SUMMARY AND CONCLUSIONS

The sedimentary basin of Kachchh is well known for extensive development of Middle Jurassic Sequence representing variable field characters and petrographic, mineralogical and geochemical composition and accordingly has created a greater interest in their study.

The present study on the Middle Jurassic Jhurio Formation of Kachchh Mainland is an attempt to provide additional information on the sedimentology and microfacies characteristics to decipher the stratigraphic and sedimentary configuration of different rock types exposed therein. The study involves a detailed field and laboratory study of the sedimentary terrain lying to the southwest of Aravallis: identification of stratigraphic units; textural analysis of coarse clastics; mineralogy of finer sediments; microfacies study of carbonate rocks; distribution of trace and rare earth elements; statistical interpretation of geochemical data and finally an attempt towards the reconstruction of palaeoenvironmental and sedimentation history with a sequence stratigraphic approach. The analytical data discussed in earlier chapters is further summarized for a meaningful understanding of the stratigraphy, depositional characteristics and sedimentation history of the Middle Jurassic succession of Kachchh Mainland, western India.

Middle Jurassic succession of Kachchh Mainland is represented by the upper part of the Jhurio Formation and the entire Jumara Formation and is exposed in the E-W trending eroded domal structures (Jumara, Jhurio and Habo from west to east). The upper part of the Jhurio Formation is represented mainly by limestone with shales with interbedded oolitic limestone beds. The limestones are jointed and bioturbated and the golden oolitic interbeds are often congolomeratic in nature. The overlying Jumara Formation is well exposed in all the

three domal structures and is represented mainly by lower carbonate and fine clastic association, middle coarse clastic association with minor shale and limestone and the upper fine-clastic and carbonate lithological associations. The shales at some levels are gypsiferous clays comprising also of other evaporitic minerals.

The lithofacies of the Jhurio Formation have been broadly grouped into three Lithofacies associations (LFA 1 to 3) representing the earlier classified seven members (Member A to G in ascending order) of Biswas (1977). These include the Golden oolitic limestone – Grey limestone lithofacies (LFA – 1; Member A-C), the Pelagic limestone – hemipelagic mudstone lithofacies (LFA – 2; Member B-F)) and the limestone - calcareous sandstone – gypseous shale lithofacies (LFA – 3; Member G) and indicate a fluctuating sea level of the depositional environments.

The overall skeletal and non-skeletal assemblage of the carbonates consisting of abundant molluscs, brachiopods, algae and other skeletal fragments of echinoids, corals and foraminifera, oolites, pellets and intraclasts suggests a shallow marine, high energy environment of deposition probably subtidal and intertidal zones. The carbonate petrographic types (dominating wackestone-packstone followed by mudstone and grainstone types) with variable allochem particles correspond to the standard microfacies SMF-5, 9, 11, 14, 15 and 16 of Wilson (1975) characterizing the facies belts of 6,7,8 & 9.

The study has documented the distribution of two broad microfacies groups, the carbonate and the mixed carbonate-siliciclastic-evaporite facies developed in a subtidal to peritidal depositional and intertidal–supratidal depositional realms and embracing five microfacies assemblages viz., peloidal, oolitic, bioclastic, bio-lithoclastic and mixed carbonate-siliciclastic-evaporite assemblages. These microfacies assemblages indicate marine transgressive features of the depositional environment followed by the lat-er regression during

Middle Jurassic. The microfacies assemblages also exhibit the preservation of four important diagenetic environments, such as marine phreatic, fresh water phreatic, burial and fresh water vadose subsequent to the deposition of the sediments resulted in a variety of cement textures.

The clastic sediment influx was more abundant during the deposition of uppermost part of the Sequence. The sedimentary structures, variation in clastic texture and the grain size data plots (Figs.5.2a-d, 5.3 and 5.4) suggest a beach to shallow marine environment of deposition of these rocks. The clustering of the sample data points (dashed area on the CM plot in Fig. 5.4) resembles the pattern of Passega (1957) given for sediments.

Petrographically, the coarse clastics correspond to Quartz arenite and Feldsphathic arenite types with little mud suggesting greater winnowing action of the depositional medium. The mineralogical composition and provenance study in association with their textural characteristic suggest that their derivation from crystalline igneous and metamorphic source (possibly from north and east) after considerable recycling (Fig.4.6 b-c).

The clay mineral association includes the lower montmorillonite-chlorite-illite assemblage, the middle kaolinite-illite assemblage, and the top illite-kaolinite-chlorite assemblage. The association of different types of clay minerals within the Middle Jurassic sequence is indicative of the oscillating nature of the depositional environments.

The geochemical observation of selected chemical parameters suggest in general a normal marine to less saline depositional environment of the with minor hypersaline condition of the depositional area.

