Pebbles of upper-amphibolite facies amphibolites of the Gosau Group from the Eastern Alps: relics of a metamorphic sole?

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INTRODUCTION

Since the dating of the Cretaceous eclogites of the Austroalpine unit in the early 90ths of the last century (THÖNI & JAGOUTZ 1992), it was obvious that in the recent Eastern Alps at least two crustal scale subduction zones were active. The most prominent of these subduction zones is Late Cretaceous to Tertiary in age and can be traced throughout the Alpine orogene by an oceanic suture zone defined by the Penninic nappes (**Fig. 1**). On the other hand Jurassic and Cretaceous subduction processes, which are related to the closure of the Neotethys Ocean and indicated by the structural and metamorphic imprint of the Austroalpine unit, are not fully understood and still under discussion (GAWLICK et al. 1999, SCHWEIGL & NEUBAUER 1997, NEUBAUER et al. 2000, SCHMID et al. 2004).

Especially the question how the Jurassic subduction process - visible in the Meliata unit - and the Cretaceous subduction - which formed the eo-Alpine eclogites of the Eastern Alps - are linked is an enigmatic problem.

In this poster we present new data on amphibolite-pebbles collected from the Cretaceous sediments of the Lower Gosau Group from Pfennigbach (Lower Austria/Austria). These pebbles show similarities to amphibolites from the metamorphic sole of ophiolite sheets from the Dinaric ophiolite belt in the Dinarides. They may be of great importance for the understanding of the Jurassic tectonic processes along the southeastern continental margin of the Austroalpine unit towards the Neotethys ocean.

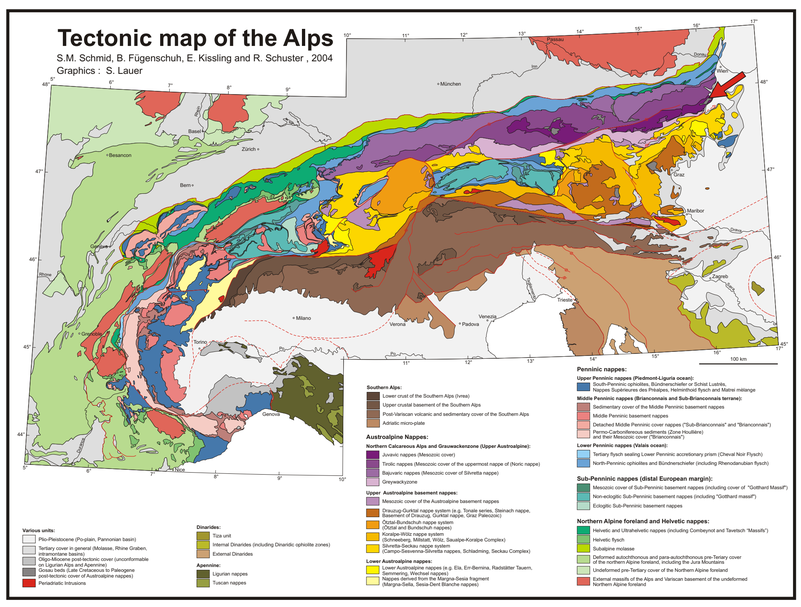

Fig. 1: Tectonic map of the Alps after SCHMID et al. (2004). Sediments of the Gosau Group are present on top of the Bajuvaric and Tirolic nappes within the Northern Calcareous Alps and on top of the Gurktal Nappe System. The sample locality in the area of Puchberg-Neue Welt ist shown by the red arrow.

GEOLOGICAL BACKGROUND

The Gosau Group in the Eastern Alps comprises synorogenic sediments of the eo-Alpine tectonometamorphic event. These sediments are Upper Cretaceous to Eocene in age. They consist of clastic material from directly surrounding Austroalpine units and a minor amount of exotic input.

According to WAGREICH & FAUPL (1994) the Gosau Group of the Northern Calcareous Alps is composed of two subunits: The Lower Gosau Subgroup is characterised by alluvial fan deposits passing into a shallow-marine succession with a broad variety of facies. It is ranging from Turonian to Santonian/Campanian, and only in a few places up to the Maastrichtian. The Upper Gosau Subgroup comprises deep-water deposits of Campanian to Eocene age.

