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Constraining Crustal Evolution on Very Short and Very Long Timescales

ABSTRACT: How continental crust is created, preserved and recycled, and whether or not these processes have changed through Earth history are important for a) understanding the geochemical and petrological stratification of the crust and b) quantifying long term geochemical and isotopic cycling in the Earth's crust and mantle. Developing models for crustal evolution requires robust geochronology on both the short and long timescales, targeting relatively rapid geologic phenomena (e.g. magma production and differentiation) as well as long term secular change. This talk highlights recent efforts to better apply high-precision U-Pb geochronology to continental magmatic systems and to develop techniques comparing magmatic systems through Earth history. Models describing the transfer of mass and heat through the crust during orogenesis demand age constraints with increasing precision and accuracy. While modern ID-TIMS U-Pb geochronology can resolve the timescales of zircon crystallization in single pulses of magma, much work is needed to relate dates to processes such as magma production, transport, differentiation, and emplacement. Our recent work focuses on integrating zircon crysallization ages and geochemistry to both understand the growth history of single zircons on <50 ka timescales and to build a framework for longer timescale geochemical evolution of two Alpine magmatic systems.

To compare differences in magmatic differentiation during crustal magmatism from the Archean to present, we develop statistical methodologies for analyzing large geochemical databases (Earthchem, etc.). Substantial differences in both crustal inputs (basalts) and indicators of differentiation to high-Si compositions suggest either secular changes in magmatic/metamorphic processes during crustal genesis and modification, or preservation bias. These results motivate further detailed investigation of Archean terranes, although robust comparison between any number of orogenic belts,

Archean or modern, require geochronology with precision that is relevant to tectonomagmatic processes. Sub-million year precision is now achievable in Archean rocks by ID-TIMS U-Pb geochronology, but necessitates careful integration of field, geochemical, and geochronological data with numerical modelling studies.