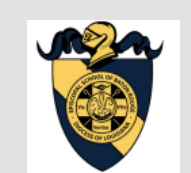


The Double Meaning of 40.5° on Stonehenge and Bush Barrow Lozenge



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Introduction

Six decades after astronomer Hawkins (1963, 1964) suggested that Stonehenge was a Neolithic computer, little consensus has been reached regarding Stonehenge's role in astronomy. By reconstructing and reinterpreting 40.5° geometrically, we demonstrate that Stonehenge was once an observatory equipped with rulers, protractors, and compasses shaped/scaled in lozenges.

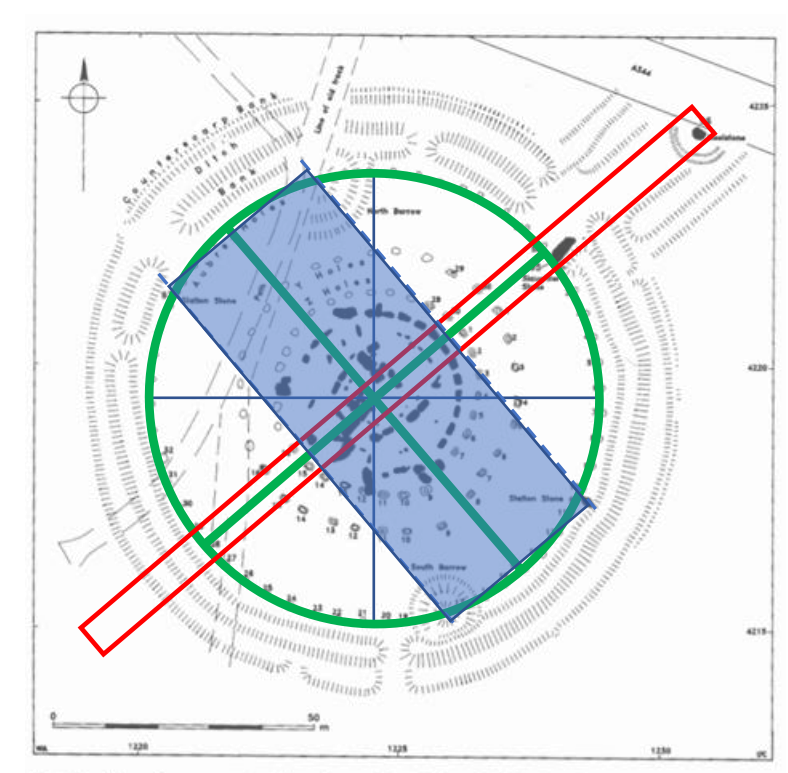


Fig. 1 (Left). Stonehenge: Aubrey Holes (Green), Station Rectangle (Blue), and the 40.5° alignment (Red) of the Avenue with solstice sunrise and sunset

Fig. 2 (Below). Four Lozenges: (a) Bush Barrow Large Lozenge (BBL): 186 × 155 mm; (b) Bush Barrow Small Lozenge (BBS): 31 × 18.6 mm; (c) Clanton Barrow Lozenge (CBL): 155 × 110 mm; (d) Upton Lovell Gold Button (ULB): 47mm in diameter, 37mm in height

