

NEWSLETTER N°7

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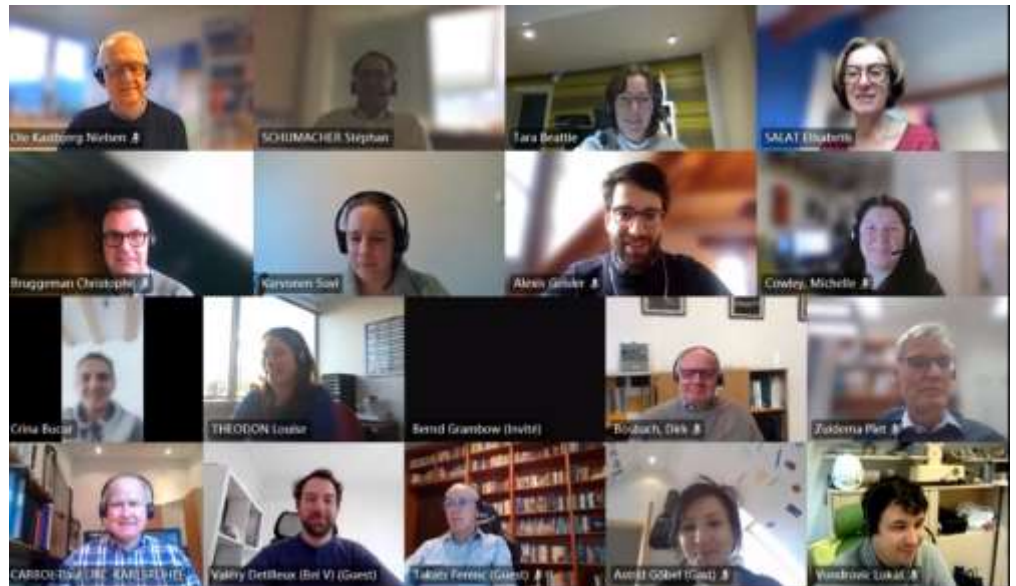
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We are out there

BREAKING NEWS

Change of Bureau and PMO members

The 10th Bureau/PMO meeting took place early December. It was the occasion to gather former and new members of each body. A warm thank you to Suvi Karvonen, Ole Kastbjerg Nielsen, Stéphan Schumacher, Ferenc Takats and Patrik Vidstrand for their engagement in the Bureau and Robert Winsley for the PMO and welcome to Michelle Cowley (PMO), and for the Bureau, Christophe Debayle, Astrid Göbel, Ioannis Kaissas and Lukáš Vondrovič.



A LOOK BACK

After months of virtual meetings, EURAD was back in-person at the IAEA International Conference on Radioactive Waste Management: Solutions for A Sustainable Future (1-5 November 2021) where EURAD was presented twice : first, as part of the Session 7: Multinational Cooperation in RWM and second, in a side event organized by the European Commission together with other EURATOM projects. The conclusion of the Session 7 stressed that EURAD is mature programme gathering different actors, countries, with different backgrounds and interests that have joined forces to develop a combined and shared programme. As quoted by the Chair of session 7: "Alone you may go faster but together you get further".

Recordings and presentations are available on EURAD website :

Session 7 – [link](#)

Side event- [link](#)



Louise Théodon (EURAD Coordinator) at the IAEA RWM Conference

SafeND Interdisciplinary research symposium: On the safety of nuclear disposal practices 2021 - Technical and Social Approaches to Managing the Hazardous Legacy of Nuclear Power Generation

In November (10/11 - 12/11/2021) the German Federal Office for the Safety of Nuclear Waste Management (BASE) hosted a three days research symposium as a big hybrid event. 200 participants were admitted to attend in presence and a lot more joined online. The symposium covered a broad range of topics, from technical questions of the decommissioning of nuclear facilities and interim storage issues to the methodology and public participation in the search for a repository. The presentations were held in three parallel topic specific sessions. EURAD took the chance to introduce EURAD and EURAD KM through four talks within a dedicated block as part of the session "From decades of international Research, Development and Demonstration to a sustainable knowledge and information management":

- Introduction to EURAD and roadmap (Piet Zuidema, ZuidemaConsult)
- State-of-Knowledge & Guidance in EURAD Knowledge Management (Astrid Göbel, BGE)
- EURAD School of Waste Management (Niels Belmans, SCK-CEN)
- Including civil society in R&D projects on RWM: Interactions with Civil Society (ICS) in EURAD (Julien Dewoghelaere, Mutadis)

In consideration of holding three parallel sessions sometimes it was a challenge to decide where to go and to follow the interactivities between the disciplines. The conference was met with great interest and positive recognition. Of course, after this long lasting lack of presence meetings it was a great pleasure to meet at least a few *colleagues face to face*.

