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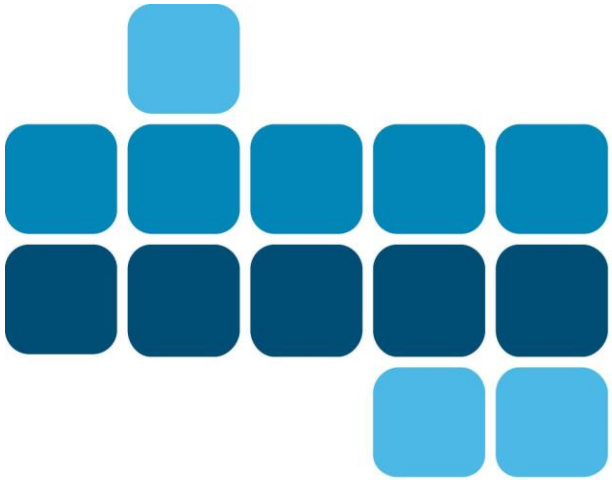

ENTRIA

ENTSORGUNGSOPTIONEN FÜR RADIOAKTIVE RESTSTOFFE:
INTERDISZIPLINÄRE ANALYSEN UND
ENTWICKLUNG VON BEWERTUNGSGRUNDLAGEN

Monitoring requirements for deep geological repositories with retrievability

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Outline

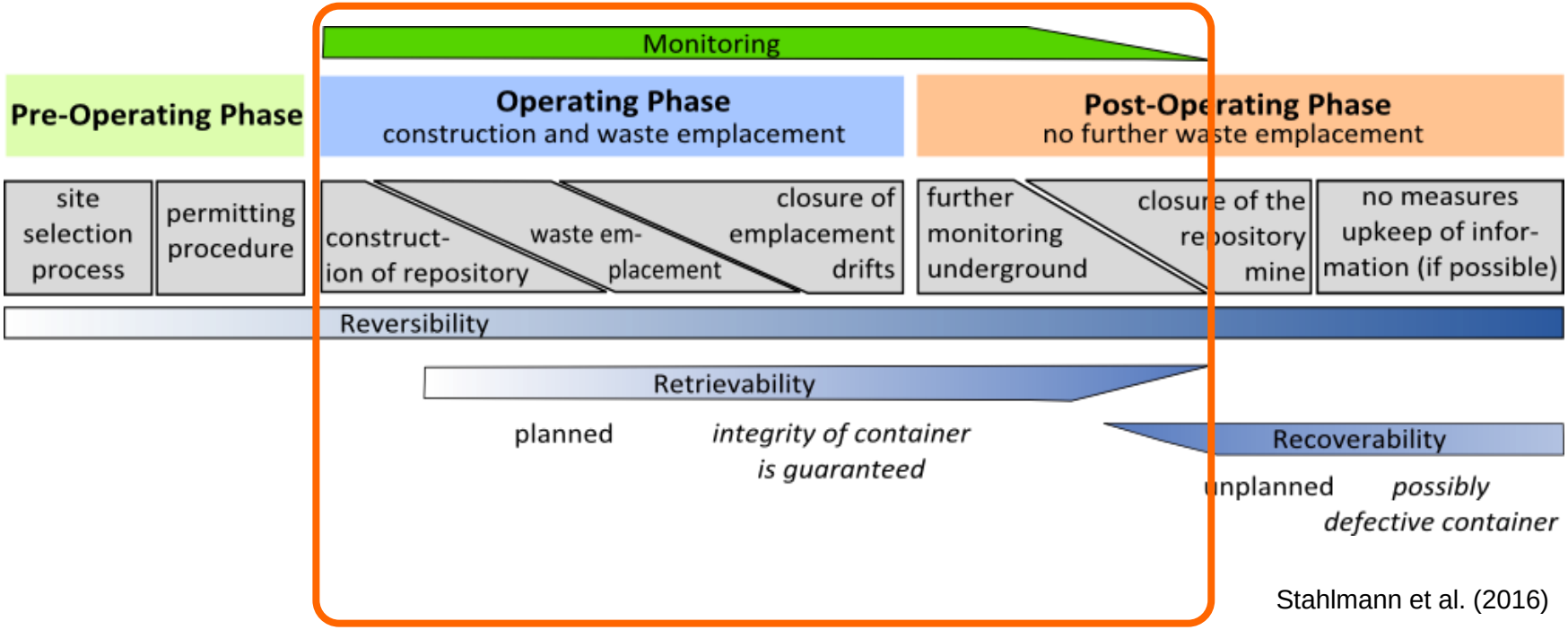
- Why geotechnical Monitoring?
- Generic Model for deep repository models
- Host rock properties
- Questions to be answered by a monitoring program
  - Monitoring Scenario
  - Examples of near-field monitoring
- Conclusions

Why geotechnical Monitoring?

- Gather data about the state of the repository system
- Verify models
- Confidence in the repository system
- Basis of decision if closure or retrieval

