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Modern pollen assemblages from Hamtah and Chhatru glaciers, Lahaul-Spiti, India: Implications for pollen–vegetation relationship in an alpine arid region of western Himalaya

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ABSTRACT

The present study deals with the pollen analysis of 25 surface samples, 15 from the outwash plain of the Hamtah Glacier and 10 from the Chhatru glacial valley, Lahaul-Spiti, Himachal Pradesh, India. The samples were collected in a linear transect from the respective sites at an altitudinal range of ~3200 masl to ~4000 masl. The area is a high altitude cold desert in the western Himalaya, characterised by scrub type of vegetation. The pollen assemblages reveal an overall dominance of extra local arboreals (conifers) over the local non-arboreals. Though it is a vegetation sparse area, the alpine meadow is well represented by the presence of non-arboreal elements, such as Rosaceae, Asteraceae, *Artemisia*, Lamiaceae, Poaceae, Apiaceae and Chenopodiaceae/Amaranthaceae. However, predominance of *Pinus* has been observed along with moderate values of *Abies* and *Picea*. The overwhelming values of *Pinus* pollen can be attributed to its profuse production and efficient dispersal through wind currents from the temperate forests and eventual deposition around the study sites. Temperate broad-leaved taxa including *Alnus*, *Ulmus*, *Betula* and *Corylus* are present in low abundance. The consistent low frequencies of fern spores, algal and fungal elements, and absence of aquatic and marshy taxa reflect the dry climatic conditions in the region. Impact of anthropogenic activities can be observed in the form of degraded patches of tree-line and evidence of extensive grazing. Palynological data from the surface samples is not coherent with the actual vegetation around the study area due to the prolific over-representation of extra local pollen over the local herbaceous taxa. Palynological studies have been initiated in the vicinity of Hamtah and Chhatru glaciers on sub-surface sediment profiles, and this data will be helpful in developing modern analogues for understanding the past vegetational changes with respect to palaeoclimatic conditions in and around the study area.

1. Introduction

Palynological studies demarcate the vegetational history of a region based on the premise that pollen/spores present in the sediments reflect the vegetation of the region through time. For reconstructing the vegetational history from sub-surface sedimentary profiles and to deduce past climatic changes, modern analogues are required with respect to pollen dispersal and vegetational distribution around the study area. Studies on modern analogues help in understanding the pollen production and preservation potential of the present vegetation with respect to climatic, edaphic, and biotic factors. A modern pollen dataset is useful for comparison between the past and present vegetational changes and is also immensely helpful in identifying and strengthening the interpretation of fossil pollen-spores recovered from the sub-surface sedimentary sequences (Wright, 1967; Flenley, 1973; Singh et al., 1973; Moore and Webb, 1978; Birks and Birks, 1980; Liu and Lam, 1985; Overpeck et al., 1985; Fall, 1992). Such modern analogues can be obtained through the pollen analysis of surface samples including surface soils/sediments, moss cushions, spider web samples, leaves, and bark that are conducive surfaces for catching the pollen rain. In this regard, comprehensive records on modern pollen assemblages and their relationship with the vegetation and climate are available from the tropical areas of Africa and Australia (Crowley et al., 1994; Kershaw

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and Bulman, 1994; Vincens et al., 1997; Walker and Sun, 2000); mainland neotropics (Grabant, 1980; Islebe and Hooghiemstra, 1995; Rodgers and Horn, 1996; Bush and Rivera, 1998; Weng et al., 2004); southern Brazil (Behling and Negrelle, 2006); central Andes (Rull, 2006); northern Ecuador (Moscol Olivera et al., 2009); tropical forests of Sri Lanka (Bonnefille et al., 1999). However, pollen rain data from the high altitude glaciated regions are somewhat lacking. From India, good data on modern pollen vegetation relationship are available from the tropical forests of south India (Anupama et al., 2000; Barboni and Bonnefille, 2001); tropical deciduous scrub vegetation in Rajasthan desert (Singh et al., 1973); northeast India (Basumatary et al., 2013, 2014); deciduous forests of central India (Quamar and Bera, 2014) and Andaman islands (Singh et al., 2010). However, a review of the literature shows that records from the Himalayan region are comparatively sparse (Sharma, 1973, 1985; Bhattacharayya, 1989; Gupta and Yadav, 1992; Chauhan and Sharma, 1993). From the Lahaul-Spiti region, only two palynological works are known, from subsurface profiles (Chauhan et al., 2000; Rawat et al., 2012). Moreover, modern pollen datasets from the glaciated sites in India are almost negligible except for a few reports from the Chota Shigri Glacier (Bera and Gupta, 1989), Pindari Glacier (Bera et al., 2011) and Gangotri Glacier (Ranhotra and Bhattacharrya, 2013). Hence, pollen analysis of surface samples from the Hamtah Glacier and Chhatru glacial valley, situated in the arid temperate zone of western Himalaya, has been taken up in this study to generate modern analogues which are a prerequisite for Quaternary climatic interpretations.

