Derivation of contact angle for evaluation of caprock's sealing performance

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Geological CO_2 storage assumes that a caprock retains injected CO_2 stably within a reservoir. However, if geochemical reactions, especially the slight alteration of mineral surfaces, change the contact angle θ, it is expected that the caprock's sealing performance would be reduced. This study aims to verify whether such a scenario is possible. For this purpose, dataset of θ with high accuracy is required, but θ values measured using traditional droplet method usually have a large margin of error. Alternatively, we propose novel method to derive θ based on the capillary pressure equation, $P_c^{th} = 2\sigma \cos\theta / r$, where P_c^{th} is the threshold pressure, σ is the interfacial tension, and r is the pore throat radius. In this method, the P_c^{th} of micro pores around 20 μm diameter drilled in target samples is measured, and then the θ is calculated from above equation applying reference value of σ.

The target samples are five kinds of minerals (quartz, albite, chlorite, calcite, and gypsum) and two types of rocks (malrite and mudstone). These samples were available for breakthrough experiments of supercritical CO_2 at 10 MPa and 40˚C. Then, θ was calculated using measured P_c^{th}. Results showed that our method enabled to derive θ in a reproducible fashion. However, some samples led to $\cos\theta > 1$, in which the θ cannot be defined. Such an inconsistency is caused by the high sensitivity of σ to θ. Therefore, we should examine more accurate data of σ, hereafter. In either case, we can estimate the magnitude relationship of each sample's θ from calculated $\cos\theta$. The study revealed that silicate minerals such as quartz, albite and chlorite, and rocks mainly composed of clay minerals such as marlite and mudstones had a wetting surface (i.e., low θ). In contrast, both calcite as a carbonate mineral and gypsum as a sulfate mineral showed a relatively non-wetting surface (i.e., high θ).

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