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HYDROCARBON PROSPECTIVE OF POLAND

NFEP&WM agreement No. 307/2021/Wn-07/FG-sm-dn/D of 21-04-2021
PGI–NRI project No. 22.5004.2101.00.1

CYBINKA-TORZYM
TENDER AREA
GEOLOGICAL PACKAGE ENGLISH ABSTRACT

VI LICENSING ROUND
FOR CONCESSIONS FOR PROSPECTION AND EXPLORATION
OF HYDROCARBON FIELDS AND PRODUCTION OF HYDROCARBONS FROM FIELDS
IN POLAND

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AND WATER MANAGEMENT

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Warsaw, 2023

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1. GENERAL INFORMATION
1.1. LOCATION

The Cybinka-Torzym tender area of 668.5 km^2 is located onshore in western Poland (concession blocks 222 and 223; Fig. 1.1). The precise location is defined by geographic coordinates listed below.

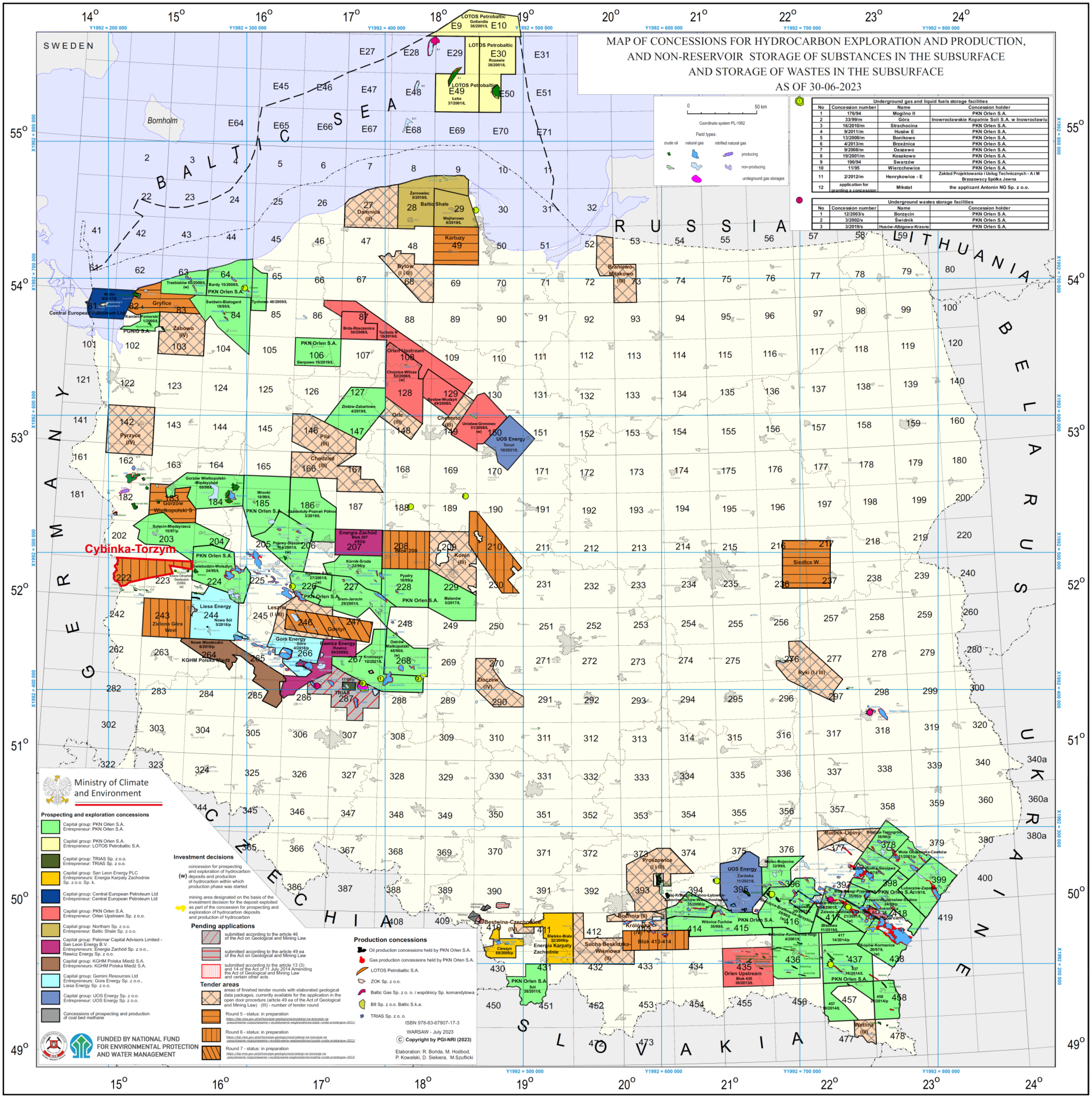
Border points	1992 coordinate system	
	X	Y
1	492887.97	260981.45
2	492844.21	261045.53
3	487287.05	260776.88
4	489935.10	244937.94
5	484261.45	246929.48
6	481351.42	231859.04
7	477639.79	215436.67
8	475861.85	213502.89
9	475467.68	212006.81
10	475232.69	209573.34
11	475217.79	209419.08
between points 11 and 12 along the state border		
12	495843.73	206676.28

Tab. 1.1. Border points' coordinates of the Cybinka-Torzym tender area (Fig. 1.2).

The Cybinka-Torzym tender area was previously subjected to hydrocarbon prospection and exploration concessions No. 6/2008/p Cybinka and No. 8/2008/p Torzym (Aurelian Oil & Gas Poland Sp. z o.o./ San Leon Energy Plc.). Currently, in the neighborhood of the tender area the concession No. 24/95/Ł Świebodzin-Wolsztyn (ORLEN S.A.) is active (Figs 1.1–1.2).

The Cybinka-Torzym is prospective for exploration of conventional oil and gas fields in the Permian Main Dolomite horizon.

→**Fig. 1.1.** Location of the Cybinka-Torzym tender area in 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 30-06-2023.


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 30-06-2023
SWEDEN
BALTIC SEA
RUSSIA
LITHUANIA
BELARUS
UKRAINE
SLOVAKIA
CZECHIA
GERMANY
Bornholm
Cybinka-Torzym
Ministry of Climate and Environment
Prospecting and exploration concessions
Investment decisions
Pending applications
Tender areas
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Elaboration: R. Bońda, M. Hodbod, P. Kowalski, D. Siekiera, M.Szuflicki

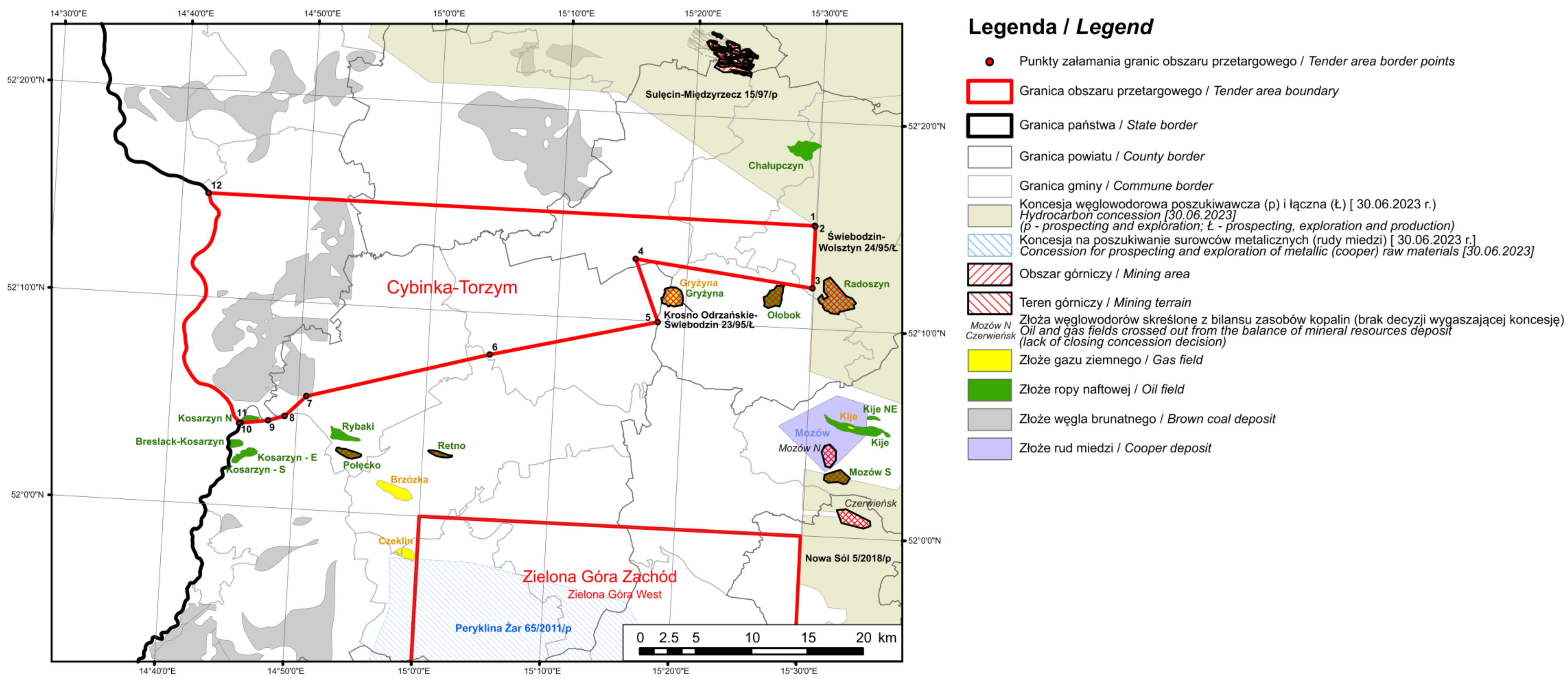


Fig. 1.2. Border points of the Cybinka-Torzym tender area and location of the hydrocarbon concessions and fields of mineral resources in the neighborhood, as of 30-06-2023.

1.2. ENVIRONMENTAL CONDITIONS

THE ENVIRONMENTAL CONDITIONS DATASHEET FOR TENDER AREA CYBINKA-TORZYM				
1.	LOCATION OF THE TENDER AREA ON THE MAP	1 : 50 000 geological map sheet	Rybocice (Brieskow-Finkenheerd) 498, Cybinka 499, Torzym 500, Ołobok 501, Rąpice (Eisenhuttenstadt) 534, Wężyska 535, Krosno Odrzańskie 536, Czerwińsk 537	
2.	ADMINISTRATIVE LOCATION	Voivodeship	Lubuskie	
		County	Krosno Odrzańskie	
		The commune and % of the area within the tendering area	Gubin (0.32%), Bytnica (19.30%), Maszewo (22.09%), Krosno Odrzańskie (0.23%)	
		County	Słubice	
		Commune	Cybinka (31.52%)	
		County	Sulęcin	
		Commune	Torzym (8.45%)	
		County	Świebodzin	
		Commune	Skąpe (1.83%), Łagów (9.75%), Świebodzin (3.66%), Lubrza (2.85%)	
3.	PHYSIOGRAPHIC REGIONALIZATION (after KONDRACKI, 2013 and SOLON et al., 2018)	Macroregion	Pradolina Warciańsko-Odrzańska (315.6)	
		Mesoregion	Dolina Środkowej Odry (315.61)	
		Macroregion	Pojezierze Lubuskie (Brandenbursko-Lubuskie) (315.4)	
		Mesoregion	Pojezierze Łagowskie (315.42), Równina Torzymska (315.43)	
4.	COORDINATES OF THE TENDER AREA BORDER POINTS	PL-1992 [X; Y]	492887.97	260981.45
			492844.21	261045.53
			487287.05	260776.88
			489935.10	244937.94
			484261.45	246929.48
			481351.42	231859.04
			477639.79	215436.67
			475861.85	213502.89
			475467.68	212006.81
			475232.69	209573.34
			475217.79	209419.08
			between points 11 and 12 along the state border	
			495843.73	206676.28
5.	SURFACE OF THE TENDER AREA	[km^2]	668.50	
6.	CONCESSION TYPE		prospecting, exploration and production of hydrocarbons	
7.	AGE OF HYDROCARBON FORMATION		Permian/Zechstein – Main Dolomite	
8.	PROTECTED NATURAL AREAS	[yes/ no] if "yes": the name of the tender area and its % within the total area		
	National Parks		no	
	Natural Reserves		Jezioro Ratno (<1%), Mechowisko Kosobudki (<1%), Młodno (<1%)	
	Landscape Parks		Gryżyński Park Krajobrazowy (<1%) wraz z otuliną (1.18%), Krzesiński Park Krajobrazowy (4.01%)	
	Protected landscape areas		OChK Puszcza nad Pliszką (26.56%), OChK Rynna Paklicy i Ołoboku (6.36%), OChK Słubicka Dolina Odry (6.68%)	
	Natura 2000, (Special Area of Conservation, SAC)		PLH080005 Torfowisko Młodno (<1%), PLH080011 Dolina Pliszki (<6.87%), PLH080028 Krośnieńska Dolina Odry	

THE ENVIRONMENTAL CONDITIONS DATASHEET FOR TENDER AREA CYBINKA-TORZYM			
			(3.72%), PLH080034 Bytnica (<1%), PLH080035 Dębowe Aleje w Gryżynie i Zawiszach (<1%), PLH080037 Lasy Dobrosułowskie (16.74%), PLH080042 Stara Dąbrowa w Korytach (<1%), PLH080048 Bory Chrobotkowe koło Bytomca (<1%), PLH080056 Diabelski Staw koło Radomicka (<1%), PLH080067 Rynna Gryżyny (<1%)
	Natura 2000, (Special Bird Protection, SPA)		PLB080004 Dolina Środkowej Odry (10.04%)
	Nature and landscape complexes		no
	Ecological area	[yes (quantity) / no]	26
	Nature monuments		35 (including 809 objects)
	Documentation positions		no
9.	PROTECTED SOIL	[yes / no]	yes
10.	FOREST COMPLEXES	[yes / no]	yes
11.	PROTECTIVE FORESTS	[yes (% of the total area / no]	119.55 km^2 (17.88%)
12.	CULTURAL HERITAGE FACILITIES Archaeological monuments	[yes (quantity) / no]	
		Hillfort	2
		Hamlet	9
		Cemetery	6
		others	no
13.	MAJOR GROUNDWATER RESERVOIRS	[yes (number, name and age of the aquifer) / no]	yes (144 Dolina Kopalna Wielkopolska, Q; 148 Sandr rzeki Pliszka, Q)
14.	PROTECTIVE ZONES OF WATER INTAKE	[yes / no]	no
15.	SPA PROTECTION ZONES	[yes / no]	no
16.	FLOOD HAZARD AREA	[yes / no]	yes
17.	POROVEN MINERAL DEPOSITS	[yes (type of mineral deposit)/ no]	yes (brown coal, crude oil, chalk, peat, natural aggregates)
18.	PROGNOSTIC AND PERSPEC-TIVE AREAS OF OCCURRENCE OF MINERAL RESOURCES (excluding hydrocarbons)	[yes (type of mineral deposit)/ no]	yes (salt, potassium salt, peat, sand and gravels, sand)
19.	NATURAL GAS PIPELINES	[yes / no]	yes
20.	UNDERGROUND GAS STORAGE	[yes / no]	no
21.	DATE OF THE DATASHEET COMPLETION	15.11.2021	
22.	*DATA COLLECTION AND ELABORATION*	Barbara Palacz, Dominika Kafara	

Tab. 1.3. The environmental conditions datasheet for the Cybinka-Torzym tender area.

→**Fig. 1.3.** Environmental Map of the Cybinka-Torzym area.

PANSTWOWY INSTYTUT GEOLOGICZNY
PANSTWOWY INSTYTUT BADAWCZY

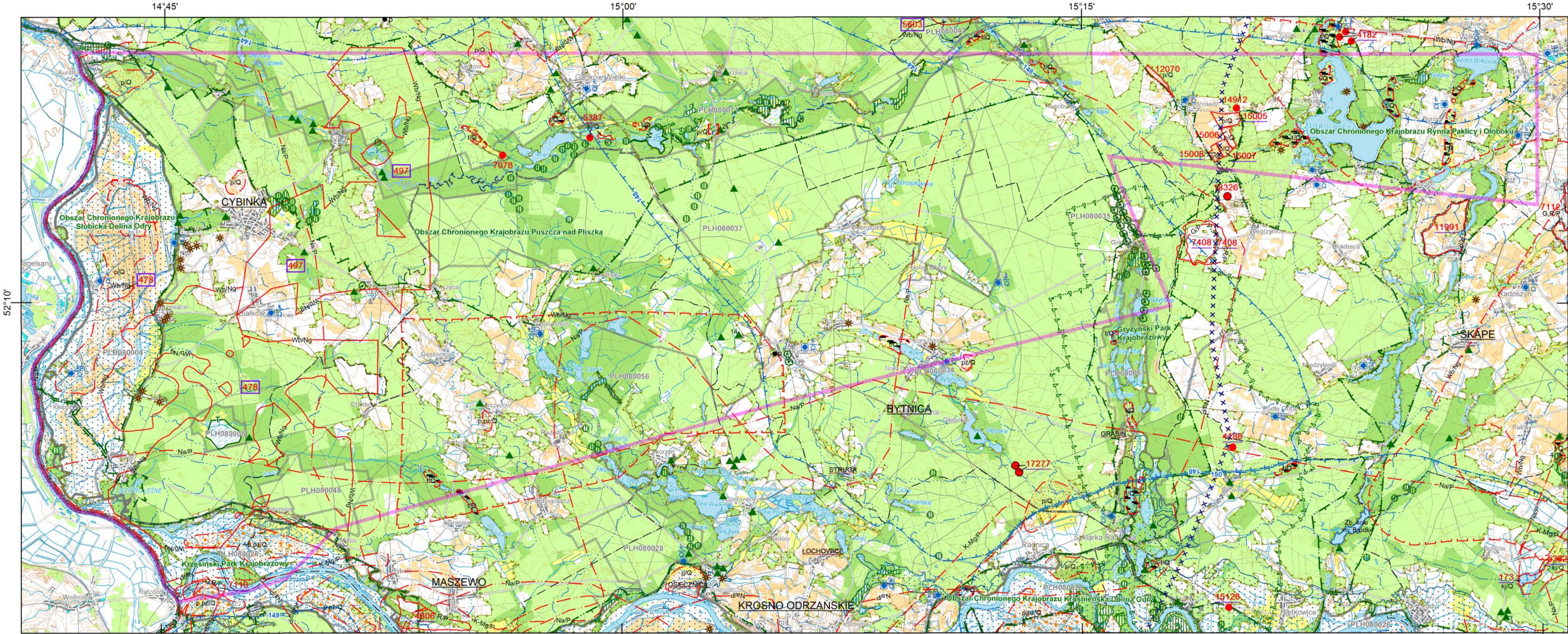
PSG

Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej

Ministerstwo Klimatu i Środowiska

Mapa środowiskowa obszaru Cybinka-Torzym

Environmental Map of the Cybinka-Torzym area



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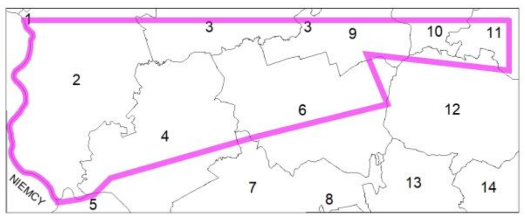
Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Położenie obszaru przetargowego na tle podziału administracyjnego

Location of tender area on administrative division map



woj. LUBUSKIE
powiat słubicki
1 - gm. Słubice
2 - gm. Cybinka
powiat sulęciński
3 - gm. Torzym
powiat krośnieński
4 - gm. Maszewo
5 - gm. Gubin
6 - gm. Bytnica
7 - gm. Krosno Odrzańskie
8 - gm. Dąbie
powiat świebodziński
9 - gm. Łagów
10 - gm. Lubrza
11 - gm. Świebodzin
12 - gm. Skąpe
powiat zielonogórski
13 - gm. Czerwieńsk
14 - gm. Sulechów

1000 m 0 1 2 3 4 5 6 7 8 9 km

Położenie obszaru przetargowego na arkuszach 1:50 000

Location of tender area on maps with a scale of 1:50 000

Zestawienie danych oraz redakcja komputerowa mapy: *Barbara Palacz*

Data compilation and map edition:

Weryfikacja: *Olimpia Kozłowska*

Verification:

Objaśnienia do mapy środowiskowej obszaru CYBINKA - TORZYM

Legend of the Environmental Map of the CYBINKA - TORZYM area

(opracowano na podstawie bazy MGŚP z zasobów PIG-PIB)*

(based on MGŚP database)*

ZŁOŻA KOPALIN ORAZ PERSPEKTYWY I PROGNOZY ICH WYSTĘPOWANIA

MINERAL DEPOSIT AND PERSPECTIVE AREA'S, PROGNOSTIC AREA'S FOR DOCUMENTING DEPOSITS

- kreda jeziorna i gytia – lacustrine chalk and gyttja
- piaski i żwiry – sands and gravels
- piaski – sands
- torfy – peat
- granica złoża – deposit boundary
- granica obszaru prognostycznego – prognostic area boundary
- granica obszaru perspektywicznego – perspective area boundary
- złoże o powierzchni ≤ 5 ha – deposit with area ≤ 5 ha
- [ ]p/Q obszar prognostyczny o powierzchni ≤ 5 ha (p - rodzaj kopaliny, Q - wiek kopaliny) – prognostica area with area ≤ 5 ha (p - type of mineral, Q - age of exploited rocks)
- 7078 identyfikator z bazy MIDAS złoża małokonfliktowego – ID from the MIDAS database of the small environmental conflict
- 173 identyfikator z bazy MIDAS złoża konfliktowego – ID from the MIDAS database of the environmental conflict
- 478 identyfikator z bazy Midas oraz nazwa złoża bardzo konfliktowego – ID from the MIDAS database of the big environmental conflict

GÓRNICTWO I PRZETWÓRSTWO KOPALIN

MINING AND MINERAL PROCESSING

- granica obszaru górniczego – boundary of the mining area
- granica terenu górniczego – boundary of the mining terrain
- obszar i teren górniczy złoża o powierzchni ≤ 5 ha – area and terrain of the deposit with area ≤ 5 ha
- p punkt niekoncesjonowanej eksploatacji kopaliny (p - rodzaj kopaliny) – point of unlicensed exploitation of a mineral (type of mineral)

Symbol kopaliny: / Mineral symbol:

- Wb - węgiel brunatny – lignite
- G - gaz ziemny – natural gas
- R - ropa naftowa – crude oil
- Na - sole kamienne – rock salt
- K-Mg - sole potasowo-magezowe – potassium-magnesium salt
- kj - kreda jeziorna i gytia – lacustrine chalk and gyttja
- t - torfy – peat
- pż - piaski i żwiry – sands and gravels
- p - piaski – sands

Symbol jednostki stratygraficznej: / Symbol of the stratigraphic unit:

- Q - czwartorzęd – Quaternary
- Ng - neogen – Neogene
- P - perm – Permian

WODY POWIERZCHNIOWE I PODZIEMNE

SURFACE AND UNDERGROUND WATERS

- obszary dolinne zagrożone podtopieniami – valley flood hazard area
- granica działu wodnego drugiego rzędu – water divide of second rank
- granica działu wodnego trzeciego rzędu – water divide of third rank
- granica działu wodnego czwartego rzędu – water divide of fourth rank
- 144 granica głównego zbiornika wód podziemnych wraz z jego numerem – principle boundary aquifer with ID number
- źródło – spring
- Zb. koło m. Bródki – zbiornik retencyjny wraz z jego nazwą – water reservoir with its name
- k/Q ujęcie wód podziemnych o wydajności ≥ 50 m³/h (k - komunalne, p - przemysłowe) – underground water intake with capacity ≥ 50 m³/h (k - municipal, p - industrial)

OCHRONA PRZYRODY, KRAJOBRAZU I DZIEDZICTWA KULTUROWEGO

PROTECTION OF NATURE, LANDSCAPE AND CULTURAL HERITAGE

- grunty orne (klasy I-IVa użytków rolnych) – arable land (class I-IVa)
- łąki na glebach pochodzenia organicznego – meadows on organic soils
- lasy – forests
- lasy ochronne – protected forests
- zieleń urządzona – urban greenery
- granice terenów zarządzanych przez Dyrekcję Generalną Lasów Państwowych – boundary of areas managed by General Directorate of the State Forests
- granica parku krajobrazowego; nazwa parku – boundary of landscape park; park name
- granica strefy ochronnej (otuliny) parku krajobrazowego – boundary of buffer zone of landscape park; park name
- granica obszaru chronionego krajobrazu; nazwa obszaru – boundary of protected landscape area; area name
- W granica rezerwatu przyrody (T - torfowiskowy, W - wodny) – boundary of natural reserve (T - peat, W - water)
- aleja drzew pomnikowych – avenue of monumental trees
- Obszary Europejskiej Sieci Ekologicznej Natura 2000; kod obszaru – Natura 2000 ecological network; area code
- n pomnik przyrody żywej (n - liczba obiektów) – animate nature monument (n - number of objects)
- użytek ekologiczny – ecological use
- n użytek ekologiczny o powierzchni ≤ 5 ha (n - liczba obiektów) – ecological use with area ≤ 5 ha (n - number od objects)
- stanowisko archeologiczne – archeological site

INFORMACJE DODATKOWE

ADDITIONAL INFORMATIONS

- granica państwa – country boundary
- granica powiatu – county boundary
- granica gminy, miasta – commune or town boundary
- CYBINKA siedziba urzędu gminy, miasta – commune or town office headquarter
- STRUGA miejscowość letniskowa – summer resort
- sieć gazociągów przesyłowych – natural gas pipeline network
- sieć elektroenergetyczna najwyższych napięć – high-voltage power network
- granica obszaru przetargowego – boundary of tender area

* *Wykorzystano informacje udostępniane przez: RZGW, GDOŚ, GDLP, IMGW-PIB, NID, PSE, GAZ-SYSTEM, urzędy morskie oraz z baz danych PSG i PSH w PIG-PIB*

* *Data source: RZGW, GDOŚ, GDLP, IMGW-PIB, NID, PSE, GAZ-SYSTEM, maritime offices and from database of PSG and PSH*

2. GEOLOGY
2.1. GENERAL GEOLOGY AND TECTONICS

The Cybinka-Torzym tender area is located on the Western European platform, also known as the Paleozoic platform (Żelaźniewicz et al., 2011; Nawrocki and Becker, 2017). It is formed of Variscan basement and Permian-Mesozoic and Cenozoic covers (Figs 2.1–2.2).

The oldest rocks in the tender area region were drilled north-east of its boundary: they are represented by synmetamorphic quartz-sericite phyllites, most likely Devonian in age (Żelaźniewicz et al., 2011). These rocks build the Wolsztyn High (Fig. 2.1B). The basement also includes strongly folded Carboniferous flysch deposits, interpreted as belonged to the Wielkopolska fold-and-thrust belt, which is a fragment of the Variscan Externides (Fig. 2.1B). These rocks were not drilled in the tender area, although their occurrence was documented in the close vicinity.

The Neoproterozoic-Paleozoic basement are covered by the Permian-Carboniferous volcanic cover and the Permian-Mesozoic sedimentary cover (Fig. 2.1). The volcanites in this area show a predominance of andesitic-basalt rocks over acidic rocks (Maliszewska et al., 2016) and constitute the regionally eastern part of the Brandenburg Volcanic Province (Benek et al., 1996). The sedimentary cover consists of the following successions: clastic Rotliegend deposits, carbonate-evaporitic Zechstein deposits, and clastic-carbonate successions of the Triassic, Jurassic and Cretaceous. The above-mentioned succession was subjected to minor tectonic deformations during the Cimmerian and Laramian tectonic movements. The Triassic, Jurassic and Cretaceous succession, depending on the location in the tender area, is stratigraphically reduced. In the southern part there are only Triassic deposits, in the central part – Triassic and Lower Jurassic, while in the north-western part, the Lower and Upper Cretaceous rocks are documented. In the Cybinka-Torzym tender area, the Permian-Mesozoic deposits form the western part of the Fore-Sudetic Monocline (Fig. 2.1A).

The Permian-Mesozoic succession of the Fore-Sudetic Monocline in the Cybinka-Torzym tender area are entirely covered by flat-lying Cenozoic sediments. They are represented by clastic-carbonate sediments of the Paleogene and clastics of the Neogene.

The further part of this report includes the characteristics of particular stratigraphic units, which is prepared basing on data from the following wells, located within the tender area: Bytomiec-1, Chlebów 1, Cybinka 1, Cybinka 2, Grzmiąc 1, Grzmiąc 2, Grzmią-ca 3, Grzmiąc 5, Grzmiąc 7, Kłopot 1, Kosarzyn-8, Kosobudz 1, Koziczyn-1, Miłów 1, Radomicko 1, Rąpice 1A, Rybaki 5, Rybaki 14, Sosna-1, Świebodzin 2 and Świebodzin 3 (their locations can be found in Fig. 2.3).

Tectonic

In the Variscan structural plan, the basement of the Cybinka-Torzym area form the Wolsztyn High, which is limited in its north-eastern part by a regional tectonic dislocation – the Dolsk fault zone (Fig. 2.2). The Neoproterozoic and Lower Paleozoic there are composed of quartz-sericite phyllites. The results obtained from isotopic dating of mica deposits determine the age of phyllite metamorphism at 340 million years (Early Visean; Żelaźniewicz et al., 2003) or at the turn of the Devonian and Carboniferous periods – approximately 359 million years. Above there are strongly inclined Carboniferous formations (reaching dips of up to 90°), cut by a network of numerous faults, in some cases, the nature of the overthrusts (Pożaryski and Dembowski, 1983; Kudrewicz, 2008), which emphasizes their block structure. They were formed in the late Carboniferous during the Variscan fold-and-thrust deformations. In the south-western part of the Cybinka-Torzym tender area, there are faults in the NW-SE and NE-SW directions. They have deep tectonic foundations related to the Middle Odra Fault Zone (Fig. 2.2). On the structural map of the Sub-Permian surface (Kudrewicz, 2007), the Variscan basement is buried at a depth of approximately -2400 m a.s.l. to over -3200 m a.s.l. (Fig. 2.4).

To the north of the Middle Odra Fault Zone there is the Middle Odra Breakup Zone (Fig. 2.5). It is related to the thinning of the Earth's crust (Oberc, 1990), as well as to an extensive system of deeply rooted steep faults, probably of a sliding nature (Aleksandrowski, 1995; Aleksandrowski et al., 1997; Kiersnowski and Petecki, 2017). The Middle Odra Breakup Zone played an important role during the sedimentation of the Permian and Carboniferous. Their deposition took place in a series of tectonic trenches (often connected to each other). According to Kiersnowski and Petecki (2017: after Aleksandrowski, unpublished information, 2016), the southern part of the Wielkopolska fold-and-thrust belt can be divided into two structural units: the northern internides and the southern externides, the boundary of which is limited by the occurrence of the Middle Odra Breakup Zone (Fig. 2.5). A significant part of the Cybinka-Torzym tender area, in the light of the above description, is located in the northernmost part of the northern internides, while the remaining part is within the southern externides (Fig. 2.5).

Throughout the entire tender area, the succession of the Laramide structural unit is unconformably deposited on older rocks. This succession consists of the Zechstein carbonate-evaporite deposits, Triassic clastic-carbonates, Jurassic clastic rocks and Cretaceous carbonate rocks. In the southern part, the Permian-Mesozoic sedimentary cover is devoid of Jurassic and Cretaceous rocks. Moving towards the north of the Cybinka-Torzym tender area, in the sub-Cenozoic plan, the Jurassic and Cretaceous consequently appear. It is worth emphasizing that despite the presence of Jurassic and Cretaceous deposits, their stratigraphic successions are reduced, as a result of the Cimmerian and Laramian tectonic movements. The Laramide structural unit is characterized by a general dip of the strata not exceeding 5° towards the north-east (Deczkowski and Gajewska, 1977). This surface is cut by numerous faults running NW-SE, N-S and NE-SE. Some of these faults create a system of tectonic trenches, which are tensional and compressional in nature (Sokołowski, 1967; Podemski, 1973; Deczkowski and Gajewska, 1977, 1980). They have older tectonic foundations (Deczkowski and Gajewska, 1977, 1980), the beginning of their development dating back to the turn of the Keuper and Rhaetian (Deczkowski and Gajewska, 1977, 1980), and even to the Early Triassic (Grocholski, 1991; Kwolek, 2000). The final reconstruction of the Triassic trench system and the remaining sub-Cenozoic surface took place at the turn of the Cretaceous and Paleogene, as a result of the Laramide tectonic movements.

In the south-western part of the Cybinka-Torzym tender area there is the northernmost part of the Middle Odra Fault Zone. It is known in the literature as the Rybaki structure (Fig. 2.6; Sokołowski, 1967; Deczkowski and Gajewska, 1977, 1979; Podemski, 1973). It occurs in the form of an elongated block, extending NNW-SSE, narrowing towards the north-northwest (Fig. 2.6). The Rybaki structure is limited by reverse faults (Fig. 2.7), NNW-SSE. Additionally, it is divided into a number of smaller blocks (Fig. 2.6). The origin of the Rybaki structure is associated with the activity of halotectonic processes (Sokołowski, 1967).

A more detailed imaging of the Permian-Mesozoic cover is provided by data obtained from the 3D seismic survey conducted by Aurelian Oil & Gas Sp. z o.o. It show in details the structural and tectonic system of the Zechstein surface and the Main Dolomite horizon. It also provides valuable information regarding other seismic horizons which, from an oil prospecting point of view are not prospective for the tender area, but play an important role in its structural structure.

Cenozoic deposits lie horizontally, covering slightly inclined Mesozoic rocks throughout the tender area. The Cenozoic is represented by Paleogene-Neogene-Quaternary clastic deposits. The occurrence of large-scale glacitectonic disturbances was observed in Quaternary sediments (Markiewicz, 2010). Their origin is related to the neotectonic reactivation of the area during the Pleistocene glaciations (Markiewicz and Kraiński, 2002; Markiewicz and Winnicki, 2005, 2007a, b; Markiewicz, 2007).

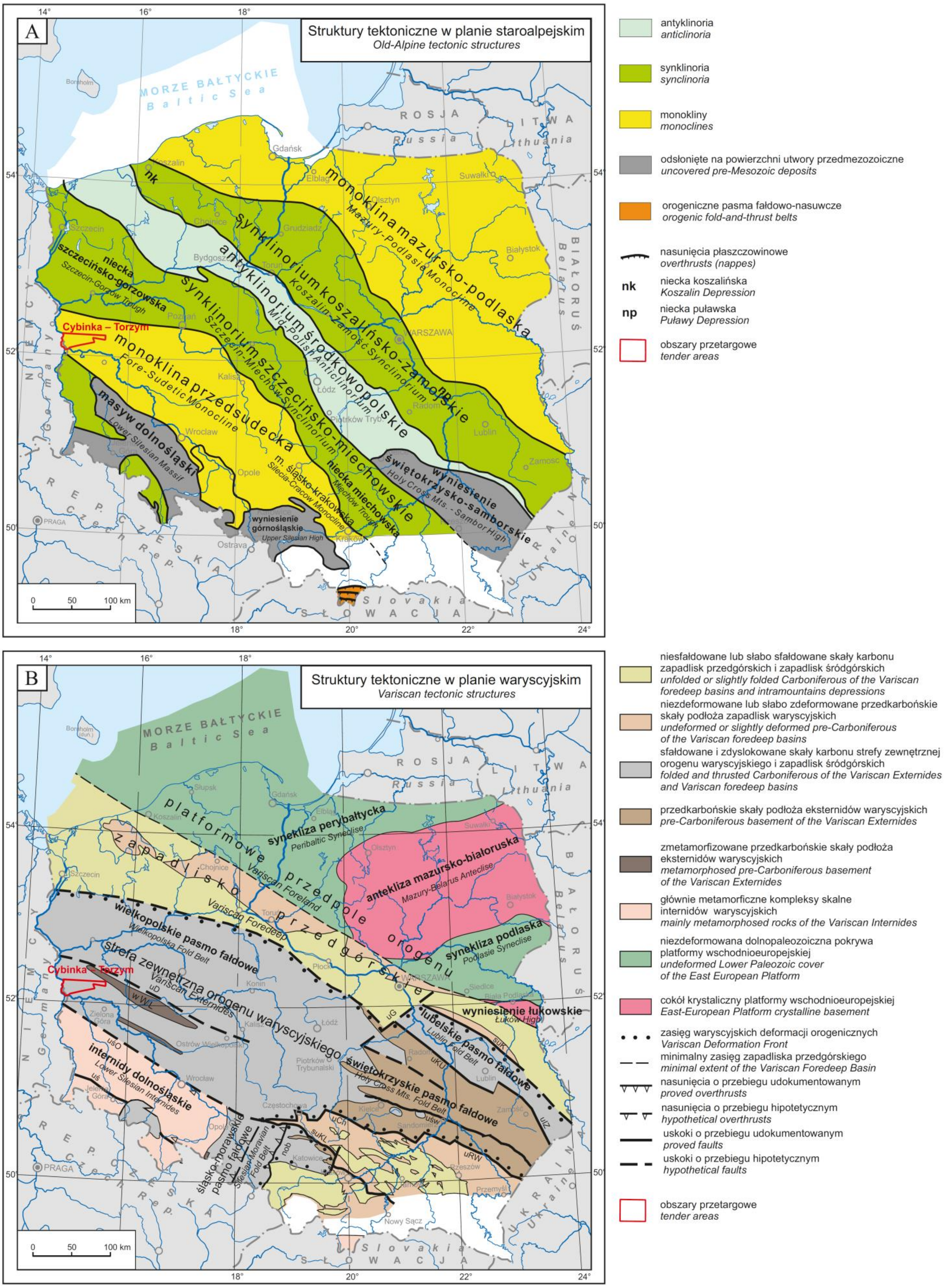


Fig. 2.1. A. Location of the Cybinka-Torzym tender area in relation to the Old-Apline tectonic structures (Nawrocki and Becker, 2017; modified). **B.** Location of the Cybinka-Torzym tender area in relation to the Variscan tectonic structures (Nawrocki and Becker, 2017; modified).

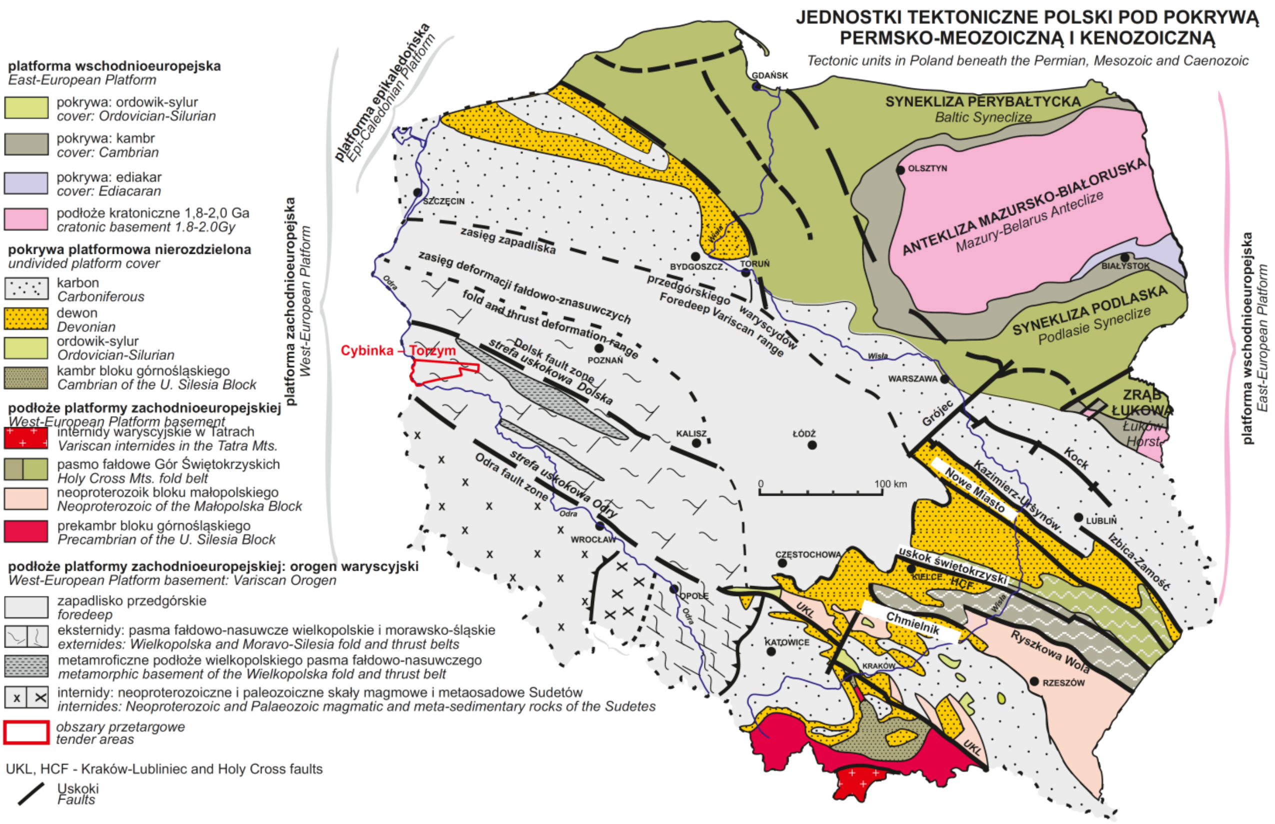


Fig. 2.2. Location of the Cybinka-Torzym tender area in relation to the main tectonic units in Poland beneath the Permian, Mesozoic and Cenozoic (Żelaźniewicz et al., 2011; modified).

