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Astronomy with Buddhist stupas of Sanchi

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Abstract. It is suggested that the Buddhist stupas of Sanchi including the Great stupa built by Sunga kings around 2nd century BC are oriented towards the moonrise and sunset on the day of Buddha purnima. The arrangement of the inner and outer balustrades of both stupa 1 and stupa 2 might have been used as luni-solar astronomical calendar. It is suggested that Sanchi stupas is one of the oldest astronomical monuments presently known in India.

Key words : Stupas—Buddhist—History

1. Introduction

In tracing the history of observational astronomy in India alignments derivable at the ancient monuments have great significance. The buddhist monuments at Sanchi, particularly the stupas are few of the oldest architectural stone monuments existing, dating back to the time of Emperor Ashoka (3rd century BC). The stupa, originally a monument built over the relics of Buddha had acquired a second meaning, it became a geometric image of Buddhist cosmology, "oriented as precisely as possible towards the four cardinal points, with its measurements based on numerical symbolism" (Volwashen 1969). Further it is stated that the structure should be interpreted in terms of "those elements derived from the Solar symbolism that set the circle of railing in motion as the course of the sun or as the infinite cosmos". The association of stupa to the course of the celestial guardians, the sun and moon, are shown in buddhist sacred texts (Kern 1963) as well as on the Satavahana coins of 1st century AD (Elliot 1885).

However the site plan of the great stupa (Stupa No. 1) shows that the north-south axis of the stupa is shifted by about 15 degrees west of south as pointed out by Sir John Marshall who has worked extensively on the monument in 1913-14. In this study we would like to stress on two aspects : one, the alignment of the stupa and two, the arrangement of railing posts. The main source of the material is from the classic work of Sir John Marshall (1940, 1983).

2. Brief history and description of the stupa

The great stupa, according to Marshall was originally built by Ashoka in the middle of 3rd century BC (~ 250 BC), as a hemispherical dome structure with a cylindrical base of

baked bricks set in clay. The original structure has a diameter of 60 feet (ft) at the base. A crowning pinnacle (harmika) surmounted by one or more umbrellas (Chatravali) is placed within a small square railing on top of the dome. The stupa may have been encompassed by a processional path (pradakshina-patha) and a circular railing on the ground level and by another smaller railing on the berm of the terrace. The railing was probably made of wood. In addition to the stupa, Ashoka had installed in 254 BC an edict pillar which stands about 50 ft away from the South Gateway.

Later around 150 BC the Sunga Kings (most probably Agnimitra) took great interest and expanded the great stupa referred to by archaeologists as stupa no. 1, to almost double its size. In addition, they also built few more smaller stupas, particularly stupa 2 and stupa 3 which will be referred to later on. The extended stupa was encased in masonary structure and the dome (anda) was increased to over 120 ft in diameter and its height to about 54 ft. This is surrounded at the base by a lofty terrace in stone (medhi), a second processional path at a height of 15 ft 6 in with an average projection of 5 ft 9 in at the foot of the dome. Access to this is provided by a double flight of 25 steps (sopana) built against it on the southern side. On the top of the anda, the harmika is located inside a square balustrade measuring 21 ft 6 in on each side containing 8 posts (a total 28). A mast provided with three umbrellas (chattre) was mounted on harmika. The whole monument is surrounded at a distance of 9 ft 6 in by a ground balustrade, the biggest and a most massively built one with a height of 10 ft 7 in, above the ground containing four entrances. These divide the balustrade into four quadrants of 30 posts consisting in all 120 posts. Later when Andhras (Satavahanas) succeeded the Sungas the entrances to the lower circumbulatory path was slightly altered and rebuilt and four splendid gates (toranas) were erected on all four sides.

The whole complex of the Buddhist monuments including stupa 1 and 3 are located on Sanchi hill which is about 300 feet high and described as whale-back in shape. Stupa 2 however is located on the western slope of the hill about 350 ft from stupa 1.

3. The orientation of stupa 1

In regard to the orientation of the stupa (figure 1) Marshall remarks that "It will be observed however from pl. 4 that this entrance (south) did not face due south but 15 degrees west to south. Probably this aberration was due to the position of the Ashoka pillar, a fixture of a kind that could not easily be shifted. As we have seen this pillar stood about 50 ft in front of the south entrance of the original brick stupa of Ashoka and had the enlarged stupa been built on the same axis as the original one, the pillar would have stood right in the middle of the southern entrance way, where it must inevitably have caused inconvenience to the worshippers passing in and out. To avoid this difficulty the axis of the restored stupa seems to have been shifted round about 15 degrees. Thus leaving the pillar to stand clear of the new constructions in the angle of the balustrade".

Further he adds "If as I suppose this alteration of the axis was due to the awkward position of the pillar, it seems to indicate that the extension to the gateways, as they now exist, though admittedly later than the ground balustrade were nevertheless part and parcel of the same design; for unless this had been so, it would not have been necessary to deviate *so far from* the true south".

