# ENGINEERED BARRIER SYSTEMS

## Multi-barrier systems in geological disposal

14th Sept 2020 • Philipp Herold (BGE TECHNOLOGY GmbH)

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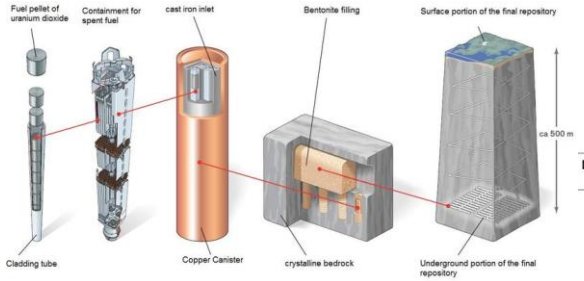


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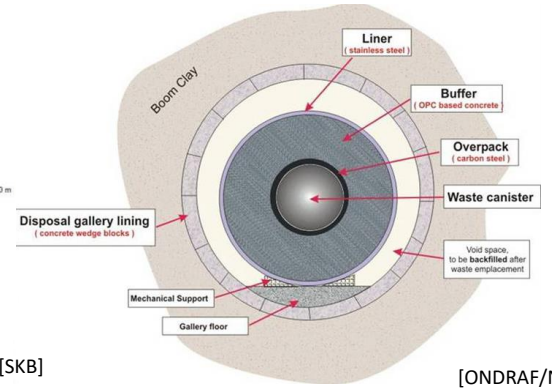


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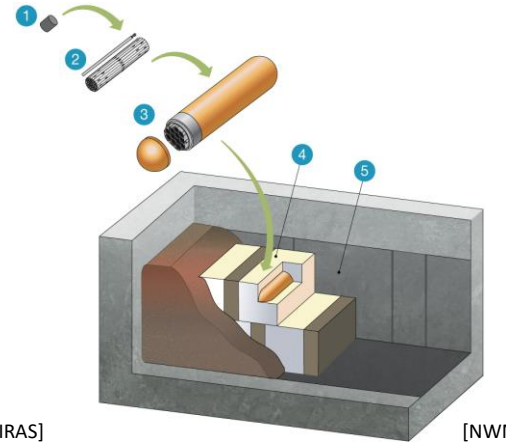


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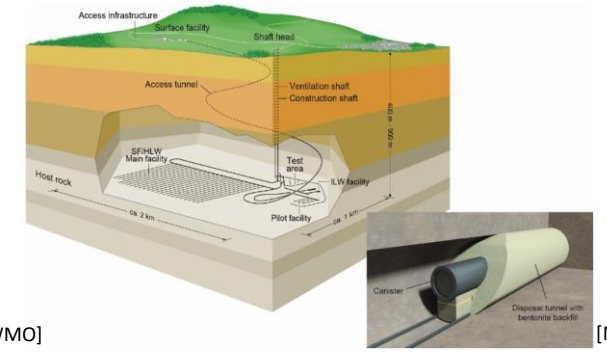


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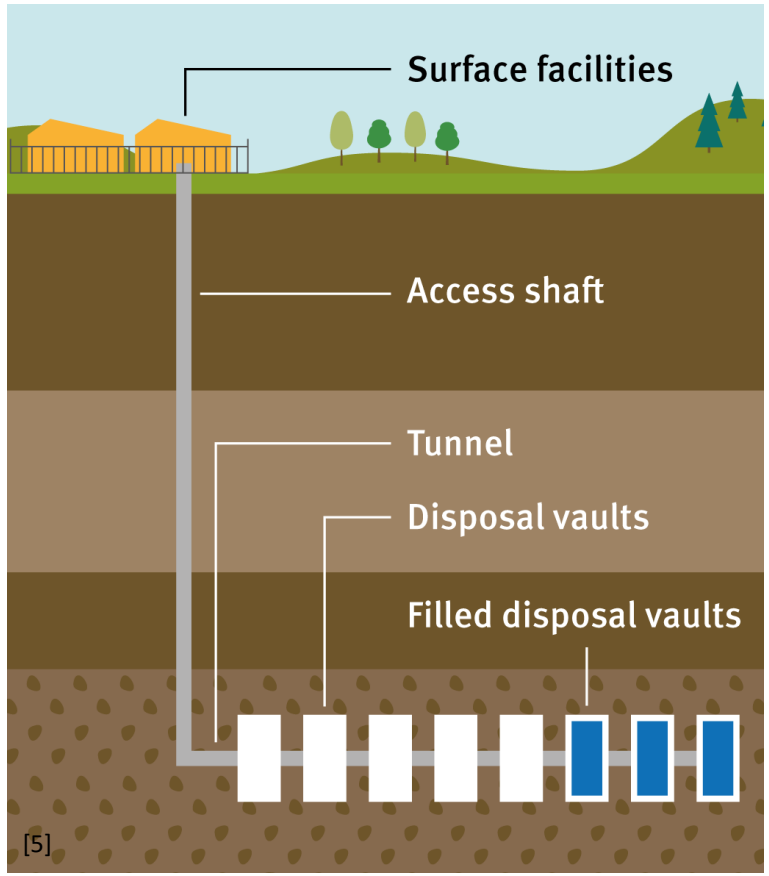
- **Deep geological nuclear waste repositories are based on the concept of a multi-barrier system**
- **Today's focus: functions, materials and technical solutions of EBS in different repository concepts**

