TERKOR

Corrosion of low and intermediate level steel wastes under in-situ disposal conditions

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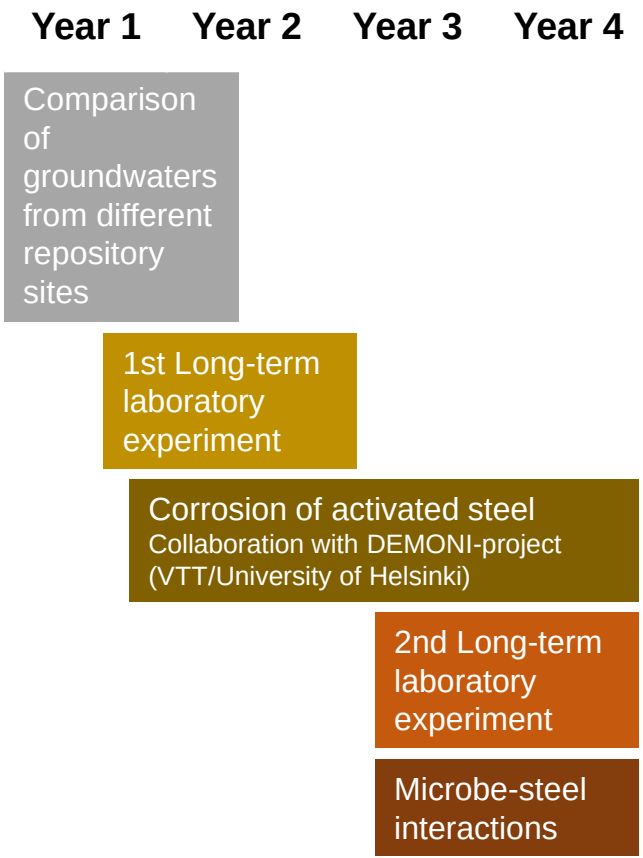
TERKOR Background

- 4-year project, started in 2019
- Steel was studied as material included in maintenance and decommissioning waste
- The results of TERKOR support the decisions to be made concerning the decommissioning phase
  - Corrosion rates of the reactor pressure vessels and other steel components
- The study also supports the decisions related to the repository for the low and intermediate level waste produced during operation

Figure: Safety case for Loviisa LILW repository 2018, Public report LO1-T3552-00023

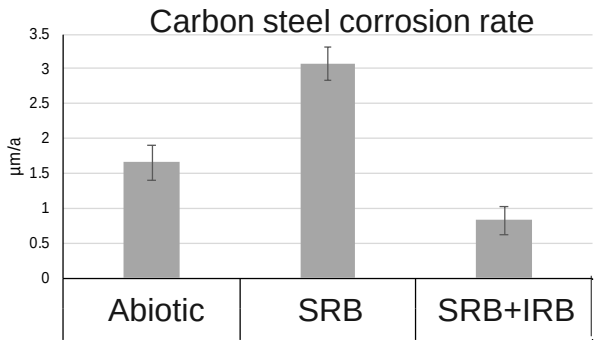


TERKOR objectives

1. Determining the **role of microbial community** on the corrosion rate and mechanisms of steels in the final repository conditions
2. Utilising the **characterisation** of corrosion products and biofilms to deepen the understanding of microbially-induced corrosion (MIC) in the final repository conditions
3. Investigating the **effect of steel activation on the corrosion rate** in the final repository conditions
4. Expanding and comparing the corrosion data to cover the activated steels and other repository environments

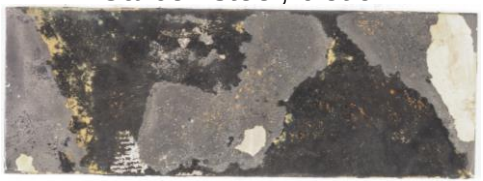
The role of microbial community on the corrosion rate and mechanisms of steels in final repository conditions

- Two exposures with the length of 9-11 months were conducted in natural groundwater at 10 °C for steels
  - 1st setup: Varied added microbial groups (SRB, IRB, IOB)
  - 2nd setup: Fixed mixture of added microbial groups in (SRB, AA, IOB, NRB)
- The corrosion rate depended on which microbes were added
- The choice of the methods matters
  - The general corrosion rate defined from mass losses tended to be similar for stainless steels in biotic and abiotic environments
  - Open circuit potentials revealed differences
  - Microbes increased pitting tendency of stainless steels compared to abiotic environment (1st setup)
- The corrosion products differed between the samples exposed to biotic and abiotic environments



