Quaternary Erosion-Induced Isostatic Rebound in the Western Alps

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Here we test the idea that enhanced Quaternary erosion of the Alps and isostatic compensation of the mass removed can account for the distribution of present-day geodetically measured rates of vertical movement in the western Alps and quaternary deformation (tilting) of benchmarks. Using the so-called Geophysical Relief (Small and Anderson, Geology, 1998) and Kuhlemann's (e.g., Kuhlemann et al., Tectonophysics 2002) estimated average erosion rate for the Alps, we quantify the spatial distribution of erosion and the volume of eroded rock, respectively. From these, we obtain a synthetic map of rock eroded within a given time span (1Ma for this study, Champagnac et al., Geology, 2007).

The calculated isostatic response of the Alpine lithosphere to erosional unloading for a variety of values of the flexural rigidity of the Alpine lithosphere reaches a maximum of ~500 m since 1 Ma in the inner Swiss Alps, and vertical movement extends across the entire belt, including peri-Alpine basins. Assuming a steady erosion rate since 1 Ma, this rebound accounts for half of the measured vertical motion of 1.1 mm/yr in the southern Valais (Kahle et al., NRP20, 1997).

Furthermore, finite deformation of lower to middle quaternary sedimentary basins of both sides of the belt exibit a tilting consistent with our modeling. Thus, the isostatic response to enhanced erosion during Plio-Quaternary times appears to be a first-order agent in the alpine realm.