2.1 INTRODUCTION

The study area comprise about 20 sq.kms in the NE portion of the toposheet no 1B/14. Topography being a confluence of both rugged (towards east) and plain (towards west) nature traverses were mainly made along the Phulbari-Tura-Singrimari road roughly in a N-S trend. Considering the geomorphology of the area, nature of the outcrops, their attitudes etc. extensive and intensive cross traverses were made along the eastern direction towards Nabhalgiri, Boldongiri, Jeldopara, Jeldupara, Gachhingiri, Bolongiri, Garomaragiri and Kharuabanda. Outcrops were examined and their features plotted on a map.

2.2 FIELD DISPOSITION OF THE LITHO-UNITS IN THE AREA

Almost twelve different rock types are disposed within this area. (Map 2). However, it may be mentioned that climatic conditions aided by physical setup of some of the litho-units, (particularly the sedimentaries) have reduced the area into a denuded hilly tract which further resulted in weathering (mostly spheroidal), thick soil cover, rich vegetation, obliteration of the nature of the outcrops and, erosion of many vertical sections thereby consequently hampering the normal process of sampling. All the sedimentary rock samples were taken after digging at least 1 foot both in the available vertical sections and the surfacial ones, (taken on grid patterns). Enclosed herewith are some salient features of the litho-units as studied in the field.

2.2.1 Precambrian Basement

A conglomeration of seven different rock types constitute the Precambrian Basement for the overlying sedimentary column. Amongst them are quartzofeldspathic gneiss, granite gneiss, amphibolite, calc-silicate gneiss, migmatite, granites and vein rocks - quartzofeldspathic (pegmatitic in certain cases) and quartz veins.

These rocks apparently mark as a ridge or edges of a bowl trending a little bit arcuately NE-SW. Towards west and north-west of the same are disposed the sedimentary units.

Quartzofeldspathic gneiss, (PI. 2.1) are the country rocks which include well foliated, leucocratic (grey to pink), medium to coarse grained varieties. The main constituents of the
rocks - quartz, feldspar and biotite initiate the mafic and felsic or, the foliation layerings which in turn are diffused in certain patches owing to widely spaced weak concentration of the minerals. Such inhomogeneity leads to local migmatitic look of the rocks otherwise, thickness of the layers vary from more than 5 cms to a fraction of a centimetre. A somewhat more leucocratic (white to light grey), fine to medium grained, quartz and feldspar (K-feldspar) rich rock showing a weakly foliated feature compared to the quartzofeldspathic gneisses have been classed as granite gneisses, (based on field observations). Lesser in abundance than the country rocks, their gneissosity is caused by general elongation of the quartz-feldspar grains and enhancement of the same by sporadic parallelism of the biotite flakes. (SW of the Nabhalgiri Water Plant) Deformational evidences are seen in these bodies in the form of puckering of these bandings.

Sporadic occurrences of calc-silicate gneisses inter-layered with quartzofeldspathic gneiss have been observed in certain localities of the area. Exhibiting typical brownish-green pitted surfaces, a comparatively large discontinuous band which runs 200 mts conformably with the quartzofeldspathic gneiss is seen SW of the Nabhalgiri Water Plant.

Inter-layered with the quartzofeldspathic gneisses are amphibolites. (Pl-2.2) Amphibolites are melanocratic, compact, medium to coarse grained entities containing chiefly hornblende, feldspar and quartz. This rock of which both poorly foliated and well foliated varieties are seen is quite persistent almost in the lines of quartzofeldspathic gneiss. However, they show large thickness variations from more than 0.5 m to a few cms. Although, sharp contact between the amphibolites and quartzofeldspathic gneisses are seen, their contrasting physical characteristics (brittle:ductile) have led to necking of the incompetent gneissic body in the event of separation of amphibolites owing to stress. Occasionally, these amphibolites are seen as lenses or pods.

Migmatites are gradations or, variations from the surrounding rocks. They show lesser melanosome and more leucosome concentrations. The leucosomes are inherently richer in quartz, feldspar and a few mafic clots. Migmatisation is dominant in the gneissic varieties than the amphibolites. Most commonly, the migmatites show stromatic and pytymatic structures.

The pink coloured K-feldspar rich megacrystic granitic bodies are intrusive into the older basement part. Spheroidally weathered, these massive bodies are very scarce in aubundance and are confined sporadically to the south-eastern part of the investigating area in Garomaragin.

