

Petrology of variscan low-pressure granulites and migmatites from the Moldanubian Superunit, Upper Austria

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Introduction

The investigated low-pressure granulite facies rocks from 1. the Danube valley (west of Linz), 2. the Muehviertel area (northwest of Linz) and 3. the Sauwald area (south of the river Danube) represent characteristic migmatic paragneisses of the Bavarian Unit, the part of the Moldanubian Superunit with a late low-pressure/high-temperature overprint. Most of these rocks underwent high degrees of melting forming meta- and diatexites ("Perlgneise"). Al-rich metapelitic migmatites (cordierite-garnet-sillimanite-granulites) with partly cm-sized garnet porphyroblasts can be found in some localities of this unit.

The migmatic paragneisses and the cordierite-garnet-sillimanite-granulites as well as some mafic granulites were used for geothermobarometry (winTWQ Version 2.34, Berman, 1991) (Figure 2-3 and 5-6). Metamorphic conditions of around 770°C to 850°C and 0.5 to 0.6 GPa were obtained. Particularly the cordierite-garnet-sillimanite bearing felsic granulites were used to calculate pseudosections (Perple_X 6.6.8) for determining the P-T evolution of the granulites. The consumption of garnet and formation of cordierite, sillimanite and spinel is compatible with temperature increase at near constant pressure. Peak conditions are around 750°C to 850°C and 0.4 to 0.6 GPa.

1. The Danube valley

The samples taken along the Danube valley (red samples in Figure 1.) are the typically Al-rich cordierite-garnet-sillimanite-granulites and contain the largest garnets of the investigated samples. Two of the samples (MA-1 and ML05-16) were used to calculate metamorphic PT-conditions (Figure 2, 3). A sample with large garnets displaying conspicuous zoning (Figure 4) was investigated in detail. A chemical zoning profile across the ca. 6 mm large garnet displayed elevated Ca-Mn-contents (Xgrs=0.23, Xsps=0.12) in the central part which decreased continuously towards the rim to Xgrs=0.03 and Xsps=0.02. Almandine and pyrope components in the core are 0.60 and Xprp=0.03, respectively and increase towards the rim to Xalm=0.85, Xprp=0.10 which is opposite to the grossular and spessartine components.

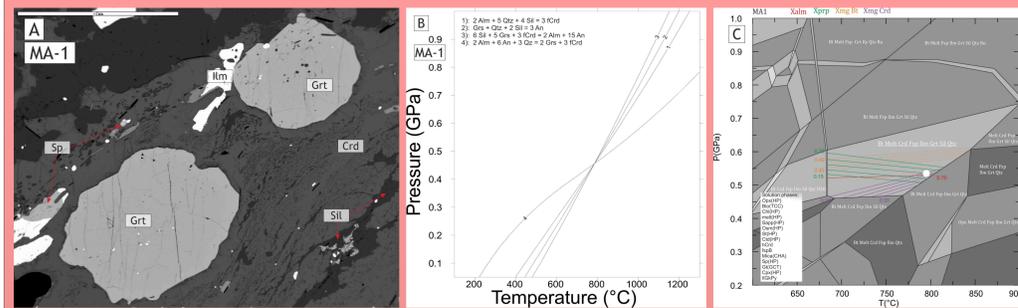


Figure 2. (A) Garnet is surrounded by cordierite which contains inclusions of sillimanite, ilmenite and spinel. (B) PT calculations using select mineral reactions, from the migmatite cordierite-garnet-sillimanite-granulite shows conditions of about 0.4 to 0.45 Gpa and 750°C to 800°C. (C) calculated Pseudosections from felsic migmatite granulite. Xmg in Biotite and Cordierite was plotted together with Xalm and Xprp and show conditions of 800°C and 0.5 to 0.55 GPa.

