

CHAPTER II

GEOLOGICAL SETUP AND LITHOSTRATIGRAPHIC CONTROLS

GENERAL

Geologically the rocks of the Heran river basin show considerable time range and formations belonging to Precambrian, Mesozoic and Cenozoic eras are encountered. Of course, the stratigraphic record is very fragmentary full of big gaps. The lithological variation is also very striking. The Precambrians are represented by the metamorphics of Champaner series and the granitic rocks of Erinpura granite age as an intrusive in the metamorphics. The next formation is of Cretaceous age consisting of the rocks known as Bagh beds. Basalts of Deccan Trap are also present. The youngest formations are the Quaternary alluvium and soils which are

seen resting over all the older formations.

The diverse geological conditions revealed by the rocks of various ages, modes of origin, lithologic and structural features have considerably influenced the surface and sub-surface hydrological conditions.

PREVIOUS WORK

Geological details of the study area are obtained by referring to a number of previous work. Although, no one has investigated the geology of the area in detail exclusively yet, a reasonably good picture has been obtained by going through the reports and publications by a large number of workers. Most of them have investigated one or the other aspect of the geology of the area and its neighbourhood or they have referred to this area as a part of regional studies. None has however, studied the area from the hydrogeological point of view. The present author has scrutinized most of the previous work to obtain a dependable picture of the geological framework of the basin in its neighbourhood. The earlier investigations on different aspects of the geology of the region are those of Carter (1857), Lush (1863), Wynne (1867), Blanford (1869), Vanpele (1869), Bose (1884) Duncan (1887), Foote (1891), Iyer (1901), Vredenberg (1907, 1908), Bose (1908), Fourtan (1918).

The recent work includes the studies carried out by Chiplunkar (1942), Murthy (1963), Chatterjee (1964), Sukeshwala & Udas (1963), Subbarao (1965), Sahni and Jain (1966), Desai and Brahmabhatt (1967), Verma (1965, 68), Sukheshwala and Sethna (1967, 69, 73), Paul and Chaudhary (1969), Guha and Shosh (1970), Sukeshwala and Avasia (1971), Rao (1974), Sukeshwala and Borges (1975), Ray (1981).

REGIONAL GEOLOGICAL SETUP

On the basis of the earlier workers the regional geological succession can be constructed as under:

Regional Stratigraphic Succession

<u>Litho-stratigraphic units</u>	<u>- Age</u>
Recent and Sub-Recent Kanker, Alluvium, soils	Quaternary
----- Erosional Unconformity -----	
Basic lava flows and intrusives (Deccan Trap)	Cretaceo- Eocene
----- Eruptive Unconformity -----	
Nimar sandstone & Bagh Beds (Infra-Trappeans)	Cretaceous
---- Erosional Unconformity -----	
Erinpura Granites & Pegmatites Quartzite, Phyllite, Schist, Dolomitic Limestone and conglomerates (Champaner's = Aravalli super group)	Precambrians
----- Erosional Unconformity -----	
Unclassified Basement Gneissic complex.	

