Petrogenetic insights from chromite in ultramafic cumulates of the Xiarihamu intrusion, northern Tibet Plateau, China

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ABSTRACT

Chromite is one of the earliest crystallized minerals from mafic melts and has been used as an important “petrogenetic indicator.” Its composition may be modified by interaction with intercumulate melt and adjacent minerals. Thus, chromite in mafic-ultramafic rocks contains clues to the geochemical affinity, evolution, and mantle source of its parent magmas. The Devonian Xiarihamu intrusion, located in the East Kunlun Orogenic Belt in the northern Tibet Plateau, China, hosts a very large disseminated Ni-Co sulfide deposit. This study focuses on geochemistry of the chromite enclosed in olivine of ultramafic rocks of the intrusion. Enrichments in Mg and Al in the rim of the chromite indicate only minor effects of alteration on the compositions of the chromite. The chromites enclosed in the olivines with forsterite percentage (Fo) lower than 87 are characterized by large variations in major and trace elements, such as large ranges of Cr·100/(Cr+Al) (Cr# = 15–47), Mg·100/(Mg+Fe2+) (Mg# = 41–65), and Al2O3 (26–53 wt%) as well as 380–3100 ppm V, 70–380 ppm Ga, and 1100–16300 ppm Zn. The chromites display positive correlations between Cr/(Cr+Al) and Ti, Mn, V, Ga, and Sc, inconsistent with fractional crystallization but indicative of an interaction between the chromites, intercumulate melts and hosting minerals. In contrast, chromites hosted in olivine with Fo > 87 in harzburgite have small variations in Cr# (ranging from 37 to 41), Mg# (48 to 51), and Al2O3 (30 to 35 wt%) as well as restricted variation in trace elements, indicating relatively weak interaction with trapped liquid and adjacent phases; these compositions are close to those of the most primitive, earliest crystallized chromites. The most primitive chromite has similarities with chromite in mid-ocean ridge basalt (MORB) in TiO2 and Al2O3 contents (0.19–0.32 and 27.9–36.3 wt%, respectively) and depletion of Sc and enrichment of Ga and Zn relative to MORB chromite. The geochemistry of the chromite indicates a partial melting of the asthenospheric mantle that was modified by melts derived from the subduction slab at garnet-stable pressures.

Keywords: Chromite, mineral geochemistry, intercumulate melt, primary magma, trapped liquid, magmatic sulfide, nickel, spinel; New Advances in Subduction Zone Magma Genesis

INTRODUCTION

It is difficult to reveal the geochemical nature of the parental magma of ultramafic cumulate rocks. There is always uncertainty in parent magma compositions, especially in the absence of demonstrably comagmatic basalts and in cases where the ultramafic cumulates are predominately adcumulate in character. In these cases, parent magma characteristics must be inferred from compositions of the cumulus minerals. Chromite is often among the first phases crystallized from mafic and ultramafic magma and is relatively refractory and resistant to alteration compared with the other early crystallizing minerals, such as olivine and pyroxene (e.g., Barnes and Roeder 2001; Kamenetsky et al. 2001). Although compositions of chromite can be changed due to reaction with hosting minerals and trapped liquids (e.g., Henderson 1975; Roeder and Campbell 1985; Scowen et al. 1991), important clues of parental magma and magma evolution can be preserved (e.g., Kamenetsky et al. 2001; Pagé and Barnes 2009). Thus, it has been used as an important “petrogenetic indicator” to reveal the geochemical natures of primary magmas and mantle sources of mafic and ultramafic rocks (e.g., Irvine 1967; Barnes and Roeder 2001; Kamenetsky et al. 2001; Procenza et al. 2004; Ahmed et al. 2005; González-Jiménez et al. 2014) and as a potential indicator for mineralized intrusions or lava flows (Barnes and Tang 1999; Barnes and Kunilov 2000; Locmelis et al. 2013; Evans 2017; Locmelis et al. 2018).

Mafic-ultramafic intrusions hosting magmatic sulfide deposits have been discovered in orogenic belts over the world, where contemporaneous basalts are commonly absent, such as in the Central Asian Orogenic Belt in northwest (NW) China (Song and Li 2009; Qin et al. 2011; Song et al. 2011; Zhang et al. 2011; Xie et al. 2012, 2014; Deng et al. 2014, 2015 and references there in)

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