S1_10

Legislation and Technical Aspects of Regulation on Waste Containing Mercury in Germany and Europe

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Who is GRS (‚Plant & Reactor Safety Ltd.‘)

- Non-profit expert and research organisation
- Assess and improve the safety of technical facilities
- Protect man and environment from technical hazards and risks
- Focus on nuclear safety and waste management
- Customers: Ministries and authorities, European Commission
- Solely bound by the principles of science and technology
- About 400 employees, offices in several European countries
- International co-operations
- ISO 9001:2000 certified

[For details see: http://www.grs.de/module/layout_upload/grse.pdf]

Preamble

Regulation (EC) No 1102/2008 on banning of exports and safe storage of metallic mercury

- Mercury = Global Threat
- Basic Aim of Regulation:
  Prevent Surplus from Re-entering Global Market
- Above-ground Storage = Temporary Solution
- → Postulation of Safe Storage in a Salt Mine
  or in Deep Underground Hard Rock Formations
- i.e. **Export Ban complemented by Storage Obligation**

Actual EC Regulation on Mercury (1)

Regulation (EC) No 1102/2008 on banning of exports and safe storage of metallic mercury

- (Art.1-1) **Export** of metallic mercury **prohibited** from **15 March 2011**
- (Art.1-3) **Mixing** of metallic mercury **prohibited** from **15 March 2011**
- (Art.2) Metallic mercury (no longer used / gained from operations) **considered as waste** and to **be disposed of** from 15 March 2011

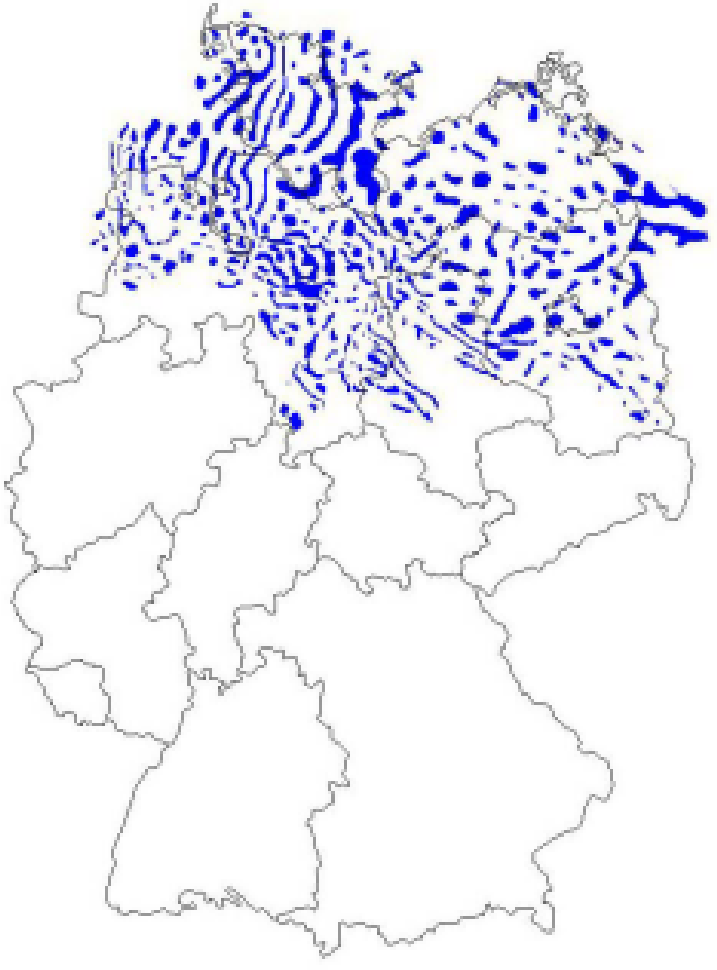
Actual EC Regulation on Mercury (2)

Regulation (EC) No 1102/2008 on banning of exports and safe storage of metallic mercury

- (Art.3) Metallic mercury (as waste) to be stored **in salt mines** or in **deep underground, hard rock** formations (providing equivalent level of safety)