More information: https://www.base.bund.de/EN/home/home_node.html



Piet Zuidema (left) and Astrid Göbel (right) at BASE Symposium.



INTERVIEW WITH MARCUS ALTMAIER (CORI WP LEADER)

CORI is an important work package in EURAD, assessing the role of organic molecules in the mobility of radionuclides from nuclear waste in cementitious environments. The on-going joint interest of WMO, TSO and research entities in your work is clearly demonstrating by the large and continuing engagement of the end-users in your WP. Can you explain us, what kind of principal messages or what requests end-users address to you? How is CORI seen by them? How does it help them?



I think that their interests are obviously in having a better technical description of the topics covered by CORI. Like the quantification of processes, how organics degrade and organics and radionuclides interact and are retained on cement-based materials, reducing their mobility. But also to gain understandings in order to add trust to models and estimations. Besides the genuine scientific interest, I can imagine that for our non-European End Users (3 from the USA and 1 from South Korea) there is also some curiosity about how such a huge collaborative project on waste disposal works, integrating experts from several different countries. This is clearly worldwide unique in terms of networking and interactions.

EURAD is heading for a step change in European collaboration in RWM. How do you get the experts from other fields, as well as young students from all around EURAD interested in your work?

EURAD is a platform that allows exchanges with other fields of expertise across many different European countries. I can maybe quote the example of CORI interactions with the ROUTES WP. As both WPs consider organics to be important, we started before the 1st Annual EURAD Event to exchange on how different our WPs handle the topic of "organics in repository". And we were glad to include the FUTURE WP in our joint Annual Workshop session, giving a second important and interesting focus on oxidation and reduction reactions influencing radionuclide mobility.

How are you succeeding inviting even interest of civil society organisations in your work? Do you think, this interaction will help you in the orientations of your research work?

I don't know the exact reasons but when the first contact was made, CORI was quite happy to answer to this initiative. It is important to keep an eye on how our scientific results are seen or understood by the civil society. It is not always easy to talk with the same language, but EURAD offers the opportunity to have this kind of discussion and I think it's really fruitful. In our particular case, we have a good opportunity to exchange on topics related to the potential significance of our results for safety with ICS but also with UMAN. A next step of the ICS-UMAN-CORI interactions will be at the EURAD Second Annual Event!

From 2015 to 2019 you were coordinator of the European project CEBAMA. How do you experience change from the context of European projects to joint programming? Would you say, we are on a good way to realize the announced step change?

Not only from CEBAMA, but previously also RECOZY, and I was strongly involved in TALISMAN by the way. For me, I do see EURAD as a step change in terms of networking and developing things jointly. We now have excellent networking opportunities and synergies that we never have had before. For instance, PhDs and early career researchers have new and excellent options to integrate into the wider community and hear about several relevant topics (i.e. at Annual Events, Lunch-and-Learn sessions, trainings). CORI will for example propose a "career development" action later in 2022 in this context. The integrated KM efforts and their structured approach are also a real step-change that will increase the impact and usability of the research performed. This should make the generated knowledge more visible over longer times. Talking as a former Coordinator, I am glad that WP Leaders can now put more focus on the technical work as overarching management and financial topics are handled at the level of the project management office.

Finally, can you give us an example, whether the potential of international research cooperation is increased by joint programming?

It's now about 15 years since I'm working in this field within EC funded projects and I've established over the years numerous bilateral exchanges, which helped the sharing of information and knowing what expertise is available where and with whom. It's hard to quantify this, but I'm deeply convinced that my own scientific work would be way poorer without all the international contacts, which to a good degree were first established via EC funded research activities. I am very sure that many other colleagues will feel similar.

SPOTLIGHT – MY STAY AT THE RESEARCH ORGANIZATION TNO TO LEARN ABOUT MEDIATED ELECTROCHEMISTRY



Since November 2019, I am a PhD student at the Paul Scherrer Institute (PSI) in the framework of the EURAD WP5 FUTURE (Fundamental-Understanding-of-Radionuclide-Retention).