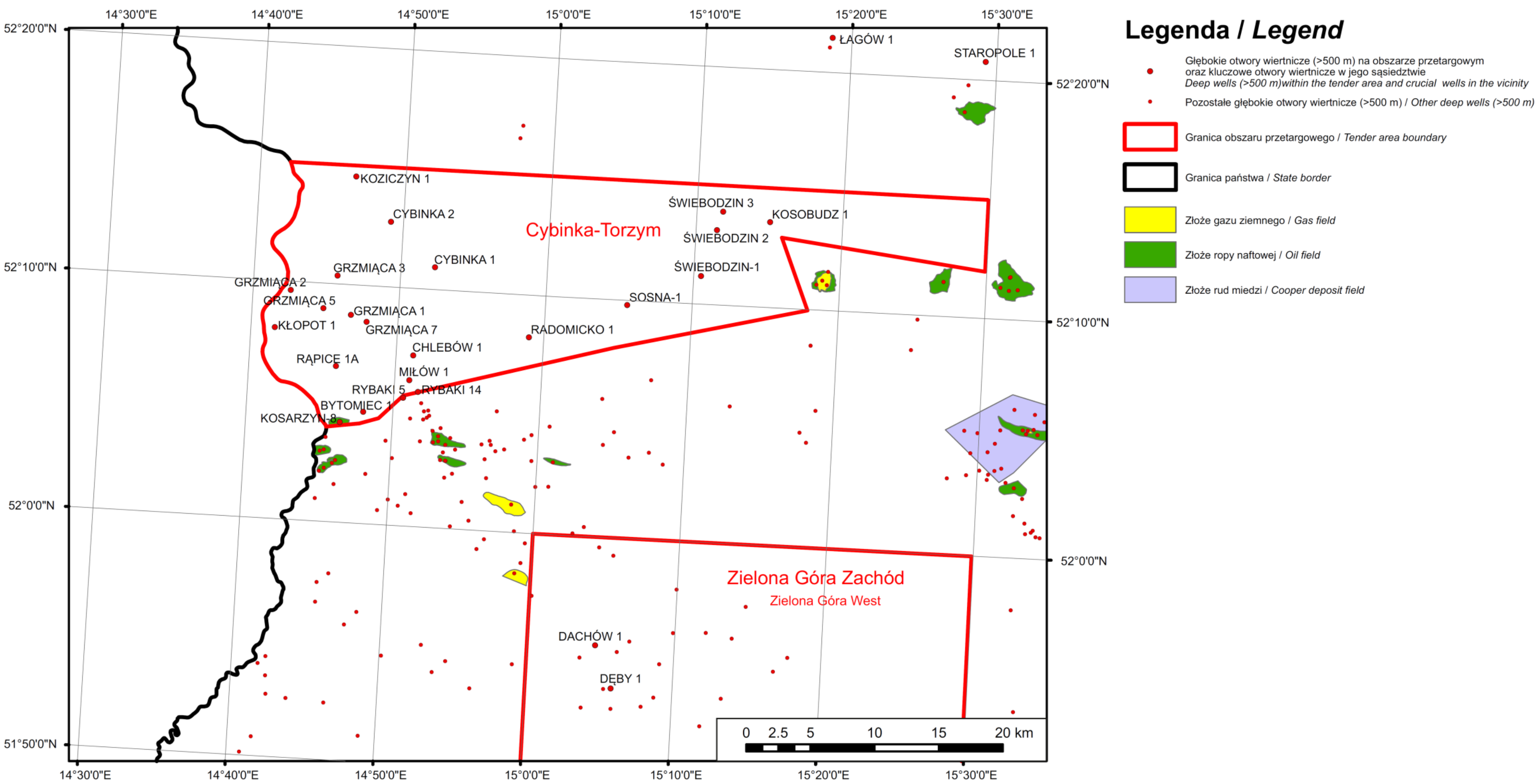


Fig. 2.3. Location of deep wells within the Cybinka-Torzym tender area as crucial for geological characteristics of the area in relation to oil and gas fields.

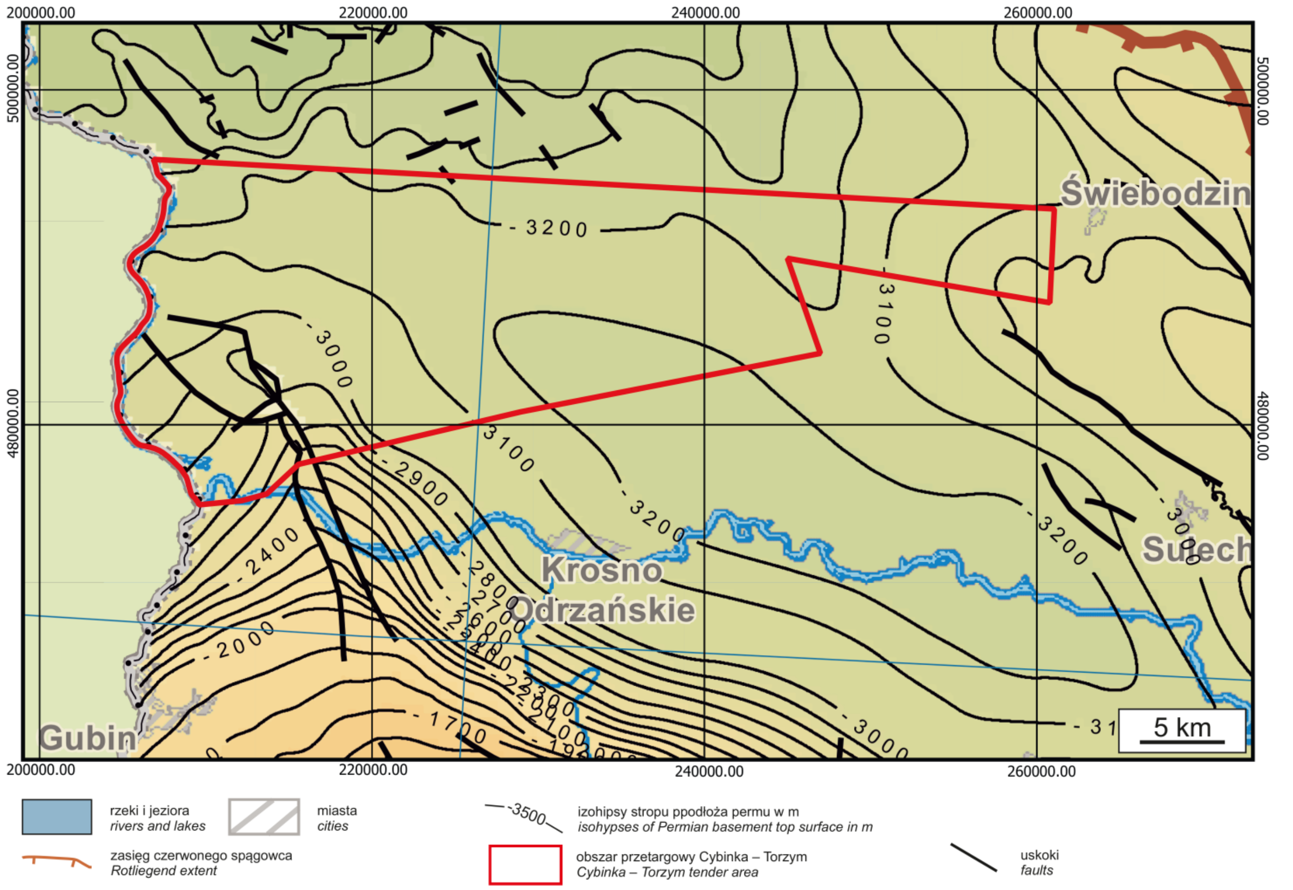


Fig. 2.4. Location of the Cybinka-Torzym tender area on the map of the Permian basement top surface (Kudrewicz, 2007).

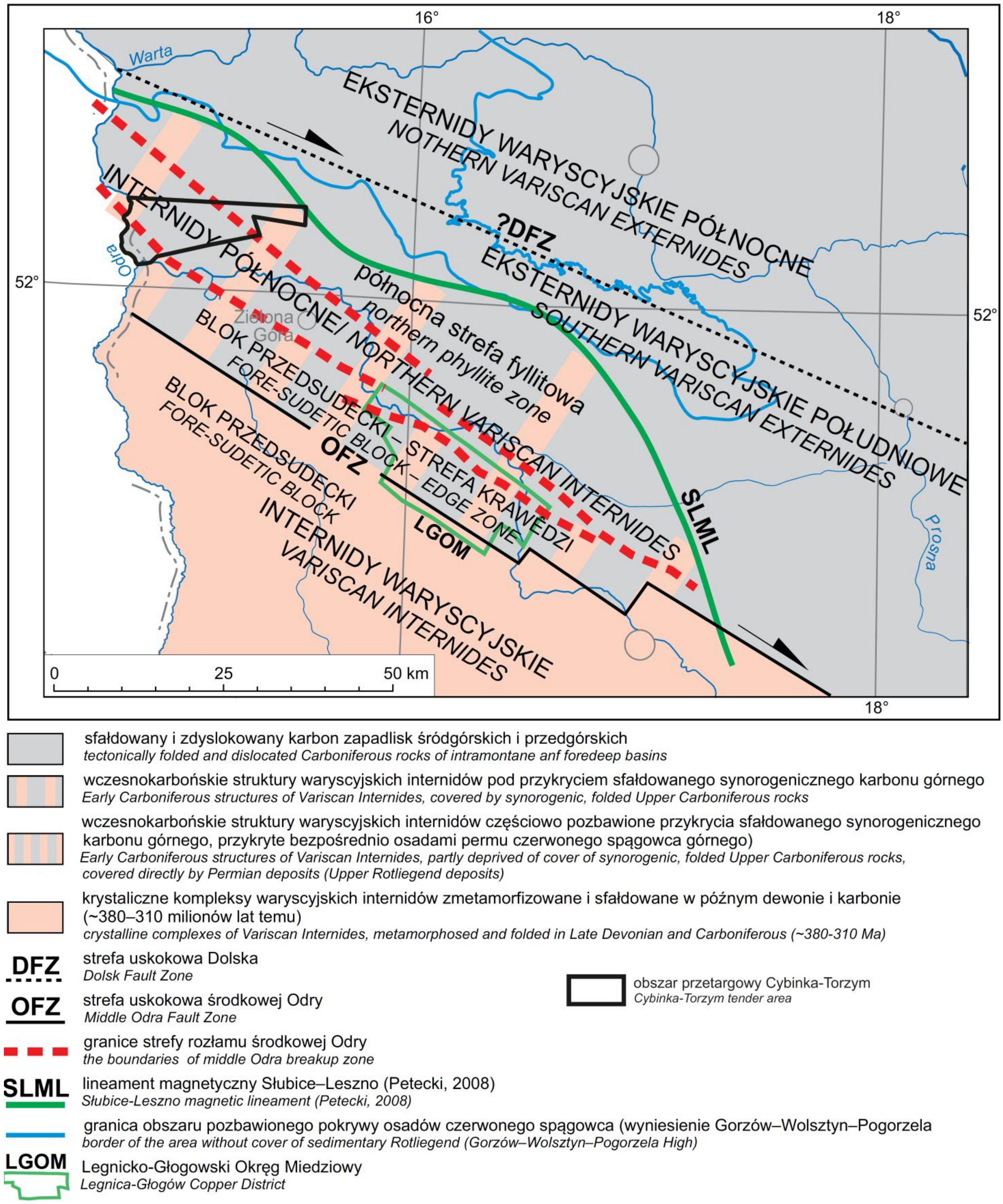


Fig. 2.5. Proposed change of the Variscan Internides and Externides ranges (Kiersnowski and Petecki, 2017).

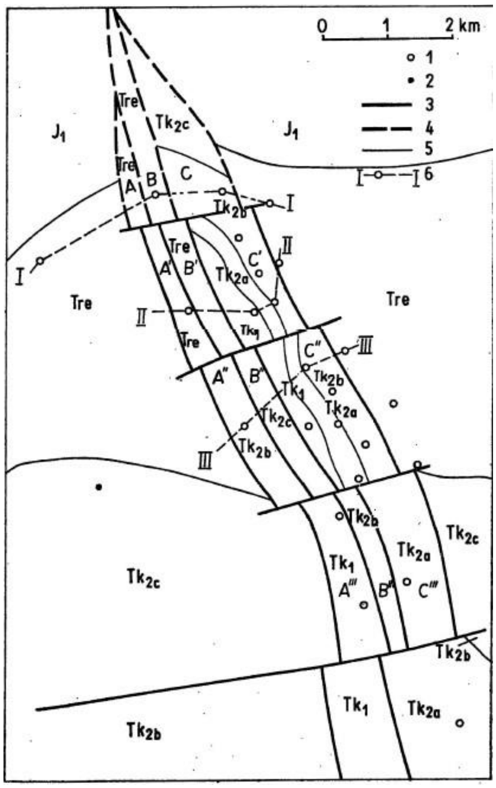


Fig. 2.6. Geological and tectonic map of the Rybaki structure (Deczkowski and Gajewska, 1977). 1 – deep wells, 2 – deep wells reaching sub-Cenozoic surface, 3 – faults proved, 4 – hypothetical faults, 5 – geological boundaries, 6 – cross sections. Stratigraphy: J1 – Lower Jurassic, Tre – Triassic Rheatian, Tk2c – Triassic Upper Gypsum Beds, Tk2b – Triassic Reed Sandstone, Tk2a – Triassic Lower Gypsum Beds, Tk1 – Triassic Lower Keuper, Tm – Triassic Muschelkalk, Tp3 – Triassic Röt, Tp2 – Triassic Middle Bunter Sandstone, Tp1 – Triassic Lower Bunter Sandstone, P2 – Permian Zechstein, P1 – Permian Rotliegend.

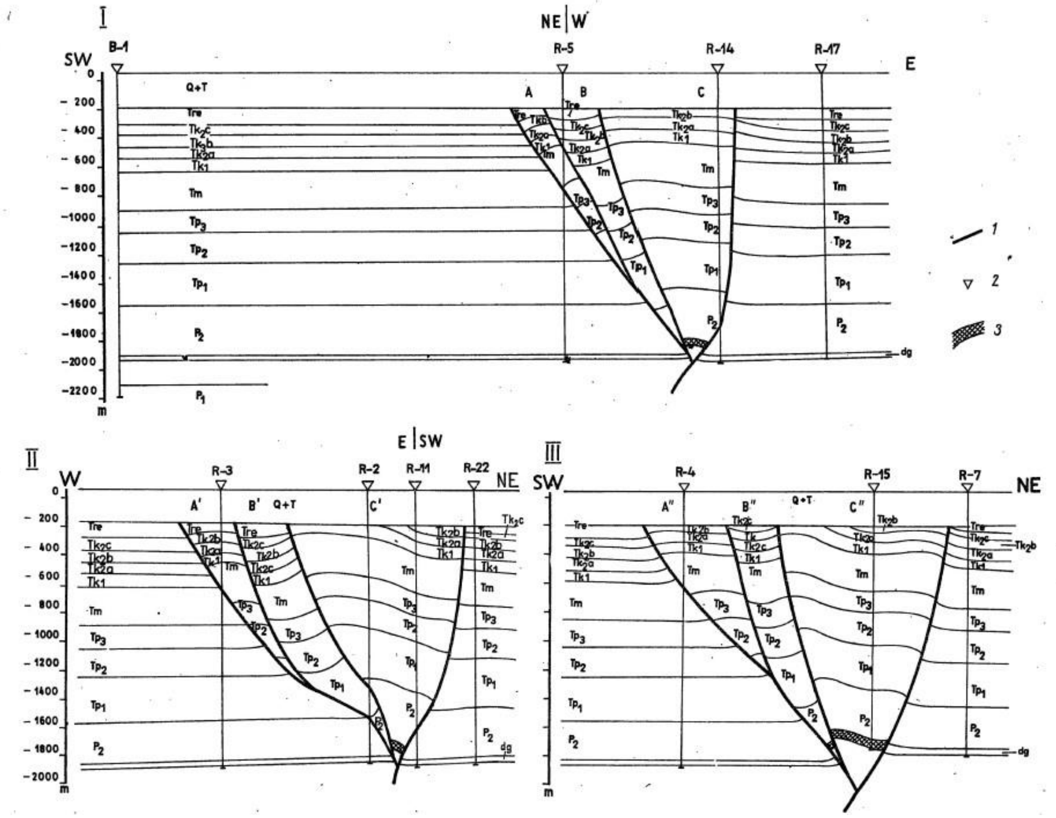


Fig. 2.7. Geological cross-section through the Rybaki structure (Deczkowski and Gajewska, 1977; location and abbreviations – Fig. 2.6). 1 – faults, 2 – wells; 3 – Rybali oil field, dg – Main Dolomite.

2.2. STRATIGRAPHY
2.2.1. CARBONIFEROUS

Distribution and thickness

The Carboniferous has not been documented in any of the wells drilled in the Cybinka-Torzym area. It was recognized only in wells located outside the tender area: Dęby 1, Dachów 1, Łagów 1 and Staropole 1 (Fig. 2.3).

Lithology and stratigraphy

The Carboniferous in the vicinity of the tender area is represented by brown-red and gray claystones, mudstones with intercalations of fine and medium-grained sandstones. These rocks are characterized by the presence of numerous cracks or tectonic mirror surfaces, as well as a high dip reaching up to 90°. According to Żelichowski (in: Wierzchowska-Kicułowa, 1984, 1987, 2007), the Carboniferous rocks recognized in the wells, e.g. Dachów 1, Niwiska 1, Piaski 1 and Staropole 1 should be treated as a complex of the Upper Westphalian-Stephanian molasses (Figs 2.1B–2.2; Fig. 2.8). Additionally, Żelichowski (in: Wierzchowska-Kicułowa, 1984, 1987) distinguished two informal lithostratigraphic units of the series rank in the Carboniferous: arkose-greywacke (lower) and quartz sandstones (upper). In the mentioned above wells, the Carboniferous rocks represent the arkose-greywacke series.

The depth of the Variscan basement in the Cybinka-Torzym tender area increases towards the north, reaching in the most northern part -3200 m a.s.l. (Fig. 2.4). Generally, the dip of the sub-Permian rocks is gentle and does not show large differences. Only in the south-western part of the tender area, quite significant dip is observed.

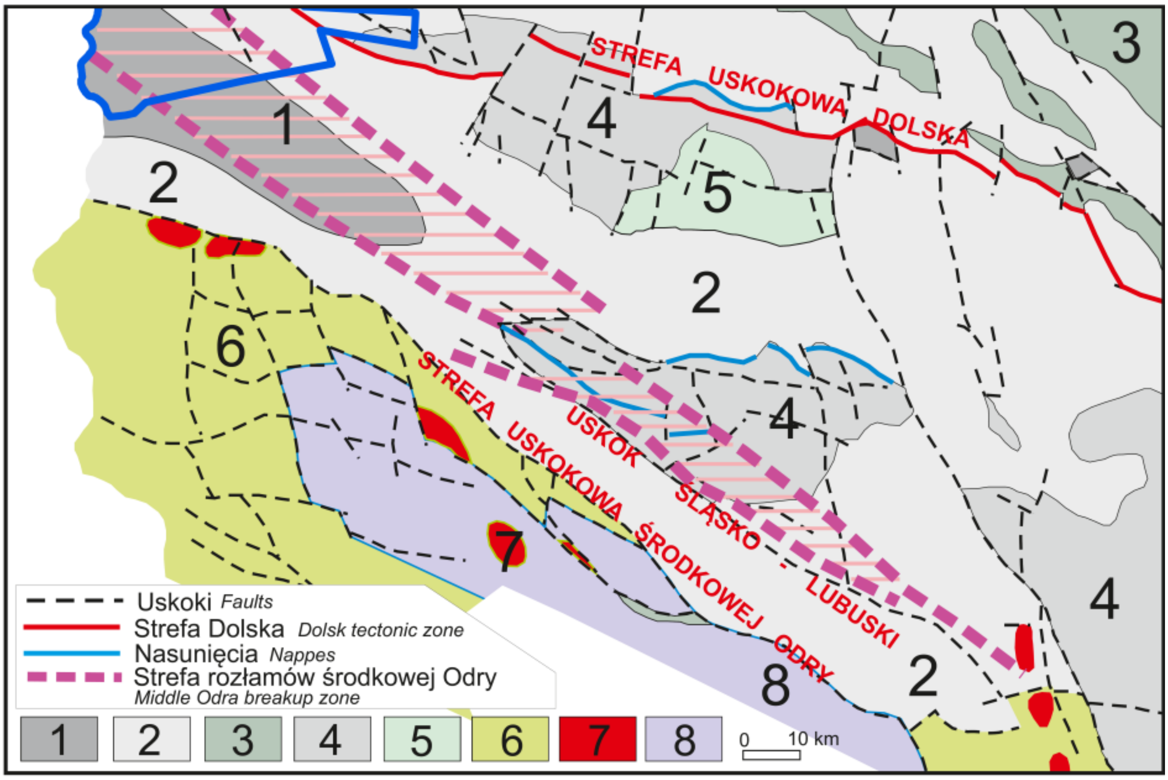


Fig. 2.8. The Cybinka-Torzym tender area (blue line) on the geological map of the sub-Permian surface of the Variscan foreland and fold-and-thrust belt (according to Wierzchowska-Kicułowa, 2007; Kiersnowski and Petecki, 2017). Explanation of colors and their numbers: 1 – youngest molasses – Stephanian-Autunian, 2 – older molasses – upper Namurian-Westphalian, younger molasses – Westphalian, 3 – younger flysch – Lower Carboniferous, Namurian and Lower Westphalian deposits folded in Early Westphalian, 4 – older flysch – Upper Devonian, Lower Carboniferous and Lower Namurian, folded in the Early Namurian, 5 – phyllites of the Leszno Block – pre-flysch structural unit, epimetamorphic series, folded in the Bretonian or Early Variscan phases, 6 – Permian-Mesozoic sedimentary rocks of the Fore-Sudetic Block, 7 – granitoids, 8 – crystalline rocks of the Fore-Sudetic Block.

2.2.2. PERMIAN – ROTLIEGEND

Distribution and thickness

In the Cybinka-Torzym tender area, the Rotliegend deposits were documented in 7 wells (none of them pierced the interval):

- Bytomiec-1: 2203.0–2240.0 m,
- Grzmiąca 3: 2616.0–2634.0 m,
- Kosobudz 1: 2765.5–2974.0 m,
- Koziczyn-1: 2853.5–3208.0 m,
- Miłów 1: 2337.0–2401.0 m,
- Rąpice 1A,
- Świebodzin 3: 2757.8–2804.0 m.

The thickness of the Rotliegend deposits varies from 18.0 to 354.4 m.

Lithology and stratigraphy

Two lithostratigraphic subdivisions are in use in the case of the Rotliegend. The first, formal subdivision, was developed by Karnkowski (1987; Fig. 2.9) and is based on lithological variability in the Rotliegend Basin. The second lithostratigraphic subdivision, informal, was proposed by Pokorski (1981, 1988, 1997; Fig. 2.9), which allows its correlation with the Northern German Basin (Hoffmann et al., 1997). The analysis and description of the Rotliegend deposits in this report was based on the informal lithostratigraphic subdivision of Pokorski (1981, 1988, 1997), which was also used in the previous works dedicated to hydrocarbon prospective (e.g. Wagner et al., 2008).

Lower Rotliegend

The volcanic and pyroclastic rocks were drilled in several wells in the Cybinka-Torzym tender area and in its vicinity. They consist of rhyolites, dacites and trachytes, as well as tuffs and tuffites. These rocks represent the Wielkopolska Volcanogenic Formation (Fig. 2.6). There is also a chance that in the tender area, among the volcanic rocks, there may be intercalations or horizons of sedimentary rocks. In the well Chyże 1 in the neighbourhood, under the rhyolites Juroszek et al. (1981) documented brown-grey tuffogenic and horizontally laminated sandstones. According to Kiersnowski (2008), this complex should be classified as intervolcanic sedimentary rocks. The Rotliegend volcanic cover occurs in almost the entire Cybinka-Torzym tender area (Fig. 2.10). Only the south-western part of the area is devoid of it due to the occurrence of the sub-Permian rocks (Carboniferous). Regional trend of increasing thickness of the Wielkopolska Volcanogenic Formation towards the west it is also observed in the Cybinka-Torzym area. The thickness of the Rotliegend volcanites usually exceeds 600 m, and only in the edge it drops to 400 m (Fig. 2.10). According to Kiersnowski (2008), the Supervolcanic Series occur over the Wielkopolska Volcanogenic Formation in the Cybinka-Torzym tender area. It was in the sedimentary environments of alluvial fans and fluvial flood plains. This series includes alluvial fans, fluvial channel and off-channel sediments, and sometimes lake deposits (including thin layers of limestones), and complexes identified as alluvial-pyroclastic (Kiersnowski, 2003). The deposition of the Supervolcanic Series sediments took place in the western part of the Zielona Góra Basin (Kiersnowski, 2008). The thickness of these formations varies and ranges from a few meters in the marginal part to over 500 m in the central part of the basin (Fig. 2.11).

Upper Rotliegend

Between the Lower and Upper Rotliegend there is a time gap of at least 10 million years (Nawrocki, 1995, 1997) or even 20 million years (personal information: H. Kiersnowski, 2021), during which an erosion and peneplanation of the volcanic cover or outcrops of pre-Permian rocks occurred.

The Upper Rotliegend (Saxonian) rocks consist of fine-, medium- and coarse-grained sandstones as well as conglomerates, mudstones and claystones. They are developed in aeolian, alluvial and fluvial facies (Fig. 2.12). The main source of clastic material was previously deposited sediments. The north and north-eastern area (Wolsztyn High; Fig. 2.12) and the south-western area (Łużyce Elevation; Fig. 2.12) constituted the alimentary areas, which were also a source of eroded clastic material, transported and deposited, among the others, in the tender area.

The Upper Rotliegend in the tender area is monoclinally inclined to the north (Fig. 2.13). It is buried in the southern part to the depth below -2200 m a.s.l. (Fig. 2.13; including the Bytomiec-1 well). The Rotliegend top surface drops gradually and to the north, reaching a depth of over -2800 m a.s.l. (Fig. 2.13; including the Koziczyn-1 well).

In the Cybinka-Torzym tender area, the Upper Rotliegend rocks have variable thickness (Fig. 2.14). Its highest values occur in the central part of the area. Towards the north-north-east and south-west, the thickness of the Upper Rotliegend decreases to less than 50 m, the Upper Rotliegend wedges out to the south-west.

The Upper Rotliegend in the tender area is represented mainly by aeolian sediments (Fig. 2.12), characterized by good petrophysical properties. The depth of burial of the reservoir rocks ranges from -2300 to -2900 m a.s.l. (Fig. 2.13). Unfortunately, in the wells in which the Upper Rotliegend interval was sampled, only the nitrogen gas flows were mainly obtained (Fig. 2.15A). Regional gas content maps indicate that the percentage of methane increases towards the north-east (Fig. 2.15A–B).

Rotliegend petrography

The results of petrographic study in the tender area can be obtained, among the others, from the final geological reports from wells: Bytomiec-1, Grzmiąca 3, Koziczyn-1, and Miłów 1. Based on the available materials, it was found that the Rotliegend sedimentary series consists mainly of fine- to coarse-grained sandstones. Conglomerate was identified in one well, also mudstone intervals were observed in places.

The sandstones are red, occasionally grey or dark grey in color. They show a psamite structure, a chaotic texture, sometimes directional, emphasized by the parallel arrangement of coarsely grained sandstone laminae. Most of the described sandstones are poorly compacted, although compact sections have also been described. The detrital material is semi-rounded and rounded, with varying degrees of sorting. The main component of sandstones are grains of mono- and polycrystalline quartz, some with inclusions of biotite and apatite. In one well, the amount of quartz was found to vary from 40% to 70% of the rock volume. Feldspars are mostly represented by albite and microcline in varying amounts. In arkoses, the average content of feldspar is about 30% by volume. In addition to the listed components, the lithoclasts, mainly of volcanic origin (on average about 10–15% by volume) and sporadically mica, were noted. Accessory minerals are: zircon, tourmaline, garnet. In the sandstones glauconite was spotted from the Koziczyn-1 well. Iron oxides and sulphides are common, although in negligible amounts.

The matrix of the sandstones is varied. The main component that gives the sandstones a brown-red color is a clay-ferruginous substance. It forms primarily a contact type matrix. In places, a clay matrix was noticed, most probably partially authigenic (chlorite, illite). Anhydrite, calcite and occasionally dolomite cements (Koziczyn-1 well) are present in the pore spaces or as a filling mass.

Mudstones were described only in the Koziczyn-1 well. They are brown-red, interbedded with fine- and medium-grained sandstones with glauconite.

The effects of the following diagenetic processes can be distinguished in the sandstones: mechanical compaction, cementation, dissolution. The weak intensity of mechanical compaction is reflected in the fact that the sandstones have been defined – mostly – as poorly compacted. The main diagenetic process was cementation. The basic component of cements is anhydrite, calcite, rarely dolomite. Due to the presence of arkose and sub-arkosic varieties, as in sandstones from other nearby areas (Maliszewska et al., 2016), it is important that the dissolution of diagenetic detrital material occurs, which affects the formation of secondary porosity.

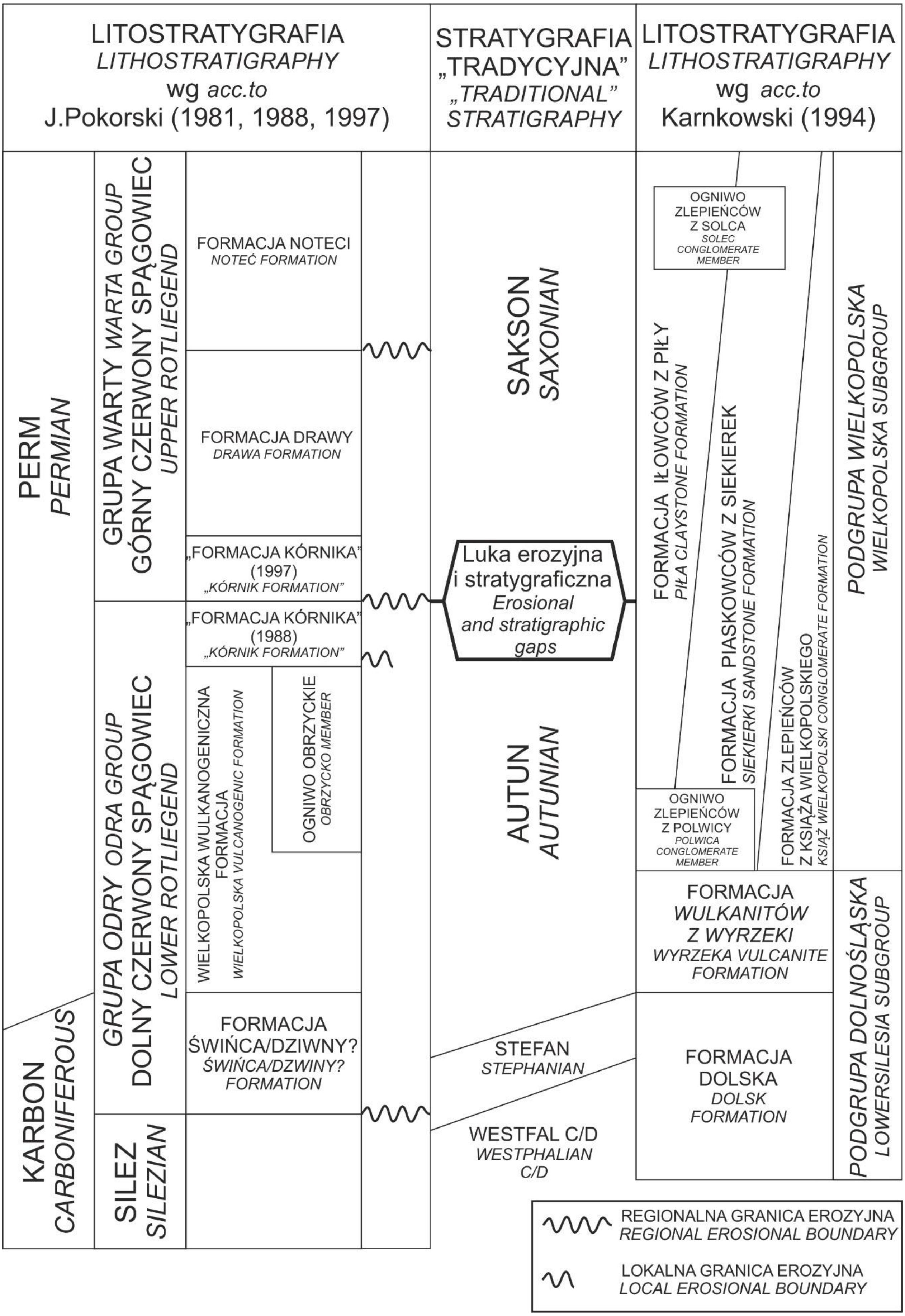


Fig. 2.6. The Rotliegend stratigraphy in the Polish part of the South Permian Basin (Kiersnowski in: Maliszewska et al., 2003).

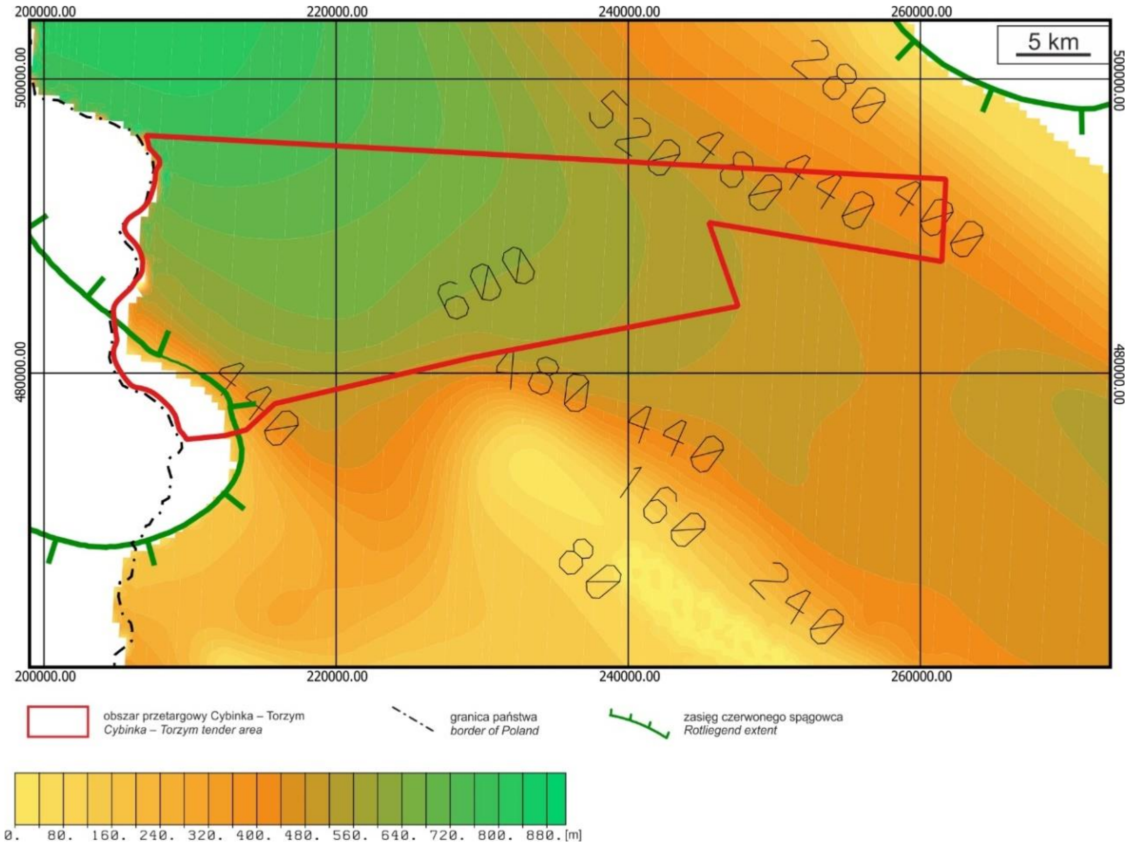


Fig. 2.7. The Rotliegend Volcanogenic Series thickness in the Cybinka-Torzym tender area (Wagner et al., 2008).

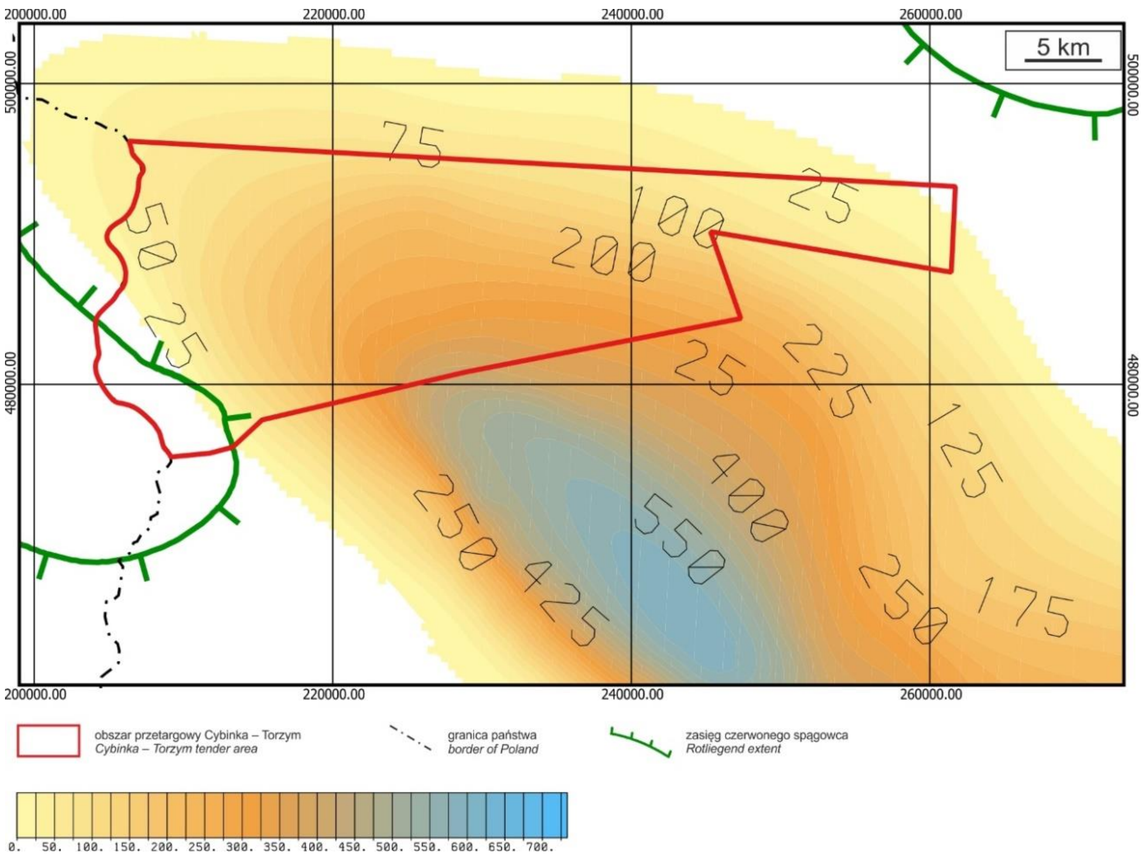


Fig. 2.8. The Rotliegend Supervolcanic Series thickness in the Cybinka-Torzym tender area (Wagner et al., 2008).

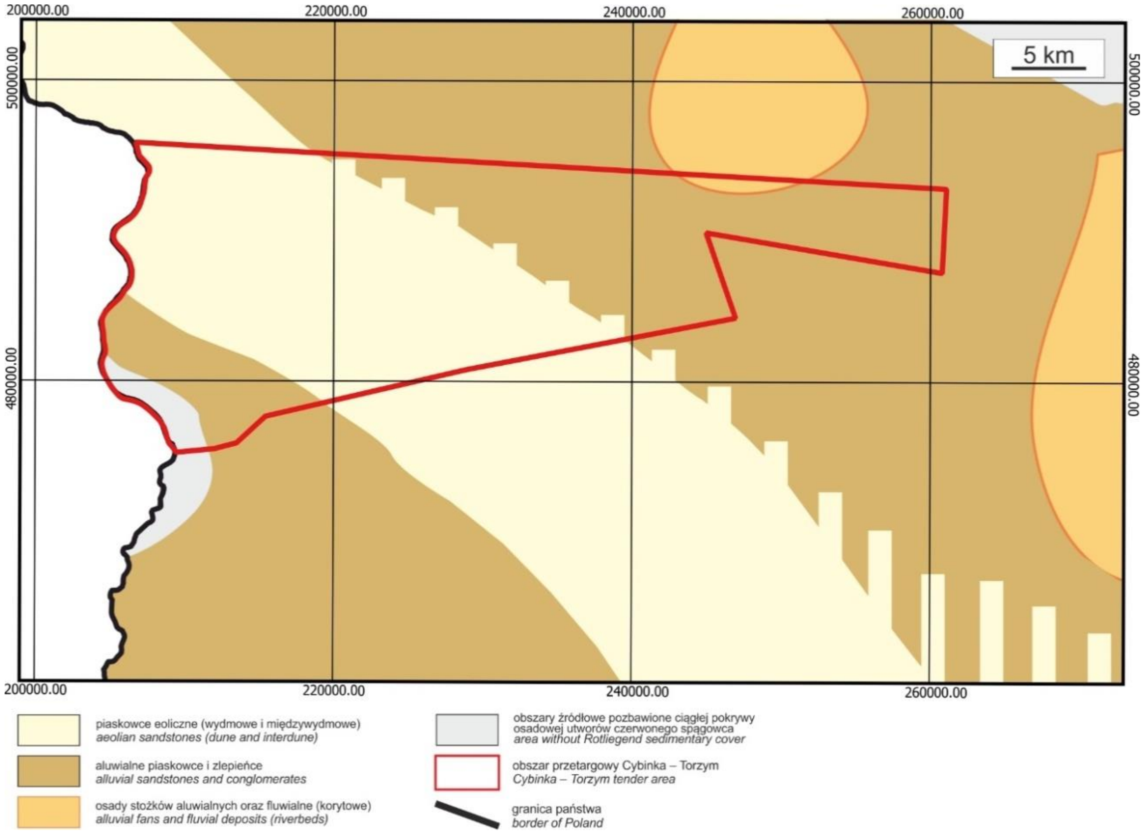


Fig. 2.9. Lithofacies and palaeogeography of the topmost part of the Upper Rotliegend succession in the Cybinka-Torzym tender area just before the Zechstein transgression (Kiersnowski et al., 2020).

