SURFACE GEOCHEMISTRY IN OIL AND GAS EXPLORATION - CASE STUDIES FROM PETROLEUM PROVINCES OF POLAND

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Introduction

The application of surface geochemical methods to petroleum exploration is almost as old as the history of the University of Mining and Metallurgy (recent name: AGH University of Science and Technology) in Kraków. During that time span a large number of geochemical methods have been developed, tested and implemented in worldwide exploration practice. According to Schumacher (2017), their proper implementation integrated with ”traditional” geological and geophysical methods may increase the success rate of exploration wells even to 80%. One of the most important geochemical method supporting the petroleum exploration is the ”free gas” technique. It is based upon the sampling and analysis of soil gas for trace amounts of hydrocarbons, which have migrated towards the Earth’s surface from deep-seated accumulations. The surface geochemical survey has been run by field working groups from our University over some tens of areas located in all the petroleum provinces of Poland. As a result, a huge database has been acquired and an extended experience has been gained, which enabled our working group to improve continuously the methodology, including the data interpretation procedures. The current paper aims to present and compare the exemplary results of surface geochemical survey carried on in various regions of Poland, integrated with the geological and petroleum deposits models. The study areas are: Drzonowo-Biała (Western Pomerania), Paproć - Cicha Góra (Fore-sudetic Monocline), Sól (Outer Carpathians) and Pawłosiów (Carpathian Foredeep).

Methodology

The soil gas samples were collected at sampling sites distributed along the sampling lines at 100 or 200 m spacings. Gas samples were collected at 1.2 m depth with the patented sampling kit (patent No. PL 184080 B1), and analyzed chromatographically for light alkanes, and alkenes. Selected samples were analyzed for isotopic composition. The populations of measured hydrocarbons concentrations and calculated geochemical indices were then processed with the statistical methods. Such data analysis enabled us to determine the geochemical background values and to delineate the surface anomalies as well as to evaluate the origin of methane, the nature of deep-seated hydrocarbon accumulations and the relative migrational activity of particular hydrocarbons. The results were integrated with geological models and seismic cross sections.

Results and discussion

Among the study areas, the less distinct geochemical signature was revealed by the Pawłosiów area located in the Carpathian Foredeep, whereas the strongest signature was found in the Sól area, in the Outer Carpathians (Tab. 1). This demonstrates diversed intensity of hydrocarbon microseepage controlled by varying geological conditions and deposit characteristics of both study areas.

Table 1. *The ranges and average values of measured concentrations of light hydrocarbons in soil gas samples taken in the studied areas.*

Component	Study area			
	Drzonowo - Biała	Paproć	Pawłosiów	Sól
Methane (ppm)	1.1 - 137000.0 *(690.0)*	0.2 - 2600.0 *(24.5)*	1.03 - 41720.0 *(128.1)*	0.83 - 243200.0 *(720.0)*
Σ alkanes C_2-C_5 (ppm)	b.d.l - 18.4 *(0.15)*	b.d.l - 5.32 *(0.47)*	b.d.l - 0.55 *(0.062)*	b.d.l - 1509.0 *(2.73)*
Σ alkenes C_2-C_4 (ppm)	b.d.l - 0.56 *(0.022)*	b.d.l - 5.88 *(0.52)*	b.d.l - 12.9 *(0.055)*	b.d.l - 2.07 *(0.065)*

