



# POLAND

## ➔ Shale gas



Polish Geological Institute  
National Research Institute



**Shale gas** – natural gas occurring in clay-silt deposits rich in organic matter.

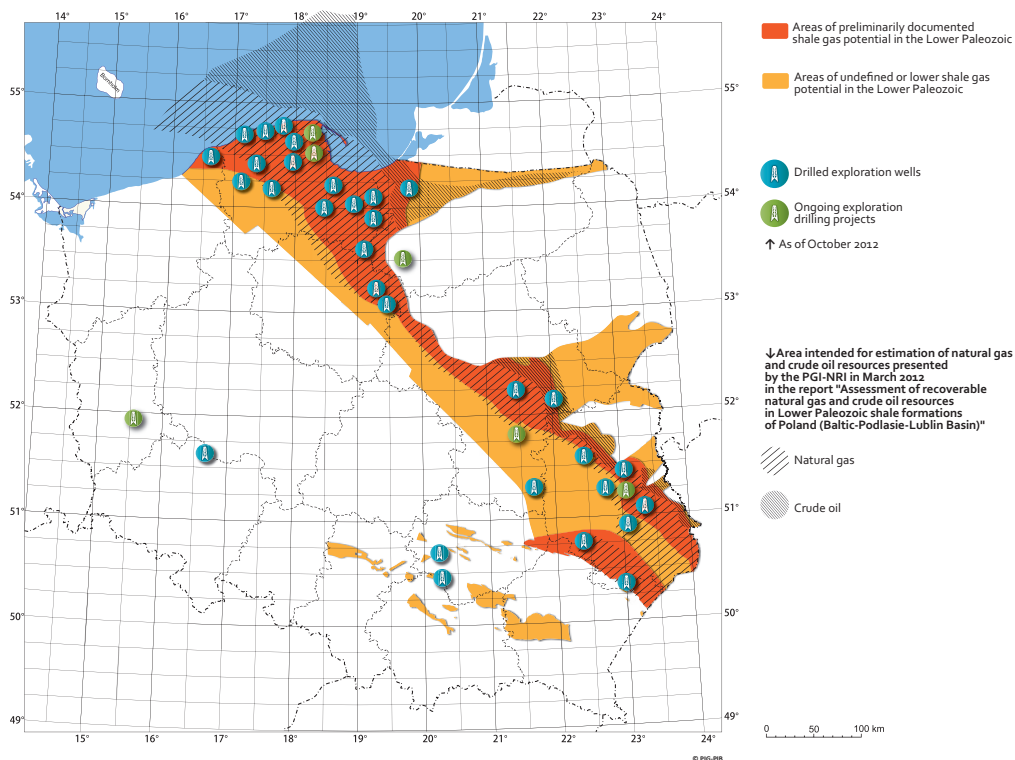
They are the source, reservoir and the seal for shale gas.

Lower Paleozoic (Silurian) shales. Tłuszcz IG 1 well;  
Drill core from a depth of 1,650 m

## Prospective areas

In Poland, an area of high probability of natural gas accumulation in shales stretches from Pomerania through eastern and northern Mazovia and Podlasie, to the Lublin region. The main prospective formations within this belt are the Upper Ordovician and Silurian. The depth to the potential gas-bearing shales is variable and ranges from about 500-1,000 m in the east to more than 4,500 m in the west.

The formations that meet the criteria for being host to natural gas in clay rocks also include Lower Carboniferous deposits of Wielkopolska and Miocene deposits of the Carpathian Foredeep.



Areas of occurrence of Lower Paleozoic shales potentially containing unconventional natural gas deposits

## Shale gas estimates – a preliminary report

In March 2012, the Polish Geological Institute – National Research Institute (PGI-NRI) presented the first report on estimates of recoverable resources of natural gas and crude oil in Lower Paleozoic shale formations of the Baltic-Podlasie-Lublin Basin.

