

## MOBILITY MISSION REPORT

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### MISSION TITLE

17th Natural Analogue Working Group workshop, Zadar, May 8-12 2023

### DESCRIPTION


#### Concerned organisations

- Research entities: SCK CEN

#### Concerned infrastructures or facilities

N/A

#### Concerned phases

- Phase 0: Policy, framework and programme establishment
  - Phase 1: Site evaluation and site selection
  - Phase 2: Site characterisation
  - Phase 3: Facility construction
  - Phase 4: Facility operation and closure
  - Phase 5: Post-closure
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## Themes and topics

- Theme 3: Engineered barrier system (EBS) properties, function and long-term performance
  - Spent Fuel and high-level waste disposal canisters
  - Containers for long-lived intermediate and low level wastes
  - Clay-based backfills, plugs and seals
  - Cementitious-based backfills, plugs and seals
  - EBS system understanding
- Theme 4: Geoscience to understand rock properties, radionuclide transport and long-term geological evolution
  - Long-term stability (uplift, erosion and tectonics)
  - Perturbations (gas, temperature and chemistry)
  - Aqueous pathways and radionuclide migration
- Theme 6: Siting and Licensing
  - Site selection process
  - Detailed site investigation
- Theme 7: Performance assessment, safety case development, and safety analyses
  - Integration of safety-related information
  - Performance assessment and system models
  - Treatment of uncertainties

## Keywords

Safety case, radionuclide migration, groundwater, climate change, geodynamics

## EXECUTIVE SUMMARY

The proposed mobility action involved attending the 17th Natural Analogues Working Group workshop, which included 2.5 days of formal (oral and poster presentations) and informal discussions on recent developments in the use of natural analogues in supporting safety cases for the disposal of radioactive waste, and reducing uncertainties. The main objective of this mobility action was to explore the usefulness of natural analogues in EURAD work packages, e.g. the UMAN task on uncertainty management. In addition, a presentation on the use of Natural Analogues for long-term climato-tectonic evolution was given by the applicant.

There was a very good introductory session with several keynotes in which, e.g., the updated NA catalogue in support of the British programme of geological disposal (NWS) was presented. In addition, many archaeological analogues were presented in the EBS-canisters session (mainly on corrosion processes (of iron, steel and copper)). A very interesting analogue is the one from Cigar Lake in Canada, where a uranium ore is found encapsulated by sedimentary clay, presented in the EBS-bentonite session (but also relevant for clay host rocks).

We had long and productive discussions with Stéphane Brassines, who is following the Natural Analogues community for NIRAS-ONDRAF. At the moment Natural Analogues are not a priority for NIRAS, but it will have to be incorporated in the programme at some point.

Finally, we had fruitful discussions with representatives of many institutions, e.g. COVRA, CEA, ENSI, NUMO, Uni Helsinki, NWS, BGE, Uni Zagreb, INER, Bedrock Geosciences etc...

Concluded is that the Working Group will remain active, and that another workshop will be planned in 2025. We expect new analogues (types as well as cases) to appear in the (near) future.

## 1. MISSION BACKGROUND

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### 1.1. R&D background

The proposed mobility action involved attending the 17<sup>th</sup> Natural Analogues Working Group workshop, which included 2.5 days of formal (oral and poster presentations) and informal discussions on recent developments in the use of natural analogues in supporting safety cases for the disposal of radioactive waste, and reducing uncertainties. Amongst others, the following topics were covered:

- Radioactive waste form stability: including vitrified waste stability and spent fuel evolution
- Repository near-field studies: including corrosion of copper and steel canisters and the long-term stability of the bentonite buffer.
- Repository far-field studies: including self (or regional) analogues of potential repository sites and assessment of potential radionuclide releases to the host rock and biosphere
- Stakeholder communication: including examples of approaches used to communicate different aspects of waste disposal to both technical and non-technical audiences

### 1.2. Mission objectives

The objective of this mobility action was to explore the usefulness of natural analogues in EURAD work packages, e.g. the UMAN task on uncertainty management. In addition, a presentation on the use of Natural Analogues for long-term climato-tectonic evolution was given by the applicant.

