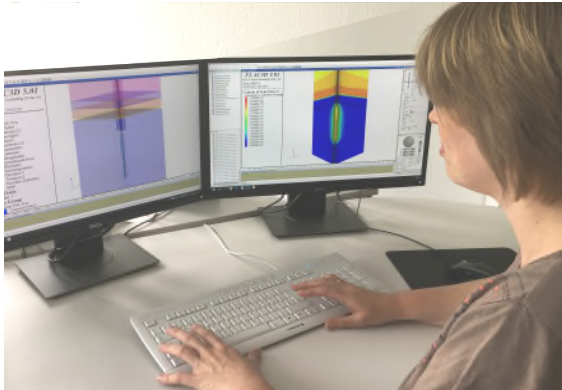


OUR SERVICES

We provide a large number of services to safeguard storage integrity: from constructing the storage site to its operation and decommissioning. We work in an interdisciplinary way with our Geology, Drilling, Completion and Thermodynamics expert groups.



- Modelling and simulation of the layout and design of storage caverns, as well as analysing different storage operation scenarios
- History analysis and evaluation of prior storage operations
- Operations monitoring and optimisation via customised storage modules
- Modelling and forecasting of convergence changes and surface subsidence, including determining the area affected
- Undertaking impact analysis to assess future underground changes in the field
- Analysing subsidence-induced stresses on cemented casings and gas completions
- Assessing the impact of work-over of old storage caverns as well as assessing casing logs to determine their residual strength
- Undertaking risk analysis
- Evaluating cavity surveys, e.g. to control rock mechanical layout parameters, for in-situ convergence measurement, and to identify cavern-wall spalling
- Preparing abandonment concepts

DEEP.KBB GmbH Convincing Competence

DEEP.KBB GmbH specialises in engineering and geo-scientific services involving consulting, planning, construction and the operation of underground energy storage facilities, as well as brine/salt extraction. Our expertise is based on comprehensive technical and scientific know-how gained from many years of experience. Our objective is to find innovative solutions which are safe and economical.

Rock mechanical investigations are required to verify the integrity – stability and tightness – of the storage site over its whole lifecycle. This applies to the layout of the load-bearing and safety concept prior to construction, monitoring each phase of the storage operation, to determining the long-term impacts after the decommissioning and abandonment of the storage facility. In addition to the access well, safe and economic operation of the storage site depends on the integrity of the rock mass surrounding it.

Our rock mechanical investigations provide comprehensive technical support for storage sites over the whole lifecycle. All of our expert groups work together in an interdisciplinary way. We are recognized by the mining authorities as an expert in rock mechanics. In addition, we are also closely associated with eminent and globally acknowledged rock mechanical experts and institutes. We rely on the high quality services provided by these institutes for laboratory investigations. In addition, we are also approved experts called on to make independent rock mechanical assessments on behalf of the responsible mining supervisory authority of the state of Niedersachsen/Germany.



DEEP.KBB

Office Bad Zwischenahn

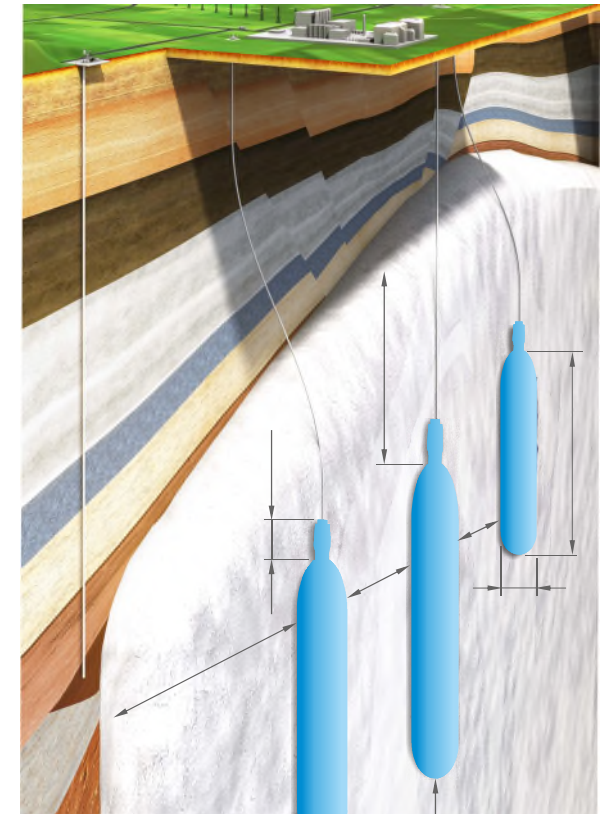
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ROCK MECHANICAL INVESTIGATIONS



INNOVATIVE ENERGY STORAGE.

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INTEGRITY AS THE HIGHEST PRIORITY

