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Advances in high-precision analysis of stable potassium (K) isotope ratios by "Sapphire" collision-cell MC-ICP-MS

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Recent studies have shown that stable potassium (K) isotopes ($^{41}K/^{39}K$) can be valuable tracers for a wide range of geological, environmental, and biological processes [1], but high-precision K isotope analysis is challenging on conventional mass spectrometers because of intense interferences related directly to the argon plasma, such as $^{40}Ar^{1}H^{+}$ on $^{41}K^{+}$. Although high mass resolution capability of modern MC-ICP-MS instruments provides one solution to this analytical challenge, it generally leads to loss of more than 90% sensitivity.

"Sapphire" MC-ICP-MS from Nu Instruments is the latest generation collision-cell MC-ICP-MS instrument. The collision/reaction cell on "Sapphire" allows for removal of Ar-related interferences to negligible levels, offering the capability of analyzing K isotope ratios under low mass resolution. Here we present assessment on "Sapphire" MC-ICP-MS for K isotope analysis based on our extensive use of this instrument for more than 1.5 year. Our results show that accurate K isotope analysis with a long-term reproducibility of better than 0.05‰ (2SD) can be achieved using the collision/reaction cell mode and a helium/hydrogen gas mixture. In addition to much improved analytical precision as compared to typical precisions achieved on conventional MC-ICP-MS, operation of low mass resolution during analysis on "Sapphire" MC-ICP-MS results in a couple of orders of magnitude increase in K sensitivity. One challenge of the collision-cell measurement by "Sapphire" is its higher susceptibility to matrix effects, effective chromatographic purification of K, therefore, tends to be the main control factor on external precision achievable for natural samples. We will present new sample preparation/purification approaches that facilitate more precise K isotope analysis on "Sapphire" MC-ICP-MS. Another challenge is that concentration mismatch between the sample and bracketing standard during collision-cell analysis can cause large biases in the measured K isotope ratios. We will present a correction method that can robustly correct for this concentration mismatch effect and, hence, significantly increases the sample throughput. This correction method is applicable to analysis of other metal and metalloid isotopes. We will also present examples how the improved analytical precision advances development of K isotopes as a useful proxy for low- and high-temperature processes.

[1] Wang et al., *Geochemistry* 81, 2021