CHAPTER - II

REVIEW OF LITERATURE

2.1 GENERAL

The establishment of Jurassic System in the Jura Mountains of Western Europe is an important milestone in the study of stratigraphy because many of the basic principles and concepts first enunciated after the study of its rocks and fossils in Europe. These classic works have been amply reviewed by Arkell (1933) and Holder (1964). Arkell's (1956) "Jurassic Geology of the World" is a measure of the proliferation of knowledge on the Jurassic sequence of various parts of the world. Jurassic was a period of marine transgression and forms an important system of the Mesozoic Era. In many parts of the world the Era began with a new phase of sedimentation.

2. 2. INTERNATIONAL STATUS

The type sections of various stages of the Jurassic are situated in England , France, West Germany and Russia. The Jurassic succession of rocks from various parts of the world has received greater attention especially for their varied depositional facies and fossil content. The literature available on stratigraphy, palaeontology, sedimentology and other applied aspects of these rocks is exhaustive and it is beyond the scope of presentation in this work. However, some of the important contributions on the Jurassic rocks related to the proposed study have been listed below.

The sedimentologic character and provenance of the arenaceous, argillaceous and ferruginous facies of Jurassic of the Northern Europe have been investigated by Allen (1969). The work of Smithson (1942) on the Middle Jurassic sandstone of northern England illustrates the complicating effects of diagenesis. Hudson (1964), in his thorough study of the petrology of Middle Jurassic Great Estuarine Sandstone Series of W.Scotland, found it profitable to use quantitative methods and the sedimentological study on the same was made by Hudson and Harries (1979). The great value of petrography and sedimentology in elucidating Jurassic depositional environments has been brought out by Hantzschel and Reineck (1968), Davies (1969), Sellwood (1972a), Knox (1973), etc. The Jurassic 'shales' of Northern Europe have been studied for their mineralogy and environmental interpretations by Hallam and Sellwood (1968) and Sellwood (1972b). The different types of pyritisation of fossils in the Oxford Clay have been dealt in detail by Hudson and Palframan (1969) and the geochemistry of the Jurassic Jet rocks and shales is discussed in Gad et al., (1969). Palaeontological aspects of clastic facies of northern Europe are discussed in Sellwood (1971) and Hallam(1972). Regional environmental analyses have been made by Hemingway (1974), Sellwood (1972b), Knox (1973), Wilson (1975), etc. The limestones and marls occurring widely to the north of Circum-Mediterranean Province, extending far into England Bajocian-Bathonian and Late Oxfordian have been investigated for their petrography, composition and depositional environments by Pugh (1968), Purser (1969), etc. By relating his observations on hardgrounds in the Middle Jurassic limestones in the eastern Paris Basin to the broader stratigraphic context and to recent discoveries in the Persian Gulf, Purser (1969) has made significant contribution to our understanding of Jurassic limestone sequences.

Palaeontological aspects of the calcareous-argillaceous sequence have been given in Hallam (1972), Sellwood (1972b), etc. The first systematic attempt to compare the British Middle Jurassic limestones with the deposits in the Bahama has been undertaken for the Great Oolite Group of the Bath area of Somerset by Green and Donavan (1969), who have subdivided the succession in to four formations and the environments of deposition of which have been interpreted by Sellwood and McKerrow (1974). Talbot (1973) has also attempted an environmental interpretation of the relationship of the limestone horizons within the Corallian to the interbedded terrigenous clastic sediments. Interesting work has also been done on the diagenesis of the corallian limestones by Talbot (1971) and Davies (1971). Bosellini and Broglio-Lorgia (1971) have undertaken the facies analysis of the Lower Jurassic sequence of the Venetian Alps. Sellwood (1970) in his comprehensive study of part of the Lower Jurassic Britain, recognized three types of minor sedimentary and faunal cycles developed in clastic and calcareous sequences.

