Geomorphology of The Southern Singalila Range

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O Sumita Samanta

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Exploration is the physical expression of the Intellectual Passion....If you march your winter Journeys you will have your reward, so long as all you want is a penguin's egg.

Apsley Cherry- Garrard: a young member of Scott's last expedition team in Antarctica (1910-13) who ultimately got his reward, i.e. the eggs of Emperor penguin during his winter march in 1911; and, discovered his Captain's body lying in a tent buried under deep snow in the late spring of 1912 (November). He could return alive.

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Preface

I started my research work on the ridges and ranges of the Darjiling Himalaya as a part of my Ph.D. programme in early 1990's at the University of Calcutta. The thesis was completed successfully in May, 1996, and the Doctoral degree was awarded; but the observations and collection of information regarding different aspects of local geography were not ceased immediately. The field work rather intensified, especially on the highly elevated Range of the Southern Singalila – mostly unknown to young Geographers, after getting my relief from the fixed schedules of the Degree-based programme. Prolonged investigations on the landscape, both geomorphological and environmental, have helped me to identify the changing attributes of morphological study all over the tract, and to evaluate the grade and type of the changes on the terrain as well. The present publication is a tiny upshot of that industrious effort though the entire work, as planned, is yet to be completed.

The matters in the book have been grouped into three main parts according to their nature of detailing. Part-I depicts physical set up of the Southern Singalila Range including its surface and sub-surface characteristics, atmospheric speciality and biospheric richness. Besides field work all over the mountain, different portions of this part, such as chapter-1, are based on information collated from previous literatures and the maps published by Governmental organizations. Wide interaction with local people as well as some broad-minded academicians, especially experts on alpine structure and environment, was also instrumental in interpretation of distinctive features described throughout the chapters-2 to 4.

Part-II of the book reveals the geomorphological analysis of the region on the basis of long-run field observations across the whole region along with some minor laboratory experiments. The first chapter of this part, i.e. chapter-5, however, expresses some theoretical aspects so that anyone, even a reader having little knowledge in geomorphology, can easily go through the next chapters of analytical description. The last chapter of Part-II deals with different types of hazard, comprising geomorphic and non-geomorphic, occurring over the Range. These are relevant and necessary for apprehension of the extent and intensity of changes in landscape of the region as a part or whole.

The chapters of Part-III in the book illustrate three case studies including the microgeomorphic characteristics of the place or area. These are: Sandakphu, the highest peak of the Range; Siri khola basin, the largest catchment area in the region under study: and the most

beautiful village of terrain named Gorkhey. These case studies are very much complementary to the preceding parts of the book.

An elaborate Glossary is presented at the end part of the book. This is required especially for the readers living outside the region. Suggested readings are given thereafter for the earnest learners. All efforts and toils of the author will end with satisfaction if more geomorphologists trek accross the range and surroundings mountains in future for finding more geomorphological features developed upon them and for analysing the occurrence of that natural sculptures as well as their changes held in time through direct observations.

Kolkata 09 December, 2022 Dr. Samir Kumar Samanta M.Sc., Ph.D Associate Proffessor, WBES

Acknowledgement

I acknowledge my friends and students who accompanied me during the trekking days over the Southern Singalila Range, even experiencing very harsh weather conditions as well as dangers from wild animal for several times. Those who showed such bond of affection are Rahul Majumdar (the group leader on my first Sandakphu visit), Abhijit S. Roy, Sherap Bhutia, Kanteswar Barman, Ganesh Naskar, Sumit K. Das, Debesh Santra, Raju Ghosh, Pratyush P. Dutta and so many others.

Always I express my deep gratitude to the local hill people for their cordial attitude throughout the periods of my field-survey on the tract. Some of them, like Balchand Pradhan, Prabhu Pradhan, Budhan Tsering Lepcha and Sange sherpa – all residing at Rimbick area, and Jaykumar Rai of Daragaon, have assisted me to identify the spectacular attributes of the terrain including local terminologies. I am willing too to recall here the names of Gajendra Sharma, former caretaker, Sandakphu Trekkers' hut-A, and Mingma Sherpa, one of the most experienced guides on the Range, who have provided services many times beyond my expectation.

Surely I am grateful to the owners of the hotels and lodges across the entire Range who always receive me as one of their kins, especially that Miss Nila Gurung (Nila-didi) of Shikhar lodge at Tumling and Dawa Doma Sherpa (Doma-didi) of Green Hill hotel at Rimbick.

I should never forget here to utter the name of my affectionate aunt – Late Kanak Mitra who always encouraged me to continue the field-surveys on the Range but to be cautious enough for avoiding all dangers. None but she persuaded me first to bring out the papers into a concise book-form which had already been written about the region in various journals and seminar proceedings. However, I cannot dare to say any thankful words, in this connexion, to my wife Suchitra Ray especially for her assistance in morphometric analyses of the terrain with care and persistence.

Lastly, but most sincerely I express my indebtedness to the following teachers, from my school level to higher studies, who have grown flared interest in me for trying my best to acquire knowledge from geomorphology and other branches of Natural science: Late Sri Rabindranath Chattopadhyay, Late Prof. Bidyut Kr. Bandyopadhyay, Late Prof. Subhash Ch. Mukhopadhyay, Prof. Manotosh Kr. Bandyopadhyay, and Prof. Malay Kr. Chattopadhyay.

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In the mountains all is pure, all is calm, All complication is cut off.

Rare are they who know to listen; Happy they who possess wisdom.

If the cold wind stings and bothers you, Sit in the sun:it is always warm there.

Its hot rays burn like flames, While, opposite, in the shade, all is frost and snow.

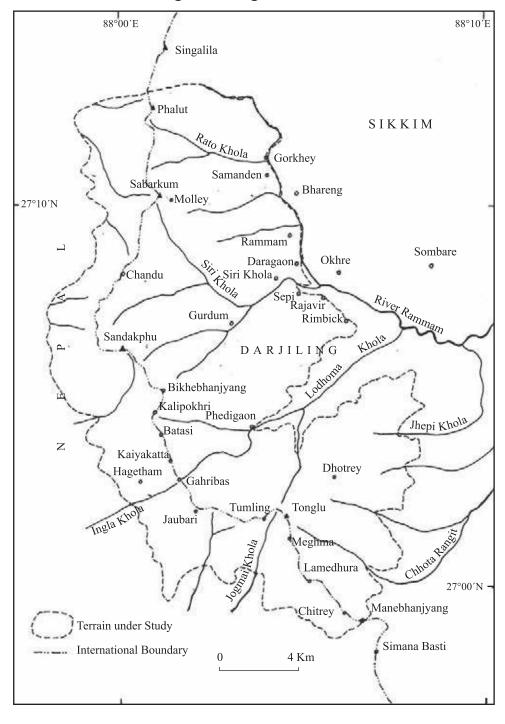
One pauses on ledges, one climbs to the foot of high clouds; One sits in the depths of a gorge, one passes windy grottos.

Here is the realm of harmony and joy, Where the past and the present become eternal.

E. Bernbaum Sacred mountains of the World

Part I Physical Set Up

Southern Singalila Range: General Introduction



Chapter 1 General Introduction

1.1.Location and Extent

Darjiling district which is world famous for its Sadar town Darjiling, the 'Hill Queen' of India, comprises four sub-divisions –Darjiling, Karsiyang, Mirik and Siliguri. Amongst these the first three include the mountains and ridges with enormous heights. As a whole the elevated tract belongs to the Lesser Himalaya being free from permanent snow cover since the last glacial age but adorned with picturesque landforms produced mostly by fluvial action. The westernmost section of the tract makes the highest mountain of the district and is well known as the 'Southern Singalila Range'. The northern part of the Singalila lies beyond the northern boundary of the district – extending from Kang peak (5580m) to Melido peak (3685m) which is commonly named as the proper Singalila peak by the tourists and trekkers.

The southern part of the Singalila Ranges, however, starts from Phalut peak (3596m) and terminates at Manebhanjyang (2000m) traversing a horizontal distance of 31km. Since the crest-line demarcates the western boundary of the district as well as of India, the western flanks of the Range, though little in areal extent, go into the territory of the neighbouring country Nepal (eastern strip of the district Panchthar and the north-eastern part of the district Ilam). The 1800m contour limits the projection of ridges and spurs towards south-east of the main Range; while the raised body of the Southern Singalila represents a picturesque panorama with vertices of several peaks – all of them rising above 3000m. The latitudinal extension of the terrain runs from 26°58' N to 27° 13' N, while its longitudinal expanse is confined between 87° 57' E and 88°07' E. Total area thus covered by the mountain is about 253 sq.km.

