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ORIGINAL RESEARCH



Trace fossil assemblage of Oligocene (Barail Group) from Zote Area, Champhai District, Mizoram

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The Barail Group (Oligocene) of Zote section, Champhai district, Mizoram has been studied, for the first time, on the basis of trace fossil. The study areas consist of different rocks like Sandstone, siltstone, shale and their admixture in various proportion. The present paper documents 14 ichnofossils such as *Arenicolites isp.*, *Gyrolithes lorcaensis*, *Helminthopsis abeli*, *H. hieroglyphica*, *H. tenuis*, *Laevicyclus mongraensis*, *Lanicodichna medulata*, *Palaeophycus sulcatus*, *P. heberti*, *Psilonichnus tubiformis*, *Skolithos linearis*, *S. verticalis*, *Teichichnus spiralis* and *Thalasinoides paradoxicus*. The different ichnoassemblages present in Zote area correspond to the *Psilonichnus*, *Skolithos* and *Cruziana* facies. With the analysis of Ichnofacies and lithofacies, studied rock of Barail Group exposed in Zote area is interpreted as to have been deposited under fluctuating energy condition, sandy substrate to sublittoral zone of shallow marine environment.

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Introduction

Trace fossils are the impression that is made on the substrate by an organism for example: boring, burrow, track and trail etc. they play very important role in palaeoenvironment studies, and often serve as sole biogenic tools for this purpose. Many trace fossils have been reported from Mizoram but detail ichnological studies has not yet done from Barail Group succession, Mizoram. In the context of Mizoram, Mehrotra *et al.*¹ reported, for the first time, *Teredolites clavatus* from the upper Bhuban unit of Bhuban formation (Surma Group). Again, Mehrotra *et al.*¹ described ichnogenus *Palaeophycus* from the Barail Group succession exposed at about 8.7 km from Champhai on the way of Aizawl to Champhai road. This was considered the first record of

Palaeophycus from the tertiary succession of the north east India. Other researchers like Tiwari *et al.*^{2,3} and Rajkonwar *et al.*^{4,5,6,7} described and illustrated ichnofossils from the middle Bhuban unit of Bhuban formation exposed around Aizawl, Mizoram.

The main aim of this study is to document trace fossils assemblage from Barail rocks (Oligocene) deposits of Zote section, Champhai District, Mizoram.

Geology of the Study Area

The study area is located in the northeastern part of Mizoram. The rocks exposed in the study area are believed to be a part of the Barail sequences. The

Barail rocks of Zote section, Champhai are well exposed and consist of rich and moderately diverse assemblage of Ichnofossils.

The Barail rocks exposed between Zote to Ngur, Champhai district comprises a fossiliferous succession of alternating sandstone, siltstone, shale and their admixtures in various proportions along. Sandstones are grey to brown in colour, very fine to fine grained while shales are light grey to dark grey in colour.

Sedimentary structures observed in the study area include heterolithic, ripple marks (current, wave, elongate ripples), wavy structure, tidal bundles, load cast, strombolites, tidal rhythmites, plumose structure, spheroidal structure like ball and pillow structure. The study area falls under Survey of India Topo Sheet No. 84 E/7. The geological map of Champhai including the proposed sections is showing at Figure 1.