This workshop is an excellent networking opportunity, as it is attended by a wide (but small, around 40-50 people) audience from all over the world.

### 1.3. Mission request

17<sup>th</sup> Natural Analogue Working Group workshop, Zadar, May 8-12 2023

### 1.4. Mission composition

#### Host organisation

Natural Analogue Working Group, represented by Bedrock Geosciences (CH) and the University of Zagreb (HR)

#### Host facility

Hotel Kolovare, Zadar, Croatia

#### Mission dates

8 May 2023 – 12 May 2023

## 2. MAJOR PRACTICES, TECHNIQUES, METHODS, TOOLS OR SYSTEMS OPERATED OR STUDIED

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### 2.1. Practice, technique, method, tool or system operated or studied during the mission

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#### Description

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#### Usage

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#### Benefits

Klikněte nebo klepněte sem a zadejte text.

#### Limitations

Klikněte nebo klepněte sem a zadejte text.

#### Applicability

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## Applicability

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### 3. MISSION FINDINGS AND CONCLUSIONS

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#### 3.1. Lessons learned and conclusions

- A very good introductory session with keynotes from Simon Norris, Heini Reijonen, Russell Alexander and Vanessa Montoya. The updated NA catalogue in support of the British programme of geological disposal (NWS) will soon be finalised. This could be a very interesting document.
- Many archaeological analogues were presented in the EBS-canisters session (mainly on corrosion processes (of iron, steel and copper))-- why is this almost completely ignored in Belgium?
- Poster on NA studies to understand radionuclides migration by Amphos 21 and ONDRAF/NIRAS.
- A very interesting analogue is the one from Cigar Lake in Canada, where a uranium ore is found encapsulated by sedimentary clay, presented in the EBS-bentonite session (of course it is not only relevant for bentonite, also for clay host rocks)
- Interesting talks in the far field session, with a well illustrated natural analogue from South Korea (uranium deposits in the Ukcheon Metamorphic Belt, but less relevant for western Europe)

We had long and productive discussion with Stéphane Brassines, who is following the Natural Analogues community for NIRAS-ONDRAF. At the moment Natural Analogues are not a priority for NIRAS, but it will have to be incorporated in the programme at some point. They are mainly interested in the NA that could provide information about radionuclides migration. Stéphane was specially interested in the NA presented by the Korean group (KAERI & University of South Korea).

Other people we spoke to a.o. Erika Neeft (COVRA), Delphine Neff (CEA), Bastian Graupner (ENSI), Saturo Suzuki (NUMO), Marija Siitari-Kauppi (Uni Helsinki), Simon Norris (NWS), Andree Lommersheim (BGE), Galla Uroic (Uni Zagreb), Russell Alexandre (Bedrock Geosciences): discussion on connections of the NAWG and the EURAD-2 idea development, Polly Tsai, (INER, Taiwan),...

#### 3.2. Relevant findings and conclusions for home organisation

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#### 3.3. Relevant findings and conclusions for host organisation

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#### 3.4. Relevant findings and conclusions for other organisations

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## 4. POTENTIALS FOR IMPROVEMENT OR DEVELOPMENT

### 4.1. Generic potentials

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### 4.2. Potentials for home organisation

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### 4.3. Potentials for host organisation

