A ductile shear zone terminating a brittle strike-slip fault: The gypsum-dominated Paluzza-Comeglians shear zone as western extension of the Fella-Save fault, Southern Alps

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Compressive and extensive horsetails are common structures on the lateral termination of brittle strike-slip faults, which forms within the shallow continental crust. Here we report another possibility, the lateral termination of a brittle strike-slip fault in a formation-parallel low-temperature ductile shear zone within sulphatic, gypsum-dominated evaporites. In the Southern Alps, over a distance of ca. 35 km, a steeply to gently S-dipping foliation, a subhorizontal stretching lineation and pure shear-dominated porphyroclast systems developed within the S-dipping Lower Bellerophon Formation of uppermost Permian age. Subordinate σ-clasts indicate dextral shear. The main-stage foliation is often overprinted by shear band structures, which also consistently indicate dextral shear along the shear zone. Open to tight faults form at several stages during shear zone development, and mainly refold the mylonitic foliation. Open folds are sometimes associated with reverse faults indicating final N-S shortening. Together, the structures within the Paluzza-Comeglians shear zone indicate transpression, which accommodated dextral displacement of the Fella-Save fault in the east.

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Analyzing hydrogeological properties of fault rocks and fracture networks in fault zones in carbonate rocks

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Around 60 % of the drinking water for Austria’s capital Vienna comes from springs at the N and NE of the Hochschwab Massif. Hydrogeological flow properties in the Hochschwab Massif are essentially governed by karstified fault zones. We investigated sinistral strike-slip fault zones exposed in the Upper Triassic Wetterstein Fm., which formed at shallow crustal depth during the process of eastward lateral extrusion of the Eastern Alps in the Oligocene and Lower Miocene.

In detailed structural field-work we analyzed fault zone anatomy and distinguished zones of certain hydrogeological properties within the fault core and the damage zone. Fault rock classification, fracture network analysis and estimates over their spatial distribution in outcrop studies were supplemented by porosity and permeability measurements from representative samples. Additionally, thin-sections have been investigated with optical microscopy, cathodoluminescence and electron microscopy using backscattered electron imaging and focused ion-beam techniques.

The results show that by trend fault zones in dolomite lack a distinct, single fault core and masterfault but show multiple branching, minor fault cores that interlock in the 3D geometry of the outcrop. Fault zone formation in dolomite is accompanied and influenced largely by fluid interaction producing large volumes of cemented fault rock. In contrast fault zones in limestone have a definite fault core characterized by a distinct masterfault and delimited cataclastic fault rock associated. There is no evidence for spacious cementation processes.

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