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Review of Literature

DURUNG DRUNG GLACIER BASIN, ZANSKAR: A GENERAL OVERVIEW

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ABSTRACT

Himalaya, the youngest and fragile mountain system on the earth surface, has a great influence on the climate control and most importantly the environment of our subcontinent. Globally it is believed that the climate change have greatly shown by the higher latitudes and thus the climatic changes in the Himalayan region gives an early warning about the change in the climatic conditions. Glacier studies help us to know about the fresh water reserves in the higher altitudes. Therefore, these studies provide us an information about the storage of the freshwater by monitoring the glaciers which gives the idea about the extension of the glacier in geological past and the present status.

Durung Drung glacier valley preserved almost all the glacial features which clearly shows the glacial activities performed by the glacier the past. Series of glacial features are preserved in the basin also shows that the glacier has change its course. The glacier took a sinuous turn in geologically younger times changing the direction of flow from NW to N-NE. The geomorphological observartions clearly support the past extension of the glacier and its present status.

Geomorphological features observed in the study area, suggests a complex set of landforms, the prominent being the cirques, crevasses, moraines, proglacial lakes, dead ice mounds / ice cored moraines, ice falls / ice cliffs, drumlins etc. beween the altitude of 4100 m and 6480 m amsl.

KEYWORDS :youngest and fragile mountain system , Geomorphological features .

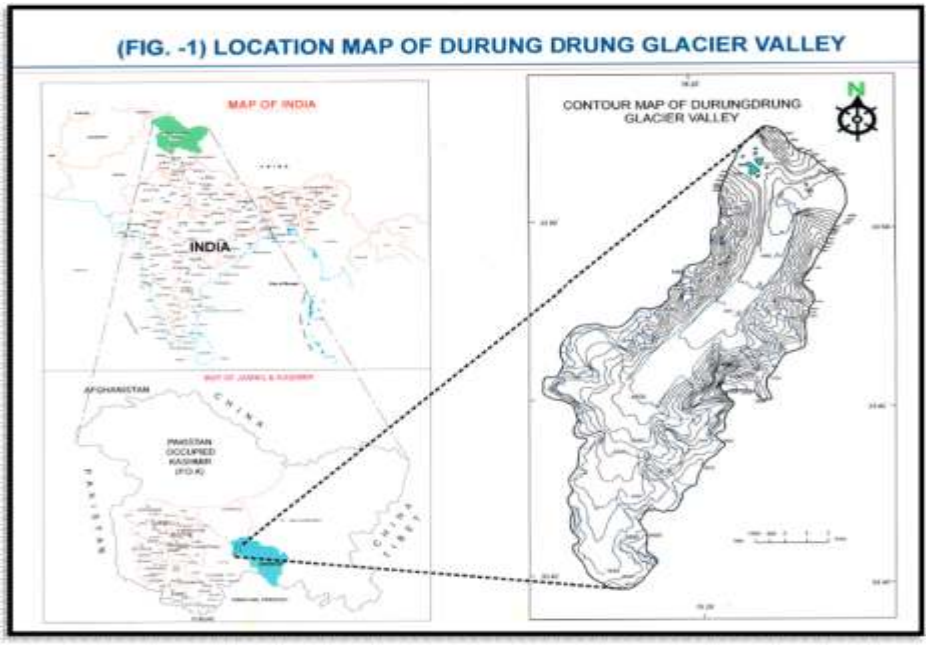
INTRODUCTION

Himalaya, the youngest mountain range, has a magnificent landscape with snow, glaciers and surging river systems covering an area of about 2400 kms spreading between Indus in northwest and

Brahmaputra in northeast. The Himalaya is a result of geological event that goes back to almost 60 Million years has attained its present elevation since 15 Million years that led to the initiation and establishment of a monsoon system in Asia. Pleistocene has been the time period when pulsating uplifts resulted in pushing Himalaya further up causing precipitation to be in the form of snow around the year giving rise to large glaciers (Valdia, 1993). The glacier regime of Himalaya as we see today is a shrunken phase in context of their large extension during Pleistocene. Himalayan glaciers comprise nearly 30% of glaciers outside the polar region and covers an area 20 times the glaciers of Alps (Wissman, 1959). In Zanskar ranges, about 268 glaciers are housed in an area of 1221.43 km^2 of Suru-Zanskar watershed. Durung Drung glacier is one the largest glacier of the Zanskar and second largest in India after Siachen.

