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# CEMENT-BASED MATERIALS, PROPERTIES, EVOLUTION, BARRIER FUNCTIONS

Newsletter, Issue 3

June 2017

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**C**ebama is a research and innovation action granted by the European Commission under the Horizon 2020 Research and Training Programme of the European Atomic Energy Community (EURATOM). The project started on 1<sup>st</sup> of June 2015 and will last for 4 years.

The overall objective of Cebama is to support the implementation of geological disposal by significantly improving the knowledge base for the Safety Case for European repository concepts. Scientific/technical research in Cebama is largely independent of specific disposal concepts and addresses different types of host rocks, as well as bentonite backfill. Cebama is not focusing on one specific cementitious material, but is studying a variety of important cement-based materials in order to provide insight on general processes and phenomena which can then be transferred to several different applications.



Photo taken at the VTT Lab

Details on the structural and formal issues of the project can be found in our website ([www.cebama.eu](http://www.cebama.eu)).

**27 beneficiaries** consisting of Research Institutes, Universities and SMEs from 9 EU members countries, Switzerland and Japan contribute to Cebama



Project website:  
[www.cebama.eu](http://www.cebama.eu)



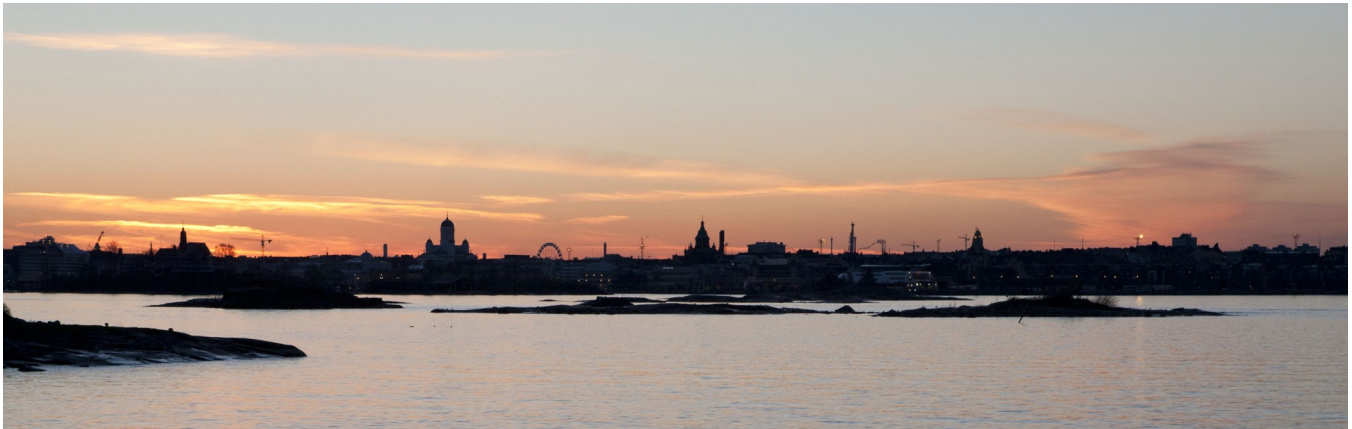
Newsletter submitting organization :

Amphos 21  
Passeig Garcia i Fària, 49-51  
Eo8o19 Barcelona (Spain)

9 NWMO's support Cebama by co-developing the work plan, participating in the **End-User Group (EUG)**, granting co-funding to some beneficiaries, and providing for knowledge and information transfer.

2 organizations joined the project as **Associated Groups (AG)**. AG are not receiving funding for participating but have interest on attending the Workshops and exchanging information related with Cebama.





*Helsinki skyline*

## The 2<sup>nd</sup> Annual Workshop . . .

The 2<sup>nd</sup> Annual Workshop was held in Espoo (Finland), 16-19 May, 2017. It was hosted by VTT Oy. There were 66 attendees at the workshop, representing beneficiaries, the End-User-Group and project external organizations.

