A panorama of Kali Gandaki Valley

Viewed north from Gorlang Danda.

CHAPTER I

I N T R O D U C T I O N

GENERAL

Himalaya has always been a challenge to the scientists, mountaineers and many other explcrers. Earth scientists have been working for more than a century in Himalaya and only because of this continued and hard work in such a difficult terrain that a fairly detailed geological picture of this mountain chain has now emerged. However, a full knowledge of this vast and gigantic mountain chain can only be obtained after a thorough investigation throughout its length and breadth. Till today, a vast area of this mountain belt still remains geologically unknown and a major portion of the Himalayan terrain has been investigated only for regional and reconnaissance type of work. Only very recently, systematic and intensive studies of various parts of Himalaya have been started and a wealth of information is being collected.

The present investigation in the Kali Gandaki Valley of Central West Nepal Himalaya by the author is a modest attempt towards a contribution to the geology of Nepal Himalaya. The present geological study of this small area, where no detailed work has been done before, has revealed many new and interesting results and these findings have been quite relevant towards solving many larger problems of Nepal Himalayan geology.

The Kali Gandaki river section across the Midlands of Nepal has an interesting geology, and workers who have mapped this part of Nepal Himalaya have given varying structural and stratigraphic interpretations. Brief references to the geology of this part of the river valley have been made by a number of geologists in the past, but none has investigated the area in detail. While scanning through the accounts of the work by the various previous investigators, the present author observed that the tectonic set up, the structural details, the stratigraphic positions and the age of the unfossiliferous rocks of Lesser Himalaya of Nepal are considerably confused and controversial, and a dependable and generally agreed geological picture of this region is yet to emerge. The author being convinced that a very detailed and systematic study of the stratigraphy and structural elements of some critical areas could answer many intriguing problems of Nepal Himalaya, took up the present investigation that pertains to a small section of the Kali Gandaki Valley.

GEOGRAPHICAL ASPECTS OF NEPAL

Nepal is a landlocked country, sandwiched between the two giants of Asia, China in the north and India to the south, covering an area of about 145,302 sq. km. This ancient kingdom is about 870 km long and 130 to 255 km in width, forming an elongate rectangular area between the N Latitudes of $26^{\circ} 22'$ to $30^{\circ} 27'$ and E Longitudes $80^{\circ} 04'$ to $88^{\circ} 12'$. Due to its geographical situation and altitude variation, Nepal shows most extreme climatic conditions, the Tropical Subtropical climate in the southern Indo-Gangetic plain to the Arctic type in the Higher Himalayan range with perpetual snow covered peaks above 5,200 m. About two third of the area of Nepal constitutes hilly terrain while the rest comprises the plains in the south situated all along its east-west length, which is the northern marginal part of the Indo - Gangetic alluvial plain.

Hagen (1969) has ideally shown the following natural sub-divisions of Nepal (Fig. I.1) from north to south:-

1. Tibetan Plateau
2. Tibetan Marginal Range

3. Valleys of the Inner Himalaya
4. Great Himalaya
5. Fore Himalaya
6. Midlands
7. Mahabharat Lekh
8. Dun valleys
9. Siwalik Range (Churia Range) and
10. Terai (Gangetic plain).

Terai

The Terai forms a belt of variable width of 30 to 40 km and with an average altitude of 200 m, all along the southern border of Siwalik Range.

Siwalik Range (Churia Range)

This southernmost mountain range rises abruptly from the Gangetic plain, its natural limits being the Gangetic plain in the south and the Main Boundary Thrust in the north. The Siwalik Range provides a rugged terrain devoid of population and covered with dense forest. The average altitude ranges from 1000 to 1500 m and rises occasionally upto 2000 m in Western Nepal. In Nepal, except east of Dharan (Eastern Nepal) and west of Karnali (Western Nepal), the Siwalik hills form two ranges and thus they have given rise to wide elongate valleys or Duns (Jogbura, Surkhet, Dang, Chitwan, Kankai etc.).

These valleys more or less have the same altitude as that of the Gangetic plain.

Mahabharat Lekh

This narrow mountain range which is higher than the Siwaliks and Midlands, rises upto about 3000 m and extends throughout the length of the country. The Mahabharat Range is intersected by narrow deep gorges at three main places and where almost all the rivers of Nepal leave the Himalaya and emerge in the Gangetic plains. This range is very characteristic due to its very rough terrain with steep slopes, the top portion being thickly vegetated with Rhododendron.