The Jurassic of United States Western Interior has been more researched than other parts of the world. The present knowledge of Jurassic of United States is due primarily to the extensive work which were carried out on stratigraphical and palaeontological aspects by Imlay (1967). Palaeontological reconstructions of the Jurassic sequences have been presented in Smith and Hallam (1970), and Smith et al., (1973). The Jurassic sea level changes have been illustrated in Hallam (1969). The palaeoclimatic studies of Jurassic Period have been made by Barnard (1973), Moore et al., (1992), Hallam (1993), etc. Veizer (1978, 1983) Morrow and Mayers (1978), Marshal and Ashton (1980), Brand and Veizer (1980), and Banner (1995) have worked on diagenesis and geochemical aspects of carbonate rocks of Phanerozoic. The other important studies on the Jurassic sequence of rocks from various parts of the world include those of Steikien et al., (1958), Powers (1962), Brown (1964) , Wilson (1974), Hallam (1969), Davies (1972), Abbate et al., (1974), De Wet (1987), Emery et al., (1989), Sellwood et al., (1989), etc. A comprehensive list of references on Jurassic work can be found in Arkell (1956), Hallam (1975) and the recent proceedings of symposia on Jurassic Geology.

The sequence stratigraphic techniques and its applications are given in many recent textbooks and research papers. The important valuable references are Sloss (1963),) Mitchum et al., (1977), Heckel (1981), Tucker (1990), Mitchum and Van Wagoner (1990), Van Wagoner et al., (1990),Wilson (1992), and Embry (1992). The sequence stratigraphic techniques on carbonate rocks are well explained in Sarg (1988). The various recent approaches of sequence stratigraphic methods adopted by many researchers are given in Wright (1995), Muto and Steel (1997), Soreghan (1997), De Wet (1998), Carter (1998), Geel (1999), and Spence and Tucker (1999).

2.3. NATIONAL STATUS

The classic outcrops of Jurassic sediments of Kachchh basin have attracted geologists since the pioneering work of Wynne and Fedden in 1868-72. The abundance of fossil faunas and the wide range of condensed sections exposing Bathonian to Pleistocene, have attracted both palaeontologists as well as stratigraphers. Latter studies brought out that it is a discrete basin formed during Gondwanaland rifting in Late Triassic. The Tertiary and Mesozoic successions which filled the basin were studied by the geologists of GSI and ONGC.

The Mesozoic successions of Kachchh Basin attain enormous thickness of about 2400 m., the thickness of marine pile being incompatible with coastal deposits. Arkell (1956) quoted this classic area probably the most favoured locality in the world for Upper Jurassic Ammonites. He also pointed out that the lower part of Callovian is probably more fully developed in Kachchh than elsewhere in the world. There has been wide variety of work carried out on Jurassic of Kachchh on stratigraphical, palaeontological and sedimentological aspects.

2.3.1. Stratigraphic studies

The effects of devastating earthquake in 1819 in Kachchh had been discussed by earliest geological work. Sykes(1834) has prepared the first document of Kachchh geology in the field of stratigraphy of lithosomes. Attempt has also been made to write a comprehensive account of the geology of Kachchh accompanied by a map and plates, it does not add much to the knowledge of geology of that area. W.T.Blandford (1865) recorded the first satisfactory account of the geology of Kachchh after a cursory examination of a small portion of Kachchh.

Wynne and Fedden (1868-72) were the first to prepare a detailed account of the geology of Kachchh along with a map in 1 inch = 4 miles scale, which is quite accurate and has been the only published map providing the basis and reference for all subsequent work. They divided the Jurassic rocks (the Cretaceous rocks also included) in to lower marine and an upper non-marine units which he termed respectively as Lower and Upper Jurassic. Their pioneering work has published by A.B.Wynne, in the Memoir (vol. IX, 1872) of the Geological Survey of India. However, the use of the terms "Lower" and "Upper" had been erroneous in as much as they had not been used to denote the two sub-divisions of the Jurassic System. Wynne's memoir on Kachchh does not give an concise description of the structures and tectonics of the region. The two units of th earliest lithostratigraphic classification are useful in regional mapping on the basis Stoliczka's field notes. Based on "mineralogical and palaeontological" characters Waa((1875) introduced a four-fold division of Kachchh Jura into "Putchum", "Char

"Katrol", and "Umia" Groups in ascending order. Waagen's classification in which the Upper part of the succession was modified by Rajnath (1933, 1942). He utilized the aforesaid divisions but with chronostratigraphic terminology, that is, called them "Series" and introduced new unit Bhuj "Series"/ "Stage" for Upper Umia Group of Waagen introducing Zamia beds (Upper Series of Wynne).

