Modelling the physics of granular rock compaction for characterisation of flow in reservoirs

Dr J-P Latham (j.p.latham@imperial.ac.uk); Dr Jason Xiang (j.xiang@imperial.ac.uk);

Prof Martin Blunt (m.blunt@imperial.ac.uk); Dr Hu Dong (iRock Technologies)

Background: Many oil and gas reservoirs draw their fluids from un-cemented or poorly consolidated sandstone formations in which the pore-throat structure controls the permeability, however the pore structure is hard to predict. Recent X-Ray CT imaging workflows and digital rock physics developments by the porous media flow and reactions research group working together with the Imperial's spin-out company iRocks Technology has revolutionised pore structure characterisation of drill core specimens. This state of the art experimentation, imaging (Fig. 1) and modelling to study multiphase flow and reactive transport in porous media has applications to CO2 storage and all types of reservoir engineering. The digitalised pore space topology once captured and converted to suitable formats enables CFD flow simulation codes to examine multiphase flow performance, unique to that sample's actual compaction history and in-situ stress conditions. Engineers need to extrapolate the flow performance of this sedimentary horizon's grain pack to different in-situ stress conditions with different degrees of compaction and this requires a realistic modification of the grain structure applicable to the different burial and tectonic histories. ***Solidity,*** developed by the Applied Computational Modelling Group, is a 3D multi-body FEMDEM code that captures grain realignments and pore-network topology changes under applied boundary stresses. (www.Solidityproject).

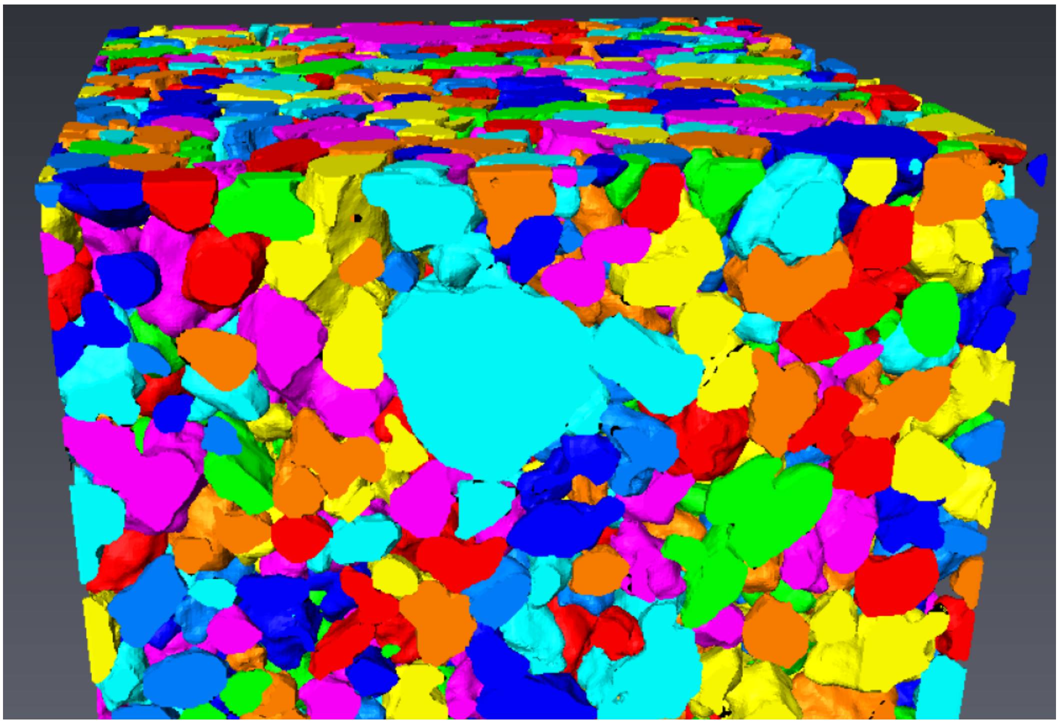

*Fig. 1 Example of a typical sandstone microstructure captured from X-Ray CT scan at 3 micron resolution, converted into surface grain meshes for individual grains; such grain skeletons to be subjected to compaction simulations using **Solidity**.*