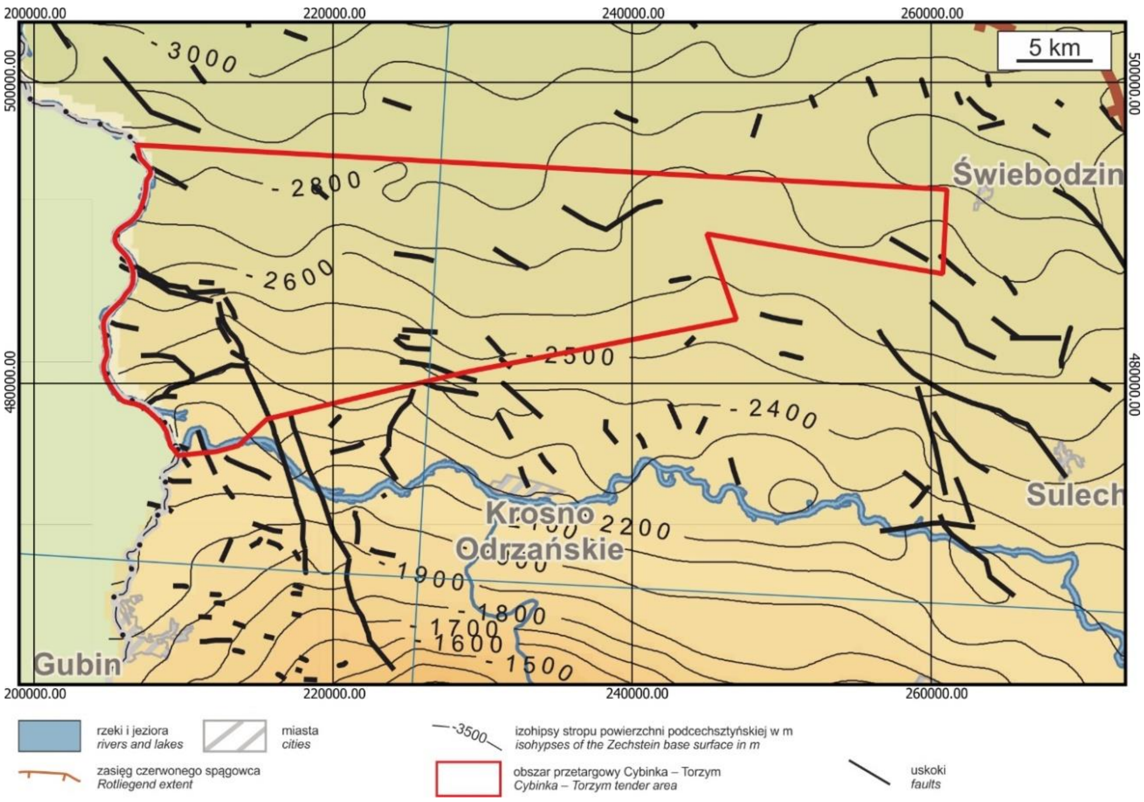


Fig. 2.10. Location of the Cybinka-Torzym tender area on the structural map of the Zechstein base surface (Kudrewicz, 2007).

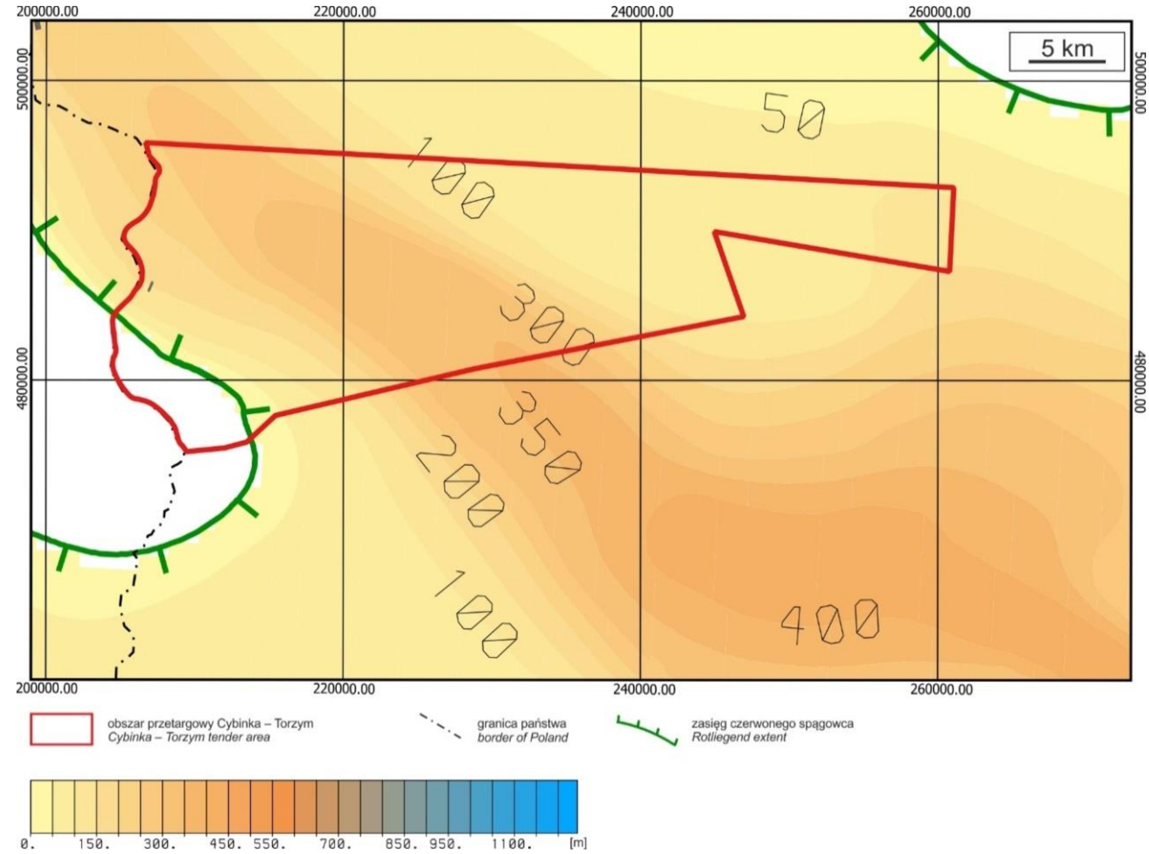


Fig. 2.11. The Upper Rotliegend thickness in the Cybinka-Torzym tender area (Wagner et al., 2008).

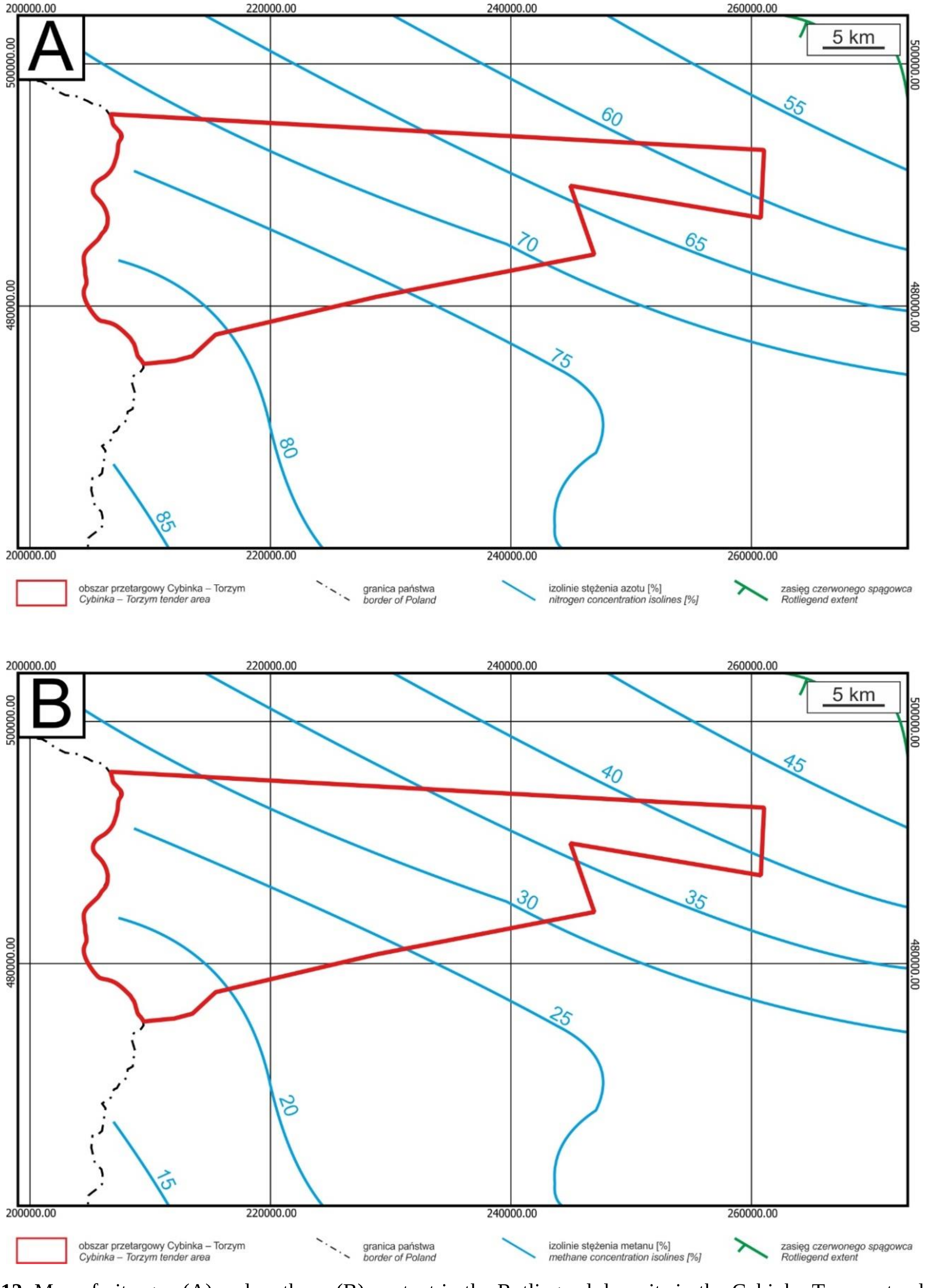


Fig. 2.12. Map of nitrogen (A) and methane (B) content in the Rotliegend deposits in the Cybinka-Torzym tender area (Wagner et al., 2008).

2.2.3. PERMIAN – ZECHSTEIN

Distribution and thickness

In the Cybinka-Torzym tender area, all wells drilled into the Zechstein deposits. Most of them reached the Upper Anhydrite (A1g) of the PZ1 cyclothem, and only 7 of them pierced the Zechstein:

- Bytomiec-1: 1597.0–2203.0 m,
- Chlebów 1: 1776.5–2135.0 m,
- Cybinka 1: 2126.0–2586.0 m,
- Cybinka 2: 2000.0–2617.0 m,
- Grzmiąca 1: 1866.0–2155.0 m,
- Grzmiąca 2,
- Grzmiąca 3: 1989.0–2616.0 m,
- Grzmiąca 5,
- Grzmiąca 7,
- Kłopot 1,
- Kosarzyn-8,
- Kosobudz 1: 1930.0–2765.5 m,
- Koziczyn-1: 1948.0–2853.5 m,
- Miłów 1: 1606.5–2337.0 m,
- Radomicko 1,
- Rąpice 1A,
- Rybaki 5: 1633.0–1988.0 m,
- Rybaki 14: 1586.0–2022.6 m,
- Sosna-1: 2017.0–2455.0 m,
- Świebodzin 2: 1943.0–1998.0 m,
- Świebodzin 3: 1905.0–2757.8 m.

The total thickness of the Zechstein in the Cybinka-Torzym tender area increases towards the north-east (Fig. 2.16). The south-western part is characterized by a thickness not exceeding 600.0 m. In the light of the palaeotectonic reconstruction, this area constituted the western part of the Wolsztyn High (Wagner, 1988). The remaining part of the tender area is characterized by an increase in thickness above 600.0 m towards the north and north-east (Fig. 2.16). It corresponds respectively to the western part of the Gorzów-Kalisz escarpment and the marginal part of the Central Polish Trough (Wagner, 1988).

Lithology and stratigraphy

The Zechstein stratigraphic scheme of Richter-Bernburg (1955) were adopted by Tokarski (1958) and Poborski (1960) for the Polish part of the Permian Basin. In the following years, this scheme was modified (Wagner et al., 1978) and supplemented, especially in its highest part (e.g. Wagner, 1987, 1988, 1994).

The Upper Permian deposits consist of four cyclothems: PZ1, PZ2, PZ3 and PZ4 (Fig. 2.17). The PZ1–PZ3 cyclothems are represented by carbonate-evaporite rocks. Their deposition took place as a result of successive transgressive-regressive cycles (Wagner, 1994; Wagner and Peryt, 1997, 1998). In the case of the last cyclothem PZ4, the carbonate-evaporite succession was replaced by the terrigenous-evaporite succession, associated with climatic fluctuations depending on the cyclical nature of dry and wet periods (Wagner, 1994).

PZ1

In the Cybinka-Torzym area, the Zechstein begins with the Kupferschiefer (T1; Fig. 2.17). It is represented by grey-black horizontally laminated bituminous limestones with fish remains (Wagner, 1994). Their deposition occurred below the storm wave zone in anaerobic conditions (Oszczepalski and Rydzewski, 1987). The thickness of the Kupferschiefer is usually from a few to several dozen centimetres, up to a maximum of 1 m. Above the Zechstein Limestone (Ca1) occurs, which consists of grey, dark grey and less often red limestones, which in some cases are replaced in the upper parts by dolomites. The Zechstein Limestone deposits were deposited in the shallow basin plain (Fig. 2.18). The thickness is small, reaching a maximum of 10 m. At the end of the deposition of the Ca1 deposits, the water depth in the sea decreased. As a consequence, the emergence of areas of carbonate platforms and basin plains occurred, and the sediments deposited in these zones underwent intensive diagenetic changes (Peryt and Piątkowski, 1976, 1977; Peryt, 1984). Another marine intrusion started the evaporite stage of the PZ1 development. In an extremely dry climate, the Lower Anhydrite sedimentation occurred (A1d; Fig. 2.17; Wagner, 1994). In the lower parts of the A1d succession, extremely shallow nodular and mosaic anhydrites occur, passing upwards into more deep-water, irregularly stratified, up to relatively deep-water laminated anhydrites (Kłapciński, 1991). The thickness of the A1d in the Cybinka-Torzym tender area is varied and ranges from almost 30 to over 150 m. Then, on the A1d, the Oldest Halite (Na1; Fig. 2.17) occurs. In the shallower zones, the rock salt filled the depressions created as a result of A1d sedimentation (Wagner, 1994). The anhydrite barriers limiting them acted as chemical traps that prevented the outflow of heavy, saturated brines. Thanks to them, a system of isolated lagoons and salt pans was created (Czapowski, 1983; Czapowski and Tomassi-Morawiec, 1985). In most cases, the thickness of these rocks reaches 60 m. Only in the south-western part of the tender area these values are much higher. In addition to the increase in thickness, the Na1 deposits may be separated by Middle Anhydrite (A1s; Fig. 2.19). An analogous case was described in detail by Dyjaczyński and Peryt (2014) for the northern part of the Wolsztyn High. The thickness of A1s is small, reaching a maximum of 7.5 m. In the case of separated Na1, their lower part is distinguished as the Lower Oldest Halite (Na1d; Fig. 2.19), and the upper one – as the Upper Oldest Halite (Na1g; Fig. 2.19); they reach a thickness of over 100 m and over 30 m, respectively. The last part of the sulphate-carbonate sequence of the PZ1 cyclothem is represented by the Upper Anhydrite (A1g; Fig. 2.17). Its sedimentation was associated with the reintrusion of waters into the area of the Permian Basin. The range of A1g is probably slightly larger than A1d and has the character of a transgressive sequence (Peryt, 1990). Most of the wells located in the Cybinka-Torzym tender area only drill the top of the A1g. In seven wells that pierced these rocks, their thickness is 18–103 m, in most cases it does not exceed 60 m. With the end of the sedimentation stage of the PZ1 sedimentation, the greater part of the Ca1 carbonate platforms was exposed, which was directly related to their erosion and diagenetic transformations. In the remaining area, sedimentation of A1g continued, under which the A1d platforms and numerous marginal isolated salt basins, as well as shallow-water open salt basins were hidden (Wagner, 1994).

The total thickness of the PZ1 cyclothem in the Cybinka-Torzym tender area is significant. Its lowest values occur in the northern and north-eastern parts of the discussed area, reaching slightly above 100 m (Fig. 2.20). In the remaining area, the succession thickness of the entire PZ1 cyclotem is characterized by values up to 300 m (Fig. 2.20).

PZ2

New transgression pulse led to the interruption of evaporite-sulphate sedimentation and its replacement by a carbonate sedimentation of the Main Dolomite (Ca2; Fig. 2.17). The palaeogeography of the Main Dolomite was closely related to the palaeomorphology of the Upper Anhydrite (A1g). The development of the A1g platform had a direct impact on the width and inclination of the slopes of the Ca2 carbonate platform, as well as on the development of its basin parts. In the Ca2 palaeogeography, there are three main zones (Wagner, 1994, 2012), which correspond to separate depositional systems (Jaworowski and Mikołajewski, 2007; Wagner, 2012):

- basin plains,
- the slope of the carbonate platforms,
- carbonate platforms.

The Cybinka-Torzym tender area is located in the western part of the Main Dolomite basin. All three facies zones distinguished by Wagner (1994, 1998, 2012) occur in this area (Figs 2.21–2.22).

The depositional system of the basin plain in the Main Dolomite can be divided into the deeper and a shallower parts. The sediments of the deeper part occur only in the northern part of the Cybinka-Torzym tender area (Figs 2.21–2.22). They consist of dark grey laminated mudstones with a small thickness, less than 10 m (Jaworowski and Mikołajewski, 2007). They are characterized by a horizontal, dense lamination whose dark smoudges are composed of clay and organic substances. The sediments of the deeper part of the basin plain have been identified, e.g. in the Świebodzin 3 and Kosobudz 1 wells (Tab. 2.1).

The shallower part of the basin plain is present in a central part of the tender area (Fig. 2.21). According to Wagner (2012), the eastern part of the carbonate platform is dissected and isolated from the rest of it by sediments of a shallow basin plain (Fig. 2.21). This estuary is one of the branches of the Będowa Bay (Wagner, 1994, 2012). However, it should be emphasized that the occurrence and extent of sediments in the shallower part of the basin plain were interpreted as interpolation: the only well documenting this deposits (Struga 1) is located outside the tender area.

The Main Dolomite of the shallower part of the basin plain consist of dolomites interbedded with layered mudstones (Jaworowski and Mikołajewski, 2007). Among them, there are also thin intercalations of wackstones, less often of packstones, the formation of which should be associated with the activity of bottom traction currents or suspension currents. The carbonate muds present in the succession were stabilized in some places by microbial activity.

The distribution, thickness and type of carbonate platform slope deposits depend on the palaeomorphology of the A1g platform, which initiated the development of the Ca2 carbonate platforms. In the Main Dolomite deposits, two types of slopes were identified: gentle and steep. Deposits of the steep slopes of the carbonate platforms occur in the central part of the tender area (Figs 2.21–2.22). They are characterized by a fairly narrow range and extent. They are represented by oolite grainstones, laminated mudstones, as well as breccias and carbonate-sulphate conglomerates (Jaworowski and Mikołajewski, 2007). The Main Dolomite steep slope deposits were recognized in the Cybinka 1 well (Tab. 2.1), and around the Gryżyna structure. Their thickness is relatively small, not exceeding 30 m.

In the eastern part of the Cybinka-Torzym tender area, there are deposits of a carbonate platform gentle slope (Fig. 2.21). They are represented by laminated limestone and dolomites – mudstones, which in some cases are enriched with clayey and/or bituminous laminae. Despite the low angle, some sediments are also deposited as a result of gravitational transport (Jaworowski and Mikołajewski, 2007).

In general, the thickness of the Main Dolomite slope deposits ranges from a dozen to 60 m. In some cases, its significant thickness up to 200 m is observed.

The central and southern part of the Cybinka-Torzym tender area is located in the westernmost part of the Sudetic-Silesian carbonate platform (Wagner, 1994, 2012). Palaeogeograpy of this platform (Figs 2.21–2.22) is interpreted in different ways, especially if to recognize the extent of the Będowa Bay. According to Wagner (2012), it was much wider and additionally divided by two openings that separated the Gryżyna microplatform (Fig. 2.21). The interpretation of Buniak et al. (2013) is different and shows a wider range of the carbonate platform towards the east and the smaller size of the Będowa bay itself (Fig. 2.22). Despite the above differences, a separate description for the isolated Gryżyna microplatform will not be presented in the following description, and only a common description of facies zones for this part of the basin.

In the Cybinka-Torzym tender area, covering the western part of the Sudetic-Silesian platform, there are two facies zones: the barrier zone and the platform plain. Moreover, two types of barriers can be distinguished: external and internal. The outer edge of the carbonate platform occurs in the central part of the tender area (Figs 2.21–2.22). It extends latitudinal, following the course of the basin plain zone, and is represented by the oncolite-oolite barrier. In the case of the second type of a barrier, the so-called internal shoal, it also consists of the same formations as the outer barrier. It is located in the form of two elevations in the south-western part of the tender area. The outer and inner barrier deposits are similar as they represent an active environment associated with high water energy. These sediments consist of peri- and sub-littoral carbonate sands and microbial facies (Jaworowski and Mikołajewski, 2007), among which carbonate sandstones and carbonate conglomerates may occur, forming grainstones, boundstones, minor packstones and, less frequently, wackstones, floatstones and rudstones. In the Cybinka-Torzym tender area, deposits of the platform's outer edge were documented in the Grzmiąca 3 well (Tab. 2.1).

Behind the zone of the carbonate barrier separating the basin plain from the platform there is a platform plain (Figs 2.21–2.22). In terms of its extent, it is the largest palaeogeographic zone found on the platform area. In addition to a large space, it is also characterized by characteristic microfacies and bathymetric diversity. Despite slight differences in the palaeomorphology of the bottom, even small changes in the shallow water environment affect the changes in sedimentary regimes. Within it, apart from the above-discussed inner carbonate plains, there are also zones of low-energy plains. The low-energy platform plain in the Cybinka-Torzym tender area is located in the western and eastern parts of the carbonate platform (Figs 2.21–2.22). It is located behind the external barriers or internal panels. The deposits of the low-energy platform plain consist mainly of dark grey sublittoral carbonate sandy silts and carbonate silts, also often carbonate silt sands and microbial formations forming wackstones, mudstones, and rarely packstones and boundstones (Jaworowski and Mikołajewski, 2007).

Main Dolomite exploration prospective

The Main Dolomite in the Cybinka-Torzym tender area was explored to varying degrees. The Ca2 top surface is characterized by a strip, parallel slope towards the north. In the south-western part of the tender area, the Ca2 occurs at depth of about 2,000 m (Bytomiec-1, Rybaki 5, Kosarzyn-8 wells; Tab. 2.1). The depth of the Ca2 top in the remaining part of the carbonate platform ranges from 2,000 m to about 2,400 m (Grzmiąca 1 well; Tab. 2.1). The rest of the tender area is characterized by an increasing burial of the Main Dolomite, the highest values of which are reached in the northern part. The depth of the Ca2 top there is over 2,600 m (e.g. Kobosudz 1 well; Tab. 2.1).

The hydrocarbon prospective in the Main Dolomite of the Cybinka-Torzym tender area is evidenced by numerous hydrocarbon fields discovered in the vicinity. Oil and gas accumulations were documented in the south, e.g. Rybaki, Połęcko, Kosarzyn, Kosarzyn N. Their formation was associated with halotectonic processes. To the south-east, the Gryżyna oil and natural gas field was explored. The reservoir rocks are divided into two parts. The lower part consists of shallow lagoon sediments with numerous caverns and fissures, and is characterized by good petrophysical properties. The upper part consists of sediments of the basin plain, devoid of good collector properties.

Individual Ca2 core sections derived from wells located in the tender area were saturated with hydrocarbons. Sampling of Ca2 deposits in some wells resulted in non-industrial oil flows and weak natural gas flows, as well as industrial hydrocarbon flows – in the case of the Kosarzyn-8 well.

The analysis and interpretation of the Cybinka-Torzym 3D seismic survey led to the mapping of new exploration objects. It is suggested that the exploration should be focused to its central and eastern part, where toe-of-slope deposits are expected as prospective.

The Ca2 in the Cybinka-Torzym tender area is overlain by the Basal Anhydrite (A2; Fig. 2.17). The boundary between these lithostratigraphic units is continuous, although there are cases in which there is a sharp, erosive boundary (Wagner, 1994). The A2 deposits consist of laminated and layered anhydrites (Kłapciński, 1991) and are characterized by small thicknesses reaching a maximum of 20 m in the tender area. In the vertical succession of the PZ2 cyclothem, the A2 is replaced by rocks of the Older Halite (Na2; Fig. 2.17). The Na2 is characterized by great diversity. Wells located in the southern part of the tender area usually drill less than 100 m of the Na2 rocks (including the Bytomiec-1 and Radomicko 1 wells). However, as a result of halotectonic activity in the area of Grzmiąca, the Na2 and Na3 constitute a single complex, the thickness of which exceeds 100 m. The northern part of the Cybinka-Torzym tender area is characterized by a radical increase in thickness, reaching up to 600 m (Koziczyn-1 well).

The upper part of the PZ2 cyclothem in the Cybinka-Torzym area is reduced. The Older Potash (K2) is absent. Sedimentation of the PZ2 cyclothem ends with the Screening Anhydrite (A2r; Fig. 2.17). The deposition of this horizon took place in a shallow water environment, and the range coincided with that of the Na2. The thickness of the A2r in the Cybinka-Torzym area is small. Most often it does not even reach 5 m.

The succession representing the whole PZ2 cyclothem in the Cybinka-Torzym area is characterized by a zonal increase in thickness (Fig. 2.23). The highest values occur in its northern part, reaching over 400 m (including the Cybinka 1 and Świebodzin 3 wells). The rest of the tender area have a thickness ranging from 107 m to 171.5 m. Only in the Grzmiąca area, the thickness of the PZ2 cyclothem not exceed 100 m (Fig. 2.23).

PZ3

The sedimentation of the PZ2 cyclothem levelled all the denivelations that occurred during the earlier stages of sedimentation (Wagner, 1994). As a result, another sea transgression entered the area of a flat, shallow basin.

The PZ3 in the tender area starts with the Grey Pelite (T3; Fig. 2.17). It is characterized by a small thickness, in most cases not exceeding 5 m. Then, in the vertical succession, there occurs the Platy Dolomite (Ca3; Fig. 2.17), which due to its very small thickness (less than 1 m) and the type of rocks (anhydrite-dolomite) is included to the Main Anhydrite horizon (A3; Fig. 2.17; Podemski, 1973). The thickness of the A3 (including Ca3) ranges from 11 m (Kłopot 1 well) to 37 m (Bytomiec-1 well). Rocks of the Younger Halite (Na3; Fig. 2.17) are deposited on the A3. If they do not occur in a tectonically disturbed form (diapirs, salt domes), their thickness varies and ranges from 47.0 m to 232.5 m.

The smallest total thickness of the PZ3 cyclothem was found in two wells located in the south-western part of the tender area (Fig. 2.24). They do not exceed the value of 90 m. In the remaining wells, the thickness of the PZ3 cyclothem ranges from 119.5 to 164.0 m. In two wells located in the southern part of the discussed area, the PZ3 cyclothem thickness is over 230 m (e.g. Rybaki 14 well).

PZ4

With the start of the sedimentation of the PZ4, the factors controlling the deposition in the basin changed. The influence of transgressive-regressive cycles decreases, disappearing completely during the subcyclothem PZ4c, in favor of climatic fluctuations (humid and dry periods; Wagner, 1994).

The PZ4a occurs in all Zechstein wells and is represented by the Lower Red Pelite (T4a; Fig. 2.17) and the Youngest Halite (Na4a; Fig. 2.17). On them, only in the Grzmiąca area (Grzmiąca 1 and Grzmiąca 3 wells), there are deposits of the PZ4b subcyclothem, consisting of the Upper Red Pelite (T4b; Fig. 2.17) and the Top Youngest Halite (Na4b2; Fig. 2.17). The Top Terrigenous Series constitutes the topmost part of the Zechstein succession and occurs in all wells (PZt; Fig. 2.17). In the Cybinka-Torzym tender area, the total thickness of the PZ4 cyclothem is 33–75 m (Fig. 2.24).

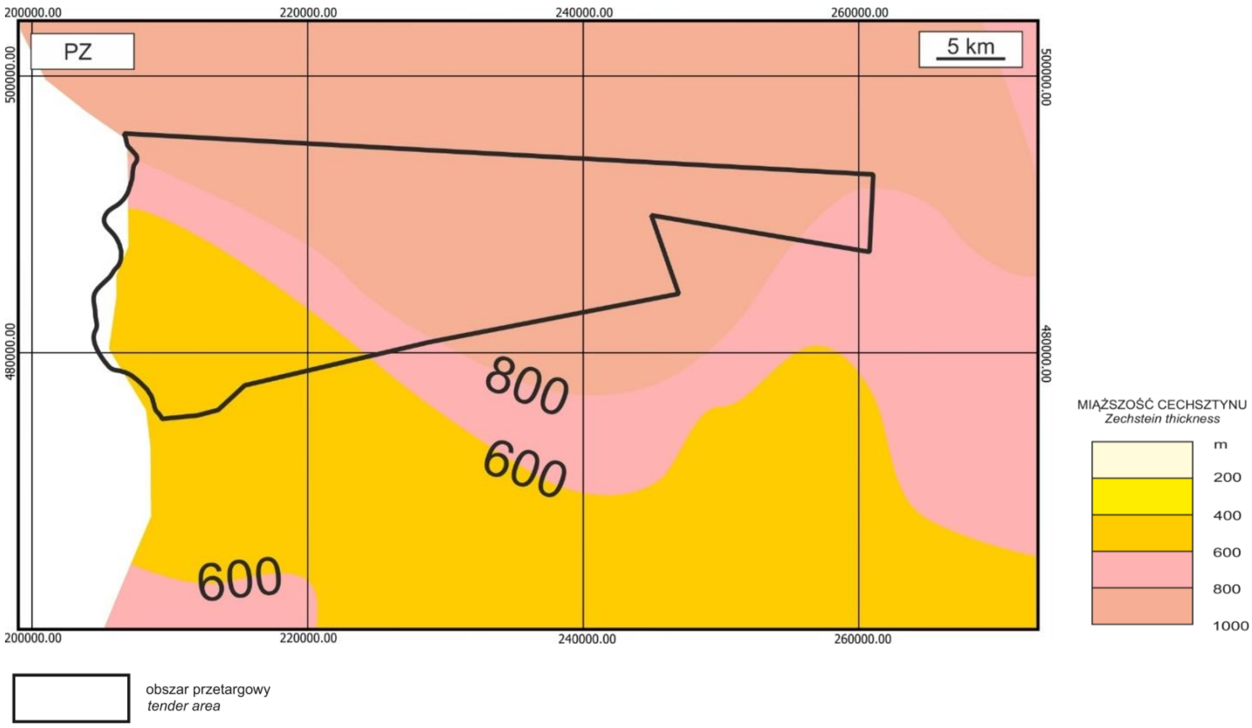


Fig. 2.16. Total Zechstein thickness in the Cybinka-Torzym tender area (Wagner, 1998).

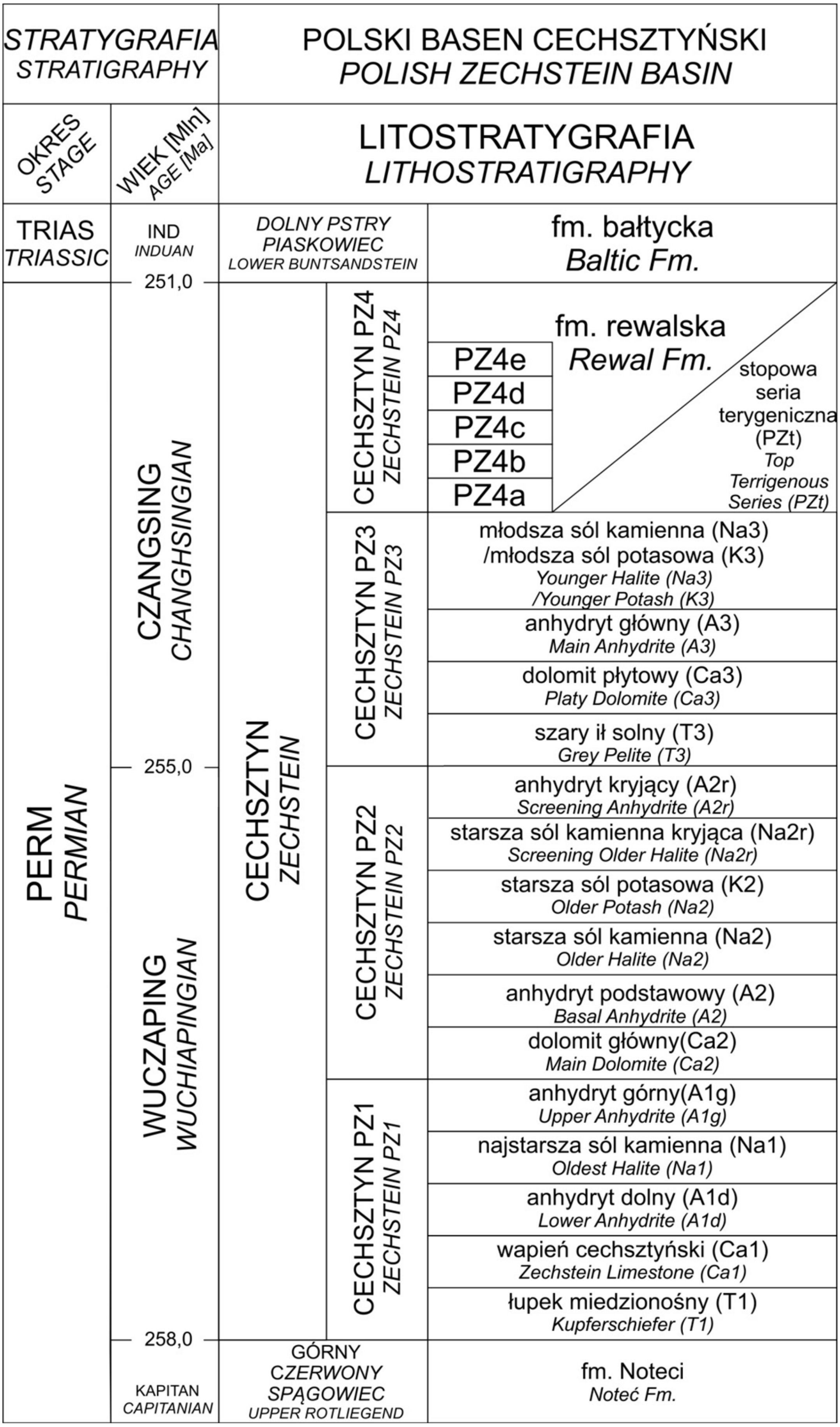


Fig. 2.17. Stratigraphy of the Zechstein in the Polish Zechstein Basin (Wagner and Peryt, 1997).

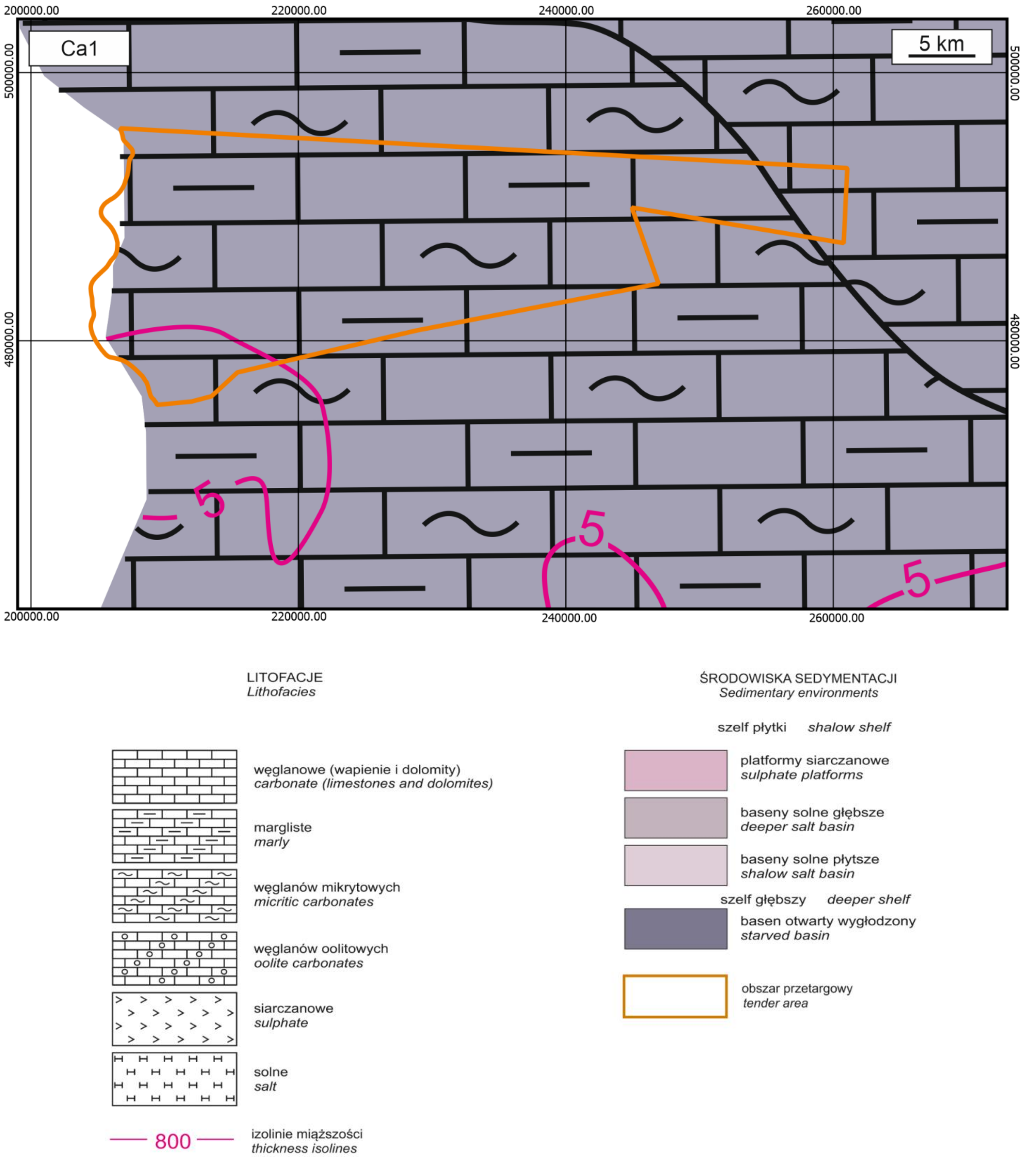


Fig. 2.18. Palaeogeography and thickness of the Zechstein Limestone in the Cybinka-Torzym tender area (Wagner, 1998).

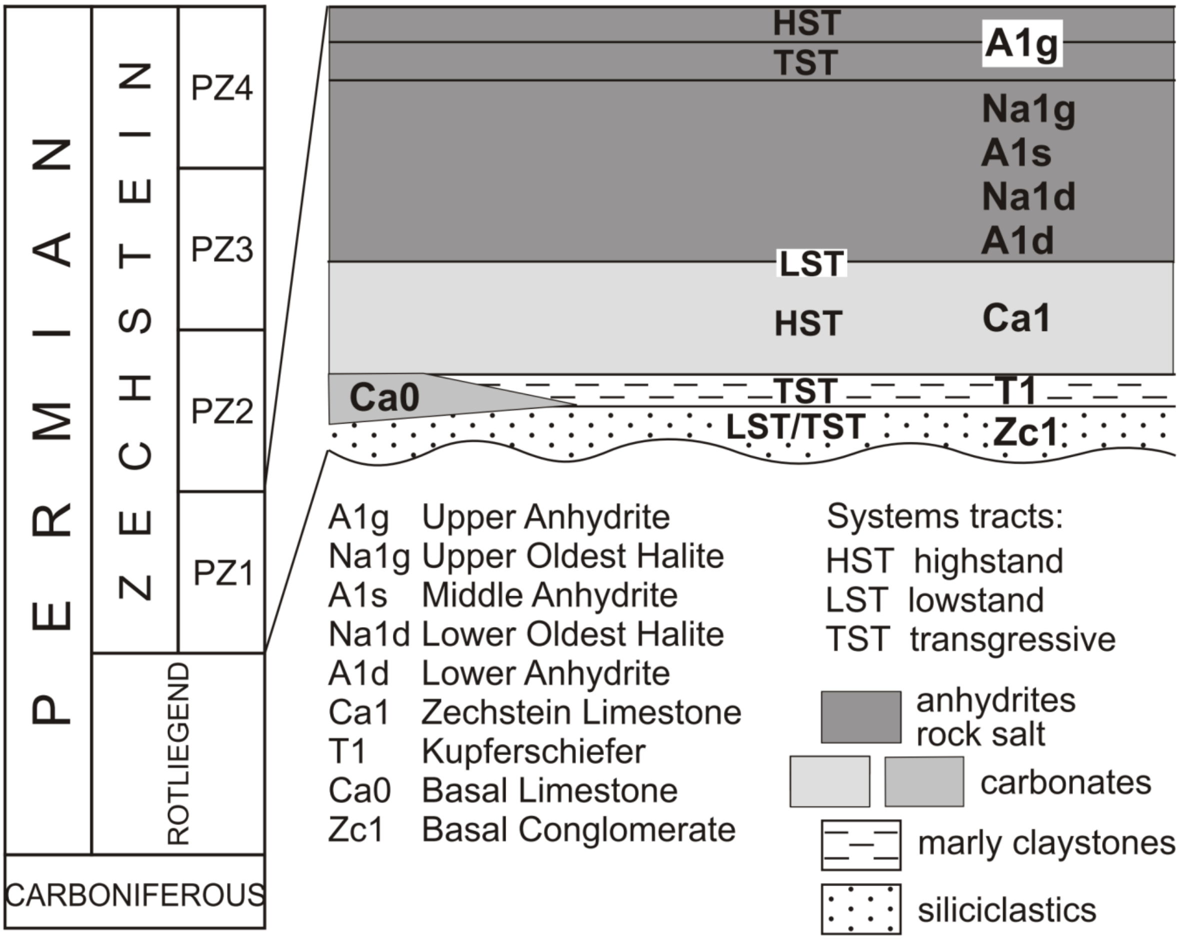


Fig. 2.19. PZ1 stratigraphy in the Branderburg-Wolsztyn-Pogorzela High (Dyjaczyński and Peryt, 2014).