The aim of my project is to better understand the surface-induced redox processes that influence or control the retention of redox-sensitive elements on Fe(II)/Fe(III) bearing clay minerals. One key parameter, is the Fe(II)/Fe(III) ratio in the different investigated clays, as it determines the redox potential and controls the redox reactions. However, due to the extremely slow electron transfer between clay minerals and working electrode, redox potentials of clay minerals are hard to measure by conventional potential measurement techniques, such as an Eh meter. Mediated electrochemical technique uses specific dissolved redox-active organic molecules so called "mediators or electron shuttles" to facilitate the electron transfer and the equilibration between the clay mineral and working electrode, thus allowing quantification of electrons transferred to or from Fe in clays. Dr. Alwina Hoving from the Netherlands organization for applied scientific research (TNO), project partner within WP Future subtask "redox reactivity of radionuclides on mineral surfaces", is a recognized expert in the application of mediated electrochemistry. In order to learn this method, which is very important in the context of my project, I have applied for the EURAD mobility grant.



I visited TNO in August 2021 and really enjoyed my time there. One of the highlights of this mobility for me was the hands-on experience, even more so after the very restrictive past year. Being on site is so different from discussing online. I was able to see the whole setup and carry out sample preparation, experiments, data analysis, and discuss under face-to-face supervision. This has helped me to get a better understanding of the technique. Additionally, getting to know other people was another big highlight. I had the chance to talk to the people working in that lab about their projects and research life. These conversations have provided me with different perspectives of doing research. Knowing different projects has broadened my view in geoscience and waste treatment field and the exchange has given me more ideas on experiment planning and PhD project management. I am very thankful for this opportunity. Overall, it is a successful collaboration between these two institutes in the frame of EURAD Future, and the cooperation continues since then. I hope my experience will be an encouraging example for those who want to apply for this mobility.

UPCOMING EVENTS

February

14th-15th - EURAD General Assembly n°6

23rd – Lunch-and-learn session with Carl-Henrik Pettersson

March

06th-10th - Waste Management 2022

21th-23rd - DAEF 2022: 3rd conference on Key Topics in Geological Disposal

28th-30th – EURAD second annual event

NOW PUBLISHED!

D11.1. Screening and review of existing/available knowledge management approaches and/or tools” published

WP11 submitted their Deliverable “[D11.1. Screening and review of existing/available knowledge management approaches and/or tools](#)” in November. This Deliverable provides insight into Knowledge Management Systems and tool used by different organisations, which will help to get a better picture of what EURAD needs and can do with regard to KM approaches and tools. The crucial input for this Deliverable was provided by participating organisations via a questionnaire, so again: a big “Thank you!” for your efforts. This report shows once again the great potential EURAD has through joint efforts and collaboration!

State-of-Knowledge report on Spent Nuclear Fuel

Spent nuclear fuel is probably one of the most complex solids in the universe,...” is one sentence you can read in the State-of-Knowledge (SoK) report on Spent Nuclear Fuel (Domain 3.1.1. of the GBS), which was authored by the expert Kastriot Spahiu (SKB, Stockholm and Chalmers University of Technology, Gothenburg, Sweden) and published in November. To find out more, you can access it via the [EURAD-Wiki](#) (Login details were distributed via ProjectPlace) or the [EURAD Homepage](#). This sentence illustrates why it is so important to have sound knowledge of Spent Nuclear Fuel. Capturing and making this kind of knowledge available is the goal of these State-of-Knowledge documents, which are an important activity of WP11 SoK. This is of course not only true for Spent Nuclear Fuel, but so many other topics on the field of RWM, as shown in the EURAD [Goals Breakdown Structure \(GBS\)](#). This is why we invite you as experts in your respective field to not only check out the SoK document on Spent Nuclear Fuel, but also to get involved in EURAD Knowledge Management (KM) as contributors, for example as authors, reviewers or by giving feedback on your expectations and experiences with EURAD KM! To find out more about how you can participate in the production of KM documents, contact WP11: Alexandru.Tatomir@bge.de or Tobias.Knuuti@bge.de

EURAD Second Annual Event

28th to 30th March 2022

‘What did we learn up until now and how can the value of this new knowledge be maximised using EURAD’s KM systems. Furthermore, what additional work is foreseen in the remainder of EURAD-1 to achieve the desired step change in European collaboration towards safe radioactive waste management?’

