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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

BLOCK 413-414

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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Project manager:
Krystian WÓJCIK

NATIONAL FUND
FOR ENVIRONMENTAL PROTECTION
AND WATER MANAGEMENT

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Warsaw, 2023

1. GENERAL INFORMATION
1.1. LOCATION

The Block 413-414 tender area of 666.2 km^2 is located onshore in southern Poland (concession blocks 413 and 414; Fig. 1.1). The precise location is defined by geographic coordinates listed below.

Border points	1992 coordinate system	
	X	Y
1	224429.40	619471.74
2	219734.09	619456.21
3	219733.92	619454.87
4	210523.09	619421.78
5	210260.58	608022.58
6	209660.93	572015.80
7	224085.46	571823.28
8	224239.14	593113.46
9	223753.00	592883.00
10	222376.00	593612.00
11	222475.00	595313.00
12	223236.00	595405.00
13	223368.00	594800.00
14	224247.38	594254.96
15	224314.01	603486.16
Excluding the area defined by points 16–29		
16	221091.02	600645.13
17	220797.73	601652.77
18	220844.14	603391.19
19	220125.97	603450.34
20	219833.40	602978.16
21	220557.32	602379.11
22	219798.82	601679.44
23	219475.76	602687.75
24	220292.07	604055.74
25	220865.93	604200.42
26	221457.15	604634.48
27	222010.11	603619.97
28	221956.85	601621.88
29	221510.53	600634.09

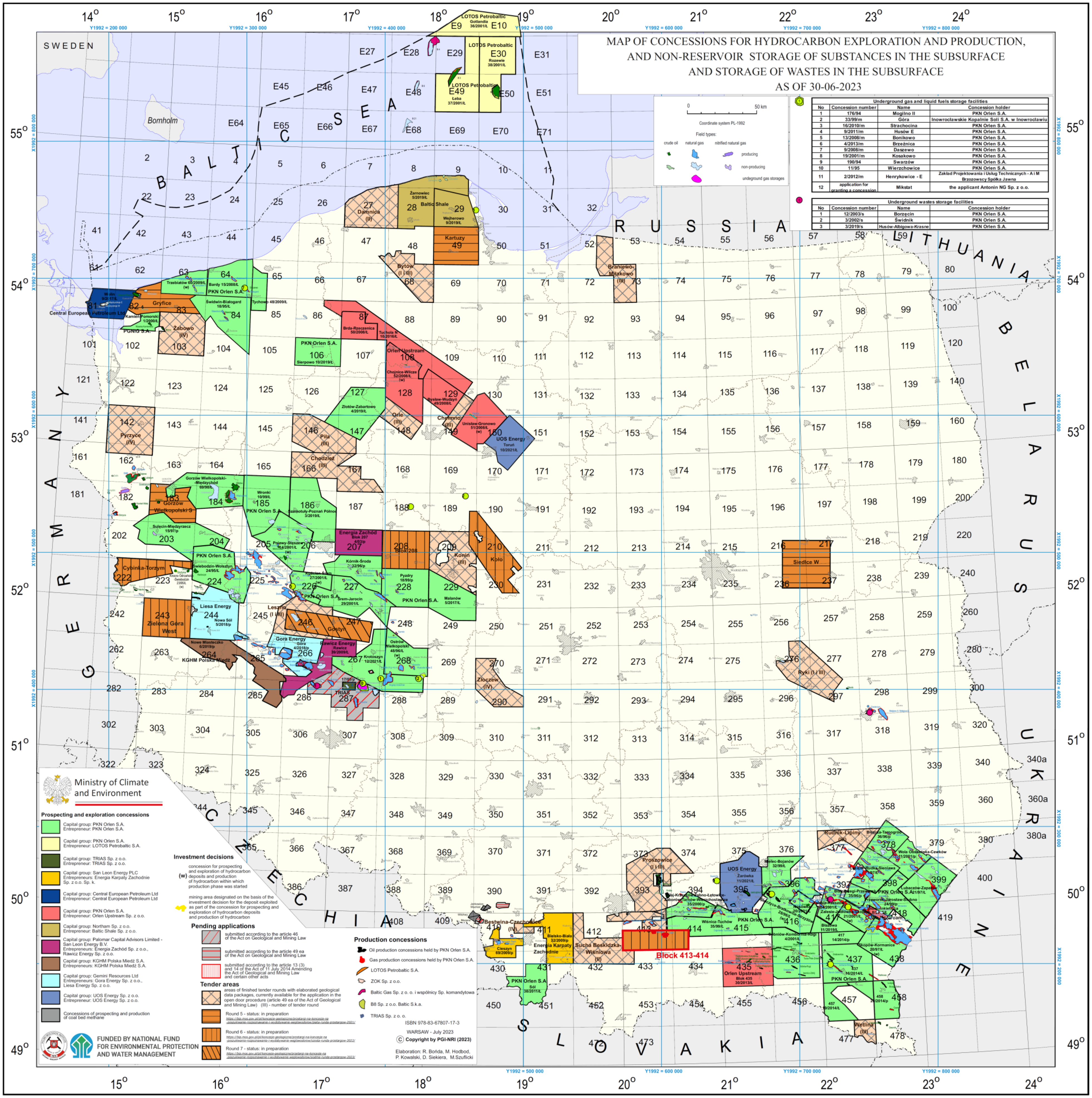
Tab. 1.1. Border points' coordinates of the Block 413-414 tender area (Fig. 1.2).