STUDY AREA

Durung Drung glacier is situated in the southwest part of Zanskar which is confined along the Great Himalayan Range and Zanskar mountains. The Great Himalayan part of Zanskar basin contains some of the highest and steepest mountain slopes having a relative relief of about 2500 meters in the main valley and 2000 meters in tributary valleys, in a horizontal distance of nearly 3 kilometers. Durung Drung glacier is located in upper reaches of Durung Drung Tokpo enclosed by high mountain peaks namely Prul (5835 m) in southwest, Haskira (6520 m) in east and Kange (6090 m) in southeast. The south boundary of the valley is a water divide between the Suru basin (Indus) and Chenab basin. It lies between the 33^0 39' to 33^0 55' N latitudes and 76^0 15' to 76^0 25' E longitudes and is located in Jammu and Kashmir State (Fig: 1). It is confined between the two remotest villages of Zanskar (Rangdum and Akshoo), and is about 105 kms from the Tehsil head quarter (Padum). The glacier basin is on the road head of Kargil-Zanskar road connecting the National Highway 21- A at Kargil (Ladakh). The glacier proper is housed in the northern slopes of Himalaya and Zanskar. The glacier can be approached by Kargil-Zanskar road, which remains closed to vehicular traffic during the winter season due to the closure of Pensi La pass as a result of heavy snowfall. It originates from the altitude of 6090 m (south) to 4054 m (northeast) and covers an area of 136.46 km^2. The glacier is adjoining the Pensi La pass that connects Zanskar valley with Suru valley.



OBJECTIVES OF THE STUDY

The studied region has a different set of a landform features mainly produced due to interaction of glacial and fluvial processes. The topographic development is polygenetic in nature resulting in existence of various processes such as slow process of glaciation and fast fluvial. All processes have played an important role from time to time. Main objective of the paper is to provide the information about the various landform features in the glacier basin.

METHOD OF STUDY

The work is mainly based on field observation carried during the field work. Various landform features were observed and photographs were taken in the field. The photographs provide panoramic view of various parts of the study area. The whole area was surveyed and various features were observed in the glacier basin. All the observed features are plotted on the map.

GENERAL OVER VIEW

The present study deals with the geomorphologic observations in the Durung Drung glacier valley. Durung Drung glacier is the largest glacier (23.75 kms long) in the Zanskar basin and the second largest after the Siachen glacier in the state. It occupies an area of 72.83 sq.kms and ice volume of 7.283 km3. The glacier on an average is 2.75 kms wide and its headwall (6090 m) lying between the two great peaks that rise to 6545 m and 6135 m. The glacier proper commences from main ice field of Western Himalaya in the vicinity of Hagshu La pass and descends to 4192 m with mean slope of 15.60. The glacier is bird foot in outline and is northeast facing clean glacier having thin debris near snout along its eastern and western margins. The location of the glacier body is on Zanskar fault (South Tibetan Detachment System) that separates the Central crystalline of high Himalayas from the sedimentary rocks of Tethyan Himalaya. The reactivation of Zanskar fault has been responsible for up throwing the block on the west (Pensi La) compelling the glacier to turn north and northeast. The glacier body is criss-cross both by longitudinal and transverse crevasses. The lower section of the glacier body particularly in ablation zone Moulin and glacier tunnels are developed on the west flank. The eastern part of the glacier is covered with thin debris. Supra-glacial streams are as wide as 2.5 m and as deep as 5m on the surface of the glacier. The glacier body is punctuated by three steps at 4350 m, 4625 m and 4880 m asl that has resulted in the formation of three icefalls. Above the icefalls the residual snow pillars have been observed. The snout position of the glacier is highly irregular and is in bird foot form with the elevation ranging between 4170 m to 4192 m.

Durung Drung glacier has a distinct climatic condition transitional between that of central Asia and monsoonal land of south Asia. The region has a cold chilly winters and mild summers. During winter season the temperature drops to - 40^{0}C and it leads to the freezing of the Suru-Zanskar River completely and the people use it as a main route to Leh. This frozen route is called as Chaadar road.

The study region is located in high altitudes covered on all sides by high mountain ranges and the region is mainly located in shadow zone. Due to these orographic factors, the region has scanty vegetation comprising of few herbs and stunted shrubs in all sides. A good number trees particularly popular and willow has been planted under the aforestation program in the vicinity of perennial streams to stabilize scree cones and fine sediment cone produced due to mass wasting. The wet ground streams are covered with taxa mainly of Polygonaceae and Cyperaceae. The vegetation of the area is highly disturbed due to over grazing.

GLACIAL GEOMORPHOLOGY

Glacial geomorphology is the scientific study of the processes, landscapes, and landforms produced by ice sheets, valley glaciers, and other ice masses on the surface of the Earth. These processes include understanding how ice masses move, and how glacial ice erodes, transports, and deposits sediment. Landscapes and landforms that developed as a result of glaciation are the dominant focus of this field since they carry distinctive features and forms related specifically to glacial processes. Likewise, glacial geomorphology encompasses the impacts of glaciation upon floral and faunal evolution, modification, and distribution; and includes study of those areas peripheral to glaciated terrains, where drainage pattern alteration, climate, vegetation, and soil conditions are all severely affected by glaciation. This field includes studies of the causes of glaciation, the chronology of glaciation through geologic time (the retreat and advance of ice masses), glacial sediment stratigraphy.

