CHAPTER 3

GEOLOGICAL FRAMEWORK

3.1 INTRODUCTION

The intensity and magnitude of landslides especially in mountain terrain is intrinsically governed by the geology of the area, particularly lithology, structure and degree of weathering. Therefore, it is essential to understand the geological conditions of the Agumbe hill range while identifying various causative factors responsible for slope instability. In this chapter an attempt is made to present the geological framework of the Western Ghats and Agumbe hill range in general and failed slopes in particular.

3.2 GEOLOGY

Western Ghats, the most important orographic feature of the Peninsular India, represents the long-lived uplift history. It is an elevated relief barrier bordering the Western Continental Margin of India with world-class landforms comparable to many well-know rifted margins. Prolonged rifting resulted in scarp retreat on a grand scale associated geo-morphological processes that caused the removal of large quantities of weathered material and deposition in marginal sedimentary basins. The Western Ghats can be conveniently divided into three distinct geographic regions based on lithology and structure.

1. Northern Konkan Region - mainly composed of Deccan Basalt/trap rocks belong to Tertiary age

2. Central Sahyadri; or Malnad Region - represented by Metamorphosed Volcano-sedimentary sequence of Archaean and Proterozoics of Dharwar Super Group (DSG).
3. Southern Malabar or Nilgiri Region – comprising high grade granulite terrain of Archaean age

Konkan Region: The northern part of Western Ghats mountain range covering Maharashtra and Goa is better known as "Konkan". It consists of horizontal to nearly horizontal sheets of basalts, cut into a steep scarp on the western side and eastward gentle slope. The highest summit in this part of the hill range is Mahabaleswar with 4540 feet above MSL, It is a flat topped and slightly elevated hilly terrain compare to Deccan plateau. The steep western margin is usually terraced and resembling the ghat or landing – stair from which this mountain range derives its name. The landward eastern slope is gentle but also terraced. Krishna, Bhima and Godavari rivers takes their birth in this part of the western ghat. There are a few passes in the Ghat and provides lines of communication between the coastal plains and the interior and also have had great strategic significance in the past history of the country.

Sahyadri region: Sahyadri hill range, which forms the central part of the Western Ghats covering Karnataka state starting from the South of Konkan (south of about 16° N latitude) upto Kasaragodu in Kerala. The nearly horizontally disposed Deccan Basalts of Konkan gives way to the ancient meta volcano-sedimentary sequence of Dharwar Super Group (DSG) in Sahyadri. Structurally, this part of the Western Ghat shows regional syncline overturned to west and posses low angle plunge towards northeast. The general trend of this hill range coincides with the regional trend of Western Ghats. The highest and the most elevated part of this region is Mullayyanagiri having an elevation of 1892m above MSL. The major rivers like Cauveri, Sharavathi, Chandranadi, Varahi, Tunga, Bhadra, Kalinadi, Gangavalli, Swarnanadi, Sita Nadi and Netravathi originate from this
Sahyadri hill range. Besides biodiversity, this part of the Western Ghats hill ranges posses rich mineral resources viz., iron and manganese ores, asbestos, corundum resources, clay and laterite etc.

**Malabar or Nilgiri Region:** Malabar hill ranges forms the southern most part of the Western Ghats occupying the Kerala state, it extends from south of Kasaragodu down to Cape Comorian. These hill ranges are essentially made up of high-grade granulite rocks of Archaean age. The general foliation of these formations coincides with the general trend of the Western Ghats (NNW-SSE) and dip varies 40° to sub vertical towards northeast direction. The most elevated part is Anaimalai 2695m above MSL. Periyar and Idamalayar rivers form the main drainage system.

### 3.3 GEOLOGY OF SAHYADRI HILL RANGE

Sahyadri hill ranges, a central segment of Western Ghats lying within the Karnataka state. This hill ranges have been broadly grouped into; a) Western Ghat belt and b) Shimoga Belt by Swaminathan and Ramakrishna (1981).

Western Ghat belt is also called, as Kudremukh Belt is well known for its scenic beauty, vast and rich iron ore deposits. It is an irregularly elongated NNW – SSE trending belt occupying the precipitous hill ranges, covered by dense forests. The belt consists of rocks of Walkunji and Narasiparvata formations of Bababudan Group lying unconformably over the Peninsular Gneissic Complex (PGC) comprising of migmatitic gneisses and granitoids of Archaean age (Balasubramanian et al 1976). Intrusives of basic-ultra basic composition have cut across these rocks.

*Walkunji Formation* represents the lower arenaceous and argillaceous members of the Bababudan Group. The formation is well developed near Walkunji, NNW of Gangamula with a basal oligomictic
conglomerate. The other associated litho units are quartzite, quartzite-sericite schist, greywacke, arkose and quartz-chlorite-biotite- schist (near Gangamula, Haranje Ghat Section). Venkataraman (1968) has described the conglomerate made up of pebbles of quartzites embedded in a siliceous matrix with current bedding.

