Methane emission from flooded coal seams in abandoned mines, in the light of laboratory investigations

Zbigniew Pokryszka, Eugeniusz Krause

Methane emission from flooded coal seams in abandoned mines, in the light of laboratory investigations

Zbigniew POKRYSZKA[1]
Eugeniusz KRAUSE[2]

[1]**INERIS, BP2, 60550 Verneuil en Halatte, France, zbigniew.pokryszka@ineris.fr**
[2]**GIG-K.D. Barbara 40-166 Katowice, Plac Gwarków 1, Poland, e.krause@gig.katowice.pl**

Emission of methane from flooded unexploited coal seams

Field experience from the flooding operations of the abandoned gassy mines, shown that the presence of water and related to it hydrostatic pressure limits the desorption and migration of methane from the unexploited seams destressed by mining. However, in the scientific literature, there is no information, being of importance from the point of view of mining practice, on detailed description of mechanisms involved.

In connection with the above, over the years 2004-2005, the INERIS Institute (France) and Central Mining Institute (Poland) carried out joint laboratory tests aimed at determining the relationships in the system "coal-gas-water", in the context of the flooding of unexploited gassy coal seams in abandoned mines.

The tests included the following main stages:

- *Determining sorption capacity of coal in the dry-air state through determining the isotherm of methane sorption on a coal sample taken from the analysed coal seam.*

  Determining the sorption isotherms enables to evaluate, with considerable accuracy, the volume of gas contained in the coal for a given level of sorption equilibrium pressure, and then to determine the quantity of the desorbable gas V_{des} from the specified mass of coal, at the drop of pressure up to the atmospheric pressure level (Fig. 4).

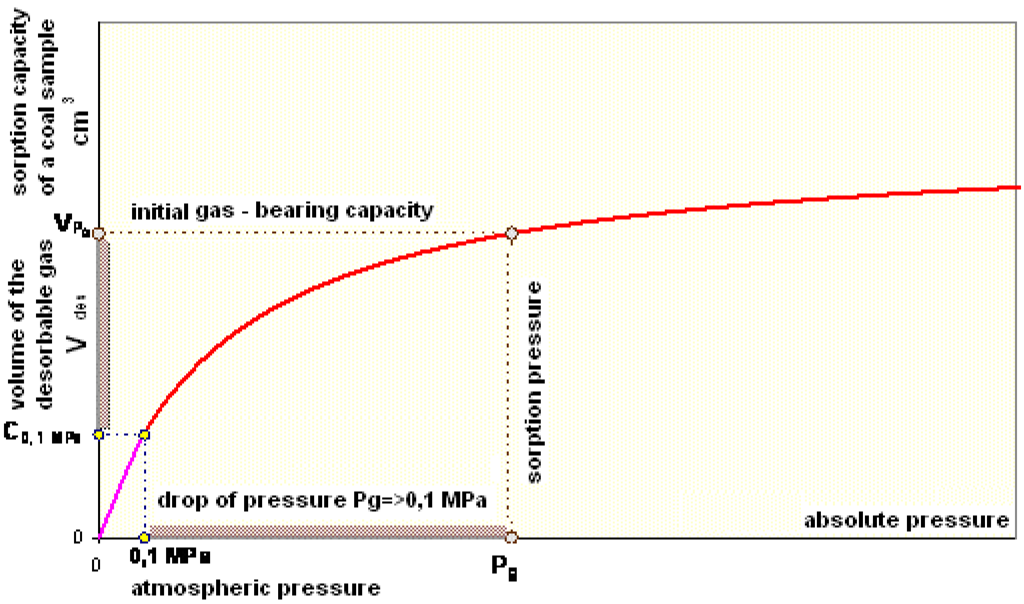

Fig 4. Isotherm of gas sorption on a coal sample

- *Saturating the coal sample with methane at a specified sorption equilibrium pressure.*

  Coal samples in dry-air state, with the grain size 0.5-1 mm were saturated with methane in the conditions of various levels of gas pressure, that is between pressure relating to strongly degassed seams (relative pressure < 0.1 MPa) and pressure close to the level of *in situ* pressure in non-degassed seams (relative pressure > 1 MPa).

