CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES
TRIP REPORT

SUBJECT: 4th DECOVALEX–2015 Workshop

DATE/PLACE: November 11–15, 2013
Mont Terri Underground Laboratory, St. Ursanne, Switzerland

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PERSONS PRESENT: Randall Fedors (NRC) and Chandrika Manepally (CNWRA) participated in the 4th workshop of the DECOVALEX–2105 project. Workshop attendees from all organizations are listed in Appendix A.

BACKGROUND AND PURPOSE OF MEETING/TRIP: The workshop was held on November 11–15, 2013, in Mont Terri Underground Laboratory Visitor Center, St. Ursanne, Switzerland. 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 deep geologic disposal of high-level radioactive 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. In addition, technical tours were conducted at the Mont Terri Underground Research Laboratory and the Paul Scherrer Institute.

SUMMARY OF ACTIVITIES: The NRC and CNWRA staffs' participation in the 4rd DECOVALEX–2015 workshop provided an opportunity to interact and discuss each organization's approach and progress in modeling field experiments encompassing near-field coupled THMC processes. The workshop agenda is included as Appendix B. The activities at this workshop included: (i) discussions 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) technical tours. Discussions of research progress on 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 NRC 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 evolves.

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 for repository performance for deep 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. CNWRA has been tasked to support Task B1. The NRC staff will continue to participate in Tasks A and C1, and all staff will continue to follow discussions for Tasks B2 and C2 to gain insights from the efforts and approaches of other DECOVALEX participants.

Use of these data could guide and constrain scenario modeling of coupled THMC processes with or without the presence of a buffer. In addition to the continued development of modeling tools and identification of required constitutive relations for near-field processes, the NRC staff will continue to use information leveraged from international interactions to refine near-field abstraction approaches and data needs for supporting insights into repository performance for a wide range of designs and geologic host media.

Trip Details

Five tasks were agreed upon at the 1st DECOVALEX–2015 workshop in April 2012. CNWRA has been tasked with supporting the NRC team in Task B1. 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 due dates listed in the tables are tentative, pending unexpected issues arising. 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

Task A	
Brief description of the overall task	SEALEX experiment at Tournemire underground research facility in France, developed by IRSN. Focus is on hydromechanical performance of bentonite seals for horizontal emplacement boreholes.
Brief description of the current steps, Task A	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. STEP 1—Blind prediction of laboratory 1/10th 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 between the bentonite buffer and the host rock is employed at start of test. 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–*in situ* test WT-1.
Participant/funding organization	Software Used
RAWRA/UGN	COMSOL; modified Cam-Clay model for plasticity, nonlinear elasticity
Quintessa/NDA	OpenGeoSys and QPAC; modified Cam-Clay model for plasticity
NRC	xFlo-FLAC
CNSC	COMSOL
CEA	CAST3M
IRSN	CODE-BRIGHT; Barcelona Basic Model for plasticity
Main conclusions and issues	1. Step 0: 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; the properties 1.67 and 1.97 g/cm^3 materials are not the same. 2. Step 1: Addressing the gap (technological void) 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 results are: • Behavior at 0 (low) suction, gel formation, flooding of gap, and spatial imbibition into sample • Over-prediction of Phase 1 water injected • Difficulty with transition between Phases 2a and 2b.

Task A	
Future work	1. Refine models and parameter estimates for Step 1, column test for bentonite/sand mixture. Focus on: • Influence of technological void • Beginning of phase 1, initial water injection • Elastic unloading at beginning of phase 2 (confining pressure removed) • Transition between phases 2a and 2b (i.e., transition between imbibition on bottom of sample to imbibition on three sides of core) • When and where plasticity might occur 2. Start modeling *in situ* WT-1 Test. Specifications to be provided December 2013.
Action items for NRC/CNWRA staff	When the modeling tool xFlo-FLAC becomes operational, NRC staff can return to Steps 0 and 1 to implement models for infiltration portion of those steps not previously completed. For the WT-1 Test, staff will explore the use of xFlo or TOUGH2, using the assumption that geomechanical processes do not have a significant effect on flow through the host rock and excavation damage zone.
Reference Man, A. and J.B. Mantino. "Thermal, Hydraulic and Mechanical Properties of Sealing Materials." NWMO TR–2009–20. Toronto, Canada: Nuclear Waste Management Organization. 2009.	

