

## Overview of Engineered Barrier Systems (EBS) Research

US NWTRB Fall 2020 Fact-Finding  
Meeting  
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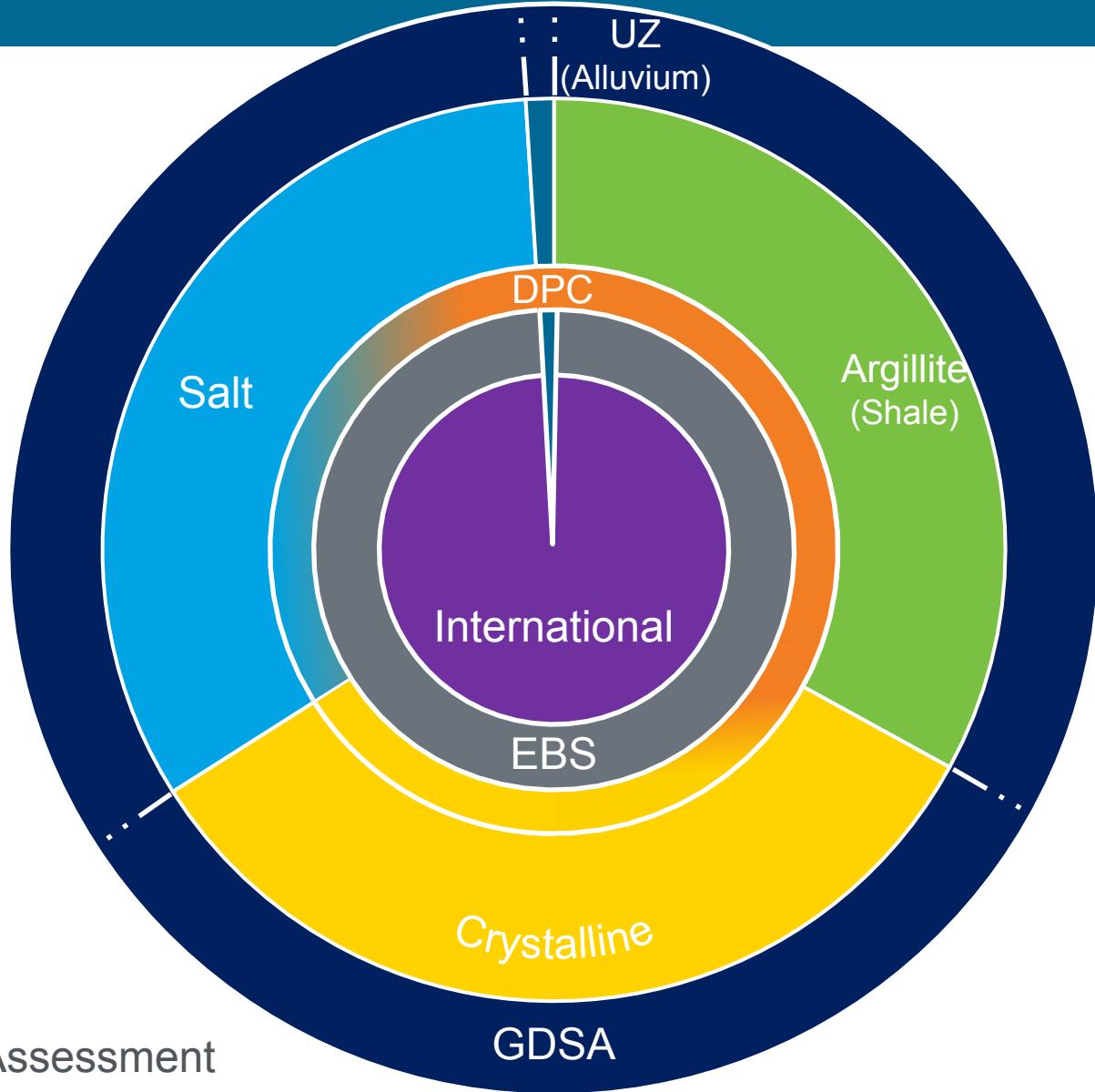
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# Overview

- 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

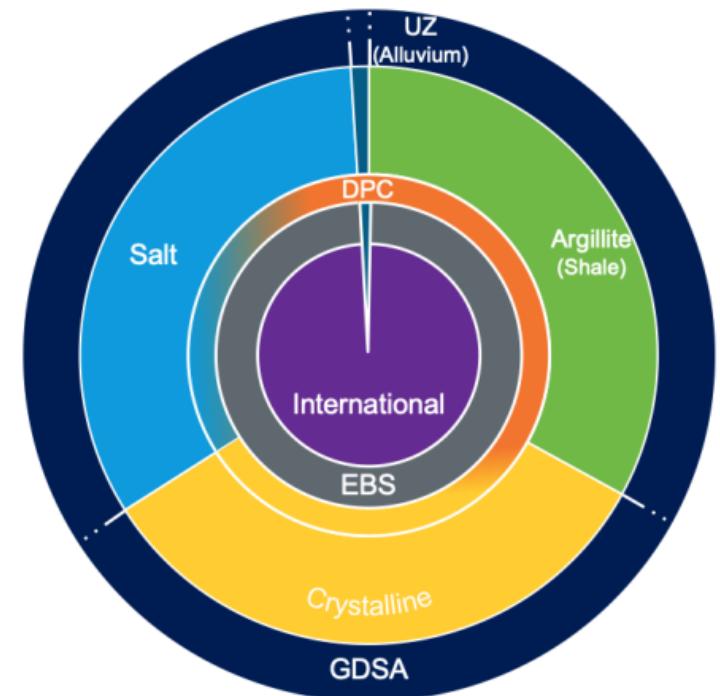
DPC = Dual Purpose Canisters

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?

