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TECTONIC INFORMATION OF METAMORPHIC DISEQUILIBRIA: EXAMPLES FROM THE HIGH GRADE EOALPINE OF THE KORALPE

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Metamorphic rocks contain valuable information about the pressure (*P*) and temperature (*T*) evolution of mountain belts, which is commonly extracted using the tools of *equilibrium* thermodynamics. Because diffusion processes are strong exponential functions of temperature, this information is largely that of the metamorphic *temperature peak*. In fact, even *P* sensitive mineral equilibria will record the metamorphic *temperature* peak because activation volumes in the Arrhenius relationship are much smaller than activation energies. While non-equilibrium thermodynamics has been a fully-developed tool in metamorphic petrology since the seventies (FISHER, 1973; JOESTEN, 1977), its methods have not found their way into the list of widely used tools in modern interpretations of metamorphic rocks (FOSTER, 1986). It remains common practice to use the methods of *equilibrium* thermodynamics to interpret *non-equilibrium* information, for example when interpreting reaction textures to infer metamorphic *PT* paths.

In the past years we have been involved in the development and application of petrological tools that can be used beyond the interpretation of *PT* paths. We do so by using *equilibrium* thermodynamics to interpret textural observations on metamorphic *disequilibria.* In particular, we have been involved with investigations of (i) cooling rate, (ii) tectonic stresses and even (iii) strain rate. While the investigation of these parameters has typically been the realm of geochronologists and structural geologists, petrological tools for their investigation are rapidly advancing. This contribution gives an overview over new developments in the field of such *petrological* tools.

Many of our investigations were applied to the Koralm crystalline complex of the eastern Alps, in part because its heterogeneous equilibration lends itself to the interpretation of metamorphic disequilibria (e.g. STÜWE & POWELL, 1995; TENCZER & STÜWE, 2001a); and in part because some burning questions on the heat sources and tectonic interpretation of the metamorphic field gradient exposed in the Koralps require the determination of functions like cooling rate or tectonic stresses (STÜWE, 1998; STÜWE & TENCZER, 2001).

Cooling Rate: The determination of cooling rates of rocks is typically performed using a series of geochronological systems with different closure temperatures. However, DODSON (1973) formalized the relationship between *grain size*, *cooling rate* and *closure temperature* for both geochronological and major element exchange systems. Thus, it is possible - in principle - to use zoning profiles of garnets to infer the cooling rate of rocks. Using statistical approach we have shown that the cooling rates of the highest temperature evolution of the Plattengneiss shear zone was extremely rapid (EHLERS et al., 1994). We believe that it was too rapid as that it could be explained by exhumation processes alone (STÜWE & EHLERS, 1998).

Stress Information: Metamorphic parageneses record only a single quantity of the stress tensor: pressure. However, by comparing pressure variations on a small scale (where lithostatic stress variations are negligible) it is possible to infer also non-lithostatic stress fluctuations in metamorphic rocks. In the Koralpe, syndeformational decompression textures within the Plattengneiss shear zone have been interpreted to indicate that the Plattengneiss deformation was an *exhuming* deformation phase. However, we have shown recently that pressure variations up to about 1 kbar are reasonable within the scale of a thin section (TENCZER & STÜWE, 2001b). Modal shifts between minerals in trivariant parageneses of the Plattengneiss shear zone are consistent with pressure variations of about 1 kbar.

Strain Rate Information: In principle, it is possible to infer strain rates from inclusion trails in garnets, if two parameters are known: 1. The relationship between strain rate and rotation rate of the crystal and 2. The growth rate of the crystal. Interestingly, garnet crystals in coarse grained rocks from the Koralpe show a wide variety of inclusion trails, even within a single thin sections. Such variations in inclusion trails may indicate that neighboring porphyroblasts may hinder or accelerate each others rotation rate for a given shear strain rate in the far field (BIERMEIER & STÜWE, 2001). We are currently in the process to measure growth rates of garnet crystals from the Koralm complex.

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