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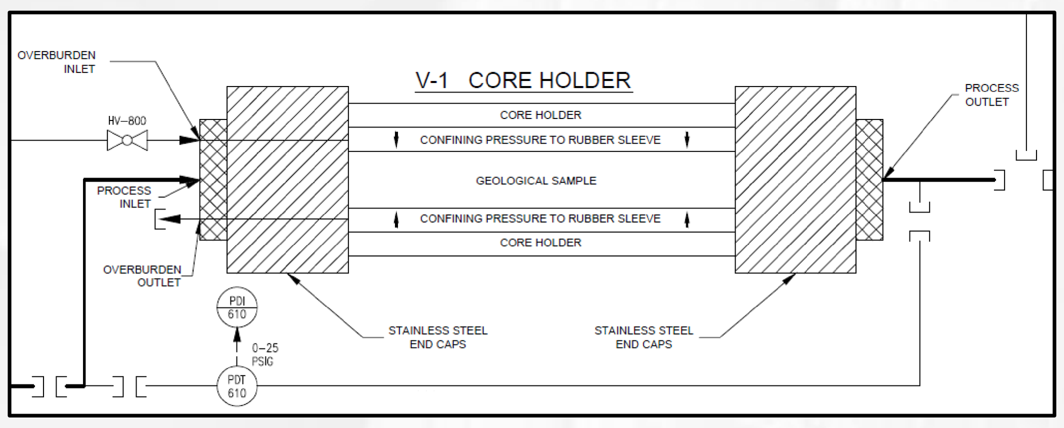
Center for Geologic Storage of CO_2

Preliminary results of 3-D Micro-CT imaging of Mt. Simon reservoir rock

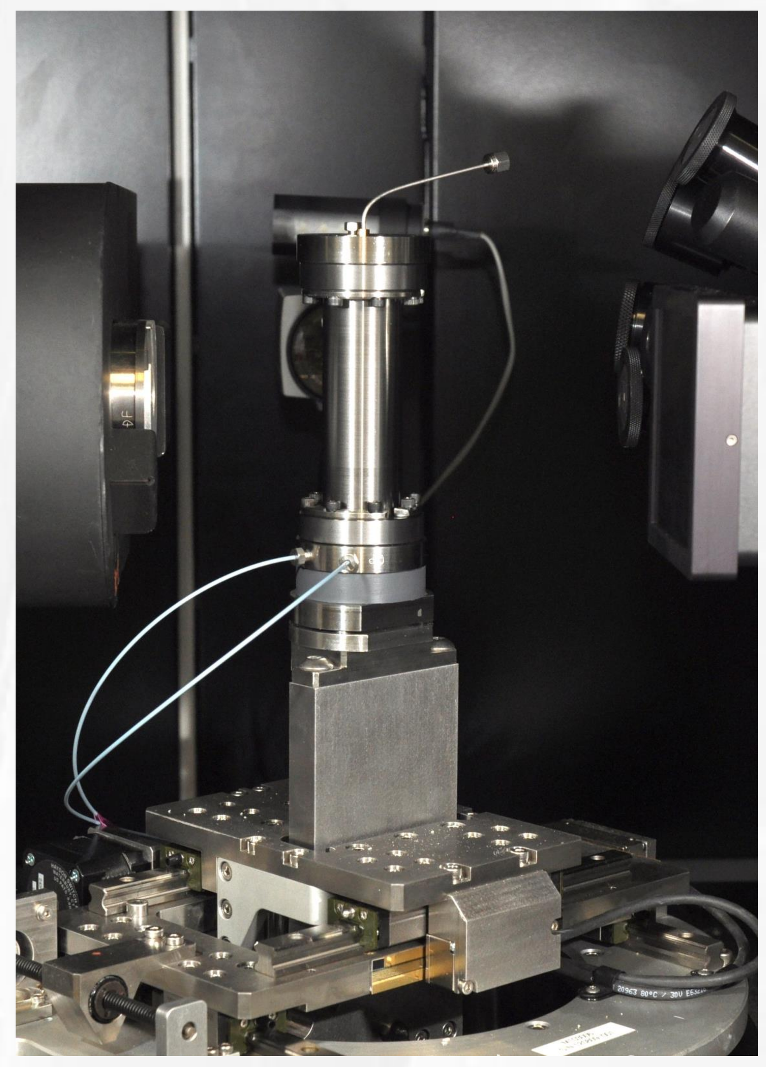
John Tudek[1], Dustin Crandall[1], Dustin McIntyre[1], and Angela Goodman[1]

