Geological aspects of any region play vital role in the manifestation of hydro-geological environment as well as overland flow component. Looking to this very fact the author has carried out a critical compilation of the available geological information on the study area and duly authenticated through field checks.

LITHOSTRATIGRAPHY

Litho-stratigraphically the rocks of Pachchham Island, (Fig. 5.1) belong to Mesozoic, Cenozoic and Quaternary Eras. The sediments characteristics of the Pachchham Island do not shows any similarity with the rocks exposed on Mainland area, however, based on palaeontological evidences broad correlation has been established by the various workers.
MESOZOICS

The overall Mesozoic litho-stratigraphic sequence of the Pachchham Island is characterized by arenites and rudites sediments, however, in the middle part of the sequence argillites and carbonates predominant. Based on sediment characteristics, the sediment pile of Pachchham Island can be divided in to two distinct formations (Biswas, 1970 and 1993) namely:

- Gora Dungar Formation
- Kala Dungar Formation

The overall stratigraphy of the Pachchham Island as envisaged by Biswas (1993) is given in Table 5.1.
Table 5.1 Mesozoic Stratigraphy of the Pachchham Island (After Biswas, 1993)

<table>
<thead>
<tr>
<th>Time Scale</th>
<th>Rock Unit</th>
<th>Lithology</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Callovian</td>
<td>Gora Dungar Formation 150 (+) m</td>
<td>Upper Part: Sandstone with minor shale. Middle Part: Shale and thin flaggy fossiliferous calcareous bands. Lower Part: Alternation of sandstone conglomerate, red and green siltstone, and occasional shale. Locally wedges of granite pebble-conglomerate are seen</td>
<td>Sub Littoral</td>
</tr>
<tr>
<td>Bathonian</td>
<td>Kala Dungar Formation 450 (+) m</td>
<td>Upper part: Yellow massive sandstone with calcareous beds. Lower Part: Alternation of sandstone conglomerate, red and green siltstone and occasional shale beds. Locally wedges of granite-pebble-conglomerate are seen</td>
<td>Littoral</td>
</tr>
</tbody>
</table>

Kala Dungar Formation

Kala Dungar sediments have been found over the crystalline basement (Biswas, 1970). The rocks belonging to this formation are fully developed and well exposed in the Kala Dungar Hill range and attain almost 450 m thickness (Biswas, 1970). The rock exposures are seen as the rugged and highly dissected terrain between Kuran and Narewari Wandh at the northwest part of scarp. Also good sections are seen in the dissected valley, cutting across the Kala Dungar hill range. Outcrops of this formation can also be observed in the deeply dissected valleys cutting across the Gora Dungar hill range.

Lithology: Dominant rock types of this formation are conglomerates, sandstones and arenaceous limestones, while shale, clay stones and siltstones constituting subordinate rock types. The various rock types merges into one another and producing wide varieties of intermediate types, such as, pebbly sandstones and shale, sandy shale, silty clay, shaley siltstone, calcareous siltstone and sandstone, arenaceous limestone and the like (Biswas, 1970).

The rocks of Kala Dungar Formation can be broadly subdivided in to three members viz.

- Babia Cliff sandstone Member.
- Kala Dungar Sandstone Member
- Dingy Hill Member

Dingy Hill Member: This member constitutes the lowest part of the formation and comprises thinly bedded alternation of green and red siltstones and brown and gray hard calcareous sandstones in the lower part, where the upper part is characterized by pink to
brownish, massive current bedded sandstones containing thin bands and lenses of granitic-pebble conglomerate, inter beds of shales, siltstones and thin fossiliferous calcareous sandstones. Rocks exposed in Kuar Bet i.e. Trans Linear Trench Zone of Great Rann of Kachchh show gross similarity as the Dingy Hill rocks (Biswa, 1993).

**The Kala Dungar Sandstone Member:** The rocks belonging to this member occupies greater portion of the northern scarp of Kala Dungar Range, and equally well exposed in the lower half of the Gora Dungar scarp. The sediments are characterized by gray to pale brown, compact massive, medium to coarse grained, mostly sub-angular, often felspathic, quartzes sandstones becoming calcareous towards the top; contains thin bands of fossiliferous calcareous sandstones at intervals and wedges of petromictic granitic-cobble-conglomerate in the north-eastern part of the Island (Biswa, 1970 & 1993). The thickness of this member is about 100 m.

