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PHOSPHORUS-RICH GARNETS FROM LEUCOCRATE IGNEOUS ROCKS (PŘIBYSLAVICE, MOLDANUBIKUM, CZECH REPUBLIC)

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In the frame of a systematic study of P-rich granitoids we found in orthogneisses, granites and aplopegmatites from an area close to the village of Přibyslavice (central-eastern Bohemia) garnets with substantial amount of phosphorus. The contents of P in the garnet locally exceed 1 wt.% of P_2O_5. Based on this observation we start a detail investigation on this unusual garnet occurrence.

The Přibyslavice orthogneiss-granite-pegmatite complex outcrops over an area of ~3 km^2, located ~5 km SSE of the town of Čáslav in the NE edge of the Moldanibicum [1]. A muscovite-tourmaline bearing orthogneiss body is enclosed in two-mica and biotite paragneisses with sillimanite and garnet. The orthogneiss show the same distinct foliation as the metamorphic country rocks. The central part of the orthogneiss body was intruded by a small stock of a Variscan muscovite granite, by several large dykes of garnet-bearing biotite-tourmaline aplite-pegmatites and by a thin dyke of a more evolved muscovite-tourmaline pegmatite.

All investigated rocks from Přibyslavice are leucocratic (< 1 wt.% Fe_2O_{3tot}), peraluminous (A/CNK 1.08 to 1.50), and rich in P (0.5–1.5 wt.% P_2O_5), B (300–500 ppm), Rb (300–700 ppm), poor in F and Li. The granite itselve is strongly enriched in Sn (200–500 ppm), Nb, and Ta.

The Přibyslavice orthogneiss-granite-pegmatite complex had attracted mineralogists for a long time, mainly related to the occurrence of phosphate rich lenses with a large number of primary magmatic to late hydrothermal or supergene phosphate minerals [1] and to the occurrence of large crystals of Mn-rich garnets [2].

Several distinct types of garnets were recognised in the investigated rocks:

1. garnet crystals in lenses and veinlets of leucosome within the orthogneiss close to the granite and aplite-pegmatite intrusions: They are pure Mn-rich almandine crystals with a size of 2–3 mm and free of inclusions of other minerals. Normally they are strongly zoned with Mn+Ca-rich cores and Fe+Mg+P-rich rims. Content of spessartine reach about 30 % in the core and 20 % in the rims, together with about 0.1 wt.% P_2O_5 in the core and 0.2 wt.% P_2O_5 in rims. The growing of these garnets can be probably related to peak of regional Variscan metamorphism.
2. individual garnet crystals and garnet-quartz nodules in the muscovite-tourmaline orthogneiss near the contact to the aplite-pegmatite bodies: The size ot the individual crystals is 5–10 mm. The nodules are generally rounded to irregular formed, 1–3 cm in diameter and without any crystal planes on the surface. Both nodules and crystals contain limited areas with graphic garnet-quartz intergrowth. Contents of spessartine varies between 15–20 % with a slight enrichment in the core. P contents are more enriched in the cores (0.5–0.6 wt.% P_2O_5) than in the rims (~0.3 wt.% P_2O_5).

3. garnet-quartz nodules and garnet crystals within the aplite-pegmatite bodies: This is the well known occurrence of garnet for mineral collections and reported in older publications [1, 2]. The homogeneous crystals of garnet are up to 1 cm large, the garnet-quartz nodules reach diameter up to 10 cm. The nodules have often a radial texture and/or are limited by combination of crystals plains. Graphic garnet-quartz intergrowths are common. Individual crystals are scarce within the pegmatitic facies, but common in transition zone between pegmatitic and aplitic facies. Nodules occur only in the aplitic facies. Most of the crystals and nodules are located within thin local shear zones crosscutting the aplite. The shear zones are characterized by new grown muscovite. The garnets are zoned with spessartine contents about 20–25 % in the core and 15–20 % in the rims. The contents of P_2O_5 reach up to 1 wt. % in core and 0.2–0.3 % in the rims.
4. garnet-quartz nodules in the muscovite granite. These irregular nodules, 1–5 cm in diameter, contain often more quartz (up to 60–70 vol.%) than garnet and have never crystal planes on the surface. Garnet occur in a cemented matrix of individual quartz grains. The nodules are homogeneous in the Mn-content (30 % spessartine), phosphorus is slightly enriched in the core (0.4 wt. % P_2O_5) in comparison to the rims (0.3 wt. % P_2O_5).

According to the trace element contents, all garnet types are enriched in HREE (10–60 ppm Yb, 1–10 ppm Lu, 40–150 ppm Y), whereas the LREE are very low (< 1 ppm La and Ce). Contents of scandium can be used as genetical indicator: metamorphic garnets (type1) contain only 40 ppm Sc, whereas all the other garnet types contain 100–200 ppm Sc.

Garnets of the types 2-4 are related to the post-metamorphic intrusion of granite and aplite-pegmatites. Graphic intergrowth of garnet and quartz was studied in detail in pegmatites in the Alps [3] and were interpreted as a product of magmatic crystallisation. In contrast in Přibyslavice, where the most garnet nodules with graphic intergrown occur within local shear zones or deformation plains, the growth of garnet is related to fluids activity. The garnet nodules in aplite-pegmatites contain about 50 % of quartz, but inclusions of other minerals (tourmaline, apatite) are very rare. This mean, that all alumino-silicates have been replaced by garnet, but quartz itself was a stable phase during the reaction. Phosphorus, primarily bound in feldspars, was incorporated into the newly formed garnet mainly caused by the lack of Ca to form apatite. The source of Fe can be found in the replaced micas and tourmaline, but Mn should be supplied by the fluids. The incorporation of phosphorus into tetrahedral position of the garnet lattice needs a compensation. One part of P is compensated with Al in the tetrahedral position (berlinite substitution), another part with Na in M^{2+} site. Further P shows a well defined positive correlation with Ti (about 0.1 % TiO_2 in P-rich domains). This means that the whole substitution roles are more complex and need additional investigations.

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