

**UDAYAGIRI HILLS IN MADHYA PRADESH – AN ANCIENT  
ASTRONOMICAL SITE**

**BY**

**ANAND M. SHARAN  
PROFESSOR  
FACULTY OF ENGINEERING  
MEMORIAL UNIVERSITY, ST JOHN'S  
NEWFOUNDLAND, CANADA  
E-MAIL: [asharan@engr.mun.ca](mailto:asharan@engr.mun.ca)**

**AND**

**MEERA DASS  
INTACH, BHOPAL  
INDIA**

## **ABSTRACT**

This work involves a detailed study of the ancient astronomical site at the Udayagiri Hills near Bhopal, Madhya Pradesh. Various spots on this site are identified based on the remains that exist now. The work shows that the important role played by Udayagiri Hills in the ancient times –was not known to the researchers in the field of archaeo - astronomy.

## NOMENCLATURE

$\alpha$	Angle in vertical plane
$\alpha_s$	Angle in horizontal plane
$\gamma$	Latitude of the place
$\delta$	Declination
$h_s$	Hour angle at any instant of time
$h_{sr}$	Hour angle at sunrise measured from noon
N	Day number of a year

## 1. GUPTA ERA AND THE FIELD OF ASTRONOMY

Gupta Era is called the golden era of India. This era brought political stability to the country. The country saw all round development across India. In this era, the monarchs were brave, and at the same time, encouraged art and learning<sup>1-6</sup>. Among different fields, astronomy was one of them. Western Malwa was annexed by Chandragupta Vikramaditya between the years 388 AD to 400 AD<sup>1,6</sup>. With this annexation, he spent considerable amount of time in this part of his kingdom, and Ujjain became important.

However, Eastern Malwa was already a part of his father's ( Samudragupta's ) kingdom. The beginning of the Siddhantic era is considered as 408 AD<sup>7</sup>. Balasubramaniam<sup>8,9</sup> has done considerable amount of research on the Gupta era including astronomical studies. Joseph<sup>10</sup> mentions that Ujjain in the Western Malwa acquired importance in the study of astronomy during this era. The principles of Suryasiddhanta<sup>11</sup> saw the consolidation of its concepts during this time. This was possibly due to the fact that it was located on the Tropic of Cancer, and it was also a holy city for the Hindus.

One can say that the importance of the locations on the Tropic of Cancer was already there amongst the astronomers in ancient India even before the annexation of Western Malwa by Chandragupta II. In this respect, Udayagiri, which was formerly called Vishnupadgiri, did have importance for solar observation. Such scientific experimentations had played important role in the formulation of the Suryasiddhanta. Other relevant information about the astronomical aspects can be seen in<sup>12,13, 17-22</sup>. Furthermore, Cunningham had spent some time at Udayagiri<sup>14-16</sup> and has written about Udayagiri.

In view of the above, this work was taken up to bring out more astronomical aspects of Udayagiri.

## **2. SOLAR OBSERVATORIES AT UDAYAGIRI.**

### **2.1 SOUTH HILL**

Udayagiri is a rare place in India where one sees the experimental science at work. The ancient astronomers had chosen special place to observe the motion of sun. Fig. 1 shows the map of Udayagiri which has a hill on the south where a solar observation platform ( Number 2 in Figs. 1, and 1C ) was built. The orientation of southern edge of this platform is parallel to the sun rise direction on the Winter Solstice day ( shown in Fig. 3C ). The authors<sup>16</sup> mention the location of the Lion Capital (Fig. 3 ) of Udayagiri to have been found at the location Number 1 ( Figs 1, and 1C ). This Capital was mounted on an octagonal pillar. Fig. 3 shows the spots where four animals / birds were carved out on each side of the pillar. These authors have made attempt to explain the significance of these eight animals / birds (four on each of the two sides of the Lion )

Fig. 2 shows the location of various caves in the passage which was cut out between the two hills (Figs 1B , and 2) , A broken segment of the octagonal pillar was found in the passage near the gate to the Elephant Path shown in Figs 1B and 2. It is just possible that the animals / birds were carved out at angular locations based on Fig. 3B which has eight vertices, and where the Lion was facing due east<sup>16</sup>. This figure shows clockwise and counter clockwise arrangements to depict the orientation of the animals drawn on the Lion Capital. Incidentally, the base of the pillar was also octagonal, and possibly, each animal was carved out in alignment with the eight edges of the octagonal base of the pillar.