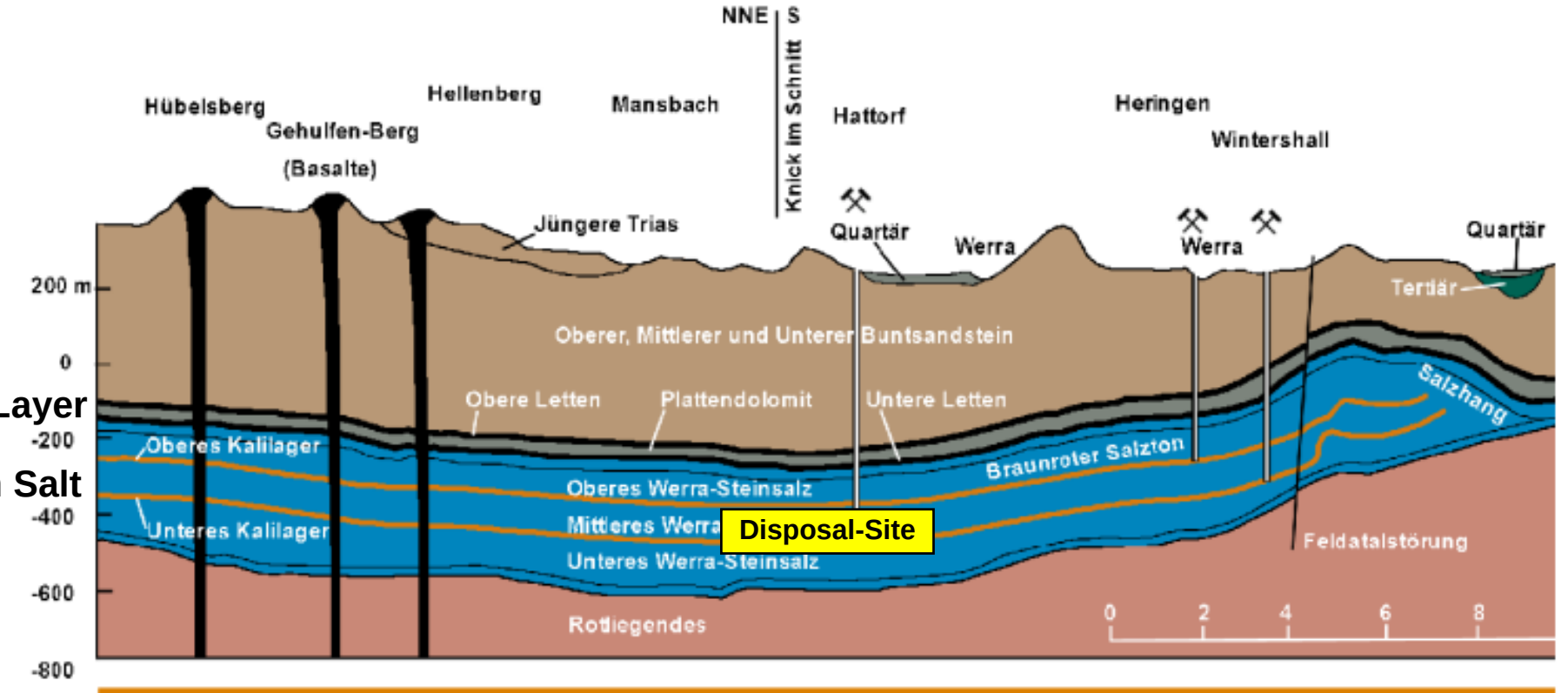
- (Art.8) By **1 January 2010** examination of
  - Need for **extending the export ban** to other mercury compounds
  - Need for **import ban**
  - Consideration of **research on safe disposal options**

