



Paleo-Environmental Significance of Ichnofossils from the Babaguru Formation of the Cambay Basin, Gujarat, India

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Abstract:

Ichnofossils are biogenic structures preserved on or within the substrate by an organism during their various movements such as dwelling, feeding, resting etc. Ichnofossils are widely used for the interpretation of the paleo-environment of the sediments / rocks. The present paper documents four ichnospecies from the ferruginous sandstone of the Babaguru Formation (early Miocene), exposed in the Amravati river section, at Bhilod village, Cambay basin, India. The Babaguru Formation consists of four ichnofossils, namely, *Laevicyclus mongraensis*, *Planolites beverleyensis*, *Skolithos linearis* and *Skolithos verticalis*. The presence of these ichnofossils indicates that ferruginous sandstone of the Babaguru Formation was deposited in shallow water near-shore / foreshore marine environment with moderate to high energy conditions. Less density of the ichnofossils and dominance of only vertical burrows among present burrows may be probably due to the paucity of the nutrients in the sediments.

Keywords: Paleo-environmental significance, Babaguru Formation, Gujarat, India

1.0 Introduction:

The Cenozoic sediments of the Cambay Basin are exposed in and around Ankleshwar between Narmada and Kim rivers. The ferruginous sandstones of the Babaguru Formation were exposed along the Amravati river section at Bhilod Village of Ankaleshwar district, Cambay Basin, India. Kundal et al., (2005) have documented seven ichnospecies, namely, *Keckia annulata*, *Ophiomorpha nodosa*, *Paleophycus tubularis*, *Planolites beverleyensis*, *P. montanus*, *Thalassinoides paradoxicus* and *Skolithos* isp. from the late Eocene to early Miocene sediments of the Cambay basin. In the present study author has tried to study in detail the distribution pattern of ichnofossils from the Babaguru Formation and their application to comment on correct paleo-environment. Thus, the present paper documents additional ichnofossils from the ferruginous sandstone of the Babaguru Formation of the Cambay basin, Gujarat, India, namely, *Laevicyclus mongraensis*, *Planolites beverleyensis*, *Skolithos linearis* and *Skolithos verticalis*.

2.0 Geological Setting:

Mathur et al., (1968) have divided the Cambay Basin into four major blocks which, from north to south, are: Ahmedabad-Mehsana Block, Cambay-Tarapur Block, Jambusar-Broach Block and Narmada Block

(Fig.1). The exposed Cenozoic sediments of the Cambay Basin are divided into five as Vagadkhol Formation (? Palaeocene), Dinod Formation (late Eocene), Babaguru Formation (early Miocene), Kand Formation (middle to late Miocene) and Jhagadia Formation (early Pliocene) in the ascending order (Agrawal, 1986).

The Vagadkhol Formation consists of conglomerates, variegated clays and siltstone. It is unfossiliferous and doubtfully dated as Palaeocene. It is overlain by the Dinod Formation which consists of fossiliferous limestone, marls and marly limestone. The Dinod Formation is dated as Late Eocene. The Babaguru Formation overlies the Dinod Formation comprising the ferruginous conglomerate and clays, dated as Early Miocene. It is succeeded by the Kand Formation which consists of conglomerate, fossiliferous limestone and calcareous sandstone, dated the Middle to Late Miocene. The overlying Jhagadia Formation is made up of mainly sandstone, gritstone, conglomerates and breccia. It is unfossiliferous and has been dated as Early Pliocene. The Holocene sediments are known as Narmada Formation which consists of sandstone, silts, clays and gravels. The following onshore Cenozoic Stratigraphy of the Cambay Basin is given as based on Agrawal (1986) (Table-1).

Table 1: The Cenozoic Stratigraphy of the Cambay Basin (Agrawal, 1986).

| Subsurface | Surface |
|-------------------------|---------------------|
| Gujarat Alluvium | Narmada Formation |
| -----Unconformity----- | |
| Jambusar Formation | Absent |
| Broach Formation | Absent |
| Jhagadia Formation | Jhagadia Formation |
| -----Unconformity----- | |
| Kand Formation | Kand Formation |
| -----Unconformity----- | |
| Babaguru Formation | Babaguru Formation |
| -----Unconformity----- | |
| Tarkeshwar Formation | Absent |
| -----Unconformity----- | |
| Ankaleshwar Formation | Dinod Formation |
| -----Unconformity----- | |
| Cambay Shale Formation | Absent |
| -----Unconformity----- | |
| Vagadkhol Formation | Vagadkhol Formation |
| -----Nonconformity----- | |
| Deccan Trap | Deccan Trap |



3.0 Systematic Taxonomy:

This study of Palichnology follows the Treatise on Invertebrate Paleontology (Haentzschel, 1975). The morphological classification of Simpsons (1975), ethological classification of Seilacher (1964) and facies classification of Seilacher (1964,1967) are adopted.

