VOLUME 23, FALL 2012

THE OSTRACON

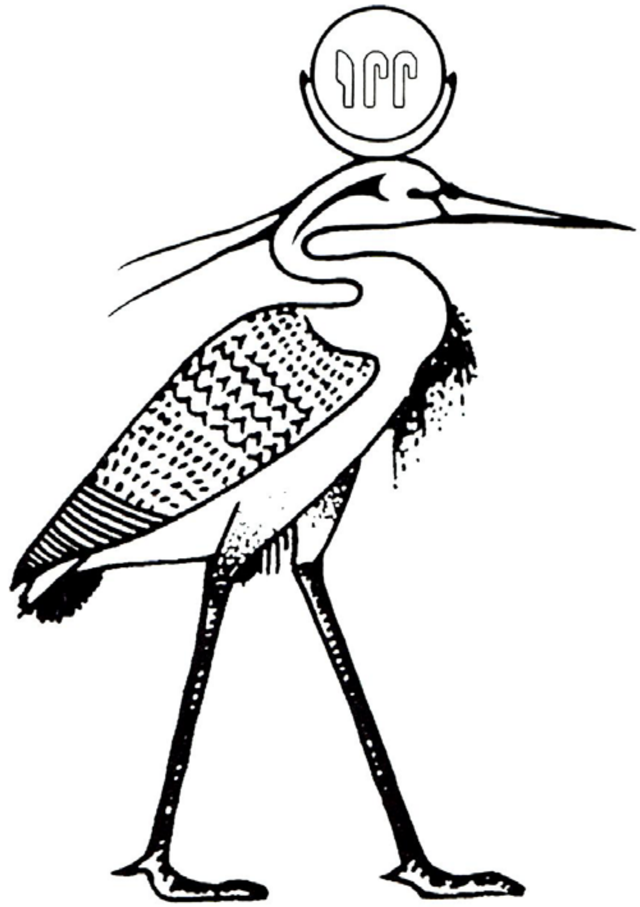
THE JOURNAL OF THE EGYPTIAN STUDY SOCIETY

The Ostracon is published annually by members of the Egyptian Study Society. The ESS is a non-profit organization whose purpose is to study ancient Egypt. It is an associate group of the Denver Museum of Nature and Science. Articles are contributed by members and scholars on a voluntary basis. Member participation is encouraged. Nothing may be reprinted in whole or part without written permission of the author.

The opinions expressed in *The Ostracon* do not necessarily represent the views of *The Ostracon* staff, the Egyptian Study Society, or the Denver Museum of Nature and Science.

Publication of The Ostracon *is supported by a grant from* THE PETTY FOUNDATION

Egyptian Study Society, Inc.
P.O. Box 40754
Denver, Colorado 80204-0754
UNITED STATES OF AMERICA



IN THIS ISSUE

CALL FOR ARTICLES

The Ostracon: The Journal of the Egyptian Study Society

Volume 24 (2013)

Submission deadline: March 1, 2013

The Egyptian Study Society announces a call for additional articles for the 2013 (Vol. 24) publication of *The Ostracon*. The publication is currently accepting more new articles, book reviews, reviews of significant lectures or exhibits, or interpretive articles that apply to the archaeology of Egypt for publication in late Fall 2013.

The Ostracon is published once a year by members of the Egyptian Study Society. The ESS is a non-profit organization whose purpose is to study ancient Egypt. It is an associate group of the Denver Museum of Nature and Science. Articles are contributed by members and scholars on a voluntary basis.

Submission guidelines are posted on the ESS website at www.EgyptStudy.org

Please submit inquiries and materials to:

Suzanne L. Moulton-Gertig, editor
E-mail: Ostracon@egyptstudy.org

For more information about the Egyptian Study Society, see www.EgyptStudy.org.

The Ostracon and the Egyptian Study Society thanks THE PETTY FOUNDATION for its generous and continuing grant support for the publication of *The Ostracon*.

The Tausert Temple Project: Report for the 2011 Season

By Pearce Paul Creasman

Fig. 1. Ground-penetrating radar survey at Queen Tausert's Theban temple.

As readers of this journal may recall, The University of Arizona Egyptian Expedition (UAEE), directed by Richard H. Wilkinson, has conducted an archaeological investigation of the 19th Dynasty Pharaoh-Queen Tausert's temple in Western Thebes since 2004.[1] Most of the UAEE's work focused on the temple proper, but the existence of several other structures adjacent to the temple was evident, also. Both the UAEE and William Flinders Petrie (who examined the site briefly in 1896[2]) recorded a variety of possible features, spanning some 500 years. Of particular interest is the likely existence of several tombs west of the temple from a later date (Late Period) underneath the embankment of a present-day road (Fig. 1).

In 1896, Petrie recorded the existence of several tombs from a later date outside the Tausert temple proper (Fig. 2, next page).[3] Yet, as Petrie focused on the Tausert components of the site, no complete investigation of these tombs was made. Furthering Petrie's observations, the 2008–2010 excavations at the western edge of the temple by the UAEE revealed direct archaeological evidence of three possible tombs.[4] Since these features were discovered late in UAEE's field season and their relationship to the temple was unclear, the UAEE was only able to reveal the entrance of one such feature partially (Fig. 3, next page), which was noted in an earlier volume of this journal.[5] Both the concern for the safety of the excavators and the fact that further disturbance of the embankment might endanger road stability contributed greatly to the decision to carry out a non-invasive survey of that area of interest, rather than an undertake an excavation at the time.

Consequently, a ground-penetrating radar survey was implemented in order to define the size and extent of any archaeological features present under the road embankment. Ultimately, the goal of the survey was to determine whether additional excavation between the road and the temple was warrant-ed and, if so, how to plan going forward with it. Permission to conduct the survey was granted kindly by the Supreme Council of Antiquities on 9 August 2011. The survey was conducted from 11-21 August 2011, and most of September and October 2011 were spent processing the data offsite.

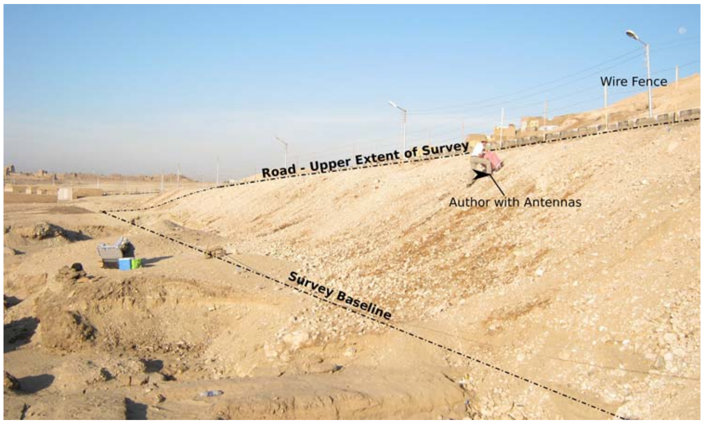


Fig. 2. A view of the road embankment looking south with survey area delineated.


Fig. 3. Mud brick foundation wall extending away from Tausert's temple (west), into the road embankment (from Wilkinson 2009, Fig. 7).