If one is to take this argument seriously, one is led to believe that Sungas designed the stupa in such a way as to make allowance for Andhras, who were to arrive on the

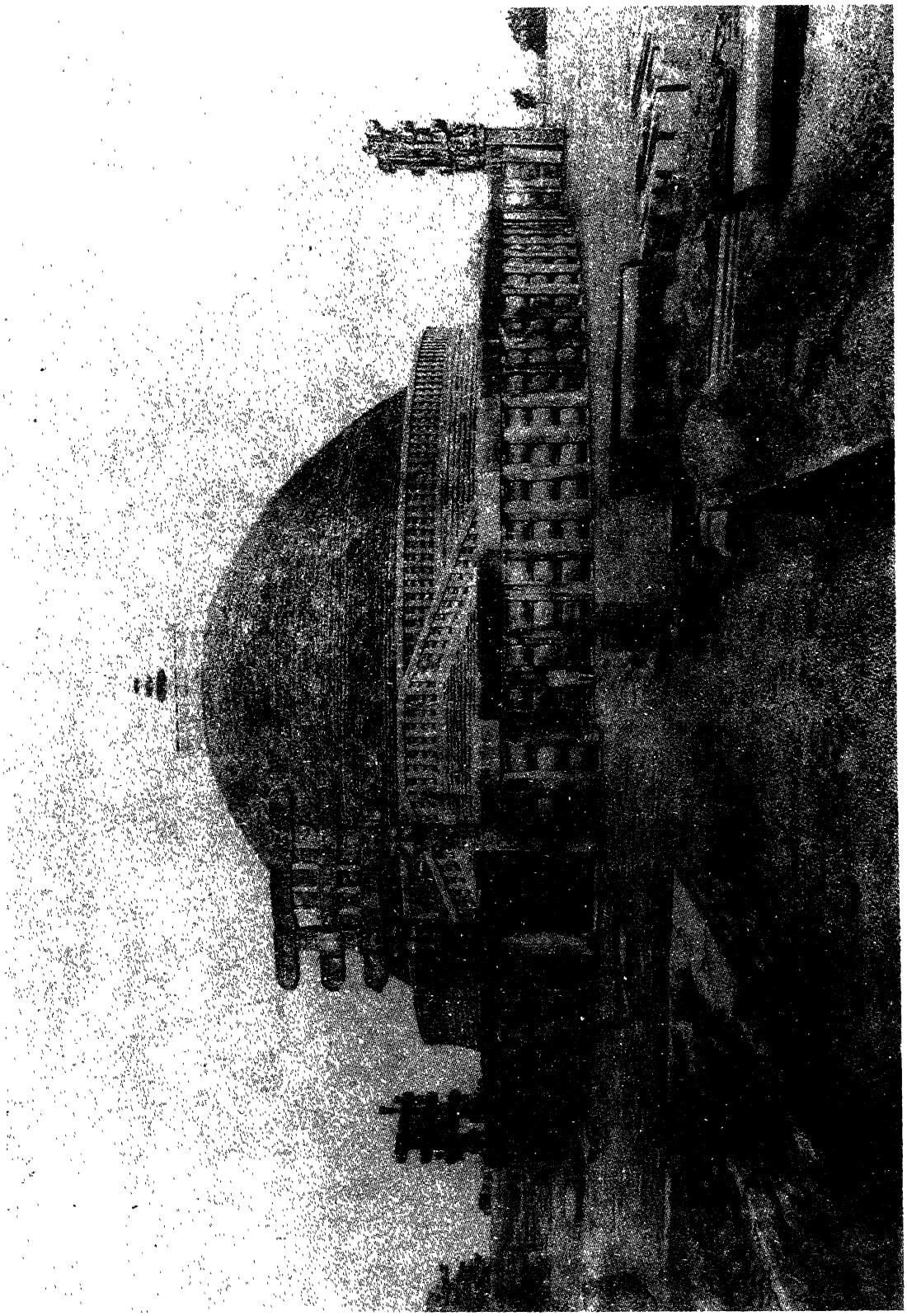

Figure 1a. The general view of the monument stupa 1 from south.

