STEM for BRITAIN

Studying Glass Corrosion Mechanisms For Storage of Nuclear Waste Using Time-of-Flight Elastic Recoil Detection Analysis

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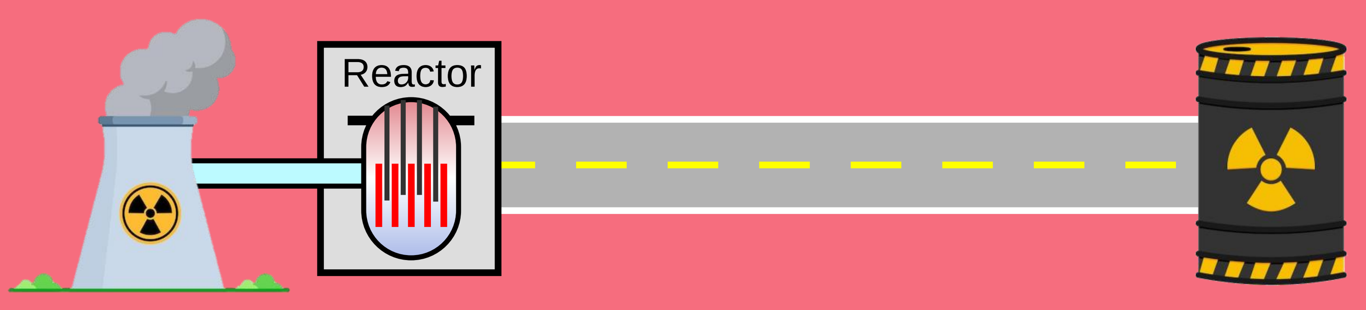
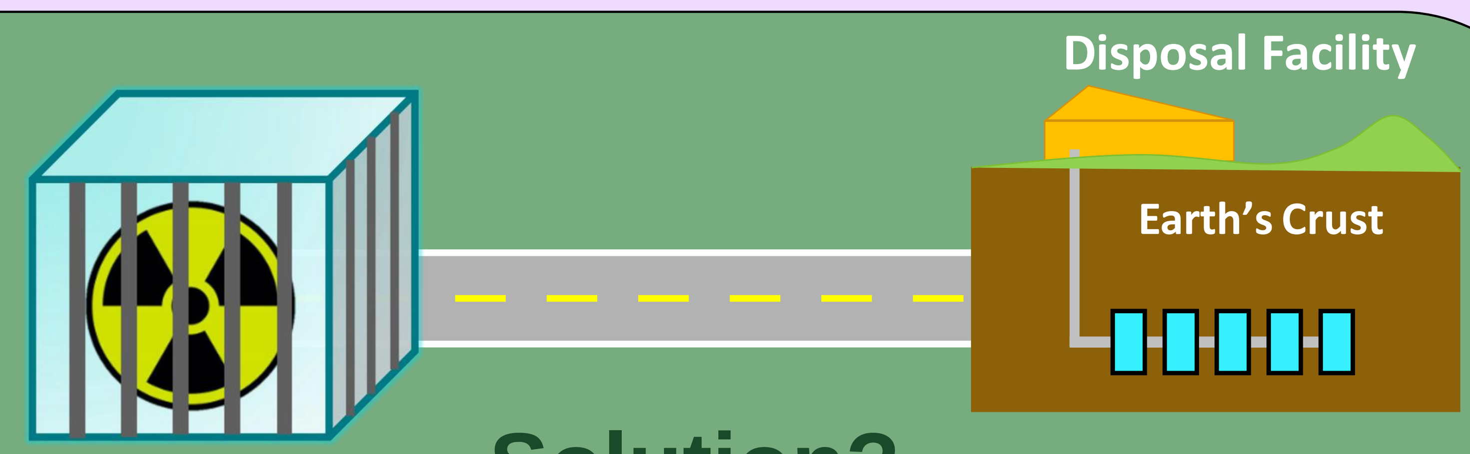
Problem

- The generation of nuclear waste is a worldwide concern - 15% of the UK's power comes from nuclear facilities, which generates waste rich in **uranium** and **plutonium**
- The UK alone has a waste inventory of **350,000 m³** (2019)[1] - awaiting disposal in a **sustainable** method



➔ Long term strategies required for the safe disposal of nuclear waste



Solution?

