DESCRIPTION OF SITES : SLOPES AND SOILS

Slope profile and soil analysis were undertaken in ten selected locations (Fig. 1.2). These were Mylliem, Ryngngain, Sohiong, Mawlat, Smith, Barnihat, Jarain, Bapung, Komrrrah and Sonapur. The first six are located in old hard rock zones of granites and gneisses. The first five offer dominantly natural landscapes. Centrally located, Barnihat is a localised area of 'Jhum'cultivation on the northern periphery of Meghalaya. The other four are located in the southern fringe of the plateau, lying on the younger soft rocks i.e. sandstones, shales and limestones. Human interference through excavations of coal and limestones has provoked important changes in the cultural landscape of this zone.

3.1: MYLLIEM :

Mylliem (Fig. 3.1), at 12km distant from Shillong is located between 25 29' to 25 30' N latitude and 91 49' to 91 50' E longitude. It falls within the physiographic unit number four (Fig. 2.1). It is a plateau with moderate slopes. Drainage pattern is dendritic to sub-parallel and seasonal in nature having main outlet to Umlew to the south. The elevation of the site ranges from 1700 to 1800 m from msl. In general, gradient is more than 50 per cent with more than 200
LOCATION OF MYLLIEM

1 : 50,000

Fig. 3.1
m slope length. Erosion is severe with rapid surface runoff. Vegetation along river valleys and hillslopes are moderately dense, while it is sparse on hill tops. Pine trees are common on the summit.

Rock types are mostly granite, quartzite, quartz-mica schist of Shillong group and Khasi greenstones with Cretaceous sandstone cappings. The perphyritic granites are intrusive both in Shillong and Khasi greenstone group of rocks. Further the coarse granites are intruded into the perphyritic granite (Chakravorty & Das, 1982). Orientation of the dips are towards NW-SE direction. The foliations are also developed in the same direction and is more prominent at the contact of the two types of rocks. Numerous joints have developed within the pluton. Main joint is along the foliation plane and vertical, while others are across or oblique to the foliation plane.

Potato cultivation on terraces was intensive in early days but it is now abandoned due to landslides.

3.1.1: Slope Profile Analysis:

Slope profile analysis in the study area shows three distinct phases as depicted in Fig. 3.2. At A, slope summit extends up to 25 m length from the crest. It is full of dried grass and thinly spread pine trees. Soil cover is 85 to 90 per cent coupled with 10 to 15 per cent of rock outcrops of the size 120 x 150 cm out of which 10 to 20 cm remain
exposed to surface. The slope extends from 7.8 to 18.5 per cent and are convex in nature. There are quite a number of hummock shaped structures measuring 120 to 150 cm in width and 210 to 300 cm in height. Slow mass movement like soil creep is observed at this site.

At B, slope with gradient 19.4 to 28.7 per cent extends upto 35 m length, out of which 5 m length was observed with exceptionally steeper gradient (47.6 per cent). It is a convexo-concave slope. The hillside drainage lines are the result of soil creep and talus creep on some concentrated line of rills and gullies with 10 cm wide and 8-10 cm deep at an interval of 60-90 cm. Rills and gullies are discontinuous because of stoney debris. There is also evidence of throughflow at the junction of the slope break.

Slope lengths of 15 m with gradient 57.7 to 78.4 per cent are observed at C. Pronounced gullies of 10 to 15 m in both width and depth are common. There are formations of tunnels and cappings of columnar shaped terracettes with rockfall, soil and talus creep type of mass movements. There are hummocks, highly prone to topples and slab slides.

Slope at D is a distinct free face and continues over 88 m length with 65° of gradient. Gullies of the same size of C were also observed here. It is full of gravels, boulders, cobbles, and pebbles. There is a vigorous throughflow underneath. Boulders, even as big as 600 x 180 x 300 cm are
observed at 45° slope. Formation of tunnels and terracettes are common.

The materials move downward from above, get deposited at E, which is a debris slope of 20 m length and gradually merges with the seasonal stream of 20 m wide wherein boulders, cobbles and pebbles are found scattered on its bed. There is hardly any space not covered by boulders, cobbles and pebbles.

3.1.2: Soil Analysis:

As shown in Table 3.4, soil depth at A and B extends upto 17 and 18 cm., respectively, while at C it extends upto 49 cm. Soil samples at D and E could not be collected because of free face and coverage of debris materials.

Soils at A are dark yellowish brown, clay loam, fine, moderate, sub-angular blocky. Soils at B have similar characteristics except the texture being loam. Soils at C are moderately shallow, excessively drained, dark yellowish

<table>
<thead>
<tr>
<th>* Size Classes of Surficial Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (cm)</td>
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<tr>
<td>&gt; 25</td>
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<tr>
<td>&gt; 7.5</td>
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<tr>
<td>1.25-7.5</td>
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<td>Upto 1.25</td>
</tr>
</tbody>
</table>
TREND OF SOIL CHARACTERISTICS AT MYLLIEM

FIG. 3.3
Table - 3.4

Soil Characteristics of Mylliem

<table>
<thead>
<tr>
<th>Site</th>
<th>Average Depth (cm)</th>
<th>Moist %</th>
<th>Sand (Si+C)/sand %</th>
<th>Org.C %</th>
<th>W.H.C. %</th>
<th>Liquid pH Limit %</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>12.1</td>
<td>0-17</td>
<td>10</td>
<td>YR 4/6</td>
<td>33.6</td>
<td>1.97</td>
</tr>
<tr>
<td>B</td>
<td>28.1</td>
<td>0-18</td>
<td>10</td>
<td>YR 4/6</td>
<td>35.4</td>
<td>1.82</td>
</tr>
<tr>
<td>C</td>
<td>65.2</td>
<td>0-16</td>
<td>10</td>
<td>YR 4/4</td>
<td>56.5</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16-30</td>
<td>5</td>
<td>YR 4/6</td>
<td>56.9</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30-49</td>
<td>5</td>
<td>YR 5/8</td>
<td>63.6</td>
<td>0.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>49+</td>
<td>5</td>
<td>YR 5/8</td>
<td>77.5</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Source: Estimated by the author.

brown, sandy clay loam very fine, weak, sub-angular blocky underlain by loam in the subhorizon. Soils of all sites are extremely acidic (pH 4.4 to 4.6). With increase in gradient from A to C (7.8 to 75.4%) there is gradual fall in finer soil fractions (silt and clay) including organic carbon (Fig. 3.3). Both WHC (Water Holding Capacity) and Liquid Limit (LL), however, showed slight increase at B, although the values sharply decreased at C corresponding with finer soil particles and organic carbon.

