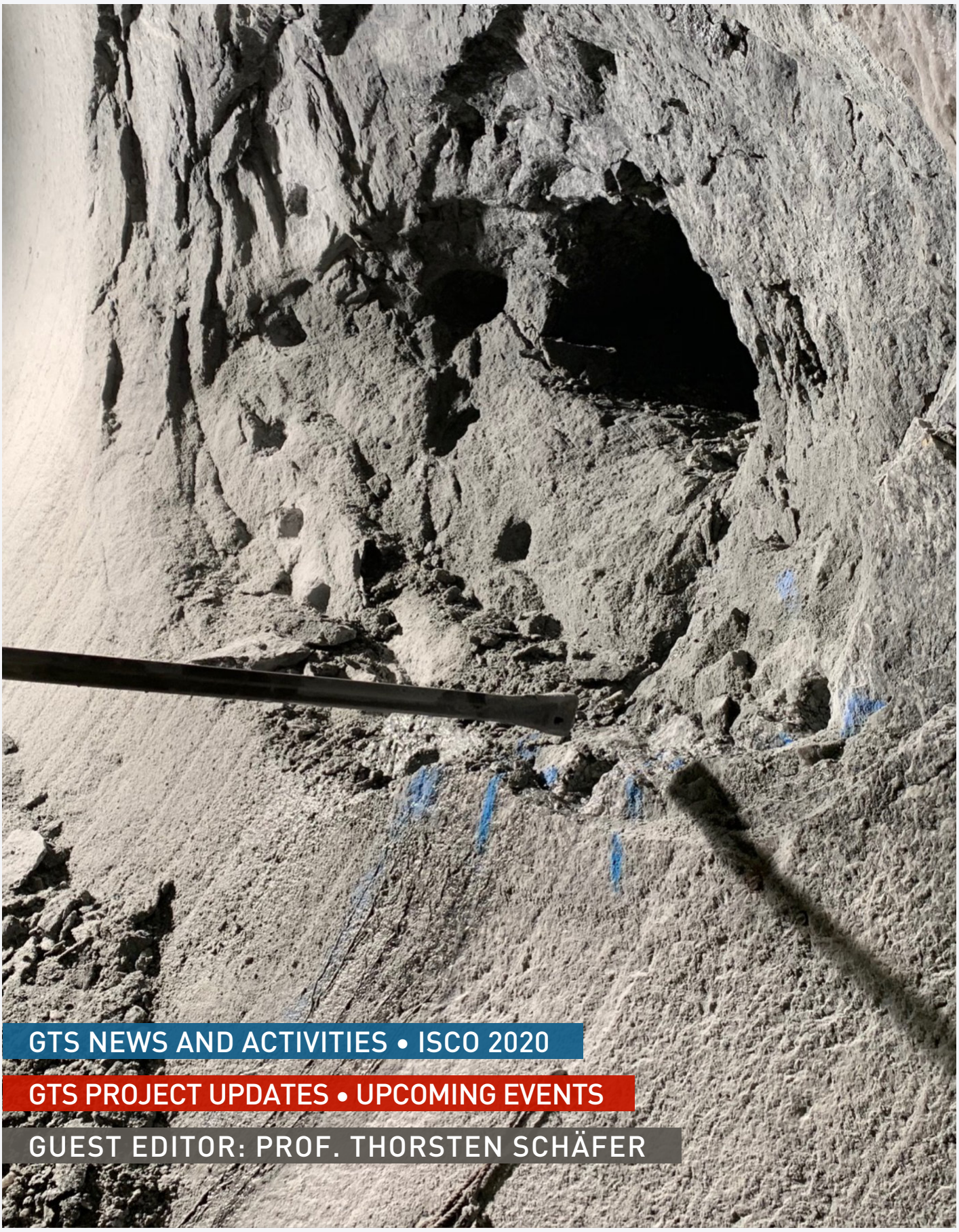
GRIMSEL TEST SITE (GTS)

NEWSLETTER

JUNE 2020 YEAR 2, VOL. 3



GTS NEWS AND ACTIVITIES • ISCO 2020

GTS PROJECT UPDATES • UPCOMING EVENTS

GUEST EDITOR: PROF. THORSTEN SCHÄFER

News and Activities . EDITOR'S NOTE

Dear colleagues and partners,

On June 3rd and 4th 2020, the annual GTS International Steering Committee meeting (ISCO 2020) took place. This year, however, under very special circumstances due to the COVID-19 pandemic.

