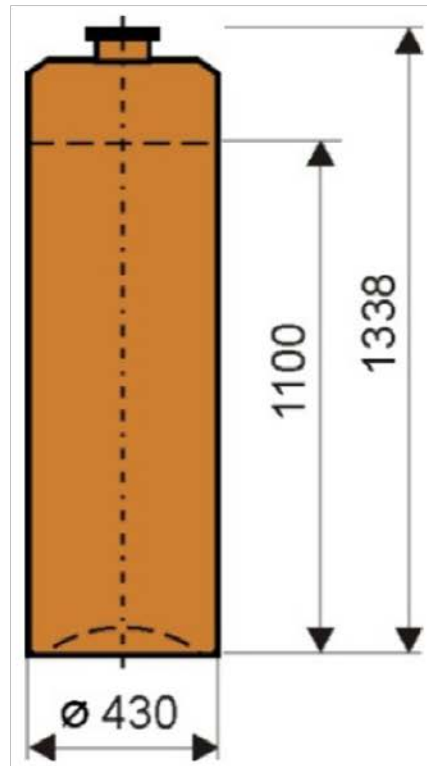


Does Deep Borehole Disposal (DBD) of HLRW have a chance in Germany ?

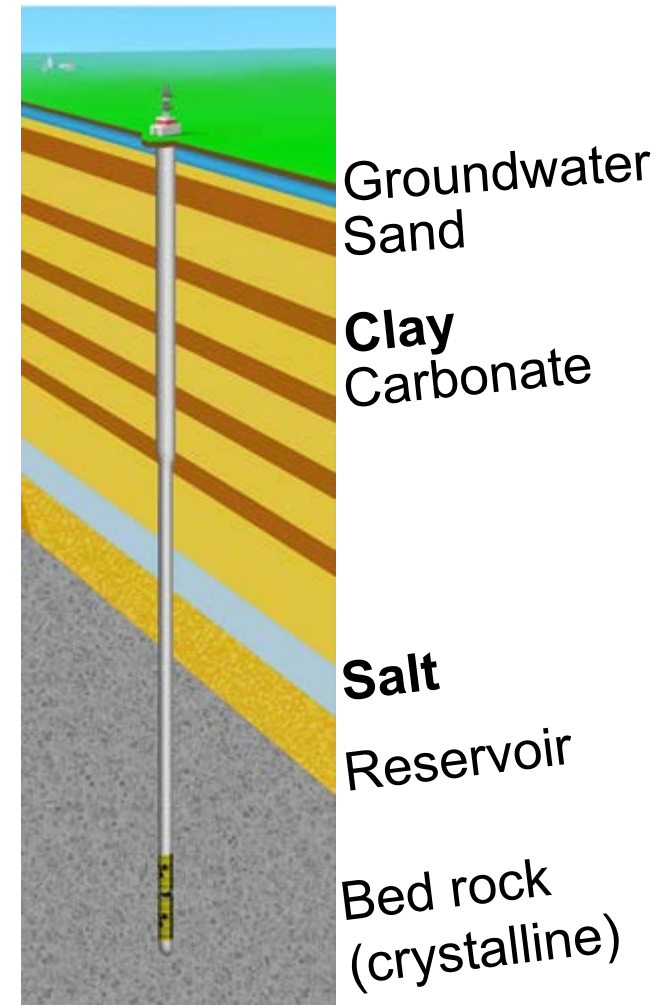
Volume of HLRW in Germany

- Spent fuel elements
- Vitrified waste
- Spent fuel pebbles



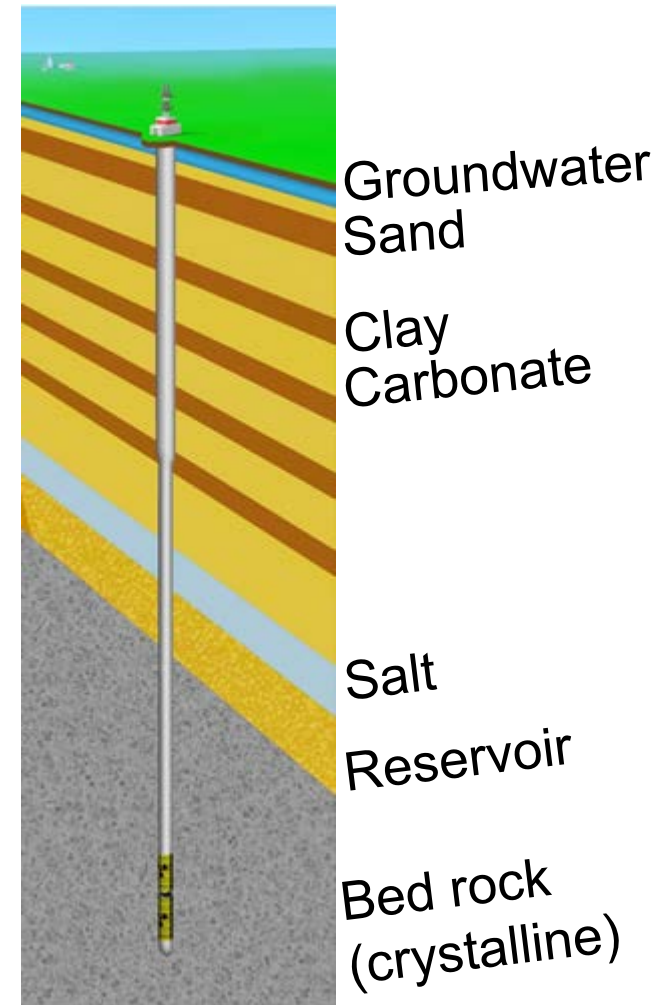
Concept

- Disposal depth of 1500 – 3500 m
- Multiple barrier system with clay and salt layers (alternating strata)