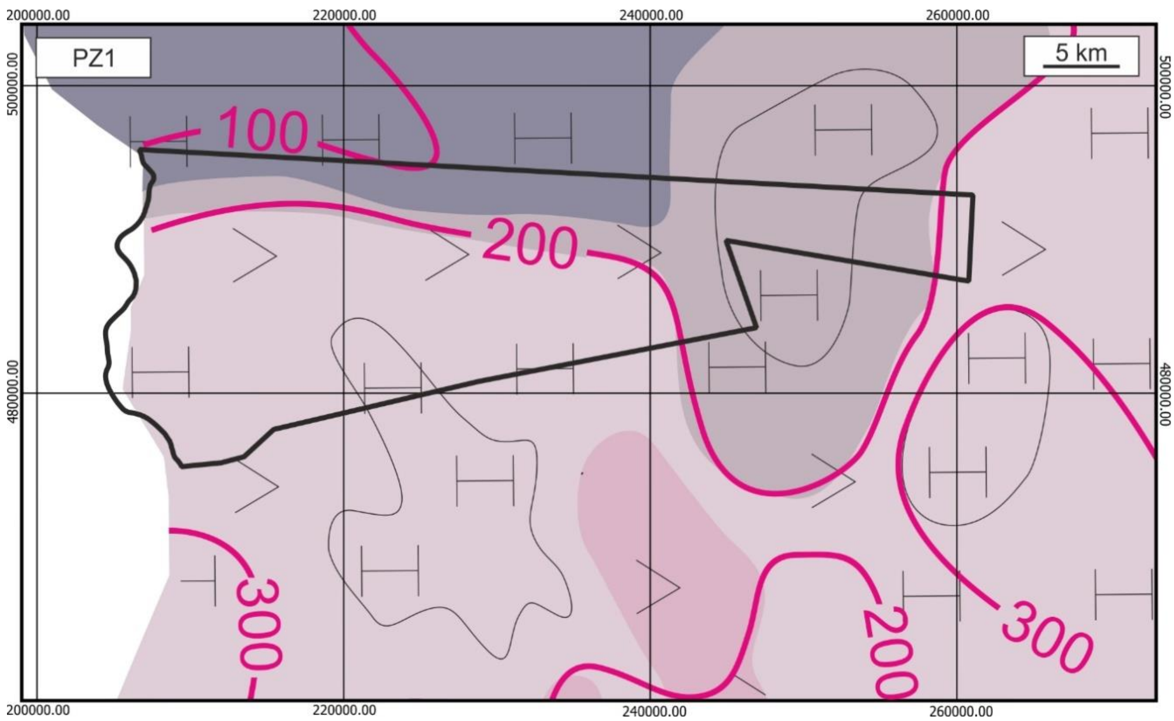


Fig. 2.20. Palaeogeography and thickness of the PZ1 in the Cybinka-Torzym tender area (Wagner, 1998). Abbreviations – see Fig. 2.18.

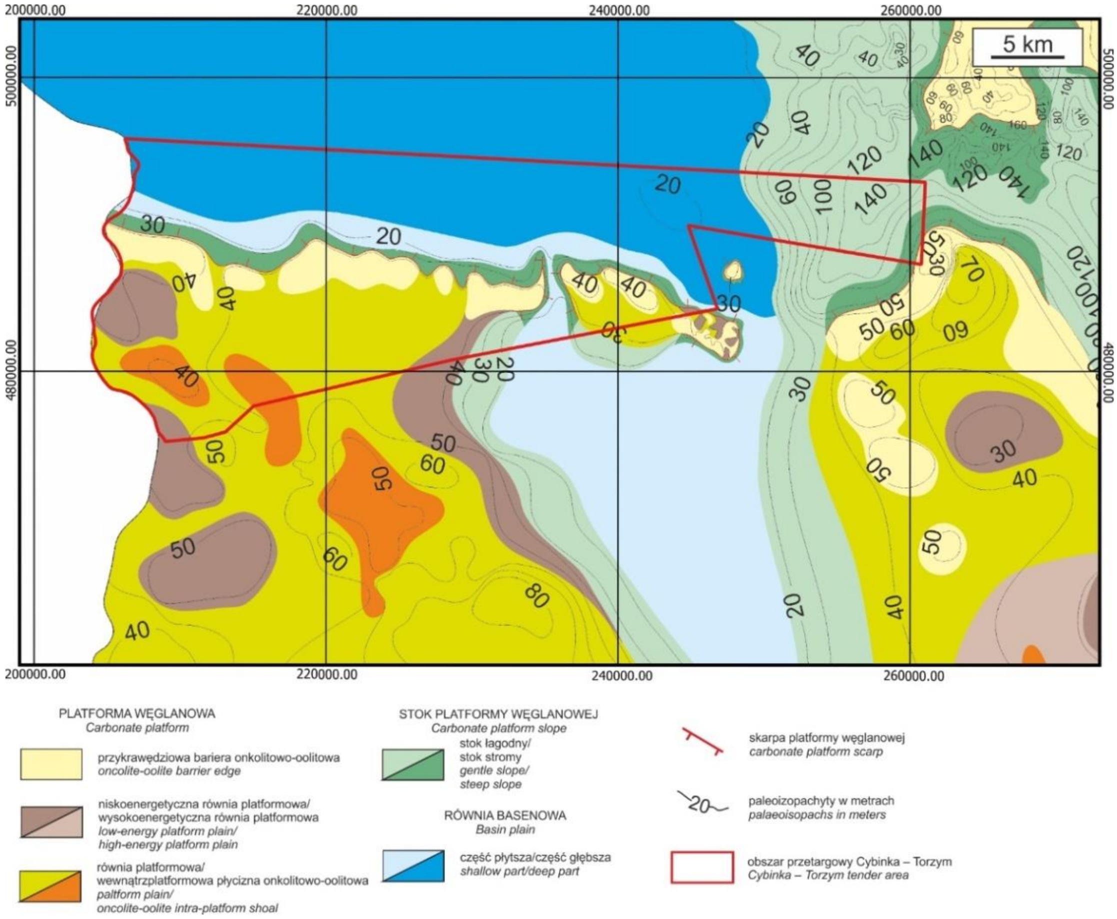


Fig. 2.21. Palaeogeography and thickness of the Main Dolomite in the Cybinka-Torzym tender area (Wagner, 2012).

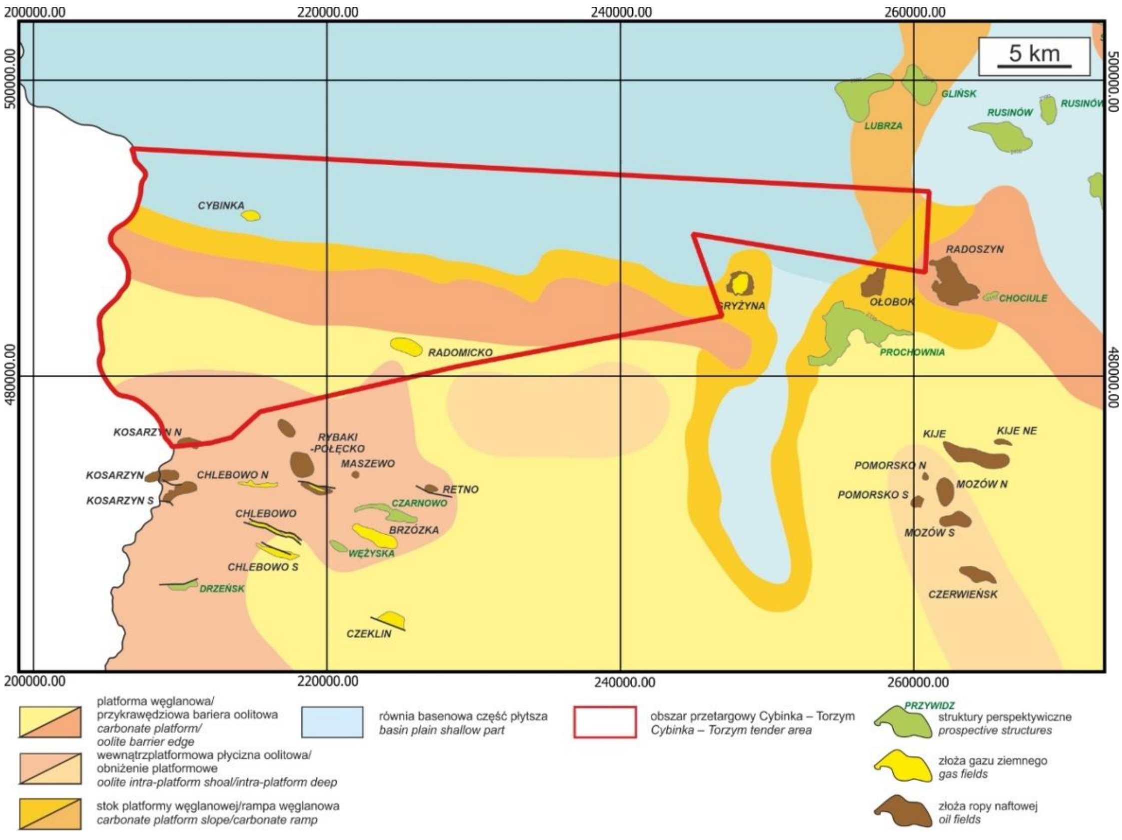


Fig. 2.22. Palaeogeography and thickness of the Main Dolomite in the Cybinka-Torzym tender area (Buniak et al., 2013).

Well name:	Top Ca2 [m]:	Base Ca2 [m]:	Well depth [m]:
Bytomiec-1	1888.5	1928.0	2240.0
Chlebów 1	2089.0	2132.0	2135.0
Cybinka 1	2538.0	2570.0	2586.0
Cybinka 2	2616.0	–	2617.0
Grzmiąca 1	2117.0	2148.0	2155.0
Grzmiąca 2	Data belong to Private Investor		2129.0
Grzmiąca 3	2273.0	2317.0	2634.0
Grzmiąca 5	Data belonged to Private Investor		2020.0
Grzmiąca 7	2049.0	2087.5	2120.0
Kłopot 1	Data belong to Private Investor		2125.0
Kosarzyn-8			
Kosobudz 1	2628.0	2652.5	2974.0
Koziczyn-1	Lack of Ca2		3208.0
Miłów 1	1985.0	2029.5	2401.0
Radomicko 1	Data belong to Private Investor		2138.0
Rąpice 1A			2402.0
Rybaki 14	1980.0	2021.5	2022.6
Rybaki 5	1960.5	–	1988.0
Sosna-1	2336.5	2376.0	2455.0
Świebodzin 3	2632.5	2649.0	2804.0

Tab. 2.1. Wells drilled the Main Dolomite in the Cybinka-Torzym tender area. Blue color indicate the Main Dolomite not pierced.

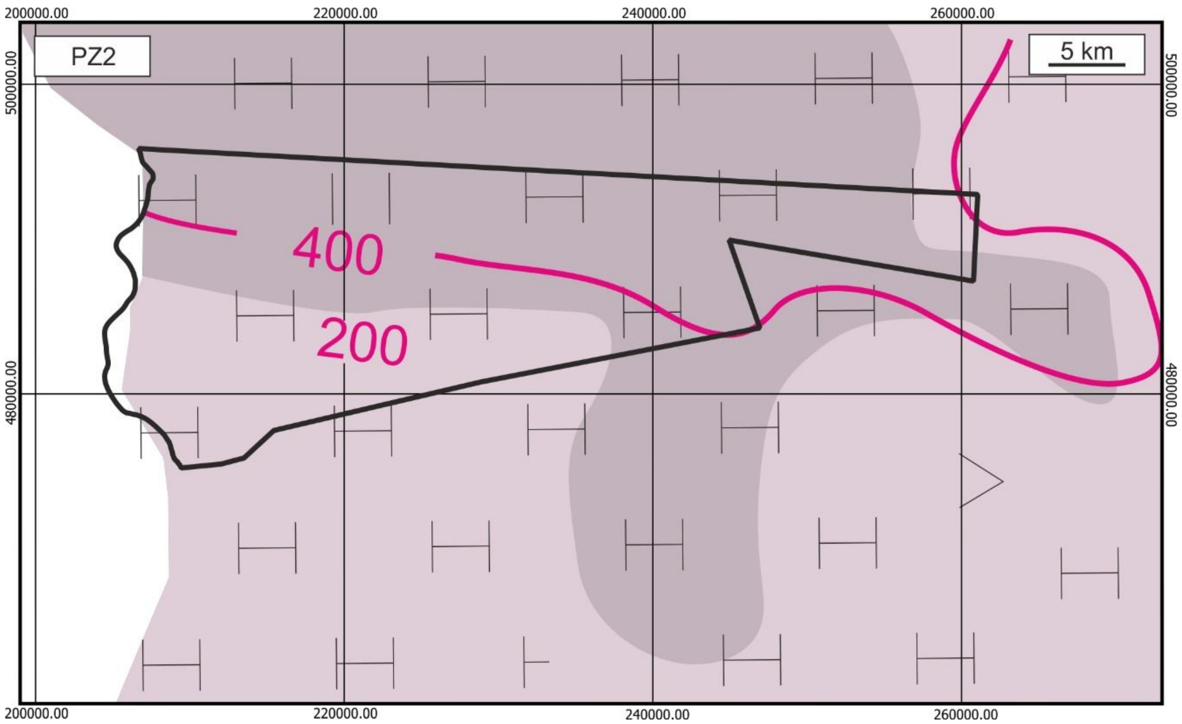


Fig. 2.23. Palaeogeography and thickness of the PZ2 in the Cybinka-Torzym tender area (Wagner, 1998). Abbreviations – see Fig. 2.13.

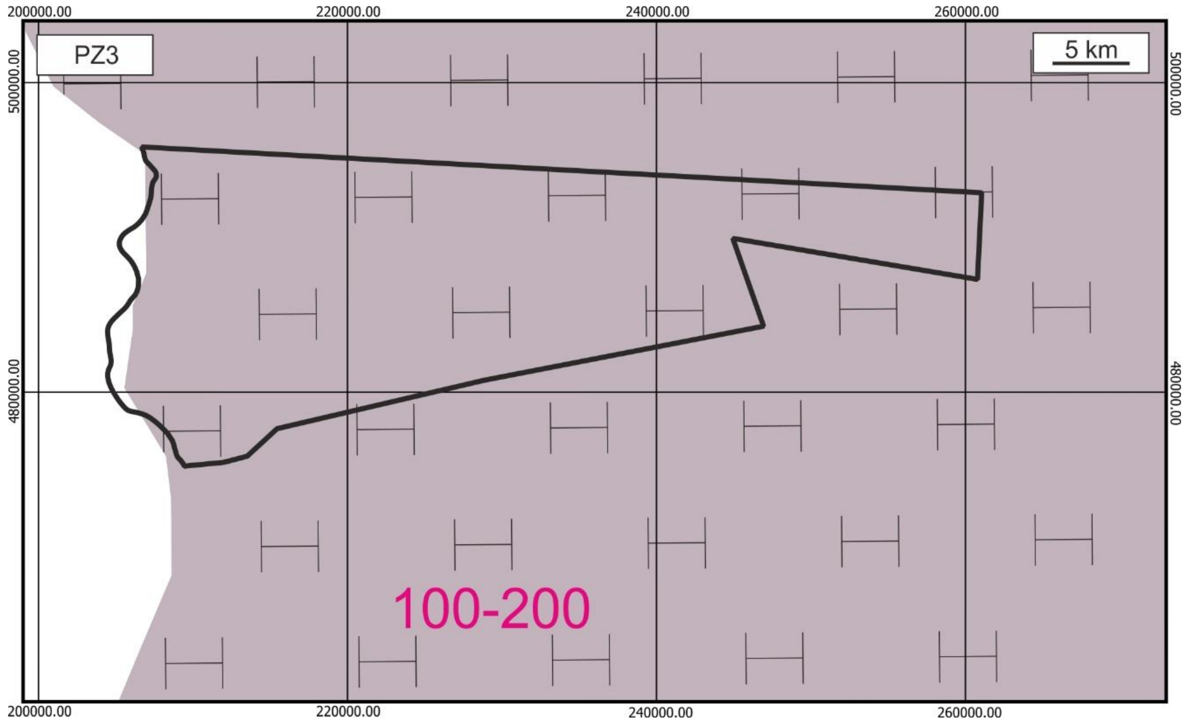


Fig. 2.24. Palaeogeography and thickness of the PZ3 in the Cybinka-Torzym tender area (Wagner, 1998). Abbreviations – see Fig. 2.18.

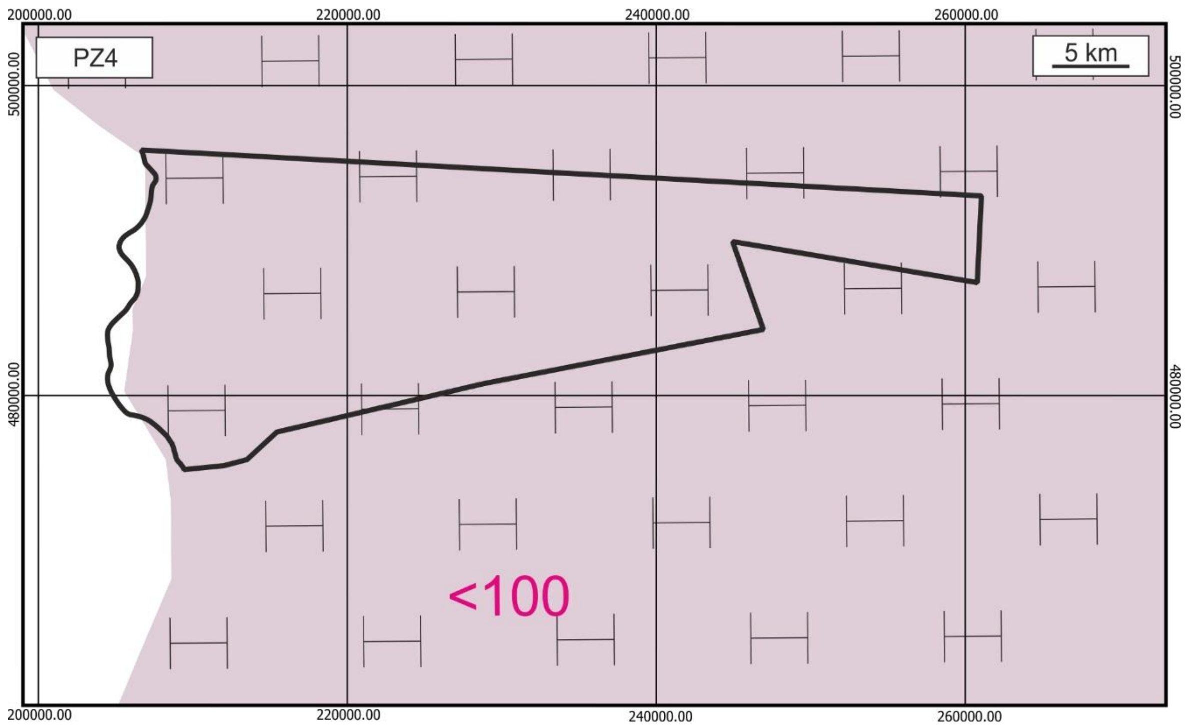


Fig. 2.25. Palaeogeography and thickness of the PZ4 in the Cybinka-Torzym tender area (Wagner, 1998). Abbreviations – see Fig. 2.18.

2.2.4. TRIASSIC

Distribution and thickness

The Triassic deposits in the Cybinka-Torzym tender area occur only in its southern part (Fig. 2.26). Of all the wells located in the discussed area, only one of them did not drill through the Triassic formations – Świebodzin 1. In the remaining ones, the Triassic was drilled in the following intervals:

- Bytomiec-1: 208.0–1597.0 m,
- Chlebów 1: 318.0–1776.5 m,
- Cybinka 1: 541.0–2126.0 m,
- Cybinka 2: 465.0–2000.0 m,
- Grzmiąca 1: 465.0–1866.0 m,
- Grzmiąca 2,
- Grzmiąca 3: 528.0–1989.0 m,
- Grzmiąca 5,
- Grzmiąca 7,
- Kłopot 1,
- Kosarzyn-8,
- Kosobudz 1: 410.0–1930.0 m,
- Koziczyn-1: 482.0–1948.0 m,
- Miłów 1: 245.0–1606.5 m,
- Radomicko 1,
- Rąpice 1A,
- Rybaki 5: 228.0–1633.0 m,
- Rybaki 14: 256.0–1586.0 m,
- Sosna-1: 426.0–2017.0 m,
- Świebodzin 1: 458.0–1503.0 m,
- Świebodzin 2: 408.0–1943.0 m,
- Świebodzin 3: 230.0–1905.0 m.

The thickness of the Triassic in the Cybinka-Torzym tender area exceeds 1000 m.

Lithology and stratigraphy

The Lower Triassic in the tender area begin with a complex dominated by brown-red and less often grey claystones. Among them, there are intercalations of fine-grained sandstones, mudstones and numerous layers and lenses of oolite limestones. This complex represents the Lower Bunter Sandstone (Szyperko-Teller, 1997). Above, the Middle Bunter Sandstone is represented by the clastic-carbonate succession. Depending on the location in the Fore-Sudetic Monocline, the share of these two lithological types will change – the percentage of carbonates in the succession increases towards the north, and the share of clastics towards the south. The Lower Triassic ends with the Upper Bunter Sandstone – Röt (Szyperko-Teller, 1997). It consists mainly of sulphate and carbonate-clay rocks. In addition, in the area of Ośno-Sulechów-Chlebowo, rock salt horizons were observed in the Röt horizon (Gajewska, 1983; Czapowski et al., 1992).

The Middle Triassic, in the great part of its succession, consists of carbonate rocks (limestones and dolomites), among which there are also marls, claystones and anhydrite intercalations (Muschelkalk; Gajewska, 1997a). Only in the highest part there is a clear lithological change. The carbonate succession is replaced by the clastic-carbonate succession. It is represented by gray, red and motley claystones, among which there are intercalations of mudstones, sandstones, limestones, dolomites and marls (Sulechów Beds; Gajewska, 1997b). Charred plant remains often appear among these rocks, forming thin layers of brown coal.

In the lower part of the Upper Triassic there are two thick complexes of red clay-mudstone rocks, of which sulphate-evaporite intercalations appear in the lower part (Lower Gypsum Beds; Gajewska, 1997b), and in the upper part the anhydrite-dolomite-sandstone content is minimal (Upper Gypsum Beds; Gajewska, 1997b). The above-mentioned complexes are separated by a sandstone succession, with very few traces of flora remains, or a clay-mudstone succession, characterized by numerous plant remains (Reed Sandstone; Gajewska, 1997b). Then, in the Upper Triassic succession, there are gray, grey-green, cherry and brown-red claystones. Among these rocks there are intercalations of dolomites, mudstones, dolomitic claystones, nodular claystones, and intercalations of conglomerates in places (Jarkowo Beds, Zbąszynek Beds; Deczkowski, 1997).

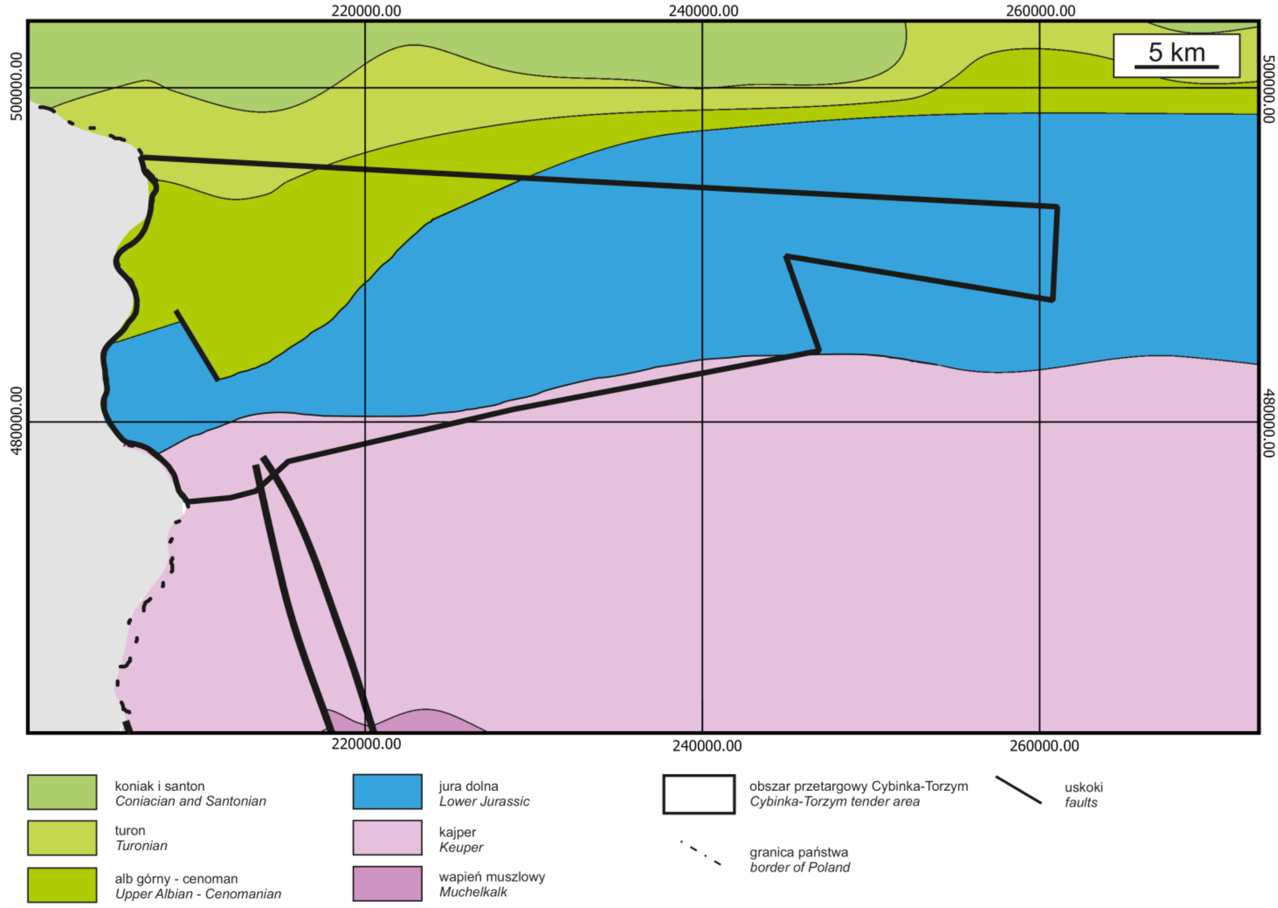


Fig. 2.26. Geological map of the Cybinka-Torzym tender area without Cenozoic deposits (Dadlez et al., 2000).

2.2.5. JURASSIC

Distribution and thickness

Jurassic rocks occur only in the central and northern part of the Cybinka-Torzym tender area (Fig. 2.26). They have been documented in the following wells:

- Chlebów 1: 198.5–318.0 m,
- Cybinka 1: 356.0–541.0 m,
- Cybinka 2: 265.0–465.0 m,
- Grzmiąca 1: 211.5–465.0 m,
- Grzmiąca 2,
- Grzmiąca 3: 232.0–528.0 m,
- Grzmiąca 5,
- Grzmiąca 7,
- Kłopot 1,
- Kosobudz 1: 230.0–410.0 m,
- Koziczyn-1: 232.0–482.0 m,
- Radomicko 1,
- Rąpice 1A,
- Sosna-1: 272.5–426.0 m,
- Świebodzin 1: 255.0–458.0 m,
- Świebodzin 2: 233.0–408.0 m,
- Świebodzin 3: 230.0–396.5 m.

The thickness of the Jurassic ranges from 148 m to 317 m.

Lithology and stratigraphy

In the Cybinka-Torzym tender area, the Jurassic is reduced. Only rocks representing its lower part were recognized (Fig. 2.26). The Lower Jurassic is developed as clastic succession. It consists of grey, fine- and medium-grained, less often coarse-grained sandstones. Horizontal or diagonal lamination is observed. In addition, there are also mostly grey claystones and mudstones. A characteristic feature is the occurrence of siderite concretions. In addition, in some wells (e.g. Koziczyn-1), there are thin brown coal horizons.

2.2.6. CRETACEOUS

Distribution and thickness

The Cretaceous was identified in 5 wells in the north-western part of the tender area:

- Cybinka 1: 272.0–356.0 m,
- Cybinka 2: 200.0–265.0 m,
- Grzmiąca 1: 193.0–211.5 m,
- Grzmiąca 3: 201.0–234.0 m,
- Koziczyn-1: 194.0–232.0 m.

The thickness of the Cretaceous is 18.5 m in the Grzmiąca 1 well to 86.0 m in the Cybinka 1 well.

Lithology and stratigraphy

No lithostratigraphic units were distinguished in the Cretaceous. According to the chronostratigraphic subdivision (Jaskowiak-Schoeneichowa, 1981), the Lower Cretaceous, represented by the Upper Albian, and the Upper Cretaceous, represented by the Cenomanian and Turonian, occur in the area.

The Upper Albian was found in the Cybinka 1 and 2 and Grzmiąca 3 wells. The Cenomanian was found in the same wells. The Turonian was recognized in the Cybinka 1 and 2 wells. In the Koziczyn-1 well, the Cretaceous stages are not separated.

The Upper Albian is subdivided into two parts: the upper part is represented by marls, while the base consists of sandstones with phosphate concretions. In the Cybinka 1 well from the Upper Albian interval a core was taken, in which the occurrence of grey marls containing remains of inoceramians, passing towards the base into various-grained marly sandstones with concretions of phosphorites and glauconite was found. The Cenomanian is composed of limestones, marly limestones and marls. In the Turonian there are limestones and marly limestones. In the Cybinka 1 well, a core was collected from the Turonian, in which light grey laminated marly limestones and grey-green marls were found. There are remains of inoceramian schells in the rock.

The boundaries of the Cretaceous are erosional. The stratigraphic gap covers almost the entire Lower Cretaceous (without the Upper Albian). In the Late Cretaceous, sedimentation in the tender area probably lasted until the Maastrichtian, but at the turn of the Cretaceous and Paleogene, and in the Paleogene, a significant part of the Upper Cretaceous was completely eroded (Jaskowiak-Schoeneichowa, 1981).

2.2.7. CENOZOIC

Distribution and thickness

The Paleogene deposits in the Cybinka-Torzym tender area are represented by the Oligocene (Jeziorski, 1987; Skompski, 1988; Sztromwasser, 2003, 2005; Chmal, 2003; Urbański and Skompski, 2012). Only in the north-eastern part of the tender area, the Eocene-Oligocene was found (Chmal, 2003). The Neogene is mainly represented by the Miocene (Jeziorski, 1987; Skompski, 1988; Sztromwasser, 2003, 2005; Chmal, 2003; Urbański and Skompski, 2012), however, in the north-eastern part of the tender area, the Pliocene-Pleistocene deposits have been documented (Urbański and Skompski, 2012). The thickness and depth of the Palaeogene-Neogene sediments were affected by the morphology of the sub-Cenozoic surface, glacitectonics and the erosive activity of the ice sheets.

Lithology and stratigraphy

The Eocene-Oligocene rocks occur only in the north-eastern part of the tender area. They are represented by grey and grey-green, fine-grained and dusty quartz sands with glauconite. Their average thickness is 6 m (Chmal, 2003). The Oligocene occurs throughout the tender area and probably form a continuous cover. Their deposition took place in marine (early Oligocene) and land (late Oligocene) conditions (Jeziorski, 1987; Skompski, 1988; Sztrom-wasser, 2003, 2005; Chmal, 2003;

Sztrom-wasser, 2005; Urbański and Skompski, 2012).

The Neogene covers the entire tender area. It is represented by fine-grained sands, dusty sands, grey silts and light grey clays and brown coals, and in places also mudstones and claystones. These deposits belong to the Lower, Middle and Upper Miocene. The Lower Miocene deposits cover the entire area, while the Middle and Upper Miocene occur only fragmentarily.

The Pleistocene was deposited during three stages of glaciation. These are sands, gravels, clays, and silts related to the glacial and periglacial accumulations.

The Holocene is associated with accumulation in rivers, lakes, and peats. These are gravels, sands, silts, clays, gyttjas, chalks, , and peats (Jeziorski, 1987; Skompski, 1988; Sztromwasser, 2003, 2005; Chmal, 2003; Urbański and Skompski, 2012).

2.4. HYDROGEOLOGY

The Cybinka-Torzym tender area is located in the Middle Odra water region. It belongs to the groundwater bodies (JCWPd) No. 58 (61% acreage) and No. 68 (39% acreage), and in small proportion No. 59 and No. 76 (0.001% and 0.003% acreage, respectively; Fig. 2.27). The area is drained by the following rivers: Odra, Nysa Łużycka, Konotop, Pliszka, Ołobok Borowianka, Świebodka, Gryżynka, Biela, Lińska Struga and in the west by Luboński Canal. There are also many lakes here: Urad, Głębokie, Leśne, Krzesińskie, Wielkie, Ratno, Trzebisz, Grochoń, Kokno, Dobrosułowskie, Małe, Gryżyńskie, Niesłysz, Ołobockie, Księżno, Lubich, Wilkowskie.

The main aquifers used for water supplies are located in Quaternary and Neogene-Paleogene deposits, which locally may be in direct hydraulic contact. Quaternary deposits are multilayered and occur as: the near-surface water-bearing horizon, the intertill water-bearing horizon (upper and lower), the subtill water-bearing horizon.

The near-surface water-bearing horizon occurs in sand and gravel deposits. The aquifer thickness is from several to 20 meters (locally more than 40 m). The potential discharge of a well varies from 5 to 76 m^3/h. It is commonly exploited in the discussed area and the largest intakes are located in Kłopot, Rąpice, Grzmiąca, Białków.

The intertill water-bearing horizon within there are two intertill aquifers – upper and lower. The upper intertill layer consists of sandy sediments of different grain size (river and fluvioglacial sands and gravels). It is found at a different depth from 2 to 26 m b.g.l. Its thickness reaches from several up to more than 40 m. The potential discharge of a well is from 10 to more than 70 m^3/h. The lower intertill layer occurs in river sediments. Its thickness reaches from several up to more than 40 m. It is intensively exploited in Gęstowice, Trzebiechów and Borów intakes.

The subtill water-bearing horizon occurs in depressions of the sub-Quaternary surface. It is built of sand and sand-gravel deposits. It is found at a depth of about 20 to more than 70 m b.g.l. The thickness of this horizon is about 10–30 m (locally more than 40 m). It is exploited in Tawęcin and Wyczółowo.

Apart from Quaternary water bearing horizons, water is also found in the Oligocene and Miocene sands. They are locally in direct hydraulic contact with Quaternary horizons. They are exploited in Trzebiechów, Bieganów, Sądów. The groundwater hazard degree ranges from high to average (Fig. 2.28).

There are two main documented Quaternary groundwater reservoirs (GZWP) within the Cybinka-Torzym tender area: GZWP No. 144 Dolina Kopalna Wielkopolska reservoir and GZWP No. 148 – Sandr rzeki Pliszka (Fig. 2.27). There are several groundwater intakes located in the discussed area. Within the boundaries of the Cybinka-Torzym tender area there are not protection zones for the groundwater intakes.

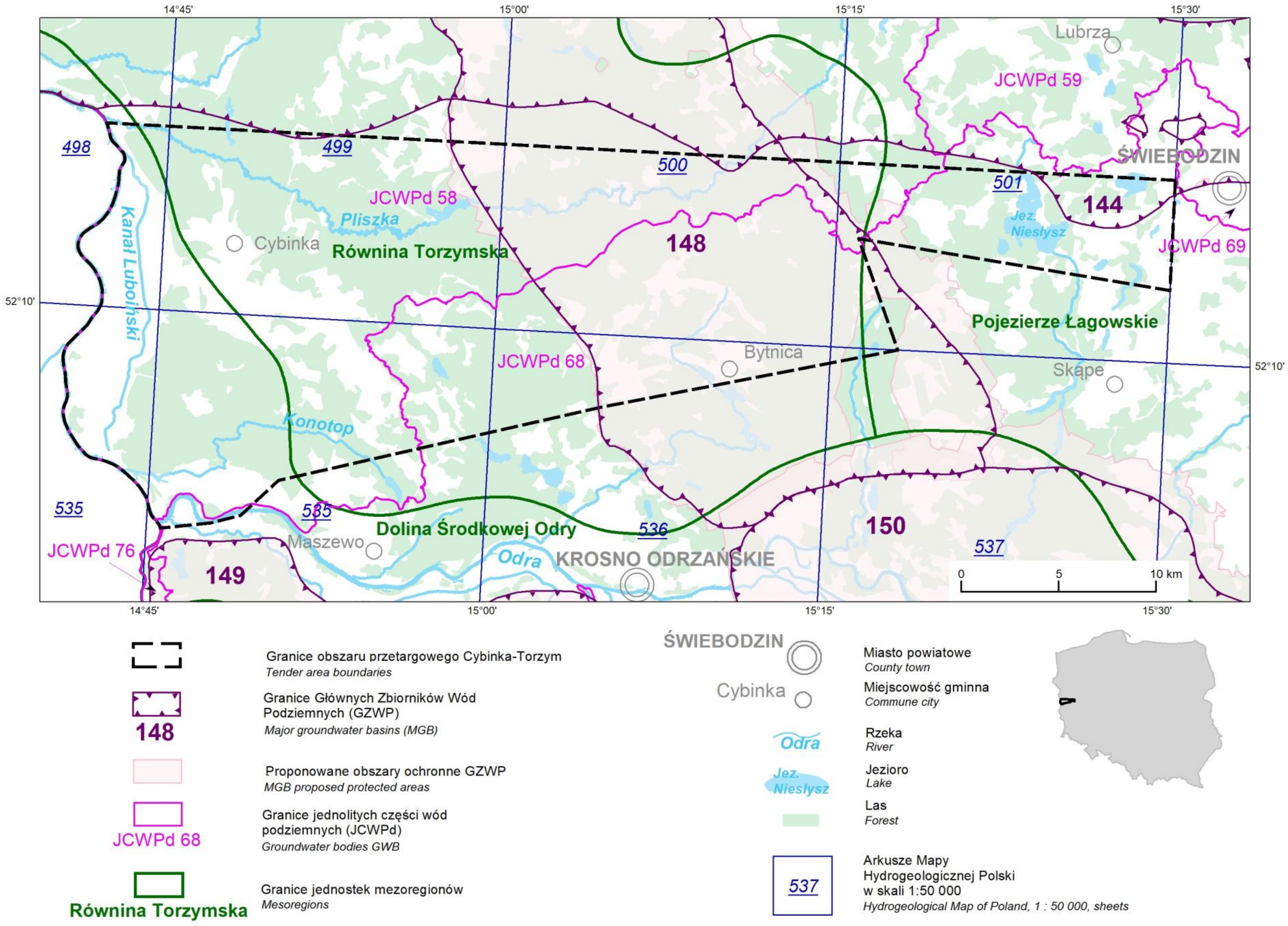


Fig. 2.24. Location of the Cybinka-Torzym tender area in relation to physico-geographic units, Major Groundwater Basins (MGB) and Groundwater Bodies (GBW).