High Impact R&D Topics	High-Priority R&D Activities	Medium-High-Priority R&D Activities
High Temperature Impacts	D-1, D-4, I-4, I-6, I-16*, E-11, S-5	I-2, I-3, I-7, E-10
Buffer and Seal Studies	I-4, E-9, E-17*, A-8, C-15*	I-2, I-3, I-7, A-4, C-6, C-8, C-11
Coupled Processes (Salt)	S-1, S-3, S-4, I-12, I-13	I-14, S-2, S-7, S-8, S-11*
Gas Flow in the EBS	I-6, I-8, I-18*	I-9, P-17*
Criticality	D-1, D-3, D-4, D-5	
Waste Package Degradation	C-16*, P-12	E-4*, E-6
In-Package Chemistry	E-14*	E-2, E-20, P-15*, P-16*
Generic PA Models		P-1, P-2, P-4, P-11*, P-13*, P-14
Radionuclide Transport		C-11*, C-13*, C-14*, P-15*, P-16*
DFN Issues		I-21*, C-1, C-17*
GDSA Geologic Modeling		O-2, O-3
THC Processes in EBS		E-3

## 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

#	Description	SFWST EBS Activity	Int'l Tie-in
E-09	Cement plug/liner degradation	Experimentally verified cement-geomaterial 3D model development in PFLOTRAN (crosscut with Argillite DR)	EBS Task Force Task Cement Task
A-08	Evaluation of Ordinary Portland Cement (OPC)	Seals in Salt (crosscut with Salt DR)	BATS Heater Test in Salt RANGERS Project
E-11	EBS High Temperature Geochemistry/Mineralogy	Hydrothermal Experiments examining host, buffer, and canister materials interaction/evolution at elevated temperature (crosscuts with Crystalline and Argillite)	HotBENT

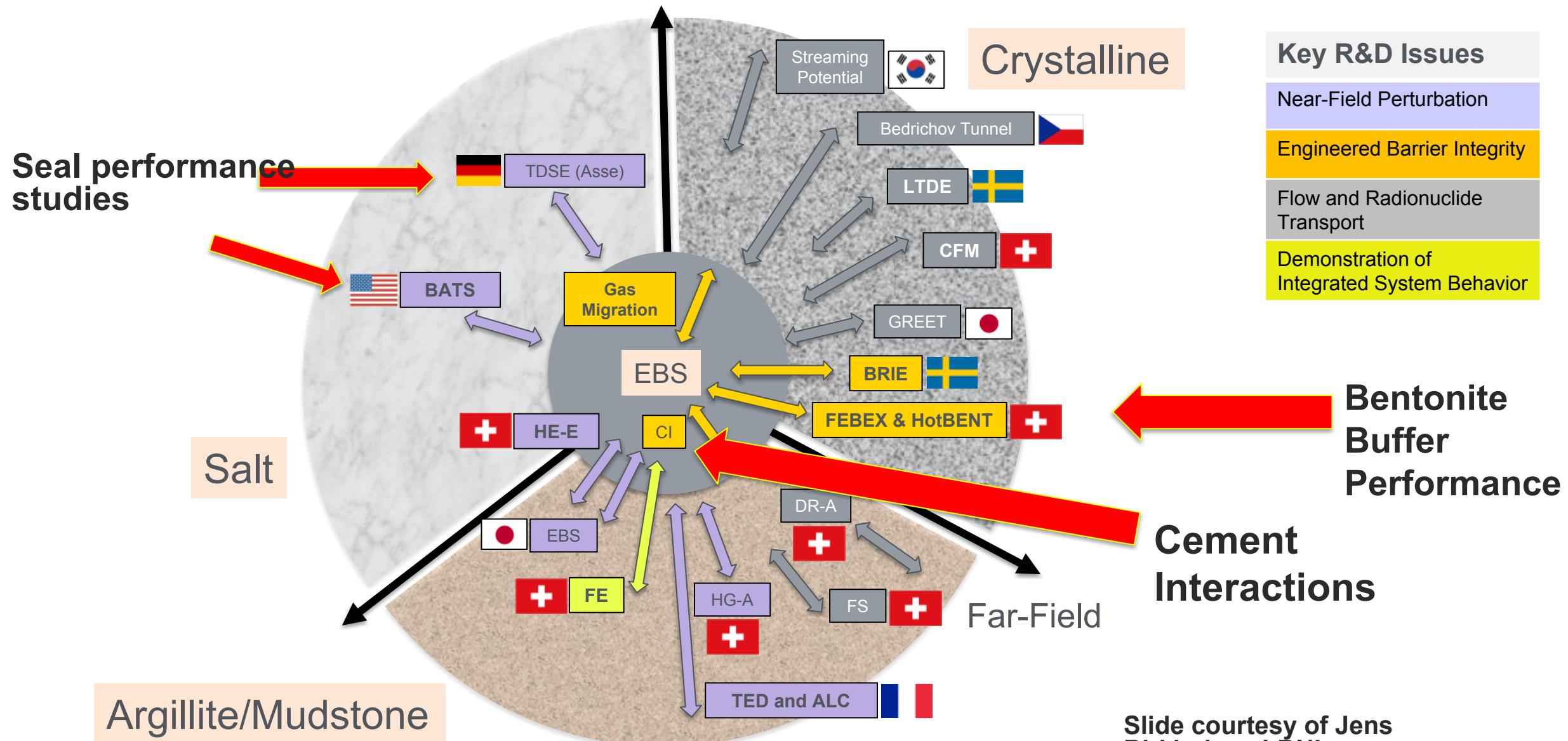
# High Priority EBS Activities (cont.)