3.2: RYNGNGAIN:

Ryngngain is located between 25° 21' to 25° 22' N latitude and 91° 52' to 91° 53' E longitude (Fig. 3.4). It
falls within the physiographic division, Fig. 2.1. It is a dissected steep rocky hill, south facing, where a road from Shillong to Dawki runs. Presently, the road is under renovation and is being widened.

It forms part of a highly dissected tableland with several deep gorges and escarpments. The average height of tableland is 1200 m from msl and originates from the edge of the scarp face and extends upto the steeply sloping hill faces down below. The drainage pattern is dendritic to sub-parallel and recharge fully during the rainy season. In general, the gradient is more than 30-50 per cent, severely eroded with rapid runoff.

The rock type is horizontally disposed with medium to coarse grained sandstones and granitic gneisses. The joints are directed towards E-W, vertical joints and dippings are towards S-W. These widely spaced joints give rise to many blocks of large dimensions.

3.2.1: Soil Profile Analysis:

Three distinct sites were identified as shown in Fig. 3.5. Site A with 18.5 to 29.7 per cent gradient for a length of 80 m, consists of a series of near planar sites separated by smoother discontinuities. It is covered with dried grasses and orchids. The surface stoniness is 15 to 20 per cent with boulders of about 50 cm in diameter. The site is affected by slow mass movement, like soil creep and
FORM OF HILLSLOPE
RYNGNGAIN

Site A

Site B

Site C

Slope values in percent
Survey station
Slope discontinuity

LEGEND

Fig. 3.5
partly, by sheetwash. Downslope, in B, the gradient is 37.3 to 39.3 per cent upto 35 m length with an exception of 24.9 per cent for 5 m. On this site exposed rocks are on the verge of breaking along the cleavages. Grass cover is thicker. The site is affected by mainly soil mass movement and partly by rock slide. Site C is having 93.3 to 119 per cent slope gradient for a length of 135 m with a 6 m wide road in between. The upper part of C, i.e. upto the road, suffers from rapid mass movement, like topples, slab slide, rock slide and rock falls. Surface materials viz. blocks, chunks and flakes of sandstone with few quartz are found. Downward the road the lower part, is covered with moderately a dense mixed forest. Large blocks of rocks with 50 to 75 cm in diameter are observed in this area.

3.2.2: Soil Analysis:

The soils at A is gray, sandy, coarse and single grained (Table 5). Soils at B are dark yellowish brown, sandy clay loam, medium, weak and subangular blocky. Soils at C are moderately shallow, excessively drained, very dark grayish brown, sandy clay loam, fine, single grained, underlain by strong browns, loam, fine, weak and subangular blocky. Soils are highly acidic throughout the slope profile.

A scrutiny of data in Table 3.5 shows that the finer soil fractions including organic carbon content increase from A to B, and thereafter, their values abruptly fall at site C
TREND OF SOIL CHARACTERISTICS AT RYNGNGAIN

**SILT + CLAY/ SAND**

- **Clay**: 0.25 - 1.00
- **Silt**: 0.25 - 0.75

**Organic Carbon**

- **Per cent**: 0.0 - 4.0

**WATER**

- **Per cent**: 30 - 70

**LIQUID LIMIT**

- **Per cent**: 10 - 40

**SITE**

A → B → C

**FIG. 3.6**
(Fig. 3.6). The variations in both WHC and LL along slope profile A to B corresponded well to that of organic carbon; but no conspicuous change was observed at C.

Table - 3.5

<table>
<thead>
<tr>
<th>Site</th>
<th>Average Gradient</th>
<th>Depth (cm)</th>
<th>Moist %</th>
<th>Colour</th>
<th>Sand %</th>
<th>Si+C %</th>
<th>Org.C %</th>
<th>W.H.C. %</th>
<th>Liquid pH Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>24.1</td>
<td>0-21</td>
<td>5 YR/1(d)</td>
<td>86.8</td>
<td>0.15</td>
<td>1.11</td>
<td>32.38</td>
<td>15.0</td>
<td>4.5</td>
</tr>
<tr>
<td>B</td>
<td>36.4</td>
<td>0.20</td>
<td>10 YR 4/4</td>
<td>56.3</td>
<td>0.77</td>
<td>3.23</td>
<td>67.38</td>
<td>35.0</td>
<td>4.8</td>
</tr>
<tr>
<td>C</td>
<td>106.2</td>
<td>0-20</td>
<td>10 YR 3/2</td>
<td>55.0</td>
<td>0.88</td>
<td>3.57</td>
<td>64.22</td>
<td>35.0</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20-75</td>
<td>7.5YR 4/6</td>
<td>46.1</td>
<td>1.16</td>
<td>1.01</td>
<td>57.12</td>
<td>32.5</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Source: Estimated by the author.

3.3: SOHIONG:

Sohiong is situated between 25° 30' N to 25° 31' N and 91° 40' to 91° 44'E longitude at an elevation of 1760 m from msl (Fig. 3.7). It falls within the physiographic division, number two, Fig. 2.1. It is a highly dissected table-land with several gorges. The topography is marked by a steep to vertical scarp face. Eroded hill slopes have hill side drainage lines which are of dendritic to sub-parallel in nature. The runoff makes a slope wash on some concentrated line, generally rills and gullies. Due to continuous rock fall, a road has been diverted and the area is converted to a rock quarry.
LOCATION OF SOHIONG
1:50,000

REFERENCES

Contour in metres
Roads
Rivers

Fig. 3.7
Main rocks of the area are shale, sandstone and granitic gneiss. Rocks are horizontally to sub-horizontally disposed. Sandstones found here, are hard and medium to coarse grained in texture. Some joints are directed towards E-W, while others towards N-S. They are widely spaced giving rise to blocks of medium to large dimensions.

