# CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

# TRIP REPORT

**SUBJECT**: 6th DECOVALEX-2015 Workshop

**DATE/PLACE**: November 10–13, 2014

London, England

**AUTHOR(S)**: Stuart Stothoff
Center for Nuclear Waste Regulatory Analyses (CNWRA®)
and

Randall Fedors
U.S. Nuclear Regulatory Commission (NRC)

**PERSONS PRESENT**: Randall Fedors (NRC) and Stuart Stothoff (CNWRA) participated in the 6th workshop of the DECOVALEX-2015 project.

**BACKGROUND AND PURPOSE OF MEETING/TRIP**: The workshop was held on November 10–13, 2014, in London, England. The **De**velopment of **Co**upled Models and Their **Val**idation Against **Ex**periments (DECOVALEX) project is an international collaboration focused on modeling thermal-hydrological-mechanical-chemical (THMC) processes associated with the geologic disposal of high-level waste and spent nuclear fuel. The purpose of the workshop was for participants to interact to identify issues and learn from the variety of approaches taken by the different teams. CNWRA participates in DECOVALEX as part of technical assistance under Task Order 9 of Contract No. NRC–HQ–12–C–02–0089.

**SUMMARY OF ACTIVITIES**: The NRC and CNWRA staffs' participation in the 6th DECOVALEX-2015 workshop provided an opportunity to interact and discuss other organizations' approaches and progress in modeling field experiments encompassing near-field coupled THMC processes. The workshop agenda is included as an attachment. The activities at this workshop included (i) discussion on approaches and progress by each participant for the relevant portions of the five tasks, (ii) informal interactions between presentations and group discussions, and (iii) field trips. Discussions of research progress for DECOVALEX-2015 tasks provided a better understanding of the technical difficulties in understanding near-field conditions and the advantages and disadvantages of several alternative approaches.

Involvement with DECOVALEX will allow the staff to leverage expertise from waste disposal programs from many countries in understanding complex near-field processes and issues in a variety of geologic environments. Leveraging international experience will help the NRC and CNWRA staff understand important technical and performance issues that may influence planning and preparation for future regulatory developments as the U.S. national waste policy and program evolve.

The continued development of modeling tools validated against large underground experiments will, in subsequent years, enable staff to provide insights on the importance of coupled processes on repository performance for geologic disposal. The NRC and CNWRA staffs will continue to develop the modeling tools to analyze coupled processes in the near-field of repositories in the saturated zone.

Use of these data could guide and constrain scenario modeling of coupled THMC near-field processes. In addition to the continued development of modeling tools and identification of required constitutive relations for near-field processes, the NRC and CNWRA staff will continue to use information leveraged from international interactions to refine near-field abstraction approaches and data for performance assessments.

**Trip Details**

Five tasks—called A, B1, B2, C1, and C2—were agreed upon at the 1st DECOVALEX-2015 workshop in April 2012. The NRC staff will continue to participate in Tasks A, B1, and C1. CNWRA has been tasked to support NRC with Task B1. All staff will continue to follow discussions for Tasks B2 and C2 to gain insights from the efforts and approaches of other DECOVALEX participants. Because of the open and collaborative environment in DECOVALEX, the staff is able to gain insights from the discussions pertaining to the other tasks. Four of the tasks involve modeling of experiments at underground facilities and the fifth task involves modeling of a complex laboratory experiment.