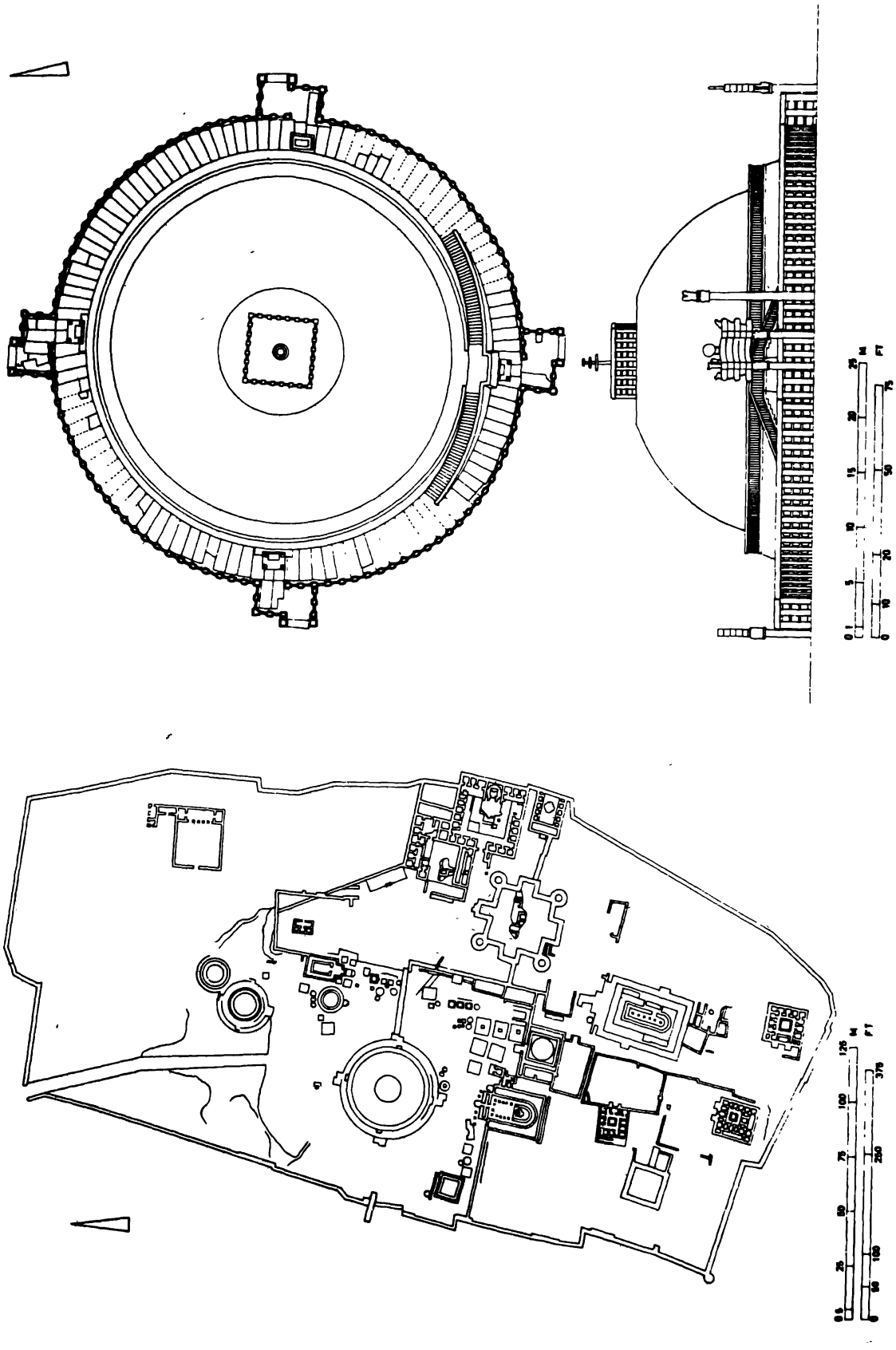

Figure 1b. The plan of stupa 1. illustrating particularly the slabs in the outer pradakshina patha. These number 115 according to the plan given in Volwashsen (1969).

