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Inter-basinal correlation of Paleogene sediments of Jaisalmer and Barmer basins, Western India: an approach by sequence stratigraphy

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Summary

Sequence stratigraphic framework of the Paleogene sediments of the Jaisalmer and Barmer basins has provided a three marker beds, which can be used for inter-basinal correlation. The present work on Paleogene sediments of the Jaisalmer and Barmer basins is based only on the outcrop study.

Introduction

The Rajasthan part of the shelf together with Indus shelf (now in Pakistan) constitutes the eastern part of Indo-Arabian Geological Province. Geologically, the Rajasthan part of the shelf on the west of Aravalli axis is known for three sedimentary basins; the Bikaner-Nagaur Basin, the Jaisalmer Basin and the Barmer-Sanchor Basin. The Jaisalmer and Barmer-Sanchor are two neighbouring basins drawing a lot of attention for the hydrocarbon exploration (Fig. 1).

The Jaisalmer Basin is a shelf basin deepening northwestwards, which is known for the Jurassic to Paleogene sediments and their hydrocarbon prospects. Lithostratigraphically, the Paleogene sediments has been grouped into Sanu (non-marine to marine, predominantly siliciclastic), Khuiala and Bandah (marine, carbonates, shales and marls) formations, which are exposed in scattered outcrops in the north western part of the basin.

On the other hand the Barmer Basin is a narrow N-S trending graben extending for more than 100 km from Mandai and Fatehgarh in the north to Barmer in the south. This graben is a northern extension of Cambay Rift. The Barmer Basin displays continental to marginal marine deposits. The faults exposed at Fathegarh in the north, on the Barmer hill near Barmer and at Sarnu in the south demarcate the Barmer Basin in the north from the Jaisalmer Basin and in the south from Sanchor part of the basin. Lithostratigraphically, the Cretaceous-Paleogene sediments of the Barmer Basin have been grouped in ascending order into the Fatehgarh, Mataji Ka Dungar, Akli and Kapurdi formations. These formations have been interpreted to represent fluvial to protected marginal marine environments.

Sedimentation ceased in both Jaisalmer and Barmer basins during Late Cretaceous (~85Ma) and marine regression during this period from western Rajasthan correlates with break away of Madagascar from India (Torsvik et al., 2001).

Theory

Correlation of surface outcrops of non-marine sequences of two different basins, that too of different settings and without index fauna or flora is not an easy task. The stacking pattern of non-marine sequences deposited along the coastal areas above mean sea-level is not independent

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of sea-level, tectonics and climatic change. The water table is always influenced by change in sea level. The water table directly influences the sediment transport and thus the stacking pattern, sedimentary structure, and sediment influx - accommodation ratio. The sequence boundaries thus created after each rise of sea level or water table can be easily understood by sudden change sedimentary attributes. The sequence boundaries and identified marker beds are aid to the correlation of time plains within and between the basins.

Conclusion

The present study of the stratigraphic framework of the Paleogene sediments of the Jaisalmer and Barmer basins has provided three marker beds, which have well been used for inter-basinal correlation. The following marker beds recognized in the present work may or may not correspond to the sequence boundaries but they certainly correspond to some events;

1) The moderately cemented siltstone bed with alternate white and pink bands is exposed at Bariyara and Sandha village sections of the Barmer Basin (Fig. 2, bed no. 17). This bed has been interpreted as lacustrine deposit, where the grain-size and composition rapidly changed due to change in energy level and climatic conditions. This unit serves as marker bed (MB I) in the Barmer Basin. Similarly, fine to medium grain low-angle cross-bedded sandstone beds with alternate white and pink bands exposed at the village Leela Pariwar of the Jaisalmer Basin (Fig. 2, bed no. 4 to 10) has been interpreted to be deposited in rapid change either in provenance or in climatic conditions during the deposition. Although the low-angle cross-beds and fine-grain sandstone do not always allow to interpret the lacustrine depositional environment, rather suggest for high energy bed load condition, however, on the basis of typical alternate thin pink and white bands and the stratigraphic position of the unit below well marked Late Paleocene and Eocene time intervals in both the basins, this unit has also been marked as marker bed (MB I) in the Jaisalmer Basin. Thus, the marker bed I (MB I), in both the basins, has been useful for inter-basinal correlation.

