CHAPTER X

SUMMARY AND CONCLUSIONS

GEOLOGICAL SETTING

The study area lies in the middle reaches of the Kali Gandaki river valley in the Lesser Himalaya of Central West Nepal. The author having been convinced that only a very detailed and systematic study of stratigraphy, structural elements could answer the many controversial problems of Nepal Lesser Himalaya took up this investigation.

The author has critically analysed all aspects of the rocks of the area that are divided into two tectonic units, separated by a prominent thrust (Phalebas Thurst), running NW-SE and passing through the villages of Phalebas and Lame Deorali. This dislocation more or less coincides with the Chail Thrust of Fuchs (1967). The author could precisely demarcate the position of the Phalebas thrust which considerably differs from the positions given by earlier workers. The thrust moderately dips due NE, it does not involve any large scale horizontal displacement and is not related to the nappe movement. Stratigraphically, the sequence on both sides are of same age.

The rocks to the north of the Phalebas Thurst (Kusma Unit) show a slightly higher grade of metamorphism as compared to the rocks of the south (Sirkang Unit). The Kusma Unit rocks belong to a low green schist facies, the rocks of the Sirkang Unit, on the other hand, indicate a very feeble metamorphism having preserved their original sedimentary nature to certain extent. This apparent metamorphic inversion is attributed to the Phalebas Thrust.

After a thorough mapping and detailed investigation of the study area, the present author has evolved the following framework comprising a Precambrian sequence for this part of the Lesser Himalaya of Nepal which varies from those of the earlier workers.

Stratigraphy of the Kusma - Bihadi
Section of Kali Gandaki Valley

Sumsa Formation	Purple, greenish and gray slates, slaty phyllites intercalated with sandstones and thin layers of siliceous dolomite.
Phoksing Dolomite	Bluish-gray to dark gray stromatolitic dolomite with minor intercalations of carbonaceous slates and intraclastic dolomite.
Bihadi Slates	Carbonaceous slates and shales with occasional layers of sandstones and dolomites
? ?	? ? ? ?
Rocks not encountered in the study area	
Balewa Formation	Quartz-sericite phyllites, gritty quartzose phyllites and flaggy quartzites
Kusma Quartzite	White to brownish quartzites with frequent lensoid intercalations of spilites.

A critical scrutiny of the outcrop pattern, foliation trends and orientations of the linear structures, has revealed an interesting structural history. The author has recognised four generations of fold. The rocks in the Sirkang Unit below the Phalebas Thrust show clear imprints of all the fold episodes as under:

(1) The F_1 (isoclinal to reclined) folds are quite conspicuous all throughout the Sirkang Unit. These folds show N-S axial planes dipping due E at varying angles and axial plane cleavages are prominently developed. The quartz rodding and cleavage bedding intersections are probably the best record of the lineation (L_1) related to this fold event.

(2) Superimposed over the isoclinal folds are the comparatively open and macroscopic folds (F_2). They extend N-S to NE-SW.

(3) The third generation folds (F_3) are widely encountered showing WNW-ESE to E-W axial trend and with sub-vertical axial planes. They are open, minor undulation type with a low amplitude. This folding has produced a wide spread E-W pucker lineations (L_3), and is attributed to the result of the movement along the lontitudinal

dislocations viz. Phalebas Thrust and the Kusma Reverse Fault.

(4) The last event of deformation (F_4) is represented by prominent N-S open undulations and micro-puckers (L_4), which show a consistently northerly trend.

The number of fold events in the Kusma Unit is also the same as that of Sirkang Unit, but here, the rocks show much complicated fold patterns as compared to the Sirkang Unit.

A majority of the dolomitic rocks analysed from different sections indicates that they are truly dolomite rocks and have been classified into following groups:

1. Very slightly magnesian dolomite
2. Dolomite
3. ~~Very~~ slightly calcitic dolomite.

X-ray and D. T. A. analyses have also confirmed these rocks to contain mainly dolomite and quartz.

Excellent exposures of stromatolitic structures resulting from the microbial activities of the blue-green algae are found occurring in these dolomite rocks. Majority of these Nepal stromatolitic structures according to the author, belong to the genus Collenia and Conophyton. Most of the forms are well comparable with the forms that are described from the Himalayan region and Peninsular India and indicate Lower to Middle Riphean age.

The lenses of basic rocks occurring within Kusma Unit have been found to be of spilitic nature. The true nature of these basic rocks, their tectonic setting and their detailed petrography and geochemistry, have been given by the author.

For the first time, an extensive study of the terraces of the river valley of Kali Gandaki has been carried out. It has been postulated that the enormous thickness of gravel deposits of this river valley accumulated in lake-like basins along the then existing river course, the basin development being due to the sudden uplift of the southern Mahabharat Range during Late Pleistocene in contrast to the relative subsidence of the Midland. It has also been envisaged that these gravel deposits were the result of fluvioglacial action. The successive terrace flat levels developed on either sides of Kali Gandaki river, point that the region has suffered at least three periods of uplift with intervening periods of quiescence during Quaternary. These uplifts are also adequately reflected in the configuration of the various tributary profiles of Kali Gandaki.

Morphometric analysis of the drainage basins of the area and slope analysis were also carried out. The relationship of these parameters with the lithological variations and structural discontinuity has been established and the overall geomorphic evolution of this region of Lesser Himalaya has been discussed.