Although the earth surface from outside are modified primarily by solar (geothermal) or gravitational energy. The science of geomorphology has two major goals, one is the scientific analysis of the landscape in context of energy that derives the landscape and second is to identify the evidences of changes in the process that have shaped them. Glacial geomorphology concerns the processes by which glacier shape the landscape and analyze the resulting glaciated landforms. Valley glaciers create unique, distinctive landscape by their vigorous erosional shaping of mountains. Durung Drung glacier has developed the landscape of Higher Himalaya and Zanskar in which tectonically stimulated fluvial erosion has produced a deepest valley with a relative relief of 3000 m. It is of fundamental importance in understanding both past and present glacial sediment system and associated geomorphological processes.

The Durung Drung glacier commences from the main ice field at an altitude of 6480 meters amsl, which is also the source of three more glaciers (Prul, Kange and Haskira). The Durung Drung glacier is the largest glacier in Zanskar basin and extends between the altitude of 6480 meters amsl to 4170 meters amsl and covers an area of 72.85 km^2 (accumulation area 40.6 km^2 and ablation area 27.15 km^2). The snout in the middle and west is calving and slumping. Durung Drung glacier and its valley is located on Zanskar fault that activated in Holocene period resulting in an up throw of the block on west (Pensi La), causing shift of the glacier from west to the north and further northeast. The sinuous course of the glacier resulted in the development of two moraine complexes, one near the present day snout and other in Pensi La in due west. The equilibrium line of the glacier ranges between an altitudes of 4902 meters amsl to 4910 meters amsl.

The Durung Drung glacier has a complex environmental conditions cold arid permafrost in the accumulation zone and glacial sub-arid in the ablation zone. The accumulation zone is primarily confined in cyclopean cirque zone, where valley walls are very steep and the rocks are highly jointed due to intense freeze and thaw action during summer. The rocks are subjected to intense pressure conditions at ice rock contact zone. The pressure conditions at a ice rock contact is a critical for mechanical weathering that produces supra-glacial angular fragments from the exposed valley walls. The angular debris falls on the surface of the glacier and ultimately leads to the soul of the glacier through basal melting. The basal slippage leads to sliding of the glacier at ice rock contact layer. The sliding of the glacier causes friction between ice and rock debris and debris is being dragged across. At certain thresholds, debris tends to stick to the bedrock rather than slide across which causes less erosion. The angular rock fragments in basal ice cut the striae and pulverize the material accumulate. The size of the fragments is more important since it controls pressure that can be exerted on bedrock and hence controls overall nature of erosion.

GLACIAL LANDFORM FEATURES

In Durung Drung glacier valley, different erosional features like roches moutonnees, striations, glacial valley and cirques were identified and studied in detail.

Striations and Polished surfaces

Striations are micro relief forms represented by 50m long scratches on the bedrock pavements. They are formed by abrading rock fragments carried in the sole of glacier ice. The intensity of marks depends upon the shape and hardness of the abrasion tools.

In the Durung Drung glacier valley, striations and polished rock surfaces are preserved along the valley walls as well as along the hanging valleys. The polished surfaces are plentiful in the valley at an altitude of 4150m in the vicinity of base camp and 4350m on the valley wall in front of the snout, bed rocks at an altitude of 4350 m in northern part of the glacier snout in the vicinity of Pensi La pass and also found in the western valley wall at an altitude of 4500 m. These are preserved on granite and slates. The striations can be prominently seen on quartzite boulders. The degree of rounding and faceting is to some extent dependent upon the size, but the nature of rock has played an important role. The quartzite boulders are frequently striated where as phyllites are rarely so. The general direction of the striations in Durung Drung valley is due NW.

Roche Mountonnees / Stoss-and-Lee Topography

Stoss-and-lee topography is a term for asymmetric bedrock prominences and small hills in a strongly glaciated terrain (Flint, 1971). The feature represents comparatively gentle abraded stoss slope and a steeper and rugged lee slope. The forms are longer than their width and attain height from less than a meter to tens of meters. The orientation of the long axis of Roches Moutonnees is roughly parallel to the direction of ice motion. They reveal the thickness of ice and indicate the sides, either stoss or lee as evidence by striae that was taken by ice.

