Geophysical Research Abstracts,
Vol. 11, EGU2009-13142, 2009
EGU General Assembly 2009

Revealing the micro-scale fault pattern from ALS-DTM data in an Alpine environment (Vorarlberg, Austria)

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The post-glacial geologic history of the Eastern Alps is dominated by erosion of over-steepened valley slopes, increased fluvial erosion and gravitational mass-movements. Increased erosion enhances the morphology of and observability of structural features, especially in high-resolution LiDAR-DTM data. The study area is located at the northern margin of the Penninic Units in Vorarlberg, Western Austria. Here, between the NW-margin of the Silvretta nappe and the Northern Calcareous Alps (NCA) a NW-SE striking fault zone supports the formation of crystalline duplex structures. Additionally, the generally E-W striking NCA units bend towards SW reflecting the overthrusting of the Alpine nappes.
A further focus lies on the mountain slopes bounding the Gargellen valley that were subjected to surface and erosional processes related to glaciation. The Gargellen valley joins the Ill-valley in the northern part of the study area. Both valleys hosted minor glaciers during the Pleistocene; the confluencing glaciers caused an increased stress on the bedrock. Thus, in this area effects of deglaciation are amplified. Typical processes acting on the slopes are: (i) frost shattering, (ii) gelifluction and after deglaciation (iii) surface runoff erosion due to increased precipitation, (iv) fluvial erosion by incising rivers. Since the beginning of the Holocene further mass wasting by sliding, slumping, fall, toppling and creep occurred. Assessment of the aforementioned micro- and mesoscale geomorphic features is needed to detect the ongoing processes and to determine the rates of deformation, incision and sediment production.
Because of their high-accuracy, LiDAR-DTMs are often applied to extract information on microtopography. A one-meter resolution LiDAR DTM was analyzed using a structural geologic approach. Results indicate that surface processes follow and reveal tectonic features. Also, a remarkable difference in geomorphologic characteristics is observable between the NW-side of the Gargellen valley and the mountain slopes on the SE-side. Whereas in the NW areas cockpits are abundant in the higher elevated regions and glacial features (e.g. moraines) can be traced very accurately, the mountain slopes on the SE-side are steep, straight slopes with triangular facets and a drainage pattern that follows a systematic grid most probably provided by fault locations. This distribution of geomorphologic features is likely to indicate different exhumation rates and neotectonic activity. A picture that is supported at a much larger scale by apatite fission track measurements form the Eastern Western Alps (e.g. Vernon et al., 2008).

Vernon A.J., van der Beek P.A., Sinclair H.D., Rahn M.K. (2008): Increase in late Neogene denudation of the European Alps confirmed by analysis of a fission-track thermochronology database. Earth and Planetary Science Letters, 270, 316-329.