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Multi-method geo- and thermochronology of glacially transported cobbles reveals the tectonic and exhumation history of the St. Elias Mountains (Alaska/Yukon)

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Multi-method dating is a powerful tool to understand tectonic processes and mountain building. In the case of inaccessible mountain regions, e.g., due to extensive glaciation, the dating of detrital material and bedrock samples from rare outcrops with geo- and thermochronologic methods is often the only applicable approach to study the timing and rates of tectonic processes.

The St. Elias Mountains of southeast Alaska and southwest Yukon are an example of a heavily glaciated orogen. With the help of detrital thermochronology of sand-sized material, exhumation patterns could be mapped, though with a low spatial resolution. In contrast, geo- and thermochronology applied to glacially derived cobbles yields provenance information from cobble lithology, zircon U-Pb dating, and the entire cooling history from multiple mineral phases. Multi-grain and multi-aliquot analyses yield high-precision crystallization and cooling ages, while sand-sized detritus requires analysis of single minerals particularly resistant to weathering.

We present a reconstruction of the Cenozoic tectonic and exhumation history of the St. Elias Mountains that was obtained from the analysis of 27 carefully selected and prepared cobble samples taken from two of the largest glacial catchments of the St. Elias Mountains. A total of 21 zircon U-Pb data sets as well as eight amphibole and seven biotite 40Ar/39Ar ages constrain the (maximum) formation and cooling ages, respectively, of the rocks in the source area. In addition, four zircon and six apatite (U-Th)/He ages as well as four apatite fission-track ages reveal the exhumation history of these source rocks. Integration of the cobble results with an additional three bedrock biotite 40Ar/39Ar ages and published geo- and thermochronologic data from along the St. Elias Mountains reveals details on the timing and rates of the Cenozoic tectonic evolution of the North American margin in southeast Alaska. Documented are the earliest Eocene spreading-ridge subduction and associated formation and cooling of the Chugach Metamorphic Complex, the beginning of flat-slab subduction of the Yakutat microplate in the late Eocene–early Oligocene, the ongoing Yakutat-North American plate collision, and rapid exhumation of the St. Elias syntaxis.

For a statistical analysis of erosion and sediment source, however, a higher number of cobbles would be necessary, which is not feasible due to the costly and time-consuming approach. Therefore, the combination of cobble- and sand-sized detritus analysis is recommended.