Polish Geological Institute
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Polish Geological Survey
Polish Hydrogeological Survey

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HYDROCARBON PROSPECTIVE OF POLAND

ŻABOWO
TENDER AREA
ENGLISH ABSTRACT

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

Financed by National Found
for Environmental Protection
and Water Management

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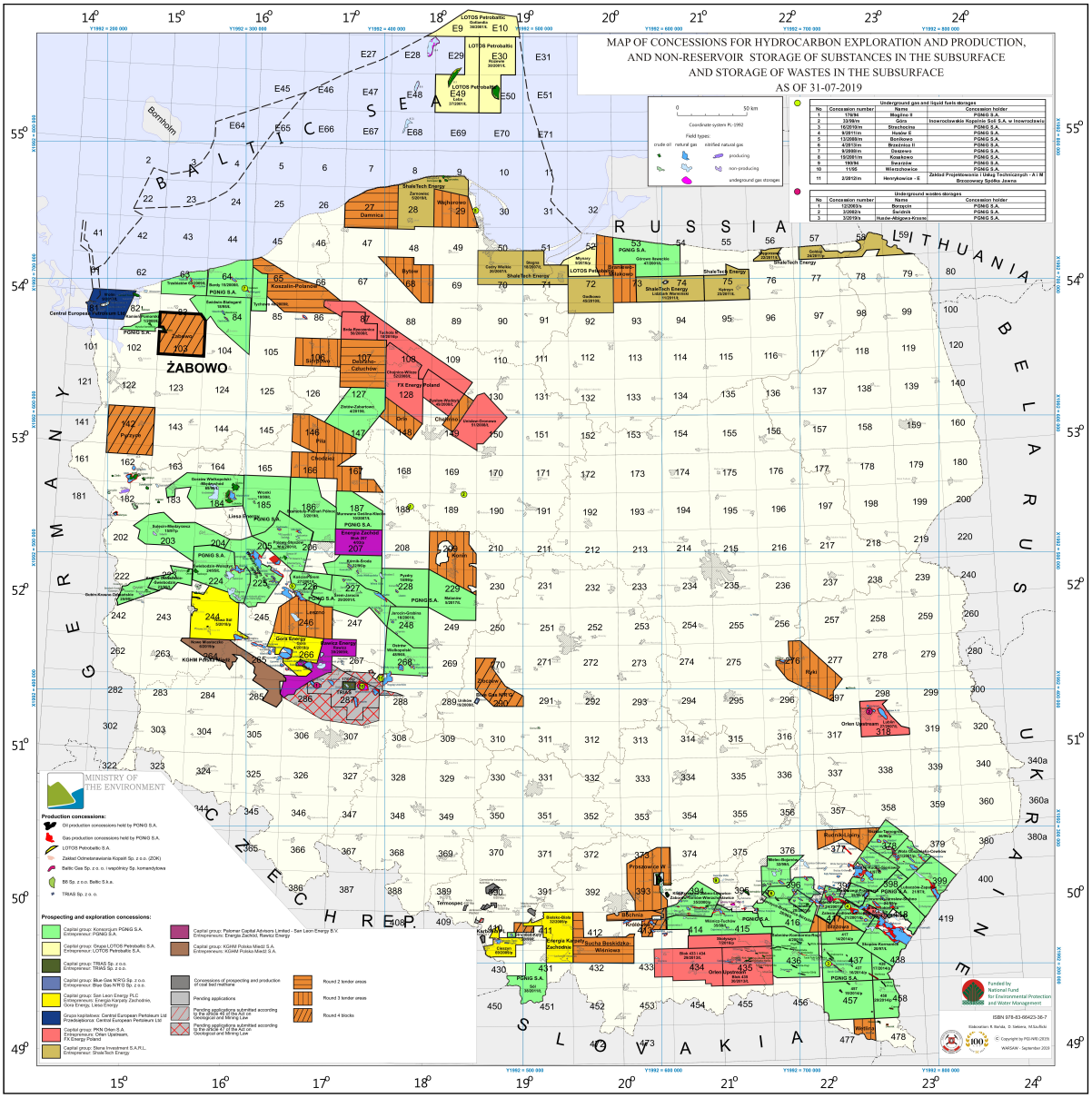


Location of the Żabowo tender area on the map of concessions for hydrocarbon exploration and production, and non-reservoir storage of substances in the subsurface and storage of wastes in the subsurface as of 31-07-2019.

1. GENERAL INFORMATION

The Żabowo tender area is located onshore in the north-western Poland, in the 83 and 103 concession blocks (Fig. 1). The precise location is defined by geographical coordinates listed below.

Border points	1992 coordinate system	
	X	Y
1	673 948.18	266 614.09
2	669 360.76	269 798.54
3	643 263.52	268 511.84
4	645 106.88	235 462.62
5	661 436.72	236 382.04
6	661 143.42	240 603.82
7	664 525.57	238 976.42
8	664 755.54	236 443.29
9	675 598.09	237 055.20

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

Administrative centre:

- Zachodniopomorskie province; Goleniów county, communes: Maszewo (participation in the tender area 0.11%), Osina (2.45%), Nowogard (28.47%); Gryfice county, communes: Gryfice (8.06%), Płoty (19.19%); Kamień Pomorski county, commune: Golczewo (4.41%); Łobez county, communes: Resko (19.41%), Łobez (0.06%), Dobra (1.52%), Radowo Małe (15.49%), Węgorzyno (0.83%).

The Żabowo tender area was previously subjected to hydrocarbon prospection and exploration concessions No. 12/99/p „Gryfice", No. 20/2000/p „Nowogard" and No. 28/2000/p „Kaleń". Currently, two hydrocarbon concessions are provided in the neigborhood of the area (Fig. 1):

- 1/2000/Ł „Kamień Pomorski" (PGNiG Polish Oil and Gas Company),
- 18/95/Ł „Świdwin-Białogard" (PGNiG Polish Oil and Gas Company).

There are numerous oil and gas fields discovered in the Rotliegend and Zechstein (Main Dolomite) in the vicinity of the tender area.

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

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

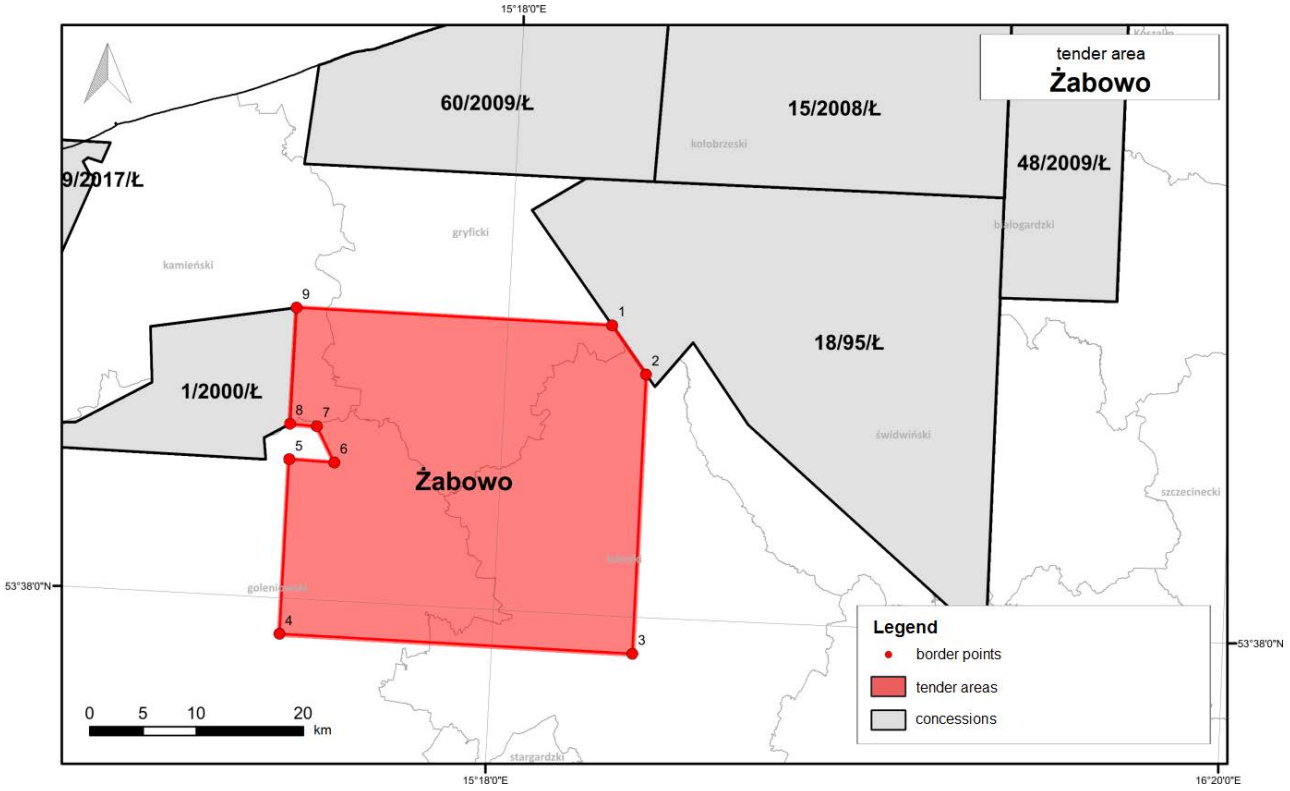


Fig. 1. Border points of the Żabowo tender area and location of the hydrocarbon concessions in the neighborhood as of 31-07-2019 (CBDG, 2019).

2. GEOLOGY

2.1. GENERAL GEOLOGICAL DESCRIPTION

The Żabowo tender area is located in the north-western Poland. It lies at the border of the Szczeciny-Gorzów Trough and Mid-Polish Anticlinorium (Aleksandrowski, 2017a; Fig. 2). Below the Permian-Mesozoic and Cenozoic cover, the Devonian and Carboniferous strata of the Variscan Foredeep occur (Aleksandrowski, 2017b; Fig. 3). They overlie the older Paleozoic rocks of the Kujawy-Pomerania Fold Belt (Żelaźniewicz et al. 2011).

The stratigraphy and lithology of the Paleozoic and Mesozoic rocks are recognized in numerous wells located within the Żabowo tender area and its close neighborhood. These are: Barkowo 1, Berkanowo 1, Błotno 1, Błotno 2K, Błotno 3, Brojce IG-1, Ciechnowo 1, Ciechnowo 4, Czaplinek IG-1,Czaplinek IG-2, Gardomino 1, Grabin 1, Grabin 2K, Karsk 1, Łososnica 1, Maszkowo 2, Moracz IG-1, Nowogard GEO-1, Piaski PIG-2, Piaski 3, Resko 1, Resko 3, Rymań 1, Samlino 1, Sławoborze 1, Sławoborze 2, Sławoborze 3, Słowieńsko 1, Smolęcin 1, Świerzno 4, Unibórz 1, Wysoka Kamieńska 2 (see Fig. 22 for location; wells located within the tender area are highlighted).

2.2. TECTONIC

Several structural stages are distinguished in the Żabowo tender area. Hypothetically, the oldest structural stage is formed by the Ediacaran-Silurian succession of the Kujawy-Pomerania Fold Belt (Żelaźniewicz et al. 2011). They form the basement of the Paleozoic Platform. However, these rocks have not been recognized by drilling, because of deep burial. Above, the continuous succession of the Devonian and Carboniferous occurs (Variscan structural stage), which forms the sedimentary cover of the Paleozoic Platform. It is separated from the Permian by the Variscan unconformity. This surface lies at depth between 3700 and 5500 m b.s.l. (Kudrewicz, 2007). The Permian-Mesozoic structural stage includes volcanites, Rotliegend and Zechstein deposits in the Permian, as well as clastic and carbonate rocks in the Triassic, Jurassic and Cretaceous. The base of the Zechstein lies at depth between 3500 and 5200 m b.s.l. (Kudrewicz, 2007). Some differences in thicknes of particular stratigraphic units in the Permian-Mesozoic succession are related to halokinetic processes and occurrence of salt diapirs developed during the Mesozoic. The youngest (Cenozoic) structural stages is built of Oligocene, Miocene and Quaternary sediments.

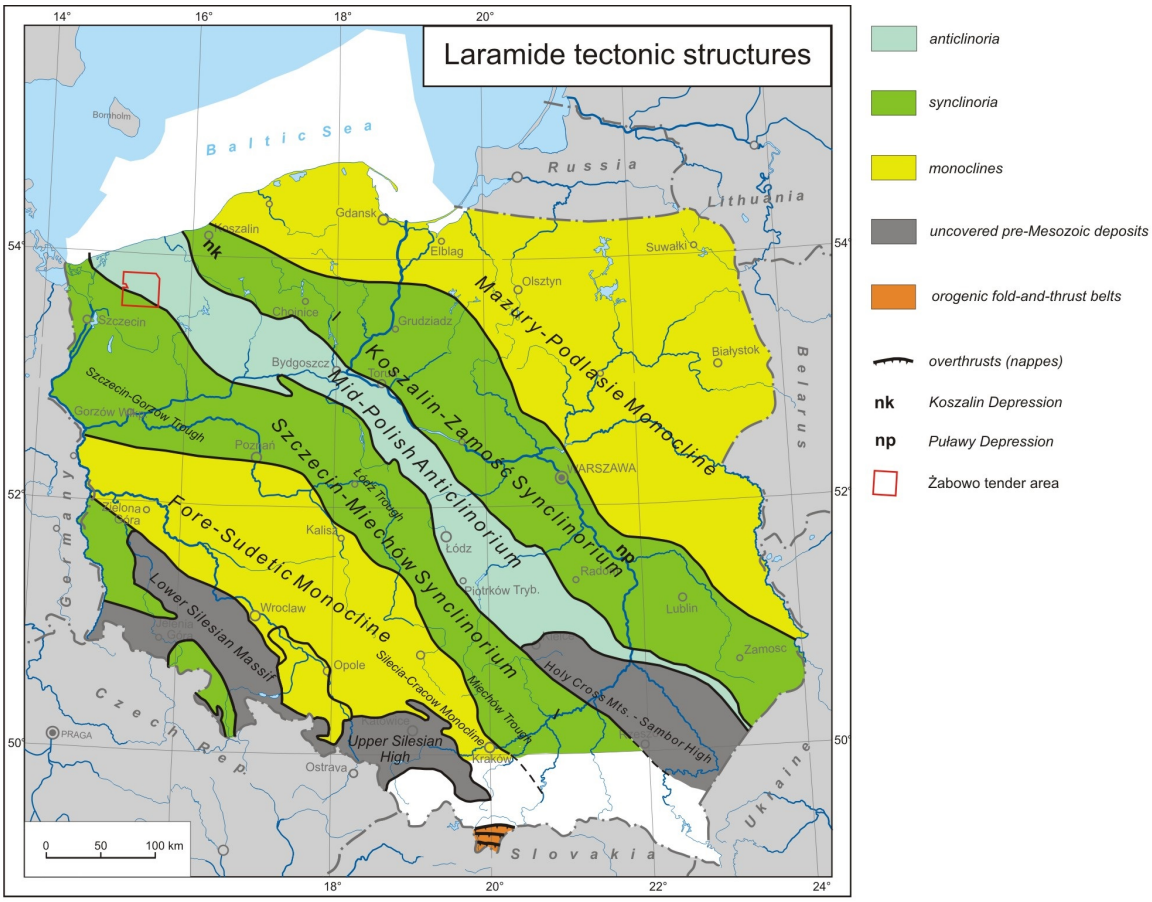


Fig. 2. Location of the Żabowo tender area on the map of Laramide tectonic structures (after Aleksandrowski, 2017a, modified).

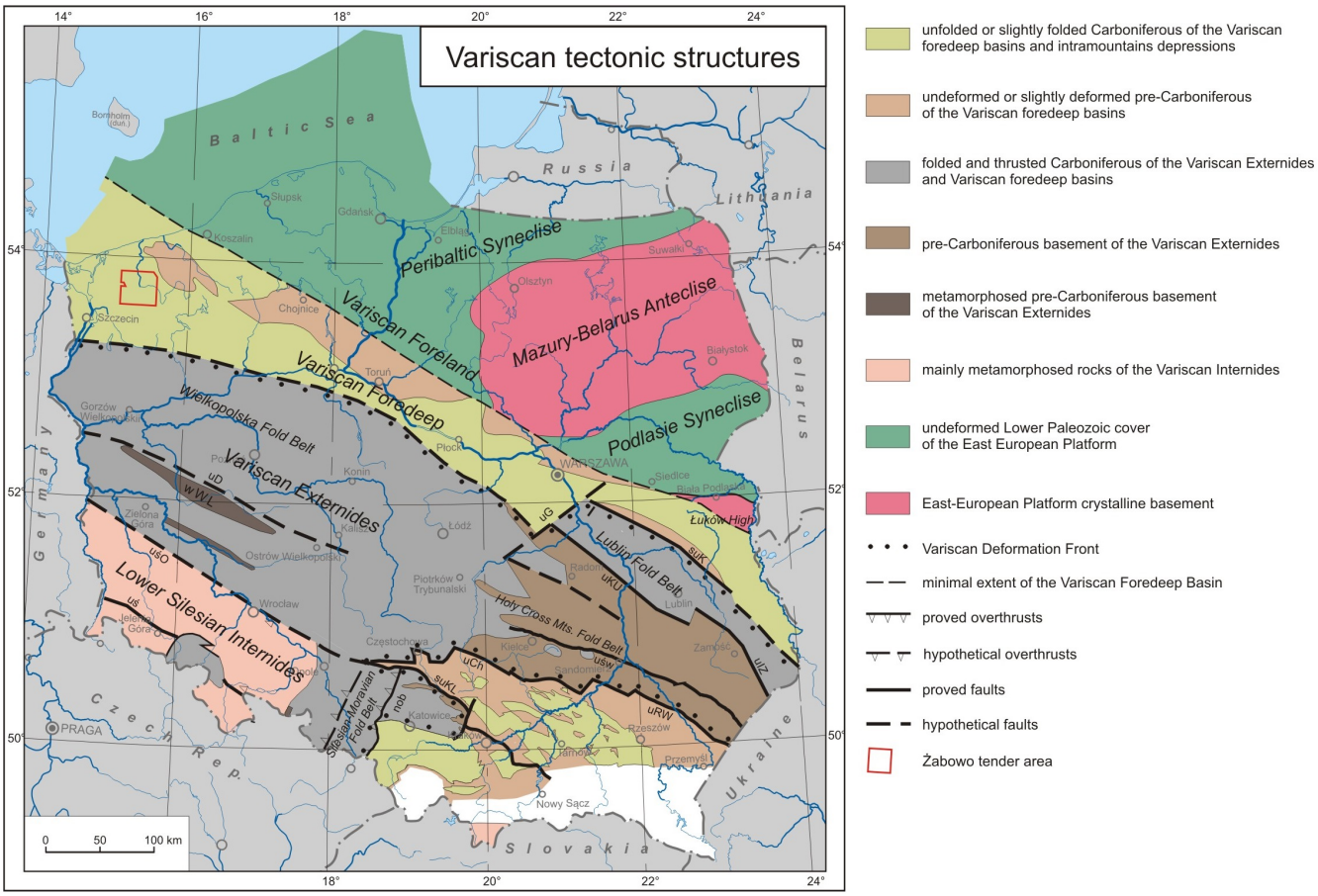


Fig. 3. Location of the Żabowo tender area on the map of Variscan tectonic structures (after Aleksandrowski, 2017b, modified). nob – Orłów-Boguszowice Thrust, suK – Kock Fault Zone, suKL – Kraków-Lubliniec Fault Zone, uCh – Chmielnik Fault, uD – Dolsk Fault, uG – Grójec Fault, uIZ – Izbica-Zamość Fault,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

2.3. STRATIGRAPHY AND LITHOLOGY

Mississippian, Visean (Figs 4–6)

Lithology: limestones with intercalations of claystones and calcareous claystones, claystones.
Lithostratigraphy: Czaplinek Limestone Formation, Nadarzyce Claystone Formation.
Wells and depth: Błotno 3 (3839.0–4500.0 m), Piaski PIG-2 (3794.0–3922.0 m).
Thickness (according to wells): 128.0–661.0 m.
References: Lipiec and Matyja, 1998; Lipiec, 1999; Matyja, 2006, 2008.

Permian, Autun

Lithology: volcanic rocks.
Wells and depth: Błotno 3 (3616.1–3839.0 m), Piaski PIG-2 (3633.0–3794.0 m), Karsk 1 (4012.5–4086.5 m).
Thickness (according to wells): >74.0–222.9 m.

Permian, Rotliegend (Figs 7–8)

Lithology: alluvial conglomerates and sandstones, marginal playa-lake sandstones and mudstones, fluvial sandstones and mudstones, playa-lake sandstones and mudstones, aeolian sandstones.
Wells and depth: Błotno 3 (3506.4–3616.1 m), Gardomino 1 (3601.0–3698.5 m), Grabin 2K (3494.7–3591.9 m), Karsk 1 (3927.0–4012.5 m), Piaski PIG-2 (3324.0–3633.0 m), Unibórz 1 (3534.0–3584.0 m).
Thickness (according to wells): >50.0–309.0 m.
References: Pomianowski and Wróbel, 2004; Kiersnowski and Buniak, 2006; Maliszewska and Kuberska, 2008; Maliszewska et al., 2016.

