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PERMO-TRIASSIC TEMPERATURE/LOW PPRESSURE METAMORPHISM IN AUSTROALPINE BASEMENT UNITS (EASTERN ALPS)

by

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Introduction

Until recently there was a consent that the Austroalpine basement units experienced their major metamorphic imprints during the Hercynian orogeny at about 370 to 300 Ma and/or the Alpine orogeny between 130 and 35 Ma. Not much was known about the time between these two collisional events when the Pangea supercontinent rifted, the continental crust thinned and the Tethys ocean transgressed to the west.

The following features are known about the general evolution of the Alps after the Hercynian orogeny: During Upper Carboniferous to Lower Permian time dextral wrench movements caused transcurrent faulting, graben formation and local transpression. This was accompanied by mostly terrestrial sedimentation and intense magmatism in vast areas of Europe. MORB-type gabbroic intrusions (e.g. THÖNI & JAGOUTZ, 1992), high temperature / low pressure metamorphism (HT/LP) (DIELLA et al., 1992), marine sedimentation and extensional structures indicate that an extensional regime developed in the southern part of Europe and the northern part of the Adriatic microplate (BERTOTTI et al., 1993) after the Middle Permian.

There is also evidence for a Permo-Triassic extension in the Austroalpine realm. Hints for such a scenario are the huge piles of sediments of the Northern Calcareous Alps, a HT/LP metamorphic imprint of still uncertain age in some of the Austroalpine basement units (e.g. Saualpe- Koralpe WEISSENBACH, 1975) and a magmatic activity (SCHUSTER & THÖNI, 1996). However, a comprehensive compilation of the data is missing. Since the last year systematic investigations have been done to unravel the timing and the characteristics of this HT/LP imprint within the Austroalpine basement units.

Results

A Permian lower greenschist facies imprint is suggested for the Wechsel and eventually for parts of the Semmering Unit (MÜLLER, 1994; BERKA et al., 1998). The Wechsel Unit it is characterized by Permian assemblages of paragonitic mica + chlorite + albite + quartz. Late Permian $^{40}Ar/^{39}Ar$ ages (c. 240 Ma) are also reported from the Innsbruck and Katschberg Quartzphyllite, but the geological significance of these data is uncertain (ROCKENSCHAUB & KOLENPRAT, 1998; GENSER & KUNZ, 1996). Pebbles with a thermal overprint at about 245 Ma can be found within the upper Gosau Group of the Weyerer Bögen (FRANK et al., 1998). Assemblages of muscovite + chlorite + albite + quartz and the resetting of the K-Ar isotopic system indicates temperatures of 400 ± 30°C for the Permian overprint.

In the Wölz Complex of the Niedere Tauern Permian garnets (269 ± 4 Ma) with inclusions of margarite prove a greenschist facies LP/HT metamorphic imprint with temperatures of more than 450°C. Contemporaneous pegmatites (c. 270 Ma) are a common feature (SCHUSTER & THÖNI, 1996).

For the southern part of the basement amphibolite facies grade, (former) andalusite bearing assemblages, andalusite-quartz veins and pegmatites are characteristic. However, the occurrence of Permian pegmatites, granitic gneisses and some Sm-Nd data of metapelite garnet ranging between 240 - 275 Ma suggest that the formation of the andalusite bearing parageneses was coeval.
Well preserved assemblages can be found in the southernmost Gailtal crystalline basement near Jenning. Andalusite developed by the reaction chlorite + garnet + muscovite ⇒ andalusite + biotite at about 500°C and 3 kbar. The andalusite is overgrowing Hercynian staurolite and garnet. In the Strieden Unit (Kreuzeckgruppe) higher conditions of more than 550°C are indicated by the prograde breakdown of the Hercynian staurolite by the reaction staurolite + muscovite ⇒ andalusite + biotite + garnet. $^{40}Ar/^{39}Ar$-cooling ages of muscovite and biotite, as well as Rb-Sr isochrons of biotite scatter between 220 and 200 Ma.

Further to the east a similar evolution reaches higher temperatures within the sillimanite stability field. In case of the Alpine metamorphic overprint the minerals of the low pressure stage are influenced in different ways. In most cases the alumosilicates are transformed into kyanite (Saualpe-Koralpe Complex), but in some localities andalusite and sillimanite are preserved within pseudomorphs of chloritoid ± staurolite ± kyanite (Strallegg Complex). For the Disthenflasergneiss of the Saualpe HABLER & THÖNI (1998) determined 590 ± 20°C at 3.8 ± 0.1 kbar. In the Strallegg Complex (BERKA et al., 1998) conditions of 580°C at 3 kbar are supposed for the 'Traibach schists' near Krieglach, whereas 600°C at about 3.5 kbar are determined for the Sopron area (Hungary). In the southernmost part of the unit migmatites related to granites of Permian age (SCHARBERT, 1990) occur.

Discussion

The Permian HT/LP metamorphism can be found over a distance of more than 500 km from Sopron in the east to Lake Como (Switzerland) in the west. It is characterized by a geothermal gradient of more than 40°C/km, over different metamorphic grades from lower greenschist facies to high amphibolite facies. Related magmatic rocks are gabbros, granites and pegmatites. These rocks are common but volumetrically subordinate with respect to the metapelites. The peak of the metamorphism was reached at about 270 Ma. Preliminary data suppose a slow cooling until 200 Ma.

There are three geotectonic environments where HT/LP metamorphism occurs:

(1) contact metamorphism,
(2) relaxation of isotherms within thickened crust and
(3) thinning of the lithospheric mantle.

In case of the characteristics of the Permian metamorphism, especially because of the constant geothermal gradient contact metamorphism can be ruled out. Further the geothermal gradient is much higher than the relaxed geotherm after the Hercynian orogeny. Based on data from the retrograde part of the Hercynian pressure-temperature path (TROPPER & HOINKES, 1996; DIELLA et al., 1992) this relaxed geotherm is about 35°C/km. It fits well with theoretical estimates for the maximum gradient which can be reached by thermal relaxation of thickened crust (ENGLAND & HOUSEMAN, 1984). Therefore an additional heat source is needed to create the Permian geothermal gradient of more than 40°C/km. Thinning of the lithosphere is the most probable mechanism for the Permo-Triassic HT/LP event. Stretching of approximately 20 % is necessary to create the observed thermal structure. The lithospheric thinning can be explained by processes related to the opening of the Neotethyan ocean.

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