CHAPTER VI

STRATIGRAPHIC CONSIDERATIONS

LESSER HIMALAYA IN GENERAL

In the investigation of the stratigraphy of Himalayan rocks, the complicated tectonics have to be taken into account. Therefore, an approach of combined stratigraphic and structural aspects is inevitable to bring out a clear geological picture. Hagen (1969) overlooked this vital point, relied only upon the tectonics and neglected the detailed stratigraphic consideration. Therefore, after his ten years of study in Nepal Himalaya, he presented a highly complicated tectonic picture consisting of 22 nappes, numerous root zones and autochthonous zones and windows, without a substantial base of stratigraphy.

Consequently, his concepts have been widely criticized. Talalov (1972, P.610) rightly commented on Hagen's work "On his rather confusing scheme, which is difficult to understand, the same rocks are sometimes shown as overlying higher and lower stratigraphical levels simultaneously, where the same horizon is branched on the map and attributed simultaneously to different ages."

Because of the lack of fossils, the vital controlling factor in the stratigraphic investigation, the Lesser Himalayan stratigraphy has been mainly built on the basis of the lithology, taking into account wherever possible, some of the characteristic rock types as the marker horizons. But, when the attempts of correlation among far apart rocks are made on the basis of the lithology, particularly taking into consideration of beds of relatively smaller thicknesses, such a correlation is often found to be unsatisfactory. Moreover, the lateral variation in rocks of Himalaya is a common phenomenon, and seldom the rocks continue uniformly for long distances. Therefore, long distance correlations between Indian Himalaya and Nepal Himalaya as attempted by Fuchs (1967) and Fuchs & Frank (1970) have been questioned by the Japanese authors (Ohta & Akiba, 1973). However, the latter favoured the lithostratigraphic correlation between adjacent areas within a limited range. Hagen (1969) even attempted to correlate the rocks of Nepal with that of the European rocks merely on the basis of the lithological characters, which lies some thousands of kilometers apart. Such correlations are highly undesirable and lead to wrong conclusions.

Because of such ambiguity and difficulty in correlating rock formations of Himalaya, more dependable lithostratigraphic subdivisions of the Lesser Himalayan metasediments were postulated by Valdiya (1964a). Instead of smaller rock units, he has taken larger divisions, measuring thousands of meters in thickness, and then has attempted to correlate them throughout the Himalaya ranging from Kashmir to NEFA. He has quite convincingly tried to show the feasibility of such broad stratigraphic subdivisions and reliability of correlation between the widely separated areas like Kumaon, Garhwal, Nepal and Sikkim-Bhutan Himalaya. Valdiya (1964a) emphasized that such classification does help in generalization of the stratigraphy of the much complicated Lesser Himalayan metasediments. According to him (Valdiya,1964a; P.20), unfossiliferous formations of the Lesser Himalaya could be divided into two lithological units: the upper argillo-calcareous and the lower arenaceous group. The arenaceous group includes quartzites, sericite quartzites, quartz-sericite schists, interbedded with purple and pink phyllites and pebble beds, constituting a prominent element of the Lesser Himalaya. He has included into this group the Jaunsar series of Simla area, Nagthat series of Garhwal and Kumaon, Chamoli quartzite of

Alaknanda valley, Berinag quartzite of Pithoragarh district, Khaira quartzite of Sutlej valley and Sanguri series (= Dalings) of Southern Nepal (Bordet, 1961). These quartzites contain abundant and extensive occurrences of interbedded basic lavas.

