Insights from regional well integrity datasets: challenges and future opportunities

Greg Lackey, Ph.D.
Research Engineer, Research & Innovation Center

(Sabbatino et al., 2017)
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Greg Lackey$^{1,2}$, Harihar Rajaram$^3$, James Bolander,$^4$ Owen A. Sherwood$^5$, Joseph N. Ryan$^6$, Chung Shih$^{1,2}$, Grant S. Bromhal$^1$, Robert M. Dilmore$^1$

$^1$National Energy Technology Laboratory, 626 Cochrans Mill Road, P.O. Box 10940, Pittsburgh, PA 15236-0940, USA

$^2$NETL Support Contractor, 626 Cochrans Mill Road, P.O. Box 10940, Pittsburgh, PA 15236-0940, USA

$^3$Johns Hopkins University, Baltimore, MD 21218

$^4$JLB Engineering, LLC, The Woodlands, TX 77380

$^5$Dalhousie University, 6299 South St, Halifax, NS B3H 4R2, Canada

$^6$University of Colorado Boulder, Boulder, CO 80309
Regional well integrity testing

- Sustained casing pressure (SCP) and/or casing-vent flow (CVF)
  - Fluid flow in an annulus outside the production casing
  - Indicative of a barrier flaw or gas invasion into well
  - Not all wells with SCP/CVF leak into groundwater
Regional well integrity testing

- Sustained casing pressure (SCP) and/or casing-vent flow (CVF)
  - Fluid flow in an annulus outside the production casing
  - Indicative of a barrier flaw or gas invasion into well
  - Not all wells with SCP/CVF leak into groundwater
- Regulatory agency and industry
- Routinely administered
- Publicly available
Canadian testing programs

- Alberta, British Columbia, and Saskatchewan
- Monitoring and management
  - CVF testing protocol
  - Serious and nonserious designation
  - Testing upon abandonment
- Leakage frequencies & trends

| Region | Wells tested | SCVF | References |
|--------|--------------|------|------------|
| AB     | >450,000     | 6.6% | Watson and Bachu, 2008; Bachu, 2017 |
| BC     | 21,525       | 10.8%| Wisen et al., 2020 |

(Sabbatino et al., 2017)
Testing programs in the US

- >900,000 active oil and gas wells
- SCP testing in the Gulf of Mexico

| Region | Wells tested | SCP | References       |
|--------|--------------|-----|-----------------|
| GOM    | 15,500       | 43% | Brufatto et al., 2003 |

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- Wattenberg Field

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| CO      | 3,923        | 13.8%| Lackey et al., 2017   |

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Project goal: build a bigger dataset for onshore wells
Patchwork of regulations

- Reviewed state databases
- Searched for:
  - SCP/CVF testing
  - Regional approach (100s-1,000s)
  - Publicly available records
- State programs that met criteria:
  - Colorado
  - New Mexico
  - Pennsylvania
Limited data availability

- Aggregated databases
- Document sorting
  - >575,000 documents
  - TensorFlow
- Text-based PDFs
- Image-based PDFs
  - >90,000 documents
  - Manual data entry web application

Entry Data

- Go Back
- Text Date (e.g. YYYY-MM-DD)
- 2011-06-28
- Initial Bradhead Pressure
- Initial Intermediate 1 Pressure
- Initial Intermediate 2 Pressure
- Initial Casing Pressure
- Initial Tubing Pressure
- Final Bradhead Pressure
- Final Intermediate 1 Pressure
- Final Intermediate 1 Pressure
- Final Casing Pressure
- Bradhead Backup Pressure
- Intermediate 1 Backup Pressure

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Largest US oil and gas well integrity dataset:
474,621 tests from 105,031 oil and gas wells in PA, CO, & NM
Test interpretation

- Pressure and flow measurements
Test interpretation

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- CVF Definition
  - Any well with a nonzero flow in an annulus outside the production casing
Test interpretation

- Pressure and flow measurements
- **CVF Definition**
  - Any well with a nonzero flow in an annulus outside the production casing
- **SCP Definition**
  - API RP 90-2
  - Diagnostic threshold (DT) = 50 psi
SCP/CVF occurrence varies over a wide range

- **Colorado**
  - Denver-Julesburg – 26.5%*
  - Piceance – 21.3%*
  - San Juan – 19.2%
  - Raton – 0.3%

