FAULT SEAL AND FAULT LEAKAGE IN THE TIMOR SEA AND THE NORTHWEST SHELF, OFFSHORE AUSTRALIA, AND THE NORTHERN NORTH SEA, OFFSHORE NORWAY

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The likelihood that a fault is capable of maintaining a significant hydrocarbon column is closely related to the stresses and pore pressure acting on the fault. We show here in several different fields that faults that are critically stressed in the current stress field (i.e., capable of being reactivated) are permeable, whereas those that are not critically stressed (i.e., faults that are inactive in the current stress field) are not permeable and are likely to be sealing. The orientation of a fault in the current stress field will determine the shear and normal stresses acting on the fault plane. Therefore, careful construction of a geomechanical model, and reliable interpretations of fault orientations, may be used to reduce the risk of encountering breached hydrocarbon reservoirs in exploration and appraisal wells.

We show the results of studies conducted on reservoir-bounding faults in three regions: the Timor Sea and the Northwest Shelf, offshore Australia, and the northern North Sea, offshore Norway. In each study, we evaluated the state of stress and pore pressure acting on the major faults bounding the reservoirs. We utilize a detailed analysis of the magnitude and orientation of all three principal stresses in a number of wells in each field. These data, along with information on pore pressure, allowed us to resolve the shear and effective normal stress acting on thousands of distinct triangular elements representing individual fault planes. By comparing the stress state resolved on each fault element to expected stress at failure (using a Coulomb failure criterion) we created color-shaded maps showing the proximity to fault slip (and hence leakage) along each fault (e.g. Figure 1). We show that only in cases where reservoir-bounding faults are not potentially active, the pore pressure difference across faults can become quite high. Hence, the leakage potential of reservoir-bounding faults appears to exert an important influence on potential hydrocarbon column heights.

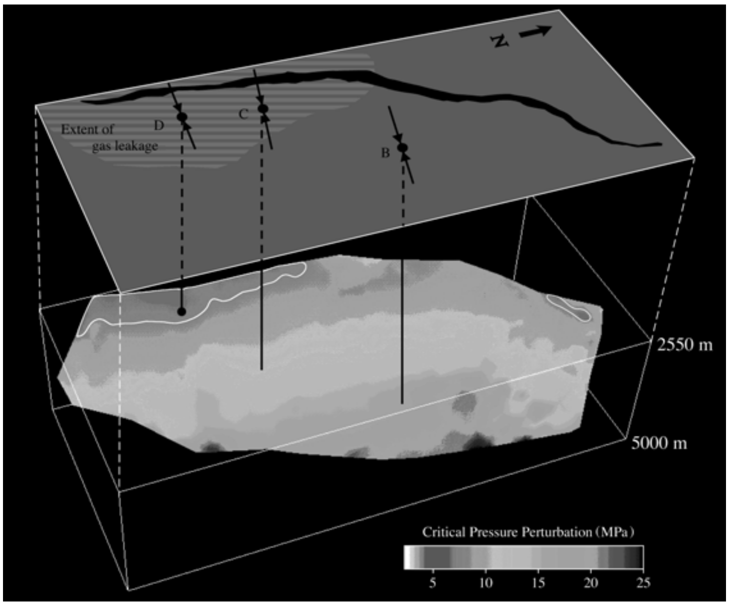

Figure 1. Map view and perspective view of the A-Central fault as determined from a three-dimensional seismic reflection survey. The map view shows the region of gas leakage inferred from reduced seismic reflectivity as well as the orientation of the maximum horizontal stress inferred from drilling induced tensile fractures observed in the three wells closest to the fault. The perspective view is shaded to show the excess pore pressure (critical pressure perturbation) needed to induce fault slip in the current stress field. The white contours indicate portions of the fault that require an excess pore pressure less than approximately 7 MPa above the reference pore pressure to cause fault slip. The largest part of the fault that is most likely to slip corresponds to that which appears to be leaking.