Synopsis

The investigation covers the following aspects:

(1) Structure

(2) Petrofabrics

(3) Metamorphism

(4) Granites

(5) Dalma volcanics

(6) Sedimentation and stratigraphy.

Structure:- Systematic analysis of the geometry of the structures reveal that there are four phases of deformation. The first phase of deformation produced isoclinal folds on bedding with a strongly developed axial plane schistosity. These first generation folds trend E-W and westward and southward gradually veer to a final NNE-SSW trend. This syntaxial bend in the fold is difficult to recognise and needs very careful analysis. Recognition of the first schistosity as parallel to the axial plane of folds on bedding is also a very crucial point, since it parallels bedding on the limbs of the isoclinal folds and cuts across the latter only at the hinge. Such intersection lines are beautifully demonstrated as scattered on almost a great circle around the second generation fold axes.

The second phase of deformation affected these rocks more effectively in the northern part and died out southward. This resulted in the formation of the Sonapet and the Dango Antiform and the Bijar and the Nalita Synform in the north. Southward through Chakradharpur and southeastward through Lapsa these folds flatten and die out gradually.

The second generation folds have approximately E-W strike of axial plane and subvertical to steeply northerly dipping axial plane. Fold attitudes vary greatly from open to tight isoclinal and from upright to reclined folds. Fold axes also vary greatly, due to synchronous cross-folding, defining axial culminations and depressions. A host of linear features are developed parallel to the fold axes.

Synchronously with the second generation folding, a folded shear zone developed close to the Dalma epidiorite boundary. Structures of the shear zone include predominantly the shear planes with downdip or almost downdip striations. Sense of movement is that of hanging block sliding down the foot block. Associated with the downdip striations are often a downdip crinkle which are crinkles parallel to 'a'. Dragfolds are also developed at right angles to the striations. These two directions constitute the most prominent linear features of the ~~sh~~ shear zone. Frequently they deviate from the downdip and subhorizontal attitudes and hence their geometrical analysis becomes complicated. Besides, further complexities are introduced by the subparallelism between these linear features and the linear features associated with the second folding - for example, a downdip crinkle (parallel to the striations) in the shear zone is frequently confused with a downdip crinkle parallel to the axes of second generation folds with a reclined attitude. Utmost care is needed to correlate these features properly.

The third phase of deformation affected the rocks in the southern half of the area and are absent in the north. This folding episode is manifested in a rich variety of structural forms ranging from flexural slip folds to intense slip folds merging into the localised shear zones. In fact near the northern, western and extreme southern margins of the zone affected by this deformation, flexural slip folds are mostly encountered, while the central zone extending eastward shows effects of intense slip folding. As a result, the varied geometrics of superposition of folds are illustrated on a grand scale. Thus, in the west, flexural slip folds of the 3rd phase are superposed on the flexural slip folds of the second phase ; due to this superposition, earlier fold axes are spread on great or small circles around the later fold axis, depending on whether the angle between the two fold axes is 90° or acute. Simultaneously the later fold axes are spread on great circle which coincides with the trace of the axial plane of the later fold. Spreading of later fold axes is caused by the super-position of the later folds on variously oriented earlier S-planes, such various orientations being caused by the earlier folding. At Lapsa, geometry of such superposition is somewhat different; here the second generation folds are present as very shallow and open folds on which the third generation slip folds are superposed. The result is a complete scattering of the 3rd generation fold axes on a great circle coinciding with the trace of the third generation axial plane. Around Chakradharpur and Rajkharswan, the second generation folds are practically absent and the third generation folds are superposed directly on the first generation folds. Here the third generation folds consist of intense slip folding, accompanied by a northerly dipping axial plane schistosity which bears a strong mineral lineation and parallel striation plunging approximately towards NNE. This schistosity is directly superposed on the first generation folds and first generation axial plane schistosity. Where the striation on the 3rd axial plane schistosity coincides with the line of intersection with the earlier S-plane, the earlier S-plane does not show any folding, so that the earlier and later S-planes look like undeformed intersecting S-planes, which were wrongly interpreted by other sorkers as forming conjugate shear planes. Where these two directions deviate one from the other, the earlier S-plane exhibits folds; linear features are either correlated with the 3rd fold axis or with the slip direction on the 3rd axial plane schistosity. The third generation slip folds have resulted in thin zones of intense slippage or shear interleaved with layers of less intense deformation, much like the "gleitbretter" of

Schmidt. Besides, there are folds in 'a' often on gigantic mappable scale.

The thrust structures of Dunn belong to this 3rd phase of deformation. It has been demonstrated in the present investigation that large-scale displacement, as expected in a thrust, is absent here and hence it is suggested that the thrust belt which is more prominent further east beyond the limits of the present area, is in a vanishing stage within this region.

The fourth phase of deformation consists of small scale drag folds, pointing to a sliding-down movement around variously oriented axes. These have deformed all earlier structures and are confined to the eastern zone only.

