Understanding presence, diversity and activity of microorganisms in swelling clays intended for use in geological disposal of radioactive wastes

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Expectations on the outcome of WG-5

- **Microbial processes need to be under control**
  - IGD-TP executive group will understand that microbial processes must be under control in a competent safety case.
- **A technical and scientific working group (TSWG)**
  - A TSWG for implementation of microbial process control in radioactive waste safety cases is launched by the executive group 31 October.

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Microorganisms in clays

Material	Aerobic bacteria	Iron-reducing bacteria	Sulphate-reducing bacteria	Autotrophic acetogenic bacteria
	Cells g^{-1}	Cells g^{-1}	Cells g^{-1}	Cells g^{-1}
Asha 505	84400	67	91	<10
Calcigel	420	110	56	<9
Callovo Oxfordian	230	114	<10	<11
Deponit CA-N	1000	7	9	<10
Febex	68600	120	10	19
Friedland	1750	6900	68	35
Ibeco Seal M-90	5830	7920	61	63
Ikosorb	4500	117	<10	<10
Kunigel V1	<10	10	<10	<11
MX-80	6600	263	<10	9
Rokle	200	110	9	<10

<u>Enrichment cultures for sulphate-reducing bacteria</u>

Desulfovibrio africanus EU659693
Desulfotomaculum sp. Mechichi-2001 AY69974
Desulfotomaculum geothermicum
Desulfotomaculum sp. NA401 AJ866942
Desulfotomaculum halophilum U88891
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Desulfotomaculum sp. Mechichi-2001 AY69974
Desulfotomaculum halophilum U88891

SKB Technical Report TR-11-06

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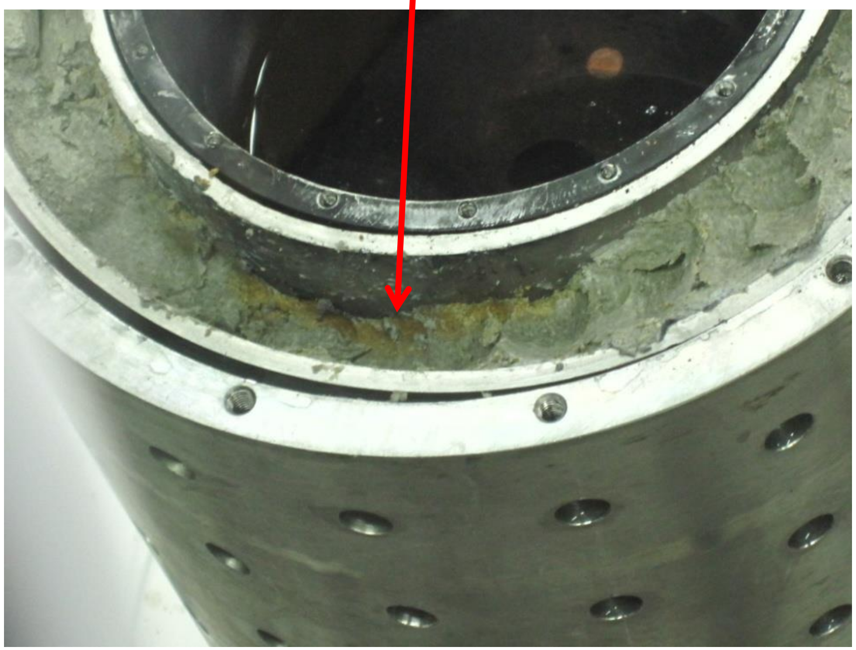
Mini-canister experiment clay wet density 1750 kg m^{-1}

Iron-reduction

80 Iron-reducing bacteria g^{-1}



Sulphate-reduction

A copper mini-canister that has been exposed to vivid microbial sulphide formation from sulphate, possibly with H_2 from the corroding cast iron insert as the electron donor. See the report **SKB-Technical Report-12-09** for details.