[1]National Energy Technology Laboratory (NETL), Morgantown WV, USA

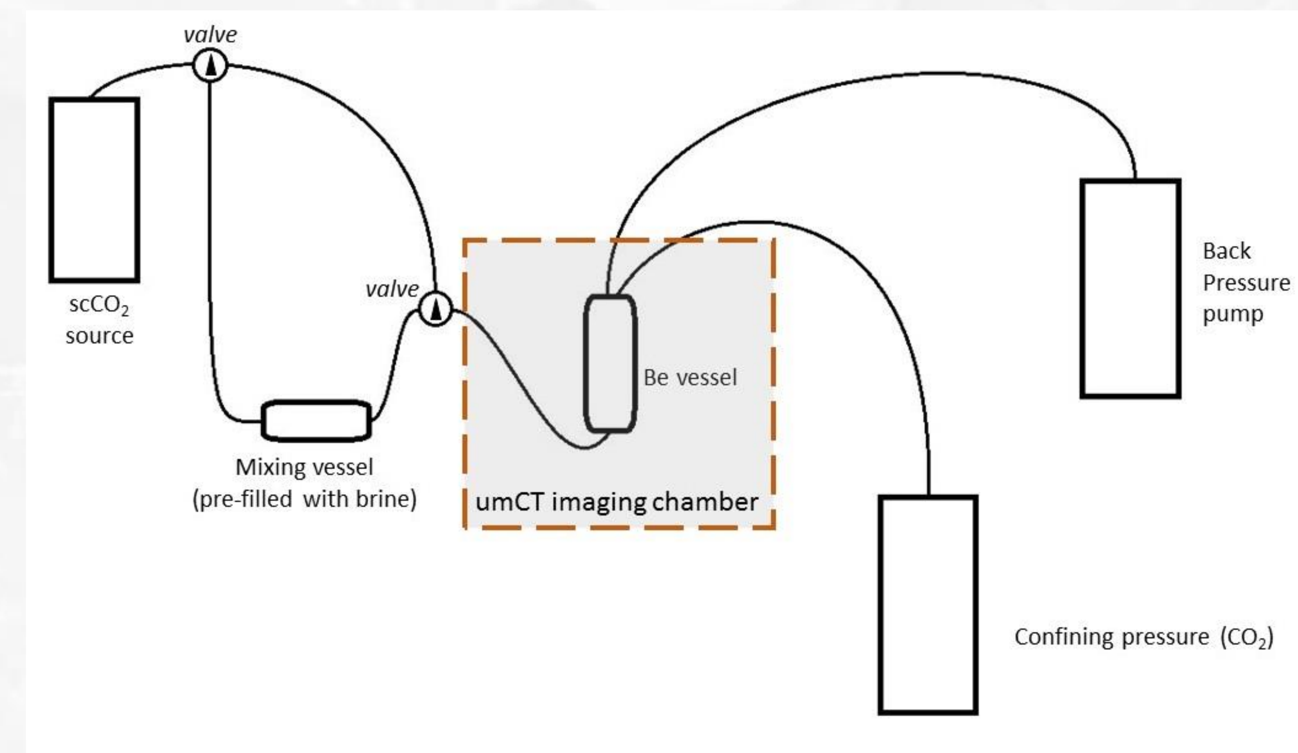
Experimental set up



Above: General diagram of the beryllium containment vessel



Right: Photograph of the inside of the Xradia MicroXCT 400 imaging chamber with the beryllium containment vessel in place for scanning. To the left of the vessel is the x-ray source. To the right of the vessel is the detector array.



