CHAPTER - 3

GEOLOGICAL SET UP

The Mesozoic strata of Kachchh basin are classified as Pachchham Series, Chhari Series, Katrol Series, Umia Series and Bhuj Series based on chronostratigraphy (Waagen, 1875). Here rank term "Series" is used, while in lithostratigraphic classification rank term "Formation" is used; and the formations are made from older to younger for the Mainland as Jhurio, Jumara, Jhuran and Bhuj Formations (Biswas,1971,1977). In the present study the author has mainly followed the lithostratigraphical classification proposed by Biswas (1971).

The study area in the Central Kachchh Highlands exposes the rocks of Bathonian to Albian in age. Tertiary rocks are not found in the area except a

few patches in the eastern part of the Khari basin. Quaternary deposits are found as alluvial and colluvial fans along the foot hills of the ranges and the banks of the rivers. Miliolite deposits occur as pockets of loosely cemented sandy biomicrites in the hollows created at mountain fronts or as obstacle dunes along the higher elevated hills. Structures have played a major role in shaping the landscape of the Khari river basin and in exposing the different rock units in nearly horizontal or inclined manner. The geology of the Khari basin is described following the classification of Biswas (1971).

MESOZOIC ROCKS

Most part of the Khari basin is covered by the Mesozoic rocks of Jhuran and Bhuj Formations (Fig.3.1). Jumara Formation occurs at many places on the hilly tracts as inliers. The oldest formation on the Mainland is Jhurio Formation which occurs in the northwest part of the basin. Chronostratigraphically, these are classified as Chhari, Katrol, Umia and Bhuj Series. Major part of the area is covered by Katrol and Bhuj series, while Chhari crops out at the centre of the domes. A few beds of Pachchham are exposed in the core.

Jhurio Formation

The oldest rocks of the Khari basin belong to Jhurio or Jhura Formation of Biswas (1971,1977). The name Jhurio is derived from Jhura hills occurring to the northwest of Khari basin, where maximum thickness of this formation is exposed as inliers (Plate 3.1). The rocks of this formation are

