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Litho-Biostratigraphy of Charada-Mansa area with special reference to Older Cambay Shale/Olpad Boundary, Cambay Basin, Gujarat, India

Abstract

The Charada and Mansa fields lie to the east of Sobhasan field stretching about 100 sq. km. area. Keeping in view the exploration objectives in Mandhali Member, Older Cambay Shale and Olpad Formations, poor resolution of Olpad/OCS boundary on the electrologs, laboratory study was undertaken to demarcate Paleocene/Early Eocene boundary based on Biostratigraphy and Olpad/OCS boundary based on Sedimentological studies. The Paleocene/Eocene boundary has been demarcated on the basis of Last Appearance datum (LAD) of *Apectodinium augustum, Rhombipollis geniculatus, Milfordia homeopunctata* and *Spinizonocolpites adamanteus*. The LADs of *Areoligera senonensis* and *Hystrichosphaeridium tubiferum* demarcate the Early Eocene/Middle Eocene boundary. Age correlation for the studied wells has been done based on electrologs and Dinocyst events. A hiatus of 1.0 Ma on the basis of dinoflagellate cyst event at the Paleocene–Early Eocene boundary. In Mansa area, the sediments were deposited as mouth bars and distributary channels under tidal influence during Early Eocene times. In Charada area the sediments consist of a mixture of partly sorted stream flow deposits and unsorted debris flow and mud flow deposits. The sediments are indicative of tidal flat environment under low energy condition with intermittent high energy influx. The lithofacies suggest deposition under proximal part of alluvial fan.

Introduction

Charada-Mansa area is well known for strati-structural prospects in the eastern flank of Ahmedabad-Mehsana tectonic block. It extends between Limbodra field in the south and Mehsana City wells in the north (Fig.1). After the discovery of oil from Mandhali Member in the well Mansa#O, the impetus of hydrocarbon exploration accelerated further resulting into several new discoveries. The sequence of events established prevalence of adequate entrapment conditions and also the existence of multiple reservoirs in the area. Recent acquisition of good quality 3D seismic data in Charada-Mansa areas in the flanks of the eastern margin has enabled in furthering exploration for Mandhali, Mehsana plays and also for Weathered Trap. Oil discovery in Mansa#B and Mansa#C, has further added a new dimension to the exploration activities in the area. In the run up to the new thrust to the exploratory efforts in this area, identification of the boundary between Olpad and the Older Cambay Shale still remains a problem due to the monotonous electrolog signatures in the subsurface.