During the course of planning of this year's ISCO 2020 meeting we had many discussions on how to proceed and whether we should postpone the meeting altogether. Finally we came to the conclusion that it is better to hold the meeting and meet our colleagues from all over the world - just in a little bit different fashion than in the past years. Thanks to modern communication technology it was possible to report on GTS activities, to discuss and exchange information about upcoming tasks.

Of course, it was not the same as the usual meeting, because, as many of you know, one of the main advantages of the ISCO meeting is to meet and talk face to face. Spending time together, not only discussing important radioactive waste management issues, but also taking care of long-standing relationships between our organisations and building new relationships has always been of paramount importance for a such small community.

Since mid-March 2020, Switzerland, like many other countries, has been in COVID-19 lock-down. Nevertheless, GTS operations have been maintained thanks to the rapid introduction of appropriate measures and now we hope that we will soon be able to return to normal operations.

However, a direct consequence of the COVID-19 pandemic is that all Grimsel Training Center (GTC) courses were postponed to 2021. Please visit our website for further details.

Many thanks to all who contributed to this newsletter with interesting content and in a timely fashion. Also, a warm thanks to Prof. Dr. Thorsten Schäfer for his guest contribution.

Your sincerely,

Ingo Blechschmidt
Head of the Grimsel Test Site (GTS)

We are glad to provide you with our 3rd newsletter with information on our major activities at the GTS and to continue bringing the "**flavour of working underground**" closer to you in these Corona times.

Stay healthy!

THE GRIMSEL TEST SITE (GTS)
INTERNATIONAL UNDERGROUND RESEARCH LABORATORY

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Guest Editorial

Working at Karlsruhe Institute of Technology (KIT) in the Institute for Nuclear Waste Disposal (INE) which belongs to the Helmholtz Association with numerous large-scale infrastructures I started participating in the GTS Phase V CRR project as a young Postdoc. I enjoyed from the beginning the international research platform provided by the partners and perfectly supported by NAGRA. Having now over 20 years' experience in the planning and realization of projects such as the Phase VI CFM project including its Long-term In situ Test (LIT) and In-Situ Bentonite Erosion Test (i-BET) the following impressions are still very present and should be kept and maintained for the young generation:

- Working in an interdisciplinary team covering fields such as structural geology, engineering geology hydrogeology, geochemistry, radiochemistry and biology with world leading experts gives the opportunity to think out of the box and solve challenges in the planning and realization phase, establish new detection techniques and push these and yourself to the limit.
- The opportunity to access a controlled zone working directly with actinides/radionuclides and not only their chemical homologues reduces significantly the uncertainty in thermodynamic benchmark calculations and reactive transport predictions.
- Upscaling sounds so simple, but coming from a laboratory working on microscopy with nanoscopic resolution and cm/dm-scale column migration experiments realization of dipole tests over several meters under near-natural flow conditions or emplacing a bentonite buffer under a given dry density are geomechanically and technically challenges that are in my opinion from a practical point of view necessarily needed for the implementation phase of a repository.