b.d.l - below detection limit; in brackets - average values

In the Drzonowo-Biała area (Western Pomerania), 10 anomalies were identified, indicating the existence of still undiscovered hydrocarbon accumulations in both the Carboniferous and formations and in the Main Dolomite reservoir. The most interesting are anomalies located in the central segment of the II-II' sampling line, which indicate oil-gas and condensate accumulations reservoired in anticlinal elevations framed by faults (Sechman et al., 2011). The studies on the Paproć-Cicha Góra gas deposit enabled us to calibrate surface geochemical data for the Fore-sudetic Monocline. Analysis of CH_4/C_2H_6 and C_2H_6/C_3H_8 indices confirmed the presence of compositionally diverse hydrocarbon reservoirs at depths. Moreover, this data supported the opinion that even small condensate accumulations result in very strong surface geochemical signature, on the contrary to deeper-seated deposits of dry gas (Sechman, 2012). In the Sól area (Outer Carpathians), the results of geochemical survey integrated with geological cross-sections and tectonic map allowed us to select the zones of high hydrocarbon potential: the Silesian Unit, the zone related to the overthrust surface of the Racza Subunit, the Rycerka Górna and Rycerka Dolna slice-folds, the Obłaz Anticline and the Sól Południowa and Sól Północna slice-folds.

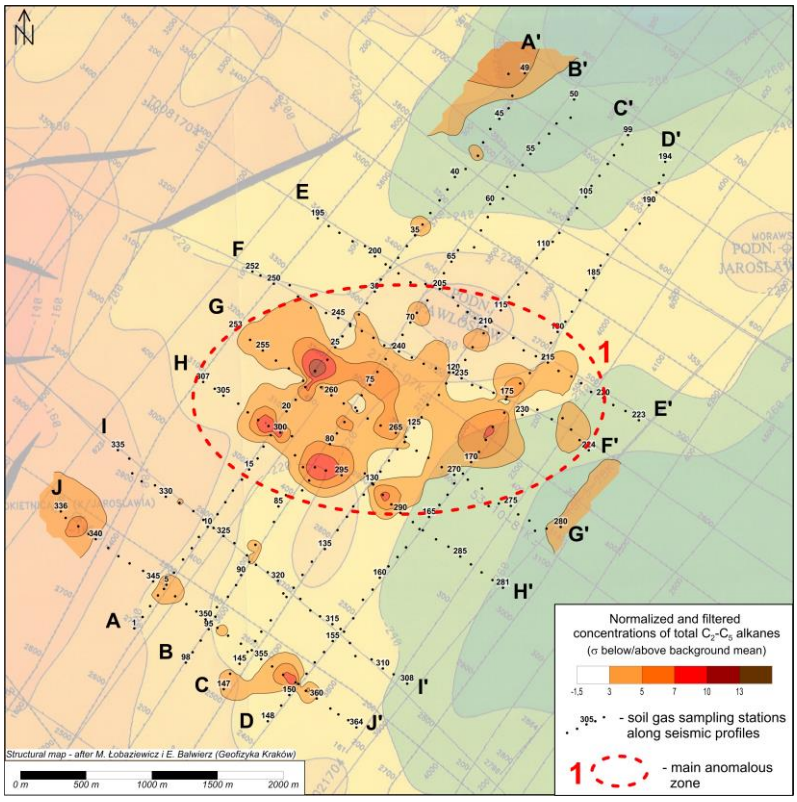

Figure 1. *Distribution of total C_2-C_5 alkanes concentrations measured in soil gas samples, on the background of the structural map of the Miocene H1 horizon (Pawłosiów area - Carpathian Foredeep).*

The No. 1 anomaly identified in the Pawłosiów area (Carpathian Foredeep) (Fig. 1) includes over 50 sampling sites, in which concentrations of total alkanes C_2-C_5 exceed 3σ. This zone is located over the southwestern slope of the Miocene compactional structure, close to the Mirocin, Jarosław and Morawsko producing gas deposits. Hence, the contoured anomaly of alkanes concentrations (Fig. 1) indicates possible gas accumulation at depths.

Conclusions

The study areas differ in concentrations of hydrocarbons in soil gas. This is an effect of various factors: depths to potential hydrocarbon accumulation, character of accumulations (gas, oil, condensate) and tectonics. Anyway, the applied statistical data processing methodology enabled the researchers to identify anomalies of total alkanes C_2-C_5 concentrations in each of the study areas. The surface pattern of hydrocarbon anomalies properly integrated with geological and seismic models may contribute to localization of conventional hydrocarbon accumulations or deep subsurface gas-saturated zones. After completion of drilling projects such localities may appear to be the commercial oil or gas deposits.

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