

A NEW PROPOSAL FOR THE DISCRIMINATION OF OPHIOLITIC CHROMITITES BASED ON MINOR AND TRACE ELEMENTS: A STUDY BY LA-ICPMS

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Abstract

Chrome Spinel chemical composition [(Mg,Fe)(Cr,Al,Fe³⁺)₂O₄], is usually used as indication of ophiolitic chromite deposits parental magmatic signature and tectonic environment of generation. In highly metamorphosed and/or hydrothermally altered (e.g. lisvenites) ophiolitic complexes frequently primary igneous silicate minerals are completely transformed to secondary minerals. To present elements that give better information and are used as tectonic discriminant elements in Chrome Spinels are Cr, Al, Fe³⁺ and Ti. In this study we present LA-ICPMS results of minor and trace elements distribution (Ga, Sc, V, Co, Ni, Zn, Mn, Ti, Zr, Nb), in representative samples of the three different compositional and tectonic setting types of chromitites hosted in the ophiolitic complexes from Mayarí, Cuba oriental; Moa-Baracoa in Eastern Cuba and Loma Perguera in Dominican Republic and we discuss the use of trace elements as discriminant for the different tectonic settings of ophiolites.

Palabras claves: Chromo Espinelo, Ofiolitas, Ambiente tectónico

Keywords: Chrome Spinel, Ophiolites, Tectonic Setting.

Introduction

Chrome Spinel chemical composition [(Mg,Fe)(Cr,Al,Fe³⁺)₂O₄], is usually used as indication of ophiolitic chromite deposits parental magmatic signature and tectonic environment of generation.

In highly metamorphosed and/or hydrothermally altered (e.g. lisvenites) ophiolitic complexes frequently primary igneous silicate minerals are completely transformed to secondary minerals. In these circumstances chromitites are the only primary lithology from which is possible to access petrogenetic information.

Elements that give better information are Cr, Al, Fe³⁺ and Ti. Different ratios of these elements allow to discriminate the tectonic setting of origin of ophiolitic chromitites (e.g. #Cr [Cr/(Cr+Al)] vs. TiO₂). Although for intermediate ratios of #Cr (0.5-0.65) there is an overlap between two types of environments as MOR/BAB and SSZ (i.e., suprasubduction zones).

Most of the ophiolitic chromitites hosted in mantle peridotites can be grouped in two different groups (Leblanc y Nicolas, 1992): i) Cr rich and Al poor (metallurgic grade) and ii) poor in Cr and rich in Al (refractory grade), both types have low TiO₂ contents (~< 0.25 %) and Fe₂O₃ (~ < 4 %). Although recently a third group of chromitites had been described characterized on being rich in Cr, Ti, Fe³⁺, and poor in Al₂O₃ (Loma Peguera at República Dominicana; Proenza et al., 2007). Following the most accepted genetic hypothesis type I chromitites (#Cr>0.6) crystallize in equilibrium with IAT-boninitic magmas while type II

(#Cr<0.6) with BABB (or MORB) magmas (see Rollinson et al., 2008). For the third type of chromitites described formerly, type-III (#Cr>0.6 and TiO₂ ~1%) it was proposed crystallization in equilibrium with oceanic plateau type magmas associated to a mantle plume (Proenza et al., 2007).

Parental magmatic composition of ophiolitic chromitites is normally obtained from the Al₂O₃ and TiO₂ content in the chromites (Kamenetsky et al., 2001). Only a few studies include minor and trace elements to determinate the type of the parental magma of ophiolitic chromitites (Dare et al., 2009; Pagé y Barnes 2009). The LA-ICP-MS analytical techniques allow to access to in situ microanalyses in chromite crystals in short time, with very low detection limits (< 1ppm) and avoiding the interferences in spectral lines of some elements that happen with analyses performed using Electronic Microprobe.

In this study we present LA-ICPMS results of minor and trace elements distribution (Ga, Sc, V, Co, Ni, Zn, Mn, Ti, Zr, Nb), in representative samples of the three different compositional types of chromitites hosted in the ophiolitic complexes described.

Analytical methodology and samples description

Representative samples from well know (field information and geochemistry) ophiolitic complexes were selected, they included:

- i) Chromitites rich in Cr from Mayarí in Cuba Oriental, generated in equilibrium with boninitic magmas (Proenza et al., 1999).
- ii) Chromitites poor in Cr (Al rich) from Moa-Baracoa in Eastern Cuba, in equilibrium with BABB/MORB magmas (Proenza et al., 1999).
- iii) Chromitites rich in Cr and Ti from Loma Parguera in Dominican Republic, probably associated with a mantle plume (Proenza et al., 2007).

