University of Strathclyde Engineering

WP 4: Structural Integrity

University of Strathclyde

Prof. R Lunn, Dr A. Hamilton, Dr G. El Mountassir, Dr M. Saafi, Dr S. Yang, Dr R. Lord, Dr J. Renshaw, Prof. A Tarantino

Three work packages

WP 4.3.1 Physical Ground Barriers for In Situ Contaminant Containment

Strathclyde

Resource: 1 PDRA, 1 PhD

WP 4.3.2 Remote Crack Detection, Infrastructure Health Prediction and Building Preservation

Strathclyde

Resource: 3 PhDs

WP 4.3.3 Development and Real-time Management of Autonomous Systems for Decommissioning

Stolkin (Birmingham), Lennox (Manchester)

Resources: 2 linked PhDs

Strathclyde Work Packages

Dr Andrea Hamilton –Leading WP 4.3.2

Senior Lecturer, Material Scientist

Research interests:

- **Chemo-mechanics**: The mechanical effect of chemical reactions in cement and geo materials.
- **Damage formation** in building materials and predicting material durability.
- **Mineral stability** (cements in particular) and dissolution kinetics.
- **Creating nanoparticles** for building preservation.

Expertise: wet cell AFM (including surface force measurements), synchrotron X-ray diffraction, colloid stability, water transport modelling.

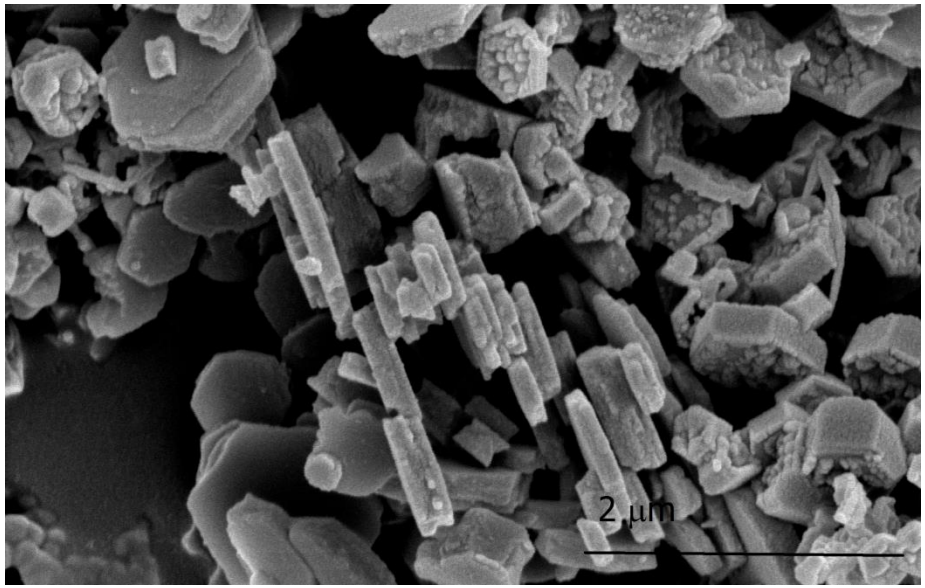
WP 4.3.2 Remote Crack Detection, Infrastructure Health Prediction and Building Preservation

PhD 1 – Riccardo Maddalena, started Jan 2014. University funded.

Education: **M.Eng** in Environmental Engineering (2013)

Topic: Controlling deterioration of contaminated storage structures.

