Experimental calibration of a new oxybarometer for silicic magmas based on the partitioning of vanadium between magnetite and silicate melt

RÓBERT ARATÓ[1]*, ANDREAS AUDÉTAT[1]

[1]Bayerisches Geoinstitut, Universität Bayreuth 95440 Bayreuth, Germany (*correspondence: arato.robi@gmail.com)

Oxygen fugacity is an important parameter in magmatic systems that affects the stability of mineral phases and fluid species. However, there is no well-established method to reconstruct the oxygen fugacity of slowly cooled magmas, such as granite. In this study, we aim at developing an oxybarometer that is based on the partitioning of vanadium (a redox-sensitive element) between magnetite inclusions and silicate melt inclusions preserved in quartz phenocrysts, where they were protected from subsolidus alteration and can be measured as entities by LA-ICP-MS.

In the first – experimental – part of this study we investigated the effects of temperature (800-950 °C), pressure (1-2 kbar), oxygen fugacity (from ΔFMQ+0.7 to ΔFMQ+4.0), magnetite composition, and melt composition on the partition coefficient of vanadium between magnetite and melt (DVmgt-melt). The vanadium partition coefficient was found to depend strongly on oxygen fugacity, and to lesser (but still considerable) degrees on melt composition and temperature. The dependence of DVmgt-melt on these parameters can be described by the following regression equation:

$$\log D(V)_{mgt/melt} = -1.22 + 0.31 * (10^5/T(°K)) + 1.73 * ASI - 0.49 * \Delta FMQ$$

First tests of the equation on natural samples were carried out on inclusions (Fe-Ti oxide and melt pairs) and microphenocrysts (paired with groundmass-compositions) of rapidly cooled tuffs and vitrophyres from variable tectonic settings, for which fO_2 could be constrained independently by the magnetite-ilmenite method. All calculated fO_2 values fall within ± 0.75 log unit within those suggested by the Fe-Ti oxybarometer, whereas 18 out of 24 samples agree within 0.5 log units. The larger discrepancies are most probably related to the lack of equilibrium between the microphenocrysts and their matrix, whereas this problem is rarely present in the case of mineral inclusion-melt inclusion pairs.