CHAPTER - 1

INTRODUCTION

In Indian subcontinent, the Mesozoic rocks are well developed in both the Peninsular as well as in the Himalayan region and also in the Andaman and Nicobar Islands of the Bay of Bengal. About 200 million years ago, during Upper Cretaceous time (Mesozoic era), an eastwardly transgressing arm of Tethys, now called Arabian sea, assaulted from Kutch of Gujarat to Dhar and Jhabua district of Madhya Pradesh (the area under investigation). Wide variations in the nature of these rocks are observed due to marine and non marine facies as well as volcanic and intrusive aspects. The non marine Mesozoic rocks are developed in the Peninsular region while the marine Mesozoic formations are well developed in extra Peninsular India. The stratigraphy of marine Mesozoic rocks of extra Peninsular had been studied in detail in the Kashmir, Spiti, and Kumaon regions. In Peninsular India, the marine Mesozoic rocks are less developed as compared to extra Peninsular and mostly occur along the coastal regions.

The present area under investigation belongs to Cretaceous period. Cretaceous period is exemplified by varied groups of micro and macro invertebrates of both fresh water and marine horizons. In upper Cretaceous time, a marine rock sequence with fluviatile characters was deposited along the northern bank of lower portion of Narmada valley which is known as Bagh Beds in Indian stratigraphy. These Beds were formed by invading water of transgressing arm of Tethys Ocean. The name, Bagh Beds was derived from the type locality Bagh, which are situated in the western part of Narmada valley in Madhya Pradesh (Fig.1.1). The Bagh town is famous for its archeological marvel while the Bagh caves are situated on the left bank of Waghni river.

These Beds occur as detached inlier in the trappean country, mostly along the right bank of the river Narmada. Presently the sediment from Bagh Beds is distributed intermittently over a distance of about 345 km from Barwah (M.P.) in east to Rajpipla (Gujarat) in the west. At many places, continental biota is also present as fossils especially the dinosaur remains. The western part of the river valley is different lithologically from its eastern part on the basis of the detached members of marine formation or contained fauna. On the southern bank of Narmada, these Beds occur in
Dhulia district of Maharashtra and Baruch district of Gujarat and in north they extend up to Anas river near Rambhapur in Jhabua district of Madhya Pradesh. The Bagh Beds can be differentiated in two regions.

1. **Eastern region**: It includes the area from Barwah (Man valley), Bagh in the Dhar district and extends up to Jobat in the Alirajpur - Jhabua district of M.P.

2. **Western region**: It extends from west of Alirajpur (M.P.) through Kawant up to Rajpipla in Baruch district, Gujarat.

The first reference of existence of fossils in Bagh Beds was noticed by Keatinge in 1857 while the detailed study of the fossils was made by Duncan in 1865. He correlated the fauna of Bagh Beds with the European upper Greensand and lower Chalk fauna. Blandford (1869) was first to publish the systematic geological account of the Bagh Beds of Narmada and Tapti valley. Bose (1884) classified the marine Cretaceous rocks into three divisions which roughly correlated to the different stages of South Indian Cretaceous deposits. In Jhabua district, the marine fossils were noticed by Heron (1910) and Mukerjee (1935). Major contribution on invertebrate fossils of Bagh were made by Vredenburg (1907, 1908), Fourtau (1918), Chiplonkar (1937-1942), Badve (1972), Ghare (1974), Dassarma and Sinha (1975), Nayak, (1983), Parwar (2006), Gangopadhyay & Bardhan (2007), Smith (2010), Gangopadhyay & Maiti (2012) and recently Jaitly & Ajane (2013) published a paper on Bagh ammonoids while the dinosaur nesting sites and egg shell fossil of Bagh Beds were made by Sahni et al. (1994), Joshi (1995), Khosla (1996), Sahni (2001), Khosla & Sahni (2003), Verma et al. (2006), Mohabey (2011) and Shrivastava & Verma (2011).

