Apatite for reduction: a potential new oxybarometer for felsic magmatic systems

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Currently, there is a lack of good oxybarometer for use in felsic magmatic systems. Existing oxygen barometer relies on either Fe-Ti oxides or zircon being present in the system. The study involves investigating a potential oxygen barometer using the partitioning behaviour of arsenic and antimony between apatite and melt. Apatite [$Ca_5(PO_4)_3F$] reaches saturation early in felsic magmas and having a range of oxidation states, is known to substitute for phosphorus. Pentavalent arsenic (As^{5+}) is more compatible then trivalent arsenic (As^{3+}) in the apatite structure; therefore, partitioning should increase with an increasing concentration of As^{5+}. Antimony also substitutes into apatite although there is some debate as to what it replaces.

Using the thermodynamic data available along with the Blundy and Wood strain lattice model an As-Sb apatite/melt partitioning model was developed to guide the calibration experiments. This model does not account for changes in speciation due to changing pressure and is sensitive to the thermodynamic data selected (which are extrapolated above normal species temperatures). As well, several key parameters in the strain lattice model could only be estimated.

Owing to an increase in the proportion of more compatible As^{5+}, the model predicts a 100-fold increase in arsenic partitioning over the interval ΔFMQ +2 to ΔFMQ +7. No significant variation in D_{Sb} is expected with $ƒO_2$, according to the model. The model predicts D_{As} increasing with increasing melt silica content and decreasing with increasing temperature. Increasing $ƒH_2O$ shifts the stability of As^{5+} to lower ƒO2 and thus D_{As} increases. Sulphur fugacity has the opposite effect, destabilizing the presence of As^{5+} in the system.

To date several experiments have been performed; however experimental issues have prevented the acquisition of quantitative data. Semi-quantitate data from two of the experiments indicate D_{As} <0.183 at the CCO buffer and D_{As} is between 0.68 and 2.16 at the Ru-RuO buffer (ΔFMQ +7). These observations concur with the models arsenic trend. Additional experiments are currently being prepared and results will be presented.

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