A B S T R A C T

The area lies within latitude 27°16'00" and 27°20'5" north and longitude 88°34'00" and 88°39'20" east. An area of about 45 sq.km has been mapped on 1 : 5,000 scale. The terrain is in the Eastern Himalaya and very difficult. The area is geologically unexplored yet. The earliest work includes that of Mallet (1875). Recent works include those of Sinha Roy (1974, 1977), Raina and Bhattacharya (1975), Acharyya et al. (1979) in adjoining areas but not exactly in this area.

The present area includes portions of the Daling Group and the Darjeeling gneiss and lies in the Inner belt of the Eastern Himalaya. The rock types are mostly phyllites, quartzites, mica-schists and gneisses with less important quartz veins, amphibolite bands and biotite rich selvages.

The structural elements belong to two phases of deformations ; F_1, the earlier phase and F_2, the later phase. Structural features of the F_1-phase include an axial plane schistosity (S_1), lineations (L_1) parallel to the F_1-axes and lineations (L_2) parallel to the direction of movement or stretching ; F_1-folds are mostly isoclinal and reclined. The F_1-deformation represents the phase of most intense deformation. Structural features of the F_2-phase include axial plane cleavage (S_2) and lineations (L_3) parallel to F_2-axes ; F_2-folds are developed only on mesoscopic and microscopic scales, are highly irregular in geometry and have deformed the earlier structures.

Systematic structural analysis indicates :

(i) the S_1-planes are only mildly deformed by the later F_2-folds. Poles of S_1-planes show a strong maximum corresponding to the orientation : Strike, N 24° W and dip, 32° towards ENE.

(ii) the L_2(mineral) lineations show a strong uniformity of orientation on the S_1-plane ; its average orientation is given by : plunge, 10° towards N 9°W. However, L_1-lineations are scattered to a limited extent by the later folds. The subhorizontal L_2-lineations lie subparallel to the strike of the S_1-planes.

(iii) the L_1-lineations (parallel to F_1-axes) are widely scattered on a great circle which represents the S_1-plane.

The area abounds in mylonites and may be designated a "shear zone". Predominant rock flowage took place during F_1-deformation parallel to the strike of the S_1-plane (which was the "shear" plane). Fold axes (L_1-lineations) were heterogeneously rotated to orientations parallel to the direction of major flowage, thereby causing great circle rotation of L_1-lineations.

Geometrically the F_1-folds mostly represent reclined flattened parallel folds and are the product of buckling and flattening. F_2-folds have extremely disharmonic profiles and represent mild heterogeneous deformation. The complexity of folds and inadequacy of the method of geometrical analysis of Ramsay have been discussed.

Detailed investigations of the microstructures and microtextures associated with rock cleavages in this area indicate four types of rock cleavages :

(1) Discrete crenulation cleavage : These are line domains and are predominantly defined by opaques.

(2) Crenulation cleavage zones : These are thin or thick cleavage zones rich in phyllosilicates and depleted in quartz and coincide mostly with the limbs of microfolds.

(3) Microbanding : These are microscopic thin differentiated bands alternately rich in quartz and phyllosilicates.

(4) Pervasive cleavage : Complete parallel orientations of phyllosilicates without preservation of characteristic microtextures of microlithons.

Role of pressure solution in bringing about the first two varieties of rock cleavages is well documented ; increasing recrystallisation and plastic flow at high temperatures are considered to play important roles in the case of the fourth variety, while the third variety is, perhaps, somewhat intermediate in nature. Solution transfer phenomena and its dependence on microfolding have been discussed. The role of initial fabric inhomogeneity, intergranular and bound fluids, recrystallisation, plastic flow etc. have been discussed.

Rock cleavages (S_2) associated with the F_2-deformation mostly belong to discrete and zonal crenulation cleavages (and to microbanding to a limited extent). Rock cleavages (S_1) associated with F_1-deformation mostly belong to the pervasive cleavage type though differentiation into microlithons and cleavage zones are recognisable at places.

