CHAPTER III

GEOLOGY OF THE AREA

SUB SURFACE GEOLOGY OF THE INDO–GANGETIC PLAINS

The Indo-Gangetic plains lying in between the Peninsular India and the Extra Peninsular region, are regarded as a major unit in the geology of the Indian sub continent. Under the term Indo-Gangetic plains, not only the plains of the Indus and the Ganga river system are meant but, also the plains of the Brahmaputra river are included. The total area covered by all these plains is more than three fourth of a million sq. km. (Plate – VII).

There has been much speculation regarding the sub-surface geology and tectonic origin of this vast depression often referred to as 'The Indo-Gangetic trough'. Various views has been expressed by Suess (1893), Burrard (1915), Cowie (1921), Glennie (1932), Hyden (1973), Oldham (1917, 1923), Pascoe (1964) and Wadia (1938, 1966) regarding this depression.

The tube wells drilled for groundwater did not go beyond a depth of 750 meters and data on solid geology of the plains, (except at few places where the bed rocks were encountered), is lacking entirely. However, the geophysical explorations in these plains about four and a half decades back, a fairly large volume of data showing the sub surface geology and structure has been obtained. The results of the geophysical surveys in the Ganga valley were published in the proceeding of a seminar (Poddar, 1962).
The aeromagnetic surveys carried out in the plains of Punjab, U.P. and Bihar (Sengupta, 1962) have provided indication of the basement's depth under these plains. The results of the gravity surveys in the Punjab and Ganga valley (Ratnam, 1965) together with the accounts of seismic surveys in the Ganga valley (Moolchand, 1964), have furnished very useful information on the subsurface structures. A detailed accounts of the sub-surface geology, stratigraphy and structure of some part of these plains have been furnished by Evan (1959) and Mathur and Evan (1964). The tectonic map of India, O.N.G.C., shows the solid geology and the structure of the rocks covered by the alluvium in these plains. The map represents a summarised account of the geological and geophysical surveys and well data together up to 1970. Krishnan (1968) has given a brief account of the sub-surface geology of the entire Indo-Gangetic plains. Except for the brief account furnished by the Krishnan (1968), no comprehensive study of the sub-surface geology of the Indo-Gangetic plains has yet been published. The salient feature of the sub-surface geology of the Indo-Gangetic plains need further studies to gain a fuller understanding of the geology and tectonic vis-a-vis Himalayan orogeny. Geologist, in general held the view that the floor of the trough contains alternate ridges and depressions. Further, they were of the opinion that there is a great diversity in the composition of the rock formation and their structural features.

**THICKNESS**

The thickness of the alluvium has been considered about 15 km by Burrard (1915) and 4.5 km by Oldham (1917). Further, the
results of the geophysical explorations and well data show that the thickness is of the order of 1000 metres. The maximum depth to the basement indicated in seismic surveys is about six km.

DIVISIONS OF THE INDO- Gangetic Plains

The Indo-Gangetic plain is divisible into five parts which are as follows:

1. The Indus Basin in Pakistan
2. The Punjab Basin in Punjab
3. The Ganga Basin in U.P. and Bihar
4. The Brahmaputra Basin in Assam
5. The Ganga-Brahmaputra Basin in West Bengal and Bangladesh.

The Indus Basin

A greater part of the Indus basin lies in Pakistan. This basin is probably 6000 m deep in Sind. A large volume of the Tertiary and Mesozoic sediments have been met under the alluvium. This thick marine sequences has thinned out towards the Rajasthan Platform in the east and towards the Sargoda-Waziristan ridge to the north.

The Punjab Basin

The Punjab wedge either outcropping or occurring under moderate thickness of alluvium in the Lahore-Sargoda area, separates the Indus basin on the west, from the Punjab depression on the east. Punjab depression follows a NW - SE and ESE and almost EW course in conformity with the trends of the Siwalik hills. The Seismic survey by O.N.G.C. (Dutta et. al., 1964) have indicated that the basement surface as well as the sediments below the alluvium, dip greatly towards the foothills. The basement becomes deep as the foothills are reached with corresponding increase in the thickness of the sediments. The maximum depth of this depression, about 4.5 km, was
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ALLUVIUM

DECCAN TRAPS AND EQUIVALENTS

GONDWANA SEDIMENTS

VINDHYAN SEDIMENTS

DELHI SYSTEM AND EQUIVALENT ROCKS

BUNDELKHAND GRANITE & GNEISSES.

