Palaeocene green algae (Dasycladaceae and Udoteaceae) from Cauvery basin, India

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Seven species belonging to family Dasycladaceae and Udoteaceae of the Class Chlorophyceae are described from Ninniyur Formation, South India. Four species i.e. *Griphoporella* sp., *Salpingoporella annulata* Carozzi, *Halimeda nana* Pia, and *Ovulites arabica* Massieux are reported for the first time from Indian succession. Two species, *Neomeris pfenderae* Konishi & Epis and *Neomeris plagenensis* Deloffre, though known from other localities of India, are recorded from this formation for the first time. Palaeogeographic and palaeoecological significances of the algal assessmblages are discussed.

Key–words- Green alage, Ninniyur Formation, Palaeocene, Cauvery Basin.

PRESENT investigation is carried out from the Ninniyur Formation exposed between Adanakkurichchi (11^0 21'N: 79^0 15'E) in the north and Sendurai (11^0 15'N 79^0 10'E) in the south, in the Ariyalur-Pondicherry Depression of the Cauvery Basin (Map 1). Ariyalur-Pondicherry Depression or sub-basin is a major linear tectonic element which is located in the northern part of the Cauvery Basin and includes the study area. It is largest in terms of area and also extends offshore which delimits its eastern boundary. Most of the sedimentary sequence over the ridge is of Tertiary age. The thick outcrops of the Cretaceous sequences are developed near the western margin of the depression. However, Tertiary sequence is not developed extensively as outcrops but is well represented in the subsurface. The sub-basin houses three important out cropping areas, viz., Pondicherry, Vridhachalam and Ariyalur, as followed from north to southwest (Map 1 B).

Cretaceous- Tertiary sequences of the area are classified into three groups and a distinct formation, viz., the Uttattur, Trichinopoly, Ariyalur Groups and the Ninniyur Formation. The most distinguishing feature of the Ninniyur Formation is its lithology and fossils, especially the rich representation of the fossil algae (Rao 1958). The Ninniyur Formation is divisible into three units: lower fossiliferous limestone; middle subcrystal-line shelly limestone; and the upper argillaceous gritty nodular limestone. Study is undertaken from lower fossiliferous limestone and middle subcrystalline shelly limestone units (Table 1).

Lithologically, the lower unit is exposed at Adanakkurichchi mines, hence called the Adanakurychchi Limestone. It comprises marl, off-white to yellowish limestone which is moderately compact and richly fossiliferous and noted for the rich miliolid assemblage (Malarkodi & Nagaraj 1997); however, its algal association is poorly developed. The subcrystalline shelly limestone is very well exposed at the Periyakurichchi and is dominantly recrystallized, hard, compact, variegated limestone. It is less fossiliferous as compared to the lower unit so far as the mega-invertebrate fossils are concerned; its fauna is largely disintegrated and characterised by the frequently occurring *Hercoglossa danica* Schlotheim along with gastropods, bivalves, ostracods and foraminifers, it is interesting to note that its algal association is very rich and is highly diversified in comparison to that of the lower unit.

The Ninniyur Formation was assigned the Danian (early Palaeocene) age on the basis of *Hercoglossa danica* Schlotheim considered to be characteristic of the Danian stage (Blanford 1862; Rao & Pia 1936; Rao 1956). Subsequent work revealed the presence of planktic foraminifera in the Ninniyur Formation. Sastry *et al.* (1965) suggested an early Palaeocene age for these beds on the basis of *Globorotalia* (*Truncorotalia*) *mossae* Hofker. However, Malarkodi

Table 1. Showing the succession of the Ninniyur Formation in the area of study (modified after Mallikarjuna & Nagaraja, 1996)

	LITHOLOGICAL UNITS	LITHOLOGY	STUDY AREA
Cuddalore Formation			
	White compact subcrystalline shelly limestone	Limestone containing broad, rounded patches of calcareous algae with milioline foraminifera, *Hercoglossa danica,* lucionoid bivalves etc. (10m).	Periyakurichchi
Ninniyur Formation	Adanakkurichchi Limestone	Argillaceous limestone with intercalated marl and clay. Few segments of small, rounded white bioclasts of clacareous algae present in association with milioline, foraminifera, polyzoans, etc. (3m).	Adanakkurichchi
Ariyalur Group			

and Nagaraj, (1997, 1998) have documented several species of benthic and planktic foraminifera from different litho-units of the Ninniyur Formation. The presence of diagnostic taxa e.g. *Morozovella praecursoria* (Morozova), *Acarinina spiralis* Bolli, *A. mckannai* (White) and the species of *Thalmanntia* indicates that it ranges from early to late Palaeocene (Danian to Thanetian) in age.

