

## Stonehenge & Timing Typhon

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**Abstract:** Hawkins 1964 proposed that Stonehenge (TPQ 3000 BCE) was designed as a “Neolithic Computer” to time eclipse danger periods. This paper updates the evidence that the constructions at Stonehenge deliberately incorporated astro-architectural features consistent with serving as a computing device to predict eclipses based *analogue* horizon alignments to the solstices ( $\pm 24^\circ$  declination) and major lunar standstills ( $\pm 29^\circ$  declination), as well as *digital* numerical artifacts designed into the architecture encoding luni-solar cycles, viz.: 19 Bluestone(s) Horseshoe :: 19 year Metonic Cycle; 56 Aubrey Hole(s) Circle and Avenue’s gap ::  $[19 \times 3] - 1 = 19 + 18 + 19 = 56$  year Stonehenge Cycle; and 29.5 Sarsen Circle uprights, 29Z & 30Y Holes,  $29 + 30 = 59$  Bluestone(s) Circle :: double month averaging the 29.5-day lunar synodic period. An additional numerical artifact is proposed, viz., the 5:12 ratio of the sides of the Station Stone Rectangle was selected from among an infinite number of possible rectangles precisely because each of its twin component 5:12:13 Pythagorean triangles uniquely delineates in *space* (Area = 30 Ratio Units<sup>2</sup> and Perimeter = 30 Ratio Units), i.e., the integer which most closely approximates in *time* the moon’s synodic period (30 days).

The efficacy of Hawkins’ Stonehenge Cycle ( $19 + 18 + 19 = 56$  years) for predicting solstice eclipse danger periods is tested by modeling in planetarium software all midwinter full moonrises 3000–1500 BCE at the Heelstone for dates of total lunar eclipses listed as visible at Stonehenge’s longitude in Espenak’s *Six Millennium Catalog of Lunar Eclipses*. The results demonstrate the utility of the Stonehenge Cycle for lunar eclipse prediction at the solstices, as well as support an astro-architectural interpretation of Eudoxus’ (c. 330 BCE) otherwise enigmatic reference to a “56-sided polygon said to belong to Typhon” (i.e., the Greek daemon-god whose blood-red shadow eclipses the moon). Hawkins’ Stonehenge Cycle is based on the ratio where  $56/3 = 18.6667$  years; i.e., a numerical artifact encoding a *spatial-time* approximation for tracking the 18.5996-year period of Regression of the Lunar Nodes with the 56 Aubrey Holes. Thus, the Stonehenge Cycle predicts triads of midwinter lunar eclipses (e.g.: Saros VII/22 Dec 22 1992; Saros III/22 Dec 1973; Saros VII/13 Jan 1955 BCE) more reliably than the 19-year Metonic Cycle. Moreover, if the 56-year Stonehenge Cycle were refined by adding two more iterations, i.e.,  $19 + 18 + 19 + 19 + 18 = 93$  years or  $93/5 = 18.600$  years for the lunar nodal cycle, then eclipse predictions would have been even more accurate.

### Introduction

The purpose of this paper is to update the controversy regarding the role of eclipse prediction inferred from the architecture of Stonehenge. In the half century since Anglo-American astronomer Gerald S. Hawkins suggested that Stonehenge was designed as a “Neolithic computer” to forecast “a danger period when eclipses are possible”<sup>1</sup>, much scholarly ink has been spilt regarding the proposal. Given that eclipse prediction implies “... that the builders of Stonehenge... were possessed of a degree of intellectual sophistication that seems inconsistent with the usual picture of the population of S. England in the 2<sup>nd</sup> millennium B.C.”<sup>2</sup>, initial skepticism was predictable. To date, scholarly opinion ranges from acceptance<sup>3 4 5</sup> to rejection.<sup>6 7 8 9 10 11 12</sup>

<sup>1</sup> Gerald S. Hawkins, ‘Stonehenge: A Neolithic Computer’, *Nature*, no. 202 (1964): p. 1258.

<sup>2</sup> Sir Fred Hoyle, ‘Speculations on Stonehenge’, *Antiquity*, no. 40 (1966): p. 262.

<sup>3</sup> Sir Fred Hoyle 1966, *On Stonehenge* (San Francisco: Freeman, 1977); C.A. Newham, *The Astronomical Significance of Stonehenge* (Warminster: Coates & Parker, Ltd., 1972).

<sup>4</sup> J.H. Robinson, ‘Sunrise and Moonrise at Stonehenge’, *Nature*, no. 225 (1970), pp. 1236-1237.

<sup>5</sup> Euan MacKie, ‘A New Look at the Astronomy and Geometry of Stonehenge’, eds. Nicholas Campion and Rolf Sinclair, *Culture and Cosmos*, Vol 16 nos. 1 and 2 (2012), pp. 89-107.

<sup>6</sup> Richard J.C. Atkinson, ‘Decoder Misled?’, *Nature*, no. 210 (1966): p.1302; ‘Hoyle on Stonehenge: Some Comments’, *Antiquity*, XLI (1977): pp. 92–95; ‘Some New Measurements on Stonehenge’, *Nature*, no. 275(1978): p. 50.

<sup>7</sup> Glynn Daniels, ‘Trouble about Stonehenge’, *Nature*, no. 213 (1967): p. 542.

## Methodology

One way to approach the problem is to test efficacy of the inverse of Hawkins' eclipse prediction hypothesis expressed in the following negative assessments:

...[D]etailed reassessments of the ideas of ...Gerald Hawkins...have shown no convincing evidence that, at any stage, constructions at Stonehenge deliberately incorporated a great many precise astronomical alignments, or that they served as any sort of computing device to predict eclipses....there is no reason whatsoever to suppose that at any stage the site functioned as an astronomical observatory.....<sup>13</sup>

Over the last forty years archaeoastronomers have revisited, reassessed, or dismissed many of the supposedly astronomical alignments at Stonehenge. ...[I]t became clear that the so-called Aubrey holes could in no way serve to predict eclipses and that many of the lunar alignments and other claims made for the monument were proved to be non-existent....<sup>14</sup>

Following the logic of scientific discovery<sup>15</sup>, let us restate the foregoing theory as a testable null hypothesis, viz.:

H<sub>0</sub>: There is no evidence that constructions at Stonehenge incorporate either a pattern of sufficiently accurate luni-solar alignments, or constructions consistent with computing eclipse predictions.

