
	IV 2							
	2m 1d.	2m 1d.						
	W.R.	W.R.						
	VI 3							

[47] Langdon-Fotheringham-Schoch, *The Venus Tablets of Ammizaduga.* (See foot-note 43.) Chapter II. S. Langdon, *Transcription and Translation.*
Professor Langdon includes a "Table of the Risings, Settings, and Periods of Visibility and Invisibility". All the Western Settings and Eastern Risings are placed in one group, and all the Eastern Settings and Western Risings in another.
The earlier translation of K 160 by Professor Sayce differs slightly from that of Professor Langdon in that some of the months and some of the numerals are not in agreement. The discrepancies come mainly between the Western Rising of Year 13 and the Western Rising of Years 16/17. They no doubt arise because the tablet is defaced and difficult to decipher.

Y	CORRECT ASTRONOMICAL SEQUENCE.				ARRANGED IN ORDER OF RISING MONTH			
E A R	W 802	K 2321+ K 3032 Obverse	K 160	R.M. II 531	K 2321+ K 3032 Reverse	R.M. 134	K 7072	S 174
5.	W.S.	W.S.						W.S.
	II 2					II 2	II 2	II 2
	18d.	15d.					15d.	15d.
	E.R.	E.R.						E.R.
	II 8						II 18	II 18
5.	E.S.	E.S.			W.S.			
	IX 25	IX 12			IX 24			
	2m 4d.	2m 4d.			m 4d.			
	W.R.	W.R.			W.R.			
	XI 29	XI 16			XI 28			
6.	W.S.	W.S.			W.S.			
	VIII 18				VIII 28			
	3d.	3d.			5d.			
	E.R.	E.R.			E.R.			
	IX 1	IX 1			IX			
7.	E.S.	E.S.						
		V 21						
	2m 11d.	2m 11d.						
		W.R.	W.R.					
		VIII 2	2					
8.		W.S.	W.S.					
		IV 25	IV 25					
	7d.	7d.	7d.					
		E.R.	E.R.					
		V 2	V 2					
8/9		E.S.	E.S.		E.S.			
		XII 25	XII 25		XII 25			
					2m 7d.			
		YEAR	YEAR		W.R.			
		NAME	NAME		III 2			
9.		W.S.	W.S.					
		III 11	11					
		9m 4d.	9m 4d.					
		E.R.	E.R.					
		XII 15	XII 15					

Y	CORRECT ASTRONOMICAL SEQUENCE.				ARRANGED IN ORDER OF RISING MONTH			
E A R	W 802	K 2321+ K 3032 Observe	K 160	R.M. II 531	K 2321+ K 3032 Reverse	R.M. 134	K 7072	S 174
10.		E.S.	E.S.		E.S.			
		VIII 10	VIII 10		VIII 8			
		2m 6d.	2m 6d.		2m 8d.			
		W.R.	W.R.		W.R.			
		X 16	X 16		X 16			
11.		W.S.	W.S.		W.S.			
		VI 26	VI 26		VI 26			
		11d.	11d.		12d.			
		E.R.	W.R.		E.R.			
		VIb 7	VIb 7		VIb 8			
12.			E.S.			E.S.		
			I 9			I 8	I 8	
			5m 16d.			5m 0d.	5m 17d.	
			W.R.				W.R.	
			VI 25				VI 25	
13.			W.S.	W.S.	W.S.			W.S.
			II 5	II 5	II 5			II 5
				7d.	7d.			7d.
			E.R.	E.R.	E.R.			E.R.
			1 ?	II 12				II 12
13.			E.S.	E.S.	E.S.			
				X 21				
			1m 0d.		2m 0d.			
			XI 21	XI 11				
14.			W.S.	W.S.	W.S.			
	VII		VII 10	VII 10	VII 11			
			1m 16d.	1m 16d.	1m 17d.			
			E.R.		E.R.			
	VIII 27		VIII 26	VIII 26	VIII 28			
15.			E.S.	E.S.				
			20	V 21				
			2m 15d.	2m 16d.				
			W.R.					
			VIII 5	IX 5				
16.			W.S.	W.S.	W.S.			

YEAR	CORRECT ASTRONOMICAL SEQUENCE. W 802	K 2321+ K 3032 Observe	K 160	R.M. II 531	ARRANGED IN ORDER OF RISING MONTH K 2321+ K 3032 Reverse	R.M. 134	K 7072	S 174
			5	VIII 4	IV 5			
			15d.	16d.	15d.			
			W.R.	E.R.	E.R.			
			20	IV 20	IV 20			
16/17			E.S.					
			XII 25	XII 15				
			3m 9d.					
			W.R.					
			III 24					
17.			W.S.		W.S.			
			XII 1 ?	XII 11	XII 11			
			4d.		4d.			
					E.R.			
					XII 15			
18.			INSERTION					
			OF					
			TABLE					
19.			W.S.					
			VIb 1					
			15d.					
			E.R.					
			VIb 17					
20.			E.S.					
			III 25					
			2m 6d.					
			W.R.		W.R.			
			VI 24		VI 1			
21.			W.S.			W.S.		
			I 27			I 26		
			7d.			6d.		
			E.R.				E.R.	
			II 3				II 3	
21.			E.S.					
					2m 0d.			
			W.R.					
			XII 28					

THE ARTIFICIAL VENUS TABLE INSERTED IN TABLET K 160

RISING				SETTING				INTERVAL	RISING			
EAST		WEST		EAST		WEST			EAST		WEST	
I	2			IX	7			3 months			XII	8
		II	3			X	9	7 days	X	15		
III	4			XI	8			3 months			II	9
		IV	5			XII	10	7 days	XII	17		
V	6			I	11			3 months			IV	11
		VI	7			II	12	7 days	II	19		
VII	8			III	13			3 months			VI	13
		VIII	9			IV	14	7 days	IV	21		
IX	10			V	15			3 months			VIII	15
		X	11			VI	16	7 days	VI	23		
XI	12			VII	17			3 months			X	17
		XII	13			VIII	17	7 days	VIII	25		

VENUS TABLET RECORD
PERIODS BETWEEN SUCCESSIVE RISING DATES

EASTERN RISING (I.C.)	WESTERN RISING (S.C.)	PERIOD BETWEEN RISINGS	REMARKS
1 XI 18	2 X 19	11m 1d	
3 VII 13	4 VI 3	10m 20d	
5 II 18	5 XI 29	10m 11d (I)	
6 IX 1	7 VIII 2	11m 1d	
8 V 2	9 III 12	10m 10d	Minimum period.
9 XII 15	10 X 16	11m 1d (I)	
11 VIb 8	12 VI 16	12m 8d	Abnormal.
13 II 12	14 I 2 *	10m 19d	
14 VIII 28	15 VIII 5	11m 7d	Maximum period.
16 IV 20	17 III 10 *	10m 19d	
17 XII 15	18 XI 16	11m 1d	
19 VII 7 *	20 VI 1 *	10m 14d	
21 II 3	21 XII 28	10m 25d	

NOTE : Table from K 160 gives maximum period as 11 months 5 days. Minimum period is, presumably, 10 months 5 days.

WESTERN RISING (S.C.)	EASTERN RISING (I.C.)	PERIOD BETWEEN RISINGS	REMARKS
2 X 19	3 VII 13	8m 23d	
4 VI 3	5 II 18	9m 15d (I)	Maximum period.
5 XI 29	6 IX 1	9m 1d	
7 VIII 2	8 V 2	9m 0d	
9 III 12 *	9 XII 15	9m 3d	
10 X 16	11 VIb 8	8m 21d (I)	
12 VI 16	13 II 12	7m 26d	Abnormal.
14 I 2 *	14 VIII 28	8m 26d (I)	
15 VIII 5	16 IV 20	8m 15d	Minimum period.
17 III 10	17 XII 15	9m 5d	
18 XI 16	19 VII 7 *	8m 20d (I)	
20 VI 1 *	21 II 3	9m 2d (I)	
21 XII 28			

NOTE : Table from K 160 gives minimum period as 8 months 12 days. Maximum period is presumably, 9 months 12 days.

* Correction to the text.

(I) Intercalary month included in the total.

Solution 1646 B.C. to 1625 B.C.
PERIODS BETWEEN SUCCESSIVE RISING DATES

EASTERN RISING (I.C.)			WESTERN RISING (S.C.)			PERIOD BETWEEN RISINGS Months & Days		Days	REMARKS
1	XI	19	2	X	19	11m	0d	324	
3	VII	17	4	VI	10	10m	23d	319	
5	II	13	5	XII	2	10m	19d (I)	314	
6	IX	2	7	VIII	5	11m	3d	328	Maximum.
8	IV	28	9	III	13	10m	15d	311	Minimum.
9	XII	16	10	X	16	11m	0d (I)	324	
11	VIb	13	12	V	6	10m	23d	318	
13	II	28	13	XII	27	10m	19d	314	
14	VIII	29	15	VIII	1	11m	2d	327	
16	IV	24	17	III	10	10m	16d	311	
17	XII	11	18	XI	12	11m	1d	325	
19	VII	9	20	VI	2	10m	23d	318	
21	II	4	21	XII	24	10m	20d	314	

WESTERN RISING (S.C.)			EASTERN RISING (I.C.)			PERIOD BETWEEN RISINGS Months & Days		Days	REMARKS
2	X	19	3	VII	17	8m	28d	263	
4	VI	10	5	II	13	9m	3d (I)	268	Maximum.
5	XII	2	6	IX	2	9m	0d	267	
7	VIII	5	8	IV	28	8m	23d	257	Minimum.
9	III	13	9	XII	16	9m	3d	268	Maximum.
10	X	16	11	VIb	13	8m	27d (I)	263	
12	V	6	13	II	8	9m	2d	268	
13	XII	29	14	VIII	29	9m	0d (I)	266	
15	VIII	1	16	IV	24	8m	23d	259	Minimum.
17	III	10	17	XII	11	9m	1d	268	
18	XI	12	19	VII	9	8m	27d (I)	262	
20	VI	2	21	II	4	9m	2d (I)	269	
21	XII	24							

NOTE : The Babylonian period, in lunar months and days, is not an exact figure. The proportion of 30 day and 29 day months between successive rising dates varies.

(I) Intercalary month included in the total.

A COMPARISON BETWEEN MAXIMUM AND MINIMUM PERIODS

PERIOD FROM EASTERN RISING TO WESTERN RISING

	K 160 Table	Venus Tablets	Solution 1646 B.C. to 1625 B.C.
MAXIMUM	11m 5d	11m 7d	11m 3d
MINIMUM	(10m 5d)	10m 10d	10m 16d

PERIOD FROM WESTERN RISING TO EASTERN RISING

	K 160 Table	Venus Tablets	Solution 1646 B.C. to 1625 B.C.
MAXIMUM	(9m 12d)	9m 15d	9m 3d
MINIMUM	8m 12d	8m 15d	8m 23d

IV. THE APPROXIMATE LATITUDE OF THE BABYLONIAN TEMPLE-OBSERVATORY AND THE DATE OF THE OBSERVATIONS

1. *Theory.* All previous attempts to establish by astronomical means the historical date of the Venus tablet record make use of setting and rising dates for Venus which have been calculated for the latitude of Babylon. If the Babylonian observatory was not close to that city, the astronomical data computed for the various solutions must itself be incorrect. Yet where else could the observatory have been, if not at Babylon? If it predated the First Babylonian Dynasty, it might have been near the ancient city of Agade.

Agade was founded about 650 years before the time of Ammizaduga by the Akkadian king, Sargon. It was the administration centre of his newly formed Empire. This Empire united all the region from the Tauros mountains to the Persian Gulf. One effect of Sargon's military conquest must have been the introduction of a uniform lunar calendar throughout Mesopotania.

This ever-varying month sequence would have been derived from the observations of one observatory only; for the precise time when the lunar crescent becomes visible changes with latitude and longitude. Then, once the first day of the following month had been determined by observation, the various population centres would have to be informed as quickly as possible. Presumably messengers radiated outwards from a site near the centre of the country. This would either be Agade itself, or its temple observatory. The natural place for Sargon to build an astronomical observatory would be near his capital.

In later times, when new dynasties came to power, the seat of government shifted; but not, presumably, the observatory. To re-site that building would be deemed undesirable for scientific reasons. The earlier astronomical observations recorded in its library could only be related to contemporary work if the point of observation remained unaltered. This would especially apply to planetary setting and rising dates.

Accordingly, when Ammizaduga ruled from Babylon, the practice may have been long established by tradition of recording the first and last visibility of Venus from a temple-observatory situated somewhere near the ruins of Agade, which would be about 34 degrees North latitude. If that surmise is correct, the Venus tablet astronomical record would have originated from there.

2. *Effect on Venus Tablet Solutions.* This theory is easily tested by computing for each solution Venus setting and rising dates for 32-5 degrees North latitude and 3-40 degrees North latitude, and then comparing the results. Accurate values are possible, if Professor B. L. van der Waerden's adaptation of Neugebauer's Tables is used.