Midlands

Further north, the Midlands ranging in height between 600 m to 2000 m constitute the heart of the Nepal Himalaya. This region is the most thickly populated area of the hilly portions of Nepal. The Midlands are bounded by Mahabharat Lekh to the south and by the Great Himalayan range in the north. Climatically, this part of Nepal shows a variation between a Tropical (in the valleys) to a Temperate climate (on the hills).

Fore Himalaya

The Fore Himalaya has been defined as an area within Midlands, in which the altitudes exceed the average of 3000 m. It differs from Midlands in many ways. The Fore Himalaya is developed in two areas only, namely in Karnali region in Western Nepal and Solu area in Eastern Nepal.

The basin of Jumla in Western Nepal is a high land with a thick snow cover in winter and bearing huge pastures and widespread coniferous forests on the higher hills. The Solu is the other zone of the Fore Himalaya. It is highland too, and has enabled the Sherpas to settle down even to the south of the main range of the Himalaya.

Great Himalaya

This division includes the highest mountain range encompassing the majority of the peaks above 8,000 m. Unlike previous divisions this does not comprise a continuous range and is dissected into different groups by the N-S flowing main rivers (Fig. I.1). The high peaks of this mountain range show extremely steep walls on all sides.

The Great Himalayan Range has a major control over the climatic conditions of the Nepal region. South of this range, the monsoon wind from SE precipitates all its moisture and consequently, the area to the north of it has a mountain desert character.

Inner Himalaya

The Inner Himalayan valleys between the Great Himalaya and the Tibetan Marginal Range conprise one of the unique landscapes of Nepal Himalaya. These valleys are the intermediate areas where the rain-bearing wind enters through the gorges between the mountain groups of Great Himalaya. The areas like Humla, Mugu, Dolpo, Manang, Kyirong, Rongshar, Karma etc. belong to this group.

Tibetan Plateau

The Tibetan Plateau area lies to the north of the Tibetan Marginal Range with a flat warped tableland. Only a very small portion of this plateau lies within the territory of Nepal. It is a mountain desert and sparsely populated.

THE STUDY AREA

Location

The area under investigation by the present author, occupies the middle reaches of the Kali Gandaki river valley in the Lesser Himalaya, which forms a part of the Survey of India Toposheet No. 62P/12. It comprises nearly an area of about 210 sq km bounded by E. Longitudes 83° 34' to 83° 45' and N. Latitudes 28° 2' to 28° 10' (Fig. I.2.).

The nearest important town Pokhara lies about 30 air km to the NE. Bhairahawa, another town near the Nepal - India border in the plains, lies approximately 55 air km to the south. Nagdanda, a small but important village situated on the Pokhara - Bhairahawa Highway (Siddhartha Rajmarg), is the nearest bus station that lies to the ENE of the area. Nepal has been divided into four regional development centres (from east to west viz. Dhankutta, Kathmandu, Pokhara and Surkhet), fourteen zones (Anchals) and seventyfive districts. The study area falls within the Western Development centre with Pokhara as its headquarter. The area lies partly in Gandaki Anchal (Zone) and partly in Dhaulagiri Anchal, occupying parts of the districts of Parbat, Baglung and Syanja. Baglung, the Zonal Headquarter of Dhaulagiri Anchal, situated along the right bank of Kali Gandaki, lies about 16 km to the north of the area. The village Kusma is the centre of Parbat district which lies nearly 6 km to the north. Phalebas is an important village near the northern boundary of the study area, situated on an extensive river terrac on the left bank of Kali Gandaki. Another important village Bihadi which is located on the wide terrac of Kali Gandaki river marks the southern limit. The other important villages within the investigated area are Sumsa, Bachha, Sirkang, Karnas, Dhullu, Bhoksing and Lame Deorali.

Topography

The area exhibits the characteristic topography of the Midlands or Lesser Himalaya with a highly undulating and rugged terrain. A striking physiographic feature of this part of Lesser Himalaya of Nepal, is the wide N - S Kali Gandaki valley with its high cliffs and wide extensive gravel terraces. The river Kali Gandaki has carved deep into its older terraces and therefore, it flows about 300 to 400 meters below the highest terrace level, with vertical walls on both the sides. The terraces of Phalebas, Karnas - Bachha and Bihadi are the notable examples. This provides an interesting contrast in the topographic configuration, the rugged terrain of Himalaya on one hand and the extensive plain terraces all along the Kali Gandaki river valley on the other hand.