Among the argillo-calcareous group, Valdiya includes Simla slates, Chail series, the Shali series with Collenia, the Deoban (Shali = Deoban, according to Pilgrim & West, 1928), Calc Zone of Pithoragarh, the Baxas of Bhutan etc. This group comprises two mutually intergrading and interdigitating facies, one calcareous and other argillaceous. Valdiya (1964a; P.23) has envisaged two sedimentary facies to suggest two different environments, representing lateral variations within groups of broadly equivalent age. He has therefore, concluded that throughout the Himalaya, the quartzitic group is older than the argillo-calcareous group, the basic volcanic activity being confined to the arenaceous group. Also in Bhutan Himalaya, Nautiyal et al. (1964) found that the basic rocks (epidiorites and amphibolites) have invaded almost all formations, but they are most abundant in the Phuntsholing Series (= purple slate series = Jaunsar series of Middle Palaeozoic) and in the quartzitic unit of the Sanchi series (= Dalings of Precambrian to older Palaeozoic). They did not encounter epidiorite or amphibolite sills in Baxa dolomite, and this led them to conclude that the basic igneous activity is older than the Baxa Dolomite. In Western Nepal, Remy (1975a, b; 1978) has also shown the basic magmatism in his quartzo-pelitic series and quartzite series which are older members of his stratigraphic scheme. Thus, it is interesting to note that the basic igneous activity has not affected the thick dolomite sequences throughout the Himalaya, ~~except~~ with a very few exceptions.

Ohta & Akiba (1973) also approached the problem of stratigraphy of Lesser Himalayan metasediments of Nepal in a manner somewhat identical to that of Valdiya (1964a). Here, they took into account the thick limestone-dolomite horizon and the thick sequence of quartzites as the markers. These Japanese authors subdivided the metasediments of Nepal Himalaya into following four major divisions though they were doubtful of the independent existence of the lowermost subdivision.

4. Upper calcareous subgroup
3. Middle siliceous subgroup
2. Lower arenaceous subgroup
1. Lowermost argillaceous subgroup

Sharma (1969 , 1975) has included all the Lower Himalayan rocks of Nepal into Mahabharat Limestone Group and has divided it into three broad lithostratigraphic sub-divisions.

The term Mahabharat Limestone Group is a misnomer, for neither the formations of this group are restricted to be found in Mahabharat area in the south nor the whole group is predominantly made up of limestones only. He has proposed a stratigraphy quite different from that of Valdiya (1964a) and Ohta & Akiba (1973). Further he has equated his Calcareous Formation with Chandpur and Chails of Indian Himalaya which is also untennable, since the Chandpurs and Chails are not predominantly calcareous formations (Fuchs & Frank, 1970; P. 10, 11, 33).

Sharma's stratigraphy of his Mahabharat Limestone Group as the Upper arenaceous formation, middle calcareous formation and the lower argillaceous formation, is just the reverse of Valdiya's and Ohta & Akiba's classifications.

STRATIGRAPHY OF WESTERN NEPAL

Many workers (Bordet et al., 1964a; Nadgir & Nanda, 1966; Fuchs, 1967; Hagen, 1969; Fuchs & Frank, 1970; Frank & Fuchs, 1970; Talalov, 1972; Ohta & Akiba, 1973; Sharma, 1969 , 1975 ; Remy, 1975a , b ; Fuchs, 1975) have attempted to workout the stratigraphy of Western Nepal Himalaya. The stratigraphic schemes of the various workers are given in table VI.1.

From this table, it is evident that the stratigraphic sequence of this part of Nepal Himalaya is much confused and controversial. While Bordet et al. (1964) have put their 'Series de Kuncha' a group of gritty, arkosic flysch type sediments (which is correlated with the Bàlewa Formation of the present author) at the top of their stratigraphic succession, the same rock formation on the other hand is placed right at the bottom of the stratigraphic column of the Suparitar series by Nadgir & Nanda (1966). Again, the same formation has been designated as the Chail series of Devonian age by Fuchs (1967). Likewise, Talalov (1972) has given entirely different stratigraphic scheme mainly on the time-stratigraphic considerations. Where he puts this formation into his Okharbot suite of Cambrian age (530 my). Hagen (1969), however, did not work out any details of the stratigraphy of his Nawakot nappe.

The present author after a detailed scrutiny of the study area, has arrived at the conclusion that some of the earlier workers appear to have been misled during their investigation of the stratigraphy by not taking into account the tectonics of the region. The stratigraphic scheme given by Bordet et al. (1964a) is also the result of the neglect of the structural aspect of the problem. He perhaps failed to recognise the thrust (the Phalebas Thrust of the present author) and therefore, the older rock sequence, i.e. the quartzite and his 'Series de Kuncha' which clearly show a fairly abrupt upgrading of metamorphic effect upward to the north, were placed at the top instead of at the bottom of the series. The fact is that the thrust has caused the older rock formations to come over the younger rocks. The base of the quartzite marks the thrust. The order of superposition of the southern rocks, as given by Bordet et al. (1964a), however, is in accordance with the present author's scheme.

