Chapter - 4

THE AREA UNDER INVESTIGATION

IV. 1. PHYSIOGRAPHICAL AND TOPOGRAPHICAL UNITS:

As earlier mentioned, the area investigated by the author, forms part of the central mainland of Kutch, with exposures of Mesozoic and Deccan Trap rock sequences.

Four main topographical units including the following are very well recognised in the area (fig. 5):

1. The Northward gently sloping plain of low ridges;
2. The East-West trending Charwar hill ranges in the central part;
3. The South-Eastward gently sloping plains with small hillocks, and,
4. The East-West trending Deccan Trap hill ranges on the extreme South.

IV.1.1. The Northward gently sloping plain of low ridges:

The Northward sloping plains incorporate villages Madhapar, Bhujodi, Kukma, Mirjapur, Sukhpur, Kalyanpur and Bhuj town. All these usually comprise outcrops of Lower and Upper Bhuj (Umia and Bhuj) sandstones exposed as low ridges. The average elevations of these hills seldom exceed 100 mts. to 140 mts. above mean sea level (MSL). The entire area is gently Northerly sloping except the Bhujiya fort hill, raising 232 mts. above MSL and consisting of resistant basic intrusion.

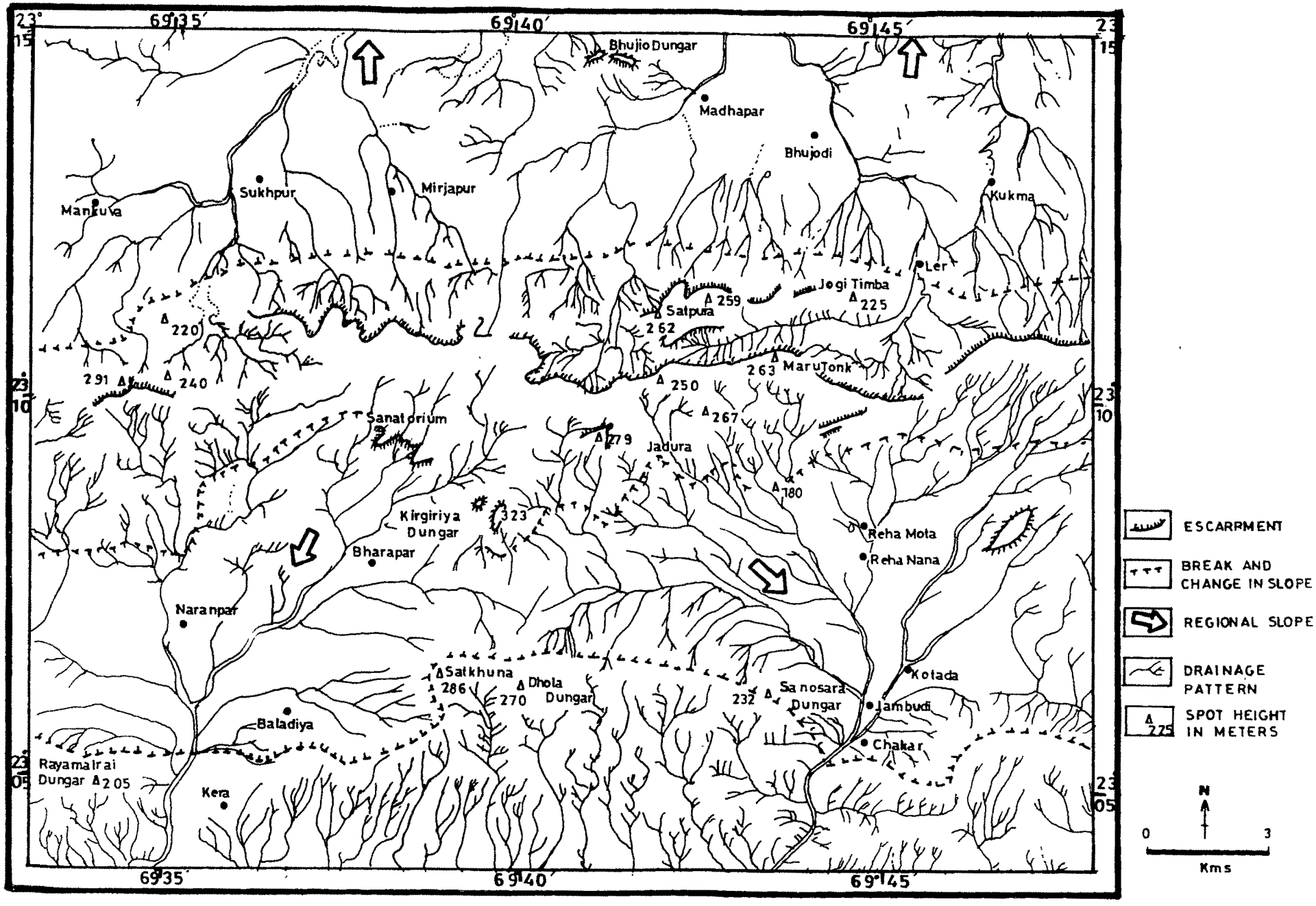


FIG 5 GEOMORPHOLOGICAL MAP OF THE STUDY AREA

IV.1.2. The East-West trending charwar hill ranges in the central part:

The middle portion of the area investigated is characterised by East-West running high ranges. These have very steep cliffy flanks facing the North and gentle sloping parts to the South. The villages surrounding these hills are Jadura Mota, Jadura Nana and the Bharapar Sanatorium. All these landforms predominantly display sandstones and shales of Mesozoic age occasionally penetrated by doleritic dykes. In general the average elevation in these ranges varies from 160 mts. to 200 mts. above mean sea level. Some of the prominent peaks in the terrain are:

1. Satpura dungar (262 mts.)
2. Marutonk (263 mts.)
3. Jogi timba (225 mts.)
4. Peak North-East of Jadura mota village (267 mts.)
5. Peak North-West of Jadura mota village (279 mts.)
6. Hill South-East of Sukhpur (258 mts.)
7. Peak South of Wandhay talav (240 mts.), etc.

IV.1.3. The South-Eastward gently sloping plain with small hillocks:

The Southern plain area is invariably composed of sandstones and shales of Cretaceous age. Here, the average elevation ranges from 140 mts.to 160mts. above mean sea level. Kirgiriya dungar (323 mts.) stands out as a prominent feature in the Northern central part of the plain and is the highest point in the area investigated. From here, this area is a gentle South-Eastward sloping. Sedat, Bharapar,

