Geochemistry of coal-bed methane in the Upper Silesian Basin, Czech Republic

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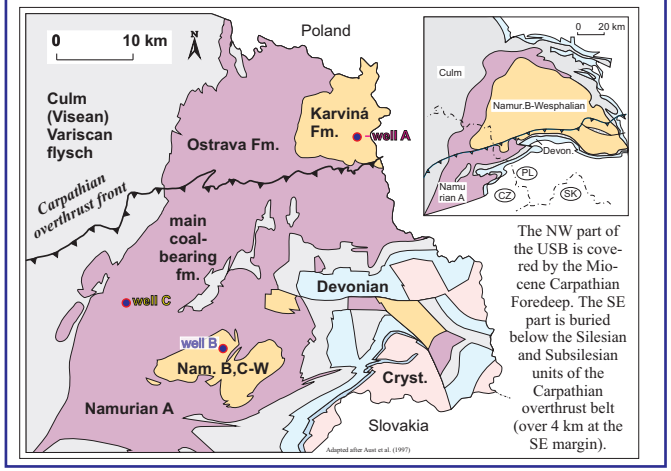
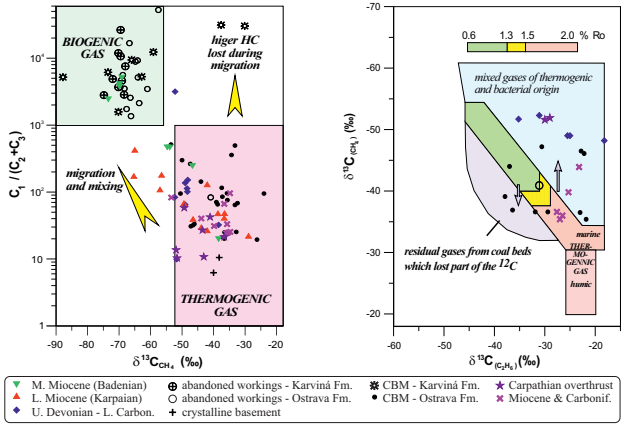
Subcrop map of the Upper Silesian Basin (Czech part)

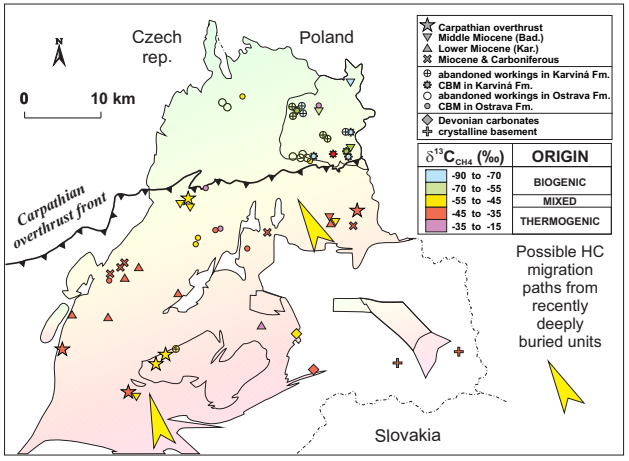


The NW part of the USB is covered by the Miocene Carpathian Foredeep. The SE part is buried below the Silesian and Subsilesian units of the Carpathian overthrust belt (over 4 km at the SE margin).

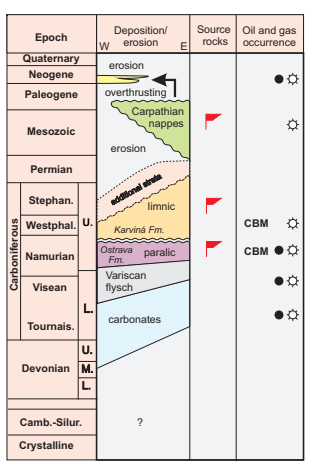
Isotopic composition and wetness of gases from different reservoirs



Regional and stratigraphic distribution of d^{13}C of methane

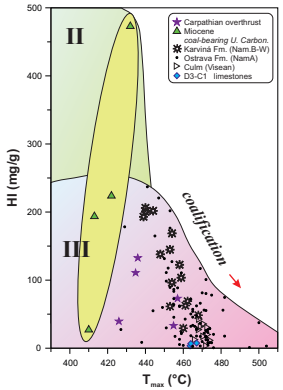


Czech part of the Upper Silesian Basin (USB) represents a foreland basin of the Rhenohercynian zone of the Variscan orogenic belt. The sedimentary fill consists of molasse-type siliciclastic rocks with numerous coal seams. The tectonic deformation increases from E to W. The surface of the Paleozoic is erosional and the partial blocks of the USB experienced different maximum burial and uplift. Rock samples from coal mines and boreholes and gases from methane drainage and drill stem tests were analyzed to evaluate the gas generation and migration.

