

PERSPECTIVE OF SHALE GAS PROSPECTION IN POLAND

by

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Background

At present, the Europe as a whole depends on import of gas. About 25 percent of its gas supplies comes from Russia. Poland is particularly depended on gas imports, with 65 percent of gas imports coming from Russia. On the other hand, the potential for shale gas production in Europe is undoubted. Gas reserves in Europe are shown in tab.1 and in tab.2 are shown resources of shale gas in major shale gas basins of Poland. According to present estimates, the Europe's total shale gas in place could be 173.2 Bcm (6.115 tcf). If these can be proven and exploited, it could dramatically change Europe's energy equation, reducing the continent's dependence on gas imports. Currently some European countries (e.g. France) have put a moratorium on shale gas activity due to environmental risks related to recovery. Poland supports the operation of gas exploration and production. Up to date more than 25 companies have been awarded 108 licenses for exploration of unconventional gas.

Tab. 1. Gas reserves in Europe

Country	Shale Gas Resources		Natural Gas Reserves	
	Bcm	Tcf	Bcm	Tcf
Poland	5295,84	187	164,256	5,8
France	5097,6	180	5,664	0,2
Norway	2350,56	83	2039,04	72
Ukraine	1189,44	42	1104,48	39
Sweden	1161,12	41	0	0
Denmark	651,36	23	59,472	2,1
U.K.	566,4	20	254,88	9
Netherlands	481,44	17	1387,68	49
Turkey	424,8	15	5,664	0,2
Germany	226,56	8	175,584	6,2
Lithuania	113,28	4	0	0
Ro+Hu+Bg	538,08	19	76,7472	2,71

Source US Energy Information Administration, April 2011

Bcm=10⁹m³, Tcf=10¹²ft³

Tab. 2. Resources of shale gas in major shale gas basins of Poland

Shale Gas Basins	Risked Gas In-Place		Technically Recoverable Resource	
	Bcm	Tcf	Bcm	Tcf
Baltic Basin	14556	514	3653	129
Lublin Basin	6287	222	1246	44
Podlasie depression	1586	56	396	14

Source US Energy Information Administration, April 2011

Bcm=10⁹m³, Tcf=10¹²ft³

Aims

The paper presents the perspective of shale gas prospection in Poland.

Methods

Both the public data published by the domestic and international companies or institutions and the unpublished results of drillings and other investigations made by POGC are studied to evaluate the resources and perspectives for production of shale gas in Poland. The main player on the Polish gas market is Polish Oil and Gas Company (POGC). The company has been awarded 15 exploration licenses covering an area of 12 799.92 square km. The companies such as KGHM, PGE and Tauron are going to join PGNIG SA (POGC) “ shale gas” projects in the nearest future. Outside of the USA and Canada, shale gas has not been explored until recently. The lessons learned from the US and Canada shale gas programs can be probably transferred to new ventures in Poland however there are aspects that need to be considered in European assets like: more densely populated areas, large number of environmentally sensitive areas, higher cost of drillings.

Results

In the U.S. shale gas exploration proved to be very successful both in terms of already documented geological resources and financial returns. However, it should be recognized that there are difficulties that may occur in the course of exploration in Poland. The risks associated with exploration of unconventional gas deposits in Poland include:

- *unrecognized geology* – most of the archive wells come from 1970s and 1980s, what results in the absence of the most required data for shale perspectivity analysis (geochemical data indicating organic matter content and maturity, kerogen type etc.). Old geophysical measurements don't give the possibility of reliable reservoir parameters estimation,
- *urbanization of the area* – population density in Poland is quite high (122 persons/km²). What is more, the perspective zones for “shale gas” exploration are located within areas used for rural activities,
- *restrictive regulations on environmental protection* – the license owner has to take into consideration local Polish and European Union law,
- *large number of environmentally protected areas and objects* – many of license areas are covered by National Parkas, Nature Preservation Areas as well as Natura 2000 zones. Exploration works are highly limited within these. Exploration should be run according to Spatial Development Plan created by local authorities,
- *negative opinions from local authorities, especially from attractive touristic areas,*
- *access to proper water reserves* – drilling and fracturing one horizontal well requires 8000-20 000 m³ of water,
- *very high capital cost (cost and number of wells, large production facilities),*
- *cost of proper technologies,*
- *uncertainty of gas prices.*

Projected shale gas reserves in Poland are evaluated by different companies at the following volumes:

- Wood Mackenzie 1.4 trillion m³;
- Advanced Resources. 3.0 trillion m³;
- U.S. Energy Information Administration (EIA) of 5.29 trillion m³.

