
EERC
Critical Challenges.
Practical Solutions.

Wellbore Integrity

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Critical Challenges. **Practical Solutions.**

OVERVIEW

- Goal of presentation
- Carbon capture and storage (CCS) project risk
- Define wellbore integrity
- Wells
- Well failure
- Corrosion
- Wellbore evaluation
- Remediating a well
- Conclusions

GOALS

- This presentation aims to help you understand:
  - What wellbore integrity is and how it fits into risk management and the overall CCS project.
  - What the potential risk indicators are for out-of-zone migration.
  - How wellbore integrity issues are monitored and identified.
  - How projects minimize risk or remedy problems if they do occur.

CCS PROJECT RISK

- Risk analysis/management is an essential component of any CCS project.
- Geologic storage is viable option for carbon management, but what are the risks for a project?
  - Operational
  - Surface Infrastructure
  - Financial
  - Reservoir integrity

CCS PROJECT RISK

- Potential pathways for out-of-zone migration:
  - Overpressurizing and cracking the seal/cap rock
  - Natural faults/fractures
  - Wells
- Wells are the most likely pathway because:
  - Reservoir and caprock pressure is typically monitored and/or understood.
    - ♦ In enhanced oil recovery (EOR), fluids are being produced, thus reducing the pressure.
  - Faults/fractures are generally known or observed before injection begins.

WELLBORE INTEGRITY

- Wellbore integrity is the ability of a well to maintain isolation of geologic formations and prevent the vertical migration of fluids. (Zhang and Bachu, 2011; Crow and others, 2010)
- For this discussion, leakage is defined as a loss of CO_2 or other fluid from its intended storage formation and not necessarily losses to the atmosphere.

WELLS

- A well is a complex hydromechanical system designed to fulfill many requirements:
  - Connects surface to storage formation
  - Long-term
  - Compatible with injection stream (CO_2 and impurities)
  - Materials (steel, cement, elastomers, annular fluids)
  - Barriers for fluid flow
  - Economical
  - Repairable
  - Geologically compatible (formations, stresses, fluids)
  - Environmentally acceptable