Distribution of Salt Domes in N-Germany



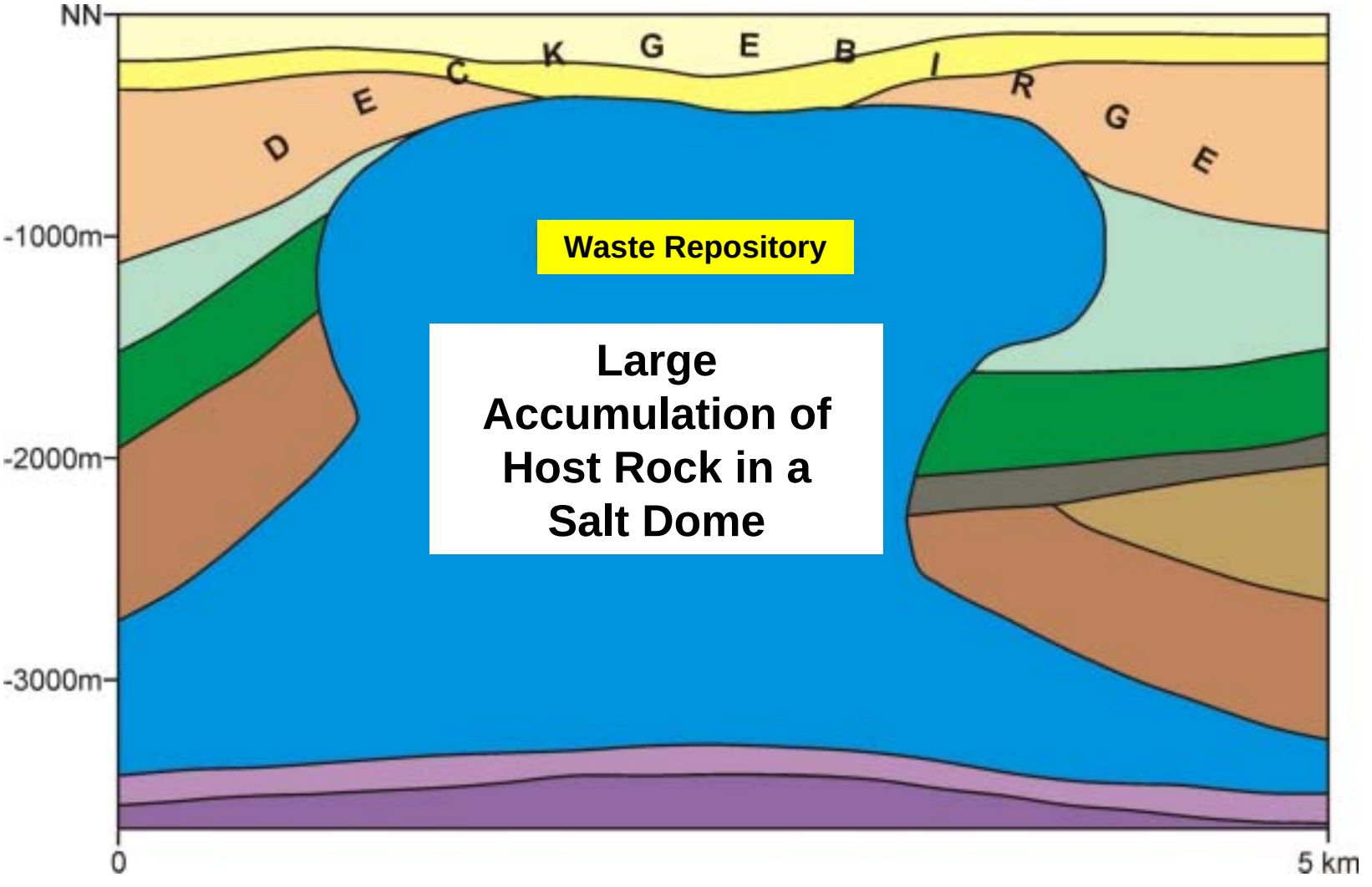
+ wide areas with thick clay layers

Concept of Underground Disposal in Layered Salt



- Thickness of 500 meters
- gastight

Concept of Underground Disposal in a Salt-Dome



Host Rock Properties - Comparison

Properties	Rock Salt	Clay / Claystone	Crystalline (e.g. Granite)
Thermal Conductivity	+	-	+/-
Hydraulic Conductivity	+	+	+/-
Mechanical Strength	+/-	+/-	+
Deformation Behavior	+	+/-	-
Stability of Cavities	+	-	+/-
In-situ-Stress	+	-	-
Solubility	-	+	+
Sorption Capability	-	+	+/-

Host-Rock Specific Aspects

- **Rock salt:**

  Complete and permanent isolation of waste from biosphere by total inclusion in host rock; **host rock = essential barrier**

- **Plastic-clayey sediments:**

  Barrier effect by geosphere and technical resp. geotechnical measures

- **Crytalline rocks / consolidated sediments (fractured):**

  System of technical barriers essential for enclosure of waste

Waste Isolation Barrier System (1)

