

2ND ANNUAL **ENERGY** & **INNOVATION** CONFERENCE

Wellbores and Drilling

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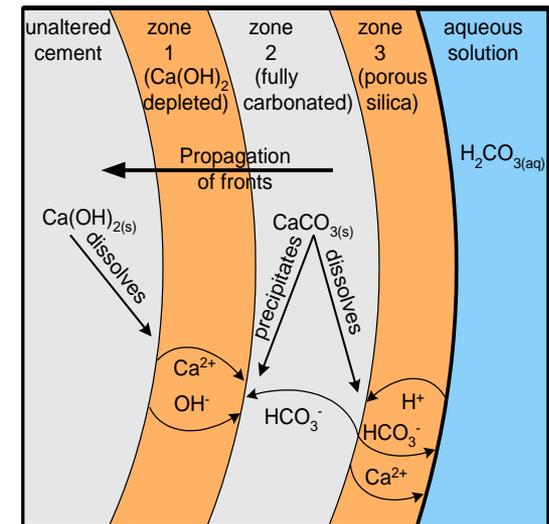
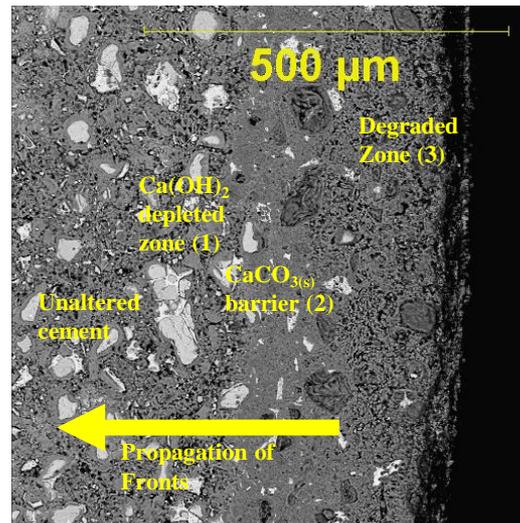
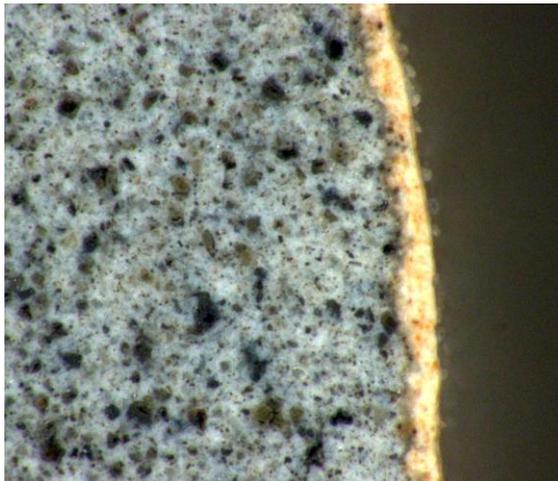
URS

Technology or Capability Overview

- 3 primary efforts related to wellbore cement
 - Risk of wellbore leakage in CO₂ storage/EOR
 - Stability of foamed cements in deep offshore wells
 - Shallow gas migration in shale gas wells
- Extreme Drilling Laboratory (XDL)
 - NETL Facility to study drilling processes under conditions that exist at extreme depths