A detailed account of the stratigraphy of the Kachchh is given in Rajnath (1934, 1942). Many researchers have been following Rajnath's classification for the Mainland. Though the map (1"= 16 miles) produced by him is not free from ambiguity it is the first and the only map which showed the stratigraphic subdivisions originally produced by Stoliczka. Among the earlier workers Cox (1940, 1952) was the first to doubt the validity of the stratigraphic names and remarked "there would appear to be little object in continuing to use such terms as "Pachham Group", "Chari Group", "Katrol Group", when the more familiar European Stage names are available.

Agarwal (1957) while mapping the Jhura Dome for biostratigraphic work renamed the terms such as "Chari Series" and its topmost constituent Dhosa Oolite used by earlier researchers as Habo Series and Mebha Oolite respectively(Table – 2.1). According to him neither Mebha Oolite nor the beds of Upper Habo series lying below it can be assigned a precise age and consequently the Upper Habo Series of Jhura dome, Mebha Oolite included there in, has been considered the Callovo-Oxfordian. Pascoe (1959) from all the available data compiled a classification in which he described each unit giving the lithological and palaeontological characteristics. The Golden Oolite Stage described by him at the base of the Chari Series is a local development in Keera dome an(in Jhura dome only. Poddar (1964) adopted Rajnath's classification, but considered that th two rank terms of "Series" and "Formation" are interchangeable. But this modification is not acceptable. Poddar's (1959) paper gives a summary of the geology of Kachchh in the context of the oil prospects of the region. His paper is not accompanied by any map.

The basement of Kachchh sediments according to Wynne (1872) is of metamorphic crystalline rocks. Wynne (1875) and Mathur and Evans (1964) also have referred it. Biswas and Deshpande (1968) reported the occurrence of similar (syenetic) rocks in Meruda Thakker Hill (24' 7' 30" N, 70' 18' 00" E) with in the limits of Kachchh Basin. Jaitly and Singh (1978) discovered another occurrence of igneous complex at Nir Wandh (23' 35' 20" N, 69' 56' 00" E) in the Eastern Kaladongar (Pachham Island) where a conglomerate bed has been found directly over it, and which in them, is overlain by sandstones and shales of Jurassic succession. This complex is described to consist of pyroxenite/hornblendite, gabbro, lamprophyres and basalts (Jaitly et al., 1980).

The exposures of Jurassic of Kachchh are excellent and tracing and mapping of beds can be done with ease. They occur in six highland areas, Kachchh Mainland, Wagad and Island belt comprising Pachham, Khadir, Bela and Chorad Islands. Biswas (1981) grouped these exposures into three lithostratigraphic provinces viz.. Kachchh Mainland, Pachham Island and Eastern Kachchh (Wagad, Khadir, Bela and Chorad). Biswas (1971; Biswas and Deashpande, 1968) rejects the old classification because of "..... lack of precise definition of units with respect to designated type sections, mappability and regional applicability ...... and improper use of stratigraphic terminology ....". He has proposed a scheme such with a different set of names such as Jhurio, Jumara, Jhuran and Bhuj Formations in ascending order with Dhosa Oolite Member between Jumara and Jhuran and Ukra Member as intertonguing in Bhuj Formation, for Kachchh Mainland. For

Pachham Island Biswas subdivided the Pachham Series into Lower Kaladongar and Upper Goradongar Formations, but the top of Goradongar and the base of Kaladongar is not exposed. In Eastern Kachchh three mappable rock units have been recognized which are formally named as the Khadir Formation, Washtawa Formation and Wagad Sandstone (Biswas, 1977).

