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ORIGINAL PAPER

Provenance, weathering, and paleoclimatic records of the Pliocene-Pleistocene sequences of the Himalayan foreland basin, NW Himalaya

Sajid Ali[1] · Binita Phartiyal[1] · Ajay Taloor[2] · Mohammad Arif[1] · Birendra Pratap Singh[3]

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Abstract
We present major oxides, trace element compositions, rare earth elements (REEs), clay mineral assemblages, and magnetic mineral parameters data for the siliciclastic fraction from the Upper Siwalik Subgroup (Parmandal, Nagrota, and Boulder Conglomerate formations) in the Tawi sub-basin of the Himalayan foreland basin, NW Himalaya in order to identify source rock compositions, continental weathering, and paleoclimate over the past 5.6 million years. The trace elemental ratios of Th/Co, Th/Sc, La/Sc, and Cr/Th suggest Upper Siwalik Subgroup sediments initially originated from a stable felsic source, which is possibly in the High Himalayan crystalline and Lesser Himalayan source regions. The REE patterns of the studied sediments with prominent negative Eu anomalies also suggest a felsic source for the Upper Siwalik Subgroup sediments deposited in the basin. The chemical index of alteration (CIA), plagioclase index of alteration (PIA), Rb/Sr ratio, and clay mineral assemblages as well as mineral magnetic parameters demonstrate the variable intensity of weathering and environmental conditions during the deposition of Parmandal, Nagrota, and Boulder Conglomerate formations between 5.6 and 0.6 Ma. The weathering proxy records of Parmandal (5.6 to 3.9 Ma) and Boulder Conglomerate (1.7 to 0.2 Ma) formations indicate relatively strong chemical weathering associated with the warm and wet climates in the source region. On the other hand, a decrease in chemical weathering intensity and change in environmental conditions during the formation of Nagrota formation (3.9–1.7 Ma) suggest a dry and cold climate in the source region.

Keywords Provenance · Weathering · Paleoclimate · Upper Siwalik · Himalayan foreland basin

Introduction

The Himalaya is undergoing widespread denudation that results in the erosion of a large amount of sediments to its foreland basin and to the Bay of Bengal and Arabian Sea (White et al. 2001; Galy and France-Lanord 2001; Clift et al. 2019 and references therein). The records indicate that the erosion and weathering of the Himalaya have been partially controlled by climate change and monsoon rainfall (i.e., Beaumont et al. 2004; Liu et al. 2007; Clift et al. 2008, 2019; Ali et al. 2015). The sediments of the foreland basin are more suited for studying changes in weathering intensity compared to the sediments of the Bay of Bengal and the Arabian Sea as the latter is a more complex mixture of materials derived from various sources (Ahmad et al. 2005; Clift et al. 2008; Cai et al., 2018, 2019; Clift et al. 2019). Moreover, the Himalayan foreland basin sediments are likely to provide better information because they may respond faster to the changes in the hinterland. The oxygen isotope records of the Siwalik sediments from the Tawi sub-basin of the Himalayan foreland basin, NW Himalaya indicate the variable intensity of monsoon precipitation over the Himalayan region during the Pliocene-Pleistocene periods (Singh et al. 2011, 2012). The geochemical records of erosion and weathering and their global importance during these periods from the region are still missing; hence, we present a multi-proxy continental erosion and

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✉ Sajid Ali
sajidali@bsip.res.in

[1] Birbal Sahni Institute of Palaeosciences, 53-University Road-226007, Lucknow, India

[2] Department of Remote Sensing and GIS, University of Jammu, Jammu 180016, India

[3] CAS in Geology, Banaras Hindu University, Varanasi 221005, India

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