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Late Pleistocene - Holocene vegetation and climate from the palaeolake sediments, Rukti valley, Kinnaur, Himachal Himalaya

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ABSTRACT

Vegetation and climate during later part of Pleistocene to major part of Holocene (~16.6–3.5 ka) has been reconstructed based on the palynological and magnetic susceptibility proxies from an exposed section of lacustrine deposit at Rukti, Sangla valley, Kinnaur, western Himalaya. Study shows that along with the general tree line succession to higher altitudes since early Holocene, the area has also captured the major climatic events of late Pleistocene to early-mid Holocene time. The area exhibits a continuation of mixed conifer - broadleaved forest at least since ~16.6 ka with intermittent phases of expansions of broadleaved tree taxa especially Oaks (*Quercus*) or invasion of conifers especially Pine (*Pinus*) with an increase (moist) or decrease (dry) of Indian Summer Monsoon (ISM) respectively. This is also supported by the variations in the magnetic susceptibility values. The climate was warm and moist during ~16.6 ka and changed to cool ~13.3 ka, followed by increasing ISM since ~11.5 ka. Distinct spike in the magnetic susceptibility values between ~8.7 and ~7.8 ka could correspond to global 8.2 ka cool event thus indicating strengthening of westerly influence and low evaporation. Subsequent warm conditions could be generalized by the advancement of Birch (*Betula*) line to higher altitude following the resultant retreat of the glacial body. Study has put forth the potential of such Himalayan sites to uncover the major climatic events of global correlation captured by various proxies within a region.

1. Introduction

The major climatic events during the late Pleistocene – Holocene are well reconstructed and teleconnected in many parts of the globe using various proxies (Alley et al., 1997; Alley, 2000; Alley and Agustsdottir, 2005; Cheng et al., 2006, 2009 and others). However, from the Indian Himalayan and Trans-Himalayan regions the data on such globally related climatic events is still limited (Juyal et al., 2004; Singh and Agrawal, 1976; Sinha et al., 2005; Owen et al., 2001; Rawat et al., 2012, 2015) that might restrict the better understanding of the dynamics of the south Asian climatic system and its teleconnection with the other climatic events occurring globally. The Indian Himalayan and Trans-Himalayan region is well characterized by the Quaternary sediments of glacio-fluvial and lacustrine depositional environments providing good archives for the multi-proxy palaeoclimatic reconstructions of the late-Quaternary time (Bhattacharyya, 1988; Brown et al., 2003; Pant et al., 2005; Phartiyal et al., 2005; Ranhotra et al., 2007; Demske et al., 2009 etc.). But very few study area from the Indian region covering the time frame since beyond Holocene has unraveled and discussed such major climatic events in global aspect (Demske et al., 2009; Dixit et al., 2014; Rawat et al., 2015). The Himalayan periglacial areas bear thick lacustrine deposits that might had formed by the impounding conditions of drainage either by reactivation of faults or due to debris flow and later got exposed by the lake-burst and subsequent entrenchment of the rivers. Many such Himalayan lakes covering a mapable area came into existence or terminated around LGM, such as in Kashmir (Agrawal et al., 1989), Kumaun (Kotlia and Phartiyal, 1999; Kotlia et al., 2010), Ladakh (Bhattacharyya, 1989; Fort et al., 1989) etc. Such deposits preserving the various biotic and abiotic proxies could be potential to reconstruct the past vegetation, climate vis-à-vis glacial episodes. Sangla Valley in Kinnaur district

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of Himachal Pradesh (Fig. 1) preserves the glacio-lacustrine deposits exposed to a large extent around the Sangla Town, Kamru and Kuppa villages that suggest the presence of a huge lake during past, which was formed due to the damming of the Baspa River. Ganjoo and Koul (2005) and recently Draganits et al. (2014a, b) studied these glacio-lacustrine deposits classifying them into various depositional facies suggestive of glacio-fluvial to lacustrine depositional environments developed by the ponding of glacial melt water. Probably, the lake was progressively filled and revived under the influence of climate as well as neo-tectonic activities, as evidenced by the presence of incised and eroded glaciogenic-lacustrine deposits by the entrenched Baspa River.

During recent years few studies (Bhattacharyya et al., 2006; Chakraborty et al., 2006; Ranhotra and Bhattacharyya, 2010) have been carried out from various tributary valleys within the main Sangla valley that relate to the palaeoclimatic reconstruction based on palynology and other proxies. The studies either cover the earlier part of Holocene, as taken from the Naradu glacier valley by Bhattacharyya et al. (2006), or not continuously resolved in the Holocene time due to palynological breaks in the records from the Rukti valley (Chakraborty et al., 2006). From the upper reaches of the Rukti valley, Ranhotra and Bhattacharyya (2010) attempted the reconstruction of past glacial extent during Holocene based on the tree line fluctuation. The recent study by Draganits et al. (2014a&b) shows the existence of huge lake since ~8000 till ~2000 ka when the lake got terminated. The later study is mainly focused on the tectonic settings and seismicity of the area as well sediment load and volume of lake considering the engineering aspects of the present running 300 MW hydroelectric projects I and II few kms downstream of Sangla town. In the same focus the climate part has also been discussed by Draganits et al. (2014a) using palynology, but with sample limitations. The present work, emphasized on the analysis of pollen and environmental magnetic data, unravels the vegetation history and major climatic events during late Pleistocene to mid Holocene from an exposed section of lake sediments along the Rukti stream and also discussed any teleconnection exists with the globally known climatic events of the time frame.