**The Babia Cliff Sandstones:** The rocks of this member are best exposed below the Babiya peak of the Kala Dungar Range. These sandstones are also seen to form the upper cliffs of the Gora Dungar scarp. The lower part of the Babia Cliff Sandstone Member consists of brown coloured, soft, compact, massive, well sorted, fine grained, micaceous and felspathic sandstones. The upper part of the member consists of brown, hard, compact, massive fine to medium grained, well sorted, calcareous towards the bottom becoming arenaceous limestones (Biswa, 1970 & 1993). The thickness of this member is 67 m.

**The Gora Dungar Formation**

The Kala Dungar Formation is overlain by the younger Gora Dungar Formation. The rocks of Gora Dungar Formation are exposed extensively in both the hill ranges, topping the gentle back-slopes. In Kala Dungar Range it occurs mostly as outliers. Its thicker development is found in southern flank of Gora Dungar Range and it attains maximum thickness in the eastern part of the range. Being covered by the Tertiary and Rann the top is not exposed. (Biswa, 1970)

**Lithology:** While describing the lithology Biswa (1970), has divided Gora Dungar Fm. into four informal members in ascending order- (i) Gora Dongar Flagstone Member, consisting of thinly bedded to flaggy, gray and yellow limestones containing fossiliferous and golden oolitic bands which resembles member of the Jhurio Formation of the
Kachchh Mainland. (ii) The Gadaputa Sandstone Member, a pale brown to pink, massive, current bedded, medium to coarse grained, quartz-arenites becoming calcareous upward. (iii) Raimalro Limestone Member, it is gray and yellow (on surface) fossiliferous pelsparite, thickly bedded, lower part pebbly, middle part characteristic with nodular cherty segregations along bedding and upper part sandy. Topographically this member is conspicuous forming scarp tops and serves as reliable marker-defined-unit; (iv) Modar Hill Member, comprises a basal olive-gray fossiliferous gypseous shales (Khavada Shale) with fossiliferous flagstone and ferruginous limestone bands, overlain by gray, coarse grained, massive, current-bedded sandstones. The latter studies on Gora Dungar Range have provided a detailed picture on the litho-stratigraphic aspects, dividing the rocks of Gora Dungar Range into three formations. A detailed litho-stratigraphy of this range as worked out by Pandey et al. (1984) is given in Table 5.2.

Table 5.2 Litho-stratigraphic Succession of Gora Dungar Range

<table>
<thead>
<tr>
<th>Age</th>
<th>Litho-stratigraphic Units</th>
<th>Dominant Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Collovian</td>
<td>Lower Chari Formation</td>
<td>Lower shale Member Silty shale with iron concentration &amp; pebble layers.</td>
</tr>
<tr>
<td>Latest late Bathonian</td>
<td>Pachchham Formation</td>
<td>Raimalro Limestone Member Sandy calcarenite with chert nodules and bands.</td>
</tr>
<tr>
<td>Early Bathonian</td>
<td>Khavada Formation</td>
<td>Gadaputa Sandstone Member Soft calcareous sandstone.</td>
</tr>
<tr>
<td>Late Bathonian</td>
<td></td>
<td>Gora Dungar yellow Flagstone Member Calcareous sandstone limestone marl and oolites transition beds sandstone</td>
</tr>
<tr>
<td></td>
<td>Middle Sandstone Member</td>
<td>Medium to coarse grained sandstone</td>
</tr>
<tr>
<td></td>
<td>Lower yellow Flagstone Member</td>
<td>Marl, sandy micrite calcarenite, sandstone</td>
</tr>
<tr>
<td></td>
<td>Eiomiodone red Sandstone Member</td>
<td>Fine grained sandstone</td>
</tr>
<tr>
<td></td>
<td>Sadhara coral Limestone Member</td>
<td>Sandy limestone and calcareous sandstone</td>
</tr>
</tbody>
</table>

