AGH DRILLING, OIL, GAS • Vol. 33 • No. 2 • 2016

http://dx.doi.org/10.7494/drill.2016.33.2.237

Stanisław Rychlicki*, Jerzy Stopa**

DIRECTIONS OF DEVELOPMENT OF POLISH GAS AND OIL

Period of 2000–2015 in exploration and production of hydrocarbons was not the most successful. The last major discovery of new reservoirs took place in the second half of XXth century and first half of XXIst century, when the reservoirs of Kościan, Brońsko, BMB and LMG were discovered. Unfortunatelly, following years did not develop these significant discoveries. We can wonder if it was connected with the lack of exploration strategy, problems with financing or less availibility of discovering new reservoirs.

Performing work over last three years enabled though first exploration successes, to be mentioned Podkarpacie and Wielkopolska. The total resources estimate of 64 million equivalent barrels of petroleum (boe). New reservoirs are Kramarzówka, Niebieszczany, Dukla, Przeworsk, Siedleczka Opalino, Miłosław and Pniewy. They are conventional fields [2] except for Miłosław and Pniewy. Pniewy 4 borehole confirmed discovery of non-conventional "tight gas" reservoir. However, borehole Miłosław 4k implicates discovery of gas reservoir and is connected with previous discoveries in that area (Wielkopolska Petroleum Province – Fig. 1) reservoirs of Lisewo, Komorze, Winna Góra, Środa and Kromolice [3].

Mentioned above effects of exploration result in increase of resources. Only in Kramarzówka, according to preliminary calculations resources are on the level of 32 million boe and according to specialists they may even reach 100 million boe. Niebieszczany is a documented resource of 3.2 million boe but its potential is estimated for 30–320 boe. In the nearest future PGNiG is planning to indicate reservoirs of Siedleczka, Dukla and Przeworsk and in 2017 Przemyśl. Next year it is also planned to make documentation of Opalino reservoir in Pomorze and Pniewy in Wielkopolska. Thanks to the new vertical boreholes and fracturing the resources may increase of 100–150 million boe [1].

* AGH University of Science and Technology, Faculty of Drilling, Oil and Gas, Krakow, Poland
** AGH University of Science and Technology, Faculty of Drilling, Oil and Gas, Krakow, Poland and PGNiG S.A.

It will enable to restore resources and maintain production on the level of about 4 mld m^3 of gas.

At present documentiation work concerning Krosno layers and Dukla-Draganowa (Małopolska Oil Province – Fig. 1) is being performed.

Fig. 1. Petroleum provinces in Poland

According to calculations by The Polish Exploration and Production Industry Organization (OPPPW), within 2010–2015 on Polish market 172 boreholes were completed, including 104 on conventional layers and 72 unconventional ones. However, in 2015 there were only 22 boreholes, including 20 conventional and 2 unconventional, one vertical and one horizontal. In comparison to 2014 there were 37 boreholes altogether, including 22 conventional and 15 unconventional. Simultaneously, since 2010, 39 enhancement procedures, including 25 cases of fracturing have been performed. 10 out of 25 were performed using directional drilling. Three last cases of fracturing were performed in 2014. Three fracturing scheduled for completion at the beginning of 2016.

22 out of the total number of 72 unconventional boreholes have already been liquidated or are about to, due to the low quality of the reservoir, unsatisfactory tests results or surrender the license by the operator. Most of the boreholes is not suitable for commercial production.

Polskie Górnictwo Naftowe i Gazownictwo SA in 2015 completed on their licences 41 explorational, appraisal and exploitational wells. They are located in Zachodniopomorskie, Pomorskie, Lubuskie, Wielkopolskie, Małopolskie and Podkarpackie province. 10 exploration and appraisal wells are positive which means that occurance of gas reservoir is confirmed. Its total resources are estimated for about 3.7 billion m^3 of

gas (around 24.2 mln boe). Additionally PGNiG's corporate's group performed seventeen exploitation boreholes. Seven of them are oil wells. Forecasted annual production of crude oil from four wells is 154 thousand tonnes (approx. 1.16 million boe), while the remaining wells to the production of gas in the amount of 90 million m^3 per year, i.e. approx. 0.35 million boe. In 2015 PGNiG incorporated into operation 15 wells – including 13 gas and 2 oil wells. Expected production from these wells is approx. 105 million m^3 of gas (in terms of high-methane gas) and 5.9 thousand tons of oil (in total approx. 0.72 million boe) per year. In 2015 PGNiG based on discoveries from previous years have documented hydrocarbon resources about the size of 27 million boe [4].