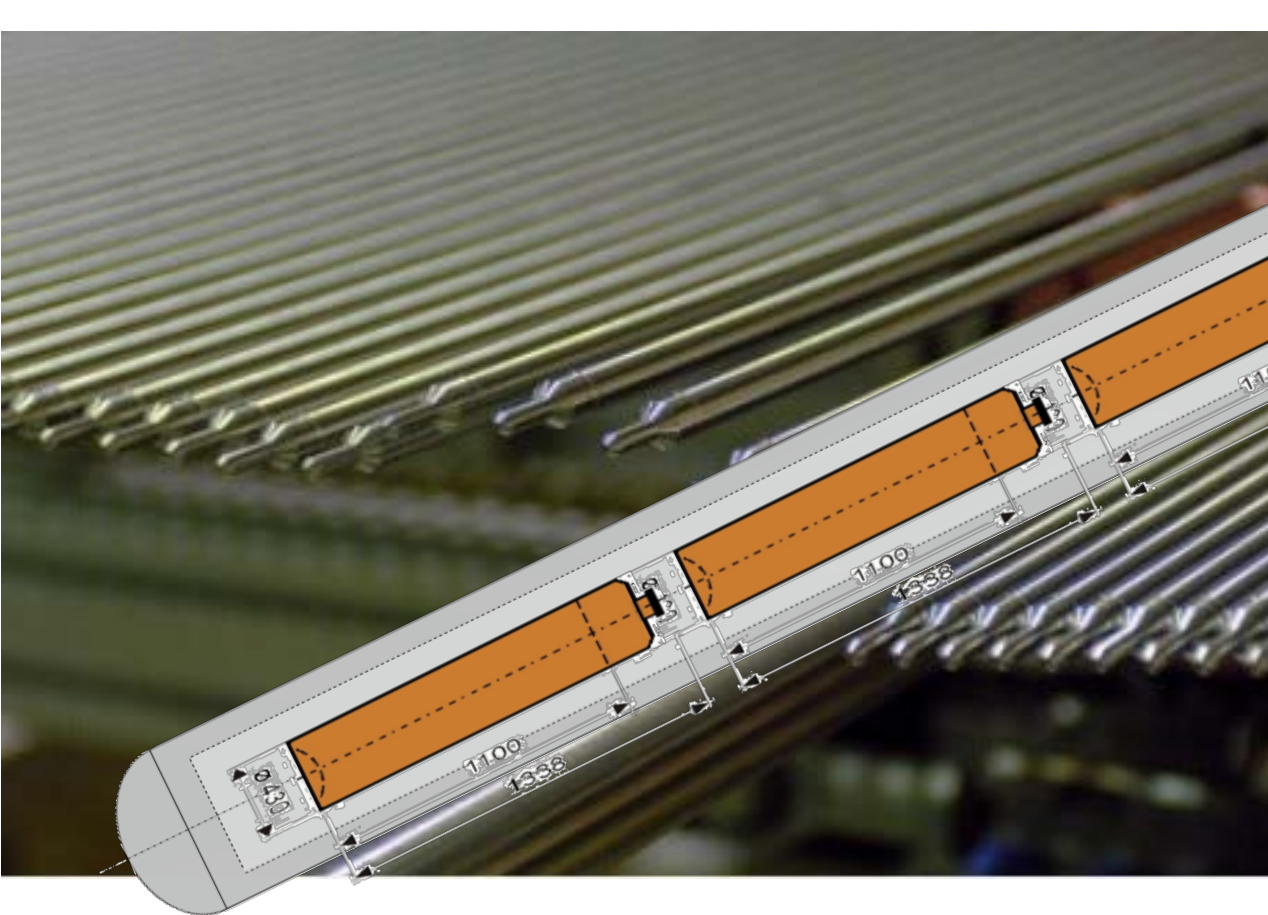


Some questions

- Diameter of borehole ?
- Container ?
- Availability in Germany ?
- „containment providing rock zone“ ?
- Reversibility ?
- ...



Deep Borehole Container – Retrieval (DBC-R)



