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ARISTOTLE, KING DAVID, KING ZHOU AND PHARAOH THUTMOSIS III HAVE SEEN COMET ENCKE

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ABSTRACT

Aristotle saw a great winter comet with a tail reaching up to Orion. It was Comet Encke on 31 December in 372 BC. When it became visible in the morning, after 9 January 371 BC, Ephoros saw its nucleus split up in two parts. The sword of the Angel of the Lord seen above Jerusalem, as punishment for the sins by King David, was Comet Encke in 964 BC. The sword was redrawn at Ornan's threshing floor on 8 June 964 BC. David bought this place and built an altar that later became the Altar of Salomon's Temple in Jerusalem. A second century BC text contains a unique record of a bright comet observed at the end of the Shang Dynasty: 'When King Wu [of Zhou] attacked King Zhou [of Shang], a comet appeared and tendered its handle to Yin'. This was Comet Encke on 22 June 1060 BC and 17 days later, on 9 July in 1060 BC, Encke seems to have been depicted on a rock carving in Sweden. A stele at the temple of Amon at Gebel Barkal in Nubia, mentions first the important victories at Megiddo, in year 33, and Mittani, in year 23 of the reign of Pharaoh Thutmosis III. However, the text also mentions an important celestial phenomenon during his 47th year of reign. The description fits very well with the bright appearance of Comet Encke at the end of January in 1460 BC. This supports the High Chronology for Egypt with 1506 BC as the first year of reign of Thutmosis III, the sixth Pharaoh of the 18th Dynasty in Egypt.

KEYWORDS: Periodic Comet Encke, Aristotle, King David, King Zhou, Pharaoh Tutmosis III

1. INTRODUCTION

During the 1990th the author studied the Swedish rock carvings from the Bronze Age and found that some motives could be depictions of total solar eclipses, a bright supernova and the appearance of bright comets (Henriksson 2005a). By comparing the position of the symbol for the eclipsed sun in relation to different ships it was possible to establish a series of six calendar ship constellations along the ecliptic, the sun's path in the sky. Comets were depicted as swords, spears, or mini-suns with tail. A sword is pointing towards the sun during the total solar eclipse in 1596 BC, (Fig. 1). A reasonable assumption is that the sword is a depiction of a comet, and this working hypothesis is tested below. That comets were considered as celestial swords is known from sources like Plinius the elder (23-79 AD), who in his *Naturalis Historia* described comets as sword-like (Heath 1932). Josephus (37-c100 AD) wrote in his *History of the Jews* that a sword hanged over Jerusalem (Whiston 1737). Henriksson (2007 & 2018) identified "the sword of the Angel of the Lord" in the Old Testament as Comet Encke. From the orientation of the swords in relation to the calendar ships it became clear that the comet's orbital inclination to the plane of the ecliptic was about 10°. This means that the only candidate among the known periodic comets is Comet Encke, with a mean inclination of about 10°.

Encke is expected to have been very bright during the Bronze Age. This hypothesis is discussed in chapter 7. Today, Encke is scarcely visible to the naked eye.

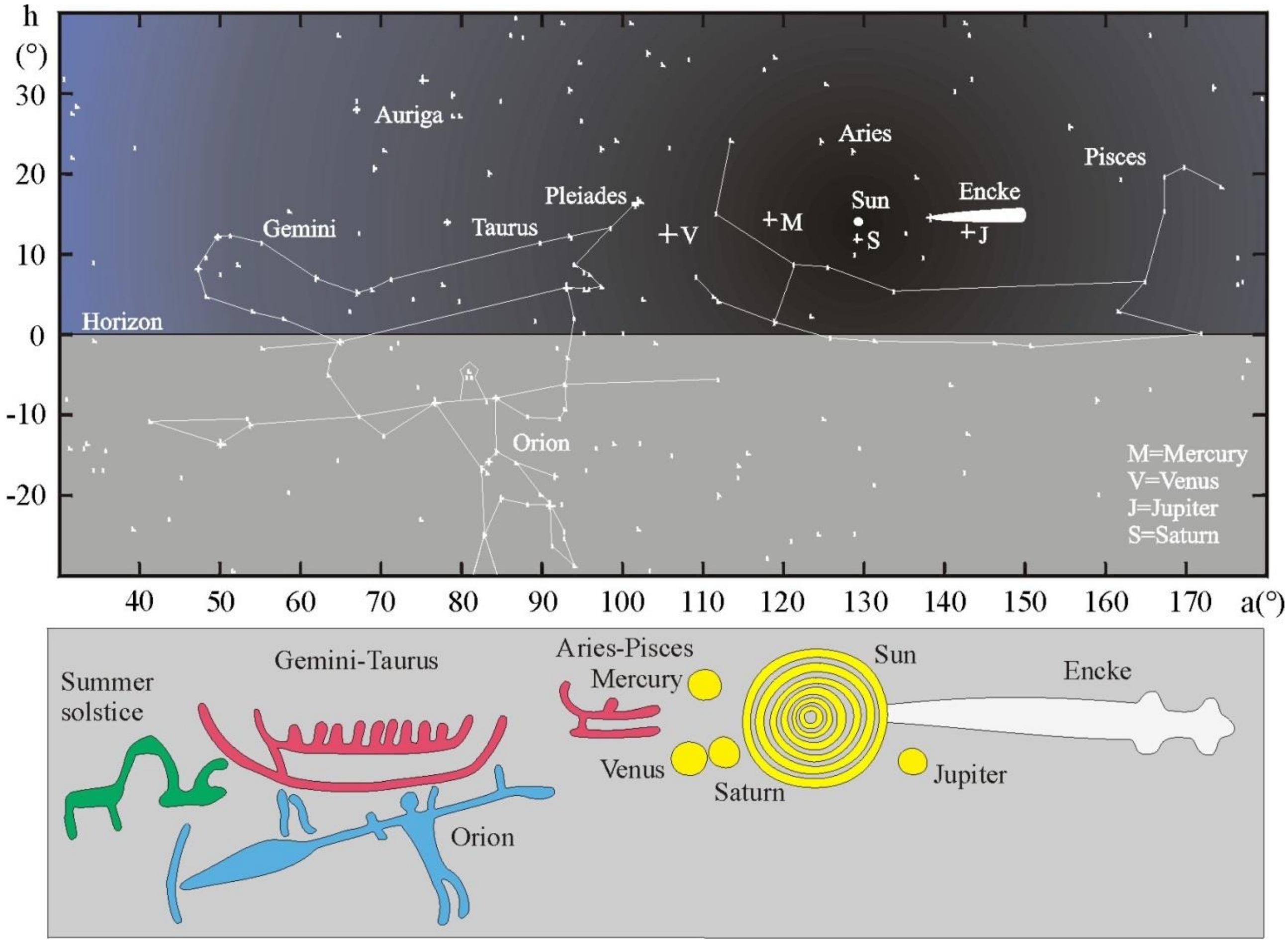

Figure 1. Upper figure: The total solar eclipse on 3/3, 1596 BC, from the horizon of Ekenberg in Norrköping. The central phase occurred at 08.57 local mean solar time, and the duration of the total phase was 2 minutes and 46 seconds. Four bright planets dominated the sky in the vicinity of the sun. But the most spectacular object was Comet Encke, visible so close to the sun because of the total solar eclipse. The time shift ΔT from the sixth order polynomial, see Figure 3, was 0.0 days. The length of the tail in the figure corresponds to 1.0 AU (1 Astronomical Unit = 150 million kilometers).

Lower figure: The totally eclipsed sun was depicted as concentric circles, with the four planets visible as cup-marks and Comet Encke as a sword in the Aries-Pisces calendar ship. To the left, below the horizon: Orion lifts the Gemini-Taurus calendar ship. Rock-carving at Ekenberg in Norrköping. After Arthur Nordén (1926).

The most common way to depict Comet Encke, on the oldest rock-carvings, was as different kind of swords. It has even been possible to follow the technical development of the swords during almost one thousand years beginning with a late Neolithic flint dagger and continuing as swords made by bronze. This symbolic representation of Comet Encke was sometimes replaced when parts of the tail come very close to the earth and it could be seen as a transparent cloud. In these situations the rock-carving artists began to depict the tail as a net around a central spear similar to a feather of a bird. On one depiction, when the nucleus was very close to the earth, the comet is depicted as a flying "Christmas tree" because of the perspective, (Fig. 8b). The most interesting example of a feather like depiction can be seen in Fig. 2a-c. It shows in a realistic way a so-called reconnection when the comet loses the outer part of its tail because of the solar wind. This can be dated exactly because the moon happened to be visible partly within the tail of the comet.