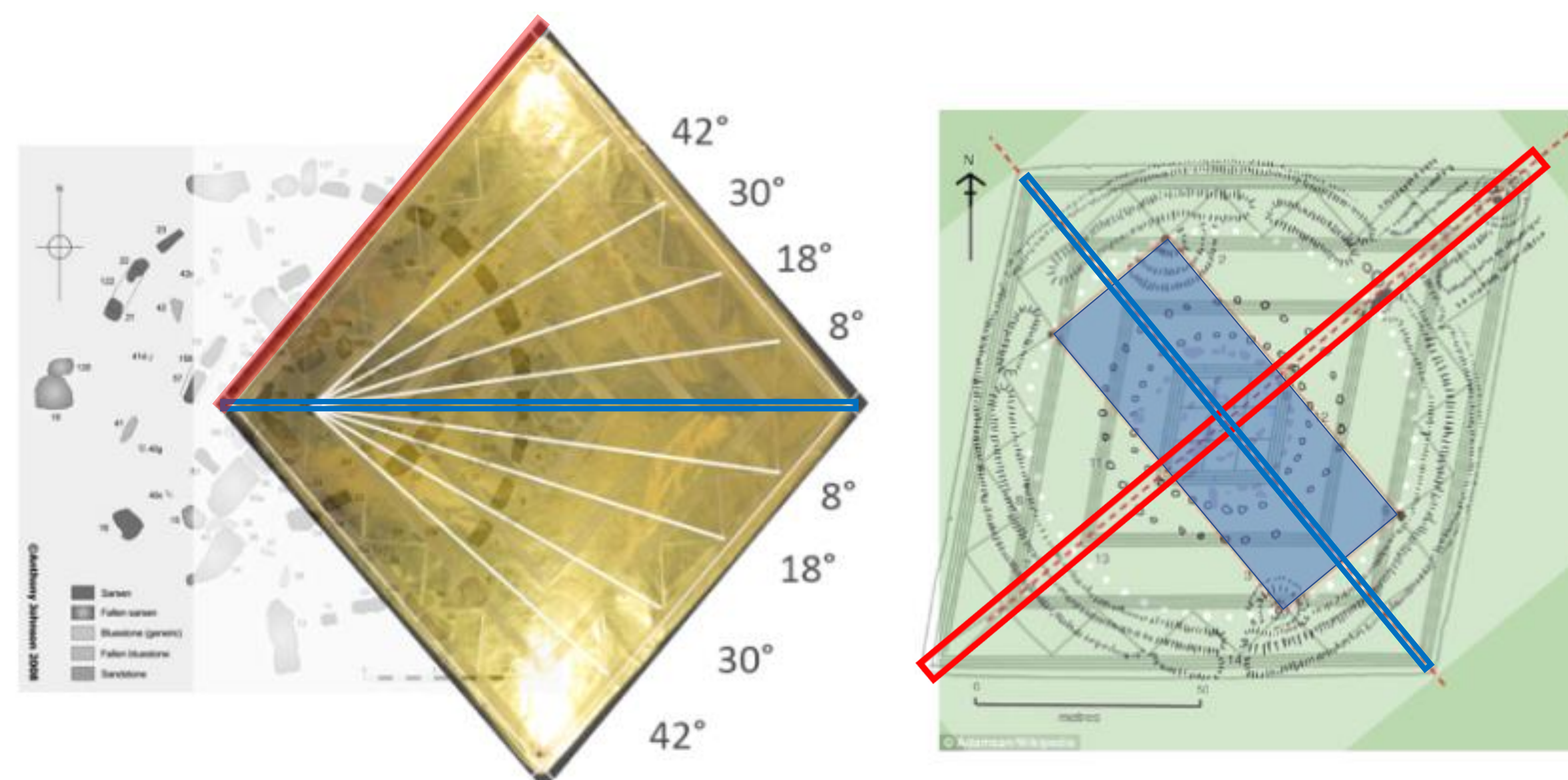
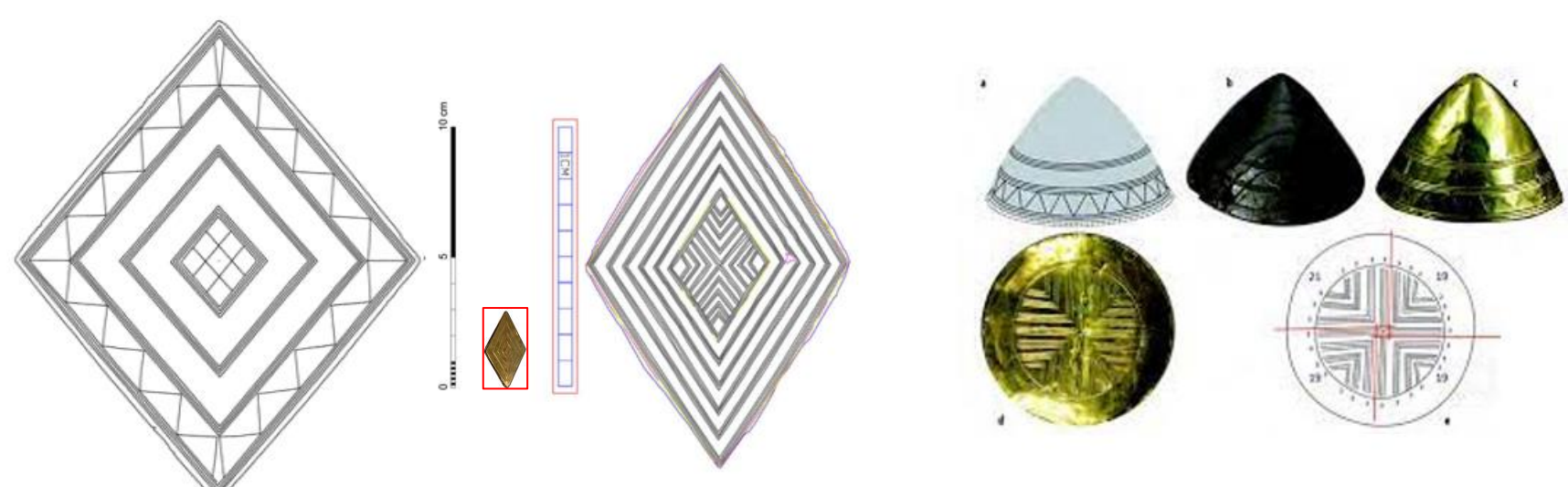
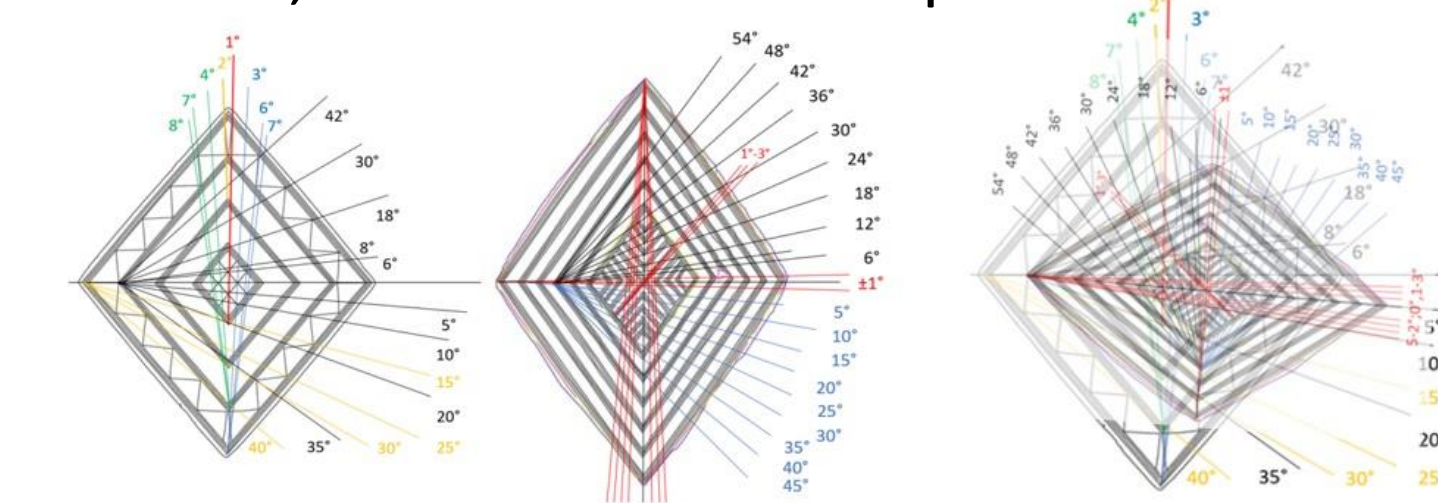