The various E - W hill ranges abut against the N - S running valley of Kali Gandaki giving rise to the interfingering appearance with one another. Apart from the main Kali Gandaki river valley, there are other minor stream valleys which meet the Kali Gandaki; they mostly run E - W and show comparatively steeper walls. Though majority of the tributary valley floors have not reached the level of the bottom of Kali Gandaki valley, there are a few like Modi Khola, Guindi Khola, Kanye Khola etc. that have cut their valleys very deep, forming scarps of about 600 to 700 m on both sides. This gives testimony of the strong erosive power of these mountain streams.

The river Kali Gandaki has cut into the Himalaya so deep that there is a sharp contrast in the heights between the nearest hill top and the bottom of the river valley. Within a distance of nearly 3 km , the 2263 m peak of the nearest hill suddenly drops to a height of about 660 m on valley floor near Sirkang village. Similarly, Gorlang Khoria (2172 m) drops to a height of nearly 600 m within a distance of 2.5 km near Phoksing. The Phoksing village itself is located on the foot of a cliff more than 500 m high. Some of the highest points within the study area are Chisapani (2263 m), Gorlang Khoria (2172 m), Dhunwakot (2088 m), Bhoksing (2006 m), and Chokya (1775 m).

Due to intensive deforestation, most of the area once thickly forested has become almost barren of vegetation except for some patches near the hill tops and the protected forests. Due to this reason, the area has been severely affected by landslides. For example, during 1977 monsoon, near Jyamireghat, a disastrous landslide washed out completely a small village lying on the slope of the hill. Similarly, Pain Khola section near Lame Deorali is highly affected by landslides. Such calamities are quite often repeated especially during the rainy seasons.

Drainage

The main drainage of the study area is marked by the river Kali Gandaki which passes through the middle of the area, flowing in a southerly direction. This holy river originates at about 4400 m in the north in the Mustang district of Nepal beyond the Higher Himalaya. Here it is known as Mustang Khola. A tributary to this Khola originating at Muktinath, joins at Kagbeni, and to the south of this confluence, the river is known as Kali Gandaki or Krishna Gandaki. In the southeast at Deoghat, it joins with the Trisuli Ganga, and subsequently the river is known as Narayani or Sapta Gandaki, a major tributary to the river Ganga.

Like many other big rivers of Nepal, Kali Gandaki is an antecedent river, originating in the north beyond the Higher Himalaya, and reaches the Midland by cutting across the giant barrier of Great Himalaya forming very deep gorges in the process. The main tributaries of Kali Gandaki river are Raughat Khola, Maygdi Khola, Modi Khola, Andhi Khola, Bari Gad Khola and Riri Khola. The smaller tributaries of this river having their confluence within the study area are (from north to south) Lamai Khola, Chirdi Khola, Kalung Khola, Chaur Khola, Lunwa Khola, Luwa Khola, Kanye Khola, Guindi Khola, Pain Khola, Palung Khola and Khahare Khola. Seti Khola, part of which lies in the southern extremity of the area joins Kali Gandaki a little south of Bihadi. The overall drainage pattern of the area is of dendritic type but there are small streams which form sub-trellis patterns of drainage with the main streams.

Climate and Rainfall

The climate of the area is pleasant and healthy. Precise meteorological information on the study area proper is not available, but the data from the adjacent areas like Beni (about 20 km north), Baglung (16 km north) and Riri Bazar (25 km SW) all of them lying in the Midlands and along the valley of Kali Gandaki, provide the background of climatic conditions. The maximum temperature during the hot days of May-June is 30^{0}C and during December-January the minimum temperature reaches as low as 7^{o} C. But since the data are taken from the places lying on the river terraces of Kali Gandaki with an average height of only 750 to 900 m above M. S. L., these values may vary with the altitude. Though the Midlands do not experience snowfalls in general, the hill-tops above 2100 m occasionally receive light snow during mid-winter, and therefore, are cooler than the low-lying areas. In other words, the river valleys are always hotter than the hill-tops.

