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Depositional model for Late Jurassic and Early Cretaceous sequences of Jaisalmer Basin, Rajasthan

Abstract

Jaisalmer Basin is a passive margin basin, lies on NW part of India. Depositional setting of the basin varies from fluvial to marine. The present study is focused on identified of depositional setting for during the Late Jurassic – Cretaceous sediments. Early Jurassic succession (Lathi Formation) starts with fluvial, deltaic, lacustrine, and marginal-marine sediments. Jaisalmer Formation has been deposited in wide spectrum of marine environment ranging from inner shelf to upper shore facies. The Baisakhi-Badesar Formation has been dated Early Oxfordian to Early Tithonian and deposited in 30-50m bathymetry in western part of the study area. The Pariwar Formation has been dated as Neocomian to Aptian on the basis of foraminiferal studies and deposited in near shore to inner neritic (30-50m bathymetry) set up. The Goru Formation marks the second transgressive cycle of Mesozoic sedimentation. The Lower Goru Formation belongs to Albian age and deposited in 40-100m bathymetry. The rich fossiliferous Cretaceous sediments have been dated as Hauterivian at the base and Santonian toward the top and are separated from Cenozoic by a pronounced hiatus i.e. KT boundary.

Key words: Depositional setting, Bathymetry, Transgressive cycle.

Introduction

The western Rajasthan shelf located to the west of Aravalli ranges constitutes three important Basins viz. Jaisalmer, Bikaner-Nagaur and Barmer (Fig.1). Each basin has unique geological and sedimentation history, although at some point of time, there were some common elements. The Jaisalmer Basin has well documented Mesozoic and Cenozoic sedimentation history. Bikaner-Nagaur and Barmer basins however are primarily Paleozoic and Cenozoic basins respectively.

Various workers have carried out studies on the depositional environment of the stratigraphic units based on out crop studies and also on sub surface well data. Based on the available literature, Lathi Formation, Early Jurassic succession starts with fluvial, deltaic, lacustrine, and marginal-marine sediments (Bonde, 2010; Lukose, 1972; Pandey et al., 2006; Srivastava, 1966). Jaisalmer Formation has been deposited in wide spectrum of marine environment ranging from inner shelf to upper shore facies (Ahmed et. al., 2017). The Baisakhi-Badesar Formation has been dated Early Oxfordian to Early Tithonian and deposited in 30-50m bathymetry in western part of the study area. The Pariwar Formation has been dated as Neocomian to Aptian on the basis of foraminiferal studies and deposited in near shore to inner neritic (30-50m bathymetry) set up. The Goru Formation marks the second transgressive cycle of Mesozoic sedimentation. The Lower Goru Formation belongs to Albian age and deposited in 40-100m bathymetry. The rich fossiliferous Cretaceous sediments have been dated as Hauterivian at the base and Santonian toward the top and are separated from Cenozoic by a pronounced hiatus i.e. KT boundary.

The sedimentation during Mesozoic period started with the deposition of Triassic sediments. The sediments of Lathi Formation indicated change in depositional environment form fluvial, deltaic to shallow marine environment. The overlying sediments of Jaisalmer Formation were deposited in overall shallow marine conditions. It was followed by partial withdrawal of the sea in NW and SW part of the basin, which resulted in deposition of Baishakhi-Badesar Formation in deltaic set up (Alberti et al., 2017). The Pariwar Formation was also dominated by a fluvio-deltaic set up during the deposition.

The end of Pariwar Formation witnessed a marine transgression throughout the basin, during which Lower Goru sediments were deposited (Khan et. al., 2015).

This study was taken up to analyse sedimentological, paleontological and palynological data generated over the years for the Late Jurassic and Cretaceous sediments in the Jaisalmer Basin. This data was integrated with other G & G data to decipher the regional depositional set up and to understand the disposition of the geological strata, depositional features and identification of the potential areas of hydrocarbon entrapment based on identified depositional setting for different stratigraphic units during the Late Jurassic – Cretaceous sediments.

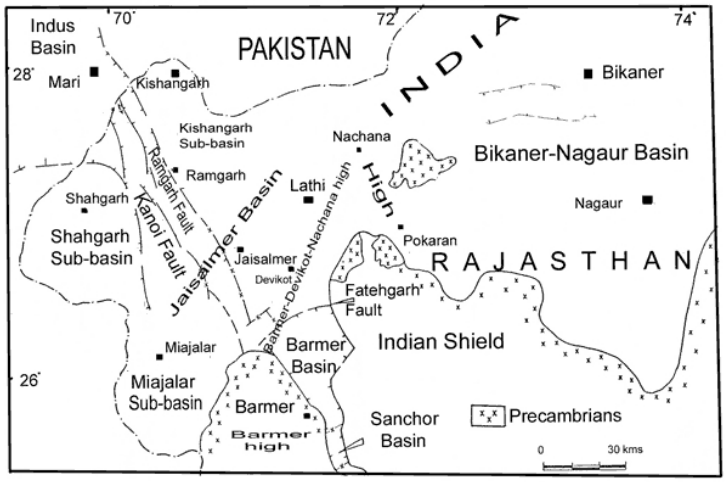

Figure-1: Tectonic map of western Rajasthan (after Misra et al. 1993).

