SAND2023-07447R

Salt International Collaborations FY23 Update

Spent Fuel and Waste Disposition

Prepared for
US Department of Energy
Spent Fuel and Waste Science and Technology

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Sandia National Laboratories

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SUMMARY

This report summarizes the international collaborations conducted by Sandia funded by the US Department of Energy Office (DOE) of Nuclear Energy (DOE-NE) Spent Fuel and Waste Science & Technology (SFWST) as part of the Sandia National Laboratories Salt R&D and Salt International work packages. This report satisfies the level-three milestone M3SF-23SN010303062. Several stand-alone sections make up this summary report, each completed by the participants. The sections discuss granular salt reconsolidation (KOMPASS), engineered barriers (RANGERS), numerical model comparison (DECOVALEX) and an NEA Salt Club working group on the development of scenarios as part of the performance assessment development process. Finally, we summarize events related to the US/German Workshop on Repository Research, Design and Operations.

CONTENTS

ACRONYMS

BATS	brine availability test in salt
BGE	Bundesgesellschaft für Endlangerung
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
DECOVALEX	Development of Coupled models and their Validation against Experiments
DGGT	Deutsche Gesellschaft für Geotechnik
DOE	Department of Energy
DOE-EM	DOE Office of Environmental Management
DOE-NE	DOE Office of Nuclear Energy
ELSA	Schachtverschlüsse für Endlager für hochaktive Abfälle
FEP	feature, event, process
FY	fiscal year (October to September)
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit
HLW	high-level waste
IfG	Institut für Gebirgsmechanik GmbH
IGSC	international group for the safety case
KOMPASS	Compaction of Crushed Salt for Safe Enclosure (English translation of German acronym)
NEA	Nuclear Energy Agency
OECD	Organisation for Economic Co-operation and Development
RANGERS	Entwicklung eines Leitfadens zur Auslegung und zum Nachweis von geo-technischen Barrieren für ein HAW Endlager in Salzformationen Design
R&D	Research and Development
SFWST	Spent Fuel and Waste Science & Technology
SNL	Sandia National Laboratories
US	United States
VSG	Vorläufige Sicherheitsanalyse Gorleben
WIPP	Waste Isolation Pilot Plant (DOE-EM site)

SALT INTERNATIONAL COLLABORATIONS FY23 UPDATE

This report summarizes international collaborations funded by DOE-NE Spent Fuel and Waste Science & Technology (SFWST) as part of the Sandia National Laboratories Salt Research and Development (R&D) and Salt International work packages for fiscal year 2023 (FY23). Several stand-alone sections make up this summary report, each section completed by its participants. The sections discuss international collaborations on granular salt reconsolidation (KOMPASS), engineered barriers (RANGERS), numerical model comparison of salt lab and field data (DECOVALEX), and a Salt Club working group on the development of scenarios as part of the performance assessment development process.

Two primary collaborative efforts funded by Salt R&D and Salt International are the co-organization of, and participation in both the US/German Workshop on Salt Repository Research, Design, and the Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA) Salt Club. Because each of the major sections of this report stands alone, each has its own references and conclusions. There is no overall summary or conclusions at the end.

1. International Collaboration through the RANGERS Project

SNL Authors: *Ed Matteo*, *Melissa Mills*, *Rick Jayne, and Kris Kuhlman*

RANGERS is a collaborative project between Sandia National Laboratories and Bundesgesellschaft für Endlangerung (BGE) Technology (including Eric Simo, Phillip Herrold, and Andree Lommerzheim). After translating to English, the RANGERs acronym means "Design and Integrity Guideline for Engineered Barrier Systems for a HLW Repository in Salt". Geotechnical barriers for a repository in salt formations have already been the subject of numerous research projects. As part of the preliminary safety analysis for the Gorleben site (Vorläufige Sicherheitsanalyse Gorleben – VSG), a verification method for the integrity of sealing elements in a high-level waste (HLW) repository in domal salt formation was developed (Müller-Hoeppe, 2012). This made it possible to carry out a more detailed verification for a shaft closure. In the ELSA (Schachtverschlüsse für Endlager für hochaktive Abfälle) project, a design of shaft closures for HLW repositories was developed (Kudla, 2013). Further research projects such as those reported in Kudla (2009) and Sitz (1999) investigated different aspects of geotechnical closure systems. Recommendations for the planning and execution of geotechnical barriers were formulated in DGGT (2017) by the working group salt mechanics of the DGGT (Deutsche Gesellschaft für Geotechnik – the German Geotechnical Society).

Despite extensive knowledge and experience about geotechnical barriers in salt formations, there is no methodology for the design and verification of such structures for an HLW repository. BGE TEC and Sandia propose to develop jointly a Design and Integrity Guideline for Engineered Barrier Systems for an HLW Repository in Salt in the framework of a joint project between Germany and US. The project aims at developing a guideline for the planning and the design of geotechnical barriers in salt formations. This guideline will serve as a reference manual for the conceptualization of an HLW repository in Germany and the US. It will summarize the current state of art available in two reports and gives an outlook about the technologies which will impact the development of geotechnical barrier systems in the future.

