Helicopter Magnetic and Methane Surveys

DCNR Natural Gas Advisory Committee Meeting
October 15, 2014
Locating Wells in Wyoming Oilfield

• 100-yr.-old oilfield undergoing tertiary recovery with \( \text{scCO}_2 \)
• \( \text{CO}_2 \) leaking to surface via annulus of old wells (poor cement)
• Operator decides to rework all existing wells
• At least 3000 existing wells; many well locations unknown or inaccurate
• Operator asked NETL for a rapid method to accurately locate wells in 40 sq. mi. oilfield

Areas where \( \text{CO}_2 \) emerged at the surface were covered with mesh to keep animals from suffocating
Locating Wells in Wyoming Oilfield

Approach

- Helicopter survey using two boom-mounted magnetometers
- Detects the unmistakable “bull's-eye” magnetic signature of vertical steel well casing

Results from Test Area

- Method located 100% of wells drilled for primary production (1912-1926)
- Method located 82% of wells drilled for secondary recovery (water flood, 1965-1990)
- Based on success locating old wells at test area, operator used helicopter method to survey entire oilfield
Results from Oilfield Survey

- Helicopter survey found more than 3500 well-type magnetic targets; about 1500 more than expected
- To date, 97% of well-type magnetic targets excavated by the operator have been wells
- Most importantly, the helicopter survey located wells beneath residences and businesses where the upward migrating CO$_2$ would have been a health hazard
Locating Wells in Teapot Dome Oilfield

Changes
- Flight line spacing- 25 m
- Nominal altitude- 20 m
- Post-processing to remove regional gradient and enhance well-type magnetic anomalies

Post-processing enhances well-type, magnetic anomalies and makes pipelines more visible
Locating Wells in Pennsylvania

Airborne Magnetic Survey

Map of Well-Type Magnetic Anomalies

Navigating to Magnetic Anomaly Location

Locating Magnetic Anomaly on the Ground

Excavation to Confirm Well Location
“it is proposed that operators be obliged to identify the location of orphaned and abandoned wells that fall within a 1,000 foot buffer of the horizontal and vertical section of a new wellbore prior to hydraulic fracturing of that well”

Proposed revisions to 15 PA Code Chapter 78 published in the Pennsylvania Bulletin on December 14, 2013 added section on Abandoned and Orphaned Well Identification (Section 78.52(a))
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How Accurate are Well Databases?

- PA IRIS database well positions often > 100 m from actual well locations
- 17 wells located in study area; six were in PA IRIS well database
- Some locations in PA IRIS well database were not close to any confirmed well
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Vertical steel well casing perturbs the earth’s magnetic field and causes the distinctive “bull’s eye” magnetic anomaly.

What if casing is missing because:

- Casing was pulled from sub-economic well to be reused in another well.
- Metal drives during World War II recovered well casing where possible to aid war effort.

Excavation of well where steel casing had been pulled; only the wooden surface conductor remained.
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What if Casing is Missing?

• This well with no casing still exhibits magnetic and conductive signatures at ground level.
Locating Wells in Pennsylvania

Historical air photos can be used to locate old wells in some areas
Helicopter Magnetic and Methane Surveys of PA State Lands with Legacy Oil and Gas Wells

Gray shading denotes legacy well density
### Scenarios Where Unconventional Shale Development May Communicate with Existing Wellbores

*(In collaboration with PA DEP and PA DCNR)*

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<th>Scenario #</th>
<th>Interactions Involved</th>
<th>Flight Area</th>
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<td>Marcellus Development/Oriskany Wellbores</td>
<td>Ole Bull State Park</td>
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<td>2</td>
<td>Upper Devonian Development/ Upper Devonian-Lower Mississippian Wellbores</td>
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<td>3</td>
<td>Utica Development/Clinton&amp; Medina Wellbores</td>
<td>Oil Creek State Park</td>
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Scenario 3

Marcellus
Oriskany
Well Communication-Marcellus Shale and Existing Oriskany Wells
Susquehannock SF
Helicopter Magnetic and Methane Surveys of PA State Lands with Legacy Oil and Gas Wells

Gray shading denotes legacy well density
Hillman State Park
Oil Creek State Park
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Legacy Well-Hillman State Park