Summary and open questions of the VSG

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Preliminary Safety Analysis of the Gorleben Site

Basics

- site characterisation and long-term prediction
- waste characterization and quantity
- safety concept and demonstration concept

Repository design

- repository concept
- repository design and optimisation

System analyses

- FEP catalogue and scenario development
- integrity assessment geol. /geotechnical barrier
- assessment of RN release scenarios
- human intrusion scenarios

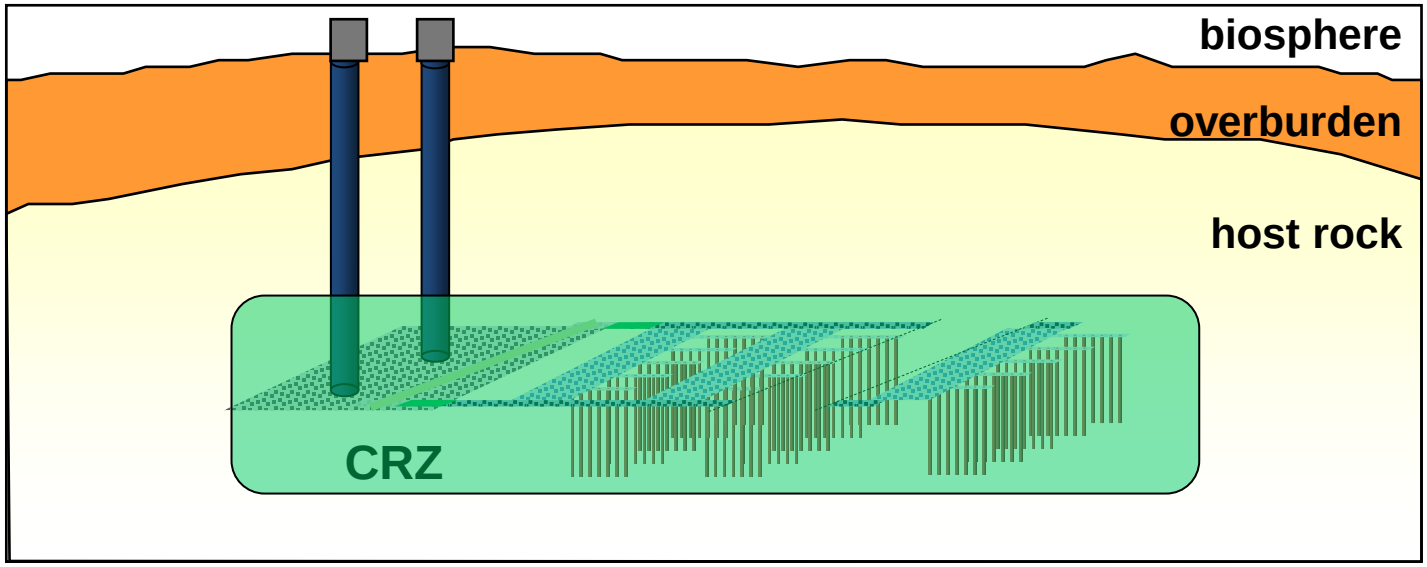
Synthesis

- assessment of results
- recommendations

Safety and Demonstration Concept

The post-closure safety concept focusses on safe containment

- **Safe containment** describes the status of the repository system in which there is at the most an insignificant release of radionuclides from the containment-providing rock zone (CRZ) during the demonstration period
- An **insignificant release** from the CRZ is a release whose radiological consequences calculated by a biosphere model are below permissible limits and thus pose no risk to subjects of protection