The authors<sup>16</sup> mention that the pillar having the Lion on its top - was used as a vertical gnomon. They mention that it was possibly used as a sun dial. They mention the existence of several holes for mounting posts on the raised platform ( Number 2 in Fig. 1C or Fig. 3C)

However, considering the fact that the Suryasiddhanta shows sophisticated principles in it<sup>11</sup>, and also, the fact that the Hindus had understood very subtle motion of the precession of the earth's axis<sup>11, 12</sup> - it is quite possible that they were carrying out more sophisticated experiments at this location. One such experiment could have been the determination of the winter and summer solstices, as well as the equinoxes<sup>22</sup>.

Fig. 4 shows an instrument / mechanism ( Yantra ) located at Ujjain. A vertical gnomon is shown at its center, and also, one can see various curves drawn out on the raised platform. It is called a Sanku Yantra. One can draw these curves by tracing the tip of the shadow of the gnomon on various days which include the equinoxes, as well as solstices. The equinoxes produce straight line as this happened on the day this photograph was taken. Thus, by constructing such an Yantra, one can determine these special days of the calendar.

Based on the value of the latitude of Tropic of Cancer in 400 AD<sup>16</sup>, calculations were performed . One can calculate  $\alpha_s$  and  $\alpha$  ( shown in Figs 5, and 6 ) using the following formulas<sup>23-25</sup>

$$\delta = 23.45 \sin \{ ( 360 / 365 ) ( 284 + N ) \} \quad ( 1 )$$

where  $\delta$  is the declination of the sun in degrees, and N is the day number, which is the number of the day in a year. For example, on January 1, N is equal to 1.

The time of sunrise,  $h_{sr}$  in hour angle from the noon, is calculated from

$$h_{sr} = \cos^{-1} \{ - \tan ( \delta ) \tan ( \gamma ) \} \quad ( 2 )$$

where,

$\gamma$  is the latitude. Denoting the instant of time in terms of the hour angle from the noon as  $h_s$ , one can write

$$\sin (\alpha) = \cos (\gamma) \cos (\delta) \cos (h_s) + \sin (\gamma) \sin (\delta) \quad (3)$$

and by expressing the angles in degrees, one can write

$$\alpha_s = \sin^{-1} \{ \cos (\delta) \sin (h_s) / \cos (\alpha) \} \quad (4)$$

if

$$\cos (h_s) > \{ \tan (\delta) / \tan (\gamma) \}$$

or

$$\alpha_s = 180^\circ - \sin^{-1} \{ \cos (\delta) \sin (h_s) / \cos (\alpha) \} \quad (5)$$

if

$$\cos (h_s) < \{ \tan (\delta) / \tan (\gamma) \}$$

The calculations were performed by dividing the morning period into 100 parts (instants of time). The afternoon values were obtained by the symmetry of the curve about the noon.

The results for Udayagiri in the year 400 AD, on important days, are shown in Fig. 7. Fig. 6 shows the shadow OO' of the gnomon OP. The curves in Fig. 7 are the plots of the point O' on different days. The height of the gnomon, OP, used for the calculations was 0.914 meters (36 inches).

Fig. 7 shows that on the summer solstice day (N = 172), at noon, the sun is almost vertical - the points O and O' in Fig. 6 are almost coincident. The nature of the curves (curvatures) on the solstice days are opposite. Of course, on the equinoxes, one gets a straight line.

## **2.2 THE PASSAGE**

The orientation of the statue of Anantasayin Vishnu ( Cave 13, Fig. 2 ) matches with the orientation of the rising sun on the Summer solstice day is well known in literature<sup>9,12,16</sup>. A view of this cave is shown in Fig. 7B. This picture was taken looking at the passage from the front of Cave 13 .

