GRIMSEL TEST SITE (GTS)

# NEWSLETTER

**JUNE 2021** YEAR 3, VOL. 5

GTS nagra.


2021

GUEST EDITOR: **DR. HIROYUKI UMEKI**

GTS **NEWS** AND CURRENT **ACTIVITIES**

GTS **PROJECT UPDATES** • GTC **COURSES**

# **News** and Activities . EDITOR'S NOTE

**Dear colleagues and partners,**

It has already been half a year since we informed you about the latest developments at the Grimsel Test Site. Despite the ongoing COVID-19 pandemic and the associated restrictions, as well as a long rather harsh winter, the first six months of 2021 were again very intensive.

Due to the still limited travel possibilities for many countries, we have decided to postpone the annual meeting of the International Steering Committee of GTS (ISCO) until September this year (22 to 23 September 2021). We hope that a face-to-face meeting or at least a hybrid variant approach will be possible again then.

Our activities onsite were particularly marked by the further emplacement works of the HotBENT (High Temperature Effects On Bentonite Buffers) experiment. In addition, it was of course also important to give all other ongoing projects and activities the appropriate attention and support - more information on those in the two focus articles and the updates in this issue.

A successful and very fruitful inspection by the Federal Office of Public Health (FOPH) at the beginning of the year inspired us to shed a little more light in this issue on the pioneering work with radioactive tracers at the Grimsel Test Site.

Furthermore, we are pleased to welcome the Federal Company for Radioactive Waste Disposal in Germany (BGE), the German implementer, which decided to participate in the GTS activities starting from this year.

Another highlight of recent weeks was the visit by Nagra's new CEO, Dr. Matthias Braun, who took over this responsible position in March this year, succeeding Dr. Thomas Ernst, who is retiring in autumn this year. During the visit, he and Prof. Dr. Lino Guzzella (the new President of Nagra's Board of Directors) learned about the laboratory's current activities. Both emphasised the important role of international cooperation in radioactive waste RD&D being carried out at GTS.

We hope that in the second half of the year we can carry out at least a few of the courses planned within the Grimsel Training Centre (GTC) programme and start with new project phases.

We would like to thank Hiroyuki Umeki (from NUMO, Japan) for his guest editorial contribution. In the thirty-seventh year since we started the Grimsel Test Site scientific programme, we are pleased to have a contribution from a colleague who himself and the organisations he represented over many years have made a significant contribution to the success of the laboratory.

Yours sincerely,

**Ingo Blechschmidt**
Head of the Grimsel Test Site (GTS)

***HotBENT Experiment site:*** *(right to left)*

*Dr. Matthias Braun, Prof. Dr. Lino Guzzella, Dr. Florian Kober and Dr. Ingo Blechschmidt.*

***HotBENT Experiment site:*** *(right to left)*
*Prof. Dr. Lino Guzzella and Dr. Ingo Blechschmidt.*


**THE GRIMSEL TEST SITE (GTS)**
**INTERNATIONAL UNDERGROUND RESEARCH LABORATORY**

✎ www.grimsel.com
Tel + 41 (0)56 437 1216
ingo.blechschmidt@nagra.ch

# **Guest** Editorial

We have a long history of R&D collaboration between Nagra and Japanese research organisations, e.g., Japan Atomic Energy Agency, since the late 1980s. The GTS has been a key vehicle for the collaboration to create scientific knowledge, develop techniques of in-situ experiments, and provide an arena for transfer of know-how and training/education. The outcome from GTS in-situ experiments contributed to the technical basis for Japanese disposal programme stepping into implementing stages with the establishment of Final Disposal Act and the Nuclear Waste Management Organization of Japan (NUMO).

The GTS programme has been expanded to promote "long-term" international collaboration by organising solid network of experts and opened to many countries, which is invaluable to continuously increase confidence in the safety cases throughout repository development projects in GTS member countries.

NUMO has been actively participating in the projects, CIM, CFM, LTD and MaCoTe to obtain scientific knowledge and information for developing more realistic modelling and database for repository design and safety assessment. For HotBENT, we participated in from the beginning to strengthen our capability for planning, execution and interpretation of in-situ and large-scale integrated tests and associated modelling. These projects are also very useful for training and education of the younger generation.

A specific feature of the GTS programme is to maintain required flexibility and diversity to cover a range of key issues for geological disposal, including fundamental research and integrated process and systems understanding. This provides a useful framework for countries at different stages of disposal programme and experts from broad disciplines to collaborate together.

Last but not least, I appreciate all of the efforts by Nagra and GTS participants to promote the programme successfully. The incredibly beautiful scene surrounding GTS is, I believe, another momentum for the progress in the programme and notably for younger generation to learn much.