**Objectives:**

The study is very significant and relevant because many ecological changes have taken place due to construction of Sardar Sarovar dam in Gujarat, Indira Sagar dam and many other small dams and canals in Madhya Pradesh. Submerging of the surrounding areas, construction of big cement factories, quarries, digging of many irrigation canals, and the construction of new roads have changed the whole scenario of the area. The availability of fossils is gradually becoming poor with blasting of
rocks for getting raw material useful in the formation of cement. This work is immensely important with respect to the vast collection of fossils which may not be possible in future due to civilization and construction of more cement factories. The study of these fossils could lead to greater understanding of the “global history.”

The present investigation is an approach to solve the existing controversies of the life that had lived previously and today. The findings of paleontologists play an important role in Zoological and Botanical periodical studies and aid in mapping of “hierarchy of living beings”. The detailed investigation of macro fossil fauna helps present day biologists in the formation of a framework, on which its accurate study can be extended further. Fossils provide the only direct evidence of life in the past. These evidences can be used in the interpretation of anatomical features and for studies of comparative relationships of living organisms with the past life.

The pattern of evolution with changing environmental conditions aids in assuming the possible future environment and the future life. Fossils are also used as an indicator for determining the age of rocks in which they occur. They provide correlations between rocks of the same age over wide geographical areas and this comes under the science of Biostratigraphy. Furthermore, they help in reconstruction of the past arrangement of the continents and the evolutionary map by correlating organisms on different continents – Palaeogeography.

In addition to collection of invertebrate fossils, there have been numerous excavations and fossil discoveries related to dinosaurs in India. Although some dinosaur eggs and their nests have been discovered, but no dinosaurs egg could be found with an intact embryo inside in India. Nests, containing dinosaurs eggs are important in understanding the laying behavior and pattern of depositing eggs. The investigation included extensive studies on the eggs of dinosaur to know their diversity in the study area.

Not only this, but the objective of this work is also to fill up the gap between the fragmentary works and studies done on macro fossil fauna previously on Narbada valley. The study will give a complete coherent picture of the distribution of different taxonomic groups of the macro fossil fauna and the extension of the fossiliferous areas in Jhabua and Dhar district. It is aimed to collect and diagnose all the available fossil varieties because there is great danger of their further vanishing due to enhanced human activities and civilization.
Location of the study area:

The present paleontological study of macro fossil fauna was carried out around the town of Bagh (22° 22′ 00″ N -74° 47′ 00″ E) specially in the area of Rampura, Badkeshwer, Bagh, Khandlai, Padalya, Zirabad, Chirakhan, Karondia and Chakrud of Dhar district of Madhya Pradesh (Fig.1.2A-C). The fossil fauna was also collected from and around the town of Pipaldehla (22° 27′ 00″ N 74° 38′ 00″ E), Rajla, Phata and Ranapur of Jhabua district of Madhya Pradesh (Fig. 1.3). The other areas viz. Awalda, Mogara, and Ali of Dhar district and Jamni, Umrali, Walpur and Udaygarh (Kanas) of Jhabua district were also surveyed for macro fossil fauna but no significant fossils could be recovered from these areas. Dhar district is situated in the South Western part of M.P., covers an area 8153 sq. km falling in between the latitudes 22° 1′ to 23° 10′ N and longitude 74° 28′ to 75° 05′ E in the survey of India degree sheet nos. 46 J, M and N. The Dhar district has a fairly good network of all weathers but lacks railway links. Jhabua district, which is situated in the South Western part of Madhya Pradesh, and covers an area 6772 sq. km falling in between the latitudes 21° 55′ to 23° 15′ N and longitude 74° to 75° E in survey of India degree sheet no. 46 J. The geological maps used for this purpose was kindly provided by the Director General, Geological Survey of India, Kolkata. The metalled roads connect Jhabua and Dhar with Indore. The nearest railway station to approach the study areas is Meghnagar on Delhi - Bombay broad gauge line of the western railway and from this place one can reach there by road. The study areas are well connected to Indore and Dhar district. Dhar is 60 km. away from Indore and Jhabua is 87 km. from Dhar district.