Some parts of the Block 413-414 tender area were previously subjected to hydrocarbon prospection and exploration concessions No. 43/2010/p Poręba (Energia Karpaty Wschodnie; Aurelian Oil & Gas Poland Sp. z o.o./San Leon Energy Plc.), No. 2/2016/p Poręba-Tarnawa (Orlen Upstream, PKN Orlen S.A.), No. 39/99/p Wysoka-Łapanów (PGNiG S.A.) and No. 25/2001/p Myślenice-Limanowa-Czchów (PGNiG S.A.) Moreover, south-western and northern parts of the block were previously dedicated to the 2nd and 4th tender rounds for hydrocarbon concessions – as components of the Sucha Beskidzka-Wiśniowa and Królówka tender areas, respectively (Fig. 1.2).

Currently, in the vicinity of the tender area, the concession No. 35/99/Ł Wiśnicz-Tuchów (PGNiG S.A. ORLEN S.A. Group) is active (Figs 1.1–1.2).

The Block 413-414 is prospective for exploration of conventional oil and gas fields in the Carpathian basement, Carpathian Foredeep and in the Outer Carpathian Silesian Unit.

→**Fig. 1.1.** Location of the Block 413-414 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
Bornholm
RUSSIA
LITHUANIA
BELARUS
UKRAINE
SLOVAKIA
CZECHIA
GERMANY
Block 413-414
Ministry of Climate and Environment
Prospecting and exploration concessions
Investment decisions
Pending applications
Tender areas
Production concessions
Underground gas and liquid fuels storage facilities
Underground wastes storage facilities
FUNDED BY NATIONAL FUND FOR ENVIRONMENTAL PROTECTION AND WATER MANAGEMENT
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Elaboration: R. Bońda, M. Hodbod, P. Kowalski, D. Siekiera, M. Szuflicki

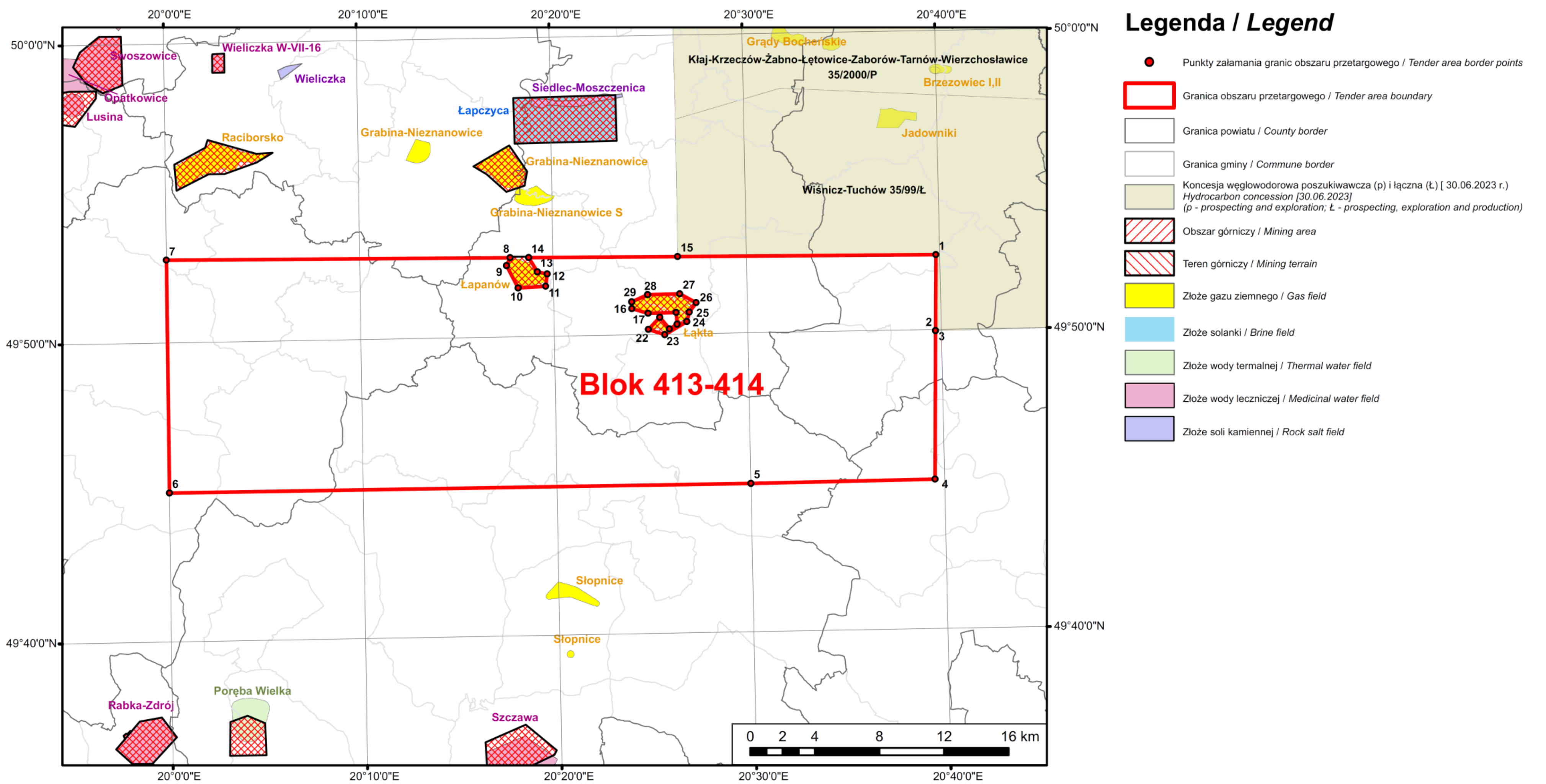

Fig. 1.2. Border points of the Block 413-414 tender area and location of the hydrocarbon concessions and fields of mineral resources in the neighborhood, as of 30-06-2023 (CGDB, 2023).