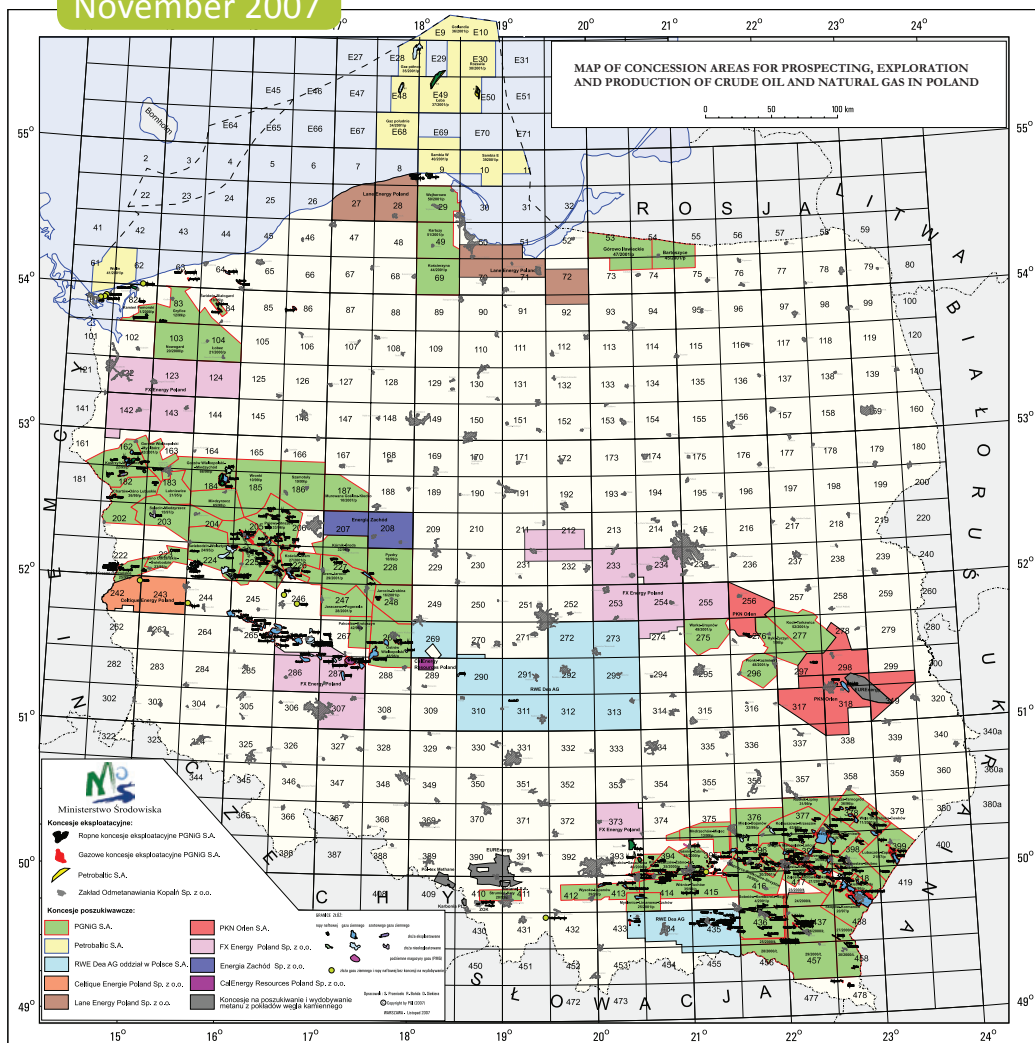
**Estimated total recoverable reserves of natural gas, in both onshore and offshore shelf basin, vary in a very wide range from 37.9 billion to 1,919.7 billion cubic meters. The extreme values, however, are characterized by a very low probability. Based on the calculation parameters that were assumed as most likely, these resources vary from 346.1 billion to 767.9 billion cubic meters.**

The report should be treated as a preliminary estimate, which was based on data obtained from 39 wells drilled by the Polish Geological Institute in the period 1950-1990. The prognosis is going to be verified according to new data from exploratory drillings that started in 2010.