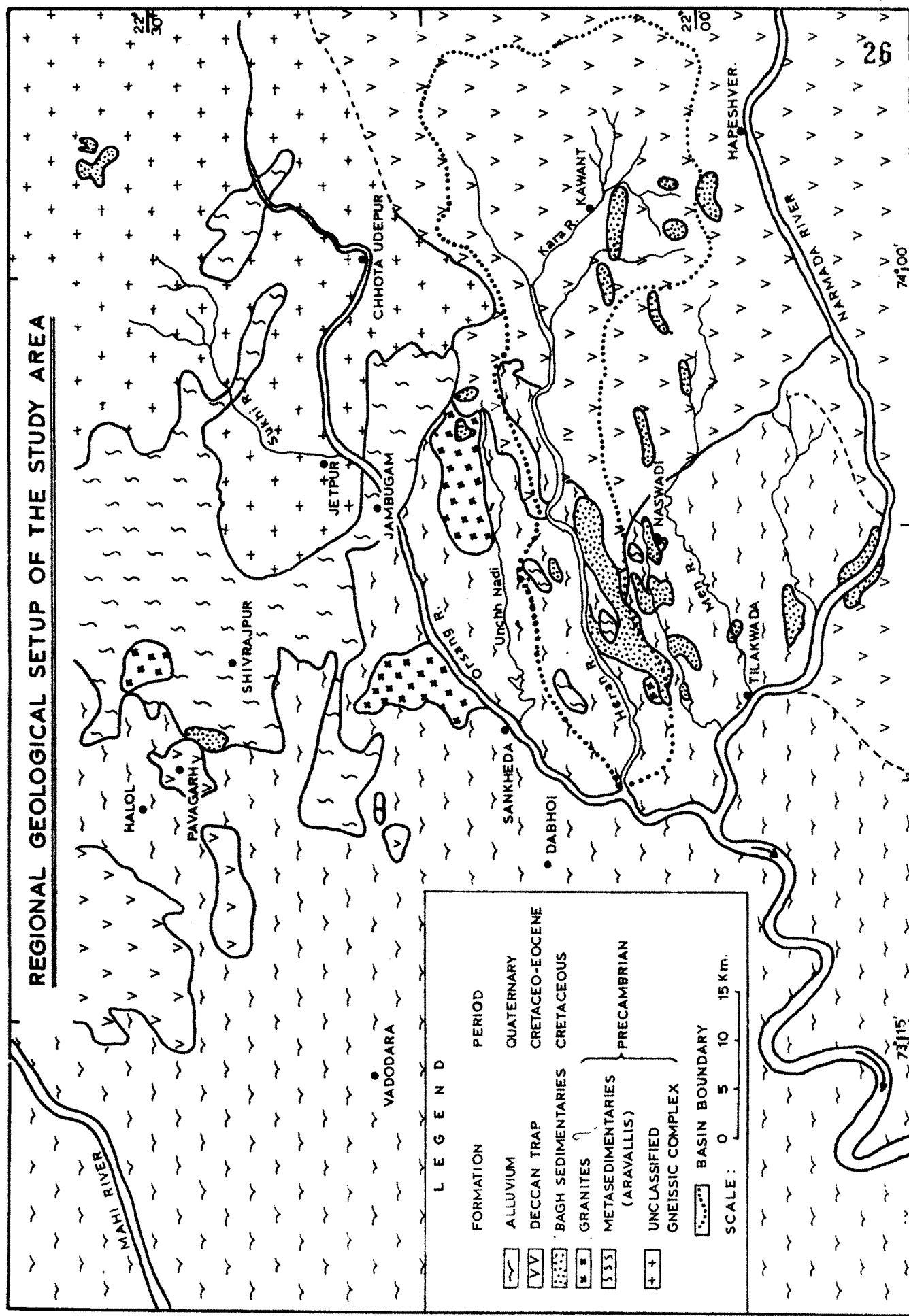
PRECAMBRIANS

The Archaean rocks forming two sequences are exposed in parts of Baroda and Panchmahal districts. An interbedded sequence of argillaceous, arenaceous and impure calcareous rocks consisting the Champaners rest unconformably over a suit of mica schists, quartzites, grits which in turn lie unconformably over a sequence of mica schists, quartzites, grits and para-gneisses. The Champaners themselves are divided by the conglomerate horizon (Jaban) into lower and upper. The lower sequence is thrown into anticlinorium consisting of a system of folds on WNW-ESE axes showing moderate WNW plunge. Shearing along definite zones and development of longitudinal and cross faults are the other characteristic structural features. The intrusive granites and gneisses which are considered as equivalent of Erinpura-Granite of south Rajasthan-north Gujarat occupy a vast stretch of area around Chotta Udepur (Fig. 2.1).

INFRA-TRAPPEANS

Exposures of Bagh Beds and Nimar sandstones occur at several places in Heran basin and in the adjoining area. Near Ambadunger they have witnessed intense faulting and Deccan volcanism. The Bagh and Nimars are exposed as inliers within basaltic flows of Deccan Trap. The gritty sandstone

FIG. 2.1



around Kawant is intercalated with ferruginous clay. The strike is almost E-W and show dip towards south. The Bagh sediments have been subjected to system of faults sympathetic to main Narmada rift in ENE-WSE & NE-SW direction.

DECCAN TRAPS

The Deccan suite of rocks comprises lava flows and the associated intrusives. In the area of Naswadi and Chhota Udepur taluka the volcanic activities have taken place on a large scale. The Deccan Traps which occur around Naswadi comprise fine grained amygdular and porphyritic lava flows. In the Phenaimata-Rangpur area, these occurs as trachy basalt, gabbro, granophyre and Nepheline syenite which have intruded into the earlier formed lava flows.

