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Geomorphic study of the Late Quaternary-Holocene piedmont fans and fluvial terraces of Kota Dun, Kumaun Himalaya

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ABSTRACT

The Kota-Pawalgarh Dun is a Half-Dun structure shaped by spatial variation in active deformation partitioning within the Main Boundary Thrust (MBT)-Himalayan Frontal Thrust (HFT) wedge in the Central Kumaun Himalayan front. The post-Siwalik Piedmont fans consist of Dun gravels and provide a geomorphic and stratigraphic constraint on the deformation partitioning on the Dun. Though the fans were mapped, the lack of ages failed to constrain the definition of their stratigraphic and structural significance in the Late Quaternary evolution of the Dun. We present the new mapping results using field and remote sensing data with chronological constraints from the Optically Stimulated Luminescence (OSL) dating of river terraces and alluvial fans across the Dun valley. These new OSL ages of the fan and terrace sediments, in addition to published dates, reveal multiple phases of fan aggradation since > 90 ka until ~19 ka and incision during the Holocene with differential uplift, fan truncation, and fluvial reorganization, driven by ongoing tectonic activity. These findings offer valuable insight into the neotectonic development of the Kota Dun valley and contribute to a better understanding of the deformation processes in the mountain front in the Himalaya Central Seismic Gap region.

Keywords: Geomorphic features, Fluvial terraces, Alluvial fan, OSL dating, Kumaun Himalaya.

INTRODUCTION

The Himalayan region evolved as a consequence of the collision and convergence of the Indian plate underneath the Eurasian plate at a rate of ~50 mm/yr since the Eocene (Molnar and Tapponnier, 1975). The continued convergence produced a series of south-propagating thrusts; namely, the Main Central Thrust (MCT), Main Boundary Thrust (MBT), and Himalayan Frontal Thrust (HFT), originating from the Main Himalayan Thrust (MHT), with younger thrusts initiating towards south (Valdiya, 1992). During the Quaternary period, while the MBT experienced segmental reactivation (Valdiya, 1992; Mugnier et al., 1994), the HFT remained the primary active fault, producing surface ruptures and shaping the topography of the Sub Himalayan Mountain front (Nakata, 1972; Karunakaran and Ranga Rao, 1979; Valdiya, 1992; Yeats et al., 1992; Bollinger et al., 2014). The Sub Himalaya, bounded by the MBT and HFT, comprises deformed foreland basin sediments and features piggyback basins filled with the Piedmont gravel, called Duns (Nakata, 1972; Valdiya, 1992; Thakur et al., 2007). These Duns, namely Soan-Pinjore Duns in Punjab, Haryana and Himachal Pradesh, Dehra Dun and Kota Dun in Uttarakhand, and the Rapti-Dang Duns in Nepal, have varied dimensions and are filled with post-Siwalik debris and fluvial deposits called Dun Gravels (Figure 1a). The Kota Dun is unique as a Half Dun, featuring asymmetric lateral boundaries and a southward step-over by the HFT, making the southward migration of the deformation front towards east; has undergone active deformation during the Late Pleistocene (Nakata, 1972; Valdiya, 1992; Goswami and Pant, 2007; Figure 1b). The changing width of the MBT-HFT wedge, is reflected in the form of lateral variation in geology, structures, landscape pattern and topography in the Kota Dun area. It is situated in the Central Seismic Gap region of Himalaya, where some major events of the 20th century, such as the 1905 Kangra and 1934 Bihar–Nepal earthquakes, did not produce surface rupture, but are manifested in folds or subtle surface deformation (Yeats and Lillie, 1991). This has emphasized the importance of temporal investigations to uncover the long-term history of surface deformation due to the recurring earthquakes in tectonically active regions (Yeats et al., 1992).

Previous studies in the Kota Dun have provided a broad understanding of the geomorphic setup and evidences of active tectonics (Nakata, 1972; Kumar et al., 2006; Goswami and Pant, 2007; Jayangondaperumal et al., 2013, 2017; Luirei et al., 2015; Rajendran et al., 2015, 2018; Malik et al., 2017; Figure 1). Following the preliminary geomorphic and tectonic setup of the region, which includes the geomorphic and structural expressions of HFT, MBT, and intra-wedge faults (Nakata, 1972; Valdiya, 1992; Joshi and Singh, 2006), Goswami and Pant (2007, 2008) and Luirei et al. (2015) mapped the river terraces, alluvial fan surfaces, wind gaps, and drainage diversions of the Dabka and Baur rivers. The paleoseismic signatures of past surface rupture earthquakes along the HFT during past millennia are explored by the trenching experiments with temporal constraints from the radiocarbon dates of the detrital charcoal samples in the colluvial wedges (Kumar et al., 2006; Malik et al., 2014; Rajendran et al., 2015, 2018; Jayangondaperumal et al., 2017; Malik et al., 2017). Further, the radiocarbon dates from terrace sediments near Ramnagar also provided evidence of fluvial incision along the Kosi River during 4985±25 yrs - 6630±25 yrs (Kumar et al., 2006). The broad geomorphic features, such as terraces and piedmont fans, and geological setup are mapped, but due to the lack of age constraints, it is challenging to build an evolutionary history of the Kota Dun.