WELLS

- Some components of a well:
  – Borehole
  – Casing
  – Cement
  – Perforations

Photo: U.S. Department of Labor – OSHA

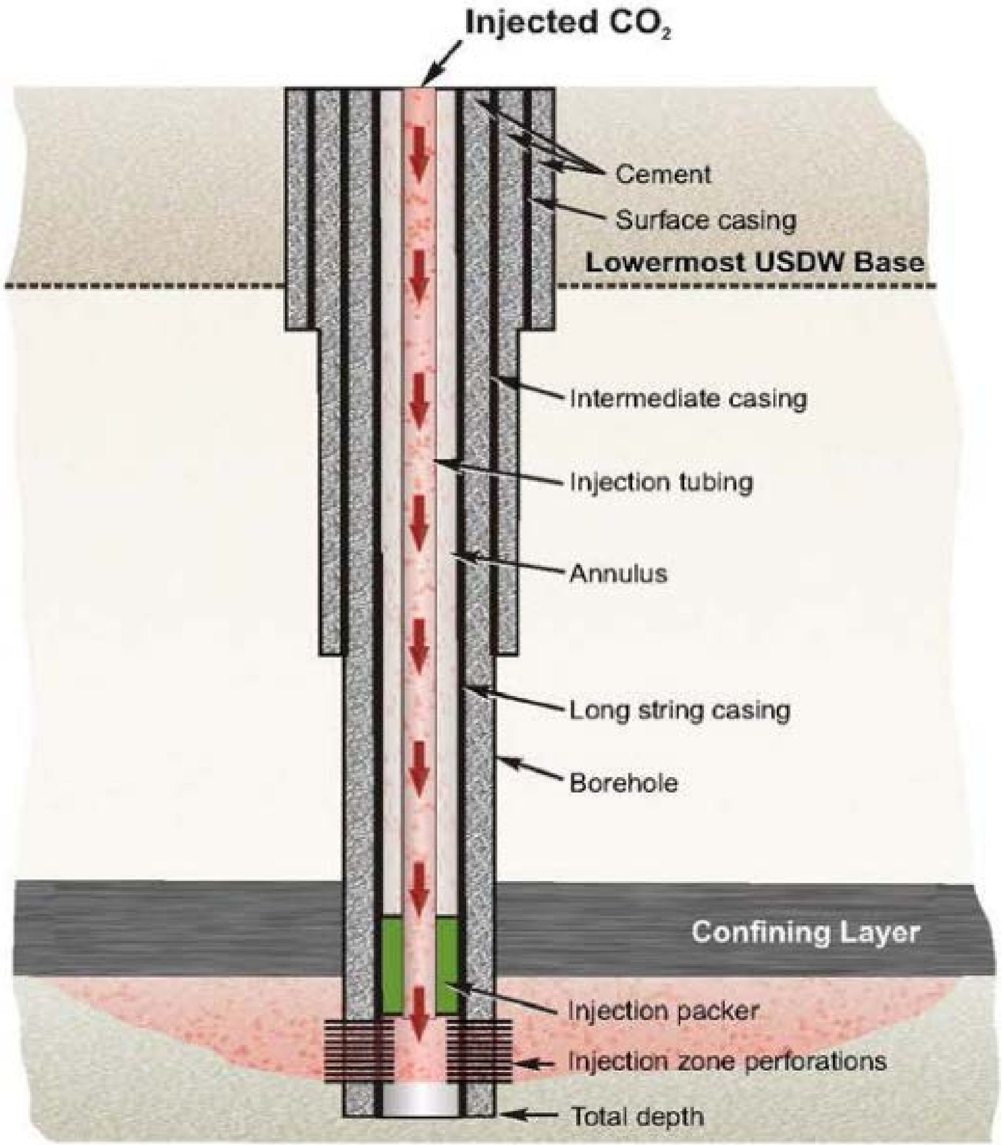
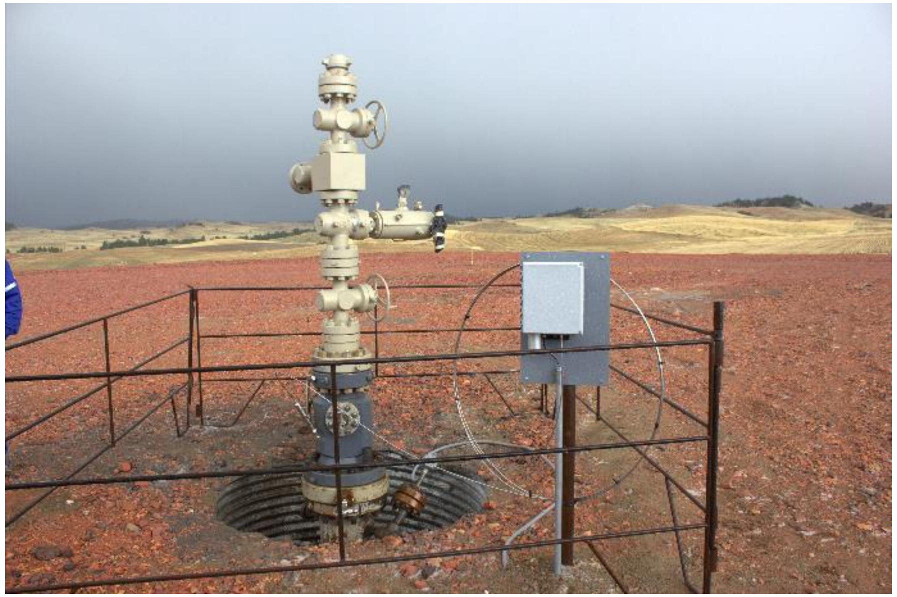