In the kinematic analysis of the structures, two topics are of general interest:

(a) Mineral Lineation - This can be classified into two groups: the first group consists of parallel alignment of elongate mineral elements ; the second group consists of parallel mineral alignment due to intersection of schistosities i.e. trace of mineral flakes parallel to one schistosity on another S-plane. The former is a true mineral lineation, while the latter is in fact related to the formation of the S-planes. True mineral lineation in a Newtonian Viscous mass is analysed theoretically and mathematically and is predicted to be parallel to the flow direction. Such analysis is not applicable to plastic bodies with Andradean Viscosity. From general considerations it is also concluded that in Andradean Viscous masses, mineral lineation would align along the flow direction. From geological point of view, in flexural slip folds, mineral lineations are aligned parallel to the fold axis whereas in slip folds, these are aligned parallel to the direction of flowage.

(b) Pebble deformations:- Two kinds of pebble deformations are envisaged - in the first case the pebbles are elongated parallel to the fold axis; these are associated with flexural slip folds. In the second case, pebbles are elongated parallel to the slip direction; these are associated with slip folds. In the first case, pebble elongation is genetically related to rotation of visco-elastic masses, in which relaxation time is an important factor. In the second case, pebble elongation is related to plastic flowage.

Petrofabrics:- It consists of three parts : The first part deals with correlation between symmetry of micro-fabric with symmetry of megafabrics. Excellent correlation is reported for fabrics showing 'ac' and 'ab' girdles. For 'bc' girdles such correlation is lacking.

The second part emphasises the difference in the mode of deformations accompanying 'ac' and 'bc' girdles of fabrics. It is concluded that 'ac'-girdles are related to ordinarily folded areas, where grain rotations are important and rate of deformation is relatively slow :

'bc'-girdles are associated with shear zones where rate of deformation is fast and where grain stretching is more important than grain rotation. This difference in the mode of deformations is correlated with the well-established three mechanisms in plastic deformation~~s~~ of metals; cell mechanism, slip mechanism and boundary flow mechanism.

The third part assumes slip mechanism to be responsible for the formation of 'bc'-girdles. On this assumption, a theoretical prediction of deformation textures in quartz is made and compared with observed facts. The prediction seems to be successful. Earlier interpretations of 'bc'-girdles are criticised in this aspect.

Metamorphism:- Metamorphism~~s~~ of the basic and pelitic rocks has been studied from the standpoint of time sequence of formation and mineralogical transformations. Three generations of high grade metamorphism are recognised; their zonal patterns are also analysed in the light of structure of the rocks. It has been concluded that the zonal boundaries are likely to indicate approximate isotherms; formation of the high-grade minerals ~~are~~ is related to a rise of temperatures, ~~in which~~ while deformation possibly catalysed the reactions. Several periods of retrogressive ~~ons~~ which have been recognised.

Granites:- Structure and petrology of the two granites - Chakradharpur granite gneiss and Arkasani granophyres are studied. It is concluded that both are of metasomatic origin. Chakradharpur granite gneiss was not emplaced towards the end of the 3rd phase of deformation, as claimed by other workers. In fact, Chakradharpur granite gneiss started to be emplaced after or synchronously with the first phase of deformation and its emplacement continued until after the 3rd phase of deformation. It is strongly felt that this granite body consists of fractions of at least two generations. The granites do not have any connection with high grade metamorphism.

Dalma Volcanics:- The study of the Dalma volcanics consists of two aspects : the first aspect consists of analysis of the primary structures and thence recognition of its volcanic character. It is also concluded that some parts of the Dalma epidiorites are intrusive sills and possibly (?) dikes; chemical analyses have been presented to support its original basaltic composition. The second aspect deals with the tectonic structures and outcrop patterns ; from such analyses, it is concluded that the Dalma volcanics do not represent a fold core, as claimed by other workers, that it represents a sheet and that it is conformable with the underlying phyllites and micaschists.

Sedimentation and Stratigraphy:- Primary sedimentary features of the rocks have been analysed. The original lithological characters are also brought out. It is concluded that these rocks represent a close similarity with the synorogenic flysch facies of the Alps.

Stratigraphy of the rocks is based on lithological considerations, structural analysis of the rocks and relations of the Dalma volcanics. The following points are observed in this connection:-

(1) Earlier classification of these rocks into the Iron Ore stage and Chaibasa stage of different orogenic cycles is untenable. The rocks are products of one uninterrupted continuous sedimentation of possibly one orogenic cycle.

(2) Earlier workers considered the Dalma volcanics at the top of the sequence, Dalma volcanics occupying the core of a syncline. It has been argued that Dalma volcanics occur as a sheet and hence are sandwitched between phyllites and mica-schists. Thus, there are phyllites and mica-schists younger than the Dalma volcanics.