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Catchment-wide erosion rates in the Central Alps of Switzerland from in situ-produced cosmogenic ^{10}Be, and correlation with rock uplift rates: steady state topography?

H. Wittmann (1), F. von Blanckenburg (1), P. Kubik (2)

(1) Institut für Mineralogie, Universität Hannover, Hannover, Germany, (2) Paul Scherrer Institut, Institute of Particle Physics, Zurich, Switzerland

(hella.wittmann@gmx.de / Phone: 0049-5542-5955)

Some of the highest erosion rates of currently uplifting mountain ranges have been measured using cosmogenic nuclides from river sediment in the Central Alps of Switzerland. We sampled ten basins from Luzern (central Switzerland) to Borgosesia (northern Italy) during low flow from exposed sand bars in the active channel, yielding 15 results in total. The sampled catchments erode at 430 - 2110 mm/kyr; the catchments range in size from 30 to 680 km^2, are partly glaciated (up to 18% in a Rhone tributary) and feature considerable relief (from 620 m in the north Alpine Drainage Basin to 1640 m in the Reuss valley). We applied production rate correction factors for additional shielding through glaciation, snow cover, and topographic shielding in order to constrain accurate cosmogenic nuclide-derived erosion rates. For five of ten samples, two different grain size fractions were measured, revealing differences of up to a factor of two. This discrepancy might result from frequent transport of sediment during mass wasting events such as landslides, mud slides, debris flows, and rock falls. Cosmogenic nuclide-derived erosion rates exceed modern erosion rates from sediment load data in Alpine rivers by a factor of 4 to 20. We attribute this systematic difference in erosion rates to differences in methodology and integration time scale, although minor perturbations introduced by glaciation may also be important. Because relations between catchment area and erosion rate are absent, spatial inhomogeneity as cause of these differences can be excluded. A causal relationship between erosion and lithology in our study area can also be ruled out, given that all catchments except one

feature metamorphosed and igneous crystalline rocks with high erosional resistance. Moreover, we do not recognize a connection between hillslope gradient, topographic relief, and erosion rate. The lacking correlation between topography and denudation points at a possible topographic steady state condition. Under the condition of topographic steady state, there are no net changes in surface elevation, i.e. all parts of a landscape are eroding at the same rate. The assumption of a steady state condition in the Central Alps of Switzerland is supported by the rough agreement of denudation rates with geodetic uplift rates. The measured recent vertical movements relative to the benchmark at Aarburg exceed 1000 mm/kyr in the rear of the Central Alps and diminish to about 200 mm/kyr in the northern foreland. In other words, we suppose that erosion rates currently balance rock uplift rates in the Central Alps of Switzerland, maintaining steady state topography. Climatic parameters such as temperature and even the extent of glaciation do not reveal a controlling function with respect to Alpine erosion However, mean annual precipitation shows a weak correlation with erosion rates. This weak relationship is seen as a secondary cause, partly concealing uplift as main controlling factor.