In-situ analysis techniques to understand the behaviour of waste and backfill materials in a GDF environment

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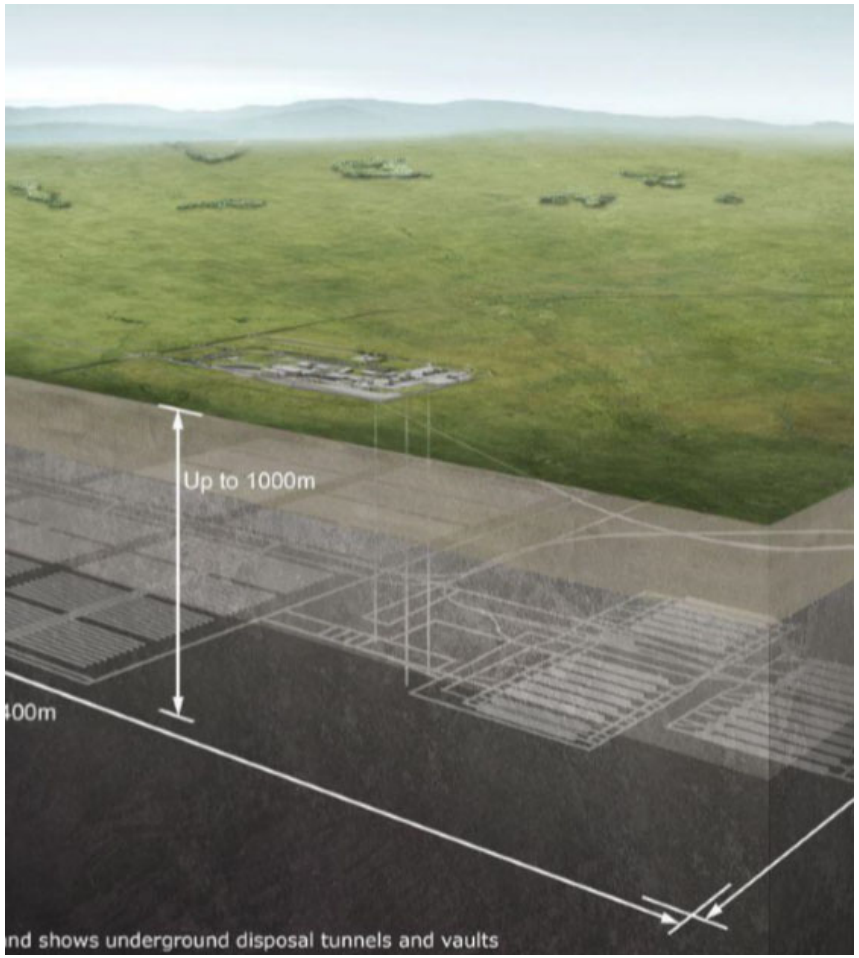
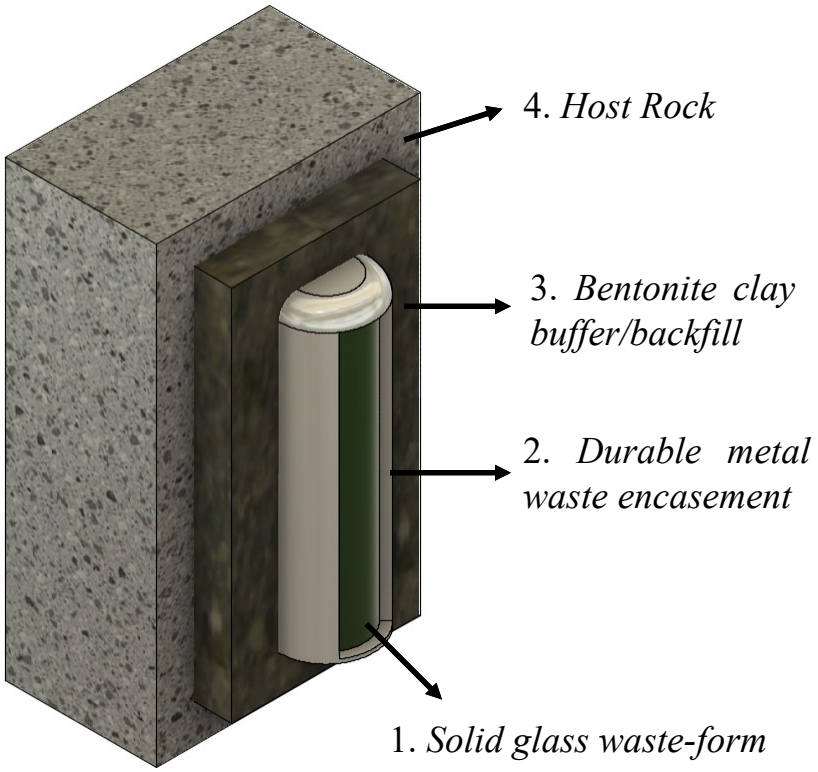


Studying Materials in a Geological Disposal Facility setting is challenging!

- Time (lots of it!)
- Conditions (which vary)
- Radiation (which reduces)
- Microbes (good & bad!)

Engineered Barrier System (EBS) concept



The concept for an **Engineered Barrier System** (EBS), comprises:

1. *Solid glass waste-form*: To prevent the dissolution of radioactive waste into groundwater.

2.Durable metal encasement: Prevents the contact of groundwater with the HAW.

3.Bentonite clay buffer/backfill: Delays the migration of radioactive substances by slowing down the movement of groundwater and blocking microbes.

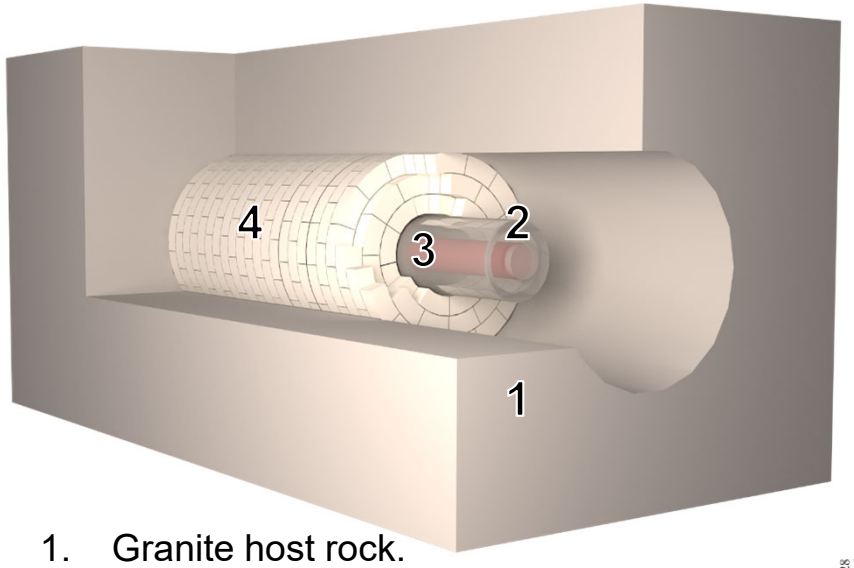
4.Host rock: To slow down the migration of radioactive nuclides to the surface.