Net volume:
~ 0,72 m³

Net mass container:
6,6 – 12 Mg

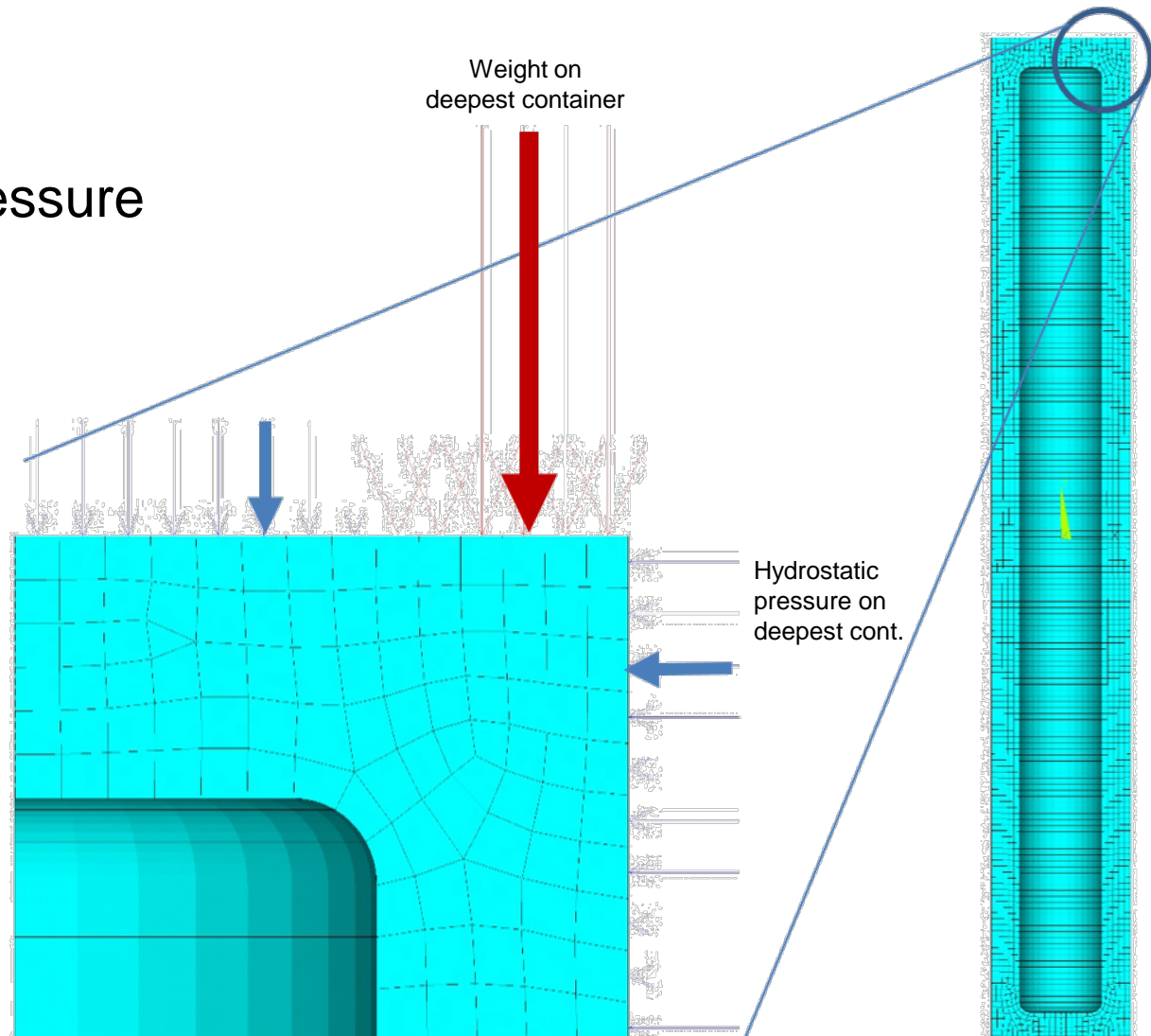
Gross mass DBC-R:
9,5 - 15,7 Mg



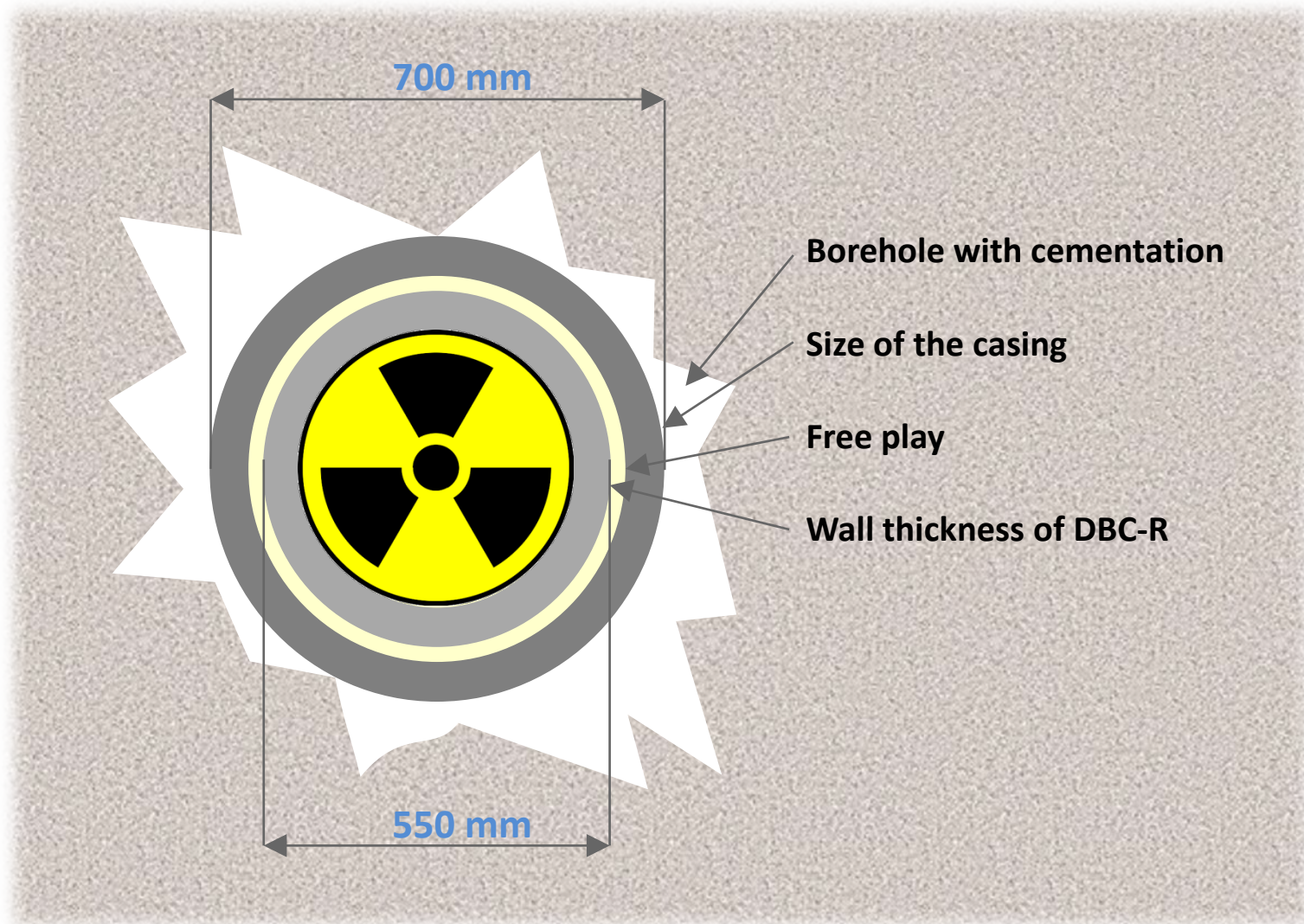
Ca. 11 000 containers

Requirements for container (wall thickness)

- Stacking
- Temperature / pressure
- Corrosion
- Tightness
- Retrievability / recoverability
- ...