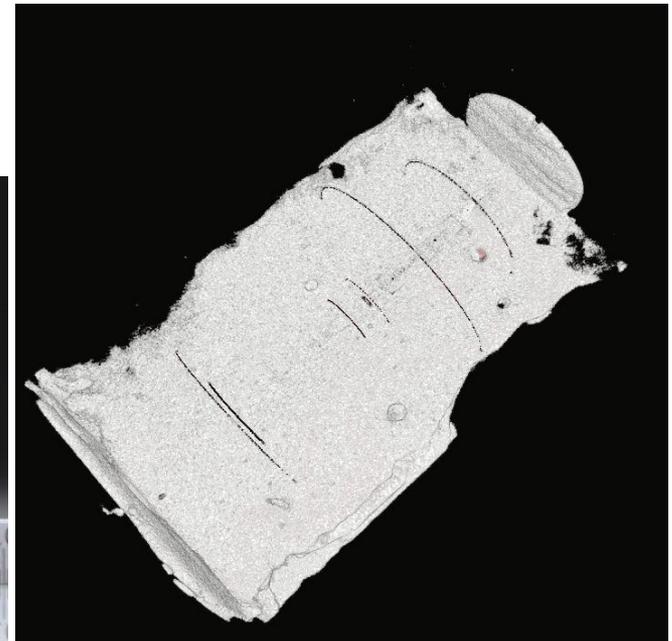
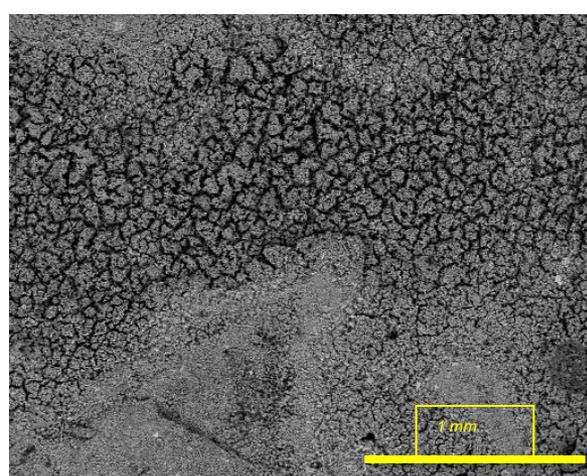
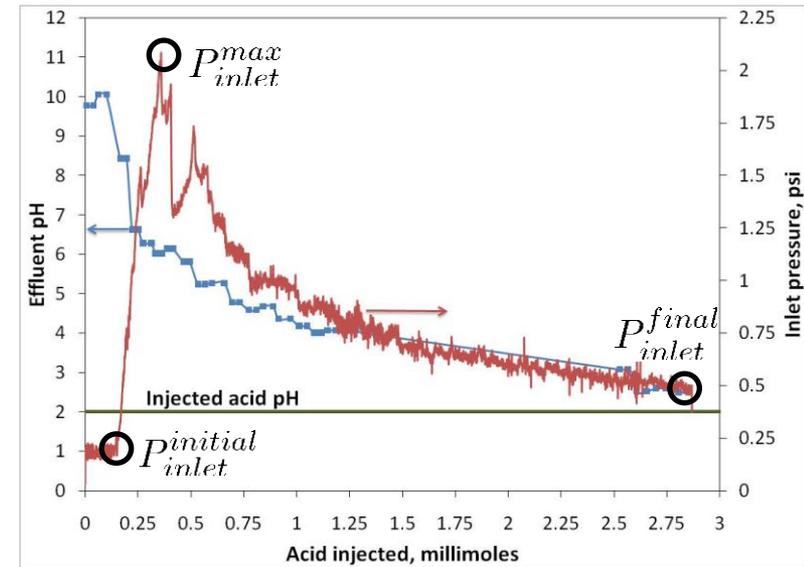
CO₂ and Wellbore Leakage Risk

- Early NETL work defined mechanism for chemical reaction between CO₂ and wellbore cement.
- Degradation of cement determined to be too slow to impact well integrity in the absence of preexisting flow paths