Kanjilal (1978) described the detailed geology and stratigraphy of the Jurassic rocks of Habo dome and proposed the name "Habo Formation" for the rocks exposed there, but not as an alternate term for the Habo Series. These proposed five divisions are (i) Black limestone Member, (ii) Dhrang Member, (iii) Jhikadi Member, (iv) Rudra Mata Member and (v) Lodai Member in ascending order. The Dhosian Stage introduced recently by Pandey and Dave (1993) constitutes marine sediments of Dhosa Shale and Dhosa Oolite, in Kachchh, is homotaxial with Oxfordian Stage (Dave,1996). The Oxfordian in Kachchh is represented by a thick succession (48m) of Transgressive Dhosa Oolite included in Dhosian Stage of Pandey and Dave (1996) corresponding stage Malm Series concluded that the Dhosian stage representing the Oxfordian in Kachchh is more than 48m (and not 1-3m, Singh,1989) and top and bottom bounded by unconformity. Though Bhalla (1977), Bardan and Datta (1987) and Cariou and Jai Krishna (1988) stressed the retention of Stolicza's terminology with suffix formation as done first by Poddar (1964) become the focus of subsequent studies.

2.3.2. Palaeontological Studies

The palaeontologists all over the world were particularly attracted by the rich invertebrate fossil fauna and fossil flora, since the beginning of the nineteenth century.

Palaeontological work started since the time of Sykes (1834) as he prepared the first document of the taxonomy of fossil biota, with the fossils he collected from Captain W.Smeeth. On the study of cephalopods Grant (1837) published lists of fossils along with his paper. On the basis of the study of cephalopods from the Jurassic of Kachchh and on the basis of other palaeontological evidences Waagen (1875) introduced a four-fold division of Kachchh Jura in to "Putchum", "Charee", "Katrol" and "Umia" Groups in ascending order. Waagen adopted the classification and defined the units by "ammonite assemblage zones", which were correlated with European Zones to fix their ages. Subsequently Gregory (1893, 1900) studied the echinoids and corals of the lower part of the Upper Pachham Series, which are in corals (in Jumara Dome) and correlated the same with Bathonian and Callovian of Europe. Vredenberg (1910) evaluated the fossil record from the Jurassic of Kachchh and made some modifications in the age assignment to different groups of Waagen. A comprehensive account on the Middle to Upper Jurassic cephalopod megafossil fauna with description of nearly 600 species, belonging to 114 genera has been given in the form of massive monograph by Spath (1924, 1927-33). Spath (1933) revised the work of Waagen on ammonites and working on the collections of Smeeth, Blake and Wynne, Rajnath further subdivided the units by ammonitic zones which he referred as Macrocephalous "Beds", Rehmani "Beds", Anceps "Beds", etc. Waagen's classification in which the Upper part of the succession was modified by Rajnath (1933,1942). Spath (1933) has the earlier palaeontologic works and for the first time he has elaborated the tie-up of the stratigraphic units with the European ammonite zones and stages.

The correlation of Trigonia with those from Europe, Somalia and South Africa has an attempt of Cox (1952) to understand the palaeogeography of Kachchh megafauna. Shukla (1953) recorded rich molluscs, brachiopods, and echinoid assemblages from Kayia Hill, northwest of Bhuj and divided the sedimentary strata in to 20 beds. Agarwal (1957) studied Jhura dome for biostratigraphic work. He carried out the studies on ammonites, brachiopods, gastropods, echinoids, corals and plant fossils mainly from Jhura-Habo Dome area and recorded essentially Callovian mega-fauna. Pascoe (1959) described each unit giving the palaeontological characteristics. Mitra and Ghosh (1964) carried out purely biostratigraphic map. They were the first to realize the significance of environment and facies change in the shallow-marine shelf deposits of Kachchh.

Pratap Singh (1975) reported seven species of nannoplankton from the Jurassic succession in the subsurface of Banni. The subsurface rocks may be referred to Oxfordian based on the presence of nannoplankton and were deposited in inner neritic environment. The biostratigraphy of Bathonian-Callovian Beds of Mouwana dome, eastern Bela Island has described by Agarwal and Kacker (1978). They proposed 28 beds in to Mouwana Formation and correlation is done based on the available fauna. According to them the Mouwana Formation appears to have been laid down under shallow marine to brackish water conditions, the depth perhaps ranging from wave base to upper neritic.