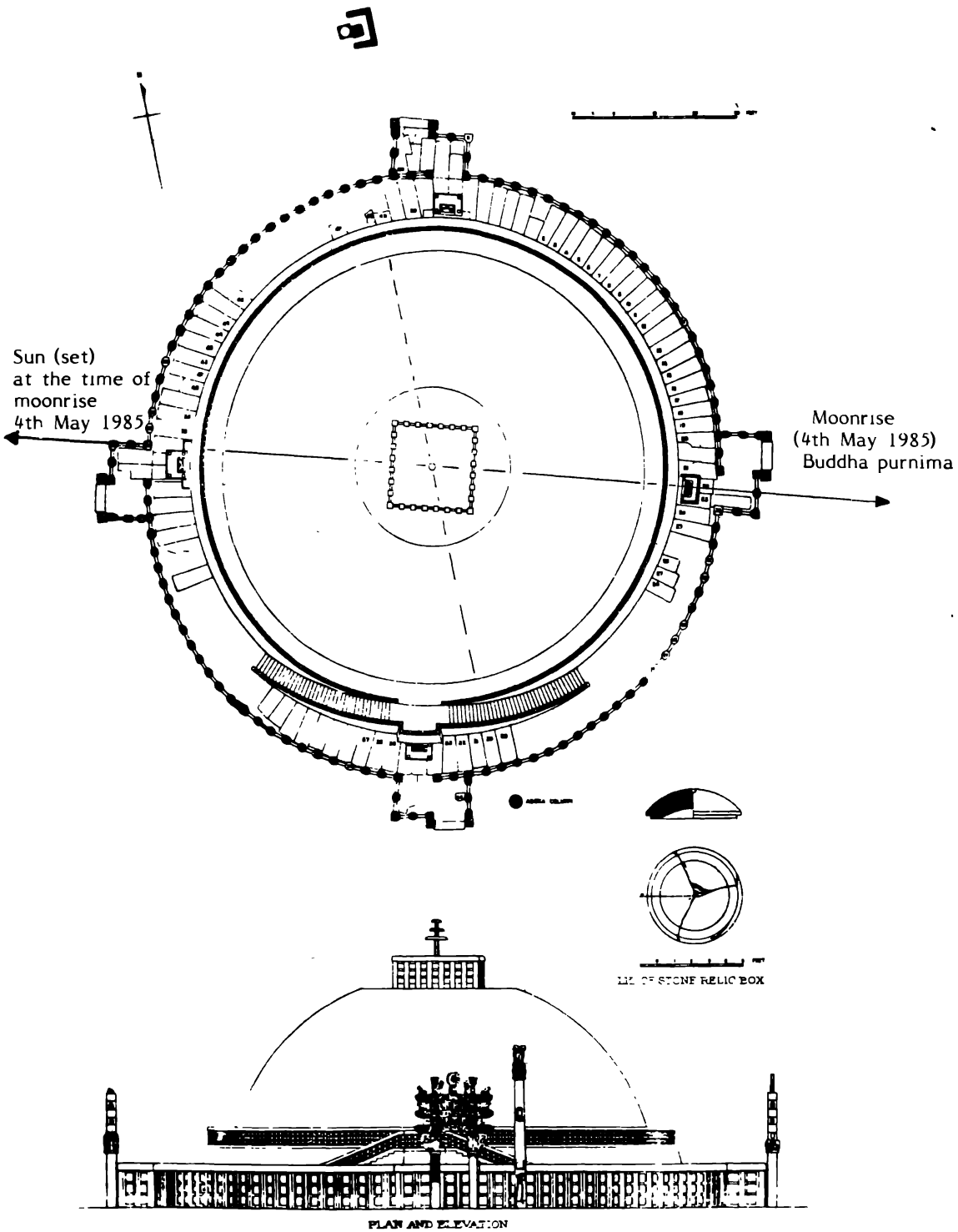

Figure 1c. The plan of stupa 1 from Marshall and Foucher. The direction of the moon rise on Buddha Purnima (on 4 May 1985) is indicated along with the direction of the Sun at that time in the West. "The stupa is here shown as enlarged and restored under the Sunga regime with the four gateways subsequently added under the Andhras. The pillars of the ground balustrade which are shown shaded in the plan, are original pillars still in situ; those without shading are modern restorations (cf. p. 16). Note that the number of steps in each flight of steps should be twenty-five, not as shown in the plan. This error on the part of the draftsman was not discovered until after the Plate had been printed", Marshall (1940).

scene 100 to 150 years later, to erect the toranas and alter the gates—which does sound too far-fetched.

Secondly, it is hard to believe that people who could expand the whole stupa to double its size and build it with stone masonary on a large scale were incapable of shifting the Ashoka pillar (if necessary).

However the main objection to Marshall's view is that if they had altered the orientation of the stupa 1 by 15 degrees, out of necessity there was no need to similarly orient other stupas, which were built around the same period (*e.g.* stupas 2 and 3). But the layout of both stupas 2 and 3 show clearly that they were also oriented exactly the same way as stupa 1 (figures 2 & 3). So it is likely that Sungas intentionally oriented the stupa 1 by 15 degrees towards west although this difference remains to be explained.

The stupa is supposed to represent Buddha. The great stupa itself has been thought to contain the relics of Lord Buddha (Marshall 1940) as such, the orientations of the stupa could be based on the events in Buddha's life. It is said (known) that Buddha (Gautama) entered nirvana at Kusinagara on the full moon day of Vaisakha in 544 BC. This is commemorated every year as Buddha purnima and is a day of major religious significance for Buddhists. At full moon time the moonrise and sunset are separated by about 180 degrees and they could be observed on the eastern and western horizons. One possibility is that Sungas (the builders of the stupa) might have oriented the stupa towards the direction of moonrise and sunset on such an auspicious day as Buddha purnima. Since it is not known when exactly the stupa was built and to which Buddha purnima they could have oriented the stupa (*i.e.* to 544 BC or the time when stupa was built, since in the lunar calendar, with intercalary months operating and the sort of cycle they adopted being not quite known, the Vaisakha purnima could have occured between April 28 and March 29 in 150 BC) we calculated directions of the moonrise and that of the sunset at Sanchi on Buddha purnima day (as given in the Indian astronomical ephemeris on May 4, 1985) when moon's declination was -14.07 degrees, to see whether this hypothesis is consistent with our thinking. As can be seen in figure 1c the orientation of the stupa's east-west entrances agree with the directions of moonrise (zenith distance = 90 degrees, azimuth = 105.35 degrees) and the sun's position (set) in the west (Z = 85.9 degrees, A = 74.3 degrees). Thus this might be one of the possible explanations to the mystery of 15 degrees misalignment of the stupa.