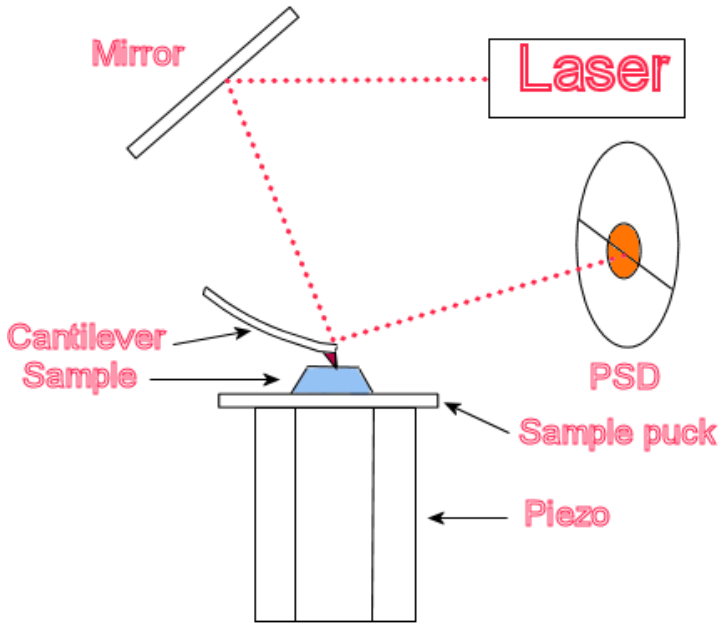
Understanding the effect of cracking on water flow through built structures (mainly concrete); environmental impact of accelerating cracking; explore solutions such as application of nanoparticle cements.

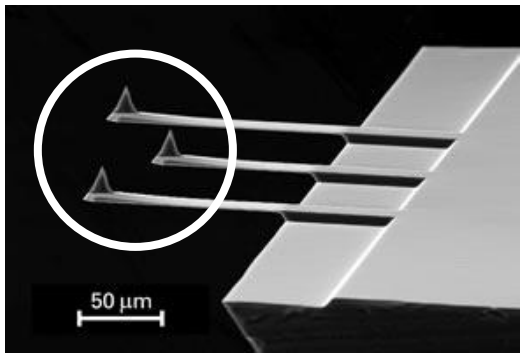


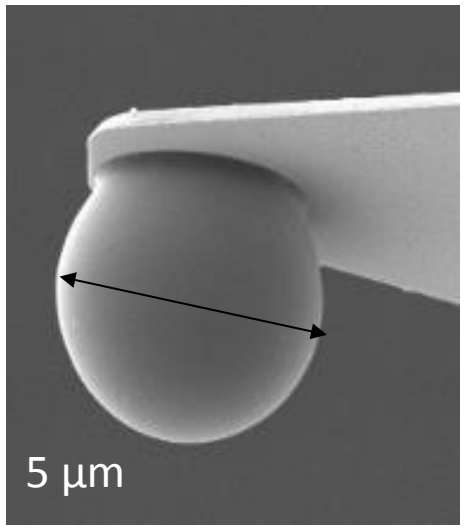
PhD 2 – Advertised, starting Oct 2014. CASE award (NDA), EPSRC.

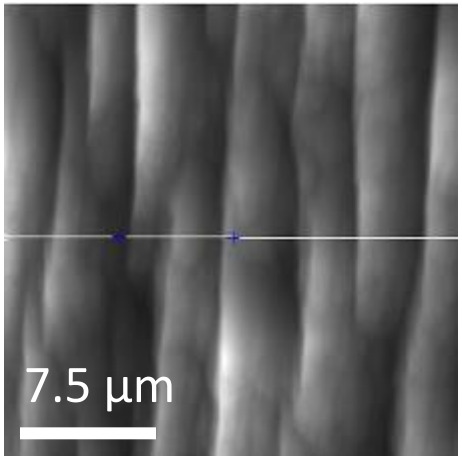
Topic: Nano-fracturing in cement

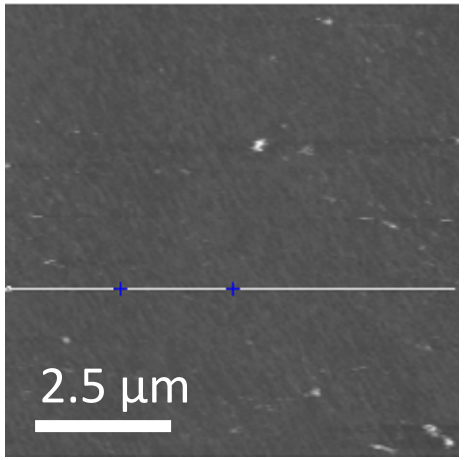
Cement stability at the nanoscale using atomic force microscopy (AFM); Mechanical effect of chemical alteration will be quantified using high energy X-ray diffraction. Goal is to establish a model for development of strain induced in cement/concrete by chemical alteration through time. *Emphasis is given to the long-term durability of cement for encapsulating intermediate level radioactive waste.*