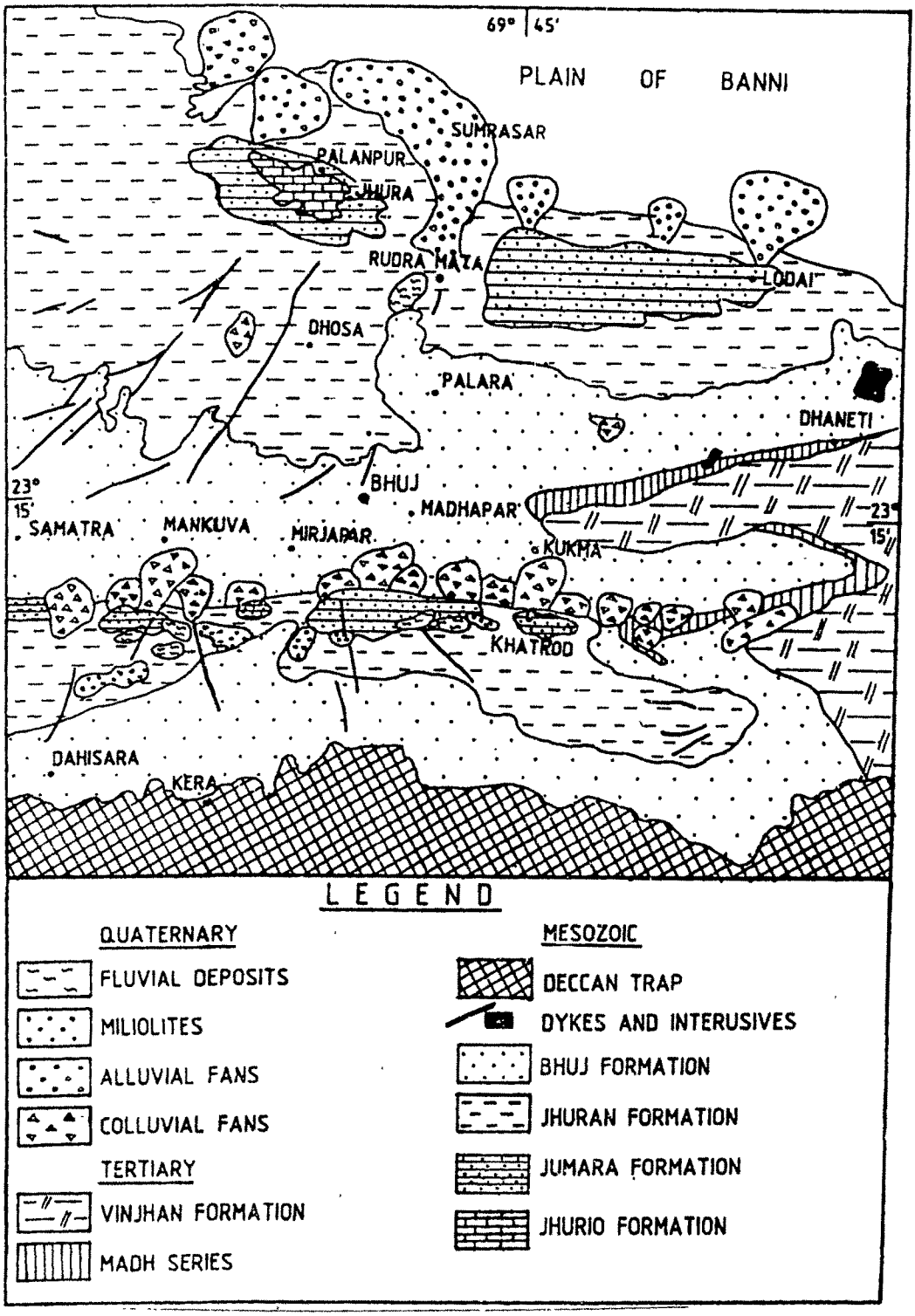

Fig. 3.1 Geological map of the study area.

also mapped in the northeastern part of the basin in the Habo hill (Fig.3.1). The type section of Jhurio Formation is located about 1/2 km SW of Badi village (23 26' 15"; 69 34' 50"). The formation has been divided into seven members marked A to G (Biswas, 1977). Lower part comprises thin beds of yellow and grey limestones (Plate 3.2) occasionally containing golden ooliths, in grey shales. Middle part is composed of thick beds of grey, yellow weathered shales alternated with thick beds of golden oolitic limestones. The upper part of the formation is made up of thinly bedded white to cream coloured limestones (pelmicrite and biomicrite) with thin bands of "golden oolites" (sandy-intrasparudite with golden ooliths) (Balgopal, 1972).

Jumara Formation

The Jumara Formation occupies the core part of Habo hills. Besides this, these occur in Jhura dome as ring shaped outcrops. The rocks of Jumara Formation are also exposed as inliers in minor domes along Katrol Hill Fault. The formation being soft, usually gives rise to a grey undulating country of low relief, resistant bands occasionally forming cuestas (Plate 3.3).

The formation is characterised by monotonous, olive-grey, gypseous, laminated shales with thin red ferruginous bands with alternating beds of limestone and occasional sandstone inter-beds (Plate 3.4). Thin fossiliferous oolitic limestone (sandy oomicrites) bands are common all along the Katrol - Charwar hill range. These bands placed itself on the top of the formation within the gypseous shales. They are called "Dhosa Oolite Beds/Stage". It is used as marker horizon in the mainland stratigraphy (Plate 3.5).

The formation is more or less uniform in thickness (~300 m) in the area. Varieties of ammonites, belemnites, brachiopods, pelycypods, corals and gastropods are found throughout the formation. Various trace fossils are also common in the formation. They include worm tubes, burrows, bounce marks and other structures related to the locomotion of peculiar organism of beach and littoral environment. The formation is the richest of all in fossil content. From the lithologic and biologic contents it appears to have been deposited below the wave base in circa-littoral environment (Biswas, 1977).

