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Significance of compositional and boron isotope variations in tourmaline of Passagem de Mariana gold mine, Quadrilátero Ferrífero, Minas Gerais, Brazil

Garda, G.M.^{1*}, Xavier, R.P.², Cavalcanti, J.A.D.³,
Trumbull, R.B.⁴ & Wiedenbeck, M.⁴

¹Instituto de Geociências, São Paulo University, São Paulo/SP, Brazil (*giagarda@usp.br)

²Instituto de Geociências, Campinas State University, Campina, Brazil

³CPRM -REFO, Serviço Geológico do Brasil, Fortaleza, Brazil

⁴GFZ German Research Centre for Geosciences, Potsdam, Germany

The association of tourmaline and gold mineralization is conspicuous in the Passagem de Mariana Mine (Minas Gerais, Brazil) [1]. Tourmaline occurs as: very fine-grained foliation-parallel crystals in massive to banded tourmalinite (type 1); coarser-grained, color-zoned crystals forming massive (type 2) or comb-texture (type 3) aggregates within tourmalinite; and in associated quartz-carbonate-sulfide veins and breccias (type 4). Compositional variations in the four types of tourmaline can be expressed in terms of TiO_2 contents, which in turn reflect the color or color zones of tourmaline crystals. Generally the TiO_2 contents correlate negatively with SiO_2 and Al_2O_3 , and positively with CaO and MgO . Na_2O and F contents increase from types 1 to 3. The most pronounced changes in composition can be observed in the very dark zones of type-4 tourmaline, e.g. related to a decrease in MgO (trend a, Fig. 1A) and the increase in FeO (trend b, Fig. 1B).

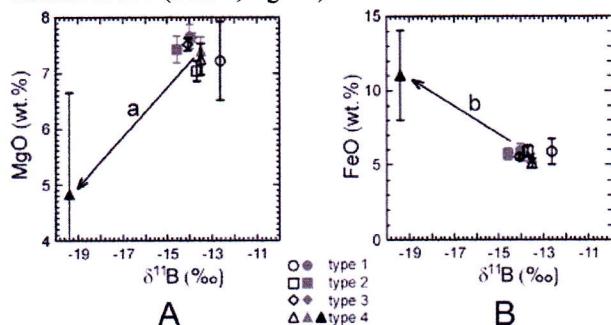


Fig. 1: MgO (A) and FeO (B) vs. $\delta^{11}B$ in tourmalines from the Passagem de Mariana Mine. Empty symbols: $TiO_2 < 0.5$ wt.%, gray symbols: 0.5 wt.% < $TiO_2 < 1.0$ wt.%, black: $TiO_2 > 1.0$ wt.%. Vertical bars on each symbol show compositional variations within the samples.

The total uncertainty in $\delta^{11}B$ values (1 s) is less than 2‰.

$\delta^{11}B$ values obtained by SIMS for the four types of tourmaline range from -19 to -12‰, indicating non-marine evaporites, metasedimentary rocks and S-type granites as possible crustal B sources [2]. Considering the geological setting, the probable B source for tourmaline of types 1 to 3 (-15 to -12‰) would be the carbonaceous phyllites of the Batatal Formation, though a contribution of boron derived from non-marine evaporites cannot be excluded. In contrast, the much more negative $\delta^{11}B$ values of -19‰ from dark zones of type-4 tourmalines (Fig. 1) cannot be explained by fractionation effects during metamorphism, but instead require an external source. External B sources may be related to thermal events of the Paleoproterozoic Transamazonian Orogeny [3] or to veining and brecciation induced by the overthrusting of the Minas Group, accompanied by gold mineralization [1].

[1] Vial, D.S. et al. (2007) *Ore Geol. Rev.*, **32**, 596-613. [2] Palmer, M.R. & Swihart, G.H. (1996) in Grew, E.S. and Anovitz, L.M. (eds.) *Rev. Mineral.*, **33**, 709-744. [3] Alkmim, F.F. & Marshak, S. (1998) *Precambrian Res.*, **90**, 29-58.

Boron variation in the calc alkaline volcanic arc of the Western Carpathians, Central Europe

Gmélign, K.^{1*}, Pécskay, Z.², Harangi, Sz.³ & Birkenmajer, K.⁴

¹Institute of Isotopes, Hungarian Academy of Sciences, Budapest, Hungary (*gmeling@iki.kfki.hu)

²Institute of Nuclear Research of the Hungarian Academy of Sciences, Debrecen, Hungary

³Eötvös University, Budapest, Hungary

⁴Institute of Geological Sciences, Polish Academy of Sciences, Krakow, Poland

Boron (B) is rarely found in the solar system, while on the Earth B is concentrated in the continental crust (~10 µg/g) [1]. The most suitable analytical technique for B concentration measurements in whole rocks is prompt gamma activation analysis (there is a PGAA instrument connected to the Budapest Research Reactor). Boron is an important tracer of the recycled materials in subduction zones as it is an incompatible and fluid-mobile element, with various abundances in different reservoirs. In the slab B is concentrated in the oceanic crust and sediments, but most of it leaves at the beginning of subduction close to the suture zone. Some minerals can retain B and carry it further down into the mantle. Thus, arc volcanic rocks have relatively high B content (~35 µg/g) [2].

