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Achieving ppm-level precision and accuracy in triple silicon isotope measurements using high–mass-resolution gas source mass spectrometry

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Triple silicon isotopes ($\Delta'^{29}Si = \delta'^{29}Si - 0.5178 \times \delta'^{30}Si$) have emerged as a powerful tracer for terrestrial planet accretion and silicon cycling on Earth [1-3], yet their broader application has been limited by analytical precision and accuracy that remain insufficient relative to the subtle isotopic variations observed in natural samples. Overcoming this analytical bottleneck is essential to fully realize the potential of triple silicon isotopes in geoscience and planetary science.

Here, we present a novel analytical protocol that achieves a 1σ standard error of ~1 ppm or better for triple silicon isotope measurements using high–mass-resolution gas source mass spectrometry (Thermo Fisher Scientific Ultra HR-IRMS), representing a substantial improvement over previously reported method. In this approach, silicates are quantitatively converted to $BaSiF_6$ and subsequently decomposed to SiF_4 gas for isotopic analysis. This strategy circumvents mass bias instabilities and matrix effects inherent to plasma-source mass spectrometry and effectively mitigates isobaric interferences from SO_2F_2 and COF_3 that can severely compromise measurement accuracy in gas source analyses.

To further ensure analytical robustness, we simultaneously monitor the mass 88 ion beam, an ion fragment derived from SO_2F_2, enabling real-time assessment of potential interference contributions and providing a critical internal check on measurement accuracy. Application of this protocol to chert samples from the Jixian section yields a $\Delta'^{29}Si$ value of -17.3 ± 1.0 ppm, consistent with previously reported data but obtained with significantly improved precision and confidence.

This protocol establishes a robust analytical foundation for triple silicon isotope measurements and provides a methodological framework directly analogous to high-precision triple oxygen isotope analysis, enabling broader application of triple silicon isotopes in geochemical and planetary studies.

References:

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