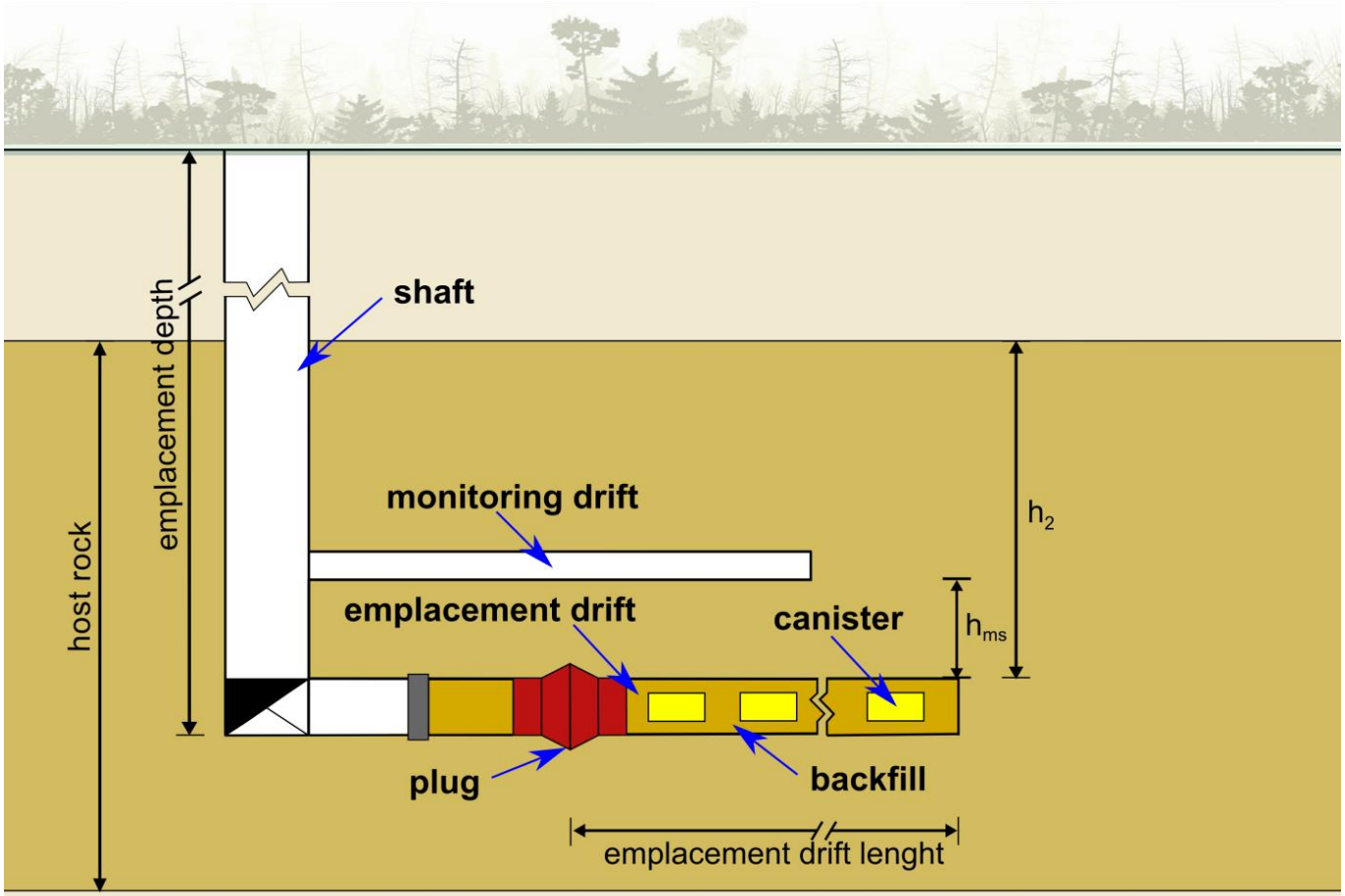
Monitoring in the life-cycle of a deep geological repository

- Monitoring starts at the beginning of the operational phase of the repository.
- Monitoring ends at closure of the repository mine.

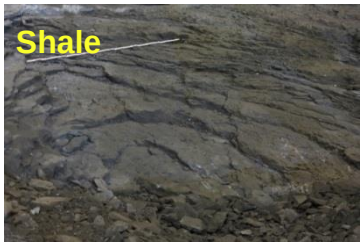


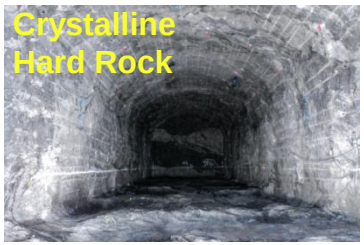
Stahlmann et al. (2016)

Generic Model for a deep geological Repository



Stahlmann et al. (2016)





Goals of the generic deep repositories

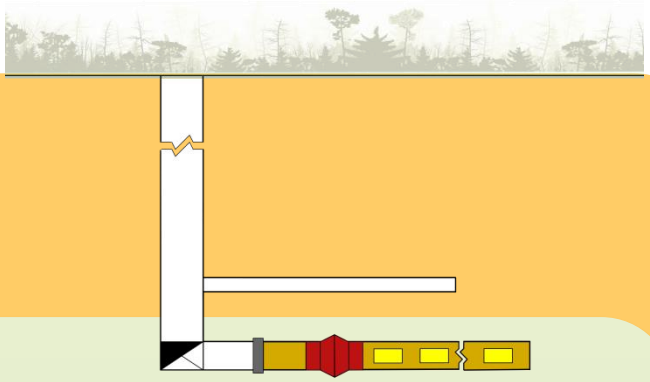
Long-term Safety

- Hardly any loss of integrity at the geological and geotechnical barriers

Accessibility of the HAW & Operational Safety

- Radiation Protection
- Protection against heat
- Stability of underground openings

Measures to goal achievement



Deep repository system

Monitoring drifts are kept open

Underground infrastructure is kept open

Emplacement drifts: Plug and Sealing Structure

Seal

Abutment

Reduction of stress rearrangement

Backfill

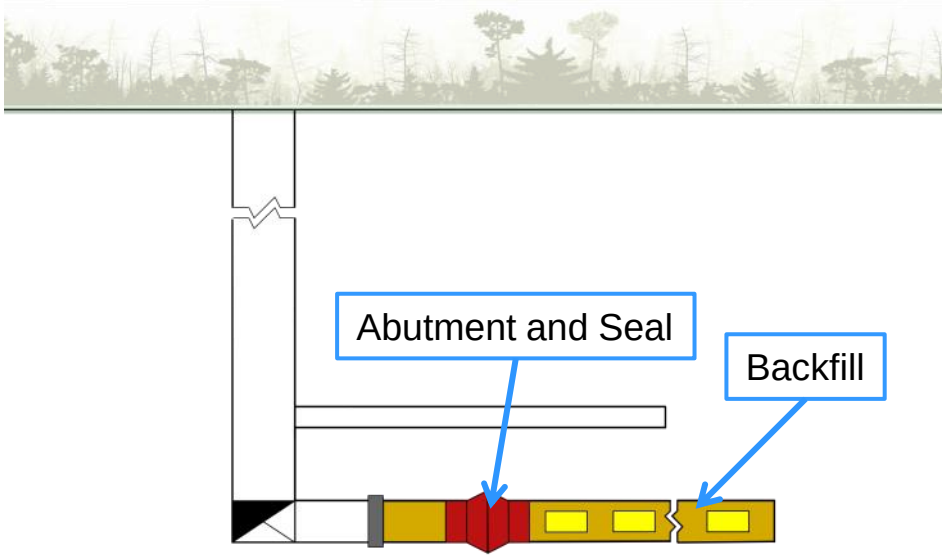
Minimize underground openings

Radiation protection

Protection against heat production

Generic Model: Host Rock Systems

	Clay	Shale	Crystalline Hard Rock	Rock Salt
Backfilling	Bentonite based			Crushed salt
Abutment	Low-pH concrete			Salt concrete
Seal	Bentonite based			