Figure 2. "Though the stupa is only two or three decades later than stupa 1 (as reconstructed under the Sungas), there seems to have been a marked difference in the contours of their domes, the explanation being that the reconstructed dome of stupa 1 had to conform to the contour of the original brick dome built by Ashoka a hundred years earlier, whereas the dome of stupa 2 followed the more elevated and spherical form in vogue in the 2nd century BC. The contour of the dome shown in this Plate is based on the drawings made by Cunnigham and Maisey, when the original fabric was still standing to more than half its height. It should be observed that the staircase of stupa 2 are on the east instead of the more usual south side of the monument. This no doubt was merely a matter of convenience, as the old approach road on this side of the hill passed by the eastern entrance of the stupa, but it seems to show that in the latter part of the 2nd century BC special importance was not attached to the principal entrance being located on the south. As in the plans of stupas 1 and 3, the original pillars of the ground balustrade are indicated by means of shading; the restored ones are without shading" (Marshall 1940). Note the division of inner balustrade into 12 portions (corresponding to 12 months). The 112/9 days corrections to the 12 lunar months to make it compatible to solar months are indicated.

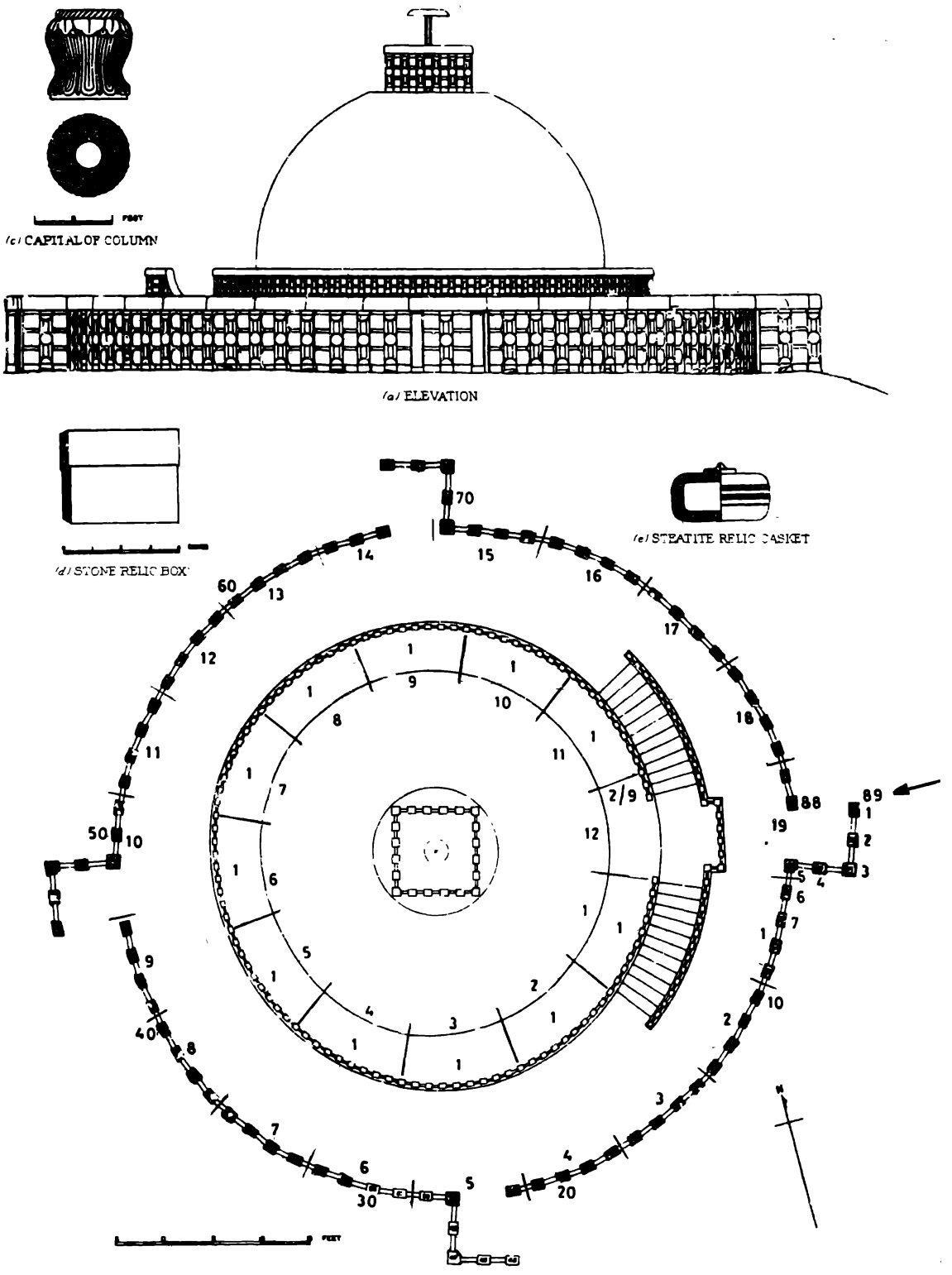

Figure 2

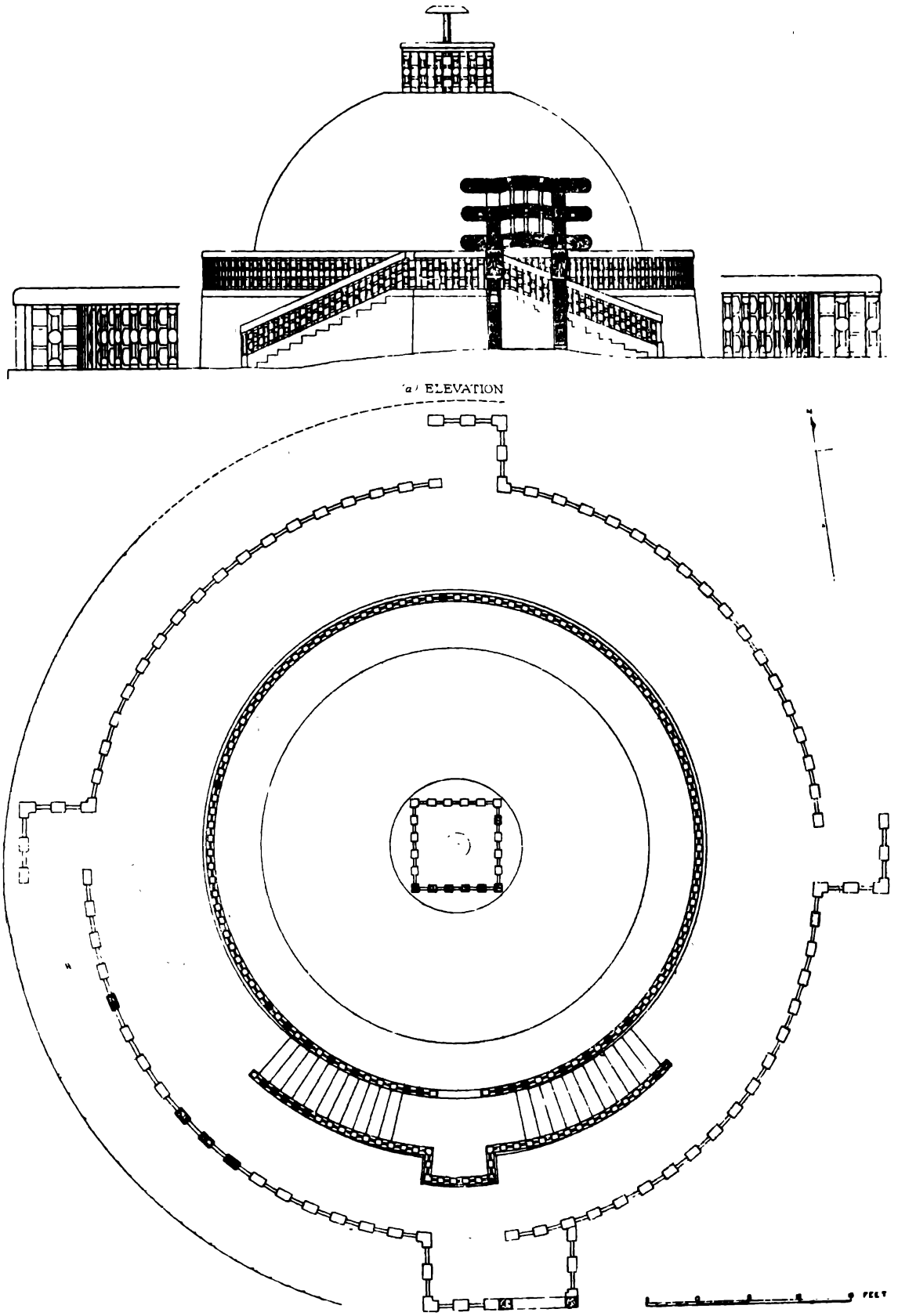

Figure 3. Elevation and plan of stupa 3. Note the direction of north-south; same as stupas 1 and 2.

Based on the above suggestion Drs G. M. Ballabh and K. D. Abhyankar have calculated the positions of Sun and Moon and find that the Buddha purnima occuring at Sanchi on April 28, 109 BC (Gregorian) has the sunset and (full) moonrise* corresponding to the east-west orientation of the Stupa (Azimuth of Sun and Moon = 285.2 degrees and 105 degrees, respectively, both with an altitude of about 1 degree). They further find that this date also corresponds to the setting and rising of two important asterisms Pleiades (Krithika) and δ Sco (Anuradha) along with Sun and Moon respectively.