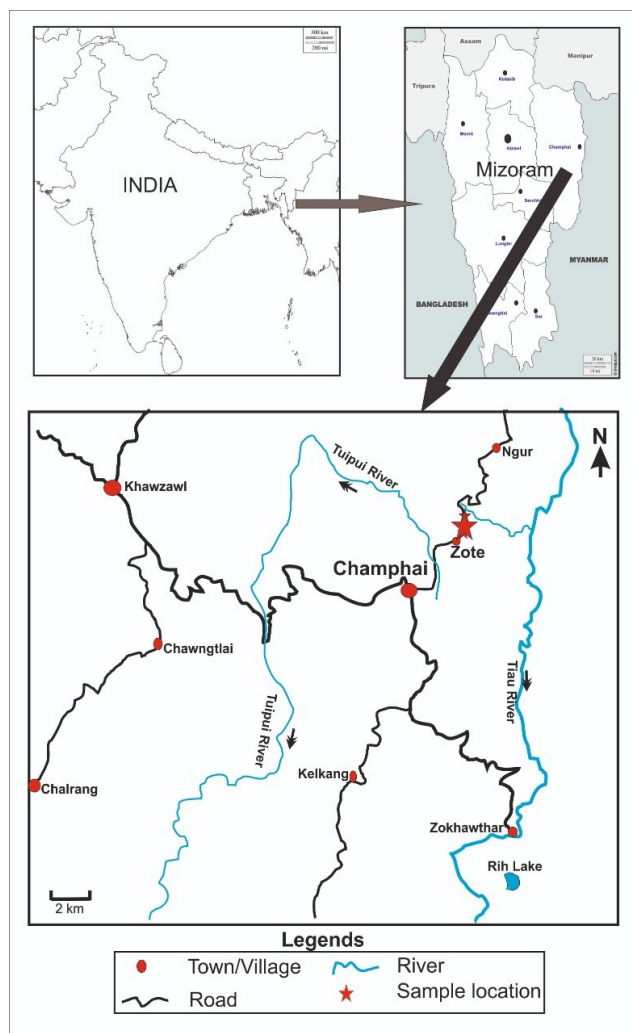


Figure 1. Geological map of Aizawl showing trace fossil localities.

Systematic Description

In the present study, ichnogenera and ichnospecies are named using the binomial system

of nomenclature and described alphabetically.

Ichnogenus: *Arenicolite* Salter (1857)

Ichnospecies: *Arenicolite* isp. (Plate 1: fig a)

Material: Specimen no. Geol/Mus/CHP/Zt-1. Field photographed of sandstone with a full relief burrow.

Description: Endichnial, full relief, vertical, u-shaped lined burrow with no spreiten. Limbs widely spaced, circular in cross section and are not parallel to each other. Diameter of the tube is 1.8-2 cm. Burrow filled is identical to the host rock. The present burrow is widening upward.

Remark: Arenicolites are generally vertical to subvertical dwelling structure made by suspension-feeding worms.^{8,9} Present specimen shows U-shaped which is in vertical structure. So, it is placed under ichnogenus *Arenicolite* but identification upto species level is not possible due to poor preservation and incomplete specimen.

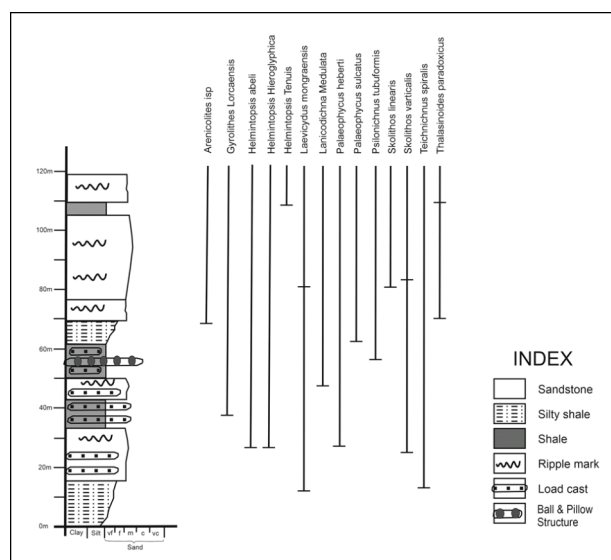


Figure 2. Lithocolumn of the Barail group in Zote area, Champhai

Ichnogenus: *Gyrolithes* Saporta (1884)

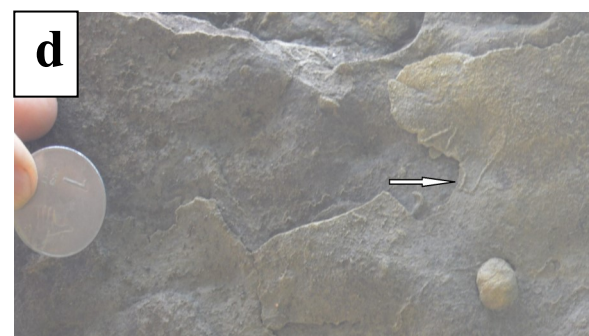
Ichnospecies: *Gyrolithes lorcaensis* (Plate 1: fig b)

Material: Specimen no. Geol/Mus/CHP/Zt-2. Field photograph of grey coloured shale with a full relief burrow.