Fig. 3. Matching: (BBL & Sarsen Circle) and (BBL & Station Rectangle) form compasses, and the 40.5° alignment implies the cardinal orientation, Axis, Aubrey Holes, and Station Rectangle are all reflected in the lozenge structure

IV. Protractor Mechanism

Inspired by a 1300 BC Egyptian protractor, we reverse engineered a protractor mechanism that involves eccentric pivoting (Fig. 8). This mechanism measures all 360 angles at a 1° accuracy. Thus, BBL and CBL were both rulers and protractors. By aligning the instruments with the cardinal directions, this indicates a compass.



$$\begin{aligned} \theta_0 &= 14.036^\circ & \theta_{10} &= 12.046^\circ & 1^\circ &= \theta_{11} - \theta_{10} = 1.04^\circ & 2^\circ &= \theta_{12} - \theta_{11} = 2.00^\circ \\ \theta_{11} &= 10.025^\circ & \theta_{14} &= 6.090^\circ & 3^\circ &= \theta_{14} - \theta_{11} = 3.04^\circ & 4^\circ &= \theta_{15} - \theta_{14} = 4.02^\circ \\ \theta_{15} &= 5.051^\circ & \theta_{18} &= 3.054^\circ & 5^\circ &= \theta_{18} - \theta_{15} = 4.97^\circ & 6^\circ &= \theta_{19} - \theta_{18} = 5.96^\circ \\ & & & & 7^\circ &= \theta_{20} - \theta_{19} = 7.00^\circ & 9^\circ &= \theta_{21} - \theta_{20} = 8.99^\circ \end{aligned}$$

Fig. 8. Lozenge Protractors: BBL and CBL can measure angle jointly or independently, where the subtraction is done by pivoting. The near-integer values in the θ -sequence enable the 1° precision

V. Beyond Stonehenge

Further insights are gained by testing the "lozenge model" including the angle (40.5°) & length (0.155m) against additional Megalithic artifacts and sites. One critical test is Woodhenge, a contemporary of Sarsen Circle (Phase 3) within a two-mile distance.

