In situ sulfur isotopes ($\delta^{34}S$ and $\delta^{33}S$) analyses in sulfides and elemental sulfur using high sensitivity cones combined with the addition of nitrogen by laser ablation MC-ICP-MS

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The sulfur isotope is an important geochemical tracer in diverse fields of geosciences[1]. In this study, the signal intensities of S isotopes were improved by a factor of 2.3 and 3.6 using the X skimmer cone combined with the standard sample cone or the Jet sample cone, respectively, compared with the H skimmer cone combined with the standard sample cone. Different cone combinations have a significant effect on the mass bias and mass bias stability for S isotopes. Poor precisions of S isotope ratios were obtained using the Jet and X cones combination at their corresponding optimum makeup gas flow when using Ar plasma only. The addition of 4-8 ml min^{-1} nitrogen to the central gas flow in laser ablation MC-ICP-MS was found to significantly enlarge the mass bias stability zone at their corresponding optimum makeup gas flow in these three different cone combinations. The polyatomic interferences of OO, SH, OOH were also dramatically reduced, and the interference free plateaus of sulfur isotopes became broader and flatter in the nitrogen mode (N_2=4 ml min^{-1}). The matrix effect among different sulfides and elemental sulfur was observed, but it could be significantly reduced using line scan ablation instead of single spot ablation under the optimized fluence. It is recommended that the d_{90} values of the particles in pressed powder pellets for accurate and precise S isotope analysis should be <10 μm. Under the selected optimized analytical conditions, excellent agreements between the determined values and the reference values were achieved for the IAEA-S series standard reference materials and a set of six well-characterized, isotopic homogeneous sulfide standards (PPP-1, MoS_2, MASS-1, P-GBW07267, P-GBW07268, P-GBW07270), validating the capability of the developed method for providing high-quality *in situ* S isotope data in sulfides and elemental sulfur.

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