Workshops was an important milestone for the project achieving different goals:

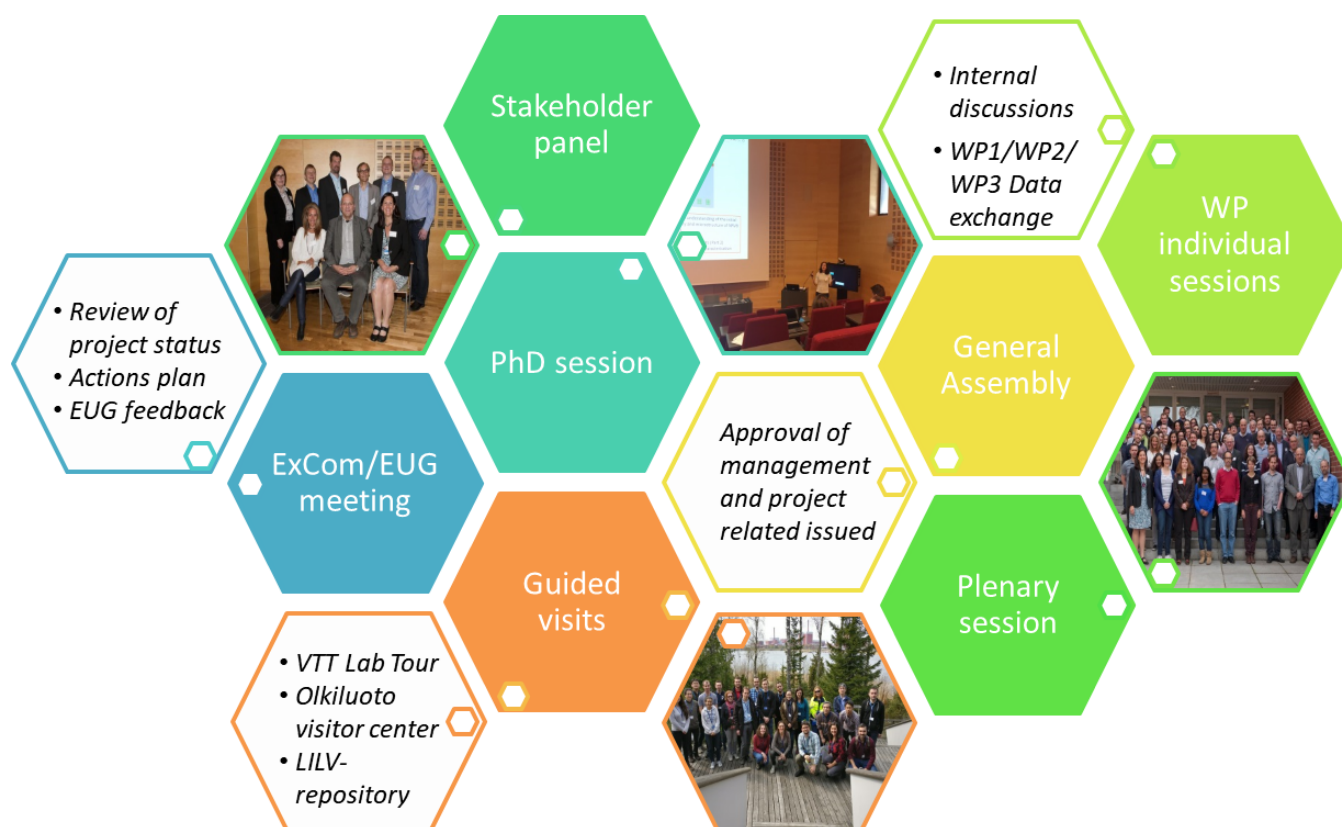
- ⇒ Results obtained during the first project years presented by project partners as posters or oral presentations
- ⇒ Exchange of data between experimental and modelling work-packages (Wp1, WP2 and WP3)
- ⇒ 1<sup>st</sup> Stakeholder Panel
- ⇒ Training activities: PhD session

Photo taken at the 2nd Annual Workshop  
(2016), Espoo (Finland)



## ... The 2<sup>nd</sup> Annual Workshop

The 4 days-workshop was a cluster of different activities which brings the place and time to interact between partners, EUG, external participants and panellists, to discuss on Cebama related issues and to discover the progress within CEBAMA.