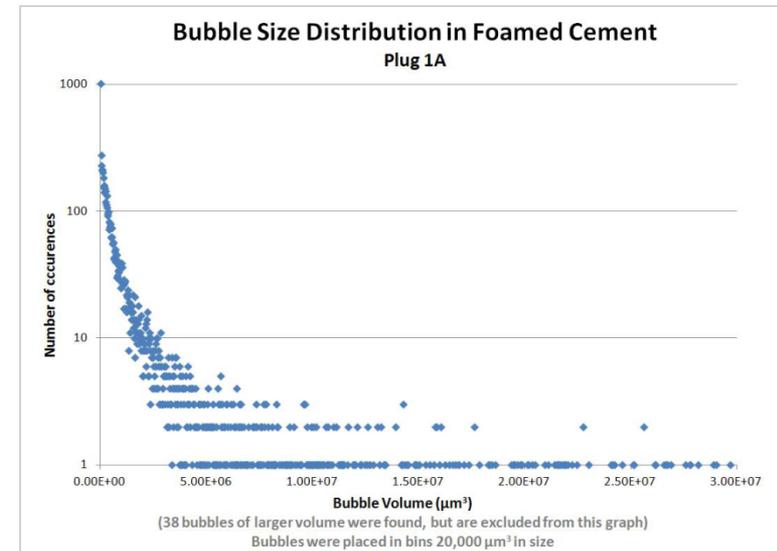
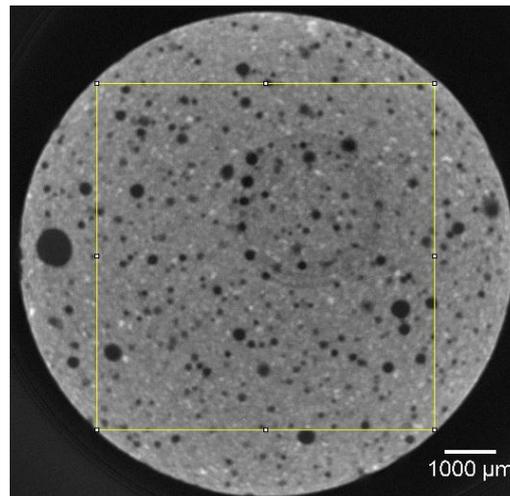
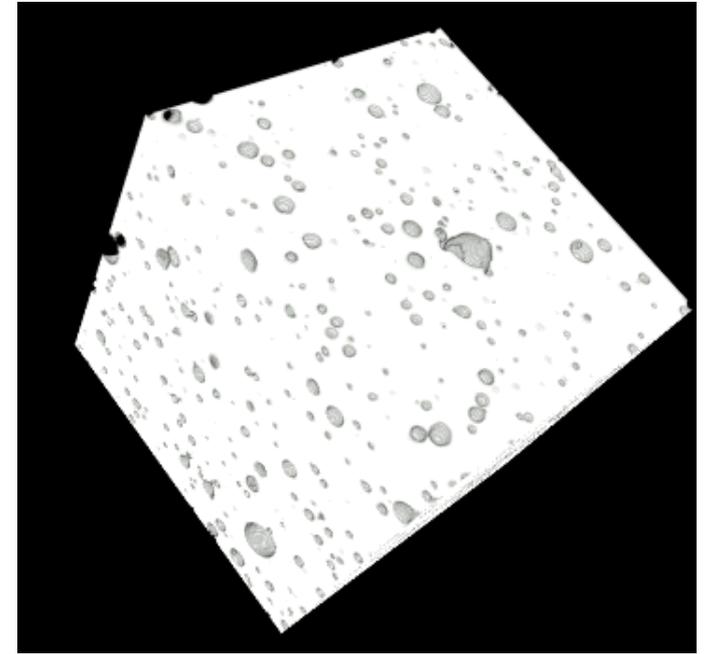
CO₂ and Wellbore Leakage Risk

- Ongoing NETL-RUA work includes experimental and numerical studies of flow through damaged cements.
- Objective is to predict time-dependant leak rates.
- Self limiting behavior observed in cases where path length is long.



