Faults controlling geothermal fluid flow in a karst geothermal system (Western Alpine Molasse Basin, France and Switzerland)

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Karst geothermal systems fluid flow is dominated by structurally controlled porosity, which constrains the paths of aquifer recharge and the upwell of geothermal fluids. In fold-and-thrust belt settings associated with continental collision, geothermal fields occur within basins generally interested by low-enthalpy geothermal systems. Despite that, the deeper and warmer levels of multiply stratified aquifers within the detached sedimentary covers are vertically connected to shallower depths by high-angle faults, thus making of them interesting targets for exploration.

In the frame of the geothermal exploration steered by the Geneva Canton, this work aims at determining how fracture connectivity, orientation and permeability anisotropy has implications on fluid flow within high-angle faults. Recent software development (e.g., FracPaQ) allows to quantify such interconnection providing insights into spatial variation of multiscale fault-controlled porosity in order to have dynamic feedbacks between fluid flow, permeability rise/fall. We use the inner Jura fold-and-thrust belt and the other carbonate relieves surrounding Geneva as an outcrop analogue for the deeper carbonate reservoir, lying at depth beneath the siliciclastic Molasse deposits. Hereby, we present new structural and morphostructural lineament maps and scan box analyses from outcrops that provide a multiscale analysis on fracturing across the study area. The sampling sites are representative of fractured fold hinges constituted of Mesozoic carbonates crossed by high-angle faults.

The map analysis show that the late Oligocene-early Miocene growing carbonate anticlines are shaped by a series of fore- and back-thrusts resulting in salient-and-recess curvy thrusts accommodating different amount of shortening across high-angle tear-faults. With the support of high-resolution LIDAR images, we observe that at the large scale (e.g., five kilometers), as fault zone broadens across transfer zones, the background fracture network is more intense at the salient flanks. Major faults occur as segmented, thus not providing near-surface structure capable of giving any earthquake significantly larger than the already measured ones (e.g., M_L 5.3, Epagny earthquake 1996). Our preliminary results identify the W- and the NNW- striking systems strike-slip faults as the preferred patterns of fluid flow. Cross-cutting relationships vary with their position into the bended belt, thus making them suitable to be multiply reactivated during the Jura arc indentation. At the outcrop scale, the most mature fault zones associated with larger displacement are characterized by high fracture intensity and connectivity. Field evidences show
that NNW- and W/NW- striking systems are vein-rich whereas N- and NE-striking systems are accompanied by open fracture sets although they may work with opposite fluid-flow vertical directivity. Mechanical and regional chronological development of the fracture network is also discussed as related to the regional fault evolution.