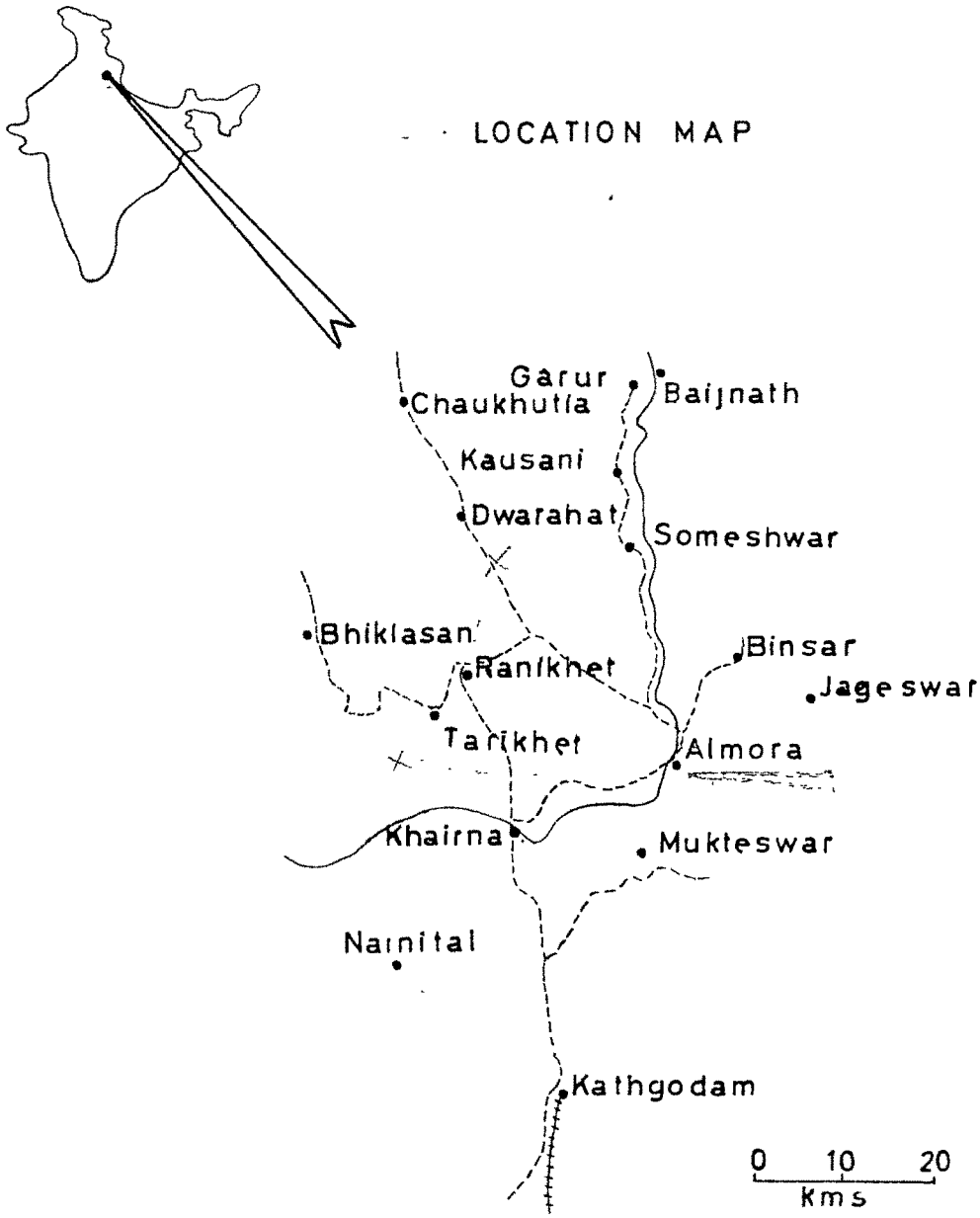
CHAPTER I

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

HIMALAYAS IN GENERAL:

The Himalayan region of the Central Kumaon (Fig. 5) is geologically very interesting, and its rocks have preserved in them valuable data which throw much light on the evolution of this part of the mountain chain. The rocks of this region belong to two distinct structural units - the Krol and the Almora Nappes, and the Almora Thrust which separates the younger rocks of the Krol Nappe, from those of the Almora Nappe, is synformally folded. The Majkhali area on which this account dwells, is situated almost in the middle of this synform, and the study of its

Fig 5


LOCATION MAP
Garur
Baijnath
Chaukhutia
Kausani
Dwarahat
Someshwar
Bhikiasan
Binsar
Ranikhet
Jageswar
Tarikhet
Almora
Khairna
Mukteswar
Nainital
Kathgodam
0 10 20
Kms

rocks, furnishes considerable information on the metamorphic and structural evolution of the area in particular and the Himalayas in general.

For the last hundred years or more, the Himalayas have been attracting geologists from all over the world, and their studies have contributed much towards the proper understanding of the geology of this magnificent mountain chain. Himalayas, however still pose a big problem, and inspite of the attention which they have received of late, only the fringes of the problem connected with their origin, age, lithology, metamorphism, structure and mineral resources, have been explored.

The present investigation is a modest contribution towards the stupendous problems of Himalayan geology which await unravelling.

The Himalayan mountains geographically consist of the following four sections:

(1)	Punjab Himalayas	- between the rivers Indus and Sutlej	- 560 km. long
(2)	Kumaon Himalayas	- between the rivers Sutlej and Kali	- 320 km. long
(3)	Nepal Himalayas	- between the rivers Kali and Tista	- 800 km. long
(4)	Assam Himalayas	- between the rivers Tista and Brahmputtra	- 720 km. long

Also the Himalayas are classified into the following three parallel or longitudinal zones:

(1) The Great Himalayas: the innermost line of high ranges, rising above the limit of perpetual snow. Their average height extends to 6080 metres; on it are situated the peaks like Mount Everest, Karakoram, Kanchenjunga, Dhaulagiri, Nanga Parbat, Gasherbrum, Gosainthan, Nanda Devi etc.

(2) The Lesser Himalayas or the Middle Ranges: a series of ranges closely related to the former but of lower elevation, seldom rising much above 3648 - 4560 metres. The Lesser Himalayas form an intricate system of ranges; their average width being 80 km.

(3) The Outer Himalayas or the Siwalik Ranges: which intervene between the Lesser Himalayas and the plains. Their width varies from 8 km. to 48 km. They form a system of low foot-hills with an average height of 912 - 1216 metres.

As regards geological structure and age, the Himalayas fall into the following three broad stratigraphical belts or zones. These zones do not correspond

to the geographical zones as a rule.

(1) The Northern or Tibetan Zone: Lying behind the line of highest elevation (i.e. the Central axis corresponding to the Great Himalayas). This zone is composed of a continuous series of highly fossiliferous marine sedimentary rocks, ranging in age from the earliest Palaeozoic to the Eocene age. Except near the north-western extremity (in Hazara and Kashmir) rocks belonging to this zone are not known to occur south of the line of snowy peaks.

(2) The Central or Himalayan Zone: Comprising of the Lesser or Middle Himalayas together with the Great Himalayas. It is mostly composed of crystalline and metamorphic rocks - granites, gneisses and schists, with unfossiliferous sedimentary deposits of very ancient (Purana) age.

(3) The Outer or Sub-Himalayan Zone: Corresponding to the Siwalik ranges, and composed almost entirely of Tertiary, and principally of Upper Tertiary sedimentary river-deposits.

Structurally, the Outer or Sub-Himalayan ranges, are quite simpler, made up of a series of broad anticlines and synclines of the normal type. Reversed overthrust faults mark the characteristic feature of the tectonics of these Sub-Himalayan ranges, the most prominent of these being the Main Boundary Fault, which extends along the length of the Himalayas from Punjab to Assam.