Diagram: U.S. EPA Class VI well guidelines

WELL TYPES

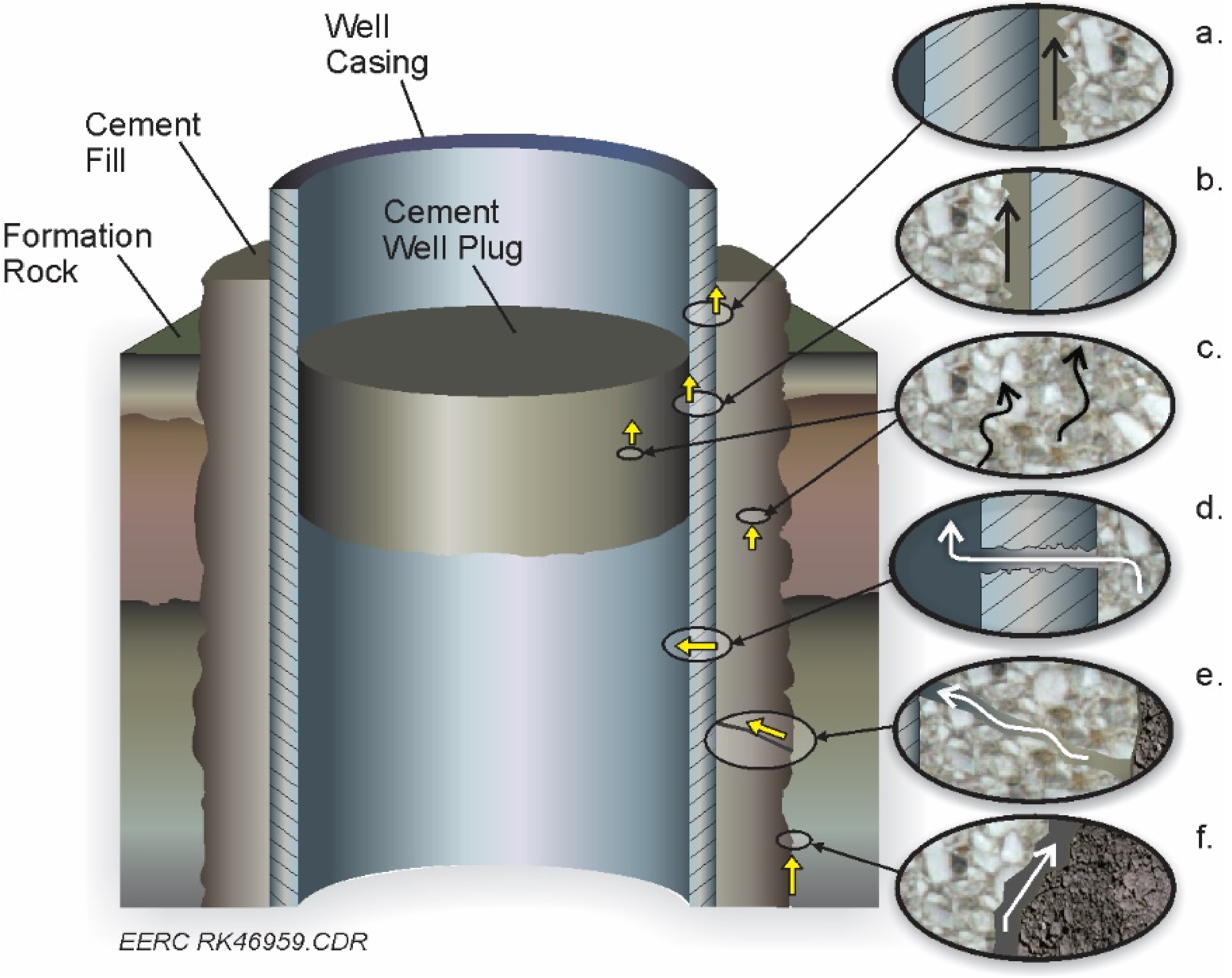
- Wellbore integrity for a CCS project involves more than the CO_2 injection well
  - Legacy wells
  - USDW wells
  - Monitoring wells
  - Pressure relief wells



WELLBORE FAILURE

- What are the leakage pathways?
- How do we evaluate wellbore integrity?

Photo: OSHA



Modified from Celia and others, 2004.

