Chapter I

INTRODUCTION

NARMADA BASIN

The Cretaceous Narmada basin is a narrow linear graben oriented ENE-WSW, and extending inland from near the Gulf of Cambay on the west coast of India to Amarkantak in Central India **(Fig.1)**. Towards east, the basin merges with the Son graben. On the western side, the Narmada basin is cut across by the oil-producing, Tertiary Cambay basin. The Barwaha outcrops mark the limit between the upper and the lower parts of the Narmada basin **(Fig.2)**. The Lower Narmada basin has several detached outcrops of the Cretaceous sedimentary rocks between Barwaha in the east and Rajpipla in the west. In the upper Narmada basin the only outcrop of importance is located around Jabalpur.

TECTONIC FRAMEWORK

The Narmada rift basin coincides with a major ENE-WSW oriented, remarkably straight lineament zone, the Narmada-Son lineament **(Fig.1)**. The basin as well as the lineament cuts across the central part of the Indian shield. The lineament existing since Early Precambrian, had undergone a long and varied geotectonic evolution (Crowford, 1978; Murty and Mishra, 1981; Chaubey, 1989; Shanker, 1990, 1991). It has been reactivated periodically and a reactivation phase of the lineament coincided with the breakup of the Gondwana and eruption of Deccan Traps during Cretaceous. In the post Deccan Trap period reactivation was more pronounced and continued through Tertiary and Quarternary times.

The Cretaceous sediments of the Narmada basin directly overlie the Precambrian basement with a pronounced unconformity. The Cretaceous Narmada basin originated as an incipient rift on the Early Cretaceous peneplain prior to

