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In-situ Sr isotope measurements for apatite: achieving precise data with high volume resolution using HR-SIMS

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Apatite provides a powerful means to determine Sr isotopic composition ($^{87}Sr/^{86}Sr$) of ancient crust as it contains enough Sr to be measured but typically little Rb. A number of studies to measure apatite Sr isotopes have been published using LA-ICP-MS, but a little using SIMS [1,2]. Although utilising LG-SIMS is beneficial for small-volume targets, e.g., inclusions, it is technically challenging to measure Sr isotopes in apatite with good accuracy and precision by SIMS, mainly due to molecular interference (e.g., Ca dimers) on Sr isotopes that have not previously been thoroughly assessed. Here we present the method developed and results obtained using a CAMECA IMS1280 instrument.

Instead of separating Ca dimers from Sr isotopes using exceedingly-high mass resolution ($\Delta m/m$ >18k), intermediate mass resolution (ca. 4500) was chosen to measure the combined signals of Sr isotopes and Ca_2 [1,2]. After evaluating theoretically possible interferences affecting Sr isotope analysis of apatite by SIMS, all mesaureable and/or estimatable interferences (mainly Ca_2 and CaPO tail) were corrected. Precise instrument tuning and mass calibration is essential to measure properly the combined signal and to minimise any interference contribution to Sr isotope measurement, as a few excess counts are critical to the accuracy of the Sr isotope ratio, particularly in low-Sr apatite. Empirical corrections were also required for the inadequate $^{40}Ca^{42}Ca$-based Ca_2 correction and for a slightly positive offset (ca. +0.0007) of unknown origin in $^{87}Sr/^{86}Sr$, and possibly for the contributions of some molecular interferences that cannot be resolved (for the apatite having high trace elements). The final corrected $^{87}Sr/^{86}Sr$ of the reference materials show good accuracy and precision with 1SE from ca. 0.0010 to 0.0002 obtained for Sr contents from <100 to 1500 ppm [3].

[1] A. Lepland & M. J. Whitehouse (2011), Int J Earth Sci 100, 1-22.

[2] J. Gillespie et al. (2021), Chem. Geol, 559, 119979.

[3] H. Jeon & M. J. Whitehouse (2021), Geostand Geoanal Res, doi:10.1111/ggr.12377