CHAPTER 4
GEOLOGY OF THE AREA
4.1. REGIONAL GEOLOGY

The regional geology of the area was studied by the officers of the Geological Survey of India and the Exploratory Tube Wells Organisation. The significant contribution is made by Theobold (1960), Blanford (1869), Crookshank (1936), Medlicot (1873), De Terra and Paterson (1939), Joshi (1958), Khatri (1961), Gee (1926), Awasthi (1951), Kailasam (1954), Rao (1961, 1965), Raychoudhary et al (1963), Rao and Subba Rao (1961), Adyalkar (1975) and Soni et al (1987). They recorded the principal rock formations, namely, Granitic complex, Bijawarls, Quartzites, Calcareous, Crystalline, Vindhyan sandstones (shales & limestone), Gondwanas (Talchirs, Barakars, Moturs Bijoris, Pachmarhis, Denwas, Bagras, Jabalpur, Lametas and Deccan Traps.

The author has prepared a geological map by land-Sat Thematic Mapper false colour composite on 1:250,000 and shown in fig. 4.1. The general geological succession of the study area and its surrounding terrain is given in table 4.1
FIG. 4.1 REGIONAL GEOLOGICAL MAP OF THE AREA
(BASED ON REMOTE SENSING DATA WITH SELECTIVE FIELD CHECKS)

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- Lower Gondwana
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**4.1.1 Archaean Super Group**

The metamorphics and crystallines belonging to the Archaean Super Group are undoubtedly the oldest in the area, with the granitic gneiss simulating the Bundelkhand granite forming possibly the oldest basement in the terrain. The main characteristic features of the granitic or the granitic gneiss is its massive structure with obscurely developed foliation and rarity of accessory minerals. It is a medium to coarse-grained rock consisting of quartz, orthoclase and hornblende. Quartz is of whitish or bluish grey in colour. Orthoclase usually red or pink colour in large cleavable crystals up to five centimetres in length, is usually the dominating feature of the rock to the extent of attributing its colour and general characteristics to it. Hornblende is usually dark coloured in less abundant quantity, and often partially or wholly replaced by
chlorite and mica Plagioclase felspar is sometimes present. Foliation is not quite clear, but when discernible the plane of foliation is more or less vertical striking generally ENE-WSW. The rock generally weathers into large spheroidal blocks. Quartz veins varies in thickness from a few centimetres to as much as hundred centimetres.

A few scattered outcrops of granite and granitic gneiss are present in the area. The Madan Mahal hill 6.5 km north-west of Jabalpur forms the eastern outcrop. Few outcrops occur to the south and south-west of Narsinghpur and one to the south-east of Piparia. They occur along the southern fringe of the Narmada alluvium, and forming the faulted southern scarp in parts of Hoshangabad, Narsinghpur and Jabalpur districts. They generally seen to project as inlier through the Narmada alluvium or through the host of other younger rocks.

4.1:2 Bijawar Group

The Bijawar rocks occur in a few scattered but well developed isolated outcrops located mainly north and east of Narsinghpur and in either case along the inner fringe of the upland valley. They are directly resting on the weathered surface of the granitic mass, almost horizontal or with a slight dip. They consist of quartzites which are no better than the fine-grained
sandstones, with a basal conglomerate containing pebbles of white quartz (Roday et. al. 1989). Inter stratified with the quartzites are the limestone breccia and the limestone. Both the breccia and the limestone are highly siliceous with the quartz appearing as thin layers or as irregular cherty segregations. The quartzites are banded ferruginous, and often associated with iron and manganese ores and basic sills. The younger members of the Bijawar sequence consists of shales, phyllites, chlorite and mica-schists. The granitic rocks at the contact of the schists and phyllites are converted into gneisses and the basic rocks epidioritised. The Bijawars are often locally disturbed accounting for the breccias as a result of crushing.

4.1:3 Vindhyan Super Group


In the tract immediately north of the Narmada valley, the lower Vindhyan in the form of Semri Group occurs as scattered inliers (Photo 4.1) in Sagar district in an otherwise continuous belt of Bhander
rocks. This occurrence is probably due to the unevenness of the floor of the older rocks on which they were deposited. These are yellow or yellowish brown, thinly bedded, slightly crumpled and micaceous, but not very fissile shale at the foot of the hill, forming the western lip of gorge.