## **2.3 THE NORTH HILL**

On this hill, one finds a broken pillar near the Surya Temple (Number 5 , Fig. 1 ). This temple is located at the highest point on this hill, and it faces exactly east. The exact alignment of this cardinal direction could have been obtained from the shadow of the pillar possibly used as gnomon ( refer to Fig. 8 ). The southern side of the pillar and that of the temple are aligned along the east – west line. This picture shows a very small part of the temple as well as the pillar in front of it.

Secondly, Figs 8B, and 8C show the fragment of a piece found near the pillar. These figures clearly show female figures which are actually part of the 27 nakshatras.( asterisms ) These female figures are the 27 nakshatras who were supposed to represent the 27 queens of the moon<sup>26</sup>. It shows that the astronomers in this era had given the field of astronomy – a human touch.

On the north hill itself, if we drop down from the top of the hill a bit to the north, we find another ancient solar observation site ( Number 6, Fig. 1 ). The photographs of this site are shown as Figs 9 and 9B. In Fig. 9B, one can see a recently built structure which would not have been there in ancient times. This way, this location would have been an excellent location for astronomical experimentations ; from this place , one could have had an unobstructed view of the rising sun.

## **2.4 SUITABILITY OF UDAYAGIRI HILLS OVER UJJAIN FOR ASTRONOMICAL OBERVATIONS**



The author has visited the Ujjain observatory also, and had a look at the astronomical site. The site lies on a flat land and one does not have as clear a view of the surroundings as Udayagiri hills offers. The picture (Fig. 4) was taken at the Ujjain site.

The preference for a hill top over a flat land with obstructed view can be seen even to-day. Examples are the astronomical observatories located on the peaks of the mountains such as those in Nainital ( India ) , Hawai, or Arizona. There are several such sites in Europe, and South America also.

### **3. CONCLUSIONS**

In this study, a historical review of the developments of Ancient Indian Astronomy was undertaken. Based on the literature search, a detailed study of this site was undertaken, and important locations on the Udayagiri Hills were identified.

It is concluded that:

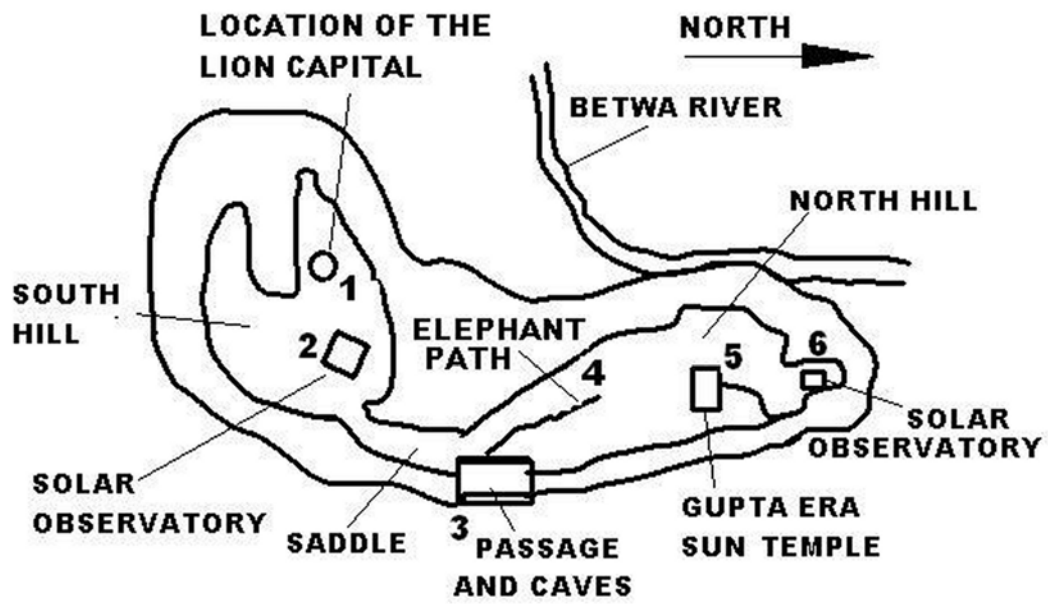
- (1) Udayagiri Hills has several important remains as far as the astronomy is concerned, and
- (2) The role played by Udayagiri in the past was far more important than what is known to the researchers these days. These researchers know that Ujjain was the only important place in this respect.