Permian, Zechstein (Figs 9–10, 12)

Lithology: limestones, dolomites, clastic rocks and evaporites including shallow-marine platform and slope carbonates in the Main Dolomite.
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), PZ3 – Grey Pelite (T3), Platy Dolomite (Ca3), Main Anhydrite (A3), Younger Halite (Na3), PZ4a – Lower Red Pelite (T4), Lower Pegmatite Anhydrite (A4a1), Lower Youngest Halite (Na4a1), Upper Pegmatite Anhydrite (A4a2), Upper Youngest Halite (Na4a2), PZ4b – Upper Red Pelite (T4b), PZ4c; Rewal Formation.
Wells and depth: Barkowo 1 (2675.0–3198.4 m), Błotno 1 (2314.0–3184.0 m), Błotno 2K (2337.9–3261.4 m), Błotno 3 (3099.7–3506.4 m), Gardomino 1 (2634.0–3601.0 m), Grabin 1 (2274.0–3238.0 m), Grabin 2K (2535.0–3494.7 m), Karsk 1 (2259.0–3927.0 m), Łososnica 1 (2451.0–3470.0 m), Piaski 3 (2346.0–3295.0 m), Piaski PIG-2 (2277.5–3324.0 m), Unibórz 1 (2155.5–3534.0 m).
Thickness (according to wells): >406.7–1046.5 m.
Wells and depth (Main Dolomite Ca2): Barkowo 1 (3157.0–3181.5 m), Błotno 1 (3181.5–3184.0 m), Błotno 2K (3250.9–3261.4 m), Błotno 3 (3237.1–3253.5 m), Gardomino 1 (3147.0–3169.5 m), Grabin 1 (3222.8–3238.0 m), Grabin 2K (3305.5–3326.1 m), Karsk 1 (3588.5–3596.5 m), Łososnica 1 (3266.5–3275.0 m), Piaski PIG-2 (2930.0–2947.5 m), Unibórz 1 (3251.0–3303.0 m).
Thickness (Main Dolomite Ca2, according to wells): 8.0–24.5 m.
References: Wagner et al., 1978; Peryt, 1984; Oszczepalski and Rydzewski, 1987; Czapowski et al., 1993; Wagner, 1994, 2012; Peryt et al., 1996, 2010; Wagner and Peryt, 1997; Peryt and Wagner, 1998.

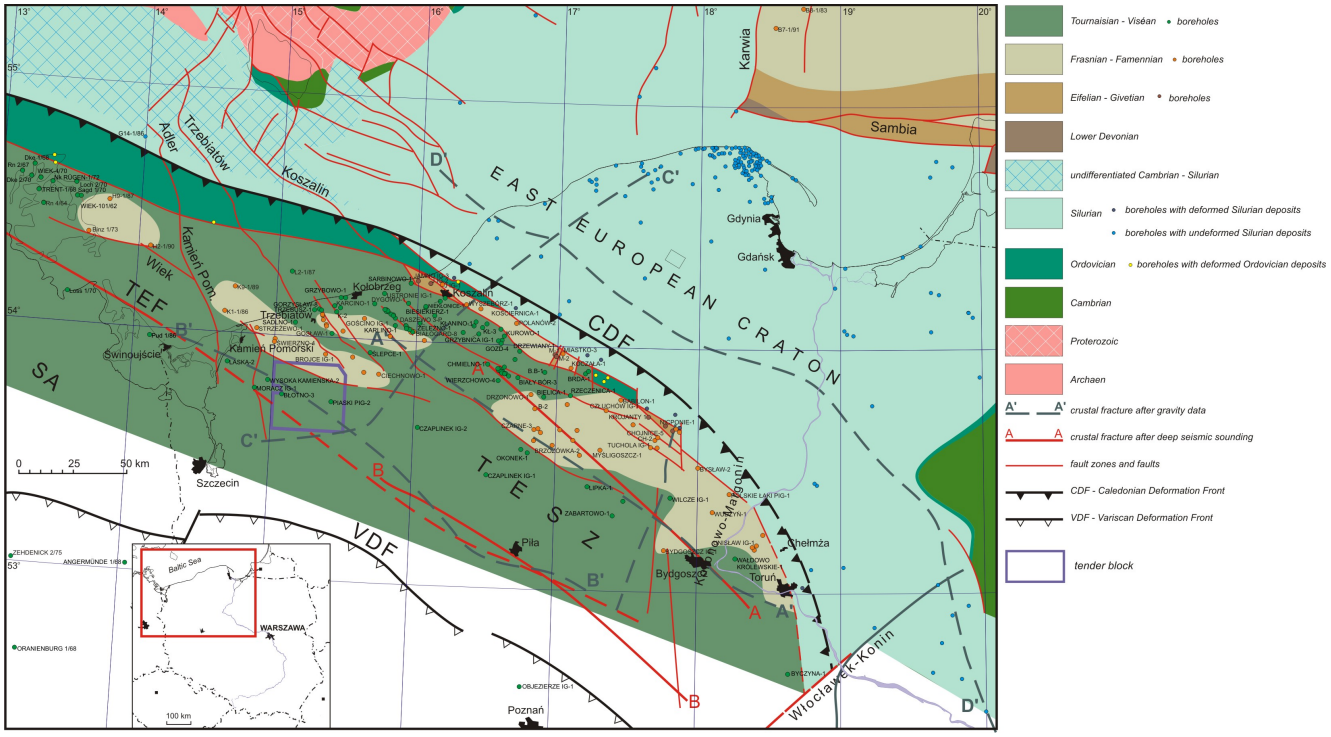


Fig. 4. Location of the Żabowo tender area on the geological map of the Western Pomerania without Permian, Mesozoic and Cenozoic cover (Matyja, 2006, 2008; modified). TESZ – Trans-European Suture Zone, CFD – Caledonian Deformation Front, VDF – Variscan Deformation Front, TEF – Trans-European Fault.

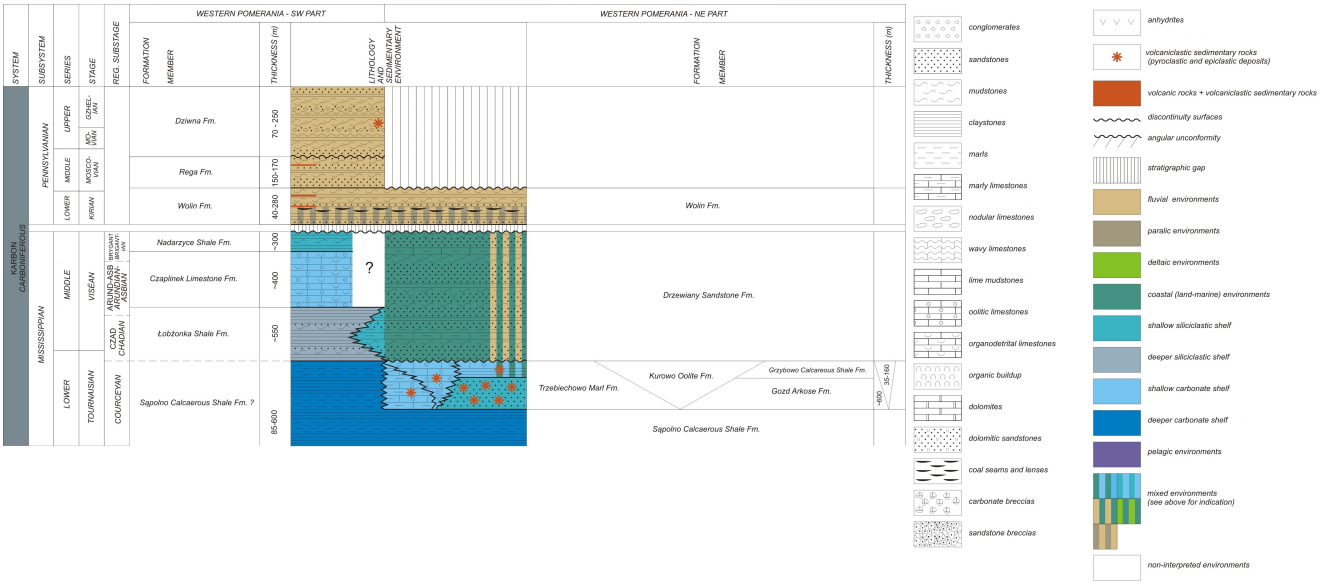


Fig. 5. Carboniferous stratigraphy and sedimentary environments in the Western Pomerania (Matyja, 2008, modified).

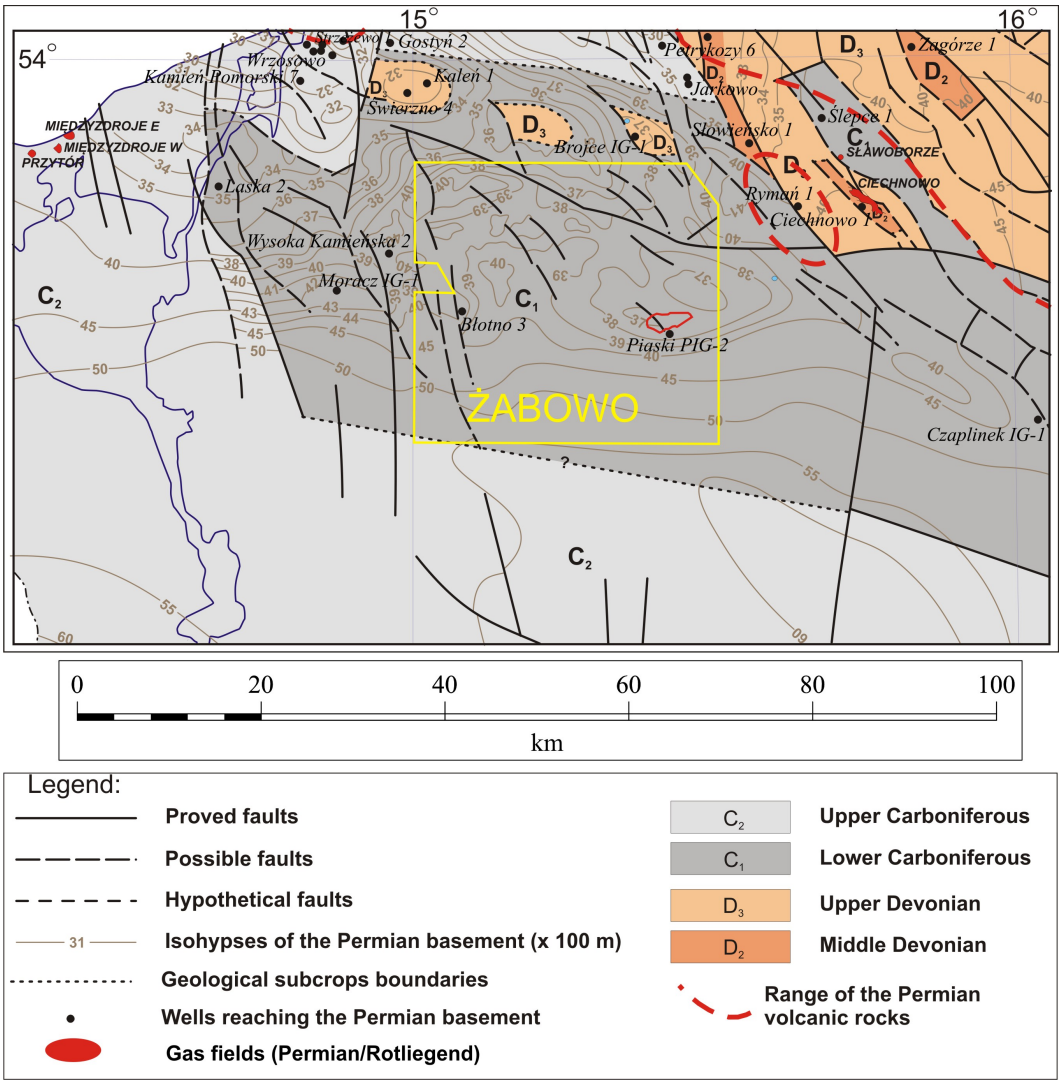


Fig. 6. Location of the Żabowo tender area on the geological-structural map of the top surface of the Permian basement (Lech, 2001; modified).

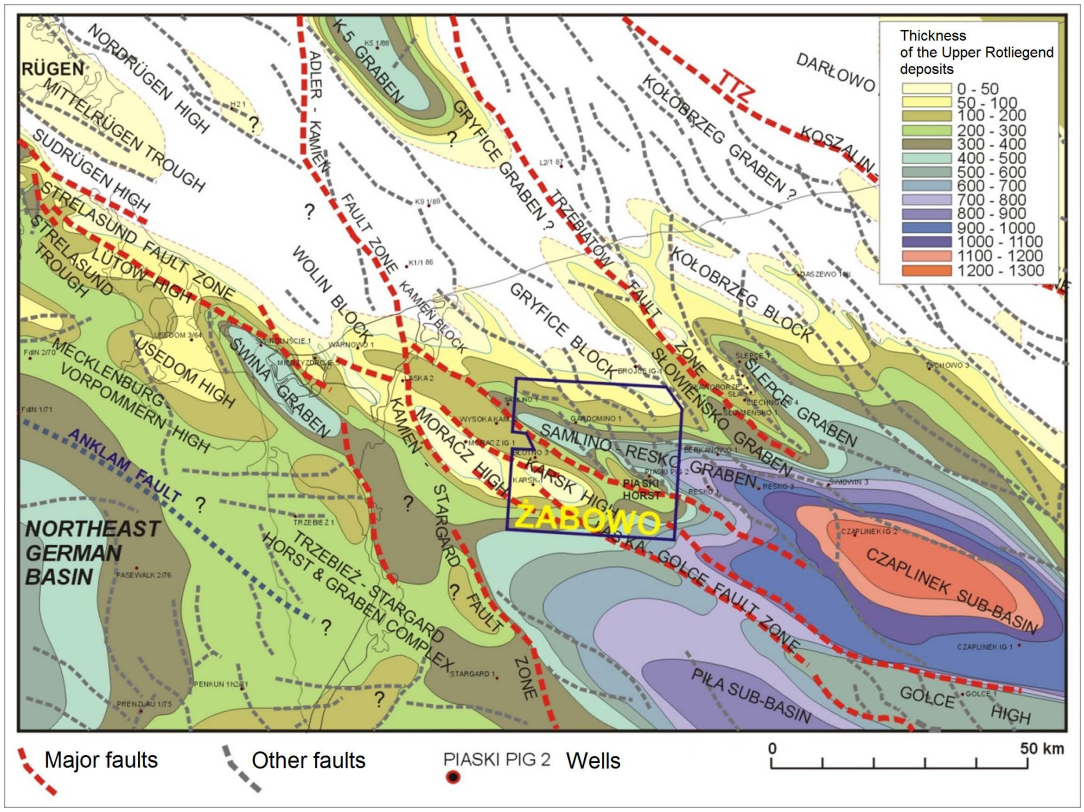


Fig. 7. Thickness of the Rotliegend deposits in the north-western part of the Polish Rotliegend Basin with location of the Żabowo tender area (Kiersnowski and Buniak, 2006; modified).

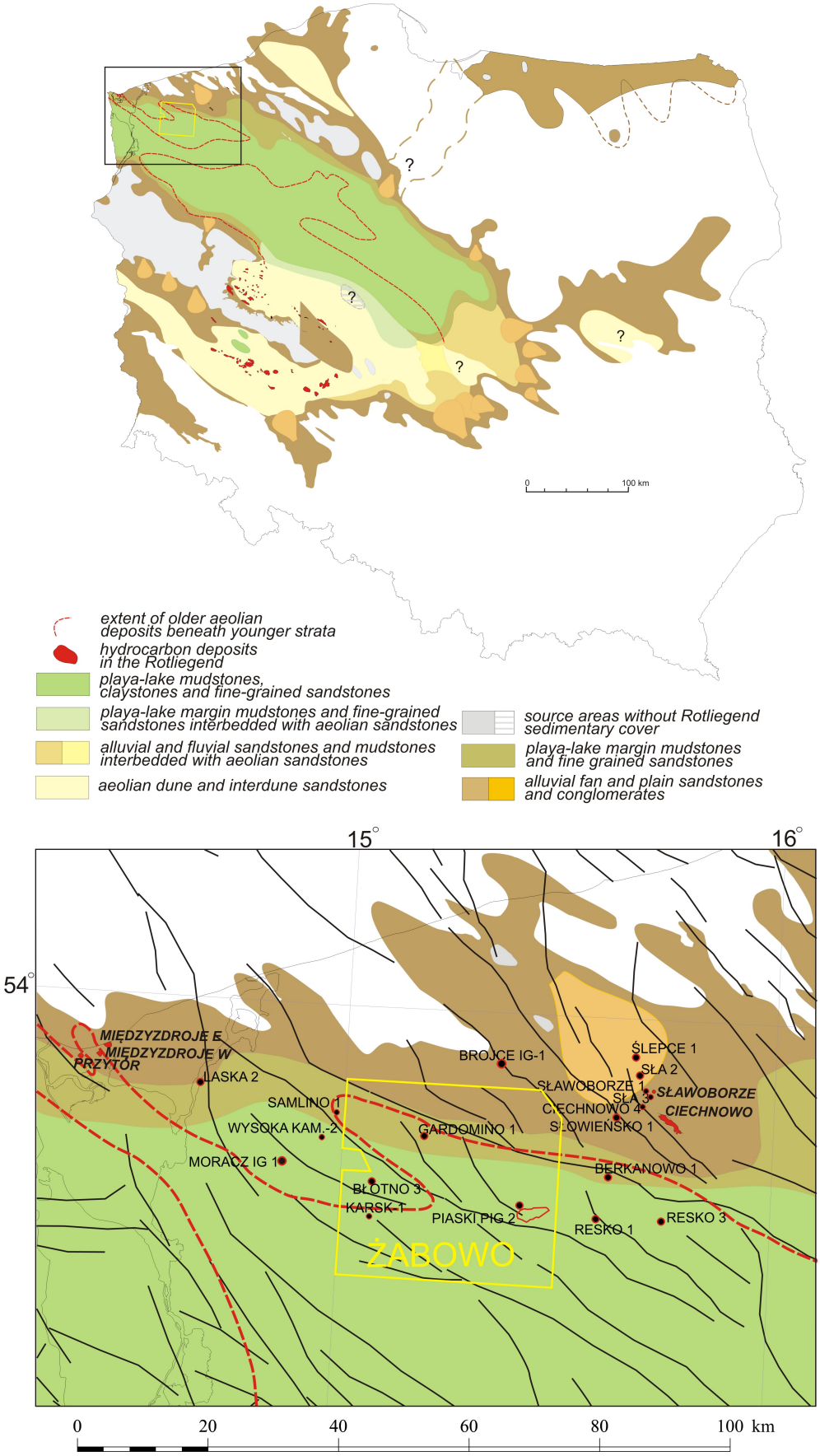


Fig. 8. Upper Rotliegend palaeogeography and facies in Poland with location of the Żabowo tender area (Kiersnowski, 2013; modified).

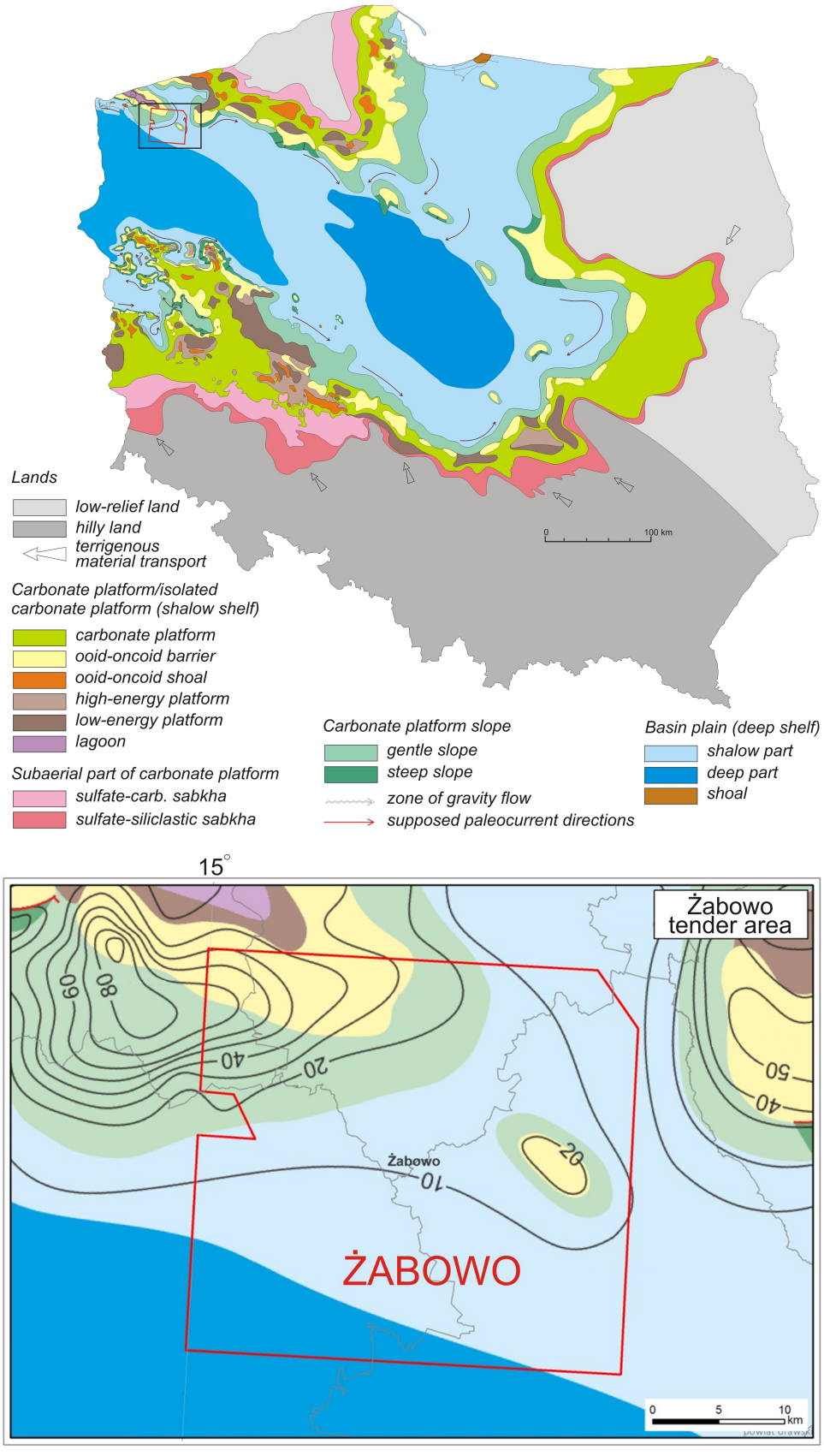


Fig. 9. Zechstein/Main Dolomite palaeogeography and facies in Poland with location of the Żabowo tender area (Wagner, 2012; modified).

