# *Chapter - 3*

# CHAPTER - III

# LITERATURE CITED

## III.1. THE EARLY HISTORY OF GEOLOGICAL EXPLORATION IN KUTCH:

The region of Kutch is very widely explored from geological point of view since the princely time, when Fox (1828) and Grant (1848) carried out some work on geology of Kutch. After the formation of the Geological Survey of India in 1851, good number of old stalwarts and researchers like Blanford (1868), Wynne (1869, 1872), Oldham (1872), Waagan (after Stoliczka 1875), Blanford and Meddlicott (1879), Gregory (1893 & 1900), Kitchin (1900), Vredunburg (1910), Spath (1924-1933), Rajnath (1932, 1933, 1942), carried out work on various aspects of geology, palaeontology, stratigraphy etc. Subsequent to this, various officers of Geological Survey of India including Poddar (1950, 1954), Sahastrabudhe (1960), Vyas (1968-69), Mehra, Verma and Srivastava (1978), Ghevariya (1978, 1983, 1985, 1986, 1988, 1990, 1991, 1993, 1995, 1996, 1997, 1998), Rakshit and Bandhyopadyay (1986 etc.), Sarathi (1980-84), Mohabey and Jain (1985, 1986) worked on specific problems and on systematic geological mapping in different parts of Kutch.

In addition to these, Rao (1957), Sahni and Prasad (1957), Agrawal (1956, 1957), Poddar (1959-1964), Singh et al (1963), Richter Bernberg and Schott (1963), Mitra and Ghose (1964), Gosh (1965, 1969), Roy (1967), Mathur et al (1970), Biswas and Deshpande (1968, 1970b), Patil (1971, 1974, 1975), Balagopal (1975), Venkat Raman and Patil (1975), Badye and Ghare (1978), Biswas (1971, 1974, 1978, 1980, 1981, 1982, 1987, 1991), Kanjilal (1978), Agrawal and Kachhara (1979), Mitra et al (1979), Kumar et al (1982), Singh et al (1982), Cashyap et al (1983), Jaitley and Singh (1983), Jaikrishna (1983), Jaikrishna et al (1983), Shringarpure (1976 onwards, 1984, 1986), Koshal (1984), Howard and Singh (1985), Bose (1986), Ghare and Kulkarni (1986), Krishna (1987), Krishna and Pathak (1989), Singh (1989), Kulkarni and Ghare (1989, 1991), Singh and Singh (1992), Fursich et al (1991, 1992), Bhatt (1996), Sahni and Bajpai (1990), Bajpai (1990, 1993), Bhandari et al (1995, 1996), Hoffman et al (1997), Venkateshan et al (1993, 1995), Panda et al (1988) have carried out significant work on various aspects. The above referred works are related to various aspects of geology, stratigraphy, fossils, geo-chronological dating, palaeontological, geo-chemical, palaeomagnetic, trace fossils, sedimentological aspects, etc.

The Mesozoic sedimentary succession of Kutch is well known in the Indian geological literature for its exciting faunal and floral records. These sediment are extensively explored by various workers in different sections for their palaeontological interest (for mega- as well as micro- fossils). The stratigraphic classification of the Mesozoic rocks is under constant revision and refinement in accordance to the code of stratigraphic nomenclature.

Blanford (1968) published a structural account of Kutch and recognised for the first time the east-west trending master faults.

Wynne (1872) published for the first time a detailed account of geology of Kutch with a classification of Mesozoic and Tertiary rocks, along with a geological map on quarter inch scale. The classification proposed by Wynne is the first one of the lithostratigraphy. He subdivided the Mesozoic rock sequence in to Lower Jurassic and Upper Jurassic and correlated it to the Oolites of England. His geological map has provided important guide for all the subsequent works on geology in Kutch. The lithostratigraphic classification, as suggested by Wynne is as follows:

**Table-II.** LITHOSTRATIGRAPHIC CLASSIFICATION OF WYNNE, 1872

| | | |
|---|---|---|
| Recent | Alluvial, blown sand and sub-recent deposits | Pleistocene |
| | Upper Tertiary unconformity | |
| Tertiary | Argillaceous group (fossiliferous) | Miocene to Upper Eocene |
| | Nummulitic group | |
| | Gypseous shale | |
| | Arenaceous group | |
| | Nummulitic group | |
| | Gypseous group | |
| | Sub-Nummulite | Eocene |
| Volcanic | Stratified Traps and Intertrappean beds | |
| | Infratrappean beds | |
| | Unconformity | |
| Jurassic | Upper Jurassic group | Oolitic |
| | Lower Jurassic group | |
| | Unconformity | |
| Metamorphic Crystalline | Syenite | |

Subsequent to Wynne, Stoliczka proposed a four fold stratigraphic classification of the Mesozoic rocks. He subdivided the stratigraphic succession on the basis of mineralogical and palaeontological characters in to Patcham, Chari, Katrol and Umia 'Groups' in ascending order. Waagen (1871, 1873-1876) studied the *ammonite* fauna in great details and correlated four fold stratigraphic classification of Stoliczka with European zones on the basis of *ammonite* assemblage zones'. Thus Waagen for the first time proposed a chronostratigraphic classification based on his work on *ammonite* fauna. This classification is in current usage by various workers with some modifications for invertebrate palaeontological observation. Waagen's (1875) classification is given below:

**Table-III.** Waagen classification (1875, after Stoliczka):

| Series | Age |
|---|---|
| Umia | Portlandian to Neocomian |
| Katrol | Portlandian |
| Chari | Oxfordian |
| Patcham | Bathonian |

Kitchin (1900, 1903) assigned Patcham series to the European Bathonian and Chari to Lower Callovian. Spath (1924, 1927, 1933) subdivided the Mesozoic rock sequence of Kutch into Bathonian, Callovian, Oxfordian, Kimmeridgian, Tithonian and Neocomian stages in ascending order. He established detailed biozonations of stratigraphic units on the basis of detailed studies on *cephalopod* fauna.

Rajnath (1932, 1933, 1942) carried out detailed work on the stratigraphic boundaries of various earlier proposed classification. He defined the stratigraphic boundaries on the basis of mega-fossils except the Patcham-Chari boundary. He recognised the Patcham-Chari boundary on the lithological characters. He suggested the extension of upper age limit of the Mesozoic rocks in Kutch. He carried out detailed biostratigraphic work of some of the best exposed section of Mesozoic rocks from western Kutch mainland and proposed several fossil assemblage zones, mentioning 26 lithological units of Patcham and Chari sequences of Jumara dome section. He also subdivided Katrol into four parts - Lower Katrol (comprising mainly shales), Middle Katrol (sandstones with minor shales), Upper Katrol (mainly shales), Uppermost Katrol (mainly hard compact calcareous sandstones). He also subdivided the Umia series (of Waagen) in to three units (stages) as - lower green oolitic rock containing fauna of Tithonian age, as Umia stage; middle calcareous fossiliferous beds as Ukra stage - containing Albian and Aptian fauna, and upper plant bearing beds as Bhuj stage assigning a middle Cretaceous age to the uppermost succession. The Umia stage (basal unit of 'Umia' was further subdivided into five beds by Rajnath. Several unconformities were recognised by him, which he correlated to and suggested fluctuations in sea level during deposition.

Cox (1940, 1952) recognised species of *Trigonia* and claimed them to be similar to those found in Europe, Somalia, South Africa and Tanganyika.

Arkell (1956) published a brief summary of the Geology of Kutch in his work on "Jurassic Geology of the World", and revised the ages of Patcham, Chari, Katrol and Umia series.

Agrawal (1957), doubted the validity of the existing stratigraphic nomenclature proposed earlier, and based on his work in Habae dome, proposed the name 'Habo Series' after Habo hills to replace the name 'Chari Series'. From his palaeontological work in Jura hills, he assigned Callovian to Oxfordian age to the three *Macrocephalus* beds and subdivided them in to lower, middle and upper parts. On the basis of faunal assemblages in Jura dome, he differentiated 18 beds in the Chari series.

Pascoe (1959) compiled a detailed classification of Mesozoic rocks with proper usage of stratigraphic terms in to series, stages, sub-stages and zones along with detailed lists of characteristic fossil assemblages occurring in different horizons. Subsequent additions/ alterations to these terms and fossil assemblages and up dating of these has been done from time to time by Geological Survey of India (Table-IV).