Sincerely yours,

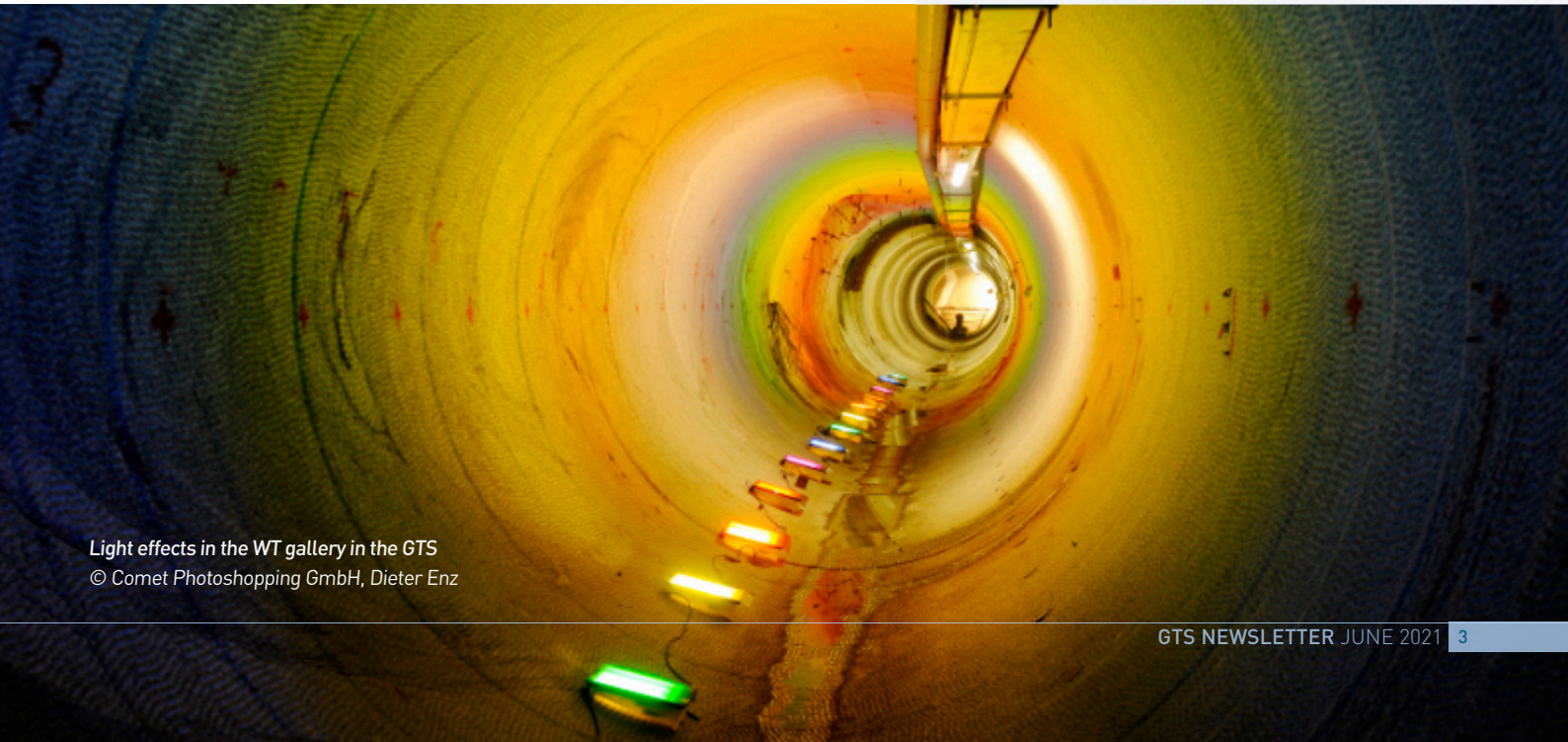
Hiroyuki Umeki

**Dr. Hiroyuki Umeki (NUMO)**

Dr. Hiroyuki Umeki is an executive director of NUMO and responsible for overall technical activities on geological disposal of HLW and long-lived intermediate-level waste, including knowledge management project to support geological disposal programme.

During his over 30 years work in radioactive waste management, he was involved in the projects for generic feasibility study on HLW geological disposal in Japan. He was a guest researcher at Nagra in Switzerland and participated in the Kristalin-I Project during 1993-1994.

Dr. Umeki has been intensively involved in international groups, particularly associated with the OECD/Nuclear Energy Agency. From November 2004 to October 2009, he was the chair of NEA IGSC and, is a bureau member of NEA Radioactive Waste Management Committee from 2016. He is also a member of ISCO Steering Committee for GTS.



*Light effects in the WT gallery in the GTS*
*© Comet Photoshopping GmbH, Dieter Enz*

## GAST

Gas-Permeable Seal Test

A. Reinicke

Gases may accumulate in the emplacement caverns of a geological repository for low/intermediate-level waste (L/ILW) due to the corrosion and degradation of the wastes and construction materials. The concept of the "Engineered Gas Transport System" (EGTS) was developed by Nagra to increase the gas transport capacity of the backfilled underground structures without compromising the radionuclide retention capacity. The EGTS concept involves seals which are constructed from specially designed sealing materials made of sand/bentonite (S/B) mixtures.

