Porosity values of fractured rocks show an exponential increase with increasing fracture densities, with an average effective porosity of 5 % for intensely fractured rocks. Fault rocks such as cataclasites show variable values of effective porosity (2% -6%) due to differences in their micro-structural fabric. The analytical methods provide an insight on deformation processes and features such as grain size reduction, cementation and recrystallization, and point out porosity and permeability differences due to deformation mechanisms and cementation events.

2D thermo-mechanical modeling of basement-cover deformation with application to the Western Alps

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The external crystalline massifs of Western Alps and the Helvetic sedimentary nappe stack result from the deformation of the European passive margin during the Alpine collision. This area has been studied extensively for the past hundred years. However although the geometry and tectonic structures are well documented, the mechanical behavior of the rocks during nappe stacking and basin inversion is still highly debated. The aim of this study is to reproduce the first order tectonic structures of the Western external Alps. We use a 2-D thermo-mechanical finite element model with visco-elasto-plastic rheology formulation to simulate the deformation of half-graben structures during collision. We systematically investigate the control of (1) the rheology, i.e. ductile vs brittle; linear vs power-law viscous rheology, and (2) the boundary condition, i.e. pure shear vs simple shear. Geometry and finite deformation patterns in both basement and sediments are then compared to cross-sections, finite strain ellipses and cleavage orientation from published field data. Orientation and distribution of plastic shear bands in the model are compared to fault distribution from field data and sand box analogue models.

Alpine evolution of the central Aar-massif (Grimsel section)

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The Aar-massif represents a polycyclic basement window representing a part of the inverted former European continental margin. The exhumation and cooling history of the Aar-massif have been already intensively discussed in the literature using fission track and U-Th/He data. However, the thermal and structural situations in the Aar massif in its adjacent tectonic units (e.g., Gotthard unit in the south, Helvetic nappes in the north) during Alpine peak metamorphic conditions (Tmax) are less clear. The maximal temperatures in the Aar massif are similar in age and level as in direct south oriented Gotthard unit and the trend can be followed towards the South into the Lepontine dome (i.e. in Oligocene-Miocene Barrovian metamorphism), a situation which is fundamentally different to other external massifs of the Western Alps (e.g., Aiguille Rouge-, Mont Blanc-, Pelvoux-massifs).

Several problems exist for the reconstruction of Tmax in such basement units: (1) the lithologies (mainly granitoids) are not ideal for P-T estimates based on conventional mineral assemblages, and (2) the timing of mineral equilibration is not clear (mixing of pre-Alpine and

Alpine temperatures). These problems in mind, we compiled metamorphic and isotope age data of the Aar massif in a central cross-section. We add own data using different geothermometers solely collected in Alpine shear zones (e.g., Ti-in-biotite, calcite-dolomite thermometry).

The available P-T conditions in the Grimsel area indicate conditions of ~450°C and 6.5 kbar, which is similar or only slightly lower as in the adjacent southern units (Gotthard units). Such elevated temperatures are found up to the central region of the Aar-massif and therefore no substantial change in temperatures from the southern to the central part is indicated. In contrast, the northern part of the massif shows fundamental lower Tmax (~250°C). These Tmax data suggest a change in the temperature field gradient from south (more constant) to north (relative steep).

The Grimsel area requires exhumation from depths of ~18 km since the Miocene, which is consistent with age and metamorphic conditions in the units further south (the thick skinned units of the Lepontine dome). The northern area shows much less vertical transport and is related to the physical emplacement conditions of the Helvetic meta-sedimentary units (thin skinned, fold and thrust belt). This variation and the related difference in vertical transport from south to north have to be connected to an array of numerous vertical shear zones inside the Aar-massif. Several of these shear zones show a steep transport direction, but also strike slip shear zones exist.

Despite the localized deformation in the individual shear zones, their large number and spatially homogeneous distribution is capable to accommodate uplift and exhumation on the scale of the entire Aar massif in a distributed manner. In other words, temperature offsets between individual shear zones are too small to be detected but in light of the whole Aar massif the shear zone arrays bring different former mid crustal levels to today's exposed position at the surface.

The lithosphere-asthenosphere boundary below the Eastern Alps and the effect of eastward extrusion

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The Eastern Alps (EA) are the result of the European and Adriatic plates convergence. The architecture of this portion of the Alpine collision has been furthermore affected by a lateral (east directed) tectonic extrusion caused by the retreating subduction of the nearby Carpathians. Analysis of Ps and Sp receiver functions from datasets collected by permanent and temporary seismic stations, located in the EA, show the presence of a low velocity layer (LVL) at depth. This LVL might indicate the velocity drop that the seismic waves undergo passing through the asthenosphere, and it testifies a sudden lateral thickness change of the lithosphere. The detected thinner lithosphere is bounded by the Bohemian Massif to the north, and by the Lavanttal fault to the South-west. The detected asthenosphere is deeper (100-130 km) below the North Calcareous Alps, and shallower (70-80 km) below the Vienna Basin and Styria Basin. Unraveling the depth extent of the coherent rigid lithosphere moving over a weak asthenosphere helps deciphering the decoupling determining plate motions and tectonics of the EA. For the first time in the area the Lithosphere-Asthenosphere Boundary is imaged with such a clear depth variation, reflecting the depth extent of the dextral extrusion of the EA towards the Pannonian Basin.