3.3.1: Slope Profile Analysis:

Slope profile analysis was carried out and three distinct sites were identified (Fig. 3.8). Site A is a summittal convex with 13.4 to 28.7 per cent slope gradient. It is covered with grass and pine trees, though growth of these trees are not luxuriant. Evidence of sheetwash in A is found from the accumulation of small fragments at the base of the vegetation. Finer soil particles are washed down with little terracettes left behind. B is limited to 15 m length in the form of a free face, with gradient 44.5 to 48.8 per cent. At this site, some thin beds, commonly attached by differential weathering into discontinuous 'galleries' are observed. It perhaps corresponds to sandy beds separated by cohesive silt and clay and also by root bindings. The C is a free face with 70-87 per cent gradient of 90 m length. The upper part of C is susceptible to mass movements of translational type, viz. rock, slab, and detritus slide. Its surface is smooth and is covered with algae and mosses. There is formation of discontinuous rills and incipient gullies of 3 to 4 cm width and 1 to 2 cm depth. At the inflexion between 41° and
FORM OF HILLSLOPE
SOHIONG

Slope values in Percent.
Survey station
Slope discontinuity

Fig. 3.
35° of this site, there is a huge accumulation of soil mass with trees, grass and other debris like boulders, cobbles, blocks and chunks with flakes and chips, which are washed away by rain and deposited over the base. Beyond C, a road with 6 m width was there. Now it is diverted away by about 20 m from the existing one. The old one is badly affected by rockfalls and other debris avalanches.

Table - 3.6

<table>
<thead>
<tr>
<th>Site</th>
<th>Average Gradient (cm)</th>
<th>Depth 0-13</th>
<th>Colour 7.5YR 4/6</th>
<th>Moist 38.3</th>
<th>Total 1.61 2.69</th>
<th>Si+C 4.9</th>
<th>Org.C. 37.0</th>
<th>W.H.C. 4.7</th>
<th>Liquid Limit 4.7</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>21.7</td>
<td>0-13</td>
<td>7.5YR 4/6</td>
<td>38.3</td>
<td>1.61</td>
<td>2.69</td>
<td>64.76</td>
<td>37.0</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13-32</td>
<td>7.5YR 4/4</td>
<td>29.4</td>
<td>1.65</td>
<td>2.40</td>
<td>1.65</td>
<td>75.40</td>
<td>37.5</td>
<td>4.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32-59</td>
<td>7.5YR 4/6</td>
<td>17.5</td>
<td>4.71</td>
<td>2.27</td>
<td>57.14</td>
<td>37.5</td>
<td>4.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>46.6</td>
<td>0-25</td>
<td>10 YR 3/3</td>
<td>74.5</td>
<td>0.34</td>
<td>2.57</td>
<td>59.87</td>
<td>26.0</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>78.4</td>
<td>0-22</td>
<td>10 YR 4/3</td>
<td>67.0</td>
<td>0.49</td>
<td>3.38</td>
<td>61.84</td>
<td>27.5</td>
<td>4.5</td>
<td></td>
</tr>
</tbody>
</table>

Source: Estimated by the author.

3.3.2: Soil Analysis:

Soils collected at sites A, B and C are shown in Table 3.6. Soils of A are moderately deep, excessively drained, strong brown clay loam, medium, moderate and subangular blocky, underlain by dark brown to strong brown, clay loam to clayey, fine to medium, moderate and subangular blocky soils.

Particle size analysis shows that relative proportion of finer soil fractions to coarser ones decreased sharply
TREND OF SOIL CHARACTERISTICS AT SOHIONG

SILT + CLAY/ SAND

Per cent

ORGANIC CARBON

Per cent

A B C

A B C

Per cent

WHC

Per cent

LIQUID LIMIT

A B C

A B C

Fig. 39
LOCATION OF MAWLAT
1: 50,000

91°57' 91°58' 91°59' 92°0'

1100
800
700
600
500
400
300
200

Fig. 3. 10

REFERENCES:
- Contour in metres
- Rivers.
from A to B and tend to increase, thereafter (Fig. 3.9). No marked change in organic carbon was noted along the slope profile both from A to B; however, its value increases appreciably at C. Both WHC and LL show variations in the whole slope profile as in (silt + clay)/sand ratio.

3.4: MAWLAT:

Mawlat, 55 km. from Shillong, is located between 25°30' to 25°35' N and 91°40' to 91°45' E longitude at an altitude of 1140 m from msl (Fig. 3.10). It falls within the physiographic division number one, Fig 2.1. The topography is hilly with steep slopes running from E to W. In general, the gradient is more than 50 per cent, even at the length of 0 to 50 m. Erosion is very severe with rapid runoff. The betel leaf is widely cultivated, but it is learnt that the cultivation is severely effected due to scarcity of water during the growth period and damages are caused by regular landslides, specially during the rainy season.

Geology is similar to the Sohiong area, where main rock types are shale, sandstone and granite gneiss.

3.4.1: Soil Profile Analysis:

Four distinct sites were identified in Mawlat area (Fig. 3.11). The A is a convex slope ranging from 36.4 to 58.9 per cent. There are scattered boulders accumulated extensively at the lower point. At the base of boulders,
FORM OF HILLSLOPE
MAWLAT

LEGEND
Slope values in percent
Survey station
Slope discontinuity

METRES
FIG. 3.11
there are large accumulations of flakes and chips which show the evidence of sheetwash. Apart from sheetwash, A is affected by talus creep and rockslide mass movement, also. The B, a mild rectilinear slope of 30 m length ranges from 17.6 to 18.5 per cent gradient. It is affected by soil creep. The C, 15m long, a free face ranges from 36.4 to 58.9 per cent. There are cracks, on the exposed rocks and slab slide, rockfalls and topples occur. The slope, then drops to about 200 m with a gradient 65 to 70 to form inaccessibility at the site D; the zone of intense rapid mass movements where translational landslide and topple, slab and wedge failure take place. There is a break of slope at 120 m length with an angle of 60°. At the base of 60° slope, detritus of blocks, boulders, cobbles and chunks are accumulated. There is a bund of boulders on the road at this point and this types of bunds are found in almost all the turns and sharp bends on the road.

3.4.2: Soil Analysis:

Soil samples were examined at each site and their morphological characteristics are shown in Table 3.7.

Soils of A are shallow, excessively drained, very dark grayish brown, sandy loam, fine, weak, granular in structure, underlain by brownish yellow, sandy loam, very fine, single grained soils resting on the bed rock. Soils of B are dark brown to brown sandy clay loam, with fine, weak, subangular
TREND OF SOIL CHARACTERISTICS AT MAWLAT

FIG. 3.12
blocky structure. Soils of C have similar character of B, except the yellowish brown colour with sand in the second layer.

Soil particle analysis and organic carbon content of slope profile show higher presence of finer soil fractions and organic carbon at B, which sharply decreases at C (Fig. 3.12). Both WHC and LL show no appreciable variation from A to B, thereafter, they decrease sharply with parallel decrease in finer soil fractions and organic carbon.