The main outcome of the Workshop will be the publication of the 2<sup>nd</sup> Annual Workshop Proceedings which will be available at the project website ([www.cebama.eu](http://www.cebama.eu)) and KIT Scientific Publishing. The proceedings compile:

- technical and scientific work-packages overview highlighting the exchange of information between the experimental and the modelling WP.
- scientific and technical contributions presenting the work conducted by each partner. These contributions are reviewed by the WP leaders and two members of the EUG.
- compilation of the Posters presented at the Workshop
- statements on the Stakeholder Panel

## Technical Work-Packages progress

The 2<sup>nd</sup> workshop brought the opportunity to all CEBAMA organizations of having extensive group discussion in each WP as well as providing the place for interacting between work-packages work.

During the individual WP sessions, time was devoted to briefly present the work progress of each partner and the work to be done during the following project year. Additionally, the data and information to be exchanged between experimental and modelling work was discussed.

During plenary sessions, the main results obtained during the first two years of the project were presented. A poster session was organized where additional results were shown. The advances achieved during this period are summarized in the Workshop Proceedings which will be ready and public by autumn this year.



*Dr. Marcus Altmaier (KIT-INE),  
coordinator of the CEBAMA project*



### ***WP1 – Experiments on interface processes and the impact on physical properties***

**WP leaders: Erika Holt (VTT, Finland), Francis Claret (BRGM, France), Urs Mäder (UNIBERN, Switzerland)**

WP1 is focused on investigating the interfaces between cementitious materials and natural host-rocks or engineered barrier components. It aims at quantifying the relevant alteration processes and their impact on physical properties, especially on the diffusive and advective transport properties for pore water and dissolved species.

At the beginning of the plenary session, F. Claret presented an overview of the WP including work progress, status of milestones and deliverables and introducing the activities performed with the benchmarking low pH cement materials.

After the overview, partners gave technical presentations on their current work, obtained results and work to be done during the following project year.

The session ended with a brief overview on the benchmark exercise. The reference mix designs were prepared by VTT. Several partners characterise (e.g., mechanical properties, chemical composition, microstructure...) these materials using different techniques (e.g., X-ray diffraction, scanning electron microscopy, mercury intrusion porosimetry,...).



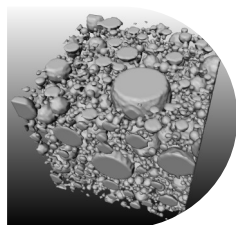


## ***WP2 – Radionuclide retention***

WP leaders: Bernd Grambow (Armines, France)

The objective of WP2 is to study radionuclide retention processes in high pH concrete environments. The aim is to provide insight on general processes and phenomena and their couplings in overall interaction mechanisms, which can then be transferred to different disposal situations and water access scenarios in a high pH repository environment with cementitious materials. It also assesses the impact of chemical alterations (e.g., high pH concrete ageing, carbonation, transition from oxidizing to reducing conditions) on radionuclide retention.

First results of Ra,  $^{14}\text{C}$ , Tc, Mo and Be studies focusing mainly on sorption onto cementitious materials and solubility, were presented during the plenary session. Other studies on radionuclides diffusion or the effect of redox conditions on S and Se binding in AFm phases were also presented.