Cretaceous Period:

The fossils collected from Bagh Beds were estimated to be of Cretaceous period. The word Cretaceous is derived from the Latin word ‘Creta means Chalk’ as the geological remains contained high chalk deposits at that time. The Cretaceous is the longest period of Phanerzoic eons, spanning 80 million years. In geological time scale, the last of the three periods of Mesozoic era is the Cretaceous period. This
period began at the end of the Jurassic period approximate 144 to 65 million years ago, followed by the Jurassic period, and was succeeded to Paleocene period. The Cretaceous period is separated into two epochs in geological time scale, the early Cretaceous epoch (145.5 to 99.6 million years before) and the late Cretaceous epoch (99.6 to 65.5 million years before). Six stages of uneven span were supposed to be created by these epochs. In turn, every stage in a meticulous locality with rocks, sediments and fossils of that vicinity is described as type area. In the stages, the Berriasian, Valanginian, Hauterivian, Barremian, Aptian, and Albian comes under the Lower Cretaceous sequence while the stages Cenomanian, Turonian, Coniacian, Santonian, Campanian, and Maastrichtia constitute the Upper Cretaceous sequence. The Aptian is enduring longest period among these stages covering about 13 million years while the shortest stage, which lasted over 2 million years, is the Santonian.

The dilemma of exact boundaries have been unraveled by geologists with reference to the stratigraphy and fossils record of the above twelve Cretaceous stages.

In the beginning of Cretaceous period, the earth’s land of two continents i.e. Laurasia in the North and Gondwana in the South, came together. Most of the present day continents were disjoined from each other by North and South Atlantic Oceans at the end of Cretaceous period. Australia was yet united to Antarctica and India was adrift in the Indian Ocean. The sea level was more elevated in the Cretaceous period than any other times and thus it played a vital role in affecting the Paleogeography of the period.

The sea level was around 100 to 200 meters higher in the early Cretaceous and approximately 200 to 250 meters higher in late Cretaceous than at the present time. The water in the ocean basin, begin to displace by the magnification of mid Oceanic ridges, might be the cause for it. Due to higher sea levels, marine water flooded the continents in the late Cretaceous, thus creating relatively shallow epicontinental seas in North America, South America, Europe, Russia, Africa, and Australia. The margins of the sea flooded all the continents, resulting in more or less smaller dimensions. Land enclosed over maximum 18 percent of the earth surface in comparison to approximately 28 percent covered today. Arctic waters were sometimes linked through the middle of North America and the central portion of Russia to the Tethys seaway. Marine animals dwelling in South Atlantic during the Cretaceous had a sea
way to Tethys through Nigeria, Niger, Chad, and Libya. Some areas like Western Europe, Eastern Australia, parts of Africa, South America, India, Madagascar, Borneo etc. were entirely covered by marine waters for some period in Cretaceous time, are the land portions in current status.

**Cretaceous fauna:**

Cretaceous period plays an important and major role during switching from the early life forms of the Paleozoic era to the advanced and varied forms of the Cenozoic era. All along in the Cretaceous period the life had variations and was spread out.

In the marine life, two Palaeobiogeographic regions have been identified i.e. Tethyan, and the Boreal. The predominant structure of Cretaceous period was Rudist. In Mexico, Venezuela, and the Tethys Middle East, it serves as petroleum reservoir rocks. The fauna of the region comprises of snails, colonial corals, calcareous algae, benthic foraminiferans, ammonites, gastropods, bivalves, and echinoids were the other animals found in the regions. Inoceramids were the significant bivalve fossils of this kingdom and these were helpful for differentiating biostratigraphic zones.

