The Weinsberg granite

– connecting the prime example of late-Variscan crustal recycling

from source to emplacement

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Occurrence close to the source in the Bavarian Unit --> Opx bearing granite S

Discordant emplacement in the eastern part of the batholith --> Granite with pseudomorphs after Opx E

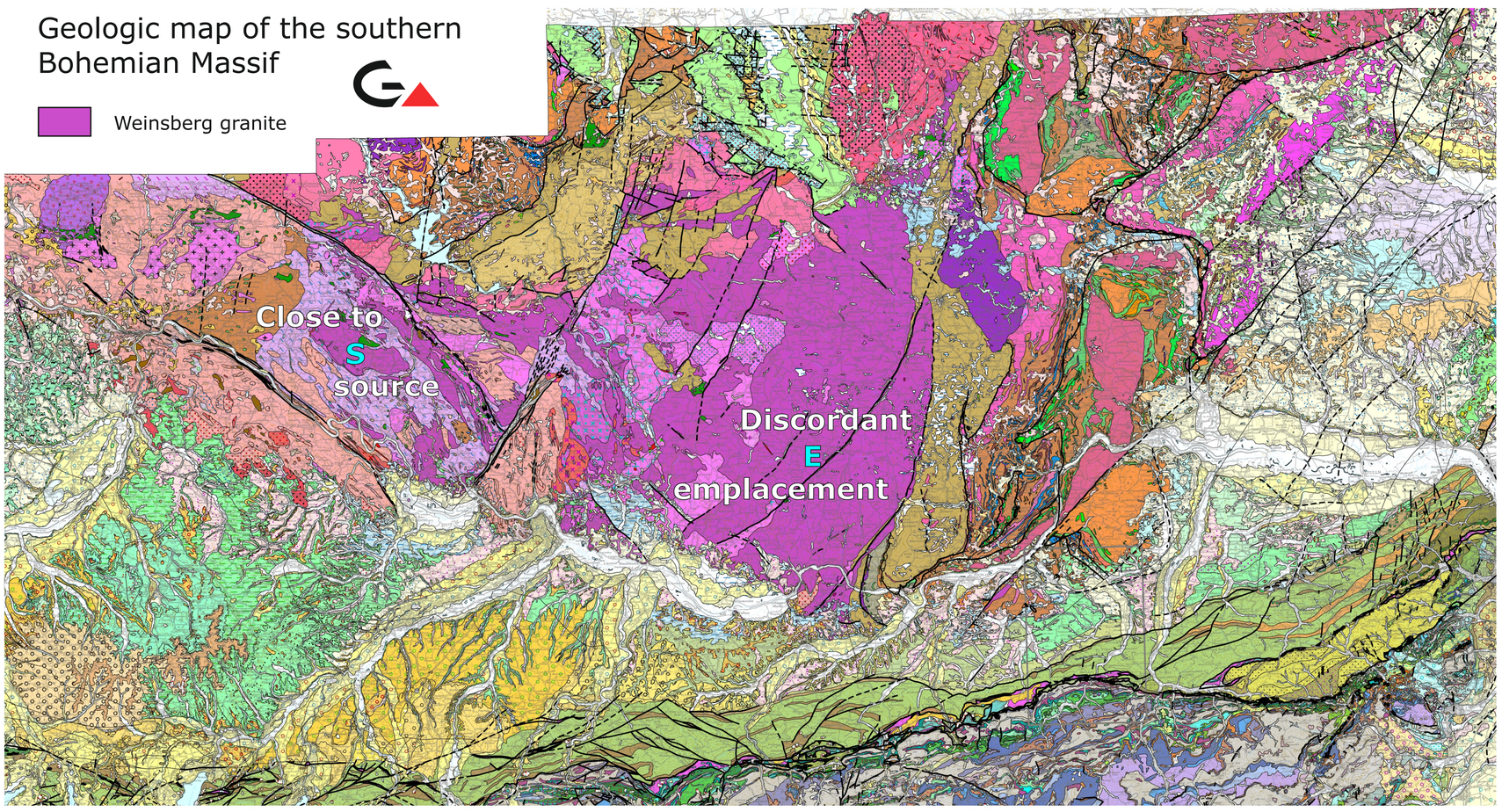
The Weinsberg granite is a very coarse-grained K-feldspar-phyric biotite-granite that dominates the South Bohemian Batholith. In the southwestern part of the batholith the granite occurs within the Bavarian Unit, mostly concordant to the migmatitic country rocks. There, rare Opx-bearing variants are found within the Weinsberg granite (*Frasl & Finger, 1988*).