Jhuran Formation

Jhuran Formation is of considerable thickness which rests upon the upper most member (Dhosa Oolite Member) of Jumara Formation (Fig.3.1). It comprises a thick sequence of alternating beds of sandstone and shale (Plate 3.6). It is defined by Dhosa oolite member below and non-marine sandstone of Bhuj Formation above. The formation is named after the Jhuran village (23° 22' 08"; sheet no. 41E/11 and 15). The village is destroyed by 1956 earthquake and a new village Jawaharnagar is built near it . The type section of lower and middle members is along Jhuran river near Jhuran village. Also middle member is very well exposed in Khari river basin around Rudramata temple, 16 km north of Bhuj.

Southern flanks of Katrol-Charwar hill ranges, and most of the northern part of Khari river basin are represented by Jhuran Formation or its equivalent Katrol Series. The typical morphologic expression of this formation is cuestas, scarps and broad valleys resulted from erosion of alternate hard and soft rocks. Kas scarp , northeast of the area is one of the examples of

such cuesta cliff (Plate 3.7).

Jhuran Formation consists of various kinds of sandstones like white, brown and pinkish grey. Shales of this formation are usually grey or reddish or dark coloured. The lower member consists of alternating yellow and red sandstone and shale beds in almost equal proportions, with thin bands of hard, yellow, fossiliferous, pebbly calcareous sandstones. It is widely exposed in Gunawari river, as well as southern valleys of the most of the mountain fronts on Bhuj-Mundra and Bhuj-Mandvi roads. The upper most part of the Lower Member in type section near Jawahar Nagar consists of grey, weathered, yellow, calcareous sandstone with large belemnites. The middle member is also exposed in lower reaches of Gunawari river. It is predominantly shaly, comprising monotonous succession of dark, grey to black well laminated weathered gypseous shales (Plate 3.8). The ferruginous bands within the shales are concretionary, encasing ammonites, exposed near Ler and Gangeshwar along Katrol hill range. The less fossiliferous middle member contains plant fragments. This member is very well developed throughout and serves as a marker horizon.

The upper member is exposed in southern low lying hills in Katrol-Charwar range. It is characterised by arenaceous, red and yellow, massive and current bedded sandstones with intercalations and alternations of shale, siltstone and calcareous sandstone bands. Total thickness of the formation in the study area is not more than 450 m.

The formation is richly fossiliferous around Ler and neighbouring localities in Charwar range. Common fossils include ammonites and belemnites. The base of the formation above the Dhosa Oolite bands

coincides with that of Katrol Series. Thus this formation includes the Katrol and Umia Series of Rajnath (1932) which indicates Kimmeridgian to Tithonian time range. However the presence of Trigonia ventricosa in the west suggests the upper age limit as Kimmeridgian to Valanginian (Richter - Bernberg et. al. ,1963)

Bhuj Formation

Major part of the central rocky plain in the area of study is represented by the rocks of Bhuj Formation. It generally occupies the lowlands between the hills associated with Mainland Fault in the north and the hill range associated with Katrol Fault in the south. The formation mainly consists of non-marine sandstone of uniform character. It is the youngest formation of Mesozoic rocks of Kachchh. The formation is named after Bhuj town, the capital of Kachchh, where it is very well exposed.

The formation is classified in two members in the study area (Biswas, 1977). The marine band that forms the basal part of the lower member in western Mainland Kachchh extends eastward in the study area. The lower member is characterised by cyclic repetition of ferruginous or lateritic bands, shales and sandstones (Plate 3.9); while the upper member consists of whitish to pale brown, massive, current bedded, coarse grained, well sorted sandstones with kaolinitic shales and ferrugenous band alternations at thick intervals. The sandstones in all the members are pale brown to buff, soft, friable, usually current bedded, fine to coarse grained, well sorted and loosely cemented quartz arenites. The formation exposed in the study area is devoid of any fossil fauna, but the shales contain fossil flora.

