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QUATERNARY GEOMORPHIC EVENTS AND RIVER TERRACES IN NORTHWEST HIMALAYA: A CASE STUDY OF BEAS BASIN, INDIA

Doctoral Dissertation Abstract (2007)

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Streams are an extremely important exogenetic agent of geomorphic change because running water is the most widespread cause of landmass degradation on the earth. A river valley possesses features that contain the record of past geomorphic events. These are in the form of the drainage system, drainage pattern, and landforms like topographic discordance, valley-in-valley, uplifted peneplains, incised meanders, alluvial terraces, knickpoints etc. In this thesis the landform features associated with the Beas River specifically the river terraces are studied as indicators of Quaternary geomorphic events. The Beas River is a left bank tributary of the Indus River in northwest Himalaya.

The Beas Kund or Solang stream is the source of Beas River. It rises on the southern slopes of the Pir Panjal ranges. However, the topographical sheets of survey India have labelled a smaller right bank tributary as the Beas River. The Beas Kund and Beas River meet each other at Palchan. The watershed of the Beas River extends over the mountain ranges of the Higher Himalaya, Lesser Himalaya, and Siwalik. The study area under this investigation is between 31o 15' N to 32o 30' N latitudes and 75o 30' E to 78o 0' E longitudes.

The southwestern and western part of the valley consists of low altitude Siwalik-Hills. Average elevation of the Siwalik is about 600 m above mean sea level. The elevation increases towards the Dhauladhar in north, Pir Panjal in northeast and the Great Himalaya in east. Kayastha (1964) divided the Beas Valley into three broad altitudinal zones: (i) The Siwalik zone, with 450-600 m average elevation in the southern and western part; (ii) The central zone of hills and valleys towards Dhauladhar, Pir Panjal, and the Great Himalaya having 600-2500 m average elevation; and (iii) The northern and eastern mountains above 2500 m average elevation.

In the present study an attempt has been made to study the drainage system, drainage patterns, and micro-geomorphic features, specially the alluvial terraces, and to formulate the geomorphic history of the Beas Valley. Attempt has also been made to study the relationship between geomorphology of Beas Valley and that of whole Himalaya. The river terraces found in the Beas Valley have been studied as indicators of events during Quaternary. The relationships between neo-tectonic movements, palaeoclimate, and the geomorphic processes in the formation of river terraces have been established.

Characteristics of the drainage system and drainage pattern are studied from drainage maps prepared from the Survey of India topographical sheets on 1:2,50,000 scale. The impact of bedrocks and neo-tectonics on the river geomorphology has been studied from the geological map that is prepared from the geological sheets No. 43P, 44M, 52H, 53A, 52 H, and 53E of the Geological Survey of India, on 1:2,50,000 scale. The stratigraphy exposed along the road cuttings or terrace scarps has been observed and correlated with the climatic, fluvial, and tectonic history of the river valley. For detailed study of selected geomorphic features field measurements have been made. The relative heights along the points of break in slope above riverbed level and the dip of bedding plane are measured by using Brunton Compass. Field photographs of river terraces, terrace deposits, and other prominent features have been taken in order to have visual evaluation of geomorphic features. The longitudinal profile of the Beas River has been studied to identify the knickpoints using Hack's Gradient Index (Hack, 1973a,b).

The study area lies between Indo-Gangetic plains in the south and Tethys Himalaya in the north. Major litho-tectonic units northward of Indo-Gangetic plains in the Beas Valley are the Siwalik, Lesser Himalaya, Higher Himalaya, and the klippen of Tethys Himalaya.

MAJOR GEOMOROPHOLOGICAL OBSERVATIONS

Drainage system

The Himalaya started emerging out of Tethys Sea during Palaeocene-Eocene and the process of emergence progressed southward. The Higher Himalaya were uplifted first and then the Lesser Himalaya and Siwalik respectively. Initial drainage evolved in the eastern side of the Beas Valley with the uplift of Higher Himalaya. The Parbati, Sainj, and Tirthan are major tributaries evolved during this phase. These rivers started to flow in east-west direction. The Beas emerged later on the southern slopes of Pir Panjal after the uplift of Higher Himalaya. The Parbati and Beas meet each other at Shamshi downstream of Kullu. Length of the Parbati upstream of shamshi is about 78 kilometres and that of the Beas is about 65 kilometres. The Parbati River being older and longer is the master stream in the valley. The Beas River follows structure in upper section and is a consequent stream. It cuts across the bedrocks in lower section and is an antecedent stream. The Beas River takes a rectangular bend at Larji and starts to flow roughly towards west. Here the Beas River joins along the right bank of a pre-existing river course of Tirthan and Sainj rivers flowing in east-west direction and forms the rectangular bend. At Pandoh the Beas River takes rectangular bend to flow in northwesterly direction due to obstructions offered by hard rocks of Kharo Formation. At Badanun the Beas River cuts across Jhukhari Dhar and takes rectangular bend to flow roughly towards west. At Mandi the rectangular bend occurs due to obstruction by Dharamsala Group of rocks and the weak zone provided by MBT. This facilitated the Beas River to flow in relatively softer rock strata of Lower Siwalik. Downstream of Mandi the uplift along thrusts has also diverted the river course. The rectangular bends formed under the influence of thrusts are along Murree or Palampur Thrust, Jawalamukhi Thrust, and along HFT. At Beas-Kunah confluence the Beas River turns towards a fault in the syncline and forms a rectangular bend. These rectangular bends in the river course are formed along faults, thrusts, and erosion resistant rocks.

