

Exploration and exploitation of oil and gas fields in Poland: a historical outline

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A b s t r a c t. Petroleum industry began in Galicia region, the former part of Poland which was in 1772–1918 a province of the Austro-Hungarian Empire. The birth of this industry was connected with petroleum distillation made by two pharmacists: Ignacy Łukasiewicz and Jan Zeh, who persistently were working to get a liquid without both light and heavy fractions of hydrocarbons, i.e. a liquid paraffin of oil. This aim was reached in spring of 1853. That time also a kerosene lamp was constructed by Adam Bratkowski under direction of I. Łukasiewicz. The set of these lamps was used in the Lviv municipal hospital during the serious surgical operation on 31 July 1853. This date was accepted as the beginning of the world oil industry. Next year I. Łukasiewicz established the oil mine in the Bóbrka village near Krosno. Oil wells then were frequently the open ones dug out to the depth of 60 m and from them oil was extracted with wooden buckets by usage of gin. When petroleum deliveries were assured I. Łukasiewicz founded in 1856 the first petroleum distillery in Ulaszowice near Jasło, the second one in 1858 in Kłęczany, and the third one in Polanka near Krosno in 1861.

In 1890s in the Carpathians the new oil deposits were discovered in the Gorlice-Jasło-Sanok region. In 1888 the Bergheim Mac Garvey Company found the new oil fields in Węglówka near Krosno and the Galician Oil Mining Company discovered oil-rich deposits in Potok, Turaszówka, Iwonicz, Stara Wieś, Rudawka Rymanowska and Wańkowa. Discoveries were also along the Carpathians thrust front where exists the zone of deep-seated folds covered by the Miocene deposits. Oil fields are here located at depth of 800–2000 m. In the Borislav vicinity a few very efficient oil fields were documented in 1896. In 1908 the highly productive “Oil City” well with oil production 2500 t/d was drilled. Exploitation in this region of the Carpathians in 1909 was 2×10^6 t, i.e. 5% of the world oil production and Galicia was the third producer in the world. During 150 years of exploration, in this part of Polish Carpathians, 67 oil and 17 gas fields were discovered. In the Carpathian Foredeep 50 gas fields and 10 oil fields were documented. The biggest success was the Jaksmanice-Przemysł gas field with 75×10^9 m³ of resources.

In the Polish Lowland in 1946, just after the Second World War, basing on gravimetric and magnetic data, the first drilling was located on the Kłodawa structure and the Zechstein salts at depth of 300 m were found. Later this drill was a base for foundation of Kłodawa salt mine. In 1961 in the Fore-Sudetic Monocline the first oil field Rybaki was discovered in the Zechstein Main Dolomite formation, and three years later, in 1964, the first gas field discovery — Bogdaj-Uciechów was found within the Rotliegend sandstone and the Zechstein Limestone unit. Until now a dozen of oil and gas fields were documented not only in the Permian formations but also in the Devonian and the Carboniferous deposits in the Lublin Petroleum Province and in the Cambrian sandstones in the Gdańsk Petroleum Province. Exploration works, initiated after the Second World War, both in the Carpathians as well as in the Carpathian Foreland and the Polish Lowland give premises of new oil and gas filed discoveries there also in the future.

Key words: history of petroleum industry, oil and gas fields in Poland, Carpathians, Carpathian Foredeep, Polish Lowland

Galicia province, recently belonged both to Poland and Ukraine, more than 150 years ago became a cradle of the petroleum industry in the world. At that time, between 1772 and 1918, it was a part of Poland area as a province of the Austro-Hungarian Empire. In this area since a long time the interest of hydrocarbon exploration existed. Christopher Kluk (1781) in his book *Rzeczy kopalnych osobliwie zdutniejszych szukanie, poznanie i użycie* (*Fossil things oddly fitter — searching, getting to know and using*) remembered oil evidences in the Carpathians (vide Szafran, 2004). Also Stanisław Staszic, the “father” of Polish geology, gave some examples of oil usage. In his book (Staszic, 1815, vide Szafran, 2004) (Fig. 1), titled *O ziemiórództwie Karpatów i innych gór i równin Polski* (*On the earth-birthing of the Carpathians and other mountains and lowlands of Poland*), he mentioned places of oil and mineral wax seepages indicating their practical and economic importance. Very exhaustively about the oil mining wrote G.G. Pusch (1859, vide Szafran, 2004) in his paper *O krajo-brazowym opisie Polski* (*The landscape description of Poland*) issued in Stuttgart where he estimated the oil productivity for 290 t/y. Bóbrka and its vicinity, as a place of first industrial oil wells, was geologically described in detail by Julian Noth (1918; vide Szafran, 2004).

However the birth of the oil industry was connected with the distillation of petroleum and receiving the distillate in form of liquid paraffins and their applying for illumination. Two pharmacists: Ignacy Łukasiewicz (Fig. 2)

and Jan Zeh (Wolwicz, 2003) who after numerous and onerous jobs in 1852–1853 obtained a kerosene. That time also a kerosene lamp was constructed by Adam Bratkowski under direction of Łukasiewicz. Set of these lamps was



Fig. 1. Stanisław Staszic, the great geologist and the Polish patriot. Painting W. Śliwicki (1820) on the background of the Staszic geological map (1806)

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Fig. 2. Ignacy Łukasiewicz, the creator of the Polish and the world petroleum industry (after Sozański, 2004)



Fig. 3. Inscription on the obelisk in Bóbrka; funded by I. Łukasiewicz on the occasion of establishing the petroleum mine in 1854 (after Sozański et al, 2002)

used in the Lviv municipal hospital during the serious surgical operation on 31 July 1853. This date was accepted as the beginning of world oil industry. In December 1853 Łukasiewicz and Zeh patented in Vienna the method of the oil distillation for getting a liquid paraffin for kerosene lamps. Six years later, in 1859, Edwin Drake made the oil borehole in Titusville in Pennsylvania to the depth of 23 m — in the world petroleum history this date is very often cited.

Łukasiewicz established the first oil-well in Bóbrka (recently there is located the museum of oil and gas industry in Poland), the fact commemorated by the obelisk with the suitable inscription (Fig. 3). Increasing demand for kerosene and lamps grew quickly, a petroleum production and export especially to Vienna, Prague and Berlin was impressive. The continued demand for oil resulted in its output increasing and in the exploration development.

First searching and exploitations works

The first petroleum wells were established by Ignacy Łukasiewicz in Bóbrka in 1854 (Fig. 4). In the same time the similar “mines of oil” existed in Siary and Sękowa near Gorlice. Also in 1854 a first street kerosene lamp was switched on by Łukasiewicz in Gorlice.

The first mining holes were the wells dug for depths of 15–60 m, from which petroleum was being drawn with wooden buckets by using gin. When petroleum deliveries were assured, Ignacy Łukasiewicz founded in 1856 the first petroleum distillery in Ułaszowice near Jasło, second one in 1858 in Kłęczany, and third one in Polanka near Krosno in 1861. The most modern factory was also built by Łukasiewicz in 1865 in Chorkówka, basing on the raw material delivered in wooden barrels from the nearby mine in Bóbrka. Products were sold to the petroleum distilleries in Galicia, Vienna, Budapest, Prague and Berlin.

Successes of Łukasiewicz caused that in surroundings of Krosno, Gorlice and Nowy Sącz many small mines and distilleries were founded. Foreign companies were interested in the oil industry in Galicia and the surname “Łukasiewicz” became well known. Rockefeller was also

interested in the development of output and processing of petroleum industry in Galicia and sent to him his own experts.

