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▶ **To cite this version:**

Annabelle Vernouillet, Charlotte Carré, Delphine Neff, Xavier Bourbon, Valérie Deydier, et al.. Corrosion of carbon-steel casing used in deep geological radioactive waste storage. 8th International Workshop on Long-term Prediction of Corrosion in Nuclear Waste Systems, Jun 2022, Baden, Switzerland. cea-03703739

HAL Id: cea-03703739
https://cea.hal.science/cea-03703739

Submitted on 24 Jun 2022

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Corrosion of carbon-steel casing used in deep geological radioactive waste storage

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Deep geological storage is considered by several countries to isolate highly and intermediate radioactive long-lived waste for as long as they are dangerous for humankind and the environment (over 100 000 years) [1]. The French National Waste Management Agency (ANDRA) started building in 2000 an underground laboratory (Bure, Haute-Marne, France) in order to test the feasibility of such a solution. A multi-barrier system was designed to confine the radionuclides. The waste is to be calcinated and vitrified before being put in a stainless steel container enclosed in a carbon-steel overpack. The containers are then placed in a horizontal micro-tunnel with a carbon steel casing. The host rock, the callovo-oxfordian claystone (Cox), 500 m underground, was chosen for its low permeability, safe confinement properties and stable pH [2].

To evaluate the degradation of the carbon steel casing over time this study focuses on its corrosion in contact with the Cox as well as with the cement grout used to isolate the casing from the Cox. The resistance of carbon-steel in contact with Cox was tested under aerated conditions, at 50°C, for 7 years in a simplified laboratory experiment. Claystone from Bure and an electrolyte which composition was adjusted to match the Cox poral water were used. The corrosion rate and products are compared to those obtained for the corrosion of carbon-steel in contact with cement in similar conditions as well as archaeological artefacts buried in claystone environments [3]. A multi-scale and multi-technique approach, including SEM-EDX, Raman spectroscopy and STXEM, was used to determine the nature and structure of the corrosion products and to better understand the mechanisms involved in the observed degradation.

[1] D.G. Bennett, R. Gens, Journal of Nuclear materials, 379, (2008), 1-8

[2] ANDRA publication, 2005, report

[3] D. Neff, Corrosion Science, 47 (2005) 515-535