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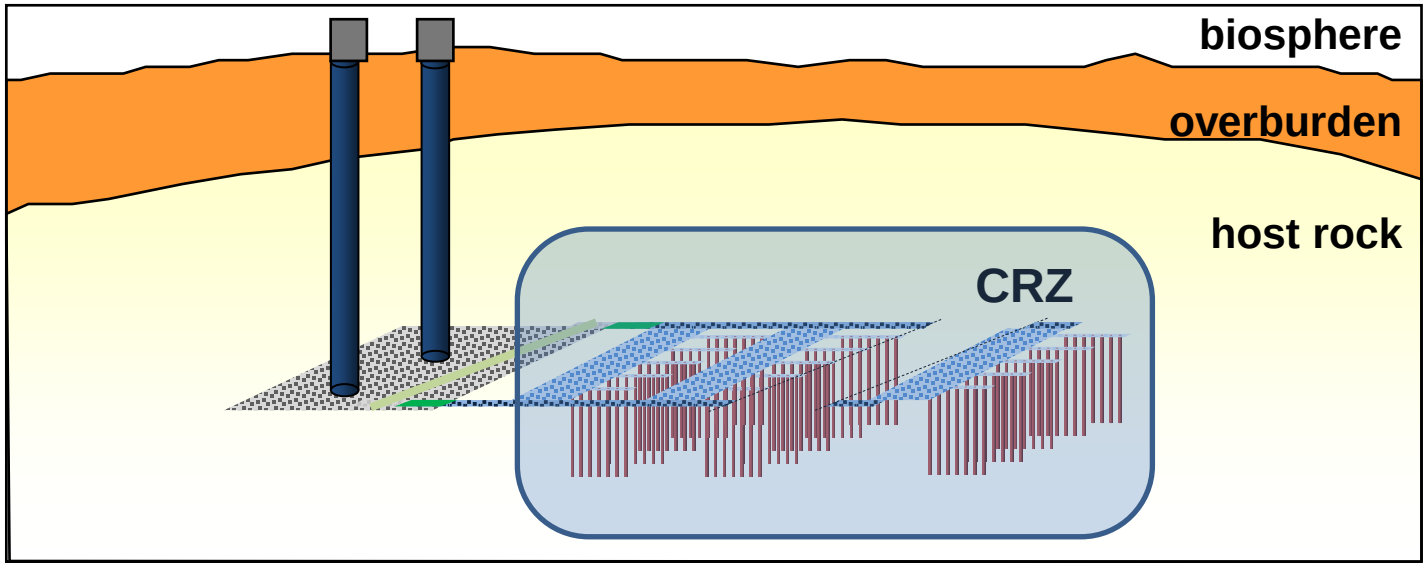
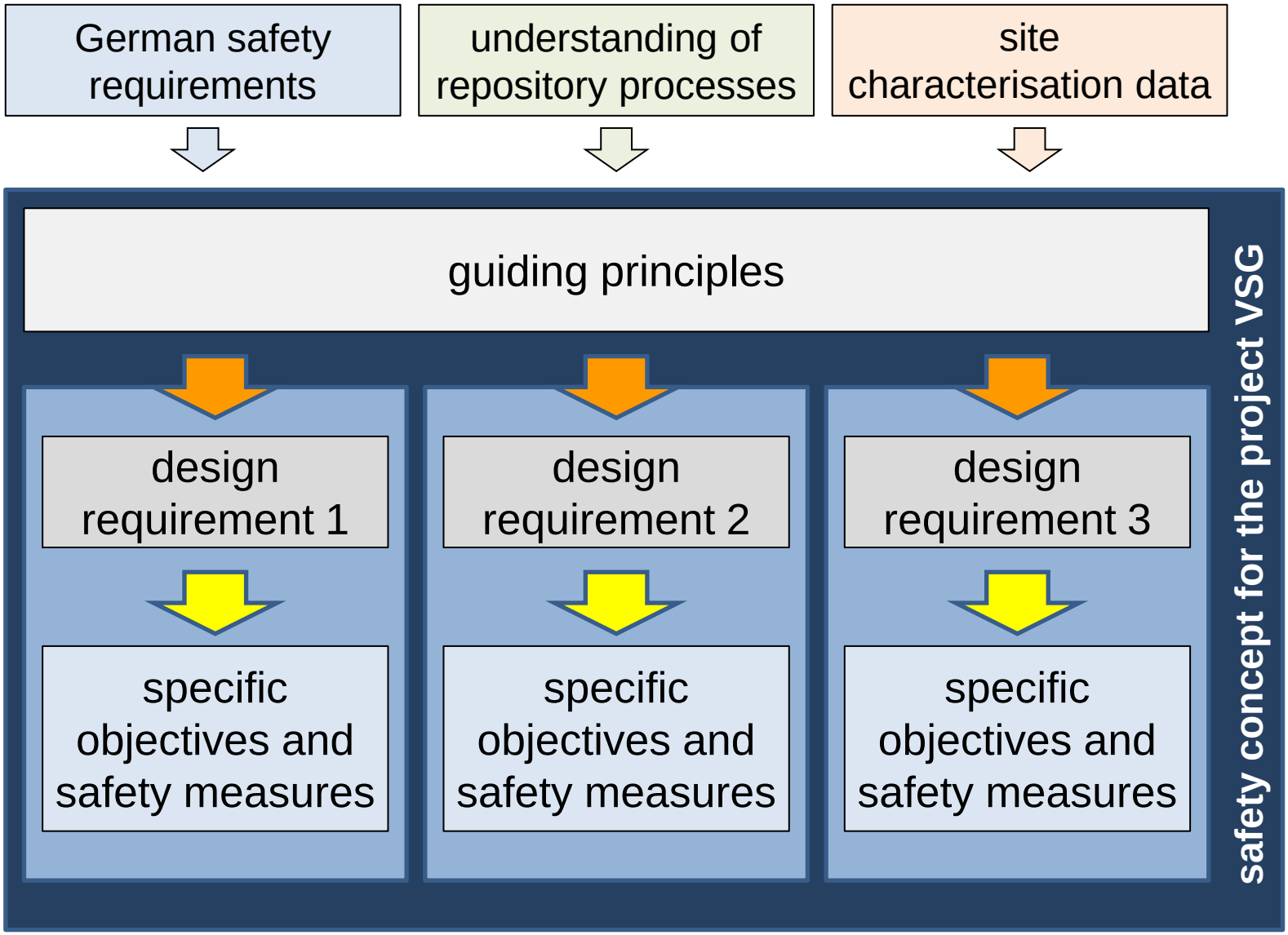


