Indian Journal of History of Science, 43.1 (2008) 83-92

ASTRO-NAVIGATIONAL ASPECTS OF THE *BHŪMI ANLA**

Altitude calculation has drawn the attention of human mind since ancient times. In India, astronomers have done pioneering work[1, 2]. None of the ancient masters or their treaties have been related to ancient *Kalinga*. *Kaliṅga* was non-Sanskrit territory, a land of the lowly and belittled in extra Orissan Sanskrit literature[3]. Bhubaneswar has been indicated as a seat of *Sadāśivs*, and *Siddhāntims* who were also *Mimānsims* and pre dated the Ādi Śaṅkara. Śatānanda and in particular Candrasekhar's[4] exploits[5] are house hold legend in Orissa[6]. Candrasekhar used embryonic proto theodolite to measure heights of mountains and hills from very wide distances. He even measured elevation of astral bodies. The duo make no mention about *bhūmi anlas* (*Ba*)[7]. Modern researchers also make no mention of *Ba*[8, 9]. The *Kaliṅgiya bakrakar rekha deul* (*KBRD*) have *Ba* fixed along each corner pilaster. They have ribs alike the medicinal fruit *Phyllanthus emblica officinialis garten* (*anla*) and they mark various levels (*bhūmi*) of the spire, hence, the natives call this non religious and abstract members as *Ba*. Standard astronomical specification for location of celestial bodies use the local vertical hemisphere of the sky as frame of reference for coordinates[10]. The coordinates being (i) azimuth-Az and (ii) altitude -Al. *Ba* is used to bring out these two cordinates to trace and track astral bodies. In place of the local hemisphere *Ba* uses the corner hemisphere as frame of reference. They operate in relation to corner coordinates and generates a grid of 5 variably spaced celestial latitudes and 18 celestial longitudes evenly spaced at 15^0. Bhattacharya[11] has presented that *Ba* series can be used for determining elevations. They offer scope for application of simple geometry to determine astral's gross declination in relation to base. Application yields a unique astrolabe, which offers global positioning possibility, to validate the ancient Hindu school of direction computing. *Ba* is a original, abstract archaeological element and an unique, exclusive aspect of *KBRD*s. It transpires to be a navigation concept. We adopt a multi-disciplinary theoretical model to discuss the possible applied meaning of the *Ba* series.

* Contributed by **Deepak Bhattacharya and P.C. Naik**, Radha Krishna, Kedar Gouri Road, Bhubaneswar – 751002, India. Email: oddisilab1@dataone.in.

Azimuth Aspect

Fig. 1 is that of the *Ba* series of Muktesvar temple (c.9th AD). The spire has five *bhūmis*, each *bhūmi* has a set of 4 *anlas*, which totals to 5 x 4 = 20 *Bas*. Each *bhūmi* marks the vertical offset of the curvilinear outline while the distance between *bhūmis* reduce in geometric progression

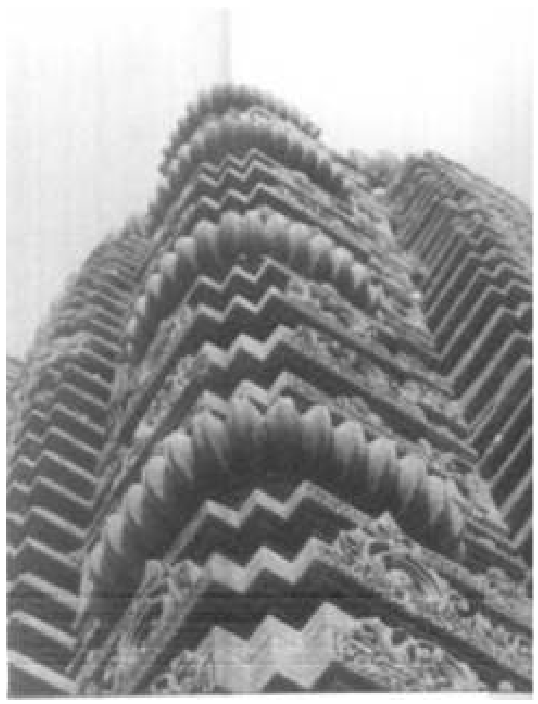

Fig. 1

with gain in elevation. Table 1, Figs. 3, 4 and 5 are based on Parasurameswar (c.650 AD) the ASI conserved best extant structure of the earliest cognate group. The 1st *bhūmi* is at a elevation of 234″ at an angle of 63 ^{0}, successive *bhūmis* are at 289″-67^{0}, 341″-70^{0}, 387″- 73^{0}, 429″-75^{0} respectively.