In the 1890s in the Carpathians new oil deposits were revealed in the Gorlice-Jasło-Sanok region. In 1888 the *Bergheim Mac Garvey Company* discovered the new oil fields in Węglówka near Krosno and the *Galician Oil Mining Company* found oil-rich deposits in Potok, Turaszówka, Iwonicz, Stara Wieś, Rudawka Rymanowska, Wańkowska. Discoveries were also along the Carpathians thrust front where exists the zone of deep-seated folds covered by Miocene deposits. Oil fields are here located at depth of 800–2000 m. In this zone in

Borislav vicinity a few very efficient oil and gas fields were documented in 1896, such as Schodnica, Mrażnica and Tustanowice. In 1893 Mac Garvey with help of Władysław Długosz and the driller Jan Rączkowski began the well “Na



Fig. 4. Equipment for manual borehole drilling; Museum of Petroleum Industry in Bóbrka (after Garncarski et al, 2001)

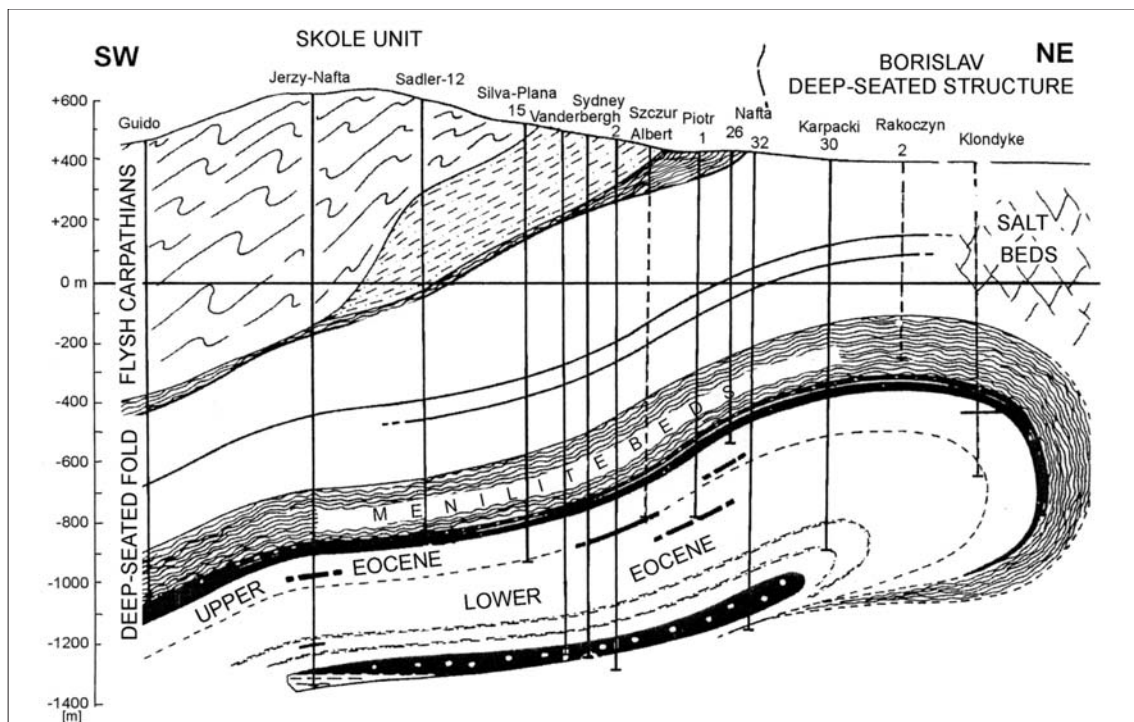


Fig. 5. Cross-section of the Borislav oil field (by Tołwiński, 1937, modified)

Potoku” in Borislav and in 1896 it reached a petroliferous sandstone. From the depth of 900 m it obtained 40 t of oil per day. Oil and gas occurrences in the eastern part of the Carpathians were stated already in 1853 but practically they initiated the exploitation of the oil field with deep drilling only in 1896.

Discovering of the “Borislav” oil field in 1896 activated drillings and hydrocarbons exploitation mainly in the Eastern Carpathians. New oil-bearing layers were discovered in so-called Borislav Sandstone (Oligocene in age) and Jamno Sandstone (of Paleocene age) from which were obtained 40–2500 t of oil per day. From 1900 till 1909 the production of oil increased 6.5 times.

The Schodnica oil field played the important role, being at the end of XIX century the first in oil production in the Carpathians region. In 1892 it exploited 3800 t of oil. In 1895, during one year, 17,000 t of oil were obtained from the “Jakub” borehole located in the same oil field (the Jamno sandstone was exploited at depth of 303 m). In 1897 S. Szczepanowski founded his own oil mine in Słoboda Rungurska from which at first only 16 t of oil per day were obtained. From financial-economical reasons it caused a mine failure.

Oil production in 1905 increased to 802,000 t and in 1907 — it reached 1.176×10^6 t. Maximum production was in 1909 when it achieved 2.076×10^6 t of oil. To the most efficient boreholes belonged Wilno-2, Nafta-2 and 3, Litwa ones with a daily production of 800 t and the famous “Oil City” — 2500 t/d.

The depth of oil-bearing horizons in the “Borislav” oil field was roughly 800–1400 m, but a lot of petroliferous sandstones appeared at shallower depths (Fig. 5). Some boreholes in the Borislav region achieved the highest total production of 250,000 t. From the “Borislav” oil field ca 20×10^6 t were derived till 1938. After 1939 the Ukrainian geologists still discovered 2 deeper folds rich in oil. Resources of this oil field are estimated at 30×10^6 t.

Exploitation in this region of the Carpathians in 1909 was 2×10^6 t, i.e. 5.2% of world oil production and Galicia took the third place in the world.

Crucial meaning in the history of the oil industry had the “Oil City” borehole in Tustanowice in the vicinity of Borislav. Thirteenth June 1908 at the depth of 1016 m took place the unexpected eruption of oil and gas. During twenty four hours 140 carriages of oil were filled (it is ca 1400 t). The production of oil grew and the peak was achieved 3000 t/d. After the fire which happened 4 July and for extinguishing it after 30 days, the oil leakage was estimated at ca 2000 t/d. This oil and gas explosion caused a great ecological catastrophe. Oil was not collected into containers and it flooded fields as well as it penetrated into the river Tyśmienica, a tributary of Dniestr River. The “Oil City” borehole appeared crucial for hitherto existing researches and since then new crews for further drillings were organized from the all Carpathians area.

During and just after the First World War, between Jasło and Krosno (Carpathians — Roztoki-Sądkowa in the Eocene flysch) as well as in the Carpathian Foredeep (the Daszawa and Opary gas fields in the Miocene deposits) considerable gas fields were discovered. These discoveries initiated construction of long gas pipelines. Especially the Daszawa gas field was important: borehole Daszawa-1 was begun in 4 October 1920, in 1921 from depth of 394 m the first gas was obtained in amount of 10 m³/min. Just after that the Daszawa-2 borehole was drilled and in 1923 the “Piłsudczyk” one where at depth of 753 m a huge gas inflow was documented.

The large contribution into the practical applying the results of geologic researches in the petroleum industry was activity of the Geologic Station in Borislav, renamed in 1932 to the Carpathian Geologic-Petroleum Institute, directed by Konstanty Tołwiński (1934–1937) (Fig. 6). In this Institute a few professional journals were edited: “Nafta”, “Petroleum Statistics” and “Oil Mining in Poland”.



Fig. 6. Professor Konstanty Tołwiński, the researcher of the Eastern Carpathians and the Borislav oil field



Fig. 7. Professor Rudolf Zuber, the outstanding Carpathian geologist



Fig. 8. Professor Józef Grzybowski, the author of micropalaeontological methodology

of Poland, was active in Lviv and in 1929 it applied modern geophysical methods (especially magnetic, gravimetric and seismic ones) to petroleum exploration. Among the



Fig. 9. Professor Henryk Świdziński, the eminent Carpathian geologist



Fig. 10. Professor Stanisław Wdowiarz, the distinguished petroleum geologist



Fig. 11. Professor Adam Tokarski, the prominent petroleum geologist

Together with the oil industry development the genuine research conceptions arose. Rudolf Zuber (1918) (Fig. 7) introduced an anticline theory of petroleum concentration. The same author on the example of the Flysch Carpathians worked out the theory about the organic origin of petroleum. In the history of petroleum geology in the Carpathians Józef Grzybowski (1897) (Fig. 8), who used foraminifers to stratigraphy creating a new scientific discipline — micropalaeontology, has an extraordinary place. Also the paper of Jan Nowak (1920) was important, presenting the conception that oil can appear in all flysch formations, if at least one layer is for oil impermeable and stretching out in the considerable area. The paper by Wawrzyniec Teisseyre (1921) about the Carpathians had an essential meaning too.

From 1928 the *Pioneer* company, well-deserved for the recognition of the geology

experts of this company were Karol Bohdanowicz, Stefan Czarnocki and Jan Samsonowicz.

In the 1930s in the petroleum geology following geologists were active: H. Goblot, H. Teisseyre, J. Obtulowicz, H. Świdziński (Fig. 9), J. Hempel, R. Olewicz, A. Habrowski, J. Wdowiarz, S. Wdowiarz (Fig. 10), H. Górka, K. Konior and first of all K. Bohdanowicz (1936), the distinguished researcher and the pioneer of this industry. Their geological investigations concentrated mainly between Gorlice and Jasło (the middle part of the Polish Carpathians). It is worthwhile here remembering that at that time a lot of geologic works were made. Tołwiński (1937) examining the Eastern Carpathians distinguished and excellently mapped the so-called Skole Unit.

However, the period of prosperity began to finish due to exhausting of resources and comparatively few new discoveries. Such decreasing-trend has continued till the Second World War and during the German occupation it enlarged. In 1938 production from the Carpathians area was 553,000 t of oil and 584×10^9 m³ of gas per year about the half of which was exported.

