Origin of topaz-bearing granites of the Saxothuringian Zone (Bohemian Massif)

M. RENÉ

Institute of Rock Structure and Mechanics AS CR, Prague, rene@irsm.cas.cz

The Variscan granitic rocks in the Saxothuringian Zone form a discontinuous belt extending about 200 km along the Czech–German border in the direction NE–SW. The granitic rocks were emplaced into metamorphosed and folded volcano-sedimentary series of Proterozoic to Silurian age in the Late Carboniferous and Early Permian. Emplacement of individual plutons and smaller magmatic bodies (stocks, dykes) is controlled by NW–SE-striking shear zones. Although intrusive rocks largely predominate among the igneous rocks produced during the Variscan magmatic activity, the emplacement of plutonic rocks was interrupted by multiple extrusions of acidic lava flows and intrusions of dykes. The most extensive volcanic activity is associated with the origin of Late Variscan Altenberg-Teplice caldera in the eastern part of the Krušné Hory/Erzgebirge Mts (Seltmann 1994) Variscan magmatic activity is also represented by dykes of acidic and basaltic rocks (granite porphyries, microgranites, granodiorite porphyries, lamprophyres).

Variscan granitoids of the Saxothuringian Zone have been traditionally divided into two major magmatic series, the Older (OIC) and Younger (YIC) intrusive complexes. The topaz-bearing granites are a part of the Younger intrusive complex. Some occurrences of two-mica granites form a link between granites of the OIC and YIC (transitional granites – TG or intermediate granites – IG) (Fiala 1968, Lange et al. 1972, Štemprok 1986) In most magmatic bodies of the YIC, three to four magmatic phases of topaz-bearing granites can be defined. Biotite granites with only accessory amount of topaz form the oldest stages of topaz-bearing granites; the youngest members are formed by medium-grained to fine-grained topaz-albite alkali feldspar granites. Topaz-bearing alkali feldspar granites in the Saxothuringian Zone were emplaced as small bodies, stocks and/or dykes. Some of them pose parts of bigger plutons or complex volcanogenic structures.

Topaz-bearing granites of the Saxothuringian Zone can be divided into two compositionally and geodynamically distinct types, which were formerly referred to a single group of topaz-albite monzogranites or syenogranites to alkali feldspar granites.

First group is formed by strongly peraluminous (A/CNK = 1.1–1.3) S-type granites with low concentrations of REE, Y, Th, Zr, Hf, Sc, Pb and moderate to high P contents. The second group is formed by weakly to moderately peraluminous (A/CNK = 1.0–1.1) (Breiter et al. 1999) A-type felsic intrusive and extrusive rocks displaying marked enrichments in HREE, Y, Th, Hf, Nb, Ta and Zr. An extreme depletion in P is the other diagnostic feature of the latter rock type. The enrichment in uranium is characteristic for the youngest topaz-albite members of both types of topaz-bearing granites. Strongly peraluminous topaz-bearing granites are evolved in granite stocks in the Fichtelgebirge (G4), Slavkovský les Mts. (Krudum massif) and the western and central part of the Krušné Hory/Erzgebirge Mts. (Nejdek-Eibenstock pluton, Blatná massif, and Podlesí stock), and small stocks of Geyer, Ehrenfriedersdorf, Satzung, and Pobershau.

Topaz-bearing granites of the A-type concentrate to the eastern part of the Krušné Hory/Erzgebirge batholith. Known occurrences include the small granite bodies, cupolas and stocks of Markersbach, Sadisdorf, Schellerhau, Sachsenhöhe, Schenkenshöhe, Altenberg, Zinnwald/Cínovec, Krupka and Preiselberg. The now proved A-type granites in the easternmost Central Krušné Hory/Erzgebirge pluton include the occurrences found in boreholes near Seiffen and Hora sv. Kateřiny. In the western part of the Krušné Hory/Erzgebirge batholith, the affinity to A-type granites is observed in the Gottesberg volcanic-intrusive complex. These rocks were emplaced at shallow crustal levels, in major shear zones of different directions (preferred strikes NW–SE and NE-SW).

