Geophysical Research Abstracts,
Vol. 10, EGU2008-A-04345, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-04345
EGU General Assembly 2008

A new method to constrain the oxidation state of basaltic series from microprobe analysis.

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The oxygen fugacity (fO_2) of basaltic magmas is a critical controlling parameter of magmatic processes. It controls the iron redox state of the melt, and it strongly influences the crystallisation sequences and the composition of minerals crystallising. We propose a new simple method for constraining fO_2 of parental magmas of igneous rocks. It uses FeO_{tot} electronic microprobe analysis in clinopyroxene (Cpx) and plagioclase (Pl). The results do not depend on stoechiometric calculations. The method is based on the difference between the exchange coefficients: ${K_D}^{Cpx-melt}_{Fe2O3/FeO}$ and ${K_D}^{Pl-melt}_{Fe2O3/FeO}$. These coefficients are equivalent to the ratio of the partition coefficient of Fe_2O_3 and FeO between Cpx and melt and between Pl and melt, respectively: $K_D^{Pl-melt}(Fe_2O_3/FeO) = D^{Fe3+}_{Pl-melt}/D^{Fe2+}_{Pl-melt}$. Using published partition coefficients, these K_D are around 0.5 and 20 for Cpx and Pl, respectively. These values show that increasing oxidation of a melt results in a decreasing of FeO_{tot} in Cpx and an increasing of FeO_{tot} in Pl. We propose an equation, based on these partition coefficients, that allows calculating the redox conditions of a partly molten system expressed in ΔFMQ values (FMQ = oxygen fugacity corresponding to the fayalite-magnetite-quartz oxygen buffer), by the input of analysed FeO_{tot} in Cpx and Pl, and an estimation of the pressure, temperature and melt composition. Error propagation reveals the limits of the model. An application to literature data attests the validity of the proposed model.