1.2. ENVIRONMENTAL CONDITIONS

THE ENVIRONMENTAL CONDITIONS DATASHEET FOR TENDER AREA BLOCK 413-414				
1.	LOCATION OF THE TENDER AREA ON THE MAP	1 : 50 000 geological map sheet	Wieliczka 997, Bochnia 998, Brzesko 999, Mszana Dolna 1016, Limanowa 1017, Rożnów 1018	
2.	ADMINISTRATIVE LOCATION	Voivodeship	Małopolskie	
		County	Bochnia	
		The commune and % of the area within the tendering area	Nowy Wiśnicz (2.02%), Łapanów (6.50%), Lipnica Murowana (7.65%), Trzciana (6.35%), Żegocina (5.06%)	
		County	Brzesko	
		Commune	Iwkowa (7.08%), Gnojnik (1.60%), Czchów (4.54%)	
		County	Limanowa	
		Commune	Jodłownik (10.44%), Laskowa (7.23%), Dobra (1.40%), Tymbark (0.37%), Limanowa (5.95%)	
		County	Myślenice	
		Commune	Pcim (1.79%), Wiśniowa (8.66%), Dobczyce (5.34%), Raciechowice (9.17%), Siepraw (0.21%), Myślenice (4.70%)	
		County	Wieliczka	
		Commune	Gdów (0.92%)	
		County	Nowy Sącz	
		Commune	Łososina Dolna (2.86%), Gródek nad Dunajcem (0.16%)	
3.	PHYSIOGRAPHIC REGIONALIZATION (after KONDRACKI, 2013 and SOLON et al., 2018)	Macroregion	Pogórze Wielickie (513.33), Pogórze Wiśnickie (513.34)	
		Mesoregion	Beskidy Zachodnie (513.4)	
		Macroregion	Beskid Makowski (513.48), Beskid Wyspowy (513.49)	
		Mesoregion	Pogórze Środkowobeskidzkie (513.6)	
		Macroregion	Pogórze Rożnowskie (513.61)	
		Mesoregion	Pogórze Wielickie (513.33), Pogórze Wiśnickie (513.34)	
4.	COORDINATES OF THE TENDER AREA BORDER POINTS	PL-1992 [X; Y]	224429.40	619471.74
			219734.09	619456.21
			219733.92	619454.87
			210523.09	619421.78
			210260.58	608022.58
			209660.93	572015.80
			224085.46	571823.28
			224239.14	593113.46
			223753.00	592883.00
			222376.00	593612.00
			222475.00	595313.00
			223236.00	595405.00
			223368.00	594800.00
			224247.38	594254.96
			224314.01	603486.16
			Excluding the area defined by points 16–29	
			221091.02	600645.13
			220797.73	601652.77
			220844.14	603391.19
			220125.97	603450.34
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			220292.07	604055.74
			220865.93	604200.42
			221457.15	604634.48
			222010.11	603619.97
			221956.85	601621.88
			221510.53	600634.09

THE ENVIRONMENTAL CONDITIONS DATASHEET FOR TENDER AREA BLOCK 413-414			
5.	SURFACE OF THE TENDER AREA	[km^2]	666.20
6.	CONCESSION TYPE		prospecting, exploration and production of hydrocarbons
7.	AGE OF HYDROCARBON FORMATION		Carpathian basement, Carpathian Foredeep, Outer Carpathians Silesian Unit
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		Bukowiec (<1%), Kamionna (<1%), Kostrza (<1%)
	Landscape Parks		Wiśnicko-Lipnicki PK (10%)
	Protected landscape areas		OChK Pogórza Ciężkowickiego (<1%), Południowomałopolski OChK (10%), OChK Wschodniego Pogórza Wiśnickiego (13%), OChK Zachodniego Pogórza Wiśnickiego (12%)
	Natura 2000, (Special Area of Conservation, SAC)		PLH120089 Tarnawka (<1%), PLH120087 Łososina (<1%), PLH120046 Kościół w Węglówce (<1%), PLH120052 Ostoje Nietoperzy Beskidu Wyspowego (5%)
	Natura 2000, (Special Bird Protection, SPA)		no
	Nature and landscape complexes		no
	Ecological area	[yes (quantity) / no]	1
	Nature monuments		101 (including 160 objects and 1 tree avenue)
	Documentation positions		0
9.	PROTECTED SOIL	[yes / no]	yes
10.	FOREST COMPLEXES	[yes / no]	yes
11.	PROTECTIVE FORESTS	[yes (% of the total area / no]	55.6 km^2 (8.3%)
12.	CULTURAL HERITAGE FACILITIES Archaeological monuments	[yes (quantity) / no]	yes
		Hillfort	3
		Hamlet	0
		Cemetery	2
		others	2
13.	MAJOR GROUNDWATER RESERVOIRS	[yes (number, name and age of the aquifer) / no]	no only locals: 436 Zbiornik warstw Istebna (Ciężkowice), 443 Raba, 442 Stradomka
14.	PROTECTIVE ZONES OF WATER INTAKE	[yes / no]	yes
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 (sandstones, tilts, sands and gravels)
18.	PROGNOSTIC AND PERSPECTIVE AREAS OF OCCURRENCE OF MINERAL RESOURCES (excluding hydrocarbons)	[yes (type of mineral deposit)/ no]	yes (sandstones, tilts, sands and gravels)
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*	Paulina Kostrz-Sikora, Dominika Kafara	

Tab. 1.3. The environmental conditions datasheet for the Block 413-414 tender area.

