Structural Architecture, Petroleum Systems, and Geological Implications for the Covenant Field Discovery, Sevier County, Utah

By
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Abstract

Structural analysis, seismic interpretation, and organic geochemistry are all part of the petroleum systems synthesis that contribute to the Covenant Field discovery in Central Utah by Wolverine Gas and Oil Corporation. The Kings Meadow Ranch 17-1 penetrates a highly porous and permeable reservoir in the Jurassic Navajo Sandstone which contains a 450-foot oil column. The Covenant Field is located along a frontal structural uplift to the Central Utah thrust belt, where Late Cretaceous – Early Tertiary compressional deformation resulted in the development of thrust faults and associated hanging wall anticlines buttressed against the ancestral Ephraim extensional fault. The traps are charged from Mississippian foreland basin sediments to the west of the discovery, and hydrocarbon generation was driven by the initial sedimentary loading (oil generation) followed by tectonic loading (gas generation) associated with the evolving thrust belt. Evaporite deposition in the overlying Arapien Formation provides a highly effective seal for the accumulations. Jurassic extensional faults may be critical in defining the location of thrust faults and antiformal stacks, which in turn define structural traps along this newly discovered onshore hydrocarbon province.
WOLVERINE GAS and OIL COMPANY
of UTAH, LLC
Energy Exploration in Partnership with the Environment

Structural Architecture, Petroleum Systems, and Geological Implications for the Covenant Field Discovery
Sevier County, Utah

Doug Strickland - Presenter

Co-Authors and special thanks to:

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 David A. Wavrek (Petroleum Systems International, Inc.)

Frank Royse, Jr., Paul Lamerson, Jim Medlin, Tadd Schermer, Bill Brown (Former Chevron employees)
Drilling 2003 *Christmas comes Early!*

Dec 22\textsuperscript{nd} Navajo at 5840 ft (instead of 7200 ft) with strong oil show

Dec 24\textsuperscript{th} established Nav-1 will flow and correlation to Rangely Weber oil

Nav-2 Duplex at 8150 ft

500' Oil Show Fluorescence Halo's
Utah Hingeline and Thrust Belt Province
Sevier County

- Utah Hingeline – Paleozoic Shelf Margin
- Wolverine Federal Unit – 65,980 acres
- Hydrocarbon Play
- Covenant Field – KMR 17-1
• Wyoming/NE Utah Thrust Belt

  – Fadel Gheit (Oppenheimer):

    “It’s very unlikely because U.S. onshore has been picked clean, if you will... That’s like finding a wallet in the subway after all the cleaners went through it. It’s possible, but very unlikely.”
Sevier County Stratigraphic Section

<table>
<thead>
<tr>
<th>Formation</th>
<th>Height (ft)</th>
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</thead>
<tbody>
<tr>
<td>Alvord, Columbia, Lake Baikal</td>
<td>1,400</td>
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<tr>
<td>Beryo Formation</td>
<td>700</td>
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<tr>
<td>Lower Member</td>
<td>700</td>
</tr>
<tr>
<td>Upper Member</td>
<td>1,000</td>
</tr>
<tr>
<td>Cassel Formation</td>
<td>500</td>
</tr>
<tr>
<td>North Horn Formation</td>
<td>1,400</td>
</tr>
<tr>
<td></td>
<td>5,550</td>
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</tbody>
</table>

- **Seal:** Arapien 5,550 ft

<table>
<thead>
<tr>
<th>Formation</th>
<th>Height (ft)</th>
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</thead>
<tbody>
<tr>
<td>Price Kim</td>
<td>1,500</td>
</tr>
<tr>
<td>Elsinore Canyon Formation</td>
<td>2,000</td>
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<tr>
<td>Funnel Valley Formation</td>
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<tr>
<td>Allen Valley Shale</td>
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<tr>
<td>Emery Shale</td>
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<tr>
<td>Cedar Mountain Shale</td>
<td>500</td>
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<tr>
<td></td>
<td>1,700</td>
</tr>
</tbody>
</table>