Table - 3.7

<table>
<thead>
<tr>
<th>Site</th>
<th>Average Depth Gradient (cm)</th>
<th>Moist Colour</th>
<th>Sand %</th>
<th>Silt + Clay %</th>
<th>Org.C %</th>
<th>W.H.C %</th>
<th>Liquid pH %</th>
</tr>
</thead>
<tbody>
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<tr>
<td>A</td>
<td>49.1</td>
<td>0-15 10YR 3/2</td>
<td>67.0</td>
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<td>3.89</td>
<td>75.45</td>
<td>40.0</td>
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<td>15-50 10YR 6/6</td>
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<td>54.45</td>
<td>28.0</td>
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<td>18.3</td>
<td>0-20 10YR 4/3</td>
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<td>4.69</td>
<td>74.66</td>
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<td>18-35 10YR 5/4</td>
<td>82.5</td>
<td>0.21</td>
<td>1.51</td>
<td>43.47</td>
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<tr>
<td>C</td>
<td>44.2</td>
<td>0-18 10YR 5/6</td>
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<td>0.10</td>
<td>0.50</td>
<td>32.56</td>
<td>17.0</td>
</tr>
</tbody>
</table>

Source: Estimated by the author.

3.5: SMITH:

Smith, 12 km. away from Shillong, is located between 25° 30' and 25° 31' N latitude and 91° 54' to 91° 55' E longitude (Fig. 3.13). It falls within the physiographic
unit number four, Fig. 2.1. The general topography consists of moderate high hills with wide valleys. The area mainly consists of Archean gneissic complex of the Meghalaya plateau. Biotite gneisses represent the country rock of the area which is traversed by basic and acidic intrusions. The biotite gneiss material is overlain by the quartz-sillimanite. Quartzites are seen exposed in most part of the area. The rocks are hard but closely jointed (GSI, Report No. 489).

3.5.1: Slope Profile Analysis:

A slope profile analysis was carried out in this area along the maximum gradient (Fig. 3.14). Site A is 90 m long with a gradient 3.2 to 24.1 per cent. It is covered with dried grass. There is rill formation of 1 to 2 cm along the slope. Previously, potato was cultivated but they are left fallow because of soil creep. Gullies are also formed in the lower part of the site with 30 cm width and 15 cm depth. Moss and algae are spread over the barren parts. B is comparatively near-planar with a length of 80 m with the maximum gradient being 10.5 per cent. Features similar to A is observed here, too. Thereafter, C of 46 m length with 14.1 per cent gradient with an exception of 55.4 per cent slope with 8 m length is identified. Immediate to this site, gully formations start. Soil creep was observed in a limited area. Potato cultivation is still practised here and seed beds are prepared with massive cowdung application. At the bottom, a
'nullah' of 12.3 per cent gradient is flowing down, where exposed granite rocks are found. After this, a concave site D with 42 m length having slopes ranging from 1.7 to 7.0 per cent gradient is identified. This site is, in fact, a valley floor of the 'nullah'. There is further upward convexity of 15 m width with 3.5 to 8.7 per cent gradient (Site E) and another 15 m with 17.6 to 30.6 per cent gradient (Site F). Beyond this, a convex slope starts with 1.7 to 5.2 per cent slope. Ten per cent of surface is covered with boulders and cobbles.

3.5.2: Soil Analysis:

Soil samples are collected from each site and their characteristics are cited in Table 3.8. Soils found on the convex slope of site A are shallow, well drained, dark yellowish brown, silt loam, fine, weak, crumb, very strongly acidic (pH 4.5), underlain by dark brown to brown silty clay loam to silty clay, medium, moderate and angular blocky. Soils of B is very dark grayish brown, silt loam, medium, moderate, subangular blocky, strongly acidic (pH 4.5). Soils of C are dark brown to brown silt loam, fine, weak, subangular blocky, strongly acidic (pH 4.5). Soils of D and E are dark brown, loam, fine, weak, subangular blocky in structure and highly acidic (pH 4.9). Soils of F are dark reddish brown to dark brown, clay loam, fine, moderate, subangular blocky and are highly acidic (pH 4.9); while soils of G are dark brown, loam, weak, subangular blocky and highly
TREND OF SOIL CHARACTERISTICS AT SMITH

FIG. 3.15
acidic (pH 4.5).

Data in Table 3.8 shows no change in total sand content from A to C beyond which its gradual increment was observed upto F with peak value at G.

**Table - 3.8**

Soil Characteristics of Smith

<table>
<thead>
<tr>
<th>Site Average</th>
<th>Depth (cm)</th>
<th>Moist Colour</th>
<th>Sand</th>
<th>Silt + Clay</th>
<th>Org.C</th>
<th>W.H.C.</th>
<th>Liquid</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradient %</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>16.9</td>
<td>0-16</td>
<td>10YR</td>
<td>4/4</td>
<td>17.8</td>
<td>4.61</td>
<td>4.66</td>
<td>81.1</td>
<td>48.5</td>
</tr>
<tr>
<td></td>
<td>16-40</td>
<td>7.5YR</td>
<td>4/4</td>
<td>13.9</td>
<td>6.19</td>
<td>1.26</td>
<td>64.5</td>
<td>42.5</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>40+</td>
<td>7.5YR</td>
<td>3/4</td>
<td>5.8</td>
<td>16.2</td>
<td>0.87</td>
<td>60.9</td>
<td>41.0</td>
<td>4.5</td>
</tr>
<tr>
<td>B</td>
<td>7.3</td>
<td>0-20</td>
<td>10YR</td>
<td>3/2</td>
<td>21.1</td>
<td>3.73</td>
<td>5.23</td>
<td>80.9</td>
<td>58.0</td>
</tr>
<tr>
<td>C</td>
<td>13.5</td>
<td>0-22</td>
<td>10YR</td>
<td>4/3</td>
<td>18.6</td>
<td>4.37</td>
<td>5.78</td>
<td>80.8</td>
<td>54.5</td>
</tr>
<tr>
<td>D</td>
<td>4.7</td>
<td>0-19</td>
<td>7.5YR</td>
<td>3/4</td>
<td>26.5</td>
<td>2.77</td>
<td>7.3</td>
<td>106.1</td>
<td>57.0</td>
</tr>
<tr>
<td>E</td>
<td>6.4</td>
<td>0-16</td>
<td>7.5YR</td>
<td>3/4</td>
<td>27.3</td>
<td>2.66</td>
<td>5.72</td>
<td>93.8</td>
<td>51.5</td>
</tr>
<tr>
<td>F</td>
<td>25.0</td>
<td>0-20</td>
<td>5YR</td>
<td>3/4</td>
<td>28.9</td>
<td>2.47</td>
<td>5.67</td>
<td>80.7</td>
<td>44.0</td>
</tr>
<tr>
<td>G</td>
<td>4.2</td>
<td>0-22</td>
<td>10YR</td>
<td>4/3</td>
<td>30.6</td>
<td>2.26</td>
<td>3.7</td>
<td>68.1</td>
<td>35.0</td>
</tr>
</tbody>
</table>

Source: Estimated by the author.