**Narasiparvata Formation** (extending between Sollebail now known as Jayapura and Sringeri) consists of porphyries, lavas, tuffs and paragneisses. Sampath Iyengar (1912) first described the opalescent quartz gneisses and included them under the Champion Gneiss. However, recent studies (Ramakrishnan and Harinadha Babu, 1981) have shown that Narasiparvata formation constitutes acid igneous suite of rocks. The common acid rock is medium grained quartz porphyry with phenocrysts of blue opalescent quartz.

### 3.4 GEOLOGY OF AGUMBE HILL RANGE

The Agumbe hill range forms a part of the West Central Group (WCG) of Dharwars (Rama Rao, 1964). Lithologically, the area is essentially comprised of rocks of Bababudan, Chitradurga and Sargur group of rocks. The Bababudan group is represented by minor bands of amphibolites, quartzites and garnetiferous mica schist of Walkunji formation and paragneisses of Narasiparvata formation. Chitradurga group has represented by shallow water sediments in the southern part and deep-water greywacke and cherty Banded iron formations of Kudremukh formations in the northern sector. The relics of high grade supra crustal rocks (Sargurs) occur as enclaves within the gneisses are found near Koppa and Balehonnur (Fig 3.1).
### Table 3.1: Lithostratigraphy of the Agumbe hill range
(Adopted from GSI publication, 2005)

<table>
<thead>
<tr>
<th>Litho type</th>
<th>Stratigraphic position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laterite</td>
<td></td>
</tr>
<tr>
<td>Basic dyke</td>
<td>Intrusive</td>
</tr>
<tr>
<td></td>
<td>Mesoproterzoic</td>
</tr>
</tbody>
</table>

#### Dharwar Supergroup

- **Garnetiferous Chlorite schist, hornblende schist**
- **Garnetiferous grunerite schist**
- **Banded Iron Formation (BIF)/Ironstone with phyllite**
- **Metabasalt and amphibolite, metagabbro**

- **Unconformity**

#### Bababudan Group

- **Banded Iron Formation**

#### Chitradurga Group

- **Chitradurga Group**

#### Peninsular Gneisses

- **Amphibolite with bands of pelitic schist**
- **Gneisses/Migmatites**

- **Sargur Group**

- **Peninsular Gneisses**

- **Archaean**
3.5 GEOLOGY OF THE FAILED SLOPES

A detailed field observation during the investigation of landslide areas indicate that the failed slopes are essentially made up of the following litho units i) Gneisses ii) Chloride schist iii) phyllites.

3.5.1 Gneisses: A northern and eastern part of the study area is comprised of gneisses/migmatites of PGC represented by gray gneisses of granodiorite to trondhjemitic composition. Gneisses generally occur as bouldery outcrops in low-lying mounds. The failed slopes near Anegundi, Hariharpura, Thirthahalli, and Megaravalli are represented by this lithounit. The gneisses occasionally contain enclaves of hornblende schist and traversed by pegmatite veins. Basic rocks, which occur as intrusives in the basement gneissic complex forms long and continuous sills and dykes. These intrusives have general trend of NNW-SSE coinciding the general trend of the Western Ghats.

The gneisses are highly weathered and fractured particularly in the region of failed slope. Volumetric estimation of discontinuity planes in the gneisses amounts more than 12 per cubic meter. The discontinuity planes include joints parallel to gneissic fabric and intersected by cross joint planes and shear planes. The joints are non-planar, open and posses short continuity. The deep surface staining indicates that the rock formation posses higher degree of weathering.

3.5.2 Chlorite schists: It is the second major lithounit of the study area. The rock is light green in colour and shows well-developed schistocity with slaty cleavages, often shows pinching and swelling structure. The general trend of the schistocity plane is N50°W -S50°E, with varying dip of 35° to 50°E. It is essentially comprised of quartz, chlorite and biotite mica. The rock is highly friable in nature susceptible for weathering and denudation. Chlorite schist is a
Fig. 3.1: Geology of Agumbe hill range
dominant litho unit in the famous Agumbe landslide area where, it is highly sheared intensely weathered and fragmented. The shear planes frequently contain clayey gauge material often associated with heavy seepages. The presence of stretched lineation, pinch and swell structures are indicating that rock has undergone higher degree of deformation.

3.5.3 Phyllite: Phyllite forms the major litho unit in Agumbe, Hosur and Begar slide areas. The rock is highly foliated brownish yellow in colour, soft and traversed by three to four sets of joints. In the failed slopes region the rock is highly sheared and show pinch and swell structures, often filled with clay, indicating that it is intensely deformed and weathered.