There are, of course, only three basic solutions within the range of historical possibility. Two of them, when the comparison is made, yield very similar results. They are the Sidersky Solution, which is dated 1702 B.C. to 1681 B.C.; and the Cornelius Solution, dated 1582 B.C. to 1561 B.C. While both have eight of their observations improved in relation to the record; the former has another eight, and the later another nine which are not so good. So neither solution supports the conjecture that the observatory was near Agade.

The third solution, however, is consistant with that idea. This solution, which is known as Smith and Ungnad's Solution, is dated 1646 B.C. to 1625 B.C. When computed for 34-0 degrees North latitude, sixteen of its setting and rising dates are closer to the corresponding Venus Tablet dates than their equivalents calculated for the latitude of Babylon. However, the agreement is less satisfactory with another eight.

While this solution is certainly improved when computed for an observatory situated 1 $^1/_2$ degrees North of Babylon, most of the observations which yield better agreement with the record are related to the Superior conjunctions. Only three of the Inferior conjunction setting and rising dates are, in fact, improved by the adjustment to the latitude; whereas four are made worse. The two previous solutions, however, are no better in this respect.

In arriving at these figures, an alternative version of Year 5, which appears on the Obverse side of Tablet K 2321 + K 3032, has been transferred to Year 18. It seems to fit in with the various computations, and for the two later solutions, one of the improvements is in relation to its rising date. The only other modification to the text is a correction to the month of setting of Year 9. Since the computed setting date is unaltered by the change of latitude, this correction makes no difference to the results.

It is wiser not to attempt to correct the text when comparing solutions. Corrections which seem valid for one solution are not always applicable to another. So a prematurely corrected text could lead to wrong conclusions. Yet the text, as it stands, sometimes presents a problem.

3. *Solution 1582 B.C. to 1561 B.C.* A peculiarity of the solution dated 1582 B.C. to 1561 B.C. arises during the 4th Year of Ammizaduga. Venus was at Superior conjunction during that year. According to the tables, the planet, as observed from Babylon, should have been absent from the sky during a period of 64-days. According to the Venus tablets, however, the actual period of invisibility was shorter. It apparently lasted only 59-days. So, taken at its face value, the recorded period seems to imply that the astronomers making the observations possessed exceptional powers of vision. Seemingly, they could still see Venus three days after its calculated setting date, and they were able to observe it again two days before its computed date of rising.

To the early investigators, any disagreement which they found between the text of the Venus tablets and the computation was of little importance. While not forgetting the limitations of the available astronomical tables, they preferred either to attribute the discrepancies to gross carelessness on the part of the Babylonian scribes, or to assume that unfavourable weather had interfered with the visual observations.

In this particular case, however, the recorded invisibility period of Year 4 is shorter than computed. Accordingly, the data could never have resulted from abnormal weather conditions. While bad visibility might prevent observation of the planet when it is about to rise or set, thus adding a few days to the computed number; not even the most perfect observing conditions can produce the opposite effect.

Carelessness of the Babylonian scribes is a more likely explanation; but how could the mistake have arisen? Venus, which should have set on 29th Sivan, remained visible till 2nd Tammuz. The fact that even the month is different, makes a transcription error unlikely. So only the rising date is suspect.

Venus rose apparently on the 3rd of Ulul instead of the 5th. Since the scribes sometimes ommitted a "ten", the actual date might have been the 13th. The setting date, the date of rising, and presumably also the conjunction date, would then seem to be occurring later than computed.

Now, the recorded setting date of Year 20 is also later than computed, and its rising date is doubtful because of a suspected scribal error. Thus the data of that year may well have the same characteristics as that of Year 4. Year 12, the remaining year of the cycle, has data which will fit in with any arrangement. So the complete cyclic group may be displaced.

This seeming displacement of cyclic setting and rising dates may be caused by two factors. One is the time interval between successive conjunctions, which varies with the orbital positions of the two planets. The other is a seasonal relationship between conjunction dates and their related setting and rising dates.

To illustrate the first factor, consider the time which elapsed between the first and second conjunction of the Venus tablets. For the solutions beginning 1582 B.C., 1646 B.C., and 1702 B.C., this interval is 290.93 days, 292.99 days, and 295.03 days respectively. Obviously, when a wrong solution is selected, the computed conjunction dates must be incorrectly spaced, but normally this is not detectable, because the actual conjunctions are not recorded. Moreover, the seasonal change in the relationship between the setting and rising dates and the date of the conjunction seems to compensate for the incorrect spacing of the later. Sometimes, however, the two factors combine to displace a cyclic sequence of invisibility periods. Apart from this, individual observations within the cycles may be further distorted by an incorrect sequence of lunar months.

Accordingly, if the cyclic group comprising Years 4, 12 and 20 is indeed displaced, it might reasonably be deduced that 1582 B.C. is not the date of the Venus tablets. However, a corruption of the text is only an assumption.

The third explanation, that discrepancies between record and computation arise through the limitations of the astronomical tables, would only be applicable to small divergencies. Since the Venus calculation tables used are the most accurate available, the Venus computation ought to be dependable. Moreover, the margin of error for the Lunar tables would normally not exceed one day. Provided the Elements on which the tables are based are correct, the computed data must be reasonably accurate.

The computed data, however, is normally only applicable to the latitude of Babylon. It would have to be calculated for a latitude $2\,^1/_2$ degrees South of that city to suit the data recorded for Year 4. Moreover, the setting date of Year 20 corresponds to an even more Southerly latitude. However, it might be assumed provisionally that the scribes have added a "ten" to the numeral.

Yet a solution based on 30 degrees North latitude is not really practical. Certainly, the observatory is more likely to have been at Babylon itself than on the shores of the Persian Gulf. Apart from that, why assume exceptionally bad observing conditions throughout the reign of Ammizaduga? While the seeming discrepancies of the other cyclic groups could, no doubt, in theory be attributed to unfavourable weather, if each group is treated independently, it is in fact found to correspond to an individual latitude of its own. Moreover, these latitudes appear to be arranged in a logical sequence. Clearly, this is not the effect of unpredictable weather conditions, or of haphazard mistakes by the scribes.

The regularity of the pattern formed from the apparent latitudes of the Superior conjunction cyclic groups is revealed by plotting them out in graphical form. The horizontal co-ordinate represents the sun's longitude in degrees measured from the Vernal equinox. The vertical co-ordinate gives degrees of latitude North and South of Babylon.

While it would be un-wise to attach too much significance to what is, in effect, a curved shape based on approximations, the graph is, nevertheless, of considerable interest. If the estimated latitude values are reasonably accurate, they support very strongly the theory that the Venus tablet observations were taken at an observatory situated around 34 degrees North latitude. This particular latitude, which is $1\,{}^{1}/_{2}$ degrees North of Babylon, is the natural zero line of the graph. The curve can be made to intersect that line at points which coincide with the sun's longitude at Apogee and Perigee.

When estimating these latitudes, Year 4 has been accepted in preference to Year 20 as representing the cyclic group comprising Years 4, 12 and 20. The data of Year 20, which probably corresponds to a latitude about 6 or 7 degrees South of Babylon, is inconsistent with the other graphical points; whereas, the latitude $2\,{}^{1}/_{2}$ degrees South derived from Year 4 seems to fit.

Now the days on which the sun is at its greatest and least distance from the Earth gradually change throughout the centuries. The Aphelion and Perihelion orbital points move away from the Vernal equinox by a little over one degree with each solution. Thus, whereas in Ammizaduga's time the sun was at Perigee in late October, it is now in that position at the beginning of the year.

The graphical curve can, of course, be fitted in well enough with the positions of the orbital points for 1582 B.C. Yet the natural position of that curve corresponds to an earlier date. It seems to be about 1850 B.C., which is outside the limits of historical possibility. However, that is merely because the estimated latitude values represented by the graphical points are not really accurate enough to pin-point the correct solution. Nevertheless, they do seem to indicate one of the two earlier solutions.

Apart from its relationship to the orbital points of the earth, the graph itself seems to have no particular astronomical meaning. It appears to be a measure of the distortion inherant in the solution 1582 B.C. to 1561 B.C. Thus it provides a perfectly good reason for rejecting that solution.

4. *Solutions 1702 B.C. to 1691 B.C. and 1646 B.C. to 1625 B.C.* Turning to the Superior conjunction data of the other two solutions, the earlier one, 1702 B.C. to 1691 B.C., has one of its cyclic groups out of position. The setting and rising dates of this group, which comprises Years 5, 13 and 21, are two to three days earlier than the dates as recorded, when computed for Babylon. When computed for 34 degrees North latitude, they yield a discrepancy which is slightly worse.

By contrast, the solution 1646 B.C. to 1625 B.C. has no similar displacement of a cyclic group. Two individual years, Years 5 and 7, have their invisibility periods out of position by about three days. This anomaly, however, is not repeated when similar Venus phenomena reappear eight years later.

So Smith and Ungnad's solution yields much better results than Sidersky's solution. Apart from any other considerations, the cyclic group distortion of the earlier solution justifies its rejection.

5. *A Lunar Anomaly of Solution 1646 B.C. to 1625 B.C.* However, Smith and Ungnad's solution has a peculiarity in that, on a number of occasions, Venus seems to have been visible on the day before its computed rising date. Out of thirteen Eastern settings there are five such examples.

Moreover, two of the Western risings may well have had the same anomoly. If, as is very likely, the scribe has omitted a "ten" from the recorded date numeral of the Western rising of Years 8/9, the date, as revised, has that characteristic. The same anomaly appears in Year 20, if an alternative version giving the rising date as 1st Ulul instead of 24th, is accepted.

It might be thought, quite reasonably, that this marked tendency for Venus to rise a day earlier than computed could be corrected by adopting a solution begining eight years later than that of Smith and Ungnad. Yet that solution, dated 1638 B.C. to 1617 B.C. has too many of its Western settings taking place a day or two earlier than their computed equivalents to be acceptable.

Accordingly, the anomaly must result from some other cause. Could it denote a fault in the lunar tables?

The effect of a wrong sequence of lunar months on the Venus observations can be produced artificially be grafting a sequence taken from one solution on to another. This produces a gradual variation, oscillating over 18-years, with approximately equal and opposite effects taking place every 9-years. The maximum deviation is about three or four days.

This tendency to produce opposite effects at 9-year intervals is one of the characteristics of the Venus tablet discrepancies. Apart from the abnormal discrepancies, the two largest variations from their respective computed values are those of the Western settings of Years 3 and 13, which are — 6 days and + 7 days respectively. These observations are separated by an interval of 9 years 6 months.

Similarly, the computed values for the Western settings of Years 1 and 11 differ from the record by – 2 and + 2 days, though the effect is not repeated in Year 21. Also, the Western risings of Years 8 and 16, which are separated by eight years, differ from the record by + 4 and – 4 days.

Such effects, while they might be coincidence, certainly suggest that the discrepancies are in some way connected with the moon. Morevoer, that impression is considerably strengthened by other evidence outwith the Venus tablets.

6. *Attested 30-Day Months.* A list of attested 30-day months was compiled by the late Dr. Fotheringham for comparison with the lunar computations of the solutions then under consideration [48]. These months are derived from documents of the Hammurabi and Larsa dynasties. As they mainly come from the reigns of kings whose intercalary months are known, they can be dated reasonably accurately. Yet the results from the solution 1646 B.C. to 1625 B.C. are somewhat enigmatical.

The overall agreement for that solution is not bad. It has 28 computed 30-day months out of a total of 47 possibles; which is 60 % of the total. In fact, only two solutions have a higher agreement Solution 1921 B.C. yields an agreement of 72 % and solution 1809 B.C. to 1788 B.C. yields 62 %.

Yet, Smith and Ungnad's solution might have had a total agreement, not of 60 %, but of 70 % had the documents from Ammizaduga's reign been excluded from the enquiry. Out of a total of ten examples from that reign only two correspond to computed 30-day months. This may be only coincidence, since there is always the possibility that cloudy weather may have prevented observation of the lunar crescent. Otherwise, if the documents are correctly dated, the lunar tables are not giving a true picture of the actual sequence of lunar events.

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[48] Langdon-Fotheringham-Schoch, *The Venus Tablets of Ammizaduga.* Oxford University Press, London.1928.
Chapter XI. J.K. Fotheringham, *Control of Babylonian Calandar by means of months of 30-days.*

The lunar tables, of course, ought to be giving a true picture. Both the visibility of the crescent and the time factor should be accurate enough to establish the correct lunar month sequence. Moreover, an incorrect sequence normally implies an incorrect Venus tablet solution; but other considerations suggest that this particular solution is the correct one.