Above: Diagram of the Xradia MicroXCT 400 as configured for scanning under reservoir pressure conditions. Items within the dashed grey area are contained within the imaging chamber. All pumps are ISCO pumps. Depending on the experiment either brine or $scCO_2$ can be delivered via the forward pressure pump.

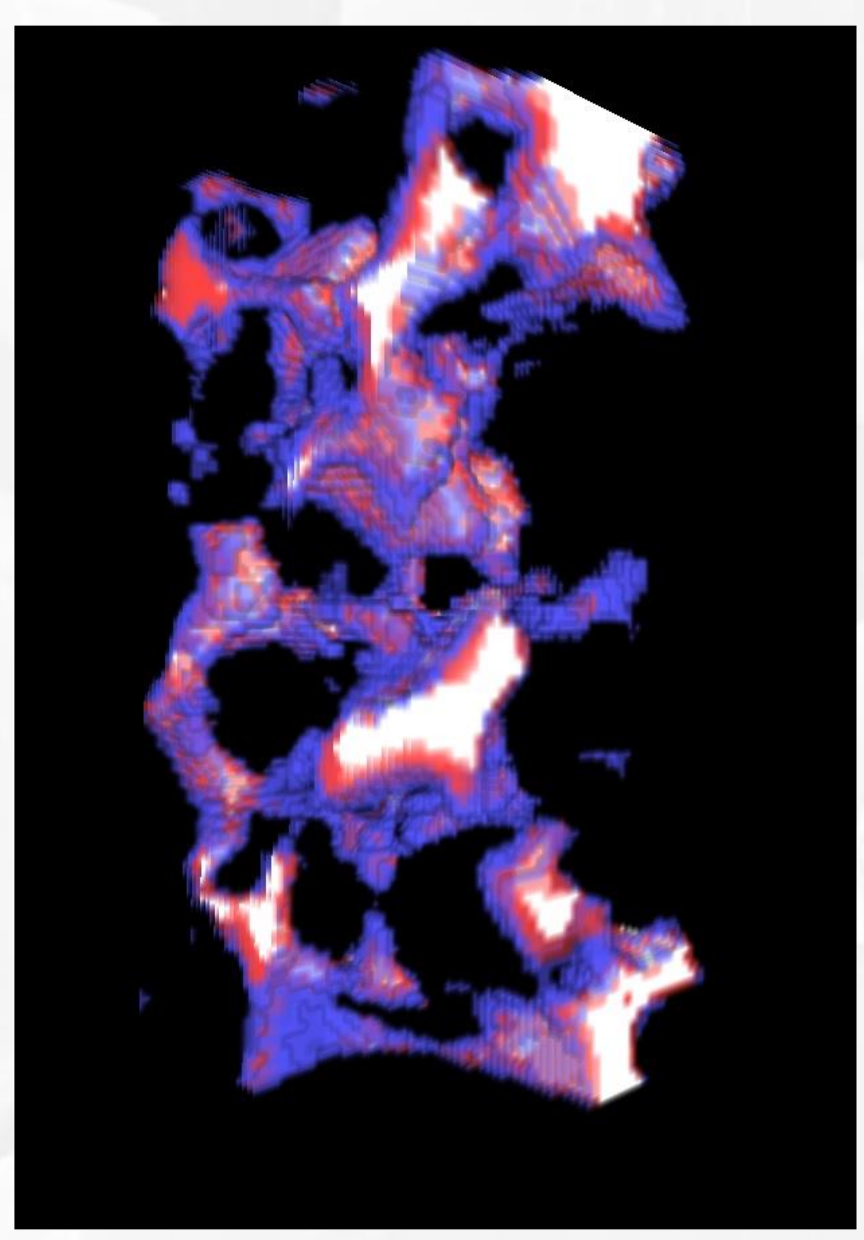
Abstract

The interactions occurring between carbon dioxide and reservoir rocks during carbon sequestration at the laboratory scale can have profound impacts our understanding of reservoir storage. Accurate descriptions of these relationships remains crucial to future carbon sequestration planning and modeling efforts. NETL, in conjunction with other agencies, is imaging cores and fluid under representative geologic pressures to understand these relationships. The resultant 3-D imagery of the discrete phases (matrix, brine, and supercritical CO2 (scCO2)) is the basis for several measured geological parameters, such as porosity and capillary resistance, used in reservoir estimation equations. Additionally, these images provide empirical data for third-party flow path and pore connectivity modeling.