  The experiment was performed in autoclaves, in the conditions of controlled temperature and pressure (Fig. 5).

- *Flooding the coal samples with water and applying a given level of hydrostatic pressure.* The samples of coal saturated with methane were rapidly flooded with water in such a way that coal should be entirely covered with a water layer 1 cm-thick. Next, a given level of pressure was set in the upper part of the autoclave, through pumping up compressed air over the water level. This pressure was transferred to coal in a form of hydrostatic pressure of water (Fig. 5). In the course of a given series of experiments, hydrostatic pressure was being set at lower, equal and higher levels, in order to produce various combinations in relation to methane sorption pressure in coal.

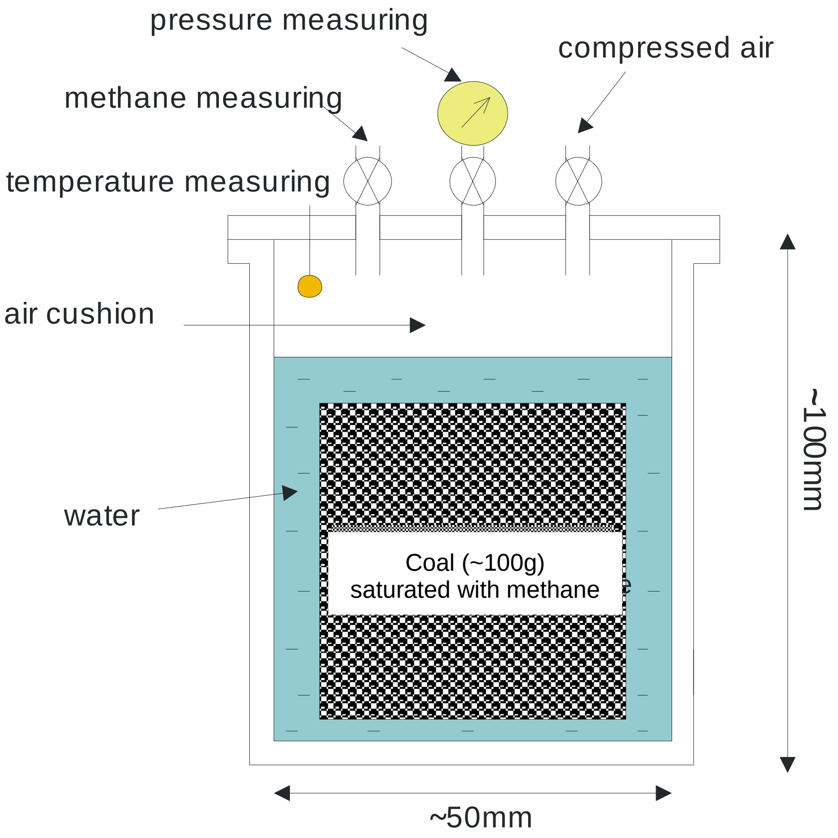

Fig 5. Autoclave used in the tests

- *Observing methane emission from flooded coal*

Methane emission was observed by measuring methane concentration in the air cushion with a specified volume over the level of water covering the coal sample. For most tests, the stabilisation of methane concentration in the air cushion was observed after 14 to 30 days. The tests were conducted on several tens of coal samples originating from the Polish Upper Silesia and French Lorraine Coal Basins, for various combinations of sorption pressure Ps

and hydrostatic pressure Ph, which allowed more precise, quantitative determination of the effects of water and hydrostatic pressure on the intensity of methane emission from coal. For comparison, tests of methane emission from dry samples were also made.
As an example, Fig. 6 presents the intensity of methane emission observed for various coal samples collected in the Albert seam in the Lorraine Basin, depending on relative overpressure of the adsorbed gas, in relation to the hydrostatic pressure.