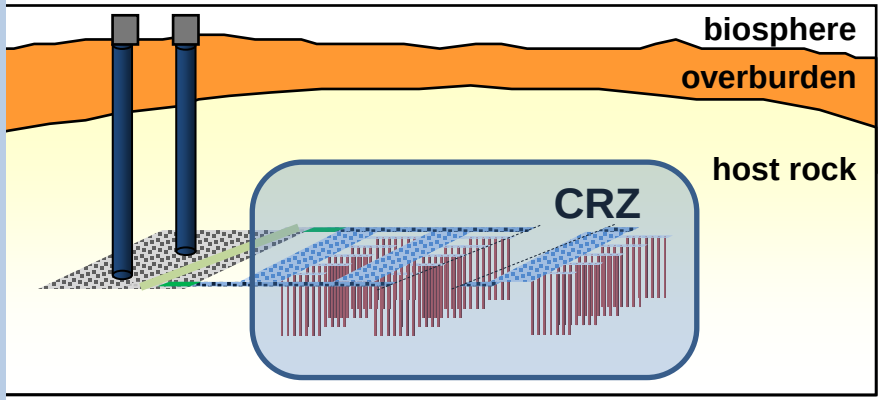
Systematic derivation of the Safety Concept



System analysis

Main questions addressed

- Will the integrity of the salt barrier remain intact under the expected loads (thermal impact, glacial cycles, etc.)?
- Will significant amounts of brine reach the waste emplacement areas?
- Will radionuclides be released from the waste?
  - ➢ If yes, will they be released from the CRZ?
  - ➢ And if so, what radiological consequences have to be expected?