Accordingly, it must be accepted that the lunar tables are, in fact, reasonably accurate. They would probably not otherwise have yielded such a large percentage agreement for the 30-day month data. Nevertheless, the motions of the moon are very complex, and there is very little reliable information available even from the Classical period for checking the accuracy of lunar tables. The astronomical data from the Hammurabi dynasty can only be used for that purpose when the historical date of the Venus tablets has been established. Then, lunar and Venus tables more accurate than the existing ones will, no doubt, be constructed, using information deduced from the Venus tablets. Meanwhile, the textual discrepancies inherent in the solution 1646 B.C. to 1625 B.C., while they certainly present an astronomical problem, are not in themselves a valid reason for not accepting that solution for dating purposes.

7. *Conclusions.* So, to summarise the argument, the graphical evidence implies that the Venus tablets record observations taken from an observatory situated about 34 degrees North latitude [49], and that they should be dated earlier than 1582 B.C. Then a revision of the computed dates to suit that latitude reveals that the only possible solution is the one dated 1646 B.C. to 1625 B.C. Thus it must be concluded that the Venus tablets were dated correctly and independently in 1940 by Professor Ungnad and by Professor Sydney Smith.

[49] Now that the theory of continental drift has been accepted, the possibility of a gradual movement of the Eurasian land mass over the centuries should be considered. 4,000 years ago 34°N. may have been the latitude of Babylon, not of Agade. The Venus Tablets alone, however, do not justify that conclusion.

Solution 1702 B.C. to 1681 B.C.

EASTERN SETTINGS AND WESTERN RISINGS OF VENUS
(Superior Conjunctions)

Cuneiform Text.		Latitude 32·5° N. (Babylon.)			Latitude 34·0° N.		
Year.	Date.	Year.	Computed date.	Diff.	Computed date.	Diff.	
2.	VIII 11.	–1700	Dec. 18 = VIII 17.	— 6.	Dec. 18 = VIII 17.	— 6.	
	X 19.	–1699	Feb. 12 = X 15.	+ 4.	Feb. 13 = X 16.	+ 3.	B.
4.	IV 2.	–1698	July 21 = IV 7.	— 5.	July 21 = IV 7.	— 5.	
	VI 3.		Sept. 21 = VI 11.	— 8.	Sept. 23 = VI 13.	—10.	W.
5.	IX 25.	–1696	Feb. 17 = IX 22.	+ 3.	Feb. 15 = IX 20.	+ 5.	W.
	XI 29.		Apr. 21 = XI 27.	+ 2.	Apr. 21 = XI 27.	+ 2.	
7.	V 21.	–1695	Oct. 3 = V 24.	— 3.	Oct. 3 = V 24.	— 3.	
	VIII 2.		Dec. 6 = VIII 1.	+ 1.	Dec. 8 = VIII 3.	— 1.	W.
8/9.	XII 25.	–1693	Apr. 19 = XII 27.	— 2.	Apr. 16 = XII 24.	+ 1.	B.
	III 2.		June 29 = III 11.	— 9.	June 30 = III 12.	—10.	W.
10.	VIII 10.	–1692	Dec. 16 = VIII 13.	— 2.	Dec. 16 = VIII 13.	— 2.	
	X 16.	–1691	Feb. 10 = X 11.	+ 5.	Feb. 10 = X 11.	+ 5.	
12.	I 9.	–1690	July 19 = III 3.	—53.	July 18 = III 2.	—52.	B.
	VI 25.		Sept. 18 = V 6.	+48.	Sept. 20 = V 8.	+46.	B.
13.	X 21.	–1688	Feb. 15 = X 18.	+ 3.	Feb. 14 = X 17.	+ 4.	W.
	XI 11.		Apr. 19 = XII 24.	—43.	Apr. 19 = XII 24.	—43.	
15.	V 21.	–1687	Oct. 1 = V 21.	+ 0.	Oct. 1 = V 21.	+ 0.	
	VIII 5.		Dec. 4 = VII 28.	+ 7.	Dec. 5 = VII 29.	+ 6.	B.
16/17.	XII 25.	–1685	Apr. 16 = XII 23.	+ 2.	Apr. 14 = XII 21.	+ 4.	W.
	III 20.		June 27 = III 7.	+13.	June 27 = III 7.	+13.	
18.	IX 12.	–1684	Dec. 14 = IX 10.	+ 2.	Dec. 14 = IX 10.	+ 2.	
	XI 16.	–1683	Feb. 8 = XI 8.	+ 8.	Feb. 8 = XI 8.	+ 8.	
20.	III 25.	–1682	July 16 = III 29.	— 4.	July 15 = III 28.	— 3.	B.
	VI 24.		Sept. 15 = VI 2.	+22.	Sept. 17 = VI 4.	+20.	B.
21.	X 28.	–1680	Feb. 13 = X 14.	+14.	Feb. 12 = X 13.	+15.	W.
	XII 28.		Apr. 17 = XII 20.	+ 8.	Apr. 17 = XII 20.	+ 8.	

Observatory North of Babylon.
Effect on Venus Data.

Better	(B)	7 = 27%.
Worse	(W)	7 = 27%.
Unaltered		12 = 46%.

Solution 1702 B.C. to 1681 B.C.

WESTERN SETTINGS AND EASTERN RISINGS OF VENUS
(Inferior Conjuctions)

Cuneiform Text.		Latitude 32·5° N. (Babylon.)			Latitude 34·0° N.		
Year.	Date.	Year.	Computed date.	Diff.	Computed date.	Diff.	
1.	XI 15.	−1700	Mar. 24 = XI 15.	+ 0.	Mar. 24 = XI 15.	+ 0.	
	XI 18.		Mar. 28 = XI 18.	+ 0.	Mar. 28 = XI 18.	+ 0.	
3.	VI 23.	−1699	Oct. 22 = VII 2.	− 8.	Oct. 22 = VII 2.	− 8.	
	VII 13.		Nov. 5 = VII 15.	− 3.	Nov. 5 = VII 15.	− 3.	
5.	II 2.	−1697	June 2 = I 28.	+ 3.	June 1 = I 27.	+ 4.	W.
	II 18.		June 15 = II 11.	+ 7.	June 15 = II 11.	+ 7.	
6.	VIII 28.	−1695	Jan. 12 = VIII 28.	+ 0.	Jan. 12 = VIII 28.	+ 0.	
	IX 1.		Jan. 15 = VIII 30.	+ 1.	Jan. 15 = VIII 30.	+ 1.	
8.	IV 25.	−1694	Aug. 5 = IV 7.	+18.	Aug. 5 = IV 7.	+18.	
	V 2.		Aug. 23 = IV 24.	+ 8.	Aug. 23 = IV 24.	+ 8.	
9.	XII 11.	−1692	Mar. 22 = XII 12.	− 1.	Mar. 22 = XII 12.	− 1.	
	XII 15.		Mar. 26 = XII 15.	+ 0.	Mar. 26 = XII 15.	+ 0.	
11.	VI 26.	−1691	Oct. 18 = VI 25.	+ 1.	Oct. 17 = VI 24.	+ 2.	W.
	VIb 8.		Nov 3 = VIb 11.	− 3.	Nov. 3 = VIb 11.	− 3.	
13.	II 5.	−1689	May 31 = I 25.	+10.	May 31 = I 25.	+10.	
	II 12.		June 12 = II 6.	+ 6.	June 12 = II 6.	+ 6.	
14.	VII 11.	−1687	Jan. 10 = VIII 25.	−34.	Jan. 10 = VIII 25.	−34.	
	VIII 28.		Jan. 13 = VIII 27.	+ 1.	Jan. 13 = VIII 27.	+ 1.	
16.	IV 5.	−1686	Aug. 3 = IV 6.	− 1.	Aug. 3 = IV 6.	− 1.	
	IV 20.		Aug. 20 = IV 20.	+ 0.	Aug. 20 = IV 20.	+ 0.	
17.	XII 11.	−1684	Mar. 20 = XII 8.	+ 3.	Mar. 20 = XII 8.	+ 3.	
	XII 15.		Mar. 23 = XII 10.	+ 5.	Mar. 23 = XII 10.	+ 5.	
19.	VIb 1.	−1683	Oct. 16 = VIb 22.	−21.	Oct. 15 = VIb 21.	−20.	B.
	VIb 17.		Oct. 31 = VII 6.	−19.	Oct. 31 = VII 6.	−19.	
21.	I 27.	−1681	May 28 = I 20.	+ 7.	May 28 = I 20.	+ 7.	
	II 3.		June 10 = II 3.	+ 0.	June 10 = II 3.	+ 0.	

Observatory North of Babylon.
Effect on Venus Data.

Better	(B)	1 =	4%.
Worse	(W)	2 =	8%.
Unaltered		23 =	88%.

Solution 1646 B.C. to 1625 B.C.

EASTERN SETTINGS AND WESTERN RISINGS OF VENUS
(Superior Conjunctions)

Cuneiform Text.		Latitude 32·5° N. (Babylon.)			Latitude 34·0° N.		
Year.	Date.	Year.	Computed date.	Diff.	Computed date.	Diff.	
2.	VIII 11.	–1644	Dec. 2 = VIII 21.	—10.	Dec. 2 = VIII 21.	—10.	
	X 19.	–1643	Jan. 27 = X 18.	+ 1.	Jan. 28 = X 19.	+ 0.	B.
4.	IV 2.	–1642	July 2 = IV 6.	— 4.	July 1 = IV 5.	— 3.	B.
	VI 3.		Aug. 31 = VI 8.	— 5.	Sept. 2 = VI 10.	— 7.	W.
5.	IX 25.	–1640	Feb. 4 = IX 27.	— 2.	Feb. 3 = IX 26.	— 1.	B.
	XI 29.		Apr. 5 = XII 1.	— 2.	Apr. 6 = XII 2.	— 3.	W.
7.	V 21.	–1639	Sept. 16 = V 27.	— 6.	Sept. 16 = V 27.	— 6.	
	VIII 2.		Nov. 20 = VIII 3.	— 1.	Nov. 22 = VIII 5.	— 3.	W.
8/9.	XII 25.	–1637	Apr. 4 = I 1.	— 5.	Apr. 2 = XII 28.	— 3.	B.
	III 2.		June 13 = III 13.	—11.	June 13 = III 13.	—11.	
10.	VIII 10.	–1636	Nov. 30 = VIII 17.	— 7.	Nov. 30 = VIII 17.	— 7.	
	X 16.	–1635	Jan. 25 = X 15.	+ 1.	Jan. 26 = X 16.	+ 0.	B.
12.	I 9.	–1634	June 29 = III 2.	—52.	June 28 = III 1.	—51.	B.
	VI 25.		Aug. 28 = V 4.	+54.	Aug. 30 = V 6.	+52.	B.
13.	X 21.	–1632	Feb. 2 = X 24.	— 3.	Feb. 1 = X 23.	— 2.	B.
	XI 11.		Apr. 3 = XII 27.	—45.	Apr. 3 = XII 27.	—45.	
15.	V 21.	–1631	Sept. 14 = V 23.	— 2.	Sept. 14 = V 23.	— 2.	
	VIII 5.		Nov. 18 = VII 30.	+ 5.	Nov. 19 = VIII 1.	+ 4.	B.
16/17.	XII 25.	–1629	Apr. 2 = XII 27.	— 2.	Mar. 31 = XII 25.	+ 0.	B.
	III 20.		June 11 = III 10.	+10.	June 11 = III 10.	+10.	
18.	IX 12.	–1628	Nov. 27 = IX 12.	+ 0.	Nov. 27 = IX 12.	+ 0.	
	XI 16.	–1627	Jan. 23 = XI 11.	+ 5.	Jan. 24 = XI 12.	+ 4.	B.
20.	III 25.	–1626	June 26 = III 27.	— 2.	June 24 = III 25.	+ 0.	B.
	VI 24.		Aug. 25 = V 29.	+24.	Aug. 27 = VI 2.	+22.	B.
21.	X 28.	–1624	Jan. 31 = X 20.	+ 8.	Jan. 30 = X 19.	+ 9.	W.
	XII 28.		Apr. 1 = XII 24.	+ 4.	Apr. 1 = XII 24.	+ 4.	

Observatory North of Babylon.
Effect on Venus Data.

Better (B) 13 = 50%.
Worse (W) 4 = 15%.
Unaltered 9 = 35%.

Solution 1646 B.C. to 1625 B.C.