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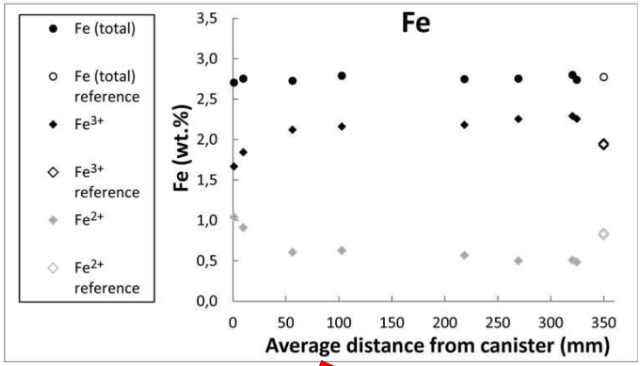
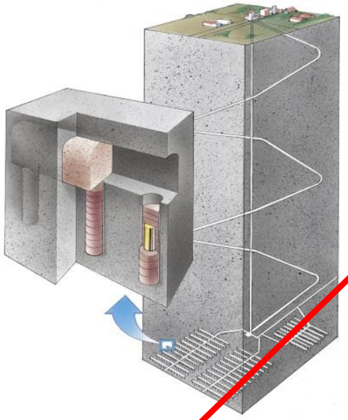
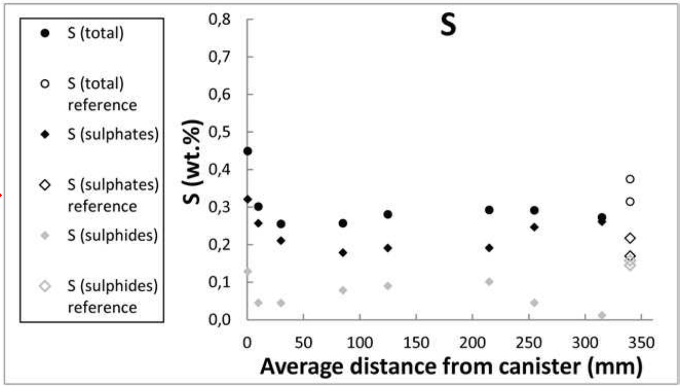
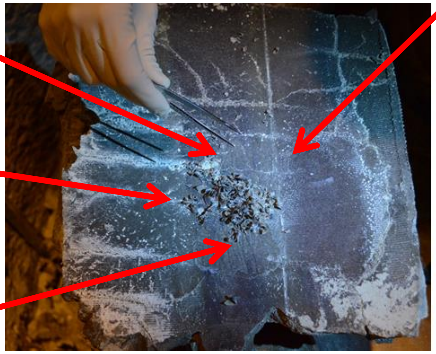
The Prototype Repository



