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Chronology of late Quaternary glaciation in the Pindar valley, Alaknanda basin, Central Himalaya (India)

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ABSTRACT

Palaeoglacial reconstruction based on geomorphological mapping in the Pindari glacier valley, Alaknanda basin (Central Himalaya), has revealed five glacial stages with decreasing magnitude. The oldest and most extensive stage-I glaciation deposited sediments at ~2200 masl (Khati village). The stage-II glaciation was around 7 km long and luminescence dated to 25 ± 2 ka, and has deposits at 3200 masl (Phurkia village). Stage-III glaciation is represented by degraded linear moraine ridges and is dated to 6 ± 1 ka and its remnants can be found around 3850 masl. A sharp crested crescentic moraine extending from around 3650 masl to 3900 masl is attributed to stage-IV glaciation and is dated to 3 ± 1 ka. Following this, there appears to have been a gradual recession in Pindari glacier as indicated by four sharp crested unconsolidated moraines (stage-V) on the valley floor which abuts the stage-IV moraine.

We suggest that the stage-I glaciation occurred during the cool and wet Marine Isotopic Stage 3/4 (MIS-3/4), stage-II glaciations began with the onset of MIS-2, whereas the stage-III and IV glaciations occurred during the mid-to late Holocene (MIS-1). We speculate that the first sharp crested unconsolidated moraines around 3600 masl correspond to the later phase of the Little Ice Age (LIA). Historical data suggests that the remaining three ridges represent Pindari glacier snout positions at 1906, 1958 and 1965. We argue that the late Quaternary glaciations in the Pindar valley were modulated by changing insolation and summer monsoon intensity including the LIA, whereas the 20th century recessional trends can be attributed to post-LIA warming.

1. Introduction

Mountain glaciers are important geomorphic agents. They create landforms and provide reliable evidence of cryosphere evolution, and contain important information on past depositional and erosional processes (Zhao et al., 2009). The Himalayan–Tibetan orogen is the most glaciated regions outside of the polar realm (Owen, 2009). Despite the importance of glaciation in high Asia, there is no strong regional pattern for the Himalayan glaciation. It is felt that there is a need for accurate reconstructions of the former extent of glaciers in order to provide valuable data for palaeoenvironmental modelling (Owen et al., 1997). Thus local glacial chronologies need to be developed to elucidate this. Kame terraces, wide ‘*U*’ shaped valleys, relict moraine ridges and proglacial lake deposits mark the extent of former glaciations. These features have been formed several km downstream of present day snouts (Owen et al., 1998). Most studies indicate multiple glacial advances in the Himalaya, quantitative estimates of their timing remained sparse. Due to the paucity of organic material in the moraines, conventional radiocarbon-dating has limited use (Owen et al., 2002). However, with the advent of optically dating technique, better understanding is emerging towards the factors responsible for glaciations in the Himalayan region.

Chronologically constrained evidence of past glaciations in the monsoon dominated Central Himalayan region are scanty (Sharma and Owen, 1996; Pant et al., 2006; Nainwal et al., 2007). Existing studies suggest that, during the late Quaternary, glaciers broadly responded to changing intensities of the Indian Summer Monsoon (ISM). It is important to mention that most of late Quaternary glaciation studies were from glaciers located in the transitional zone between the higher Himalaya and the Trans-Himalaya where the influence of the southwest summer monsoon is regulated by the orographic higher Himalayan barrier. However, the Pindari glacier is on the southern face of the higher Himalaya and therefore provides a rare opportunity to understand the temporal variability in ISM and its impact on glacier dynamics. In addition to this, the Pindari glacier is one of the few glaciers in the Indian Himalaya,

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which has been the subject of historical observations back to 1845 (Strachy, 1847). Sketches were drawn and a general description of the glacier provided. Further information was provided by Cotter and Brown (1907). During the mid and late 20th century, snout positions of this glacier was monitored by the Geological Survey of India in 1958, 1962 and 1966. A cumulative retreat of ~1040 m in the snout position has been suggested since 1906 (Tewari and Jangpangi, 1966).

Considering the above, the present study is an attempt to reconstruct the glacial stratigraphy, ascertain the chronology using optical dating technique and finally to ascertain the role of past temperature and precipitation changes in the monsoon dominated upper Pindar valley.

