Chapter - I

PHYSICAL BACKGROUND

A. GEOLOGY

The Himalaya is geologically a complicated mountain system. The complexity of structure and metamorphism, which the rocks have undergone has posed challenging problems for correlation of the different rock formations on a regional scale. Geological investigations in Darjiling and the adjoining regions began in the middle of the last centuary. J.D. Hooker, in 1854, reported the geological finding of his extensive travels spread over two years (1848-49). He traced the regional domal picture of the gneisses and observed the overlying sedimentary bedding. But the systematic geological examination of the Darjiling area was first done by Mallet in 1874. He classified the metamorphic rocks of Darjiling and Western Daurs into the Daling 'series' and Darjiling gneiss. Since then local observations have been recorded by several officers of the G.S.I. as well as many scientists. Among them Ray (1935) has differentiated progressive zones of metamorphism in the rocks of the Daling series and the Darjiling gneiss, Ghosh (1950) has carried out a detailed geological mapping in parts of Darjiling Himalayas. M.B. Pawde and S.S. Saha (1982) have also studyed the Darjiling Himalayas extensively.

Morphologically the area is well defined. The mountain ranges rise steeply above the vast stretch of North Bengal plains (Terai and Duars). The sub-Himalayas are made up of Siwalik deposits of Tertiary age. Altogether from regional considerations, the Siwaliks have been reported to be missing over certain stretches of the sub-Himalayas, good exposures of the Siwaliks occur in the Darjiling foot hills with well preserved sections along the Tista river. North wards the Siwaliks are succeeded by the coal bearing lower Gondwana formations comparable to the Damudas of the Pennisular India and the Daling groups of rocks (Precambrian) and further north the Dalings are succeeded by the Darjiling gneiss. The generalised sequence of the various geological formations of this area is given in (Table 1.1 and Fig.1.1) in their chronological order.

In the higher reaches of the hills, the Darjiling gneiss occupies a greater part of the district including Darjiling town. The coorse grained gneiss is found mostly as schistose and at some places in gneissose texture. The rock has attained a very coarse texture due to influx of a considerable amount of quartzo-felspathic materials. From Kurseong to Darjiling the gneiss is continuous. The dips are uncertain and irregular but varies from 40, to 65°, northerly near Kurseong and southerly near Darjiling. The gneisses are also exposed along Darjiling-Ghum-Sukhia Pokhri-Manebhanjang-Tanglu-Sandakphu-Phalut Rd. and Phalut-Rammam-Rimbik-Jhepi-Pulbazar-Darjiling Rd.

The gneiss is highly micaceous and is composed of colourless or grey quartz, white opaque feldspar, muscovite and biotite. It varies in texture from fine grained to moderately coarse rock, lenticular layers of different degrees of coarseness being commonly inter-banded. It contains bands and lenses of pegmatite and apatite. These rock types are associated with sills of epidiorite which probably represent the basic sills intruded prior to the deformation. These epidiorities are now present only as lenticles

Table 1.1

Chronological Order of Various Geological Formations

Recent	Sub-aerial formations Alluvial deposits	Younger flood plain deposits of the rivers and nalas comprising of sand, gravel, pebble etc. and soil covering the rocks.
Pleistocene	Raised Terraces	Sand, clay, gravel, pebble, boulder etc. representing older flood plain deposits.
Pliocene to Lower Pleistocene	Siwalik	Micaceous sand stones with silt stones clays, lignite lenticles etc.
	Thrust (Main Boundary Fault)	
Permian	Gondwana	Quartzitic sand stone with slaty bands, seams of graphitic coal, lamprophyre sills and minor bands of limestone.
	Thrust	
	Daling Series	Slate, Chlorite-sericite schist.
Precambrian		
	Darjiling Gneiss	Fine grained augen and banded gneiss of ten garnetiferous mica schist with extensive intrusions of biotite, hornblend and tourmaline granites, golden silvery mica schists, carbonaceous mica schist, coarse grained gneiss.