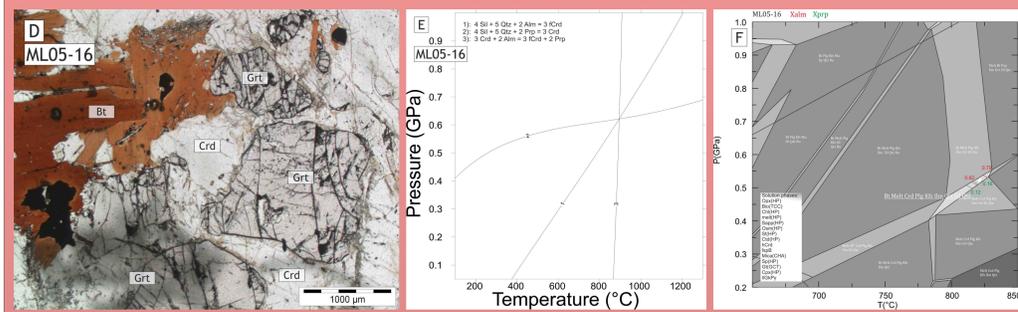


Figure 3. (D) Sample ML05-16 is a Grt-Crd-Bt bearing migmatite (E) Geothermobarometric calculation using the reaction Grt+Sil+Qtz=Crd (F) The garnet isopleths cross in a field with the typical mineral assemblage in this type of granulites and show similar conditions as in sample MA-1 with slightly higher temperature value.

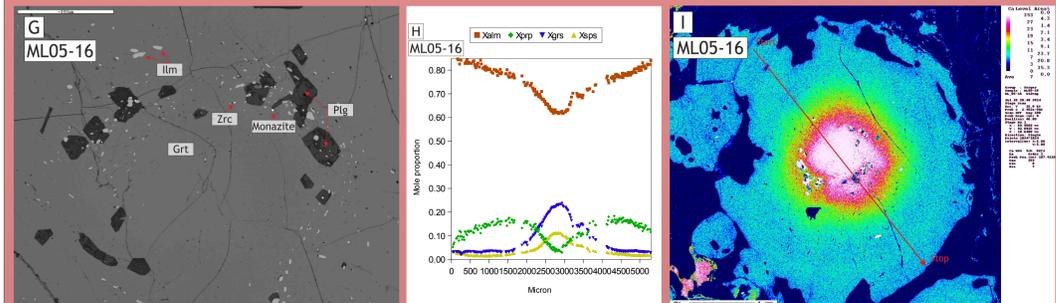


Figure 4. (G) The Plagioclase Inclusions in the zoned garnet (Fig 2 A) show a high Ca-value (Xan=0.9), furthermore there are ilmenite, zircon and monazite inclusions in all of the larger garnets (2-5mm). (H, I) A ca. 6 mm large garnet porphyroblast displays a Grs-Sps-richer and Alm Prp-poorer core. Also the elemental mapping shows a high Ca-value in the core and a rapid decrease towards the rim. The outermost rim of the garnet is characterized by retrograde diffusion (decrease in Prp and increase in Alm component) if in contact with Crd or Bt.

3. The Sauwald area

The investigated samples from the Sauwald area (blue samples in Figure 1.) are type "Wernstein" migmatites (Figure 7.) and contain no garnet, but a high amount of cordierite and biotite. The metamorphic conditions in this area were obtained by Tropper et al. (2006). The values of the peak assemblage of 750°C-840°C and 0.29-0.53 Gpa, which are similar to the calculated conditions of the danube valley samples (Figure 2,3).