There was foremost prevailing time of the Cretaceous period that administers the earth today and the prehistoric life. The leading group of land animals was the Dinosaurs. They appeared in Triassic but conquered the land in mild warmer climate of the Jurassic period. Gradually the temperature increased in the Cretaceous period; as a result the dinosaur’s diversity was at its peak. They dominated until the end of Mesozoic. Their extinction took place at the end of Cretaceous. Thus they ruled the continents for over 160 million years.

It is proved by evidences that the dinosaurs were oviparous animals like many modern reptiles. The present work highlights the Cretaceous record and paleobiological concept of dinosaur’s eggs, egg shells and nesting sites in the study area. These remains can be seen still embedded in the rocks. In addition to paleontologists, as a result of curiosity of media and public, a lot of interest has been created to uncover the mystery of these dominated land animals. In geologic history,
the fossils of dinosaur might represent a relative chronological guide. It also points out towards the extinction of dinosaurs.

**Paleoclimate during Cretaceous:**

The temperature in Cretaceous period was higher than present time. From what it is now, the temperature difference between the poles and the equator was around half. The Cretaceous and Jurassic period, had the same climate i.e. hot and damp. In the environment a few striking changes took place. The insect population became more numerous and with this the flowering plants (angiosperms) made their appearance for the first time. The changes in flora and fauna were the result of the change in climate which was cool for a longer period. Due to volcanic activity and increase in carbon dioxide level in the air, the climate began to get warmer after nearly 125 million years. In early Cretaceous period, the temperature was fairly higher; it goes to highest in the mid-Cretaceous and then gradually decreased with time in the last two ages of the period. Ice sheets and glaciers were found only in the high mountains otherwise they were almost completely lacking. The end of the Cretaceous period was much cooler than at the beginning of the period but it was still warmer than today. The water temperature of surface varies, it was about 30 °C at the equator, but at the poles it was 14 °C in winter and 17 °C in summer. Oxygen isotope measurements of the calcitic remains of marine organisms have been used to calculate the temperature values.

**Paleogeography of India:**

At the time of late Paleozoic, Laurasia, Saberia, Baltica and Gondwana continents changed their positions and came nearer, which resulted in the formation of a super continent Pangea till early Permian. The two big oceans, Paleo- Tethys Ocean and Pantholassic Ocean were centrally separated i.e. Paleo-Tethys Ocean to the east and Pantholassic Ocean to the west side and thereby Pangea attained its position from
North to South Pole. During that period India was positioned in the Southern hemisphere (Acharya and Lahiri, 1991).

Pangea was a single land mass till the Carboniferous period came to an end. In the Cretaceous period of the Mesozoic era (from 135-65.5 million years), it had started splitting. Some remarkable incidences like severe marine encroachment (Cenomanian-Turonian), winding of oceans (the Atlantic) and spreading of chalk deposition occurred during splitting of continents. In Mesozoic period, a marine revolution took place along with massive extinction. At high southern latitudes, India nestled in the Pangea and also started its lone journey from south to north and finally collided with Asia.

Though the Madagascar was attached to the west coast of India, before it was separated from it, during the Cretaceous. Due to Bagh group of carbonate deposits along the newly rejuvenated EW trending, Narmada graben in the sea water of Turonian - Coniacian marine encroachment made its route into western and central India. Chatterjee and Scotese (1999) have described splitting of Gondwana in detail and made an area cladogram showing the biogeography and evolution of the Indian plate from its Pangean origin (Fig.1.4A).