The aim of the project is to develop a guideline for the design and verification of geotechnical barrier systems in repositories in salt formations that incorporates the existing knowledge and experience about geotechnical barriers of BGE and BGE Technology as well as of Sandia and of others. Recommendations for the design and verification of geotechnical barriers based on the state of the art in science and technology will be formulated and an overview of new concepts, building materials and technologies that will shape the state of the art of tomorrow will be given. Four sub-goals are formulated for this purpose:

1. Compilation of existing knowledge and experience for the design and construction of geotechnical barriers and compilation of new concepts and technologies about geotechnical barriers.
2. Development of a guideline based on the state of the art in science and technology for the design and verification of geotechnical barriers.
3. Preliminary design and verification of the geotechnical barrier system for selected repository systems based on the developed guideline.
4. Comparison of design results according to the new guideline with results of previous design and assessment.

The outcome of the project KOMPASS – another binational project between Germany and the US (see next section) – about the compaction of crushed salt as a key element of a sealing system in a salt HLW repository will be exploited in this project.

Overall, significant progress has been made in FY23 at SNL and BGE. Considerable work has been completed on compilation of existing data (i.e., state-of-the-art report). Because further work in RANGES depends on Performance Assessment (PA) and establishment of a Salt Reference Case, RANGERS has been participating in integration activities with DECOVALEX Task F and the NEA "Salt Scenarios" workshop (see later in this report). Salt Scenarios brings together researchers from the US, Germany, Netherlands, and the UK.

1.1 RANGERS FY23 Publications

In FY23, the RANGERS continued work on the State of the Art SOTA) #2, which is to be completed by the end of 2023.

The RANGERS project gave an in-person presentations at the 12th US/German Workshop, titled *RANGERS – Engineered Barrier Systems in Salt (Kris Kuhlman).*

The RANGERS project also gave two in-person presentations at the 13th US/German Workshop (June 2023), titled *RANGERS – Integrity of Shaft Seals (Paola León-Vargas)*, and *RANGERS - Summary of State-of-the-Art in EBS Materials (Ed Matteo)*

The RANGERS project is finishing its fourth and final year, as the project will end with completion of the SOTA#2 in December 2023.

1.2 References

Simo, E., P. Herold, A. Keller, A. Lommerzheim, E.N. Matteo, T. Hadgu, R.S. Jayne, K.L. Kuhlman & M.M. Mills, 2022. *State of the Art and Science on Engineered Barriers in Salt Formations*, (117 p.) SAND2022-0204R. BGE TECHNOLOGY GmbH & Sandia National Laboratories. https://doi.org/10.2172/1855075

Simo, E., E.N. Matteo, K.L. Kuhlman, R.S. Jayne, P. León Vargas, P. Herold, A. Lommerzheim & A. Keller, 2022. *Design and Performance Assessment of Engineered Barrier Systems in a Salt Repository for HLW/SNF*. SAND2022-2624C, Salt Mech X proceedings.

2. International Collaboration through the KOMPASS Projects

SNL Authors: *Jibril B. Coulibaly, Melissa Mills, Benjamin Reedlunn, and James Bean*

Joint Project KOMPASS is a collaboration of German, Dutch, and American researchers seeking to improve thermo-hydro-mechanical models for crushed salt (i.e., run-of-mine or granular salt). Partners conduct experiments to understand crushed salt behavior and further develop, calibrate, and validate models for crushed salt. After translating to English, the acronym KOMPASS stands for "Compaction of Crushed Salt for Safe Enclosure". The KOMPASS partners are Bundesgesellshaft für Endlangerung Technology (BGE) (Peine, Germany), Institute für Gebirgsmechanik (IfG) (Leipzig, Germany), Technical University of Clausthal (TUC) (Clausthal, Germany), Gesellschaft für Anglagen-und Reaktorsicherheit (GRS) (Köln, Germany), Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) (Hannover, Germany), Centrale Organisatie Voor Radioactief Afval (COVRA) (Nieuwdorp, The Netherlands), Utrecht University (UU) (Utrecht, The Netherlands) and Sandia National Laboratories (SNL).

The first phase of the KOMPASS project (KOMPASS-1) was completed in 2020, with a comprehensive final report produced (Czaikowski et al., 2020). During this phase, experimental techniques for consolidation were thoroughly evaluated to produce adequate pre-compacted and compacted samples under various conditions, which included characterizing sufficient reference material. A total of 34 different samples were produced, and several underwent microstructural investigations to document associated deformation mechanisms.

In addition to laboratory testing and analysis, model benchmarking initiatives revealed that while most models are capable of reproducing results, they still require a well-founded laboratory database to predict functional relationships to further characterize the THM-coupled compaction behavior of crushed salt. The various constitutive model approaches (i.e., C-WIPP, Heeman (BGR), Olivella/Gens (GRS), Callahan (Sandia)) were compared in the first phase to determine the main influencing factors or properties of each and identify specific lab tests needed for sufficient validation.