Asymmetry in the valley

The Beas River divides the upper Beas Valley into two unequal parts. The right bank tributaries section is smaller than the left bank. Right bank tributaries flow on Dhauladhar whereas the left bank tributaries have their sources on the Great Himalaya. Higher Himalayas were uplifted earlier than the Dhauladhar. The left bank tributaries are older. Older tributaries are longer as these got more time to grade their profiles. Drainage of the lower valley section is also asymmetrical. However, here the longer tributaries come down from Dhauladhar along right bank and the smaller tributaries from Siwalik along left bank.

Larji gorge

The Beas River cuts across Dhauladhar at Larji and forms an antecedent gorge. Elevation of the gorge is about 740 m above the present riverbed level. Considering the parity between uplift rates of 0.55 mm/year (Sharma et al., 1978) and rate of erosion the gorge down cutting must have started c. 1.35 Ma. A period of floodplain formation occurred at about 520 m above the riverbed level. This surface was abandoned at c. 0.95 Ma if the uplift rate (0.55 mm per year) and rates of erosion were uniform and equal. After floodplain formation very fast vertical erosion started in response of uplift. This resulted in a very steep sided narrow valley. The elevation of this narrow valley is about 500 m above the river bed level. This phase of gorge downcutting was initiated at c. 0.91 Ma considering the equality between uplift rate (0.55 mm/year) and the rate of erosion.

Channel patterns

Alternating narrow single thread, incised meandering, and broad braided channel patterns are important geomorphic features of the Beas Valley. The Beas River course upstream of Nadaun is deeply incised meandering. The sinuosity index of this segment is 2.45. This meandering segments lies along JT induced uplift plane in Siwalik. At the time of meander formation this region had gentle sloping surface like Indo-Gangetic plains of today and there were no Siwalik-Hills. As the processes of uplift across JT went on, more and more landmass was uplifted and the Beas River kept cutting the uplifted landmass and retained the meandering course formed prior to uplift. Meandering channel could survive only along the uplift plane where vertical erosion predominated. Upstream of uplift plane in the decelerated flow zone the processes of deposition predominated that buried the meandering channels. Lateral erosion along decelerated flow zone led to widening of the floodplain. The spread of water could not submerge all the deposited material and formed islands and bars. This led to formation of braided channel patterns.

Gradient

Gradient analysis along the river course reveals a highly uneven longitudinal profile of the Beas River. High values of SL/K highlight knick-points. The highest value of SL/K is 11.27 between 760-780 m contour under the influence of MBT, PT, and erosion resistant Kainchwa granites. The low value of SL/K between 780-800 m contours is due to easily erodible Gahr Member of Lesser Himalaya. In Beas Valley high values of SL/K are associated with thrust-induced uplift axes, braided channel patterns, and erosion resistant rocks. Low values of SL/K are along narrow single thread channels, incised meandering channels, and easily erodible bank rocks.

River terraces

River terraces at five sites in the Beas Valley have been studied. The Banol terrace is about 8 kilometres downstream of Pandoh along the right bank. It is about 160 m above the present river bed level. If equality between uplift rates of 0.55 mm/year (Sharma et al.,

1978) and rates of erosion is assumed then the Banol surface was abandoned at c. 0.29 Ma. At this site the 30 m high Dhoda terrace along left bank was abandoned at c. 54.5 Ka considering equal uplift rates and rate of erosion. Under this condition the 8 m high Balh terrace was abandoned at c. 14.5 Ka. This is the time when LGM (15 Ka) in Himalaya had been terminated and strengthening of monsoon led to abandoning of lowest terrace (Suresh et al. 2002; Chauhan, 2003; and Chauhan,Patil, and Suneethi, 2004). The huge size and highly angular boulders on the present riverbed suggest minimum action of weathering and erosion and are derived from nearby surroundings. Conversely the medium size rounded and sub-rounded boulders were derived from the interior part of the valley. Tirra-Sujanpur terrace is about 110 m above the riverbed level along left bank. The huge size boulders in the terrace deposits are of fluvial origin. The red coloured terrace deposits are indicative of hot and humid climatic condition (Federoff, 1966) and a relatively older age (Folk, 1976). Three levels of river terraces at Nadaun suggest three phases of downcutting. Three levels of terraces along left bank are inclined towards north at Dehra-Gopipur. Northward inclination might have been due to greater uplift in the south under the influence of HFT. More than 5 m thick deposits of mud beds on T3 surface suggest a long spell of climatic and tectonic stability. Elevation of T3 surface is about 50 m near Phera village and it declines to 3 m on moving about 10 kilometres further upstream. The higher elevation is associated with BBT induced uplift and low elevation with the synclines. The processes of vertical erosion predominated along the uplift and of deposition along the synclines. Three levels of terraces are observed at Harripur-Guler along right bank of the Banganga which is a right bank tributary of the Beas River. Here the lowest terrace is erosional in nature. About 1.5 m thick terrace deposits lie on highly tilted beds of Siwalik. High degree of inclination suggests excessive folding of Siwalik strata due to continuous northward movement of Indian plate.

Abbreviation Used

c.	circa	HFT	Himalayan Frontal Thrust
Ma	Million years ago	MBT	Main Boundary Thrust
Ka	Kilo (one thousand) years ago	MCT	Main Central Thrust
PT	Panjal Thrust	JT	Jawalamukhi Thrust
VT	Vaikrita Thrust	LGM	Last Glacial Maximum