Fuchs (1967) and Fuchs & Frank (1970), on the other hand, in an attempt to develop a uniform stratigraphy for the entire Himalayan region, made the stratigraphy of Western Nepal still more complicated. A correlation between the Indian Himalaya and the Western Nepal Himalaya which are separated apart by an intervening area of more than 300 km length and which is very poorly investigated and understood, has rendered such an attempt of these authors not very convincing. Another drawback of the stratigraphic interpretation by them is that they have taken rather small rock units of merely few tens of meters to a few hundred meters thickness for correlation purposes. As the Himalayan rocks commonly exhibit lateral change of sedimentary facies, the similarity in lithology of rocks represented by a few tens of meters thick and separated by some hundreds of kilometers distance, do not necessarily correspond to the same age or are correlatable, unless it is sufficiently established by other criteria. Moreover, the stratigraphic position of the rock units of Indian Himalaya itself, which Fuchs (1967) has taken for correlation purposes, are not free from controversies (Valdiya, 1964a; Fuchs & Frank, 1970 , P.60, 61, 62; Pilgrim & West, 1928). It is for these reasons that the present author has been discouraged in attempting correlation between remote areas without sufficient grounds.

The geological maps of Fuchs (1967) and Fuchs & Frank (1970) show the thin band of black carbonaceous shales and slates occurring near the village of Bihadi, which they consider as the Infra-Krol, because they are underlying the dolomites (Krol-Shali of Fuchs). The black shales and slates intercalated in the dolomite has been designated as Shali slates by these authors (Fuchs & Frank, 1970 , P.16). The purple rocks consisting of alternating pinkish slates and phyllites with dolomitic sandstones, siliceous dolomites and graywacke type of rocks, overlying the dolomites, have been classified as the Chandpurs by Fuchs (1967) showing these rocks to be older than the dolomites. But the careful study around Bhoksing and Sirkang section of the study area has clearly indicated that the dolomites are undoubtedly overlain by these purple rocks without any sign of large-scale inversion. The northern extension of these rocks is terminated by the NW-SE trending Phalebas Thrust. The present author obviously therefore, does not agree with Fuch's (1967) proposed stratigraphy which is based on a vague correlation with Indian Himalayan rocks. The arguments (Fuchs & Frank, 1970 , P.59) against the French geologist's stratigraphic scheme (Bordet et al., 1964a) are also unacceptable as it has been sufficiently shown in the chapter of structural geology that the Midlands of Western Nepal lying between the Main Central Thrust and the Main Boundary Fault, comprise a single major tectonic block, free from any regional nappe, and are instead dissected by longitudinal reverse faults and thrusts. Thus, one single stratigraphic sequence for the whole of the study area is envisaged. Separate stratigraphy for the two units (north and south of Phalebas thrust) is not warranted. The present author's contention is also supported by the works of Nadgir & Nanda (1966), Talalov (1972), Ohta & Akiba (1973), Sharma (1975), Remy (1975a,b) and Stocklin & Bhattarai (1977).

