First Occurrence of Gahnite and Chrysoberyl in an Iberian Hercynian Pluton: the Belvís de Monroy Granite(NE Cáceres, Spain)

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INTRODUCTION.

Gahnite and chrysoberyl as accessory mineral phases have been mainly described in granitic pegmatites (i.e. Alfonso *et al.* 1995; Neiva & Champness, 1997; Szuszkiewicz & Lobos, 2004; Soares *et al.* 2007), or in metamorphic rocks (Downes & Bevan, 2002). Only the work of Tulloch (1981) cited gahnite in an alkali-feldspar granite, together with columbite, but without chrysoberyl.

Gahnite and chrysoberyl occur as accessory mineral phases in the peraluminous Belvís de Monroy leucogranite (NE Cáceres), in the Montes de Toledo Batholith (Spain). This work is the first report of gahnite and chrysoberyl in a granitic pluton from the Iberian Hercynian Belt.

Gahnite is euhedral with a Zn/Fe ratios lower than other igneous spinels, but with a Mg content typical of igneous associations. Chrysoberyl is also euhedral, and seems to be also magmatic.

Igneous gahnite and chrysoberyl are usually related to high alumina content in the granite melt, together to an increase of some trace element concentration (Zn, Be) during magma differentiation.

GEOLOGICAL SETTING.

The Belvís de Monroy pluton is located in the Hercynian Montes de Toledo Batholith (MTB). This batholith is a linear plutonic array extending from Madridejos (Toledo) to Belvís de Monroy (Cáceres) (Villaseca *et al.*, 2008). The western segment of the batholith has the most peraluminous granitic plutons (ACNK > 1.3), having higher P_2O_5 and lower CaO contents, in contrast with the eastern sector. The Belvís de Monroy granite is the westernmost pluton of the batholith, and it extends over an area of approximately 15 km^2. The wall-rocks are mainly Ordovician metapelites and quartzites. The origin of this granite is presumably related to the partial melting of Proterozoic metapelites of the Schist-Greywacke Complex during the Hercynian Orogeny (Villaseca *et al.*, 2008).

This granite is the most felsic (SiO_2>73 wt%), and perphosphorous (P_2O_5 from 0.63 to 0.85 wt%) of the MTB (Villaseca *et al.*, 2008). The leucocratic character is also reflected in the very low MgO content (<0.2 wt%). It is worth to note that it shows high U content (up to 13.5 ppm), mainly hosted in the Zr-Y-REE rich accessory phases (e.g. monazite and xenotime; Pérez-Soba *et al.*, 2009). The Belvís granite also shows the highest Be and Zn contents of the MTB (54 ppm and 60 ppm, respectively).

The mineral paragenesis of this granite consists of Qtz, Kfs (Or), Pl and Ms (>Bt), and Sil, Crd, Tur, Rut, Ilm, Ap, Zrn, Mnz, Xnt and other Ca-Fe-Al-Si-OH phosphates as accessory minerals. This study is focused on the textural description and chemical composition of gahnite and chrysoberyl, two uncommon accessory mineral phases in granites.

ANALYTICAL TECHNIQUES.

Gahnite (Zn-spinel) was found both in thin section and mineral concentrates, whereas chrysoberyl was found only in concentrates. Minerals were separated from the granite by crushing and hand picked under binocular microscope, and mounted into epoxy resin. Major-element compositions were analysed in the Centro de Microscopía Electrónica "Luis Bru" (Universidad Complutense de Madrid) using a Jeol JXA-8900 M electron microprobe with four wavelength dispersive spectrometers. Analytical conditions were an accelerating voltage of 15 kV, an electron beam current of 20 nA, and a beam diameter of 5 µm. Elements were counted for 10s on the peak and 5s on each background position. Corrections were made using the ZAF method. BeO content in chrysoberyl was estimated by stoichiometry. Averaged chemical analyses are presented in Table 1.

RESULTS.

Gahnite.

Gahnite occurs as euhedral to subeuhedral small crystals (up to 0.7 mm) and greenish in colour. It occurs in the most fractionated marginal facies of the pluton. Gahnite is occasionally included within quartz, and more frequently in white mica or K-feldspar (Fig. 1A).

Gahnite chemistry varies between 52.11 to 66.27 mol% of gahnite ($ZnAl_2O_4$), 31.66 to 45.29 mol% of hercynite ($FeAl_2O_4$), 1.31 to 2.63 mol% of spinel ($MgAl_2O_4$), and 0.38 to 0.95 mol% of galaxite ($MnAl_2O_4$). The averaged gahnite structural formula is $(Zn_{4.32}Fe_{3.08}Mg_{0.15}Mn_{0.06})_{\Sigma 7.6}Al_{16.2}O_{32}$.