(After Pandey, et al. 1984)

The Cenozoic Time-Stratigraphy

The Tertiary rocks are seen to outcrop as narrow strips bordering the southern and western margins of Pachchham Island. Tertiary outcrops occur as discontinuous patches due to overlapping by the Recent deposits. Existence of Tertiary rocks in the Banni, the Great Rann and the Little Rann basins, beneath the Recent sediments is indicated by the patchy outcrops in the marginal areas of the highlands adjacent to the basins and also from shallow holes drilled in these areas (Biswas, 1970). The Tertiary is represented by
rocks ranging in age from Paleocene to Pliocene. The Pliocene rocks are overlain by the Qua
ternary sediments at places, but, it is difficult to mark a line where the Pliocene ends and the Quar
ternary beings. The Quarternary is represented by an un-consolidated admixture of fluvial-aeolian and marine sediments of Recent to Holocene age. The Tertiary strips fringing the highlands are usually overlain by a strip of Recent aeolian sands and the marine sediments of the Rann.

The Tertiary sediments represent the rocks of the Madh Series. This unit constitutes a distinctive type of volcano-clastic rocks deposited in continental to supra-littoral environment (Biswas, 1970). The name of this series is after its type exposure near village Mata-no-Madh in Western Kachchh. The sequence of bed in ascending order is seen in the Pachchham Island is as follows.

- Reddish, current-bedded, medium to coarse grained ferruginous sandstones.
- White to yellowish, friable, fine grained, locally pebbly sandstones.
- White, soapy, clays with thin beds of ferruginous sandstones and large hematitic concretions containing plant fossils
- Red and brown laterite locally bauxite, relics of greenish trap rock with piesolitic structures are seen.

At some places in Pachchham the upper surface of the Madh rocks once blanketed by the extensively lateritised post-Trappean (Early Paleocene) surface, which formed the platform for the latter Tertiary sediments (Biswas, 1970).

**TECTONIC FRAMEWORK**

The tectonic framework of Pachchham Island constitutes part and parcel of regional tectonics of the Kachchh. Therefore, it has to be viewed in regional perspective. Also, the various tectono-geomorphic units as described in preceding chapter, ideally reflects the controls exercised by the various tectonic elements. Considering the regional tectonic framework Eardly (1962) recognized four major uplifts viz. Island Chain, Wagad Highland, Kachchh Mainland and Kathiawad Peninsula. These uplifts occur in four sub-parallel lines trending generally from east to west in quasi en-echelon arrangement (Fig. 5.2A).
The Pachchham Island occurs in the form of uplift in the north of the Kachchh district. The Pachchham uplift isolates from other uplifts by residual depressions. It is separated from Mainland uplift by a stretch of Banni to the south and from the other Island uplift by...
the Great Rann of Kachchh. To the north and west it is surrounded by the plains of the
Great Rann of Kachchh (Belousov, 1962). The pair of step faults striking NW-SE and
Each step forms a unilateral box fold having a gentle back-limb facing the north.

The north and south steps comprises Kala Dungar and Gora Dungar hill ranges in north
and south parts respectively. The Kala Dungar fault is not exposed but it can be
conjectured by the various geo-morphological features while Gora Dungar fault is well
exposed along the foot of the Gora Dungar hills and towards the east it passes into the
flexure with the diminishing structural relief. Between the two hill ranges the Central
valley occupies the structural low at the foot of the southern step. Here the beds are
folded in an asymmetric syncline

The structural pattern of the Pachchham uplift shows similarities with the Mainland
Pattern on smaller. Same as Mainland the Median High crosses the Gora Dungar, Kala
Dungar structures and the Central syncline. The folds plunge both to the east and west of
this high. The drainage anomaly and presence of a subsurface high near village Dhorawar
in the middle of the Central Valley shows two plunging synclines to the east and west of
the Dhorawar High (Biswas, 1993).

Besides faults and folds there are three domes contributing the Kala Dungar fold complex
namely Kuar Bet, Dingy and Flamingo domes. These are isolated uplifts bounded by the
faults and placed en echelon, close to the faulted edge of the Pachchham uplift. Both Kala
Dungar and Gora Dungar folds are affected by innumerable normal faults of minor
intensity. Fig. 5.2b shows tectonic aspects of the Pachchham uplift.