Talalov (1972) reinterpretated the geology and stratigraphy of the Nepal Himalaya and proposed a stratigraphy entirely different from those of the earlier workers. Mainly based on his own work and also on the earlier works of Hagen etc., the stratigraphy of Lesser Himalaya given by Talalov is impressive but the present author has found it unconvincing. Talalov has divided the unfossiliferous metasediments of Lesser Himalaya of Nepal into various suites of rocks ranging from Upper Proterozoic to Upper Palaeozoic, excluding the younger fossiliferous rock sequences. Though some of his observations are supported by radiometric dates, they are too few in number to apply with precision for the whole of Nepal Himalaya. Moreover, there are even contrasting results of radiometric dates determined by different workers. Talalov (1972) has found out the absolute ages of his Okharbot suite of rocks as 530 my (chlorite schist, Okharbot), and Khan & Tater (1970) found the ages for the rocks lying south of Phalebas Thrust as 540 ± 17 my (slate, Ramdighat Ghat) and 559 ± 18 my (Shale, Purtighat). Whereas, Krummenacher (1966) dated the rocks of 'Series de Kuncha' (the Chail Formation of Fuchs, 1967 ; Okharbot suite of Talalov, 1972) and found to be much older (872 my). The rocks lying south of Phalebas Thrust are by no means the same suite as that of Okharbot suite as shown by Talalov in his geological map (Fuchs, 1967; Bordet et al., 1964 ; Nadgir & Nanda, 1966; Fuchs & Frank, 1970; Nanda, 1973 ; Sharma, 1969, 1975). The absolute ages determined by Talalov perhaps represent the age of the metamorphism (post-Lower-Vindhyan or Lake Superior diastropic movements, Valdiya, 1964b ; P.270) rather than the age of the rocks. Therefore, the division of rocks representing from Upper Proterozoic to Devonian age as suggested by Talalov (1972) seems rather uncertain. In his geological map, Talalov has shown the same continuous calcareous rock unit of Central-West Nepal to split into two the Upper Proterozoic (Hilang suite) and Silurian (Phulchoki suite), which is very doubtful.

Sharma's (1969, 1975) scheme of stratigraphic subdivisions of Lesser Himalayan metasediments of Western Nepal as already been discussed, differs from Ohta & Akiba (1973) in respect of the position of arenaceous formation. However, as shown in the geological map (1969), he puts his argillaceous formation (= partly equivalent to 'Series de Kuncha' of Bordet et al. (1964a) and Chail Series of Fuchs (1967) to be older than the calcareous formation. But, Sharma's subdivisions of calcareous formation is not in agreement with any of the earlier workers and also with the present author's classification. Instead of placing his member (2) of the calcareous formation, at the top, Sharma has fixed its position between the carbonaceous slate and dolomites.

Correlation of the lithostratigraphy of Ohta & Akiba (1973) with other workers is somewhat difficult, as the former have not shown in details the lithology of the area in their geological map.

Nadgir & Nanda (1966) and Nanda (1973) worked out the stratigraphy of Western Nepal in fair detail. These authors have recognised a thrust (Lame Deorali Thrust) which roughly coincides with the Phalebas Thrust of the present author. To the north of the thrust, they have shown exposed the older rocks of their stratigraphic subdivision, the grits and phyllites, quartzites and metabasics. To the south, the younger rocks like their Purple Formation, stromatolitic dolomite and carbonaceous slates etc. are exposed. In their stratigraphic scheme, these authors put the white quartzite stratigraphically above the basics volcanic facies. But, the white quartzites are intimately, associated with the basic volcanics in the form of sills and tuffaceous layers. This clearly indicates that the white quartzite and basic volcanics were contemporaneous. However, the stratigraphy given by these authors is quite different from that proposed by other workers including the present author.

Remy (1975), has broadly included the rocks of Kali Gandaki area into his 'Nepalese series' which is divided into the older 'Quartzo-pelitic series' and the younger 'Upper series' phyllites with quartzites, limestones and dolomites.

REVISED STRATIGRAPHY OF KUSMA-BIHADI SECTION

The present author on the basis of his detailed investigation of the area of about 200 sq.km and a few north-south traverses along Kali Gandaki river valley outside the study area, has attempted to give a revised stratigraphy of this part of Western Nepal Himalaya. However, the author is fully aware of the fact that the vast terrain of Lesser Himalayan metasediments pose many problems in stratigraphic investigation and the stratigraphy proposed here does not include all the rock units of the Lesser Himalayan meta-sediments of Western Nepal, as the area covered by the present investigation is very small when compared to the whole of Lesser Himalaya of Nepal. Nevertheless, the stratigraphy of this part of Midland is very important, as it occupies a crucial position in deciding the overall stratigraphy of the entire Lesser Himalayan area of Western Nepal.

The author does not intend to correlate each of these subdivisions in detail, with the Indian Himalaya, and neither advocates the use of terminologies borrowed from there. A very general correlation of larger units like stromatolitic dolomites on the basis of different forms of the algal structures have been attempted in the chapter VII, for these organo-sedimentary structures have been used successfully in such correlation purposes have been used successfuly in such correlation purposes within Indian Himalaya and elsewhere.

