Geophysical Research Abstracts
Vol. 14, EGU2012-11745, 2012
EGU General Assembly 2012

Towards an International Molybdenum Standard: NIST Standard Reference Materials 610, 612 and 3134

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Over the last decade, molybdenum (Mo) isotopes have become an important tool in paleo-oceanography and other areas of low- and high-Temperature geochemistry. Modern MC-ICP-MS enables us to measure the Mo isotope compositions of various geological materials to a precision of $\leq$ 0.1 ‰ (on the 98Mo/95Mo ratio). In addition, LA-ICP-MS is increasingly used to measure in situ micro-scale Mo elemental concentrations in different geological and non-geological materials. In order to obtain precise and accurate Mo concentration data using LA techniques, external calibration materials are required.
However, highly accurate and precise data on widely accessible homogenous and well defined standard reference materials (SRM) for both Mo isotope and in-situ [Mo] measurements are still lacking. Molybdenum concentration and δ98/95Mo values of NIST SRM 610, SRM 612 (solid silica glasses) and SRM 3134 (lot no. 891307; liquid) as well as the IAPSO ocean water standard are presented, based on comparative measurements performed in laboratories at Bern and Oxford Universities. Liquid SRM 3134 and solid SRM 610 and SRM 612 from NIST have identical and homogeneous 98Mo/95Mo. We therefore suggest to use SRM 3134 as reference for the δ9x/95Mo notation (δ9x/95MoSRM 3134), and to employ SRM 610 or SRM 612 as solid silicate secondary standard, in the absence of an isotopically homogeneous rock powder standard for Mo. The δ98/95MoJMC Bern composition (Johnson Matthey ICP standard solution, lot 602332B as reference) of the NIST SRM 3134 is 0.25 $\pm$ 0.09‰Ṫhis value indicates significant variations between commercially available Mo ICP standard solutions.
Based on five new measurements, we more precisely determined the mean open ocean δ98/95MoSRM 3134 of 2.09 $\pm$ 0.07 ‰ which equals the value of δ98/95MoJMC Bern = 2.34 $\pm$ 0.07 ‰Ẇe also refined the Mo concentration data of SRM 610 to 412 $\pm$ 9 μg/g and SRM 612 to 36.4 $\pm$ 0.7 μg/g by isotope dilution. We propose these concentration and isotope ratio data as new working values, allowing for more precise calibration of in-situ Mo concentration and isotope ratio analysis.