Naranpar, Baladia, Kera, Reha, Kotada, Jambudi, Chakar villages are situated on this slope.

IV.1.4. The East-West trending Deccan Trap hill ranges on the extreme south:

Another series of East-West running ridges parallel to the first one (Northern Charwar range), are observed at the extreme South in the area. These hill ranges also show typical characters similar to the Northern ranges, i.e. steep Northern face and gently sloping Southern flanks. The general elevation of the Southern hill ranges varies from 180 mts.to 270 mts. above MSL. The nearby villages on the North are Chakar, Baladia, Kera etc., while on the South are Jumkha, Warjhari, Bandra etc. These hills are covered by Deccan Trap lava flows. Some of the peaks, which stand out in the area are:

1. Satkhuna hill (286 mts.);
2. Dhola dungar (270 mts.);
3. Sanosara dungar (233 mts.), etc.

IV. 2. DRAINAGE:

There are three main rivers in the area viz., the Bhubhi or the Ganga nadi flowing towards South in the Southeastern part of the area; the Rudrani nadi also flowing towards South in the Southwestern part of the area (it is known as Nagvanti nadi after its confluence with tributaries from Northeast and Northwest directions in between Naranpar and Kalyanpar); and the Dhorava nadi flowing towards North from the Northern (Charwar) hill ranges towards Northeastern edge of the study area. The Gunawari nadi, a small stream, flows towards East

from its head region, which is a water divide in the Southern part of the Satpura dungar (262 mts.). While, the Mathal nadi, which is a tributary of the Bhubhi or the Ganga nadi flows towards the South from the Northern Charwar hill ranges in the Eastern part of the area. As could be studied from the topographic map, the major drainage is oriented either towards the North or the South with minor fluctuating change in drainage orientation toward Northeast, East, Southeast and Southwest. The Dhorava nadi, the Gunawari nadi, and the Rudrani nadi are non-perennial and influent in nature, whereas the Ganga nadi, the Nagavanti nadi and their tributaries being influent for major part, show effluent nature, when both of them pass through Deccan Traps. The Ganga nadi and tributaries have cut 40 mts. to 50 mts. deep gorges in the Trap country.