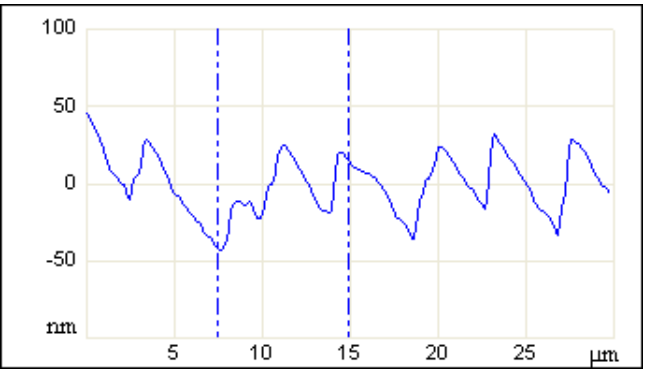


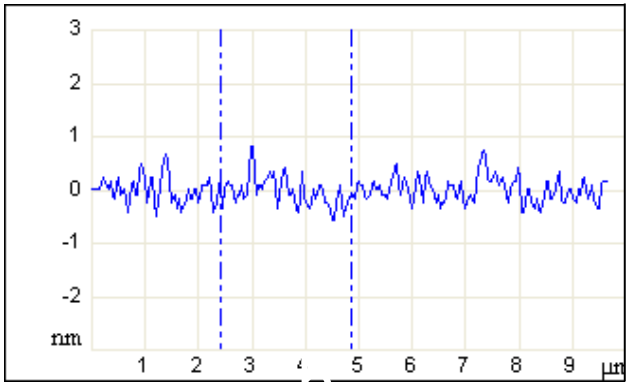












Arcanite (potassium sulphate)

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a) Naturally striated surfaces

b) Surface grown by template growth and stabilised by 5 ppm inhibitor, Cr^{3+}

Hamilton et al., 2010.

CRYSTAL ENGINEERING: Small changes in surface reactivity can be seen and quantified, crystal surfaces can be tailored by doping and forming. Strain can be measured using high energy X-rays.

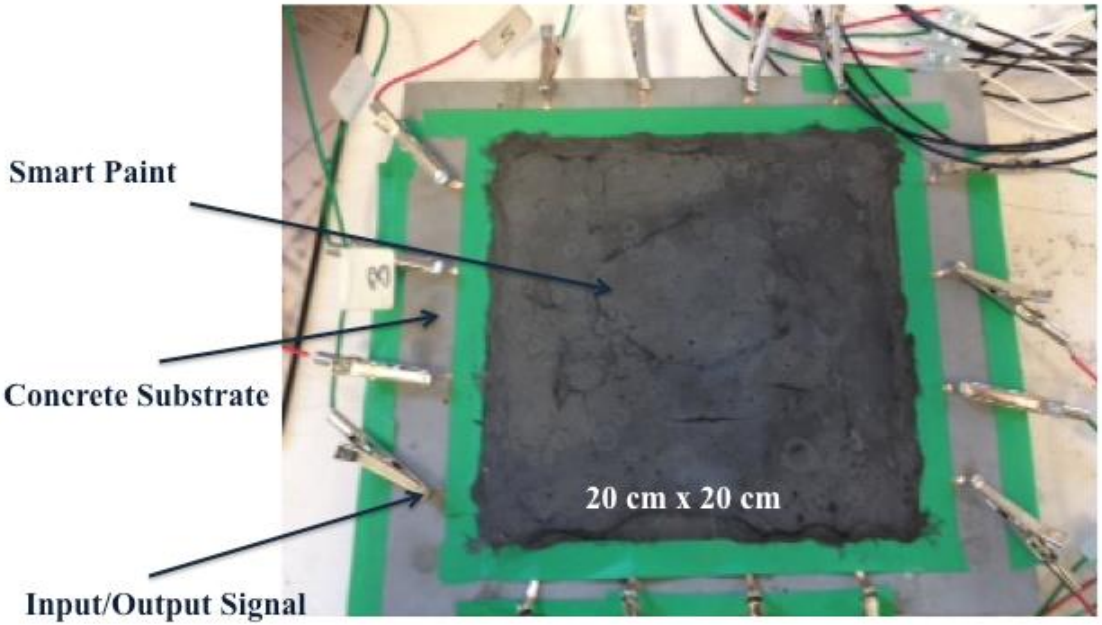
PhD 3 – Currently underfunded, University part-funded (~£6K per annum shortfall).