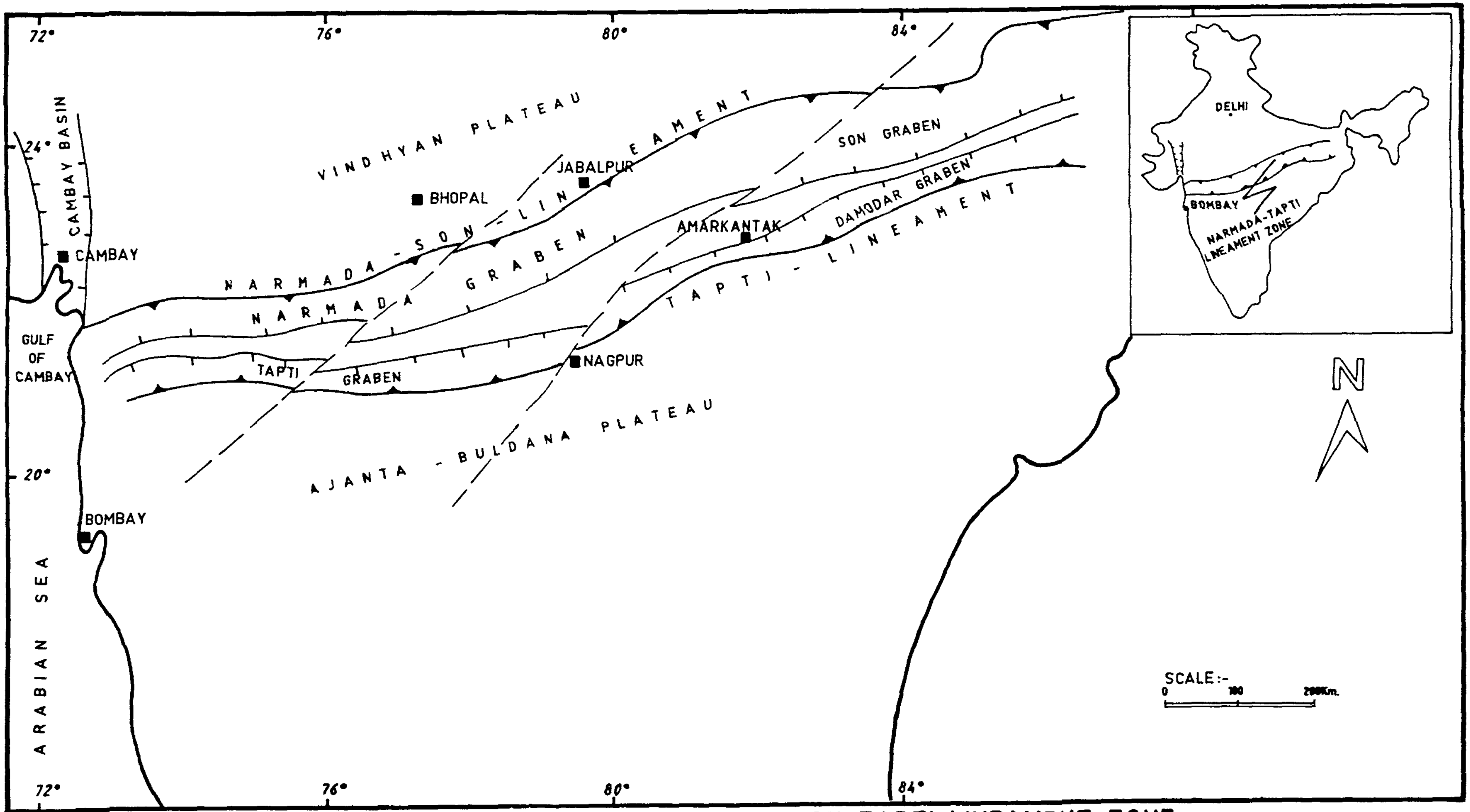

Fig 1: PRINCIPAL TECTONIC FEATURES OF THE NARMADA-SON-TAPTI LINEAMENT ZONE (After Ravi Sanker, 1991).

