Ferric ferrous ratios in mantle xenoliths by Synchrotron Mössbauer Source Spectroscopy

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Synchrotron Mössbauer Source (SMS) spectroscopy (ESRF, Grenoble, France) has high spatial resolution (~20 microns) and has been successfully applied to measuring Fe^{3+} concentrations in diamond inclusions [1,2]. Over the last few decades a number of studies have been conducted on individual minerals from mantle xenoliths in order to determine the oxidation state of the upper mantle [3,4]. These studies were conducted using ≥50 mg of handpicked grains as opposed to individual crystals.

In this study, we applied SMS to measure ferric iron contents of individual spinels, orthopyroxenes, clinopyroxenes and garnets from 5 spinel peridotite xenoliths and 1 pyroxenite and 2 eclogite xenoliths. Spinel xenoliths derive from Kilbourne hole, Mont Briançon and Ichinomegata. Spinels from these xenoliths were previously analysed by Mössbauer spectroscopy on bulk separates [4]. Eclogite xenoliths (UAS 1055, UAS 1525) and pyroxenite xenolith (UAS 510) were obtained from Udachnaya kimberlite pipe in Siberia.

In spinel peridotites measured ratios range between 0.04-0.14 Fe^{3+}/Fe_{tot} for Opx, 0.14-0.19 Fe^{3+}/Fe_{tot} for Cpx and between 0.15-0.23 for Spl. These values are broadly in agreement with previous measurements [3]. In eclogites and pyroxenite, the ratios range between 0.05-0.16 for garnet and 0.07-0.17 for Cpx, showing $D^{Grt/Cpx}$ for Fe^{3+} of 0.8-1.9.

Oxygen fugacities derived from the spinel-olivine-orthopyroxene oxybarometer are consistent with previous results for the continental lithosphere fO_2 of between -1 and +1 log units relative to the FMQ buffer [5]. Nevertheless we observe small differences between our results on individual grains and previous data on bulk separates.

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