Up to date 22 companies (including 3 Polish companies: PGNiG SA (POGC), Orlen Upstream and Lotos) have been awarded 108 licenses for exploration of unconventional gas (Fig. 1). Another submitted applications wait for awarding decision in the Polish Ministry of Environment.

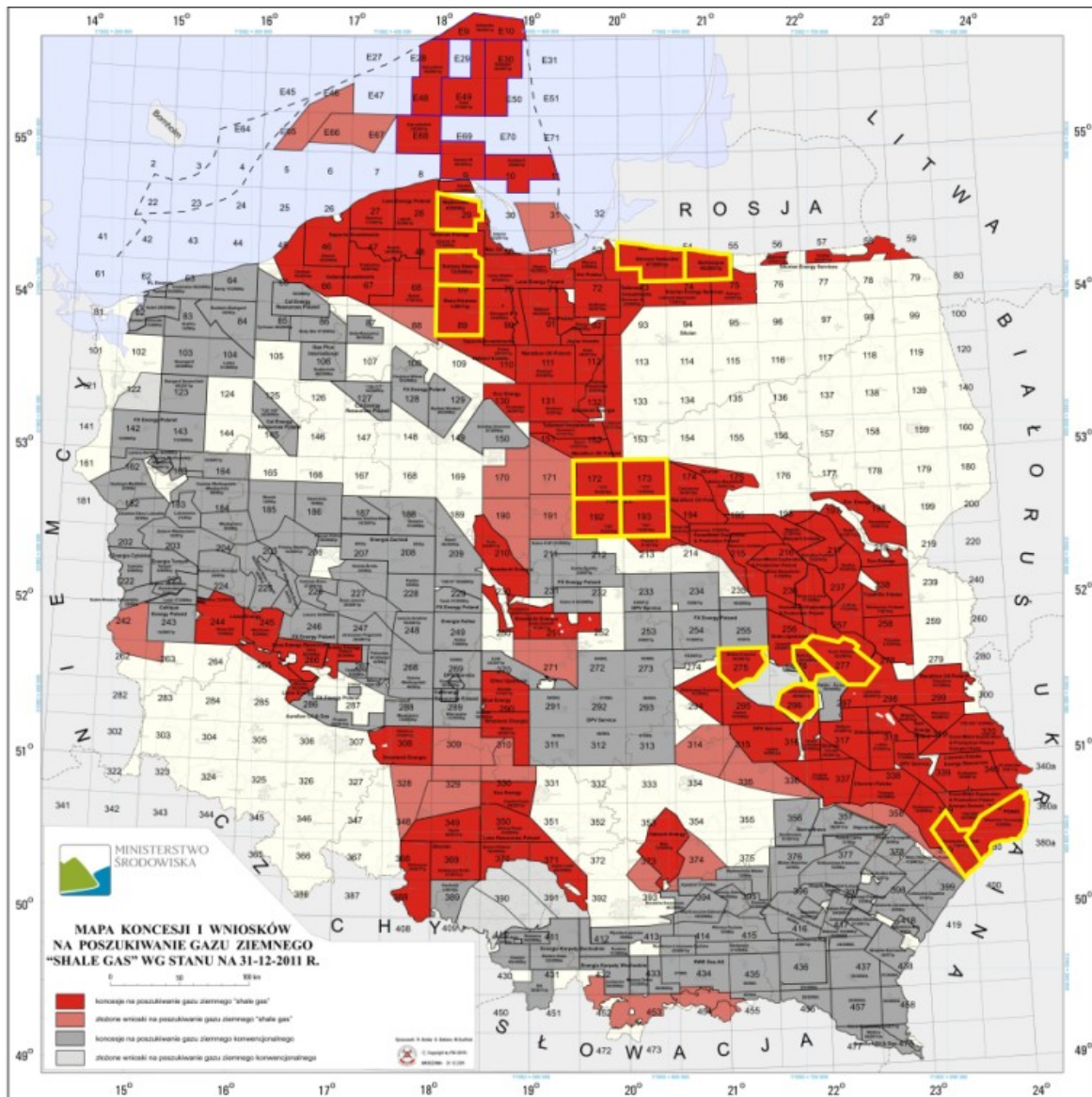


Fig. 1. Awarded shale gas exploration licenses in Poland.
PGNiG SA (POGC) licenses marked in yellow.

International companies show high activity in exploration in Poland. The work program for each of the concessions involves seismic, drilling of an exploratory well and a production test (if well is positive). Supermajors such as Chevron and ExxonMobil have been joined by Total and large number of smaller players.

Talisman is carrying out seismic acquisition on concession in the Baltic Basin and is committed to drill one well on each of their three licenses. Three additional optional wells with horizontal sections will be drilled after a successful first phase testing. San Leon Energy is engaged in a five-year exploration and development program on its two concessions. Recently, Nexen has entered into agreement with Marathon to jointly explore ten concessions in Poland and to invest USD 100 million into shale-related activities. The company has recently bought 40% of shares in these ten licenses. Marathon is acquiring 2D seismic and plans to drill six to seven wells

during 2012. Another company, the Realm Energy holds three licenses in Poland and currently is designing seismic programs and reprocessing of existing seismic data to determine the well locations. 3Legs Resources (held through subsidiary company Lane Energy Poland) holds six exploration and prospection licenses in the Baltic Basin and two other permits in Cracow region. The company, in cooperation with ConocoPhillips, drilled two shale gas exploration wells on the Leborck