EVIDENCE

Near the base of the modern road embankment, the UAEE excavations at the northwest corner of Tausert's temple revealed a mud brick wall extending away from the temple that appears to represent the entrance area of a tomb (Fig. 3). Additionally, the UAEE uncovered indirect evidence of two possible additional tombs at the western edge of Tausert's temple complex (immediately south of the suspected tomb in Fig. 3). Large, similarly-sized mounds of rock chips above the strata of the temple are interpreted as the primary sign of tombs adjacent to the southwest and central-western parts of the temple, whereas multiple factors seem to indicate a tomb at the northernmost corner including: 1) the large volume of the rock chip mound and its location, 2) a mud brick wall with bricks that differ in size from those used in Tausert's temple, 3) location and direction of the mud brick wall construction (outside of and away from the temple) and, 4) Late Period date of various items of material culture scattered around the area in which the mud brick wall is located.[6] Here, the scattered remains of at least ten individuals, coffin fragments, and other objects from one or more burial assemblage/s provide further evidence of a possible tomb, its likely date, and of looting in antiquity. The area around the two southern rock chip mounds, however, yielded no indication of post-burial disturbance. For example, in a stratigraphic layer above the remains of the temple, the 2008 season found flakes from the nearby stone outcropping. When the edge of the first tomb came to light, we realized these flakes were the byproduct of tomb construction. If the southern chip mounds in fact indicate nearby tombs, there is a possibility that the tombs remain intact.

In order to establish the identity of these anthropogenic features, their purpose, and their condition, the decision was made to employ ground-penetrating radar (GPR) that could image the subsurface with high resolution. The topography of the site presents a physical challenge to both excavation and the use of GPR due to the modern road embankment which impedes upon the area of interest. This necessitated positioning the GPR grid and maneuvering the equipment along a very steep slope, which rose 5 meters above the excavation level and, in some locations, exceeded 30 degrees. Presumably, this embankment covers artifacts and features, as well as the original sedimentary formations seen below and around the temple compound.

METHODS

GPR uses echolocation to investigate the subsurface: features with contrasting electromagnetic properties that backscatter transmitted radar waves back to a recording receiver. With knowledge of the subsurface velocity (collected by on-site tests) and the total travel time to and from the contrasting target (recorded during data collection), the depth and shape of subsurface features can be imaged in three dimensions. On sites with significant variations in the topography (e.g., steep slopes or excavation pits, both of which are present at this site), however, it is necessary to use advanced mathematics and methods that are employed more commonly for geological and seismic analysis, but can be adapted to an archaeological setting. Essentially, a three-dimensional map of the existing surface is made by an extensive site survey and then used as a “baseline,” allowing interpretation of subsurface features from a “level” perspective. Therefore, the topography of the site was surveyed at a 2 m x 2 m sampling grid, using a stadia rod and survey level. These topographic data were then interpolated for each of the 3,438 transmitter and receiver locations (Fig. 4).

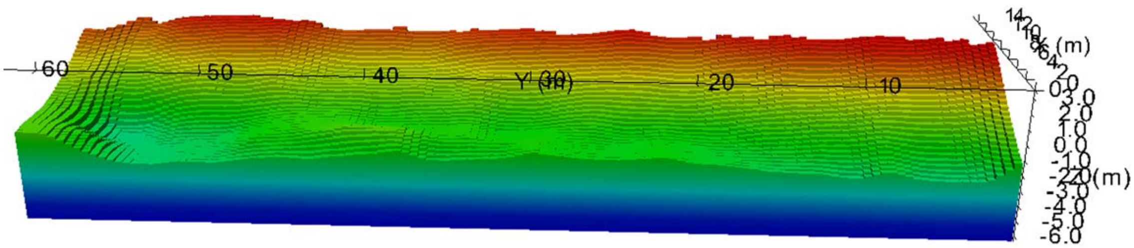


Fig. 4. Topographic model (“baseline”) used to assist the interpretation of subsurface imaging (D. Sassen).

Prior to imaging, irrelevant signals and other sources of interference were removed via filtering and muting in accordance with standard geophysical practices, and as necessitated by the uniqueness of the survey area. For example, strong interference from the metal fence posts along the road was deleted from the data when found/possible, but with the consequence of degrading the image resolution and potential for accurate interpretation near the road.

INTERPRETATION

The main features of the road embankment/survey area are, first, the unevenly textured upper layer interpreted as recent debris associated with the road, and, second, the low-amplitude, finely-structured lower layer interpreted as the consolidated sedimentary material seen in and around the temple site (Fig. 5). In the lower portions of the slope near the present-day limits of the archaeological excavation, several ancient features can be seen (Figs. 6-7, next page). At 3.9 meters below the reference elevation (1.5 meters below current excavation levels), two strongly-reflective rectangular

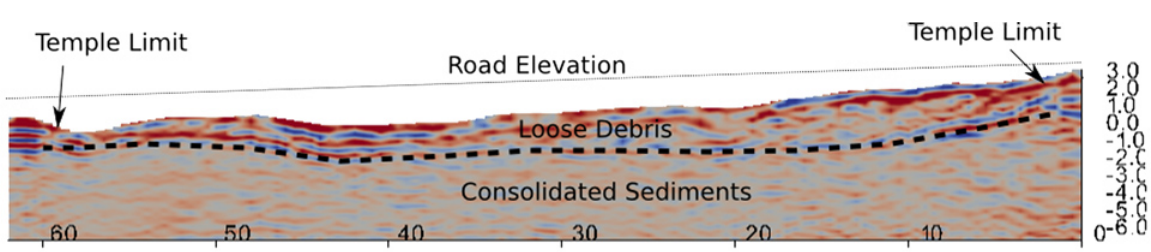


Fig. 5. Profile view of the interior of the road embankment, 10 meters from the baseline, looking toward the road from the temple (D. Sassen).

features appear (Fig. 6-A & 7-A). Most likely, these rectangular features are associated with tombs or the foundations of Tausert's temple. Both in cross section and in depth view, several other potentially anthropogenic structures can be seen close to the current extent of the archaeological excavation (Figs. 6 and 7 B-F). The subsurface area near the road is devoid of any obvious anthropogenic features, but high levels of interference have likely had an impact on it, including a buried active power line running parallel to the road.

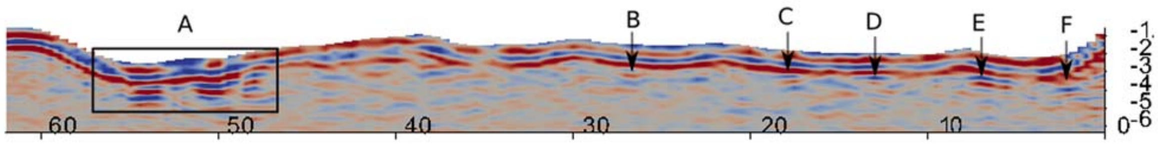


Fig. 6. Profile view of the interior of the road embankment 1 meter from the baseline looking toward the road from the temple. The rectangular components of a feature are seen in the box labeled A. Other potentially anthropogenic features are labeled B-F.

