CHAPTER VI

R E S U M E

GENERAL

Geologically the study area comprises the south-eastern extremity of ~~the~~ Auden's Krol belt. As compared to the type area, this part of the Krol belt has received inadequate attention in the past. The Naini Tal and its neighbourhood shows a complex geology, its rocks having been extensively folded and faulted. Some workers in the past have investigated this area, but none made any serious attempt to unreavel its structural and stratigraphic complexities. Heim and Gansser have given a fairly good account of these rocks, yet their work was rather vague and needed revision in many respects. These workers did

not work out the correct stratigraphy and structure of the area, and found it quite difficult to decipher a correct tectonic picture. The present author's work, in a way, is the first detailed geological study of the Nainital and its neighbourhood.

In the various chapters of this thesis, the reader must have found answers to many unsolved problems of the geology of the Naini Tal area. The author has succeeded to a considerable extent in throwing some light on the problems connected with the stratigraphy, structure and geomorphology of this part of the Krol belt.

STRATIGRAPHY

Succession

In the matter of broad stratigraphic outline, the present author has mainly relied on the works of Auden and Heim and Gansser but so far as the details of stratigraphy and correlation are concerned, he has differed much from the previous workers. One of the important aspects on which the author has disagreed with Heim and Gansser, is that of the correlation of the lowermost quartzite rocks that overlie the traps of Bhowali. These two workers correlated them with the Nagthats. But the present author has established that they are not Nagthats

but Blainis. He came across no evidence to consider these quartzites of Nagthat age. While on the other hand, the various criteria conclusively put them as equivalent to the Blainis.

The author has found that the various formations of the study area typically represent an almost complete Blaini-Infra-Krol- Krol sequence, and these Krol group rocks have been pushed over the autochthonous Lower Siwaliks. The rocks show the following generalised stratigraphic succession:-

Formation			Lithology	Thickness
Siwalik			Sandstones and shales	?
Krol	Upper	(iv)	Oolitic (Siliceous) limestones	60-120 m
		(iii)	Dolomitic limestones	200-300 m
	Lower	(ii)	Red shales (slates with thin bands of limestones)	60-120 m
		(i)	Thinly bedded limestones with intercalated slates	120-250 m
Infra-Krol		(iii)	Pebbly quartzites and slates interbedded	60-120 m
		(ii)	Slates, silty slates and quartzites interbedded	120-200 m
		(i)	Purple and carbonaceous slates	30-60 m
Blainis		(ii)	Purple and red slates with limestone	10-30 m
		(i)	Pebbly quartzites and sub-greywackes	120-200 m
- - - - - - - - - - - - - - - Unconformity - - - - - - - - - - - - -				
Blainis are resting over the foliated traps				

Depositional history

The various formations of the Krol group from Blaini to Krol comprise an almost unbroken sedimentary sequence, the entire sequence forming a single litho-stratigraphic group. The rocks show a depositional history, quite identical to that of the Krol belt type area.

The oldest formation, viz. the Blaini, typically represents shallow-water turbidites deposited between littoral and infra-littoral zones under tectonically unstable conditions. The pebbly and bouldery beds of the Blaini formation, according to the author, are not glacial or fluvioglacial but comprise slump deposits involving shallow water sediments. The occurrence of limestone near the top of this formation also goes against the glacial origin.

The transition of Blainis upward into the Infra-Krol is quite gradational. The red slates in the upper part of the Blainis are quite identical to those of the lowermost Infra-Krols, and in fact, the Blainis imperceptibly grade into the Infra-Krols. The slate sequence in the lower part of the Infra-Krols suggests a comparative deepening of the

basin, while on the other hand the upper part indicates shallow water conditions. Perhaps the Infra-Krols were deposited in a transitional deltaic environment.

The basin again deepened during the Lower Krol times, characterised by an environment of mixed clastic and carbonate deposition and indicating a stable tectonic set up. Oxidising conditions are indicated during the deposition of the Red Shale member, though the marine conditions continued to prevail. The upper two members of the Krol formation represent a regime of carbonate sedimentation in shallow marine conditions. The oolitic nature of the uppermost Krol member speaks of a near-shore environment, oolites indicating extreme shallowness and current agitated waters. It is surmised that the basin became very shallow and sub aerially exposed at the close of Krol deposition, and perhaps the area became positive soon after. This explains the absence of Tal formation in this ~~front~~ part of Kumaon.

Correlation and age

Considerable similarity exists between the sedimentary sequence of Naini Tal and the Krol group of Simla, and the author has found the broad correlation of these rocks with those of the type area made by Heim and Gansser quite valid. The author has, however, differed from the two above workers

in respect of the rocks in the east and north-east. These so called Nagthat rocks in fact, comprise partly Infra-Krols and partly Blainis. The pebbly and gritty quartzites and the overlying purple slates with lensoid limestone belong to Blaini formation, while the gritty quartzites of Lariakanta ridge represent topmost Infra-Krols.

