

Underground Storage & Disposal - The Salt Concept

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Who is GRS (,Plant & Reactor Safety Ltd.')

- Non-profit, independent expert and research organisation
- Assess and improve safety of technical facilities
- Focus on nuclear safety and waste management
- Customers: Ministries and authorities, European Commission
- Technical support of Federal Ministries conc. safety of chemicals, e.g. Hg

Background: EU Storage Obligation for Metallic Mercury

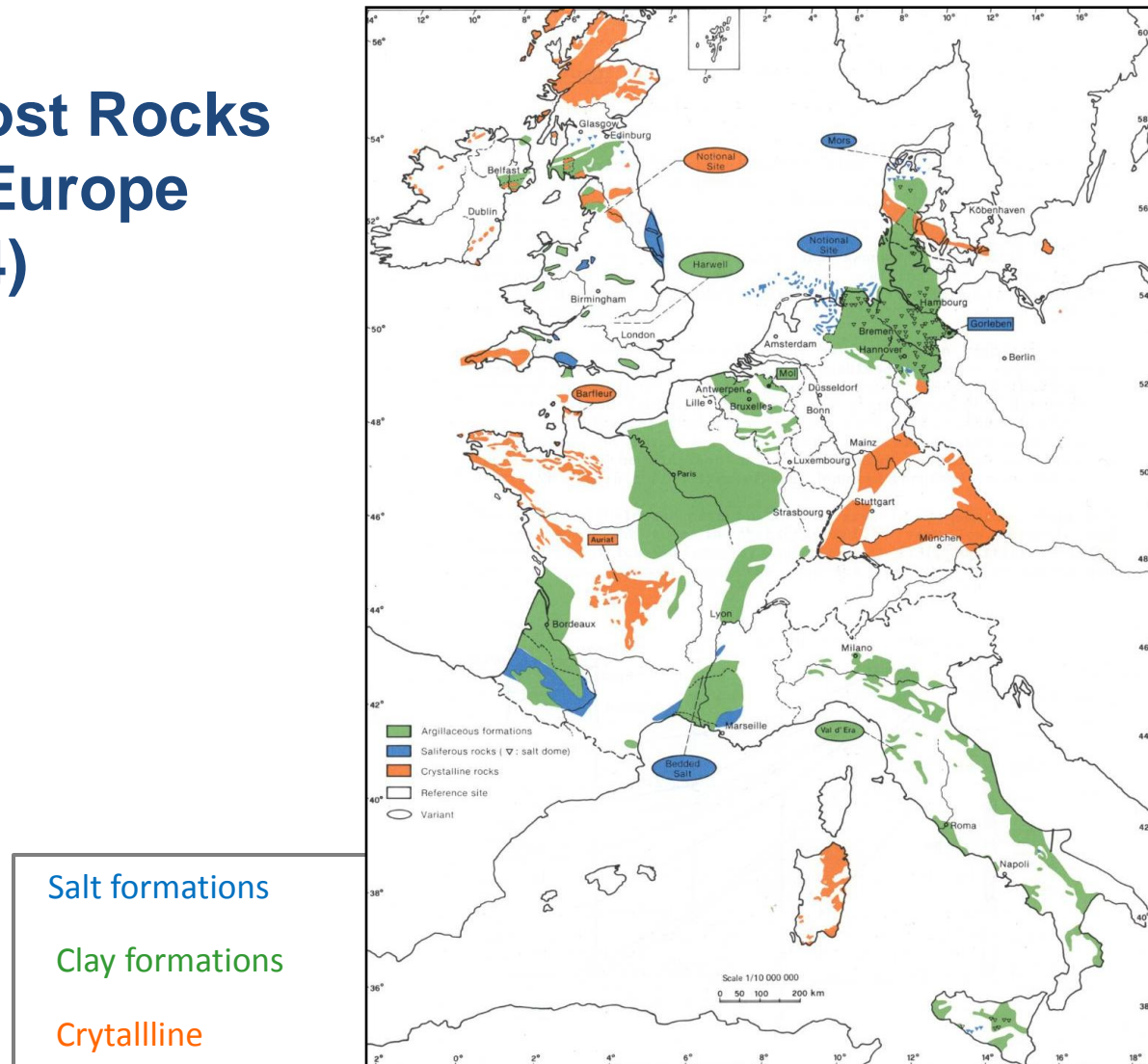
Regulation allows only few storage options, e.g.:

Temporary or **permanently** in salt mines^{*)} or in deep underground hard rock formations^{**)}

*) adapted for the disposal of metallic mercury

**) providing a level of safety and confinement equivalent to that of salt mines

Potential Host Rocks in Western Europe (PAGIS 1984)

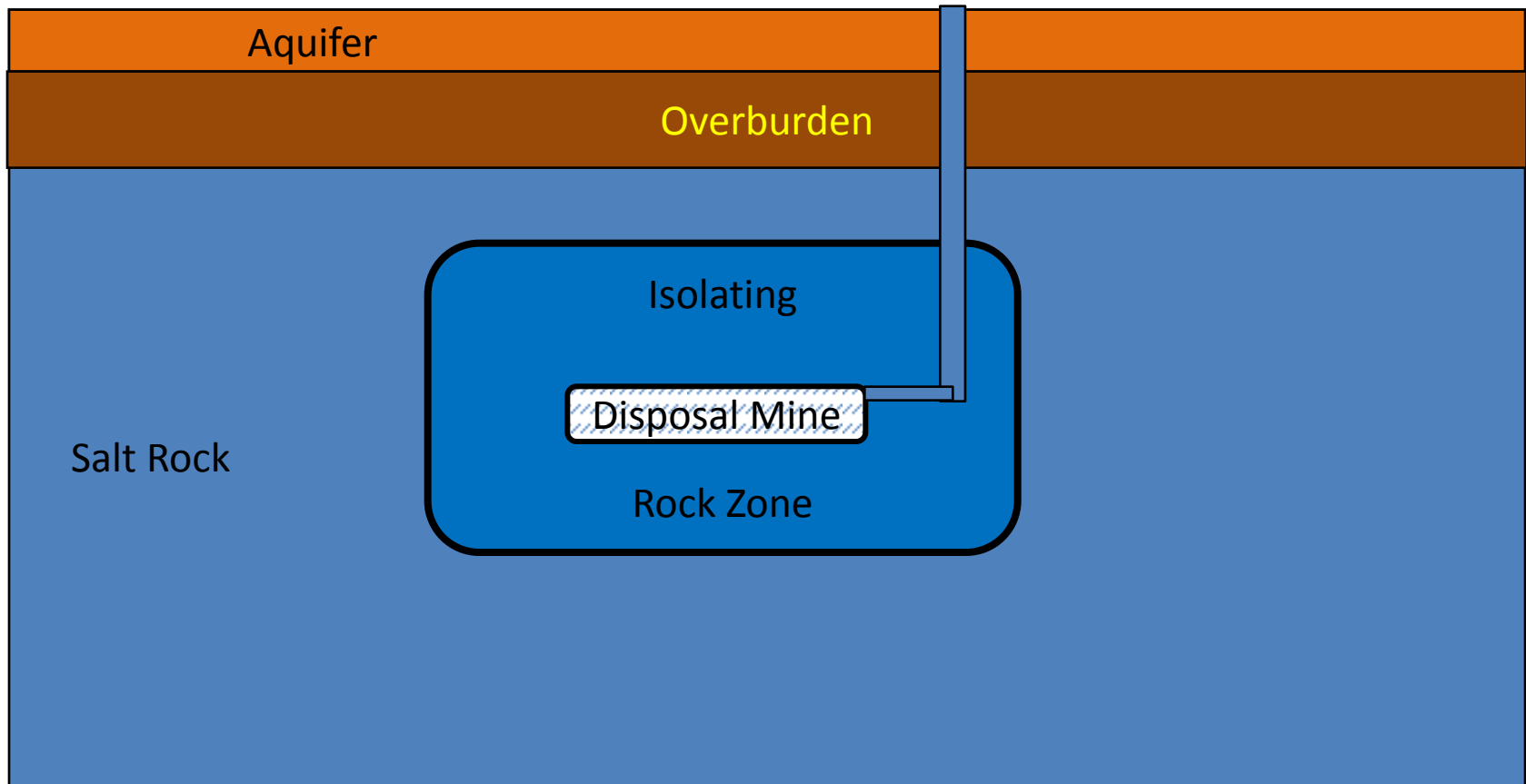


Salt formations

Clay formations

Crystalline

Salt Rock: Concept of Complete Inclusion



Host Rock Type - Rock Salt

Properties of Rock Salt

- Mechanical stability
- Viscoplastic behavior
- High creeping capability
- Low porosity
- Low permeability
- High thermal conductivity
- Low water content