PKN Orlen is planning exploration work on the acquired in 2015 areas. Preparations are underway for the acquisition of 3D seismic on the license Lublin, started the drilling of Bajerze-1K, located on the concession Unisław-Gronowo in Kujawsko-Pomorskie. It is located near Chojnice-Wilcze concession, where in 2013 Tuchola reservoir was discovered. Its 2P reserves are estimated for 272 million Nm^3 of natural gas. In 2016 PKN Orlen is planning to continue exploration, reconnaissance and exploitation work ongoing in Poland in the area of 29 concessions, located within 8 provinces.

Above mentioned information suggest that there are plans for further hydrocarbon exploration in Poland. The question is whether there are prospective resources. Starting from 1992 in the Oil and Gas Institute and AGH University of Science and Technology in Krakow, began calculation of resources using prognostic genetic method. It was first used geodynamic analysis of sedimentary and petroleum basins. It is the primary method of assessing these resources for undiscovered hydrocarbon potential. This analysis associated in a unified physical system geodynamic conditions of oil formation, ie. the bedrocks, reservoir rocks and sealing rocks with thermodynamic conditions of the creation phases of hydrocarbon and their migration, leading to the accumulation of oil and natural gas.

The size of original prognostic resources of conventional hydrocarbons for the area of Poland according to assessments of independent research institutes are as of 31.12.1996 (Ministry of Environment) for crude oil 377.8 million tons, and natural gas 2,392.6 billion m^3. In the case of unconventional hydrocarbon assessment are varied. Their size is shown in the Tables 1 and 2.

The Figures 2–4 indicate the three most likely areas of occurrence of unconventional natural gas and crude oil in Poland.

A report published by the Polish Geological Institute (PGI) in 2015 shows that in the three listed in Figures 2–4 Polish areas estimated tight gas resources range from 1.53 to 1.99 trillion m^3, although according to some signals may even be much more, to 5.21 billion m^3. As possible to the extraction are estimated at the level of 153–200 billion m^3. Slawomir Brodziński stated that "PIG Report 2015 was made at a very careful assumption that only 10% of the gas can be extracted, and the practice shows that it can be even 30%. This would give at least an additional 500 billion m^3. It might be translated into the production of 15 billion m^3 per year." The report refers to the PGI resources of undiscovered deposits. It does not include pre-documented structure of the gas in the closed region of Siekierki and Pniewy near Poznan. San Leon is estimated to have gas reserves at approx. 60 billion m^3 including approx. 30% extracted, and in the case of

the structure in the region Sicin (near Leszno) approx. 1,000 billion m^3 possible to extract tight gas. Of course it is possible that together with the gas tight oil appears, it is particularly likely in the coastal area – said Dr. Hubert Kiersnowski of PIG, one of the authors of the above-mentioned report.

Table 1

Shale gas Poland [6]