concession. In August 2011, fracturing jobs have been completed in horizontal wells Lebien LE-2H and Warblino LE-1H. Currently production tests are ongoing. Polish company, Orlen Upstream, has drilled one well, Syczyn OU-1 of the total depth 2900 m, and is under drilling Berejów-1 well in the Lublin Basin now.

Up to date about ten exploration wells were drilled by foreign companies in Poland. The results suggest the presence of gas in Silurian and Ordovician formations. Two more wells are being drilled currently by Chevron and Marathon and their outcomes will be known soon. By the end of 2012 foreign companies plan to drill around fifteen to sixteen additional wells. Italian ENI is going to perform 2 wells. American Marathon in cooperation with Canadian Nexen is ready to drill six to seven exploration wells, of the total depth around 2500-4000 m. BNK tends to carry out three more holes. Chevron declared 4 new wells to the Mining Authority.

Polish national company PGNiG SA (POGC) has been awarded 15 licenses covering an area of 12 799.92 square kilometers. PGNiG SA (POGC) licenses are located within important Palaeozoic sedimentary basins, starting from the Baltic Basin in the northern Poland, through Podlasie Basin in the central part, ending in the Lublin Basin in the south (Fig. 2). Lower Paleozoic shales of Silurian and Ordovician age are considered as the most perspective horizons for unconventional gas and are the main target for “shale gas” exploration. Accessible geological, geophysical and geochemical data suggest that Ordovician and Silurian shales are rich enough in organic matter and are thermally mature enough to be worth an inputted interest (Tab. 3). According to available data, PGNiG SA (POGC) licenses are located within the area of different, but generally high, exploration potential (Fig. 2), what creates hope for the future success.