A systematic examination of Stonehenge's architectural design should determine the presence or absence of a pattern of "numerical artifacts"<sup>16</sup> associated with tracking luni-solar horizon positions over time. If the null hypothesis is not refuted by the evidence, then it emerges as the better theory. Conversely, if such evidence is present, the eclipse prediction theory succeeds and the null hypothesis fails. The reader is invited to consider the following astro-architectural evidence.

## Numerical Artifacts

Table 1 summarizes nine numerical artifacts as evidence in the design of Stonehenge's architectural features and whose astronomical significance is discussed in the following sections.

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<sup>8</sup> Aubrey Burl, 'Holes in the argument,' *Archaeoastronomy* (Center for Archaeoastronomy) 4(4) (1991), p. 17.

<sup>9</sup> Clive Ruggles, "Astronomy and Stonehenge," in *Science and Stonehenge*, Proceedings of the British Academy, Book 92 (1997) (B. Cunliffe & C. Renfrew, eds.), pp.203-229; 'Archaeoastronomical anomalies,' *Nature*, no. 294 (1981): pp. 485-486.

<sup>10</sup> Anthony F. Aveni, 'The Myth of Stonehenge,' *Sky and Telescope*, 72(1986), p. 460; 'Between a rock and a hard place,' *Nature*, 383 (1996): pp. 403-404.

<sup>11</sup> Marcello Ranieri, 'Geometry at Stonehenge,' *Archaeoastronomy* (Center for Archaeoastronomy), XVII (2003), p. 81.

<sup>12</sup> Albert Kainzinger, 'The mathematics in the structures of Stonehenge,' *Archive for the History of Exact Sciences*, 65 (2011), pp. 67-97.

<sup>13</sup> Clive Ruggles, 'Astronomy and Stonehenge,' *Science and Stonehenge*, Proceedings of the British Academy (Book 92) (B. Cunliffe & C. Renfrew, eds.), (1997): p. 203.

<sup>14</sup> Stanislaw Iwaniszewski, 'The Twelve Days at Stonehenge,' *Calendars, Symbols, and Orientations: Legacies of Astronomy in Culture, Proceedings of the 9<sup>th</sup> (2001) Annual Meeting of SEAC* (Upsalla: 2003), p. 27.

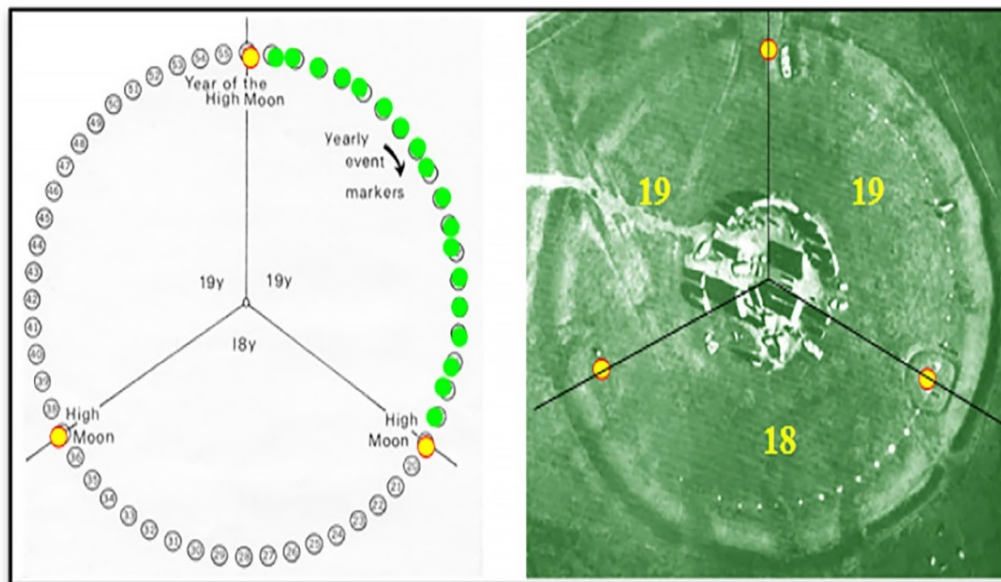
<sup>15</sup> Sir Karl Popper, *Objective Knowledge*, (Oxford: University Press, 1972), pp. 13-17; cf. *The Logic of Scientific Discovery*, (London: Taylor & Francis, 2002).

<sup>16</sup> Gerald S. Hawkins, unpublished audio tape recording, April 2003.

| Phase          | TPQ BCE | TAQ BCE | Numerical Artifact          | Archaeological Feature                           | Astronomical Interpretation                                                  |
|----------------|---------|---------|-----------------------------|--------------------------------------------------|------------------------------------------------------------------------------|
| 1<br>Neolithic | 3000    | 2900    | 56                          | Aubrey Holes                                     | $56/3 = 18.67$ years<br>$\approx$ Regression of Lunar Nodes (18.61 years)    |
|                |         |         | 51° 10' N                   | Latitude                                         | SSSR (+24° dec) $\perp$ MajLSS (+29° dec)                                    |
|                |         |         | +0.6°                       | Altitude of Local Horizon                        | Refraction is canceled.<br>Luni-solar alignments are reciprocal.             |
| 2<br>Bronze    | 2900    | 2800    | 30 Ratio Units <sup>2</sup> | Area, 5:12:13 Station Stone Triangles            | Lunar Synodic Period (29.53 days)                                            |
|                |         |         | 30 Ratio Units              | Perimeter, 5:12:13 Station Stone Triangles       | Lunar Synodic Period (29.53 days)                                            |
| 3b/ii          | 2600    | 2400    | 29.5                        | 29 Sarsen Circle Uprights + Stone #11 ("Shorty") | Lunar Synodic Period (29.53 days)                                            |
| 3c/iv          | 2280    | 1930    | 59 (Estimated)              | Bluestone Circle                                 | Double Month = Lunar Synodic Period<br>$30 + 29$ days = $2 \times 29.5$ days |
| 3v             | 1930    | 1600    | 19                          | Bluestone Horseshoe                              | Metonic Cycle (19 years)                                                     |
| 3vi            | 1600    | 1520    | 59                          | 30 Y & 29 Z Holes                                | Double Month = Lunar Synodic Period<br>$30 + 29$ days = $2 \times 29.5$ days |