The Roches Moutonnees are located at different altitudes in the study region and are observed near the fringe of glacial retreat. These are preserved at two elevation zones, one at 4150m and second at 4350m (Pensi La). The moutonnees near snout are 30m to 50m long, 25m wide and 15m to 20m high from the valley floor and in the vicinity of Pensi La they are 40 m to 60 m long, 35 m wide and 20 m to 30 m high from the floor. Their stoss side slope ranges between 300 to 400 and lee side slope from 600 to 700.

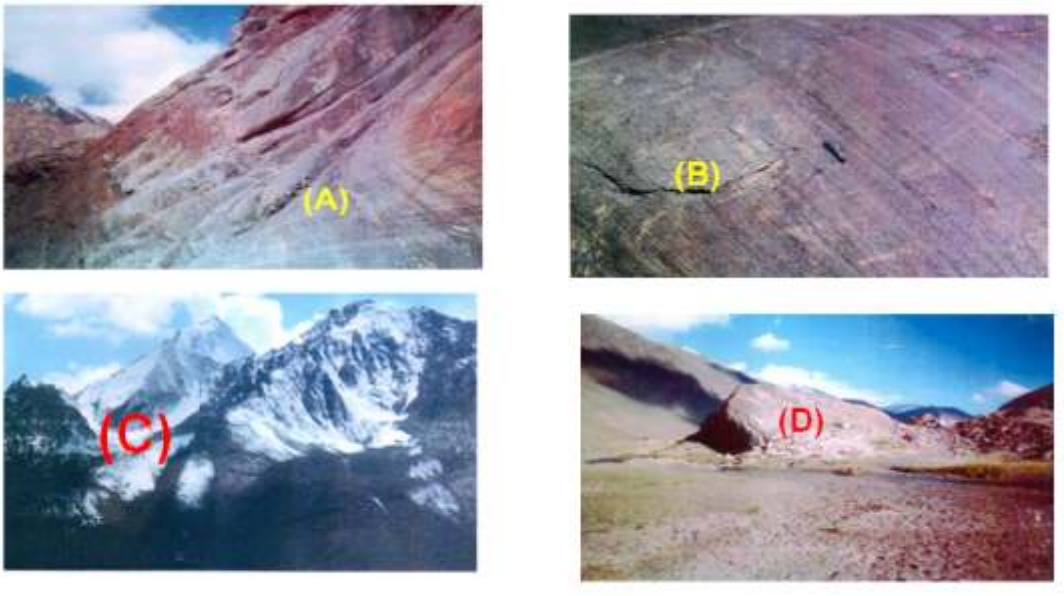
Cirque

The cirques are universal in occurrence in the glaciated mountain regions and the most recurrent worldwide feature in glacial landscape. Cirques have distinctive forms such as a steep back wall, a convex lip and a break of slope at the junction of cirque walls and rock basins. Cirques are indiscriminate in terms of lithology, however, they tend to expand in zones of rock joints and faults and cut deep into basins of soluble rocks like limestone and dolomites.

In Durung Drung glacier valley total fourteen big and small cirques have been identified in the field and investigated in detail. Two small size cirques covered with ice are confined in the eastern part of the valley and are identified as arm chair features bounded upstream by steep slope, but in open downstream, one large size cirque is present which joins the main glacier at an altitude of 5300 meters amsl. The break of slope between the cirque floor and mountain have been observed in the field and precisely located on topographic sheet. One inaccessible ice-filled cirque located in the southern part of the valley from where the main glacier commences from 6090 m to 5240 m and is cyclopean cirque

(one above another), second cirque has commences from 5200 m. In the south western part of the glacier valley two big cirques are located commence from 5700 m and joins the main glacier at 4840 m and 4880 m. Remaining six cirques are located in the western part of the glacier valley having their orientation towards SE direction. The various geometric dimensions pertaining to the length, breadth and height were measured for individual cirque. Height of the lip was measured with altimeter and orientation of cirque floor by compass.

The large cirques are located at higher altitudes (upper section of valley) between 6400m and 4800m. These cirques house the two accumulation lobes of Durung Drung glacier from where the glacier proper commences. The lip of the cirques is confined at an altitude of 5240m. The cirques in this section of the valley have south-northwest and west-southeast orientation. Cirque stairway has been identified in the right lobe of the cirque. The higher small cirque is 750 m long and its headwall is 120 m high. The lower cirque is 1750 m in length and 650m in height. Further three cirques are located in the middle section of the valley on western side of the glacier valley between the altitude zone of 5400m and 5000m along the western margin of the main glacier. All the cirques are covered with ice and act as avalanche type glaciers during the winter season. Only scree cones apex can be seen at the lip of these cirques due steep slope. They are free from moraines. The valley wall is uneven and rough, which is attributed to the freeze and thaw action resulting to the shattering.