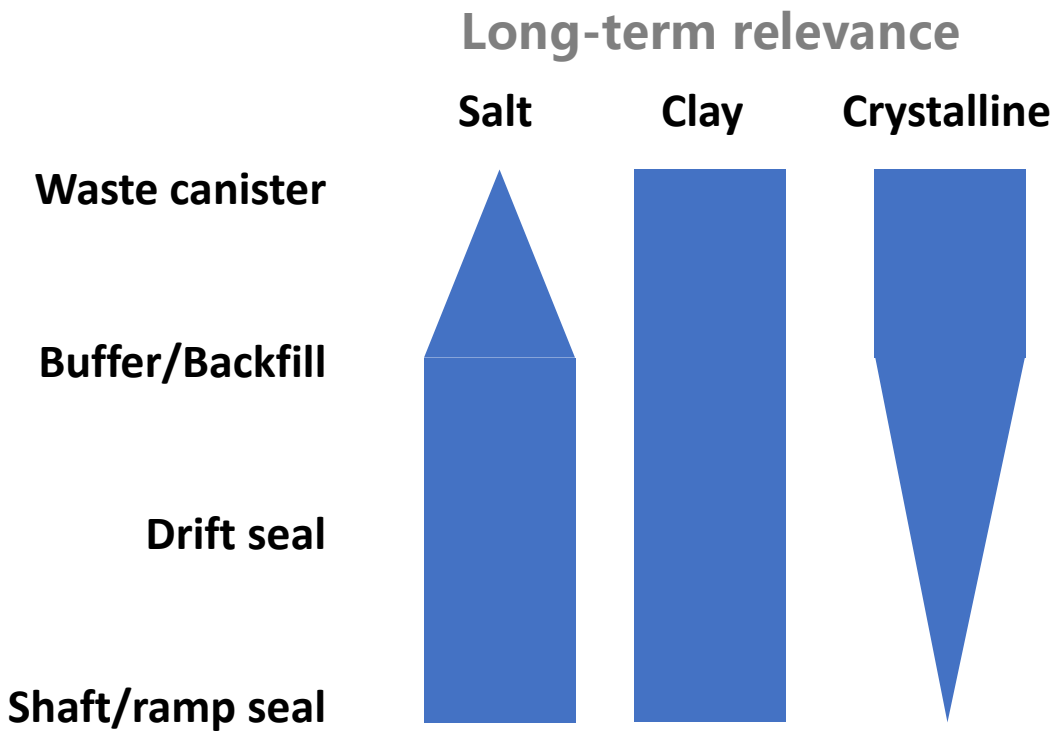
# MULTI-BARRIER SYSTEM

- Contain and isolate the waste from the biosphere as a general goal
- Host rock and overlying formations represent the natural barrier
- In most concepts important barrier with long-term sealing function
- In addition, Engineered Barrier Systems (EBS) as technical/man-made components
- Important part of the near field



