Halina Jędrzejowska-Tyczkowska
Oil and Gas Institute, Krakow

Polish Shale Gas

The most frequent question asked recently in Poland of a person known to be dealing with issues related to geology is – "What about that great boom concerning shale gas?" The only reply, justified by known, revealed facts is that we will see in the future.

Quoting from the published interviews with the main geologist of the country, Henryk Jacek Jezierski, we can also say that appointed, independent consulting companies estimate the shale gas resources in Poland at 1.7 to even 3.0 trillion m^3. For comparison, the annual gas consumption in Poland amounts to 13.5 billion m^3.

Currently, the world shale gas extraction is estimated at 9 billion m^3 annually with forecast increase up to 30 billion m^3 annually by the year 2020. For comparison, estimated shale gas resources in the USA, including the leading, well-known Barnett deposit, reaches 110 trillion m^3 – out of which only 13 trillion m^3 is extractable.

What is the story of the hypothesis (not discovery yet) of shale gas occurrence in Poland? Still in the middle of the first decade of the year 2000, the map of the Polish resources (Fig. 1) published by SPECTRUM did not show any information referring to the fact. Currently published data clearly indicate the occurrence of shale strip in Poland, running in the NW-SE direction, parallel to the

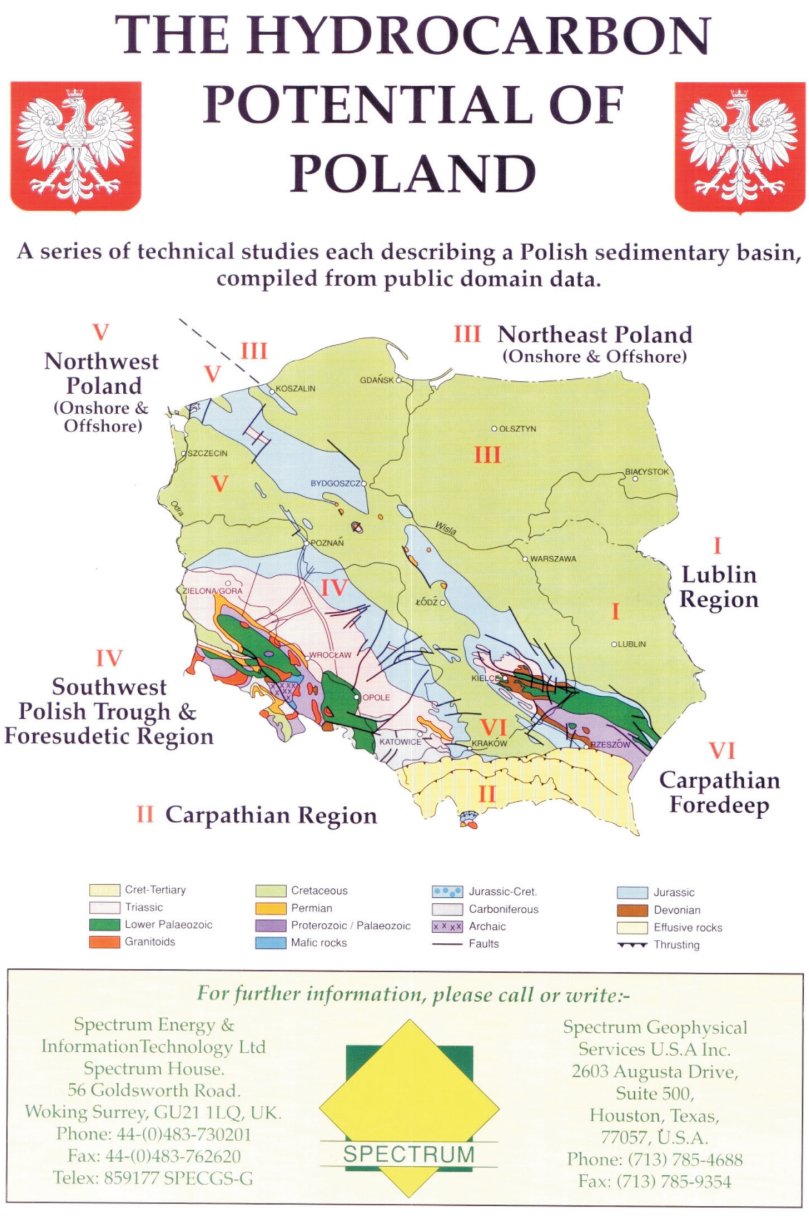

Fig. 1. Map of the Polish resources in the first decade of the year 2000 (after SPECTRUM)

edge of the East European Craton (Fig. 2) described geographically by the location of such cities as Łeba in the north-west and Lublin-Zamość in the south-east; the stratigraphic reference points to the Silurian shale. Tentative estimation of the extractable properties of the shale were graded as "poor – medium size"; recently they have been said "to be good".