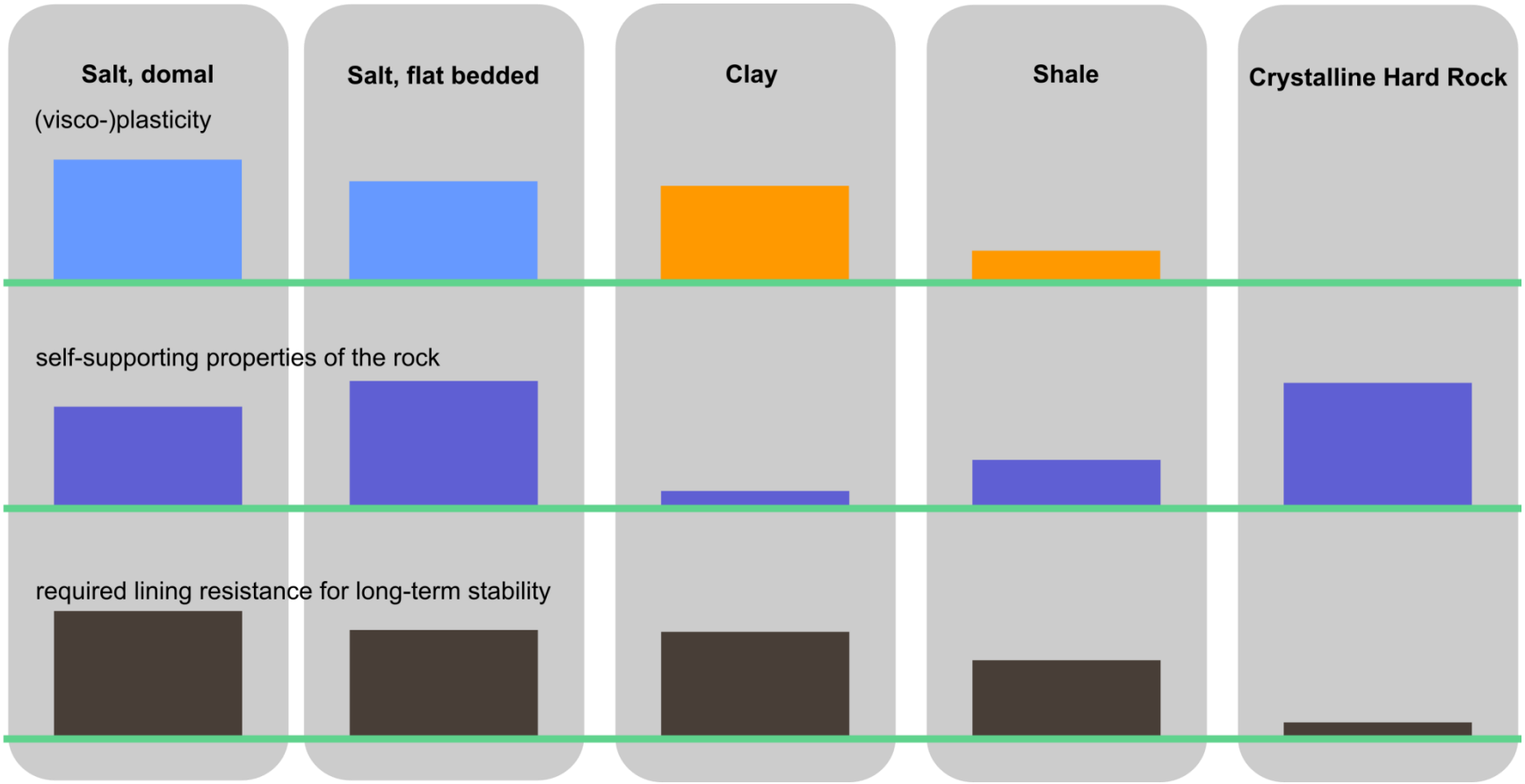
Main Properties of Host Rock

Property	Rock Salt	Clay	Shale	Crystalline Hard Rock
Primary state of Stress	isotropic	slightly anisotropic	anisotropic	anisotropic
Plasticity and creep ability	creeping	plastic / creeping	slightly plastic	brittle
Joint system	no open joints	latently joints	highly fissured	joint system
Long-term self-supporting properties of host rock	low	low	moderate	high
Convergences	high	high	moderate	very low
Excavation Damage Zone (EDZ)	big	big	big	small
Groundwater in repository	none	stagnating ground water	stagnating groundwater, possible flow paths on joints	joint aquifer