Your sincerely,

Thorsten Schäfer

Photo: © Anne Günther, FSU Jena, Germany

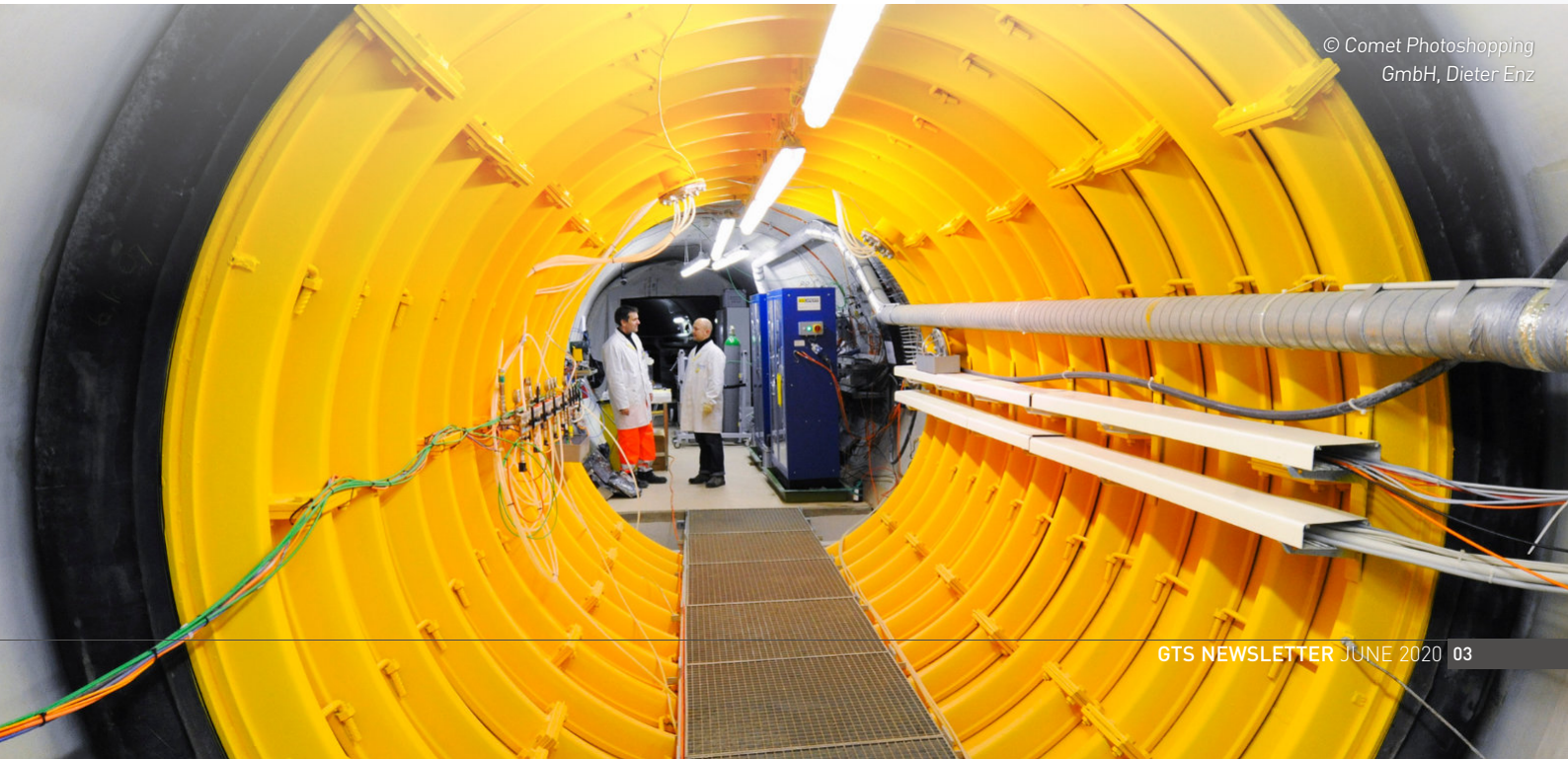
Prof. Thorsten Schäfer

PhD in Geochemistry (University of Mainz, Germany) and venia legendi in Hydrogeology (Freie Universität Berlin, Germany).