Many Northerly running streams are found to lose their course and disappear in the porous sandy country. Certain streams have meandering courses, when they pass through shale or clay country.

The drainage in the terrain can thus be grouped under following heads:

1. Dendritic drainage,
2. Rectangular drainage,
3. Localized radial drainage associated with rectangular drainage.

As could be seen from the drainage map (fig 5), the drainage that is initially rectangular, becomes dendritic, when number of streams meet together, and join the main streams.

The Charwar hill ranges, which occur South of Bhuj town, form East-West running water divide, which separates Northerly draining and

Southernly draining streams It also forms (occupies) source area of famous Hamirsar talav of Bhuj The line of higher elevation passing through (point) *225,*259, *262, *250, *258 and Tapaka devi temple hill form water divide. The Southern Deccan Trap hill ranges also form parallel lines of elevations dividing Southeasterly and Southernly drainage systems in the Southern part of the area. As could be ascertained from the field studies, the drainage is mainly controlled by lithology and structure.

The drainage system typically affects the water supply in the area investigated. Water supply for domestic purpose is a severe problem in the area covered by Jurassic rocks, i.e. in the central part of the area occupied by Northern Charwar hill ranges. Jurassic rocks yield saline and unpottable water. The Northern and central flat terrain, mainly occupied by the Cretaceous rocks, constitute potential source for domestic and other requirement of water. The chief source of water supply in the area, as such, are dug wells, tube wells, ponds, tanks, and rivers. In the Northern part of the area around Bhuj, and in the area covered by central valley portion, almost every village has a water supply scheme.

The depth of water table varies from 30 mts. to 35 mts., depending on elevation of ground and rock formations. Springs are common in the areas covered by Jurassic rocks, and also at the junction of Bhuj sandstones and Deccan Traps.

IV. 3. GENERAL GEOLOGY AND ROCK STRATIGRAPHY:

In the area under investigation the oldest rocks exposed are thick silty shales intercalated with thin bands of limestones, argillaceous limestones, calcareous sandstones, followed by shale-sandstone intercalations, sandstones, sandstone-shale intercalations and oolitic silty limestone (Dhosa oolites). These older rocks are exposed South of the Katrol fault in the Western part of Gangeshwar Mahadev, and belong to Chari series as per chronostratigraphic classification and Jumara formation as per lithostratigraphic classification of Biswas (1977). Dhosa oolite is followed by silty shale-sandstones, shales and sandstones of Katrol series (approximately lower and middle Jhuran formation), in turn succeed by silty to gritty sandstones of Umia series (approximately upper part of Jhuran formation and Bhuj formation). The Mesozoic succession is followed by Deccan Trap volcanics and Tertiary sediments which are exposed in parts of the area investigated. Very flat younger Quarternary Miliolitic sandstones are found covering many gentle hill slopes and deep lying valleys.

It is interesting to note that in the area under study, the Patcham and lower Chari Series rocks are not exposed. But successive rocks are found exposed, in the central part of domal structures (Amundra-Ler anticline) in between Madhapar and Jadura, in the Charwar range.As proposed by Pascoe (1959), Chari series, here, occupies rows of inliers in the Charwar range South of Bhuj, where the Chari beds are brought up at intervals along the Southern side of the great Katrol fault in form of anticlines. These rocks are further greatly disturbed and cut by faults. Still, however, the different bands can be easily recognised viz., the Dhosa oolite with Terebratula (lophrothyris) euryptycha kitch., the white Peltoceras (Athleta) beds, and the bands

with the so called Terebratula aff. biplicata are always conspicuous, in the field.