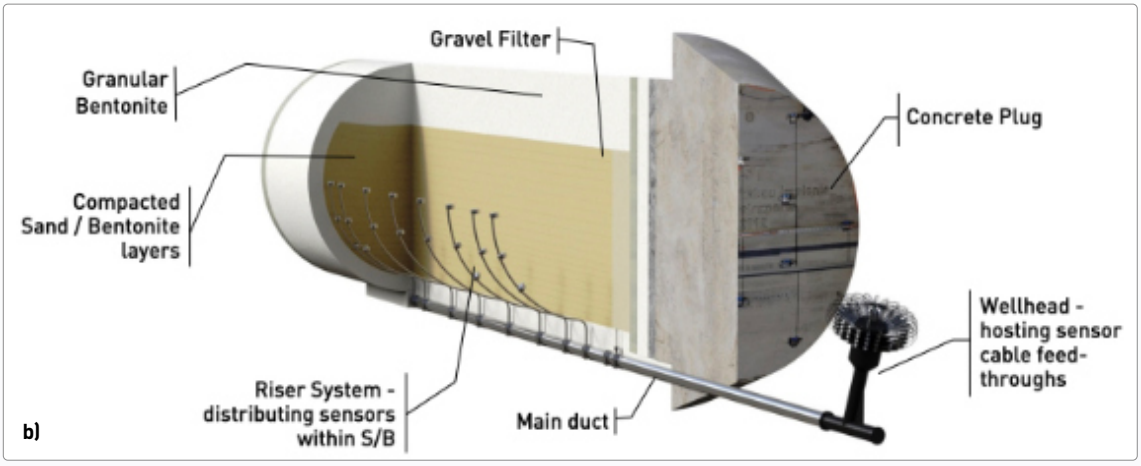




*Fig. 1:*
*a) Photo from the experiment construction – S/B emplacement.*

*b) Schematic illustration of the full-scale GAST Experiment*

*© Comet Photoshopping GmbH, Dieter Enz*

The GAs permeable Seal Test (GAST) at the Grimsel Test Site has the main objective to demonstrate the functionality of this specific seal concept at full scale and realistic boundary conditions. For this purpose, the GAST project was started in 2011 by construction of the sand/bentonite seal element encased in granular bentonite (GB) and confined by two filters for artificial saturation and testing of the water and gas transport properties (see Figs. 1 a & b).

The first set of gas property tests (GPT) was performed successfully in 2018. Afterwards the pressure and saturation homogenisation of the seal was continued and by now the GAST project has entered its final phase, the project completion (see more below).

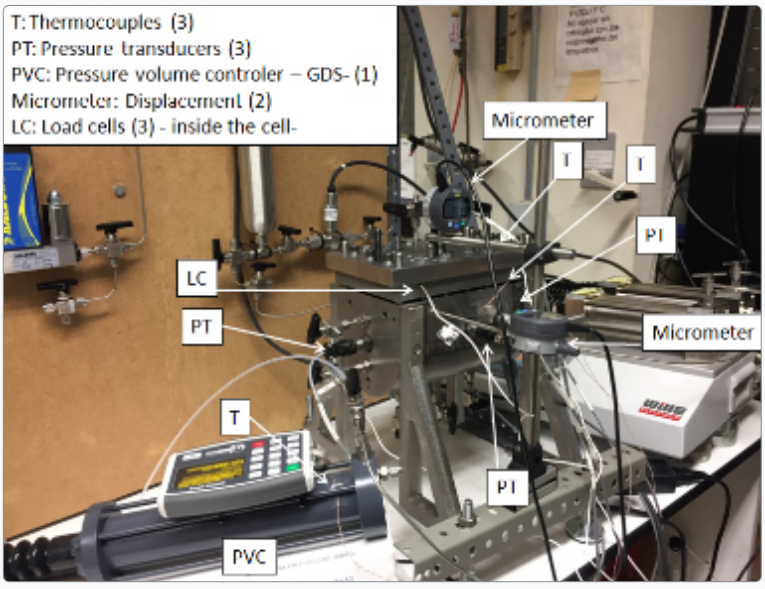



*Fig 2:*
*The mini-GAST cell during test execution.*

*© Nagra / Grimsel Team, Switzerland*

Since 2019 the full-scale experiment is accompanied by a mock-up investigation at dm-scale. The mock-up, or so called mini-GAST, is run at Universitat Politècnica de Catalunya (UPC) in Barcelona and allows for detailed investigations of two-phase flow transport phenomena and repeat testing. Two different cell sizes have been built and first testing is ongoing. Fig. 2 shows the smaller cell equipped with various sensors during test execution.

