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EVOLUTION OF THE LARGE SCALE DRAINAGE PATTERN OF THE SWISS ALPS IN RESPONSE TO COLLISION TECTONICS

Adrian Pfiffner & Andreas Kühni

The present day structure of the Swiss Alps is largely the result of a continent-continent collision which occurred in the past ca. 40 Ma. This collision led to the exhumation of high grade metamorphic rocks. A steeply N-dipping backthrust in the south (Insubric Line) is associated with denudation of a nappe pile 25 km thick. Further north, subsequent thrust faulting resulted in external basement uplifts, and associated denudation removed about 10–15 km of section.

The large scale 1st order geomorphic characteristics of this chain include two water divides and two belts of high elevations. On an erodibility map these areas of high elevation correlate to bedrock types with low erodibility (granitic rocks).

Numerical surface process modeling was carried out to examine the coupling between surface and deep processes. Surface processes include fluviatile and hill slope diffusive mass transfer. Deep processes are modeled with tectonic forcing as deduced from the crustal evolution of the Swiss Alps. This includes two uplift maxima: an earlier uplift along a model-Insubric Line which is followed by uplift of a model-external basement uplift. Combining a model-crust with rocks of homogeneous erodibility with this Alpine-type tectonic forcing results in a drainage pattern dominated by very stable rivers insensitive to changes in uplift rates. These rivers maintain their course perpendicular to the orogen axis almost irrespective of changes in uplift rates or erosional parameters. Only if two uplift maxima are taken to operate simultaneously do two water divides develop. If on the other hand a highly erodible unit, intended to represent a 2 km thick nappe stack of sedimentary rocks sandwiched between crystalline basement, is included in the model, the drainage pattern undergoes a profound change. Instead of incising the later forming northern model-basement uplift, axial rivers get captured by headward erosion of longitudinal rivers developing along the highly erodible units. The defeat of these axial rivers is held responsible for the ensuing development of the secondary water divide and the migration of the main water divide away from the maximum uplift of the model-Insubric Line.

Applied to the Swiss Alps the model results suggest that the primary signature of the collision, a nappe stack composed of rocks of very different erodibilities, together with the late-collisional uplift played an important role in the reorganization of the Miocene drainage pattern with axial rivers to the longitudinal rivers flowing today.

Authors' address:
Prof. A. Pfiffner, Institute of Geological Sciences, University of Bern, Baltzerstr. 1, CH-3012 Bern, Switzerland; Dr. A. Kühni, Holderbank Management and Consulting Ltd, CH-5113 Holderbank, Switzerland