Advantages for Underground Disposal

- ⇒ Construction of large cavities without special lining
- ⇒ Fast closing of cavities
- ⇒ No connected fissures and fractures
- ⇒ Self-healing of fractures
- ⇒ Negligible transport of fluids and gas
- ⇒ Fast removal of heat

⇒ Rapid and complete inclusion of wastes

Host Rock Type - Rock Salt

Additional advantages of rock salt formations

- High persistence of rock salt deposits
 - Salts of Zechstein-age within salt domes since app. 250 m.y. without contact to aquifers
- Deposits in geological stable regions with low earthquake activity
- Large accumulations of host rock esp. in salt domes
- Long lasting experience from mining
- Numerous & widespread deposits (low conflict of interests)
- Effects of earthquakes in salt generally lower^{*)}

^{*)} but high seismicity will be an overall exclusion criterion!

Host Rock Type - Rock Salt

Disadvantages of rock salt

- High water solubility^{*)}
- Low sorption capacity
- Low gas permeability
- Geological complex structure of salt domes

^{*)} reason for prohibition of fluids!

Why Rock Salt?



Large and stable
cavities

Why Rock Salt?

Former drift in a salt mine

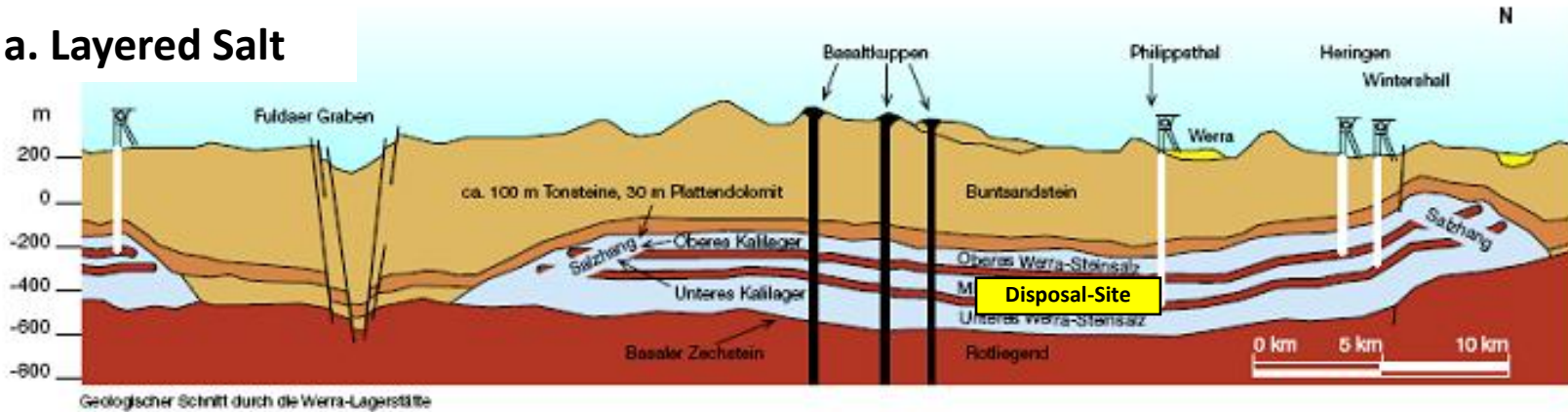
Unique rock properties,
esp. plastic behaviour