Picture (A) and (B) shows striation marks, picture (C) shows cirques and picture (D) shows roche mountonnees.

The headwall of the cirque rises up to 125 meters to 650 meters. The lips cirques are developed 5m to 10m high from sloping valley. All the cirques are primarily carved in phyllite and quartzite and are well developed.

GLACIAL DEPOSITIONAL LANDFORM FEATURES

The principal depositional effect of moving glaciers is that they carry with them loose material which is deposited eventually. The material is supplied to the glacier body by the processes of entrainment and transport. These two processes impart distinctive fabrics to glacial sediments. Due to

ice flow the elongated stones in the debris tend to become oriented in the line of ice flow and analysis of such fabrics has become a major field of investigation. The glacial depositional features are created directly by advance and retreat of glacier. They therefore provide much of the information about the glacial history. The advance and retreat in the glacier are closely related to glacier mass balance. Positive balance leads to the advance of glacier. During the advance, the glacier deposits the excessive load on either side in a linear fashion in a longitudinal form. During negative balance the glacier produces inter woven debris across the glacier valley. The volume of deposition therefore is closely related to the material supplied through weathering and erosion and carried forward by supra-glacial, sub-glacial and en-glacial means.

The detail study of glacial chronology of Himalaya including Karakoram was initiated early in this century by pioneering work of de Philipi's expedition to Himalaya, Karakoram etc. (Daneili, 1922). On the basis of mapping of Indus especially Skardu a fourfold glacier sequence was proposed. Sangewar (2001) worked on the glacial landforms of Himalayas where he recognized maximum glacial advance during last Pleistocene. The quaternary glacial history of the Zanskar Range of NW Himalayas have been studied by Osmaston (1975, 1994), , Owen et al. (1998) and Sharma et al. (2008). They have identified broad U-shaped valleys with subdued moraine ridges and other glacial landforms of the region. Ganjoo and Koul (2005) studied the moraine structure of Zanskar and Nubra valley and related their morphology to the climatic characteristics.

The Durung Drung glacier valley has nearly 60% of the total area by glacial depositional feature particularly by moraines and all. The majority of the morainic soils contains sub rounded to rounded rock fragments brought from valley heads and valley walls of higher Himalaya and Zanskar mountains. The high degree of sub rounded particles exhibit that, rock particles have resulted from short distance movement of sediments by sub-glacial and en-glacial means. The concentration of high percentage of finer material in the glacial matrix in the vicinity of present day snout clearly reflects that supra-glacial channels are primarily fed by sub-glacial means particularly by basal melting routes. It also reflects that abrasion is the major erosional agent that shapes the landscape and produces lot of rock flour that finally entrained in the glacial streams.

Major part of the glaciated landscape is covered by moraines arrange in ridges parallel to each and also to the sides of the valley. These ridges stretch from an altitude of 4054 m to 4880 m in the valley. These morphological features produced at the margin of the active glacier ice clearly document the phases of glacier retreat and approximate thickness of the glacier during its maximum advance. Subsequent retreat of the glacier and its shrinking has resulted in the deposition of ice marginal features at different altitudes and heights within the valley. The distribution of moraines also reveals a close relationship between the landform orientation and ice flow direction. The study also shows typical distribution of non-stratified till in the moraines. Four principle groups of moraines identified in the field are terminal (end), lateral, medial and fluted ground moraines.

SUBGLACIAL LANDFORMS

Lateral moraines

Lateral moraines are the most eminent depositional morphological feature that can be seen in a valley glacier. They are evident along the sides of the valleys, but these have much poorer chance of surviving. Hill slope movement and subsequent rock falls combine to obliterate them. The debris is primarily derived from valley sides as rock fall than the glacial erosion, is stranded at the glacier's side margins. The ablation rate of the ice under the debris cover is reduced in comparison to the exposed ice surface. Hence when the glacier shrinks, the clear ice near the center will melt at faster rate than that at

the edges. Consequently, an ice cored ridge is left in place of original glacier surface, sloping towards the valley wall. A line of debris or moraine, marking the earlier longitudinal edge of the glacier is finally left when the ice core melts. Therefore lateral moraines are particularly helpful in documenting the extent of post glacial advances.

The lateral moraines are the commonest feature in the study area and are primarily in the form of thrust ridges. They extend from an altitude of 4160 m to 4880 m and show distinct gradation in height and width from the valley head to the valley bottom. The discontinuity in the moraine ridges are observed particularly at the low levels due to the movement of material of the upper hanging moraines. Moraines are also breached at several places by scree cones. In the vicinity of hanging valleys, the lateral moraines form an arcuate loop having a box like pattern. This pattern indicates controlled deposition and orientation with regard to the direction of movement of ice.

