Journal of Asian Earth Sciences 111 (2015) 328–338

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

journal homepage: www.elsevier.com/locate/jseaes

Micromorphological investigations of the Late Quaternary loess–paleosol sequences of the Kashmir Valley, India

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ARTICLE INFO

Article history:
Received 2 December 2014
Received in revised form 20 June 2015
Accepted 6 July 2015
Available online 6 July 2015

Keywords:
Paleoclimate
Micromorphology
Pedogenic $CaCO_3$
Clay illuviation
Paleosols

ABSTRACT

The loess–paleosol sequences of the Karewa Group preserve a valuable repository of the Late Quaternary climatic changes and the landscape evolution history of the Karewa Basin of Kashmir Valley in their lithological and pedogenic records. Three representative loess–paleosol sections at Shankerpora (SP), Khan Sahib (KS) and Pattan (PT) localities were chosen for detailed lithostratigraphic fieldwork and micromorphological observations of thin sections. Lithostratigraphic analysis revealed lateral and vertical variation in thickness and number of paleosol profiles from south-west to north-west of the Karewa Basin suggesting the availability of land-surface for periodic loess deposition. The SP section is marked by 6 (SP-S6, S7, S8, S9, S10, S12), KS section by 3 (KS-S2, S4, S5) and PT section by 2 (PT-S1, S3) thick mature paleosol profiles. Theses paleosols have well developed 'A_h' and 'B_{tk}' horizons representing prolonged land-surface stability when pedogenic processes outpace loess deposition. On the other hand comparatively thin to thick paleosol profiles represent weak to moderate pedogenic maturity indicating short stratigraphic breaks with rapid loess deposition. Micromorphological observations of thin sections suggested that clay illuviation and $CaCO_3$ accumulation have operated within the paleosol profiles. $CaCO_3$ features are often associated with clay coatings suggesting decalcification of carbonates followed by clay illuviation. Pedogenic $CaCO_3$ probably resulted from the precipitation of the soil solution near the average depth of wetting front. The pedogenic $CaCO_3$, illuvial clay, mottles, iron manganese features, pedal microstructure and blocky aggregates reveal variation in the pedogenic maturity among and within the loess–paleosol sections. The morphological (both micro- and macro-morphological) attributes of loess–paleosols suggest variation of climatic conditions during the Late Quaternary period in the Karewa Basin of Kashmir Valley, India.

1. Introduction

Micromorphology provides important information about the complex soil forming processes. It deals with the measurement, description and interpretation of various pedological features at the microscopic level (Bullock et al., 1985; Srivastava et al., 2010). The changing climatic conditions and geomorphic processes in terrestrial environments produce a great complexity of stratigraphic records because of the changes in pedological and land-surface processes (Kraus, 1999; Kemp and Zarate, 2000; Kemp, 2001). Paleosols often preserve such evidence of the past geomorphic and climatic changes in their pedogenic features. In this milieu, understanding of the local pedogenetic response to climate change and geomorphic evolution can be improved by micromorphological approach (Kraus, 1999).

Loess inter-bedded with paleosol profiles is widely distributed over Kashmir Valley and is geographically the most extensive surficial deposit in the region (Fig. 1). Radiocarbon and thermo-luminescence dating techniques have been used to date these loess–paleosol sequences. Radiocarbon dates were obtained from the organic fractions and the carbonate extracted from the loess–paleosols. The top three paleosols preserved across the Kashmir Valley yielded ^{14}C ages ca. 5, 18 and 25 kyr years (Kusumgar et al., 1980). Numerous radiocarbon and thermo-luminescence (TL) dates from the loess–paleosol sequences were published over the last few decades by various researchers (Kusumgar et al., 1980; Bronger et al., 1987; Singhvi et al., 1987; Agrawal et al., 1989). With the improvements in the TL methodology, the published ages of the loess–paleosols were revised toward older ages. As indicated by TL dating, the loess below the triplet paleosols is greater than 80 kyr old (Agrawal et al., 1989). The TL dating of Karapur section gives an age of 130 kyr at 12 m depth below the top surface (Singhvi et al.,