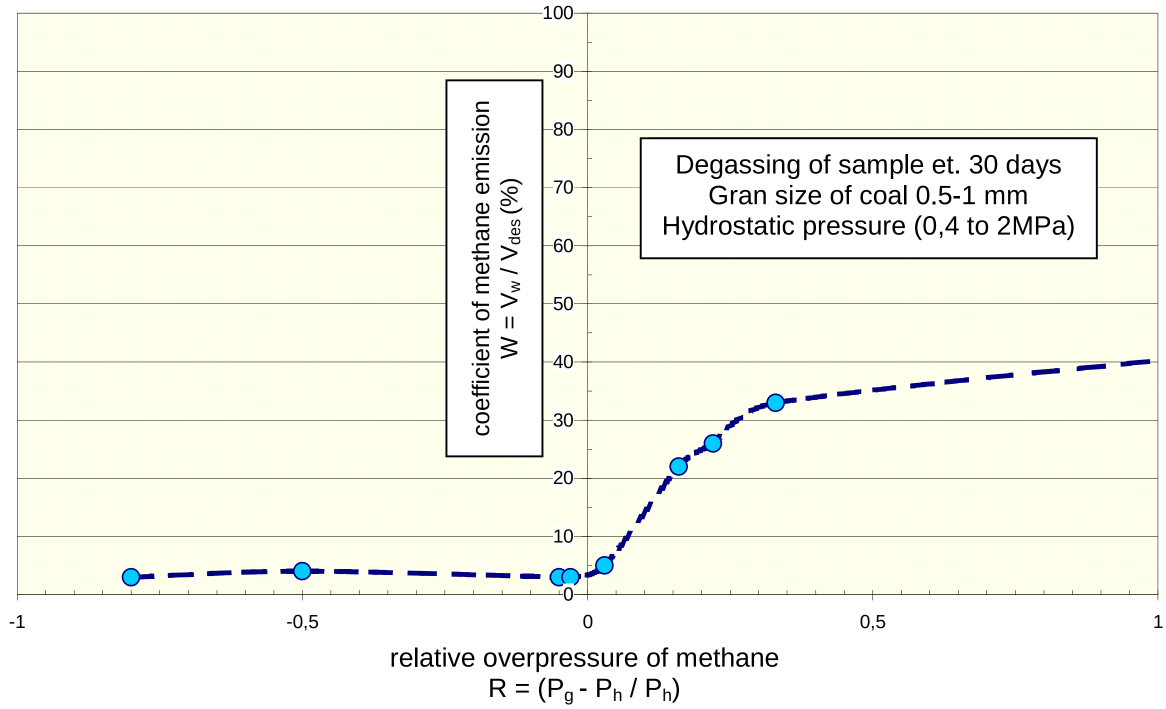

Fig 6. An example of the hydrostatic pressure effect on emission of the methane from a sample of flooded coal. Coal taken from the Albert seam, Lorraine Basin.

Coefficient W of methane emission from coal is given by:

$$W = V_w / V_{des}$$

where :
V_w – volume of methane emitted from coal of a specified sample,
V_{des} – volume of methane desorbable at the pressure drop from a specified initial pressure to atmospheric pressure, show in Fig. 4.

The relative overpressure of methane R is given by a relationship:

$$R = (P_g - P_h)/P_h$$

where :
P_g – initial absolute pressure of methane in coal corresponding with sorption equilibrium pressure,
P_h – absolute hydrostatic pressure of water covering the methane-containing coal sample.

The results of tests presented above, and of tests on other Polish and French coals point out that hydrostatic pressure of water considerably reduces the emission of methane from coal. This effect increases with increasing pressure of water in relation to initial sorption equilibrium pressure of methane in coal.
The value of the gas emission coefficient becomes a minimum in the case of equilibrium between hydrostatic and gas pressures. Then, it remains approximately constant, in spite of increasing predominance of hydrostatic pressure in relation to gas in the coal pressure. In this range of hydrostatic pressure, the volume of gas released in the experiments conducted remained less than 10% of theoretical desorbable volume.