Basic Data	Basin/Gross Area		Baltic/Warsaw Trough (16,200 mi²)			Lublin (4,980 mi²)	Podlasie (6,600 mi²)			Fore Sudetic (19,700 mi²)
	Shale Formation		Llandovery			Llandovery	Llandovery			Carboniferous
	Geologic Age		L. Sil - Ord. - U. Cambrian			L.Sil-Ord-U.Cambrian	L. Sil - Ord. - U. Cambrian			Carboniferous
	Depositional Environment		Marine			Marine	Marine			Lacustrine
Physical Extent	Prospective Area (mi²)		830	2,070	5,680	2,390	1,000	1,100	860	9,070
	Thickness (ft)	Organically Rich	820	820	820	415	540	540	540	330
		Net	451	451	451	228	297	297	297	182
	Depth (ft)	Interval	6,500 - 9,800	7 - 13,000	9 - 16,000	7,000 - 16,000	6 - 9,000	6,500 - 11,500	10- 16,000	8 - 16,000
		Average	8,200	10,000	12,500	11,000	7,500	9,500	12,500	12,000
Reservoir Properties	Reservoir Pressure		Mod. Overpress.	Mod. Overpress	Mod. Overpress.	Slightly Overpress.	Slightly Overpress.	Slightly Overpress.	Slightly Overpress	Slightly Overpress.
	Average TOC (wt. %)		3.9%	3.9%	3.9%	3.0%	3.0%	3.0%	3.0%	3.0%
	Thermal Maturity (% Ro)		0.85%	1.15%	1.80%	1.35%	0.85%	1.15%	1.80%	1.60%
	Clay Content		Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Resource	Gas Phase		Assoc. Gas	Wet Gas	Dry Gas	Dry Gas	Assoc. Gas	Wet Gas	Dry Gas	Dry Gas
	GIP Concentration (Bcf/mi²)		36.6	131.0	181.1	91.2	27.4	82.3	122.4	67.2
	Risked GIP (Tcf)		12.1	108.5	411.5	45.8	6.6	21.7	25.3	106.7
	Risked Recoverable (Tcf)		1.2	21.7	82.3	9.2	0.7	4.3	5.1	21.3

Table 2

Shale oil Poland [6]

Basic Data	Basin/Gross Area		Baltic/Warsaw Trough (16,200 mi²)		Podlasie (6,600 mi²)	
	Shale Formation		Llandovery		Llandovery	
	Geologic Age		L. Sil - Ord. - U. Cambrian		L. Sil - Ord. - U. Cambrian	
	Depositional Environment		Marine		Marine	
Physical Extent	Prospective Area (mi²)		830	2,070	1,000	1,100
	Thickness (ft)	Organically Rich	820	820	540	540
		Net	451	451	297	297
	Depth (ft)	Interval	6,500 - 9,800	7,000 - 13,000	6,000 - 9,000	6,500 - 11,500
		Average	8,200	10,000	7,500	9,500
Reservoir Properties	Reservoir Pressure		Mod. Overpress.	Mod. Overpress.	Slightly Overpress.	Slightly Overpress.
	Average TOC (wt. %)		3.9%	3.9%	3.0%	3.0%
	Thermal Maturity (% Ro)		0.85%	1.15%	0.85%	1.15%
	Clay Content		Medium	Medium	Medium	Medium
Resource	Oil Phase		Oil	Condensate	Oil	Condensate
	OIP Concentration (MMbbl/mi²)		42.2	12.8	36.2	11.1
	Risked OIP (B bbl)		14.0	10.6	8.7	2.9
	Risked Recoverable (B bbl)		0.70	0.53	0.43	0.15

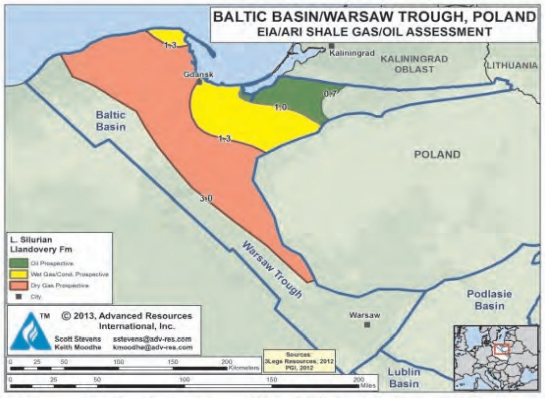

Fig. 2. Resource areas – Baltic Basin/Warsaw trough [6]