This zone is succeeded by a belt of more compressed isoclinal folds, strictly autochthonus in their position. This, in turn is generally followed by a system of recumbent overfolds, severed by thrust planes, along which large slices of the mountains have moved bodily southwards, characterising the Nappe Zone of Himalayas.

The structure of the Inner Himalayas has not yet been investigated, and a great deal of work remains to be done before it is possible to say something regarding the structure of these inner parts.

THE STUDY AREA:

Majkhali is about 13 km. NNE of Ranikhet(an important town of the Almora District of Uttar Pradesh), about 32 km. W of Almora, the district place, and about 61 km. NNE of the famous hill station of NainiTal. The rocks investigated occupy a more

Location

or less rectangular area of about 80 sq. km., enclosed by E. Longitudes 79°27'45" to 79°37'30" and N. Latitudes 29°37'30" to 29°42'15". In the west, the area extends upto grassfarm at Upat village, while its eastern boundary is marked by Maini village. On its southern boundary is the village Bhainsoli while the northern limits run from the villages Naugaon in the west to Selani and Kestra villages in the east, the two villages lying in the north-eastern corner of the area.

Topography

The area shows a fairly undulating terrain and forms a part of Nag-Tibba range of the Lesser Himalayas. The typical physiographic features of the area, expressed as hills of varying heights dissected by a number of rivulets, rivers, nalas, waterfalls, gorges and escarpments, are directly related to and controlled by the lithology and the structure of the area. The shapes of the highground in general are irregular though tending to show elongation in one direction. Except for the few summit areas, the higher ground is rather flat topped. On the whole, the elevated ridges on the western part of the area trend NNW-SSE. The ridges in the east strike NE-SW, while the few elevated areas in the centre show almost N-S trend. It is significant to note that the

trend of the high ground is indicative of the fold pattern of the rocks, and at most places, the crestal portions of the folds mark the high ground. The elevation of the region varies approximately from 1500 m. to a little more than 2000 m. The highest point of the area is at Malla Riuni, 2186 metres in height and having Bhaironath temple on its top. The other conspicuous summits are Kaphalkot (2040 metres) and the ridge (2140 metres) to the WSW of Majkhali.

Obviously, the mechanical erosion has dominated over the chemical, in the evolution of landscapes of the region. The action of frost, aided by rain and running water is the dominant agent of denudation in carving out the ravines. Further, vertical erosion has predominated over the lateral, because of the steep gradient and constant action of running water. However, the lateral erosion has been facilitated by rainwash and frost action. The fast and rapid decay of softer rocks, has given rise to steep slopes. These slopes, in turn, have been affected by landslides, making them very precipitous. The action of rain and frost on these bare faces, has further cut them into ravines, thus making the whole terrain difficult from the communication point of view.

Drainage

The streams of the area belong to the drainage systems of the Kosi and Gagas rivers the latter being a major tributary of the river Ramganga. The drainage is of consequent type and controlled by the underlying structure and tectonics of the region. The courses of the streams are seen to follow fault planes, and major joints and in many cases flow in softer rocks. As has been stated, the streams of the area, ultimately join the rivers Kosi and Gagas. The Kosi river which lies to the east of the area flows due south forming typical meanders.

Among the tributaries of the Kosi, draining the Majkhali area, the most important ones are the Jaurasi nala which flows southward, and Kaligad nala near Bhainsoli, and both ultimately join the Kosi river near Khairna outside the limits of the present area. The other major stream is the Gagas river, a major tributary of the Ramganga, which flows due SW and drains the NW corner of the area. Another prominent stream flows SSE, draining the western part of the area and meets the Gagas river near Kotli Biant. Most of these streams are perennial in nature. These streams in turn are fed by a number of smaller nalas and streamlets

which are local and form an intricate network. The hill of Bhaironath temple and that south of Bhainsoli offer good examples of radial drainage (Fig. 6) where the stream patterns radiate in almost all directions. The parallel drainage (Fig. 6) is also noticed where streams flow down the ridge slopes and join the main stream flowing along the strike of the rocks. Because of the interbanding of competent and incompetent strata and their subsequent folding, the two drainage patterns form a broad dendritic drainage system (Fig. 6).