In the Waldviertel area the Weinsberg granite intruded the Moldanubian nappes clearly discordantly. No Opx-bearing variants were found. In contrary, angular intergrowth of biotite, quartz (with additional ilmenite and apatite) within aggregates of biotite were recently identified. These findings may be products of breakdown from peritectic Opx, which were entrained from the source region together with the ascending magma. After emplacement the pseudomorphs formed by reaction of Opx with Afs and melt.

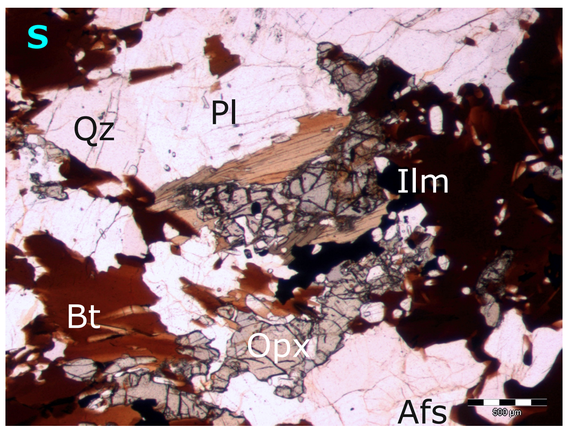
These differences may be attributed to key processes of granite genesis and evolution: magma formation by partial melting of continental crust (crustal recycling), melt transport in the Bavarian Unit as well as final stage of discordant emplacement in the eastern part of the batholith with pseudomorphs after Opx, indicating the crustal source.

Geologic map of the southern Bohemian Massif

Weinsberg granite

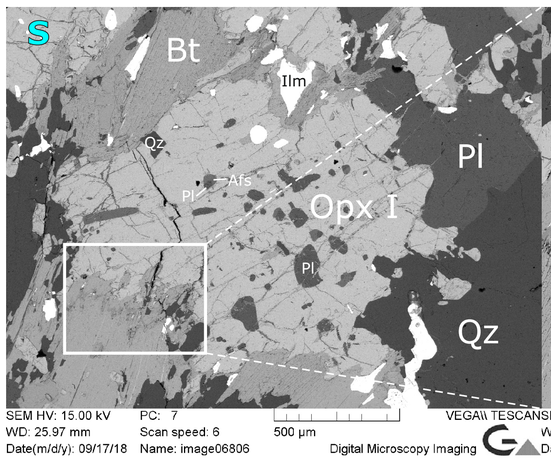


Opx bearing granite



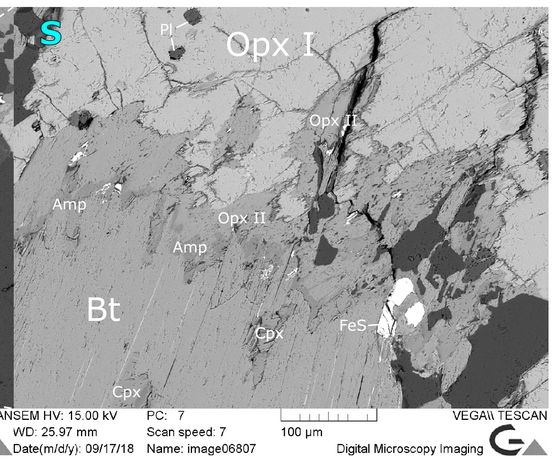
Peritectic assemblage
Opx+Afs+Pl+Qz+Ilm(+Bt?)

Opx I as peritectic phase



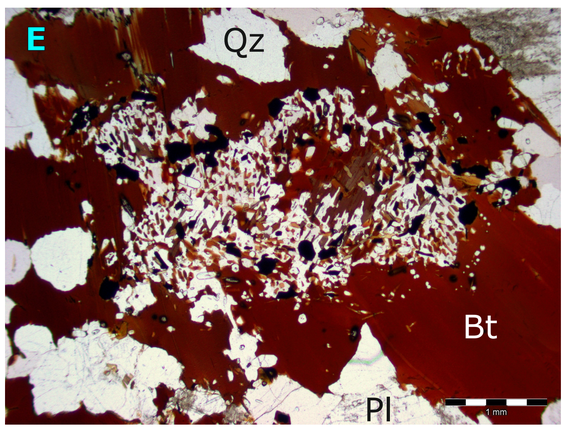
Peritectic Opx I indicated by polyphase Afs, Pl and Qz inclusions