Both types of topaz-bearing granites are characterized by higher contents of incompatible elements such as Li, Rb, Cs, Sn, Nb, Ta and W. The content of Rb in these granites is usually 850–2500 ppm. The content of Nb in topaz-bearing granites of the Saxothuringian Zone is usually 20–110 ppm, the highest content of Nb was found in zinnwaldite granites from the Cínovec cupola (56–107 ppm). The content of Ta in topaz-bearing granites is 15–76 ppm, the highest content of Ta was found in alkali feldspar granites from the Geyer stock (37–76 ppm). The content of Nb and Ta in topaz-bearing granites of the Saxothuringian Zone is controlled by the occurrence of Nb-Ta-rutile and other Nb-Ta oxides, or by the presence of Nb-wolframite (Rub et al. 1998, Dolejš and Štemprok 2001, René et al. 2001).

P-high and P-low topaz-bearing granites of the Saxothuringian Zone are characterized by some differences in REE contents and distributions. The highest aREE content was found in P-low granites of the Cínovec cupola. Lower aREE content is typical for P-high granites and the lowest aREE was found in leucocratic granites of the Geyer stock. P-high topaz-bearing granites are also characterized by higher LREE/HREE ratio. LREE/HREE ratio for alkali feldspar granites from the Krudum massif is 1.6–4.8. A similar value was also found for alkali feldspar granites from the Western and Central Erzgebirge/Krušné Hory pluton (Podlesí stock LREE/HREE = 2.2–4.1, Ehrenfriedersdorf LREE/HREE = 1.5–3.6). Significantly lower values of this ratio were found in P-low granites from the Cínovec cupola (protolithionite granites LREE/HREE = 1.0–1.9, zinnwaldite granites LREE/HREE 1.0–1.8). REE contents in both types of topaz-bearing granites are controlled by variable amounts of REE-bearing accessory minerals (monazite, xenotime, apatite, zircon). Some rare minerals of REE from the crandallite-beudantite group and REE-fluorocarbonates group were formed during younger fluid fractionation. A product of hydrothermal alteration of these granites was probably also brabantite, which was found in topaz-bearing granites from the Krudum massif, Podlesí and Cínovec.

The strong peraluminous group of topaz-bearing granites was formed by strong fractionation of granite melt that originated by partial melting of metapelites and metagreywackes of upper crust. The second, A-type group of topaz-bearing granites was very probably formed by fractionation of relatively dry melt of granulitic composition, which was fractionated under conditions of lower part of continental crust.

The majority of topaz-bearing granites are influenced by intense fluid-rock interactions, associated with the origin of tin-tungsten ore mineralization. These post-magmatic altered rocks cannot be always easily distinguished from primary magmatic compositional patterns. The most effective method of distinguishing magmatic and hydrothermal stages is cathodoluminescence microscopy of quartz and albite and/or the occurrence of the tetrad effect in the distribution of REE. The origin of the tetrad effect is very probably connected with the redistribution of REE during post-magmatic alteration due to strong fluorine complexation (Irber 1999, Monecke et al. 2002).This alteration is also accompanied by depletion of Th and U. In topaz-bearing granites with high to moderate P contents, hydrothermal alterations are also connected with changes in chemical composition of apatites. Hydrothermally generated apatites have a higher content of MnO. During younger fluid fractionation of P-low granites and their hydrothermal alteration, the value of aluminium saturation index is rising. Protolithionite granites from the Cínovec cupola are characterized by A/CNK values of 0.9–1.1, whereas granites with higher influence of F-rich fluids and younger hydrothermal alterations by A/CNK values of 1.1–3.0). Hydrothermal alteration of topaz-bearing granites is also associated with the origin of clay minerals (kaolinite and illite) or Li-bearing chlorite.

The work was supported by the Ministry of Education, Youth and Sports of the Czech Republic (Project No. ME-364).