The study area lying almost in the central part of Nepal, both the monsoon and winter rains, are received. The average annual rainfall of Beni - Riri Bazar (average of 1957 to 1975) is about 1430 mm and the maximum amount of

Precipitation (more than 70 %) is restricted to the four months from June to September.

Flora

In the Himalaya, the vegetation is controlled by the altitude and climatic conditions as under:

Height in meters	Flora
6400	
5500	
	Alpine meadow
4600	
3600	Rhododendron and Conifer
2700	
	Oak and Chestnut
1800	
	Chilaune and Chestnut
900	
300	Sal trees, Riverine-sisso and Khair

The low lying areas of Kali Gandaki valley with an average altitude of approximately 1200 m , chiefly contain Sal (*Shorea robusta*), Fir (*Abies spectabillis*), Bombax (*Salmalia malabarium*) , Alder (*Alnus nepalensis*) , Bel (*Aegle marmelos*) , Magnolia (*Magnolia sp.*) etc. Above the altitude of 1200 m , Chir pine (*Pinus roxburghii*) , Blue pine (*Pinus exceisa*), Chestnut (*Costanopsis indica*), Chilaune (*Schima wallichii*), Walnut (*Jugians regia*), and Rhododendron (Rhododendron arboreum) are common.

Apart from this, the common fruits like apricot, citrous fruits, etc. are also grown. Recently, in the areas of the altitude above 1500 m, apple trees are being grown. Potatoes, onions, tomatoes, cabbages, cauliflowers, peas etc. also are grown in the villages.

Fauna

Due to extensive deforestation, the wild animals are now very limited in number and restricted only to the areas where some remnants of the original dense forests are present. They are mostly found in the upper reaches of the stream valleys and near the hill summits. Leopards (Felis iabuta) and panthers (Felis paradus) are common among the survivors. Black bears are reported to be present in the Bhalu Lekh to the NE, a little outside the study area. Spotted deers (Carvas unicolar), Jackals (Carvis querus) are more commonly encountered.

Birds comprise a variety of several species. Danfe or Lophophorous (Impeyan pheasant), the national bird of Nepal is found above the height of about 1800 m . The other important birds are Roller, Falcon, Tree Sparrow, Dove, Cuckoo-Koel, Swallow, Kalij Cock, Jungle Foul, Crow , Minivets, Bulbul, Mynah and varieties of others.

Land use and Agriculture

The Midlands of Nepal are very densely populated, and nearly 60 % of Nepalese people live in this part. Due to the fast and multiple growth of population, the pressure on the agricultural land is increasing day by day and more and more vegetated areas are being converted into agricultural land. So much so that this too has come to a saturation point where there is no further possibility of expansion. The forests have been wiped out almost completely. All possible sites of hill slopes have been converted into terraced fields to the maximum extent. Also the flood plains of the river valleys and smaller stream valleys have been utilized for agricultural purpose. Barring the very steep and rocky slopes and some hill summits where some Rhododendron trees or bushy plants still flourish, no area is left without utilization. But unfortunately with such an extensive land use, the agricultural production is still very poor. The produce is even then not adequate enough to feed the people of this area, and therefore, substantial food grains have to be brought from the plains. This situation is mainly due to a less fertile soil, soil erosion during rainy season and poor irrigational facilities.

In the low lying areas below 1200 m where there are good irrigational facilities, rice is grown during monsoon period. In winter, the same fields are utilised for wheat. On the hill slopes, where no irrigation is possible maize is grown once a year. Maize is the staple food of the majority of the people of Midland. Barley, millet, mustard etc., are also grown on a limited scale.

Communication

Until very recently this part of Midland was one of the inaccessible areas of Nepal. The only mode of communication between Kathmandu and Pokhara was by air. But now, with the construction of Kathmandu - Bhairahawa road that passes through Pokhara, an eight hour bus journey from Kathmandu to Pokhara (Prithvi Rajmarg) and approximately one more hour journey from Pokhara to Nagdanda, the nearest bus station situated on the Pokhara - Bhairahawa Highway (Siddhartha Rajmarg) , provides an easy entrance to the study area. From Nagdanda, a ten hour walk on foot (approximately 30 km) via Seti Dobhan and Karkineta leads to the village of Phalebas on the northern extremity of the study area. From Karkineta, a major track goes to Kusma - Baglung - Beni and then to Jomson in the Thak Khola valley beyond the Great Himalaya. From the southern limit of the area, the nearest bus station is Waling (approximately 25 km from Bihadi) situated on Siddhartha Rajmarg.