It is interesting to note that organic carbon content increase gradually from A to C reaching its peak value (7.3%) at D; thereafter the value decreases maintaining a constant level (5.7%) at E and F and an abrupt fall (3.7%) at G (Fig. 3.15).

There is no conspicuous change in WHC from A to C. Abrupt increase in WHC at D and gradual fall thereafter, may be related to organic matter content of soils.

A scrutiny of data in Table 3.8 shows that rise or fall in liquid limit at slope Site A to D is quite opposite to
LOCATION OF BARNIHAT

1: 50,000.

REFERENCES

Contour in metres

Rivers

Roads

FIG. 3.16
that observed for (silt+clay)/sand ratio. The liquid limit values, however, show gradual fall from D to G, although the rate of fall may not be at par, as observed in (silt+clay)/sand ratio.

3.6: BARNIHAT:

The study areas near Barnihat, G. S. Road, on the Assam Meghalaya border is located between 26° 2' to 26° 3' N and 91° 52' to 91° 53' E longitude (Fig. 3.16). It falls within the physiographic unit number three, Fig. 2.1. The 'jhum' cultivation is highly localised and practised in a small area.

The area is made up of granites and gneisses which, however, is concealed by layers of alluvium. It is widely accepted that indiscriminate destruction of forests as a result of shifting cultivation, coupled with high rainfall in this region, has led to slope instability including mass movements and soil erosion, with consequent siltation of rivers causing floods in the lower sectors of the main river system. This increases enormous losses of cultivated land every year. The associated soil losses resulting from jhuming have been established by ICAR'S studies (ICAR, 1978).

3.6.1: Slope Profile Analysis:

A slope profile analysis was carried out in this area (Fig. 3.17). A convexo-rectilinear site was identified as a typical recurring type of the area. The measured site A is 80
FORM OF HILL SLOPE
BARNIhat

METRES 10 O 10 20

Site A

LEGEND
--- Slope value in percent
| Survey station |
| Slope discontinuity |

Fig. 3.17
m length with a gradient of average 21.4 per cent. Soil creep is identified as the main mass movement at this site. It is followed by a free face of 50 m length with 274 per cent gradient (site B). It is characterised by wedge slide and topples. The base of this slope is terminated by a narrow (15 m) stream valley (site C). The accumulation of soils at the base of some relatively permanent trees give an approximate indication of rate of soil creep. Other sites of this type can be more extensive.

3.6.2: Soil Analysis:

Three soil samples one each at A, B and C were collected and their characteristics are described in Table 3.9. Soils of A are dark yellowish brown, sandy loam, medium, moderate, sub-angular blocky. Soils of B are clay loam, dark brown, coarse, strong, sub-angular blocky, while soils of C are moderately deep, dark brown to brown, clayey, moderate, medium, subangular blocky underlain by dark yellowish brown, clayey, medium, strong, angular blocky soils. They are strongly to very strongly acidic in nature.

Loss of finer soil particles due to 'jhuming' at A and severe mass movement at B result their accumulation at valley (C) and thus, resulting in a higher (silt + clay)/Sand ratio (Fig. 3.18). There is a gradual fall in organic carbon content from A to C. No regular pattern in variations of WHC in the whole slope profile were noted. The variation in LL could be related to, either finer soil accumulations or
TREND OF SOIL CHARACTERISTICS AT BARNIHAT

FIG. 3.18
organic carbon distribution.

Table 3.9

<table>
<thead>
<tr>
<th>Site</th>
<th>Average Depth Gradient (cm)</th>
<th>Moist Total Colour</th>
<th>Silt+clay %</th>
<th>Org.C %</th>
<th>W.H.C. %</th>
<th>Liquid limit pH</th>
<th>Sand %</th>
<th>% limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>21.45 0-22 10YR 3/4 45.7</td>
<td>1.18</td>
<td>2.17</td>
<td>57.8</td>
<td>30.5</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>274 0-20 7.5YR3/4 43.2</td>
<td>1.31</td>
<td>2.13</td>
<td>53.6</td>
<td>35.0</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>2.9 0-21 7.5YR4/4 27.6</td>
<td>2.62</td>
<td>1.98</td>
<td>56.1</td>
<td>33.0</td>
<td>5.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21-81 10YR 4/6 21.6</td>
<td>3.65</td>
<td>1.01</td>
<td>53.2</td>
<td>36.0</td>
<td>4.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Estimated by the author.

3.7: JARAIN:

Jarain, a coal mining zone, extends from 25° 17' to 25° 20' N and 92° 7' to 92° 10' E longitudes with an altitude ranging from 600 to 1000 m from msl (Fig. 3.19). It falls within the physiographic unit number five, Fig. 2.1. Drainage types are both perennial and seasonal. Humid tropical vegetation with cultivable patches are common. In general, hills are moderately steep, irregular, having hillside drainage lines. The rapid runoff thereon, induces a slope wash on some concentrated line, commonly rills and gullies.

The geology in this area is the Cherra Sandstone of the Theria Stage (Paleocene) of Jaintia Series. It overlies the rocks of Shillong series (Proterozoic). Coal seams are found interbedded with shales and sandstones of Cherra Sandstone. Thin layers of coal are found all around Jarain, thickness of which varies from 15 cm to 40 cm. The Cherra Sandstone is
composed of block alum shale, ferrigenous sandstone, black shale and friable sandstone (Changkakoty 1964).

3.7.1: Slope Profile Analysis:

A profile facing E-W was selected for site analysis (Fig. 3.20) and five distinct sites were identified. From the crest, site A extends up to 25m which has sumital convexity. Surficial materials comprises of coarse sand, gravels with grits, flanks and chunks. There are many exposed rocks of size 30x60x30 cm. The presence of algae and mosses are the indices of sheetwash and soil creep mass movement. Below this (B), a convex slope, varying from 17.6 to 46.6 per cent slope gradient is identified. It is essentially a denudational form, underlain by solid rock and bearing only a veneer of detritus, either at rest or moving very slowly downwards owing to high rainfall action. In this site, the weak rocks of shales are removed and step and rise like structure 15cm x30 cm are observed which shows the weak materials are moved due to rock slides and talus creep. In this site, the exposed rocks are covered by moss and algae. Quite a number of pitcher plants are available. Similar types at steep erosional sites tend to occur on the lower parts of valley sides associated with channel under cutting at the base.

