Constraining the geodynamic evolution of the Alps with sedimentary provenance and detrital thermochronometer data

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In this project we aim at disentangling sedimentary signals related to changes in the deep lithosphere, the upper crust, and climate change in the Alps. The overarching hypothesis of this proposal is that if lithospheric reorganisation in the Alps (e.g. slab breakoff at 30-32 and 25 (?) Ma, slab reversal at ca. 20 Ma) occurred, then it led to spatial and temporal changes in buoyancy that relocated the focus of rock uplift and erosion (Fig. 1). These changes are preserved in diverse sedimentary and geochemical records in the Alpine foreland basins.

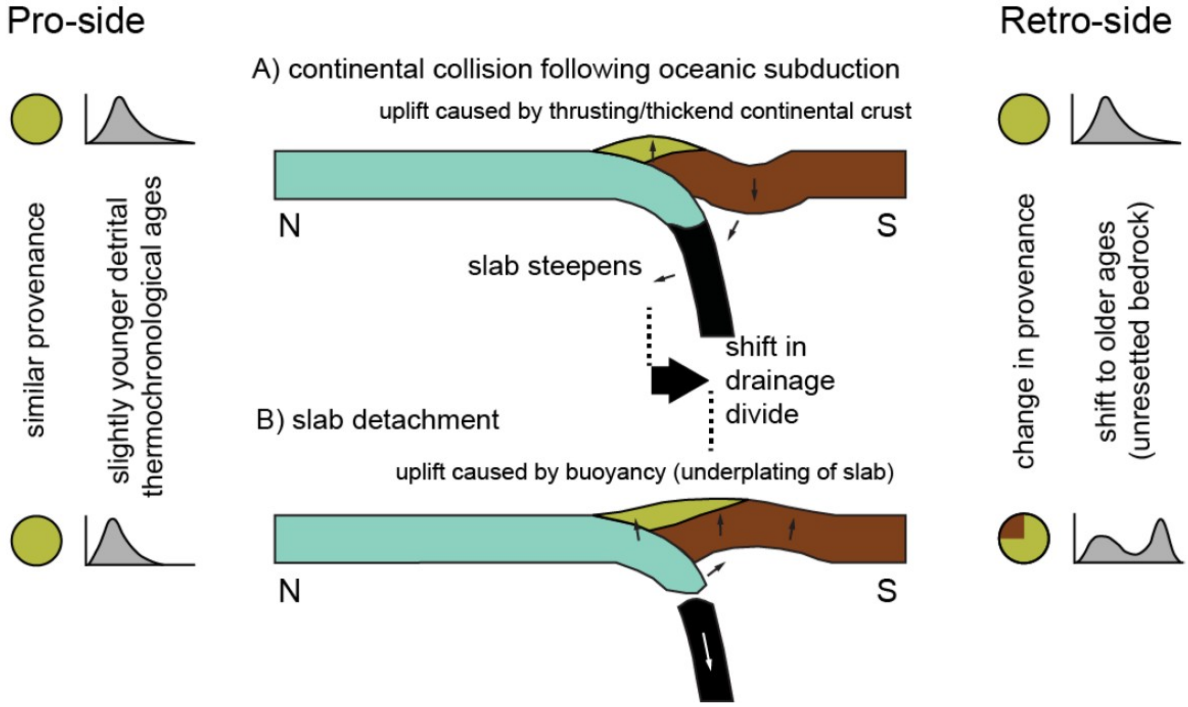

Fig. 1: Proposed model of the coupling of deep-seated lithospheric processes and surficial response. Slab processes can shift the focus of uplift and erosion, and therefore change the provenance of sediments.

In order to test this hypothesis, we apply a multi-proxy provenance approach at key stratigraphic time slices preserved in circum-Alpine proximal fan deposits (Swiss foreland basin, Austrian foreland basin, Po basin). Our approach overcomes the limitations of previous studies, by bridging methodological, temporal and integrational gaps through the combination of detrital geo-thermochronology (apatite and zircon triple dating with U-Pb, fission track and (U-Th)/He) dating, and provenance tools (petrography, heavy mineral composition, garnet chemistry).