Thorsten has more than two decades experience working in the field of deep-geological disposal research at Karlsruhe Institute of Technology (Germany) and Brookhaven National Lab. (USA).

Currently he is Full Professor of Applied Geology at the Institute for Geosciences of the Friedrich-Schiller-University Jena and is actively involved inter alia in projects covering the fields of radionuclide transport in the vadose zone and bio-geo interaction in former uranium mining sites.

Thorsten is over the years involved in the Steering Committee of the Grimsel Test Site, the NEA OECD ClayClub and the recently established Crystalline Club.



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HotBENT

Bentonite at high temperatures

F. Kober

The HotBENT project was introduced in an earlier newsletter. It is dedicated to the long-term study of elevated temperature effects on the engineered barrier system. The Febex drift, which hosted the former FEBEX experiment, will host four heater modules heated up to 200°C and backfilled over a roughly 35 m long section with granular bentonite material. The design, the instrumentation, and the material preparation is on-going. The emplacement of the HotBENT will start later this year. In order to emplace the experiment and most importantly the entire instrumentation related to the operation over a period of 20 years, several site preparatory works had to be carried out.

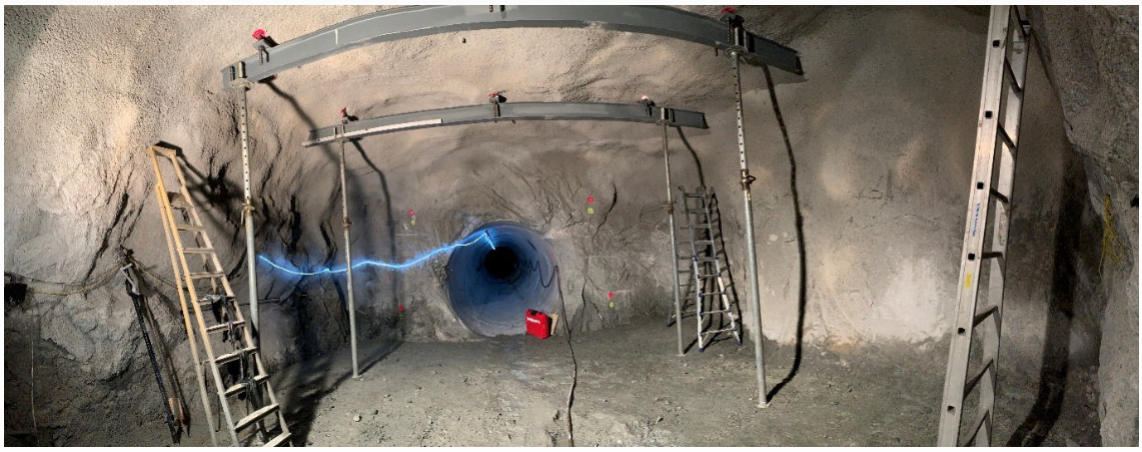
As an initial step, the old floor from FEBEX had to be removed as the concrete floor in the experiment will consist of low pH concrete. The concrete formulation resembles the concrete used for the plug in GAST.

The design of HotBENT includes four enhanced geosphere pressurization boreholes. These boreholes run parallel to the drift and their purpose is to increase the pressure in the near field of the experiment. In order to drill the enhanced geosphere pressurization boreholes, to host the data acquisition system of the experiment and also to facilitate various steps during the emplacement, a cavern was excavated. Using drill & blast methods a 7 by 6.3 by 3.3 m cavern was constructed between the Febex tunnel meter 23 and 30. The drilling of the enhanced geosphere pressurization boreholes is performed by an endless core barrel with an outer diameter of 86 mm. The resulting core can be very well correlated geologically with the tunnel walls. Three of the four borheoles were already drilled by the end of June.