The passages of Encke have been dated from total solar eclipses or phases of the Moon.

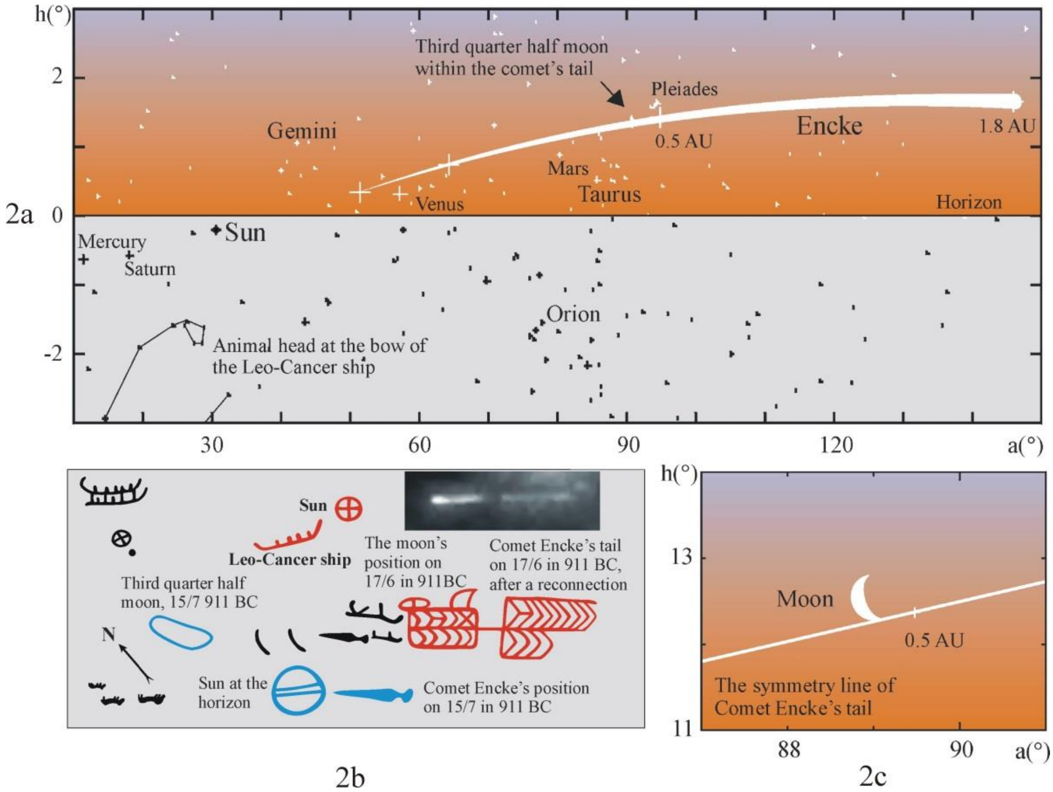

Figure 2a. Comet Encke just before sunrise on 17/6, 911 BC, at 02.10 local mean solar time at Himmelstalund in Norrköping. The position of the sun, one week before the summer solstice, was above the animal head at the bow of the Leo-Cancer ship. The moon, phase=297.7°, was visible within the tail of the comet, just above its axis of symmetry. (m<4.5, ΔT = -5.5 days).

Figure 2b. The depiction of the half moon within and above the tail of the comet has been reproduced with great sharpness on this rock carving from Himmelstalund by Nordén (1926). The comet was moving downwards and the moon moved to the left and on 17/6 it moved in front of the comet's tail and reached the depicted position. At the bottom we can see the sun at the horizon, marked by the double lines, and Encke depicted as a sword. Encke was difficult to observe at this moment, but the picture may be an extrapolation to the day of the third quarter half moon, 15/7, symbolized by the right foot to the left.
The inserted photo in the upper right corner is Encke's reconnection on 20 April 2007, taken by the LASCO solar satellite.

Figure 2c. Detail of Figure 2a. At 02.00, on 17/6 in 911 BC, two days after the third quarter half moon, the moon was visible 0.25° above the symmetry line of Encke's tail and 0.5 AU from its nucleus. (Lunar phase = 297.6°, mean anomaly = 356.9°, distance to the sun = 0.426 AU and distance to the earth = 0.743 AU and ΔT = -5.5 days).

The comet that is called Encke was discovered by telescope in 1786 by Pierre Méchain at the Observatory of Paris. Johann Franz Encke realized that the same comet had also been observed in 1795, 1805 and 1818 and he computed its first orbit in 1819. This was a very difficult and laborious task and therefore the comet was named "Encke" to honour him. Encke's period is 3.3 years with aphelion between Mars and Jupiter and perihelion within Mercury's orbit. It has been very difficult to determine the evolution of Encke's orbit because of perturbations from non-gravitational forces due to the rocket effect of out-gassing volatiles from the icy-conglomerate nucleus, according to the paper: "A comet model I. The acceleration of comet Encke" by Fred Whipple (1950). An ambitious attempt was made to find Comet Encke among the more than 300 early Chinese records of comets (Whipple and Hamid 1972). Unfortunately, not a single identification of Encke could be made.

In May 1994 the author asked Dr Mats Lindgren to calculate the orbit for Comet Encke back to 2000 BC, from all available observations since 1786, the year of its modern discovery by telescope, but without non-gravitational forces. He was one of the experts from the Comet Group at the Observatory in Uppsala, lead by professor Hans Rickman, former IAU president. The non-gravitational forces were weak for this comet and I assumed that no other forces than the gravitational forces from the sun and the planets significantly changed the orbital elements. Further, because the inclination is so low the component of the forces in latitude is negligible and it is reasonable from celestial mechanic arguments that a model with one component in longitude is enough. This means that the only significant effect of the non-gravitational forces was a shift of Encke's position along its orbit, determined from the gravitational forces.

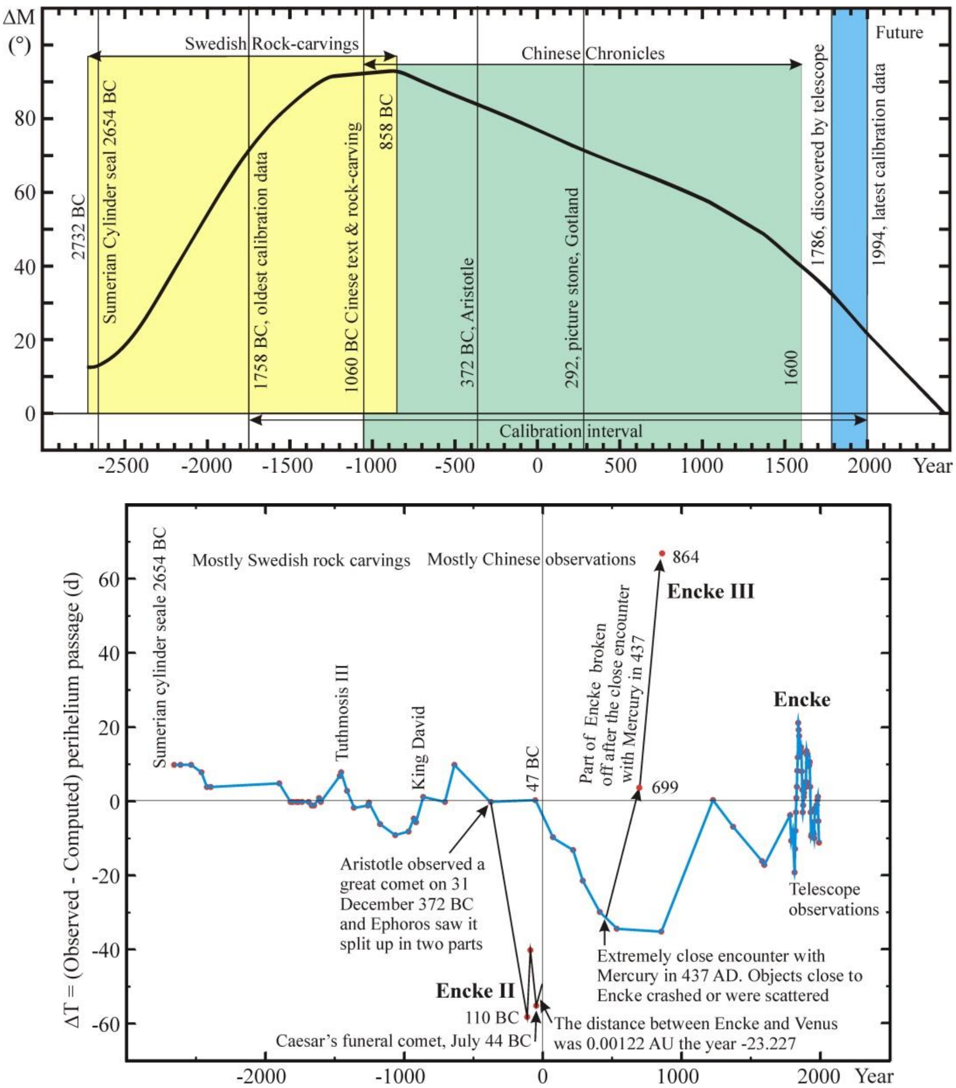

Figure 3. Upper figure: The deviations in Comet Encke's mean anomaly, ΔM, caused by non-gravitational forces represented as a sixth order polynomial determined from observations 1758 BC - 1994. No observations of Encke are known between the last visual Chinese observation in 1600 AD and its discovery by telescope in 1786.

