Petrology of the Weinsberg granite in the South Bohemian Batholith: New data from the mafic end members

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The Weinsberg granite, a very coarse-grained granite with megacrystic K-feldspar, is the most prominent and widespread magmatic rock in the Variscan South Bohemian Batholith. The rock type crops out over an area of more than 1000 km^2, showing a considerable compositional variation from quite mafic, quartz-monzodioritic variants with orthopyroxen, through biotite-granite (dominant lithology) to felsic, muscovite-bearing end members (Frasl – Finger 1991).

Based on differences in zircon typology, two facies have been distinguished (Weinsberg granite 1 and 2), the Weinsberg granite 1 being rather of the I-type, the Weinsberg granite 2 rather of the S-type (Stöbich 1992, Finger – Clemens 1995). Finger and Von Quadt (1992), and Gerdes (2001), have shown that the Weinsberg granite 1 and 2 also clearly differ in their initial Sr isotopic compositions. The SiO_2 range of the Weinsberg granite 2 is c. 65–76 %, whereas the Weinsberg granite 1 comprises also mafic variants (SiO_2 c. 56–73 %).

There are two contrasting views how the mafic end members of Weinsberg granite can be best explained in terms of petrogenesis. Finger and Clemens (1995, 2001) suggested that these rocks represent a cumulate magma, whose crystallisation started within the P-T stability field of Opx. They considered that the Weinsberg magma (as a whole) originated under granulite facies conditions, through partial melting of heterogeneous, high-K, biotite-bearing, lower crustal sources.

In contrast to this, Koller (1994) and Klötzli et al. (2001) proposed that the mafic Weinsberg granites with Opx are contaminated by much older, xenolithic crustal material. They hypothesized that the pyroxenes in these rocks are xenocrystal in origin, derived from a Cadomian magmatic rock that crystallised some 200 Ma earlier, and are accidentally incorporated into the Weinsberg magma.

The mafic variants of Weinsberg granite occur mainly in a plutonic body NW of Linz, with prominent outcrops close to the villages of Sarleinsbach and Sprinzenstein (Frasl – Finger 1988). In summer 2002 a new investigation campaign on these rocks was started. In the field, two different subtypes of mafic Weinsberg granite could be distinguished. One is a generally dark, brownish-grey rock with quartz-monzodioritic or quartz-poor granitic to granodioritic composition (Sarleinsbach quartz-monzodiorite in the sense of Frasl – Finger 1988). Like all granites assigned to the Weinsberg type, the rock contains large K-feldspar crystals. These are, however, of unusual glassy and grey appearance, exhibiting partly an orthoclase crystal structure. Orthopyroxene is typically present in this rock, but often marginally overgrown and replaced by clinopyroxene, amphibole and biotite-quartz symplectites. Furthermore, the orthopyroxenes exhibit various exsolution and recrystallisation phenomena. Shapes of pseudomorphs and textural relationships indicate that the original Opx crystals were mostly early magmatic minerals (some may be restitic), with a size of up to several millimeters. Opx-Cpx thermometry suggests that Cpx formed at temperatures of c. 750 °C, by a retrograde reaction which occurred during cooling of the magma.

The second subtype of mafic Weinsberg granite looks whiter, because its K-feldspar megacrysts are generally milky-white microclines. However, there is much biotite and also some amphibole in the groundmass.

Despite of the quite striking macroscopic contrasts, the two subtypes of mafic Weinsberg granite have actually the same major and trace element geochemistry. Both obviously represent the same magma. We interpret the mineralogical differences in terms of a different freezing history, probably resulting from a different activity of H_2O in different parts of the plutonic body.

Both rock types show a record of continous deformation from magmatic to solid-state conditions, including partial recrystallisation of magmatic minerals. Such processes, which are generally common in this part of the batholith (Büttner 1999), have considerably blurred the original igneous fabrics.

Furthermore, it was found that both subtypes of mafic Weinsberg granite often contain fine-grained, dark enclaves. Some may represent restite, however, from their morphology and composition most are best interpreted as former globules of ± contemporaneous mafic and intermediate magma. U/Pb zircon dating confirmed that these enclaves are of Variscan age like their host rocks (329 ± 9 Ma). Textures are partly igneous, partly affected by recrystallisation processes. Locally, mingling phenomena between the enclave magma and the Weinsberg magma are evident. Magma mingling might therefore have been a potentially important process in the genesis of the mafic variants of Weinsberg granite.

Geochronological work has been carried out on two samples of mafic Weinsberg granite. In a first, Opx-bearing sample (Sarleinsbach quartz-monzodiorite), several precise, concordant single-grain zircon ages have been determined clustering around 323 Ma. There can be little doubt that this age represents the magmatic crystallisation stage of the rock. Most of these 323 Ma old zircons displayed a ~J4 morphology in the sense of Pupin (1980). Zircons of this J4 type have previously been considered as representing a population of inherited Cadomian zircons in the Sarleinsbach quartz-monzodiorite (Klötzli et al. 2001). This could not be confirmed. Like in most other Weinsberg granite 1 samples (see Stöbich 1992), such zircons with dominant (100)+(101) faces obviously represent crystals that precipitated from the Variscan granitoid melt.

Zircons from a second sample of mafic Weinsberg granite from Sarleinsbach (with amphibole) were studied by means of the SHRIMP method. In accordance with the other sample, the main phase of zircon growth was constrained at 322 ± 4 Ma. Some inherited cores, which have been identified by means of CL imaging, showed very high ages of around 2 Ga, one core gave a concordant age of c. 450 Ma. A record of a Cadomian zircon-forming event was not found. Likewise, zircon ages of c. 350 Ma, reported by Klötzli et al. (2001) to be very abundant in the opx-bearing samples of mafic Weinsberg granite, could not be found.

Concerning the age of the Weinsberg granite in general, there is now firm and overwhelming geochronological evidence for melt formation and crystallisation at between ~330 Ma and 320 Ma, with individual Weinsberg granite units being of slightly different age (Gerdes, this volume, Gerdes 2001, Friedl et al. 1996, Finger – Von Quadt 1992). Concepts involving formation and intrusion of the Weinsberg granite at c. 345–350 Ma (Scharbert 1987, Koller – Klötzli 1998, Klötzli et al. 2001), which were also contradictory to field relations (an older age than granulite metamorphism in the Moldanubian unit !) seem to be little realistic.

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