Polish Geological Institute
National Research Institute

Polish Geological Survey
Polish Hydrogeological Survey

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HYDROCARBON PROSPECTIVE OF POLAND

PYRZYCE
TENDER AREA
ENGLISH ABSTRACT

Tomasz ŻUK, Ewelina KRZYŻAK, Joanna ROSZKOWSKA-REMIN,
Teresa ADAMCZAK-BIAŁY, Paweł ALEKSANDROWSKI, Justyna ARASZKIEWICZ,
Dariusz BRZEZIŃSKI, Martyna CZAPIGO-CZAPLA, Witold DYMOWSKI,
Andrzej GŁUSZYŃSKI, Ryszard HOC, Dominika KAFARA, Anna KALINOWSKA,
Hubert KIERSNOWSKI, Sylwia KIJEWSKA, Paulina KOSTRZ-SIKORA,
Olimpia KOZŁOWSKA, Joanna KRASUSKA, Tadeusz PERYT, Olga ROSOWIECKA,
Leszek SKOWROŃSKI, Krystian WÓJCIK

IV LICENSING ROUND
CONCESSIONS FOR HYDROCARBON
PROSPECTION, EXPLORATION AND PRODUCTION
IN POLAND

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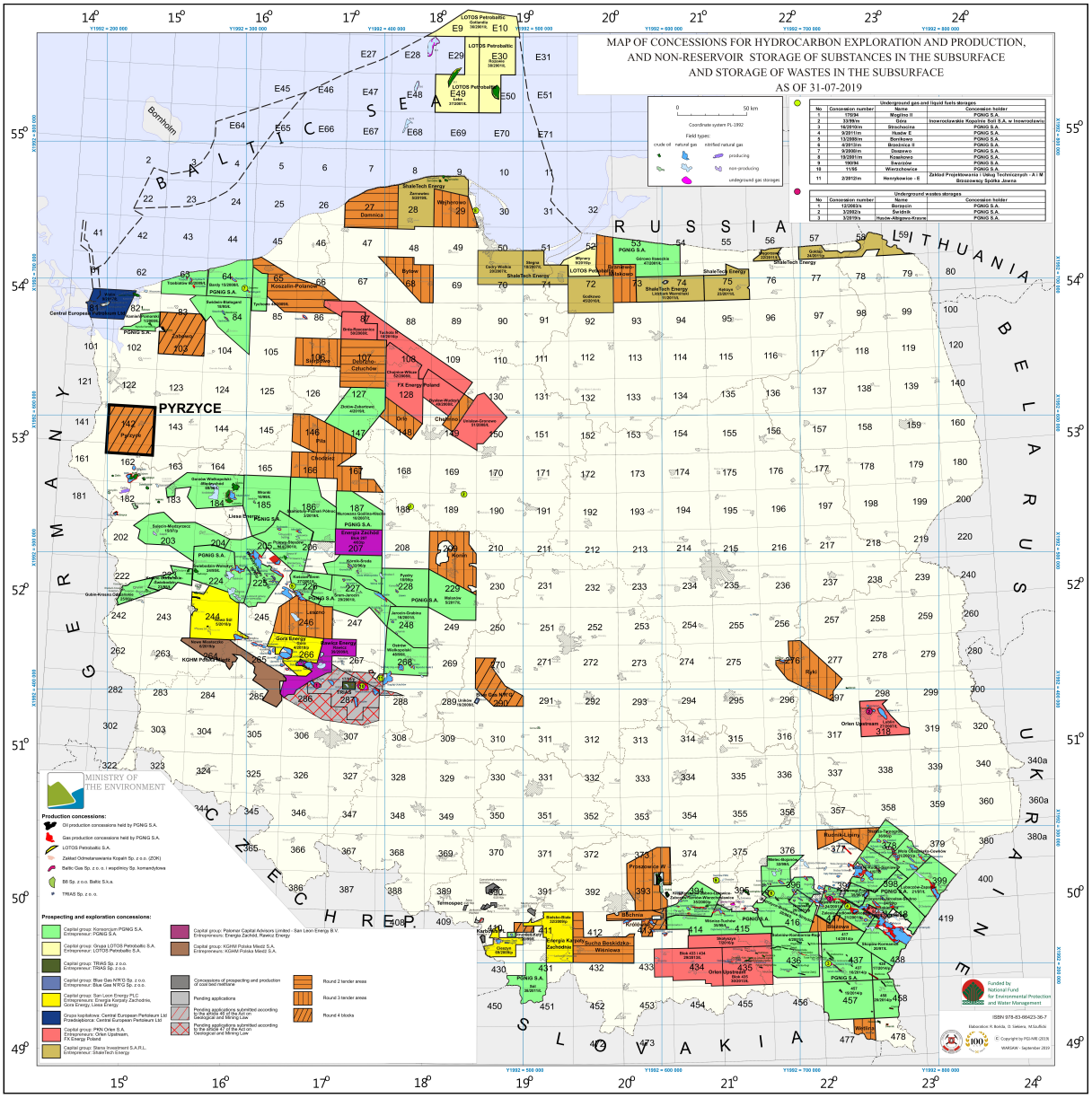


Location of the Pyrzyce tender area on the map of concessions for hydrocarbon exploration and production, and non-reservoir storage of substances in the subsurface and storage of wastes in the subsurface as of 31-07-2019.

1. GENERAL INFORMATION

The Pyrzyce tender area is located onshore in the north-western Poland, in the 142 and 162 concession blocks (Fig. 1). The precise location is defined by geographical coordinates listed below.

Border points	1992 coordinate system	
	X	Y
1	607 760.99	199 928.41
2	605 776.69	233 253.30
3	570 804.18	231 298.33
4	572 915.76	197 736.11

Tab. 1. Border points coordinates of the Pyrzyce tender area (Fig. 1).

Administrative centre:

- Zachodniopomorskie province; Gryfino county, communes: Stare Czarnowo (participation in the tender area 0.32%), Widuchowa (4.65%), Chojna (4.80%), Trzcińsko-Zdrój (6.34%), Gryfino (10.24%), Banie (17.62%), Myślibórz county, communes: Nowogródek Pomorski (0.33%), Myślibórz (14.99%), Pyrzyce county, communes: Przelewice (<0.01%), Warnice (3.75%), Lipiany (6.06%), Bielice (6.58%), Kozielice (8.07%), Pyrzyce (16.19%), Stargard country, commune: Stargard (0.06%)

The Pyrzyce tender area was subjected to hydrocarbon prospection and exploration concession No. 12/2006/p (FX Energy Poland) from 24 October 2006 to 24 October 2012. Afterward, only northern part of the 162 block was operated by FX Energy Poland. Currently, the Gorzów Wielkopolski–Międzychód concession No. 69/98/Ł (PGNiG – Polish Oil and Gas Company) is located to the south-east (Fig. 1).

There are still no oil and gas discoveries in the Pyrzyce tender area, so far. However, the area is prospective, since many oil and gas fields have been discovered to the south. They are related to the Main Dolomite carbonate platform. These are for example: Różańsko gas field, and Zielin, Barnówko-Mostno-Buszewo, Gajewo and Lubiszyn oil-and-gas fields.

The main exploration targets in the Pyrzyce tender area are related to conventional and unconventional oil and gas accumulations in the:

- Carboniferous and Permian (with Rotliegend deposits as main reservoir rocks),
- Permian (with Zechstein/ Weissliegend and Main Dolomite as main reservoir rocks).

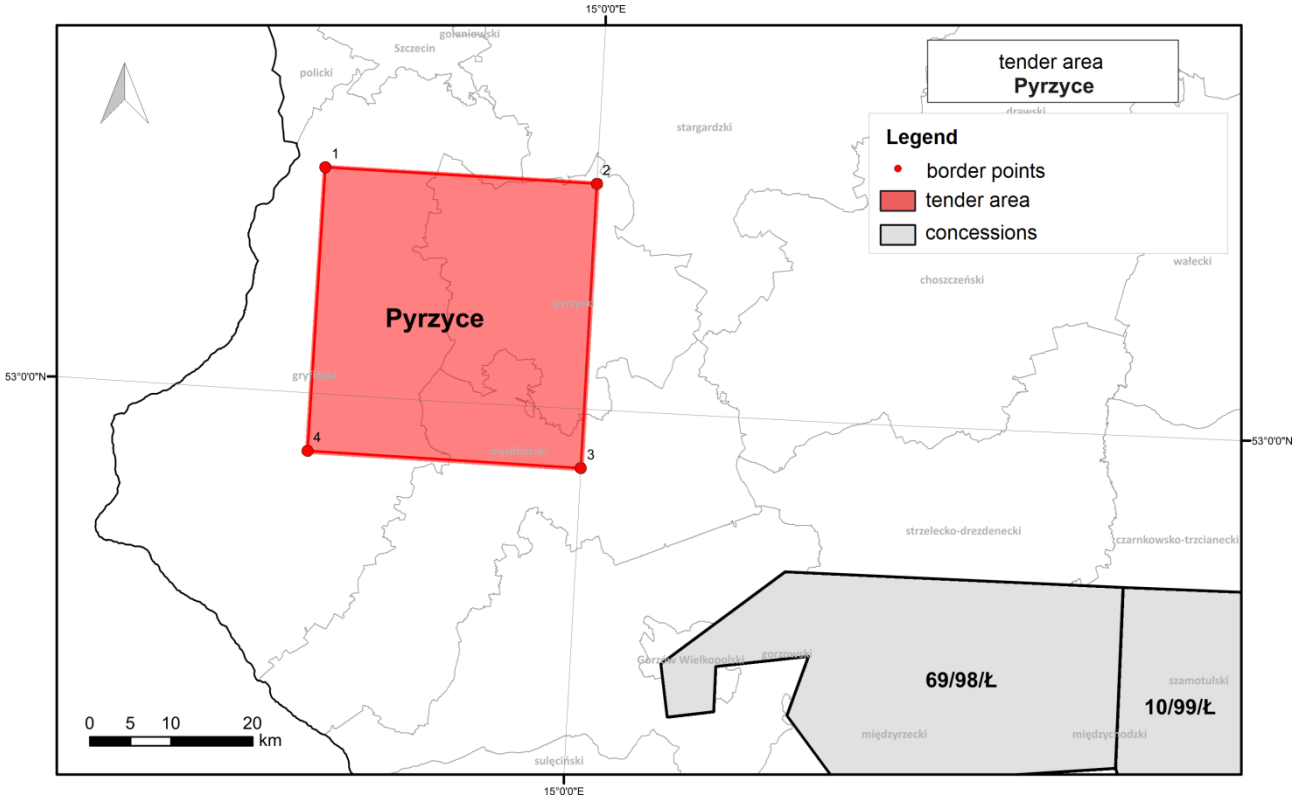


Fig. 1. Border points of the Pyrzyce tender area and location of the hydrocarbon concessions in the neighborhood as of 31-07-2019 (CBDG, 2019).

2. GEOLOGY

2.1. GENERAL GEOLOGICAL DESCRIPTION

The Pyrzyce tender area is located in the north-western Poland. It lies within the Szczeciny-Gorzów Trough (Aleksandrowski, 2017a; Fig. 2). Below the Permian-Mesozoic and Cenozoic cover, the Carboniferous strata of the Variscan Externides occur (Aleksandrowski, 2017b; Fig. 3).

The stratigraphy and lithology of the Paleozoic and Mesozoic rocks are recognized in several wells located within the Pyrzyce tender area and in its close neighborhood. These are: Banie 1, Błotno 3, Chabowo 1, 2, 3, Moracz IG-1, Myślibórz GN-1, Stargard 1, (see Fig. 16 for location; wells located within the tender area are highlighted).

2.2. TECTONIC

The Pyrzyce tender area is located within the Paleozoic Platform, about 170–200 km west from the border of the East-European Craton. The Carboniferous strata – as the oldest recognized in the wells – form the Variscan structural stage of the Paleozoic Platform cover. Above, the Permian-Mesozoic deposits lie with a disctinct angular unconformity. This succession is formed by the Permian Rotliegend and Zechstein deposits, which (together with Carboniferous basement) are the main exploration target. Above the Triassic–Cretaceous succession occurs. This part is deformed due to halokinetic processes: the Chabowo and Swobnica salt pillows are located in the northern and western part of the tender area.

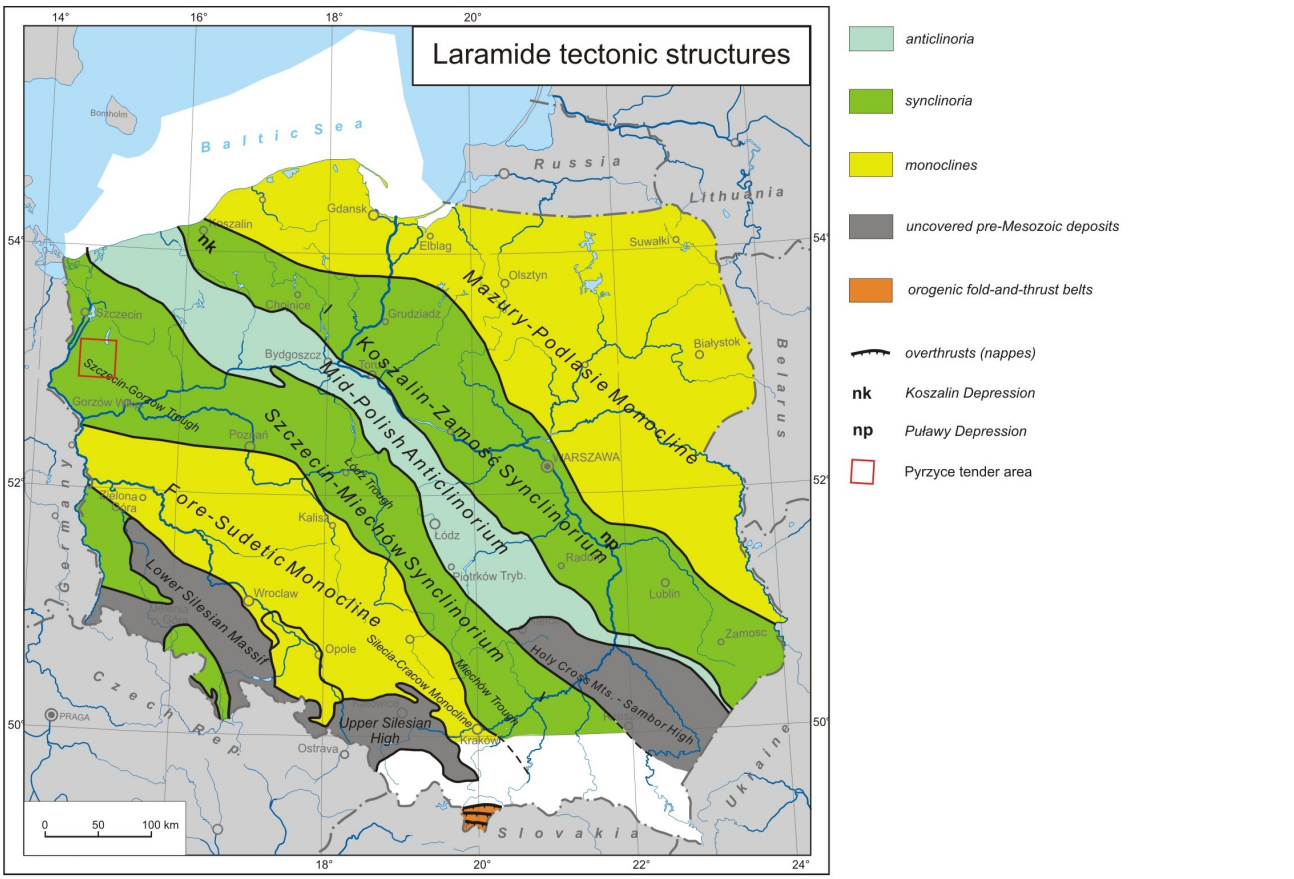


Fig. 2. Location of the Pyrzyce tender area on the map of Laramide tectonic structures (after Aleksandrowski, 2017a, modified).

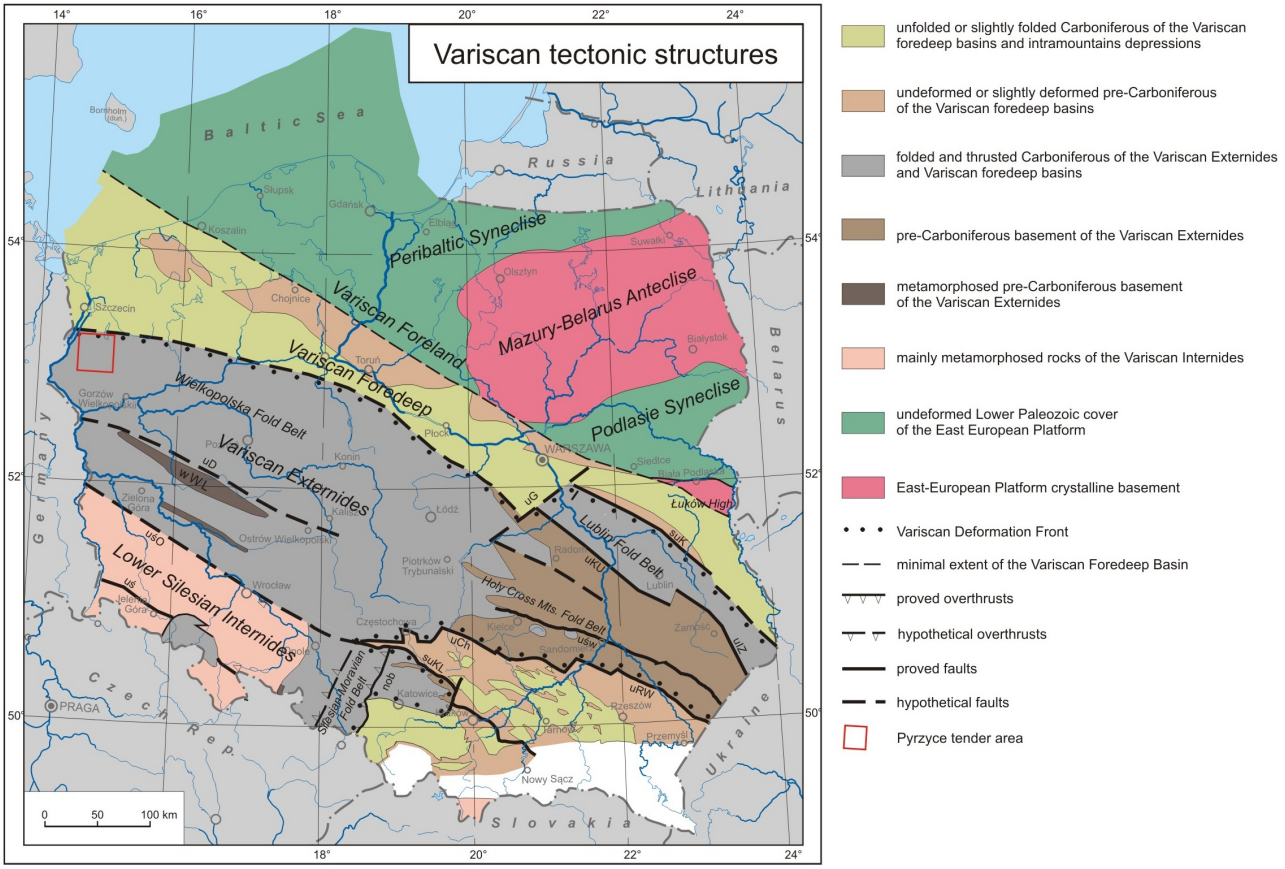


Fig. 3. Location of the Pyrzyce tender area on the map of Variscan tectonic structures (after Aleksandrowski, 2017b, modified). nob – Orłów-Boguszowice Thrust, suK – Kock Fault Zone, suKL – Kraków-Lubliniec Fault Zone, uCh – Chmielnik Fault, uD – Dolsk Fault, uG – Grójec Fault, uIZ – Izbica-Zamość Fault, uKU – Kazimierz-Ursynów Fault, uRW – Ryszkowa Wola Fault, uś – Intra-Sudetic Fault, uśO – Mid-Odra Fault, usw – Holy Cross Mts. Fault, wWL – Wolsztyn-Leszno High.