The lower time limit of the formation is indicated by the upper limit fixed for the Jhuran formation, which is Valanginian. Mathur et al. (1970) on palynological evidences fixed the upper limit of formation at Santonian. Absence of fauna, richness of flora, lithology, sedimentary structure, paleocurrent directions and marine tongues in the down basin direction suggest that the Bhuj Formation represents deltaic deposits with front part towards the west of the Mainland Kachchh and proximal fluvial part to the east of the Mainland.

Intrusive rocks

The Mesozoic rocks in the area are intruded by a number of basic dykes trending mostly N-S or NW-SE (Plate 3.10). The dimension of the dykes vary at places but the common is 2-4 m wide and 2-10 km long. Most of the dykes are doleritic in composition. All dykes are located in the vicinity of faults. The dykes and the associated faults trend in the same direction suggesting syntectonic nature of the intrusive rocks (Biswas and Deshpande,1973).

TERTIARY ROCKS

The triangular basin of Khari river basin has a couple of patches of Tertiary rock units (Fig.3.1); especially Madh Series of Paleocene age exposed north of Kukma village which extends further northeastward upto Paddhhar. The other important Tertiary unit is the Vinjhan Formation of Upper Miocene age which occurs in the form of scattered patches.

Plate 3.1 Photograph of the central part of Jura dome to the south of the mainland fault. The steeply dipping resistant rock on the left is the hard grey nodular limestone. (Loc. near Badi village).

Plate 3.2 Grey coloured limestone of Jura formation exposed on the eastern flank of the Jura dome. (Loc. Jhura village).

Plate 3.3 Photograph of southward dipping rocks of Jumara Formation to the south of Katrol Hill Fault forming Cuesta cliffs (Loc.Near Tapkadevi Mandir)

Plate 3.4 Thinly bedded sandstone and gypseous shales (calcareous) of Jumara Formation exposed in a road cutting (Loc. 7 km south of Bhuj on Bhuj-Mundra road).

Plate 3.5 Steeply dipping Dhosa Oolite beds (upper member of Jumara Formation) on the eastern flank of Jura dome.

Plate 3.6 Massive ferruginous sandstone showing huge channel fill structures and occurring over black shales of Juran Formation at the base.(Loc. 6 km north of Bhuj along Khari river).