The Borislav area dominated in production and in the Western Carpathians several interesting hydrocarbons discoveries were noticed as follows: “Gorlice”, “Kryg”, “Lipinki”, “Dominikowice”, “Magdalena”, “Roztoki”, “Sobniów”, “Męcinka”, “Jaszczew”, “Harkłowa”, “Węglówka”, “Bóbrka”, “Krościenko”, “Grabownica”, “Strachociny”, “Lipie-Czarna” and many others.

Exploration and exploitation in 1945–2005

Carpathians. A gradual reconstruction and an intense development of the oil industry took place after the Second World War. In the Carpathians geological works resulted in new discoveries of petroleum resources, e.g. in Folsz and Mrukowa (Tokarski, 1946), Osobnica and the earlier discovered fields as: “Strachocina” (gas), “Grabownica”, “Węglówka”, “Kryg”, “Lipinki-Dominikowice”, “Magdalena” and “Wańkowa” (oil) were better recognized. These discoveries and intensification of exploitation caused the production increase from 86,000 t of oil and 115.1×10^6 m³ of gas in 1945 to 210,000 t of oil and 235×10^6 m³ of gas in 1952. Such result was due to efforts of many geologists, e.g. R. Ney, Z. Śliwiński, S. Depowski (1964), J. Hempel, K. Chyła, S. Jucha, K. Konarski, S. Wdowiarz (Fig. 10), J. Wdowiarz, A. Tokarski (Fig. 11), W. Uryga, Z. Jabczyński, K. Skarbek, J. Obtulowicz, S. Kwolek, C. Fik,



Fig. 12. Photo of Polish geologists team during the Carpathian-Balkan Association in Cracow in 1963 (from left: Stanisław Wdowiarz, Feliks Łaszczyc, Jadwiga Urbaniak, Walery Goetel, Mieczysław Mrozowski, Henryk Świdziński, Stanisław Krajewski, Marian Kamiński and others)

H. Świdziński (Fig. 9), M. Książkiewicz with his team (1956), J. Kruczek (1997, 1999), P. Karnkowski, W. Moryc and others (Fig. 12).

During 150 years of exploration, in the recognized part of Polish Carpathians, 67 oil and 17 gas fields were discovered (Karnkowski P., 1999) (Fig. 13).

Carpathian Foredeep. In the Carpathian Foredeep applying new geophysical methods (gravimetry and mainly seismic) enabled new discoveries: at first — findings of gas and next — of oil (Fig. 13). The first discovered gas field after the Second World War was the “Dębowiec Śląski” one, located within the Miocene deposits (Tołwiński, 1948a). Documented resources were little (ca $100 \times 10^6 \text{ m}^3$) but their occurrence induced further works.

In 1955 the “Niwiska” gas field was discovered and two years later the “Lubaczów” one. The Lubaczów 2 borehole was a discovering drilling (Moryc, 1961; Karnkowski P., 1969), established after results of seismic acquisition (Obuchowicz, 1963). Natural gas was available there from the Jurassic carbonates and anhydrite series of the Miocene (Moryc, 1961). The later boreholes confirmed gas occurrence also in sandy series of the Miocene (Badenian and Sarmatian). Gas reserves were calculated at $6\text{--}10 \times 10^9 \text{ m}^3$. Further prospection continued basing on very insufficient geological and seismic data and finalized in discovery “Jaksmanice-Przemyśl” gas field (1958–1962), the biggest one in Poland within the Miocene deposits, with resources ca $80 \times 10^9 \text{ m}^3$ of gas (Obuchowicz, 1960, 1963; Karnkowski P., 1969; Cisek & Czernicki, 1988).

In the “Jaksmanice-Przemyśl” gas field there are 26 gas horizons located at depth of 600–2600 m (Fig. 13) and up to date over $50 \times 10^9 \text{ m}^3$ of gas was exploited from this field. Actual resource estimation indicated over $80 \times 10^9 \text{ m}^3$ of gas. In the world gas field classification resources over $85 \times 10^9 \text{ m}^3$ are included to a giant one. The mentioned gas field and others as: “Jarosław” (1959), “Żołyńia” (1962), “Husów-Albigowa-Krasne” (1959–1968) (Fik, 2006),

“Tarnów” (1967) enabled the exploitation, increase in the Fore-Carpathian region from $235 \times 10^6 \text{ m}^3$ in 1952 to $5 \times 10^9 \text{ m}^3$ in 1971.

After 1971 exploration was concentrated in the border zone of Carpathians, it means on the Miocene deposits beneath the Carpathian overthrust. The following gas fields were discovered (Jawor, 1999): “Pruchnik” (1971), “Dzików” (1968–1988), “Leżajsk-Kuryłówka” (Borys, 1996), “Dąbrówka” (1976), “Pilzno” (1984), “Szczepanów” (1990), “Tarnów E” (1990). In the last years basing on modern methods of seismic acquisition and interpretation especially the eastern part of the Carpathian Foredeep became the area of intensive exploration. New multihorizontal gas fields were discovered: “Książpol”, “Stobierna”, “Jasionka”, “Biszczka”, “Palikówka”, “Wola Obszańska”, “Wola Różaniecka”, “Terliczka”, “Trzebownik”, “Kupno”, “Dzików”, “Rudniki” and the others (Borys, 1996).

In the deposits underlying the Carpathians the biggest gas fields were discovered in the Miocene strata in the Przemyśl-Tarnów zone (Fig. 14): “Sędziszów” (1965), “Brzozowiec” (1976) “Rzeszów” (1978), “Jodłówka” (1980), “Tuligłowy” (1982), “Zalesie” (1982), “Rylowa” (1987) and “Kielanówka” (Jawor, 1999). In the last years the multihorizontal gas field “Nosówka W” was discovered in similar geological conditions (Czernicki & Moryc, 1992).

In the Carpathian Foredeep basement also gas and oil fields were found: “Partynia-Podborze” (1958; oil, the Upper Jurassic reservoir), “Grobla-Pławowice” (1968; Jawor, 1999) (the Upper Jurassic-Cretaceous reservoirs, resources of $3.6 \times 10^6 \text{ t}$ of oil, exploited — $2.8 \times 10^6 \text{ t}$), “Nosówka” (oil, the Lower Carboniferous reservoir; Czernicki & Moryc, 1992), “Tarnów”, “Łakta” (gas, the Cretaceous-Jurassic reservoirs; Jawor, 1999), “Stryżawa” (gas, the Devonian reservoir; Jawor, 1999).

Summarizing, in the Carpathian Foreland more than 50 gas fields and 10 oil fields were discovered and docu-