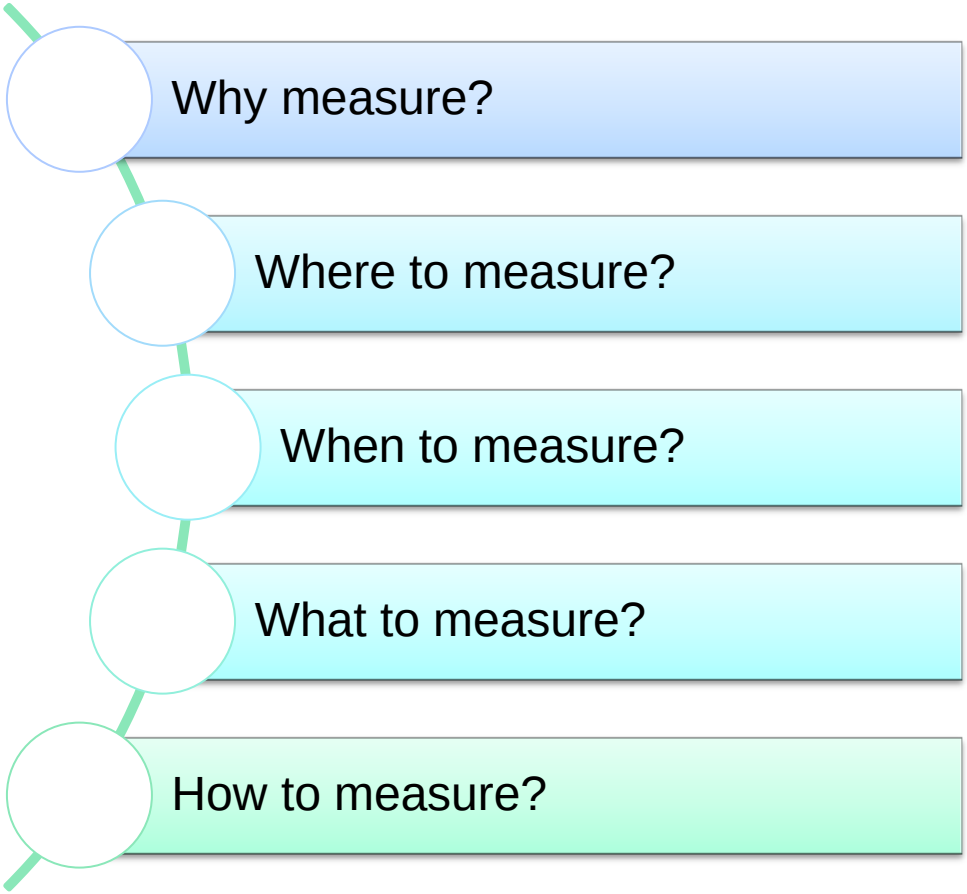
operational safety

long-term safety

Host rocks: differences regarding retrievability



Five Questions to be answered in a Monitoring program



according to MoDeRn (2011)

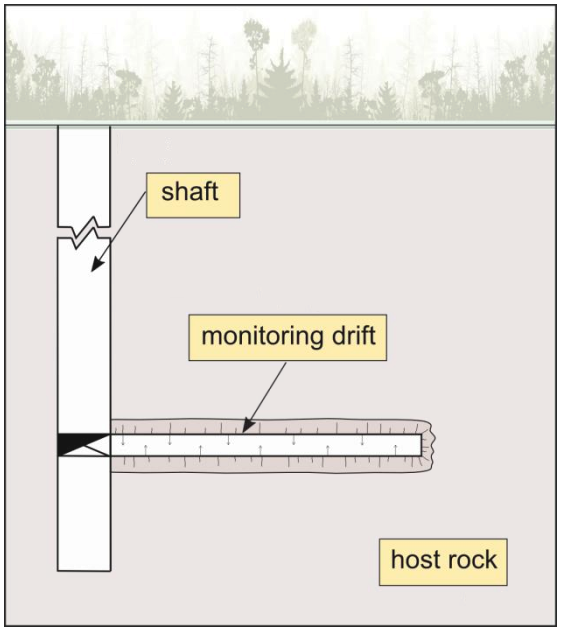
Why to measure? Model verification

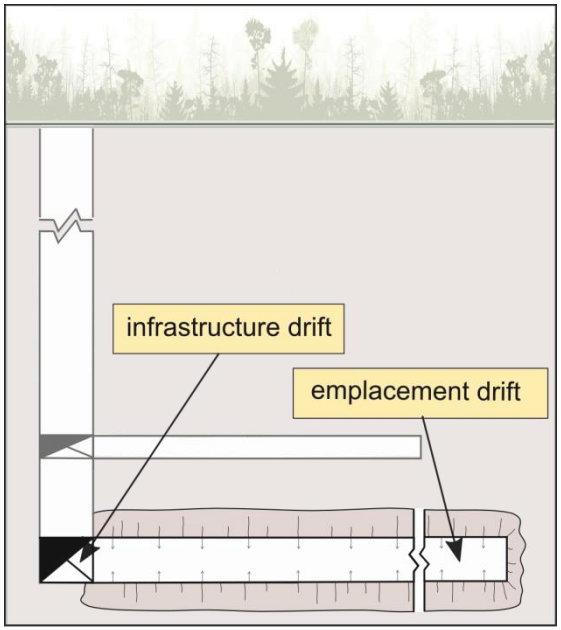
- Salt: dry repository mine
- Clay: little formation water, no groundwater flow
- Shale: Little formation water, groundwater flow may be possible on fissures
- Crystalline Hard Rock: groundwater

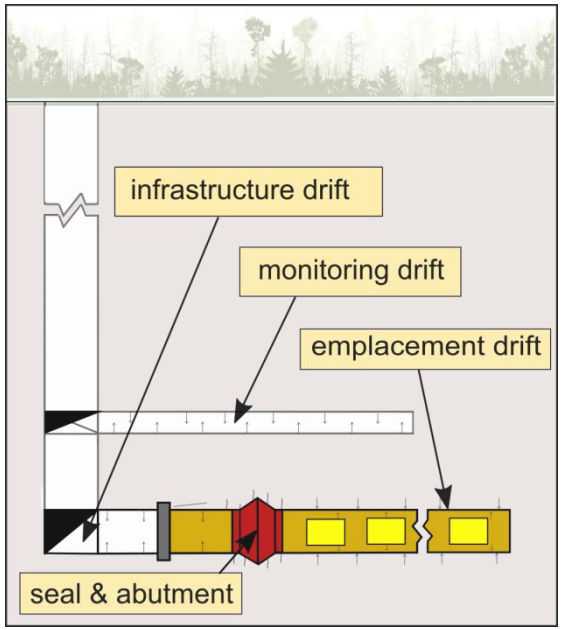
→ Hardly any loss of barrier integrity

↓ Monitoring help to prove if the repository system develops as expected

Where and when to measure?





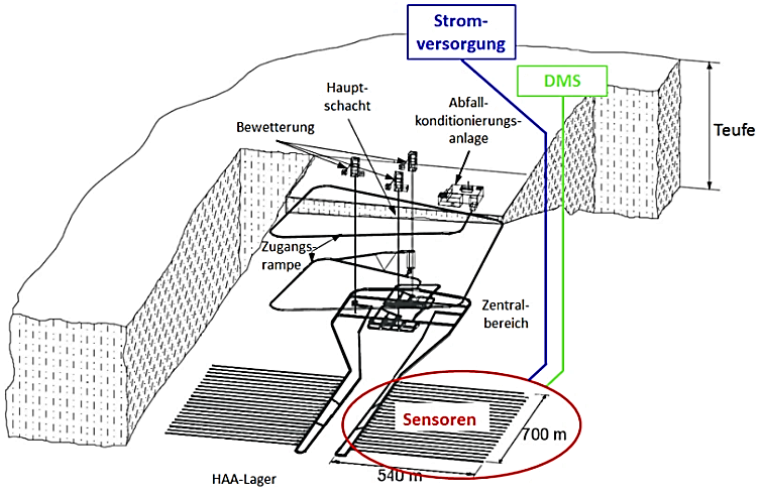


Where: Infrastructure drifts are directly accessible; Sealing structure and backfilled emplacement drift are not directly accessible