IV.3.1. CHARI SERIES:

This series derives its name from the village Chari, about 50 km. Northwest of Bhuj. It is composed of five stages, each marked by its mineral characters and fossils. As a whole, the group is much more shaly, but, hard bands of limestone or calcareous sandstone are included which form ridges and can be distinguished by characteristic *ammonites* (*Taramelliceras, Mayaitesmaya, Peltoceratoides, Euaspidoceras, Reineckeites, Orionoides, Indospinctes, Sivajiceras, Macrocephalites* etc.). The five stages in ascending order are: (1) Golden oolite stage, (2) Rehmanni stage, (3) Ancep stage, (4) Athleta stage, (5) Dhosa oolite stage. Out of these five stages, the Golden oolite stage is not exposed in the study area.

Rehmanni Stage: As to Pascoe (1959), the lower most beds exposed here are probably from Rehmanni stage. It is in between upper Macrocephalus limestones (Golden oolite stage) and the Ancep beds, in the type area Jumara, the rock is yellow limestone in which two zones of ammonites have been identified -

(2) *Reineckeia tyranniformis, Sivajiceras kleidos, Idiocycloceras singulare* (Spath).

(1) *Reineckeia rehmanni* (Oppel), *Kellawaysites greppini* (Oppel), *Sivajiceras cf. fissum* (sow.), *Idiocycloceras singulare* (Spath).

which are assigned to lower Callovian. A large number of *cephalopods*, various *echinoderms, brachiopods*, and *mollusca* also identified. In

the area under study, rocks from this stage are mainly silty shales intercalated with thin grey coloured argillaceous limestones and calcareous sandstones. Krishnan modified the age of these beds to middle Callovian after Arkell (1956).

Ancep Stage: The next higher stage comprises dark shales, often black with ferruginous bands and concretions, some times nodules are of white limestone. The shales are locally sandy and associated with sandstones. The chief palaeontological peculiarity of the Ancep beds is the extreme abundance of a *Terebratula* regarded by Sowerby as a variety of the Cretaceous *T.biplicata.* The shales frequently contain plant remains, but no determinable impressions are recorded. In Jumara section these beds have been divided into two zones:
(2) Upper 'Anceps' beds - *Kinkeliniceras sp.*, (yellow limestones) *Hubertoceras mutans* (waag.) *Reineckeites spp.*
(1) Lower 'Anceps' beds - *Reineckeia ? ravana Spath,* (sandy calcareous *Indosphinctes calvus* (sow.), shales) *Sivajiceras fissum* (sow.).

These beds comprise varieties of *cephalopods, brachiopods* and *lamellibranchs.* The age of the 'Anceps' stage is middle Callovian. The lower zone includes *Reineckia smithi* Spath, *R. ressi steinm* and other species formerly included under the term *Perisphinctes 'anceps'*- hence the name. Pascoe (1959) proposed the name ''Reineckeia'' stage in place of 'Anceps' stage including 'Rehmanni' stage.

Athleta Stage: This stage of Chari series is a relatively thin band of light grey shales, with layers of limestone, which are generally white but occasionally yellowish or brown in colour. Usually this stage is recognisable by its colour and its position beneath the Dhosa oolite.

In Jumara section, it has been divided into three zones:-

(3) *Metapelloceras spp., Peltoceras ponderosum waag. et. spp., Orionoides indicus spath.*

(2) *Peltoceras metamorphicum spath, Orionoides purpurus spath.*

(1) *Peltoceras spp. including P. kachhense spath; Reineckeites sp.*

These zones include more than one species of *Peltoceras*, especially *P. kachhense* of the lower zone, originally "*Ammonites (Peltoceras) athleta*", after which the stage has been named. The age of the lowest zone is lower Divesian, that of zones (2) and (3) upper Divesian. The Athleta beds contain *cephalopods, brachiopods, lamellibranchs*, vertebrae and fish remains. The age of Athleta stage has been modified to upper Callovian by Krishnan (1968) after Arkell.

Dhosa Oolite stage: Lithologically and palaeontologically the uppermost chari - the Dhosa oolite stage is most characteristic. It has limited thickness to few meters but generally is more developed than the Athleta beds, and consists of grey, reddish or brown oolite, sometimes sandy and often nodular. It contains abundant *cephalopods* and at many places there are large number of *Terebratula* named by Dr. Kitchin as *euryptycha* closely related to *T.elleridgei* of the English Inferior Oolite. At Jumara the following zones have been established.

