



Paleo-Environmental Significance of Ichnofossils from the Bhuj Formation (Gondwana Sediments) of the Kachchh Region, Northwestern India

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Abstract:

The Mesozoic sediments are well exposed in and around Bhuj district of Kachchh, Gujarat, India. These Mesozoic rocks are represented by Jhurio Formation, Jumara Formation, Jhuran Formation and Bhuj Formation in ascending order of deposition from Bathonian to Albian. In the present study, the section of Upper Member (Albian) of the Bhuj Formation exposed at global co-ordinates N 23° 16' 27"; E 69° 21' 25" near Yaksh village, approximate 32 kms west of Bhuj along Bhuj - Nakhatrana Road, is investigated. The ichnofossils namely, *Palaeophycus heberti*, *P. tubularis*, *Planolites beverleyensis* and *Skolithos linearis* have been documented from the present section. This ichnofossils assemblage suggest that the sandstone horizon of the Upper Member of the Bhuj Formation was deposited in shallow to deep water marine environment with moderate to high energy conditions.

Keywords: Ichnofossils, Upper Member of the Bhuj Formation, Depositional Environment, Kachchh, India.

1.0 Introduction:

The Kachchh region of Gujarat is paradise of sedimentary rocks; thick sequences of the Mesozoic sediments are exposed in and around Mainland Kachchh. These Mesozoic rocks are represented by Jhurio Formation, Jumara Formation, Jhuran Formation and Bhuj Formation in ascending order of deposition ranging in age from Bathonian to Albian (Biswas, 1991). Some part of the Bhuj Formation is considered to be equivalent of the Gondwana sediments. Pant and Murty (2004) have correlated eight peninsular Gondwana basins for stratigraphy which include Rajmahal, Damodar, Rewa, Satpura, Godavari East Coast and Kachchh. The Kachchh basin consists of Jurassic to Lower Cretaceous sediments. Earlier Lower Cretaceous sediments were considered as Umia Formation. Biswas (1971, 1991) has included all Lower Cretaceous sediments into the Bhuj Formation and further he divided it into three members as Upper Member (Albian), Ukra Member (Aptian) and Lower Member (Neocomian). Earlier, Howard and Singh (1985) have studied the Mesozoic sediments from the Kachchh region of India for

ichnofossils. Casshyap et al., (1985) studied ichnofossils in and around Bhuj and they have documented ichnofossils and classified them up to generic level as *Planolites*, *Skolithos* and *Thalassinoides*. In the present investigation, we have

studied a section of the Upper Member of the Bhuj Formation for the documentation of ichnofossils and their significance for deducing depositional environment.

2.0 Methodology:

The sedimentological, ichnological variation and responses of ichnofossils to sediments have been studied from the present section in the field and accordingly litho-section has been prepared. All the measurements of the ichnofossils have been done in the field. All ichnological interpretations are based on field observations and no type specimens have been collected for repository. This study of palichnology follows the Treatise on Invertebrate Paleontology, (Haentschel, 1975), the morphological classification of Simpson (1975) and ethological classification of Seilacher (1964).

3. Systematics of Ichnofossils:

Ichnogenus: *Planolites* Nicholson, 1873

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).

Ichnospecies: *Planolites beverleyensis* Billings, 1862 (Pl. I, Figs. 2PB, 5PB)



Fig.1: A) Location Map of India (Source –Google Map), B) Location Map of Gujarat, (Source –Google Map), C) Location Map of Study area (Source-Google Earth).

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

Description: Burrows are preserved as positive epirelief, dominantly cylindrical ridges, straight to slightly curved burrow without lining, disposed inclined to the bedding plane, circular to semicircular in cross section, burrow fill material is different from the host rock. Burrows are isolated. Dimensions vary from burrow to burrow. The length of the burrow varied from 6-13.5 cm and width from 14-16 mm.

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 inclined

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 Sangarwar (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).

Occurrence: The sandstone of the Upper Member of the Bhuj Formation exposed near Yaksh village, Kachchh.

Ichnotaxonomy: *Palaeophycus* Hall, 1847

Diagnosis: Lined, straight to tortuous, smooth to irregularly walled, elliptical to circular in cross-section, variable dimensions, burrow fill same to the host rock or colour of burrow identical to that of host rock (Pemberton and Frey, 1982).

Ichnospecies: *Palaeophycus heberti* (Saporta) (Pl. I, Fig. 6PH)

Diagnosis: Thickly Lined, straight to tortuous, smooth to irregularly walled, elliptical to circular in cross-section, variable dimensions, burrow fill same to the host rock (Pemberton and Frey, 1982).