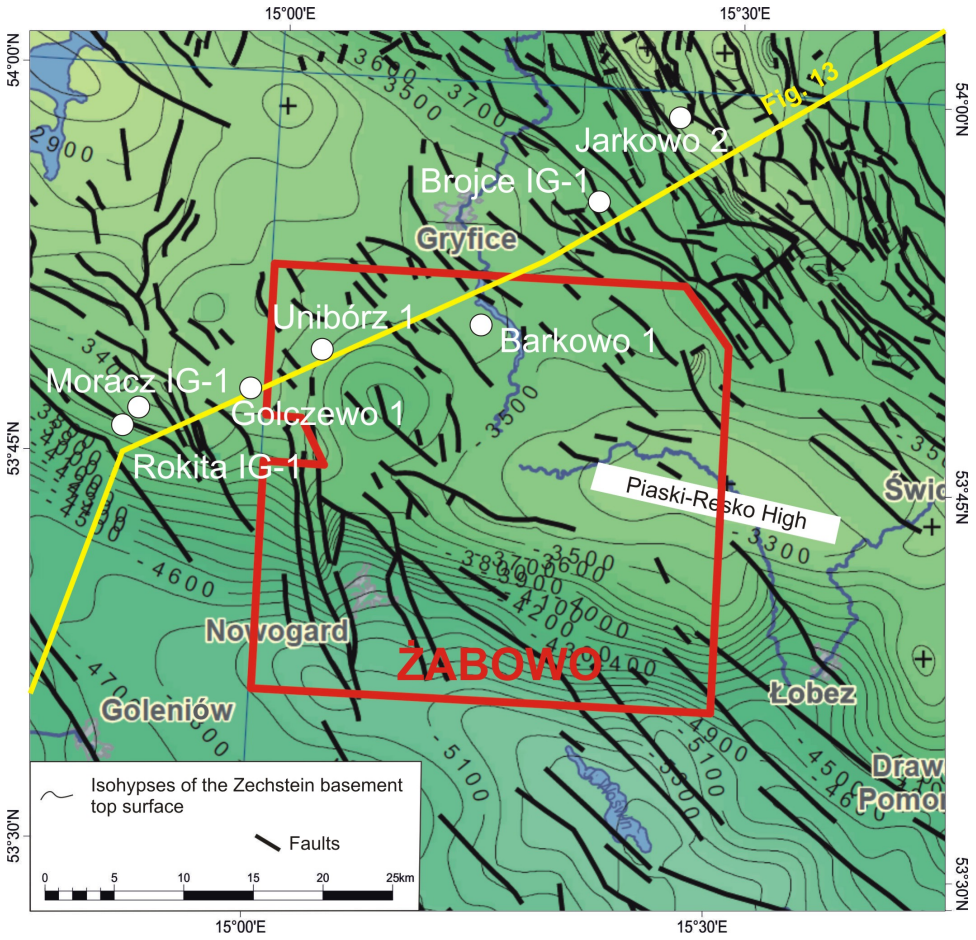


Fig. 10. Location of the Żabowo tender area on the structural map of the top surface of the Zechstein basement (Kudrewicz, 2007; modified).

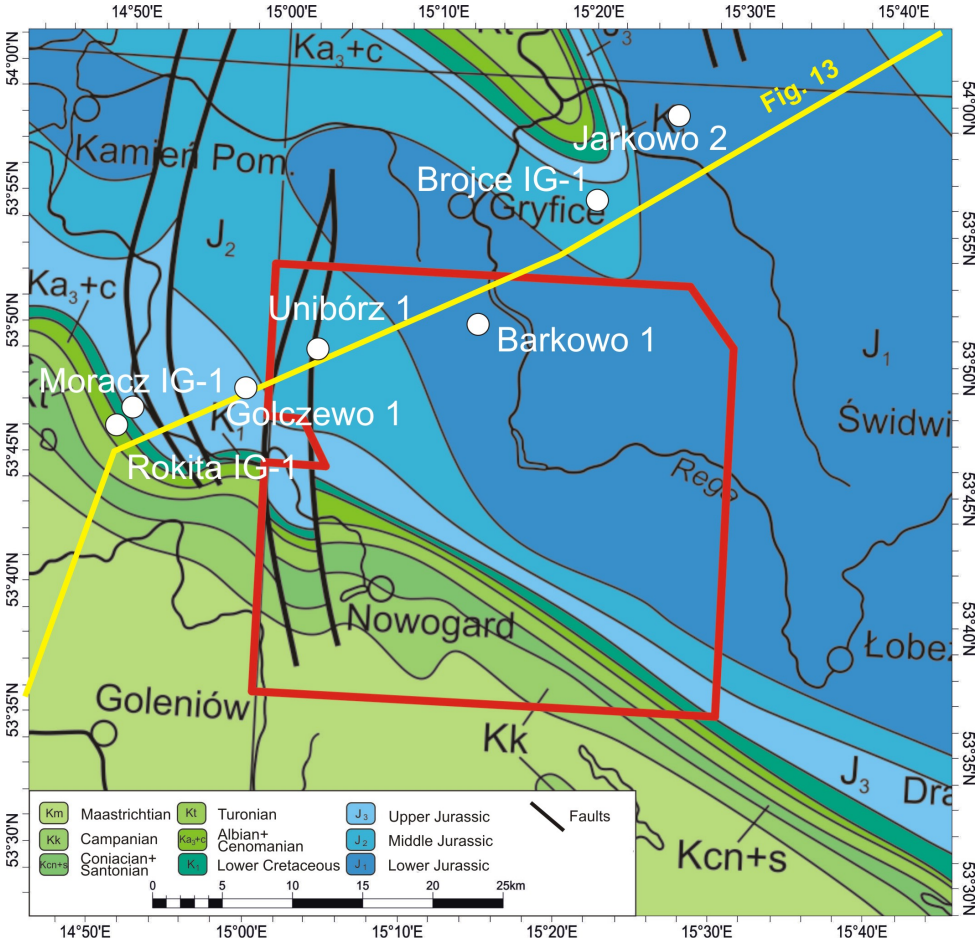


Fig. 11. Location of the Żabowo tender area on the geological map of Poland without Cenozoic cover (Dadlez et al, 2000; modified).

Triassic

Lithostratigraphy: Buntsandstein (Baltic Formation, Połczyn Formation, Barwice Formation); Muschelkalk; Keuper (Sulechów Beds, Lower Gypsum Beds, Reed Sandstone, Zbąszynek Beds, Wielichów Beds).
Lithology: Buntsandstein – variegated claystones with anhydrite intercalations, sandstones intercalated with variegated claystones, variegated claystones and mudstones intercalated with limestones and marls; Muschelkalk – limestones and marls; Keuper – clastic rocks including variegated claystones and mudstones.
Wells and depth: Barkowo 1 (976.0–2675.0 m),
Błotno 1 (1801.0–2314.0 m),
Błotno 2K (1980.0–2337.9 m),
Błotno 3 (1860.0–3099.7 m),
Gardomino 1 (1020.0– 2634.0 m),
Grabin 1 (1561.0–2274.0 m),
Grabin 2K (1571.0–2353.0 m),
Karsk 1 (1818.0–2259.0 m),
Łososínica 1 (1144.0–2451.0 m),
Piaski PIG-2 (708.5–2277.5 m),
Unibórz 1 (1523.0–2155.5 m).
Thickness (according to wells): 441.0–1699.0 m.
References: Pieńkowski, 1988, 1989; Menning and Hendrich, 2002.

Jurassic (Figs 11–12)

Lithostratigraphy: Lower Jurassic – Zagaje Formation, Skłoby Formation, Ostrowiec Formation, Łobez Formation, Komorów Formation, Ciechocinek Formation, Borucice Formation; Middle Jurassic – Limnic Series in the lower part and undivided upper part; Upper Jurassic – Łyna Formation, Chociwel Formation, Brda Formation, Pałuki Formation, Kcyń Formation.
Lithology: Lower Jurassic – sandstones, claystones and mudstones, claystones, mudstones; Middle Jurassic – claystones and mudstones, fine-grained sandstones with intercalations of mudstones and coal beds, sandstones; Upper Jurassic – mudstones, limestones, marly limestones, sandy limestones and marls.
Wells and depth: Barkowo 1 (65.0–976.0 m),
Błotno 1 (22.0–1801.0 m),
Błotno 2K (21.0–1980.0 m),
Błotno 3 (21.0–1860.0 m),
Gardomino 1 (52.0–1020.0 m),
Karsk 1 (16.0–1818.0 m),
Łososínica 1 (61.0–1144.0 m),
Nowogard GEO-1 (1128.0–1201.0 m),
Piaski PIG-2 (161.5–708.5 m),
Unibórz 1 (32.0–1523.0 m).
Thickness (according to wells): 73.0–1839.0 m.
References: Dadlez, 1964, 1969; Dayczak-Calikowska, 1977, 1987; Dembowska, 1979a, b; Brochwicz-Lewiński, 1987; Dadlez et al., 2000; Pieńkowski, 2004.

Cretaceous (Figs 11–12)

Lithostratigraphy: Kcyń Formation, Rogoźno Formation, Bodzanów Formation, Włocławek Formation, Mogilno Formation and undivided Albian-Maastrichtian interval.
Lithology: sandstones, sandy-mudstones, mudstones, claystones, marls, limestones and opokas.
Wells and depth: Nowogard GEO-1 (225.0–1128.0 m),
Maszkowo 2 (63.0–303.4 m).
Thickness (according to wells): 240.4–903.0 m.
References: Raczyńska, 1979, 1987; Jaskowiak-Schoeneichowa, 1979, 1981, 1987; Dadlez, 1980; Marek, 1988; Leszczyński and Dadlez, 1999.

Cenozoic

Lithology: clays, muds, sands, gyttjas, bog limes, tills.
Thickness: 21.0–225.0 m.

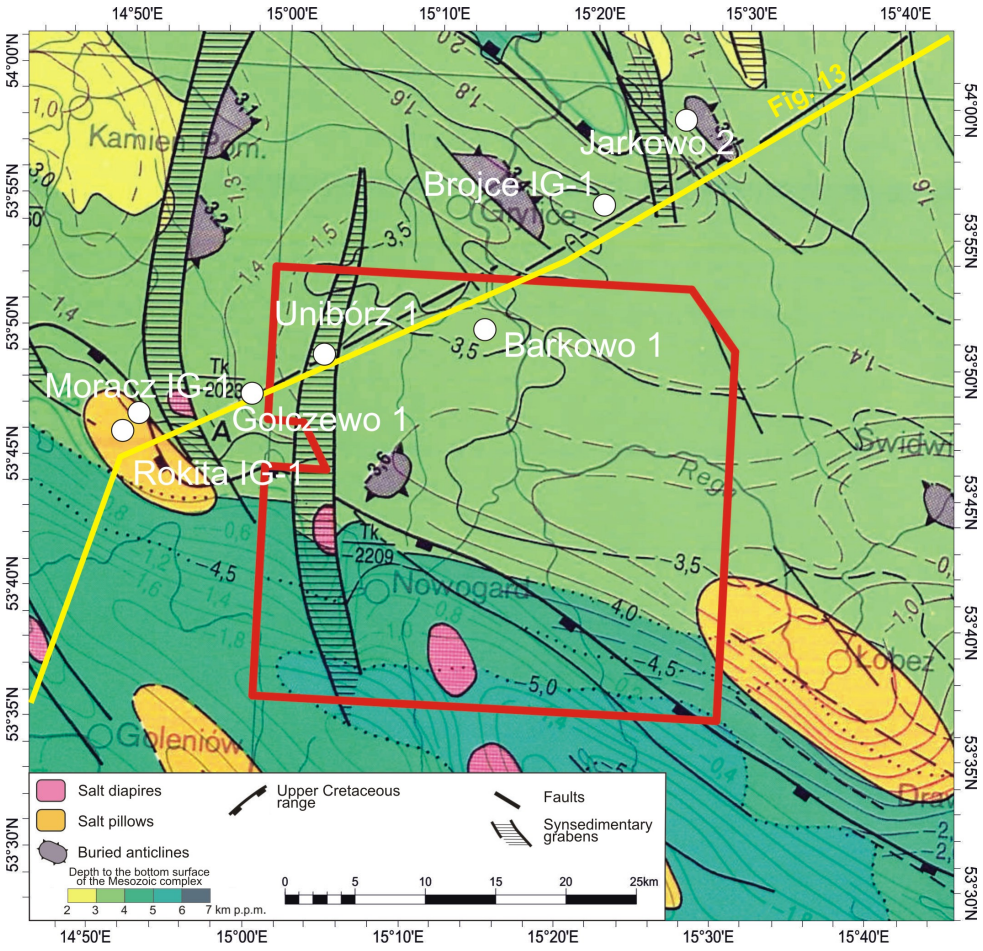


Fig. 12. Location of the Żabowo tender area on the tectonic map of the Zechstein-Mesozoic complex (Dadlez, 1998; modified).

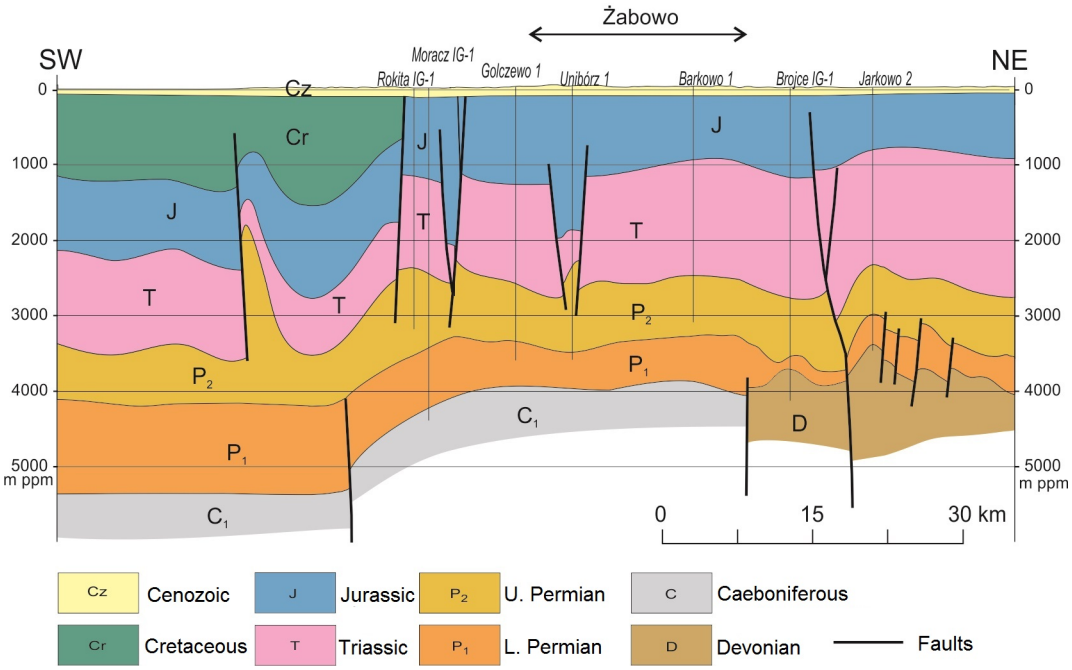


Fig. 13. Geological cross section through the Żabowo tender area in the north-western Poland (Aleksandrowski and Krzywiec, 2017; modified).
For location – see Figs 10–12.

3. PETROLEUM SYSTEMS

Two conventional petroleum systems are developed in the Żabowo tender area (Fig. 14). These are:

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

They are separated by succession of evaporites of the first Zechstein cyclotheme (A1d, Na1, A1g).

Carboniferous-Permian (Rotliegend) petroleum system

Source rocks: Mississippian fine-grained clastic rocks and carbonates.
TOC = max. 9.0% (Błotno 3).
T_{max} = 429°C (Błotno 3).
R_o = 0.6–0.9% (Błotno 3).
Kerogen type: III, III/II.

Reservoir rocks: aeolian sandstones within the Rotliegend succession, alluvial conglomerates and sandstones and fluvial sandstones and mudstones at the top of the Rotliegend succession.
Porosity (average in wells) = 1.03–4.82%.
Permeability (average in wells) = 0.0–0.9 mD.

Seal rocks: succession of evaporites of the first Zechstein cyclotheme (A1d, Na1, A1g).

Thickness of the overburden: 3324–3927 m.

Traps: structural and stratigraphic (related to narrowing of sandstone layers) in the Carboniferous, stratigraphic (related to interfingering of aeolian sandstones with alluvial/fluvial/playa-lake sediments) within the Rotliegend succession, structural (related to the top of the Rotliegend).

Hydrocarbon fields: Ciechnowo, Sławoborze.

References: Kotarba et al., 1992, 1999, 2004, 2005; Kiersnowski and Buniak, 2006; Burzewski et al., 2009; Grotek, 2010; Pletsch et al., 2010; Kiersnowski, 2013.

Zechstein (Main Dolomite) petroleum system

Source rocks: organic-rich interbeds within the Main Dolomite succession
TOC = 0.7–2.0 (average 1.2%).
T_{max} = 441–452°C.
S2 = 0.2–0.6 mgHC/g rock.
R_o = 0.55–1.55% (average 1.14%).
Kerogen type: III, II.

Reservoir rocks: Main Dolomite carbonates.
Porosity (average in wells) = 0.58–4.22%.
Permeability (average in wells) = 0.0–12.5 mD.

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

Thickness of the overburden: 2930–3588 m.

Traps: structural, stratigraphic.

Hydrocarbon fields: Błotno, Rekowo, Sławoborze, Wysoka Kamieńska.

References: Semyrka, 1985; Gąsiewicz and Wichrowska, 1996; Darłak et al. 1998.

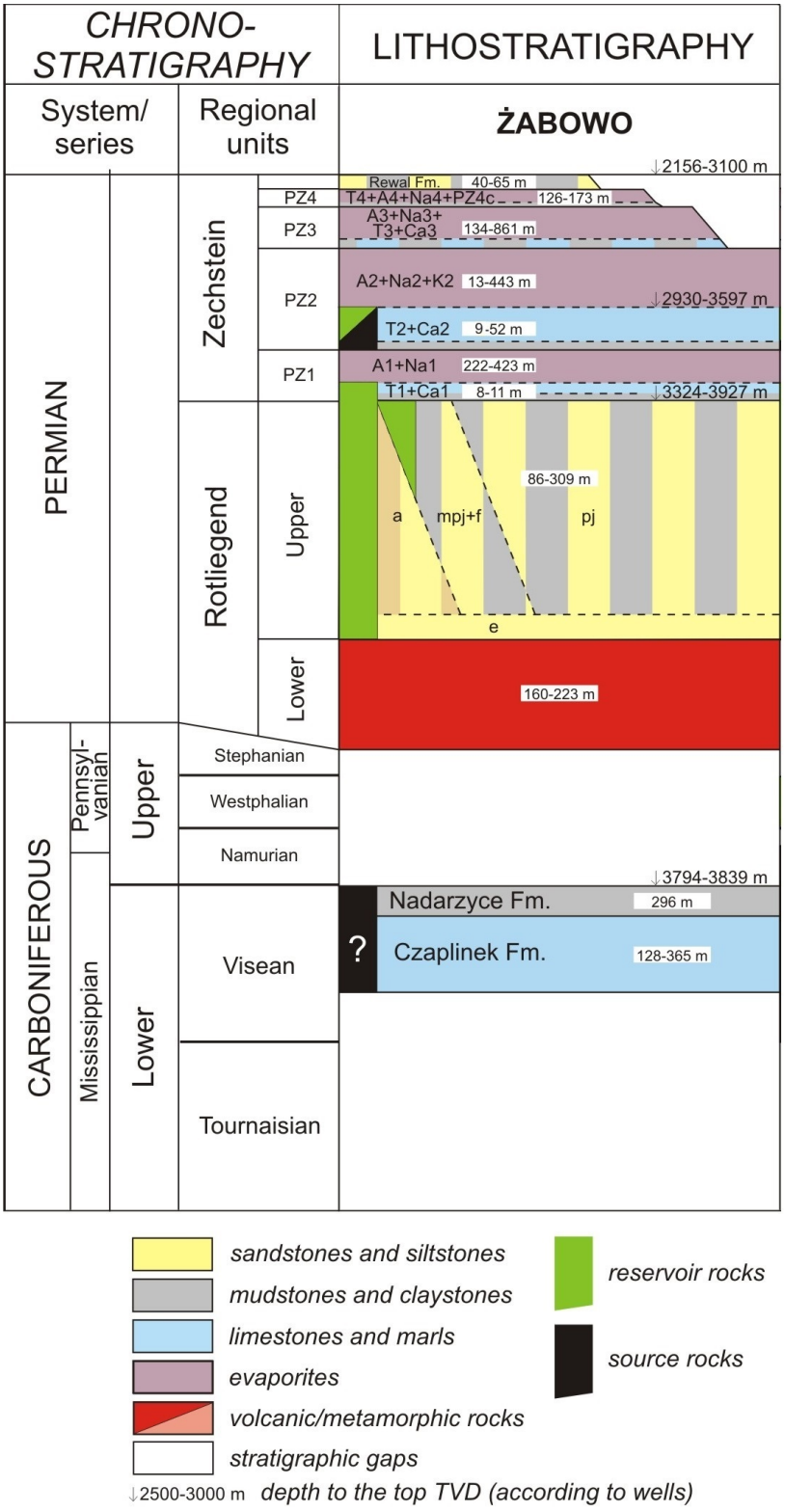


Fig. 14. Stratigraphy, lithology and major elements of petroleum system (main horizons of source and reservoir rocks) in the Żabowo tender area (Jagielski et al., 2019; modified).
a – alluvial deposits, e – aeolian deposits, pj – playa-lake deposits, mpj+f – marginal playa-lake and fluvial deposits

4. HYDROCARBON FIELDS

Numerous hydrocarbon fields have been discovered in the close neighborhood of the Żabowo tender area. These are (Fig. 15):

- Błotno oil field (NR 4803),
- Ciechnowo gas field (GZ 6723),
- Sławoborze gas field (GZ 13325),
- Sławoborze oil field (NR 10334),
- Rekowo oil field (NR 4847),
- Wysoka Kamieńska oil field (NR 4804).