2. Study area and morphology

The 9 km long south facing Pindari glacier lies in between 30°16′15″–30°19′10″N and 79°59′00″–80°01′55″E (Fig. 1). The Pindar river originates from the Pindari glacier at about 3740 masl (position monitored in 2008) and meets the Alaknanda River at Karnaprayag. The present work has been carried out in the upper catchment of the south facing Pindari glacier area. The lithology of the glaciated valley is dominated by Higher Himalayan crystalline rocks belonging to the Pindari formation of the Vaikrita Group (Valdiya, 1999). The terrain has preserved diverse glacio-geomorphological features, both erosional and depositional These include the *U*-shaped glacial trough of trunk and tributary glaciers,

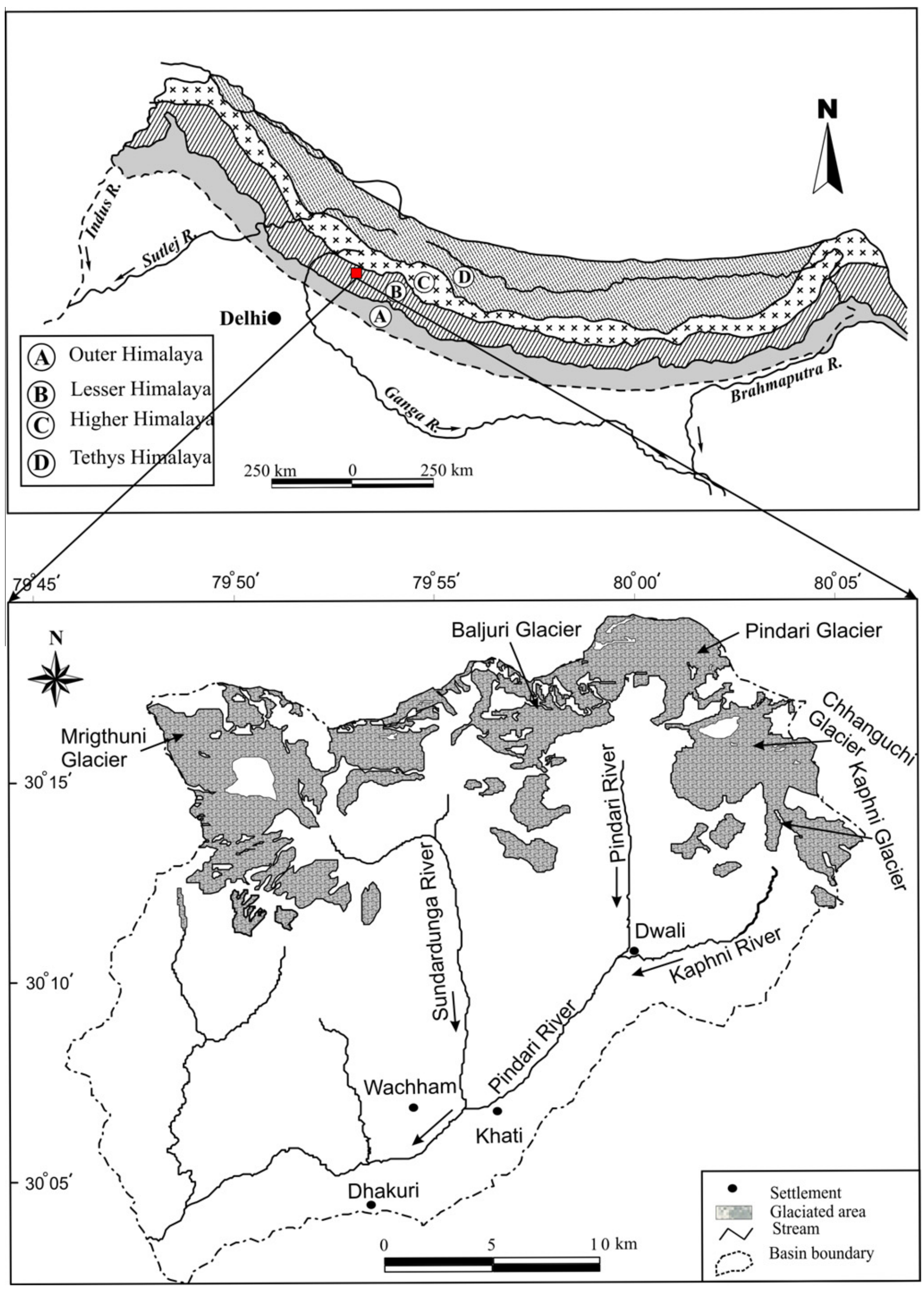

Fig. 1. Location map of the Pindari valley.