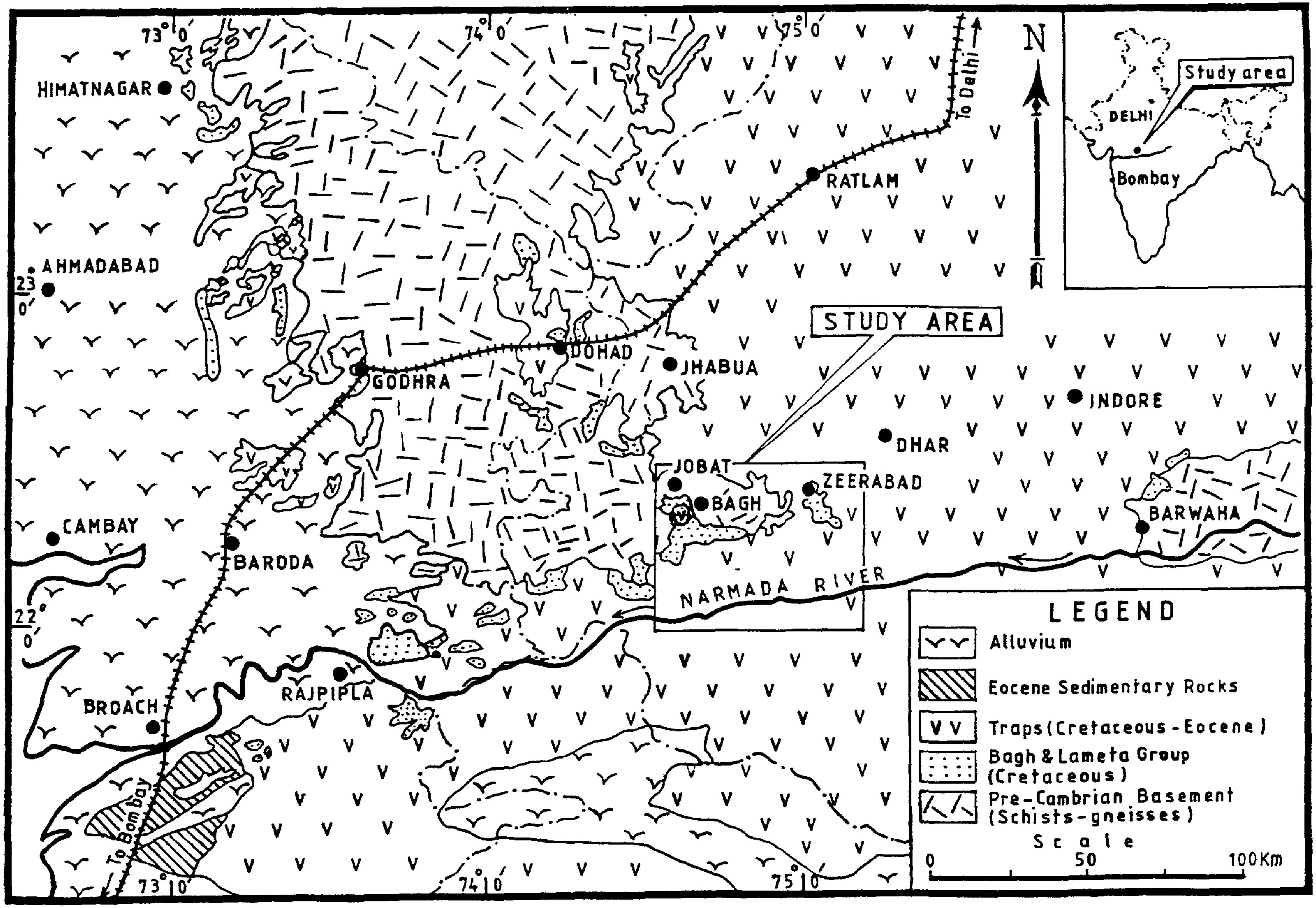

Fig.2 _GEOLOGICAL MAP OF THE LOWER NARMADA BASIN. (Based on Geological Survey of India. 1mm=2km map, 1962 edition)

continental breakup and extrusion of the Deccan Traps in Maestrichtian times. The rift coincided with the Narmada-Son lineament. Although petrofacies study of the Cretaceous sandstones by Khan (1990) and this study do suggest fault-bounded uplifts and tectonic activity within the basin, the small thickness of the sequence preserved within the Narmada basin does not match the typical rift basin fills described by Miall (1985) and Ingersoll (1988). The Narmada sedimentary sequence extends upto Turonian and is overlain unconformably by Maestrichtian Deccan Trap formation. It implies that a considerable thickness of the Upper Cretaceous sediments has been removed by erosion prior to outpouring of basaltic flows belonging to the Deccan Trap formation.

STRATIGRAPHY AND AGE

The first account of Geology of the Narmada basin was given by Blanford (1869), followed by a detailed report by Bose (1884). In the Lower Narmada basin the Cretaceous sedimentary rock sequence, informally designated 'Bagh Beds' by Oldham (1858), occurs in patches as inliers surrounded by younger basaltic flows.

The underlying Precambrian basement comprises mainly granite-gneisses and metasediments such as phyllites and quartzites. The basement is generally exposed in the eastern part of the study area.

The Bagh Group is divisible into a lower clastic Unit (Nimar Sandstone) overlain by an essentially carbonate sequence comprising the Karondia Limestone (Nodular Limestone) and the Chirakhan Limestone (Coralline Limestone) (Biswas, 1990). The names Nodular Limestone and Coralline Limestone are deeply entrenched in geological literature due to long use but should be discarded because of several reasons: (i) the names do not represent any type locality; (ii) nodular character of bedding is not well developed all over the basin; (iii) the

Coralline Limestone hardly contains any corals.

The Nimar Sandstone is mainly sandy and shaly with locally developed conglomerates. The overlying Karondia Limestone comprises fossiliferous mudstones and wackestones. These are overlain by cross-bedded bioclastic packstones-grainstones (Chirakhan Limestone). There is much lateral variation in lithology, even within short distance. The Chirakhan Limestone is almost missing from the western part of the study area, where it is replaced by terrigenous micrite and calcareous sandstones. In the present study, the lithostratigraphic classification proposed by Biswas (1990) has been slightly modified **(Table 1).**

Table 1 : Stratigraphic sequence of the Lower Narmada basin (modified after Biswas, 1990).