- Answers needed for all probable and less probable scenarios
  - ➢ Distinction is required by German regulation
- Scenarios are systematically identified and described by using FEPs

Some important results (I)

Integrity of rock salt barrier

- Thermo-mechanical calculation show that dilatancy and brine pressure criterion is temporarily violated at top of salt dome due to thermal stresses.
- Above the repository, several 100 m of rock remain without integrity violation
- EDZ: Local violations of the dilatancy criterion (several cm – approx. 3 m).
- Temperature criteria for carnallitite are met (no thermal disintegration)

Fluid-dynamic system evolution

- Significant gas release from waste with negligible heat evolution, affecting the pressure regime in emplacement area for HLW (→ optimization)
- Pore volume in a number of emplacement drifts for HLW will become solution-saturated, depending on boundary assumptions for model calculations

Some important results (II)

Radionuclide release from CRZ

- solution pathway
  - no RN release from CRZ at 1% final porosity in crushed salt backfill
  - Insignificant release at 2% final porosity
- 2-Phase modelling (3D)
  - Independent of final porosity relevant C-14-release in the gas phase via drift seal
  - Gas formation enhances gas flow through compaction
  - Crushed salt reconsolidation due to salt creep is main driving force for gas flow
  - Results are affected by location of individual waste forms (→ optimization)

Methodological approaches, in general, have been applied successfully & are considered to be applicable for other sites with domal (bedded) rock salt

Important scientific issues to revisit

Process understanding

- Re-consolidation of crushed salt backfill, transport relevant properties at low porosities
- 2-phase-flow behaviour (model parameters) in consolidating crushed salt backfill
- Release Mechanisms of volatile radionuclides from waste forms

Safety significance of hydrocarbons present in rock salt

Suitability of methodological approach to scenario development

Relevance of processes not dealt with

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- waste characterization and quantity — GRS-274, GRS-278
- safety concept and demonstration concept — GRS-271, GRS-277

Repository design

- repository concept — GRS-272, GRS-279
- repository design and optimisation — GRS-281

System analyses

- FEP catalogue and scenario development — GRS-282, GRS-283, GRS-284
- integrity assessment geol. /geotechnical barrier — GRS-286, GRS-288
- assessment of RN release scenarios — GRS-289
- human intrusion scenarios — GRS-280

Synthesis

- assessment of results — GRS-290
- recommendations — GRS-304

VSG Reports (I)

GRS-271: Grundzüge des Sicherheits- und Nachweiskonzeptes

GRS-272: Endlagerkonzepte

GRS-273: Salzgeologische Untersuchungen der Integrität der geologischen Barriere des Salzstocks Gorleben (2012)

GRS-274: Abfallspezifikation und Mengengerüst: Basis der Laufzeitverlängerung der Kernkraftwerke

GRS-275: Geowissenschaftliche Langzeitprognose

GRS-277: Sicherheits- und Nachweiskonzept (*replaces GRS-271)*

GRS-278: Abfallspezifikation und Mengengerüst: Basis Ausstieg aus der Kernenergienutzung (u*pdate of report GRS-273 after Fukushima*)

GRS-279: Einschätzung betrieblicher Machbarkeit von Endlagerkonzepten

VSG Reports (II)

GRS-280: Human Intrusion

GRS-281: Endlagerauslegung und –optimierung

GRS-282: FEP-Katalog für die VSG: Konzept und Aufbau

GRS-283: FEP-Katalog für die VSG: Dokumentation

GRS-284: Szenarienentwicklung

GRS-285: Berücksichtigung der Kohlenwasserstoffvorkommen in Gorleben

GRS-286: Integritätsanalyse der geologischen Barriere

GRS-287: Integritätsanalyse der geotechnischen Barrieren – Teil 1: Vorbemessung

VSG Reports (III)

GRS-288: Integritätsanalyse der geotechnischen Barrieren – Teil 2: Vertiefte Nachweisführung

GRS-289: Radiologische Konsequenzenanalyse

GRS-290: Synthesebericht

GRS-304: Forschungs- und Entwicklungsbedarf auf Basis der Erkenntnisse aus der VSG sowie Empfehlungen

all reports available via: http://www.grs.de/german-publications?page=1&title=VSG&field_author_value=&field_year_value=&tid_1=&tid=All