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Geomorphological evidences of fluctuations of the Bara Shigri Glacier in the Himachal Himalaya, India under Global Climate Change

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Abstract: *Characteristic geomorphological evidences, preserved around the snout of the Bara Shigri Glacier in the district of Lahaul-spiti in the Himachal Himalaya, suggest that this glacier underwent successive stages of fluctuation during its retreat after a considerable surge in the Little Ice Age under climatic deterioration. Three sets of conspicuous retreat moraines with varying sizes and extensions have been identified and interpreted. Fresh lateral and terminal moraines, extending from the snout of the glacier down to the Chandra River bed for a distance of about four kilometres, suggest that the maximum advance during the Little Ice Age took place down to that position and formed a temporary shallow lake to the west of the existing morainic ridge which dammed the Chandra River. The study also reveals that in the present day the glacier is shrinking alarmingly under the Global Climate Change. Occurrence of fresh hummocky morainic drift in the foreground of the retreating snout has been attributed to this contemporary rapid retreat of the glacier.*
Keywords: *Argillaceous metamorphics, Base map, Tethys Himalaya, Glacio-morphological characteristics, Little Ice Age*

I. Introduction

Characteristic geomorphological evidences preserved in the glacial environments in the Lahul-Spiti in Himachal Pradesh as elsewhere in the Himalaya suggest that more or less all the glaciers surged to a certain extent during the Little Ice Age and thereafter continued to retreat, the rate of which has reached at an alarming state in the present day. Early geographers (De Terra & Hutchinson, 1936), in their observations, suggested successive phases of glacial fluctuations (as many as four phases) in the Himalaya during the long period of the Pleistocene glaciations. Their reports are in conformity with the observations made elsewhere in the world. This author (Chattopadhyay, 1986, 2008a, 2008b 2010, 2011, 2012a, 2012b, 2013, 2016) has obtained similar evidences in the Eastern Himalaya. A section of the book of Roethlisberger (1986) deals with the Bara Shigri glacier. In this book the printed photograph of the glacier's snout area, taken in 1863 by P.H. Egerton, is considered as the oldest photograph of any Himalayan glacier. The Bara Shigri was first described by J. Calvert in 1873 (*cf.* Roethlisberger, 1986), and in 1893 Egerton and Tyacke (*cf.* Roethlisberger, 1986) wrote that the River Chandra was dammed to a lake by the end moraine (with ice) that existed as late as 1863. It has also been stated (Kick, 1972) that the period 1906-1980 was marked by the great recession of the Bara Shigri glacier. This paper discusses the glacio-morphological characteristics of the Bara Shigri Glacier of its existing snout and the surrounding areas in Lahul-Spiti as studied in recent decades. The study was undertaken in order to interpret the geomorphological features developed down the valley as a result of the fluctuations of this glacier from its state in the Little Ice Age, during the period extending from the 16th to the 19th centuries (Lamb, H. H., 1972, Matthes F. E (1939). Field investigations, conducted over the last 30 years (in 1988, 1992 and 2010) was concentrated on identification of the lateral, terminal and hummocky morainic ridges and humps built by the glacier and the associated supra glacial deposits occurred around its present snout position. A Geomorphological map has been prepared upon the field investigation on the base map of Survey of India Topo-sheet (1:50,000).

II. Bara Shigri glacier and its physical environment

Bara Shigri Glacier, located in the Chandra valley of Lahul-Spiti district, is the largest glacier in Himachal Pradesh which feeds the Chandra River with the water channel. Its original length was more than 25km and width of about 3km near its snout part at its maximum. This glacier occurs in the long trough of deep valley extended through the Pir Panjal Range at southeast-northwest direction and is fed by numerous small tributary glaciers descending from the mountain slopes on its both sides. The glacier itself is surrounded by high mountains on three sides.