Poddar (1959, 1963), proposed a short and regional account of Geology of Kutch, synthesizing the salient stratigraphic and structural aspects. He considered Patcham series to be of Bathonian or slightly older, Chari series as Callovian-Oxfordian, Katrol series to be Kimmeridgian-Tithonian and Umia series to be Neocomian-Aptian in age.

Bernberg and Schott (1963) studied a few sections in the Islands and in the Katrol hill section in mainland; and assigned Bathonian age to Kuar bet beds, Callovian age to Khavda nallah section of Patcham Island and Upper Oxfordian age to Dhosa Oolite band of the mainland. According to them the Trigonia beds of Lower Umia belong to Lower Cretaceous age.

Mitra and Ghosh (1964) were first to recognise importance of the environment and facies changes in the shallow marine shelf deposits of Kutch. They also pointed that the correlation should be based on the basis of the assemblage zones instead of *ammonite* index fossils.

Rao (1964) on the basis of faunal evidences concluded a Bathonian or Lowest Callovian to post-Aptian age of deposition.

Krishnan (1968) in his text book on Geology of India and Burma, adopted a classification given by Rajnath (1932, 1942) with modifications of ages according to Arkell (1956). He followed the earlier four fold classification with little modification of Bhuj series as 'Bhuj stage' within his 'Umia series'.

Hardas (1968) studied the complete sequence of depositional environments and suggested a sequence of depositional environments varying from infra-littoral to fluvial.

Gosh (1969a) suggested that the mega fossil assemblages of Kutch shows more affinity to east and south Africa assemblage than that of Himalayan or European Jurassic and ranges in age from Bathonian to Argovian (Gosh, 1969b).

A concise version of all the above work and their European equivalents are summerised in following table following Bhalla and Abbas (1980).

Table 3: CLASSIFICATION OF MESOZOIC SUCCESSION OF KUTCH AS COMPILED BY PASCOE (1959).

| SERIES | STAGE | AGE |
|---|---|---|
| Ukra beds | | Aptian |
| | Sandstones and shales with plant remains and a few marine fossils | ?Purbeckian to Neocomian. |
| Umia series | Unfossiliferous shales | Portlandian |
| | Trigonia sandstones | |
| | Oolitic sandstones, shales and conglomerates, with marine fossils | |
| Katrol series | 5. Katrol sandstone (unfossiliferous), Gudjinsir bed (marine fossils), Zamia shales. | |
| | 4. Brown and red ironstones (Upper) | Kimmeridgian. |
| | 3. Basal Ammonite bed (Middle) | |
| | 2. Jurun Belemnite marls (Lower) | |
| | 1. Kantkot sandstone | Argovian |
| Chari series | 5. Dhosa Oolite (Upper) | Divesian |
| | 5. Dhosa Oolite (Lower) | |
| | 4. Athleta stage (Upper) | |
| | 4. Athleta stage (Lower) | |
| | 3. Anceps stage (Upper) | Callovian |
| | 3. Anceps stage (Lower) | |
| | 2. Rehmanni stage | |
| | 1. Golden Oolite (Upper Macrocephalus beds) | |
| | 1. Golden Oolite (Middle Macrocephalus beds) | |
| Pachhim series | 2. Upper stage, or Lower Macrocephalus beds | Bathonian |
| | 1. Lower stage. | |

**Table-V:** After Bhalla and Abbas (1980):

| Series | Thickness | European stratigraphic equivalent |
|---|---|---|
| Bhuj | 450 m | Post-Aptian |
| Umia | 900 m | Upper Tithonian to Aptian |
| Katrol | 300 m | Upper Oxfordian to Middle Tithonian |
| Chari | 366 m | Lower Callovian to Lower-Upper Oxfordian (part) |
| Patcham | 300 m | Upper Bathonian to Lower Callovian (part) |
| | | Archaean granites and gneisses |

Guha and Pandey (1973) carried out microbiozonation and lithostratigraphy of well section for oil exploration and divided the sequence into eight biozones on the basis of *foraminifers* and *ostracodes* and range in age from Bathonian to Albian (?). They also classified the Mesozoic sequence in to Kaladungar, Patcham, Chari, Katrol, Umia and Bhuj Formations. Pratap Singh (1972a, b) suggested that the basal part of the sequences were deposited in brackish to marine conditions, whereas the rest of the sequence was deposited in the inner neritic environments.

