CHAPTER VI

STRUCTURAL EVOLUTION

STRUCTURAL FRAMEWORK

Though appearing simple to a casual observer, the area presents many structural complexities when studies in detail. It is seen to form a big antiformal structure, extending NNW-SSE, the two limbs of which do not correspond. This anomaly has been found to be due to a major dislocation that extends along the Khastari Gadhera. This tectonic plane has been referred to by all previous workers as North Almora Thrust and has been recorded almost all over the Inner Lesser

Himalaya of Kumaon from E to W. As already stated earlier, most workers have taken this dislocation to be the south dipping flank of the synformally folded Almora Thrust. With this assumption, the rocks to the north and east of this so called thrust, have been included in the paraautochthonous Krol Nappe (or Garhwal Group) over which lie the rocks of Almora Dudatoli Thrust Sheet (Dudatoli Group). The author's investigations have, however, shown that the Almora Thrust does not run along the Khastari Gadhera, but it lies concealed below the upthrown Krol Nappe rocks. According to the present author, the Khastari dislocation is just a big reverse fault that has truncated the NNW-SSE anticline along its crest, having pushed up the eastern limb over the western limb. Accordingly, the author has recorded and named following major structures:

1. Chaukhutia Anticline - the main antiformal structure that extends almost NNW-SSE.

2. Khastari Fault - the reverse fault that extends NNW-SSE along the Khastari river is supposed to run along the crest of the Chaukhutia anticline and along which the eastern limb has been pushed over the western.

These major structures have impressed upon the rocks, a variety of structural and metamorphic characters, a study of which has revealed an interesting deformational history.

STRUCTURAL CHARACTERS OF THE KARCHULI GROUP

Structurally, the schists, quartzites and gneisses of Karchuli Group, are not very interesting. As these Almora Nappe rocks, occupy a very small portion of the study area, they contain only a few of the many characteristic structural features reported from these crystalline rocks in the south and southeast by earlier workers (Merh and Vashi 1965, Sarkar et al. 1965, Shah 1972). The reclined folds in quartzites encountered in Ranikhet and Almora areas are nowhere recorded in the Karchuli rocks. Vashi and Merh (op. cit.) have reported an interesting structural history for the Almora synform, comprising three folds events:

1. Reclined folding (F_1) that gave rise to the main schistosity along the axial plane of this folding. The axes (L_1) of these folds are seen to be plunging due SSW on the northern limb of the synform.
2. Synformal folding (F_2) that gave rise to the existing NW-SE synformal shape to the crystalline thrust sheet. Related to folding, are seen abundant

puckers (L_2) that plunge generally due SE or NW at very gentle angles.

3. Open N-S to NE-SW flexures superimposed on both the limbs of the synform. The fold axes and the related puckers L_3 that developed on the northern limb of the synform plunge due S or SW.

The following relationship between the major and minor structures has been suggested by the above authors (Vashi and Merh, 1974).

Tectonic events	Minor structures developed			
	Planar structures		Linear structures	
Load (?)	Bedding schistosity	(S)	-	
Isoclinal folding (F_1)	Schistosity and gneissic foliation Axial planes of minor folds Phyllonitic cleavage	(S_1)	Axes of the minor folds on S in quartzites Striping or ribbons Axes of quartz veins Quartz rods	(L_1)
Synformal folding of Almora Thrust (F_2)	Axial planes of chevron folds and related strain-slip cleavage	(S_2)	Axes of crinkles, folds and puckers	(L_2)
Open NNE-SSW folding (F_3)	Axial plane of small folds stray strain-slip cleavage	(S_3)	Faint puckers	(L_3)

In the present area, it is seen that nowhere the reclined folds (F_1) and the lineations (L_1) related to it, are encountered. The two pucker lineations recorded and mentioned above, appear to be the L_2 and L_3 of Vashi and Merh (1974).

STRUCTURE OF THE CHAUKHUTIA-MANWADEVI GROUP

The rocks of this group are structurally more interesting. The antiformal structure made by these rocks is quite obvious. Not only here, but the workers in the NW (Auden, 1937; Heim and Gansser, 1939; Gansser, 1964) as well as in the SE (Valdiya, 1961, Munshi, 1973) have all recognised the fold. But the noncorrespondence of the two limbs of the antiform has always intrigued them. The likelihood of the so called North Almora Thrust to be a reverse fault, quite distinct from the northern flank of the Almora Thrust, was for the first time mooted by Vashi and Merh (1974). The present investigation, according to the author has further clarified the regional structural picture. It is most likely that the structural pattern deciphered in Chaukhutia area, can also be applied for the neighbouring areas in the NW and SE.

Fold History

The author has recognised effects of two fold events in these rocks. The Chaukhutia anticline comprises the early fold while on its two limbs are seen superimposed late open flexures whose axial planes strike broadly NE-SW.