They are still exploited.

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

ŻABOWO TENDER AREA

0 2 4 8 12 16 20 km

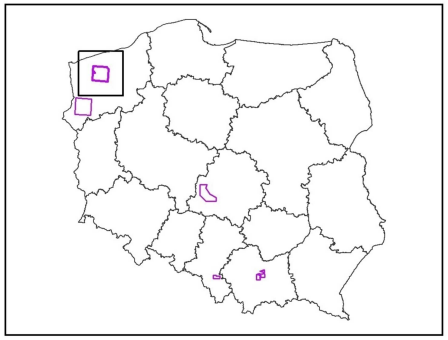
Legend

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

Border points

coordinate system – PL 1992

Point no.	X	Y
1	673948.18	266614.09
2	669360.76	269798.54
3	643263.52	268511.84
4	645106.88	235462.62
5	661436.72	236382.04
6	661143.42	240603.82
7	664525.57	238976.42
8	664755.54	236443.29
9	675598.09	237055.20



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

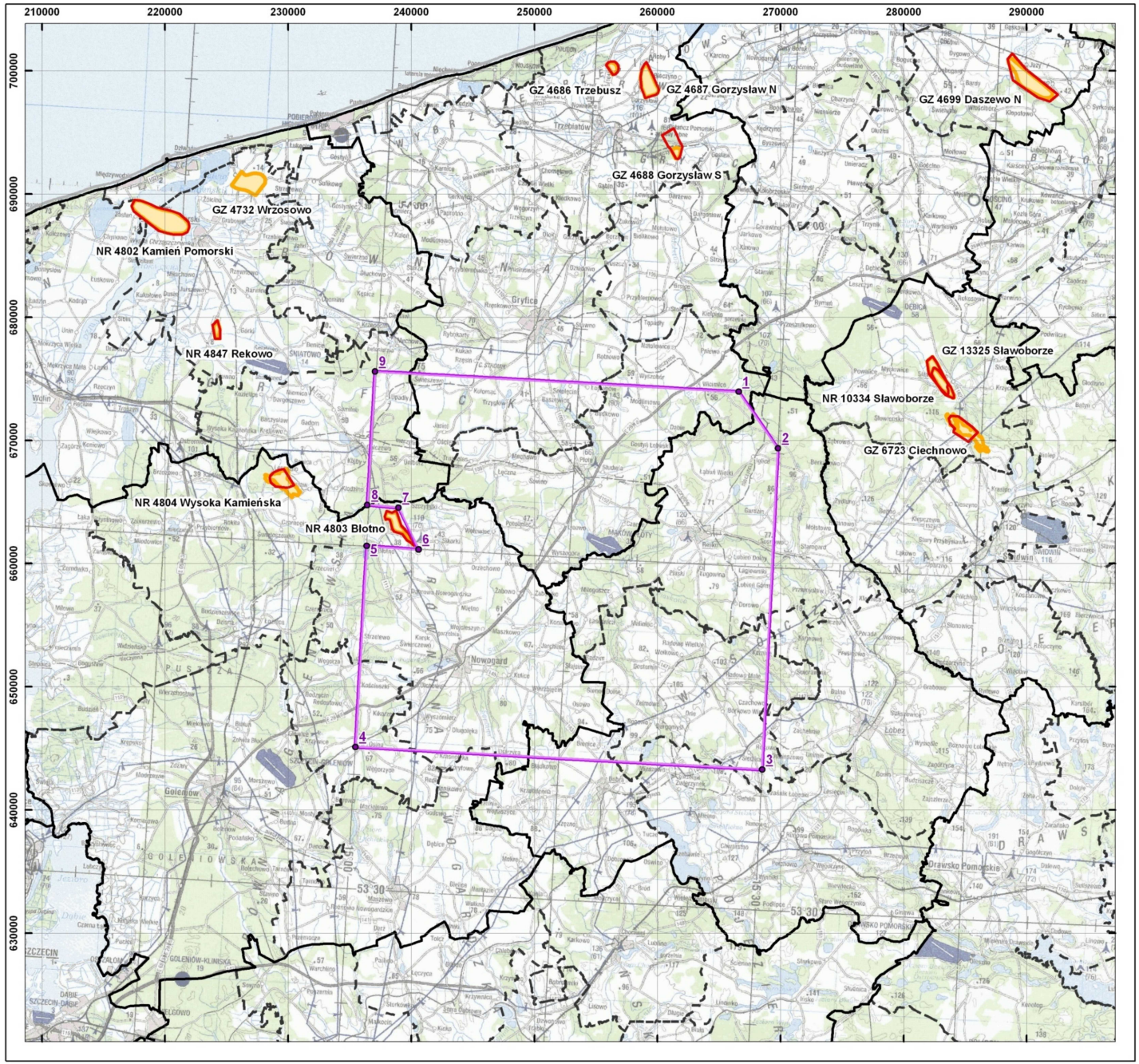


Fig. 15. Oil and gas fields in the neighborhood of the Żabowo tender area.

Błotno oil field

Acreage: 165.72 ha.
Depth: from -3143.4 m a.s.l. to -3185.5 m a.s.l.
Stratigraphy: Permian/Zechstein (Main Dolomite).
Resources:

- Extractable balance resources as of 2017:
  8.29 ktonnes of oil in cat. C,
  1.96 million m^3 of natural gas in cat. C,
- Economic resources in place as of 2017:
  8.26 ktonnes of oil,
- Production in 2017:
  0.42 ktonnes of oil,
  0.04 million m^3 of natural gas.

Parameter	Average value	Unit	Comment
reservoir pressure	27.38	MPa	15.09.2008
primary reservoir pressure	60.02	MPa	calculated
porosity	1.27	%	–
permeability	0.11	mD	fracture
maximum efficiency V_{max}	128.00	t/month	–
gas-oil ratio	213.50	m^3/t	annual average

Tab. 2. Quality parameters of the Błotno oil field (MIDAS, 2019; according to Łapa and Nowak, 2009).

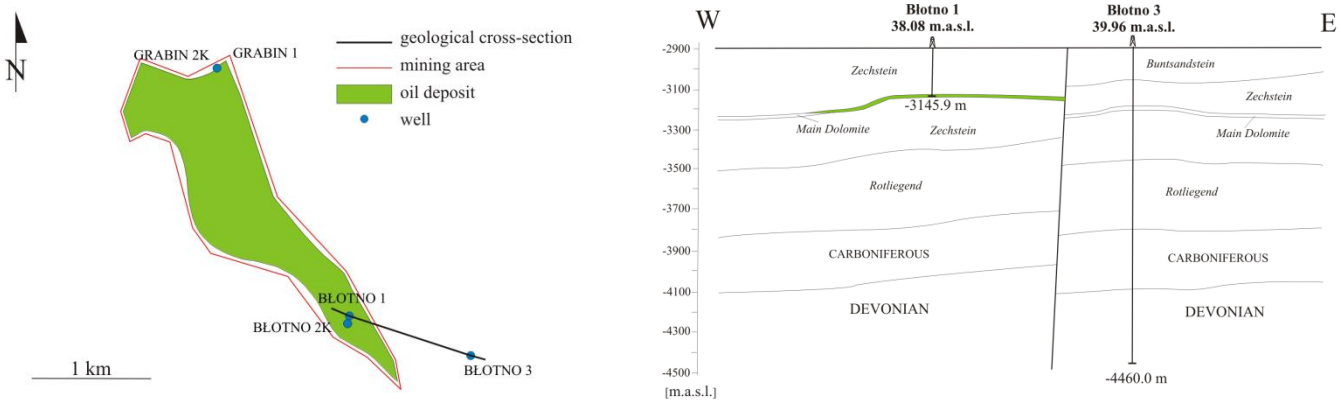
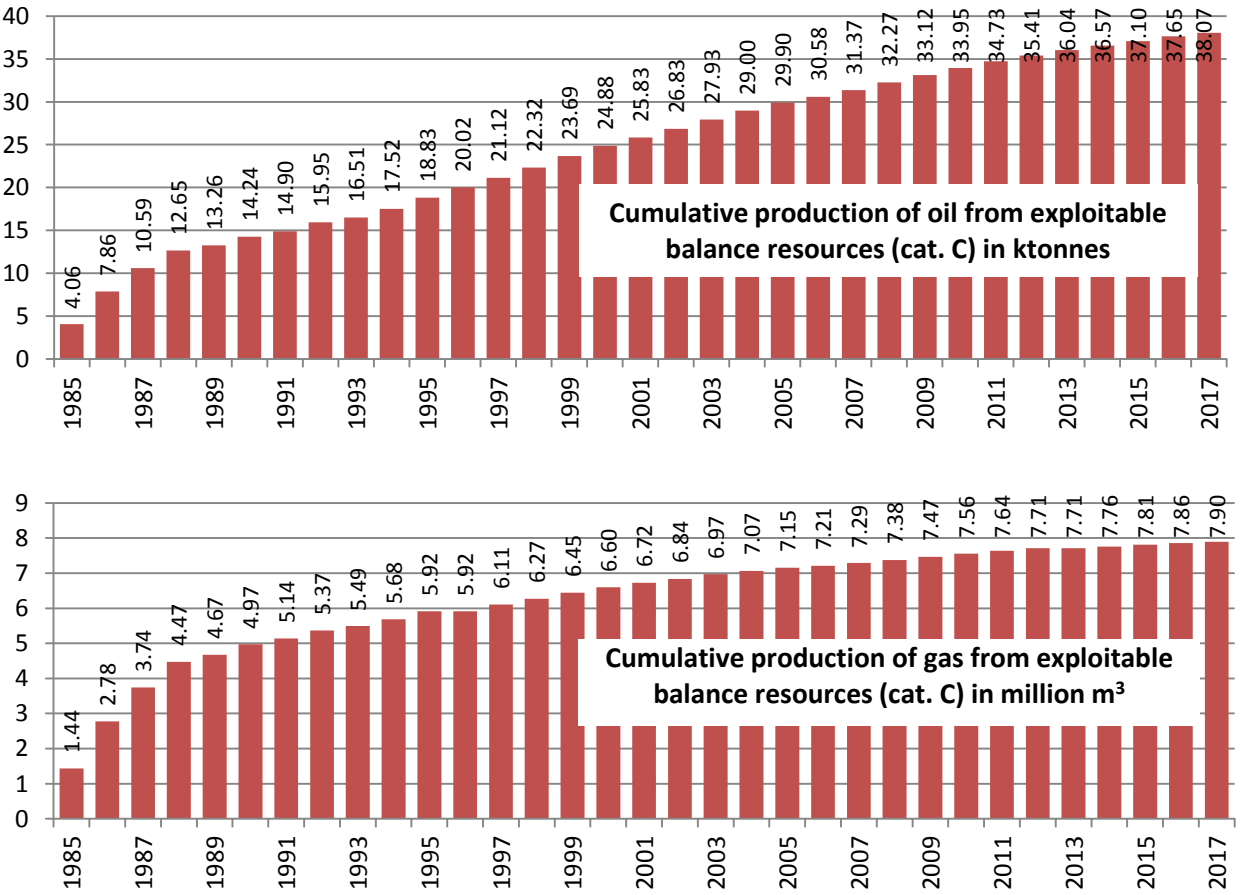


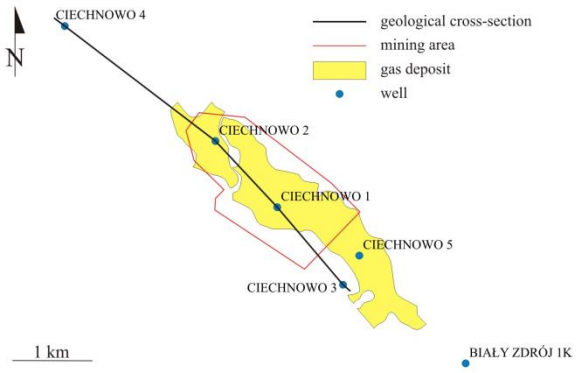
Fig. 16. Map and geological cross section through the Błotno oil field (CBDG, 2019; Binder et al. 1985).



Ciechnowo gas field

Acreage: 246.10 ha.
Depth: the depth is ambiguously determined due to the low permeability of the collector (sandstone; bottom in the Ciechnowo I block: -3720.3 m a.s.l., bottom in the Ciechnowo II block: -3697.12 m a.s.l.).
Stratigraphy: Permian/Rotliegend.
Resources:

- Extractable balance resources as of 2017: 15.92 million m^3 of natural gas in cat. C,
- Economic resources in place as of 2017: 27.73 million m^3 of natural gas,
- Production in 2017: 7.11 million m^3 of natural gas.



Parameter	Average value	Unit	Comment
reservoir pressure	40.12	MPa	Ciechnowo I block on June 28, 2002
reservoir pressure	40.48	MPa	Ciechnowo II block on June 28, 2002
primary reservoir pressure	46.65	MPa	Ciechnowo I block
primary reservoir pressure	45.98	MPa	Ciechnowo II block
aquifer depth	-3743.66	m	Ciechnowo I block
effective deposit thickness	34.65	m	Ciechnowo I block
effective deposit thickness	24.32	m	Ciechnowo II block
porosity	4.85	%	Ciechnowo I block
porosity	4.48	%	Ciechnowo II block
permeability	16.40	mD	Ciechnowo I block
permeability	81.420	mD	Ciechnowo II block
total efficiency V_{tot}	359.00	m^3/min	Ciechnowo 1 well – measurement on June 28, 2002
total efficiency V_{tot}	299.00	m^3/min	Ciechnowo 2 well – measurement on June 28, 2002
total efficiency V_{tot}	44.00	m^3/min	Ciechnowo 5 well – measurement on June 28, 2002

Tab. 3. Quality parameters of the Ciechnowo gas field (MIDAS, 2019, according to Pawłowski, 2003).

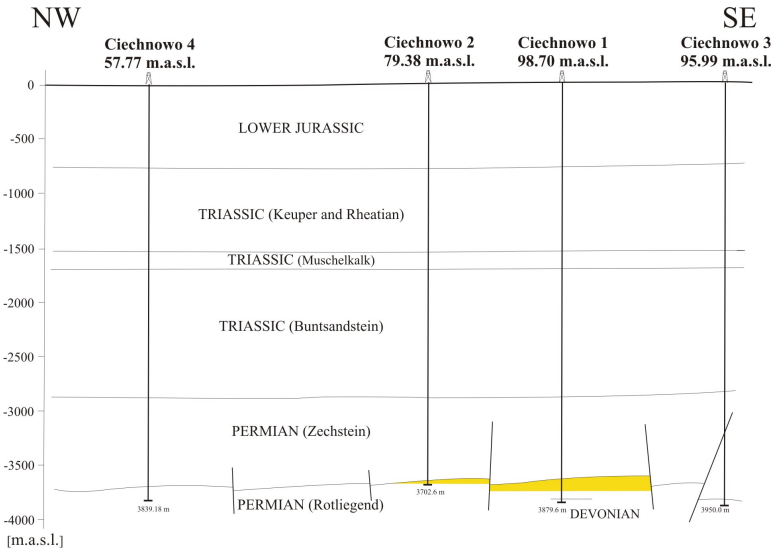
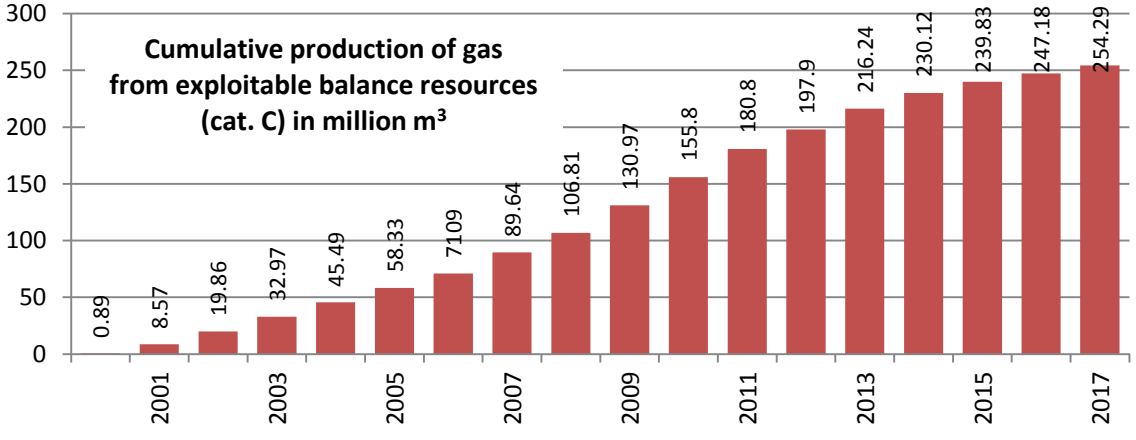


Fig. 17. Map and geological cross section through the Ciechnowo gas fields (CBDG, 2019; Nowicka, 1995).



Sławoborze gas field

Acreage: 213.00 ha.
Depth: from -3577.66 m a.s.l. to -3637.51 m a.s.l.
Stratigraphy: Permian/Rotliegend.
Resources:

- Extractable balance resources as of 2017: 59.19 million m^3 of natural gas in cat. C,
- Economic resources in place as of 2017: 58.32 million m^3 of natural gas,
- Production in 2017: 5.53 million m^3 of natural gas.

Parameter	Average value	Unit	Comment
reservoir pressure	45.97	MPa	–
net pay	28.79	m	–
effective porosity	3.97	%	–
permeability	5.415	mD	Sławoborze 1well
permeability	0.497	mD	Sławoborze 3 well
total efficiency V_{tot}	526.00	m^3/min	Sławoborze 1 well
total efficiency V_{tot}	39.00	m^3/min	Sławoborze 3 well

Tab. 4. Quality parameters of the Sławoborze gas field (MIDAS, 2019, according to Nowicka, 2009).

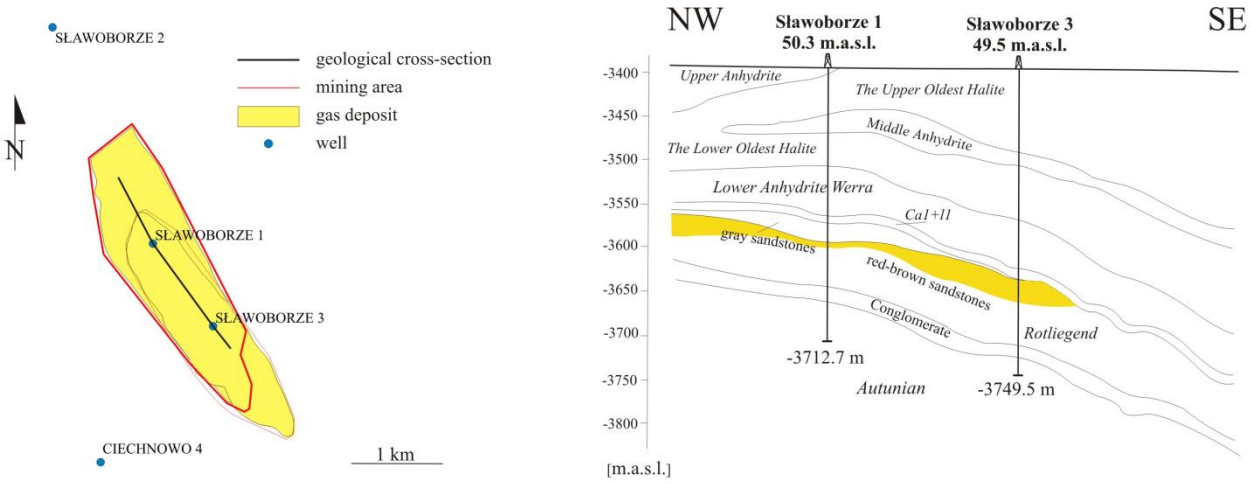
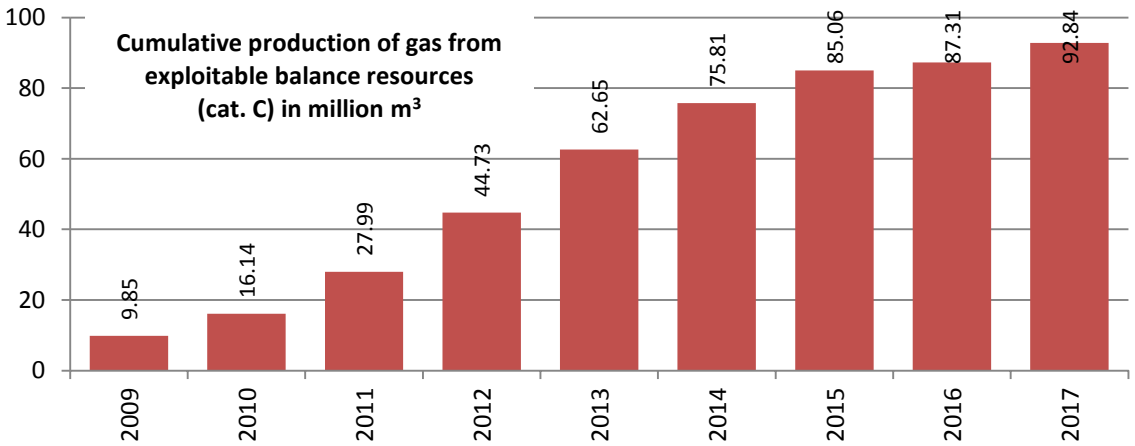


Fig. 18. Map and geological cross section through the Sławoborze gas fields (CBDG, 2019; Nowicka, 2009).