## ***WP3 – Interpretation and modelling***

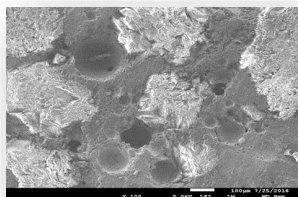
WP leader : Andrés Idiart (Amphos 21, Spain)

The main goal of WP3 is to contribute in filling critical gaps by modelling and interpretation of experimental results generated within the project. The focus is mainly on physical and chemical processes that can lead to changes in transport properties both in the cementitious systems as well as their interfaces with clays or compacted bentonite. Specific objectives of WP3 are (1) to improve the validity of existing numerical models to predict changes in transport properties of cementitious systems, (2) to support advanced data interpretation and process modelling of WP1 and WP2 experiments by mechanistic modelling of chemically-induced changes in transport properties, and (3) to enhance our ability to extrapolate models of system-level to modelling for Safety Case application (length and time upscaling).

An essential basis for WP3 is the outcome of the experiments performed within the project. Each WP3 partner has already established collaborations with Work Packages 1 and 2 to model specific sets of experiments.

During the plenary session, seven partners present their advances on modelling testing an validation while WP1-2 data is being produced.

## Some conclusions ■ ■ ■

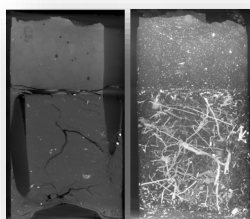
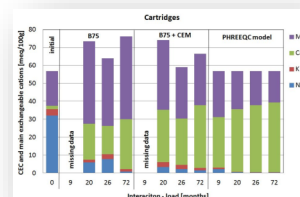


*Evolution of porosity in cementitious materials during early stage of alkali-activation: a spin echo small angle neutron scattering and SEM-EDS investigation (TU-Delft)*

- ⇒ CEM I 52.5 N - SR3/NA showed much more deterioration while CEM III 42.5 N LH/HS and CUGLA mortar showed similar behaviour during exposure.

*Interaction between cement and Czech bentonite under temperature load and in-situ conditions: Results after first testing period (UJV-CTU)*

- ⇒ The dominant driving force for cation exchange is the composition of groundwater (Ca-Mg-SO<sub>4</sub>-HCO<sub>3</sub> type). A minor effect from alkaline front (OPC) has been observed.

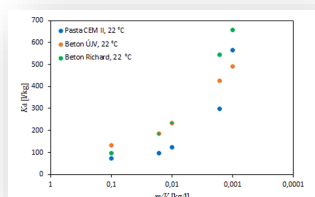
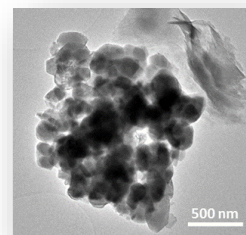


*Preliminary experimental results on the changes in microstructure, mineralogy and transport properties of Boom clay - concrete interface (SCK-CEN and BRGM)*

- ⇒ Increase in total porosity at the concrete interface due to Ca-leaching dominance compared to carbonation and decrease of porosity in the clay indicating precipitations which may clog the clay pores in the long-term.

*Effects of the hydrogeochemistry of the FEBEX in situ test on the aging of the concrete plug (UAM, CSIC and CIEMAT)*

- ⇒ There are exchange of solutes between concrete and bentonite: portlandite dissolution, Friedel's salt formation, secondary ettringite, Ca enrichment and Mg depletion in the exchangeable population of the bentonite, calcite dissolution/precipitation, Mg-rich phases precipitation.

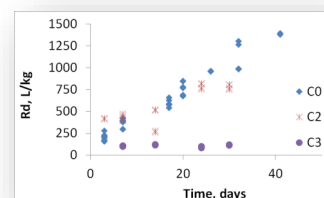


*Sorption of <sup>223</sup>Ra on cementitious materials (CTU)*

- ⇒ Experiments carried out with synthetic cement pore water (simulating deeper circulation of GW in the fissure environment of crystalline rocks) show greater sorption of radium than with Ca(OH)<sub>2</sub> saturation solution.