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http://dx.doi.org/10.1016/j.jseaes.2015.07.004
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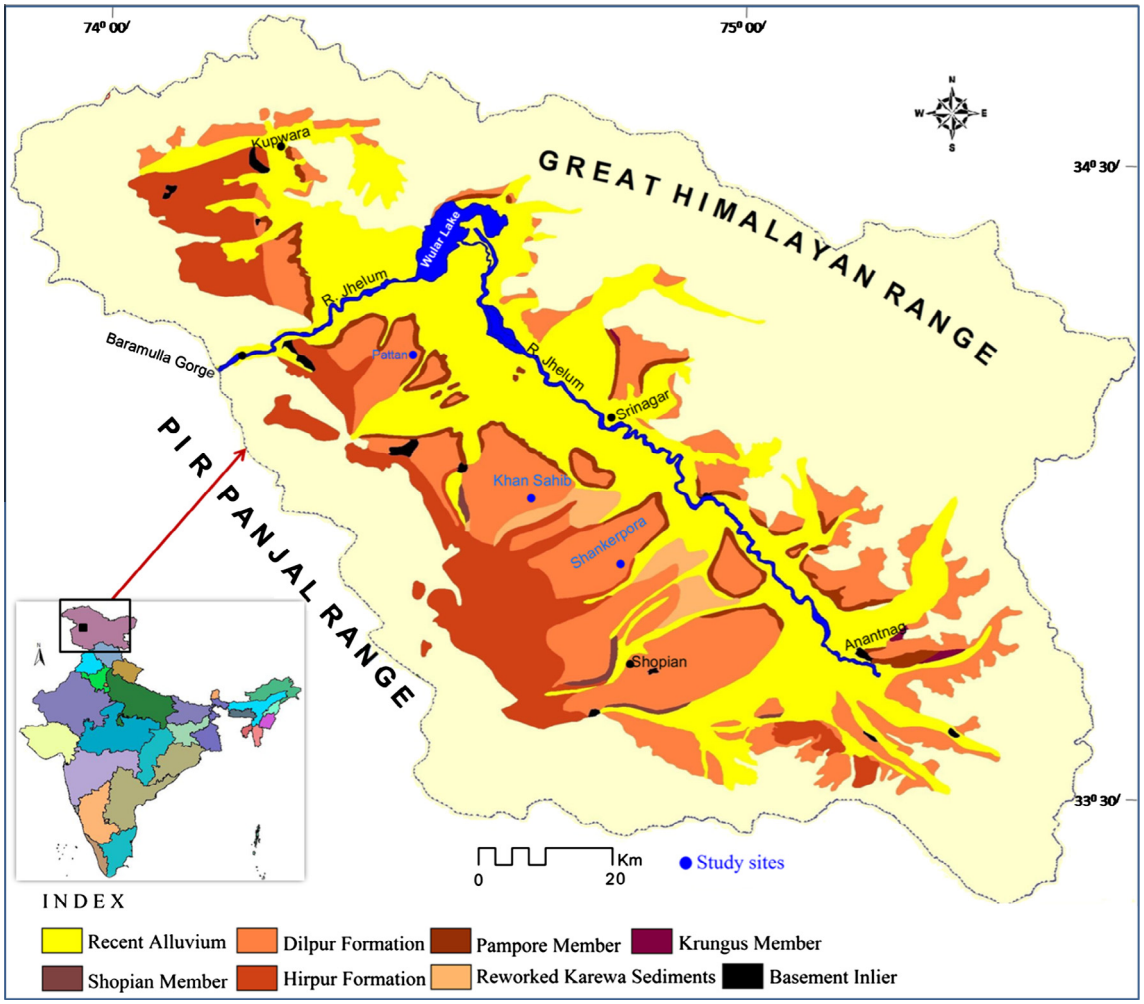

Fig. 1. Geological map showing the distribution of loess–paleosol sediments of the Dilpur Formation in the Karewa Basin of Kashmir Valley.

1987). According to Agrawal et al. (1989), the loess deposits date ca. 200 kyr on the SSW side and 80 kyr on the NNE side of the Kashmir Valley.

Paleosols are common in Kashmir loess representing the periods of climate change and land-surface stability during which time pedogenesis outpace loess deposition. However, there are uncertainties as to what degree pedogenic processes may have occurred during paleosol formation and therefore what climate may have prevailed at the time of the pedogenic modification of each paleosol profile. Some workers have previously attempted to deduce the Quaternary climate changes in the Kashmir Valley using micromorphic approach (Bronger et al., 1987; Gardner, 1989). On the basis of the micromorphological studies of the top three paleosols across the basin, Bronger et al. (1987) concluded that warm and mostly humid climatic conditions prevailed during their formation in the Kashmir Valley. Similarly, Gardner (1989) suggested that paleosol profiles represent similar climatic condition except the two paleosols formed in the later part of the last glacial. However, none of these studies have integrated the detailed micromorphic and field evidences to interpret the pedogenic maturity and paleoclimate of the individual paleosol profiles. In this paper, an attempt has been made to consider the role of pedogenic and geomorphic processes in modifying the loessic sediments, focusing on the resulting properties as indicators of past climatic conditions and landscape evolution.

Three representative loess–paleosol sections at Shankerpora Village (33° 53′ N and 74° 48′ E) along the southwestern part, Khan Sahib Village (33° 56′ N and 74° 39′ E) in central Kashmir and Pattan Town (34°18′ N and 74° 54′ E) along the Northwestern part of the Kashmir Valley were selected for detailed lithostratigraphic and micromorphological research work (Fig. 1). These sections were chosen on the basis of the undisturbed state, accessibility and the presence of fresh exposures.

2. Geomorphic setting and climate

Kashmir Valley, India lies between the Great Himalayan Range to the northeast and the Pir-Panjal Range to the southwest. The valley possesses almost complete stratigraphic record of rocks of all ages ranging from Archean to Recent. The geomorphic setting of the Kashmir Valley reveals that due to rise of the Pir-Panjal Range, the drainage was impounded as a vast lake (Karewa Lake) in which the sediments of Karewa Group were deposited (Kotlia, 1985a,b; Bronger et al., 1987; Kotlia and Mathur, 1992; Basavaiah et al., 2010; Dar et al., 2013a, 2014; Kotlia, 2013). The Plio-Pleistocene sequence of Karewa Group is broadly classified into two divisions as Lower (Hirpur Formation) and Upper Karewa (Nagum Formation), separated by an angular unconformity (DeTerra and Paterson, 1939; Bhatt, 1982; Kotlia, 1990, 1992; Kotlia et al., 1998). Lower Karewa is subdivided into Dubjan, Rambiara and Methawoin Members. The Upper Karewa is subdivided into Shopian, Pampore and Krungus Members. Dilpur Formation, occurring as cap sediment to the Upper Karewa, is