Overview of Engineered Barrier Systems (EBS) Research

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Overview

- Engineered Barrier Systems (EBS) Research relative to other SFWST research areas
- Knowledge and Capability Gaps
- Research Priorities
- HotBENT Deep Dive (presented by Liange Zheng)
R&D Priorities

- Gaps in understanding of fundamental processes
  - Integrity of Repository Seals
    - Drift and shaft seals
    - Degradation evolution, esp. permeability evolution
  - Processes at material interfaces
    - Engineered materials and Disturbed Rock Zone (DRZ)
    - Waste Package materials, buffer, and host rock

UZ = Unsaturated Zone
DPC = Dual Purpose Canisters
EBS = Engineered Barrier System
GDSA = Geologic Disposal Safety Assessment
Knowledge and Capability Gaps

- Gaps in understanding of fundamental processes (cont.)
  - Coupled processes
    - Chemo-mechanics
    - Thermal-Hydrologic-Mechanical-Chemical
    - Multi-phase flow
    - Multi-scale phenomenon
    - Linking microstructural scale to continuum scale
  - Particular attention on cementitious materials and bentonite
## How are EBS Knowledge Gaps Prioritized?

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<td>DFN Issues</td>
<td>I-21*, C-1, C-17*</td>
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<td>GDSA Geologic Modeling</td>
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<td>THC Processes in EBS</td>
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<td>E-3</td>
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</tbody>
</table>

**Activity Designator Legend:**

- **A** – Argillite
- **C** – Crystalline
- **S** – Salt
- **D** – Dual Purpose Canisters
- **E** – Engineered Barrier System
- **I** – International
- **O** – Other
- **P** – Performance Assessment

* – indicates Gap Activity
# High Priority EBS Activities

<table>
<thead>
<tr>
<th>#</th>
<th>Description</th>
<th>SFWST EBS Activity</th>
<th>Int’l Tie-in</th>
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<td>E-09</td>
<td>Cement plug/liner degradation</td>
<td>Experimentally verified cement-geomaterial 3D model development in PFLOTRAN (crosscut with Argillite DR)</td>
<td>EBS Task Force Task Cement Task</td>
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<td>A-08</td>
<td>Evaluation of Ordinary Portland Cement (OPC)</td>
<td>Seals in Salt (crosscut with Salt DR)</td>
<td>BATS Heater Test in Salt RANGERS Project</td>
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<td>Hydrothermal Experiments examining host, buffer, and canister materials interaction/evolution at elevated temperature (crosscuts with Crystalline and Argillite)</td>
<td>HotBENT</td>
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<td>#</td>
<td>Description</td>
<td>SFWST EBS Activity</td>
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<td>FEBEX activities</td>
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<td>- chemical controls</td>
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<td>- molecular scale</td>
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<td>- bench scale</td>
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<td>- drift scale</td>
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<td>I-08</td>
<td>Advective gas flow in bentonite</td>
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<td>DECOVALEX 2023</td>
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<td>• Task B: Modeling Advection of Gas in Clays (MAGIC)</td>
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<td>• Task C: THM Modeling of the FE Experiment</td>
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<td>• Task E: Brine Availability Test in Salt (BATS)</td>
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<td>Benchtop High Temp Bentonite Column Test</td>
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<td>EBS Task Force Column Test</td>
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<td>E-10</td>
<td>High Temperature Behavior</td>
<td>Modelling Support of HotBENT and Benchtop Tests</td>
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Knowledge and Capability Gaps

- Gaps in Process Models
  - Cement models for evolution of plugs and liners
    - Chemo-mechanical coupling
    - Fracture models
  - Saturation/Re-saturation of Cementitious Materials and Bentonite
  - Bentonite buffer
    - THMC models refinement

- Benefits of filling these gaps:
  - Impact representation of seal representation in GDSA, or at least improve confidence in permeability values for seals/interfaces
  - Improve understanding of near field geochemistry
EBS Involvement with International Activities

- **FEBEX**
  - Two-stage heater test with bentonite block buffer in the Grimsel granodiorite
  - Engineered Barrier System Task Force Task 9 (completed March 2020)

- **DECOVALEX 2023 Task B, Task C, Task E**

- **Engineered Barrier System Task Force New Tasks**
  - Cement-Bentonite Interactions
  - HotBENT Column Test at LBNL

- **RANGERS**
  - shaft and drift performance study in collaboration with Germany

- **HotBENT Field Test**
  - High temperature bentonite field test

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FEBEX = Full-scale Engineered Barriers EXperiment
DECOVALEX = Development of Coupled models and their Validation against Experiments
RANGERS = Entwicklung eines Leitfadens zur Auslegung und zum Nachweis von geo-technischen Barrieren für ein HAW Endlager in Salzformationen
HotBENT = High Temperature Effects on Bentonite Buffers
Priority R&D – A Forward Look

- **Continued participation in International EBS Studies**
  - Continued participation in EBS Task Force, DECOVALEX, HotBENT, etc.
  - Collaboration with German partners in salt investigations of seal performance
  - Other emerging collaborative URL-based activities

- **Improved understanding of fracture development in EBS materials, esp. cementitious materials and bentonite**
  - Leverage tools for fracture representation from Crystalline or GDSA
  - Meshless methods for fracture representation

- **Next generation materials, including cementitious materials**
  - 21st century materials for are evolving towards a decarbonized energy infrastructure
  - Availability of supplemental cementitious materials (e.g. fly ash)
  - New materials, e.g. cements /binders with lower carbon intensity
References


SFWST EBS Research Teams

**Lawrence Berkeley National Laboratory**

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**Sandia National Laboratories**
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**Vanderbilt University**