1:2 Ratio between Woodhenge and Stonehenge, scaled at 500 and 1000 Lozenges, respectively

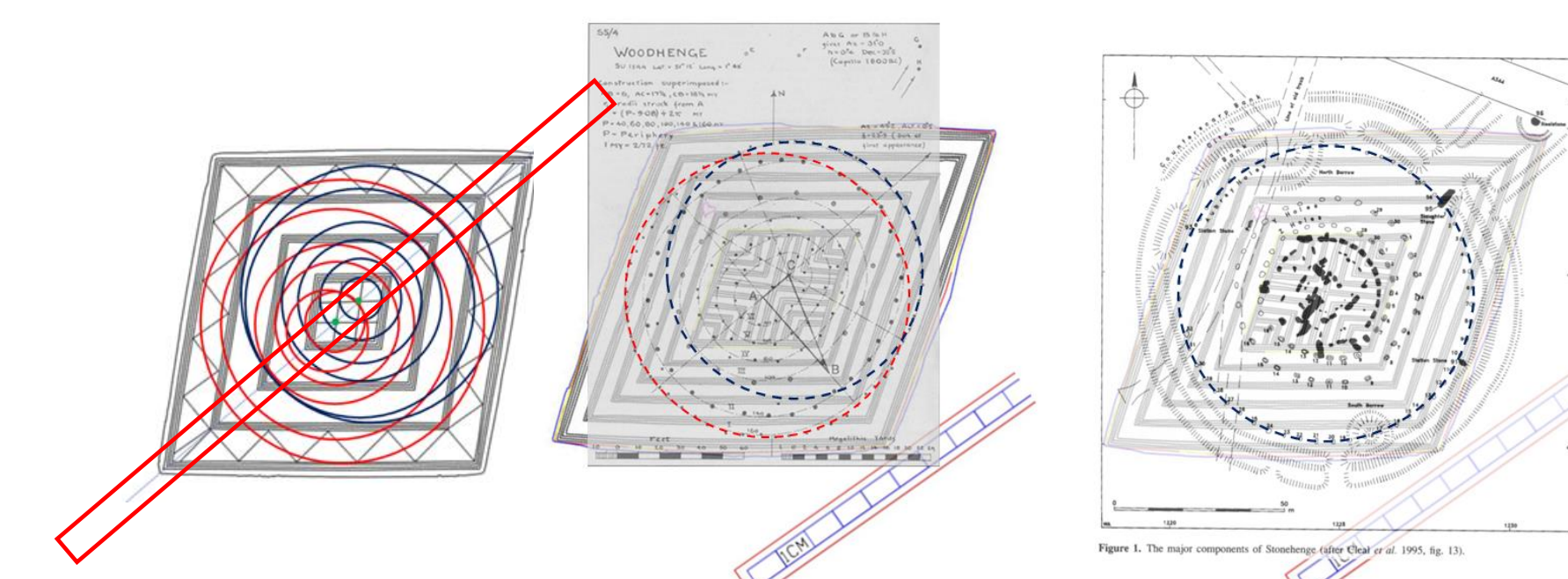


Fig. 9. Woodhenge: we model the site plan as two sets of concentric circles. By inscribing the outer layer with BBL, the two centers match exactly the two cross points along BBL's 40.5° diagonal. By further circumscribing both sites with CBL, the 1:2 ratio between Stonehenge and Woodhenge is revealed.

By circumscribing Woodhenge with lozenges, we discovered a 1:2 scale ratio between these two sites. This ratio not only verifies Woodhenge's conformance in orientation and scale, but also generates a resonance with Stonehenge to enlighten a lasting tradition passed down from the Neolithic Era to the Bronze Age. **Q.E.D.**

II. From Matching to the Base Unit

By circumscribing Aubrey Holes with Clanton Barrow Lozenge (CBL), every interior ring of Stonehenge is circumscribed by a band on CBL (Fig. 4), suggesting they followed one common pattern. This matching is highly unlikely a coincidence due to the presence of its striking scale factor—1:1000. Consequently, a base unit is hinted at, which is further reinforced by the common length between the long axis of CBL and the short axis of BBL (Fig. 5). BBL and CBL thus become rulers for this base unit. Because of this common length, 0.155m, we call this unit one Lozenge.