Monday 28th (afternoon only): Opening session, strategic plenary session with keynotes lectures and panel

Tuesday 29th (full day): breakout sessions, interactions with civil society (ICS) session

Wednesday 30th (full day): PhD event/posters, WPs views, concluding session of the breakouts and closing remarks



Location:
IRSN
31 Av. de la Division Leclerc
92260 Fontenay-aux-Roses
FRANCE

DID YOU KNOW ?



MAGIC WP - The Interactive Data Platform for Cement (IDPC) is activated!

From December 13th 2021, the IDPC is officially activated. The IDPC creation supporting the knowledge development in the **MAGIC WP** is a first step towards **transparency process for data sharing**. After four months of discussions to define the objectives, the tool and platform design and also to test it, the IDPC is now ready to receive contributions from MAGIC's participants. The last step put in place was the dissemination of a survey in which partners were requested to identify the last missing information.

WHAT IS THE GOAL OF THE IDPC? Building a tight and trustworthy relationship between partners by ensuring a transparent data transfer. Indeed, data sharing and transparency are topics of concern in MAGIC, but more broadly in EURAD. The different objectives of the IDPC are the following:

- Data production management and sharing;
- Stimulate discussions between partners from different tasks;
- Ensure consistency between information provided by tasks 2 & 3 and needs identified by modellers in task 4;
- Determine criteria and use them to evaluate at the end of the WP, the level of interest, interaction and uses of the experimental data in models developments.

WHAT IS THE PHILOSOPHY OF THE IDPC? Keeping a continuous interaction between modelers and experimenters, but also between the different specialties (Chemistry, Microbiology & Mechanics) by interacting and sharing results throughout the project.

IN PRACTICE, the IDPC is a Teams group associated with a Sharepoint website. Two different sections make up the IDPC: the "modellings" and the "experiments" sections. The two sections include forms to be filled in that contain modelling/experiment related information (modelling/experiment's name, modeller/experimenter's name, organisation's name, involved partners, and more specific information). Once the forms are filled in, Sharepoint enables to sort data among other potential tricks. Several experiments were created to set examples for the participants. Modellers and experimenters are able to fill in one or several forms and modify them to share their data and/or their results and facilitate a continuous interaction between the MAGIC participants. So far, the IDPC is filled with fifteen contributions on both sections.

Experiment's title	Name of the ex...	Organisation's ...	Involved partners	Task number	Subtask
IMCB	Majdi NEJI	IRSN	UIHLSINIKI HZDR	Task 3	ST3.1
IMCB	Majdi NEJI	IRSN	UIHLSINIKI HZDR	Task 3	ST3.1
PM2SH	Charlotta Dewitza	IRSN	LMDC	Task 3	ST3.1
PM2SH	Charlotta Dewitza	IRSN	LMDC UIHLSINIKI	Task 3	ST3.1
14 years old ESOREC concrete - Poromecha...	Michele Celli	Fmas	ISI	Task 3	ST3.2

An insight into the IDPC

WORK PACKAGE 2: ASSESSMENT OF CHEMICAL EVOLUTION OF ILW AND HLW DISPOSAL CELLS (ACED)

ACED is about to finish a deliverable (D2.18) on model abstraction methods for upscaling and integrating scientific knowledge into reactive transport models at the disposal scale. Model abstraction is a systematic approach to decrease (numerical) model complexity but maintaining the validity of the simulation results for the specific questions or variables of interest. The report gives an overview of the workflow and different model abstraction techniques. Current applications for assessing chemical evolution of disposal cells available in the literature are discussed. Model abstraction can be used for optimization, sensitivity and uncertainty analyses. In the next step, some methods discussed in the report will be applied to our four generic disposal cell designs and compared with full geochemical model results.

