Geophysical Research Abstracts
Vol. 16, EGU2014-11739, 2014
EGU General Assembly 2014

Strong coupling between tectonic fractures, postglacial erosion and sediment flux in alpine environment, Alaska

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Erosion of a landmass is a function of external parameters (tectonic or climate), modulated by the internal strength of the rock. The density and length of joints is thought to increase the erodibility of the rock, favouring the landslides, the plucking by glaciers and rivers, as well as the frost shattering. However, only a few studies explicitly document the importance of the faults and joints density on the erosion rate. Here I provide a spectacular case study from the Granite Range, Alaska. The western part of this range shows a well preserved typical glacial landscape (U shaped valleys, cirques etc.), with vegetation where the slope and the elevation permit it, whereas it eastern part the overall glacial landscape is not preserved despite the fact that it is closer to the glaciers. Vegetation is scarce, and valleys have be reshaped to V-shape, typical of fluvial and hillslope processes. The geology of the Granite Range is quite homogeneous, mostly made of granite and metapelites.

Hypsometric characterization of the landscape confirms the important topographic difference between these two settings, with a higher hypsometric integral for the fluvial landscape than the glacial landscape. Thanks to a widespread resetting of the topography by glaciers during the Last Glacial Maximum, many low relief, smooth surface can provide remnants of a topography prior the onset of fluvial dissection of the landscape. This allows interpolation between glacial surface remnants, hence to calculate volume of fluvial erosion. The spatial distribution of eroded material is highly inhomogeneous, with much more erosion to the east, in agreement with the first intuitive field observations. Maximum incision is up to ∼600m below the reconstructed surface, and the mean erosion to the eastern part of the range is of the order of 200m, whereas the mean erosion rate to the western part is much lower, of the order of 50m. The difference between the maximum incision and the mean erosion (and to an even larger extent between the deeper canyons and the preserved surfaces) imply that the erosion is highly not homogeneously distributed over the entire area.

Field (and airplane) observations show that fracturing is dense, pervasive, associated with thick fault gouges, kakirite and cataclase to the Northeast, whereas rock is very compact, with only a few widely space fracture to the West. Remote sensing detection of more than 1000 fracture also exhibit a striking difference of the fracture density, very penetrative to the North East, and widely spaced to the south and SW. These fractures are preferably oriented ENE-WSW, and to a minor amount E-W and NW-SW. The two main river draining this range have similar drainage basin (∼400km2) toward the North, but the one draining the densely fractured / incised landscape shows an impressive fan delta prograding onto the Chitina River floodplain. This study highlight the strong coupling between tectonic fracturing of rock, erosion and sediment transfer in alpine environments.