Distribution of Fe^{3+} and H in minerals during partial melting and metasomatism of spinel peridotite

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Oxygen fugacity and water content are crucial parameters for many chemical and physical properties of the Earth's mantle, for example bearing on fluid type, melting initiation, and deformation [e.g. 1-3]. However, the exact behaviour of Fe^{3+} and H during melting and metasomatism is still under debate [e.g. 1-3]. Here, the $Fe^{3+}/\Sigma Fe$ ratio (Mössbauer and EMP) and water content (FTIR) of peridotite minerals are analyzed in mantle xenoliths from Kilbourne Hole (KH), NM, and Dish Hill (DH), CA (USA, [4,5]). These spinel peridotites have compositions consistent with partial melting with variable degrees of metasomatism (undetectable to cryptic to modal). Pyroxenites also allow us to study melt-rock reactions.

Calculated bulk-rock Fe_2O_3 content of the KH peridotites correlates with indices of melting (positive with bulk-rock Al_2O_3 and Cpx content, and negative with spinel Cr# and bulk-rock MgO content) confirming that Fe^{3+} behaves as an incompatible element during melting [e.g. 6]. Correlations of the $Fe^{3+}/\Sigma Fe$ ratio of Cpx with these melting indices indicates that Fe^{3+} is also incompatible in Cpx. However, Opx and spinel $Fe^{3+}/\Sigma Fe$ ratios depend on equilibration temperature. Water contents in olivine, Cpx and Opx from most KH peridotites can be explained by partial melting [4] and correlate negatively with the $Fe^{3+}/\Sigma Fe$ ratios of spinel and Opx but positively with that of Cpx. This indicates partial control of Fe^{3+} on the incorporation of H in pyroxene, but not related to a redox equilibrium in Cpx. The higher $Fe^{3+}/\Sigma Fe$ ratio of spinel and ΔFMQ recorded in the metasomatized KH and DH peridotites, and in the pyroxenites confirms that oxidation characterizes modal metasomatism [7, 8]. Metasomatism, however, is not necessarily accompanied by water addition.

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