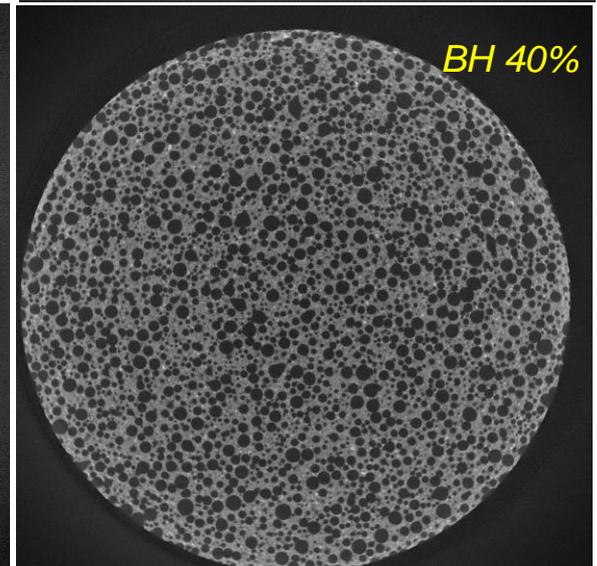
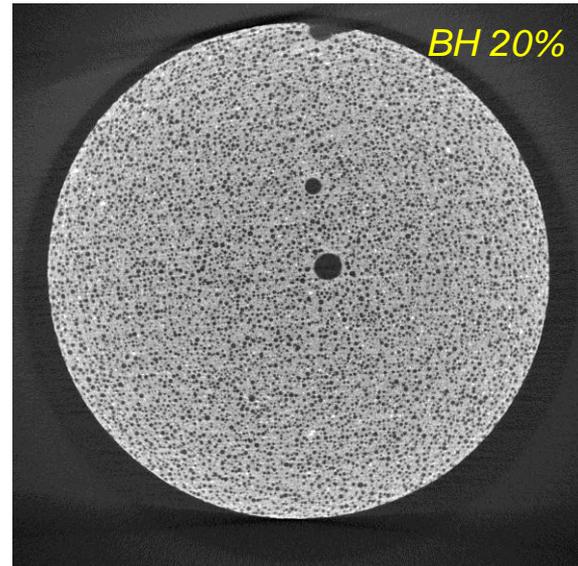
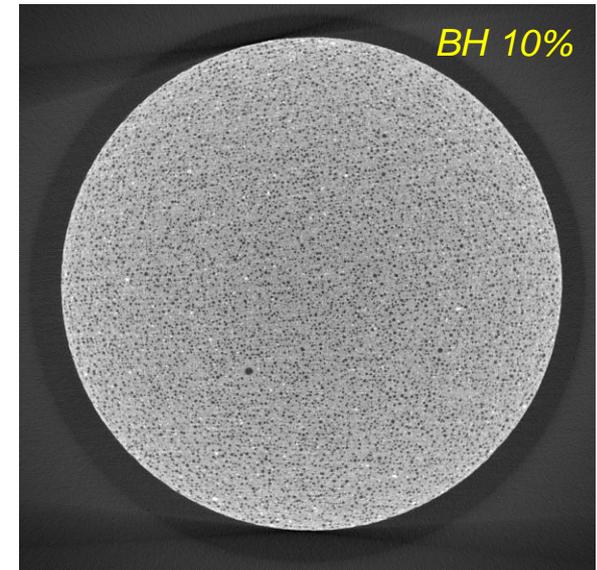
Stability of Foamed Wellbore Cements

- Stability of foamed cements is critical to safety of deep offshore drilling.
- NETL facility can measure 3D bubble size distributions under varying pressures.
- Significant improvement over current industry testing methods



Stability of Foamed Wellbore Cements

- Laboratory experiments to study the properties of foamed cements at various pressures, shear rates, and foam qualities.
- Determine foam stability at conditions simulating various depths in the well and correlate those properties with the current method of atmospheric testing.
- Significant industry interest and cooperation



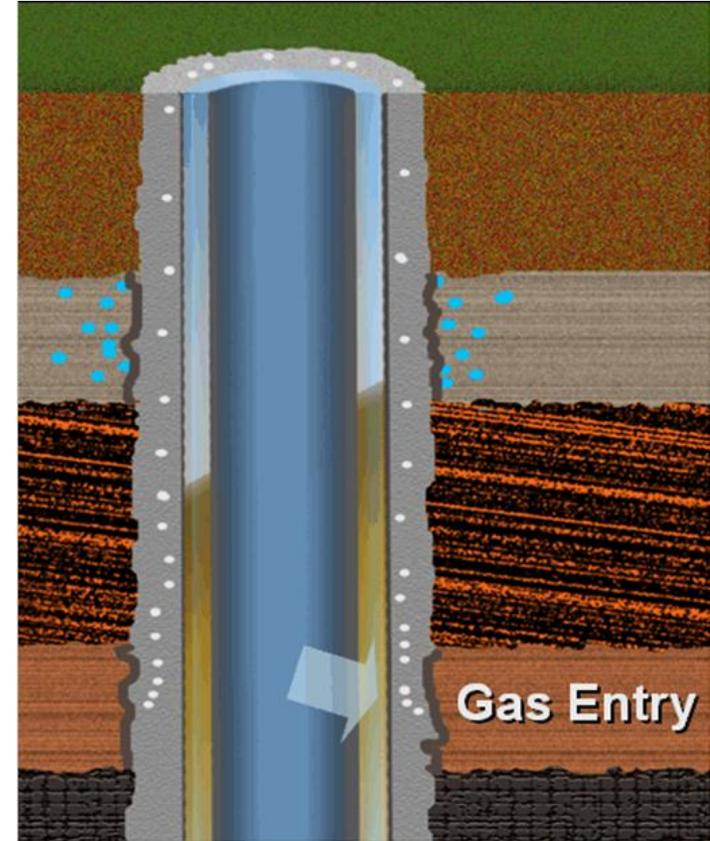
Gas Flow from Shallow Gas Formations

Background

- Sandstone and coalbed formations in the groundwater zone have the ability to inject gas at high pressures into wellbore while cement is transitioning from a liquid to a gelled state.
- Several occurrences of well failure due to shallow gas flow over past five years in Pennsylvania.