The second phase of the project (KOMPASS-2) was completed in 2023, with a comprehensive final report to be published in the Fall of 2023 (Friedenberg et al., under internal review). Based on results from the first phase, a systematic test series was planned to further establish reproducible and predictable correlations between stress, duration of compaction, moisture states, and respective target porosity. Microstructural investigations were continued in the second phase with BGR, UU, and SNL studying equivalent samples to compare measurements of various relevant quantities, such as the grain size and subgrain size, and observed deformation mechanisms. On the modeling side, each partner calibrated their model(s) against test TUC-V2 on KOMPASS reference material, developed model improvements as necessary, and used the resulting calibrated model(s) to simulate the closure of a drift backfilled with crushed salt.

The large amount of testing initially planned could not be completed within the framework of the KOMPASS-2 project. A proposal for a follow-up project titled "Multi-scale experimental and numerical analysis of crushed salt material used as engineered backfill for a nuclear waste repository in rock salt" (MEASURES) is under development. This next phase will retain the overall framework of the KOMPASS projects (compaction experiments, microstructural studies, and modeling), but will attempt to narrow the focus to a few specific, to be determined, questions. The proposal will be submitted to the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) in Fall 2023, and funding would begin no earlier than Spring 2024 if the proposal is accepted.

2.1 KOMPASS Microstructural Investigations

During FY23, Sandia prepared and analyzed the pre-compacted and compacted samples, which underwent various testing conditions and types (i.e., triaxial, oedometric, and large or small scale). Table 1 gives details of each sample and their conditions. Photos of samples are shown in Figure 1. Samples with diameters less than 10 cm were cut into billets, typically from center locations, using a low damage IsoMet1000 saw (Buehler) with isopropanol as the cutting fluid. Larger sample blocks from big oedometer were cut using a low damage diamond wire saw (MTI Corp.), also with isopropanol as the cutting fluid. Each billet was then vacuum impregnated with a two-part epoxy doped with rhodamine B dye for contrast, glued to a glass slide, and cut a few mm thick. A semi-automatic grinder/polisher (Buehler Ecomet) was used first with 400 grit diamond embedded resin plate for coarse grinding, followed by 1000 grit for fine grinding, and polishing with 9, 3, and ¼ µm diamond suspensions all with alcohol-based lubricant (Struers). After polishing, thick sections were also etched in a solution of methanol saturated with $PbCl_2$ for several seconds flowed by submergence in butanol for several seconds, then thoroughly dried with compressed air. All thick sections were examined under an optical microscope (ZEISS AxioScope 5), equipped with imaging software (ZenCore), in both reflected and transmitted light (RL, TL). Reflected light was utilized to observe grain sizes, shapes, boundaries, and pore structures, where transmitted light to view fluid inclusion planes and bands with any attributable microcracks in the grain structure from deformation.

Table 1: Samples from IfG and TUC with their respective test conditions and porosities.

Partner	Sample	Test Type	Humidity	Temperature Range (°C)	Stress Range (MPa)	Total Duration (days)	Initial porosity (%)	Final porosity (%)
IfG	684/OEDO1/TCC1	Pre-comp Oedom. → Comp Isos.	dry	25 to 60	5 to 20	197	14.39	11.09
	684/OEDO1/TCC2	Pre-comp Oedom. → Comp Isos.	dry	25 to 60	10 to 30	197	15.6	7.77
	684/OEDO1/TCC3	Pre-comp Oedom. → Comp Isos.	dry	25 to 60	1 to 10	197	12.9	11.7
	684/OEDO1/TCC5	Pre-comp Oedom. → Comp Isos.	wet (1%)	25	5 to 20	28	16	1.3
	684/OEDO1/TCC6	Pre-comp Oedom. → Comp Isos.	wet (1%)	25	1 to 10	28	16.21	0.88
	684/OED01/Dry "Big Cell" Block	Pre-comp Oedom	dry	25	0.4 to 8	28	33.75	12
	684/OED04/Wet 3 "Big cell" Block	Pre-comp Oedom	wet (1%)	25	0.4 to 12.8	28	33.3	2
TUC	TUC14	Pre-comp Plain strain	wet (0.5%)	25	5	2	26	14
	TUC15	Pre-comp Plain strain	wet (0.5%)	25	5	2	27	14
	TUC18	Pre-comp Plain strain	dry (0.1%)	25	2	2	22	17
	TUC21	Pre-comp Plain strain	wet (1%)	25	5	4	27	18


684/OED01/TCC1
a.
684/Oed01/TCC2
b.
60°C
dry
684/OED01/TCC3
c.
684/OED01/TCC5
d.
60°C
wet
684/OED01/TCC6
e.
684/OED01 TROCKEN
UNTEN
HORIZONTAL
STAINLESS STEEL
WESTCOTT
f.

