Deep mantle origin and ultra-reducing conditions in podiform chromitite: Diamond, moissanite, and other unusual minerals in podiform chromitites from the Pozanti-Karsanti ophiolite, southern Turkey

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ABSTRACT

The Pozanti-Karsanti ophiolite situated in the eastern Tauride belt, southern Turkey, is a well-preserved oceanic lithosphere remnant comprising, in ascending order, mantle peridotite, ultramafic and mafic cumulates, isotropic gabbros, sheeted dikes, and basaltic pillow lavas. Two types of chromitites are observed in the Pozanti-Karsanti ophiolite. One type of chromitites occurs in the cumulate dunites around the Moho, and the other type of chromitites is hosted by the mantle harzburgites below the Moho. The second type of chromitites has massive, nodular, and disseminated textures. We have conducted the mineral separation work on the podiform chromitites hosted by harzburgites. So far, more than 100 grains of microdiamond and moissanite (SiC) have been recovered from the podiform chromitite. The diamonds and moissanite are accompanied by large amounts of rutile. Besides zircon, monazite and sulfide are also very common phases within the separated minerals. The discovery of diamond, moissanite, and the other unusual minerals from podiform chromitite of the Pozanti-Karsanti ophiolite provides new evidences for the common occurrences of these unusual minerals in ophiolitic peridotites and chromitites. This discovery also suggests that deep mantle processes and materials have been involved in the formation of podiform chromitite.

Keywords: Ophiolite, chromitite, diamond, moissanite

INTRODUCTION

Ophiolites represent remnants of ancient oceanic lithosphere that were tectonically emplaced onto the continents (Dilek and Furnes 2011; Pearce 2014; Whattam and Stern 2011). Podiform chromitites commonly occur in ophiolites of different ages and areas (González-Jiménez et al. 2014; Rollinson and Adetunji 2015; Yang et al. 2015; Zhang et al. 2016; Zhou et al. 2014). According to the chemical composition of chromite, chromitites can be classified into high-Cr group ([Cr# = Cr/(Cr+Al)] of chromite > 0.6) and high-Al group ([Cr# < 0.6] (Dickey 1975; Thayer 1970). Both high-Al and high-Cr chromitites may occur in the same ophiolite (Akmaz et al. 2014; González-Jiménez et al. 2011; Uysal et al. 2009). High-Cr chromitites are interpreted to form by the reaction between boninitic or arc-related magmas with the depleted harzburgite in a suprasubduction zone environment (Arai 1997; Uysal et al. 2007; Xiong et al. 2015; Zhou et al. 1996), whereas high-Al chromitites are suggested to crystallize in equilibrium with MORB-type melts in a mid-ocean ridge or back-arc environment in a subduction zone (Arai and Matsukage 1998; Pagé and Barnes 2009; Zhou et al. 2001, 2014). In general, previous genetic models all suggest that chromitites formed by melt-rock reaction, magma mingling, and crystallization in the shallow depth (~30 km) and no deep processes or materials have been involved.

The redox states of the Earth’s mantle have been established and suggested to be progressively reduced with increasing depth based on natural igneous rock samples and a series of experiments (Frost and McCammon 2008; Stagno et al. 2013). The upper part of the upper mantle where podiform chromitites are suggested to form, has oxygen fugacity within ±2 log units of the fayalite-magnetite-quartz (FMQ) oxygen buffer (Frost and McCammon 2008). Recently, diamond, moissanite, and other unusual minerals have been recovered from peridotites and podiform chromitites (both high-Cr and high-Al types) in ophiolites of different ages and orogenic belts (Howell et al. 2015; Robinson et al. 2015; Tian et al. 2015; Yang et al. 2015). As these minerals are mostly unexpected to be found in the chromitites and peridotites, people have questioned the factitious contamination origin of these minerals. However, in situ diamonds (enclosed by OsIr alloy) (Yang et al. 2007), moissanite (enclosed by chromite) (Li et al. 2014), coesite (rimming FeTi alloy) (Yang et al. 2007), and exsolution clinopyroxene lamellae (in chromite) (Yamamoto et al. 2009) have been observed in chromitite of Luobusa ophiolite in China and Ray-Iz ophiolite in Russia. Thus, these unusual minerals are intrinsic rather than contaminated to ophiolitic peridotites and podiform chromitites (Howell et al. 2015). Natural diamonds generally crystallize at depths exceeding ~150 km and temperatures above 950 °C at fO2 conditions around iron-wüstite (IW) buffer in the upper mantle (Cartigny 2005; Jacob et al. 2004; Stagno et al. 2015; Stagno and Frost 2010) and occasionally in the lower mantle (Kaminsky et al. 2009; Stachel et al. 2008). Recently, diamond, moissanite, and other unusual minerals in podiform chromitites from the Pozanti-Karsanti ophiolite also provide new evidence for the common occurrences of these unusual minerals in ophiolitic peridotites and chromitites.