Geophysical Research Abstracts
Vol. 14, EGU2012-1192, 2012
EGU General Assembly 2012

# Combined apatite fission track and U-Pb dating by LA-ICPMS

D.M. Chew (1) and R.A. Donelick (2)

(1) Department of Geology, School of Natural Sciences, Trinity College Dublin, Dublin 2, Ireland (chewd@tcd.ie), (2) Apatite to Zircon, Inc., 1075 Matson Road, Viola, Idaho 83872-9709, U.S.A.

Apatite is a common accessory mineral in igneous, metamorphic and clastic sedimentary rocks. It is a nearly ubiquitous accessory phase in igneous rocks, is common in metamorphic rocks of pelitic, carbonate, basaltic, and ultramafic composition and is virtually ubiquitous in clastic sedimentary rocks. In contrast to the polycyclic behavior of the stable heavy mineral zircon, apatite is unstable in acidic groundwaters and has limited mechanical stability in sedimentary transport systems. Apatite has many potential applications in provenance studies, particularly as it likely represents first-cycle detritus.

Fission track and U-Pb dating are very powerful techniques in apatite provenance studies. They yield complementary information, with the apatite fission-track system yielding low-temperature exhumation ages and the U-Pb system yielding high-temperature cooling ages which constrain the timing of apatite crystallization. This study focuses on integrating apatite fission track and U-Pb dating by the LA-ICPMS method. Our approach is intentionally broad in scope, and is applicable to any quadrupole or rapid-scanning magnetic-sector LA-ICPMS system.

Calculating uranium concentrations in fission-track dating by LA-ICPMS increases the speed of analysis and sample throughput compared to the conventional external detector method and avoids the need for neutron irradiation (Hasebe et al., 2004). LA-ICPMS-based uranium measurements in apatite are measured relative to an internal concentration standard (typically $^{43}$Ca). Ca in apatite is not always stochiometric as minor cations ($Mn^{2+}$, $Sr^{2+}$, $Ba^{2+}$ and $Fe^{2+}$) and REE can substitute with $Ca^{2+}$. These substitutions must be quantified by multi-elemental LA-ICPMS analyses. Such data are also useful for discriminating between different apatite populations in sedimentary or volcaniclastic rocks based on their trace-element chemistry.

Low U, Th and radiogenic Pb concentrations, elevated common Pb / radiogenic Pb ratios and U-Pb elemental fractionation are challenges in apatite U-Pb dating by LA-ICPMS. Isochron-based approaches to common Pb correction require a significant spread in common Pb / radiogenic Pb ratios. This is not usually possible on individual detrital apatite grains and hence the $^{204}$Pb-, $^{207}$Pb- and $^{208}$Pb-correction methods are preferred. Uranium concentration measurements by ICPMS employ large peak jumps (the internal standard is a Ca isotope) which require a quadrupole or a rapid-scanning magnetic-sector LA-ICPMS system. These single-collector instruments require a prohibitively long dwell time on the low intensity $^{204}$Pb peak to measure it accurately and hence the $^{207}$Pb- and $^{208}$Pb-correction methods are preferred.

Uranium-concentration measurements in fission-track dating require well-constrained ablation depths during analysis and hence spot analyses are preferred to rastering. Laser-induced U-Pb fractionation is corrected for by sample-standard bracketing using a variety of apatite standards (Durango, Emerald Lake, Fish Canyon Tuff, Kovdor, Otter Lake and McClure Mountain syenite). Of these, Emerald Lake (Chew et al., 2011) and McClure Mountain syenite apatite are recommended as primary standards with Durango apatite making a suitable secondary standard. Offline data-reduction uses custom-written software for ICPMS data processing (the UPbICP package of Ray Donelick) or the freeware IOLITE data-reduction package of Paton et al. (2010).

References:

Chew et al. (2011) Chemical Geology 280, 200–216.

Hasebe et al. (2004) Chemical Geology 207, 135-145.

Paton et al. (2010) $G^3$, 11 Q0AA06.