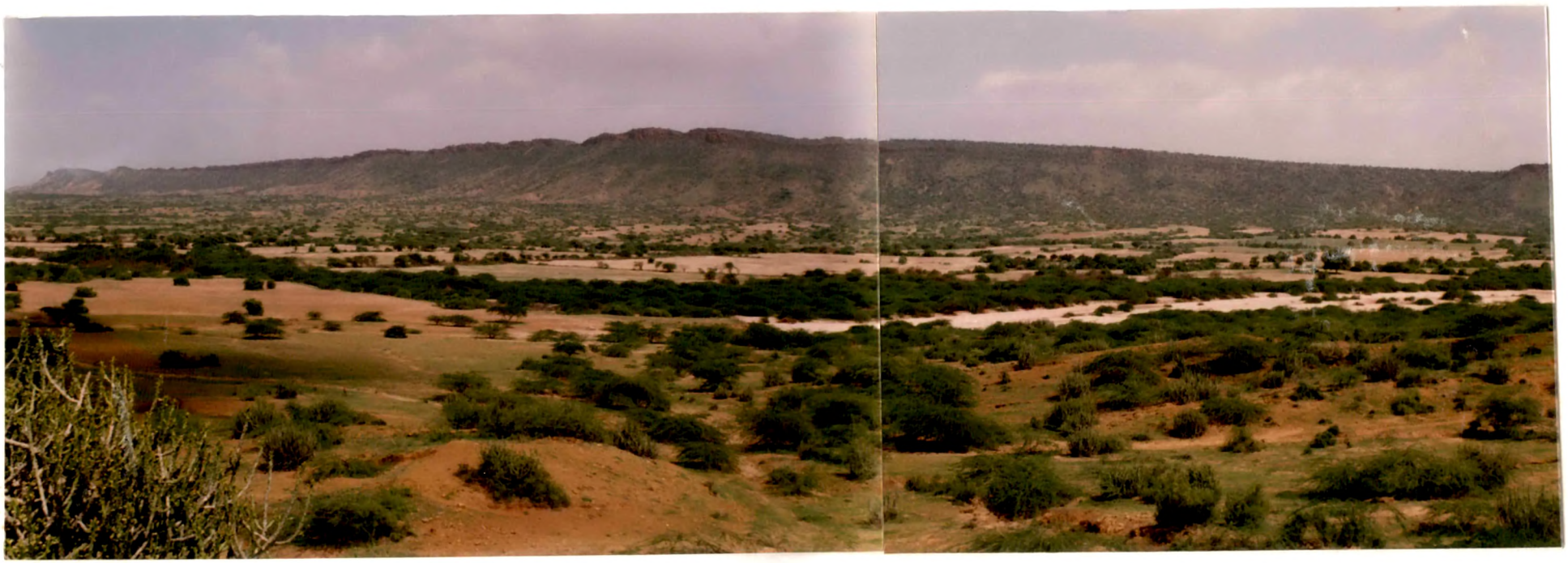

Plate 3.7 ENE-WSW trending Kas Hill Scarp exhibiting typical morphologic expression of Juran Formation.(Loc. 12 km NE of Bhuj on Bhuj-Lodai road).

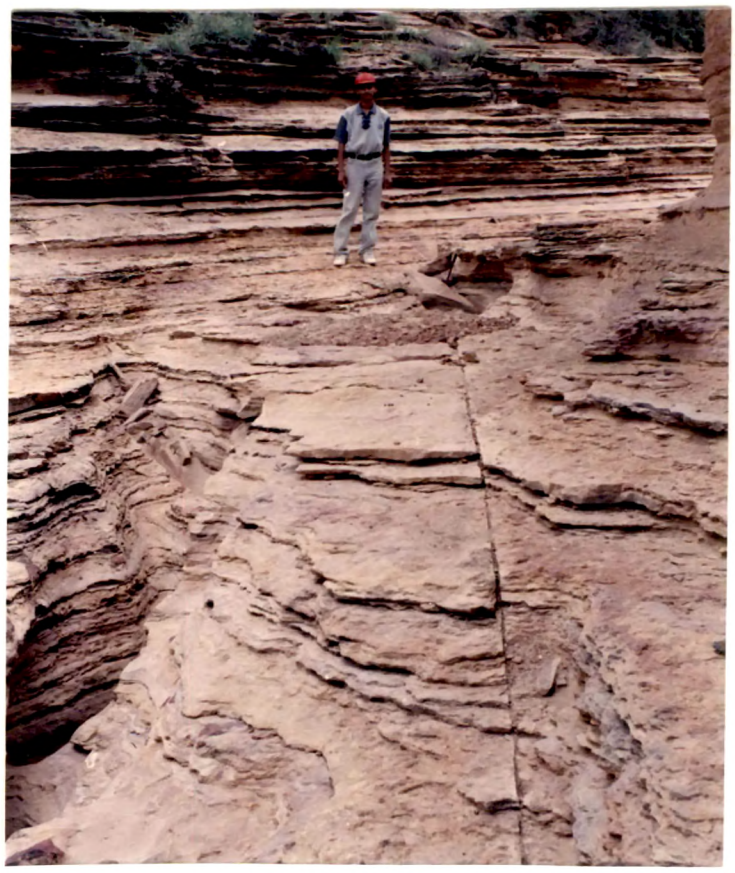

Plate 3.8 Buff, yellow coloured gypseous shales with intercalated thinly bedded calcareous sandstones of Juran Formation exposed in Gunawari river.(Loc. 2 km south of Gangeshwar Mahadev in Gunawari river).