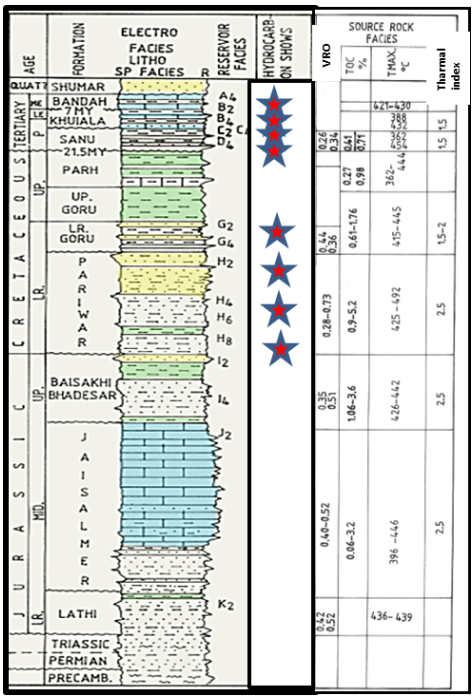

Fig. 2: Stratigraphic column of the basin

Generalized Litho-Stratigraphy of Jaisalmer Basin

Subsurface Stratigraphy (Mishra, 1993) of the area based on the integration of surface geological data alongwith wells has been established considering the lithological changes, biostratigraphic data (paleontological/ palynological studies), core data and log data (Fig.2).

Paleogeographic Reconstruction

Biostratigraphic and sedimentological studies of cores and cuttings of several wells of the Basin has been carried out by RGL, Vadodara. This data is utilized to understand the depositional model, age, planktic zonation, and paleobathymetric analysis.

For the preparation of paleogeographic maps for each formation, the isopach data and the gravity data were integrated along with the paleontological, sedimentological and bathymetry data of the wells from different laboratory reports. Data from some of the selected wells has been compiled and analysed for the present study and is tabulated below:

Baisakhi-Badesar Formation

Well	Fossils	Bathymetry	Sedimentary Structure	Depositional Environment
LT-A	***Ctenidodinium ornatum, Oligosphaeridium patulum, Omatia montgomeryii***	**30-50m** (within the **Inner shelf environment)**	--	Palynofloral association suggests deposition under **sub tidal to inner shelf**

				conditions.
RT-A	***Dinoflagellate, Cyst Zone, C. ornatum, N.pellucida, R.cladophora, O.patulum***	**30-50m**	Clean bimodal sandstone suggest reworking by tides	Fluvial and distributary channel sands under regressive condition along with subtidal to inner shelf condition.
GTF-A	***Dinoflagellate, Cyst Zone, R. aemula-Valensiella sp, Valensiella sp- Gonyaulacysta***	**30-50m**	--	Deposited under subtidal to intertidal condition

Das et. al., 2009, 2010, 2011, 2012; Shanmukhappa et. al., 2008; Singh J. & Nayak, K.K., 2012.

Pariwar Formation

Well	**Fossils**	**Bathymetry**	**Sedimentary Structure**	**Depositional Environment**
MT-A	***Dinoflagellate, Cyst Zone, Nummus similis-Fomea cylindrical Phoberocysta-neocomia-Pseudoceratium- pelleriferum***	**30-50m** (Inner shelf)	Mud flaser, Borrows and bores	Massive glauconitic sandstone along with mud flaser and burrows indicate stacked channel deposits
BN-A	***G. blowi, H. sigali, G. hoterivicia zone.***	Fluctuating **30-50m/** little deeper (broadly inner shelf)	Clean bimodal sandstone suggest reworking by tides, Flaser bedding, Bioturbation	Fluvial and distributary channel sands under regressive condition along with sub tidal to inner shelf condition
GTF-A	***Dinoflagellate, Cyst Zone, R. aemula, Valensiella sp, Valensiella sp. Gonyaulacysta***	Fluctuating **50-100m**	Cross beddings	Deposited under fluctuating energy condition as evidenced by siderite oolitic mudstone facies and coarsening up sequences in sandstone.
GT-D		Fluctuating **30-50m/** little deeper (broadly inner shelf)		Coastal bar
CT-C	***G. hoterivica, H. sigali***	**30-50 m** (inner shelf)	Cross beddings	Tidal Channel and mixed flats
CT-D	***G. hoterivica, H. sigali***	**30-50m** (inner shelf)	--	--
GT-A	***G. blowi, G. ferreolensis***	**30-60m** (inner shelf).	Cross beddings	Coastal bar and oolitic sandstone

Das et. al., 2009, 2010, 2011, 2012; Shanmukhappa et. al., 2008; Singh J. & Nayak, K.K., 2012.

