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# ICHNOFOSSILS FROM THE LATE EOCENE TO EARLY MIOCENE OF THE NARMADA BLOCK OF THE CAMBAY BASIN, GUJARAT, INDIA

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## ABSTRACT

The yellow limestone of the Dinod Formation (late Eocene) exposed at Dinod village, Ankleshwar taluka, Broach District, Gujarat has yielded one ichnospecies, namely *Skolithos* ichnosp., whereas the alternation of sandstone and clays of the Babaguru Formation (early Miocene) outcropping at Bhilod village of Valia taluka of Broach District shows presence of six ichnospecies, viz. *Keckia annulata, Ophiomorpha nodosa, Paleophycus tubularis, Planolites beverleyensis, Planolites montanus* and *Thalassinoides paradoxicus*. *Skolithos* ichnospecies belonging to *Skolithos* facies indicates that the Dinod Formation was deposited under littoral to very shallow sublittoral zone under high energy conditions. The ichnoassemblage from the Babaguru Formation is referable both to *Skolithos facies* and *Cruziana* facies which indicate that the Babaguru Formation was deposited under littoral to shallow sublittoral environment.

**Key words**: Ichnofossils, late Eocene-early Miocene, Cambay Basin, Gujarat, India

## INTRODUCTION

The Tertiary sequence exposed in the southeastern part of the Cambay Basin contain several rich fossiliferous beds which range in age from?Palaeocene to early Pliocene (Agrawal, 1986). Except the record of six ichnofossils by Abbas and Patel (1998) from the subsurface sediments of the Ahmedabad-Mehsana Block of the Cambay Basin, no record of ichnofossils has been made from other blocks of the basin. As ichnofossils have become an important tool of palaeoenvironmental interpretation, the documentation of ichnofossils from every block of the basin needs to be made. The present paper records ichnofossils from the Tertiary sequence of the Narmada Block of the Cambay basin. The assemblage comprises one ichnospecies, namely *Skolithos* ichonsp. from the 2 m thick yellow limestone of the Dinod Formation (late Eocene) exposed at Dinod village , Ankleshwar taluka of Broach District, and six ichnospecies, namely *Keckia annulata, Ophiomorpha nodosa, Paleophycus tubularis, Planolites beverleyensis, Planolites montanus* and *Thalassinoides paradoxicus* from the 4 m thick alternation of sandstone and clays referable to the Babaguru Formation (early Miocene) exposed at Bhilod village of Valia taluka, Broach District.

## GEOLOGICAL SETTING

The Cambay Basin is an intercratonic rift basin. 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 Tertiary sequence of the Cambay Basin is classified into five formations, which, in order of superposition, are: Vagadkhol Formation (? Palaeocene),

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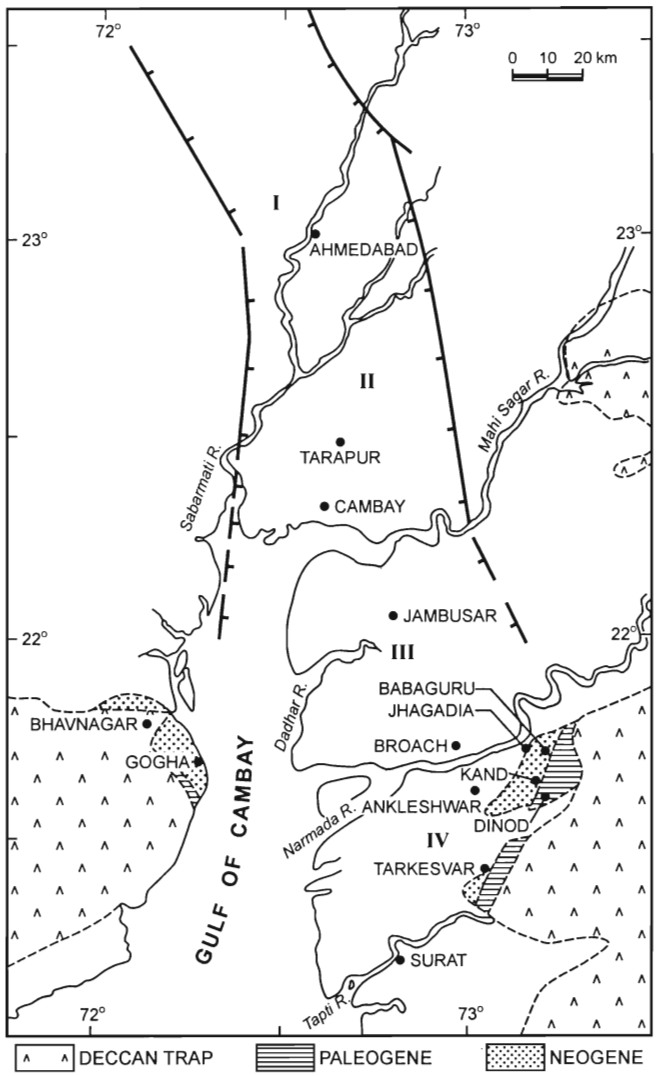



