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Pliocene isostatic rebound of the Western Alps infered from topographic analysis and sediment budget

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The Western Alps currently undergo large-scale horizontal extension, which because of isostasy would lead to a deacrease in mean elevation, but leveling measurement show that the core of the Swiss alps is rising, as rapidly as 1.4mm/yr. Several mechanisms proposed to explain this vertical component of movement (post-glacial rebound, slab break-off…), are still being debated. We infer that a significant portion of the rock uplift of the Western Alps is due to isostatic response to erosion, which has been high since the beginning of the Pliocene.

We used the current topography of the Western Alps and the sediment budget from Kuhlemann (2000) to estimate both the volume *and* the spatial distribution of the "missing mass" (the eroded rock). The sediment budget from Kuhlemann. shows a dramatic increase in erosion of the Western Alps approximately at the beginning of the Pliocene. He estimates that for the last Myr, the average erosion rate in the Western Alps is 0.48mm/yr, 3 times the average for Miocene time. We assume the Upper Miocene rate to be a steady-state background rate of 0.15mm/yr. Thus we can split the Pliocene erosion rate in two parts: 0.15mm/yr for the steady-state part (for which we assume that erosion of the peaks has been similar to that of the valleys), and 0.33mm/yr for the "non-steady-state" part of the last 1 Ma (which we assume occurred by deepening of the valleys). We use the "Geophysical Relief" (Small and Anderson, 1998) as an indicator of the volume of the valleys by calculation of the volume between the topography and a surface envelope of the highest peaks within a circular sliding

window. Changing the radius of this circle allows us to correlate the volume of the non-steady-state part of the sediment budget (33 x 10^6km^3 for the last Myr) and the volume of the Geophysical Relief. This correlation shows that the volume of the Geophysical Relief in the Western Alps with a radius of 2km (circle of 12 km^2) matchs the steady-state part of Kuhlemann's volume of erosion since 1 Ma. The steady-state background rate is added to the Geophysical Relief to generate an erosion map. With a 2D point load flexural code, and using realistic elastic thicknesses of the Alpine lithosphere, we calculated the isostatic response for the mass of material eroded since 1 Ma. The maximum rock uplift is more than $\sim$ 500m in the Southern Valais and more than 400m for most parts of the Western Alps. Variation of the alpine elastic thickness in a realistic range of values (7km to 20km) yields isostatic responses that do not differ by more than 50m. This corresponds to half of the geodetically measured vertical rate of 1.1 mm/yr in the Southern Valais from re-measurement of leveling lines (Kahle et al., 1997), whereas the maximum geodetic uplift is located a few tens of km further to the NE. Thus, a significant fraction of the modern rock uplift is related to isostatic response to the enhanced erosion since the beginning of the Pliocene..

Kahle, H. G., et al. (1997), in *Results of NRP 20; deep structure of the Swiss Alps.*

Kuhlemann, J., (2000), *Mem. Sci. Geol. Padova, 52(1).*

Small, E. E., and Anderson, R. S. (1998), *Geology*, 26.