Table 1: Numerical Artifacts, Archaeological Features and Astronomical Interpretations at Stonehenge

**56 Aubrey Holes** (Phase 1, c. 2950–2900 BCE). Thanks to Atkinson's extensive field work at Stonehenge, we know that "[t]here are fifty-six Aubrey Holes, set in an accurate circle 288 ft. in diameter.... Thirty-four of them have been excavated.... The locations of the unexcavated holes have been found by probing and 'bosing' [sub-surface echo-location]" <sup>17</sup> (Fig. 1).



<sup>17</sup> Richard J. C. Atkinson, *Stonehenge*, (Bristol: Western Printing, 1956), pp. 11-12.

*Fig. 1: Fifty-six Aubrey Holes as Hawkins' Neolithic Space-Time Computer*<sup>18</sup>

However, Atkinson's contention that Hawkins' 56-year eclipse cycle as "hitherto unrecognized"<sup>19</sup> must be rejected in light of the following passage attributed to the Greek astronomer Eudoxus of Cnidus (fl. 370 B.C.) by Plutarch (AD c.46-120) explicitly linking the 56-sided (or 56-angled) polygon to lunar eclipses<sup>20</sup>:

"There are some who give the name Typhon to the shadow of the earth, into which they believe the moon falls and so suffers eclipse...which the sun remedies by instantly shining back upon the moon when it has escaped the shadow of the earth...."The Pythagoreans also clearly believe Typhon to be a demonic power, for they say that he was born on an even measure, the 56<sup>th</sup>; further, they say that the nature of the triangle belongs to Hades, Dionysus and Ares, that of the quadrilateral to Rhea, Aphrodite and Demeter, Hestia and Hera, and that of the dodecagon to Zeus, while that of the 56-sided polygon is said to belong to Typhon, as Eudoxus [of Cnidus, Greek astronomer, fl. 370 B.C.] has reported...." <sup>21</sup>

The design choice of a 56-sided polygon for the 56 Aubrey Holes is of fundamental importance because the 56/3 (=18.67) (Fig. 1) ratio so closely approximates the lunar nodical cycle (18.61 years) where the moon's skyline position and phase synchronize enabling eclipse danger period prediction.

**51° 10' North Latitude** (Phase 1, c. 2950–2900 BCE). Within a few miles of the latitude of Stonehenge, the extreme positions of the sun (annually) and moon (every 18.6 years) form a right angle on a flat horizon.<sup>22</sup> The azimuth of the summer solstice sunrise is at a 90° angle to the midwinter moonset in the year of the Major Lunar Standstill, just as the winter solstice sunset is at a right angle to the midsummer moon rise. "...[W]e must accept, I think, that the positions of at least the Heel Stone and the Station Stones, and indeed the latitude of Stonehenge itself, are astronomically determined".<sup>23</sup>

**+0.5° Horizon Altitude** (Phase 1, c. 2950–2900 BCE). Stonehenge is sited in an elevated natural depression affording the observer a uniformly flat local horizon. According to the 1972 aerial photogrammetric survey sponsored by Hunting Surveys, the altitude of the local horizon ranges between +0.33° and +0.63°. <sup>24</sup> The reason why summer solstice sunrise and winter solstice sunset alignments are reciprocal (180° apart in azimuth) at Stonehenge is due to the SW and NE horizons each having +0.5° horizon altitude which cancels the effects of atmospheric refraction. The compensating effect is relevant because, "Midsummer sunrise and midwinter sunset are not diametrically opposite; the angle is about 178°, depending upon the altitude of the horizon."<sup>25</sup> Although, the raised circular bank outside the Aubrey Holes may have originally functioned as an artificial horizon, erosion has removed too much soil to confirm this possibility by field survey (Figs. 2 and 3). However, reasonable estimates of the

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<sup>18</sup> After Hawkins and Hubert A. Allen, *Stonehenge Earth and Sky*, (Salisbury: Wessex Books, 2004), p. 41; and Hawkins, *Beyond Stonehenge*, (New York: Harper & Row, 1973), p. 53, Plate 14.

<sup>19</sup> Atkinson, 'Decoder Misled?', p.1302.

<sup>20</sup> Vance R. Tiede, "New Light on Stonehenge from Ancient Greeks", <http://yale.academia.edu/VanceTiede>, conference presentation slides nos. 6, 7, and 11.

<sup>21</sup> Plutarch (c. AD 120), *De Iside et Osiride*, (J.G. Griffiths, J.G., trans.)(Cardiff: University of Wales Press, 1970), XXX:20, XLIV:14 and LV:18, pp. 165, 189, and 207.

<sup>22</sup> Hawkins with John B. White, *Stonehenge Decoded*, (New York: Doubleday & Company, 1965), p. 54.

<sup>23</sup> Atkinson, "Hoyle on Stonehenge: Some Comments," *Antiquity*, XLI (1977), p. 94.

<sup>24</sup> Hawkins, *Beyond Stonehenge* 1973, 61; cf. Sir Norman Lockyer, *Stonehenge and Other British Stone Monuments Astronomically Considered*, (London: Macmillan, 1906), p. 67, <http://www.sacred-texts.com/neu/eng/sac/sac10.htm>.