Lower figure: Time corrections, ΔT, to the 6th order polynomial that represents Comet Encke's deviations in mean-anomaly. ΔT= (Observed - Computed) perihelion passages for Comet Encke, 2654 BC - 1994.

A negative sign means that Encke's arrival time at perihelion was delayed.

The time shift was first approximated as a parabola through the modern observation after 1786 and the positions in 1596 and 858 BC when the comet was depicted on rock-carvings during total solar eclipses, Henriksson (2018). With this parabola it became possible to identify some of the Chinese observations and to get more points on the curve and to use higher and higher order polynomials and finally, with a sixth order polynomial, it was possible to calculate all comet observations from ancient texts or rock-carvings, that could be expected to be Comet Encke, back to 2654 BC with individual time shifts ΔT less than 10 days, Figure 3.

In June 1994, Dr Mats Dahlgren, Uppsala Comet Group, wanted to test my hypothesis that the secular non-gravitational perturbations of Encke's orbital elements were small and that the gravitational orbit was stable. After one night with orbital integrations on the main computer at the Observatory, with 30 different equally distributed starting positions along Encke's orbit, he concluded that all the orbital elements varied very little back to 2000 BC and there was no risk that Jupiter could capture it.

The author included the gravitational orbit of Encke in the computer program for positions of the sun, moon, planets and stars in order to determine non-gravitational corrections to its position along the orbit. It has mainly been calibrated from depictions on Swedish rock carvings and Chinese texts and gives useful results at least back to 2654 BC when it was depicted on a Sumerian cylinder seal during a total solar eclipse (Henriksson 2017).

The time-shifts from this six order polynomial were less than 10 days except during about 300 years after the splitting of Encke's nucleus in two parts observed by Ephoros (ca 405-330 BC) before sunrise some days after 9 January 371 BC. Ephoros, the first historian of science (Barber 1935), saw the nucleus split up and became two comets. Aristotle reported that he had seen a great winter comet, Book I, Meteorologica VI (Lee 1952). That must have been during the last days of 372 BC, before the splitting of its nucleus. The main part of the great winter comet was not severely disturbed by the splitting and is today identical with Comet Encke, while the minor part has not survived to modern times, Figure 3.

The first identified observation of the broken off part of comet Encke, Encke II, was recorded in Chinese chronicles on 25 May in 110 BC, with ΔT = -58 days. Encke II appeared also during the funeral games for Julius Caesar in July 44 BC with ΔT = -55 days. This comet was depicted on Roman coins and was claimed to be the soul of Julius Caesar and proved that he had became a god.

However, Encke II had a very close encounter with Venus 20 years later, on 24 March in 24 BC, and came as close to the planet as 0.00122 AU or 183 000 km, about half the distance between the earth and the moon, Figure 3.

The earliest identified observations of the main component of Encke after the split up were made at the end of June 47 BC, with ΔT = 0.0 days. After that its speed decreased slowly but in January 437 AD there was an almost catastrophic encounter with Mercury. Encke itself was not heavily disturbed, but one observation of another comet, Encke III, in the same orbit as Encke, but somewhat time shifted, has been possible to identify in the Chinese texts. It was observed on 12 March 699 AD, with ΔT = +3.8 days. On that day the Earth passed through the tail of Encke III. The last observation of Encke III was made on 26 June 864 with ΔT = +67 days, Figure 3.

When I tried to integrate Encke's orbit backwards from 537 AD, it seemed impossible to go to the position recorded in 414 AD because the calculated position of the comet was scattered in all directions by an extremely close encounter with Mercury in 437. According to the Chinese Chronicles a star appeared during daytime, at 15.00 -17.00, on 27 January 437, in the NE by the side of Tung-Ching (Gemini). It was necessary to find a combined value of the gravitational and the non-gravitational forces with 10 digits accuracy to avoid a collision! The reason for this problem must have been a small error in the position in 537. Some broken off pieces of Encke, with deviating non-gravitational forces, resulted probably in a shower of particles that were spread out along Encke's orbit and hit the earth during a close encounter with the earth around the autumn equinox in 437.

After Encke's close encounter with Mercury in 437 it seems to have been caught in a resonance orbit with the earth with the main resonance period 78.99 years. The next observations were made in 537 and 857; see lower part of Figure 3.

2. COMET ENCKE OBSERVED BY ARISTOTLE AND EPHOROS IN 372/371 BC

Aristotle (384-322 BC) discussed different hypothesis about the nature of comets in Book I, Meteorologica VI (Lee 1952). Aristotle wrote: "For the great comet, which appeared about the time of the earthquake in Achaea and the tidal wave, rose in the west (towards the equinoctial sunset)" and further, "For instance, the great comet which we mentioned before appeared during the winter in clear frosty weather in the west, in the archonship of Asteius: on the first night it was not visible as it set before the sun did, but it was visible on the second, being the least distance behind the sun that would allow it to be seen, and setting immediately. Its light stretched across a third of the sky like a cord (or band), as it were, and so was also called a path. It rose as high as Orion´s belt, and there dispersed.", see Figure 4.

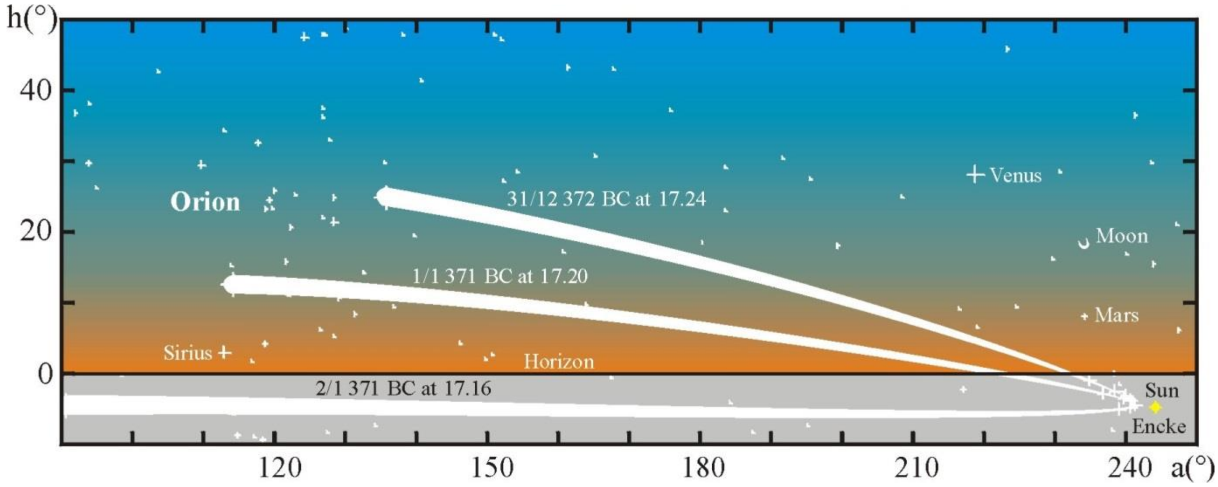

Figure 4. Comet Encke on 31/12 in 372 BC - 2/1 in 371 BC, from the horizon of Athens. The sky corresponds to 1/1 in 371 BC, at 17.20 local mean solar time. With the time shift ΔT = 0.0 days Encke's mean anomaly was 3.66°, the distance to the sun 0.455 AU, the distance to the earth 0.533 AU, the magnitude of the nucleus -5.9 and its altitude was -3.9°. The length of the tail has been estimated to be 0.6 AU as it reached up to the belt of Orion. The altitude of the sun was -4.4°and the phase of the moon was 25.5°.

