



# SaskCO<sub>2</sub>USER

Saskatchewan CO<sub>2</sub> Oilfield Use for Storage and EOR Research

## Saskatchewan CO<sub>2</sub> Oilfield Use for Storage and EOR Research (SaskCO<sub>2</sub>USER)

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Saskatchewan  
Ministry of the  
Economy



BUREAU OF  
ECONOMIC  
GEOLOGY



EERC  
Energy & Environmental Research Center  
Putting Research into Practice



Saskatchewan



UNIVERSITY OF  
SASKATCHEWAN

# Petroleum Technology Research Centre

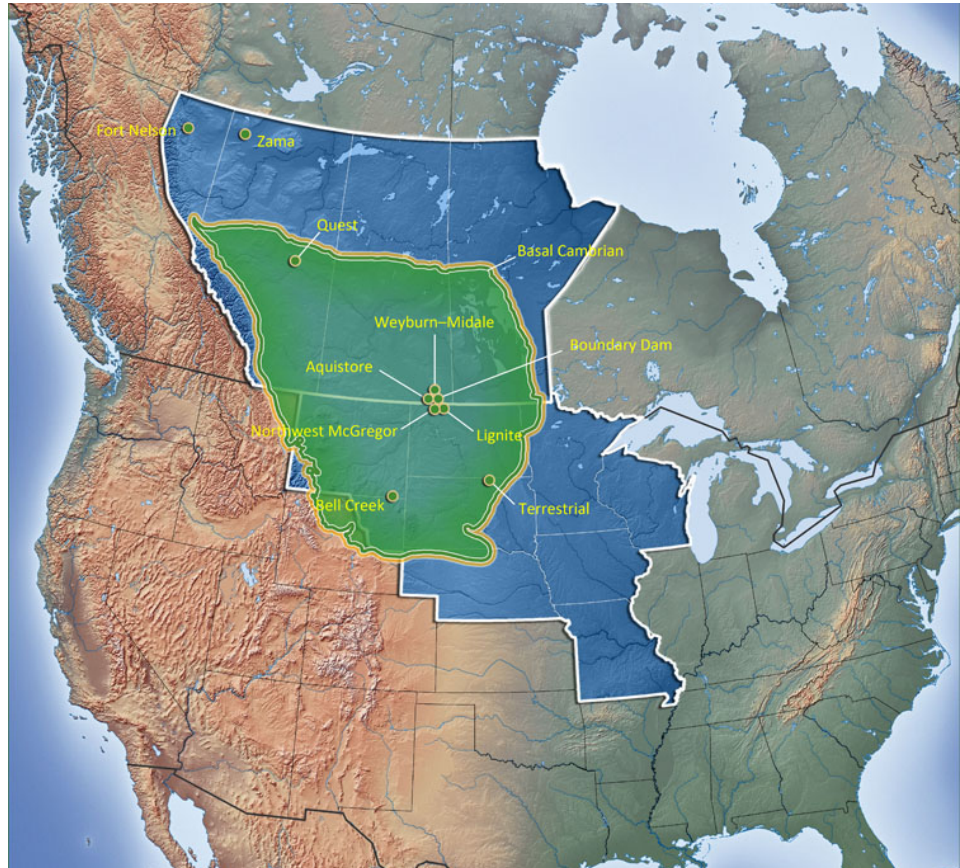
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- Non-Profit Research & Development
- Collaborative partnerships with Industry, Government and Research Organizations
- Committed to improving oil recovery
- Research projects associated with CO<sub>2</sub> management
  - IEAGHG Weyburn –Midale CO<sub>2</sub> Monitoring & Storage Project
  - SaskCO<sub>2</sub>User
  - Aquistore