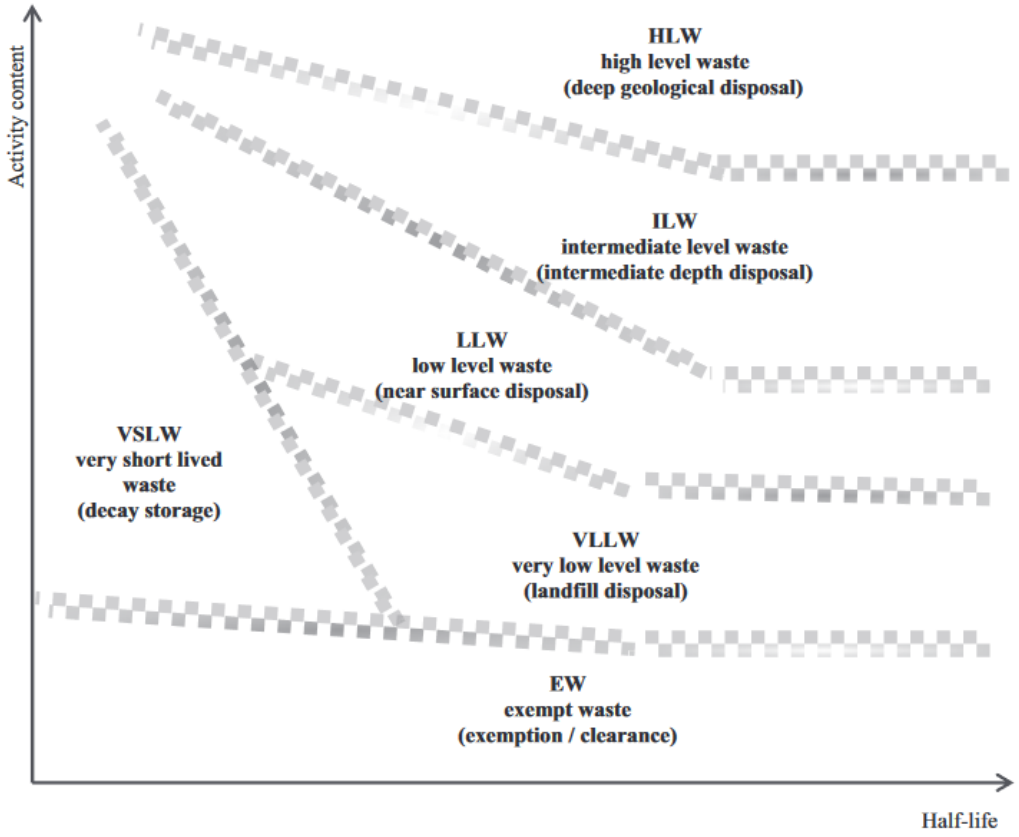
# ENGINEERED BARRIER SYSTEMS (EBS)

- **Components: waste forms, waste canisters, buffer, backfill material and seal**
- **Functions:**
  - radionuclide containment/retention and retardation of radionuclides
  - physical, chemical, hydraulic and biological isolation
  - Minimize flow processes/control gas generation and transport
- **Importance for long-term safety varies between host rock and national concepts**



# WASTE FORMS

- Main functions: provide a stable matrix to resist leaching and give slow rates of radionuclide release as well as of other toxic parts
- Strong dependance on the waste class that has to be disposed
- For deep geological disposal, more or less given boundary condition and difficult to adapt or influence




[IAEA]

# WASTE CANISTERS OR OVERPACKS

- **Main functions:**
  - Facilitate waste handling, emplacement
  - Provide containment for a defined long period
  - Facilitate retrieval
- **Relevance for long-term performance varies between host rock and disposal concept**
- **E.g. disposal in salt formations in Germany, waste canister has no significant long-term function**
- **E.g. Scandinavian KBS-3 concept, waste package and buffer with main barrier function**


[BGETEC]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# SHIELDED OR UNSHIELDED DESIGN AS SIGNIFICANT ASPECT OF OPERATIONAL SAFETY

- **Shielded waste packages**
  - Increased size and weight of the DWPs
  - Offer advantages during handling (transport and emplacement)
- **Unshielded waste packages**
  - Allow design of smaller DWPs
  - Additional technical measures for radiation protection needed, e.g. transfer package


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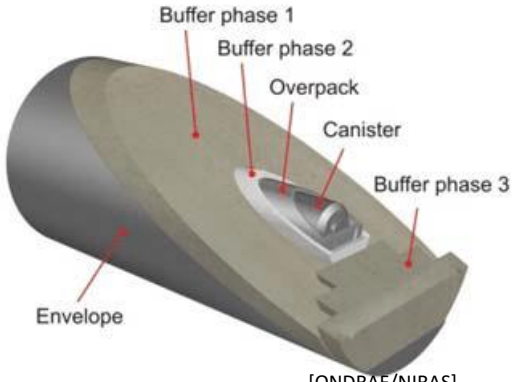