The following tables provide information related to the task description, participants, discussion points, future work, and action items specific to NRC/CNWRA for each task. The acronyms used in the tables for each task are as follows:

| | |
|---|---|
| BGR | Federal Institute for Geosciences and Natural Resources, Germany |
| CAS | Chinese Academy of Sciences |
| CEA | Commissariat à l'Energie Atomique, France |
| CIMNE | Centre International de Métodes Numèrics en Enginyeria, Barcelona, Spain |
| CNSC | Canadian Nuclear Safety Commission, Canada |
| DOE | Department of Energy, USA |
| ENSI | Swiss Federal Nuclear Safety Inspectorate, Switzerland |
| IC | Imperial College of London, UK |
| IRSN | Institut de Radioprotection et de Sûreté Nucléaire, France |
| JAEA | Japan Atomic Energy Agency |
| KAERI | Korea Atomic Energy Research Institute, Korea |
| KINS | Korea Institute of Nuclear Safety |
| KRMC | Korea Radioactive Waste Management Corporation |
| KIGAM | Korea Institute of Geoscience and Mineral Resources |
| KTH | Royal Institute of Technology, Sweden |
| LBNL | Lawrence Berkeley National Laboratory, USA |
| NAGRA | Nationale Genossenschaft für die Lagerung radioaktiver Abfälle, Switzerland |
| NDA | Nuclear Decommissioning Authority, UK |
| RAWRA | Radioactive Waste Repository Authority, Czech Republic |
| SNL | Sandia National Laboratories, USA |
| SNU | Seoul National University |
| TUL | Technical University of Liberec, Czech Republic |
| UFZ | Helmholtz Centre for Environmental Research, Germany |
| UPC | Universitat Politècnica de Catalunya, Spain |
| UGN | Institute of Geonics, Science Academy of Czech Republic |
| UoE | University of Edinburgh, UK |
| Quintessa | Quintessa Ltd., UK |

<table>
<tr><th colspan="2">Task A</th></tr>
<tr><td>Brief Description of the Overall Task</td><td>SEALEX experiment at Tournemire underground research facility in France, developed by IRSN. The task focus is on hydromechanical performance of bentonite seals for horizontal emplacement boreholes.</td></tr>
<tr><td>Brief Description of the Current Steps, Task A (Completed Steps Are Included. Last Item Listed is the Current Step)</td><td>STEP 0—Modeling of bentonite-sand mixture hydromechanical behavior and parameters identification from various laboratory tests such as (i) water retention curves, (ii) infiltration test under constant volume condition, and (iii) swelling and compression tests under suction control condition.<br><br>STEP 1—Blind prediction of laboratory 1/10$^{th}$ mock-up test using parameters obtained from Step 0. Simplifications used for the mock-up test are the elimination of bentonite-host rock interaction and axisymmetric geometry. The initial gap is employed at start of test.<br><br>STEP 2—Modeling the hydrological response of the host rock around water injected under a pressure head into a borehole section isolated with a stainless steel packer.<br><br>STEP 3—Modeling of one of the SEALEX tests, PT-A1. Field scale test of bentonite/sand seal with asymmetrical technological gap and injected water to enhance resaturation rate</td></tr>
<tr><td>Participant/Funding Organization</td><td>Software Used for Step 2</td></tr>
<tr><td>RAWRA/UGN</td><td>COMSOL</td></tr>
<tr><td>Quintessa/NDA</td><td>OpenGeoSys and QPAC</td></tr>
<tr><td>NRC</td><td>xFlo-FLAC</td></tr>
<tr><td>CNSC/IRSN</td><td>COMSOL</td></tr>
<tr><td>IRSN</td><td>CODE-BRIGHT</td></tr>
<tr><td>Main Conclusions and Issues</td><td>1. Step 0—HM modeling of lab tests for the bentonite/sand mixture. Compression tests reproduced by all teams, but infiltration test still causes some difficulties; problems with matching the entire suite of curves, which probably illustrates the importance of free swelling and of hydromechanical coupling in general. Curiously, hydrologic-only calibrations fit just as well as the hydromechanical-coupled fits. Mixing of retention curves in the other parts of Step 0 may have caused some problems; mixing of 1.67 and 1.97 g/cm$^3$ materials.<br><br>2. Step 1—HM modeling of the 1/10$^{th}$ mockup lab test. The gap and change in boundary condition for the mock-up test are challenging aspects to this problem. Continuous change in properties from initial dry density material (1.97 g/cm$^3$) to a material comparable to 1.67 g/cm$^3$ (dry density) as the gap is filled suggests possible approach is to make hydromechanical properties a function of void ratio. A few issues in the results are:</td></tr>
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| Task A | |
|---|---|
| | • Behavior at 0 (low) suction, gel formation, flooding of gap, and spatial imbibition into sample<br>• Over-prediction of Phase 1 water injected<br>• Difficulty with transition between Phase 2a and 2b<br><br>3. Step 2—Modeling the host rock during the WT-1 *in situ* flooding test. Teams addressed important aspects discussed by teams at the previous workshop:<br><br>• Location (borehole wall or gallery wall) for the atmospheric boundary condition, and the need to incorporate steady or seasonal fluctuation of temperature and relative humidity at that boundary condition. *Updated modeling suggests that the most appropriate approach uses the gallery wall for the pressure condition and accounts for seasonal fluctuations.*<br><br>• Importance of incorporating borehole and/or gallery excavation damage zone in models, and should the properties evolve as rewetting occurs? *Updated pressure modeling suggests that the EDZ heals after resaturation (permeability drops by almost a factor of 5 over a year).*<br><br>4. Step 3—Modeling the PT-A1 test, which features a 60-cm diameter horizontal drift with cylindrical bentonite disks initially compacted to 1.97 $Mg/m^3$ resting on the bottom of the drift, sealed with water-tight packers, and flooded with water, ultimately yielding a saturated bentonite density of 1.67 $Mg/m^3$. Teams presented modeling results for the PT-N2 and PT-A1 tests using 2D axisymmetric and 3D HM models.<br><br>• IRSN provided an updated assessment of the initial water injection to reconcile the initial 80 kg of injected water, which was previously thought to be explained by the technological void space (space between bentonite plug and host rock); there was also a gap between the downstream lid and the rock, and other minor gaps within bentonite plug.<br><br>• Some of the sensors in the bentonite responded asymmetrically, suggesting rapid saturation. Participants speculated that perhaps a seam between bentonite disks was a flow pathway. |
| Future Work | 1. Prepare journal paper on Steps 0 and 1 of this task.<br><br>2. Prepare journal paper on Steps 2 and 3 of this task.<br><br>3. Complete modeling for Step 3 test, PT-A1.<br><br>4. Groups are to provide information and results for the journal papers. Improvements in models for Steps 1 and 2 if judged necessary.<br>5. First version of final report before August 2015. |