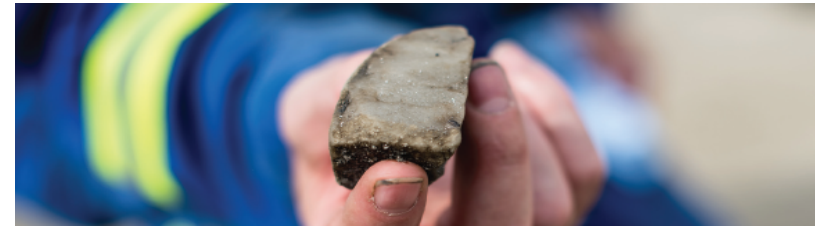
# Objectives of the Program

- 2014 -2015 Research Program
- Applied research for commercial applications of CO<sub>2</sub>-EOR operations and CO<sub>2</sub> storage.
- **Focus on commercialization**
  - CO<sub>2</sub> conformance
  - Wellbore Integrity
  - Monitoring



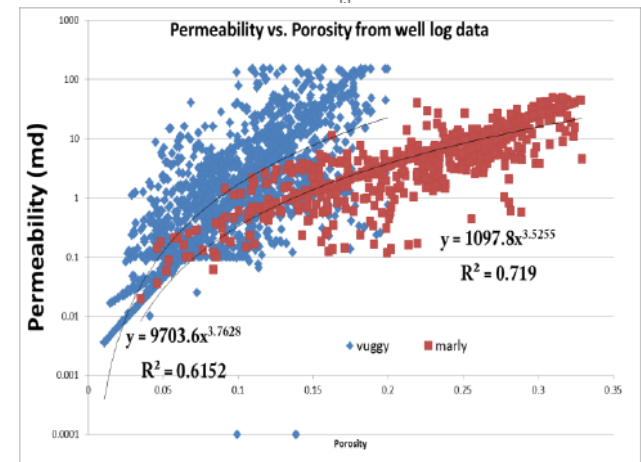
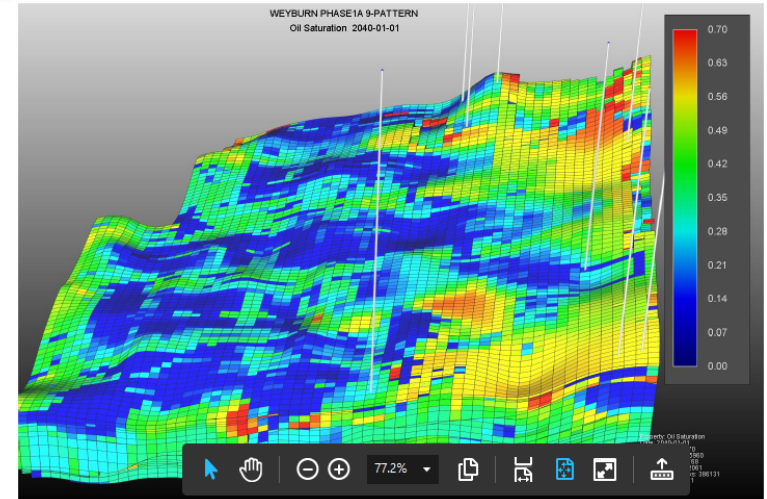
# SaskCO<sub>2</sub>USER Program

1. Evaluating minimum data sets
2. Storage integrity
3. Passive seismic monitoring
4. History-matched modelling
5. Wellbore design
6. Casing corrosion
7. Core assessment



# Minimum Data Set Requirements

- How many wells needed to predict permeability field and model potential migration pathways (e.g., high permeability, faults)?
  - Analysis of variograms with various data set sizes
  - Analysis of realizations
- How many monitoring wells (producing well locations) needed to predict leakage / capture leakage event?



