Variscan potassic-alkaline magmatism in Stara planina, Bulgaria – Composition, source and geodynamic significance

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Three Variscan potassic-alkaline plutons: Svidnya, Buhovo-Seslavtzi and Shipka outcrop in Western and Central Stara planina, Bulgaria. The rocks intrude Silurian, Ordovician and Devonian metasediments. The existing isotopic data indicate an emplacement age between 340-320 Ma for Svidnya, the first TIMS results on zircons for Buhovo-Seslavtzi yield 352±22 Ma.

The plutons have essentialy intermediate monzonite - syenite composition, with minour amounts of granite. The metaluminous intrusive varieties predominate, but in the three plutons magmatic activity terminates with the separation of strongly peralkaline dyke residue. The peralkaline dyke rocks are of quartz syenitic and granitic composition and contain sodic-calcic and sodic pyroxenes and amphiboles. The rocks have pronounced potassic character, with K_2O in the range 5.49 – 11.04 wt.%, and very high LILE and Th – U contents. Synchronous with the peralkaline tendency the contents of HFSE and REE increase.

Preliminary isotopic results show that the rocks have isotopic signature plotting in the enriched quadrant of Sr-Nd systematic. $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ for Svidnya pluton are 0.709 – 0.712 and 0.51192 – 0.51194 respectively. For Buhovo-Seslavtzi $^{87}Sr/^{86}Sr$ is 0.709 and $^{143}Nd/^{144}Nd$ is 0.51191 – 0.51188, coupled with εHf from -3.8 to -5.2. Concordant with the moderate enrichment in incompatible elements Shipka pluton shows less enriched composition: $^{87}Sr/^{86}Sr$ is 0.705 and $^{143}Nd/^{144}Nd$ is between 0.51215 and 0.51217.

The rocks present fractionated trend of distribution of REE with La/Lu_N: 23 (Svidnya) and 17 (Buhovo-Seslavtzi), which features are consistent with the presence of residual garnet in the source. The rocks from Shipka have less fractionated trend with La/Lu_N - 10 which implies on the presence of residual spinel in the source. Low rate melting of enriched mantle is the probable mechanism for the magma generation of this Variscan association.

The very high K_2O and the dominance of LILE, Th and U over HFSE indicate significant crust – mantle interractions and involvment of crustal materials into the mantle. The potassic rocks asssociate with S and I type granitoids and this fact is in favor of the orogenic character of the whole Varsican magmatism in Stara planina, Bulgaria. The rocks have isotopic fabrics and are formed after the main orogenic events.

Controls on major and trace element zoning in hydrothermal garnet

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Garnet from the Navachab gold deposit, Namibia, records complex zoning profiles that reflect the alteration history during mineralization. The deposit is situated in the Southern Central Zone of the Damara Orogen, a typical low-P metamorphic terrane. It is hosted by late Proterozoic shelf sediments that are dominated by marbles and calcsilicate rocks, consisting of highly variable proportions of Cal, Cpx, Kfs, An and Qtz. The P-T conditions of formation have been estimated at c. 550-600°C and 2-3 kbars, consistent with the low-P regional metamorphism in the Damara belt.

The garnets investigated in this study are from a massive "replacement-style" sulfide lens and associated alteration zone. Hydrothermal alteration was mainly driven by an increase in bulk rock Mn, Si, and Fe. Two types of alteration can be distinguished that are interpreted to have formed contemporaneously: one dominated by Grt-Cpx-Kfs-Qtz, the other one mainly consisting of Grt and Bt. Textural analysis, coupled with detailed mineral-chemical investigations reveal two distinct garnet generations, and a two-stage growth history.

Stage I garnet usually forms the cores of individual porphyroblasts, and is highly enriched in spessartine. It commonly records a classic bell-shaped zoning profile, in which the XMn progressively decreases from core to rim. This type of zoning profile formed during pervasive hydrothermal alteration, leading to the progressive depletion of Mn in the fluid.

Stage II garnet overgrows the early garnet, and is best-developed in zones of intense fluid-rock interaction. Most of the major and trace elements (including the REE) were mobile at this stage. Stage II garnet is Ca-rich, and records variable zoning patterns that are controlled by the permeability in the different alteration zones. In the Grt-Bt alteration, stage II garnet is characterized by µm-scale oscillations. The oscillations document the episodic supply of fluid in zones of strongly reduced permeabilities. In high-permeability zones, such as the massive sulfide lens, the compositional variations are more progressive, suggesting a rather constant fluid supply in these units.

The garnet zoning pattern are related to different stages during the development of the hydrothermal system. They document the complete history of initial fluid-rock interaction during the onset of pervasive hydrothermal alteration, subsequent fluid pressure built up towards critical values, and final hydraulic fracturing in zones of high fluid pressures. There is no evidence for changing P-T conditions during garnet growth.