# Concessions for prospecting and exploration of natural gas from shale

Over the last 10 years, around the world, including Poland, there is an increased interest of oil companies in exploration and exploitation of shale gas. Due to the development of new technologies, especially directional drillings and multiple operations of hydraulic fracturing, the exploitation of previously inaccessible unconventional deposits has become economically viable.

November 2007







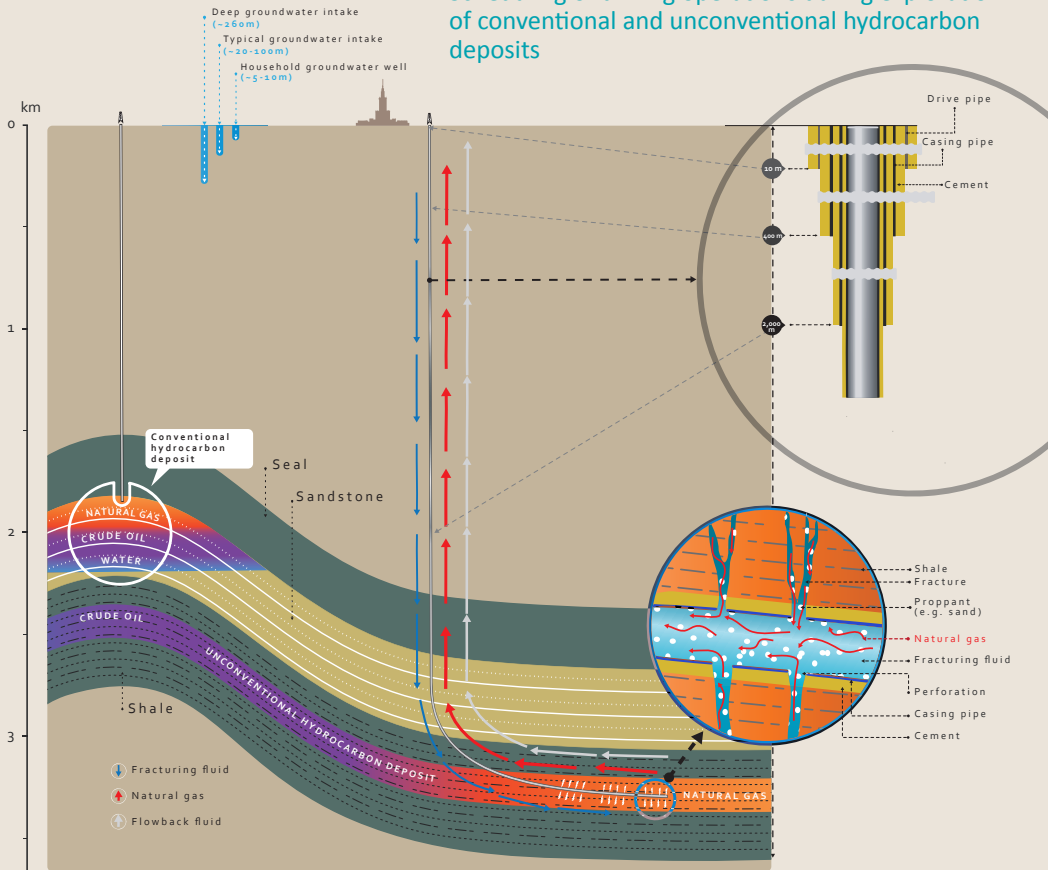
# Prospecting and exploration

Exploration begins with a thorough analysis of archival geological information – wellbore documentations and drill cores. The next stage of work is geophysical investigation, usually seismic surveys. They allow for the optimal location of the well. Interpretation of data obtained during drilling of the exploratory well facilitates making a decision about the advisability of drilling a horizontal hole and performing hydraulic fracturing.

The results of formation tests can determine the implementation of subsequent wells. The exploration procedure is neither short-lived nor cheap. However, the benefits can be enormous. Some unconventional natural gas deposits can be exploited for several tens of years!