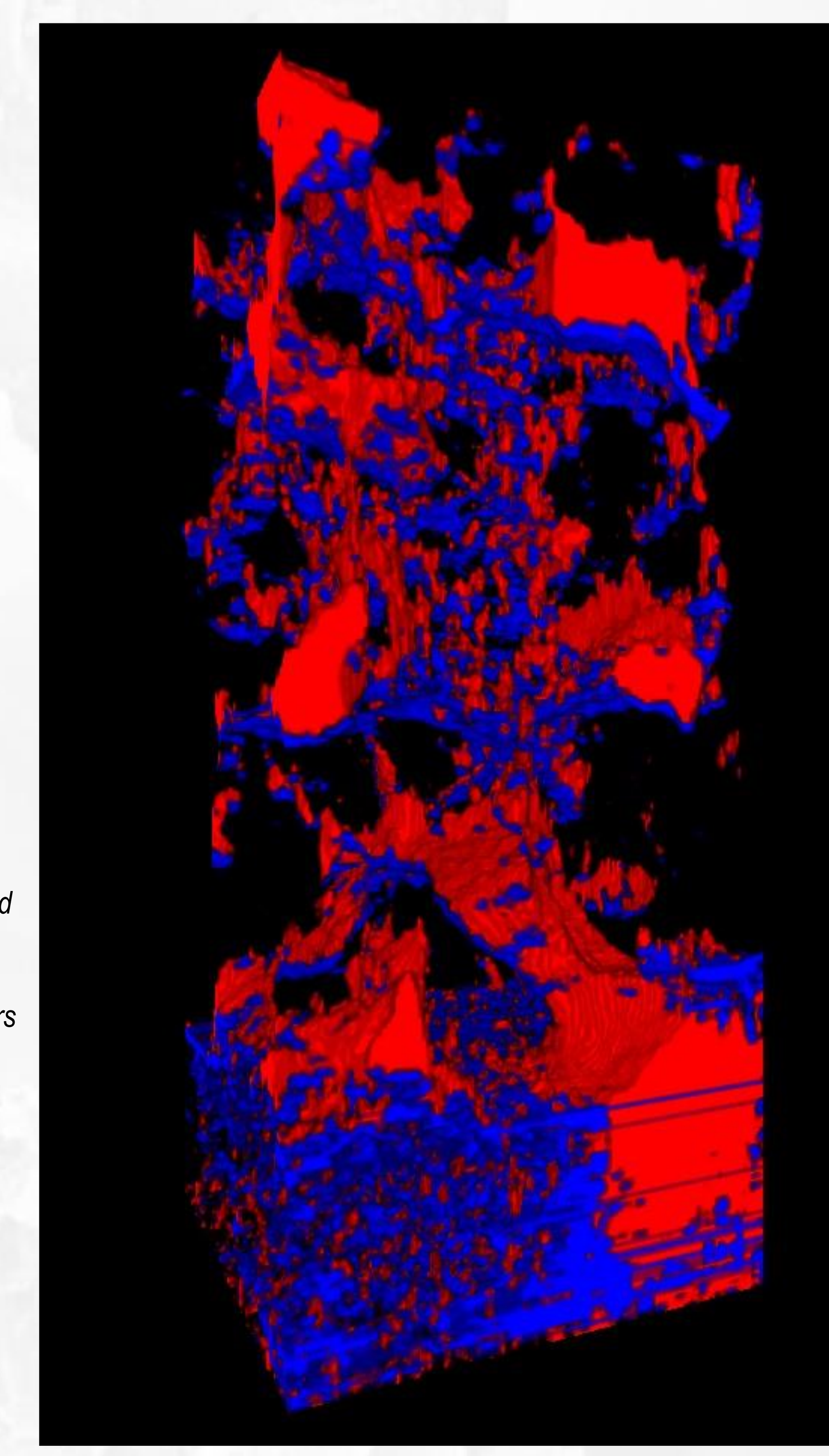
Successful imagery has been obtained from three samples of the lower and basal sections of the Mount Simon sandstone formation and from one Berea Sandstone sample. A fourth sample, from the upper Mount Simon, was determined to have insufficient permeability for flow-through experiments. Images were acquired with a micro-CT scanner used in conjunction with a high pressure micro-core holder. This resulted in a voxel resolution on each sample of ≈5 micrometers. Preliminary measurements of the lower Mount Simon show porosity between 6-13%, depending on the sample.