Description: Unbranched burrows disposed horizontal to the bedding plane, lined burrow with thick wall, material infilled in the burrow similar to the host rock. The diameter of the burrow is 18 mm while the diameter of the wall is 6 mm.

Remark: Burrow is unbranched and horizontal to the bedding plane. The wall of burrow is considerably thick. Colour of burrow and host rock is same. It is cylindrical to subcylindrical in outer appearance and elliptical to roughly circular in cross section. It is a lined burrow filled with sediments typically identical to those of the host rock. As the present burrow has thick wall, this is described under *Paleophycus heberti* (Saporta) (Pemberton and Frey, 1982). They are interpreted morphologically as tunnel and ethologically as fodinichnia. Badve (1987) and Kundal and Sanganwar (1998) reported this species from Bagh Group of Madhya Pradesh. Kundal and Dharashivkar (2006) documented this species from Kalyanpur Limestone Member of Dwarka Formation.

Occurrence: The sandstone of the Upper Member of the Bhuj Formation exposed near Yaksh village, Kachchh.

Ichnospecies: *Palaeophycus tubularis*, (Pl. I Figs. 3PT, 6PT)

Diagnosis: Thickly Lined, straight to tortuous, smooth to irregularly walled, circular in cross-section, variable dimensions, burrow fill same to the host rock, appears just like tube with uniform thickness (Pemberton and Frey, 1982).

Description: Thinly lined unbranched burrows disposed inclined to the bedding plane, infilled material is same as that of host rock, circular to

semicircular in cross section. The diameters of the burrows vary from 12 to 14 mm and the length ranges from 7.3 to 19.6 cm.

Remark: Burrows are unbranched, thinly lined, cylindrical to tube like in appearance. They are preserved as positive epirelief and circular to semicircular in cross section and inclined to the bedding plane. Burrows are filled with material typically identical to that of surrounding matrix or host rock. The present burrows are, thinly lined and filled with material same to that of host rock. Therefore, they are described under *Paleophycus tubularis* Hall (Pemberton and Frey, 1982). They are interpreted morphologically as tunnel and ethologically as fodinichnia. Badve (1987) and Kundal and Sanganwar (1998) described this species from Bagh Group of Madhya Pradesh. Kundal et al., (2005) documented it from Babaguru Formation at Bhilod village, Broach district, Gujarat, Kundal and Dharashivkar (2006) recorded this species from Positra Limestone Member of Dwarka Formation.

Occurrence: The sandstone of the Upper Member of the Bhuj Formation exposed near Yaksh village, Kachchh.

Ichnotaxonomy: *Skolithos* Haldemann, 1840

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

Ichnospecies: *Skolithos linearis* Haldemann, 1840 (Pl. I, Figs. 2SL, 3SL, 4SL, 5SL)

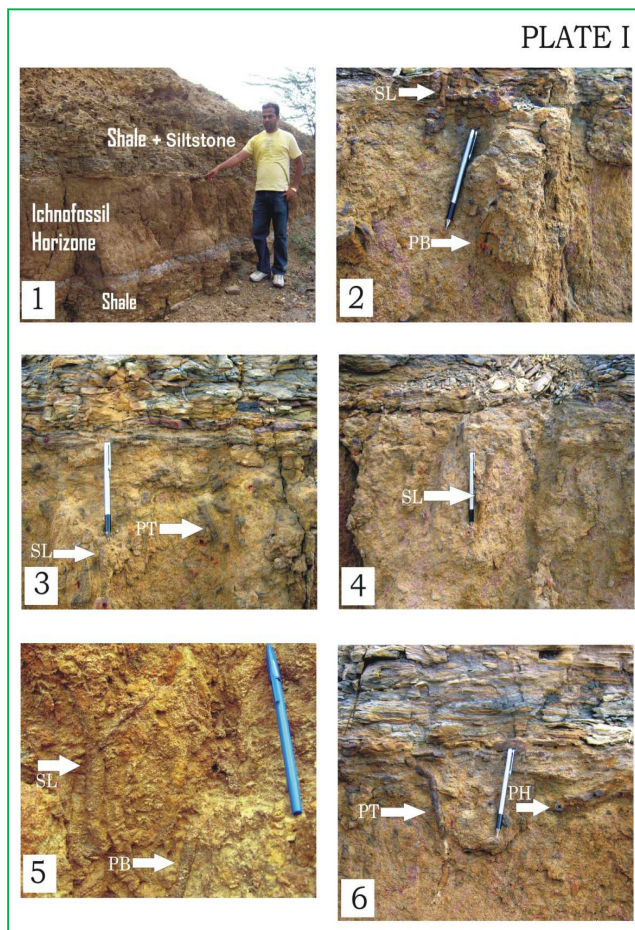
Diagnosis: Straight to slightly curved, cylindrical burrow, vertical to inclined and smooth wall, in some case uneven wall.