The longitudinal profile drawn across the highest portions of the Range, gaiting from Manebhanjyang to Sandakphu, is serpentine and very much wavy in vertical landscape. There are at least four gaps breaking the axis of which Gahribas is the deepest (2600m). The peak Sandakphu (3631m) gives a grand view of the Great Himalayan mountain

system for more than 300km along its length which traverses four out of the five highest peaks in the world, viz. Mount Everest (8848m), Kangchendzonga (8586m), Lhotse (8516m) and Makalu (8463m) along with many other seven thousanders like Chamling, Jannu, Kabru, Pauhanri, Chomolahri, etc.² From Sandakphu to Phalut the lineation of the mountain resembles an open sine curve and is almost unbroken having some minor downwarpings in between them.

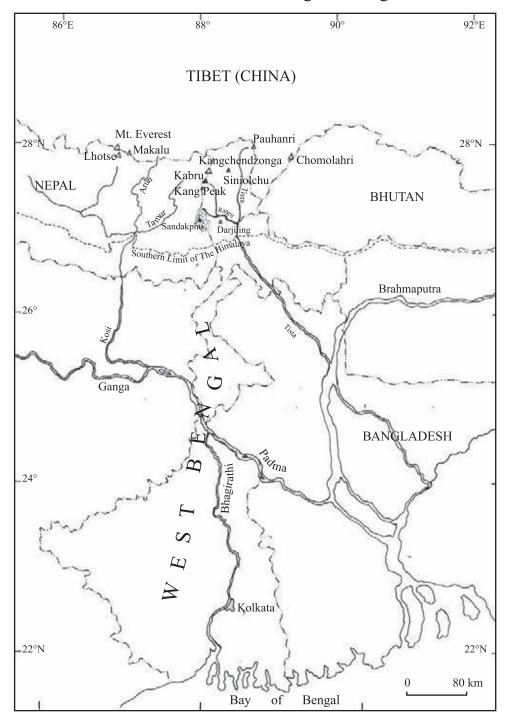
Prolonged denudation processes have developed a series of alternate ridge and valley topography on the both sides of the main Range. The streams rising from its western slopes such as the Prangbong and Hinwa khola are important headstreams of the Tamur – the easternmost tributary of the famous river Kosi. On the contrary, the torrents coming down from the eastern face of the Range like the Rammam, Siri khola, Gurdum khola, Lodhoma khola and Chhota Rangit represent themselves as the headstreams of the Bari Rangit which ultimately merges into the mighty river Tista near Melli, little north of Tista bazaar. Due to regular supply of waters from innumerable springs and jhoras all the streams are perennial in nature. Two tectonic lakes, though very small in size, are also found over the terrain – one at the head of the Lodhoma khola (Kalipokhri) and the other at the head of the Siri khola (Chandupokhri).

Though the tract of the Range is very much elevated in respect to surrounding valleys and southlying plains the region has been inhabited by man since time immemorial. Each part of the terrain which is habitable is used for growing settlements and agricultural fields. Pasture lands are also common features in the patches of alpine meadow and in the clearing points of dense forest. Two large settlements situated on the eastern flank of the mountain are Manebhanjyang and Rimbick (altitude around 2000m). They are connected with bituminous road with each other as well as the headquarters of the district Darjiling. Both of them act as markets for local people and are growing rapidly in recent years.

1.2. Functional Glories

The name Singalila has been derived from the Tibetan word 'Singley-la' meaning the mountain pass covered with alder (Alnus nepalensis) trees. The number of the tree in the upper forest areas is at present very low, but is found with high density in the midaltitudinal belts of the ridges. The Range had been used as a prominent hill-track since time immemorial as its summit line upto Chiabhanjyang (lying north of Singalila peak) provides a very easy route for the local people from where the valleys of north-eastern Nepal and that of western Sikkim can be reached without any hard climb.

Location of Southern Singalila Range



In 1830's the mountain was attracted first by the European trekkers. The wilderness of the tract as well as the magnificent panoramic view from the high crags – both became the key factors for popularising the Range to the foreign travellers. Between Sandakphu and Phalut the crest-line is the most significant part of the region from where the effect of Sunset imparted the notion first to the western explorers that Mount Everest, unnamed till then, goes much higher than Kangchendzonga.³

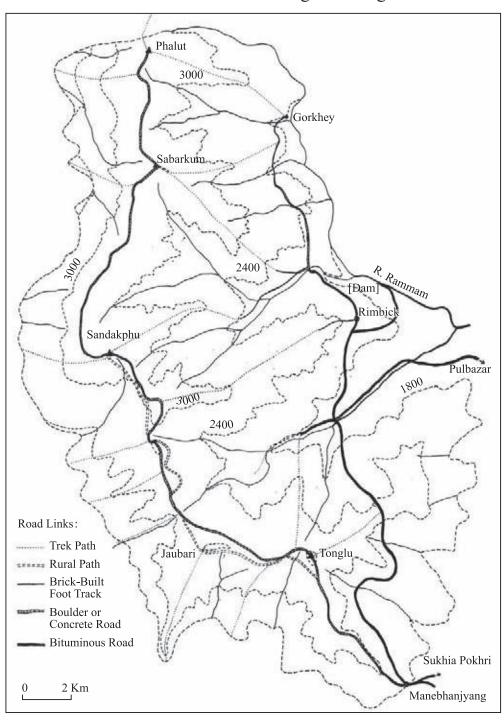
Besides the scientific information stated above the border road depicts some more glorious episodes: the explorative journey of famous naturalist Joseph Dalton Hooker in 1848, the visit of another scientist and artist Herman Von Schlagintweit in 1858, the march of the first expedition to Kangchendzonga led by Aleister Crowley in 1905, and the return journey of Charles Evans' team in 1955 after their first triumphant climb on the highest summit of that giant!

The worldwide sensation in the decade of 1950's by the great mountaineering feats all along the Himalayan tops inspired very much the Indian people in the sports of high altitude trekking and climbing. Since this ushering time the Southern Singalila Range also began to be visited frequently by the indigenous mountain lovers, especially by the Bengalee youth. Most of them used to select the Range as their practising ground for their harder achievements in future. Many new foot-tracks were discovered by them along the slopes of the ridges. Ultimately each part of the mountain became accessible to them as well as to the scientists of different arena such as geology, geography and ecology. The general tourists also started to go to Sandakphu, or even to Phalut by riding ponies or vehicles (landrovers) along the boulder-strewn road to enjoy the scenic beauty around the peaks.

Facilities for accommodation were very poor over the Range during that period. The Forest bungalow and a Government Rest house at Sandakphu (established in 1968), two other Forest bungalows at Tonglu and Phalut, and several Tea houses along the border road (one each at Meghma, Gahribas and Kalipokhri) were providing limited rooms to the tourists. The groups of adventuresome hiker, of course, hired porters, carried tents and other required provisions all throughout their journey. Manebhanjyang, at the gateway of the mountain, was a little village in those days with a tea-stall and a few groceries. Rimbick, on the other hand, having a small private lodge (Pradhan Hotel, established in 1954) and some shops was generally used by the trekkers as their last stop after a long weary travel.

In between 1980 and 1995 the tourism landscape of the mountain was improved enough, especially in regard of lodging facility. Three Trekkers' huts were erected at Sandakphu and one each at Tonglu, Gahribas, Molley, Phalut, Gorkhey, Rammam, Siri khola and Rimbick (all of them owned by Government). Besides these, many homestays started to grow in the following years at every halting place over the Range – at

Road Links: Southern Singalila Range



Manebhanjyang, Chitrey, Tumling, Kaiyakatta, Kalipokhri, Bikhebhanjyang, Sandakphu, Gurdum, Siri khola and Gorkhey. Three large hotels were set up at Rimbick (Sherpa Hotel, Green Hill Hotel and Tenzing Hotel). Solar lamps were arranged in the Trekkers' huts on the crests; while wireless Tele-communication system started to work first at Sandakphu in March 1998.