Upper Vindhyans namely Kaimur. Rewa and Bhander groups of rocks have a thickness of three to four times that of the lower Vindhyans. In the Narmada valley South-east of Bhopal, rocks of the Kaimur group occur as escarpments bordering it on the northern side in Sehore and Raisen districts of Madhya Pradesh, Where they comprise Conglomerate (Phot.4.2) and sandstones (Photo.4.3 a & b) of red and brown colour. According to Auden (1933), the Kaimurs were deposited under fluviatile condition. Due to limitations in the outcrops, other lithological units of Kaimur are not observed in the area immediately north of the Narmada upland valley.

The rocks of the Rewa Group have been deposited upon the sloping floor of the older Kaimurs. These rocks have a thickness more than 300 metres near Katangi and about 1825 metres north of Hoshangabad in the Narmada valley, while in Dhar area further west is of the order of 3000 meter. Here, the Rewa sandstones, both upper and lower members, with an intervening thin band of soft Jhiri shales (Photo.4.4) occur as purplish,
quartzite rocks with frequent ripple marks and conglomerate.

The rocks of the Bhandari group are very extensive in their areal extent by virtue of their occurring in a very flat basin. In the area north of the Narmada valley, considerable portion of the Bhandari lies underneath the trap cover, with the result that the inliers of the Ganurgrah shales at the bottom and the sirbu shales at the top are of usual shaly type. The Bhandari limestone is the most variable rock unit of this group. It is peculiar concretionary variety generally compact, earthy and of grey, yellow or reddish colour. It weathers into smooth grey slabs with distinct but moderately thick bedding often varied with yellow and brown argillaceous bands. Bhandari sandstone of both lower and upper horizon, occur east of Bhopal.

The rocks of the Vindhyan sequence in the area north of the Narmada upland valley lies in a W.N.W.-E.S.E. synclinal axis with a northerly dip of $10^\circ$-$15^\circ$. From the relatively unaltered condition of the Bhandari, it can be inferred that the younger member of the Vindhyan have not been subjected to any great super incumbent pressure, which has affected the older groups. The sedimentary structures seen in the upper Vindhyan are ripple marks, current bedding, rain prints and
load cast. At few places, pot holes are also seen in the Vindhyan limestone.

4.1.4 GONDWANA SUPER GROUP

The rocks of this group in the area lying unconformably on the older group of metamorphics. The Lower Gondwana in the area, lying distant south of the Narmada upland valley and extending right upto Kamthi (24° 14' : 70° 1.2') in three or more discontinuous patches, are represented by the rocks of Talchir and Demuda groups.

(a) LOWER GONDWANA

Talchirs are represented by fine greenish grey or alive shales and soft sandstones underlain by a boulder bed. The composition of boulder is similar to the Vindhyan quartzite sandstone and limestone. The boulders vary in diameter from five to as much as twentyfive centimetres and are relict of their movement from a far off place in the form of their flattened and also possibly straited facts. They are thus relict of the past glacial activity, when the glaciers are reported to have moved from the Vindhyans highlands south-eastward down to the Pranhita-Godavari valley, leaving their imprint enroute at the reported occurence for south of the Narmada upland valley. Talchirs also occur continuously along the southern boundary of the
main Satpura Gondwana belt immediately south of the Upland Narmada valley. At the head of Tawa Valley, they are very thick and well exposed on the hill sides. They are also exposed along the northern half of the boundary where they are faulted and very much disturbed. Their outcrops in an east-west line have been recorded at the following:

* At Nibhora (22° 46' : 78° 59') west of Dudhi river where the Bagra conglomerates rest on them.
* At Mohpam on the Chitarewa river, they are associated with the Barakars.
* In the gorge of the Anjan river at its junction with the Pathapani above Fatehpur (22° 42' : 78° 31') as two small separate inliers in the Denwa beds.
* A small inlier at south and a little east of Pindarai (22° 42' : 78° 28').
* Three large outcrops located south-east, south and south-west of Piparia railway station where they are overlain by the Denwa Beds or trap intrusion. There are two or three inliers of Archaean metamorphics. Deccan Traps are also associated with the Talchirs. In the Satpura region, the Talchirs are estimated to be of the order of 300 metres in thickness.
Talchirs are overlain by the rocks of Damuda group which are represented by the rocks or Barakar, Motur and Bijori formations. The rocks of the Barakar are much coarser than the Talchirs sediments over which they lie excluding the boulder bed. It is composed of white to fawn coloured sandstones and grits with occasional conglomerates and shales including carbonaceous shales and rich coal seams. The sandstones are generally coarse, current bedded and highly felspathic. A common sequence in the area is that of a sandstone, often Pebbly, followed by a shale or carbonaceous shale and a coal seam overlain by a coarse sandstone or grit forming the roof of the seam and this is followed again by a fresh cycle of rhythmic succession. The thickness of the Barakars in the Satpura region is reported to be 150 m. The sediments are well sorted and of fluviatile and/or lacustrine origin. The evidences of this are the presence of coal, frequent splitting of coal seams in lateral extension, association of terrestrial flora, coarseness associated with current bedding of the sandstones and direct passage of coal seams into carbonaceous shales. The Barakars are faulted with both strike and dip faults, with the result that the general northerly dip of $60^\circ$ to $10^\circ$ is often attenuated along the east-west strike faults.

The rocks of the motur formations are essentially
thick, soft, coarse, earthy white, grey or brown sandstones with lenticles of clay and shale the latter usually sandy but rarely carbonaceous. The clays are calcareous and when unweathered buff to pale green in colour giving rise to mottled red near the weathered surface, a characteristic in which they resemble the older Talchir clays. The thickness of the Motur formation in the Satpura region ranges from 1200 to 1750 metres. The Moturs, unlike the Pachmarhis, do not occupy precipitous scarps but produce a more barren form of debris than stiff white soil of older rocks.

In the Satpuras, the youngest member of Damuda group is represented by the rocks of Bijori formation exposed in Denwa valley at the southern base of the Pachmarhi hills, where they extend for over 100 km. between the Moturs in the south and the Upper Gondwana in the north, with two small faulted inliers northwards. The rocks of Bijori formation comprise micaceous flagstones, sandstones and shales, the latter occasionally Carbonaceous. They differ from the Denwa clays of the Upper Gondwana sequence from their more shaly and micaceous nature in addition to being fossiliferous. The thickness of the Bijori formation, west of Pachmarhi is only 180-240 metres. There are several minor faults resulting in the rolling down of the beds and developing a northerly dip under the
Pachmarhis.

(b) UPPER GONDWANA

In the Satpura region, the junction of the Bijori of the Lower Gondwana with the Pachmarhis of the Upper Gondwana is faulted and typically unconformable south of the upland Narmada valley as seen clearly to the east of Tamia (22° 21' 78° 40'). It is further evidenced by the irregular nature of the junction with rises and falls, sudden change in lithology, topography and flora and change of dip at some places. The rocks of the Damuda group of the Lower Gondwanas are overlain unconformably by the rocks of the Upper Gondwana represented by the Lower Mahadeva group and the Upper Jabalpur group, all lying immediately south of the upland alluvial valley under which they possibly extend northwards. The Mahadevas are subdivided into Pachmarhis, Denwa and Bagra formation in ascending order but their distinction laterally are not so sharp with the result that the pachmarhis are seen to merge eastwards with the following Denwas, and the latter with the succeeding Bagra with insible gradations. The rocks of this group have a maximum width of about 40 km. in the central part close to Pachmarhis. The maximum thickness of the beds is not exceeding 1500 metres.

The rocks of the lower Pachmarhis formations
consist of soft, coarse, white sandstone with intervening thin pebbly horizons. These coarser layers include angular chips of felspars but not to the extent they form part of the motur beds. Pachmarhis, have throughout red clays at their base. In the type area the Pachmarhis occupying hith ranges of hills and vertical scarps attain a thickness of 1000 meter which at places dwindles to that of mere 150 metres. Pachmarhis are reported to give rise to typically barren soil of its kind suitably only for lowlying shrubs. They are considered as lacustrine or more particularly the sand bank deposits, derived from the southern hills as evident from the absence of Jasperoid Pebbles in them. They give rise to typically barren soil of its kind suitable only for lowlying shrubs.

