In-situ Lu-Hf dating of xenotime by reaction cell isotope separation

THOMAS ZACK AND JOHAN HOGMALM

Department of Earth Sciences, University of Gothenburg, Sweden

Hafnium isotope measurements by LA-MC-ICP-MS have revolutionized interpretations derived from zircon by combining Hf information with U/Pb ages from the same spot. However, those studies are only possible due to very low Lu/Hf (ca 0.0003) and Yb/Hf (ca 0.003) ratios in zircon. In cases of higher ratios, isobaric interferences of ^{176}Yb and ^{176}Lu prevent successful corrections for accurate ^{176}Hf/^{177}Hf determinations.

With the installation of one of the first Agilent 8800QQQ coupled to a LA system devoted to geochemistry, we are able to explore the removal of isobaric interferences with the help of a reaction cell sandwiched between two quadrupoles (MS/MS mode). Optimization of parameters for carrier gas flow, lens settings and reaction cell gases leads to conditions where Hf isotopes are largely transferred as a compound to a higher mass (mass shift), while almost no Yb and Lu reacts, but is effeciently transmitted (on mass). Compared to a no gas mode, ca 50% of Hf is transferred in reaction gas mode, while less than 0.5‰ Lu and 0.0005‰ Yb are transferred. In contrast, nearly 100% of Lu is measured on mass compared to no gas mode.

This almost ideal behavior enables us to directly date HREE-rich minerals by the Lu/Hf method. In this proof-of-concept study, we dated 1.8 Ga old xenotime. Even at Lu/Hf ratios of 1000 and Yb/Hf ratios of 10000, the amount of ^{176}Hf* of all isotopes with mass 176 is always more than 75%. Measurement of 11 spots in xenotime with various Lu/Hf and Yb/Hf ratios results in corrected ^{176}Hf*/^{176}Lu ratios of 0.0342± 1.4%(2s), corresponding to ages within error to U/Pb ages. Since a quadrupole ICP-MS is involved, errors are in the low-% range (and not epsilon-errors typically achieved by multi-collector). This nevertheless transfers to age uncertainties of only 0.6% due to the high initial Lu/Hf ratios and pooling of repeated measurements.

Although xenotime can be dated rather easily by the U/Pb method, the technique introduced here has the advantage of being less prone to laser-induced isotope fractionation and is hence likely less matrix dependant. This opens up the opportunity to date a range of HREE-rich minerals like gadolinite, aeschynite and euxenite where no matrix-matched standards for U/Pb dating exist. Furthermore, it can be expected that Hf is more immobile than Pb when it comes to metamictisation, reheating and/or hydrothermal alteration.