Based on : Mallet (1874)

and cannot be traced for long distances. The accessory minerals present are kyanite, sillimanite and garnet. Kyanite and sillimanite are not always present though the rocks have attained the respective

GEOLOGICAL MAP OF DARJILING DISTRICT
(After Mallet)

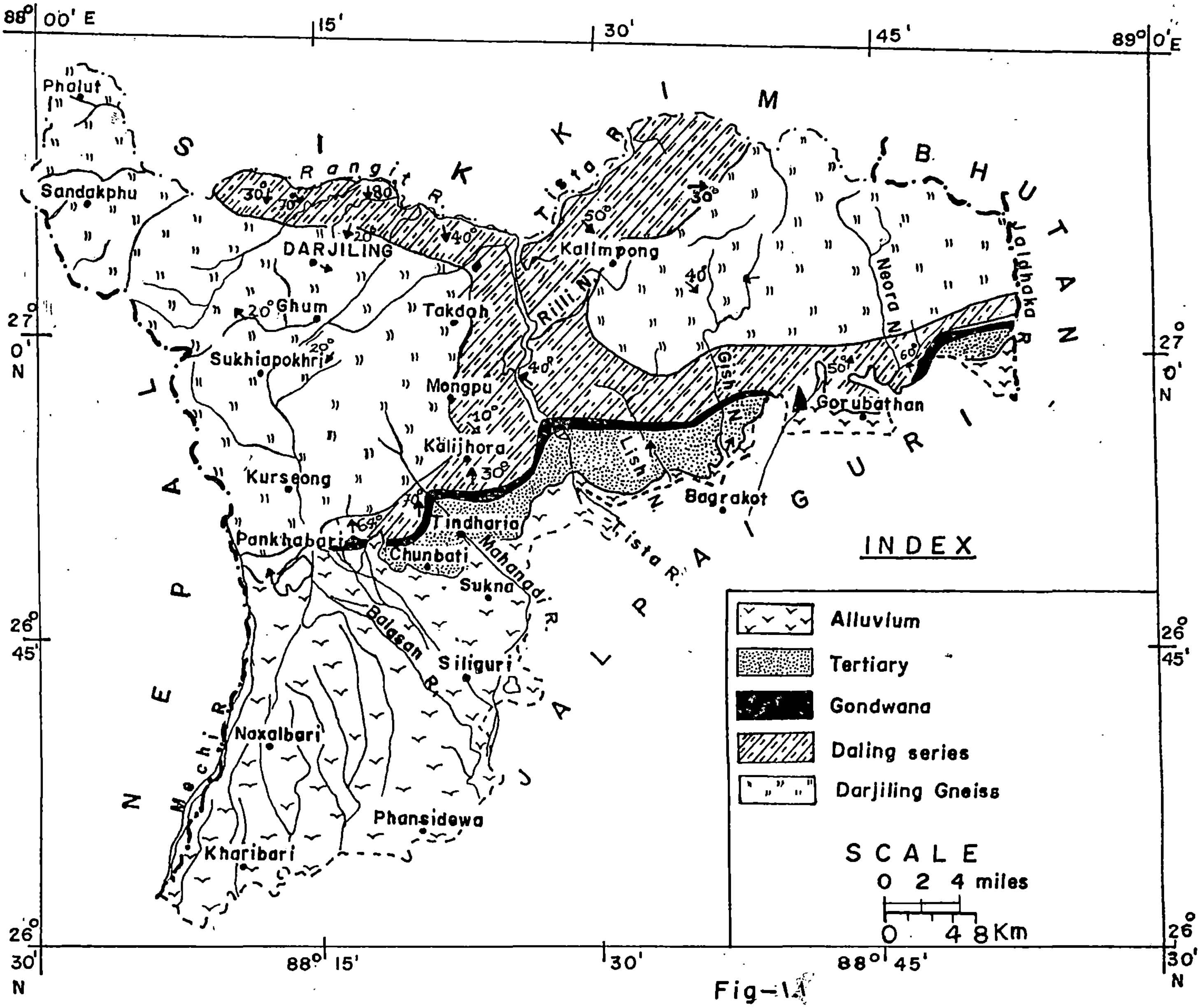

Fig-1A

grades of metamorphism. This can be explained by the fact that the bulk composition of the original sediments were always not suitable for the formation of these minerals. Hence it is not possible to separate the kyanite and the sillimanite zones from each other. The gneiss in the Ghum-Manebhanjang spur show an abundance of kyanite with some graphite and sillimanite. The sillimanite gneiss extends upto the Tukvar spur.

