Fracture Modeling with Seismic Constraints

Model Fracture Density, Orientation, Dispersion

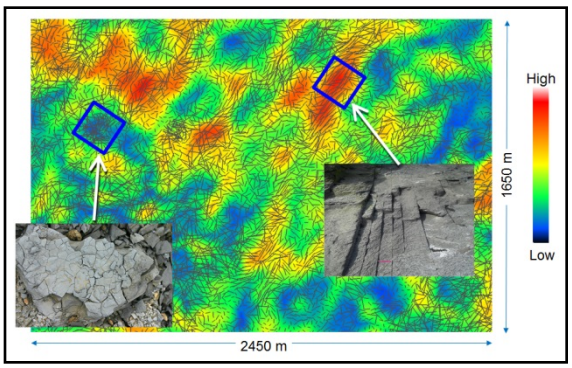
iReservoir workflow and examples for estimating Natural Fractures from Seismic Data with application to Discrete (DFN) and Continuous (CFM) Fracture Network Modeling for Flow-Simulation

iReservoir uses a seismic based statistical methodology to estimate fracture orientation and dispersion for single dominate fracture sets and also for multiple fracture sets using seismically-calculated 3D structural attributes. The dispersion parameter, the circular variance, can be easily be associated with the Fisher coefficient, a key parameter in the probability density function used in discrete fracture network modeling (DFN) to stochastically constrain discrete fracture orientations. These same seismic apparent-fracture density and fracture set orientation grids can be used as fast-CFM fracture constraint input to flow simulation models before any DFN networks are created or finalized. These same seismic apparent-fracture property grids can be used stand-alone for high-grading exploration well locations.

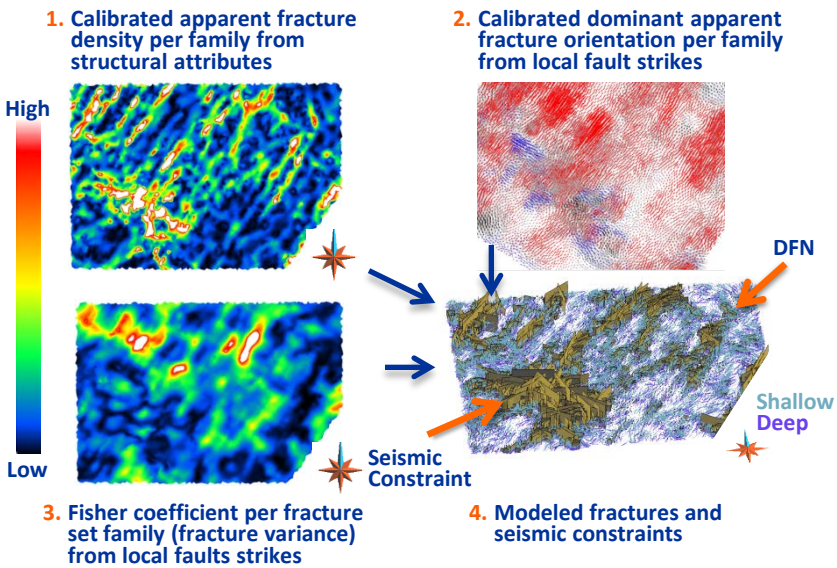
Variability in Fracture Dispersion (Fisher Coefficient)

Examples of Fractured Shale Pavement Outcrops

From Local Orientations to Fisher Coefficient



Seismic Input for CFM or DFN Modeling

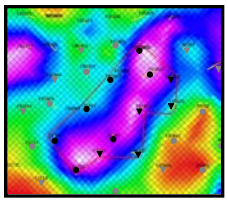


Seismic Fracture Constraints for Flow Simulation

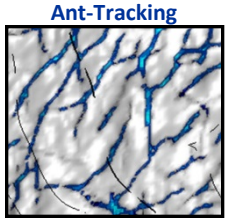
The iReservoir seismic fracture workflow is documented in URTeC paper 1581308 and The Leading Edge (Dec. 2013, 1502-1512) using seismic constrained DFN model examples for fractured flow simulations showing possible pressure implications for drainage of naturally fractured, unconventional reservoirs.