Enables complete inclusion
of waste disposed off

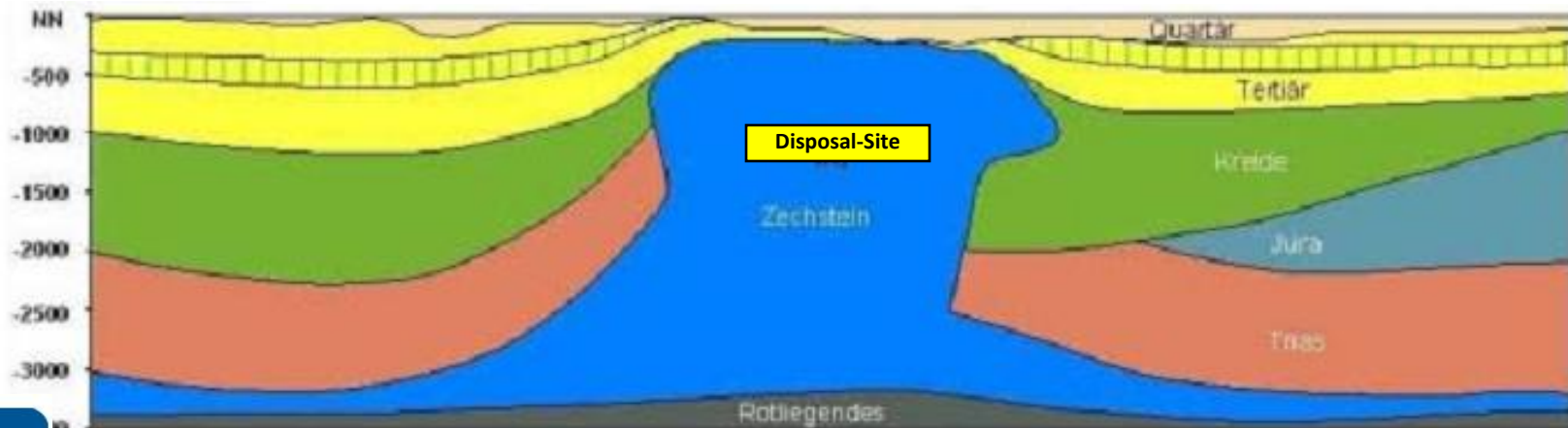
Former drift in a salt mine

Concept of Underground Disposal in Salt Rock

a. Layered Salt



b. Salt Dome



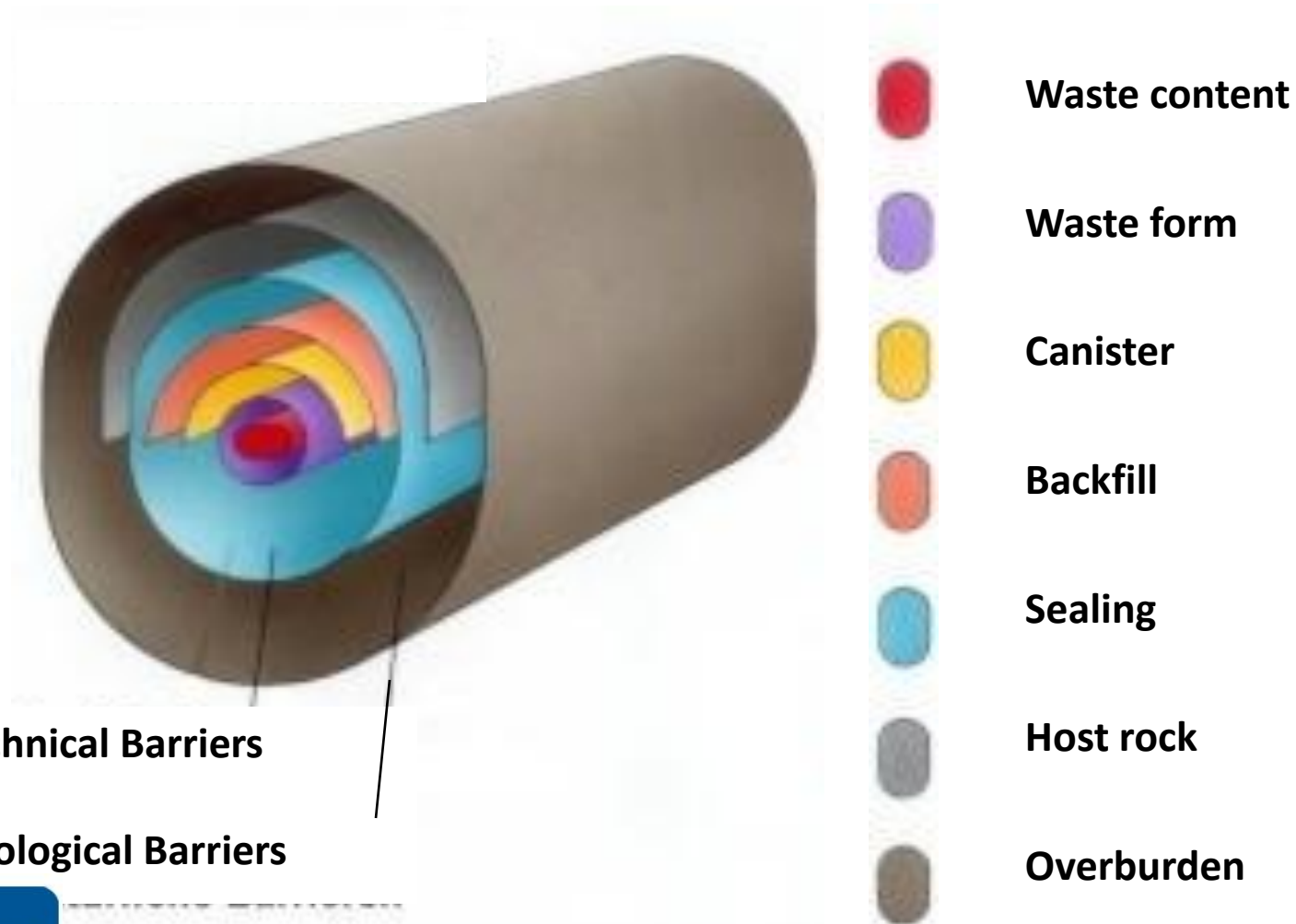
Types of Geosystems - Rock Salt