The factors which condition the quality of an extractable formation are [3]: its depth, thickness of the saturated layer, content and type of the organic substance, thermal maturity, porosity, petrologic properties. "The Polish shale gas" lies at the depth of 1200 to 2500 m in the north, to the depth of 2500 to 4500 m in the south. It is a challenge both for the prospecting companies in Poland, like Polskie Górnictwo Nafty i Gazu, and for over sixty companies which have been granted prospecting licence by the Ministry of Environment.

It should yet be explained what this specific prospecting challenge consists in:

• the gas-bearing bituminous shale, contrary to the majority of gas deposits is a strongly compressed rock, which considerably affects its elastic and geomechanical properties; what is more, it is characterized by unusually low porosity and scarce permeability [4]. Therefore, before undertaking the prospecting work in which the seismic method plays dominant role, it should be assessed à priori how such geological object will be manifested in the elastic field image. The most strongly marked feature of the shale formation is their anisotropy [5, 6]. It can be expected that the recorded image analyzed in different directions will be significantly different, though indeed, it constitutes an elastic response of the same formation. Moreover, variability of properties in a specific direction may be very strongly diversified quantitatively, which equally often depends, apart from the real variability of the physical properties on the adopted observation scheme. Precise information relating to the above topic is mostly the intellectual property of particular companies and it is not publicized.

The above facts are only the beginning of the road to prospecting. After the shale layer has been located, the process of drilling begins; at first vertical, and then horizontal, collecting the cores and doing laboratory tests of petrophysical, metrological properties and organic matter maturity.

In the future prospecting in Poland, the beginning of horizontal drilling, in case the prospecting scenario is successfully accomplished is forecast for the years 2015–2016. What the forecast does not mention is the fact that the tests described above are a continuous process of learning the properties and conduct

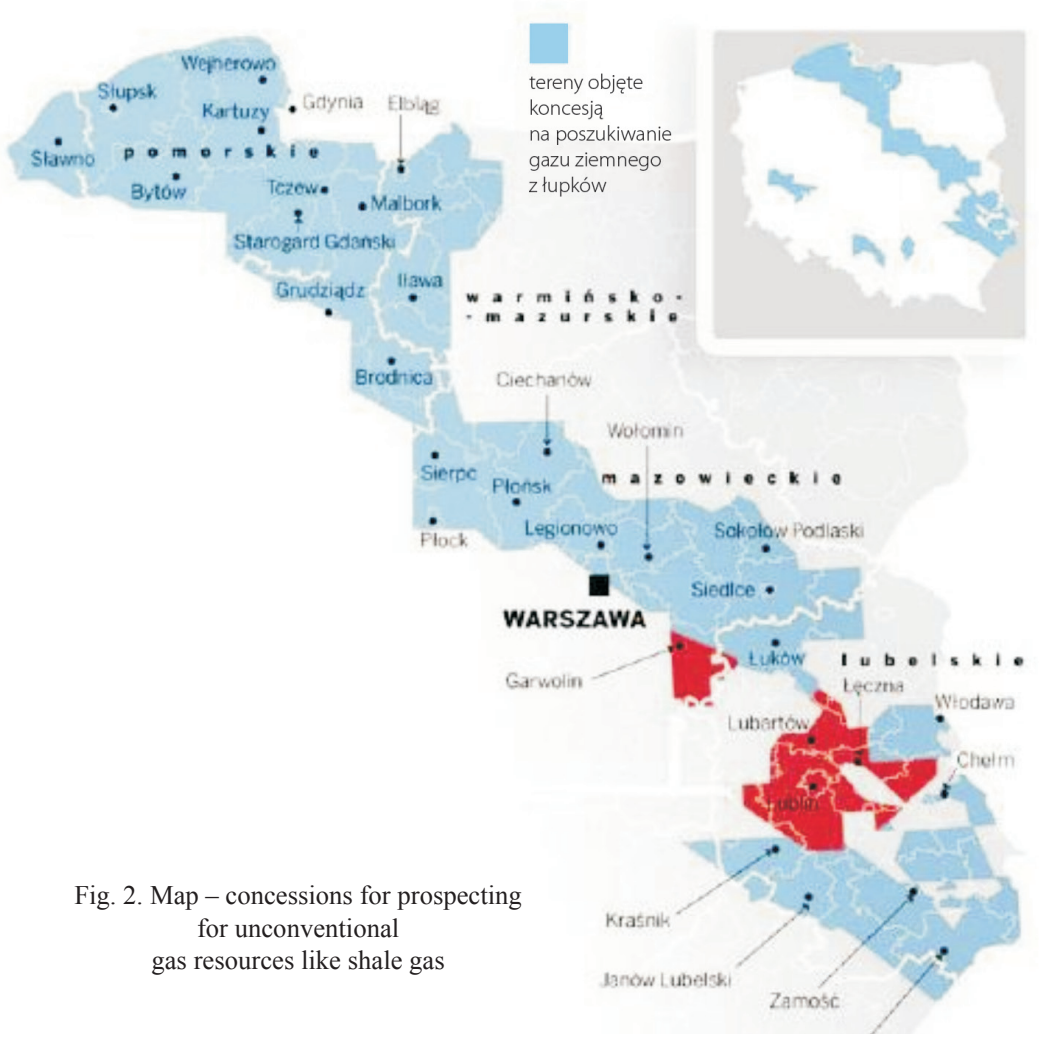

Fig. 2. Map – concessions for prospecting for unconventional gas resources like shale gas

of the geological formation, which has been regarded before as uninteresting, as far as prospecting is concerned. If the test results are promising and permit achieving success, the most difficult stage in the process of obtaining gas from the shale will begin, consisting in overcoming the specific hydrodynamic rules in the shale gas deposit, where idiopathic flow cannot be expected.