<sup>25</sup> Hawkins with John B. White, *Stonehenge Decoded*, p. 173.

embankment's original altitude may be possible in future with 3D computer assisted design software.

**5:12 Station Stone Rectangle** (Phase 3, c. 2600 BCE). The Station Stones form a rectangle whose width to length ratio is 5:12, i.e., whose diagonals form twin 5:12:13 Heronian-Pythagorean rational right triangles with a common hypotenuse (Fig. 2)<sup>26</sup>.

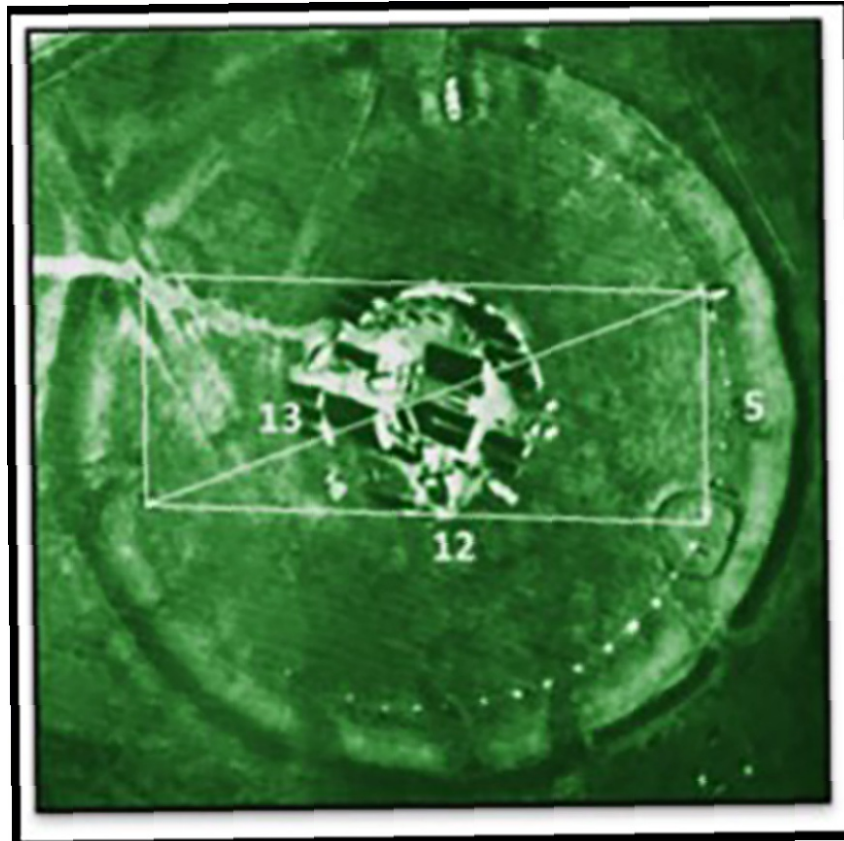


Fig. 2: The Station Stone Rectangle of twin 5:12:13 Triangles on the Aubrey Hole Circle<sup>27</sup>

Three remarkable properties deserve notice regarding the 5:12:13 triangle:

1. It is one of three primitive Pythagorean triples (i.e., 3:4:5; 5:12:13; 12:35:37) found at megalithic sites in Britain<sup>28</sup>
2. Its Area (=  $[5 \times 12]/2$  Ratio Units squared  $[RU^2]$ ) and its Perimeter (=  $5 + 12 + 13$  linear RU) equal the same spatial numerical value (30); and
3. The same numerical value (30) is the nearest integer in time to the moon's Synodic Period (29.5306 days).

<sup>26</sup> William E. Dibble, 'A possible Pythagorean triangle at Stonehenge,' *Journal for the History of Astronomy*, Vol. 7 (1976), pp. 141–142; Atkinson, 'Some New Measurements on Stonehenge,' *Nature*, Vol. **275** (1978), p.50; and Ranieri, 'Geometry at Stonehenge'.

<sup>27</sup> After Hawkins, *Beyond Stonehenge*, (New York: Harper & Row, 1973), p. 53, Plate 14.

<sup>28</sup> Alexander Thom, *Megalithic Sites in Britain*, (Oxford: University Press, 1967), p. 27.

Not only did the designers of the Station Stone Rectangle incorporate twin 5:12:13 rational right triangles into their astro-architectural plan anticipating both Pythagoras of Samos (c.570 BCE–c.495 BCE) and Heron of Alexandria (c. 75 AD) by more than 2,000 years, but they also oriented the sides of the 5:12 Station Stone Rectangle to the extreme risings and settings of the midwinter and midsummer Moon ( $\pm 29^{\circ\text{decl}}$ ) and Sun ( $\pm 24^{\circ\text{decl}}$ ). Given that the architects of Stonehenge chose from an infinite number of other quadrilaterals located on the Aubrey Hole Circle to align with the lunisolar horizon extrema, the numerical equivalency of a 5:12:13 triangle's area ( $30 \text{ RU}^2$ ) and perimeter (30 RU) with respect to the lunar synodic period (30 days) uniquely coincide with the dimensions of the 5:12 Station Stone Rectangle.

**29.5 Sarsen Circle Uprights** (Phase 3ii, c. 2600–2400 BCE). The Sarsen Circle contains a total of 29 and one-half stone uprights (Figs. 3 and 4). It remains an open question among archaeologists as to why one of the stones (No. 11 “Shorty”) was reduced in size (height  $\approx 103$ ”).

“The original number of uprights in the circle was thirty, but of these only sixteen remain in position. *One stone in the circle, no. 11, is much smaller than the rest, measuring only 4 ft. wide by 2 ft. thick. It now stands only 8 ft. out of the ground, but presumably at some time the upper part has been broken off and removed from the site. The use of this markedly undersized stone (there can be no question of its width or thickness having been reduced since its erection) suggests that the builders were hard put to it to find sufficient blocks of the requisite size to complete the circle*”<sup>29</sup>

“If we move a little around the sarsen ring to stone 11, we find a diminished, stumpy thing, less than 3m high compared to the normal 4m.... It could not have held a lintel connecting to the two adjacent full-size stones....”<sup>30</sup>



Fig. 3: Author measuring and Partial Solar Eclipse over Sarsen Circle Stone No. 11 (“Shorty”) <sup>31</sup>

<sup>29</sup> Atkinson, *Stonehenge*, pp. 23-24.