3.6 STRUCTURE AND TECTONICS

The Agumbe hill range, which forms a part of the Sahyadri escarpment, comprises NNW-SSE trending en-echelon hills and mountain ranges. These hill ranges abruptly end as a steep scarp slope with a break at their northwestern end and occur as west facing high scarps of more than 700m with reference to plain land. This part of the western ghat belt has multiple NNW-SSE faults. Foliation and schistocity planes follow the general trend of the scarp line. In the northern part, the strike of these planes ranges between NNW-SSE to WNW-ESE with an average dip of 50° due north. Whereas, in the southern part, the attitude ranges from NW–SE to EW with southerly dip ranging between 25-55°. Occasionally, the attitude of the foliation changes to NNW – SSE coinciding with the general trend of the Western Ghats with nearly vertical dip. The eastern part of the study area is structurally dominated by large scale overturned antiforms and synforms. Kanara Granite has been emplaced along regional SE plunging anticlinal fold (Balasubramanian, 1976).
According to Radhakrishna (1993), the present day easterly drainage of the southern peninsula appears to be a post Deccan Trap feature, caused by the cymatogenic upwarp of the crust along the axis, and little west of the present day Western Ghat Scarp. Rivers like Godavari, Tungabhadra, Krishna and Cauvery originate at the crest of the Ghat, but flow eastward traversing the whole width of the plateau. Evidently, the easterly drainage is the effect of an easterly tilt that has given rise to the peninsular landmark. The line of the Western Ghat represents a hinge, causing the eastward tilt of the Peninsula.

3.6.1 Lineaments

Lineament map of Agumbe hill range shows that the disposition and extent of lineaments/faults (Fig3.2). While analyzing the lineament map it is observed that, there are three major and five minor lineaments/faults oriented in almost NNW – SSE direction and are almost sympathetic to Western Ghat scarp line passing through the area under investigation.

3.6.1.1 Major lineaments

Valdiya (2001) has identified Magundi – Thirthahalli Fault (MTF) and inferred that it is an active fault. In addition to this, two major faults were identified during the course of present study. They are;

a) Kunchikal – Patali Fault (KPF) runs in NNW-SSE almost diagonally in the study area. There are three water falls located along the alignment of KPF viz., Kunchikal Abb Falls (20m) in the NW corner, Vanake Abb falls (15m) in the centre and Patali falls (25m) in the SE part of the study area. This is probably an active fault.
b) Someshwara – Gangamula (SG) lineament is located southern part of the study area, Suttinabbi waterfalls (22m) is associated with this lineament.

3.6.1.2 Minor lineaments

Five minor lineaments recognized in the study area are having similar orientations (NNW-SSE) and appears to be sympathetic to major lineaments/faults. All along these lineaments there is an anomalous behavior of stream i.e., abrupt stream deflection and stream ponding, which indicates faulting/displacement.

The western edge of the Western Ghat Scarp has been identified as a region of high heat flow. The existence of thermal springs at Puttur near Mangalore is an indication of recent faulting activity (Krishnaswamy, 1981 and Ravishankar, 1991). The presence of major and faults/lineaments with alignment of many waterfalls, hot springs, anomalous behavior of streams indicates that the area is neotectonically active.

3.6.2 Escarpments

Agumbe Hill Range forms a part of the typical Western Ghats escarpment exhibit long asymmetrical ridge like structure of steep western slope and gentle eastern slope, with contrast drainage characteristics on either side. Hence, it is popularly known as “the Sahyadri, the Great escarpment of Indian Subcontinent” (Radhakrishna, 2001). The scenery of this escarpment region is a complex palimpsest. The Digital Elevation Model (DEM) of the study area shows asymmetry of the escarpment and undulating scarp line at its apex, which virtually divides east and west flowing drainage system. According to Subrahmanya (1994) the evolution of Western Ghats reveals up-warping, evidenced by emergence of land along the
Fig. 3.2: Structural features of Agumbe hill range
western margin of the Indian subcontinent and anomalous behaviors of streams.

3.6.3 River ponding

In certain parts of drainage network of the study area, the rivers and streams exhibit ponding, indicating these are structurally controlled river courses. Field observations reveal that, river ponding near Anegundi where Thunga River takes right angle turn. Initially the river course is S60°W direction and then takes turn to N30°W direction. Further, the east flowing Thunga River takes remarkably a straight NNW-SSE course for several kilometers at SW of Thirthahalli and shows ponding of river water. Incidentally, this area has witnessed a huge landslide in the year 1999 which caused complete blocking of Sringeri –Thirthahalli road over three months. Malathi Hole a tributary of river Thunga also exhibits ponding where it intersects NNW-SSE striking major fault in the study area. The phenomenon of ponding of Thunga River and its tributary Malathi Hole around SW region of Thirthahalli may be due to continued movements of major fault along the NNW-SSE direction. According to Valdiya (2001) this sort of characteristic feature is one of the anomalous behaviors of active tectonics. River ponding provides very convincing evidence of very recent rather continuing movements of faults that traverse in their channels.