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Top Seal Fracturing in the Carnarvon and Otway Basins, Australia

In recent times in Australian basins, recognition of top seal failure through shear and tensile fracturing has increased, largely through the expanding use of image logs. The combination of image logs with geomechanical theory, in situ stress and formation pressure tests together with, where possible, laboratory geomechanical, microstructural and capillary pressure data provides powerful information for assessing top seal fracture potential. For example, comparison of the in situ stress field with laboratory geomechanical properties of the Muderong Shale (the regional top seal in the Carnarvon Basin) suggest that the intact shale is not generally at risk of hydrofracture but that pre-existing faults and fractures may well be critically stressed in the current day stress field. Evidence for seal breach comes from post-Muderong hydrocarbon shows and stacked hydrocarbon columns above and below the Muderong. Recent work on image logs in the Otway Basin has demonstrated the existence of conductive fractures through the Laira Formation, the seal for the local exploration target in the Pretty Hill Formation. Leakage through this seal can be attributed to the interaction between seal properties, associated faults and the regional stress field. Major faults transecting the top seal cause stress field reorientation resulting in locally high differential stress and brittle fracture. A number of partially breached traps in the region may be attributed to the formation of structural permeability networks in the cap rock, allowing migration of hydrocarbons from those structures. A methodology is suggested using these examples for risking top seal breach in petroleum systems.