The technology of shale gas extraction is the object of patent of the American company Devon Energy, estimated at 3.5 billion dollars. It accounts for the borehole stimulation and hydraulic fracturing, as well as pressure pumping. At this stage, huge volumes of water are mentioned, necessary for hydraulic destruction of the compact rock (shale) structure and large amounts of sand forced into the created fractures, in order to prevent renewed shutting of the fractures. It is indispensable to select the fracturing parameters by means of intensive lab tests.

The fracturing process and accessing boreholes, as well as drilling other horizontal branches for vertical boreholes entails using the seismic method again in the multicomponent option, time lapse seismics. The multicomponent seismics have basic and fundamental meaning here. The information on velocities of longitudinal and sheare wave propagation is the most reliable information, and, which is important, it is obtained from the surface, with relation to dynamics of the fracturing process, the progress in pressure pumping and the type of saturating fluid.

The interpretation of the results of seismic measurements is supported by the results of lab tests on the cores. And here, a new quality appears in respect of result integration – this new quality may be defined as a scale issue.

The processes which occur in sedimentation basins observed from indications of the seismic methods, describe the phenomena in macro and possibly in micro scale, which is aided with the methods of geophysical profiling in boreholes. Whereas the lab tests relate to processes in the scope of nanotechnology.

In the future, determination of the type of these nano and macro processes and stability of their relations depending on the progress of extraction, that is in the function of time, will be an object of many tests [1]. The results of these tests should optimize shale gas extraction.

In the sense of effectiveness and expensiveness, this field should be regarded as the poorest recognizable, as opposed to basin modeling, modeling of the elastic wave field, geostatistic procedures used to popularize the "micro properties" on the basis of the wave field and procedures of seismic inversions, AVO, as well as determination of Poisson`s coefficients, *Vp*/*Vs* etc. responsible for the rock mechanical and physical properties.

And finally one more question – are there any appropriate procedures which will enable necessary calculations. The answer is affirmative [2], which does not mean that geological interpretation of numerous integrated measurements is simple. On the contrary, and this is the greatest challenge that the shale gas poses for the Polish geologists and geophysicists – to organize the chaos of unbridled nature, putting our ignorance into ordered physical laws.

Artykuł nadesłano do Redakcji 28.03.2011 r. Przyjęto do druku 13.04.2011 r.

Literature

[1] Jędrzejowska-Tyczkowska H., et al.: *Dynamic seismic velocity modeling*. First Break, vol. 29, p. 73–78, 2011.
[2] López C., Davis T.L.: *Permeability prediction and its impact on reservoir modeling at Postle Field, Oklahoma*. The Leading Edge, vol. 30, no 1, p. 80–88, 2011.
[3] Matyasik I., Jędrzejowska-Tyczkowska H.: *Niekonwencjonalne złoża gazu – ryzyko, niepewność, intuicja czy udokumentowana teoria, poprawnie uwarunkowane równania i potwierdzenie zdarzeniami z praktyki*. Wiadomości Naftowe i Gazownicze, nr 7 (147), p. 4–13, 2010.
[4] Ortega J. Alberto, et al.: *The nanogranular acoustic signature of shale*. Geophysics, vol. 74, no 3, D65-D84, 2009.
[5] Tsvankin I., et al.: *Seismic anisotropy in exploration and reservoir characterization*. Geophysics, vol. 75, no 5, p. A15–A31, 2010.
[6] Jędrzejowska-Tyczkowska H., et al.: *Ocena anizotropii w rzeczywistym ośrodku geologicznym na podstawie danych sejsmicznych i pionowego profilowania sejsmicznego. Teoria, modele, zastosowanie praktyczne*. Projekt badawczo-rozwojowy nr R09 020 01, 2007-2010.

Prof. dr hab. inż. Halina JĘDRZEJOWSKA-TYCZKOWSKA – kierownik Zakładu Sejsmiki INiG. Ekspert w Radzie Stałej RWPG, stypendysta UNESCO (Francja, Włochy) oraz British Council (Wielka Brytania, Uniwersytet Cambridge). Specjalizacja zawodowa: geofizyka i sejsmika (przetwarzanie oraz interpretacja danych sejsmicznych; wprowadzanie zaawansowanych technologii).