Från:	Johan Swahn <johan.swahn@mkg.se>
Skickat:	den 27 januari 2021 13:05
Till:	John Scully
Kopia:	Tim Hicks; Strömberg, Bo; Hannu Hänninen; Ingmar Persson; Peter Szakálos; Christofer Leygraf; Christine Anvegård; Oscar Alarik
Ämne:	The copper corrosion results of the LOT experiment
Bifogade filer:	MKG input to SSM review of SKB LOT results autumn 2020 201008 (corrected).pdf; Translation of exchange between SSM and MKG on Oct 28 and Nov 3 2020.pdf; MKG second input to SSM review of SKB LOT results autumn 2020 201109.pdf; MKG third input to SSM review of SKB LOT results autumn 2020 201211.pdf; Correction and followup comments MKG Third input from MKG to the SSM quality assurance review of the SKB LOT project corrosion results 201217.pdf; ATT00001.txt

Dear Prof. Scully,

I have understood that you have been given the task from the Swedish regulator SSM to review the scientific integrity and quality of the the SKB report TR-20-14. The report presents the copper corrosion in two 20-year old packages (A3 and S2) in the LOT experiment in the Äspö Hard Rock Laboratory.

I work for an environmental organisation called MKG and we have for many years followed the scientific discourse on the long-term integrity of the copper canisters planned for the Swedish repository for spent nuclear fuel in Forsmark. Already in 2008-2009 when the copper corrosion results of the 5-year old LOT A2 package retrieved in 2006 were presented, we realised that the copper corrosion in the package was unexpectedly high. At that time SKB refused to acknowledge that the corrosion of the central tube was of any scientific interest. The LOT A2 report was very weak in the reporting of copper corrosion and there were not even metallographic cross sections of the copper coupons in the report. It was, however, possible to indirectly try to estimate the corrosion on the hottest part of the central tube by measuring the copper in the clay. But this of course only gives a rough estimate and does not take into account the corrosion products on the tube itself.

As time went by the important question became if it was likely that the unexpectedly large corrosion in the A2 package could be explained by trapped oxygen in the experiment. For MKG it with time became clear that systems of ground water, copper and clay become anoxic very quickly. Ground water in a matter of days (the REX experiment) and even a whole tunnel with clay in a matter of months (the FE experiment). There may be chemical reactions that consume oxygen, but more importantly nearly all bacteria that are available in a repository environment can consume oxygen. They have a preference for oxygen as an energy source, even though they have with time evolved to consume other energy sources (facultative anaerobes).

In the case of the LOT experiment the gaps between the copper and clay and the clay and rock were filled with ground water from a hole drilled the adjacent rock before the experimental packages were sealed and the heating begun. This water system then supplied water at a slight over-pressure to the packages throughout operation. This water has been measured to be anoxic. With the results of the REX experiment in mind, it is highly unlikely that any major amounts of oxygen has reached to surface of the copper tube or the copper plate throughout the experiment. Not unless considerable amounts of oxygen in the clay has not been consumed by chemical and biological processes and instead has managed to get through to the copper while passing the biologically anoxic zone near the copper tube surface. For the bottom plate it is even more difficult to see how any oxygen could be available in the adjoining sand filled with the anoxic groundwater from the watering system and from surrounding groundwater that would quickly become anoxic.

From what MKG understands, SKB still claims that all the corrosion on the copper tube and bottom plate must come from entrapped oxygen from before closure of the experimental packages. [Not even SKB claims that any oxygen has leaked into the over-pressurised packages and watering system to reach the copper tube.] It is problematic that SKB has made it impossible to verify their claim that all corrosion comes from trapped oxygen. No detailed study has been made of the corrosion on the bottom plate and the corrosion on the hottest parts of the copper tubes. Instead a similar estimate as for the tube corrosion of the A2 package has been made by measurements of copper in the clay. Not even a picture exists of the corrosion products on the tube itself. But if the corrosion on the hottest part of the central tubes is anything like the corrosion on the bottom plate (at 80°C) — that is pictured — it is likely that the copper measurements from the clay heavily underestimate the corrosion on the tubes.

Any claims that the copper in the central rod or the bottom plate is not exactly the same as canister copper is of course irrelevant for scientifically understanding how copper as a metal in general corrodes in a repository environment.

For MKG it is clear that the explanation that all the corrosion on the hottest part of the copper tubes and the bottom plate comes from entrapped oxygen appears to be false. Counting that almost all the oxygen in all volumes in the packages have corroded the copper tube and bottom plate — despite the understanding that oxygen is likely consumed very fast — and then not in detail studying how much corrosion has actually taken place on the hottest parts of the copper tubes and the bottom plate is not credible science.

There may certainly be other issues with the report, but MKG is also very concerned that there is no independent and quality-assured underlying report with the results from the consultants that have worked for SKB. Instead SKB has worked together with the consultants directly to produce only the report TR-20-14.

After the publication of the report from the A2 package in 2009 MKG repeatedly demanded that the next LOT package be retrieved to show how the copper corrosion has developed with time. We have been clear about the necessity that the analysis of the copper corrosion in retrieved packages needs to done with transparency and independence from SKB as the results may show problems that SKB has no interest in revealing. As SKB is a private company the work done by them is not accessible according to the otherwise well-developed Swedish freedom of information legislation that applies to public entities such as SSM.

SKB decided to retrieve the A3 and S2 LOT packages in the autumn of 2019 as they had promised to do so in the R&D programme submitted to the government in 2016. But they did so secretly and when this was revealed SKB first said no results would be published until after the government had licensed the planned spent nuclear repository. When this became an untenable position SKB promised to present the results in 2020 and what we have is the report TR-20-14.

MKG understands that the regulator SSM may have positively influenced the SKB decision to publish the results and we have hopes that the regulatory review of the results will hold scrutiny for high scientific integrity. MKG has provided three inputs to the SSM quality assurance review on Oct. 8, Nov. 9 and Dec.11. The first and third inputs were followed by corrections and exchanges with SSM. These inputs are appended this e-mail. The appendixes to the inputs are all available on the MKG web site with all the documents that SSM has decided to make public from their review (http://www.mkg.se/ssm2020-5740-kvalitetsgranskning-av-skbs-lot-experiment).

In the interest of transparency I copy this message to copper corrosion experts at Galson Sciences, SSM, the Swedish Council for Nuclear Waste and the Royal Institute of Technology.

Best regards,

Johan

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Johan Swahn

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