Elk Petroleum, Inc.

Grieve Field, Natrona County, WY
CO$_2$ Potential
Key Reservoir Parameters

- **Formation**: Cretaceous Muddy “Grieve Sand”
- **Average Depth**: 6900 feet
- **Porosity**: 20.4% Average Core
- **Permeability**: 220 md Average Core
- **Average Thickness**: 45 feet
- **Original Oil/Gas Column**: Oil - 700 feet; Gas - 900 feet
- **Original Gas/Oil/Water Contact**: O/W - 70
- **Gas Oil Ratio**: 861:1
- **Initial Pressure**: 2950 psi SIP DST (datum +106)
- **Drive Mechanism**: Gas expansion and partial water drive
- **Character of oil and gas**: Oil gravity - 37° API, Gas 1168 BTU
- **Cumulative Production 9/03**: 29,932 MBO, 71,438 BCFG, 32,861 MBW
- **Average Dip**: 15°
Field Production History
Why CO$_2$?

- Almost 30 million barrels produced through gas cycling
- No secondary water-flood
- Excellent reservoir: thickness, quality, and depth
- A discrete reservoir with good top, bottom and lateral seals
- 30 useable well bores in the unit
  - 28 Shut in and pressure tested
  - 1 Producing oil well (#9 ➔ 15 BOPD)
  - 1 Water disposal well
- Centrally located with good access to pipelines and natural gas reserves in both the Wind River and Powder River Basins.
- Good Production, Pressure and Reservoir information to provide a good model for CO2 feasibility.
EORI Timeline

• First contact in January, 2007
• Contact signed April, 2007
• Three primary parts to study:
  – Stratigraphic core study: Beverly DeJarnett
  – Reservoir Petrology: Peigui Yin
  – Reservoir history match & simulation: Shaochang Wo
• Initial completion date: end of September, 2007
Gross Sand/Structure Map

Structure with 15° dips and a well defined reservoir pinch-out.

Field geometry provides a virtual storage tank.

Net sand contour interval = 5'
Structure contour interval = 200'
Maximum core permeability > 2 Darcies

Samples above 15% porosity and 100 md dominate the sample distribution
Stratigraphic Core Study

Facies A: Fine to medium-grained cross-stratified sandstone

Facies B: Very fine-grained rippled sandstone

Facies C: Very fine-grained muddy boiturbate sandstone
Grieve #12 Muddy Core
Grieve #20 Muddy Core
Grieve Muddy Sandstone: Porosity vs. Permeability by Facies

- **Facies A**: Average Perm. 371, Average Pore. 21.5
- **Facies B**: Average Perm. 130, Average Pore. 17.9
- **Facies C**: Average Perm. 26.1, Average Pore. 14.7
- **Facies SS**: Average Perm. 7.4, Average Pore. 12.8
Minimal Pressure Maintenance

Grieve Field Pressure History

- Low on Structure
- Gas Pressure
Figure 2. A 3D view of original fluid distributions where the gas-oil contact is set at 675 ft above the sea level and oil-water contact is set at -73 ft below the sea level.

Figure 3. A bottom view of the grid pore volume distribution above the oil-water contact.
Figure 21. Initial oil, gas, and water distributions in August 1954, top view (left) and bottom view (right).
Figure 23. Ternary view of simulated oil, gas, and water distributions in March 1992, top view (left) and bottom view (right).
Figure 43. Ternary view of oil, gas, and water distributions at the beginning of CO2 injection in Scenario 3, top view (left) and bottom view (right).
Figure 15. Well bottom-hole pressures measured from pressure build-up tests in comparison with history matched reservoir average pressure.
Figure 30. Reservoir pressure at the beginning of CO2 injection and injection/production well locations.
Figure 32. Field CO2 injection rates of the three simulated scenarios.
Figure 33. Field cumulative CO2 injection volumes of the three simulated scenarios.
Figure 43. Ternary view of oil, gas, and water distributions at the beginning of CO2 injection in Scenario 3, top view (left) and bottom view (right).
Figure 44. Ternary view of oil, gas, and water distributions after 27 months of CO2 injection followed by 21-month injection/production in Scenario 3, top view (left) and bottom view (right).
Figure 45. Ternary view of oil, gas, and water distributions at the end of a 14-year CO2 flooding operation in Scenario 3, top view (left) and bottom view (right).
Figure 34. Field oil production rates of the three simulated scenarios.
Figure 35. Field cumulative oil productions of the three simulated scenarios.
Solid: Observed
Green: Calculated
Key Operational Constraints:

- A maximum of 50 MMSCF/D of CO2 will be available for purchase;
- Up to 100 MMSCF/D produced gas can be processed for reinjection.
NITEC Projections

**Prediction Summary**

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<th>L1</th>
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<th>L3</th>
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<td>OOIP (MSTB)</td>
<td>16,106</td>
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<td>Np@1/2007 (MSTB)</td>
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<td>NPac (2007-2035) (MSTB)</td>
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**Average Annual Field Rates**

*Base Case*

- **Oil Rate (STBD)**
- **Gas Prod**
- **CO2 Inj**

**Key Parameters**

- Incremental Np@2035 (MSTB): 18,924
- Incr Recovery (% of OOIP): 28.0%
- CO₂ Purchased (MMSCF): 170,932
- CO₂ Injected (MMSCF): 748,960
- CO₂ Utilization (MSCF/STB): 9.0
- CO₂ Injection (MSCF/STB): 39.6
- Time to Oil Peak Rate (months): 48
- Peak Oil Rate (STB/D): 10,000
- Np @ fifth year (MSTB): 6,838
- Time to First Oil Prod (100 STB/D): 22
These two studies have resulted in a Ryder Scott reserve certification of 18.6 million barrels of Possible (3P) reserves.

Ryder Scott has also valued this Enhanced Oil Recovery project at $305 million (unrisked NPV10)

The values assumes $85/bbl oil.
New Birth for an Old Field!

*Baby Elk photo taken in Grieve Field May 18, 2008