2.3. STRATIGRAPHY AND LITHOLOGY

Carboniferous

Lithology: claystones and mudstones with intercalations of limestones and sandstones in the Nadarzyce and Łobżonka Formations, limestones in the Czaplinek Formation; Namurian and Westphalian shales, mudstones and sandsatones.
Lithostratigraphy: Łobżonka Shale Formation, Czaplinek Limestone Formation, and Nadarzyce Shale Formation in the Visean; Namurian and Westphalian undivided.
Wells and depth: Myślibórz GN-1 (3765.5–3893.0 m),
Błotno 3 (3834.4–4500.0 m),
Moracz IG-1 (4211.0–4722.0 m).
Thickness (according to wells): 127.5–665.6 m.
References: Pożaryski and Dembowski, 1983; Pokorski and Miłaczewski, 1997; Lipiec, 1999; Matyja, 2006, 2008, 2018; Lech, 2013; Aleksandrowski and Buła, 2017.

Permian, Autun

Lithology: volcanic rocks, clastic rocks with intercalations of volcanic rocks.
Wells and depth: Banie 1 (3926.0–4090.0 m),
Stargard 1 (5086.0–5444.0 m).
Thickness (according to wells): 164.0 m.

Permian, Rotliegend (Figs 4, 6)

Lithology: alluvial conglomerates and sandstones, marginal playa-lake sandstones and mudstones, playa-lake sandstones and mudstones.
Wells and depth: Banie 1 (3906.0–3926.0 m),
Stargard 1 (4766.0–5086.0 m).
Thickness (according to wells): 20 m.
References: Pokorski, 1988; Kiersnowski, 1997, 1998; Karnkowski, 1999; Buniak, 2004; Kiersnowski and Buniak, 2006; Kiersnowski et al., 2010; Kiersnowski, 2013.

Permian, Zechstein (Figs 5, 7)

Lithology: limestones, dolomites, clastic rocks and evaporites.
Lithostratigraphy: PZ1 – Cooper Shale (T1), Zechstein Limestone (Ca1), Lower Anhydrite (A1d), Oldest Halite (Na1), Upper Anhydrite (A1g), PZ2 – Main Dolomite (Ca2), Basal Anhydrite (A2), Older Halite (Na2), Older Potash (K2), Screening Older Halite (Na2r), Screening Anhydrite (A2r), PZ3 – Grey Pelite (T3), Platy Dolomite (Ca3), Main Anhydrite (A3), Younger Halite (Na3), PZ4a – Lower Red Pelite (T4a), Lower Pegmatite Anhydrite (A4a1), Lower Youngest Halite (Na4a1), Upper Youngest Halite (Na4a2), Upper Red Pelite – Lower part (T4b1), Separating Salt (Na4b1), Upper Red Pelite – upper part (T4b2), Top Youngest Halite (Na4b2), Zechstein PZ4b, Top terrigenous Series PZt.
Wells and depth: Banie 1 (2908.5–3906.0 m),
Myślibórz GN-1 (2750.0–3765.5 m),
Stargard 1 (4024.0–4766.0 m),
Chabowo 1 (2632.0–2708.0 m).
Thickness (according to wells): >76.0–997.5 m.
Wells and depth (Main Dolomite Ca2):
Banie 1 (3765.5– 3767.5 m),
Myślibórz GN-1 (3628.0– 3643.5 m),
Stargard 1 (4602.5–4609.0 m).
Thickness (Main Dolomite Ca2, according to wells): 2.0 m.
References: Wagner, 1994; Peryt et al., 1996; Peryt, 2010; Wagner and Peryt, 1997; Peryt and Wagner, 1998; Wagner, 2012, Buniak et al., 2013.

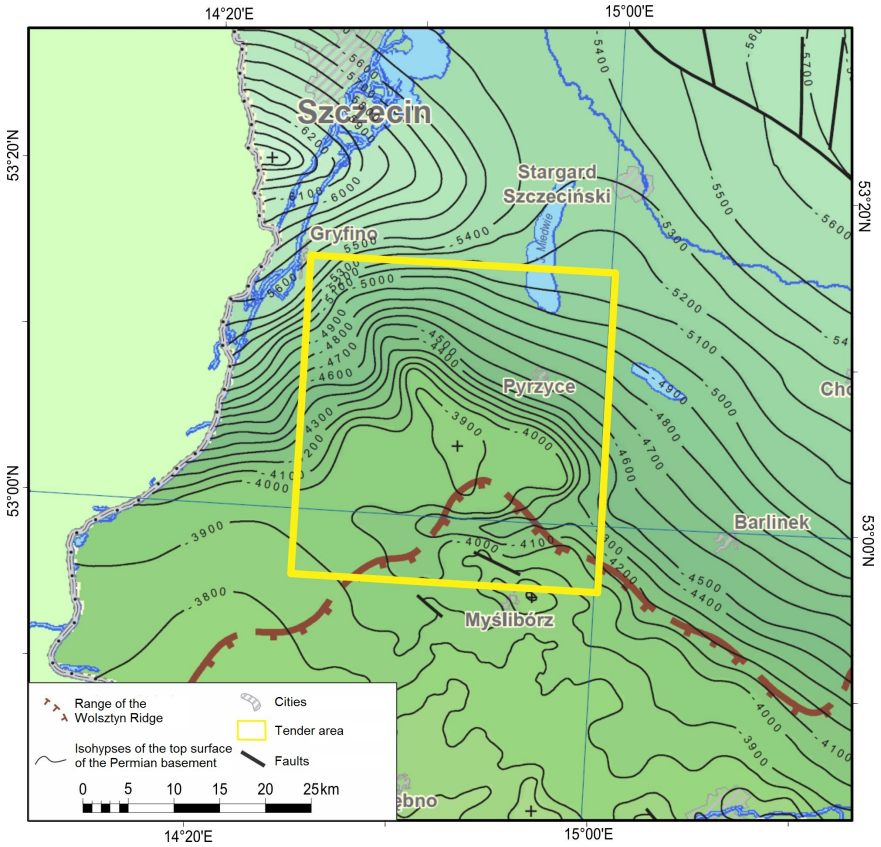


Fig. 4. Location of the Pyrzyce tender area on the structural map of the top surface of the Permian basement (Kudrewicz, 2007; modified).

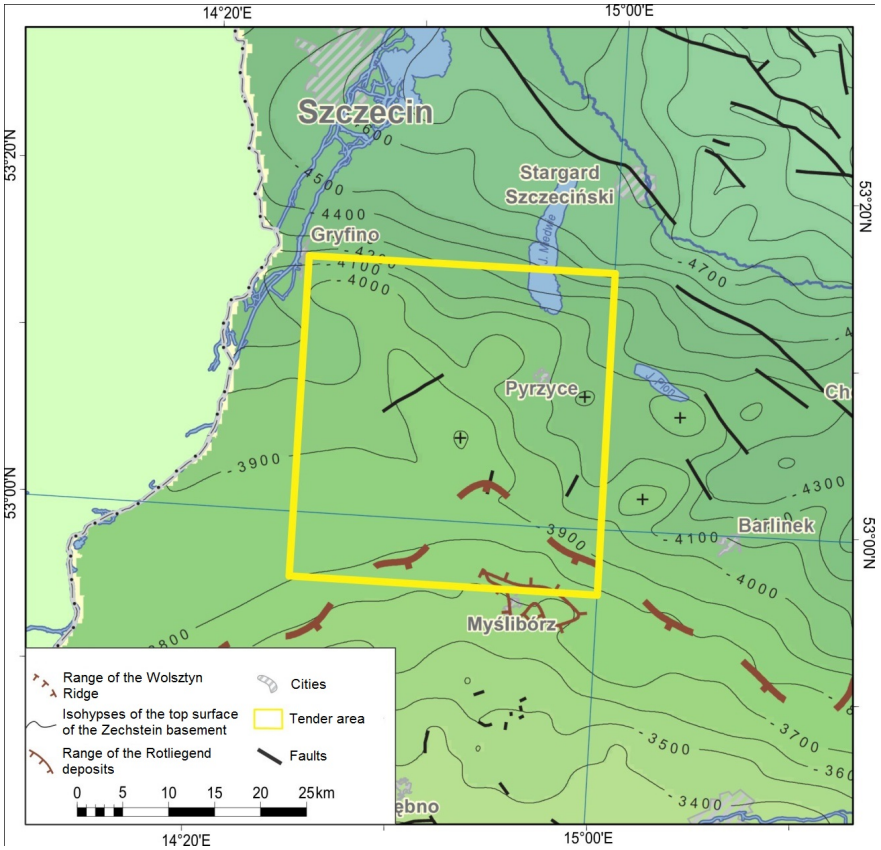


Fig. 5. Location of the Pyrzyce tender area on the structural map of the top surface of the Zechstein basement (Kudrewicz, 2007; modified).

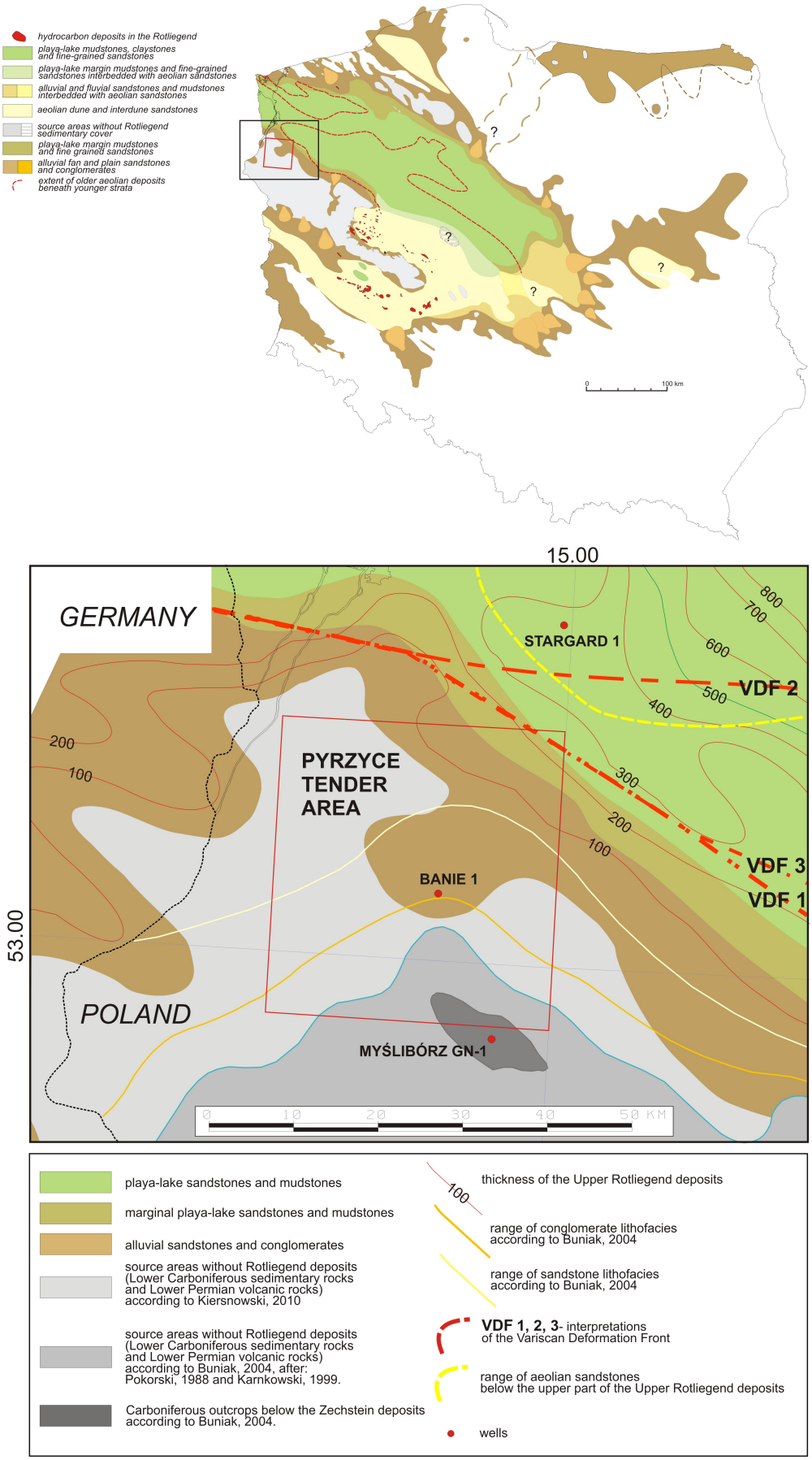


Fig. 6. Location of the Pyrzyce tender area on the map of the Upper Rotliegend palaeogeography and facies in Poland (Kiersnowski, 2013; modified).

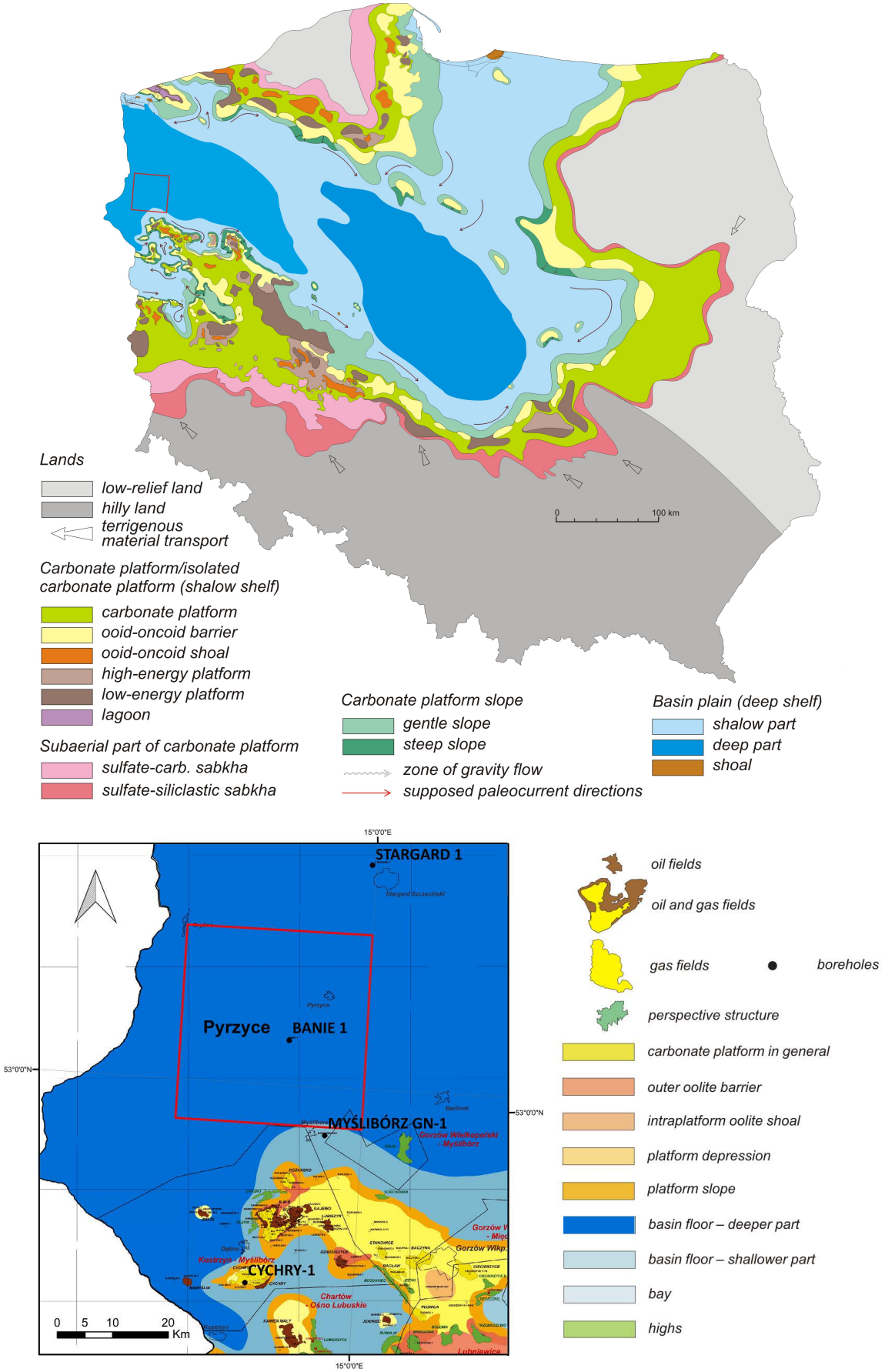


Fig. 7. Location of the Pyrzyce tender area on the map of the Zechstein/Main Dolomite palaeogeography and facies in Poland (Wagner, 2012, Buniak et al., 2013; modified).

Triassic (Figs 8–9)

Lithostratigraphy: Baltic Formation, Pomorze Formation, Połczyn Formation, Rhoet; Muschelkalk; Keuper (including Lower Gypsum Beds, Reed Sandstone, Upper Gypsum Beds, Zbąszynek Beds, Jarkowo Beds and Wielichowo Beds.
Lithology: claystones with intercalations of limestones and anhydrites (Baltic and Pomorze Formations), sandstones and claystones with gypsum clasts (Połczyn Formation), claystones with clasts of marls, limestones, dolomites and anhydrites (Rhoet); dolomitic marls, limestones, dolomites and claystones (Muschelkalk); claystones with gypsum clasts (Keuper Lower and Upper Gypsum Beds), clasytones with sandstone clasts (Keuper Reed Sandstone), clasystones (Zbąszynek, Jarkowo and Wielichowo Beds).
Wells and depth: Banie 1 (1513.0–2908.5 m),
Chabowo 1 (1163.0–2632.0 m),
Chabowo 2 (1218.5–1760.0 m),
Chabowo 3 (1511.5–2090.0 m),
Myślibórz GN-1 (1343.0–2750.0 m).
Thickness (according to wells): >541.5–1395.5 m.