| Task A | |
|---|---|
| Action Items for NRC Staff | Staff progress in 2014 was limited by Yucca Mountain responsibilities. As staff time affords, NRC staff expects to return to Steps 0 and 1 to implement models for infiltration portion of those steps not previously completed, before considering model development for Step 3 (PT-A1 test). |
| **Task B1** | |
| Brief Description of the Overall Task | HE-E experiment run by a consortium of European Union countries at Mont Terri underground research laboratory in Switzerland; focuses on thermal-hydrologic-mechanical performance of two types of bentonite buffers surrounding a horizontally-emplaced analog waste package heated up to 140 °C in a low permeability argillaceous host rock. |
| Brief Description of the Current Task (Completed Steps Are Included. Last Item Listed is the Current Step) | STEP 1a—Opalinus Clay study: Numerical modeling of the thermal-hydrological-mechanical behavior in Opalinus Clay host rock at a heater test in the Mont Terri tunnel system (i.e., the HE-D test).<br><br>STEP 1b—Buffer material study: Numerical modeling of CIEMAT column cells with focus on processes understanding and parameter determination. The objective of this step is to calibrate the constitutive relationships for the bentonite pellet mixture based on back analysis of the column tests and literature study. The main parameters are associated with moisture retention curve, dependencies of thermal conductivity and water permeability on degree of saturation, and mechanical constitutive relationships.<br><br>STEP 2—HE-E predictive modeling: Numerical modeling of the thermal-hydrological-mechanical behavior in the swelling bentonite buffer and Opalinus Clay host rock at the HE-E heater test in the Mont Terri tunnel system. |
| Participant/Funding Organization | Software Used |
| UFZ /BGR | OpenGeoSys |
| CAS | Elasto-Plastic Cellular Automaton (EPCA) 3D |
| LBNL/DOE | TOUGH-FLAC |
| ENSI | OpenGeoSys |
| CNSC/IRSN | COMSOL |
| JAEA | THAMES |
| KAERI | FLAC |
| CNWRA/NRC | xFlo-FLAC |
| Summary of Discussion | 1. Some presentations during the workshop revisited the column cell test, reporting improved model behavior regarding the THM processes in the column cell material. |