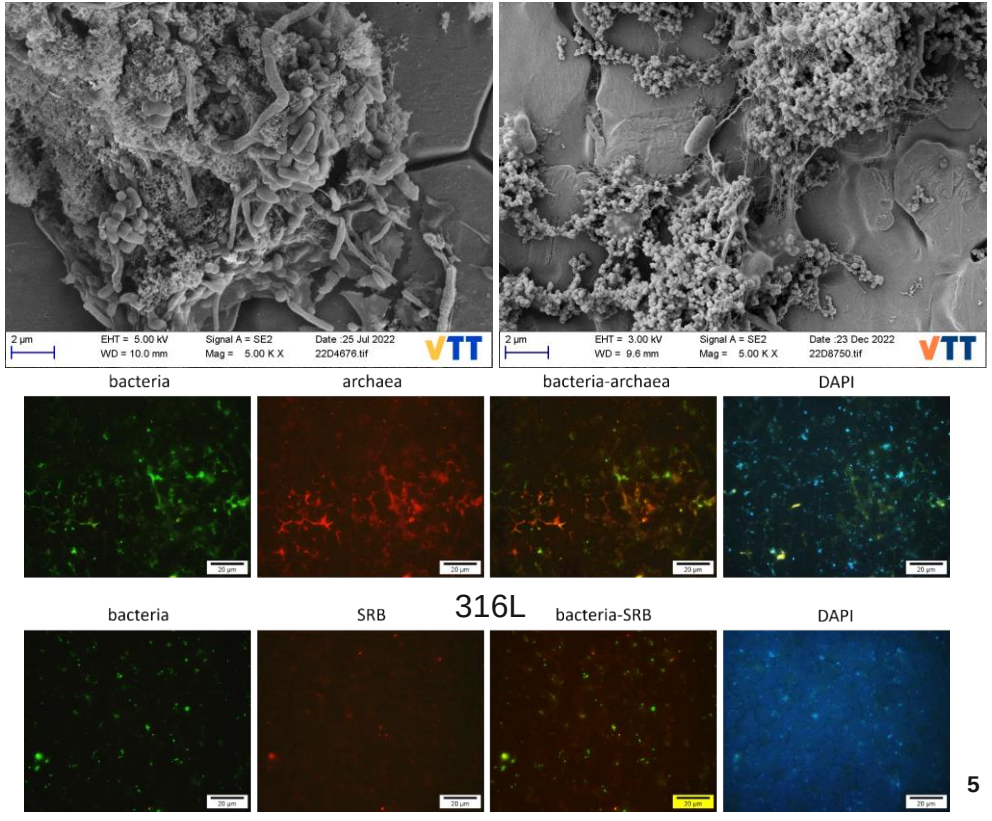
Carbon steel, abiotic

Carbon steel, biotic



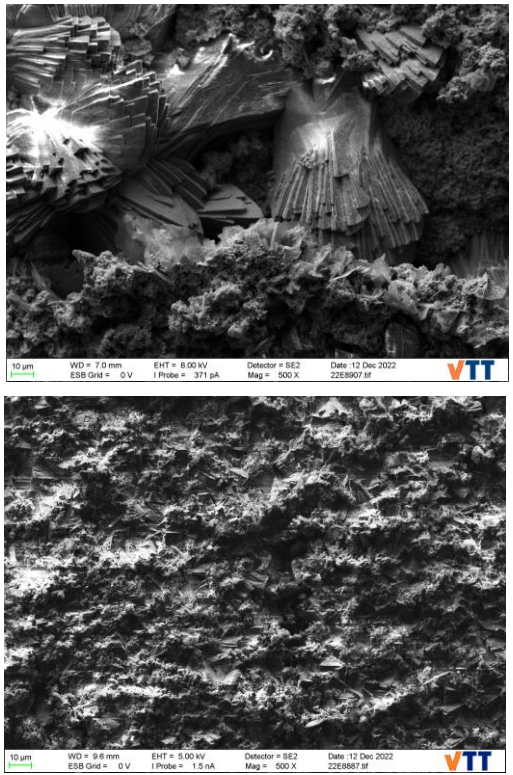
Characterisation of corrosion products and biofilms to deepen the understanding of microbially-induced corrosion (MIC) in final repository conditions

- Characterisation of biofilms and corrosion products with materials characterisation methods (SEM, EDS, XRD) and microbiological methods (qPCR, amplicon sequencing, HCR-FISH)
- Visualisation of biofilm:
  - A hybridization chain reaction-fluorescence in situ hybridization (HCR-FISH) protocol for biofilm morphology analysis was developed
  - In general, clear and high-contrast epifluorescence microscopy images were obtained