WESTERN SETTINGS AND EASTERN RISINGS OF VENUS
(Inferior Conjunctions)

Cuneiform Text.		Latitude 32·5° N. (Babylon.)			Latitude 34·0° N.		
Year.	Date.	Year.	Computed date.	Diff.	Computed date.	Diff.	
1.	XI 15.	-1644	Mar. 8 = XI 17.	— 2.	Mar. 8 = XI 17.	— 2.	
	XI 18.		Mar. 11 = XI 19.	— 1.	Mar. 11 = XI 19.	— 1.	
3.	VI 23.	-1643	Oct. 2 = VII 1.	— 7.	Oct. 1 = VI 29.	— 6.	B.
	VII 13.		Oct. 19 = VII 17.	— 4.	Oct. 19 = VII 17.	— 4.	
5.	II 2.	-1641	May 17 = II 2.	+ 0.	May 17 = II 2.	+ 0.	
	II 18.		May 28 = II 12.	+ 6.	May 29 = II 13.	+ 5.	B.
6.	VIII 28.	-1640	Dec. 26 = VIII 28.	+ 0.	Dec. 26 = VIII 28.	+ 0.	
	IX 1.		Dec. 30 = IX 2.	— 1.	Dec. 30 = IX 2.	— 1.	
8.	IV 25.	-1638	July 21 = IV 11.	+14.	July 21 = IV 11.	+14.	
	V 2.		Aug. 7 = IV 28.	+ 4.	Aug. 7 = IV 28.	+ 4.	
9.	XII 11.	-1636	Mar. 6 = XII 14.	— 3.	Mar. 6 = XII 14.	— 3.	
	XII 15.		Mar. 9= XII 16.	— 1.	Mar. 9 = XII 16.	— 1.	
11.	VI 26.	-1635	Sept. 29 = VI 25.	+ 1.	Sept. 28 = VI 24.	+ 2.	W.
	VIb 8.		Oct. 16 = VIb 12.	— 4.	Oct. 17 = VIb 13.	— 5.	W.
13.	II 5.	-1633	May 15 = I 28.	+ 7.	May 15 = I 28.	+ 7.	
	II 12.		May 26 = II 8.	+ 4.	May 26 = II 8.	+ 4.	
14.	VII 11.	-1632	Dec. 24 = VIII 26.	—45.	Dec. 24 = VIII 26.	—45.	
	VIII 28.		Dec. 28 = VIII 29.	— 1.	Dec. 28 = VIII 29.	— 1.	
16.	IV 5.	-1630	July 19 = IV 8.	— 3.	July 19 = IV 8.	— 3.	
	IV 20.		Aug. 4 = IV 23.	— 3.	Aug. 5 = IV 24.	— 4.	W.
17.	XII 11.	-1628	Mar. 3 = XII 9.	+ 2.	Mar. 3 = XII 9.	+ 2.	
	XII 15.		Mar. 6 = XII 11.	+ 4.	Mar. 6 = XII 11.	+ 4.	
19.	VIb 1.	-1627	Sept. 26 = VIb 21.	—20.	Sept. 25 = VIb 20.	—19.	B.
	VIb 17.		Oct. 14 = VII 9.	—21.	Oct. 14 = VII 9.	—21.	
21.	I 27.	-1625	May 12 = I 22.	+ 5.	May 12 = I 22.	+ 5.	
	II 3.		May 23 = II 3.	+ 0.	May 24 = II 4.	— 1.	W.

Observatory North of Babylon.
Effect on Venus Data.

(Better (B) 3 = 12%.
(Worse (W) 4 = 15%.
(Unaltered 19 = 73%.

Solution 1638 B.C. to 1617 B.C.

EASTERN SETTINGS AND WESTERN RISINGS OF VENUS
(Superior Conjunctions)

Cuneiform Text.		Latitude 32·5° N. (Babylon.)			Latitude 34·0° N.		
Year.	Date.	Year.	Computed date.	Diff.	Computed date.	Diff.	
2.	VIII 11.	–1636	Nov. 30 = VIII 17.	— 6.	Nov. 30 = VIII 17.	— 6.	
	X 19.	–1635	Jan. 25 = X 15.	+ 4.	Jan. 26 X 16.	+ 3.	B.
4.	IV 2.	–1634	June 29 = IV 2.	+ 0.	June 28 = IV 1.	+ 1.	W.
	VI 3.		Aug. 28 = VI 4.	— 1.	Aug. 30 = VI 6.	— 3.	W.
5.	IX 25.	–1632	Feb. 2 = IX 24.	+ 1.	Feb. 1 = IX 23.	+ 2.	W.
	XI 29.		Apr. 3 = XI 27.	+ 2.	Apr. 3 = XI 27.	+ 2.	
7.	V 21.	–1631	Sept. 14 = V 23.	— 2.	Sept. 14 = V 23.	— 2.	
	VIII 2.		Nov. 18 = VII 30.	+ 2.	Nov. 19 = VIII 1.	+ 1.	B.
8/9.	XII 25.	–1629	Apr. 2 = XII 27.	— 2.	Mar. 31 = XII 25.	+ 0.	B.
	III 2.		June 11 = III 10.	— 8.	June 11 = III 10.	— 8.	
10.	VIII 10.	–1628	Nov. 27 = VIII 12.	— 2.	Nov. 27 = VIII 12.	— 2.	
	X 16.	–1627	Jan. 23 = X 11.	+ 5.	Jan. 24 = X 12.	+ 4.	B.
12.	I 9.	–1626	June 26 = II 27.	—47.	June 24 = II 25.	—45.	B.
	VI 25.		Aug. 25 = IV 29.	+56.	Aug. 27 = V 2.	+54.	B.
13.	X 21.	–1624	Jan. 31 = X 20.	+ 1.	Jan. 30 = X 19.	+ 2.	W.
	XI 11.		Apr. 1 = XII 24.	—44.	Apr. 1 = XII 24.	—44.	
15.	V 21.	–1623	Sept. 11 = V 19.	+ 2.	Sept. 11 = V 19.	+ 2.	
	VIII 5.		Nov. 16 = VII 26.	+ 9.	Nov. 17 = VII 27.	+ 8.	B.
16/17.	XII 25.	–1621	Mar. 30 = XII 23.	+ 2.	Mar. 28 = XII 21.	+ 4.	W.
	III 20.		June 8 = III 6.	+14.	June 9 = III 7.	+13.	B.
18.	IX 12.	–1620	Nov. 25 = IX 8.	+ 4.	Nov. 24 = IX 7.	+ 5.	W.
	XI 16.	–1619	Jan. 21 = XI 7.	+ 9.	Jan. 21 = XI 7.	+ 9.	
20.	III 25.	–1618	June 22 = III 21.	+ 4.	June 20 = III 19.	+ 6.	W.
	VI 24.		Aug. 23 = V 25.	+28.	Aug. 24 = V 26.	+27.	B.
21.	X 28.	–1616	Jan. 29 = X 17.	+11.	Jan. 28 = X 16.	+12.	W.
	XII 28.		Mar. 30 = XII 20.	+ 8.	Mar. 30 = XII 20.	+ 8.	

Observatory North of Babylon.
Effect on Venus Data.

Better (B) 9 = 35%.
Worse (W) 8 = 30%.
Unaltered 9 = 35%.

Solution 1638 B.C. to 1617 B.C.

WESTERN SETTINGS AND EASTERN RISINGS OF VENUS
(Inferior Conjunctions)

Cuneiform Text.		Latitude 32·5° N. (Babylon.)			Latitude 34·0° N.		
Year.	Date.	Year.	Computed date.	Diff.	Computed date.	Diff.	
1.	XI 15.	–1636	Mar. 6 = XI 14.	+ 1.	Mar. 6 = XI 14.	+ 1.	
	XI 18.		Mar. 9 = XI 16.	+ 2.	Mar. 9 = XI 16.	+ 2.	
3.	VI 23.	–1635	Sept. 29 = VI 25.	— 2.	Sept. 28 = VI 24.	— 1.	B.
	VII 13.		Oct. 16 = VII 12.	+ 1.	Oct. 17 = VII 13.	+ 0.	B.
5.	II 2.	–1633	May 15 = I 28.	+ 4.	May 15 = I 28.	+ 4.	
	II 18.		May 26 = II 8.	+10.	May 26 = II 8.	+10.	
6.	VIII 28.	–1632	Dec. 24 = VIII 26.	+ 2.	Dec. 24 = VIII 26.	+ 2.	
	IX 1.		Dec. 28 = VIII 29.	+ 2.	Dec. 29 = VIII 29.	+ 2.	
8.	IV 25.	–1630	July 19 = IV 8.	+17.	July 19 = IV 8.	+17.	
	V 2.		Aug. 4 = IV 23.	+ 9.	Aug. 5 = IV 24.	+ 8.	B.
9.	XII 11.	–1628	Mar. 3 = XII 9.	+ 2.	Mar. 3 = XII 9.	+ 2.	
	XII 15.		Mar. 6 = XII 11.	+ 4.	Mar. 6 = XII 11.	+ 4.	
11.	VI 26.	–1627	Sept. 26 = VI 21.	+ 5.	Sept. 25 = VI 20.	+ 6.	W.
	VIb 8.		Oct. 14 = VIb 9.	— 1.	Oct. 14 = VIb 9.	— 1.	
13.	II 5.	–1625	May 12 = I 23.	+12.	May 12 = I 23.	+12.	
	II 12.		May 23 = II 3.	+ 9.	May 24 = II 4.	+ 8.	B.
14.	VII 11.	–1624	Dec. 21 = VIII 22.	—40.	Dec. 21 = VIII 22.	—40.	
	VIII 28.		Dec. 26 = VIII 26.	+ 2.	Dec. 26 = VIII 26.	+ 2.	
16.	IV 5.	–1622	July 17 = IV 4.	+ 1.	July 17 = IV 4.	+ 1.	
	IV 20.		Aug. 2 = IV 19.	+ 1.	Aug. 3 = IV 20.	+ 0.	B.
17.	XII 11.	–1620	Mar. 1 = XII 6.	+ 5.	Mar. 1 = XII 6.	+ 5.	
	XII 15.		Mar. 4 = XII 8.	+ 7.	Mar. 4 = XII 8.	+ 7.	
19.	VIb 1.	–1619	Sept. 24 = VIb 18.	—17.	Sept. 23 = VIb 17.	—16.	B.
	VIb 17.		Oct. 11 = VII 4.	—17.	Oct. 11 = VII 4.	—17.	
21.	I 27.	–1617	May 10 = I 19.	+ 8.	May 10 = I 19.	+ 8.	
	II 3.		May 21 = I 29.	+ 4.	May 21 = I 29.	+ 4.	

Observatory North of Babylon.
Effect on Venus Data.

Better (B)	9	= 23 %.
Worse (W)	1	= 4 %.
Unaltered	19	= 73 %.

Solution 1582 B.C. to 1561 B.C.

EASTERN SETTINGS AND WESTERN RISINGS OF VENUS
(Superior Conjunctions)

Cuneiform Text.		Latitude 32·5° N. (Babylon).			Latitude 34·0° N.		
Year.	Date.	Year.	Computed date.	Diff.	Computed date.	Diff.	
2.	VIII 11.	-1580	Nov. 12 = VIII 17.	— 6.	Nov. 12 = VIII 17.	— 6.	
	X 19.	-1579	Jan. 10 = X 18.	+ 1.	Jan. 10 = X 18.	+ 1.	
4.	IV 2.	-1578	June 7 = III 29.	+ 3.	June 4 = III 26.	+ 6.	W.
	VI 3.		Aug. 10 = VI 5.	— 2.	Aug. 10 = VI 5.	— 2.	
5.	IX 25.	-1576	Jan. 19 = IX 28.	— 3.	Jan. 19 = IX 28.	— 3.	
	XI 29.		Mar. 18 = XI 29.	+ 0.	Mar. 18 = XI 29.	+ 0.	
7.	V 21.	-1575	Aug. 28 = V 26.	— 5.	Aug. 28 = V 26.	— 5.	
	VIII 2.		Nov. 1 = VIII 3.	— 1.	Nov. 3 = VIII 5.	— 3.	W.
8/9.	XII 25.	-1573	Mar. 18 = I 1.	— 6.	Mar. 16 = XII 29.	— 4.	B.
	III 2.		May 26 = III 12.	—10.	May 26 = III 12.	—10.	
10.	VIII 10.	-1672	Nov. 10 = VIII 14.	— 4.	Nov. 10 = VIII 14.	— 4.	
	X 16.	-1571	Jan. 8 = X 15.	+ 1.	Jan. 8 = X 15.	+ 1.	
12.	I 9.	-1570	June 4 = II 24.	—45.	June 1 = II 21.	—42.	B.
	VI 25.		Aug. 8 = V 1.	+53.	Aug. 8 = V 1.	+53.	
13.	X 21.	-1568	Jan. 17 = X 24.	— 3.	Jan. 17 = X 24.	— 3.	
	XI 11.		Mar. 16 = XII 26.	—35.	Mar. 16 = XII 26.	—35.	
15.	V 21.	-1567	Aug. 25 = V 21.	+ 0.	Aug. 25 = V 21.	+ 0.	
	VIII 5.		Oct. 29 = VII 27.	+ 7.	Oct. 31 = VII 29.	+ 5.	B.
16/17.	XII 25.	-1565	Mar. 16 = XII 27.	— 2.	Mar. 14 = XII 25.	+ 0.	B.
	III 20.		May 24 = III 9.	+11.	May 24 = III 9.	+11.	
18.	XI 12.	-1564	Nov. 8 = IX 11.	+ 1.	Nov. 8 = IX 11.	+ 1.	
	XI 16.	-1563	Jan. 5 = XI 11.	+ 5.	Jan. 6 = XI 12.	+ 4.	B.
20.	III 25.	-1562	May 31 = III 18.	+ 7.	May 29 = III 16.	+ 9.	W.
	VI 24.		Aug. 5 = V 26.	+28.	Aug. 6 = V 27.	+27.	B.
21.	X 28.	-1560	Jan. 15 = X 21.	+ 7.	Jan. 15 = X 21.	+ 7.	
	XII 28.		Mar. 14 = XII 23.	+ 5.	Mar. 14 = XII 23.	+ 5.	

