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# Paleoenvironment and Paleoecological Significance of Microforaminiferal Linings in the Akli Lignite, Barmer Basin, Rajasthan, India

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## Abstract

The palynological assemblage of the Akli Lignite in Barmer District of Rajasthan contains a rich variety of microforaminiferal linings.Three types of microforaminiferal linings belonging to benthic communities occur. Two main occurring morphotypes: trochospiral and single chambered types are most common in the assemblage. These linings are less abundant than spores , pollen grains and dinoflagellates.The paleoecological and paleoenvironmental significance of these microforaminiferal linings suggesting their deposition in low salinity conditions and at a relatively shallow depths in an embayment of an epicontinental sea of Paleocene-Eocene age in Barmer Basin.

***Keywords:*** *Palynology, Microforaminiferal linings, Barmer Basin, Palaeocene-Eocene, India.*

## Introduction

The Microforaminiferal linings are abundant in palynological assemblages recovered from Girla Lignite Mine Section near Barmer City, Barmer District , Rajasthan, India. Location and the lithocolumn of the lignite mine along with the position of the samples studied are shown in Figure 1.

This palynological assemblage consists of 99 species belonging to 69 form genera. It is a rich diverse flora and fauna with angiosperm pollen (60.72%), pteridophyte spores (17.10%), algal cysts (8.70%), microforaminiferal test linings (5.77%), gymnosperms (3.10%) and fungal remains (1.18%). In addition, many Paleozoic and Mesozoic reworked gymnosperm pollen types occur in these sediments (Table1) Distribution pattern and frequency of different marker palynotaxa of Tertiary age in the studied succession and comparison with those from other contemporaneous sediments in India and a perceptible change observation in the distribution of palynotaxa has been led to the demarcation of the Paleocene- Eocene strata in the area.

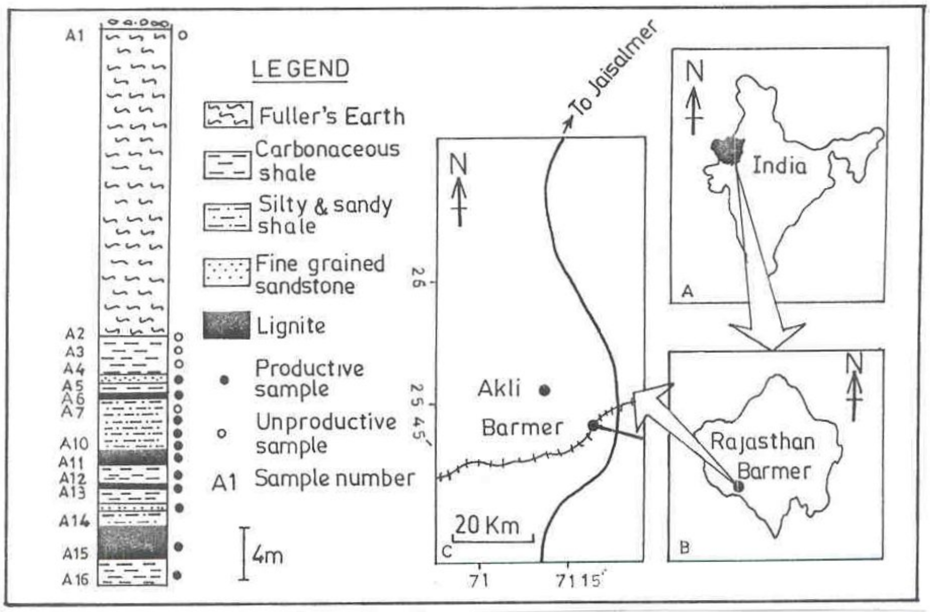


**Figure 1 - Locality Map and Lithosuccession of the Akli Lignite**

**Table 1- Palynological Data From The Akli Lignite**
**(The Stratigraphic Position Of The Samples Is Illustrated In Figure 1)**

