# AN INTEGRATED, QUANTITATIVE APPROACH TO ASSESSING FAULT SEAL RISK.

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Fault sealing is one of the key factors controlling hydrocarbon accumulations and trap volumetrics and can be a significant influence on reservoir performance during production. Fault seal is, therefore, a major exploration and production uncertainty. We introduce a systematic framework within which the geological risk of faults trapping hydrocarbons may be assessed.

A fault may seal if deformation processes have created a membrane seal or if it juxtaposes sealing rocks against reservoir rocks, and the fault has not been reactivated subsequent to hydrocarbons charging the trap. It follows from this statement that the integrated probability of fault seal can be expressed as: $\{1 - [(1 - a)(1 - b)]\} \times (1 - c)$, where *a, b* and *c* are respectively the probabilities of deformation process sealing, juxtaposition sealing, and of the fault being reactivated subsequent to charge. This relationship provides an assessment of fault seal risk that integrates results from the critical parameters of fault seal analysis that can be incorporated into standard exploration procedures for estimating the probability for geological success. The integrated probability of fault seal for each prospect can be visualised using the fault seal risk web, which allows rapid comparison of success and failure cases through construction of prospect risk web profiles.

The impact of uncertainty (U) and the value of information (VOI) for each aspect of fault sealing on the overall fault seal risk may be determined via the construction of data webs and the relation $U = [1 - \{(\sum nw) / n\}] \times 100$, where *nw* is the value given to each data web parameter and *n* is the number of data web components. For example, the data web components required to assess fault reactivation risk are the orientation and magnitude of the in situ principal stresses, pore pressure, fault architecture and the geomechanical properties of the fault.

Risking of the Apollo prospect, Dampier sub-basin, North West Shelf, Australia is presented as a worked example. Fault seal risking for the Apollo prospect has been conducted on 10 ft and 100 ft oil columns to allow integration with volumetric probabilistic statements. The critical parameter for fault seal risking at the Apollo prospect is the ability of disaggregation zone faults (low SGR fault gouge) to support increasingly large hydrocarbon columns. Evaluation of the individual components of fault sealing indicates $a = 0.3$ (10 ft column) and $a = 0.1$(100 ft column), $b = 0.2$, and $c = 0.1$. The overall probability of the Apollo trap-bounding fault sealing a 10 ft oil column is 0.4 or 40% (seal condition moderately unlikely). The likelihood the fault seals oil columns >100 ft is 0.3 (seal condition unlikely). Data web error margins for the Apollo prospect are 20% (juxtaposition uncertainty), 26% (fault rock process uncertainty) and 27% (fault reactivation uncertainty). Recalculating each parameter by its uncertainty, for a 10 ft oil column the upper value of integrated fault seal risk is 0.5 (seal condition intermediate), and the lower value is 0.3 (seal condition unlikely). The upper value of integrated fault seal risk for a 100 ft oil column is 0.3 (seal condition unlikely) and the lower value is 0.2 (seal condition very unlikely). The variation in the Apollo final risk calculation reflects the lack of prospect specific data. The greatest VOI benefit for Apollo fault seal prospectivity is sedimentary architecture data.