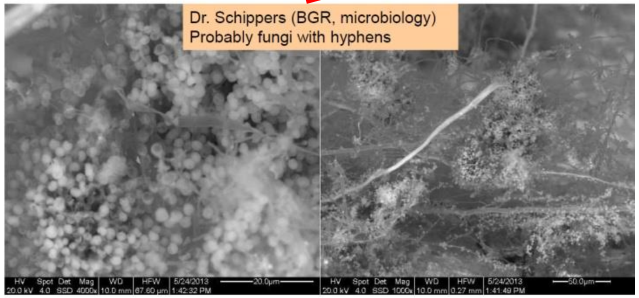




Iron-reducing bacteria were cultured from the clay



Fe^{2+} and sulphur were enriched in buffer close to the canister



Desulfovibrio aespoeensis DNA signature on canister surface

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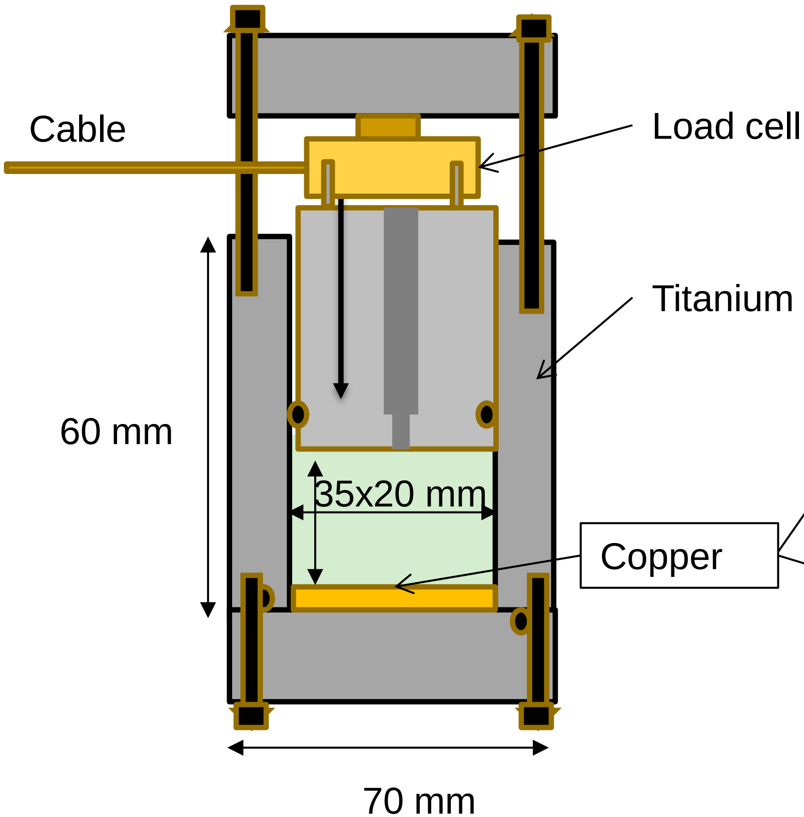
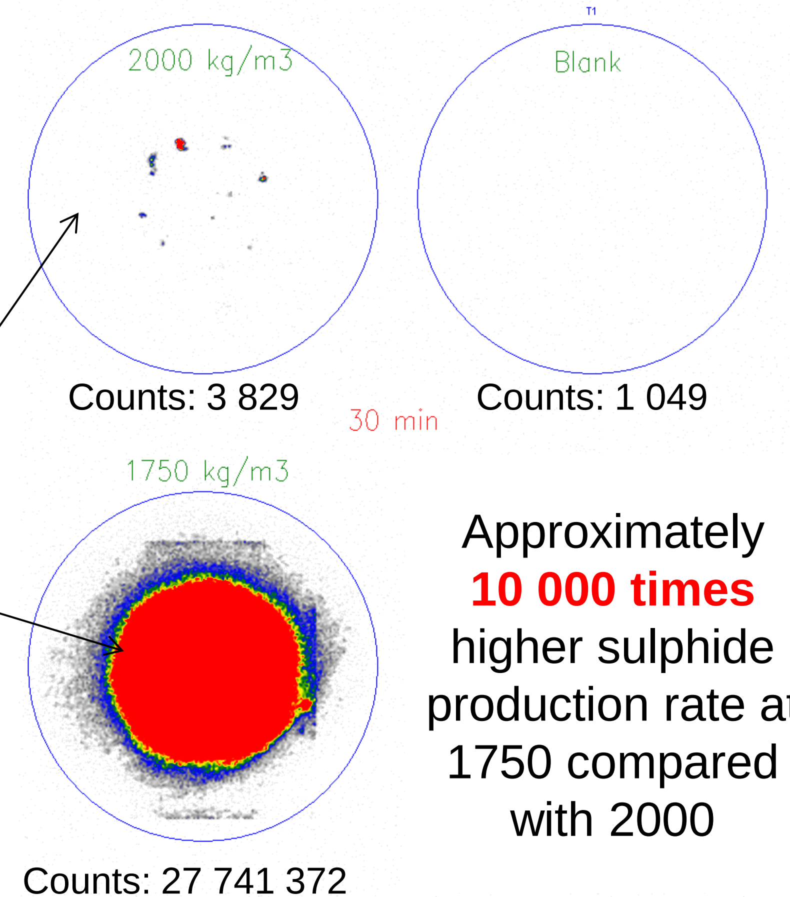
Microbial sulphate reeduction of $^{35}SO_4$ to sulphide that react with the copper and form radioactive copper sulphide





