Behavior of ferric iron (Fe^{3+}) during partial melting of MORB-mantle source

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Recently measured $Fe^{3+}/\Sigma Fe$ ratios in MORB show a very narrow range, from 0.15 to 0.18, which corresponds to an oxygen fugacity (fO_2) close to the Fayalite-Magnetite-Quartz (FMQ) buffer [1] [2]. Since Fe^{3+} in an incompatible element (D^{Fe3+} min/liq ~ 0.1[3]), its content in glasses should correlate with partial melting degree. However, such a relationship has not been observed in MORB and this paradox is still a matter of debate [1] [2]. In order to better understand the role of Fe^{3+} during partial melting of a MORB-mantle source, we performed partial melting experiments of a spinel peridotite at 1.5 GPa, between 1320 and 1450°C, over a range of fO_2 varying from FMQ-3 to FMQ+3. Changes in oxygen fugacity were achieved using different capsule materials. Fe^{3+} contents of the spinels and glasses have been obtained using X-ray Absorption Near Edge Structure (XANES) in full field mode (transmission mode), at Grenoble Synchrotron (France).

Our results show that, at a given fO_2, the $Fe^{3+}/\Sigma Fe$ ratio in melts remains quite constant with partial melting degree. This is explained by a slight decrease of D^{Fe3+} while partial melting increases. We also notice that increasing fO_2 causes a decrease in D^{Fe3+}. The Fe^{3+} content of resulting melts is thus “buffered” to a very narrow range, as we observe for MORB. This observation is also confirmed by pMELT calculations at different fO_2 conditions. We conclude that the Fe^{3+} content in MORB could be accounted for by a D^{Fe3+} min/liq ranging from 0.1 to 0.3 and a mantle source containing 0.1-0.5 wt% Fe_2O_3. There appears also be to a correlation between oxygen fugacity, i.e. increasing Fe^{3+} content of a system, and the degree of partial melting of peridotite. This is to some extent explained by FTIR measurements that reveal the presence of water in the most oxidized experiments (up to 900 ppm in glass). Comparison with a new set of dry experiments, however, shows that a significant effect on the melting degree comes from the presence of Fe^{3+} alone.

[1] Bezos and Humler (2005), *GCA* **69**, 711-725. [2] Cottrell and Kelley (2011), *EPSL* **305**, 270-282. [3] Canil et al. (1994), *EPSL* **123**, 205-220.