According to their locational and dimensional characteristics, they are categorized as high, medium high and low lateral moraines. The low lateral moraines are confined to the upper part of valley low heights. High and medium high lateral moraines are located in middle and lower part of the glacial valley. They have greater heights (80 m) from the valley floor.

Medial moraines

Two well developed medial moraines have been identified in the study area. First is in the vicinity of the main glacier valley and second is present in the vicinity of Pensi La. The medial moraines on the glacier body have a varying height ranging between 20 m to 45 m and their length is 6.75 kms located between 4200 m to 4620 m. Medial moraines are not in singular linear pattern, they are present in three rows one starts from the altitude of 4620 m and reached to 4470m in the western part, second starts from 4560 m to 4350 m in the eastern part and in the central part it starts from 4420 m to 4200 m. The orientation of the medial moraine is due east up to the altitude of 4400 m from where they are showing northern orientation then after 4300 m they again shifted its direction towards the east and is in arc shape.

In the vicinity of Pensi La (4480 m) with the length of 1.5 kms and the height ranges between 30 to 45 m, along with series of terminal moraines. This medial moraine divides the Pensi La area into two equal parts from its valley walls. This moraine is well settled having vegetative cover of grasses and some shrubs. There are pro-glacial lakes that have been developed on either side of the moraines of varied dimensions, which are further divided into small size lakes by the terminal moraines. These moraines are not likely to remain permanent feature and are likely to be distorted with the retreat of glacier shrinks. The medial moraines in the glacier indicate the direction of ice movement to northeast (4620 to 4420 m) to northern direction (4400 to 4200 m) and further moves to northeast direction. Crystalline rocks dominate the rock fragments in the medial moraines.

Terminal/ End moraines

The end moraines in the Durung Drung glacier valley are markedly located in trough between the depression and outermost steep edge of the valley. They owe their formation due to both pushing as well as dumping. Majority of end moraines have been partly destroyed by the glacier melt-water stream or obscured by later glacio-fluvial deposition. The form of end moraines indicates the role of ice and water in their deposition and the extent of their dissection. The debris of the moraines is primarily composed of granites, phyllites, sandstone and schist inherited primarily from the valley walls and valley head. The boulders and pebbles occupy the major share of the debris. Ablated boulders can also be seen in the morainic till.

Two push end moraines have been observed in the Durung Drung glacier valley during the field visits. They are confined to smaller area of the valley section extending in elevation at 4165 m. They are prominent and their height rises between 2.5 m and 3 m. The dumped moraines have been formed all along the valley from the altitude of 4160 m to the vicinity of base camp except the section under push end moraines. Four series of dumped moraine ridges have been observed near the snout (4165m). These ridges are almost at regular levels and primarily comprise of angular fragments. The moraine loop at an altitude of 4150 m is highly deflated and the axial streams have removed most of the soil matrix. Parts of the moraine are also covered by vegetation.

There are series of terminal moraines that are deposited in the vicinity of Pensi La area, which is the palaeo path of the glacier. These terminal moraines are deposited in three sets at different altitudes while the glacier was shifting its course from west to the present day direction. The first set is at an altitude of terminal moraines deposited between 4400 to 4480 m having an average height of 15 to 25 m.

Inter-Morainal lakes

In the study region the large number of inter-morainal lakes is formed in the Pensi La area where the glacier left behind a series of terminal moraines with a 1.5 km long medial moraine in the middle section of the Pensi La. There are large number of inter-morainal lakes which were formed during the retreat of the glacier. But many of the lakes have been dried up; only 9 lakes are present which are remained with water. A large medial moraine (1.5 km) divide these inter-morainal lakes from each other and increases their number. The shape of the lakes is somewhat like horse shoe and is fresh water lakes.

In the study region number of inter-morainal lakes have been observed in the vicinity of Pensi La area where they are present well in between the series of terminal moraines which were deposited by the glacier while it revert back from its original flow direction. These lakes are divided by a long medial moraine which is also an outcome of the glacial shift. They are situated at an altitude between 4450 m to 4400 m spread all over the upper Pensi La area.

Pro-Glacial lakes

Whenever glaciers impede drainage, topographic closure may occur, resulting in the ponding of runoff. The term ‘pro-glacial lake’ has been used for lakes that owe their existence to the presence of a confining glacier margin (ice-marginal lakes),and for lakes that were strongly influenced by glacial melt water.

Ground Moraine

A ground moraine is a feature almost entirely of basal till which at places may be capped by ablation drift. Ground moraines develop extensive areas of flat to gently rolling terrain, such as in parts of Europe and North America. The underlying bedrock topography and the pre-glacial valley systems over which the Pleistocene continental glaciers moved are partly or completely covered by a variable thickness of till. In topographic depressions and broad pre-glacial valleys, the till is thickest. In areas of moderate to strong relief only a thin coating of till covers the slopes. If the till covers is thin enough to reflect the underlying bedrock, the ground moraine is known as till sheet.