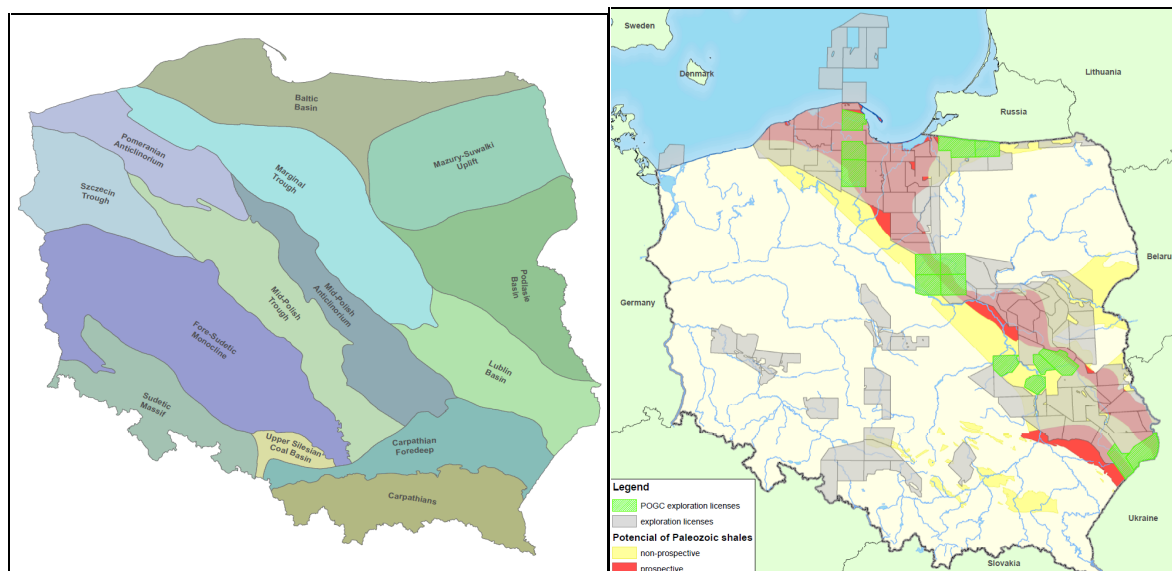


Fig. 2. Geotectonic map of Poland (left). Ordovician and Silurian perspectivity map for “shale gas” exploration (right) with marked in green PGNiG SA (POGC) licenses.

Tab. 3. Shale gas properties in major shale gas basins of Poland



Basic Data	Basin/Gross Area		Baltic Basin (101,611 mi ²)	Lublin Basin (11,882 mi ²)	Podlasie Basin (4,306 mi ²)
	Shale Formation		Lower Silurian	Lower Silurian	Lower Silurian
	Geologic Age		Llandovery	Wenlock	Llandovery
Physical Extent	Prospective Area (mi ²)		8,846	11,660	1,325
	Thickness (ft)	Interval	330 - 820	330 - 1,115	360 - 720
		Organically Rich	575	415	540
		Net	316	228	297
	Depth (ft)	Interval	8,200 - 16,400	6,560 - 13,450	5,740 - 11,350
Average		12,300	10,005	8,545	
Reservoir Properties	Reservoir Pressure		Overpressured	Overpressured	Overpressured
	Average TOC (wt. %)		4.0%	1.5%	6.0%
	Thermal Maturity (%Ro)		1.75%	1.35%	1.25%
	Clay Content		Medium	Medium	Medium
Resource	GIP Concentration (Bcf/mi ²)		145	79	142
	Risky GIP (Tcf)		514	222	56
	Risky Recoverable (Tcf)		129	44	14

Source US Energy Information Administration, April 2011

Basing on the performed analysis of the archive dataset the most perspective area for “shale gas” exploration is located in the Baltic Basin. Wejherowo, Kartuzy-Szemud and Stara Kiszewa are the most promising of PGNiG SA (POGC) licenses. Regarding available geological data, the organic matter content (%TOC) in Ordovician and Silurian horizons, within Baltic Basin, ranges between 0,5-2. These shales are also in wet to dry gas generation window showing vitrinite reflectance (Ro) values at the range of 1,1-3. What is more, in light of “shale gas” exploration, the mineral composition of these rocks is also favorable. The silica content is generally around 50%, what is preferable in terms of hydraulic fracturing processes and future production. The structural framework of Baltic Basin is not complicated as well. Geological beds have monoclinical structure and dip gently (up to 10°) in the south-western direction.