Fig. 1. Geological map of the Cambay Basin (modified after Mathur *et al.*, 1968). **I.** Ahmedabad-Mehsana block, **II.** Cambay-Tarapur block, **III.** Jambusar-Broach block, **IV.** Narbada block.

**Table 1: Onshore Tertiary Stratigraphy of the Cambay Basin (after Agrawal, 1986).**

| | ( Subsurface ) | (Surface) | Lithology |
|---|---|---|---|
| Holocene | | Gujarat Alluvium | Narmada Fm. Sandstone, silts, clays and gravels |
| | ----------Unconformity---------- | | |
| Pleistocene | Jambusar Fm. | Absent | |
| Pliocene | Broach Fm. | Absent | |
| | Jhagadia Fm. | Jhagadia Fm. | Sandstone, gritstone, conglomerate, breccia, clays, silts |
| | ----------Unconformity---------- | | |
| Miocene | | Kand Fm. | Kand Fm. Conglomerate, fossil, limestone, Calcareous sandstone and gravelly clay |
| | ----------Unconformity---------- | | |
| | Babaguru Fm. | Babaguru Fm. | Conglomerate, sandstone, Cherry red and highly ferruginous clays |
| | ----------Unconformity---------- | | |
| Oligocene | Tarkeshwar Fm. | Absent | |
| | ----------Unconformity---------- | | |
| | U Ankleshwar Fm. | Dinod Fm. | Fossiliferous limestone and marls |
| | ----------Unconformity---------- | | |
| | M | | |
| Eocene | ----------Unconformity---------- | | |
| | L Cambay Shale | | |
| | ----------Angular Unconformity---------- | | |
| ? Palaeocene | Vagadkhol Fm . | Vagadkhol Fm. | Conglomerate, grit, sandstone, variegated clays and siltstone |
| | ----------Unconformity---------- | | |
| Cretaceous | Deccan Trap | Deccan Trap | Basalt, trachyte, etc. |

Dinod Formation (late Eocene), Babaguru Formation (early Miocene), Kand Formation (middle to late Miocene) and Jhagadia Formation (early Pliocene) (Agrawal, 1986).

Agrawal (1986) divided the onshore Tertiary rocks of the Cambay Basin into five formations, namely Vagadkhol, Dinod, Babaguru, Kand and Jhagadia (Table 1).

The Vagadkhol Formation consists of conglomerate, gritstone, variegated clays and siltstone, and is unfossiliferous and doubtfully dated as Palaeocene. This formation was deposited under fluvial to shallow marine environment. It is over-