### **4. REFERENCES**

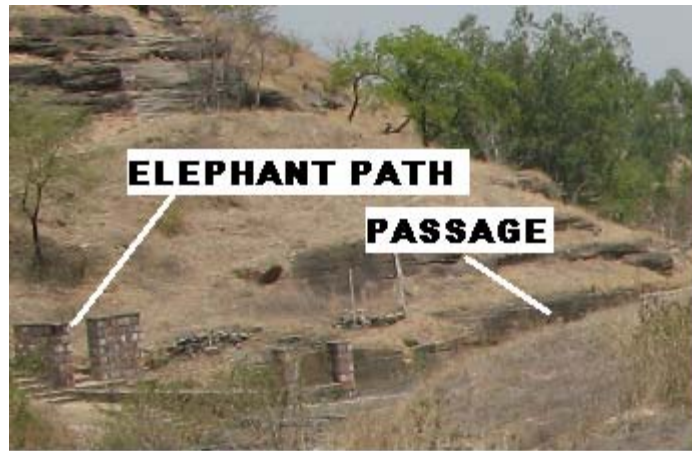
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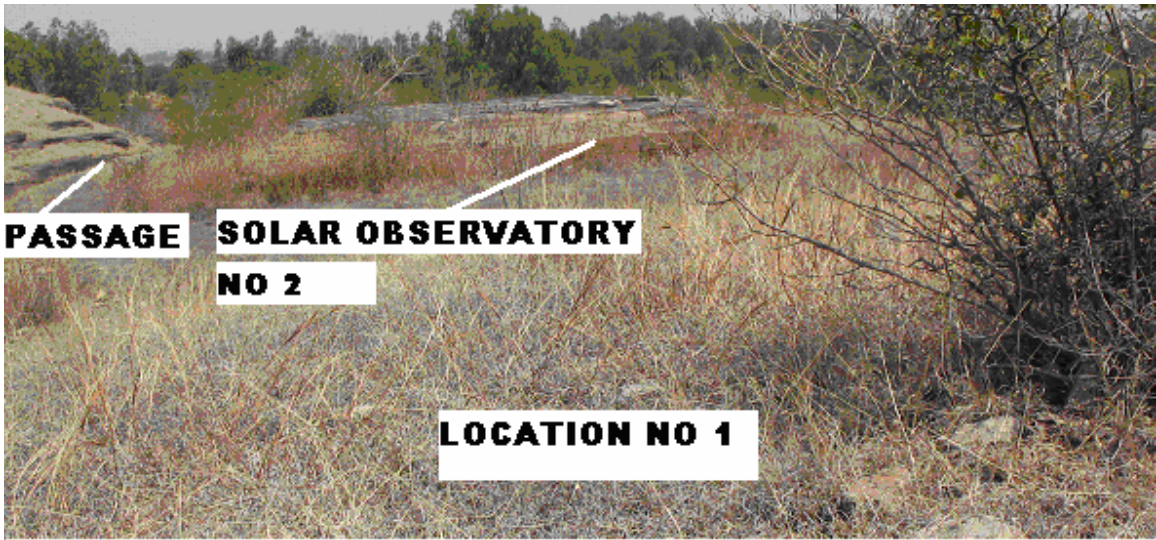
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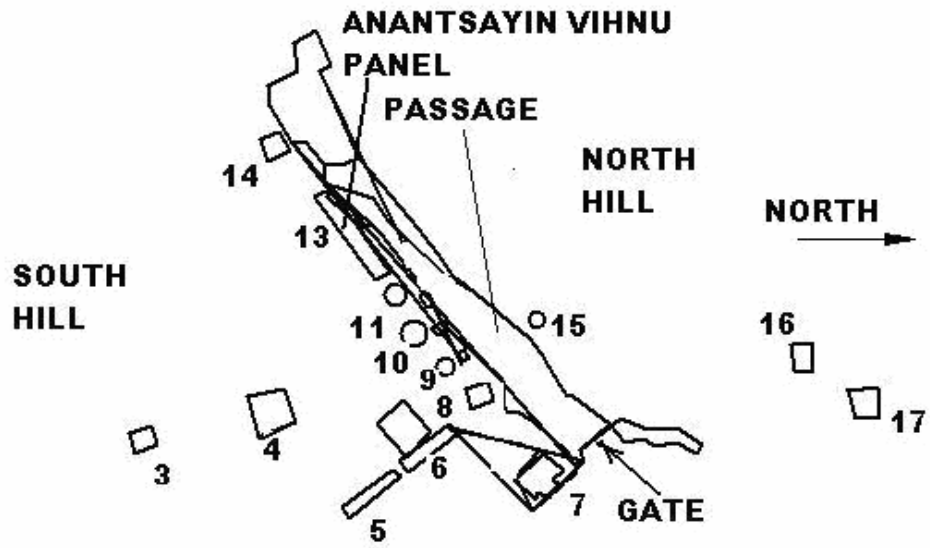
**FIG. 1 GENERAL PLAN VIEW OF THE ASTRONOMICAL SITE AT UDAYAGIRI**