After 2000 some of the homestays have been upgraded to hotels and lodges. Many more private hotels have been set up at Manebhanjyang, Tumlimg, Kalipokhri, Sandakphu, Gorkhey, Rammam, Siri khola, Sepi and Rimbick. But the region is still lacking the amenities of modern commodities including conventional energy supplies, especially along its summit level. The condition of drinking water is the severest at this belt. A Canadian organization (non-governmental) erected some metal-nets at Kalipokhri by 2001 (along with some other settlements of the Ilam district in Nepal). Water-drops were collected from ionised droplets of the clouds passing through the nets and were restored in the tanks for drinking purposes. But the system soon failed due to the lack of their maintenance.

The use of ponies as human-carriers across the summit section of the Range has ceased after 1980 with the increasing use of landrovers. At present the number of these small but sturdy vehicles exceeds forty. They stride regularly from Manebhanjyang to any of the peaks over the Range except in the days of heavy snowfall. The condition of the Border road has significantly improved in recent years. First stretch of it, from Manebhanjyag to Chitrey, has been converted to bituminous path. From Chitrey to Sandakphu many segments of the road are now being upgraded to concrete pavements. Along the mid-altitudinal terraces encircling the mountain have also extended many motorable roads, either bituminous or boulder-strewn, for connecting the large settlements grown over there.

Apart from the magnificent sceneries and adventure glories the Singalila Ranges reveal a great geo-political importance too which made it a battlefield for several times during the period of late 18th – early 19th centuries. In 1780's the Gorkhas of Central Nepal crossed first the river Kosi and overpowered the Limbu and other tribal groups who had been residing at the eastern part of the valley for centuries. In 1788-89 they invaded further east – across the slopes of the Singalila. The tract was then inhabited mostly by the timid Lepchas under the rules of the Sikkim (or Sikhim) Rajah. The Gorkhas advanced up to His capital, killed most of the guards and seized His palace at Rubdentze (at the lower terrace of present Pemyangtse, West Sikkim). Their plundering went on in a continued manner until 1815 when the British force, being invited by the Rajah, pushed them back beyond the crest-line of the mountain. Peace restored, and the International boundary was set up between Nepal and Sikkim along the water divide of the Ranges from Kang la to Manebhanjyang and thence along the river Mechi southward.

The friendship between the British and the Sikkim rulers showed a well-warmish relation in the next three decades. During this favourable time the Sikkim Rajah, on a request of the British authorities, leased them a narrow strip of land stretching from the village of Darjeeling (or Darjiling - to be the Sadar town later) to Sukna area via Ghum, Kurseong (or Karsiyang) and Pankhabari. The deed granting the land was signed in February 1835.⁴

The cordial situation thus prevailing over the region began to break in mid1840's through some provocative activities created by a group of influential persons in Sikkim. As a consequence the British force captured all lands extending from the eastern slopes of the Southern Singalila to the Tarai (or Terai) lying in between the river Mechi and Sukna area. Thus the British Darjiling district was formed in 1850 under the jurisdiction of Bengal province. By the last treaty signed between the British and the Bhutan Rulers in November 1865 the hills of Kalimpong and Dalingkot area were also annexed to the district and the final territorial figure of Darjiling came to be shaped into its familiar form.

The partition of Bengal in August 1947, on the eve of independence of India, left intact the boundaries of Darjiling district.⁶ Since then the entire tract encompassing the eastern flank of the Southern Singalila Range has been an important part of the State of West Bengal: the single State in India which can boast of its marvellous north-south extent, from the mighty Himalaya to the Bay of Bengal, exhibiting a wide variation in geographical features including multi-racial culture!

1.3. Physiographical Entity

The narrowest but mostly inhabited mountain in the entire Eastern Himalaya (lying in between the valleys of Arun-Kosi in the west and Siang-Dihang in the east) is the Southern Singalila Range. Though it is a part of Lesser Himalaya it shows a very rough and dissected topography with slopes steeper than any other part of the Darjiling Himalaya. Serrated landforms across the wavy summit section, grandeur precipices at the side of deep glens, cascading valley-floors and intermittent faults along with fault-line scarps all over the Range as well as its associated ridges are the common but conspicuous terrainic characteristics for the whole region. As a true mountain it has a massive structure (massenerhebung) with main body rising high above the Pleistocene glacial line and experiencing cryonival processes acting on its surfacial layers situated above its shoulder.

The northernmost peak of the Southern Singalila Range is Phalut (27°13' N, 88°01' E, altitude 3596m) from where the orogenic waves of the mountain begins to propagate southward. The peak stands as a stout guard gazing at the sagging zone lying at its ubac

side. This valley (upper stretch of the Rammam or Rangbong) confines the southern limit of the Northern Singalila Range. Topography of Phalut is characterized mainly by its dome-shaped barren top (the Lepcha word Phak-lut meaning the denuded mountain) which is rested upon hard gneissic structure with some igneous intrusions resulted in thrusting effect (to be discussed elaborately in the next chapter). The western face of the peak is deeply excavated by several gullies, and hence the gradient becomes high – more than 40°.

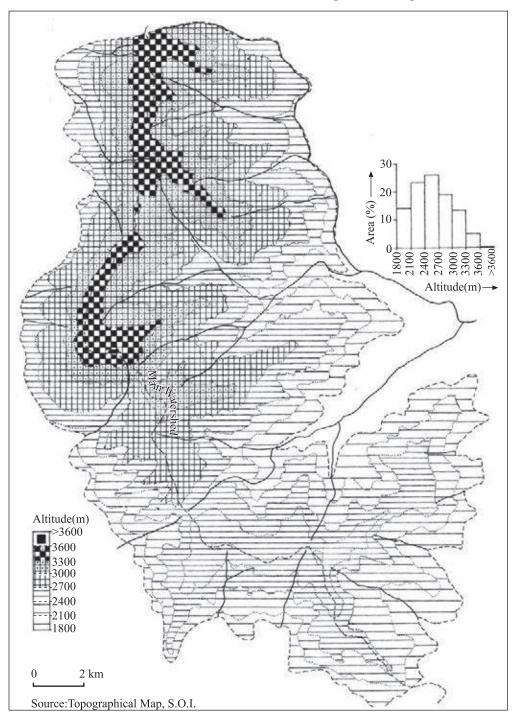
Towards the east the summit projects a long ridge (5.5km), the Kingsa danra, which shows a slightly dwindling crest-line with steeper slopes southward. The ridge acts as the southern boundary of the Rammam or Rangbong valley. The headstream of Rammam originates from a small lake 'Mong doe' lying little north-east of Phalut and flows through a shallow strath for the first 3km, and then through a deep gorge for the latter parts forming all along the boundary between Darjiling district and the state of Sikkim. Near Rajavir it merges with the Siri khola, becomes a large river 'Rammam', and ultimately joins the river Bari Rangit at Jorethang (27°07' N, 88°17' E) after traversing a total distance of 42km.

Little south of Phalut a spur with short length (1.5km) has been projected towards west. The summit line of the main Range advances SSE for 4.5km with a slightly serpentine alignment and then it projects its second peak Sabarkum (27°10' N, 88°01' E, altitude 3543m). The peak has a steep slope (about 35°) toward west being marked by occasional landslips; whereas the ridge projected south-eastward from the peak shows a gentler gradient (less than 15°) all along its crestal profile. The longitudinal section of Sabarkum danra is almost straight having a length of 6.5km. Before termination of the ridge at the confluence of the Rammam and its main tributary Siri khola, the slope of its frontal part increases enormously and exceeds 50° below Daragaon village. First part of the ridge, i.e. the section of 4.5km, starting from the peak represents the most densely wooded area of the entire tract. The latter part, extending downslope, is however widely used for agricultural work.

