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What's old is new again: can old, unpreserved core be used for modern seal rock characterisation?

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With the demands for decarbonisation due to anthropogenic climate change, earth scientists are looking to the subsurface for its storage potential for carbon capture and storage (CCS) and underground hydrogen storage (UHS). Depleted oil and gas reservoirs as well as deep saline aquifers have been proposed as potential storage sites for CCS and UHS. Important to the understanding of potential storage sites is the long-term integrity of the seal overlying the proposed reservoir units. In this study, we aim to understand the physical properties of old shale core, stored under atmospheric conditions in a core shed since the 1970s, compared to a similar, recently acquired core that has been preserved to modern standards. This study presents the results of a suite of experiments to characterise the physical properties on old, unpreserved cores and new, preserved cores taken from geological units of similar age and depth in order to determine the difference in properties between the old and new samples. Our aim is to determine the suitability of older cores for studies examining the performance of shales with respect to secondary storage. The new, preserved core has water content approaching in-situ, which is therefore higher than in the nearly 50-year old unpreserved core. Porosity was measured by helium pycnometry, mercury intrusion porosimetry, and broad ion beam scanning electron microscopy (BIB-SEM). Although there is variation of the porosity measurements between the methods, there is relatively good agreement within each method for the old core vs the new core. The differences of the average porosity of the new samples from the average porosity of the old samples is 3.8 for helium pycnometry, 3.2 for mercury intrusion, and 3.0 for BIB-SEM. The preserved core, therefore, has slightly higher porosity than the old, unpreserved core. The lower porosity in the old core is interpreted as the result of pore closure due to drying and shrinkage of the samples at the scale measured by the above methods. Minor to moderate cracking is observed in the SEM images of the unpreserved core samples, which supports some volumetric changes due to drying of the unpreserved samples. Multistage triaxial compression testing of the samples was undertaken to determine their strength parameters, including cohesion, friction angle and unconfined compressive strength (UCS). The old, unpreserved samples show higher strength parameters than the preserved samples. This is a result of lower water content and slightly lower porosity. Furthermore, the UCS values for the unpreserved core do not correlate well with Poisson's ratio and Young's modulus, whereas they do for the preserved core. This indicates that the strength testing results for the unpreserved core may not be reliable. The results of this study show that there is variation in the porosity results between the different methods, and that preserved core has slightly higher porosity than the unpreserved core. Although the preserved core does have higher porosity, the difference is relatively small. Therefore, unpreserved core that is otherwise in good condition can be considered appropriate for porosity characterisation. Conversely, there are significant differences in strength parameters between old and new core, suggesting that unpreserved core is not suitable for such testing methods.