Waste content

Waste form

Canister

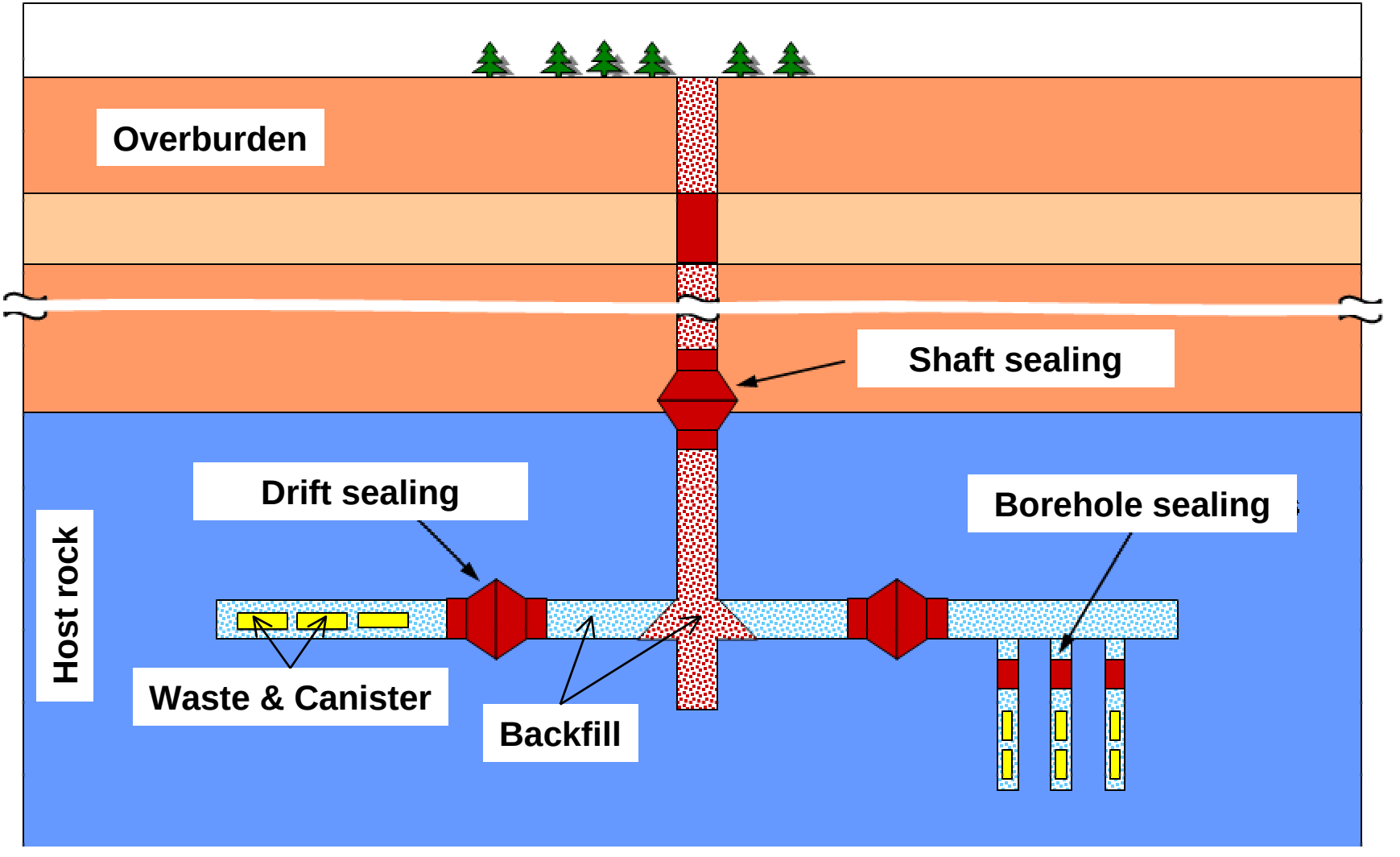
Backfill

Sealing

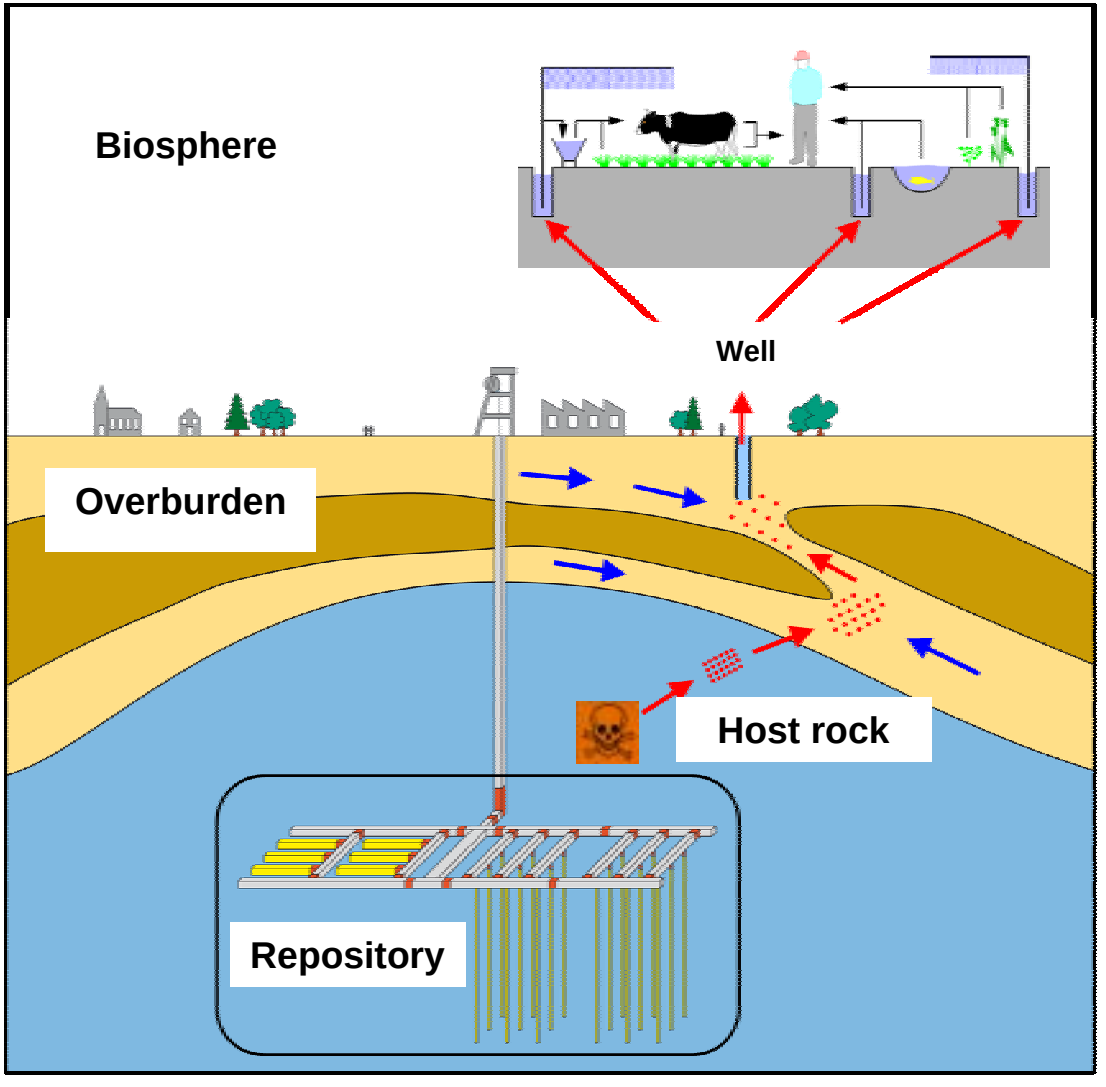
Host rock

Overburden

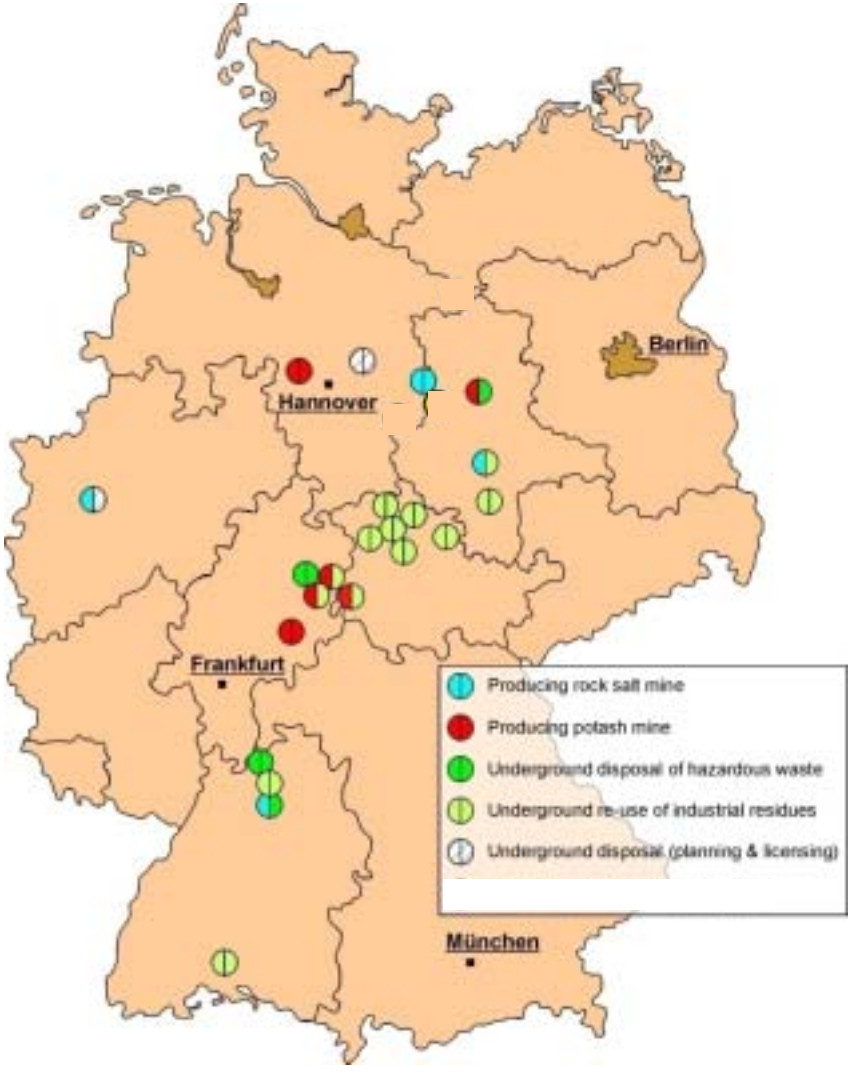
Waste Isolation Barrier System (2)



Underground Disposal System & Scenario



Underground Waste Deposits in Germany



Experiences and Practice in Germany

Underground Disposal Sites

- Experiences since 1972 (Herfa-Neurode in operation)
- Host rock = rock salt
- Exclusive usage of still existing or abandoned mines
- Broad spectrum of hazardous wastes
- Operated commercially (‚polluter pays‘)
- Operated cost covering and profitable