The sample material presented in this study was collected from the Lower Gosau Group of the locality Grünbach-Neue Welt (Austria/Lower Austria) (**Fig. 2A**). The sucessions (**Fig. 2B**) start with breccias derived from directly underlying Triassic rocks. Above reddish conglomerates containing the exotic material occur. Only the conglomerates in the western part of the outcrop area contain basic volcanic rocks and amphibolites. The conglomerates are overlain by a coal bearing series of shallow marine, fluviatile and limnic sediments, marine sandstones ("Orbitoidensandstein") and marls ("Inoceramenmergel"). As the coal-bearing series is Campanian in age a Santonian age of the reddish conglomerates is proposed by GRUBER et al. (1992).

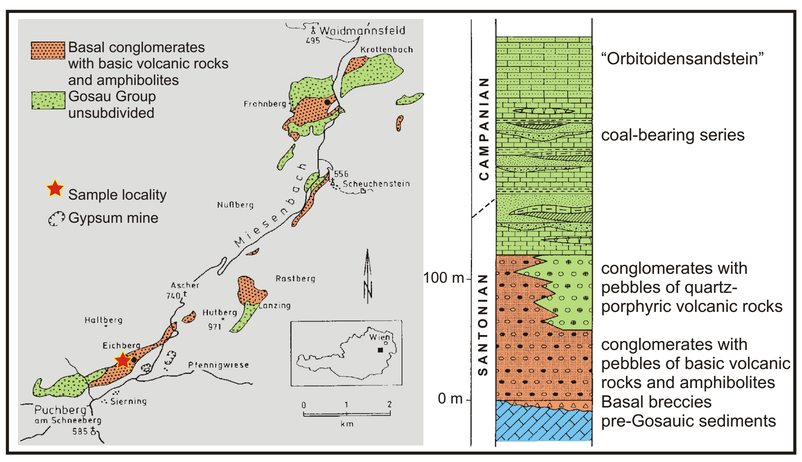

Fig 2: Scatch map showing the distribution of Gosau Group sediments in the area of Miesenbach and Pfennigbach (Lower Austria). Shown are (A) the sample localities and (B) a simplified stratigraphic column after GRUBER et al. (1992).

SAMPLE LOCALITY

The locality for the samples discussed in here is at Eichberg, about 2 km NE of Buchberg am Schneeberg (**Fig. 2**). Pebbles have been collected along the forest road which starts behind the buildings of the gypsum mine and runs upwards in direction to the Northwest. Several small outcrops are only present in c. 660 m altitude (WGS83 E 015°55'24" / N 47°48'00"). Visible are badly sorted conglomerates with a reddish matrix. The content of exotic material reaches up to 30%, the components are well rounded and up to 30 cm in diameter. Along the road the pebble spectrum shows variability. Even light greyish shallow water carbonates are dominating the frequency of diverse carbonatic rocks, radiolarites, metaquartzite, phyllites, volcanic rocks and amphibolites is variable.

Additionally pebbles from the Schafkogel (WGS83 E 015°55'25" / N 47°48'04") and from Lanzing (WGS83 E 015°57'34" / N 47°49'12") have been collected.

SAMPLE MATERIAL

During this study pebbles of amphibolites from the locality Eichberg have been investigated. Additionally the thin sections of AMPFERER (1919) and GRUBER et al. (1992) have been reinvestigated. In total about 20 samples of amphibolites are available. Four of them are garnet-bearing.

PETROLOGY

The amphibolites are fine-grained, exhibit a metamorphic fabric and a mineral assemblage of amphibole + plagioclase ± garnet ± clinopyroxene ± titanite + ilmenite (**Fig. 3**). The observed garnet forms up to 1 mm large rounded grains (**Fig. 3A-D**). It is poor in inclusions of titanite. Typical are symplectitic rims of amphibole and plagioclase around garnet. These rims are up to 0.3 mm wide and very fine grained in some cases (**Fig. 3E, 3F**). The chemical composition of garnet from sample RS6/01 is very homogeneous within the single grains and varies slightly within the scale of the thin section. It ranges from Alm0.48-0.50 Pyr0.18-0.15 Gros0.30-0.32 Spes0.02-0.03 (**Fig. 5A**). Clinopyroxene is partly replaced by amphibole. It is characterised by an Xmg of 0.716, a high Ca-tschermakite component (0.13 mol%) and low jadeite component (<0.05 mol%) (**Fig. 3G, 3H, 5B**). Amphibole grains are up to 2 mm in size and xenomorphic. They are tschermakite to pargasite in composition. Plagioclase is often altered and replaced by albite and chlorite. However, the preserved plagioclase is characterised by an anortithe component of An32-43. The plagioclase of the symplectites shows a lower anorthite component of about An15. Locally ilmenite forms symplectites together with amphibole and quartz .