- Green Upper Dhosa Oolite

3. *Taramelliceras jumarense spath, lithacoceras aff. krentzi Siem.*

- Brown Lower Dhosa Oolites

2. *Mayaites maya (sow.), Peltoceratoides semirugosus (waag.).*

1. *Euaspidoceras p.*

Zone 1 is equated with the upper Divesian (*renggeri* zone), zone 2

with the lower Argovian (*cordatus* zone), and the zone 3 with the upper Argovian (*transversairus* zone). The Dhosa oolite, therefore, includes the topmost Divesian and most of the Argovian. Now a days terms Divesian and Argovian are out of date and in place of it term Oxfordian is used. It marks a break in the uniformity of the deposits; at places it is a brown oolitic rock, often conglomeratic, with its fossils corroded and coated with oysters and showing limonitic crust. Its most characteristic feature is the presence of gigantic ammonites of the type of *Stephanoceras* (*Epimayaites*) *polyphemus* (*Waag.*).

As to Singh (1989), this stage represents transgressive condensed horizon at the time of lower Oxfordian followed by a hiatus during middle and upper Oxfordian. The Dhosa oolites contain abundant *cephalopods, brachiopods, pelecypods* and fossil wood on top part of upper band. Krishnan (1968) gave upper to lower Oxfordian age to this stage after Arkell (1956).

IV.3.2. KATROL SERIES:

The Katrol series is of considerable thickness, which rests upon the uppermost subdivisions of the Chari beds. It consist of sandstones of various kinds - white, brown, pinkish, grey etc., and shales which are usually gray or reddish, but are some times very dark coloured - carbonaceous shales, prevail towards the base of the group and some times contain ferruginous nodules and concretions. Although shales on a whole predominate, the upper portion is composed largely of sandstones. The Katrol series has been divided into three main divisions:

(1) Lower Katrol stage,

(2) Middle Katrol stage,

(3) Upper Katrol stage and Gajansar beds.

Lower Katrol Stage: The earliest fauna, as to Pascoe (1959), of the Katrol series has been collected mostly from the 'Katrol Ammonite beds' of Ler and neighbouring localities in the Charwar range, preserved in a dark phosphatic grit and dark red to black limonitic bands. As to Dr.Spath [in Pascoe (1959)], the fauna of the basal Katrol bed appears to belong to middle Kimmeridgian rather than lower.

These beds consist of gray, calcareous and gypseous shales and gray to brown, calcareous, occasionally micaceous and gritty sandstones. Agrawal (1957) recorded the occurrence of *Trigonia (Indotrigonia) katrolensis* from these beds. The bands of shales and sandstones alternate and former contains ferruginous concretions having *Oppelia* and *Haploceras* as the core.

Here, *Phylloceratids* for the first time appear in large number. The main features of the fauna are: the increase in the number of species of *Oppelids* and *Aspidoceratids*, the comparative rarity of *Perisphinctids* other than *Torquatisphinctes* and complete absence of *Euaspidoceras* and *Ataxioceras*.

Middle Katrol Stage: Above the basal Katrol phosphatic grit and accompanying shales, follow various brown and red ironstones from some what varying horizons consist of fauna allied to the lower Katrol assemblage and approximately homotaxial to the European

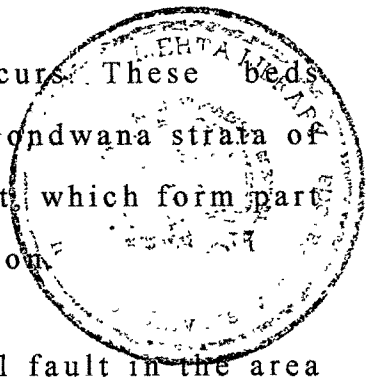
(*Steraspis* zone or *Gravesia* beds of the) middle Kimmeridgian. The abundance of *pachysphinctes* and *katroliceras* is the most notable feature of the middle Katrol assemblage. This division consist of a monotonous sequence of shales with minor intercalations of sandstones and fossiliferous marls.