Topic: Sensor development for monitoring structural integrity

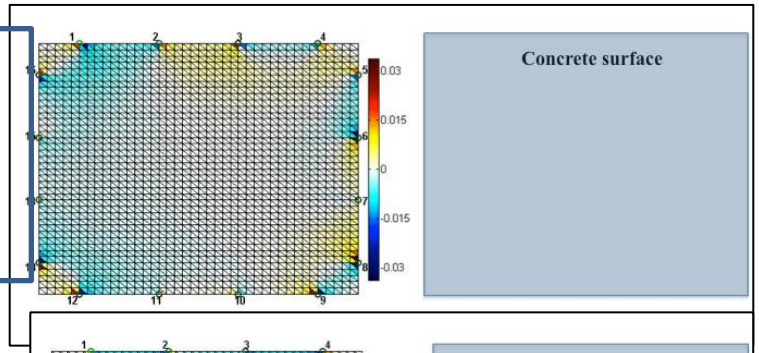
Design, fabrication and evaluation of embeddable moisture/chloride sensors for applications in concrete.

The embeddable sensors will be developed using various systems: graphene, carbon nanotubes (CNTs) and MicroElectromechnical Systems (MEMS).

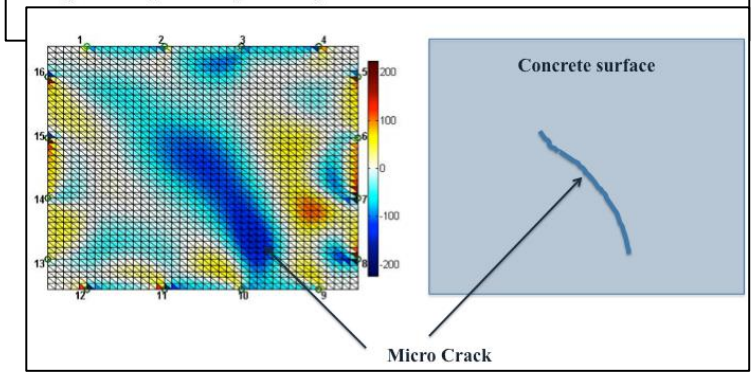
Small scale samples and field trials will be used to evaluate the performance of the sensors in terms of durability, sensitivity and resolution.



NO Damage



With Damage



Strathclyde Work Packages

Dr Grainne El Mountassir –Co-leading WP 4.3.1

Lecturer, Geotechnical Engineering

Research interests:

- **Novel grouts** for waste containment structures.
- **Biomineralisation** and biomimetics in nanoparticle development.
- **Unsaturated soils** and ground improvement

Expertise: Experimental Geotechnics, development of multi-disciplinary technologies.