*C-14 sorption on CEM I: effect of HCP degradation on C-14 uptake (RATEN)*

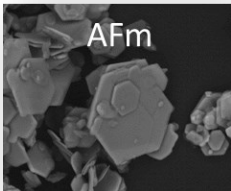
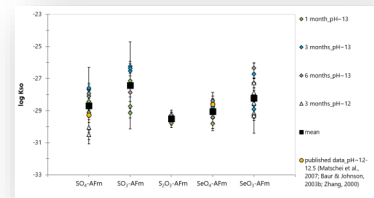
- ⇒ Different Rd values have been measured depending on the degradation state of the cement paste used. Very low Rd values have been measured for the most degraded cement paste.



## ■ ■ ■ Some conclusions

### *Effect of redox conditions on sulfur and selenium binding in AFm phases (PSI/EMPA)*

⇒  $\text{SO}_4^-$  and  $\text{SeO}_4^-$ -AFm phases tend to be more stable than  $\text{SO}_3^-$  and  $\text{SeO}_3^-$ -AFm phases.

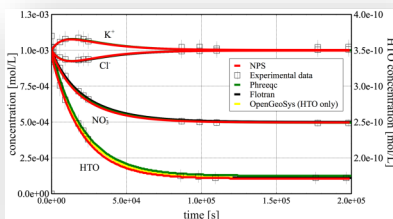
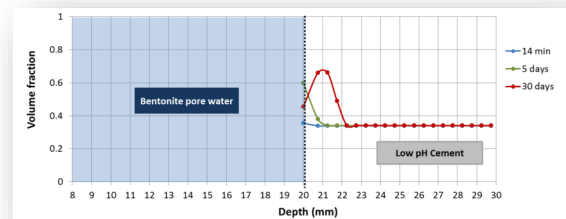


### *Structural investigations on the uptake of long-lived safety relevant radionuclides by cementitious materials (JÜLICH)*

⇒ Neither changes on  $^{99}\text{TcO}_4^-$  concentration over 60 days nor significant uptake of Tc in all tested model systems (CSH0.9, CSH1.4, Ettringite, AFm-( $\text{SO}_4/\text{CO}_3$ ), hydrogarnet, calcite, portlandite) are observed.

### *Modelling of radionuclides migration in the low pH cement/clay interface (KIT-INE)*

⇒ The low pH cement is damaged relatively fast with bentonite porewater and its porosity increases up to 65% at ~1 mm from the interface. Main processes: dissolution of C-S-H phases and precipitation of calcite.

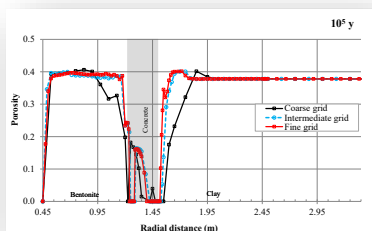
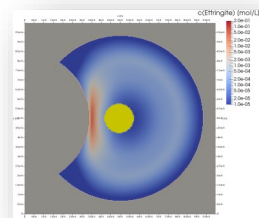


### *Rapid development of a reactive transport code with FEniCS and Re (PSI)*

⇒ Successfully verification of the implementation of the developed code based on Nernst-Planck equations.

### *Implementation of crystallization and precipitation mechanisms in pore-scale models based on the Lattice-Boltzmann method (JÜLICH, A21)*

⇒ Crystallization and precipitation mechanisms using a pore-scale reactive transport model allows observing ettringite formation (see color scale) within the pore space after 0.1 s runtime, using the exponential target saturation transfer function (gypsum: yellow, AFm: grey). Dimensions are 10x10  $\mu\text{m}$ .



### *Discretization errors and porosity feedback for the long-term RTM of the interactions of concrete, compacted bentonite and clay in a HLW repository in clay (UDC)*

⇒ Magnetite (corrosion product) precipitation reduces bentonite porosity at the canister-bentonite interface and concrete degradation leads to high pH plume and mineral precipitation reducing the porosity in the concrete and the clay.

