permeability system.
(1) Fractured matrix is characterized by analyzing small-scale fractures and joints, which carry most of the fracture volume of the reservoir. Quantitative and semi-quantitative empirical classifications are used for measuring the total joint surface in a volume of rock (P32 expressed in m² per m³ rock), which is related to fracture porosity. Data shows an exponential increase of porosity and permeability with increasing fracture density.
(2) Cataclastic faults form marked discontinuities in the fractured host rock characterized by damage zones of strongly fractured wall rock or dilatation breccia and different types of cataclasite in the fault core. Fault rocks form about 7.5 % of the rock mass. Cataclasites show relatively high porosity (up to 6,5 %) but very low to low permeability (kGas 0.3-5.4 md). For extensional breccias samples indicate both higher porosity (4.5-8.5 %) and permeability (5-13 md). Data therefore support a complex fault model with high-porosity / low-permeability cataclasite in the fault core sandwiched by fault-parallel high-porosity / high-permeability zones formed by fractured wall rock and/or dilatation breccia. Quantitative fault mapping shows that Miocene NNE- to NE-striking sinistral faults and E-W-directed normal faults are by far the most important structures. About 78 % of the total fault population formed during Middle to Late Miocene deformation (sinistral faults: 50 %; normal faults: 28 %). The third group of abundant faults includes Pliocene to Quaternary NE-directed normal faults (11 %). Faults are very closely spaced with average distances between individual faults of a particular set of about 5 to 30 m. Intersecting faults therefore delimit blocks of wall rock with diameters ranging from less than 5 m to about 20 m.
The observed complex fault properties (low-permeability fault cores and high-permeability damage zones) and the existence of mutually cross-cutting faults related to distinct deformation events are regarded as the key features controlling the general reservoir properties. First, the closely-spaced high permeability streaks corresponding to fault damage zones appear extremely efficient in draining the fractured matrix blocks between faults. Second, abundant cross-cutting faults form a well-connected 3D network of damage zones allowing to bypass the low-permeability cataclasite, which otherwise would act as a fault seal.

Tectonometamorphic evolution of the Texel Complex, Southern Tyrol, Italy

Desch, A.[1], Flöss, D.[1], Speckbacher, R.[1], Fügenschuh, B.[1], Tropper, P.[2] & Mair, V.[3]

[1]Institute of Geology and Paleontology, University of Innsbruck, Innrain 52, A-6020 Innsbruck, Austria; [2]Institute of Mineralogy & Petrography, University of Innsbruck, Innrain 52, A-6020 Innsbruck, Austria; [3]Amt für Geologie und Baustoffprüfung, Eggentalerstrasse 48, I-39053 Kardaun (BZ), Südtirol/Italien; Angelika.Desch@student.uibk.ac.at, David.Floess@student.uibk.ac.at, Romed.Speckbacher@student.uibk.ac.at, Bernhard.Fuegenschuh@uibk.ac.at, Peter.Tropper@uibk.ac.at

The Upper Austroalpine Ötztal-Stubai basement complex (Schmid et al. 2004) is separated from the high-pressure rocks of the Texel complex by the NW-dipping Schneeberg complex. Sölva et al., 2001 termed this contact Schneeberg normal fault, which was described as a top to the NW normal fault allowing for the extrusion/exhumation of the Texel complex from high grade to near surface conditions. Based on the concept and the defined deformation sequence of Sölva et al. (2001) and Habler et al. (2006) the current project investigates the prolongation of the Schneeberg normal fault towards the SW.
Structural mapping revealed a spectacular km-scale antiform-synform pair refolding the main foliation around steeply (W)NW-dipping fold axes. NW-SE trending stretching lineations and top-NW shear sense indicators are related to the earlier main foliation and are thus refolded as well.
This refolded composite foliation traces the continuation of the SNFZ towards the W(SW) and thus delimits the area of possible Cretaceous high-P relics. As already proposed by Schmid & Haas (1989) the SNFZ can be linked with the Vinschgau Shear Zone (VSZ) along the folded mylonites.
The near-surface expression along the Schlinig fault can be continuously traced along the Vinschgau shear zone into the Schneeberg fault zone, thus extending this intra-basement shear zone (Schmid & Haas 1989) further towards the east.
The present-day NW-dip of the Schneeberg fault zone is due to post-Cretaceous folding and overturning.
Zoning patterns of hornblende-bearing gneisses reveal the polymetamorphic evolution of these rocks. Garnet and plagioclase show discontinuous zoning, most likely associated with the strong Eo-Alpine metamorphic overprint known in this area (e.g. Habler et al. 2006). P-T estimates, using coexisting rim compositions, yield 520-580°C and 0.72-0.92 GPa, interpreted to represent the decompression stage following peak metamorphic conditions.