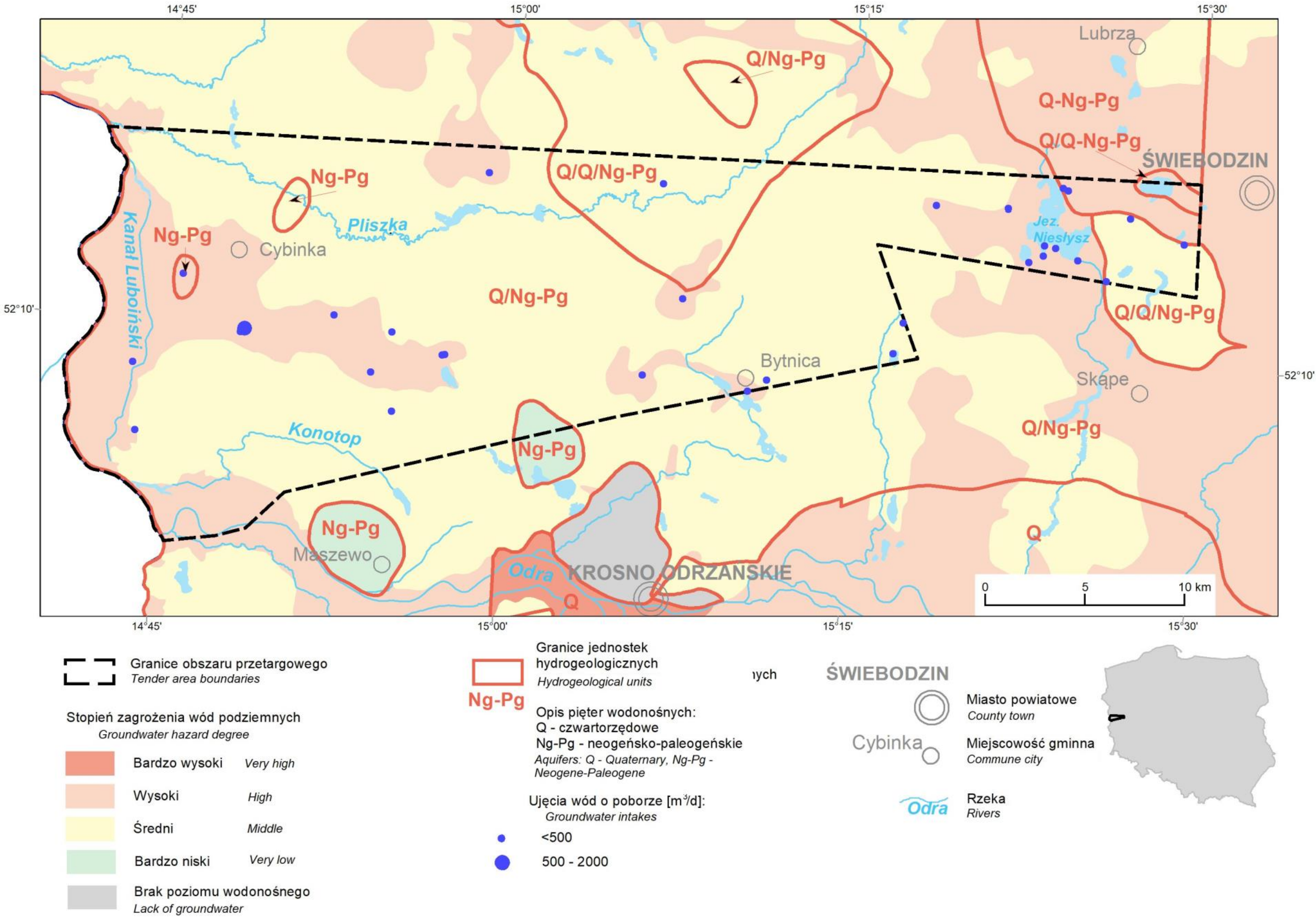


Fig. 2.25. Location of the Cybinka-Torzym tender area in relation to hydrogeological units

3. PETROLEUM PLAY

3.1. GENERAL CHARACTERISTICS

The petroleum play is defined as the set of geological and petroleum processes leading to the formation of a hydrocarbon field. The petroleum play includes source rocks, reservoir rocks, and seal rocks. In addition, an essential element of the petroleum play in conventional accumulations is a trap, which, due to its structural, stratigraphic, lithological and tectonic features, creates a place of accumulation of hydrocarbons. The existence of a petroleum play and the formation of a hydrocarbon reservoir require a set of processes located in space, as well as in geological time, consisting of generation, expulsion, migration and accumulation of hydrocarbons and formation of a reservoir trap. The temporal interrelationships between the mentioned elements and processes of the petroleum play allow the formation of oil and gas fields.

The geology and tectonic of the Cybinka-Torzym tender area, as well as geochemical parameters, and results of petrophysical studies in individual lithostratigraphic units, allow to distinguish one conventional petroleum play, comprising the Zechstein Main Dolomite rocks.

The Zechstein/Main Dolomite petroleum play is a closed hydrodynamic system. This means that the system is completely sealed from the surrounding, and the Main Dolomite (Ca2) act as both the source and reservoir rocks (Fig. 3.1). The source rocks are of microbial and algal origin (Kotarba and Wagner, 2007; Słowakiewicz and Gąsiewicz, 2013; Słowakiewicz et al., 2016). The reservoir rock consists most often of limestones and dolomites represented by grainstones and packstones. Among them, numerous oil and gas shows were noted on drilling cores, as well as numerous hydrocarbon fields were discovered. For example, in the south-western part of the tender area, the Kosarzyn oil field was discovered with the Kosarzyn-8 well, the exploitation of which was temporarily abandoned. The Main Dolomite petroleum play has a double, highly effective seal. From the base and top it is sealed with thick evaporites of the PZ1 and PZ2 cyclothems (Fig. 3.1).

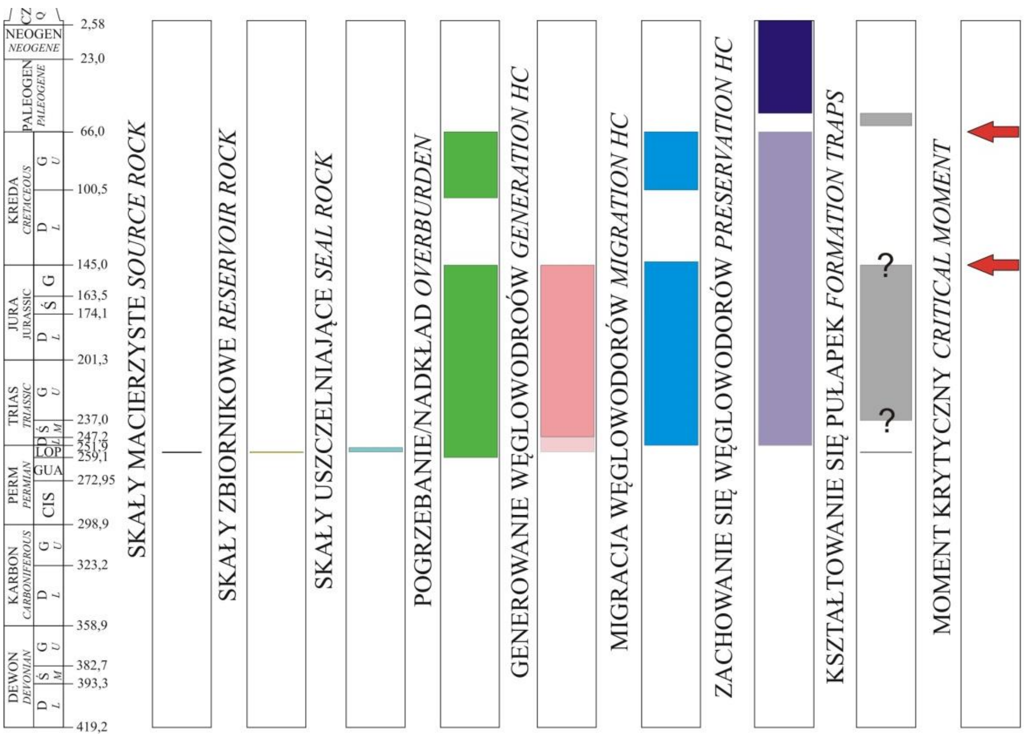


Fig. 3.1. Main Dolomite petroleum play in the Cybinka-Torzym tender area.

3.2. SOURCE ROCKS

Main Dolomite
Dolomites and limestones, mudstones, boundatones, packstones and grainstones

Geochemical studies of the Main Dolomite of the northern part of the Silesian-Sudetic Platform (including the Cybinka-Torzym tender area) were presented in the works of Kosakowski and Wróbel (2010) and Kosakowski and Krajewski (2014). Kosakowski and Wróbel (2010) performed geochemical tests in 39 wells. According to the palaeogeographic map of the Main Dolomite (Wagner, 2012), more than half of these wells are located in the north-western and northern parts of the Silesian-Sudetic Platform. The organic matter consists mainly of macerals of the liptinite group, indicating type II kerogen (Fig. 3.2). Zonal thermal maturity of organic matter is observed, which reflects the palaeogeographic arrangement of the Main Dolomite (Kosakowski and Wróbel, 2010). It is characterized by an increase in the thermal maturity of organic matter from the sediments of the carbonate platform towards the basin plain. The vitrinite reflectance of the northern part of the Silesian-Sudetic Platform ranges from 0.5 to 1.35% Ro (Fig. 3.2), which corresponds to the oil window. The Main Dolomite samples collected for geochemical research from the area of the northern and north-western part of the Silesian-Sudetic Platform confirm that they were active source rocks (Fig. 3.2).

Detailed sedimentological and geochemical studies of the Main Dolomite as the source rock were presented in the work of Kosakowski and Krajewski (2014). The results of the research show the regional microfacies and geochemical characteristics of, among the others, the northern part of the Silesian-Sudetic Platform (Tabs 3.1–3.3), the most extreme, north-western part of which is represented by the Cybinka-Torzym tender area.

Quantitatively, the best parameters of hydrocarbon index (HI) and total organic carbon content (TOC) are found in carbonate platform sediments (Fig. 3.3; Pletsch et al., 2010). However, in the vertical geochemical profile, the Main Dolomite shows greater variation. High contents of TOC and HI seem not to occur in the entire succession, but only in its shallowest buried parts (Fig. 3.3; Kotarba and Wagner, 2007).

In the light of geochemical studies (Kosakowski and Krajewski, 2014), the sediments of the carbonate platform slope have a weak or good hydrocarbon potential (average bitumen content 1430 ppm; Fig. 3.4), carbonate platform sediments – good hydrocarbon potential (average bitumen content 4930 ppm; Fig. 3.4), while the deposits near the edge of the barrier have the highest hydrocarbon potential (average bitumen content 9560 ppm; Fig. 3.4).

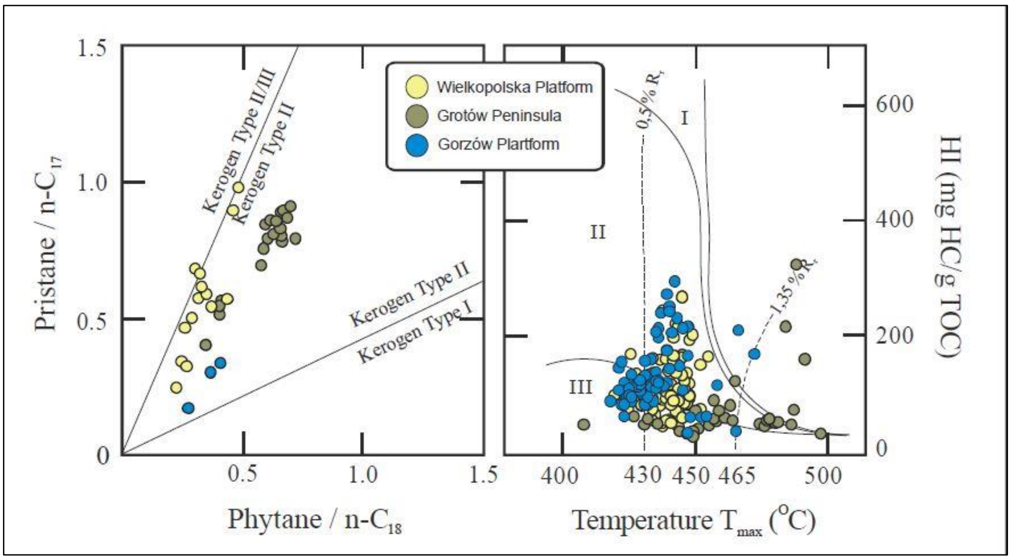


Fig. 3.2. Characteristics of Zechstein Main Dolomite source rocks in SW Poland (Kosakowski and Wróbel, 2010).

Index	II		III		IV		V		VII		IX		XI		XIII	
Total organic carbon	0.01 to 3.36	(183)	0.00 to 3.87	(34)	0.00 to 0.77	(30)	0.04 to 0.11	(10)	0.01 to 0.04	((10)	0.01 to 0.83	(20)	0.01 to 0.77	(7)	0.01 to 0.11	(5)
(TOC) (wt. %)	0.21	(13)	0. 83	(8)	0.19	(7)	0.08	-(2)	0.02	-(1)	0.19	(3)	0.27	(1)	0.03	(1)-
$S_1 + S_2$ (mg HC/g rock)	0.18 to 3.12	(38)	0.08 to 10.71	(8)	0.11 to 0.98	(8)	–		–		0.51 to 2.51	(5)	0.33 to 2.26	(4)	–	
	0.86	(5)	2.01	(4)	0.65	(5)					1.24	(1)	1.25	(1)		
Hydrogen index (HI)	25 to 225	(38)	67 to 166	(8)	56 to 10	(8)	–		–		52 to 170	(5)	90 to 145	(4)	–	
(mg HC/g TOC)	75	(5)	116	(4)	83	(5)					109	(1)	119	(1)		
Oxygen index (OI)	6 to 219	(38)	5 to 180	(8)	8 to 204	(8)	–		–		93 to 604	(5)	69 to 223	(4)	–	
(mg CO_2/g TOC)	103	(5)	74	(4)	113	(2)					280	(1)	159	(1)		
T_{max} (°C)	434 to 510	(31)	435 to 462	(6)	420 to 456	(8)	–		–		433	(1)	433 to 442	(2)	–	
	454	(5)	449	(3)	436	(5)							–	(1)	–	
Production index (PI)	0.30 to 0.89	(38)	0.22 to 0.53	(8)	0.36 to 0.56	(8)	–		–		0.38 to 0.69	(5)	0.33 to 0.87	(4)	–	
	0.50	(5)	0.31	(4)	0.45	(5)					0.58	(1)	0.56	(1)	–	
Bitumens (ppm)	210 to 2800	(19)	190 to 2370	(8)	440 to 1070	(3)	–		–		100 to 5380	(3)	1880	(1)	–	
	1000	(5)	1068	(4)	653	(3)					2303	(1)				
Aromatics HC (%)	13 to 46	(10)	29 and 39	(2)	36		–		–		–				–	
	33	(5)	–	(2)									22			
Saturated HC (%)	10 to 37	(10)	28 and 32	(2)	16		–		–		–				–	
	22	(5)	–	(2)									19			
Resins (%)	3 to 22	(10)	20 and 21	(2)	12		–		–		–				–	
	14	(5)	–	(2)									16			
Asphaltenes (%)	14 to 49	(10)	9 and 22	(2)	36		–		–		–				–	
	31	(5)	–	(2)									43			

TOC – total organic carbon; Tmax – temperature of maximum of S_2 peak; S_2 – residual petroleum potential; S_1 – oil and gas yield (mg HC/g rock); PI – production index; HI – hydrogen index; OI – oxygen index. Range of geochemical parameters is given as numerator; median values in denominator, in parentheses: number of samples from wells (numerator) and number of sampled wells (denominator).

←**Tab. 3.1.** The results of Rock-Eval and bitumens analyses in the Main Dolomite slope and too-of-slope facies (Kosakowski and Krajewski, 2014). TOC – total organic carbon; Tmax – temperature of maximum of S2 peak; S2 – residual petroleum potential; S1 – oil and gas yield (mg HC/g rock); PI – production index; HI – hydrogen index; OI – oxygen index. Range of geochemical parameters is given as numerator; median values in denominator, in parentheses: number of samples from wells (numerator) and number of sampled wells (denominator). II – Microbioclastic-peloid calcisilte, dolopackstone and dolomudstones (allochtonous and autochtonous lower-middle slope and toe-of slope facies); III – Microbreccia, lithoclastic dolopackstone, grainstone, dolofloatstone, dolomudstone (upper-middle steep slope facies slump breccias,debrites, unites of fine grainstone, packstone and lime mudstones); IV – Aminated peloidal dolopackstone, dolobindstone, dolomudstone (low-angle platform slope/ramp with microbial-peloidal mud-mound facies); V – Ooid dolograinstone-packstone (high energy shallow subtidal platform margin bar/back-bar and inner platform oolitic shoal, upper platform slope); VII – Microbial dolobindstone- microframestone, dolopackstone (shallow subtidal margin and inner platform microbial reef facies); IX – Aggregate-grain, lump, algal dolopackstone grainstone, dolobindstone (shallow subtidal open/restricted inner platformwide facies, microbial-algal mounds); X – Bioclastic-peloidal dolowackestone-mudstone (shallow subtidal protected inner platform (restricted lagoon) facies with moderate-low water circulation); XI – Fenestral microbial dolobindstone, dolomudstone, dolopackstone (inner platform tidal flat facies); XII – Pisoid dolorudstone-grainstone (meteorically affected (supratidal) shoal and bar facies); XIII – Lithoclastic dolorudstone-floatstone, dolopackstone (inner platform lag facies in tidal channels and flats); XIV – Poorly laminated micrite, microsparite with evaporitic minerals (salina or evaporitve tidal flats facies).

Index	Facies			
	V		XII/V	
Total organic carbon	0.09 to 1.92	(3)	0.37 to 1.13	(5)
(TOC) (wt. %)	0.83	(1)	0.75	(1)
$S_1 + S_2$ (mg HC/g rock)	4.50 and 9.87	(2)	4.07 to 11.75	(5)
	–	(1)	6.62	(1)
Hydrogen index (HI)	147 and 164	(2)	147 to 207	(5)
(mg HC/g TOC)	–	(1)	156	(1)
Oxygen index (OI)	24 and 94	(2)	24 to 153	(5)
(mg CO_2/g TOC)	–	(1)	156	(1)
T_{max} (°C)	434	(1)	–	
Production index (PI)	0.68 and 0.84	(2)	0.79 to 0.86	(5)
	–	(1)	0.83	(1)
Bitumens (ppm)	12440	(1)	7540 to 12800	(3)
			9560	(1)
Aromatics HC (%)	21	(1)	–	
Saturated HC (%)	45	(1)	–	
Resins (%)	7	(1)	–	
Asphaltenes (%)	27	(1)	–	

Tab. 3.2. The results of Rock-Eval and bitumens analyses in the Main Dolomite marginal platform barrier facies (Kosakowski and Krajewski, 2014). Explanations for geochemical parameters and microfacies – Tab. 3.1.

Index	II		IX		X		XI		XIV	
Total organic carbon (TOC) (wt. %)	0.03 to 2.95 / 0.35	(30) / (3)	0.01 to 1.32 / 0.23	(86) / (7)	0.03 to 1.33 / 0.23	(19) / (3)	0.03 to 0.71 / 0.27	(6) / (4)	0.07 to 0.84 / 0.27	(8) / (1)
$S_1 + S_2$ (mg HC/g rock)	0.58 to 5.16 / 2.32	(13) / (3)	0.23 to 11.8 / 2.32	(30) / (6)	0.52 to 3.20 / 1.62	(5) / (2)	0.22 to 2.21 / 0.74	(4) / (3)	0.28 to 1.90 / 0.70	(5) / (1)
Hydrogen index (HI) (mg HC/g TOC)	70 to 106 / 88	(13) / (3)	70 to 106 / 88	(30) / (6)	60 to 116 / 101	(5) / (2)	63 to 180 / 106	(4) / (3)	72 to 152 / 103	(5) / (1)
Oxygen index (OI) (mg CO_2/g TOC)	17 to 233 / 101	(13) / (3)	69 to 336 / 172	(30) / (6)	16 to 153 / 88	(5) / (2)	45 to 261 / 153	(4) / (3)	43 to 95 / 80	(5) / (1)
T_{max} (°C)	437 to 448 / 445	(7) / (2)	438 to 457 / 445	(11) / (4)	437 to 446 / 442	(4) / (2)	429 to 444 / 434	(3) / (2)	429 to 441 / 437	(5) / (1)
Production index (PI)	0.44 to 0.94 / 0.67	(13) / (3)	0.27 to 0.83 / 0.59	(30) / (6)	0.46 to 0.77 / 0.60	(5) / (2)	0.19 to 0.85 / 0.56	(4) / (2)	0.33 to 0.47 / 0.43	(5) / (1)
Bitumens (ppm)	870 to 5360 / 2500	(11) / (2)	510 to 15760 / 2500	(15) / (5)	1950 to 4440 / 2950	(3) / (2)	660 and 1010 / –	(2) / (2)	660 and 1320 / –	(1) / (1)
Aromatics HC (%)	24 and 29 / –	(2) / (2)	19 to 34 / 26	(8) / (4)	20		20 and 28 / –	(2) / (2)	–	
Saturated HC (%)	39 and 40 / –	(2) / (2)	9 to 69 / 40	(8) / (4)	14		14 and 40 / –	(2) / (2)	–	
Resins (%)	17 and 17 / –	(2) / (2)	7 to 24 / 14	(8) / (4)	17		9 and 29 / –	(2) / (2)	–	
Asphaltenes (%)	14 and 22 / –	(2) / (2)	3 to 56 / 20	(8) / (4)	21		23 and 37 / –	(2) / (2)	–	

TOC – total organic carbon; Tmax – temperature of maximum of S_2 peak; S_2 – residual petroleum potential; S_1 – oil and gas yield (mg HC/g rock); PI – production index; HI – hydrogen index; OI – oxygen index. Range of geochemical parameters is given as numerator; median values in denominator, in parentheses: number of samples from wells (numerator) and number of sampled wells (denominator).

Tab. 3.3. The results of Rock-Eval and bitumens analyses in the Main Dolomite inner platform flat facies (Kosakowski and Krajewski, 2014). Explanations for geochemical parameters and microfacies – Tab. 3.1.

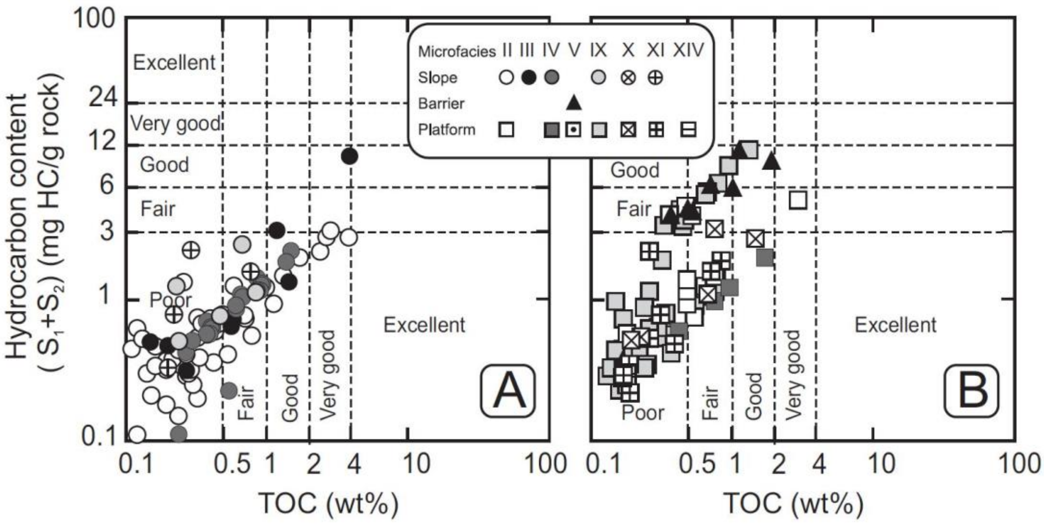


Fig. 3.3. Petroleum source quality diagram for organic matter from Zechstein Main Dolomite in western part of the Wielkopolska Platform (Kosakowski and Krajewski, 2014 and citations therein).

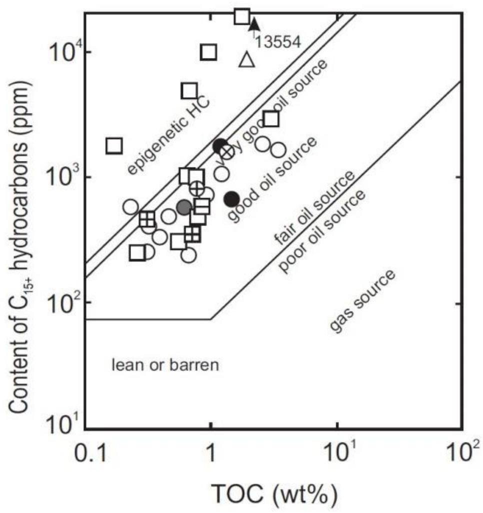


Fig. 3.4. Petroleum source quality diagram for organic matter of Zechstein Main Dolomite in the analysed part of the Wielkopolska Platform (Kosakowski and Krajewski, 2014 and citations therein).

3.3. RESERVOIR ROCKS

Main Dolomite
Dolomites and limestones,
grainstones and packstones

Thickness: in the northern part up to 30 m; in the south-western part 20–50 m; in the south-eastern part from a few to 40 m; in the north-eastern part from 20 to over 140 m.
Top surface depth:

- <2000 m in the area of Kosarzyn-Grzmiąca-Rybaki (south-western part of the area),
- >2500 m – Cybinka 1 (northern part of the area),
- ~2000–2500 m in the Radomicko-Sosna-Świebodzin area (south-eastern and southern parts of the area).

The Main Dolomite deposits in the Cybinka-Torzym tender area are very diverse in terms of microfacies. They underwent almost complete early dolomitisation (Peryt, 1978). The southern part of the area is located on the carbonate platform and its slopes, where there are grainstones, packstones, boundstones and mudstones/wackstones several dozen meters thick (Wagner, 2012). In the northern part of the area, there are mudstones of small thickness deposited in the deeper environment of the basin plain (Wagner, 2012). The mentioned deposits were characterized by completely different reservoir properties. Platform deposits, at least locally, could be characterized by good porosity and permeability, which are, however, deteriorated during diagenesis mainly as a result of cementation of the pore space and chemical compaction. Basin sediments from the beginning were characterized by poor reservoir properties.

In the Cybinka-Torzym tender area, the following diagenetic processes have been documented, which affected the petrophysical properties of the rocks: dolomitisation, calcitization (dedolomitisation), anhydritization, early- and late-diagenetic cementation (dolomite, calcite, anhydrite, halite), recrystallization, dissolution (e.g. early aragonite cement, parts of skeletons of organisms/bioclasts), compaction, stylolitization (Peryt, 1978). Diagenetic processes had various, usually destructive effects on reservoir properties. Only dolomitisation could theoretically contribute to the increase of intergranular microporosity, and dissolution processes to the development of macroporosity. Fracturing is also often observed in Ca2 samples/cores, which, unless the fractures are re-filled with cements, has a very large impact on porosity and permeability. Other diagenetic phenomena (in particular, cementation and dissolution under pressure/stylolitization) led to a reduction in porosity and permeability.

Semyrka et al. (2015) analysed porosity and permeability of Ca2 sediments of the Grotów Platform, the northern part of the Wielkopolska Platform and the eastern part of the Gorzów Platform, which are located north of the tender area. They distinguished three basic microfacies there: grain-compacted (packstones, grainstones, floatstones and rudstones), mud-compacted (mudstones and wackstones) and microbial (boundstones – microbial mats; Tab. 3.4). The separated microfacies are characterized not only by different lithological composition, but also by different petrophysical parameters. Based on the statistical analysis, the petrophysical parameters of the three microfacies mentioned above were compared and it was found that compacted grain sediments are characterized by the best reservoir properties (Tab. 3.4). High average effective porosity and high average dynamic porosity for gas and oil were found for these deposits. They are also characterized by high permeability. The values of Ca2 reservoir parameters measured on cores from wells located in the tender area are presented in Tab. 3.2. The porosity in individual samples is very low and ranges from 0 to about 3% and in a few cases to almost 6% (data from 9 wells; Table 3.5). The permeability is also very low – usually close to zero, up to 2–3 mD in two wells and more than 18 mD in one well (Kosobudz 1; Tab. 3.5).

In the Cybinka-Torzym area, in all wells in which Ca2 was cored, there are spot traces of hydrocarbons (mostly crude oil; Tab. 3.6). Some of the exploration wells did not receive a flow of fluids during the tests (Tab. 3.6).

This does not mean that all wells in the Cybinka-Torzym area had negative reservoir results. Brine, gasified brine, as well as non-industrial natural gas with 30% hydrocarbon content inflows were noted (Tab. 3.6). In addition, in the Kosarzyn-8 well, an industrial crude oil flow was obtained in the tender area (Tab. 3.6), documenting the Kosarzyn N deposit.

	Boundstones	Packstones	Grainstones
Skeletal density [g/cm^3]	2.79	2.75	2.76
Volume density [g/cm^3]	2.47	2.51	2.37
Effective porosity [%]	12.09	8.92	14.16
Capillar diameter [µm]	0.49	0.82	1.65
Specific surface [m^2/g]	0.62	0.64	0.49
Threshold diameter [µm]	9.67	6.08	9.43
Dynamic porosity dor oil [%]	5.79	5.67	8.45
Dynamic porosity for gas [%]	10.80	7.92	13.64

Tab. 3.4. Results of porosimetric measurements of the Main Dolomite microfacies (based on Semyrka, 2013 from Waśkiewicz and Kiersnowski, 2020) from the area of the Grotów Peninsula, the northern part of the Wielkopolska Platform and the eastern part of the Gorzów Platform, which may constitute analogous for the Cybinka-Torzym tender area.

Well name:	Depth [m] (samples)	Permeability [mD] (average)	Porosity [%] (average)	Bitumins [%] (average)
Bytomiec 1	1894.9–1898.3 (33)	0.0189–0.1599 (0.059)	0.08–2.91 (0.79)	0.0118–0.1185 (0.0338)
Chlebów 1	2092.5–2135.0 (34)	0.0434–0.4676 (0.1688)	0.18–5.72 (1.11)	0.0133–0.147 (0.0379)
Cybinka 1	2539.7–2569.6 (10)	0.035–0.083	0.11–0.57	Ślady–0.063
Grzmiąca 1	2117.8–2152.0 (24)	<0.01–0.2356 (0.0921)	0.23–3.3 (1.17)	0.018–0.1975 (0.0486)
Grzmiąca 3	2274.8–2316.3 (44)	0.0255–0.3364 (0.1021)	0.15–2.57 (0.6723)	0.015–0.2113 (0.0696)
Kosobudz 1	2631.0–26532 (4)	0.72–18.034	0.41–1.04	0.0205–0.1625
Rybaki 5	1960.5–1988.0 (10)	0	0.8–2.41	0.0270–0.1165
Rybaki 14	1980.0–2021.5 (11)	0.107–0.938	0.28–4.88	0.0225–0.1790
Świebodzin 3	2631.0–2649.0 (10)	0.22–2.527	0.54–2.28	0.033–0.3325

Tab. 3.5. Reservoir properties of the Main Dolomite in the Cybinka-Torzym tender area – data from final geological well reports.

Well name:	HC shows (core):	Tested intervals [m]:	Results:	Content: Brine [g/l] Gas [%]
Bytomiec-1	+	1884.5–1909.0	no inflow	–
		1903.0–1937.5	no inflow	
Chlebów 1	+	2087.0–2118.0	no inflow	–
		2095.0–2135.0	no inflow	
Cybinka 1	+	–	-	–
Grzmiąca 1	+	2114.5–2135.0	no inflow	–
		2120.9–2155.0	no inflow	
Grzmiąca 3	+	2276.0–2304.1	no inflow	–
Kosobudz 1	+	2655.0–2655.0	brine inflow	Cl: 176.5908 SiO_3: 0.2481

				HCO_3: 0.2440 SO_4^{3-}: 2.4651 Fe^{+++}: 1.6477 Ca^{++}: 55.9688 Mg^{++}: 13.1882 Na^{++}: 24.7416
Rybaki 5	+	1961.0–1988.0	after acidification production of 49.4 thous. l of brine and 10 l of oil	Cl: 251.5114 SiO_3: 0.0810 HCO_3: 1.8422 SO_4^{3-}: 0.3374 Fe^{+++}: 0.1553 Ca^{++}: 3.3337 Mg^{++}: 2.7338 Na^{++}: 154.7606
Rybaki 14	+	1980.0–2021.5	inflow 100 l/h brine	Cl: 252.4752 SiO_3: 0.8357 HCO_3: 2.1472 SO_4^{3-}: 3.2101 Fe^{+++}: 2.2493 Ca^{++}: 18.8476 Mg^{++}: 21.0672 Na^{++}: 102.3366
Świebodzin 3	+	–	–	–

Tab. 3.6. Hydrocarbons shows and test results in the Main Dolomite in wells from the Cybinka-Torzym tender area – data from final geological well reports. *HC shows found in A2. **Main Dolomite was not tested; the results come from production test. ***average gas content from production test (MIDAS, 2022).

3.4. SEAL ROCKS

The Main Dolomite is sealed from the base and top by the evaporite succession of the PZ1 and PZ2 cyclothems, respectively (Fig. 3.1). An effective top seal is formed by the A2 and Na2 horizons, which in the Cybinka-Torzym tender area have a total thickness from 50 m to 519 m (Grzmiąca 1 and Świebodzin 3 wells, respectively). The overlying rocks constitute the overburden, which consists of PZ3 and PZ4 cyclothems, as well as Triassic, Jurassic, Cretaceous and Cenozoic sediments (Fig. 3.1). Its total thickness is 1787.0–2357.0 m (Bytomiec 1 and Cybinka 1 wells, respectively).

3.5. GENERATION, MIGRATION, ACCUMULATION AND TRAPPING

Main Dolomite

Source rocks: mudstones, boundstones, packstones and grainstones.
Reservoir rocks: dolomitized grainstones and packstones.
Seal rocks: PZ1 and PZ2 evaporites.
Overburden: PZ3 and PZ4 cyclothems, Triassic, Jurassic, Cretaceous. They have a total thickness 1787.0–2357.0 m.
Shape and size of the traps: small traps and medium-sized structural or structural-stratigraphic types.
Age and mechanism of trap formation: Primary synsedimentary traps (Kotarba et al., 2000) associated with the platform edges and its toe-of-slope deposits, as well as basin Ca2 elevations (shallow water carbonate granular facies). The second type is associated with later halotectonic processes (A1g, Ca2 and A2 uplifts).
Age and mechanism of generation, expulsion, migration and accumulation of hydrocarbons: The first stage of hydrocarbon generation in the Main Dolomite began during the Late Permian (Fig. 3.1). At this

stage, an autochthonous methane was generated as an effect of the microbial activity of bacteria transforming the organic matter (Kotarba et al., 2000). The main stage of hydrocarbon generation in the Cybinka-Torzym tender area should be associated with the entrance of the Main Dolomite rocks into the oil window. According to Dadlez et al. (1995), the heat flux was the highest in the Late Permian and Early Triassic, and cooled in the Mesozoic until it reached a temperature close to modern at the end of the Cretaceous. Increased subsidence, started in the Permian, and continued in the Early, Middle and Late Triassic (Fig. 3.1; Fig. 3.5). As a result, the Main Dolomite basin plain deposits, which were buried to a depth of more than 1,500 m, were heated with a temperature exceeding 80°C, entering the initial stage of the oil window (Kosakowski and Wróbel, 2010). The greatest burial of the Main Dolomite rocks occurred in the Late Jurassic (Fig. 3.5). This period also coincides with the main stage of hydrocarbon generation (Fig. 3.1). Due to the high thermal flux, the generation potential of rocks of the basin plain had already been exhausted in the Late Triassic, and in the case of the carbonate platform facies – in the Middle Jurassic (Pletsch et al., 2010). The hydrocarbon expulsion began in the Early Triassic and lasted until the end of the Late Jurassic and the beginning of the Early Cretaceous, when it was interrupted by the Cimmerian tectonic movements (Fig. 3.1). Kosakowski and Wróbel (2010) showed that the migration process started and lasted at a similar time as the generation process. In the Cybinka-Torzym tender area, the migration of hydrocarbons took place already in the early Triassic, continued in the Late Jurassic, and finished in the Late Cretaceous (Fig. 3.1). According to Kotarba and Wagner (2007), the hydrocarbon generation process was taking place in two paths. In the first case, the generation was a one-stage process. It was associated with a continuous and progressive phase of transformation of organic matter, whose hydrocarbon potential was exhausted at the end of the Triassic. The second path is characterized by two stages of hydrocarbon generation. The first, during which 80 to 90% of the hydrocarbon mass was generated from kerogen, lasted until the end of the Late Jurassic. For the remaining part of the hydrocarbon mass, generation took place already in the post-Cretaceous period. As a consequence, the accumulation of oil in the traps took place at the turn of the Triassic and Jurassic periods, the saturation of oil deposits with gas took place at the end of the Late Jurassic, and the final generation of gas took place in the Paleogene and Neogene. Geological and geochemical studies indicate that the migration of hydrocarbons from the source rock to the reservoir rock took place within a range of only a dozen or so kilometeres (Kotarba and Wagner, 2007).

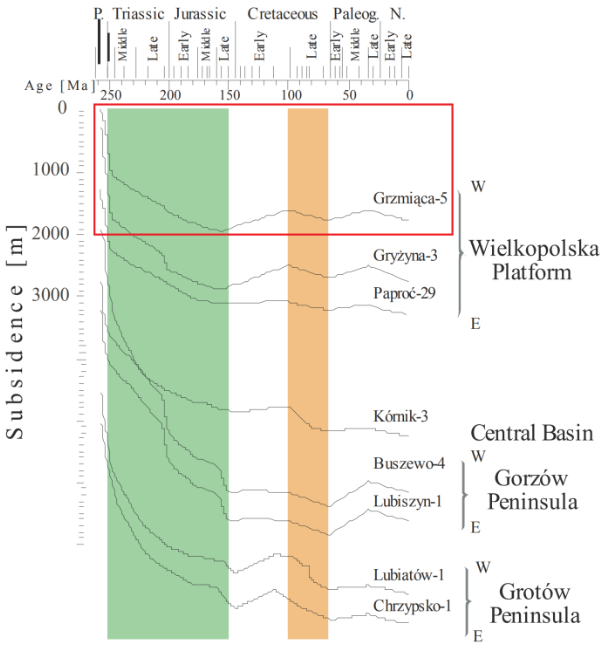


Fig. 3.5. Total subsidence curves of bottom of Zechstein Main Dolomite and transformation of kerogen for the investigated wells, and amount of hydrocarbons generated/expelled in Lubiatów-1 well (Kosakowski and Wróbel, 2010). The red dashed line shows the approximate extent of the Main Dolomite in the Cybinka-Torzym tender area.

4. HYDROCARBON FIELDS

Within the Cbinka-Torzym tender area there is one oil field documented in the Main Dolomite (Fig. 4.1):

- Kosarzyn N crude oil field
  (NR 7110; Figs 4.2–4.4);

Seven hydrocarbon fields have been documented within the close neighborhood of tender area (Fig. 4.1). These are:

- Radoszyn oil field
  (NR 7112; Figs 4.5–4.7),
- Ołobok oil field
  (NR 11991; Figs 4.8–4.10),
- Gryżyna oil field
  (NR 7408; Fig. 4.11),
- Rybaki oil field
  (NR 4806; Figs 4.12–4.14),
- Breslack-Kosarzyn oil field
  (NR 5498),
- Kosarzyn E oil field
  (NR 5987),
- Kosarzyn-S oil field
  (NR 5508),

Moreover, at a slightly greater distance there are also (Fig. 4.1):

- Połęcko oil field
  (NR 19512),
- Retno oil field
  (NR 6920),
- Chałupczyn oil field
  (NR 20693).

All of the above mentioned fields are documented in the Main Dolomite horizon. To characterize the tender area, the first five were selected and described as the closest ones and potential analogues for further exploration in the Cybinka-Torzym tender area. Information about the remaining fields will be available to interested parties upon request in the DATA ROOM in the National Geological Archive during the 6th round for hydrocarbon concessions in Poland.

→ **Fig. 4.1.** Hydrocarbon fields within and in the neighborhood of the Cybinka-Torzym tender area.