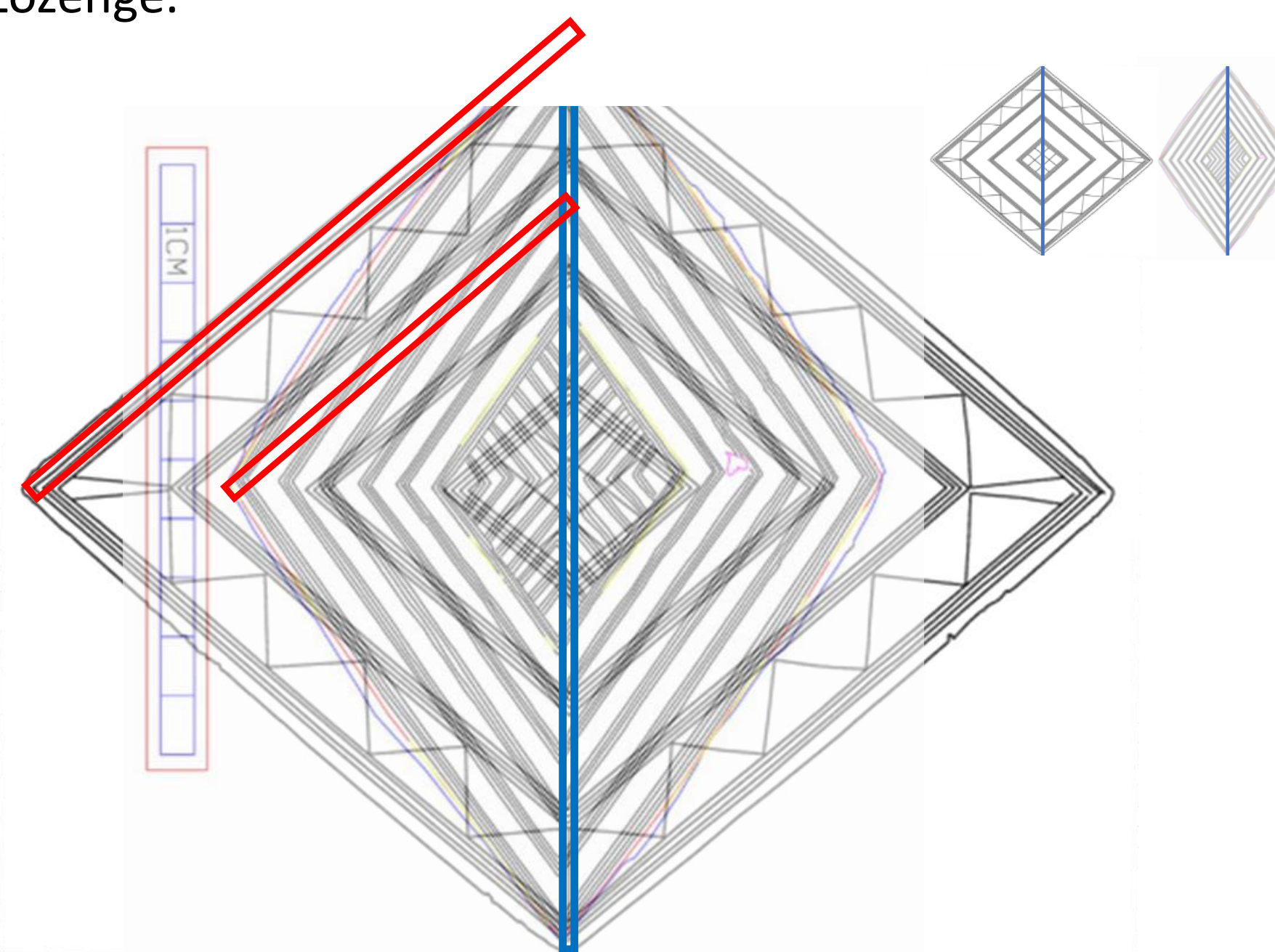


Fig. 5. Base Unit of Length: the matching length, 0.155m (Blue) qualifies BBL and CBL as rulers; and the 40.5° alignment (Red) on both BBL and CBL demonstrates a possible origin independent to Latitude 51.2°

In the unit of Lozenges, BBS is scaled at 0.2, ULB is scaled at 0.3, the gap between Sarsen stones is 20, and the gap between Aubrey holes is 10π . In addition, the Megalithic Yard, MY, is $(2\pi) \tan 40.5^\circ$ Lozenges. Factor π indicates the use of ropes looping around circular tree trunks, drums, or wheels with diameters in Lozenges, which could have been a practical feature for large sites.