In the Zn-Mg-Fe diagram (Fig. 2) Belvís gahnite enlarge the previous igneous compositional field towards higher Fe contents, showing an almost constant Mg/Fe ratio (0.4 to 0.6).

Chrysoberyl.

Chrysoberyl grains are colourless and from 0.1 mm to 0.3 mm in size. It is regular in shape showing well developed faces and prismatic habit (Fig. 1B).

Chrysoberyl has a FeO content ranging from 0.44 to 0.60 wt%, much lower than those from metamorphic rocks (2.5 to 3.2 wt%, Downes & Bevan, 2002), and

palabras clave: Gahnita, Crisoberilo, Cinturón Hercínico Ibérico, Granitos Peralumínicos Perfosfóricos.

key words: Gahnite, Chrysoberyl, Iberian Hercynian Belt, Perphosphorous Peraluminous Granites.

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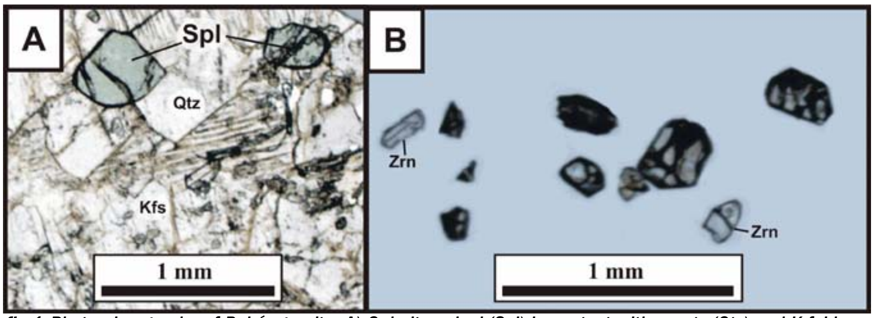

fig 1. Photomicrographs of Belvís granite: A) Gahnite spinel (Spl) in contact with quartz (Qtz) and K-feldspar (Kfs). B) Concentrate of chrysoberyl with zircon (Zrn) grains.

	Gahnite (n=20)	*Chrysoberyl* (n=13)
SiO_2	0.08	0.02
Al_2O_3	58.45	79.63
FeO	15.66	0.50
MnO	0.28	0.01
MgO	0.44	0.01
TiO_2	0.00	0.62
NiO	0.02	0.05
Cr_2O_3	0.03	0.03
ZnO	24.97	-
BeO*	-	19.21
Total	99.93	100.04

*Table 1. Average of electron microprobe analyses of gahnite and chrysoberyl. * BeO estimated by stoichiometry. n = number of samples.*

slightly lower than in granite pegmatites (0.67 to 1.79 wt%; Franz & Morteani, 1984; González del Tánago, 1991). TiO_2 content varies from 0.05 to 1.71 wt%, whereas the Cr_2O_3 content is almost negligible (up to 0.06 wt%). Chrysoberyl in metamorphic rocks usually has TiO_2 below detection limits whereas Cr_2O_3 content is up to 1.36 wt% (e.g. Downes & Bevan, 2002).

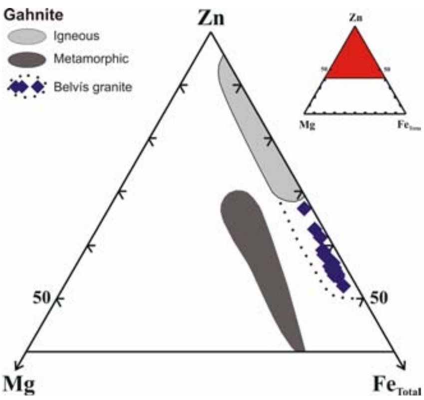

fig 2. Gahnite chemical composition from Belvís granite plotted in the Mg-Zn-Fe_{Total} (in molecular ratios) diagram. It is also shown the igneous and metamorphic compositional fields according to Batchelor & Kinnaird (1984).

DISCUSSION.

The subeuhedral to euhedral shape of gahnite and chrysoberyl indicates local equilibrium in the melt, and hence, a magmatic origin. According to Batchelor & Kinnaird (1984), gahnite with low Mg contents is typical of granite pegmatites or, as in this case, of highly fractionated granites. Mg is incorporated in early crystallized mafic phases (Bt), and is depleted in the residual melt. In contrast, in metamorphic processes, Mg could be re-mobilized due to the breakdown of biotite, producing Mg-rich spinels (MgO: 1.59 to 9.9 wt%) (Fig. 2).

