FAST: A NEW APPROACH TO RISKING FAULT REACTIVATION AND RELATED SEAL BREACH

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The integrity of structurally-bound hydrocarbon traps is dictated by the sealing potential of their caprocks and bounding faults. Both caprocks and faults can be breached by several failure mechanisms including membrane failure, fault juxtaposition and dynamic reactivation (Watts, 1987; Jones et al, 2000). FAST (Fault Analysis Seal Technology) mapping is an innovative new technique for assessing the risk associated with hydraulic or dynamic failure/reactivation of faults within the contemporary stress field. This technique advances previously published methodologies. For example, the dilation and slip tendency of Morris et al (1996) and Ferrill et al (1999) address the probability of tensile and shear failure separately and ignore the role of rock properties. Other techniques assume Coulomb failure envelopes with no cohesive strength therefore precluding the possibility of tensile failure (Barton et al, 1995). FAST assesses risk of all modes of failure by incorporating failure envelopes with realistic estimates of cohesive strength. Reactivation risk is expressed as the pore pressure increase (ΔP) required to induce failure (Figure 1).

Contemporary hydrocarbon leakage in the Bonaparte Basin is recognised to be closely associated with faults (eg. Whibley and Jacobsen, 1990; O'Brien and Woods, 1995). Caprock lithologies are believed to be thick and regionally extensive suggesting that fault juxtaposition is not a dominant failure mechanism. Capillary pressures of the regional seals are very high and seal failure due to capillary leakage is unlikely (Kivior et al, 2002). In addition, there exists an extensive body of empirical evidence demonstrating fault-related hydrocarbon leakage across the Bonaparte Basin (Lisk et al, 1998; O’Brien et al, 1998; O’Brien and Woods, 1995).

Predictions of the likelihood of fault reactivation for five fault-bound prospects in the Timor Sea are made using the FAST (Fault Analysis Seal Technology) technique. Calculations are made using a stress tensor appropriate for the area, a conservative fault-rock failure envelope and the structural geometries of each prospect. Empirical evidence of hydrocarbon leakage at each trap is used to investigate the accuracy of the fault reactivation-based predictions of seal integrity. There is a good correlation between evidence of leakage and the risk of reactivation predicted using the FAST technique. This study allows the fault reactivation predictions to be calibrated in terms of risk of seal breach (Figure 2). Low integrity traps are associated with ΔP values less than 10 MPa, moderate integrity traps correspond with values between 10 and 15 MPa and high integrity traps correspond with values greater than 15 MPa. Fault strike in the Timor Sea area can vary as much as 60° and still maintain relative high risk of reactivation given dip magnitudes greater than 60°. This calibration allows other structurally bound prospects in the Timor Sea to be risked in terms of fault reactivation.

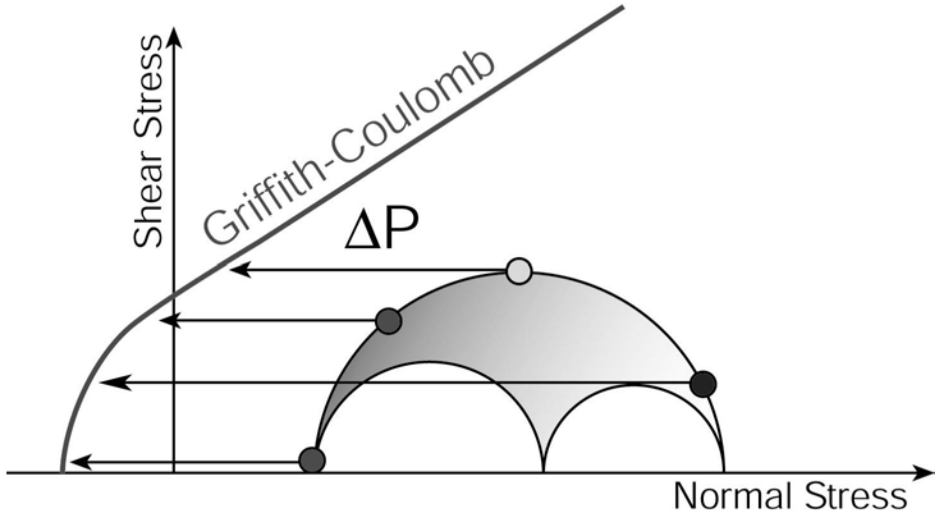

Figure 1 Three-dimensional Mohr diagram with composite Griffith-Coulomb failure envelope. All possible orientations of planes lie within the shaded area. The horizontal distance between any orientation and the failure envelope (which may be thought of as the increase in pore pressure, ΔP, is required to cause failure) is used to assess the propensity of a plane to failure.

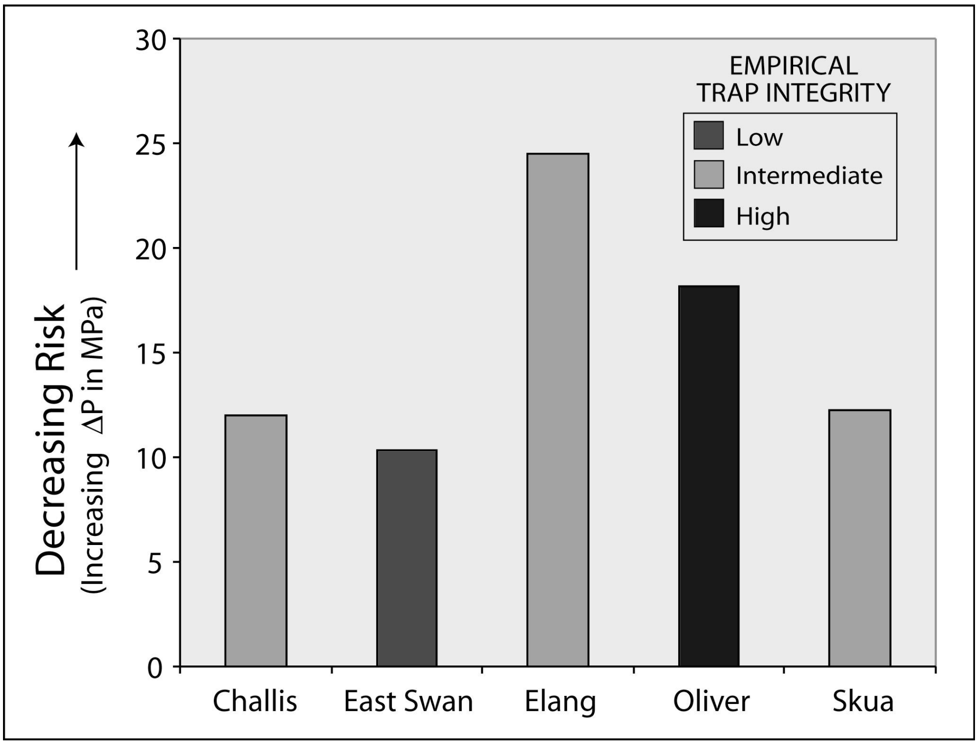

Figure 2 Comparison of empirical trap integrity with predicted fault reactivation risk. Fault reactivation risk is an average of the maximum risk for each individual bounding fault of a trap.

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