Jurassic (Figs 8–9)

Lithostratigraphy: Lower Jurassic – Zagaje Formation, Skłoby Formation, Ostrowiec Formation, Łobez Formation, Komorów Formation, Ciechocinek Formation, Borucice Formation; Middle Jurassic – Moglino Formation; Upper Jurassic undivided.
Lithology: sandstones, mudstones and claystones in the Lower and Middle Jurassic; limestones in the Upper Jurassic.
Wells and depth: Banie 1 (1054.5–1513.0 m),
Chabowo 2 (714.5–1218.5 m),
Chabowo 3 (1024.0–1511.5.0 m),
Myślibórz GN-1 (931.0–1343.0 m).
Thickness (according to wells): 458.5–487.5 m.

Cretaceous (Figs 8–9)

Lithology: Lower Cretaceous sandstones and marls, and Upper Cretaceous limestones, marls, opokas and chalk.
Wells and depth: Banie 1 (200.0–1054.5 m),
Chabowo 1 (92.5–678.5 m),
Chabowo 2 (101.0–714.5 m),
Chabowo 3 (159.0–1024.0 m),
Myślibórz GN-1 (233.0–931.0 m).
Thickness (according to wells): 586.0–865.0 m.

Paleogene and Neogene
(Eocene, Oligocene and Lower Miocene)

Lithology: sands, silts and clays with brown coal intercalations in the Lower Miocene.
Wells and depth: Banie 1 (0–200.0 m),
Chabowo 2 (68.5–101.0 m),
Chabowo 3 (130.0–159.0 m),
Myślibórz GN-1 (74.0–233.0 m).
Thickness (according to wells): 29.0–200.0 m.

Quaternary

Lithology: gravels, sands, clays, tills.
Thickness: ~11–224 m.

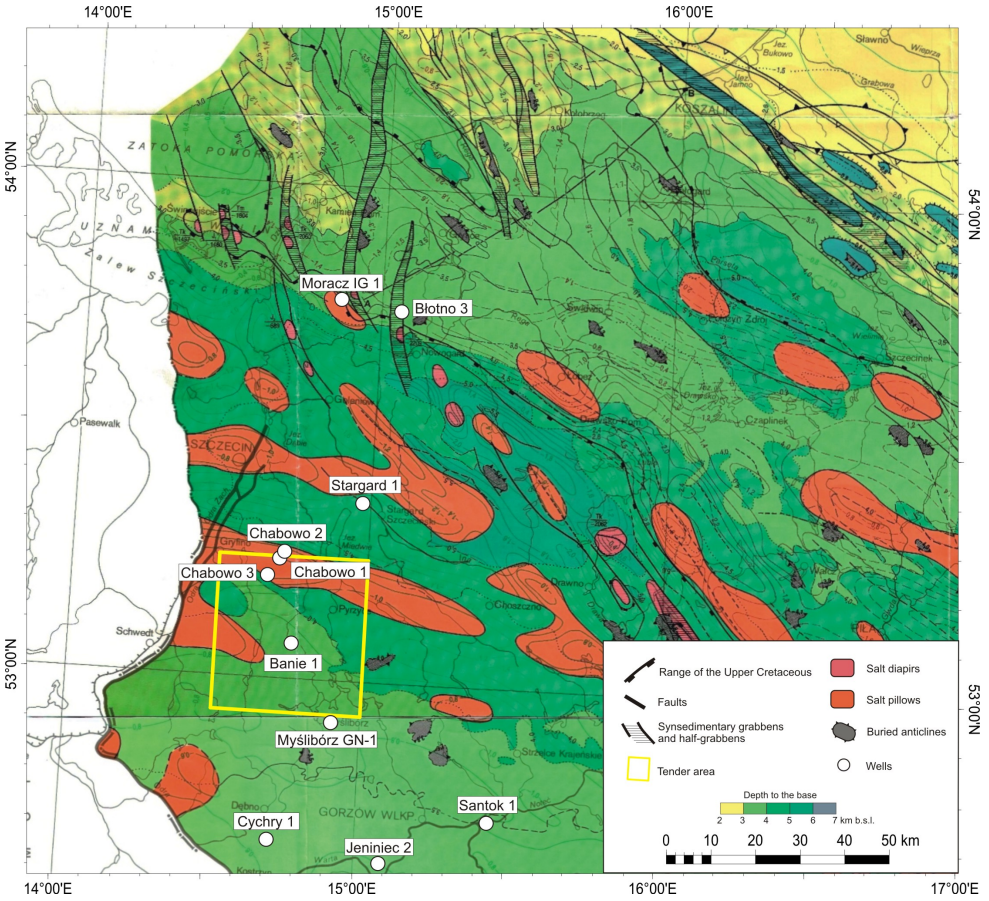


Fig. 8. Location of the Pyrzyce tender area on the tectonic map of the Zechstein-Mesozoic complex (Dadlez, 1998; modified).

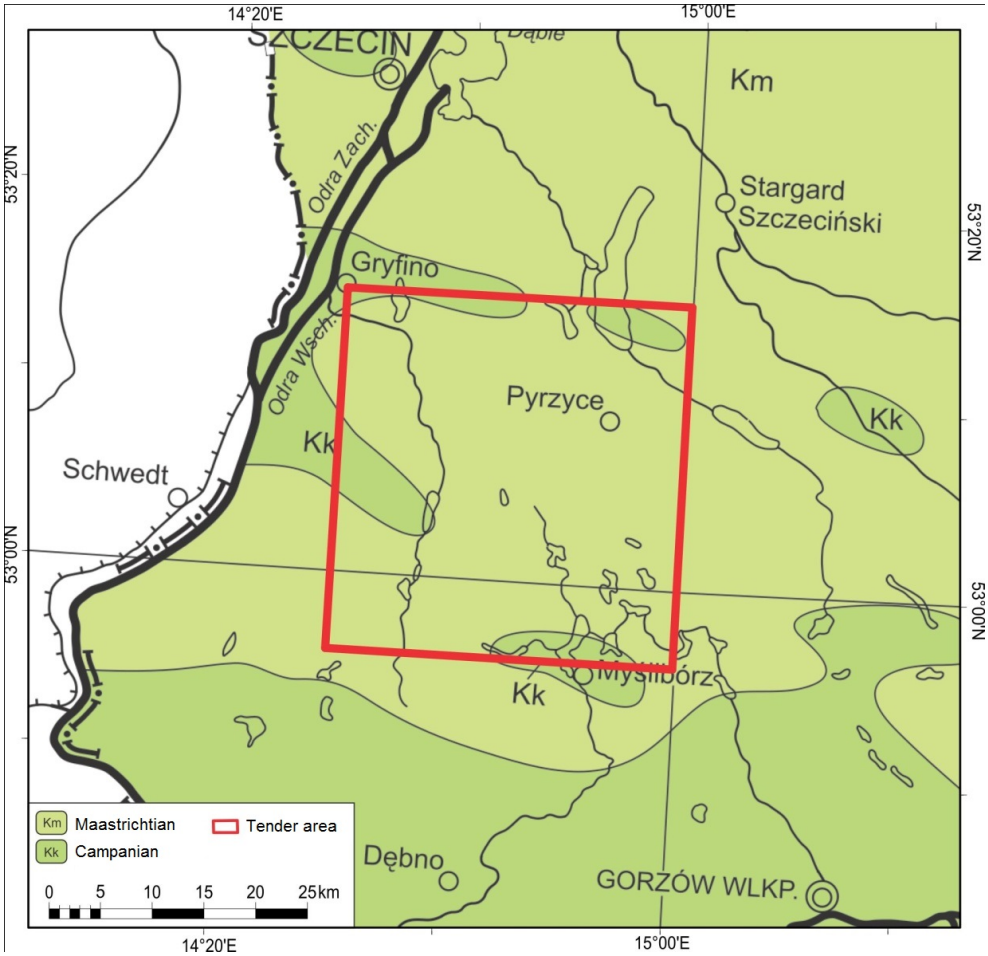


Fig. 9. Location of the Pyrzyce tender area on the geological map of Poland without Cenozoic cover (Dadlez et al., 2000; modified).

3. PETROLEUM SYSTEMS

Two conventional petroleum systems are developed in the Pyrzyce tender area (Fig. 10). These are:

- Carboniferous-Permian petroleum system (with Rotliegend and Weissliegend as reservoir rocks),
- Permian petroleum system (with Zechstein/Main Dolomite as reservoir rocks).

They are separated by succession of evaporites of the first Zechstein cyclotheme.

Carboniferous-Permian (Rotliegend and Weissliegend) petroleum system

Source rocks: Carboniferous fine-grained clastic rocks.
TOC = 0.8–4.0%.
Kerogen type: I, II, III.

Reservoir rocks: Rotliegend and Weissliegend sandstones.
Porosity (average in wells) = 0.78–5.52%.
Permeability (average in wells) = 0.05–2.8 mD.

Seal rocks: succession of evaporites of the first Zechstein cyclotheme.

Thickness of the overburden: 3906.0–4766.0 m.

Traps: structural and stratigraphic (narrowing of sandstone layers of alluvial fans) at the top of the Rotliegend/Weissliegend succession.

Hydrocarbon fields: none.

References: Pożaryski and Dembowski, 1983; Kotarba, 1997; Pokorski and Miłaczewski, 1997; Nowak, 2003; Burzewski et al., 2009; Pletsch et al., 2010; Poprawa and Kiersnowski, 2010; Botor et al., 2013.

Zechstein (Main Dolomite) petroleum system

Source rocks: organic-rich interbeds within the Main Dolomite succession (stromatolites and algae mats of carbonate platforms, carbonate muds and sands of platform slopes).
TOC = 0.01–6.0%.
TOC_0 = 0.8–5.0%.
T_{max} = 445–482°C.
Kerogen type: II, III, I.

Reservoir rocks: Main Dolomite carbonates.
Porosity (average in wells) = 0.9–18.0%.
Permeability (average in wells) = 0.3–42.0 mD.

Seal rocks: succession of evaporites of the second, third and fourth Zechstein cyclothemes.

Thickness of the overburden: 3628.0–4603.0 m.

Traps: structural and stratigraphic (related to carbonate platform deposits in the Main Dolomite).

Hydrocarbon fields: Barnówko-Mostno-Buszewo, Gajewo, Lubiszyn, Różańsko, Zielin.

References: Pikulski, 1998; Kotarba and Wagner, 2002, 2007.

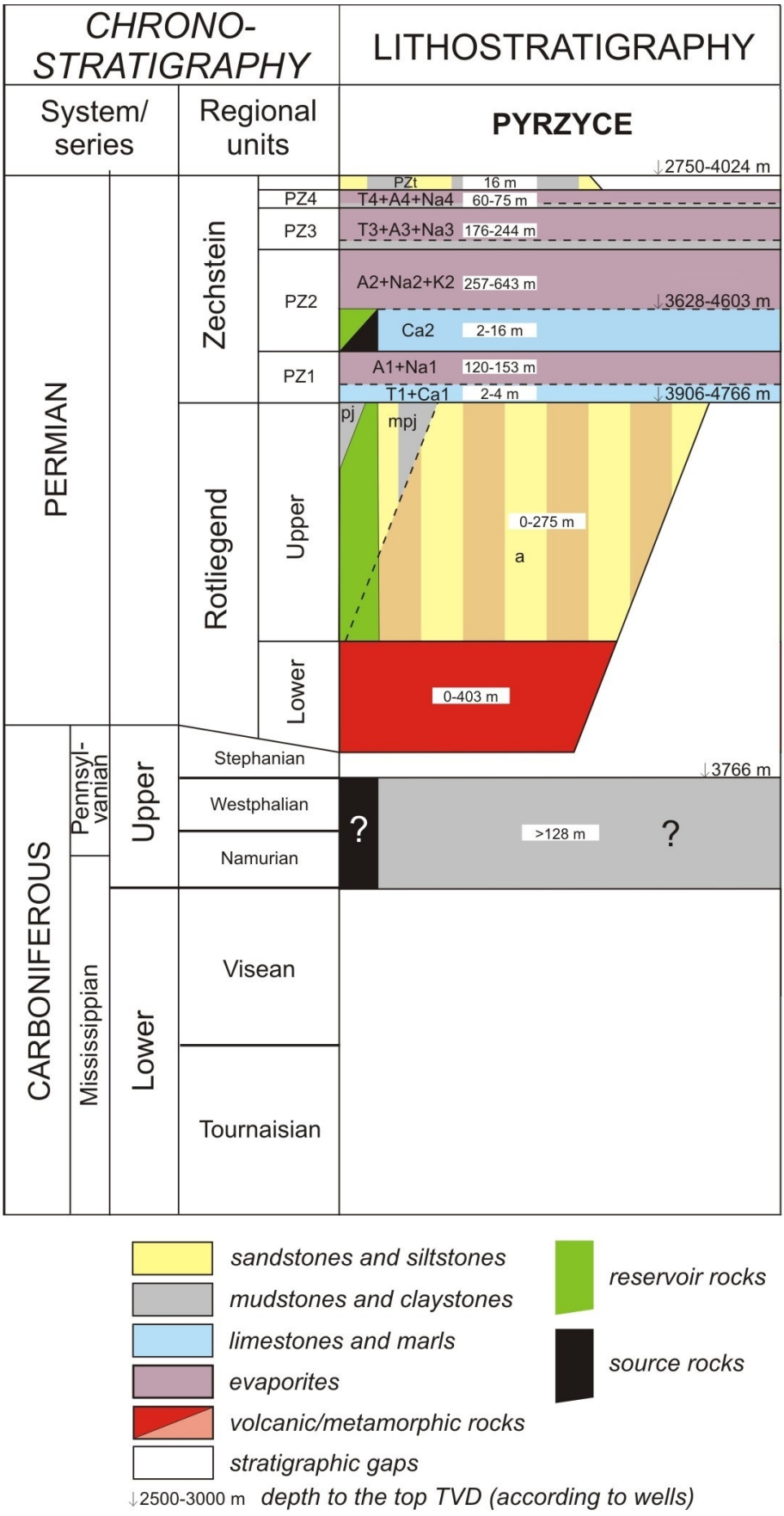


Fig. 10. Stratigraphy, lithology and major elements of petroleum system (main horizons of source and reservoir rocks) in the Pyrzyce tender area (Jagielski et al., 2019; modified).
a – alluvial deposits, pj – playa-lake deposits, mpj– marginal playa-lake deposits

4. HYDROCARBON FIELDS

Numerous hydrocarbon fields have been discovered in the southern neighborhood of the Pyrzyce tender area in the Main Dolomite. These are (Fig. 11):

- Różańsko gas field (GZ 6732),
- Barnówko-Mostno-Buszewo oil field (NR 7065),
- Gajewo oil field (NR 15122),
- Lubiszyn oil field (NR 7407),
- Zielin oil field (NR 5513).

They are still exploited.

Concession for prospection, exploration and exploitation of hydrocarbons from a deposit in Poland 2018

PYRZYCE TENDER AREA

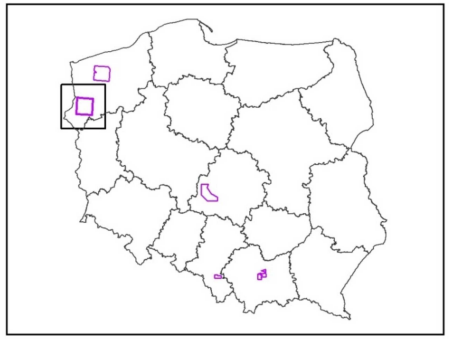
0 2 4 8 12 16 20 km

Legend

- tender area
- oil and gas fields
- mining areas
- communes
- counties
- voivodeships

Border points
coordinate system - PL 1992

Point no.	X	Y
1	607760.99	199928.41
2	605776.69	233253.30
3	570804.18	231298.33
4	572915.76	197736.11



The source of data:
System of management and protection of mineral resources in Poland - MIDAS

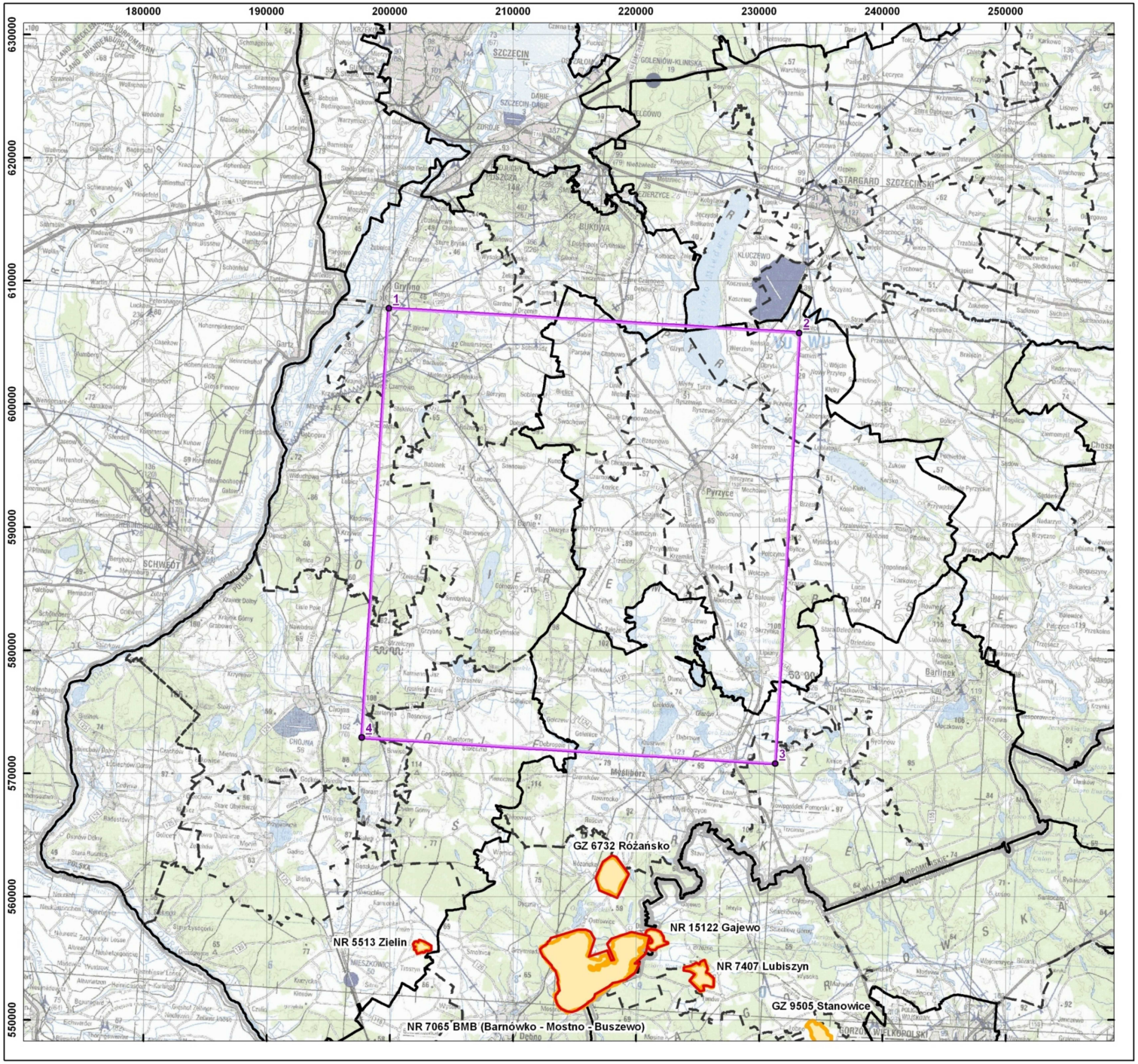


Fig. 11. Oil and gas fields in the neighborhood of the Pyrzyce tender area.