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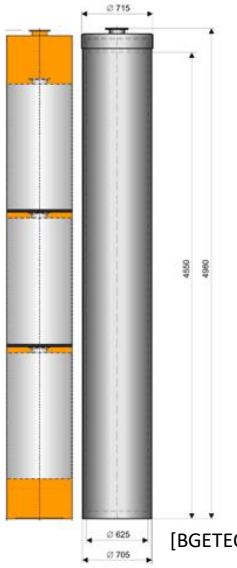
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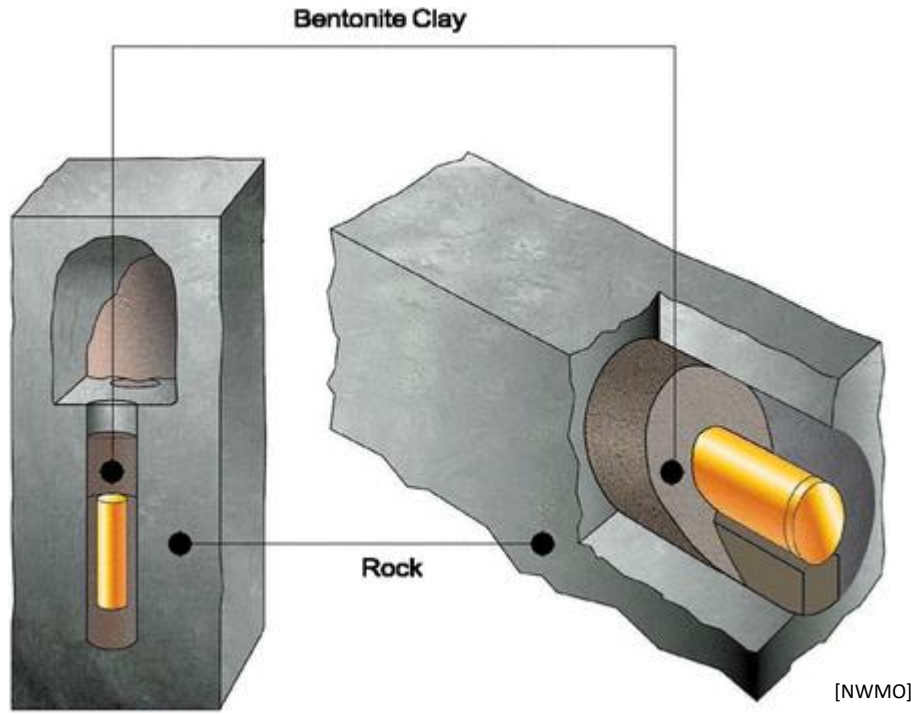
# BUFFER AND BACKFILL

- **Main functions:**
  - Stabilize excavations (mechanically)
  - Stabilize thermo-hydromechanical-chemical conditions
  - Provide low permeability and/or diffusivity
  - Retardation of radionuclide migration

- **Buffer –next/close to the waste packages**
- **Backfill – in other excavations and drifts**



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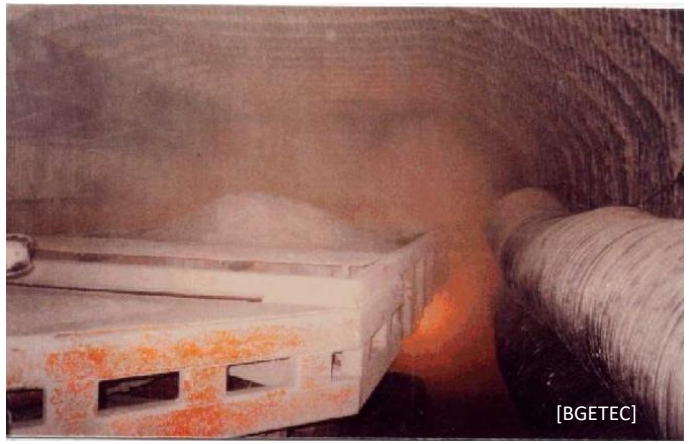
# BACKFILL IN ROCK SALT FORMATIONS

