Imperial College London

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Pore-scale characterisation of granular materials

Insights into fluid flow, water retention and deformation patterns

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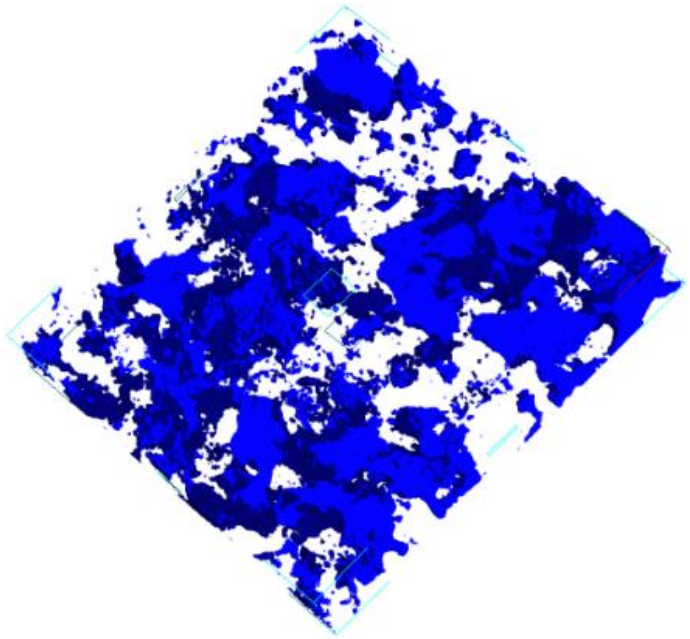
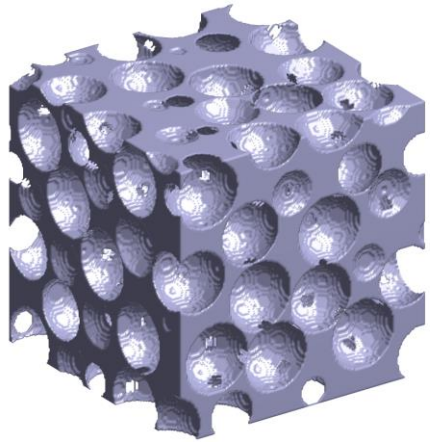
Complexity of the pore space in real & idealised geomaterials

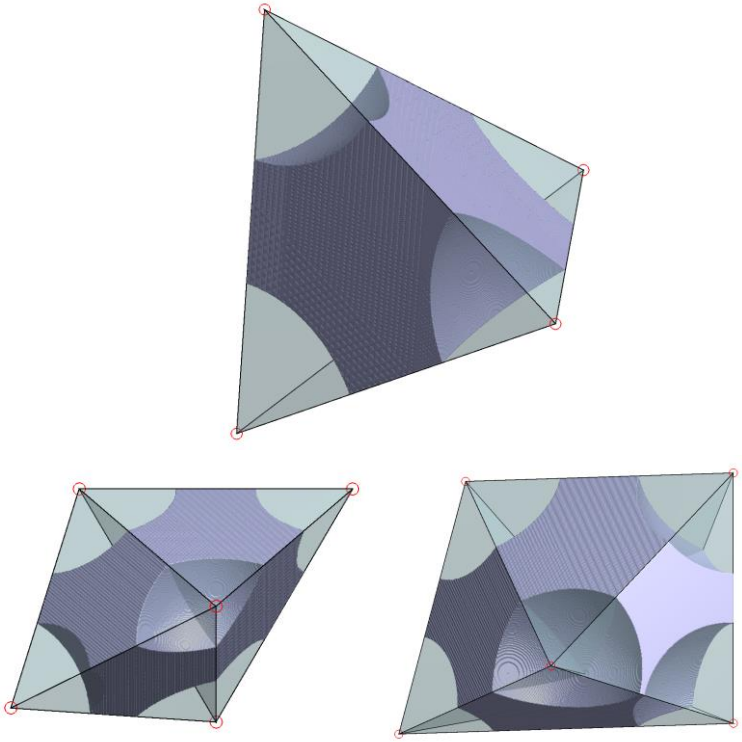


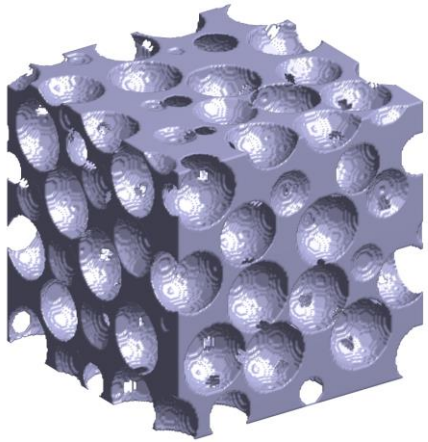
X-ray CT imaging of pore space in Gosford sandstone