Lower Goru Formation

Well	**Fossils**	**Bathymetry**	**Sedimentary Structure**	**Depositional Environment**
SG-B	***Hedbergella gorbachikae-Tincella roberti***	--	--	Middle shelf condition at the bottom to intertidal condition towards top

LT-A	***P.buxtorfii-Favusella washistensis, Tinicella roberti, Rotalipora***	**80-120m**	--	Middle to outer shelf have been inferred for the Lower Goru in this well
CT-C	***F.washitensis-Ticinella robertii,***	**70-100m** (Inner to middle shelf)	--	Middle to Inner shelf
CT-D	***H.sigali- H.maslakovae-H troicoidea***	**70-100m** (Inner shelf environment) have been inferred for the deposition of sediments belonging to this bio zone.	--	Middle to outer shelf
MT-Q	***P. buxotorfi-Fauvusella washitensis- Tincella bejuaensis- Ratalipora ticinensis***	**40-60m** (Middle to Inner shelf).	--	Middle to Inner shelf

Das et. al., 2009, 2010, 2011, 2012; Singh J. & Nayak, K.K., 2012.

Paleogeography

Baishakhi-Badesar Formation

The generalised lithology of the formation includes beds of glauconitic shale in the bottom part followed by gritty sandstone, oolititic limestone with abundant species of ammonites in the middle while the top part is dominated by shale with disseminated pyrites and streaks of lignite. Towards the top of the sequence, silicified wood trunks are frequently observed. The presence of oolites in the middle unit indicates that the deposition took place under strong wave action. The presence of ammonoids in the sediments suggest shallow marine environment. The sediments towards top were deposited in high energy near shore environment as evident by presence of fossil wood and current bedding in the sandstone. The integration of lithological and biostratigraphic data suggest deposition of the sediments in a bathymetry of 30-50m in wells RT-A, AT-A and GTF-A in the SW part of the study area. On the whole, a shallow marine to near shore environment has been inferred for this unit. In the subsurface, the sandstone beds appear to be stacked shore face aggradational deposits. The presence of black carbonaceous shale indicates coastal and swampy environment (Upadhyay & Narender, 1989). Beach sand has been reported based on the core studies in the drilled wells of Bakriwala, Kharatar and Ghotaru areas.

Based on the above analysis, it is inferred that the deposition of Baishakhi-Badesar Formation initiated in an overall deltaic regime with tidal influence while the top part was dominated by a delta plain environment. From the above it can be inferred that the middle part is dominated by the delta front sand reservoir while the bottom and the top parts of the sequence are rich in shaly facies which represent source rocks.

The source input for the sediments of Baisakhi- Badesar Formation is inferred from east and north-east (Fig. 5).

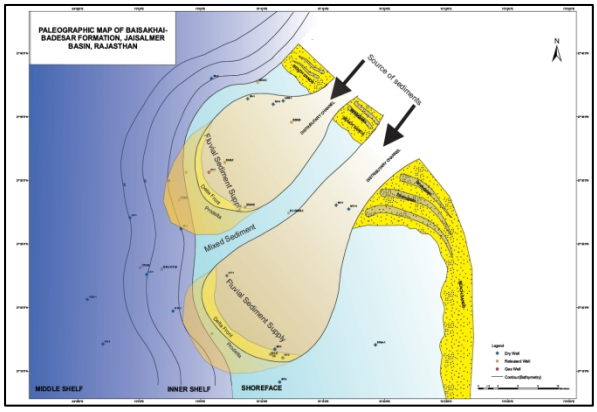

Fig: 5-Paleogeographic map of Baisakhi-Badesar Formation

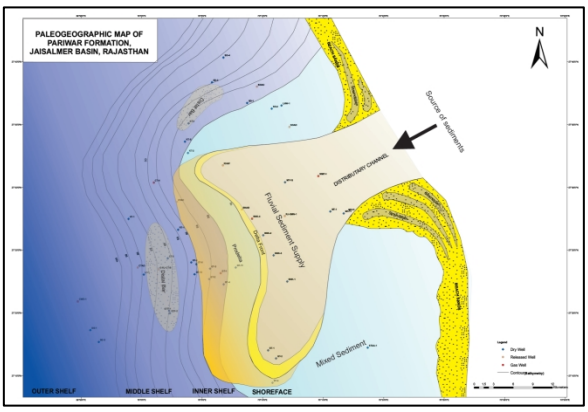

Fig: 6-Paleogeographic map of Pariwar Formation

Pariwar Formation

The integration of lithological assemblages with the biostratigraphic data in few selected studied wells across the basin suggests deposition of the sediments in 30-50 m bathymetry in Bankia, Chinnewala Tibba and Manhera Tibba areas.