Observatory North of Babylon. Effect on Venus Data.

Better (B) 6 = 23 %.
Worse (W) 3 = 12 %.
Unaltered 17 = 65 %.

Solution 1582 B.C. to 1561 B.C.

WESTERN SETTINGS AND EASTERN RISINGS OF VENUS
(Inferior Conjunctions)

Cuneiform Text.		Latitude 32·5° N. (Babylon.)				Latitude 34·0° N.			
Year.	Date.	Year.	Computed date.		Diff.	date.		Diff.	
1.	XI 15.	–1580	Feb. 19 =	XI 18.	— 3.	Feb. 19 =	XI 18.	— 3.	
	XI 18.		Feb. 21 =	XI 19.	— 1.	Feb. 21 =	XI 19.	— 1.	
3.	VI 23.	–1579	Sept. 9 =	VI 24.	— 1.	Sept. 9 =	VI 24.	— 1.	
	VII 13.		Sept. 29 =	VII 13.	+ 0.	Sept. 30 =	VII 14.	— 1.	W.
5.	II 2.	–1577	Apr. 28 =	I 30.	+ 2.	Apr. 28 =	I 30.	+ 2.	
	II 18.		May 8 =	II 9.	+ 9.	May 8 =	II 9.	+ 9.	
6.	VIII 28.	–1576	Dec. 4 =	VIII 25.	+ 3.	Dec. 4 =	VIII 25.	+ 3.	
	IX 1.		Dec. 11 =	IX 1.	+ 0.	Dec. 11 =	IX 1.	+ 0.	
8.	IV 25.	–1574	July 3 =	IV 10.	+15.	July 3 =	IV 10.	+15.	
	V 2.		July 19 =	IV 25.	+ 6.	July 20 =	IV 26.	+ 5.	B.
9.	XII 11.	–1572	Feb. 16 =	XII 13.	— 2.	Feb. 17 =	XII 14.	— 3.	W.
	XII 15.		Feb. 19 =	XII 15.	+ 0.	Feb. 18 =	XII 14.	+ 1.	W.
11.	VI 26.	–1571	Sept. 7 =	VI 20.	+ 6.	Sept. 6 =	VI 19.	+ 7.	W.
	VIb 8.		Sept. 27 =	VIb 10.	— 2.	Sept. 27 =	VIb 10.	— 2.	
13.	II 5.	–1569	Apr. 26 =	I 26.	+ 8.	Apr. 26 =	I 26.	+ 8.	
	II 12.		May 5 =	II 5.	+ 7.	May 5 =	II 5.	+ 7.	
14.	VII 11.	–1568	Dec. 1 =	VIII 20.	—39.	Dec. 1 =	VIII 20.	—39.	
	VIII 28.		Dec. 9 =	VIII 27.	+ 1.	Dec. 9 =	VIII 27.	+ 1.	
16.	IV 5.	–1566	July 1 =	IV 7.	— 2.	July 1 =	IV 7.	— 2.	
	IV 20.		July 17 =	IV 22.	— 2.	July 18 =	IV 23.	— 3.	W.
17.	XII 11.	–1564	Feb. 14 =	XII 9.	+ 2.	Feb. 14 =	XII 9.	+ 2.	
	XII 15.		Feb. 17 =	XII 11.	+ 4.	Feb. 17 =	XII 11.	+ 4.	
19.	VIb 1.	–1563	Sept. 5 =	VIb 17.	—16.	Sept. 4 =	VIb 16.	—15.	
	VIb 17.		Sept. 25 =	VII 6.	—19.	Sept. 25 =	VII 6.	—19.	
21.	I 27.	–1561	Apr. 24 =	I 23.	+ 4.	Apr. 24 =	I 23.	+ 4.	
	II 3.		May 2 =	I 30.	+ 3.	May 2 =	I 30.	+ 3.	

Observatory North of Babylon.
Effect on Venus Data.

Better (B) 2 = 8 %.
Worse (W) 5 = 19 %.
Unaltered 19 = 73 %.

A Comparison of Solutions

EFFECT ON THE RELATIONSHIP BETWEEN RECORDED AND COMPUTED SETTING AND RISING DATES OF VENUS IF OBSERVED FROM 34-0 DEGREES NORTH LATITUDE INSTEAD OF FROM BABYLON

Solution	Effect	Superior Conjunction Observations		Inferior Conjunction Observations		Both types Combined	
1702 B.C.	Better.	7	27 %.	1	4 %.	8	15 %.
to 1681 B.C.	Worse.	7	27 %.	2	8 %.	9	17 %.
	Unaltered.	12	40 %.	23	88 %.	35	68 %.
1646 B.C.	Better.	13	50 %.	3	12 %.	16	30 %.
to 1625 B.C.	Worse.	4	15 %.	4	15 %.	8	15 %.
	Unaltered.	9	35 %.	19	73 %.	28	55 %.
1638 B.C.	Better.	9	35 %.	6	23 %.	15	29 %.
to 1617 B.C.	Worse.	8	30 %.	1	4 %.	9	17 %.
	Unaltered.	9	35 %.	19	73 %.	28	54 %.
1582 B.C.	Better.	6	23 %.	2	8 %.	8	15 %.
to 1561 B.C.	Worse.	3	12 %.	5	19 %.	8	15 %.
	Unaltered.	17	65 %.	19	73 %.	36	70 %.

Solution 1582 B.C. to 1561 B.C.

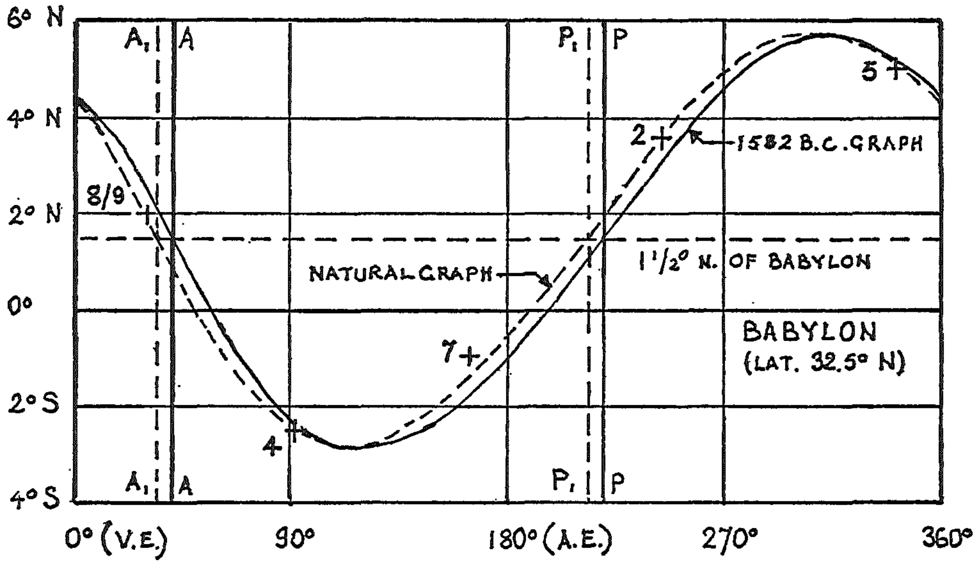
Geographical Latitudes corresponding to the Cuneiform Dates
SUPERIOR CONJUNCTIONS

Eastern Settings and Western Risings (Graph.)

Cuneiform Text. Year.	Date.		Julian Date.		Equivalent Latitude and Date. Degrees North or South of Babylon.	Corresponding Julian Date		Diff.
5.	IX	25.	Jan.	16.	5 N.	Jan.	16.	+ 0.
	XI	29.	Mar.	18.	5 N.	Mar.	19.	+ 1.
13.	X	21.	Jan.	14.	5 N.	Jan.	15.	+ 1.
	XI	11.	Feb.	1.	5 N.	Mar.	17.	—45.
21.	X	28.	Jan.	22.	5 N.	Jan.	13.	— 9.
	XII	28.	Mar.	19.	5 N.	Mar.	14.	— 5.
8/9.	XII	25.	Mar.	12.	2 N.	Mar.	15.	+ 3.
	III	2.	May	16.	2 N.	May	26.	+10.
16/17.	XII	25.	Mar.	14.	2 N.	Mar.	14.	+ 0.
	III	20.	June	4.	2 N.	May	24.	—11.
4.	IV	2.	June	10.	$2^1/_2$ S.	June	10.	+ 0.
	VI	3.	Aug.	8.	$2^1/_2$ S.	Aug.	7.	— 1.
12.	I	9.	Apr.	20.	$2^1/_2$ S.	June	6.	+47.
	VI	25.	Sept.	30.	$2^1/_2$ S.	Aug.	7.	—54.
20.	III	25.	June	7.	$2^1/_2$ S.	June	3.	— 4.
	VI	24.	Sept.	3.	$2^1/_2$ S.	Aug.	4.	—30.
7.	V	21.	Aug.	23.	1 S.	Aug.	28.	— 5.
	VIII	2.	Oct.	31.	1 S.	Oct.	31.	+ 0.
15.	V	21.	Aug.	25.	1 S.	Aug.	25.	+ 0.
	VIII	2.	Nov.	5.	1 S.	Oct.	28.	— 8.
2.	VIII	11.	Nov.	6.	$3^1/_2$ N.	Nov.	12.	+ 6.
	X	19.	Jan.	11.	$3^1/_2$ N.	Jan.	11.	+ 0.
10.	VIII	10.	Nov.	6.	$3^1/_2$ N.	Nov.	10.	+ 4.
	X	16.	Jan.	9.	$3^1/_2$ N.	Jan.	9.	+ 0.
18.	IX	12.	Nov.	9.	$3^1/_2$ N.	Nov.	7.	— 2.
	XI	16.	Jan.	10.	$3^1/_2$ N.	Jan.	7.	— 3.

SOLUTION 1582 B.C.-1561 B.C.

GRAPH SHOWING THE RELATIONSHIP BETWEEN THE LATITUDES CORRESPONDING TO THE CUNEIFORM DATES AND THE EARTH'S ORBIT



SUPERIOR CONJUNCTIONS

BASED ON FIRST EIGHT YEARS

V.E. = Vernal Equinox.

A.E. = Autumn Equinox.

A = Earth's Aphelion in 1582 B.C.

A, = Aphelion required by graph.

P = Earth's perihelion in 1582 B.C.

P, = Perihelion required by graph.

ATTESTED 30-DAY MONTHS

Solution 1646 B.C. to 1625 B.C.

Ruler and Year of Reign.	Attested lunar month. Babylonian.	Gregorian.	Year. B.C.	Following month. Gregorian.	Days in Month.
RIM-SIN					
6.	IV.	June 13.	1817.	July 13.	30.
10.	II.	May 31.	1813.	June 29.	29.
10.	XII.	March 23.	1812.	April 20.	29.
30.	XII.	Feb. 10.	1792.	March 12.	30.
32.	X.	Nov. 23.	1791.	Dec. 22.	29.
32.	XII.	Jan. 20.	1790.	Feb. 19.	30.
35.	XII.	Feb. 16.	1787.	March 17.	29.
42.	VII.	Oct. 3.	1781.	Nov. 2.	30,
44.	XI.	Jan. 8.	1778.	Feb. 6.	30.
58.	II.	May 11.	1765.	June 10.	30.
59.	V.	July 28.	1764.	Aug. 27.	30.
HAMMURABI.					
4.	I.	April 7.	1789.	May 6.	29.
7.	XII.	Feb. 23.	1785.	March 25.	30.
26.	V.	Aug. 30.	1767.	Sept. 29.	30.
30.	X.	Dec. 12.	1763.	Jan. 11.	30.
32.	VIII.	Oct. 21.	1761.	Nov. 20.	30.
32.*	XI.	Jan. 18.	1760.	Feb. 17.	30.
34.	XII.	Feb. 25.	1758.	March 26.	29.
39.	VIII.	Nov. 4.	1754.	Dec. 4.	30.
41.	XII.	Mar. 9.	1751.	April 8.	30.
42.	XII.	Feb. 26.	1750.	March 28.	30.
43.	XI.	Jan. 17.	1749.	Feb. 15.	29.
SAMSUILUNA.					
1.	VIII.	Oct. 10.	1749.	Nov. 8.	29.
5.	III.	April 30.	1745.	May 30.	30.
7.	IV.	June 7.	1743.	July 7.	30.
7.	IX.	Nov. 1.	1743.	Dec. 1.	30.
9.*	XI.	Feb. 5.	1740.	March 7.	30.
28.	IX.	Nov. 10.	1722.	Dec. 10.	30.