- Waste and glasses are mixed in a vitrification process to **immobilise** radioactive elements[2]
- Vitrified waste then stored in geological disposal facilities for long term disposal[2] – **1K to 1M years**

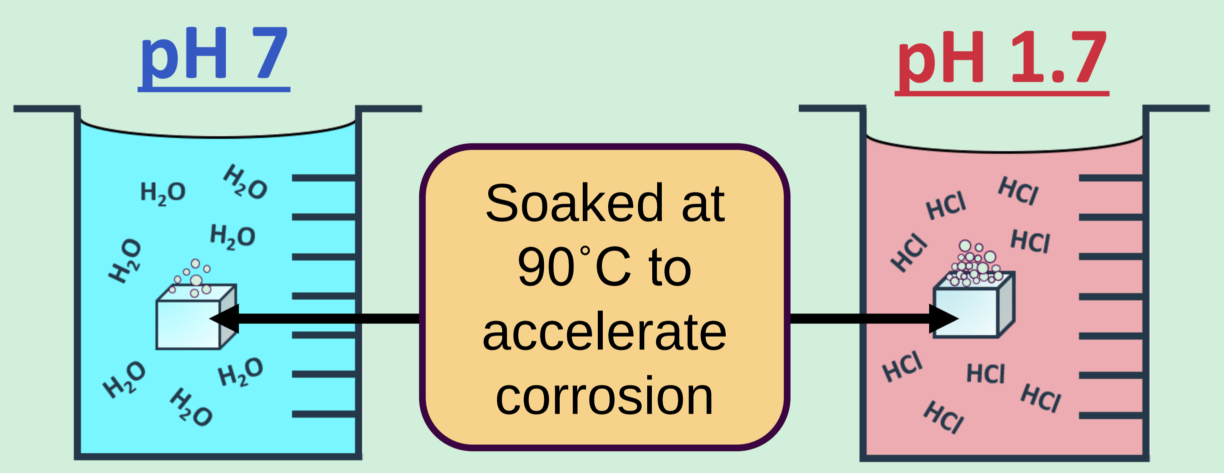
➔ How stable are these glasses to future geological conditions? How to model?

Ancient glasses are used to validate accelerated conditions - used to mimic future glass behaviour over shorter time spans (< 1hr)

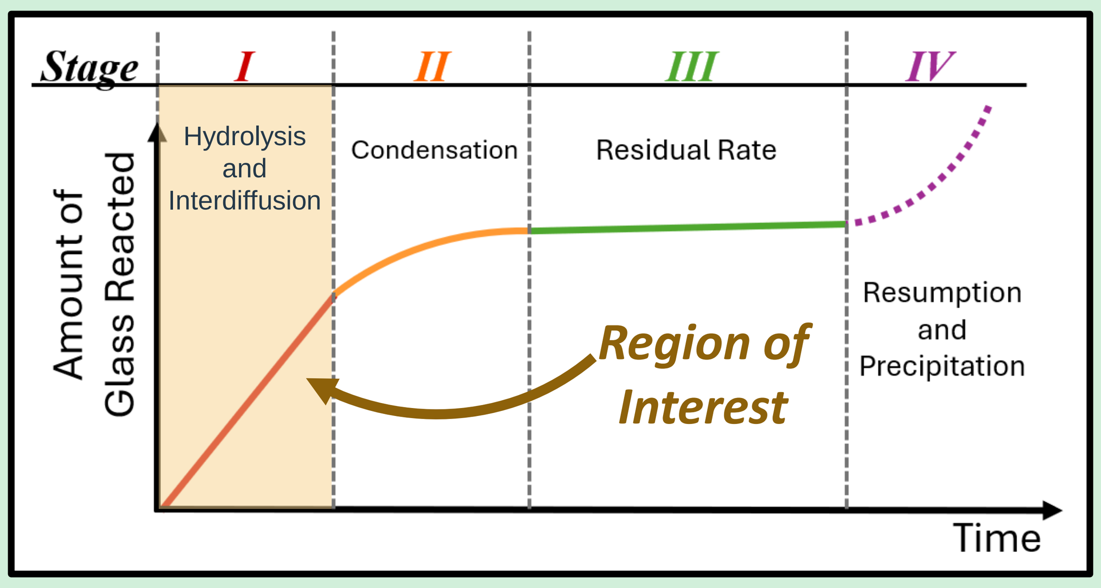
Past (1000s of Years) **Present** (1000s of Years) **Future**