Future onsite steps include the hydrogeological characterisation of the pressurization boreholes, the construction of the floor, the construction of a concrete liner (half of the heater at the end of the tunell will be placed in a section with a concrete liner), the installation of rails for the emplacement machine and then finally all activities related to the emplacement, which we will introduce in a next newsletter. The start of emplacement is planned for Fall 2020.

Drilling blasting holes (left)

Cores of Hot 20.002, one of the four enhanced geosphere pressurization boreholes (right)



View of the excavated HotBENT cavern with the light system as blue line

MaCoTe

Material Corrosion Test

A. Martin

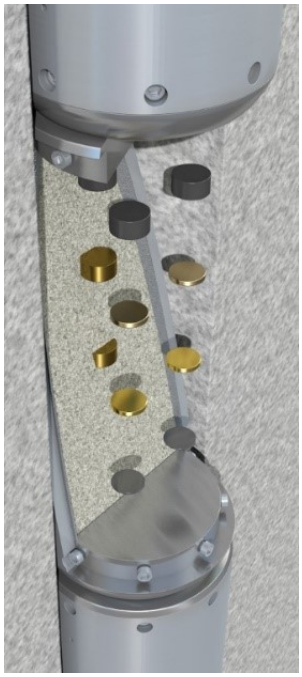
The broad aims of the MACOTE project are to:

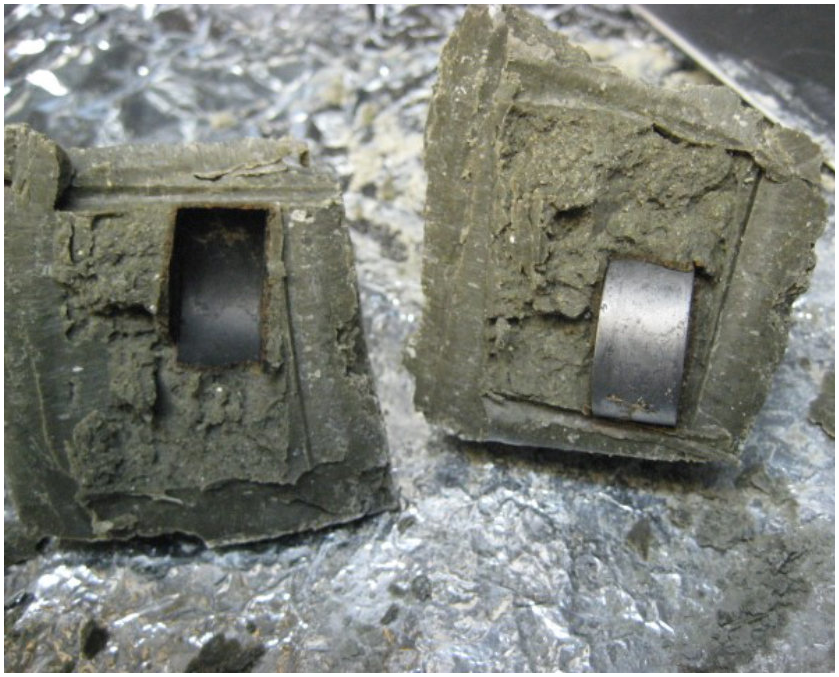
- Study in-situ anaerobic corrosion of candidate canister materials of high-level radioactive waste
- Investigate corrosion products and material interactions (e.g. copper-bentonite, steel-bentonite)
- Demonstrate the influence of microbial activity by using low and high bentonite densities; bentonite swelling pressure and low water activity is expected to reduce the activity and survival of microorganisms
- Investigate the influence of heat on anaerobic corrosion

Currently two in-situ tests have been running since 2013 – one focusing on anaerobic corrosion under ambient temperatures and a heated experiment were test coupons are tested at 70°C.

