CHARACTERIZATION OF FRACTURES AND THEIR EFFECT ON RESERVOIR DIRECTIONAL FLOW IN TENSLEEP SANDSTONES, WYOMING

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TENSLEEP SANDSTONE RESERVOIRS, WYOMING

Presented Reservoir

Major Reservoirs
Cores
Outcrops

Eolian Sandstone

Marine Carbonate
TENSLEEP PRODUCTION

Water Cut (%) vs. Recovery Factor (%) plot.
FRACTURE TYPES IN TENSLEEP SANDSTONES

- Gouge-filled fractures
- Mineral-filled fractures
- Partially-filled fractures
- Open fractures

Barriers or baffles

Conduits
Gouge-filled Fractures in Cores
Gouge-filled Fractures
Mineral-filled Fractures in Cores
Mineral-filled Fractures in Outcrops
Partially-filled Fractures in Cores
Open Fractures in Cores
FAULT AND FRACTURE DISTRIBUTION IN OUTCROPS

Flat Top Mountain
Gouge-filled fractures on Outcrops

Brokenback Anticline
Bighorn Mountain

Sinks Canyon
Wind River Range

Zeisman Dome
Bighorn Mountain

Cottonwood Creek
Ferris Mountain
FRACTURE PERMEABILITY AND FRACTURE ORIENTATION IN A RESERVOIR

- 3-D reservoir structure construction
- Curvature calculation to indicate fracture intensity
- Average matrix permeabilities of wells from core analysis and well log data
- Total permeabilities of wells from matching wells’ production history
- Multi-well flow simulation to verify fracture orientation and estimate average fracture/matrix permeability ratio
FRACTURE DISTRIBUTION IN CORES
(From the Presented Tensleep Reservoir)
Fracture Spacing vs. Core Porosity

Average Fracture Spacing (ft) vs. Average Porosity (%)

- 8 ft at 5% porosity
- 8.5 ft at 7% porosity

Average core porosity

ESTIMATED TOTAL PERMEABILITY FROM PRODUCTION HISTORY

vs

AVERAGE MATRIX PERMEABILITY FROM CORES AND WELL LOGS

estimated permeability from production – average permeability = fracture permeability (+ -)
DISTRIBUTION OF MATRIX PERMEABILITY
DISTRIBUTION OF FRACTURE PERMEABILITY

Fracture Permeability
- Permeability (Total Perm>Matrix Perm)
- Permeability (Total Perm<Matrix Perm)
CURVATURE DISTRIBUTION FOR THE PRESENTED RESERVOIR STRUCTURE

Gaussian Curvature  Maximum Curvature  Minimum Curvature

Mean Curvature  Dip Curvature  Strike Curvature
Curvature vs. Fracture Permeability

- Curvatures, $10^{-6}$/ft ($10^{-9}$/ft for Gaussian Curvature)
- Difference between Production Perm. and Log Correlation Perm., md

Legend:
- Maximum
- Minimum
- Gaussian
- Mean
- Dip
- Strike
WELL INTERFERENCE TEST

Fracture Orientation

Observation Well
Active Well
Measured and Simulated BHP Drop Down in Well 12
(from well interference test)

Simulation matched permeabilities:
Permeability at N30°E (Ky) = 18 md
Permeability at S60°E (Kx) = 3 md
CONCLUSIONS & APPLICATIONS

- Four different types of fractures are observed in the Tensleep well cores and outcrops: gouge-filled, mineral-filled, partially-filled, and open fractures.
- Open and partially-filled fractures can act as conduits for reservoir flow, whereas gouge- and mineral-filled fractures can act as barriers or baffles.
- Fracture permeability is estimated by subtracting average matrix permeability (from core analysis and log data) from total permeability (calculated from production history).
- Curvatures calculated from 3-D reservoir structure may predict fracture intensity but show no good correlation with fracture permeability in the Tensleep sandstones.
- Fracture orientation is obtained through well interference tests.
- Multi-well flow simulation is used to verify fracture orientation and estimate average fracture/matrix permeability ratio.