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Palynological Evidences of Early Eocene Vegetation and Climate From Kutch Basin, Western India

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Abstract:
The Early Eocene was a period of very rich and diversified vegetation reflecting climatic conditions which facilitated the diversification of angiosperms. During this time, swamp forests formed, new palm taxa emerged, diversification occurred, and multistoried rain forests blanketed the entire subcontinent [1]. The palynological study from Naredi Cliff section from Kutch basin, of similar age shows the presence of angiosperms, pteridophytes and dinocysts. The dominanace of elements belonging to Arecaceae family (*Spinizonocolpites, Neocouperipollis and Proxapertites)* along with the dinocysts, indicates marine influence while the sediments were being deposited.

Keywords: pollen, dinocysts, Eocene, Kutch, paleoclimate, paleovegetation

1. Introduction

The sudden changes in the history of life on Earth causes disruption in the evolution of species. Paleocene-Eocene Thermal Maximum (PETM) is one of such warming events when some of the major changes have been observed in the flora and fauna. The period witnessed dramatic warming, because of an increase in CO_2 concentration brought on by the release of methane [2]. The precipitation pattern changed due to increase in temperature. The changing environments posed a lot of competition to migrating species. Many new plant species emerged while some plant species vanished. Extensive research has been done in this regard, but still not much is known about how the tropics responded to high temperatures around the world. In an attempt to address the same, this research was undertaken. The palynological studies are carried from Naredi village, Gujrat, which during the PETM was influenced by a tropical climate. During the Late Palaeocene, the Indian subcontinent was situated in a humid equatorial zone. The area provides excellent exposures of Early Palaeogene age that has facilitated to generate valuable data for age determination, biotic affinities and palaeoenvironmental interpretations. Pollen, spores and dinocysts have been used as a proxy to infer the paleovegetation vis-à-vis paleoclimatic conditions during which the sedimentation has taken place. Dinoflagellate cysts have complemented the present study by providing information about the stratigraphic age of the sections.

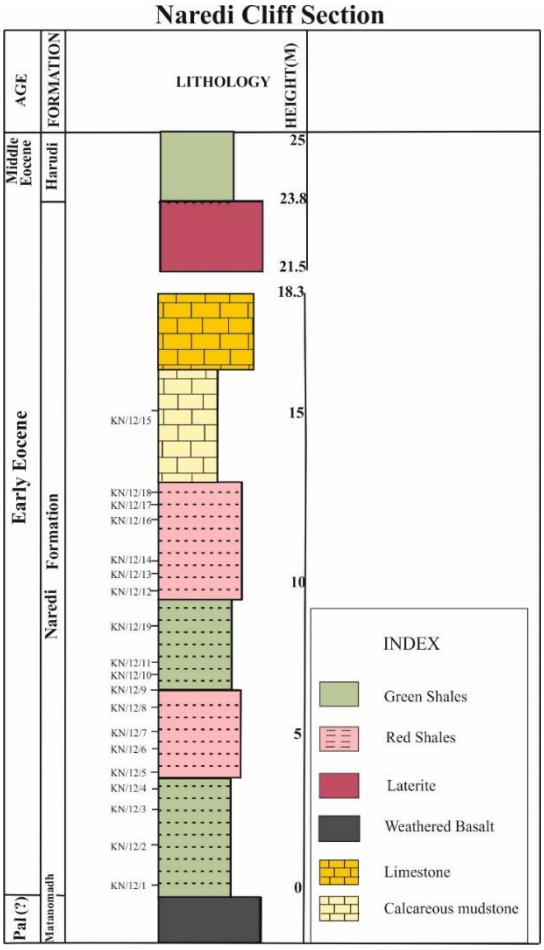
Kutch basin exposes more or less complete sequence of tertiary rocks in the area. Its richness of flora and fauna from Paleocene to Pliocene has made it a type area for the tertiary stratigraphy in India. Detailed palynology and biostratigraphy of Paleocene Matanomadh Formation of Kutch basin is published by various researchers [3-10]. Early Eocene Naredi Formation unconformably overlains Matanomadh

formation. Mathur (1963)[11], Venkatachala and Kar (1969)[12] and Sah and Kar (1969, 1970[13]), Kar (1985[10]) have reported a good number of spores and pollen grains from the formation. The environment of deposition has been deciphered as estuarine. Harudi and Fulra limestone Formations represent the Middle Eocene succession of Kutch. Maniyara fort formation of Oligocene age overlies the The Fulra limestone [4,6,10] . Khari Nadi Formation overlies the Maniyara Fort Formation which is succeeded by Chhasra Shale formation. These two litho-units are of Miocene age and are devoid of palynofossils. Palynological information from Pliocene sediments of Kutch is available through the works of Mathur and Mathur (1969[14]) from Naera-Baraia area.

