Interplay between Assimilation, Fractional Crystallization and Magma Mixing – the Story of the high-K calc-alkaline Kozárovice Intrusion, Central Bohemian Pluton

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The Kozárovice granodiorite is a typical representant of the high-K calc-alkaline Blatná suite, demonstrating processes of general importance not only to the petrogenesis of this part of the Central Bohemian Pluton, but also Hercynian calc–alkaline granitoids in general.

Harker plots for the granodiorite show strong negative correlations between SiO_2 and FeO*, MnO, MgO, CaO and TiO_2, that, if interpreted on the basis of a fractional crystallization model, point to fractionation dominated by ferromagnesian phase(s) and plagioclase. Least-squares modelling implies that the whole compositional spectrum could have been derived by up to 45% fractional crystallization of 35–42% amphibole, 28–33% plagioclase, 7–13% K-feldspar and 13–22% biotite; and this is in line with modelling using LILE and REE data.

The Kozárovice granodiorite is associated with K-rich pyroxene-bearing monzonitic rocks (Zalužany monzonite and Lučkovice melamonzonite–monzogabbro). In a quarry SE of Kozárovice small bodies of biotite–amphibole quartz monzonite occur that are net-veined and broken into microgranular mafic enclaves at the contact with the granodiorite. Hornblendes in both of these rocks enclose resorbed relics of biotite flakes. This texture can be explained either by a decrease in a_{SiO2} or an increase in a_{plag} of the melt, possibly due to its sudden basification (Castro, 1993). Both rocks also contain nearly monomineralic amphibole clots, the shapes of which often resemble those of pyroxene phenocrysts. In the quartz monzonite, quartz and K-feldspar form large oikocrysts; apatite is long prismatic or acicular.

The plagioclase of the quartz monzonite frequently shows discontinuous zoning (the terminology used follows that of Wiebe, 1968). Relatively large andesine ($An_{34–43}$) cores with oscillatory zoning are common and are overgrown by calcic andesine–labradorite spikes (surges in An content, up to An_{56}) and normally zoned oligoclase–andesine rims ($\rightarrow An_{26}$). Some lath-shaped crystals of oligoclase–andesine ($An_{28–32}$), may be unzoned while crystals with andesine–labradorite cores (An_{46-60}) are overgrown by sodic, normally zoned rims ($\rightarrow An_{26}$). The plagioclase of the granodiorite may be unzoned oligoclase–andesine, or consists of crystals with andesine–labradorite cores ($An_{42–51}$) overgrown by normally-zoned oligoclase rims (An_{28-29}); narrow calcic spikes or slight reversals in the zoning are scarce.

These textures can be explained - in agreement with the major- and trace-element based mixing tests - by mingling of granodioritic and monzonitic magmas. The acid magma chamber was invaded by basic magma and, especially close to the contact, partly crystallized plagioclases were exchanged. In the monzonite, sodic cores (early-formed crystals captured from the granodiorite) were overgrown by calcic spikes. In addition, the strong undercooling of the basic magma triggered the nucleation of numerous lath-shaped plagioclases, some with calcic cores. After thermal re-adjustment crystallization proceeded relatively slowly. The spikes graded into normally-zoned oligoclase–andesine rims and quartz and K-feldspar oikocrysts developed. In the granodiorite most of the plagioclase crystals are normally-zoned sodic andesine–calcic oligoclase, but those with partly resorbed calcic cores overgrown by normally-zoned sodic rims represent crystals locally captured (together with pyroxene, now amphibole) from the monzonitic magma. Even more complex zoning patterns represent repeated exchange between the two magmas possibly resulting from vigorous convection caused by instability following the influx of hot basic magma.

The Sr–Nd isotopic composition of the Blatná suite documents an important role for open–system processes. A mixing model involving monzonitic and evolved granodioritic magmas can account for the observed $^{87}Sr/^{86}Sr_i$–epattern. However, in a 1/Nd–e plot, the Kozárovice and Blatná intrusions form independent, curved trends. Binary mixing and conventional assimilation and fractional crystallization (AFC) in which r (the rate of assimilation/fractional crystallization) and D (the bulk distribution coefficient) are constant ought to produce linear trends. The curvature observed can be explained by changing either D or r in the course of AFC (Powell, 1984). For the Kozárovice intrusion, the most feasible of the models tested assumes an increase in D_{Nd} ($1.3 \rightarrow 4.5$ for $r = 0.5$ and a typical Moldanubian paragneiss as a contaminant).

Taken together, the petrography and geochemistry of the Kozárovice intrusion reflect open system processes, probably AFC with variable D_{Nd}. Interaction with monzonitic magmas, at least locally, played an additional important role.

References

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