The adjoining Ambadungar area have witnessed intense volcanic activities and exhibit varieties of rock types viz.; basalt flows, dolerite and granophyre dykes, breccias, agglomerates-tuffs, dykes and plugs of alkaline rocks like nepheline syenite, phonolites, ijolite and lamprophyre. The carbonate rocks around the centre of Ambadungar structure comprises different varieties of rock types. Numerous dykes of different composition and having trends mostly E-W to ENE-WSW occur in area between Panwad and Mohan fort.

QUATERNARIES

The Recent and Sub-Recent formations are represented by laterite, kankars, alluvium, soils etc. The laterite capping on traps is characterised by light red to dark brown colours and mottled vesicular structures, occurs at higher elevations. Nodular concretionary lime commonly known as Kankar is often met within the soil, covering the crystalline rocks in the areas adjoining the trap. Thick pile of alluvium covers the western and south-western part of the Heran Orsang Basins and Naswadi - Tilakwada areas.

GEOLOGICAL SETTING OF THE HERAN BASIN

The litho-stratigraphic succession of the basin area as worked out by previous literature and field checks is given in Table 2.1.

Table 2.1 Stratigraphic Succession of the Heran Basin

Age	Formation	Remark
Quaternary	Alluvial sands, clays, kankars and soils	Alluvium
Lower Eocene to Late Cretaceous	Carbonatites Lamprophyres, Nepheline Syenite, Dolerite and Basalt dykes, Granophyres, Quartz-felspar rock & Gabbro Andesitic basalt, Trachybasalt and Trachytic dykes.	Deccan Traps
----- Eruptive Unconformity -----		
Middle Cretaceous	Fossiliferous limestone with shaly intercalations. Coarse to medium grained sandstone (Nimar sandstone) Purple shale, Coarse, grained (Basal) sandstone with a conglomeratic base.	Bagh Beds (Infra-trappeans)

Table 2.1 (contd)

Age	Formation	Remark
----- Erosional Unconformity -----		
Precambrians	Granites (Post-Delhi Intrusives) Quartzites Phyllites and Biotite Schists.	Aravalli supper Group
----- Erosional Unconformity -----		
	Unclassified Gneissic complex	B.G.C.

PRECAMBRIAN METASEDIMENTARIES

The Precambrian metamorphics and unclassified gneissic complex form the peneplained basement. These are unconformably overlain by the Bagh sedimentaries and the Trappean lava flows. The metamorphics occur as elongated hills striking NW-SE. They are exposed in the north-western part of the area near Panvad and they further extend northward beyond the study area towards Chhota Udepur. Sporadic inliers are recorded in the western part near Songir, Ghantoli and Vora (Fig.2.2). The rock types comprise an intercalated sequence of biotite schists, phyllites and quartzites. They are seen intruded by a pink porphyritic granite (=Erinpura granite). Near Ghantoli they are unconformably overlain by horizontal Bagh beds (Basal sandstone). Here, the steeply dipping metamorphics underlying the Bagh sedimentaries present an illustrative exposure of an angular unconformity (plate II.1).

The intrusive granites extensively occur in the far northern part of the basin area. However, in the lower parts of the basin under the cover of thick alluvium of 60-80 m, it is recorded in the deep borewell logs near Rampura, and Malpur villages of Sankheda taluka. The well exposed intercalated sequence of quartzites and phyllites is seen across the river flow near songir fort (Plate II.2). Near Vora the phyllites are seen cropping out within the alluvium and river bed (Plate II.3). Large size xenolithic patches of this granite in basaltic flows are also found near Phenaimata (Plate II.4).

BAGH SEDIMENTARIES

The stratigraphic aspects of the Bagh beds in its type area have invoked great interest to all the workers because of the highly fossiliferous nature of these beds. These rocks are of marine origin and represent a marine transgression along the Narmada valley. All over the Lower Narmada valley the Bagh beds are seen outcropping as an isolated patches either resting over the Precambrians or as inliers within the Deccan Trap.