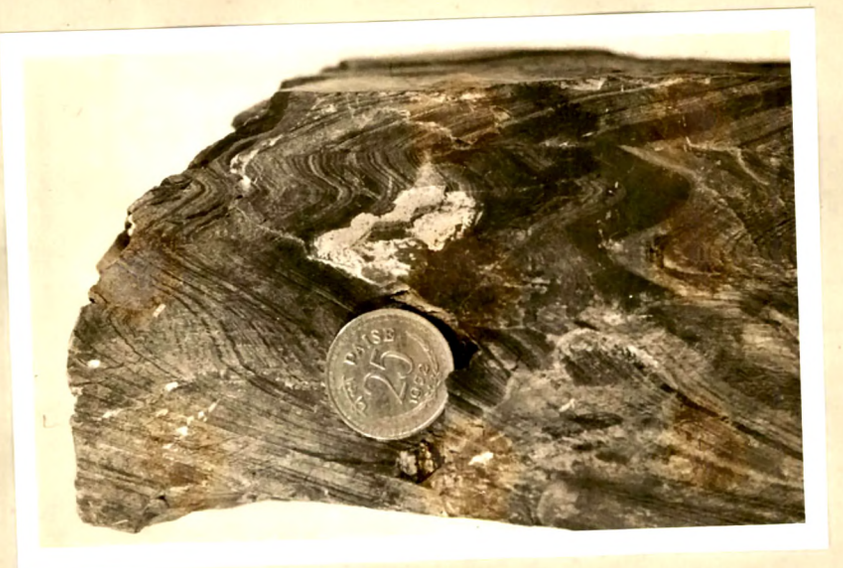
The Chaukhutia anticline is truncated along its crest by Khastari fault, and it is obvious that the rocks on west dipping limb have been pushed down with respect to those on the eastern limb. The exact shape of this anticline is rather difficult to visualize, but looking to the numerous related folds in the slates, quartzite and limestones, it is reasonable to presume that the western limb of the anticline must have been fairly steep with some local overturning. The faulting followed by erosion, has resulted into the existing outcrop pattern (Fig. 6.1).

The dolomitic limestone shows abundant folding related to the regional anticlinal structure. In most case these folds are sharp and angular, several meters in amplitude, and conspicuous along the valley

sides. The southwestern limb is always steeper, quite often almost vertical, while the northeastern limb is seen to dip rather gently. The axes of these fold have been measured to be plunging with moderate angles to the SE. The slaty layers in the limestone show very interesting small-scale chevron type folds with development of axial plane slaty cleavage. The cleavage bedding lineation is conspicuous and is seen plunging due SE (Plate 6.1). The slate quartzite sequence beneath the limestone is also seen highly folded at places, the size of the folds are rather smaller, never exceeding a meter or two in amplitude. The western limb of these minor folds is either vertical or slightly overturned to the east. The slaty layers also are seen folded. It appears that this slate-quartzite sequence folded by a flexure slip mechanism while the slaty layers within the limestone developed axial plane slip folds. The subgraywackes, above the limestones also show folds identical to those recorded in limestone (Plate 6.2).

The effect of second folding is not very well marked, and is noted in the form of gentle flexures with axial planes striking NE-SW. The folding is also

PLATE 6.1



Chevron folds in slaty layers within lime-
stone. (Loc. near Tarag Tal)

PLATE 6.2

Folds in subgraywacke.
(Loc. Punniabagar)

reflected in the fluctuation of the strike trend at the different formations. The cross-folding between the early and the late fold is also recognised in the slightly dome-shaped outcrop pattern at a few places. It is observed that the axes of the late flexures plunge due SW in the gneissic rocks, while they show a NE plunge in the limestone, chlorite schist and subgraywackes. This is obviously due to the fact that these have been superimposed on the two opposite limbs of the early anticline.

FAULTS

In addition to the Khastari Fault, the author has recorded four transverse faults, three of them trend almost E-W, while one has a NE-SW strike. The two E-W faults lie to the west of the Khastari Fault to the south and north of the village Kedar. These faults appear to be strike-slip faults and are seen affecting the rocks of Karchuli group also. It is not clear what age relation exists between these faults and the Khastari Fault, but there is all

probability that they are the youngest structures. Both faults show dextral movements.

The two faults in the east also are of strike-slip type, one has a NE-SW trend while the other is E-W, and the two meet near the village Amsari. It is seen that on account of these faults, a wedge of rocks has been pushed eastward.

It is further observed that these transverse strike slip fault die out on reaching the limestones. Perhaps the limestone being plastic and incompetent, have failed to transmit the stresss any further.

The Khastari Fault is affected by the NE-SW (late) folds and thus it is obvious that this faulting took place prior to late folding. On the other hand, the various strike-slip faults appear to have developed perhaps at the time of late folding or even later.

The structural history of the Chaukhutia-Manwa Devi group can be summarised as under:

1. Development of the Chaukhutia anticline.
2. Reverse faulting on the crest of the above anticline, such that eastern limb was pushed over the western limb,

3. Superimposition of late NE-SW flexures over the Chaukhutia anticline.
4. Transverse strike-slip faulting.

REGIONAL CONSIDERATIONS

The structural framework suggested for the study area, when considered in the regional context, reveals many new facts. The various deformational events recognised in the present area, could be fitted in the general scheme of the tectonic evolution (Merh, 1968) of this part of Kumaon as under:

	Chaukhutia area
I. Isoclinal folding in the Almora crystallines (F_1) with related schistosity (S_1)	Schistosity in Karchuli group
II. Culmination of F_1 into Almora Thrust	Shearing of the gneisses
III. Folding of the Almora Thrust (F_2)	Chaukhutia anticline
IV. -	Faulting of the Chaukhutia anticline
V. N-S to NE-SW flexures (F_3)	NE-SW flexures
VI. Transverse faults	E-W and NE-SW faults