Diodorus of Sicily mentioned also a great comet in Book XV, 50 (Oldfather 1954): "When Alcisthenes was archon at Athens, the Romans elected eight military tribunes with consular power, Lucius and Publius Valerius, Gaius Terentius, Lucius Menenius, Gaius Sulpicius, Titus Papirius, and Lucius Aemilius, and the Eleians celebrated the hundred and second Olympiad in which Damon of Thurii won the stadium race. During their term of office, after the Lacedaemonians had held the supremacy in Greece for almost five hundred years, a divine portent foretold the loss of their empire; for there was seen in the heavens during the course of many nights a great blazing torch which was named from its shape a "flaming beam," and a little later, to the surprice of all, the Spartans were defeated in a battle and irretrievely lost their supremacy. Some of the students of nature ascribed the origin of the torch to natural causes, voicing the opinion that such apparitions occur of necessity at appointed times, and that in these matters the Chaldeans in Babylon and the other astrologers succeded in making accurate prophecies. These men, they say, are not surpriced when such a phenomenon occurs, but rather if it does not, since each particular constellation has its own peculiar cycle and they complete these cycles through age-long movements in appointed cources. At any rate this torch had such brilliancy, they report, and its light such strength that it cast shadows on the earth similar to those cast by the moon."

Seneca (4 BC-65 AD) writes about comets and the earthquake in Achaea, in his book Natural Questions VII, 5. (Corcoran 1971): "Callisthenes reports that a similar likeness of an extended fire appeared just before the sea covered Buris and Helice. Aristotle says that this was not a Beam but a comet. Moreover, he says that because of its excessive brightness the fire did not appear scattered but as time went on and it blazed less it recovered the usual appearance of a comet. In that fire there were many worthy things which should be noted, but nothing more so the fact that when it flashed in the sky the sea immediately covered Buris and Helice.

Did Aristotle believe, then, that not only this one but all Beams are comets, with this difference, that Beams have a continuous fire, comets a scattered fire? For Beams have an even flame, not interrupted at any point or dull but collected in the end parts like the fire Callisthenes reported was in the one which I just mentioned."

According to Seneca, Natural Questions VII, 16, 2, the historian Ephorus from Cyme had discovered that the comet that was seen before the earthquake in Achaea one night was divided into two stars. This seemed to be unbelievable to Seneca and he suggest that he manipulated the text to explain the destruction of the two cities, according to the principle, one comet for each city.

Diodorus had followed extensively the now lost important work by Ephorus who saw the comet with his own eyes. The content in the text by Diodorus can be accurately dated in two independant ways to 372/371 BC. The first Olympiad was celebrated after the summersolstice in 776 BC, which gives 372 BC for the one hundred and second Olympiad, and the archonship of Alcisthenes can be dated to the same year from the inscriptions on the Marble Parium.

The dating of the text by Aristotle is somewhat more complicated. He dates first the great comet to ”about the time of the earthquake in Achaea”, but later he says more specifically that it appeared ”in the archonship of Asteius”, who according to Diodorus was the archon in the year of the earthquake in Achaea, which from Marble Parium can be fixed to 373/372 BC.

The dating by Aristotle of the comet to the archonship of Asteius seems to be approximate, but the dating of the earthquake in Archaea to be exact. But Callisthenes have, according to Seneca, reported that an extended fire in the sky (a comet) appeared before the sea covered Buris and Helice. However, the position of the tail of Encke as high as the belt of Orion, on 31 December in 372 BC, fits perfectly with the description by Aristotle of the great winter comet. Only one great comet was mentioned by Aristotle and Diodorus. According to Diodoros it appeared in the sky in 372/371 BC, which agrees exactly with the calculated bright passage by Encke at the same time.

A recent paper discusses the role of observational astronomy in ancient Greece, Hannah (2015).

3. COMET ENCKE AS THE SWORD OF THE ANGEL OF THE LORD

A great effort to solve the problem with the many early indications of passages of bright comets was made by Donald K Yeomans and Tao King (1981) when they performed an ambitious integration of the orbit of Comet Halley back to 1404 BC. They had to stop that year because of a very close encounter with the earth that made further calculations useless. They assumed that the comet’s non-gravitational forces remained constant from one appearance to the next. Nowadays, after a detailed study of the Chinese and other sources, the earliest known observation of Comet Halley was made in 240 BC. This seems to be the first appearance of Comet Halley in the inner solar system.

In this paper I will identify King David’s comet as Comet Encke, which is expected to have been extremely bright during the Bronze Age. I want to test the hypothesis that the motion in the sky above Jerusalem of “the sword of the Angel of the Lord”, mentioned in 1 Chronicles, in the Old Testament, was a description of Comet Encke’s appearance at the end of May and beginning of June 964 BC when it first was circumpolar and finally sets at the northern horizon of Jerusalem. This date is in good agreement with known facts.

It is written in 1 Chronicles 21:15-16, "And God sent an angel to Jerusalem to destroy it, but as he prepared to destroy it, the LORD looked and relented from the calamity. And He said to the angel bringing the destruction, ‘It is enough. Remove your hand.’ The angel of the LORD was then standing by the threshing floor of Ornan the Jebusite. 21:16: Then David lifted up his eyes and saw the angel of the LORD standing between earth and heaven with his sword drawn in his hand stretched out over Jerusalem. So David and the elders, covered in sackcloth, fell on their faces".

King David decided to buy the threshing floor of Ornan and to build an altar there. This became the Altar for the Great Temple that later was built by his son Solomon. The year 964 BC for this bright passage of Comet Encke falls perfectly within the historical estimates 965-960 BC for the foundation of the Altar of Solomon’s Temple in Jerusalem.

If King David, in the evening of 8 June 964 BC, had been watching the sky in the North, from the roof terrace of his palace, close to the main gate in the upper part of ”David’s City”, the oldest part of Jerusalem, he had seen Comet Encke setting at Ornan’s threshing floor at 21.59 local mean solar time in Jerusalem, Figure 5. The roof terrace is assumed to have been about 5 m above the ground level (Henriksson 2018).

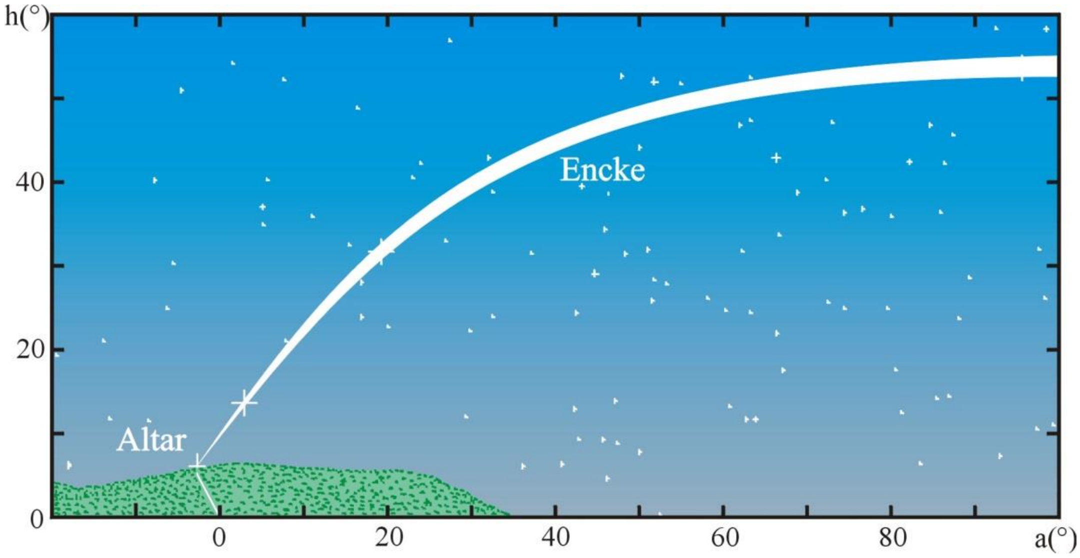

Figure 5. The setting of Comet Encke on 8 June in 964 BC, at 21.59 local mean solar time in Jerusalem. The comet had earlier been circumpolar and visible all the night, but for every night it came closer to the northern horizon. The point at the horizon where Encke was setting for the first time corresponded to the threshing floor of Ornan. King David decided to build an altar at that place. This became later the Altar of the Temple in Jerusalem. The people of Jerusalem saw the tail of Comet Encke as a straight line above their heads. In Figure 5 the tail is bent because of projection effects.