UNCATEGORIZED CRYSTALLINES & GNEISSES (Aravalli & Satpura).

LOCATION MAP OF GANGLA BASIN.
noted near Dasuya.

THE BRAHMAPUTRA BASIN

The Brahmaputra basin may be divided into a western and an eastern part. The western part lying in between the Shillong and the Mikir hills and the Himalayan foothills. The eastern part lying in between the Naga hills and Himalayas. The western part is shallow in most of the southern portion and near the foothills, the sediments, mainly the equivalents of Siwaliks, attain appreciable thickness. The depth to the basement increases to the north, towards the Himalayan foothills, but becomes shallower towards the Mikir hills.

THE GANGA BASIN

The Ganga basin is one of the major sedimentary basins in India, located in the northern margin of the Indian platform. The western margin of the basin is limited by possible extension of the Delhi meta-sediments to the north, forming a ridge like feature in the sub-surface (Delhi-Hardwar ridge) and eastern margin by a similar though broader Mongyer - Saharsa ridge of Satpura metamorphics.

To the north the Ganga basin is limited by the outermost Siwalik foothills, bounded by series of reverse faults. Briefly the Ganga basin starts from the east of the Delhi - Ambala ridge and ends up to Mongyer - Saharsa ridge. The Ganga basin can be divided into the following sub divisions (Plate IX AND X).

A - East Uttar Pradesh Shelf and Gandak Depression

B - West Uttar Pradesh Shelf
6. Delhi - Muzaffarnagar ridge.
Tectonic Map of Ganga Basin & Adjoining Areas

Legend:
- **Gondwana (Lower and Upper undifferentiated)**
- **(Upper Carboniferous-Lower Cretaceous)**
- **Vindhyan**
- **(Upper Proterozoic-Lower Palaeozoic)**
- **Limits of Mesozoic Effusives** (Deccan Traps/Rajmahal Traps, etc.)

Teopnctic and Structural Features:
- Structures of Super Order-Synclises
- Structures of First Order Negative
- Structures of First Order Positive
- Structures of Second Order Negative
- Structures of Second Order Positive
- Structures of Third Order Local Hinges
- Faults (Major)
- Thrusts (limiting the platform margin)
- Other Thrusts
- Trend Lines
- Anticlinal Axes
- Synclinal Axes
- *Basement* Depth Contours (based on aeromagnetic data)

NOTE A: Inserted columns indicate the complete sedimentary sequence (thickness not according to scale) and the age of the basement.

NOTE B: Hachings indicate the oldest sedimentary sequence directly underlying the basement.
Denser hachings stand for greater thickness of entire platform cover.

(After Tectonic Map of India, 1968 by Oil & Natural Gas Commission)
A. EAST UTTAR PRADESH SHELF AND GANDAK DEPRESSION

The East Uttar Pradesh Shelf is delimited by the Mongyer - Saharsa ridge to the east and the the Faizabad-ridge to the west (Plate X). This shelf merges to the north into the Gandak depression. The shelf zone is mainly characterised by the E-W trending. Aeromagnetic contours indicating several easterly plunging highs and lows. The basement here is assumed to be overlain successively by the Vindhyan and Neogens sequence. (Sasteri et al 1971, Rao 1973). (Plate XII).

Faizabad Ridge

The Faizabad ridge is the most important tectonic elements differentiating the Gandak depression, is a north - eastward sub-surface projection of the Bundelkhand massif. (Plate X).

Gandak Depression

The Gandak depression is distinguished from the East Uttar Pradesh shelf on the basis of the sedimentary thickness of more than 6000 m. A deep well drilled near Raxaul at the north eastern margin of the depression, encountered at Pre-Siwalik unconfirmity at a depth of 4128m below which lies the Vindhyan. (Plate X).

