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Paleoenvironmental insights into the Piacenzian from the Lower Karewa lacustrine sequences of the Kashmir Himalaya, India

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ABSTRACT

The Plio-Pleistocene lacustrine sequences of Kashmir Valley, NW Himalaya, represent one of the important terrestrial paleoenvironmental archives in the Indian subcontinent. However, their paleoenvironmental potential has not been studied in detail and thus represents an untapped reservoir of past climate changes. In this study, we integrated multi-proxy data, including phytolith assemblages, phytolith-based climatic indices (I_w, I_c, I_a), and major oxide geochemical data augmented with the previously existing magnetostratigraphy, to understand the depositional environment and the climatic conditions of the Pliocene Period, particularly the Piacenzian , from the basement sequences known as the Dubjan Member of Lower Karewa, Kashmir Valley, India. Phytolith assemblages indicate grass-dominated vegetation with mixed C_3 and C_4 grasses, reflecting shifts between warm and cool climatic conditions. This is augmented by Chemical Index of Alteration values (~62-78), implying moderate chemical weathering, closely linked to climate and vegetation changes. Sedimentological evidence also suggests deposition in a fluvio-lacustrine system with alternating low- and high-energy conditions. Climatic indices reveal alternating warm–cool and humid–dry phases, with a clear signal of the MPWP (~3.3–3.0 Ma) followed by increasing aridity associated with Northern Hemisphere glaciation, as reported elsewhere. The lacustrine sequences of the Lower Karewa thus provide a robust terrestrial record of climate–vegetation–weathering interactions during a critical phase of Plio-Pleistocene climatic transition.

1. Introduction

The Piacenzian (Late Pliocene; ~3.6-2.58 Ma), encompassing the Mid-Pliocene Warm Period (MPWP; ~3.264-3.025 Ma), was a globally significant climatic interval characterized by temperatures ~2-4 °C higher than pre-industrial levels, elevated CO_2 concentrations, reduced ice volume, and intensified hydrological cycles (Haywood et al., 2016; Dowsett et al., 2016). The climatic conditions comparable to modern values make this period the best geological analogue for understanding the response of Earth systems to elevated CO_2 conditions and global warming (Pagani et al., 2010; Bartoli et al., 2011; Martínez-Botí et al., 2015; Tan et al., 2017). Consequently, major international initiatives, including the Pliocene Research, Interpretation and Synoptic Mapping (PRISM) project and the Pliocene Model Intercomparison Project (PlioMIP), have been undertaken to understand Piacenzian climate dynamics (Haywood et al., 2013, 2016; Dowsett et al., 2016). Despite these advances, important uncertainties remain regarding how terrestrial ecosystems responded to Piacenzian warming and associated hydroclimatic changes. In the Himalaya, the period coincides with active tectonic uplift and monsoon reorganization, making it a critical interval for understanding vegetation–climate interactions in response to both climatic and tectonic forcing.

The Kashmir Valley, in the northwestern Himalaya, archives more than a km thick fluvio-glacio-lacustrine sequence known as the Karewa Group (Bhatt, 1976), which records environmental changes linked to Himalayan uplift and monsoon variability (Agrawal et al., 1989) for the past ~4 million years encompassing the MPWP. Previous paleoclimatic studies on the Karewa sediments have largely focused on sedimentology,

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