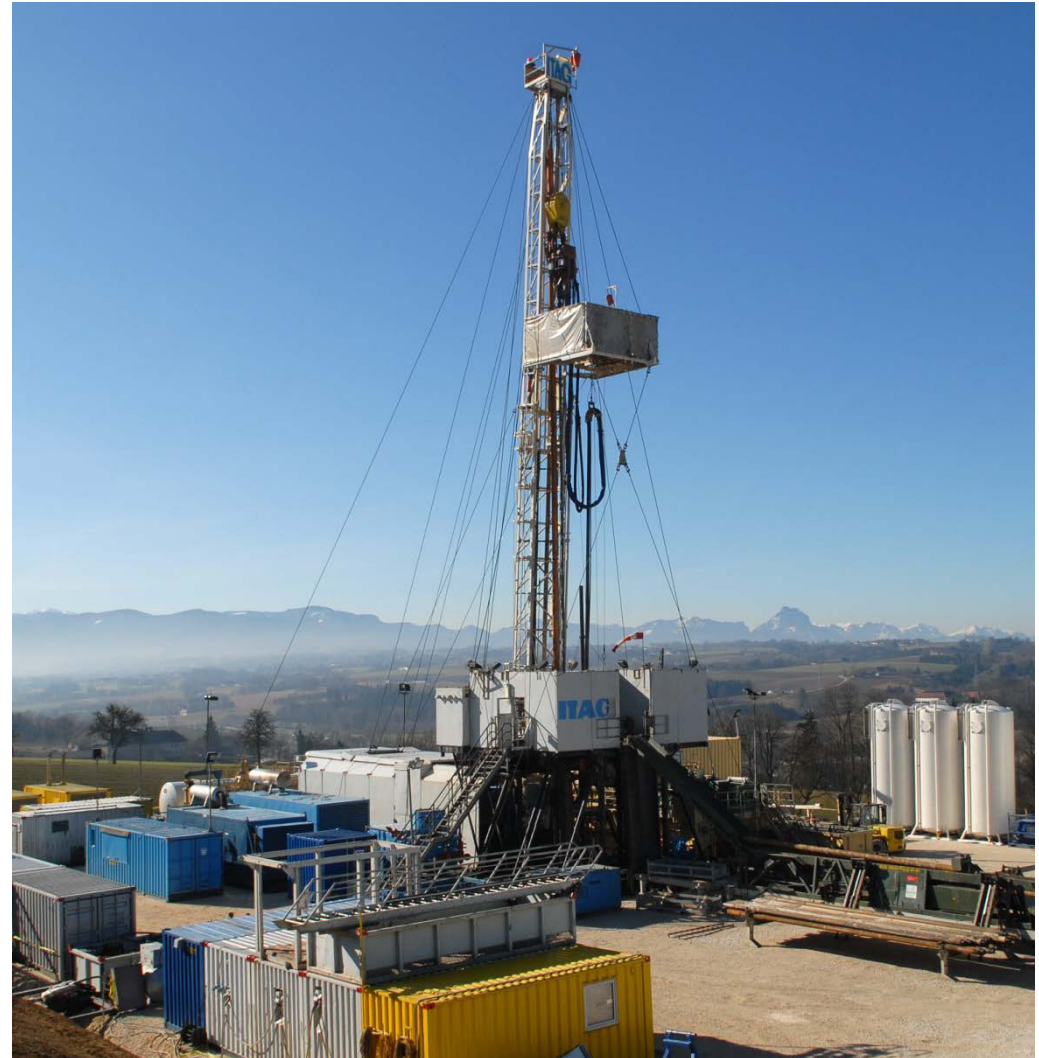
Casing / container



How many boreholes ?

| Disposal depth | Wall thickness DBC-R | DBC-R per borehole | Number of boreholes | Diameter of borehole |
|-----------------|----------------------|--------------------|---------------------|----------------------|
| 3 000 - 3 600 m | 4.5 cm | 103 | 107 | 75 cm |
| 3 000 - 4 200 m | 6.5 cm | 205 | 55 | 80 cm |
| 3 000 - 5 000 m | 10 cm | 363 | 31 | 90 cm |