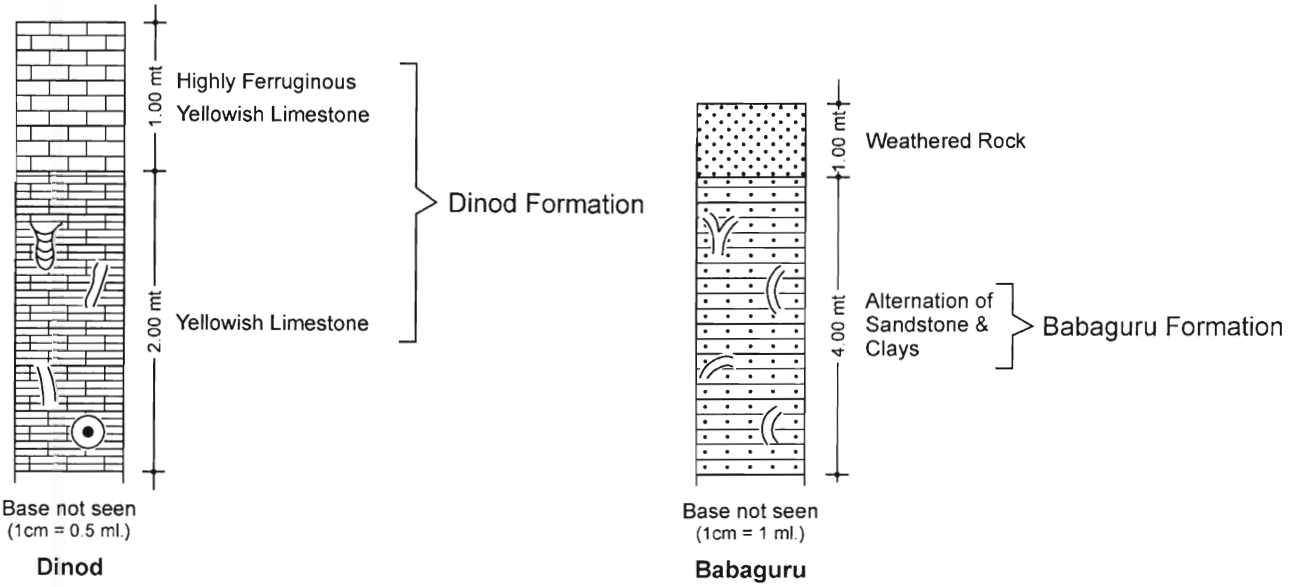



Fig. 2: Lithosections at Dinod and Bhilod.

lain by the Dinod Formation which consists of fossiliferous limestone and marl. The Dinod Formation is dated as early Eocene and was deposited under shallow marine environment (Fig.2).

The Babaguru Formation overlies the Dinod Formation comprising the ferruginous conglomerate and clays. It was deposited in a fluvial to shallow water environment and dated as early Miocene. It is succeeded by the Kand Formation which consists of conglomerate, fossiliferous limestone and calcareous limestone. The Kand Formation was deposited under shallow inner shelf conditions and has been assigned the middle to late Miocene age. The overlying Jhagadia Formation is made up mainly of sandstone, gritstone, conglomerate and breccia. It is unfossiliferous and has been assigned the early Pliocene age.

## SYSTEMATIC DESCRIPTION

This study of Invertebrate Palaeontology follows the Treatise on, (Haentschel (1975). The morphological classification of Simpson (1975), ethological classification of Seilacher (1964) and facies classification of Seilacher (1964,1967) are adopted in the present work.

All the specimens studied in the present paper are housed in the Repository of Postgraduate Department of Geology, R.T.M. Nagpur University, Law college square, Nagpur.

*Ichnogenus* ***Keckia*** Glocker

*Keckia annulata* Glocker

(Pl. I, fig.2)

*Material*: Specimen No. PGTDG/IF/33

*Dimensions*: Diameter of burrow - 5 to 8 mm., Nos. of annulations per cm - 7 to 8

*Remarks*: Burrows curved, unbranched and thinly lined having varying length. With transverse annulations; preserved as positive epirelief and negative hyporelief. The present burrows are distinctly annulated and curved; therefore they are described as *Keckia annulata* Glocker. Many workers, Chiplonkar and Ghare (1975a), Badve (1987), Kundal and Sanganwar (2000) and Nayak (2000), recorded *K. annulata* from the Bagh Group of M.P. Kulkarni and Ghare (1989) recorded it from the Gangta Member of the Khadir Formation, Kutch. Kundal and Dharashivkar (2005) reported it from the bioclastic limestone of the Kalyanpur Limestone Member of the Dwarka Formation of the Dwarka-Okha area, Gujarat.

*Classification*: Morphological-Tunnel; Ethological: Fodichnia and Facies-*Cruziana*.

*Horizon and Locality*: Sandstone and clays of the Babaguru Formation exposed at Bhilod village (Amaravati river section )

*Ichnogenus* ***Ophiomorpha*** Lundgren

*Ophiomorpha nodosa* Lundgren

(Pl. I, fig.1)

*Material*: Specimen No. PGTDG/IF/34.

*Dimensions*: Diameter of burrow - 8 to 10 mm, Diameter of pellets: 1 to 2 mm.