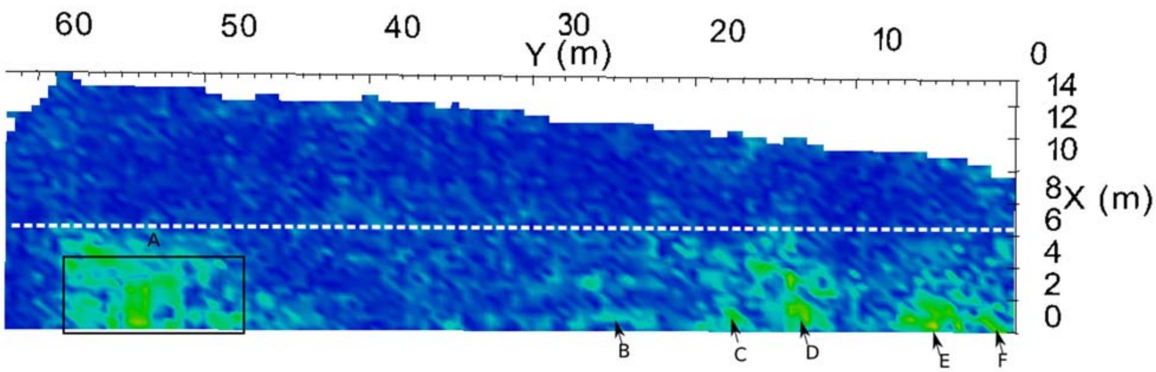


Fig. 7. A depth slice at -3.5 meters. The rectangular features are seen in A. Other high-amplitude features include B through F. (D. Sassen).

LIMITATIONS AND SUGGESTIONS FOR FUTURE INVESTIGATIONS

The interpretation of the GPR data in this case is limited to resolving features of sufficient size and contrast in order to separate them from the background material. With decreasing size, features of less than the dominate wavelength of the signal (~1 meter) become increasingly difficult to differentiate from the background. Additionally, differentiating structural features from modern or ancient debris (evident on the surface of the survey area) becomes difficult if the electromagnetic properties of the materials used in construction of archaeological features are similar to those of the background materials and debris (e.g. mud brick). This occurs, for example, if prior excavation, looting, or construction activities have disturbed the structures in such a way that building material has become mixed with surrounding debris. Accumulation of small errors in data acquisition and image processing complicate these limits further. Therefore, features B though F (Figs. 6 & 7) should be considered only potential targets for further examination. Other features lacking the size or contrast to be seen with the GPR may exist within the road embankment and could be revealed by subsequent excavation, also.

NOTES

1. This work would not have been possible without the kind permission of the Supreme Council of Antiquities; support from the members of the SCA Permanent Committee; Dr. Mohamed Ismael, SCA Director of Foreign Missions, for his kind and continued help in arranging our work in

Egypt; Mansour Boraik, Director of Upper Egypt; Mustafa El-Waziry, Director of West Bank Antiquities; Mohamed Hamdan, Director of the West Bank Missions Office; American Research Center in Egypt, especially Mme Amira Khattab; SCA Inspector Mohamed el Azab; Reis Ali Farouk Sayed El-Quftawi; Reis Omar Farourk Sayed El-Quftawi; Laboratory of Tree-Ring Research and the University of Arizona for support; the Institute of Maritime Research and Discovery for support; and particularly Dr. Mark Everett and Dr. Rick Giardino of the Department of Geology and Geophysics, Texas A&M University.

The author served as field director for the field season. Douglass Sassen, a geophysicist from Lawrence Berkeley National Laboratory, also joined the expedition and contributed significantly to data collection, interpretation, and the text provided in this manuscript. Damian Greenwell was present for the first part of the season and helped familiarize us with the site and local team members.

2. William M. F. Petrie, *Six Temples at Thebes 1896* (London: Bernard Quaritch, 1897), 18.
3. Petrie, *Six Temples*, 1897, 18.
4. Richard H. Wilkinson, "The Tausert Temple Project: The 2008 Season," *The Ostracon: The Journal of the Egyptian Study Society* 19 (2008): 5; Richard H. Wilkinson, "The Tausert Temple Project: The 2009 Season," *The Ostracon: The Journal of the Egyptian Study Society* 20 (2009):6-9; Richard H. Wilkinson, "Six Seasons at Thebes: The University of Arizona Tausert Temple Project," in *Thebes and Beyond: Studies in Honor of Kent R. Weeks*, ed. by Zahi Hawass and Salima Ikram (Cairo: Supreme Council of Antiquities, 2011), 221-22.
5. Richard H. Wilkinson, "The Tausert Temple Project: The 2008 Season," *The Ostracon: The Journal of the Egyptian Study Society* 19 (2008).
6. Further information about these components and sources of evidence can be found in the forthcoming book *The Temple of Tausret: The University of Arizona Egyptian Expedition Excavations, 2004-2011*, edited by Richard H. Wilkinson, The University of Arizona Egyptian Expedition, Tucson, AZ. Additionally, a more detailed description and analysis of the GPR survey can be found in the above volume: "Chapter 10: Remote Sensing," co-authored by Pearce Paul Creasman and Douglas Sassen.

About the author

Dr. Pearce Paul Creasman
Curator of Collections & Assistant Research Professor of Dendrochronology
Laboratory of Tree-Ring Research
University of Arizona

Pearce Paul Creasman has directed research in Egypt and the Mediterranean for approximately a decade, with a focus on ancient Egyptian ships and maritime life. He completed his doctoral studies in the Nautical Archaeology Program at Texas A&M University and is the President and Founder of the Institute of Maritime Research and Discovery, Ltd., a non-profit scientific and educational research organization. He also serves as Associate Editor of the quarterly peer-reviewed publication Journal of Ancient Egyptian Interconnections *and Field Director for the University of Arizona Egyptian Expedition. Pearce Paul's research interests include the interpretation of ship timber to understand human/environment interactions, maritime archaeology, dendrochronology, and Egyptian archaeology.*

Problem No. 48 of the Rhind Mathematical Papyrus

By George M. Hollenback

Problem no. 48 of the Rhind Mathematical Papyrus consists of the simple operations of multiplying 9 *sṯ3t* (a land area measure equal to a square of 100 cubits on a side) by 9 to obtain 81 *sṯ3t* and multiplying 8 *sṯ3t* by 8 to obtain 64 *sṯ3t*. Accompanying these purely numerical tallies is a drawing of a square in which is inscribed some poorly-drawn figure and the numeral 9 seen in Fig. 1.[1] Although there is a consensus among interpreters that what is depicted is a square with a side of 9 and an area of 81 inscribed with some other figure that has an area of 64, there is disagreement over the exact identification of the other figure. Earlier interpreters such as Eisenlohr, Peet, and Chase took the inscribed figure as a circle.[2] That interpretation was based on problem no. 50, in which a circle with a diameter of 9—equal to the side of the square in problem no. 48—was found to have an area of 64; the method was to take 8/9 of the circle's diameter of 9 to obtain 8 and then to square 8 to obtain the area of 64.