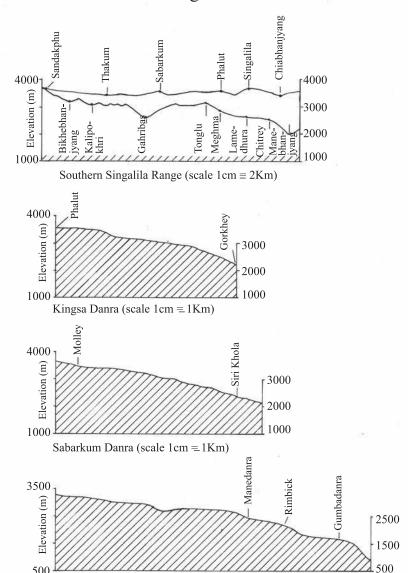
In a structural point of view the Sabarkum danra is a synclinal ridge with a prominent thrust plane all along its southern flank. Middle part of that flank has been carved by vigorous attack of the Siri khola. The main headstream of this river rises below Sabarkum peak and after merger with its tributaries near Gurdum village becomes the largest drainage system on the tract. The river plunges into the river Rammam near Rajavir (27°7.5' N, 88°06' E, altitude1600m). The geomorphological characteristics of the basin of this important river will be explained elaborately in chapter 11.

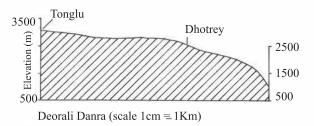
From Sabarkum to Thakum the Singalila Range stretches for 4km straight due south. This segment is marked by a series of distinctive mounds with bevelled, round-shaped tops over them with gentle gradients on all sides. They seem to be degradated at a slow

Altitudinal Zones: Southern Singalila Range



Longitudinal Profiles





Rimbick Danra (scale 1cm = 1Km)

but steady rate because the zone lies in the most stable part of the whole Range. After Thakum the summit line runs for another 4.5km making a great arc – convexity projecting westward. At the end of this arc ascends the peak Sandakphu (27°06′ N, 88°00′ E, altitude 3631m). It is the highest peak of the entire Range having two rocky outcrops (more than 30m high above their base) on its south-western corner. All sides of this lofty summit show formidable precipices with gradient not less than 55° except the northern part where the uppermost segment of the Sandakphu khola, a headstream of Siri khola, is making a gentle slope by its continuous but slower activities of corrasion.

Highly crumpled Sandakphu danra is extended from the north-eastern face of Sandakphu peak. Though this ridge is of short length (5km), it shows some unique landform characteristics having a sharp crest-line with at least four breaking zones caused by minor faults. At the nose of this ridge, above the hamlet Gurdum (27°07' N, 88°04' E, altitude 2350m), there lies a large, steep (more than 65°) fault-line scarp which is receding rapidly.

Another long ridge stretches from the western part of Sandakphu peak which runs towards west and is ultimately truncated by the westernmost rivuleps of Debmai Khola. Due to inaccessibility the ridge is yet to be studied properly by the author. The main summit line of the Singalila Range, however, advances south-eastward for another 2.5km sagging firstly to make a conspicuous valley named Bikhebhanjyang, and then rising sharply again to form a subsidiary peak (27°05' N, 88°01' E, altitude 3288m) from which the Rimbick danra bifurcates north-eastward – almost parallel to the Sandakphu danra, and is separated by the valleys of Partham khola and Gurdum khola. The length of this ridge is 8.5km having a mean gradient of about 9° along its crest-line. Low gradient and whale-back landscape of the ridge have invited the local people to initiate pasturing and other agricultural activities across its lower part though the higher altitudinal zones are covered with dense forest till now. At the end of this ridge lies the old and famous village Rimbick (27°07' N, 88°06' E, 2000m).

To the east of Rimbick another spur is originated namely Gumba danra. It stretches towards the confluence point of the river Rammam and Lodhoma khola (27°07' N, 88°8.5' E, altitude 850m). The length of that spur is only 2.5km which shows very unstable structure due to severe contortion in its rock masses. It slopes down abruptly to the river valleys with gradients of more than 50°.

About 1.5km south of the subsidiary peak of Sandakphu a small spur, Lalbans danra, bifurcates towards west. It is characterized by close folding with collapsed masses at its head. The sacred lake Kalipokhri (27°04.5' N, 88°01' E, altitude 3000m) lies over the Range – little before the starting point of that spur. Parallel to Lalbans danra and 1.25km south of it another spur, namely Lali danra, has been projected westward. It is also short

in length and descends quickly to the valleys developed by the streams like Dhuwan khola and Chisopani.

The summit line of the Singalila Range runs SSE for 2km from Kalipokhri lake showing slightly undulating sky-line up to Kaiyakatta knob and then descends suddenly (in 1.5km) for 400m before reaching Gahribas saddle (27°03' N, 88°01.5' E, altitude 2600m). The saddle is the reflection of a deep seated transverse fault and presently occupied by wide river valleys stretching on its both sides – Lodhoma khola to its northeast and Ingla khola to its south-west. After crossing the fault the Range is elevated again and reaches the 3000m altitude within 1.25km at Jaubari (27°02' N, 88°02' E). From this point a small spur climbs down abruptly due south heading towards the headquarters of the Nepalese district Ilam.

From Gahribas the lineation of the Range is eastward. Altitude increases after Tumling village (2km from Jaubari) and reaches 3063m at the highest point on Tonglu peak (27° N, 88°05' E, one km from Tumling). It is the last pinnacle jutting on the Singalila Range representing a typical Hogback landform descending steeply on all sides except the segments of the main Range and the ridge stretching eastward from the peak. The ridge is named as Deorali danra which traverses about 3.5km until it terminates at the long (2.5km) crescent-shaped scarp which is severely carved by the headstreams of the Jhepi khola and Laring khola – a tributary of the river Chhota Rangit.

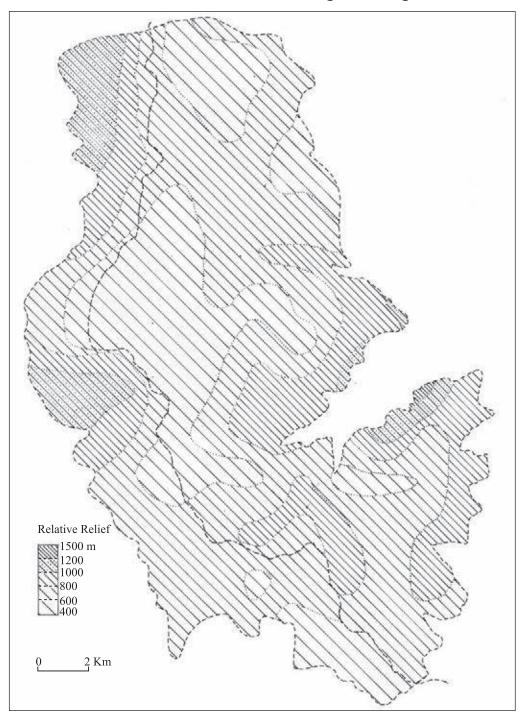
After Tonglu the altitude of the summit line begins to fall – at first abruptly 250m within one km (upto Meghma), gently 150m in the following 1.75km (upto Lamedhura), more gently another 100m in next 2km (upto Chitrey), and very steeply 550m in the last stretch of 1.5km before petering out at Manebhanjyang (26°59.5' N, 88°07.5' E). The extension of the Range between Tonglu and Manebhanjyang is directed towards SSE, the summit being narrow at some places due to sub-aerial erosion on its both sides and the gradient of the flanks exceeds 45°at many places.

[The latitude and longitudinal values of any peak or place given in this chapter bear the accuracy up to $0^{\circ}05'$. While descriptions regarding the drainage systems developed on the Range is abridged here because a separate chapter is kept for this purpose (chapter 8)].