Habler, G., Thöni, M. & Sölva, H. (2006): Tracing the high-pressure stage in the polymetamorphic Texel Complex (Austroalpine basement unit, Eastern Alps): P-T-t-d constraints. - Mineralogy Petrology, **88**: 269-296.
Schmid, S., Fügenschuh, B., Kissling, E. & Schuster, R. (2004): Tectonic map and overall architecture of the Alpine orogen. - Eclog. Geol. Helv., **97**: 93-117.
Sölva, H., Grasemann, B., Thöni, M., Tiede, R.C. & Habler, G. (2005): The Schneeberg normal fault zone: normal faulting associated with Cretaceous SE-directed extrusion in the Eastern Alps (Italy/Austria). - Tectonophysics, **401**: 143-166.

Recognizing different brittle tectonic events based on the different deformation mechanism of deformation bands and typical frictional faults

Draganits, E.[1], Grasemann, B.[2], Wiesmayr, G.[3] & Hager, C.[4]

[1]Institute for Engineering Geology, Vienna University of Technology, A-1040 Vienna, Austria; [2]Department of Geodynamics and Sedimentology, University of Vienna, A-1090 Vienna, Austria; [3]Rohöl-Aufsuchungs AG, Schwarzenbergplatz 16, A-1015 Wien, Austria; [4]Department of Geology, University of Kansas, Lawrence, KS 66045-7613, USA; Erich.Draganits@tuwien.ac.at, Bernhard.Grasemann@univie.ac.at, Gerhard.Wiesmayr@rohoel.at; hager@ku.edu

The interpretation of frictional faults suffers from the fact that these structures are difficult or often impossible to date by geochronological methods and therefore they are mainly dated by cross-cutting relationships. We have investigated deformation bands and zones of deformation bands from the quartzites of the Lower Devonian Muth Formation in the Pin Valley, NW Himalayas (Draganits et al. 2005). Thin section analyses show that the deformation bands in the Muth Formation formed early in the diagenetic history before porosity was lost. Deformation mechanisms involved cataclasis, translation, rotation of quartz grains and effective porosity reduction. Maximum conditions of about 80°C and 60 MPa lithostatic pressure are estimated from the amount of overburden during the middle Cretaceous. Because genetically unrelated, the orientations of the deformation bands cannot be reasonably grouped with the orientations of faults related to Himalayan deformation in the Pin Valley. Additionally the deformation bands are superposed by Eo-Himalayan (Eocene) folds, which in turn are cut by later faults. The later faults that cross-cut the Eo-Himalayan folds developed in already cemented Muth Formation at much higher temperature and pressure conditions by crystal plastic deformation mechanisms, indicated by quartz crystals with undulatory extinction, abundant kink bands, dislocation glide, elongated subgrains, slightly curved deformation lamellae and pronounced shape preferred orientation. These two completely contrasting deformation mechanisms on the microstructural scale characterize two distinct fault sets which are unrelated in space and time. The deformation bands are of pre-Himalayan origin and therefore represent a set of rare pre-Himalayan deformation structures. The age of the deformation bands in the Muth Formation is bracketed by an early Devonian sedimentation age of the Muth Formation and a middle Cretaceous age of considerable cementation as deduced from compiled burial histories. We suggest the deformation bands are due to either the Neo-Tethys rifting event beginning in the early Carboniferous or the extension related to Late Carnian/Early Norian rapid subsidence, although a hitherto unknown deformation event can not be excluded. Our example from the NW Himalayas shows that the deformation bands can be separated from other, frictional deformation structures by their characteristic microstructural properties, spatial architecture and stratigraphic position. Their correct interpretation, in combination with studies on the stratigraphy and sedimentology, essentially contributes to the reconstruction of the tectonic complex areas, even in severely folded and faulted orogens like the Himalayas.

DRAGANITS, E., GRASEMANN, B. & HAGER, C. (2005): Conjugate deformation band faults in the Lower Devonian Muth Formation (Tethyan Zone, NW India): evidence for pre-Himalayan deformation structures. - Geol. Mag., **142**: 765-781, London.

Prospektion auf Thermalwasser führende Störungszonen bei Wildbad Einöd/Stmk.

EBNER, F.[1], GRATZER, R.[1], SCHMID, C.[2], POPELKA, K.[3] & GAISBERGER, G.[4]

[1]Montanuniversität Leoben, Department Angewandte Geowissenschaften und Geophysik, A-8700 Leoben, Österreich; [2]Joanneum Research, Institut für WasserRessourcenManagement, Roseggerstr. 17, Österreich; [3]Paladin Energy LTD, Grand Central, First Floor, 26 Railway Road, Subiaco WA 6008, Australia; [4]Fugro Austria, Einödstr. 13, A-8600 Bruck/Mur, Österreich; fritz.ebner@unileoben.ac.at, [2)]reinhard.gratzer@unileoben.ac.at, christian.schmid@joanneum.at, klaus.popelka@paladinenergy.com.au, gert.gaisberger@gmx.at

Das durch den Europäischen Fonds für regionale Entwicklung (EFRE) und das Land Steiermark finanzierte Projekt zielte auf die Entwicklung/Erprobung von Untersuchungsverfahren ab, die geeignet sind, in komplexen alpinen Tal- und Beckenlandschaften von mächtigeren Sedimenten verborgene Austritte von Thermalwässern zu orten. Die dafür einzusetzende Methodik (geologisch/strukturgeologisch Aufnahme, seismische Untersuchungen, Infrarot-Temperatur- und Bodengasmessungen) wurde im Raum von Wildbad/Einöd getestet.