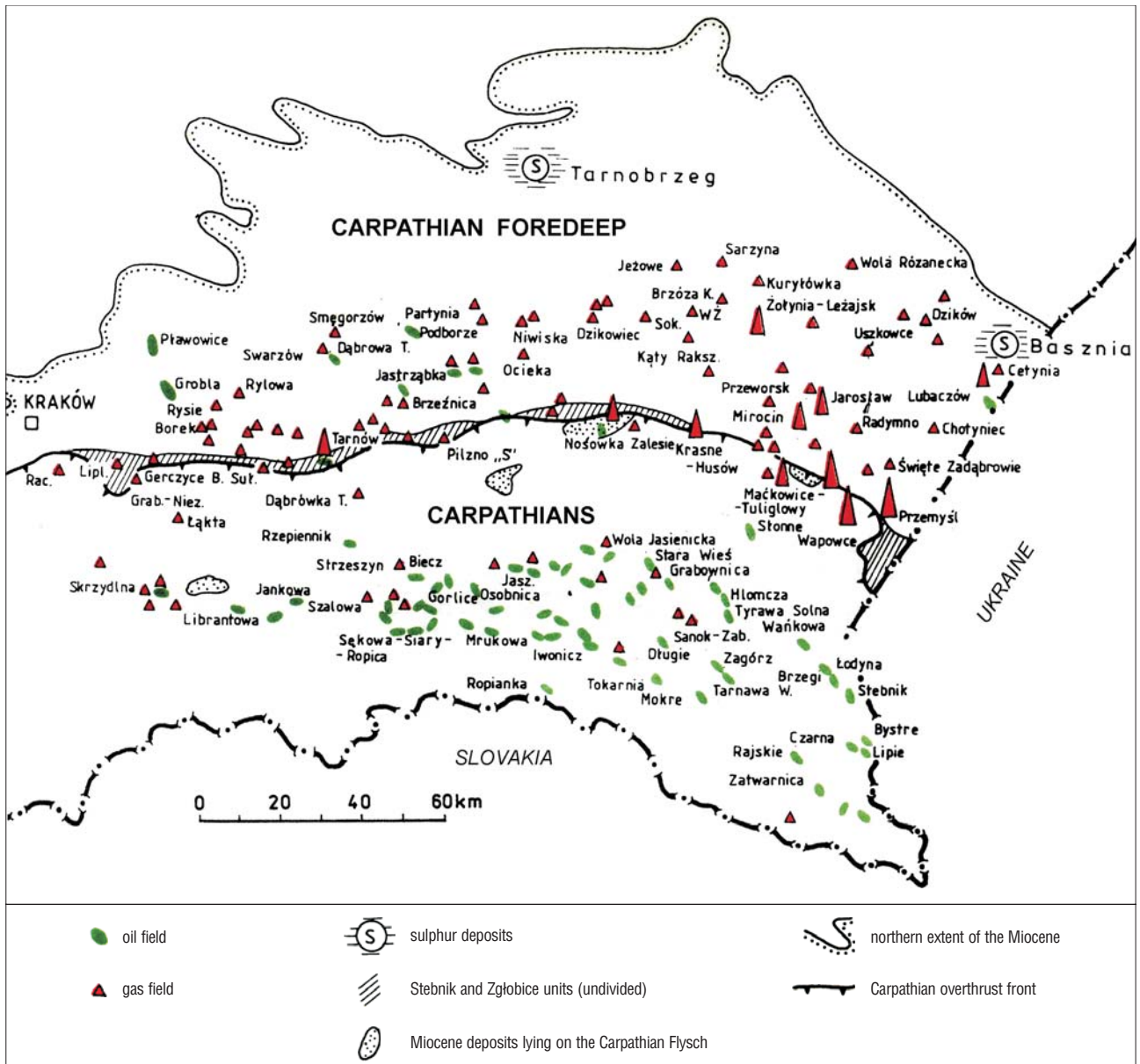


Fig. 13. Schematic map of oil and gas fields in the Carpathians and their foreland (after Karnkowski P., 1993, modified)

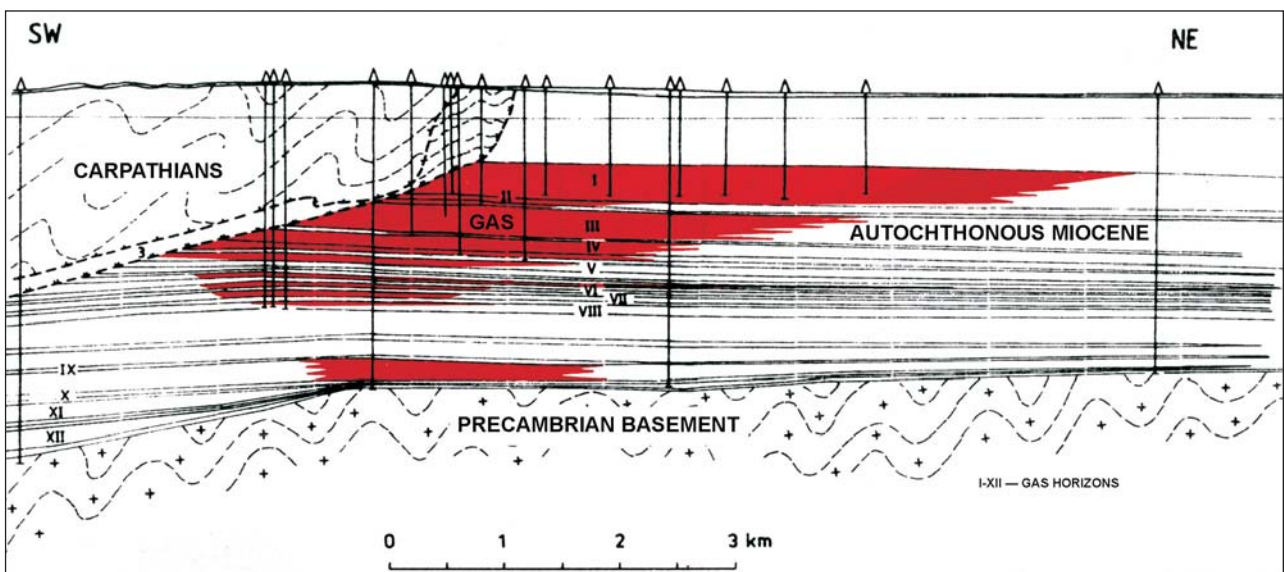


Fig. 14. Cross-section through the Przemyśl gas field, the biggest one in Poland (after Cisek & Czernicki, 1988, modified)

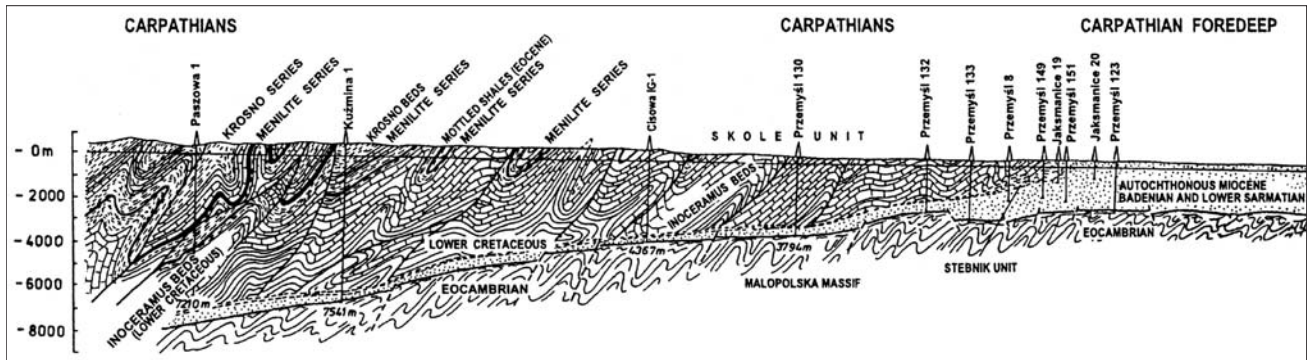


Fig. 15. Geological cross-section in the eastern part of the Polish Carpathians (after Karnkowski P., 1993)

mented from which more than $100 \times 10^9 \text{ m}^3$ of gas and $3.3 \times 10^6 \text{ t}$ of oil were exploited.

In the Carpathians the question of new targets is still open. To testify the problem of deep-seated folds (Borislav-Dolina type) two deep boreholes: Paszowa-1, depth of 7210 m and Kuźmina-1, depth of 7541 m, were drilled (Fig. 15). The Kuźmina-1 well drilled the Carpathian Flysch, the autochthonous Miocene and it achieved the Precambrian basement. The question on deep-seated folds waits for further research.

Polish Lowland. Polish Lowland as a potential petroliferous area was dated from 1930s. In a few geological papers (Czarnocki, 1935; Paszkiewicz, 1936, 1938; Bohdanowicz, 1936) possibilities of oil discoveries were presented by analogy to the Hannover region in Germany where in the Mesozoic deposits a lot of oil fields were discovered then (Skoczylas, 1999).

Just after the Second World War, already in 1945, the Petroleum Institute in Cracow decided to explore in the Polish Lowland. During the scientific meeting in Krosno, organized after the initiative of Geological Committee of the Petroleum Institute by J. Obtulowicz, the petroleum geologists discussed about directions of petroleum exploration in Poland and they decided to organize new institution. It was established as a "department of exploration" within the Central Board of Liquid Fuels (CBLF) in Krosno, later it was replaced to Cracow. On the 1 January 1946 the *Oil Company* was founded in Cracow. Following persons highly directed then the development of exploration of Polish Lowland: Z. Wilk — the director of the CBLF, J. Wojnar — the director of the Petroleum Institute in Cracow, K. Tołwiński, J. Wdowiarz and T. Trawiński. The next director of Petroleum Company became J. Obtulowicz co-working with K. Łodziński, J.J. Zieliński and J. Wdowiarz. The aim of the company activity was: *to come to unknown oil-bearing regions not neglecting also the areas less or more earlier recognized* (Wdowiarz, 1960). In the company three departments were organized: the geological one (directed by J. Wdowiarz), the geophysical one (by A. Klisłó), and the drilling department (by R. Piątkiewicz). In the Drilling Department three branches were established named after prospecting regions: "Carpathians", "Carpathian Foreland" and "North".

A scientific base for exploration in the Polish Lowland were geophysical (gravimetric — Pawłowski, 1947, 1948; Olczak, 1951) and geological expertises and papers of: Teisseyre (1921); Czarnocki (1935); Lewiński (1936); Tołwiński (1948b) and Zwierzycki (1951).

First drillings were planned in the Kujawy region (Kłodawa-1) where geophysical studies detected a salt diapir. The drilling was begun in 1946 and at the depth of 325 m salt rocks were achieved. Drillings done around this diapir did not confirm suggestions on oil occurrence.

Systematic studies of structural units of the Polish Lowland were initiated in 1955 by the Petroleum Geological Survey (managed by A. Tokarski, S. Wdowiarz and Z. Obuchowicz) in collaboration with the Polish Geological Institute (Obuchowicz et al, 1959; Dadlez & Marek, 1969). The projects were based on the concepts of J. Zwierzycki (1951), A. Tokarski, S. Wdowiarz, Z. Obuchowicz, K. Konior and Z. Olewicz (1959).

