

# **Final Disposal in Deep Boreholes Using Multiple Geological Barriers: Digging Deeper for safety**

## **Endlagerung in tiefen Bohrlöchern unter Nutzung mehrfacher geologischer Barrieren : Weiter in die Tiefe gehen für die Sicherheit**

International Expert-Workshop on June 5 and June 6, 2015

Berlin, Germany

## **Second Circular**

Organization: KIT, TU Freiberg, Herrenknecht GmbH

*Participation : Baker-Hughes, Deutsches GeoForschungsZentrum Potsdam, IAEA, IfG, GNS, GRS, Piewak & Partner, Sandia RWTH Aachen, TU Clausthal-Zellerfeld, NAGRA, University Uppsala, , Hydroisotop, MIT, BGR, BMWi, BMUB, Umweltministerium BaWü,, Uni Freiburg, Regierungspräsidium BaWü, Ökoinstitut, DBETec, ....*

Are deep boreholes (shafts) for final disposal of high level radioactive waste an efficient option to safely store radioactive waste? Together with specialists from Europe and abroad we will highlight the chances and challenges of deep drilling/shafting for final disposal in geological multi-barrier systems on the current state of technical knowledge and safety requirements in Germany.

### Aim of the Workshop

The scope of the workshop is to analyse and discuss the state of the art, the required technological developments, and to define the necessary R&D activities in order to further optimize the interaction between technical, geo-technical and geological barriers for long-term safety. All process steps along the chain from site survey, construction, emplacement operations, abandonment and monitoring will be addressed concerning technical feasibility, reliability, long-term protection of the environment, and acceptance. With respect to the goal of a long-term protection of the living environment (human health, drinking water and biosphere) technical and geotechnical barriers shall interact with geological barriers with different mechanical, chemical, and physical features and shall provide a containment for high-level radioactive waste for 100 000's of years. A combination of independent and passive mechanical, physical, and chemical barriers can provide an enhanced safety for the environment. Using deep boreholes for disposal may combine the advantages of all host rocks (salt, clay, crystalline rock if technically feasible).

The workshop shall provide a platform for interdisciplinary discussion of the features and challenges of deep boreholes as an alternative option to an underground mine for nuclear waste disposal.

## Programm

The workshop format provides presentations (English) and ample time for discussions where all participants are welcome to prepare some slides (German and English) to support their comments.

Friday, June 5

<b>Time</b>	<b>Main Topic</b>	<b>Subtopics and Key Note Presentations</b>
<b>9:00</b>	<b>Welcome</b>	
	<ul style="list-style-type: none"> <li>- Frank Schilling: Introduction to the workshop concept (Workshop Einführung)</li> <li>- Andrew Orrell: Genesis of the US program for deep well bore proposals (Entstehung des US Programmes der Bohrlochlagerung)</li> <li>- Pat Brady: Status of deep wellbore disposal in the US (Stand der Bohrlochlagerung in den USA)</li> <li>- Guido Bracke (GRS): Deep Borehole disposal of radioactive waste for Germany as an alternative option ? Safety requirements, criteria, analyses, acceptance, challenges? (Endlagerung von radioaktiven Abfällen in tiefen Bohrlöchern als alternative Option für Deutschland? Sicherheitsanforderungen, Kriterien, Analysen, Akzeptanz, Herausforderungen?)</li> </ul>	
10:10	Coffee Break	
<b>10:20</b>	<b>Geological and Physical Barriers</b> Geologische und phys. Barrieren	Geological and Physical Barriers Suitable Geology Excluding criteria
	<ul style="list-style-type: none"> <li>- Wolfgang Minkley: Integrity of geological barriers in salt formation (Dichtigkeit von Salzbarrieren)</li> <li>- Ralf Littke: Geological Barriers of oil and gas reservoirs (Geologische Barrieren für Erdöl und Erdgas)</li> <li>- Chris Juhlin: Appraisal of geological barriers in the upper crust based on some crystalline rock drilling projects and geophysical data (Bewertung krustaler geologischer Barrieren bei Bohrvorhaben im Kristallin auf der Basis geophysikalischer Daten)</li> <li>- Frank Schilling (KIT): Safety increase by multibarrier systems (Sicherheitsgewinn bei Multibarrierensystemen)</li> </ul>	
11:45	Discussion	
12:30	Lunch	
<b>13:30</b>	<b>Deep Drilling / Shaft building</b> Bohren und Schachtbau	(directional) drilling, well completion, shaft building
	<ul style="list-style-type: none"> <li>- Matthias Reich (TU Freiberg): Typical operational areas and equipment of deep drilling technology (Typische Einsatzbereiche und Ausrüstungen der Tiefbohrtechnik)</li> <li>- Thomas Roedel (Piewak&amp;Partner): Drilling with large diameters in crystalline rocks – experience from KTB (Große Durchmesserbohrungen im Kristallin – Erfahrungen aus der KTB)</li> <li>- Helmut Mischo (TU Freiberg): Disposal Technology for Deep Drill Holes – Status and requirements from a miner’s point of view</li> </ul>	
<b>15:00</b>	Discussion	
<b>15:45</b>	Coffee Break	
<b>16:00</b>	<b>Technical Barriers and Emplacement Technology for High P/T conditions</b> Technische Barrieren, Einbringungstechnologie bei hohen Temperaturen und hohen Drücken	Canisters, Filling, Integrity, Capacity, Back-fill material, Plugging, Segmentation, Thermal loading limits
	<ul style="list-style-type: none"> <li>- Tim Vietor (NAGRA): Multiple barrier concept for high level waste repository in Switzerland. Scientific basis and demonstration. (Multibarrierenkonzept für die Endlagerung hochradioaktiven Abfalls in der Schweiz - wiss. Grundlagen und Demovorhaben)</li> <li>- R. Graf (GNS); Status of Cask Concepts for Disposal of SF in Germanys (Behälterkonzepte für die Lagerung von radioaktivem Abfall in Deutschland)</li> </ul>	
<b>17:00</b>	Discussion	