Vein rocks are the most conspicuous features of the basement and two types have been identified - quartzofeldspathic (pegmatitic in certain cases) and quartz veins. Grain size variations...
range from coarse to medium, (quartz veins being coarser) Attitudes of these veins are not constant and they often act as an easy marker to evaluate the deformational imprints - folding or, faulting, (Pl.-2.3). Quartzofeldspathic veins are older than the the quartz veins and in one outcrop of quartzofeldspathic gneiss, (in the Water Falls area) in the vicinity of a folded pegmatitic vein, an augen gneissic outlook is exuded, (Pl.-2.1). This could be due to bleb like separation of the quartzofeldspathic materials (mostly K-feldspar) during the intrusion involving complex processes of metamorphic differentiation.

The aforestated units exhibit inhomogeneity like planar-, linear- fabric, folds of minor importance, faults, fractures, joint planes, shearing etc.

Gneissosity or, schistosity is the dominant planar fabric. Marked by mostly flaky biotite and elongated quartz grain, they are often obliterated and diffused. Generally trending NE-SW at moderate degrees, the alignment fluctuates in between the ranges from NNE-SSW to ENE-WSW owing to the later deformations marked by F, and F, folds or, other tectonic disturbances. While the $F_i$ folds are dominant (with NW-SE axial plane and similar nature), the $F_j$ ones are open and minor warps. Most of the $F_i$ folds are easily distinguished along zones of venation and migmatisation. Lineations on the other hand are marked by hornblende and augen like inclusions within the amphibolites, fold axis and boudins (rectangular to lensoid). Fractures and joints are the most pervasive deformational imprints, (Pl.-2.1). Almost four sets of post-tectonic joints are seen in the area which affect all the rock units. Along some weak planes displacement is also seen in micro scale. This sort of on-field features indicate the possibility of a bigger fault in the vicinity.

2.2.2 Sedimentary Units

The sedimentary units are confined within the Precambrian Basement to the east and a sea like alluvial tract to the west. The area is sandstone dominated with two distinctly contrasting major units being disposed all over. However, within this confinement a total five varieties of sedimentary rocks are found each being characteristic from their surficial and genetical traits. Rock types like carbonaceous shale, siltstone or claystone are not of much magnitude to be demarcated specifically in detail while mapping. However, as a field entity and due to their significance in evaluating the depositional characteristics of the basin of deposition, they are described here. Enumerated below are some of the on-field characteristics of the rock types.
2.2.2.1 Pebbly sandstones

The pebbly sandstones which show fining upward features, (Pl.-2.4) unconformably overlies the Precambrian Basement and is in itself the basal member of the overlying sedimentary column. Atleast two truncated fining upward cycles are seen. This buff-brown, friable-compact, occasionally gritty, (Pl.-2.5) unit which is exposed north of the area shows gradational pinching towards south with its tail portion being lastly exposed in Singrimari Timiali. This sandstone body encloses coarser clasts right upto the boulder size whose concentration increases baseward. It may be mentioned that towards the base, they are a bit conglomeratic and very hard. These rocks are physically inhomogenous resulting in poor texture and, weathering. The coarser clasts are composed of angular to rounded quartzites, gneisses and amphibolites. Amidst these clasts are seen concentration of medium grained sand and silt sized materials - fresh exposures of which exude a bit of greenish tint. Although massive, attitudes could be measured at some sites which show the sandstones striking mostly from and within N10°E-S10°W to N30°E-S30°W with a maximum variability of 20°. Dipping W to NNW, the inclination is a maximum of 20°. The measured attitudes are further substantiated by statistical trends of ‘c-axis’ of the pebbles, 159 counts of which show a maximum plot concentration within N10°E to N30°E. Moreover, the coarser clasts show a trend of a(p) and a(i), (where, p = parallel and i = imbricate). Inter-layered with carbonaceous shale strata, this unit shows fluvial genesis in the form of pot holes and, sporadic current beddings, (Pl.-2.6) where the foreset inclination is a maximum of 25° dipping N to NNE.

Some of the interesting features associated with this unit are

I. The enclosed layer of carbonaceous shale towards which the sandstone shows drastic fining of grain sizes and almost nil concentration of any coarser clasts, (even pebbles). Upwards from the shaly layer at a distance of 1 foot the pebble-cobble concentration is on the rise, i.e., coarsening upwards, (Pl.-2.7). These features of fining upward in cyclicity may be aptly used to describe this litholog as cyclothem. Two such distinct layers of pebbles and coarser clasts are seen and, they hint about unstability of the basin of deposition and upliftment of it for the same number of times. Moreover, within the carbonaceous shale layers, the sandstone body too shows pinching and swelling.