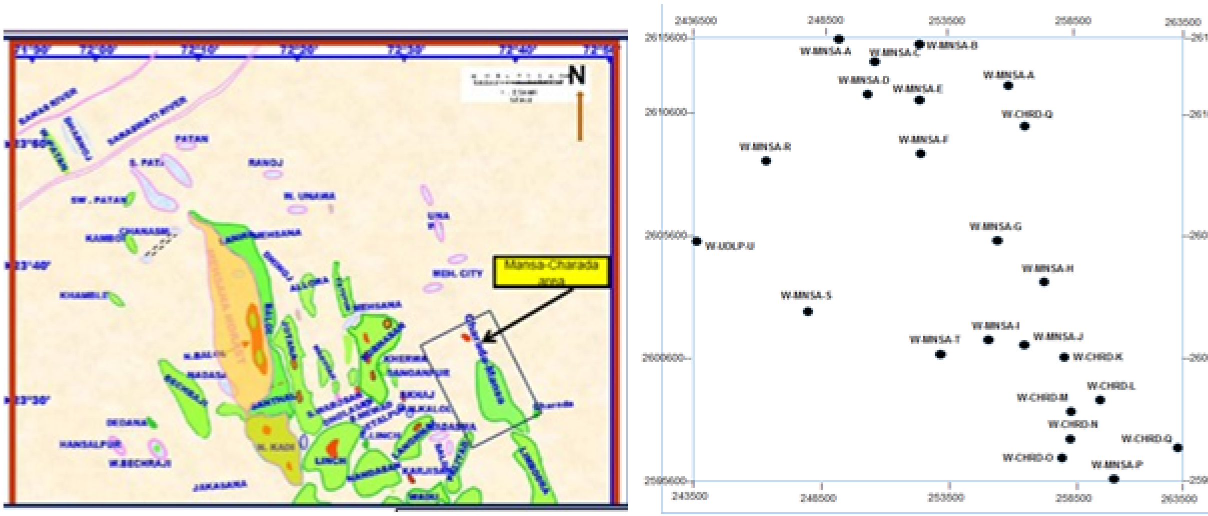


Fig 1: Location Map of the Study Area

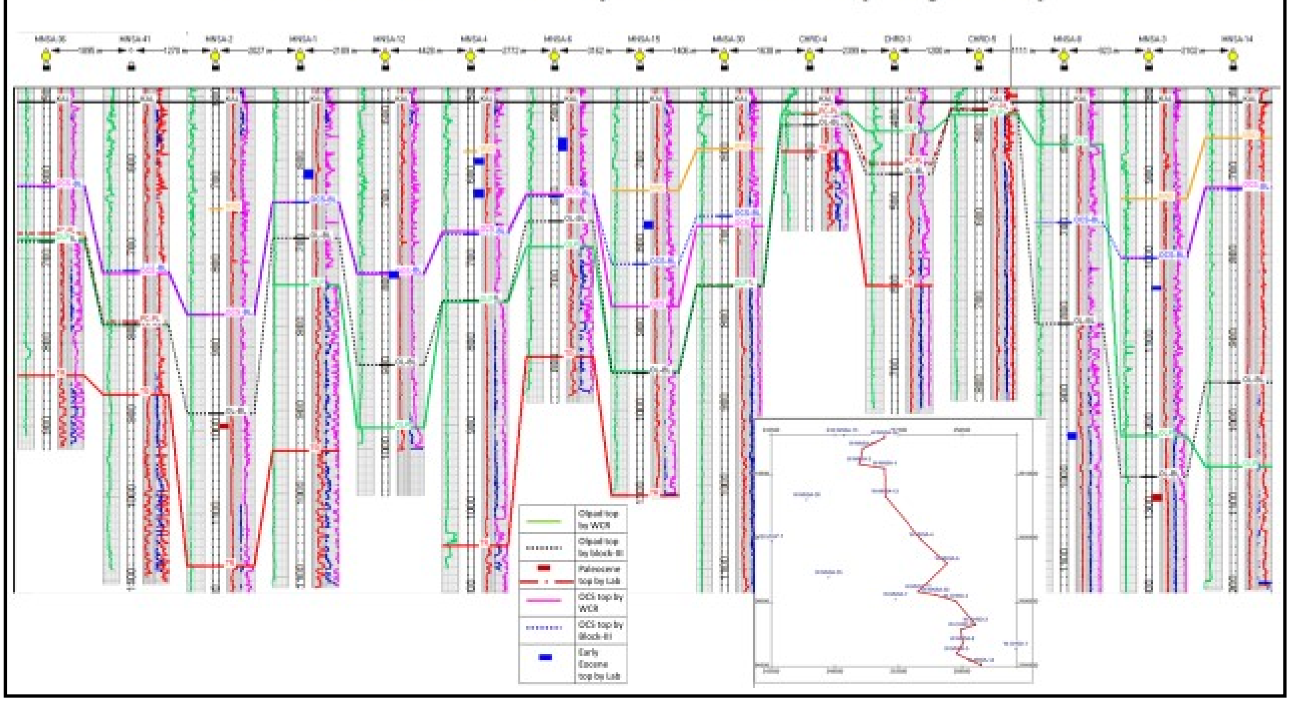
Objective

To firm up the Older Cambay Shale/Olpad boundary in Charada and Mansa area on the basis of time index attribute exclusivity of the biostratigraphic markers and extend the same using standard electrolog correlation techniques and associated litho-stratigraphic features.