→**Fig. 1.3.** Environmental Map of the Block 413-414 area.

PAŃSTWOWY INSTYTUT GEOLOGICZNY
PAŃSTWOWY INSTYTUT BADAWCZY

Mapa środowiskowa obszaru BLOK 413-414

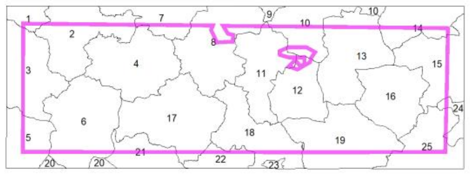
Environmental Map of the BLOCK 413-414 area

Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej

Ministerstwo Klimatu i Środowiska

Położenie obszaru przetargowego na tle podziału administracyjnego

Location of tender area on administrative division map

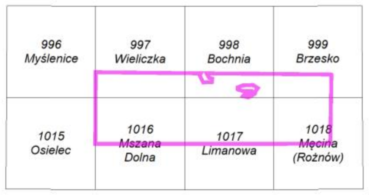


woj. MAŁOPOLSKIE
powiat myślenicki
1 - gm. Siepraw
2 - gm. Dobczyce
3 - gm. Myślenice
4 - gm. Raciechowice
5 - gm. Pcim
6 - gm. Wiśniowa
powiat wielicki
7 - gm. Gdów
powiat bocheński
8 - gm. Łapanów
9 - gm. Bochnia
10 - gm. Nowy Wiśnicz
11 - gm. Trzciana
12 - gm. Żegocina
13 - gm. Lipnica Murowana
powiat brzeski
14 - gm. Gnojnik
15 - gm. Czchów
16 - gm. Iwkowa
powiat limanowski
17 - gm. Jodłownik
18 - gm. Limanowa
19 - gm. Laskowa
20 - gm. Mszana Dolna
21 - gm. Dobra
22 - gm. Tymbark
23 - m. Limanowa
powiat nowosądecki
24 - gm. Gródek nad Dunajcem
25 - gm. Łososina Dolna

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: *Dominika Kafara*
Data compilation and map edition:

Weryfikacja: *Olimpia Kozłowska*
Verification:


Objaśnienia do Mapy środowiskowej obszaru
BLOK 413-414
Legend of the Environmental Map of the BLOCK 314-414 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
piaski i żwiry
sands and gravels
piaskowce
sandstones
żwiry
gravels
gliny
tills
3253
identyfikator z bazy MIDAS złoża małokonfliktowego
ID from the MIDAS database of the small environmental conflict
9848
identyfikator z bazy MIDAS złoża konfliktowego
ID from the MIDAS database of the environmental conflict
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
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
pc
punkt niekoncesjonowanej eksploatacji kopaliny (pc - rodzaj kopaliny)
point of unlicensed exploitation of a mineral (pc - type of mineral)
Symbol kopaliny:
Mineral symbol:
G - gaz ziemny
natural gas
R - ropa naftowa
crude oil
pc - piaskowce
sandstones
g(gc) - gliny ceramiki budowlanej
tills for ceramic
pż - piaski i żwiry
sands and gravels
ż - żwiry
gravels
Symbol jednostki stratygraficznej:
Symbol of the stratigraphic unit:
Q - Czwartorzęd
Quaternary
Ng - Neogen
Neogene
Pg - Paleogen
Paleogene
Cr - Kreda
Cretaceous
J - Jura
Jurassic
C - Karbon
Carboniferous
D - Dewon
Devonian
Cm - Kambr
Cambrian
WODY POWIERZCHNIOWE I PODZIEMNE
SURFACE AND UNDERGROUNG 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
435
granica głównego zbiornika wód podziemnych wraz z jego numerem
principle boundary aquifer with ID number
(443)
granica lokalnego zbiornika wód podziemnych wraz z jego numerem
local boundary aquifer with ID number
granica strefy ochrony ujęcia wód
water intake protected area boundary
Zb. Dobczyce
zbiornik retencyjny wraz z jego nazwą
water reservoir with its name
k
ujęcie wód powierzchniowych (k - komunalne, p - przemysłowe)
surface water intake (k - municipal, p - industrial)
k Q
ujęcie wód podziemnych o wydajności 25 - 50 m³/h
(k - komunalne, p - przemysłowe, Q - wiek ujmowanych utworów)
underground water intake with capacity 25 - 50 m³/h
(k - municipal, p - industrial, Q - age of exploited rocks)
k Q
ujęcie wód podziemnych o wydajności ≥ 50 m³/h
underground water intake with capacity ≥ 50 m³/h
WARUNKI PODŁOŻA BUDOWLANEGO
BUILDING SUBSTRATE CONDITIONS
tereny osuwiskowe i zagrożone ruchami masowymi
landslides and mass movements hazard area
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
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 obszaru chronionego krajobrazu; nazwa obszaru
boundary of protected landscape area; area name
L
granica rezerwatu przyrody (L - leśny)
boundary of natural reserve (L - forests)
N
rezerwat przyrody lub obszar ochrony ścisłej (os) w obrębie parku narodowego o powierzchni ≤ 5 ha (N - przyrody nieożywionej)
boundary of natural reserve or strict nature reserve within national park with area ≤ 5 ha (N - inimate nature)
Obszary Europejskiej Sieci Ekologicznej Natura 2000; kod obszaru
Natura 2000 ecological network; area code
aleja drzew pomnikowych
avenue of monumental trees
n
pomnik przyrody żywej (n - liczba obiektów)
animate nature monument (n - numer of objects)
pomnik przyrody nieożywionej
inanimate nature monument
użytek ekologiczny
ecological area
użytek ekologiczny o powierzchni ≤ 5 ha
ecological area with area ≤ 5 ha
stanowisko dokumentacyjne przyrody nieożywionej
documentation site of inanimate nature
geostanowisko o znaczeniu regionalnym
geosite of regional importance
geostanowisko o znaczeniu lokalnym
geosite of local importance
n
jaskinia lub grupa jaskiń, niezakwalifikowana jako pomnik przyrody (n - liczba obiektów)
cave or group of caves, not qualified as natural monument (n - numer of objects)
obiekt z Listy Światowego Dziedzictwa UNESCO
site from the UNESCO World Heritage List
stanowisko archeologiczne
archeological site
INFORMACJE DODATKOWE
ADDITIONAL INFORMATIONS
granica powiatu
district boundary
granica gminy, miasta
commune or town boundary
S7
oś autostrady lub drogi szybkiego ruchu
highway or express route
WIŚNIOWA
siedziba urzędu gminy, miasta
commune or town office headquarter
sieć gazociągów przesyłowych
natural gas pipeline 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 Block 413-414 tender area has a complicated geology. Various rocks belonging to the Precambrian, Lower Cambrian, Devonian, Carboniferous, Permian, Jurassic, Cretaceous and Miocene were identified here, as well as Mesozoic-Paleogene Carpathian flysch occurs here in an allochthonous position. These formations undergone a complex, multi-stage tectonic evolution. The Precambrian and Paleozoic basement is formed by two tectonic units: Upper Silesian Block and Małopolska Block, separated by the Kraków-Lubliniec Fault Zone (Buła and Habryn, 2008, 2010). Above, the Permian-Mesozoic cover forms the Silesian-Cracow Monocline, which is covered by the autochthonous Miocene of the Carpathian Foredeep and Outer Carpathian flysch (Figs 2.1–2.3).