Fig. 2 is a schematic representation of the circular cross section of a *Ba*. Of a circular cross section of the *Ba's* — its inner 90^{0} (¼th) is embedded into the *koni-paga* (corner buttress arrangement), the remaining 270^{0} (¾ th) is exposed. Each quadrant i.e. *agni*, *nairtya*, *vāyu*, & *aisanya* is of 90^{0} arc, have 5 ribs including 4 embedded that mark the four cardinal direction (5x4+4=24). Of the 24 ribs, 17 ribs project out i.e., a *Ba* covers 270^{0} at a

Table 1

Name	X	Y	tan θ =Y/X	θ in Deg.
Bada	120	168	1.4	54.4623
1st *Bhūmi*	117.5	234	1.991	63.3314
2nd *Bhūmi*	115	289	2.513	68.3
3rd *Bhūmi*	113	341	3.017	71.662
4th *Bhūmi*	105	387	3.685	74.817
5th *Bhūmi*	96	429	4.46	77.362
B, A & Ay	0	528	inf.	90.00

span of 15^0 per rib. Counting clock wise (from TN), of the 17 exposed ribs of the *Ba,* the 3rd & the 9th mark out NE and SE corners respectively. The 1st (embedded) & the 12th mark the N-S line (local longitude). The 6th & the 18th (embedded) mark the E-W line (local Lat.) respectively. In reference to Fig. 2, sp-ii is a star located in the north eastern direction visually aligned with the 3rd rib (mid). This marks the corner. It is the most convenient point

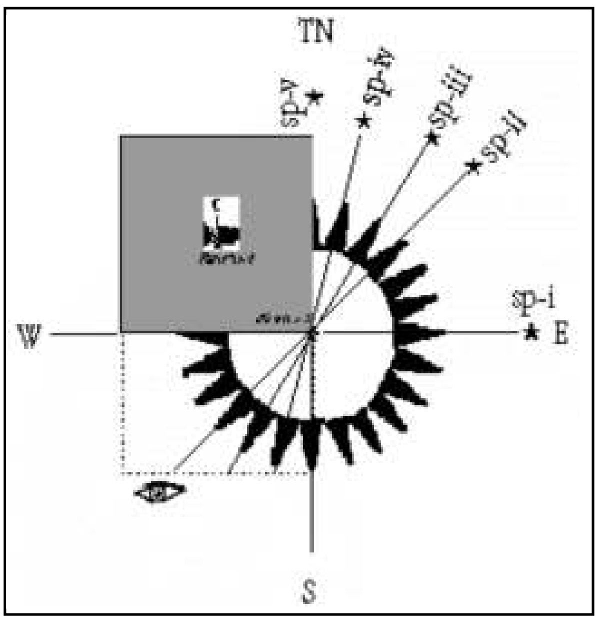

Fig. 2

of alignment. All stars in line with it and around are in the same quadrant. sp-iii & sp-iv mark the theoretical alignment points @ 150 arc separation as a star transits through the zone.

In relation to Fig.3 , the 1st *bhūmi* (Table 1) is the lowest at 63^0 angle, it is of practical use in naked eye Az observations & readings in relation to local longitude. The observer's position i to iv is along a parallel (to N-S base line) at a distance equal to the height of the *1st Bhūmi* (234″). When a viewer stands on the south side of the structure, the Az arc of the northern sky can be visualized using only 4 ribs (Fig. 2&3). This works out to 15^0 x 4 = 60^0 on either side of the viewer or 120^0 of azimuthal arc span. Beyond 60^0 (i.e. sp-v, Fig.2) the viewer has to use a corresponding *Ba* on the opposite *koni paga*.