	Upper (Main) Deccan Trap (Late Maestrichtian-Danian)	
	II Effusive activity	
NARMADA SUPER GROUP	Lameta Group (Upper Turonian-Coniacian)	Navagam Limestone and equivalent Songir Sandstone and equivalent
NARMADA SUPER GROUP	----------Break/Unconformity----------	
NARMADA SUPER GROUP	Lower Deccan Trap (Lower Turonian)	
NARMADA SUPER GROUP	I Effusive activity	
NARMADA SUPER GROUP	**Bagh Group** (Albian-Cenomanian)	Karondia Limestone Nimar Sandstone
	----------Unconformity----------	
	Precambrian basement	

Taking into consideration the lateral variability in the limestone sequence, the subdivision 'Chirakhan Limestone' has been dropped and the entire limestone sequence has been treated as one formation and designated 'Karondia Limestone'. Thus, the Bagh Group is divisible into two formations; a lower essentially clastic formation, the Nimar Sandstone, and an upper mainly calcareous formation, the Karondia Limestone.

The thickness of the Narmada Cretaceous sediments increases westward from a few metres near Barwaha to nearly few hundreds of metres near Rajpipla. West of Rajpipla, outcrops disappear and the basin is covered by recent alluvium. Near Baroda the Nimar Sandstone is about 128 m thick in the subsurface (Dhar and Singh, 1990).

Due to a general lack of fauna in the Nimar Sandstone its age is not conclusive, and subject to controversy. An Upper Cretaceous age was assigned to the Nimar Sandstone on the basis of marine fossils occurring in its upper part (Dassaram and Sinha, 1975). Chiplonkar et al. (1977) assigned Cenomanian age on the basis of Shark teeth and bivalves and Jafar (1982) considered the formation to be Turonian on the basis of nannoplanktons. However, some plant fossils indicate that the formation may be older, upto Hauterivian or Wealden (Sahni, 1936; Murty et al., 1963). Inspite of many controversies, an Early Cretaceous age for the Nimar Sandstone is generally accepted by most workers.

The Karondia Limestone contains abundant fauna. Several studies published on the fauna and age of the Limestones have been reviewed by Chiplonkar and his coworkers (Chiplonkar et al., 1977; Chiplonkar, 1980). Other workers including Verma (1968), Jain (1969) and Sharma (1976) have contributed valuable information on these aspects. These studies suggested an Albian to

Turonian age for the limestones.

A recent study of the Cretaceous in the Narmada valley by Biswas (1990) has thrown new light on the stratigraphy and age of these rocks. A flow of Trap of Turonian age was observed to overlie the limestones of the Bagh Group of Albian-Cenomanian age. This lower flow is followed, after erosion, by the Lameta sediments in the Bagh area and by the Navagam Limestone in the westernmost part of the basin. The Lameta Group is believed to range in age from Late Turonian to Post Coniacian. Biswas (1990) suggested that the Navagam Limestone and associated Songir Sandstone of the Narmada basin were deposited during Late Turonian transgression along the eastern margin of the Cambay basin. In the easterly areas of the Narmada basin, largely estuarine to nonmarine Lameta sediments were deposited during the same period but in certain outcrops marine Turonian strata with nannoplankton assemblage are present (Jafar, 1982).

PALEOGEOGRAPHY AND PALEOENVIRONMENTS

The subsurface information obtained from wells drilled by the Oil and Natural Gas Commission of India has helped in reconstructing the Cretaceous paleogeography in western India (Biswas, 1990). The Lower Narmada basin first experienced a marine transgression in Late Albian with the onset of rifting there and initiation of uplift in the adjacent areas. The transgression reached its peak in the Cenomanian when maximum area in the Narmada basin was covered by the sea. A global regression at the Cenomanian-Turonian boundary (Haq et al., 1987) coincided with a short lived effusive activity in the Narmada basin (Lower Deccan Trap). The following Late Turonian transgression covered only a small area in the westernmost part of the Narmada basin. Widespread effusive activity during Late Maestrichtian to Danian is represented by the Main/Upper Deccan Trap.