The length of Encke's tail in this image is 0.5 AU. If the total length had been 1.0 AU = 150 million kilometers it had reached the horizon in the south. (Mean anomaly of Encke = 350.4°, distance to the sun = 0.838 AU, distance to the earth = 0.275 AU, magnitude = -6.1, ΔT = -8.03 days, phase of the moon = 13.1° and stellar magnitudes <4.5).

4. COMET ENCKE WAS MENTIONED IN A CHINESE TEXT ON 22 JUNE, IN 1060 BC, AND WAS DEPICTED 17 DAYS LATER, ON 9 JULY, ON A SWEDISH ROCK-CARVING

Ho Peng Yoke (1962) writes in his Catalogue of Chinese Guest stars:

"11th century B.C. 'When King Wu-Wang waged a punitive war against King Chou a (hui) comet appeared with its tail pointing towards the people of Yin.' (Huai Nan Tzu 15/6b).

No earlier sources of reference to this observation have been found other than this singular record by Liu An, the Prince of Huai-nan in the 2nd century B.C. Moreover, the year when the war took place has long been an open question. It has been regarded as 1122 B.C., 1109 B.C. 1055 B.C. and even 1030 B.C. A recent study by CHANG HUNG-CHHIAO (1958) (p. 93 ff) suggests that the year 1055 B.C. was most probable."

Zhentao Xu, David W. Pankenier and Yaotiao Jiang write on page 107 (Zhentao Xu et al. 2000): "The 2nd century BC text Huainanzi contains a unique record of a bright comet observed at the end of the Shang Dynasty: 'When King Wu [of Zhou] attacked King Zhou [of Shang], a comet appeared and tendered its handle to Yin'."

The exact date of this event can be calculated from the very well defined time shift ΔT = -9.0 days determined during the same passage of Comet Encke depicted on a Swedish rock-carving at Herrebro in the parish of Borg, in Norrköping. The unique situation described in the Chinese text when a comet tendered its handle to Yin-Tê in Draco can be identified as Comet Encke's rising in the morning of 22 June 1060 BC, at about 04.05 local mean solar time in Anyang, Figure 6a.

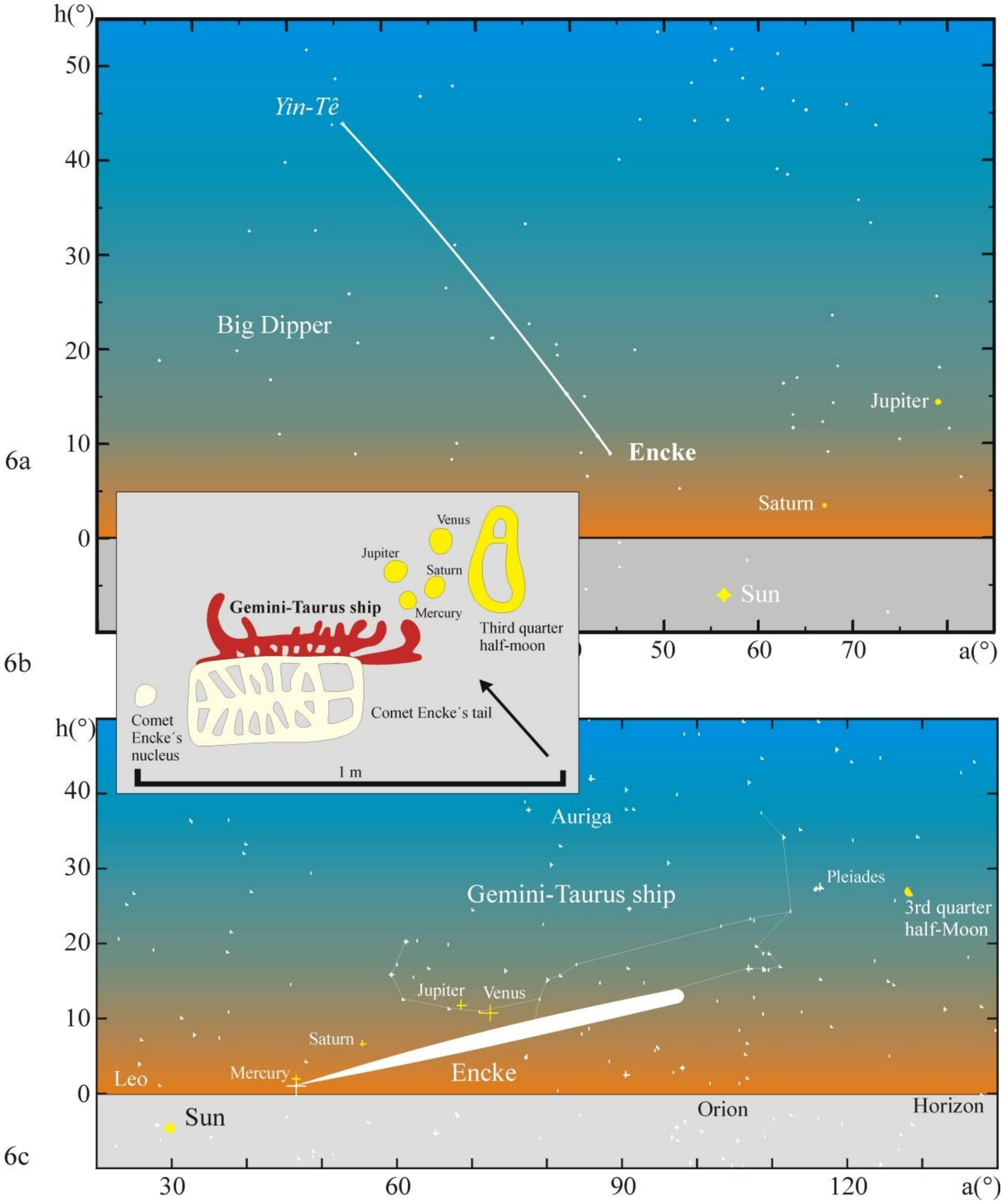

Figure 6a. The rising of comet Encke on 22 June 1060 BC, at 04.05 local mean solar time in Anyang. The tail was pointing at Yin-Tê in Draco. ΔT= -9.0 days, gives mean-anomaly 353.45°, distance to the sun 0.643 AU, distance to the earth 0.402 AU and magnitude -5.78. The length of the tail is estimated to be 0.30 AU. Altitude of the sun -5.79°, lunar phase 47.56° and lunar altitude -41.44°. Stellar magnitudes < 4.5. Camera projection is used, which means that the units on the axis are not exactly azimuth and height.

Figure 6b. The rock carving at Herrebro shows Comet Encke's tail as a frame figure just below and parallel to the keel of the Gemini-Taurus ship and with the bright nucleus as a cup mark in front of the comet's tail. The visible planets Venus, Jupiter, Saturn and Mercury have been depicted as cup marks to the left of the third quarter half-moon. After G. Burenhult (1973).

Figure 6c. Comet Encke, on 9 July in 1060 BC, at 02.10 local mean solar time at Herrebro, in the parish of Borg in Norrköping. The sky was bright, but the long tail had been visible in earlier mornings. The time shift ΔT was –9.0 days, the comet's mean anomaly was 358.6°, its distance to the sun 0.343 AU and to the earth 0.808 AU. The length of the comet's tail can be estimated as 0.7 AU. The phase of the moon was 260.7° and the magnitude of the stars <4.5.

On the rock carving at Herrebro, Encke's tail is depicted as a frame figure just below and parallel to the keel of the Gemini-Taurus ship and with the bright nucleus as a cup mark in front of the comet's tail. This might indicate that the tail had recently been separated from the nucleus by a reconnection. The depiction can be dated by the right foot with the toes pointing downwards, representing the third quarter half-moon, at a position to the right of the bow of the Gemini-Taurus ship that it only occupies every 19th year and always on 8-10 July during this period of the Bronze Age. Encke's position below the Gemini-Taurus ship is a second very strong independent dating condition, as Encke only once, on 9 July in 1060 BC, had appeared at this position between 2000-500 BC. The four visible planets Venus, Jupiter, Saturn and Mercury have been depicted as cup marks to the left of the third quarter half-moon, see Figure 6b-c.