The intense geophysical surveying and drilling activity were facilitated by the Government Act No 62 which allocated additional funds for such purposes. In 1956 the Central Petroleum Board accepted the organization of Petroleum Exploration Company in Piła (the birthplace of Stanisław Staszic — the creator of Polish geology; Fig. 1). Geological studies were managed by: S. Maryan, J. Stemulak, K. Mrozek, T. Kasprzak, Z. Korab, E. Jawor, L. Cima-szewski, J. Sokołowski and W. Wiśniak. The efforts and activity of organizers and the staff of new company have to be emphasized because they started in a ruined town struggling with enormous technical and living problems.

In early 1956 the *Petroleum Geophysical Company* was established in Kraków. The organizer and the first director was J. Szul. In the Polish Lowland geophysical surveying was realized by several field groups managed by: J. Żytko, M. Bał, W. Gadzała, A. Kisłó, M. Madej, W. Oleszczuk, A. Ptak, W. Prijma, J. Romański, L. Rudzik, W. Słota, Z. Sojka, K. Sojka, Z. Wiśniewski and others. During that time the applied seismic methods enabled recognition of the sub-Tertiary and the sub-Quaternary structures. Results of the first exploration phase in the Polish Lowland were presented in reports edited by Pożaryski (1960, 1962).

Further development of exploration activity allowed the United Petroleum Industry to organize several new companies: the *Geological Documentation and Project Bureau* — GEONAF TA (1962–2002), the *Petroleum Exploration Companies* in Wołomin (1967–1997) and in Zielona Góra (1968) and the *Geophysical Company* in Toruń (1968). In organization works participated especially A. Ćwierz, S. Dutka, J. Pilch and J. Stemulak.

For many years the petroleum industry has focussed on the Polish Permian Basin. In the Permian formations the most of oil and gas fields were discovered. Seismic surveying played a fundamental role in these efforts. In that period the significant progress was made both in available new methods and the measurement techniques. The equipment

was modernized first in 1960s when the oscillographic data recording was replaced by the analogue and the magnetic methods and later in 1970s when digital data recording was introduced. The latter completely updated in 1980s and in 1991–94. The pioneers of these modern methods were: K. Sojka, L. Rudzik, L. Król, Z. Śliwiński, E. Poleszak, A. Kisłowski, J. Bukowski, T. Rokosz, H. Tarnowski, Z. Soja, S. Plewa and W. Twaróg (Jawor & Kruczek, 1994).

In the last years the *Polish Oil and Gas Company* became deeply restructured. The two exploration and production divisions were established: the first one in Zielona Góra (prospecting the western and the northern part of Poland) and the next one in Sanok (for the eastern and the southern part of Poland). The Department of Exploration in Warsaw concentrates mainly on exploration in foreign countries and on cooperation with companies realizing their prospecting works in Poland.

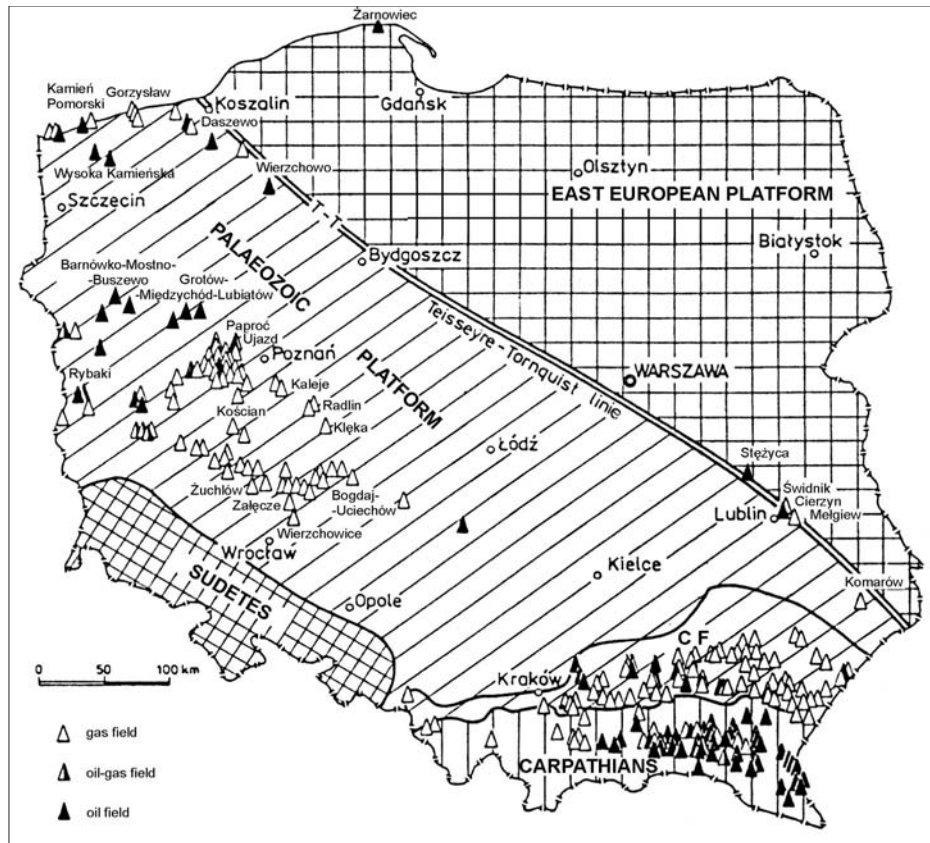


Fig. 16. Principal geological regions of Poland (without the Cenozoic deposits): oil and gas fields (after Karnkowski P., 1993, modified)

Fore-Sudetic Monocline. In the Polish Lowland the first discovery of oil was in 1961 (borehole Rybaki-1) in the carbonates of Zechstein Main Dolomite Formation at depth of ca 1800 m. The initial oil output was more than 100 t/d. From this oil field 130,000 t of oil was totally exploited. Discovering of the “Rybaki” oil field considerably influenced on intensifying exploration in the Polish Lowlands, and especially in the Fore-Sudetic Monocline area (Depowski et al, 1978).

In 1964 the first gas findings in the Rotliegend sandstones and the Zechstein limestones were documented (Bogdaj-Uciechów gas field; Karnkowski P. et al, 1966). The resources of this field were estimated at ca $16 \times 10^9 \text{ m}^3$ at the depth interval 1520–1620 m. Content of hydrocarbons is 57%, nitrogen — 42.5% and helium — 0.4%. From this field and the others around helium is liquefied in a cryogenic factory.

Continued exploration in the next years finalized in discovering the new oil and gas fields from which the more important are following (Fig. 16):

□ “Załęcze” (1971), gas — av. depth 1400 m, the Rotliegend reservoir, resources — $23 \times 10^9 \text{ m}^3$, methane — 74.2%, helium — 0.17%;

□ “Wierzchowice” (1971), gas — av. depth 1560 m, the Rotliegend sandstone and the Zechstein Limestone reservoirs, resources — $12 \times 10^9 \text{ m}^3$, methane — 69%, helium — 0.31%;

□ “Kaleje” and “Kłęka” (1974), gas — av. depth 3120 m, the Rotliegend reservoir, resources — $1\text{--}2 \times 10^9 \text{ m}^3$, methane — 80%;

□ “Żuchłów” (1978), gas — depth 275–1325 m, the Rotliegend reservoir, resources — $24.5 \times 10^9 \text{ m}^3$, methane

— 60%, helium — 0.22%, hitherto it is the biggest gas field in the Polish Lowland;

□ “Paproc” (1982), gas — av. depth 2688 m, the Rotliegend sandstone and the Zechstein Limestone reservoirs, resources — $6 \times 10^9 \text{ m}^3$, methane — 50–70%, it depends on a horizon;

□ “Radlin” (1985), gas — depth 3077–3112 m, the Rotliegend sandstone reservoir, resources — $12 \times 10^9 \text{ m}^3$, methane — 83%, it is the most rich gas field on the northern slope of the Wolsztyn Ridge;

□ “Kościan” (1995–1997), gas — depth 2132–2207 m, the Zechstein Limestone reservoir, resources — $10 \times 10^9 \text{ m}^3$, methane — 80%. This field started 1975. Then the Kościan-1 borehole documented a gas and the next four drillings were negative. The field was very quickly exploited (only $22.4 \times 10^6 \text{ m}^3$). In 1995 after new 3D seismic acquisition and the new geological interpretation of this region (Peryt & Dyjaczynski, 1991; Dyjaczynski, 1995; Górski & Trela, 1996, 1997) carbonate buildups were defined. The Kościan-6 borehole discovered a new gas field and documentation of its resources was continued (Dyjaczynski et al, 1997; Radecki, 1997; Radecki & Jastrzab, 2002). Moreover, in the same region with the same methodology, a few other gas fields in the Zechstein Limestone unit were found (“Brońsko”, “Wielichowo”, “Ruchoćice”);