With respect to the mineralogical composition the rocks were formed at upper-amphibolite facies conditions. Based on Plag-Amph and Amph-Garnet temperatures of 650-750°C can be estimated at pressures of ~5 kb.

Based on geochemistry the amphibolites are basalts plotting in the MORB field in most of the discrimination diagrams. However, their Ti/V values range around 30 and the Zr/Y ratio indicates a more with-in plate origin of the basalts.

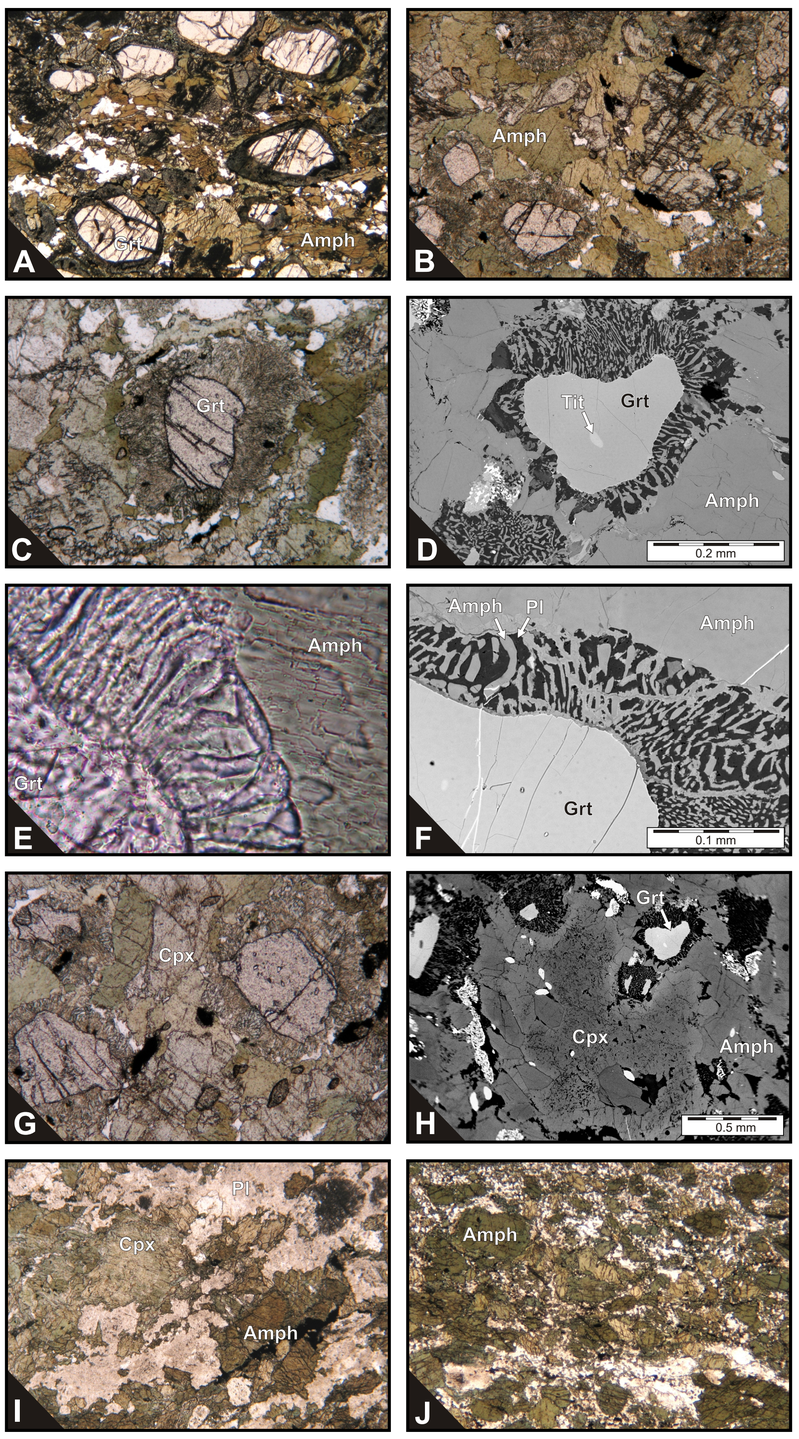

Fig. 3: Thin sections of amphibolite pebbles from the Gosau Group:
A) sample Mb3 from AMPFERER (1919): garnet and clinopyroxene bearing amphibolite.
B-H) sample RS6/01: B) overview of garnet and clinopyroxene bearing amphibolite, C) garnet with symplectitic rim, D) BSE- picture of garnet with symplectitic rim, E) detail of symplectitic rim composed of amphibole, plagioclase and opaque ore, F) BSE-picture of symplectitic rim composed of amphibole, plagioclase and opaque ore, G) clinopyroxene partly replaced by amphibole, G) BSE-picture of clinopyroxene partly replaced by amphibole.