The three main types of parasequences, the building blocks of a depositional sequence, are recognized resulting in development of the Jhurio Formation, which are Subtidal, Peritidal and Intertidal-supratidal parasequence types and exhibits a general shallowing upward trend of environment. The pelagic fauna characterizes transgressive part of the parasequence and

facies unit and other features associated with the high water depth. The near-shore fauna and the facies unit characterize the regressive part of the parasequence. Genetically related parasequences are stacked in to Parasequence sets (PSS) which are numbered as 1, 2, 3 and 4 (Fig. 7.1& 7.2). These parasequences are stacked in to a retrogradational stacking pattern at the lower in which oolitic grainstones are stacked as aggradational type and prograded at the upper part of the Jhurio Formation. The Jhurio Formation, is thus named as Sequence-I which is developed during the third order sea level change. The Sequence-II is marked on top by the upper surface of the Ridge Sandstone and the Sequence –III was developed during the peak of transgression followed by the high stand and regression. This is documented by the regressive oolitic grainstones (Dhosa Oolitic limestone). These three sequences are stacked in to a retroagradational to progradational stacking pattern forming a Megasequence (Fig.7.3) developed during Middle Bathonian to Oxfordian during a major second order transgressive-regressive phase. .

The diagenetic model of the Megasequence of Middle Jurassic of Kachchh Mainland explained with the depositional model (Fig. 7.3). The transgressive parasequence/sequence are characterized by the early marine cementation during TST and the regressive part is shown by the coarse sparite cementation during dissolution-reprecipitation during the fresh water diagenesis during the HST and LST. The respective evidences are documented from the facies units, which can be fitted with the depositional model (Fig. 7.1, 2 & 3).

CONCLUSIONS

1. Three Lithofacies associations (LFA 1 to 3) recognized in the Jhurio succession include the Golden oolitic limestone – Grey limestone lithofacies (LFA – 1), the Pelagic limestone – hemipelagic mudstone lithofacies (LFA – 2)) and the limestone - calcareous sandstone –

gypseous shale lithofacies (LFA – 3) indicate a fluctuating sea level of the depositional environments.

2. Sedimentary depositional structural and textural study supports for a fluctuating beach to shallow marine environment.
3. The petrographic observations reveal the presence of a variety of carbonate microfacies assemblages representing the three important microfacies groups viz., Subtidal, Peritidal and Intertidal –supratidal facies indicating a fluctuating sea level during Middle Jurassic.
4. The vertical distribution of the carbonate microfacies and the results of the goochemical and clay mineralogical study further substantiate above conclusions.
5. The cyclicity of sedimentation recognized from the above data which upon application of sequence stratigraphic techniques facilitated the identification of three types of parasequences (Subtidal, Peritidal and Intertidal-supratidal cycles) that form the parasequences sets which are stacked in to the retrogradational stacking pattern (subtidal peloidal microfacies) sandwiched with the aggradational peritidal facies (Oolitic grainstone microfacies) and progrades in to the intertidal –supratidal facies (Sandy mudstone-sandstone microfacies) in the Sequence-I.
6. A diagenetic model has been proposed using the relationship of sea-level changes and the diagenentic signatures.

SCOPE FOR FURTHER STUDY

The present study conducted on the outcropping sequence of rocks in Kachchh mainland reveal a variable nature of rock-types and lithological associations on account of their varying environments of deposition. It is generally believed that most of the hydrocarbons are formed in dark coloured, fine grained, marine sediments originally rich in organic matter, which are likely, to get accommodated in clastic-carbonate associations

(Landes, 1951; Leverson, 1956). Any well developed sedimentary sequence particularly, of the shallow marine to shelf facies is thus worthy of being explored.

The Middle Jurassic sequence of Kachchh Mainland comprise both clastic and carbonate facies followed by mainly sandstone and shales of Upper Jurassic. The entire sequence is characterized by a major transgressive cycle followed by a regression. The sedimentary thickness greatly increases towards west. The variable nature of carbonate rocks in association with coarse clastics and abundant organic material including calcareous algae etc. are considered favourable for inducing conditions for generation and preservation of hydrocarbons. The complex associations of clastic-carbonate sediments within the succession, having abundant organic constituents, variable porosity characters and environments of deposition, favour the conditions of hydrocarbon generation and entrapment. The gradation of carbonate facies suggests the possibility of development of biohermal build up, further down basin. The dark colored shales of Jhurio and the unexposed older formations might form source rocks in the deeper basinal parts of the west. The degree of maturation of the organic content would obviously be attained in the deeper part of the basin due to increased overburden of the sedimentary column. The bedded and the massive sandstones overlying these shales are good and readily available reservoirs.

The present study made on the exposed sequence does not provide any definite indication about the occurrence of hydrocarbons in the area, however, further study in conjunction with the subsurface data will certainly give a better account of the hydrocarbon generation and accumulation potentiality of the basin.

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