2) An about 1-4.5m-thick oncoid packstone/siltstone unit (top of Fatehgarh Formation) exposed in the top part of the Bariyara section, near the top of cliff-sections on the east and west of Sandha village (Fig. 2, bed no. 19) and north of Kotra village of the Barmer Basin is a marker bed II (MB II). The oncoid unit has been interpreted as deposited in an oxygenated shallow water lacustrine environment with very low to no influx of sediment. The bed is bounded by erosional surfaces. The top erosional surface of this bed, which is overlain by volcanic siliceous earth, is a sequence boundary (SB II).

   Similarly, poorly sorted, alternating paleosoles and intensively bioturbated (by non-marine crustaceans) beds (Fig. 2, bed no. 2 to 5) exposed NW of village Leela Pariwar of the Jaisalmer Basin, which have been interpreted as deposited in flood plain depositional environments with rich nutrition supply and a very low rate of sediment influx, have been correlated with marker bed II (MB II) of the Barmer Basin. In both the basins, based on stacking pattern and coarsening upward sequence the MB II represents top of HST and is followed by a sequence boundary, however, numbering the sequence boundaries below and above MB II in the two basins do not match (Fig. 2). This is probably either due to lack of adequate outcrops or differential omission of the units in the two basins owing to different tectonic settings.

3) Overlying, 1.5m thick, cross-bedded, fine-grain, well-cemented calcareous to ferruginous sandstone, occasionally with pebbles from the underlying bed (Fig. 2, bed no. 20), which serves as cap rock on all the hill ranges around, such as Kotra Dungar, hill ranges west of Sandha, south of Pavanasar, west of Dharvi Khurd, etc., is another marker bed in the

Barmer Basin (MB III). This sandstone unit belongs to the Mataji Ka Dungar Formation and has been interpreted as TST deposited under continental, very low accommodation-influx ratio conditions. Here, the very low accommodation-influx ratio has been interpreted a consequence of a very high terrestrial input. The base of this unit is a transgressive surface and a sequence boundary (SB II).

In the Jaisalmer Basin also the sediment directly overlying the MB II (mentioned above) is a cross-bedded, fine-grain to coarse-grain, well-cemented, ferruginous and calcareous sandstone (Fig. 2, bed no. 22), which also forms cap rock on the entire hill range around Leela Pariwar, west of Sanu, etc. This bed too has been interpreted as deposited in high energy depositional environment with increased rate of influx in response to increase of temperature. Based on similarity in lithology, stratigraphic position and relationship with underlying sediments this bed in the Jaisalmer Basin has been designated and correlated with MB III and thus, forms a useful unit for inter-basinal correlation.

The remaining Eocene sediments in the two basins are quite diverse. According to traditional lithostratigraphical classification the Khuiala Formation begins with coarse-grain sandstone 'orthoquartzite'. However, sequence stratigraphically, in the Jaisalmer Basin both the formations begin with fine-grain sediments. The Khuiala Formation begins with carbonate sediments (TST). The contact with underlying non-marine sediments could not be observed in the surface outcrops. Similarly, the contact of the formation with the overlying Bandah Formation could not be traced. The Bandah Formation begins with variegated claystone has been interpreted to be deposited in low energy, marginal marine depositional environment. The Eocene sediments of the Barmer Basin can be grouped into two packages: (i) the non-marine siliciclastic sequence of Mataji Ka Dunagr Formation and (ii) marginal marine fossiliferous bentonite-lignite sequence of the Akli Formation. Both the packages are contemporary or little time transgressive.

The Khuiala and Bandah formations of the Jaisalmer Basin represent at least six sequence cycles (SB V to SB X), which predominantly consist of transgressive systems tract (TST) and highstand systems tract (HST). The stacking pattern of these two formations suggest that during the deposition of Khuiala Formation, where majority of the carbonates sediments were stacked in HST, the basin was receiving plenty of carbonate sediments. On the contrary, during the deposition of Bandah Formation the most carbonate sediments were deposited during TST. The HST is either represented by fine-grain siliciclastic sediments of my marlstones.