Upper Katrol Stage and Gajansar Beds: The middle Katrol shales with their fossils are followed first by barren shales and then by a great thickness of Katrol sandstones equally devoid of *ammonites*. A fauna believed to be younger than the Katrol faunas so far considered, but, older than the Tithonian Umia assemblage has been described by Dr.Spath from Gajansar. Pascoe (1959) designated these beds to Portlandian (now a days lower Tithonian). Krishnan (1968), after Arkell (1956), placed Gajansar beds in slightly upper position claiming that it belongs to middle Tithonian with leading fossils *Belemnopsis gerardi, Streblites gajansarensis, Phylloceras cf. plicatius, Hildoglochiceras spp.*, while upper Katrol which assigned to lower Tithonian contains fossils of *Aulacosphinctoides meridionalis, Virgatosphinctes indosphinctoides.*

IV.3.3. UMIA SERIES:

As a whole, the Umia series, called after a small village in Western Kutch, is equal in development to nearly all Jurassic sequence below it. As a rule, it consists of sandstones of various kinds and more or less sandy shales. The sandstones are usually soft, friable, white or pale brown in colour, occasionally variegated pink, red, and often very argillaceous with a tendency to decompose into a loose, sandy soil. Among the sandstones, there occur a few bands of thin, hard, quartzitic sandstone or black brown ferruginous

grit. In a few instances carbonaceous shale occurs. These beds show a marked resemblance to some of the upper Gondwana strata of central India. In some oolites glauconite is present, which form part of the Umia succession, suggests slow sedimentation.



The Umia series covers Northern part of the Katrol fault in the area investigated, extending East to West around Bhuj town as well as East-West trending plains North of the Deccan Trap range and South of the Charwar range.

Towards the base of this series, there is a thick band of hard gray, yellow, calcareous conglomerate, occasionally ferruginous, associated with sandstones and shales. In this conglomerate and associated beds marine fossils are numerous. Throughout rest of the group, marine fossils are rare but plant remains are common, but often not sufficiently well preserved to be identified. The basal Umia bed has yielded *cephalopod* fauna which indicates at the latest a lower Tithonian or even possibly an uppermost Portlandian age. Important fossils for correlation purpose are *microacanthoceras* and *virgatosphinctes*. While Krishnan (1968) considered this bed to the upper Tithonian.

Above this Tithonian Ammonite bed - separated by approximately 60-90 mts. sandstones - there occurs a *Trigonia* bed capped by upper Umia shales and sandstones. *Trigonia smeei* is the most typical fossil, others are *Trigonia ventricosa, T.crassa* and *Astarte major.* This *Trigonia* bed is assigned to lower Neocomian. The same is proposed to be Valanginian by Krishnan (1968). From the basal 15 meter sequence, coral *Stylina* recorded by Rajnath (1932).

The plant remains of the Umia series assigned to the uppermost Jurassic or the base of the Neocomian. But later on Krishnan (1968) placed barren sandstones and shales above *Trigonia* beds, and Bhuj beds (Umia plant beds) in upper Neocomian and post-Aptian respectively and included Rajnath's Bhuj series as Bhuj stage within his Umia series. The uppermost beds of Umia series are covered unconformably by the Deccan Traps.

Pascoe (1959) compiled his classification from all available data, and as we have discussed, he described each unit giving the lithological and palaeontological characteristics, however, did not include the Bhuj series in the classification.

IV. 4. STRUCTURE:

The area under investigation shows a very good conformity of structures with topography. Domes and anticlines usually stand out as hills, while synclines form valleys.

The rocks generally show a regional East-West structural strike. This East-West trend, as suggested by Deshpande (1972) reflects the trend of the Precambrian basement in the area.

An interesting and striking feature of the area is the existence of a number of anticlines and domes with intervening synclines. Furthermore, folding and faulting are interrelated. The major fold system in the area include - (1) Walakhawas anticline, (2) Amundra-Ler anticline, (3) Katrol hill anticline, (4) North-West part of Nigat-Harudi-Brachi anticline, (5) Kukma syncline, (6) South-West part of Pur

river syncline, (7) Bhuj anticlinal nose, (8) Kalyanpur nose, (9) Tapkadevi-Sanatorium syncline (?), (10) Charwar range flexure zone (fig. 2 & 6).

