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The Early Eocene Naredi Cliff Section, Kutch Basin, Gujarat, India: Evidences of a Condensed Stratigraphic Section

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Abstract

This paper presents the multidisciplinary evidences of a condensed stratigraphic section in the Naredi cliff, of the Early Eocene Naredi Formation, in onshore part of the Kutch Basin. The presence of glauconite and Ca-apatite minerals, predominantly fine grained sediment, and reducing environmental condition during the deposition of glauconite bearing sediments point out towards the Naredi cliff section sediments being a condensed stratigraphic section. This identified condensed stratigraphic section of the Naredi cliff can serve as an important tool for regional and chronostratigraphic correlation with the Early Eocene sediments occurring in Kutch Basin's offshore parts.

Keywords: Condensed section, glauconite, foraminifera, naredi, early Eocene, kutch, India.

Introduction

Glauconite-rich sediments are generally associated with condensed sections, transgressive system tracts or maximum flooding surfaces[1-5]. The presence of glauconites indicates diagenesis of terrigenous material during periods of low sediment accumulation in water depths ranging from 50 to 500m in marine environment[6-10]. The formation of glauconite generally occurs in reducing environment in/near the oxygen-minimum zone[1,5,6,11-13].

Condensed sections play an important role in stratigraphic study and correlation. Condensed sections are thin marine stratigraphic units consisting of pelagic to hemipelagic sediments characterized by very low-sedimentation rates[2]. They are areally most extensive at the time of maximum regional transgression of the shoreline. Condensed sections are associated commonly with apparent marine hiatuses and often occur either as thin but continuous zones of burrowed, slightly lithified beds (omission surfaces) or marine hardgrounds[14,15]. Condensed sections may also be characterized by abundant and diverse planktonic and benthic microfossil assemblages, authigenic minerals (glauconite, phosphorite, and siderite), organic matter, and bentonites and may possess greater concentration of platinum elements such as iridium. The condensed section assumes far greater significance because it is produced during a period of extremely low-sedimentation rates as a result of a relative sea-level rise and abrupt transgression of the shoreline[2]. As the shoreline transgressed, the place of terrigenous deposition moves further landward, effectively starving shelf areas and the deeper parts of the basin of terrigenous material.

This paper identifies a condensed stratigraphic section in the form of Naredi cliff section sediments, of Early Eocene Naredi Formation, in Kutch region and present evidences for it.

Material and Methods

This study involves field documentation and laboratory investigations of the sediments of the Naredi cliff section (figure-1, 2). Detailed lithologic logs were prepared (figure-1). Fresh samples were collected from the exposed section for preparation of thin sections. Petrographic studies were carried out using Nikon eclipse e200 petrological microscope with Nikon Coolpix camera.

Figure-1
Photograph showing Naredi Cliff Section

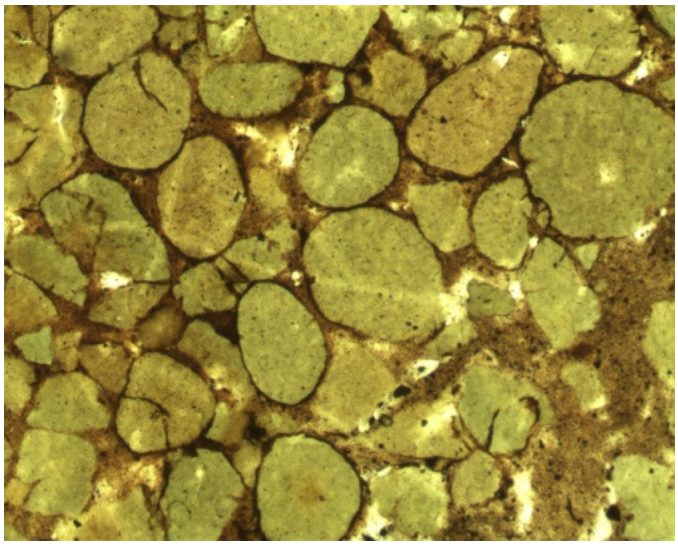

Figure-2
Photomicrograph of green shales in plane polarized light (Magnification ×5). Glauconite is present predominantly

