Ber. Inst. Erdwiss. K.-F.-Univ. Graz	ISSN 1608-8166	Band 9	Graz 2004

ON DEFORMATION AND METAMORPHISM OF THE PLATTENGNEISS SHEAR ZONE, EASTERN ALPS

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Introduction

The Plattengneiss shear zone is one of the largest shear zones of the Eastern Alps. It is about 1 km thick, flat lying and is exposed over an area of about 600 km^2 in the Koralpe. During the Eo-Alpine peak metamorphic event it experienced eclogite facies metamorphism with peak pressures of 14 kbar and peak temperatures of 700°C. Overall, it is one of the highlights of hard rock geology in the Alpine orogen. However, surprisingly few geologists work on the shear zone and many puzzling questions remain. This contribution summarizes our motivation to study aspects of its structural and metamorphic history and some recent approaches of our working group to tackle them.

Questions and Motivations

Our principle motivation for working on the Plattengneiss stems from considerations of the Eo-Alpine metamorphic heat budget which indicate that the Eo-Alpine thermal event may need interpretation in terms of heating and cooling mechanisms that are outside our normal understanding of Barrovian terrains (e.g. Stüwe, 1998):

- *The metamorphic grade*: The metamorphic grade of the Plattengneiss indicates a ratio of peak temperature to peak pressure of some 14°C per Kilometer (using 700°C/14 kbar and 1 kbar ~ 3.6 km) (e.g. Stüwe and Powell, 1995). Such low *T/P* ratios can only be attained and preserved if rocks are buried and exhumed in a time interval that is shorter than the time required for thermal equilibration. However, fission track ages of the Koralpe indicate that final exhumation was no earlier than about 50 Ma (Hejl, 1997), so that several tens of my were available for its metamorphic cycle. This indicates that heating and cooling may not be related to conductive equilibration and exhumation, respectively.

- *The metamorphic field gradient*: The metamorphic field gradient from the Plattengneiss in the southern Koralpe to the Gleinalm crystalline is smooth indicating that these units acted as one continuous sequence during the Eo-Alpine (Tenczer and Stüwe, 2003). However, interestingly, pressures drop much more rapidly with distance than temperatures: Some 50 km north of the major Plattengneiss exposures, rocks still experienced peak temperatures around 600°C - 650°C, but peak pressures are significantly lower around 8-10 kbar. The field gradient appears therefore to indicate a heating mechanism where rocks at higher crustal levels were more thermally perturbed than those at lower crustal levels.

- *Preservation of isotopic and metamorphic equilibria*: Despite temperatures around 700°C, the major elements and isotopes of the Plattengneiss are extremely ill-equilibrated. This has long been a problem for geochronologists and metamorphic petrologists alike. The lack of equilibration at such high temperatures is likely to indicate either (a) extremely dry conditions or (b) extreme short duration for the high temperatures with the latter being difficult to reconcile with a "normal" heat source for metamorphism.

- *Tectonic setting and timing relationships*: The Eo-Alpine metamorphic peak occurred at a time when the Austroalpine nappe pile was already thickened. However, despite the over thickened crust, there in no obvious evidence that significant topography was developed at this time. One interpretation for this is that not only the crust, but also the mantle part of the lithosphere were over thickened at this time (Stüwe and Sandiford, 1995). While this interpretation is consistent with the absence of topography, it is inconsistent with the occurrence of Eo-Alpine metamorphism which should lead to cooling rather than heating.

All these considerations indicate that there is a problem with the metamorphic heat budget. In the past we have worked on these problems by investigating details of the PT path and cooling history (Stüwe and Powell, 1995; Ehlers et al., 1994; Stüwe and Ehlers, 1998) as well as the stresses and strain rates (Tenczer and Stüwe, 1999; Biermeier and Stüwe, 2003) during the Eo-Alpine. Aspects of our recent and as yet unpublished work in this general region is summarized here.

Metamorphism in the Plattengneiss

In order to constrain some of the questions discussed above, in particular the question on the duration of metamorphism, the heat source and the dryness of the rocks, we have aimed at constraining both details of the metamorphic *PT* path and the evolution of fluid content of the Plattengneiss (Tenczer et al., 2004).