2.1 Geographical environment of the study area

As a part of the inner Himalaya the relief of the Lahul-Spiti area is characterized by the occurrence of lofty mountain ranges (parts of the Zanskar Range) often rising above 6,400m (21,000ft) with extensive snowfields giving rise to numerous valley glaciers and neveé fields. Fantastically deep gorges, mountain slopes often covered with frost-shattered rock debris and morainic drifts, and high rising cliff-walls are the characteristic landform features of this part of the Trans-Himalaya. Being situated in the rain-shadow of the Pir Panjal Range the area is markedly deficient in rainfall and thus remains almost completely barren: a feature very much in common with that of the Tibetan landscape.

Geologically this region falls within the Tethys Himalaya with complex folding and exposure of a wide variety of metamorphic rocks. The base of the sedimentary column is formed by argillaceous metamorphics, where mica-schists predominate. Clay-slates and pinkish quartzites occur in horizons (Gansser, 1964). The name Bara Shigri originally comes from the Lahuli term meaning the 'Large Glacier' (*Bara* meaning Large and *Shigri* meaning stream of snow and ice). The southern border of the uppermost part of it is located near the ridge summit of the Pir Panjal that forms the barrier between Kullu and Lahul-Spiti districts. The source of the glacier lies at an elevation of 6,632m (21,750 ft), at 32°06′N & 77°44′E. As many as eleven large and small tributary glaciers contribute to the volume of the Bara Shigri on its extension to the north. Existing snout position of the glacier rests approximately at 4,000m (13,120 ft) elevation and at a distance of about four kilometres from the Chandra river bed.

Figure 1 about here

Fig. 1 Image of the area around the snout of Bara Shigri Glacier

III. Present observations

Observations were made by this author in the field with the help of an accessible base map of the area. Major glacial and associated landforms were detected and on the basis of these a geomorphological map (Figure 1) has been prepared. The major points of geomorphological observation have been analysed here.

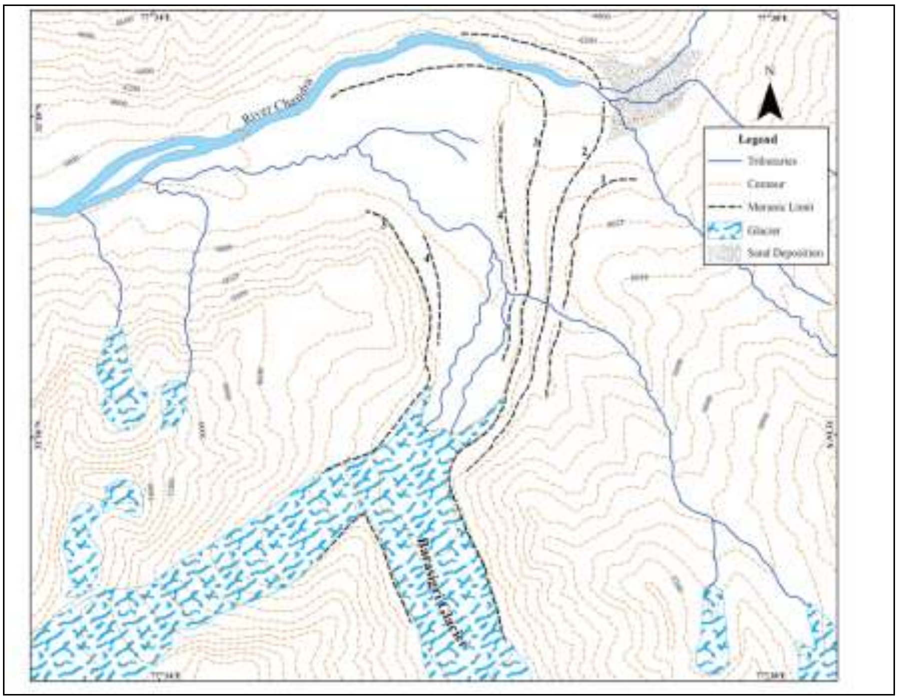

Fig. 2 Extent of distinct morainic landforms and associated features around the Bara Shigri glacier snout