The Western Carpathian calc alkaline volcanic arc serves a special case, as these volcanic rocks show subduction related trace element pattern and B content, although there is no seismic sign of a subducted slab under the studied area [3]. We focused on the B geochemistry of different type of Western Carpathian volcanic rocks originating from different volcanic eruptions of various ages (9.4-16.7 Ma; B 2-90 µg/g). The variation in the B content is the highest in the Central Slovak Volcanic Field (4-76 µg/g), as is the case for the variation in the age of the measured rocks. The range of B content is also similar in the Tokaj Mts. (7-68 µg/g). Smaller the changes in the B content in the other volcanic areas: Börzsöny Mts. (11-43 µg/g); Visegrádi Mts. (7-43); Mátra Mts. (8-30 µg/g). For comparison B content of connected andesite intrusions from the Pieniny and Moravia (3-30 µg/g), flysch sediments from the Pieniny region (60-154 µg/g), lower and upper crustal xenoliths (0.1-2.5 and 50-60 µg/g) and mantle xenolith (0.1-0.26 µg/g) samples were measured from the Carpathian Pannonian region. The higher B content of volcanic rocks generally originates (1) from the subducted slab: the altered oceanic crust and sediments; 2) form the metasomatic effect of an earlier subduction; or 3) from melting the more B enriched upper crust. In active subduction zones the slab derived B content of volcanic arcs is decreasing toward the back arc region [4]. However, the age and the spatial distribution of the Western Carpathian volcanics do not show any correlations with their B content or other trace elements. The relatively high K_2O/Sm vs B/Sm ratio refers to fluid enrichment mainly originating from a crustal material rather than from subducted sediment (represented by the flysch samples). All these support the assumption [5,6] of the decompression melting of a previously metasomatised lithospheric mantle and lower crustal materials, rather than a direct fluid induced melting under the Western Carpathians.

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[1] Taylor, S.R. & McLennan, S.M. (1995) *Rev. Geophys.*, **33**, 241-265. [2] Leeman, W.P. et al. (1994) *Geochim. Cosmochim. Ac.*, **58**, 149-168. [3] Grad, M. et al. (2006) *J. Geophys. Res. Sol. Ea.*, **111**, B3, B03301. [4] Ryan et al. (1995) *Science*, **270**, 625-628. [5] Lexa, J. & Konečný, V. (1998) *Geol. Surv. Slovak Rep.*, 219-240. [6] Harangi, Sz. (2001) *A. Geol. Hung.*, **44**, 223-258.



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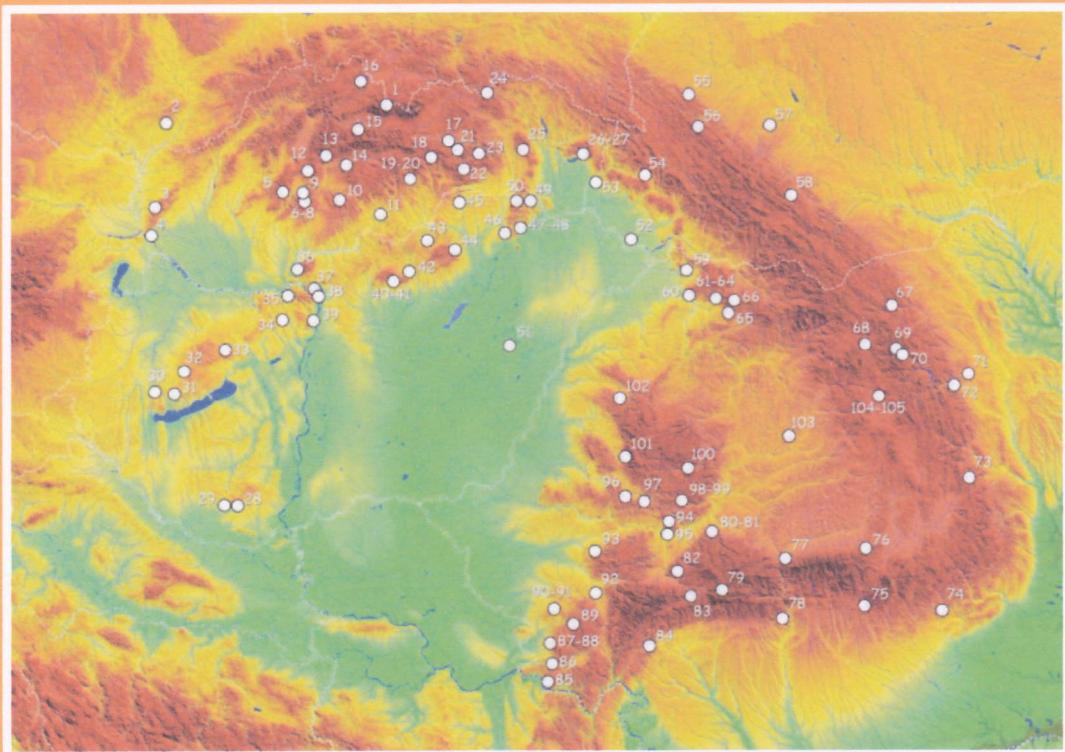
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