The post Mesozoic tectonism in Kachchh region has manifested innumerable
deformational structures of major and minor scales. The responses to these tectonic
events in Pachchham region are described in terms of numerous mega folds, domes and
faults (Plates 5.1 – 5.3). The core of the Kala Dungar fold is intensively intruded by the
basic igneous rocks in the form of dyke swarms, sills and plugs (Plate 5.4). In contrast,
the intrusions are much less in Gora Dungar though the structures there are much more
complicated (Biswas, 1982 and 1993). Salient characteristics of some of the important
deformational structures as described by Biswas (1970, 1982) are mentioned in Table 5.3.
Table 5.1 Photograph showing Exposure of Raimal Rao Anticline near village Mota Paiya.

Plate 5.2 Exposure of Gora Dungar Fault on Khavada Tuga Road.

Table 5.3 Structural Characteristics of Pachchham Island

<table>
<thead>
<tr>
<th>Region</th>
<th>Important Structure</th>
<th>Trend</th>
<th>Magmatism</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kala Dungar</td>
<td>Asymmetric anticline</td>
<td>W - E</td>
<td>Dyke swarms in core region</td>
<td>Northern Edge of Island between Dedhro and Simari Nala known as Kala dungsar fold</td>
</tr>
<tr>
<td></td>
<td>Domes</td>
<td>--</td>
<td>Gabbroid Plutons</td>
<td>North-west tip of Island near village Kuran &amp; Nirwandh (Dingy &amp; Flamingo)</td>
</tr>
<tr>
<td></td>
<td>Longitudinal major fault</td>
<td>NNW-SSE</td>
<td>Dykes</td>
<td>Norther edge of Kala Dungar</td>
</tr>
<tr>
<td></td>
<td>Oblique faults</td>
<td>NNE-SSW</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Gora Dungar</td>
<td>Anticlines</td>
<td>WNW-SES</td>
<td>Gabbroid dyke</td>
<td>Raimralrao hill, Juna, Khavada, Ludia, Andhau, Halanori, Kank hill</td>
</tr>
<tr>
<td></td>
<td>Syncline</td>
<td>South-West Plunging</td>
<td>--</td>
<td>Between anticlines</td>
</tr>
<tr>
<td></td>
<td>Dome</td>
<td>--</td>
<td>Dyke</td>
<td>Eastern end of Gora Dungar Near village Sadhara</td>
</tr>
<tr>
<td></td>
<td>Marginal Gora Dungar Fault</td>
<td>ENE-WSW</td>
<td>--</td>
<td>Northern edge of Gora Dungar</td>
</tr>
<tr>
<td></td>
<td>Secondary transverse faults</td>
<td>NE-SW and NW-SE</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intersecting faults</td>
<td>E-W</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Central Valley</td>
<td>Syncline</td>
<td>WNW-ESE</td>
<td>--</td>
<td>Between Kala Dungar anticline and Gora Dungar fold complex</td>
</tr>
</tbody>
</table>

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The few characteristic features of the Pachchham uplift that require attention are

- The Kala Dungar block has a simpler structural form than the Gora Dungar block in spite of its greater uplift.
- Longitudinal tensional faults and cross faults are predominating in Kala Dungar uplift, while cross faults are more frequent in Gora Dungar uplift.
- Though simple in structural pattern, the Kala Dungar fold is strongly invaded by igneous intrusions whereas such intrusions are strikingly few in the complex Gora Dungar structure.
- The Pachchham uplift has been traversed by the Median ridge so that the structural relief of the uplift diminishes on both sides of the elevated central part causing the folds of plunge both ways
- A group of small individual domical uplifts bounded by fault occur as en-echelon the north west of this uplift.

The understanding of lithologies and tectonic features of the study area is pre-requisite for in depth study of groundwater occurrence, distribution and its chemistry. This worked out geological information has been utilized by the author for hydrogeological categorization and evaluation of the Pachchham Island.