Fracture Stimulation in the Redevelopment of a Mature Waterflood (SPE 76723)

Case Study: Elk Hills Field, CA
MBB Reservoir

- Average depth 6500 ft [1,981 m]
- Turbidite sands within ‘B’ member of Miocene Monterey formation
  - Average porosity 18 – 24 percent
  - Average air perms 10 – 250 md
- Discovered in 1941 but ‘opened-up’ in 1976; initial rates 500–2000 BOPD/well [80–318 m³/d per well]
- Peripheral flood initiated 1978
Location of Elk Hills Field

Main Body B (MBB) Waterflood Optimization

- Peripheral flood successful except in ‘tight rock’ area, but
- Surveillance activities demonstrated that higher perm sands were very efficiently swept, but poorer quality or discontinuous sands were not
- Fracture stimulations applied to exploit unswept sands
- Major challenge: to contain treatments with the objective sands and avoid propagating into high perm, high pressured (flooded) sands above or below
B Interval Members Log Character


Figure 5 – Type logs for 31S and Main Body B Reservoir
MBB Bypassed Oil

MBB RFT Showing Differential Sweep

Vertical Pressure Profile: Well 316X-35S

Figure 12 - 316X-35S log showing pressure profile

MBB Waterflood Fronts

Relative Positions of Flood Fronts, SE Nose TVT Net Sand UBB3U&L and UBB4


Figure 11 - Relative Positions of Flood Fronts, SE Nose TVT Net Sand UBB3U&L and UBB4
Elements of Optimization Planning

- Detailed in-situ stress profiling
- Perforation placement options
- Hydraulic fracture modeling
- Models calibrated to previous MBB treating pressure responses
- Models then used to predict fracture height growth and contact with adjacent water bearing intervals
Execution of Frac Treatments

- Front-end diagnostic injection test
  - Refine stress and leakoff profiles
  - Determine quality of near wellbore connection

- Real-time assessment of proppant distribution to limit overall net pressure development and minimize vertical fracture growth

- Employed downhole tiltmeter deformation mapping to measure fracture geometry

- Used surface tiltmeter mapping to evaluate fracture orientation (azimuth and dip) and horizontal fracture component
Example MBB Fracture Performance

Results To Date

- Generally successful in confining fracs to desired intervals
- Oil production in project area has doubled, with only 40% increase in water production
- Significant reserve additions and EUR increases
Performance of Waterflood Redevelopment Area


Figure 24 – South East Nose Production Curve