II. Pervasive joints traversing the whole unit. Four sets have been identified with the trends being horizontal (Pl.-2.8), NE-SW, NW-SE, WSW-ENE. Moreover, the joint planes are a bit distorted whenever a coarser clast is on its way owing to the competency of these clasts.
To ease the sampling processes and for better distinction, this variety of basal sandstone has been coded as “B-type Sandstone” or, “Basal Sandstone”

2.2.2.2 CARBONACEOUS SHALE

The strata of carbonaceous shale which are inter-layered within the pebbly sandstones trend N15°E/10°-NNW, (Pl.-2.9). Exhibiting laminations on whose surfaces specks of pyrite are clearly seen, these layers bear some palaeoflora impressions of Glossopteris, Vertebraria, Calamites, Schizoneura and, some trace fossils, (see Chapter-7). Intense brittle deformation has resulted in the shales being broken into blocks and, along the intersection of joint planes specks of coal - Jhama (?) has been seen to form. These features however, are confined in the vicinity of the intrusives. The carbonaceous shale shows pinching and swelling character. One particular exposure at extreme north, (east of the BSF camp) shows a lensoid body of pebble less medium grained sandstone engulfed within two layers of carbonaceous shale which branch out and then merge, (Pl.-2.10). One interesting feature seen in these almost northerly trending shales is a sort of step like slippages of the layers towards west, (Pl.-7.1). As such, a mylonite like impression becomes apparent on the slip faces. However, the reflectance of these faces also reveal a coal like shine which may be quite possible under such circumstances.

2.2.3 SILTSTONE

A grey and compact layer of siltstone found in only one outcrop near Singrimari Tiniali seems to act as a demarcator between the pebbly sandstones and the overlying buff-pink fine grained sandstones. This layer which is surficially stained yellow shows a pinching tendency towards south and is composed of very fine, angular quartz and flaky micaceous minerals. Being competent by nature this 1 ft thick layer is a bit warped and jointed and, is almost free from any weathering, (Pl.-2.11).

2.2.4 FINE GRAINED SANDSTONE

Overlying the siltstone layer are the fine grained sandstones, (Pl.-2.12). These buff-pink coloured sandstones which are physically more homogenous than the pebbly sandstones show pinching tendency towards N-NNE and, spreads itself towards the south with the Precambrian basement and the pebbly sandstones being its boundaries towards east and west. However, a variation in their physical set up has been found in the sense that towards north where these sandstones
are in close proximity of the basal or, pebbly sandstones, they are hard, compact and bears sporadic pebbles of apparently sedimentary affinity and much similarity with that of the basal sandstones, *(PI.-2.13, PI.-2.14)*. These rounded sedimentary pebbles reflect a minor upliftment of the basement. In the present case, they may be considered as product of a hiatus. Southward, they are a bit fragile, more weathered and contain feldspathic laminations. Trending roughly N-S, they are often spheroidally weathered which could be due to erosion or smoothening along the joint planes. Further, it may be said that these spheroidal sandstone domes are concentrated towards NE. Inter-layered within this sandstone body are small layers of claystone, and Fe-laminations.

The layers of claystone, *(PI.-2.15)* trend N-S and are highly laminated. Pervasive jointing have reduced this nearly 1 ft. thick layer into curved blocks (pencil sort). Such features shown by these clay layers are indicative of action by some kind of sheared deformational stresses. However, these features are shadowed by the pervasive brittle deformational structures.

The claystones are inter-laminated by 2-4 mm thick Fe-laminations. Coloured red, the laminations are a bit harder than the claystones. The sandstone host shows fining tendency towards the claystone layer and coarsening away from it and, within this gradation, they are mud coloured. These fining and coarsening features seem to be a product of seasonal events under a fluvial setup.

To ease the sampling processes and for better distinction, this variety of finer sandstone has been coded as "A-type Sandstone" or, "Upper Sandstone".

### 2.2.3 Intrusives

Towards northern portion of the area are seen E-W to ENE-WSW trending long bodies of mafic, melanocratic, granular-aphanitic rocks which are intrusive (dolerite) by nature. Exposed along its trend, *(along the Nabhalgiri Water Plant)* in the form of spheroidal boulders, *(PI.-2.16)* this body shows minor protrubations on both sides of their generalised trend. Cutting mainly the pebbly sandstones, this body shows two varieties: coarser and finer. The finer variety is located along the protrubations and seem to bear zeolite (?) like incrustations sporadically.