The kinetic of gas desorption from coal and quantity of desorbed methane are also limited just by presence of water, without the important effect of hydrostatic pressure.Fig. 7 presents the results of tests on methane emission conducted on a sample of dry coal collected from No. 361 seam of Pniówek mine (Silesian Basin), and on samples flooded with water at various levels of hydrostatic pressure (0 ; 0,2 ; 0,4 i 0,5 MPa), at identical initial pressure of gas sorption equilibrium (0,4 MPa).

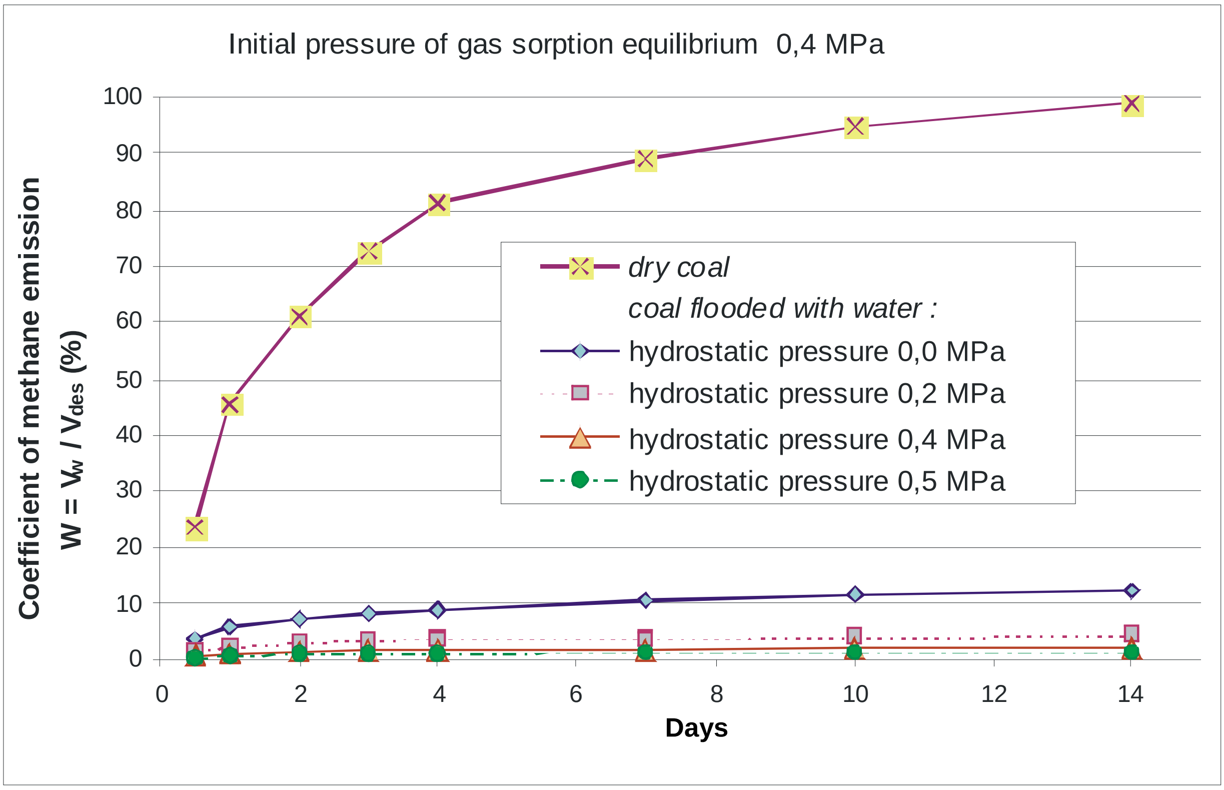

Fig. 7. Comparison of methane emission from the sample of dry coal and coal samples flooded with water at various hydrostatic pressures. Coal taken from No.361 seam of Pniówek mine (Silesian Basin)

The results of tests have shown that the intensity of methane emission from coal flooded with water, without the effect of hydrostatic pressure, was, in similar conditions, approximately 9 times lower than that from dry coal, and substantially decreased, in accordance with the results from Fig.6, on applying hydrostatic pressure of a considerable value.