□ “Górzycza” (1988), oil and gas — depth 2704 m, the Main Dolomite reservoir, resources — $1.5 \times 10^6 \text{ t}$ of oil and $2 \times 10^9 \text{ m}^3$ of gas;

□ “Barnówko-Mostno-Buszewo” BMB (1993) (Fig. 17), oil and gas — depth 3100–3200 m, the Main Dolomite reservoir, resources — $20 \times 10^6 \text{ t}$ of oil and $15 \times 10^9 \text{ m}^3$ of gas (Górski & Trela, 1996, 1997, Mamczur et al, 1997). It

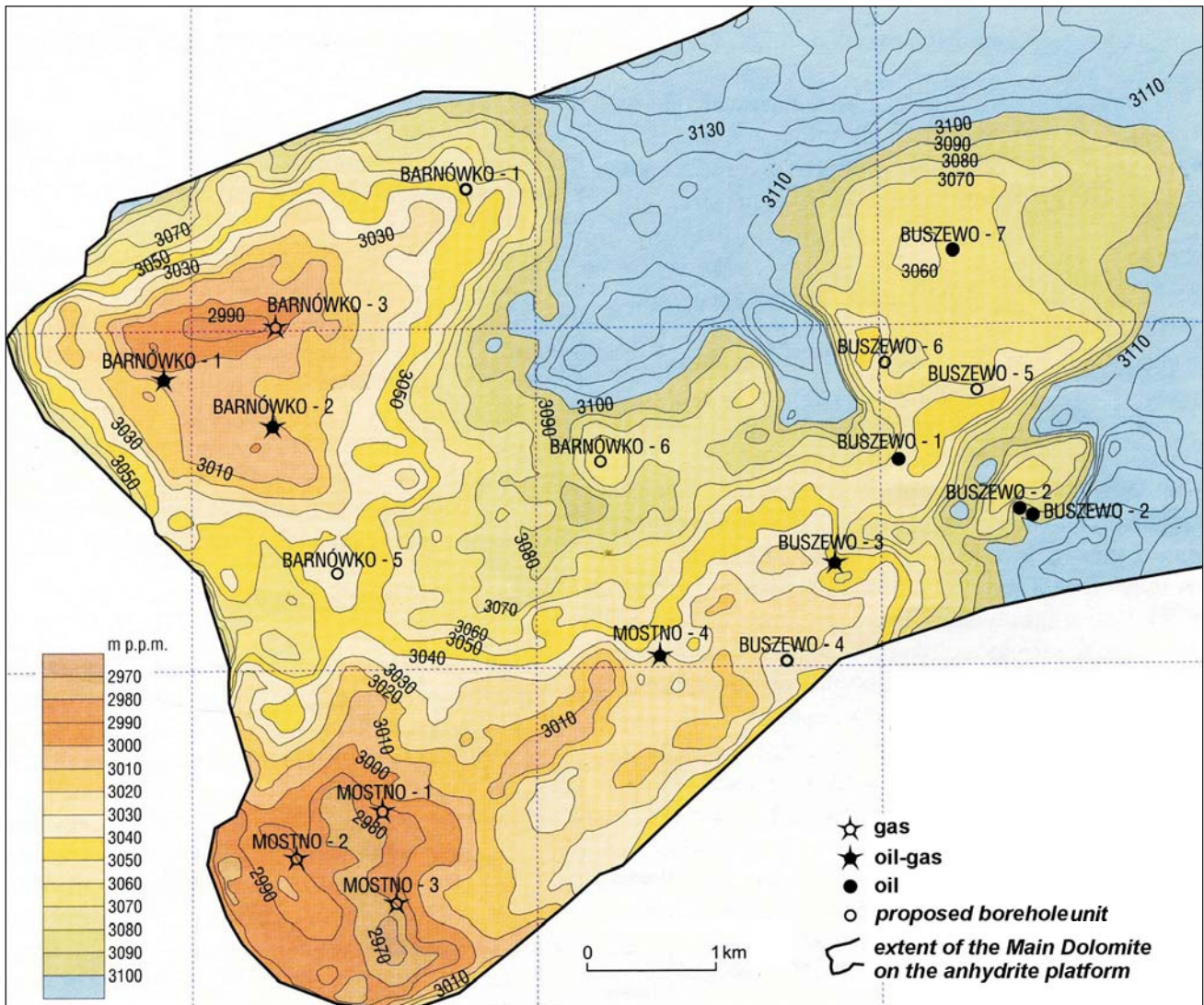


Fig. 17. "Barnówko-Mostno-Buszewo" (BMB) oil-gas field in the Main Dolomite unit (after Górski & Trela, 1997)

is the biggest oil field in Poland discovered after the Second World War;

□ "Międzychód-Lubiatów-Grotów-Sowia Góra" (2002), oil and gas — depth 3209–3260 m, the Main Dolomite reservoir, resources — comparable to the BMB, works in progress.

Considerable resources increase in 1990s resulted of applying, among the others, 3D seismic and the methodology of basin analysis (Narkiewicz, 1997; Karnkowski P.H., 1999).

Pomerania Region. In the area of Western Pomerania the first important discovery was the "Kamień Pomorski oil field" (1972) located in the Main Dolomite carbonates. In spite of considerable exploration effort in this area comparable results were not achieved as for the Fore-Sudetic Monocline. However, few economic oil and gas field were here documented. The most important are:

□ "Kamień Pomorski" (1972), oil and gas — depth 2232–2315 m, the Main Dolomite reservoir, resources — 1.9×10^6 t of oil and 240×10^6 m³ of gas;

□ "Wysoka Kamieńska" (1978), oil and gas — depth 3036–3069 m, the Main Dolomite reservoir, resources — 400,000 t of oil;

□ "Daszewo" (Karlino) (1980), oil and gas — depth 3126–3220 m, the Main Dolomite reservoir, resources — 160,000 t of oil. This is very famous for a huge fire being from 8 December 1980 to 16 January 1981.

□ "Wierzchowo" (1972), gas — av. depth 3015 m, the Lower Carboniferous reservoir, resources — 420×10^6 m³ of gas, methane — 60%;

□ "Gorzysław" (1976), gas — depth 2831–2870 m, the Upper Carboniferous reservoir, resources — 1.3×10^9 m³ of gas, methane — 47%;

□ "Daszewo" (1987), gas — depth 3216–3220 m, the Upper Carboniferous reservoir, resources — 1.4×10^9 m³ of gas, methane — 65%.

Łeba Elevation. Łeba elevation is a part of the Baltic Basin in which the oil-bearing zone is mostly offshore. Onshore only very small oil fields were documented as for example "Żarnowiec oil field" at depth of 2714–2722 m, the Middle Cambrian reservoir, resources 50,000 t of light oil.

Offshore exploration is managed by the *Petrobaltic* petroleum company. In 1981 in the Middle Cambrian sandstones the oil-gas field was discovered (Kurek, 1997). Actually the *Petrobaltic* produced 300,000 t/y from three oil fields.

Lublin Region. Lublin region from a petroleum point of view belongs to the Upper Palaeozoic Basin located in the border zone of the East European Platform. Exploration here has started in 1960s. A few oil and gas fields are discovered. The most important are following:

□ “Komarów” (1976), gas — depth 2363–2421 m, the Middle Devonian reservoir, resources $80 \times 10^6 \text{ m}^3$, methane — 95%;

□ “Świdnik” (1981), oil — av. depth 1000 m, the Upper Carboniferous reservoir, resources 26,000 t, oil is heavy — 0.914 g/cm^3 ;

□ “Ciecierzyn” (1983), gas — av. depth 3840 m, the Upper Devonian reservoir, resources $1 \times 10^9 \text{ m}^3$, methane — 97%;

□ “Mełgiew” (1994) gas — depth 3400–4040 m, the Upper Devonian reservoir, resources $1 \times 10^9 \text{ m}^3$, methane — 97%;

□ “Stężycza” (1994), oil and gas — depth 2324–2338, the Upper Carboniferous reservoir, resources are still documented.

Summary and conclusions

Described above the historical review of exploration of oil and gas fields in Poland, at least spacious, is superficial and fragmentary. Due to a limited article volume many fields were not named, as well as many geologists, geophysicists and drillers well-deserved for the development of prospecting and discoveries of oil and gas fields in Poland. The list of their surnames is long, both these ones who are continuing working and their predecessors.