5. THE REIGN OF PHARAOH THUTMOSIS III DATED BY THE APPEARANCE OF COMET ENCKE IN 1460 BC

Thutmosis III was the sixth Pharaoh of the Eighteenth Dynasty. When Thutmosis II died his son Thutmosis III was too young to rule and the deceased pharaoh's sister, Hatshepsut, became the new pharaoh. However, Thutmosis III became soon her co-regent, but with limited power. The rule of Hatshepsut was quite prosperous. When Thutmosis III reached a suitable age and had demonstrated his capability, she appointed him to lead her armies. During the first 22 years of Thutmosis' reign he was co-regent with his aunt, Hatshepsut. On the earliest surviving monuments, both were assigned the usual royal names and insignia and neither is given any obvious seniority over the other. When Hatshepsut died, Thutmosis III became the pharaoh of the Egyptian kingdom. After 17 campaigns he had created the largest empire Egypt ever had seen. He had conquered territories from Syria to Nubia.

Thutmosis III reigned from 1479 BC to 1425 BC according to the Low Chronology of Ancient Egypt. This has been the standard Egyptian chronology since the 1980s, although some scholars still use the older dates 1504 BC to 1450 BC according to the High Chronology of Egypt, Kitchen (1987). These dates, just as all the dates of the Eighteenth Dynasty, are open to dispute because of the uncertainty about the circumstances surrounding the recording of the Heliacal Rising of Sothis (Sirius) during the reign of Amenhotep I. A papyrus from Amenhotep I's reign records this astronomical observation, which, theoretically, could be used to perfectly correlate the Egyptian chronology with the modern calendar. However, to do this the latitude where the observation was made must be known. This document has no note of the place of the observation, but it can safely be assumed that it was made in either the Delta cities Memphis or Heliopolis, or in Thebes further south. The two latitudes give dates 25 years apart, the High and Low chronologies, respectively.

The end of Thutmosis III's reign is known to the day thanks to information found in the tomb of the court official Amenemheb because he recorded Thutmosis III's death to his master's 54th regnal year, on the thirtieth day of the third month of Peret.

However, a remarkable celestial phenomenon is mentioned on a stele at the temple of Amon in Gebel Barkal in Nubia, south of Egypt. The terrified Egyptians described it as "an arrow shooting against them from the south". The stele was according to the inscription written in the 47th year of rule of Pharaoh Thutmosis III, and the story about the remarkable celestial phenomenon ends the text, that has been partly damaged. The text was written as a "royal hymn" to glorify Thutmosis III, and mentions first his important victories at Megiddo, in year 33, and Mittani, in year 23. That the text also mentions a celestial phenomenon during his 47th year of rule, described, as "something similar has never been witnessed", means that it had a great significance for Thutmosis.

Different scholars have earlier discussed this celestial phenomenon. It has for instance been considered as a meteorite, but the verbs used suggest a slow evolution, according to Dr Patrik Wallin, at the Institute of Egyptology, at the University of Uppsala, who has studied the original text and made a linguistic analysis (Wallin 1996).

We and some other investigators have come to the conclusion that the text fits best as a description of a bright comet with an unusually long tail. Other scholars have earlier mentioned Comet Halley as the most likely candidate, but this hypothesis must now be abandoned, as no certain observations of Comet Halley are known before 240 BC.

During the second half of December 1461 BC and January 1460 BC the southern sky in Egypt was dominated by Comet Encke and on 28 January its magnitude was –6.3 with a very long tail. In my opinion the description on the stele at Gebel Barkal fits convincingly well for Comet Encke.

As pointed out above there exist two alternative chronologies for Thutmosis III, and the 47th years of rule dates the text to either 1458 or 1433 BC. However, it is only the appearance of Comet Encke in 1460 BC that fits with the description in the text and the fact that it has been mentioned among the most significant events during the rule of Tutmosis III indicates that it must have been a recent phenomenon that still was treated with great respect, Figure 7.

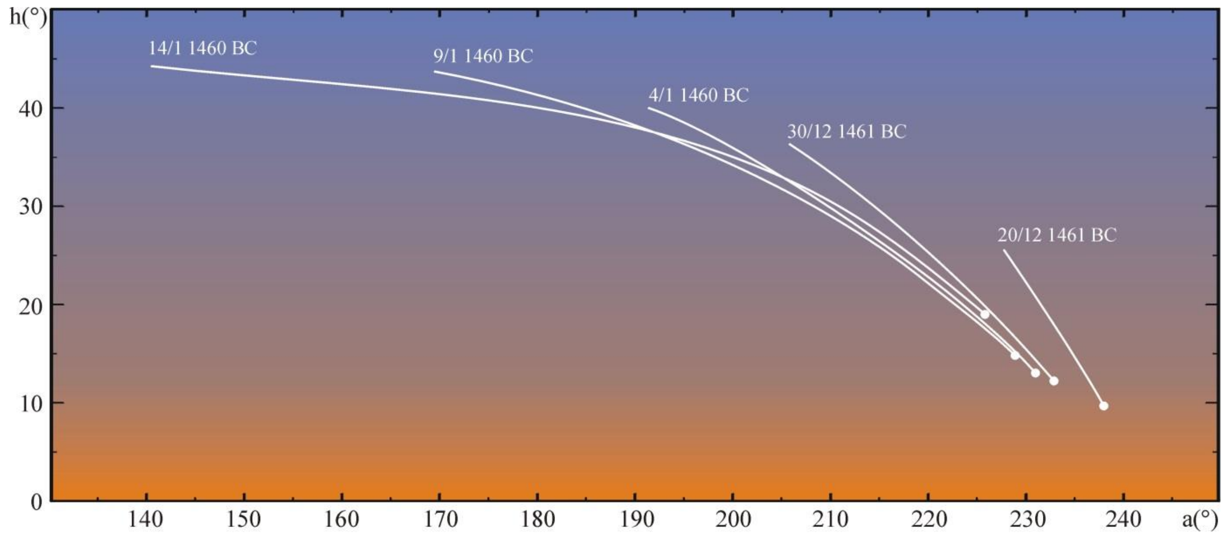

Figure 7. During the second half of December 1461 BC and January 1460 BC Comet Encke dominated the southern sky in Egypt. All the pictures of the comet are made for 18.00 local mean solar time in Gebel Barkal in Nubia, south of Egypt. The time shift ΔT was +7.0 days and this means that Encke had its perihelion passage on 20 December 1461 BC. At 18.00, the mean-anomaly was 0.12°, the distance to the sun 0.311 AU, and to the earth 1.029 AU and the magnitude was -5.40.

The comet moved northwards and appeared higher up in the sky for every night. On the last date in the figure, 14 January 1460 BC, its mean-anomaly was 7.57°, distance to the sun 0.709 AU, and to the earth 0.362 AU and the magnitude was -5.82. The length of the tail in the figure is 0.4 AU. Encke come closer to the earth for every night and on 28 January it reached its closest distance 0.215 AU. That evening Encke's mean-anomaly was 11.73° and the distance to the sun was 0.963 AU. The magnitude was -6.33, which means 9 times brighter than Venus at its maximum.

The most likely of the two chronologies is therefore the highest one with 1506 BC as the first year of rule of Thutmosis III, the sixth pharaoh of the Eighteenth Dynasty in Egypt.

This date of the rule of Thutmosis III is in good agreement with my earlier dating of the end of the Eighteenth Dynasty and the beginning of the Nineteenth, based on 8 solar eclipses. Both results supports the High Egyptian Chronology (Henriksson 2007). The Low Egyptian Chronology is based on an attempt to correlate with the Low Babylonian Chronology. However, after my identification of two well documented total solar eclipses in Babylon, it is clear that none of the three earlier suggested Babylonian chronologies are correct, (Henriksson 2005b).

The careful recent C14-datings by Manning et al. (2014) supports the High Egyptian Chronology.

6. COMET ENCKE ON SWEDISH ROCK CARVINGS ON 8 FEBRUARY 1460 BC

After the impressive appearance in the sky above Thutmosis III, during his 47th year of rule, Comet Encke moved to the north, and on 8 February 1460 BC it was depicted on the Swedish rock-carvings at Järrestad, parish of Järrestad, in the southern province of Scania, and at Lökeberget in the parish of Tanum, in the western province of Bohuslän. This part of Encke's orbit is very well defined from 8 passages 1662-1355 BC depicted on Swedish rock carvings. Three important celestial events were visible in southern Sweden in 1460 and 1407 BC. It began with the appearance of Comet Encke in the beginning of February 1460 BC. It was brightest on 28 January when it was mentioned in a text on a stele from the 47th year of Pharaoh Thutmosis III.

