PERMIAN GABBROIC INTRUSIONS WITHIN THE LOWER AUSTROALPINE GROBGNEISS UNIT (EASTERN ALPS): ORIGIN, EVOLUTION AND TECTONIC SETTING

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Abstract: Within the Austroalpine Grobgneiss Unit metagabbros are quite common. Several individual intrusions with an Alpine metamorphic overprint of ~520°C/~11 kbar were recently investigated. They range from olivine gabbro to gabbronorite. Some of them show a preserved magmatic textures and mineral assemblages with a well defined Permian intrusion age and a subsequent cooling history. The stable isotope data define a progressive crustal contamination from olivine gabbro to the normal gabbros.

Key words: Permian intrusions, Austroalpine, Sm-Nd age, U-Pb zircon age

Introduction geological setting:

Within the Lower-Austroalpine Grobgneiss Unit in the eastern part of the Alps meta-gabbros are quite common. The gabbro intrusions of two areas close to the villages of Kirchschlag and Birkfeld were chosen to investigate the geological significance of these mafic intrusions. The gabbros occur together with Variscan granites, which underwent an Alpine metamorphic overprint and they have been transformed into the so-called Grobgneiss.

The Austro-Alpine Nappe Complex can be divided according to Tollmann (1977) into three individual units, named Upper, Middle and Lower Austro-Alpine nappe. In more recent tectonic models (Frank et al., 1983, Schuster et al., 1999) all these three units represent no lateral neighbouring areas any more. Topic of this paper is only the Lower Austro-Alpine nappe (LAA), which can be divided into a lower Wechsel- and a higher Grobgneiss Unit in the investigation area.

More recently both nappes are defined as Wechsel and Semmering Unit (Schuster et al., 1999) and they form the cover of the Penninic Windows of Bernstein and Rechnitz.

The gabbroic rocks were studied first by Schwinner (1935), who mapped the "Saussuritgabbros" near Birkfeld. Later, Wiesender (1961) reported also the presence of spinel, corundum and chloritoid in the same rock types. However, the relations of metamorphic minerals to cooling history of the gabbros, as assumed by Wiesender (1961, 1965), and the effect of Alpine metamorphic overprint remained unclear. A Variscan Rb/Sr isochrone age for several Grobgneiss samples by Scharbert (1990) supported previously the idea of Variscan gabbro intrusions.

The investigated metagabbros form intrusions with few 100 m in diameter and occur near margins or within the Grobgneiss bodies (Koller et al., 2002). In general the metagabbros show an intensive metamorphic overprint. Only some of them contain a preserved igneous mineral assemblage. Caused by the intensive weathering no contact relations between the gabbros and surrounding Grobgneiss were exposed. Therefore fresh Grobgneiss rocks were sampled as close as possible to the gabbroic outcrops.

Petrogaphic description and mineral chemistry:

Two different types of gabbros were observed, one type is represented by olivine gabbros sometimes with well preserved magmatic textures and mineral assemblages, the other one consists mainly of olivine free gabbros. The latter contain only relictic magmatic minerals or textures and contain normally a clear metamorphic re-crystallization of all primary mineral phases.

Olivine gabbro with well-preserved magmatic textures was found in the NE part of the Kirchschlag area only. It shows a medium grained ophitic texture with hypidiomorphic olivine, clinopyroxene, orthopyroxene, plagioclase, biotite and ilmenite. Olivine composition ranges from Fo_{75} – Fo_{69} although no regular zoning within single crystals was observed. Orthopyroxene is rich in enstatite end-member composition with $En_{74.2}$ $Fs_{25.1}$ $Wo_{0.7}$. Clinopyroxene is a diopside with an X_{Mg} of 0.850 ($Wo_{45.7}$ $En_{45.9}$ $Fs_{8.4}$). Plagioclase shows regular zoning with a decrease of anorthite content from core (An_{66}) to rim (An_{37}). Magmatic biotite has high X_{Mg} contents of about 0.83 – 0.84 and intergrows with orthopyroxene.