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	Step 1b involved modeling the thermal-hydrological-mechanical behavior in a column of granular bentonite with a height similar to the buffer material thickness in the HE-E test (Villar et al. 2012). The column test was designed to mimic the boundary conditions prescribed at the heater side and at the Opalinus Clay side. Isothermal and nonisothermal infiltration tests are considered. Though the experiment was originally designed as a 1D model, lateral heat losses observed need to be modeled using a 2D model.
Participant/Funding Organization	Software Used
UFZ /BGR	OpenGeoSys
CAS	Elasto-Plastic Cellular Automaton (EPCA) 3D
LBNL/DOE	TOUGH-FLAC (and ROCMASS for comparison)
ENSI	OpenGeoSys
CNSC/IRSN	COMSOL
JAEA	THAMES

Task B1	
KAERI	FLAC
CNWRA/NRC	xFlo-FLAC
Summary of Discussion	<u>Task B1 Updates</u> 1. The Task B1 is proceeding per schedule. The data for the HE-E test will be made available during the 5th workshop. HE-E Test details will be made available in 6th workshop. 2. A summary report for the HE-D test is in preparation by the Task Leader. Participants will be notified to provide comments on the draft. <u>Column test</u> 1. Each team discussed its numerical model and calculated results. Most of the teams presented results for the TH modeling with the exception of UFZ/BGR team that had THM results. 2. The efforts focused on determining the appropriate input parameters. The Task Leader identified the main input parameters: (i) moisture retention curve, (ii) thermal conductivity and its dependency on degree of saturation, (iii) dependency of water permeability on degree of saturation, and (iv) mechanical constitutive law 3. The granular bentonite can be conceptualized as a double/triple porosity continuum (Benoit's presentation). 4. The effect of heat loss was illustrated by comparing it to analytical solution and the temperature measurements (see slide 13 of Task Force Meeting Presentation). 5. Teams were able to represent the TH processes reasonably. The match for temperatures better than RH. 6. Dependency of thermal conductivity on temperature is not significant. The range of dry and wet thermal conductivity is rather small (0.3–0.4 W/m-K).

Future Work	1. The heat loss through the lateral boundaries needs to be estimated appropriately especially if using heat source as input. 2. The basis for the thermal and hydrologic parameters needs to be adequately justified. 3. Need to account for the influence of mass balance of air (pg) and the air pressure developing at bottom 4. Need to evaluate the vapor diffusion induced by temperature gradient. The low permeability of the granular bentonite implies that diffusion is the dominant transport mechanism. 5. Evaluate the moisture retention curve. It should be noted that there is scant data at high suction ranges. 6. Account for insulation and changes in laboratory temperature in determining the boundary conditions.
Action Items for NRC/CNWRA staff	1. Use information in the Rizzi et al. (2012) report for the TH parameters. 2. The moisture retention curve parameters estimated by the LBL

	group seems to be a good starting point given that they matched the Rizzi et al. (2012) data and were able to match the temperature and RH measurements 3. Incorporate the use of the Klinkenberg parameter. 4. Canadian group used Dirichlet boundary condition. Discussions indicated that it is an option that can be used for xFlo.
Reference: Rizzi, M., A. Seiphoori, A. Ferrari, D. Ceresetti, and L. Laloui. "TU-SA-BENT: Analysis of the Behaviour of the Granular MX-80 Bentonite in THM-Processes; TU-GEO: Analysis of the THM-Behaviour of Opalinus Clay." AN 12-102. Wettingen, Switzerland: Nagra. 2012.	

Task B2	
Brief Description of the Overall Task	"EBS" experiment planned at Horonobe underground facility in Japan; will focus 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. The measurements include temperature, degree of saturation/water content, hydraulic pressure, stress and salt concentration.
Brief Description of the Current Task	Step 0: Preparation phase. Literature review and analyses of laboratory test data, especially for backfill. Step 1 (revised): Set up input data for two analyses; one analysis to support sensor layout, and one analysis to predict long-term behavior.
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. Teams presented the model results for Step 1. 2. There were combinations of 1D/2D/3D models by the participants. 3. LBL team used Klinkenberg parameter and calibrated vapor diffusion coefficient to match the TH processes.
Future Work	1. All participants need to provide input to the interim report (n deadline at the end of Dec., 2014).
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 a novaculite (dense microcrystalline quartz rock) and a granitic rock. The experiments are described in Yasuhara et al. (2006) and

