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Effect of lithostatic stress on methane sorption by coal: Theory vs. experiment and implications for predicting in-situ coalbed methane content

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Abstract

Recent research has demonstrated that confining stresses applied to the solid framework of coal can reduce its gas sorption capacity by several percent to perhaps several tens of percent. To evaluate the magnitude of this effect more rigorously in relation to predicting in-situ coalbed methane (CBM) content, a better understanding of the effects of stress on methane sorption by coal is needed. In this paper, a previous thermodynamic model for the effects of stress on CO_2 sorption by coal is revised and applied to CH_4. The revised model predicts that in-situ CBM content is indeed determined not only by the geological factors generally considered, such as coal rank, coal composition, moisture content and temperature, but also by lithostatic or confining stress, which is usually ignored. This prediction is tested by means of experiments performed on a composite cylindrical sample of Brzeszcze 364 high volatile bituminous coal subjected to 10MPa methane pressure at a temperature of 40˚C, varying the hydrostatic stress or confining pressure in the range 11-43MPa. In these experiments, we determined if CH_4 was desorbed as confining pressure was increased by subtracting the poroelastic expulsion of CH_4 from the total CH_4 expelled, assuming the former to equal the gas volume expelled in control experiments performed using Helium. The experimental results show that the equilibrium sorption capacity for CH_4 at 10MPa gas pressure and 11MPa confining pressure (1MPa Terzaghi effective stress) was 0.808mol/kg_{coal}. This was reduced by at least ~6% by increasing the confining pressure to 43MPa (33MPa effective stress), confirming the validity of our model. We apply our model to predict in-situ CBM concentration as a function of coal seam depth for dry, high volatile bituminous coal, assuming a geothermal gradient of 32˚C/km. The results indicate a maximum CH_4 concentration of ~0.76mol/kg_{coal} at a burial depth of ~900m, which is ~3% lower than conventional predictions. This