3.1 Observations on the geomorphological characteristics of morainic ridges

As one approaches from the north-east through the Chandra valley one has to traverse at least three distinct sets of morainic ridges (Ridges 2, 3 and 4 in Figure 1) before entering into the enclosed valley of the Bara Shigri glacier. The first ridge to negotiate (Ridge 2) is rather low, rising hardly above 5m from the surrounding ground level. This is formed by the rubbles of angular blocks (pink quartzite and clay-slates) with very little amount of fines. This ridge extends from the hill slope though the valley, down to the bed of the Chandra River. The farthest and dissected part of it is noticed to have extended up to the opposite side (right bank) of Chandra in the form of a terminal moraine.

The second set of morainic ridge (Ridge 3) lies at about half a kilometre farther to the west. This ridge rises much higher (appx. 20m) above the surrounding ground and is composed of fresh-looking blocks of gneiss and schists. This continues from the snout area of the glacier, in parallel with the Bara Shigri stream down to the

Chandra River where it turns westward. A third but relatively insignificant ridge (Ridge 4) of lateral moraine can be seen further to the west in the valley. The left side of the Bara Shigri valley is much steeper showing exposed rock-wall and, ostensibly due to-slope washing, paired morainic ridges are not distinct. Only two sets of lateral moraine were detected on this side, the uppermost of which (Ridge 3) corresponds with the outermost morainic ridge on the right bank of the Bara Shigri stream (Ridge 3) as has been reported above. Humps of small hummocky and ground moraine are occur all over the valley floor through which the braided channels of Bara Shigri stream is flowing down to meet the Chandra River.

IV. Interpretation and consolidation

Existence of the above morainic ridges with their typical locations, extensions, varying thickness and elevations can be interpreted in the following manner. The first ridge (Ridge 2) of moraine can be attributed to the maximum limit of the 'Little Ice Age' glacier advance. This is in conformity with the view of Egerton & Tyacke, 1893 (*cf.* Mayewski and Jeschke, 1979), who maintained that the Chandra River was dammed to a lake by this glacier advance during the Little Ice Age. The observed scattered deposits of verved clay materials around the Chandra river bed adjacent to the morainic ridge (Ridge 2) bear clear evidences lake deposits. However, the low height of the morainic ridge across the river bed suggests that at the maximum stretch, although the glacier temporarily chocked the flow of the river, it was just sufficient to give rise to a shallow lake of temporary form. One possible way by which the lake ceased to diminish was by the water flowing over the ice-barrage. This has been common for the lakes held up by the sub-polar and temperate glaciers (Maag, 1969 *cf* Grove, 2003; Sissons, 1979). Several instances of Glacial Lake Outbrust Flood have also been reported from many glaciated parts of the higher Himalayan regions (*viz.,* ICIMOD, UNEP (2002).

Fig. 3 Debris covered snout part of the Bara Shigri glacier

Fig. 4: Exposure of clay and sand materials to the west of the barrier of lateral morainic ridge showing the evidence deposits of former moraine-dammed lake

Occurrence of hummocky moraines and associated till deposits in the Bara Shigri valley in between the glacier snout and the Chandra river bed can be described as the record of the glacier's oscillation during the period of its retreat from its maximum extension in the Little Ice Age. Presence of the second set of terminal moraine (extension of Ridge 3) along the left bank of the Chandra River shows the position at which the Bara Shigri glacier terminus came to a temporary halt during the period of its retreat. If the maximum advance of the Bara Shigri glacier had culminated at around 1863 (Egerton & Tyacke, 1983 *cf.* Mayewski and Jeschke, 1979) then it can be assumed that the glacier has experienced a retreat of four kilometres during the last 157 years (till 2010). From other evidences and measurements (e.g. Bandyopadhyay, 1979) it can also be mentioned that this glacier is on a distinct and alarming rate of retreat in the present day.

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