Zn is commonly concentrated in residual melts during magma differentiation. Belvís gahnite displays Zn/Fe ratios lower than those previously described in igneous rocks (Fig. 2). Low Mn content in this gahnite may indicate that most of the available Mn in the melt has been favourably incorporated in the crystallization of phosphates, like fluorapatite (with a MnO content up to 3.8 wt%), childrenite (MnO up to 19.45 wt%), or other Ca-Fe-Al-Si phosphate phases with a significant Mn content.

The absence of beryl in the Belvís granite suggests that chrysoberyl crystallization is not related to breakdown of previous magmatic Be-rich phases. According to Soman & Nair (1985), chrysoberyl crystallization could be related to the CO_2 presence in the melt, which reduces the Si solubility in residual melts. However, the low Mg content in highly fractionated granite melts combined with high Al concentrations, and the increase in some trace element contents (Zn, Be), could stabilize gahnite and chrysoberyl as minor accessory minerals in the granitic paragenesis. Moreover, the excess of alumina content in the melt explains the formation of a complex aluminous mineral paragenesis composed by sillimanite, muscovite, cordierite, tourmaline and Al-rich phosphates.

This study also shows that Fe-rich gahnite (with molecular spinel < 2.7 %) could be of igneous origin, thus, enlarging the igneous gahnite compositional field proposed by Batchelor & Kinnaird (1984).

ACKNOWLEDGEMENTS.

We thank Alfredo Fernández Larios for his assistance with the electron microprobe analysis in the CAI of Microscopía Electrónica (UCM). This work is included in the objectives of, and supported by, the CGL2008-05952-CO2-01/BTE project of the Ministerio de Educación y Ciencia of Spain, and the CCG07-UCM project.

REFERENCES.

*Alfonso, P., Corbella, M.C., Melgarejo, J.C. (1995): Nb-Ta minerals from the Cap the Creus pegmatite field, eastern Pyrenees: distribution and geochemical trends. Mineral. Petrol., **55**, 53-69.*

*Batchelor, R.A. & Kinnaird, J.A. (1984): Gahnite compositions compared. Mineral. Mag., **48**, 425-429.*

*Downes, P.J. & Bevan, W.R. (2002): Chrysoberyl, beryl and zincian spinel mineralization in granulite-facies Archaean rocks al Dowerin, Western Australia. Mineral. Mag., **66**, 985-1002.*

*Franz, G. & Morteani, G. (1984): The formation of chrysoberyl in metamorphosed pegmatites. J. Petrol., **25**, 27-52.*

*González del Tánago, J. (1991): Las pegmatitas graníticas de Sierra Albarrana (Córdoba, España): Mineralizaciones de berilio. Bol. Geol. Min. Esp., **102**, 90-114.*

*Neiva, A.M.R. & Champness, P.E. (1997): Nigerite and gahnite from the granitic pegmatite veins of Cabanas, Ponte do Lima, northern Portugal. N. Jb. Miner. Mh., **9**, 385-409.*

*Pérez-Soba, C., Merino, E., Villaseca, C., Orejana, D. (2009): Zr-REE-Y-Rich Accesory Minerals from Peraluminous Granites of the Montes de Toledo Batholith (Iberian Hercynian Belt). Macla, **11**, 145-146.*

*Soares, D.R., Beurlen, H., Ferreira, A.C.M., da-Silva, R.R. (2007): Chemical composition of gahnite and degree of pegmatitic fractionation in the Borborema Pegmatitic Province, northeastern Brazil. An. Acad. Bras. Cienc., **79**, 395-404.*

*Soman, K. & Nair, N.G.K. (1985): Genesis of chrysoberyl in the pegmatites of Southern Kerala, India. Mineral. Mag., **49**, 733–738.*

*Szuszkiewicz, A. & Lobos, K. (2004): Gahnite from Siedlimowice, Strzegom-Sobótka granitic massif, SW Poland. Mineral. Polon., **35**, 15-21.*

*Tulloch, A.J. (1981): Gahnite and columbite in an alkali-feldspar granite from New Zealand. Mineral. Mag., **44**, 275-278.*

*Villaseca, C., Pérez-Soba, C., Merino, E., Orejana, D., López-García, J.A., Billström, K. (2008): Contrasting crustal sources for peraluminous granites of the segmented Montes de Toledo Batholith (Iberian Variscan Belt). J. Geoscie., **53**, 263-280.*