The ARGUS multicollection noble gas mass spectrometer

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The ARGUS noble gas mass spectrometer (GV Instruments, Manchester, UK) was built specifically for argon isotopes analyses. It has five fixed Faraday cups in positions suitable for the simultaneous analysis of ^{36}Ar, ^{37}Ar, ^{38}Ar, ^{39}Ar, and ^{40}Ar. The signal is amplified to the 10^{11} (cup H2 used for ^{40}Ar) and 10^{12} for all other cups, allowing a very large dynamic range, as well as lower sample irradiation times and therefore a reduction of interference from other production reactions (e.g, $^{40}Ar_K$ and $^{36}Ar_{Ca}$). The volume of the mass spectrometer is ca. 490 cc, and the sensitivity is $1.35x10^{-3}$ A/torr. The simultaneous measurement of all five argon isotopes reduces the analytical problems related to signal decay, a major contribution to analytical uncertainty in classical single-collector mass spectrometers used in peak-jumping mode. One particularity of multicollection is that it is the isotopic ratios that are regressed to time zero, instead of the intensities of the individual isotopes. This allows for further reduction of the analytical uncertainty, which is typically <1‰ on the $^{40}Ar/^{36}Ar$ and $^{40}Ar/^{39}Ar$ ratios for beam sizes larger than 10^{-10} cc_{STP}. The analytical uncertainty on calculated ages, taking into account all analytical uncertainties including the one on the irradiation factor, is typically <3‰. The analytical results obtained with the ARGUS multicollection mass spectrometer are more than one order of magnitude more precise than those obtained with the classical MAP215-50 mass spectrometer. Reproducibility of air $^{40}Ar/^{36}Ar$ ratio over a period of a day, a week or a month is systematically <2‰, more often <1‰ for signals of $3x10^{-8}$ to $1x10^{-7}$ cc_{STP} of ^{40}Ar ($1.3x10^{-12}$ to $5.5x10^{-12}$ mol).

One analysis typically consists of one block containing 20 cycles of 20 one-second integrations. The regression to time zero is based on the cycle data following a polynomial law of second order. The baseline is measured during 20 seconds at the beginning of the analysis on masses 39.5 and 40.5. The corresponding ultra-high vacuum extraction and purification line has a volume of ca. 700 cc and is fully automatic, including laser heating.

Because of its large dynamic range and low analytical uncertainty margins, ARGUS is particularly well adapted to dating of ultra-young samples (<<1 Ma), with application to historic volcanic eruptions and ^{14}C dating intercalibration. It will also be quite useful in intercallibration with other decay systems, and therefore very valuable for the Earthtime initiative.