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Phytolith insights into palaeosol formation and climate dynamics in the Pliocene Karewa deposits, Kashmir Himalaya, India

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ABSTRACT

The phytolith study of sedimentary deposits serves as a valuable tool for reconstructing past vegetation and environmental changes. In this study, we carried out a phytolith analysis of a palaeosol and a clay bed from the Pliocene Lower Karewa deposits of the Kashmir Himalaya, India. The palaeosol lies directly over the hard rock basement. The material that forms the palaeosol is thought to represent sedimentation at the time of Kashmir Valley formation around 4 Ma owing to the uplift of the Pir Panjal Range. The phytolith assemblages suggest the area supported a complex vegetation structure during palaeosol formation and clay bed deposition. The phytolith assemblages, commonly associated with C_4 grasses — characteristic of warm, arid, and low CO_2 environments, and some woody plants and shrubs, suggest warmer and drier climatic conditions during palaeosol formation. However, micromorphological analysis and detailed field observations suggest that the material that forms the palaeosol was deposited much later than the commencement of valley formation. The co-occurrence of phytoliths of diverse climate and vegetation types along the depth of palaeosol indicates a thorough mixing of material during its deposition, possibly by pedogenic, glaciotectonic or mass–wasting processes. Our study provides a renewed viewpoint on the oxidized palaeosol, suggesting that previous interpretations about its formation during basin formation need reconsideration. On the other hand, the clay bed depicts less diverse phytolith assemblages, suggesting a possibly harsher, colder environment. The phytolith morphotypes of the clay bed depict a more controlled climate, and each lamina suggests the phytolith of a particular time period.

1. Introduction

Global climate has evolved progressively through the Pliocene, mainly attributed to orbital changes, variations in solar energy, sunspot activity, distant cosmic radiation fluxes, as well as internal changes including land–ocean–ice configuration, weathering reactions, release of trapped gases from volcanoes and deep oceans, and tectonic uplift (Kodera, 2004; Hameed and Lee, 2005). The tectonic uplift of the Himalaya has a strong influence on regional and global atmospheric circulation patterns (Molnar and England, 1990; Owen et al., 2002). The uplift was also associated with the formation of several basins, such as Kathmandu Basin (Central Nepal), Heqing Basin (Yunnan, China), and Kashmir Basin (India) that acted as sinks for the sediments eroded from the rising mountain ranges (Fujii and Sakai, 2002; Goddu et al., 2007; Dar et al., 2014). The Kashmir basin is bounded by the Pir Panjal and Greater Himalayan Ranges in the NW Himalaya. The uplift of the surrounding mountain ranges, especially the Pir Panjal Range, resulted in the formation of a topographic barrier for the southwest monsoon winds that resulted in changes in climate and drainage patterns in the Kashmir Valley (Dar and Zeeden, 2020). As the uplift continued, the fluvial environments changed into a lacustrine environment, which subsequently got infilled with eroded sediments (Burbank and Johnson, 1983; Agrawal et al., 1989; Dar et al., 2013, 2014). These sediments, known as Karewa, act as a record of climate change since the inception of the Pir Panjal uplift (4 mya) and provide an opportunity to understand environmental changes that have occurred during the Pliocene and Pleistocene. Several studies have attempted to understand the stratigraphy, chronology and depositional environment of the Karewa group of sediments (Basavaiah et al., 2010; Dar et al., 2014; Farooqui et al., 2021; Shah et al., 2024). Despite the promising nature palaeoclimatic importance of these deposits, limited attention however has been paid to past vegetation and yet only little quantitative data is available for palaeoenvironmental reconstruction.

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