Climate and Rainfall

The climate of the area is very pleasant and healthy. The average temperature is 27°C during summer (Mid April-June) and 5°C during winter(November-January). The monsoon, by westerly winds, which breaks earlier than the plains, lasts from middle of June to September and the area receives about 1500-1700 mms. of rainfall. The area suffers occasional snowfall during the month of January.

Flora

The flora of the region presents a striking variety ranging from the submontane tropical growths of the Bhabar to those of temperate zone, where cedars, oaks, pines and rhododendrons are found. The vegetation varies according to altitude. Sal (Shorea

FIG 6

DRAINAGE PATTERN IN MAJKHALI AREA

robusta), the Sain (Terminoua tomentosa) are found upto the elevation of 1700 metres. Beyond this altitude, higher up the Chir (Pinus longifolia) and banj oak (Quercus incana) are common. Hillsides form open pasture lands, richly adorned in the summer with brilliantly coloured alpine species of flowers. As regards the fruit trees, apple, apricot, citrous fruits, strawberry, black berry and oranges are very common. Besides this, fig and kaphal are the common local fruits. Among vegetables, potatoes, onions, tomatoes, cabbages, cauliflowers and other typical hill vegetables are usually grown.

Fauna

Wild animals like leopards (Felis jabuta), panther (Felis paradus) and black bears (Ursusto quatus), usually frequent the forested areas. Spotted deer (Carvas unicolar), jackals (Cavis querus) and pigs are also very common. Numerous species of birds are also found. In the forested valleys, large pythons are also met with. The rivers abound in fish. The domestic animals such as dogs (Canus jamiliains), bullocks (Bos indicus), goats (Hemitragus himalayan) and ponies are confined to the inhabitated areas.

Agriculture

The cultivation is confined to the hillslopes in terraced fields. (Plate 1) The soil is thin on most hillsides and is alluvial. The northern slopes of the hills are usually less abrupt and less denuded by the action of rain than the southern slopes. Fields, therefore, on the northern slopes contain thicker and richer soil. The sera lands, which occur generally low down near the irrigating streams, grow fine rice and are the richest.

During the year, two harvests are obtained, the 'Kharif' and the 'Rabi'. Rice and mandua are the chief Kharif crops, while the principal Rabi crops are wheat, barley and mustard.

Water is brought into the fields from rivers or rivulets by means of channels called 'guls' cut along the contours of the hills.

Habitation

Mostly, the people of the area are Hindus, though Muslims, and Christians are also found. Over 63% of the people speak Kumaoni dialect and 36.3% speak either Hindi, Hindustani or Urdu as their mother tongue. A few families speak Nepalese.

PLATE 1

Photograph showing terraced fields

Common diseases prevalent in the region are cholera, smallpox, plague fevers dysentry or diarrohea and respiratory ailments.

Majkhali is connected with the nearest railway station Kathgodam, the terminus of NE railway, in south by by a 98 km. long all-weather motorable road. The importance of Majkhali is all the more increased by the installation of I.A.F. Radar base for the border areas in Himalayas.

Communication

SCOPE OF PRESENT WORK

Detailed geological studies in this part of the Kumaon Himalayas were started about 8 years ago under the supervision of Prof. S.S. Merh, and to begin with instructive and interesting conclusions were drawn by him (Merh and Vashi, 1965) in the neighbouring Ranikhet area. Since then the investigations of this region have furnished very valuable information with regards to its geology, metamorphism, and structures. The author was introduced to the present area by Prof. S.S. Merh in the year 1964.

