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A multidisciplinary perspective on fault zone hydrogeology

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Deformation of rock in fault zones at shallow depth (e.g. <3 km) in the Earth's crust introduces permeability heterogeneity and anisotropy, which has an important impact on geological processes, such as hydrothermal fluid circulation, hydrocarbon migration, and regional groundwater flow. However, the direct evaluation of the impact of faults to fluid flow patterns remains a challenge and requires an multidisciplinary research effort of structural geologists and hydrogeologists. These disciplines often use different methods often with little interaction between them. In this presentation, we discuss the current multi-disciplinary understanding of fault zone hydrogeology. We review outcrop and subsurface data from diverse rock types such as clastic sedimentary, crystalline, volcanic and carbonate rocks. For each rock type, we review the suite of existing conceptual models of fault zone hydrogeology and deformation processes. In the field, we find that fault zones commonly have a permeability structure indicating they should act as complex conduit-barrier systems in which along-fault flow is encouraged and across-fault flow is impeded. The various types of hydrogeological observations related to fault zones reported in the literature show a broad agreement with outcrop-based assessments of fault zone hydrogeology. Our review highlights that fault-parallel fluid flow and transport should be expected in a variety of structural and hydrogeologic settings.