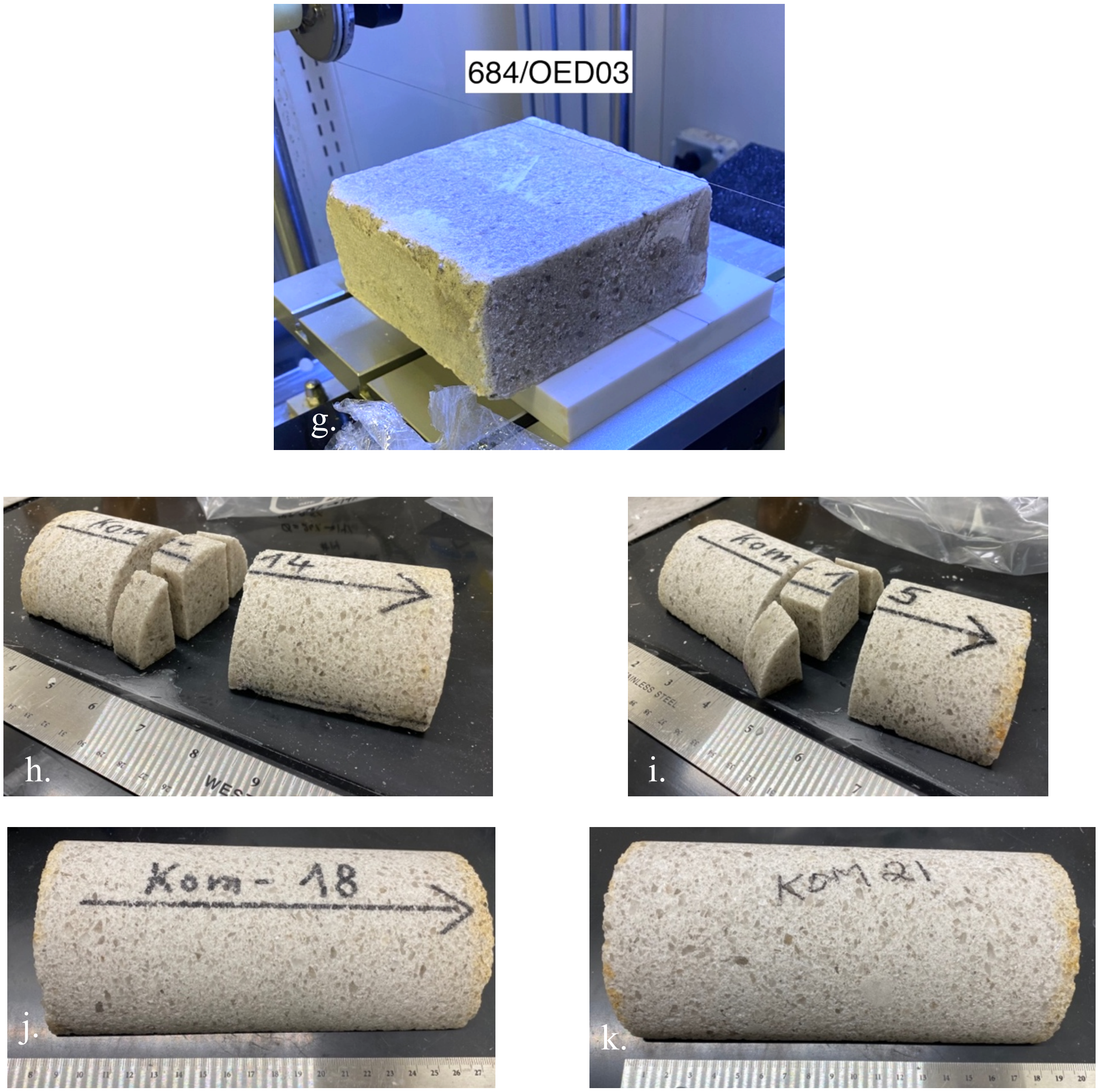
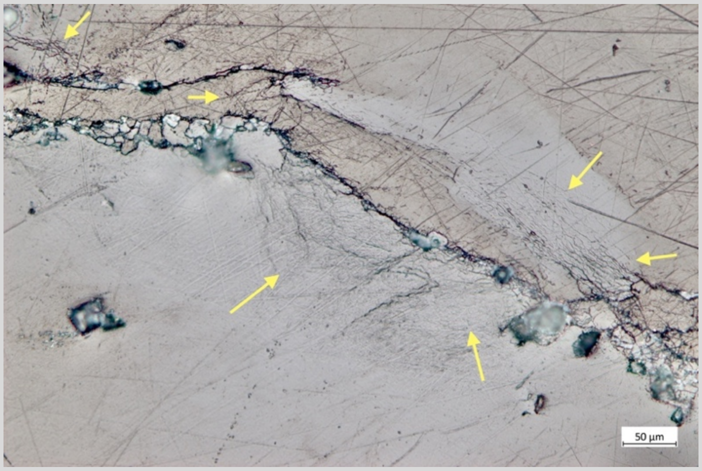


Figure 1. Reconsolidated granular salt samples from oedometric tests at IfG (parts a through g) and triaxial tests at TUC (parts h through k)

For KOMPASS-2, Sandia's focus was on investigating and determining any microstructural effects that added moisture had on pre-compaction and compaction methods. From analysis, clear difference is seen within microstructures of samples compacted with added moisture. A few examples are given in the following figures. Etched surfaces of the "Big Cell" pre-compacted samples are shown in Figure 2a and Figure 2b. The dry sample experiences crystal plastic deformation, marked by areas of dense slip bands (yellow arrows, Figure 2a). In contrast, Figure 2b displays a very tight grain boundary at center in the wet sample with no apparent slip bands in the substructure. Fluid-assisted grain boundary migration is evident by recrystallized, cubic, strain-free grains (white arrows).