Ice Cored moraines or ablation moraines

In Durung Drung glacier valley ice cored moraines are found in the vicinity of the snout of the

glacier. They are present in the front portion of the snout at central part and are also in the eastern part, of varied dimensions and shapes. Their length stretches to 150 m in the central part, and height ranges between 5 to 35 m with a width of 15 to 35 m and in the eastern part there are two ice cored moraines has been observed with different heights. The ice cored moraines in extreme east has a elongated shape with length of 70 m, its height ranges between 20 to 25 m and the other ice cored moraine has a height of 20 m and its width is 25 m. These ice cored moraines has become calmy mounds when the ice gets melted out with the passage of time.

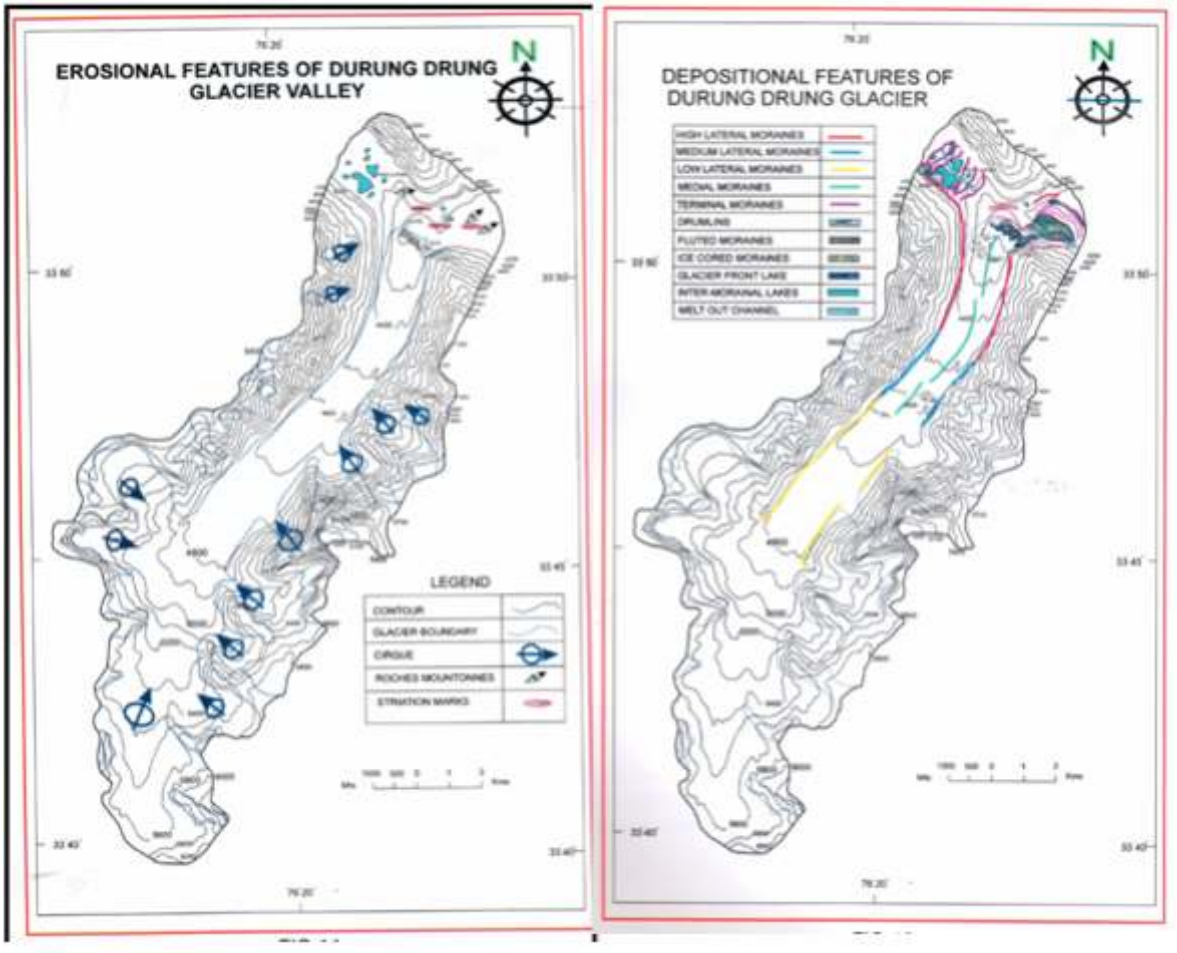
Crevasse Filled Ridges

Durung Drung glacier has two crevasse filled ridges in front of the snout of Durung Drung glacier. There distance in between ranges from 1 to 2.5 m. They are mainly formed by debris deposited in between the crevasses and these crevasses get detached from the main body of the glacier and move towards the material deposited by the glacier. These ridges are small in their height ranging between 1.5 to 2.5 m, they are 80 m long. These ridges become ice front cones in the first phase and then deposited in the form of dump moraines in the second phase.