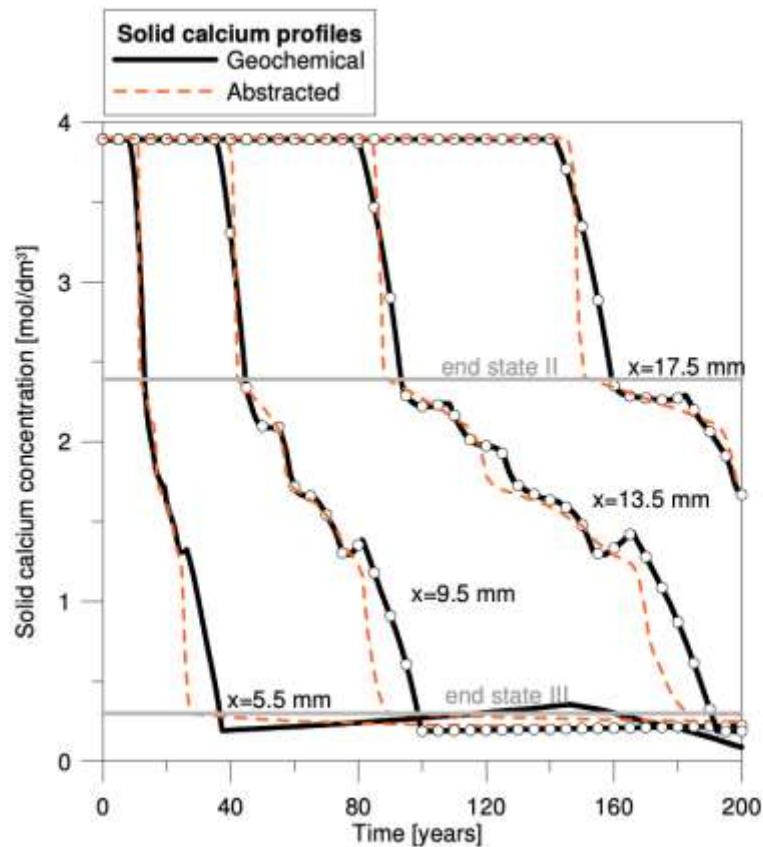
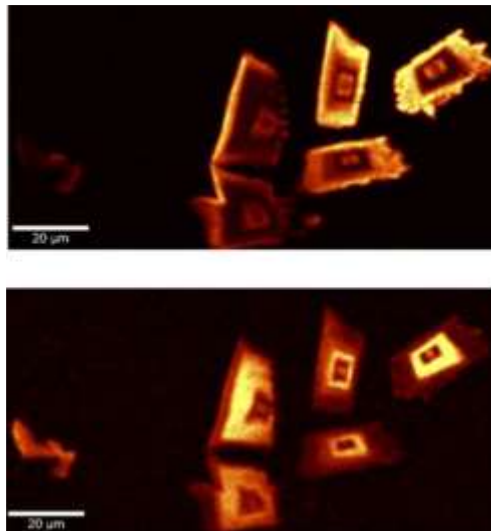


Figure 1: [Jacques et al., 2011] Comparison of geochemical and abstracted model simulations to assess the speed of leaching of cementitious materials in terms of reaching the end of complete portlandite dissolution (end state II) and C-S-H dissolution (end state III).

WORK PACKAGE 5: FUNDAMENTAL UNDERSTANDING OF RADIONUCLIDE RETENTION (FUTURE)

Enigma of oscillatory crystal growth revealed

The formation of solid solutions is an important radionuclide retention mechanism, which can lead to an irreversible uptake of radionuclides. Moreover, due to the partitioning of ions between solid and fluid phases the concentration of the radionuclide in solution can be reduced far below the solubility of pure phases. Thus, barium sulfate solid solutions can be efficient sink for radium. One of the open questions in reactive transport phenomena is related to the nucleation and growth mechanism of solids in confined media. The nucleation probability is known to depend on the pore size distribution and can follow a complex reaction pathway. Joint development of “lab on a chip” microfluidic experiment and its digital twin represented by high fidelity reactive transport simulation model conducted in Eurad WPs FUTURE and DONUT enabled a systematic study of the nucleation and growth of oscillatory-zoned $(\text{Ba,Sr})\text{SO}_4$ crystals in a designed porous medium at different transport regimes. The combination of the experiments and modelling reveals that the composition of the nucleating phases and the chemical zoning in the studied system can be explained by using classical nucleation theory. The composition of the precipitating phase is determined by competition between the diffusion-limited transport of solutes and the kinetics of nucleation and growth. The results of the study are published in Poonoosamy et al. 2021 Scientific Reports (11): 23678, <https://doi.org/10.1038/s41598-021-02840-9>



Oscillatory zonation in $(\text{Ba,Sr})\text{SO}_4$ crystals formed in a microfluidic experiment as obtained by *in situ* Raman spectroscopy indicating Sr-enriched (top) and Ba enriched (bottom) phases.