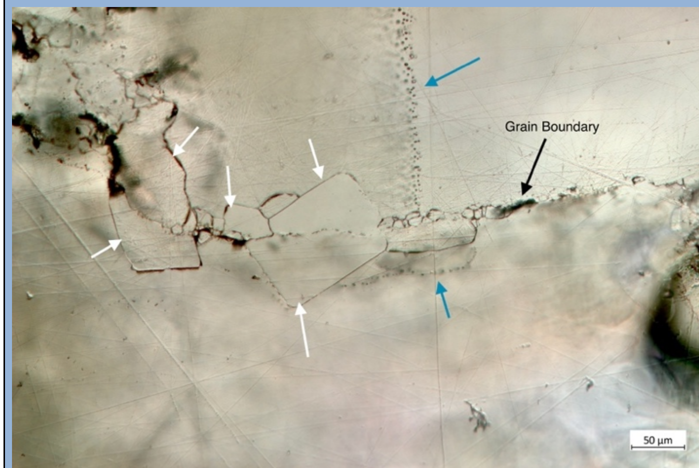
For samples fully compacted at 20 MPa (Figure 3), static recrystallization aided by pressure solution is seen in the dry sample (Figure 3a), surrounded by high dislocation density areas (slip bands) with elongated subgrains indicative of high stress regions. The wet sample, on the other hand, exhibits further recovery with full dynamic recrystallization by fluid assisted grain boundary migration through subgrain rotation creating new grain boundaries (left of Figure Figure 3b), and irregular, strain-free subgrains. The wetter sample reconsolidates faster and more favorably than the drier sample.

684/OED01/**Dry** "Big Cell" Block



a.

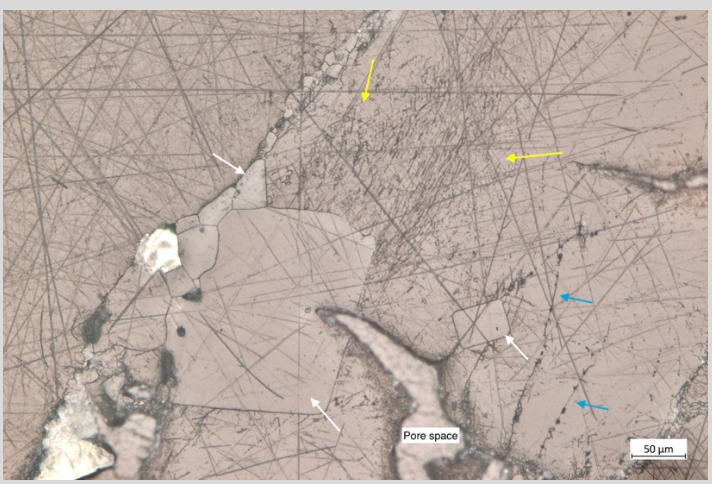
684/OED04/**Wet** 3 "Big Cell" Block



b.

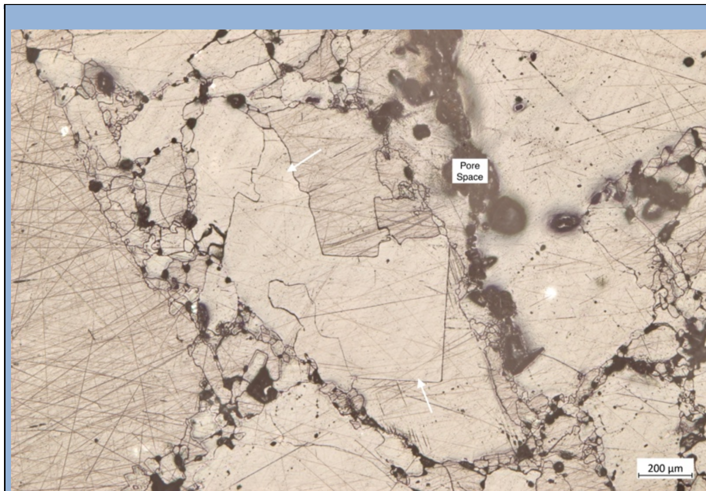
Figure 2: Etched photomicrographs from "Big Cell" pre-compacted samples under dry (a) and wet (b) conditions.

TCC1 (dry, 20 MPa)



a.

TCC5 (wet, 20 MPa)



b.

Figure 3: Etched photomicrographs from samples compacted at 20 MPa under dry (a) and wet (b) conditions.