*Remarks*: Burrow horizontal, branched. Wall of burrow consisting of crowded discoid and ovoid pellets. The present burrow has dense discoid to ovoid pellets over it and hence it is kept under *O. nodosa* (Frey *et al.*, 1978 and Frey and Howard, 1985). It has been recorded by Chiplonkar and Ghare (1975b) from the Bagh Group of Dhar district of M.P.; Kundal and Sanganwar (2000) from the Nimar Sandstone (Formation) of the Bagh Group at Baria, the Dhar district, M.P.; and Kundal and Dharashivkar (2005) from the Ashapura Clay Member of the Gaj Formation of the Dwarka-Okha area of Gujarat.

*Classification*: Morphological-Shaft; Ethological: Domichnia and Facies-*Skolithos/Cruziana*.

*Horizon and Locality*: Sandstone and clays of the Babaguru Formation exposed at Bhilod village (Amaravati river section)

*Ichnogenus* ***Palaeophycus*** Hall

*Palaeophycus tubularis* Hall

(Pl. I, fig.4)

*Material*: Specimen Nos. PGTDG/IF/ 36, 41

*Dimensions*: Diameter of burrows - 6 to 8 mm.

*Remarks*: Burrows nearly cylindrical, unbranched, thinly lined, semicircular in cross-section and preserved as positive epirelief. The colour of the burrows and the host rock is same. As these are thinly lined, they are described as *Palaeophycus tubularis* Hall (Pemberton and Frey, 1982). Badve (1987) and Kundal and Sanganwar (1998) described it from the Bagh Group of M.P. Kundal and Dharashiwkar (2005) described this species from the Positra Limestone Member (middle Miocene) of the Dwarka Formation, Dwarka-Okha area, Gujarat.

*Classification*: Morphological-Tunnel; Ethological: Fodichnia and Facies: *Cruziana*.

*Horizon and Locality*: Sandstone and clays of the Babaguru Formation exposed at Bhilod village (Amaravati river section).

*Ichnogenus* ***Planolites*** Nicholson

*Planolites beverleyensis* (Billing)

(Pl. I, figs. 6)

*Material*: Specimen Nos. PGTDG/IF/ 37,38,39

*Dimensions*: Diameter of burrows - 8 to 16 mm.

*Remarks*: Burrows large, cylindrical to subcylindrical, straight to gently curved, undulose, preserved as positive epirelief. They cross over. The colour of the burrows differs from that of the host rock. Pemberton and Frey (1982) have differentiated the two species of *Planolites*, namely *P. beverleyensis* and *P. montanus* on the basis of the diameter of burrows. According to them, the diameter of *P. beverleyensis* is more than 8 mm, while the that of *P. montanus* is less than 5 mm. The present burrows are large having diameter more

than 8 mm and hence they are described as *Planolites beverleyensis* (Pemberton and Frey, 1982). Borkar and Kulkarni (1992) described *P. beverleyensis* from the Wadhawan Formation of Gujarat, and Kundal and Dharashivkar (2005) described it from the Shankhodhar Sand Clay Member (upper Miocene) of the Dwarka Formation of Gujarat. Kundal and Sanganwar (1998, 2000) described this species from the Bagh Group of M. P.

*Classification*: Morphological-Tunnel; Ethological: Fodichnia and Facies-*Cruziana*.

*Horizon and Locality*: Sandstone and clays of the Babaguru Formation exposed at Bhilod village (Amaravati river section)

*Planolites montanus* Richter

(Pl.I, fig. 3)

*Material*: Specimen Nos. PGTDG/IF/40

*Dimensions*: Diameter of burrows - 2 to 4 mm.

*Remarks* : Burrows small, straight to slightly curved and undulose; disposed parallel to bedding planes and preserved as positive epirelief. The present burrows are small having diameter ranging from 2 to 4 mm and therefore they are placed under *Planolites montanus* (Pemberton and Frey, 1982). Badve and Ghare (1978, 1980), Sanganwar and Kundal (1997) and Kundal and Sanganwar (1998, 2000) reported *P. montanus* from the Bagh Group of M. P. Chiplonkar and Ghare (1979) described it from the Trichinopoly Group, Tamil Nadu and Kundal and Dharashivkar (2005) described it from the Shankhodhar Sand Clay Member (upper Miocene) of the Dwarka Formation of Gujarat.

*Classification*: Morphological-Tunnel; Ethological: Fodichnia and Facies-*Cruziana*.

*Horizon and Locality*: Sandstone and clays of the Babaguru Formation exposed at Bhilod village (Amaravati river section).