## Scheduling of drilling operations during exploration of conventional and unconventional hydrocarbon deposits

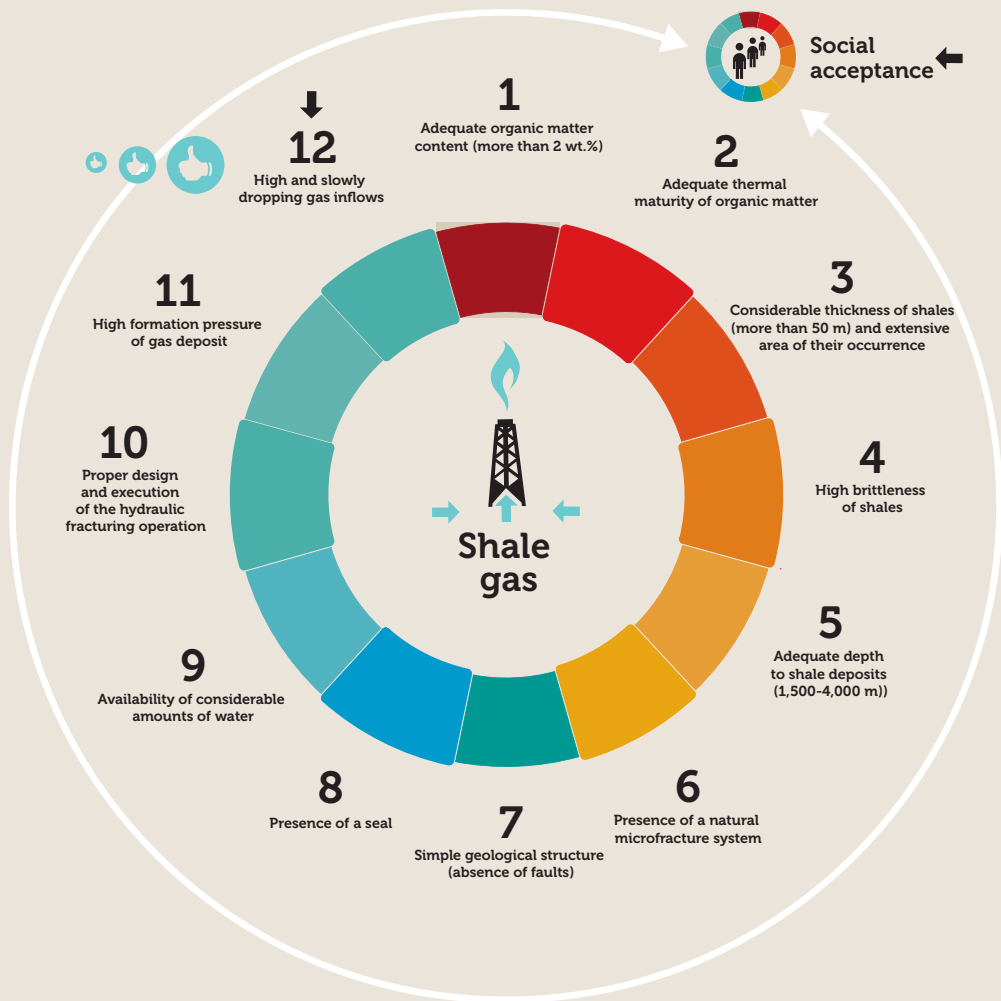


## Drilling/hydraulic fracturing/production tests

The first stage of drilling operations, like during the search for conventional deposits, relies on the drilling of a vertical hole to the gas-bearing formations. If the analysis of drill core samples indicates potential gas deposits, then operations typical for exploration of unconventional deposits starts – i.e. horizontal drilling. Subsequently, the pipes in the horizontal section of the well are perforated, and the fracturing fluid is injected under high pressure through the perforation. The process results in the formation of a dense network of tiny fractures in the rock, which, thanks to backfilling material (e.g. sand), do not tighten, but form gas flow paths.

