博士論文の要約

The provenance and the paleo-environment of the Siwalik Group along the Muksar Khola section, eastern Nepal Himalaya

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The Siwalik Group extending east to west co-linear with the main Himalayan range is considered as an important archive. It records the early Miocene–Pleistocene Himalaya exhumation history and consequent climate change due to this topographic change. This study deals with the Siwalik Group along the Muksar Khola section in eastern Nepal and mainly focuses on the lithostratigraphic classification, sediment provenance and hinterland phenomena, and interpretation of the fluvial environment. Results from the present study are further compared and discussed with the results of other Siwalik sections to understand the Himalaya.

In the present study, the Siwalik Group is divided into the Lower Siwaliks, the Middle Siwaliks, and the Upper Siwaliks based on lithology and grain size variation. In comparison with the preexisting depositional age, the Lower Siwaliks was deposited before 10 Ma and consists of grey to olive black mudstone to siltstone interbedded with light-grey, very fine- to fine-grained sandstone and a very thick succession of the intraformational conglomerate. Middle Siwaliks was deposited in between 10.0–3.5 Ma and is characterized by the domination of sandstone. In the present study, this sub-group is divided into the lower member and the upper member based on the variation on the lithology and their thickness, its composition, and sandstone induration degree. The lower member deposited before 5.9 Ma consists of fine- to medium-grained “salt and pepper” sandstone with greenish-grey to olive-grey mudstone. While the upper member is characterized by less indurated, light grey to white, medium- to very coarse-grained sandstone with an increased proportion of grey, dark grey to black mudstone. The Upper Siwaliks consists of a poorly sorted, clast supported conglomerate associated with very thickly bedded coarse- to very coarse-grained sandstone and very thickly bedded dull yellowish-grey to grey colour mudstone.

Study of the provenance, reveal continuous denudation of the eastern Nepal Himalaya and simultaneous shift of the provenance around middle Miocene–Pliocene. The sandstone petrography, heavy minerals assemblage, the chemical composition of detrital tourmaline and garnet, and Sr-Nd isotopes equivocally suggest provenance shifted from

shallow to the deeper part of the Higher Himalayan Crystalline around 10.6 Ma. Lesser Himalaya Sequence supplied a considerable amount of sediments after 7.5 Ma and the Higher Himalayan Crystalline boosted the supply of sediments after 4.0 Ma. The occurrence of volcanic lithic fragments and the uniform occurrence of heavy minerals like titanite and the Zircon-Tourmaline-Rutile index reveals Tibetan Tethys Himalaya was a continuous source. The occurrence of detrital chromian spinel in the older section and extreme Ca-rich garnet (Grs+And>90) in the younger section suggests Indus Tsangpo Suture Zone as a potential source. This change in the provenance was controlled by the exhumation of eastern Nepal Himalaya, which was observed at two stages: first around 11.0 Ma due to activation of the out-of-sequence thrust known as Sunkoshi Thrust and second due to the formation of the duplex structure in the underlying Lesser Himalaya Sequence after 4.0 Ma. This provenance study also reveals two important ideas: the chemical composition of detrital garnet is very suitable for determining the provenance in the Himalaya as it traces every change which is hardly defined by other proxies and the Sr-Nd isotopic values of the Siwalik sediments are dependent on the grain size.

Based on the facies analysis, five facies associations were discovered representing the fluvial environment. These are interpreted as the flood plain dominated fine-grained meandering river (FA1), flood dominated overbank environment (FA2), sandy meandering river (FA3), anastomosing river (FA4), and debris flow dominated braided river (FA6). These changes in the fluvial environments were controlled by the interplay between hinterland tectonics, climate and sea-level change. The absence of rapid exhumation of the hinterland, raised sea level and comparative weak monsoon before 10.0 Ma resulted in the flood plain dominated fine-grained meandering river (FA1). High discharge due to intensified monsoon and rapid fall of the sea level around 10.5 Ma caused flood dominated overbank environment (FA2). Asymmetric subsidence of the foreland basin and less sediment supply due to the absence of duplex structure and activation of the out-of-sequence thrust resulted in the sandy meandering river (FA3) after 10.0 Ma. After the 5.9 Ma rise in the base level due to subsidence of the foreland basin and sea-level rise along with the strengthening of the monsoon gave rise to the anastomosing river (FA4). Debris flow dominated braided river (FA6) after 3.5 Ma was resulted due to the increase in the proximity of the basin close to the hinterland.

The genesis of the intraformational conglomerate of the FA2 suggests monsoon intensified at around 10.5 Ma in the eastern Nepal Himalaya. The present study also reveals continuous shifting of the foreland basin towards the hinterland. This change in the location of sediment deposition resulted in the coarsening upward succession in the

sediments of Siwalik sediments. Further, this study shows a difference in the exhumation history of the eastern Nepal Himalaya compared to central and western Nepal Himalaya, subsequently, this brought a difference in the fluvial environment.