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The new Ar-Ar geochronology facility at Freiberg, Germany: Instrumentation, applications, and current limitations

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The Argonlab in Freiberg is equipped with a low volume ($\sim$500 cm^3) ARGUS noble gas mass spectrometer connected to a low volume ($<$500 cm^3) gas extraction line comprising a CO_2-thermal laser and a resistance furnace with autosampler for step heating experiments. Sample transfer into the furnace is achieved without wrapping to minimize blank signals. Gas purification is performed by two SAES AP10N getter pumps (St101), one hold at room temperature and one at $\sim$400˚C. The lab is used for a broad range of applications from dating young volcanic eruptions to thermochronologic studies applied to continental tectonics.

The ARGUS mass spectrometer is equipped with five faraday cups for a simultaneous measurement of all five Ar isotopes. 10^{12} Ohm resistors are used on mass positions 36 to 39 and a 10^{11} Ohm resistor in mass position 40. Baseline drifts per hour are 1.5 ppm, 1.7 ppm, 0.7 ppm, -2.5 ppm and -1.3 ppm on the L2, L1, Ax, H1 and H2 amplifiers at noise levels between 2 x 10^{-5} and 6 x 10^{-5} V. The static rise under normal conditions is between 6.8 x 10^6 and 3.4 x 10^7 atoms ^{40}Ar/min (1.1 x 10^{-17} to 5.6 x 10^{-17} mol/min) and 6.5 x 10^5 atoms ^{36}Ar/min (1.1 x 10^{-18} mol/min; measured over 20 min). The sensitivity at 208 μA trap current is 1.25 x 10^{-3} A/Torr corresponding to 2.8 x 10^{-14} mol/V on a 10^{12} Ohm resistor. Air aliquot measurements within the last two years yielded ^{40}Ar/^{36}Ar ratios between 298 and 304 dependent on source adjustment with an intraday reproducibility typically better than 0.5 - 1.0 per mill (1σ, n=4-8) at ^{36}Ar intensities between 20 and 300 mV at 10^{12} Ohm (5.6 x 10^{-16} to 8.4 x 10^{-15} mol).

The reported sensitivity allows to determine reliable data for mg-sample weights with ages $<$1Ma. For example, we determined a plateau age of 353 $\pm$ 62 ka from 2.96 mg of biotite isolated from the Dachsbusch volcanic sequence (Eifel, Germany) by applying CO_2 laser step heating. This age is consistent with the previously published K-Ar age of 346 $\pm$ 40 ka (Schmincke & Mertes, 1979). Higher precision is obtained by using the resistance furnace with higher sample weights. For 60.1 mg of sanidine from an Azores lava, we obtained a plateau age of 283.0 $\pm$ 4.6 ka. The plateau age for mineral standard HDB1 (Heidelberg biotite) was determined to 24.62 $\pm$ 0.10 Ma, in excellent agreement with the published 24.59 $\pm$ 0.12 Ma age (Mark et al., 2009).

Our observations demonstrate that the described low-volume Ar extraction system in combination with an ARGUS multicollector noble gas mass spectrometer is an excellent tool for rapid and precise Ar isotope ratio determinations applicable to a wide range of geo- and thermochronological problems.

References: Mark, D.F., Barfod, D., Stuart, F.M. & Imlach, J., 2009, Geochem. Geophys. Geosys., 10. Schmincke H.-U. & Mertes, H., 1979, Naturwissenschaften, 66, 614-615.