# Monitoring of CO<sub>2</sub>-EOR Sites for Storage Integrity

- Design an MMV Strategy
- 40 regulations and guidance documents reviewed (US, Canada, SK, AB, Texas, etc.).
- Automated workbook to allow for organization of the technology and rating
- Design technology deployment schedule
- Application of technology based on project risk and areas of concern for two leakage scenarios
- Ability to rank technology with equations based on rating categories





# Monitoring of CO<sub>2</sub>-EOR Sites for Storage Integrity



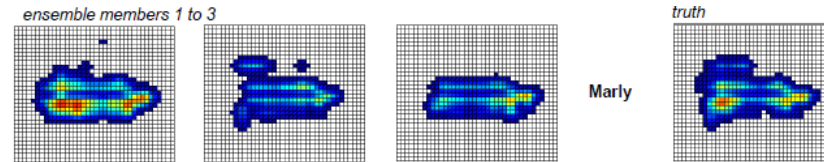
- Historical events detected, located and reviewed using US Array, USGS, and GSC data
- Industrial activity reviewed and injection and production data for CO<sub>2</sub>-EOR field compiled
- 3 broadband stations installed. All observed events appear anthropogenic
- Ongoing work, tied in with monitoring network at Aquistore.
- World stress map data to be incorporated with anisotropy to determine stress conditions and pore pressure increases necessary to induce seismicity.



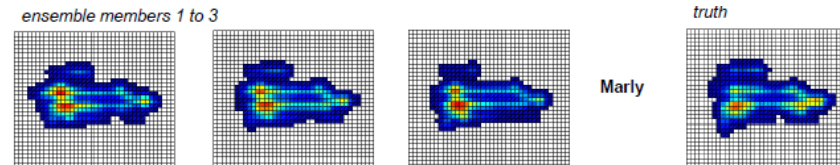
# Stochastic inversion of Time Lapse Seismic Coupled with Flow Simulations for Reservoir Porosity-Permeability

- Iterative version of the Ensemble Kalman Filter (EnKF) applied to inversion/history matching experiments.
- Results indicate models improve when historical seismic data is included in the inversion model.
- Improved matches to seismic maps were obtained in all cases.
- The best match was obtained when seismic data was used for each formation.

Before History Match



Following History Match





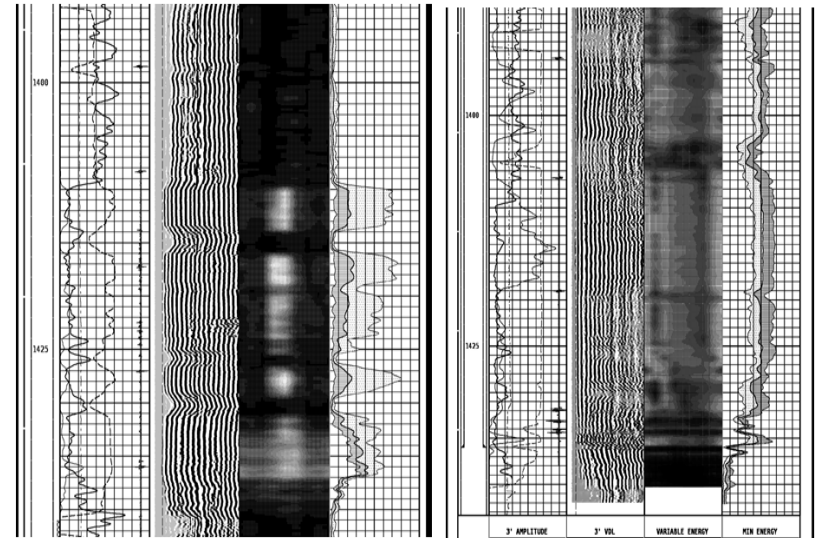
# Construction and Abandonment Design for Lifecycle Wellbore Integrity

- Wellbore design features to maintain wellbore integrity for long term abandonment
  - Enhanced cementing techniques
  - Positioning of downhole completion equipment
  - Material requirements for critical well sections such as the packer/tailpipe region
- Estimate additional costs for proposed designs compared to existing well designs
  - Wellhead upgrades, downhole completion tools and CRA casing
  - Estimated well construction cost differences for wells that require conversion to CO<sub>2</sub> EOR injection.
- Outline and procedure for abandoning horizontal well
  - CO<sub>2</sub> resistant cement plug in the horizontal section
  - Squeeze cementing option below the production packer
  - Cementing above the packer to a defined formation top.



