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Basin and river profile morphometry: a new index with a high potential for (at least) relative dating of tectonic uplift

Alain Demoulin

FSR-FNRS Belgium and Université de Liege, Dept. of Physical Geography and Quaternary, Liege, Belgium (ADEMOULIN@ULG.AC.BE, 0032 4 3665722)

Geomorphometry may be a powerful tool to describe the characteristics of the landscape's response to tectonic signals, but the meaning of morphometric indices is often obscured by the interplay between the many variables controlling the geomorphological evolution. Moreover, although the so-called hypsometric integral refers to the basin scale, most indices are generally derived from the river long profiles and thus focus mainly on the short-term response of a drainage network to base level change, providing limited information in regions of older and/or moderate uplift. Here, using the Rhenish shield (western Europe), an area of moderate Quaternary uplift, as a test case, I attempt first to build an index yielding a comprehensive view of the stage attained by the landscape's response and, indirectly, an evaluation of the timing of the triggering base level change. This index, called R_1, is a ratio of differences between the three integrals linked respectively to the classical basin's hypsometric curve, to the main river's long profile, and at the intermediate level, to a 'drainage network's hypsometric curve'. While its ratio form minimizes the lithological effect on R_1, this index is strongly correlated with basin size (regional correlation coefficients are in the range 0.88-0.93), reflecting the way an erosion wave propagates from the outlet of a basin toward its headwaters. Therefore, it is not directly usable as a proxy for relative uplift age. However, one can show that the relation between R_1 and basin size is theoretically expected to change with time. Following uplift, the slope S_r of the linear relation $R_1 = f(lnA)$ first increases rapidly but briefly, then it gradually diminishes over several million years. This is fully confirmed by the analysis of R_1 and S_r in the Rhenish shield study area. Once its initial increase is completed (assumedly in a few ten thousand years), S_r appears to be a reliable indicator of relative uplift (or any other cause of base level lowering) age. The next natural step of the research is to estimate the R_1 and S_r values in areas worldwide where the age of a recent base level change is more or less well constrained, in order to assess whether a quantitative relation might be derived, that would allow one to infer absolute ages of uplift from the index values. At present, the Mattole and Big River catchments near the Mendocino triple junction, and the drainage networks of eastern central Scotland, of the Montagne Noire (southern Massif Central), and of several subareas of the Bohemian massif have been investigated. The new data tend to indicate that, provided one corrects the indices for second-order effects such as catchment elongation (influencing the rate at which erosion diffuses in the entire catchment), uplift age has an exponential dependence on S_r.