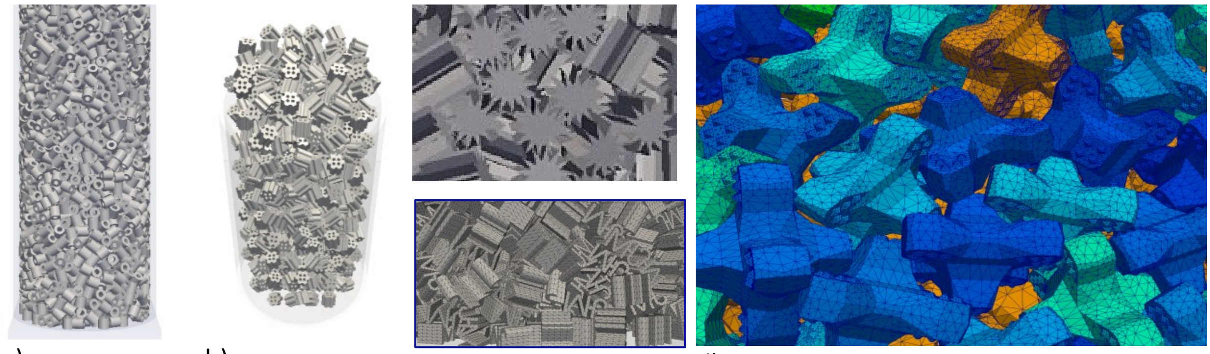

*Fig. 2 Packing simulations that make calls to **Solidity**; a) single holed pellet pack, b) multi-holed grooved pack, c) star and JM-shaped packs, d) Accropode II Unit packs for coastal structures.*

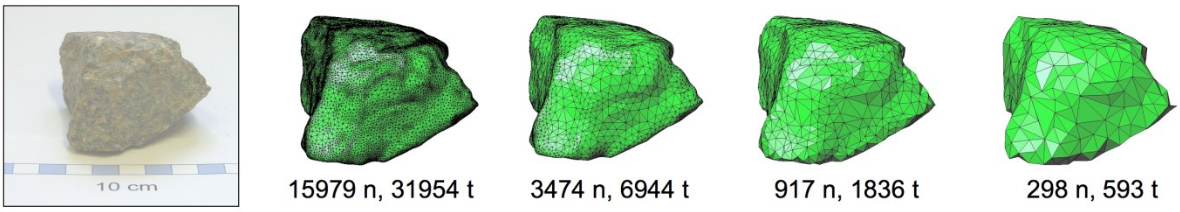

Fig. 3 Example of a digital rock grain taken from Solidity's digital shape library that uses polyhedral grain shape meshes stored at various resolutions.

Methods: You will start with the AVISO software that analyses voxel formats that come directly from X-Ray CT scanned outputs to make geometry files such as shown in Fig. 1. The definition of separate grain boundaries from the AVISO software comes at very high resolutions and the formats are not yet ideal for direct use and creation of solid body mechanical models in our Solidity code. You will receive help in overcoming these 'workflow' issues, so that you can represent the real rock grain structures mechanically in the Solidity FEMDEM code. You will then apply stress regimes for different e.g. overburden depths and staged stress histories and compare void topologies. These technologies will provide the basis to study their consequences for CO_2 storage and multiphase flow behaviour using powerful CFD and pore-network flow codes.

Outputs: One output could be a diagenetic process sedimentary rock model builder that includes grain size and shape distributions (see Fig. 2 for examples of sedimentation and packing of complex shapes in industry applications and Fig. 3 for the shape library), together with cementation and clay mineral effects. Keep an open mind to making new discoveries as, to date, very little scientific study has been done to systematically explore permeability as a function of the grain fabric components and stresses associated with depth of burial.

For more information please contact John-Paul Latham (j.p.latham@imperial.ac.uk).
For application details please contact Samantha Symmonds (sam.symmonds@imperial.ac.uk).
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