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Fracture network topology and characterization of structural permeability

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There are two fundamental requirements for successful geothermal development: elevated temperatures at accessible depths, and a reservoir from which fluids can be extracted. The Australian geothermal sector has successfully targeted shallow heat, however, due in part to the inherent complexity of targeting permeability, obtaining adequate flow rates for commercial production has been problematic. Deep sedimentary aquifers are unlikely to be viable geothermal resources due to the effects of diagenetic mineral growth on rock permeability. Therefore, it is likely structural permeability targets, exploiting natural or induced fracture networks will provide the primary means for fluid flow in geothermal, as well as unconventional gas, reservoirs. Recent research has focused on the pattern and generation of crustal stresses across Australia, while less is known about the resultant networks of faults, joints, and veins that can constitute interconnected sub-surface permeability pathways. The ability of a fracture to transmit fluid is controlled by the orientation and magnitude of the in-situ stress field that acts on the fracture walls, rock strength, and pore pressure, as well as fracture properties such as aperture, orientation, and roughness. Understanding the distribution, orientation and character of fractures is key to predicting structural permeability. This project focuses on extensive mapping of fractures over various scales in four key Australian basins (Cooper, Otway, Surat and Perth) with the potential to host geothermal resources. Seismic attribute analysis is used in concert with image logs from petroleum wells, and field mapping to identify fracture networks that are usually not resolved in traditional seismic interpretation. We use fracture network topology to provide scale-invariant characterisation of fracture networks from multiple data sources to assess similarity between data sources, and fracture network connectivity. These results are compared with other permeability indicators such as drilling fluid losses, and pore pressure measurements. Initial work with these techniques has led to new developments in our ability to image subsurface faults and fractures at a variety of scales from independent datasets. We establish a strong relationship between features identified using seismic attribute analysis and interpreted natural fractures. However, care must be taken to use these methods in a case-by-case basis, as controls on fracture distribution and orientation can vary significantly with both regional and local influences. These results outline and effective method by which structural permeability can be assessed with existing petroleum datasets. However, unlike the broad stress field, mapping fracture orientation and characteristics within the Australian Continent is complicated as the distribution, geometry, areal extent and connectivity of fracture networks can vary significantly.