Podiform chromitites from the Calzadilla de los Barros serpentinite, Iberian Massif, SW Spain

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Abstract. Podiform chromites occur as in situ and removed bodies in the Calzadilla de los Barros Serpentinite (Iberian Massif, SW Spain), a set of ultramafic massifs made up of partly serpentinized harzburgite with minor dunite and gabbros. They consist of massive to semi-massive chromitites, frequently with nodular texture. Chromite chemistry is characterized by high Al₂O₃ contents and up to 0.4 wt.% TiO₂, in agreement with a MORB affinity of the parental melt. Platinum-group element abundances are similar to most Al-chromitites reported in the literature except for an unusual enrichment in Pt and Pd. High Pt and Pd values were probably caused by late metamorphic alteration.

Keywords. podiform chromitites, platinum-group elements, Iberian Massif

1 Introduction

The variety of chromite textures exhibited by podiform chromitites located in the mantle section of ophiolite complexes compared to those occurring in stratiform igneous intrusions as well as their chemical composition, trends and platinum-group element contents allow identifying isolated ultramafic massifs as portions of dismembered ophiolite sections. Thus, we have studied different, in situ and removed chromitite bodies in the Calzadilla de los Barros Serpentinite, a set of partly serpentinized peridotite massifs located in the Iberian Massif, SW Spain, to confirm their supposed ophiolitic nature (Monterrubio 1991) and to understand their magmatic and metamorphic features.

2 Geological context

The Calzadilla de los Barros serpentinite massifs are located in the NE flank of the Olivenza-Monesterio antiform, a major WNW-ESE-trending Variscan structure occupying a central position within the Ossa-Morena zone of the Iberian Massif. These massifs mainly consist of two serpentinite bodies named Cerro Cabrera and Sierra Cabeza Gorda, as well as a narrow band of highly deformed serpentinites occurring along a NW-SE shear zone located to the SW of the major serpentinite bodies, close to the contact with Cambrian sediments (Fig. 1). The serpentinite massifs underlay the pre-cambrian tuffaceous materials of the Malcocinado Formation and occur in tectonic contact with the schists and shales of the Serie Negra Formation (Jiménez-Díaz et al. 2010; Fig. 1).

The different massifs are made up of strongly serpentinized harzburgite and dunite with minor chromitite. Some gabbroic rocks occur at the NW contact of the Cerro Cabrera massif. The tectonite foliation is poorly preserved but when visible it is oriented from N130ºE to N160ºW dipping to the NE and NW at high angles.

3 Chromitite deposits

3.1 Mineralogy and texture

Chromitites form variable sized, layers and lenses (pods) hosted by serpentinized dunes. They mainly show semi-massive (60-85% chromite) to massive texture (>85% chromite) although few centimetre-thick layers of disseminated chromitite (20-60% chromite) were drilled in the SW zone of Cerro Cabrera. Semi-massive chromitites often show nodular texture consisting of rounded to euhedral grains (up to 1 cm across) with interstitial Mg-chlorite. Single chrome nodules are not homogeneous crystals but aggregates of rounded grains (1-3 mm across) arranged in cubic packing. Disseminated chromitite layers are made up of subhedral, partly corroded chrome crystals associated
with interstitial Mg-chlorite and antigorite. Chromite grains are fractured and show variable thick (<250\textmu m), alterations rims progressing from grain boundaries and fractures inward.

3.2 Mineral chemistry

The analysed samples come from removed pods in the SE (Cuco 7, 8 & 9 and CAB 2 & 10) and NW (RO 8 and 9) zones of Cerro Cabrera, as well as from a in situ, 4 m long and 1 m thick pod (CM-4), located in the SE end of Sierra Cabeza Gorda (Fig. 1). Only unaltered nuclei have been analysed to obtain the primary composition of chromite. This composition is similar in all samples but RO-8 and RO-9, and is characterized by small variations in Mg# [Mg# = Mg/(Mg+Fe\textsuperscript{2+}) = 0.52-0.69] and Cr# [Cr# = Cr/(Cr+Al) = 0.49-0.55] (Fig. 2A).