Plate 3.9 Photograph showing alternation of ferruginous sandstone and carbonaceous shales of Bhuj Formation cut by a NW-SE trending fault. (Loc. 7 km east of Bhuj on Bhuj-Kodki road).

Plate 3.10 NW-SE trending dolerite dyke cutting across Bhuj Formation. (Loc. 8 km east of Bhuj on Bhuj-Kodki road).

Plate 3.11 Photograph of Katrol Hill Fault scarp showing gullies and colluvial fans at the base. (Loc. 4 km SE of Kukma village).

Madh Series

The rocks of this series are 15 to 20m thick comprising laterite layers alongwith conglomerates, bauxites, bentonitic clays, tuffaceous shales and gritty, friable sandstones. The lower boundary of the series is recognizable in the north and northeast of Kukma and Ratnal villages. Heavily lateritised lower part of the series suggests sub-aerial exposures of Deccan basalts. The ash beds and tuffaceous shales are also found along with betonitic clays.

Vinjhan Stage

Very small strip of Khakhi coloured weathered gypseous clays with hard marl beds of this stage are exposed near Paddhar and Dhaneti, east of Bhuj. The formation occurs in the structural lows developed during tectonic evolution of the landscape.

QUATERNARY DEPOSITS

Quaternary deposits in the study area are mainly in the form of alluvial and colluvial fans, fluvial sandbars, valley fill miliolites and fluvio-aeolian miliolite patches (Fig.3.1,3.2, Table 3.1). Cultivated lands on the pediments near the Katrol foot hills overlie either the Cretaceous Bhuj Formation or Madh or Khari Series. They are composed of loose sand clay or alluvium.

Alluvial fans

The alluvial fans mapped are associated with Katrol Hill Fault and Mainland Fault (Fig.3.2). Alluvial fans are formed under a distinct set of