There might be other astronomical events like the rising of bright stars, to which the stupa could have been oriented. This orientation of 15 degrees east of north is also seen in other ancient astronomical sites. It is interesting to note that the builders of *Teotihaucan*, the most influential city in all ancient Mesoamerica built around 1 century AD, have oriented the major axis of the city defined by the Street of Dead facing the pyramid of Moon by 15 degrees 25 minutes to the east of north. This orientation is ascribed to the direction of the setting of Pleiades in 150 AD (Aveni 1979). Teotihaucan is the earliest of the similar pyramids and astronomical site in Mexico called the 17 degrees family by Aveni.

4. Balustrades around the stupas

Regarding the balustrades Volwashen remarks that "The ends of the Swastikas which constitute the approaches to the lower pradakshina-patha symbolize the course of the sun. The custom of circumbulation was closely connected with ancient solar cults, as is shown by the fact that the procession always begins in the east and follows the course of the sun southwards and then westwards. The number of uprights is presumably related to the division of the Zodiac into twelve parts and to the division of the sun's course from horizon to horizon into twelve hour-angles" thus providing an astronomical context to those structures. The symbol Swastika which appears even on Harappan seals (2000 BC) is itself associated with Sun (Ions 1967). Another striking aspect about the balustrades is its resemblance in the arrangement of the posts to the arrangement of holes and stones at Stonehenge, particularly the Aubrey holes. This similarity led us to think that there might be an astronomical basis for the arrangement of the posts of the balustrade and we tried to explore in this paper whether the number of posts or their arrangement (or combination of these numbers) could be related to obvious astronomical phenomenon.

The general arrangement is such that there are two circular balustrades around each stupa and a square balustrade around the harmika on the top of the dome.

(i) *Balustrades of stupa 2*

We shall first attempt to discuss the plan of stupa 2 and then go to stupa 1. Stupa 2, which was also built by Sungas few decades after stupa 1 (figure 2) is simpler in construction. Its ground balustrade, according to Marshall (1940) "by lucky chance still possesses 85 out of 88 pillars of which it once consisted of". In addition this stupa was not altered by later Andhras to incorporate toranas.

The plan consists of (figure 2) : (1) The outer balustrade of the pradakshina patha consisting of 88 posts (Stambhas) (marked as dots) connected by horizontal cross bars

*Also happens to be a night of lunar eclipse according to Oppolzer's canon der Finsternisse.

(suci) is arranged in 4 sectors with entrances located at four sides (same directions as stupa 1). The diameter of this circle is ~ 71 ft (as measured on the plan). (2) The other pradakshina patha of the inner balustrade has the steps leading to it on the eastern side. (3) In the astronomical context 88 number of posts of the outer balustrade immediately suggests to us the number of days in three lunar months ($29.5 \times 3 = 88.5$ days one season − 4 seasons/year). Since half days cannot be represented in counting the posts, it would be counted as either 29 or 30. If we go along the balustrade counting the number of posts starting with post 1, to come back to post 1 again it would result in a count of 89 posts and the spaces (or intervals) in between posts would be 88. If we proceed by counting the posts in the first round and counting the space in between the post in the second round it would result in a count of 89 (30, 29, 30) and 88 (29, 30, 29) days assuming each count represents a day. Thus a cycle of four rounds around the balustrade alternately counting the posts and the spaces in between would lead to a cycle of 89, 88, 89, 88 days with a total of 354 days. This corresponds to an arrangement of alternating full (30 days) and hollow (29 days) months equaling the total 354 days in 12 lunar months *i.e.* (full moon to full moon−12×29.5 days = 354 days). Thus the four rounds would represent the total number of days in a lunar year.

(ii) *Balustrade of Stupa 1* (the Great Stupa)

Here we will consider only the structure which was built by Sungas and disregard the extensions to the entrances of the outer balustrades (to accommodate the gateway-toranas) built by Andhra Kings (Satavahanas).

1. The outer balustrade has a diameter of about 141 ± 1 feet, twice the size of stupa 2. It consists of a total of 120 posts. (sthambas) including the entrance posts. Like in Stupa 2 they are also depicted in four sectors, each consisting of 30 posts and 29 Suci links (or interpost connections) with 3 rounds of horizontal cross bars (Suci). Similar to the scheme proposed for stupa 2, if a count of posts (30) and Suci (29) is made alternately in one round, it would be about 118 and the three rounds would make it 354, numbers corresponding to the days in a chaturmasa and a lunar year, respectively. To arrive at an undistorted full circle it would require 108 (*i.e.* 120−16+4) posts (denoted as outer circle): *i.e.* excluding the 16 entrance posts and including one nonexisting post at each entrance, equally spaced with respect to other posts. This is the same number as the inner circle of stupa 2.

There are other numbers which would emerge by counting the posts or the combinations which might have some astronomical relevance (or coincidence).

The inner balustrade consists of 227 poss with a gap on the south where the staircase joins. There are also seven posts correponding to the balustrade of the platform on the top of the stairs (which might fill up the gap). Thus the total inner posts are 234.

There are number of single slabs which are laid on the pradakshina path extending the full width of the path, these number 115 according to the plan (figure 1b). Thus the total number of outer balustrade posts (120) and slabs (115) give a count of 235 to the outer circular path which might correspond to 235 lunations of the Metonic cycle.