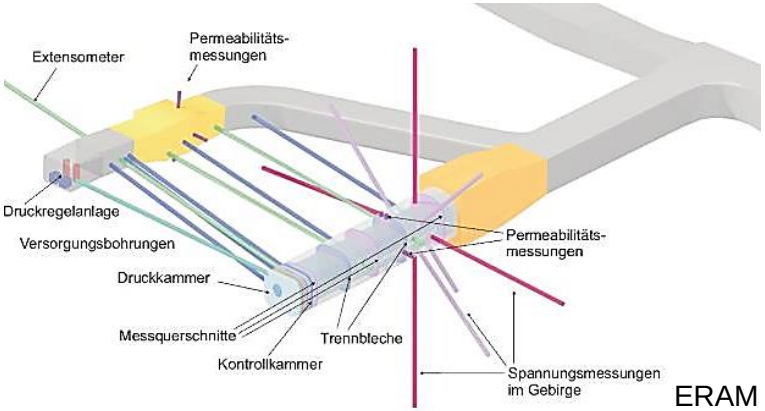
When: to obtain reference values:
At the excavation beginning of each drift

Time and place limitations

- reliability of sensors
  - defective sensors can lead to wrong data
  - change possibility is required
- data transfer
  - wireless technology available, only short distances possible
- energy (for more than 10 years)
  - stand-alone power supply is not available
    - → Cables required from the surface
  - no cables through geotechnical barriers

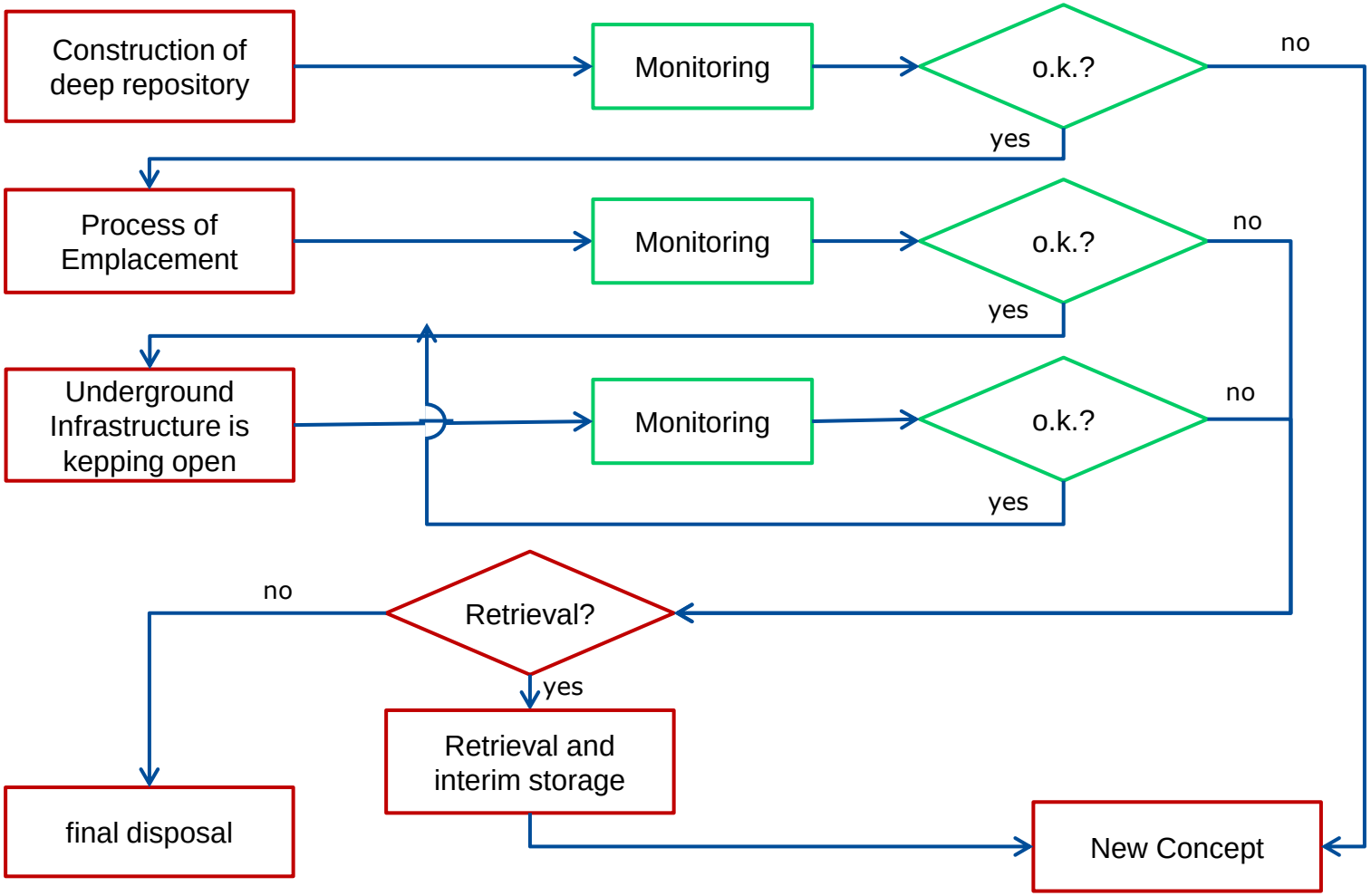


Jobmann et al. (2011)