AMMIDITANA.

1.	XII.	Jan. 28.	1682.	Feb. 27.	30.
4.	VIII.	Sept. 28.	1680.	Oct. 27.	29.
4.	XII b.	Feb. 22.	1679.	March 24.	30.
5.	XII.	Feb. 11.	1678.	March 13.	30.
24.	VII.	Sept. 17.	1660.	Oct. 17.	30.
26.	VI.	July 28.	1658.	Aug. 27.	30.
26.	IX.	Oct. 24.	1658.	Nov. 23.	30.
31.	II.	May 5.	1653.	June 3.	29.
31.	XII.	Feb. 23.	1652.	March 25.	30.
34.	IX.	Nov. 25.	1650.	Dec. 24.	29.

AMMIZADUGA.

1.	VIII.	Nov. 11.	1646.	Dec. 10.	29.
3.	VI.	Aug. 21.	1644.	Sept. 19.	29.
4.	XII b.	March 5.	1642.	April 3.	29.
13.	XII.	Feb. 24.	1633.	March 24.	29.
15.	XII.	March 3.	1631.	April 2.	30.
16.	I.	April 2.	1631.	May 1.	29.
16.	V.	July 29.	1631.	Aug. 27.	29.
16.	XI.	Jan. 23.	1630.	Feb. 21.	29.
16.	XII.	Feb. 21.	1630.	March 22.	29.
20.	XI.	Jan. 8.	1626.	Feb. 7.	30.

* It is uncertain whether this contract belongs to HAMMURABI 32 or SAMSUILUNA 9.

Solution 1646 B.C. to 1625 B.C.

ATTESTED 30-DAY MONTHS

Ruler.	Number of Computed Months of 30-days.	Number of Computed Months of 29-days.	Percentage Agreement.
RIM-SIN.	7.	4.	69 %.
HAMMURABI.	7.(or 8).	3.	70 %.
SAMSUILUNA.	5.(or 4.)	1.	83 %.
AMMIDITANA.	7.	3.	70 %.
AMMIZADUGA.	2.	8.	20 %.
Totals.	28.	19.	60 %.

Note : Number of Actual months of 30-days is 47.

If Ammizaduga's reign is excluded, the agreement, based on 26 computed 30-day months out of a total of 37, is 70 %.

V. THE PATH OF "HOSTILE VENUS"

1. *Introduction.* The name NIN-SI-ANNA is used on the Venus tablets for the planet Venus, but Tablet K 2321 + K 3032 finishes with the sentence, "Twenty-four conjunctions of NIN-SI-ANNA AHUTUM". The adjective AHUTUM in this context may merely indicate that the groups on the back of the tablet are arranged in a different order from those on the front. However, it might also be translated as "hostile".

If "hostile Venus" is the correct translation. the Babylonians presumably associated the planet with natural disasters. That is quite possible, since the storm-god, ADAD, represented one aspect of Venus.

However, the planet itself would not normally cause earthquake and volcanic activity on the earth. Only in very exceptional circumstances not existing today it might conceivably join forces with the moon to cause a disaster. The pull of the moon would presumably set in motion latent forces in the earth's crust, if it happened to act at the correct angle to some weakness in the lithosphere. [50]

The movements of the moon at the time of Ammizaduga seem to have been different from what the tables assume. The variations between the Venus tablet data and the data computed for the solution 1646 B.C. to 1625 B.C. are too great for the astronomical tables not to be incorrect in some respect. These variations may, in fact, denote planetary as well as lunar differences. Any change in the eccentricity of the Venus orbit would naturally influence the path of the moon. Such a change should be detectable, however, since the Venus tablet discrepancies would then be related to an astronomical framework. Accordingly, the discrepancies must now be examined to ascertain if this is indeed the case.

2. *The Superior Conjunction Pattern of Variations.* For Superior conjunctions only, assuming the earth's orbit to be circular, Venus at conjunction would be

[50] William Digby, *Natural Law in Terrestial Phenomena,* Hutchinson & Co., Trafalgar Buildings, Charing Cross, London. 1902.
Page 14. Sir Isaac Newton's geometrical analysis of the pull of the moon. The book itself comprises a luni-solar theory on the causes of earthquakes and volcanoes.
Nowadays, earthquakes are usually thought to be caused by forces other than those of the moon. Yet, if internal forces building up in the earth's crust had already reached the stage when a movement of the rocks along some fault was imminent, might it not be that the pull of the moon, if it happened to act on the danger area, could add that little bit of extra stress required to "trigger off" a catastrophe? If the presence of Venus, or some other body, were to deflect the moon closer to the earth than normal, the gravitational force of the moon would naturally become greater, and there would be exceptionally high ocean tides. On the land a natural disaster, if it did take place, might well be a major catastrophe.

at its greatest distance from our planet when at the Aphelion end of its own orbit, and the earth would be in line with the major axis of the Venus orbit. During the reign of Ammizaduga, the earth would pass through this axis line every year about 23rd December (Julian), irrespective of the position of Venus.

During Years 2, 10, and 18, according to the solution 1646 B.C. to 1625 B.C., Venus set respectively 21 days, 23 days, and 25 days before December 23rd. According to the Venus tablets, however, the first two settings in that order took place respectively 10 days and 7 days earlier than computed, and the third on the computed date.

Similarly, during the same years, but in the reverse order, Venus as computed became visible again 32 days, 33 days, and 36 days after its Aphelion date. On the first occasion, Year 18, the Venus tablet rising took place 4 days later than calculated. On the other two years it occurred on the computed date. So combining the settings and risings, and denoting early dates by "—" and late dates by "+", gives the sequences — 10, — 7, + 0; + 4, + 0 and + 0. This seems to be the nucleus of a pattern with the maximum variation at the Venus Aphelion, and decreasing sharply the more distant Venus happens to be from that point.

If the pattern is genuine, however, it is clearly being obscured by the limitations of the lunar tables. The data of Year 18 seems to be out of position. If the dates are adjusted on the assumption that the first visible moonlight appeared two days later than computed, which is a reasonable error for an incorrect lunar sequence, the variations become — 10, — 7, — 2; + 2, + 0 and + 0.

This revision is certainly an improvement, but there seems to be rather a jump from — 7 to — 2, and from + 2 to + 0. Since, however, there are a number of occasions where Venus was apparently visible a day before its computed rising date, the same anomaly may also apply to Years 2 and 10. That adjustment would alter the sequence to — 9, — 6, — 2; + 2, + 1 and + 1, which is more reasonable [51].

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[51] A further modification to the sequence is possible on the assumption that unfavourable weather prevented observation of Venus near the setting dates of Years 2 and 10. Years 2, 10 and 18 have invisibility periods of 67, 64 and 62-days respectively. If 62-days is the normal period of that cyclic group, the setting date of Year 2 can be adjusted within a limit of 5-days. Similarly, that of Year 10 can be adjusted within a limit of 2-days. Accordingly, provided the weather did not prevent observation on the rising dates, the values — 10 and — 7 could both be altered to — 5. So the sequence may have been — 6, — 5, — 2, + 2, + 1 and + 1. However, it should be remembered that the data for Year 18 comes from an alternative version of Year 5. It is only an assumption that Year 18 had an interval of 62-days. If that is not correct, the argument breaks down. So it seems better to ignore the possible effect of the weather.

However, the sequence has only significance if it can be related to an overall pattern. During Year 7 Venus was last observed 31 days before December 23rd. Accordingly, that setting date comes into the sequence immediately before the rising date of Year 18. To fit the pattern it ought to have taken place two days later than computed. Since, according to the Venus tablets, it occurred three days earlier, an adjustment of five days is required to the begining of the lunar month. This is a large adjustment, but it is at least consistent with the setting date of Year 7, which would require the same adjustment to conform to the overall pattern.

While it is not essential that setting and rising dates from the same year should have to be adjusted by exactly the same amount, they are nevertheless, linked together, and can only vary from each other by one or two days. It depends on whether the actual and computed 30-day and 29-day months comprising the invisibility period correspond to each other, or are different.

The next observations to consider are those belonging to Year 15. The setting date should probably be adjusted by one day, and presumably the same adjustment applied to the rising date. The rising date, however, comes in between those of Years 10 and 2. In that position its value is too great for the sequence pattern. Unfavourable weather could help to explain that, however; as indeed, it could explain similar divergencies.

On the other hand, the rising date of Year 5 diverges also from the pattern; but that divergence calls for a different explanation. If the setting date is correctly adjusted, the rising, in order to fit the overall pattern, would require to take place two days later than computed. This is quite possible, however. The computed lunar cycle allows two 29-day months to that particular invisibility period. Thus, if the actual period contained two 30-day months, the discrepancy would be accounted for.

Having thus isolated the effects of both unfavourable weather and incorrect astronomical tables, it would be surprising not to detect the third effect caused by errors of the scribes. The setting date of Year 21, and the rising dates of Years 8/9, Years 16/17, and of Year 4 are all examples of the common mistake of either adding, or subtracting a "ten". Also, the alternative version of Year 20 must be accepted.

When all these factors have been allowed for, the resulting pattern is an ordered sequence of numerals related to the orbital points of Venus. The setting dates range from — 9 days at Aphelion to + 1 day at Perihelion. The rising dates between the same points range from + 1 day to + 0 days. The adjustments to the computed dates required to produce this pattern are mainly of one day only. Year 7, which requires an adjustment of five days, is an exception.

3. *Astronomical Significance of the Variations.* Once the sequence has been isolated, the astronomical significance of these related variations from the computed Superior conjunction data becomes apparent. The Venus orbit at the time of Ammizaduga was more elliptical in shape than the astronomical tables allow for.

This conclusion can be arrived at by using a simplified model. The earth's orbit is represented by a true circle, and the Venus orbit by an ellipse with greater eccentricity than the present orbital shape. Venus on this orbit, as compared with the present one, would approach nearer the sun at Perihelion, and move with greater orbital velocity. Similarly, the planet would recede further from the sun at Aphelion, and its orbital velocity at that point be correspondingly reduced. Since for Superior conjunctions the earth and Venus are on opposite sides of the sun, when Venus is at its greatest distance from the sun, it is also at its greatest distance from the earth. Thus the two planets are furthest apart when Venus is at Aphelion, and closest when that planet is at Perihelion.

Immediately before or after a Superior conjunction, Venus when seen through a telescope, is fully illuminated; but the disc of the planet is too small for visual observation. Its apparent diameter increases, however, as it approaches the earth; though the illuminated surface becomes less. The combined effect is to gradually increase the brightness to the point when it becomes visible to the naked eye.

If it can be assumed, for simplicity, that the distance between the earth and Venus at the critical visibility point remains the same, irrespective of the shape of the Venus orbit, then the greater the distance between the two planets when Venus is at Aphelion, the wider the arc of orbit to be traversed by that planet between setting and rising dates. Since in any case, the orbital velocity at that point is less than the present value, the effect must be to lengthen the invisibility period. It follows that settings near the planet's Aphelion point would have taken place earlier than computed, and risings later. That deduction is consistant with the Venus tablet data. In much the same way, the reverse effect would take place when Venus is near Perihelion. That again, is consistant with the recorded data.

4. *Inferior Conjunction Variations.* It is not enough, however, that the Venus tablet variations at Superior conjunction should appear to conform to the effect caused by a Venus orbit more elongated than the present one. The Inferior conjunction data must also be consistent. The latter data is more difficult to evaluate.

For both types of conjunction, the duration of the invisibility periods depends on the same basic factors; distance from the earth, and orbital velocity. These factors, which combine at Superior conjunction to produce the same effect, now act against each other.

If the earth's orbit was a true circle and the Venus orbit an ellipse, the shortest distance between them would be at the Venus Aphelion point. As this position is roughly equidistant between two sets of Venus tablet observations, taken in May and late July, Venus under these ideal conditions would be the same distance from the earth in each case.

However, when the Babylonian observations in May were being taken, Venus was passing through the Ecliptic. By the end of July it was well above that plane. So the planets would be closer together in May than in July.

Now it seems reasonable to assume that the proximity of Venus in May would be the dominant factor in determining the duration of the invisibility periods during that month. This would certainly have the effect of reducing the time during which Venus was absent from the sky. Two of the invisibility periods in that month are, in fact, shorter than computed; but the other is longer. However, the longer interval is probably due to a scribal error.