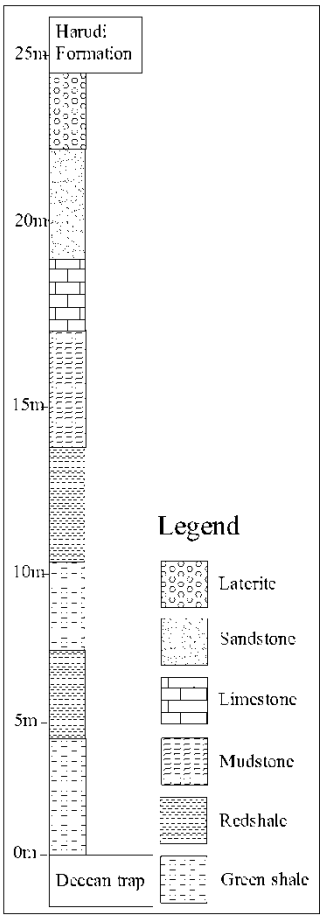

Figure-3
Litholog of Naredi Cliff Section

Results and Discussion

Thin section study shows well rounded to ovoidal, light to dark green colour glauconite mineral in quite abundant amount, along with the matrix in green shales (figure-3). The formation of glauconite requires marine water near normal salinity, reducing conditions, appropriate source materials[16] and slow rate of sedimentation. Apart from the glauconite mineral, P-enriched mineral (Ca-apatite) has been also reported in earlier studies[17]. Earlier studies have shown rich presence of benthic and planktonic foraminifera. Studied shales contain abundant minute foraminifera including planktonic genera *Guembelitria*, *Chiloguembelina* and small *globigerines* and *globorotalids*. Casts of bivalves (e.g. Venerecardia) has been also reported[18]. Earlier studies reported the common occurrence of *Nummulites*, *Rotalia*, *Cibicides*, *Asterigerina*, *Bolivina* and planktonic foraminifers *Acarinina*, *Chiloguembelina* and *Jenkinsina*[19]. Several planktonic species *(Chiloguembilina, Heterohelix)* characterize the oxygen minimum zone of the water column and thus must prefer or tolerate low oxygen levels[20]. The presence of *Chiloguembilina*[19,21] in green shales point out towards the low oxygen levels which may have favoured the formation of glauconite in green shales of the Naredi Formation. Glauconite is often found in transgressive systems tracts and condensed sections. Glauconite with greater concentrations of potassium seems to be common in condensed sections[2]. The presence of *Acarinina* suggests warm water conditions during the deposition, as *Acarinina* were specialized surface water dwellers with a preference for warm water[22-26].

The presence of glauconite and Ca-apatite mineral, radioactive K-bearing glauconite, predominantly fine grained sediment, and reducing conditions during deposition of green shales point out towards the Naredi cliff section being a condensed deposit.

Significance of Naredi cliff condensed stratigraphic section: This identified condensed stratigraphic section of the Naredi cliff can serve as an important tool for regional correlation with the Early Eocene sediments occurring in Kutch Basin's offshore parts. For example an Early Eocene shale with limestone stringers having thickness of 447 m in well SP-1-1, 424 meter thick Eocene limestone with minor shale, siltstone, and coals bands in well GK-1-2, Early Eocene section of 125 m of limestone and shale in well GK-20-1 in Kutch basin[27]. The age of the sediments is correlable. However, the thickness of the Early Eocene sediments in offshore parts is relatively large in comparison to the Early Eocene equivalent sediments occurring in onshore Naredi cliff section, signifying the condensed nature of the Naredi cliff section sediments. Lithologically also it is correlable as shale and limestone is occurring in the Naredi cliff section as well as offshore parts of the Kutch Basin. More detail data is not available from the offshore Kutch basin to discuss and correlate in detail. However, it signifies the importance of condensed sections, in geological correlation in time and space, as an important stratigraphic and chronostratigraphic tool.

Conclusion

The presence of glauconite and Ca-apatite mineral, radioactive K-bearing glauconite, predominantly fine grained sediment, reducing conditions (shown by the presence of *Chiloguembilina* foraminifera and glauconite) identified in this study point out towards the Naredi cliff section being a condensed deposit. *Acarinina* suggests warm water conditions during the deposition. This study also signifies the importance of Naredi cliff section, in geological correlation in time and space, as an important stratigraphic and chronostratigraphic tool.

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