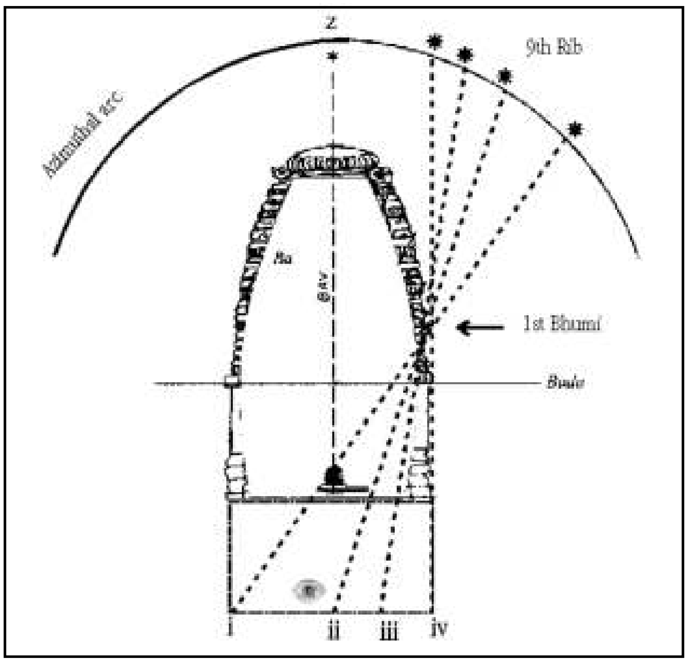

Fig. 3

Altitude Aspect

Cross section of the *Bas* reduce with gain in *bhūmi*, set at a reducing geometric progression (Table 1). Ribs of all the *Bas* are repetitive, cyclic arcs, are therefore cordant (Fig. 1), they deviate at 15^0, allows projection of a imaginary zenithal celestial grid (longitudes) theoretically enmeshing the structure. Fig.4, schematically presents the altitude aspect. Astrals that are aligned with the local altitude (AL) attain the *mastaka* (zenith) position, which is the highest Al. Envisages use of 5 *Bas* and the *mastaka* along line