Earlier, Rao and Pia (1936), Rao and Gowda (1953), Gowda (1953), Verma (1952, 1954) and Misra *et al.* (2000) have reported the green algal assemblage from Ninniyur Formation e.g. *Acicularia* sp., *A. dyumatsenae* Pia, *Acitabularia* sp., *Clypenia sahnii* Varma, *Dissocladella* sp., *D. undulata* Pia, *D. savitriae* Pia, *Indopolia satyavantii* Pia, *Neomeris* sp., *Orioporella malaviae* Pia, *Pianiae niniyurensis* Gowda, *Indopolia* sp., and *Cymopolia* sp.

Sampling Sites

Samples were collected from the Ninniyur Formation exposed in Adanakkurichchi (11° 21'N: 79° 15'E) and Periyakurichchi mines (11° 17'30"N: 79° 12'E) (Map 1C).

Adanakkurichchi Section: This section is about 4.5 km south of Vellar River and is situated about 10 km NE of Mattur village. It exposes the lower unit of the Ninniyur Formation. The section shows a 3 m thick sequence of the carbonate rocks which are characterized by well preserved megafossils and the poor assemblage of calcareous algae only in fragmented form.

Periyakurichchi Section: This section is about 4.0 km south of Mattur and represents the middle unit of the Ninniyur Formation. It is exposed at Periyakurichchi mines in the vicinity of the Ninniyur village which is nearly 4.5 km southwest of Periyakurichchi. The sequence is about 10 m thick and comprises subcrystalline to crystalline shelly limestone. The general lithology shows compact hard limestone at the base and the marl beds above.

The calcareous algae are present in bands and have brought about a total of seven species of six genera belonging to Dasycladaceae and Udoteaceae.

All the thin sections and samples are deposited at the Algology Laboratory, Botany Department, University of Lucknow, Lucknow.

SYSTEMATIC DESCRIPTION

Division–Chlorophyta Papenfus 1946

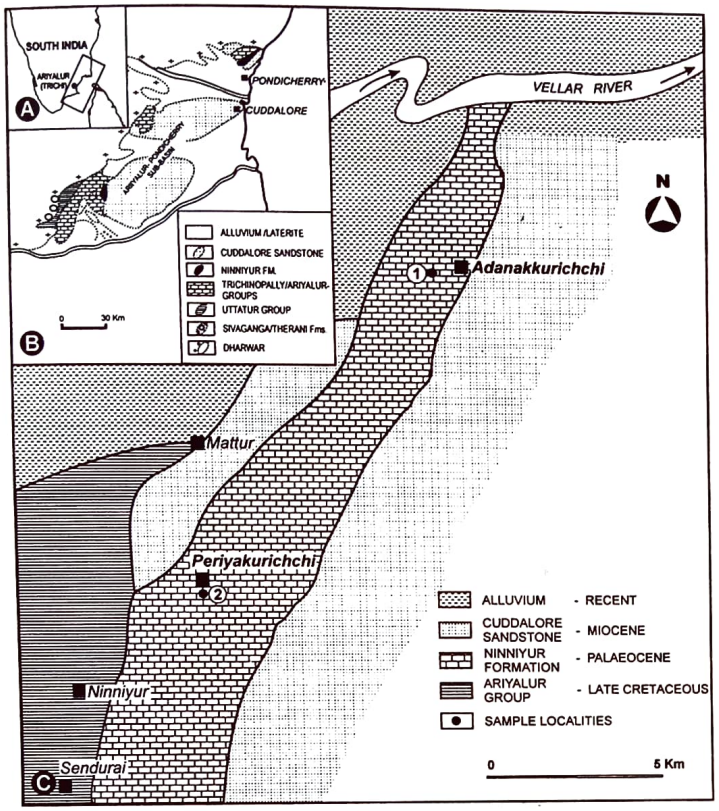
Class–Chlorophyceae Kutzing 1843

Order–Siphonales Backman & Tansley 1902

Family–Udoteaceae Feldmank 1946

Genus–*Halimeda* Lamouroux 1812

Individual plants erect, although some may be draped like vines on steep slopes in deep waters. Calcified segments, varying in shape from flattened to subcylindrical forms, separated by weakly calcified nodes. Internally, they consist of longitudinal filaments in the medullary region and in turn develop into lateral filaments in the cortex where they terminate in a surface layer of cortical urticle.