GEOLOGICAL EVOLUTION

Depositional History

The study area characteristically points to two depositional sequences - an early Precambrian marine, and the late gravel deposition of Quaternary times. While the former represents a geological phenomenon of deposition, uplift and deformation essentially Pre-Himalayan and Himalayan, the latter typically comprises a product of Quaternary deposition and tectonism.

The enormous thickness of rocks of Kusma Quartzite and Balewa Formation deposited in the northern marginal part of the Indian continental mass in a shallow marine environment shows a facies change upward. This change in lithology from a more arenaceous group (Kusma Quartzite, Balewa Formation) to a carbonate group (Phoksing Dolomite) is a conspicuous change observed in the entire Himalayan belt. This marked change in the lithology suggests a very significant alteration in the physico-chemical conditions in the basin environment. The influex of terrigenous material was reduced and instead precipitation and deposition of thick carbonate rocks continued for a long time.

The rocks of Balewa Formation show predominantly immature constituents and essentially comprise graywacke type of sediments, indicative of the nearness of the provenance with a varied lithology. The nature and huge thickness of these graywacke type rocks indicate that sediments were supplied from the south, flanking the marginal part of the Indian continent where an elevated land mass (Aravalli ?) must have existed to supply these sediments.

An important feature of Kusma Quartzite and Balewa Formation is their association with basic volcanics, which represent the penecontemporaneous lava flows. Though the main phase of basic volcanism was restricted during the deposition of Kusma Quartzite, it continued sporadically at the time of deposition of Balewa Formation. This basic volcanism ceased before the deposition of the carbonate rocks (Phoksing Dolomite) at least in this part of Himalaya.

The onset of deposition of carbonate rocks was a marked change in the environment. Perhaps, this coincided with the further shallowing of the sea. A widespread and explosive development of algal life characterises the onset of carbonate deposition. The environmental conditions were most favourable for the luxuriant growth of these algae and there was an extensive development of stromatolites in these carbonate rocks. This implies that the basin was very shallow with warm marine conditions and the carbonate was deposited in a subtidal-intertidal to supratidal conditions. The formations of intraclastic layers and minor associations of argillaceous and arenaceous rocks indicate that the area was still unstable and periodic disturbances were prevelant.

The carbonate sediments upward grade into the rocks of Sumsa Formation, which again indicate a somewhat changed environment , with an increased influx of terrigenous material. The thin carbonate layers show intercalation with the argillaceous rocks and sometimes even intergrade with each other. Here a delicate balance between the carbonate precipitation and terrigenous influx appears to have been controlled by tectonics, and indicates rapidly changing environments. The presence of sun-cracks, ripple marks etc. point to the deposition in a very shallow basin, even under partly sub-aerial conditions. Due to the high influx of terrigenous material, the environment was not suitable for the development of the low forms of life algae and therefore, no stromatolitic structures were developed in carbonate bands of Sumsa Formation.

The striking terraced gravel deposits on the Kali Gandaki valley indicate a complex interplay of depositional and erosional processes related to the various events of Himalayan uplifts during the Quaternary. The initiation of the process of gravel accumulation was due to the uplift of the Mahabharat range, which dammed the south flowing Kali Gandaki. This resulted in the formation of numerous stagnant lake-like water bodies all along the course of the river, and it was in these that the gravelly debris brought from the north accumulated. Subsequent uplifts punctuated by periods of quiescence in due course of time gave rise to the existing terraced morphology to the gravel deposits.

Deformational History

The successive events of deformation that have been recorded in the rocks of the area, point to a long history dating from as far back as at least Late Precambrian times. The various structural elements and related phenomena can be quite convincingly chronologically arranged as under:

Pre-Himalayan

1. F_1 and F_2 folds - These essentially Pre-Himalayan deformational events have been observed from all parts of the Himalaya. Various authors have recognised

them, and broadly these have been correlated with Late Precambrian structures of the Indian Peninsula.

Himalayan

2. F_3 and the longitudinal dislocations like Phalabas Thrust and Kusma Reverse Fault - These are obviously Himalayan structures related to the Tertiary uplifts. It is not clear how far these are ultimately related to the N-S nappe movements, but within the limits of the study area and its neighbourhood, the two dislocations point to a phenomenon of high-angled thrusting related to perhaps some block uplift. No large scale displacements are indicated. Strong NNE-SSW compressional stresses, appear to have given rise to the longitudinal dislocations and the related F_3 flexures.

Post-Himalayan

3. F_4 folds and NNE-SSW faults - These are probably of Quaternary period, affecting almost all the formations. Such transverse

structures have been observed from all over Himalaya, and are seen affecting even the Siwaliks.

4. Terraced gravels - perhaps indicate the last deformational event -Late Quaternary to Sub-Recent.

CONCLUDING REMARKS

In the foregoing pages of this thesis, an attempt has been made to provide a picture of the geological evolution of the study area. The author has been able to collect as much data as was possible within his limited means and resources. But the facts revealed by this study do throw much light on the various geological complexities, and if a systematic study of all parts of the Midlands is taken up on the identical lines, it will no doubt furnish a much clearer panorama, which in turn may, provide valuable clues to a number of unanswered problems of Nepal Geology.