The fracturing fluid usually consists of more than 99% of water and backfilling material. The rest is represented by chemical additives to improve the process of hydraulic fracturing (to reduce friction, lower viscosity, maintain proper pH, prevent pipe corrosion and bacterial processes and support backfill material suspension). To perform hydraulic fracturing in one horizontal well, several thousand cubic meters of water are necessary. On average, 15 to 30% of the injected fluid returns to the surface (returned fluid) and, after purification, it can be re-used in subsequent fracturing operations.

# The most important factors determining successful exploration





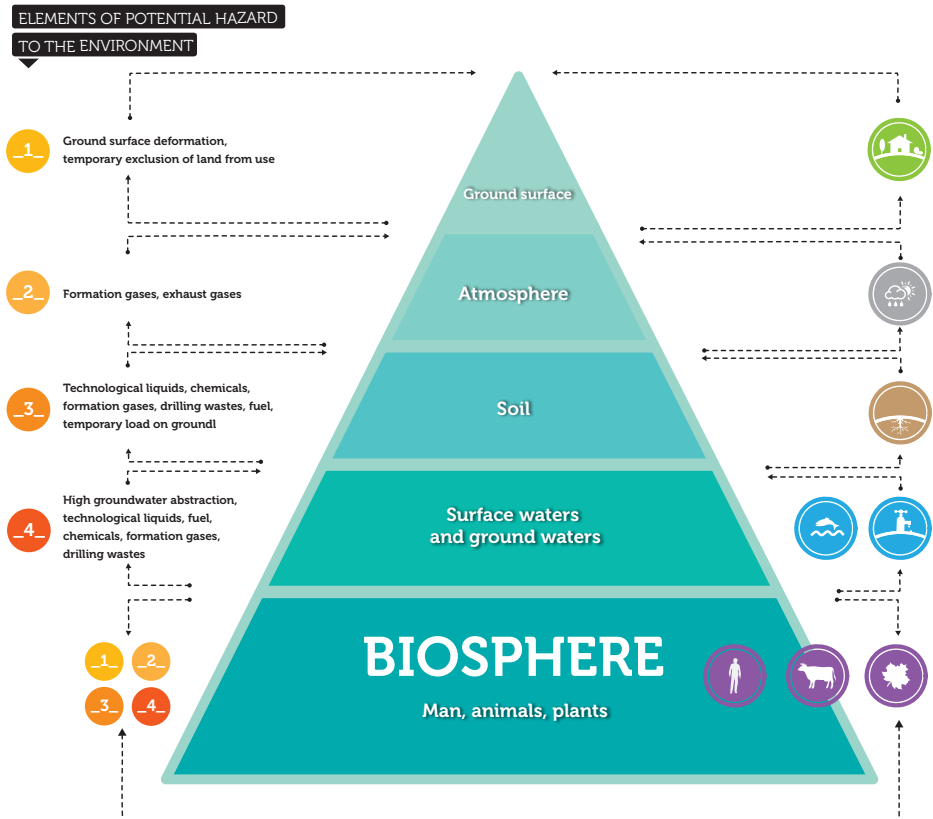
# Environmental protection

Shale gas exploration, like any other mining activities, may pose a threat to the environment. The most sensitive element of the environment is water (both surface waters and groundwater), ground surface (soil) as well as the atmosphere. Changes in the landscape, increased road traffic and noise of heavy vehicles, adversely affecting the quality of life for people and animals, are also important. Most of these effects are short-lived and could be minimized by the installation of soundproof screens and the use of low-emission equipment and surface insulation materials.

Proper construction of wells - especially effective protection of aquifers - prevents contamination of water intended for drinking. Adequate surface protection and reclamation of the drilling site allows full restoration of its original character and the way of land use. However, we cannot rule out emergency situations caused by e.g. the unreliability of equipment or the failure to follow procedures. Given the potential risk for the environment, it is necessary to monitor the entire exploration process.

