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Strontium isotopic ratio measurement using inductively coupled plasma mass spectrometry

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Introduction

Strontium (Sr) has four natural occurring, stable isotopes: ^{84}Sr, ^{86}Sr, ^{88}Sr, ^{87}Sr. Of those, only ^{87}Sr is radiogenic, the other three formed as radioactive decay products of ^{87}Rb isotope[1]. Thus, Strontium isotopic ratio in the environment varies spatially and it is largely affected by the variability of the geological background. The spatial representation of Sr isotopic ratio variation across a landscape can offer valuable information according to the bedrock age and geological origins. In this study, the Sr isotopes quantification was validated using and inductively coupled plasma mass spectrometer (ICP-MS), using a triple quadrupole mass filter (Thermo Scientific iCAP TQ instrument).

Materials and methods

NIST 987 standard reference material (SRM)[2], purchased directly from NIST, was used to verify the developed method's accuracy and reproducibility. Millipore ultrapure water was used for dilution and Suprapur nitric acid (5% concentration) for cleaning before and after each batch run.

In last decades, sample preparation requires special resin extraction of Sr isotopes, to avoid isobaric interference ^{87}Rb that alters $^{87}Sr/^{86}Sr$ value, which translates into longer, more expensive, sample preparation step. Thist was avoided in the present study by using a triple-quadrupole ICP-MS and a reaction/collision cell pressurized with oxygen around second quadrupole. In this way, even if both ^{87}Sr and ^{87}Rb pass through first quadrupole (Q1), Sr reacts with oxygen in Q2 forming $^{87}Sr^{16}O$ and Rb ions are filtered out in Q3, shifting the detected mass of ^{87}Rb from 87 to 103, which is interference free[3].

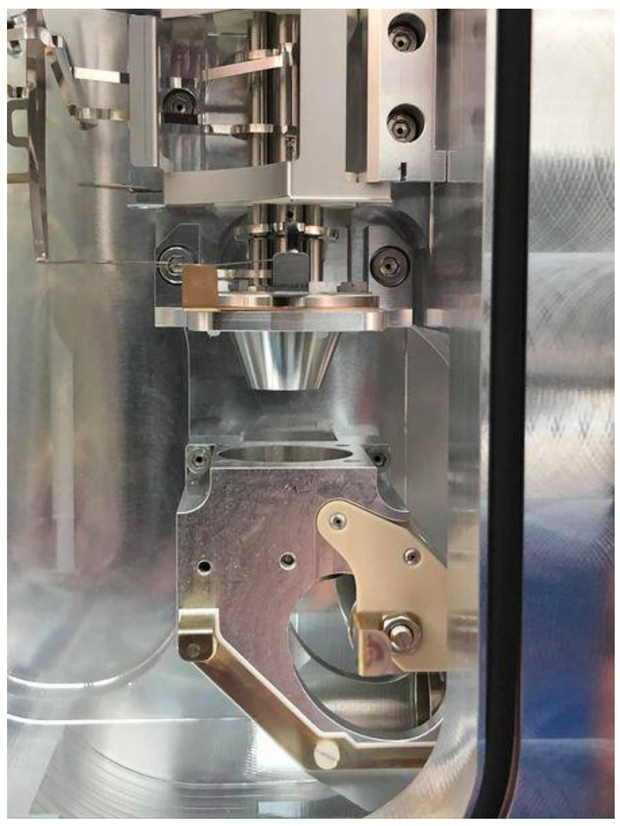
Detector was kept in *counting mode* for optimum accuracy. Larger values from *Faraday mode* domain were discarded and the sample was further diluted and read again, if necessary (only for $^{88}Sr/^{86}Sr$, since ^{88}Sr is the most abundant isotope, with a natural abundance of 82.58%)[4]. Detector deadtime setting was optimized before the analysis. Before each batch samples, the signal/noise ratio was optimized using manufacturer suggested procedures.

Results and discussion

A batch of 20 replicates of NIST 987 SRM were considered for this study. The obtained results ($^{84}Sr/^{86}Sr$ = 0.0551 ± 0.0003, $^{87}Sr/^{86}Sr$ = 0.7186 ± 0.0020, and ^{88}Sr /^{86}Sr = 8.5412 ± 0.0244, graphically shown in Figure 1) are in good agreement with certified values of the standard reference material[2], considering the intrinsic limitation of a quadruple ICP-MS for isotopic ratio measurements. Deviation from certified values was expected, but this is mitigated during sample analysis by bracketing calibration. Standard deviation for each isotope ratio measurement is below 0.6% for all measured isotopes.

Conclusion

Isobaric interferences were removed by using a reaction cell and a triple-quad ICP-MS, thus allowing the detection of all Sr stable isotopes. This approach transforms the ICP-MS technique into a powerful tool in developing methods with applications in many fields, from verifying agricultural products authenticity to establishing archaeological artifacts origin or age, in a historical framework.



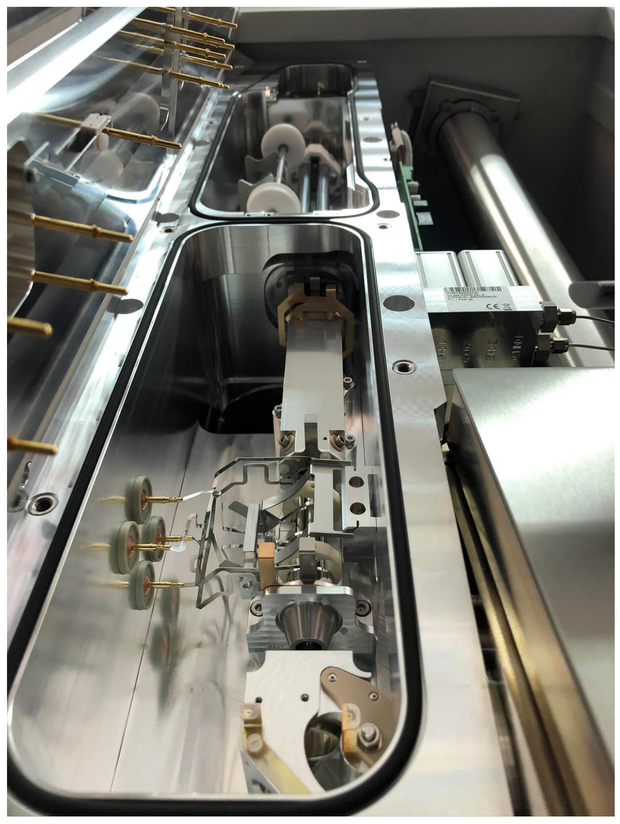


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Figure 1. Plot presentation of the obtained results for the $^{84}Sr/^{86}Sr$ (A), $^{87}Sr/^{86}Sr$ (B), ^{88}Sr /^{86}Sr (C) isotope ratios