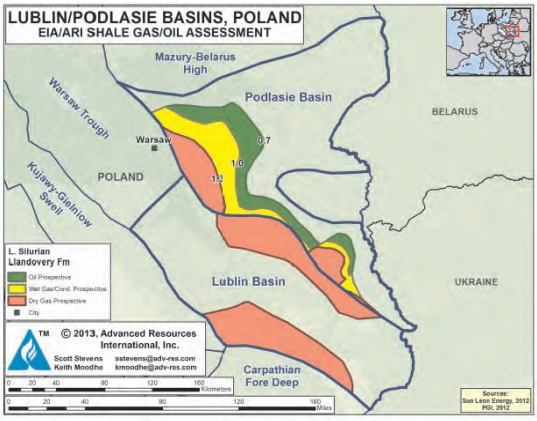

Fig. 3. Resource areas – Lublin/Podlasie Basins [6]

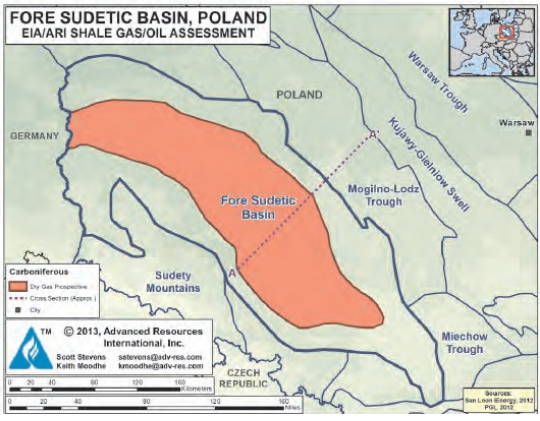

Fig. 4. Resource areas – Fore Sudetic Basin [6]

On the basis of what is written above it can be concluded that there are in Poland possibilities of new discoveries, although it is worth noting that, with their diminishing number, which is a global trend, it is observed increased interest in oil reserves in the final phase of the exploitation, as well as unconventional resources.

From mature reservoirs derive about 70% of world production of hydrocarbons. It is also worth noting that developed in recent years new methods of oil production from unconventional resources resulted in a reversal of a long-term decline in US production. This happened mainly due to the development of the exploitation of "shale" and "tight" gas. In Poland in recent years carried out (unfortunately without success) attempts to transfer American technology on native resources of "shale gas", among others, funding projects under the "blue gas". This caused a significant negligence in the other possibilities of increasing production from domestic fields, especially of tight and mature conventional reservoirs.

Taking into account current situation on the world oil markets one should prefer cheap technologies to optimize production both from conventional and tight fields.

It seems that it is important to undertake measures to increase oil and gas production in Poland, both through the revitalization of old fields and the use of new technologies in the reservoirs with poor properties, which in the past have been declared unfit for exploitation. Taking into account spectacular failures that have occurred due to technical reasons (Lubocino 2H, Niebieszczany, Dukla, Huwniki, Fredropol and many others), despite the involvement of recognized foreign companies, it seems important to increase the involvement of their engineering teams to plan activities and analysis and understanding of the phenomena occurring in the reservoirs as well as the causes of the previous failure to learn from mistakes. It must be accepted the possibility of failure in terms of both technical and geological interpretation, which at the current small-scale works is likely. Hence the need to treat such projects as research, for which it is not necessary to achieve economic efficiency. Otherwise, small mines will not be able to finance them and for large ones, technical risk and cost is higher.

In conclusion, the most important problems connected with exploration and development reservoirs include [7]:

- the occurrence of reservoirs at great depths, mostly above 3500 m,
- difficult geological conditions,
- the need for drilling directional or horizontal,
- very low permeability of rock matrix,
- permeability, mainly through the network of fractures,
- large water exponent,
- the need to develop large intervals,
- a small capacity and the necessity of drilling numbers of holes.

REFERENCES

[1] CIRE 5.11.2015.
[2] Wójcik T.: Biznes. Alert.pl; 9.11.2015.
[3] Komunikat Prasowy PGNiG S.A. z dnia 02.10.2015 r.
[4] Komunikat Prasowy PGNiG S.A. z dnia 29.01.2016 r.
[5] CIRE 3.02.2016.
[6] Advanced Resources International, 2013.
[7] Maksym A., Polit J.: *Nowe wyzwania w poszukiwaniu węglowodorów w Polsce*. Polski Kongres Naftowców i Gazowników, Bóbrka 2015.