3.1 Ichnogenus : *Laevicyclus* Quensdete, 1876

Diagnosis: Vertical to slightly inclined burrows consisting of scraping circles surrounding a central vertical shaft, perpendicular to the bedding planes.

3.2 Ichnospecies: *Laevicyclus mongraensis*, Verma 1971 (Pl. I Figs. 3, 4, 8)

3.2.1 Diagnosis: Vertical to slightly inclined burrows perpendicular to the bedding planes, scraping circles surrounding a central vertical shaft, two distinct circles visible in transverse section Verma (1971).

3.2.2 Description: Scraping circle surrounding a central vertical shaft, perpendicular to inclined to the bedding plane and preserved as positive epirelief. The diameter of the central shaft is 17 mm and 25 mm of scraping circle.

3.2.3 Remarks: Scraping circle surrounds a central vertical shaft. Burrow is disposed perpendicular to incline to the bedding plane and preserved as positive epirelief. Diameter of central shaft and scraping circles show close similarities with *Laevicyclus mongraensis*, Verma. Verma (1971) originally described it from Nimar Sandstone at Mongra, Amba Dongar area, Gujarat. They are morphologically shaft and ethologically domichnia. Kundal and Sanganwar (1998) reported this species from Bagh Group of Madhya Pradesh while Kundal and Dharashivkar (2006) documented this species from Shankhodhar Sand-Clay Member, Dingshwar Mahadev Cliff, Gujarat.

3.2.4 Occurrence: Ferruginous sandstone of the Babaguru Formation, exposed at Bhilod Village, Amravati river section.

3.3 Ichnogenus: *Planolites* Nicholson, 1873

3.3.1 Diagnosis: Unlined, rarely branched, straight to tortuous, smooth to irregularly walled, elliptical to circular in cross-section, variable dimensions, burrow fill different in lithology from host rock, colour of burrow differ from that of host rock. (Pemberton and Frey, 1982)

3.4 Ichnospecies: *Planolites beverleyensis* Billings, 1862 (Pl. I, Fig. 4)

3.4.1 Diagnosis: straight to gently curved or tortuous cylindrical burrow burrows, smooth and thick.

3.4.2 Description: Burrows are preserved as positive epi-relief, dominantly cylindrical ridges, straight to slightly curved burrow without lining, disposed parallel to the bedding plane, circular to semicircular in cross section, burrow fill material is different from the host rock. Burrow is isolated. Dimensions vary from burrow to burrow. The length of the burrow varied from 6-14 cm and width from 6-10 mm.

3.4.3 Remark: As, the burrow fill is different from that of the host rock and burrows are straight to tortuous, they are identified as *Planolites beverleyensis* (Billings) (Pemberton and Frey, 1982). It is horizontal burrow, morphologically tunnel and ethologically fodinichnia. The genus *Planolites* is commonly recognized from shallow water marine environment (Seilacher, (1967). Borkar and Kulkarni (1992) and Kundal and Sanganwar (1998, 2000) recorded *Planolites beverleyensis* (Billings) from the Wadhawan Formation of Gujarat and Bagh Group of Madhya Pradesh, respectively. Kundal et al., (2005) documented it from the Babaguru Formation at Bhilod village, Broach district, Gujarat. Kundal and Dharashivkar (2006) recorded this species from the Shankhodhar Sand-Clay Member of the Dwarka Formation. Recently, it has been recorded from the Ambalapuzha Formation (Warkalli Beds, Mio-Pliocene) at Papanasam, Varkala cliff Section (Mude et al., 2012).