2.2 KOMPASS Numerical Modeling

The KOMPASS partners generally used different constitutive models and calibrations to attempt to match several laboratory tests on crushed salt. Sandia National Laboratories used the crushed salt constitutive model developed by Callahan (1999). During KOMPASS-1 project, a preliminary model calibration that combined two pre-existing parameter sets was used. The predictions from this preliminary model calibration differed substantially from the TUC-V2 test measurements (Figure 4) and were considered a starting point from which an improved calibration of the model to the measurements would begin. During KOMPASS-2, a proper Callahan model calibration was created and documented in greater detail by Coulibaly (2023). The process of calibrating against the TUC-V2 measurements revealed several shortcomings of the Callahan model (Coulibaly, 2023) that SNL plans to address in the coming years. Nevertheless, this new Callahan calibration successfully captures the experimental response of the KOMPASS reference material (Figure 4) and is subsequently used by SNL for KOMPASS work such as the Demonstrator model.

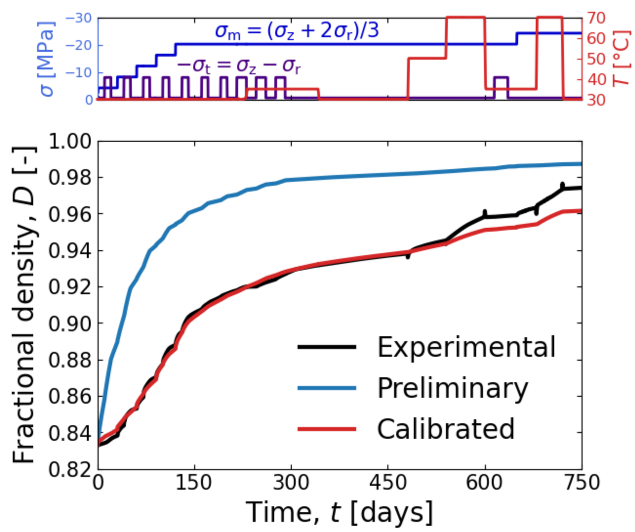


Figure 4. Comparison of the preliminary (KOMPASS-1) and new (KOMPASS-2) calibration of the Callahan crushed salt constitutive model against laboratory test TUC-V2

A Demonstrator model, developed by Ole Rabbel of IfG, was proposed to the KOMPASS-II partners. The model was designed to allow comparison of numerical simulations of the creep closure of an excavated room in a host rock salt formation. The excavated region was modeled with crushed salt completely filling the room. All partners were required to use the same constitutive model formulation and parameterization for the host rock, such that any observed differences in simulated backfill compaction (porosity) history would be primarily due to the constitutive models and calibrations used to represent the backfill material. The behavior of the crushed salt was determined from each partner's calibration of their models to the TUC-V2 laboratory test. Using the preliminary model calibration from KOMPASS-1 and the new calibration of the Callahan crushed salt model from KOMPASS-2 (described above), two simulations of room closure were performed.

Figure 5a shows the mesh discretization in the region near the backfilled excavation at time 0 years, corresponding to the initial state prior to the onset of backfill compaction. Figure 5b, taken from the KOMPASS-2 calibration simulation, shows the deformation of the backfill at 500 years when the crushed salt backfill has been compacted to a state close to that of the surrounding host rock salt (porosity ~0.005).

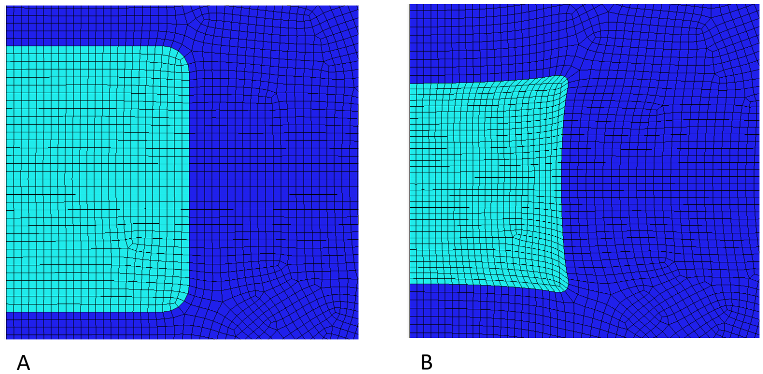


Figure 5. Demonstrator model of 3.7 m tall drift simulated deformation using Callahan crushed salt model with KOMPASS-2 calibration. A) *t* = 0 years (uncompacted), B) *t* = 500 years (near full compaction)

The Demonstrator room closure simulations were performed out to a period of 500 years. Figure 6 shows the backfill porosity histories for both the preliminary calibration (KOMPASS-1) and the final calibration (KOMPASS-2) to TUC-V2 test data. In this figure the plotted backfill porosity is the average porosity obtained by summing each element value of porosity and dividing by the number of elements in the backfilled region. Despite the better "match" to the TUC-V2 test data provided by the KOMPASS-2 calibration, the average porosity histories are nearly identical for the first 10 years. After 10 years, they diverge, especially when one compares the time required to reach a small porosity. For example, the KOMPASS-2 calibration requires 500 years to reach a porosity of 0.497%, while the KOMPASS-1 calibration requires only 101 years to reach the same porosity. The decreased compliance of the KOMPASS-2 calibration is consistent with the simulations of the TUC-V2 test (see Figure 4). Comparison of all partner results for quantities of interest (e.g., roof, floor, and wall displacements, and backfill porosity, host rock and backfill stresses at various locations in the model) for the Demonstrator model will be documented in the KOMPASS-2 final report.