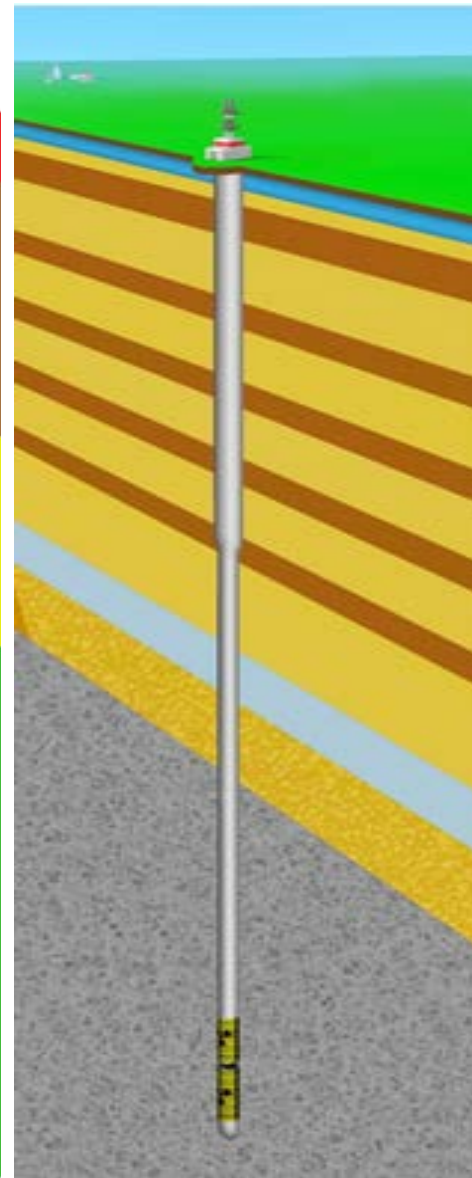
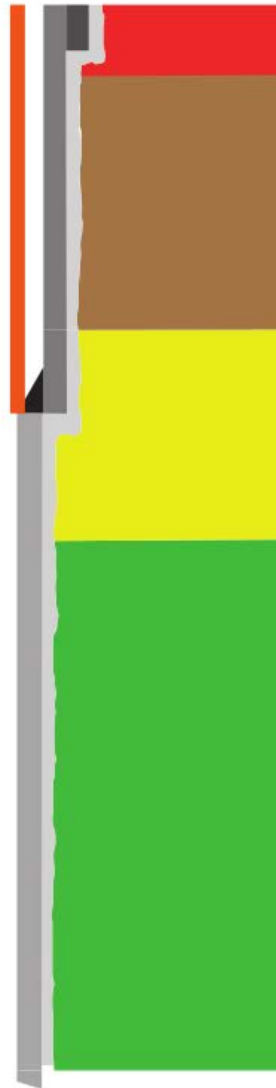
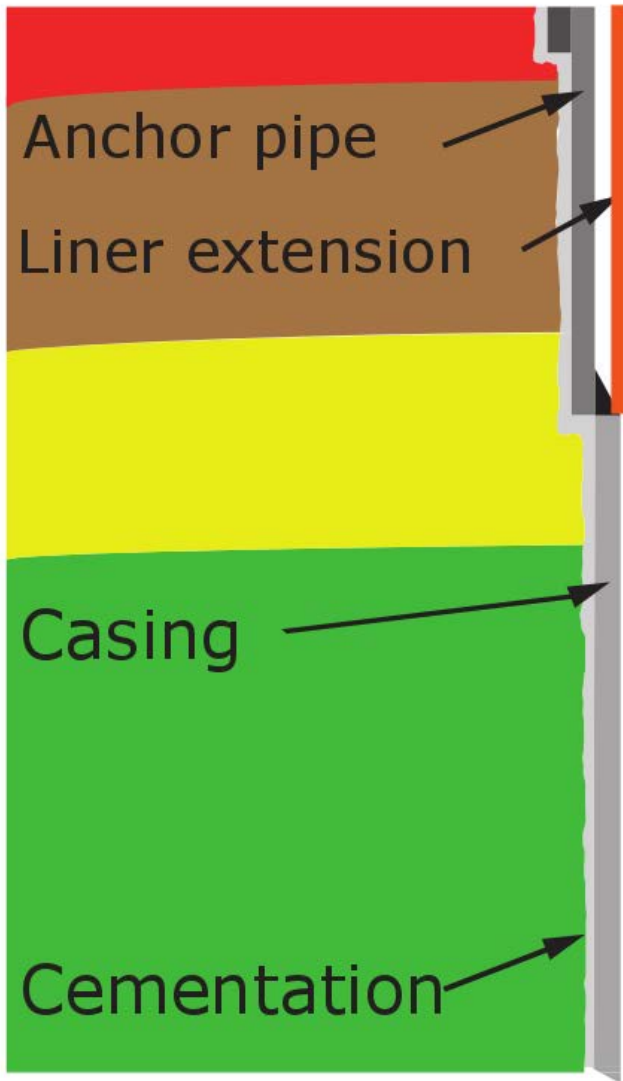
Drilling technology