Task C1	
	Yasuhara et al. (2011).
Brief Description of the Current Steps	Step 0: Basic benchmarking for novaculite: • Use profilometer data as a representation of the topology of fracture surfaces to guide grid generation or estimation of statistical parameters of aperture distribution. • 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). • Geochemistry Benchmark Test: Represent stylized batch experiment of silicate dissolution in deionized water under no-flow conditions in a 10-µm aperture fracture and no mechanical coupling at temperatures of 20, 60, and 120 °C. Step 1: Continue modeling of Yasuhara et al. (2006) experiment • Include the flow reversal, stop at ~1,500 hours. Step 2: Continue to end of Yasuhara et al. (2006) experiment • Includes nonisothermal portion of 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 (2) HBGC123D+Aperture Module (stress incorporated only in the Aperture Module)
RAWRA/TUL	Geochemist's Workbench, Semchem software, Transport, Flow123D, FEFLOW
Summary of Discussion	1. Previous Workshops – General agreement that mechanisms other than pressure dissolution need to be considered. Too many inconsistencies noted by different team's analyses for pressure dissolution to be dominant process. Yasuhara and Elsworth (2008) reference provided by NRC team to illustrate other potential processes, such as stress corrosion cracking. – Discussed issue of matrix diffusion or, more generally, any interaction with matrix. Questions of hydrological properties of the novaculite, especially porosity and permeability, were discussed. Initial suggestion was that because of low permeability and porosity, there would be little effect induced by matrix. For time periods way beyond laboratory scale, matrix diffusion may become important. – Extensive discussions on how to use topology data. Some teams were using it to create grids, though upscaling was needed. Other teams (e.g., NRC) were not using the topology data, but suggested that statistical parameters

Task C1	
	based on the data could be used to support realizations of apertures. This latter approach would create a link to other fracture data published in the general literature. – Large factors for reactive surface area were needed by some teams to match data; other teams put uncertainty into other factors. Practical (process-based) definition of reactive surface area may be needed to avoid “length of coast” problem (depends on scale of observation). – To help isolate the uncertainty, it was decided to re-do the thermal-chemistry benchmark test at 20, 60, and 120 °C using a consistent set of reactions, solubility constants, and kinetic rates provided by Task Leader. – Unresolved issue of aperture change (increase) at flow shut-off; the cause may have something to do with the laboratory method or aggregation of data. Also, normalized pressure difference was nonzero at alleged no-flow period—this would appear to violate Darcy’s Law, or any variation in flow equations thereof. – Unknown initial water chemistry may be a concern. Nonzero inlet silica concentration and unknown pH were mentioned as a point of uncertainty for Yasuhara et al. (2006) experimental data. Also, care should be taken to avoid mixing up dissolved concentrations reported as Si versus SiO_2. 2. Mont Terri Workshop – Channeling of flow potential and the enhanced roughness factor of 10^6 both point to better utilization of the topology data – Multiple processes may be leading to the silica concentration in the effluent, and acting at different phases of the experiment; teams indicated that either pressure dissolution or stress corrosion processes could be used to approximate the measured effluent data, but that there was little information to delineate these processes.
Future Work	• Continue novaculite experiment through to the completion of the experiment (include phases with different levels of supplied heat). Focus on the following issues: – Determine alternative ways to utilize pre-test fracture profile data and post-test aperture data – Determine quantitative way to delineate processes that lead to changes in aperture (e.g., pressure dissolution, stress corrosion, and any other process) – Further literature review for equilibrium and kinetic constants for chemistry, especially considering different polymorphs of quartz; different grain sizes may also link this topic to the roughness factor – Consider potential contaminant that may influence quartz dissolution • Teams should search for a venue to publish or present the

Task C1	
	results of the novaculite modeling
Action Items for NRC/CNWRA staff	NRC staff promised to complete a literature survey from other experiments that used fracture surface topology or aperture distribution and to describe the types of statistics used to describe those surfaces or apertures.
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 water ages based on analyses of natural tracers and rock mineral dissolution to incorporate water chemical compositions. The basic set of data includes (1) tunnel inflow rates; (2) tunnel Inflow chemistry; (3) tracer test data; (4) background/boundary conditions such as surface temperature, rainfall, reservoir level; and (5) hydrogeological properties of the host rock.
Brief Description of the Current Task	The task involves development of the numerical models using a 2D/3D segment of the tunnel 1. Hydrological processes: (i) fit the water inflow (hydraulics), (ii) fit the lumped parameter models of tracers, and (iii) fit the batch reaction experiment (crushed granite leaching) 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) 3. Additional modeling tasks: (i) refine the water inflow conceptual model and data, (ii) calculate 2D/3D transport with simplified chemistry (iii) combine/calibrate all together, and (iv) 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