Map 1- Location and geological map of the area of study. **A.** Position of the Cauvery Basin in India (inset) indicated by a rectangle. **B.** The general geological map of the Cauvery basin showing distribution of the studied succession in the Ariyalur/Pondicherry sub-basin. **C.** The geological map of the area showing the sampled localities where the outcrops of the Ninniyur Formation are exposed.

Halimeda nana Pia 1932

Pl.1, Figs. 2-6

Thallus up to several millimetres long 1.8 mm, 0.72 mm in diameter. Medulla composed of few filaments, subparallel to the axis of the thallus, pores on the outer surface approximately 45 μm in diameter .

Sample No. – Per/3; Per/4.

Slide No.– YST/P3-C2; YST/P-4.

Locality – Periyakurichchi.

Horizon – Subcrystalline shelly limestone.

Genus- *Ovulites* (Lamarck) Munier-Chalmas 1879

Irregular segments, shape of thallus globular. Specimens hollow, suggesting unclassified medullary region, though a finally perforate network preserved in the cortex.

Ovulites arabica (Pfender, 1939) Massieux 1966

Pl.1, Fig.1

Thallus pear shaped, 0.8-1.2 mm in diameter, thin calcified, wall perforated by perpendicular crossing with a constant tiny canals, 90 μm in length.

SampleNo. – Per/3.

Slide No. – YST/P3-C2.

Locality – Periyakurichchi.

Horizon – Subcrystalline shelly limestone.

Order–Dasycladales Pascher 1931

Family - *Acetabulariaceae* (Endlicher) Hauck 1885

Tribe - Neomereae (Cymopoliinae) Granier & Deloffre 1993

Genus-*Neomeris* (Lamouroux) Bassoullet *et al.* 1979

Plant comprising a central stem from which arise very regular whorls of primary branches, characterized by egg-shaped, calcareous capsules (ampullae), grouped in rings either independent or tightly soldered together, primary branch divides into two sterile secondary branches, calcification limited to the ampullae and the secondaries, but not the primaries, weakly calcified or uncalcified.

Neomeris plagnensis Deloffre 1970

PI. 2, Fig. 1

Thallus fragmented 0.75 mm long and 0.24 mm wide. Slender, sterile and pear-shaped, fertile branches present, presumably of second order and arise from uncalcified primaries. Primary branches short and divide into secondary branches (20-40 μm). Egg-shapped sporangial cavities separated by thin secondary, sporangia 150 μm in diameter.

Sample No. – Per/3.

Slide No. – YSP/P-3.

Locality – Periyakurichchi.

Horizon – Subcrystalline shelly limestone.

Neomeris pfenderae Konishi & Epis 1962

PI. 2, Fig. 2

Thallus fragmented 1.5 mm long and 0.3 mm

wide. Slender, sterile and elliptical-shaped, fertile branches present, presumably of second order and arise from uncalcified primaries. Primary branches short and divided into secondary branches (30-50 μm). Elliptical-shaped sporangial cavities separated by thin secondary, sporangia 70-80 μm in diameter.

Sample No. – Per/3.

Slide No. – YSP/P-3.

Locality – Periyakurichchi.

Horizon – Subcrystalline shelly limestone.

Tribe Salpingoporelleae

Genus–*Salpingoporella* Pia 1918

Thallus small, cylindrical and unbranched. Primar laterals arranged in regular whorls, small at their junction with the central stem but enlarge towards the exterior, do not bifurcate or develop in clusters. Fertile blisters probably present in the central stem.

Salpingoporella annulata Carozzi, 1953

Pl. 2, Fig. 5

Oblique-section of inarticulated cylindrical skeletons, the upper elliptical semicrown more developed than the below one, because the skeleton resulted slightly curved towards this side therefore intersected with a bigger inclination. Thallus unbranched, 0.72 mm in length and 0.45 mm in width. Primary branches arranged in regular whorls; perpendicular to the axial vacity, 225 μm in diameter and small at their junction with the central stem but become large towards the exterior; do not bifurcate or develop in clusters. Primary branches 195 μm in length and 120-150 μm in width. Sporangia not present.

Sample No. – Per/4.

Slide No. – YSP/P-30

Locality – Periyakurichchi

Horizon – Subcrystalline shelly limestone.