| Sample Number | Foram. Lining | Pterido phytes | Angio sperm | Phyto plankton | Gymno sperm | Fungal remains | Reworked Fossils | Lithology |
|---|---|---|---|---|---|---|---|---|
| A5 | - | - | 38% | 37% | - | - | 25% | Shale |
| A6 | - | 37% | 43% | - | - | 12% | - | Lignite |
| A8 | 2.5% | 2.5% | 88% | 7% | - | - | - | Shale |
| A9 | 18% | 30% | 52% | - | - | - | - | Shale |
| A10 | 12% | - | 80% | 8% | - | - | - | Shale |
| A11 | - | 11% | 85% | - | 4% | - | - | Lignite |
| A12 | 4% | 18% | 70% | 6% | - | - | 2% | Shale |
| A13 | - | 45% | 51% | - | 4% | - | - | Lignite |
| A14 | 27% | 13.5% | 36% | - | 23% | - | - | Shale |
| A15 | - | 22% | 60% | 16% | - | - | 2% | Lignite |
| A16 | - | 9% | 65% | 21.5% | 2.5% | <1% | 1.5% | Shale |
| **Ave.** | 5.77% | 17.1% | 60.7% | 8.7% | 3.09% | 1.18% | 2.77% | - |

## Geological Setting and Lithostratigraphy

The sedimentary sequences in Rajasthan are predominantly intracratonic. These sediments, geologically forming a part of western Rajasthan shelf, can be subdivided into four basins comprising Middle Jurassic-Early Eocene rocks in north-south trending grabens (Dasgupta, 1977). The Paleocene-Eocene rocks in Barmer Basin are divided into the Fatehgarh, Barmer, Akli, Mataji Ka Dungar and Kapurdi Formations, in stratigraphic order: Fatehgarh Formation the lowest unit, is made up of sandstone mixed with clay bands and gastropod casts at the top. On a lithological basis, this unit can be correlated with the nonmarine sandstone member of subsurface Sanu Formation of Jaisalmer Basin (Dasgupta, 1977). The lower part of the overlying Barmer Formation consist of fluvial sediments, whereas its upper part is exclusively marine in nature. The lower part of Barmer Formation, on the basis of palynological studies, is Paleocene in age. The Akli Formation unconformably overlies the Barmer Formation. The lower part of this unit is made up of a sandstone-lignite sequence, whereas the upper part is a volcanogenic bentonitic clay succession. Coarse and ferruginous sandstone with pisolites and pebbly sandstone dominantly comprise the Mataji Ka Dungar Formation. Fuller's Earth deposits interbedded with marine bioclastic limestone constitute the overlying Eocene Kapurdi Formation. The Tertiary stratigraphic succession of western Rajasthan proposed by Dasgupta (1975&1977) is given below :

| ***BARMER BASIN*** | ***JAISALMER BASIN*** | ***BIKANER BASIN*** | ***AGE*** |
|---|---|---|---|
| Kapurdi Formation<br>Mataji Ka Dungar Formation | Bandah Formation | Jogira Formation | Eocene |
| Akli Formation | Khuaila Formation | Marh Formation | Paleocene<br>Eocene |
| Barmer Formation<br>Fatehgarh Formation | Sanu Formation | Palana Formation | Paleocene |

## Previous Works

Blanford (1876), Oldham (1886), La-Touche (1902), and Bhola (1947) described the geology of the area. Most of their work concentrated on the bentonitic clay deposits of the Akli Formation. La-Touche (1902) first described the occurrence of angiosperm leaves in the Barmer Sandstone. Dicot leaves; spores, pollen grains and fungal remains have been described by Bose (1952) from the Barmer Sandstone. Jain, Kar and Sah (1973) studied the Barmer Formation and concluded that this unit is not older than Paleocene. Similarly, Naskar and Baksi (1976) on the basis of palynological data suggested a Paleocene-Eocene age for the Akli Lignite. The most recent palynological work in the area was carried out by Tripathi (1993,1995 and 1997). He studied the subsurface samples of Kapurdi area, Barmer, Rajasthan. The assemblage described by Tripathi includes: dinoflagellate cysts, fungal remains, pteridophytic spores, and angiosperm pollen grains. This assemblage suggests a tropical-subtropical palaeoclimate and a coastal depositional environment for these sediments.

First studies on microforaminiferal linings occurred in the 1950s by

Wilson and Hoffmeister (1952), Hoffmeister (1955), and Grayson (1956). These studies were summarized by Wetzel (1957) and Muir and Sarjeant(1977).

