Questions for SKB (v1, 9 Nov 2020)

Questions for SKB in advance of the second project meeting on measurement methods and analysis:

1. TR-20-14 states up front that copper coupons were 'not intended or prepared for detailed corrosion analysis', but the 1998 LOT test plan (IPR-99-01) stated that the copper coupons and 'interesting' parts of the central copper tubes will be analysed to evaluate the mean corrosion rate, and to identify pitting corrosion and corrosion products. Some detailed corrosion analysis has been undertaken, although various caveats are noted in TR-20-14, such as lack of pre-characterisation of the surfaces of the copper coupons and tubes.
    a. Why was the pre-characterisation not done?
    b. How significant are the uncertainties associated with this lack of pre-characterisation? That is, do these uncertainties significantly affect confidence in results?
2. What is the significance of having a milled side and a polished side to the copper coupons?
3. Were any deviations from the activity plan for division and retrieval of the parcels necessary?
4. 'Hand tools' were used to extract the coupons so as not to damage or scratch them. What tools were used and was damage avoided?
5. Were there any issues identified with regard to calibration and are calibration records available?
6. The tube copper had a higher O content than the Cu-OFP used in the copper disposal canisters. What is the significance of the difference in Cu grade in terms of possible corrosion rates and mechanisms?
7. Regarding the reference materials:
    a. Was any pre-characterisation work done on the reference coupons and reference tube?
    b. Have estimates been made of the rate and type of any corrosion expected on the reference coupons and tube during dry storage? In Section C1.2, it is noted that there is cuprite on the reference coupons.
    c. Table 3-3 of TR-20-14 indicates that, during storage, the reference coupons corroded more than the test coupons. Was this expected, or is it possible that what is seen on the reference coupons are surface defects that could be present on manufacture?
    d. Would there be any benefit in looking further at the surface of newly prepared copper to understand its characteristics and surface defects on manufacture (as noted in Section 4.3)?
8. Regarding microbes:
    a. IPR-99-01 stated that microbial populations in groundwater will be analysed before emplacement and at the end of the experiment and that bentonite samples will be examined for microbial populations. Was information on microbial populations obtained?

     b. How was information at the start of LOT recorded and stored, and was information about preparation of the bacteria samples managed separately to result in the information being lost?

9. The formation water supplied to the boreholes was observed to become more saline and alkaline over the duration of the test. Is there an explanation for these changes and could they influence copper corrosion mechanisms or bentonite behaviour in any significant way?

10. Why was monitoring of the corrosion potential of the copper or redox potential not attempted during LOT?

11. Tube samples were chosen for SEM cross-section analysis based on visual appearance (Section 2.3). What criteria were used to judge the area to select?

12. What is accuracy of the mass loss measurements?

13. Regarding the XRD results, Figure C-2 shows a peak at position 42 for coupon A3/K. The peak is attributed to Cu_2S, but isn't it Cu_2O? Also, on a close look, the peak at position 30 seems to coincide with a small Cu_2O peak rather than bentonite clay. Any correspondence with components of bentonite clay does seem very weak.

14. What is the source of the C contamination noted in the EDS results (e.g. Figure C-46)?

15. Has any reason been found for the detection of zinc in the reference coupons?

16. For the EDS analysis (Section 3.3), would it be possible to identify a bentonite composition or fingerprint that would enable the bentonite component to be removed from the EDS results to give clearer focus on the corrosion product composition?

17. The EDS analysis (Section 3.3.1 and Appendix C) does appear to consistently indicate a Cu_2S phase at the surfaces of the coupons that were at cooler temperatures (block 30) but not at the surfaces of the coupons that were warmer (block 22). Is there any explanation for this? Is it statistically significant? The results for tube sample S2 (Figure 3-20) appear to contradict this so perhaps it is not significant.

18. The diffraction analysis (Section C1.4.3) appears to provide a means of identifying the composition of corrosion products, but the discussion is complex and the d values to compare with 1/d do not seem to be provided. Will a more detailed explanation and results be published?

19. In Figure D-7, it is not convincing that Cu_2S is being indicated as present on coupon S2/P. Is the figure showing the reflections discussed in Section C1.2 rather than a signal for Cu_2S?

20. What is the purpose of the H measurements? Is it to provide evidence to support arguments that hydrogen embrittlement doesn't occur?

21. Could the measured amount of corrosion and the expected rate of corrosion give an indication of the timescale for oxygen consumption in LOT?

22. Are there any further views on why coupon S2/P was less corroded than other coupons?