PGNiG SA (POGC) chose Wejherowo License as the priority for unconventional gas exploration. The first vertical exploration well, Lubocino-1, was drilled at the beginning of 2011. The well ended up in Cambrian deposits and drilled 1843,5 m of Silurian and 63 m of Ordovician strata. 800 m of core was collected, which was further analyzed to examine geochemical, petrophysical and geomechanical parameters of rocks. Wide set of wireline logging measurements was also applied. The results of combination of both, laboratory and geophysical analysis, turned out to be very promising and confirmed the presence of unconventional gas in Ordovician and Silurian strata (Fig. 3 and Fig. 4).

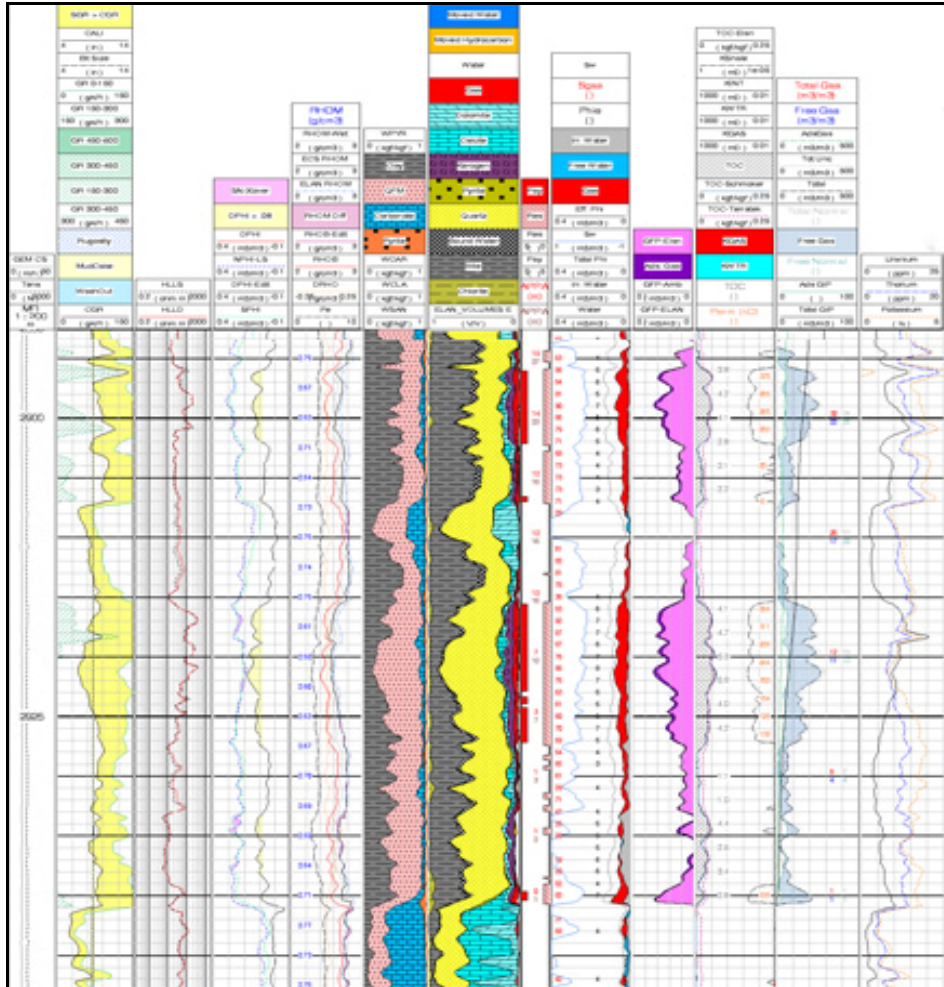


Fig. 3. Wireline logs and petrophysical interpretation of Lower Silurian and Ordovician deposits