The Darjiling gneiss is highly foliated and the foliation dips being generally from north to north-west, and the amount of dip ranges from 30 to 50°. Within the confines of Darjiling town the foliation dips of the rocks are generally towards the east, ranging from 20 to 40°. There are two prominent sets of joints in the gneiss, one running roughly NW-SE and the other NNW-SSE. Both the joints have steep westerly dip varying from 40 to 70°. The general direction of the hill spurs agreeing with the joint directions, indicate that blocks of rocks loosen easily along joints.

The rocks of the Daling 'Series' and Darjiling gneiss groups are thrust over the Gondwana and represent sediments which have undergone metamorphism. Petrological studies show a gradual increase in metamorphism from the Dalings to Darjiling gneisses, the top most member of which is the sillimanite-gneiss indicative of the higher grades of metamorphism over those of a lower grade. The Darjiling gneisses due to the extensive development of the alumino-silicate minerals suggest metamorphism of argillaceous sediments.

The eastern slope of the Jalapahar-Katapahar ridge is composed of loose boulders resting on a steep slope varying from 40-55°. The rocks below the talus cover are gneissic interbeded with mica-schist dipping at 40° in the north and 30° in the east.

On the top of the Jalapahar ridge, the gneisses and schist composing the hill sides are overlain by talus. The foliation dip vary from horizontally to 40° easterly. Foliation in certain parts on the eastern face of the hill-sides are inclined at an angle less than the hill-slope. On these slopes the soft schist beds occur interbeded with the gneisses dipping at angles over 30°.

The crest of the Jalapahar ridge is covered with debris resting over gneisses. The dip of the foliation of the gneiss is nearly 30 to 40° towards ESE. The talus on the eastern face of the hill is more than 3 m in thickness, but on the western face it is much thicker. The structural deposition of the underlying rocks is stable.

The slopes at Rockville reservoir are covered by the superficial layer of sandy clay and boulders originally resting at an angle of 40°.

On the Lebong spur, except for the locally steeper slopes, the hillsides are inclined on an average of 25-30°. According to the geological evidence, the top layers on the eastern slopes in Darjiling town and Lebong consists of soil, talus and disintegrated rocks. The <u>in-situ</u> rocks are gneisses and schists and are exposed in a gulley on the south-west, indicating that the debris are only superficial. The foliation dips of the gneisses and schists in the Lebong and Darjiling proper on the eastern slopes are easterly (ENE to WSW) varying at angles of 15 to 25°, while the slope angle varies from 40-60°.

The trace of the axial plane of the major synform trends about ENE-WSW. This major synform appears to have been further refolded.

This synform probably forms a part of the major recumbent fold which has been postulated by the earlier works of Heim and Gansser (1964) to explain the structure of Darjiling Himalaya . Small replicas of this major recumbent fold are also noticed in the area. In these small folds, the foliation planes of the rocks are parallel to the relict bedding and bent around at the nose of the fold. The presence of abnormal dips in the wider Darjiling gneisses as well as inter colating of quartzites and schists recognised by Garwood as early as 1903, indicate further complications. The Darjiling type gneisses are very widespread, mostly in regions where inverted metamorphism takes place in argillaceous formation.

B. CLIMATE

The climate of Darjiling is specially noteworthy because of the wide difference in altitudes, the powerful effect of the monsoons against the Himalayan barrier and the peculiar configuration of the neighbouring mountains which deflect winds and affect local temperature and rainfall.

The local climate depends largely on the elevation which rises abruptly from the foot hills to 3,600 m. Spring and autumn are the most important seasons favoured by the tourist, but they are very short lived. The monsoon or the rainy season is the most dominating in Darjiling, characterised by mist and continuous rain which starts from mid-May and continues upto September. This monsoon is followed by a short period of autumn and from December to late February continues the winter season usually too cold and unpleasant.