Jaikrishna and Westermann (1987) have recorded faunal associations of Middle Jurassic ammonite genus Macrocephalites in Kachchh. They distinguished six successive new larger and stratigraphically controlled Macrocephalites, which are collected from Jumara. The macrocephalid succession probably starts in the uppermost Bathonian, certainly the basal Callovian and terminates below the top of Lower Callovian. Pandey and

Dave (1990) based on the changes in the foaminiferal assemblage, defined the Jurassic/Cretaceous (J/K) boundary at the top of the green oolite bed in Mundhan Anticline. In this paper the authors described the important benthic foraminifera of Tithonian and Neocomian. The major changes at this (J/K) boundary include (a) regression and elimination of calcareous benthic foramnifera followed by an arenaceous foraminifera in a new termination, (b) evolutionary development in some arenaceous foraminifera, (c) termination of older ammonites in the upper Trigonia bed of Umia, and (d) less significant change in the spore pollen assemblage.

Fursich and Oschman (1991) revealed the faunal response to transgressive-regressive cycles in Jurassic of Kachchh. The transgressive phases are represented by thin layers of reworked and bored concretions, sometimes in association with skeletal concretions, the regressive phases are documented by much thicker units of largely fine-grained sediments. The authors also found that the benthic fauna of transgressive and regressive phases differs markedly and thus mirrors the sedimentary cycles.

The microfossils of Kachchh Mesozoic were studied very little. Subbotina et al., (1960) described a rich assemblage of Jurassic foraminifera referable to the Chari Series from southeast of village of Lodai, on the eastern flank of Habo dome and form shales of Khavda. The faunal assemblage was assigned a Callovian to Oxfordian Age following the views of Poddar (1959). Smaller benthic foraminiferal fauna from the Habo dome was reported by Agarwal and Singh(1961). Rao (1964) on the evolution of faunal evidences suggested a Callovian age for Pachham Series, Callovian to Early Oxfordian for the overlying Chari Series, Upper Argovian (Oxfordian) for Katrol Series and Late Tithonian to Post-Aptian for the top most Umia Series. Tewari (1957) reported the occurrence of Autotortus and few other foraminiferal genera from the Habo dome. Bhalla and Abbas (1978) and Shringarpore (1975) studied on foraminifers.

Pandey and Wurzburg (1994) described the ammonite *Parapatoceras tuberculatum* (Baugier and Sauze, 1843) from the Early Callovian "Macrocephalus Beds" of Pachham Island of Kachchh also. Shukla and Singh(1993) recorded marine macroinvertebrate from Bhuj sandstone for the first time. These are shell impressions (external moulds) of Indotrigonia and a marine bivalve. Highly porous nature of Bhuj sandstones caused dissolution of shells during diagenesis, destroying the body fossils but preserving the fossils.

The Jurassic foramninifera from the Pachham-Chari Formations of Jhurio Hill were described by Niti Mandal and Singh (1996). The description of Middle Jurassic ammonites from Jumara Dome is given in Sreepat Jain (1997). Recent finding of fossil remains of dinosaurs from the Middle Jurassic sediments of Kachchh (Sathyanarayana et al., 1999) is also an important milestone in the palaeontological studies. The biostratigraphic classification of Middle Jurassic to late Jurassic succession of Kachchh is given in the Table 2.1.

2.3.3. Sedimentological and Other Investigations

Though detailed stratigraphy and palaeontology of Mesozoic succession has been worked out, little information is available on the detailed sedimentoloy of the Jurassic rocks of Kachchh. Important contributions on the sedimentology of the Jurassic rocks of Kachchh include those of Balagopal and Srivastava (1973), Balagopal (1977), Biswas (1977, 1981,1982, 1987), Singh (1989), Fursich et al (1992), Bhalla (1996) and Nandi and Dessai (1997), Dubey and Chatterjee(1997) and Osman and Mahender(1997).