Capacity of two major UTD's

Underground Disposal Plant UTD Herfa-Neurode UTD Zielitz	Solution for highly contaminated waste Goal: the permanent and sustainable exclusion of the contaminants from the biosphere
Technical capacity	metric t / year
UTD Herfa-Neurode	200.000
UTD Zielitz	40.000

Herfa-Neurode - Prerequisites

Based on Technical Instructions, resp. Landfill Ordinance

- Storage of waste requires a disused, excavated area of a mine, remote from the mineral extraction part.
- The area, in which waste is to be deposited, has to be able to be sealed off from the area where extraction is taking place.
- The cavities resulting from mineral extraction have to remain open. There must be no backfill obligation.
- The mined cavities have to be stable, they must remain accessible even after a prolonged time.
- The mine, in which the waste is stored, has to be dry and free of water.
- The cavities, in which the waste is stored, have to be sealed off from water-bearing layers.

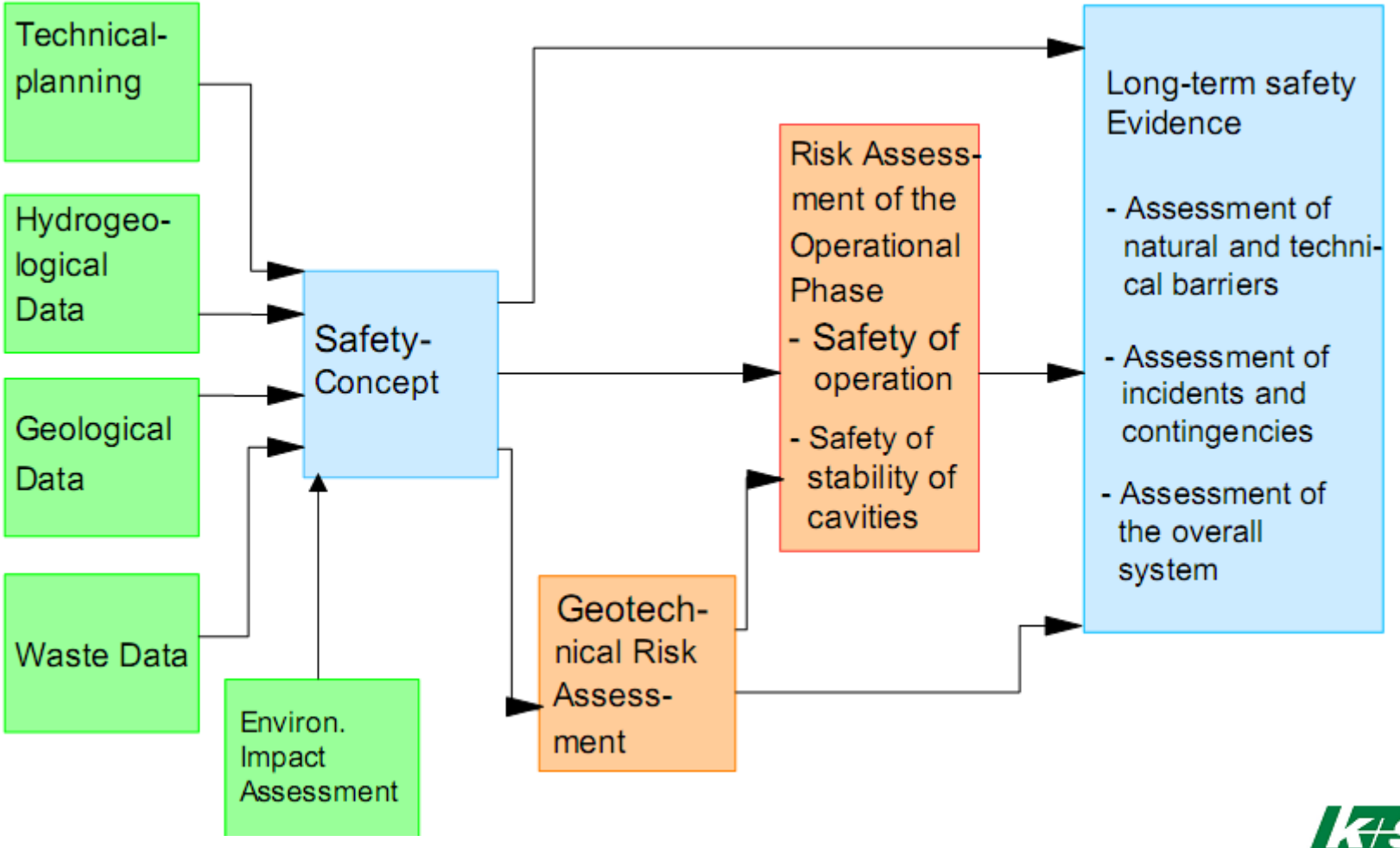
Herfa-Neurode – Exclusion Criteria

Based on Technical Instructions, resp. Landfill Ordinance