Long-term experiments

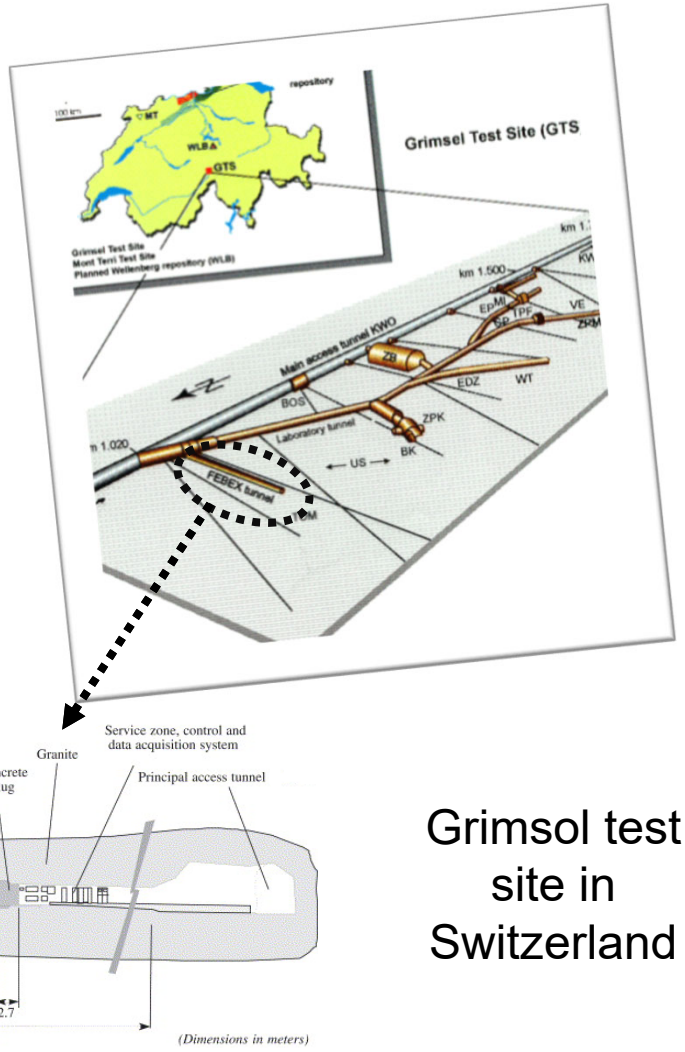
FEBEX in situ test

100°C for 18 years

Full-scale High Level Waste Engineered Barriers (FEBEX)



1. Granite host rock.
2. Heater.
3. Steel liner.
4. Compacted bentonite blocks.

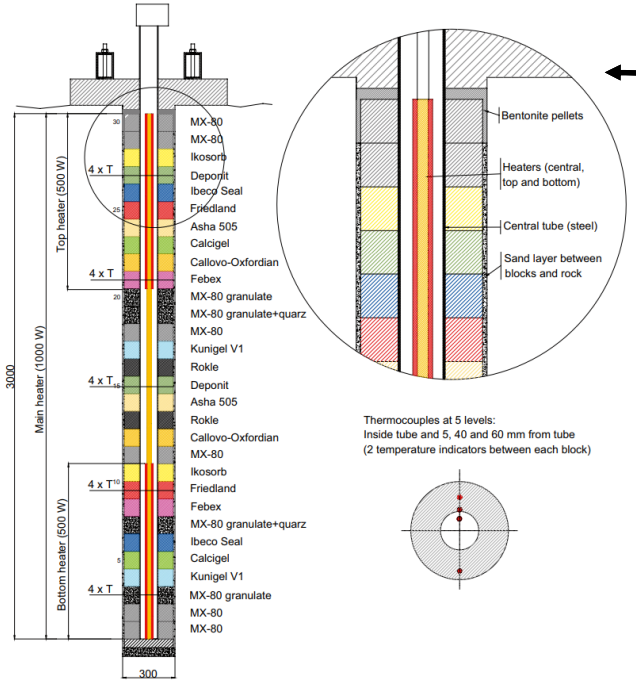


Grimsol test site in Switzerland

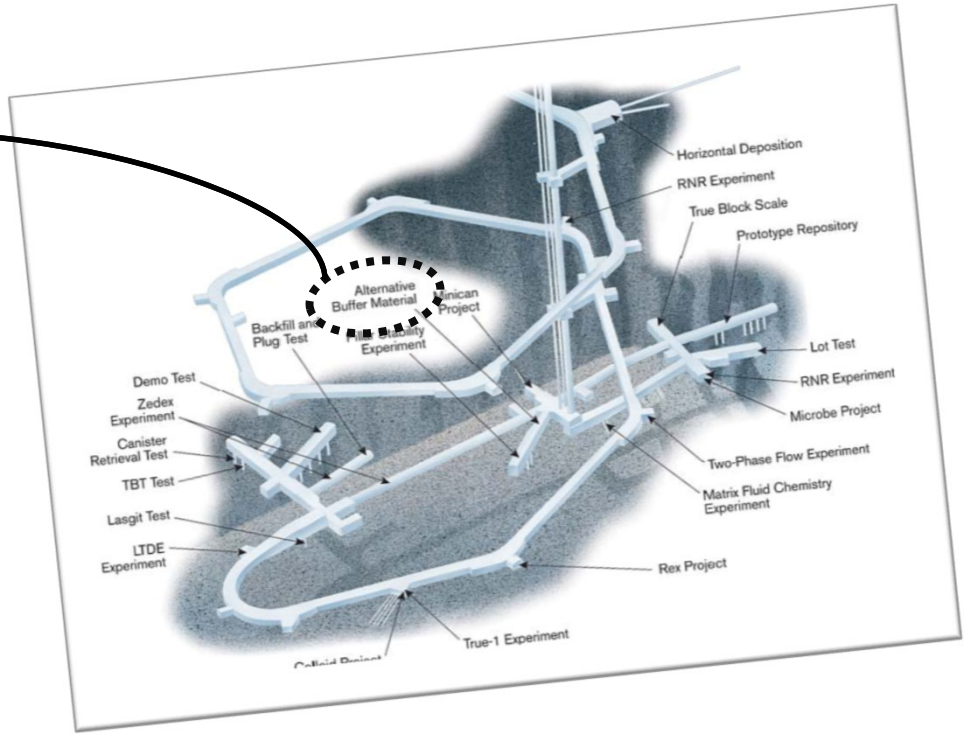
Long-term experiments

Alternative Buffer Material (ABM) project

130°C for 6.5 years



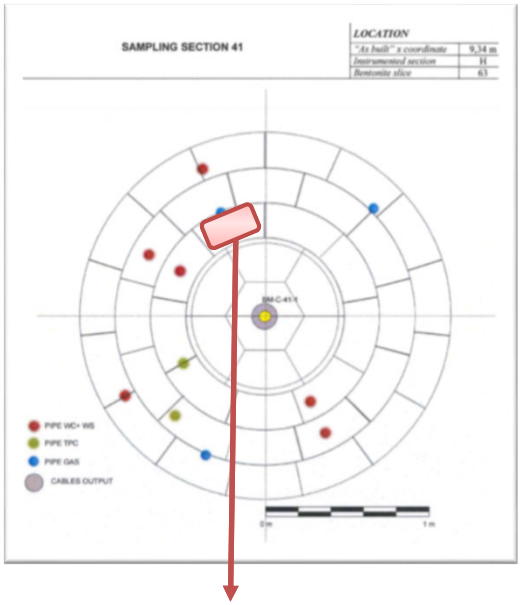
Schematic layout ABM experiment (test package 1)



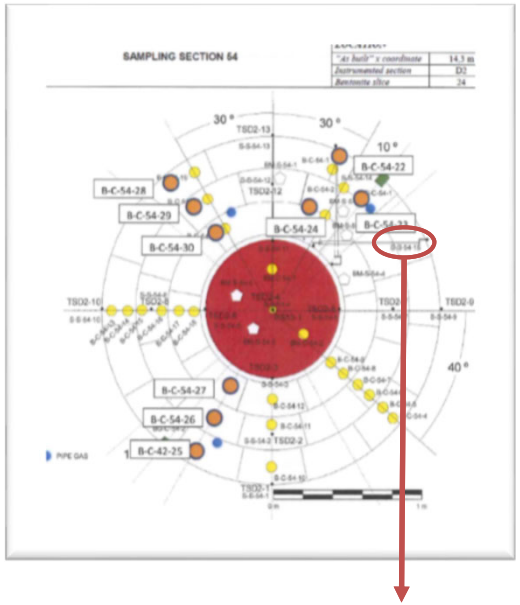
Äspö Hard Rock Laboratory, Sweden

A suite of incredibly important samples!