#	Description	SFWST EBS Activity	Int'l Tie-in
E-03	TH/THC Processes in EBS	Various Bentonite Studies -chemical controls -molecular scale -bench scale -drift scale	FEBEX activities DECOVALEX 2023
I-08	Advectional gas flow in bentonite		<ul style="list-style-type: none"> <li>Task B: Modeling Advection of Gas in Clays (MAGIC)</li> <li>Task C: THM Modeling of the FE Experiment</li> <li>Task E: Brine Availability Test in Salt (BATS)</li> </ul>
I-04	Experiments of Bentonite at High Temperature	Benchtop High Temp Bentonite Column Test	HotBENT EBS Task Force Column Test
E-10	High Temperature Behavior	Modelling Support of HotBENT and Benchtop Tests	

# Knowledge and Capability Gaps

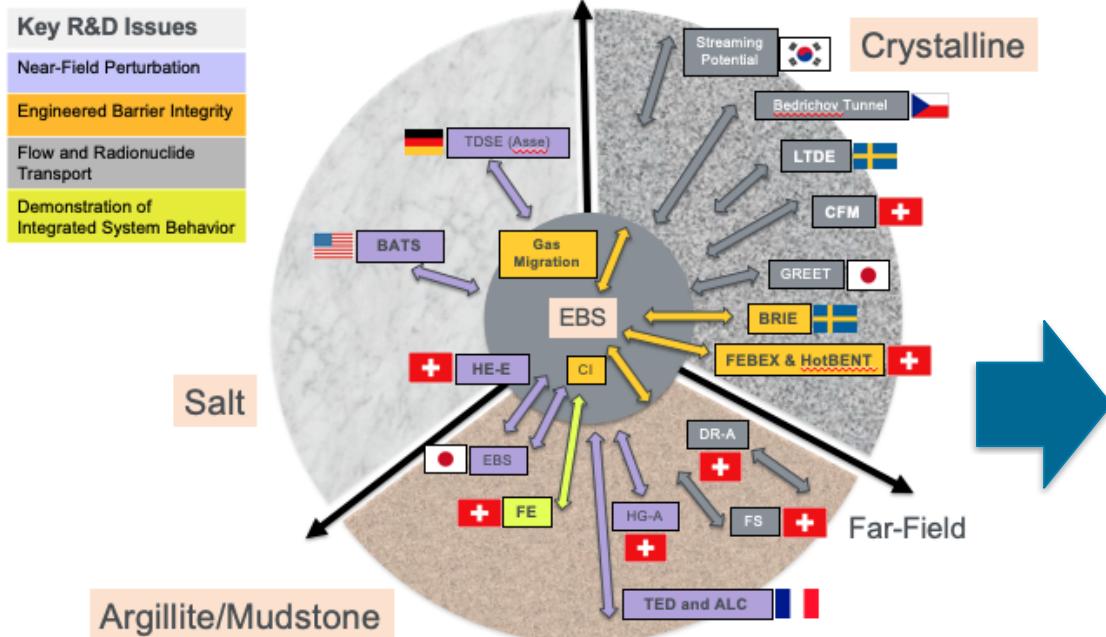
- **Gaps in Process Models**
  - Cement models for evolution of plugs and liners
    - Chemo-mechanical coupling
    - Fracture models
  - Saturation/Re-saturation of Cementitious Materials and Bentonite
  - Bentonite buffer
    - THMC models refinement
- **Benefits of filling these gaps:**
  - Impact representation of seal representation in GDSA, or at least improve confidence in permeability values for seals/interfaces
  - Improve understanding of near field geochemistry

# Knowledge and Capability Gaps also Crosscut with the International Field Test Portfolio and Host Media



Slide courtesy of Jens Birkholzer, LBNL

# 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**

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
  - 21<sup>st</sup> 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

# SFWST EBS Research Teams

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