<sup>30</sup> Mike Pitts *Hengeworld*, (London: Arrow Books, 2001), p. 265.

<sup>31</sup> Photo Credits: Clea T. Waite, 15 Sep 2016 (left); Grant Privett, 4 Jan 2011 (right); cf. Tiede, “New Light on Stonehenge from Ancient Greeks”, <http://yale.academia.edu/VanceTiede>, conference presentation slides nos. 28-29.

Atkinson's suggestion that "the builders were hard put to it to find sufficient blocks of the requisite size" for fashioning a full-size 30<sup>th</sup> upright is belied by the local sarsen stone quarries.<sup>32</sup> On the other hand, the astronomical explanation is simply "...that small stone (no. 11) in the sarsen circle was intentional, and that the circle represented the 29.5 days of the lunar month"<sup>33</sup> as was known to Sumerians (c.1800 BCE) and Greeks (c.500 BCE). How else would a Stonehenge mason cut the *fraction* "½", other than by reducing a stone's height, length and width by half with respect to the 29 other Sarsen Circle uprights?

**59 Bluestone(s) Circle** (Phase 3iv, c. 2550–1600 BCE). To date, British archaeologists have yet to agree on the exact number of stones in the Bluestone Circle (Fig. 4). Excavations by Hawley (1924–28) and Atkinson (1954) "...when plotted on a large-scale plan in combination with surviving stones, enable a new and far more accurate estimate to be made, of 57 stones with a possible error of one stone more or less."<sup>34</sup> "Atkinson in 1956 thought there had been 56, 57 or 58, but four years later he revised his estimate upward, to 59, 60 or 61"<sup>35</sup> "They may have originally numbered 60."<sup>36</sup> "Atkinson, with the advantage of Hawley's excavations, estimated sixty, give or take a stone...."<sup>37</sup>

Pending a definitive Bluestone Circle count (e.g., with a Ground Penetrating Radar survey), an interim value for the number of bluestones is the median (58.5) of the estimated range of 56 to 61. Therefore, one might reasonably estimate that there 59 stones in the Bluestone Circle. While the number 59 holds no special significance for archaeologists, historians of astronomy recognize the integer 59 as the ancient approximation of paired lunar Synodic Periods (each 29.5306 days) which avoids fractions, viz., two alternating integers, such that 29 days + 30 days = 59 days:

"The strong possibility that there were fifty-nine blue stones inside the Sarsen circle would provide a more suitable means of representing... the 59 days of two lunar months."

"The numbers associated with the bluestone circle and the rings of Stonehenge II have not been definitely established by archaeologists at the present time. The current estimates for the stones in the bluestone circle are 59, 60 and 61. The first figure, of course, would give the best fit to the lunar month....a counting system that was known to exist in later eras elsewhere in the world."<sup>38</sup>

In fact, the "Double Month" of 59 days was well known in the ancient world, e.g., at the Sumerian city of Mari (modern Tell Hariri, Syria) c.1800 BCE, grain allocations "were already reckoned on the basis of alternating 29- and 30-day lunar months."<sup>39</sup> The Greek astronomer Geminus of Rhodes (c. 10 BCE) records that Solon, Archon of Athens (594/3 BCE), taught that, "The moon-year has 354 (= 12 x 29.5) days. Consequently they took the lunar month to be 29 ½ days and the double month to be 59 (= 29 + 30) days. Hence it is that they have hollow (29 day) and full (30 day) months alternatively, namely because

<sup>32</sup> Brian John, "Stonehenge Speculations," (21 November 2011) <http://brian-mountainman.blogspot.com/2011/11/sarsen-speculations.html>

<sup>33</sup> C. A. Newham, *The Astronomical Significance of Stonehenge*, (Warminster: Coates & Parker, Ltd., 1972, p. 47.

<sup>34</sup> Atkinson, *Stonehenge*, p. 38.

<sup>35</sup> Hawkins and White, *Stonehenge Decoded*, p. 59.

<sup>36</sup> Rosamund M. J. Cleal, et al., *Stonehenge in its Landscape*, English Heritage: Arch. Report 10 (1995), p. 29.

<sup>37</sup> John D. North, *Stonehenge: A New Interpretation of Prehistoric Man and the Cosmos*, (New York: Free Press, 1996), p. 430.

<sup>38</sup> Hawkins, *Beyond Stonehenge*, p. 301.

<sup>39</sup> <http://cdn.preterhuman.net/texts/other/crystalinks/calendars2.html>

the two-months period according to the moon is 59 days....<sup>40</sup> The alternating 29- & 30-day month convention is still observed in both the Jewish (לוח העברי *Ha-Luah ha-livri*) and Muslim (*Hijri*) calendars.<sup>41</sup>

**19 Bluestone(s) Horseshoe** (Phase 3v, c. 2550–1600 BCE). Inside Stonehenge’s Sarsen Circle, 19 dolerite bluestones once stood in a horseshoe open to the midsummer sunrise (Fig. 4).

