

STONEHENGE AS A SOLSTICE INDICATOR

One of the most impressive megalithic structures in the world is Stonehenge just north of Salisbury, England. I first visited the monument during my post-doctorate year in Europe back in 1961 and have been back several times since then. Its circular layout including huge semi-cut vertical sarasens topped by horizontal lintels is a remarkable achievement by people living some 4500 years ago. Here is a close-up picture which I took during my first visit-

CLOSE-UP OF STONEHENGE
(picture taken in 1961)



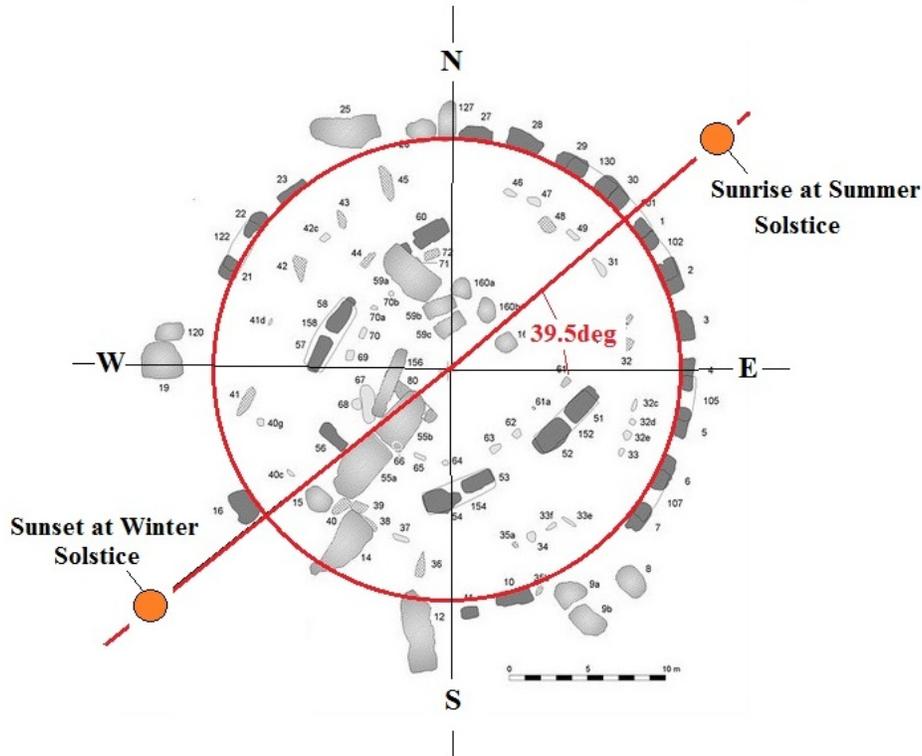
At that time one was free to roam throughout the structure, unlike today where a fence restricts access.

There have been numerous theories throughout the years by hundreds of archeologist and other researchers concerning the purpose of Stonehenge. The two major suggestions have been that it was an astronomical observatory measuring the position of the sun or that it was mainly a structure of religious significance used for worship and as burial sites. More recently there has also been the suggestion that the pre-bronze age people who built Stonehenge were using it to demonstrate their mastery of mathematics (see “Solving Stonehenge” by Anthony Johnson). All of these theories have their strong and weak points. My own view is that Stonehenge indeed was started as a primitive astronomical observatory as first proposed by Gerald Hawkins in his 1988 book “Stonehenge Decoded” and then developed into a place of religious significance. I agree with the critics, such as archeologist Richard Atkinson, that it is difficult to see how Stonehenge could be a

super-sophisticated astronomical observatory used for things other than simple winter and summer solstice determinations. Certainly Hawkins's claim that it was also used to predict solar eclipses and moon phases seems highly unlikely concerning the knowledge of people living at that time. Also I dismiss that Stonehenge was used to demonstrate skill in advanced geometry. There are much simpler ways to demonstrate such skills. Certainly the ability to level the slightly elevated ground upon which Stonehenge sits and to draw perfect circles using just a stake and a fixed length rope can account for all the geometry needed for constructing Stonehenge. There should be no need for more sophisticated geometry such as constructing 56 sided polygons as suggested by Johnson. To transport large stones over long distances, standing them erect and then placing lentils across the top is always possible with the efforts of a sufficient number of people (think of ancient Egypt and the building of the pyramids). The orientation of Stonehenge at the angle chosen was easy to establish by noting the position of the sun during sunrise and sunset on the longest and shortest days of the year. This requires no calendars or clocks. That the monument also became a religious center used for ceremonies and burials also makes sense since the observed daily and yearly perceived movements of the sun over this open plane must have made the locals think that such machine like precision must be controlled by their gods whom they should thank and worship for the changing of the seasons. It was certainly extremely important for these Neolithic people to know precisely when to plant and harvest their crops and Stonehenge was the key for knowing this by simply counting the days from winter and summer solstice. The fact that Stonehenge was also a burial place is attested to by the numerous graves and human bones found in its vicinity. Carbon dating has given the age of some of these as old as 2500BC.