Methodology

A focused approach has been employed to determine the combination of tools for conducting this study. Palynological studies capable of throwing undisputable evidence with global acceptance levels take precedence in this case. These include both qualitative and quantitative studies of dinoflagellate cyst and spore-pollen combinations. Dedicated efforts have helped retrieve minute palynotaxa from the subsurface samples through precision standard processing techniques as followed in Regional Geoscience Laboratories. Statistical methods like counts of spore-pollen, dinoflagellate cysts have been employed for deciphering the depositional environments. Frequency distribution of dinoflagellate cysts in the subsurface well sections have been put to use to work out the instances of appearance and disappearance. Disappearance levels of marker species plotted against studied well columns helped in age determination. Spore–pollen versus dinoflagellate cysts percentage plots indicates depositional environments. The study has enhanced the support level in standardizing the basis of identification of bio-chrono horizons and thereby facilitate lateral correlation of the events. The Sedimentological studies include Electrolog correlation, (Fig.2), megascopic observation, petrographic investigation and SEM studies wherever possible to supplement the outcome from palynological findings.

N-S Profile with Paleocene & Early Eocene data from Palynological study:



General Geology and Stratigraphy of the area

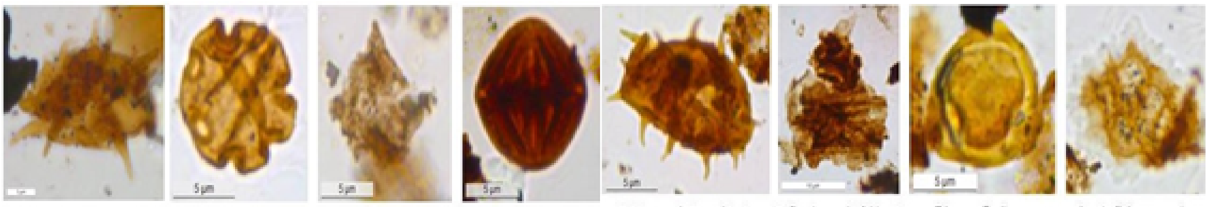
The study area sits on the rising flank of the eastern rift shoulder having a series of NNW-SSE trending normal step faults which have controlled the sedimentation of different stratigraphic units in the western side towards Nardipur low. The Deccan Trap forms the technical basement and the overlying stratigraphic sections from deeper to shallower consists of Olpad, Cambay Shale, Kadi, Kalol, Tarapur Shale Formations and other younger sequences.

Age Philosophy

Age dates are based on Haq et al., (1987), Williams et al., (1985) and Williams et al. (1993) and Geological Times Scale of Gradstein 2004 have been considered for all practical purposes. The Last Appearance datum (LAD) of dinoflagellate cyst species of Late Paleocene have been considered as a standard in Cambay Basin for the purpose of delineating the Paleocene / Early Eocene boundary (Table-I).

Palynostratigraphy

Palynological studies have been carried out to determine the precise age and decipher the paleodepositional environments. The palynofloral yield is moderate to good throughout the studied section and consists of assemblages of angiosperm pollen, gymnosperm pollen, pteridophytic spores, fungal spores and dinoflagellate cyst taxa. The assemblages have been grouped under two heads, marine and terrestrial. Appropriate recordings are made for all the examined samples for Palynological interpretations. Amongst the palynomorphs, dinoflagellate cysts have the advantage of including a planktonic stage in their life cycle. These have globally documented biostratigraphic ranges. These characteristics make dinoflagellate very useful as biostratigraphic indicators in shallow marine environments. Together with terrestrial palynomorphs, dinoflagellates can also help in recognizing paleoenvironmental changes in the strata (Plate-1).