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## APPENDICES

## Mission journal

Monday 8 <sup>th</sup> May		
	Travel to the venue	
17:00 – 18:00	Registration at the hotel pool	
18:00 – 20:00	Icebreaker and finger food at the swimming pool	
Tuesday 9 <sup>th</sup> May		
	<b>Introduction and registration</b>	
09:00 – 09:10	Opening of the workshop and organisational aspects	Russell Alexander, NAWG chairman
09:10 – 09:20	Welcome to Zadar	Zelimir Veinovic, University of Zagreb
09:20 – 09:40	Current status of the Croatian national programme	Galla Uroic, Croatian Decommissioning Fund
<b>Session I</b>	<b>Exploring the current use of natural analogues in developing and supporting the safety case</b>	<b>Chair: Erika</b>
09:40 – 10:25	Natural Analogues – A proposed strategy for implementation within the Nuclear Waste Services (UK) programme of geological disposal	Simon Norris, NWS, UK
10:25 – 10:55	<i>Coffee/tea (with cakes)</i>	
10:55 – 11:25	A critically reviewed catalogue of NAs to support the Nuclear Waste Services (UK) programme of geological disposal	Russell Alexander, Bedrock Geosciences, Switzerland
11:25 – 11:45	Use of NAs in the Finnish safety case – the Complementary Considerations approach	Heini Reijonen, GTK, Finland
11:45 – 12:15	NAs and long-term evolution: upscaling towards repository	Venessa Montoya, SCK-CEN, Belgium

	relevant space and time scales	
12:15 – 13:45	<i>Lunch</i>	
<b>Session IIa</b>	<b>EBS – waste forms</b>	<b>Chair: Simon</b>
13:45-14:15	Natural glass alteration under hyperalkaline conditions for about 4000 years	Ryosuke Kikuchi, University of Hokkaido, Japan
<b>Session IIb</b>	<b>EBS - canisters</b>	<b>Chair: Simon</b>
14:15 – 14:45	Multi-scale and isotopic analyses to understand the corrosion mechanisms of 400 year old archaeological iron analogues	Delphine Neff, CEA Saclay, France
14:45 – 15:15	MICA: overview of Phase I of the Michigan International Copper Analogue project	Ismo Aaltonen, GTK, Finland
15:15-15:45	A potential NA for the longevity of iron and steel in a clay from NW Scotland	Tony Milodowski, Independent, UK
15:45 – 16:15	<i>Coffee/tea (with cakes)</i>	
16:15 – 16:35	Archaeological analogues – an essential contribution to canister lifetime modelling	Vlatislav Kaspar, UJV Rez, Czech Republic
16:35 – 17:05	The use of NA information in assessing the chemical evolution of HLW disposal cells	Erika Neeft, COVRA, The Netherlands
17:05	Close of Day 1	
19:00	Dinner in the hotel	
<b>Session III</b>	<b>Posters: will be on display throughout the workshop</b>	
An application of research for buffer/backfill materials through estimation of Cs diffusion in compacted Taiwan bentonite	Chuan-Pin Lee, National Tsing Hua University, Taiwan	
Bioreduction of aqueous uranium(VI) under conditions relevant for deep geological repository of nuclear waste	Dawoon Jeong, KAERI, South Korea	
Advances in the understanding of radionuclides migration	Olga Riba, Amphos 21, Spain	

processes in natural analogues systems		
Batch experiments for determining uranium dissolution kinetics using uranium-containing coaly slate and groundwater from a natural analogue site in Korea		Hakyung Cho, Jeonbuk National University, South Korea
<b>Wednesday 10<sup>th</sup> May</b>		
<b>Session IIc</b>	<b>EBS - bentonite</b>	<b>Chair: Andree</b>
09:00 – 09:30	The ongoing IBL project - recent results	Heini Reijonen, GTK, Finland
09:30 – 10:00	Microbiology of barrier component analogues of a deep geological repository	Rachel Beaver, University of Waterloo, Canada
10:00 – 10:30	Microbial occurrence and their growth in compacted bentonite in subsurface environments	Yuki Amano, JAEA, Japan
10:30 – 11:00	<i>Coffee/tea (with cakes)</i>	
11:00 – 11:30	Cigar Lake: behaviour of <sup>129</sup> I and implications for transport in clay barriers	Zhenze Li, CNSC, Canada
11:30 – 12:00	Fracture filling smectites as NAs for the bentonite buffer - case studies from Finland	Heini Reijonen, GTK, Finland
12:00 – 13:30	<i>Lunch</i>	
<b>Session IIc (cont.)</b>	<b>EBS - bentonite</b>	<b>Chair: Andree</b>
13:30-14:00	Thermal alteration of bentonite: an overview	Russell Alexander, Bedrock Geosciences, Switzerland
14:00-14:30	Experimental and geochemical modelling investigations of Cs, Sr and Co sorption on Zhisin Clay, Taiwan	Polly Tsai, INER, Taiwan
<b>Session IVa</b>	<b>Far-field studies - radionuclides in natural systems</b>	<b>Chair: Russell</b>
14:30 – 15:00	A natural analogue study in uranium deposits of the Okcheon Metamorphic Belt,	Min-Hoon Baik, KAERI, South Korea