2. Study area

Kinnaur Province in the extreme east of Himachal Pradesh comes under the transition zone of the Greater and Trans-Himalayan Regions and experiences the effect of both Indian Summer Monsoon (ISM) as well as Western Disturbances (WD), the later being stronger compared to ISM. Geologically as a part of Tethys Himalaya (Bassi et al., 1983), the area is considered as a continuation of Lahaul-Spiti basin and south-east extension of Zanskar basin of Ladakh, Trans-Himalaya (Bhargava and Bassi, 1998). Sangla valley (31° 10′ to 31° 40′ N Lat. and 78° 05′ to 78° 45′ E Long.), also known as Baspa valley, is situated in the north-west part of Kinnaur district. The valley is intersected by the Baspa River that originates from the Arsomang and Baspa Glaciers at an altitude of ~4200 m amsl and after traveling the distance of ~72 km it joins the River Satluj at Karcham (~1890 m amsl). The Baspa glacier with a length of ~18 km is the largest glacier in the Beas and Sutlej valleys of Himachal Pradesh (Sangewar and Shukla, 2001). The basin holds

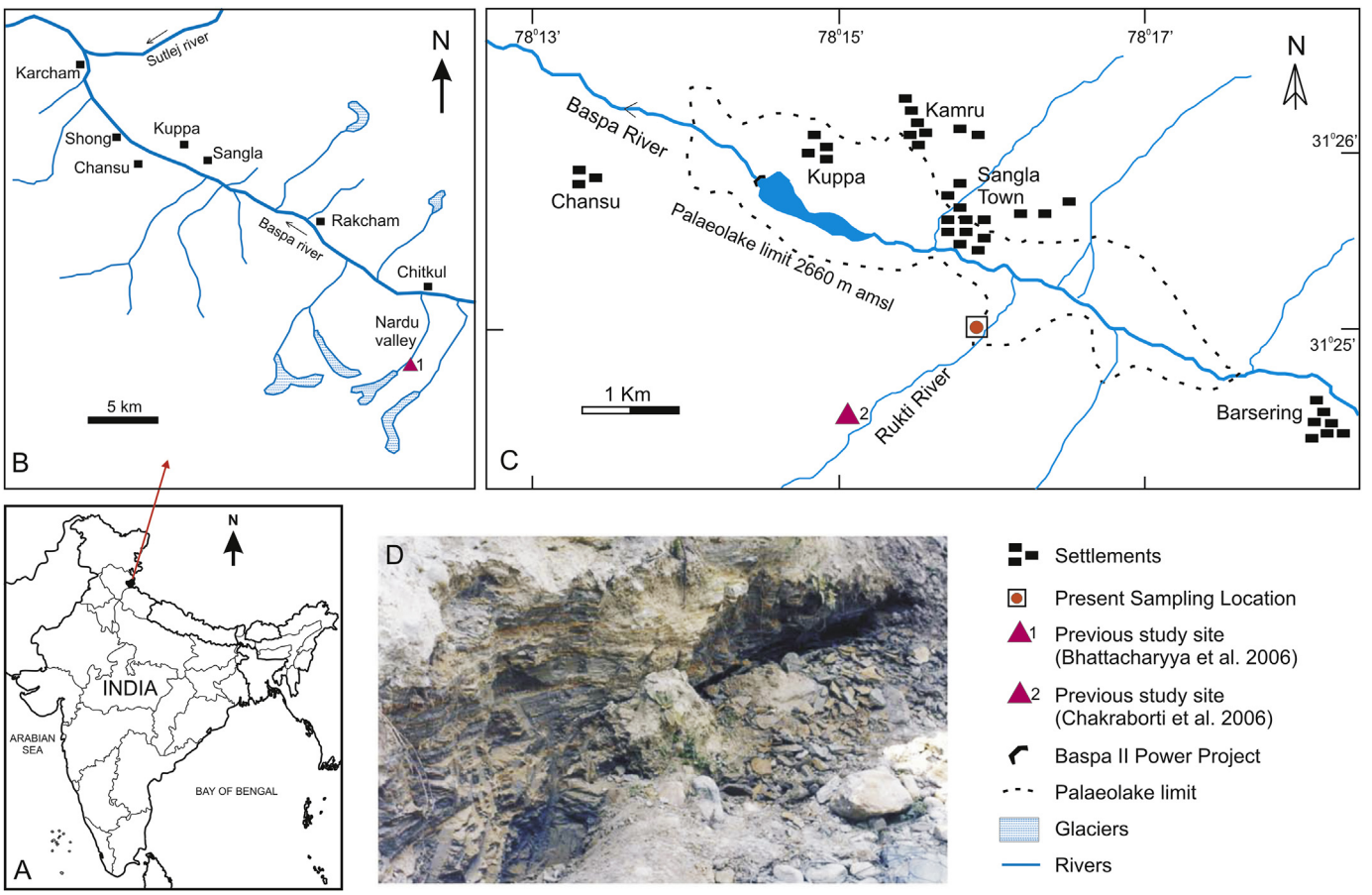

Fig. 1. A) Map of India with the location of Kinnaur. B & C) Site map of Baspa valley showing the sampling location along the Rukti river for present study and also the sampling location of previous studies. D) View of the exposed section of the lacustrine deposits along the Rukti river.

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