The rocks of the Denwa formation Comprise principally, soft, thick, variegated Clays are stratified with discontinuous and subordinate bands of white and yellow sandstones(Photo.45). These are exposed in the westernly course of Denwa river, and in the valley of the Dudhi, north of the Pachmarhi plateau, where they present a marked contrast to the massive Pachmarhi sandstones over which they lie conformably and into which they merge laterally. Denwa clays are calcareous. Containing often calcitic nodules. The colour varies from green, buff to red. They are more
soft than the younger Jabalpur and the older Pachmarhi sandstones.

The rocks of Bagra formation overlie the rocks of Denwa and Pachmarhi formations which are exposed in the northerly course of the Tawa river in the Satpuras and lie along the northerly fringe of the Gondwana outcrops immediately south of the Upland Narmada valley. These are more calcareous than Denwas but composed of conglomerate and pebbles beds with occasional bands of calcareous sandstones, variegated clays, limestones and even dolomites. The pebbles and boulders are very well rounded and of many kinds including the Jaspers and Jasperoids derived from the Bijawars and Vindhyan rocks. The Denwa-Bagra sequence increase in thickness from zero in the east to as much as 500 metres in the west.

The rocks of the Jabalpur formation extend from Southern Rewa west words upto south-east of Hoshangabad, where they cap the northern hills of the Satpuras. The rocks of the lower chaugan formation and the upper Jabalpur formation are considered similar except for palaeontological concern. Jabalpur rocks lie conformably over the rocks of Bagra-Denwa formation in the Chitarewa and Dhudhi valley, but in other parts of the Satpura they seem to lie unconformably over the Bagras, Denwas, Pachmarih, Bijoris and the gneisses, and
in turn are overlain by the Lametas and/or by the Deccan traps. They consist of soft, massive, Porous sandstone alternating with soft white clays. These are in addition thin subordinate beds of conglomerate, earthy hematite, shale, red clay and chert. The basal bed is generally compact quartzitic sandstone overlapping the Mahadevas or the gneissic rock or else conglomeratic with the pebbles of earthy rock in a porcellanic condition. The thickness of the Jabalpur formation is about 300 metres. These are highly fossiliferous.

4.1:5 LAMETA GROUP

The rocks of the Lameta group underlie the upper Gondwana and overlay the Deccan Trap. They comprise light coloured limestone, sandstones and clays or shales of fresh water origin. Limestone is the most persistent bed either in pure form or in most other cases full of sand and gravel assuming calcareous grit which is occasionally associated with cherty bands due to silicification. Where they rest on the crystalline and the metamorphics rocks, the latter generally present denuded upturned edges. Further, the contact of the Lametas with the overlying Deccan Trap in Jabalpur an Narsinghpur districts is conformable. Dinosaurian faunas are found in the Lametas. The thickness of Lametas varies from 20 to 50 metres in the Satputra region.
4.1.6 DECCAN TRAP

Deccan Trap overlie unconformably all the older formations and occurs in the form of volcanic flows, dykes and sills throughout the area of its occupation, including that around the Tapi and Purana upland valley and along the north and distant south of Narmada Upland valley. It is always some form of basalt or dolerite, the prevailing type being a dark green or nearly black basalt with out olivine. There is a wide variety of textural characters presented by the rocks of Deccan Trap. Exfoliating concretionary structure in the form of spheroids is observed on the weathered surface. Columnar or roughly columnar structure (Photo 4.6) is found in the lower flows of Malwa Plateau as also west of Hoshangabad and in Gouilgarh hills. Sometimes red bole bed 3.3m. or more in thickness is encountered below the massive trap but generally overlying the vesicular member. Deccan Traps are remarkable in their persistent flatness with a gentle or very gentle dip towards north in the upland valley region. Occasionally, the junction between the two trap flows are marked by an inter-trappean bed, 0.3m. to as much as 6m. or more in thickness with very limited area extent, comprising thin bands of chert, limestone, shale or clay and rarely sand gravels, pebbles and boulders.
4.1.7 ALLUVIUM

