

## **Translation of exchange between SSM and MKG on Oct 28 and Nov 3 2020**

### **Bo Strömberg, SSM, to MKG on Oct 28, 2020**

Hi Johan!

We have looked a little more in detail at your letter and have some questions:

A question under point no. 4 to understand your views on corrosion under different redox conditions.

"MKG would like to strongly stress that the way SKB continually keeps stressing that a number of copper corrosion products can only occur if the environment has been anoxic is fundamentally flawed."

Should it not be: "... can only occur if the environment has been oxic is fundamentally flawed." It would also be good to find out what is meant by "a number of corrosion products" i.e. what phases are meant?

"MKG is of the understanding that it should be clear by now that SKB has no interest in improving the scientific understanding of this issue as it allows the company to claim that all copper corrosion is anoxic, while in fact it is much more likely that very little of the copper corrosion in experiments carried out in hard rock laboratories is anoxic."

Same question here, it should not be "company the company to claim that all copper corrosion is oxic, while in fact it is much more likely that very little of the copper corrosion in experiments carried out in hard rock laboratories is anoxic"

A question under 2. About FEBEX

There was quite intensive corrosion ( $\approx 100 \mu\text{m}$  and pitting) on copper coupons after 18 years in the FEBEX experiment as reported in the report "FEBEX-DP Metal Corrosion and Iron-Bentonite Interaction Studies, P. Wersin & F. Kober (eds.), Arbeitsbericht NAB 16-16, Nagra, October 2017"

The formulation is ambiguous as to whether  $100 \mu\text{m}$  refers to pitting depth or general corrosion with additional contributions from pitting. The previous alternative seems to agree best with page 22, page 192, page B-5, B-20 (Nagra Arbeitsbericht NAB 16-16).

A question under 3. About LOT A2

"The calculated corrosion rate is  $2-4 \mu\text{m}$  per year for a position representing clay zone 15 and to this number an amount (up to times 4?) should be added to correspond to the corrosion products left on the copper surface. "

Is there an explanation or reference that justifies up to times 4?

Otherwise, I can announce that we have had problems with certain files in the diarium to be sent out. This is because the files are so large that the system has trouble handling them. I hope this can be fixed as soon as possible

Best regards Bo

### **MKG to Bo Strömberg, SSM, on Nov 3, 2020**

Hey Bo!

Thanks for your questions. Here are MKG's answers.

#### Point 4 on oxic vs anoxic

It is quite true that it should say "oxic" instead of "anoxic" in the two places that you point to in your letter. I enclose a corrected version to replace the previous letter.

Regarding corrosion products in oxic or anoxic corrosion, I have understood that if the anoxic corrosion comes from oxygen in water molecules, the corrosion products will be the same as in oxic corrosion. It may also be more explicable as to why there are corrosion products with hydroxides in the case of anoxic corrosion where water molecules are involved.

#### Point 2 on the FEBEX results

Regarding the corrosion depth in FEBEX the 100 µm specifically applies to the depth found in the image on page B-5 in the Nagra report NAB 16-16 which is available as appendix 1 to the letter. The text that describes the pictures says:

"The maximum penetration depth for this zone is about 100 microns. Apart from this, the copper coupon shows a generalized corrosion."

The author talks about "localized corrosion". It is somewhat uncertain what the author means by "zone". It looks like there are the beginning of pits around the copper coupon, even though there are pits mainly on the side where the magnification is.

#### Item 3 on LOT A2

Regarding how much copper can be left in corrosion products on a surface where clay has been removed, I refer to page 4 in appendix 11 to the letter entitled "Correspondence between Peter Szakálos KTH and Stephan Kaufhold BGR 090602-090603". I realize that the correspondence started already on May 28 and not June 2, but there Peter Szakálos writes:

"My estimation was based on copper profile data from copper / bentonite exposures in Canada (F. King et al.) Where he correlated the profiles with actual weight loss

measurement. Roughly, if I remember correctly, by multiplying the corrosion rate based on "Cu-profile in bentonite" with around 5 it gave the "true" total corrosion rate."

I have dug further into the issue and based on page 15 in Peter Szakálos' presentation at the Swedish Nuclear Waste Council's meeting on copper corrosion on 16 November 2009, which is attached, I have identified the source "F. King et al. "(1). I understand that the reference is the attached article" A Mechanistic Study of the Uniform Corrosion of Copper in Compacted Na-Montmorillonite Sand Mixtures F. King et al Corrosion Science, Vol. 33, no. 12, pp. 1979-1995, 1992" that is based on the report" A Mechanistic Study of the Uniform Corrosion of Copper in Compacted Clay-Sand Soil Litke Ryan King AECL-10397 1992".

What is mentioned in the article on page 1991 at the bottom is that more than half of the copper is found in the corrosion products on the surface:

"Precipitation of copper inevitably occurred in all of the tests, with usually more than half of the total copper corroded being in the form of precipitate rather than being sorbed on the clay."

This is developed a little more in the report on page 10:

"The amount of copper in the form of adherent corrosion product and precipitate ( $\Delta w_p$ ) was estimated by subtracting the total amount of copper in the buffer ( $\Delta w_b$ ) from the overall weight loss of the coupon ( $\Delta w$ ). The fraction ( $\Delta w_p / \Delta w$ ), which represents the proportion of precipitated copper, varied from test to test. In 1- and 2-month tests at 50 ° C,  $\Delta w_p / \Delta w$  was as high as 0.95, indicating that only 5% of the dissolved copper diffused into the buffer. In general, the amount of copper in the buffer increased with exposure time, although in most of the experiments more than 50% of the dissolved copper had precipitated on or near the coupon. For longer exposure periods, however, most of the dissolved copper may diffuse through the buffer rather than precipitate at the interface. "

How this can be converted into a factor to multiply the content in the clay by to get the total amount of corroded copper is to me somewhat unclear. But in the work done in Canada there has been an ambition to make an estimate. The results presented by the nuclear waste company SKB in the report SKB TR-20-14 completely lack the ambition to make such an estimate, despite the fact that it is important to be able to evaluate the company's conclusion that all corrosion for 20 years in the LOT packages is caused by oxygen trapped in the test packages.

#### Closing comments

MKG still intends in the near future to submit a second contribution to SSM's quality review work based on issues raised while reviewing of the report SKB TR-20-14.

Concerning SSM's handling of large files in the diarium, MKG can inform the authority that the organisation's e-mail system has no restrictions on how large files can be received.

Best regards,

Johan

(1) The presentation is interesting to take in as a whole and still feels very current over ten years later. There is probably other things from the seminar that are still relevant. Here are two news stories on MKG's website about the seminar:

<http://www.mkg.se/inga-svar-pa-karnavfallsradets-kopparkorrosionsseminarium>

<http://www.mkg.se/kth-forskarna-skickar-extra-material-till-korrosionsseminariets-expertpanel>