Davey (1970) noted that the occurrence of microforaminiferal linings in sediments of Cenomanian age and related their presence to paleoenvironment. Piasecki (1986) recorded rare microforaminiferal linings in brackish marine sediments of Early Cretaceous age. Batten (1982) conversely, observed that microforaminiferal linings are often abundant in marine palynofacies in the presence of amorphous matter. Davis (1985), in a study of the Early and Middle Jurassic sediments of Portugal, documented the presence of common microforaminiferal linings in the absence of dinoflagellate cysts in sediments of Aalenian age. Cross *et al.,* (1966) studied samples from southern California and related the presence of Microforaminiferal linings to the upwelling of nutrient rich waters, higher salt concentrations and local shallow water conditions.

Stancliffe (1989) examined the British Oxfordian assemblages containing the five main types of microforaminiferal linings. He instituted an informal classification for the microforaminiferal linings occurring in the palynological assemblages.

The palynological studies carried out to date show that the microforaminiferal linings have been documented in a preliminary manner from the Mesozoic, Tertiary and Quaternary sediments of India with the exception of the studies by Baksi (1962),Venkatachala(1968), Jain and Dutta (1978), and Phadtare and Thakur (1992). Yet these publications do not use the linings for interpretation of biostratigraphic, paleoenvironmental and paleoecological analyses of the depositional basins.

## Morphological Classification

The classification systems of microforaminiferal linings proposed by various palynologists can be subdivided into two types: (1) Informal, (2) Formal. The former classification of microforaminiferal linings was proposed by Goczan (1962), who described five coiled types from the Cretaceous rocks of Hungary. Macko (1963) and Deak (1964) described formal generic and specific names for Microforaminiferal linings from Cretaceous and Eocene sediments. However, the application of a formal classification was rejected by Tappen and Loeblich (1965) who stated that the additional "form species" and "form genera" would " merely add to an already burdensome forminiferal taxonomy". On the basis of this, Stancliffe (1989) described an informal classification for microforaminiferal linings . The informal classification proposed by Stancliffe has been followed in the present study. This informal classification includes the description of overall chamber relationship, chamber overlap , neck development, length to breadth and change in the plane of flattening.

**Systematics**

Single Chamber Type I, STANCLIFFE 1989
Plate 1, figures 8 -12

**Description :** These are isolated chambers of the microforaminiferal lining. Chambers have well developed neck, ranges from 4-16 µm in length. Size range 60-135x54-122 µm. Wall thickness 1-4 µm , irregularly folded,surface ornamentation smooth-slightly granulose.
Number of Linings studied : 14
Present occurrence : A9-2/2, A9-1/5, A10-1/3, A14-1/2 of Akli Formation, Barmer, Rajasthan

Planispiral Type IV, STANCLIFFE 1989
Plate 1, figures 1,2

**Description:** A planispiral morphotype characterized by non-overlapping chambers. The chambers are wider than their length.The chambers after the first complete whorl merely touch those of the primary whorl. The Linings surface ornamentation is smooth.
Measurements :
Number of chamber: 5-8
First chamber: 18-20x15-16 µm
Second chamber: 20-21x14-15 µm
Last chamber: 45-50x29-41 µm
Overall size: 65-100x55-86 µm

Number of Linings studied : 6
Present occurrence : A9-2/10 of Akli Formation, Barmer, Rajasthan

Trochospiral Type I, STANCLIFFE 1989
Plate 1 figures 3-7

**Description:** This is a trochospiral form characterized by a distinct overlapping of the adjacent chambers. The larger chamber is connected to the preceding and succeeding chambers.The number of whorls ranges from 2 to 3. The surface ornamentation of the chambers varies from smooth-granular.

Measurements:
Number of chamber: 6-9
First chamber: 15-25x15-20 μm
Second chamber: 15-23x13-20 μm
Last chamber: 35-54x25-46 μm
Overall size: 55-98x42-72 μm
Number of Linings studied : 15
Present occurrence: A8-1/4, A10-3/7, A12-1/1, A14-2/3, and A14-2/7 of Akli Formation, Barmer, Rajasthan

**Paleoenvironment and Paleoecology**

The lower Tertiary palynological assemblage examined in this study contains principally three types of microforaminiferal test linings. These are Trochospiral, Planispiral and Single chambered types. Of these the dominant forms are Trochospiral and Single chambered. Most of the linings were recovered from carbonaceous, sandy and silty shale samples belonging to the Akli lignite. These linings are less common in the samples than dinoflagellates , and spores and pollen grains. The abundance of the different palynomorph types in the studied samples are shown in Table 1.