“[They]...are so called from their colour, which in dry weather is a bluish-grey. But when they are wet after rain they acquire a noticeably blue tinge.... There can be no doubt now that it was from this very restricted region [in Wales] that the bluestones were chosen and brought to Stonehenge [in England]. The technological implications of this extraordinary undertaking are discussed below.... The spacing of the surviving stones makes it clear that the horseshoe originally contained nineteen pillars....”<sup>42</sup>

While a modern archaeologist may have no use for an astronomical interpretation, both the color and number of the bluestones could well have had ritual significance for, say, an ancient astro-architect. Although the color choice of *bluestones* reflecting a connection to the *blue sky* is as hypothetical as it is self-evident, astronomers have pointed out that the architect’s choosing 19 bluestones for the horseshoe constitutes an independent numerical variable memorializing the 19-year cycle of the moon’s 235 Synodic months (or lunations); a cycle used by Greek astronomers Meton and Euctemon of Athens to regulate the Attic Calendar c.432 BCE. Moreover, British archaeologist Robert S. Newall pointed out<sup>43</sup> that the ancient Greek historian Hecataeus of Miletus (c.550-476 BCE) referred to a spherical temple to Apollo on the large island of *Hyperborea* (Beyond the North Wind) where “...the god [*theon*, i.e. Moon deity *Selene* – V.T.] visits the island every 19 years, the period in which the return of the stars [*astron* or “luminous bodies” – V.T.] to the same place in the heavens is accomplished....”<sup>44</sup>

“Either the 19 year phase cycle or the 18.61 year nodal cycle was represented by the 19 blue stones inside the trilithon ‘horseshoe’.”<sup>45</sup>

“It is, of course, the eclipse year...which has the powerful relation to the number 19, since an eclipse occurring at one moment will reoccur almost exactly 19 eclipse years in the future”.<sup>46</sup>

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<sup>40</sup> Aristarchus of Samos (c. 250 BC). Translated by Heath, T. L., *Aristarchus of Samos*, (New York: Dover, ([1913]1981), p.287 with translation of Geminus (c.10 BC), *Isagoge*, c.8, 34-35, 112.28-114.7.

<sup>41</sup> <http://stevemorse.org/jcal/mrules.htm>.

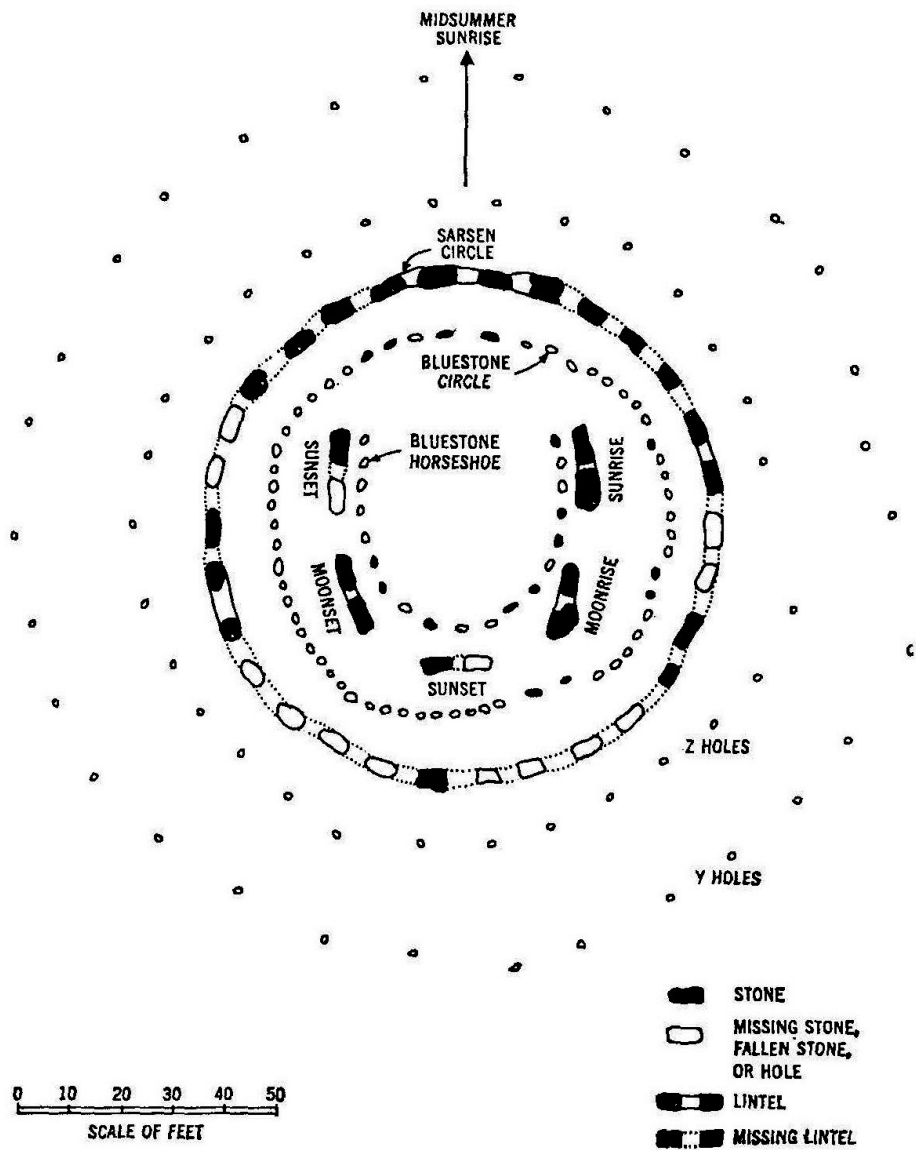
<sup>42</sup> Atkinson, *Stonehenge*, pp. 34, 36, and 42.

<sup>43</sup> Hawkins, *Stonehenge Decoded*, p. 96.

<sup>44</sup> Diodorus of Sicily ( c.50 BC), *Diodorus of Sicily In Twelve Volumes*, (Charles Henry Oldfather ,trans.), (Cambridge, Massachusetts: Harvard University Press, 1935) Book II, 4: 5-48, p. 47.

<sup>45</sup> Newham, *The Astronomical Significance of Stonehenge*, pp. 47-48.

<sup>46</sup> Hoyle, *On Stonehenge*, p. 130.