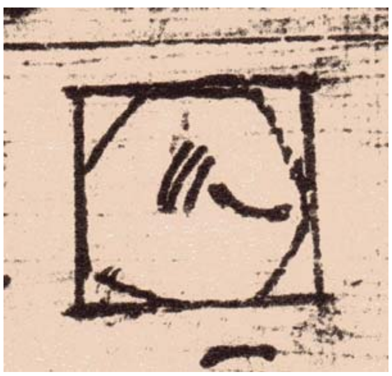


Fig. 1. Enlargement of the figure illustrated in problem no. 48.

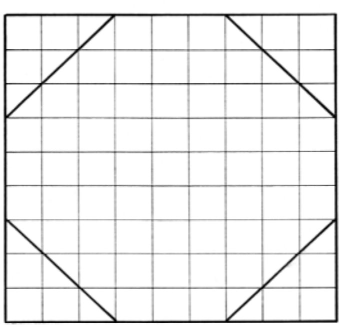


Fig. 2. Interpretation of the figure according to Vogel and Gillings. Illustration by author.

Followed by Gillings, Vogel interpreted the figure later as an octagonal approximation of a circle.[3] Cutting 3 x 3 right triangles from the corners of a 9 x 9 square leaves a semi-regular octagon with an area of 63 as seen in Fig. 2, closely approximating the circle area of 64. Note that the pairs of corners can be joined together to form two 3 x 3 squares each having an area of 9. Subtracting the sum of those squares from the area of the large square leaves the area of the octagon.

More recently, Guillemot interpreted the figure as a keystone-shaped octagon formed by cutting 3 x 3 right triangles from one pair of opposite corners and 2 x 4 right triangles from the other pair of opposite corners, as seen in Fig. 3 (next page).[4] What commends this interpretation particularly is that it resembles the actual figure most closely and has an area of exactly 64. The lopsided keystone shape of the figure, however, would appear to be a poor choice for a polygonal approximation of a circle.

Of particular interest in the actual sketch on the papyrus is the double line on its top side. It appears as if the scribe began drawing a line down and to the right at a shallow angle from the top of the square and then changed his mind and abruptly

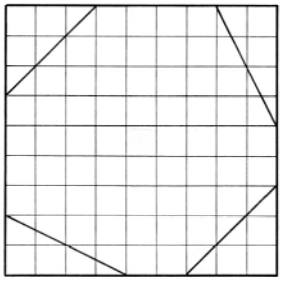


Fig. 3. Interpretation of the figure according to Guillemot. Illustration by author.

angled the line down more steeply. This suggests that the scribe may have been having trouble copying the figure and that the figure may not have been accurately transmitted.

A slight emendation to Guillemot's reconstruction, however, may restore the intended shape of the figure and reveal its heuristic purpose. The emendation consists of redrawing the line cutting the 2 x 4 right triangle from the upper right corner of the square so that the long side of the triangle lies in the top of the square and the short side lies in the right side of the square shown in Fig. 4. Thus redrawn, the 2 x 4 right triangle cut from the upper right of the square can be joined to the 2 x 4 right triangle cut from the lower left of the square to form a 2 x4 rectangle with an area of 8; the configuration of the triangle cut from the upper right corner of Fig. 3 *cannot* be so joined to its opposite to form such a rectangle. The redrawing of the upper right triangle according to Fig. 4 restores the symmetry of the polygonal approximation of a circle to the figure, also, which is something that was lost in Guillemot's keystone-shaped reconstruction.

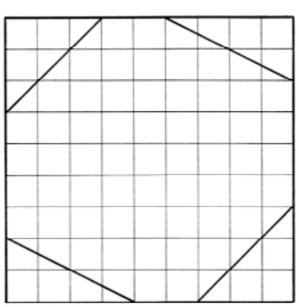


Fig. 4. New interpretation of the figure. Illustration by author.

Of particular interest is the fact that the areas of the 3 x 3 square (= 9) and the 2 x 4 rectangle (= 8) assembled from the triangular corners cut from the original square correspond to the size of the *sṯꜣt* plots multiplied in the problem to obtain the areas of the original square and its inscribed figure: Multiplying the square plot of 9 *sṯꜣt* by 9 gives a total of 81 *sṯꜣt*, and multiplying the rectangular plot of 8 *sṯꜣt* by 8 gives a total of 64 *sṯꜣt*. Fig. 5 (next page) illustrates graphically how 9 square plots of 9 *sṯꜣt* each can be assembled into a square with an area of 81 *sṯꜣt*, and how 8 rectangular plots of 8 *sṯꜣt* each can be assembled into a square with an area of 64 *sṯꜣt*.

In summary, the problem was most likely meant to illustrate a polygonal approximation of a circle with an area of 64 inscribed within a square with an area of 81 in such a way that the curved shape of a circle may be visualized instead in a form whose area can readily be understood in the context of non-curved figures such as triangles, squares, and rectangles. Moreover, the triangles cut from the corners of the square to produce the peculiar octagonal approximation of a circle possess the unique property of being able to be used to reconstitute both the original square with an area of 81 and a second square with an area of 64, equal to the area of the inscribed figure. The mathematical significance of problem no. 48 is that Middle Egyptian mathematicians recognized a constant circle-to-square area ratio—64/81—that which was obtained between a square and its inscribed circle. Because the side of the square in which the circle is inscribed is equal to the diameter

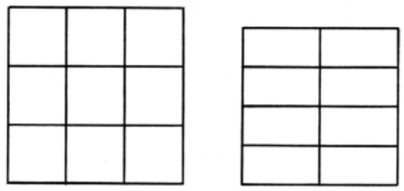


Fig. 5. Nine 3 x 3 squares assembled into a larger square with an area of 81 alongside eight 2 x 4 rectangles assembled into a smaller square with an area of 64. Illustration by author.

of the circle, the given diameter of a circle can be operated upon in such a way as to yield a circle area equal to 64/81 of the squared diameter: Squaring 8/9 of the diameter—the method employed in problem no. 50—yields the same result as taking 64/81 of the squared diameter.

NOTES

1. Fig. 1 is enlarged from photograph xix in Chace 1929.
2. Eisenlohr 1877, 117; Peet 1923, 88-89; Chace 1927, 91.
3. Vogel 1958, 66; Gillings 1972, 140-145.
4. Guillemot 1992, 137-139.

REFERENCES

Chace, Arnold Buffum et al. 1927. *The Rhind Mathematical Papyrus: British Museum 10057 and 10058. Volume 1: Free Translation and Commentary*. Oberlin, Ohio: Mathematical Association of America.

________. 1929. *The Rhind Mathematical Papyrus: British Museum 10057 and 10058. Volume 2: Photographs, Transcription, Transliteration, Literal Translation*. Oberlin, Ohio: Mathematical Association of America.

Eisenlohr, August. 1877. *Ein mathematisches Handbuch des alten Ägypter (Papyrus Rhind des British Museum) übersetzt und erklärt. Erster Band: Commentar*. Leipzig: J. C. Hinrichs.

Gillings, Richard J. 1972. *Mathematics in the Time of the Pharaohs*. Cambridge, MA: MIT Press.

Guillemot, Michel. 1992. "A propos de la 'géométrie égyptienne des figures." *Sciences et Techniques en Perspective* 21:125-146.

Peet, T. Eric. 1923. *The Rhind Mathematical Papyrus: British Museum 10057 and 10058. Introduction, Transcription, Translation and Commentary*. London: Hodder &Stoughton Limited.