Obszary wytypowane do postępowania przetargowego na koncesje na poszukiwanie i rozpoznawanie złóż węglowodorów oraz wydobywanie węglowodorów ze złóż (VI runda przetargowa)

Areas selected to the tender procedure for concessions for hydrocarbons fields prospection and exploration and for hydrocarbons production from fields (6th tender round)

Cybinka-Torzym

0 2,5 5 10 km

Układ współrzędnych / *Coordinate system: PL-1992*

Objaśnienia / *Legend*

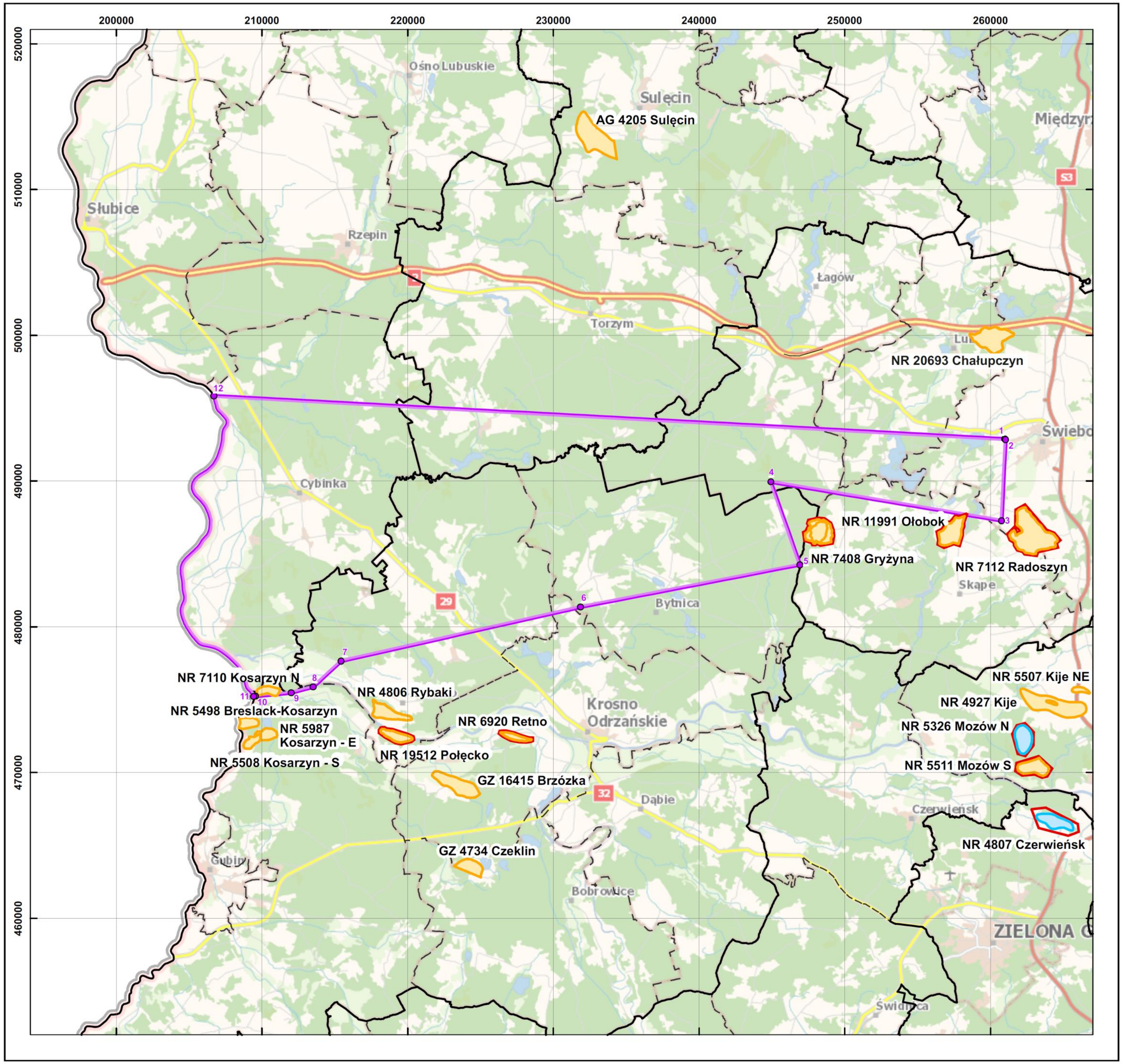
- obszary wytypowane do przetargu / *areas selected to the tender procedure*
- złoża węglowodorów / *hydrocarbon fields*
- złoża węglowodorów skreślone z bilansu zasobów / *Hydrocarbon fields crossed out from the balance of mineral resources deposits in Poland*
- obszary górnicze wyznaczone dla złóż węglowodorów / mining areas assigned for hydrocarbon fields
- granice gmin / *commune border*
- granice powiatów / *county border*

Współrzędne punktów wyznaczających granice obszaru przetargowego, ukł. wsp. PL-1992
Coordinates determining the borders of tender area, coordinate system PL-1992

Nr punktu / Point No	X	Y
1	492887,97	260981,45
2	492844,21	261045,53
3	487287,05	260776,88
4	489935,10	244937,94
5	484261,45	246929,48
6	481351,42	231859,04
7	477639,79	215436,67
8	475861,85	213502,89
9	475467,68	212006,81
10	475232,69	209573,34
11	475217,79	209419,08
między punktami 11 i 12 po granicy państwa / between points 11 and 12 on the border of the country		
12	495843,73	206676,28

Udokumentowane złoża kopalin, obszary i tereny górnicze: Państwowy Instytut Geologiczny - Państwowy Instytut Badawczy System Gospodarki i Ochrony Bogactw Mineralnych Polski MIDAS
Podkład topograficzny: Główny Urząd Geodezji i Kartografii Mapa podkładowa BDOO i BDOT10k (usługa WMTS)

Documented field, mining areas and mining counties: Polish Geological Institute - National Research Institute System of Management and Protection of Mineral Resources in Poland MIDAS
Topographic background: Head Office of Geodesy and Cartography Background maps of BDOO and BDOT10k (WMTS service)



Kosarzyn N crude oil field

The total field acreage: 77.0 ha
Depth: from -1,745.00 to -1,783.00 m
Stratigraphy: Permian/Zechstein Main Dolomite
Resources:
The primary exploitable anticipated economic resources (as of 2012):
34.50 kt of crude oil in cat. B
5.59 MCM of natural gas in cat. B

The exploitable anticipated economic resources as of 31 XII 2022:
lack of resources
The economic resources in place as of 31 XII 2022:
lack of resources
The production in 2022:
lack of production

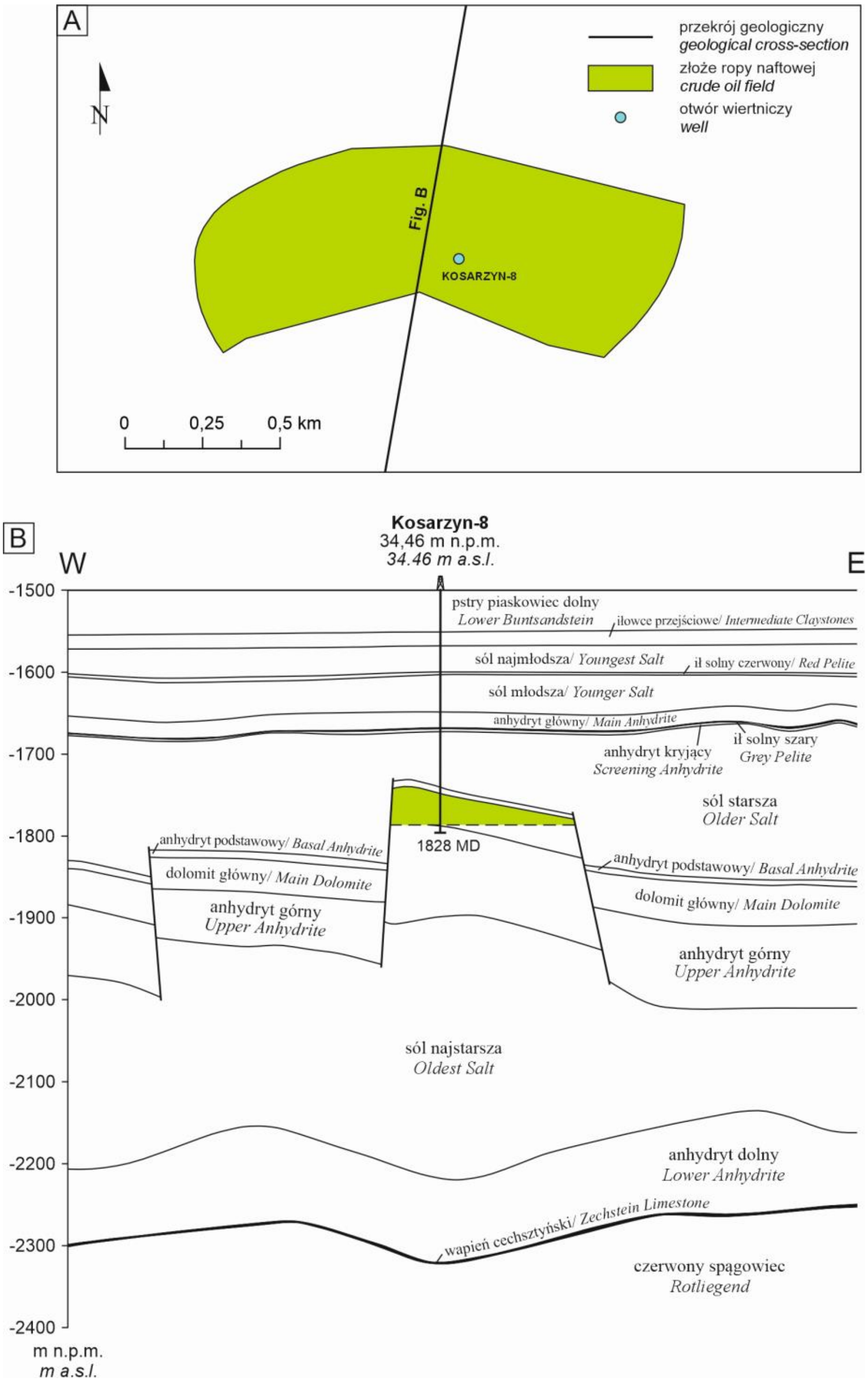


Fig. 4.4. Location of the wells drilling the Kosarzyn N crude oil field and its neighborhood (CGDB, 2023). **B.** Geological cross-section through Kosarzyn N crude oil field (Chruścińska, 2014).

Parameter	Minimum value	Maximum value	Average value	Unit	Comments
current pressure	---------	---------	2.530	MPa	
primary reservoir pressure	---------	---------	11.240	MPa	at the depth of -1,775 m
depth of underlying water	---------	---------	---------	m	not stated
effective reservoir thickness	---------	---------	6.800	m	
oil saturation	---------	---------	84.000	%	
porosity	---------	---------	3.500	%	
permeability	---------	---------	1.920	mD	
mineralization degree of formation water	---------	---------	306.800	g/l	
reservoir temperature	---------	---------	343.150	°K	
reservoir temperature	---------	---------	70.000	°C	
chemical type of formation water	---------	---------	---------	–	Cl-Mg-Na-Ca brine
production conditions	---------	---------	---------	–	pumping
production factor	---------	---------	0.310	–	
permitted efficiency V_{dozw}	---------	---------	4,000	t/d	temporarily, as of 2012
boreholes efficiency	---------	---------	12.000	t/d	
primary efficiency	---------	---------	450.000	t/month	as of 1998
gas exponent	---------	---------	162.000	m^3/t	
water exponent	---------	---------	1.914	m^3/t	
quality parameters of crude oil (main raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
oil specific gravity	0.850	0.850	0.850	g/cm^3	
mercury Hg	---------	---------	---------	%	not measured
paraffin content	---------	---------	6.890	% w/v	
sulfur content	---------	---------	1.170	% w/v	
quality parameters of natural gas (accompanying raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
combustion heat	33.640	36.710	35.050	MJ/m^3	
calorific value	30.540	33.370	31.850	MJ/m^3	
C_2H_6	11.883	13.370	12.429	% v/v	
CH_4	41.380	42.969	41.961	% v/v	
CO_2	0.020	0.149	0.110	% v/v	
He	0.000	0.136	0.134	% v/v	
N_2	35.774	37.508	36.881	% v/v	
H_2S	0.000	0.153	0.141	% v/v	
heavy hydrocarbons C_{3+} content	6.988	9.179	8.322	% v/v	

Tab. 4.1. Parameters of Kosarzyn N crude oil field and quality parameters of raw materials (MIDAS, 2022).

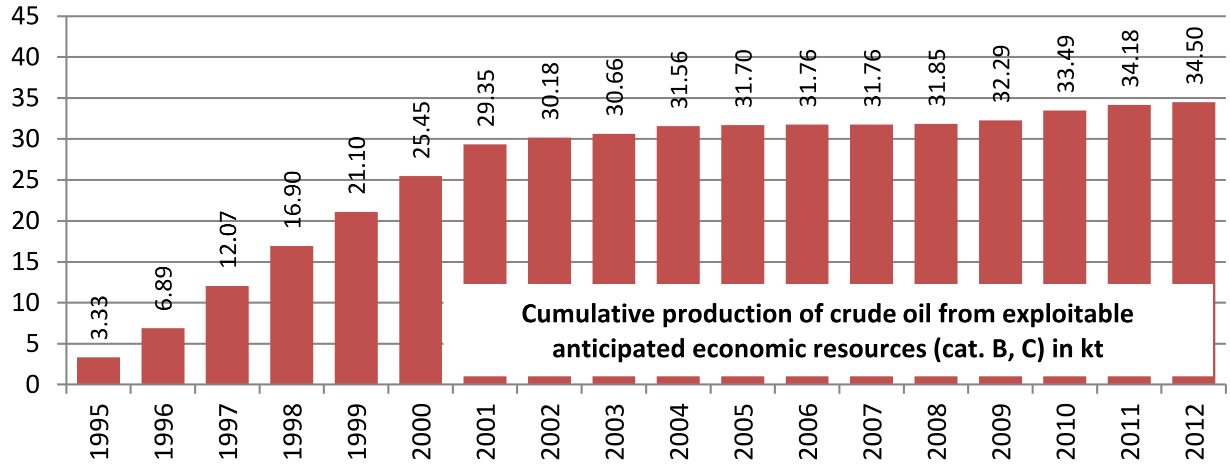


Fig. 4.3. Graph of crude oil (main raw material) production from Kosarzyn N field (Chruścińska, 2014).

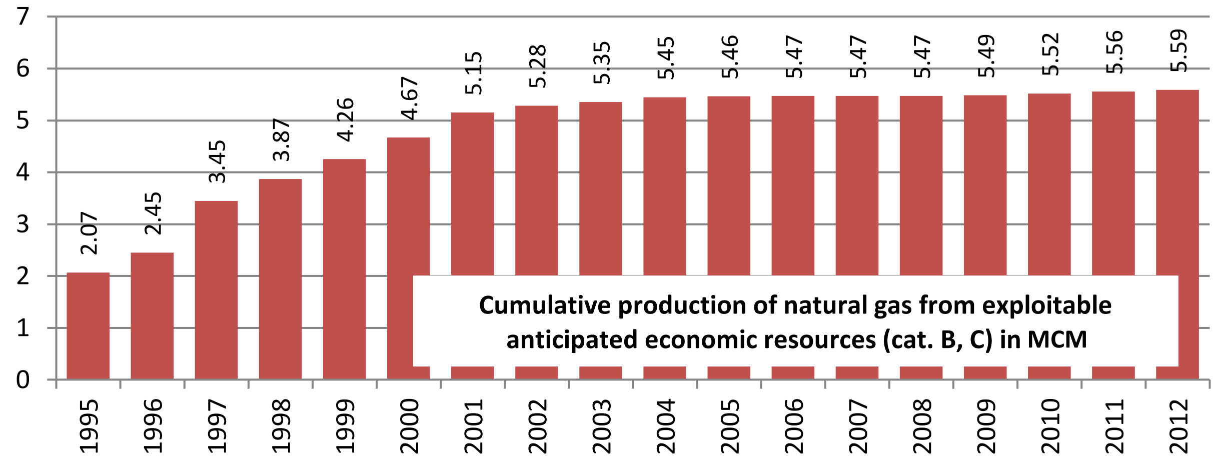


Fig. 4.4. Graph of natural gas (accompanying raw material) production from Kosarzyn N field (Chruścińska, 2014).

Radoszyn crude oil field

The total field acreage: 540.0 ha
Depth: from -2,285.0 m do -2,328.5 m
Stratigraphy: Permian/Zechstein Main Dolomite
Resources:

The primary exploitable anticipated economic resources (as of 2007):
665.00 kt of crude oil in cat. B
27.00 kt of crude oil in cat. C
129.00 MCM of natural gas in cat. B
5.00 MCM of natural gas in cat. C

The exploitable anticipated economic resources as of 31 XII 2022:
480.23 kt of crude oil in cat. B
27.00 kt of crude oil in cat. C
93.37 MCM of natural gas in cat. B
5.00 MCM of natural gas in cat. C

The economic resources in place as of 31 XII 2022:
90.82 kt of the crude oil economic resources in place in cat. B
3049.41 kt of the crude oil sub-economic resources in place in cat. B
275.00 kt of the crude oil sub-economic resources in place in cat. C
23.15 MCM of the natural gas economic resources in place in cat. B
591.20 MCM of the natural gas sub-economic resources in place in cat. B
53.00 MCM of the natural gas sub-economic resources in place in cat. C

The production in 2020:
11.72 kt of crude oil
2.97 MCM of natural gas

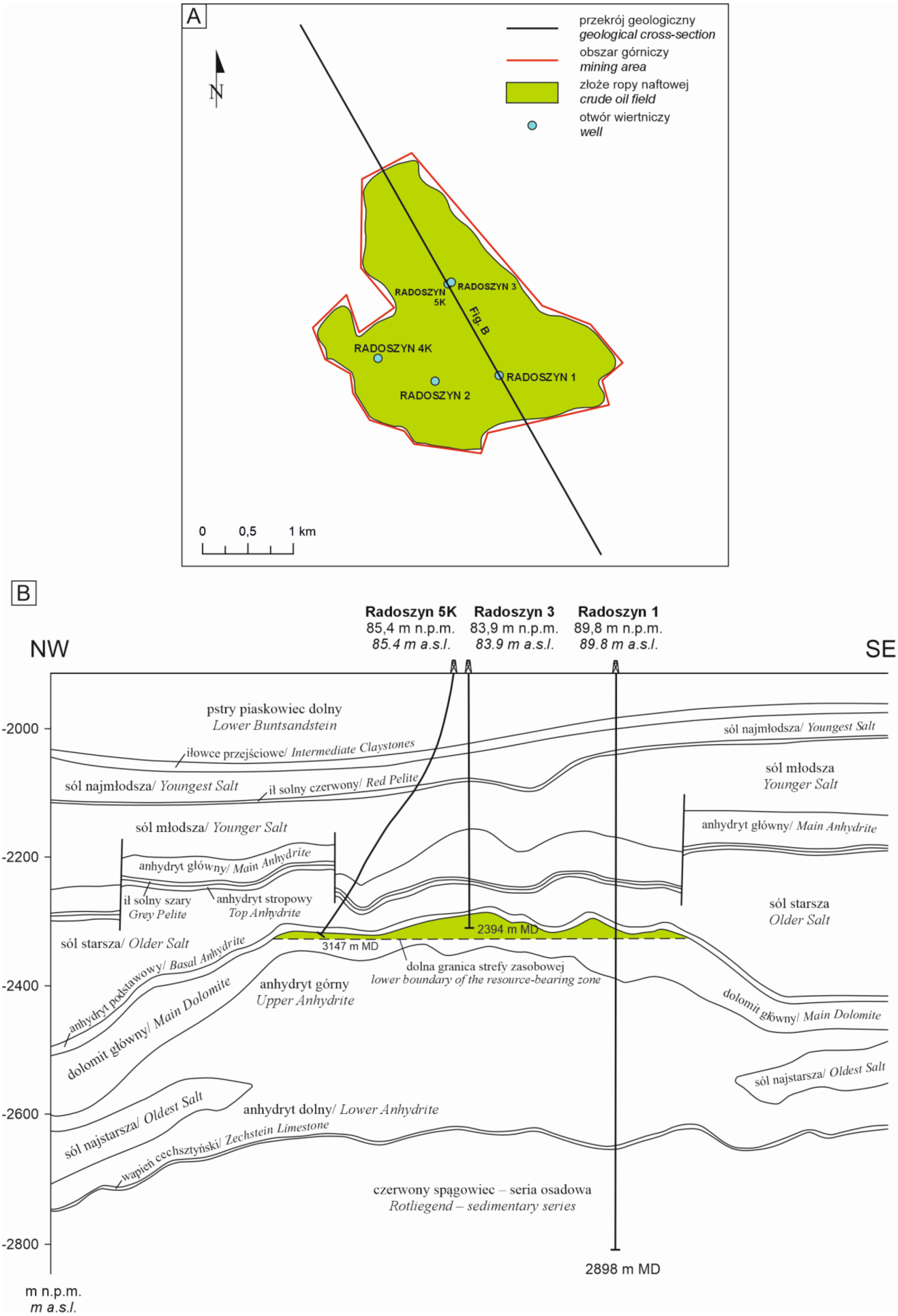


Fig. 4.5. A. Location of wells drilling the Radoszyn crude oil field and its neighborhood (CGDB, 2023). **B.** Geological cross-section through Radoszyn crude oil field (Chmielowiec-Stawska, 2008).

Parameter	Minimum value	Maximum value	Average value	Unit	Comments
current pressure	---------	---------	25.960	MPa	as of 18 VI 2008
primary reservoir pressure	---------	---------	29.510	MPa	at the depth of -2,297 m
depth of underlying water	---------	---------	-2,328.500	m	
effective reservoir thickness	---------	---------	14.850	m	for the field, on the basis on the map of effective thickness
effective reservoir thickness	---------	---------	15.700	m	in cat. B
effective reservoir thickness	---------	---------	14.000	m	in cat. C
reservoir thickness	---------	---------	15.100	m	in cat. C
reservoir thickness	---------	---------	18.300	m	in cat. B
oil saturation	---------	---------	69.000	%	
effective porosity	---------	---------	14.460	%	calculated value, from boreholes data
effective porosity	---------	---------	11.200	%	in cat. B
effective porosity	---------	---------	6.050	%	in cat. C
permeability	---------	---------	8.500	mD	
mineralization degree of formation water	---------	---------	340.210	g/l	
reservoir temperature	---------	---------	361.950	°K	
chemical type of reservoir water	---------	---------	---------	–	Cl-Na-Ca brine
hydrocarbons saturation factor	---------	---------	0.708	–	in cat. B
hydrocarbons saturation factor	---------	---------	0.732	–	calculated value, from boreholes data
hydrocarbons saturation factor	---------	---------	0.601	–	in cat. C
production factor	---------	---------	0.100	–	in cat. C
production factor	---------	---------	0.200	–	in cat. B
gas exponent	---------	---------	163.000	m^3/m^3	primary for the field, from PVT studies for Radoszyn 2 borehole
gas exponent	---------	---------	195.000	m^3/t	primary for the field, from PVT studies for Radoszyn 2 borehole
quality parameters of crude oil (main raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
density	0.825	0.848	0.835	g/cm^3	in temperature of 20°C
viscosity	4.800	12.260	9.120	cSt	in temperature of 20°C
chlorides content	1.700	148.400	19.620	mg/dm^3	
naphtha fraction content	22.500	26.000	24.250	% v/v	
oil fraction content	19.500	---------	---------	% v/v	
paraffin content	2.600	9.340	5.070	% w/v	
sulfur content	0.470	1.270	0.880	% w/v	
hydrogen sulfide content	183.000	617.000	351.250	mg/dm^3	
quality parameters of natural gas (accompanying raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
combustion heat	46.332	62.410	52.848	MJ/m^3	

density	0.921	1.084	0.986	–	in relation to air (calculated val-ue)
Wobbe index	48.260	59.960	53.156	MJ/m^3	
H_2S	---------	---------	54,655.30	mg/m^3	
calorific value	42.150	57.150	48.270	MJ/m^3	
C_2H_6	12.972	18.970	15.081	% v/v	
CH_4	41.480	48.928	45.263	% v/v	
He	0.006	0.031	0.019	% v/v	
Hg	0.164	9.367	5.710	$\mu g/Nm^3$	
N_2	10.770	18.994	15.488	% v/v	
H_2S	1.253	3.872	2.640	% v/v	
hydrocarbons content	76.589	87.621	81.236	% v/v	
heavy hydrocarbons C_{3+} content	14.690	27.171	20.892	% v/v	

Tab. 4.2. Parameters of Radoszyn crude oil field and quality parameters of raw materials (MIDAS, 2022).

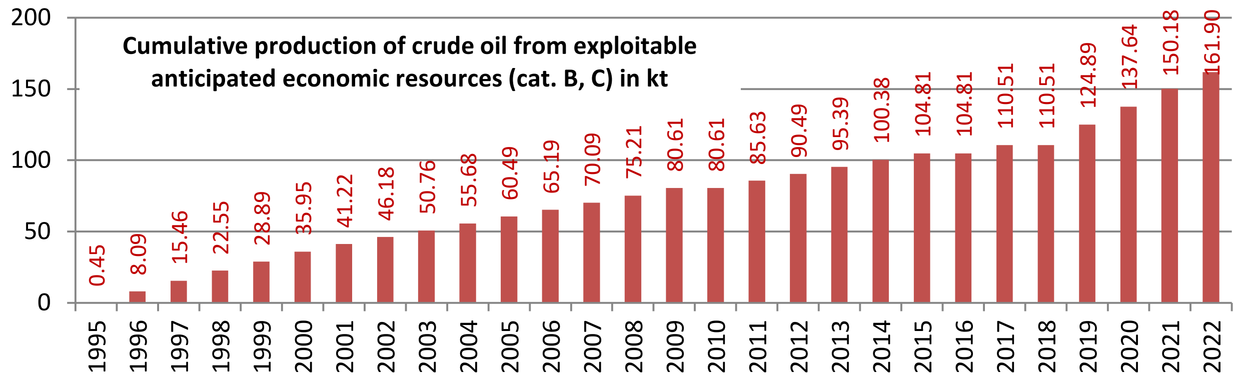


Fig. 4.6. Graph of crude oil production from Radoszyn field (MIDAS, 2022; Chmielowiec-Stawska, 2008).

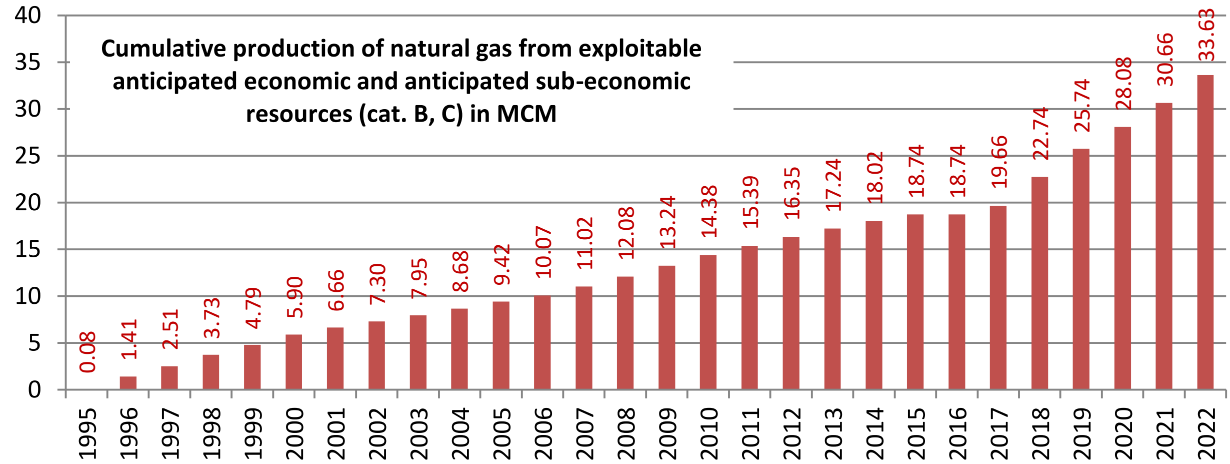


Fig. 4.7. Graph of natural gas production from Radoszyn field (MIDAS, 2022; Chmielowiec-Stawska, 2008).

Ołobok crude oil field

The total field acreage: 216.0 ha
Depth: from -2,394.2 m to -2,410.5 m TVDSS
Stratigraphy: Permian/Zechstein Main Dolomite
Resources:

The primary exploitable anticipated economic resources (as of 2007):
- 32.00 kt of crude oil in cat. C
- 6.00 MCM of natural gas in cat. C

The exploitable anticipated economic resources as of 31 XII 2022:
- 19.54 kt of crude oil in cat. C
- 4.19 MCM of natural gas in cat. C

The economic resources in place as of 31 XII 2022:
- 14.86 kt of the crude oil economic resources in place in cat. C
- 295.67 kt of the crude oil sub-economic resources in place in cat. C

lack of the natural gas economic resources in place
- 62.18 MCM of the natural gas sub-economic resources in place in cat. C

The production in 2020:
- 1.32 kt of crude oil
- 0.13 MCM of natural gas

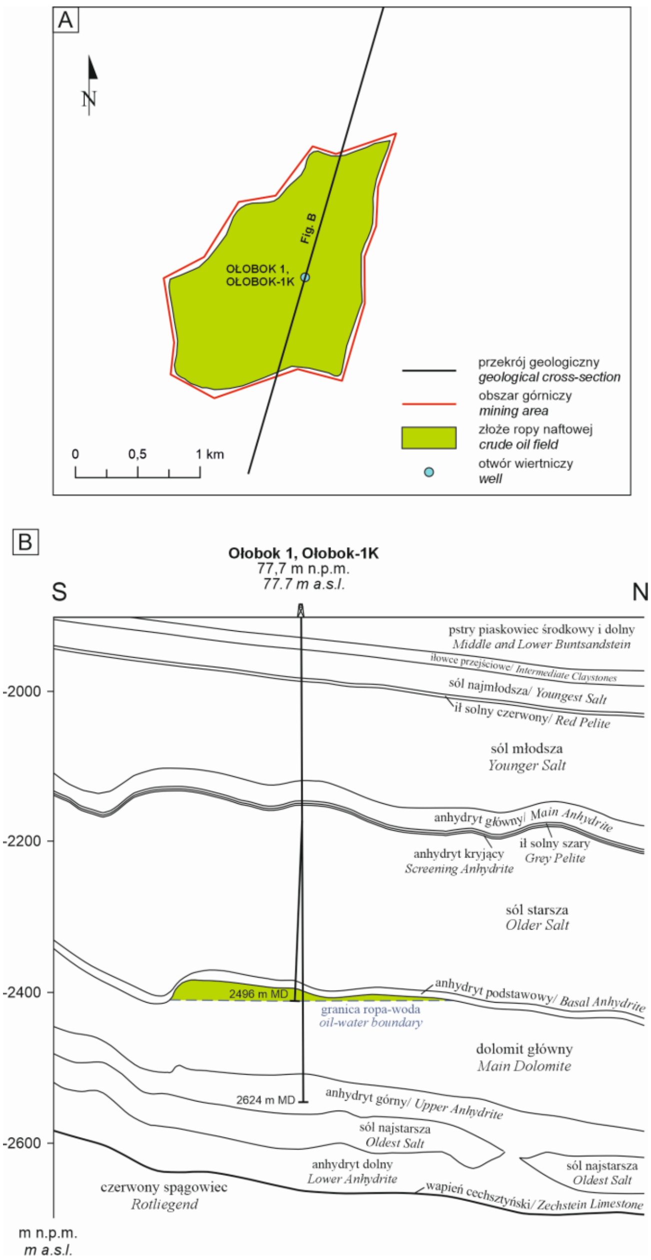


Fig. 4.8. A. Location of wells drilling the Ołobok crude oil field and its neighborhood (CGDB, 2023). **B.** Geological cross-section through Ołobok crude oil field (Kuczak, 2008).

Parameter	Minimum value	Maximum value	Average value	Unit	Comments
current pressure	---------	---------	30.270	MPa	as of 11 III 2008
primary reservoir pressure	---------	---------	31.000	MPa	at the depth of -2,392.3 m
depth of underlying water	---------	---------	---------	m	not stated
effective reservoir thickness	---------	---------	7.800	m	on the basis of the map of effective thickness
effective reservoir thickness	---------	---------	14.600	m	total
effective porosity	---------	---------	6.480	%	
permeability	---------	---------	0.418	mD	
mineralization degree of formation water	---------	---------	423.780	g/l	
reservoir temperature	---------	---------	88.000	°C	at the depth of -2,392.3 m
reservoir temperature	---------	---------	361.150	°K	at the depth of -2,392.3 m
chemical type of formation water	---------	---------	---------	–	Cl-Ca-Na brine (genetic type according to Sulin – Cl-Ca, metamorphosis degree according to Sulin 0.37)
production conditions	---------	---------	---------	–	expansion of gas dissolved in crude oil
hydrocarbons saturation factor	---------	---------	54.900	%	
production factor	---------	---------	0.100	–	
permitted efficiency V_{dozw}	9.000	10.000	---------	t/d	Ołobok-1K borehole
gas exponent	167.000	167.000	167.000	m^3/m^3	
quality parameters of crude oil (main raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
density	0.844	0.846	0.845	g/cm^3	in temperature of 15°C
viscosity	9.140	9.610	9.375	cSt	in temperature of 20°C
viscosity	36.000	36.000	36.000	API	
chlorides content	0.161	0.431	0.296	mg/dm^3	
paraffin content	2.000	2.900	2.350	% w/v	
sulfur content	0.980	0.980	0.980	% w/v	
hydrogen sulfide content	0.143	0.197	0.170	mg/dm^3	
quality parameters of natural gas (accompanying raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
combustion heat	49.580	55.790	52.070	MJ/m^3	
density	0.956	1.041	0.996	–	in relation to air, calculated value
Wobbe index	50.130	54.690	52.160	MJ/m^3	
calorific value	45.290	51.050	47.590	MJ/m^3	
C_2H_6	13.220	15.210	14.390	% v/v	
CH_4	42.480	46.840	44.790	% v/v	
CO_2	2.473	2.904	2.807	% v/v	
H_2	0.002	0.016	0.005	% v/v	
He	0.014	0.025	0.018	% v/v	

Hg	1.744	3.944	2.887	µg/m^3	
N_2	13.760	18.360	16.070	% v/v	
H_2S	2.377	3.366	2.953	% v/v	
hydrocarbons content	---------	---------	78.150	% v/v	
heavy hydrocarbons C_{3+} content	7.410	11.062	9.164	% v/v	

Tab. 4.3. Parameters of Ołobok crude oil field and quality parameters of the raw material (MIDAS, 2022).

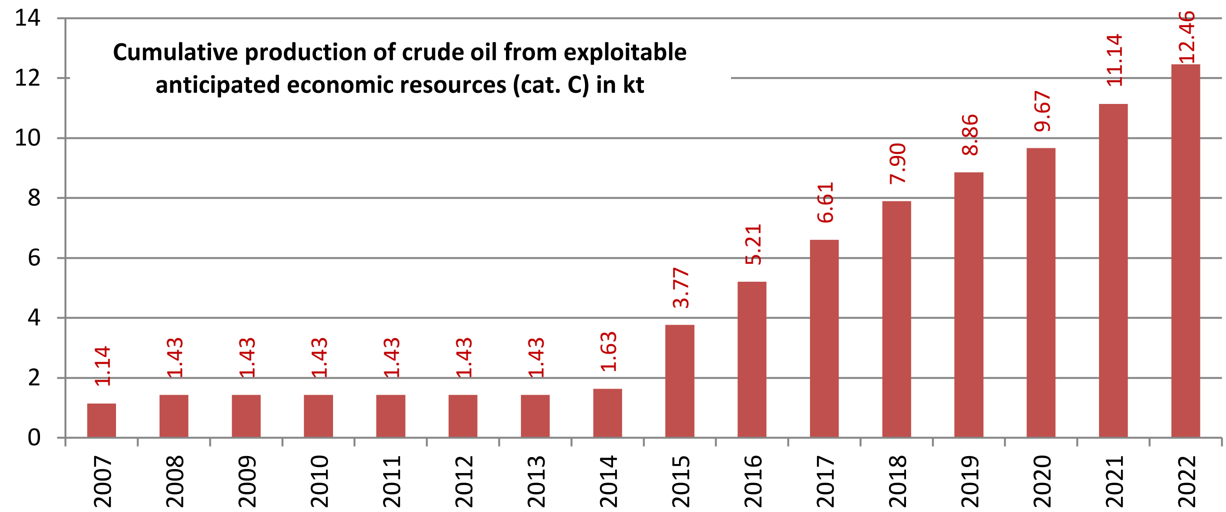


Fig. 4.9. Graph of crude oil production from Ołobok field (MIDAS, 2022).

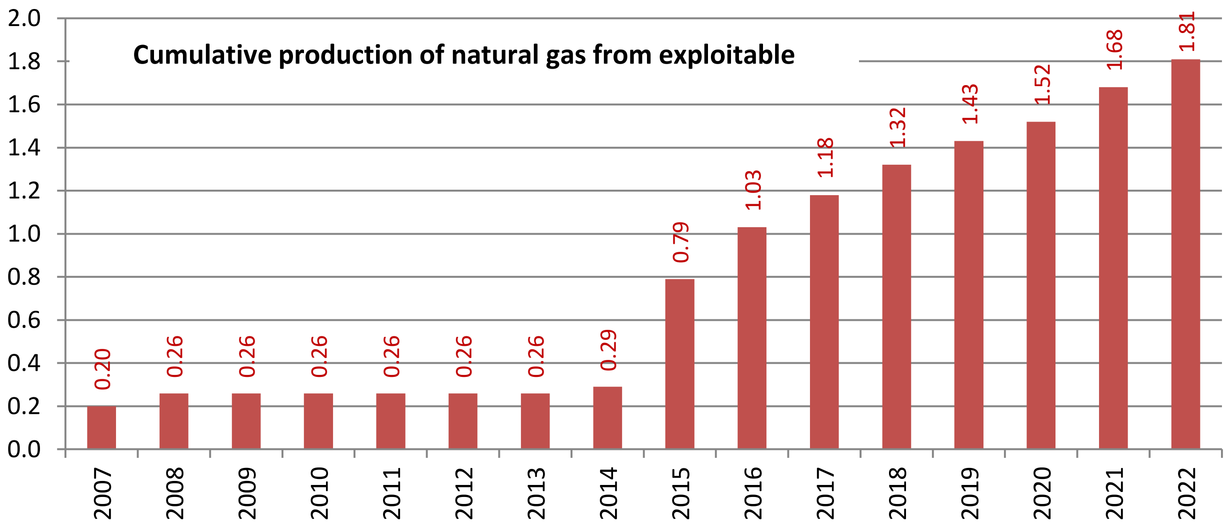


Fig. 4.10. Graph of natural gas production from Ołobok field (MIDAS, 2022).

Gryżyna crude oil field

The total field acreage: 239.07 ha
Depth: oil-bearing zone
from -2,376.3 m to -2,411.1 m TVDSS,
gas-bearing zone
from -2,316.0 m to -2,376.3 m TVDSS
Stratigraphy: Permian/Zechstein
Main Dolomite
Resources:
The primary exploitable anticipated economic resources (as of 2017):
82.00 kt of crude oil in cat. B
410.00 MCM of natural gas (gas cap) in cat. B
13.00 MCM of natural gas (dissolved in crude oil) in cat. B
The exploitable anticipated economic resources as of 31 XII 2022:
72.31 kt of crude oil in cat. B
21.70 MCM of natural gas (gas cap) in cat. B
820.00 MCM of natural gas (dissolved in crude oil) in cat. B
The economic resources in place as of 31 XII 2022:
55.39 kt of the crude oil economic resources in place in cat. B
444.92 kt of the crude oil sub-economic resources in place in cat. B
21.26 MCM of the natural gas (gas cap) sub-economic resources in place in cat. B
133.44 MCM of the natural gas (dissolved in crude oil) economic resources in place in cat. B
1260.00 MCM of the natural gas (dissolved in crude oil) sub-economic resources in place in cat. B
The production in 2022:
lack of production

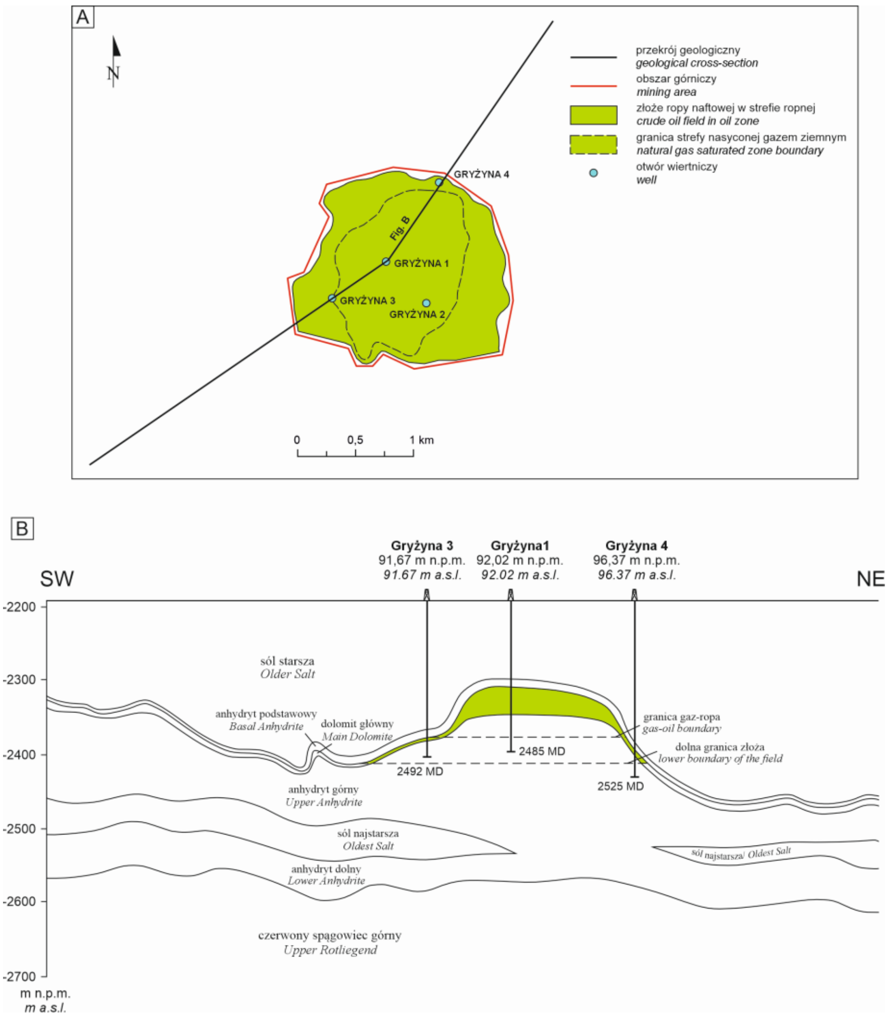


Fig. 4.11. A. Location of wells drilling the Gryżyna crude oil field and its neighborhood (CGDB, 2023). **B.** Geological cross-section through Gryżyna crude oil field (Sowa, 2018).

Parameter	Minimum value	Maximum value	Average value	Unit	Comments
current pressure	---------	---------	30.270	MPa	oil-bearing zone, as of 30 IX 2013
current pressure	---------	---------	30.680	MPa	gas-bearing zone, as of 30 IX 2013
primary reservoir pressure	---------	---------	30.660	MPa	oil-bearing zone
primary reservoir pressure	---------	---------	30.680	MPa	gas-bearing zone
effective reservoir thickness	---------	---------	4.800	m	oil-bearing zone
effective reservoir thickness	---------	---------	17.000	m	gas-bearing zone
porosity	---------	---------	9.930	%	oil-bearing zone
porosity	---------	---------	13.560	%	gas-bearing zone
permeability	---------	---------	4.120	mD	oil-bearing zone
permeability	---------	---------	11.410	mD	gas-bearing zone
reservoir temperature	---------	---------	83.850	°C	oil-bearing zone
reservoir temperature	---------	---------	99.850	°C	gas-bearing zone
production conditions	---------	---------	---------	–	oil-bearing and gas-bearing, volumetric
hydrocarbons saturation factor	---------	---------	81.080	%	oil-bearing zone
hydrocarbons saturation factor	---------	---------	96.000	%	gas-bearing zone
production factor	---------	---------	0.160	–	oil-bearing zone
production factor	---------	---------	0.160	–	gas-bearing zone
production factor	---------	---------	0.650	–	gas-bearing zone
absolute efficiency V_{abs}	17.530	27.830	23.690	m^3/d	oil-bearing zone
absolute efficiency V_{abs}	122.078	149.095	135.587	m^3/min	gas-bearing zone
gas exponent	---------	---------	137.500	m^3/m^3	oil-bearing zone
quality parameters of crude oil (main raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
oil specific gravity	0.828	0.845	0.838	g/cm^3	
viscosity	---------	---------	1.660	°E	
solidification temperature	---------	---------	5.000	°C	
chlorides content	---------	---------	567.400	mg/dm^3	
naphtha fraction content	---------	---------	25.700	% v/v	
oil fraction content	---------	---------	17.900	% v/v	
Hg	---------	---------	0.813	$\mu g/Nm^3$	
paraffin content	---------	---------	11.190	% w/v	
hydrogen sulfide content	2.704	3.695	3.128	% v/v	
water content	---------	---------	8.150	% w/v	
quality parameters of natural gas (accompanying raw material, gas dissolved in crude oil)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
combustion heat	41.970	59.050	51.820	MJ/m^3	
calorific value	38.170	54.000	47.280	MJ/m^3	
C_2H_6	12.369	13.367	12.811	% v/v	

CH_4	37.743	46.204	40.582	% v/v	
CO_2	2.345	3.220	3.034	% v/v	
He	0.049	3.220	2.731	% v/v	
N_2	18.265	23.913	20.350	% v/v	
H_2S	2.704	3.695	3.128	% v/v	
heavy hydrocarbons C_{3+} content	12.465	25.009	20.086	% v/v	
quality parameters of natural gas (accompanying raw material, gas from gas cap)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
combustion heat	27.360	28.930	27.840	MJ/m^3	
calorific value	24.840	26.280	25.280	MJ/m^3	
C_2H_6	8.223	10.341	9.054	% v/v	
CH_4	35.465	36.415	36.171	% v//v	
CO_2	1.078	1.207	1.099	% v//v	
He	0.000	0.000	0.000	% v//v	
N_2	45.308	46.940	46.392	% v//v	
H_2S	0.994	1.730	1.199	% v//v	
hydrocarbons content	---------	---------	51.249	% v//v	
heavy hydrocarbons C_{3+} content	5.551	6.503	6.024	% v//v	

Tab. 4.4. Parameters of Gryżyna crude oil field and quality parameters of raw materials (MIDAS, 2022).

