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CO2 Storage Potential of Low-rank and Medium-rank coal deposits from Austria and Kazakhstan

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To assess the CO_2 storage capacity of coals with different ranks, coal samples were collected from an abandoned coal mine in Austria (Fohnsdorf) and a highly productive coal seam in Kazakhstan (D6 seam in the Lenina mine; Karaganda Basin). A variety of techniques, including Rock-Eval pyrolysis, organic petrography, and measurements of ash yield and sulfur content measurements, were applied to compare the coal composition and characteristics. Additionally, low-pressure N_2 and CO_2 adsorption measurements were employed to investigate the pore structure characteristics and gas storage capacity of the coals. The thermal maturity assessment indicated that Austrian coals are subbituminous coals with a mean vitrinite reflectance (%Ro) value of 0.46% and a mean temperature of maximum hydrocarbon generation (T_{max}) of 414 °C. In contrast, Kazakh coals are medium-volatile bituminous coals with mean %Ro and T_{max} values of 1.21% and 466 °C, respectively. The mean total organic carbon (TOC) content in Austrian coals was 66.2%, while in Kazakh coals, it was 80.4% reflecting the differences in maturity. Sulfur and ash measurements showed mean values of 1.3% and 5.48% for Austrian coals and 0.4% and 11% for Kazakh coals, respectively. According to the N_2 adsorption measurements at 77 K, subbituminous coals showed a lower BET-specific surface area (BET-SSA) (avg. 1.91 m^2/g) and BJH pore volume (avg. 0.007 cm^3/g) than medium-volatile bituminous Kazakh coals (avg. BET-SSA = 2.98 m^2/g; BJH pore volume = 0.01 cm^3/g). The lower BET-SSA and pore volume of subbituminous coals resulted in a lower N_2 adsorption capacity of subbituminous coals (4.68 cm^3/g @STP vs. 6.65 cm^3/g @STP). However, the CO_2 volume adsorbed at 273 K by subbituminous coals was higher (18.26 cm^3/g) than that of medium-volatile bituminous coals (11.46 cm^3/g). This could show that the BET and BJH methods applied in the N_2 adsorption data may not sufficiently estimate CO_2 adsorption capacity trends in the investigated sample set. Additionally, the existence of a hysteresis loop between CO_2 adsorption and desorption isotherms in all subbituminous and medium-volatile bituminous coals indicates the occurrence of weak chemisorption during CO_2 adsorption. This process enhances CO_2 uptake and storage safety, as the bonds that are established via the weak chemisorption process are stronger than those formed by pure physisorption. Overall, this study revealed that low-rank coals (Austrian subbituminous coals) had a higher CO_2 storage capacity than medium-rank coals (medium-volatile bituminous Kazakh coals). This could be due to the filling of pores by generated hydrocarbons in the medium-rank coals, leading to a lower CO_2 adsorption capacity.

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