LongTermCorr 2016: an event of the European Federation of Corrosion (EFC event N° 403) in Canada

by Damien Féron, Chairman of the Working Party on Nuclear Corrosion (EFC WP4)

Among the options considering how to deal with radioactive wastes, geological disposal is the internationally preferred method. Observing the degradation process and predicting the lifetime of the metallic barrier in a robust and reliable manner represents one of the greatest scientific and technical challenges for the manmade structures, since the required period for their integrity largely exceeds that of any industrial application. This issue was already explored during five previous successful workshops: Cadarache (France, 2001 - EFC event 2656), Nice (France, 2004 – in conjunction with Eurocorr 2004), Pennsylvania State University (USA, 2007 - EFC event 301), Bruges (Belgium, 2010 - EFC event 329) and Asahikawa (Japan, 2013-EFC event 360).

The 6th international workshop on long-term prediction of corrosion damage in nuclear waste systems (LongTermCorr 2016 or LTC2016 in short, EFC event no. 403) took place in Toronto (Canada), from May 9 to May 12, 2016. It has been organized by the nuclear waste management organization (NWMO) of Canada. The local scientific committee included well-known Canadian scientists (David Shoesmith from Western U., Fraser King from Integrity Corrosion Consulting and Peter Keech from NWMO) and succeeded to gather more than 70 participants from 15 different countries for this workshop where 38 oral presentations and 30 posters were presented. A conference first, three students (Charly Carrière, Joseph Turnbull and Taylor Martino) were awarded prizes for their posters and invited to give oral presentations. The one-day technical tour to the NWMO facilities of Oakville (Ontario) was a part of the official workshop program. This technical tour included viewing of a Canadian transportation container and transportation vehicle, an Ontario power generation dry storage container, bentonite blocks fabricated via isostatic methods, the NWMO adobe brick maker, copper coated used fuel container prototypes, destructive test results from pressure testing, crushed laser weld rings, and much more. The visit of a full-scale demonstration facility for engineering barrier systems was very instructive and very well organized by the staff.

Following the NWMO tour, conferees proceeded to Niagara, where a short excursion to Niagara Falls was organised, prior to a conference networking opportunity and dinner at a local Ontario winery, the Trius Pavilion, of Peller Estates. The wines and landscapes were greatly enjoyed together with friendly exchanges and a warm atmosphere.

The main objective of these workshops is to get together scientists and engineers from various countries that are developing high-level nuclear waste disposal technologies, with the goal of promoting scientific and technical exchanges concerning long term behavior of metallic containment materials and engineered barrier systems. In particular, the workshop will compare the approaches that are being developed worldwide for predicting long-term corrosion phenomena, including corrosion strategies for interim storage and geological disposal. The 2016 edition has been divided into 12 oral sessions and one poster session which addressed the major following items:

- Overview of national programs (Canada, France, Czech Republic) with emphasis on similarities, common challenges and different approaches, legal issues, retrievability….
- Experimentation of candidate materials (copper and carbon steel mainly, titanium also) including laboratory tests, full-scale demonstration, in-situ testing, methodology
- Modeling and long-term prediction with the determination of mechanisms, the fundamental of prediction, numerical analysis and simulation

National projects have recently undergone some changes, but not turmoil. Swedish, Finnish and Canadian programs are in strong interaction: for these three countries, the geological environment is granite, the metal used fuel container is made of steel with an external coating of copper and the set is placed in a bentonite which provides a buffer with the surrounding geological environment effect. The main differences are in the technology used: Sweden and Finland put a plating of pure copper on steel while Canadians are using a spray or an electro-deposited copper coating. For the Swiss program, if steel remains the reference solution in their clay geological site, they are studying two alternatives: coated steel with copper (Canadian technology) or a ceramic container (with Andra). The evolution of the French project also resulted in a presentation emphasizing the consideration of results of the experiment MCO for the redefinition of steel grades and the establishment of a filling grout.

Unlike the previous meeting (the 5th Workshop), little work on biocorrosion phenomena and on archaeological analogues were presented, even if the subjects have been returned several times during the discussions.

The study of copper behaviour over the long term has been dominated by the controversy in Sweden by G. Hultquist on copper corrosion in pure water: he published several years ago that corrosion rates of copper in pure water without oxygen are in the order of few micrometers per year. The work carried out by SKB (C. Lilja et al.) and by independent researchers from the University of Uppsala mainly (Mr. Boman et al.) refute the conclusions of G. Hultquist: no new thermodynamically stable compound is found and corrosion rates observed are in the order of few nanometer per year or even less.

The question of the effect of sulfides on the stability of copper has also been reviewed attentively, especially through modeling diffusion of sulfides in bentonite (S. Briggs et al.). Regarding copper coatings, the effect of a deep fault has been investigated and quantify by by X-ray tomography (T. Standish et al.).

On the steel side, several studies regarding stress corrosion were presented by French, Belgian and Japanese teams. Other talks focused on the effect of irradiation on the corrosion kinetics. The presented results led to disparate conclusions, irradiation accelerates corrosion from 3 Gy/h according to Japanese (Y. Ogawa et al.), above 20 Gy/h according to the CEA/France (Lameille J.M. et al.) and only at high doses according to the Chinese and Belgian (B. Kursten & E. H. Han et al.). For the latter two groups, the integrated dose is the most important factor and not the dose rate. Other studies have aimed to investigate in situ corrosion of carbon steel in the bentonite or argillite (Liljia C. et al., N. Smart et al., etc.).

As for titanium, the work presented by a Canadian group (J. Noël et al.) investigated mainly crevice corrosion with an ingenious mounting decoupling the anode and cathode parts. These studies have shown that oxygen served as a motor for this type of corrosion (outside cathodic reaction as expected), although the reduction of protons into the crevasse is responsible for 60 to 90% of the damage observed. The explanation given was that the consumed oxygen served to maintain acidic conditions within the crevasse.

The attendees thanked their Canadian colleagues for the perfect organization of the workshop and its outstanding scientific and technical content. The exchanges were very useful to the scientists and engineers who are developing appropriate technologies for high level nuclear waste isolation and valuable to the operating nuclear waste authorities and regulators who evaluate solutions to nuclear waste disposal issues.

Illustration 1: Attendance of the 6th international workshop on long-term prediction of corrosion damage in nuclear waste repository (LTC 2016 in short)

NWCO photography

Illustration 2: the LTC2016 group during the visit of the NWCO full-scale demonstration facility for engineering barrier systems

NWCO photography