WP 4.3.1 Physical Ground Barriers for In Situ Contaminant Containment

PDRA – Matteo Pedrotti, August 2014

Education:

- **M.Eng.** in Civil Engineering (2010)
- **PhD** in Civil and Environmental Engineering (2014)

Research Interests:

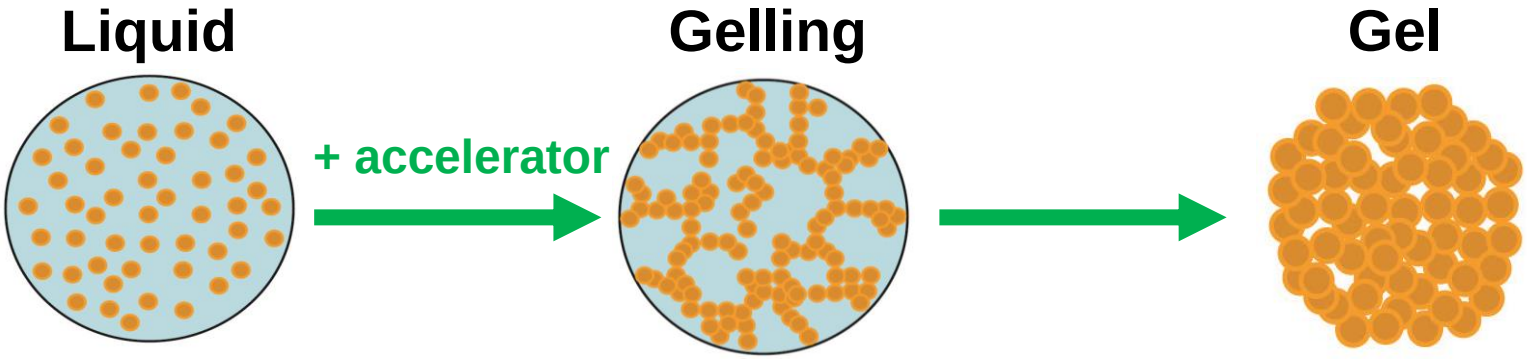
- Particle interactions, Micro-to macro-behaviour, Measurement and control of soil suction, Experimental clay mechanics

PhD student– Chris Wong, Started October 2013

M.Eng in Civil Engineering, Cardiff University (2013)