During middle Jurassic, because of volcanic activities, splitting of Pangea into two continents took place: Laurasia in the north and Gondwana towards the south. In the late Jurassic period Gondwana split apart from oldest ocean floors into two approximately equal parts. The eastern Gondwana consisted of Madagascar, India, Australia, and Antarctica, on the other hand western Gondwana comprised of Africa and South America. From Jurassic to early Cretaceous time, the formation of Somali and Mozambique basin takes place by splitting of Gondwana. South Atlantic Ocean is formed with the separation of South America from Africa, while the Central Indian Ocean was constructed by separation of Indo-Seychelles-Madagascar block from Antarctica and Australia. These two oceans opened gradually. The opening of South Atlantic Ocean took place from south to north while northeast to southwest opening occurred by the Central Indian Ocean. The sea floor in mid Cretaceous time, which was in the Somali basin, had stopped spreading. The incessant widening of central Indian Ocean was due to expanding of sea floor between the Indo-Madagascar-
Seychelles and Antarcto-Australia blocks. The subarial and volcanic Kergulen plateau is created in the south central Indian Ocean. A discontinuous dispersal route between India and Antarctica has been established by this plateau. The rifting of Indo-Seychelles block from Madagascar acquired during late Cretaceous. Lastly, from other Gondwana continents, it was entirely isolated (Fig.1.4B).

As a result of clashing of Greater Somalia with India, a biogeographic passage was formed with Africa in late Cretaceous. The India’s short period of separation ended with this clash. The dispersal path between Europe & Africa, between the Europe & North America and between South and North America were set up again about the same time. Thus, India and the other Gondwana continents became ultimately coupled by these biotic links. The Indian Ocean between India and Antarctica got extended making ninety east ridges in the Late Cretaceous idle for biotic dispersal between two land masses. During Cretaceous - Tertiary period a new gap was formed between Indo-Somalia and Seychelles. It also marked the disappearance of dinosaurs. The Central Indian ridge moved northwards from the Madagascar basin to a new spot, subsists in the midway of Seychelles and India.

A speedy movement of India is continued towards Asia. Corresponding to the cost line of Arabia, the India was carried with Greater Somalia northwards and moved towards Iran – Afghanistan in the Paleocene. The northward movement of India predicted was about 20 cm/year to 4.5 cm/year. There is much controversy about the timing of collision between India and Asia. The hypothetical time was from late Cretaceous (> 65 Ma) to latest Eocene (< 40Ma). The assessment in age difference at the time of collision is due to variation in the speed of the Indian plate. Between 55 and 50 Ma in early Eocene, the preliminary collision of India with Asia took place. The collision has taken place along the north east corner of Greater India. Due to this collision, the marine sedimentation came to an end and terrestrial deposition commenced.

An extra movement of 2000 km. northwards by India, resulted in the creation of Himalaya. The formation of Himalayas took place much after the time of a preliminary collision of India with Asia due to horizontal pressure. The Himalayan crystalline uplift and wearing down resulted in the sedimentation of Bengal fan delta,
which is the world’s largest submarine fan. Further confirmation has been provided for the instant of the Himalayan uplift, by sedimentation in the Bengal Fan delta. During the last 15 Ma, the Himalayan chain has been uplifted. The distribution of terrestrial vertebrates between India and other parts of Asia is prohibited due to orographic and climatic obstructions.

**General Geology of the study area**

The present work was undertaken in some areas of district Jhabua and Dhar of Madhya Pradesh. The area under investigation is a part of the Narmada valley. The geological setup in the study area is represented by Archaeans, Bijawars, Bagh Beds, Lameta formation, and Deccan traps in ascending order. As a whole, Bagh Beds principally consist of marine fossiliferous sequences namely Nimar sandstone, Nodular limestone, and Bryozoan limestone or Coralline limestone (Fig.1.5A and 1.5B).

**Nimar sandstone:**

It forms the basal unit of Bagh Beds. It attains a thickness of about 150 meters near the Western region and 15 – 30 meters thick near the Eastern side of the Bagh area. Near Bagh caves and Ambadongar region, Chiplonkar & Badve (1972); Chiplonkar et al., (1977) and Badve & Ghare (1978) have already identified an Oyster bed within the lower portion of Nimar sandstone. Oyster bed also occurs around Phata which is 1 km. away from the village Dholiya, district Dhar. Dassarma and Sinha (1975) found the Nimar sandstone near village Walpur of district Jhabua. They have noticed variations in thickness of Nimar sandstone in these Beds.