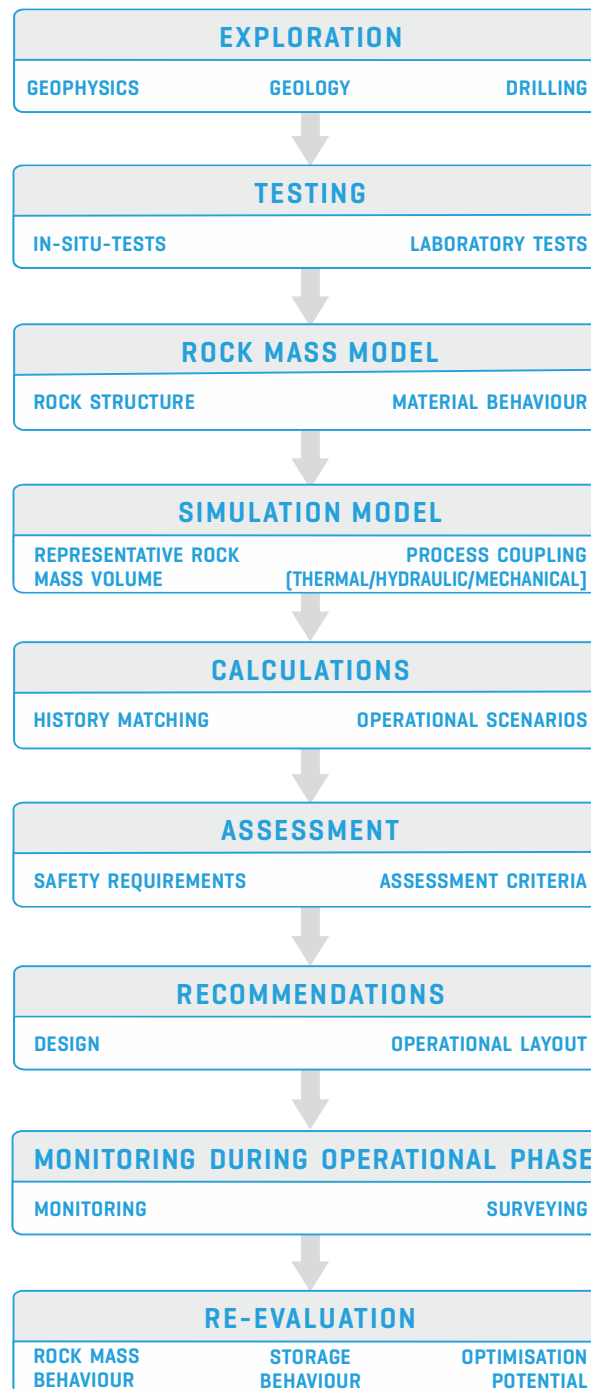
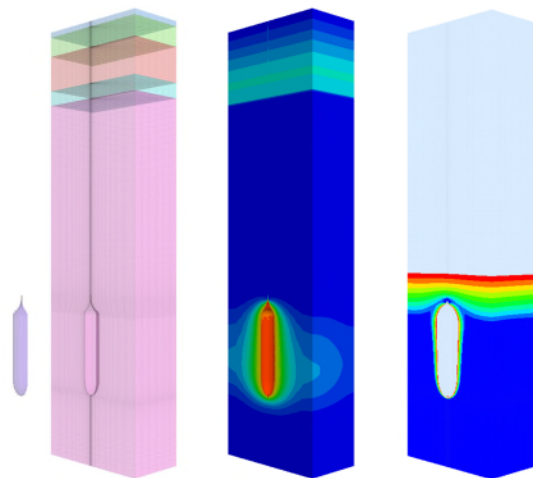
Rock mechanical investigations are undertaken to verify the stability and tightness – the integrity – of a storage facility in its underground geological setting. The underground strata provide the load-bearing system which encloses the cavern as an underground construction, and is therefore responsible for its integrity.

EVALUATING THE UNDERGROUND SYSTEM

Unlike surface structures, an underground storage site is constructed in an existing but initially poorly understood load-bearing system. The underground system is described on the basis of geophysical and geological investigations. This is backed up by testing of the in-situ rocks to determine their mechanical properties [strength and deformation behaviour] and the tightness of the rock. This evaluation can be carried out in-situ as well as in rock mechanical laboratories.

IMPLEMENTATION IN A MODEL

The preliminary investigations are used as the basis for creating a theoretical rock mechanical model of the rock mass, which when combined with the investigated underground structure – the wells and the storage cavern – can be implemented in a calculation model by using appropriate calculation methods. The calculation model is used to analyse the relevant construction and operational processes for all operational phases. The results of this analysis are assessed in terms of integrity requirements.



INCORPORATING THERMODYNAMICS

The storage space and the enclosing rock mass are permanently linked with one another by mutual processes which attempt to balance out the ambient conditions. If heat flow is important, such as in the case of gas caverns, thermodynamic/rock mechanical coupled simulation calculations are carried out. Using the thermodynamic simulations in this way can help to optimise complex storage scenarios and modes of operation.

RECOMMENDATIONS FOR CONSTRUCTION AND OPERATION

A rock mechanical investigation results in recommendations being made for the design and operation of salt caverns in the form of design and layout parameters.

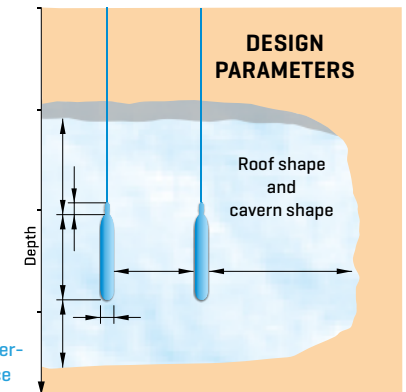
LAYOUT PARAMETERS

Minimum and maximum internal cavern pressure

Maximum pressure change rate

Maximum volume flow

Optimisation of convergence and subsidence



Regular cavity surveys are carried out after construction to monitor the behaviour of the rock mass during the operational phase. This is accompanied by surface levelling and analysing the operational monitoring data which can result in a possible re-evaluation.

RESPONSIBILITY FOR THE FUTURE

The impact on the areas surrounding a cavern is not restricted, however, to just the construction and operational phase: the long-term behaviour of the cavern with respect to convergence, and the impact on the surface, also have to be taken into consideration. Subsidence analysis and abandonment concepts are therefore an integral part of the overall rock mechanical concept, and round off our portfolio of services in this special discipline.