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Temperature and pressure effects on the partitioning of V and Sc between clinopyroxene and silicate melt: Implications for mantle oxygen fugacity

Yuan Li[1,*]

[1]State Key Laboratory of Isotope Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China

Abstract

The partition coefficients of V and Sc between clinopyroxene and silicate melt ($D_V^{Cpx/SM}$ and $D_{Sc}^{Cpx/SM}$) have been determined experimentally at 1200–1400 °C and 0.8–2.3 GPa, using a hornblende- and clinopyroxene-rich mantle rock in graphite-lined $Pt_{95}Rh_{05}$ capsules. The results show that the $D_V^{Cpx/SM}$ and $D_{Sc}^{Cpx/SM}$ values decrease from 3.8 to 2.3 and from 2.6 to 1.1, respectively, as the experimental temperature and pressure vary from 1200 °C and 0.8 GPa to 1400 °C and 2.3 GPa. The presence of water in silicate melts may also reduce $D_V^{Cpx/SM}$ and $D_{Sc}^{Cpx/SM}$. These results imply that the effects of temperature, pressure, and melt water content on $D_V^{Cpx/SM}$ should be considered when using V systematics in cratonic mantle peridotites to constrain cratonic mantle oxygen fugacity (f_{O_2}). However, although the dominant V in the present silicate melt is mixed V^{3+} and V^{4+}, the $D_V^{Cpx/SM}/D_{Sc}^{Cpx/SM}$ together with literature data obtained at similar f_{O_2} shows a nearly constant value of 1.68 ± 0.26, regardless of temperature, pressure, melt composition, and melt water content, indicating that these factors cannot cause fractionation of Sc^{3+} from mixed V^{3+} and V^{4+} in mantle melts through clinopyroxene/silicate melt partitioning. Therefore, in combination with V/Sc systematics in primitive MORBs and arc basalts, using $D_V^{Cpx/SM}$ and $D_{Sc}^{Cpx/SM}$ obtained at 1 bar and dry conditions should be valid to constrain mantle f_{O_2}, except for the case that the $D^{Cpx/SM}$ for Sc^{3+} can be demonstrated to be fractionated from the $D^{Cpx/SM}$ for mixed V^{4+} and V^{5+}, which are present in oxidized basalts.

Keywords: Oxygen fugacity, upper mantle, vanadium, scandium, partitioning, clinopyroxene, silicate melt