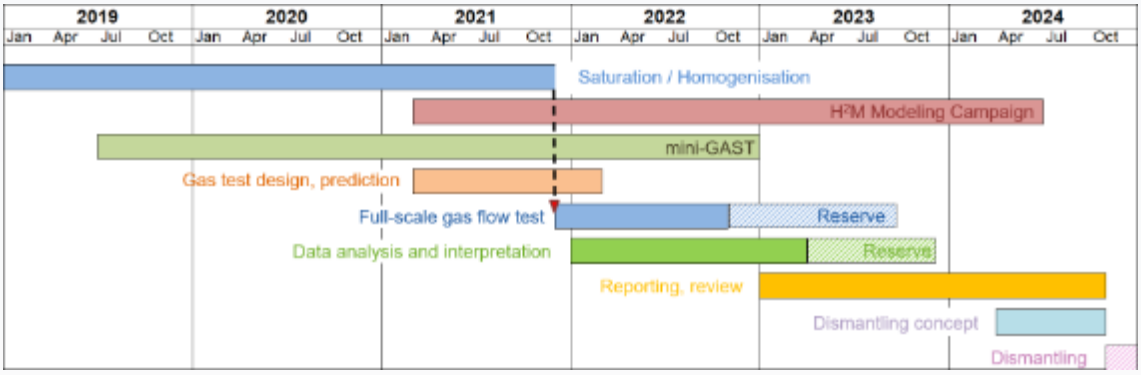


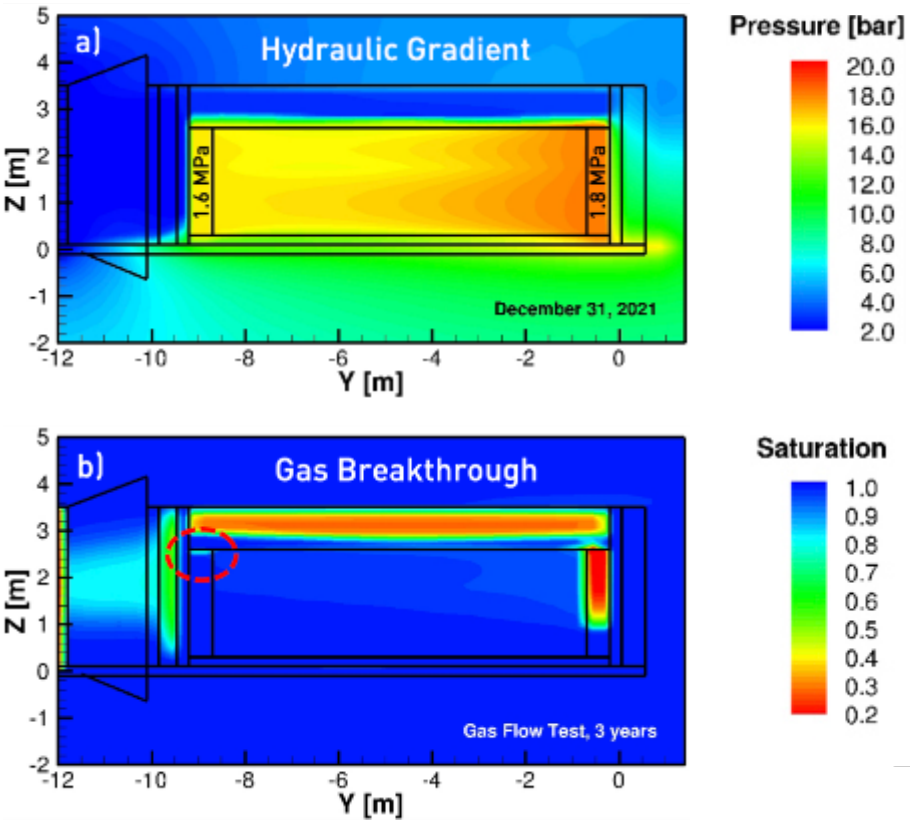

*Fig. 3:* *Indicative Timeline of the GAST experiment.*

In the course of the gas flow test (GFT) preparations, various characterisation tests have been executed recently to map the saturation and hydraulic conductivity distribution within the GAST system. The GPT in 2018 indicated that the interface between S/B and GB features locally high hydraulic conductivities that might impact the execution of the final gas flow test. Consequently, mapping of the properties of this interface is of high importance for the GFT preparations. The latest characterisation campaign has demonstrated that the interface has consistently low conductivities by now and the level of saturation is high.

The low conductivity interface has been confirmed by the TOUGH model that is used to support the planning of the experiment. The TOUGH model has been re-calibrated with the latest data sets and the updated model allows for predictions of equilibration times, pressure distributions at GFT start as well as the assessment of various gas injection scenarios. An important outcome of this assessment is the advantage to pre-impose a hydraulic pressure gradient between the two end filters of the GAST system. This gradient helps to drive the gas through the S/B body and limits leak-off towards the GB in the head space. The pre-imposed pressure gradient and saturation distributions are illustrated in Fig. 4. Different gradient scenarios are currently tested with the TOUGH design model. Ultimately, the chosen gradient will be deployed at GAST some months prior to the GFT start.