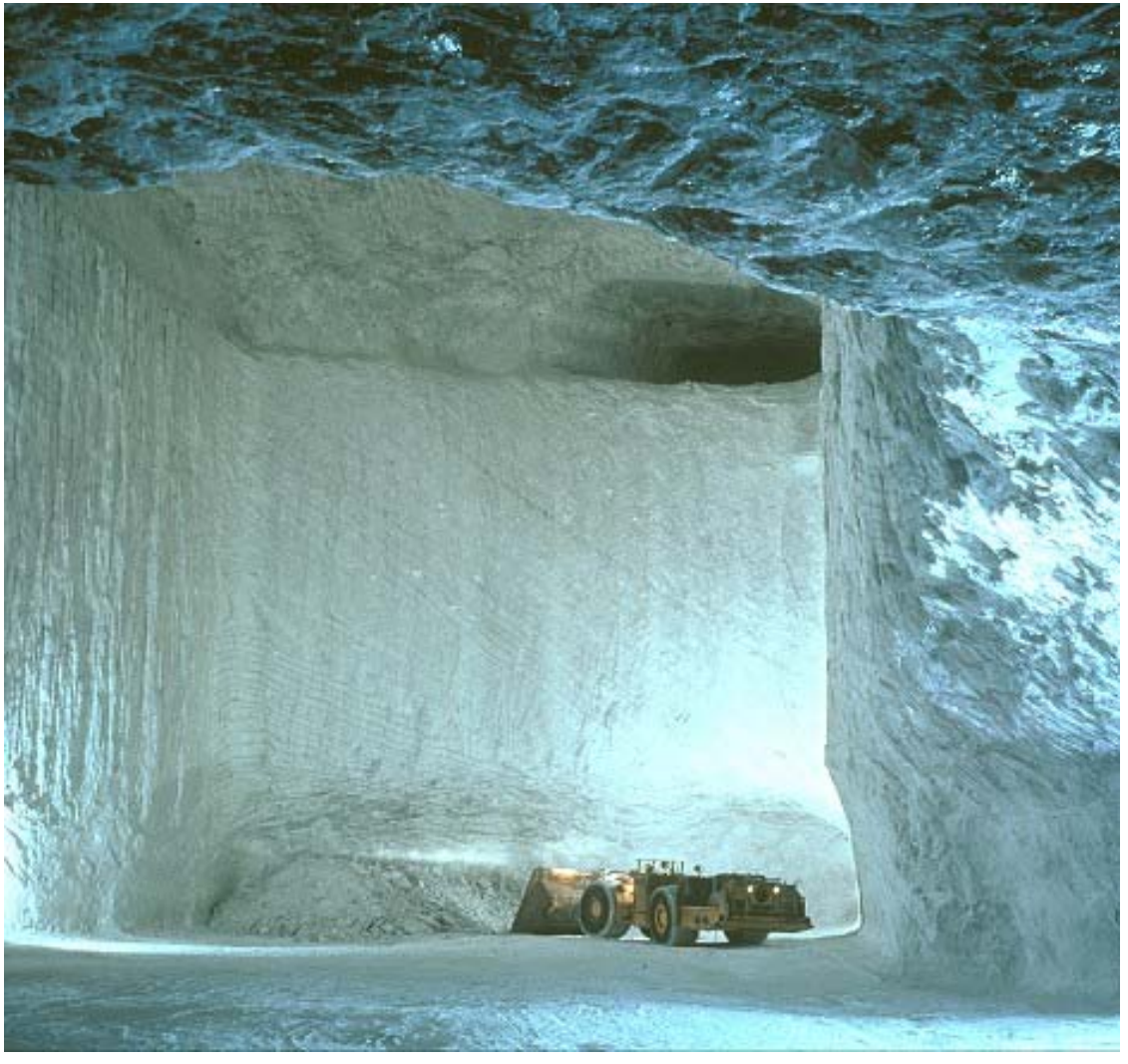
Not acceptable for the underground disposal
are wastes which:

- are explosive
- are self inflammable
- are spontaneous combustible
- are infectious
- are radioactive
- are releasing hazardous gases
- are liquid [to be modified for fluid Mercury]
- bearing risk of increasing their volume

Site Specific Safety Assessment (Herfa-Neurode)



Underground Cavity in Rock Salt



Herfa-Neurode – Operational Photos

Important Regulations on Underground Disposal

- **Technical Instructions on Waste (1991 - D)**
  - Underground disposal of hazardous waste, site specific proof of long-term safety is mandatory, waste specific requirements and exclusion criteria
- **Council Directive on the Landfill of Waste (1999 – EU)**
  - Key piece of EU-legislation in the field of waste disposal
- **Landfill Ordinance – DepV (2002 - D)**
  - Instructions on the maintenance of long-term safety records within the context of site-related safety assessments for mines in salt rock (currently under revision)
- **Council Decision on Criteria and Procedures (2003 – EU)**
  - Objectives and requirements