Vogel, Kurt. 1958. *Vorgriechische Mathematik. Teil I: Vorgeschichte und Ägypten*. Hannover: Hermann Schroedel.

About the author

George M. Hollenback has a B.A. with a double major in Greek and religion from Baylor University, his interest in Egyptian mathematics stemming from his earlier studies in biblical metrology. He is the author of several published articles on ancient metrology and mathematics. This is his second article for The Ostracon.

Year Counts in the Egyptian Calendar

By James Lowdermilk

The ancient Egyptians used a calendar that counted 365 days every calendar year. Surviving evidence suggests that the count of 365 days was never altered.[1] The creators of the calendar started the count at some unidentified time in the distant past. The principle objective of this article is to offer a possible date for this commencement.

Among other things, the Egyptian calendar was used to mark the Feast of the Sothic Rise. The calendar date of this festival was presumably moved forward one day every fourth calendar year to compensate for the Egyptian calendar's want of leap year adjustments, like those created for the Canopic, Julian, Alexandrian, and modern Gregorian calendars. In the following paragraphs, alignments will be established between the Egyptian calendar and the Canopic, Julian, and Alexandrian calendars, all of which were used in Alexandria, Egypt.

For purposes of the discussion, certain assumptions are made:

1. Regulating the date of the Feast of the Sothic Rise moved this festival one day on the Egyptian calendar every fourth year *without adjustment* throughout the calendar's use.

   Due to lack of evidence, it is unknown whether the four year movement of the festival date was ever altered. The Gregorian calendar was designed to follow the cycle of the seasons making it necessary to skip four year adjustments almost every century. The Canopic, Julian and Alexandrian calendars were designed to remain unaltered from their four year cycle of leap years, as is the modern proleptic Julian calendar.[2]

2. The first day of the introductory 365-day year began with an appearance of the star Sirius/Sothis that the feast celebrated later.

   The movement of the Feast of the Sothic Rise allowed Sirius to wander slowly across each of the Egyptian calendar's 365 days. The cycle of the feast's date through a complete 365-day calendar year has 1460 feasts celebrated in 1461 Egyptian calendar years under assumption 1 above. (See Fig. 1). This has attained a formal name called the Sothic Cycle. These cycles can be counted into the past where, at some point, they predate the initiation of the 365-day Egyptian calendar. That point is the day someone began accounting for the 365-day calendar.

Fig. 1. Sothic Rise Feasts and Egyptian Calendar Years. Graph illustration by author.

Since it is unknown if months were named when the 365-day Egyptian calendar was inaugurated, the first day of the new 365-day calendar will be called *Calendar day one*, Cd(1). The first day of each Egyptian calendar year shall be called *Calendar year day one*, Cyd(1). The following formula is offered: Cyd(1) = Cd(365*n+1) where "n" is the number of completed Egyptian calendar years from Cd(1).[3] The question arises: did the Egyptians retain knowledge of "n"?

A count of years kept by the ancient Egyptians could reveal *Calendar day one*, but such a count is elusive. If a count of years were kept from the beginning of the 365-day calendar, the Egyptians might have based the timing of their actions upon this count, which was something akin to the perceptions surrounding the millennium celebrations when the Common Era counted the year 2000 in the Gregorian calendar. Specifically, such a millennium count might influence the creation of new calendars based on the old.

From the paragraph above, a theory could be posited that a count of the Egyptian calendar years was the arcane province of some segment of the Egyptian priesthood throughout the Egyptian calendar's use. It follows that a count kept from the pre-dynastic Sothic date of July 20, 4243 BCE aligns the Egyptian calendar to the Julian, Alexandrian, and Canopic calendars used in Late Period Alexandria, Egypt. In addition, the following paragraphs consider how such a count was maintained without the use of the written word in order to survive such a long period from a distant pre-dynastic date.

ALIGNMENT TO TEXT

Roman author Censorinus referred to the Sothic Rise occurring on *Calendar year day one*, Cyd(1) in the year 139 CE. In *The Birthday Book*, he said, ". . . it was on 20 July, the very day on which Sirius the Dog Star usually rises."[4] In a 2003 article, Patrick O'Mara suggests that Censorinus may have acquired a Julian/Egyptian calendar conversion table from the Egyptian community in Rome with some information "secured from a priest of Isis, whose cult had been established in Rome for centuries."[5] Under debate is whether this cult regulated this feast based on observation or on a regular movement of the Egyptian calendar. Certainly such a cult would not celebrate its festival based on an observation made in Rome. It would celebrate it according to some agreed upon date that was the custom in Egypt. This would have the Feast of the Sothic Rise align with Cyd(1) in the years 136 – 139 CE, 1325 – 1322 BCE, 2785 – 2782 BCE, 4245 – 4242 BCE and further multiples of Sothic cycles, Cd(1461*k*365+1), on July 20th of the proleptic Julian calendar.

Alignment of the Egyptian calendar to these dates is in keeping with fixed dates found in Ptolemy's astronomical manual *Almagest*, the *Babylonian Diaries*, and his Egyptian texts.[6] All fixed reference dates come from the Late Period or even later.[7] The earliest mention of the Egyptian calendar is during the Fifth Dynasty reign of Shepsekaf.[8] A possible reference to Sothis associated with the beginning of a year appears on a tablet from the First Dynasty reign of Djer, but remains debatable.[9] The extant Egyptian texts mention only the year of a pharaoh's reign and never state a running count. The survival of papyrus texts fragments, however, does not rule out the possibility that such a count was somehow maintained.

MANETHO

A running count of Egyptian calendar years kept by Egyptian priests from the start of the calendar may have been referred to in Manetho's *Book of Sothis*, which is known mainly through transmission by Byzantine chronicler Georges Syncellus. Manetho states, "Now, among the Egyptians there is current an old chronography."[10] As he does many times, Syncellus claims that this assertion led Manetho astray. Manetho continues, "Hephaestus has no period assigned, because he shines night and day. Helios, son of Hephaestus, ruled for 30,000 years. Then Chronos (it says) and the remaining gods, 12 in number, reigned altogether for 3,984 years."[11] In Greek, *Chronos* means time. The "reign of Chronos" could mean the length of measured time, as in the 12-month Egyptian calendar.

A count of 3,984 Egyptian calendar years from 4245 – 4242 BCE would come to 264 – 261 BCE. This is during the reign of Ptolemy Philadelphus (281 – 246 BCE) under whom Manetho served. Manetho's quote could be a reference to an accurate count being kept by the Egyptian priests.[12] When citing imprecise and seemingly exaggerated periods of time, Herodotus states, "The Egyptians claim that they know these matters absolutely because they are continually making their calculations and continually writing down the number of the years."[13] If Manetho's count is accurate, the earliest starting dates (around 4245 – 4242 BCE) that were proposed independently first by George St. Clair[14] and then by Eduard Meyer[15] near the turn of the nineteenth century, but later disputed, need to be re-evaluated.