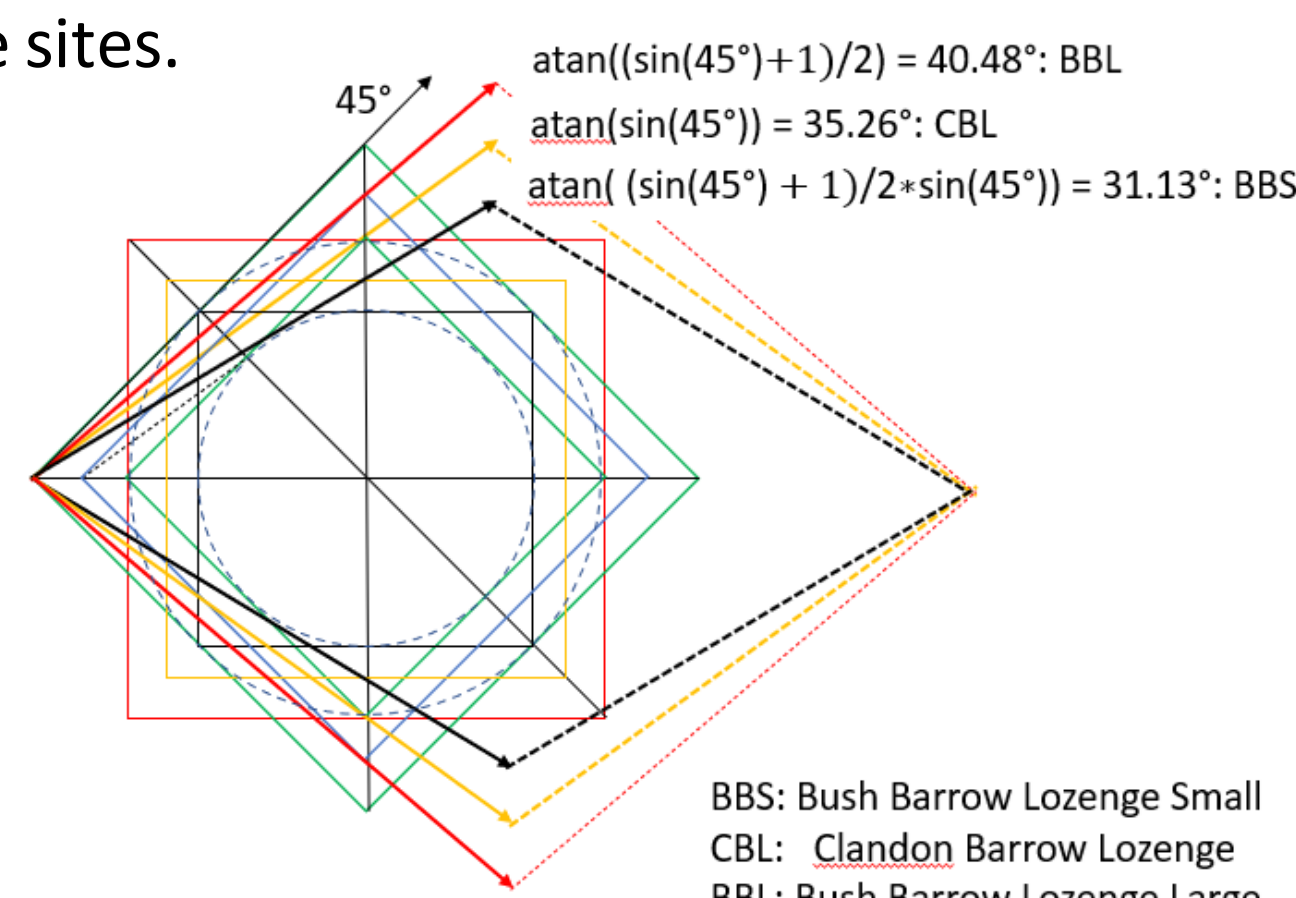


Fig. 6. Nested Square Pattern: (a) The pattern can be constructed by rotating squares by 45° or inscribing circles and squares in sequence. (b) It models BBL, CBL, and BBS more accurately than current models

III. Nested Square Pattern

We propose a nested square pattern (Fig. 6) to characterize both layers and angles of the lozenges in Fig. 2. Some derived forms are shown in Fig. 7.

Algebraically: $X_1 = 1$; $X_2 = \frac{(X_1 + X_3)}{2}$; $X_3 = \frac{1}{\sqrt{2}}$; $X_i = \frac{X_{i-2}}{\sqrt{2}}$ for $i \geq 4$

Numerically: $X = \{1; 0.854; 0.707; 0.604; 0.5; 0.427; 0.3536; 0.302; 0.25; \dots\}$

Approximately: $X_1 : X_2 : X_3 = 7 : 6 : 5$; $X_4 : X_1 \approx \frac{3}{5}$; $X_7 : X_2 \approx \frac{5}{12}$

Trigonometrically: $\theta = \arctan(X)$

$\theta_1 = 45^\circ$ models a square
 $\theta_2 = 40.48^\circ$ models Bush Barrow Large, BBL
 $\theta_3 = 35.26^\circ$ models Clanton Barrow Lozenge, CBL
 $\theta_4 = 31.13^\circ$ models Bush Barrow Small, BBS