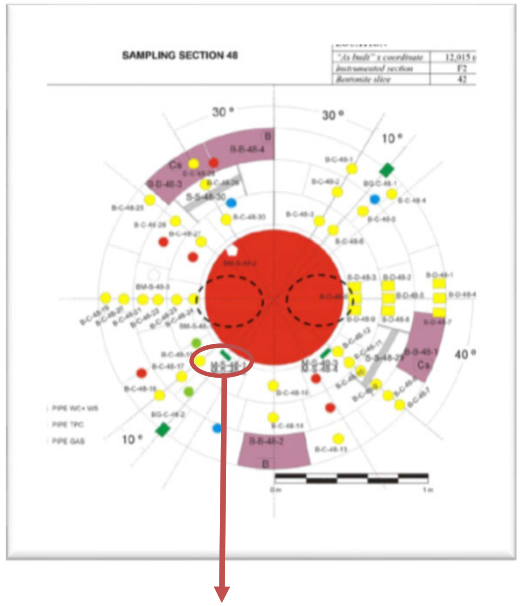
Example - Sampling the FEBEX in situ tests



Sample BM-B-41-1



Samples S-S-54-15-A/B/C/D/E

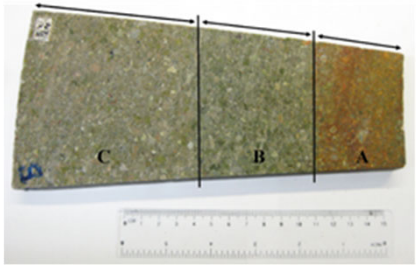


Sample M-S-48-1

Important observations for alteration

Inspection FEBEX and ABM samples

Sometimes no result is a good result!