<b>17:30</b>	Sum-up Day 1
<b>19:00</b>	Joint Dinner

Saturday, June 6

<b>9:00</b>	<b>Recovery</b> Rückholung/Bergung	Fishing, Winches
	Bernhard Prevedel : Brief Overview Fishing (angefragt)(Kurzer Überblick zu Bergungsmöglichkeiten aus tiefen Bohrlöchern)	
10:00	Discussion	
<b>10:30</b>	<b>Coffee Break</b>	
<b>10:45</b>	<b>Abandonment &amp; Sealing</b> <b>Stilllegung &amp; Bohrlochverschluss</b>	Emplacement material Cementation & Sealing
	Matthias Gruner/ Wolfram Kudla/H. Mischo (TU Freiberg) Abandonment Technology for Deep Borehole Disposal. – Shaft Sealing application (Stilllegungstechnologie für die Endlagerung in tiefen Bohrlöchern)	
12:00	Discussion	
<b>12:30</b>	<b>Lunch Break</b>	
<b>13:30</b>	<b>Geochemistry and Monitoring</b> Geochemie und Überwachung	Hydro-geochemistry (Hydrogeochemie), Radionuclide mobility (Mobility der Radionuklide), Migration at P&T (Migration bei hohen Drücken und hoher Temperatur), Robust monitoring technology (Monitoringtechnologie), Nuclear Safeguards (Sicherheitsvorkehrungen)
	<ul style="list-style-type: none"> <li>- Kück (angefragt): Logging Tools Overview (Messmethoden)</li> <li>- Thorsten Schäfer/Bernhard Kienzler: Conceptual ideas about the radio-geochemical monitoring during the operational phase (Konzeptionelle Ideen für das radio-geochemische Monitoring in der Betriebsphase)</li> <li>- Florian Eichinger : Diffusion of dissolved constituents in low permeable bedrock within the nuclear waste deposition in deep boreholes (Diffusion und gelöste Inhaltsstoffe in wenig durchlässigem Gestein bei der Endlagerung in tiefen Bohrlöchern)</li> <li>- Broder Merkel: Thermodynamic data for the range 0 to 300°C and 1 to 80 MPa" (Thermodynamische Daten für den Bereich 0 bis 300°C und 1 bis 80 MPa)</li> </ul>	
<b>15:15</b>	Discussion	
<b>15:45</b>	Coffee Break	
<b>16:15</b>	<b>Summing Up</b>	
	Main Messages: <ul style="list-style-type: none"> <li>- State of the art (Stand von Wissenschaft und Technik)</li> <li>- advancements of existing technologies (Weiterentwicklung vorhandener Technologien)</li> <li>- Innovation and research requirements (Innovations- und Forschungsbedarf)</li> <li>- No go criteria Abbruchkriterien</li> </ul> <p style="text-align: center;"><b>→ Suggestions towards a Road Map Vorschläge für das weitere Vorgehen</b></p>	

### Language

All presentations will be in English, the discussion will be in German. The majority of slides will be provided to all participants in paper format.

All German presenters are asked to provide a short description of their presentation as well as the most important figures of their presentations in German. The organizers will use this information to prepare handouts

### **Field Trip to KTB Site at Windischeschenbach**

The field trip will provide the opportunity to get an impression on deep drilling into crystalline rock. The KTB well is 9101 m deep and had been drilled 25 years ago with rather wide diameters until 3 kms. Drilling, well logging technology improved from the challenges of high P/T-conditions. During the field trip you will learn about the technological innovations, the fascinating but also unexpected scientific results but also the problems that have been encountered during the drilling phase and that had to be mastered.

We will depart in Berlin in the evening of June 6 after the workshop by car, have a ca. 4 h ride to Windischeschenbach with a dinner stop and reach the hotel in the very late evening.

In the morning of June 7 a guided tour on the drill site is offered.

Costs: A fee of 10 € to cover the guided tour is required. The hotel costs in the region are ca. 45 € incl. breakfast. Transportation costs and costs for dinner on June 6 and lunch on June 7 is on your own expenses.

Travel: At least 2 private cars will drive to Windischeschenbach on June 6. One of them will return to Berlin on June 7. On June 7 there will be trains in the afternoon back to Berlin or elsewhere.

Contact: If you are interested in the field trip, please contact Thomas Röckel ([thomas.roeckel@piewak.de](mailto:thomas.roeckel@piewak.de)). Depending on the number of participants, we will arrange the transportation.

Fees: We do not ask for conference fees. Coffee breaks and lunches on Friday and Saturday are also free. Travel and accommodation is on your own expenses.

Please let us know whether you will participate on own expenses at the joint dinner buffet in the evening of Friday June 5 at the Holiday Inn hotel. They offer starters, salads, different main dishes and desserts for 23€. If you would like to join us, please send an e-mail to [Jessica.blackwell@kit.edu](mailto:Jessica.blackwell@kit.edu).

### **Venue:**

The workshop location is the Holiday Inn Berlin Airport Conference Center: Holiday Inn Berlin Airport - Conference Centre, Hans-Grade-Allee 5, 12529 Schönefeld b. Berlin. The travel to and from the venue is described in the attached pdf-files.