Geosystem		Thickness of host rock body	Potential disposal depth
Host rock	Variant		
Rock salt	Salt dome	up to > 1,000 m	800 m
Rock salt	Layered salt	app. 100 m	650 – 1,100 m

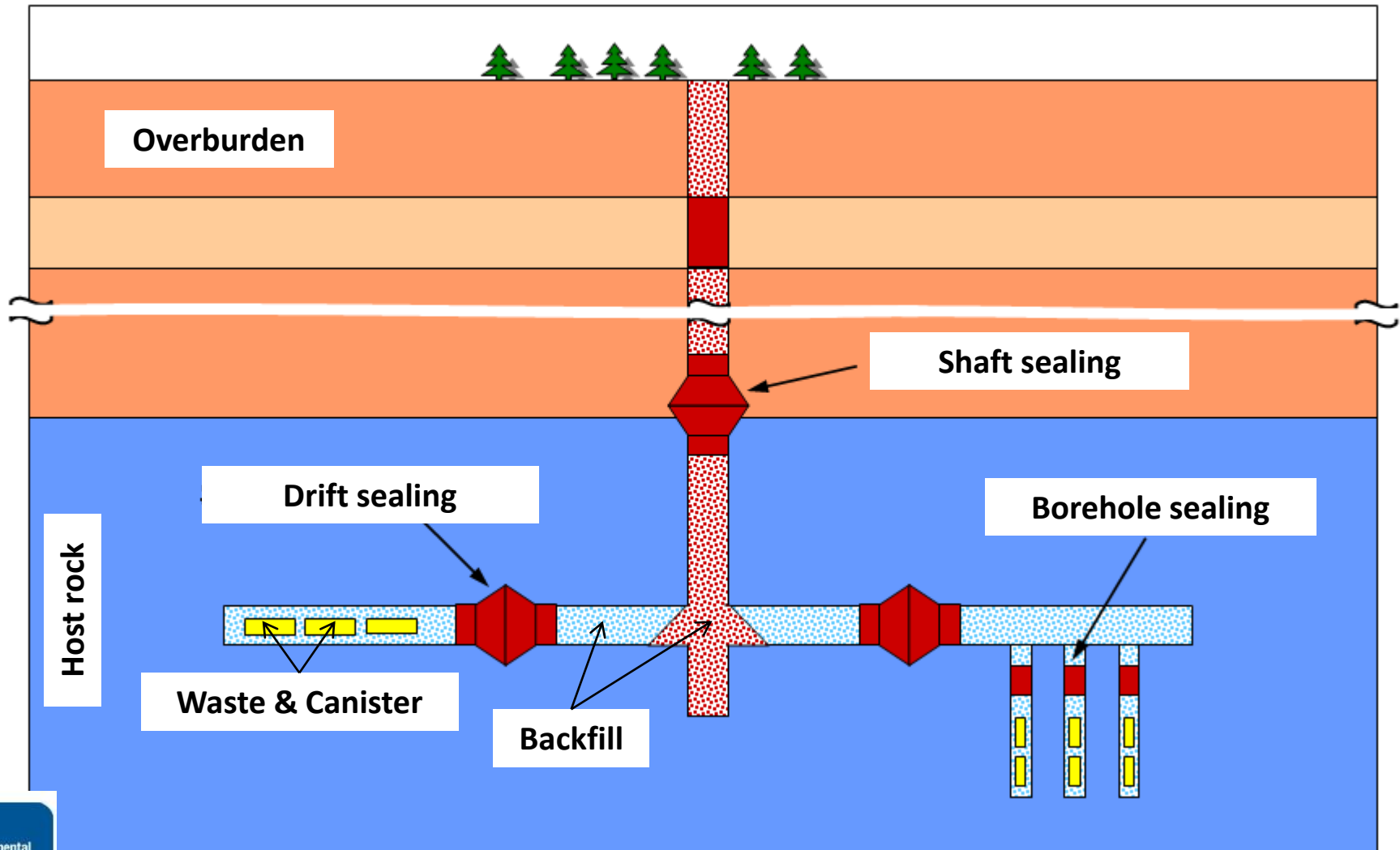
Host Rock Properties - Comparison (Detail)