Slope leads down to valley floor (site C). It is bunded for paddy cultivation. The gradient ranges from 0.8 to 4.3 per cent. The site is however, presently kept fallow and is
Fig. 3.20
full of weeds. Crossing this towards west, D is identified which is convex with an inflexion of 14.1 to 37.3 per cent gradient. It extends upto 35 m with soil and talus creep mass movement. Beyond this, a summital convex slope E ranging from 2.6 to 3.5 per cent gradient prevails, where soil creep is prominent.

This is a typical convexo-concave slope comprising an upper convexity and lower concavity. Such slope forms are typical of weak rocks like shale, sandstone in the Jaintia Hills area, where the actual variety of landscape from place to place is a reflection of differences in the lengths and heights of the slopes.

3.7.2: Soil Analysis:

The morphometric and physico-chemical properties of soils collected at different sites are shown in Table 3.10. Soils of A and B are dark gray, loamy sand, fine, weak, single grained, while soils of C are dark grayish brown, sandy, fine, weak, single grained. The west facing soils of D&E are more brownish. Soils of D are brownish yellow, sandy clay loam, medium, moderate, sub-angular blocky and soils at E are dark brown to brown, sandy loam, with medium sub-angular blocky structure. Soils are very strongly acidic (pH 4.6 to 4.9).
TREND OF SOIL CHARACTERISTICS AT JARAIN

**SILT + CLAY/SAND**

**ORGANIC CARBON**

**PER CENT**

**WATER HOLDING CAPACITY**

**LIQUID LIMIT**

Site

FIG. 3.21
Table - 3.10

Soil Characters of Jarain

<table>
<thead>
<tr>
<th>Site</th>
<th>Average Depth (cm)</th>
<th>Moist Gradient (%)</th>
<th>Colour (°)</th>
<th>T.S. Si+C (%)</th>
<th>Org.C (%)</th>
<th>W.H.C. (%)</th>
<th>Liquid limit (%)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.7 0-16</td>
<td>10YR 4/1</td>
<td>87.9</td>
<td>.13</td>
<td>0.69</td>
<td>28.01</td>
<td>15.0</td>
<td>4.0</td>
</tr>
<tr>
<td>B</td>
<td>30.2 0-18</td>
<td>10YR 4/1</td>
<td>84.8</td>
<td>.17</td>
<td>2.35</td>
<td>42.04</td>
<td>15.0</td>
<td>4.8</td>
</tr>
<tr>
<td>C</td>
<td>2.8 0-25</td>
<td>10YR 4/2</td>
<td>90.5</td>
<td>.10</td>
<td>1.08</td>
<td>38.33</td>
<td>12.0</td>
<td>4.8</td>
</tr>
<tr>
<td>D</td>
<td>26.8 0-17</td>
<td>10YR 6/8</td>
<td>54.9</td>
<td>.82</td>
<td>0.73</td>
<td>46.09</td>
<td>25.0</td>
<td>4.6</td>
</tr>
<tr>
<td>E</td>
<td>3.2 0-16</td>
<td>7.5YR4/4</td>
<td>77.7</td>
<td>.28</td>
<td>1.51</td>
<td>43.37</td>
<td>-</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Source: Estimated by the author.

Soil analytical data shows that finer soil particles relative to coarse fractions remain more or less constant from A to B; thereafter, it decreases (Fig. 3.21). Rapid rise in (silt + clay)/sand ratio at D may be due to the depositional effect of finer soil particles transported from the west facing slope at site E.

There is an increase in organic carbon content at B but its value gradually declined to D with an abrupt increase at E. Variation in WHC and LL in the whole slope profile could be related to both the finer soil fractions and the organic matter content.

3.8: Bapung:

This site is similar to that of Jarain and is under coal producing zone of Meghalaya. The area is located between 25 24' to 25 26' N and 92 18' to 92 20' E longitude (Fig. 3.22). It falls within the physiographic unit number four,
LOCATION OF BAPUNG
1: 50,000

FIG. 3.22
FIG. 3.23
Fig. 2.1. In general, the area is of low amplitude and moderate slopes, covered with Theria sandstones of Lower Paleocene age. These are more or less friable, soft to medium hard, medium to coarse grained, reddish brown to brownish white colour with bands of shales, carbonaceous shales and coal. Theria Sandstone is unconformably underlain by granites and gneisses and met in the valley portion (Barkakoty, 1972).

3.8.1: Slope Profile Analysis:

A slope profile analysis was applied over a typical valley side (Fig. 3.23). Site A consists of 2.6 to 3.5 per cent gradient, showing a uniform summital convexity measuring 15 m length. There is quite a luxuriant growth of pine vegetation. The surficial materials are gravels covering 20 per cent of the surface area. Sheetwash mass movement is observed at this site. Below this, is B, extending 35 m, a convex slope with 17.6 to 54.2 per cent gradient. Trees are cut here for a proposed orchard where dried leaves are spread over it. Soil creep mass movement is prominent at this site. Beyond this, site C forms up to 55m where some small rills of 3 to 4 cm. width and 15 to 20 cm. depth are observed exhibiting soil and talus creep. Large numbers of boulders (30 x 30 x 20 cm) are scattered over the slope covering 40 per cent of the area. D is identified with the same characteristics of surficial materials below C, but the gradient is 8.7 to 17.9 per cent. A road runs across this slope just after D and below this, are E and F, where paddy
is cultivated. The gradient of E is 2.6 to 4.3 per cent, while that of F is 0.8 to 1.7 per cent. In E, bunds are more frequent than F for stagnating water. There is evidence of prominent cracks developed on the surface. Mass movement process is practically nil at these sites.