3-D reconstructions from micro-CT scanning clearly show the preferred scCO2 flow paths within the brine saturated matrix. The scCO2 flowpaths can now be isolated from the brine and analyzed separately. This allows for further quantification on the preferred throat size and tortuosity for future modeling.

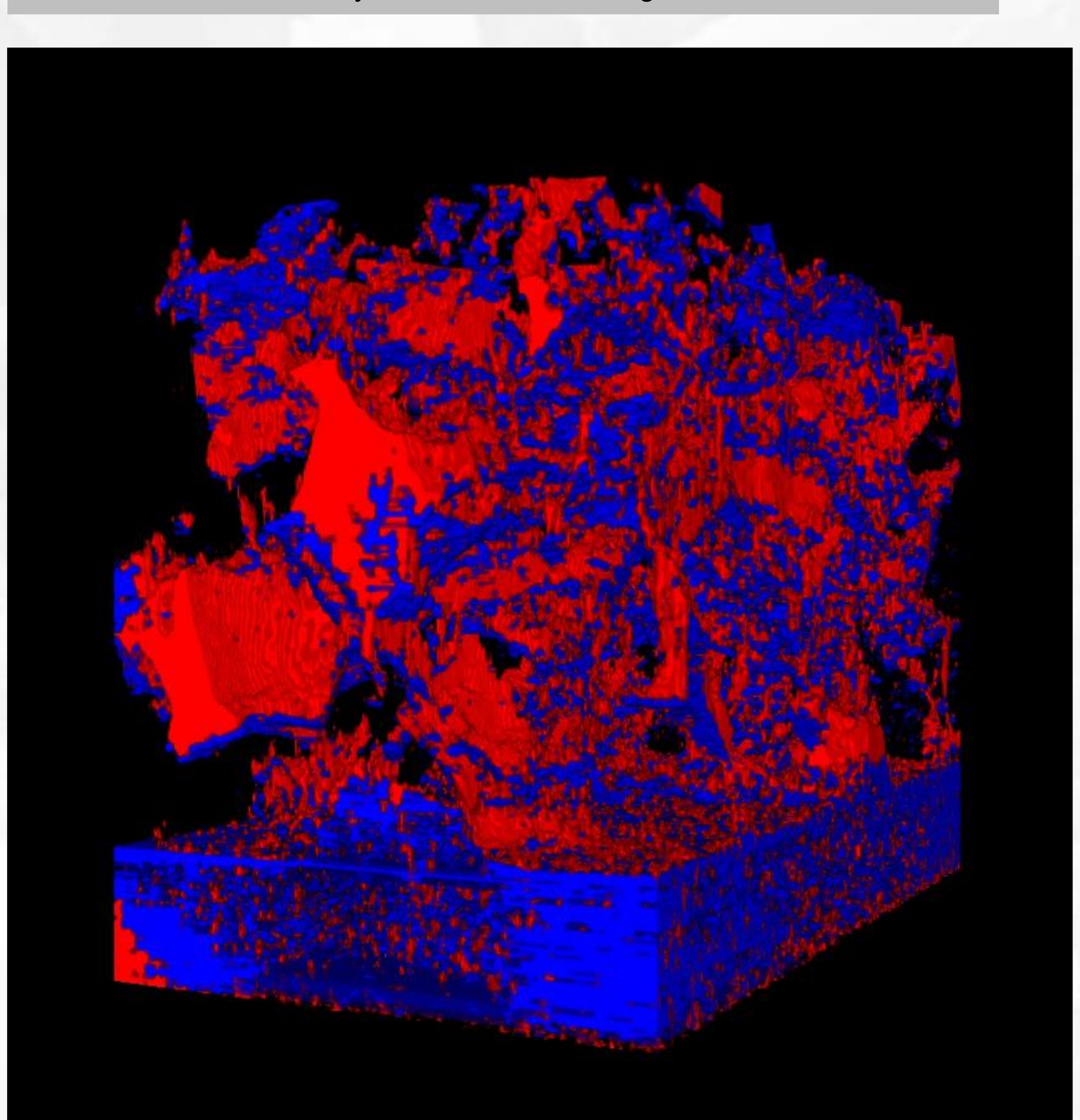
Examples of CT scanned high resolution 3-D imagery