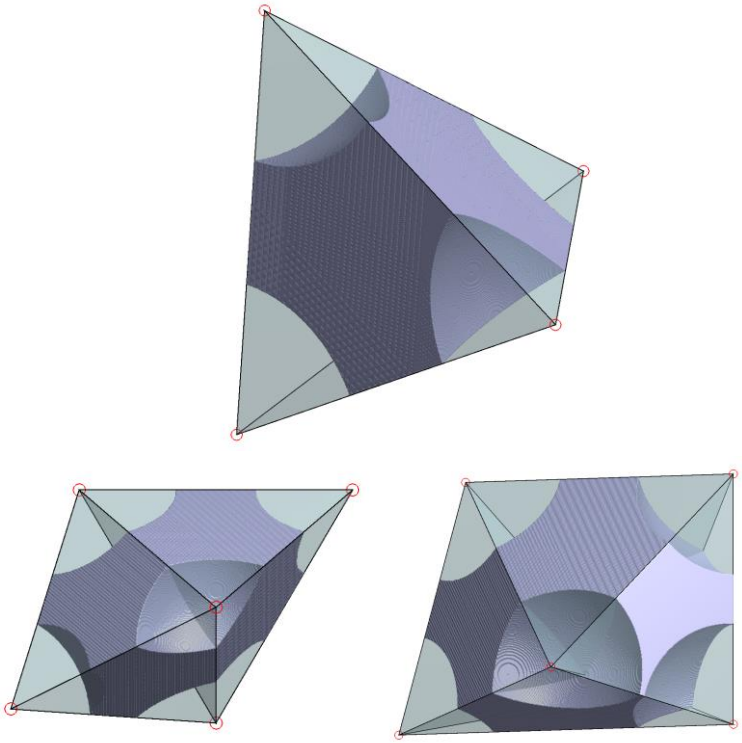
Render of the pore space in a packing of spheres

Tessellating/discretising the continuous pore space





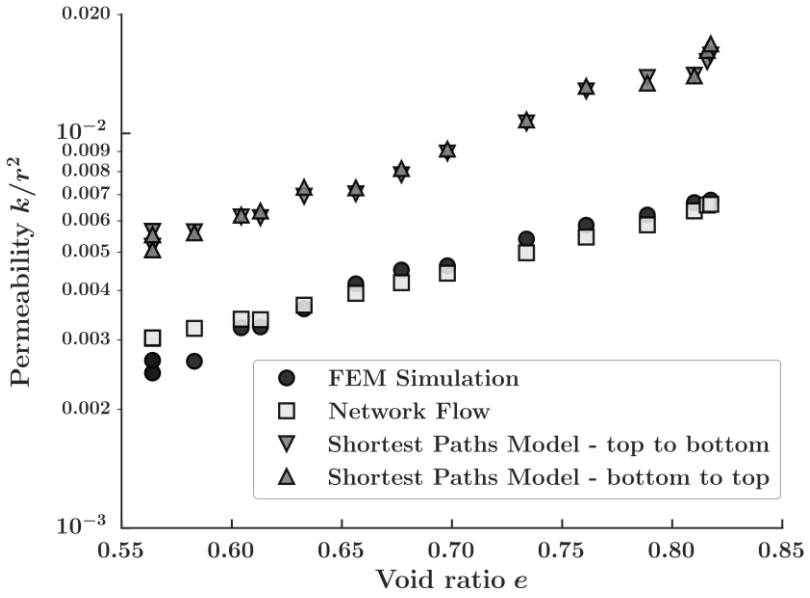
Characterisation at the pore-scale



- Properties of individual pores at the pore-scale is more easily defined than considering the continuous pore space as a whole:
  - Volume
  - Area
  - Shape
  - Orientation
  - Connectivity

Network description at the pore-scale to estimate permeability

- *Network model* of pore space – Individual pores are connected to adjacent pores via their shared faces (or constrictions)
- Define a local conductance across constriction (based on the pore volumes and throat areas)
- Obtain an estimate of permeability by solving $Q = C \cdot \Delta P$
  - Refined models attempt to approximate preferential flow paths using concept of *shortest paths*