Exploration managed by the *Polish Oil and Gas Company* (POGC) in the period after the Second World War resulted in discoveries of about 140 oil fields and 200 gas fields. Totally, $48 \times 10^6 \text{ t}$ of oil and $310 \times 10^9 \text{ m}^3$ were documented. From these resources $22 \times 10^6 \text{ t}$ of oil and $200 \times 10^9 \text{ m}^3$ of gas was exploited (Karnkowski P., 1998). The present resources are $26 \times 10^6 \text{ t}$ of oil and $110 \times 10^9 \text{ m}^3$ of gas.

Actually the exploitation level is estimated by POGC at 500,000–550,000 t of oil and $5\text{--}5,5 \times 10^9 \text{ m}^3$ of gas per year (Radecki, 2006). *Petrobaltic* produces also 200,000–300,000 t of oil and small amount of gas used in the plant power in Władysławo. In 1999–2000 the Dębno oil and gas mine (BMB field) near Gorzów Wielkopolski was open. It is the biggest such field in Poland. It exploits 400,000 t of oil and $4 \times 10^9 \text{ m}^3$ of gas per year.

The prognostic resources for Poland are estimated at $640 \times 10^9 \text{ m}^3$ of gas and $120 \times 10^6 \text{ t}$ of oil. The last calculations of prognostic resources made by the Institute of Oil and Gas in Cracow and the Technical University (AGH — Kraków) (Górecki, 2003; Raczkowski, 2004) showed that in the Polish Permian Basin these resources could be enlarged to $1200 \times 10^9 \text{ m}^3$ of gas and $120\text{--}200 \times 10^6 \text{ t}$ of oil. These values should be the encouragement for further exploration (Radecki, 2006) (Fig. 17).

In the 1990s POGC modernized technical and technological equipments which gave positive effect in new discoveries (e.g. BMB, “Kościan”, “Międzyzchód”, “Książ-pol” and “Basznia” fields, (Weil et al, 1994, 1997, 1998). But the above prognostic values need new explorations especially using 3D seismic and deep drillings.

Oil and gas exploration also contributed to discovering the mineral raw resources: a copper ore, found in boreholes

Wschowa-1 and Ostrzeszów-1 in 1957, initiated by professor A. Tokarski. Their preliminary results were sent to dr Jan Wyżykowski from the Polish Geological Institute, the best copper ore researcher in Poland. Also the huge lignite coal deposits near Bełchatów were discovered. The largest Polish power plant is now supplied from the lignite open pit situated near Bełchatów. Petroleum exploration enabled also recognition of salt deposits (potash and polyhalite) and salt diapirs in Poland, e.g. Kłodawa salt diapir exploited by the underground salt mine.

Except the mentioned above raw materials also fresh, geothermal and mineral waters were recognized. These achievements didn't come easy. Through the long time drill crews, seismic and geological groups worked in the toughness conditions in different areas of Poland obtaining the new information, creating new concepts and frameworks for a subsurface geology. Every core sample and every diagram of geophysical examinations was studied in details. After these data geophysicists and geologists recognized conditions of petroleum generation in different geological structures.

From almost 20 years the foreign companies have explored in Poland obtaining licenses from the Ministry of Environment. They are as follows: *Apache Polska Sp. z o.o.*, *CalEnergy Gas Polska Sp. z o.o.*, *Energia Zachód Sp. z o.o.*, *EuroGas Polska Sp. z o.o.*, *FX Energy Polska Sp. z o.o.*, *Medusa Polska Sp. z o.o.* and *RWE-DEA Polska Sp. z o.o.* The *Apache Poland Company* discovered a gas field in the Upper Carboniferous deposits not so far from Warsaw. *FX Energy Polska* also has found a gas field in the Rotliegend sandstone in the Fore-Sudetic Monocline.

The main points of this short historical review are:

□ After the Second World War Poland had in the Carpathians $5 \times 10^6 \text{ t}$ of oil and $5 \times 10^9 \text{ m}^3$ of gas reserves. From that time to nowadays $22 \times 10^6 \text{ t}$ of oil and $200 \times 10^9 \text{ m}^3$ of gas were exploited. The present documented reserves are $26 \times 10^6 \text{ t}$ of oil and $110 \times 10^9 \text{ m}^3$ of gas. During the last 55 years the petroleum industry highly supported the national economy.

□ The positive results of previous discoveries proves the actual gas supply from the Polish sources at a level equals 30–35% of consumption.

□ The author is sure that present way of exploration in Poland is effective to find new reserves. It is the proper direction but still conservative. New researching concepts are necessary focussed on following subjects: reefs of the Main Dolomite and the Zechstein Limestone units; the Rotliegend and the Upper Carboniferous sandstones as a potential reservoirs in the Polish Basin; the Mesozoic deposits of the Polish Lowland with a special attention to the secondary structures located between the salt diapirs; the Miocene deposits of the Carpathian Foredeep in the peri-Carpathians zone and northward from Rzeszów; the Carpathian Flysch and its basement in the Sanok region and in the Magura Nappe.

□ Recently the oil industry equipped with the modern hardware and software is able to solve these problems as well as finances for these investigations should be found. The work is feeling much and specialists are waiting for the new impulse to add the next fruitful chapter in the history of oil and gas exploration and exploitation in Poland.