*Ichnogenus* ***Skolithos*** Haldeman

*Skolithos* ichnosp.

(Pl. I, fig.5)

*Material*: Specimen Nos. PGTDG/IF/42

*Dimensions*: Diameter of burrows - 4 to 8 mm.

*Remarks*: Burrows cylindrical, unbranched, disposed perpendicular to bedding plane. Surface annulations are not seen. Since burrows are perpendicular to the bedding plane, the surface annulations are not clearly visible, hence present burrows are described as *Skolithos* ichnosp.

*Classification*: Morphological-Shaft; Ethological: Domichnia and Facies-*Skolithos*.

*Horizon and Locality*: Fossiliferous yellowish limestone of the Dinod Formation exposed at Dinod village.

*Ichnogenus* ***Thalassinoides*** Ehrenberg

*Thalassinoides paradoxicus*

(Pl. I, fig.7)

*Material*: Specimen Nos. PGTDG/IF/45

*Dimensions*: Diameter of burrows - 8 to 15 mm.

*Remarks*: "Y"-shaped isolated burrows, disposed horizontal with respect to the bedding plane; unornamented and swollen at the point of bifurcation and preserved as positive epirelief. Meniscates are seen at places. The present burrows are isolated and hence they are described as *T. paradoxicus*. Sanganwar and Kundal (1997), and Kundal and Sanganwar (1998, 2000) reported this species from the Bagh Group of M.P. It has been recorded by Kundal and Dharashivkar (2005) from the Dwarka and the Chaya formations of the Dwarka-Okha area, Gujarat.

*Classification*: Morphological-Tunnel; Ethological-Domichnia and Facies: *Cruziana*.

*Horizon and Locality*: Sandstone and clays of the Babaguru Formation exposed at Bhilod village (Amaravati river section)

## DISCUSSION AND CONCLUSIONS

The ichnofossil investigation from the exposed rocks of the Narmada block of the Cambay Basin reveals that the ichnofossils have not yet been reported from the sediments of the Vagadkhol, Kand and Jhagadia Formations . This study records *Skolithos* ichnosp. from the Dinod Formation and six ichnospecies (*Keckia annulata, Ophiomorpha nodosa, Paleophycus tubularis, Planolites beverleyensis, Planolites montanus* and *Thalassinoides paradoxicus*) from the Babaguru Formation.