Sławoborze oil field

Acreage: 156.90 ha.
Depth: from -3150.00 m a.s.l. to -3207.66 m a.s.l.
Stratigraphy: Permian/Zechstein (Main Dolomite).
Resources:

- Extractable balance resources as of 2017:
  4.42 ktonnes of oil in cat. B,
  1.45 million m^3 of natural gas in cat. B,
- Economic resources in place as of 2017:
  4.42 ktonnes of oil,
  lack of econ. resources in place of natural gas,
- Production in 2017:
  0.12 ktonnes of oil,
  0.06 million m^3 of natural gas.

Parameter	Average value	Unit	Comment
reservoir pressure	60.96	MPa	at a depth of -3199 m
net pay	21.87	m	–
porosity	1.32	%	–
permeability	2.792	mD	–
oil saturation index	0.90		–
maximum efficiency V_{max}	67.00	t/d	Sławoborze 1 well
maximum efficiency V_{max}	55.00	t/d	Sławoborze 3 well
gas–oil ratio	460.00	m^3/m^3	–
gas–oil ratio	575.00	m^3/t	–

Tab. 5. Quality parameters of the Sławoborze oil field (MIDAS, 2019, according to Nowicka, 2009).

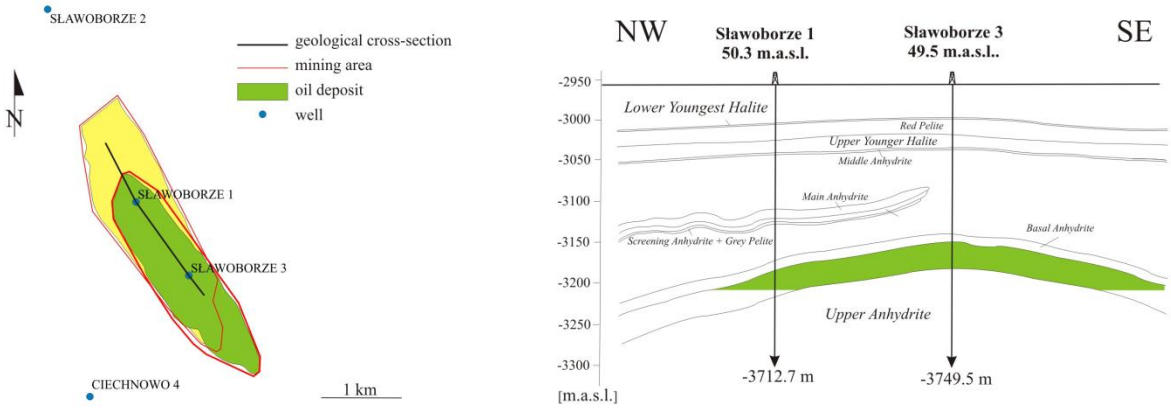
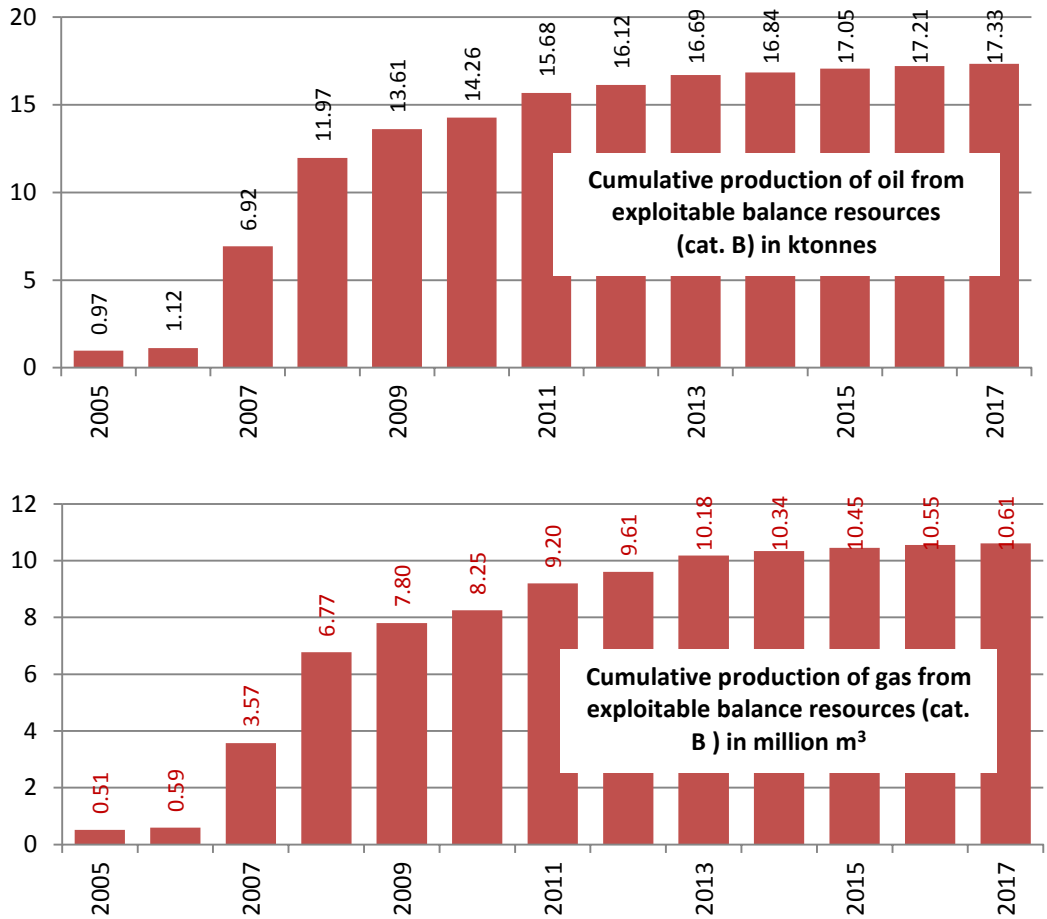


Fig. 19. Map and geological cross section through the Sławoborze oil fields (CBDG, 2019; Nowicka, 2009).



Rekowo oil field

Acreage: 53.12 ha
Depth: from -2665.00 m a.s.l. to -2658.05 m a.s.l.
Stratigraphy: Permian – Zechstein (Main Dolomite).
Resources:

- Extractable balance resources as of 2017:
  1.37 ktonnes of oil in cat. B,
  0.27 million m^3 of natural gas in cat. B,
- Economic resources in place as of 2017:
  1.45 ktonnes of oil,
  lack of econ. resources in place of natural gas,
- Production in 2017:
  0.08 ktonnes of oil,
  0.01 million m^3 of natural gas.

Parameter	Average value	Unit	Comment
reservoir pressure	49.911	MPa	at a depth of -3199 m
porosity	0.5–3.1	%	–
permeability	0.016–1.163	mD	–

Tab. 6. Quality parameters of the Rekowo oil field (MIDAS, 2019, according to Pawłowski, 2005).

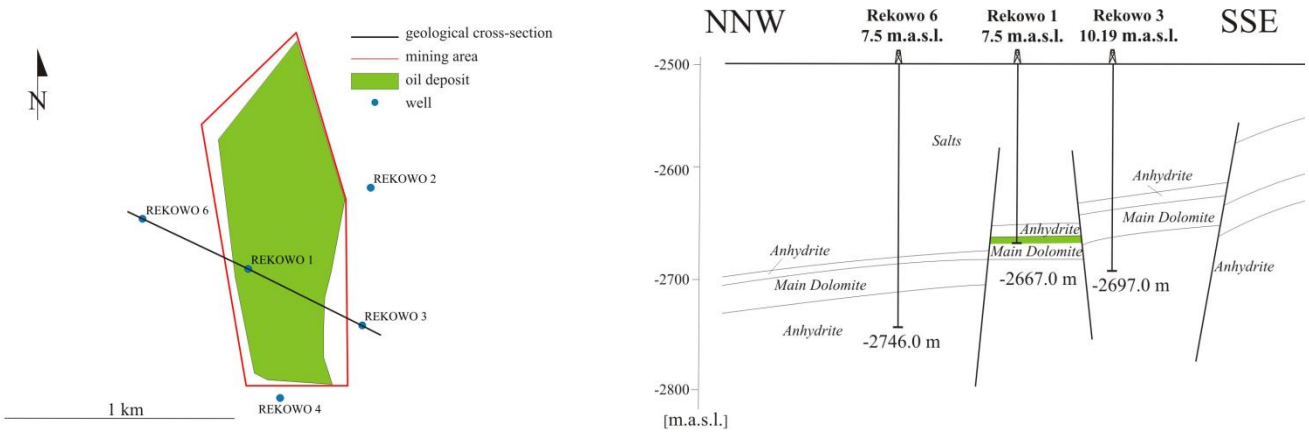
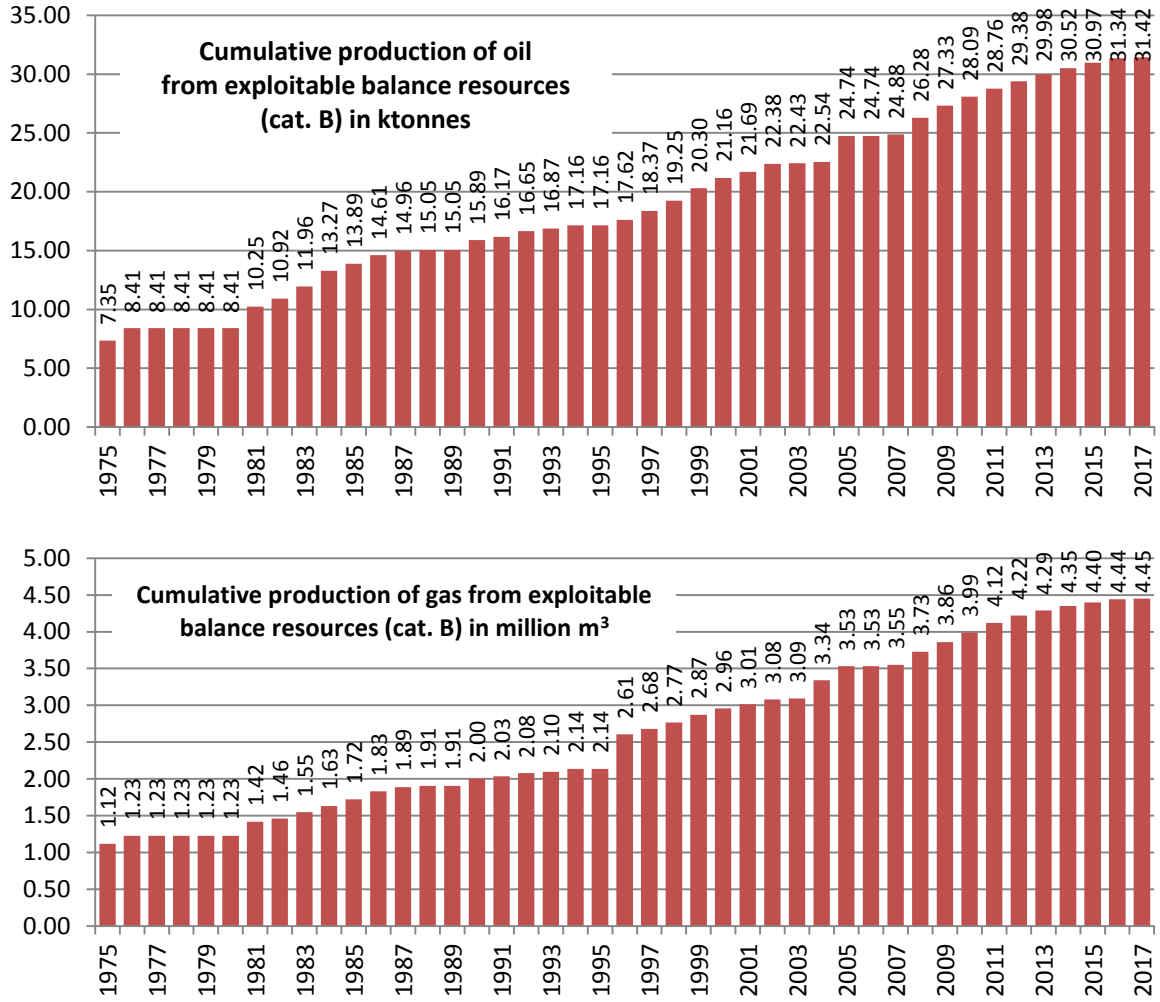


Fig. 20. Map and geological cross section through the Rekowo oil fields (CBDG, 2019; Pawłowski, 2005).



Wysoka Kamieńska oil field

Acreage: 256.20 ha.
Depth: from -3010.30 m a.s.l. to -3060.70 m a.s.l.
Stratigraphy: Permian/Zechstein (Main Dolomite).
Resources:

- Extractable balance resources as of 2017:
  16.09 ktonnes of oil in cat. A,
  2.74 million m^3 of natural gas in cat. A,
- Economic resources in place as of 2017:
  16.61 ktonnes of oil,
  lack of econ. resources in place of natural gas,
- Production in 2017:
  3.73 ktonnes of oil,
  0.27 million m^3 of natural gas.

Parameter	Average value	Unit	Comment
reservoir pressure	54.600	MPa	–
aquifer depth	-3060.70	m	–
net pay	21.43	m	–
porosity	4.58	%	–
permeability	10.21	mD	–
maximum efficiency V_{max}	608.00	t/month	whole deposit
gas-oil ratio	73.00	m^3/t	–

Tab. 7. Quality parameters of the Wysoka Kamieńska oil field (MIDAS, 2019, according to Nowak, 2004).

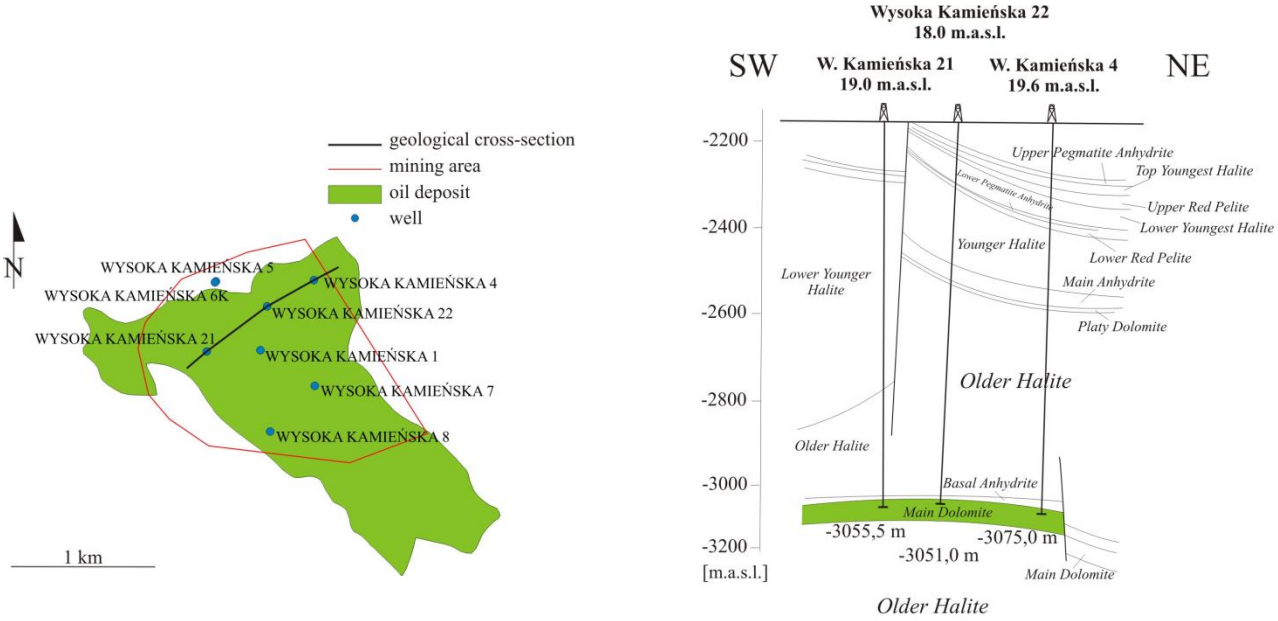
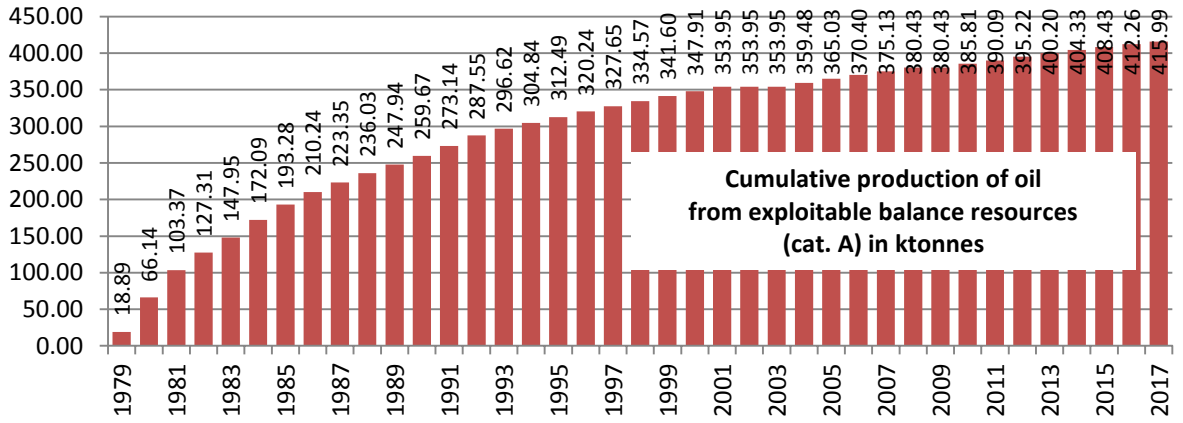
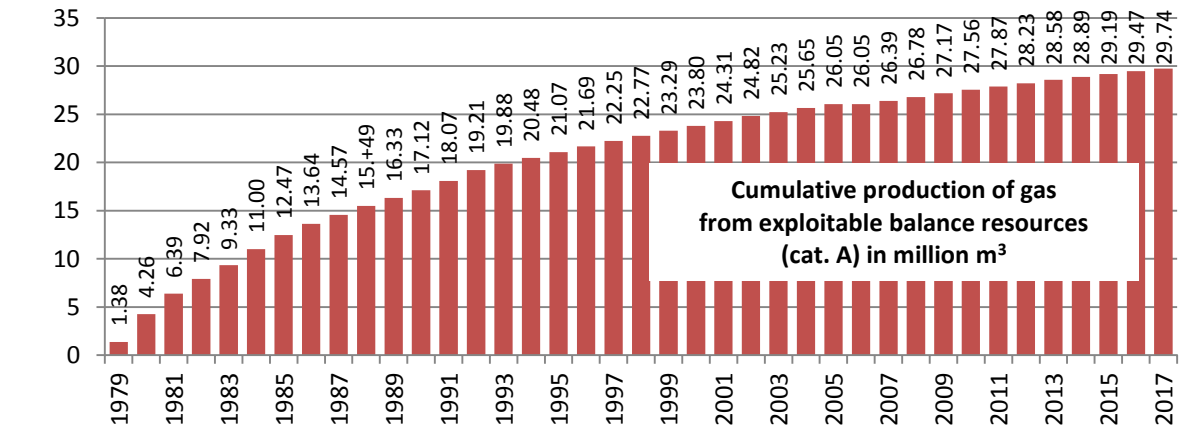


Fig. 21. Map and geological cross section through the Rekowo oil fields (CBDG, 2019; Zoła, 1996).





5. WELLS

Forteen deep wells (> 500 m TVD) reached the prospective intervals within the Żabowo tender area and in its close neighborhood (Fig. 22). These are: Barkowo 1, Błotno 1, 2K, 3, Gardomino 1, Grabin 1, 2K, Karsk 1, Łososnica 1, Nowogard GEO-1, Pisaki PIG-2, 3, Smolęcin 1, Unibórz 1 (wells located within the tender area are highlighted).