The preparations for the GAST gas flow test are in full operations and we are looking forward to present and discuss the fully developed operational plan of the GFT during the ISCO meeting in September.

*Fig. 4:* *Forecasts of pressure gradient prior to final gas flow test (a) and gas breakthrough towards the second filter at moderate gas overpressures (b).*



## Radiation protection at the Grimsel Test Site

A. Martin

A unique feature of the GTS amongst worldwide URLs is the inclusion of a radiation protection-controlled zone. This allows radionuclides to be injected and/or circulated in the geosphere itself under realistic and natural groundwater flow-field conditions. Results for such field tests can be used to upscale and improve confidence in results of small-scale laboratory experiments, and to test model calculations of the migration of radionuclides. Radionuclides used to date include amongst others: H-3, Na-22, C-14, Cl-36, Ca-45, Sr-85, Tc-99, I-131, Cs-137, Th-232, U-238, Np-237, and Pu-238. As well as improving realism, using radionuclides also has the added benefit of ease of detection and lower uncertainties in the results compared with stable isotope tracers, especially for the gamma emitters.

The first experiments using radionuclides were carried out in the late 80s. The duration of the migration tests has increased substantially with time (Figure 5, initially lasting just a few weeks and months but more recently lasting two to three years or more.

Currently the following three international projects are, or are soon to be, 'running hot' in the radiation-controlled zone:

- The LTD project, which is investigating the diffusion of radionuclides in both the rock matrix and a natural shear zone;
- The CFM project, which is studying the behaviour of radionuclides in bentonite and the effect of bentonite colloids on the migration of sorbing radionuclides in a water-conducting zone; and
- The CIM project, which is primarily studying the retardation of C-14 and I-129, as well as other long-term safety relevant radionuclides (e.g., Cl-36), through 15-year-old cement mortar under natural in-situ conditions.

The GTS is regulated by the Swiss Federal Office of Public Health (FOPH) who carry out annual inspections of the controlled zone. FOPH also issues licenses for each experiment that uses radionuclides. The radionuclide cocktails are either prepared by the Paul Scherrer Institute (PSI) in Switzerland, the Nuclear Research Institute Rez plc in the Czech Republic or the Karlsruhe Institute of Technology (KIT), Germany (Figure 6).

The radiation-controlled zone is presently designated as an IAEA level C. This means that there are potentially open radioactive sources but no air contamination. When there is a risk of air contamination, or the number of total radionuclide activity exceeds a certain limit, the controlled zone is upgraded to level B. In this case the tunnel is sealed, and outflowing air is filtered. Workers entering the zone need to wear gas masks and full radioprotective clothing. This can also be required during certain activities such as overcoring a test zone containing alpha emitting radionuclides.

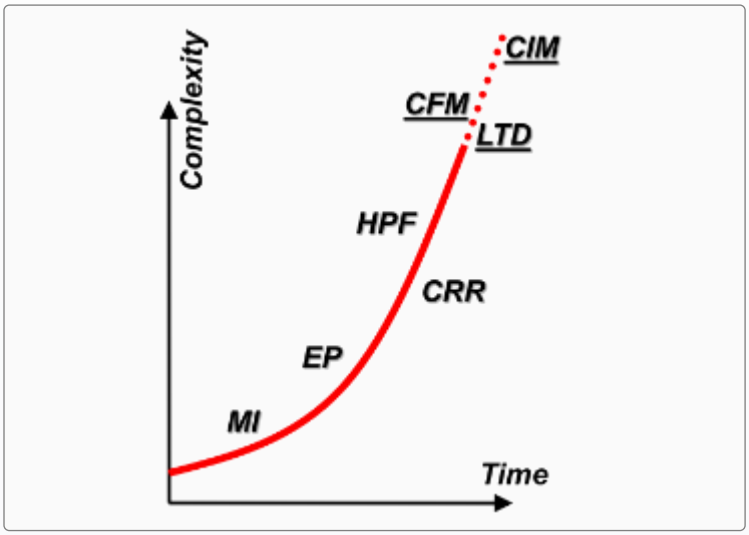



*Fig. 5: Evolution of radionuclide migration experiments carried out at the GTS since 1988. MIgration test (MI), Excavation Project (EP), Colloid and Radionuclide Retardation (CRR), Hyperalkaline Plume in Fractured rock (HPF), Long-term Diffusion Test (LTD), Colloid Formation and Migration (CFM), and C-14/I-129 Migration in cement (CIM). (Underlined ongoing experiments; details can be found in Schneeberger et al. 2019/NTB 19-01).*