BM-B-41-1

S-S-54-15-A/B/C/D/E

Kunigel V1

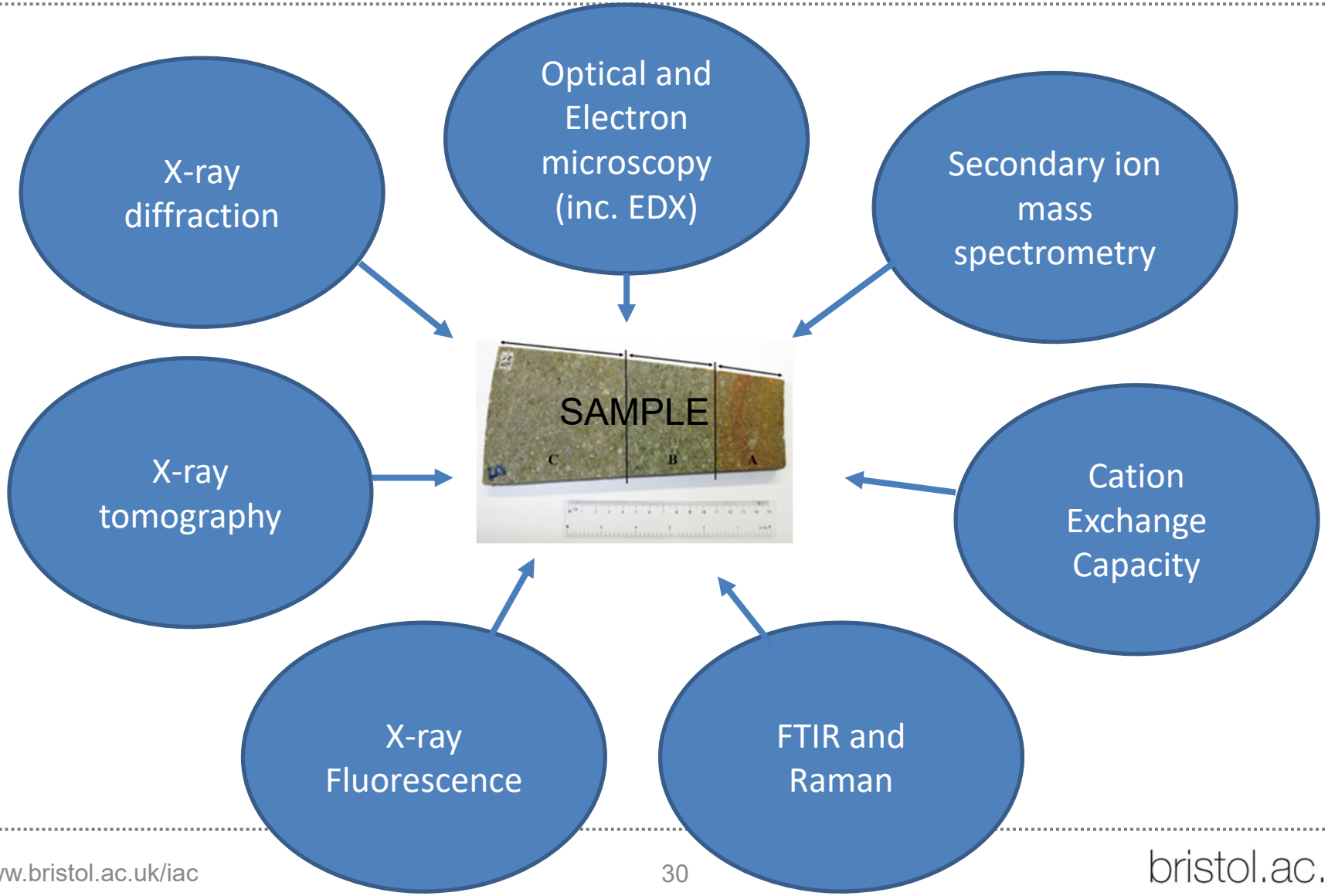
MX-80

Deponit

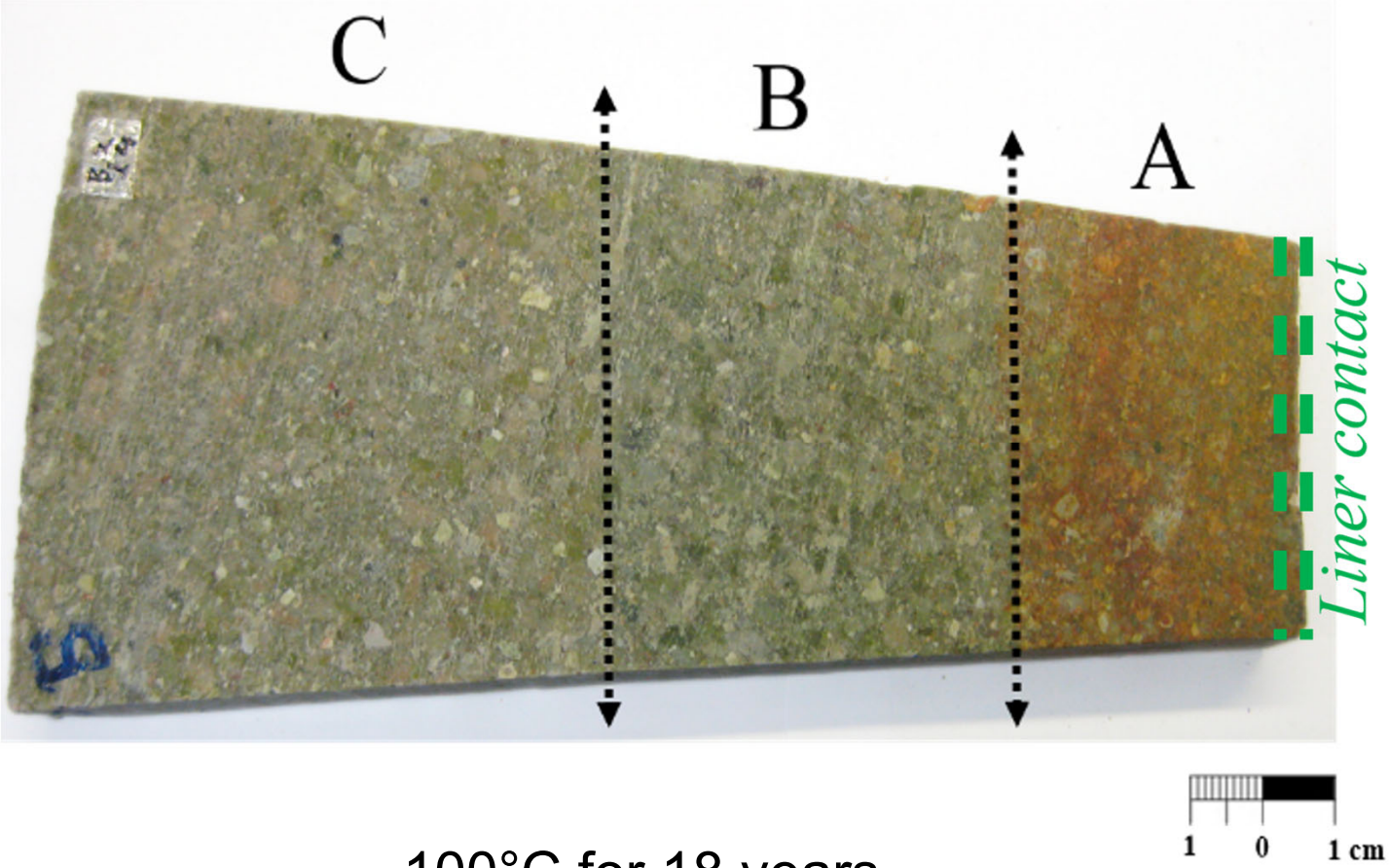
Febex

- Sample BM-B-41-1 from the Febex experiment, displays a visual discolouration.
- Samples from ABM experiment, showed no appreciable differences detected.
- Also verified using advanced materials analysis techniques

A multi-technique analysis approach



Example - Febex Bentonite alteration



100°C for 18 years

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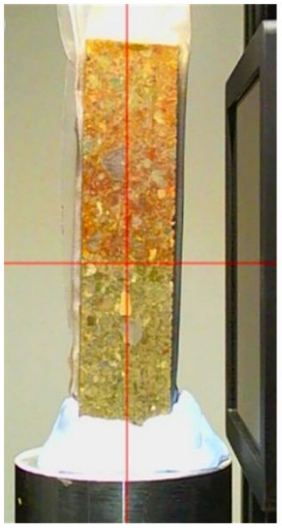
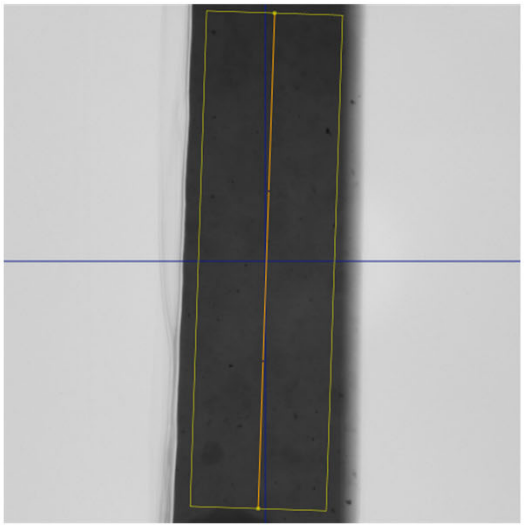
XRT

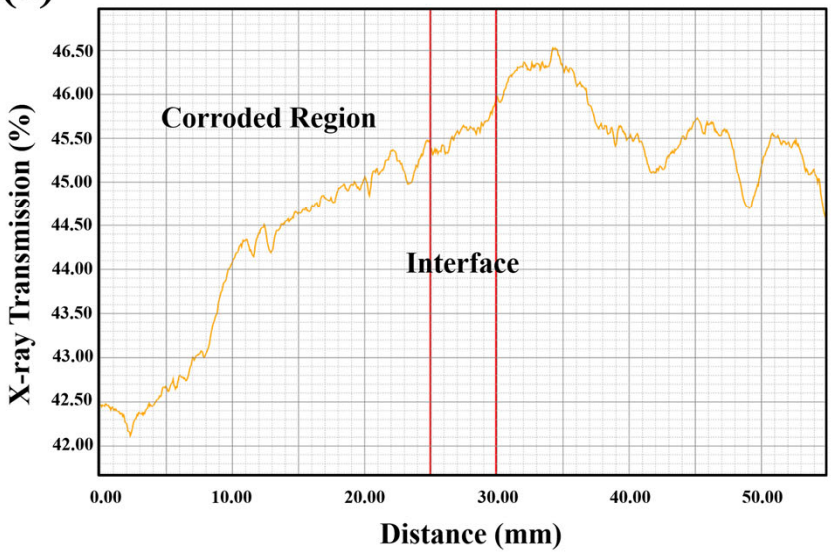
(a)

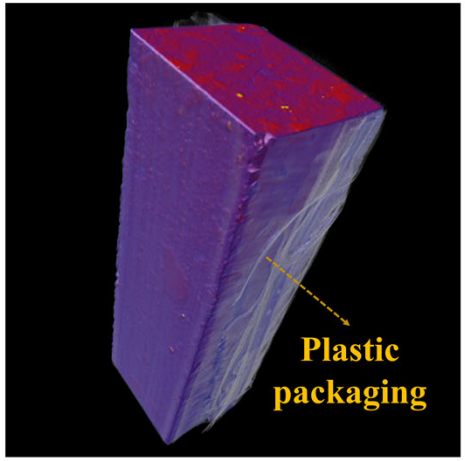


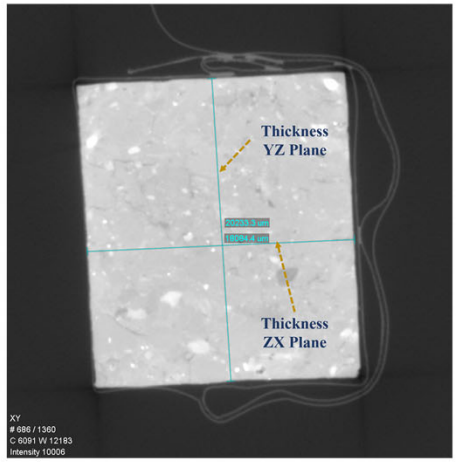
(b)