3.4.4 Occurrence: Ferruginous sandstone of the Babaguru Formation, exposed at Bhilod village, Amravati river section.

3.5 Ichnogenus : *Skolithos* Haldemann, 1840

3.5.1 Diagnosis: Straight tubes or pipes perpendicular to bedding plane, shafts parallel to each other, subcylindrical to cylindrical, unbranched.

3.6 Ichnospecies: *Skolithos linearis* Haldemann, 1840 (Pl. I, Figs. 1, 2)

3.6.1 Diagnosis: Straight to slightly curved, cylindrical burrow, vertical to inclined and smooth wall, in some case uneven wall.

3.6.2 Description: Cylindrical to sub-cylindrical, vertical to slightly inclined burrows, unbranched, with variable diameter of the burrow, and the wall of

the burrows are distinctly visible. It appears as a full relief shaft perpendicular to the bedding plane and diameter of burrow ranges from 15-25 mm.

3.6.3 Remarks: Burrows are large, vertical and thickly lined as compare to other ichnospecies of *Skolithos*. They are interpreted as domichnia, suspension feeder. *Skolithos linearis* has been documented from Kulakkalnattam Sandstone of Garudamangalam Formation, Ariyalur, Tamil Nadu (Nagendra et. al, 2010). It has been recorded from the Ambalapuzha Formation (Warkalli Beds, Mio-Pliocene) at Papanasam, Varkala cliff Section (Mude et al., 2012). The genus *Skolithos* is widely recognized in near shore /shallow water marine environment (Seilacher, 7). Such types of burrows are resultant of suspension feeding of polychaetes like *Amphinome rostrata* and *Nereis costoe* (Patel and Desai, 2009).

3.6.4 Occurrence: Ferruginous sandstone of the Babaguru Formation, exposed at Bhilod village, Amravati river section.

3.7 Ichnospecies: *Skolithos verticalis* Hall (Pl. I, Figs. 3, 5, 6, 7)

3.7.1 Diagnosis: Straight to slightly curved, cylindrical burrow, vertical to inclined, usually shorter and smaller.

3.7.2 Description: Vertical shaft, disposed perpendicular to the bedding plane without branching. The diameter of the burrows varies from 15-20 mm.

3.7.3 Remarks: Burrows are cylindrical, unbranched, and disposed perpendicular to the bedding plane. *Skolithos verticalis* are generally shorter in length and smaller in diameter as compare to *Skolithos linearis*. They are suspension feeder, ethologically domichnia and morphologically shaft. The genus *Skolithos* is widely known in near shore /shallow water marine environment (Seilacher, 1967). The suspension feeding burrows are the resultant of the feeding activities of polychaetes

like *Amphinome rostrata* and *Nereis costoe* (Patel and Desai, 2009).

3.7.4 Occurrence: Ferruginous sandstone of the Babaguru Formation, exposed at Bhilod Village, Amravati river section.

4.0 Discussion and Conclusions:

The ichnofossils / ichnofossils assemblage provides an excellent opportunity to reconstruct paleoenvironment and paleobathymetry (Seilacher, 1967). When body fossils are not preserved in the sediment due to various causes, the ichnofossils plays an important role to uncover the depositional conditions / facts of the sediments. Frey and Pemberton (1985) have grouped all the ichnofossils into eight ichnofacies on the basis of their morphology and occurrence from rocky coast to abyssal zone. The vertical or vertical to slightly inclined biogenic structures are commonly recognized from semi-consolidated substrate (Frey and Pemberton, 1985) and they are characteristic features of the nearshore / foreshore marine environment, with moderate to high energy conditions (Seilacher, 1967). The horizontal structures are the members of the *Cruziana* ichnofacies and generally occur in shallow water marine environment with reducing energy (Seilacher, 1967).

In the present study four ichnofossils have been documented *Laevicyclus mongraensis*, *Planolites beverleyensis*, *Skolithos linearis* and *S. verticalis* from ferruginous sandstone of the Babaguru Formation at Bhilod village, Amravati river section, Gujarat, India. The dominance of the vertical biogenic structures over the horizontal structures indicates that the ferruginous sandstone of the Babaguru Formation was deposited in nearshore / foreshore marine environment with moderate to high energy conditions and very less density of the ichnofossils clearly indicate paucity of nutrients during the deposition of the Babaguru Formation.