So far as the slates and limestones above the Infra-Krols are concerned they have been correlated with the Krol formation of the type area. There is a striking similarity between the rocks of the two areas.

As regards the age of this Blaini-Infra-Krol-Krol sequence, the author has mostly relied on the works of the various geologists in Simla, Garhwal and Naini Tal areas of Krol belt, and taking into account their views, the author has suggested the following stratigraphic ages for the various formations.

Formation	Age
Tal	Lower Cretaceous to Jurassic
Krol	Triassic
Infra-Krol	Permian
Blaini	Permo-Carboniferrous

STRUCTURE

Fold pattern

The study area comprises two main tectonic units (i) the autochthonous rocks to the south below the Krol thrust (= Main Boundary Fault) made up of Lower Siwaliks, and (ii) the allochthonous rocks of Krol group lying above and to the north of the Krol thrust.

The Krol nappe rocks form an open ESE-WNW synform (Naini Tal syncline). The hinge of this synclinal structure is cut by a large fault (Naini Tal Lake fault). The author has further established that the rocks to the north and east of the Naini Tal Lake fault comprise two fairly tight and isoclinal macroscopic folds, both overturned to north east. These folds belong to an event of folding older to that which gave rise to the Naini Tal syncline. The slaty cleavage of the rocks is related to this easy fold episode and is of axial-plane type.

The rocks of Naini Tal area show folds belonging to following three main episodes:-

F_1 - Two large structures (Gainthia-Gangal anticline and Chorsa-Dunakhal syncline) overtunred to NE; slaty cleavage is related to this folding; these two folds are of the same generation as that of the Bhowali anticline.

F_2 - The main (ESE-WNW trending) Naini Tal syncline; folds of this generation are rather open with axial-planes either vertical or steeply dipping due N or S. The prominent pucker lineation (L_2) is related to this episode.

F_3 - Open NE-SW flexures recorded sporadically; the last tectonic event that affected the entire Kumaon including the Siwaliks.

Fracture pattern

The fracture pattern is genetically related to the Krol thrust, and the numerous faults occurring in the area, perhaps originated during the thrust movement.

The Krol thrust is the major dislocation and in this part of the Kumaon Himalaya, it coincides with the Main Boundary Fault. The F_2 folds appear to be related to this thrust, and have been considered as compressional folds developed in the Krol group during its upthrust along the dislocation.

The two normal faults, viz., Naini Tal Lake fault and Lariakanta fault also originate from the Krol thrust. In addition, the numerous other faults - (Khurpa Tal fault,

Talli Baijun fault, Pokhra fault and Talla Kun fault) also meet the Krol thrust and are of the nature of tear faults developed during the main thrust movement.

It is quite obvious that the tectonic evolution of the study area is essentially controlled by its nearness to the Krol thrust.

GEOMORPHOLOGY

Lakes

A unique combination of faulting, folding and climatic factors has given rise to the various lakes of the area.

On the basis of detailed structural studies, the author has suggested that the lakes are fault controlled. Certainly, they are not of glacial origin.

The formation of the lakes could be attributed to the following two main factors:-

(i) Subsidence of rock segments at fault intersections.

(ii) Rock slides.

All the lakes are situated in the "fault-line valleys". The rock slides have considerably aided the process. For causing rock slides, again the lithology, fracturing, heavy rains and frost action are important.

Scarps

Faults have played a very important role in scarp formation too, lithology having contributed its own share. The striking scarps of China Peak, Deopatha hill and Lariakanta, are all fault controlled; the rocks are such that their weathering by rains and frost action have resulted into steep and craggy scarp surfaces. The scarps indicate a young fault topography, such that the agents of weathering have not yet fully destroyed and smoothened out the height differences.

Rock falls and Rock slides

Sudden fall of huge boulders and chunks of hard rocks take place all along the steep cliffs mainly in the areas of Upper Krols. Big masses of rock near the edge of the cliffs get progressively detached by the action of rain, frost and heat, and then all of a sudden during a heavy downpour and sometimes even without it, they come tumbling down the cliff sections.

Sometimes, masses of softer rocks and weathered rock mantle on steep slopes slide down under the effect of gravity. Such rock slides are confined to highly cleaved and fractured lower Krol rocks. Rain water percolating below and lubricating the weaker planes triggers off the sliding movement.

Drainage

The drainage of the area is also controlled by the structural features. The overall stream pattern can be regarded as rectangular or angulate, and it reflects the control of faults, folds and cleavages. Almost all the major streams follow the fault lines.

CONCLUDING REMARKS

On going through the various chapters of this thesis, the reader must have realised that the stratigraphy and structure of the Naini Tal area are more complex than visualised in the past. This much folded and faulted area, poses many problems of structure, stratigraphy and geomorphology, which have intrigued the previous workers. But the present study has amply shown that these problems could have been easily answered, had someone undertaken a patient and painstaking structural study of the entire area. The author did this in collaboration with others in the neighbouring areas, and his efforts have been fully rewarded.