WELLBORE FAILURE

- Problems may include:
  - Poor cement job.
  - Joint failure.
  - Casing corrosion.
  - Poor abandonment plugs.

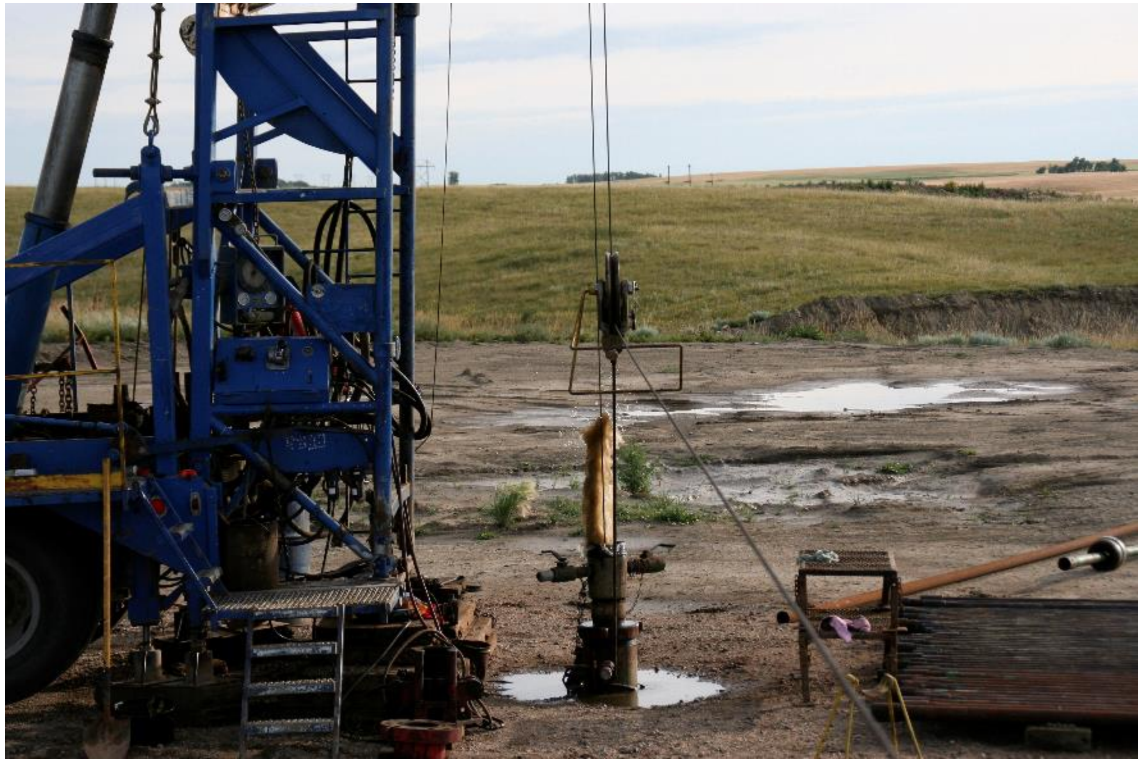


Photo: OSHA

CORROSION

- Industry is actively addressing the issues surrounding wellbore integrity.
- Corrosion is a complex, naturally occurring phenomenon involving the deterioration of materials because of reactions with the environment.
- Total cost of corrosion according to NACE International (2014) is US$1.372 billion:
  - US$589 million in surface pipeline and facility costs
  - **US$463 million annually in downhole tubing**
  - US$320 million in capital expenditures related to corrosion

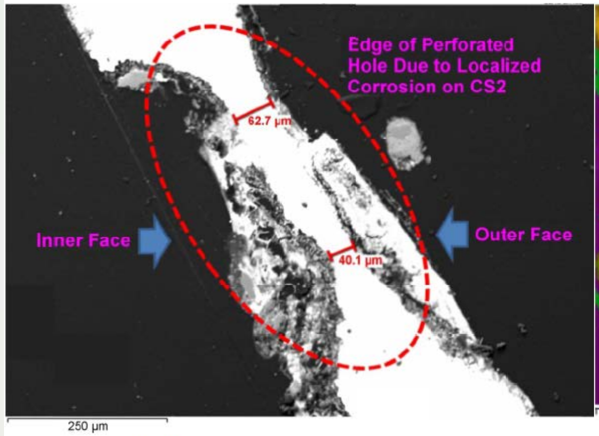


Figure 13. SEM backscatter electron micrograph of the Specimen CS2 cross section.