CANOPIC DECREE

The Canopic Decree was an attempt to reform the Egyptian calendar by adding one day every fourth year to create a new calendar meant to be synchronous with the rising of Sirius. It was enacted by Ptolemy III Euergetes on July 19, 238 BCE to keep the Sothic Rise consistently on the first day of the tenth month (Payni). In so doing, various " feast days shall be celebrated in definite seasons for them to keep for ever, and after the plan of the heaven established on this day and that the case shall not occur, that all the Egyptian festivals, now celebrated in winter, shall not be celebrated some time or other in summer, on account of the procession of the rising of the Divine Sothis by one day in the course of 4 years, and other festivals celebrated in the summer, in this country, shall not be celebrated in winter, as has occasionally occurred in past times."[16]

A count of 4000 Egyptian calendar years would align the Feast of the Sothic Rise on the first day of the tenth month (1 – X). This would occur in the years 247 – 244 BCE, if the count were kept from July 20, 4245 – 4242 BCE dates. Once again, with the Canopic Decree enacted on July 19, 238 BCE, this is six to nine years and one day off from what would have been a great millennial event had the count been kept from this quadrennium. The 4000th Egyptian calendar year would have marked the 1000th movement of the Feast of the Sothic Rise; the Canopic Decree would have discontinued this adjustment on what could have been the 1001st or 1002nd movement.

Initially, the Canopic Decree had the full backing of the Egyptian priesthood, but apparently received support for less than a century.[17] It states, "a general feast in Egypt is celebrated yearly in its time so shall similarly be prepared a great festival in its time to King Ptolemaios . . . on the day of the rising of the Divine Sothis."[18] This establishes clearly that the new festival is separate from the feast celebrated by the Egyptians. The festival of the Ptolemaic king may have been postponed for political reasons and, subsequently, unsupported by the priesthood of Egypt. In addition, a postponement could explain the July 19th date.

The July 20, 4243 BCE date for Cd(1)[19] could provide an explanation for a postponement. This start date would have the 4000th Feast of the Sothic Rise celebrated on 1 – X in 245 BCE. Ptolemy II Philadelphus would die just six months later. The decree states that the priests of Egypt came together "when His Majesty assumed the dignity from his father."[20] The imminent death of Ptolemy II could have caused a delay in implementing the suggested calendar reform. The decree was enacted seven years later, so the feast moved to the second day of the tenth month (2 – X).

The Greeks would have wanted their new calendar to begin on the first day of the Egyptian month with the same name (Payni) and call that the Rising of the Divine Sothis. By 238 BCE, that date would correspond to July 19th, one day removed from the Egyptian feast. If the reform were delayed one more year, the Feast of the Sothic Rise would have moved to 3 – X, and the first of the month would fall on July 18th. This may have motivated them to enact the decree without delay, or miss the opportunity. It could, moreover, explain why the new calendar was eventually unsupported.

JULIAN CALENDAR

According to Pliny the Elder, the Julian calendar was created, by Sosigenes of Alexandria, an Egyptian astronomer and priest. The new calendar was enacted on January 1, 45 BCE. This date corresponds to the last day of the fourth month of the Egyptian calendar. The first day of the Julian calendar began with the last day of the season of *akhet*.[21] The previous year of the Roman calendar was adjusted grossly to have 455 days, making the starting day of the Julian calendar a deliberate marker.[22]

A count of years from the 4245 – 4242 BCE dates would count 4199 – 4202 Egyptian calendar years to the start of the Julian calendar. If the count were kept from July 20, 4243 BCE, then the count of years would have been 4200. Note that January 1 comes before the July 20th date of the Sothic Rise feast and 4200 is divisible by four, so the feast date would move that year. This would cause January 1 of the following year to align with the first day of the planting season of *peret*. The implication would be that a new calendar was "planted." Additionally, the first years of the Julian calendar would correspond to the years 4201, 4202, 4203 . . . in the counted Egyptian calendar.[23] This appears to be more intentional than random.

ALEXANDRIAN REFORM

The Roman Emperor Augustus ordered the Egyptian calendar to be reformed with the addition of an extra day every fourth year beginning on August 29, 25 BCE[24] which was Cyd(1) of that year. This was forty days after the July 20th Feast of the Sothic Rise. This feast would have been celebrated in the 4220 Egyptian calendar year as counted from 4243 BCE. This year would correspond again to a movement of the feast and the Alexandrian year would always begin forty days after the feast with corresponding leap years.

The Alexandrian reform was created for the Roman emperor and was maintained initially for Roman purposes. This reform was later utilized by the Coptic Church. The Egyptian 365-day calendar was not abandoned for this or other reforms as it was in use clearly in parallel fashion to these foreign calendar systems that were based upon its 365-day design. All three dates for calendar reforms: the suggested Canopic reform, the Julian reform, and the Alexandrian reform correspond to years when the Sothic Rise moved if counted from the 4243 BCE date.

NABTA PLAYA

Without a doubt, the 4243 BCE proposed start date for the Egyptian 365-day calendar is much earlier than the approximately 3000 BCE date for the unification of Egypt and the first dynasty. Writing was in use by the first dynasty, but not as early as the suggested date for *Calendar day one*. The hieroglyphic symbol for the number "one million" is found on the Narmer mace head, which dates to around 3000 BCE. The ability to count the multitudes of sheep and cattle mentioned on the mace head proves the capacity to count repeatedly to 365 or even a few thousand. Numerical representation in the form of notched sticks, knotted rope, or piled pebbles are a much lower standard than the written word. For this reason, no further consideration will be given to Nabta cattle herders' level of sophistication in accounting. The facility to maintain the count over the years will be discussed subsequently.

The possibility does exist that the count of Egyptian calendar years could have been retro-calculated for their calendar back to this early date. The time period does, however, correspond to the site of Nabta Playa in southern Egypt where stones were placed with astronomical alignments. These alignments point to the location on the horizon where Sirius and other stars appeared. Note that a star's rising point will move over the centuries due to equinoctial precession. While agreeing on the exact location of the stones, excavators of Nabta Playa and subsequent analysis by researchers of the site via satellite disagree on which stars were observed and what specific dates those observations took place. They both agree that Sirius was observed, however. In a 2008 publication, the Nabta Playa excavators suggest observations were made around 4600 BCE to 4300 BCE.[25] The satellite-based analysis by Brophy puts forth an alignment to Sirius as early as 6100 BCE (which is disputed by Malville) and three other alignments to Sirius dating to 4500, 4000, and 3500 BCE[26] These dates all correspond with the proposed July 20, 4243 BCE date when the Sothic Rise could have started the calendar.

PLANETARY ALIGNMENTS

Astronomy software[27] shows that on July 20, 4243 BCE the planets Venus and Mercury were near their greatest elongations, subsequently placing them at their zenith above the horizon in the morning sky. When viewed from the location of Nabta Playa, these planets create the shape of a huge triangle with the newly rising Sirius.[28] Aside from the moon, these three brightest objects in the morning sky may have been memorialized in the story of the "benben" triangle that appeared in the creation myths of the Pyramid Texts.[29] The event chosen to begin the 365-day calendar could have been this triangular conjunction of Mercury, Venus, and Sirius. The first possible appearance of Sirius that year, the literal day of the Sothic Rise, would have come days earlier when the star moved ahead of the morning twilight when it was not bright enough to create the effect of seeing a triangle rise into the morning sky to be consumed only by the sunrise. The 365-day calendar may not have commenced with the actual first sighting of Sirius, but with a future visible and dramatic event to enhance the spectacle.