In a first step, we sample modern fluvial sand of major alpine rivers (e.g. Adige, Inn, Isère, Rhine) as well as small, mono-lithological catchments draining different tectonic units and different lithologies (e.g. granites, metamorphic rocks, ophiolites). Provenance analysis of the sediment from mono-lithological catchments will establish compositional endmember fingerprints of the most important lithologies, which can then be used to estimate their relative contributions to the major rivers through mixing modeling. This will result in a modern-day erosion map of the Alpine orogen (e.g. Fig. 2). By comparing the data to published erosion rates and seismological data, we can test the sensitivity of the applied proxies and validate our methods.

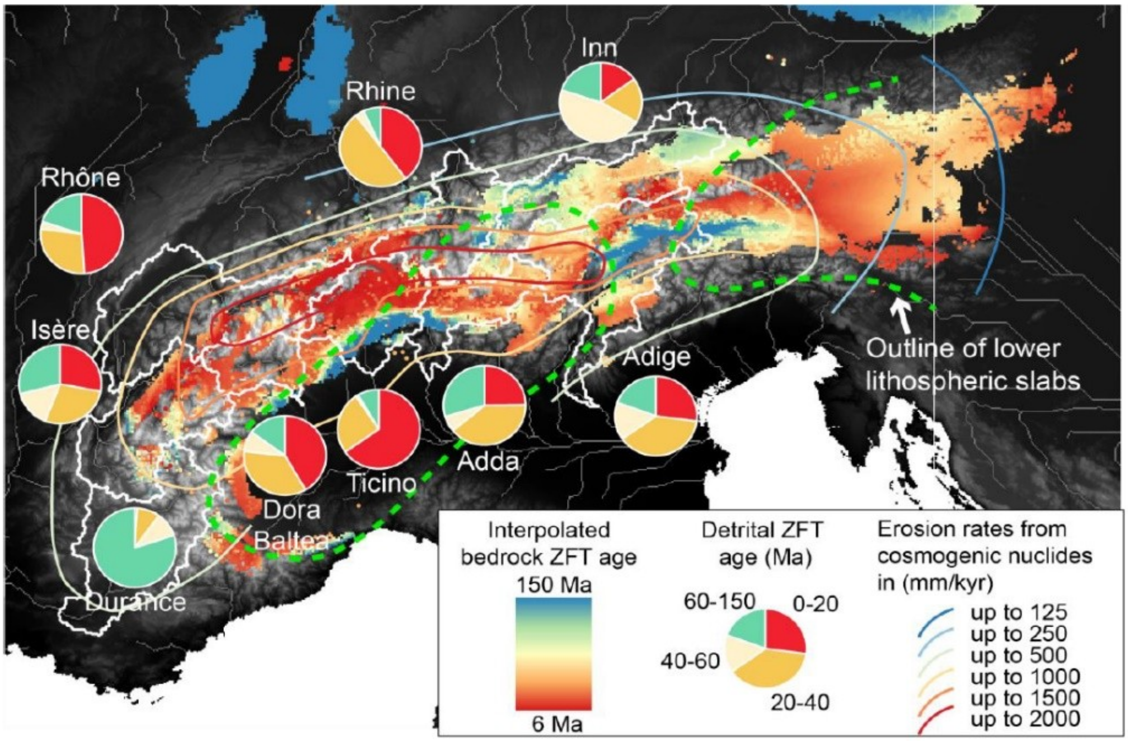

Fig. 2: Example of our approach using published zircon fission track (ZFT) ages from modern river sands (pie charts) and the interpolated ZFT ages of the alpine bedrock (after Bernet et al. 2004a,b). Assuming uniform erosion, the proportions of ZFT in the river sands should agree with the proportions of ages that occur in the catchment of the river. Over- or underrepresentation of individual age groups may point towards focused erosion of specific source units.

In a second step, we will analyze the composition of proximal sandstones deposited in basins on the pro- and retro-side of the orogen using the same methods. Here, we choose six time slices that are of particular interest to test the relationship between deep-seated processes and surface response (28, 25, 20, 17, 15 and 12 Ma). This will yield important insights into the distribution of source rocks, drainage patterns and exhumation hotspots through time.

These orogen-wide reconstructions will enable us to identify potential climate, tectonic or deep lithospheric drivers based on the location, timing and magnitude of events/changes. Our results will be used to test proposed geodynamic, climatic and basin evolution models.