Objectives

- Quantify the potential for gas flows from shallow formations containing groundwater aquifers to affect the integrity of wellbore cement during in-situ hydration.
- Provide data to calibrate and validate predictive models for risk assessment and groundwater impacts being developed in other tasks in the program.

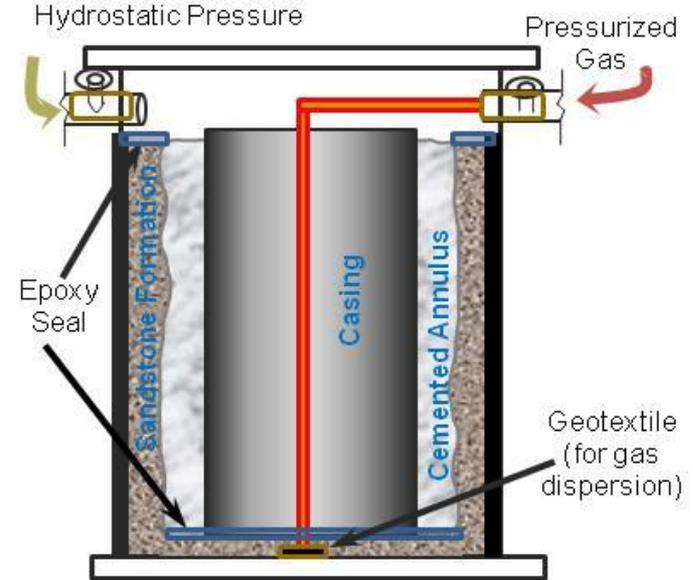


From halliburton.com

Gas Flow from Shallow Gas Formations

- **Plans for FY13**

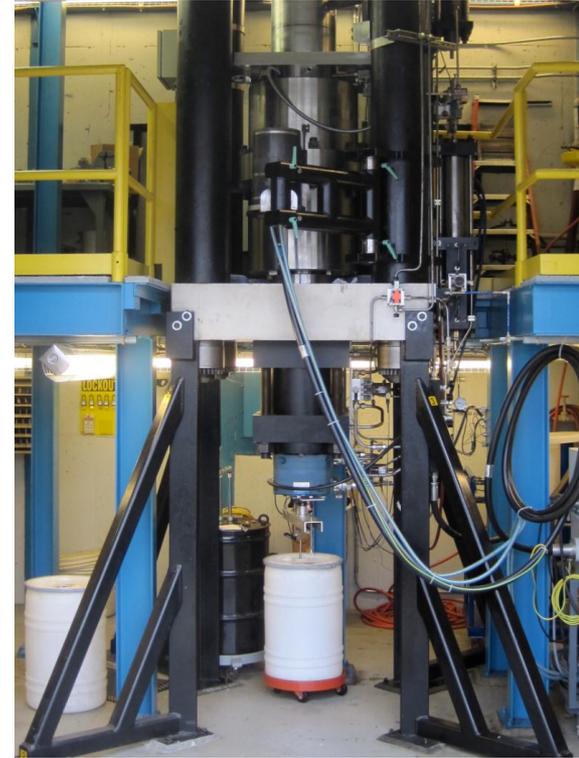
- Identify critical conditions contributing to the loss of wellbore integrity due to shallow gas flow
 - Development of a database of background information on the types of shallow formations known to be associated with gas flows
 - Geologic conditions
 - Completion logs
 - Case studies of failures from PA DEP (6-8)
 - Laboratory simulation of high risk field conditions to quantify gas flows.



Extreme Drilling Laboratory (XDL)

Ultra-deep Drilling Simulator

- **One-of-a-Kind Research Facility**
- **Capabilities:**
 - Employs a Rotating Actuator with Single Cutter
 - Operating Pressures to 30,000 psi (200 MPa)
 - Operates with Drilling Fluids
 - Direct Visualization into Cell with X-Ray and High Speed Video System
 - Images of Cutting at Down-hole Conditions
 - X-Ray Provides Visualization of Cutter and Rock Immersed in an Optically Opaque Drilling Fluid



UDS Initially Developed with TerraTek, a Schlumberger Company, under DE-FC26-05NT42654

Extreme Drilling Laboratory (XDL)

Fluids Lab

Viscosity Measurements

Chandler Model 7600 Viscometer

- Max Temp (600 F)
- Max Pressure (40,000 psi)



Marsh Funnel
Viscometer



Fann Model 35
Viscometer



Viscosity Measurement:

Fluid in annulus between concentric cylinders. One cylinder rotates, the other measures forces exerted through the liquid.



