POSSIBLE FEEDBACK MECHANISMS BETWEEN EROSION AND TECTONICS IN OROGENIC SYSTEMS

Fritz Schlunegger

Institute of Geological Sciences, University of Bern; schlunegger@geo.unibe.ch

Conceptual studies proposed a close linkage between lithosperic processes and surface erosion during the evolution of orogens. The sensitivity of erosion to tectonics (and vice versa) is particularly acute in active orogens, where accretion of lithospheric material leads to self-similar growth of a critical wedge at a rate that is controlled by the relative importance of crustal accretion and surface erosion. An increase in crustal accretion rates at constant erosion rates, for instance, will perturb this balance, causing the orogenic fronts of a critical orogen to shift towards more distal sides, and initiating a vertical growth of the topography in order to keep the critical self-similar geometry. Because of the vertical growth of topography, erosion rates and exhumation rates will increase and then remain at constant, but higher magnitudes. A similar effect, but with a substantially different exhumation pattern, yields a decrease of erosion rates at constant rates of crustal accretion. The response of a critical orogen to such a perturbation is a lateral self-similar growth. However, in contrast to the previous example, the erosional flux will first decrease, and then increase to the magnitudes prior to the perturbation. This increase occurs because erosion operates at a successively larger surface as the orogen widens. The orogen will enter a stable and steady situation when the accretionary flux will be balanced by the erosional flux. Note, however, that at this new stage exhumation rates will be lower than prior to the perturbation. Hence, the response of a climate-driven lateral growth of a critical orogen is a change from predominantly vertically- to laterally-driven exhumation. In a final case, an increase in the erosional flux larger than the accretionary flux will destroy the critical topography, leading to a smaller active wedge where deformation focuses in the core of the orogen to restore the critical taper. The result is a change towards a more vertically-directed exhumation in the orogen core.

This conceptual model potentially explains three major stages in the evolution of the Swiss Alps. The *first stage* between ca. 35 and 20 Ma is considered to represent the response to the indentation of the Adriatic promontory of the African plate into the interface between the upper and lower crust of the European continental plate. The result is a net accretion of crust into the orogen and a predominantly vertical growth of the Alpine edifice and the topography. The response on the surface was an expansion of the drainage network towards the rear of the orogen and downcutting. The data that is consistent with this interpretation is an increase in sediment discharge, a shift in the petrographic composition of conglomerates towards more crystalline constituents with sources in the rear of the Alps, lateral coalescence of alluvial fans, and high exhumation rates indicating a vertically-directed exhumation. The *second stage* started in the Burdigalian and lasted until the end of the Miocene. It is characterized by a lateral expansion of the wedge by ca. 100% as the southern Alps and the Jura mountains became incorporated into the wedge. This growth of the deforming wedge was associated by a decrease of exhumation rates and sediment flux. It implies a change from predominantly vertically-directed exhumation to lateral extrusion. Because the distal shift of the deformation fronts also enhanced the area on which erosion operated (though at lower magnitudes), sediment flux most likely increased until accretionary flux was balanced by the erosional flux. This appears to have been the case at end of the Burdigalian when the erosional flux reached similar magnitudes as at the end of the Aquitanian. The *third stage* of Alpine development started in the Late Miocene or early Pliocene. At that time, thrusts beneath the Po Plain became sealed by undeformed Pliocene, shortening in the Jura decreased, the North Alpine foreland basin became inverted and eroded, and active deformation started to focus in the core of the Alps where Quaternary thrusts were mapped. At the same time, sediment flux from the Alps increased to reach the highest magnitudes since the time of continent-continent collision. It caused the Alps to enter a destructive stage and the locus of active deformation to shift towards to the orogenic core, but it also resulted in a net unloading of the orogen and thus in a flexural rebound of the foreland plate.