WP 4.3.1 Physical Ground Barriers for In Situ Contaminant Containment

Silica sol



Stable dispersion of SiO_2 nanoparticles

Reduction in repulsion

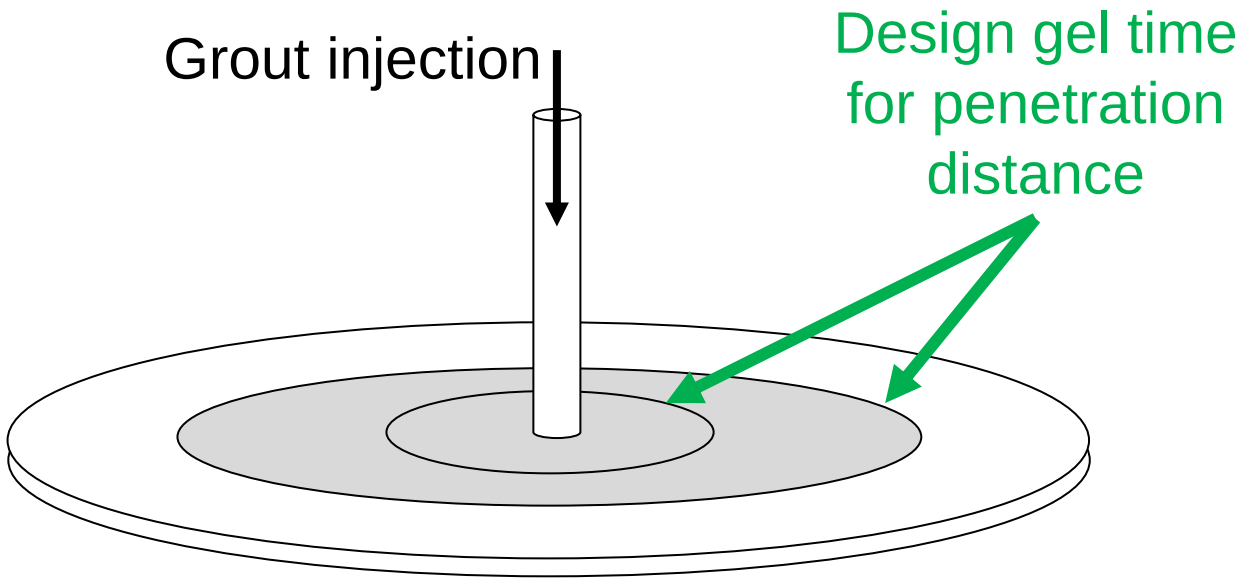
Siloxane (Si-O-Si) bonds formed

BEFORE

AFTER!

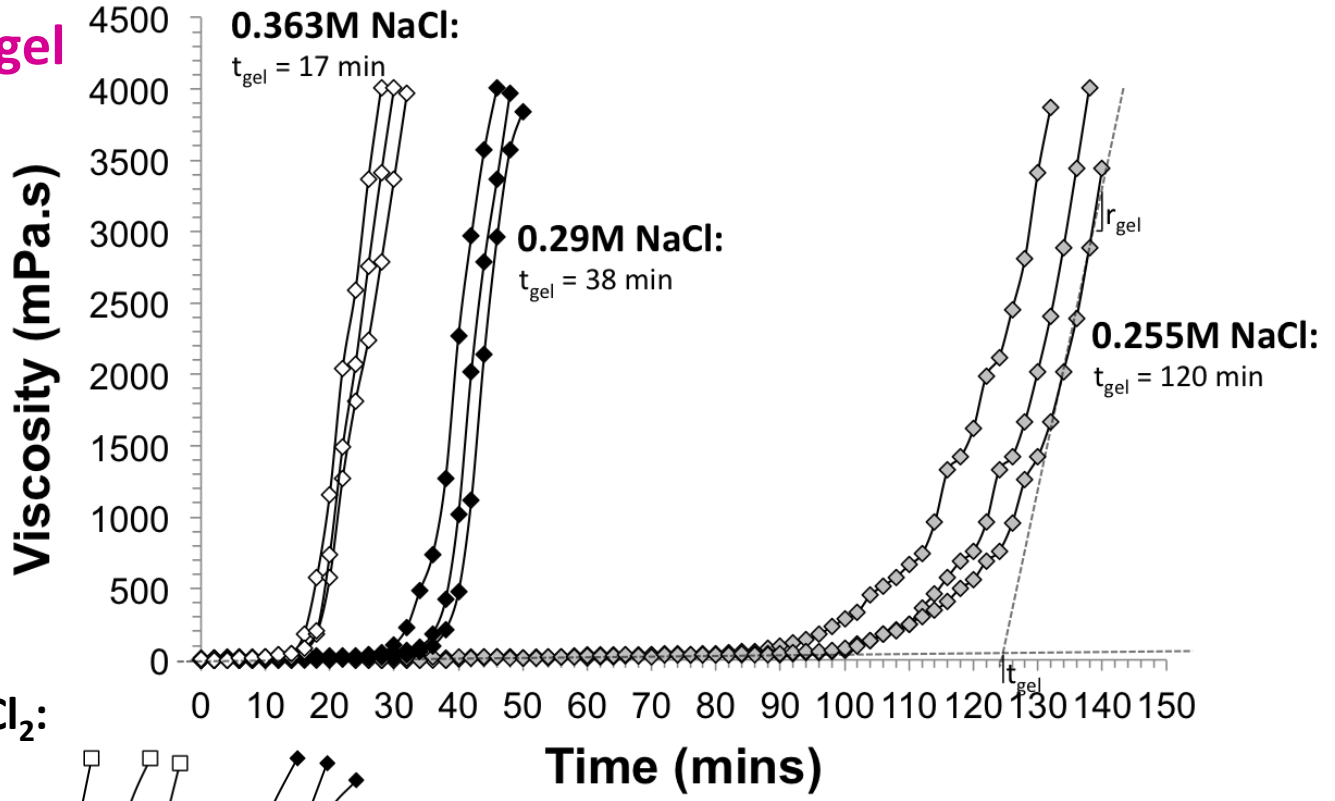
Aim: To develop hydraulic barriers that can be injected in low permeability sediments