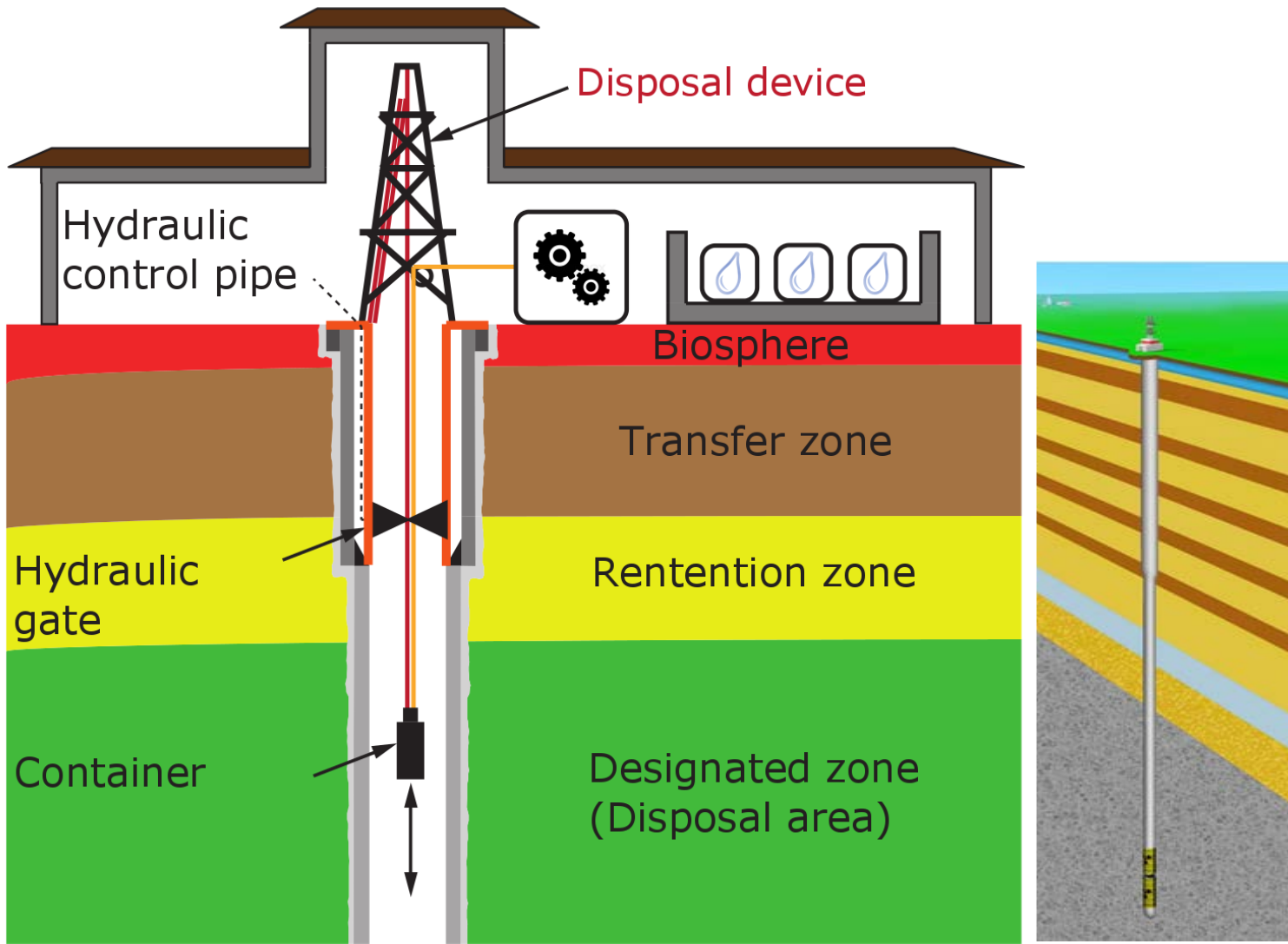
Drilling Site for 18 boreholes



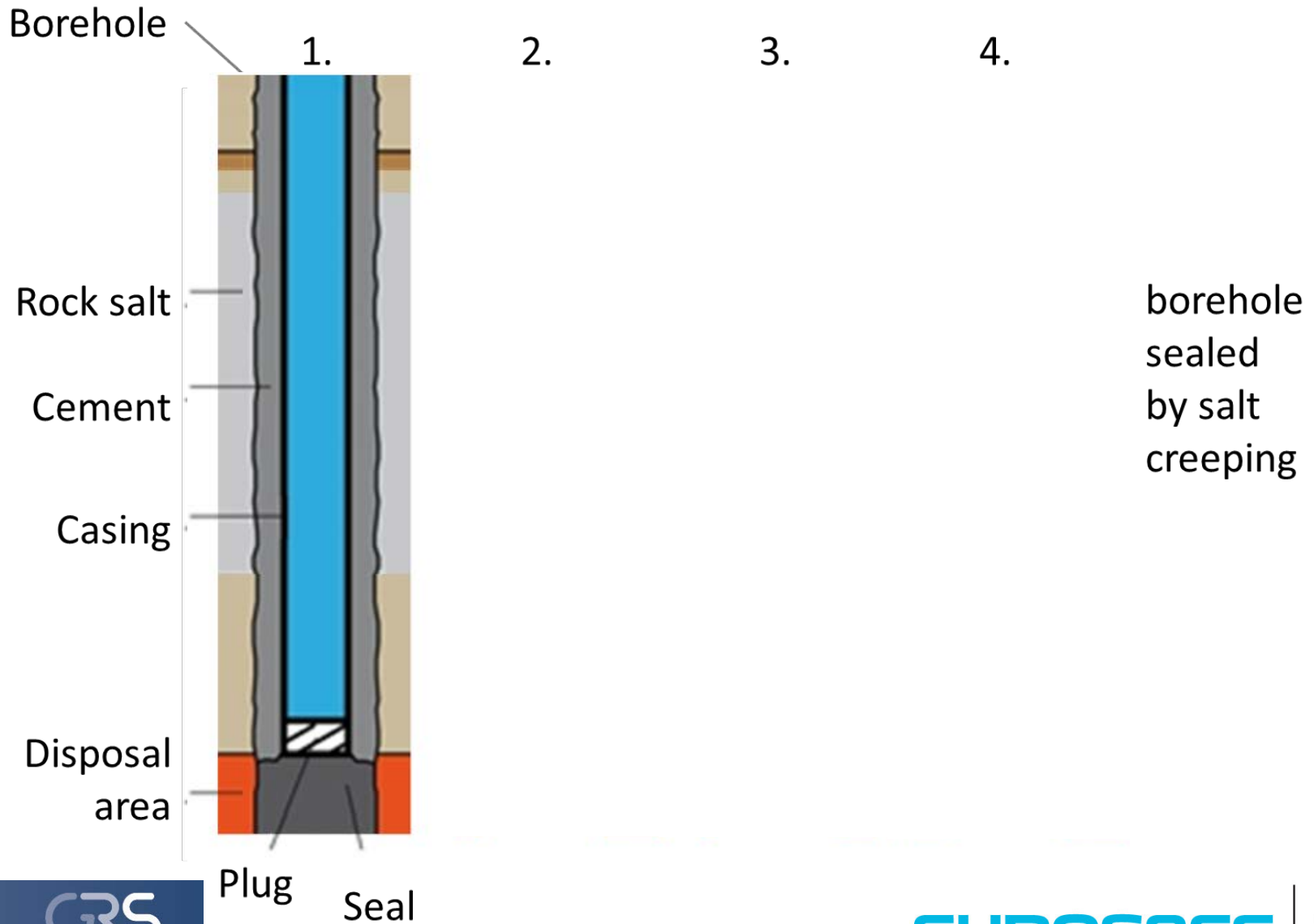
Casing of borehole



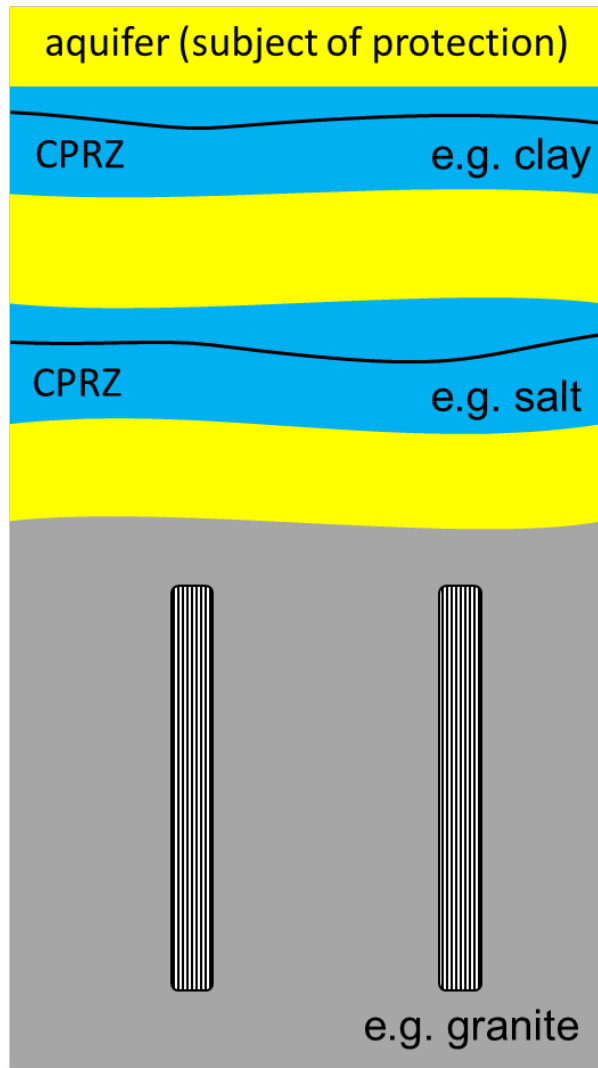
Disposal operation







Borehole seals: Example for salt