Taking into account all aspects discussed above, the author has worked out the stratigraphy of the Kusma-Bihadi section of the Lesser Himalayan metasediments of Central Western Nepal (Table VI.2).

Table VI.2 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.

PROBLEMS OF AGE AND CORRELATION

As regards the age of the rocks of Kali Gandaki area, there is considerable controversy. Till date, there are no reports of presence of fossils in these metasediments of Mid-lands and thus there is no direct evidence to fix up the precise age. Radiometric age determinations of these rocks are far and few, and again it has its own limitations. However, the prolific stromatolitic structures have found to be of some help in the age consideration of the rocks of this area.

All the available data on the Radiometric age determinations of the rocks of Kali Gandaki valley and similar rocks of elsewhere, are summarisec in table VI.3. Though many more rocks have been subjected for such studies, only a few are useful, because most of them give the age of the metamorphism instead of that of deposition.

From the table, one fact clearly emerges that majority of these rocks show Proterozoic age. However, the two samples of rocks viz., the slate and black shale showing 540 ± 17 and 559 ± 18 my respectively (Khan & Tater, 1970) perhaps do not represent the actual age of the rocks and represent the age of older (Pre-Himalayan) metamorphism.

esser Himalaya of Nepal

Author<	Age my	Correlation with the rocks of study area
Krumme	728	? Balewa Formation
Bordet	872	Balewa Formation
Krumme Bordet	819 ± 80	Balewa Formation
and Kre cher e	831	? Balewa Formation
	1280	? Balewa Formation
	605 ± 24	? Balewa Formation
Khan & k	540 ± 17	? ? ?
k	559 ± 18	Bihadi Slate
	1195 ± 33	? ? ?
k	1150	? Balewa Formation
Talalo (1'k	740	? Balewa Formation

One of the important observations made by Krummenacher (1966) is that the K/Ar age determinations on rocks collected from the cross section of Kali Gandaki showed two periods of metamorphism - one Precambrian (800 - 1250 my) and the other Alpine (Himalayan: 15 - 25 my). He has found the rocks of his 'Formation du Moyen-Pays Nepalais' to be at least as old as 1280 my near Tansing area. Further, to the north near Tatopani, the gabbro associated with the 'Series de Kuncha' showed the age of 819 $\pm$ 80 my. This is a significant observation for fixing the age of the rocks of 'Series de Kuncha'. He considers the rocks near Tatopani to be the uppermost part of the 'Series de Kuncha', and the volcanic rocks may also represent the base of the rocks of the first group of Tatopani-Dana, which abut with the 'Series de Kuncha'. From the above observations, it is evident that the upper part of rocks of 'Series de Kuncha' (cal. total thickness 6000 - 8000 m) are atleast older than 819 $\pm$ 80 my, and the basal part of the same may range upto 1280 my or older.

Krummenacher (1966) also correlated the rocks of 'Nawakot nappe' of Okhaldunga region in Eastern Nepal to be probably equivalent of 'Series de Kuncha' of Kali Gandaki section. These rocks of Eastern Nepale according to him gave the age of 728 my (Krummenacher, 1961), which is quite comparable to the age of the rocks of Kali Gandaki area.

The rocks of Tama Kosi river (Quartz-chlorite schist) of Eastern Nepal gave the age of 1150 my (Talalov, 1972). Stocklin & Bhattarai (1977) have correlated these rocks with the 'Series de Kuncha' of Western Nepal. Similarly, Daram Suite (740 my) of Talalov (1972) has been correlated by Stocklin & Bhattarai with 'Series de Kuncha', and possibly even with younger formations (their Dandagaon Phyllites).

All these available radiometric ages of the rocks of 'Series de Kuncha' (Balewa Formation of the present author) point to the conclusion that these rocks are definitely Proterozoic and are as old as 1280 my and possibly the lowermost section might represent still older age.

The stromatolitic structures (Chapter VII) that are occurring in the Phoksing Dolomite are significant. These represent Lower to Middle Riphean age. Phoksing Dolomite is younger than the Balewa Formation (Series de Kuncha). The rocks of Balewa Formation would be obviously therefore, older than Lower Riphean or may partly represent the Lower Riphean age.