**Special supervision should be directed to the following issues:**

- **Quality of surface waters**
- **Quantity and quality of groundwater**
- **Noise level**
- **Concentration of gases and particulate matter in the air**
- **Composition and concentration of gases in soil air**





## A report from Łebień - summary of the results of environmental impact of hydraulic fracturing

In August 2011, the first hydraulic fracturing experiment in Poland was carried out in the Łebień LE-2H well. On the initiative of the Ministry of the Environment, the impact of this experiment on the environment was analyzed by a team more than 30 specialists from five institutions. The results are presented in a report prepared by the Polish Geological Institute - National Research Institute which coordinated the operation. The conclusions were demonstrated at a press conference on March 2, 2012.

**Analysis the environment (atmosphere, ground surface, soil, surface waters, groundwater) performed at the drilling site and in the immediate vicinity showed no negative effects of hydraulic fracturing.**

- There was no increase in methane and radon concentrations in soil air.
- There was no methane in the atmosphere, and the emission of diesel engine exhausts did not exceed the permissible levels.
- There were no vibrations or shocks that may pose a threat to buildings or infrastructure.
- There were short-term exceedances of noise limits, but only in the immediate proximity to the processing line.
- There was no change in relation to the state defined before fracturing in surface waters and groundwater.
- The use of almost 18 thousand cubic meters of water did not cause any reduction in groundwater resources in the drilling zone.
- During continuous monitoring, there was no leakage of fluids back into the environment.
- There was no objection about the waste and wastewater management. Much of the returned fluid was purified in a special installation at the drilling site, and stored for re-use during the next operation in another well. The rest of the fluid was sent to a specialized recycling facility as industrial waste. A small amount of solid waste was disposed of at a municipal landfill.
- All work was carried out with the measures to minimize any possible negative impact on the environment.

# Shale gas in research projects of the Polish Geological Institute – National Research Institute

Since the 1920s, the PGI-NRI has conducted geological surveys that allowed preliminary identification of prospective areas of shale gas resources.

Currently, the PGI-NRI conducts a number of research projects on exploration of hydrocarbon deposits, including unconventional sources. Some of these activities are performed at the request of companies that hold licenses for prospecting and exploration of hydrocarbons.

In 2009-2010, a research project entitled “Research on hydrocarbon basins of Poland in terms of possible occurrence and resources, as well as licensing for prospecting for unconventional natural gas deposits - phase I” was carried out at the request of the Minister of the Environment. The project was financed by the National Fund for Environmental Protection and Water Management (NFOŚiGW).

In 2010, the Polish Geological Institute - National Research Institute, acting as the State Geological Survey, on its own initiative, partnered with the U.S. Geological Survey (USGS) in order to estimate the hydrocarbon resources in the Lower Paleozoic shales in Poland, using the methods employed in the United States. The cooperation resulted in a report published in March 2012: “Estimates of recoverable resources of natural gas and crude oil in Lower Paleozoic shale formations of the Baltic-Podlasie-Lublin Basin”.

On the initiative of the Ministry of the Environment and in agreement with the investor (Lane Energy Poland company), a research team, coordinated by the Polish Geological Institute - National Research Institute, made an assessment of environmental aspects of Poland's first hydraulic fracturing experiment performed in shales in a horizontal section of the Łebień LE-2H well (in August, 2011). The research report was published in March 2012.

Within the framework of a research project entitled “Assessment of environmental hazard caused by the process of prospecting, exploration and exploitation of unconventional hydrocarbons”, Director General for Environmental Protection commissioned an analysis of the environmental impact of operations related to prospecting, exploration and exploitation of shale gas in selected wells. The work is carried out by a consortium composed of the Polish Geological Institute - National Research Institute (leader), University of Science and Technology, and Technical University of Gdańsk. The task is financed by the National Fund for Environmental Protection and Water Management (NFOŚiGW).



# Future challenges

In setting research directions related to the expected future development of prospecting, exploration and exploitation of shale gas, PGI-NRI offers research assistance and advice, pointing to the necessity of taking the following actions:

- Environmental monitoring in the areas of reconnaissance, exploration and production.
- Monitoring of compliance with the procedures at every stage.
- Targeting of research for new technologies to reduce the impact of the operations on the environment.
- Identifying alternative sources of water supply.



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