Basal Sandstone

The sequence of Infratrappean Rocks commences with a coarse grained sandstone having a conglomeratic base with unconformably overlies the Precambrian metasediments and the

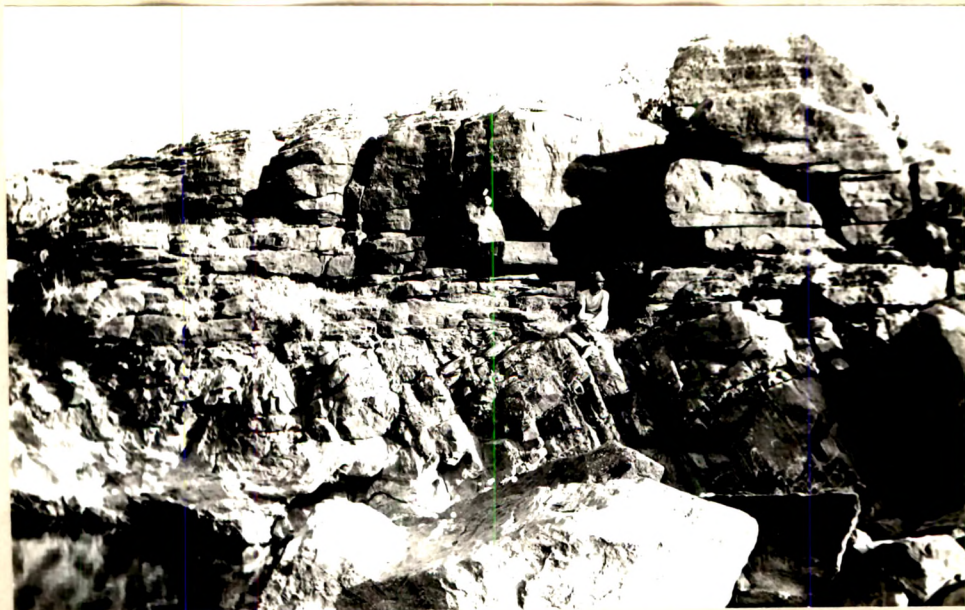


Plate II.1 Field photograph showing angular unconformity between Bagh sandstone (Cretaceous) and Champaner metamorphics in (Precambrian) in the Heran river bed. (Loc. Near Ghantoli-railway bridge).

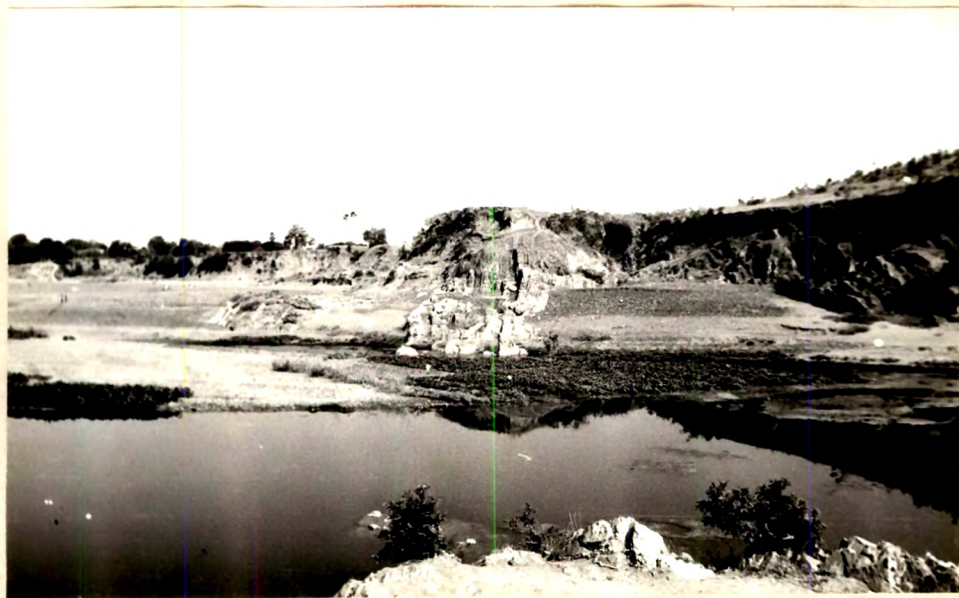


Plate II.2 Field photograph showing exposures of the Precambrian quartzite and gneiss in the Heran river bed. (Loc. Near Songir Fort).



Plate II.3 Field photograph showing exposure of Phyllite striking across the river and the section of the alluvial deposits seen in the far background (Loc. Near Vora).