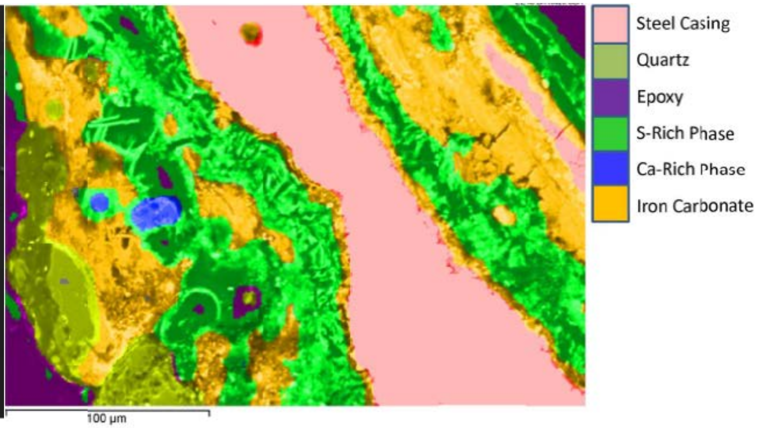


Figure 14. SEM mineral phase map of Sample CS2, with the outside surface on the right and the inside surface on the left.

WELLBORE EVALUATION

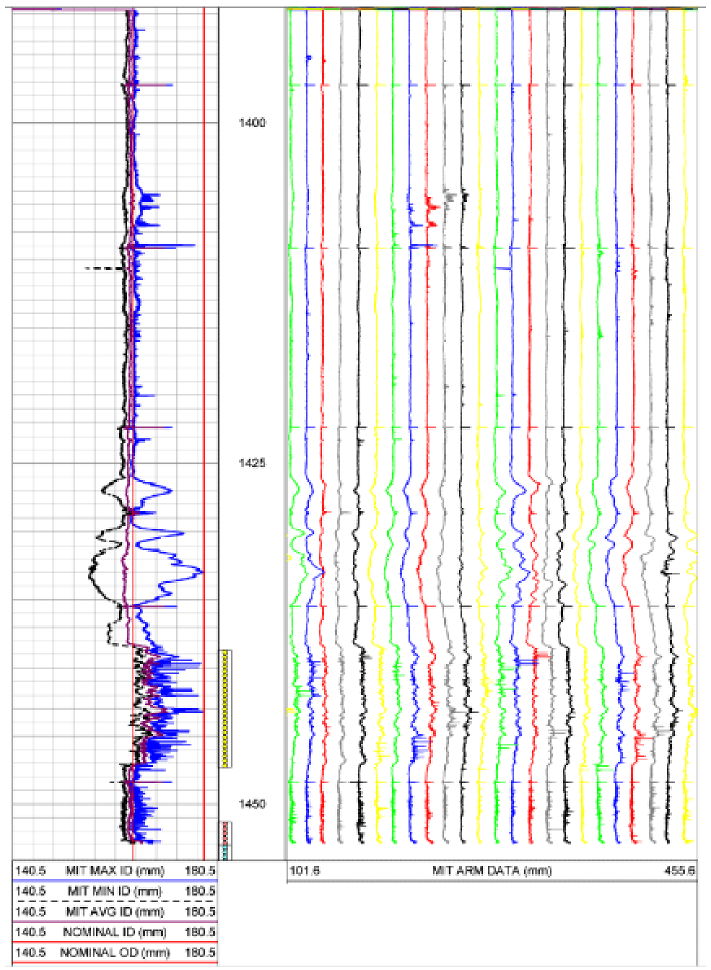
- Methodologies have been developed for high-level evaluation of leakage potential.
  - (Watson and Bachu, 2007, 2008; Bachu and others, 2012)
- Potential indicators based on this research include:
  - Age of the well.
  - Regulations.
  - Abandonment method.
  - Cement.
  - Completion activities.
  - Operator.
  - Well type.
- Data-driven methodology.
- Results intended to direct future efforts to assess wellbore integrity.