Opx I as breakdown reactions



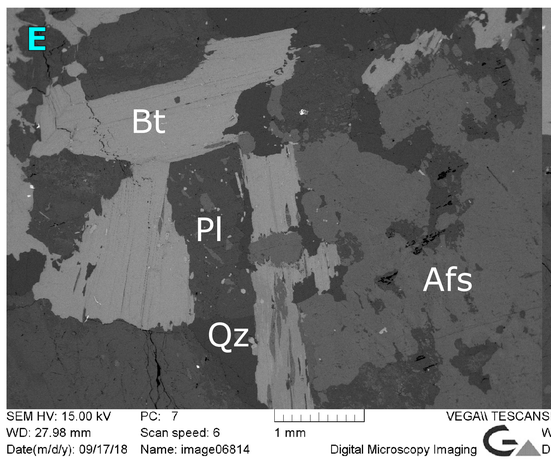
Opx II, Cpx and Bt formed by reactions of Opx I and melt

Pseudomorphs after entrained Opx



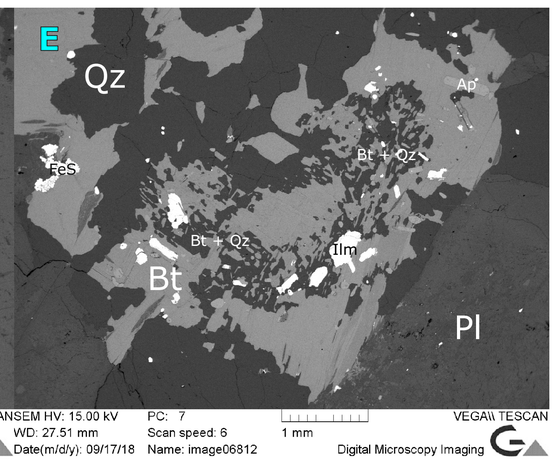
Pseudomorphs (very fine grained Bt+Qz+Ilm+Ap) within coarse grained Bt

Magmatic assemblage



Magmatic assemblage Afs + Bt + Pl +Qz

Replacement of Opx



Fine grained intergrowth of Bt + Qz +- Ilm

Discussion on Opx-bearing variants of the Weinsberg Granite

Opx-bearing granites in the Bavarian Unit give evidence to magma formation by large-scale fluid absent melting of biotite, plagioclase and quartz in the lower crust at 850°C and maximal 0.7 GPa. Opx-rich variants were interpreted as cumulates (*Finger & Clemens, 1995*). In contrast *Klötzli et al. (2001)* revealed two independent magmatic assemblages and assigned the coarse grained Opx to an inherited Cambrian magmatic assemblage enclosed by the dominant Afs+Pl+Qz+Ilm Carboniferous assemblage of the Weinsberg Granite.

Textural relations of the Opx-bearing granite and thermodynamic forward modelling indicate that orthopyroxene was most likely formed by fluid-absent melting proposed by *Finger & Clemens (1995)*. The breakdown reactions to orthopyroxene II and clinopyroxene took place during crystallization and cooling of the magmatic assemblage.

Discussion on pseudomorphs after Opx in the Weinsberg Granite

Orthopyroxene does not appear in the emplacement area in the eastern part of the batholith. However new findings of pseudomorphs of fine grained biotite, quartz, ilmenite and apatite point to replaced orthopyroxenes with probably small amounts of clinopyroxene. Perpendicular intergrowths of biotite and quartz are interpreted as mimics of the cleavage of former orthopyroxene. Additionally, the Ca of clinopyroxene would then be incorporated in apatite. These observations indicate that orthopyroxenes were entrained by the ascending magma and then pseudomorphically replaced. This points to a source region comparable to the Opx-bearing Granites in the Bavarian Unit.

Orthopyroxene in the Weinsberg Granite as an indicator of crustal recycling

Opx bearing granite

:: Orthopyroxene was formed as peritectic phase due to fluid absent-melting of rocks with biotite, plagioclase and quartz, indicating of anatexis at a relatively high crustal level.

:: Orthopyroxene-rich variants indicate in the Bavarian Unit an area close to the source of the Weinsberg Granite.