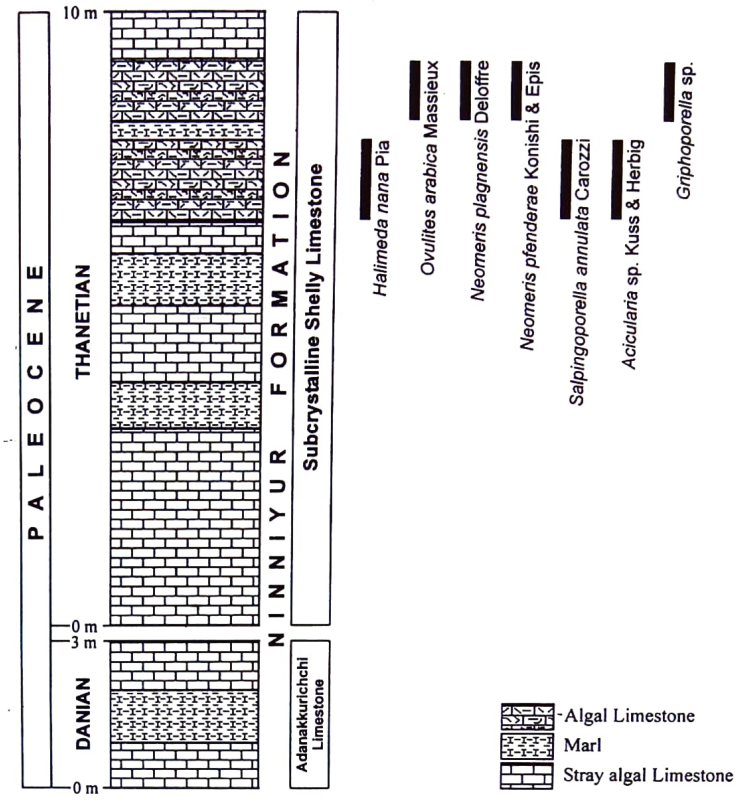


Fig. 1. Range of green algae within Palaeocene Limestone of the Ninniyur Formation

Remarks – The present specimen is comparable with *Salpingoporella annulata* Carozzi in the morphology of primary branches and their arrangement in the central cavity.

Tribe- Acetabularieae

Family - Acetabulariaceae (Endlicher) Hauck 1885

Genus - *Acicularia* d'Archiac 1843

The plant is delicate and distinctive, a few centimetres high, slender central stem bearing an inverted umbrella shaped disc at apex. Specialized calcareous disc made up of radially arranged rays that contain spherical sporangial, cavities, usually individual calcareous rays or fragments resulting from the disaggregation of the apical disc.