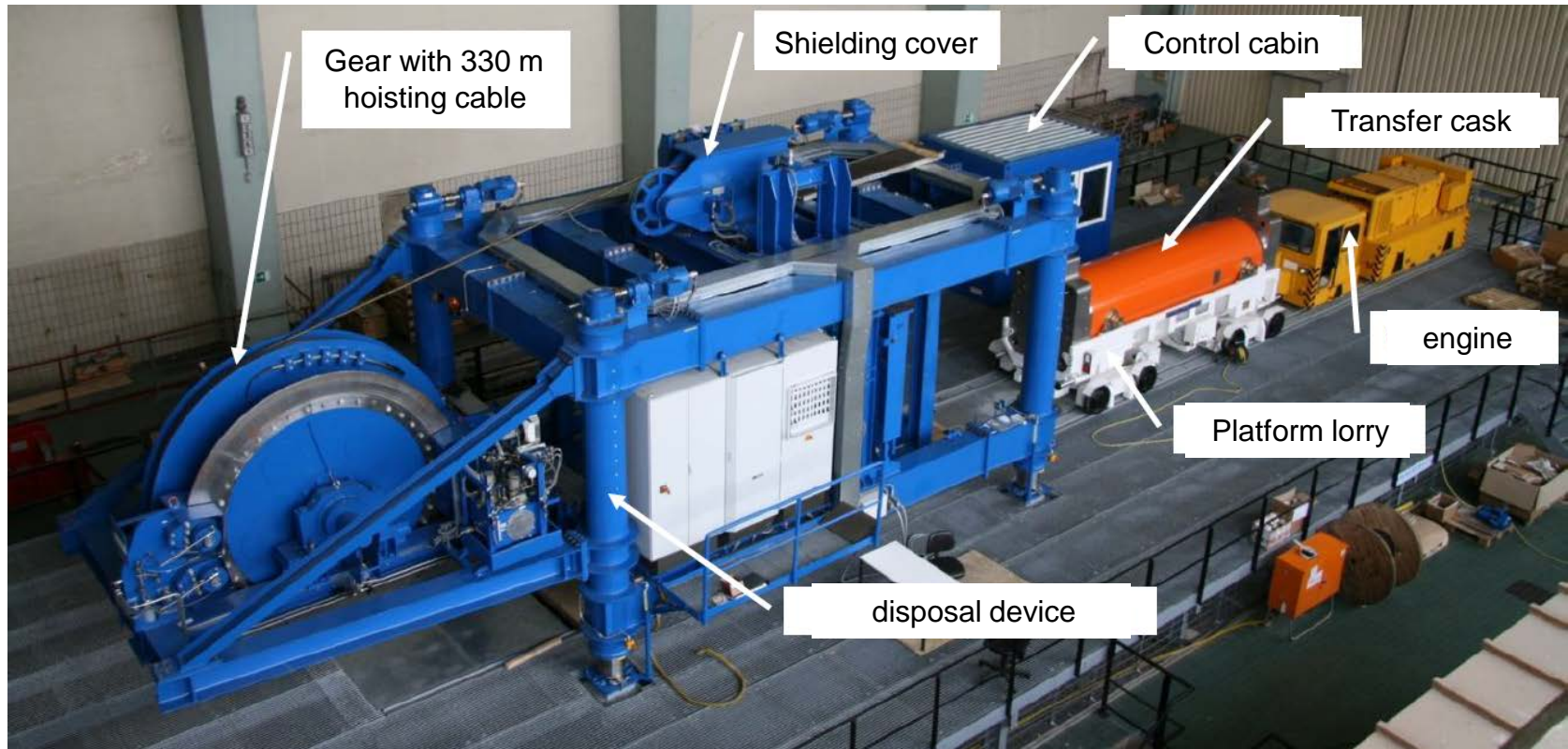
Containment providing rock zone (CPRZ)



-  Rock without barrier functions
-  Rock with barrier functions (clay, salt)
-  Limit of containment providing rock zones (CPRZ)
-  Waste disposal zone (crystalline)