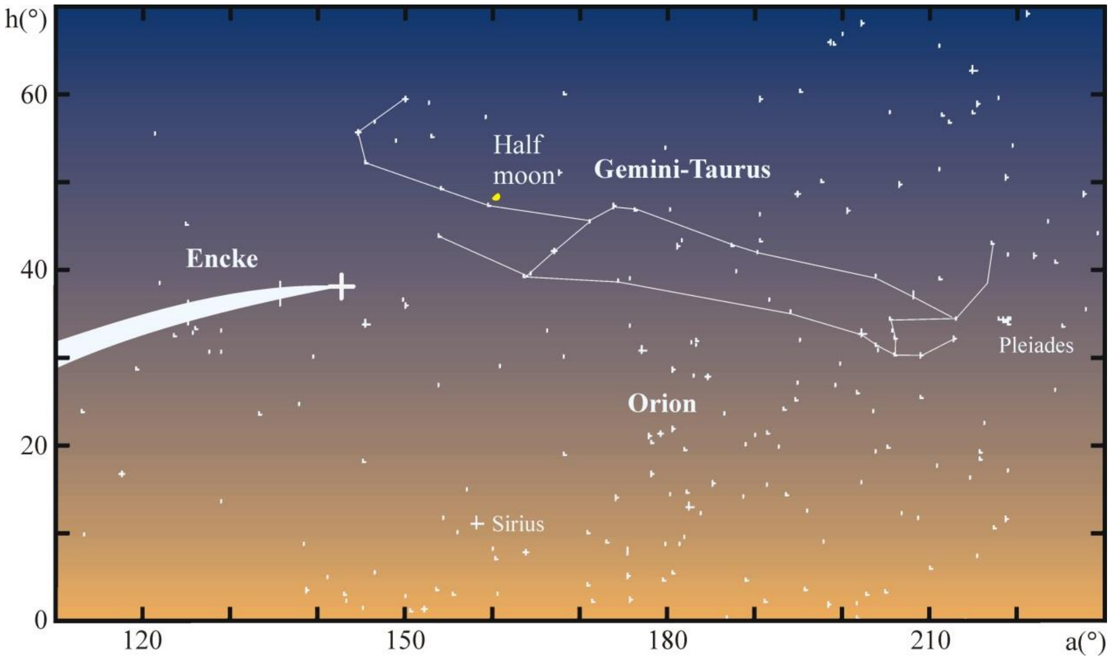

Figure 8a. The southern sky on 8 February in 1460 BC, at 17.30 local mean solar time at Lökeberget, in the parish of Tanum in the western Swedish province of Bohuslän. For ΔT= +7.0 days the mean-anomaly was 15.05°, distance to the sun 1.145 AU, distance to the earth 0.319 AU and magnitude -5.13. The assumed length of the tail is 0.4 AU, the phase of the moon 95.76°, the altitude of the sun -6.06° and stellar magnitudes < 4.5.

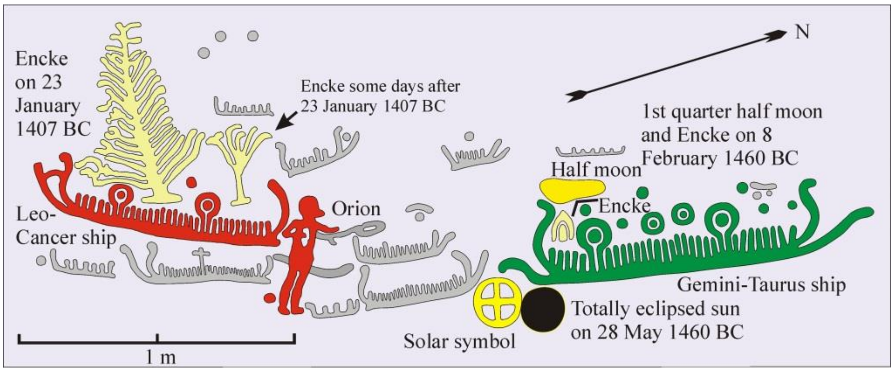

Figure 8b. Rock carvings at Lökeberget, in the parish of Tanum, in the province of Bohuslän. After Lauritz Baltzer (1881).

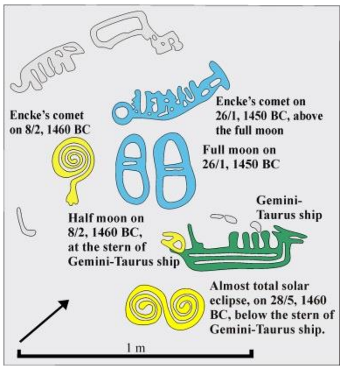

Figure 8c. Rock carving at Järrestad, in the province of Scania. (After Burenhult 1973).

When Comet Encke was depicted at Lökeberget on 8 February 1460 BC, it was visible behind the stern of the Gemini-Taurus ship on a night with the half-moon within the stern of this ship, Figure 8a-b. The symbol for the first quarter half-moon, a left foot, is here depicted horizontally above the stern, which means that it was not placed exactly on its observed position in the ship. The reason may be that the rock-carver did not immediately realize the importance of this event and decided to add Encke and the half-moon afterwards even if there was not free space enough at the stern of the existing Gemini-Taurus ship. It was made after the total solar eclipse almost four month later. A small image of Encke with its tail pointing downwards, a very unusual orientation, can be found below the half-moon. On a rock carving at Järrestad, parish of Järrestad and province of Scania, there exist another depiction from the same evening, with the tail of Encke pointing downwards, and the half-moon correctly depicted behind the stern of the Gemini-Taurus ship, Figure 8c. The most important celestial event during 1460 BC was the total solar eclipse on 28 May, correctly depicted below the stern of the Gemini-Taurus ship at Lökeberget and Järrestad, Figures 8b-c. For some reason the responsible rock-carver decided to re-use this beautifully made ship to record also the passage of Encke almost four months earlier, Figure 8a-b.

The almost identical carving technique indicates that the same rock carver may also have been active when Encke had an extremely close passage of the earth on 20 January in 1407 BC and some days later. Encke was visible in the middle of the Leo-Cancer ship and was depicted as a flying spruce, like a Christmas tree, above this ship about one metre behind the Gemini-Taurus ship, see the left part of Figure 8b. The top of the tree represents the position of the furthest end of Encke's tail, at a distance of 100 million km, and the root end corresponded to the nucleus of the comet that was as close as 12 million km from the earth on 21 January. The shape of the spruce with its wide low branches and narrow top has skilfully been used to illustrate this perspective effect.

The angle between the symmetry axis of the tree and the rail of the ship corresponds to the appearance of Encke in the evening of the 23 January in 1407 BC, see Figure 8b. The magnitude of the nucleus of Encke was -8.2 when it was closest to the earth. The brightest of the planets, Venus, has the maximum magnitude -4.

7. THE BRIGHTNESS OF ENCKE'S NUCLEUS

Comet Encke is expected to have been extremely bright during the Bronze Age. This hypothesis can be verified because at Högsbyn, parish of Tisselskog and province of Dalsland, there exist a rock carving with the nucleus of Encke depicted with the same symbol as Venus (Rex Svensson 1982), Figure 9. It was made on 21 November in 1355 BC, 5 days before Encke's perihelion passage. Venus' magnitud was -4.1 and the calculated magnitude of Encke's nucleus was -5.2. The calculated magnitude –5.2 for the nucleus of Encke must be increased by at least –0.7 and the corrected magnitude will be –5.9. It is now possible to get an estimation of the decrease of the mean magnitude of the nucleus of Encke as its maximum magnitude in 2000 AD is about 5.0.

We have the relation: (5.9+5.0)/33.55 magnitudes/century = 0.33 magnitudes/century.

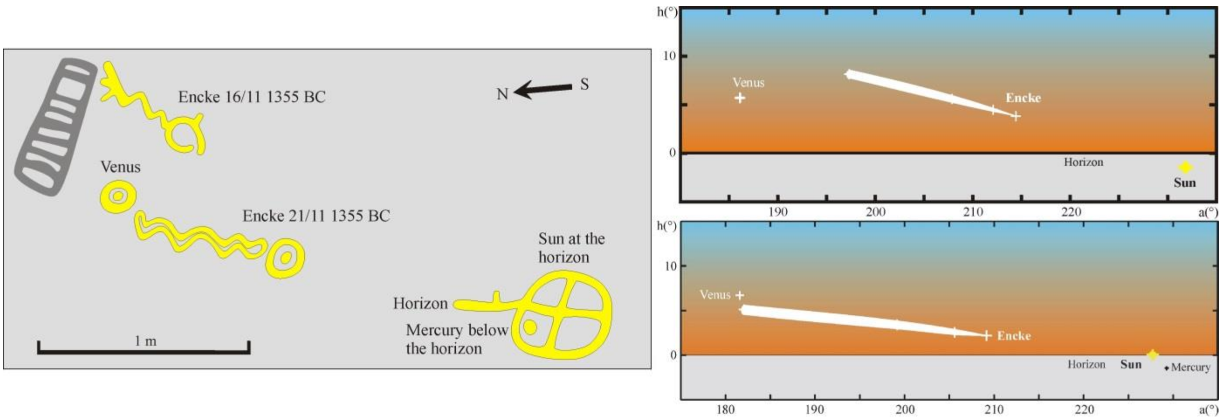

Figure 9. Left. Rock carvings at Högsbyn, province of Dalsland. The upper comet may be Comet Encke on 16/11 in 1355 BC, 10 days before its perihelion passage on 26/11. The lower comet may be a depiction of the last evening the nucleus of Encke was visible above the horison. The horisontal line to the left of the sun marks that it was at the horizon. The position of Mercury is below the horizon. After K. Rex Svensson 1982).

