CHAPTER IX

DEPOSTIONAL ENVIRONMENTS

GENERAL

Various characteristics and data on the Jurassic sediments of Jaisalmer Basin, collected from the field and laboratory studies have been discussed in detail in the earlier chapters of this thesis. In the present chapter, an attempt has been made to evolve the depositional model based on the field and laboratory investigations. For better understanding, the depositional environments are discussed formation wise in the preceeding pages or paragraphs.

LATHI FORMATION

Lithofacies and sedimentary structures

The lower most formation of Jurassic sediments, Odania Member, comprises a sequence of conglomerate, poorly sorted, coarse grained, gritty sandstone and siltstone with abundant fossil wood, which are mostly ferruginous and occasionally silicified. The conglomerates are characterised by rounded pebbles mainly of quartz, chert and Jasper in sandy matrix. The ripple marks and current bedding (tabular and lenticular types) are the commonly observed feature in exposed fine grained sandstone section. (Plate IV. 2A).

The upper part of Lathi Formation i.e. Thaiyat Member is

characterised by a sequence of thin interbeds of fine grained, yellow to buff coloured sandstone and variegated siltstone. The sandstone is calcareous in nature, at places shows 'Karbub' structure, (a sort of tubercle like concretionary structure) caused by aeolian erosion. The upper contact of the member shows gradational relationship with the overlying Jaisalmer Formation (Plate IV. 4A).

The general coarser nature and poor sorting of the sediments along with the sedimentary feature like ripple marks, current bedding, presence of plant impressions and fossil wood in the lower section of the Lathi Formation suggests their deposition in fluvial to deltaic environment. The upper part of the Lathi Formation shows better sorting, finer sandstone, with buff colour and calcareous nature, suggesting a gradual transition from deltaic to marine environment, which is also evidenced by the gradational contact of the upper part of Lathi Formation with the overlying Jaisalmer Formation (Plate IV. 3A).

Textural attributes

The variation in mean grain size of clastic sequence in Odania Member shows fining upward trend, while the upper part of Thaiyat Member shows coarsening upward trend (Table IV. 1), suggesting dominance of fluvial environment in basal part of Lathi Formation grading to deltaic with marine influx in upper part of the formation.

The bivariate analysis data and binary plots-skewness Vs standard deviation (Moiola and Weiser; 1968, Fig V.1) show that the majority of the samples of the lower part of Lathi Formation are lying in

river deposit region, while most of the samples of upper part of Lathi Formation are lying in transitional zone. Similar observations have also been made by the author while examining the binary plots-skewness Vs standard deviation (Friedman, 1967; Fig. V.3) and mean diameter Vs standard deviation (Moiola and Weiser 1968; Fig V.4). Binary plots of standard deviation Vs mean diameter showing gradational changes in sorting and grain size with environments (Glaister and Nelson, 1974; Fig V.5) suggests majority of the samples of Lathi Formation are falling in river deposits in interdistributary channel and a few samples of upper part of Lathi Formation in transitional zone in delta and mature beach region.

The C-M diagram based on textural analysis of clastic sequence of the area under study (Passega, 1964, Passega and Baramjee, 1969; Fig. V.6). shows that majority of the samples plots of Lathi Formation are falling in QR and partly in RS segments, suggesting that the sediments were transported by the graded suspension as well as partly by stronger currents, during their deposition.

In the present study the cumulative probability curves were plotted and compared with curve shapes of Visher, 1969. It has been observed that the lower part of the Lathi Formation is characterised by moderately sorted saltation population with minor occurrence of poorly sorted surface creep, suggesting their deposition as distributary channel in deltaic regime. The upper part of Lathi Formation is predominantly fine grained, well sorted sandstone classified as quartz arenite, shows predominance of moderately sorted, truncated and winnowed saltation

population having a slope of 70-80°, with moderately sorted suspension and surface creep populations (Fig V.9) suggesting their deposition in marine condition with small tidal regime.

Mineralogical and Geochemical characterstics

Clay minerals from clastic sequence of upper member of Lathi Formation are characterised by the presence of kaolinite (90-95%), illite (5-10%) along with traces of chlorite, calcite and dolomite (Fig VII.1), suggesting the influx of saline water during deposition of the sediments within transgressive phase of shallow marine condition.

The heavy minerals in the clastic sediments of Lathi Formation, covering the lower and upper part are characterised by garnet with sporadic occurrence of hypersthene, hornblende, zircon and sphene (Fig. VII.4) suggesting the admixture of mafic igneous and metamorphic provenance responsible for derivation of the clastic sediments during deposition.