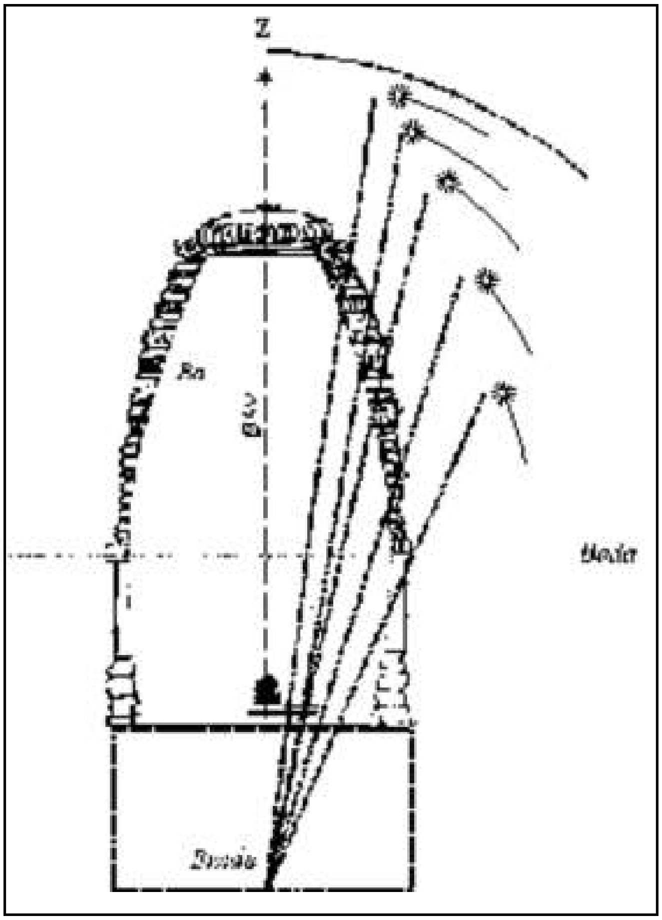

Fig. 4

'bindu' (central vertical) extending up to position ii (Fig. 3) from the structure's base. Our Fig. 3 & 4 present a skill acquired methodology easy to adopt and quick to determine the Az & Al. It does not require knowledge about geographical and astronomical domains. In contrast to modern system (magnetic pole based direction computation) the *Ba* scheme envisages corner oriented direction computing, which is why, these are located on the *koni paga* (corner buttress arrangement). Simultaneous alignment from 4 corners yields good global positioning and a grid lock methodology which can be validated from poly positions and for numerous astral bodies. This model can be used anywhere.

Planispheric Astrolabe Aspect

Astrolabe is a navigational device having world wide distribution and acceptance during times past[12]. Members datable to historical medieval period have been reported from various parts of India[13]. Nature based source inspiration of astralabes (if any) has remained unexplained. Using the *Bas* we can also generate Fig.5. It yields a valid geographical grid consisting of 6 circular zones. The zones constrict geometrically with gain in *bhūmi* due to acute angles determined by the *bakrakar* outline in relation to the *śambhu*. These can be assumed as celestial latitudes. They have (approximately) the *theta* values (Table 1). In crass terms it covers a arc space of 35^0 in any direction, accounted from the local zenith. This leaves a 55^0 arc space as the horizon (error) zone. This is the zone of the Earth's inclination, surface curvature related impaired visibility and maximum optical aberration. In relation to Fig. 2 we can use the 24 ribs to generate a set of 24 evenly spaced radial lines (theorised longitudes) having a angular separation @ 15^0 emanating from the *bindu* to generate a imaginary inverted cone. It is generable using any of the extant erstwhile state sponsored *KBRD*s datable between

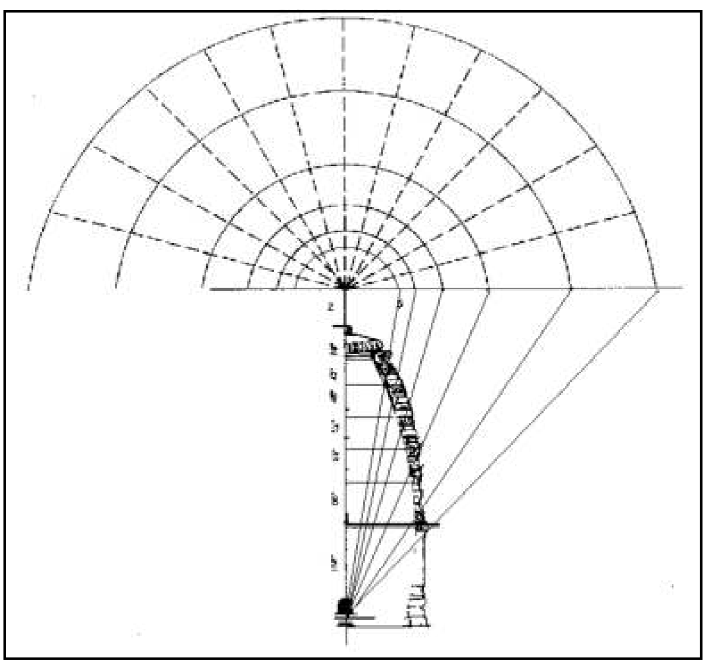

Fig. 5

c.650-1700 A.D. Fig. 5 gives a shematic semi circular for appreciation. When 5 theorised latitudes and 24 longitudes are transposed together we get a *bindu* centric conical zenithal projection. Such a theoretical format can then be reflected on the ground around *bindu* or at any unknown place covering the visible span of the night sky. When such astrolabe is held overhead or placed on ground at specific *ghaḍi* (hour) in relation to known locations of other astral bodies in any hemisphere, true direction towards *Yogatārā* (reference star, *bindu*) can be instantly interpolated. This makes the *Ba* scheme a proto geo-positioning compass. We know, zenithal maps give accurate angles which is why they are used in navigation. In wind and tide assisted sailing (non fuelled transport), it is true angles that matters most. Such format is also noted in medieval astrolabes and in modern zenithal projections.