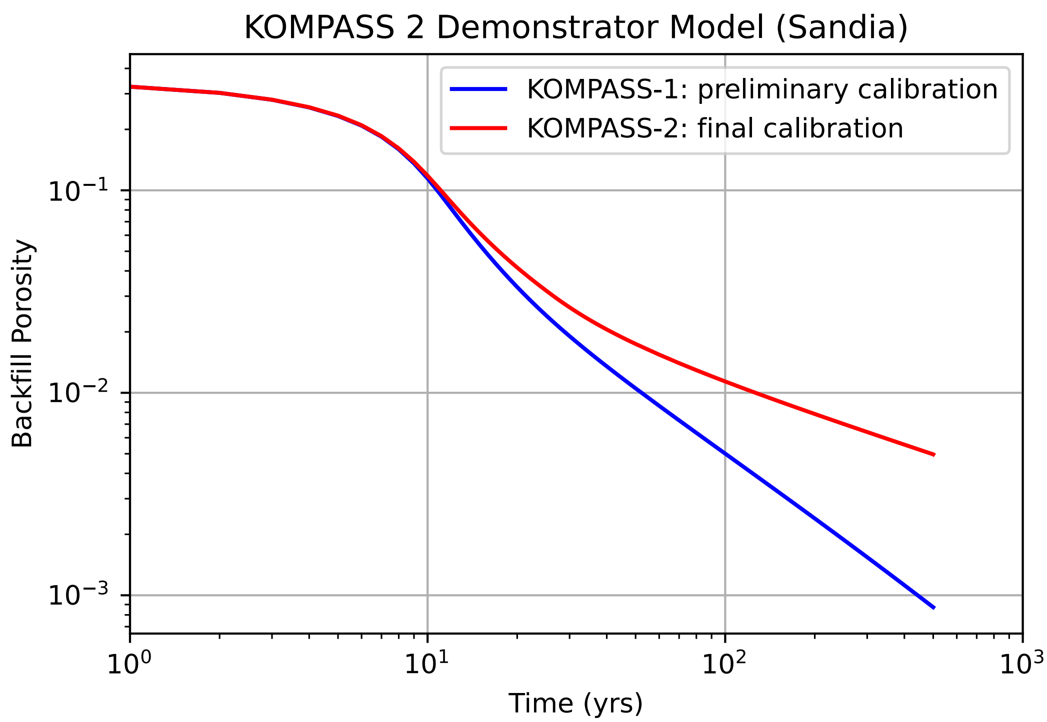


Figure 6. Backfill porosity histories using the preliminary and final calibration of the Callahan crushed salt model for the KOMPASS-II Demonstrator Model.

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3. NEA Salt Club

SNL Authors: *Kris Kuhlman*

Personnel from SNL and Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) continue to progress a long-standing development of a comprehensive Features, Events and Processes (FEPs) catalogue and FEP database (Freeze et al., 2020). This work is extended through the development of a generalized approach to scenario development for a high-level waste repository at a generic salt site. This work is being conducted for the Nuclear Energy Agency (NEA) Salt Club expert group, which is a sub-group under the NEA International Group for the Safety Case (IGSC).

The Salt Scenarios working group held a two-day mini symposium on human intrusion. The meeting was held on MS-Teams 10-11 January 2023, and discussed the applicable regulations and practices associated with human intrusion, focusing on salt repositories. The meeting had contributions from US, German, UK, Dutch, and Australian colleagues, and the group continues to progress on a NEA Salt Club report on scenario development, tentatively planned to be completed in FY24. A small group also has continued to meet approximately monthly to finalize a journal manuscript on the topic of scenario development.

The group presented its status at the in-person NEA Salt Club meeting and the US/German Workshop on Salt Repository Research, Design & Operation in Santa Fe New Mexico in June 2023.

3.1 Reference

Freeze, G., S.D. Sevougian, K. Kuhlman, M. Gross, J. Wolf, D. Buhmann, J. Bartol, C. Leigh & J. Mönig, 2020. *Generic FEPs Catalogue and Salt Knowledge Archive*, (151 p.) SAND2020-13186. Albuquerque, NM: Sandia National Laboratories. https://doi.org/10.2172/1815346

4. DECOVALEX 2023 – Task E

SNL Author: *Kris Kuhlman*

The Brine Availability Test in Salt (BATS) is a field test that is being implemented at the US Department of Energy's (DOE) Office of Environmental Management's (DOE-EM) Waste Isolation Pilot Plant (WIPP) and funded by the DOE Office of Nuclear Energy (DOE-NE) (Kuhlman et al., 2020; Kuhlman et al., 2021; Kuhlman et al., 2022a). This field test is the focus of Task E in the 2020-2023 round of DECOVALEX (DEvelopment of COupled models and their VALidation against Experiments) model benchmarking exercise. The November 2022 DECOVALEX-2023 meeting (#6) was held in-person in Albuquerque, NM (7-10 November 2022). SNL Salt R&D staff helped organize and host this meeting, along with SNL GDSA staff involved with Tasks F1 and F2 (crystalline and salt performance assessment). The May 2023 DECOVALEX-2023 meeting (#7) was held in Busan, South Korea (22-25 May 2023). After five online-only DECOVALEX meetings due to the coronavirus pandemic, it was widely felt that it was very productive to meet in person finally.