Task C2	
Summary of Discussion	All the participants have developed 3D models that simulate flow and transport in the tunnel. Participants discussed the importance of including the topography in their numerical models to simulate the flow conditions. The participants also discussed the use of having two subdomains in the model—shallow unsaturated zone and deep saturated zone.
Future Work	An interim report that includes a summary of the calibrated hydraulic model is expected to be ready by December 2013.
Action Items for NRC/CNWRA staff	None. NRC is not a participant in this task

Technical Site Visit

Technical visits included the Mont Terri Underground Rock Laboratory, the Paul Scherrer Institute (Swiss Synchrotron Light Source SLS and the Proton and Neutron sources), and the medium/low-level radioactive waste interim storage facility at Zwilag.

At the Mont Terri facility[1] near St. Ursanne, a guided walking tour of the entire length of the research portion of the tunnels was led by the staff from Swisstopo, the operator of the site. The Mont Terri Underground Laboratory visit included a visit to the locations of the HE-D and HE-E tests, which are part of Task B1. Another stop of note on the tour was the site of the FE experiment, which will be a full scale loading demonstration experiment for the Swiss repository design. Currently being instrumented prior to initiation of heating, the FE experiment was mentioned as a possible task for a future phase of DECOVALEX.

At the Paul Scherrer Institute[2] near Brugg, a general overview of the research facilities and activities was followed by a discussion and tour of relevant equipment used to support disposal research. The tour guide was part of two research teams, one that used neutron scattering to analyze radionuclide migration in both the disposal host rock and in bentonite, and another that used the same instrument to increase understanding of changes in pore structure of swelling clays (bentonite) as they become saturated. As bentonite becomes saturated, its permeability drops significantly; thus, it is frequently suggested for isolation of waste packages in saturated zones.

A tour of the ZWILAG facility[3], which handles processing and interim storage for both spent fuel and low level waste for Switzerland, was the third part of the tour. The highly radioactive vitrified waste and spent fuel elements are placed in tightly sealed transport and storage casks and stored in the cask storage hall[4]. Operating at temperatures of up to 20,000° C[5], the plasma plant for processing low level waste was said to be the first in the world to be used in the steps leading up to storage and eventual disposal. The process included both combustion of materials and melting of metallic parts and concrete, leading to a significant reduction in waste volume in the now vitrified waste.

[1] http://www.mont-terri.ch/internet/mont-terri/en/home/experiments.html
[2] http://www.psi.ch/
[3] http://www.zwilag.ch/
[4] http://www.zwilag.ch/en/cask-storage-hall-_content---1--1054.html
[5] http://www.zwilag.ch/en/plasma-plant-_content---1--1047.html

APPENDIX A
WORKSHOP ATTENDEES LIST

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Confédération suisse
Confederazione Svizzera
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DECOVALEX 2015

4th Workshop & Steering Committee Meeting
Mont Terri, Switzerland, 11 – 15 November 2013

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APPENDIX B
WORKSHOP AGENDA

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Swiss Federal Nuclear Safety Inspectorate ENSI

DECOVALEX 2015

4th Workshop & Steering Committee Meeting

Mont Terri, Switzerland, 11 – 15 November 2013

Organized by ENSI

(November 11, 2013)

Day 1 (November 11)

12:00 - 13:00 Lunch and on-site registration

Opening and Special session

13:00 – 13:10 Address of welcome (M. Wieser, ENSI)

13:10 – 13:20 Address of welcome (H. Hauser, swisstopo)

13:20 – 13:30 Opening of the Workshop and Welcome (J. A. Hudson, IC, UK)

13:30 – 14:00 Radioactive waste disposal in Switzerland (M. Wieser, ENSI)

14:00 – 14:10 General research strategy of ENSI (R. Mailänder, ENSI)

14:10 – 14:30 ENSI's research on waste disposal and its role in safety assessment (A.-K. Leuz, ENSI)