Mongyer-Saharsa Ridge

The Mongyer-Saharsa ridge represents a NNE projecting basement promoting of the Chhotanagpur plateau and is likely to be composed of rock complexes of the Satpura FOLDED BELT. The shallow nature of the basement is apparent from the aeromagnetic data. (Plate X). The boundary of the ridge delineated on the basis of the gravity - ground magnetic and seissmic data of ONGC, which
indicate that the sedimentary thickness over the ridge does not exceed 3000 m and the Neogene sediments directly overlies the basement.

B. **WEST UTTAR PRADESH SHELF**

The west Uttar Pradesh Shelf is the best studied area of the entire Ganga basin. This zone has broadly been divided into two parts namely the area east of Moradabad fault and the area west of it. The Vindhyan sequence overlies the Aravali folded basement in the former and the quaternary alluvial directly overlies the Delhi basement in the later area. Two major NE-SW trending faults have been shown on the map. The eastern coincides with the faulted contact of the Aravali folded belts with the Vindhyan outcrops (Plate X).

**Kasqañj - Tanakpur spur**

It marks the eastern limit of Aravali horst. Sarda river flows along northernly edge of this spur. The eastern edge of this spur coincides with the sub-surface extension of the Great Boundary fault of Rajasthan where it separates Aravali rocks from the Vindhyan. Analysis of structural pattern of exposed foothills and gravity anomaly alongwith basement contour map of the plains suggest that these spur are fault boundary (ONGC, 1983). (Plate X)

**Sharda Depression**

The Sharda depression represents the northern part of the West Uttar Pradesh shelf from which it is tectonically distinguished on the basis of the inferred sedimentary thickness of more than 6000 m by NW - SE trending structures. (Plate XI).
**Ramganga Depression**

The Ramganga depression is limited to the northwest by Hardwar - Rishikesh spur and to the southeast by Kasganj - Tanakpur spur which is northern extension of the Badayun arc in the Ganga valley (Shastri, 1971). The depression is marked by the schuppen structures in major part of the area. The Paleogene rocks preserved in this depression continue into Sharda depression across Tanakpur spur (ONGC, 1983). (Plate XI).

**Pawalgarh - Chandausi Spur**

It is lineament exceeding towards Chandausi to the south. Kosi-Dubka river system flows this spur. The foothills fault of Kumaon exposing Paleogene sediments takes a sharp inwards swing along this spur. The foothills fault of Kumaon exposing Paleogene sediments takes a sharp inwards swing along this spur.

**Kalsi Spur**

Yamuna river enters the plain along the Kalsi spur. This spur coincides with the western limit of traditional Delhi - Muzaffarnagar ridge.

**Moradabad Fault**

The Moradabad fault which is traceable on the shield area forms a tectonic boundary between the Delhi folded belts and the Vindhyan. The Vindhyans have tectonically not been reported west of this fault.

**Delhi - Muzaffarnagar Ridge**

In a gravity anamoly map (Plate XII) it shows a fairly prominent nose like feature to the east and north east of the Shamli about 150 km north of Delhi, suggesting a sub surface
basement ridge plunging NNE (Fig. 11). However, this feature dies out before Deoband is reached, in its place a trough plunging in the same direction is indicated. The nose like basement ridge near Shamli but further northeast, the basement goes down considerably, is an indication of sub surface ridge from Delhi to Shamli plunging NNE. Probably high degree of peneplanation of the crystalline basement has taken place before the Siwalik formation were deposited. The gravity map shows a strongly negative anomaly near Hardwar, with very steep gradient upto Bijnor in south. This high is mainly based on aeromagnetic data and the ridge is taken to limit the western extends of the Ganga basin. The gravity and seismic data point to a plunging basement high near Shamli. Further east near Bijnor the probable depth to the basement in these portions is around 1500 m. The frontal deep belt at the foot of the Siwalik hills in this region is very deeper, though this belt here becomes narrow, a generally high basement portion up to about Muzzafarnagar is known as Delhi-Muzzafarnagar ridge. The ridge near Shamli and Bijnor are only the main offshoots of the main basement high, separating the Punjab basin from the Ganga basin.