Fluid Filtration Measurements

Filtration behavior and wall cake-building characteristics of a drilling fluid affect the solids in the fluid and their interactions with each other and rock formation.



Filter Press
(low temperature, low pressure)



Complete HTHP Filter Press

Fluid Aging Experiments

In the lab, an Aging Cell is used to subject fluids to high temperature

- **HTHP Test Cell for Heat Aging**
 - Typically, aging is for 16 hrs
 - Max Temp (450 F)
 - Max Pressure (1,500 psi)



Model 705ES Roller Oven



Extreme Drilling Laboratory (XDL)

Geo Lab

Pre-Test Measurements

- *Hardness*
- *Strength*
- *Porosity*
- *Composition*

Post-Test Measurements

- *Cut Imaging*
- *Cutting –size Distribution, and Micro-structure Analysis*

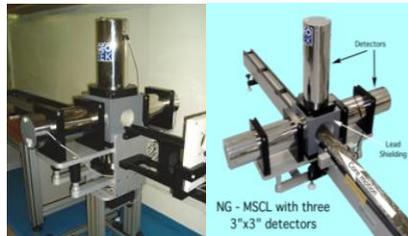
Gamma Density

The gamma density measures the variations in bulk density of the rock, which are correlated with variations in rock type, hardness, and rock strength.

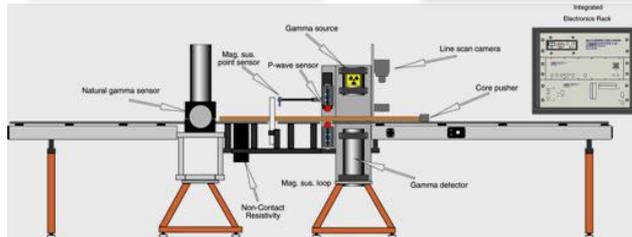
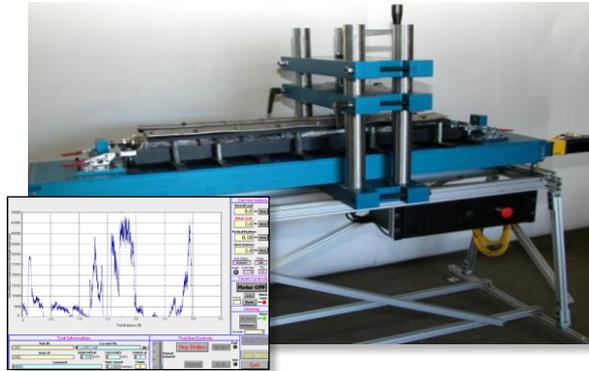


Natural Gamma Radiation

Natural gamma is an indicator of rock composition, particularly the abundance of potassium, uranium, and thorium.



Strength Indexing System



Multi Sensor Core Logger System

Confocal Scanning Laser Microscope



Industry Significance/Applications

- **Ability for operators to quantify risk for CO₂ storage and EOR**
 - Site characterization
- **Improve safety of natural resource production by inform operators and regulators**
 - Testing of foamed cements
 - Well completion practices
- **Improve deep drilling practices**
 - Cutter design
 - Drilling parameters (rate, weight, etc.)
 - Drilling fluids

Partnership Opportunities

- Is this technology or capability part of a current research project?
 - Cement studies are part of current projects
 - XDL is currently on hold pending opportunities/funding
- Are you looking for CRADA partner, licensing opportunity?
 - Yes, opportunities for field data/case studies are welcome.
- Are you looking for funding?
 - XDL is in need of funding.
- Is there possible applications of this capability that could assist industry to solve their challenges?
 - Yes, as explained on previous slide

Benefits to Partner

- Unique facilities
 - State-of-the-art flow and imaging capabilities
 - Unique ability to study extreme p/T conditions (XDL)
- Ability to tailor studies to specific cases relevant to partner
 - eg. Foamed cement studies focus on Baker-Hughes and Schlumberger cement formulations.

Contact Information

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