Description: Smooth, unlined, unbranched, Corkscrew-shaped spiral burrows oriented perpendicular to bedding and composed of few, irregularly curved coils. Tunnel cross-section is sub-circular to circular or oval. Burrow width is 4mm and whorl radius is 5 mm. 6 whorls are visible, two or three whorls are missing at the top.

Remarks: *Gyrolithes* is a vertically oriented burrow that shows a tightly spiraling form in vertical section; the breadth of the spiral is consistent throughout the length of the burrow. In some

PLATE I



(a) *Arenicolite* isp.
(d) *Helminthopsis hieroglyphica*

(b) *Gyrolithes lorcaensis*
(e) *Helminthopsis tenuis*

(c) *Helminthopsis abeli*
(f) *Laevicyclus mongraensis*

instances, *Gyrolithes* is spiraling offshoot of *Thalassinoides* and can extend for several meters into a sedimentary sequence. Hantzschel¹⁰ suggested decapode crustaceans are the probable trace maker for *Gyrolithes* burrow.

Ichnogenus: *Helminthopsis* Heer (1877)

Ichnospecies: *Helminthopsis abeli* (Książewicz, 1977) (Plate 1: fig c)

Material: Specimen no. Geol/Mus/CHP/Zt-3. Field photographed of sandstone bed with burrow.

Description: Hypichnial, smooth, horizontal, semicircular ridges, preserved in semi-relief. It forms deep, winding and irregular meanders. Horse shoe like turn, Maximum observed length of the burrow is 40 mm and diameter is 3 mm. Burrow fill is massive.

Remark: Present specimen is closely resembles with *Helminthopsis abeli*.¹¹ *Helminthopsis* is interpreted morphologically as pascichnial grazing trails, produced by deposit feeders.¹² Various tracemakers can be considered; Polychaete annelids in brackish to fully marine environments, different types of arthropods, nematodes and insect larvae in freshwater settings and larvae of Diptera in modern ponds. Tiwari *et al.*² documented this ichnospecies from Middle Bhuban unit, Bhuban Formation, Mizoram.

Ichnospecies: *Helminthopsis hieroglyphica* (Plate 1: fig d)

Material: Specimen no. Geol/Mus/CHP/Zt-4. Field photographed of sandstone bed with full relief burrow.

Description: hypichnial, smooth, semicircular ridges, 1mm wide, preserved in semi-relief. It forms deep, winding and box shape. 2.5 cm long

Remark: The present specimen shows box shaped fold appearance. So, it is placed under *Helminthopsis hieroglyphica*. These ichnospecies are essentially differentiated on the analysis of their course and their diameter. From those, *H. abeli* shows horseshoe like turns, and the most characteristic feature of *H. hieroglyphica* is the presence of straight element with often windy curves giving box-shaped fold appearance.

Ichnospecies: *Helminthopsis tenuis* (Książewicz, 1968) (Plate 1: fig e)

Material: Specimen no. Geol/Mus/CHP/Zt-5. Field photograph of sandstone with burrow.

Description: Irregular meandering convex, hypichnial, unlined, smooth ridges, which are about 0.9mm wide and upto 160 mm long. They are similar to the host rock. High amplitude windings but only with U-turns, without horseshoe-like turns

Remarks: The presents specimen shows irregular, high amplitude windings but only with U-turns, without horseshoe-like turns. Therefore, it has been named *Helminthopsis tenuis*. Various tracemakers can be considered; polychaete annelids in brackish

to fully marine environments; different types of arthropods, nematodes and insect larvae in freshwater settings, and larvae of Diptera in modern ponds. *Helminthopsis* is common in deep-marine deposits, but is also in shallow-marine and non-marine environments;¹² thus, this ichnogenus can be considered as a 'facies-crossing' occurring in a variety of ichnofacies.¹³

Ichnogenus: *Laevicyclus* Quensdet (1879)

Ichnospecies: *Laevicyclus mongraensis* Verma (1977) (Plate 1: fig f)

Material: Specimen no. Geol/Mus/CHP/Zt-6. Field photographed of sandstone block with full relief burrow.