“The double circle or spiral of the ‘Y’ and ‘Z’ holes represented the 59 days of two solar months.”<sup>49</sup>

“The 30 Y and 29 Z holes were an improvement in the counting device. Alternate months could use the short 29-day interval, giving a mean month of 29.5 days.... The rings contain numerical information that corroborates the possible connection with the moon.”<sup>50</sup>

### Neolithic Computer

The efficacy of Hawkins’ Stonehenge Cycle ( $19+18+19 = 56$  years) for predicting solstice eclipse danger periods is tested by modeling in planetarium software all midwinter full moonrises 3000–1500 BCE at the Heelstone for dates of total lunar eclipses listed as visible at Stonehenge’s longitude in Espenak’s *Six Millennium Catalog of Lunar Eclipses*.<sup>51</sup>

Figure 5 illustrates how the design and orientation of the Heelstone viewed from the center of the Sarsen Circle supports an interpretation that it was designed as a purpose-built lunisolar timing device consistent with a 56/3-year cycle. A Bronze Age observer of the midwinter moonrises over the Heel Stone from inside Sarsen Circle archway 30-1 also had a high probability of also (weather permitting) witnessing a lunar eclipse before moonset. A “complete analysis shows that the stone computer is accurate for about three hundred centuries, then the Moon phenomena will begin to occur one year too early.... The sarsen circle could also have been a vernier for predicting the exact day of the eclipse. A lunar eclipse occurs when the moon stone is in archway 30-1; a solar eclipse when the Moon stone is in 15-16.”<sup>52</sup>

The results demonstrate the utility of the Stonehenge Cycle for lunar eclipse prediction at the solstices, as well as support an astro-architectural interpretation of Eudoxus’ (c. 330 BCE) otherwise enigmatic reference to a “56-sided polygon said to belong to Typhon” (i.e., the Greek daemon-god whose blood-red shadow eclipses the moon). Hawkins’ Stonehenge Cycle is based on the ratio where  $56/3 = 18.6667$  years; i.e., a numerical artifact encoding a *spatial-time* approximation for tracking the 18.5996-year period of Regression of the Lunar Nodes with the 56 Aubrey Holes. Thus, the Stonehenge Cycle predicts triads of midwinter lunar eclipses (e.g.: Saros VII/22 Dec 22 1992; Saros III/22 Dec 1973; Saros VII/13 Jan 1955 BCE) more reliably than the 19-year Metonic Cycle. Moreover, if the 56-year Stonehenge Cycle were refined by adding two more iterations, i.e.,  $19+18+19+19+18 = 93$  years or  $93/5 = 18.6000$  years for the lunar nodal cycle, then eclipse predictions would have been even more accurate.<sup>53</sup>

Hawkins’ hypothetical “Neolithic Computer” to time eclipse danger periods can be modeled with planetarium software.<sup>54</sup> Table 2 and Figure 5 reconstruct a sample of midwinter total lunar eclipses viewed at Stonehenge to illustrate the efficacy of the Aubrey Hole Circle to predict total lunar eclipses at midwinter of 1992, 1973 and 1955 BCE in accord with the cycle of  $19+19+18 = 56/3 = 18.67$  years. If the Aubrey Hole Circle dates from the earliest phase of construction (ca. 3000 BCE), then the architects of Stonehenge may have had prior knowledge of a 56/3 year approximation for the lunar nodal cycle.

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<sup>49</sup> Newham *The Astronomical Significance of Stonehenge*, p. 47.

<sup>50</sup> Hawkins, *Beyond Stonehenge*, p. 301.

<sup>51</sup> Fred Espenak, ‘Six Millennium Catalog of Lunar Eclipses: -2999 to +3000 (3000 BCE to 3000 CE),’ (2014), <http://www.eclipsewise.com/>.

<sup>52</sup> Hawkins, ‘Stonehenge: A Neolithic Computer’, p. 1261.

<sup>53</sup> Suggested by Michael Faison, Department of Astronomy, Yale University.

<sup>54</sup> The author used Starry Night Pro Plus 6.

Table 2 shows five total midwinter lunar eclipses and one penumbral (1955 BCE) occurring in two consecutive 56-year cycles of 112 years.<sup>55</sup> In any event, as Hawkins points out, “In favor of this solution - that the Aubrey Holes were used as a computer- are these facts: (1) the number 56 is *the smallest number* that measures the swing of the moon with an over-all accuracy of better than 3 days, and (2) lunar cycles provide the only method of long-range eclipse prediction related to the seasons of the year.”<sup>56</sup>

| Obliquity<br>Astro-Solstice |                 |       |             |                    |             |                  |         |                     |                   |
|-----------------------------|-----------------|-------|-------------|--------------------|-------------|------------------|---------|---------------------|-------------------|
| Year                        | (decl.)         |       | -15<br>days | Winter<br>Solstice | +15<br>days |                  |         |                     |                   |
| -2000                       | <u>+23d 55'</u> |       | Dec-21      | Jan-05             | Jan-20      |                  |         |                     |                   |
|                             |                 |       | Midwinter   |                    |             |                  |         |                     |                   |
| Year                        | Year            | Years |             |                    | Saros       | Lunar<br>Eclipse | Moon    | Eclipse<br>Visible? | Eclipse<br>Zenith |
| Astro                       | BCE             | Δ     | Month       | Day                | Num         | Type             | Decl.   | Yes/No              | Long.             |
| -2028                       | 2029            | -     | Dec         | 11                 | -17         | Penumbral        | 21° 38' | Y                   | 87E               |
| -2009                       | 2010            | 19    | Dec         | 11/12              | -7          | Total            | 20° 52' | Y                   | 91E               |
| -1991                       | 1992            | 18    | Dec         | 22                 | -7          | Total            | 22° 29' | Y                   | 42W               |
| -1972                       | 1973            | 19    | Dec         | 21/22              | 3           | Total            | 22° 20' | Y                   | 41W               |
| -1954                       | 1955            | 18    | Jan         | 12/13              | -7          | Total            | 22° 29' | Y                   | 59E               |
| -1935                       | 1936            | 19    | Jan         | 12/13              | 3           | Total            | 22° 48' | Y                   | 64E               |

Table 2: Periodicities of Midwinter Total Lunar Eclipses Visible at Stonehenge, 2010–1936 BCE<sup>57</sup>