## Stakeholder panel . . .

The 2<sup>nd</sup> Annual Workshop of CEBAMA featured the 1<sup>st</sup> Stakeholder Panel composed of five high level Finnish panellists from the National and Local Government, Electricity Generators, Safety Authority and Waste Managers and Social Experts. The panel discussion was chaired by Erika Holt (VTT).

- ◆ Liisa HEIKINHEIMO, Deputy Director General, Energy Department Finnish Government – Ministry of Economic Affairs and Employment
- ◆ Sami HAUTAKANGAS, Head of Spent Fuel and Disposal, Fortum Oy
- ◆ Vesa JALONEN, President, Municipal Council, Eurajoki
- ◆ Timo SEPPÄLÄ, Senior Advisor, Nuclear Waste Services Unit, Sannio & Riekkola Consulting Engineers
- ◆ Jaakko LEINO, Head of Nuclear Waste Safety Assessment, Finland's Radiation and Nuclear Safety Authority (STUK)
- ◆ Matti KOJO, Post-Doctoral Researcher, Faculty of Management, University of Tampere



Each panellist gave a brief introduction on their background and experience with stakeholder engagement. After their introduction, time was devoted to questions & answers. Three types of questions were included in the panel:

- \* Questions distributed by the panel chair to the panellist before the session
- \* Questions submitted by Workshop attendees during the workshop
- \* Open questions from the audience (questions raised during the panel discussions)

Questions were focused on different topics: 1) Communication with Stakeholders, 2) Dissemination and Interaction, 3) Use of Technical Information, 4) Assisting Less Advanced Programs, 5) CEBAMA project specific issues(cementitious & clay materials, radionuclides, modelling ...) and 6) Others.



## ■ ■ ■ Stakeholder panel

“Politicians and decision-makers understand that there are no better **alternatives** than geological disposal for long term waste management.”

“It is fundamental that the process of selecting a site is **fair** for making the communication successful.”

“Risk should be communicated by comparison with some other risk that common people could have in their **normal life**.”

“We see the **economical benefits** and thus, because we produce nuclear power, we have the **responsibility** for spent fuel.”

“Decision-makers do not have to know every issue, neither every detail. They can **trust** regulators and operators.”

“It is important to pay attention in the **nuclear waste** issues even in the very beginning from the design of the NPP.”

“Specific people should be trained to be able to **communicate** the scientific results in a way people from the general public can understand.”



“Nuclear operators explained citizens when something went wrong, the reasons and solutions. **Transparency** is a really important issue.”

“Finland has national **R&D programs** that are **independent** from both Posiva’s program and nuclear power producers.”

“The **framework** must be good in order that communication can succeed.”



## PhD and young scientist session

The 1<sup>st</sup> Cebama PhD session was organized on Thursday afternoon. The session aimed at promoting training of the students and offering a forum for networking. Students were encouraged to apply for Cebama mobility measures during their PhD to perform part of their PhD in other institutions.

The session was chaired by two of the students (S. Lange, Juelich and R. Vasconcelos, U. Sheffield). 9 students gave a presentation on their investigations and discussed their results.



Experimental and modelling studies on low pH cement / bentonite interface processes

*Naila Ait Mouheb (KIT-INE, Germany)*



Diffusion of radionuclides through cement based materials: from laboratory experiments towards evaluation and modelling

*Toma Rosendorf (UJV-CTU, Czech Republic)*



Characterisation of UK cement backfill material and preliminary groundwater leaching experiments

*Rita Vasconcelos (USDF, UK)*



Chemical evolution of bentonite by modelling in repository conditions

*Aku Itälä (VTT, Finland)*



Short-term interaction of concretes with ground-waters: percolation tests

*Álvaro Fernández-Pérez (CSIC, Spain)*



H-M-C coupling analysis considering several scenarios of long-term alteration in cement-bentonite system