### 2.3 Geological Setting

Based on the aforestated compilations, the following geological setting of the rocks exposed in and around Singrimari is proposed.
### AGE LITHOTYPES

<table>
<thead>
<tr>
<th>AGE</th>
<th>Lithotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent</td>
<td>Alluvium</td>
</tr>
<tr>
<td>Jurassic ?</td>
<td>Basic Intrusives - Dolerite</td>
</tr>
<tr>
<td>Permo-Carboniferous</td>
<td>Fine grained sandstones bearing sedimentary pebbles at the base towards north, claystone, siltstone.</td>
</tr>
<tr>
<td>Precambrian</td>
<td>Quarto feldspathic gneiss - granite gneiss, calc-silicate gneiss, amphibolite, migmatic, granite, vein rocks - quartz feldspathic (pegmatite in certain cases) and quartz vein.</td>
</tr>
</tbody>
</table>

#### 2.4 PREVIOUS LITERATURE / WORKERS

Though one finds passing reference of Singrimari in many Gondwana related geological reports particularly on the aspects of ‘distribution of Gondwanide rocks in India’, very little work has been done in Singrimari although it bears enough potentiality to shed some light into many aspects of geology concerning NE India.

Credit goes to C.S. Fox (1934) who discovered imprints of *Vertebraria* in Singrimari and reported about this area for the first time as one bearing Lower Gondwana rocks. Following him was Chatterjee (1944) who studied the heavy minerals from the sandstones of the area and classed them as Barakars. Apart from them, there are no other published reports although NER-GSI (1974) and DGM-Assam (1982) had worked here. While GSI looked upon the area from the economic point of view for coal (Sarma, 1986), DGM-Assam made a customary study.

While GSI found Talchir rocks here, DGM unearthed Barakars. However, amongst the recent workers may be named Baruah (1998), Baruah and Das (1996, 1998a, 1998b).
Plate 2.1: Photograph showing intense quartzofeldspathic venetion, augen like inclusions within the invaded country rocks and fracture along axial plane of a broad latter generation fold. *Locality: Water-falls area.*

Plate 2.2: Photograph showing quartzofeldspathic infiltration, (migmatitic venetion) within amphibolite showing tight to open fold geometry. *Locality: Water-falls area.*
Plate 2.3: Photograph showing minor displacement marked by a quartzo-feldspathic vein within the host quartzo-feldspathic gneiss. *Locality: North of the water-falls area.*

Plate 2.4: Photograph showing a basal sandstone, (pebbly or, B-type sandstone) with fining upward feature. *Locality: West of BSF Camp.*
Plate 2.5: Photograph showing a gritty variety of the basal sandstone, (pebbly or, B-type sandstone). *Locality*: West of BSF Camp.

Plate 2.6: Photograph showing traces of a current-bedding within the basal sandstone, (pebbly or, B-type sandstone). *Locality*: South-east of BSF Camp.
Plate 2.7: Photograph of a vertical section showing contact between the basal sandstone and carbonaceous shale with coarsening upward features. **Locality:** Nabhalgiri.

Plate 2.8: Photograph showing a sub-horizontal joint plane within the basal sandstone, (pebbly or, B-type sandstone). **Locality:** South-east of BSF Camp.
Plate 2.9: Photograph of a vertical section showing contact between the basal sandstone and carbonaceous shale. Locality: Nabhalgiri.

Plate 2.10: Photograph showing lensoid body of a pebble-less basal sandstone hosted within carbonaceous shale. Locality: North-east of BSF Camp.
Plate 2.11: Photograph showing a fractured siltstone layer. Locality: Singrimari Tiniali.

Plate 2.12: Photograph showing the upper sandstone, (fine grained or, A-type sandstone) with three joint sets. Locality: South of Singrimari Tiniali.
Plate 2.13: Photograph showing spheroidal weathering of the upper sandstone, (fine grained or, A-type sandstone). Also seen are small sedimentary pebbles within the host. 
Locality: East of Singrimari Graveyard.

Plate 2.14: Photograph showing hand specimen of the sedimentary pebbles as recovered from the upper sandstones.
Plate 2.15: Photograph showing claystone layerings within the upper, fine grained sandstone. 
Locality: South of Singrimari Tiniali.

Plate 2.16: Photograph showing a spheroidally weathered medium grained intrusive (dolerite) rock. 
Locality: Near Nabhalgiri Water Treatment Plant.