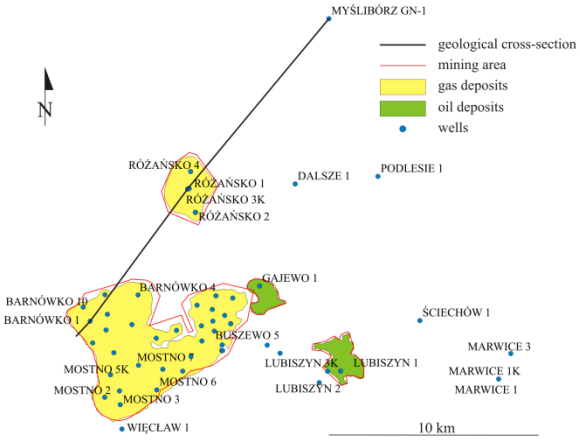
Różańsko gas field

Acreage: 496.75 ha.
Depth: from -3122.68 m a.s.l. to -3160.50 m a.s.l.
Stratigraphy: Permian-Zechstein (Main Dolomite).
Resources:

- Extractable balance resources as of 2017: 2231.52 million m^3 of natural gas in cat. C,
- Economic resources in place as of 2017: 744.49 million m^3,
- Production in 2017: none.

Parameter	Average value	Unit	Comment
casing head pressure	43.53	MPa	Różańsko 1 well
initial reservoir pressure	56.40	MPa	–
total depth	-3160.93	m	= aquifer depth; Różańsko 1 well
total depth	-3160.86	m	= aquifer depth; Różańsko 2 well
total depth	-3160.50	m	total depth for measurements
aquifer depth	-3160.50	m	based on geophysical measurements & core analysis
net pay	18.12	m	–
bed volume	90 031 250	m^3	–
effective porosity	14.83	%	–
permeability	15.59	mD	–
efficiency	613.00	m^3/min	Różańsko 1 well

Tab. 2. Quality parameters of the Różańsko gas field (MIDAS, 2019; according to Liberska, 1995).



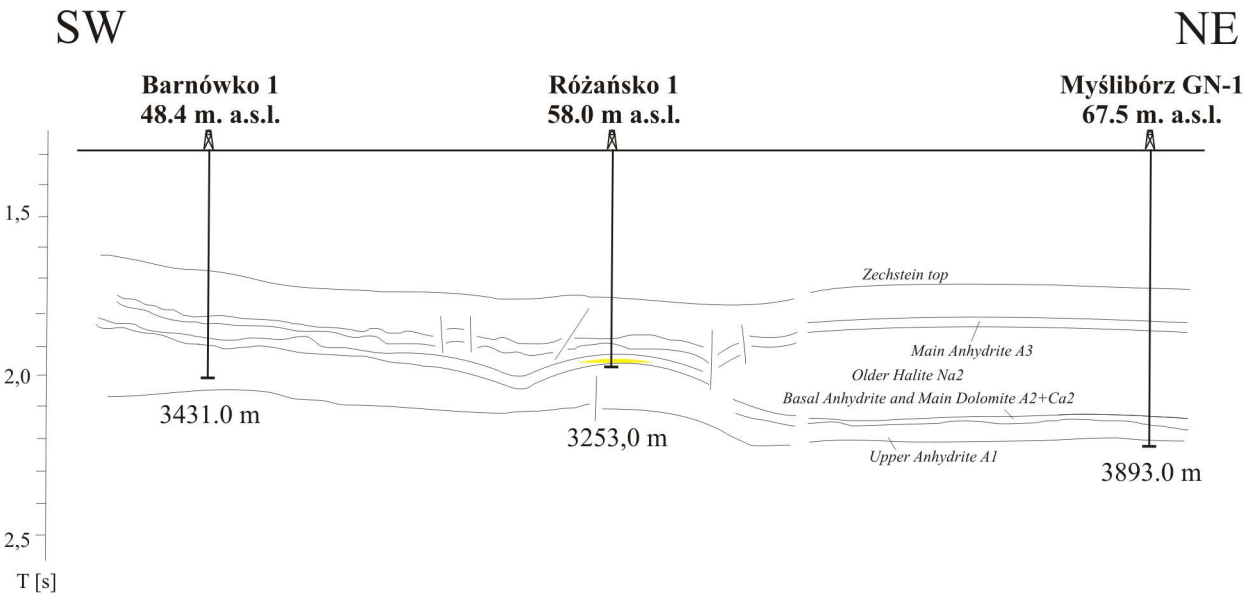
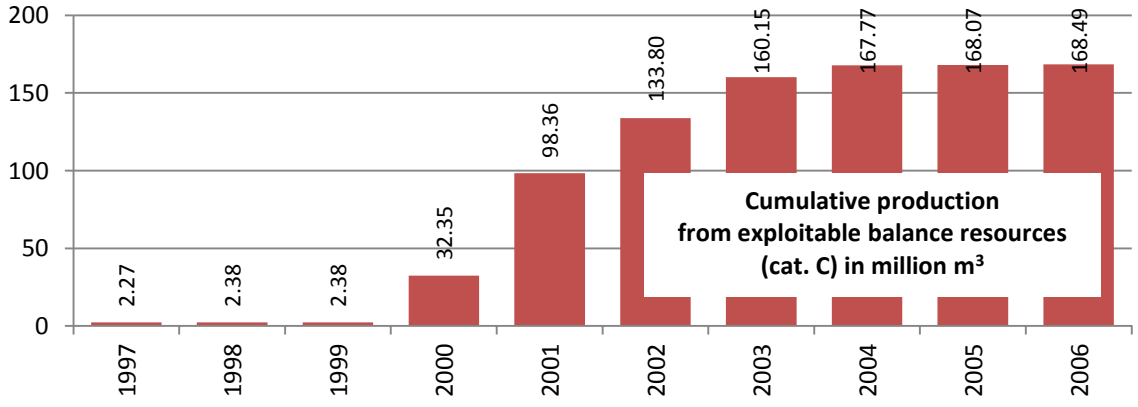


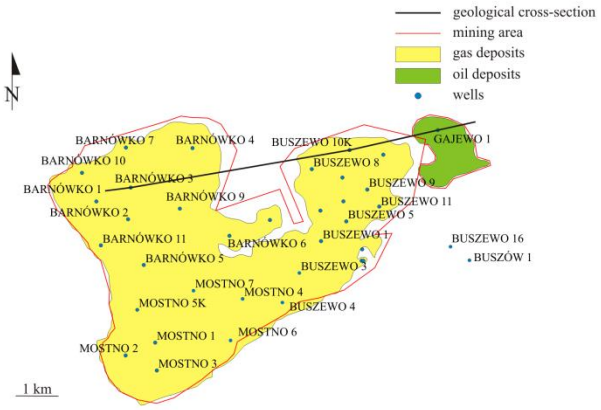
Fig. 12. Map and geological cross section through the Różańsko gas field (CBDG, 2019; Karnkowski, 1999).



Barnówko-Mostno-Buszewo oil field

Acreage: 2977 ha (oil field: 2840 ha
and gas field 1380 ha)
Depth: from -2981.0 m a.s.l. to -3098.0 m a.s.l.
(gas cap from -2981.0 m a.s.l. to -3047.5 m a.s.l.),
(oil accum. from -3047.5 m a.s.l. to -3098.0 m a.s.l.).
Stratigraphy: Permian/Zechstein (Main Dolomite).
Resources:

- Extractable balance resources as of 2017:
  6190.95 ktonnes of oil in cat. B,
  2574.22 million m^3 of natural gas in cat. B,
- Economic resources in place as of 2017:
  3727.49 ktonnes of oil,
  none of natural gas,
- Production in 2017:
  302.55 ktonnes of oil,
  398.94 million m^3 of natural gas.



Parameter	Average value	Unit	Comment
actual pressure	50.30	MPa	oil accumulation, as of 05.2005
bottom hole pressure	55.15	MPa	oil accumulation, Buszewo 3 well, as of 07.11.1996
aquifer depth	-3098.00	m	oil accumulation
net pay	25.50	m	oil accumulation
effective porosity	17.06	%	oil accumulation
permeability	10.50	mD	oil accumulation
maximum efficiency V_{max}	1495.00	t/d	efficiency of oil accumulation
gas-oil ratio	226.00	m^3/m^3	oil accumulation
actual pressure	50.750	MPa	gas cap, as of 05.2005
primary reservoir pressure	55.648	MPa	gas cap on depth -3047.5 m
aquifer depth	-3098.00	m	gas cap
net pay	22.95	m	gas cap
effective porosity	17.40	%	gas cap
permeability	12.23	mD	gas cap
total efficiency V_{tot}	7889.00	m^3/min	efficiency of gas accumulation
maximum efficiency V_{max}	775.00	m^3/min	efficiency of gas accumulation
gas-oil ratio	276.00	Nm^3/t	–

Tab. 3. Quality parameters of the Barnówko-Mostno-Buszewo oil field (MIDAS, 2019, according to Liberska, 2006).

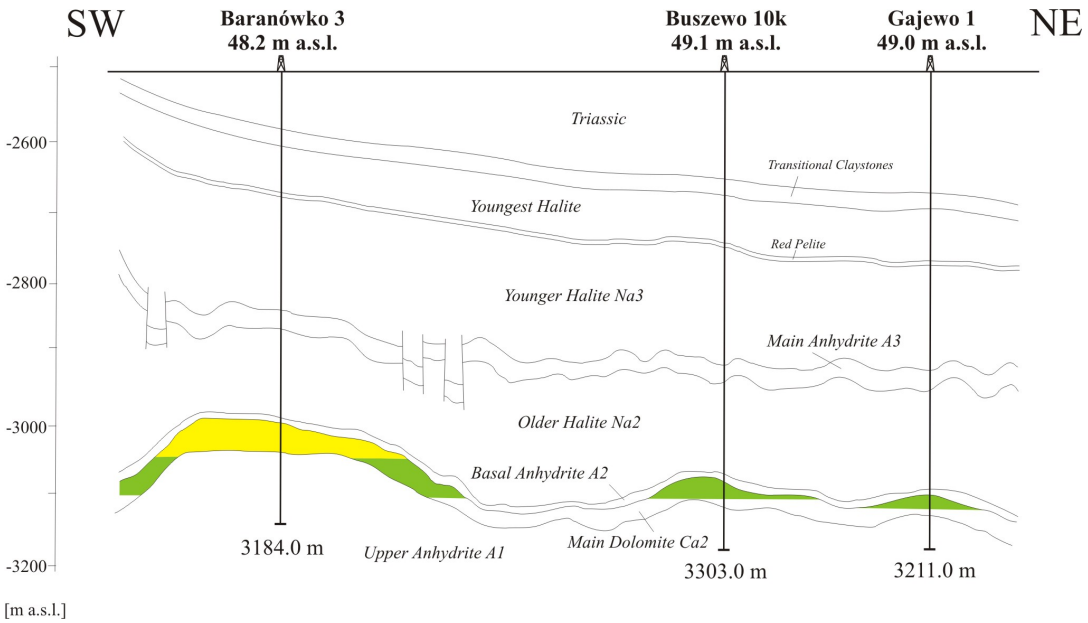
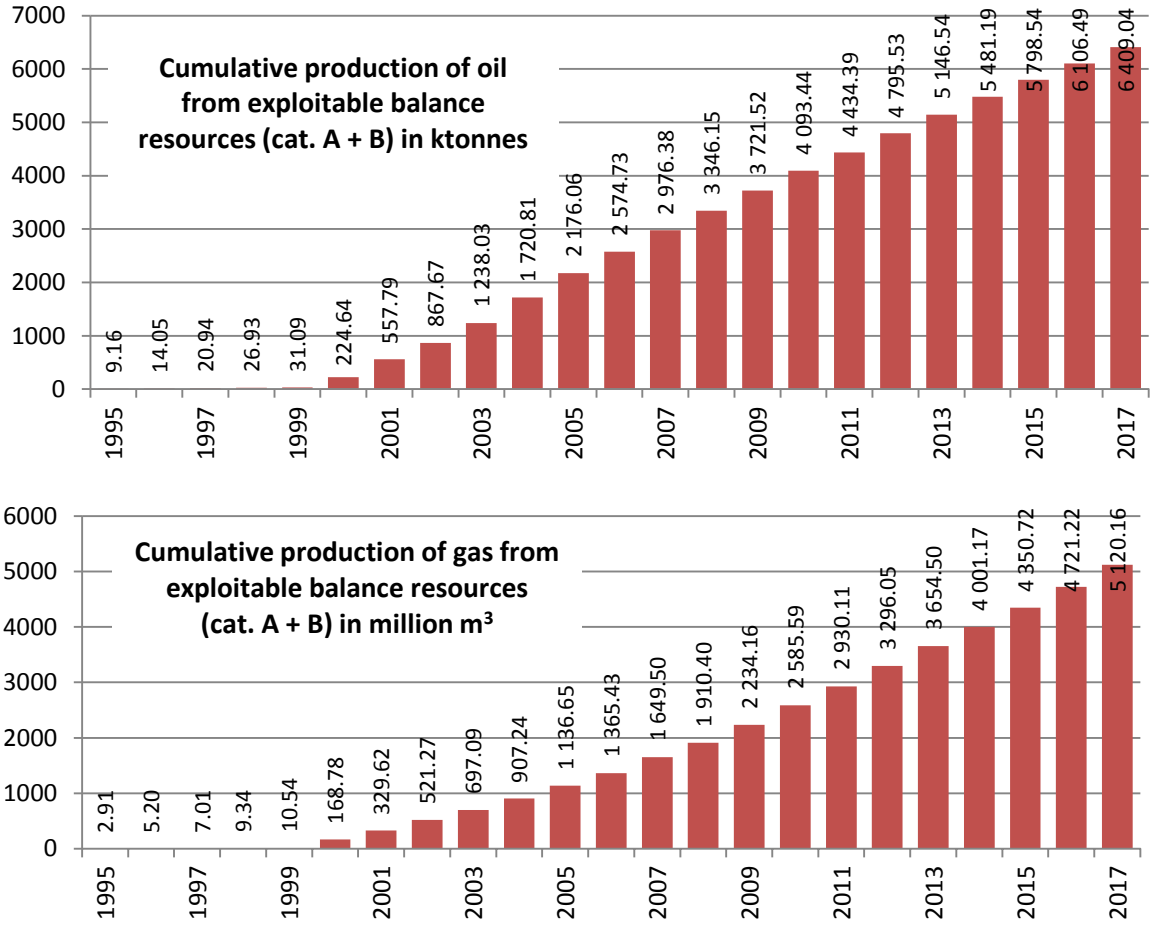


Fig. 13. Map and geological cross section through the Barnówko-Mostno-Buszewo oil field and Gajewo oil field (CBDG, 2019; Mamczur et al., 1997; Żurawik, 1996).



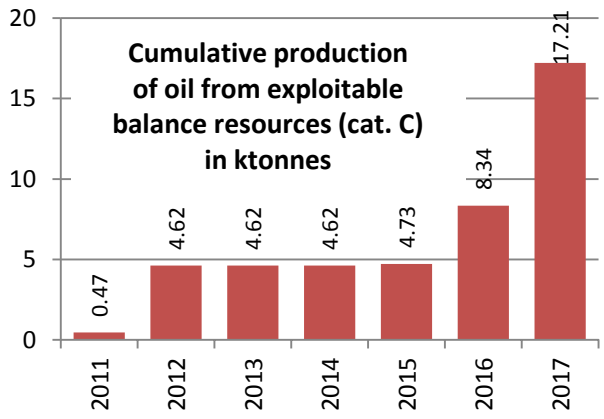
Gajewo oil field

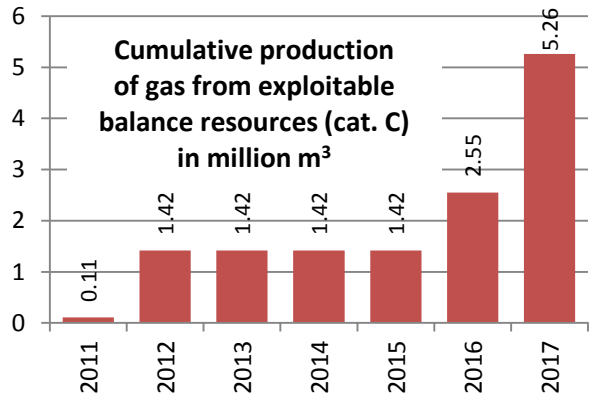
Acreage: 166.00 ha.
Depth: from -3090.50 m a.s.l. to -3108.50 m a.s.l.
Stratigraphy: Permian-Zechstein (Main Dolomite).
Resources:

- Extractable balance resources as of 2017:
  36.51 ktonnes of oil in cat. C,
  13.15 million m^3 of natural gas in cat. C,
- Economic resources in place as of 2017:
  37.68 ktonnes of oil,
  13.44 million m^3 of natural gas,
- Production in 2017:
  8.87 ktonnes of oil,
  2.71 million m^3 of natural gas.

Parameter	Average value	Unit	Comment
primary reservoir pressure	55.670	MPa	January 1998
actual pressure	50.480	MPa	November 2010
net pay	6.20	m	–
effective porosity	14.700	%	–
permeability	20.645	mD	effective permeability
maximum efficiency V_{max}	9.500	m^3/min	for gas; choke 8/64"
maximum efficiency V_{max}	0.033	m^3/min	for oil; 47,35 m^3/day; choke 8/64"
gas-oil ratio	289.000	m^3/m^3	351 m^3/t

Tab. 4. Quality parameters of the Gajewo oil field (MIDAS, 2019, according to Kuczak, 2011).





Lubiszyn oil field

Acreage: 277.00 ha.
Depth: from -3050.50 m a.s.l. to -3080.00 m a.s.l.
Stratigraphy: Permian/Zechstein (Main Dolomite).
Resources:

- Extractable balance resources in 2017:
  5.96 ktonnes of oil in cat. C,
  2.14 million m^3 of natural gas in cat. C,
- Economic resources in place in 2017:
  5.82 ktonnes of oil,
- Production in 2017:
  2.36 ktonnes of oil,
  0.88 million m^3 of natural gas.