Samples

- International Simple Glass (ISG-2) samples used – borosilicate glass standards
- Samples subjected to simulated geological conditions for varying time spans:



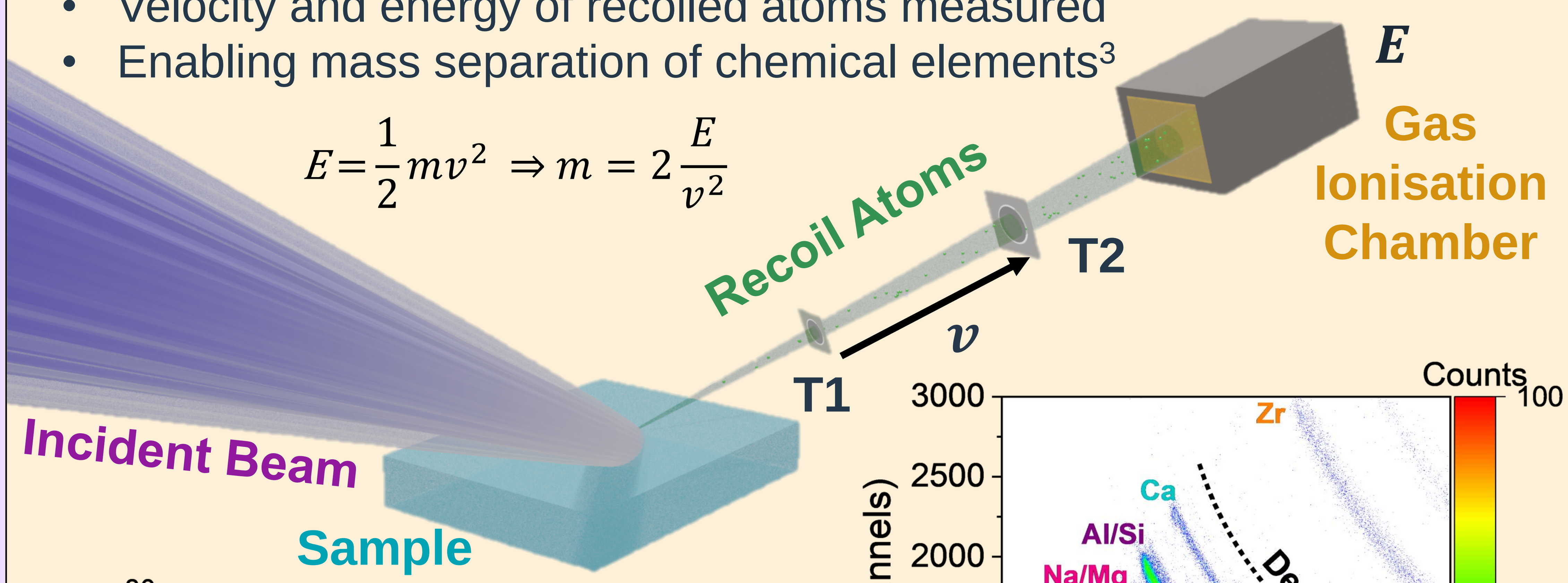
- Investigating the rapid alteration of glasses:

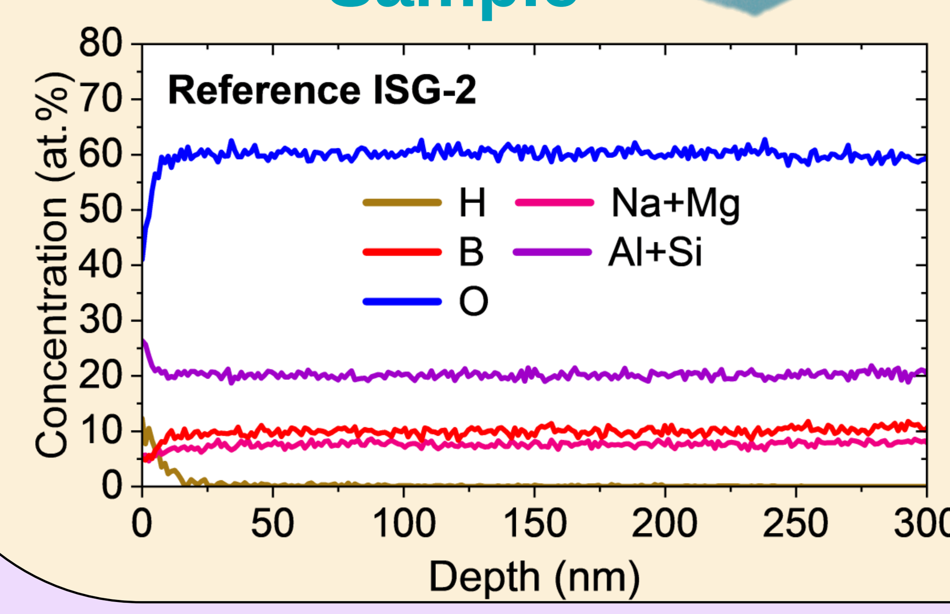


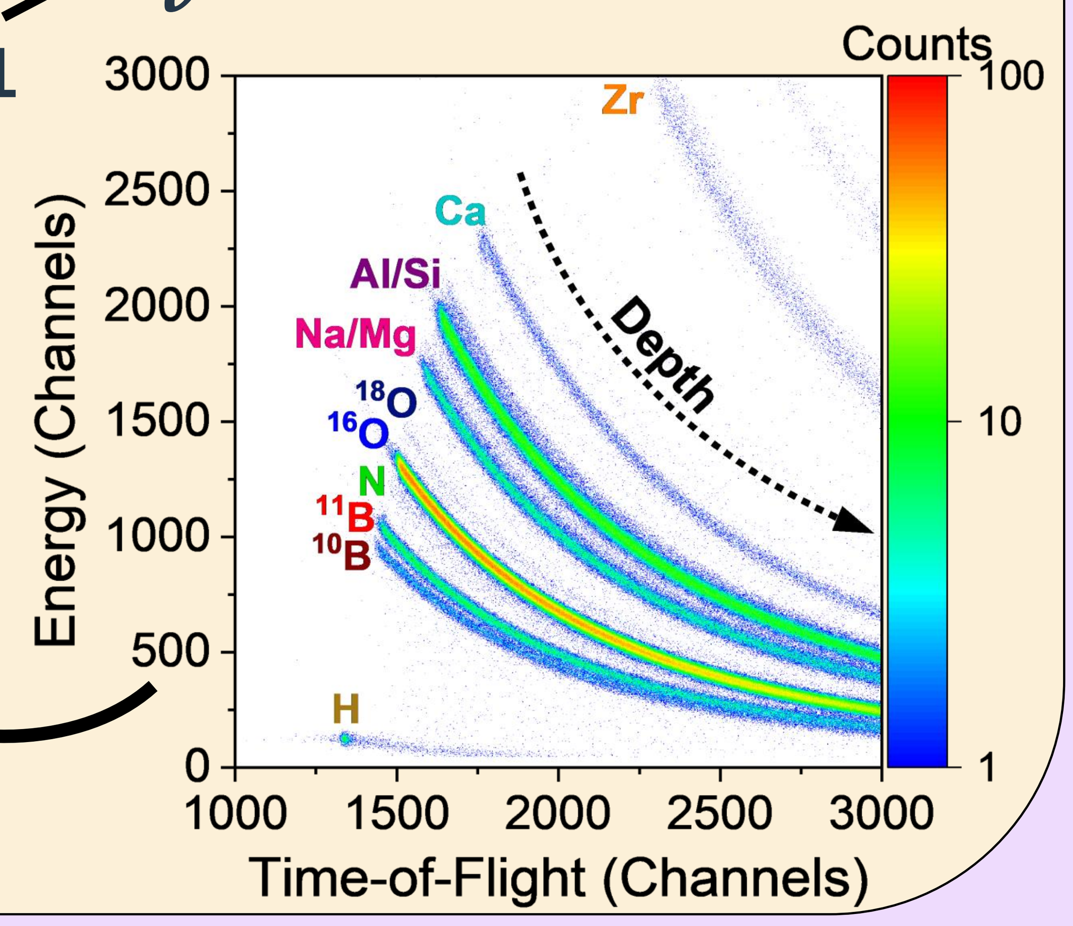
Time-of-Flight Elastic Recoil Detection (ToF-ERD)