Properties	Rock Salt	Clay / Claystone	Crystalline (e.g. Granite)
Thermal Conductivity	high	low	medium
Hydraulic Conductivity	nearly impermeable	very low - low	very low (without joints) - permeable (jointed)
Mechanical Strength	medium	low - medium	high
Deformation Behavior	viscous (creep)	plastic - brittle	brittle
Stability of Cavities	self-stability	timbering necessary	high (without joints) - low (intensively jointed)
In-situ-Stress	lithostatic isotropic	anisotropic	anisotropic
Solubility	high	very low	very low
Sorption Capability	very low	very high	medium - high

Waste Isolation Multibarrier System (1)



Waste Isolation Multibarrier System (2)



Strategy of Long-term Safety Assessment

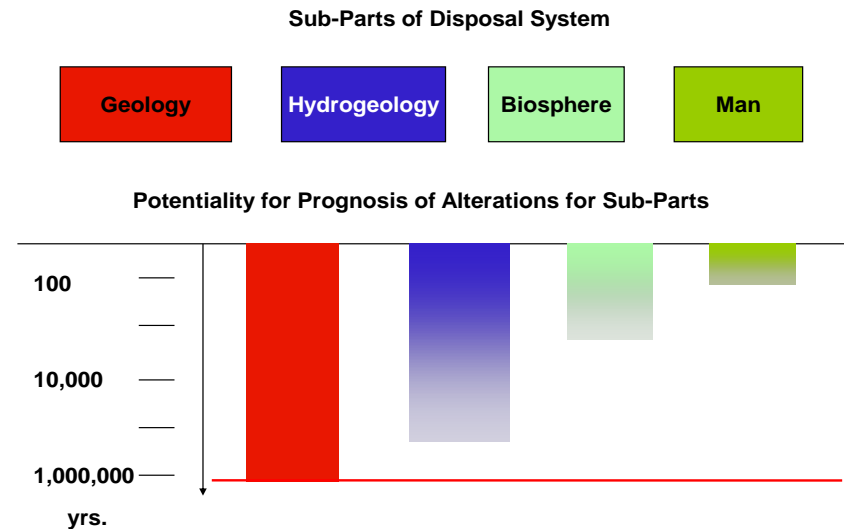
Geo-scientific long-term prognosis on site development

Knowledge of site characteristics

- Rocks and their properties
- Hydrology (regional/local)
- Hydrogeology
- (Biosphere)

Design of disposal facility

Running off processes



Important Questions Concerning Mercury

Scientific Knowledge on Mercury

- What is the behavior of metallic Mercury in contact with air and brines ?
- How much is the solubility of metallic Mercury influenced by impurities ?
- Does the conversion of metallic Mercury in Hg-sulfides hold advantages ?
- → significant in case of waste not isolated totally

Demand of Regulations

- Which of the existing criteria are likely to be unsuitable for liquid Hg ?
- Which specific provisions for the containment are necessary and how does it effect the system ?

Citations - DE

- Technical Instructions on Waste (TA Abfall) -
<http://www.bmu.de/files/pdfs/allgemein/application/pdf/taabfall.pdf> (in German)
- Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal -
<http://www.bmu.de/files/pdfs/allgemein/application/pdf/promoting.pdf>
- Ordinance on Landfills and Long-Term Storage Facilities (Landfill Ordinance – DepV) -
Annex 2: Instructions on the maintenance of long-term safety records within the context of site-related safety assessments for mines in salt rock -
http://www.bmu.de/files/pdfs/allgemein/application/pdf/deponievo_engl.pdf
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