In the non-heated test, test coupons of cast and forged carbon steel, stainless steel, standard wrought copper and two types of copper coatings are emplaced in Wyoming bentonite in specially designed modules inserted into a borehole. The borehole is sealed using a double packer system. Modules are gradually retrieved and analysed over a period of at least 10 years to obtain corrosion rates and to analyse oxides that form on the surface of the metal test coupons. Analyses are currently ongoing on a module pair - one with a low bentonite density and one with a high bentonite density, that was retrieved from the borehole after 4.5 years. Additional modules containing metal test coupons from KIT (steel, Cu and Ni alloy, Zircaloy) and KIGAM (Korean institue of geosciences and mineral resources; copper), two new partners who recently joined the MACOTE project, will be inserted into the borehole later this year.

In the heated in-situ experiment a 4-year module was already removed for analysis earlier this year by ÚJV Řež, a.s. The results will be compared with analyses of metal coupons from the 4.5 year module pair retreived from the non-heated experiment above. In addition to Wyoming bentonite, Czech BaM bentonite is also being tested in the heated test. Both experiments use the latest DNA sequencing techniques to investigate microbial populations in the bentonite, surface of metal coupons and ground water. Baseline measurements were also carried out at the start of the in-situ tests.





3-D image showing a test module filed with bentonite and metal coupons from the non-heated experiment (left)

Bentonite and carbon steel coupon removed from one of the modules in a glove box (right)

GTS Projects. UPDATES

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

Project	Description
CFM i-BET In Situ Bentonite Erosion **I. Blechschmidt**	First results from i-BET indicate that bentonite saturation time is slightly longer than expected and the bentonite is still saturating. Most of the emplaced relative humidity sensors indicate that the relative humidity is close to 1, however the pressure sensors continue to measure slightly increasing pressures. Groundwater samples taken from the near-field monitoring boreholes show that the colloid concentration is slightly, but not significantly higher than in the background. Strikingly, the groundwater from the monitoring borehole beneath the source borehole shows the strongest variations, which might indicate a gravity influence on the bentonite erosion.
CFM LIT The Long-Term In-Situ Test **I. Blechschmidt**	Multiple preparatory works are currently been carried out to allow for tracer tests within the MI shear zone within CFM Phase 4. Aside, a saw for the CFM LIT core is being developed and tested. The saw will be used to sub-sample the core under radioprotection measures and under protected atmosphere. Based on the sampling a diverse laboratory analytical programme was established.
CIM C-14 and I-129 Migration **A. Martin**	Drilling, borehole instrumentation and installation of surface equipment is completed. A non-radioactive solution equilibrated with porewater squeezed and analysed from the CIM mortar porewater in the borehole has been circulating since November 2019 with no signs of clogging of the injection lines. This is considered prerequisite for the injection of a radioactive tracer. Injection and circulation of radionuclides (C-14, I-129, Cl-36, Ba-133, Cs-134 and HTO) will start later this year. In parallel to the in-situ experiment, radionuclide sorption tests on CIM mortar material were completed at PSI (Paul Scherrer Institut).
GAST Gas-Permeable Seal Test **A. Reinicke**	The third phase of the GAST project – namely the 'Project Completion' Phase was officially kicked-off end of 2019. The new phase includes the setup of a new hydromechanical coupled model to understand the prevailing stress conditions in more detail. This enhanced understanding is key input for the development of the gas injection protocol for the Gas Flow Test (GFT). The GFT is planned for the end of 2021 / beginning of 2022 February 2022 latest. Currently the pressure/saturation homogenisation looks favourable which might allow for an earlier GFT execution. As basis for the new modelling activity, a draft report has been produced that compiles and concludes all former TOUGH based approaches for planning, interpretation and data worth analysis within the GAST context. The final version of this modelling report is expected within the second half of this year. In parallel, the "mini-GAST" project has delivered the first dm-scale setup. The cell and test setup mimics the GAST flow geometry but allows for fast saturation and repeated gas flow testing. The work is executed at UPC in Barcelona and first test runs and results are expected in autumn this year.
HotBENT Bentonite at High Temperatures **F. Kober**	See highlight section.
LASMO Large Scale Monitoring **F. Kober**	LASMO activities in the GTS are focusing on the monitoring of hydraulic pressures throughout the entire laboratory. The datasets are especially studied to discriminate potential perturbations related to the ongoing site preparation works for the HotBENT project (mainly excavation of a cavern).
LTD Long Term Diffusion **A. Martin**	3-D modelling of radioactivities measured in rock cores and coupons taken from monopole-2 are ongoing. Detailed preparation and site characterisation work is continuing at the former GAM site in the radiation controlled zone at the GTS. Measured pressures in the GAM shear zone are still increasing but approaching values expected for a sealed system. Preparation of a preliminary migration test with non-radioactive tracers in a target dipole is ongoing. The test will be used as a basis for carrying out a longer term 2-year migration test with radionuclides in the GAM shear zone.
MaCoTe Material Corrosion Test **A. Martin**	See highlight section.