Koshal (1973) for the first time on the basis of microspore analysis of the subcrop samples from Banni wells in Kutch established four assemblages ranging in age from Rhaetic to Lower Cretaceous.

Biswas (1971, 1977) proposed a rock stratigraphic classification defining each unit, boundary, stratotypes, type sections and important biota in accordance to the International Code of Stratigraphic Nomenclature (Hedburg, 1972).

He also published a geological map of Kutch showing the distribution of each formational Unit. He proposed separate stratigraphic classification for the Islands, mainland and Eastern Kutch - Wagad Island.

Biswas and Deshpande (1970, 1988) published a detailed and comprehensive geological and tectonic map of Kutch.

Ghevariya and Rakshit (1983), while working in western Kutch suggested a slight modification in the boundary criteria of Katrol and Bhuj Formation based on their studies in Amiya, Mundhan, Kateshar and Ghuneri areas. They proposed inclusion of section of Biswas's "Kateshar Member" of Jhuran, a part of Bhuj Formation on the basis of similarity of the lithological and sedimentological and trace fossils.

Some other workers like Howard and Singh (1985), Jaikrishna (1983), Jaikrishna et al (1983), Mitra et al (1979), opposed Biswas' classification considering the units of the old classification of Waagen and Rajnath and those of lithostratigraphic classification of Biswas as identical. They on the basis of priority of usage, suggested the retention of old nomenclature.

Biswas (1991) again argued that nomenclature of one category of stratigraphic classification can not be changed or used into another by changing the rank terms without proper justification. According to him, the categories of the two classifications are different, and therefore there was no question of priority of usage. He also argued that the boundaries of lithounits of two classifications do not correspond exactly to each other. The boundaries of the older classification are defined by time planes indicated by ammonite index assemblage zones, while lithostratigraphic boundaries are strictly defined on the basis of major lithological breaks, unconformities, change over from one environment to another. More over, Biswas (1991) has put forward revised and refined chronostratigraphic classification on the basis of original work of Waagen (1875) and Rajnath (1932), with reference to stratotype identified.

Biswas (1978, 1980, 1981, 1982, 1983, 1987, 1991) in a series of papers has discussed stratigraphy, structure, basin framework, tectonic framework and its evolution and sedimentary evolution of Mesozoic rock sequences of Kutch on a regional scale.

Kanjilal (1978) carried out geological and stratigraphical work on Jurassic rocks of Habo hills.

Agrawal and Kachhara (1979) worked on detail biostratigraphy of Habo (Chari) beds exposed in the eastern part of Ler.

Shringarpure (1984, 1986) investigated the rocks of Wagad region, eastern Kutch, from ichnological point of view and for the first time interpreted these structures in terms of their ethology, palaeoecology, animal sediment relationship, event stratigraphy and depositional environments. For the first time, more than 45 ichnogenera and 75 ichnospecies were recorded by him. Shringarpure and his students also carried out important ichnological studies in the Tertiary carbonate sequence in the NW parts of Kutch, and the Mesozoic sequences in the island region of Khadir and mainland areas of Kutch.

Singh (1989) discussed the Dhosa Oolite Member of Chari series in relation to sedimentological, ichnological and palaeontological aspects and proposed it to be a transgressive condensation horizon of Oxfordian age.

Fursich et al (1991, 1992) discussed palaeontological and palaeoenvironmental conditions of Chari rocks covering various escape structures in the mainland Kutch.

Ghevariya et al (1993a) described the Mesozoic rock record of Kutch and its implications on the palaeoclimatic cycles during the Mesozoic and Upper Gondwana sedimentation. Ghevariya et al (1993b) described in detail the *Dinosaurian* fauna from the Mesozoic rocks of Gujarat and also discussed about the various factors that affected their distribution and continuance. Ghevariya and Shringarpure (1998) for the first time described records *dinosaurian* fauna and dinosaurian history from the Mesozoic rocks since its beginning from Bathonian to its lasts of Cretaceous-Tertiary transition. They also briefly discussed their ecology and various factors that affected their population. They, for the first time discussed the various physical evidences on a multi-disciplinary approach to the problem of *dinosaurian* extinction.

---