Patterns of inclusions in garnet porphyroblasts are described and on this basis nine types of patterns are recognised. The inclusions are shown to represent two varieties : fine grained trails of schistosity (S_1) and bands of coarse grained quartz of pressure shadow zones. On the basis of these patterns and their relationship to Se it has been concluded that synkinematic (with respect to F_1-deformation) porphyroblasts show curved, single or double, spirals of inclusions and postkinematic porphyroblasts show straight trails of Si, occasionally rotated by F_2-folds (-postcrystalline rotation). There are combinations of different types of trails in a single porphyroblast representing synkinematic to postkinematic growth. The downplunge view of the rotated porphyroblasts consistently indicate clockwise rotation (i.e., dextral shear). The relative rates of growth versus rate of rotation in controlling the inclusion patterns are discussed. The inclusion free garnets probably represent slow postkinematic growth.

There are no suitable strain markers from which the strain patterns can be uniquely determined. But the mesoscopic and microscopic features indicate the following strain patterns :

(1) Regional structural geometry of planar S_1-planes and uniform mineral lineations (L_2) indicate subhorizontal laminar flow on S_1-planes.

(2) Analysis of the F_1-fold geometry indicate a major flattening on S_1-planes.

(3) Analysis of the axial plane schistosity (S_1) also indicate major flattening on S_1-planes.

(4) Investigations of the microtextures of rotated porphyroblasts of garnet indicate a clockwise rotation (-dextral shear) in a downplunge view.

Combining these evidences it appears most probable that a combination of flattening and simple subhorizontal dextral shear on S_1-planes represent the strain pattern.

The NNW-SSE strike of the "shear" plane (S_1) with subhorizontal simple shear stands in contrast to the general E-W strike of the thrust planes and downdip movement on the thrust planes in the Himalaya in general. A model is presented to reconcile the two contrasting geometries of movement : it is shown that the general south directed thrusting movement of the Eastern Himalaya can be conveyed by a strike slip movement on the transverse (i.e., NNE-SSE strike) S_1-planes.

Textural evolution of the phyllites, the mica-schists and the gneisses indicate that there had been one phase of prograde metamorphism, synkinematic to postkinematic with respect to F_1-deformation and prekinematic with respect to F_2-deformation.

The phyllites belong to chlorite and biotite grades, the mica-schists to garnet and staurolite grades and the gneisses to biotite grade. Kyanite occurs only in one spot.

Garnet and staurolite are totally absent from the phyllites and the gneisses. K-feldspar is present in the gneisses and some of the mica-schists. Mineral parageneses indicate that the K-feldspar was obtained by recrystallisation of original K-feldspar grains present in the parent rocks and was not derived by muscovite breakdown reaction. Modal compositions of the mica-schists and gneisses indicate their complete gradational nature.

It is concluded that these represent metamorphosed products of original pelites grading into graywacke/arkose (which contained K-feldspar grains).

Biotite/garnet, chlorite-biotite/garnet, and garnet/staurolite isograds have been mapped. It has been shown that the isograds closely follow the lithological boundaries and are extended along the strike of S_1-planes. Exception to this general pattern is observed in the following case : Garnet and staurolite zone rocks of the mica-schists are cut by transverse faults which control the pattern of distribution of these two zones.

The garnet/staurolite isograd lies wholly within the mica-schists. The isograd dips at 20° toward ENE. Staurolite grade rocks overlie the garnet grade rocks and thus document reverse metamorphism. A method of analysing theoretically the geometry of the isograds in terms of isotherms, isobars and thermal gradients has been presented. It has been shown that reverse metamorphism is caused in three models, each defined by particular configurations of isotherms, in relation to isobars and thermal gradients. The present example of reverse metamorphism was caused by an upwardly directed thermal gradient. The possible cause and limitations of this situation is discussed.