The Block 413-414 is located in the north-eastern edge of the Upper Silesian Block. The most important part of the crystalline basement is formed by the Archaean-Early Proterozoic Rzeszotary horst. The Paleozoic sedimentary cover is built of the Lower Cambrian clastic rocks, covered by the Middle and Upper Devonian and Lower Carboniferous carbonates, Lower Carboniferous marine clastic rocks (Culm) and Upper Carboniferous continental clastics. The stratigraphic gap from the Middle Cambrian to Lower Devonian is the result of uplift of the south-eastern part of the Upper Silesian Block (Buła and Żaba, 2005; Buła and Habryn, 2010). The Late Carboniferous was a period of increased erosion and intense block tectonics of the Variscan Orogeny.

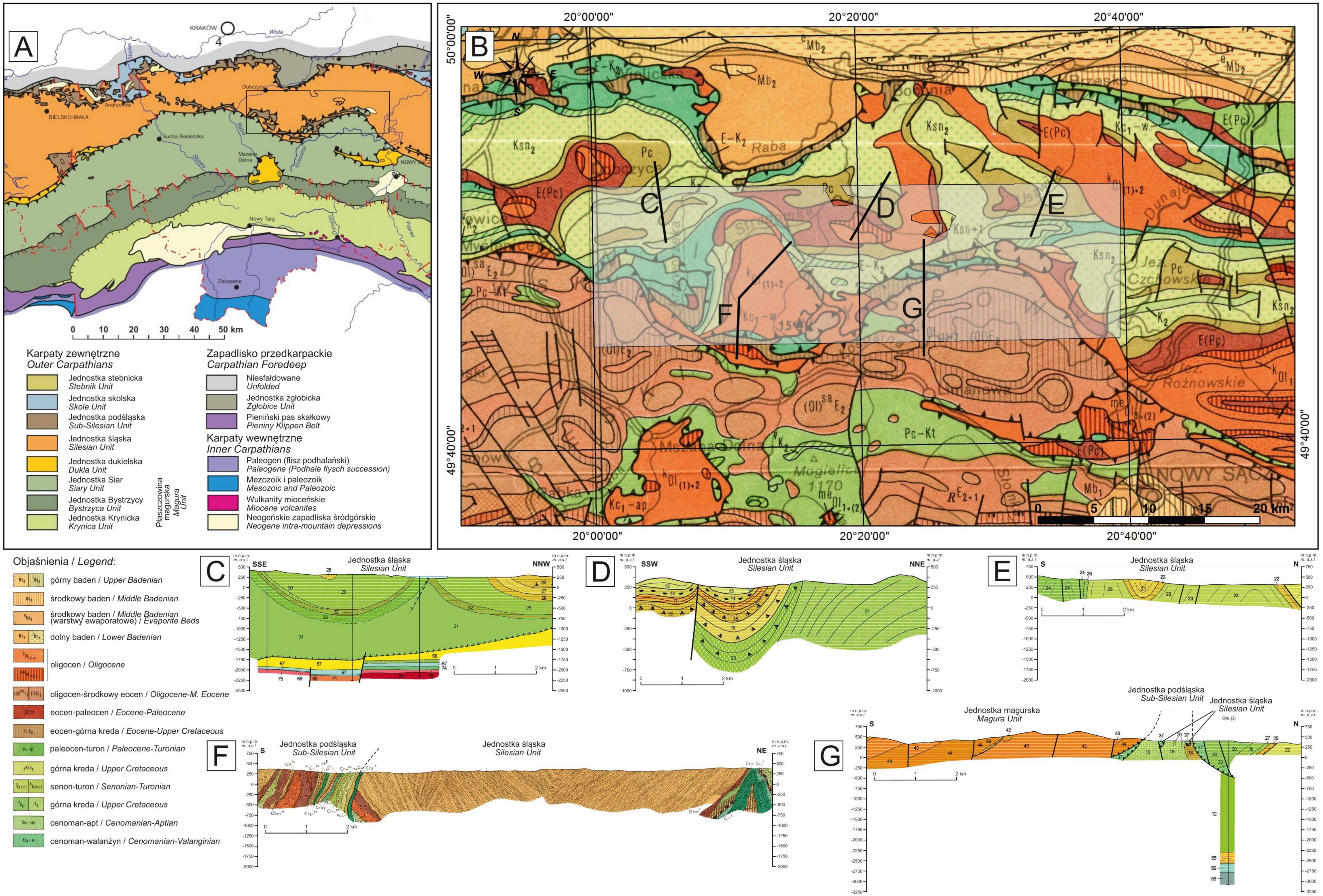
In the central part of the tender area, the Paleozoic formations are overlain by a thick sedimentary succession, often referred to as the Permian-Triassic (Kiersnowski, 2001). The Permian and Lower Triassic were deposited within the Liplas tectonic Trench, which was divided into several smaller sub-basins of different rates of subsidence. In the Late Triassic and Early Jurassic denudation processess peneplenized the area. At the same time, extensive palaeovalleys were formed with accumulation of Middle Jurassic fluvial deposits. The Callovian transgression brought clastic sedimentation, which filled the remaining depressions. The Upper Jurassic (Oxfordian) is dominated by carbonate rocks, although the palaeomorphology still influenced the facies diversity. In the Early Cretaceous, denudation and karstification of Jurassic limestones occurred. Therefore, during the next transgression in the Cenomanian, numerous bays and islands were formed (Konior, 1978). In the Late Cretaceous, the southern part of the area was slowly rised along the reactivated older tectonic faults and denudation of the Mesozoic rocks developed. The Permian-Mesozoic succession was folded during the Laramide tectonic movements: a system of dislocations developed, causing a rapid thinning of the Mesozoic deposits towards the south. The erosional surface formed in this way