I) sample 355/3 from GRUBER et al. (1992): clinopyroxene bearing amphibolite.
J) sample RS14/01: amphibolite with altered plagioclase.

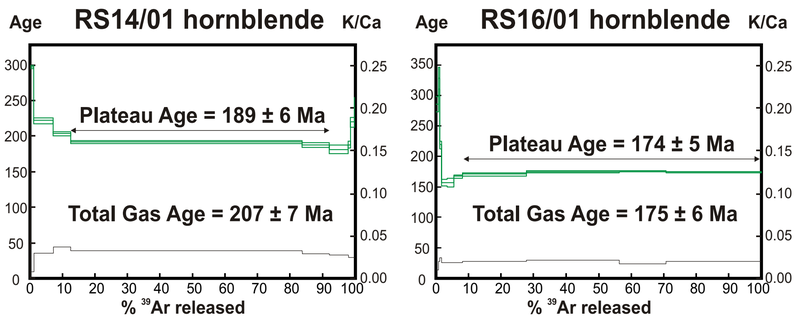

Fig. 4: Ar-Ar age spectra from amphibolite pebbles sampled from conglomerates of the Lower Gosau Group at the locality Eichberg (Lower Austria/Austria). Both samples yield Jurassic age values. These ages indicate a medium-grade Jurassic imprint of the metabasic rocks.

ISOTOPE GEOLOGY

Isotopic ratios of three samples are in the range of 0.706564 to 0.707817 for $^{87}Sr/^{86}Sr$ and 0.512960 to 0.513058 for $^{143}Nd/^{144}Nd$ respectively.

Ar-Ar ages on hornblende yielded Jurassic plateau ages of 174 ± 5 Ma (RS14/01) and 189 ± 6 Ma (RS16/01) (**Fig. 4**).

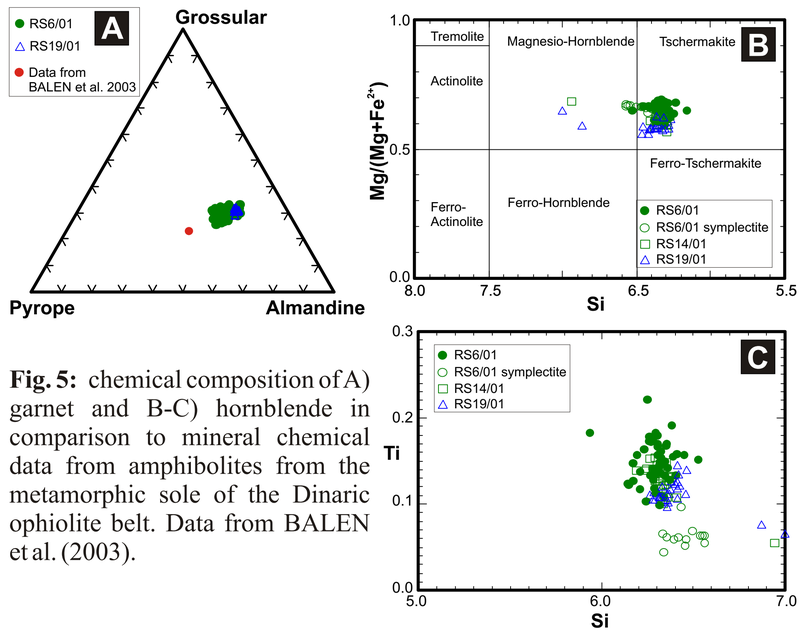

Fig. 5: chemical composition of A) garnet and B-C) hornblende in comparison to mineral chemical data from amphibolites from the metamorphic sole of the Dinaric ophiolite belt. Data from BALEN et al. (2003).