Balewa, situated on the river terrace of Kali Gandaki opposite to Kusma village, is connected by air service to Pokhara, Bhairahawa and Kathmaadu. The internal communication is very poor. The Kali Gandaki river has only a few bridges over it viz. at Jyamireghat (Phalebas), Karnas and Purtighat (Bihadi). At Kusma, there is a wireless facility for the general public connecting Kathmandu, Pokhara, Bhairahawa and other important places.

People

The population of the area almost exclusively comprises of Hindus and Buddhists. In the higher altitude areas the Gurungs, belonging to a Tibeto - Burman group dominate over other communities, whereas at the lower altitudes, Brahmins, Kshatriyas, Goldsmiths, Blacksmiths etc., are predominant. The Gurungs speak their own dialect, that has more affinity towards the Tibetan language. Rest of the people speak Nepali, the national language of Nepal. Nepali language is spoken and understood by majority of the population. Considerable influence of Hindi is found and therefore, this language is generally understood by many people.

SCOPE OF INVESTIGATION

The purpose for which the present study was taken up, has already been alluded to in the beginning of this chapter.

Though, several workers have visited this area in connection with their regional studies, none has given the details in respect of the stratigraphy and structure of the area and its neighbourhood. Obviously, most previous workers have attempted to explain the geology of Bihadi-Phalebas - Kusma section, in the light of their own regional concepts. As a result, considerable confusion prevails in the matter of the stratigraphy and structure of this part of Midlands. The author, therefore, decided to conduct a very detail survey of all geological features, and synthesise the data into an integrated picture which has relevance to some of the major problems of the Himalayan geology of Nepal. The present study and the inferences, thus are based on a very faithful and critical evaluation of a large number of observations from all parts of the study area.

In order to obtain a suitable regional background, the author before mapping the study area took a few selected traverses in Kumaon Himalaya during October 1975, worked around Nainital, Bhowali, Garampani and Ranikhet areas to get acquainted with the geology of the adjoining Kumanon Himalaya. This work in Kumaon greatly helped the author in many ways, because the Kumaon Himalayan rocks have often been correlated with the rocks of the study area by some earlier workers.

The mapping of the area was completed by the author in the course of three field trips, extending over 32 weeks during the years 1975 to 1978. In addition to taking long traverses to cover all parts of the area, all crucial portions were investigated in greater detail, the observations being collected from each and every accessible outcrop. As the rock exposures are excellent throughout the area and accessibility is fairly good excepting the high cliffy portions of the dolomitic terrain in the south, more than 700 observations were made and about 400 representative samples were collected.

In order to understand the structural pattern, a large number of readings on bedding, cleavages and 'b' lineations were taken. Unfortunately, the rocks have not ~~not~~ adequately preserved structural elements. But all available data was interpreted in the light of the structural data from the area to the north where planar and linear elements of more than one generations have been better preserved.

Thin sections of more than 250 representative and typical specimens of various rock types were studied, and detailed petrography of all the rock types of the area worked out. Chemical analyses of 16 selected samples of dolomite from various localities, 9 samples of basic rocks, 4 samples of slates and phyllites and 2 samples of gritty quartzose phyllites were also carried out. To study the mineralogy of the microcrystalline, dolomite, 2 samples were subjected to X-Ray studies, and D. T. A. curves of five similar very finegrained dolomites were also obtained to identify the carbonate minerals and to study their behaviour at elevated temperatures.

Geomorphological studies were also carried out, and these comprised (a) morphometric analysis of drainage, and (b) a critical evaluation of the various terrace levels.

The present author has been able to throw new light on the geology of the area on the following points :

1. He has revised and established a new stratigraphy of this region which has considerable bearing on the regional stratigraphy of the entire Central and Western Nepal Himalaya.

2. One of the important contribution made by the author is the establishment of the structural history of the area that comprised four deformational events.

3. The stromatolites from the dolomites have been studied in detail for the first time and these are of great value in fixing the age of these unfossiliferous rocks.

4. On the basis of the author's work, petrographical and petrochemical, the basic rocks of the area have been established to be of spilitic in nature. So far no spilites have been reported from Midland Nepal Himalaya.

5. The geomorphological studies have provided much information on the neotectonism and geomorphic evelution of the area.