Left: The composite of three 3-D scans showing the infiltration of brine into the system. Blue is void space filled with brine in the first wave. Red is the void space filled in the second wave. White is void space that continues to have CO_2.

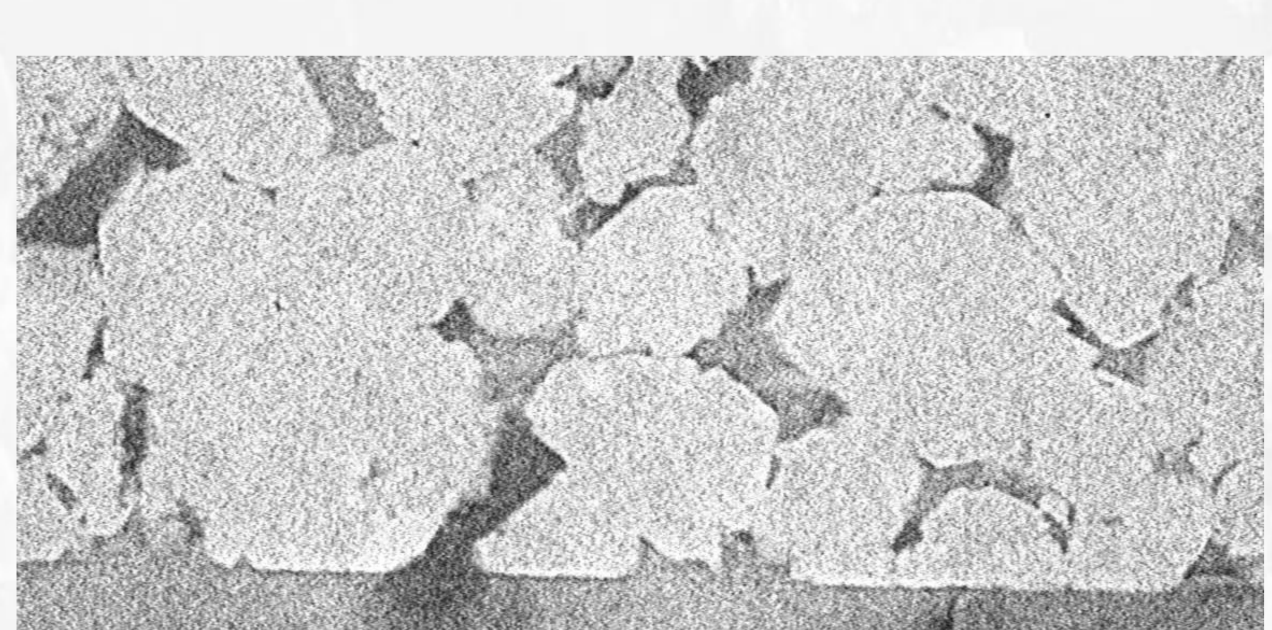


Right: A 3-D image of a single, connected porespace after injected with CO2 followed by brine. The CO2 preferentially favors the largest void spaces and the centers of the while the brine favors the smaller spaces and along the matrix walls. Brine is pushed onto the far walls due to the large differential in pressure (500 psi) between the CO2 and the brine.