A coronitic texture can be observed in all olivine gabbros in the contact between plagioclase and olivine formed by cummingtonite in the inner rim and pargasite or edenite at the outer rim. Along Opx/Plg and Cpx/Plg boundaries small reaction zones of amphibole occur. The amphibole composition ranges from edenite to pargasite. Orthopyroxene can be replaced by cummingtonite. All these amphibole varieties indicate a post-magmatic origin and were formed during cooling of

olivine gabbro. Rarely present are fine-grained actinolite patches. The replament of clinopyroxene is probably mainly of metamorphic origin.

Ol-free metagabbro from Kirchschlag and Birkfeld areas display similar textures and mineral assemblages. Further they a newly formed metamorphic paragenesis containing amphibole, albite, epidote, white mica, chlorite, garnet, biotite, quartz, sphene and ilmenite. In the Kirchschlag locality and only rarely in the Birkfeld area, relic magmatic textures are characterized by the presence of relicts of pyroxenes replaced by amphiboles, plagioclase altered by white mica and clinozoisite and by biotite with skeletal ilmenite (of primary euhedral crystals). Biotite is sometimes the only preserved igneous phase in the Birkfeld metagabbro. Corundum-spinel and chloritoid, as reported by Wiesender (1961) were not found in our samples so far.

At least two textural and three compositional varieties of amphibole are present in the metagabbro. The older pale-green to colourless tabular amphibole is cummingtonite, the others are green amphiboles of alumino-tschermakite to magnesio-hornblende composition.

Geochemistry and isotope data:

Due to a possible pyroxene controlled fractionation of the primary magma all samples are enriched in LREE and slightly depleted in HREEs. The incompatible elements confirm the evidence for all investigated gabbro melts to derive from a sub-continental mantle source. Enrichment of mobile incompatible elements (Rb, Th, K, La) can be observed in all series due to metamorphic overprint or to crustal contamination. Most of the samples exhibit a slight Nb-anomaly compared to primitive mantle (Sun & McDonough, 1989). The less evolved gabbros define on base of bulk and trace element composition a clear within-plate basalt geochemistry. The more evolved gabbros might derive from a basaltic source with a more island-arc affinity or this is related to crustal contamination. Rb/Sr- and Sm/Nd-isotope data as well as $\delta^{18}O$ isotope data define a progressive crustal contamination from olivine gabbro to the normal gabbros.

Isotope geochemistry and geochronology:

A clear Permian magmatic age is defined for the gabbros based on one Sm/Nd mineral isochron for the olivine gabbro, further on $^{206}Pb/^{238}U$ data of zircons of three different gabbros from Kirchschlag and Birkfeld area and on one Ar/Ar date of a magmatic biotite of the same olivine gabbro. Zircons from closest related Grobgneiss outcrops also give evidence for a Permian age for at least some of the Grobgneiss bodies. This age is similar to the emplacement age of the gabbro intrusions.

Evolution of the gabbros:

The evolution of the gabbros can be subdivided into a magmatic stage and subsequent postmagmatic cooling event, both of Permian age. Finally all gabbros underwent a Cretaceous Alpidic metamorphic overprint.

Only the olivine gabbro exhibits a clear defined magmatic history with temperatures > 800 °C and pressures of ~4 kbar based on mineral assemblages and oxygen isotope data. Corona textures between mafic minerals, mainly olivine, and plagioclase indicate the Permian post-magmatic cooling resulting in the formation of cummingtonite, pargasitic, and edenitic amphiboles. For the amphibole-bearing reactions a temperature range of 780 – 660 °C can be calculated on the basis of coexisting amphibole-plagioclase pairs. These temperatures are definitely higher than the following Cretaceous Alpine metamorphic overprint.

P-T conditions, estimated for the Alpine overprint in metagabbros are around 520°C/ ~11 kbar. Compositional zoning in garnet indicates a prograde evolution with a normal P-T-path. Ar/Ar muscovite age data from one Grobgneiss sample with an age of ~86 Ma define the early cooling history of this metamorphic event. The further evolution is controlled by similar fission track ages for both, Grobgneiss and Wechsel Unit in Tertiary according to the results by Dunkl (1992). This is also related to the uplift of the Penninic Rechnitz Unit as a core complex.

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