Since the Inferior conjunction intervals are of relatively short duration, variations from the present orbital velocities are unlikely to be a major factor, except where the velocity reaches its maximum at Perihelion on the Venus orbit. Its effect there, as the dominant factor, would be to shorten the invisibility periods in December. However, the only reliable December period, that of Year 6, is in fact, as computed.

On the other hand, till Venus was quite near its Perihelion, the duration of the invisibility periods probably still depended upon the distance between the two planets. At that end of the orbit, the effect of the distance would be to lengthen the periods.

There are two groups of invisibility periods which have intervals of longer duration than computed. These are in March and October. They are the nearest observations to those on the Venus Perihelion point, and are equidistant from that point. The periods of invisibility in March vary between one and two days more than computed, and in October that of Year 3 is two days greater. Year 11 probably had an interval which was three days greater than computed, assuming the scribes ommitted a "ten" from the text, and the text of Year 19 is corrupt. Thus the theory is consistent with the recorded data for both months.

Having thus checked the duration of the invisibility periods, the Inferior conjunction setting and rising date variations can be adjusted to form a sequence pattern. This pattern is only tentative, however, because it is difficult to determine exactly what form it ought to be taking. Yet it should be close enough to its correct relationship to give some indication of the adjustments requiring to be made to the lunar month sequence.

To form the Inferior conjunction variation pattern, a much higher proportion of the lunar months require adjustment by more than one day than was the case with the Superior conjunction pattern. This is surprising, because the effect caused by a displacement of the lunar cycle should be similar for both types of conjunction. However, if the shape of the Venus orbit was a very pronounced ellipse, the close proximity of Venus to the earth on certain months of the year would certainly cause large perturbations of the earth and moon, if not perturbations of the moon itself. The effect of that situation would, of course, be confined to the Inferior conjunction data.

The only group of Inferior conjunction observations which requires no obvious adjustment has its setting and rising dates in December. Venus was at Perihelion, and at its greatest distance from the earth. The planet in that position was certainly not capable of causing any modification to the lunar path.

At the other end of the Venus orbit, however, a maximum variation of 7-days apparently took place during Year 13. This event occurred in May, when Venus was on the plane of the ecliptic, and at its closest to the earth. Under those conditions, the gravitational forces of both Venus and the sun would combine to produce their maximum effect. Yet there took place no similar variation during the adjoining Years 5 and 21. The Venus conditions were, presumably, similar, but the moon would be in a different longitude. Thus the forces acting upon it must have been different.

Venus was also in close proximity to the earth in July and August. Apparently, equal and opposite variations of 4-days took place then, during the successive Years 8 and 16. However, similar roughly equal and opposite effects took place in October, when Venus ought to have receded far enough not to be the cause. The effect in both months may be caused by an incorrect lunar cycle.

Similar astronomical conditions to those in October took place in March. Two of the sets of observations there are only out by one day. The other is four days out, but that again could be the effect of incorrect lunar tables.

Taken as a group, the arrangements of lunar adjustments is not necessarly inconsistent with the supposition that Venus may have had some effect on the movements of the moon, but the evidence is not so definite as to rule out the possibility of some other explanation. Under present day conditions, the earth and moon tend to react to external planetary forces as a unit. Under other conditions the effect may well be different, but there is no available data to establish that theory.

5. *Conclusions.* The Inferior conjunction observations, as far as they can be checked, are consistant with the findings deduced from the similar data at Superior conjunction. Accordingly, it would appear that some modification in the shape of the Venus orbit has taken place since the time of Ammizaduga. Whether the orbit then was really so very different from its present is open to question. It may be that only a slight increase of the orbital eccentricity would have a disproportionate effect on the setting and rising dates of Venus. Yet if Venus was, in fact, coming close enough to the earth to cause lunar perturbations, the change in orbital eccentricity must have been quite considerable.

Moreover, if in addition, the moon was being diverted closer to the earth than normal, there is obviously a greater possibility that the very long invisibility period of Year 12 was caused by a natural catastrophe occurring during Year 11. It is possibly only coincidence that Venus during the latter year happened to be at inferior conjunction about a month before the earth reached its perihelion. Thus, on its present orbit at least, that planet would have been about its closest to the earth; and according to Schoch's tables, it was at its maximum stellar magnitude of — 4.4 on November 17th — 1635. That would make Venus the brightest object in the morning sky during Tesrit of Year 11. So the Babylonians would naturally link it up with any disaster which may have occurred about the same time. Hence, maybe, the title "Hostile Venus".

However, it is of more significance that the recorded data, when related to the solution 1646 B.C. to 1625 B.C. does conform in some degree to an astronomical pattern. That pattern in itself, irrespective of how it is interpreted, strengthens considerably the case for accepting Smith and Ungnad's solution as the correct one.

November, 1965. J.W.D.

Solution 1646 B.C. to 1625 B.C.

Relationship to Orbital Points of Differences between Recorded and Computed Periods of Invisibility of Venus at Superior Conjunction

Year.	Computed date. (Julian.) Latitude 34-0° N.	Geocentric latitude of Venus.	Invisibility Period of Venus. (Days.) Venus Tablet.	Computed.	Diff.	Orbital points. (Approximate Julian dates.)
						Perihelion : — Venus June 23
20.	-1626 June 24.	— 0° 18′	63.**	64.	— 1.	
	Aug. 27.	— 1° 16′				
12.	-1634 June 28.	— 0° 25′	(163)	63.	(+100.)	
	Aug. 30.	— 1° 14′				
4.	-1642 July 1.	— 0° 29′	59.	63.	— 4.	
	Sept. 2.	— 1° 11′				
15.	-1631 Sept. 14.	— 1° 24′	72.	66.	(+ 6.)	
	Nov. 19.	+ 0° 37′				
7.	-1639 Sept. 16.	— 1° 22′	70.	67.	+ 3.	
	Nov. 22.	+ 0° 41′				
						Perihelion : — Earth Nov. 16
18.	-1628 Nov. 27.	— 0° 11′	62.	58.	+ 4.	
	-1627 Jan. 24.	+ 1° 25′				
10.	-1636 Nov. 30.	— 0° 3′	64.	57.	+ 7.	
	-1635 Jan. 26.	+ 1° 25′				
2.	-1644 Dec. 2.	— 0° 2′	67.	57.	+10.	
	-1643 Jan. 28.	+ 1° 25′				
						Aphelion : — Venus Dec. 23

Year. Computed date. (Julian.) Latitude 34·0° N.			Geocentric latitude of Venus.	Invisibility Period of Venus. (Days). Venus Tablet.	Computed.	Diff.	Orbital points. (Approximate Julian dates.)
21.	–1624 Jan.	30.	+ 1° 6′	67.*	62.	+ 5.	
	Apr.	1.	+ 0° 44′				
13.	–1632 Feb.	1.	+ 1° 7′	78.*	62.	+16.	
	Apr.	3.	+ 0° 41′				
5.	–1640 Feb.	3.	+ 1° 9′	61.	63.	— 2.	
	Apr.	6.	+ 0° 36′				
16/17.	–1629 Mar.	31.	+ 1° 26′	72.*	72.	+ 0.	
	June	11.	— 0° 48′				
8/ 9.	–1637 Apr.	2.	+ 1° 25′	74.*	72.	+ 2.	
	June	13.	— 0° 52′				
							Aphelion : — Earth May 17

* Text of Venus Tablets corrected.

Yr. 8/9 W.R. III 20 assumed to be III 12.
Yr. 13. W.R. XI 11 assumed to be I 11.
Yr. 16/17 W.R. III 20 assumed to be III 10.
Yr. 21 E.S. X 28 assumed to be X 18.

** Alternative version.

Yr. 20. W.R. takes as VI 1.
(K 2321 + K 3032 reverse.)

Solution 1646 B.C. to 1625 B.C.

EASTERN SETTINGS AND WESTERN RISINGS OF VENUS

Relationship to Venus Orbital Points of Differences between Recorded and Computed Dates

(Superior Conjunctions)

Venus Aphelion : – Dec. 23. (± 0.)

Number of days Computed Date is Before (+) or After (—) Aphelion date.	Year of reign.	Date as computed. (Julian.)	Days Computed Date is Before (+) or After (—) Recorded Babylonian Date. As Recorded. E.S.	As Recorded. W.R.	Lunar month Adjustment.	As adjusted. E.S.	As adjusted. W.R.
— 21.	2.	Dec. 2.	—10. ***		+ 1.	— 9.	
— 23.	10.	Nov. 30.	— 7. ***		+ 1.	— 6.	
— 25.	18.	Nov. 27.	+ 0.		— 2.	— 2.	
— 31.	7.	Nov. 22.		— 3	+ 5.		+ 2.
+ 32.	18.	Jan. 24.		+ 4.	— 2.		+ 2.
+ 33.	10.	Jan. 25.		+ 0.	+ 1.		+ 1.
— 34.	15.	Nov. 19.		+ 4. ***	+ 1.		(+ 5.)
+ 36.	2.	Jan. 28.		+ 0.	+ 1.		+ 1.
+ 38.	21.	Jan. 30.	— 1.*		+ 0.	— 1.	
+ 40.	13.	Feb. 1.	— 2.		+ 1.	— 1.	
+ 42.	5.	Feb. 3.	— 1.		+ 1.	+ 0.	
— 98.	7.	Sept. 16.	— 6.		+ 5.	— 1.	
+ 98.	16/17.	Mar. 31.	+ 0.		+ 0.	+ 0.	
+ 99.	21.	Apr. 1.		+ 4. ***	+ 0.		(+ 4.)
—100.	15.	Sept. 14.	— 2.		+ 1.	— 1.	
+100.	8/9.	Apr. 2.	— 3.		+ 1.	(— 2.)	
+101.	13.	Apr. 3.		(—45.)	+ 1.		(—44.)
+104.	5.	Apr. 6.		— 3.	+ 1.		(— 2.)
—112.	4.	Sept. 2.		— 7.	+ 2.		(— 5.)
—115.	12.	Aug. 30.		(+52.)	+ 0.		(+52.)
—118.	20.	Aug. 27.		— 1.**	+ 0.		— 1.
+170.	16/17.	June 11.		+ 0.*	+ 0.		+ 0.
+172.	8/9.	June 13.		— 1.*	+ 1.		+ 0.
—176.	4.	July 1.	— 3.		+ 1.	(— 2.)	
—179.	12.	June 28.	(—51.)		+ 0.	(—51.)	
—182.	20.	June 24.	+ 0.		+ 1.	+ 1.	

Venus Perihelion : — June 23. (± 183.)

* Text of Venus Tablets corrected.

** Alternative version.

*** Possible ajustment assuming unfavourable weather.

Yr. 2 : — — 10 may be — 5 Yr. 15 + 4 may be + 2

Yr. 10 : — — 7 may be — 5 Yr. 21 + 4 may be — 2.

Solution 1646 B.C. to 1625 B.C.

Relationship to Orbital Points of Differences between Recorded and Computed Periods of Invisibility of Venus at Inferior Conjunction

Year.	Computed date. (Julian.) Latitude 34·0° N.			Geocentric latitude of Venus.	Invisibility Period of Venus. (Days.) Venus Tablet.	Computed.	Diff.	Orbital points. (Approximate Julian dates.)
								Perihelions : – Earth Nov. 16. Venus Dec. 23.
14.	–1632	Dec.	24.	— 5° 11′	?.	3.	?.	
		Dec.	28.	— 5° 51′				
6.	–1640	Dec.	26.	— 5° 24′	4.	4.	+ 0.	
		Dec.	30.	— 6° 3′				
17.	–1628	Mar.	3.	— 8° 6′	4.	3.	+ 1.	
		Mar.	6.	— 7° 57′				
9.	–1636	Mar.	6.	— 8° 0′	4.	2.	+ 2.	
		Mar.	9.	— 7° 49′				
1.	–1644	Mar.	8.	— 7° 49′		2.	+ 2.	
		Mar.	11.	— 7° 47′				
21.	–1625	May	12.	— 1° 27′	6.	10.	— 4.	
		May	24.	+ 1° 8′				
13.	–1633	May	15.	— 0° 59′	7.	10.	— 4.	
		May	26.	+ 1° 23′				
5.	–1641	May	17.	— 0° 42′	6.**	11.	(— 5)	
		May	29.	+ 1° 49′				
								Aphelions : — Earth May 17. Venus June 23.
16.	–1630	July	19.	+ 6° 40′	15.	16.	— 1.	
		Aug.	5.	+ 8° 14′				
8.	–1638	July	21.	+ 6° 47′	18.*	17.	+ 1.	
		Aug.	7.	+ 8° 18′				
19.	–1627	Sept.	26.	+ 7° 29′	16.?	19.	— 3.?	
		Oct.	14.	+ 5° 3′				
11.	–1635	Sept.	28.	+ 7° 15′	22.*	19.	+ 3.	
		Oct.	17.	+ 4° 37′				
3.	–1643	Oct.	1.	+ 7° 1′	20.	18.	+ 2.	
		Oct.	19.	+ 4° 21′				

* Text of Venus Tablets corrected.