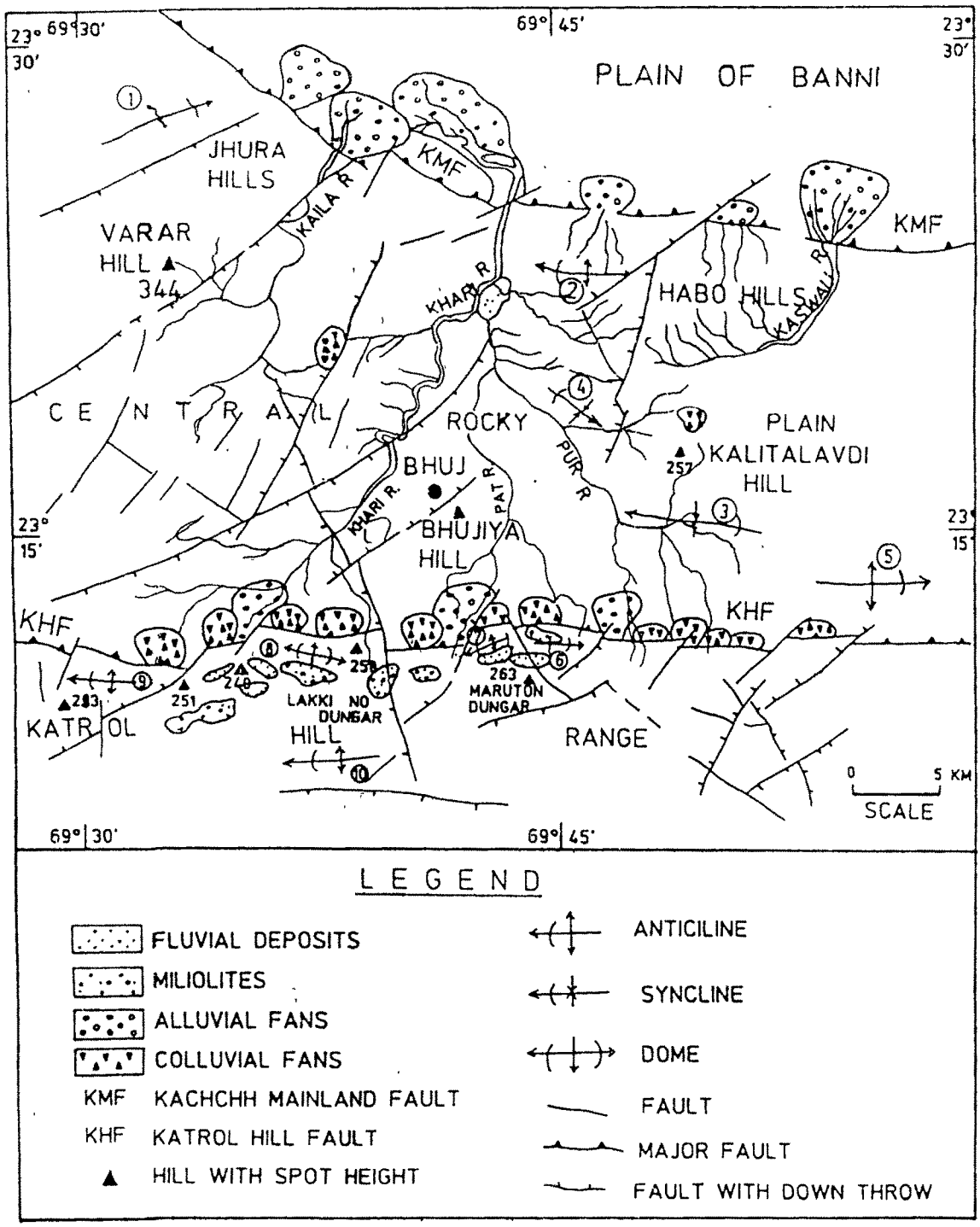

Fig. 3.2 Map of the study area showing distribution of Quaternary deposits along major faults.

Table 3.1 Stratigraphy of the Quaternary deposits of the study area

QUATERNARY DEPOSITS	LITHOLOGY	AGE
Alluvial deposits	Fine sands, silts and clays; river alluvium	Late Pleistocene to Recent
Miliolites	Sandy sheet of miliolite with boulders and pebbles along river valley; And biomicritic accumulation on the hill slopes	Middle Pleistocene
Alluvial and colluvial fan deposits (along E-W faults)	Angular to sub-angular pebbles and cobbles embedded in sandy to gravely matrix	Lower Pleistocene

geological conditions. An abrupt physiographic break marked by an active fault leading to the unconfinement of the channel is essential. In the study area, the abrupt physiographic break is provided by the mountain front scaprs of Katrol Hill Fault and the Kachchh Mainland Fault. The sudden unconfinement of the rivers as they cross these faults have led to the formation of small alluvial fans along the fault margins. Well developed fans are observed along the rivers like Khari and their tributaries. The fans are mainly composed of sub-angular to rounded fragments alongwith fine to medium sands. The alluvial fans formed in the vicinity of Mainland Fault and near the mouth of the rivers like Khari, Kaswali, Kaila, and Bhurud have rounded fragments and flat to gentle conical morphology while those associated with Katrol Hill Fault have less rounded fragments in their texture.

Colluvial fans

The northern faces of the Katrol hill range exhibits mountain front scarps where the steeply conical and dissected colluvial fans directly overlie the Jhuran or Bhuj Formation (Plate 3.11). The fans are composed of angular to sub-angular fragments of Mesozoic rocks embedded in loose sand or clay (Plate 3.12). Significantly large colluvial deposits are observed at the base of Khatrod hill scarp, south of Kukma village, Marutonk Dungar scarp south of Gangeshwar Mahadev, Lakki scarp near Shiv-paras temple, Northern faces of Tapkeshwari hills near Hamadra lake.

