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High spatial resolution analyses of strontium isotopes by LA-MC-ICP-MS: Application to apatite inclusions in zircon

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Strontium isotopes have been widely used in crustal evolution studies because they provide a unique time-integrated record of mantle–crust interactions processes. However, one major issue with approaches based on bulk-rock analyses is the poor robustness of the Rb-Sr system during secondary process of crust evolution (e.g., metamorphism, alteration). Consequently, there has been increasing interest in analysing low Rb/Sr phases that can be dated with the U-Th-Pb method, and which are present as primary phases in the rock matrix and/or as inclusions within zircon. Apatite is one of the most abundant accessory minerals in felsic rocks, it is commonly found within zircon, and given its low Rb content, its $^{87}Sr/^{86}Sr$ ratio reflects the isotopic composition of the source from which it crystallised. The integrated study of zircon and apatite therefore represents an exciting new development in crustal evolution studies.

One current challenge is to obtain high-quality *in-situ* Sr isotope data in apatite, as LA-(MC)-ICP-MS techniques have shown limitations due the presence of polyatomic interferences on Sr isotopes, such as $CaPO^+$ and doubly charged Yb and Er. Here we present a new routine procedure to analyse Sr isotopes in apatite by LA-MC-ICP-MS, with a Thermo Scientific Neptune XT MC-ICP-MS coupled with a Teledyne Cetac Analyte Excite+ 193 nm laser ablation system. A specific approach, based on repeated analyses of apatite standards and calibration solutions, was used to determine optimal instrument set-up and data reduction schemes, for laser ablation spot sizes between 50 µm and 5 µm. The $^{87}Sr/^{86}Sr$ ratios of Durango, Madagascar, Slyudyanka, Sumé and Ipirá apatites are within error of both published values and new solution data for these standards. A precision of ~100 ppm (2 s.e.) can be achieved for ~80000 μm^3 of material ablated, and the precision remains better than 3000 ppm for volumes as small as 800 μm^3.

We applied this approach to the analysis of apatites and apatite inclusions in zircons from the Caledonian high Ba-Sr granitoids (Northern Highland Terrane, Scotland). The comparison between new *in-situ* data and previous bulk-rock data provides new insights into the behaviour of the Rb-Sr system in granitic rocks.