+ Environmental Impact Assessment

EC Criteria for Underground Disposal (1)

Council Decision 2003/33/EC establishing criteria and procedures for the acceptance of waste at landfills

- **Criteria for underground storage**

- A site-specific safety assessment as defined in **Annex A**

- **Importance of geological barrier**

- Ultimate objective of **underground storage =** Isolation of wastes from the biosphere

- Wastes + geological barrier + cavities + engineered structures + technical aspects must fulfill the corresponding requirements

EC Criteria for Underground Disposal (2)

Council Decision 2003/33/EC establishing criteria and procedures for the acceptance of waste at landfills

- **The site-specific assessment of risk requires the identification of:**

- The hazard (deposited wastes)
- The receptors (biosphere and possibly groundwater)
- The pathways by which substances from the wastes may reach the biosphere
- The assessment of impact of substances that may reach the biosphere

EC Criteria for Underground Disposal (3)

Council Decision 2003/33/EC establishing criteria and procedures for the acceptance of waste at landfills

- **An integrated performance assessment analysis, including:**

- Geological assessment
- Geomechanical assessment
- Hydrogeological assessment
- Geochemical assessment
- Biosphere impact assessment
- Assessment of the operational phase
- Long-term assessment
- Assessment of the impact of all the surface facilities at the site

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 ?

ANNEX

Supplementing informations

Preamble to 1102/2008 (1)

Regulation (EC) No 1102/2008 on banning of exports and safe storage of metallic mercury

- Mercury releases are recognized as a **global threat**
- Necessity to **reduce the risk of exposure** to mercury for humans and the environment
- The **export** of metallic mercury, … from the Community **should be banned** in order to significantly reduce the global mercury supply
- The **safe storage** within the Community of this mercury should be ensured
- The safety assessment required for underground storage (Decision 2003/33/EC) should be complemented by **specific requirements** and should also be made applicable to non-underground storage

Preamble to 1102/2008 (2)

Regulation (EC) No 1102/2008 on banning of exports and safe storage of metallic mercury

- The storage conditions in a salt mine or in deep underground, hard rock formations, …, should notably meet the principles of **protection of groundwater** against mercury, prevention of vapor emissions of mercury, impermeability to gas and liquids of the surroundings and - in case of permanent storage - of **firmly encapsulating** the wastes at the end of the mines' deformation process
- The above-ground storage conditions should notably meet the principles of **reversibility** of storage, **protection** of mercury against meteoric water, impermeability towards soils and prevention of vapor emissions of mercury
- The above-ground storage of metallic mercury should be considered as a **temporary solution**

German Ordinance on Landfills (1)

Annex 2: Instructions on the maintenance of long-term safety records

General:

- Objective = complete and permanent sealing of waste from biosphere
- No impairment of the biosphere – proof by long-term safety record
- Salt rock in adequate spread and thickness = barrier rock
- Further geological barriers = additional protection (not compulsory)
- Penetrations of geological barrier (e.g. shafts) must be sealed (acc. to latest state of the art)

German Ordinance on Landfills (2)

Annex 2: Instructions on the maintenance of long-term safety records

Long-term safety:

- Based on
  - Safety Concept
  - Record of Geotechnical Stability
  - Safety Record for the Operational Phase
- Comprises entire system: ‚Waste - Underground Mine - Rock Body‘
- Due regard for scheduled and non-scheduled incidents (scenarios)
- Proof of complete enclosure dispenses from model calculations on pollutant disseminations in the overburden

German Ordinance on Landfills (3)

Annex 2: Instructions on the maintenance of long-term safety records

Required Basic Informations:

- Geological conditions
- Informations about the drifts
- Hydrogeological conditions
- Emplacement of waste

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

Source: BGR

Conclusions on Mercury

- Metallic Hg is stable under the conditions of repositories in salt formations
- The high vapor pressure of metallic Hg poses high demands on the handling and ventilation
- Contact with brines: Solubility of Hg(0) is low, but higher Hg concentrations must be expected due to impurities with higher solubilities
- Conversion into Hg-sulfides is feasible. The benefit is dependant on the form and mass of impurities
- Specific waste acceptance criteria need to be determined
- Containment is important

Citations (1) - EC

- Regulation (EC) No 1102/2008 of the European Parliament and of the Council of 22 October 2008 on the banning of exports of metallic mercury and certain mercury compounds and mixtures and the safe storage of metallic mercury - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:304:0075:0079:EN:PDF

- 2003/33/EC: Council Decision of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:011:0027:0049:EN:PDF

- Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste - http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=31999L0031&model=guichett

Citations (2) - DE

- 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
- 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
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