The alluvial formations of the upland basin of Narmada are in the form of prism or pyramidal frustums. They are thickest near the southern margin and thin near the northern margin of Narmada basin. The Narmada alluvium comprises over 364m. thick alluvial deposits filling the faulted trough of the Narmada rift valley and occupies the valley region over 325 km. long from Jabalpur to Harda and 65 km. wide in its broadest Tonga (22° 3' : 78° 22') Dukrikhera (22° 39' : 78° 22') section in the districts of Jabalpur Narsinghpur, Hoshangabad, Sehore and Raisen. The river Narmada almost occupies a somewhat northerly part of the valley. The great plain is composed of stiff, reddish, brownish or yellowish clay with numerous intercalated bands of sand and gravel. While Kankar abounds throughout the deposit, Pisolitic iron granules occur frequently in the argillaceous beds. Between Hoshangabad and Narsinghpur, old river terraces are rising to about 35 m. above the stream.

4.2 GEOLOGY OF THE STUDY AREA

The study area consists of only alluvial formation of Narmada river (fig 4.2). It comprises clays, sands, gravels and boulders together with pieces of agate, chalcedony, calcareous nodules, etc, all evidently derived from the surrounding trap country and
FIG. 4.2 GEOLOGICAL MAP OF TAWA COMMAND AREA, HOSHANGABAD DISTRICT (M.P.)
(BASED ON REMOTE SENSING DATA WITH SELECTIVE FIELD CHECKS)

LEGEND

**KARMAHA ALLUVIUM**
representing the distance to which the materials have been carried. Top clayey layer of Narmada alluvium varying from a metre to a few metres and merging with the gravel conglomerate bed along their southerly fringe, is often separately delineated as "Black cotton soil".

There are also a few tiny outcrops of laterite located in the vicinity of Itarsi. It is essentially a loose, ferruginous, porous or cavernous material of brick red colour with gravelly texture derived essentially from the basalt where gravels and pebbles are often encloses. The fact of the particular significance is that detrital laterite is also reported from various depth ranges of the bore holes located at Magarmuha, Sawalkhera and Pawarkhera of the upland Narmada valley. These are helpful in interpreting the paleoageography of the upland valley region of the Deccan peninsula.

4.3. SUBSURFACE GEOLOGY

With large number of scattered boreholes throughout the length and breadth of the Tawa Command area, an attempt has been made to get a realistic picture of the subsurface geology of the area. The bore holes are neither evenly distributed nor are they aligned in certain specific traverse and/or longitudinal
FIG 4.3 LINEAMENT MAP OF TAWA COMMAND AREA HOSHANGABAD DISTRICT (M.P.)
(BASED ON REMOTE SENSING DATA WITH SELECTIVE FIELD CHECKS)