Spinizonocolpites echinatus *Pseudonothofagidites sp.* *Palaeoperidinium pyrophorum.* *Rhoipites kutchensis.* *Spinizonocolpites echinatus* *Deflandrea oebisfeldensis* *Triporopollenites sp.* *Apectodinium augustum*

Sedimentological studies

Megascopic study of the representative samples of Olpad Formation reveals that the rock is claystone which is grey, hard, compact and non-calcareous in nature. Sand sized pyroxene crystals indicate that the claystone may be product of weathered trap. Petrographic study of Cambay Shale Formation states that the samples are silty shale which is composed of clays and silt sized detrital grains with carbonaceous matter seen as discontinuous laminations. SEM images show the presence of trap wacke with dolomite/calcite and siderite crystals (Figs. 3 & 4).

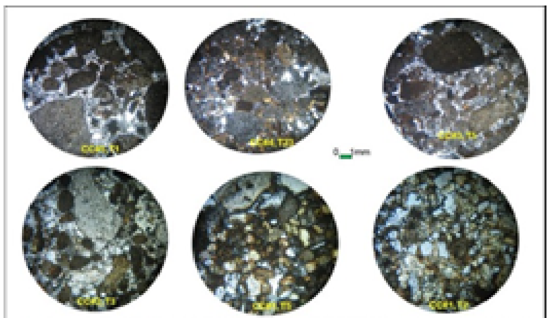


Fig 3: Photomicrograph of core samples belonging to Olpad Formation in the well Charada#M exhibiting trap conglomerate floating in argillaceous matrix

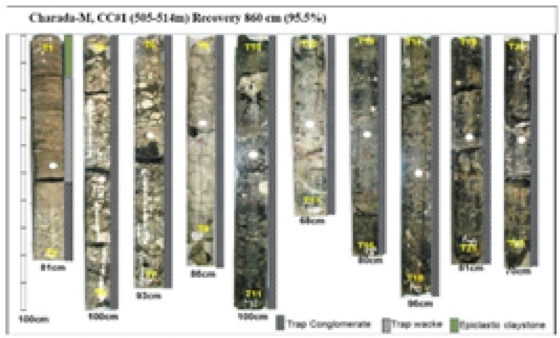


Fig 4: Core photograph of CC#1 showing Trap conglomerate (T-23,3), Trapwacke (T-2) & Claystone (T-1)

Paleogeography of the area

The Paleocene sediments in Mansa-Charada area are considered to have been deposited under the proximal fan with certain influence of fluvial streams. The identified floral assemblages within the deposited sediments are suggestive of a dominantly supratidal environment. The sediments during Early Eocene times, as identified in Mansa area, on the other hand, are indicative of deposition as mouth bars and distributary channels under tidal influence. In Charada area, however, the sediments represented by intercalations of carbonaceous shale, claystones at places sideritic claystone with abundance of broken shell fragments, are indicative of tidal flat environment under low energy condition with intermittent high energy influx (Figs. 5 & 6)