The author spent an aggregate period of about 25 weeks in the field during the summer and autumn months of the years 1965, 1966, 1967. The area forms parts of 1 Inch Survey of India Topographical Sheet No.53 O/10 and 53 O/6. The mapping was carried out on a 1:15840 scale (enlarged from the original 1" = 1 mile toposheets). The rock types encountered consist of pelitic and semipelitic schists, gneisses (migmatites) and psammites of a single stratigraphical unit. A systematic study of every individual outcrop was made and the various observations were noted down either on the map or in the field note book. Various lithological units were carefully observed and distinctions based on field characters were recorded. Field evidence of metamorphic changes and degree of migmatisation were also noted. In addition to the bedding and foliation, various other structural elements such as minor folds, cleavages, lineations and joints were noted. Patterns of minor folds and mutual relationships of various structures were examined.

All the data collected in the field was analysed in the Department of Geology, M.S. University of Baroda. A large collection of rock specimens was made, out of which

250 samples were selected for the purposes of this study. More than 100 selected thin sections of various types were investigated, and critically examined under microscope. In order to understand the structure of the area correctly, the various structural elements were studied in detail. A large number of readings of (1) foliations,(2) lineations including fold axes, (3) strain-slip cleavages, (4) joints etc. were taken and systematically analysed with the help of a stereographic equal-area net. About 40 rock samples were chemically analysed. The chemical data was utilized in (a) preparing ACF, AKF diagrams to determine the metamorphism of the rocks, and (b) understanding the nature and trend of the migmatisation of pelites to gneisses.

The results of the present study, which though is confined to the rocks of a comparatively small area of Kumaon Himalayas, explain many aspects of the metamorphic and structural evolution of the region as a whole.

BRIEF GEOLOGY:

In the following lines, the salient points of the geology of the area, as worked out by the author, have been briefly given and this has been purposely done to

facilitate a proper understanding of the detailed account given in subsequent chapters.

The rocks of the Majkhali area and its neighbourhood consist of mostly pelites (garnet mica schists) and semi-pelites (varieties of siliceous mica schists) with graphite pockets and psammitic layers (interbedded quartzites). In the southwest and northeast corner, the schists have changed over to gneissic rocks (migmatites). Stratigraphically the rocks could be assigned to the Chandpur Stage of Jaunsars and belong to the Almora Nappe of Heim and Gansser (1939) forming the eastern extension of the Garhwal Nappe of Auden (1937). The Almora (= Garhwal) Thrust, separates older crystalline rocks from the underlying younger Nagthats-quartzites of the Krol Nappe. The Almora Thrust has been folded into a big synform, and its two flanks in the North and South have been designated as 'North Almora Thrust' and 'South Almora Thrust' (Heim and Gansser, 1939; Gansser, 1964; Merh, 1968). The crystalline assemblages of Majkhali forms a part of the southern limb, except in the NE corner, where the synformal fold axis of the folded nappe is encountered. The 'South Almora Thrust' lies about 20 km. to the south.

The rocks of the Majkhali area show the following successive stages of regional metamorphism:

(i) Load Metamorphism

(ii) Progressive Regional Metamorphism

(iii) Retrogressive Metamorphism

(iv) Mineralogical and Textural changes

(v) Late hydrothermal changes.

Structures belonging to three episodes of folding are present in the area. The earliest recognisable structures, referred to as first folds (F_1), have folded the rocks into a series of recumbent isoclinal folds. The main foliation (S_1) of the area, is mainly a product of the early deformation and characterises the axial plane of the first folds. At a late date, the area was subjected to second folding (F_2) on WNW-ESE axis which gave rise to major structures like Upradi-Someshwar synform. It is this folding that was responsible for the chevron-type micro-folding of the earlier schistosity and the development of a strain-slip cleavage (S_2) at a number of places. The third deformational (F_3) episode has developed folds on all scales along NNW-SSE to N-S axes. Due to this folding, the foliation trend is seen to fluctuate from WNW-ESE to E-W and further to NE-SW.

A number of faults have been recorded, most of them happen to be quite late in tectonic framework and cut all the earlier structures and are unaffected by any folding.