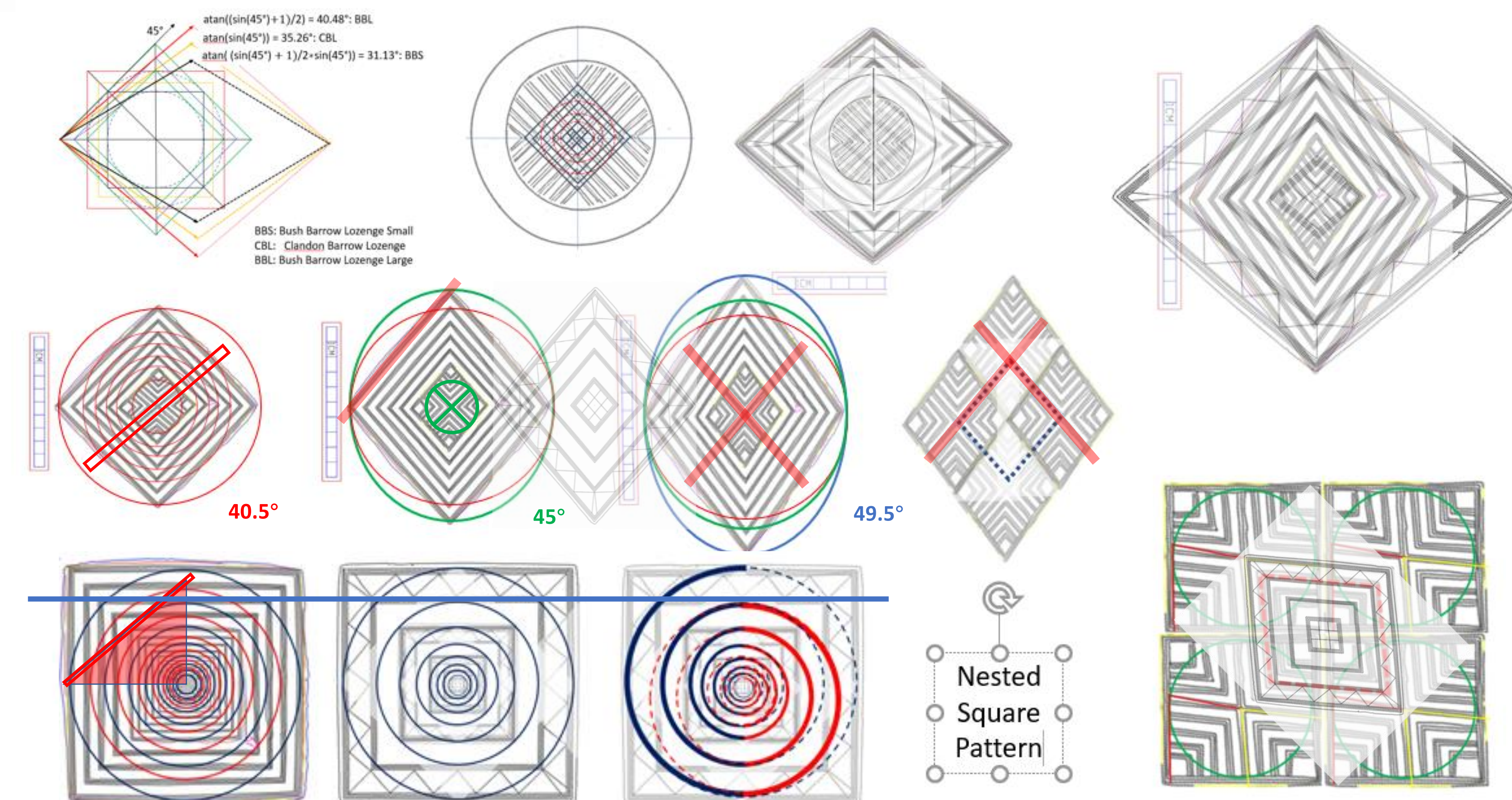


Fig. 7. Expressions of the Nested Square Pattern: mesh structure on CBL and ULB, concentric rings, spirals, and nonorthogonal crosses of 81° and 99°

Conclusion

40.5° means the solstice sunrise/sunset alignment at Latitude 51.2°; it also means a latitude-independent geometric pattern including a family of special angles and ratios between layers. Implied in this pattern were a base unit of length, 0.155m; the Base-2 and Base-10 scaling; measuring devices: ruler, protractor, and compass; and all the logical fundamentals: star gazing, time keeping, geometrical reasoning, design thinking, learning, and innovating. Profoundly intertwined, the double meaning of 40.5° uncovers Stonehenge's pivotal role as an astronomical observatory & standard bearer in the prehistoric world through its siting, design, construction, and operation.