The lower part of the dominantly arenaceous sequence is devoid of microfauna though it has yielded rich palynofloral assemblage of Lower Cretaceous age (Mathur, 1966). Fossil leaf impressions belonging to two species of Ptyllophyllum have been recorded from a core sample (1182 - 1202m) in well ST-A, which also indicates Lower Cretaceous age. Presence of glauconitic sandstone and shales are indicative of shallow marine conditions, whereas, ferruginous sandstone, grey shales with fossil leaf impressions, tree trunks, current bedding and streaks of lignite are suggestive of continental to paralic environment. Dasgupta (1975) suggested a continental to deltaic environment of deposition for the formation. However, Lucose (1977) interpreted shallow marine, brackish water to continental environment based on palynofossil assemblages.

Paleogeographic map of Pariwar Formation envisages deposition in a dominantly fluvial set up at the basal part followed by a set up dominated by delta, along with mud flats. Depositions of beach sands are envisaged in the Manhera Tibba, Ghotaru and Sadewala areas. Based on the present study, the sediment supply is envisaged from the provenance area in the north and north-eastern direction (Fig. 6).

Lower Goru Formation

The Lower Goru Formation dominantly comprises of greenish grey, feebly calcareous, micaceous, and occasionally pyritic shale which is silty at places. The shales are often interbedded with light grey to greenish grey, fine grained, occasionally calcareous, argillaceous, glauconitic sandstone. The Upper Goru however is mainly argillaceous unit composed of shale, siltstone and marl. The shales are grey to green, fissile, slightly calcareous and silty with dissemination of pyrite. Siltstone intercalations are light grey, compact and calcareous. Grey to dark grey, silty and pyritic marl beds constitutes the upper part.

The litho-association along with faunal and floral assemblages suggests deposition of these sediements in inner to middle shelf in Chinnewala Tibba, Ghotaru and Manhera Tibba areas. Presence of argillaceous limestone, marl and calcareous clay/shales along with the rich assemblage of micro planktons like *Marginotruncana helvitica*, *M. schneegansi* and *M. sigali* etc are suggestive of an open marine environment ranging from middle to outer shelf (Fig. 7).

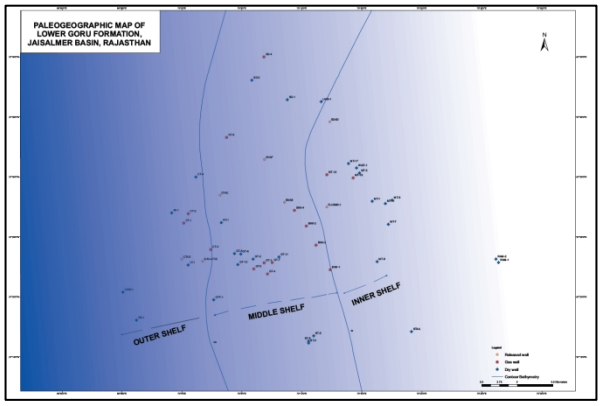

Fig: 6-Paleogeographic map of Lr Goru Formation

Conclusions

Based on the above analysis, it is inferred that the deposition of Baishakhi-Badesar Formation was initiated in an overall deltaic regime with tidal influence while the top part was dominated by a delta plain environment. Good thickness of reservoir facies is developed within Baishakhi- Badesar Formation in areas around Ghotaru, Chinnewala Tibba and Sadewala areas. The deposition of the Pariwar Formation is envisaged in a dominantly fluvial set up at the basal part followed by a set up dominated by delta, along with mud flats. Depositions of beach sands are envisaged in the Manhera Tibba, Ghotaru and Sadewala areas. The sand reservoirs with better thickness within Pariwar Formation are observed in Ghotaru, Chinnewala Tibba, Kharatar and Sadewala areas. Deposition of

Lower Goru Formation took place in inner to middle shelf in Chinnewala Tibba, Ghotaru and Manhera Tibba areas. Development of better reservoir facies has been observed in Chinnewala Tibba, Kharatar and Sadewala areas.

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