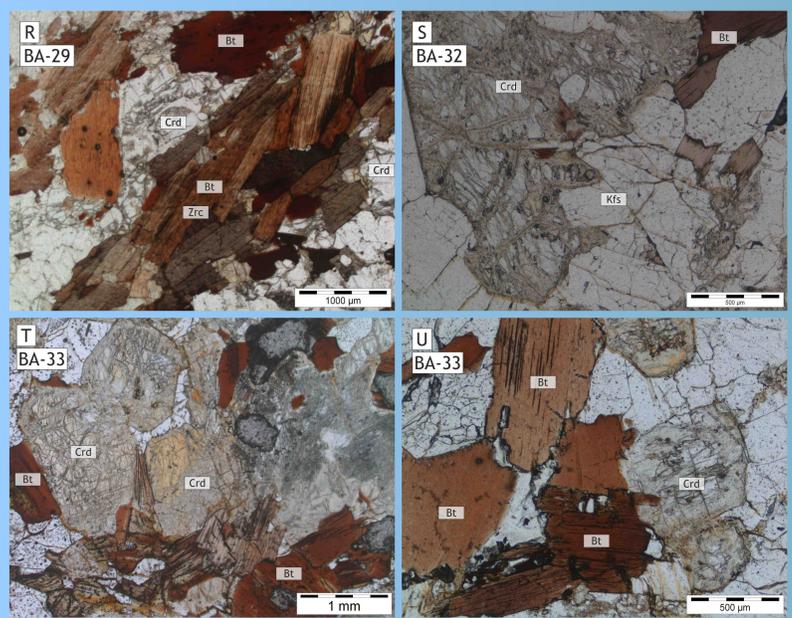


Figure 7. Cordierites in samples from Sauwald Zone are partly pinitised and replaced by biotite. (R) BA29 is a fine grained (<3mm) homogenous Bt-Crd-migmatite. The biotites often contain zircon inclusions. (S) BA-32 is coarser grained (<6mm) and heterogenous molten, (T, U) BA-33 is heavily molten and recrystallised and shows no relict foliation. The cordierite grains are pinitised and the biotite is also partly replaced by chlorite.

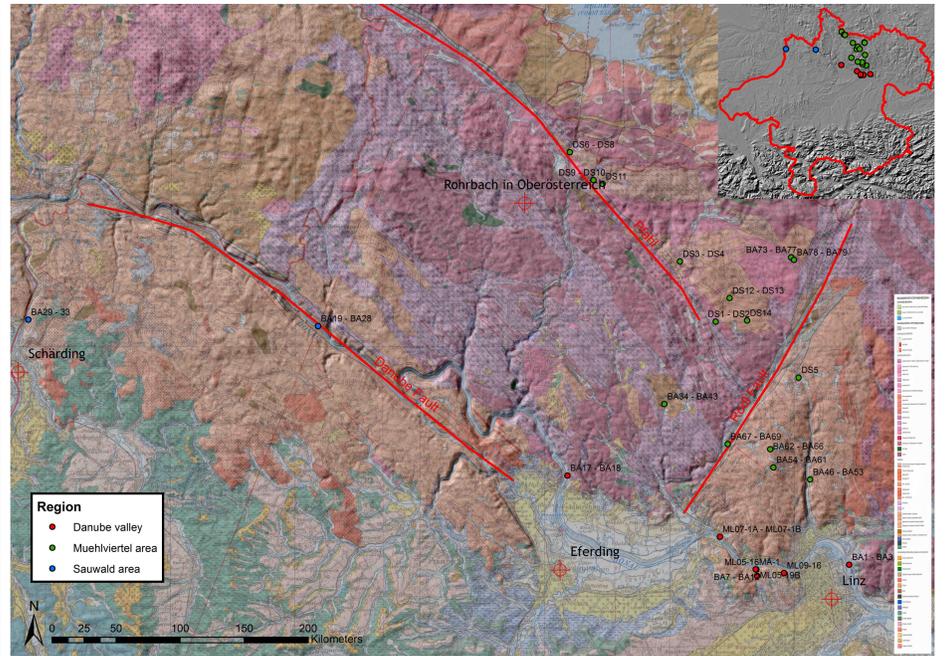


Figure 1. DEM and geological map of the Danube valley, Muehviertel and Sauwald with the three big fault systems of this area (Rödl Fault, Danube and Pfahl Fault) and positions of sampled locations. The small DEM shows the shape of the federal state of Upper Austria.