The colluvial fans at the base of fault scarps are indicative of their degradation. The presence of the majority of colluvial deposits along the E-

W trending faults if very conspicuous. The NNW-SSE trending fault scarps show very little or negligible colluvial material. This suggests comparatively recent activity along these faults. Total absence of gullies or projecting spurs along these scarps are further indicative of very recent movements. In contrast, the E-W fault scarps notably the Katrol Hill Fault shows evidences of erosion of the fault plane in the form of gullies and colluvial material. The colluvial material at the base are incised by various streams. The colluvial deposits at the base of Katrol Hill Fault are overlain by miliolite deposits suggesting that these deposits are of Early Quaternary age (Plate 3.13).

Miliolites

Miliolites occur as small inliers within the rocky area. Biswas (1971) compared these deposits with the miliolites of Saurashtra and described them as aeolian deposits with Saurashtra as their provenance. The miliolites occur as obstacle dunes and as sheet deposits and occupy low lying lands of the hills, topographic depressions within hilly areas and hollows in the slopes of high hills and ridges (Fig.3.2). The sheet miliolites (Plate 3.14) occurring extensively in the area are studded with cobbles and pebbles suggesting a fluvial component in the origin of these deposits (Plate 3.15). The sheet deposits mostly occur as steep vertical scarps along the banks of the various rivers (Plate 3.14).

In some parts of Katrol hills in their northern faces miliolitic (sandy biomicritic) rocks occur on the tops of these towering hills. The aeolian miliolites occurring as obstacle dunes are found on the southern faces of the

higher hills of Katrol range (Plate 3.16). These are also found in the wide valleys created within the Katrol range. A wide lower order stream of Khari, SW of Bhuj, on Bhuj-Mandvi road exhibits 8-10 m high miliolite cliffs (Plate 3.14) known as valley fill miliolites. They are also observed at the highest point of the hill range which confines the valleys. The lower part of these deposits comprises rounded to sub-rounded pebbles and cobbles while the upper part if finer. Miliolites are also found in the northern face of Bhujiya hill at a very great height.

Alluvial deposits

Alluvial deposits are confined within the various stream channels. These deposits occur along the river channel bounded by rocky cliffs. Within the uplands at places, these occupy the valleys bounded by cliffs of sheet miliolites indicating that these deposits represent post miliolite depositional phase. The sediments comprise mainly sandy alluvium deposited as channel deposits. In Gunawari river near Marutonk Dungar (Plate 3.17), and near Bhata Talav these deposits show faulted contact with the pre-Quaternary rocks (Plate 3.18). These faults trend either NNW-SSE or NNE-SSW. Immediately to the north of Mainland Fault in the Banni plains, these deposits show incision of 1.5 to 3 m.

Plate 3.12 Close up view of colluvial deposits showing unsorted, angular to sub-angular pebbly to bouldery clasts embedded in a gravelly matrix. (Loc. 5 km SE of Kukma village).

Plate 3.13 Photograph of a section in a gully at the base of Katrol Hill Fault showing Miliolites resting over colluvial material. (Loc. 4 km SE of Kukma village).

Plate 3.14 Valley fill sheet Miliolites forming vertical cliffs along a stream in Katrol Hill. Small mounds in the background are of Mesozoic rocks. (Loc. 11 km SW of Bhuj on Bhuj-Mandvi road).

Plate 3.15 Quarry section showing pebbles and cobbles of Mesozoic rocks in Miliolites indicating their fluvial origin. (Loc. 11 km SW of Bhuj on Bhuj-Mandvi road).

Plate 3.16 Aeolian Miliolites occurring as obstacle dunes on the southern slopes of Katrol Hills. (Loc. 11 km SW of Bhuj on Bhuj-Mandvi road).

Plate 3.17 Vertical cliff of Quaternary fluvial deposits unconformably overlaying the Jhuran shales in Gunawari river (Loc. 2 km south of Gangeshwar Mahadev in Gunawari river).

Plate 3.18 Quaternary fluvial deposits showing N-S trending faulted contact with the Juran shales near Bhata Talav.