CHAPTER III

STRUCTURAL ELEMENTS

Before attempting the structural history of the area, a brief description of structural elements measured in the field is given. The structural elements can be broadly grouped into:

1. Planar elements.
2. Linear elements.

1. PLANAR ELEMENTS

The important planar elements are bedding and different cleavages. Different sets of joints have also been
measured at a few localities but not much attention has been given in recording them. The planar structures, excepting joints, have been termed as S surfaces in the conventional manner. The order in which the different planar elements are recorded and numbered (S₁, S₂ etc.) represents the order in which they have been developed in the rocks. Bedding being the primary planar structure is designated as S₁ and the later developed cleavages as S₂ and S₃. The cleavages do not correspond to folding episodes which are designated as F₁, F₂ and so on because not in all folding episodes a cleavage is developed. The schistosity in the different mica schists and the cleavage (S₂) in other lithologies parallel to bedding are produced during F₁ folds episode and as such they are termed as S₂.

a) Bedding (S₁): Bedding is the most prominent planar structure which is very distinctly identified in the quartzites by the presence of colour banding, grain size variation and the presence of thin pelitic layers parallel to bedding. In the amphibolites it is characterised by the presence of different coloured layers (Pl.12.1, 12.2) and thin psammitic layers. In the metapelites bedding is very obscure and cannot be identified excepting when psammitic layers are present in them. In the impure limestone and marble also bedding can hardly be recognised because of the
high degree of weathering.

b) Cleavages: Three cleavages (including schistosity in metapelites) have been recognised in the area. The first cleavage \( (S_2) \) which trends NNE is the most dominant and is well developed throughout the area. A fracture cleavage \( (S_3) \) parallel to the axial surfaces of \( F_3 \) folds, largely confined to hinge area is present. The other cleavage, a crenulation cleavage \( (S_4) \) is poorly developed and restricted to the micaceous rocks only. This cleavage is well developed in the hinge portion of \( F_4 \) folds at a few places.

i) First cleavage \( (S_2) \): The \( S_2 \) cleavage is the most prominent and is a penetrative element which can be seen in all the lithounits of the area. It is a slaty cleavage developed parallel to the axial plane of the first folds. It has always been observed to the bedding. Since no major first fold closures are seen in the area under investigation its relationship with bedding in the closure region could not be clearly shown. In all other later deformations this cleavage is seen deformed along with the bedding.

ii) Second cleavage \( (S_3) \): A crude cleavage parallel to the axial surface of the \( F_3 \) folds (Pl. 21.3) has been observed at several places. This cleavage is also nearly parallel to
the first cleavage ($S_2$), but at a few places it's angular relationship with the early cleavage and bedding can be seen.

iii) **Third cleavage ($S_4$)**: This cleavage is poorly developed and mostly restricted to the more mica rich variations of the different mica schists. It is a crenulation cleavage, parallel to the axial surface of the fourth folds (Pl. 12.3). It generally occurs as partings subparallel to the crenulations. In hard rocks like quartzites a weak fracture cleavage has developed in the nose portion of the minor folds which is also considered equivalent to this cleavage.

iv) **Axial surfaces of the folds**: Although the axial surface is a planar element it has a different status as compared to bedding or cleavage. This is not a structure physically seen in the rocks. So the axial surface is omitted from the various $S$-surfaces. If there is a cleavage parallel to the axial surface of a set of folds the situation is different. A strong cleavage is developed parallel to the axial surface of the first folds, which now trends NNE and dips at moderate to high angles. The axial surface of the $F_2$ folds trend NNE - SSW to ENE - WSW in general, with large variation in attitude depending upon their position on the later superposed folds. No cleavage is developed parallel to the axial surface of the
F₂ folds. The axial surface of the F₃ folds trend nearly NNE-SSW to N-S and they are steeply inclined to vertical. In some of the folds studied, a weak fracture cleavage has developed parallel to the axial surface of these folds. The axial surfaces of F₄ folds trends NNW-SSE and dip steeply to the NE. In mica schists a cleavage is developed parallel to axial surface of these folds whereas in the hard quartzite and amphibolites a fracture cleavage is observed in the hinge areas of the folds. The axial surface of F₅ folds, which are very open warps, trends almost east-west and dips at high angles.

c) Joints: Joints are well developed in almost all the rock types. Three sets of joints are identified in the area. One set trends NW-SE and dips at moderately high angles towards northeast, another set trends almost NE-SW dipping at moderately high angles towards southwest, The third set is almost E-W and dips at low angles.

2. LINEAR ELEMENTS

Any kind of linear structure on or within a rock has been termed as lineation by Cloos (1945, 1946). He identified 15 different types of lineations and classified them as primary and secondary; the primary lineations being current lineations,
and the secondary lineations being of tectonic origin.

The lineations described here are exclusively of tectonic origin. Since the tectonic history of the area is complex and several folding episodes have been recognised, the lineations associated with these folding episodes are identified and separated in the field. It may be mentioned that in some cases it has not been possible to fix the folding episode in which the lineation developed.

**Fold axes:** Five different folding episodes have been recognised and the minor folds of these episodes have been distinguished and their axes are recorded. The axes of these folds are represented as the lineations in the lineation map of the area (Pl.5). Third and fourth folds are prominently developed, but the first and second folds are very rare. The lineations representing the first and second axes have been recorded at many places.

**Intersection of bedding and cleavage:** It has already been pointed out that the first cleavage is always parallel to bedding, and the second cleavage is poorly developed at few localities only. The lineation produced by the intersection of bedding and second cleavage is recorded at a few places only (Pl.14.1).
**Puckers, Wrinkles:** This is the most dominant lineation in micaceous rocks. The crenulations are of third folds as such this lineation invariably indicates the third fold axes (Pl. 13.2).

**Pebble elongation:** The basal conglomerates contain pebbles of different size which are highly deformed. In general the longest axes of these pebbles plunge down the dip of the cleavage plane (Pl. 11.2). The long axes of the pebbles represent a lineation which is probably related to $F_1$ folding episode.

**Mullions:** Fold mullions have been recorded at a few places in the more micaceous zones in the quartzite. The hinges of the $F_3$ folds give rise to mullion structure.

**Boudins:** There are numerous thin quartz veins in all the lithounits/pegmatite veins intrusives are also seen in all the rock types excepting the conglomerates and quartzites. These quartz and pegmatite veins are occasionally stretched and show pinch and swell structure (Pl. 15.3) and boudins (Pl. 15.1, 15.2). The detached lensoid or necked veins in the strike continuation of the formation invariably plunge at high angles down the dip of the cleavage and bedding.
Striae and grooving: This is a lineation commonly associated with faults zone only. These have been observed at a few localities in the quartzites east of Gudas and north-west of Sulia dangar (hill 2396).

Mineral lineation: In the amphibolites and mica schist the hornblende crystals and streaks of micaceous minerals form a lineation on the cleavage surface. However, this lineation is rarely seen.