The choice of beginning a 365-day calendar with an alignment of Venus and Mercury has its merits, as well. Venus returns to the same visible location in the sky every eighth year with small error. Mercury returns every twentieth year with larger error. With the use of a 365-day calendar year, both errors are diminished. This is sufficient for both to return every fortieth Egyptian calendar year with small error.[30] As the error accumulates through the years, the location of each subsequent observance will stray slowly from the initial observation. Beginning with the 4243 BCE alignment of Venus and Mercury, the two planets appeared in the sky together, although they strayed from greatest elongation on Cyd(1) every fortieth calendar year for a thousand years.

The 365-day calendar was broken into weeks of ten days each. The twelve months were divided into thirty-six weeks with an additional short week of five days called the *epagomeni*. If the celebration of the Sothic Rise moved one day every fourth year, then it required forty years for the feast to move through one week. Therefore, on the years when both Venus and Mercury were visible on Cyd(1), the feast day moved into a new week. Adopting this method would aid a pre-literate society greatly in maintaining a regular calendar of this design and explain the choice of 10-day weeks. The cycles would provide a check to the four-year movement. If an error in counting occurred, the planets would return in a year without a proper feast date movement and indicate the error.

Furthermore, as error accumulates, separating one alignment of Venus and Mercury, other alignments move into configuration. Remarkably, Mercury returns to its same visible location every 1461st Egyptian calendar year with some error. This is the period of time defined above as the Sothic Cycle. If the 365-day calendar began in 4243 BCE with an alignment of Venus and Mercury, the first Sothic Cycle would end on July 20, 2783 BCE with Mercury near the same visible location, in this case, near greatest elongation. Coincidentally, Venus appeared 2.5 degrees from Mercury on this morning while maneuvering through a different 40-year cycle.

This subsequent cycle with Venus and Mercury visible on Cyd(1) began more than midway through the proposed first Sothic Cycle in years when the feast date was moved onto day 5 of the week. The feast had to move through the short 5-day week of the *epagomeni* at the end of the Sothic Cycle. This would cause the appearance of both Venus and Mercury to return to Cyd(1) on a new 10-day week with the start of the second Sothic Cycle. This would keep the two planets visible on Cyd(1) of years when the feast was to move into a new week for another thousand years. The two given cycles of Venus and Mercury would have aided those people responsible for maintaining the 365-day calendar greatly.

Those who understood the 365-day calendar could attain the year count by counting the days the feast moved from Cyd(1), multiply by four, then add the one, two, or three years since the last movement. This design made keeping the physical count redundant to the movement. The use of these formulas enhances the probability that the information survived over the long period these people worked without the aid of writing. The existence of people motivated to rearrange stones to line up with the Sothic Rise and the observable cycle of planetary movements that align with the 365-

day calendar's potential start date of July 20, 4243 BCE point to an observational beginning to the Egyptian calendar rather than to a retro calculation.

FIRST SOTHIC CYCLE

The most important date for the Egyptian calendar to reach would have been the first time the Feast of the Sothic Rise returned to Cyd(1) which marks the end of the first and the beginning of the second Sothic Cycle. If the cycles of Mercury and Venus were recognized, the completion of a Sothic Cycle would answer the following question that could have been asked fourteen-hundred years prior: "Will these planets and brightest of stars return to their predicted positions after that specific length of time?" The answer: Mercury is three days past its position 1461 Egyptian calendar years earlier, and Sirius is one to two days removed from its previous height.[31]

The only reference to the Egyptian calendar near the suggested day when the first Sothic Cycle ran its course is an ambiguous reference during the reign of Den. There is no historical record of the Sothic Cycle's completion being recognized at this early date. This may be because it was privileged information among the priests and the Egyptian calendar did not become publicly recognized until it became secularized for use in the temples.

It is likely that the seasons were named near the end of the first Sothic Cycle because cattle herding society that frequented Nabta would not have recognized the seasons of planting and harvest. The seasonal lakes at Nabta evaporated and refilled annually, so this could explain the why the Egyptian calendar begins with the season of the inundation, even if those responsible for its creation did not know of the temporal correlation of the Nile flood with the Sothic Rise.

Maintenance of the Egyptian calendar count would have been relegated to a small select group of people who were capable of understanding the mathematics involved. To be able to calculate the completion of a Sothic cycle, they must have been members of the multiple-dynasties-old Egyptian priesthood. They possessed not only the knowledge to keep count of the 365 calendar-days, but also the necessary resources to maintain their cult. Their political influence may have discouraged all attempts to alter the design of the 365-day calendar.

The completion of the proposed first Sothic Cycle took place near the beginning of Dynasty II as the pharaohs unified Upper and Lower Egypt. The completion of the next Sothic Cycle occurred during the reign of Ramesses II (1279 – 1213 BCE). It is possible that his building spree was in part commemorative of a completion of a Sothic Cycle. These milestones occurred at pivotal times in Egypt's history. The completion of the next Sothic Cycle, mentioned by Censorinus, was suggested by German Egyptologist Ludwig Borchardt to have been commemorated on a coin minted in Alexandria. It was struck in the second year of emperor Antonius Pius (139 BCE) and depicts him with a phoenix bird.[32]

CONCLUSION

Given a regular four-year movement of the Egyptian calendar there are only a few dates when the Feast of the Sothic Rise repositions itself on the first day of the 365-day calendar year. Each group of four-year alignments is separated by 1460 Julian years. If the Egyptian calendar were begun with the feast positioned on the first day of the 365-day calendar year, then the choices for its inaugural date are limited. One of these options, July 20 4243 BCE, positions 4000 counted Egyptian calendar years toward the Canopic calendar decree and 4200 Egyptian calendar years to the beginning of the Julian calendar. A count of Egyptian calendar years links the Egyptian dates of these events to the first day of the month of Payni mentioned in the Canopic decree and the change from the Egyptian flood season to planting season at the start of the Julian calendar. In addition, this choice keeps the Alexandrian calendar new-year forty days after the Feast of the Sothic Rise in perpetuity.

The given day corresponds to megalithic alignments that were used to observe the Sothic Rise at the site of Nabta in southern Egypt. Useful and visually striking conjunctions of the planets Mercury and Venus are aligned to the suggested Egyptian calendar start date. July 20, 4243 BCE is a compelling date for the beginning of the 365-day calendar that was used throughout the history of pharaonic Egypt. Furthermore, the design of the 365-day calendar incorporating the conjunctions of Venus and Mercury would have enabled a precise count of years for those responsible for its maintenance, even and especially among a pre-literate culture.