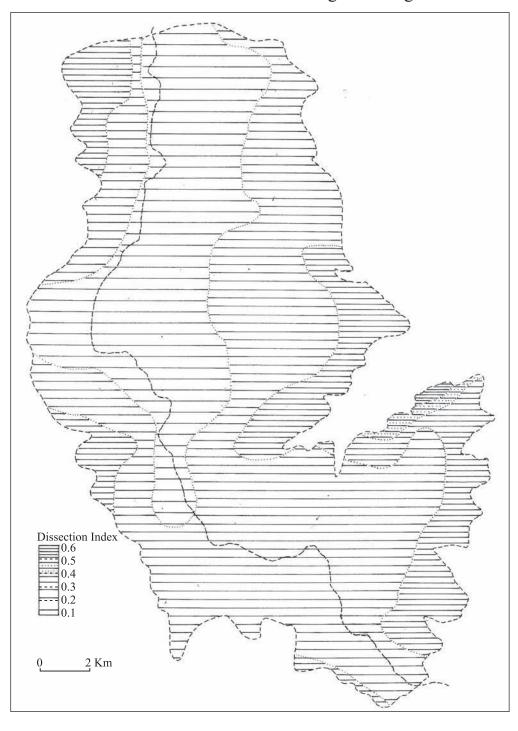
1.4. Relief and Dissection of The Terrain

As said earlier the altitudes of the Southern Singalila Range vary enormously – from 1800m, at the south-eastern periphery, to 3000m and above along its summit section. The altitudinal belt lying in between 2100m and 2700m occupies the maximum area of the region – 49.2%, while the tract of the mountain rising above 3300m covers only

Relative Relief: Southern Singalila Range



Dissection Index: Southern Singalila Range



4.7% of the terrain under study. The measures of relative relief, i.e. the difference between maximum and minimum elevations within a unit area also vary widely. Maximum figures of relative relief (more than 1000m) are found in the lower parts of the terrain – in northwestern section of Phalut, in the south of Sandakphu, and along the mid-Rammam valley including adjacent dales of Siri khola and Lodhoma khola. On the contrary, minimum figures of relative relief (less than 600m) are noticed in two segments over the summit section – from Sandakphu to Kalipokhri and across the upper portion of Sabarkum ridge.

Dissection index, i.e. the ratio between relative relief and maximum elevation of a unit area, is a very important measure in study of geomorphological study of a terrain. It expresses the quantum of dissection done by differential erosivon very precisely. It also helps to apprehend the phase or stage of erosional activities run over the landforms which are developed in the area under computation. Thus the high values of dissection index (more than 0.4) covering the lower portion of the Lodhoma valley indicate the high degrees of dissection. The landform of that portion has been exposed to erosional activities since the Early Holocene epoch (as soon as the last glacial age ends) and has obviously reached at maturity. While the summit section of the Range stretching from Phalut to Kalipokhri reveals low values of the index (below 0.2) because of lower degrees of dissection. That segment has been exposed to erosional activities in very recent (not before 1500years before present). Landforms situated in that part have hardly passed early youthful stage in regard of cycle of erosion.

^{1.} From Manebhanjyang to Sandakphu=18km, and from Sandakphu to Phalut=13km. The corresponding lengths of the border road traversing along the summit section are 31km and 21km respectively.

^{2.} According to the opinion of many world travellers Sandakphu is the best point of mountain-views. The renowned British poet Gertrude Bell wrote after reaching the peak in February 1903 during her second world-tour in 1902-03 "People who have seen many things say that the view from Sandakphu is the most beautiful in the world." Another Belgian artist uttered the same comment to this author in May 1997.

^{3.} Kangchendzonga was considered to be the highest 'mountain' in the world in the first half of the 19th century. But the delayed Sunset on Mount Everest (about 9 minutes) viewed from the summits of the Southern Singalila proved it wrong in spite of the longitudinal difference between the two peaks (2° 04').

The actual highest peak was unnamed to the Europeans until 1865 when the present name was introduced by the Survey of India in honour of its first Surveyor-General and the pioneer geodesist Sir George Everest (1790 -1866). Later at least two Tibetan names for the peak were found –Jomokankar and Chomolungma.

First authentic survey was carried for Mount Everest in 1848-49 by a team of Survey of India led by J.O. Nickolson from 6 distant survey stations (more than 100 km from the peak), the computation being done in 1852. On the contrary, the tops of Kangchendzonga were surveyed almost in the same time, in 1849, with immediate results due to the closer location of the massif from the survey stations (less than 30 km).

- 4. Excerpt of the said Deed is shown below.
- 5. The remaining part of Sikkim lying to the north of Darjiling district continued her sovereignty till 1975, in which year she became a State of India with a consensus of the majority of her people.
- 6. Very recently, in February, 2017, the tract lying east of the river Tista (the hills of former Kalimpong and Dalingkot area) has been separated from the district to give birth to a new district Kalimpong.



Deed of Grant making over Darjeeling to the East India Company



The Governor General having expressed a desire for the possession of the hill of Parjeeling on account of its cool climate for the purpose of enabling the servants of his Government suffering from sickness to avail themselves of its advantages.

I, the Sikkimputee Rajah, out of friendship to the said Gobernor General, hereby present Darjeeling to the Kast India Company, that is all the land south of the great Rangeet River, east of the Balasun, kahail, and Little Rangit Rivers, and west of the Rungpee and Mahanuddi Rivers.

(Seal of the Rajah)

Dated 9th Maugh, Sambat1891 [AD 1835]





Chapter 2 Geological Background

2.1. Introduction

The first attempt to depict any of the lithological characteristics of the Darjiling-Sikkim Himalaya was made by W. S. Sherwill, a British revenue-collector and keen searcher in geology. In 1854, he prepared a geological map in which some structural facts of the Singalila Ranges were added though not in details. In 1874, F. R. Mallet, an officer of Geological survey of India, published a rough coloured map with his report on the economic products of the Darjiling district in which he endeavoured to delineate the line of junction of the Darjiling gneiss with the Daling phyllite mainly exposed in the eastern part of the Tista valley. The name of the latter coined by him pertains to the classic composition of the same rock group in Daling hill on the head of the river Chel in Kalimpong district.

In 1878, the Darjiling Himalaya was traversed again by a German geologist L. V. Loczy who described the structural 'uniqueness' of the region on the basis of complex folding and thrusting. Following his account Eduard Suess, an Austrian expert on the Alpine structure, explained elaborately the nature of the strata covering the region in his voluminous book 'Das Antlitz der Erde' (1883-88). He proposed "Nappism is the only solution for the extension of the puzzling strata across the terrane".

Advancement of the concept regarding 'Nappe'-structure went on by the explorers of the 20th century. In the meantime a much accurate map for the region was prepared by E. J. Garwood, a British cartographer and the assisting member of D. W. Freshfield's team of the expedition 'Round Kanchenjunga' in 1899. The book entitled the same included his map and was published in 1903. J. B. Auden, the famous Himalayan expert examined the lithology as well as stratification of the Darjiling-nappe in a modern outlook during his visit in 1956. He represented first a schematic but most scientific sectional diagram of the Southern Singalila with all its thrusting features. Later, the Indian geologists, especially the scholars from different Universities, studied the region in details. They

discovered all the 'puzzling' formations of the mountain through their micro-level surveys and explained them in the light of 'Tectonic mechanism'.

2.2. Tectonic Mechanism

The tectonic mechanism of the Northern and Southern Singalila Range is closely related to the rising system of the entire Karakoram-Himalayan mountain chain which started to swell up from the Palaeozoic Tethys sea-bed by the end of Cretaceous period, especially in its Maastrichtian stage. During that time the Indian Plate completed its long journey (for about 200million years) towards north and began to push against the heavy Asian Plate including the large Tibetan island. The welding between Tibetan and Indian landmasses was completed in Palaeocene epoch of Lower Tertiary period. In consequence of this event an orogenic force was created along the colliding belt resulting in crustal shortening across the whole region. Successively huge waveforms emerged in the Tethyan sediment as well as massive contortion initiated beneath their bedrocks. The upliftment-process of all of these solid materials continued throughout the Tertiary period and is still in progress.

The palaeontological analysis together with radiometric dating of different layers in the Himalayan mountain ranges reveal that they rose by five major diastrophic impulses each of which lasted for several thousand of years:

Rise	Period	Epoch	Tectonic Events
First	Tertiary	Early Eocene	Upheaval of the axial parts of the Great Himalaya and adjacent Lesser Himalayan Ranges for some hundred metre above the sea- level by simple folding.
Second		Late Eocene	Upliftment of the mountains for two to three thousand metre by closed and complicated folds; southward tilting of the blocks also started.

Chapter 2 : Geological Background

Rise	Period	Epoch	Tectonic Events
Third	Tertiary	Oligocene	Thrusting occurs all along the mountain system; clear division between the Great and Middle Himalayan Ranges was marked by the Main Central Thrust; rising of the Trans Himalayan Ranges started beyond the Northern Boundary Fault after squeezing up the Tethyan sediments; altitude increased for more than one thousand metre all along the system.
Fourth		Pliocene	The mountains were elevated for more than two thousand metre; increased tensional forces created many large and medium faults in the mountains; Siwalik ridges started to grow to the south of the Lesser Himalaya (beyond the Himalayan Boundary Fault).
Fifth	Quaternary	Pleistocene	All segments of the Himalayan mountain system were uplifted and attained almost their present altitudes showing the most complicated folds and faults; rock benches and terraces were formed along the valleys representing the relics of the Tertiary landforms.