- Crushed rock salt from excavation
- Material similar to host rock
- Thermal impact of the waste and convergence of the rock produce properties similar to host rock
- Provides long-term sealing function in addition to natural barrier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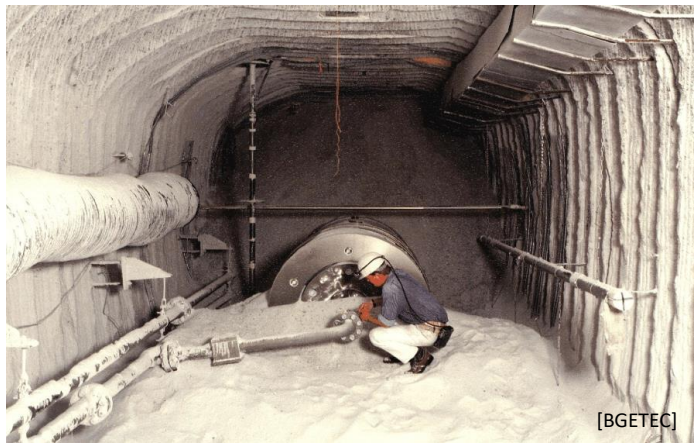
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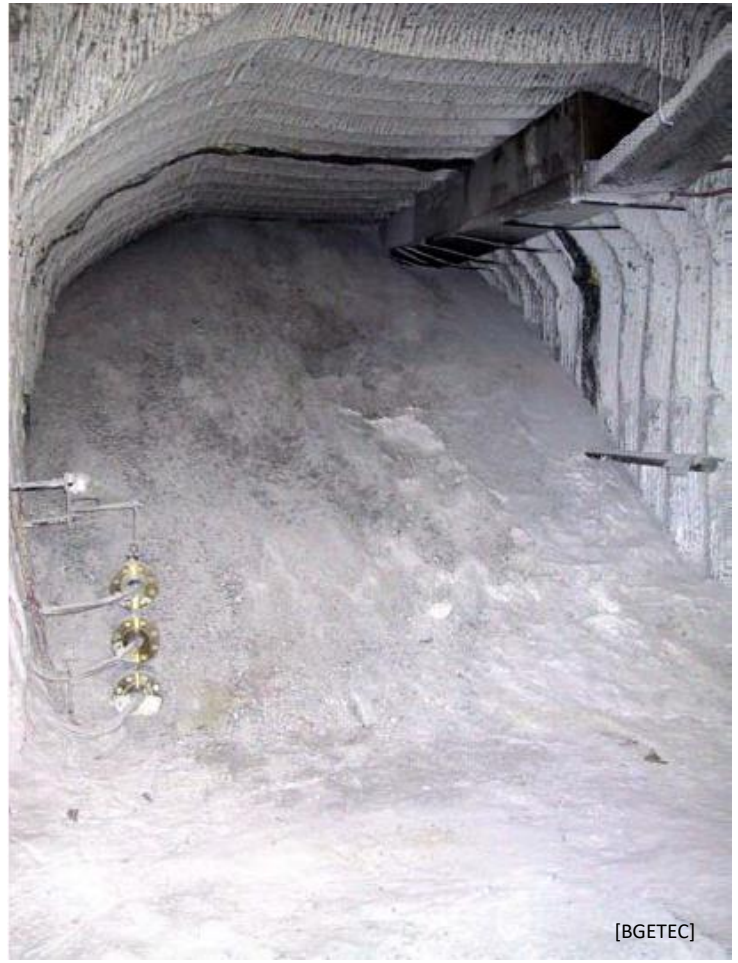
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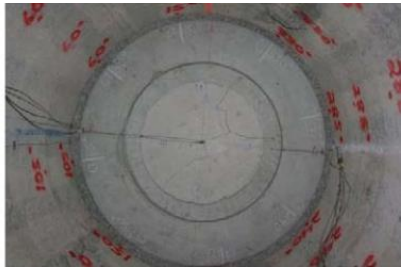
# BUFFER IN CLAYSTONE AND CRYSTALLINE

- **Clay-based materials such as bentonite**
- **Pure or as mixtures of bentonite and sand or excavated material**
- **Important properties:**
  - Swelling pressure and low permeability
  - Sorption capacity
  - Easily adaptable by the type of bentonite, mixture and installation technique