i) Rainfall : On account of the hilly nature of the terrain there is a sharp variation in rainfall even between nearby stations. The average annual precipitation for 10 years along the eastern slope of the Jalapahar-Katapahar-Birch Hill-Lebong spur is 267.34 cm. while along the ridge the precipitation is 225.92 cm. and on the western spur of the ridge i.e. including the Happy Valley tea garden and other neighbouring tea gardens the precipitation is 206.67 cm. The precipitation during the south-west monsoon constitutes about 80% of the annual rainfall, July being the wettest month. Thunderstroms accompanied by rain occur in early summer (Mid-May) and during October i.e. the retreating monsoons. There is some variation in the annual rainfall of Darjiling town. Fig. 6.7 shows the distribution of annual rainfall of Darjiling town for the last 100 years. There is no particular trend in the annual precipitation as the graph shows a fluctuating tendency. One year of high rainfall is followed by another year of less rainfall. However on an average the precipitation ranges between 2200-3400 mm. The 20 years running average shows (Fig.6.7) that there has been a decline in rainfall in Darjiling town since 1930 onwards. On an average there are about 120 rainy days (i.e. days with rainfall of >2.5 mm.) in a year. During January-February Darjiling town sometimes experiences snowfall varying from 0.76 cm. on 29th January 1972 to 63.5 cm. on 20th February 1989. Most of the old houses in Darjiling town have slanting roofs made up of light tins of corregated sheets but the houses built recently have flat heavy concrete roof-tops which may cave in during such snowfalls, as the snow accumulating on these flat roofs cannot be cleared easily like those on the slanting roofs and this adds more weight ultimately disturbing the equilibrium of the underlying structure.

ii) Temperature : In the hilly regions of the district both day and night temperatures are higher during monsoon, but after the withdrawal of the south-west monsoon, these begin to decrease more rapidly from November. The average maximum temperature of the town is 15.82°C while the average minimum temperature is 9.13°C. January is the coldest month of the year and the temperature in Darjiling town being 8.6°C. Frost are fairly common throughout the cold season.

iii) Humidity : Over the northern tracts of the district the atmosphere is highly humid throughout the year, the relative-humidity ranges between 90-95% during the rainy season.

iv) Cloudiness : During the monsoon season the sky is heavily overcast while for the rest of the year it is high to moderately clouded. Cloudiness increases in May. In winter mornings fogs frequently cover the hills. In Darjiling town fog or mist is also very common in July and August.

v) Winds : During November to May upper winds over the Himalayan region are predominantly westerly. At extreme heights these winds are strong and often rise to gale. During monsoons, wind direction is most unsteady and the monsoon current occasionally rises to great heights. On such occasions the air current over the Eastern Himalaya becomes southerly or south-easterly. In October, with the withdrawal of the monsoon, the westerly movement begins and becomes progressively steady as winter condition sets in. From November throughout the winter the prevailing direction of the wind in Darjiling town is east-north-east. In spring upto June there is a tendency for a west to south-west component of the wind to enter and in the monsoon (June to September) the prevailing direction of the wind is east-south-east.

C. SOILS

The soil of the upland is usually red and gritty while that of the plains is dark and more fertile. Red and yellow soils have developed on the gneisses and schists in the higher slopes of the Darjiling Himalaya. The greater portion of the hilly area lies on Darjiling gneiss which most commonly decompose into a stiff reddish loam but may also produce almost pure sand or a stiff red clay. The colour of the red soil, derived as it is by meteoric weathering from gneisses and schists, is due more to wide diffusion than to high proportion of iron content. This type of soil is mainly siliceous and aluminous, with free quartz as sand. It is usually poor in lime, magnesia, ironoxide, phosphorous and nitrogen, but fairly rich in potash, some areas being quite rich in potassium derived from the muscovite and feldspar present in the gneiss. The podzolic soils in the hilly areas are suitable for the cultivation of tea. Parent material variations exert a stronger influence on soil characteristics of the Darjiling Himalaya, than climate or vegetation. In this area, there is a top soil of about 3 to 5 m. near the crest of the ridges, but the thickness decreases down wards and the lower slopes are generally, covered with boulders rolled down from the top. On the Darjiling gneiss there is a cover of reddish, sticky soil. The soil everywhere is residual, i.e. derived by the weathering of the underlying rocks. Weathering is selective in the Darjiling gneiss and proceeds along some susceptible bands i.e. mica-rich bands in preference to quartzose bands, and also along joint and sheer planes. As a result, blocks of fresh rocks are generally found encircled on all sides by highly weathered rocks of the nature of clay. The clay is found mixed up with grains of quartz, felspar and flakes of mica. This has got an important bearing on the landslips which has been discussed Chapter IV.