At present the structure of the Singalila Ranges is totally composed of a gigantic Nappe, as stated earlier, having a series of low-angled thrusts. Prolonged sub-aerial denudation has removed the upper half of the Nappe. Spectacular rock pinnacles are represented by the sharp end of the synclinorium; whereas round-headed crags are found over the mountain as stable central parts of that synclinorium. The entire terrane was elevated mostly through isostatic pressure which was exerted by the great Kangchendzonga-Kabru massif (one of the largest massifs in the world) during the third violent movement. The direction of thrusting waves flowing through the mountain masses is exactly due south as they propagated from the base of the said massif - lying just north of the head of Northern Singalila Range. Resemblance of such tectonic effect is also exhibited in its sister mountains: the Mungbreu Range of South Sikkim (whose frontal lobe makes the Ghum ridge-Dow hill section, after crossing the Bari Rangit valley) and the Chola Range extending from Dongkiya mountain to Kalimpong hills passing across the terrane of south-eastern Sikkim.

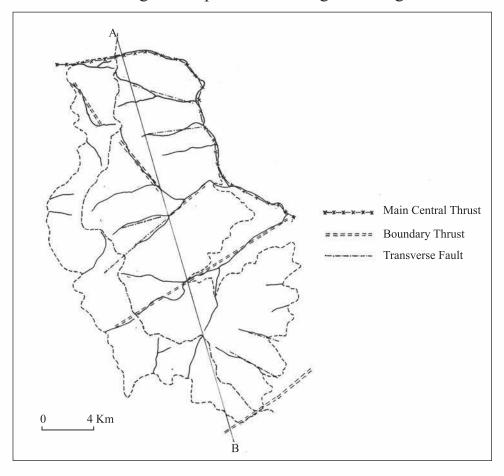
The Main Central Thrust (M.C.T.), a deep rooted fault dividing the Northern and Southern Ranges of the Singalila, and the Boundary Thrust separating Ghum ridge from the Southern Singalila were set in during the same movement mentioned above but most probably in its last phase. The tectonic movements occurring in Late Pliocene epoch elevated the tract high enough but, simultaneously, broke its central axis by several transverse faults. Present gaps in the mountain and the scarp-faces along the ridge-slopes bear the evidence of such faulting.

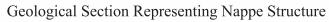
The last upheaval of the terrane came about in Early Pleistocene epoch when the mountain reached almost its existing height. Degradation rate became slower during the glacial ages (due to the protection from glacial covers) which ended about 7000 years before present. Series of upwarping and thrusting has also taken place in the latter parts of the Quaternary period though not in large scale. The structure of the region is, however, affected by that events noticeably. The strata as well as landforms produced upon them are thus found to be complicated so much with small faults and shear displacements within very short distances. Crushing and crumpling of old rocks have caused rearrangement in their mineral assemblage at many places too.

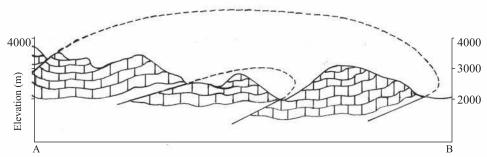
2.3. Lithological Characteristics

Major parts of the Singalila Nappe, especially its higher levels are composed of gneissic rocks which were folded and thrusted during the orogenic movements as described in

Geological Map: Southern Singalila Range







the previous paragraphs. In general they belong to Archaean genesis overlying two thin layers of Proterozoic formations: the Daling and Buxa series. The first series contains slate and phyllite, while the latter is composed of schist and quartzite. Both of the formations are highly metamorphosed forms of Tethyan deposits found well below the thrust waves (Daling rocks from Aphebian sediments, Buxa rocks from Riphean deposits). Due to tight folding and crumpling these strata are closely associated without showing any prominent unconformity plane in between them as well as below their covering stratum.

The valley-bottoms of the streams, lying between 1500m and 1800m, expose a thick bed of shale and partly metamorphosed sandstone which shows its origin in Permian period with a clear but undulating unconformity roofing above it. Lastly the deposited materials of Early Tertiary, from Palaeocene to Oligocene epochs, are overlain completely by the above rock groups. They can only be noticed below 1000m—along the valley-sides of the rivers Rammam and Chhota Rangit in the form of greywacke, shale and conglomerate. Thus the whole terrane shows an inverted structure: the principal feature of Nappism in this mountain. The thrusted masses of the mountain are always found to be bulging out towards south.

Due to severe orogenic stress and successively high grade of metamorphism all strata of the Southern Singalila exhibit no traces of fossils. The Archaean gneisses, which constitute lion's share of rockmasses, are intensely folded, badly jointed, highly micaceous and of varied textures. Mylonite and migmatite are also common rocks found in gneiss-dominated strata though in small volumes. Besides the common minerals such as quartz, feldspar, feldspathoids and micas, hornblende, garnet, sillimanite and kyanite are also present in these rocks. Pegmatite and granite have formed at many sections of this layer by altering processes through rock cycle, especially the process of granitization of parental gneisses during the tectonic disturbances in Tertiary period.

The phyllite, slate and schist of lower strata are also garnet-rich and are sometimes found in carbonecious composition. These rocks are often interbedded by hard quartzites with quartzose veins. The Permian rock group, mainly quartzites, can be distinguished easily by low grade metamorphism though the stratum is also highly jointed and faulted following the deformation of the beds of former series. The most striking feature in the stratigraphy of the region is the absence of Carboniferous-Permian coal seam which is very conspicuous in other parts of Darjiling district as well as in Sikkim and Eastern Nepal.

Chapter 2: Geological Background

The Rock sequences of the terrane along with their ages are depicted in the following table:

Rock sequence	Era/ Period	
i) Alluvia at river beds and loose debris on the hill slopes	i) Quaternary (Holocene)	
ii) Pebbles and cobbles rich in quartz, feldspar, feldspathoids and garnet,especially along the fault-planes	ii) Quaternary (Pleistocene)	
iii) Greywacke, shale and conglomerate	iii) Tertiary	
iv) Partly metamorphosed shale and sandstone	iv) Permian- carboniferous (Gondwana)	
v) Schist and quartzite	v) Mid- Proterozoic (Riphean)	
vi) Phyllite and slate of Daling series	vi) Early Proterozoic (Aphebian)	
vii) Gneiss, mylonite and migmatite	vii) Archaean	

2.4. Soil Characteristics

On the crests of the Range and over moderately steep slopes thin layers (less than a metre) of residual soil have developed through which huge rocky boulders and pinnacles are frequently unveiled by weather elements. While the layers of transported soils found at the break of slopes or over the planation surfaces show enough thicknesses, sometimes exceeding several metre (at Samanden, Daragaon, Majhua, etc). The reddish tint in the soils of open surface is caused partly by the decomposition of gneiss and schistose rocks but mostly by the diffusion of iron compounds in their upper solum section in per humid climate. The soils under dense forest cover are, however, typical grey brown types—the deep hues are due to high degree of podsolization under thick coniferous mulch.

Geomorphology of the Southern Singalila Range

Texture of all soils over the mountain varies from medium to coarse containing highly siliceous materials with free quartz almost in everywhere. They are fairly rich in potash and organic matter; but poor in phosphorous, magnesia, nitrogen and lime. The pH value remains low all over the region: ranging from 4.5 to 5.5 except in the grassy meadows and in the areas covered with ringals – where it rises up to 6.5. Unstable ground and harsh climatic conditions make the soil brittle and susceptible for wearing away readily.