Table - 3.11

Soil Characteristics of Bapung

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.2</td>
<td>0-20</td>
<td>10YR4/4</td>
<td>53.2</td>
<td>0.3</td>
<td>3.45</td>
<td>64.51</td>
<td>34.5</td>
<td>4.8</td>
<td></td>
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</tr>
<tr>
<td>B</td>
<td>39.7</td>
<td>0-28</td>
<td>10YR4/6</td>
<td>76.9</td>
<td>0.69</td>
<td>1.01</td>
<td>34.83</td>
<td>16.0</td>
<td>4.9</td>
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<tr>
<td></td>
<td>0-28</td>
<td>10YR5/8</td>
<td>58.9</td>
<td>0.11</td>
<td>0.83</td>
<td>41.66</td>
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<td>0-28</td>
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<td>0.07</td>
<td>23.60</td>
<td>9.5</td>
<td>5.4</td>
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<td>C</td>
<td>32.1</td>
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<td>10YR4/3</td>
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<td>1.20</td>
<td>5.01</td>
<td>63.50</td>
<td>40.0</td>
<td>4.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>12.7</td>
<td>0-20</td>
<td>10YR4/3</td>
<td>22.2</td>
<td>3.50</td>
<td>3.38</td>
<td>82.06</td>
<td>54.0</td>
<td>4.7</td>
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<td>2.47</td>
<td>4.04</td>
<td>94.99</td>
<td>55.0</td>
<td>4.5</td>
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<tr>
<td>F</td>
<td>1.1</td>
<td>0-25</td>
<td>10YR3/2</td>
<td>34.0</td>
<td>1.94</td>
<td>4.69</td>
<td>87.73</td>
<td>51.5</td>
<td>4.7</td>
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<td></td>
</tr>
</tbody>
</table>

Source: Estimated by the author.

3.8.2: Soil Analysis:

A perusal of data in Table 3.11, shows that soils of A are dark yellowish brown, sandy clay loam with fine, weak and sub-angular blocky. Soils of B are moderately deep, excessively drained, dark yellowish brown, sandy loam, fine, weak and sub-angular blocky, underlain by yellowish brown, sandy clay loam to sandy, medium and moderate sub-angular blocky soils. Soils of C are dark brown to brown, sandy clay loam, medium, moderate, sub-angular blocky and are
TREND OF SOIL CHARACTERISTICS AT BAPUNG

**SILT + CLAY/SAND**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
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<tbody>
<tr>
<td></td>
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**ORGANIC CARBON**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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<td></td>
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</tr>
</tbody>
</table>

**WHC**

<table>
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<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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**LIQUID LIMIT**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

FIG. 3.24
excessively drained. Texture of D, E and F soils gradually decrease to finer size and colour change from dark brown to very dark grayish brown. Structures are fine, moderate and sub-angular blocky. Soils are strongly acidic (pH 4.5).

There is a gradual increase in (silt + clay)/sand ratio from A to B, there after the ratio falls at E and F (Fig. 3.24). There is no regular pattern in the variations in the organic carbon content in the whole profile. Its value sharply decreases from A to B and thereafter, increases abruptly at C. The second fall in organic carbon content was observed at D, wherefrom, values gradually increase upto F. Like organic carbon both W.H.C. and L.L. decline at B, beyond which the latter sharply increases upto D, and tends either to remain constant or decrease at F.

3.9: Komrrah:

It lies between 25°10' to 25°15' N latitude and 91°40' to 91°45' E longitude (Fig. 3.25). It lies within the physiographic division number one, Fig. 2.1. The area comprises of E-W trending rugged hills, dissected by small tributaries of the Umsohryangkew river. The southern part of Shillong plateau is dissected by a sharp escarpment. Beyond these hill ranges, there are the flat plains towards south bordering Bangladesh. The altitude of the summit is 150 m above msl.
The area is a limestone quarry and is being carried out by KLMC (Komrrah Limestone Mining Co.Ltd.), where both India and Bangladesh governments are participating.

3.9.1: Slope Profile Analysis:

Slope profile analysis was carried out along the measured slope of about 330 m long consisting of steep to very steep forested hills underlain by limestone interbedded with sandstone and shales (Fig. 3.26). It is a south facing profile. The higher parts of the profile consists of site A with 3.5 to 8.1 per cent gradient extending upto 30 m. The area is covered with arecanut palms, betelvine and turmeric cultivation. The underlain bed rock is composed of sandstone. This slope is affected by soil creep mass movement. There is a convexo-linear slope B, ranging from 19.4 to 35.4 per cent where rills and gullies of B of 10 cm width and 15 cm depth have developed. The geology of this 40 m long slope is composed of limestones tending towards E-W and interbedded with shales that are mostly exposed. The surficial materials found in this site are boulders, mostly 30x60x30 cm covering 50 per cent of surface area. In this site, soil and talus creep of mass movements are identified. A rectilinear slope C is identified with 40 m length having 35.4 to 38.4 per cent gradient. It is covered with big boulders with almost 90 per cent coverage. Rapid mass movement e.g. slides and topples occur in this area due to...
FIG. 3.26
quarring and blasting. The size of the gullies extend up to 30 to 45 cm width and 20 to 25 cm depth. There are prominent cavities and sink holes exhibiting typical rugged limestone zone. A free face slope D of 150 m length with 214 per cent slope was also observed where topples and landslides are vigorous due to quarring and blasting. It consists of gravel deposits, boulders, pebbles and cobbles with 90 per cent surface cover.

Downwards this of site, there is a disturbed site, 15 m length with an angular inflexion of 30° where debris materials get accumulated from above. Beyond this, a near planner, E with an average gradient 7.8 per cent is identified. Beyond that, a channel flows, whose bed is 6 to 7 m deep and full of boulders, cobbles and blocks.

3.9.2: Soil Analysis:

The morphology and physico-chemical characteristics of soils are presented Table 3.12.

Soils of A and B are dark brown to brown, sandy loam, fine, weak, sub-angular blocky and strongly acidic (pH 5.2). Soils of C are also similar to the above, exception being that the soils are neutral (pH 7.1). Soils of E are yellowish brown, sandy loam, single grained and slightly acidic (pH 6.3).

Particle size analysis shows gradual loss of finer soil
TREND OF SOIL CHARACTERISTICS AT KOMRRAH

Fig. 3.27
fractions along the slope profile (A to E) (Fig. 3.27). Similar results are also observed in organic carbon content with its slight increase at C. Both W.H.C. and LL behave similarly as organic carbon upto B, thereafter, the former increase at C maintaining constant level upto E, while the latter linearly increases upto the end point of the slope profile.