Chromite in RO-8 and RO-9 has almost identical composition with higher Mg# (0.74-0.89) and lower Cr# (0.46-0.49) than those from the other studied samples (Fig. 2A). TiO\textsubscript{2} content varies from 0.1 to 0.5 wt.% and correlates negatively with Cr# (Fig. 2B). This diagram also shows that chromite from Calzdilla de los Barros serpentinite plots on a field where the composition of chromite from MORB- and Island Arc-type lavas overlap. MnO varies from 0.2 to 0.9 wt.%, V\textsubscript{2}O\textsubscript{3} is <0.28 wt.%, NiO is <0.23 wt.% and ZnO is <0.39 wt.%. These compositions mostly overlap with those of Al-rich chromitites from Coto (Philippines), Sangun Zone (Japan) and Moa-Baracoa (eastern Cuba) ophiolites (Fig. 2A).

3.3 Platinum-group elements

Thirty-six representative rock samples of the different chromitite pods were analysed for whole rock PGE geochemistry in Genalysis Laboratory Services Pty. Ltd., Maddington (Western Australia). Platinum-group elements were analysed by ICP-MS after nickel sulphide digest. Detection limits were 2 ppb for Ir, Os, Ru, Pd and Pt, and 1 ppb for Rh.

Chromitite samples show low PGE abundances. Total PGE contents range from 105 to 291 ppb but two samples show even lower PGE values: 29 and 52 ppb. Nevertheless, these chromites are unusually rich in Pt (up to 66 ppm) and, mainly, Pd (up to 172 ppm) compared with most ophiolite chromitites.

Chondrite-normalized PGE patterns plot between 0.4 and 0.002 times the chondritic values and are characterized by a variably slope (from positive to nearly flat) from Os to Ru followed by significant depletion in Rh and a positive-sloped segment from Rh to Pd. These patterns partly resemble those reported for Al-rich chromitites from Moa-Baracoa and Sangue de Táñamo ophiolite massifs (Proenza et al. 1999; Gervilla et al. 2005; González-Jiménez et al. 2011) but differ in the high Pt (up to 0.065 Pt N) and Pd (up to 0.3 Pd N) chondrite-normalized values.

4 Concluding remarks

The Podiform shape of the in situ chromitite body from Sierra Cabeza Gorda, the nodular texture of most samples from both in situ and removed chromitite
bodies, and the chemical composition of all studied chromite grains, similar to that of chromitites from Coto (Zambales ophiolite, Philippines; Leblanc and Violette, 1983; Zhou et al. 2000), Sangun Zone ophiolites (Matsumoto et al. 1997) and Moa Baracoa (Mayari-Baracoa Ophiolitic Belt, Proenza et al. 1999) evince the ophiolitic nature of the Calzadilla de los Barros chromitites and serpentinite (Monterrubio 1991). The Al-rich composition of chromite (Fig. 2) further suggest that these chromitites formed in the upper part of the ophiolite mantle section or in the mantle-crust transition zone, close to the overlaying crustal gabbros, as occur in Mayari-Baracoa (Proenza et al. 1999), Oman (Ahmed and Arai 2002) and Bay of Islands (Bédard and Hébert 1998) ophiolite complexes. In fact, the Al₂O₃-richest chromitite (samples RO) are those located close to the gabbro outcrop. The Al₂O₃ content of the melt in equilibrium with chromites [calculated from Maurel and Maurel’s (1982) ecuation] varies from 15.98 to 16.45 wt.% in RO samples and from 14.97 to 15.96 wt.% in CM, Cuco and CAB samples, and agrees with a MORB affinity of such melt. TiO₂ contents also support such affinity, probably related with a Back Arc geodynamic setting (Fig. 2).

PGE abundances resemble those of ophiolithic chromitites; however, chondrite-normalized PGE patterns do not show the characteristic negative slope from Ru to Pd (e.g. Leblanc 1991) but an unusual Pt and Pd enrichment up to values close to those of Ru. These anomalous Pt and Pd contents could be either of primary origin or related with the metamorphic alteration that affected the chromitites and the host serpentinite. The low PGE contents of MORB melts hardly support the primary origin of such Pt and Pd enrichment but point to a secondary enrichment in these PGE during metamorphism. This interpretation agrees with the fact that Pd and, at lesser extent, Pt are the most soluble PGE in hydrothermal fluids.

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References