Davey (1970) studied the Cenomanian strata of England, France and North America and suggested that the presence or absence of microforaminiferal test linings in a palynological assemblage is directly related to the paleoenvironment of sediments and can be used to determine as marine or non-marine environments. Piasecki (1986) noted the absence of microforaminiferal linings in the Lower

Cretaceous brackish water sediments of Denmark and suggested that their presence suggests normal marine conditions. The recovered pollen of Nymphaeceae, Meliaceae, Polygalaceae and Malvaceae families in the Barmer Basin sediments suggest probably a very low salinity condition ranging from fresh to brackish water. The basin is suggested to be coastal type since the mioflora recovered from the Akli Lignite contains pollen grains of coastal vegetation like Palmae, Ctenolophonaceae and Rhizophoraceae, in addition to common microforaminiferal linings and algal cysts.

Batten (1973,1982) completed a detailed palynostratigraphic investigation of the Lower Cretaceous sediments of south England and described several palynofacies. In these works, Batten demonstrated that there was a progressive increase in the frequency of microforaminiferal linings from non-marine to marine facies in the area. He further added that microforminiferal linings are generally associated with the amorphous matter which is a good source for hydrocarbon generation. However, in the present study the microforaminiferal linings are found associated with land-derived humic-woody matter and suggests a distinct marine connection of the Barmer Basin.

Warrington (1978 and 1982), Davies (1985), and Courtinat (1989) noted an inverse relationship between the abundance of microforaminiferal linings and dinoflagellates. This may be attributed to an ecological factor where the dinoflagellates floods kill foraminifera during red tides. Warrington(1978) observed that an increase in the number of microforaminiferal linings coincided with the reduction of dinoflagellate population whereas acritarch abundance mimics that of the foraminifera. However, in the present study dinoflagellate abundance is higher than the foraminifera by (8:5)for that particular samples(Table1), probably indicating closeness to the shore.

Cross *et al.*, (1966) suggested that microforaminiferal linings generally occur in areas with upwelling of nutrient rich waters , higher salinities and local shallow marine conditions. However, this study suggests that microforaminiferal linings are not only restricted to the zones indicated by Cross *et al.*, (1966), but can also be found in low salinity as well. Decommer (1982) suggested that microforaminiferal linings occur only in the marine environments. Melia (1984) conversely, interpreted the presence of abundant microforaminiferal test linings in shallow marine condition due to upwelling and their decreasing in number with increasing depth.

Traverse and Ginsburg (1966) interpreted that foraminiferal test linings are derived from benthic foraminifera. McKee et al.(1959) observed abundant microforaminiferal linings in the lagoon of Kapingamarangi Atoll at depth shallower than 7 m although rare specimens occur as deep as 9200 m. Bradford (1977) suggested that the distribution of microforaminiferal linings in marine sediments is comparable to the distribution of benthic foraminifera. Bradford also observed a coincident abundance of microforaminiferal linings in coarser sediments, deposited in shallower condition with high salinity and high summer temperatures.

The microforaminiferal linings in the Akli Lignite were deposited in low salinity conditions and at a relatively shallow depths perhaps in an embayment of an epicontinental sea of Paleocene-Eocene age where the summer temperature might have been quite high, since India was palaeogeographically not very far from equator. The surrounding land was covered with the thick rain forest that contributed a diverse pollen flora into the basin. Thus, the occurrence of microforaminiferal linings in the spore/pollen dominated palynological assemblage of the Akli lignite indicates the deposition of vegetal matter very near to an ancient shoreline. The basin was probably connected to the open sea.

**Conclusion**

The microforaminiferal linings are abundant in palynological assemblages recovered from Akli Lignite in Barmer District of Rajasthan, India.

This palynological assemblage contains of angiosperm pollen , pteridophyte spores, algal cysts, microforaminiferal test linings, gymnosperms and fungal remains.

Three types of microforaminiferal linings belonging to benthic communities occur. Two main occurring morphotypes: trochospiral and single chambered types are most common in the assemblage.

The paleoecological and paleoenvironmental significance of these microforaminiferal linings suggesting their deposition in low salinity conditions and at a relatively shallow depths in an embayment of an epicontinental sea of Paleocene-Eocene age. The occurrence of microforaminiferal linings in the spore/pollen dominated palynological assemblage of the Akli Lignite indicates the deposition of vegetal matter very near to an ancient shoreline.

