Implementing Discriminative Water Saturation Criteria to Determine Prime Production Remnants in Morrow County*

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Abstract

The Morrow Consolidated Oil Field was analyzed as a part of a project examining the technical and economic feasibility of CO₂ utilization and storage in Ohio. The Morrow Field produces from the Copper Ridge Dolomite, also known as the Trempealeau Formation. After deposition of the Trempealeau, the area underwent large scale erosion, leaving behind remnants that become encased in the Wells Creek Shale. These remnants are irregular in size and distribution and serve as the primary reservoir for the field. Historically, these remnants have been difficult to identify. We present a method for identifying remnants including those with high production potential.

In total, 74 wells from the northeast portion of the field were analyzed for net to gross, porosity, and water saturation using Gamma Ray, Resistivity, Neutron Porosity, and Bulk Density wireline logs. Many of the wells in the study area did not penetrate the entire Trempealeau Formation; instead drilling was terminated between 50 and 100 feet from the top.

As such, a water saturation (Sw) cutoff criterion was identified to establish the bottom of the reservoir for uniform calculation purposes. When applied to the cross sections created for the field, the Sw cutoff helped distinguish between “elevated” remnants and non-remnants in study area. Additionally, good correlation exists between remnants identified with the water saturation cutoff and production data. Mapping the wells that met the water saturation cut off yielded a remnant map for the study area without the use of field wide seismic data.

Reference Cited


Selected Website

Implementing Discriminative Water Saturation Criteria to Determine Prime Production Remnants in Morrow County

American Association of Petroleum Geologists
Eastern Regional Meeting, Fall 2015
CO2 Utilization for Enhanced Oil Recovery and Geologic Storage in Ohio

- Funded by Ohio Coal Development Office (MRSCCP cost share)
  - Phase 1 - April 2014 to September 2015
  - Phase 2 - October 2015 to December 2017

- Research Goals
  - Develop process understanding and evaluate technical and economic feasibility of CO2 utilization and storage in Ohio’s depleted oil fields
  - Focus on Clinton sandstone and Knox dolomite formations (under-pressured, low permeability reservoirs with poor primary production)
  - Provide systematic assessment of EOR and geologic storage potential in these reservoirs
OCDO EOR: Morrow Consolidated Oil Field Analysis

- Knox Formation: Morrow Consolidated Oil Field
- Age: Cambrian
- Rock Type: Dolomite
- Play Type: Erosional Remnant
- Modern Analog: Ha Long Bay, Vietnam

http://www.scotese.com/
# Morrow County Stratigraphy

## Generalized Lithostratigraphy

<table>
<thead>
<tr>
<th>System</th>
<th>Series</th>
<th>Formation/Group</th>
<th>Depositional Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordovician</td>
<td>Upper</td>
<td>Queenston Sh</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cincinnati gp</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Utica Sh</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Point Pleasant Fm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lexington / Trenton Ls</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Black River Group</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wells Creek Fm</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>Lower</td>
<td>Beekmantown dol</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rose Run ss</td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td>Knox Dol</td>
<td>Upper Copper Ridge Dol</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper Ridge &quot;B-zone&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower Copper Ridge</td>
<td></td>
</tr>
<tr>
<td>Cambrian</td>
<td>Upper</td>
<td>Kerbel Fm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conasauga Gp</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>Mt. Simon Ss</td>
<td>Unnamed Conasauga ss</td>
<td></td>
</tr>
</tbody>
</table>

![Map of Morrow County Stratigraphy](image)
Morrow County Production History

- Originally discovered in 1959
- 177 MMBbls OOIP
- 46.3 MMBbls recovered
- 2,469 wells drilled

http://www.ohgeosoc.org/publications/017.pdf
Log Coverage
Type Log

Trenton
Black River
Copper Ridge
MCOF North-South

- Trenton
- Black River
- Copper Ridge
MCOF West-East
Problem: Most wells did not penetrate the full Copper Ridge Section

Solution: Utilize a Water Saturation Cutoff to delineate reservoir remnants
MCOF North-South with Water Saturation Cutoff
MCOF West-East with Water Saturation Cutoff
MCOF Copper Ridge Total Isopach
MCOF Copper Ridge Reservoir Isopach
## Copper Ridge Petrophysical Averages

<table>
<thead>
<tr>
<th></th>
<th>Gross</th>
<th>Net</th>
<th>Net to Gross</th>
<th>Average Porosity</th>
<th>Porosity Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>113</td>
<td>82</td>
<td>76%</td>
<td>6%</td>
<td>5</td>
</tr>
<tr>
<td>Range</td>
<td>3-545</td>
<td>3-248</td>
<td>30%-100%</td>
<td>3-9%</td>
<td>0-17</td>
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</tbody>
</table>

## Copper Ridge Petrophysical Averages with Sw Cutoff

<table>
<thead>
<tr>
<th></th>
<th>Gross</th>
<th>Net</th>
<th>Net to Gross</th>
<th>Average Porosity</th>
<th>Porosity Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>35</td>
<td>34</td>
<td>90%</td>
<td>7%</td>
<td>2</td>
</tr>
<tr>
<td>Range</td>
<td>3-128</td>
<td>3-128</td>
<td>0%-100%</td>
<td>3-18%</td>
<td>0-10</td>
</tr>
</tbody>
</table>
MCOF Structural Surface
The “GR Marker” is a lithologic marker bed observed on gamma ray-neutron logs in the MCOF (Dolly and Busch, 1972). The marker bed is a 10 ft argillaceous carbonate in the lower portion of the Black River Group. Pick was made at the base of the marker bed (base of the gamma ray signature).
MCOF Zones and Layers

- 4 horizons, 3 zones, and 17 layers.

<table>
<thead>
<tr>
<th>Morrow Consolidated Oil Field</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone</td>
<td># of Layers</td>
<td>Average Layer Thickness (ft)</td>
</tr>
<tr>
<td>Gamma Marker</td>
<td>1</td>
<td>131.4</td>
</tr>
<tr>
<td>Copper Ridge Reservoir</td>
<td>15</td>
<td>1.7</td>
</tr>
<tr>
<td>Base</td>
<td>1</td>
<td>108.6</td>
</tr>
</tbody>
</table>

* Copper Ridge Dolomite reservoir in red, water saturated Copper Ridge in blue
Model Surface Incorporating Reservoir Zone
Correlation to Production

Thickness

Porosity

Water Saturation

Production
MCOF Remnant - Production Bubble Map
Acknowledgements

- Ohio Development Services Agency Coal Development
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