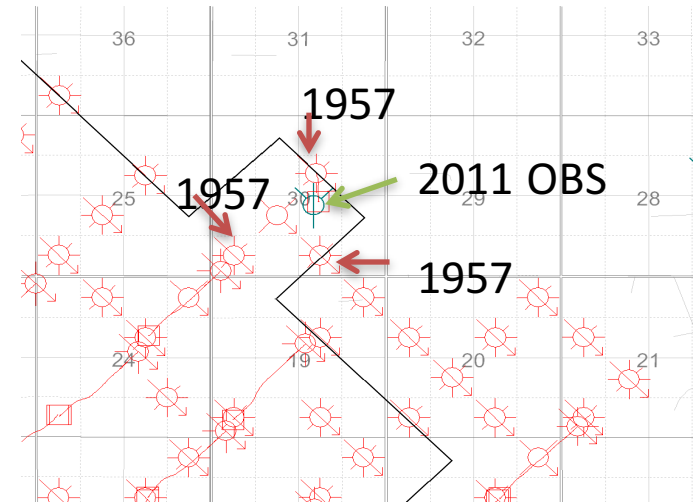
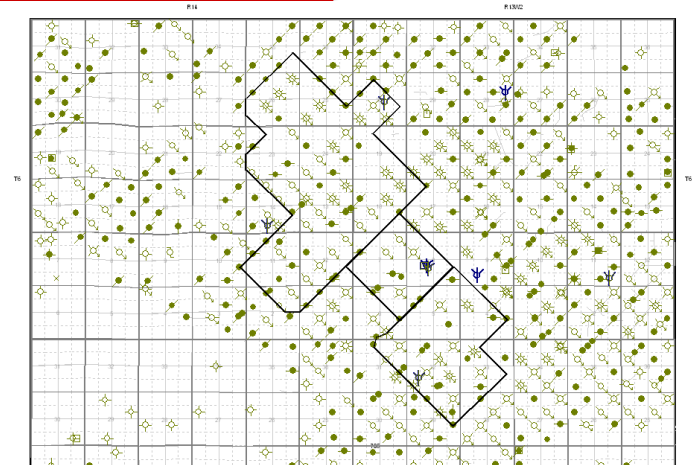
# Corrosion and Failure Assessment for CO<sub>2</sub>-EOR and Storage

- Estimate in situ corrosion rates of casing/cement and contributing factors for wells located in the Weyburn–Midale Field
- Database created of public and nonpublic log data (cement bond log, multi-finger caliper log and ultrasonic log)
- Three wells from ~3100 chosen for the case study were producers, water injectors, and eventually CO<sub>2</sub> injectors
- Evidence the rate of casing corrosion increases near the lower sections of the well, near the production perforations.