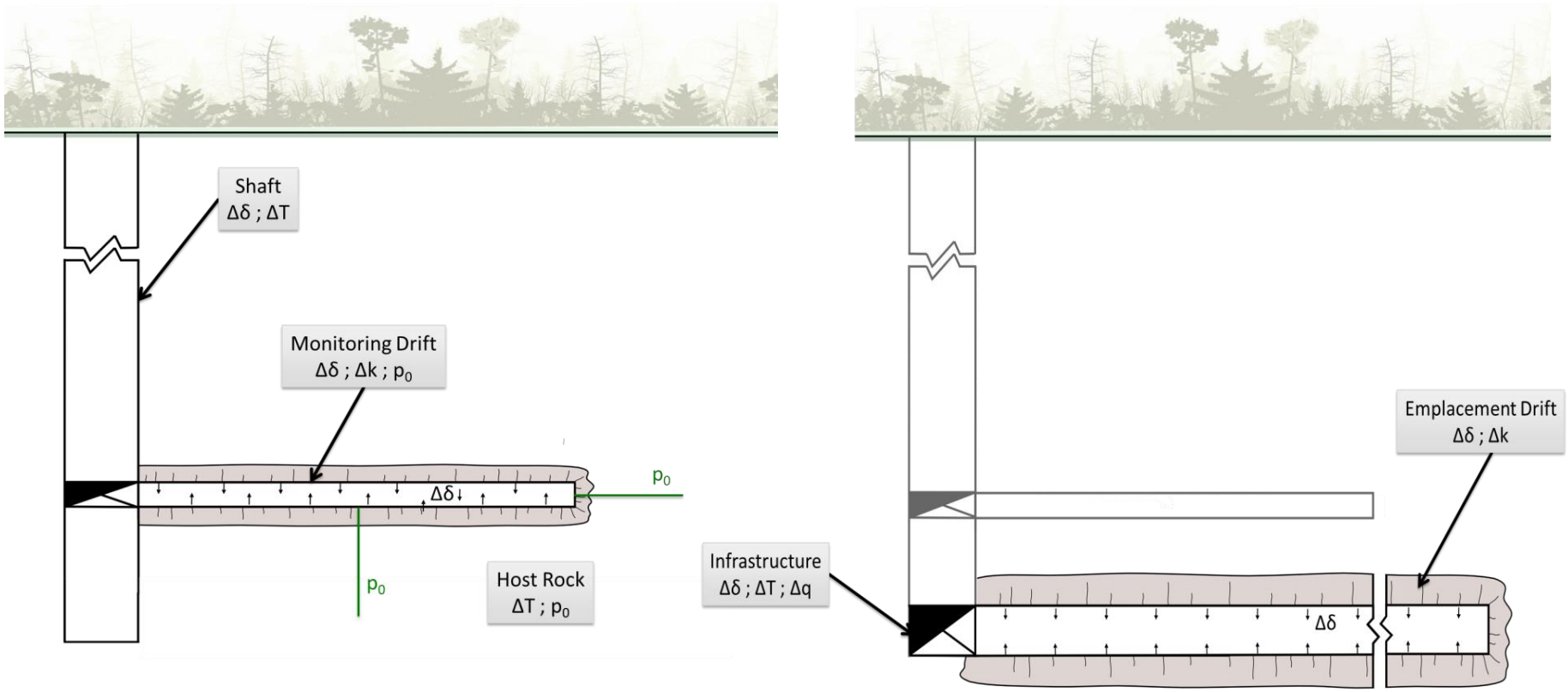


ERAM

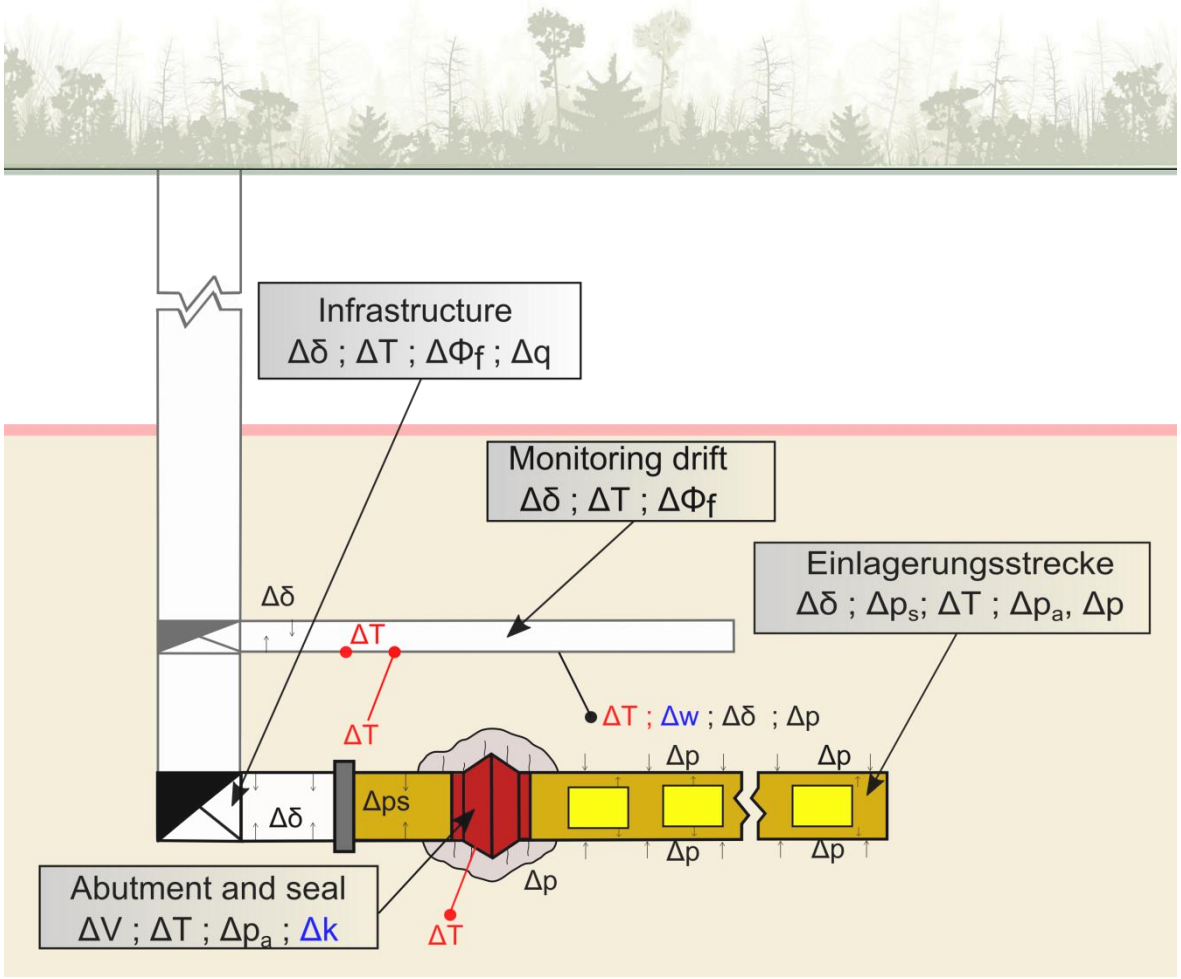
When to measure: Monitoring as a process