G P S and Mariners Compass

Tripathy and Rout[14] have held that to & fro ocean sailing is possible with the help of geostrophic and seasonal alternating sea surface winds. However, we know meteorologically such simplistic concepts is loaded with uncertainties. Moreover, repetitive direction maintenance and adhering to course and time schedule (3 most vitals) would not be possible specially in the event of inclement weather which is very common in the geographical domain of interest. Mariners we also know carried something on board called a *yantra* (device)[15]. If the Kaliṅgān mariners did not have a *yantra* or a well practiced methodology to sail through seas, then Aśoka the mighty emperor (most powerful in the then period) surely would not have entrusted the care of his only daughter Sanghamitra, to them for her maiden sojourn to the doldrums Island of Sri Lanka in pursuit of state sponsored (*Rāj datta*) religion propagation. In *Tārakā* (*IJHS*)[16] we have presented a epochal celestial 9 pointed star alias *Nakṣatra* in relation to the equator. Therein 9 vertices mark 9 bright stars. If we superimpose the celestial *Nakṣatra* on Fig. 5 we then arrive at Fig.6. It is much alike the modern 8 pointed compass. Relevantly, this compass limits vision to within 60^0 of arc space in any hemisphere and in applied terms mean stars that have declination $>35^0$ are not accounted. Accounting from $+20^0$ lat. the visual sweep includes $+55^0$ of the N and -10^0 of the S hemispheres respectively, which encompasses all the ancient civilisations**[17]**. In Fig. 6, α *Leo* marks the east, the seasonally visible α

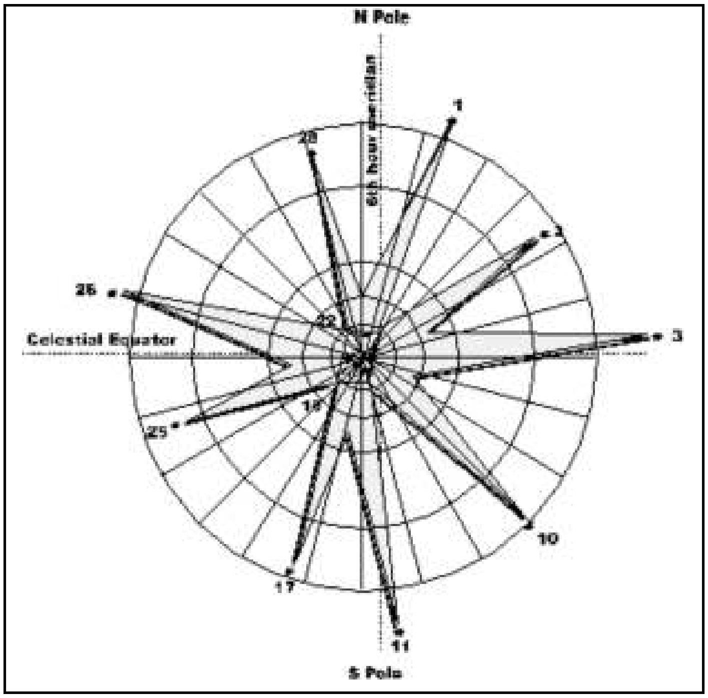

Fig. 6

Curcis marks the south, the *aisanya* is marked by α *Pegasus,* α *Crater* (*Pakhirāj*) represented by star No.10 marks the zone of the *Bāli yātrā* i.e. the south-east archipelago. On the spire of any of our candidate *KBRDs* it is marked by sp-ii as in Fig.2. On Fig. 6 the island Bali is located on the rim of the 5^{th} latitudinal zone away from *Kaliṅga* when α *Ori*. is at the zenith of *Kaliṅga* i.e. aligned with $+20^0$ lat.