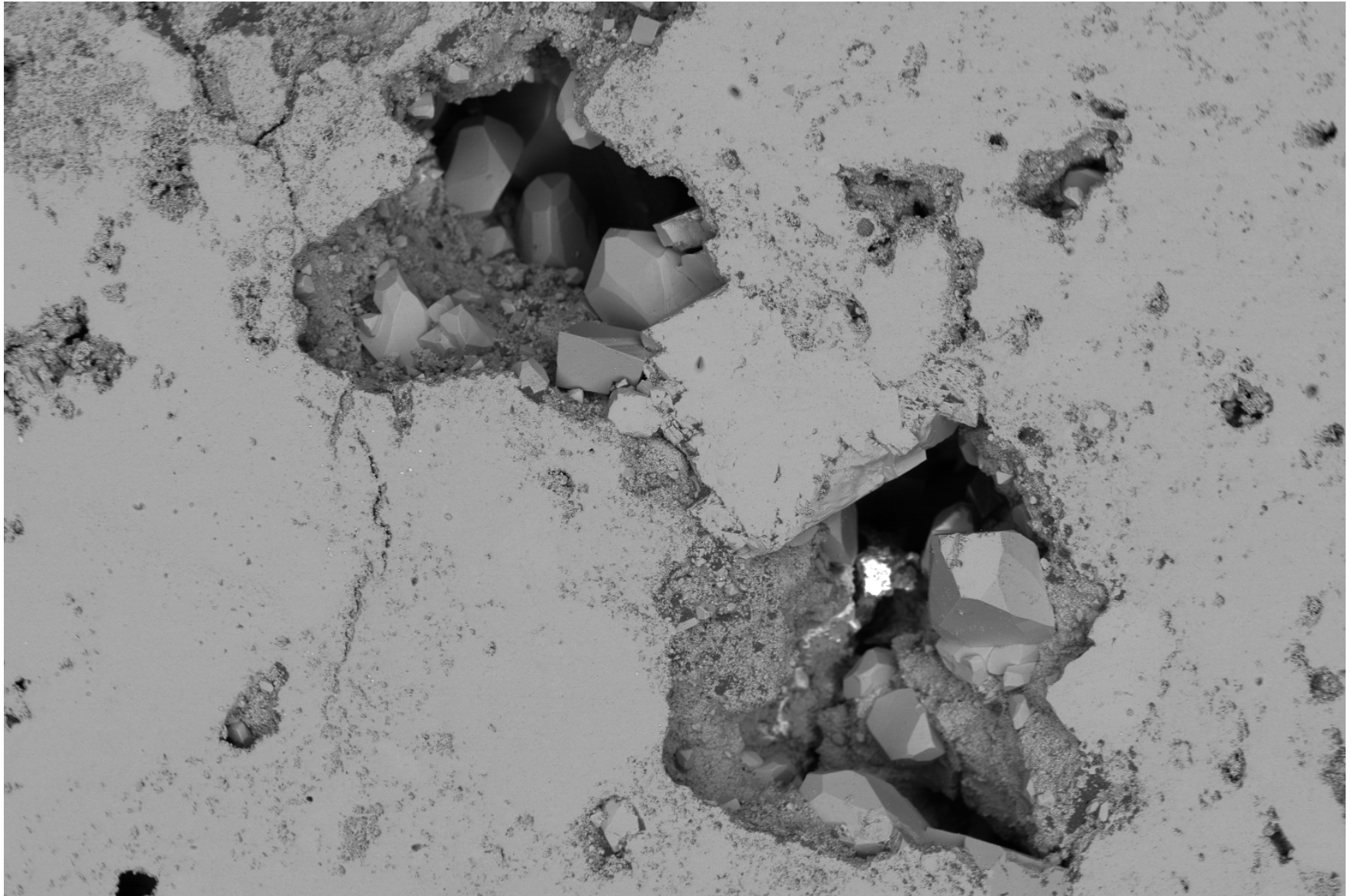


# Core Assessment

- Investigate the influence of injected CO<sub>2</sub> in the rock and pore framework.
- CO<sub>2</sub> concentrations over 10 years established and 4 well locations chosen (3 cored wells and 1 observation).
- QEM scan completed and analysis of data vis-à-vis change in porosity and permeability completed.
- ~3-4% decrease in porosity – potentially CO<sub>2</sub> injection related or variability in the reservoir.
- Two additional core samples being analyzed