Plate II.4 Field photograph showing xenolithic patch of the Basement granite within the basaltic flow. (Loc. Sodhwad).

granite. It occupies wide expanse in the area around Ghantoli, Songir, Wanmala and Vajiria. There it exhibits faulted relationship with the older rocks in the Heran river near the Ghantoli Railway bridge. It is covered by the Deccan Trap lava flows southwest of Wanmala.

The base of the sandstone which is marked by a conglomeratic horizon imperceptibly grades upward into coarse grained sandstone. This conglomeratic horizon which is hardly 2 to 3 metres in thickness is mostly composed of quartzite and vein quartz pebbles, granite pebbles, though extremely rare in their occurrence, are never absent. The quartzite pebbles are generally circular or oval in shape. At the outcrop they are seen to have fallen off from the matrix of the rock leaving behind circular or oval shaped depressions. Such pebbles are strewn all over the surface at the outcrops. Conglomeratic horizon with such pebbles are exposed in the outcrop of south of Wasna. The matrix of the conglomerate is composed of coarse sand grains cemented by siliceous and ferruginous material.

The sandstone overlying the conglomeratic horizon is hard and compact in nature. Unlike its extension in lower reaches of the basin the sandstone in middle part is nonflaggy. It is composed of coarse sand grains cemented in either pure siliceous or partly ferruginous matrix. The difference in the

cementing material imparts a dull white and brown alternating layer to the rock.

Purple Shale

A thin irregular and linear exposure of a purple shale overlying the basal sandstone can be seen over a strike length of about 2.5 km in the hills south and southwest of Naswadi, they are interbeddedly observed in the well sections along Kalediya-Krishnapura road. Near Naswadi it is seen overlaid by upper sandstone.

Upper Sandstone

This sandstone is exposed in force as elongated exposures in the south eastern hilly region. They run for several kilometre in length in ENE-WSW trend with varying width of 100 to 1000 metres. Such exposures are exposed between southwest of Wankla and WNW of Nawagam, between Bagliya and south of Devliya; south of Thargaon and Artiya. In north of Artiya they occur in faulted contact with the Deccan Traps. This sandstone is also a coarse to medium grained with thin horizons of peanut sized pebbles of quartz, alternating with coarse grained sandstone such pebbly nature of the sandstone is extremely common in the exposures south of Artiya and southwest of Thargaon. This shows a very shallow nature of their deposition. Towards the top, the sandstone is intercalated with fossiliferous limestone and

shaly limestone, which in turn indicates that during the later phases of the deposition of the Bagh beds the basin deepened sufficiently to facilitate the deposition of calcareous rocks. The cementing material in the sandstone is both calcareous and ferruginous. The calcareous varieties are characterised by their white colour whereas the ferruginous ones exhibit deep brown, pink, red and even shades of yellow colour. The sandstone is traversed by dykes of dolerite, fine grained basalt and porphyritic basalt. Near Panvad, Bagh beds, mostly sandstone occur scattered throughout the area. At places they grade into a coarser conglomeratic variety.

Limestone

The limestone forms the upper most bed of the Bagh sequence and is seen interbedded with the upper sandstone in the southeastern part of the middle basin and area around Karipani (Plate II.5). Considerably larger exposures of limestone can be seen in the hilly area south of Devliya, Andhali, south of Artiya and north of Wankaner. The exposed thickness of limestone bands rarely exceeds 50 metres. The lower portion of the limestone is invariably shaly in nature and carries rich assemblage of marine fossils. The limestone band south of Artiya is highly cherty in nature and exhibits characteristic banded nature. The limestone by and large

appears to be siliceous.

DECCAN TRAPS

The Deccan lava flows are the principal rock types of the area and occupy a wide expanse of the Heran river basin. Except for the occurrence of Bagh beds as linear outcrops (inliers), the entire Eastern, southern and southeastern hilly terrain of upper and middle basin is completely made up of the Deccan Traps. They form lofty hills and rise above the general surface several hundreds of metres. The hill ranges show a general ENE-WSW trend which also conforms the trend of the lava flows. In the central part of the basin they largely lie buried under a soil cover of 3 to 5 m thickness derived by their own disintegration while in the northwestern part they are covered by the alluvium. The trap flows directly overlies the basal sandstone of the Bagh beds in the area south of Khandibaru village i.e. in the Rami reservoir (Plate II.6), while at places these have faulted contact with Baghs.