Discussion & Conclusion

This *Kaliṅgiya* system is consonant with ancient Indian *Siddhānta*, thought, literature, tradition and practice, whereas other Indian regional and non Indian schools of architecture have not been examined from such perspective. They merit study. India is a large country loaded with a millennia old extant archaeology. Regional variations of the siddhāntic component is a strong possibility, apart from unique and atypical aspects. This voluntary original historical note is a theory, is interphased with extant archaeology, is not exhaustive, non chauvinistic, merits early report so that scholars may critically re-check our averments.

Theoretically, the *kaliṅgiyas* had a astro based navigation methodology cum compass. Apparently, for these very many reasons the *kaliṅgiya* societies down their historical period(s) have celebrated the non religious, abstract *Bas* and have permatised them as did no other society in respective built heritage. The *KBRDs* in general position themselves as model variants of ancient armillary and offer wide and fascinating scope to study a gamut of issues associated with space, time, direction, positional astronomy, applied navigation, mathematics and engineering sciences. *Ba* in particular can also be used to determine global position in the unknown. On one hand the application aspects of the *Ba* validate the *nirayana* coordinates and on the other, positions itself as a robust independent school. It is comprehensive, composite and versatile. Inter-disciplinary approach involving geographical information systems, positional astronomy, geometry, related mathematics, iconography, historical phonetics and literature on the bed platform of dated *Rāj datta kirtis* helps to unravel *kiṃbadanti* (traditions) and provides a window into the history of ancient science.

Reference & Notes

1. K. S. Shukla, *Āryabhaṭīya of Āryabhaṭa* , INSA , 1976 .
2. D. Arkasomayaji, *Commentary to Siddhānta Śiromaṇi of Bhaskaracharya*, Kendriya Sanskrit-Vidyapeetha, Tirupati, 1980.
3. C. R. Das, *A Glimpse into Oriya Literature*, Orissa Sahitya Academy , Bhubaneswar, 1st ed, 1982, p. 10.
4. P. C Naik, "Date of Birth of Samanta Chandra Sekhar", *IJHS*, 35.2 (2000) 149-160.
5. Dhukhisyama Pattanayak, *Mahamahopadhyaya Samanta Chandra*, Commemoration vol. Directorate of Culture, Govt. of Orissa,1976.
6. Śatānanda (11th AD) lived & worked at Puri. Also see *Bhāśvatī,* Orissa State Mmuseul-Palm Leaf Manuscript No. Jy.1A, 285 & 408B.
7. Samanta Chandra Sekhara (1835-1904), *Siddhānta Darpaṇa*, Indian Depository, Calcutta, 1899. Samanta belonged to Khandapada, wrote his Mss. at Kolkata.
8. P.K. Misra, *Evaluation of the Accuracy of Measurements in Indian Astronomy*, *IJHS*, 31.3 (1996) 281-289.
9. P. C. Naik, *Science Reporter*, April, 1995.
10. W. M. Smart,*Text Book of Spherical Astronomy*, Cambridge Uni. Press,1947, pp.25-27.

11. Deepak Bhattacharya, "*Few Archaeometry Aspects of Orissan Curvilinear Temples*" , Engineering Congress – 2006, Gold Medal , Civil Engineering Division, The Institution of Engineers India [Or.], 23rd Jan, 2006.

12. Gibbs, et.al, *Planispheric Astrolabes from National Museum Of American History*, Washington City, 1984 .

13. S. R. Sarma, *Kaṭpayadi Notation on a Sanskrit Astrolabe*, *IJHS,* 34.4 (1999) 273-287.

14. S. Tripathi, & L. N. Rout, "Monsoon Winds and Marine Trade: A Case Study, Historical Evidence from Orissa", *Current Science*, 90.6 (2006) 864-71.

15. Moti Chandra - *Trade & Trade Routes in Ancient India*, Abhinava Publication, New Delhi - pp, 144 .

16. D. Bhattacharya & P.C. Naik, " Astro – Archaeoastronomy at Bhubaneswar : A Polygonal & Mathematical Model – TĀRAKĀ" , *Indian Journal of History of Science*, Indian National Science Academy, 41.1 (2006) 53-75.

17. In relation to the view from Kaliṅga i.e. the sailor's home zone, these astral members have low declination and ultra short diurnal arc transit, which act as excellent direction markers on high seas.