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Sedimentation, tectonics and climate in Ladakh, NW Trans-Himalaya-with a special reference to Late Quaternary Period

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ABSTRACT

Ladakh, the newly formed Union Territory of India, is a cold arid high altitude desert lying in the Trans-Himalaya and is an important region for geographers and geologists, because of its lunar/martian landscapes, exposures of sedimentary, metamorphic and igneous rock types, glacial, fluvial lacustrine sediments and active tectonic and climatic processes. This paper sums up the sedimentary characteristics, tectonic and climatic history with examples from the variety of sediment exposures along the Indus River. The overall geomorphological evolution of Ladakh is basically governed by two sets of geological processes—the continental scale geological processes that have primarily provided the basic framework for the landscape and second the regional/local scale geological processes in which the role of tectonics and climate which has been significant in determining the glacial, fluvial, lacustrine and aeolian processes. The transient topography of the region is attributed to (a) the movement along active Stok thrust, along the Indus Suture Zone; (b) long term steady state perturbed by climate change; (c) location in orographic rain shadow zone; and (d) the landscape being not in cosmogenic steady state due to topographic effect and methodological uncertainties of data.

1. Introduction

The Himalayan topography is characterized by horizontal compression of the lithosphere, topographic uplift, erosion and sedimentation ever since the collision of the Indian plate with Eurasia. Due to the Hindukush-Karakoram-Pamir Knot in the extreme northwestern side of the Himalayan mountain chain, thrusts along the 2500 km long east-west trending Himalaya viz., Himalayan Frontal Fault, Main Boundary Thrust, Main Central Thrust, and Karakorum Fault as well as the Indus Suture Zone (ISZ) and Shyok Suture Zone (Fig. 1), make the entire area tectonically active. Recording abundant earthquakes of intermediate depths between 70 and 300 km (Burtman and Molnar, 1993) the entire Himalayan arc is also earthquake prone. Apart from being tectonically dynamic, the Himalaya also determines the physiographic distinctions of the Indian landmass, where it acts as a barrier for the northward moving moisture laden monsoon winds during the summer season (Summer monsoon) and also restricts the entry of icy winds (Westerly) coming from the Mediterranean region during winter season.

Ladakh in the Trans-Himalaya situated southwest of the Tibetan Plateau and also known as 'Little Tibet' for the purpose of tourism, extends from north of the Higher Himalaya to Karakoram mountains (Fuchs, 1979). The Himalayan mountain front creates obstruction for the Indian summer monsoon (ISM) thereby making this regional rain shadow zone and a high altitude cold desert. Precipitation in the region is controlled dominantly by Westerly disturbance in the form of snowfall during the winter months. Ladakh constitute of high mountain ranges, wide valleys, narrow constricted gorges occupied by rivers: Indus, Shyok, Nubra, Tangtse, Hanley, Yapola, Markha, Tsarap-Lingti, Zanskar; big lakes (Tsokar, Pangong Tso, Tso Morari); glacial valleys (with glaciers, ice patches, moraines etc.) and several proglacial lakes occupying the crest of the Ladakh Range (Phartiyal et al., 2005, 2018, 2020, 2021) (Fig. 2).

Indus River Valley in the Ladakh region is an intermontane basin formed as a result of the continental collision along the Indus Suture Zone (ISZ), and forms one of the spectacular examples of active orogen building and climatic forcings. This coupling between the geological and tectonic evolution with climatic shifts at different time scales has led to great diversity of environment, landscape and landform types throughout the Ladakh terrain. The region hosts abundant potential archives to study the nature of intermontane basin evolution developed as a result of continental collision, quantifying landscape evolution and paleoclimatic

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