GTS facts and figures. KWO LARGE-SCALE CONSTRUCTION WORKS

Why and how to replace a 90 year old dam?

The Spitallamm dam is one of two dams on Lake Grimsel, which is essential for electricity production at Kraftwerke Oberhasli AG (KWO). As the GTS is located close the Lake Grimsel hydropower stations (Grimsel I/II) we are very interested in the activities around this large KWO project - especially as many activities related to the Grimsel lake (lake water level changes, blasting, etc) may generate interesting data for the GTS geosphere monitoring system in comparison with our long baseline observations (see LASMO project for example).

The engineers of the Spitallamm dam adopted pioneering techniques in the 1930s. The dam on Lake Grimsel was one of the first large arch-gravity dams. The downstream side is divided into steps and measures 114 metres from foundation to crest. This construction/design made it one of the tallest dams in the world at the time of completion. KWO coevally built the Seeuferegg gravity dam to complete Lake Grimsel.

The Spitallamm dam is now over 90 years old. Following in-depth investigations and tests in the 1960s, it was revealed that slight movements occur in the structure of the dam due to its construction methods and subsequent repairs. The dam crest and the face concrete of the Spitallamm dam started to delaminate over time from the rest of the dam.

Further investigations showed that alkali aggregate reactions may occur in the concrete of the dam wall, affecting the long-term stability of the concrete. In addition, an increasingly large amount of sediment collected in front of the dam, resulted in an accumulation on the lower discharge installations on the lake side of the Spitallamm dam. Consequently, in autumn 2015 KWO decided to build a new dam directly in front of the old structure instead of renovating the old one.

In 2017, KWO submitted a construction application with the corresponding environmental impact assessment to the Canton of Bern for the construction of the new dam. KWO estimates that the construction costs will be around 125 million CHF in total. After receiving the construction licence, KWO started the "new build" project in June 2019.

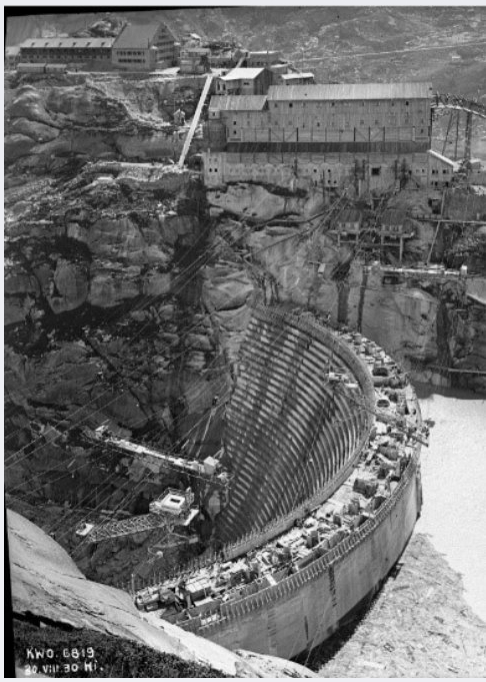
The old Spitallamm dam will be preserved and flooded later with a hydraulic connection between the inter-dam space and the lake.