<table>
<tr><th colspan="2">Task A</th></tr>
<tr><td></td><td>2. Not all teams were at a stage to model the HE-E test. The modeling efforts for the HE-E test ranged from 1D to 3D. Most of the groups had calculated temperature, relative humidity, and pore pressures at the selected sensor locations. The overall best matches tended to be for temperature, then relative humidity, then pore pressure. The best matches tended to be closest to the heater and were poorer with radial distance, although trends tended to be in qualitative agreement.<br><br>3. The first stage of predictive modeling was considered reasonably successful, though it was suggested that all teams (i) switch to using power, instead of specified temperature, as the thermal boundary condition, (ii) better represent the initial conditions (i.e., ventilation effect), and (iii) consider refining vapor diffusion models. (In addition, most teams are still using the Richards approximation rather implementing a multiphase flow model). Also, it was not clear that temperature dependence for the retention constitutive relation was needed for the HE-E test.</td></tr>
<tr><td>Future Work</td><td>1. Teams with refined column test model calculations should provide final results by 11/24/2014.<br><br>2. Provide results of interpretive modeling of the HE-E test by 3/30/2015.<br><br>3. Provide final report and results on HE-E testing to leader by 6/1/2015.<br><br>4. Task Lead will provide first draft of final report to groups by 6/30/2014.<br><br>5. Journal paper on HE-D test, deadline TBD.<br><br>6. Journal paper on column test, deadline TBD.<br><br>7. Journal paper on HE-E test, deadline 6/30/2015.<br>8.</td></tr>
<tr><td>Action Items for NRC/CNWRA staff</td><td>1. Revise model calculations for the column test and submit results by 11/24/2014.<br><br>2. Continue work on HE-E test modeling and provide predictive model calculations by 3/30/2015.</td></tr>
<tr><th colspan="2">Task B2</th></tr>
<tr><td>Brief Description of the Overall Task</td><td>“EBS” experiment planned at Horonobe underground facility in Japan. The experiment focuses on THMC processes in a bentonite buffer surrounding a vertically-emplaced analog waste package heated to 100 °C in an argillaceous host rock of moderate permeability. Salt accumulation is the chemical process of interest.</td></tr>
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| Task A | |
|---|---|
| Brief Description of the Current Task | Step 0—Preparation phase. Literature review and analyses of laboratory test data, especially for backfill.<br><br>Step 1—Code comparison analysis. Set up input data for two analyses; one analysis to support sensor layout, and one analysis to predict long-term behavior.<br><br>Step 2—Prediction analysis. Run model analyses, comparing with selected sensor data from the field experiment. |
| Participant/Funding Organization | Software Used |
| JAEA | Couplys and PHREEQC |
| BGR | OpenGeoSys coupling with PHREEQC, ChemApp, GEMIPM2K |
| CAS | Elasto-Plastic Cellular Automaton (EPCA) and TOUGH2 |
| LBNL/DOE | TOUGH-FLAC and ROCMASS (complementary software for confidence building) |
| KAERI | TOUGH2-FLAC3D |
| Summary of Discussion | 1. Models are mostly 3D, and most models quite consistent with each other for temperature, to a lesser extent pressure and stress, and less so for saturation.<br><br>2. Heaters in the EBS experiment will be turned on in January 2015, though it is unlikely that data will be available for comparisons to model predictions. |
| Future Work | 1. Step 2—Continue prediction analysis for design of the sensors layout in the buffer material.<br><br>2. Develop papers and final report. |
| Action Items for NRC/CNWRA staff | None. NRC is not a participant in this task. |

