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Relationship between lithofacial variation and the amount and molecular composition of the gases collected from the rock cores degassing

ABSTRACT

The research subject discussed in this dissertation was chosen in order to systematize the years-long analyses being carried out for KGHM Polska Miedź S.A. and expand them to include correlation and interpretation aspects of gas chromatographic tests results, in reference to additional geochemical tests (including pyrolytic and isotope analyses) and petrophysical rock properties. The obtained results are the basis for identifying potential gas accumulation areas and forecasting gas and gas-geodynamic threats for copper ore deposits, based on the example of the Sieroszowice Copper Mine.

The main purpose of the thesis was to determine the relationship between the lithofacial variation and the amount and molecular composition of gases from the degassing of rock cores collected from the "OG Sieroszowice" region, exploited by "O/ZG Polkowice-Sieroszowice", a part of KGHM Polska Miedź S.A. Additionally, the research conducted as part of this dissertation concerned the following issues:

- Explaining the presence of large amounts of i.e. excess nitrogen, hydrocarbons and sulphur compounds in desorbed and residual gas.
- Qualitative and quantitative evaluation of gases originating from the degassing of rock cores against the selected petrophysical properties of the rocks.
- An attempt to answer the question whether gas closed inside the pores (in rock core samples of different lithological variation) was generated and trapped "in situ" in the rock or is the result of migration (predicted origin of individual gaseous components).
- Determining the thermal maturity of the organic matter in terms of the hydrocarbon generation process (with the hydrocarbons being a component of the desorbed gases).
- Assessment of gas-bearing properties of different lithofacial formation rocks in selected areas of "OG Sieroszowice" to indicate the preferences of gas accumulations.

The research is based on rock samples collected from a copper-bearing formation in the southern part of the Fore-Sudetic Monocline, which were subjected to gas capacity assessment. The tested samples differed in terms of their lithological character and petrophysical properties. During laboratory tests, the molecular composition of gases was

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analysed for light hydrocarbons (C1, C2, C3, i-C4, n-C4, neo-C5, i-C5, n-C5, ∑C6, ∑C7, ∑C8, ∑ C9 and ∑C10), carbon dioxide, excess nitrogen, helium, hydrogen as well as sulphur compounds, and the exact amount of the released gas was also determined. The tests were carried out both for samples of desorbed (free) gas, representing the part of the gas that is in the open space of the rock pore and which is free to migrate, and for samples of residual (also called occluded) gas released from the rock after the crumbling of the sample. The composition and quantity of the gas were analysed for a large population (803 samples in total, including 59 sandstone samples, 28 copper-bearing shale samples, 254 dolomite samples, 298 anhydrite samples and 164 rock salt samples) with reference to their lithological differences and selected petrophysical properties of the rocks.

The presented results of statistical, quantitative and qualitative analyses of both desorbed and residual gases were evaluated in terms of various interdependence aspects. First of all, the dependence of the total gas content and its individual components in the lithological profile was discussed in relation to its petrophysical properties and the location in the area of "OG Sieroszowice" operations (divided into five regions). Such an approach allowed to determine certain regularities of the distribution of gas and its individual components, which is important in forecasting zones with increased gas exhalation potential. Additionally, an assessment of the generation possibilities of individual lithofacies included in the copper-bearing formations was carried out and the correlation of gases from the rock cores degassing with natural gases accumulated in the adjacent deposits was demonstrated.

When analysing the samples from the cupriferous level in individual lithologies, different gas accumulations are observed to exhibit a certain variability in the chemical composition in the vertical profile of the deposit, with a definite dominance of nitrogen in all analysed lithological formations. This variability may be caused by the mixing of different types of gases, i.e. autochthonous and allogeneic (migratory) gases, which was also proved by isotope tests of selected residual gas samples.

The distribution of nitrogen in the "OG Sieroszowice" area proves the dominance of vertical migration factor of gases from the lower layers of the beds (probably from Carboniferous deposits), while its accumulation in northern parts may indicate a certain share of lateral migration from the neighbouring fields of the nitrogen-rich natural gas of the Rotliegend strata.

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Based on the isotope tests and Rock-Eval pyrolysis, it has been proved that natural gas in the study area can be at least partially generated from the organic matter contained in copper-bearing shales. The examined shale samples demonstrated large amounts of Type II organic matter at the level of thermal maturity that allows for the generation processes in the main phase of the oil window. Dolomite and anhydrite also have some generation possibilities (but much lower than in the case of copper-bearing shale).

Rock salt deposits, located in the northern part of the studied "OG Sieroszowice" area, constitute an additional sealing of the copper ore deposit, which poses a risk of gas accumulation.

As proved by the conducted research, gas distribution in the rock formations of copper ore deposits shows a clear dependence on lithological variation, divided into five lithofacies. Moreover, gas-bearing variability depending on the location (vertical and lateral) was demonstrated, which is undoubtedly implied by geological conditions (structure and tectonics), including the vicinity of natural gas deposits.

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