Parameter	Average value	Unit	Comment
actual pressure	48.33	MPa	as of 31.12.1998
primary reservoir pressure	55.03	MPa	–
net pay	23.50	m	Lubiszyn 1well
net pay	10.18	m	Lubiszyn 3k BIS well
porosity	2.321	%	Lubiszyn 1 well, based on laboratory measurements
porosity	9.211	%	Lubiszyn 3k BIS well, based on laboratory measurements
effective porosity	5.20	%	–
permeability	0.028	mD	Lubiszyn 1 well, based on laboratory measurements
permeability	0.728	mD	Lubiszyn 3k BIS well, based on laboratory measurements

Tab. 5. Quality parameters of the Lubiszyn oil field (MIDAS, 2019; according to Pikulski, 1999).

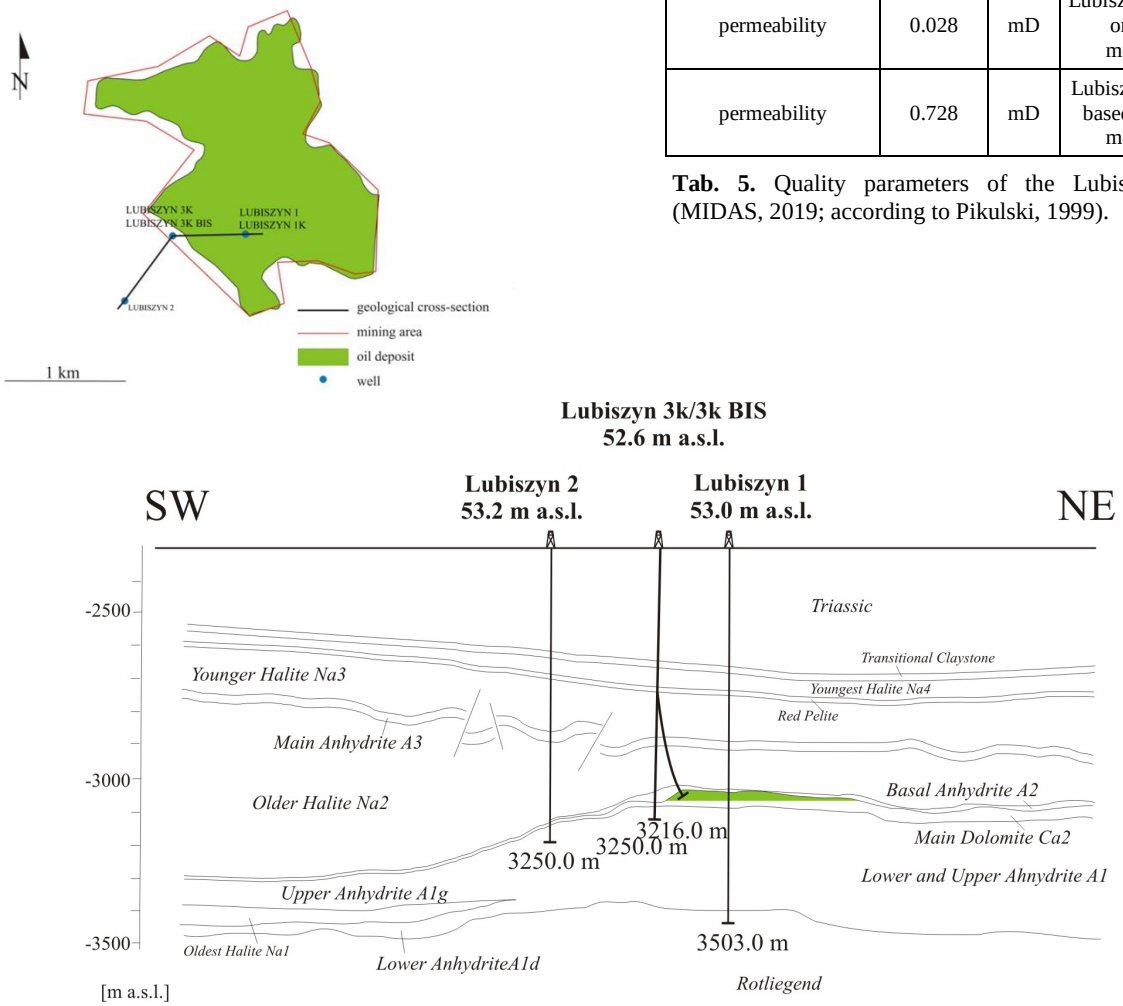
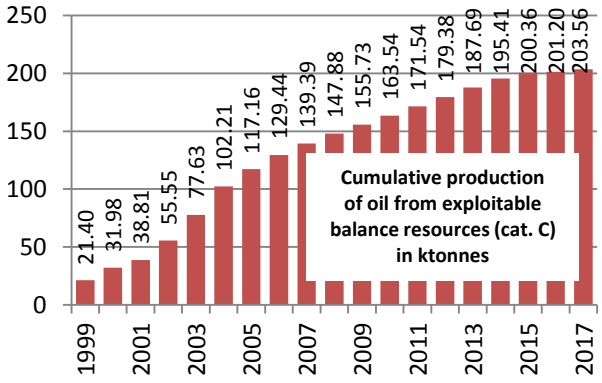
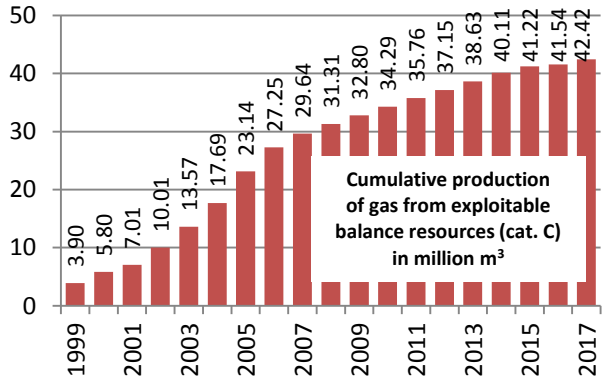


Fig. 14. Map and geological cross section through the Lubiszyn oil field (CBDG, 2019; Pikulski, 1999).

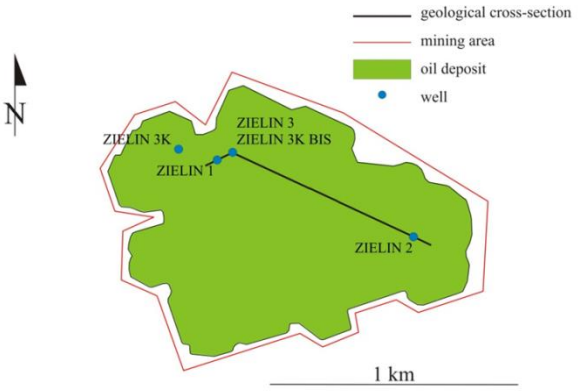




Zielin oil and gas field

Acreage: 93.61 ha.
Depth: from -3202.00 m a.s.l. to -3150.80 m a.s.l.
Stratigraphy: Permian/Zechstein (Main Dolomite).
Resources:

- Extractable balance resources in 2017:
  0.82 ktonnes of oil in cat. B,
- Economic resources in place in 2017:
  0.42 ktonnes of oil,
- Production in 2017:
  0.89 ktonnes of oil,
  5.43 million m^3 of natural gas.



Parameter	Average value	Unit	Comment
actual pressure	20.39	MPa	as of 19.06.2007
initial reservoir pressure	67.98	MPa	–
aquifer depth	–	m	unknown, deeper than -3202.0 m
net pay	17.94	m	–
porosity	5.18	%	Zielin 1 well, Zielin 3K BIS well
porosity	6.48	%	Zielin 2 well
permeability	3.37	mD	–
maximum efficiency V_{max}	23.00	t/d	Zielin 2 well
maximum efficiency V_{max}	23.00	t/d	Zielin 3K BIS well (01.11.2007)
gas-oil ratio	3615.00	m^3/t	as of 31.12.2006
gas-oil ratio	1514.00	m^3/t	initial

Tab. 6. Quality parameters of the Zielin oil field (MIDAS, 2019; according to Pawłowski, 2007).

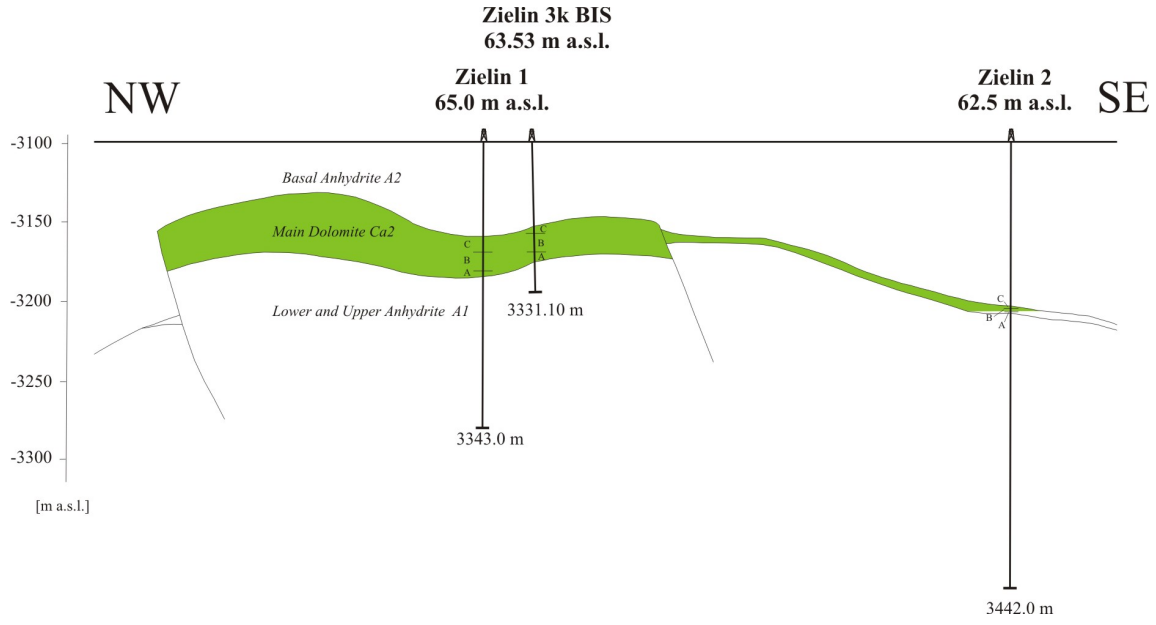
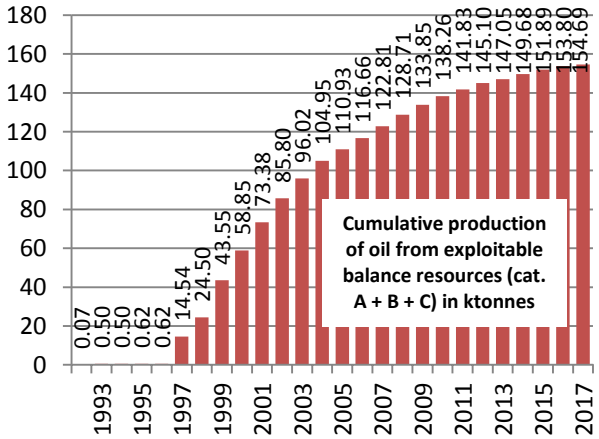
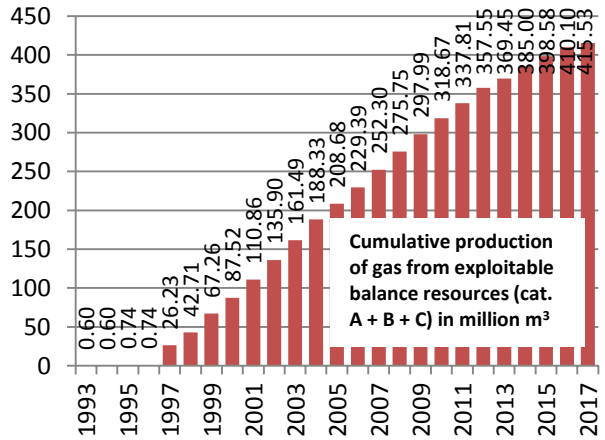


Fig. 15. Map and geological cross section through the Zielin oil field (CBDG, 2019; Pękalska-Oświęcimska, 1995).





5. WELLS

Seventeen deep wells (> 500 m TVD) reached the prospective intervals within the Pyrzyce tender area and in its close neighborhood (Fig. 22). These are: Banie 1, Chabowo 1, 2, 3, Cychry 1, Myślibórz GN-1, Różańsko 1, 1A, 3, 3K, 4, Stargard 1, Zielin 1, 2, 3, 3K, 3K BIS (wells located within the tender area are highlighted). Data from wells located at the Różańsko and Zielin fields belong to the investor (PGNiG – Polish Oil and Gas Company) and cannot be disclosed in this report. Basic information, accessible in CBDG databases and scientific papers (Mamczur et al., 1997, Pikulski, 1998) are summarized in Tab. 11.

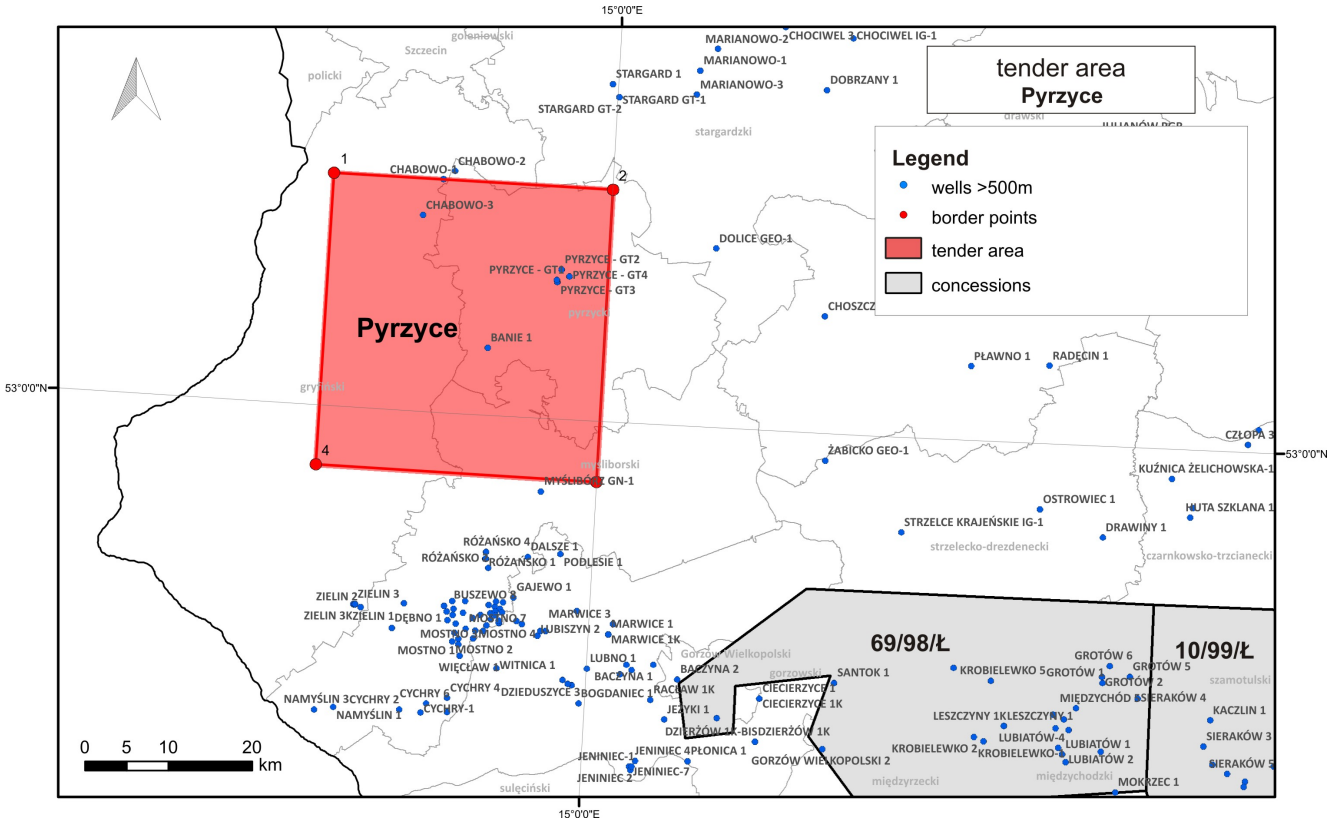


Fig. 16. Deep wells (> 500 m TVD) reaching the prospective intervals within the Pyrzyce tender area and in its close neighborhood.