In Darjiling town the western slope is generally covered with soil which ranges from 1-3 m. in thickness while the eastern slope shows mainly a thick cover of talus with only a thin capping of soil at places. Rock in situ is exposed in small patches on both the sides, though such outcrops are more common on the eastern slope. The rocks exposed on the western slopes are generally weathered.

The reason for formation of the soil-covered western slope contrasting with the boulder-covered eastern slope is probably to be attributed to the characteristic structural features of the underlying rocks, i.e. joints, foliation dip, etc. in the respective areas. On the eastern slopes, foliation plane and joints are favourable for loosening the blocks to form talus while on the western slope, the foliation dip being inward, the loosening of blocks is retarded and the rocks get time to weather into soil.

D. NATURAL VEGETATION

J.D. Hooker, the doyen of Himalayan Botany, in his introductory essay in the Flora Indica, divides the district into two zones. The lower, stretching from the plains to 5,000 ft. above sea-level he called the tropical zone, and the higher upto the snow line the temperate. The most remarkable feature of the forest of

Darjiling town falling in the temperate group is the different variety of species that they contain. Most of the trees grow up to a great height.

Of the flora in and around Darjiling town, including both-wild and cultivated species, nearly 50% are indigenous to the Himalayas. Of the rest, Japan has supplied about 14% North America 7%, Australia and China 6% each, Malay and Europe 4% each, S. America and the tropical zone of Asia 3 each, Central America 2, Burma 1 and Africa 0.5.

The greater part of Darjiling Division falls in the Northern Wet Temperate forest zone which is characterised by rather overmature specimen of Oaks, Magcapolias and laurels. The species are numerous but the principal being the Oaks, Buk (Quercus lamellosa) Sungre Katus (Q. Bachyphylla) Katus (tribuloides) Kawalas (Machilus spp.), Champs (Miehclia spp.) Ghoge champ (Magnolia campbellii) Kharane (Symplocos spp.) . The trees are poor in appearance, stag -headed and covered with moss and lichens. The undergrowth is relatively dense and contains many nettes, raspberries, ferns especially the 'welcome fern' (Gleicheria linearis) and bamboos. Around the Brich Hill the Birch or saur (Betula alnoides) was once the dominant species, but at present only few Birch trees can be found here and there. Plantation in Darjiling was extensive and consisted mainly of Dhupi (Cryptomeria japonica) introduced from Japan in the late 19th centuary and also Utis, Pipli, and Rhododendron (mainly the red, white, pink and purple varieties). But at present due to the increase in population and the growth of urbanization in Darjiling town, there is hardly any forest cover within the Municipality boundary except for few pockets which are either under the Govt. control (Zoological Park, Botanical Garden) or private schools (St. Paul's estate, St. Joseph's estate and Mt. Hermon estate). Even the Tiger Hill-Sinchal which is supposed to be one of the oldest high-altitude game sanctuary in the country has hardly any forest cover. Moreover the Senchal forest which forms a catchment area of the lakes from where the drinking water is provided to the urban centre of Darjiling town, has hardly any dense jungle. (Photo 6.1).

At present, in Darjiling town the Dhupi (Cryptomeria japonica) is the dominant species. In Chaudhuri's plan (1929-37) Cryptomeria japonica was given such importance that a Cryptomeria Working Circle in the Ghum-Simana Range was forced to raise the species to supply box planks for the tea industry. But as the timber was too soft and spongy to suit the purpose, it is now used instead for interior panelling and production of paper pulp. The needle like leaves of Dhupi trees contain acid and as such the soil underneath become acidic with the accumulation of falling leaves and this acidic soil does not allow any amount of undergrowth below these trees. As long as the land is under Dhupi cover there is less fear of landslip or soil erosion, but once the forest is cleared, the land during rain becomes prone to erosion and landslip as the soil particles being acidic in nature have little binding capacity. Moreover the absence of undergrowth also helps in this process of soil erosion.

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