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Erosion, transport and deposition along the South-Central Chilean margin: the detrital apatite fission track perspective

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Detrital fission track analysis has become a powerful tool for the study of sediment provenance and exhumation of orogens. Many studies focus on zones of continental collision with no or little volcanic activity, but there are less examples from active arc-trench systems. This type of orogen has a strong magmatic signature, and upper plate tectonothermal histories that are distinct from collisional mountain belts. Uplift and denudation histories are different, and may comprise long periods of relative upper plate stability, which can be identified by thermochronological methods.

In this study, we apply apatite fission track (AFT) single-grain age dating and sediment provenance analysis to modern and Pleistocene turbiditic sediments from the Chilean trench system (trench fans, trench fill, continental slope) complemented by a study of modern sediment samples from large Chilean rivers. The study area covers a ca. 1200 km long north to south transect (29°S to 47°S) encompassing areas of strongly variable characteristics, such as large latitudinal gradients in climate and terrigenous sediment input into the trench. This approach allows us (1) to trace sediment pathways on- and offshore focusing on all parts of the system, i.e. the bedrock sequences of the source, the fluvial transport system, and finally the sink within the trench, (2) to label those units that are under- and overrepresented, respectively, in the sink, making use of drainage system modeling and comparisons of grain age distributions to the cooling age pattern of the bedrocks of the feeder area, and (3) to test thermochronological concepts, such as a negligible transport time within the lag-time concept.

We find that AFT dating and sediment analysis point to opposing major sediment sources in the Chilean margin: Whereas sediment petrography mirrors the evacuation of large volumes of volcanic detritus, reflecting the high rate of erosion of volcanic edifices, no such young volcanic signal is seen in the detrital AFT signature. Plutonic units are identified as the main, often unique sources for shedding apatite into the sedimentary system. This finding has important implications for studies on stratigraphically older sequences, where the feeder area has long been eroded, and where the youngest age population is often interpreted as an indicator for active volcanism.

The most obvious feature observed within the detrital age population pattern along strike of the Chilean margin is an increasing contribution of sediment from the Andean Range to the south. This is explained by first-order controlling parameters such as lithology, increasing rainfall to the south, as well as ongoing uplift of the Coastal Cordillera. This recent mode of uplift, however, is not reflected in the actual (mainly Cretaceous) age of the population, which dominates the grain-age distributions in the northern half of the study area. This indicates a long-term relative tectonic stability of the forearc, corroborating that subduction erosion rather than tectonic erosion is the prevailing tectonic mode of this long-lived segment of the South American continental margin.

For the southernmost study area in the Patagonian Andes, it can be shown, that the sediment is derived from only small portions of the drainage along the main divide. This points to focused and rapid glacial erosion along the highest elevations. The results show, that in addition to the actual FT age, a second signal of short-term tectonic and erosional processes is preserved within the grain-age patterns.