Table - 3.12
The Morphology and Physico Chemical Characteristics of Soils

<table>
<thead>
<tr>
<th>Site</th>
<th>Average Depth</th>
<th>Moist Gradient (cm)</th>
<th>Total Colour</th>
<th>Sand</th>
<th>Silt+Clay</th>
<th>Org.C</th>
<th>W.H.C.</th>
<th>Liquid</th>
<th>pH</th>
<th>limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5.8</td>
<td>0-25</td>
<td>7.5YR4/4</td>
<td>67.5</td>
<td>0.48</td>
<td>1.75</td>
<td>55.1</td>
<td>24.0</td>
<td>5.2</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>25.5</td>
<td>0-15</td>
<td>7.5YR4/4</td>
<td>72.0</td>
<td>0.38</td>
<td>1.24</td>
<td>43.6</td>
<td>17.0</td>
<td>5.3</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>36.9</td>
<td>0-11</td>
<td>7.5YR4/4</td>
<td>74.6</td>
<td>0.34</td>
<td>1.44</td>
<td>45.7</td>
<td>20.0</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td>D*</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>7.8</td>
<td>0-25</td>
<td>10YR 5/6</td>
<td>79.6</td>
<td>0.25</td>
<td>0.81</td>
<td>46.1</td>
<td>21.0</td>
<td>6.3</td>
<td></td>
</tr>
</tbody>
</table>

* - Soils not available

Source: Estimated by the author.

3.10: SONAPUR:

Sonapur is located in the southern part of the Shillong plateau and extends from 25° 0' to 25° 10' N and 92° 15' to 92° 25' E longitude. It falls under the physiographic division number one, Fig. 2.1. It comprises a flat topped hill area, where altitude ranges from 250 to 300 m above msl. The hills are dissected by deep gorges and canyons. A river drains the surface water into the Surma valley in Bangladesh. (Fig. 3.28).
LOCATION OF SONAPUR
1:253,440

REFERENCES

Contours in feet
Rivers
Tentative International boundary

FIG. 3. 28
Rock types of the area consists mostly of sandstones and limestones of Upper Cretaceous to Eocene age. The sandstones are massive, ferrigenous and intermixed with siltstone and shales. These are highly brecciated and fractured towards the bottom. The interbedded Umlatdoh Limestone (Lower Eocene) is also massive to thinly bedded limestones with thin marly and sandy limestone bonds occurring towards the middle and rich calcareous sandstone zones at the base (Chakravarty and Bhattacharya, 1972).

The site is well known for natural landslide and is responsible for several incidents of calamities especially during the rainy season.

3.10.1: Slope Profile Analysis:

Slope profile analysis shows that the site A is a convex slope (Fig. 3.29). It is full of evergreen vegetation. The surrounding parts consist of rocks with distinct cracks and joints. The rocks are of irregular shape controlled by local joint system. The free face, B stands with an angle of 75° over about 200 m length. It is bare, usually consists of joints over fault surfaces. Mass movements of topples and landslides are common with boulders of Size 210x240x240 cm. After this, C of talus (scree) slope developes, which is an accumulation of rocks that fall as topples, slab slide and wedge slide. The slope gradient drops to 0.6 per cent towards the end of this site. After this, a mild convexity develops
having a plain bed rock with boulders (site D) consisting of sandstones. The boulders, blocks and cobbles and chunks are, however, of different kinds including limestones. The soil conservation department is taking measures by wrapping big boulders together with hard perforated nets, which prevent them from quick falling. A concave site E with slope ranging from 46.6 to 60.1 per cent is identified which is full of boulders, cobbles, pebbles and angular to sub-angular blocks, chunks and flakes. The bed rock is sandstone, interbedded with shales and distinct lineaments are formed. In this zone, water still flows (i.e. during the month of January) as seepage (between marl and sandstone junction). After this, a convexo-linear slope is identified ranging from 29.6 to 36.4 per cent gradient which is the main transportational slope (site F). Transportation of material by sheetwash is most prominent as larger stones tend to have accumulations of smaller rock fragments and finer soil particles washed downwards of the slopes, leaving little terracettes behind them. Moreover, soil and talus creep and rockslide type of mass movements are taken place this site. There are formation of tunnels in the sub-surface, which shows lowering of cohesion and shearing stress. In this zone also, the boulders are wrapped with perforated plastic net. Pebbles, flakes are common along with boulders and blocks. Gullies of size 30 cm wide and 30 to 60 cm length are common. There are numerous rills and incipient gullies. Rise and step like structures are common. A few broom plants are also found in the
TREND OF SOIL CHARACTERISTICS AT SONAPUR

**FIG. 3.30**
cleavages. Columnar structure of bed rocks and capping on small rocks are frequent. Few logs are lying around there. Logs are slippery and are full of mosses which show continuous fluvial actions on it. The last site G, including the edge of the road has the similar character as the above but its magnitude of actions are slightly less. The slope ranges from 17.6 to 28.7 per cent. Soil and talus creep of low magnitude occur at this site. After this, there is a 7 m wide road and it is the place where blockage due to landslide always occurs, especially during the rainy season.

3.10.2: Soil Analysis:

Three soil samples were collected in site C, F and G and their characteristics are shown in Table 3.13.

The soils of C are brownish yellow, silty clay, medium and moderate sub-angular. Soils of F are dark yellowish brown, sandy clay, medium, weak, sub-angular and both soils are extremely acidic (pH 4.1). Soils of G change to dark brown, loam fine, weak, sub-angular and slightly acidic (pH 6.3) in nature.

Soil analysis shows the (silt+clay)/sand ratio decreases sharply from C to F and thereafter, increases at G. Other parameters as organic carbon, WHC, LL follow the similar pattern in variations corresponding with the (silt+clay)/sand ratio (Fig. 3.30).
Table - 3.13

Soil Characteristics of Sonapur

<table>
<thead>
<tr>
<th>Site</th>
<th>Average Depth (cm)</th>
<th>Moist Gradient</th>
<th>Colour</th>
<th>Sand</th>
<th>Silt+Clay</th>
<th>Org.C</th>
<th>WHC</th>
<th>Liquid limit pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>A*</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>B*</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C</td>
<td>13.7</td>
<td>0-20</td>
<td>10YR 6/6</td>
<td>18.8</td>
<td>4.31</td>
<td>0.35</td>
<td>44.47</td>
<td>35.0</td>
</tr>
<tr>
<td>D*</td>
<td>-</td>
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</tr>
<tr>
<td>E*</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>F</td>
<td>33.6</td>
<td>0-19</td>
<td>10YR 4/4</td>
<td>73.6</td>
<td>0.35</td>
<td>0.08</td>
<td>27.17</td>
<td>12.0</td>
</tr>
<tr>
<td>G</td>
<td>22.1</td>
<td>0-20</td>
<td>7.5YR2/4</td>
<td>44.7</td>
<td>1.23</td>
<td>4.07</td>
<td>94.96</td>
<td>58.5</td>
</tr>
</tbody>
</table>

* - Soils not available
Source: Estimated by the author.

The intra and interrelationship amongst the slope and mass movement and soil properties with their statistical interpretations are given in the Chapter IV.