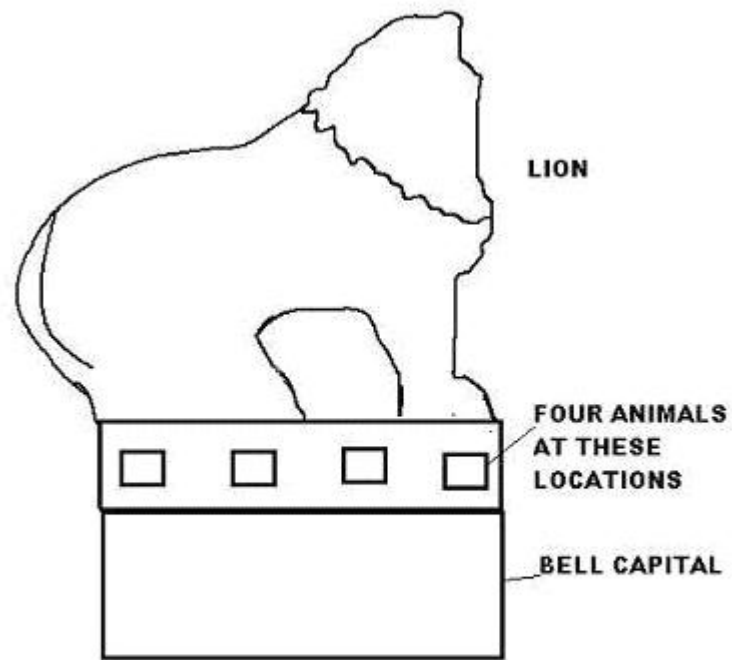
**FIG. 1B A VIEW OF THE PASSAGE  
FROM THE SOUTH HILL**