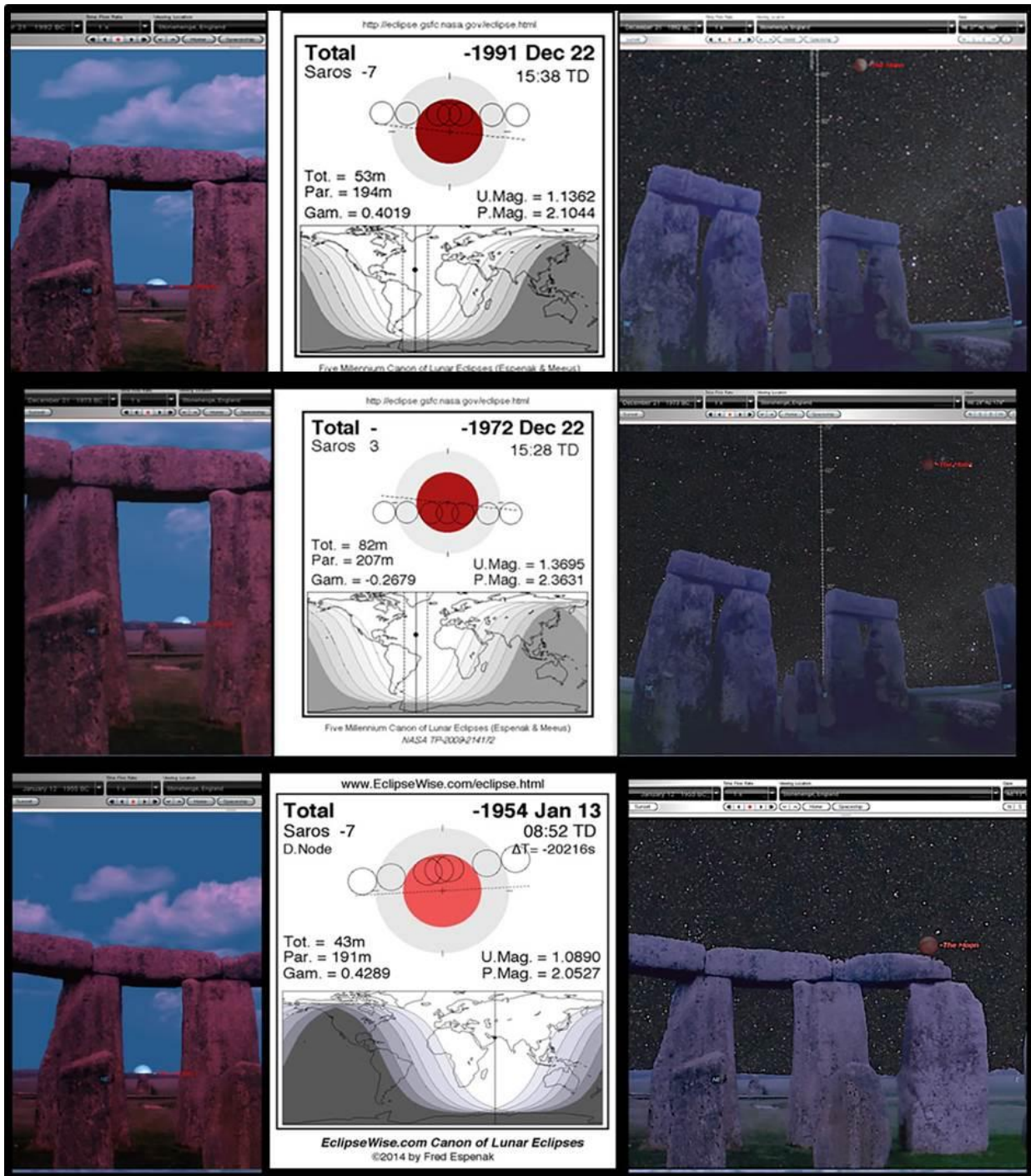
To paraphrase Ossendrijver (2016), the procedures of the architects of Stonehenge are geometrical in a different sense than the methods of the mentioned Greek astronomers, since the geometry of Stonehenge describes configurations both in *physical space* as well as an abstract mathematical space defined by *time and velocity* (cyclical displacement).<sup>58</sup>

<sup>55</sup> Interestingly, a contemporaneous Minoan (c. 1600–1100 BCE) a star-shaped stone die for pouring molten metal features pinholes inside a circle of 112 holes (Bronze Age “double precision” ?) has been interpreted as a portable eclipse calculator by Minos Tsikritsis, E. Theodossiou, V.N. Manimanis, P. Mantarakis & D. Tsikritsis, ‘A Minoan Eclipse Calculator,’ *Mediterranean Archaeology and Archaeometry* 13 (2013), no.1, pp. 265-275.

<sup>56</sup> Hawkins and White, *Stonehenge Decoded*, p. 144.

<sup>57</sup> Table 2 is the prototype for an expanded table (3000-1500 BCE) to be posted in 2017 at <http://yale.academia.edu/VanceTiede>.

<sup>58</sup> Cf. M. Ossendrijver, ‘Ancient Babylonian astronomers calculated Jupiter’s position from the area under a time-velocity graph’, *Science*, 351(2016) pp. 482-484, [http://www.ms.uky.edu/~sohum/ma330/files/babylonians\\_jupiter.pdf](http://www.ms.uky.edu/~sohum/ma330/files/babylonians_jupiter.pdf)



pattern of sufficiently accurate luni-solar alignments as well as constructions consistent with computing eclipse predictions, then Hawkins' eclipse prediction hypothesis is more reasonable than the null hypothesis.

Although cultural anthropologists and historians have long acknowledged the significance of solar and lunar eclipses in traditional societies and historical records, inferring astronomical information from archaeological features is remains an open field for future research. When Astronomy is no longer *terra incognita* in university Archaeology curricula, the potential for recovering astro-calendric knowledge from ancient monumental architecture will be realized.