Table-2.1 Biostratigraphic Classification of Middel to Late Jurassic Sediments of Kachchh, Gujarat

Stages	Waagen 1933	Spath 1937	Agarwal 1957	Kanjilal 1974	Mitra et.al 1979	Bardhan 1987	Krishna 1987	Prasad 1988	S.Prasad 1998
Oxfordian	Dhosa Oolite	Upper Dhosa Oolite Lower Dhosa Oolite			Peltoceras	Biozone 6	Discontinuity unnamed Semirugose	Perisphintes Maya Semirugose	Helenae Maya
Callovian	Athleta Beds	Upper Athleta Beds Lower Athleta Beds	Reinekeia	Hect.Lirens-Hubert Omphales-Orionoides		Biozone 5	Unnamed Athleta	Laladeanum Athleta	Atleta
	Anceps Beds	Upper Anceps Beds Lower Anceps Beds		Sub-kossmatia Indiocyclo-ceras	Obtusicosites	Biozone 4 Biozone 3	Coronatum Ancephs Opis	Ancephs Opis	Ancephs
	Macrocephalum Beds	Upper Macrocephalus Beds Middle Macrocephulas Beds Lower Macrocephulas Beds	Macrocephalite	Macro-cephalites	Macrocephalite	Biozone 2 Biozone 1	M.semiloevis M.formosus M.chrysolithicus M.medagaskerenis M.triangularis	Formosus	Formosus
Bathonian									Triangularis

Balagopal (1972) has classified the Pachham and Chari limestones of Jhura and Habo domes, on the basis of their modal classification following Folk's classification of carbonate rocks. He divided the Chari Series in to four subdivisions (Ci to Civ). Of which, Ci and Civ are predominantly calcareous, while Cii and Ciii are overwhelmingly arenaceous and include several bands of conglomerates. Also the petrography of Chari arenites were studied by Balagopal and Srivastava (1973) and they proposed a classification to these arenites and included it as a part of the orthoquartzite-carbonate facies. Desai et al., (1975) discussed the depositional environment of Western Wagad Mesozoic sediments and suggested a warm and moderate environment of deposition. Deshpande (1978) has stratigraphically divided the Wagad rocks in to three formations, namely Washtawa Formation, Kantkote Formation and Wagad Sandstone in ascending order. The Mesozoic sediments of western Wagad and their depositional environments has been described by Desai and Shringarpore (1975). They proposed a sedimentation model of the western Wagad depositional cycle. Deshpande and Merh (1980) proposed a sedimentary model of Wagad Hills, which is comprising environments of deposition, basin geometry, lithic fill, lithic arrangement, directional structures and tectonic setting. According to Biswas (1977) the environment of deposition of the units indicates that Bathonian to Oxfordian (represented by the Kaladongar, Goradongar, Khadir, Washtawa, Jhurio and Jumara Formations) was a period of transgression when the environment changed from littoral to neritic and post Oxfordian to Lower Cretaceous (represented by the Wagad Sandstone, Jhuran and Bhuj Formations) was the period shifting the environment from neritic to fluvio-deltaic as the depocentre moved westward. It is clear from the stratigraphic description and the trend of facies variation that the sea transgressed from west to east and receded westward after attaining the peak of transgression framework is also indicated by the facies pattern.

The basin framework, palaeoenvironment and depositional history of Mesozoic sediments of Kachchh basin have been described by Biswas (1981) in detail. The lithostratigraphy of Mesozoic Kachchh Mainland proposed by Biswas (1981) is given in the Table-2.2. According to him the two distinct sedimentary parts with in the basin are a lower marine carbonate-shale section and an upper clastic section, which represents a major transgressive- regressive cycle. Biswas (1981) proposed the environment of deposition as sub-littoral. He also recorded intertonguing facies tracts and their distribution shows spatial arrangement of environment during a time period. According to Biswas (1981) the upper clastic section represented by the deltaic Jhuran and Bhuj Formations and Wagad Sandstone is diachronous. The delta build up took place in a time span from Oxfordian to Kimmeridgian (when it started to prograde from the eastern margin of the basin) to Lower Cretaceous (when reached the depocentre).