**FIG. 1C A VIEW SHOWING RELATIVE LOCATIONS ON THE SOUTH HILL**

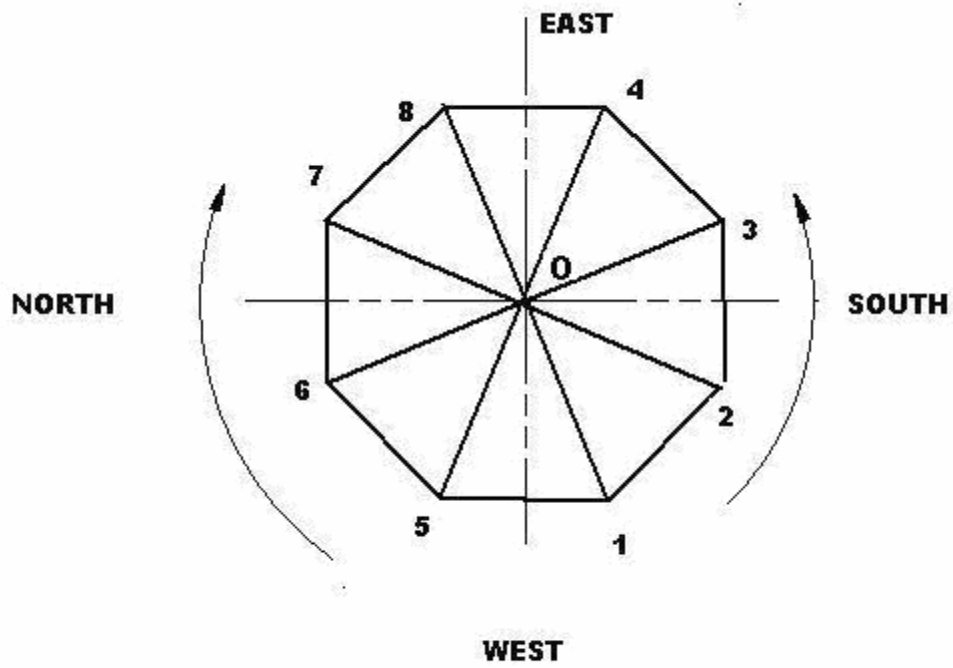


**FIG. 2 PLAN VIEW SHOWING LOCATIONS OF CAVES AND PASSAGE**



**FIG. 3 THE LION CAPITAL AT UDAYAGIRI**





**FIG.3B FACES OF ANIMALS ARRANGED IN CYCLICAL ORDER**



**FIG. 3C