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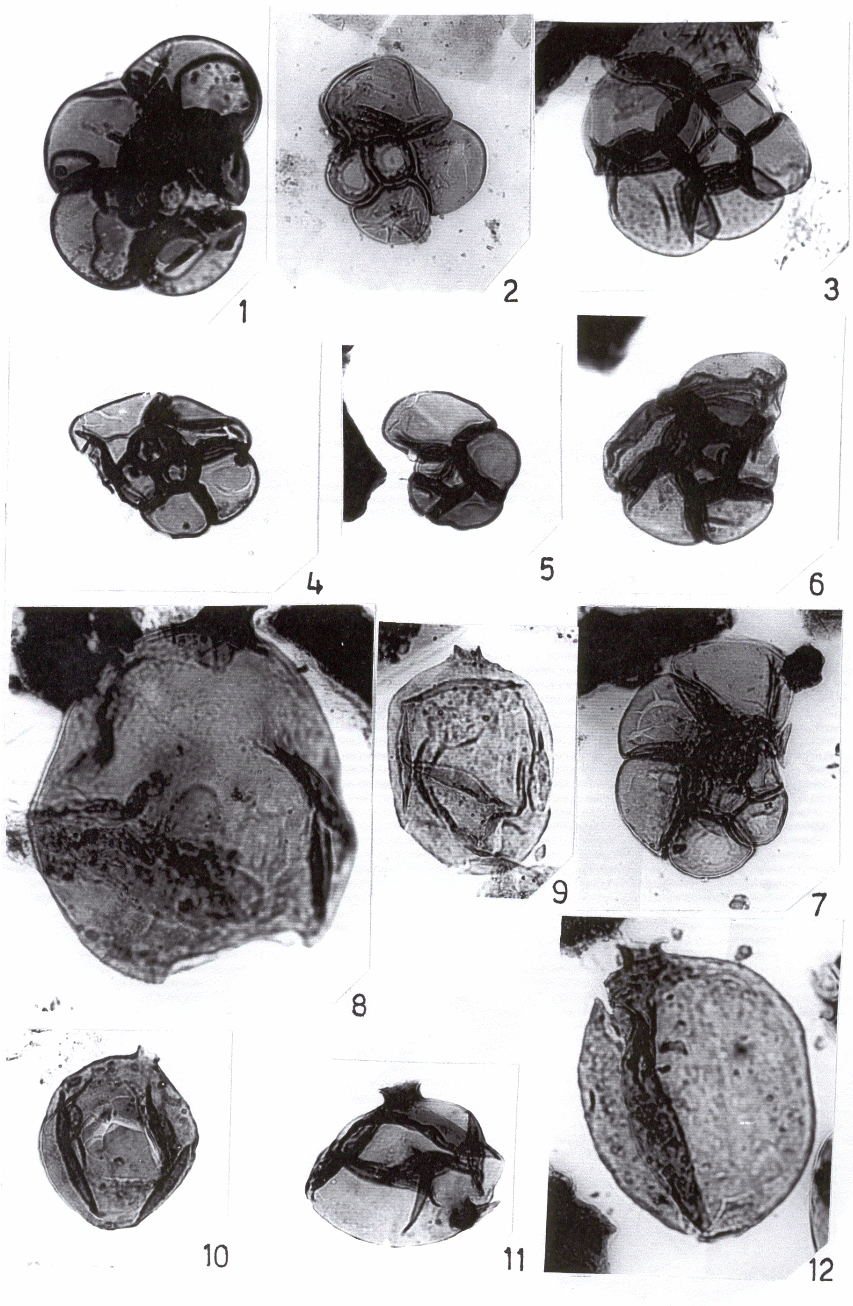
PLATE 1

All the photographs 500X magnification, The slides are stored in the Paleontological Lab of the Mining Engineering Department, Esfahan University of Technology, Esfahan, Iran

1,2 : Planispiral type IV, A9-2/10,Paleocene-Eocene, Barmer,India.
3 - 7 :Trochospiral type I ,A8-1/4,A10-3/7,A14-2/3 ,A14-2/7 and A12-1/1
Paleocene-Eocene, Barmer, India.
8-12: Single chamber, A10-1/3,A9-1/1,A14-1/2 and A9-2/2,Paleocene-Eocene,Barmer,India.

PLATE 1



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