Drumlins

A drumlin (derived from the Gaelic word druim (“rounded hill,” or “mound”) is an elongated whale-shaped hill formed by glacial ice acting on underlying, unconsolidated till or ground moraine. These are smooth, low streamlined hills of bedrock or of stratified and non stratified drifts, with long axis parallel to the movement of the ice, with the blunter end facing into the glacial movement. They lie well inside the margins of end moraines. Drumlins occur in areas affected both by continental glaciers and broad temperate valley glaciers. Their shape varies from elongated ridges to mamillary hills. The size of drumlins varies from one drumlins field to the other

A drumlin fields have been observed in the vicinity of Pensi La area. In the southern margin there is a huge drumlin field having number drumlins formed between the lateral and terminal moraines between the altitude of 4480 to 4460 m, due to which numbers of small inter morainal lakes have been developed, out of which some are dried up and some have little water in them. There height ranges between 20 to 30 m, and are elongated in shape. There length is almost equal to each other ranges between 25 to 35 m and width between 15 to 20 m. It reveals that the glacier has not show any dynamic activity, it was blocked by some obstacle resulted that it stood there for some time and deposited its carried material.



CONCLUSIONS

The major findings drawn from the present studies suggest that the study suggests that Durung Drung Mustagh was peripherally closed valley during the geological past and was under the huge cover of ice and present day the glacier is the shrunken phase. The glacier is trilobite compound, comprising of 14 tributary glaciers in all, five glaciers joining the main glacier body along the east and two glaciers joining the glacier body along the west and seven glaciers are confined at higher altitudes as hanging niche glaciers. The glacier commences from the ice field of western Himalaya in the vicinity of Hagshu La pass and descends to 4177 m with a mean slope of 150. It is north facing clean glacier (23.75 km long) having thin debris along an eastern and western margin near snout. The glacier snout is located at an altitude of 4177 m is almost at a distance of 1 km from the road head. The glacial erosional landscape of the valley is characterized by distinctive erosional feature with striation etched on their surface. The higher concentration of erosional features and striation marking on its bed in the middle section of valley is suggestive excessive erosional intensity. The striation markings are etched along the eastern and northeastern face of the rocky mound at an altitude of 100 m above the valley section. The striation marking suggests that substantial ice was generated by the growth of large transfluent glaciers having a minimum thickness of above 100 meters. The distribution of Roches mountonnees at two altitude zones (4150 m and 4350 m) of Durung Drung valley are suggestive of two glacial advances experienced during Late Pleistocene/Holocene epoch. The striation marking on top of the base camp mountonnees (4150 m) indicate about its extension and thus they provide undisputed information regarding vigorous

glacial action. The characteristic clustering of cirques at two altitudinal zones (5400 m and 4920 m) of the valley document two former period of cirque occupation levels. It clearly reflects the snowline depression during Holocene 480 m. They closely corroborate with the two altitudinal zones of Roches mountonnees and steep risers of the valley. Examination of depositional landscape reveals close relationship between landscape orientation and ice flow direction. The high lateral moraine takes a sinuous course at an altitude 4450 m towards Pensi La pass up to the altitude of 4160 m. Whereas eastern high lateral moraine has preserved a curvature in its orientation towards west at an altitude of 4350 m. The moraines suggest that the Durung Drung glacier was extended to Pensi La valley on due west. This is further corroborated by the orientation of medial moraine on glacier body towards west. The palaeo direction of the glacier body due west has been estimated on the basis of presence of various lateral and terminal moraines along Durung Drung glacier valley. The medial moraine running from an altitude 4400 m to 4300 m over a length of 1.5 km, has developed a moraine morphology along its eastern and western side where four terminal moraines fused with the lateral moraine to develop serial of inter-morainal lakes of different shapes. A distinctive location of end moraine of dump and triangular ice cored moraines in the vicinity of snout provided evidences of slow retreat of glacier. It is primarily formed due to the accumulation of fine sediments below the fractured snout that leads to push the en-glacial material in early spring and subsequently depositing dump moraine on its outer fringe speaks of well slow secular retreat. The distinctive location of end moraines at two altitudinal sites followed by recessional moraine complex along the western margin of Pensi La section and third end moraine near the base camp (4150 m) provides an evidence of three separate phases of deposition during inter-glacial stage.

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