Die Korrelation der Aufnahme-/Messergebnisse mit der Position der derzeit in Wildbad/Einöd fördernden Quellen (Calcium-Hydrogencarbonat-Sulfat-Thermalsäuerlinge) bestätigt die Brauchbarkeit der gewählten Methodik. Darüber hinaus wurden mit refraktionsseismischen Messungen der Tiefgang des Sedimentbeckens und die Struktur der unter der Sedimentfüllung verborgenen Felsoberkante dargestellt. Mit Infrarot-Temperatur- und CO_2-Bodengasmessungen war es möglich, den thermal beeinflußten Mischungsbereich im Grundwasserfeld abzugrenzen. He-Bodengasanomalien deuten auf verborgene Bruchstrukturen im Untergrund. Die strukturgeologischen Arbeiten definieren das Thermalwasserfeld von Wildbad-Einöd über einer tektonisch kontrollierten Zone im Überschneidungsbereich NNE-SSW streichender Teiläste der Olsastörung, E-W orientierter und nur im Bereich von Wildbad-Einöd auftretender Kluftscharen und Auflockerungszonen im Bereich der Überschiebungsfläche des oberostalpinen Murauer Paläozoikums auf das mittelostalpine Kristallin.

Die in Wildbad/Einöd genutzten Wässer sind Mischwässer höher temperierter Primärwässer, die entlang von Störungen in den quartären Sedimentkörper des glazial übertieften Tales aufsteigen und sich dort mit kühlem, nicht mineralisierten Talgrundwasser mischen. Eine nachhaltige Nutzung erfordert einen verbesserten Aufschluß und eine Fassung der primären Thermalwässer im Felsuntergrund vor ihrem Austritt in den Sedimentkörper, der zusätzlich durch eine postglaziale Gleitmasse kompliziert wird. Vor Bohrungen, die auf einen verbesserten Aufschluss der Thermalwässer im Felsuntergrund des Beckens abzielen, wird jedoch eine ca. 130 m tief abzuteufende Struktur-Kernbohrung im Bereich des östlichen Kurparks empfohlen.

ZETINIGG, H. (1992/1993): Die Mineral- und Thermalquellen der Steiermark. - Mitt. Abt. Geol. Paläont. Landesmus. Joanneum, **50/51**: 362 S.

ZÖTL, J. & GOLDBRUNNER, J.E. (1993): Die Mineral- und Heilwässer Österreichs. Geologische Grundlagen und Spurenelemente. - 324 S., Springer Verlag.

Late and post-Variscan sedimentary evolution in the ALCAPA-region

EBNER, F.[1], VOZÁROVÁ, A.[2], VOZÁR, J.[3] & KOVÁCS, S.[4]

[1]University of Leoben, Dept. Applied Geosciences and Geophysics, A-8700 Leoben, Austria; [2]Comenius University Bratislava, Dept. Min. Petrol., Sk-84215 Bratislava, Slovakia;[3]Geological Institute, SAS, Sk-84005 Bratislava, Slovakia; [4]Eötvös Loránd University, Geol. Res. Group, HAS, H-1117 Budapest, Hungary; fritz.ebner@unileoben.ac.at, vozarova@fns.uniba.sk, jozef.vozar@savba.sk, skovacs@iris.geobio.elte.hu

The Circum-Pannonian region is composed of mega terranes which amalgamated from the Middle Jurassic till the Early Miocene. One is ALCAPA (Eastern **Al**ps, Central West **Ca**rpathians, basement of the northern **Pa**nnonian Basin with isolated outcrops of the Pelso Composite Terrane). Significantly the Late Paleozoic sedimentary environments are individually affected by the Variscan orogeny suggesting that diverse elements were amalgamated during the Alpine cycle. Regarding Devonian – Permian sedimentation and Variscan metamorphism/deformation the following zones can be distinguished (EBNER et al. 2008, VOZÁROVÁ et al. 2008):

(1) Variscan metamorphic zone (Mediterranean Crystalline Zone) in the Eastern Alps and Western Carpathians.

(2) Veitsch-Nötsch-Szabadbattyán-Ochtiná zone where sedimentation began in foreland/remnant basins in front of (1) within the late Early Carboniferous.

(3) Oceanic and volcanonosedimentary units in parts of the Upper Austroalpine and Gemeric units affected by a Mid-Carboniferous orogeny/low grade metamorphism and with an unconformable continental cover.

(4) Variscan Flysch zone - Viséan - Bashkirian syn-orogenic flysch (?) in the Eastern Alps and the Western Carpathians Turòa unit.

(5) Siliciclastic turbiditic or pelagic carbonate environments until the Bashkirian without evidence of Variscan deformation/metamorphism (parts of the Graz Paleozoic; Szendrö, Uppony Mts.).

(6) Late Pennsylvanian - Permian shallow marine sediments concordantly following (5) (Bükk, Uppony Mts.).