The bentonite-lignite section of the Akli Formation represents a secluded condition of deposition in the centre of the Barmer Basin. The sediments range in age from Paleocene to Eocene. The fossil record suggests that the sequence has been deposited in coastal to marginal marine environment. The lignite seam units have been considered at the base of the sequence cycle, overlain by bentonite/shale units representing HST. In all 12 sequence cycles have been recognized. The correlation of the sequence boundaries within the Akli Formation with those of non-marine Paleocene to Eocene sediments of the Mataji Ka Dungar Formation in the Barmer Basin and marine sediments of Khuiala and Bandah formations in the Jaisalmer Basin could not be worked out in lack of published record of detail micropaleontological data from the Akli Formation.

Three marker beds (MB I, II & III) and sequence stratigraphic framework of the Paleogene sediments in the Jaisalmer and Barmer basins have been found very useful in inter-basinal correlation of some sedimentary packages in the two adjacent sedimentary basins on the western part of the Indian Craton (Fig. 2). The present study reveals that the upper part of Fatehgarh Formation and basal part of Mataji Ka Dungar Formation of the Barmer Basin, which are hydrocarbon bearing sands, are coeval with Sanu Formation of the Jaisalmer Basin. This correlation of the Paleocene sediments of Jaisalmer and Barmer basins would

not been possible in lack of information about marker beds and sequence stratigraphic framework.

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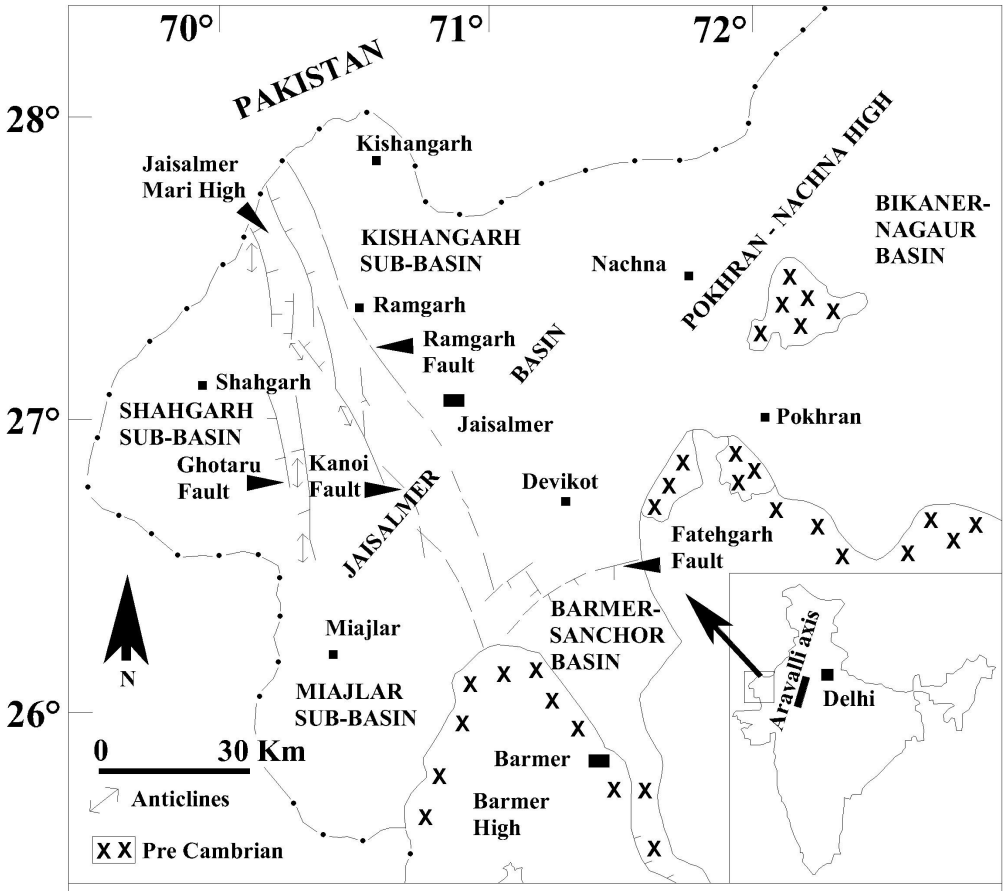

