LLNL-PROC-416752

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September 11, 2009

American Geophysical Society Fall Meeting
San Francisco, CA, United States
December 14, 2009 through December 18, 2009

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Influence of Bulk Chemical Composition on Relative Sensitivity Factors for $^{55}Mn/^{52}Cr$ by SIMS: Implications for the ^{53}Mn-^{53}Cr Chronometer

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The ^{53}Mn-^{53}Cr systematics of meteorite samples provide an important high resolution chronometer for early solar system events. Accurate determination of the initial abundance of ^{53}Mn ($\tau_{1/2}$=3.7 Ma) by secondary ion mass spectrometry (SIMS) is dependent on properly correcting for differing ion yields between Mn and Cr by use of a relative sensitivity factor (RSF). Ideal standards for SIMS analysis should be compositionally and structurally similar to the sample of interest. However, previously published Mn-Cr studies rely on few standards (e.g., San Carlos olivine, NIST 610 glass) despite significant variations in chemical composition. We investigate a potential correlation between RSF and bulk chemical composition by determining RSFs for $^{55}Mn/^{52}Cr$ in 11 silicate glass and mineral standards (San Carlos olivine, Mainz glasses KL2-G, ML3B-G, StHs6/80-G, GOR128-G, BM90/21-G, and T1-G, NIST 610 glass, and three LLNL pyroxene-composition glasses). All standards were measured on the Cameca ims-3f ion microprobe at LLNL, and a subset were also measured on the Cameca ims-1270 ion microprobe at the Geological Survey of Japan. The standards cover a range of bulk chemical compositions with SiO_2 contents of 40-71 wt.%, FeO contents of 0.05-20 wt.% and Mn/Cr ratios between 0.4 and 58. We obtained RSF values ranging from 0.83 to 1.15. The data obtained on the ims-1270 ion microprobe are within ~10% of the RSF values obtained on the ims-3f ion microprobe, and the RSF determined for San Carlos olivine (0.86) is in good agreement with previously published data. The typical approach to calculating an RSF from multiple standard measurements involves making a linear fit to measured $^{55}Mn/^{52}Cr$ versus true $^{55}Mn/^{52}Cr$. This approach may be satisfactory for materials of similar composition, but fails when compositions vary significantly. This is best illustrated by the ~30% change in RSF we see between glasses with similar Mn/Cr ratios but variable Fe and Na content. We are developing an approach that uses multivariate analysis to evaluate the importance of different chemical components in controlling the RSF and predict the RSF of unknowns when standards of appropriate composition are not available. Our analysis suggests that Fe, Si, and Na are key compositional factors in these silicate standards. The RSF is positively correlated with Fe and Si and negatively correlated with Na. Work is currently underway to extend this analysis to a wider range of chemical compositions and to evaluate the variability of RSF on measurements obtained by NanoSIMS.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.