Origin of the Ganga Basin

There are various views regarding the origin of the Ganga basin. It was interpreted to be a fore-deep (Suess, 1904) or a great rift valley (Burrard, 1915), filled up with the alluvium
of thickness of 4.5 km (Oldham, 1917) to 20 km (Pascoe, 1924)

A more recent view regards it a sag in the crust. But at present it is generally accepted that the Ganga basin was formed as a result of buckling down northern fringe of the peninsular shield thrust over from north (Krishnan, 1968). Valdiya (1982), interpreted it as a resultant effect of the sagging of northern flank of the platform around the Bundelkhand shield, following the main episode of the Himalayan orogeny. The depressed platform became the site of the sedimentation by various fluvial agencies predominately from the newly risen Himalayas.

Contrary to the above views recently Indo-Gangetic plain is considered as peripheral foreland basin (Dickenson, 1974) formed as a result of continent - continent collision between Indian and Asian plates. In fact, major sedimentary basins develop between fold - thrust belts and the craton over which the mountain belt is thrust, known as foreland basin (Dickenson, 1974 ) rather than foredeep (Miall, 1981, Bally, 1981) to emphasize the position of most of them on the subducting continental foreland. Foreland basin is asymmetrical and deepest near to the fold-thrust belt. They migrate towards the foreland and have resulted from the downward fluxuring of the lithosphere by the overloading fold - thrust belt (Beaumont, 1981). The evolution of the foreland basin being coupled to that of the adjacent mountain belt.

The most impressive present day peripheral foreland basin is the Indo-Gangetic trough (Plate XIV). South of the seismically
active Himalayas which have been and still are rising at the rate of 70 cm per 1000 years since the mid-Miocene, giving a maximum uplift of about 18 - 20 km (Mehta 1980). Sediment eroded from the rising mountains is deposited in the basin as an alluvial fans transverse to the tectonic axis. Rates of erosion and alluviation are governed not only by the tectonic but also by climate. The Himalayan foothills are built of the older middle Miocene to the Pleistocene Siwalik sediments, more than 5 km thick, similar to those of present alluvial valley (Prakash, Sharma and Roy, 1980). Two features of the Siwaliks are important and typical of all foreland basins. Firstly the Siwalik trough migrates southwards towards the foreland with time and there was continual uplift, erosion and redeposition of older Siwalik material. Secondly, transverse faults in the basement of the Indian plate not only divide the Indo-Gangetic trough into segments, but also govern the location of the existing transverse rivers (Valdiya, 1976).

I.B. Singh (1989) is also of the opinion that the Gangetic plain is a part of the active foreland basin (Peripheral type), developed on the underthrusting Indian plate, in response to the thrust fold belt loading in the Himalaya. During the thrust fold loading in the Himalaya, the Son-Narmada lineament much to the south of the foreland basin was reactivated, causing uplift of Bundelkhand-Vindhyan plateau and development of northerly slope. The rate of the subsidence of the old rigid and cold crust of the Indian shield was also low and sediments input by the rivers high, so that no marine transgression of Neogene was occurred.
SUB-SURFACE GEOLGY OF THE STUDY AREA

The study area lies west of Moradabad fault and it is in the southeast of Delhi - Muzaffarnagar ridge. In a borehole drilled at Upehara village by Oil and Natural Gas Commission, where the Delhi Quartzite was encountered as bed rock at 572.9 metre below ground level. On the basis of the above the sub-surface geology of the area is as under.

GEOLOGICAL SEQUENCE

Quaternary Alluvium - Alternate beds of sand and clay > 572.9m.
with intercalation of calc-concretion

Middle Protozoic - Delhi Quartzite
1600 - 1200 m.y.

Probably on the eroded surface of the Delhi Quartzite, Quaternary sediments were deposited comprising alternate beds of sand and clay with the intercalation of Calcareous concretion. The thickness of the alluvium increasing towards Ganga banks and further beyond. The alluvium constitutes an asymmetric prism sediments with the axis of thickest deposition close to Himalayan foothills.

In all, there are eight aquifers have been encountered at Upehara village which occurs in depth range of

(I) 10.3 - 50.2 (II) 62.2 - 96.2 (III) 110.3 - 170.2
(IV) 192.3 - 263.3 (V) 292.3 - 338.3 (VI) 361.3 - 392.5
(VII) 408.3 - 489.4 (VIII) 501.3 - 553.9 m.b.g.l. respectively.
MORPHOMETRIC ANALYSIS IN PART OF
GANGA BASIN, DISTRICT GHAZIABAD

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--- II ORDER

--- III ORDER