was covered by the Miocene deposits of the Carpathian Foredeep, which are represented here by the Badenian claystones (Skawina Beds; Chowaniec et al., 2010). The Carpathian flysch formations of the Magura, Silesian and Sub-Silesian Units are overthrusted onto the Carpathian Foredeep Miocene (Żytko et al., 1989; Figs 2.1–2.2).

The Carpathian orogenic prism consists of several tectonic units, which were detached as fragments of Carpathian sedimenraty basin(s) and overthrusted each-other. Contemporary cartographic studies in the tender area and adjacent regions indicate the existence of additional deformation stages transforming the thrusts into complex fault structures (cf. Jankowski, 2015). The Block 413-414, like the entire Outer Carpathian area, undergone many stages of tectonic deformation (Mazzolli et al., 2010; Jankowski and Probulski, 2011; Jankowski, 2015; Jankowski and Margielewski 2021). The Carpathian prism structure was originally arranged in the transpressive regime (oblique collision) and developed as a result of thrusting one unit onto another. However, at least two stages of tectonic development, after the stage of orogenic prism formation, are of significant importance: the strike-slip regime and the orogenic collapse stage (Jankowski et al., 2012; Jankowski and Margielewski 2021). The current view on the evolution of the Carpathian Mountains can be found in

Castellucio et al. (2016; see also Oszczypko, 2004; Ślączka et al., 2006; Fig. 2.5).

The following chapter presents a brief description of individual stratigraphic units. Data from the following wells located within the tender area were used to describe the lithology and stratigraphy: Czchów 1, Dobczyce 5, Iwkowa 1, Jaworzna 1, Kamionna 1, Leszczyna 1, Leszczyna 2, Leszczyna 3, Leszczyna 4, Leszczyna 21, Leszczyna 22, Lipnica Górna 1, Łapanów 2/2K, Łąkta 4, Łąkta 9, Łąkta 11, Łąkta 13, Łąkta 14, Łąkta 22, Łąkta 24, Łąkta 25, Łąkta 30K, Muchówka 1, Muchówka 2, Połom Duży 2, Raciechowice 1, Rajbrot 1, Rajbrot 2, Tarnawa 1, Tymowa 1, Wiśniowa IG-1, Wiśniowa 3, Wiśniowa 4, Wiśniowa 6, Wolica 1, Żegocina 1. Their location can be found in Fig. 2.4.