Description: Endichnial, full relief, scraping circle surrounding a central vertical shaft, perpendicular to the bedding plane. The diameter of the central shaft is 4-5mm and 6-10mm of scraping circle. The sediment fill is identical to surrounding.

Remarks: Diameter of central shaft and scraping circles show close similarities with *Laevicyclus mongraensis* Verma. They are morphologically shaft and ethologically domichnia. Verma originally described from Nimar Sandstone at Mongra, Amba Dongar area, Gujarat.¹⁴ Various workers from India like Kundal and Dharashivkar,¹⁵ Kundal and Sanganwar,¹⁶ Mude *et al.*¹⁷ documented from the Babaguru Formation, Gujarat. And Tiwari *et al.*² and Rajkonwar *et al.*^{5,6,7} described it from Bhuban Formation, Aizawl, Mizoram.

Ichnogenera: *Lanicoidichna* Chamberlain (1971)

Ichnospecies: *Lanicoidichna metulata* Chamberlain (1971) (Plate 2: fig a)

Material: Specimen no. Geol/Mus/CHP/Zt-7.

Description: U-shaped vertical burrow with a secondary gallery branching at the base of the main U form burrow and running parallel to it yielding a W-shaped structure; linked at the base by a horizontal burrow. Each tube of the burrow shows uniform diameter of 1.5 cm and penetrate upto 12 cm. The whole system of burrow is 6 cm. The burrow field material is darker than the host sediments and consists of fine grain sediments.

Remarks: *Lanicoidichna* is considered as the permanent shelters of vagile or hemisessile animals procuring food outside sediment. It also resembles occasionally to the W-shaped tubes of the recent polychaete *Lanice*.¹⁸

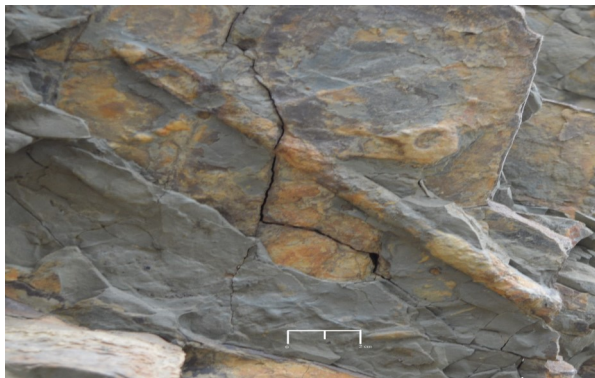
Ichnogenus: *Palaeophycus* Hall (1847)

Ichnospecies: *Palaeophycus heberti* Saporta (1872) (Plate 2: fig b & c)

Material: Specimen no. Geol/Mus/CHP/Zt-8. Field photographed of brown coloured sandstone with burrow

Description: Smooth, thickly lined, unornamented, straight, hypichnial burrows. Length

PLATE II



(a) *Lanicodichna mongraensis*
(e) *Psilonichnus tubiformis*

(b) *Palaeophycus sulcatus*
(f) *Skolithos linearis*.

(c & d) *Palaeophycus heberti*

of the burrow is 200 mm in broken specimen (Plate 2b) whereas diameter is of 15 mm. Burrow fill is structureless and identical to the host rock. Thick wall of the burrow can be seen due to differential weathering.

Remarks: *Palaeophycus heberti* is distinguished from other species of *Palaeophycus* by its thick wall lining.¹⁸

Ichnospecies: *Palaeophycus sulcatus* Miller and Dye (1878) (Plate 2: fig d)

Materials: Specimen no. Geol/Mus/CHP/Zt-9. Field photographed of grey coloured sandstone with semi relief burrow.

Description: Endichnial, horizontal, straight to gently sinuous, lined burrow. Often the burrow enlarges at some distance and shows variation in diameter. The observed length of the burrow is 9-10 cm and diameter is 1.2 -2 cm. nature of the burrow fill is similar to that of the host rock.