*Shinji Ito (Kobe Uni., Japan)*



Nanostructural modification of Ordinary Portland Cement

*Tapio Vehemas (VTT, Finland)*



Preliminary results from the study of radionuclide retention in cementitious systems and single mineral phases

*Matthew Isaacs (SURREY, UK)*



Rapid development of a reactive transport code with FEniCS and Reaktoro

*Leonardo Hax Damiani (PSI, Switzerland)*

## Visits to GTK and VTT Underground Laboratory



GTK MUSEUM

On Tuesday afternoon, T. Ruskeeniemä from the Geological Survey of Finland (GTK) gave an overview of the Siting process for HLW disposal in Finland.

After the talk, a guided visit to the geological museum area took place. Picture on the left was taken at the museum.

The VTT Underground Research Lab Tour took place on Thursday. Visitors gained an insight on the investigations developed at the VTT Laboratory besides the work carried out for the Cebama project (see pictures below).

The tour was divided in two different groups. A photo of the first group visiting the laboratory is presented on the right.

VTT UNDERGROUND LAB



Facilities of the VTT Underground Lab where cementitious samples for Cebama were prepared (left) and some VTT Cebama experiments are conducted (right).



## Posiva Site Excursion

On Friday the visit to the Olkiluoto Visitor Centre and the Low & Intermediate level repository was organized. About half of the Cebama Workshop participants attended the visit.

The visit started with a overview presentations of Posiva's and TVO's on cementitious materials used from the point of view of safety.

OLKILUOTO VISITOR CENTER



On Friday afternoon the guided tour at the underground repository for low-intermediate level waste (VLJ-repository) and the ONKALO Research Gallery took place. Visitors had the opportunity to see the complete spent nuclear fuel cycle at the different areas of the scientific exhibition of the Visitor Center "Electricity from Uranium".

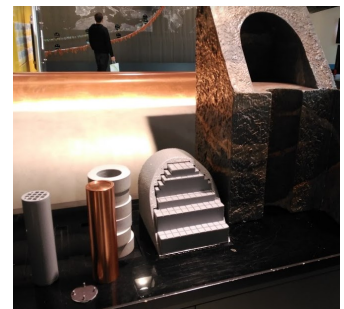
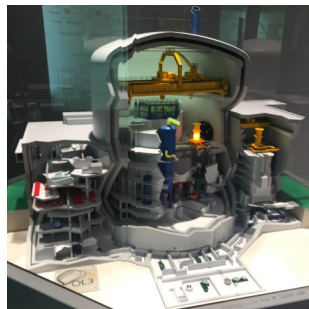
ONKALO Research Gallery



VLJ-repository



Visitor Center





## Dissemination of Cebama and Project Events

Several dissemination actions are implemented in order to inform a wider community besides direct project participants on the current investigations as well as the events organized in the frame of Cebama project.

**CEBAMA PROJECT - SECOND ANNUAL WORKSHOP**

Cebama\*, Other events

Date: 16 May 2017 9:00 - 19 May 2017 17:00

Duration: 3 Days 8 Hours

The 2<sup>nd</sup> Annual Workshop of the Collaborative Project Cebama will be held in Espoo, 16<sup>th</sup> to 19<sup>th</sup> May 2017, hosted by VTT. Cebama addresses key issues relevant for long term safety and key scientific questions related to the use of cement-based materials in nuclear waste disposal applications. The project is implemented by a consortium with 27 Beneficiaries from EURATOM Signatory States, Japan and Switzerland. National Waste Management Organisations contribute to the running project by participation in the End-User Group, by co-funding Beneficiaries, and provide for knowledge and information transfer.

**Objectives of the workshop**

This workshop aims to provide a forum for discussion of scientific and technical project results, preparation for periodic reporting and planning for the future project programme. The Project Workshops contribute to integration within the project and communication with a broader interested community.

See the **CEBAMA Flyer** for more information.