→**Fig. 2.1. A.** Location of the Block 413-414 tender area in relation to Western Carpathians tectonic units. **B**. Location of the Block 413-414 tender area on the Geological Map of the Western Carpathians (Żytko et al., 1989). **C.** Geological cross-section through the flysch formations in the north-western part of the tender area (SMGP 1: 50 000, Wieliczka sheet). Silesian Nappe: 26–28 – Upper Istebna Beds (Paleocene), 29–30 – Lower Istebna Beds (Upper Cretaceous-Paleocene), 31 – undivided Paleogene formations, 32–33 – Godula Beds (Upper Cretaceous), Carpathian Foredeep: 57 –undivided Miocene, Carpathian basement: 66 – Upper Cretaceous, 67 – Upper Jurassic, 68 – Middle Jurassic, 71 – Permian+Triassic, 74 – Silurian, 75–76 – Proterozoic. **D.** Geological cross-section through the flysch formations in the northern part of the tender area (SMGP 1: 50 000, Bochnia sheet). Silesian Nappe: 13 – Lower Krosno Beds (Oligocene), 14 – Menilite Beds (Oligocene), 17 – Variegated Shales (Paleocene-Eocene), 18 – Upper Istebna Shales (Paleocene), 19 – Upper Istebna Sandstones (Paleocene), 20 – Lower Istebna Shales (Upper Cretaceous-Paleocene), 21 – Lower Istebna Sandstones (Upper Cretaceous-Paleocene). **E.** Geological cross-section through flysch formations in the north-eastern part of the tender area (SMGP 1: 50 000, Brzesko sheet). Silesian Nappe: 21 – Upper Istebna Sandstones (Paleocene), 22 – Lower Istebna Shales (Paleocene), 23 – Lower Istebna Beds (Upper Cretaceous), 24 – Godula Beds (Upper Cretaceous), 26 – Variegated Shales (Upper Cretaceous). **F.** Geological cross-section through flysch formations in the south-western part of the tender area (SMGP 1: 50 000, Mszana Dolna sheet). Olksb – Krosno Beds (Oligocene), Crksb – shales and sandstones (Lower Cretaceous), Olks – Krosno Beds (Oligocene), Olmes – Menilite Shales with Jasło Shales (Oligocene), PeEs – Variegated Shales (Eocene), Cris – Lower Istebna Beds (Upper Cretaceous), Crg – Godula Beds (Upper Cretaceous), peCrgs – Variegated Shales of the Godula Beds (Upper Cretaceous), Crls – Lgota Beds (Lower Cretaceous), Crgrs – Grodziszcze Beds (Lower Cretaceous), mbE – Layered White Marls (Eocene), Pccz – Glauconitic Sandstones from Czerwin (Paleocene), Crszps – Bryozoan-Lithothamnium Sandstones from Szydłowiec (Cenomanian-Senonian), Crwg – Variegated Węglówka Marls (Cenoman-Senon), MeCr – Gray Marls with Exotics (Cenomanian-Senonian), Crgi – Godula-Inoceramian Beds (Cenomanian-Senonian), Crwps – Verovice Shales (Valanginian-Albian), Crgrps – Grodziszcze Beds (Valanginian-Albian). **G.** Geological cross-section through flysch formations in the southern part of the tender area (SMGP 1: 50 000, Limanowa sheet). 12 – Krosno Beds (Oligocene), 18 – Variegated Węglówka Marls (Upper Cretaceous-Eocene), 19 – Frydek Marls (Upper Cretaceous), 20 –Żegocina Marls (Upper Cretaceous), 22 – Lower Krosno Beds (Oligocene), 25 – Variegated Shales (Paleocene-Eocene), 27 – Lower Istebna Shales (Upper Cretaceous-Paleocene), 28 – Lower Istebna Beds (Upper Cretaceous-Paleocene), 30 – Godula Beds (Turonian-Maastrichtian), 33 – Istebna Beds (Albian-Cenomanian)), 37 – Upper Cieszyn Shales (Valanginian-Hauterivian), 42 – Magura Beds (Eocene-Oligocene), 43 – Magura Beds (Eocene-Oligocene), 44 – Sub-Magura Beds (Eocene-Oligocene), 48 – Variegated Shales (Paleocene Eocene), 55 – Skawina Beds (Baden), 56 – sandstones, claystones, limestones, dolomites and mudstones (Middle-Upper Jurassic), 59 – limestones, sandstones, mudstones and claystones (Carboniferous).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Andrychów
BIELSKO-BIAŁA
Sucha Beskidzka
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NOWY SĄCZ
Nowy Targ
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Karpaty zewnętrzne
Outer Carpathians
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Stebnik Unit
Jednostka skolska
Skole Unit
Jednostka podśląska
Sub-Silesian Unit
Jednostka śląska
Silesian Unit
Jednostka dukielska
Dukla Unit
Jednostka Siar
Siary Unit
Jednostka Bystrzycy
Bystrzyca Unit
Jednostka Krynicka
Krynica Unit
Płaszczowina magurska
Magura Unit
Zapadlisko przedkarpackie
Carpathian Foredeep
Niesfałdowane
Unfolded
Jednostka zgłobicka
Zgłobice Unit
Pieniński pas skałkowy
Pieniny Klippen Belt
Karpaty wewnętrzne
Inner Carpathians
Paleogen (flisz podhalański)
Paleogene (Podhale flysch succession)
Mezozoik i paleozoik
Mesozoic and Paleozoic
Wulkanity mioceńskie
Miocene volcanites
Neogeńskie zapadliska śródgórskie
Neogene intra-mountain depressions
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20°20'00"
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Bochnia
Raba
Dobczyce
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Limanowa
Nowy Sącz
Jez. Czchowskie
Jez. Rożnowskie
Dunajec
0 5 10 15 20 km
Objaśnienia / Legend:
górny baden / Upper Badenian
środkowy baden / Middle Badenian
środkowy baden / Middle Badenian (warstwy ewaporatowe) / Evaporite Beds
dolny baden / Lower Badenian
oligocen / Oligocene
oligocen-środkowy eocen / Oligocene-M. Eocene
eocen-paleocen / Eocene-Paleocene
eocen-górna kreda / Eocene-Upper Cretaceous
paleocen-turon / Paleocene-Turonian
górna kreda / Upper Cretaceous
senon-turon / Senonian-Turonian
górna kreda / Upper Cretaceous
cenoman-apt / Cenomanian-Aptian
cenoman-walanżyn / Cenomanian-Valanginian
C
SSE
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Jednostka śląska
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S
NE
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Sub-Silesian Unit
Jednostka śląska
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Magura Unit
Jednostka podśląska
Sub-Silesian Unit
Jednostka śląska
Silesian Unit
m n.p.m.
m a.s.l.
0 1 2 km