***Acicularia* sp.** Kuss & Herbig 1993

Pl. 2, Fig. 4

PLATE 1

Fig. 1. *Ovulites arabica* Massieux x 50

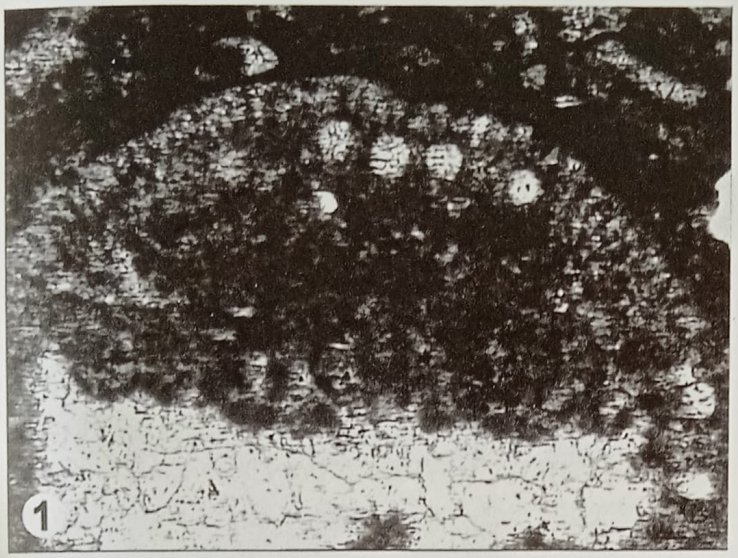
Fig. 2. *Halimeda nana* Pia x 50

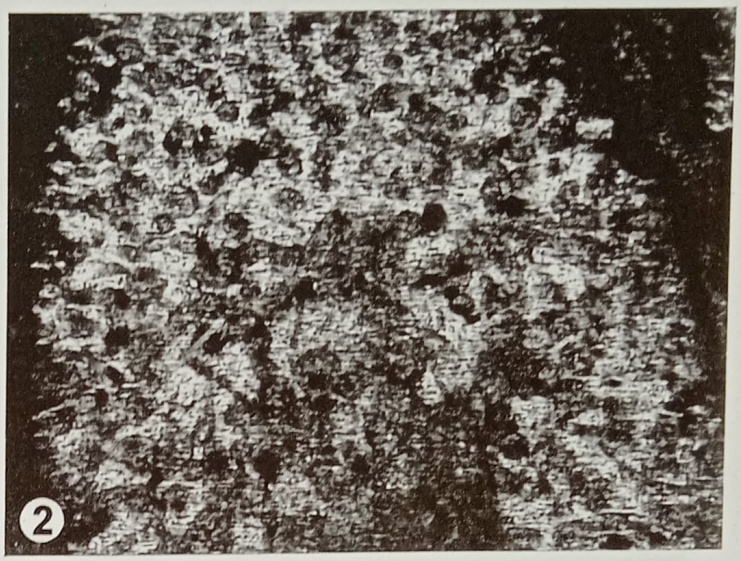
Fig. 3. *Halimeda nana* Pia x 50

Fig. 4. *Halimeda nana* Pia x 50

Fig. 5. *Halimeda nana* Pia x 50

Fig. 6. *Halimeda nana* Pia x 150





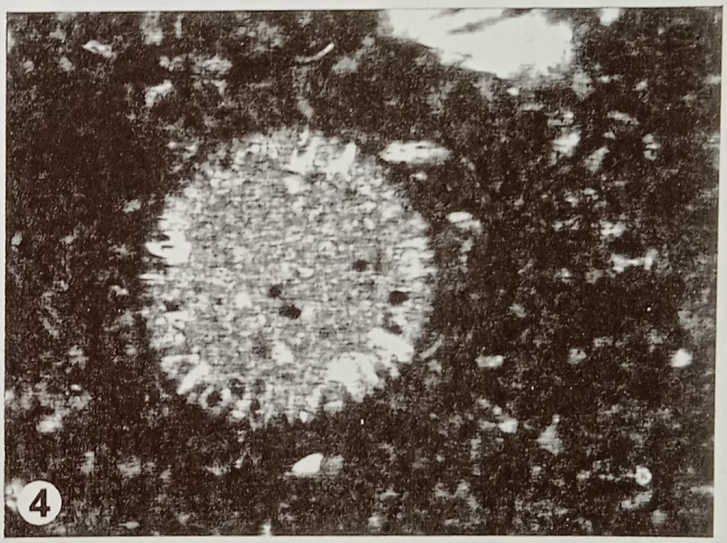


PLATE 1

Section oblique, showing single spicule, 315 μm in width and 570 μm in length. Sproangial cavities arranged regularly around the edge of the disc, commonly 11 in number, sporangia spherical, 45-60 μm in diameter.

Sample no. – Per/4.

Slide No. – YSP/P-30.

Locality – Periyakurichchi.

Horizon – Subcrystalline shelly limestone.

Tribe- Mastoporeae

Family-Seletonellaceae Deloffre 1988

Genus - *Griphoprella* Pia 1915

Genus usually shows thin calcareous skeleton where shape and arrangement of primary branches are difficult to determine.

***Griphoporella* sp.**

Pl. 2, Figs. 3,6

Thallus cylindrical to slightly club-shaped, simple and unbranched. The calcareous wall thin in comparison with the width of the central cavity. Thallus 3.9 mm long and 285 μm in diameter. Primary branches 75 μm thick, arranged in very close, alternate whorl. Reproductive organs unknown (not calcified).

Sample no. – Per/3.

Slide No. – YSP/P3-C2.

Locality – Periyakurichchi.

Horizon – Middle Unit (Subcrystalline shelly limestone)

Remarks – The present specimen is comparable with *G. curvata* Pia in the general arrangement of primary branches but *G. curvata* Pia is known only in upper Triassic.

DISCUSSION

Dasycladales primarily live in tropical seas areas where the annual mean temperature is about 20° C. They prefer a shallow environment (inner infralittoral zone), with low hydrodynamism and normal salinity. These algae are often abundant also in the rough environments of reefs; however, in these habitats, they are never present in the zones directly exposed to hydrodynamism, but they live in depression or where the presence of other organisms assures them a protective shield (De Casro 1997). *Acicularia* and *Neomeris* are adapted to very shallow littoral environments and are able to survive under quite restrictive conditions. Also the co-occuring udoteacean genus *Ovulites,* comparable to the present-day littoral genus *Penicillus,* thrived in only few meters deep marginal environments (Deloffre 1970). *Halimeda* is also an important sediment contributor and its presence points to a warm, shallow-water environment, as found in a lagoon. Its sudden abundance indicates the advent of a reefal environment in the Ninniyur Formation (Ghose 1977).