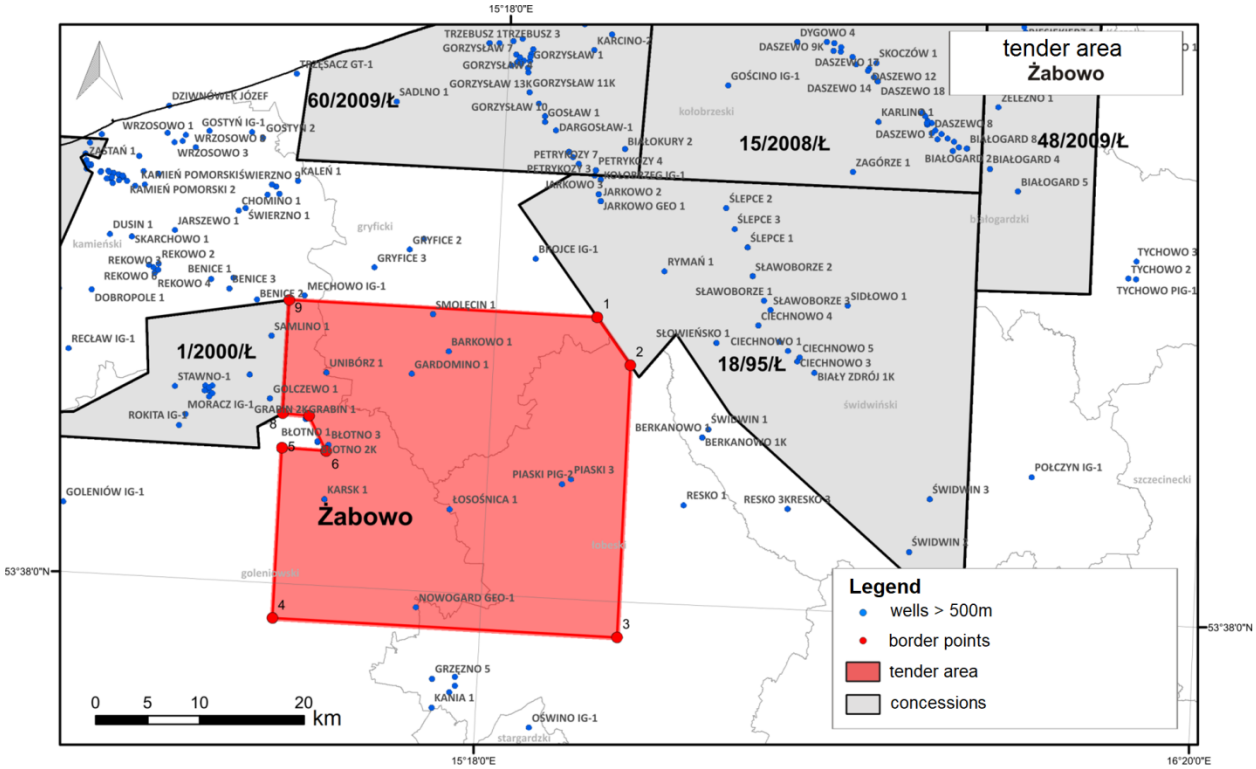


Fig. 22. Deep wells (> 500 m TVD) reaching the prospective intervals within the Żabowo tender area and in its close neighborhood.

STRATIGRAPHY		BARKOWO 1				BŁOTNO 1				BŁOTNO 2K				BŁOTNO 3				GARDOMINO 1		GRABIN 1			
		top	bottom	Porosity min–max [%]	Vertical permeability min–max [mD]	top	bottom	Porosity min–max [%]	Vertical Permeability min–max [nm^3]	top	bottom	Porosity min–max [%]	Vertical Permeability min–max [nm^3]	top	bottom	Porosity min–max [%]	Vertical Permeability min–max [nm^3]	top	bottom	top	bottom	Porosity min–max [%]	Vertical Permeability min–max [nm^3]
QUATERNARY		0.0	65.0			0.0	22.0			0.0	21.0			0.0	21.0			0.0	52.0	0.0	23.0		
JURASSIC	UPPER					22.0	99.5			21.0	76.0			21.0	70.0					23.0	122.0		
	MIDDLE					99.5	703.0			76.0	468.0			70.0	456.0					122.0	331.0		
	LOWER	65.0	976.0			703.0	1801.0			468.0	1980.0			456.0	1860.0			52.0	1020.0	331.0	1561.0		
TRIASSIC	UPPER	976.0	1252.0			1801.0	1980.5							1860.0	2216.0			1020.0	1380.0	1561.0	1721.0		
	MIDDLE	1252.0	1555.0											2216.0	2495.0			1380.0	1528.0				
	LOWER	1555.0	2675.0			1980.5	2314.0			1980.0	2337.9			2495.0	3099.7			1528.0	2634.0	1721.0	2274.0		
PERMIAN		2675.0	3198.4			2314.0	3184.0			2337.9	3261.4			3099.7	3839.0			2634.0	3698.5	2274.0	3238.0	3.03 –11.14	3.06
Rewal Formation		2675.0	2740.0															2634.0	2690.5	2274.0	2320.0		
Zechstein PZ4c		2740.0	2746.5																				
Top Youngest Halite Na4b2		2746.5	2765.0															2690.5	2715.5	2320.0	2330.0		
Upper Red Pelite T4b		2765.0	2795.0															2715.5	2736.5	2330.0	2368.0		
Upper Youngest Halite Na4a2		2795.0	2824.0															2736.5	2774.5				
Upper Pegmatite Anhydrite A4a2		2824.0	2825.0															2774.5	2776.5				
Lower Youngest Halite Na4a1		2825.0	2864.0															2776.5	2838.0				
Lower Pegmatite Anhydrite A4a1		2864.0	2865.0																				
Youngest Halite		2865.0	2866.0																				
Lower Red Pelite T4a		2866.0	2898.5															2838.0	2838.5				
Younger Halite Na3		2898.5	3013.0							2337.9 3082.5	3048.1 3216.1			3099.7	3186.6								
Upper Younger Halite Na3g																		2838.5	2884.0			3.03 – 11.14	3.06
Lower Younger Halite Na3d																		2890.0	3003.5	2368.0	3218.0		
Main Anhydrite A3		3013.0	3029.0							3048.1	3052.1	1.64	4.07	3186.6	3224.1			2884.0 3003.5	2890.0 3034.0				
Platy Dolomite Ca3 + Grey Pelite T3		3029.0	3032.0							3052.1 3216.1	3057.1 3222.8	3.12 – 10.29 0.14 – 11.21	10.66 0.19 – 5093.01					3034.0	3043.0				
Screening Anhydrite A2r		3032.0	3034.5							3057.1 3222.8	3082.5 3225.3	2.00	9.17					3043.0	3044.5				
Screening Older Halite Na2r		3034.5	3036.0																				
Older Potash K2		3036.0	3065.5			2314.0	3178.5			3225.3	3245.7							3044.5	3124.5				
Older Halite Na2		3065.5	3134.0											3224.1	3233.6								
Basal Anhydrite A2		3134.0	3157.0	0.52 – 5.99	0.01 – 0.56	3178.5	3181.5			3245.7	3250.9	0.28 – 1.30	2.47 – 7.30	3233.6	3237.1			3124.5	3147.0	3218.0	3222.8		
Main Dolomite Ca2		3157.0	3181.5	0.44 – 11.4	0.01 – 4.44	3181.5	3184.0	0.79–2.3	58.2–337.9	3250.9	3261.4	0.07 – 3.61	0.64 – 160.60	3237.1	3253.5	0.08 – 13.61	1.34 – 3.09	3147.0	3169.5	3222.8	3238.0	1.23 – 20.57	9.18 – 419.22
Upper Anhydrite A1g		3181.5	3198.4											3253.5	3425.2	0.07 – 0.37	2.47	3169.5	3468.5				
Oldest Halite Na1														3425.2	3448.6			3468.5	3543.5				
Lower Anhydrite A1d														3448.6	3495.9			3543.5	3592.5				
Zechstein Limestone Ca1														3495.9	3505.9			3592.5	3601.0				
Copper Shale T1														3505.9	3506.4								
Upper Rotliegend														3506.4	3616.1			3601.0	3698.5				
Lower Rotliegend														3616.1	3839.0								
CARBONIFEROUS – VISEAN														3839.0	4135.0								
Nadarzyce Claystone Formation														3839.0	4135.0								
Czaplinek Limestone Formation														4135.0	4500.0	0.37 – 1.75	0.7 – 160.27						

Tab. 8. Stratigraphy and petrophysical characteristics in the Barkowo 1 (Ryba, 1975), Błotno 1 (Lech, 1981), Błotno 2K (Lech, 1983b), Błotno 3 (Lech, 1984), Gardomino 1 (Binder, 1982), Grabin 1 (Binder, 1986).

STRATIGRAPHY		GRABIN 2K				KARSK 1				ŁOSOŚNICA 1				NOWOGARD GEO-1		PIASKI PIG-2				UNIBÓRZ 1			
		top	bottom	Porosity min–max [%]	Vertical Permeability min–max [nm^3]	top	bottom	Porosity min–max [%]	Vertical Permeability min–max [mD]	top	bottom	Porosity min–max [%]	Vertical Permeability min–max [mD]	top	bottom	top	bottom	Porosity min–max [%]	Vertical Permeability min–max [mD]	top	bottom	Porosity min–max [%]	Vertical Permeability min–max [mD]
QUATERNARY		0.0	23.0			0.0	16.0			0.0	22.5			0.00	225.0	0.0	108.5			0.0	32.0		
PALEOGENE										22.5	61.0					108.5	161.5						
CRETACEOUS														225.0	1128.0								
JURASSIC	UPPER	23.0	122.0			16.0	194.0							1128.0	1201.0					32.0	54.5		
	MIDDLE	122.0	332.0			194.0	447.0			61.0	196.0									54.5	197.0		
	LOWER	332.0	1571.0			447.0	1818.0			196.0	1144.0					161.5	708.5			197.0	1523.0		
TRIASSIC	UPPER	1571.0	1855.0			1818.0	2259.0			1144.0	1410.0	1.18 – 9.95				708.5	1007.0						
	MIDDLE									1410.0	1519.0					1007.0	1192.0			1523.0	2155.5		
	LOWER	1855.0	2353.0							1519.0	2451.0					1192.0	2277.5						
PERMIAN		2353.0	3591.9			2259.0	4086.5			2451.0	3470.0					2277.5	3794.0			2155.5	3584.0		
Rewal Formation		2353.0	3135.0							2451.0	2496.0					2277.5	2327.5			2155.5	2195.5		
Zechstein PZ4c																2327.5	2344.0						
Top Youngest Halite Na4b2										2496.0	2504.0					2344.0	2354.0			2195.5	2240.0		
Upper Red Pelite – upper part T4b 2										2504.0	2538.5					2354.0	2366.5			2240.0	2286.5		
Intrastratal Halite Na4b1																2366.5	2371.0						
Upper Red Pelite – lower part T4b 1																2371.0	2382.0						
Upper Youngest Clay Halite Na4a2t																2382.0	2396.5						
Upper Youngest Halite Na4a2										2538.5	2567.0					2396.5	2428.0						
Upper Pegmatite Anhydrite A4a2										2567.0	2568.0					2428.0	2429.0						
Lower Youngest Halite Na4a1										2568.0	2605.0					2429.0	2464.5			2286.5	2325.5		
Lower Pegmatite Anhydrite A4a1										2605.0	2606.5					2464.5	2465.5						
Youngest Halite																							
Underlying Halite Na4a0																2465.5	2467.5						
Lower Red Pelite T4a										2606.5	2622.0					2467.5	2500.0			2325.5	2361.0		
Top Anhydrite A3r	2353.0	3135.0																					
Younger Halite Na3					2259.0	3148.0			2622.0	2785.0					2500.0	2769.0	1.35 – 2.73	0.1	2361.0	3220.0		
Lower Younger Halite Na3d	3140.0 3198.0	3141.8 3264.0																					
Main Anhydrite A3	3141.8 3150.8 3264.0	3142.8 3198.0 3291.3	0.07	7.0 – 16.0	3148.0 3433.0 3546.5	3236.5 3436.0 3568.5			2785.0	2820.5	0.07 – 5.38	1			2769.0	2806.0	0.68 – 9.85	0.1 – 0.32				
Platy Dolomite Ca3	3142.8 3291.3	3150.8 3296.6	4.71 2.65	2.0 – 458.0 9.0 – 69.0	3236.5 3436.0	3241.5 3440.5			2820.5	2824.0	0.07 – 6.87	0.2 – 68			2806.0	2808.5	5.84	0.1	3220.0	3221.5		
Grey Pelite T3					3472.5 3568.5	3481.5 3577.5									2808.5	2809.5						
Screening Anhydrite A2r					3241.5 3440.5 3481.5	3242.5 3462.5 3500.0			2824.0	2845.0					2809.5	2814.5	0.7	0.1	3221.5	3227.0		
Screening Older Halite Na2r															2814.5	2823.5						
Older Potash K2	3296.6	3299.6			3242.5 3462.5	3433.0 3472.5			2845.0	3265.0					2823.5	2888.5						
Older Halite Na2					3500.0 3577.5	3546.5 3585.0									2888.5	2918.5			3227.0	3245.0		
Basal Anhydrite A2	3299.6	3305.5	0.07	14.0	3585.0	3588.5			3265.0	3266.5	0.14	2			2918.5	2930.0	0.33	0.1	3245.0	3251.0	1.26	
Main Dolomite Ca2	3305.5	3326.1	1.03	8–2005	3588.5	3596.5			3266.5	3275.0	0.07 – 2.24	0.5 – 61			2930.0	2947.5	0.35 – 2.49	0.1	3251.0	3303.0	0.04–2.66	fracturing
Upper Anhydrite A1g	3326.1	3421.6	0.8 – 1.39	<200	3596.5	3866.0			3275.0	3395.0	0.07	9			2947.5	3166.5	1.05 – 2.12	0.1	3303.0	3438.5		
Oldest Halite Na1	3421.6	3438.4			3866.0	3870.0			3395.0	3437.5					3166.5	3275.0			3438.5	3479.0		
Lower Anhydrite A1d	3438.4	3484.4	0.86	32	3870.0	3917.5			3437.5	3470.0					3275.0	3316.0			3479.0	3525.0		
Zechstein Limestone Ca1	3484.4	3494.7	0.58	4 – 844	3917.5	3926.0									3316.0	3323.4			3525.0	3534.0	0.62–0.93	0.0–7.85
Copper Shale T1					3926.0	3927.0									3323.4	3324.0						
Upper Rotliegend	3494.7	3591.9	1.23	1 – 249	3927.0	4012.5	3.27–7.19	0.1–0.95							3324.0	3633.0	0.75 – 17.91	0.1 – 47	3534.0	3584.0	1.5–2.2	0.0–1.24
Lower Rotliegend					4012.5	4086.5									3633.0	3794.0	0.37 – 4.46	0.1 – 0.8				
CARBONIFEROUS – VISEAN															3794.0	3922.0						
Czaplinek Limestone Formation															3794.0	3922.0	0.37 – 1.47	0.1				

Tab. 9. Stratigraphy and petrophysical characteristics in the Grabin 2K (Binder, 1987), Karsk 1 (Lech, 1982), Łosośnica 1 (Lech, 1989), Nowogard GEO-1 (Wróbel, 1963), Pisaki PIG-1 (Miłaczewski, 1991), Piaski 3 (Frydtych, 2015), Unibórz 1 (Lech, 1983a).

Well:	BARKOWO 1	BŁOTNO 1	BŁOTNO 2K	BŁOTNO 3	GARDOMINO 1	GRABIN 1	GRABIN 2K	KARSK 1	ŁOSOŚNICA 1	NOWOGARD GEO-1	PIASKI PIG-2	PIASKI 3	SMOLĘCIN 1	UNIBÓRZ 1
Depth:	3198.4	3184.0	3439.0	4500.0	3698.5	3238.0	3674.0	4086.5	3470.0	1201.0	3922.0	3900.0	3600.0	3584.0
Drill core – storage	NAG: Chmielnik	NAG: Chmielnik	NAG: Chmielnik	NAG: Chmielnik	NAG: Chmielnik	PGNiG: Chmielnik	NAG: Chmielnik	NAG: Chmielnik	NAG: Chmielnik	NO core	NAG: Hołowno	NO core	NO core	NAG: Chmielnik
PK	25.0 – 3175.0	25.0 – 3100.0	2455.0 – 3430.0	25.0 – 4500.0	25.0 – 3690.0	25.0 – 3050.0	1700.0 – 3670.0	25.0 – 3975.0	25.0 – 3470.0		150.0 – 3620.0			0.0 – 3575.0
PŚr	21.0 – 3172.0	3.0 – 3101.0	242.0 – 3435.0	8.0 – 3644.0	22.0 – 3684.0	5.0 – 3072.0	247.0 – 3215.0	4.0 – 4065.0	104.0 – 3472.0		2.0 – 3922.0		300.0 – 3600.0	0.0 – 3576.0
mPŚr			3350.0 – 3434.0				2016.0 – 2216.0				3550.0 – 3829.0			
PEksc			2097.0 – 2301.0	3060.0 – 3538.0			247.0 – 343.0							
A1	190.0 – 3164.0													
PA						2173.0 – 3071.0	2160.0 – 3670.0				106.0 – 3620.0			
PAa					1896.0 – 3598.0									
PAc		1190.0 – 3170.0	500.0 – 3438.0								100.0 – 3630.0			
PAdt	190.0 – 3164.0		3192.0 – 3435.0	1200.0 – 4500.0	2650.0 – 3583.0			2245.0 – 4080.0	105.0 – 3470.0		1675.25 – 3800.00		300.0 – 3600.0	3200.0 – 3511.0
PAt					2700.0 – 3598.0									
PAt1	190.0 – 3164.0		3192.0 – 3435.0	1200.0 – 4500.0	1896.0 – 3583.0			2197.0 – 4065.0	105.0 – 3470.0					3200.0 – 3511.0
PAt2			3192.0 – 3435.0	1200.0 – 4500.0	2650.0 – 3583.0			2197.0 – 4065.0	105.0 – 3470.0					3200.0 – 3511.0
PG	5.0 – 3175.0	0.0 – 3180.0	0.0 – 3435.0	0.0 – 4500.0	3550.0 – 3685.0						1675.0 – 2769.0			
PG SP–62					0.0 – 3581.0	0.0 – 3073.0	0.0 – 3400.0	10.0 – 4080.0	0.0 – 3470.0		0.0 – 3922.0			40.0 – 3246.0
PGG		0.0 – 1810.0		3060.0 – 3651.0	0.0 – 188.0	2145.0 – 3073.0			105.0 – 3470.0		156.0 – 1049.0		300.0 – 3600.0	
PGG SP-62											1675.0 – 3922.0			
PNG	7.0 – 3175.0	0.0 – 3180.0	32.0 – 3435.0	0.0 – 4500.0	2850.0 – 3685.0	0.0 – 3073.0								
PNG SP–62					0.0 – 3581.0		0.0 – 3400.0	10.0 – 4080.0	0.0 – 3470.0		0.0 – 3922.0			40.0 – 3246.0
logPNG		1765.0 – 3180.0	32.0 – 3435.0	0.0 – 4500.0	3550.0 – 3685.0									
logPNG SP–62					165.0 – 3581.0	0.0 – 3073.0	0.0 – 3400.0	3125.0 – 4080.0	0.0 – 3470.0					
PNN											2719.0 – 3922.0			
PNNnt														
PS	21.0 – 2606.0	3.0 – 3101.0	243.0 – 3435.0	8.0 – 4500.0	23.0 – 3684.0	5.0 – 3072.0	247.0 – 3215.0	161.0 – 4065.0	105.0 – 3265.0		2.0 – 3922.0			9.0 – 3576.0
PI									105.0 – 1515.0					
PO	3.0 – 3101.0 A8.0M1.0N 21.0 – 3172.0 A2.5M0.25N 21.0 – 2606.0 N5.7M0.4A 21.0 – 3175.0 A5.0M0.4N 21.0 – A0.5M0.1N 21.0 – 2606.0 A1.0M0.1N 21.0 – 2606.0		243.0 – 3435.0	8.0 – 4500.0 EL09 202.50 – 1930.0 EL16 202.50 – 1930.0	A0.5M0.1N 23.0 – 2636.0 A1.0M0.1N 23.0 – 3684.0 A2.5M0.25N 23.0 – 2636.0 A5.7M0.4N 23.0 – 3684.0 A8.0M1.0N 23.0 – 3684.0 N5.7M0.4A 23.0 – 2636.0	A0.5M0.1N 5.0 – 2169.0 A1.0M0.1N 5.0 – 3072.0 A2.5M0.25N 5.0 – 2169.0 A5.7M0.4N 5.0 – 3072.0 A8.0M1.0N 5.0 – 3072.0 N5.7M0.4A 5.0 – 2169.0	A0.5M0.1N 247.0 – 2385.0 A1.0M0.1N 247.0 – 3672.0 A2.5M0.25N 247.0 – 2385.0 A4.0M0.5N 2345.0 – 3215.0 A5.7M0.4N 247.0 – 2385.0 A8.0M1.0N 247.0 – 3215.0 N5.7M0.4A 247.0 – 2385.0	A0.5M0.1N 161.0 – 2250.0 A1.0M0.1N 161.0 – 4065.0 A2.5M0.25N 161.0 – 2250.0 A5.7M0.4N 161.0 – 4065.0 A8.0M1.0N 161.0 – 4065.0 N5.7M0.4A 161.0 – 2250.0 EL03 155.0 – 4065.0	A0.5M0.1N 105.0 – 2501.0 A0.5M0.1N 105.0 – 2501.0 A1.0M0.1N 105.0 – 3470.0 A2.5M0.25N 105.0 – 2501.0 A5.7M0.4N 105.0 – 3470.0 A8.0M1.0N 105.0 – 3470.0 N5.7M0.4A 105.0 – 2501.0		156.0 – 3920.0 A2.0N 2399.0 – 3920.0 B2.5A0.25M 156.0 – 2376.0 M2.5A0.25B 156.0 – 2376.0 N6.0M0.5A 2399.0 – 3920.0			A0.5M0.1N 9.0 – 2206.0 A1.0M0.1N 9.0 – 3576.0 A2.5M0.25N 9.0 – 2206.0 A5.7M0.4N 9.0 – 3576.0 A8.0M1.0N 9.0 – 3576.0 N5.7M0.4A 9.0 – 2206.0
POg											2.0 – 160.0			
POp											2.0 – 160.0			
POst	190.0 – 3172.0	2268.0 – 3101.0	3192.0 – 3435.0	210.0 – 4500.0	1650.0 – 3684.0			1995.0 – 4065.0	3278.0 – 3470.0		2399.0 – 3922.0		300.0 – 3600.0	2205.0 – 3576.0
POst LL3				211.75 – 1933.0										
logPOst			3192.0 – 3435.0	210.0 – 4500.0	2670.0 – 3684.0	2173.0 – 3072.0	2345.0 – 3400.0	1995.0 – 4065.0			1675.0 – 3290.0			
mPOst			3192.0 – 3435.0	3103.0 – 4500.0	3120.0 – 3200.0		3200.0 – 3400.0	3740.0 – 4080.0			3290.0 – 3920.0			3245.0 – 3511.0
logmPOst			3192.0 – 3435.0	3103.0 – 4500.0	3120.0 – 3417.0		3200.0 – 3400.0	3740.0 – 4065.0			2750.0 – 3150.0 3290.0 – 3620.0			
PEM			2200.0 – 3087.0											
PTc			40.0 – 2136.0											20.0 – 3165.0
PGaz				3105.0 – 3965.0	1672.0 – 2646.0									3247.0 – 3332.0
Velocity survey	20.0 – 3000.0	20.0 – 3100.0		20.0 – 4460.0	20.0 – 2975.0	13.0 – 2743.0	20.0 – 3550.0	20.0 – 4030.0		19.0 – 1169.0	20.0 – 3850.0	15.0 – 3897.65	532.0 – 3600.0	20.0 – 3530.0
MSFL													300.0 – 3600.0	
NPHI													300.0 – 3600.0	
RHOB													300.0 – 3600.0	
sPGbezU													300.0 – 3600.0	
PM														2000.0 – 3245.0