- **Reservoir:** Navajo 1,200 ft
  Twin Creek 350 ft

- **Dune face**
Arapien Valley Bedrock Geology

View East – Sanpete Valley
West flank of anticlinorium

Arapien Outcrop as first mapped by Dutton, 1870
Fed. 17-2 Mudlog
4300' – 5000'

Arapien Seal
Reservoir: Navajo
Navajo Sandstone Outcrops
Inter-dune Coarse Deposits

- Climbing Bedforms on Low Permeability Lacustrine base
- Stoss slope
- High permeability sands
- Wind
- Dune Cross-Strata
- Interdune Strata
Aeolian Anisotropy
Reservoir: Twin Creek
Pre-Drill Geology

- Pre-Drill, hanging wall anticline target at 7,200 feet
- 1981 Chevron well – 17,423’ (hanging wall and footwall)
- Modeled as simple fault-bend fold

Balanced Cross Section
D. Schelling, 2001

Arapian Shale
Navajo Sandstone
Seismic line over anticline
Post-Drill
Post-Drill Geology

- Post-Drill – duplexing of hanging wall
- Repeated Navajo
- Similar to Alberta Foothills structural style
“TRAP” Summary

Salina structure = large-scale fault bend fold
Passive-roof duplexing w/ detachment in Arapien
Tectonic repetition of Navajo section
Tertiary extensional faulting along Arapien detachment
Sequential unconformities define structural evolution of Salina trend
Role of thin-skinned deformation, passive-roof duplexing, and extensional faulting critical to trap-development at Covenant field
Covenant Field Status (May 24th 2005)

- Wells drilled in oil pay (6)
- Production rates (2 wells)
  - 1600 bopd
  - 160 bwpd
  - 40 API oil: low GOR

- Cum Production 5-2004 to date:
  - 286,479 BO for KMR 17-1
  - 2,977 BW
  - 397,698 BO for field

- Offset tests to drill (6) from 2 surface pads
  - 5,000 bopd CPF on line in Fall

Navajo Structure (ss) and proposed drilling

Navajo Structure Pre-Drill (ss)
We have drilled a small fault in the field.

Notice the oil/water contact in the 17-5 is 122 feet lower than the other wells.
KMR 17-1 Petrophysics

- Gross pay: 487’
- Net pay: 424’
- Average porosity: 12%
- Average Sw: 38%
- Net to Gross: 0.87
- Perm – up to 100mD
- Water Drive
• NVJO KMR 17-1 & Federal 17-2 Core Data
• Mississippian Paleogeography
New Paradigm SOURCE ROCK
Mississippian Formations

Summary:
- measured over 15%TOC
- corrected (PG) 25% TOC
- 1000+ ft over 2% TOC
- highly oil-prone OM
Hydrocarbon Generation – How it got started!

Neocomian (130 Ma) initial oil generation by sedimentary loading
Turonian (90Ma) initial “tectonic” loading drives gas generation
Foreland areas with rapid sediment loading provide wet gas charge
In short, the key to commercial charge is determining the formation
of the trap in context of the evolving kitchen areas (vs. burned out
kitchens and fault cutoff migration pathways)
Schematic Deformed and Restored Tectonic Cross Sections

revised from Wavrek (2001)
Federal Unit Prospect Generation Timeline

1957  Chevron drills Sigurd Unit #1
1981  Chevron drills Salina Unit #1 – great dipmeter and good analog for lithology
1995 & 1997 Chevron acquires seismic data
2000  Wolverine buys acreage from Chevron
      (April) SEISMIC License 120 miles Chevron
            GEOLOGY (reprocess – map)
                    Regional/Prospect
2001  GEOCHEM  Source study
      STRUCTURE  Timing of hydrocarbon migration
2002  FIND DRILLING PARTNERS
      N.A.P.E. (Houston)
      Prospect Exchange (Calgary)
2003  N.A.P.E. (Houston)
      Prospect shown to 65 Companies
      (July) FORM FEDERAL UNIT
      (Nov)  SPUDD  Wolverine Gas and Oil - Kings Meadow Ranches 17-1
2004  Complete discovery
2005  Develop Covenant Field
Finding costs (leasehold, G&G, drilling and completion):

$5.5 million

Fully developed costs (Covenant Field):

$56.3 million