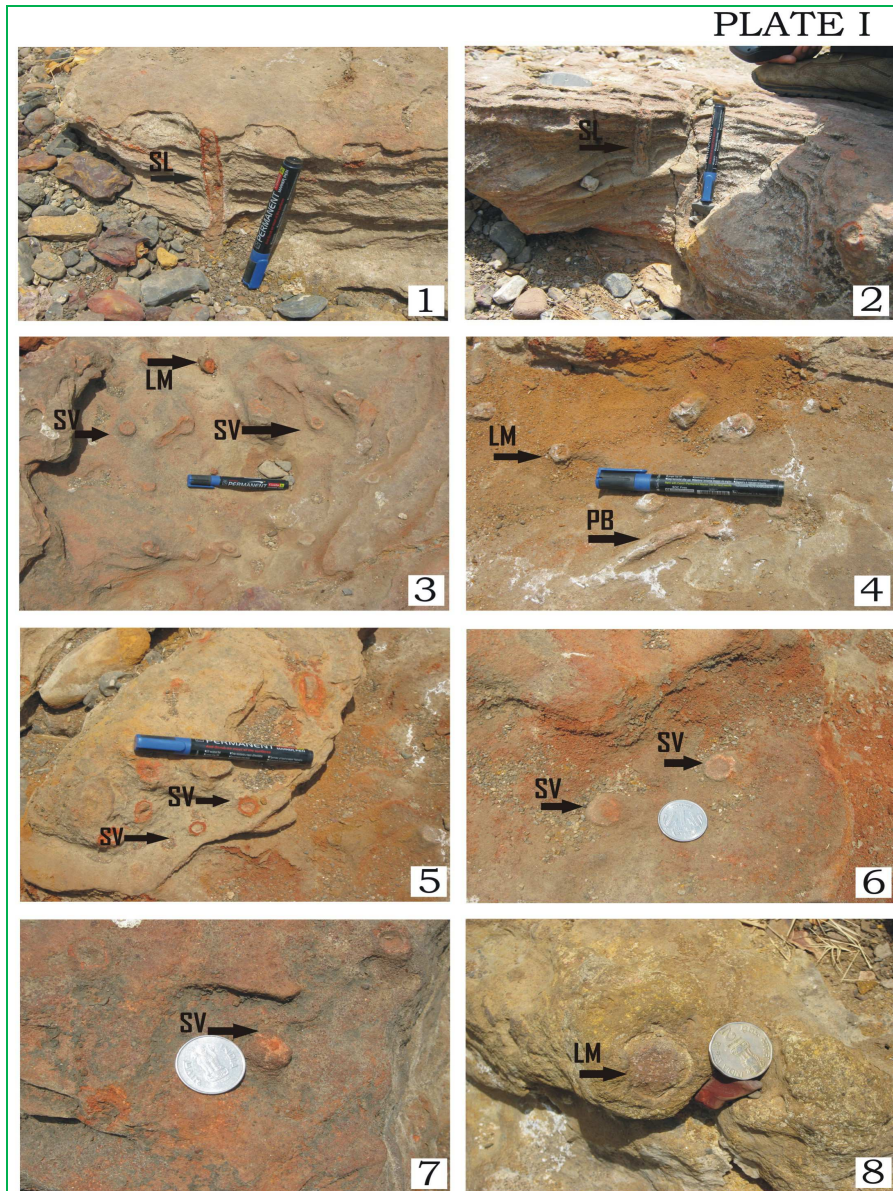


Plate: I. Ichnofossils from ferruginous sandstone of the Babaguru Formation, Cambay Basin, Gujarat

1. *Skolithos linearis*, large vertical to slightly inclined burrow, thickly walled.
2. *Skolithos linearis*, large vertical burrow, thickly walled.
3. a & b) *Skolithos verticalis*, small, vertical thinly lined burrows and
- c) *Laevicyclus mongraensis*, vertical burrow showing two circles.
4. a) *Laevicyclus mongraensis*, vertical burrow showing two circles and
- b) *Planolites beverlensis*, horizontal burrow without wall.
5. *Skolithos verticalis*, small vertical thinly lined burrows.
6. *Skolithos verticalis*, small vertical thinly lined burrows.
7. *Skolithos verticalis*, small vertical thinly lined burrows.
8. *Laevicyclus mongraensis*, vertical burrow showing central shaft.

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