We want here to briefly look at the astronomical aspects of Stonehenge. We start with a sketch of a top view of the monument as given by Anthony Johnson and then superimpose a closed red circle upon this sketch and also mark the north-south and east west directions by thin black lines. The resultant picture looks like this-

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We'll explain the diagonal red line later.

One notes that Stonehenge is located at exactly LAT 51.1788N and LONG 1.8262W. So we can easily calculate the hour angle HA at sunrise and sunset for any day in the year, if the sun's declination is known. The basic formula for doing so follows-

$$\cos(HA) = -\cot(COLAT) \cot(CODEC) = \tan(LAT) \tan(-DEC)$$

This formula originates from the spherical law of cosines after setting COALT to $\pi/2$ since the altitude ALT is zero at both sunrise or sunset. If we now consider the winter solstice on Dec 21, the declination will be -23.5deg and the latitude LAT=51.1788. Thus the Hour Angle becomes-

$$HA = 0.9998982 \text{ rad} = 57.28959 \text{ deg}$$

The fact that this hour angle is very close to one radian is interesting since it is only at the Stonehenge's latitude that this will happen during Winter Solstice.

We next take the calculated hour angle HA to determine the azimuth(AZM) using the formula-

$$AZM = \arcsin\{\sin(HA)\cos(DEC)\}$$

to produce-

$$AZM = 50.500398 \text{ deg}$$

Thus the sunset at Stonehenge during the Winter Solstice will be $90 - 50.500398 = 39.499602$ deg relative to the east- west line. We have drawn a diagonal red line through the monument center showing this angle. The midsummer sunrise will occur along this same line but in the north-east quadrant as shown. The fact that sunrise and sunset lie along the same line must have been again something very mysterious to the Neolithic inhabitants of Stonehenge.

If we now examine the above schematic in more detail, it becomes clear that the ground plan of Stonehenge is clearly symmetric about this 39.5 deg diagonal line, **leaving no doubt that the monument was used as a solstice indicator**. This fact is further supported by the location of a tall stone (Heel Stone) standing some 77.4 meters away from the monument center in the north-east quadrant and near the 39.5 deg line. It presumably helped with the sighting of sunrise during the summer solstice. One should look for some ground disturbance along the 39.5 degree line at 77.4 meters from the monument center in the south-west quadrant to see if there might have been another Heel Stone at one time to help with locating sunset during the winter solstice. You will notice that it is the large trilithons inside the stone circle and the stones 16 and 56 which play the critical role in the solstice determination. The outer stone circle seems to have no astronomical significance. It was probably added to make things look more impressive and to help with the religious aspects of the place. Certainly solar alignments at solstice can be achieved with just two rocks placed along a line of sight or even just one stone and its cast shadow.

A few miles from Stonehenge one finds the town of Avebury. Some of its houses sit in the middle of a huge 400 meter diameter circular elevated berm believed to have been constructed by the same Neolithic people as were living at Stonehenge. It is possible that the circular berm had some astronomical significance before becoming more of a religious site. The row of vertical stones found just inside the berm could have been used to mark certain days of the year and thus served the purpose of a yearly calendar. The berm acts as an artificial horizon where the sunset or sunrise on a given day can be uniquely determined by someone standing at the circle center. The points where the rising sun first appears over the berm or where it first sinks completely below the berm would be recorded and stone markers placed to indicate these points. The accuracy of such a measurement for summer and winter solstices would be expected to be more accurate than that achieved at Stonehenge by a factor of $200/77.4$. The sunrise and sunset points throughout the year would lie in two 79 deg sectors each bisected by an east west line passing through the circle center. The actual length along the berm between sun rise at the winter solstice and sunrise at the summer solstice would be about 276 meters.

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