2. Area of study

For the present palynological studies nineteen samples were collected from around 25 m thick Naredi cliff section, Kutch basin , 23°39'49" N: 68°40' 38" E (Figure 1). It is the Naredi Formation's type location. Talus scree, up to two meters thick, covers the lowest portion of this entire region. Subsurface lateritized basaltic rocks were observed to be covered by the Naredi Formation in a nearby riverbank area. The lower portion is made up of alternate red and green shale layers. The uppermost portion of the cliff is composed of limestone and calcareous mudstone. The summit of the Naredi Formation is made up of ripple laminated sandstone that is visible beyond the cliff. The Naredi and Harudi Formations are divided by laterite. *Nummulites* and *Assilina* are found in the calcareous mudstone and limestone found in the top portion of the cliff [24]. The lithotypes range from shale, siltstone to limestone. The majority of the litho units contain fossils.

Figure 1 Field photograph and lithology of Naredi Cliff section.



3. Materials and methods

For the palynological studies the sediments were processed following standard maceration techniques. About 30 gm of sediment sample was treated with dil. HCl to remove any carbonate, after which treatment with HF (to remove silica) and HNO_3 was done. The permanemt slides were prepared by double mounting method where macerated sample was first mixed with polyvinyl alcohol and later mounted in Canada balsam.

4. Paleoclimate, paleovegetation and Paleodepositional environment:

Naredi cliff section is not palynologically rich but have yielded diversified palynoflora. The assemblage is well represented by pteridophyte, angiosperms, dinoflagellates and fungal remains. There is overall dominance of dinocysts as compared to the terrestrial palynomorphs. The angiosperm taxa recognized in the assemblage mostly belong to Arecaceae family. Forms assigned to this family have been ascribed to different species of the genera *Arengapollenites*, *Longapertites*, *Proxapertites*, *Palmaepollenites*, *Pilatricolporites*, *Retipollenites*, *Spinizonocolpites*, etc. *Proxapertites* and *Spinizonocolpites* are known to have a pantropical distribution [15-20]. *Spinizonocolpites* is comparable to the current *Nypa* pollen. According to Tripathi et al. (2003) and Saxena et al. (2012), the angiosperm *Spinizonocolpites* prefers to live in quiet estuaries or shallow lagoons with freshwater influxes. Furthermore, the fungal fruiting bodies prevalence in the palynomorphs is also suggestive of warm, humid weather with a lot of rainfall [21,22]. The dinocysts are represented by *Cordosphaeridium gracile, Diphyes spinula, Homotryblium Pallidum, Kenleyia complex, polysphaeridium subtile, Systematophora* sp. Although the profile is not very rich in

the palynotaxa nevertheless the presence of *Spinizocolpites*, *Proxapertites*, and *Retipollenites* indicates that truly tropical conditions were thriving.

From the presence of *Nypa* like pollen along with dinocysts it can be inferred that the sedimentation took place in humid tropical climate prevalent along the coastal marshes. The dinocysts being the major taxa among the palynomorphs show that the deposition took place during the marine transgressive phase when the sea has intruded the continent. Subsequent to the volcanic activity during Creataceous which led to the formation of Deccan trap, there was subsiding of the western margin of India, causing marine transgressive event in the Indian subcontinent [24].

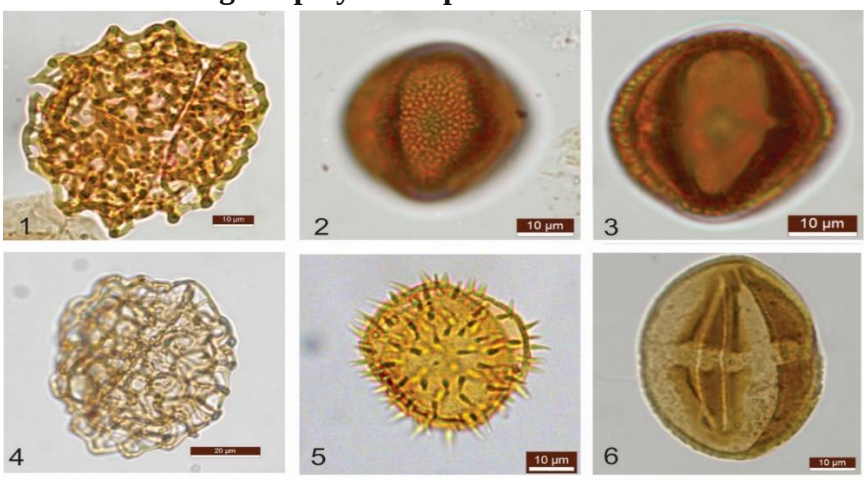
5. Age considerations

Saraswati et al 2012 have assigned the age of Naredi Formation as Early Eocene, ranging from shallow-benthic zones SBZ6 to SBZ11. Garg et al. 2011 on the basis of the occurrence of *Kenleyia* complex from the basal part of the section have assigned Naredi formation to be of Early Eocene. The presence of dinocysts *Homotryblium Pallidum, Kenleyia complex,* in the present study are in confirmation with the Early Eocene age for the Naredi section. Further the pollen *Retipollenites confusus, Pilatricolporites eocenicus,* and *Spinizonocolpites echinatus,* which are known from Early Eocene (Ypresian) sediments section also affirms the age.

