Spatial Modeling and Prediction of Fractures and Small-Scale Faults in Reservoirs

Renjun Wen
Geomodeling Research Corporation, Calgary, Canada, T2P, 3E5, e-mail: renjun@telusplanet.net. http://www.geomodeling.com

Abstract

Fractures and small faults are numerous in many reservoirs. They are known to have a large impact to reservoir management at several stages, from in-fill drilling to heterogeneity modeling in production forecasting. However, fractures and faults with displacement less than ca. 10 m are not observable on seismic images, except on cores and FMS images at few well locations. This talk presents an integrated approach to model and predict spatial distributions of small faults and fractures in reservoirs. The approach integrates all available geological and geophysical information related to fractures and faults in a computerized model.

The conceptual model of geologists plays a commanding role in the quantitative modeling of fractures and faults. A spatial stochastic model, instead of geomechanical model, has been chosen to represent spatial distributions of fractures and faults in a reservoir. Such a model is very convenient to capture major characteristics in the conceptual model. The spatial pattern of fractures and faults can be quantitatively modeled by a pair-correlation, whereas the orientation distribution of fractures is shown to be insufficient to describe a fracture pattern. The size distribution of fractures and faults can be modeled by a fractal or log-normal distribution, which allows us to predict the number of fractures and faults below the resolution limit of seismic data. Pitfalls of applying a scale-independent fractal model will be analyzed. The spatial density function of large faults can be estimated from mapped faults. Under certain assumptions, the density of large faults can be used to predict the density of small faults and fractures.

The spatial prediction of fractures and small-scale faults is made possible by generating multiple realizations of fractures and faults by conditional simulations of the spatial stochastic model. Each realization honors all available data, including large faults observed from seismic data and small faults and fractures observed at well locations. Probability of meeting at least one (or more) faults within a selected size range (e.g., between 1 and 5 meters of displacement) can be calculated from realizations at every location. The method has been validated by reproducing statistically similar fault patterns of artificially removed small-faults interpreted from 3D seismic data. Application examples in North Sea oil fields will be presented. The talk will be ended by a brief demonstration of software.

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