OUTCROP FRACTURE CHARACTERIZATION FOR GEOTHERMAL RESERVOIRS:

OPTIMIZED INPUTS FOR RESERVOIR MODELS

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Keywords: Fractures, Reservoir assessment, Topology, Flow Simulation.

ABSTRACT

Analysis of outcrop analogs can reduce risk in early stages of reservoir characterization and assessment in geothermal systems. The Sotra islands in western Norway provide good exposures of heavily fractured crystalline rocks, which are suitable analogs for naturally fractured reservoirs in conventional and enhanced geothermal systems.

We explore two-dimensional fracture connectivity using topological methods in digitized fracture networks. We analyzed connectivity at different scales of observation depending on pixel image resolutions, from drone photography to satellite imagery and digital elevation models (0.1 to 50m pixel size). The results are further compared with published datasets of faulted sedimentary sequences for which the change of scale is achieved by censoring faults by their offsets (Watterson et al., 1996; Nixon et al., 2012).

We present a preliminary analysis of the geological data, which indicates that the topological character of the interpreted networks in Sotra have little variation in connectivity patterns as the scale and resolution is changed, i.e. all datasets capture similar connectivity regardless of image resolution. In contrast, the faulted sedimentary sequences show decreasing connectivity trends as the censoring increases.

In addition, we present initial flow simulations considering two-dimensional flow and heat transport, to study the impact of the network characteristics on its flow and transport behavior. The simulations are based on Discrete Fracture Matrix (DFM) principles, using the PorePy computation framework (Keilegavlen et al., 2017). DFM models combine high accuracy of flow in fractures with efficient representation of smaller scale fractures in an upscaled matrix permeability, where the latter is populated using numerical upscaling of the observed fractures at different scales.

REFERENCES

Keilegavlen, E., Fumagalli, A., Berge, R., Stefansson, I., Berre, I., 2017. PorePy: An Open-Source Simulation Tool for Flow and Transport in Deformable Fractured Rocks. *arXiv preprint arXiv:1712.00460*.

Nixon, C.W., Sanderson, D.J., Bull, J.M., 2012. Analysis of a strike-slip fault network using high resolution multibeam bathymetry, offshore NW Devon UK. *Tectonophysics* **541**, 69-80. 10.1016/j.tecto.2012.03.021

Watterson, J., Walsh, J., Gillespie, P., Easton, S., 1996. Scaling systematics of fault sizes on a large-scale range fault map. *Journal of Structural Geology* **18**(2), 199-214. 10.1016/S0191-8141(96)80045-9