



## Corrosion of ductile iron under saline and elevated temperature conditions.

**Nikoleta VOZAROVA<sup>1</sup>, Nicolas FINCK<sup>1</sup>, Dieter SCHILD<sup>1</sup>, Horst GECKEIS<sup>1</sup>, Michel SCHLEGEL<sup>2</sup>**

<sup>1</sup> *Institute for Nuclear Waste Disposal - Karlsruhe Institute of Technology, Germany*

<sup>2</sup> *Service d'Etudes Analytiques et de Réactivité des Surfaces (SEARS), CEA, Université Paris-Saclay, France*

In deep underground facilities for the final disposal of nuclear waste, thick-walled steel containers will be used to encapsulate the hazardous radioactive material. To predict the long-term behavior and for safety assessment the knowledge of steel corrosion rates and corrosion mechanisms are important, as secondary corrosion products can potentially provide an additional barrier against radionuclide migration.

We have investigated the corrosion of spheroidal graphite iron (SGI) (ductile iron) used as canister material for spent fuel in anoxic and saline environments to understand its performance in potential salt rock formations in Germany and the United States. Long-term corrosion experiments (3-7 months) were performed in brines saturated with NaCl and MgCl<sub>2</sub> and both with and without further addition of low amounts of sulfates at temperatures of 25°C and 90°C. Samples were characterized by complementary microscopic and spectroscopic techniques (XPS, SEM-EDX, XRD and Raman) under anoxic conditions.

At 90°C, SGI samples were prone to graphitic corrosion regardless of the brine composition, leading to the abrasion of graphite inclusions significantly contributing to the corrosion rate. In NaCl-rich brines, sheet silicate phases were detected, (e.g., greenalite Fe<sub>3</sub>Si<sub>2</sub>O<sub>5</sub>(OH)<sub>4</sub> and cronstedtite Fe<sub>3</sub>(Si,FeO<sub>5</sub>)(OH)<sub>4</sub>) present in competition with the chloride phase β-Fe<sub>2</sub>(OH)<sub>3</sub>Cl. The addition of sulfate ions decreased the corrosion rate by slowing down the formation of the secondary phases, with the formed phases remaining the same. In saturated MgCl<sub>2</sub> brines, a single chloride phase β-Fe<sub>2</sub>(OH)<sub>3</sub>Cl was formed with significant coverage of the corroding iron surface. β-Fe<sub>2</sub>(OH)<sub>3</sub>Cl is a metastable phase and is expected to transform into green rust chloride/sulfate with time, depending on the presence of sulfate in the brine. Addition of sulfates again hindered the formation of secondary phases and the corrosion rate decreased. Weight loss measurements further indicated a strong temperature dependence for all brines.

We have obtained additional information by applying synchrotron based XRF and XRD, as well as XAS at the Fe K-edge with a micro-focused beam scanning across the corrosion front on crosscuts. Data show the formation of several phases distributed heterogeneously through the corrosion front, in agreement with results obtained earlier, e.g. by SEM-EDX. This finding hints at the establishment of specific local chemical conditions favoring the formation of specific corrosion phases upon steel corrosion. This work provides novel systematic evolution of the corrosion mechanism including corrosion phases identification under anoxic, saline and elevated temperature conditions.

Acknowledgment: This work is performed within the framework of KORSO project, funded by the German Federal Ministry of Economic Affairs and Energy (BMWi) under contract no. 02 E 11496 B. We acknowledge the provision of the beamtime at the Soleil synchrotron, France.