The earliest workers, Blanford (1869) and Bose (1884) considered the Nimar Sandstone to be estuarine/fresh water deposits. Murty et al. (1963) found plant fossils and suggested fresh water environment of deposition for the sandstones. Guha and Ghosh (1970) interpreted them as marine deposits on the basis of sedimentological studies. Chiplonkar and Ghare (1974) and Badve and Ghare (1977) on the basis of presence of oyster beds and trace fossils suggested fluvial depositional environment. The facies variation studies by Raiverman (1975) suggested deposition in varied environments like alluvial flats, coastal marsh and beach, supratidal and intertidal flats and subtidal shelf. Integrated studies of paleontological and sedimentological data by Singh and his coworkers (Singh and Ghose, 1977; Singh and Dayal, 1979; Singh and Srivastava, 1981) demonstrated that the lower part of the Nimar Sandstones was formed in fresh water while its upper part originated in a marine environment. The Karondia Limestone was deposited in intertidal to deeper subtidal environments (Singh and Srivastava, 1981). A recent study on the Nimar Sandstone in the western part of the basin suggested deposition in a macrotidal estuarine complex environment comprising shallow channels and mud flats (Ahmad and Akhtar, 1990).

The Lameta sediments of the Jabalpur area in the eastern part of the Narmada basin were interpreted as exclusively marine deposits of an estuarine complex (Singh, 1981). However, a model advocating a fluvial and pedogenically modified semi-arid fan-palustrine flat system for the development of the Lameta rocks of the Jabalpur area was recently proposed by Tandon et al.(1990).

LOCATION OF THE STUDY AREA

The study was carried out in the Lower Narmada basin between the Jobat town ($22^\circ25'$: $74^\circ35'$) and Zeerabad village ($22^\circ24'$: $75^\circ05'$) **(Fig. 3).** The study area also includes the type locality of Bagh town after which the Narmada sequence was informally designated as 'Bagh beds'. The Cretaceous sedimentary rocks of the basin exposed westward of the study area have been recently studied by Ahmad and Akhtar (1990), Khan (1990) and Akhtar and Ahmad (1991).

Zeerabad outcrops almost mark the eastern end of a series of exposures extending upto Rajpipla in the western part of the basin, beyond which the basin is covered by recent alluvium.

The Cretaceous sedimentary rocks are mainly exposed as inliers within the Deccan Traps. The Precambrian basement is exposed at many localities. Best exposures of the Karondia Limestone in the basin are met in the study area and hence it offers a good opportunity for a detailed study of the limestones in addition to the basal Nimar Sandstone.

AIM AND SCOPE OF WORK

The study was carried out with a view to recognizing the various clastic and carbonate facies types and to interpreting their depositional models. Sedimentological information on the Nimar Sandstone of the Lower Narmada basin, recently gathered, helped in recognizing its facies and reconstructing its depositional environments (Ahmad, 1989; Khan, 1990). However paleoenvironmental reconstructions of the Cretaceous limestones of the Narmada valley published so far are broad and generalized and essentially based on faunal and paleoecological considerations. Very scanty information has been

