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Enhancing in-situ Rb-Sr Geochronology with Combined ICP-MS/MS and MC-ICP-MS

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The fundamentals of Rb-Sr dating have been established since the 1940s. However, until recently the technique was hindered by a slow turnaround times due to the necessity of wet chemistry. The development and democratisation of LA-ICP-MS/MS have addressed these challenges by "bypassing" isobaric interferences, and enabling fast data acquisition, while retaining contextual microstructural information owing to its in-situ nature.

Despite these advantages, ICP-MS/MS instruments are not ideally suited for precisely measuring $^{87}Sr/^{86}Sr$ in low-Rb phases, leading to broad and often simplistic assumptions about the initial $^{87}Sr/^{86}Sr$ composition. Theoretical isochrons derived from such assumptions maybe problematic and potentially imprecise because: (1) Sr isotopic composition can vary greatly in geological materials (e.g. crustal contamination; inherited-recycled components), and (2) multiple mineral populations derived from independent events may coexist within a sample.

To assess the accuracy of Rb-Sr dates obtained by LA-ICP-MS/MS, this study explores the potential of combining LA-MC-ICP-MS measurements of Sr ratios of low-Rb phases to complement ICP-MS/MS analyses of high-Rb minerals. In the presented case study, a sample was dated by LA-ICP-MS/MS using Rb-Sr in apatite+albite+biotite, while the low-Rb phase (apatite) also had its $^{87}Sr/^{86}Sr$ measured by LA-MC-ICP-MS. Although the average values of all measurements from both techniques were similar — 0.7674 ± 0.0068 (ICP-MS/MS) and 0.7628 ± 0.0088 (MC-ICP-MS) — the precision on individual measurements was significantly higher with MC-ICP-MS, which yielded a typical $^{87}Sr/^{86}Sr$ uncertainty (2s) of 0.0002 compared to 0.005 for ICP-MS/MS. Increased precision allowed identification of two isotopically distinct apatite populations with $^{87}Sr/^{86}Sr$ ratios of 0.7541 ± 0.0007 and 0.7715 ± 0.0014, respectively.

Incorporating a more accurate initial Sr composition and correctly assigning the appropriate apatite population as anchor for age calculations improved both accuracy and precision of the obtained age. Single ICP-MS/MS approach yielded an isochron age of 1332 ± 22 Ma (MSWD = 13), whereas combined ICP-MS/MS + MC-ICP-MS resulted in an age of 1346.7 ± 0.7 Ma (MSWD = 0.98). The high-precision measurements of MC-ICP-MS not only allowed for accurate determination of initial Sr composition, but also enabled quantitative resolution of distinct mineral populations/generations, which could not be distinguished by ICP-MS/MS due to its lower precision.