

## Sedimentological reconstruction of extreme flood events in the western Himalaya

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**Project background:** Extreme geomorphic events underpin the landscape development of active mountain ranges and represent major natural hazards; data and model predictions indicate an increasing frequency of monsoon-related storm events for the western Himalaya. The only way to assess changes in their magnitude or frequency beyond the historical timescale is to use the sedimentary record. Dated terrace sediments in the southern foothills of the western Himalaya, and in the Ladakh region to the north of the Himalaya record a combination of fluvial and lacustrine sedimentation punctuated by evidence of events such as debris flows and erosion. We also have a record of recent events from which we can explore the erosional and depositional record: In the Ladakh region of northern India, the monsoon of Aug. 2010 generated a once in a century event that mobilised vast amounts of sediment as debris flows and sediment laden rivers. In a unique study, we have been able to reconstruct the distribution and magnitude of this storm event (Hobley et al., 2012). Similarly, in summer 2013 extreme flooding in Uttarakhand resulted in thousands of deaths due to flooding and massflows; the sedimentological record of this event is preserved in thick (up to 30m) accumulations draping terrace regions. These recent events provide an opportunity to analyse the geomorphic and sedimentological signature of these events and to calibrate against the stratigraphic record preserved in terraces. The results will assess whether there has been a change in the magnitude and frequency of extreme events, and will compare the historical record with that of ca. 9000 yrs ago when the monsoon was considered more intense than at present; this may yield insight into the trajectory of change looking to the future.

**Key research questions:** Have extreme geomorphic events changed in frequency in response to changing climate during Holocene times? How has the signal changed from the front versus the lee of the Himalaya?

**Methodology:** This project will firstly reconstruct the sedimentological flux from the 2010 event in Ladakh and the 2013 in Uttarakhand using field data and repeat satellite imagery. Secondly, it will analyse the sedimentology of event beds in lacustrine terraces throughout the Indus and neighbouring valleys that are dated from ~60Kyr to present, and from the terraces of the Alaknanda Valley dated at 40Kyr to present. These data will inform on the depositional processes, provenance and will test whether anecdotally recorded increases in storm events in this region are valid. Additional OSL dating will be used where necessary. We will also look at historical meteorological data from meteorological stations in the region using the website Aphrodite (<http://www.chikyu.ac.jp/precip/>.)

**Training:** A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. Training will be given in sedimentological and geomorphological techniques using field and remote sensed data. Also in ArcGIS. Statistical methodologies will also be developed. OSL dating will be carried out at SUERC, and training will be given in sampling and processing of samples.

**Requirements:** The student will need to be able to carry out extensive fieldwork in remote regions, and have a reasonable knowledge of basic sedimentology and fluvial geomorphology. Good numerical skills for data analysis is beneficial.



*Figure showing lake terrace levels dated at ca. 12,000 yrs at toe of alluvial fans in the Indus Valley near Leh. Recent sedimentation on valley floor is a result of the 2010 storm event.*

**Further reading:**

Fort, Monique, Douglas W. Burbank, and Pierre Freytet. "Lacustrine sedimentation in a semiarid alpine setting: an example from Ladakh, Northwestern Himalaya." *Quaternary Research* 31.3 (1989): 332-350.

Hobley, D. E., Sinclair, H. D., & Cowie, P. A. (2010). Processes, rates, and time scales of fluvial response in an ancient postglacial landscape of the northwest Indian Himalaya. *Geological Society of America Bulletin*, 122(9-10), 1569-1584.

Hobley, D., Sinclair, H.D., Mudd, S. (2012) Reconstruction of a major storm event from its geomorphic signature: the Ladakh floods, 6 August 2010: *Geology*  
doi:10.1130/G32935.1

Phartiyal, Binita, et al. "Quaternary geology, tectonics and distribution of palaeo-and present fluvio/glacio lacustrine deposits in Ladakh, NW Indian Himalaya—a study based on field observations." *Geomorphology* 65.3 (2005): 241-256.

**Project summary:** The sedimentology of dated river and lake terraces in the western Himalaya records the history of extreme geomorphic events, enabling modern data to be placed in a longer-term trajectory of change.