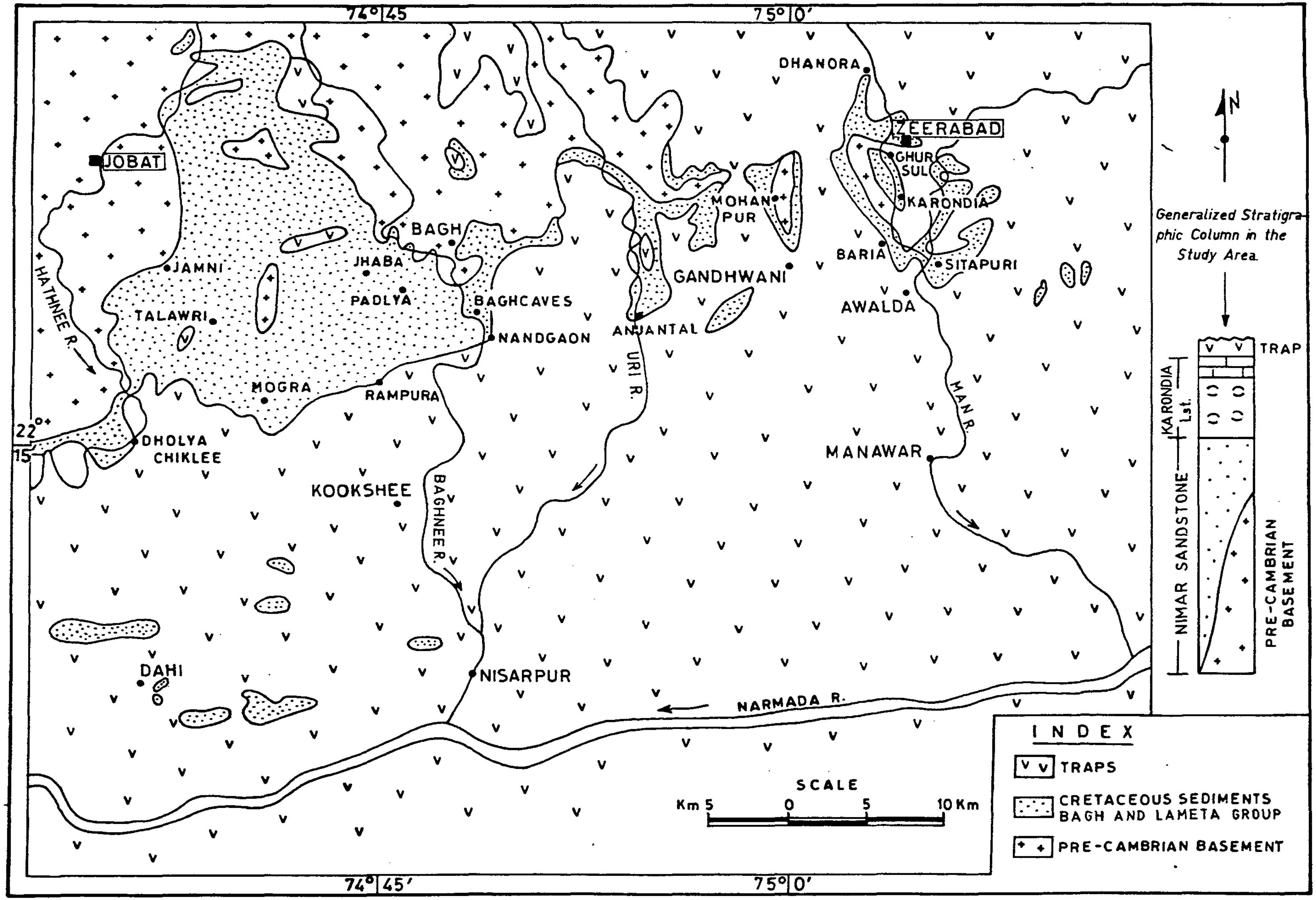

Fig 3 : GEOLOGICAL MAP OF THE ZEERABAD - JOBAT AREA (Modified after Blanford, 1869).

published on the sedimentological aspects of the limestones. This study mainly focusses attention on the limestones and for the first time presents a detailed account of their petrography, microfacies and facies associations. An attempt has been made to construct a depositional model of the limestones by integrating the petrographic and field data.

A total of 19 lithostratigraphic sections of the Cretaceous sedimentary sequence were measured and sedimentological information such as lithology, nature of contacts, beding types, sedimentary structures and geometry of lithounits were collected.

Petrography, petrofacies and dispersal pattern of the sandstones were studied for the purpose of (i) understanding hydrodynamic conditions and processes of deposition, (ii) petrographic classification and (iii) interpretation of provenance. 57 samples of sandstones showing least modification of texture by diagenesis and compaction effects were selected for the purpose of textural study and 300-400 grains were counted in each thin section for grain size analysis. Roundness of detrital grains was estimated visually with the help of Powers'(1953) comparison chart for roundness. Textural maturity of the sandstones was determined on the basis of clay percentage, sorting and roundness according to Folk's (1980) concept. The sandstone composition was studied in 54 thin sections with a view to classifying the rocks and to interpreting their provenance and depositional history with its tectonic setting. 123 azimuths on large-scale cross-beding were collected to reconstruct the sediment dispersal pattern of the sandstones. Carbonate rocks were studied for the purpose of facies analysis and constructing their depositional model. A total of 97 thin sections, stained with Alizarin red S were examined for determining the textural constituents of limestones. The percentages of allochems, micrite and spar were estimated by 300-400 counts in each thin section. On the basis of percentages of various constituents 13 types of microfacies were identified. The microfacies were regrouped into 5 types of facies associations on the basis of field and laboratory data. 169 azimuths on large-scale cross-bedding were collected to reconstruct the dispersal pattern of lime grainstones. Finally, a depositional model was constructed for the limestones.