Maintenance experiences from underground facilities in Swedish crystalline rock

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Healthcare, industry and research

Operational waste

Spent fuel

Nuclear power plant

Final repository for short-lived radioactive waste

Central interim storage facility for spent nuclear fuel and encapsulation facility

Final repository for spent nuclear fuel
Safety first!

SAFE DISPOSAL

LONG-TERM ISOLATION AND CONTAINMENT

ISOLATION, RETENTION, RETARDATION, AND DILUTION OF RADIONUCLIDES

FAVOURABLE NEAR-FIELD CONDITIONS

SLOW TRANSPORT IN THE GEOSPHERE

SLOW RELEASE FROM THE SPENT FUEL MATRIX

SLOW DIFFUSIVE TRANSPORT IN THE BUFFER

PROVEN TECHNICAL QUALITY OF THE ENGINEERED BARRIER SYSTEM

FAVOURABLE, PREDICTABLE BEDROCK AND GROUNDWATER CONDITIONS

WEll-CHARACTERISED MATERIAL PROPERTIES

DEPTH

ROBUST SYSTEM DESIGN
Two sites – two facilities

SFR

Äspö Hard Rock Laboratory (HRL)
Facility data

**SFR**
- Final Repository for low and intermediate operational waste
- Construction period 1983 – 1986
- Total length of tunnels and caverns 4 km
- Maximum 150 m below sea level
- Systematic support with bolts and shotcrete in operational and deposition areas
- Selective support in service tunnels
- No gouting in deposition area

**Äspö (HRL)**
- Research facility
- Total length of tunnels 4.2 km, One shaft
- Maximum 450 m below sea level
- Minimum shotcrete to allow geoscientific studies
- Bolts and wire mesh
- Limited grouting to limit disturbance of ground water conditions

*Both facilities are systematically monitored with respect to degradation*
Site conditions - SFR

- Granite. UCS 170 – 210 MPa
- Maximum horizontal stress 12 – 15 MPa at 150 m depth
- Strongly waterbearing faults outside the facility
- Minor faults in the operational area
- Limited inflow in the operational area
- Locally very saline water
Site conditions – Äspö HRL

- Diorite. UCS 180 – 230 MPa
- Maximum horizontal stress 25 – 30 MPa at 450 m depth
- The access cross a major fault at 180 m depth
- The spiral ramp pass through some minor faults a number of times
- Increasing salinity with depth
Decreasing inflow over time

SFR

Construction period

Äspö (HRL)
Problems caused by water

Multiple system of hoses to collect dripping water from the roof

Mineral precipitation from outflowing water. Also leaching of shotcrete. Clogging of drains
• Steel fiber reinforced shotcrete experienced rapid corrosion of steel fibers. Only "skin deep".

• High humidity and dripping water has been a significant problem. Major efforts to reduce humidity and prevent dripping. Membrane in some caverns.

• Reduced humidity has caused shrinkage cracks in the shotcrete

• Extensiometer monitoring has never shown any displacements after construction

• Scaling needed of unsupported surfaces
• All surfaces are inspected and scaled every second year.
• Blast damage, especially in the end of the round (bottom charge) show the most frequent blast damage.
• More frequent scaling has also been carried out in areas with localized stress concentrations, such as tunnel intersections.
• Scailed volumes has slightly decreased over time.
• The research facility require however continuous resources for inspection, scaling and support measures, when needed.
General degradation problems – Äspö HRL (2)

- Scaling and supporting with net in the unsupported raise bored shaft is a significant effort.
- Works are carried out from the roof of the elevator cage.
Managing dripping water in new caverns

- SFR need to be expanded with 6 caverns for disposal of decommission waste from closed-down power plants
- Umbrella-type membrane is planned to prevent dripping
- Sprayed-on liner is one option that is currently tested in a 20 m long part of a service tunnel.
Summary

- The use of standard rock support measures commonly used in Scandinavian crystalline rock has been working well in a saline, corrosive environment for 30 years.
- The air humidity causes corrosion in rock support and installations.
- Reducing the humidity causes shrinking of the shotcrete.
- Scaling needs of unsupported rock decrease over time.
- Careful blasting reduce but not eliminate the scaling need.
- The annual maintenance cost is significantly higher for the unsupported HRL. The total costs for these works over 20 years of operations has however not yet come up to the cost for a systematic support of the entire facility, if installed during construction.
- Reduced inflow over time is an effect of clogging by mineral precipitation. This causes maintenance problems of drain systems.
Future works

Final Repository for Spent Fuel. Accesses and first deposition tunnels for spent fuel (KBS-3 method)

Expected long lifetime

SFR expansion for decommission waste

Deposition tunnels for spent fuel. Short operational time