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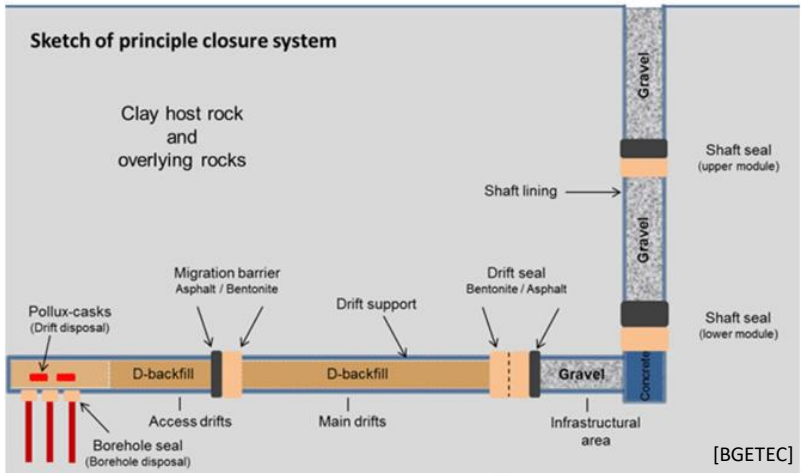
# SEALS GENERAL

- **Main functions:**
  - prevent releases through drifts and shafts
  - prevent access to the repository
- **Importance of retardation and blocked access varies between host rocks**
- **Concrete- and clay-based materials with wide range of properties/compositions**
- **Special materials such as MgO concrete in salt or bitumen/asphalt in German concepts**



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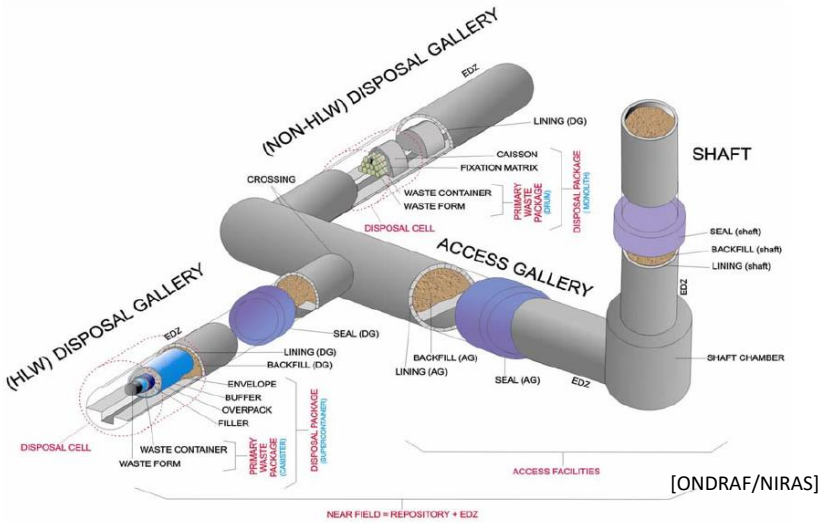

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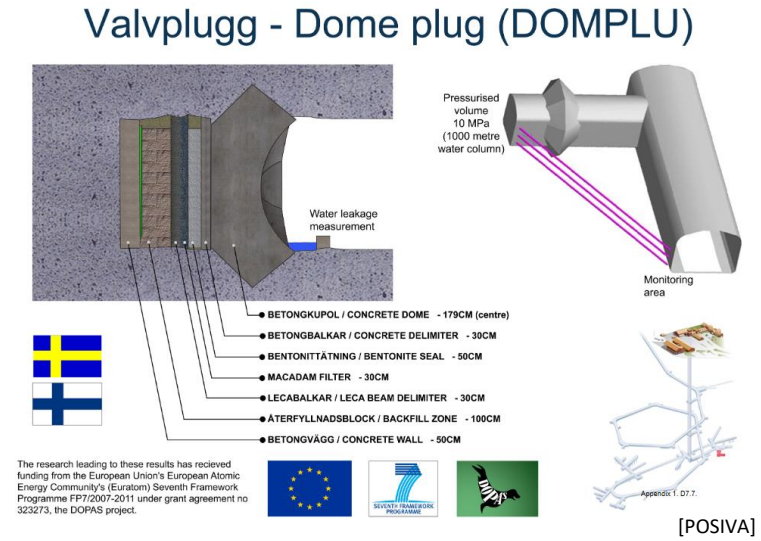
# SEALS IN DRIFTS