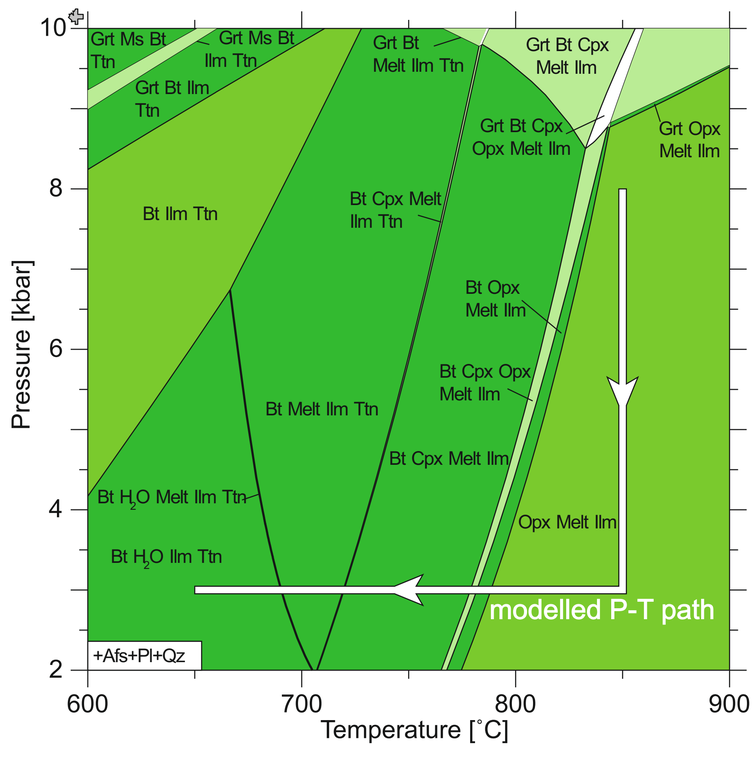
:: Breakdown reactions of peritectic orthopyroxene I to orthopyroxene II and clinopyroxene appear in a very narrow temperature range.

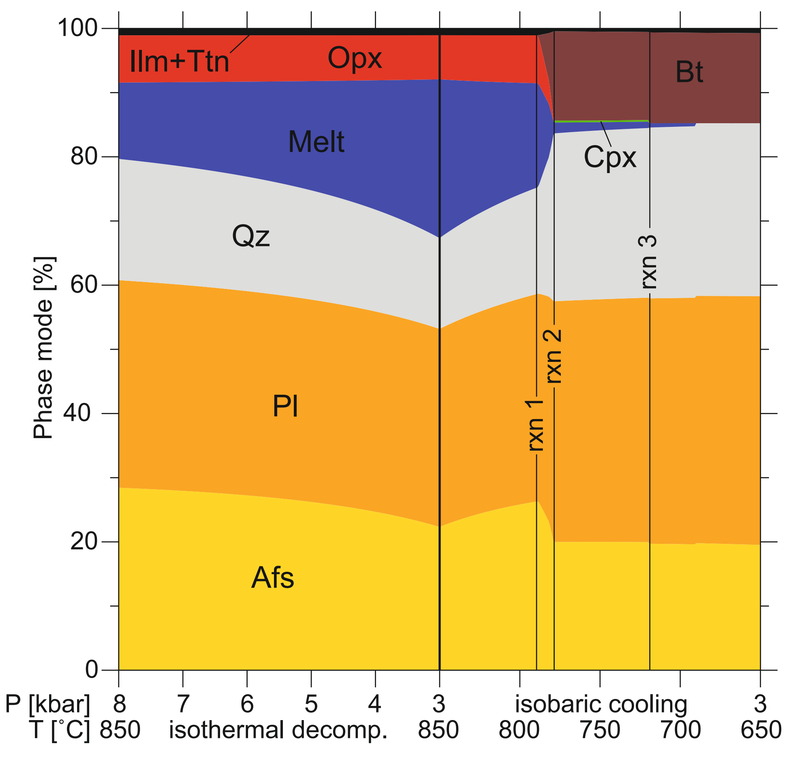
Granite with pseudomorphs after Opx

:: Ascending melts may entrain orthopyroxenes from the source.

:: Entrained orthopyroxenes are replaced bybiotite+quartz+ ilmenite+apatite pseudomorphic aggregates during intrusion.

:: The pseudomorphs after orthopyroxene connects the eastern part of the Weinsberg Granit to a crustal source similar to the Bavarian Unit.





Thermodynamic forward modelling with the Theriak-Domino software package (De Capitani & Petrakakis, 2010). Calculations in the NaCaKFMASHTi system, no H_2O excess. Modelling of phase modes along a simple exhumation path, isothermal decompression at 850°C followed by isobaric cooling at 3 kbar:

- Orthopyroxene is a peritectic phase for T≥778°C.
- Biotite appears at 788°C: **Opx**+**Melt**+Ilm+Afs = **Bt**+Pl+**Qz** (rxn 1).
- Clinopyroxene appears (in very small mode 0.25-0.30%) at 781°C: **Opx**+**Melt**+Ilm+Afs = Bt+**Cpx**+Pl+Qz (rxn 2).
- Clinopyroxene disappears at 719°C: **Cpx**+**Melt**+Ilm+Afs = **Bt**+**Ttn**+Pl+Qz (rxn 3).
- Orthopyroxene and clinopyroxene are stable together in very narrow temperature range.