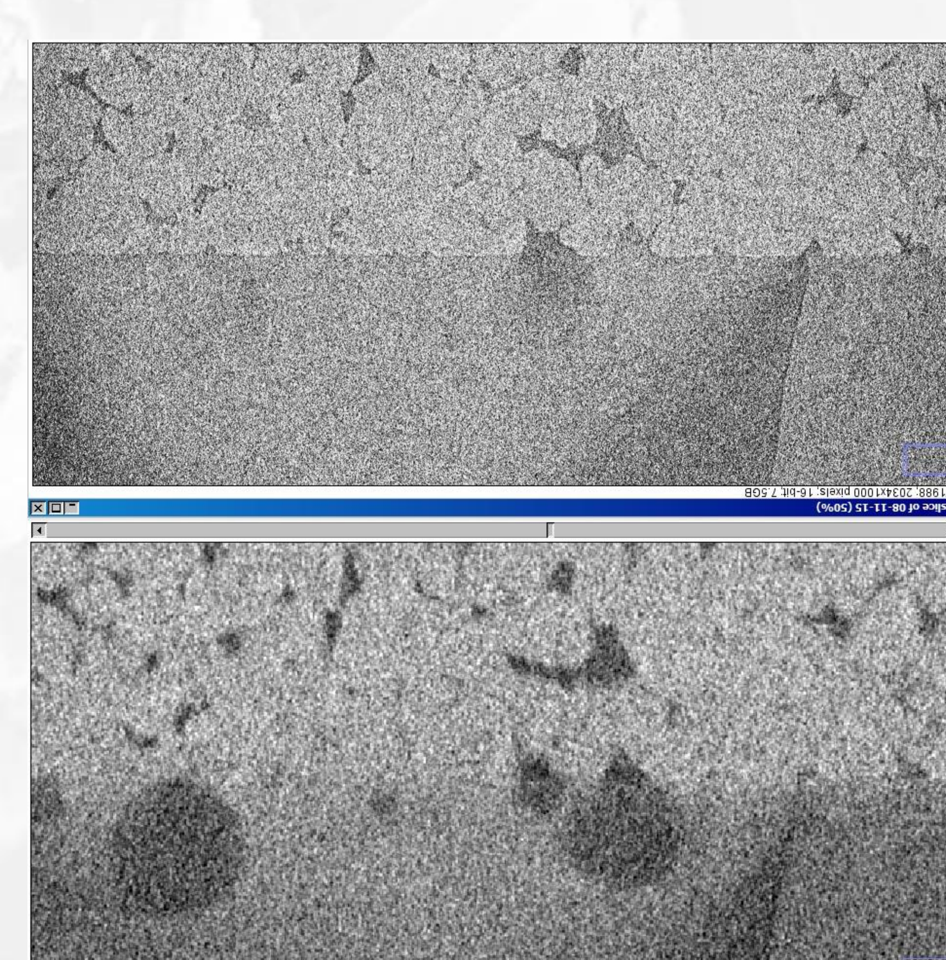


Below Left: A 3-D image taken using the 4x detector of the pore space volumes in the Mt. Simon sandstone. Blue volumes indicate laboratory (KI doped) brine while red volumes indicate $scCO_2$. Direction of flow is downward. The large blocky area at the base is the end of the core sample and is mostly occupied by brine. The scan took approximately 10 hours to acquire.

Below: A slice of the original 4x greyscale scan from which all the 3-D models were created. Medium greyscale values are brine while dark values are $scCO_2$. The sample was under confining pressures of ~1800 psi for several days. The experiment began with a brine injection, followed by a $scCO_2$ injection, followed by another brine injection.



Below: The difference in detail between a Macro 70 scan (top) and a 4x scan (bottom). Both images are at the same scale The 4x scan was taken about a day after the Macro 70 scan which can explain the changes in bubble size.



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