Case Study

Ash Minnelusa Unit Sweep Improvement

Jim Mack
MTech Ventures LLC
Denver, Colorado
# Ash Minnelusa Sand Unit Reservoir Data

| General: | July 3, 1987  
|          | Minnelusa “B” Sandstone  
|          | Stratigraphic  
|          | 7775  
|          | Rock and Fluid Expansion  
|          | 40 Acre  |
| Rock Properties: | Permeability Range  
|          | 5 – 3000 md  
|          | Average Permeability  
|          | 300 md  
|          | Permeability Variation  
|          | 0.746  
|          | Average Porosity  
|          | 16.3%  
|          | Average Water Saturation  
|          | 15.5%  
|          | Temperature  
|          | 140°F  |
| Fluid Properties: | Formation Volume Factor  
|          | 1.01  
|          | Oil Viscosity  
|          | 30 cps  
|          | Oil Gravity  
|          | 20°API  |
| Injection Data: | Cumulative Polymer  
|          | 33.6% PV  
|          | Cumulative Water  
|          | 138.4% PV  
|          | Cumulative Total  
|          | 172.0%PV  |
| Recovery Data: | OOIP  
|          | 2,170 MSTBO  
|          | Primary Recovery  
|          | 14.1% OOIP  
|          | Current Oil Recovery  
|          | 45.4% OOIP  |
Total Field Production

Ash Minnelusa Sand Unit

Monthly Production & Conc (mg/L)

May 86  Aug 87  Dec 88  May 89  Aug 90  Sept 91  Jan 93

BOPM

BWPM
## Ash Minnelusa Sand Unit
### Polymer-Augmented Processes

<table>
<thead>
<tr>
<th>Process</th>
<th>BBLs</th>
<th>% Pore Volume</th>
<th>Avg. Polymer Conc, mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility Control</td>
<td>424,598</td>
<td>16.3</td>
<td>705</td>
</tr>
</tbody>
</table>
Production Efficiency

Ash Minnelusa Sand Unit

- Cumulative Oil Recovery (MBBLs)
- Water - Oil Ratio

Start Mobility Polymer
Injection Wellhead Pressure and Producing Well Hydrostatic Pressure

Ash Minnelusa Sand Unit

Hydrostatic Pressure (psi)
Injection Pressure (psi)

Cumulative Injection (MBBLS)
## Ash Minnelusa Sand Unit
### Polymer-Augmented Processes

<table>
<thead>
<tr>
<th>Process</th>
<th>BBLs</th>
<th>% Pore Volume</th>
<th>Avg. Polymer Conc, mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility Control</td>
<td>424,598</td>
<td>16.3</td>
<td>705</td>
</tr>
<tr>
<td>CDG</td>
<td>180,000</td>
<td>6.9</td>
<td>431</td>
</tr>
</tbody>
</table>
Ash Minnelusa Sand Unit

Cumulative Injection (MBBLs) vs. Cumulative Pressure, PSI-Days (M) plot.

Start CDG's indicator on the plot.
Total Field Production

Ash Minnelusa Sand Unit

Start CDG’s

Monthly Production (BBLs, Conc, mg/L)

Input / Output Ratio

BOPM
BWPM
Chloride (mg/L)
Polymer (mg/L)
Production Efficiency

Ash Minnelusa Sand Unit

Cumulative Oil Recovery (MBBLS)

Water – Oil Ratio

Start CDG’s

Start Mobility Polymer

0 100 200 300 400 500 600

0 0.01 0.1 1 10

0 100 200 300 400 500 600

Cumulative Oil Recovery (MBBLS)
## Ash Minnelusa Sand Unit
### Polymer Augmented Processes

<table>
<thead>
<tr>
<th>Process</th>
<th>BBLS</th>
<th>% Pore Volume</th>
<th>Avg Polymer Conc, mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility Control</td>
<td>424,598</td>
<td>16.3</td>
<td>705</td>
</tr>
<tr>
<td>CDG</td>
<td>180,000</td>
<td>6.9</td>
<td>431</td>
</tr>
<tr>
<td>Bulk Gel (MARCIT)</td>
<td>10,192</td>
<td>0.4</td>
<td>1,500 2,250 3,000 4,000</td>
</tr>
</tbody>
</table>
Total Field Production

Ash Minnelusa Sand Unit

Monthly Production (BBLS, Conc, mg/L)

Start CDG’s  Bulk Gels MARCIT  End CDG’s

Input / Output Ratio

BOPM  BWPM  Input / Output  Chloride (mg/L)  Polymer (mg/L)
Production Efficiency

Ash Minnelusa Sand Unit

Cumulative Oil Recovery (MBBLs) vs. Water - Oil Ratio

- Start WF
- Start Mobility Polymer
- Start CDG’s
- End CDG’s

Bulk Gels MARCIT
Injection Efficiency

Ash Minnelusa Sand Unit

Cumulative Oil (MBBLs)

Cumulative Injection (BBLs)

End CDG’s

Bulk Gels MARCIT

Start CDG’s
Total Field Production

Ash Minnelusa Unit - Field Production

- Oil Production - BOPM
- Water Production - BWPM
Production Efficiency

Ash Minnelusa Unit
Water-Oil Ratio vs. Cumulative Oil Recovery

> 400,000 STB Incremental Oil

Cumulative Oil Recovery
Ash Minnelusa Unit Conclusions

- Monitor, monitor, monitor. Make changes based upon reservoir response
- Improved understanding of the problem improves process application and results
- Volumetric sweep (gels) should be applied before mobility control
- Implement gel processes early for maximum benefits
- Incremental oil expected to exceed 400,000 BBLS (18.4% OOIP) for $0.88/BBL
- Field experience is critical with gel processes. Experience at Ash can be applied to other reservoirs.