STRATIGRAPHY		BANIE 1				CHABOWO 1				CHABOWO 3				CYCHRY 1				MYŚLIBÓRZ GN-1				STARGARD 1			
		Top [m]	Bottom [m]	Porosity min–max [%]	Permeability min–max [mD]	Top [m]	Bottom [m]	Porosity min–max [%]	Permeability min–max [mD]	Top [m]	Bottom [m]	Porosity min–max [%]	Permeability min–max [mD]	Top [m]	Bottom [m]	Porosity min–max [%]	Permeability min–max [mD]	Top [m]	Bottom [m]	Porosity min–max [%]	Permeability min–max [mD]	Top [m]	Bottom [m]	Porosity min–max [%]	Permeability min–max [mD]
CENOZOIC		0.0	200.0			0.0	92.5			0.0	159.0	–	–	0.0	205.0			0.0	233.0			0.0	371.0		
CRETACEOUS		200.0	1054.5			92.5	678.5	35.2–41.3	9.6	159.0	1024.0	9.5–39.3	0.1–5.6	205.0	682.0			233.0	931.0			371.0	1842.0		
JURASSIC		1054.5	1513.0			678.5	1163.0			1024.0	1511.5			682.0	972.5			931.0	1343.0			1842.0	2414.5		
UPPER TRIASSIC		1513.0	1949.0			1163.0	1589.0	3.3–20.1	0.3–331	1511.5	1965.5	1.6–16.9	0.34–102.0	972.50	1442.0	9.01–13.65	0.21	1343.0	1830.0			2414.5	3095.0		
MIDDLE TRIASSIC		1949.0	2285.0			1589.0	1918.0	1.8–21.0	0.0–34.8	1965.5	2049.0	0.6–17.4	0.91–74.0	1442.0	1775.0	2.08–11.85	0.12–11.30	1830.0	2180.0			3095.0	3324.0		
LOWER TRIASSIC		2285.0	2908.5			1918.0	2610.0	0.2–14.5	0.0–28.0					1775.0	2381.0	5.21–18.45	0.49–2.05	2180.0	2750.0			3324.0	4024.0		
PERMIAN	*Rewal Formation*					2610.0	2632.0	1.36	–																
	Top terrigenous Series PZt	2908.5	2924.0											2381.0	2396.0										
	Zechstein PZ4b					2632.0	2708.0	–	–																
	Top Youngest Halite Na4b2	2924.0	2934.0															2750.0	2757.5			4024.0	4032.50		
	Upper Red Pelite – upper part T4b2	2934.0	2935.5																						
	Separating salt Na4b1	2935.5	2938.0															2757.5	2761.0			4032.5	4037.50		
	Upper Red Pelite – Lower part T4b1	2938.0	2941.0																						
	Upper Youngest Halite Na4a2	2941.0	2984.0											2396.0	2442.5							4037.5	4098.00		
	Lower Youngest Halite Na4a1																	2761.0	2806.0						
	Lower Pegmatite Anhydrite A4a1	2984.0	2985.0															2806.0	2807.5						
	Lower Red Pelite T4a	2985.0	2993.0											2442.5	2448.0			2807.5	2809.5			4098.0	4102.00		
	Younger Halite Na3	2993.0	3150.0											2448.0	2589.0			2809.5	2925.0			4102.0	4320.00		
	Main Anhydrite A3	3150.0	3172.5											2589.0	2614.0			2925.0	2983.0	1.0	1.7	4320.0	4342.50		
	Platy Dolomite Ca3																					4342.5	4346.00		
	Grey Pelite T3	3172.5	3177.5											2614.0	2616.0			2983.0	2985.0						
	Screening Anhydrite A2r	3177.5	3179.0											2616.0	2619.0			2985.0	2987.0			4346.0	4348.50		
	Screening Older Halite Na2r	3179.0	3181.0																						
	Older Potash K2	3181.0	3196.0															2987.0	3020.0			4348.5	4371.00		
	K2 + Na2																					4371.0	4599.00		
	Older Halite Na2	3196.0	3762.5											2619.0	3064.0			3020.0	3624.0	0.4 – 3.1	0.3 – 1.7				
	Basal Anhydrite A2	3762.5	3765.5											3064.0	3073.0			3624.0	3628.0	0.4 – 0.7	0.3 – 0.7	4599.0	4602.50		
	Main Dolomite Ca2	3765.5	3767.5											3073.0	3076.0			3628.0	3643.5	0.3 – 1.4	0.2 – 0.5	4602.5	4609.00		
	Upper Anhydrite A1g	3767.5	3808.5																			4609.0	4668.00		
	Oldest Halite Na1	3808.5	3856.0																			4668.0	4714.00		
	Lower Anhydrite A1d	3856.0	3903.5															3643.5	3763.5			4714.0	4762.00	0.14–0.3	0.0
	Zechstein Ca1	3903.5	3906.0	0.0	0.0													3763.5	3764.5			4762.0	4766.00		
	Copper Shale T1																	3764.5	3765.5						
	Upper Rotliegend	3906.0	3931.0	0.1 – 25.9	0.0 – 31.0																	4766.0	5041.00	0.1 – 5.9	0.0 – 0.4
	Lower Rotliegend	3931.0	4090.0																						
	Autunian																					5041.0	5444.00	0.1 – 4.0	0.0 – 0.7
CARBONIFEROUS																		3765.5	3893.0						

Tab. 7. Stratigraphy and petrophysical characteristics in the Banie 1 (Ryba and Knitter, 1975), Chabowo 1, 3 (Biraga et al., 1990), Cychry 1 (Wojtkowiak, 1973), Myślibórz GN-1 (Wolnowski and Czarniecki, 1971), Stargard 1 (Ryba and Sikorska-Piekut, 1977).

Well:	BANIE 1	CHABOWO 1	CHABOWO 3	CYCHRY 1	MYŚLIBÓRZ GN-1	STARGARD 1
Depth:	4090.0	2708.0	2090.0	3076.0	3893.0	5440.0
Drill core – storage	NAG: Chmielnik	NAG: Szurpiły, Halinów	NAG: Szurpiły	NO core	NAG: Chmielnik	NAG: Chmielnik
PK		0.0 – 2700.0	0.0 – 2075.0	2150.0 – 3070.0		
PŚr	225.0 – 4050.0	33.0 – 2700.0	200.0 – 2075.0	10.0 – 3064.0	27.0 – 3880.0	0.0 – 1898.0
PAa2				285.0 – 2207.0		
PAc		30.0 – 2280.0	15.0 – 2025.0	10.0 – 3028.0		
PAdt	225.0 – 4056.0	208.0 – 1440.0		2200.0 – 3075.0		0.0 – 1381.5
PAt1				2200.0 – 3075.0		
PAt2				2200.0 – 3075.0		
PG	44.0 – 4051.0	150.0 – 2270.0	2.0 – 2075.0		9.0 – 3885.0	2268.2 – 3120.0
PG SP–62		2.0 – 2700.0		1.00 – 3072.0		
PGG		150.0 – 2270.0	4.0 – 1595.0			
PNG	46.2 – 4051.0				10.0 – 3885.0	2268.2 – 3120.0
PNG SP–62		2.0 – 2700.0		1.00 – 2210.0		
PNNnt		150.0 – 2270.0	4.0 – 2088.0			
PS	230.0 – 2910.0	33.0 – 2700.0	203.0 – 2085.0	35.0 – 2209.0		
PO	230.0 – 2925.0					
	EL28 234.7 – 4056.0	A0.25M0.1N 205.0 – 2700.0	A0.5M0.1N 203.0 – 2085.0	B4.0A0.5M 35.0 – 2209.0	EL28 40.0 – 3880.0	EL02 2045.5 – 3057.7
		A1.0M0.1N 205.0 – 2700.0	A1.0M0.1N 203.0 – 2085.0	M2.5A0.25B 35.0 – 2072.0		EL03 2045.5 – 2886.2
		A2.5M0.25N 205.0 – 2700.0	A2.5M0.25N 203.0 – 2085.0	M4.0A0.5B 35.0 – 2209.0		EL09 2045.5 – 3052.75
		A4.0M0.5N 800.0 – 2700.0	A5.28M0.82N 203.0 – 2085.0	M8.0A1.0B 35.0 – 300.0		EL19 2045.5 – 3132.0
		A5.28M0.82N 1550.0 – 2700.0	N2.5M0.25A 203.0 – 2085.0			EL28 2045.5 – 3132.0
		B2.5M0.25N 1732.0 – 2270.0	EL09 202.5 – 2085.0			EN16 2045.5 – 3132.0
		N2.5M0.25A 205.0 – 1735.0	EL18 206.0 – 2078.0			
POg		A2.5M0.25N 33.0 – 2220.0				
POp		B2.5A0.25M 33.0 – 2270.0				
		N2.6M0.25A 2220.0 – 2700.0				
POpł		150.0 – 2270.0	10.0 – 2088.0			
POst	3767.0 – 4056.0	1732.0 – 2700.0		2209.0 – 2072.0		
POst LL3						
mPOst				2209.0 – 3070.0		
PTu		2.0 – 2704.0				
PTc				9.0 – 2074.0		
PGaz				663.0 – 2215.0		
Velocity survey	20.0 – 3720.0				20.0 – 3620.0	13 – 3956

Tab. 8. Well geophysics. Logs available in digital format are highlighted. PK – deviation log, PŚr – caliper, PAa2 – amplitude, acoustic log using dipole transmitter probe, PAc – cement bond log – acoustic log, PAdt – interval transit time – acoustic log, PAt – travel time T – acoustic log using SPAK-4 probe, PAt1 – travel time T1 – acoustic log, PAt2 – travel time T2 – acoustic log, PG – gamma ray log, PG SP-62 – gamma ray log using SP–62 probe, PGG – density log, PNG – neutron-gamma ray log, PNG SP-62 – neutron-gamma ray log using SP–62 probe, PNNnt – epithermal neutron log, PS – spontaneous potential log, PO – conventional electric log, POg – electric log using gradient probe, POp – electric log using N1.0M0.1A potential probe, POpł – salinity log, POst – focussed electric log, POst LL3 – focussed electric log using LL3 probe, mPOst –focussed electric microlog, PTu – temperature log in thermal equilibrium, PTc – temperature log after cementation, PGaz – gas log, velocity survey.

Wells	Top [m]	Bottom [m]	Stratigraphy	Flow kind
Banie 1	3865.5	3909.5	Lower Anhydrite–Zechstein–Rotliegend	3800 l flow of brine strongly gasificated with combustible gas, in autoclave: preassure – 80 atm; hydrostatic preassure – 591.3 atm, temp. 134°C, flow rate of brine – 1.34 m^3/h
Chabowo 1	2272.0	2277.0	Buntsandstein	No flow
	2072.0	2073.5		drilling fluid flow – ca.0.3 m^3, temp. 63°C at depth 2040 m
	1800.0	1805.0	Muschelkalk	no flow, temp. 67°C at depth 1814 m
	1623.0	1625.0	Keuper	no flow, temp. 56°C at depth 1592 m
	1623.0	1626.0		drilling fluid flow – ca.0.32 m^3, temp. 58°C at depth 1620 m
	750.0	747.5	Jurrasic	6.2 m^3 flow of slightly salinated fluid with hydrogen sulphide odour, temp. 36°C at depth 750 m
	725.5	727.0		5.85 m^3 flow of slightly salinated fluid with hydrogen sulphide odour, temp. 35°C at depth 718 m
	678.5	681.5		5.5 m^3 flow of black, slightly salinated fluid, temp. 32°C at depth 675 m
	519.5	530.0	Cretacerous	drilling fluid flow – 0.5 m^3, temp. 30°C at depth 520 m
Chabowo 3	1057.0	1147.0	Jurrasic	formation fluid flow – 7.8 m^3 within 56.5 min, temp.38.5°C at depth 1056 m
	1075.0	1077.0		formation fluid flow – 3.2 m^3 within 179.6 min, temp. 38°C at depth 1054 m
	1163.5	1166.5		formation fluid flow – 4.4 m^3 within 68.9 min, temp. 42°C at depth 1152 m
	1305.0	1308.0		formation fluid flow – 1.97 m^3 within 50.2 min, temp. 46°C
	1375.0	1385.0		formation fluid flow – 4.9 m^3 within 38.3 min, temp. 49°C
	1775.0	1780.0	Triassic	Formation fluid flow – 6.2 m^3 within 183.4 min.
	2031.0	2037.0		formation fluid flow – 6.6 m^3 within 127.7 min, temp. 82°C at depth 2030 m
Cychry 1	3073.0	3076.0		gas eruption
Myślibórz GN-1	922.0	927.0	Cretacerous	formation water flow
	2282.0	2295.0	Lower Triassic	no flow
	3630.0	3646.0	Main Dolomite and Lower Anhydrite	before casing, minimum flow of combustible gas with no formation water
				torpedoing, minimum flow of combustible gas, gasification
	3740.0	3806.4	Lower Anhydrite – Zechstein – Copper shale – Carboniferous?	no flow during drillig, in open hole
	3740.0	3879.2		
Stargard 1	4715.0	4863.0	Lower Anhydrite – Zechstein – Rotliegend	no flow, temp. 154°C at depth 4703 m
	4715.0	4937.0		minimum flow shows, formation preassure – 709 atm.

Tab. 9. Tests during drilling.

Wells	Top [m]	Bottom [m]	Stratigraphy	Shows
Banie 1	3765.50	3767.50	Main Dolomite	self-outflow of drilling fluid – 15 dm^3/h, outflow of mineralized formation water during flushing/cleaning
	3856.00	3903.50	Lower Anhydrite	hydrogen sulphide odour
	3906.0		Upper Rotliegend	gasification of drilling fluid 8% (20–50% of methane)
	3909.5			brine flow – 2.8 m^3, with gasification shows
Chabowo 1				NO shows
Chabowo 3				NO shows
Cychry 1	2215.0		Lower Triassic	circulation loss – 12 m^3
	2249.0	2280.5		circulation loss – 3 m^3
	3072.6		Basal Anhydrite	circulation loss – 4.13 m^3
	3073.1	3076.0	Main Dolomite	gas eruption
Myślibórz GN-1	3628.0	3643.5	Main Dolomite	gasification– 3.5%, gasification of drilling fluid, point gas traces in the core, hydrogen sulphide odour
	3765.5	3893.0	Carboniferous?	Gasification – 2.5%
Stargard 1	4746.0	4764.0	Lower Anhydrite, Zechstein	traces of gas
	4911.0		Rotliegend	circulation loss – 500 l/h
	4937.0			gasification of drilling fluid – 4% at
	5420.0	5425.0	Autunian	readings up to 40% at circulating gas logging
	5420.0	5444.0		numerous oil traces na spękaniach i powierzchniach oddzielności

Tab. 10. Hydrocarbon shows during drilling.

Well	Depth [m]	Stratigraphy at the bottom	Core: No. of boxes / magazin	Logs*	Main Dolomite		
					Thickness	Avg. porosity [%]	Avg. permeability [mD]
Różańsko 1	3253.0	Zechstein	No core	mPOst, PAdt, PAt1, PAt2, PG, PHI, PK, PNG, PNN, PO, POg, POst, PS, PSr	42.5–80.0	10–18	2.5–42
Różańsko 1A	3198.0	Zechstein	No core	dRoB, mPOst, PAc, PAt1, PAt2, PG, PGaz, PHI, PNG, PNNd, PO, POg, POst, PSr, RHOB			
Różańsko 2	3305.0	Zechstein	No core	APHI, BS, DPHI, dRoB, logPOst, NPHI, PAdt, PAP, PAt1, PAt2, PAt3, PAt4, PG, PGG, PHI, PK, PNG, PNN, PO, POg, POst, POTA, PS, PSr, RHOB, sPGbezU, THOR, TURA, URAN			
Różańsko 3K	3201.0	Zechstein	17/Chmielnik	BS, dRoB, MSFL, PSc, PSdt, PAt1, PAt2, PAt3, PAt4, PG, PGG, PHI, PK, PNG, PNNd, PNNk, PO, POg, POst, PS, PSr	No data	No data	No data
Różańsko 4	3201.5	Zechstein	12/Chmielnik	dRoB, mPOst, PAc, PAdt, PAt1, PAt2, PG, PGaz, PGG, PHI, PNNd, PNNk, PO, POg, POst, PS, PSr, RHOB	No data	No data	No data
Zielin 1	3343.0	Permian	33/Chmielnik	mPOg, mPOp, PAdt, PAt1, PAt2, PG, PGG, PK, PNG, PNN, PO, POst, PS, PSr, PT	25.0	4.21	2.53
Zielin 2	3442.0	Permian	228/Chmielnik	APHI, BD, DPHI, dRoB, ILD, ILM, MSFL, NPHI, PAdt, PAt1, PAt2, PAt3, PAt4, PEF, PG, PGaz, PGG, PK, PNG, PNN, PO, POst, POTA, PS, PSr, PT, RHOB, sPGbezU, THOR, URAN	4.5		
Zielin 3	3342.0	Permian	136/Chmielnik	PAc, PAdt, PAt1, PAt2, PG, PGG, PK, PNG, PNN, PO, POst, PS, PSr, PTn	1.3		
Zielin 3K	3331.1	Zechstein	No core	PK, POst, PSr	–		
Zielin 3K BIS	3256.9	Zechstein	14/Chmielnik	PAc, PAdt, PAt1, PAt2, PG, PK, PNG, PO, POst, PSr	23.0		

Tab. 11. Basic information about wells located at the Różańsko and Zielin fields.

*APHI: acoustic porosity, BS: Bit Size (caliper), DPHI: porosity from density, dRoB: correction of density, logPOst: focussed electric log (logarithm), mPOst: focussed electric microlog, MSFL: micro spherically focussed laterolog, NPHI: neutron porosity log, PAc: cement bond log – acoustic log, PAdt: interval transit time – acoustic log, PAt1: travel time T1 – acoustic log, PAt2: travel time T2 – acoustic log, PAt3 – travel time T3 – acoustic log, PAt4: travel time T4 – acoustic log , PG: gamma ray log, PGaz: gas log, PGG: density log, PHI: porosity, PK: deviation log, PNG: neutron-gamma ray log, PNN: neutron–neutron log, PNNd: neutron–neutron log long, PNNk: neutron–neutron log short, PO: conventional electric log, POg: electric log using gradient probe, POst: focussed electric log, POTA: potassium log, PS: spontaneous potential log, PSr: caliper, RHOB: bulk (electron) density, sPGbezU: uranium-free gamma-ray log, THOR: thorium log, URAN: uranium log, mPOg – electric microlog using gradient probe, mPOp – spontaneous potential microlog, ILD – deep-induction log, ILM – medium-depth induction log, PEF – photoelectric absorption factor log, PTn – temperature log in thermal disequilibrium.

BANIE 1
WELL LOG

GEOGRAPHIC COORDINATES

BEGINNING: 21.12.1974

FINISHING: 24.06.1975

DEPTH: 4090 m

X_1992 586869.13

Y_1992 218267.23

ALTITUDE: 70 m a.s.l.

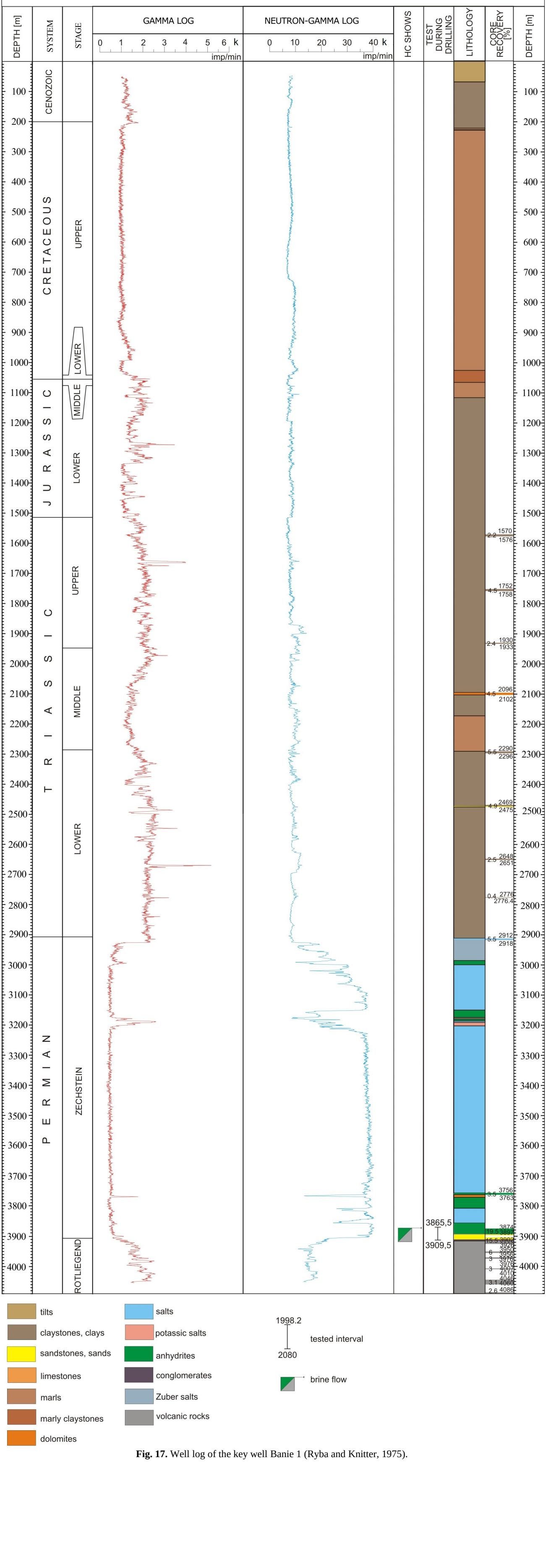


Fig. 17. Well log of the key well Banie 1 (Ryba and Knitter, 1975).