Gel time governs grout penetration

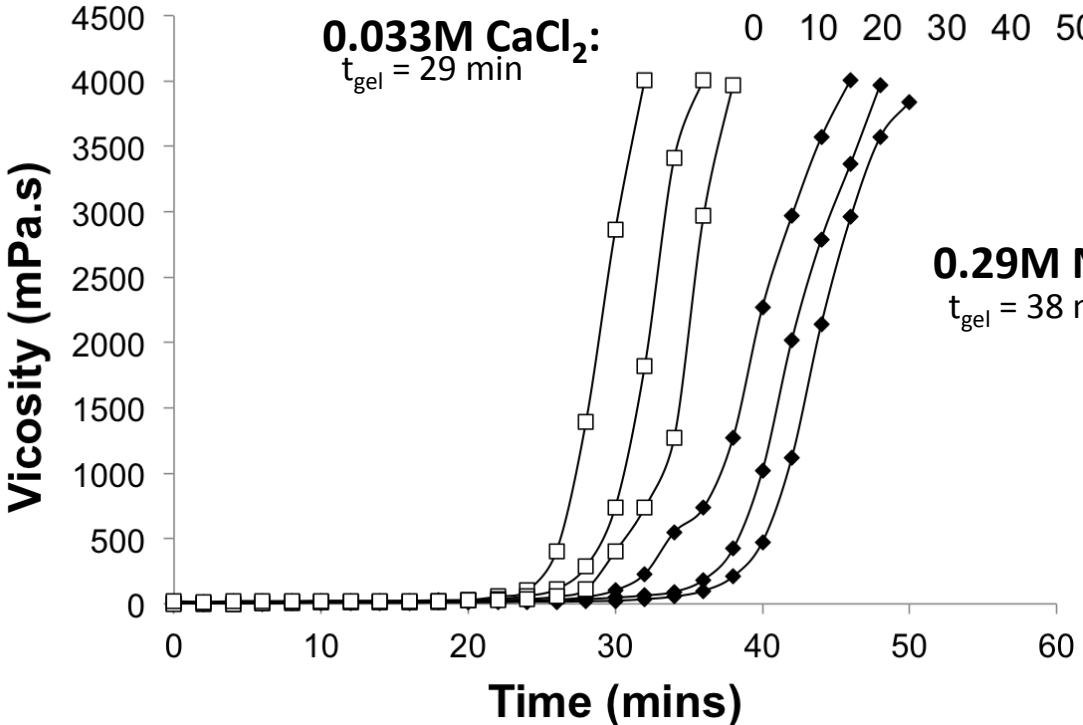


Variables influencing gel time:

- Accelerator concentration
- Cation valency
- Cation specificity
- pH



5:1 Silica sol: NaCl accelerator



Challenges:

- Groundwater will naturally contain a variety of different cations ($Na^{+,}$ $Ca^{2+,}$ Mg^{3+}…..)
- Varying groundwater pH
- Soil composition - clay, silt, sand composition
- Combinations of all of the above

Applications

- **Can we design a horizontal barrier?**
- **Can we design a combined chemical/hydraulic barrier?**

Questions for industry partners

- What problems do onsite buildings face and what techniques/methods have already been tried?
- What are the storage issues with intermediate level waste encapsulated in cement? What has already been tried?
- What remote monitoring systems or sensors are currently in use? Has the data proven useful/illuminating?

WP 4.3.3 Development and Real-time Management of Autonomous Systems for Decommissioning

Two linked PhD projects at Birmingham and Manchester

(1) Novel remote material characterization technologies in extreme radiation environments

(2) The real-time on-site management of autonomous systems with improved control systems.