Major elements contents of chromite analyses were carry out by EMP at Serveis Científicotècnics, Barcelona University. Minor and trace elements analyses were performed at the Laboratory of Geochronology of the Geological Survey of Canada, Ottawa with a Photon-Machines Analyte 193nm Excimer laser ablation combined with ICP-MS Agilent 7500cx quadrupole. Data reduction calculated with the software GLITTER 4.4.2.

Results and discussion

Rich Cr chromitites from Mayarí District (#Cr>0.6, TiO₂<0.2 %) show the lower Ga (~27 ppm), V (~827 ppm), Ni (1025 ppm), y Zn (332 ppm) from the three samples studied (fig. 1).

The Cr poor chromitites from Moa-Baracoa (#Cr<0.6, TiO₂<0.4 %) show higher contents Our preliminary results indicate that minor and trace elements are heterogeneously distributed in the three types of chromitites (Fig. 1). As a consequence, we propose that trace elements content in chromitites can become a useful tool to discriminate chromitites originated in different environments (Fig. 1). As an example the Ni vs Ga diagram show that the chromites belonging to the Cr rich chromitites of Mayarí have a composition similar to chromitites of boninitic lavas as Thetford Mine chromitites described by Pagé y Barnes, 2009. Although the composition of the Cr poor chromitites of Moa-Baracoa is coherent with the composition of MOR basalts chromites (Fig. 1B).

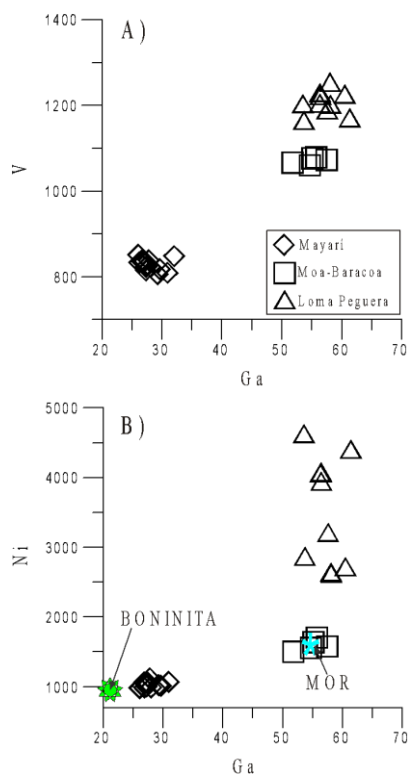


Figura 1: Different chromitites compositions relative to different trace elements. V vs. Ga (A) and Ni vs. Ga (B). Chromite composition in MOR basalts and boninites are from Pagé y Barnes (2009). Note the positive correlation with respect to V and Ga.

Ophiolitic chromitites rich in Cr and poor in Ti (metallurgic grade) are low in Ga, V, Ni, y Zn and slightly enriched in Mn y Sc compared with ophiolitic chromitites poor in Cr and rich in Al (refractory grade). Higher contents in Co, Mn, and Zn in the chromites of Loma Peguera chromitites are probably in equilibrium with the primary magmatic liquids composition because they show the highest content in Ni. Zn, Mn and Co may be removed during hydrothermal alteration but in this case Ni is low (Pagé y Barnes, 1999). Minor and trace elements composition of this chromites suggest that they represent a different compositional group rich in Cr, Ti, Fe^{3+} , Ga, V, Ni, Co, Zn, Mn, y Nb. This enrichment could be the result of crystallization from magmas associated to a mantle plume as the oceanic plateau magmas and would define a new type of ophiolitic chromitites (oceanic plateau type) as previously suggested by (Proenza et al., 2007).

The Ga and V contents correlate positively with increasing #Cr in our samples. Although it was considered (Pagé y Barnes, 1999) that a lower #Cr implies an increase in V and Ga contents. Our results show that to make this assumption is not correct and a negative correlation between the #Cr and Ga and V contents is not always the case. Loma Caribe chromitites are rich in Cr and show the highest contents in Ga and V (Fig.1).

In our samples V content present a positive correlation with Fe_2O_3 and it suggest that V partition is dependent of $f\text{O}_2$ (Dare et al., 2009; Pagé y Barnes, 2009).

Finally, the data discussed in the present abstract allow conclude that the primary magmatic Ga, V, Ni, Mn, Zn, Co and Sc compositions of magmas could be preserved in chromites of ophiolitic complexes and they become an excellent tool to discriminate the parental magmatic composition in equilibrium with the chromites and the tectonic setting of origin.

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