



EXPERIMENTAL CALIBRATION AND IMPLICATIONS OF OLIVINE-MELT VANADIUM OXYBAROMETRY FOR HYDROUS MAGMAS FROM MUTNOVSKY VOLCANO (KAMCHATKA)

Shishkina T.^{1,2}, Portnyagin M.^{1,3}, Botcharnikov R.², Almeev R.² & Holtz F.²

¹V.I.Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow, Russia

²Institute for Mineralogy, Leibniz University of Hannover, Hannover, Germany

³GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany

A promising method for the quantification of the redox conditions (oxygen fugacity, fO_2) in basaltic systems, which might be applied to quenched melt inclusions in olivine, exploits the partitioning of vanadium between olivine and coexisting silicate melt (D_V^{Ol-M}). Strong correlation of D_V^{Ol-M} with fO_2 was investigated in a number of experimental works on dry mafic and ultramafic melts in a wide range of fO_2 conditions at pressures of 1 atm and 0.5–2 GPa, temperature range of 1150–1530°C (e.g., Canil&Fedortchouk, 2001; Mallmann&O'Neill, 2009; 2013). Only a few melt compositions equilibrated with olivine at $T \leq 1250^\circ\text{C}$ were studied so far. Although it was shown that melt composition, pressure and temperature have small effect on D_V^{Ol-M} , more data are required to extend the calibration of the V oxybarometry to hydrous low-temperature basalts representing island arc magmas.

This study presents new data on D_V^{Ol-M} gained from crystallization experiments performed with an high-Al basalt from Mutnovsky volcano (Kamchatka) at various aH_2O , 0.1 and 0.3 GPa, 1025–1150°C and $\Delta QFM = -0.5$ to +3.2 at the Institute of Mineralogy in Leibniz University of Hannover. Concentrations of vanadium in experimental and natural glasses and olivines were analyzed at the Institute of Geosciences at the University of Kiel by LA-ICP-MS (Agilent 7500s, 193nm GEOLAS Pro). The determined D_V^{Ol-M} in run products varies between 0.007 and 0.079 and $\log D_V^{Ol-M}$ shows a strong linear correlation with $\log fO_2$ in the experiments.

For calibration of the V oxybarometer for low temperature hydrous basaltic magmas we used 7 experiments from this study together with 26 experiments performed at $T \leq 1250^\circ\text{C}$ in fO_2 range of $-2.0 < \Delta QFM < 3.2$ with melts containing less than 12 wt% MgO and less than 4 wt.% Na₂O from previously published data. The resulting linear correlation between D_V^{Ol-M} and ΔQFM can be described with an equation: $\Delta QFM = -3.51 \cdot \lg D_V^{Ol-M} - 4.20$ ($R^2 = 0.96$). This equation reproduces experimental ΔQFM conditions within $\pm 0.35 \log$ units for 70% of the experiments.

This equation was applied to estimate redox conditions for Mutnovsky volcano magmas using compositions of melt inclusions in olivine from basaltic tephros. Vanadium concentrations vary in the range of 266–382 ppm in glassy inclusions and of 4.2–6.1 ppm in their host olivines. This corresponds to $D_V^{Ol-M} = 0.0152$ –0.0185. The calculated ΔQFM values vary between +1.8 to +2.2 which is similar to the calculations using the equation from Canil and Fedortchouk, 2001 and is about 1 log unit of fO_2 below the value calculated with the oxybarometer proposed by Mallmann and O'Neill (2013). The determined redox conditions for Mutnovsky are in a good agreement with redox estimates using independent methods and confirm relatively oxidizing nature of island-arc basaltic magmatism.

References

Canil, D., Fedortchouk, Y. (2001): Olivine-liquid partitioning of vanadium and other trace elements, with applications to modern and ancient picrites. *Can. Min.*, **39**, 319-330.

Mallmann, G., O'Neill, H. St.C. (2009): The crystal/melt partitioning of V during mantle melting as a function of oxygen fugacity compared with some other elements (Al, P, Ca, Sc, Ti, Cr, Fe, Ga, Y, Zr and Nb). *J. Petrol.*, **50**, 1765-1794.

Mallmann, G., O'Neill, H. St.C. (2013): Calibration of an empirical thermometer and oxybarometer based on the partitioning of Sc, Y and V between olivine and silicate melt. *J. Petrol.*, **54** (5), 933-949.