Yr. 8. W.S. IV 25 assumed to be IV 15
Yr. 11. E.R. VI b 8 assumed to be VI b 18
Yr. 19. W.S. VI b 1 assumed to be VI b 21
E.R. VII b 17 assumed to be VII 7

** Alternative version.

Yr. 5. E.R. Taken as II 8 (W. 802).

Solution 1646 B.C. to 1625 B.C.

WESTERN SETTINGS AND EASTERN RISINGS OF VENUS

Relationship to Venus Orbital Points of Differenses between Recorded and Computed Dates

(Inferior Conjunctions)

Number of days Computed Date is before (+), or after (—) Perihelion date.	Year of reign.	Date as computed. (Julian.)	Days Computed Date is before (+), or after (—) Recorded Babylonian Date.				
			As Recorded.		Lunar mont Adjustment.	As Adjusted.	
			W.S.	E.R.		W.S.	E.R.
VENUS PERIHELION.		Dec. 23.					
+ 1.	14.	Dec. 24.	(—45.)		+ 0.	(—45.)	
+ 3.	6.	Dec. 26.	— 1.		+ 0.	+ 0.	
+ 5.	14.	Dec. 28.		— 1.	+ 0.		— 1.
+ 7.	6.	Dec. 30.		— 1.	+ 0.		— 1.
— 65.	3.	Oct. 19.		— 4.	+ 4.		+ 0.
— 67.	11.	Oct. 17.		+ 5.* ***	— 3.		(+ 2.*)
— 70.	19.	Oct. 14.		+ 2.*	?.		?
+ 70.	17.	Mar. 3.	+ 2.		— 4.	— 2.	
+ 73.	17.	Mar. 6.		+ 4.	— 4.		+0.
+ 73.	9.	Mar. 6.	— 3.		+ 1.	— 2.	
+ 75.	1.	Mar. 8.	— 2.		+ 1.	— 1.	
+ 76.	9.	Mar. 9.		— 1.	+ 1.		+0.
+ 78.	1.	Mar. 11.		— 1.	+ 1.		+0.
— 83.	3.	Oct. 1.	— 6.		+ 4.	— 2.	
— 86.	11.	Sept. 28.	+ 2.		— 3.	— 1.	
— 88.	19.	Sept. 25.	+ 1.*		— 2.	— 1.	
—130.	8.	Aug. 7.		+ 4.	— 4.		+0.
—140.	16.	Aug. 5.		— 4.	+ 4.		+0.
+140.	21.	May 12.	+ 4.		— 4.	+ 0.	
+143.	13.	May 15.	+ 7.		— 7.	+ 0.	
+145.	5.	May 17.	+ 0.		+ 0.	+ 0.	
+152.	21.	May 24.		— 1.	+ 1.		+0.
+154.	13.	May 26.		+ 4.	— 7.		—3.
—155.	8.	July 21.	+ 3.* ***		— 4.	+ 0.	
—156.	16.	July 19.	— 3.		+ 4.	+ 1.	
+157.	5.	May 29.		— 5.**	+ 0.		—5.
VENUS APHELION.		June 23.					

* Text of Venus Tablets corrected.

** Alternative version.

*** Possible adjustment assuming unfavourable weather.

Yr. 8 : — + 4 may be + 1 Yr. 11 : — + 5 may be + 3

POSTSCRIPT

1. *The Conjunction Date Pattern.*

It is possible to calculate from the Venus tablet setting and rising dates superior and inferior conjunction dates for Venus. They are computed on the assumption that the same relationship between setting, conjunction and rising date holds good for both the recorded and the computed data. It is also possible to establish from Schoch's Oxford Tables the effects on theoretical average conjunction dates of the orbital eccentricities of Venus and the earth. That information provides a basis of comparison for the variations between the Venus tablet conjunctions and the computed conjunctions.

Computed conjunction and average conjunction dates coincide when Venus and the earth are both on the line of the major axis of the Venus orbit. Every year the earth passes through this axis on, or about December 23rd and June 23rd. It might be expected, therefore, that the Venus tablet conjunctions in December would take place on the same day as their computed equivalents. It might also be expected that the July and May conjunctions would either coincide with the computed dates, or be not more than one day out. In fact, in all three months there are variations of up to 5-days.

Moreover, the maximum variation due to the Venus eccentricity ought to occur with the March and October conjunctions; but the same degree of variation is found there as at the orbital points. That would seem to suggest that the discrepancies are mainly caused by a divergency of the lunar table data from the actual movements of the moon. Thus the Venus variations are being camouflaged by the lunar variations. If sufficient recorded data was available they should correspond to the average variation of their respective cyclic groups.

For the superior conjunctions, the March sequence tends to average out at about + 1-day, and the October sequence at — 2-days. Also, their respective positive and negative signs are as they should be.

For the inferior conjunctions the arrangement of positive and negative signs is a little perplexing. Two of the March conjunctions have a value of — 1-day. That is in agreement with the superior conjunction findings. Yet the third conjunction has a variation of + 4-days, and the resulting average is + 1 or + 2-

days. Similarly, the October conjunction average, which should have a plus, has a minus sign.

If this arrangement is authentic, the earth itself had greater orbital eccentricity than it has at present. The 12-day interval recorded for Year 11, if it is genuine, would seem to require that to be the case.

However, the Venus tablet data could be misleading, for only 21-years of a very much longer lunar cycle is available for study. If the sequence had covered a longer period in time, the inferior conjunction average might have been found to conform to the expected Venus pattern without assuming change in the shape of the other orbit.

The maximum divergence of the computed conjunctions from the average is 3-days caused by the earth's orbital eccentricity, and 1-day caused by the orbital eccentricity of Venus. Assuming the same relationship between orbital eccentricity and its effect in "days" holds good for both planets, the Venus tablet conjunctions could diverge from the computed conjunctions by a maximum of 2-days, and Venus would still not have an eccentricity greater than that of the earth at present. While it is impossible to establish the true average with such a limited portion of the lunar cycle available, it seems likely to come within those limits [52].

[52] Le Verrier's Tables, which appeared in the French publication "Connaissance de Temps" for 1970, assume both Venus and the earth within the historical period, had greater orbital eccentricity than is the case today. The present day values are for Venus 0.00681, and for the earth 0.01674. In 1646 B.C., according to those astronomical tables, the eccentricity of the Venus orbit was 0.008883 and that of the earth's orbit 0.018087. Those figures were computed for me by Dr. Roy of the University of Glasgow. My Postscript had been completed before that information reached me.

Superior Conjunctions

Year.	Venus tablet calculated conjunction dates	Computed conjunction dates. Lat. 34.0° N.	Relationship of computed dates to Venus tablet dates. Days before + Days after —	Relationship of average dates to computed dates. (Days.) Earth only.	Venus only.	Combined effect.
		Nov. 16	Perihelion of Earth.			
		Dec. 23	Aphelion of Venus. (Or Dec. 25 according to Oxford Tables.)			
18.	Dec. 26	Dec. 24	+ 2.	+ 2·18	— 0·10	+ 2·08
10.	Dec. 22	Dec. 26	— 4. (to — 3.)	+ 2·20	+ 0·09	+ 2.29
2.	Dec. 24	Dec. 29	— 5. (to — 3.)	+ 2·20	+ 0·30	+ 2·50
21.	Mar. 10*	Mar. 8	+ 2. (to — 2.)	+ 3.15	+ 1·58	+ 4·73
13.	Mar. 19*	Mar. 11	+ 8. (to — 3.)	+ 3·08	+ 1·61	+ 4·69
5.	Mar. 11	Mar. 13	— 2.	+ 2.98	+ 1·57	+ 4·55
		May 17	Aphelion of Earth.			
16/17	May 19*	May 19	+ 0.	— 0·19	+ 0·89	+ 0·08
8/9.	May 19*	May 21	— 2. (to — 1.)	— 0·17	+ 0·89	+ 0·72
		June 23	Perihelion of Venus. (Or June 25 according to Oxford Tables.)			
20.	July 25	July 25	— 0. (to — 2.)	— 3·11	— 0·73	— 3·84
12.	July 23	July 27	— 4. (to — ?.)	— 3·10	— 0·83	— 3·93
4.	July 24	July 29	— 5.	— 3·19	— 0·93	— 4·12
15.	Oct. 7	Oct. 7	— 0. (to — 1.)	— 2·12	— 1·56	— 3·68
7.	Oct. 5	Oct. 10	— 5.	— 2·03	— 1·54	— 3·57

* Text of Venus tablets corrected.

Yr. 8/9. W.R. III 2 assumed to be III 12.
Yr. 13. W.R. XI 11 assumed to be I 11.
Yr. 16/17. W.R. III 20 assumed to be III 10.
Yr. 21. E.S. X 28 assumed to be X 18.

Inferior Conjunctions

Year.	Venus tablet calculated conjunction dates.		Computed conjunction dates. Lat.	34·0° N.	Relationship of computed dates to Venus tablet dates. Days before + Days after —	Relationship of average dates to computed dates. (Days.) Earth only.	Venus only.	Combined effect.
			Nov.	16	Perihelion of Earth.			
			Dec.	23	Perihelion of Venus. (Or Dec. 25 according to Oxford Tables).			
14.	Dec.	24	Dec.	25	—1.	+2·19	0·00	+2·19
6.	Dec.	26	Dec.	27	—1.	+2·20	—0·16	+2·04
17.	Mar	10	Mar.	6	+4.	+3·18	—1·56	+1·62
9.	Mar.	8	Mar.	9	—1.	+3·12	—1·59	+1·53
1.	Mar.	10	Mar.	11	—1.	+3·08	—1·16	+1·47
21.	May	18	May	16	+2.	+0·02	—0·88	—0·86
			May	17	Aphelion of Earth.			
13.	May	24	May	18	+6.	—0·05	—0·89	—0·94
5.**	May	19	May	20	—1. (to —0.)	—0·14	—0·89	—1·03
			June	23	Aphelion of Venus. (Or June 25 according to Oxford Tables).			
16.	July	24	July	28	—4.	—3·12	+0·85	—2·27
8.*	Aug.	3	July	30	+4. (to +2.)	—3·21	+0·95	—2·26
19.*	Oct.	8	Oct.	9	—1. ?	—0·07	+1·55	—0·52
11.*	Oct.	16	Oct.	12	+4. (to +3.)	—1·96	+1·53	—0·43
3.	Oct.	10	Oct.	14	—4.	—1·85	+1·57	—0·28

* Text of Venus tablets corrected.

Yr. 8. W.S. IV 25 assumed to be IV 15.
Yr. 11. E.R. VIb 8 assumed to be VIb 18.
Yr. 19. W.S. VIb 1 assumed to be VIb 21.
E.R. VIb 17 assumed to be VII 7.

If Yr. 19 had an invisibility period of 20-days, the Western Setting may have been VIb 17. The conjunction date would then be October 7th, a difference of — 2.

** Alternative version.

Yr. 5. E.R. II 8. (See Tablet W 802).

2. *Orbital variations of the Planets.*

The idea of variable eccentricity of the planetary orbits dates from about 1850, when James Croll put forward the theory that the Ice Age had been caused by a long-term change in the earth's orbital eccentricity. That eccentricity was thought to vary between two extremes over a period of 92,000 years.

Recent work at Glasgow University into the past history of Jupiter and Saturn has yielded information about long-term periodic changes in the shapes of the orbits of those two planets. If the Venus orbit follows the same long-term pattern, as it would have to do if its variations are closely inter-related with those of Jupiter and Saturn, it is doubtful whether it could have altered enough in 4,000 years for the change to be detectable in a historical document.

However, Venus follows a very much smaller path round the sun than does Jupiter. So it may be found that the duration of those periodic changes for Venus are very much scaled down in relation to those of Jupiter; but that is speculation.

On the other hand, given that the Venus tablet data implies more than just a slight modification to the astronomical tables, it might be inferred that a relatively large body may have entered the solar system and passed close enough to Venus and to the earth and moon to cause temporary perturbations of their orbits. Subsequently, such a body might have broken up and been "captured" by Jupiter. Presumably, the distorted orbits of the inner planets would then tend to return, perhaps very quickly, to their natural shapes.

Yet such a body, if it existed, is more likely to have caused changes to the lunar orbit than to that of Venus. It could explain why Schoch's lunar tables are not giving true information about the movements of the moon as recorded by the Venus tablets. Otherwise, a simple modification of the lunar elements may be found to remove the discrepancies.

Moreover, even with an external body present, the change in the shape of the Venus orbit could still fit into the pattern of gradual change. However, the facts can only be established by a mathematical analysis. So far, the computer has not been used to investigate the past history of the earth and lunar orbits, or of the orbit of Venus.

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