CONCLUSIONS

Amphibolites with the observed features are not known from the Austroalpine metamorphic units. Especially the symplectitic textures and the Early to Middle Jurassic cooling ages are unique in the Eastern Alps.

On the other hand the pebbles show many similarities to amphibolites from the metamorphic sole at the base of the Dinaric ophiolite sheets. These amphibolites reached amphibole- to granulite facies conditions. They show similar mineral assemblages (**Fig. 6**), similar symplectitic rims around garnet (**Fig. 6A, 6B**) and similar ages (BALEN et al. 2003, LUGOVIC et al. 2006). Based on our knowledge from the metamorphic sole in Albania, the chemical characteristics of these rocks range from MORB to with-in plate basalts.

The association of the amphibolite pebbles with serpentinites, basic volcanic rocks and radiolarites supports the idea that the pebbles derived from an obducted ophiolite nappes and/or melange. However, according to GRUBER et al (1992) the basic volcanic are tholeiitic and alkalibasaltic in composition and might have formed during initial rifting at a passive continental margin. Therefore basaltic material derived from ophiolites has not been found until now in the conglomerates from the locality Eichberg.

In any case nappes with exotic material at least partly derived from the Neotethys Ocean occupied a high tectonic position at the southern Austroalpine margin since Late Jurassic times, similar as in the Dinarides. During the Cretaceous these units have been eroded and their detritus is present in the Late Jurassic and Cretaceous sediments of the Austroalpine unit (FAUPL & WAGREICH 2000, MANDL 2000).

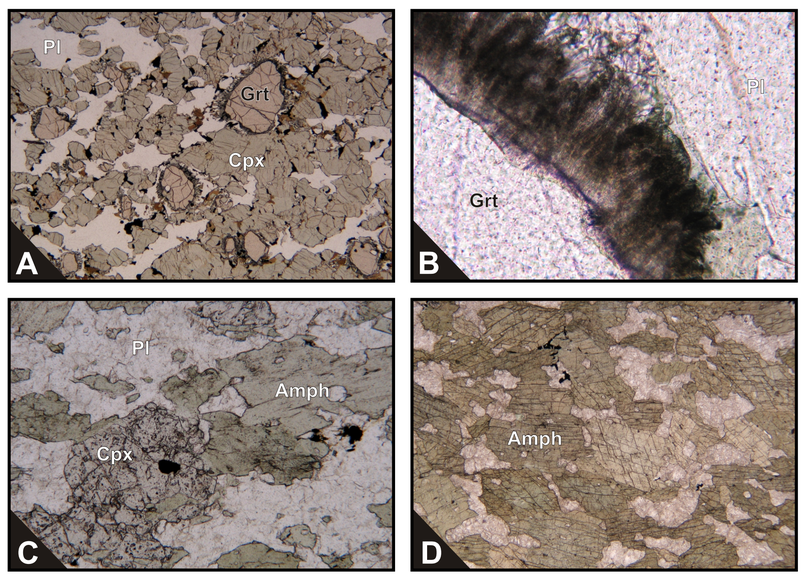

Fig. 6: Amphibolites from the metamorphic sole of the Dinaric ophiolite zone of central Bosnia and Herzegovina. Samples were collected in the Krivaja-Konjuh area. A) granulite facies metabasite composed of garnet, clinopyroxene, amphibole and plagioclase (sample 06R55), B) detail of symplectite around garnet. The symplectitic rim is composed of amphibole, plagioclase and opaque ore (sample 06R55), C) clinopyroxene-bearing amphibolite (sample 06R50), D) amphibolite facies metabasite composed of amphibole and plagioclase (sample 06R65).

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