- **New Mexico**
  - San Juan – 9.9%
  - Raton – No data
  - Permian – 7.0%*

*Targeted testing in DJ, Piceance, and Permian Basins potentially skews percentages
Higher occurrence in PA than previously estimated

- Pennsylvania – 14.1% of tested wells
  - Northwest district – 10.7%
  - Southwest district – 14.2%
  - Eastern district – 22.2%
- Previous studies estimated 2.6-6.2% (Davies et al., 2014)
- Highest previous regional estimate: 10.8% in BC (Wisen et al., 2019)
Significant spatial variations

- Significant SCP/CVF variation between regions
  - E.g., San Juan Basin: 19.2%, Raton Basin: 0.3%
- Statistically significant hotspots within regions
SCP/CVF more common among directional wells

- SCP/CVF in 30.3% of directional wells
- SCP/CVF in 11.0% of vertical wells
- Trend observed in PA & CO but not NM
No trend of increased SCP/CVF among older wells

- Wells drilled after 2007 in PA reported an increased frequency of SCP/CVF
- Issues among older wells may be underreported
- Unconventional drilling may contribute to observed trend
Future challenges

- Dataset maintenance
  - Changing websites and data reporting practices
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• Dataset maintenance
  • Changing websites and data reporting practices

• Dataset expansion
  • Lack of information? Or lack of access?
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• Creation of a unified dataset
  • Reporting differences
    • E.g., negative test results in AB
  • Different testing standards
Future opportunities

• Characterizing environmental impacts
Future opportunities

- Characterizing environmental impacts
- Understanding leakage trends
Future opportunities

- Characterizing environmental impacts
- Understanding leakage trends
- Leakage prediction and risk forecasting

Reported Methane Emissions from Active Oil and Gas Wells in Pennsylvania, 2014–2018
Anthony R. Ingraffea*, Paul A. Wawrzynek, Renee Santoro, and Martin Wells

Characterizing oil and gas wells with fugitive gas migration through Bayesian multilevel logistic regression
E. Sandil 1, 2, A.G. Cahill 1, L. Welch 1, R. Beckie 1
1 Earth Sciences and Resources, Simon Fraser University, 8888 University Drive, Burnaby, BC, V5A 1S6, Canada
2 The Royal College, Centre for Education, 1960 11th Avenue, Vancouver, BC, V6H 1Y9, Canada

Predicting gas migration through existing oil and gas wells
James A. Montague, George F. Pinder, and Theresa L. Watson

Accuracy
Sensitivity
Specificity
O-Means
Conclusions

• Regional well integrity testing programs create valuable data that have significantly improved our understanding of well integrity

• Current datasets can be improved with:
  • Data from additional regions
  • More uniform testing and reporting guidelines/standards
  • A more streamlined protocol for gathering data from different regions

• Future opportunities:
  • Understanding well integrity issues and their impacts
  • Factors that influence integrity loss
  • Leakage prediction/risk forecasting
NETL
RESOURCES

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@NationalEnergyTechnologyLaboratory
Data compatibility

Raw Data

Python scripts

Cleaning

Formatting

Quality Control

Uniform dataset

Raw Data

Cleaning

Formatting

Quality Control

Uniform dataset
Testing variations

- **Colorado** – SCP testing since 1990
  - 115,468 tests on 22,108 wells
  - Biennial testing of CBM wells
  - Targeted testing in the DJ and Piceance Basin

(Denver-Julesburg, Piceance, Raton, San Juan, Permian)
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- **New Mexico** – earliest SCP test from 2003
  - 33,631 tests on 11,967 wells
  - Triennial testing in San Juan Basin
  - Targeted testing in Permian Basin
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- **Pennsylvania** – testing since 2014
  - 254,942 tests on 56,998 wells
  - Yearly testing of conventional wells
  - Quarterly testing of unconventional wells
Compliance issues

- Incomplete reporting
- Inconsistent use of flags
  - Ingraffea et al., 2020
- Dropped tests in data QC
Gas migration

- SCP buildup can result in groundwater contamination
Gas migration

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- SCP buildup can result in groundwater contamination
- Gas circumvention
Gas migration

- SCP buildup can result in groundwater contamination
- Gas circumvention
- Increased gas migration potential
  - CO: 3% of wells, NM: 0.1% of wells, PA: no data