LEGEND

LINEAMENTS
direction. Hence, it is preferred to draw one section along the lines of boreholes covering the entire length of the area in the SW-NE direction for subsurface correlation of the litho-units. The lithological logs of the boreholes supplied by the driller have been used in the preparation of the Section. Generally, the deep boreholes have been considered for preparation of the section. The lithological logs of boreholes are given in appendix 4.1. Location of representative bore holes are shown in Fig 4.4. Along the Sontalai-Chandon line of the geological Section (Fig 4.5) are located the bore holes drilled in the villages Sontalai, Timurni, Pagdhal, Dharamkundi, Sawalkhera, Hoshangabad, Ari, Babai, Semri, Sobhapur, Piparia, Nibhora and Chandon. Out of these boreholes, the Piparpani and Kherua falls out side the command area but these are taken into consideration for the lateral correlation of the litho-units. The section line represents SW-NE direction covering a distance of about 195 kilometres in Hoshangabad district of Madhya Pradesh. The profile is almost a level ground, except for the broad depression of the Narmada valley and a few sharp ones to account for the rivers. Coming to the diagrammatic geological section profile, it is better and more revealing to proceed north-eastwards from Sontalai. At Sontalai forming a horizon of dolomitic limestone is encountered
FIG. 44. LOCATION MAP OF REPRESENTATIVE DEEP TUBE WELLS
DRILLED IN THE TAWA COMMAND AREA M.P.
at a depth of 111.53 metres below ground level (i.e. 186.47 m. above MSL); productive granular zone comprising sands and gravels is limited to a depth of 35.05 metres below ground level. The thickness of this zone is 6.99 metres. The boreholes located at Timurni is shallow but it is drilled upto the bed rock. The horizon of basalt encountered at a depth of 28.35 metres below ground level; a gravel bed is encountered at a depth of 17.37 metres below ground level having a thickness of 3.66 metres; a sandy clay horizon struck at a depth of 27.43 metres below ground level. Its thickness is very limited i.e. 0.92 metres. The total depth of this borehole is 32.61 metres below ground level. The borehole located at Pagdhal is also drilled upto the bedrock. A horizon of basalt is encountered at a depth of 63.40 m. below ground level; a productive groundwater zone comprising gravel, medium to coarse sand and some clay is struck at depth of 16.76 metres below ground level. Second productive granular zone is encountered at a depth of 63.40 metres below ground level having a thickness of 3.05 metres. In Dharamkundi borehole, bed rock of quartzite is encountered at a depth of 118.26 metres below ground level. A granular zone of coarse sand mixed with little clay is encountered at a depth of 9.45 metres having a thickness of 2.44 metres. The second zone is struck at a depth of 15.24 metres having a thickness of 6.71 metres below
ground level. Borehole located at Sawalkhera is a shallow but drilled up to the bedrock (basalt) which is encountered at a depth of 27.43 metres below ground level. In this borehole no granular zone is encountered. The borehole located at Hoshangabad is drilled up to a depth of 60.96 metres below the ground level. A very thick productive granular zone comprising gravel, coarse sand with some pebbles and boulders are encountered at a depth of 16.76 metres. It has a thickness of 41.15 metres.

In Ari borehole, the bed rock namely hornblend granite is struck at a depth of 188.37 metres; the granular zone consisting of fine to medium sand, gravel with fragments of quartz and jasper is encountered at a depth of 6.71 metres below ground level having a thickness of 31.39 metres. The borehole located at Babai is not drilled up to the bed rock. The total depth of this borehole is 137.16 metres below ground level; first granular zone comprising sand with some clay is encountered at a depth of 6.10 metres having a thickness of 6.70 metres; the second granular zone is struck at a depth of 19.20 metres consisting of coarse sand and gravel with fragments of chert and jasper having a thickness of 34.45 metres; the third granular zone consisting of fine to coarse sand is struck at a depth of 59.44 metres. It has a thickness of 43.50 metres.
In Semri borehole, the bed rock quartzite is encountered at a depth of 170.38 metres below ground level; first granular zone is struck at a depth of 30.48 metres below ground level having a thickness of 15.24 metres with coarse sand and gravel; second granular zone of gravel with fragments of jasper is encountered at a depth of 58.39 metres having a thickness of 3.05 metres; third granular zone consisting of gravel with kanker occurs at a depth of 143.26 metres having a thickness of 9.14 metres. In Shobhapur borehole, the bed rock quartzite is encountered at a depth of 318.52 metres below ground level; first granular zone of medium to coarse sand is struck at a depth of 15.85 metres having a thickness of 9.45 metres; second zone of gravel with fragments of quartz, jasper is encountered at a depth of 33.83 metres having a thickness of 7.01 metres; third zone with gravel and pebbles is struck at a depth of 47.24 metres having a thickness of 12.81 metres; fourth granular zone of gravel occurs at a depth of 112.78 metres having a thickness of 9.44 metres; fifth granular zone of fine to coarse sand is encountered at a depth of 244.45 metres having a thickness of 28.04 metres. The borehole at Piparia is drilled upto the granite bed rock which occurs at a depth of 260.06 metres below ground level. First granular zone of fine to coarse sand and gravels is struck at a depth of 3.05 metres having a thickness
of 19.20 metres; second granular zone of medium to coarse sand is encountered at a depth of 64.92 metres having a thickness of 4.27 metres; third granular zone of gravel and fine to coarse sand is struck at a depth of 72.54 metres and has thickness of 12.19 metres. In Nibhora borehole, the bed rock shale is encountered at a depth of 265.48 metres; the first granular zone of fine to coarse sand occurs at a depth of 7.01 metres and it has thickness of 14.02 metres; the second granular zone of fine to coarse sand is encountered at a depth of 28.04 metres having a thickness of 10.97 metres; the third granular zone of medium to coarse sand is struck at a depth of 46.02 metres having a thickness of 7.01 metres; the fourth granular zone of fine to medium sand with fragments of quartz and basalt is struck at a depth of 67.05 metres and has a thickness of 3.97 metres; the fifth granular zone of gravel with fragments of quartz, felspar occurs at a depth of 88.09 metres and has a thickness of 7.01 metres; the sixth zone of sand with little clay occurs at a depth of 119.18 metres below ground level. It has a thickness of 7.01 metres. In chandon bore hole, the bed rock sandstone is encountered at a depth of 208.48 metres below ground level; first granular zone of coarse sand is struck at a depth of 20.42 metres and has a thickness of 46.03 metres; second granular zone of fine to coarse sand is encountered at a depth of 69.49 metres and has a thickness of 7.02
metres; third granular zone of gravel with fragments of quartz, jasper, etc., occurs at a depth of 90.53 metres below ground level and has a thickness of 10.97 metres.

