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Fold-related fractures – a brittle tectonic case study of the Helvetic zone in Vorarlberg (western Austria) and Upper Allgäu (Bavaria)

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In the eastern Alps the Helvetic units exposed at the surface form a narrow belt restricted to the westernmost part of Austria and the northerly adjacent southernmost part of Bavaria. The Helvetic zone represents a Tertiary fold-and-thrust belt made up of Jurassic to Cretaceous shelf sediments deposited on the European margin of the Eurasian plate. In the course of an industry-funded project, the potential of these units for deep hydro-geothermal energy is investigated. Potential targets for hydrothermal exploration are more or less thick carbonate sequences that can be traced throughout the Helvetic zone, namely the Late Jurassic Quinten Limestone and the Early Cretaceous Schrattenkalk-Fm. In depths of at least 3000m below sea level, that have to be drilled to gain water with at least 90°C, uncemented fractures at any scale are the only cavities within these carbonates to be expected. Therefore, brittle structures are studied at differing scales of observation; aerial photos and surface outcrops are analyzed as well as thin sections. All the data obtained so far were collected in areas deformed homogenously: measuring stations were located outside large scale shear zones and either in fold-limbs or hinge zones. A constantly geometrical relationship between the orientation of the various fractures, the sedimentary layering and the trace of the axial planes can be inferred, as already stated by Hancock (1985). Besides extension fractures, veins and stylolithes, conjugated hybrid and shear fractures are quite common, indicating layer-parallel shortening normal to the axial planes as well as axial elongation. Hence, all of the structures observed can be genetically linked with thrusting and folding during regional N-S compressional stress, that is reported from eastern Switzerland too (Pfiffner, 1981) . Large or important deviations of this stress regime can't be observed so far. However, fractures related to 2nd and 3rd order local stress fields, can alternate. This hampers the definition of a generalized, relative age succession of the different fractures. Apart from the genesis of these brittle features, their spatial distribution is of interest too. From scanline measurements along appropriate outcrops, statistical probability parameters concerning fracture-length, -spacing and -connectivity can be obtained. Thereof values for fracture-porosity can be derived; i.e. the hydraulic conductivity of the Schrattenkalk-Fm. is between 10-5-10-3 m/s (Büttner et al., 2003). Although there are some indications for at least partially uncemented fractures at the surface, the porosity values obtained are a rough estimation, due to the unknown degree of cementation in great depths. A large number of fractures are filled with mainly calcite-cements; quartz-cements occur subordinate. Inclusions within these often idiomorphic cement-crystals will be investigated, to get knowledge first about the chemism of the fluids involved and second according the p/T- conditions the cementation took place.

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