WORK PACKAGE 8: SPENT FUEL CHARACTERIZATION AND EVOLUTION UNTIL DISPOSAL (SFC)

Segmented mandrel ductility tests of hydrogenated fuel cladding tubes to simulate PCMI

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Abstract

The mechanical interaction between the nuclear fuel pellets and the cladding tubes (PCMI) is very important for safety studies as this phenomenon could lead to fuel failure and release of radioactivity. During a reactivity-initiated accident (RIA) considered in nuclear power plant safety analyses, the power increases suddenly due to a large reactivity increase in the reactor and the fuel pellet interacts with the cladding due to its sudden thermal expansion. Similarly, it is important to investigate the long-term behaviour of irradiated claddings exposed to corrosion and hydrogen uptake in normal operation and in an interim dry storage facility.

Examination of the ductility of the fuel claddings as well as the cracking and fracture behaviour is important both for normal operation and accident scenarios. Brittle claddings might fail in the elastic range whereas ductile material is expected to resist after significant plastic deformation induced by the sudden increase of mechanical stress. To model the mechanical interaction between the pellet and the cladding, tests are often performed using a multi-element segmented expanding mandrels to determine the ductility limit of the cladding tubes or rings.

To investigate the ductility of E110 Zr1%Nb cladding tubes used in WWER nuclear power plants, several segmented mandrel tests were performed in the Centre for Energy Research (EK) in Hungary. Feasibility analyses and three-dimensional finite element numerical model calculations were performed in order to prepare the experiments. A modified mandrel test setup was used to model the mechanical interaction between the rigid fuel pellet fragments and the cladding tubes. The mandrel ductility tests were conducted at room temperature and at 300 °C with inactive, as-received and pre-hydrogenated cladding ring samples. The results show a gradual decrease in ductility as the hydrogen content increases. Minimum ductility was reached above 1500 ppm hydrogen content.



Figure 1: Stages of sample deformation during the test: Small elastic deformation (left); large plastic deformation, the width and wall thickness of the ring is visibly reduced (middle); ductile crack nucleation just before failure at the centre of a region affected by significant necking (right).

WP8 : SFC



Figure 2: State of a ductile (627 ppm hydrogen, left side) and a brittle (2059 ppm hydrogen, right side) hydrogenated E110opt sample after the same spike displacement.

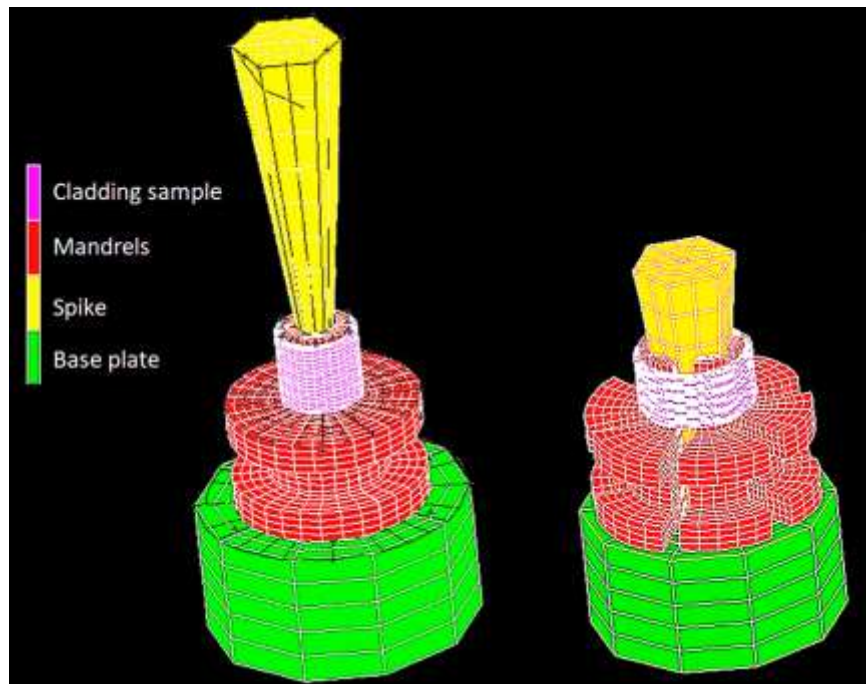


Figure 3: The finite element model of the finalized segmented tool during the test.