Stochastic: Discrete Fracture Network (DFN)

Excess Perm



Ant-Tracking



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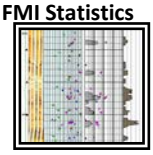
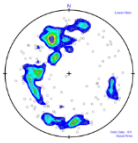
Golder's Fracman or FRED

FMI Statistics





Fracture Rules

- Orientation dist.
- Fracture height dist.
- Fracture length dist.
- Fracture aperture dist.
- Fault damage zone
- Fracture intensity by Facies
- Background intensity etc

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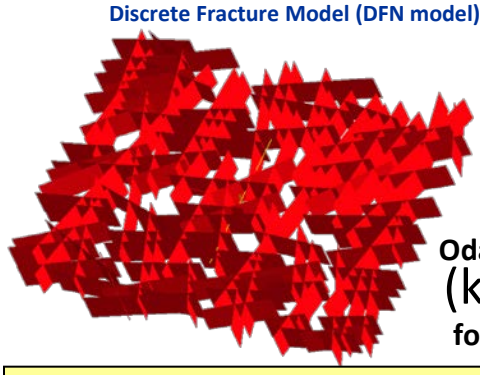
Discrete Fracture Model (DFN model)

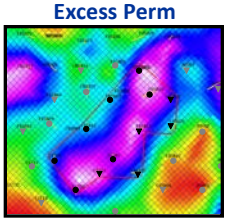


Oda Upscaling (k_f, ϕ_f, σ) for flow-sim

DFN used to create ECL Fracture Properties for Dual Porosity or Dual Perm models

Deterministic: Continuous Fracture Network "Models" (CFM)

Excess Perm



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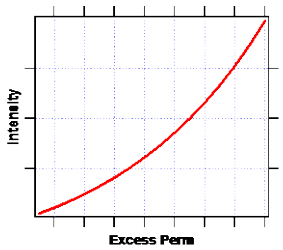

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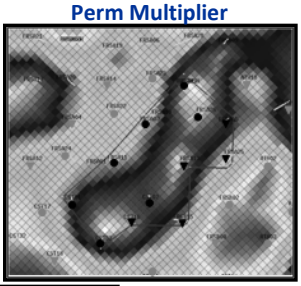
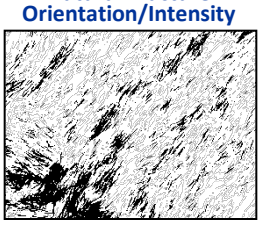
Perm Multiplier



Natural Fracture Orientation/Intensity



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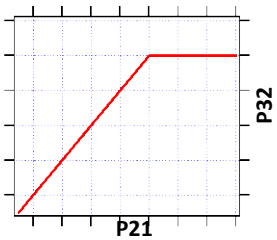

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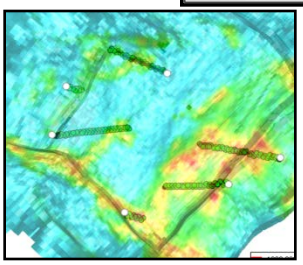


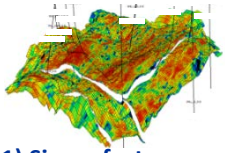
Total ECL Perm Multipliers

Calibrated Fracture Properties

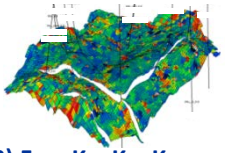
CFM Model (k_f, ϕ_f, σ) to flow-sim

Attributes Mapped to Flow Simulation Grid

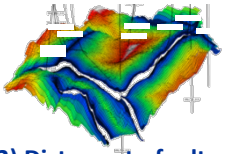
Fracture Properties (per family and type)



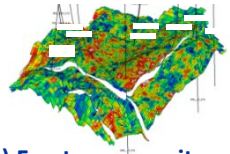
1) Sigma factor



2) Frac Kx, Kx, Kz



3) Distance to faults



4) Fracture porosity

Flow Sim Results: Pressure Field after 100 Days