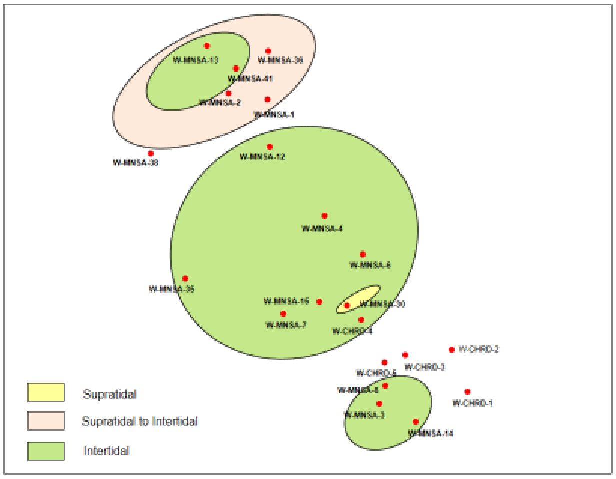


Fig. 5. Paleogeography during Early Eocene time

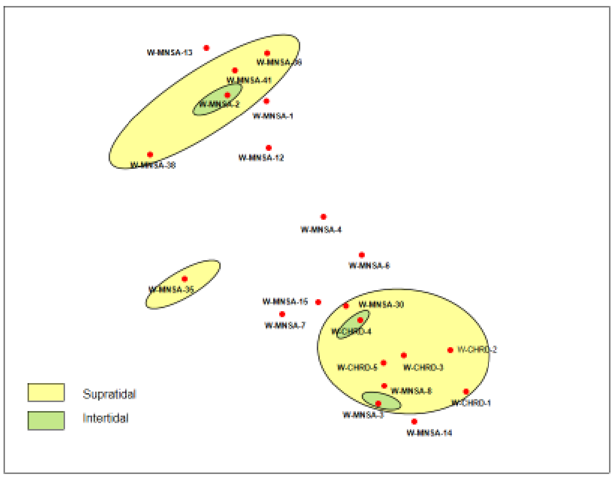


Fig. 6. Paleogeography during Late Paleocene time

SL. No	WELL NAME	CORE & CUTTINGS DEPTH INTERVAL in mts	DINOFLAGELLATE CYSTS EVENTS	INDEX MARKER PALYNOTAXA	AGE	PALEO ENVIRONMENT
1	CHARADA # 1	CC# 2(410-413) T21		*Rhombipollis geniculatus*	Late Paleocene	Supratidal
		CC# 3(438-441) T4				
2	CHARADA # 3	445-450		*Rhombipollis geniculatus*	Late Paleocene	Supratidal
		455-460				
		470-475		*Nuxpollenites plena*		
		475-480				
3	CHARADA # 4	440-445	*Deflandrea oebisfeldensis*		Early Eocene	Intertidal
		450-455				
		455-460		*Spinizonocolpites baculatus*		
		460-465			Late Paleocene	
		465-470	*Apectodinium augustum*			
		470-475				Supratidal
4	CHARADA # 5	470-475	Deflandrea oebisfeldensis	Spinizonocolpites baculatus	Late Paleocene	Intertidal
		475-480				Supratidal
		485-490		Porocolpopollenites sp.		
5	MANSA # 1	CC#1(613-622) T46		Rhoipites kutchensis	Early Eocene	Supratidal
6	MANSA # 2	CC#1(993-996) T6	Deflandrea oebisfeldensis	Rhombipollis geniculatus	Late Paleocene	Intertidal
7	MANSA # 3	CC#4(1035-1038)	Deflandrea oebisfeldensis		Early Eocene	Intertidal
		CC#6(1285-1290)	Apectodinium augustum	Rhombipollis geniculatus	Late Paleocene	
8	MANSA # 4	CC#1(579.2-588.2) T3	Deflandrea oebisfeldensis	Matanomadiasulcites maximus	Early Eocene	Intertidal
		CC#2(618-627) Box-1/7				Supratidal
		CC#2(618-627) T8				
		CC#3(733.6-742.6) Box-4				
9	MANSA # 6	CC#3(531.5-545)	Deflandrea oebisfeldensis	Proxapertites assamicus	Early Eocene	Intertidal
10	MANSA # 7	CC#2(1186.2-1192)	Deflandrea oebisfeldensis	Proxapertites operculatus	Early Eocene	Intertidal
11	MANSA # 8	CC#3(948-952)	Deflandrea oebisfeldensis	Rhoipites kutchensis	Early Eocene	Intertidal
12	MANSA # 12	CC#2(788-795)	Deflandrea oebisfeldensis	Polycolpites flavatus	Early Eocene	Intertidal
13	MANSA # 13	CC#1(818-827) Box-1/5	Deflandrea oebisfeldensis	Proxapertites assamicus	Early Eocene	Intertidal
14	MANSA # 14	CC#1(674-684.7) Box-5/7	Deflandrea oebisfeldensis	Proxapertites operculatus	Early Eocene	Intertidal
15	MANSA # 15	CC#1(772-781)			Early Eocene	Intertidal
		CC#1(772-781) Box-3/9	Deflandrea oebisfeldensis	Proxapertites operculatus		
16	MANSA # 30	652-655			Early Eocene	Supratidal
		665-670		Rhoipites kutchensis		
		680-685	Deflandrea oebisfeldensis			
		695-700				
		700-705				
		715-720				
		730-735				
		745-750				
		760-765		Milfordia homeopunctata Spinizonocolpites adamanteus	Late Paleocene	
		775-780				
		795-800				
17	MANSA # 35	2105-2110	Cerodinium speciosum		Early Eocene	Intertidal
		2125-2130	Deflandrea oebisfeldensis			Supratidal
		2140-2145				Intertidal
		2156 Bott up		Milfordia homeopunctata	Late Paleocene	Supratidal
		2170-2175				