WORK PACKAGE 10: UNCERTAINTY MANAGEMENT MULTI-ACTOR NETWORK (UMAN)

Second UMAN Seminar

The UMAN Work Package (WP) is dedicated to the management of uncertainties potentially relevant to the safety of different radioactive waste management programmes and phases. Task 5 of the WP is in charge of organizing pluralistic analyses of key outcomes of other tasks of UMAN through a set of yearly seminars. The outcome of these interactions allows to enrich the results of UMAN.

Following the first Seminar providing a global picture on uncertainties and their management, Seminar n°2 held remotely on October 04, 05 and 11 (half-days), explored one domain of uncertainties addressed in UMAN, namely "Site and Geosphere related uncertainties". The aim was to identify and discuss the views of different types of actors on the following topics:

- Preferences regarding possible uncertainty management options,
- Possible evolutions of uncertainties throughout different phases of a disposal programme,
- How the interactions with civil society could contribute to the management of uncertainties.

It gathered 51 participants providing a well-balanced representation of the views of Waste Management Organisations, Technical Support Organisations, Research Entities and Civil Society Organisations. A representative from the NEA Forum of Stakeholders Confidence (FSC) and regulators from Belgium and England also participated.

Three different topics were selected in order to focus the exchanges on concrete examples of interest to several actors: fault detection and reactivation, climate evolution with a focus on future glaciations and site's natural resources. A first session presented the possible evolutions and safety significance of uncertainties related to these topics as well as possible options to represent these uncertainties in a safety assessment and, where needed, to reduce, avoid or mitigate them. The provided information was notably based on the outcome of other UMAN tasks.



Figure 1: Europe during its last glaciation

This first session included also a presentation dedicated to the perspectives of the Civil Society larger group involved in EURAD on these "site and geosphere" uncertainties. These presentations constituted an information basis for the pluralistic discussions that took place during the Working Group sessions of the second half day. During this second session, the discussions were focused on concrete cases that illustrated the issues related to the 3 selected topics presented during the first session. The third session was dedicated to the presentation and discussion of the outcome of the Working Group sessions.

WP 10: UMAN

Several results emerged from the discussions and notably the fact that a stepwise, transparent & flexible decision-making « process » was needed to manage Site and Geosphere uncertainties. It involves decisions regarding the selection and use of complementary measures at different programme phases to avoid/reduce safety-significant uncertainties and to mitigate residual uncertainties and manage « surprises » that could occur, for instance, during construction and through monitoring (even if very unlikely). Civil Society should have the possibility and the means (i.e. access to independent expertise, legal provisions etc) to be involved early in this process and monitor the situation now and in the future (several generations involved). The concept of rolling stewardship was identified as a possible way to ensure this multigenerational participation and will thus be further discussed during the next seminars.

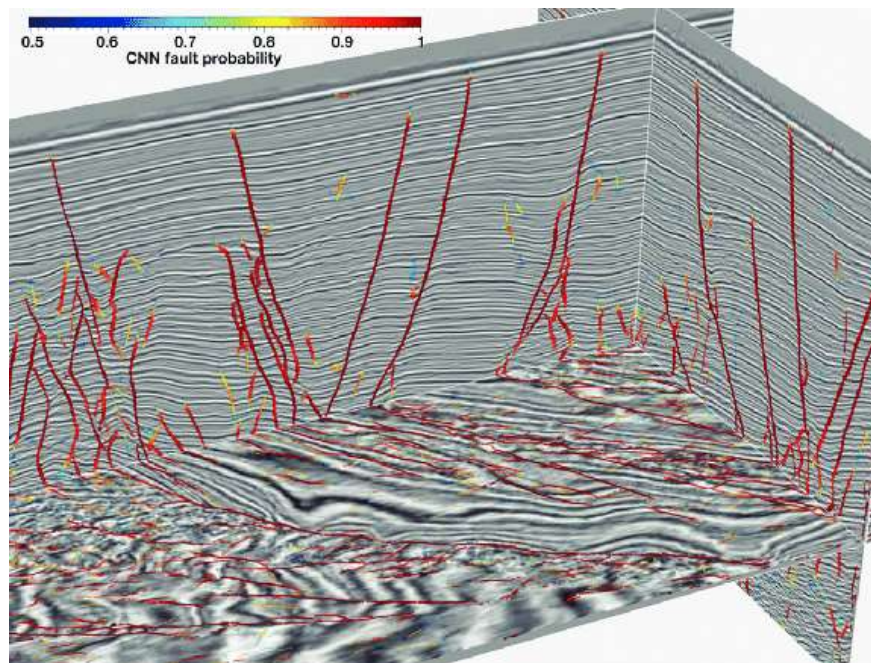


Figure 2: Example of fault detection based on seismic data and associated probability