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 10 to 14 mm.

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, 1967). Such types of burrows are

resultant of suspension feeding of polychaetes like *Amphinome rostrata* and *Nereis costoe* (Patel and Desai, 2009).

Occurrence: The sandstone of the Upper Member of the Bhuj Formation exposed near Yaksh village, Kachchh.



Explanation of Plate-I

Figure: 1: Section the Upper Member of the Bhuj Formation near Yaksh Village, Kachchh, Gujarat, India

Figure: 2: i) *Skolithos linearis*
ii) *Planolites beverleyensis*

Figure: 3: i) *Skolithos linearis*
ii) *Palaeophycus tubularis*

Figure: 4: i) *Skolithos linearis*

Figure: 5: i) *Skolithos linearis*
ii) *Planolites beverleyensis*

Figure: 6: i) *Palaeophycus tubularis*
ii) *Palaeophycus heberti*

4.0 Discussion and Conclusion:

Seilacher (1964, 1967) suggested that relatively small number of ichnofossils communities reappear throughout Phanerozoic Era and these communities could be used to interpret paleobathymetry. Crimes (1975) noticed that various factors control the behavioral responses of animals and these responses are controlled by energy conditions at a depositional interface, substrate type and availability of food. Thus, ichnofossils are very sensitive to environmental conditions and can be used as environmental indicators. *Skolithos* ichnofacies are mainly associated with beach and intertidal environment while *cruziana* ichnofacies can occur in bays, lagoons, and estuaries as well as shallow waters, at certain places the *Skolithos* and *Cruziana* ichnofacies overlap broadly (Howard and Frey, 1975).

Howard and Singh (1985) have studied the Mesozoic sediments from the Kachchh region of India for ichnofossils. They have studied the sediments of the Patcham Formation, the Chari Formation, the Katrol Formation and the Umia Formation for ichnofossils and they have collected ichnofossils from all formations with varying degree of preservation. They concluded marine depositional environment for the Bhuj Member of the Umia Formation (Now Bhuj Formation, Upper Member, Biswas 1971, 1991) on the basis of *Rhizocorallium* bioturbated horizon. Casshyap et al., (1985) studied ichnofossils in and around Bhuj (23° 12' 16"; 69° 40' 13") and SE of Bhuj i.e. Anjar village and they have documented ichnofossils up to generic level as *Planolites*, *Skolithos* and *Thalassinoides*.

In the present study, ichnofossils namely- *Palaeophycus heberti*, *P. tubularis*, *Planolites beverleyensis* and *Skolithos linearis* have been recorded from the sandstone of Upper Member of the Bhuj Formation (Albian). The ichnofossils, *Palaeophycus heberti*, *P. tubularis*, *Planolites beverleyensis* belong to *Cruziana* ichnofacies while *Skolithos linearis* belongs to *Skolithos* ichnofacies. This ichnofossils assemblage suggest that the sandstone horizon of the Upper Member of the Bhuj Formation was deposited in shallow to deep water marine environment with moderate to high energy conditions. This documentation also enriches the knowledge of ichnofossils from the sediments of the Bhuj Formation.

References:

- 1) Badve, R. M. (1987): A reassessment of Stratigraphy of Bagh Beds, Barwah area, Madhya Pradesh, with description of trace fossils, *Jour. Geol. Soc. India*, 30: 106-120.
- 2) Billings, E. (1862): New species of fossils from different parts of the Lower, Middle and Upper Silurian rocks of Canada" In: Palaeozoic Fossils, *Geol. Soc. Canada Adv. Sheet*, 1:96-168.
- 3) Biswas, S. K. (1971): Note on the Geology of Kutch. *Qurt. Jur. Geol. Min. Met. Soc. India*, 43 (4) : 223-235.
- 4) Biswas S.K. (1991): Stratigraphy and sedimentary evolution of the Mesozoic basin of Kutch, western India. In: S.K. Tandon (ed.) Stratigraphy and sedimentary evolution of western India: 54-103
- 5) Borkar, V. D. and Kulkarni, K. G. (1992): On the occurrence of *Planolites* Nicholson from the Bhaduka Limestone of the Wadhwan Formation (Cretaceous), Kathiawar, Gujarat. *Jour. Geol. Soc. India*, 40: 468-473.
- 6) Casshyap, S. M., Dev, P., Tewari, R. C. and Raghuvanshi, A.K.S. (1983): Ichnofossils from Bhuj Formation (Cretaceous) as palaeoenvironmental Parametres. 52 (2): 73-74.
- 7) Crime, T. P. (1975): The stratigraphical significance of trace fossils. In: The study of Trace Fossils (Ed.), Frey, R. W. *Springer Verlag, Berlin*: 109-130.
- 8) Haentzschel, W. (1975): Trace fossils and Problematica, 2nd edition. In: Treatise on Invertebrate Palaeontology, Pt. W. *Misc. Suppl. Geol. Soc. America, Inc. and Univ. Kansas, Boulder Colorado and Lawrence Kansas*: 269.
- 9) Haldemann, S.S. (1840): Supplement to number one of a monograph of the Limniades and other freshwater bivalves shells of the apparently new animals in different classes, and names and characters of the subgenera in Paludina and Anculosa," *Philadelphia*: 1-3.
- 10) Howard, J. D. and Frey, R. W. (1975): Estuaries of the Georgia coast, U. S. A.: Sedimentology and biology II. Regional anomal-sediment characteristics of Georgia coast. *Senckenberg. Marit.*, 7: 33-103.
- 11) Howard, J. D. and Singh, I. B. (1985): Trace fossils in the Mesozoic sediments of Kachchh Western India. *Palaeogeo., Palaeoclimat., Palaeoecol.*, 52 (1-2): 99-121.
- 12) Kundal, P. and Dharashivkar, A. P. (2006) : Ichnofossils from the Neogene and Quaternary deposits of Dwarka-Okha area, Jamnagar district, Gujarat, India. *Geol. Soc. India, Jour. Geol. Soc. India*, 68: 299-315.
- 13) Kundal, P. Mude, S. N. and Humane S. (2005): Ichnofossils from Late Eocene to Early Miocene of Narmada block of Cambay Basin Gujarat, India. *Jour. Paleo. Soc. India*, 50(2): 177-182.
- 14) Kundal, P. and Sangnwar, B. N. (1998): Stratigraphy and Palichnology of Nimar Sandstone, Bagh Beds of Jobat area, Jhabua district, M. P. *Jour. Geol. Soc. India*, 51 (5): 619-634.
- 15) Kundal, P. and Sangnwar, B. N. (2000): Ichnofossils from Nimar Sandstone Formation, Bagh Group of Manawar area, Dhar disteict, Madhya Prasdesh. *Memo. Geol. Soc. India*. 46: 229-243.
- 16) Mude, S. N., Sarkar, P. K., Ukey, M., and Jagtap, S. A. (2012): Ichnofossils from Ambalapuzha Formation (Mio-Pliocene), Varkala Cliff Section, Kerala, South India. *Gond. Geol.Magz. India* (Inpress)
- 17) Nicholson, H.A. (1873): Contributions to the study of the errant annelids of the older Paleozoic rocks, *Procee. Royal Soc. of London*, 21: 288-290.
- 18) Nagendra, R., Patel, S.J., Deepankar, R. and Reddy, A.N. (2010) : Bathymetric Significance of the Ichnofossils Assemblages of the Kulakkalnattam Sandstone, Ariyalur area, Cauvery Basin, *Jour. Geol. Soc. India*, 76: 525-532.
- 19) Pant, P. R. and Murty, B.V.S. (2004) Geological exploration of coal: the Indian Scenario. *Memo. Geol. Soc. India*, 59:310.
- 20) Patel, S. J. and Desai, B. G.(2009): Animal-sediment relationship of the crustaceans and polychaetes in the intertidal zone around Mandavi, Gulf of Kachchh, Western India," *Jour. Geol. Soc. India*, 74: 233-259.
- 21) Pemberton, R. K. and Frey, R. W. (1982): Trace fossils nomenclature and *Planolites Palaeophycus* dilemma. *Jour. Paleontol.*, 56 (2): 416-439.
- 22) Seilacher, A. (1964): Biogenic sedimentary structures. In Imbrie, J. and Newell, N. D., (Ed), Approaches to palaeoecology. *John Willey and Sons, New York*, : 246-316.
- 23) Seilacher, A. (1967): Bathymetry of trace fossils. *Marine Geology*, 5: 413-428.
- 24) Simpson, S. (1975): Classification of trace fossils, In : Fery, R. W (Ed), The study of Trace Fossils , *Springer Verlag, Berlin* : 39-54.