- Samples bombarded with 16 MeV $^{127}I^{8+}$ using 2 MV accelerator
- Velocity and energy of recoiled atoms measured
- Enabling mass separation of chemical elements[3]

$$E = \frac{1}{2}mv^2 \;\Rightarrow m = 2\frac{E}{v^2}$$







Results

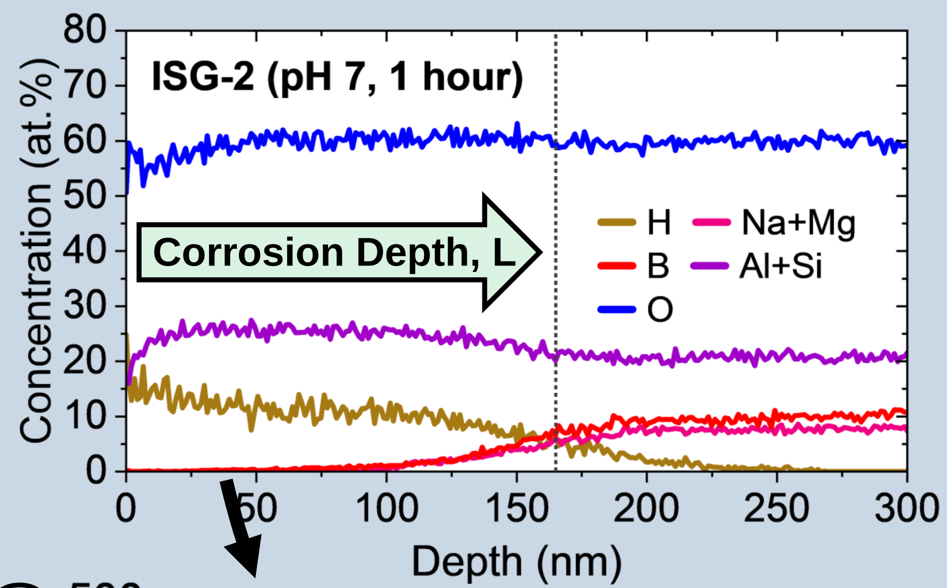
- ToF-ERD results used to track elemental release and distributions throughout corrosion process
  - Observed formation of protective gel layer
- Corrosion interface depths monitored with respect to time and pH
- Depth of corrosion governed by Fick's second law[4]