The sandstones of Lathi Formation are in general rich in SiO_2 (80-85%). However considerably low SiO_2 (49%) is observed in the upper part of Lathi Formation, which contains bioclastic as well as calcareous matrix, suggesting transgressive phase of deposition.

JAISALMER FORMATION

Lithofacies and Sedimentary structures

The Jaisalmer Formation is characterised by the predominance of

carbonate facies, interbedded with calcareous sandstone, oolitic and bioclastic pelletal limestone with shale at top. Limestones are invariably oolitic, pelletal and at times with terrigenous admixture are also seen. The sandstones are generally soft, fine to medium grained, whitish to buff and brown colour, often characterised by herring bone cross lamination (Plate II.6B). Gypsum crystals are present as thin sheets parallel to bedding and occasionally in perpendicular cracks in the upper part of the Jaisalmer Formation. The lower part of Jaisalmer Formation dominated by clastic sediments, are represented by Hamira and Joyan members were deposited in a near shore, coastal water environment influenced by fresh water influx. The overlying sediments of middle Jaisalmer Formation represented by Fort and Badabag members were deposited in coastal marginal marine environment.

The variation and regional distribution of microfacies of carbonate section in Jaisalmer Formation shows predominance and thickening of clastic sequence in basal part of subsurface section in Bhuana, Sumarwali Talai, Bhakhari Tibba, and Sadewala structures from SSE to NNW direction (Fig. IX.1)., while this unit occurs as, thin intercalation at the base of Hamira, Joyan, Fort and Badabag members in exposed outcrop section in SE & SSE direction of the basin. The dominance of wackestone and mudstone facies in basinal part than shelf area, and persistent occurrence of grainstone facies with association of pellets and oolites in shelf area has been observed. Such variation in microfacies suggest that during initial phase of sedimentation of Jaisalmer Formation, the basin was very unstable and frequent oscillatary condition were observed which resulted in sedimentation of both clastic and carbonate sediments. Thus the