Key References

Lockyer (1906)
 Hawkins (1963,1964)
 Thom (1967,1974)
 Hoyle (1977)
 Taylor (1980)
 Lawson (1997)
 Doutre (2001,2003)
 North (2007)
 Johnson (2008)
 Maumené (2017)
 Illiffe (2019)
 Jiang and Jiang (2021)

Materials and Methods

Materials (publicly available data)

- Photos and scales of artifacts and sites (e.g., Figs. 1-2)
- Phases and dating info: 3100-1700BC
- Astronomy and geometrical background

Methods

- Perform measurement and numerical experiments objectively
- Search for significant angles, simple ratios, scale-free patterns, and logically necessary instruments such as a protractor
- Design and test geometric models and keep simplifying them
- Mix and match artifacts with sites across locations, periods, and scales

Results

I. Matching for Cardinal Orientation

Bush Barrow Lozenge (BBL), "crown jewel of the King of Stonehenge," was unearthed within 800m of Stonehenge. By finding a good pivot, we obtain 12° multiples on BBL (Fig. 3). Meanwhile, the Sarsen Circle (Phase 3) locks BBL to the cardinal orientation and turns itself into a compass. Alternatively, by matching the Station Rectangle (Phase 3) with BBL's zig-zag vertices, the east-west direction is locked. Therefore, there is no need to assume prehistoric Britons encoded a Pythagorean Triple, 5:12:13, in the Station Rectangle.

1:1000

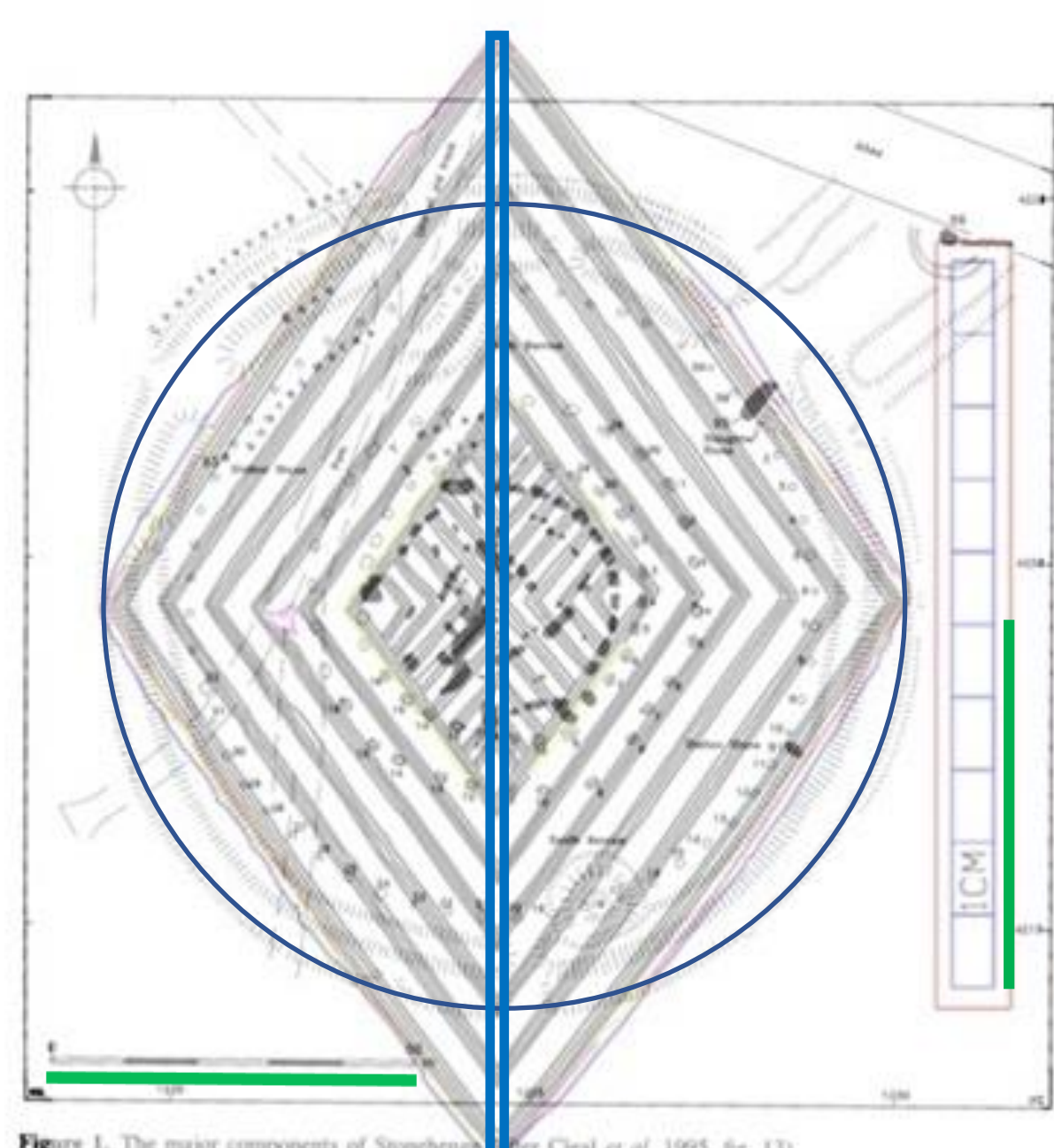


Fig. 4. Scaling: the 1:1000 scaling can be verified by the inscription of Aubrey Holes and by the outer bank of diameter 110m.