Remarks: Present burrow show variation in diameter, So, it is placed under *Palaeophycus sulcatus*. *Palaeophycus sulcatus* differs from *P. striatus* by anastomosing rather than longitudinal striations and from *P. alternatus* in having consistent rather than alternating striations. *Palaeophycus* is interpreted as structures produced by deposit-feeders or predators, usually moving parallel to the sediment surface.¹⁹ This is previously described by Tiwari *et al.*² from Middle Bhuban unit, Bhuban Formation, Mizoram

Ichnogenus: *Psilonichnus* Fursich (1981)

Ichnospecies: *Psilonichnus tubiformis* (Plate 2: fig e)

Material: Specimen no. Geol/Mus/CHP/Zt-10. Field photographed of grey coloured silty sandstone with full relief burrow.

Description: vertical, unlined cylindrical burrows with ovate cross section, short horizontal side branches, diameter of the burrow is 2-3 cm and length of that is 22-30 cm.

Remarks: Presence of short horizontal branch burrow show similarities with *Psilonichnus tubiformis*. *Psilonichnus* was named and described from Upper Jurassic, marginal-marine strata of Portugal.²⁰ *Psilonichnus* is now known to occur in the *Skolithos*, *Glossifungites* and *Psilonichnus* ichnofacies.

Ichnogenus: *Skolithos* Haldemann (1840)

Ichnospecies: *Skolithos linearis* Haldemann (1840) (Plate 2: fig f and Plate 3: fig a)

Material: Specimen no. Geol/Mus/CHP/Zt-11. Field photographed of shale with full relief burrow.

Description: Burrows are isolated, unbranched, cylindrical or subcylindrical, unlined, straight to slightly curved and perpendicular to the bedding plane with structure-less fill. The observed depth of the burrow is 15-25 cm and diameter varies from 2-4 cm. Infill material is different than the surrounding

matrix and mostly is light coloured

Remarks: Morphologically, this specimen has been placed under *Skolithos linearis* as described by Alpert,²¹ Curran and Frey²² suggested that *Skolithos* may have been dwelling burrows of suspension feeding polychaetes. Singh *et al.*²³ reported it from upper Eocene-Lower Oligocene Transition of the Manipur, Indo-Myanmar Ranges. Rajkonwar *et al.*⁶ recorded this ichnospecies from Bhuban Formation, Aizawl, Mizoram.

Ichnospecies: *Skolithos verticalis* Hall (1843) (Plate 3: fig b)

Materials: Specimen no. Geol/Mus/CHP/Zt-12. Field Photographed of block sandstone with full-relief burrow.

Description: Burrows are thick, stout, isolated, cylindrical, perpendicular to the bedding plane and widely spaced or as isolated form. The burrows are emplaced in fine grained sandy sediments and filled material are structureless.

Remarks: *Skolithos verticalis* differs from the *Skolithos linearis* by the filled material, latter is filled with muddy sediments. It is widely recognized in the shallow water, intertidal deposits²³ and various shallow marine environments^{21,25} and is probably thought to be produced by annelids or phoronids.²¹ Rajkonwar *et al.*⁶ recorded this ichnospecies from Bhuban Formation, Aizawl, Mizoram.

Ichnogenus: *Teichichnus* Seilacher (1855)

Ichnospecies: *Teichichnus spiralis* Mikulas, 1990 (Plate 3: fig c)

Material: Specimen no. Geol/Mus/CHP/Zt-13. Field photograph of Silty-shale with burrow

Description: Long, unbranched, unlined, gutter shaped, oblique coiled structure with three backfill lamellae. Top part of the specimen is broken.

Remarks: *Teichichnus spiralis* is a tunnel system made by crustaceans, it is characterized by the presence of tightly siparaled gutter- like backfill lamellae. *Teichichnus* was introduced by Seilacher²⁴ for describing horizontal, dwelling-feeding structures, in the form of walls with parallel laminae, made by deposit-feeders, moving within the deposit.