14:30 – 15:00 Research strategy of the IRSN (J.-D. Barnichon, IRSN)

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 – 15:55 Presentations of IRSN team (IRSN, France)

15:55 – 16:10 Presentations of CNSC team (CNSC, Canada)

16:10 – 16:30 Presentation of NDA team (Quintessa, UK)

16:30 – 16:50 Presentation of NRC team (NRC, USA)

16:50 – 17:10 Presentation of RAWRA team (UNG, Czech)

17:10 – 17:40 General discussions on Task A (Led by Alain Millard)

18:30 – 21:00 Welcome Reception

Finish day 1

Day 2 (November 12)

Technical visit 1

08:30 – 09:45 Introduction to the Mont Terri rock laboratory

09:45 – 12:00 Visit the Mont Terri rock laboratory

12:00 – 13:30 Lunch

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

13:30 – 13:40 Briefing for problem or step of Task B1 (Benoit Garitte, NAGRA,Switzerland)

13:40 – 14:00 Presentations of BGR/UFZ team (BGR/UF, Germany)

14:00 – 14:20 Presentation of CAS team (CAS, China)

14:20 – 14:40 Presentation of DOE team (LBNL, USA)

14:40 – 15:00 Presentation of ENSI team (ENSI, Switzerland)

15:00 – 15:30 Coffee/tea break

15:30 – 15:50 Presentations of IRSN team (IRSN/CNSC, Canada)

15:50 – 16:10 Presentation of JAEA team (JAEA, Japan)

16:10 – 16:30 Presentation of KAERI team (KAERI, Korea)

16:30 – 16:50 Presentation of NRC team (CNWRA/SWRI, USA)

16:50 – 17:20 General discussions on Task B1 (Led by Benoit Garitte)

Finish day 2

Day 3 (November 13)

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

08:30 – 08:40 Briefing for problem or step of Task B2 (Yutaka Sugita, JAEA, Japan)

08:40 – 09:00 Presentation of BGR team (BGR, Germany)

09:00 – 09:20 Presentations of CAS team (CAS, China)

09:20 – 09:40 Presentation of DOE team (LBNL, USA)

09:40 – 10:10 Coffee/tea break

10:10 – 10:30 Presentation of JAEA team (JAEA, Japan)

10:30 – 10:50 Presentation of KAERI team (Inha University, Korea)

10:50 – 11:20 General discussions on Task B2 (Led by Yutaka Sugita)

11:20 – 12:50 Lunch

<u>Session 4: Task C1 – THMC of single fractures (Chaired by Alex Bond)</u>

12:50 – 13:00 Briefing for problem or step of Task C1 (Alex Bond, NDA/Quintessa, UK)

13:00 – 13:20 Presentation of BGR team (BGR/UFZ, Germany)

13:20 – 13:40 Presentations of CAS team (CAS, China)

13:40 – 14:00 Presentation of NDA team (NDA/Quintessa, UK)

14:00 – 14:30 Presentation of NDA team (IC, UK)

14:30 – 15:00 Coffee/tea break

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

15:20 – 15:40 Presentation of RAWRA team (TUL, Czech)

15:40 – 16:00 General discussions on Task C1 (Led by Alex Bond)

16:30 – 17:30 ***<u>Task Force Meeting for Task A (Led by Alain Millard)</u>***

18:00 – 19:00 Guided tour through St-Ursanne, meeting at the Bridge in St-Ursanne (tourist office)

19:15 – 22:00 Dinner at Hotel du Boeuf

Finish day 3

Day 4 (November 14)

<u>Session 1: Task C2 – Bedrichov Tunnel Test Case, Czech Republic (Chaired by Milan Hokr)</u>

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

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

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

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 ***<u>Task Force Meeting for Task B1 (Led by Benoit Garitte)</u>***