Chapter 3 Weather and Climate

3.1. Introduction

The weather found on the Southern Singalila Range is quite distinct from that of the adjacent valleys and hills with lower elevations. Generally the tract shows a cyclic pattern in its changing diurnal phenomena: bright sunny condition from dawn to noontime; misty or cloudy atmosphere till evening; and the dewy or snowy hours with more or less chill effect at night. The altitudinal extension of the region, of course, exhibits a typical 'Highland climate' (after G. T. Trewartha, 1965) which tends much to be cool moist temperate type. Since the air pressure decreases with increasing altitude, local adiabatic lapse rate remains always very high – approximately 10° C per km, i.e. equivalent to the value found in the driest atmospheric layers. Thus the temperature conditions measured on this mountain differ significantly with that of the headquarters of the district Darjiling. The maximum and minimum temperatures over the summit section always go down far below the figures recorded at Darjiling Meteorological station (2130m), generally the differences bringing about 15°C. In a cloudless day the scorching sunshine, however, makes the environment of the Range more comfortable in comparison to dank weather of the Sadar town area.

Inspite of low temperatures prevailing over the high altitudinal belt of the Range relative humidity also remains low at its every place which expresses a typical 'Keen' type of climate (as per G. Taylor's climographic representation). If vegetation characteristics are considered at micro-level study the climate of the summit section extending from Lamedhura to Sandakphu can be classified as the cool Temparate; from Sandakphu to Sabarkum, Taiga; and, from Sabarkum to Phalut, Tundra type. The slopes of the Range (below 2600m) along with the valley sections are, however, experienced with warm temperate climate. Relative humidity is also found high over these mid-altitudinal zones.

The decrease in atmospheric pressure is felt prominently above 2800m, i.e. along the crest-line beyond Meghma. From Sandakphu to Phalut the isoberic value can be noticed

little more than 66 per cent of the normal figure (at sea level) – the value never exceeds 700 hPa. Many weak tourists and trekkers feel respiratory problem and irregular heart-beats over the peaks and sometimes succumb to death.¹

Thin atmospheric cover over the Range causes lower amounts of ozone molecules and other suspended particles. As a result the rock and soil surfaces along the summit section receive much higher levels of solar radiation including ultra-violet rays. The effect of the u-v rays is clearly noticed as the darker hues on open body parts of the trekkers wandering over the tract. Clear and rarified air-blanket makes the sky deep blue at daytime and the number of stars seen at night enhances manifold. The extended, balcony-like position of Sandakphu helps to watch extra-ordinary shapes of Rainbows in monsoon months – including double, inclined and elliptical types.

3.2. Seasons

Like other parts of the high Himalayan mountains the Southern Singalila also shows an aquaintance with three well-marked seasons which are tabulated below:

Season	Nepali term	Duration
i) Spring	i) Garam, meaning warm	i) EarlyApril to mid- May
ii) Rainy season	ii)Barkha, meaning rainy season	ii) Mid- May to early October
iii) Winter	iii)Hiunda, meaning cold season	iii) Late October to early April

Among all the seasons spring is the most pleasant here which brings warmth over the Range, even on the summits. True summer is completely absent here. The temperatures at Sandakphu, Sabarkum and Phalut seldom exceed 10°C. Nevertheless, in early May, the lower parts of the valleys gain somewhat a warmer condition – daytime temperature often rises above 25°C with relative humidity less than 50%. Maximum part of a day shows clear weather except the times of afternoon when the high altitudinal zones are covered with light but widespread stratocumulus clouds. Spring gales often break out with high velocities – more than 120km/hour. They cause heavy thunders and occasional

flares with forest-fire across the coniferous forests. Short spells of sleet, frequent generally in the late hours of a day, lowers quickly the surrounding temperature; but it rises again in the following sunny days.

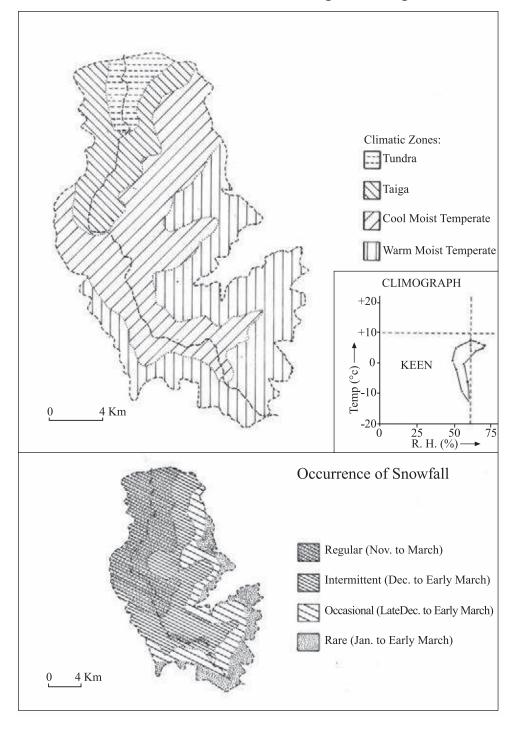
The warm and dry environment is replaced suddenly by mild temperature and high relative humidity with the advent of scuds shoved by the pre-monsoon winds in any day of mid-May. The long rainy season starts since that day. The temperature varies from 7°C to 12°C around Sandakphu during the rains while it exceeds 18°C in the lower valley areas. Relative humidity also enhances and touches frequently the saturation mark, i.e. 100% in the latter areas. Wind speed, of course, remains low throughout that period – hardly exceeding 20km /hour.

The rainy season of the region is closely related with the circulation of Indian Monsoon, the famous South-West Monsoon, which sets in here earlier (very first week of June) than southlying plains. The whole region is thereafter exposed to heavy orographic rains which continue for the next 135 – 140 days. More than 75% of the annual precipitation occurs during this time. The main Range and its associated ridges remain covered with thick altocumulus and cumulonimbus clouds for most parts of the daytime. The hill-slopes are found to be inaccessible because of infinite number of cascades and torrents flowing over them. Excessive downpour in the rainy days may often cause a meteorological hazard (to be discussed elaborately in chapter-9.3). The attack of the torrential rains on the badly weathered rock-masses results in huge rock-slides as well as other types of degradational processes, though the forests grow its maximum covers during this period. In early October the mountain becomes free from such hellish situation when the Monsoon winds retreat completely from the Eastern Himalaya.

Autumn, a transitional phase between the rainy season and winter, is very short but much more delightful for exhibiting a clear and fine weather. Temperatures (0°C to 7°C above the peaks; much warmer in lower elevations) and relative humidities (55% to 60%) are favourable for mankind during this phase. Precipitation occurs merely in the form of dews (frost and verglas over the crest line) in early morning. Wind speed decreases below 5km/hour.

After the withdrawal of the Monsoon winds Northerly winds begin to spread over the region. Originating from the Tibetan Highland they bring the actual winter over the tract with rapid decrease in temperature. In late November the temperature persists below

Climatic Zones: Southern Singalila Range



the freezing point at Sandakphu and its north-lying peaks. The weather becomes harsher when it goes down to – 15°C in January and February. Relative humidity also decreases (below 45%) in this season. Precipitation obviously takes place in the forms of snow and ice flakes during these months. The border road, from Kaiyakatta to Phalut, seems to be a white ribbon being tucked in thick layer of verglas and the forest tracks get hidden beneath the icy slopes. All springs and water-pools are frozen during the said months. Chill winds blowing from Kangchendzonga region often make the condition more severe than usual. The speed of those winds occasionally exceeds 70km/hour over the summits and the situation is aggravated with their forceful gusts.

During the winter months snowfall sometimes occurs as a hazardous event. The mountain slopes are covered with more than a metre of firn even after a single spell of such semi-solid precipitation. The effects of a large scale snowfall can be noticed successively through its melting stage in the following sunny days: it invites a rapid weathering of the surface rock along with solifluction on the hill slopes, feeds enormously the rivulets, and lowers the temperature as low as -20° C (from Sabarkum to Phalut section). Record snowfalls tracked by the author during his field work occurred in 1994-95, 2003-04, 2011-12 and 2015-16 when the summit-level remained ice-caped fully from late December to late February.

In the last part of winter blizzard is very common with its disastrous blows – as high as 100km/hour. Sometimes it becomes a hindrance for trekking over the mountain and cuts off all communication system for several days.