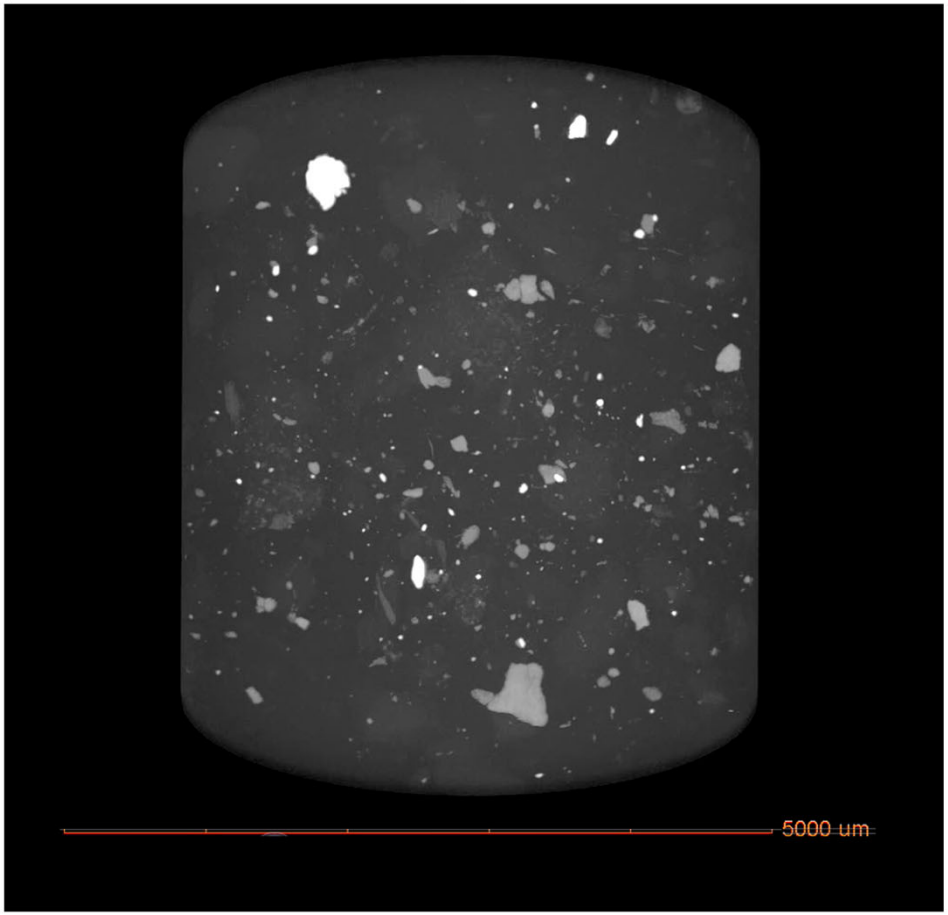


(c)









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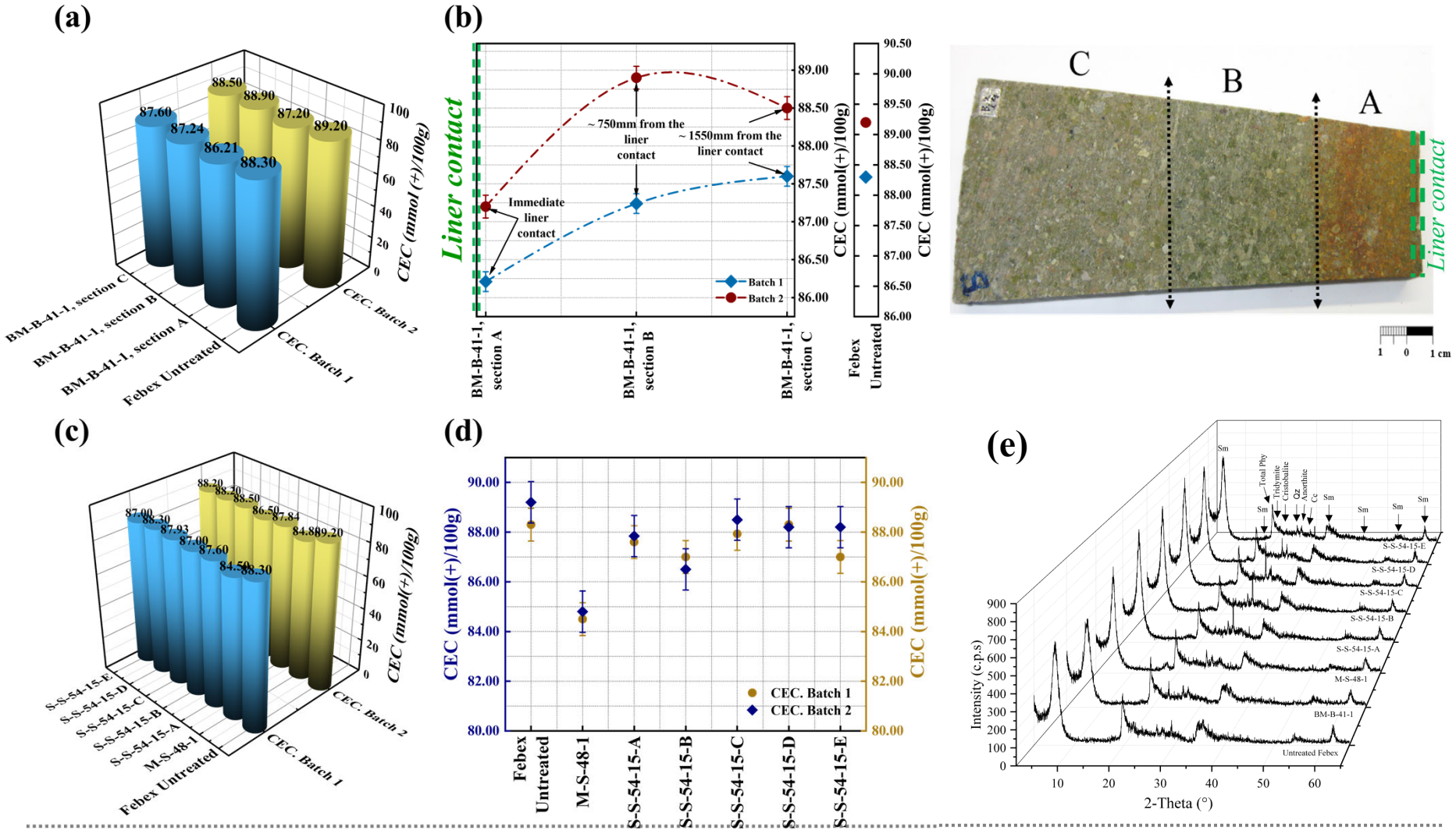
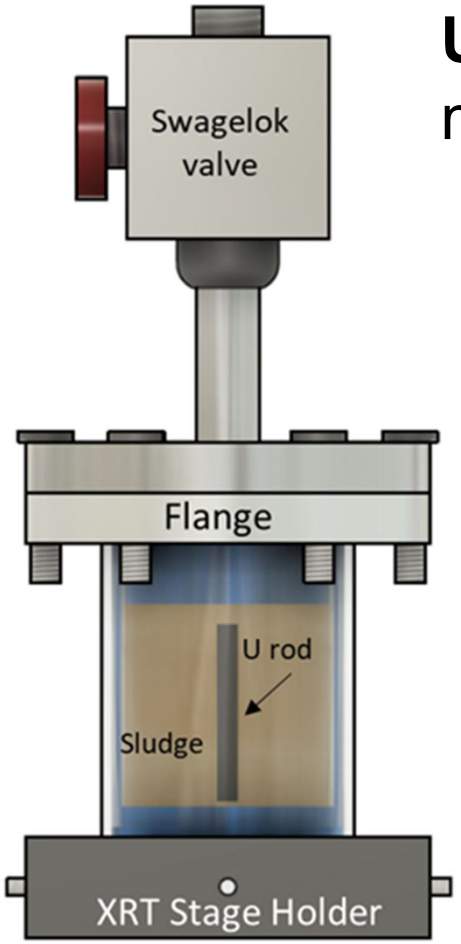
XRD and CEC results



Example – In situ analysis



Uranium and **Uranium Carbide** are fuel materials that will be emplaced in a UK GDF.