6. SEISMIC SURVEYS

In the Pyrzyce tender area, the first seismic surveys were conducted in 1960s. Unfortunatelly, analog recording of the data (they are available only in a paper version) caused their usage is limited. At the beginning of 1970s, recording was provided still on a paper, but it can be comparable with current seismic images (Tab. 13). Digital recording in the Pyrzyce tender is provided since 1978. It is especially in the eastern and central part of the area. A lot of 2D and 3D seismic surveys were conducted south of the Pyrzyce. Only in a few cases they reached the area (Tab. 12).

The most recent seismic surveys in the Pyrzyce tender area were made in 2011. They were ordered by FX Energy Poland Ltd. As a part of the seismic project, new seismic survey, as well as reprocessing and reinterpretation of archival data were carried out. Four analog seismic line from 1972 were reinterpreted. They were scanned, geocoded and next recorded to the SEGY files. Approximate location of all analog seismic lines measured for the Pyrzyce – Choszczno seismic project in 1972 (Radoń et al., 1972) is shown on Fig. 18. Also, a part of P1 seismic line – done in 1997 for a deep seismic sounding of the POLONAIZE'97 project – cut the Pyrzyce tender area. However, because of depth and a goal of this project, it cannot be used in terms of hydrocarbon prospection.

Name	Year	Seismic project name	Owner	Length [km]
T0350378	1978	Myślibórz-Krzyż	State Treasury	4.4
T0600378	1978			5.1
T0040379	1979			18.9
T0120379	1979			13.6
T0610379	1979			5.6
TA040379	1979			25.3
W0250386	1986	Chociwel-Czaplinek		6.7
W0270386	1986			21.0
W0020189	1989	Niż Polski		34.1
WA030189m	1989			12.0
W0010190m	1990			7.8
W0040190m	1990			5.1
W0070190m	1990			19.2
W0080190	1990			6.1
WD020189	1990			8.3
WE020189	1990			8.3
T0160295	1995	Dzieduszyce-Gorzów Wlkp.-Lubniewice	PGNiG S.A.	3.4
T0370696	1996			4.5
T0380696	1996			3.8
T0050603	2003	Ławy	State Treasury	3.2
T0060603	2003			3.7
FX227811	2011	Niecka Szczecińska		14.3
FX237811	2011			13.0
FX247811	2011			7.7
FX267811	2011			3.1
FX287811	2011			6.7
FX297811	2011			18.4
FX307811	2011			4.5
			SUMMARY:	
			State Treasury	**276.1**
			Investor	**11.7**
			Total amount	**287.8**

Tab. 12. Seismic surveys conducted on the Pyrzyce tender area (CBDG, 2019).

No. NAG PGI-NRI	Year	Authors	Seismic lines
3620/64	1972	Radoń, Z., Szpinalska, S., Nowacka, M.	1-XI-72T 2a-XI-72T 2-XI-72T 3a-XI-72T 3-XI-72T 4a-XI-72T 4-XI-72T 5-XI-72T 6-XI-72T 7-XI-72T 8-XI-72T 9-XI-72T 10-XI-72T 12a-XI-72T 12-XI-72T 13-XI-72T 14-XI-72T

Tab. 13. A line list of analog seismic survey in the Pyrzyce tender area (Radoń et al., 1972).

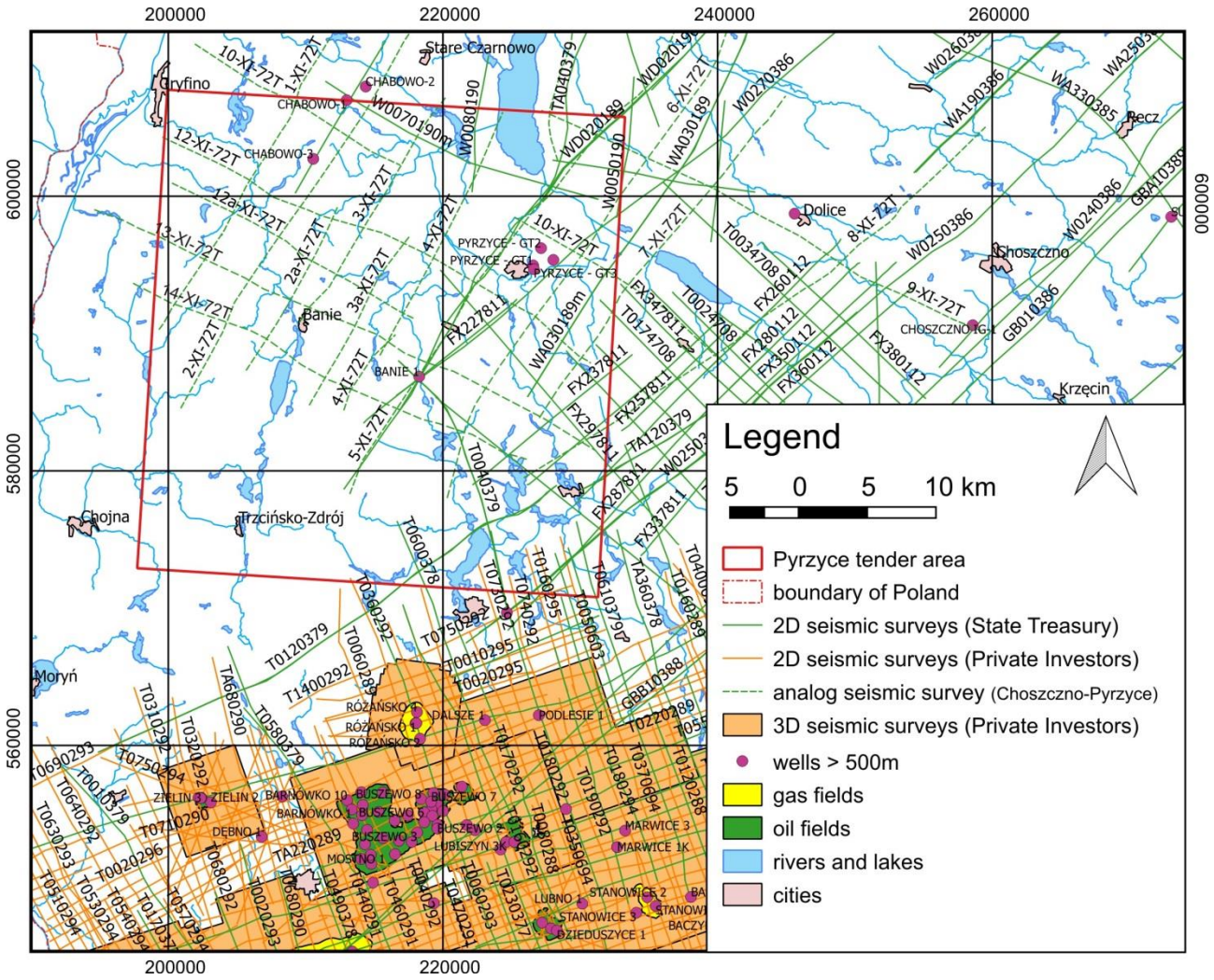


Fig. 18. Seismic surveys conducted on the Pyrzyce tender area.

7. GRAVIMETRY, MAGNETOMETRY AND MAGNETOTELLURICS

7.1 GRAVIMETRY

Three gravimetric surveys were completed in the Pyrzyce tender area. First of them – the "Szczecin Synclinorium" (Fig. 19 – No. 5; Bochnia and Duda, 1963) – was collected with average density of 3.5 stations/km^2. It is adjacent to the northern border of the Pyrzyce tender area. The rest of the area is covered by the „Fore-Sudetic Monocline" survey (Fig. 19 – No. 4; Pasik et al., 1971; Kleszcz, 1973), with a little lower point density (2 stations/km^2). The third survey was collected on behalf of PGNiG S.A. (Fig. 19 – No. 6; Musiatewicz and Lisowski, 1993). Average data point density of the survey is 5.5 stations/km^2. The survey is currently not available in the CBDG – it is the only survey, which does not belong to the State Treasury.

There are only a few detailed surveys within the Pyrzyce area. The Chociwel–Lębork profile (Fig. 19 – No. 3; Kleszcz, 1975) was collected with 200 m step. All another profiles shown on Fig. 19 (Okulus et al., 1981; Smrek, 1981) were measured with 50 m step. Such surveys were focused on brown coal exploration, but in case of the analysed area the result was negative (Gaczyński i in., 1986).

Królikowski and Petecki (1995) proposed a division of Poland into several gravity regions. Thus, the Pyrzyce tender area is placed at the north-western edge of the Szczecin-Mogilno-Miechów Low (Fig. 20). The Szczecin part of the Low is caused partly by light Cretacerous and Jurrasic infill of the Szczecin Syncline, but an essential source of gravity depression should be sought much deeper – perhaps in light, acid rocks such as granites or granite-gneiss (Cieśla et al., 1997).

Salt tectonics have an important impact on local gravity image (Fig. 21), as well. Salt structures are characterized by contrastingly low density in comparison to surrounding rocks. Relatively negative local anomalies can result from salt structures piercing the Mesozoic overburden. On the other hand, relatively positive anomalies results from the uplifted Cretacerous or Triassic rocks, with salt underneath (Cieśla et al., 1997). They can be connected with the presumed presence of isolated carbonate platforms of the Main Dolomite, as well. The absence of magnetic anomalies in this domain suggests either consistently lower magnetization of the basement rocks, or a smooth top of the basement at a great depth.

7.2. MAGNETOMETRY

Semidetailed, ground survey of total magnetic field intensity T in the Pyrzyce tender area and in its close neighbourhood was collected with an average density of 4.5 stations/km^2 (Fig. 22 – No. 1; Kosobudzka, 1991). The complementary one, but with lower density (1 station/km^2), was collected to the north from the Pyrzyce tender area (Fig. 22 – No. 2; Wybraniec and Cieśla, 1995).

The magnetic anomaly map (Fig. 23) was drawn on the basis of the Magnetic Map of Poland (Petecki et al., 2003; Petecki and Rosowiecka, 2017), which is divided into several regions with different magnetic characteristic. The Pyrzyce tender area is located within the Central and Western Poland domain (CWPd) – vast magnetic low (Fig. 23), bounded to the north by the Szczecin–Stargard Szczeciński–Piła–Inowrocław (SSPI) gradient zone (Petecki, 2008), and by the Słubice-Leszno lineament to the south.

The absence of magnetic anomalies in this domain suggests either consistently lower magnetization of the basement rocks, or a smooth top of the basement at a great depth.

7.3. MAGNETOTELLURICS

320 soundings along 9 profiles were measured as a part of a project: „Rating of potential, heat balance, and perspective geological structures for Hot Dry Rocks systems in Poland" (Stefaniuk et al., 2011). Only one of them – the 1-HDR-10 profile – enters the Pyrzyce tender area (Fig. 24). Northern end point of the profile was designed by the Banie 1 well, where the parametric sounding was measured. Results of the sounding showed that the shallowest sediments of the Cenozoic are characterized by resistivity of some tens of Ωm. There are the Cretacerous sediments below them, with resistivity of several of Ωm. The Jurrasic and Upper Triassic rocks (<1 Ωm) lie on the Middle and Lower Triassic rocks, characterized by a little higher resistivity. The Zechstein complex (tens of Ωm) has a thickness of cca. 1 km, and there is again decrease of resistivity in the Rotliegend (Stefaniuk et al., 2011).

The geoelectric model along the 1-HDR-10 profile, calculated with the Occama method, can be described as a 5-layer one (Fig. 25). The same calculated with the SBI method is characterized as 6-layer model (Fig. 26) – a high-resistive evaporate complex of the Zechstein, not visible on 5-layer mode, makes the difference.

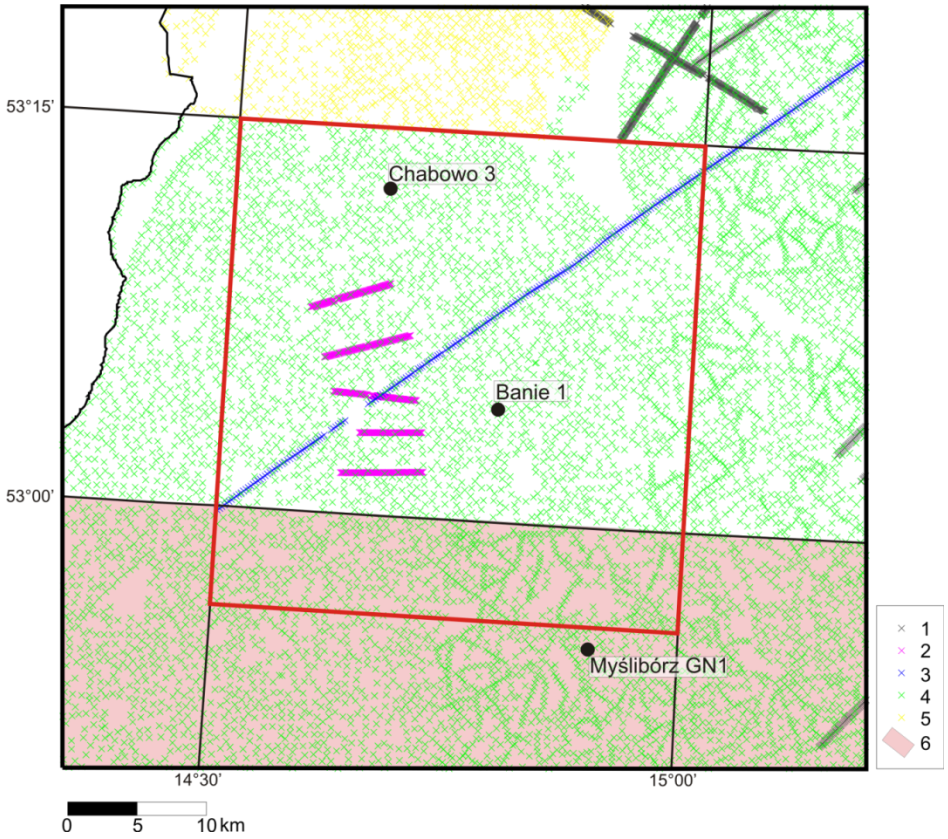


Fig. 19. Distribution of gravimetric measurements in the Pyrzyce tender area and in its close neighbourhood: 1 – Smrek (1981); 2 – Okulus et al. (1981); 3 – Kleszcz (1975); 4 – Pasik et al. (1971) and Kleszcz (1973); 5 – Bochnia and Duda (1963); 6 – Musiatewicz and Lisowski (1993). Red line – boundaries of the tender area; black dots – key wells.

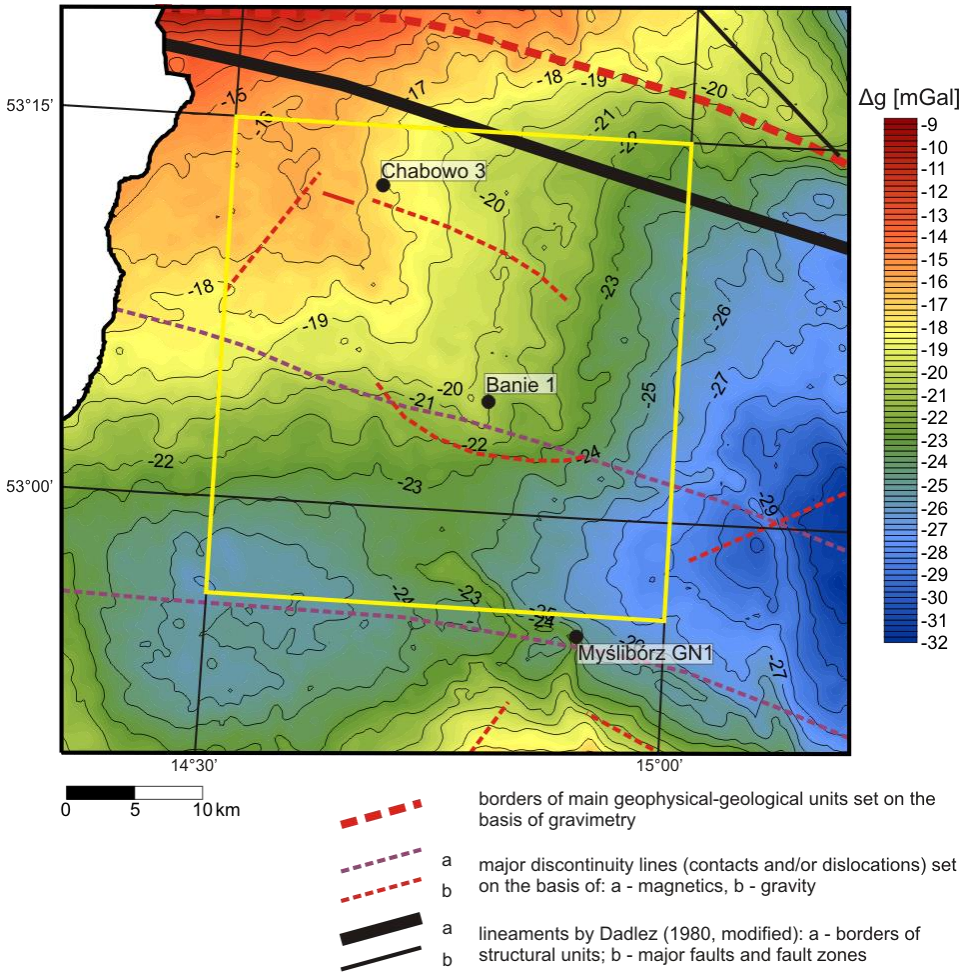


Fig. 20. Location of the Pyrzyce tender area on the Bouguer gravity anomaly map of Poland, with a reduction density of 2.25 g/cm^3; lineaments taken from Cieśla et al. (1997). Yellow line – boundaries of the tender area; black dots – key wells.

