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Scaling and geometric properties of extensional fracture systems in the Proterozoic basement of Yemen

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Development of basement fractured reservoirs “in and around igneous rocks”, for both oil exploration and geothermal industries, have been carried out in recent years. Analyses of field rock analogues are thus required for a better understanding of the scaling characteristics of fracture systems, which could guide the interpretation of regional data and its extrapolation to other different scales.
Multi-scale mappings of fracture systems in the crystalline basement of Yemen (pan-african) are presented. Fracture datasets are described through statistical analyses of direction, length, spacing, density, and spatial distribution. Results are combined with field observations and can be directly used to model the geometry of the fracture networks in analogue basement rocks, from multi-kilometric to decametric scales. The fractured reservoir analogue is defined with a dual porosity model in which tectonic and joint systems correspond to the basement reservoir “backbone” and “matrix” respectively. These two end-members reveal contrasting geometrical, reservoir, and scaling properties. In tectonic systems, multi-scale geometries are “self-similar”, the fracture network shows fractal behavior (power-law length distribution and clustered spacing), and fault zones show hierarchical organization of geometrical parameters such as length, thickness, and spacing. Three orders of fault zone and block size dimensions have been defined from multi-kilometric to multi-hectometric scales, where fault zones of same order are almost regularly spaced when looking between two fault zones of higher order. In joint systems, the fracture network is scale dependent with negative exponential length distribution, and shows anti-clustered spacing. However, these two end-members have both well-connected properties, with fault zones acting as main drain and joint systems acting as the fluid supply.