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Determining Well Connectivity - Topological Modelling of Natural and Synthetic Fracture Systems

Naturally fractured reservoirs are playing an ever increasing role in oil company portfolios. Stochastic models of discrete fracture networks (DFN) are being used to generate reservoir properties for full field flow simulations. The validation of such DFN models is a key component in both exploration and development plans.

Such validation can be achieved by undertaking flow simulations of the fracture networks, history matching against well pressure tests and 'tuning' the petrophysical parameters of the fracture networks until a match is achieved. However this is time consuming and the history can often be matched by a wide range of tuned parameters and by multiple combinations of parameters.

Topological analysis of DFNs provides a useful tool for validation of synthetic fracture networks and for the connectivity analysis of natural systems. Decoupling of topological characteristics from the actual fracture geometry permits depiction of both two- or three-dimensional fractures and their intersections as vertices and edges in a graph representation. This analyses is rapid and allows multiple fracture sets to be analysed and a decision-based approach to be used.

There are a number of geologically valid analyses that may be undertaken. These include; connected-component analysis to identify groups of mutually connected fractures; topological shortest path analysis; computation of fracture hierarchies; determination of mutual connectivity (topological distance) and identification of the best connected fractures in the network.

Furthermore, by incorporating wells into the graph the degree of connectivity between, for example, injection and production wells can be determined without recourse to physical flow modelling.