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Technological Advances in High-Resolution In-Situ 87Sr/86Sr Analysis of Carbonates by LA-MC-ICP-MS

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High-precision ^87Sr/^86Sr measurements in carbonates are traditionally obtained by ID-TIMS or solution MC-ICP-MS, achieving precision at the 5th–6th decimal place. However, these approaches require full dissolution, chromatographic purification, and bulk homogenization, potentially masking micro-scale isotopic heterogeneity and limiting analytical throughput. We present a refined LA-MC-ICP-MS protocol optimized for high-resolution in-situ ^87Sr/^86Sr analysis in compositionally complex carbonate matrices, emphasizing interference control, detector configuration, and analytical validation. Analyses were conducted using a 193 nm ArF excimer laser coupled to a Neptune Plus MC-ICP-MS. Raster ablation employed a 40 µm beam, 700 µm line length, 10 µm s^{-1} scan speed, 7 Hz repetition rate, and 6.26 J cm^{-2} fluence. Helium carrier gas flow was 0.55 + 0.35 L min^{-1}. ICP conditions included 1220 W RF power, Jet sample cone, X skimmer cone, and low-resolution mode. A critical methodological improvement was the implementation of high-resistance 10^{13} Ω amplifiers for low-intensity beams, significantly enhancing signal-to-noise ratios in domains with low Sr concentration (<300 ppm) and enabling stable measurements down to ~0.3 V on ^88Sr. Sr intensities ranged from 0.3–8 V in samples (≈145–4000 ppm Sr) and 15–17 V in JCp-1 (~7290 ppm). On-peak corrections included ^84Kr and ^86Kr (gas blank monitoring), ^87Rb interference via mass 85 tracking, and offline correction of doubly charged REE species and Ca-based polyatomics. Mass bias was internally normalized using ^86Sr/^88Sr = 0.1194. External reproducibility of JCp-1 yielded ^87Sr/^86Sr = 0.709210 ± 0.000020 (2σ), compared to ID-TIMS values of 0.709090 ± 0.000003, representing one order of magnitude lower precision but preserving microtextural control. Homogeneous domains reproduce to the 5th decimal place; Rb-bearing zones typically degrade to the 4th decimal, allowing objective filtering through integrated data-reduction protocols. Relative to solution methods, the in-situ workflow reduces preparation time from days to hours, eliminates chromatographic blanks, and enables >50 spots per session (~6000 integrations in 10 h). This protocol establishes a robust and transferable analytical framework for resolving micro-scale isotopic variability in heterogeneous carbonate systems, where spatial resolution provides critical geological insight beyond bulk precision.