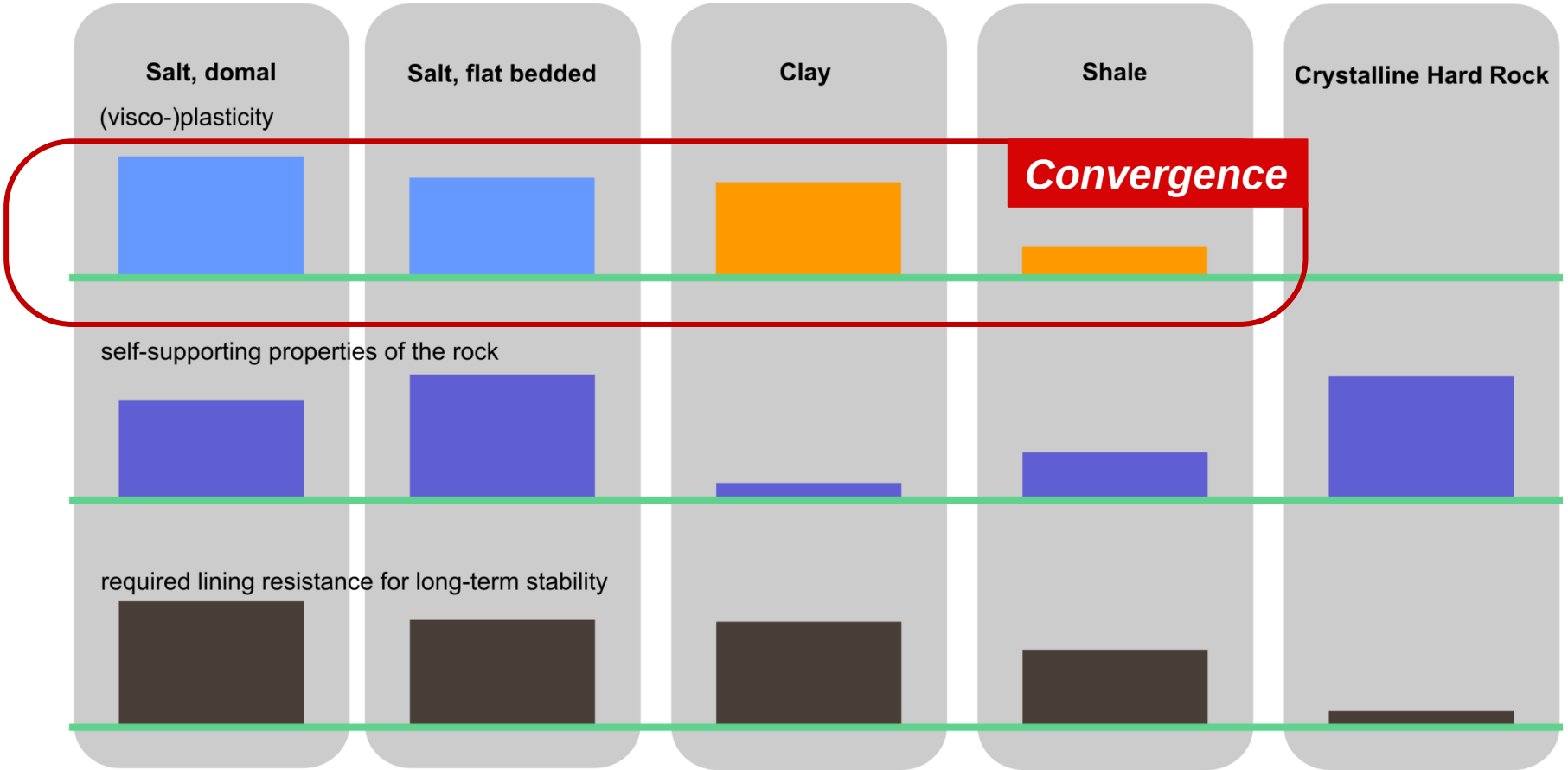
What to measure?



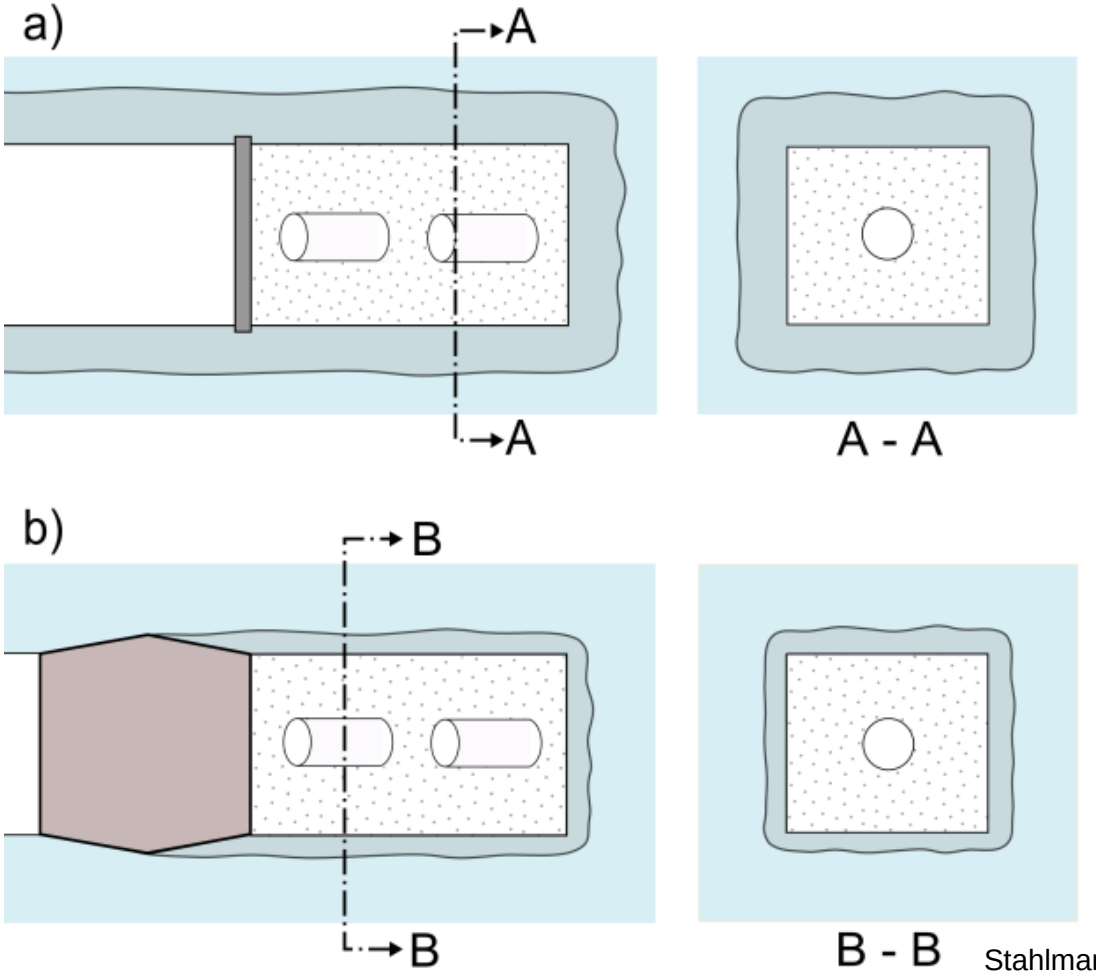
What to measure?