	Korea: basic investigations and future prospects	
15:00 – 15:30	<i>Coffee/tea (with cakes)</i>	
15:30 -16:00	Water-rock interactions of uranium deposits: a field study in the Okchoen Metamorphic Belt, Korea and laboratory batch experiments	Sung-Wook Jeen, Jeonbuk National University, South Korea
<b>Session IVb</b>	<b>Far-field studies - climatic evolution</b>	<b>Chair: Russell</b>
16:00-16:30	NAs for long-term climatotectonic evolution scenarios	Koen Beerten, SCK-CEN, Belgium
16:30	Close of Day 2	
	Free evening – enjoy Zadar	
<b>Thursday 11<sup>th</sup> May</b>		
<b>Session IVc</b>	<b>Far-field studies - rock matrix diffusion</b>	<b>Chair: Polly</b>
09:00-09:30	Analogue Studies of Rock Matrix Diffusion in Higher Strength Rocks	Simon Norris, NWS, UK
09:30-10:00	Matrix diffusion at the small scale and the role of heterogeneity	Marja Siitari-Kauppi, University of Helsinki, Finland
10:00 – 10:20	To be confirmed	To be confirmed
<b>Session VI</b>	<b>General studies</b>	<b>Chair: Stephane</b>
10:20 – 10:50	Ultra-trace analysis with AMS in the frame of experiments relevant for nuclear waste disposal	Francesca Quinto, INE-KIT, Germany
10:50-11:20	<i>Coffee/tea (with cakes)</i>	
11:20 – 11:50	Recent activities on NA studies in Japan	Satoru Suzuki, NUMO, Japan
<b>Session VII</b>	<b>Excursion</b>	<b>Chair: Stephane</b>
11:50 – 12:10	Concrete longevity studies: current status and future potential	Russell Alexander, Bedrock Geosciences, Switzerland
12:10 – 12:30	Introduction to the excursion sites	Jagor Blazic, Independent, Croatia
12:30	Close of the workshop	Russell

12:45	Leave from the front of the hotel by bus	Packed lunch will be provided on the bus
ca. 18:00	Return to the hotel	
19:30	Workshop dinner in a local restaurant	Details to be confirmed

## Mission bibliography

## MISSION BENEFICIARY

Koen BEERTEN  
 Project Leader  
 Engineered and Geosystems Analysis unit  
 Belgian Nuclear Research Centre SCK CEN, Belgium

## PARTNER EXPERTS CONTRIBUTING TO THE MISSION

### Host organisation experts

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### Home organisation experts

- Klikněte nebo klepněte sem a zadejte text.

### Other organisations experts

- Klikněte nebo klepněte sem a zadejte text.

## REPORT APPROVAL

Date	Beneficiary	Home mentor/supervisor	Host mentor/supervisor
12/06/2023	Koen Beerten	Diederik Jacques	N/A
	Klikněte nebo klepněte sem a zadejte text.	Klikněte nebo klepněte sem a zadejte text.	Klikněte nebo klepněte sem a zadejte text.