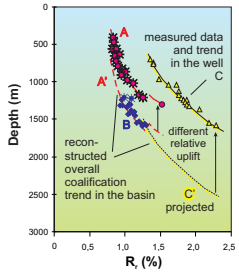


Most of the coal seams are situated in the Ostrava Fm. (Namurian A) and Karviná Fm. (Namurian B, C and Westphalian). Possible source rocks for gas are also in the Carpathians. Oil and gas reservoirs are located at different stratigraphic levels.

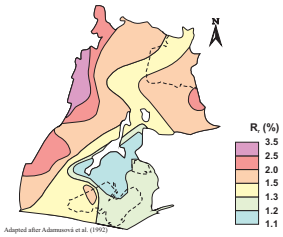
Rock-Eval pyrolysis of the source rocks



The humic type of organic matter is similar in both Ostrava and Karviná Fms., the hydrogen index is controlled by coal rank. Kerogen in the Miocene is immature (green field). Carpathian nappes are in oil window. The Culm and Devon-ian to L. Carboniferous carbonates are at a late mature phase with low residual source potential.



Coalification shows different trends in the partial blocks of the Upper Silesian Basin. When projected, they form almost a continuous trend representing the situation during the deepest burial.



Isoreflectance contour map at the surface of the Ostrava Fm. The lowest thermal maturity occurs in the SE area with the maximum present burial depth. This suggests that the coalification is frozen since the Paleozoic .

CONCLUSIONS

Several types of gases occur in the Czech part of the Upper Silesian Basin:

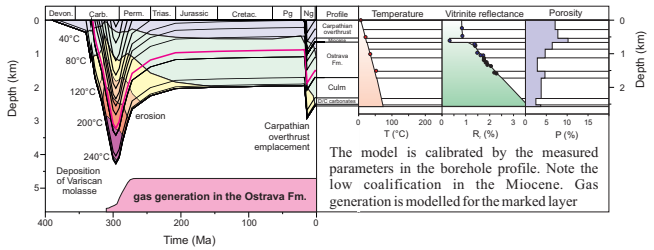
1. Biogenic gas (isotopically-light and dry) is associated
stratigraphic aspect - with coal seams of the Karviná Fm. (uppermost Paleozoic, water infiltration)
- Middle Miocene (Badenian)
secondary processes - with abandoned workings in the coal mines
region/ tectonics - in front of the Carpathian overthrust belt

2. Thermogenic gas (isotopically heavy and wet) occurs in
stratigraphy - coal beds of the Ostrava Fm., well sealed L. Miocene (Karpatian) and the overthrust belt
region/ tectonics - below the Carpathian overthrust which acts as an efficient seal.

Thermal modelling suggest that the recent hydrocarbon generation and migration from below the deeper parts of the Carpathian Flysch Belt is possible. Miocene thrusting, burial and heating may have affected the coal sorption properties and induced local sorbed gas redistribution.

CO_2 associated with methane suggests different rate of CH_4 oxidation in abandoned and active mine workings. The Badenian methane gases originate probably due to microbial CO_2 reduction.

Well C: Burial History with temperature zones and present maturity profile

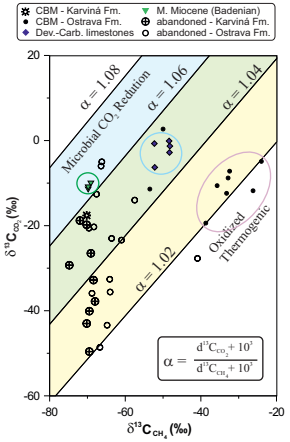


The model is calibrated by the measured parameters in the borehole profile. Note the low coalification in the Miocene. Gas generation is modelled for the marked layer

Application of basin modelling (Petromod, IES) provides a quantitative assesment of the paleo-geo-thermal gradient, depth of burial and extent of erosion of the Late Paleozoic strata. The emplacement of the Silesian and Subsilesian nappes buried part of the Upper Silesian Basin to elevated temperature in the Early/Middle Miocene. The importance of this second burial and heating increases to the SE.

The Upper Silesian Basin may be divided into the following gas-geochemical systems:
1. U. Carbonferous coal bearing strata
- in front and
2. - below the Carpathian overthrust
3. - abandoned workings in coal mines
4. L. and Middle Miocene + overthrust

Carbon dioxide vs. methane



Lines show constant isotopic fractionation between the coexisting gases. Microbial CO_2 reduction occurs in the Miocene (Badenian). Oxidized biogenic and thermogenic gases occur in the abandoned and active workings.