Rybaki crude oil field

The total field acreage: 171.68 ha
Depth: from -1,628.00 m to -1,695.00 m TVDSS
Stratigraphy: Permian/Zechstein Main Dolomite
Resources:
The primary exploitable anticipated economic resources:
138.45 kt of crude oil in cat. B
(as of 2017)

The exploitable anticipated economic resources as of 31 XII 2022:
lack of resources
The economic resources in place as of 31 XII 2022:
lack of resources
The production in 2022:
lack of production
As of the end of 1998 the resources of natural gas were crosses out from the register.

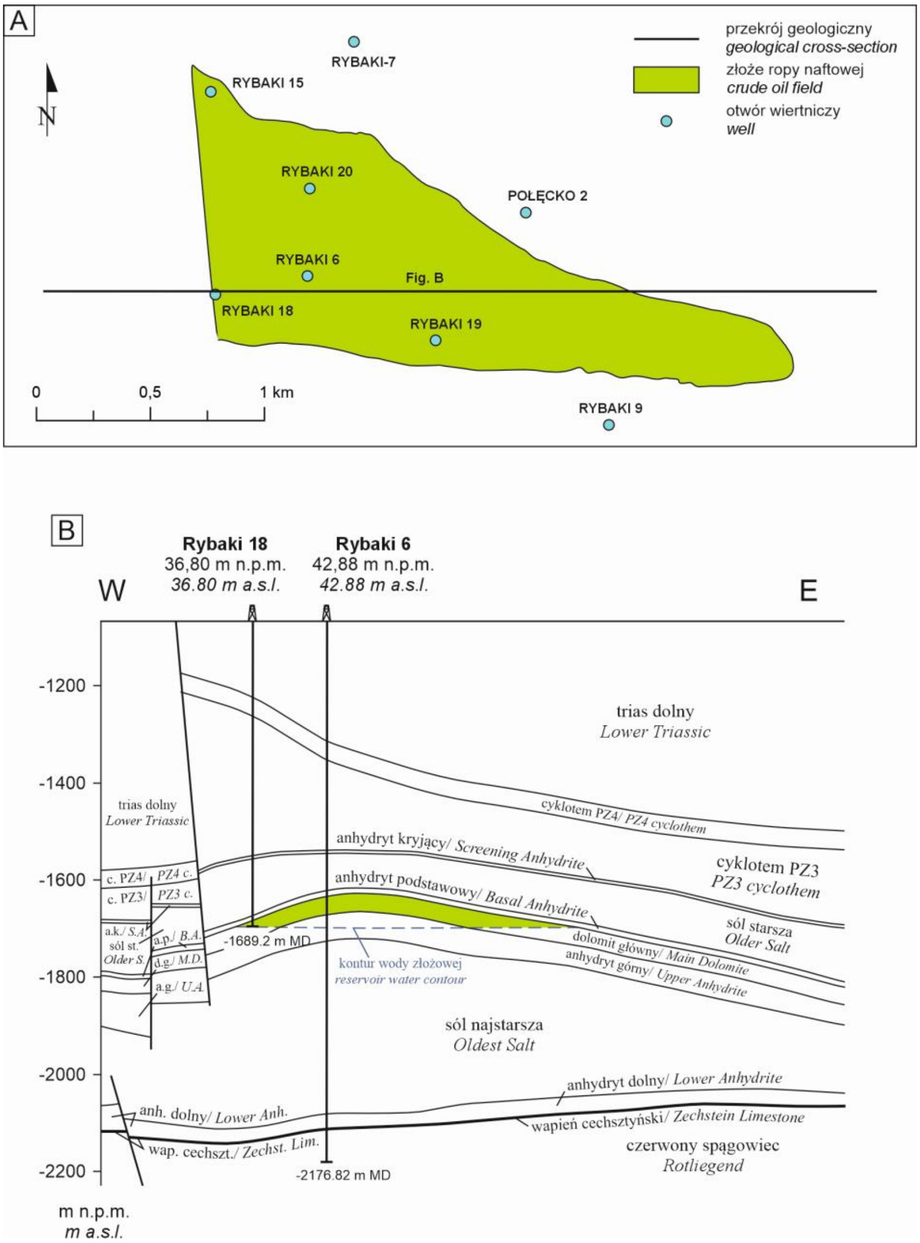


Fig. 4.12. A. Location of wells drilling the Rybaki crude oil field and its neighborhood (CGDB, 2023). **B.** Geological cross-section through Rybaki crude oil field (Czyż, 2018).

Parameter	Minimum value	Maximum value	Average value	Unit	Comments
current pressure	---------	---------	6.310	MPa	at the depth of -1,670 m TVD, as of 27 IX 2000
primary reservoir pressure	---------	---------	21.020	MPa	at the depth of -1,670 m TVD
depth of underlying water	---------	---------	-1,695.000	m	TVDSS
effective reservoir thickness	---------	---------	36.000	m	average from the map of effective thickness
porosity	---------	---------	2.230	%	
permeability	---------	---------	2.870	mD	
mineralization degree of formation water	---------	---------	330.000	g/l	
reservoir temperature	---------	---------	68.000	°C	
chemical type of formation water	---------	---------	---------	–	Cl-Na

production conditions	---------	---------	---------	–	mixed: formation water pressure, resilience of reservoir rocks and liquids
hydrocarbons saturation factor	---------	---------	85.000	%	
production factor	---------	---------	0.230	–	
water exponent	341.138	3,379.712	1,303.470	kg/m^3	
quality parameters of crude oil (main raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
density	0.854	0.866	0.862	g/cm^3	
solidification temperature	---------	---------	18.330	°C	
chlorides content	---------	---------	7.700	mg/dm^3	
naphtha fraction content	---------	---------	20.900	% v/v	
oil fraction content	---------	---------	16.930	% v/v	
paraffin content	1.900	7.770	4.220	% w/v	
hydrogen sulfide content	---------	65.600	19.500	mg/dm^3	
water content	---------	---------	0.150	% w/v	
quality parameters of natural gas (accompanying raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
density	---------	---------	1.437	–	in relation to air
calorific value	---------	---------	55.300	MJ	
C_2H_6	---------	---------	20.052	% v/v	
CH_4	---------	---------	41.506	% v/v	
CO_2	---------	---------	0.055	% v/v	
gasoline content	---------	---------	495.308	g/m^3	
H_2	---------	---------	0.473	% v/v	
He	---------	---------	0.025	% v/v	
N_2	---------	---------	15.878	% v/v	
H_2S	---------	---------	0.000	% v/v	

Tab. 4.5. Parameters of Rybaki crude oil field and quality parameters of raw materials (MIDAS, 2022).

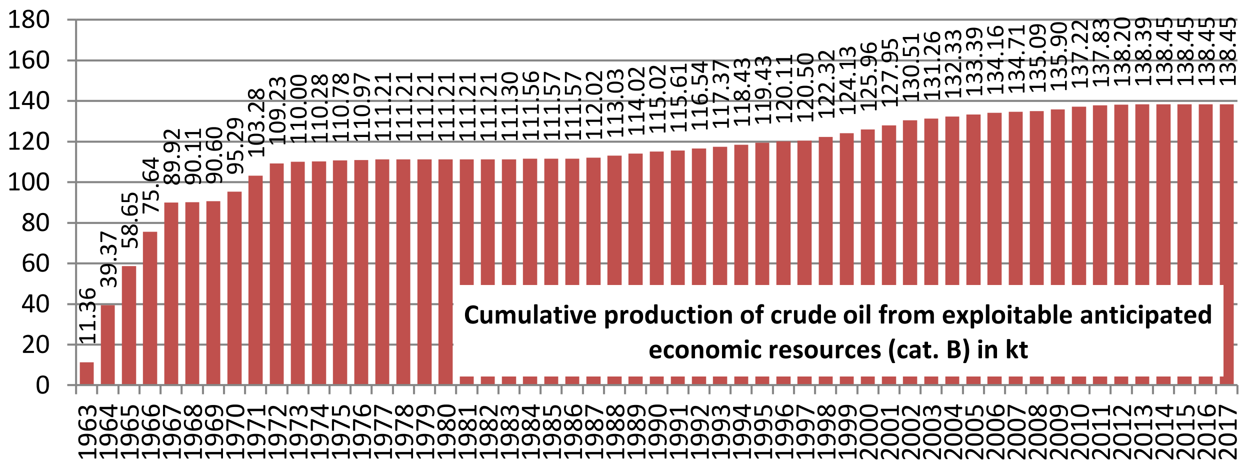


Fig. 4.13. Graph of crude oil production from Rybaki field (MIDAS, 2022).

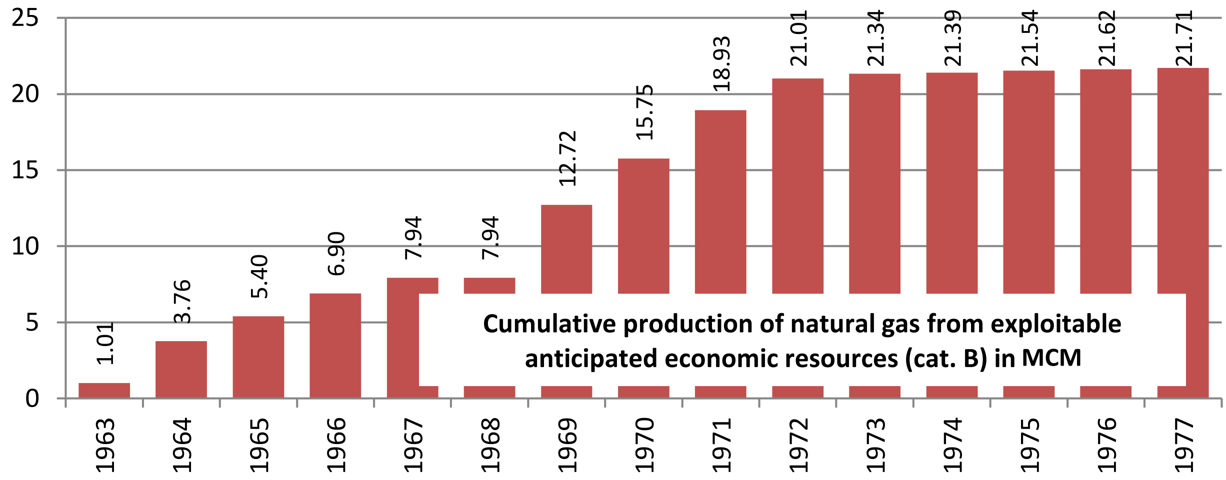


Fig. 4.14. Graph of natural gas production from Rybaki field (MIDAS, 2022).

5. WELLS

The following deep wells (>500 m MD) reached the prospective intervals in the Cybinka-Torzym tender area:

Well name	Year	HC concessions (after 1994)	Owner	Depth [m]	Stratigraphy at the bottom
Bytomiec-1	1971		State Treasury	2240.0	Rotliegend
Chlebów 1	1971		State Treasury	2135.0	Zechstein
Cybinka 1	1963		State Treasury	2586.0	Zechstein
Cybinka 2	1970		State Treasury	2617.0	Zechstein
Grzmiąca 1	1971		State Treasury	2155.0	Zechstein
Grzmiąca 2	1994	Grzmiąca-Cybinka 79/92/p	Investor	2129.0	Zechstein
Grzmiąca 3	1970		State Treasury	2634.0	Rotliegend
Grzmiąca 5	1996	Grzmiąca-Cybinka 33/95/p	Investor	2020.0	Zechstein
Grzmiąca 7	1997		Investor	2120.0	Zechstein
Kłopot 1	1995	Grzmiąca-Cybinka 79/92/p	Investor	2125.0	Zechstein
Kosarzyn-8	1995		Investor	1828.0	Zechstein
Kosobudz 1	1965		State Treasury	2974.0	Rotliegend
Koziczyn-1	1971		State Treasury	3208.0	Rotliegend
Miłów 1	1989		Investor	2401.0	Rotliegend
Radomicko 1	1994	Radomicko-Czarnowo 80/92/p	Investor	2138.0	Zechstein
Rąpice 1A	1995	Grzmiąca-Cybinka 79/92/p	Investor	2402.0	Permian
Rybaki 5	1963		State Treasury	1988.0	Zechstein
Rybaki 14	1964		State Treasury	2022.6	Zechstein
Sosna-1	2012	Torzym 8/2008/p	State Treasury	2455.0	Zechstein
Świebodzin-1	1962		State Treasury	1503.0	Lower Triassic
Świebodzin 2	1964		State Treasury	1998.0	Zechstein
Świebodzin 3	1966		State Treasury	2804.0	Rotliegend

Location of the above-mentioned wells can be found in Fig. 5.1. Their general characteristics are shortly summarized in Tab. 5.1. The Bytomiec-1 i Koziczyn-1 wells are illustrated in Figs 5.2–5.3 as examples.

The original data from the wells, which belong to the State Treasury, are collected in the DATA ROOM and will be available at the Polish Geological Institute – National Research Institute in Warsaw during the 6th tender round.

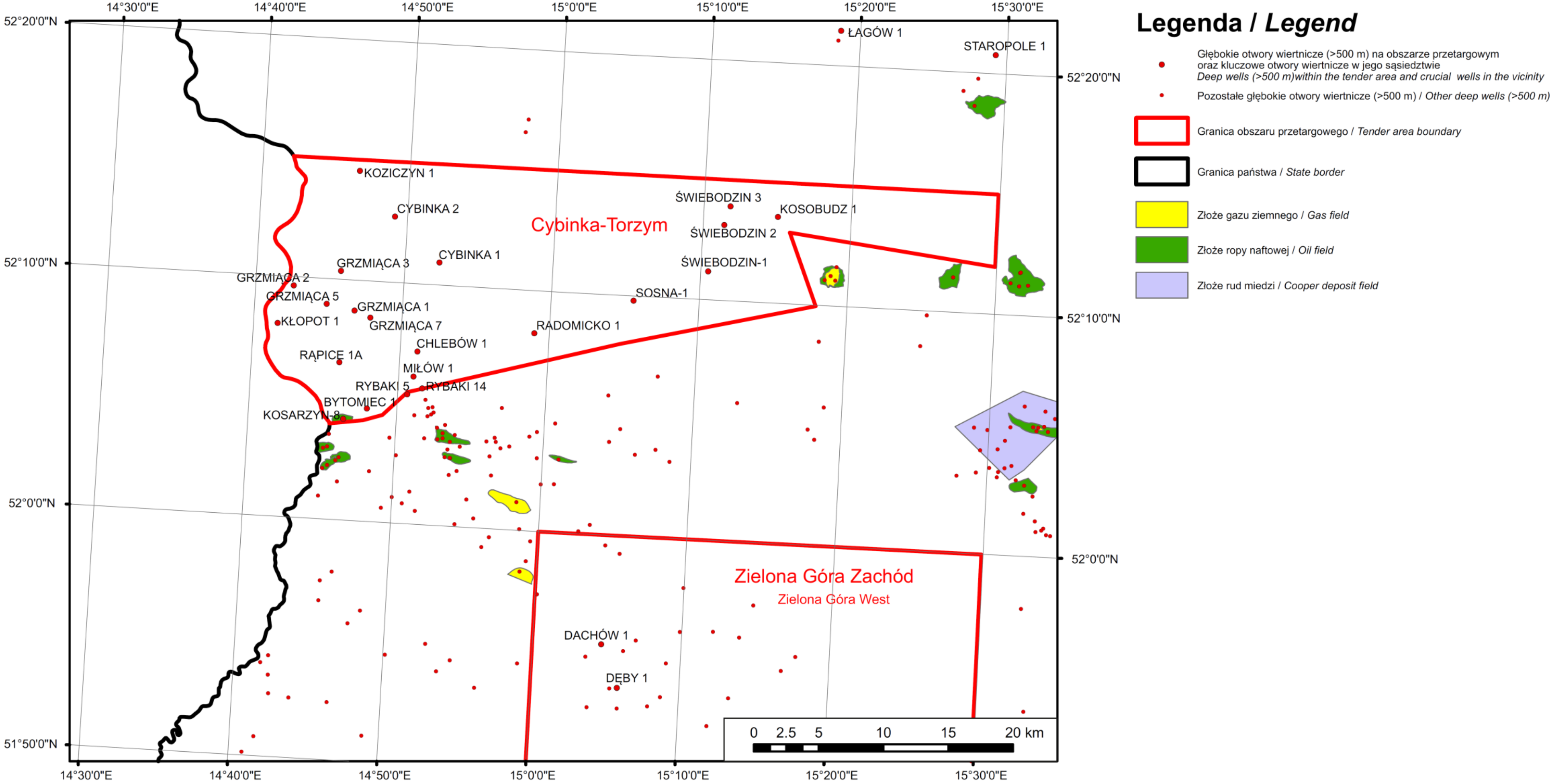


Fig. 5.1. Deep wells (>500 m MD) located within the Cybinka-Torzym tender area and in its close neighborhood.

STRATIGRAPHY	Bytomiec-1		Chlebów 1		Cybinka 1		Cybinka 2		Grzmiąca 1		Grzmiąca 3		Kosobudz 1	
	top – bottom [m]		top – bottom [m]		top – bottom [m]		top – bottom [m]		top – bottom [m]		top – bottom [m]		top – bottom [m]	
CENOZOIC	0.0	208.0	0.0	198.5	0.0	272.0	0.0	200.0	0.0	193.0	0.0	201.0	0.0	230.0
CRETACEOUS					272.0	358.0	200.0	265.0	193.0	211.5	201.0	232.0		
JURASSIC			198.5	318.0	358.0	590.0	265.0	465.0	211.5	465.0	232.0	528.0	230.0	438.0
TRIASSIC	208.0	1597.0	318.0	1776.5	590.0	2126.0	*465.0*	*2000.0*	*465.0*	*1866.0*	*528.0*	*1989.0*	438.0	1930.0
PERMIAN	1597.0	2240.0	1776.5	2135.0	2126.0	2586.0	*2000.0*	*2617.0*	*1866.0*	*2155.0*	*1989.0*	*2634.0*	1930.0	2974.0
Top Terrigenous Series PZt	*1597.0*	*1610.0*	*1776.5*	*1788.0*	*2126.0*	*2137.5*	*2000.0*	*2017.0*	*1866.0*	*1876.0*	*1989.0*	*2003.0*	*1930.0*	*1941.0*
Top Anhydrite A4a														
Top Youngest Halite Na4b2									*1876.0*	*1879.0*	*2003.0*	*2007.0*		
Upper Red Pelite T4b									*1879.0*	*1881.0*	*2007.0*	*2010.0*		
Lower Youngest Halite-Na4a1	*1610.0*	*1642.0*	*1788.0*	*1820.0*	*2137.5*	*2184.0*	*2017.0*	*2056.0*	*1881.0*	*1916.0*	*2010.0*	*2053.0*	*1941.0*	*1979.5*
Pegmatite AnhydriteA4a					*2184.0*	*2187.5*							*1979.5*	*1981.0*
Red Pelite T4a	*1642.0*	*1645.5*	*1820.0*	*1825.0*	*2187.5*	*2193.0*	*2056.0*	*2059.0*	*1916.0*	*1925.0*	*2053.0*	*2057.0*	*1981.0*	*1985.0*
Younger Halite Na3	*1645.5*	*1747.5*	*1825.0*	*1953.0*	*2193.0*	*2334.0*	*2059.0*	*2186.0*	*1925.0*	*2032.5*	*2057.0*	*2160.0*	*1985.0*	*2106.5*
Main Anhydrite A3	*1747.5*	*1784.5*	*1953.0*	*1968.0*	*2334.0*	*2353.9*	*2186.0*	*2214.0*	*2032.5*	*2057.5*	*2160.0*	*2175.0*	*2106.5*	*2133.0*
Grey Pelite T3	*1784.5*	*1787.0*	*1968.0*	*1973.0*	*2353.9*	*2357.0*	*2214.0*	*2217.0*	*2057.5*	*2061.0*	*2175.0*	*2185.0*	*2133.0*	*2134.5*
Screening Anhydrite A2r	*1787.0*	*1791.5*	*1973.0*	*1977.5*	*2357.0*	*2361.5*	*2217.0*	*2224.0*	*2061.0*	*2067.0*			*2134.5*	*2136.5*
Older Halite Na2	*1791.5*	*1870.0*	*1977.5*	*2078.0*	*2361.5*	*2522.0*	*2224.0*	*2601.0*	*2067.0*	*2107.0*	*2185.0*	*2266.0*	*2136.5*	*2620.0*
Basal Anhydrite A2	*1870.0*	*1888.5*	*2078.0*	*2089.0*	*2522.0*	*2538.0*	*2601.0*	*2616.0*	*2107.0*	*2117.0*	*2266.0*	*2273.0*	*2620.0*	*2628.0*
Main Dolomite Ca2	*1888.5*	*1928.0*	*2089.0*	*2132.0*	*2538.0*	*2570.0*	*2616.0*	*2617.0*	*2117.0*	*2148.0*	*2273.0*	*2317.0*	*2628.0*	*2652.5*
Upper Anhydrite A1g	*1928.0*	*1987.5*	*2132.0*	*2135.0*	*2570.0*	*2586.0*	*2132.0*	*2135.0*	*2148.0*	*2155.0*	*2317.0*	*2420.0*	*2652.5*	*2676.0*
Oldest Halite Na1	*1987.5*	*2045.9*									*2420.0*	*2453.0*	*2676.0*	*2732.5*
Lower Anhydrite A1d	*2045.9*	*2192.5*									*2453.0*	*2611.0*	*2732.5*	*2761.5*
Zechstein Limestone Ca1	*2192.5*	*2203.0*									*2611.0*	*2616.0*	*2761.5*	*2765.5*
Kupferschiefer T1														
Upper Rotliegend	*2203.0*	*2208.5*									*2616.0*	*2634.0*	*2765.5*	*2952.0*
Lower Rotliegend	*2208.5*	*2240.0*											*2952.0*	*2974.0*

STRATIGRAPHY	Koziczyn-1		Rybaki 5		Rybaki 14		Sosna-1		Świebodzin-1		Świebodzin 2		Świebodzin 3	
	top – bottom [m]		top – bottom [m]		top – bottom [m]		top – bottom [m]		top – bottom [m]		top – bottom [m]		top – bottom [m]	
CENOZOIC	0.0	194.0	0.0	228.0	0.0	256.0	0.0	272.0	0.0	255.0	0.0	233.0	0.0	230.0
CRETACEOUS	194.0	232.0												
JURASSIC	232.0	482.0					272.0	425.0	255.0	458.0	233.0	408.0	230.0	424.0
TRIASSIC	482.0	1948.0	228.0	1633.0	256.0	1533.0	425.0	2017.0	458.0	1503.0	408.0	1943.0	424.0	1905.0
PERMIAN	1 948.0	3 208.0	1633.0	1988.0	1533.0	2022.6	2017.0	2455.0			1943.0	1998.0	1905.0	2804.0
Top Terrigenous Series PZt	*1948.0*	*1957.5*	*1633.0*	*1643.0*	*1533.0*	*1550.0*	*2017.0*	*2056.0*			*1943.0*	*1958.0*	*1905.0*	*1919.5*
Top Anhydrite A4a							*2056.0*	*2058.0*						
Top Youngest Halite Na4b2														
Upper Red Pelite T4b														
Lower Youngest Halite-Na4a1	*1957.5*	*1999.5*	*1643.0*	*1678.0*	*1550.0*	*1620.0*	*2058.0*	*2108.0*			*1958.0*	*1988.0*	*1919.5*	*1954.4*
Pegmatite AnhydriteA4a			*1678.0*	*1680.0*			*2108.0*	*2110.0*			*1988.0*	*1998.0*	*1954.4*	*1956.0*
Red Pelite T4a	*1999.5*	*2003.0*	*1680.0*	*1684.5*	*1620.0*	*1625.0*	*2110.0*	*2117.5*					*1956.0*	*1963.0*
Younger Halite Na3	*2003.0*	*2127.0*	*1684.5*	*1815.0*	*1625.0*	*1857.5*	*2117.5*	*2182.0*					*1963.0*	*2075.5*
Main Anhydrite A3	*2127.0*	*2152.0*	*1815.0*	*1830.0*	*1857.5*	*1872.5*	*2182.0*	*2204.0*					*2075.5*	*2110.0*
Grey Pelite T3	*2152.0*	*2154.0*	*1830.0*	*1832.5*	*1872.5*	*1875.0*	*2204.0*	*2207.0*					*2110.0*	*2111.5*
Screening Anhydrite A2r	*2154.0*	*2157.0*	*1832.5*	*1837.0*	*1875.0*	*1877.5*	*2207.0*	*2211.0*					*2111.5*	*2113.5*
Older Halite Na2	*2157.0*	*2756.5*	*1837.0*	*1948.0*	*1877.5*	*1970.0*	*2211.0*	*2320.0*					*2113.5*	*2623.5*
Basal Anhydrite A2			*1948.0*	*1960.5*	*1970.0*	*1980.0*	*2320.0*	*2336.5*					*2623.5*	*2632.5*
Main Dolomite Ca2			*1960.5*	*1988.0*	*1980.0*	*2021.5*	*2336.5*	*2376.0*					*2632.5*	*2649.0*
Upper Anhydrite A1g	*2756.5*	*2774.5*			*2021.5*	*2022.6*	*2376.0*	*2455.0*					*2649.0*	*2673.0*
Oldest Halite Na1	*2774.5*	*2807.0*											*2673.0*	*2718.3*
Lower Anhydrite A1d	*2807.0*	*2848.0*											*2718.3*	*2754.1*
Zechstein Limestone Ca1	*2848.0*	*2853.5*											*2754.1*	*2757.8*
Kupferschiefer T1														
Upper Rotliegend	*2853.5*	*3208.0*											*2757.8*	*2804.0*
Lower Rotliegend														

Tab. 5.1. Summary of stratigraphy with prospective exploration horizons in the wells located within the Cybinka-Torzym tender area. Data from wells: Grzmiąca 2, Grzmiąca 5, Grzmiąca 7, Kłopot 1, Kosarzyn-8, Radomicko 1, Rąpice 1A, and Sosna-1 belngs to the Investor and cannot be published here.

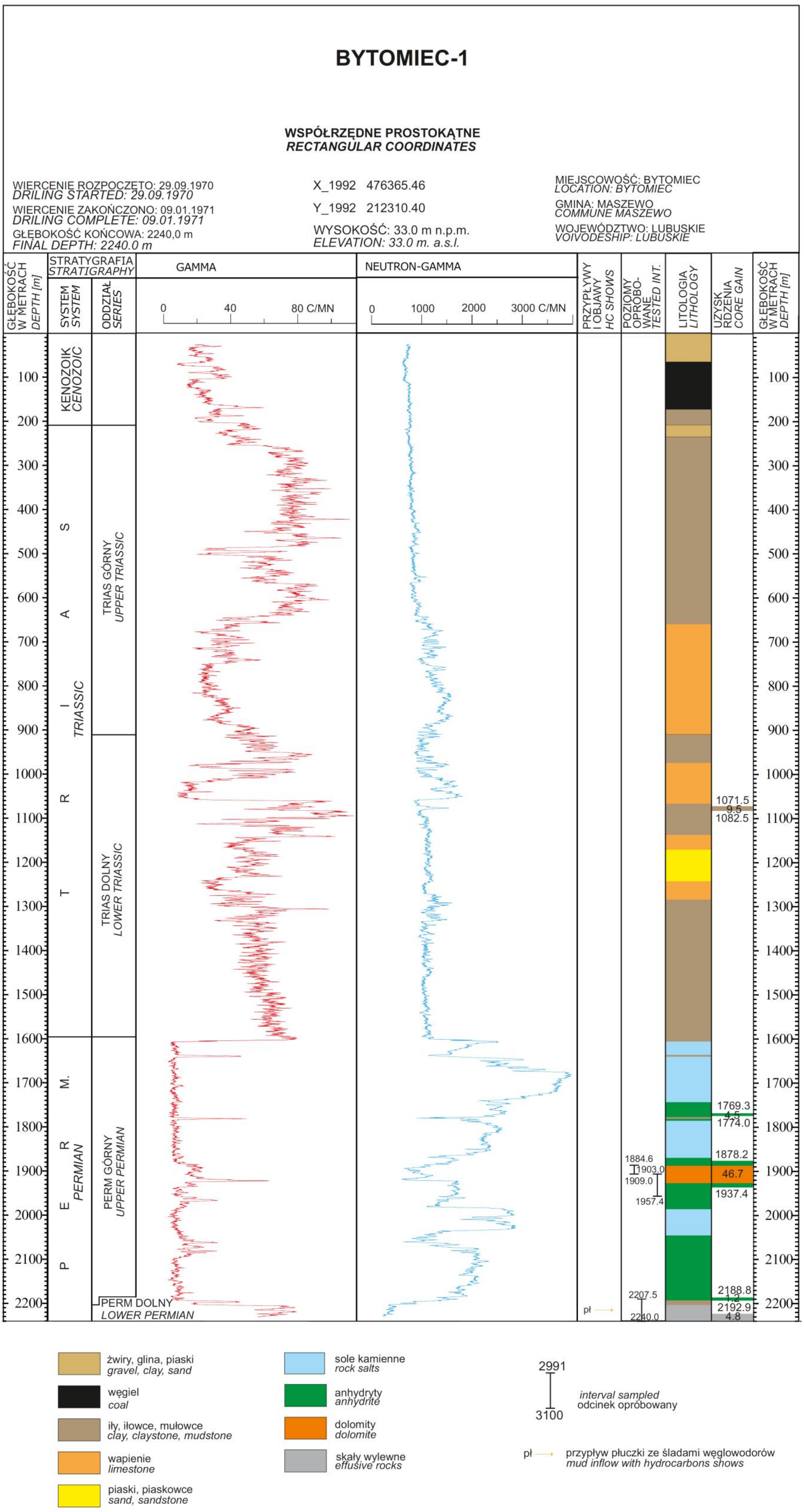


Fig. 5.2. Bytomiec-1 well lithology, stratigraphy and geophysics (Krzyżanowski and Łysik, 1972).

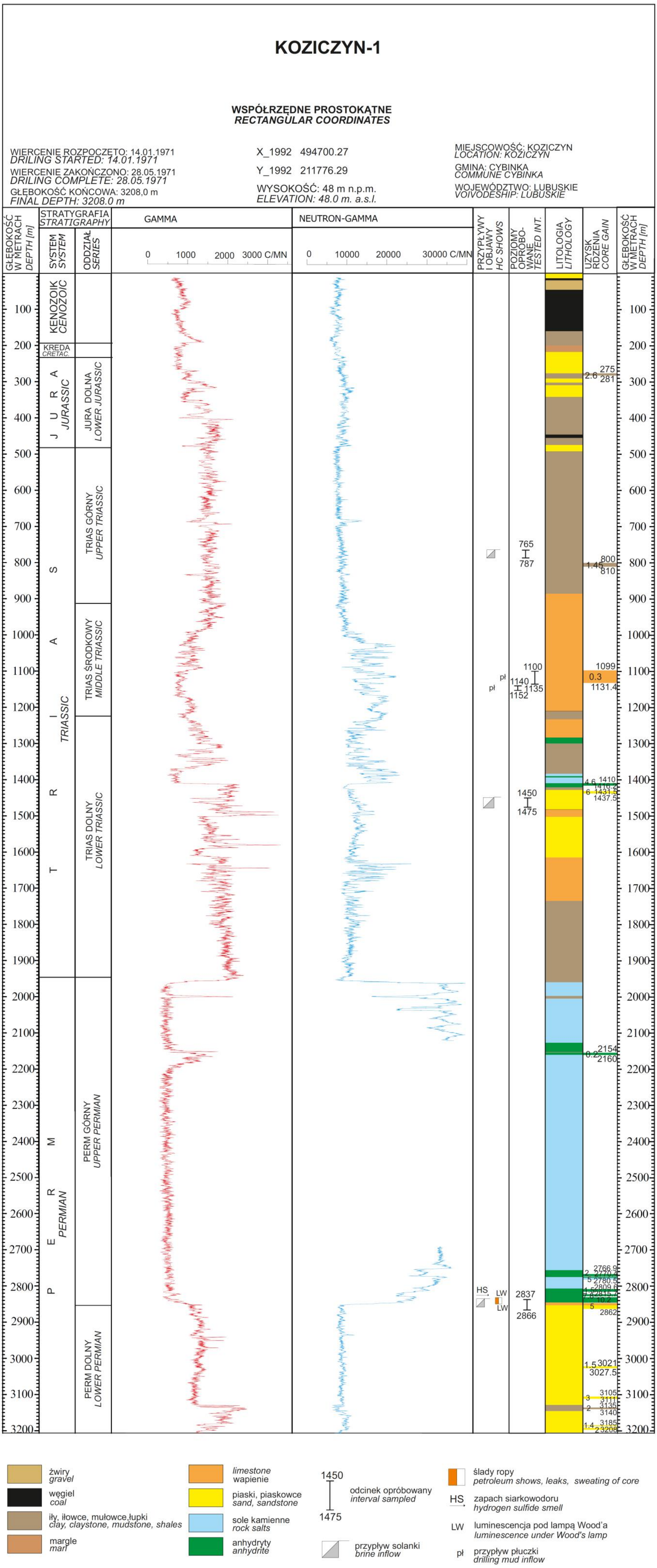


Fig. 5.3. Koziczyn-1 well lithology, stratigraphy and geophysics (Żurawik and Tubielewicz, 1972).

6. SEISMIC SURVEYS

LINE NAME	YEAR	PROJECT	OWNER	LENGTH [km]
T0150876	1976	Kostrzyń-Skwierzyna	State Treasury	14.14
TA150876	1976	Kostrzyń-Skwierzyna	State Treasury	6.72
TB150876	1976	Kostrzyń-Skwierzyna	State Treasury	10.79
T0050477	1977	Sulęcin-Świebodzin	State Treasury	2.45
T0060477	1977	Sulęcin-Świebodzin	State Treasury	12.68
T0080477	1977	Sulęcin-Świebodzin	State Treasury	2.76
T0100477	1977	Sulęcin-Świebodzin	State Treasury	3.18
T0750477	1977	Cybinka-Nowa Sól	State Treasury	6.71
T0040478	1978	Cybinka-Nowa Sól	State Treasury	12.27
T0520478	1978	Cybinka-Nowa Sól	State Treasury	27.2
T0540478	1978	Cybinka-Nowa Sól	State Treasury	2.89
T0750478	1978	Cybinka-Nowa Sól	State Treasury	15.9
T0800478	1978	Cybinka-Nowa Sól	State Treasury	8.47
T0820478	1978	Cybinka-Nowa Sól	State Treasury	19.68
T0200383	1983	Świebodzin-Zielona Góra-Nowa Sól	State Treasury	5.88
T0170384	1984	Świebodzin-Zielona Góra-Nowa Sól	State Treasury	5.64
T0290784	1984	Świebodzin-Zielona Góra-Nowa Sól	State Treasury	5.76
T0320785	1985	Świebodzin-Zielona Góra-Nowa Sól	State Treasury	5.89
TA100785	1985	Świebodzin-Zielona Góra	State Treasury	4.41
T0090686	1986	Rzepin-Krosno Odrzańskie	State Treasury	14.3
T0100686	1986	Rzepin-Krosno Odrzańskie	State Treasury	14.48
T0110686	1986	Rzepin-Krosno Odrzańskie	State Treasury	17.06
T0120686	1986	Rzepin-Krosno Odrzańskie	State Treasury	8.05
T0130686	1986	Rzepin-Krosno Odrzańskie	State Treasury	13.18
T2110686	1986	Rzepin-Krosno Odrzańskie	State Treasury	4.42
T0030687	1987	Rzepin-Krosno Odrzańskie	State Treasury	19.75
T0040687	1987	Rzepin-Krosno Odrzańskie	State Treasury	6.17
T0050687	1987	Rzepin-Krosno Odrzańskie	State Treasury	4.45
T0060687	1987	Rzepin-Krosno Odrzańskie	State Treasury	10.43
T0070687	1987	Rzepin-Krosno Odrzańskie	State Treasury	6.38
T0140687	1987	Rzepin-Krosno Odrzańskie	State Treasury	9.57
T0170687	1987	Rzepin-Krosno Odrzańskie	State Treasury	7.93
T0180687	1987	Rzepin-Krosno Odrzańskie	State Treasury	8.93
T0190687	1987	Rzepin-Krosno Odrzańskie	State Treasury	12.33
T0200687	1987	Rzepin-Krosno Odrzańskie	State Treasury	4
T0210687	1987	Rzepin-Krosno Odrzańskie	State Treasury	9.2
T0220687	1987	Rzepin-Krosno Odrzańskie	State Treasury	13.93
T0230687	1987	Rzepin-Krosno Odrzańskie	State Treasury	13.73
T0240687	1987	Rzepin-Krosno Odrzańskie	State Treasury	15.84
T0280687	1987	Rzepin-Krosno Odrzańskie	State Treasury	8.56
T0290687	1987	Rzepin-Krosno Odrzańskie	State Treasury	5.64
TA200687	1987	Rzepin-Krosno Odrzańskie	State Treasury	15.89
T0010688	1988	Rzepin-Krosno Odrzańskie	State Treasury	19.71
T0020688	1988	Rzepin-Krosno Odrzańskie	State Treasury	6.61
T0150688	1988	Rzepin-Krosno Odrzańskie	State Treasury	9.15
T0160688	1988	Rzepin-Krosno Odrzańskie	State Treasury	6.19
T0210688	1988	Rzepin-Krosno Odrzańskie	State Treasury	15.3
T0220688	1988	Rzepin-Krosno Odrzańskie	State Treasury	10.81
T0230688	1988	Rzepin-Krosno Odrzańskie	State Treasury	11.74
T0320688	1988	Rzepin-Krosno Odrzańskie	State Treasury	9.27
T0820688	1988	Rzepin-Krosno Odrzańskie	State Treasury	12.26
T0860688	1988	Rzepin-Krosno Odrzańskie	State Treasury	10.59
T0990688	1988	Rzepin-Krosno Odrzańskie	State Treasury	13.07
T1010688	1988	Rzepin-Krosno Odrzańskie	State Treasury	13.8
T1020688	1988	Rzepin-Krosno Odrzańskie	State Treasury	13.66
T1030688	1988	Rzepin-Krosno Odrzańskie	State Treasury	12.84

T1040688	1988	Rzepin-Krosno Odrzańskie	State Treasury	13.13
TB240688	1988	Rzepin-Krosno Odrzańskie	State Treasury	2.13
T0100689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	9.86
T0110689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	8.54
T0120689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	12.79
T0130689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	15.7
T0150689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	12.58
T0160689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	17.12
T0170689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	17.78
T0180689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	16.89
T0190689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	16.43
T0200689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	8.49
T0210689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	13.76
T0220689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	8.39
T0230689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	4.6
T0250689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	16.71
T0260689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	14.41
T0270689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	17.48
T0280689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	11.95
T0830689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	10.26
T0840689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	11.25
T0870689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	11.7
T0880689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	11.22
T0890689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	10.63
T0900689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	4.2
T0910689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	5.23
T0940689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	5.37
T0950689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	5.5
T0960689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	7.34
T0970689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	4.4
T0980689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	4.39
T1080689	1989	Rzepin-Krosno Odrzańskie	ORLEN S.A.	2.73
T0140690	1990	Rzepin-Krosno Odrzańskie	ORLEN S.A.	19.16
T0290690	1990	Rzepin-Krosno Odrzańskie	ORLEN S.A.	13.71
T0300690	1990	Rzepin-Krosno Odrzańskie	ORLEN S.A.	12.18
T0810690	1990	Rzepin-Krosno Odrzańskie	ORLEN S.A.	4.99
T0820690	1990	Rzepin-Krosno Odrzańskie	ORLEN S.A.	5.8
T0830690	1990	Rzepin-Krosno Odrzańskie	ORLEN S.A.	4.97
T0850690	1990	Rzepin-Krosno Odrzańskie	ORLEN S.A.	5.94
T0860690	1990	Rzepin-Krosno Odrzańskie	ORLEN S.A.	4.55
T0870690	1990	Rzepin-Krosno Odrzańskie	ORLEN S.A.	6.05
T0970690	1990	Słubice-Krosno Odrzańskie	ORLEN S.A.	8.63
T1010690	1990	Rzepin-Krosno Odrzańskie	ORLEN S.A.	7
T1020690	1990	Rzepin-Krosno Odrzańskie	ORLEN S.A.	8.4
T1030690	1990	Rzepin-Krosno Odrzańskie	ORLEN S.A.	10.44
T1040690	1990	Słubice-Krosno Odrzańskie	ORLEN S.A.	7.05
T1050690	1990	Słubice-Krosno Odrzańskie	ORLEN S.A.	8.75
T1060690	1990	Słubice-Krosno Odrzańskie	ORLEN S.A.	5.89
T1070690	1990	Słubice-Krosno Odrzańskie	ORLEN S.A.	10.23
T0010691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	4.87
T0020691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	11.7
T0030691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	8.08
T0040691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	12.54
T0050691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	9.04
T0060691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	10.02
T0070691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	9.56
T0100691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	7.05
T0110691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	13.44
T0120691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	5.6
T0130691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	8.55

T0140691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	11.3
T0150691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	7.56
T0160691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	6.53
T0170691	1991	Rzepin-Krosno Odrzańskie	ORLEN S.A.	11.86
T1530691	1991	Słubice-Rzepin	ORLEN S.A.	5.15
T1570691	1991	Słubice-Rzepin	ORLEN S.A.	3.48
T0010692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	6.54
T0020692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	7
T0030692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	7.41
T0040692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	5.29
T0050692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	5.76
T0060692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	5.67
T0070692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	6.03
T0080692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	7.66
T0090692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	6.5
T0130692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	9.03
T0140692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	8.8
T0150692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	6.04
T0160692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	5.68
T0170692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	5.28
T0180692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	9.91
T0190692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	5.71
T0200692	1992	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	5.63
T0210692	1992	Cybinka-Krosno Odrzańskie	ORLEN S.A.	6.61
T0220692	1992	Cybinka-Krosno Odrzańskie	ORLEN S.A.	10.87
T0240692	1992	Cybinka-Krosno Odrzańskie	ORLEN S.A.	7.5
T0250692	1992	Cybinka-Krosno Odrzańskie	ORLEN S.A.	3.5
T1250692	1992	Krosno Odrzańskie-Świebodzin	ORLEN S.A.	3.08
T1300692	1992	Krosno Odrzańskie-Świebodzin	ORLEN S.A.	3.54
T1310692	1992	Krosno Odrzańskie-Świebodzin	ORLEN S.A.	5.72
T5330692	1992	Krosno Odrzańskie-Świebodzin	ORLEN S.A.	2.11
T0810293	1993	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	5.55
T0820293	1993	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	6.8
T0830293	1993	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	4.1
T0880293	1993	Cybinka-Krosno Odrz.-Gubin	ORLEN S.A.	5.64
T0110595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	5.24
T0120595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	17.36
T0130595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	14.52
T0140595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	4.18
T0150595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	6.61
T0160595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	13.2
T0170595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	20.03
T0180595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	14.33
T0190595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	6.22
T0200595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	11.15
T0210595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	9.83
T0220595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	9
T0230595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	8.65
T0240595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	8.23
T0250595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	3.49
T0270595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	11.45
T0280595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	10.47
T0290595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	8.35
T0300595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	8.08
T0310595	1995	Słubice-Krosno Odrzańskie	ORLEN S.A.	9.97
T0210696	1996	Słubice-Krosno Odrzańskie	ORLEN S.A.	3.62
T0220696	1996	Słubice-Krosno Odrzańskie	ORLEN S.A.	8.88
T0230696	1996	Słubice-Krosno Odrzańskie	ORLEN S.A.	9.78
T0240696	1996	Słubice-Krosno Odrzańskie	ORLEN S.A.	9.43
T0250696	1996	Słubice-Krosno Odrzańskie	ORLEN S.A.	8.83

T0600596	1996	Słubice-Krosno Odrzańskie	ORLEN S.A.	14.18
T0010597	1997	Słubice-Krosno Odrzańskie	ORLEN S.A.	8.9
T0020597	1997	Słubice-Krosno Odrzańskie	ORLEN S.A.	15.12
T0030597	1997	Słubice-Krosno Odrzańskie	ORLEN S.A.	9.57
T0040597	1997	Słubice-Krosno Odrzańskie	ORLEN S.A.	9.17
T0310497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	13.94
T0320497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	14.6
T0330497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	13.52
T0340497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	8.7
T0350497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	19.29
T0360497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	12.39
T0370497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	11.91
T0380497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	11.3
T0390497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	13.29
T0400497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	10.7
T0410497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	14.68
T0420497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	10.54
T0430497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	8.47
T0440497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	5.03
T0470497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	29.97
T0480497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	4.17
T0510497	1997	Cybinka-Świebodzin-Krosno Odrz.	ORLEN S.A.	7.07
			State Treasury	597.9
			ORLEN S.A.	1294.14

Tab. 6.1. 2D seismic surveys (lines longer than 2 km) within the Cybinka-Torzym tender area.