*Fig. 6: Handling of a flask containing a radionuclide cocktail prepared by KIT for the CFM experiment. © Comet Photoshopping GmbH, Dieter Enz.*

# GTS Projects . UPDATES

For project objectives, and details please visit: www.grimsel.com

| Project | Description |
|---|---|
| **CFM i-BET**<br>In-Situ Bentonite Erosion<br>**I. Blechschmidt** | i-BET is implemented in a fractured zone in granitic host rock. The test, which is expected to last 2.5 years, is focused on erosion of bentonite in a natural environment. The total pressure cells that are part of the experimental setup and record swelling pressures indicate that the natural saturation of the bentonite blocks (groundwater from the fracture zone) is almost complete. However, the variance in the recorded data of the relative humidity sensors indicates that the saturation is heterogeneous. Current efforts are focusing on understanding the geochemical interactions occurring between the bentonite source and the surrounding groundwater. Colloid concentrations in the groundwater sampled from surrounding boreholes are analysed by nanoparticle tracking analysis (NTA) by FSU Jena. In parallel, the ongoing analysis of the background concentration of colloids in the groundwater in the nearfield allows to further constrain the estimation of eroded mass in advance of the dismantling. |
| **CFM LIT**<br>The Long-Term In-Situ Test<br>**I. Blechschmidt** | The long-term in-situ test after running for 4.5 years (RN spiked bentonite source intersecting a shear zone) was successfully overcored in early 2019 and firstly subsampled to 5 cm thick 300 mm diameter slices (non-active). Those slices were analysed in two laboratories (KIT-INE and Ciemat) to test the subsampling strategy and give feedback to the optimal cutting strategy of the "active" 300 mm diameter core (consisting of granite, carbon steel, and bentonite with radionuclides). Cutting of those samples is planned for late summer 2021. The maintenance of the CFM site is ongoing and it includes the de-watering of the mega-packer and a thorough inspection of the resin seal of the shear zone and of all surface packers. The maintenance aims for a site ready for additional tracer tests in the near future. |
| **CIM**<br>C-14 and I-129 Migration<br>**A. Martin** | PSI is finalising preparation of the radionuclide cocktail (HTO, C-14, Cl-36, I-129, Ba-133 and Cs-134). There was some delay with delivery of I-129 from one of the suppliers due to Covid, so injection and start of radionuclide circulation is currently planned for August. In the meantime, monitoring and circulation of cementitious porewater solution in the borehole has continued. Comparative laboratory-based radionuclide (Cl-36, I-125, C-14, I-125) sorption experiments on the aged cement matrix from CIM experiment and fresh ordinary portlandite cement (OPC) have been completed. |
| **GAST**<br>Gas-Permeable Seal Test<br>**A. Reinicke** | See highlight section. |
| **HotBENT**<br>Bentonite at High Temperatures<br>**F. Kober** | The installation of the HotBENT experiment has entered the last phase. The experiment has been actively implemented since September 2020 after the preparatory work that was described in more detail in the last GTS newsletter (No. 4, December 2020). All 4 heaters were installed by the end of May 2021, with the fourth and last heating module being completed by middle of June with GBM (granular bentonite material) backfilling. While the first three modules used bentonite blocks and GBM of the Wyoming type, the fourth module consists of Czech BCV bentonite (Bentonite Černý vrch deposit). While Sector 1 (this includes Heater #1 and #2) has been closed by a sandwich plug since February 2021, Sector 2 with Heaters #3 and #4 will be closed with a second sandwich plug (both made of shotcrete, sand layers and bentonite block walls) by the end of August 2021. The 24 (of finally 28) instrumented sections as well as other spatially evenly distributed data acquisition systems (fiber optics - FO, electrical resistance - ERT), are already recording the isothermal "cold" phase of the already emplaced experiment parts. A heating scheme with different temperature ramps and durations is currently being discussed with the HotBENT partners and heating will commence in the next months, according to the conclusion of these discussions. The HotBENT modelling platform is using the as-built data for initial modelling exercises and the date for the next modelling meeting will be announced shortly. |
| **LASMO**<br>Large Scale Monitoring<br>**F. Kober** | The LASMO project will be formally completed this year. A follow-up project "BAMODA" has been initiated and is described below. |
| **BAMODA**<br>Base line Monitoring and Data<br>**R. Schneeberger** | In continuation of the earlier GTS LASMO project (Large Scale Monitoring, see previous GTS newsletter or NTB 19-01), the baseline monitoring programme of hydraulic, geodetic data and various other parameters relevant to the construction and implementation of a future repository will be continued, using GTS as an analogue for underground works. The already extensive GTS database will continue to expand. The database supports on-going experiments as well as planning of new ones and the testing and updating of existing models (e.g., hydrological, structural, geotechnical, etc.). Conventional measurements are carried out on a routine, automated basis, however, novel techniques can also be used or tested, for which the GTS partners are invited to discuss them with us. |
| **LTD**<br>Long Term Diffusion<br>**A. Martin** | A migration test with non-radioactive tracers was carried out in the target flow channel (PT-1 dipole) at the start of the year. Based on this it was possible to confirm the suitability of the PT-1 dipole for use as a long-term radionuclide migration test and to finalise the design of the packer-systems and surface equipment for the radionuclide migration test which will start at the end of this year and run until 2023. Two cores were taken of the target fracture near the tunnel wall on behalf of UJV and SURAO for laboratory based migration experiments in support of the in-situ test. |
| **MaCoTe**<br>Material Corrosion Test<br>**A. Martin** | Detailed analysis of 4.5 year-modules containing test metal specimens emplaced in bentonite are still ongoing in both the non-heated and heated experiments. Throughout the year water samples were taken for microbial analysis at the Technical University of Liberec from all five boreholes of the heated experiment. Additional modules containing candidate canister materials from NUMO (Japan), KIT (Germany) and KIGAM (South Korea) are still currently being prepared in Jacobs' labs in Harwell, Oxfordshire, U.K. Unfortunately, there were further delays due to Covid. It is now planned to insert the new modules into the non-heated test borehole in November 2021. Before these emplacement activities the 7-year modules will be retrieved for analysis. |