2. Regional setting

The Hamtah Glacier is a north–westerly flowing valley glacier in the Lahaul-Spiti District of Himachal Pradesh State, India and is situated between 32°17′00″ and 32°13′00″ N and 77°21′00″ and 77°24′00″ E. It is located within the fifth order Chandra Basin of the fourth order Chenab Basin and is part of the first order Indus Basin (Geological Survey of India (2012)). The Hamtah Basin covers an area of about 35.25 km^2, of which the glacier occupies about 3.25 km^2; the Hamtah Glacier is the trunk glacier of the Hamtah Basin (Fig. 1). The glacier is approximately 6 km long with an average width of 0.50 km; the snout is located at an altitude of ~4020 masl. The glacier is approachable from Chhatru, the nearest road head, through a 8 km long foot/mule track along the Hamtah *Nala* (stream) joining the Chandra River. The glacier during the past extended to the Chandra River, as a tributary of the Chandra trunk glacier. Gradual recession has resulted in its present disposition. The glacier is bounded by both right and left lateral moraines of which the right lateral moraine is better developed and extends 4 km downstream of the snout, while the left one is broken beyond 1.5 km by debris cones. Higher levels of lateral moraines can be observed which indicate that the glacier has shrunk both vertically and horizontally since the last glacial. Multiple serrac faces, calving of ice blocks, dead ice mounds and series of recessional/terminal moraines are further evidence of the decaying nature of the glacier during the present interglacial. The area downstream the snout upto 2 km is characterised by a gentle gradient, with a typical glacial valley profile. This valley encompasses the outwash plain which is criss-crossed by melt water streams and bounded by fluvio-glacial terraces and lateral moraines (Fig. 2).

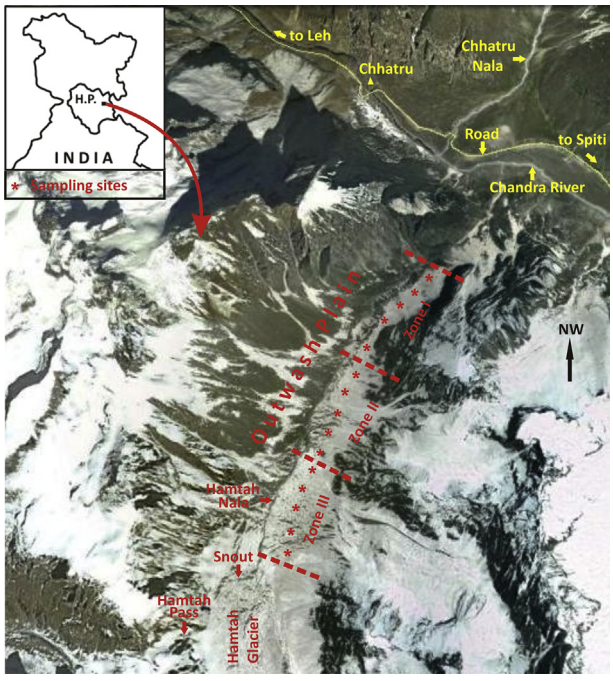

Fig. 1. Map showing Hamtah Glacier and location of sampling sites (Google Earth).

The Chhatru Glacier is located nearby (32°19′8″ N; 77°21′47″ E) on the opposite side of the Hamtah Glacier and has a southern orientation (Fig. 3). It is a comparatively small glacier that has presently receded to its cirque. During the past, it extended to the Chandra River as a tributary glacier and joined the Chandra trunk glacier. Presently, meltwater from the glacier flows in the form of a narrow stream, the Chhatru *Nala*, which joins the Chandra River opposite to the Hamtah *Nala*. The Chhatru Glacier during its retreat has covered out a hanging valley, which is littered with morainal debris. Due to relative steepness, lateral moraines, terraces, and outwash plain are not well developed. The Chhatru Glacier can be approached from Chhatru by a 2 km long track along the Chhatru *Nala* (Fig. 4).

2.1. Climate and vegetation

The area experiences cold dry climate, although the Southwest Summer Monsoon has been found to be active in the area during July–September. Hamtah Basin in particular receives much more rainfall as compared to rest of the Chandra Basin due to its closeness to the Hamtah Pass, which allows the passage of clouds into this otherwise rain shadow zone. The Western Disturbances are much more active and result in heavy snowfall during the winter months. Snowfall invariably starts during the end of September and continues to March/April. The entire Hamtah valley is normally covered with snow until May. The average temperature ranges from a minimum of −15° to a maximum of 28 °C (Geological Survey of India (2012)).

The Lahaul-Spiti District of Himachal Pradesh State, India, is a typical high-altitude cold desert, characterised by alpine scrub type of vegetation. In the western trans-Himalayan region, the alpine scrub vegetation occurs throughout a large belt at an altitude of 3000–4000 m, across Garhwal, Kumaon, Lahaul-Spiti and Ladakh regions, and merges in the north with the Tibetan Plateau. The alpine vegetation of India contains a number of plants that are common to the alpine regions of Europe. There are also central Asian, Tibetan and Japanese elements in the alpine belt of Himalayas (Puri, 1960; Champion and Seth, 1968). The flora has, over the years, come under excessive anthropogenic influence due to which the vegetation has been subjected to and is still under the process of degradation.

The region is a vegetation sparse area, and arboreal taxa are almost negligible. Conifers are conspicuous by their absence around the study sites. However, luxuriant coniferous forests are