NAME	YEAR	CONCESSIONS (after 2001)	OWNER	ACREAGE [km^2]
Gryżyna 3D	1999		ORLEN S.A.	3.38
Ołobok-Radoszyn 3D	2003	Krosno Odrzańskie-Świebodzin 23/95/p Świebodzin-Wolsztyn 24/95/p	State Treasury	15.22
Cybinka-Torzym 3D	2010	Cybinka 6/2008/p Torzym 8/2008/p	State Treasury	225.94
			State Treasury	241.16
			ORLEN S.A.	3.38

Tab. 6.2. 3D seismic surveys within the Cybinka-Torzym tender area.

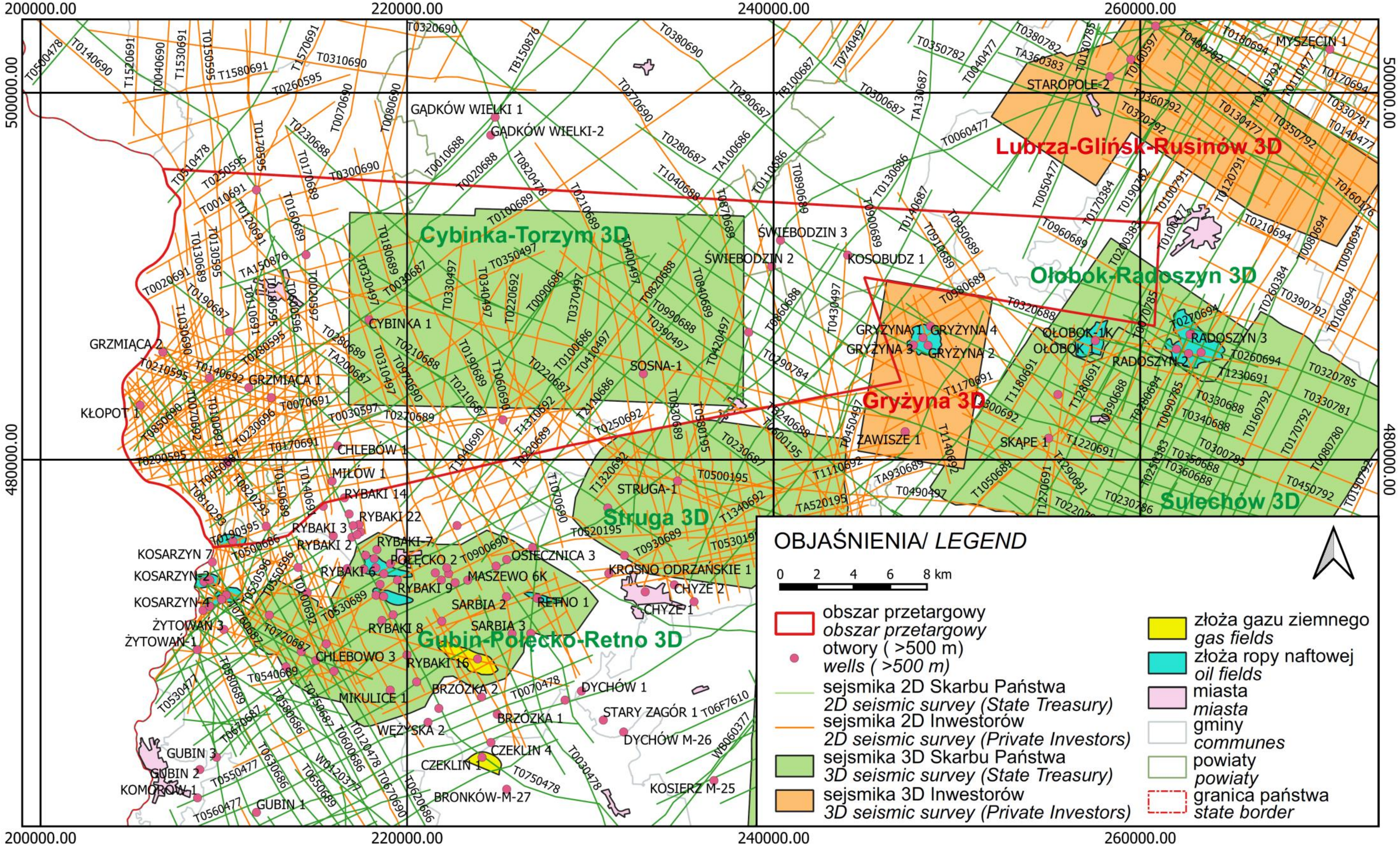


Fig. 6.1. Seismic survey within and in the neighborhood of the Cybinka-Torzym tender area (CGDB, 2023).

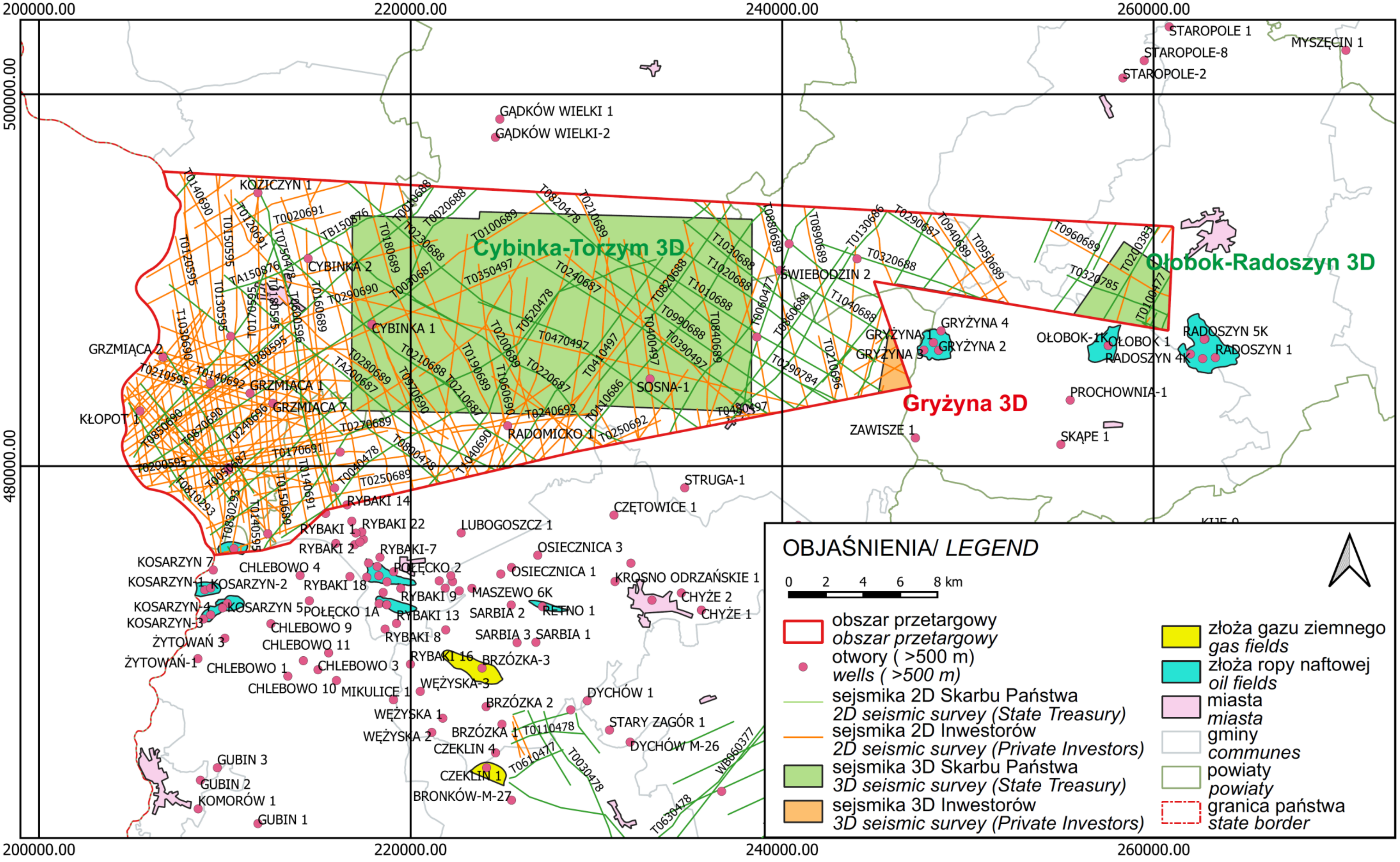


Fig. 6.2. Seismic survey within the Cybinka-Torzym tender area (CGDB, 2023).

7. GRAVIMETRY, MAGNETOMETRY AND MAGNETOTELLURICS

7.1. GRAVIMETRY

Semidetailed gravimetric surveys in the Cybinka-Torzym tender area and in its close neighbourhood were collected with a point density c.a. 5.5 stations/km^2 (Fig. 7.1). All data are available in the CGDB (2023). There are 3742 data points within the tender area coming from the Gubin-Zielona Góra survey (Pisuła and Ostrowski, 1990).

There are some detailed surveys in the tender area too. One of them, the Krosno Odrzańskie survey (Bochnia and Duda, 1972) at the south border of the tender area was collected with an irregular point distribution, with density of ca. 30 stations/km^2. It was focused on halokinetic structures in Main Dolomite. Two detailed profiles crossing the tender area were collected with 250 m (Reczek, 1962). Some profiles in close neighbourhood of the Cybinka-Torzym tender area were focused on lignite exploration (Okulus, 1980; Łaszczyńska et al., 1982).

Królikowski and Petecki (1995) proposed a division of Poland into several gravity regions. Thus, the Cybinka-Torzym tender area is placed within north-west part of the Silesia High – the so called Krosno-Ostrzeszów High, covering the Fore-Sudetic Monocline without the north-western part and the Fore-Sudetic Block. The origin of the regional anomaly in the Fore-Sudetic Monocline is most often associated with the elevation of the Moho and metamorphic Cambrian-Devonian deposits cause second-order anomalies (Królikowski and Grobelny 1991; Królikowski and Petecki, 1995).

7.2. MAGNETOMETRY

Eastern part of the Cybinka-Torzym tender area is covered with the Fore-Sudetic monocline semidetailed survey (Pasik, 1974). The survey has an average density of 1 station/km^2. There is more dense (3 stations/km^2) and newer survey at western part of the tender area (Kosobudzka, 1991). An image of magnetic anomalies presented on Fig. 7.4 is taken from magnetic map of Poland (Petecki and Rosowiecka, 2017). The map is divided into several regions with different magnetic characteristic. The Cybinka-Torzym tender area is located within north-western part of the Sudetic domain (Sd). One of the most prominent magnetic feature in the N part of Sd is a zone of positive anomalies trending NW-SE (appearing in the southern part of the Cybinka-Torzym tender area). These anomalies are related to the sub-Permian Wolsztyn-Leszno High. As part of another study (Cieśla et al., 1997), maps of anomalous elements of both potential fields (linear and structural) were developed. The results are presented in Fig. 7.5.

7.3. MAGNETOTELLURICS

In the years 2007-2008, the first stage of the project of magnetotelluric works was carried out in the region of the Pomeranian segment of the Mid-Polish Trough (Miecznik and Stefaniuk, 2005). This stage involved taking measurements on two profiles, BMT-5 and D-PL. The first crosses the Cybinka-Torzym tender area (Figs 7.6–7.7). This profile is 300 km long and runs along the line of the P2 DSS profile (POLONAISE'97 program). The results are presented as resistance sections with geological interpretation on a horizontal scale of 1 : 500,000. Based on the magnetotelluric, seismic and borehole results, a geophysical and geological model of the sedimentary cover was developed along the BMT-5 profile (Dziewińska in: Stefaniuk et al., 2008, Fig. 7.7).

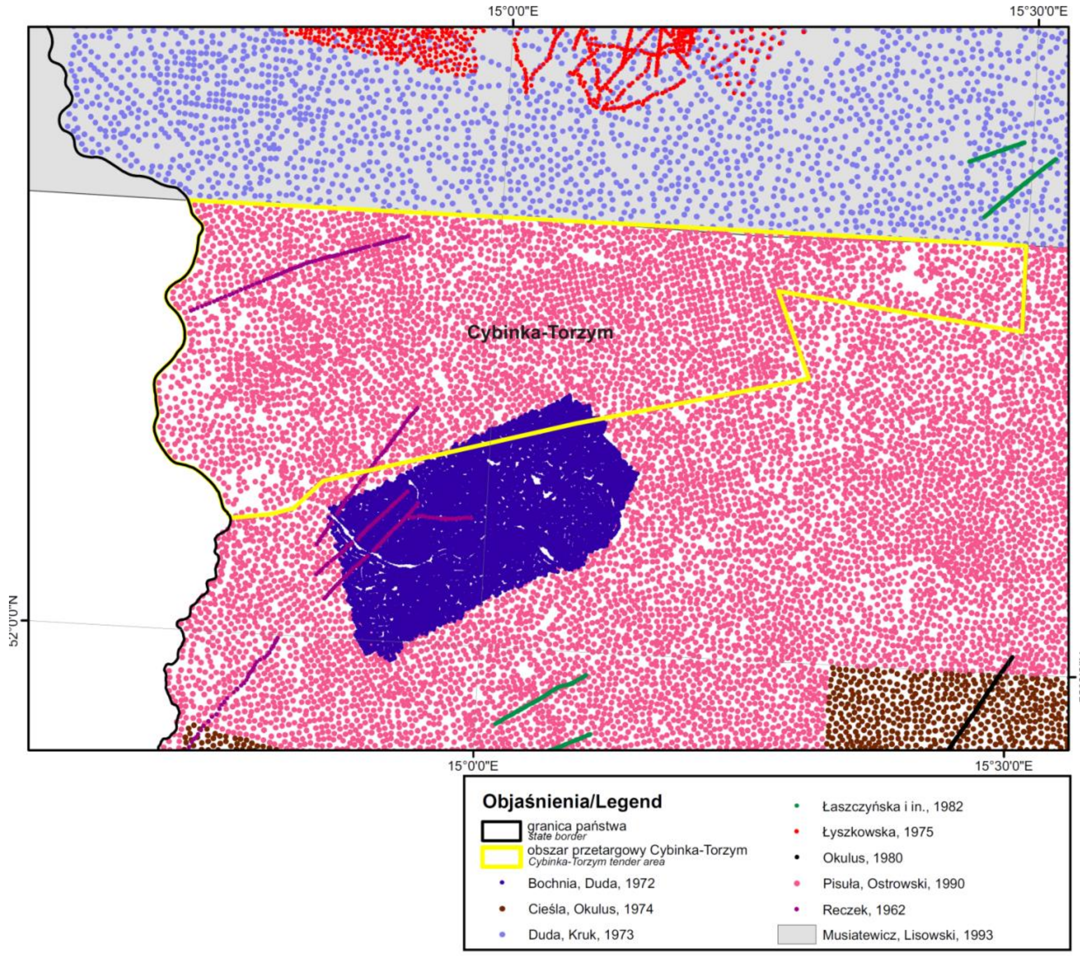


Fig. 7.1. Distribution of gravimetric measurements in the Cybinka-Torzym tender area (CGDB, 2023).

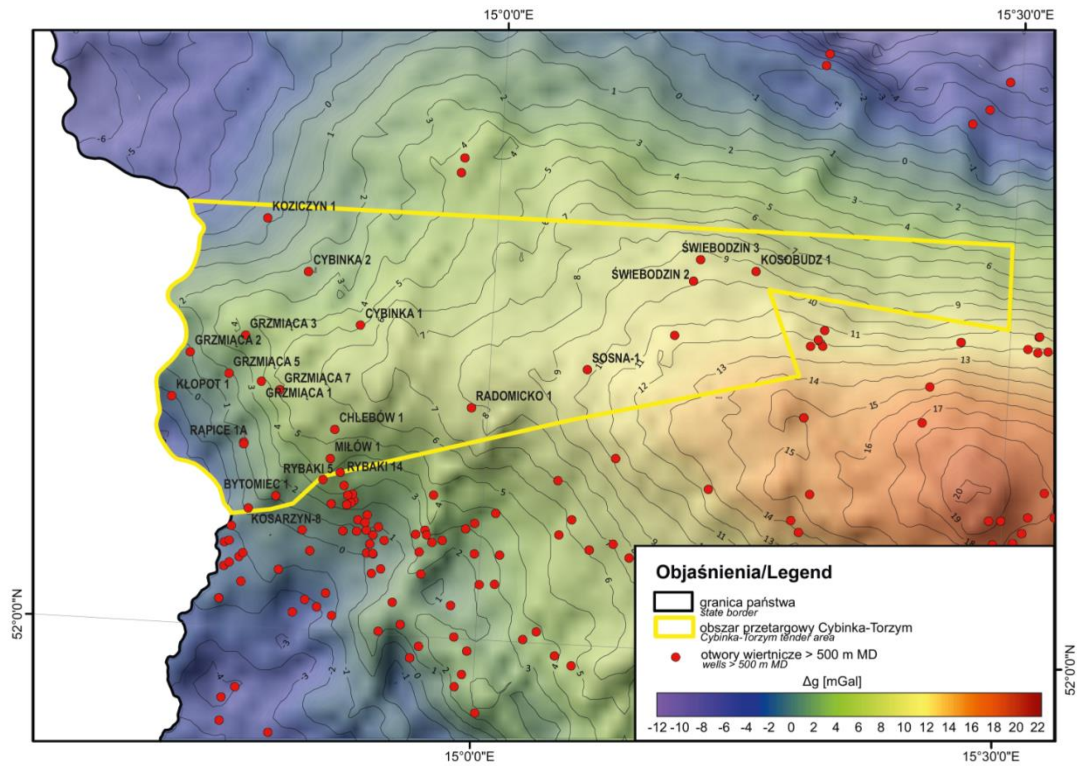


Fig. 7.2. Location of the Cybinka-Torzym tender area on the Bouguer gravity anomaly map of Poland (Królikowski and Petecki, 1995).

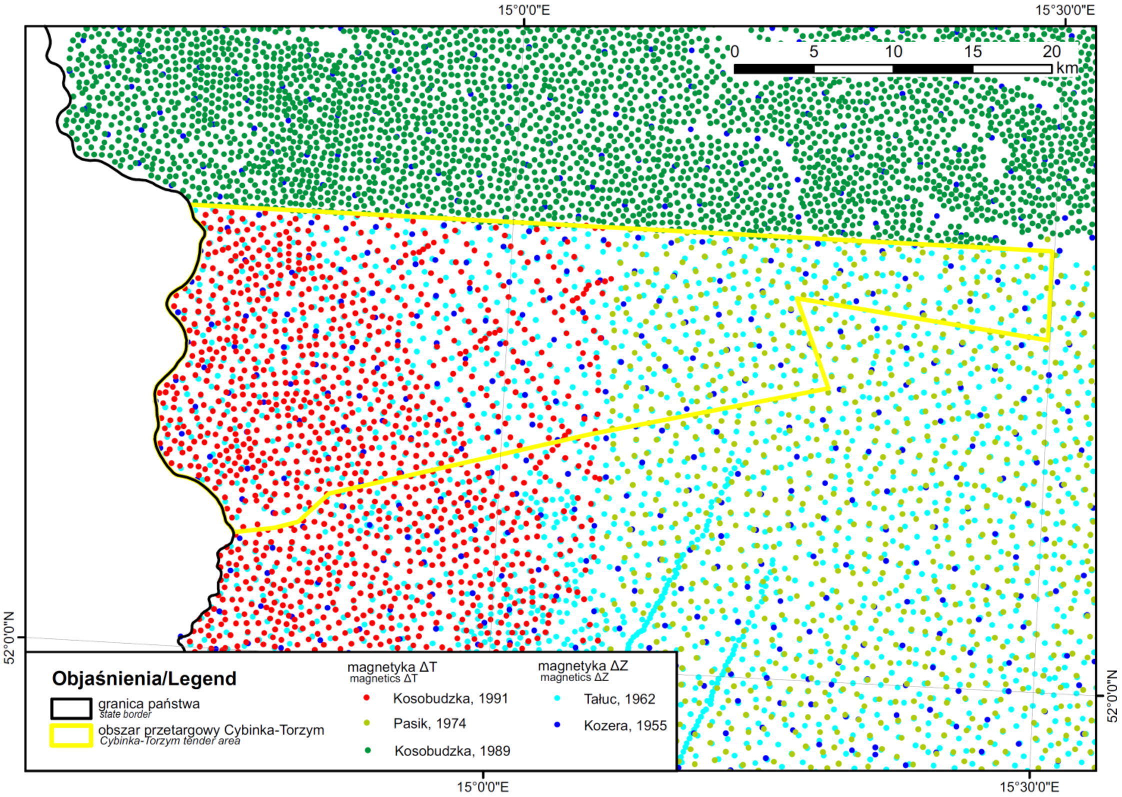


Fig. 7.3. Distribution of magnetic stations in the Cybinka-Torzym tender area (CGDB, 2023).

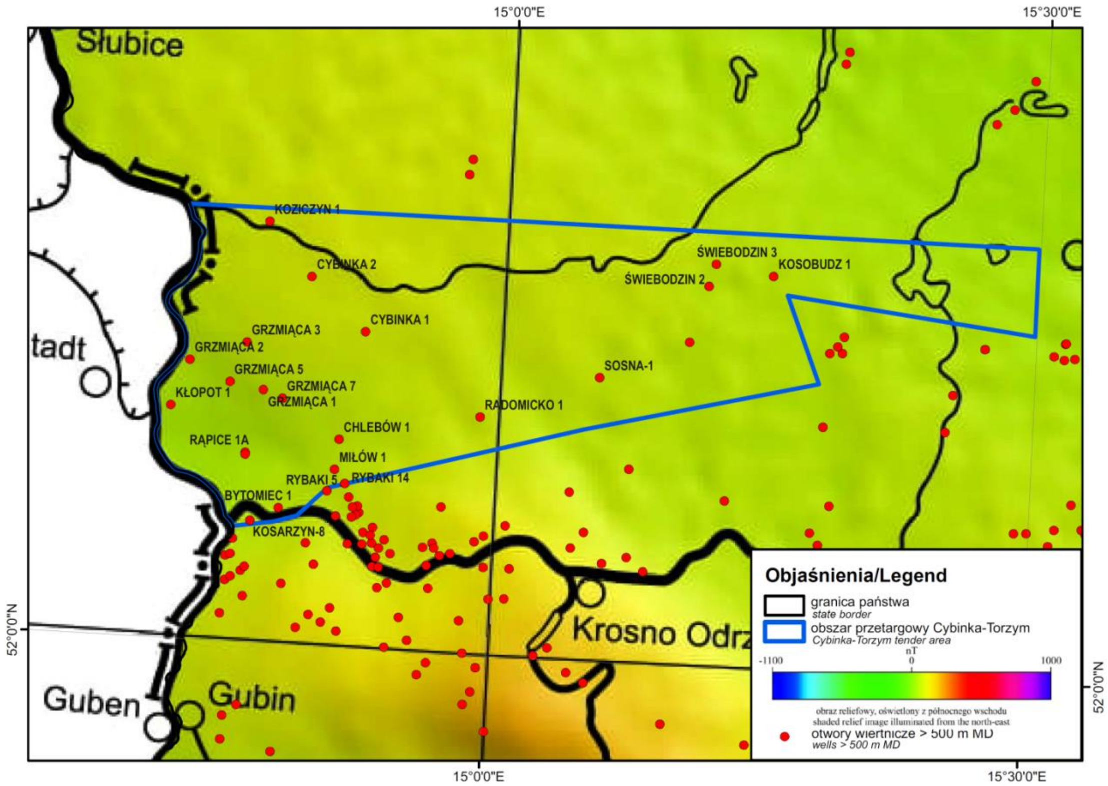


Fig. 7.4. Location of the Cybinka-Torzym tender area on the Magnetic anomaly map of Poland (Petecki and Rosowiecka, 2017).

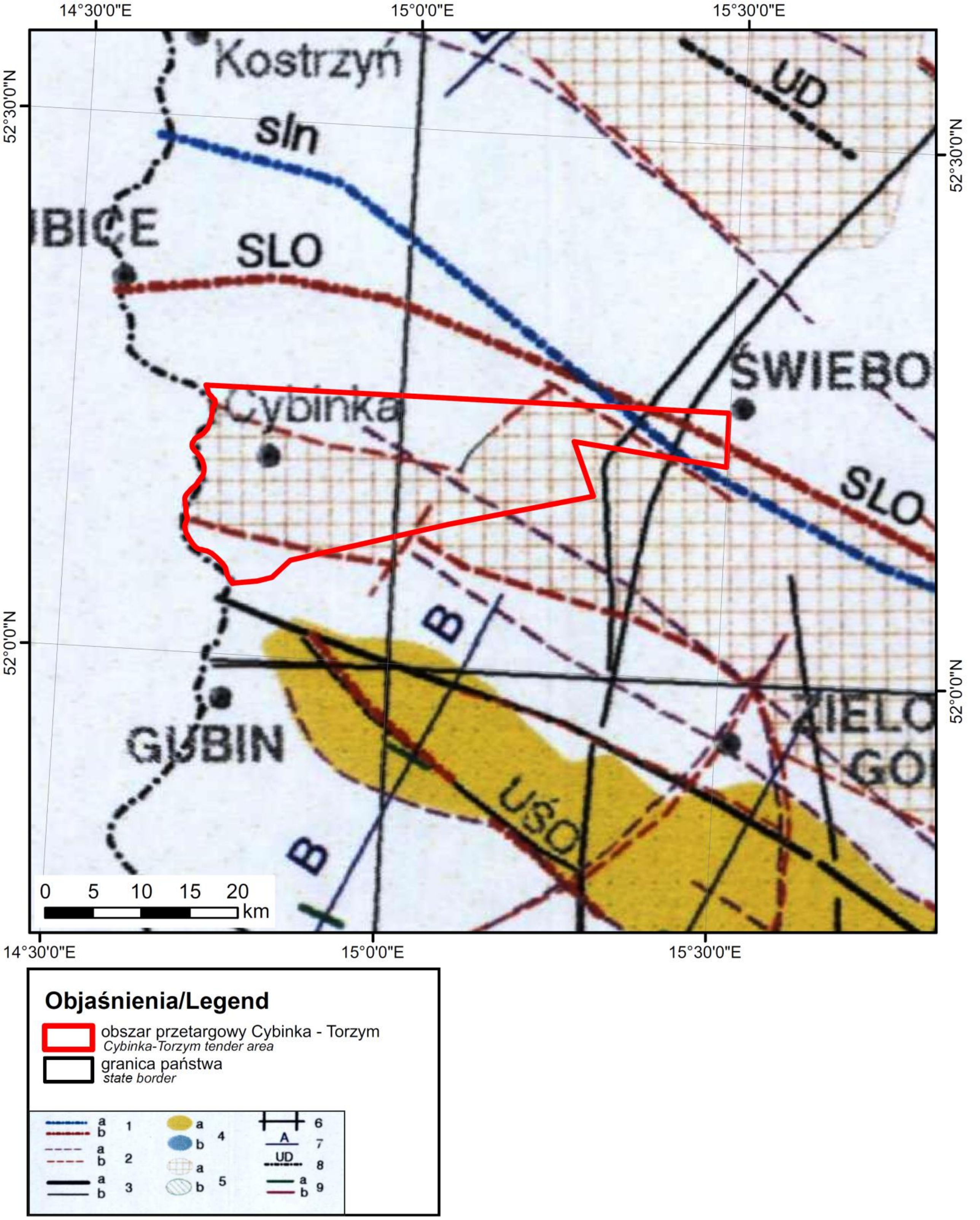


Fig. 7.5. Linear and structural elements interpreted on the basis of magnetic and gravimetry surveys (Cieśla et al., 1997). 1 – boundaries of larger geophysical and geological units on the basis of a – magnetic survey (small letters), b – gravimetry (capital letters); 2 – the most important discontinuities (contacts and/or dislocations) on the basis of a – magnetic survey, b – gravimetry; 3 – linear elements on the basis of a – boundaries of structural units, b – main faults and faut zones; 4 – blocks investigated on the basis of magnetic survey: a – with higher values of magnetic properties, b – with lower values of magnetic properties; 5 – blocks interpreted on basis of gravimetry: a – with higher density, b – with lower density; 6 –S-part of VII DSS profile with the mark of the positions of deep faults; 7 – interpreted profiles; 8 – Dolsk Fault; 9 – borders on the basis of modeling: a – dislocations (gravimetry), b – magnetic contacts.

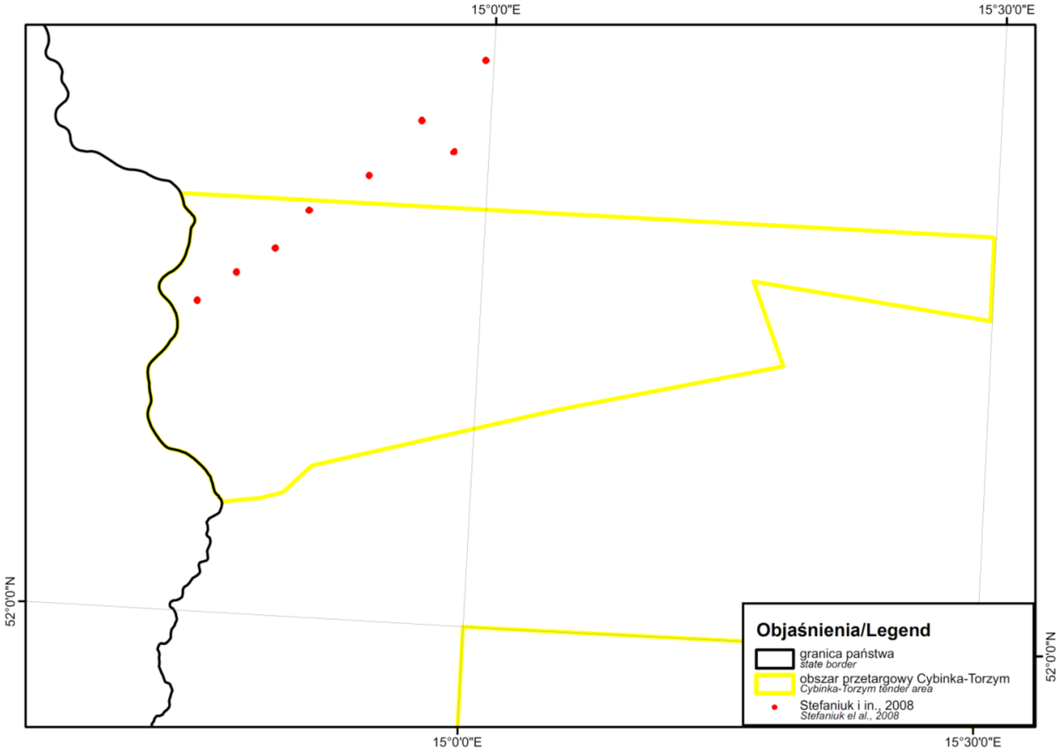


Fig. 7.5. Distribution of magnetotelluric survey in the Cybinka-Torzym tender area (CGDB, 2023).

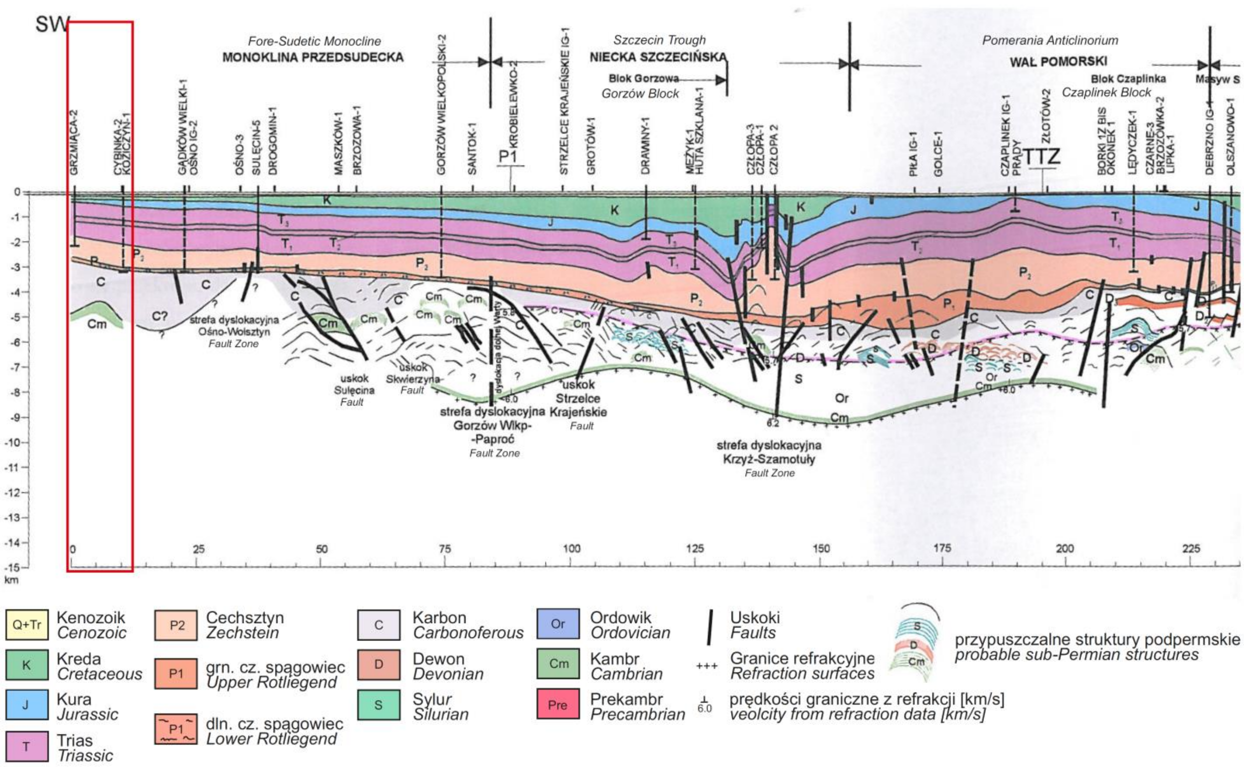


Fig. 7.7. Geophysical-geological model of sedimentary cover along the BMT-5 section (Dziewińska, in: Stefaniuk et al., 2008). The segment adjacent to the Cybinka-Torzym tender area is marked with red polygon.

8. SUMMARY CHART

General information:	**Tender area:**	**CYBINKA-TORZYM**
	Location:	Onshore Hydrocarbon concession blocks: 222, 223 Administrative location: Lubuskie Voivodeship, Krosno Odrzańskie county, communes: Gubin (0.32%), Bytnica (19.30%), Maszewo (22.09%), Krosno Odrzańskie (0.23%); Słubice county, commune Cybinka (31.52%); Sulęcin county, commune Torzym (8.45%); Świebodzin county, communes: Skąpe (1.83%), Łagów (9.75%), Świebodzin (3.66%), Lubrza (2.85%)
	Concession type:	prospection and exploration of hydrocarbon deposits and production of hydrocarbons from a deposit
	Time:	concession for 30 years, including: prospection and exploration phase (5 years), production phase – after investment decision
Participation:		winner of the tender 100%
Acreage [km^2]:		668.50
Accumulation type:		conventional oil and gas fields
Structural stages:		Cenozoic, Laramide, Variscan
Petroleum plays:		Conventional in Main Dolomite
Reservoir rocks:		Main Dolomite dolomitized grainstones and packstones
Source rocks:		Main Dolomite mudstones, boundstones, packstones and grainstones
Seal rocks:		Zechstein evaporites PZ1 and PZ2
Trap type:		structural, structural-stratigraphic
Oil and gas fields:		Kosarzyn N, Radoszyn, Ołobok, Gryżyna, Rybaki
Seismic surveys (owner):		1976 Kostrzyń-Skwierzyna 2D, 3 lines (State Treasury) 1977 Sulęcin-Świebodzin 2D, 4 lines (State Treasury) 1977-1978 Cybinka-Nowa Sól 2D, 7 lines (State Treasury) 1983-1985 Świebodzin-Zielona Góra-Nowa Sól 2D, 4 lines (State Treasury) 1985 Świebodzin-Zielona Góra 2D, 1 line (State Treasury) 1986-1991 Rzepin-Krosno Odrzańskie 2D, 96 lines (ORLEN S.A., State Treasury) 1990 Słubice-Krosno Odrzańskie 2D, 5 lines (ORLEN S.A.) 1991 Słubice-Rzepin 2D, 2 lines (ORLEN S.A.) 1992-1993 Cybinka-Krosno Odrzańskie-Gubin 2D, 21 lines (ORLEN S.A.) 1992 Cybinka-Krosno Odrzańskie 2D, 4 lines (ORLEN S.A.) 1992 Krosno Odrzańskie-Świebodzin 2D, 4 lines (ORLEN S.A.) 1995 Słubice-Krosno Odrzańskie 2D, 30 lines (ORLEN S.A.) 1997 Cybinka-Świebodzin-Krosno Odrzańskie 2D, 17 lines (ORLEN S.A.) 1999 Gryżyna 3D, 3.38 km^2 (ORLEN S.A.) 2003 Ołobok-Radoszyn 3D, 15.22 km^2 (State Treasury) 2010 Cybinka-Torzym 3D, 225.94 km^2 (State Treasury)
Wells (depth):		BYTOMIEC-1 (2240.0 m) CHLEBÓW 1 (2135.0 m) CYBINKA 1 (2586.0 m) CYBINKA 2 (2617.0 m) GRZMIĄCA 1 (2155.0 m) GRZMIĄCA 2 (2129.0 m) GRZMIĄCA 3 (2634.0 m) GRZMIĄCA 5 (2020.0 m) GRZMIĄCA 7 (2120.0 m) KŁOPOT 1 (2125.0 m) KOSARZYN-8 (1828.0 m) KOSOBUDZ 1 (2974.0 m) KOZICZYN-1 (3208.0 m) MIŁÓW 1 (2401.0 m) RADOMICKO 1 (2138.0 m) RĄPICE 1A (2402.0 m) RYBAKI 5 (1988.0 m) RYBAKI 14 (2022.6 m) SOSNA-1 (2455.0 m) ŚWIEBODZIN-1 (1503.0 m) ŚWIEBODZIN 2 (1998.0 m) ŚWIEBODZIN 3 (2804.0 m)

Possible minimum work program for the prospection and exploration phase

- Archival data reinterpretation and analysis

- Drilling of one well to the maximal depth 5000 m TVD with obligatory coring of prospective intervals

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