| Task C1 | |
|---|---|
| Brief Description of the Overall Task | Investigate and mathematically model coupled THMC processes using data from laboratory experiments on single fractures through novaculite (dense microcrystalline quartz rock) and a granitic rock. The experiments are described in Yasuhara, et al. (2006) and Yasuhara, et al. (2011). |
| Brief Description of the Current Steps | Step 0—Basic benchmarking for novaculite:<br><br>• Use profilometer data as a representation of the topology of fracture surfaces to guide grid generation or estimation of statistical parameters of aperture distribution.<br><br>• Use the aperture distribution data from Yasuhara, et al. (2006) to reproduce the observed flow rate at the start of the experiment only (stop at 1,292 hours, before flow reversal).<br><br>• Geochemistry Benchmark Test: Represent stylized batch experiment of silicate dissolution in deionized water under no-low conditions in a 10-µm aperture fracture and no mechanical coupling at temperatures of 20, 60, and 120 °C.<br><br>Step 1—Continue modeling of Yasuhara, et al. (2006) experiment:<br><br>• Include the flow reversal, stop at ~1,500 hours.<br><br>Step 2—Continue to end of Yasuhara, et al. (2006) experiment:<br><br>• Includes nonisothermal portion of experiment.<br><br>Step 3—Yasuhara, et al. (2011) granite experiment: develop geochemical model for granite<br><br>Step 4—Simulate isothermal part of Yasuhara, et al. (2011) granite experiment<br><br>Step 5—Simulate nonisothermal part of Yasuhara, et al. (2011) granite experiment |
| Participant/Funding Organization | Software Used |
| Quintessa/NDA | QPAC and OpenGeoSys |
| UFZ /BGR | OpenGeoSys |
| CAS | Elasto-Plastic Cellular Automaton (EPCA) and TOUGHREACT |
| NRC | (1) Compartmental approach, modified from that in Yasuhara papers<br>(2) HBGC123D+Aperture Module (stress incorporated only in the Aperture Module)<br>(3) Geochemist's Workbench |
| RAWRA/TUL | Geochemist's Workbench, Semchem software, Transport, Flow123D, FEFLOW |

| Task C1 | |
|---|---|
| Summary of Discussion | Teams presented initial attempts at modeling granite experiment by focusing on geochemical model for granite. Teams followed Yasuhara's (Yasuhara, et al., 2011) (apparent) assumption of minerals and percentages; quartz, orthoclase, albite, anorthite, and biotite (both annite and phologopite). Further literature searches on the composition of the Mizunami Granite may be helpful.<br><br>Also, the appropriate scale to use for surface area, and use of the provided profilometer data, continues to be an unresolved issue. The roughness factor for chemical modeling was calibrated (or assumed) to be approximately five orders of magnitude finer than that implied by the profilometer data. Intuitively, different scales of surface area are appropriate for hydrologic (channeling), geomechanical (stress per asperity contact area), and chemical (reactive surface area), but little literature information has been found by the teams for what the appropriate scale is for the different processes. Models used by different teams range from homogenized batch-reactor type to statistically generated pore-scale representations.<br><br>Teams revisited modeling of the novacutlite experiment, in part because of questions on the relative importance and timing of processes acting to open and close the fractures during thermally perturbed portions of the experiments. Models developed from the novaculite data, but applied to the granite data using the appropriate chemical reactions, led to different fracture behavior between the two rock types. This emphasized the ongoing concern that little information has been found from the literature, or delineated from the modeling, for the timing and relative importance of (i) pressure dissolution (enhanced mineral dissolution at asperity contacts areas); (ii) solubility and chemical reaction rates as a function of temperature; (iii) stress corrosion cracking (microfracturing at asperity contacts); (iv) thermal expansion; (v) channeling; and (vi) matrix diffusion (i.e., contributions to and interaction with fracture water chemistry from within the rock). |
| Future Work | 1. Teams continue with Steps 3 through 5, though re-visiting steps 0 and 1 have been viewed as useful by some teams.<br><br>2. Develop final report, submitting final draft reports to task lead by 5/31/2015.<br><br>3. Finalize papers at Workshop 7 (April 2015). |
| Action Items for NRC staff | Staff progress in 2014 was limited by Yucca Mountain responsibilities. As NRC staff time affords, a model will be developed for the granite experiment using Geochemist's Workbench, and staff will consider how to delineate the relative importance of the different processes. |