Three rock types are distinguished under the traps, viz (i) Fine grained basalt (ii) Amygdaloidal basalt and (iii) porphyritic basalt. Dykes of dolerite, basalt, trachyte and alkaline rocks are intruded in the traps.



Plate II.5 Field photograph showing interbedded sequence of Bagh sedimentaries, Shale and Sandstone. (Loc. Kawant-Karipani road section).



Plate II.6 Field photograph showing Trap overlying Baghs. (Loc. Rami reservoir Khandibaru village).

Fine grained basalt

The bulk of the rock shows remarkable uniformity in both megascopic character and mineral composition. The rock is of a black or very dark grey in colour, with a brownish tinge. The rock is invariably vesicular in the top portion of individual flows.

Amygdaloidal Basalt

Nowhere in the area amygdaloidal basalt was seen as a distinct flow. Only the top portions of fine grained basalt, here and there, assume amygdular character. Hence, it does not differ much in its composition from the fine grained basalt except that it contains subrounded to rounded vesicles generally filled with secondary minerals like chalcedony, zeolites and quartz-calcite.

Porphyritic Basalt

Exposures of porphyritic basalt are exposed all over the entire upper basin and southern part of middle basin near Thadgaon and Nava-Timberva-Amadra in northern part of middle basin.

Other than these three main basalts there are other basaltic varieties and contemporaneous alkaline intrusives

are also present which are mainly seen to occur in the middle part of the basin (associated with Phenaimata activity) and in upper reaches of the basin (associated with Ambadungar activity).

Alkaline, Basic and Basaltic Dykes

The infra-trappean rocks as well as the Deccan Traps and the intrusive rocks of Phenaimata hill are traversed by a number of dykes of alkaline, basic and basaltic character. The dykes are particularly abundant in the southeastern hilly terrain of the basin as well as around Panvad-Karajwant. The river beds of Heran Rami and Kara expose a large number of dykes of varied rock types including acid, basic and alkaline rocks (Plate II.7). These dykes cut across the older formations along weak planes and joints, and are generally disposed in NE-SW, ENE-WSW, NW-SE directions.

The dolerite dykes are most abundant among the dykes rocks. They are more particularly seen cutting the basaltic flows in the southeastern hilly terrain. Some of them are displaced by faulting. Dykes of porphyritic basalt are seen cutting the Bagh sandstone south of Thargaon-Khandibaru and the basaltic flows south of Pataria, Karipani and north of Chipan.

CARBONATITE BRECCIA

Towards the top of the Bagh sequence, the sandstones change in appearance. The white/pink sandstone turn chocolate brown in colour with a marked change to spheroidal type weathering resulting in scarp faces with curved ledges. This characteristic feature helps to distinguish carbonate from the unaffected sandstones. Near the base the carbonatite breccia maintains stratification and current bedding and has nearly the same dip as the underlying sandstones. Higher in the sequence, the brecciated character with fragments of metamorphics and basalt progressively increase. The rock thus resembles an igneous breccia. The carbonatites are exposed in the area around Artiya, Ghantoli, Waghdhara, Siriwasan, Mongra, Padwani, Bonja and Motichikhli.

SOILS AND ALLUVIUM

The youngest formation of the area is represented by soils and alluvium. Soils are the product of mechanical disintegration and chemical decomposition of the older rocks.

The residual soils covers vast expanse of the study area comprising basaltic rocks, and are represented mainly by black cotton soils and lateritic soils of silty-clay in nature. The thickness of soil cover varies between 0.5 and 3.50 m from area to area.

The colluvial sediments are mainly constitute soils of fluvial in origin. The fluvial sediments occupying river valleys, intermontane zones, levee and hills pediments. They are generated by the combined effect of water and earth gravity. The thickness of this alluvium in the middle parts ranges from 5.00 m to 15.00 m or more. The area between Bagaliya and Kosindra is typically made up of these fluvial deposits which are sandy and gravelly in nature. This material shows of huge thickness in the lower reaches of the basin area, where it is seen forming conspicuous terraces near Vora Wasan and Bhilodiya with thickness as much as 32 m. (Plate II. 8.). The alluvium mainly consists of intercalated sequence of sandy-silty and clayey deposits.