# GTC Grimsel Training Centre . COURSES 2021

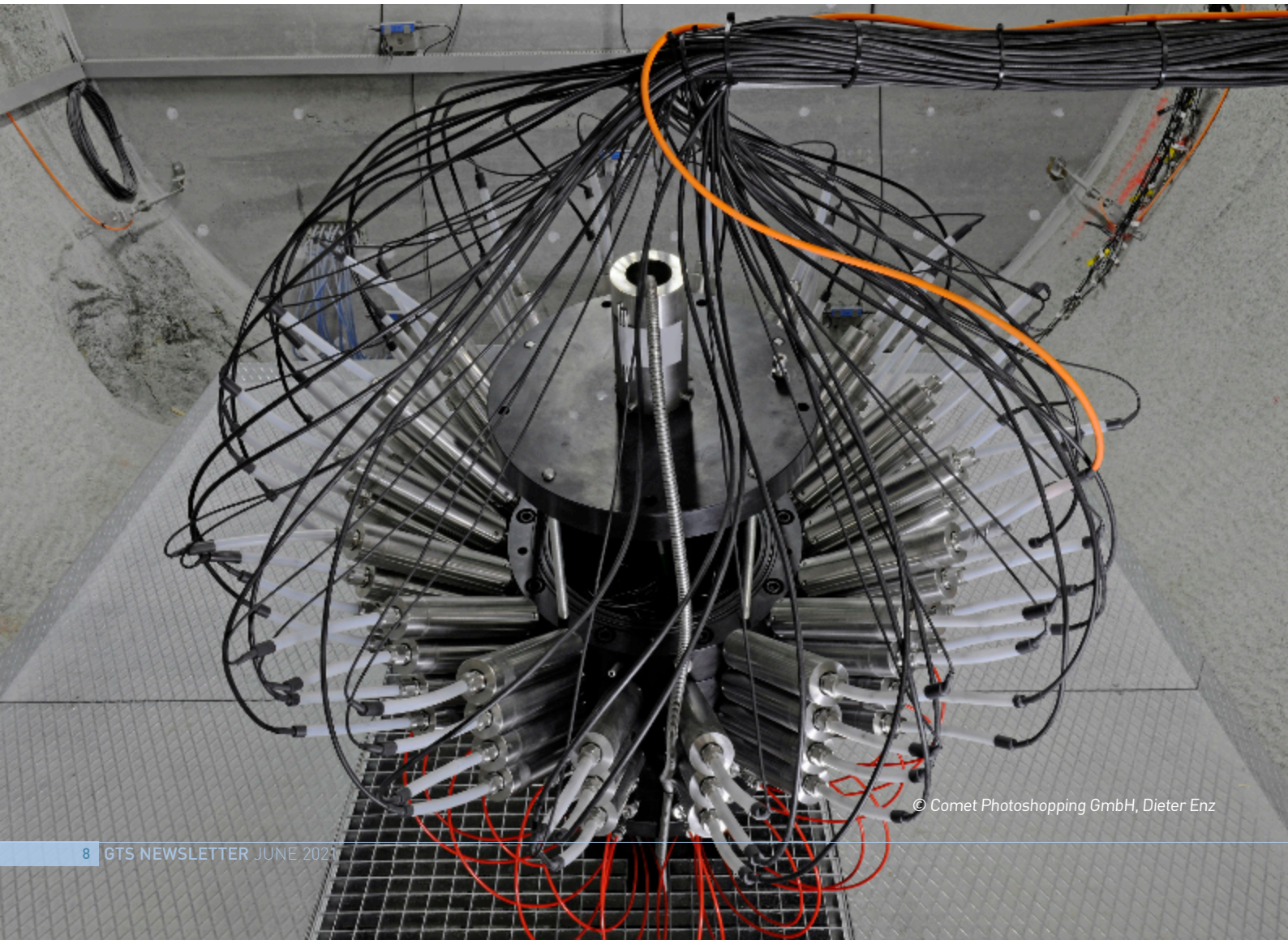
GTC Grimsel Training Centre

www.grimsel.com

Please note that due to ongoing restrictions (especially travel restrictions) due to the Corona Pandemic, the 2021 course programme had to be adjusted and we are offering two instead of three on-site courses. The third course will be included in next year's programme.

| Date | Description |
|---|---|
| **30.08.2021 to 01.09.2021**<br>at the GTS<br>3 days | **Use of radioactive tracers in URL experiments (input to safety cases)**<br>The GTS is one of only a few URLs where radioactive tracers can be used in tracer migration tests in the geosphere at activities requiring a license. This course aims to show how such in-situ tests can produce results that are more reliable and realistic than standard in-situ tests using non-radioactive tracers. Focus is on showing how results from laboratory based experiments, (the derived parameters of which are used as input to performance assessment calculations), are linked to field scale (1 – 10 m) in-situ tests, as well as improving process understanding of how radionuclides behave both in water conducting fault zones and in the rock matrix.<br>Optional visit of an active deep drilling site or a guided tour at Mont Terri rock laboratory on 01.09.2021 (1 day) is offered. |
| **06.09.2021 to 10.09.2021**<br>at the GTS<br>1 week | **Engineered Barrier System (EBS) Bentonite properties and applications**<br>This course aims to provide an opportunity to exchange key information and ideas on clay barrier research in order to support engineering designs. Key physiochemical, geochemical and hydromechanical properties as well as relevant analytical techniques and conceptual models will be introduced. The course includes onsite discussion of the large-scale experiments at the GTS studying and demonstrating the performance of bentonite materials. |

We are happy to discuss any needs and interests for additional courses or workshops be it custom made or general - please contact us.



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# **GTS** The view from the GTS onsite team

