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 examined 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 to examine melt-rock reactions.

Bulk-rock Fe_2O_3 content of the KH peridotites correlates with indices of melting (positive with bulk-rock Al_2O_3 and Cpx Yb contents, and negative with spinel Cr#) confirming that Fe^{3+} behaves as an incompatible element during melting [e.g. 6]. Correlations of the $Fe^{3+}/\Sigma Fe$ ratio of minerals with these indices, however, indicates that Fe^{3+} is incompatible in Cpx but compatible in Opx and spinel during melting. Water contents in olivine, Cpx and Opx from most KH peridotites can be explained by partial melting [4] and correlate negatively with the $Fe^{3+}/\Sigma Fe$ ratio 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 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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