6. Conclusion

The Naredi cliff section's palynological assemblages suggest a nearshore depositional environment that is close to tropical rainforests. The majority of palynomorphs exhibit traits typical of hot, humid tropical weather. The assemblage's predominance of mangrove pollen and the presence of dinocysts point to a marine influence during the deposition of the sediments. Ypresian is the lower age limit of the Naredi section, as confirmed by the presence of pollen from *Retipollenites confusus, Arengapollenites achinatus,* and *Tribrevicolporites eocenicus* in the assemblage together with *Polysphaeridium subtile* and *Homotryblium pallidum* dinocysts. The Naredi section bears close similarity to the other Early Eocene lignite-bearing stages in Cambay, Rajpardi and Barmer Basin [26-31]. During the Early Eocene, when the Indian Plate was moving across the equator, a very wet climate led to the production of coastal lowland peats, which were subsequently turned into coal and lignites.

Plate 1 showing the palynomorphs from Naredi Cliff Section



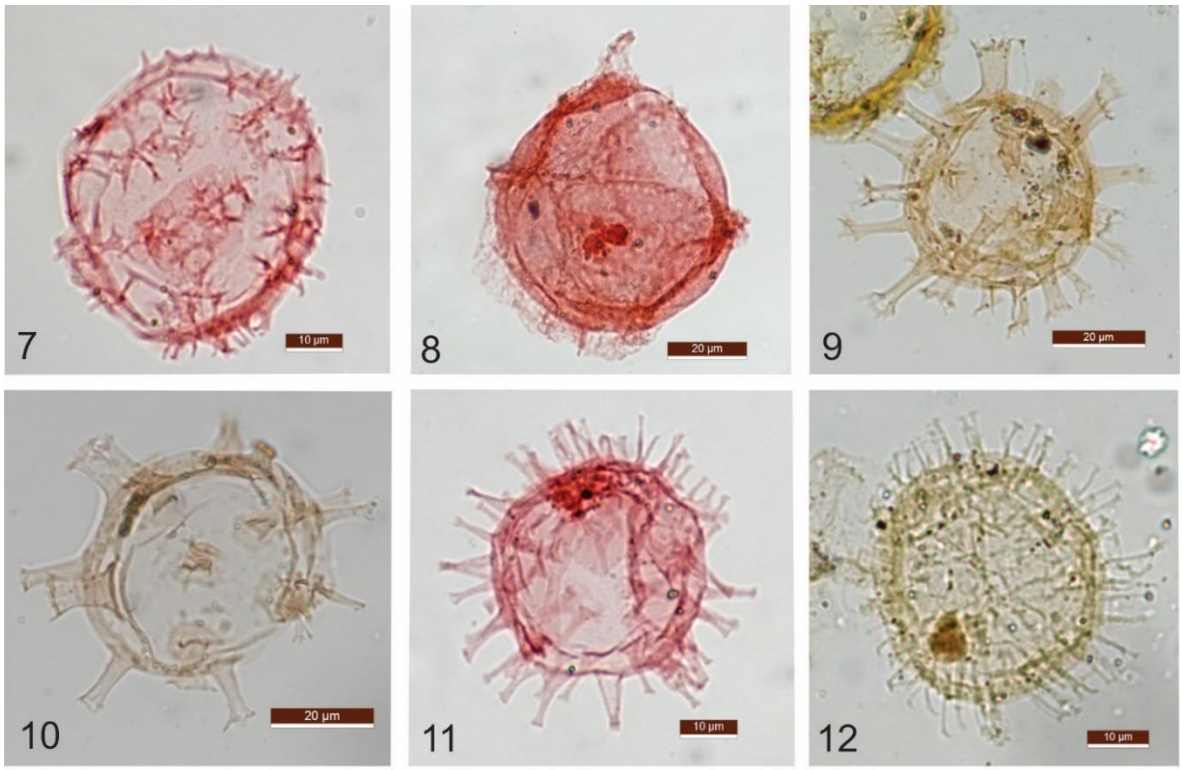


Fig.1-4 : *Retipollenites echinulatus*. Fig.2, 3 : *Pilatricolporites eocenicus*. Fig.5: *Spinizonocolpites echinatus*. Fig.6: Tricolporoidate pollen.Fig.7: *Systematophora* sp. Fig.8:*Kenleyia* sp. Fig.9: *Cordosphaeridium gracile*. Fig.10: *Homotryblium palliidum*. Fig. 11: *Diphyes spinula* . Fig. 12: Polysphaeridium subtile.

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