The harmika balustrade has a square format with 7 posts on each side which correspond to 28 posts in total. Square symbolically refers to something which is permanent and that which does not move (*e.g.* The inner chamber *i.e.* the sanctum sanctorum of the God in South Indian temples is always represented as a square). This

might suggest or represent the 28 "Lunar mansions" (nakshatras or stellar groups) in the lunar path (Dikshit 1969). This kind of arrangement of nakshtras is also seen in the old Tamil texts and called 'Servato Bhadra Chakra' (John Warren 1825).

There appears to be a systematic approach to the arrangement of the various balustrades in both stupas. The outer balustrade represents the lunar months and other aspects related to movements of moon, whereas the inner balustrade represents solar or lunar-solar connection like the Metonic cycle or the corrections to the lunar calendar to be compatible with solar months. Finally the inner most harmika balustrade represents the nakshtras which are farther away than both moon and sun.

Marshall describing the railing around the monuments (balustrades) remarks that there existed a cult of erecting such structures around sacred objects from earlier times to project them and proclaim their sanctity, "But they were often employed in this way sometimes, indeed, without any practical raison d'etre whatever". On the contrary (to Marshall's belief) these structures around Sanchi stupas might have significance and probably sanctity was bestowed on them by their use for astronomical purpose.

5. Similarity with stonehenge numbers

1. The plan of stupa 1, particularly the arrangements of the outer balustrade posts show a remarkable similarity to Stonehenge arrangement of Aubrey holes and the Z, Y holes. In fact the diameter of the outer balustrade of stupa 1 is about 141 $\pm$ 1 feet (as measured on the scaled map given by Marshall), and the mean diameter of Aubrey circle holes is 283.6 feet (Thom & Thom 1974) which is almost double that of the stupa, whereas the full circle of the outer balustrade has 108 (104+4) posts and Aubrey circle has 56 holes which is almost half. Thus the stupa balustrade is reduced by a factor of 2 and compensated by an increase in the number of posts (or holes) by 2.

2. As mentioned by Lanchester Brown (1976) the total number of holes and stones at Stonehenge is 234 (19 blue stones, 10 Sarsen trillithons, 60 outer blue stones, 30 Sarsen circle stones, Z and Y hole-circles count 29 and 30 respectively and finally 56 Aubrey holes), the same number as our inner circle posts 234 (227 $\pm$ 7). The other obvious representations of the days of lunar months (29, 30 days alternatively) have already been included as part of posts and spaces of the cross bars (Suci). The representation of the blue stone circle of 60 stones in stonehenge looks similar to that represented as 120 posts of the outer balustrade posts.

The Metonic cycle of 19 years (the Golden year numbers) is probably incorporated into the posts of inner balustrade with 227 posts. 19 blue stones exist in the horseshoe of Stonehenge.

What appears to be not represented at Sanchi compared to Stonehenge are the sight lines (alignments) with respect to sun's or moon's rising or setting at various important occasions like the solstices, although the stupa itself might have been oriented to the moon rise and sun set on Buddha purnima day. The absence of sight lines may be partially explained due to the fact that the time of Sanchi (2nd century BC) or even earlier, such requirements may not have been felt or the astronomers of Sanchi were able to calculate such events using other methods.

There does not appear to be a preferred position to look for such sight lines (like the centre of the circle etc.) at Sanchi. However it would be interesting to investigate such possibilities by surveying. Looking at the plan of the monuments at Sanchi, stupa 2

appears to be in the direction of sunset on summer solstice day from the western entrance (platform) of stupa 1. This might also answer the questions posed by Marshall namely 'It is not, at first sight, clear why so much trouble was taken to build up this small terrace (centering stupa 2) apart from and below (350 yards down the western slope) the other stupas'.

However it appears that Sanchi monument might be one of the oldest Indian astronomical monuments presently known (see Neugebauer 1975 for general historical account of Indian astronomy). The location of Sanchi itself has some astronomical significance namely the latitude of Sanchi (23°28'N—Marshall 1940: long: 77°48' E) is close to the declination of the sun on summer solstice day (within the angular radius of the sun ~ 16': the obliquity = 23°42' in 150 BC) as such the noon sun would be at the zenith on the longest day of the year.

6. Conclusions

1. Sungas who extended the stupa 1 and built stupas 2 and 3 were astronomicaly quite knowledgeable to orient the stupa 1 in the proper direction. It is likely they oriented the stupa towards the moon rise and sun set on Buddha purnima day which is very auspicious day for Buddhists.

2. The balustrades of the stupas were probably used to represent the luni-solar calender (mostly lunar). The reason to build the Great stupa (and expand it) might be due to the need to incorporate the large number of posts in the balustrade.

It is not easy to assess to what extent the astronomers of Sanchi would have used the stupa as described here, but the knowledge was well within contemporary Greek astronomy. In this regard it would be a great help if independent sources could be found to corroborate the above interesting coincidences of numbers.

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