References:

Yasuhara, H., A. Polak, Y. Mitani, A. Grader, P. Halleck, and D. Elsworth. "Evolution of Fracture Permeability Through Fluid–Rock Reaction Under Hydrothermal Conditions. *Earth and Planetary Science*. Letters 244. pp. 186–200. 2006.

Yasuhara, H. and D. Elsworth. "Compaction of a Rock Fracture Moderated by Competing Roles of Stress Corrosion and Pressure Solution. *Pure and Applied Geophysics*. Vol 165. pp. 1,289–1,306. 2008.

Yasuhara, H., N. Kinoshita, H. Ohfuji, D.S. Lee, S. Nakashima, and K. Kishida. "Temporal Alteration of Fracture Permeability in Granite Under Hydrothermal Conditions and Its Interpretation by Coupled Chemo-Mechanical Model. *Applied Geochemistry*. Vol. 26. pp. 2,074–2,088. 2011.

| Task C2 | |
|---|---|
| Brief Description of the Overall Task | Regional flow and transport in saturated fracture network above the Bedrichov tunnel, Czech Republic, using measured data for conservative and nonconservative tracers. Constraints on flow and transport to be enhanced by utilization of natural tracers for water age from natural tracers and rock mineral dissolution to incorporate water chemical compositions. |
| Brief Description of the Current Task | Update steady-state hydraulics and pulse tracer and perform introductory transient hydraulics. The task involves development of the numerical models using a 2D/3D segment of the tunnel<br><br>1. Hydrological processes: (i) fit the water inflow (hydraulics), (ii) fit the lumped parameter models of tracers, and (iii) fit a batch reaction experiment (crushed granite leaching).<br><br>2. Coupled processes/cross-validation: (i) develop 1D reactive transport using field chemical data, (ii) fit the isotope tracers with 2D/3D numerical transport (including hydraulics), and (iii) compare 2D/3D numerical advection with lumped parameter (fictitious tracer).<br><br>3. Refined modeling tasks: (i) refine the water inflow conceptual model and data, (ii) calculate 2D/3D transport with simplified chemistry, (iii) combine/calibrate all together, (iv) consider transient hydraulics and (v) inverse method (data fitting by optimization methods) and uncertainty analyses. |
| Participant/Funding Organization | Software Used |
| TUL/RAWRA | Flow123D |
| SNL/DOE | PFloTran and DAKOTA |
| BGR | RockFlow, OGS |
| Summary of Discussion | The workshop focused on meshing, calibration, and analysis of the tracer data using models focusing on processes in large fracture networks to better understand mean residence times and mixing of waters from different regimes and temporal input times. Previous workshops focused on regional models relating infiltration to inflows along the tunnel, though a closer analysis of seasonality of infiltration and the fraction of precipitation to use as infiltration were both discussed at this workshop. |
| Future Work | The teams will focus on detailed comparisons of results for the steady-state and transient models. Real tracer models will focus on porosity, dispersivity, and diffusion. Observed concentration and residence time data will be used for calibration.<br><br>A joint paper and an individual paper will be developed. Input for the final synthesis report, as with other tasks, will be due in the summer of 2015. |
| Action Items for NRC/CNWRA staff | None. NRC is not a participant in this task. |

**Technical Site Visit**

As each of the participating teams hosts a workshop, the host generally arranges for a site visit to their underground facility, relevant laboratory, or waste facility. At this workshop, however, there was no relevant technical site visit.