		2195-2200	Apectodinium augustum			
		2210-2215				
		2225-2230				
		2240-2245				
		2255-2260	Conneximura fimbriata			
		2270-2275				
		2285-2290				
		2300-2305				
		2315-2320				
		2330-2335				
		2345-2350				
18	MANSA # 36	550-555			Early Eocene	Supratidal
		570-575				
		590-595				
		610-615				
		630-635				
		650-655				
		670-675		Milfordia homeopunctata	Late Paleocene	
		690-695				
		710-715				
		735-740				
19	MANSA # 38	1780-1785		Triangulorites bellus	Early Eocene	Supratidal
		1795-1800	Deflandrea oebisfeldensis			
		1810-1815		Milfordia homeopunctata	Late Paleocene	
		1830-1835				
		1850-1855				
		1870-1875				
		1890-1895				
20	MANSA # 41	700-705		Rhoipites kutchensis	Early Eocene	Intertidal
		730-735				
		760-765	Cerodinium speciosum			
		790-795				
		820-825	Glaphyrocysta ordinata	Rhombipollis geniculatus	Late Paleocene	
		850-855				Supratidal
		880-885				
		895-900				
21	UDALPUR # 1	2010-2015	Cerodinium speciosum		Early Eocene	Intertidal
		2020-2025	Deflandrea oebisfeldensis			
		2030-2035		Spinizonocolpites baculatus	Late Paleocene	
		2070-2075		Rhombipollis geniculatus		Supratidal
		2080-2085		Porocolpopollenites sp.		
		2100-2105				
		2160-2165				

Table: 1 Showing Age and Paleoenviornment in Charada-Mansa area

Conclusions

1. The Olpad sediments of Mansa-Charada areas have been dated as Late Paleocene in age, while the Older Cambay Shale sediments have been dated as Early Eocene in age. Demarcating the interface between these horizons on the basis of electrologs, however, remained a difficult proposition. Applying biostratigraphic parameters for ascertaining this boundary has been useful with a fair degree of success.

2. Results of this study, by and large, corroborates the current understanding on Paleocene top. Electrolog correlation has been validated on the basis of biostratigraphic data.

3. The palyno-floral assemblage indicates supa tidal to intertidal environment for Early Eocene sediments and dominantly supratidal environment for Paleocene sediments.

4. The above studies are based on spot samples and not on continuous samples.

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Recommendations

The inferred findings from this study on the Olpad-OCS boundary can be extended in space and time through electrolog correlation with the wells falling within the encircling cluster in the immediate vicinity.

A horizon close to the Olpad-OCS top established through laboratory studies can be identified on seismic data in and around the study area and cross checked for integrity with random sample checks.Collation of the palynological, sedimentological and electrologs data sets with seismic data including VSP data is strongly recommended for enhancing the understanding of the Olpad-OCS boundary across the block.