From date to process: Integrating geochemistry and geochronology on very short and very long timescales

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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 contribution 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.

Evolution of temperature and precipitation during Marine Isotope Stage 5 recorded in speleothems from the Hüttenbläserschachthöhle, western Germany

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We present high-resolution $\delta^{18}O$, $\delta^{13}C$ and trace element profiles for two stalagmites from Hüttenbläserschachthöhle, western Germany, which grew during Marine Isotope Stage (MIS) 5.

HBSH-1 provides a climate record with decadal to centennial resolution between 130 and 80 ka, which shows four growth interruptions coinciding with the Greenland Stadials. This shows that stalagmite growth is a very sensitive proxy for cool and dry conditions in the northern hemisphere.

We interpret stalagmite $\delta^{18}O$ as a proxy for past temperature changes, whereas stalagmite $\delta^{13}C$ rather reflects changes in the hydrologic balance. The $\delta^{13}C$ record shows three pronounced negative peaks during MIS 5, and the timing of those is in agreement with MIS 5e, 5c and 5a. This suggests warm and relatively humid climate in western Germany for these phases.

During the Last Interglacial, the evolution of $\delta^{18}O$ and $\delta^{13}C$ is opposite. Whereas the $\delta^{18}O$ signal suggests the warmest conditions around 125 ka followed by a gradual decrease, the $\delta^{13}C$ signal indicates wetter conditions towards the end of the Last Interglacial. This 'decoupling' of temperature and humidity during MIS 5e is also visible in a series of snapshot simulations performed with the general circulation model FAMOUS.

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