Approximately **10 000 times** higher sulphide production rate at 1750 compared with 2000

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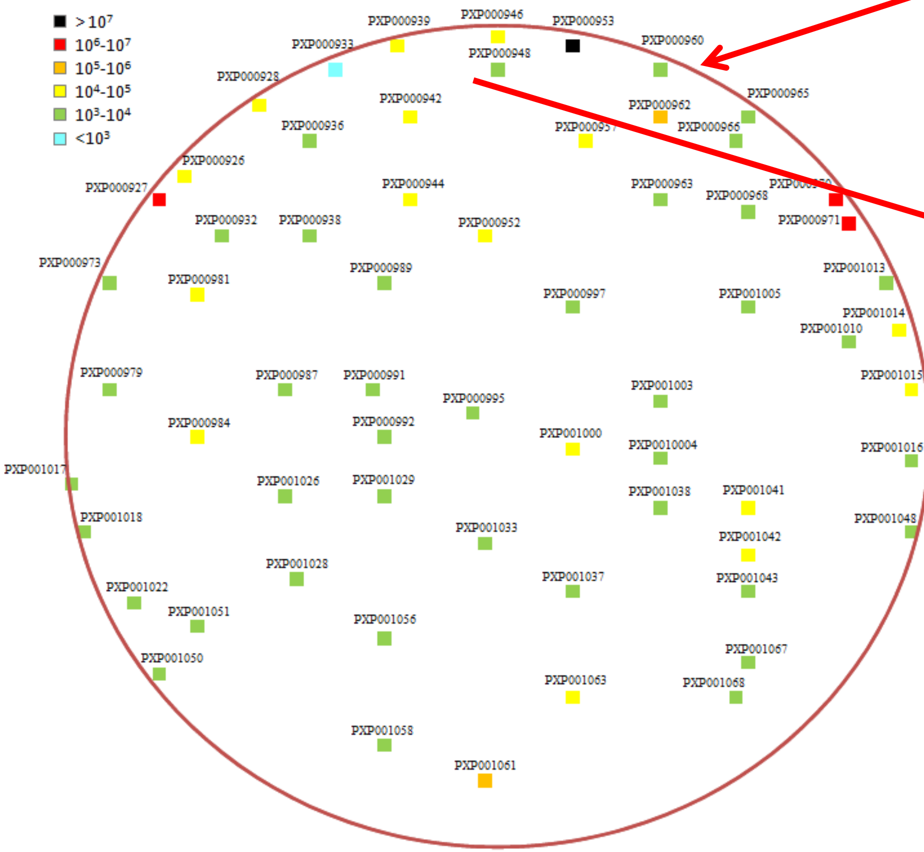
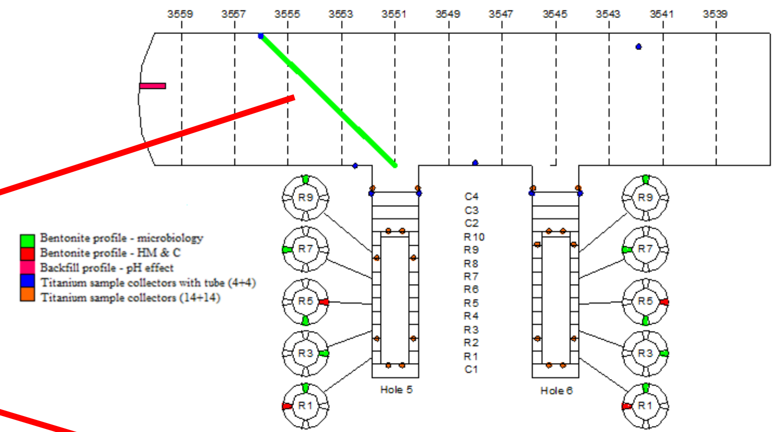
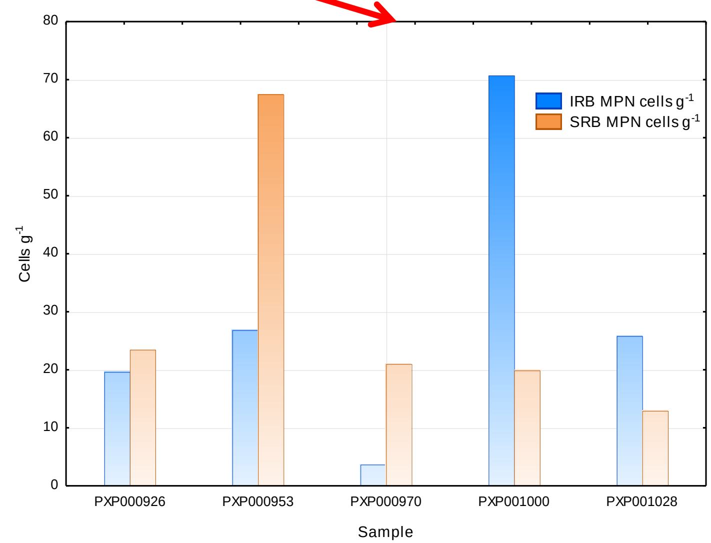
Backfill in the Prototype