By building a new replacement structure, KWO is making sure that the water from Lake Grimsel can be used over the long term without placing any restrictions on the production of electricity.

Construction work in the high alpine environment is extremely demanding in terms of logistics. The work takes place seven days a week from May to October over the course of six years. The final crest height of the new dam will also be around 113 metres and around 212 metres crest length. This will involve approximately 215,000 cubic metres of concrete being used.

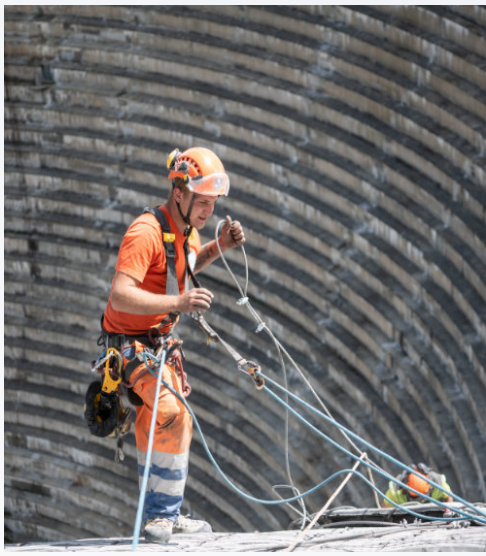
One of the main challenges that needs to be overcome in the work is the proximity of the tunnel to the existing infrastructure, e.g. the electricity pylons or the historic Grimsel Hospiz hotel. Various measuring devices record vibrations caused by the construction works and feed into an alarm system.

The construction site is clearly visible from the Grimsel Hospiz. More than 90 years after the construction of the first dam, construction machinery once again is making the journey up to the Spitallamm dam. KWO offers visitors to the Grimsel region a detailed tour of the spectacular mountain construction site in a public site tour - we will invite ISCO delegates to visit the construction site in 2021 (✎ www.grimselstrom.ch).



Spitallamm dam and Hospiz 1930 (© KWO)

Visualisation of new dam in front of the old structure (© David Ormerod, KWO)



Worker preparing the blasting for the basement excavation 2019 (© KWO)

GTS The view from the GTS onsite team

Portrait of Mr. Toni Baer

Toni Baer, the local GTS electrician, has been working at GTS since 1982. He is a trained electrical engineer and currently works one day a week at GTS. He is responsible for various activities related to electricity, electricity installation and auxiliary works in the various projects whenever needed. This includes frequent inspections of all handheld devices, the proper functioning of the electricity for the various projects as well as regular inspections by the Swiss authorities to ensure a safe working environment and to comply with the safety regulations. This also includes the inclusion of the numerous foreign electrical devices used in the partner projects and their compliance with the Swiss electricity regulations.

The planning and implementation of the upcoming HotBENT experiment and the associated power supply is currently a particularly challenging topic for him, including the provision of the requirements for the emplacement works and later for the planned 20-year trial life, where more than 1000 sensors and 4 heaters should work smoothly and receive the necessary power.

One point that is mentioned frequently is that due to the proximity to the hydropower plant, we should not have a lack of never-ending free energy. Although there is no shortage and it is not free, it still must be changed, maintained, and secured in our laboratories - a not negligible task in a URL that Toni is responsible for! However, these challenges have made the job of the "GTS home-electrician" so interesting, varied, and fascinating over the years.

And finally - Toni is part of the good soul of the GTS with the longest active experience in the laboratory.

GTS Information . **MISCELLANEOUS**

GTS Website	The GTS virtual tour was recently extended: ✎ www.grimsel.com/Virtual_Tours/
GTS Publications	Please visit our GTS publication area to find the most recent updates on reports and publications: ✎ 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: ✎ www.nagra.ch/en/
GTC Programme	The GTC programme is available under: ✎ www.grimsel.com/gts-information/grimsel-training-centre-gtc

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