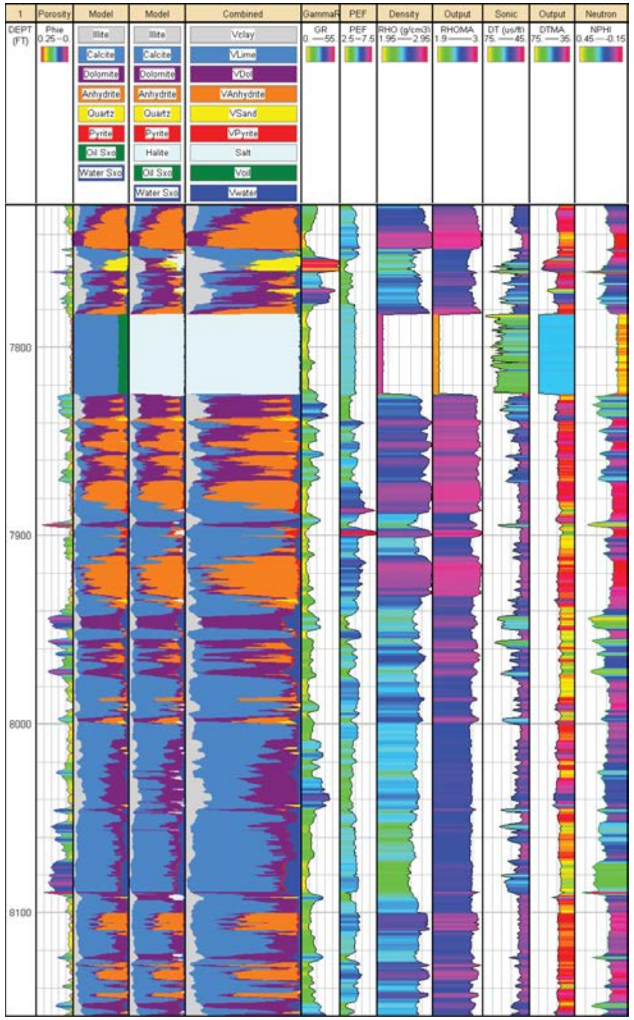
WELLBORE EVALUATION

- Site specific methods
  - Operational indicators:
    - Pressure
    - Fluid production
  - Mechanical integrity tests.
  - Well logs:
    - Caliper
    - Casing imaging tool
    - Vertilogs
    - Cement bond logs (CBL)
    - Sector bond logs (SBL)
    - Ultrasonic logs
    - Noise logs

WELLBORE EVALUATION

- Logs offer a visual representation of what is present downhole.
- Logs show:
  - Formation characteristics.
  - Casing condition.
  - Cement condition.
  - Joint locations.
- Expensive to run; typically only run when there is an indication of an issue.
- Logs frequently targeted to a specific depth interval.





REMEDIATION

- The problems discussed can be remediated.
  - Oil and gas industry has decades of experience and numerous techniques to address problems.
- Repair:
  - Squeeze job
  - Casing patches or new sections
- Plugging and abandonment
  - Closure of access to storage formation
  - Multiple steel/elastomer/cement plugs
  - Optimal placement of plugs

MINIMIZING RISK

- Awareness of safety
- Understanding CO_2 pathways
- Project planning
  – Monitoring, verification, and accounting (MVA), modeling, risk assessment, and site characterization
- Regulation

MINIMIZING RISK

- Increased experience and understanding
  - Geology
  - Wellbore construction
    - ♦ Materials
    - ♦ Barriers
    - ♦ Monitoring

SUMMARY

- Maintaining wellbore integrity of all wells is important in any CCS project.
- Various tools and techniques are available for monitoring and remediating wells.
- Significant resources are available on this topic.

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THANK YOU!

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