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Erosion and weathering rates on timescales of 10^1 to 10^4 years derived from cosmogenic ^{10}Be and river loads

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In order to unravel the Quaternary landscape evolution in Variscan mountain ranges typical of central Europe, we determined erosion rates on timescales of 10^1 to 10^4 a. We chose catchments draining Palaeozoic sediments in the northeastern Rhenish Massif and granitic watersheds in the Black Forest. Long-term erosion rates derived from in-situ produced ^{10}Be concentrations in stream sediments show an averaged value of 57 $\pm$ 15 mm/ka for the Aabach and Möhne watersheds in the Rhenish Massif and 73 $\pm$ 22 mm/ka for the river catchments Acher and Gutach in the Black Forest. These spatially-averaged erosion rates integrate over 5 to 23 ka.

Short-term erosion rates were inferred from suspended and dissolved river loads subsequent to (1) correcting for atmospheric and anthropogenic inputs amongst others by using the stable isotope signature of δ^{13}C and δ^{34}S, (2) establishing rating curves that relate the amount of suspended load to discharge, and (3) estimating the amount of bedload. Geogenic short-term erosion rates, which integrate over the last 5 to 75 a, range from 9 $\pm$ 2 to 25 $\pm$ 4 mm/ka in five watersheds of the Rhenish Massif and are constantly 22 $\pm$ 5 mm/ka for the two catchments Acher and Gutach in the Black Forest. These erosion rates are only about one third of those derived from cosmogenic in situ ^{10}Be.

Using the geogenic dissolved load, we determined silicate weathering rates in order to quantify short-term CO_2 consumption rates through weathering. In the granitic watersheds of the Black Forest these short-term (5 to 75 a) CO_2 consumption rates by silicate weathering are more than twice (334 to 397 $\times$ 10^3 mol/km^2/yr) as high as in river catchments of the Rhenish Massif (28 to 150 $\times$ 10^3 mol/km^2/yr). This difference is likely due to steeper slopes in the Black Forest leading to higher mechanical erosion with respective higher amounts of fresh unweathered rock particulates and due to the fact that the sediments in the Rhenish Massif have already passed through at least one erosion cycle. In the long-term (10^3 to 10^4) rates of chemical weathering increase proportionally with rates of erosion (Riebe et al. 2004). Therefore, the long-term erosion rates derived from cosmogenic ^{10}Be – which are a factor of three higher than the short-term erosion rates – imply long-term silicate weathering rates and respective CO_2 consumption rates that are three times higher than those derived from the dissolved loads.

Riebe, C.S., Kirchner, J.W., Finkel, R.C., 2004. Erosional and climatic effects on long-term chemical weathering rates in granitic landscapes spanning diverse climate regimes. Earth Planet. Sci. Lett. 224, 547–562.