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The ARGUS multi-collector mass spectrometer: ^{40}Ar-^{39}Ar mineral age standards

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ARGUS is a static vacuum gas-source multi-collector mass spectrometer specifically designed for argon isotopic analyses. It is characterised by five technical innovations; a low volume analyser (490cc), a modified high-sensitivity Nier-type source, true isotope multi-collection, precise electronic Faraday collector inter-calibration combined with high-gain amplifiers. The source is configured to focus in both Z and X axes and has a measured sensitivity of 1.35x10^{-3}A/torr at 200 μA trap. Five precisely inter-calibrated Faraday collectors are configured to simultaneously collect data for ^{36}Ar through ^{40}Ar. Each collector is fitted with a 10^{-12} ohm resistor (baseline noise $\sim$2x10^{-17} A), except the collector used for ^{40}Ar detection (high 2 position) that has a 10^{-11} ohm resistor (baseline noise $\sim$1x10^{-16} A). The analyser background contains 1.5x10^{8} atoms ^{40}Ar (n=10).

A standard 15 minute analysis (20 cycles) of our air standard achieves a precision of 0.2% on a 2.85 V ^{40}Ar signal (10^{-11} ohm resistor) and 0.4% on a 9.4x10^{-3} V ^{36}Ar signal (10^{-12} ohm resistor). In a single analytical period of 28 air calibrations, ^{40}Ar and ^{36}Ar signals (same signal sizes as above) display an overall variation of 0.1%, while the average ^{40}Ar/^{36}Ar (300.6 $\pm$ 0.3) has a similar degree of uncertainty.

Inter-comparison of co-irradiated mineral age standards has been performed and ages calculated relative to Taylor Creek Rhyolite sanidine (28.34 Ma; Renne *et al*., 1998). Argon was released in a two-step heating schedule using a CO_2 laser; a low-power

degassing step was followed by a high-power fusion step (used for all age determinations). Multiple determinations of Alder Creek sanidine yield an average age of 1.193 $\pm$ 0.005 Ma (n=57) that overlaps the accepted age of 1.193 $\pm$ 0.001 Ma (Nomade *et al*., 2005). Heidelberg biotite yields a similar story, giving an age of 25.0 $\pm$ 0.3 Ma (n=3) that is indistinguishable from the accepted age of 24.7 $\pm$ 0.3 Ma (Fuhrmann *et al*., 1987). Analysis of sanidine from the Limberg Tuff yields an age of 17.2 $\pm$ 0.2 Ma (n=3) that is slightly older than the 16.3 $\pm$ 0.4 Ma (n=6) age reported by Kraml *et al*. (2006). This discrepancy does not result from non-linearity of sensitivity since the Limberg Tuff sanidines yielded ^{40}Ar signals of between 1.3 and 8.9 volts with no apparent age trend. The best explanation is that excess ^{40}Ar yields anomalously older ages in the single-step age calculations. Further high-resolution step-heating experiments will test this hypothesis.

The Earthtime scientific initiative is aimed at sequencing Earth history through the integration of high-precision geochronology and quantitative chronostratigraphy. High-precision ^{40}Ar-^{39}Ar ages determined for mineral age standards using ARGUS demonstrate that the multi-collector mass spectrometer is extremely valuable for intercalibration with other decay systems and techniques.