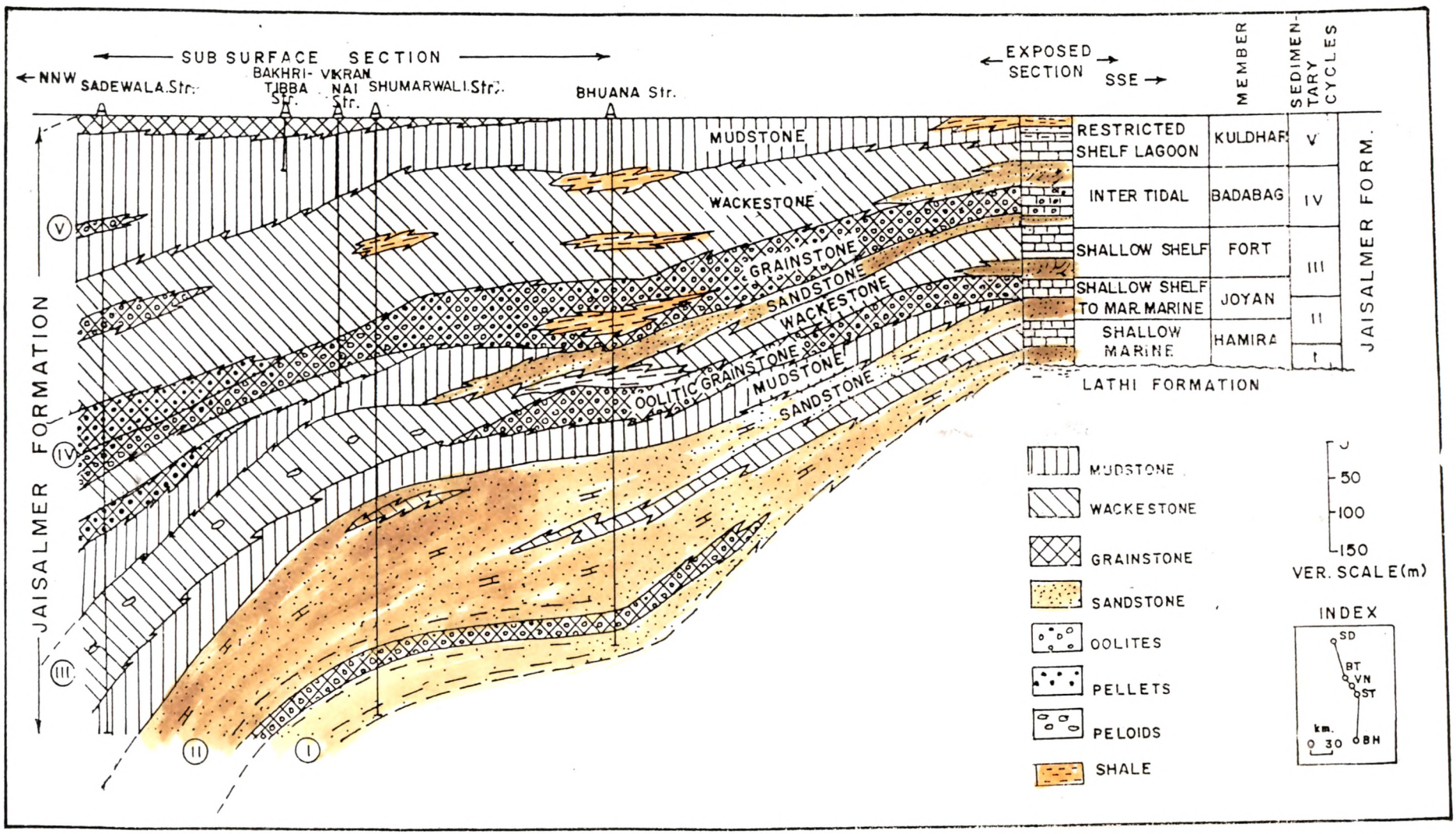

FIG. IX-1: REGIONAL VARIATION OF MICROFACIES AND DEPOSITIONAL ENVIRONMENTS OF CARBONATE SECTION OF JAISALMER FORMATION, JAISALMER BASIN, WESTERN RAJASTHAN.

basal part of Jaisalmer Formation was deposited in near shore environment throughout the Jaisalmer Basin. The Hamira and Joyan members of Jaisalmer Formation are equivalent to basal part of Jaisalmer Formation in subsurface.

After deposition of basal part, a wide shelf lagoon regime developed resulting in carbonate sediments which comprises mudstone and wackestone with intercalated oolitic grainstone facies. These are results of periodic transgression and regression. The Fort and Badabag members were represented by sandy limestone with intercalation of sandstone, which indicate a very shallow setting of deposition in intertidal environment.

The upper part of Jaisalmer Formation i.e Kuldhar Member in surface area indicate restricted to shelf lagoonal deposit which correspond to wackestone-mudstone association in subsurface section, which is followed by the regressive phase resulting in oolitic grainstone facies on the top of the formation.

On the basis of variation in microfacies and occurrence of their different constituents, prevailing energy conditions has been identified, and in general five sedimentary cycles (1-V) has been established in Jaisalmer Formation (Fig. IX.1). In general mudstone and wackestone facies were deposited in low energy condition, packestone and grainstone facies in moderate to high energy condition. The sandstone which is basically calcareous quartz wacke and quartz arenite represent moderate to high energy condition in near shore environments.

Fossil assemblages

The Jaisalmer Formation as a whole has a rich variety of fossils, belonging to diverse groups such as gastropods, pelecypods, echinoderms, corals, algae etc. as reported by several workers (Pl.refer chapter IV). The bioclastic and arenaceous nature of limestone with above faunal assemblage also suggest lagoonal to shallow marine environment of deposition.

Mineralogical and Geochemical characteristics

The evaporite minerals like gypsum in association with dolomite along with the lithoassociation of oolitic beds in the Kuldhar Member, suggest a restricted lagoonal environment, with moderate to high energy conditions at the end of sedimentation of Jaisalmer Formation. For better understanding of the oxidising and reducing conditions during the depostion of sediments, the stability of minerals is an important indicator (Krumbien and Garrels 1952). The absence of iron sulphides, presence of iron rich chlorite, glauconite and hematite minerals in the matrix of clastic sediments in Hamira, Joyan and Fort members suggest a neutral to oxidising condition during deposition of sediments (Chilingar,, 1955). This is also being supported by the presence of rich variety of the fossils and benthonic forams in sediments.

The deposition of carbonate sediments, especially the predominance of calcite in Jaisalmer Formation suggest pH value of at least 7.8 (Krumbein and Garrels op. cit.) representing the dominance of alkaline condition during the deposition of sediments.