Should containment fail, both are **reactive materials** that can also be **leached** by contacting waters.

To study their GDF evolution you **must analyse them in situ!**

Data Collection

- 20 days after preparation
- 50 days after preparation
- 360 days after preparation

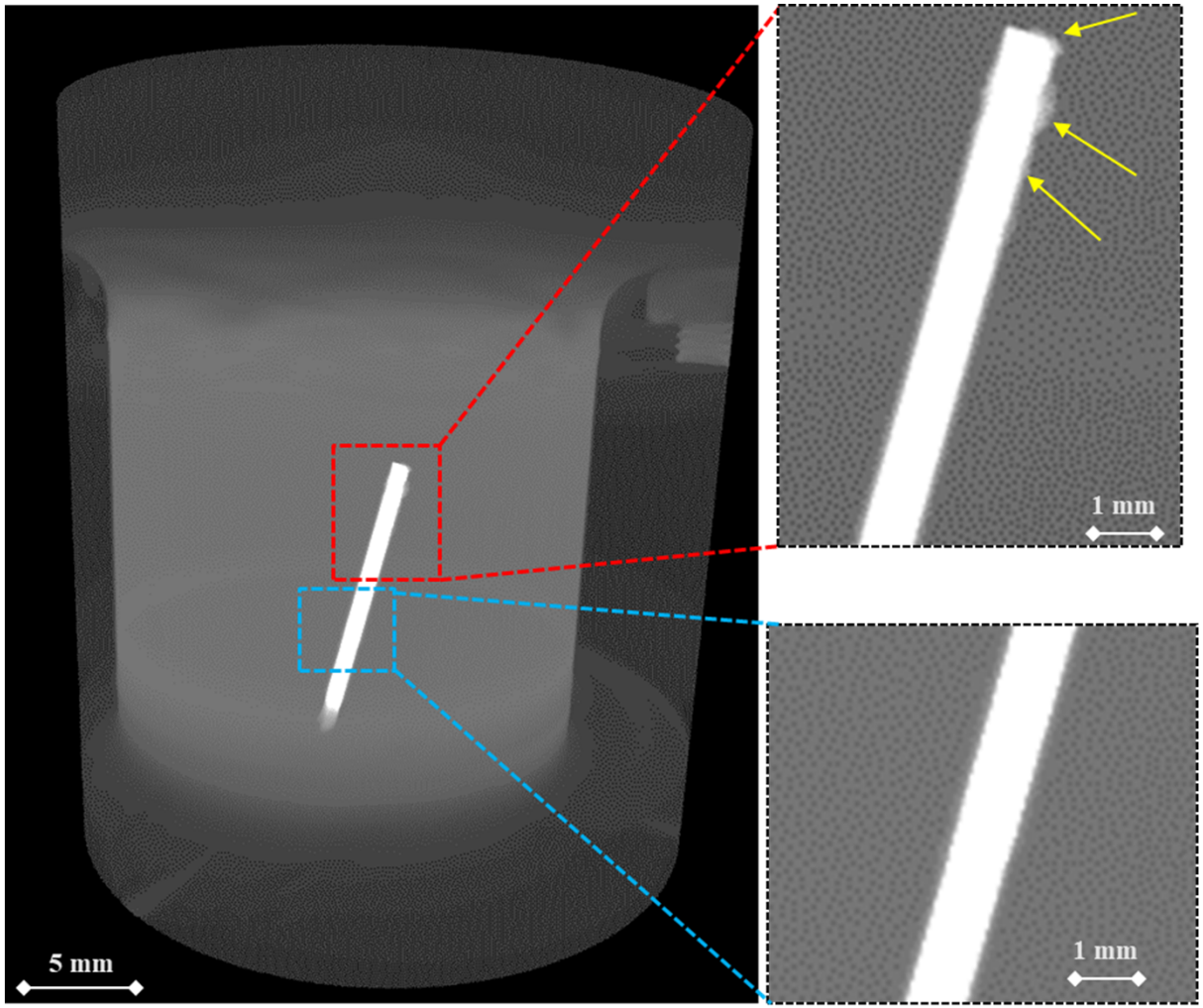
XRT Scans

- Low-resolution, high FOV (~30µm/pixel, ~1 h 30 mins/scan)
- High-resolution, low FOV (~2.8µm/pixel, ~20 hours/scan)

In situ XRT analysis of U metal

- Both U metal and U carbide ‘stick’ samples have been placed in sealed X-ray transparent cells.
- Some are in water (different chemistries), some in Magnox sludge simulant (as shown).
- XRT analysis allows direct inspection of the samples without breaking containment.
- Doing so would disrupt the system and allow O_2 ingress.

20 days in-situ….



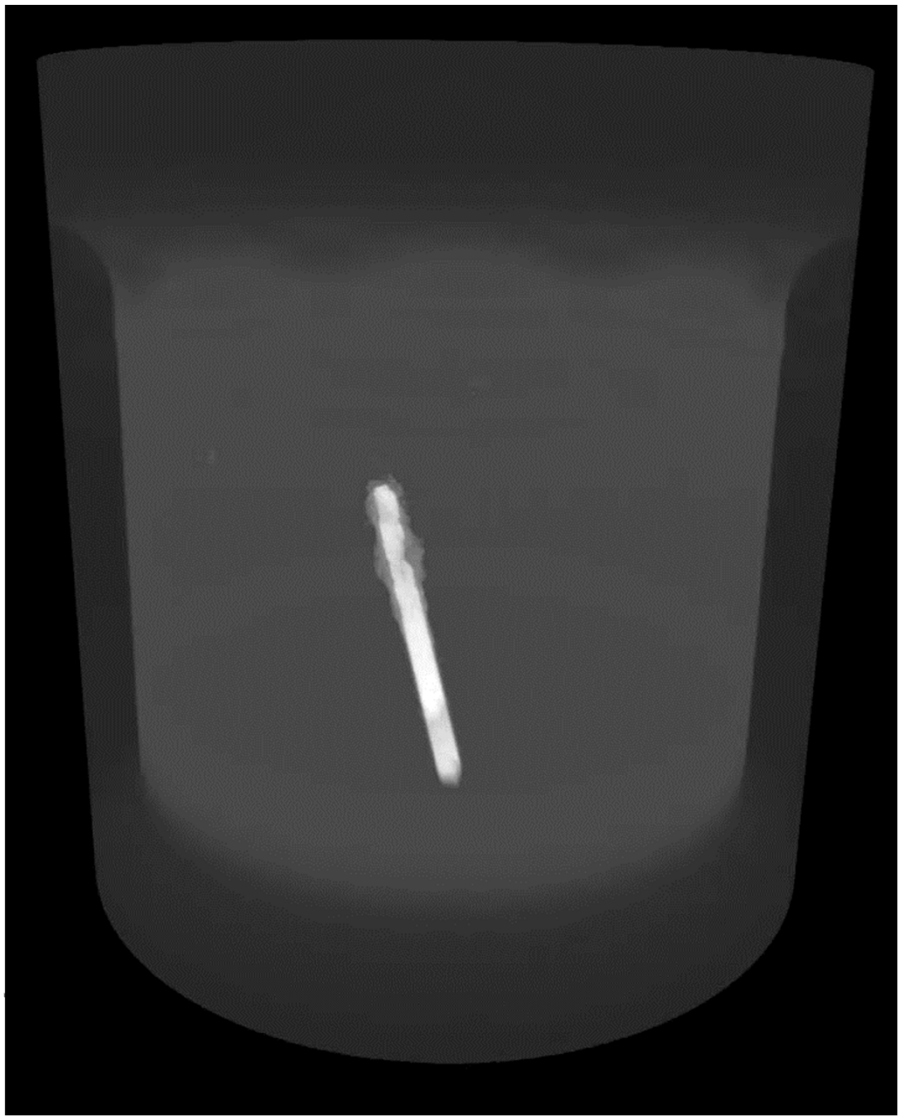
Key findings

- *First signs of corrosion*
- *Crater/blister type of morphology – No Layer*
- *No signs of corrosion across lower uranium*
- *No evidence of bubble formation in the sludge*