Jaikrishna et al., (1983) found numerous wave-built sedimentary structures, abundant marine fossils and highly bioturbated and glauconite-rich beds. Based on this, authors proposes a marine origin for the entire Kachchh succession. Singh (1989) described the genesis, fossil content, sedimentological characteristics and stratigraphic significance of Dhosa Oolite. He suggested that the Dhosa oolite is a transgressive condensation horizon representing the time-span, related to the worldwide sea-level rise. According to him the mixing of ammonite fauna of various ammonite zones is probably a result of the combination of processes, slow rate of sedimentation, burrowing activity of organisms and storm events causing sediment reworking. Biswas (1981) considers Dhosa

Table : 2.2 MESOZOIC LITHOSTRTATIGRAPHY OF KUTCH MAINLAND (After Biswas, 1981)

AGE	Formation	Member	Lithological charactersitics	Depositional environment
Neocomian to Albian (Lower Cretaceous)	BHUJ FORMATION (350-900mt +) (Thickening Westwards)	Upper	Light coloured sandstone, kaolinitic claystone and sandy iron-stone bands. Sandstones, medium to fine grained feldspathic wackes, coarse arenites in channel fills; Crossbedded-planar & tabular, cut and fill. Occasional plant fossils, fossil wood common.	Upper deltaic plain to fluvial
		Middle	Green glauconitic sandstones and shales, thin fossiliferous limestones and red ironstone bands containing pelecypods, gastropods and ammonites. Large chunks of fossil wood in random orientation. Interfingers with Upper and Lower members towards the east.	Restricted Bay or lagoon
		Lower	Deeply coloured, red and yellows andstones: ferruginous, feldspathic wacke, fine grained. moderately sorted; coarse to fine grained arenites in channel fills showing fining up. Rhythmites of sandstones shales ironstone bands; Cross-bedded (planar) ripple marked; abundant leaf impressions. Occasional coal beds.	Lower deltaic plain
Kimmerdgian to Neocomian	JHURAN (420 – 850 M+) (Thickening westwards)	Katesar	Greenish yellow sandstone: calcareous and ferruginous feldspathic wacke, very fine to medium grained; moderately to well sorted; Cross-bedded (planar, trough & festoon); (contain Trigonia sp. & Astarte sp.)	Delta front (distributory complex)
		Upper	Mainly sandstones with subordinate shale. Sandstones: fine to medium grained, moderately well sorted feldspathic wacke; Current bedded (tabular, festoons, & herring-bones), ripple marked; convolute bedding, load casts, cut & fills common. Local bandsofpelecypods and also plant beds.	Delta fringe
		Middle	Mainly grey shales with fine grained, fissilesandstone bands. Highly fossiliferous in the west but sparsely so in the east, mainly ammonites, pelecypods, belemnites, gastropods, cut& fill structure common.	Prodelta
		Lower	Shale/sandstone alternation. Sandstones: fine grained, moderately sorted feld-spathic wacke; Cross-bedded, ripple marked; fossiliferous in the west, less so in the east.	Sub-littoral
Callovian to Oxfordian	JUMARA (280 m)	Upper	Greenish grey, gypseous glauconitic shales well laminated with thin limestone alternations. Characteristic oolitic bands near the top. Highly fossiliferous. diverse (mainly cephalopods, brachiopods, pelecypods and corals).	Upper Infra-littoral Lower shales Circa-littoral
		Middle	Base biomicrite, middle yellow calcareous sandstone, top conglomerate. Fossiliferous with pelecypods. Represented in the west by fossiliferous limestones with golden oolites (oolitic intrasparrudite).	Littoral
		Lower	Olive and grey shales with thin limestone bands, containing rich crop of fossils: ammonites, corals, brachiopods, pelecypods, belemnites etc.	Circa-littoral
Bathonian to Callovian	JHURIO (300 m)	Upper	Interbedded micritic (biopelmicrite) and sparitic (biopelsparite, oosparite) limestones with "golden oolite" (oolitic intasparite and intrasparrudite), with iron-oxide coated pseudo-oolitic bands in the lower part. Fossiliferous: cephalopods, brachiopods, pelecypods etc.	Littoral Wave zone-Intertidal
		Middle	Thickly interbedded shales and limestones (mainly "golden oolites"- Oolitic intrasparrudite). Fossiliferous: brachiopods, pelecypods, cephalopods etc.	Littoral (Peritidal) to Sub-littoral
		Lower	Interbedded shales and limestones, with lenticular "golden oolites". Fossiliferous as above.	Littoral to Sub-littoral

Oolite to mark the maximum transgression related to the deposition of regressive coastal deposits of Katrol and Umia Formations.