References

- BOHDANOWICZ K. 1936 — Niektóre zagadnienia geologii ropnych złóż. *Rocz. Pol. Tow. Geol.*, 12: 486–568.
- BORYS Z. 1996 — Aktualne problemy poszukiwań węglowodorów w wschodniej części Przedgórze Karpat. *Prz. Geol.*, 44: 1019–1023.
- CISEK B. & CZERNICKI J. 1988 — Złoże gazu Przemysł oraz perspektywy poszukiwań ropy i gazu na Przedgórzu. *Prz. Geol.*, 44: 1019–1023.
- CZARNOCKI S. 1935 — Nafta w Wielkopolsce i na Kujawach. *Prz. Gór. Hutn.*, 27: 94–104.
- CZEKAŃSKI E. 2002 — Bilans dotychczasowych odkryć i perspektywy na przyszłość. *Szejk*, 12: 11–18.
- CZERNICKI J. & MORYC W. 1992 — Złoże ropy naftowej Nosówka koło Rzeszowa. *Nafta*, 4-6: 49–54.
- DADLEZ R. & MAREK S. 1969 — Styl strukturalny kompleksu cechsztyńsko-mezozoicznego. *Kwart. Geol.*, 13: 543–565.
- DEPOWSKI S. 1964 — Złóża ropy i gazu w Polsce. *Kwart. Geol.*, 8: 519–520.
- DEPOWSKI S., PERYT T., PIĄTKOWSKI T. & WAGNER R. 1978 — Sedymentacja i paleogeografia cechsztyńskiego dolomitu głównego, a jego ropo- i gazonośność. *Prz. Geol.*, 26: 141–146.
- DYJACZYŃSKI K. 1995 — Analiza geologiczno-geofizyczna w celu określenia miejsc możliwego występowania raf w wapieniu cechsztyńskim w rejonie Zbąszyń-Nowy Tomyśl-Grodzisk Wlkp. *Arch. BG Geonafci*, Warszawa.
- DYJACZYŃSKI K., MAMCZUR S. & RADECKI S. 1997 — Nowe perspektywy poszukiwań złóż gazu ziemnego w utworach wapienia cechsztyńskiego na monoklinie przedsudeckiej. *Prz. Geol.*, 45: 124–125.
- FIK J. 2006 — Oddział Karpacki Polskiego Towarzystwa Geologicznego w Jaśle, powstanie i jego działalność. *Prz. Geol.*, 54, 7: 584–588.
- GARNCARSKI J., MUNIA J., SŁYŚ-JANUSZ E., TWARÓG M. & WILGA S. 2001 — W kręgu światła lampy naftowej. *Wyd. Muzeum Podkarpacie, Muzeum Przemysłu Naftowego i Gazowniczego w Bóbrce*, Krosno.
- GRZYBOWSKI J. 1897 — Otwornice pokładów naftowych okolic Krosna. *Kosmos*, 33.
- GÓRECKI W. 2003 — Perspektywy rozwoju górnictwa naftowego w Polsce. *Wiad. Nafta i Gaz*, 65, 9: 3–8.
- GÓRSKI M. & TRELA M. 1996 — Opracowanie badań sejsmicznych 3D w rejonie Barnówko-Lubiszyn. *Arch. BG Geonafci*, Warszawa.
- GÓRSKI M. & TRELA M. 1997 — Układ geometryczny i ocena właściwości serii zbiornikowych złoża ropy naftowej BMB, na podstawie zdjęcia sejsmicznego 3D. *Prz. Geol.*, 45: 685–692.
- JAWOR E. 1999 — Aktualne spojrzenie na możliwości odkrycia nowych akumulacji węglowodorów w środkowej części Karpat i Przedgórze. *Mat. Konfer., Raba Niżna-Kraków. Arch. Geonafci*, Kraków: 1–7.
- JAWOR E. & KRUCZEK J. 1994 — Geologia złóż ropy i gazu. [In:] Wolowicz R. (ed) *Historia polskiego przemysłu naftowego*. *Stow. Inż. i Techn. Przem. Naft., Brzoźów-Kraków*: 61–159.
- KARNKOWSKI P. 1969 — Formowanie się złóż ropy naftowej i gazu ziemnego na Przedgórzu Karpat. *Wyd. Geol.*, Warszawa: 1–108.
- KARNKOWSKI P. 1993 — Złóża gazu ziemnego i ropy naftowej w Polsce. T 1 — Niż Polski; T 2 — Karpaty i Zapadlisko Przedkarpacie. *Geos AGH*, Kraków.
- KARNKOWSKI P. 1998 — Złóża ropy i gazu ziemnego w Polsce i perspektywy dalszych poszukiwań. *Nafta i Gaz*, 1: 3–8.
- KARNKOWSKI P. 1999 — Oil and Gas Deposits in Poland. *Wyd. Geos*, Kraków: 1–380.
- KARNKOWSKI P., SOKOŁOWSKI J. & STEMULAK J. 1966 — Odkrycie pierwszego w Polsce złoża gazu ziemnego w utworach czerwonego spągowca. *Geof. i Geol. Naft.*, 1-2: 1–6.
- KARNKOWSKI P.H. 1999 — Origin and evolution of the Polish Rotliegend Basin. *Pol. Geol. Inst. Spec. Pap.*, 3: 1–93.
- KSIĄŻKIEWICZ M., SAMSONOWICZ J. & RÜHLE E. 1956 — *Zarys geologii Polski*. *Wyd. Geol.*, Warszawa.
- KRUCZEK J. 1999 — Zagadnienia geologii i ekonomiki złóż ropy i gazu ziemnego w 1999 roku. *Pr. Nauk. UŚL*, 1809: 33–54.
- KUREK J. 1997 — Poszukiwanie i eksploatacja złóż ropy i gazu ziemnego na Bałtyku. [In:] *Konf. Nauk. na AGH w XXX-lecie Wydziału Wiertnictwa*. *Arch. AGH*, Kraków.
- LEWIŃSKI J. 1936 — Polska, budowa geologiczna. *Świat i Życie*, 4. *Książnica-Atlas*, Lwów.
- MAMCZUR S., RADECKI S. & WOJTKOWIAK Z. 1997 — O największym złożu ropy naftowej w Polsce: Barnówko-Mostno-Buszewo (BMB). *Prz. Geol.*, 45: 582–588.
- MORYC W. 1961 — Budowa geologiczna rejonu Lubaczowa. *Rocz. Pol. Tow. Geol.*, 31: 47–83.
- NARKIEWICZ M. 1997 — Analiza basenów sedymentacyjnych Niżu Polskiego. *Prz. Geol.*, 45: 679–684.
- NOWAK J. 1920 — Nafta Karpat polskich w świetle geologii regionalnej. *Prz. Geogr.*, 6: 3–25.
- OBUCHOWICZ Z. 1960 — Wyniki poszukiwań złóż ropy i gazu — perspektywy odkryć. *Prz. Geol.*, 8: 516–518.
- OBUCHOWICZ Z. 1963 — Złóża ropy i gazu w Zapadlisku Przedkarpacie. *Rocz. Pol. Tow. Geol.*, 33: 397–411.
- OBUCHOWICZ Z., OLEWICZ Z., TOKARSKI A. & WDOIARZ S. 1959 — Obecny stan rozpoznania geologicznego i możliwości nowych odkryć złóż ropy i gazu w Polsce. *Nafta*, 4: 92–102.
- OLCZAK T. 1951 — Mapa grawimetryczna Polski. *Biul. Inst. Geol.*, 64: 1–59.
- OLEWICZ Z. 1959 — Baseny sedymentacyjne i strukturalne ziem Polski. *Pr. Inst. Naft.*, 63: 1–95.
- PASZKIEWICZ A. 1936, 1938 — *Zagadnienia Wielkopolsko-pomorsko-kujawskiego Zagłębia Naftowego*. Cz. I, II. *Nakł. autora*, Kcynia.
- PAWŁOWSKI S. 1947 — Anomalie magnetyczne w Polsce. *Biul. Państw. Inst. Geol.*, 44: 1–59.
- PERYT T. & DYJACZYŃSKI K. 1991 — An isolated carbonate bank in the Zechstein Main Dolomite Basin, Western Poland. *J. Petrol. Geol.*, 14: 445–458.
- POŻARYSKI W. 1960 — Badania podstawowe Niżu Polskiego w poszukiwaniu ropy i gazu ziemnego. *Prz. Geol.*, 8: 515–516.
- POŻARYSKI W. 1962 — Pierwszy etap badań Niżu Polskiego. *Prz. Geol.*, 10: 561–568.
- RACZKOWSKI J. [ed] 2004 — *Nafta i Gaz Podkarpacia — zarys historii*. *Inst. Nafty i Gazu*, Kraków.
- RADECKI S. 1997 — Rejon Kościana nowym obszarem gazonośnym Polski. *Nafta-Gaz*, 7-8: 11–12.
- RADECKI S. 2006 — Możliwości pozyskania gazu ziemnego ze złóż krajowych. *Materiał zjazdowy PZITS*, nr 865/2006. *Arch. PGNiG*, Warszawa.
- RADECKI S. & JASTRZĄB M. 2002 — Wyniki prac poszukiwawczych w Górnictwie Naftowym. *Arch. BG Geonafci*, Warszawa.
- SKOCZYLAŚ J. 1999 — Poszukiwanie ropy naftowej na Niżu Polskim w 65-lecie gorączki naftowej w Kcyni. *Prz. Geol.*, 47: 438–439.
- SOZAŃSKI J.Z. 2004 — Ignacy Łukasiewicz, 1822–1882 — życie, dzieło i pamięć. *Wyd. Tekst*, Bydgoszcz.
- SOZAŃSKI J.Z., KUK S. & JARACZ C. 2002 — *Światło Ziemi*. *Wyd. Tekst*, Bydgoszcz.
- SZAFRAN S. 2004 — Narodziny i główne nurty rozwoju półtorawiecznego polskiego górnictwa naftowego. *Rok Ignacego Łukasiewicza*. *Muzeum Przemysłu Naftowego i Gazownictwa w Bóbrce*: 1–20.
- TEISSEYRE W. 1921 — O stosunku wewnętrznych brzegów zapadliska przedkarpacieckiego do krawędzi fliszu karpackiego. *Spraw. Państw. Inst. Geol.*, t. 1, z. 2: 103–121.
- TOKARSKI A. 1946 — Zachodnia część fałdu Mrukowej oraz możliwości ropne terenów Pielgrzymki i Fulusza. *Nafta*, 8: 378–385, 416–422.
- TOŁWIŃSKI K. 1937 — Kopalnie nafty i gazów ziemnych w Polsce. *Biul. Karp. Inst. Geol. Naft.*, 22: 1–381.
- TOŁWIŃSKI K. 1948a — Na zachodnim brzegu Karpat. *Odkrycie Dębowa*. *Czytelnik*, Kraków-Zakopane.
- TOŁWIŃSKI K. 1948b — Geograficzne rozmieszczenie złóż naftowych i gazowych w Polsce. *Życie Gosp.*, 17a: 13–16.
- WDOIARZ S. 1960 — Ropa naftowa i gaz oraz perspektywy poszukiwawcze na obszarze Karpat. *Prz. Geol.*, 8: 518.
- WEIL W., KARNKOWSKI P. & GÓRECKI W. 1997 — Ropa naftowa i gaz ziemny w Polsce. [In:] *Rozwój polskiej myśli w poszukiwaniach naftowych*. *Konferencja*. *Kraków*, 25–26.09.1997. *AGH*, Kraków: 31–48.
- WEIL W., GÓRECKI W., KRUCZEK J. & KARNKOWSKI P. 1998 — Odkrycia węglowodorów w ostatnim dziesięcioleciu i stan bazy zasobowej. *Prz. Geol.*, 46: 318–325.
- WEIL W., JASTRZĄB M., KARNKOWSKI P. & RADECKI S. 1994 — Poszukiwania ropy i gazu ziemnego w 1993 r. i zamierzenia na przyszłość. *Nafta-Gaz*, 6: 227–233.
- WOLWOWICZ R. 2003 — Ludzie polskiej nafty. *Mat. Konf. SITPNiG-Bóbrka 93*. *Muzeum Przemysłu Naftowego i Gazownictwa w Bóbrce*.
- ZUBER R. 1918 — Flisz i nafta. *Pr. Nauk. TN*, Lwów, dział II, t. 2: 16–381.
- ZWIERZYCKI J. 1951 — Sole potasowo-magnezowe na północ od Wrocławia. *Pr. Państw. Inst. Geol.*, 7: 257–295.