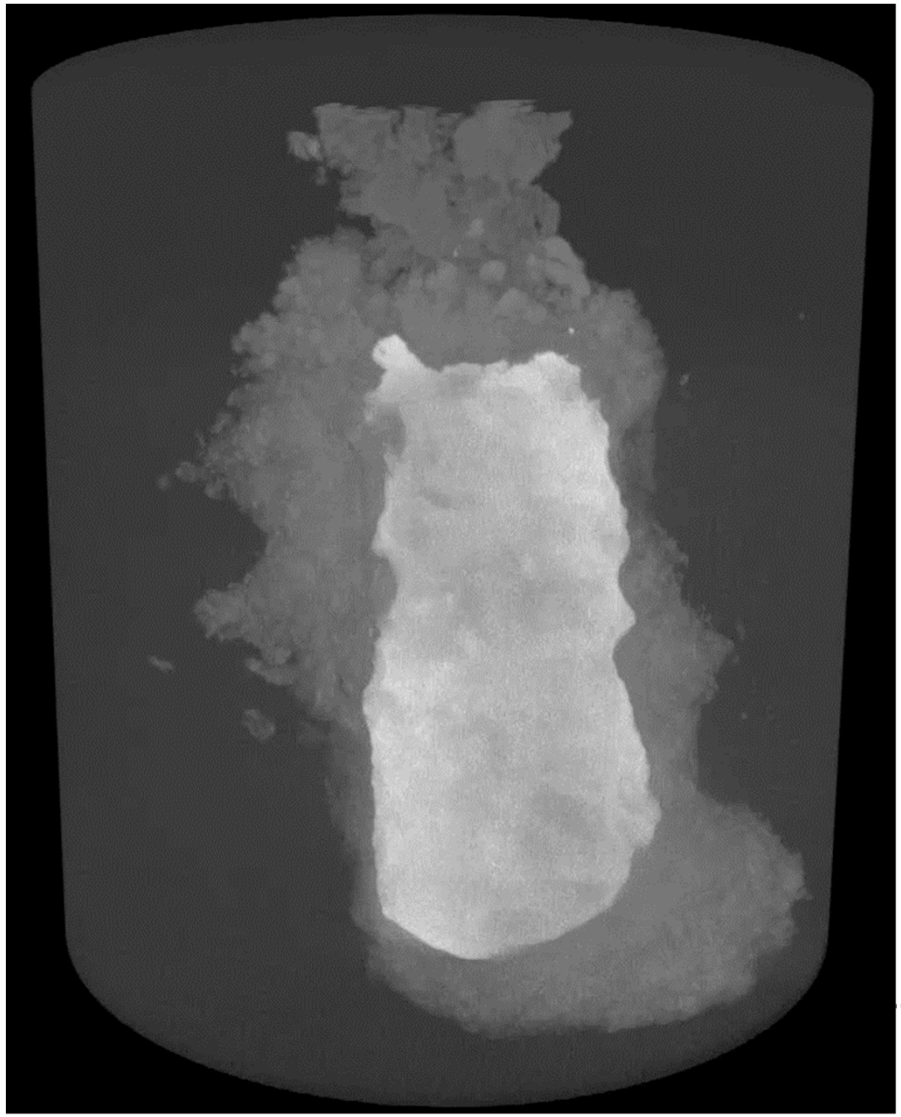
50 and 360 days in-situ….

