Confocal μ-XANES as a tool to analyse Fe oxidation state in heterogeneous samples: The case of melt inclusions in olivine from Hekla volcano

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Here we present a confocal Fe K-edge μ-XANES method for the analysis of Fe oxidation state in melt inclusions of one-side polished samples, potentially applicable to any heterogeneous sample. The new technique allows for an analysis of small volumes with high spatial 3D resolution of <100 μm^3. Using a confocal setup, the probed volume is restricted to that just beneath the surface of the exposed object. This protocol avoids contamination of the signal by the host mineral and minimizes self-absorption effects. This technique has been calibrated and tested on a set of experimental glasses with a wide range of $Fe^{3+}/\sum Fe$ ratios. The method was applied to the analysis of natural melt inclusions trapped in forsteritic to fayalitic olivine crystals of the Hekla volcano, Iceland. Our measurements reveal changes in $Fe^{3+}/\sum Fe$ from 0.17 in basaltic up to 0.45 in dacitic melts, whereas magnetite-ilmenite equilibrium testifies redox conditions with $Fe^{3+}/\sum Fe \leq 0.20$ (close to FMQ, Fayalite-Magnetite-Quartz redox equilibrium) along the entire range of Hekla melt compositions. This discrepancy indicates that the oxidized nature of glasses in the melt inclusions could be related to post-entrapment process of diffusive hydrogen loss from inclusions and associated oxidation of Fe in the melt. The $Fe^{3+}/\sum Fe$ ratio in silicic melts is particularly susceptible to this process due to their low FeO content and it should be critically evaluated before petrological interpretation.