Tab. 10. Well geophysics. Logs available in digital format are highlighted. PK – deviation log, PŚr – caliper, mPŚr – caliper - microlog, PEksc – eccentricity log, A1 – amplitude acoustic log, PA – acoustic log using SPAK-4 probe, PAa – amplitude acoustic log, 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, PGG SP-62 – density log using SP–62 probe, PNG – neutron-gamma ray log, PNG SP-62 – neutron-gamma ray log using SP–62 probe, logPNG – neutron-gamma ray log (logarithm), logPNG SP-62 – neutron-gamma ray log (logarithm) using SP–62 probe, PNN – neutron–neutron log, PNNnt – epithermal neutron log, PS – spontaneous potential log, PI – induction 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, logPOst – focussed electric log (logarithm), mPOst – focussed electric microlog, logmPOst – focussed electric microlog (logarithm), POst odwr – reversed focussed electric log, PEM – electromagnetic log, PTu – temperature log in thermal equilibrium, PTc – temperature log after cementation, PGaz – Gas log, Velocity survey: MSFL – micro spherically focussed laterolog, NPHI – neutron porosity log, RHOB – bulk density log, sPGbezU – uranium-free gamma-ray log, PM – magnetic log.

Wells	Top [m]	Bottom [m]	Stratigraphy	Flow type	Flow quantity [m^3/h]
Barkowo 1	3157.0	3181.0	Zechstein	gasificated brine	0.24
Błotno 1	3180.0	3184.0	Zechstein	oil	9.0
Błotno 2K	3252.0	3439.0	Zechstein	oil with brine	
	3252.0	3439.0		oil with brine	
	3252.0	3439.0		gasificated brine, oil traces	0.102
	3394.0	3434.0		gasificated oil	
Błotno 3	3240.0	3256.0	Zechstein	NO	0.0
Gardomino 1	3135.0	3168.0	Zechstein	gasificated brine	0.24
	3135.0	3610.0	Zechstein, Rotliegend	gasificated brine	0.57
	3611.0	3698.0	Rotliegend		0.0
Grabin 1	3073.0	3238.0	Zechstein	gasificated brine	
Grabin 2K	3379.0	3394.0	Zechstein		0.0
	3394.0	3398.0		gasificated brine	0.34
	3562.0	3605.0	Rotliegend		0.0
	3608.0	3674.0			0.0
Karsk 1	3930.0	3981.0	Rotliegend	gasificated brine	15.0
Łososnica 1	3266.0	3274.0	Zechstein	gas traces	
	3274.0	3305.0		gas traces	
Piaski PIG-2	2921.0	2931.0	Zechstein	gasificated brine	20.3
	3386.0	3404.0	Rotliegend	minimum gas flow	
	3596.0	3638.0		gas	
	3600.0	3621.0		gas	
	3600.0	3637.0		gas	
	3774.0	3827.0	Rotliegend, Visean		0.0
Unibórz 1	3274.0	3332.0	Zechstein	gasificated brine	0.31
	3247.0	3278.0			0.0
	3510.0	3583.0	Zechstein, Rotliegend		0.0

Tab. 11. Tests during drilling.

Wells	Top [m]	Bottom [m]	Stratigraphy	Shows
Barkowo 1	0.0	3128.3		NO
	3128.3	3162.0	Older Halite +Basal Anhydrite+Main Dolomite	0.1–0.15% of hydrocarbons in drilling fluid
		3162.0		4% of hydrocarbons in drilling fluid
	3181.0	3198.4	Main Dolomite+Upper Anhydrite	hydrogen sulphide odour
Błotno 1	3181.5	3184.0	Main Dolomite	point traces of oil and gas
		3184.0		outflow of drilling fluid with traces of oil and gas; circulation loss – 16 m^3
Błotno 2K	3422.0	3434.0	Basal Anhydrite, Main Dolomite	point traces of gas
	3436.0	3439.0.0		
Błotno 3	3238.0	3256.0	Main Dolomite, Upper Anhydrite	point traces of oil
	3482.0	3500.0	Lower Anhydrite, Zechstein	
Gardomino 1	3154.0	3168.0	Main Dolomite	point traces of oil
	3168.0	3196.0	Main Dolomite, Upper Anhydrite	traces of heavier hydrocarbons
Grabin 1	1724.0	1765.0	Buntsandstein	circulation loss
		1993.0		drilling fluid gasification
	3231.0	3236.0	Main Dolomite	slight bituminous odour
Grabin 2K	3391.0	3394.0	Main Dolomite, Upper Anhydrite	circulation loss – 5.2 m^3
	3387.0	3402.3		hydrogen sulphide and hydrocarbons odour
Karsk 1	3698.0	3752.0	Upper Anhydrite	bituminous odour
		3938.5	Rotliegend	circulation loss – 30 m^3
Łososnica 1	3265.0	3274.0	Basal Anhydrite, Main Dolomite	point traces of gas
		3274.0		drilling fluid gasification
		3470	Lower Anhydrite	drilling fluid gasification
Unibórz 1	3261.0	3296.0	Main Dolomite	point traces of oil and gas
	3296.0	3301.0		bituminous odour

Tab. 12. Hydrocarbon shows during drilling.

PIASKI PIG-2
WELL LOG

GEOGRAPHIC COORDINATES

BEGINNING: 03.04.1989

FINISHING: 31.12.1990

DEPTH: 3922.0 m

X_1992 657938.61

Y_1992 263236.97

ALTITUDE: 65 m a.s.l.

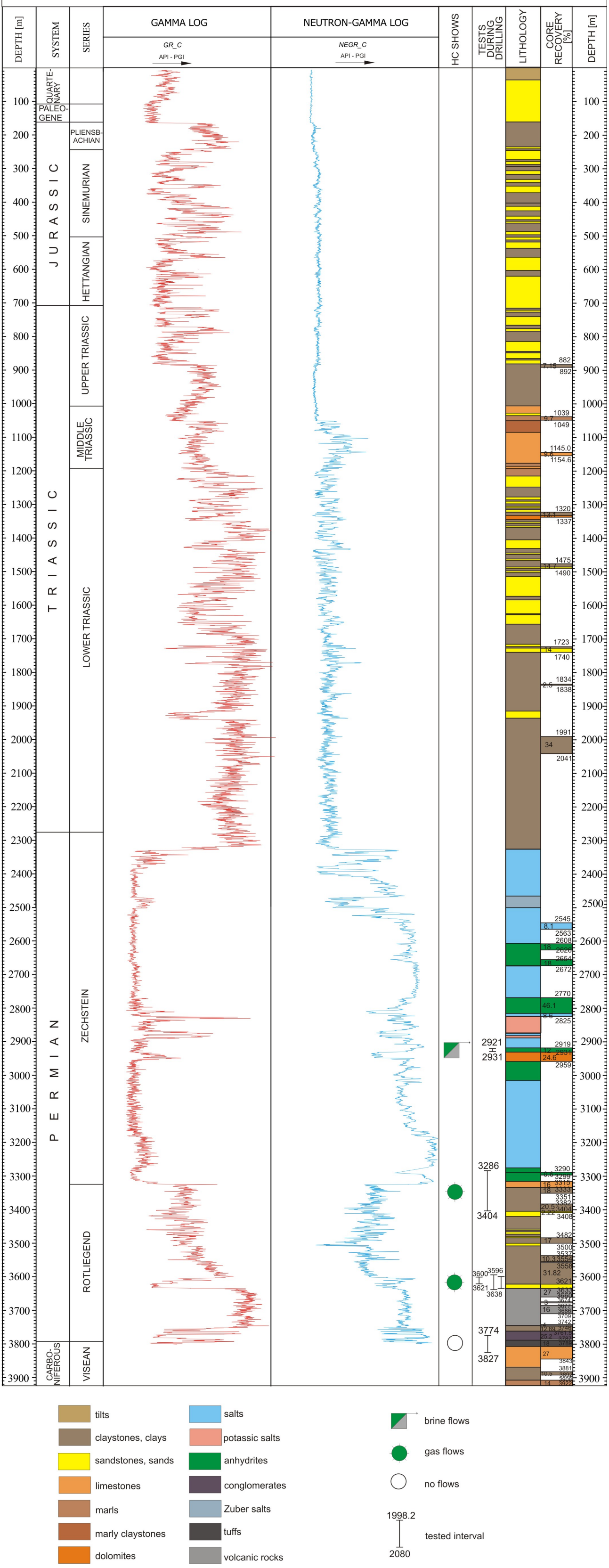


Fig. 23. Well log of the key well Piaski PIG-2 (Miłaczewski, 1991).

6. SEISMIC SURVEYS

The Żabowo tender area is explored by 2D seismic surveys executed in 1976-2006 (99 lines of total length of 1370.0 km; Tab. 14, Fig. 23). No 3D seismic surveys have been carried out, so far.

Most of the Żabowo tender area is covered by a dense grid of 2D seismic profiles, except for a southern part of the area, which has not so many data (Fig. 24). Numerous structural objects were interpreted in the most recent seismic documentations (Burek et al., 2001; Grzywa and Burek, 2001; Wróbel and Burek, 2003; Wnuk and Saj, 2007; Tab. 15). They are related to the Main Dolomite (Z2), Rotliegend (Z1) and Carboniferous (C) deposits.

Name	Year	Seismic project name	Owner	Length [km]
T0180576	1976	Gorzysław-Petrykozy	State Treasury	3.3
T0420576	1976	Wysoka Kamieńska		20.4
T0440576	1976			14.5
T0150279	1979	Wysoka Kamieńska-Białogard		6.1
T0170279	1979			13.2
T0180279	1979			13.2
T0190279	1979			15.5
T0200279	1979			21.4
T0240279	1979			14.1
T0250279	1979			16.9
T0280279	1979			28.3
T0320279	1979			12.9
T0160280	1980			7.2
T0190280	1980			5.4
T0210280	1980			23.5
T0230280	1980			11.8
T0260280	1980			14.5
T0270280	1980			28.3
T0310280	1980			15.4
T0330280	1980			14.9
T0440280	1980			16.0
T0550280	1980			9.3
T0560280	1980			17.1
T0670580	1980			12.1
T0830580	1980			21.1
T0870580	1980			10.6
TA810580	1980			14.0
TA900580	1980			7.8
T0090281	1981			13.2
T0130281	1981			10.5
T0140281	1981			7.7
T0190281	1981			6.5
T0270281	1981			13.8
T0280281	1981			13.5
T0290281	1981			18.9
T0490281	1981			8.3
T0500281	1981			7.7
T0510281	1981			9.2
T0520281	1981			8.8
T0530281	1981			5.3
T0540281	1981			5.6
T0780581	1981			6.8
T0790581	1981			11.6
T0800581	1981			16.5
T0880581	1981			17.3
T0890581	1981			9.8
T0920581	1981			7.6
T0930281	1981			26.0
T0940281	1981			17.2
T0950281	1981			21.1
TA120281	1981			4.6
TA240281	1981			8.7
T0390282	1982			18.0
T0400282	1982			19.9
T0660282	1982			19.7
T0770582	1982			3.7
T0850582	1982			14.1
T0960282	1982			13.2
T0060583	1983			11.3
T0130583	1983			6.3
T0140583	1983			12.6
T0180583	1983			4.2
T0200583	1983			14.8
T0210583	1983			8.9
T0270583	1983			10.9
T0280583	1983			14.9
T0290583	1983			20.5
T0300583	1983			11.1
T0320583	1983			7.7
T0330583	1983			11.2
TA320583	1983			16.0
T0250584	1984			19.1
T0260584	1984			18.8
T0010500	2000	Kamień Pom.-Gryfice-Trzebiatów	PGNiG	24.7
T0040500	2000			24.6
T0010402	2002	Piaski-Resko	State Treasury	17.9
T0020402	2002			19.4
T0030402	2002			22.2
T0040402	2002			28.1
T0050402	2002			23.0
T0060402	2002			12.5
T0070402	2002			10.8
T0080402	2002			10.1
T0090402	2002			7.8
T0100402	2002			6.5
T0110402	2002			3.6
T0270402	2002			16.4
T0280402	2002			23.9
T0290402	2002			16.5
T2060402	2002			16.5
T0023106	2006	Rybokarty-Komorowo		4.4
T0033106	2006			12.4
T0043106	2006			10.2
T0053106	2006			17.9
T0063106	2006			19.0
T0073106	2006			12.1
T0083106	2006			19.4
T0093106	2006			14.1
T0103106	2006			14.1
			SUMMARY:	
			State Treasury	**1320.7**
			Private Investors	**49.3**
			Total	**1370.0**

Tab. 14. Seismic surveys conducted on the Żabowo tender area (CBDG, 2019).

Object name	Horizon	Object name	Horizon
Barkowo	Z1, Z2	Międzyrzecze W	Z1, Z2
Błotno (W,N,E)	Z1, Z2	Modlimowo	Z1
Darszyce	Z1, Z2	Orzechowo	Z1, Z2
Darszyce S	Z1	Piaski	C
Gardomino	Z1, Z2	Piaski N	Z1, Z2, C
Grabin	Z1	Piaski W	Z1, Z,
Gryfice	Z1	Smolęcin W	Z2
Kaczały	Z2	Smolęcin	Z1, Z2
Karsk	Z1, Z2	Sosnkowo	Z1
Komorowo	Z1, C	Taczały	Z2
Komorowo N	Z1, Z2	Trzaski,	Z2
Komorowo W	Z1, Z2	Unibórz S	Z1, Z2
Lestkowo	Z2	Unibórz	Z1, Z2
Łososnica	Z1, Z2	Wyszobór	Z2
Łososnica N	Z1	Żabowo	Z1, Z2
Maszkowo	Z2		

Tab. 15. Structural objects mapped in Żabowo tender area (Grzywa and Burek, 2001; Wróbel and Burek, 2003; Wnuk and Saj, 2007)

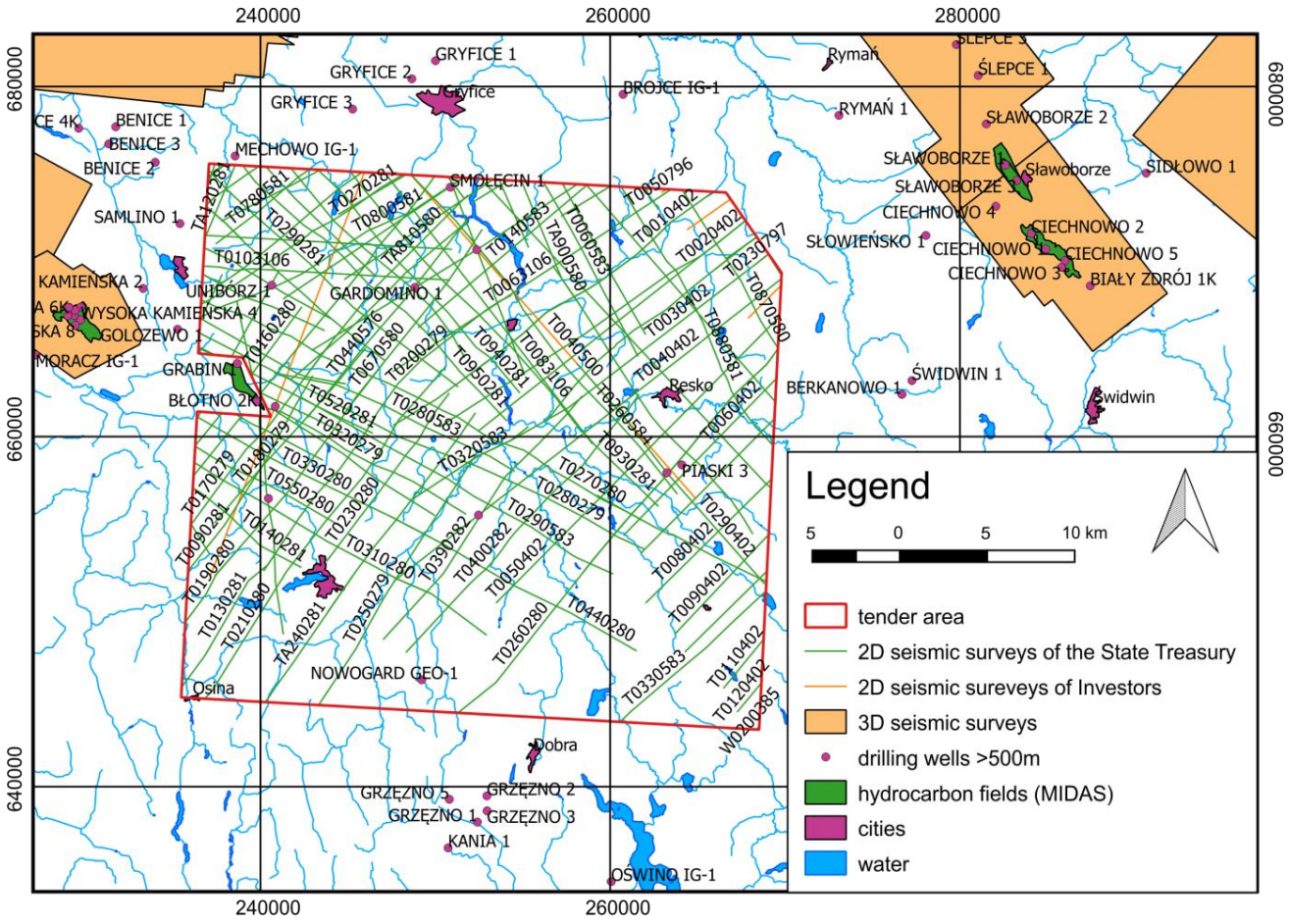


Fig. 24. Seismic surveys conducted in the Żabowo tender area.

7. GRAVIMETRY, MAGNETOMETRY AND MAGNETOTELLURICS

7.1 GRAVIMETRY

Semidetailed gravimetric surveys in the Żabowo tender area and in its close neighbourhood were collected with a point density varying from 1.5 to 4.0 stations/km^2 (Fig. 25). All data are available in the CBDG (2019). There are 2095 data points within the tender area (Fig. 25; Duda and Bochnia, 1963; Bochnia and Duda, 1968; Duda et al., 1973). The western part is covered by the „Łódź Synclinorium" survey (Duda and Bochnia, 1963), with average point density of 2.1 stations/km^2. The southern part of the area is covered by the "Szczecin-Mogilno Synclinorium" survey (Bochnia and Duda, 1968), with average density of 1.5 stations/ km^2. The "Pomeranian Anticlinorium" (Duda et al., 1973) covers the northern part.

There are 354 data points of detailed survey, collected along 25 profiles with 100 m step (Smrek, 1979a, b). Only 4 out of them are located within the Żabowo tender area. The survey was focused on brown coal exploration.

The most recent detailed survey, not included in the CBDG yet (and therefore not shown on Fig. 25), covers the northern and eastern part of the tender area. The „Piaski-Resko" survey (Ostrowski, 2002) was focused on tectonic structure of the Permian-Mesozoic and top part of Sub-Permian sediments.

Królikowski and Petecki (1995) proposed a division of Poland into several gravity regions. Thus, the Żabowo tender area is placed at the distict gradient zone (Fig. 26) which is a border between two gravity regions: The Pomeranian High from the north-east and the northern part of Szczecin-Mogilno-Miechów Low from the south-east.

7.2. MAGNETOMETRY

Two ground, semidetailed surveys of total magnetic field intensity were conducted in the Żabowo tender area (western part – Wybraniec and Cieśla, 1995; eastern part – Kosobudzka and Paprocki, 1997). Both surveys has an average density of 2 stations/km^2. All data are available in the CBDG (2019). There are 1903 data points within the Żabowo tender area (Fig. 27).