A VIEW OF THE PLATFORM  
ON THE SOUTH HILL WITH ONE SIDE  
ALIGNED WITH WINTER SOLSTICE  
DIRECTION**



**FIG. 4 SANKU YANTRA AT UJJAIN ON MARCH 21, 2005**

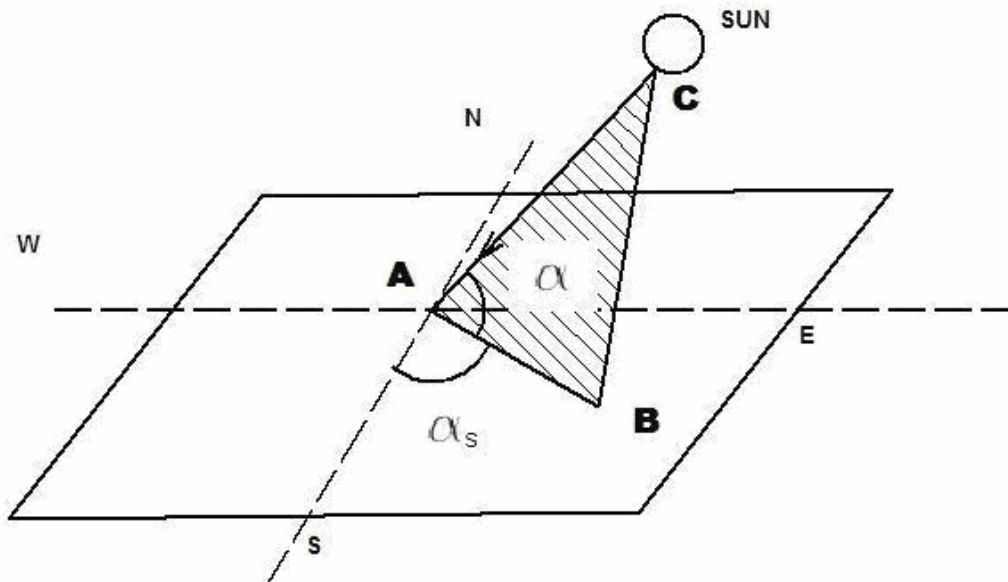
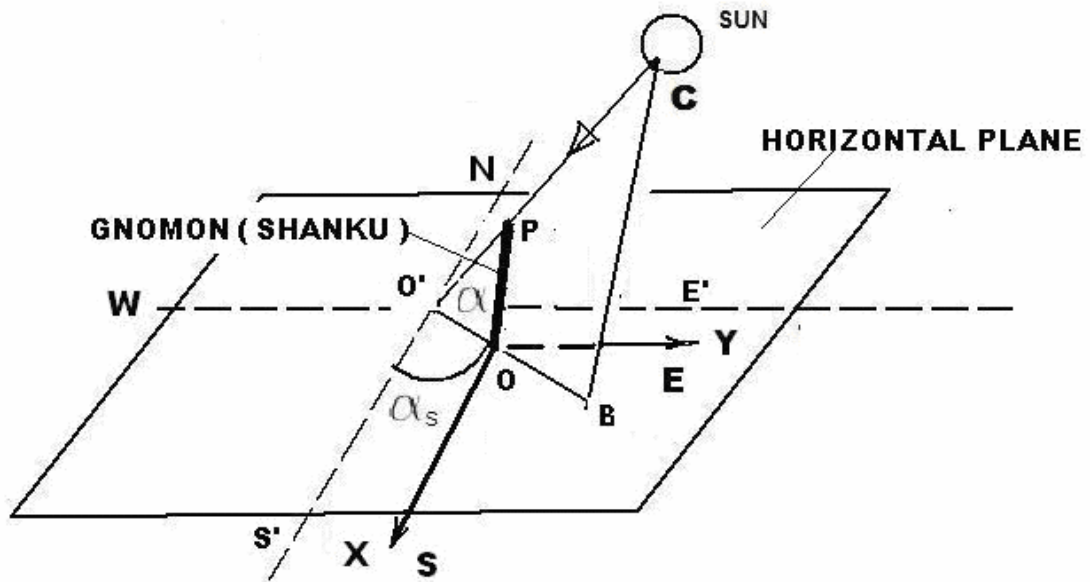
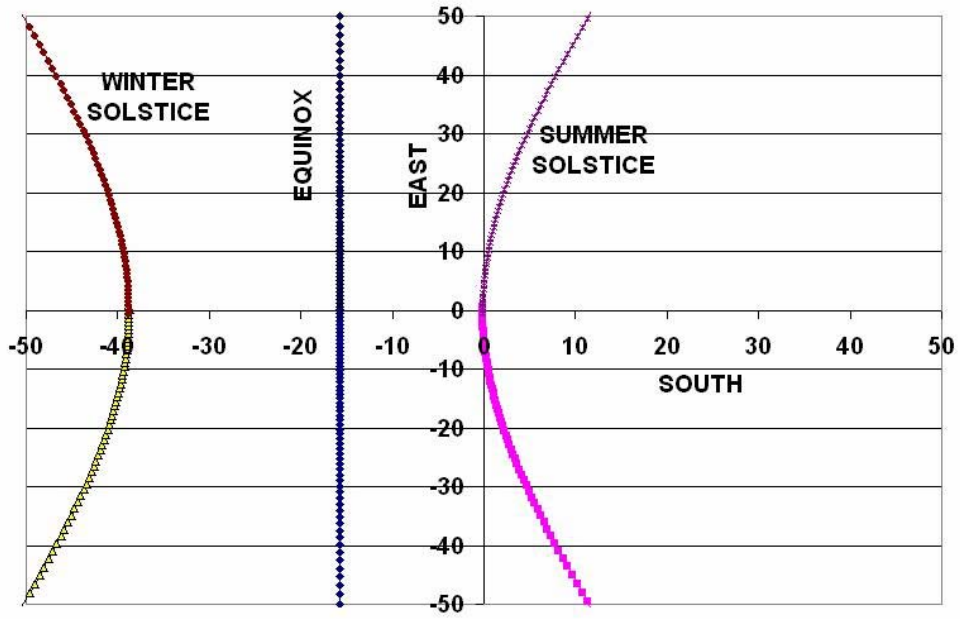