Registration: [www.registerforevent.net](http://www.registerforevent.net) (event name: CEBAMAWORKSHOP2017, password: CEBAMA2017)

Deadline for registration: 1<sup>st</sup> May 2017

Location: VTT campus, Espoo, Finland (Address: Betonimiehentie 4, 02151 Espoo).

Contact: Workshop organisers at [info\(at\)cebama.eu](mailto:info(at)cebama.eu)

Official website: [www.cebama.eu](http://www.cebama.eu)

IGD-TP webpage

### ⇒ Annual Workshop Announcements and other events

- \* Mailing
- \* IGD-TP webpage
- \* Cebama webpage
- \* LinkedIn

### Results from Cebama



- \* Annual Workshop Proceedings
- \* Project Deliverables
- \* Newsletters

*Note: All these documents are public and available at the project website*

Deliverables
Public deliverables of the project
WP1: Experiments on interface processes and the impact on physical properties
<ul style="list-style-type: none"> <li>D1.01 Detailed description of scientific work</li> <li>D1.02 Agreement and documentation of systems to be studied</li> <li>D1.03 State of the art report related with WP1 topics</li> <li>D1.04 Report on WP1 established experimental boundary conditions, experimental methods</li> <li>D1.05 Report on WP1 selected experimental materials to be used, including both new laboratory and aged in-situ samples</li> </ul>
WP2: Radionuclide retention in high pH concrete
<ul style="list-style-type: none"> <li>D2.01 Detailed WP2 description of scientific work</li> <li>D2.02 Agreement and documentation of systems to be studied</li> <li>D2.03 State-of-art report related to WP2 topics (initial)</li> </ul>
WP3: Interpretation & modelling
<ul style="list-style-type: none"> <li>D3.01 Detailed description of scientific work</li> <li>D3.02 Review and definition of modelling approach to be followed in the project: scale of analysis, physico-chemical processes, software, HPC resources</li> <li>D3.03 Consolidated plan for Upscaling Modelling task</li> <li>D3.04 Description of and results from the modelling of external lab and/or field experiments</li> </ul>
WP4: Knowledge Management, Training, Education, Dissemination, Communication
<ul style="list-style-type: none"> <li>D4.01 Generic poster presenting the project</li> <li>D4.02 Set up of project webpage</li> <li>D4.04 Planning on interaction with socio-political stakeholders</li> <li>D4.05 Communication action plan</li> <li>D4.06 Planned dissemination of final results</li> <li>D4.08 Draft of the 1st Annual Project Workshop Proceeding</li> <li>D4.09 Basis for application to Safety Case and Performance Assessment</li> </ul>

CEBAMA webpage

VTT Technical Research Centre of Finland amb Vesa Jalonien.

Data i hora: 18 maig 12:46 · 🌐

Great panel discussion yesterday for the CEBAMA project workshop, about best practices in public Stakeholder engagement for understanding of safety for nuclear waste management. With TEM, Fortum, Eurajoki Municipality, Saanio & Riekkola, STUK and University of Tampere experts (back row from left).

Mostra la traducció

M'agrada Comenta Comparteix

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VTT Facebook

### ⇒ Posts on Cebama Annual Workshops

- \* Cebama LinkedIn
- \* Cebama Webpage
- \* Newsletters
- \* VTT social media (Facebook, LinkedIn, Twitter)



Kick-off meeting (July 2015, Brussels)



2nd Annual Workshsop (May 2017, Espoo)

### 1st periodic report

### 4th Annual Workshop

The Workshop will take place in Karlsruhe (Germany), hosted by KIT-INE.

The Final Cebama Workshop will be organized in connection to the Workshop "Mechanisms and Modelling of Waste/Cement Interactions".

June2015



1st Annual Workshop (May 2016, Barcelona)



1st Stakeholder Panel

### 3rd Annual Workshop

The Workshop will take place in Nantes (France), hosted by Subatech/Armines. The 3-days workshop will be held in the week of 16-20 April 2018.

June2019