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Methods for determining the CO_2 sorption capacity of coal: Experimental and theoretical high pressure isotherms

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One way to reduce CO_2 emissions discharged into the atmosphere is by trapping it and storing it in suitable repositories, including coal-bearing strata. The history of coal mining in the Czech Republic is very rich but most of the mines have been closed down in recent years. However, the unmined coal seams are interesting for the purposes of CO_2 storage, especially due the opportunities they offer for recovering coal-bed methane. Mine structures of this kind can be found in large parts of the Upper Silesian Basin, where the total storage capacity has been estimated at about 380 Mt CO_2. This is an interesting storage potential. In order to identify a suitable high-capacity locality for CO_2 storage within a coal seam, it is necessary to study not only the geological conditions within the seam, but also the textural properties of the coal, which control the mechanism and the extent of the storage. The major storage mechanism is by sorption processes that take place in the coal porous system (adsorption in micropores and on the surface of meso/macropores, and absorption in the macromolecular structure).
The CO_2 sorption capacity is generally indirectly determined in a laboratory by measuring the amount of carbon dioxide captured in a coal sample at a pressure and temperature corresponding to the in situ conditions, using high pressure sorption techniques. The low pressure sorption technique can be used, by setting the partial volumes of CO_2 according to its binding and storage mode. The sorption capacity is determined by extrapolation to the saturation pressure as the sum of the individual partially sorbed volumes. The aim of the study was to determine the partial volumes of CO_2 bound by different mechanisms in the individual parts of the porous system of the coal, and to compare the sum with the results obtained by the high pressure isotherm. The study was carried out with 3 samples from a borehole survey in the Czech part of the Upper Silesian Basin. A high pressure volumetric sorption apparatus working within the temperature range of 30°C to 65°C at a pressure of 15 MPa was used for measuring the CO_2 high pressure isotherms. The data for constructing the theoretical high pressure isotherm were obtained from a gravimetric sorption apparatus and a mercury porosimeter. The Dubinin, Langmuir, and Gibbs equations were used for evaluating the data. The measured experimental high pressure isotherms were compared with the theoretical isotherms using linearized Langmuir isotherms. The Langmuir parameters confirmed a reasonable correspondence between the sorption capacities derived using the two approaches applied here.