The initial Task E specification (Kuhlman, 2020) laid out the initial plan for the numerical comparison between the modeling teams and both historical and recent field observations. Most of the DECOVALEX-2023 project has now completed (Green arrow in Table 2). The interim DECOVALEX-2023 Task E report was completed last year (Kuhlman et al., 2022b). The final Task E report will build upon this interim report and will be completed before the final (#8) DECOVALEX-2023 meeting in Troyes France (13-17 November 2023).

Table 2. High-level DECOVALEX Task E schedule (Step 3 has been dropped)

	Apr.	Nov.	Apr.	Nov.	Apr.	Nov.	Apr.	Nov.
	2020		2021		2022		2023	
Step 0								
Step 1								
Midterm Report → (Nov 2021)								
Step 2								
~~Step 3~~								
					Papers and Final Report → (Nov 2023)			

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5. US/German Workshop

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The US/German Workshop on Salt Repository Research, Design & Operation is a multi-national annual meeting on repository science in salt, that has often met jointly with the NEA Salt Club plenary meeting. The proceedings from past US/German workshops are published on the Sandia National Laboratories salt repository research webpage: https://www.sandia.gov/salt/us-german-workshop/

Table 2. US/German Workshop Venues

#	Dates	Location	Salt Club?
1	25-27 May 2010	Mississippi State Univ, Canton, USA	
2	9-10 Nov. 2011	Hotel Schönau, Peine, Germany	
3	8-11 Oct. 2012	SNL, Albuquerque, USA	
4	17-18 Sep. 2013	Hollywood Media Hotel, Berlin, Germany	×
5	8-10 Sep. 2014	La Fonda Hotel, Santa Fe, USA	
6	7-9 Sep. 2015	Hotel Pullman Dresden Newa, Dresden, Germany	
7	7-9 Sep. 2016	Crystal City Embassy Suites, Washington DC, USA	×
8	5-7 Sep. 2017	COVRA, Middelburg, The Netherlands	×
9	10-11 Sep. 2018	BGR, Hannover, Germany	×
10	28-30 May 2019	SD School of Mines, Rapid City, USA	×
11	2 Feb, 17 Jun., 8-9 Sep. 2021	Virtual (MS-Teams)	
12	6-8 Sep 2022	Hotel Steigenberger, Braunschweig, Germany	×
13	20-23 Jun 2023	Drury Plaza Hotel, Santa Fe, USA	×

In late FY22 (6-8 Sep 2022), the 12^{th} US/German Workshop was held in Braunschweig, Germany. In FY23 (20-23 June 2023), the 13th US/German Workshop was held in Santa Fe, New Mexico. The workshop is co-hosted by Michael Bühler (PKTA), Jörg Melzer (PKTA), Philipp Herold (BGE TECH), Melissa Mills (SNL), and Kris Kuhlman (SNL).

Despite its name, the US/German workshop includes participants from several countries. The 13^{th} US/German workshop included more than 60 in-person participants and several virtual participants from the following countries and organizations:

- Germany:
  - BASE (Bundesamt für die Sicherheit der nuklearen Entsorgung),
  - BGE (Bundesgesellschaft für Endlagerung) and BGE TECHNOLOGY,
  - BGR (Bundesanstalt für Geowissenschaften und Rohstoffe),
  - BMUV (Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbaraucherschutz),

- GRS (Gesellschaft für Anlagen- und Reaktorsicherheit),
- IfG (Institut für Gebirgsmechanik),
- KIT PTKA (Projektträger Karlsruhe Karlsruher Institut für Technologie),
- KIT-INE (Institut für Nukleare Entsorgung des Karlsruher Instituts für Technologie),
- TU Bergakademie Freiberg,
- TU Clausthal,
- Technische Universität Braunschweig

- United States:
  - Sandia National Laboratories,
  - Los Alamos National Laboratory,
  - Lawrence Berkeley National Laboratory,
  - Department of Energy Office of Nuclear Energy,
  - Department of Energy Office of Environmental Management,
  - Environmental Protection Agency,
  - RESPEC,
  - Nuclear Waste Technical Review Board,
  - SC&A (EPA Contractor)
- The United Kingdom:
  - Nuclear Waste Services (virtual)
- The Netherlands:
  - Centrale Organisatie Voor Radioactief Afval
- Australia:
  - Commonwealth Scientific and Industrial Research Organisation (virtual)
- International:
  - The International Atomic Energy Agency (virtual)

The last two in-person US/German Workshops (Braunschweig and Santa Fe) were successful, and the attendees were asked at the end of the 2023 Santa Fe workshop if attendees through travel and smaller attendance (purely online meetings had closer to 100 attendees) were worthwhile for the benefit of in-person collaborations and interactions. The overwhelming response was in favor of in-person meetings moving forward. The next US/German Workshop will either be in the United Kingdom or in Germany in June or July 2024.