The geographical distribution of present algal species recorded from Ninniyur Formation indicates that four species occur exclusively in the Palaeocene-Eocene of Egypt and Morocco (*Acicularia* sp. Kuss & Herbig, *Neomeris plagnensis* Deloffre, *Halimeda nana* Pia and *Ovulites arabica* Massieux) as reported by Kuss & Herbig 1993, whereas the remaining three (*Griphoporella* sp., *Salpingoporella annulata* reported by Carozzi (1953) and *Neomeris pfenderae* by Konishi & Epis 1963) occur in the different areas of tethyan realm. In general, most of the documented elements of green algae have been found to be characteristic the Palaeocene-Eocene succession of the tethyan region (Fig.1).

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PLATE 2 ⟶

Fig. 1. *Neomers plagnensis* Deloffre x 50

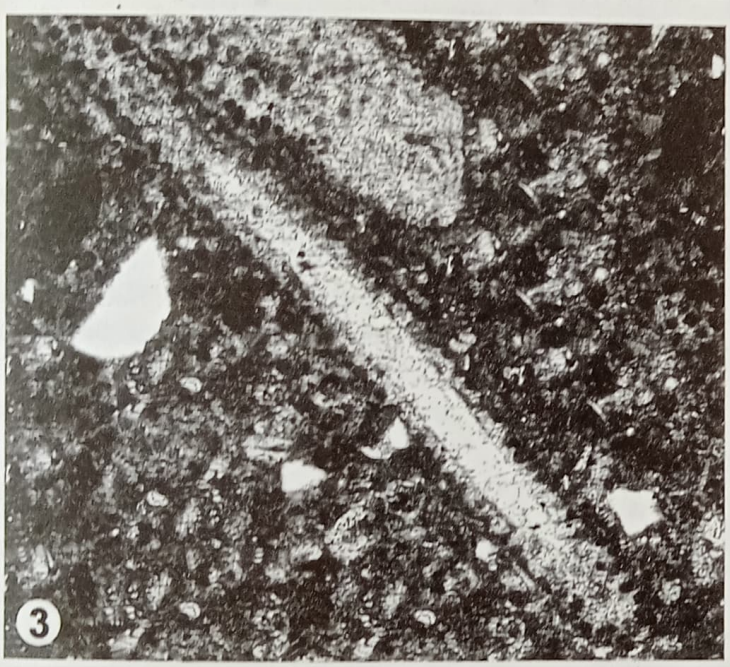
Fig. 2. *Neomeris pfenderae* Konishi x 50

Fig. 3. *Griphoporella* sp. x 50

Fig. 4. *Acicularia* sp. Kuss & Herbig x 50

Fig. 5. *Salpingoporella annulata* Carozzi x 50

Fig. 6. *Griphoporella* sp. x 150



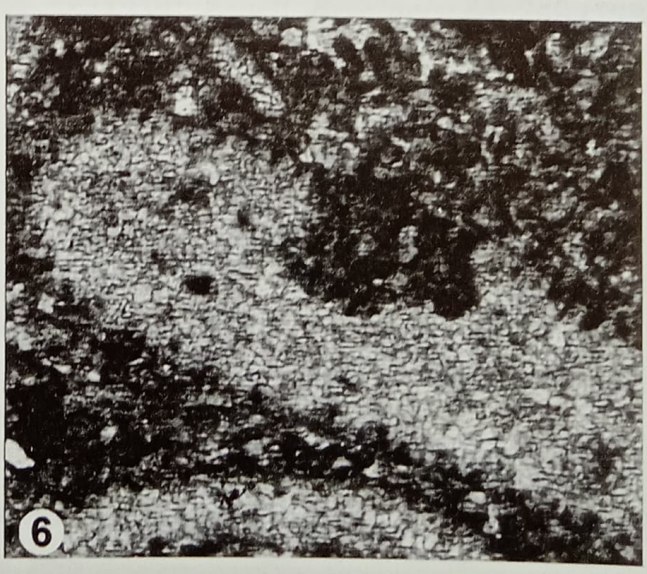


PLATE 2

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