NOTES

1 Depuydt 1995, 56.
2. The Julian calendar has been in use since 45 BCE and has maintained a leap year adjustment once every fourth year since 4 CE. The proleptic Julian calendar counts this *same* adjustment into the past and future. This article will use the proleptic Julian dating system.
3. Given any Julian Day and the Julian Day of Cd(1) one can compute the corresponding calendar day Cd(x) = Jd(x) – Cd(1) + 1, calendar year day Cyd(x) = Cd(x) mod 365, and year n = Cd(x) div 365. The month and day of the month can be computed similarly from Cyd(x) with div/mod 30.
4. Censorinus, 50. The morning of the rising of the star depends upon the latitude of the observer as well as atmospheric conditions. For this reason, the appearance of Sirius would vary over more than five days from the first cataracts in the south to the delta in the north. This author believes that Censorinus is making reference to the day the rising is religiously observed, the Feast of the Sothic Rise.
5. O'Mara 2003, 24. O'Mara is arguing against the veracity of Censorinus' choice for July 20, but this choice keeps the dates cited in Ptolemy aligned.
6. For a discussion of texts which align to the Egyptian calendar, see Anna Sophie von Bomhard's *Egyptian Calendar*, p. 40-45. She confirms this alignment here as early as the Sothic Cycle beginning near 1322 BCE.
7. Depuydt 1995, 53.
8. Clagett 1995, 28.
9. *Ibid*, 10-11.
10. Manetho, 227-9.
11. *Ibid*.
12. Lowdermilk 2007, 12.
13. Herodotus 2.145.
14. St. Clair 1898, 16.
15. Meyer 1904, 178. St. Clair was cautious, suggesting merely the earliest Sothic dates, whereas Meyer recommended his date as the start of the calendar and even as the time of the rule of Menes, the supposed unifier of Upper and Lower Egypt. Meyer used July 19 erroneously as calculated from the Canopic Decree, but St. Clair used July 20 correctly for his datum, thus arriving at the correct quadrennium. For this reason, this author believes that St. Clair deserves some credit for his calculations which predate Meyer's by six years. His other research will not be addressed here except that a biography and bibliography may be found at http://members.westnet.com.au/gary-david-thompson/page5.html
16. Birch 1876, 87.
17. Bennett 2011, 14.
18. Birch 1876, 86.
19. Giving Cd(1) = Jd(July 20, 4243) = 171868.
20. Birch 1876, 83.
21. The Egyptian calendar was broken into three seasons; *akhet, peret, shemu,* of four 30-day months each season. These were followed by five additional days outside the months or seasons.

22. The day could have also been chosen because the new moon occurred about 1:15 pm, local time at Rome, on January 1, 45 BCE. The new moon occurred also on March 1, the new year of the previous Roman calendar at about 10:30 am in that year. Of course, these moons were not visible.
23. Jones 2000, 163-4. The Romans erred in the calculation for leap years adding the additional day every third year until Augustus corrected the error by 4 CE. Alexander Jones notes that records computed by Egyptians in Alexandria used the correct calculation.
24. Dawood 2007, 7.
25. Malville 2008, 138.
26. Bauval 2011, 126.
27. *Starry Night* v6.4.3. *Starry Night* is a multi-volume astronomy software package published by the Stimulation Curriculum Corporation. www.starrynight.com
28. Lowdermilk 2007, 12.
29. Lowdermilk 2007, 13-4.
30. Lowdermilk 2007, 13.
31. According to *Starry Night* v6.4.3 with the location set to the site of Nabta, latitude 20 deg 30.5 min N, longitude 30 deg 43.5 min E, at the computed time of sunrise on July 20, 4243 BCE Sirius resided at 18° 41.5' altitude, 131° 47.7' azimuth and Mercury resided at 13° 15.8' altitude, 70° 6.6' azimuth. On July 20, 2783 BC at the computed time of sunrise Sirius resided at 18° 54.7' altitude, 124° 26.8' azimuth and Mercury resided at 15° 17.7' altitude, 70° 41.1' azimuth.
32. Krauss 2006, 442.

REFERENCES

Bauval, Robert and Thomas Brophy. 2011. *Black Genesis: The Prehistoric Origins of Ancient Egypt*. Rochester, VT: Bear & Co.

Birch, Samuel. 1876. *Records of the Past Vol. VIII. Egyptian Records*. London: Samuel Bagster and Sons.

Bennett, Chris. 2011. *Alexandria and the Moon: An Investigation into the Lunar Macedonian Calendar of Ptolemaic Egypt*. Leuven, Belgium: Peeters.

Bomhard, Anne-Sophie von. 2000. *Egyptian Calendar*. London: Periplus Publishing.

Clagett, Marshall. 1995. Ancient *Egyptian Science, Volume II: Calendars, Clocks, and Astronomy*. Philadelphia: American Philosophical Society.

Censorinus. 2007. *The Birthday Book*. Translated by Holt N. Parker. Chicago and London: University of Chicago Press.

Dawood, Bishoy K. R. 2007. "The Coptic Calendar." copticheritage.org.

Depuydt, Leo. 1995. "On the Consistency of the Wandering Year as the Backbone of Sothic Chronology." *The Journal of the American Research Center in Egypt*. 32: 43-58.

Herodotus. 1987. *The History*. Translated by David Green. Chicago and London: University of Chicago Press.

Jones, Alexander. 2000. "Calendrica II: Date Equations from the Reign of Augustus." *Zeitschrift für Papyrologie und Epigraphik*. 129: 159-166.

Krauss, Rolf. 2006. "Egyptian Sirius/Sothic Dates, and the Question of the Sothis-Based Lunar Calendar." In *Ancient Egyptian Chronology*, edited by Erik Hornung, Rolf Krauss, and David A. Warburton. Pp. 439 – 457. Boston: Brill.

Lowdermilk, James. 2003. "Unit Fractions: Inception and Use." *The Ostracon*. 14.2: 6-9.

________. 2007. "The Phoenix and the Benben: The Start of the Egyptian Calendar as the First Time." *The Ostracon*. 18(1): 12-18.

Malville, J. McKim. 2008. "Astronomy of Nabta Playa." In *African Cultural Astronomy: Current Archaeoastronomy and Ethnoastronomy Research in Africa*, edited by Jarita Holbrook, R. Thebe Medupe, Johnson O. Urama. Pp. 131-143. [Berlin]: Springer.

Manetho. 1997. *Manetho*. Loeb Classical Library. Translated by W. G. Waddell. Cambridge, London: Harvard University Press.
Meyer, Eduard. 1904. *Aegyptische Chronologie*. Berlin: Der Königliche Verlag.
O'Mara, Patrick F. 2003. "Censorinus, the Sothic Cycle, and Calendar Year One in Ancient Egypt: The Epistemological Problem." *The Journal of Near Eastern Stu*dies. 62(1): 17-26.
St. Clair, George. 1898. *Creation Records Discovered in Egypt*. London: David Nutt.
Wendorf, Fred and J. McKim Malville. 2001. "Megalithic Alignments." In *Holocene Settlement in the Egyptian Sahara, Vol. 1: The Archaeology of Nabta Playa*, edited by Fred Wendorf and Romauld Schild. Pp. 489-502. New York: Kluwer Academic.

About the author

Jim Lowdermilk is the owner and operator of Mathemagician *tutoring. He has his MA from Univ. of Montana and BA from CSU, both in Applied Mathematics. He has published many articles in* The Ostracon *and presented his work to the Egyptian Study Society and the American Research Center in Egypt. He has traveled to Egypt many times and has worked on a dig in Giza. Jim is a past president of the Egyptian Study Society and is currently on the board as a member-at-large.*