Advancing Climate Change Prevention

Earth Sounds the Climate Change Fire Alarm

"We can simulate carbon capture sequestration scenarios, address complex environmental problems, and drive meaningful change in the world. Oracle has helped us break the barrier of computational power in the lab."

—Saswata Hier-Majumder, Reader in Geophysics, Royal Holloway, University of London

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Earth Sounds the Climate Change Fire Alarm

Rising global temperatures. Warming oceans. Shrinking ice sheets. Rising sea levels. Retreating glaciers.

Examples of the Earth's climate change fire alarms caused by heat trapping carbon dioxide being exponentially emitted into the Earth's atmosphere since the mid 20th century, most likely resulting from human activity. Royal Holloway, University of London geophysics professor Saswata Hier Majumder and his team of PhD students (Ryan Payton, Yizhou Sun and Paul Ross Thomson) are responding to the Earth's fire alarms. They are leading the way to prevent climate change by drastically reducing atmospheric carbon emissions through carbon capture and sequestration   capturing atmospheric carbon and permanently storing it in underground rocks. Accelerating carbon capture technology is essential in reducing carbon dioxide emissions. Traditional carbon capture technology methods impeded predicting suitable future carbon storage sites. Royal Holloway, University of London researchers needed a new approach.

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Developing a New Carbon Sequestration Approach to Battle Climate Change

- Royal Holloway, University of London researchers wanted to develop a simulation that analyzes digital images of rocks and predicts their capacity to absorb carbon dioxide and organically remineralize it—a game-changing advantage for identifying suitable future carbon storage sites based on favorable geologic storage reservoirs and how much carbon the reservoirs can store over time.
- They envisioned a simulation engine capable of processing massive amounts of scanned real rock images captured with 3D microtomography to determine the pore volume of each rock fragment—important for identifying the carbon sequestration efficiency and capacity of future storage sites.
- On-premise super computers needed the power of enterprise computing to process the very large data sets from Royal Holloway University's 3D microtomography. Royal Holloway, University of London researchers turned to Oracle's high-performance cloud infrastructure to develop a novel computational approach that lets the research team pick the amount of memory and threads needed to process the massive amounts of scanned images in a way that the team's previous, on-premise computers couldn't. This enabled the research team to more accurately predict future carbon storage site suitability in a fraction of the time and at a much lower cost than previously thought possible.

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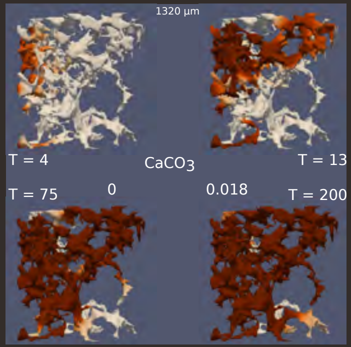
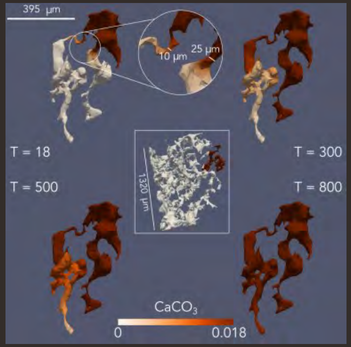
Data Outputs

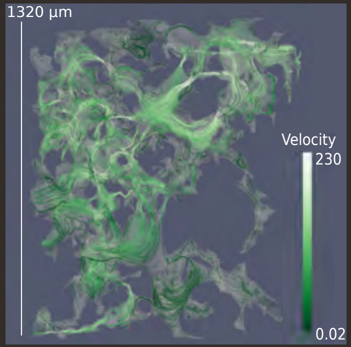
CO_2 injection through a connected pore structure, color is representative of mineralised carbon concentration full stop



A smaller sub region is examined for the effect of pore throat narrowing on carbon migration full stop



Calculated velocity streamlines throughout the connected structure.



Oracle Cloud Architecture

- VM.Standard2.1 head mode - running Ubuntu 16.04
- BM.HPC.36 compute node - running Ubuntu 16.04
  - 72 VCPUs & 384 GB memory
- Ran a cluster of 4 BM nodes managed from the VM head node set up using terraform:
  - Automatic install of FEniCS 2017.2.0 – requires Ubuntu for best install method
    - FEniCS limitation: MPI unable to communicate across nodes so we used a single BM.HPC2.36
  - Automatic install of ParaView
- Transfer input data to head node via rsync to a folder shared by the nodes
- Simple mpirun –n 72 python script.py command from headnode
- Zip the results files and rsync to local workstation for analysis

Performance

- Local compute time = 2 mins 49 seconds per iteration = 47 hours per simulation
- Oracle Cloud compute time = 1 min 12 seconds per iteration = 20 hours per simulation