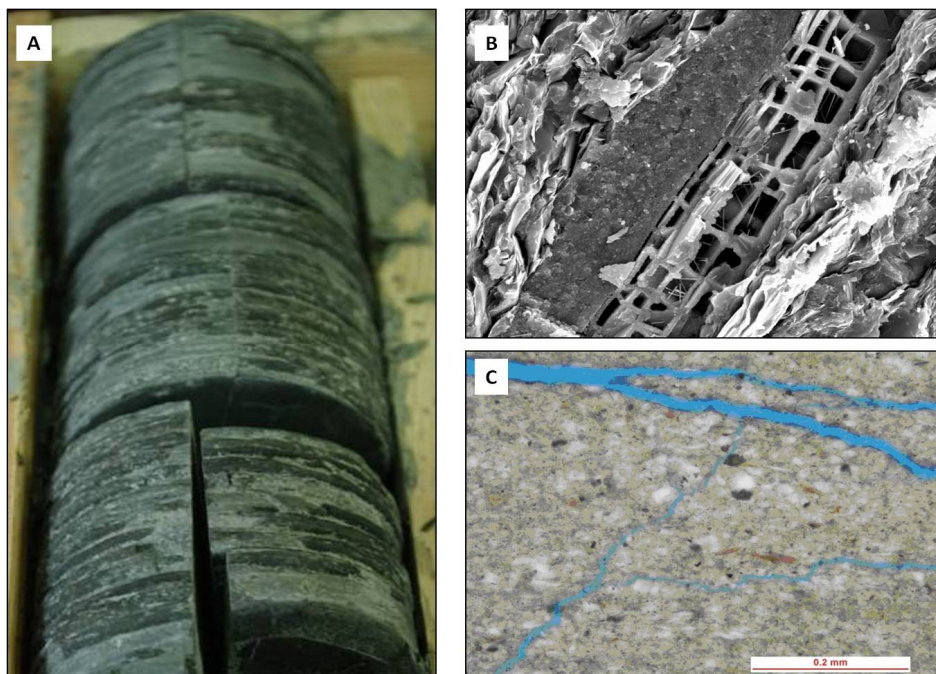


Fig. 4. Black shales of Silurian age (A); Microporosity (B) and micro-fractures (C) in Silurian shales

The 13 m vertical section in Ordovician horizon was hydraulically fractured (Fig. 5) and the inflow of gas was recorded. In 2012 the hydraulic fracturing will be performed in Silurian horizons to test their perspective for shale gas exploration. Currently the 3D seismic survey is being acquired in the area of Lubocino-1 well to recognize in detail the pattern of faults and fractures in the region and to be able to better optimize the horizontal well trajectories in the future. In the 1st quarter of 2012 PGNiG SA (POGC) plans to drill another vertical well, Opalino-2, located few kilometers west of Lubocino-1. What is more, the drilling of horizontal Lubocino-2H well is also planned. The horizontal section will be drilled within Ordovician horizon. Its length is planned to be around 1000-1200 m.



Fig. 5. Lubocino-1 well drilling pad (left); fracking job at Lubocino-1 well (right)

PGNiG SA (POGC) is also running an exploration works in the southern Lublin Basin which is too, highly perspective in terms of unconventional resources. The first, vertical exploration well, Lubyca Królewska-1, is going to be drilled this year. The analysis of available geological data from that area points to the promising results of that well. The well is going to recognize 1300 m of Silurian and 250 m of Ordovician deposits. The plan is to take 958 m of continuous core and subject it to the detailed laboratory analysis. The well is also going to be logged with all necessary tools to get the reservoir characteristic as accurate as possible.

Summary/Conclusions

Poland has the Europe's largest known reserves of shale gas. The development of the unconventional gas in Europe is still in the preliminary stage. Author's research and experience show that exploration of unconventional natural gas deposits will not be easy but one should remember that such gas deposits create opportunities for both Europe and for companies starting the exploration. The existing evaluations of the shale gas potential in Poland are promising. Further evaluation is ongoing and each month brings new data. The understanding of Palaeozoic formations increases with each drilled well. It is very possible that Poland could have gas on a large enough scale not only to cover its demand, but probably to export gas or to displace coal-power generation as well.