3.3. Local Winds and Humidity

Since the region has diversified topography, reversal of diurnal winds is very much prominent. The flows of the winds are evidently controlled by local thermal conditions. During daytime the upper parts of the mountain, especially along the denuded rock pinnacles, are heated directly by sun-rays. This results in an increase of temperature of the contiguous airmass as well as decrease in its density which eventually pull the valley air upward (anabatic wind). The upslope wind carries fogs and clouds toward the summits, makes the atmosphere hazy, and creates a disturbed weather notably after noontime. On the other hand, bare rocks of the summit-level are cooled rapidly after the sunset with

huge loss of solar energy through widespread radiation. As a result both the temperature and density of the adjacent airmass change accordingly to their reciprocal co-relation. This creates a downflow of wind (katabatic wind) and makes the atmosphere of the upper level transparent during the late hours of night. The upper parts of the Range, lying above 2600m, thus shows relatively extreme weather conditions than that of the valley bottoms where the diurnal variation in temperature is moderate. The velocities of anabatic and katabatic winds attain obviously their maximum marks by twilights which may turn into light gales (the velocity varies seasonally) for many times.

Like the fluctuating temperature conditions found in the region the figure of relative humidity also varies here both diurnally and annually. During daytime rapid rise in temperature lowers the figure abruptly, sometimes below 45%; while the fall in temperature at night increases its mark as high as 90%. The percentage varies too with the seasonal variation – very low in dry periods and nearly at saturation level in the Rainy season. The low density of the air, however, causes the absolute value of humidity remaining always low.

3.4. Other Weather Phenomena

Due to high altitudinal location the mountain slopes are enveloped regularly with fog and mist, especially in the morning and evening hours. Two types of fog are very much conspicuous over the tract. The down-valley fog is generally found below 2400m which may act as a translucent veil in the early hours of a day almost in all seasons. It is formed by the cooling process of moist air during the night and condensation thereafter. Whereas the crest-line fog can occur generally in dry periods, especially in late afternoon. It is formed by the expansion of moist anabatic wind over the cooling slopes of the crests and is accumulated obviously around them. The latter is slightly clearer in visibility than the former one - sometimes sporadic in nature and, almost absent in Rainy season when the evening weather becomes cloudy and rainy.

Mist may generate occasionally in the region. It is found to be extensive more than fog with homogeneous character by the density of condensation nuclei. It obliterates the distant views and acts as a smoke-glass for nearer objects - smearing the notion of actual

distance of the neighbouring ridges. Any survey-work or other type of observations can be seen impossible in a misty weather. The illusive condition disappears only in deep night-hours when chill winds begin to blow and the condensed droplets become heavy for precipitation over the Range.

3.5. Changes in Weather Phenomena

Minute changes in weather phenomena have been noticing during the last three decades most probably due to the effect of Global warming. The spring season is being shorter and pre-monsoon rains are starting earlier than normal dates. Number of spring-storms with thunders is also decreasing while the spells of snowfall are increasing with longer intervals. Most interestingly, the periglacial conditions, which existed recent past in between Sabarkum and Phalut, cannot be found presently at all.

^{1.} An incident of such miserable events came about in the afternoon of the 25th Apil, 2017. It was a day of very much inclement weather when an expirenced but aged trekker (foreigner) died near Sabarkum with great exhaustion and severe heart- attack.

Chapter 4 The Biospheric Wealth

4.1. Introduction

Like other parts of the Eastern Himalaya the topography of the Southern Singalila Range is covered with rich biosphere including large varieties of flora and fauna. Though solid structure of the ground does not permit a deep encroachment of the zone, the favourable atmospheric ocean expands its upper boundary: up to mid-tropospheric layer above the mountain tops – the spreading limit of the pollens as well as the flying levels of some avian animals.

The maximum surface area of the region belongs to wildlife sanctuary having important habitat of valuable organisms reared under benign to cool temperature premises which are privileged further by the prevalence of moist anabatic winds from the adjacent valleys throughout the year. In 1986 the eastern part of the summit line, the trapezoid joining Tumling, Phalut, Gorkhey and Rimbick, was declared as 'Singalila National Park'. Total area of the Park is about 78sq.km and the altitudinal variation lies between 1900m and 3600m. Within and outside the National Park altitude and climatic level of a particular site play the most vital role in determining the establishment factor for 'niche' of a particular set of plants and wild animals confined within it.

4.2. Floral Distribution

Due to luxuriant growth of cool climatic forests mostly covered with fir, rhododendrons (both trees and shrubs), mountain bamboos and brambles many portions of the Range are inaccessible to general tourists still today, though the density of trees have largely been decreased in recent years. Each part of the forests is dominated by a single genus or family of trees depending upon its own altitudinal belt along with characteristic undergrowths and epiphytes. Thus the mountain slopes are radiant with multiple hues

of flowers - generally blooming here twice a year: the first in Spring time when red, yellow, yellowish white and pink colours of rhododendrons spread over the ridges and spurs with middle heights superimposed by white patches of champ and magnolias; and again after the end of Rainy season when the forests of lower altitudes shine with widespread spectrum of primula, geranium and rich orchids.

In autumn, 1848 the famous explorer Joseph Dalton Hooker first examined the vast floral resource of the region. After that the forests crawling across the mountain slopes have attracted many botanists and naturalists. Based on elevation and local climate three distinct belts of plant types are found over the tract though widely overlapping along their margins. Below 2600m the first belt of temperate forests is mainly composed of oaks (genus Quercus, banjhi in Nepali) along with buk oak (Quercus lamellosa, katus in Nepali, buk in Lepcha), mountain figs (genus Ficus, khaniun in Nepali), laurel (Machilus gammieana), Himalayan alder (Alnus nepalensis, uttis in Nepali, kowal in Lepcha, single in Tibetan), yew (Taxus baccata, dhengre salla in Nepali, cheongbu in Lepcha), poplar (Populas ciliate, bangikat in Nepali) and walnut (Juglans regia, okhar in Nepali) with slender bamboos (pareng in Nepali and Lepcha), many leguminous vegetations and ferns (including Tree fern, Cyathea brunoniana, uniu in Nepali, pashien in Lepcha). The forest soils are seldom exposed due to carpeting of lichens, mosses and lycopodium (a special variety of mosses having medicinal properties, nagbeli in Nepali). This belt has, however, been mostly affected by indiscriminate forest clearing due to the extension of human settlements and arable lands.

The second belt of forests is almost continuous extending from 2400m to 3200m which is fully dominated by rhododendrons (genus Rhododendron, gurans in Nepali). At this altitude they are giant trees intermingled with mountain bamboos (genus arundinaria, maling in Limbu) and other varieties of large tree like maple (Acer caesium, kapasay in Nepali), birch (Betula utilis, bhurjpatra in Sanskrit, saur in Nepali), champ (Michelia doltsopa, swet champ in Nepali) and magnolias (genus Magnolia, especially Magnolia campbellii). Thickets of brambles (family Rosaceae) including blackberry (Rubus fruticosus) and several types of epiphytes with gooseberries (genus Ribes) are also found in this section. True boreal forests of pines (genus Pinus, dhupi in Nepali, neet kung in Lepcha) and larch (Larix griffithiana, saar in Lepcha) are grown at some selected places, especially above Rimbik, Rammam and Samanden. Some Hemlock trees (Tsuga dumosa, semedung in Lepcha) are also found over the ridges at and around 2800m. A variety of large fungus (genus ganodarma) is grown on these trees with their hard, fan out mushrooms. It is perennial in nature and occasionally consumed by local tribes.

The third and the highest belt is extended upward from 3000m which is ruled by fir (Abies densa, gobre salla in Nepali) –the tallest tree (more than 45m) grown over the



1a. Everest group: from Sandakphu



1b. Kangchendzonga massif: from Sandakphu



2a. Manebhanjyang: The Thrust-end of the Southern Singalila Range



2b. Busy terminus of landrovers: Manebhanjyang



2c. Lamedhura



3a. Meghma with its old homestay



3b. Tonglu peak with its Trekkers' hut



3c. Jaubari



4a. Gahribas



4b. Kalipokhri, Sandakphu peak on the background



5a. Bikhebhanjyang



5b. Winding road towards Sandakphu



5c. Sandakphu after a snowfall



6a. Morning glory of Kangchendzonga: from Sandakphu



6b. Sabarkum danra, Singalila peak peeping behind it



6c. Rounded Topography: in between Sabarkum and Phalut



7a. Chandupokhri- 2001



7b. Phalut peak



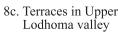
7c. Trek-path from Molley to Samanden



8a. Open gorge of the mid-Rammam valley



8b. Rimbick







8d. Man-made dam on the Rammam