Monazite petrochronology by laser ablation split stream inductively coupled plasma mass spectrometry (LASS-ICPMS)

JOHN M. COTTLE[1*], ANDREW KYLANDER-CLARK[1] AND BRADLEY R. HACKER[1]

[1] Department of Earth Science, University of California Santa Barbara, CA 93106-9630, USA, cottle@geol.ucsb.edu (* presenting author)

Because monazite readily incorporates actinide and lanthanide elements and is reactive across a broad range of pressure, temperature, and fluid conditions, it is an ideal recorder of the nature and rates of a wide variety of diagenetic, metamorphic, magmatic and fluid-flow processes. It is common for monazite to preserve multiple episodes of growth, dissolution and re-precipitation within distinct intra-crystal compositional domains that are typically at, or below, the tens of micron scale. Development of measurement protocols to obtain age and petrologic information at high spatial resolution is therefore crucial to advancing monazite petrochronology.

This contribution details a new analytical configuration that enables simultaneous collection of both isotope and trace-element data. The laser ablation split stream inductively coupled plasma mass spectrometry (LASS-ICPMS) system at the University of California, Santa Barbara, uses two mass spectrometers (a Nu Plasma HR and an AttoM) coupled to a 193 nm ArF excimer laser ablation system to rapidly determine simultaneous *in-situ* U/Th-Pb dates, Sm-Nd isotopic compositions and trace-element concentrations. Hardware innovations include i) a modified collector configuration that enables simultaneous determination of Th-Pb and U-Pb dates by LA-MC-ICPMS using either Faraday cups or ion counters for Pb isotopes, and ii) increased instrument sensitivity and signal transmission resulting in a spatial resolution of 5 μm for U-Th-Pb dates and 9 μm for U-Th-Pb + Sm-Nd + trace-element determinations on Tertiary monazite; these allow the ability to directly tie measured dates to specific petrologic processes via Sm-Nd ratios, and/or trace-element abundances and ratios. Long-term accuracy and precision for Th-Pb and U-Pb dates is ~2% (2σ). Individual Nd ratio measurements have precisions of 20–30‰ and are accurate to within 5‰. Trace-element concentrations are accurate to within 3–5%.

The utility of the LASS approach—combining U-Th-Pb dates, isotopic compositions and trace-element abundances and ratios—will be illustrated with a broad range of geologic examples ranging from new insight into detrital monazite provenance, resolving fine-scale timing and duration of ultrahigh-pressure tectonics and unraveling the pressure–temperature history of Himalayan metamorphic rocks.

δ^{66}Zn profiles in five highly Zn-contaminated soils

E. COUDER[1,2*], E. SMOLDERS[3], B. DELVAUX[1], C. CAMBIER[1] & N. MATTIELLI[2]

[1] Earth and Life Institute, Université catholique de Louvain, 1348 Louvain-la-Neuve, Belgium - Eleonore.Couder@uclouvain.be (*presenting author)

[2] Laboratoire G-TIME, Université Libre de Bruxelles, 1050 Brussels, Belgium - nmattiel@ulb.ac.be

[3] Division of Soil and Water Management, Katholieke Universiteit Leuven, 3001 Heverlee, Belgium

Metalurgical industry, through emission and slag dumping, has strongly modified metal biogeochemical cycling. The soil-plant system is crucial for the understanding of metal transfer between terrestrial pools. In Belgian soils, zinc (Zn) is a main inorganic pollutant.

Variations in δ^{66}Zn between compartments of the plant-soil system are indicative of abiotic and biotic processes. Our previous data indicate that Zn isotopic compositions (δ^{66}Zn) of topsoils reflect the Zn isotopic signature of the main Zn-emitter. The main goal of the present study consists to examine the δ^{66}Zn profiles in five contrasted soils covered by various plant species.

Two natural soils, a calcareous soil (CS) and a shale-derived soil (SS), both contaminated by Zn aerial fallouts, and three soils developed on a slag heap were chosen. Throughout the soil profiles, the soils have been characterized: (i) the total Zn concentrations in bulk soil (Zn_{tot}), which vary from 0.2 up to 74.8 g kg^{-1}, and (ii) the oxidizable Zn fractions (Zn_{ox}, i.e. proportion of Zn-bearing organic matter *vs* Zn_{tot}) ranging between 3.5 and 34.7 % of Zn_{tot}. High precision δ^{66}Zn data measured by MC-ICP-MS are reported (relative to the JMC Zn standard solution) for bulk soils, gravity soil solutions, surrogate soil solutions obtained by 0.01M $CaCl_2$-extraction and shoots from plants growing on-site.

Relative to the bulk soils (δ^{66}Zn from -0.7±0.03‰ to +0.56±0.03‰), enrichment in light Zn isotopes is observed both in the gravity and surrogate solutions (δ^{66}Zn varies from -0.25±0.01‰ to +0.25±0.01‰ (±2SD)) as well as in shoots (δ^{66}Zn from -0.05±0.02 to +0.14±0.02‰). As a result of Zn uptake by plants or Zn leaching, the residual topsoils will be comparatively enriched in heavy isotopes.

Throughout the soil profiles (CS and SS), an increase in δ^{66}Zn values with depth is observed and is negatively correlated with Zn_{ox}. This trend reflects transport of Zn-bearing organic matter, coming from the dead plant material and enriched in light Zn isotopes, from the topsoil to the depth via bioturbation and/or mass movement processes.

In summary, the δ^{66}Zn profiles in the five contaminated soils reflect the combined processes: (i) soil leaching, (ii) dead plant return to soil, and (iii) organic matter transfer to depth.