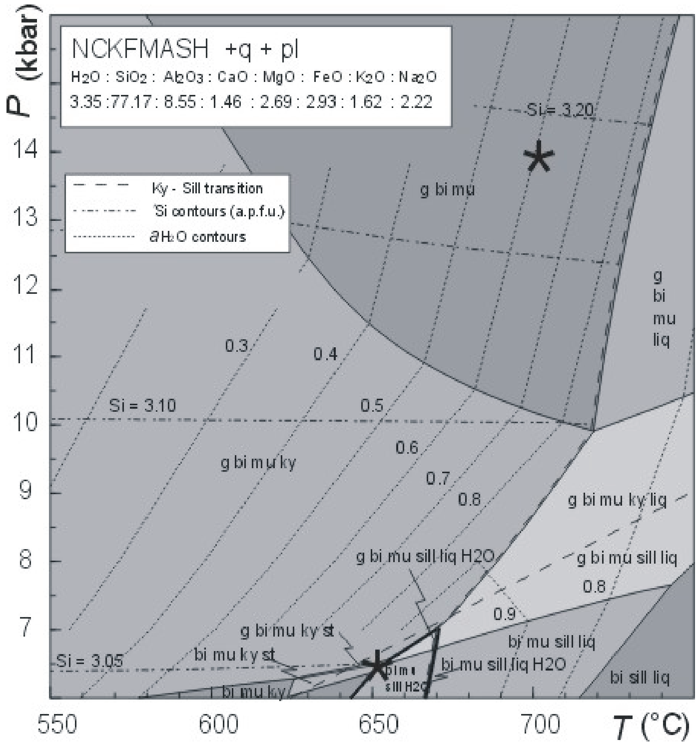

Fig. 1: Thermodynamic PT pseudosection in the System NCKFMASH for a bulk composition appropriate to the Plattengneiss. The bulk composition was derived from a whole rock analysis by subtracting appropriate proportions of phases that did not re-equilibrate during the Eo-Alpine metamorphic event (see Tenczer et al., 2004 for details). The Asterisk marks the Eo-Alpine and Permian metamorphic peak conditions.

As a principal result of this work, we present in Fig. 1 a *PT* pseudosection for kyanite-absent varieties of the Plattengneiss. Among many other interesting features, this phase diagram highlights the possibility that partial melting may have occurred during the Eo-Alpine evolution both at the metamorphic peak (if the water content is slightly higher) and during substantial isothermal decompression.

Deformation of the Plattengneiss shear zone

While several studies have investigated the significance of the mylonitic deformation of the Plattengneiss shear zone (Krohe, 1987; Kurz et al., 2002), the large scale geometry of the shear zone and its post-Eo-Alpine deformation history remains not very well understood. However, in view of the importance of its potential contribution to the mechanical energy production in the region, its volume and geometry are of crucial importance. Fig. 2 shows some results of a recent 3D modeling study in which we determined the present geometry of the shear zone within the Koralpe.

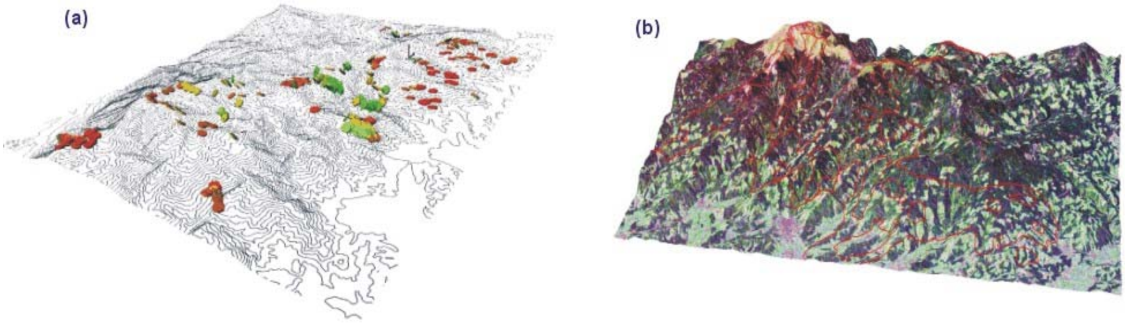

Fig. 2: A 3 dimensional model of the Plattengneiss shear zone. (a) Field data on dip and strike of the Plattengneiss superimposed on a contoured digital elevation model for the Koralpe. The view is from SE towards the NW across the Speikkogel. (b) Model result: The image shows a Landsat image draped over the digital elevation model for the Koralpe looking west across the Speikkogel. The lines show the intersection of the modeled Plattengneiss with the topography.

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