An image of magnetic anomalies presented on Fig. 28 is taken from magnetic map of Poland (Petecki et al., 2003). The map is divided into several regions with different magnetic characteristic (Petecki and Rosowiecka, 2017). The Żabowo tender area is located within the Western Pomerania domain (WPd), characterized by NW-SE trending low-amplitude anomalies. According to Petecki (2001), the anomaly pattern in this area reflects a considerable depth of ~18.5 km to the top of the magnetic basement.

7.3. MAGNETOTELLURICS

Magnetotelluric measurements along two regional profiles: D-PL and BMT-5 were collected in 2007-2008 (Stefaniuk et al., 2008). MT soundings were separated by approx. 4.6 km from each other along the profiles (Fig. 29). Resistivity sections and geological models are the most important result of the survey. An example of 2D inversion of MT-data together with geological interpretation along S-PL profile is shown on Fig. 30 (Stefaniuk et al., 2008).

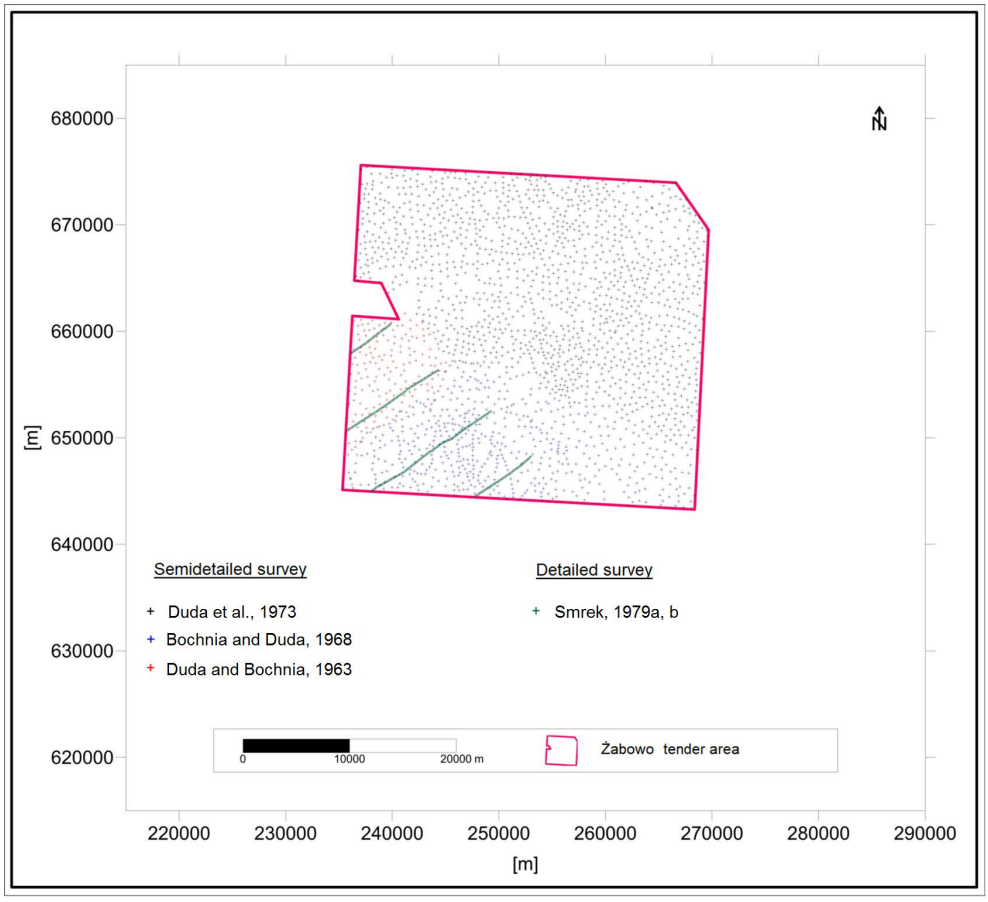


Fig. 25. Distribution of gravimetric measurements in the Żabowo tender (based on CBDG, 2019).

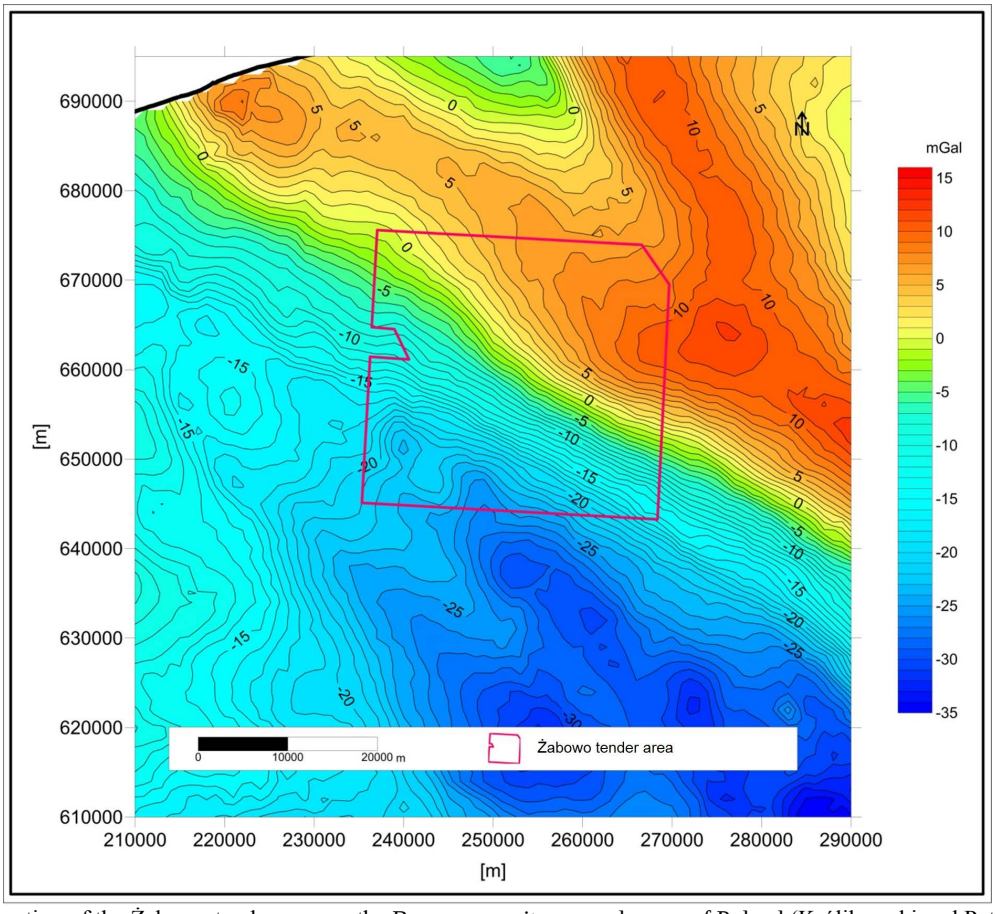


Fig. 26. Location of the Żabowo tender area on the Bouguer gravity anomaly map of Poland (Królikowski and Petecki, 1995).

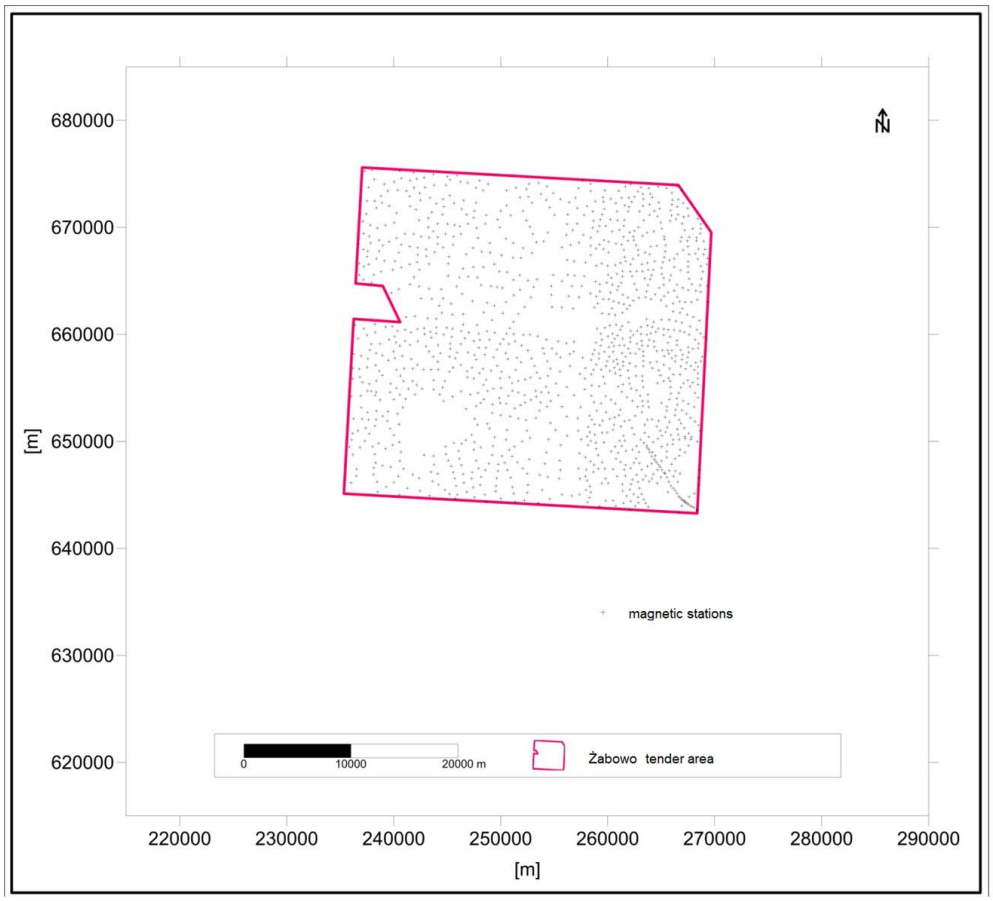


Fig. 27. Distribution of magnetic stations in the Żabowo tender area (based on CBDG, 2019).

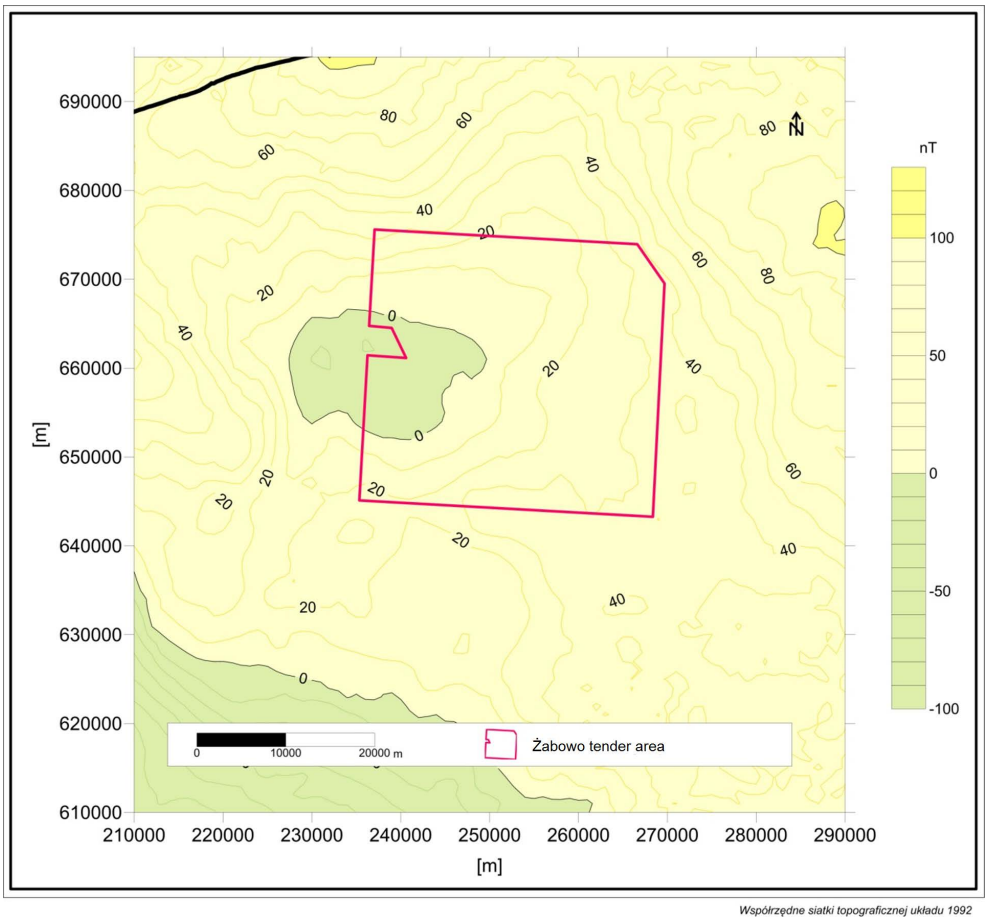


Fig. 28. Location of the Żabowo tender area in the magnetic anomaly map of Poland (Petecki et al., 2003).

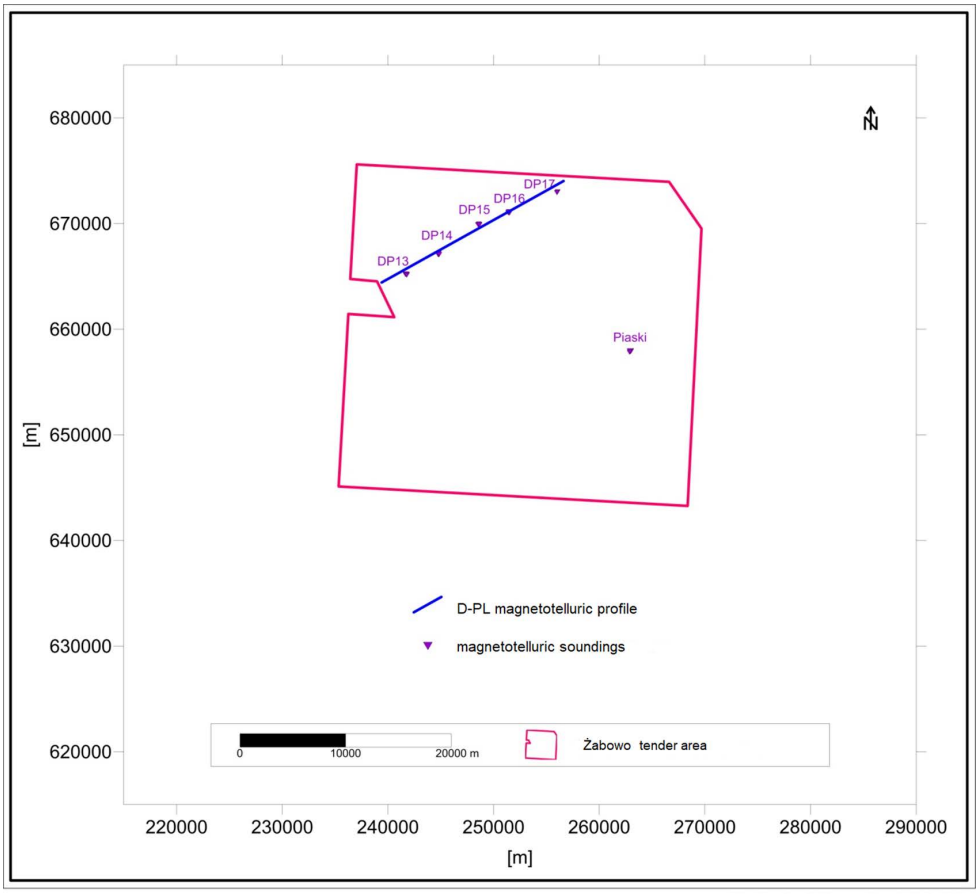


Fig. 29. Distribution of magnetotelluric survey in the Żabowo tender area (based on CBDG, 2019).

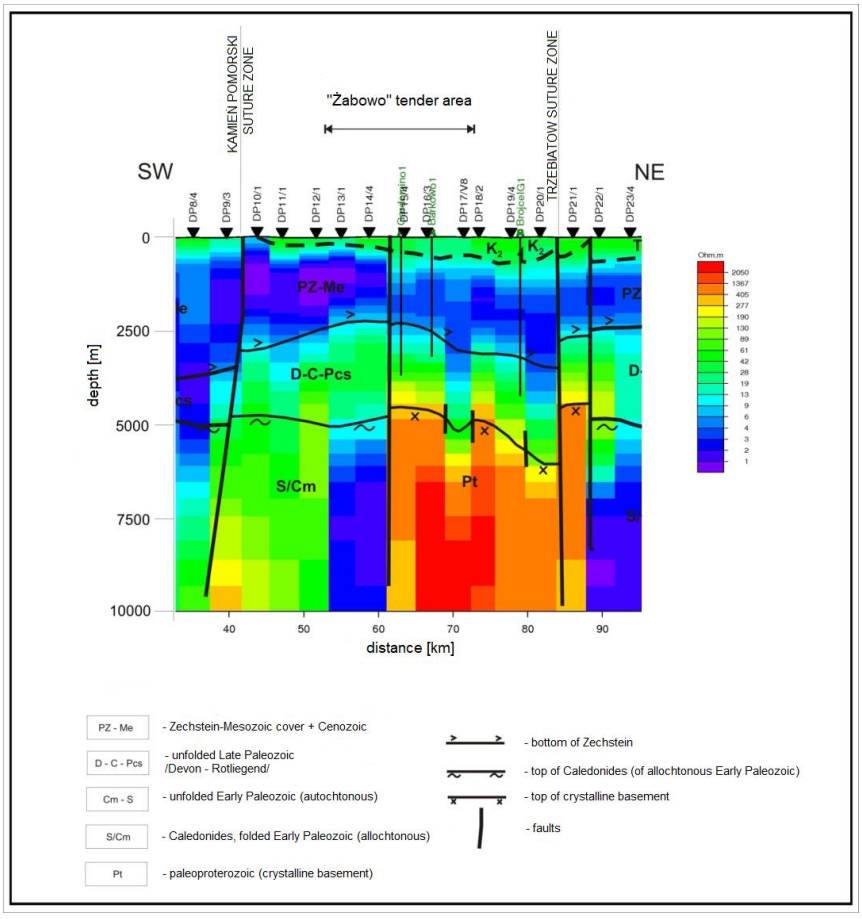


Fig. 30. Results of 2D inversion of magnetotelluric data. Geological interpretation by Pokorski (Stefaniuk et al., 2008).

8. HYDROCARBON PROSPECTIVE

The Żabowo tender area is located in the north-western Poland, in the Western Petroleum Province (Fig. 31). Here, the Lower Paleozoic rocks are subsequently covered by the Devonian and Carboniferous strata of the Variscan Foredeep and Permian-Mesozoic succession of the Mid-Polish Anticlinorium and Szczecin-Gorzów Trough. The main exploration targets are related to conventional oil and gas accumulations in the Permian Rotliegend and Main Dolomite deposits.

Two independent petroleum systems work in the Żabowo tender area. The first occurs in the Carboniferous-Permian, in which gas is generated from the Lower Carboniferous shales and accumulated in the Rotliegend 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 have been discovered in the close neighborhood of the Żabowo tender area, are related to the Rotliegend (Ciechnowo, Sławoborze) and Main Dolomite (Sławoborze, Błotno, Rekowo, Wysoka Kamieńska) deposits.

The Żabowo area is well recognized by seismic survey: 99 seismic profiles of total length about 1370 km have been conducted, so far. As a result, 33 structural object have been mapped in the Permian and its basement. Fourteen deep wells drilled out the prospective horizons in the Żabowo tender area and in its neighborhood. The hydrocarbon shows occurred in the Carboniferous, Main Dolomite and Rotliegend.

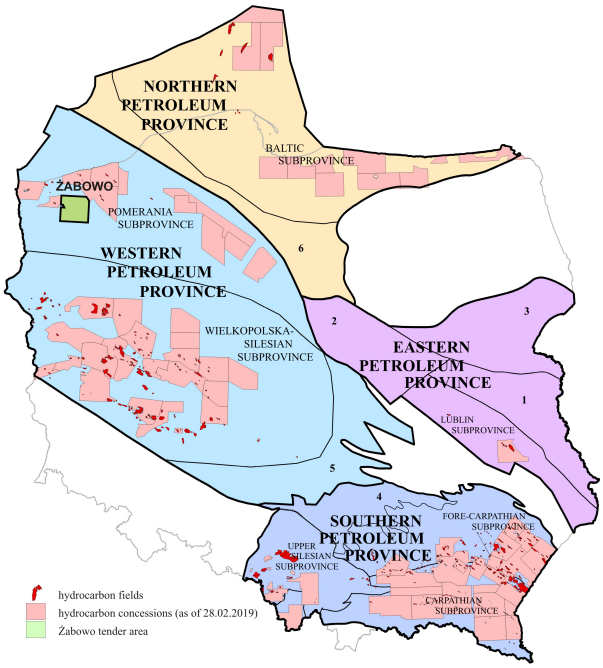


Fig. 31. Hydrocarbon subdivision of Poland (PIG-PIB, 2019) with location of the Żabowo tender area. 1–6 – petroleum regions (of unconfirmed/hypothetical prospective): 1 – Chełm Region, 2 – Płock-Warszawa Region, 3 – Podlasie Region, 4 – Małopolska Region, 5 – Łódź-Wieluń Region, 6 – Słupsk-Grudziądz 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 (90 km) or conduction of 3D seismic surveys (45 km^2) and drilling of one well to maximum depth of 6000 m TVD with obligatory coring of prospective intervals.

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