Cultivable bacteria

Cells g^{-1}







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Microbes, buffer and backfill

- Microbial iron- and sulphide-reducing activity will possible in any clay barrier with wet densities below 2000 kg m^{-3} i.e. in backfill, and in low- and intermediate waste repositories.
- Because it appears difficult to obtain full density (2000 kg m^{-3}) close to the canister, microbial activity may commence at the surface of waste canisters.
- Repositories with densities below 2000 kg m^{-3} will experience microbial activity that may compromise the safety case

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The safety assessment perspective
A competent safety case

- **Robust low and intermediate radioactive waste repositories that tolerate microbial processes**
  - Vivid microbial activity will be unavoidable in buffers and backfills of low and intermediate radioactive waste repositories. The safety case must embrace such activity and ensure that the repository design is robust enough to mitigate the effects from microbial activities such as biogas formation, biocorrosion and microbial radionuclide migration.
- **Engineered barriers that resist detrimental microbial processes**
  - Research have indicated that microbial activity in buffers will cease with increasing compaction of the clay. For Wyoming MX80 bentonite, results indicate a threshold somewhere between 1750 – 2000 kg m^{-3} wet density. The exact limit needs to be confirmed for each WMO case. The longevity and resistance of engineered barriers to microbial illitization and canister corrosion processes must be confirmed.

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Remaining issues and a proposal for research (additions to WG5 list)

- **Important R&D uncertainties:**
- **Under what conditions can we exclude** that sulphide producing microorganisms increase corrosion rates of metal containers for radioactive wastes?
- **Under what conditions can we exclude** that iron-reducing microorganisms damage the swelling capacity of buffers and backfill?
- **How do we model microbial processes** in repositories over a very long time period? Present day models and requirements for the future.

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Acknowledgements

- B+TECH, Finland (Kumpulainen, S.) for Fe and S data in prototype.
- BGR/LBEG, Germany (Dohrmann, R., Kaufhold, S.) Image of microbes in Prototype
- Clay Tech AB, Lund Sweden for help with access to samples
- The research was supported by funds from Swedish Nuclear Fuel and Waste management Co (SKB)

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