There were two invited presentations at the beginning of the workshop. John Martin of Radioactive Waste Management Limited[1] provided a summary and status of the radioactive waste disposal program in the United Kingdom, including (i) mission, roles, and responsibilities, (ii) work and research program, (iii) future science and technology plan, and (iv) expected transition to site-specific research. There is an ongoing geologic survey across the United Kingdom for suitable geologic areas, which will be followed by an invitation for communities to volunteer. The current assumption is that an operating disposal facility will open by 2040. In the second presentation, Dan Galson of Galson Sciences Limited discussed the treatment of coupled THMC processes in the United Kingdom's generic safety assessment, and in the context of safety assessments in Sweden, France, and the United States.

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[1] http://www.nda.gov.uk/rwm

# WORKSHOP AGENDA

Building 587
Curie Avenue
Harwell Science and Innovation Campus
Didcot
Oxon, OX11 0RH
United Kingdom

# 6th Workshop & Steering Committee Meeting
## Hotel Novotel London City South
## London, United Kingdom, 10th – 13th November 2014

## Organized by Radioactive Waste Management Limited (RWM)

### *Day 1 (10th November 2014)*

11:45 - 13:00 On-site registration with coffee/tea, lunch from 1200

***Opening and Special session***

13:00 – 13:10 Welcoming address (S. Norris, RWM)

13:10 – 13:20 Opening of the workshop and welcome (J. A. Hudson, IC, UK)

13:20 – 13:40 UK programme update (J. Martin, RWM)

13:40 – 15:00 **Guest presentation**: *Treatment of Coupled Processes in Geological Disposal - Review of UK Work, and Treatment of Coupled Processes in Performance Assessments in other Countries* (Dan Galson, Galson Sciences Limited, UK)

15:00 - 15:30 Coffee/tea break

***Session 1. Task A—The SEALEX In-Situ Experiment, Tournemire Site, France (Chaired by Alain Millard)***

15:30 – 15:40 Briefing for problem or step of Task A (Alain Millard, France)

15:40 – 16:10 Presentations of IRSN team (IRSN, France)

16:10 – 16:30 Presentations of CNSC team (CNSC, Canada)

16:30 – 17:10 Presentation of RWM team (Quintessa/RWM, UK)

17:10 – 17:30 Presentation of RAWRA team (UNG, Czech Republic)

17:30 - 17:50 Coffee/tea break

17:50 – 18:30 General discussions on Task A (Led by Alain Millard)

18:30 – 19:30 ***Task Force Meeting for Task A (Led by Alain Millard)***

Finish day 1

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## *Day 2 (11th November 2014)*

***<u>Session 2. Task B1 — HE-E Heater Test, Mont Terri, Switzerland (Chaired by B. Garitte)</u>***

09:00 – 09:10 Briefing for problem or step of Task B1 (Benoit Garitte, NAGRA, Switzerland)

09:10 – 09:30 Presentations of BGR/UFZ team (BGR/UF, Germany)

09:30 – 09:50 Presentation of CAS team (CAS, China)

09:50 – 10:10 Presentation of DOE team (LBNL, USA)

10:10 – 10:30 Presentation of ENSI team (ENSI, Switzerland)

10:30 – 11:00 Coffee/tea break

11:00 – 11:20 Presentations of IRSN team (IRSN/CNSC, Canada)

11:20 – 11:40 Presentation of JAEA team (JAEA, Japan)

11:40 – 12:00 Presentation of KAERI team (KAERI, Korea)

12:00 – 12:20 Presentation of NRC team (CNWRA/SWRI, USA)

12:20 – 13:00 General discussions on Task B1 (Led by Benoit Garitte)