Upper right. Comet Encke on 16/11 in 1355 BC, at 15.40 local mean solar time at Högsbyn, 10 days before the perihelion passage. The time shift ΔT = -2.0 days gives the mean anomaly 357.27°, distance to the sun 0.403 and to the earth 1.199 AU. The length of the tail was 0.7 AU and the altitude of the sun= -0.96°.

Lower right: Comet Encke on 21/11 in 1355 BC, at 15.40 local mean solar time at Högsbyn, 5 days before the perihelion passage. The time shift ΔT = -2.0 days gives the mean anomaly 358.76°, distance to the sun 0.335 and to the earth 1.044 AU. The length of the tail was 0.7 AU and the calculated magnitude of the nucleus of Encke was -5.2.

The nucleus of Encke has been marked with the same symbol as Venus, with magnitude -4.1, but somewhat greater. The altitude of Venus and Encke was 6.4° and 2.1° respectively. After correction for atmospheric extinction, with extinction coefficient 0.15, the apparent magnitude became -2.8 for Venus and -2.1 for Encke. Even if Mercury was impossible to observe, it has been depicted almost correctly below the horizon close to the sun. The observers have seen Mercury as a morning star some weeks earlier and realized that it must be close to the sun that day.

8. REALISTIC DEPICTIONS OF COMET ENCKE

Most of the Swedish rock carvings are cut on rough rock surfaces and are sometimes difficult to see if they not are painted. However, at Järrestad, in the southern province of Scania, the rock carvings are cut in the very smooth and hard Cambrian quartzite and are very well preserved. In this case there is no need to use paint, Figure 10. The details in Encke's head and tail are carved with great care. This picture was made on 15 January in 1354 BC, 55 days after the depiction in Fig. 9, from 21 November in 1355 BC. Both depictions are so realistic that we can recognize the wave-like structure in the tail even if the distance between the rock carvings are more than 400 km.

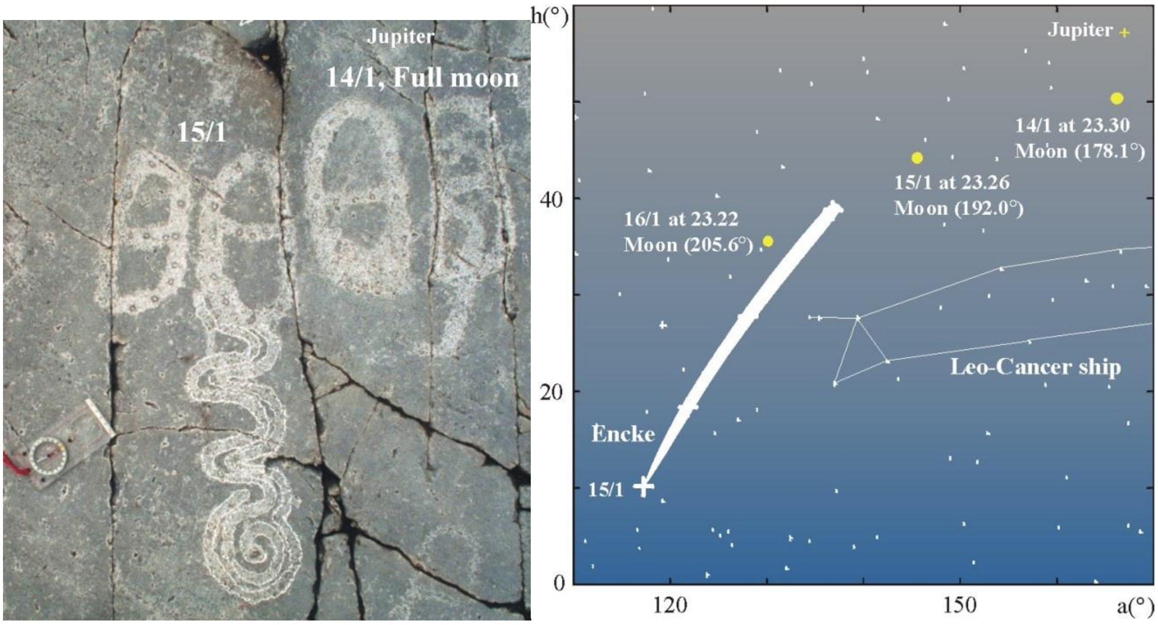

Figure 10. To the left: A photo of a rock carving at Järrestad, parish of Järrestad, province of Scania. It shows Comet Encke below the moon on 15/1 1354 BC, one day after full moon. The full moon to the right is symbolized as a normal pair of feet. However, above the very detailed depiction of Comet Encke we can see a strange pair of feet with a left foot the to the left of the right foot. (Photo by G. Henriksson)

To the right: The figure shows the tail of Comet Encke below the moon, on 15/1, 1354 BC, at 23.26 local mean solar time at Järrestad. This was the day after the full moon. Time shift ΔT = -2.0 days gives the mean anomaly 15.22°, distance to the sun 1.155 and to the earth 0.249 AU and the calculated magnitude of Encke's nucleus -5.7. The length of the tail corresponds to 0.7 AU as in Figure 9. Stellar magnitudes < 5.0.

9. DISCUSSION - CONCLUSION

We have dealt with Comet Encke identified in ancient chronicles and in Swedish rock art. Though the historical accounts are a valuable source of information with which modern scientific tools can validate or dispute, the rock art depictions are a risky area and any interpretations should be received with due caution. Indeed, a sound hermeneutical system, the normative nature of interpretation must be recognized and accounted for. The publications so far show that little hermeneutical restraint has been exercised in rock art research, and that the Rock Art discipline's credibility requires the expulsion of the arbitrary interpretations that have been created by it (Bednarik, 2013). Direct dating also of rock art is still not established and thus cautiously one should consider depictions (Liritzis et al., 2017; Bradley, 1997). We are aware of the need to balance the social and scientific aspects of rock art and archaeoastronomy is an extremely delicate matter, which, leads some (authors and journals) to unsounded, imaginable, uncontrolled speculation nurturing on fallacy. In the scientific orthodoxy archaeoastronomy is based on measurements, sound processing and integrity, and any "astronomical" interpretation should be cautiously made but arbitraries strictly removed (Liritzis et al., 2020, sect.5; Ruggles, 1999).

No improvements of the orbital element of Comet Encke have been necessary since November 1999. The original idea from 1994 that it was possible to determine a useful orbit of Comet Encke without non-gravitational forces included has after 25 years of testing been confirmed. A comparison has been made between orbital elements calculated with only gravitational forces and with gravitational forces combined with a Fourier approximation of the non-gravitational forces determined from observations 1758 BC – 1994 AD. When the orbital elements are plotted in the same diagram the curves cover each other completely. This means that we can calculate the orbital elements of Comet Encke without bothering about the non-gravitational forces. However, if we want to identify an ancient observation we must be able to determine the time-shift along the orbit.

Comet Encke is the greatest surviving remnant of the so called Great Taurid Comet that entered the inner parts of the solar system before 100.000 years BP. An impact in the Laurentide Ice Sheet by a major body from this comet complex is believed to have initiated the sudden cold period Younger Dryas about 12.900 BP or 10.900 BC (Napier 2010) and Jaye (2019). I have calculated Encke's orbit back to 32.000 BC and have found a strong correlation between the dating this climate event and the extremely low inclination of Encke's orbit, 3.5°, around 10.860 BC and its nodal crossing in 10.899 BC. This gives a very strong support for this hypothesis. The low orbital inclination to the ecliptic means that there was an increased risk for collisions between objects that moved along Encke's orbit and the planets Mercury, Venus, Earth and Mars.

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