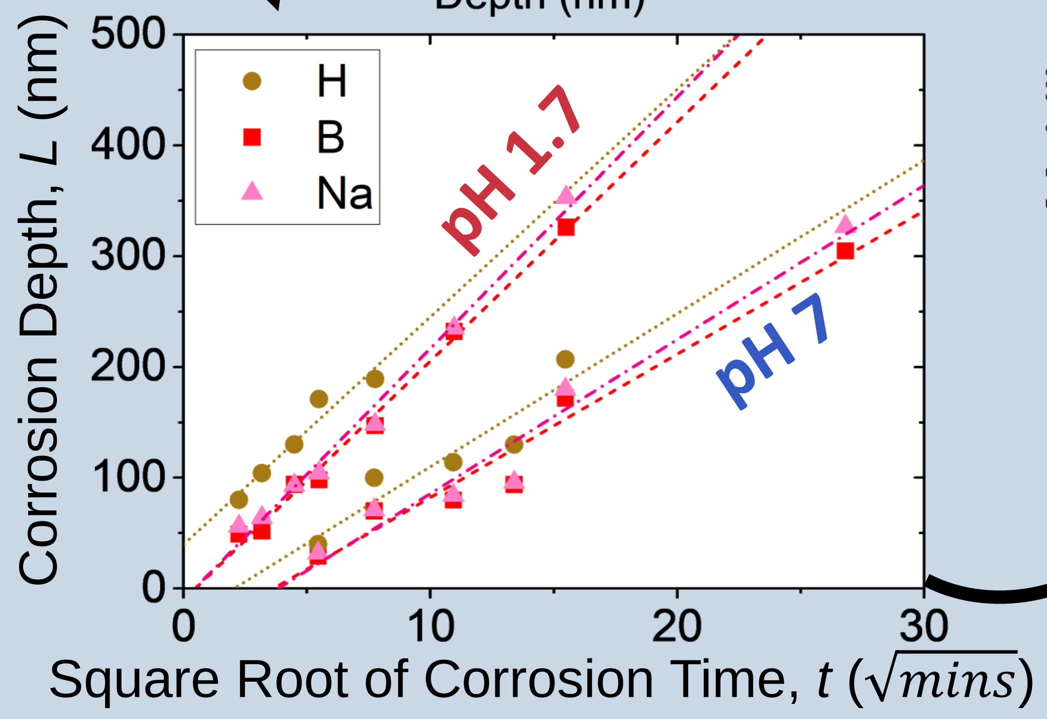
$$L \propto \sqrt{Dt}$$

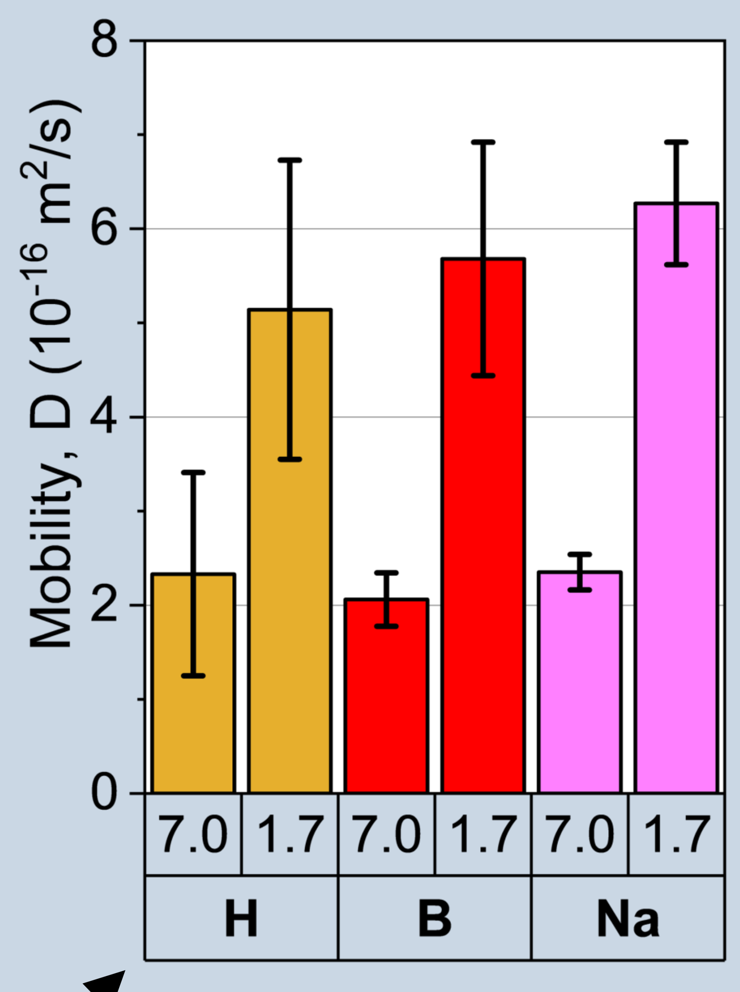
Corrosion Depth (L), Mobility (D), Time (t)

- Gradients from linear fits used to determine elemental mobility for each pH value
- Mobilities increased by a factor of 2.5 due to extreme acidic conditions

➔ Gives insights to enhance predictive models of long-term glass stability for disposal of nuclear waste







Summary

- ToF-ERD is a powerful technique in building a fundamental understanding of glass corrosion
- Study aids in building confidence in the long-term use of geological facilities for disposal of nuclear waste

References

[1] "Inventory for geological disposal Main Report", Didcot, (2021)
[2] S. Gin, Proc. Mat. Sci., **7**, 163–171, (2014)
[3] Y. Shi, et al., Appl. Phys. Lett., **123**, 261106, (2023)
[4] G. Y. Park, J Eng Fiber Fabr, **14**, (2019)