The effect of matrix electron affinity on ion beam currents for BeO analysis

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We report experiments designed to help optimize accelerator mass spectrometry (AMS) for ^{10}Be. In many geochronologic applications, the precision of AMS is restricted by Poisson-distributed counting statistics for ^{10}Be, which scale inversely with the square root of the total number of collected ions, and therefore depend upon the intensity of the BeO^- beam current. For samples with low cosmogenic nuclide abundance, AMS precision is inherently low, even with long counting times. In order to improve the ion beam current, BeO is typically mixed with a metal powder matrix. At CAMS, the preferred matrix is Nb powder, which delivers higher currents than other common matrices, including Cu or Ag powders. The use of Nb for this purpose has improved sensitivity at CAMS for applications such as measuring the erosion rate of very unstable terrain or burial dating of shielded samples.

At CAMS, we systematically investigated the matrix-induced current enhancement by monitoring ion beam currents as a function of matrix composition, matrix concentration, and sample position in the ion source. By testing ion beam currents for BeO prepared in a variety of matrices, we found that (1) the effectiveness of Nb diminishes at higher Nb:BeO mole ratios, (2) other matrices, such as V, W, and Mo, behave comparably to Nb, (3) and Ta provides the best counting efficiency in dilute samples. In addition, we observed an inverse linear correlation between matrix electron affinity and AMS counting efficiency (ions detected per Be atom loaded). This correlation suggests that, in the ion source, the propensity of the matrix to competitively attach electrons impacts the BeO^- beam current.

In order to explore practical implications of this work, we have studied the effect of common oxide impurities (electron sinks?) that may exist in BeO samples separated from quartz digests (e.g. TiO_2 and Fe_2O_3). We find that TiO_2 (e.a. = 1.59 eV) does not significantly affect ion beam currents, possibly on account of its low electron affinity compared to BeO (e.a. = 2.10 eV). Conversely, Fe_2O_3 (e.a. = 3.16) exhibits a retarding effect on beam currents, presumably due to its relatively high electron affinity. These observations are substantiated by additional experiments, in which we have measured the effect of an artificial, electron absorbing impurity, Au (e.a. = 2.31), which significantly decreases ion beam currents, albeit to a lesser extent than Fe_2O_3. The process inferences which these data permit are important for improving analytical sensitivity in geochronologic applications for which sample sizes are limited or ^{10}Be activity is very low.