2. The Muehviertel area

The Muehviertel is the northern part of the investigated area (green samples in Figure 1.), northwest of Linz and north of the river Danube. Compared with the samples from the Danube valley most of the garnets are consumed by cordierite. The small garnet grains (<500µm) have a homogeneous almandine rich composition. They display a single-phase growth, a slightly increase of iron and decrease of magnesium at the rim typical for retrograde diffusion zoning during cooling. Four of these samples were used for geothermobarometric calculations (Figure 5, 6).

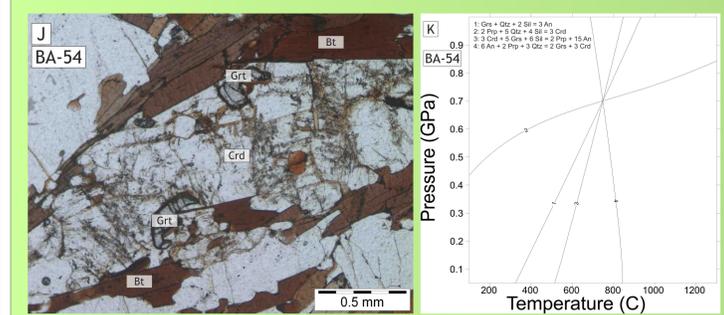
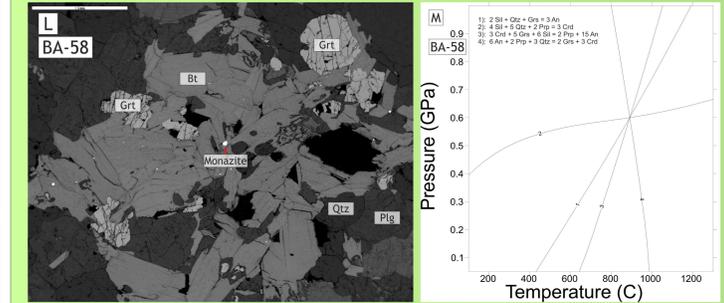


Figure 5. Cordierite is a common mineral in the felsic granulites, together with biotite, sillimanite and garnet. The reaction Grt+Sil+Qtz=Crd explains possible processes that took place while the metamorphism indicated by the displacement of garnet and the appearance of cordierite. A cordierite-biotite-migmatite (J) still contains a small amount of garnet, but most are consumed by cordierite.



(L) BA-58 is a garnet-biotite-gneiss. The garnet grains have a size of 0.5mm-1mm and show a homogenous iron rich composition. PT-calculations of the garnet bearing samples (K, M) using the reaction Grt+Sil+Qtz=Crd shows conditions of about 750°C to 850°C and 5.5 to 6.5 GPa.

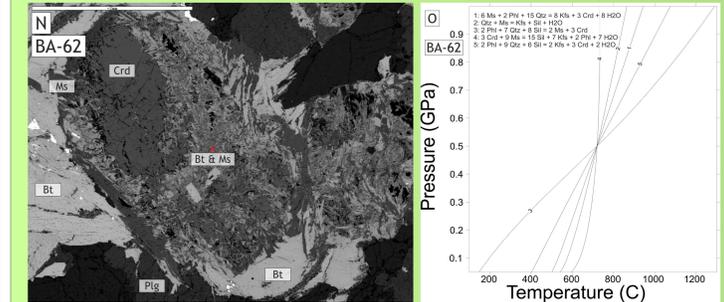


Figure 6. (N) Sample BA-62 is a biotite-cordierite-migmatite but compared to BA-54 and BA-58 it contains no garnet and the cordierite grains are strongly pinitised and formed fine grained biotite and muscovite. (P) The cordierites in sample BA-76 are not as much pinitised, but already contains biotite lamellae and retrograde grown muscovite. (O, Q) The PT-calculations of both samples show reactions where the retrograde muscovite is involved and therefore these conditions record a stage of recrystallisation. The obtained values are from 700°C to 750°C and around 0.5 GPa.