LITHO-STRATIGRAPHIC CONTROLS

Diversified geological formations, lithological variations, tectonic and structural complexity, geomorphological and hydrometeorological dissimilarities produce the variations in the groundwater situations. However, in relation to mode of occurrence of groundwater, hydraulic properties of aquifer systems, a three fold hydrogeological classification of the geological formations have been prepared (Charlu & Dutt 1982, Davis & DeWiest 1970, Todd 1980).

1. Unconsolidated or Non-indurated formations (also, described as hard/crystalline rocks in various

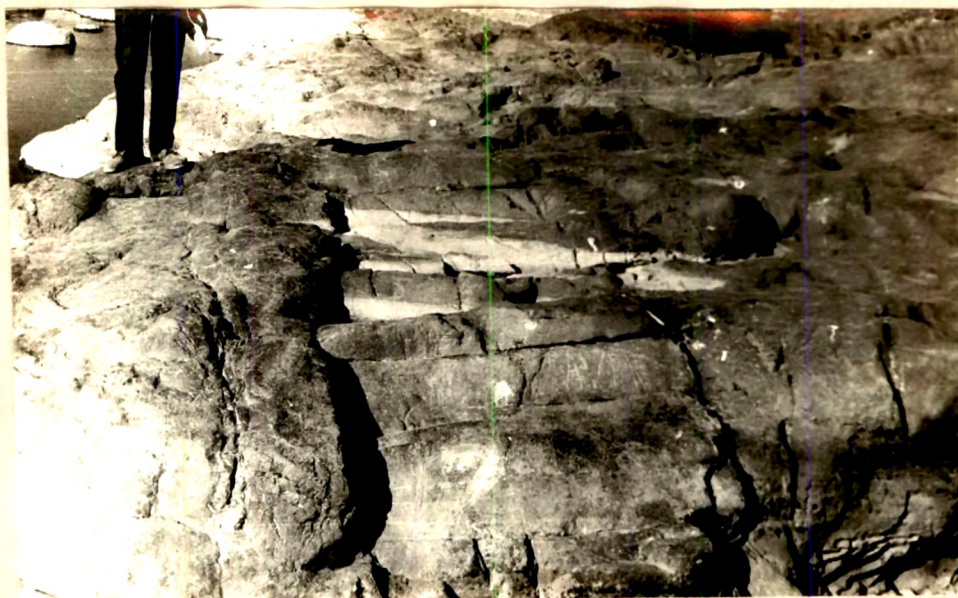


Plate II.7 Field photograph showing basaltic dyke in trap flow. (Loc. Heran river bed near Rangpur)



Plate II.8 Field photograph showing river terraces along Heran river (Loc. Near village Vora).

literatures on hydrogeology).

2. Semiconsolidated or Poorly-indurated formations.
3. Consolidated or Indurated formations.

The present study area has a wide variation in rock types and depending upon their mineralogical composition, textural characters and mode of origin they have produced inhomogeneity of groundwater occurrence. Thus from the hydrogeological point of view all the rock formations of the basin have been categorised into two as under:-

UNCONSOLIDATED FORMATIONS

The unconsolidated formations in basin area include Quaternary deposits comprising the recent alluvium and older alluvium. The sediments are essentially composed of clays, silts, sands, gravels, pebbles, cobbles, boulders, ferruginous nodules, calcareous concretions etc.

CONSOLIDATED FORMATIONS

These includes all the rocks of Precambrian crystallines, Infratroppeans and Deccan Traps. The major lithologien viz. granite, granite gneisses, quartzite, phyllite and schists, sandstone, limestone, basalts, granophyres, gabbro, nepheline syenite, andesite and carbonatites etc., have formed a part of this category.

The absence of semiconsolidated formations in the study area is due to a big chronological hiatus from Eocene to Quaternary. The basis of hydrogeological classification of rocks being the consolidation or induration property generally goes in accordance with the geological age of the formation. Older the rocks it becomes more indurated and younger as non-indurated.

In the present area of study, the two hydrogeological categories with extreme characters of ground-water occurrences have been encountered. The unconsolidated formations mainly comprise the lower parts of the basin covering 30 % area of the total basin, and rest 70 % area constitutes the consolidated formations.

The lithostratigraphic variations have exercised significant control over the groundwater occurrence. The detail account of their nature and pattern have been enumerated in the subsequent chapter on hydrogeological evaluation.