Reversibility: Retrieval / Recovery

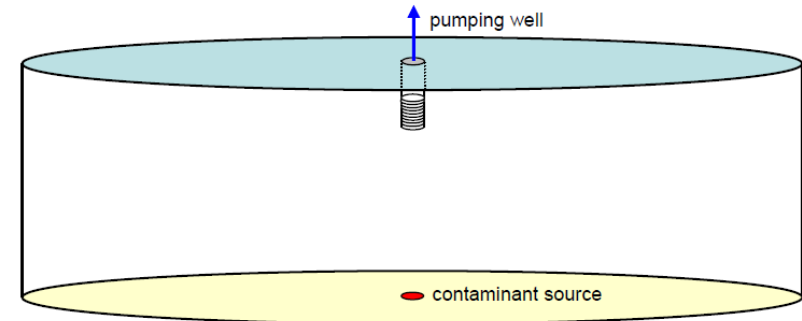
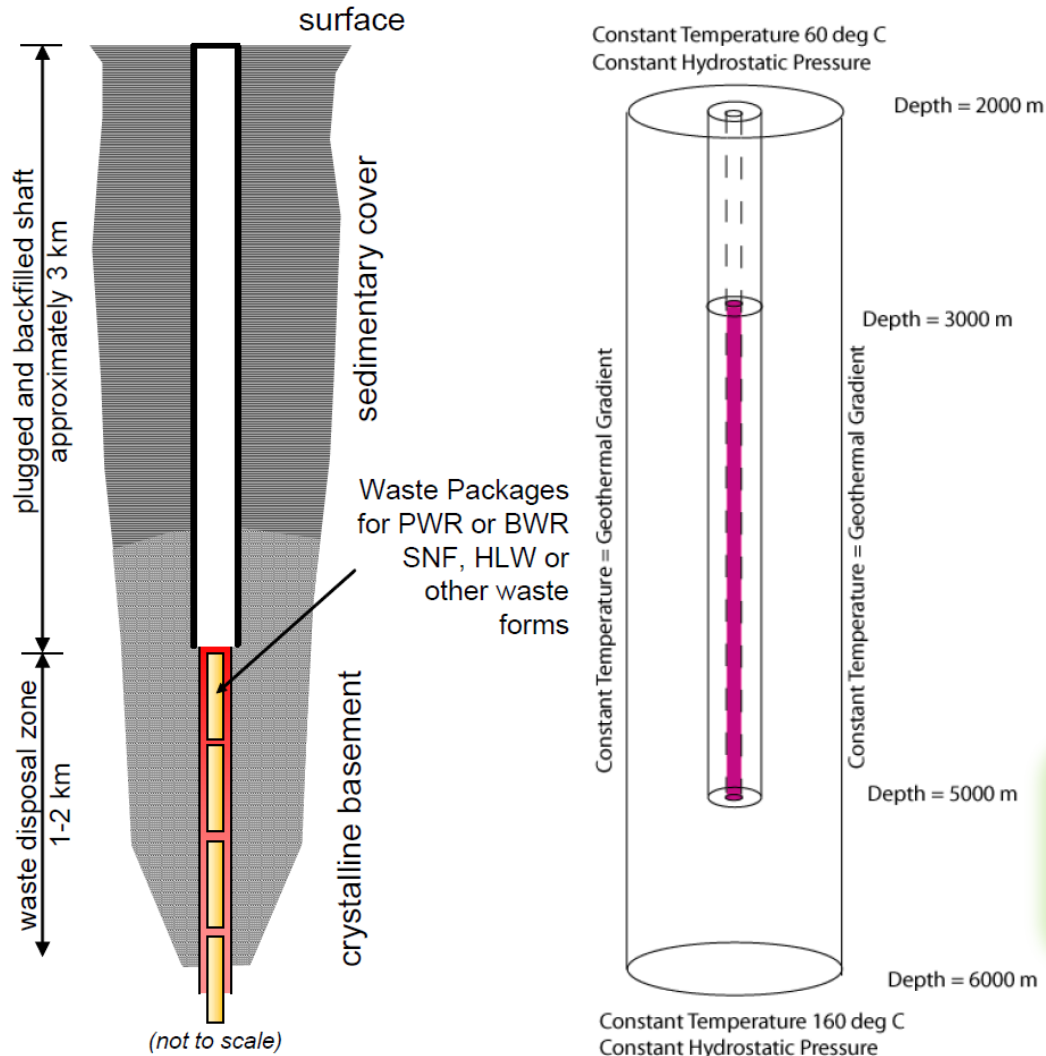


- ... but will container last for 500 years ?

Site Selection Procedure

| Geoscientific requirements / criteria | applicable | Comment |
|---------------------------------------|------------|--|
| Exclusion | ✓ | Deep geological disposal ! |
| Minimum | ✓ | No maximum depth ! |
| Weighting | (✓) | <ul style="list-style-type: none">• gas compatibility• temperature (disputed)• hydrochemistry of disposal zone and CPRZ) |

Long-term Safety Assessment *



very positive results* but
to be verified for CPRZ

Research and Development

- Borehole diameter of 0.75 m beyond today's standard shelf technology
- Considered feasible for 3 600 m
- Concept to be detailed (e. g. container, monitoring, technology)
- Operational and long-term safety analyses
- Feasibility demonstration (drilling, disposal and retrievability)
- Development of containers for recoverability for 500 years

Summary

- Concept shown
- Container
- Disposal operation
- Geoscientific requirements and criteria
- Safety analysis
- Research and development

Some advantages



and disadvantages

- Multiple barrier system (great depth)
- Manless disposal
- Several sites possible
- No proliferation
- Less costs and faster implementation
- ...

- Research and development
- Exploration for every drilling site
- Corrosion of containers
- Recoverability
- ...

Answer

DBD should / could be a feasible and alternative technical option for deep geological disposal in Germany.

Conclusions

Needs active support of research and development

The requirement of recoverability for 500 years should be reconsidered