**Portrait of Ann-Sofi Dorrer**

Ann-Sofi Dorrer has been part of the GTS onsite team since 2010 making her one of the longest-serving employees on site. While the Nagra project managers take care of the technical aspects of the laboratory and the projects, Ann-Sofi is the "good soul" of the GTS. For most of the year, she makes everyday life underground easier with a fully equipped and well-maintained main facility at the GTS as well as smaller jobs in the laboratory. As soon as the GTS visitor season starts in June (which runs until the beginning of October), her focus lays also on coordinating guided tours, organizing transport and safety logistics. Aside from public tours, many of our international colleagues may have got to know Ann-Sofi on the numerous special occasions such as for project support or technical visits.

*Ann-Sofi in "Heidi's House" - actually the purposely built "HotBENT Contractors Office" inside the GTS. © Comet Photoshopping GmbH, Dieter Enz.*

Having a close contact with the villagers of Guttannen as well as the entire Haslital valley, Ann-Sofi often handles urgent inquiries or needs of the GTS, especially in winter when the roads are closed and tunnel servicing is required. And, should you ever wish to have a feast or lunch during one of your visits - Ann-Sofi is the right person to ask. Of course, Nagra's project managers are also aware of these dedicated services and often call upon them.

*Andrea Wettstein and Ann-Sofi (left to right) during an ISCO- Meeting excursion. © Comet Photoshopping GmbH, Dieter Enz*

# GTS Information . MISCELLANEOUS

| | |
|---|---|
| **GTS** Website | The GTS virtual tour was recently extended:<br>✎ www.grimsel.com/Virtual_Tours/ |
| **GTS** Publications | Please visit our GTS publication area to find the most recent updates on reports and publications:<br>✎ www.grimsel.com/media-and-downloads/grimsel-test-site-publications/grimsel-brochures |
| **GTS** Meetings | Planned upcoming GTS project meetings and GTC activities are online now. |
| **GTS** Links | News from the Swiss national programme:<br>✎ www.nagra.ch/en/ |
| **GTC** Programme | The GTC programme is available under:<br>✎ www.grimsel.com/gts-information/grimsel-training-centre-gtc |


## THE GRIMSEL TEST SITE (GTS)

International Underground Research Laboratory

**GTS onsite**
**Grimsel Test Site**
info@nagra.ch
Tel +41 (0)33 973 1225

**General GTS enquiries**
**Andrea Wettstein - De Marco**
andrea.wettstein@nagra.ch
Tel +41 (0)56 437 1310

**Visits to the GTS facilities**
**Renate Spitznagel**
renate.spitznagel@nagra.ch
Tel + 41 (0)56 437 1282