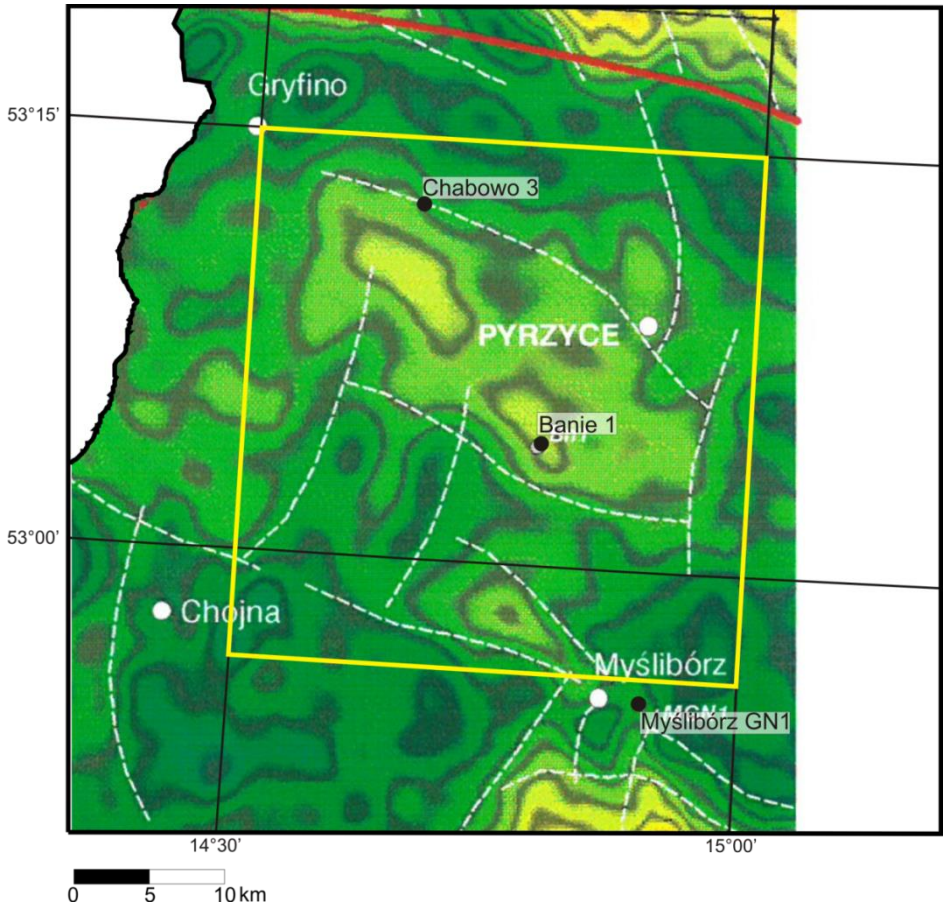


Fig. 21. Gravity, residual anomalies (differentia anomalies with r2 – r1, r2 = 10 km, r1 = 1 km). White dashed lines – presumed discontinuity lines (contacts and/or dislocations), red line – presumed border of major gravity units (Cieśla et al., 1997). Yellow line – boundaries of the Pyrzyce tender area; Black dots – key wells.

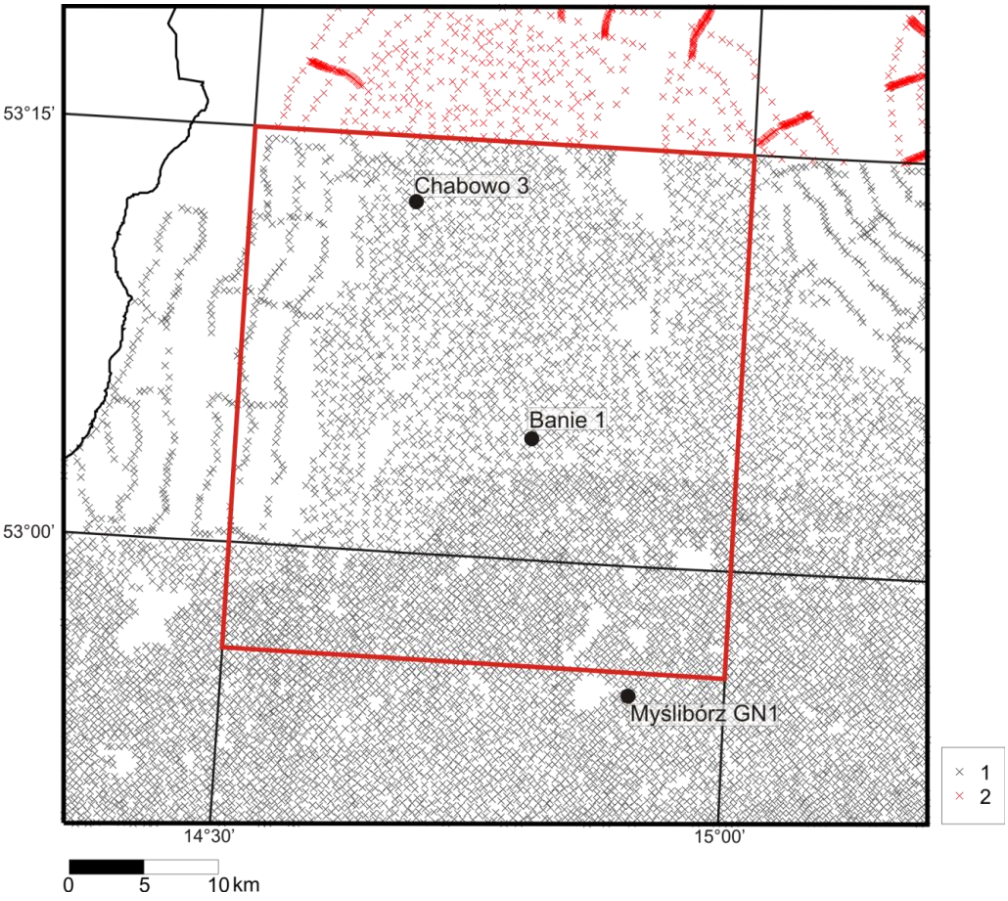


Fig. 22. Distribution of magnetic stations in the Pyrzyce tender area and in its close neighbourhood: 1 – Kosobudzka, 1991; 2 – Wybraniec and Cieśla, 1995. Red line – boundaries of the tender area; black dots – key wells.

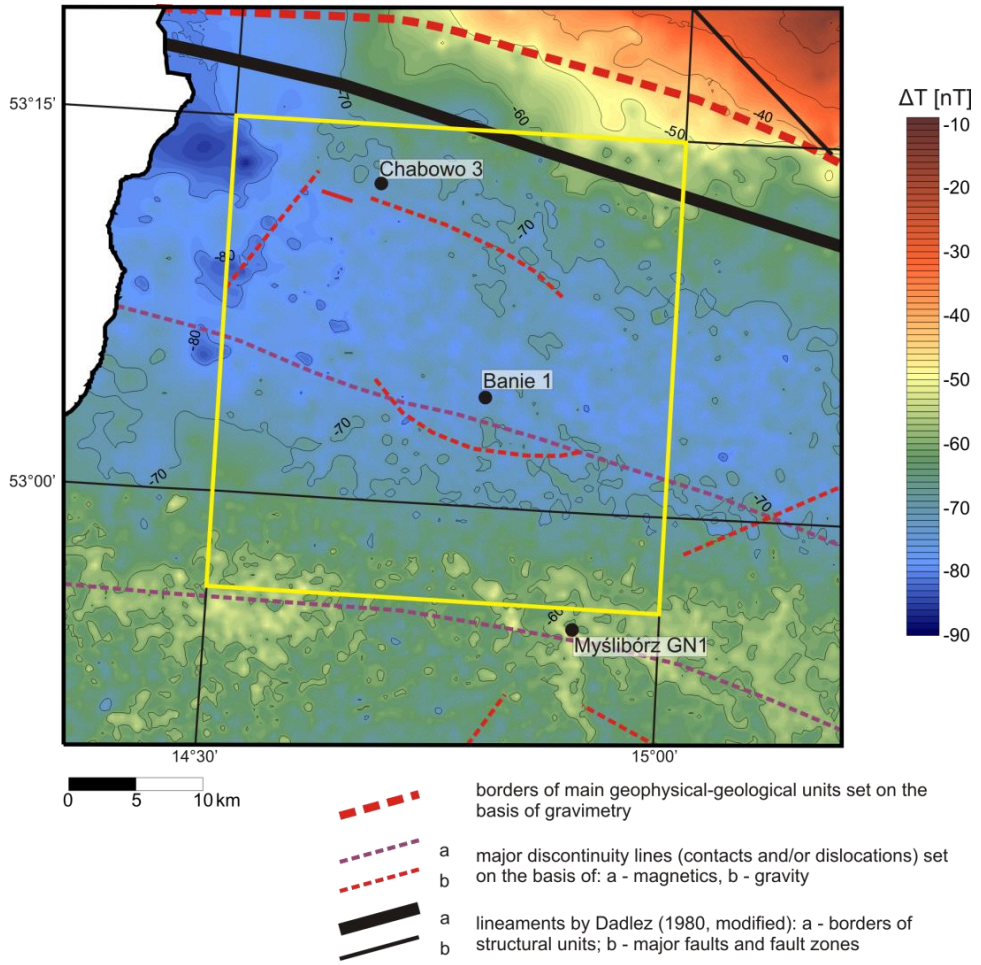


Fig. 23. Location of the Pyrzyce tender area on the magnetic anomaly map of Poland (based on CBDG, 2018). Yellow line – boundaries of the tender area; black dots – key wells. Lineaments taken from Cieśla et al. (1997).

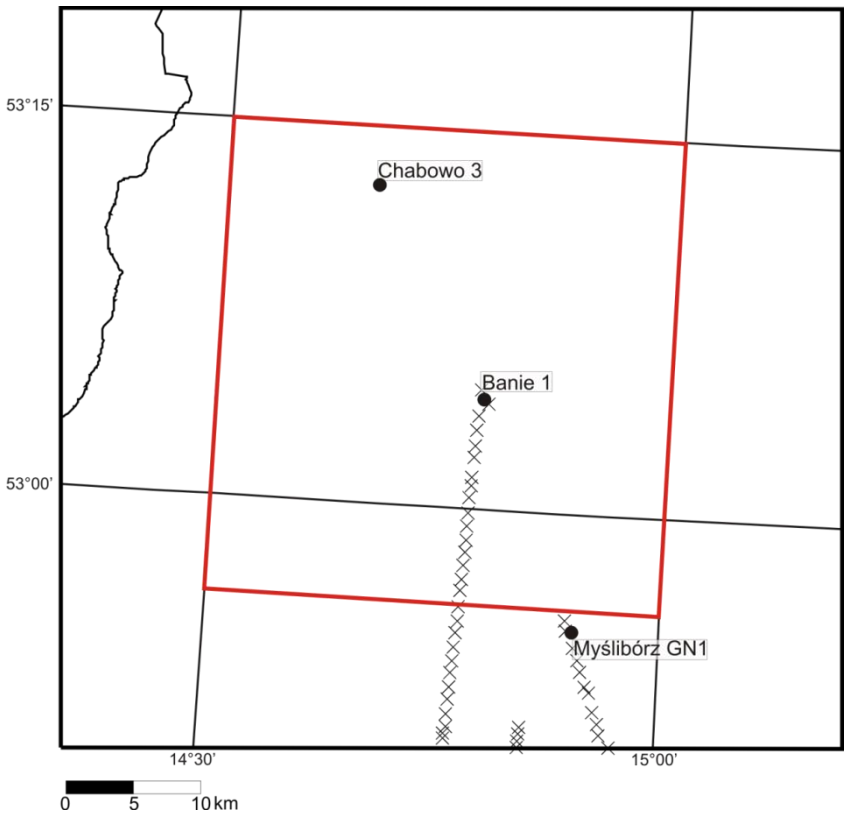


Fig. 24. Distribution of magnetotelluric survey in the Pyrzyce tender area (Stefaniuk et al., 2011). Red line – boundaries of the tender area; black dots – key wells.

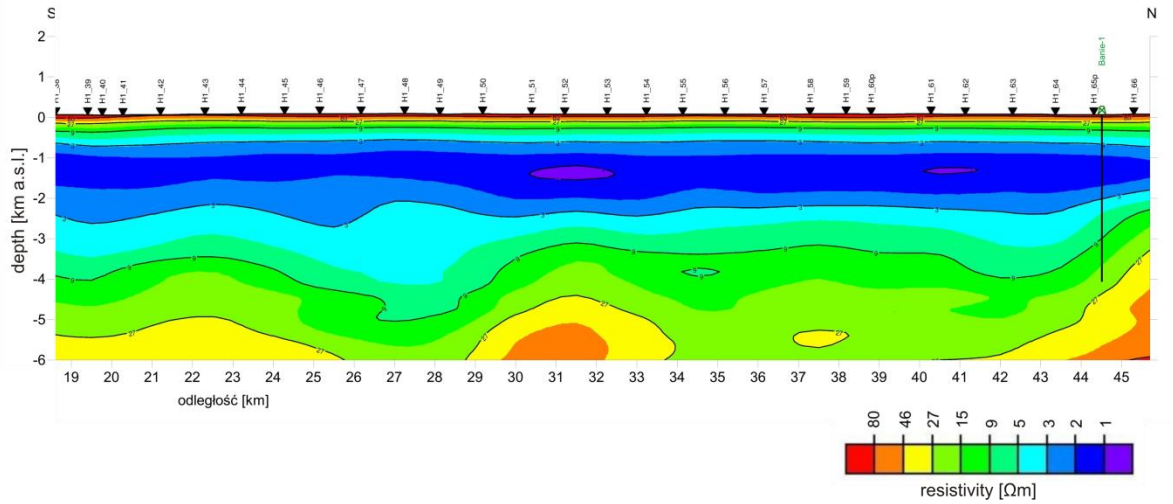


Fig. 25. Results of 1D inversion by Occam, along 1-HDR-10 profile (Stefaniuk et al., 2011). Location of the profile – see Fig. 24.

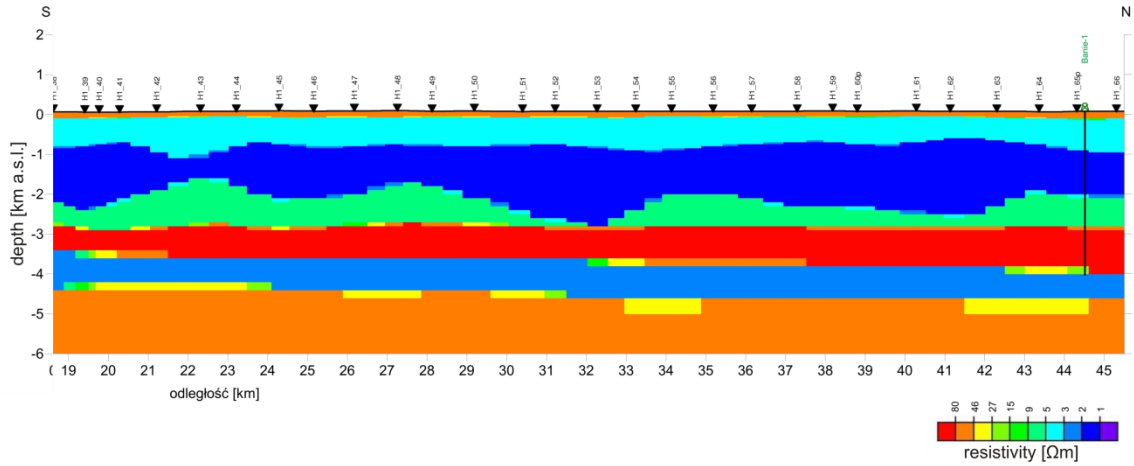


Fig. 26. Results of 2D inversion by SBI, along 1-HDR-10 profile (Stefaniuk et al., 2011). Location of the profile – see Fig. 24.

8. HYDROCARBON PROSPECTIVE

The Pyrzyce tender area is located in the north-western Poland, in the Western Petroleum Province (Fig. 27). The area is located within the Paleozoic Platform, in which the Carboniferous strata (as the oldest recognized by drilling) form the structural stage of the Variscan Externides. Above, the Permian-Mesozoic cover of the Szczecin-Gorzów Trough occurs.

Two independent petroleum systems work in the Pyrzyce tender area. The first occurs in the Carboniferous-Permian, in which gas is generated from the Lower Carboniferous shales, being accumulated in the Rotliegend and Weissliegend deposits. The second system occurs in the Zechstein Main Dolomite, in which oil and gas are expected in the carbonate deposits, while organic-rich interbeds are supposed to be the source rocks. Numerous hydrocarbon fields, which occur in the close neighborhood of the Pyrzyce tender area, have been documented in the Main Dolomite (Barnówko-Mostno-Buszewo, Gajewo, Lubiszyn, Różańsko, Zielin).

The Pyrzyce area is poorly recognized in terms of geology and hydrocarbon prospective. Only few wells reached the Permian or Carboniferous within and in the close vicinity of the area. Also, only 28 seismic profiles of total length of 287.8 km have been conducted, so far. However, if to take into consideration numerous oil and gas fields recognized to the south, the Pyrzyce tender area seems to be prospective for new discoveries of conventional oil and gas accumulations in the Main Dolomite (especially occurrence of isolated carbonate platforms are expected), as well as conventional accumulations of gas in the Rotliegend. Also, unconventional accumulations of carbonate shale gas in the Main Dolomite are supposed.

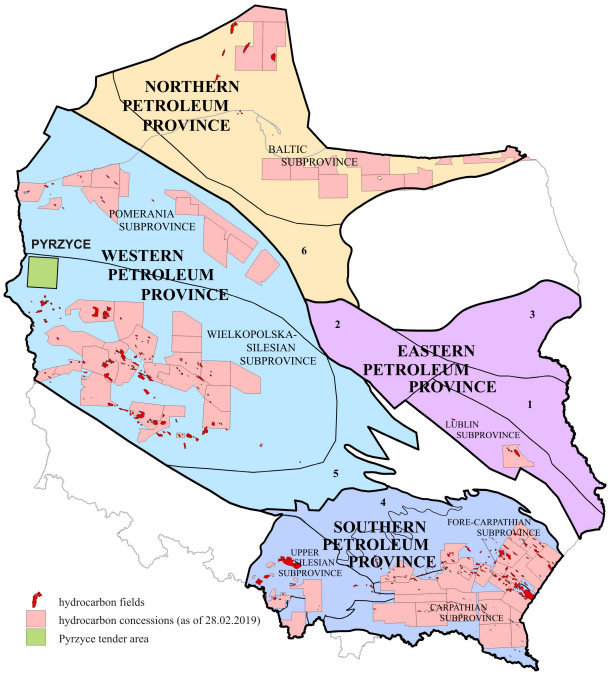


Fig. 27. Hydrocarbon subdivision of Poland (PIG-PIB, 2019) with location of the Pyrzyce tender area. 1–6 – petroleum regions (of unconfirmed/hypothetical prospective): 1 – Chełm Region, 2 – Płock-Warszawa Region, 3 – Podlasie Region, 4 – Małopolska Region, 5 – Łódź-Wieluń Region, 6 – Słupsk-Grudziądz Region.

Possible minimum work program for prospection and exploration phase:

- Stage I (12 months) – integration and reinterpretation of archival geological data;
- Stage II (48 months) – conduction of 2D seismic surveys (50 km) or conduction of 3D seismic surveys (25 km^2) and drilling of one well to maximum depth of 4200 m TVD with obligatory coring of prospective intervals.

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