It is clear from the section (Fig 4.5) that the thickness of alluvium in the Tawa command area is more between Tawa and Dudhi rivers than other parts of the area. It is less between the Tawa and Machak rivers. In general, there is a change in litho-facies both vertically as well as horizontally. For the lateral correlation of the litho-facies, the clay, clay with kankar, top clay, etc., is considered as one unit; the sand fine, medium, coarse, gravels with pebbles and fragments of quartz and jasper is considered as another unit. The lenses of clay and granular zone are present in the area. The potential ground water reservoir is present in the area between Tawa and Dudhi rivers because they have adequate and enough thickness of granular zone.

The thickening and thinning characteristic of the alluvial formation is also noticed from the section. The maximum thickness of the alluvium in the area is about 321 metres evidenced from the borehole drilled at the village Shobhapur.
4.4 STRUCTURE:-

The Archaean consists of meta-sediments and metamorphosed basic intrusives. Except in the case of calc-silicate rocks, the bedding plane is recognisable in the other meta-sediments by their compositional banding. The general dip is $70^\circ$ to $75^\circ$ towards south-$30^\circ$ east. Foliation generally parallel to bedding planes is well developed in the schists. Repetition of litho-horizons development of strong foliation and minor folds suggest isoclinal folding. The foliation plane represent axial plane foliation. The plunge of the axis of minor folds varies $50^\circ$-$60^\circ$ towards N $76^\circ$ E.

The basic rocks intruded along the bedding and foliation planes are folded and metamorphosed indicating comparatively less intense second phase folding. The northern margin of the Archeans is marked by a ENE-WSW trending fault and alluvial fan zone and Narmada alluvium occur on its north. This fault trend could be possibly a fundamental fault system bounding Narmada valley at its south.

The Vindhyans are more or less horizontal to gently dipping ($8^\circ$-$15^\circ$) along fault margins where they show comparatively steep dips ranging from $23^\circ$ to $35^\circ$. They are highly folded. A number of minor high angle faults are present. Two major sets of joints well developed in the sandstone are recognised from the
imagery.

The Narmada valley does not appear to be the result of a simple trough fault but appears to be bounded on its south by an ENE-WSW fault trend (both cross faults) running parallel to the river and on its northern slope by a system of minor and major vertical fracture system at times oblique and at times more or less parallel to the river. Lineament traces and trends are seen in the imagery. Some of the faults appears to be local in nature and hinging. While some others reflect fundamental basement groin (fault) having reflection on the surface as "lineaments." An E-W trending fault along the Narmada between Budhi (22°46':77°42') and Hoshangabad exposes the down faulted block of lower Bhandar sandstone in the river bed.

