Detrital fission-track geochronology, provenance studies and modern erosion rates in the Alps

Marco G. Malusà, Sergio Andò, Eduardo Garzanti,
Marta Limoncelli, Marta Padoan, Alberto Resentini, Giovanni Vezzoli
Laboratory for Provenance Studies, University of Milano-Bicocca (Italy) (marco.malusa@unimib.it)

Erosion is a key process in the evolution of orogenic belts. Fission-track grain-age distributions of detrital apatites mirror faithfully bedrock fission-track ages within drainage basins. When apatite content in source rocks is taken into account, as well as hydraulic sorting and related intersample/intrasample apatite variability (Garzanti et al. 2008, 2009), detrital fission-track studies constrain both long-term (10^6–10^8 a) and short-term (10^2–10^5 a) erosion rates in exhuming orogens.

Detrital apatites from the Po Delta show a young prominent peak, consistent with bedrock cooling ages observed in a small portion (12%) of the orogenic source areas, but accounting for 46% of dated grains (Malusà et al. 2009). This observation suggests that specific areas of the belt may have experienced short term erosion rates one order of magnitude higher than neighbouring areas. In order to track this young apatite signal upstream, we have analyzed samples of modern sands all along the Po River trunk and in most of its tributaries. We found that young apatites are chiefly shed from rivers draining the External Crystalline Massifs and the Lepontine Dome. This scenario differs substantially with respect to the late Oligocene - early Miocene one, when most of the detritus collected south of the Alps was eroded from the growing Lepontine Dome (Garzanti & Malusà, 2008).

Along the Aosta Valley transect, long-term and short-term erosion rates can be constrained with even greater detail, shedding light on the relationships between erosion and tectonics in that area. Rates of exhumation based on bedrock fission-track data, corresponding to long-term erosion rates in the lack of major low-angle normal faults, are higher in the fault-bound western block, which comprises the Mont Blanc massif, than in the eastern block (0.4–1.5 vs. 0.1–0.3 mm/a). Short-term erosion rates based on high-resolution petrography and heavy mineral analyses of bed-load in the Dora Baltea drainage display the same pattern, and have similar magnitudes in related sub-basins (0.4–0.7 vs. 0.04– 0.08 mm/a) (Malusà & Vezzoli 2006). This estimate is confirmed by unpublished detrital fission-track data along the Dora Baltea trunk, pointing to faster erosion rates in the western block.

The available data set suggests that climate, relief and lithology are not the controlling factors of erosion along the Aosta Valley transect. The main driving force behind erosion is instead tectonics, that causes the differential upward motion of crustal blocks.

References:

Garzanti E., Malusà MG (2008). The Oligocene Alps: Domal unroofing and drainage development during early orogenic growth. Earth Planet. Sci. Lett., 268, 487-500.

Garzanti E, Andò S, Vezzoli G (2008). Settling equivalence of detrital minerals and grain-size dependence of sediment composition. Earth Planet. Sci. Lett., 273, 138-151.

Garzanti E, Andò S, Vezzoli G (2009). Grain-size dependence of sediment composition and environmental bias in provenance studies. Earth Planet. Sci. Lett., 277, 422-432.

Malusà MG, Vezzoli G (2006). Interplay between erosion and tectonics in the Western Alps. Terra Nova, 18, 104-108

Malusà MG, Zattin M, Andò S, Garzanti E, Vezzoli G. (2009). Focused erosion in the Alps constrained by fission-track ages on detrital apatites. In Lisker et al. (eds), Geol. Soc. London Spec. Publ. 324, 1–12.