JIN Zhenmin, WU Yao, XU Mengjing, FEI Yingwei and Paul T. ROBINSON, 2015. How Depth is the Tibetan Chromite: Experimental Study. *Acta Geologica Sinica* (English Edition), 89(supp. 2): 35.

How Depth is the Tibetan Chromite: Experimental Study

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Podiform chromitites are generally lenticular bodies of massive to disseminated chromite typically hosted in mantle peridotites in ophiolites. Most such chromitites are surrounded by envelopes of dunite, a few centimeters to a few meters wide. Based on their textures and compositions, podiform chromitites have been interpreted as magmatic rocks formed as partial melting of mantle peridotite under low-pressure conditions in the upper mantle or by magma mingling and melt-rock reaction.

However, the discovery of ultrahigh pressure (UHP) minerals, such as micro-diamonds, coesite and moissanite and highly reduced native elements and metallic alloys in podiform chromitites in the Luobusa ophiolite of Tibet suggests a much deeper origin for these enigmatic bodies. A deep origin is also suggested by the discovery of coesite and clinopyroxene exsolution lamellae in magneisochromite grains from this ophiolite. In order to investigate the stability field of magnesiochromite and the origin of the coesite and clinopyroxene exsolution lamellae, we undertook a number of experiments in the magnesiochromite+SiO_2 system at temperatures of 1000–1600^{o}C and pressures 5–15 GPa. The experimental results show that: 1) magnesiochromite is transformed into a new phase (Fe, Mg)$_2$(Al, Cr)$_2$O$_5$ with a modified ludwigite structure at pressures >14 GPa and a temperature of 1600^{o}C; 2) Si solubility in the magnesiochromite increases slightly with increasing pressure and temperature, reaching a maximum of 2.44wt% and then decreasing significantly in the new phase; 3)There is a negative correlation between Si and Cr+Al and no correlation between Si and Mg+Fe. Thus, Si4+ and Ca2+ substitution in chromite may be simultaneously controlled by $2X^{3+} \leftrightarrow Ca^{2+} + Si^{4+}$(X: Al, Cr) and $4X^{3+} \leftrightarrow 3Si^{4+} + \Delta$ (X: Al, Cr; Δ: vacancy). We propose that podiform chromitites with these characteristics formed at the top of the mantle transition zone (12-14GPa) where Si, Ca and Mg are incorporated into chromite with a CF structure. The coesite and clinopyroxene lamellae formed by exsolution as the chromitites were transported to shallow mantle levels. The diamonds and other UHP minerals were preserved as inclusions in magnesiochromite grains. The chromitites and their host peridotites were preserved as ophiolites in suprasubduction zones where they underwent some modification by slab-generated melts. Therefore, our experimental results suggest that some of chromite in Tibet come from the top of transition zone and the maximum depth of formation for chromite is less than 400 km.

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