13:00 – 14:00 Lunch

***<u>Session 3: Task B2 — EBS Experiment, Horonobe, Japan (Chaired by Yutaka Sugita)</u>***

14:00 – 14:20 Briefing for problem or step of Task B2 (Yutaka Sugita, JAEA, Japan)

14:20 – 14:40 Presentation of BGR team (BGR, Germany)

14:40 – 15:00 Presentations of CAS team (CAS, China)

15:00 – 15:20 Presentation of DOE team (LBNL, USA)

15:20 – 15:40 Coffee/tea break

15:40 – 16:00 Presentation of JAEA team (JAEA, Japan)

16:00 – 16:20 Presentation of KAERI team (Inha University, Korea)

16:20 – 16:40 General discussions on Task B2 (Led by Yutaka Sugita)

***<u>16:40 – 17:40 Task Force Meeting for Task B1 (Led by Benoit Garitte)</u>***

***19:00 – 22:30 Workshop Dinner at Hotel Novotel London City South***

*Finish day 2*

## *Day 3 (12th November 2014)*

***Session 4: Task C1 – THMC of single fractures (Chaired by Alex Bond)***

08:30 – 08:40 Briefing for problem or step of Task C1 (Alex Bond, Quintessa, UK)

08:40 – 09:00 Presentations of CAS team (CAS, China)

09:00 – 09:20 Presentation of RWM team (Quintessa/RWM, UK)

09:20 – 09:40 Presentation of RWM team (Imperial College, UK)

09:40 – 10:00 Presentation of NRC team (NRC, USA)

10:00 – 10:10 Coffee/tea break

10:10 – 10:30 Presentation of RAWRA team (TUL, Czech)

10:30 – 10:50 Presentation of SNL team (SNL, USA)

10:50 – 11:10 Presentation by KTH team (KTH, Sweden)

11:10 – 11:40 General discussions on Task C1 (Led by Alex Bond)

***11:40 – 12:15 Task Force Meeting for Task C1 (Led by Alex Bond)***

12:15 – 13:00 Lunch

Afternoon:

Technical Tour, led by Quintessa

13:00 Depart from the hotel

We will take a boat along the river from Bankside pier to Greenwich. At Greenwich we will visit the Royal Observatory, which includes the Meridian Line (0° Longitude), as well as the original observatory building designed by Christopher Wren in 1675. We will also visit the National Maritime Museum where there is an exhibition on the race to determine longitude at sea, including Harrison's clocks. We will return to Bankside pier on the boat at around 5.30 pm.

*Finish day 3*

## *Day 4 (13th November 2014)*

***Session 1: Task C2 – Bedrichov Tunnel Test Case, Czech Republic (Chaired by Milan Hokr)***

08:30 – 08:40 Briefing for problem or step of Task C2 (Milan Hokr, Czech Republic)

08:40 – 09:00 Presentations of DOE team (SNL, USA)

09:00 – 09:20 Presentation of RAWRA team (TUL, Czech Republic)

09:20 – 09:40 Presentation of BGR team (BGR, Germany)

09:40 – 10:00 General discussions on Task C2 (Led by Milan Hokr)

10:00 – 10:30 Coffee/tea break

10:30 – 11:30 ***Task Force Meeting for Task C2 (Led by Milan Hokr)***

11:30 – 12:30 ***Task Force Meeting for Task B2 (Led by Yukata Sugita)***

***Parallel session***

10:30 – 12:30 ***Steering Committee meeting***

12:30 – 13:30 Lunch

13:30 – 16:00 ***Plenary session: Planning for DECOVALEX D-2019***

13:30 – 14:30 **Guest presentation** *Studies of gas – bentonite interactions, potential for new DECOVALEX case study* (Jon Harrington, British Geological Survey, UK)

14:30 – 16:00 Presentation and discussion of other potential D-2019 tasks

16:00 – 16:15 John Hudson – feedback from Steering Committee meeting / wrap-up

16:15 – 16:45 Coffee/tea break/departure

*Finish day 4*