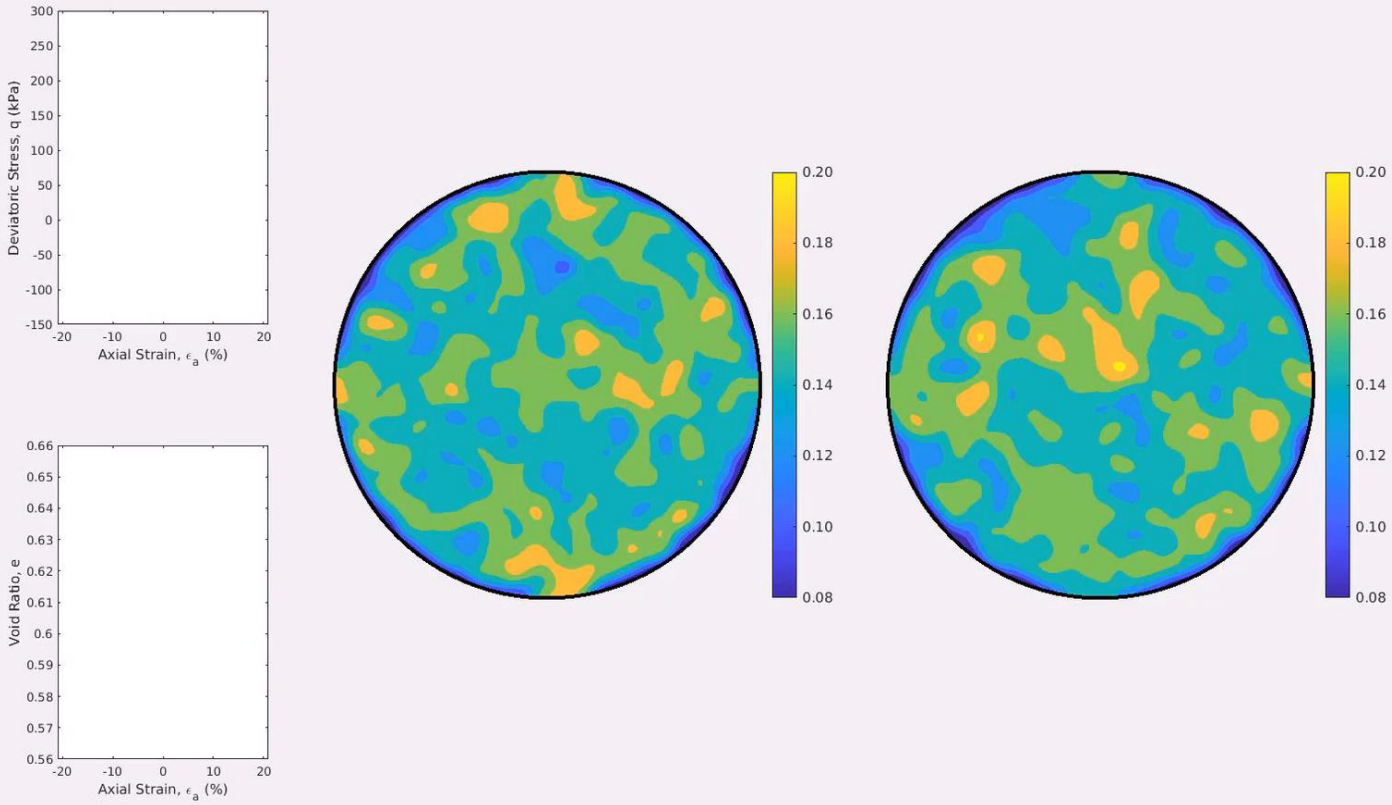
(Work conducted in collaboration with Joost van der Linden, Guillermo Narsilio and Antoinette Tordesillas at the University of Melbourne)

Exploring deformation patterns using pore orientation

- Induces anisotropy in contacts and particles.

- Induced anisotropy in pores when looking at elementary pore units.
  - Smaller pores align perpendicular to the stress direction (direction of expansion)
  - Large pores align parallel to the stress direction (direction of compression)

Evolving stereonet of pore orientation



Looking at internal erosion using pore-scale methods

- Network model to simulate migration of fines through a coarse matrix:
  - Fines enter and exit through constrictions/faces and are stored in the pore bodies
  - Stokes flow approach can dictate where fines travel
  - Can explore the influence of anisotropy by assigning pore orientation (relative to flow)
  - Percolation/clogging problem to look at critical fines content
- Limitations to using pore scale methods:
  - Assessment is off a purely geometric nature
  - Limited reference to the hydraulic effects (e.g. seepage velocity)
  - Use coupled CFD-DEM analysis to probe hydromechanical origins of instability

Thank you!

Collaborators:

- Adrian Russell (University of New South Wales)
- Andrew Whittle (Massachusetts Institute of Technology)
- Mohammad Saadatfar (Australian National University)
- Joost van den Linden, Guillermo Narsilio & Antoinette Tordesillas (University of Melbourne)