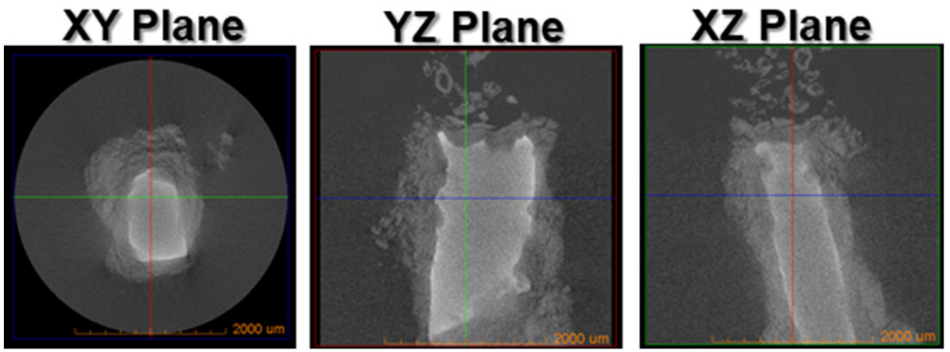
50 days

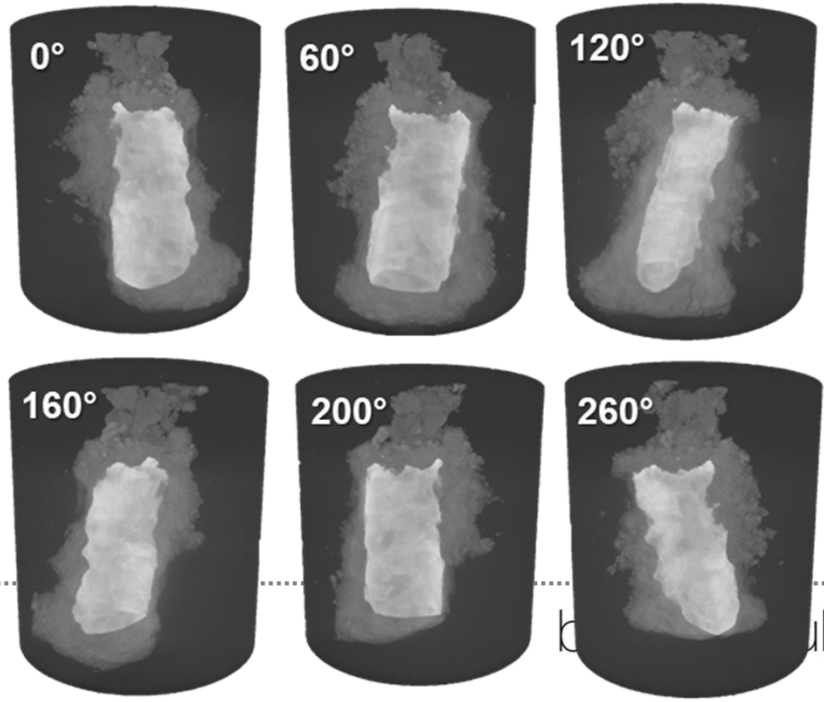
360 days



High Magnification Scan – 360 days



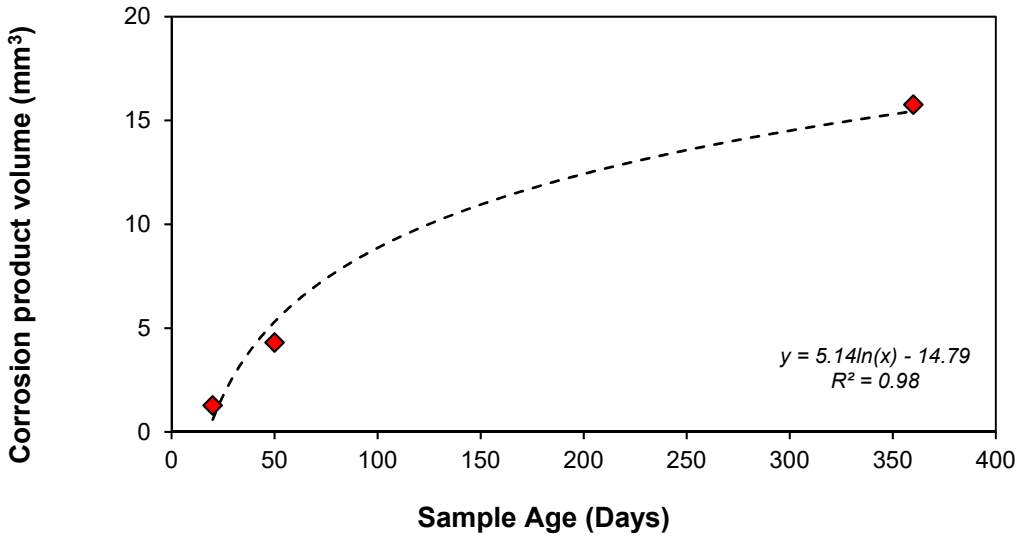


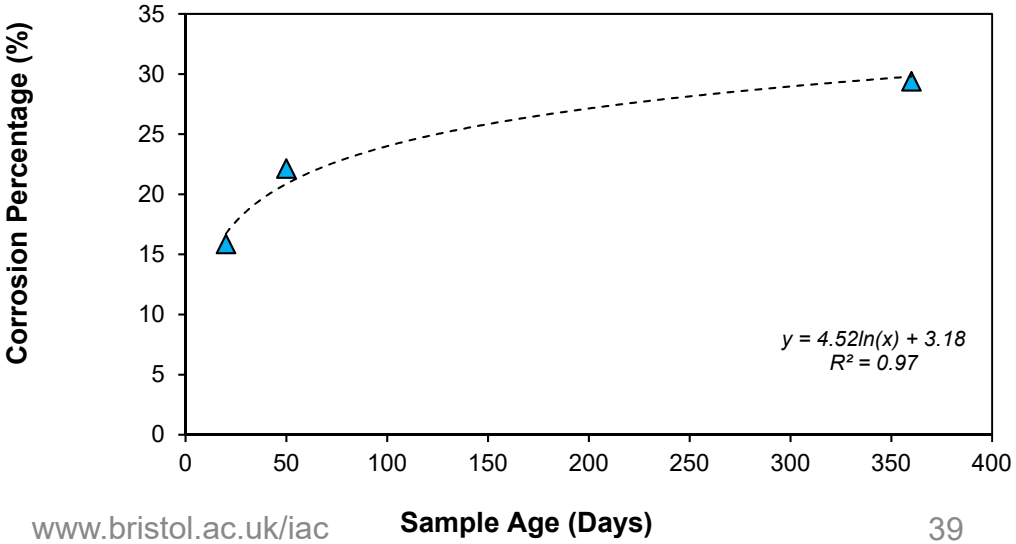


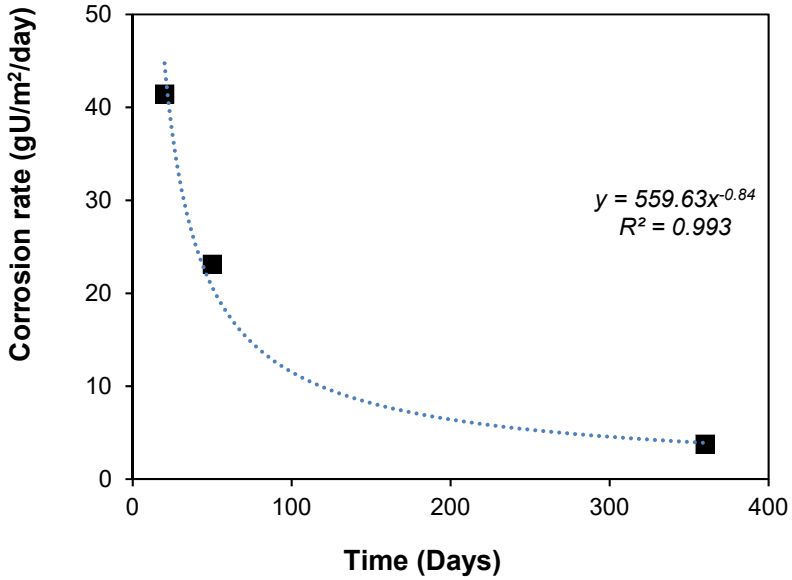
Quantitative analysis – rate data

Analysis

- *Image Segmentation*
- *Phase Separation*
- *Volume Calculations*
- *Corrosion Rate/Percentage*

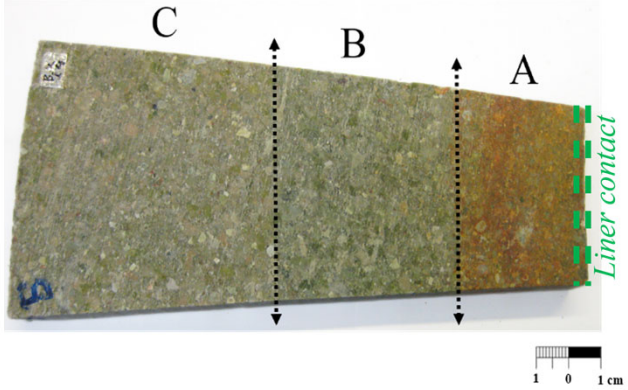


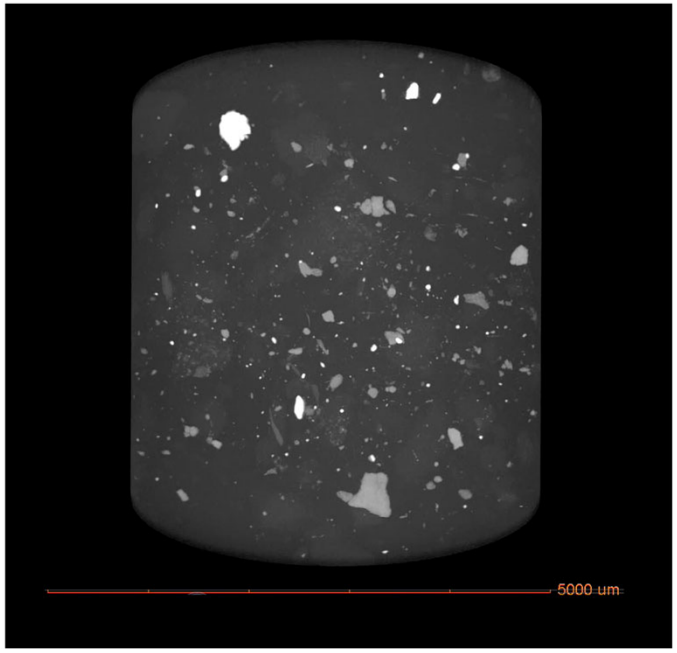




Summary and Conclusions

- Analysis of **long-duration test** samples is **incredibly valuable** for providing credible evidence for GDF performance.
- **In-situ analysis** of materials is challenging but highly-important for facilitating **time-resolved** studies of materials.
- A **multi-technique approach** for research on GDF materials is a necessity.
- We have the **experimental tools and methodologies ready** for site specific studies to commence in the UK.





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Acknowledgement

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THANK YOU!