11:30 – 13:00 Lunch

13:00 – 14:00 ***<u>Task Force Meeting for Task B2 (Led by Yutaka Sugita)</u>***

14:00 – 15:00 ***<u>Task Force Meeting for Task C1 (Led by Alex Bond)</u>***

15:00 – 15:30 Coffee/tea break

15:30 – 16:30 ***<u>Task Force Meeting Task C2 (Led by Milan Hokr)</u>***

16:30 – 18:30 **<u>Steering Committee meeting</u>**

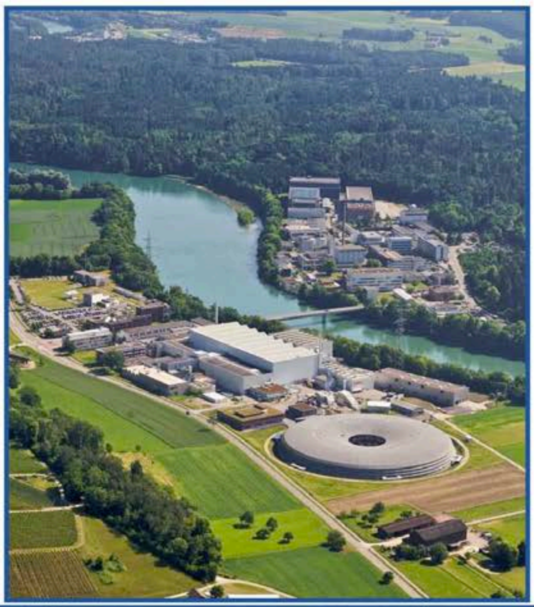
Finish day 4

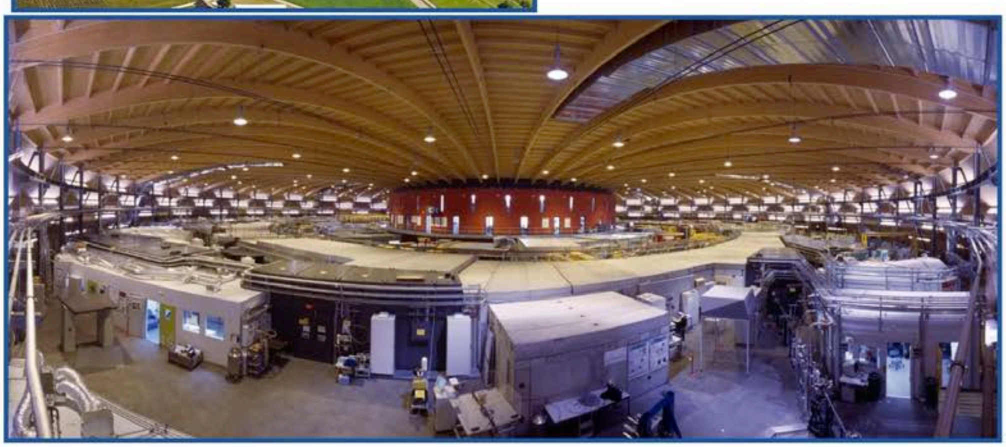
Day 5 (November 15)

07:30 – 17:30 **Technical visit 2**
- *Paul Scherrer Institute*

- Leaving Mont Terri and staying the next night in Brugg, Baden or Zurich if necessary

Finish of the 4th DECOVALEX-2015 workshop





Information about field trips & transportation

General course of the workshop:

The workshop starts at 1 o'clock pm on Monday with welcome addresses. Participants of the workshop will stay in hotels in or close to St. Ursanne until Friday. The price will be about 95 CHF per night (CHF…Swiss Franc). A shuttle service will be arranged.
The first "field trip" will be the visit of the Underground Rock Laboratory Mont Terri on Tuesday morning.

The scientific part of the workshop will be finished on Thursday. Friday is reserved for the second field trip that will lead us to the Paul Scherrer Institute (PSI). There we will be visiting among others the Swiss Synchrotron Light Source SLS and the Proton and Neutron sources and scientists of the PSI will present results of experiments with these sources regarding nuclear waste disposal.

The PSI is located close to Brugg, which is very well connected to Zurich Airport (45 minutes, 4 times per hour) as well as to Basel EuroAirport (1:10 h, 3 times per hour). Therefore we will not return to St. Ursanne. The bus will bring you to Brugg on Friday afternoon and you may continue your journey or you can stay in Brugg for another night. A limited number of hotel rooms are reserved in Brugg (125 – 160 CHF / night). If you are interested in one of these rooms please notify this on your registration form. I will send you the necessary information about the hotel.

Arrival:

Zurich Airport:	Trains 3 times per hour, travel time to St. Ursanne: about 2.5 h at XX:04 leaves a train via Basel with only 1 train change in Basel
Basel EuroAirport:	Trains every 30 Minutes, travel time to St. Ursanne: about 1.5 h At XX:10 leaves a train via Basel main station with only 1 train change in Basel