- Importance of retardation and blocked access varies between host rocks
- Separate sealing and abutment function
- Bentonite-/clay-based material for sealing function
- Concrete-based materials for mechanical stability



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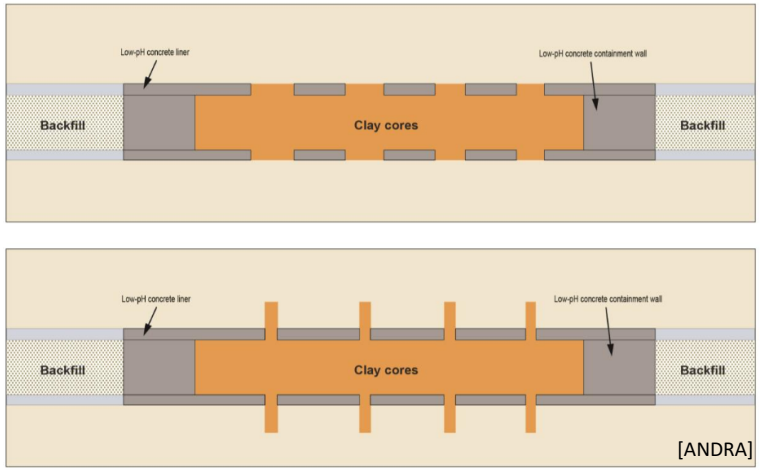
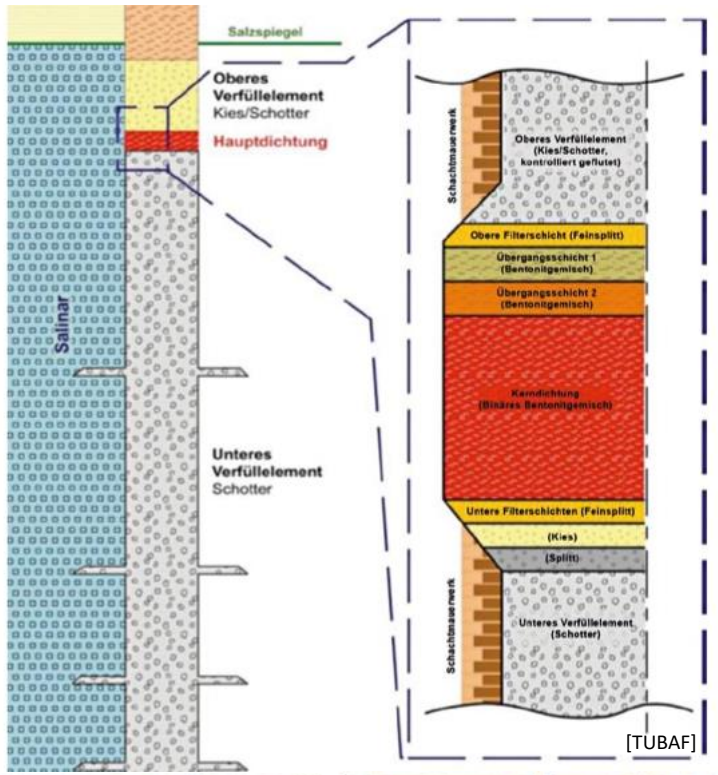


[ANDRA]

# SEALING OF SHAFTS AND RAMPS

- **Importance of retardation and blocked access varies between host rocks**
- **For salt major technical barrier to separate surface and subsurface**
- **For crystalline blocked access more relevant**
- **Material and locations adapted to geologic profile**
- **Wide range of materials:**
  - Bentonite and clay-based materials
  - Concrete-based materials
  - Crushed rock (salt)
  - Gravel (filling columns) and sand (e.g. filter layers)
  - Organic materials such as bitumen/asphalt (in Germany)



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# SUMMARY

- **Multi-barrier systems include host rock as natural barrier (far field) and engineered barrier systems as technical barriers (near field)**
- **Waste form, waste canister, buffer/backfill and seals as main components**
- **Contain and isolate the waste from the biosphere as a general goal**
- **Materials and designs of the EBS depend on the host rock and the actual repository concept**
- **General/overall literature:**
  - IAEA SSR5: Disposal of Radioactive Waste
  - OECD NEA « Engineered Barrier Systems and the Safety of Deep Geological Repositories - State-of-the-art Report"