How to measure: differences regarding retrievability



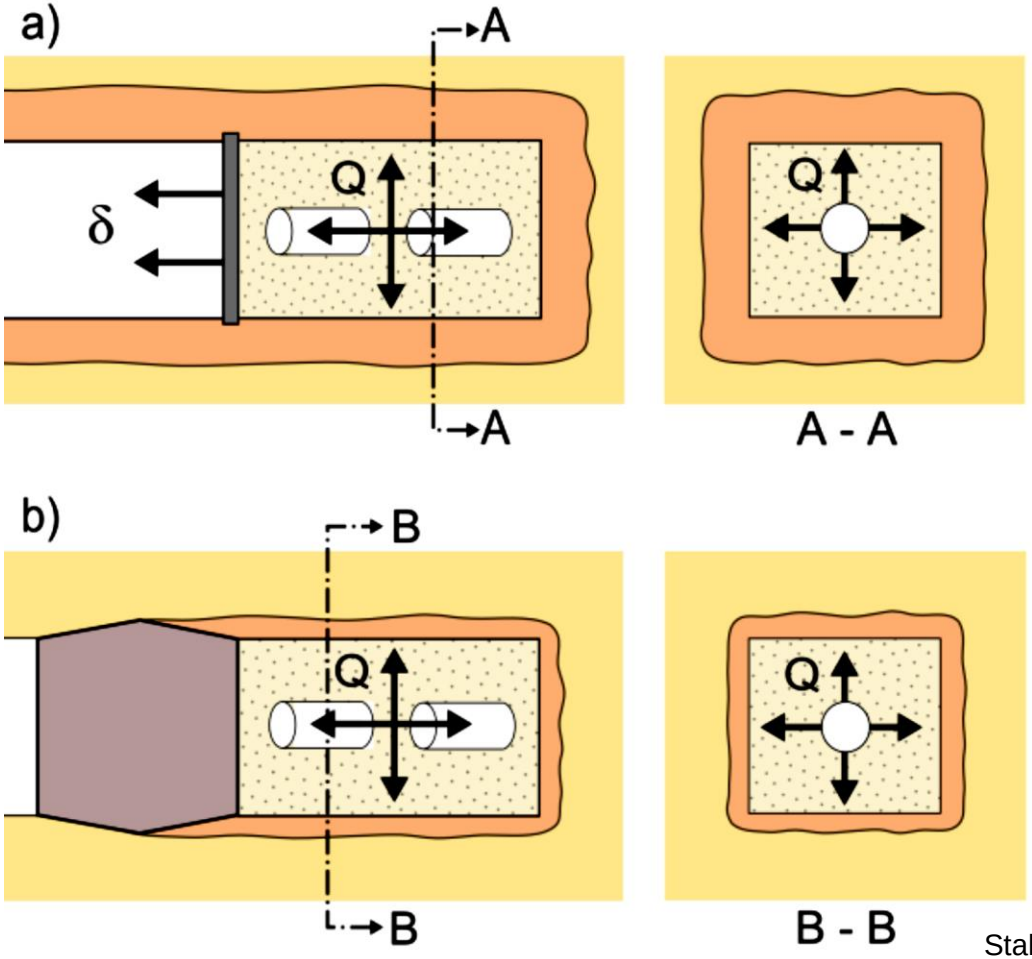
Convergences in emplacement drift



- no stress reduction, EDZ grows as in open drifts
- Abutment reduces stress deviator in emplacement drift
  - reduced convergence in emplacement drift

Stahlmann et al. (2016)

Swelling Pressure in Soft Rock



- Swelling pressure can not built up, as wall displaces; no reduction of stress deviator
- Without displacement of the Abutment, swelling pressure can rise and reduces stress deviator in emplacement drift
  - EDZ does not expand

Stahlmann et al. (2016)

More Aspects of Monitoring

- Up to now, only geotechnical Monitoring was looked upon. Futher aspects to be discussed are:
  - Who will be in charge of monitoring?
  - Who will control the monitoring staff?
  - How will be the data interpreted?
  - How will be communicated these Interpretation?
    - public access to raw data or interpreted data
  - Is there enough interest of the society to proceed a monitoring program?

Conclusions

- Monitoring at deep geological repository is both technical and societal very complex issue
- A compromise between monitoring short-term evaluation and reducing long-term safety need to be found
- Monitoring and retrievability are raising the technical risk of disposal as more open drifts are necessary…
- …but on the other hand, there is the possibility to react immediately if something not expected happens

- www.entria.de

„Beobachten ist gut, solange das Hauptaugenmerk auf "achten" liegt.“
(E. Schumacher)

- **02S9082A**
  02S9082B
  02S9082C
  02S9082D
  02S9082E

GEFÖRDERT VOM
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Literatur

ERAM: http://www.bfs.de/DE/themen/ne/endlager/morsleben/morsleben.html, zuletzt geprüft am 27.10.2016

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Stahlmann, J.; Leon Vargas, R.; Mintzlaff, V. (2016): Geotechnische und geologische Aspekte für Tiefenlagerkonzepte mit der Option der Rückholung der radioaktiven Reststoffe. Bautechnik 93 (2016), No. 3. S. 141-150 Wiley, Weinheim

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