The main fracture and fault zones found in the area are:

(1) Katrol hill fault in East-West direction with associated flexures.
(2) East-West running fault South of village Bhujodi alongwith flexures.
(3) Marutonk dungar fault running in Northwest-Southeast direction, filled up with doleritic dyke extending from North of Reha mota to South of Jamaywadi, affecting Jurassic (Chari and Katrol) rock sequences.
(4) Fracture zone appx. 4 km., South of Bhuj on the way to Tapkadevi extending on both the sides of Katrol hill fault (in N30°W -S30°E direction), associated with doleritic intrusion in Katrol rocks; while fractures extending in Bhuj rocks in N30°W - S30°E to N - S directions are empty.
(5) Satpura dungar fault and a fault North of Reha mota village, in ENE - WSW direction; both are affected by NW - SE running Marutonk dungar fault and affecting Jurassics only. Satpura dungar fault associating a flexure zone having compact folds with nearly vertical pitch.
(6) A fault running in NNW - SSE direction in Katrol rocks North of Satpura dungar.
(7) Fault zone in ENE - WSW direction in Tapkadevi region.
(8) ENE - WSW to E - W trending fracture zone containing sandstone dykes.

The interesting features in the area are the asymmetric major anticlines and domes that have sub-vertical fore limbs near the faulted margin

and gently dipping back limbs at the back slopes (especially Charwar hill range). The folds having such characters are termed as unilateral box fold (Beloussov, 1968, p75-76).

In the central part of the anticlines and domes, particularly, Amundra-Ler anticline, rocks are nearly horizontal with neighbouring highly inclined fringe of the anticline. These very often hallucinate image of an angular unconformity.

Katrol hill fault produces a sharp flexure (Charwar range flexure zone) with a chain of folds along it, mainly synclines with both the limbs dipping at high angles. The Katrol hill fault is a vertical high angle reverse fault frequently passing into vertical to steeply inclined normal fault - a kind of 'up thrust' fault (Prucha et. al., 1965, p970). Another characteristic feature for the Katrol fault is its subsidiary longitudinal boundary fault, whose upthrow side lies towards South while the downthrow side is on the North, and it though results into a series of step faults occurring in Kutch. The rocks of Chari and Katrol formations are variedly affected by this fault. The rocks on upthrow side are less crushed in comparison to the highly friable sandstones of Bhuj formation towards downthrow side. Ofcourse, the rocks on the upthrow side are highly upwarped and folded near fault zone.

The step faulted blocks have Southward tilt with North side up, which have produced down throw basins towards the North and half grabens in the South (Weeks, 1952, p.2089-2105). The sedimentary strata on these basins have synclinal form.

The forelimbs of flexures (Charwar range flexure zone) - synclines and anticlines near the Katrol hill fault dip at an angle of 30° to 90°, while back limbs show dip around 10°- 40°, which appear to be quickly flattens, away from the fault. The flexure zones are cross folded to produce a string of elongated domes and basins. At times flexures near fault zones are over turned forming inclined isoclinal folds.

As suggested by Biswas (1980), other faults occur as tensional and shear faults, which are localized (in the tension and shear zones of the basement).

The rocks of the area under investigation, show two prominent directions of joints parallel to dip direction and bedding. The joints are seen radiating from the center of domes and anticlines.

The Mesozoic rocks in the area are further found intruded by several doleritic dykes and a plug consisting of rhyolitic breccia with ash material and fragments of country rocks (North of Jadura).

Most of the above described structures are confined within the limits of Mesozoic rock exposures, studied by the author.

IV. 5. SOIL COVER AND VEGETATION:

Vegetation cover in the area is very thin and scanty. The area having Jurassic sediments usually consists of a very thin and poorly developed vegetation cover. The sandstone plains and high grounds, East of Sanatorium, surrounding Kirgiriya dungar and area West of Bhuj (known as Mochirai), contain a dense cover of xerophytic vegetation.

In similar way, in valley areas and near reservoirs of check dams and tanks, dense shrubs are developed. Trap ranges are typically devoid of thick vegetation.