**Nodular limestone:**

It is one of the hardest units of Bagh Beds and is white to bluish white, compact argillaceous limestone (Dassarma and Sinha, 1975). In the Eastern region, in Barwah, a few detached outcrops are visible while in Man river valley and in south west of Bagh, it attained an average thickness of about 15 meters. In west of Alirajpur, this unit disappeared completely (Dassarma and Sinha, 1975).
Bryozoan limestone:

The Bryozoan limestone formation is also known as Coralline limestone or Barwah Bryozoan limestone or Chirakhan limestone (Gangopadhyay and Bardhan, 2002). It is hard, granular, yellow or yellowish green and red in color which richly consists of Bryozoa. Good exposure of the Bryozoan limestones is visible in the Man river where it attains a thickness of about 10 meters near Karondia and Sitapuri localities. In Bagh area, the Bryozoan limestone is 5-7 meter in thickness and is well exposed in nearby villages viz. Ajanta, Thuati and Jamanipura. The limestone thins out southwards and finally disappears to the west of Alirajpur (Dassarma and Sinha, 1975). In the area under investigation, the Bryozoan limestone is well exposed near Bagh and Chakrud, whereas it is completely absent in Dholiya, Padiyal and Walpur sections.

Lameta formation:

The Lameta formation is a widely distributed sequence of fluviatile deposits extending over 10000 km. (Sahni et al., 1994; Sahni and Khosla, 1994). Its discontinuous patches are exposed in parts of Gujarat, Madhya Pradesh, Maharashtra, and Andhra Pradesh. The Bryozoan limestone is unconformably overlain by sandy, nodular, and cherty Lameta limestone, rich in dinosaur eggs and eggshell fragments. The unit attains a thickness of about 3 meters in the study area.

In Man river valley, the Lameta are well preserved and the sequence consists of shale at the base followed by sandstone and conglomerate (Roy-Chowdhury and Sastri, 1962). To the west of the Man river valley, particularly at Bagh and Alirajpur, the Lameta are also well exposed and represented by shale, sandstone, and cherty limestone (Dassarma and Sinha, 1975). In Man valley the upper part of sandstone contains numerous fossil wood fragments and calcareous concretions resembling coprolites in the lower part of the formation (Roy-Chowdhury and Sastri, 1962; Dassarma and Sinha, 1975).

The Lameta formation is also exposed 3 km south west of Bagh village in Dhar district of Madhya Pradesh, where it attains a maximum thickness of 9 meter...
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and is subdivided into three units. The sequence comprises red sandstone (2.5 m) at the base followed by calcareous sandstone (2 m) which ultimately merges upwards into 4.5 m thick dinosaur egg-rich cherty limestone (Joshi, 1995).

Deccan traps:

The volcanic rocks known as Deccan traps and they constitute the uppermost unit overlying the Lameta formation, Bagh Beds, Bijawars and Archaeans. The Deccan trap lava flows cover a wide area. Beside the western coast of India, the exposed thickness of the Deccan traps is 1.5 km which progressively narrows to the northeastern region to about 100 m (Khosla, 1996).

Formation and the nature of macro fossil fauna in the study area

When the animal dies, the soft parts of the animal immediately attacked by bacteria get decomposed. After the burial, the organisms test/ body becomes a hollow container, thus forming the internal moulds. It is then filled up by super saturated CaCO₃ solution and sometimes by mud in case of gastropods and bivalves, but in case of cephalopods i.e. ammonites (in the present case) the hollow phragmocone is filled up by sparry calcite cement and the body chamber is filled up by micritic mud. In the present case, the infilling muddy material and the host limestone sediment is the same. It proves the fossils are autochthonous i.e. in situ. The molluscan fossils in the rocks are found at different altitudes. It proves that these autochthonous fossils have been distributed by natural disturbances before final fossilization. -