Conclusions

1. During and after closure of a methane coal mine, the rise of methane concentration and pressure takes place in the isolated post-mining voids, and creates them a possibility of further gas migration into the surface trough overburden strata or directly connected workings.
2. In the conditions of flooding the closed methane mines, the presence of water and related hydrostatic pressure limits the desorption and migration of methane from unexploited gassy coal seams, and thereby contributes to reduction of of methane migration to the surface of post-mining areas.

3. The presented results of investigations performed with the aim to determine the relationships present in the coal-gas-water system, in view of closed coal mines can be used in predicting emission of methane into flooded coal mines, and in elaborating the rules of methane hazard control, in the course of mine closure and on the surface of post-mining areas.

References:

Burrel R., Friel S. (1996) – *The effect of mine closure on surface gas emission* – Proc. of the conference on the environmental management of mine operations, IBC (eds), London (UK)

Besnard K. Pokryszka Z. (2005) - *Gases emission monitoring in a post-mining context* - International Conference Post-Mining 2005, 16-17 novembre, Nancy (France)

Kral V., Platenik M, Novotny R. (1998) - *Methane from closed-down mines in the soil* – Proc. of the International Conference on Coal-bed Methane Technologies of Recovery and Utilisation – GIG (eds) – Katowice (Poland)

Krause E., Łukowicz K.(2000) - Dynamiczna prognoza metanowości bezwzględnej ścian (poradnik techniczny). Instrukcja nr 14 GIG

Krzystolik P., Kobiela Z., Krause E., Płonka A. (2002): *Post-outburst spaces in the Wałbrzych Coal District: physico-chemical model*. In: Kotarba M.J. (Ed) Gas hazard in the near – surface zone of the Wałbrzych Coal District caused by coal mine closure: geological and geochemical controls, Chapter 6 (this volume). Society of Research on Environmental Changes "GEOSPHERE", Kraków (Poland)

Novotny R., Platenik M., Takla G., Kral V. (2001) – *Reduction of uncontrollable mine gas emission in the Czech part of Upper Silesian hard coal basin devastated by past mining activity* - Proc. of the 7th international mine ventilation congress – Research & Development Center EMAG (eds) – Cracow (Poland) – ISBN 83 913109 1 4

Pokryszka Z., Tauziede C. (2000) - *Evaluation of gas emission from closed mines surface to atmosphere* – Proc. of the 6th international conference on environmental issues and management of waste in energy and mineral production, Calgary (Canada) – Balkema (eds) – ISBN 90 5809 085 X

Pokryszka Z., Tauziede C., Lagny C., Guise Y., (2005) - Gas Migration from Closed Coal Mines to the Surface. Risk assessment Methodology and Prevention Means, Symposium Post-Mining 2005, November 16-17, Nancy, France

Pokryszka Z., Krause E. (2007) - Methane emission from flooded coal in abandoned mines in the light of laboratory investigations. IX international Conference " Natural Risks in Mines 2007", Ustroń, November 2007

Prokop P. (2001) – *Gas leak effects on environment of Ostrava basin* - Proc. of the 7th international mine ventilation congress – Research & Development Center EMAG (eds) – Cracow (Poland) – ISBN 83 913109 1 4

Robinson R. (2000) - *Mine gas hazards in the surface environment*. Transactions of the institution of mining and metallurgy, section A, Mining technology, vol 109, September - December 2000, pp228-238.

Sizer K., Creedy D., Sceal J. (1996) - *Methane and other gases from disused coal mines : the planning response* – Technical report for the department of the environment – Wardell Armstrong – The Stationery Office (eds) – London (UK)

Tauziede C., Pokryszka Z., Barriere J.P.(2002) - Risk assessment of gas emission at the surface of French abandoned coal mines and prevention techniques publication : Transactions of the Institution of Mining and Metallurgy – Section A. Mining Technology – Vol.111 Dec.2002.