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Calibration curve generation for the use of Xenon as a pressure indicator in porous media using micro computed tomography

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Subsurface carbon-dioxide (CO_2) and hydrogen (H_2) storage are considered a promising approach to reduce the greenhouse gas emissions of large polluters like the steel, chemical and cement industries. In order to develop gas storage techniques in geological formations it is crucial that we can describe and monitor the associated multiphase flows. Micro computed tomography (Micro CT, X-ray technology) has opened up new opportunities to analyse the behaviour of gases and fluids inside the porous media at high resolutions reaching sub-pore level. However, measuring in-situ pore pressures is still particularly challenging. Xenon (Xe) is a heavy, non radioactive, inert, ideal gas already used as a tracer [1,4,2]. In this study performed in a micro CT scan, energy level dependent, linear Xenon pressure- attenuation curves have been derived at different scales from static, single gas phase experiments in a Bentheimer sandstone core.

Xenon is confirmed to have a potential to function as a pressure indicator on the basis of its high atomic mass. Earlier research in a low-resolution medical CT-scan (sub porelevel) has been confirmed [5], but now by analyzing images at the pore level in a Xe-pressurized core between 0-25bar Xe, with $5\mu\text{m}$ resolution, see the Figure attached (Xenon void core Prange3.png). Material and geometry dependent artifacts as pseudo-enhancement [3] were observed. They prevent for this moment the universal use of the obtained calibration curves, though specified to the used material and set-up, the curves prove great potential. The static pressure-attenuation calibration relations are aimed to be the starting point of a method to describe pressures in static and dynamic multiphase flow in porous media.

Figure: Xenon void core Prange3.png

caption: The pressure dependence of Xenon visualized by microCT scanning of a void space in a plastic ring and a cylindrical Bentheimer sandstone core, both seen in A. The resulting cross sections of the void space and the Bentheimer core at pressure levels of 1, 15 and 25 bar are presented in B. and C. respectively. Though hardly visible in the picture, the measured Xenon signal in the pores of the core differs from the void signal at the same pressure as a consequence of pseudo-enhancement. At 15 and 25 bar the Xenon in the pores has a higher (brighter) signal than the sand grains around, opposite to the image at 1 bar.

Participation

In-Person

References

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Primary authors: Dr VAN DER NET, Antje (Institute of Geoscience and Petroleum, Norwegian University of Science and Technology (NTNU), Trondheim, Norway); Dr RUECKER, Maja (Mechanical Engineering, Technical University Eindhoven, the Netherlands); Mr WILLEMSZ, Mark (Mechanical Engineering, Technical University Eindhoven, the Netherlands)

Presenter: Mr WILLEMSZ, Mark (Mechanical Engineering, Technical University Eindhoven, the Netherlands)

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