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Characterization of a molybdenite reference material for Re-Os

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There is a growing need for a reference material for the well-established molybdenite Re-Os geochronometer [1,2,3]. We present the results of our joint characterization of a new molybdenite Re-Os Reference Material (RM). This RM was produced from a 5.5 kg bulk sample of homogeneous molybdenite acquired from the Henderson mill in Colorado, USA. Henderson is an Oligocene (~29-27 Ma) Climax-type stockwork molybdenum deposit associated with an evolved granitic intrusive complex [4]. This particular molybdenite was chosen for the RM for several reasons. The Henderson deposit was apparently emplaced in a short period of time, the ore is nearly monomineralic, and the Henderson mill processes only ore from the Henderson mine. These factors along with the milled origin of the molybdenite provide for a homogeneous sample with respect to Re and ¹⁸⁷Os elemental concentrations and age. Importantly, the deposit is young and contains relatively low Re (~11 ppm) and radiogenic ¹⁸⁷Os (~3.2 ppb). These factors make this RM potentially suitable for use in both high-level and low-level Re-Os laboratories.

The froth flotation residues were removed from the flotation separate by multiple treatment with acetone and ethanol. The cleaned molybdenite powder was then mixed, split, and packaged into 10 gram bottles at the U.S. National Institute of Standards and Technology (NIST), from whom this RM will be available in the near future.

The material is being analyzed in two labs, AIRIE at Colorado State University, and RIF at the University of Alberta. Each lab is analyzing six randomly selected bottles using two different spiking methods, each in duplicate, for a total of 24 analyses from each lab. The two spikes are (1) mixed ¹⁸⁵Re plus normal Os, and (2) mixed ¹⁸⁵Re-¹⁸⁸Os-¹⁹⁰Os [5]. Carius tube digestion was used in all analyses. Final precision on the true age is expected to be better than 0.5% within the 95% percent confidence interval. (*This work is supported by NSF EAR-0111876*).

References

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The TITANiQ: A Titanium-in-Quartz thermometer

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We propose an experimentally calibrated geothermometer that is based on the temperature dependence of Ti solubility in quartz. The theory behind the TITANium-in-Quartz (TITANiQ) thermometer is straightforward: If the chemical potential of TiO₂ is fixed by the presence of rutile, the equilibrium constant for the reaction $TiO_2(rutile)=TiO_2(quartz)$ is equal to the activity of TiO₂ in quartz. This leads to the relation

$$-\Delta G^0/RT = \ln(a_{Ti,qtz}).$$

As a first approximation, we can assume that the activity of Ti is proportional to its concentration in the quartz, and that the log of Ti concentration will vary inversely with T.

Experiments performed to date, in which we equilibrated quartz with rutile at temperatures ranging from 700°C to 1000°C at 1 GPa, yield the relation:

$$T(K) = -4240/[\log(X_{Ti,qtz}) - 6.15]$$

where the Ti content of quartz is expressed in ppm (wt). According to this preliminary calibration, quartz that crystallized in equilibrium with rutile at 750°C will have a Ti content of 100 ppm. At 800°C, 158 ppm Ti will be present in quartz. Not only are these Ti concentrations easily measured by electron microprobe, but estimated analytical errors promise temperature uncertainties below ±5 °C. Even lower uncertainties can be achieved using the ion microprobe, which should also allow application of the TITANiQ thermometer to quartz precipitated at temperatures of 400°C and below. Although our initial calibration of the thermometer assumes a TiO₂ activity of one, TITANiQ can also be applied to systems lacking a pure TiO₂ phase if Ti activity can be estimated by some other means.

Because quartz is one of the most abundant minerals in Earth's crust, we expect our launch of the TITANiQ thermometer – which has a precision roughly an order of magnitude better than that of most geothermometers in application today - to shed light on the thermal histories of many rock types. TITANiQ promises to prove especially powerful when combined with imaging of cathodoluminescence intensity, which often reveals a detailed record of growth history, and which appears to be strongly correlated with the Ti content of quartz.