# 2010 well: Lower Midale (Vuggy)



SRC

10/31/2014  
3:04:43 PM

det  
BSED

HV  
15.00 kV

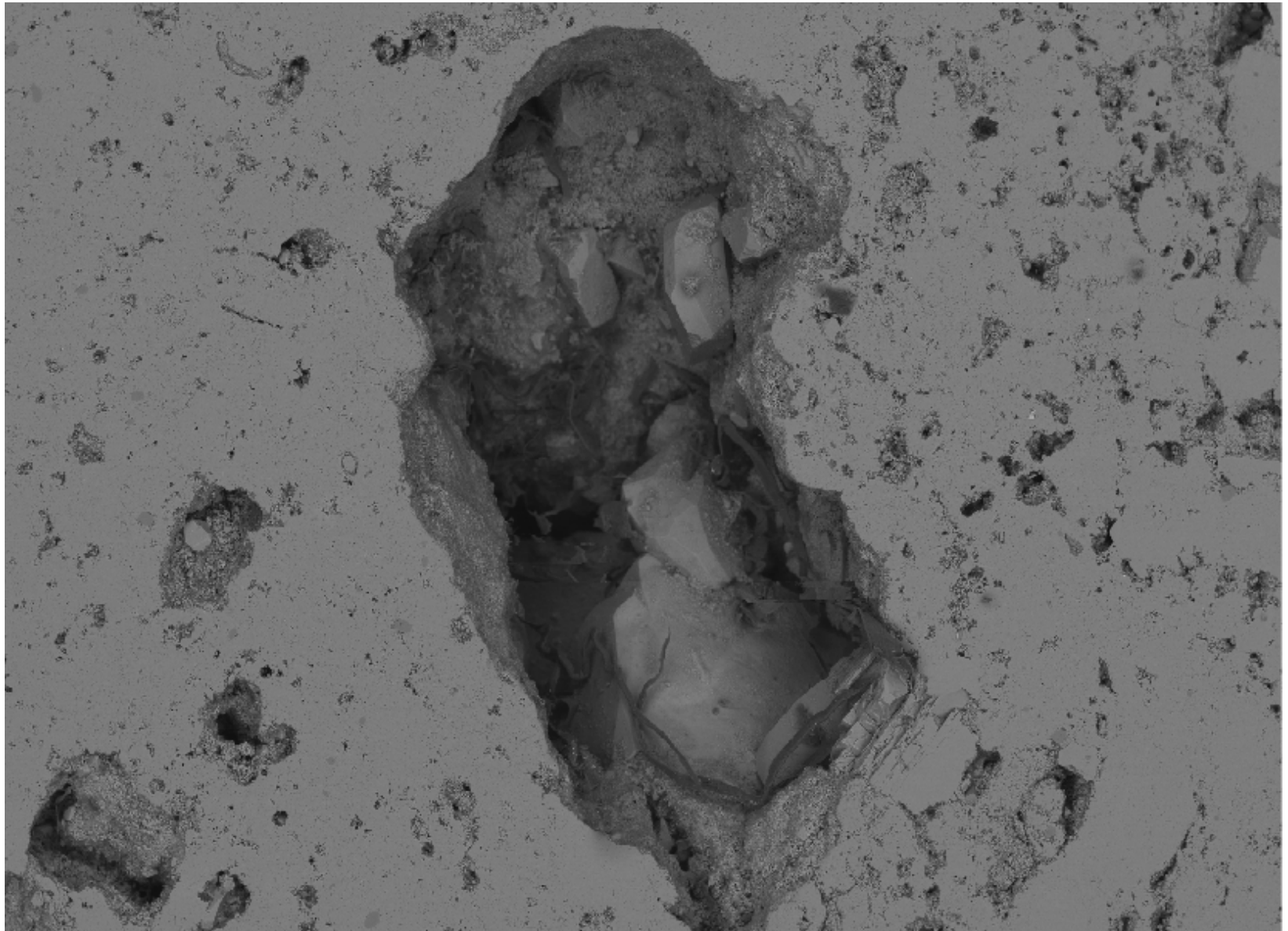
spot  
3.0

HFW  
2.68 mm

WD  
12.6 mm

500 μm

# 1957 well: Lower Midale (Vuggy)



SRC

1/5/2015  
3:29:53 PM

det  
BSED

HV  
15.00 kV

spot  
3.0

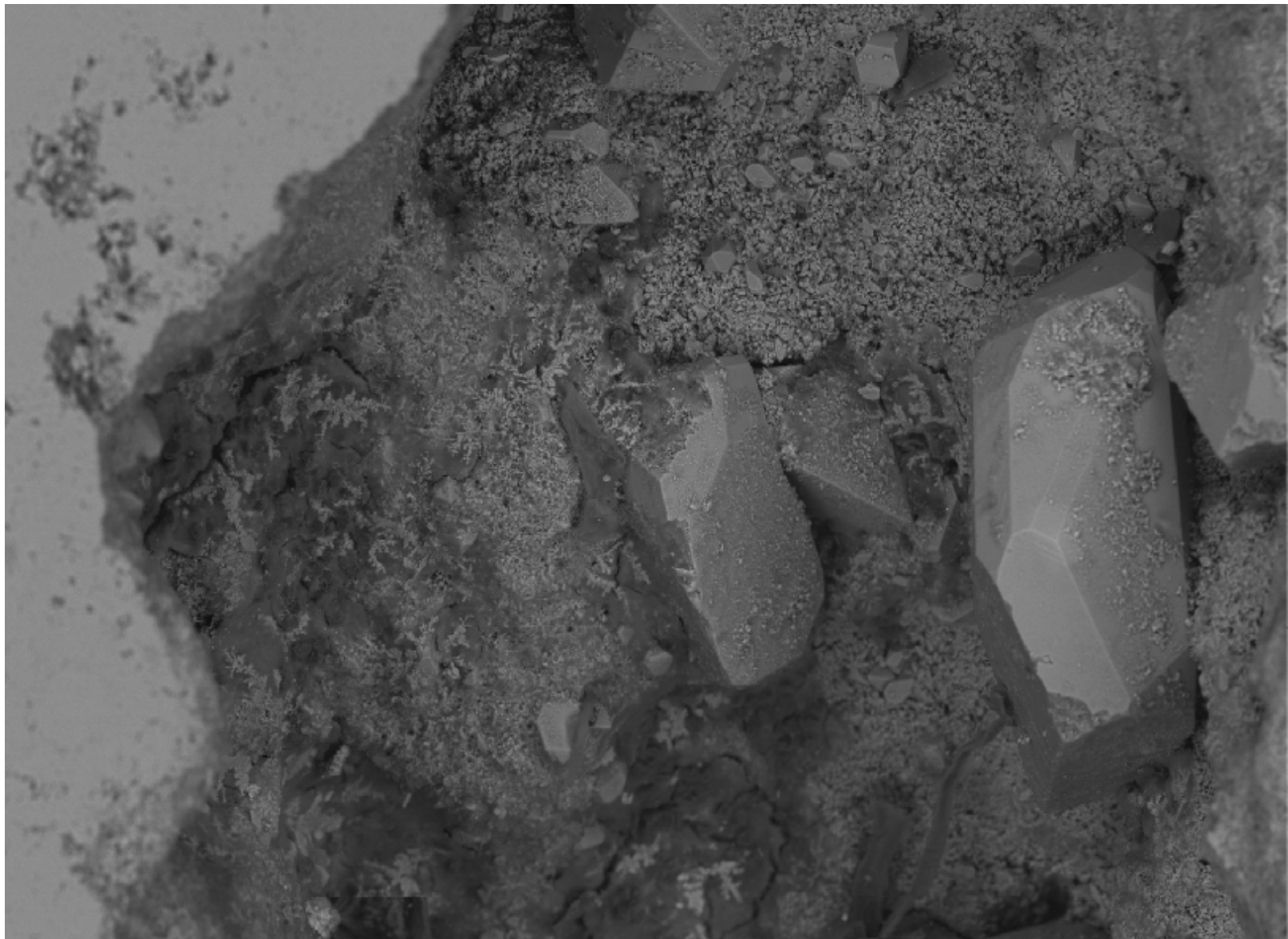
HPW  
1.67 mm

WD  
12.3 mm

500  $\mu$ m

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# 1957 well: Lower Midale (Vuggy)



SRC

1/5/2015  
3:50:13 PM

det HV  
BSED 15.00 kV

spot  
3.0

HPW  
518  $\mu$ m

WD  
11.0 mm

100  $\mu$ m

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# Summary of Accomplishments

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- Project launch
- RFPs, contracts awarded, executed, March 2014
- Phase I Kick-Off Meeting held, July 2014
- Project Update 1 Meeting held, Nov 2014
- Project Update 2 Meeting held, June 2015
- Final Reports, September 2015
- (Forthcoming) Elsevier Supplement, IJGGC, 2016



**QUESTIONS?**

**Thank you.**

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