Using Geomechanical Modeling to Constrain Discrete Fracture Networks and Fractured Reservoir Permeability Structure

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Fractured reservoir models are used for many purposes, from prospect generation and well planning, reservoir simulation and depletion planning, to risk assessment and reserve calculations. Discrete Fracture Network (DFN) models constructed from seismic data, facies models, borehole image data and dynamic data provide the most robust estimates of fracture permeability for use in full-field reservoir simulation. However, the results of geomechanical modeling are generally not directly integrated into DFN models.

We use a boundary element / elastic dislocation approach to forward model strains related to faulting. Elastic dislocation (ED) theory is widely used by seismologists to predict surface deformation following earthquakes. The displacement boundary conditions on the modeled faults along with the regional strains are used to determine the strain tensor at a predefined set of solution points. The stress tensor is computed from the strain tensor so that the orientation and magnitudes of the principal stresses, the relative intensity and the mode and most-likely orientations of failure through the reservoir are determined.

Predictions of fracturing from the elastic dislocation model are tested and calibrated against "ground truth" data, including observed fracture density and orientation data from borehole image logs. A DFN is constructed by combining this information with 3D facies distributions. Fracture permeability is calibrated to field dynamic data by simulating fluid flow in the DFN. The final model provides fracture permeability, porosity, and equivalent matrix block dimensions for each model cell, which vary as a function 1. facies distribution, 2. observed well data, 3. predicted strains, 4. predicted failure mode, and 5. predicted failure orientations.