American Mineralogist, Volume 91, pages 1863–1870, 2006

New experimental data on biotite + magnetite + sanidine saturated phonolitic melts and application to the estimation of magmatic water fugacity

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Abstract

New experimental data are presented that allows the biotite–magnetite–sanidine equilibrium to be used for estimating water fugacity (f_{H_2O}) in hydrous phonolitic magmas. It is also demonstrated that the partly ionic model gives the best estimate for the annite activity (a_{annite}). Crystallization experiments were carried out on a representative sample of peralkaline, phonolitic obsidian of Montaña Blanca (MB) pumice deposit, Tenerife, Canary Islands. Experiments were performed from 720–810 °C and 50–250 MPa. Redox conditions were varied between NNO (nickel + nickel oxide) + 1 (±0.2) and FMQ (fayalite + magnetite + quartz). The majority of the experiments were done under H_2O saturation conditions ($P_{water} = P_{total}$). Several experiments were done using a mixed H_2O-CO_2 fluid phase whereas in other experiments 10 or 20 wt% powdered alkali feldspar was added to the starting material. The pre-eruptive f_{H_2O} of the Montaña Blanca magma is estimated at 676 ± 200 bars. The pre-eruptive f_{H_2O} for the Fish Canyon tuff (753–2978 bars) and Bishop tuff rhyolite (1065–2440 bars) were also calculated, as well as f_{H_2O} for metamorphic biotite from Au Sable Forks (≈ 130 bars). The results of this study suggest that this geohygrometer can be used in any magmatic system in which biotite–magnetite–sanidine is a stable assemblage.

Keywords: Crystallization experiments, geohygrometer, phonolitic magmas, water fugacity