FIG. 5 DIAGRAM SHOWING THE SOLAR RAY DIRECTION USING TWO ANGLES



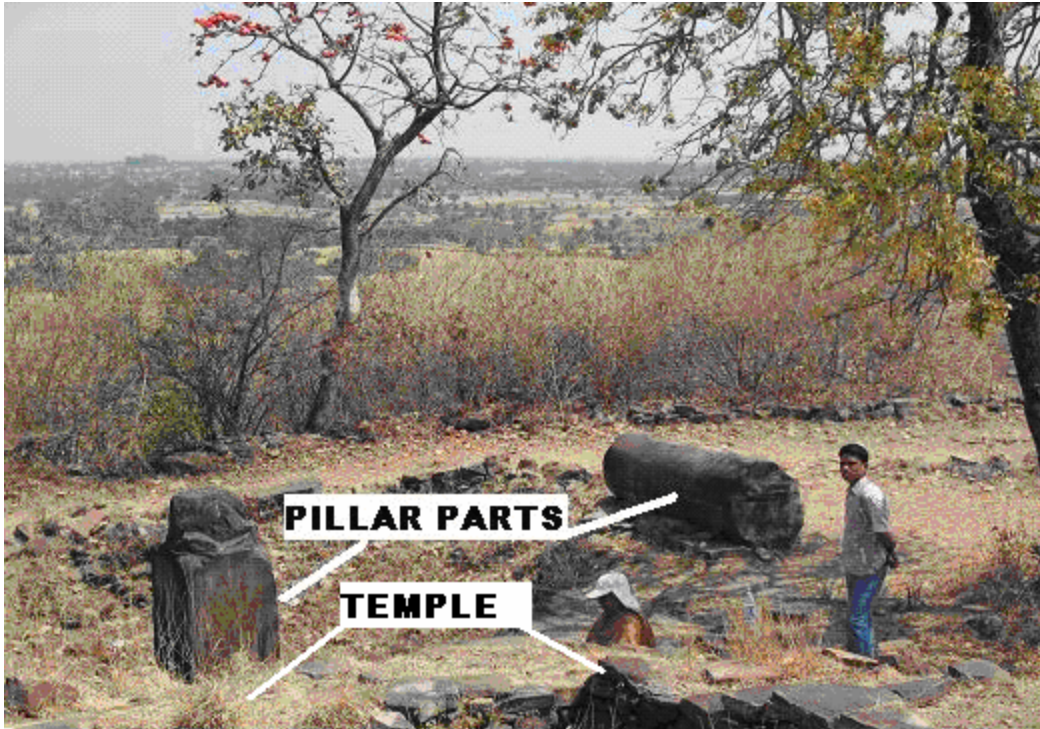
**FIG. 6 USE OF VERTICAL GNOMON IN DETERMINING ASTRONOMICAL PLANAR CURVES**



**FIG. 7 PLOT OF THE TIP OF THE SANKU ON VARIOUS IMPORTANT DAYS**

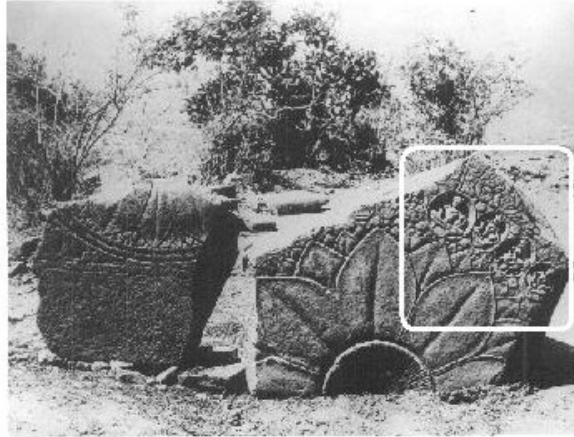


**FIG 7B A VIEW OF THE PASSAGE FROM THE FRONT OF CAVE 13. THE DIRECTION IS PARALLEL TO THE SUN RISE DIRECTION ON THE SUMMER SOLSTICE DAY**



**FIG. 8 BROKEN PILLAR IN FRONT OF SURYA TEMPLE**





**FIG. 8A BROKEN PIECES NEAR  
THE PILLAR AT SUN TEMPLE**



**FIG. 8B AN ENLARGED VIEW OF THE SELECTED AREA IN  
FIG. 8A. IT SHOWS THE FEMALE FIGURES  
REPRESENTING THE NAKSHATRAS.**



**FIG. 9 A VIEW OF THE SOLAR  
OBSERVATION SITE ON THE NORTH HILL**



**FIG. 9B A CLEAR VIEW OF SURROUNDINGS FROM NORTH HILL**

