REALISTIC FAULT DESCRIPTION FOR RESERVOIR MODELLING

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The most important aspect of fault seal is fault geometry. For the purpose of analysing a reservoir fault geometry is most efficiently represented as part of a fully integrated 3D reservoir model. In any 3D model fault geometry is one of the more difficult aspects to generate, but also happens to be one of its most important parameters. Furthermore, there are considerable uncertainties associated with both fault and structural geometries. Therefore any realistic reservoir model not only needs to make a realistic representation of the reservoir in question, it also needs to be able to handle its associated uncertainties.

Faults are usually mapped from seismic data and resulting interpretations contain only information above seismic resolution (typically 10-30m fault displacement). Only rarely can additional information constraining seismic scale fault geometry be obtained from well data. Seismic data contains many errors in fault imaging which are generally associated with migration. Commonly these lead to incorrect fault locations of many 10's of metres, poor definition of fault surface geometry and poor resolution of important geometrical features. Seismic imaging of faults is continuing to improve, but still many errors persist. Fault interpretation can generally be described as a subjective science. The detail and accuracy to which a set of faults can be interpreted depends largely on the time available and the personal interests/inclinations of the interpreter. Such a subjective approach also leads to errors and can lead to over simplification of fault related structures which may be critical to fault continuity and subsequently to reservoir performance predictions. Fault interpretations are usually a single deterministic realisation. Although the interpreter knows that different interpretations of the data are possible, alternative realisations are rarely produced. Some advances have been made in an attempting to autotrack faults, however these techniques are not yet commonly applied and are not universally applicable to all geological situations. However they do have the advantage that they are repeatable and they can estimate the constraints fault location error.

A good faulted reservoir model not only contains an accurate representation of the fault surfaces, but also a realistic representation of seismic and geological horizons. Seismic horizons not only define the shape of a reservoir, but also define the displacement along fault surfaces. The problem with the definition of fault displacement relates to poor imaging of horizons around faults. Horizon autotracking and/or manual interpretation can be used to constrain horizons around faults, but it is not unusual to produce errors of >10m in a fault's displacement. This often leads to highly variable displacements along individual faults. Some horizon based modelling techniques try to overcome these errors by using horizon projection techniques, but these do not always lead to significant improvements.

Seismic data only gives information at the scale above seismic resolution. Therefore in any seismic interpretation care has to be taken that seismically continuous faults may in fact be segmented by sub-seismic relay structures and seismically defined relay structures may be connected by small-scale faults. Both of which will have a substantial impact on reservoir performance if they are ignored.

A number of algorithms exist for predicting the sealing properties of faults, in particular the estimation of fault thickness and permeability, which are used to calculate fault transmissibilities. These algorithms use empirical relationships (eg between SGR and permeability or fault thickness and displacement), which are determined from data with a significant spread. Furthermore these fault seal algorithms rely on a detailed stratigraphic model and a good structural representation, which have their own associated uncertainties. A stochastic approach is therefore recommended to account for all uncertainties associated with fault seal and transmissibility multiplier calculations.

In order to make a realistic, high quality reservoir model, it is necessary to use a 3D modelling tool that is fast, accurate and repeatable. The modelling tool must be able to build fault surfaces as mapped from the seismic data and include horizons with realistic representation of both seismic and geological horizons. However this leads to a single deterministic realisation. Considering the errors that have been outlined above, a single realisation must be wrong and will never cover the range of possibilities available within the constraints of the data. Therefore a multi-deterministic or stochastic approach must be taken whereby a number of realisations are built which cover the possible range in structural uncertainties. Such a model will include horizon, fault geometry, fault seal and reservoir properties as uncertainties. Currently the available 3D reservoir modelling tools are only capable of building single deterministic realisations and many of these are not very efficient or accurate in the area of fault modelling. Many improvements are required, both in maturing existing methods, but also in developing new and better fault modelling techniques. Furthermore the introduction of a stochastic based structural model has only so far been introduced in a few research codes, which still need considerable effort to develop these into commercial products.