The effect of steel activation on corrosion in final repository conditions

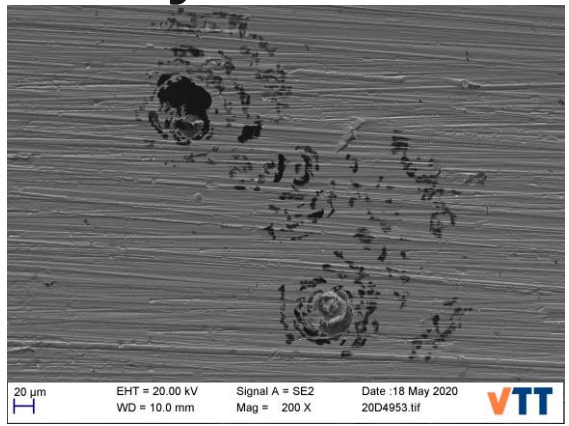
- This was studied with activated and non-activated pressure vessel steels exposed in natural groundwater and simulated water (in collaboration with KYT-DEMONI):
  - Corrosion rates, corrosion products and microbiology
- Appearance of the corrosion products on the activated steel was more porous than in the non-activated
- The composition of the corrosion products varied between the activated and non-activated samples
- The corrosion rate of the activated steel seems to be on average slightly higher after 1 year exposure, but there was a lot of scatter, especially in the activated samples

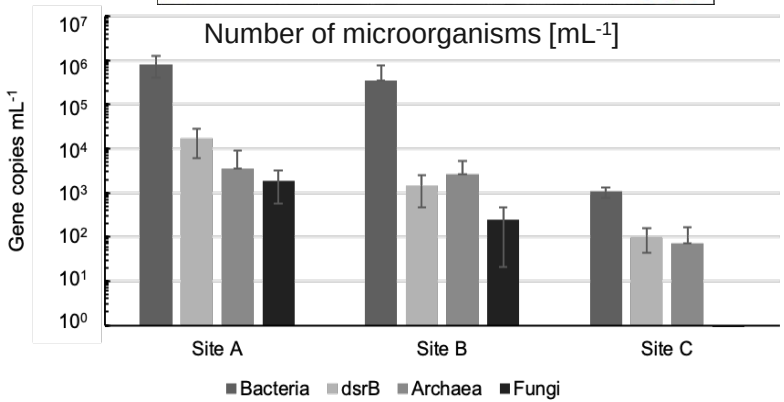


Activated (top) and non-activated (bottom) pressure vessel steel exposed to real groundwater for 3 years.

Expand and compare corrosion data to cover the activated steels and other repository environments

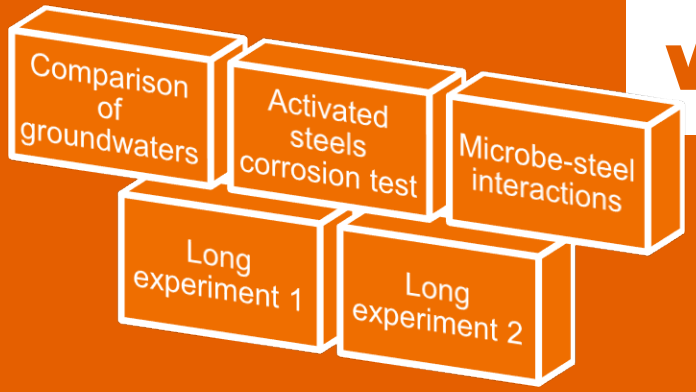
- Exposure of carbon steel and stainless steels (304, 316L) to three natural groundwaters and a simulated groundwater for electrochemical measurements
- Local groundwater conditions (chemical and biological properties of the water) have a marked effect on corrosion tendency and corrosion form
- Overall, considering the localised corrosion in addition to general corrosion is essential in defining the corrosion performance of materials





M. Somervuori et al. Corrosion and Materials Degradation. 2021; 2(4):603-624.

TERKOR Summary



Results demonstrate that

- The presence of microbes and varying microbial community composition lead to differences in corrosion outcome
- Local groundwater conditions (chemical and biological) have a marked effect on corrosion tendency and corrosion form of steel
- Appearance/composition of corrosion products on activated steel differ from non-activated

Dissemination:

- Currently 6 scientific publications, 1 M.Sc. thesis, 4 conference presentations, 2 reports and 2 other presentations, more in preparation

Next steps:

- How the environment and microbes affect the welded steels in LILW repositories

The Team 2019-2023

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