The depositional environment of Bhuj sandstone was traditionally considered fluvial or deltaic though recently it has been argued that the Bhuj sandstone represents Coastal marine sand (Jaikrishna et al.,1983; Howard and Singh, 1985). Shukla and Singh (1990) distinguished five distinct lithofacies in Bhuj sandstone. Lithofacies 1 to 4 represent deposition in a prograding estuarine, tide-dominated coastline, while lithofacies 5 represents deposition on shallow shelf below wave base during the events of sea-level rise (transgression). The authors suggested that the Bhuj sandstone is made up of repeated complete or incomplete facies cycles punctuated by short lived transgressive events in dominated estuarine coastal line. Fursich and Oschmann (1992) made an attempt to document the features such as hardgrounds, reworked concretion levels and condensed horizons in the Jurassic rocks, to unravel the sequence of events that led to their formation and discussed their significance for the depositional history of Kachchh basin.

Phansalkar and Kadkikar (1992) revealed the sedimentary characters of the Jhuran Formation (Late Jurassic) – Bhuj Formation (Early Cretaceous) clastics exposed near Bhuj and have thrown light on their depositional environment. The interlayered sandstone-shale succession of Jhuran Formation shows shallow marine environment of deposition, and the essentially sandstone of Bhuj Formation with a polymict conglomerate at its base, shows a change from a shelf to an estuarine environment. Shukla and Singh (1991) described the significance of Bhuj sandstone. According to the authors, these bioturbated sandstone horizons show complex superimposition of dense networks of various burrow systems, and thus represent submarine non-depositional events related to sea-level rise or short-term transgressions.

Khadkikar (1996) suggested that the beginning of break-up of Gondwanaland recorded in the ironstones of Jurassic rocks of Kachchh basin system. According to him the older ironstone known as Golden Oolite documents the formation of a mid-oceanic ridge after a period of rifting the Greater India as a discrete continental land mass, from the Gondwanaland. He suggested that the iron content in the ironstones is on account of hydrothermal plumes.

The stratigraphic and sedimentologic account of the Middle Jurassic (Callovian) succession of Habo dome is given in Osman and Mahender (1997). The stratigraphic variation of field observations made by them and also the texture and mineralogical characters suggest an early regressive latter transgressive phase of depositional environment. On the basis of lithologic characters and depositional textures and their inferred relationships, five lithofacies associations have been identified. Dubey and Chatterjee (1997) has given a detailed study on the provenance and basin evolution of Kachchh basin during Mesozoic based on the quantitative and qualitative analyses of mineralogical composition of sandstone. According to them the Mesozoic sedimentation in Kachchh basin commenced with the deposition of retrogradational and aggradational successions (RS & PS) in the lower part followed by the progradational succession (PS) in the upper part. The petrographic and geochemical characters and comparative account of diagenesis and stable isotope geochemistry of the Middle Jurassic carbonates is given in Nandi and Dessai (1997). The importance of Kachchh basin as regards to the geology, stratigraphy, tectonics and mineral resources has been discussed at the recently held

National Seminar on Kachchh Basin at the Department of Geology, Banaras Hindu University, Varanasi from 21-23rd Dec 2000. Recently, due to the devastating earthquake on January 26, 2001, the Kachchh area has once again attracted the attention of scientists world over.

From the review of literature it is very clear that there has been a very little emphasis made in the past to understand the lithofacies distribution, microfacies variation, depositional and diagenetic history of the basin during the initial sedimentation in Jurassic Period resulting in the deposition of Middle Jurassic sediments in a transgressive Tethys Sea over the Kachchh basin. Therefore, the present work is an attempt to study the above parameters.