BAISAKHI FORMATION

Lithofacies and Sedimentary structures

The Baisakhi Formation comprises predominantly grey to dark grey shale sequence with minor association of fine grained soft sandstone and variegated claystone with occasional gritty sandstone layers and streaks of gypseous clays. The lithoassociation suggests their depositional environment in lower deltaic to shallow marine condition.

Mineralogy and Textural attributes

The presence of degraded illite - with minor occurrence of montmorillonite in the upper section of the formation suggests marine transgression during the deposition of sediments. The very presence of degraded nature of illite suggests marine diagenesis during sedimentation. This is also being supported by sudden decrease in percentage of SiO_2 in this section.

The distribution of mean grain size in the vertical profile shows coarsening upward trend. The binary plots of skewness Vs standard deviation (Moiola and Weiser, 1968, Fig. V.1) shows that majority of the sample plots of lower section of Baisakhi Formation are falling in the transitional zone, suggesting their deposition in deltaic to shallow marine condition. Similar observations have been made in binary plots of standard deviation Vs mean diameter, indicating maturity trends (Glaister and Nelson, 1974) where majority of samples of the lower section of Baisakhi Formation are falling in mature beach deposit suggesting marine influence during deposition of the sediments.

BHADASAR FORMATION

Lithofacies and Sedimentary structures

The Bhadasar Formation is characterised by alternation of ferruginous gritty sandstone and friable red sandstone with intercalation of clays followed by brown argillaceous sandstone with broken ammonites. The upper part of the formation is characterised by cross bedded feature containing fossil wood and fragments of broken, reworked bivalves and gastropods. The absence of an apparent break between the upper and lower members of the formation and their lithological association with broken shell fragments represent gradual change from shallow, oscillatory marine to continental environments.

Textural attributes

The mean grain size of vertical profile of the clastic sequence of Bhadasar Formation show predominance of fining upward trend with minor association of coarsening upward trend. The binary plots skewness Vs standard deviation (Moiola and Weiser, 1968, Fig. V.1) mean diameter Vs standard deviation (Friedman 1967, Fig. V.2), skewness Vs standard deviation (Friedman 1967, Fig. V.3) show that majority of the sample plots are lying in river sand regime, suggesting their deposition as fluvial deposits. Standard deviation Vs mean grain size plots, showing maturity trends (Glaister and Nelson, 1974) indicate multi channel deposits. However the C-M pattern (Passega, 1964) of samples plots of the formation suggests that majority of sediments were transported by graded suspension. The probability grain size curve shapes show predominance of well sorted saltation population with minor occurrence of

suspension and surface creep population suggest that the sediments were deposited in regressive cycle in fluvio-deltaic environment as channel deposits under moderate to high energy condition.

Mineralogical and Geochemical characteristics

The dominance of stable minerals such as tourmaline with sporadic occurrence of zircon and rutile suggest an admixture of acid igneous and medium grade metamorphic provenance responsible for supplying the detritus to the sediments. The presence of hematite along with occurrence of calcite and dolomite in the matrix suggests prevailing oxidising conditions during the sedimentation.

DEPOSITIONAL MODEL

The Jurassic sequence in the Jaisalmer Basin represents a typical shelf zone sedimentation of orthoquartzite-limestone association resting on a peneplained Pre-Cambrain surface. The sedimentation started from Lias with continental deposits of Lathi Formation where sediments were derived from the peneplained Pre-Cambrian basement consisting of acid igneous and metamorphic rocks. This is followed by first marine transgression in Callovian-Oxfordian time during deposition of Jaisalmer Formation.

Eustatic movement of the sea commenced in Callovian during silting up of the basin as evidenced by intertonguing contact of Jaisalmer limestone and Lathi sandstone. Subsequently the subsidence brought in neritic to infraneritic environments under life supporting marine facies. The clastic dominating lower part of Jaisalmer Formation were deposited

in near shore, coastal water environment influenced by fresh water influx. The middle part of Jaisalmer Formation represented by Fort and Badabag members are being represented by coastal marginal marine environment.

The presence of evaporite minerals in association of dolomite and oolites in upper part of Jaisalmer Formation represented by Kuldhar Member suggest restricted lagoonal environment with varying energy condition indicating rhythmic movement of marine environment at highly unstable shelf.

The succeeding Baisakhi Formation had continental epineritic marine facies, as evidenced by presence of frequent alternation of sandstone, shale and gypseous shale suggesting oscillatory depositional conditions.

In the late Tithonian, the sedimentation of Bhadasr Formation shows repetitive cyclic change in environment from shallow oscillatory marine to continental suggesting end of regressive phase.