A New S-in-Apatite Oxybarometer for Magmatic Systems

BRIAN A. KONECKE1, ADRIAN FIEGE1,2, & ADAM C. SIMON1

1 Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI, USA. 2Department of Earth and Planetary Sciences, American Museum of Natural History, New York, NY, USA.

Apatite—generally Ca10(PO4)6(F,Cl,OH)2—is a common accessory phase in terrestrial and extraterrestrial geologic systems [1], and can structurally incorporate about 1/3 of the periodic table of elements, including volatile and redox sensitive elements such as sulphur (S) [2]. Considering apatite’s ability to crystallize from melts and magmatic-hydrothermal fluids [2], the intra- and inter-crystalline zonation with respect to S contents and oxidation states (e.g., S6+, S4+, S2−) may serve as a proxy to reconstruct redox processes, and the budget of S in magmatic systems [3,4].

In this study, we performed apatite crystallization experiments at fixed T-P-X (i.e., 1000°C; 300 MPa; mafic silicate melt, containing ~0.35 wt.% bulk S), and variable fO2 (e.g., where log fO2 [ΔFMQ] = -1, +0, +0.25, +0.8, +1.2, and +3), in order to test the hypothesis that the integrated peak area ratios of S oxidation states (S6+/ΣS) in apatite can be used as a oxybarometer. Micro X-ray absorption near-edge structures (μ-XANES) spectroscopy at the S K-edge was used to measure the oxidation state(s) of S in experimental crystallized apatite. The integrated S6+/ΣS peak area ratios of the apatite were calculated following the methodology of [4], where: S6+/ΣS = 0.134 (FMQ-1), 0.137 (FMQ), 0.504 (FMQ+0.25), 0.962 (FMQ+0.8), 0.958 (FMQ+1.2), and 0.964 (FMQ+3). The integrated S6+/ΣS peak area ratios vs. ΔFMQ results were fitted using a (Boltzmann) sigmoidal function (adjusted r2 = 0.99). The calibration curve exhibits a sharp transition (e.g., slope of inflection point) from low S6+/ΣS to high S6+/ΣS, indicating that the S-in-apatite oxybarometer is highly sensitive with respect to redox conditions from ~FMQ+0 to ~FMQ+0.8. This redox range is particularly relevant for MORB systems, and relatively reduced (e.g., <FMQ+1) arc related basalts, that can oxidize upon degassing of a S-bearing fluid [5]. Although the S-in-apatite calibration can be applied for the conditions investigated in this study, future work will focus on the extension of the calibration over a broader range of T-P-X.

This abstract is too long to be accepted for publication. Please revise it so that it fits into the column on one page.