Source Wu et al. (2019). Building realistic structure models to train convolutional neural networks for seismic structural interpretation. *Geophysics* 85(4):1-48, October 2019.

PHD CORNER

Dimitra Zerva : 2020-2023 – Paul Scherrer Institute WP FUTURE

Supervised by: Prof. Sergey Churakov, Dr. Martin Glaus

Title: Diffusion and retention of strongly sorbing radionuclides in compacted clay minerals



I graduated in 2016 from the Geological School of Aristotle University of Thessaloniki (Greece) and continued with my Master in Environmental Hydrogeology at the same university. In 2020 I started my PhD at the Paul Scherrer Institute and since then I conduct my experiments in the Hot Labor of the Nuclear Energy and Safety department.

The safe disposal of radioactive waste is of great importance to many societies and hopefully the results of my survey will contribute, will add a gravel to the environmental protection wall that we try to build during FUTURE project.

Approximately 10,000 years after the disposal of the radioactive waste into a deep-geological repository, the canisters in which the waste were emplaced will presumably start to fail and the radioactivity will start to migrate through the 3rd barrier which is the geological formations. What happens then? What mechanisms might possibly enhance their transport? Which impact on diffusion rates may be induced by a change of pore water chemistry of the argillaceous rocks? If yes, how? Is there any difference on the clay microstructure due to an alteration?

To answer such questions I use conditioned illite (an important argillaceous constituent of the Opalinus Clay) in different ionic forms such as Li⁺_illite, Na⁺_illite, K⁺_illite, and Cs⁺_illite with varying electrolyte concentrations. I apply different diffusion techniques: through-diffusion of uncharged species for the evaluation of the geometrical factor, which is related to the microstructure and in-diffusion/profile analysis to study the diffusion properties of strongly sorbing tracers.

The use of radioactive tracers is mandatory for my experiments. So I use tritiated water (HTO) and ³⁶Cl⁻, ⁵⁷Co²⁺, ⁶³Ni²⁺ and ⁶⁵Zn²⁺ not only for monitoring purposes, but also because part of them are among dose-relevant nuclides in long-term safety cases (such as ³⁶Cl⁻ and ⁶³Ni²⁺).

First conclusions could already be drawn from my initial studies. Results obtained with Na⁺_illite and K⁺_illite showed that the potassium clay has a smaller geometrical factor and a higher accessible porosity for anions, leading to a higher effective diffusion coefficient (D_e) of ³⁶Cl⁻. In the case of ⁵⁷Co²⁺, as a cation, the effect of illite alteration was also clear revealing a decreasing diffusivity of the radioactive tracer as we go from Li⁺_illite, to Cs⁺_illite.

An indispensable part of my work is the geochemical and transport modeling with PhreeqC and Comsol simulations for the interpretation of our experimental data and the verification of our model concepts.

Ideally, I want to combine the experimental work with appropriate synchrotron techniques that will provide us an additional evidence of the microstructural variations and transport effects in our model system.

WE ARE OUT THERE



Laura Aldave de las Heras • 2e

Senior Expert at European Commission

1 mois • 🌐

Our H2020 **#SHARE** Project was in the spotlight yesterday, together with **#PREDIS**, **#EURAD** and **#MICADO**, at the **#IAEA** International Conference on Radioactive Waste Management: Solutions for a Sustainable Future side event "Collaborative Research and Innovation in RWM in the Euratom Community". Proud to be a part of this event together with Anthony Banford, Erika Holt, Massimo Morichi, Louise Théodon and Seif Ben Hadj Hassine. Panel discussions focused on international cooperation, outreach to early stage countries, knowledge management and strategic research agendas related to RMW.

[Voir la traduction](#)