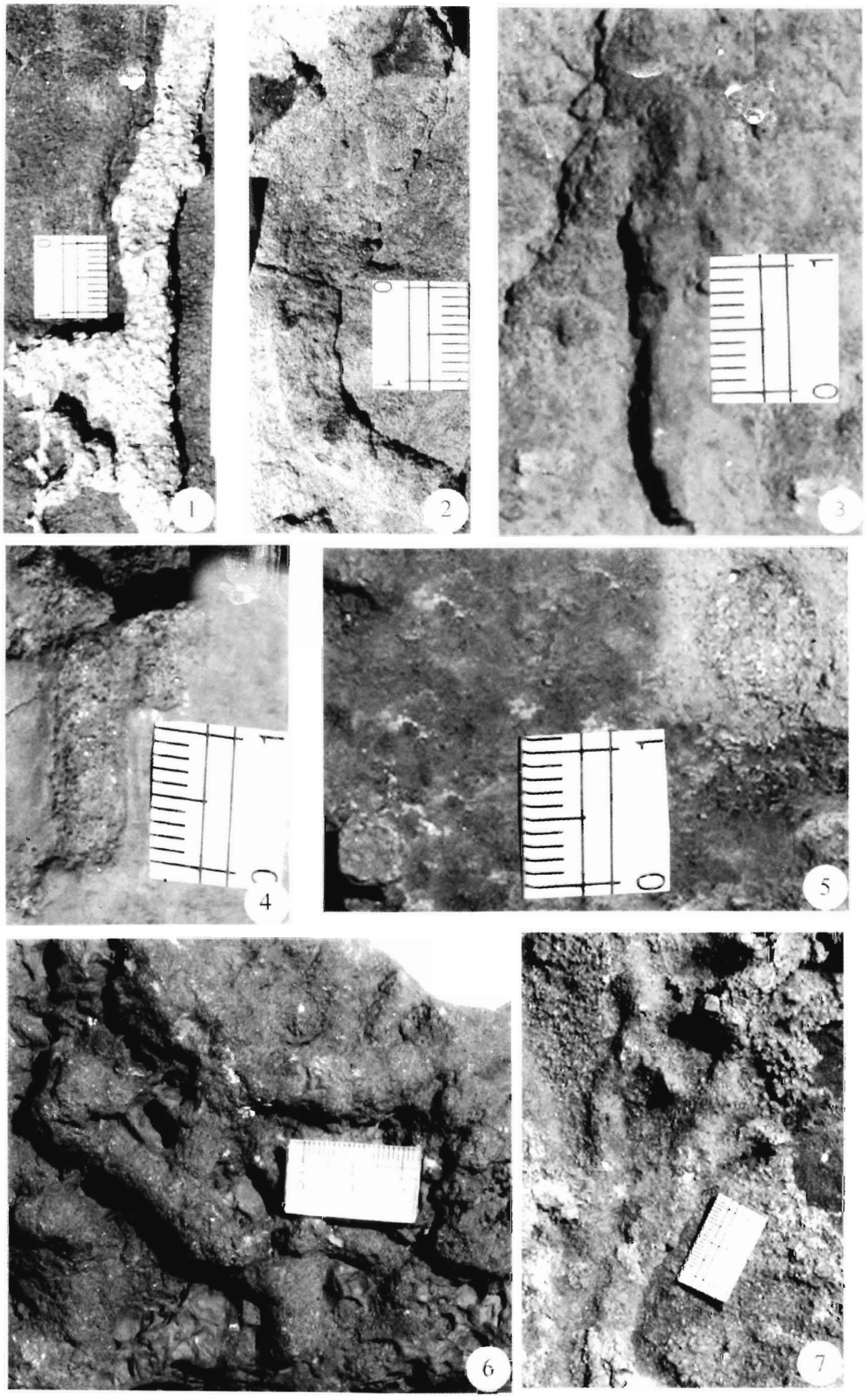
There exists a close relationship between fodichnia and domichnia (Simpson, 1975). The ichnospecies from the late Eocene Dinod Formation and early Miocene Babaguru Formation are a mixture of fodichnia (57.14%) and domichnia (42.86%) and support the Simpson's (1975) point of view.

The Dinod Formation shows presence of only one ichnospecies, i.e. *Skolithos* which is characteristic of *Skolithos* facies. Seilacher (1967) outlined that *Skolithos* facies is indicative of littoral to very shallow sublittoral environment under high-energy conditions. Its presence indicates that the Dinod Formation was deposited in littoral

## EXPLANATION OF PLATE I

1. ***Ophiomorpha nodosa*** Lundgren Specimen No. PGTDG/IF/34
2. ***Keckia annulata*** Glocker Specimen No. PGTDG/IF/33
3. ***Planolites montanus*** Richter Specimen No. PGTDG/IF/40
4. ***Palaeophycus tubularis*** Hall Specimen No. PGTDG/IF/ 36
5. ***Skolithos* ichnosp.** Specimen No. PGTDG/IF/42
6. ***Planolites beverleyensis*** (Billing) Specimen No. PGTDG/IF/ 37
7. ***Thalassinoides paradoxicus*** Specimen No. PGTDG/IF/45

**Plate I**



to very shallow sublittoral zone under high-energy conditions. Presence of foraminifers, such as *Discocyclina* and *Nummulites*, was noticed in the fossiliferous limestone of the Dinod Formation (Merh, 1995). These foraminifers generally occur in shallow sublittoral environment.

The Babaguru Formation was earlier considered as a fluvial to shallow-water deposit formed under mildly oxidizing conditions (Pandey and Dave, 1988). Out of six ichnospecies reported from the Babaguru Formation, *Ophiomorpha nodosa* is one that belongs both to *Skolithos* and *Cruziana* facies, whereas the remaining five ichnospecies are characteristic of *Cruziana* facies. Seilacher (1967) suggests that *Cruziana* facies is suggestive of shallow sublittoral environment. As the ichnofossils from the Babaguru Formation are characteristic of both the *Skolithos* and *Cruziana* facies, it is indicated that the depositional environment of the Babaguru Formation may have ranged from littoral to shallow sublittoral zones of environment. The present observations do not support the fluvial environment of deposition for the Babaguru Formation earlier concluded by Pandey and Dave (1988).

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