Fig. 1: Structural elements in western Rajasthan

(modified after Misra et al., 1993)

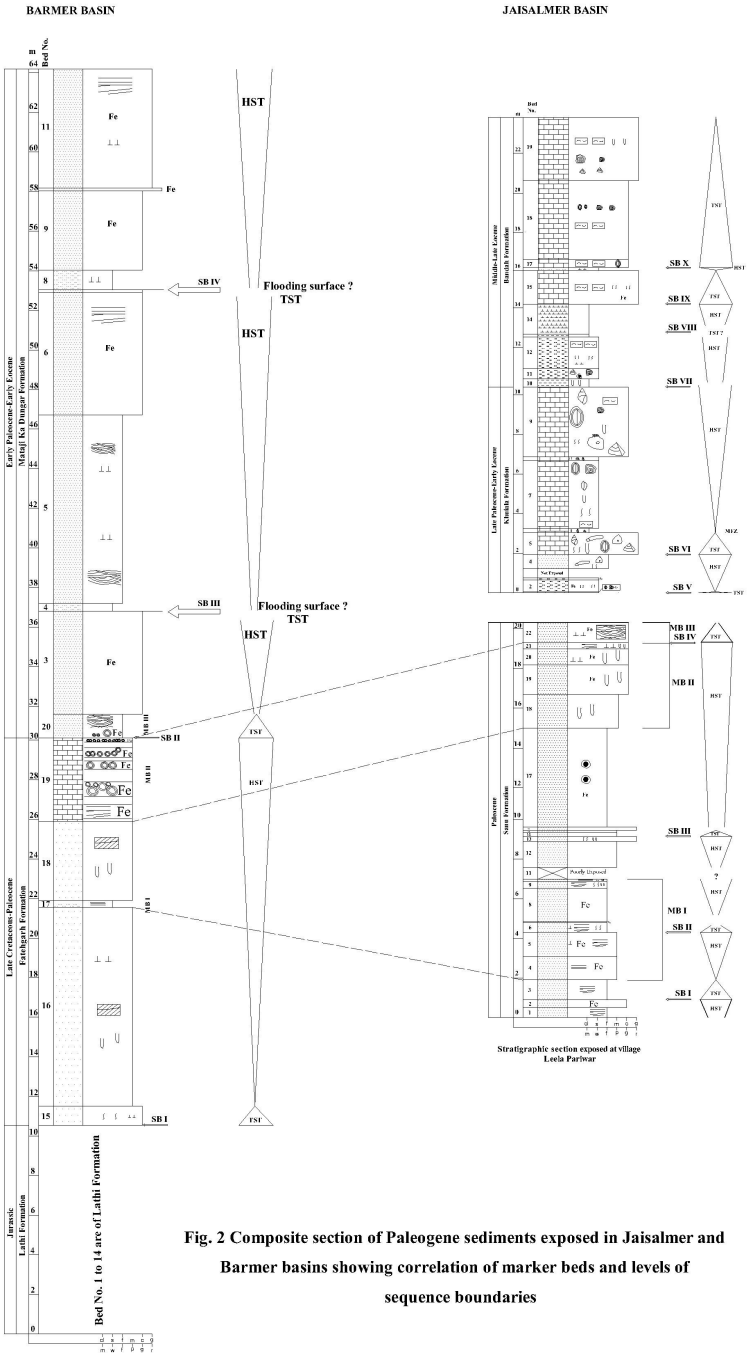

Fig. 2 Composite section of Paleogene sediments exposed in Jaisalmer and Barmer basins showing correlation of marker beds and levels of sequence boundaries