Ichnogenus: *Thalassinoides* Ehrenberg (1944)

Ichnospecies: *Thalassinoids paradoxicus* Woodward (1930) (Plate 3: fig d)

Material: Specimen no. Geol/Mus/CHP/Zt-14. Field photographed of silty-shale and sandstone bed with full relief burrow.

Description: Horizontal, Endichnial or hypichnial, cast is preserved in full relief, 3D structure irregular burrow system. The branches are T or Y shaped and also show swelling at junction. The burrow in fill is different than the surrounding. Burrow diameter varies 2-4 cm. Burrow branch consist of inclined shaft.

Remarks: Present specimen resembles well with

PLATE III



(a) *Skolithos linearis*

(b) *Skolithos verticalis*

(c) *Teichichnus spiralis*

(d) *Thalassinoides paradoxicus*

the specimen of *Thalassinoides paradoxicus* described and figured by Rieth.²⁶ *Thalassinoides paradoxicus* is different than the *T. horizontalis* consisting of vertical or inclined shaft and branch dichotomous. *Thalassinoides* is usually interpreted morphologically as tunnel and ethologically as a fodinichnial/domichnial structure, passively filled, but occasionally an agrichnial behavior has been interpreted for the tracemaker,^{27,28} Singh et al.²³ reported it from upper Eocene-Lower Oligocene Transition of the Manipur, Indo-Myanmar Ranges, also Tiwari et al.², Rajkonwar et al.^{5,6,7} also documented this ichnospecies from Bhuban Formation, Mizoram.

Discussion and Conclusion

A total of 14 ichnospecies have been identified from the collection, photographed and described such as *Arenicolites* isp., *Gyrolithes lorcaensis*, *Helminthopsis abeli*, *Helminthopsis hieroglyphica*, *Helminthopsis tenuis*, *Laevicyclus mongraensis*, *Lanicodichna medulata*, *Palaeophycus sulcatus*, *Palaeophycus heberti*, *Pylonichnus tubiformis*, *Skolithos linearis*, *Skolithos verticalis*, *Teichichnus spiralis* and *Thalassinoides paradoxicus*. Out of these 14 ichnospecies, seven ichnospecies, *Arenicolite* isp., *Gyrolithes lorcaensis*, *Laevicyclus mongraensis*, *Lanicodichna medulata*, *Pylonichnus tubiformis*, *Skolithos linearis* and *Skolithos verticalis*, belongs to *Skolithos* ichnofacies that indicates shifting sandy substrates, high energy conditions and a rapid change in sedimentation rate and erosion of surface sediment in foreshore zone of shallow marine environment.^{29,30} *Arenicolites* is characterized as typical of shallow marine realm with several deep water instances.³¹ In general, this trace fossil implies high energy intertidal to subtidal condition of deposition.³² Though known to occur in diverse environments including non-marine,³² it is typical of shallow-marine settings.³⁴ *Skolithos* occurs in shallow-marine environments,²⁴ but also rarely in non-marine environments.^{31,35,36,37}

While other 7 ichnospecies like *Helminthopsis abeli*, *Helminthopsis hieroglyphica*, *Helminthopsis tenuis*, *Palaeophycus sulcatus*, *Palaeophycus heberti*, *Teichichnus spiralis* and *Thalassinoides paradoxicus*, represent *Cruziana* ichnofacies indicating unconsolidated, poorly sorted soft substrate low energy condition in the sublittoral zone of shallow marine environment. *Helminthopsis* is common in deep marine deposits, but is also in shallow marine and non-marine environments;¹² thus, this ichnogenus can be considered as a “facies-crossing” occurring in a variety of ichnofacies.¹³ *Thalassinoides* is a facies crossing form and very typical of shallow marine environments, frequently related to oxygenated situations and soft but fairly cohesive substrate.^{38,39,40,41}

Ethologically, most of the present ichno-

assemblage is dominated by domichnia, fodichnia and pascichnia meaning dwelling, feeding and grazing burrows and most of them belongs to *Skolithos* and *Cruziana* ichnofacies.

Therefore, the Barail rock of Zote area can be interpreted as to have been deposited under fluctuating energy condition, sandy shore to sublittoral zone of shallow marine environment.

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