The Gondwana formations are more or less horizontal or gently dipping towards NNW or SSE at 10° to 35° and rarely 40°. A broad synclinal structure with its axis running NNE-SSW is interpreted.

The Deccan Traps constitute horizontal lava flow layers of 5 to 20 metres in the thickness and are jointed.

4.4 Satellite Imagery Interpretation

Fig.4.1 represents the general regional
geology of the area. A number of linears and lineaments are traced in the area and shown in Fig 4.3.

Lineament may be defined as those features on the surface of the earth which are linear to curvilinear and of geologic significance. Billing (1954), called any topographically controlled line on aerial photographs is a lineament. Blanford (1869) used the term "fracture" for abundant lineation discernible on aerial photographs. He differentiated micro-fractures as being up to four kilometres and macro-fractures as ranging from 4 to 800 km. in length. Das & Patel (1984) used the term "Surficial lineaments" for linear features as aerial photographs regardless of lengths. Crawford (1978) suggested that lineaments were generally rectilinear zones or times of structural discordance of regional extent which generally exceeds about 100 km. in length, while linears were the single lines on imagery usually 1-10 km. in length.

On satellite imagery, the linear features mapped are mainly fractures and/or faults and sometimes major joints, etc. Lineaments show well on imagery and air photos as (a) linear topographic features, trenches or ridges, river alignments, etc. and (b) linear vegetation and soil/land use pattern on the map "major" lineaments as macro features and/or faults and some minor lineamentes as major joints, micro-features are shown.
The faults are either normal–steep angled reverse or transvers, some of these appear to hinge out. Some of these minor lineaments may also turns out to be faults (local) on field check.

4.6 Discussion on lineaments and tectonic activities along Narmada line

The rather overall straight trend of the westerly flowing Narmada river have attracted the attention of geologist from early days. Vredenburg (1906) attempted to establish the interrelationship between the courses of Narmada and Tapi rivers as being influenced by tectonic disturbance lines. Crookshank (1936) elaborated the concept of "Narmada Rift Valley" considered to have developed as a result of pronounced faulting at the end of the Deccan trap period. Auden (1949) assigned Miocene age for the formation of the Narmada rift. He regarded this rift as a major crustal features of ancient origin, reflecting sub-crustal structure and is influencing the deposition and folding of Vindhyan and Gondwanas. On the evidence afforded by the distribution of the Vindhyan and Gondwana rocks in Narmada-Son area, west(1962) suggested the Narmada-Son lineament as a line of weakness from early times, with relative movements at north and south of this line. Auden (1969) based on the increase in thickness of Miocene sediments
on the two sides of the Broach-Narmada line also concluded that activity along this zone lasted from Eocene up to the Miocene age. The 2200 metres thick past Miocene formation just north of Ankaleshwar have led him to summarise that activity along the postulated parts and flanks of the Vindhyan basin continued into the Pleistocene age.

An analysis of the lineaments and folding styles in the Vindhyan rocks, specially the "Jabera dome" or doubly plunging antiform among others occurring mostly north of the river Narmada indicates that in the tectonic evaluation of Vindhyas, they underwent peribasinal folding and faulting with a centrifugal stress field. At situations such as Jabera, the folds may have developed due to drag effect govern by basement set up. Although no major, single continuous fault is traceable along Narmada, several arcuate or straight disconnected faults may represent a "fault system". In keeping with the great thickness of Vindhyan, the lineament distribution pattern and the outcrop distribution, it may be presumed that the Vindhyan basin was bounded by basement faults (e.g. ENE-WSW) fault bordering Archeaens (south of Itarsi) and fracture system of Narmada valley region which possibly had acted as faults of varying magnitude during sedimentation in a slowly settling basin. They again became active during uplift of the
Vindhyan (post Vindhyan time) and continued through post Deccan Trap times and possibly even up to historic and present times, as evidenced by Broach earthquake, and entrenched nature of Narmada river in Hoshangabad area. Later cross faults and minor faults may have developed as adjustments. Thus, it may be concluded that the Narmada valleys apparently an active fault zone with continuous tectonic disturbance at various period in geologic time.