→**Fig. 2.2.** Location of the Block 413-414 tender area (red square) and geological cross-sections C–G (Fig. 2.1) on the Detailed Geological Map of Poland (SMGP) 1 : 50 000.

WIELICZKA SHEET (Wójcik, 2009). Holocene: 1–10; **Pleistocene**: 11–20; **Silesian Unit**: 21 – Krosno Beds (Oligocene); 22 – Menilite Shales (Oligocene); 23 – Hieroglyphic Beds (Eocene); 24 – Variegated Shales (Eocene); 25 – Ciężkowice Sandstone (Eocene); 26–28 – Upper Istebna Beds (Paleocene); 29–30 – Lower Istebna Beds (Upper Cretaceous–Paleocene); 31 – Undivided Cretaceous and Paleocene; 32 – Variegated Godula Shales (Upper Cretaceous); 33 – Godula Beds (Upper Cretaceous); 34 – Jasper Beds (Upper Cretaceous); 35 – Gaize Beds (Cretaceous); 36 – Mikluszowice Hornfelses (Cretaceous); 37 – Lgota Beds (Cretaceous); 38 – Lower Gaize Beds (Lower Cretaceous); 39 – Verovice Beds (Lower Cretaceous); 40 – Grodziszcze Beds (Lower Cretaceous); 41 – Upper Cieszyn Shales (Lower Cretaceous); **Sub-Silesian Unit**: 42 – Krosno Beds (Oligocene); 43–44 – Menilite Beds (Oligocene); 45–46 – Variegated Beds (Eocene); 47 – Ciężkowice Sandstones (Eocene); 48 – Upper Istebna Beds (Paleocene); 49 – Tomaszkowice Sandstones (Upper Cretaceous-Paleocene); 50 – Variegated Węglówka Marls (Upper Cretaceous); 51 – Variegated Godula Shales (Upper Cretaceous); 52 – Gaize Beds (Cretaceous); 53 – Lgota Beds (Cretaceous); 54 – Verovice Beds (Lower Cretaceous); 55 – Grodziszcze Beds (Lower Cretaceous); 56 – Upper Cieszyn Beds (Lower Cretaceous); **Carpathian Foredeep Miocene**: 57 – Miocene undivided; 58 – Gdów Beds; 59 – Bogucice Sands; 60 – Chodenice and Grabowiec Beds; 61 – Chodenice Beds; 62 – tuffites; 63–64 – Wieliczka Beds; 65 – Skawina Beds.

BOCHNIA SHEET (Kopciowski et al., 2009). Holocene: 1–6; **Pleistocene**: 7–12; **Silesian Unit**: 13 – Lower Krosno Beds (Oligocene); 14 – Menilite Beds (Oligocene); 15 – Hieroglyphic Beds (Eocene); 16 – Ciężkowice Sandstone (Eocene); 17 – Variegated Shales (Paleocene-Eocene); 18–19 – Upper Istebna Beds (Paleocene); 20–22 – Lower Istebna Beds (Upper Cretaceous–Paleocene); 23 – Godula Beds (Upper Cretaceous); 24 – Godula Shales (Upper Cretaceous); 25 – Lower Godula Beds (Lower Cretaceous); 26 – Lower Lgota Beds (Lower Cretaceous); 27 – Gaize Beds (Lower Cretaceous); 28 – Verovice Beds (Lower Cretaceous); 29 – Grodziszcze Beds (Lower Cretaceous); 30 – Upper Cieszyn Shales (Lower Cretaceous); **Sub-Silesian Unit**: 31 – Lower Krosno Beds (Oligocene); 32 – Menilite Beds (Oligocene); 33 – Ciężkowice Sandstones (Eocene); 34 – Variegated Shales (Paleocene-Eocene); 35 – Tomaszkowice Sandstones (Upper Cretaceous-Paleocene); 36 – Żegocina Marls (Upper Cretaceous); 37 – Variegated Węglówka Marls (Upper Cretaceous); **Zgłobice Unit**: 38 – Bogucice Sands; 39 – Chodenice Beds; 40 – Chaotic Complex; 41 – tuffites; 42 – Gypsum and clays; 43 – Wieliczka Beds; 44 – Skawina Beds; **Carpathian Foredeep Miocene**: 45 – Grabowiec Beds.

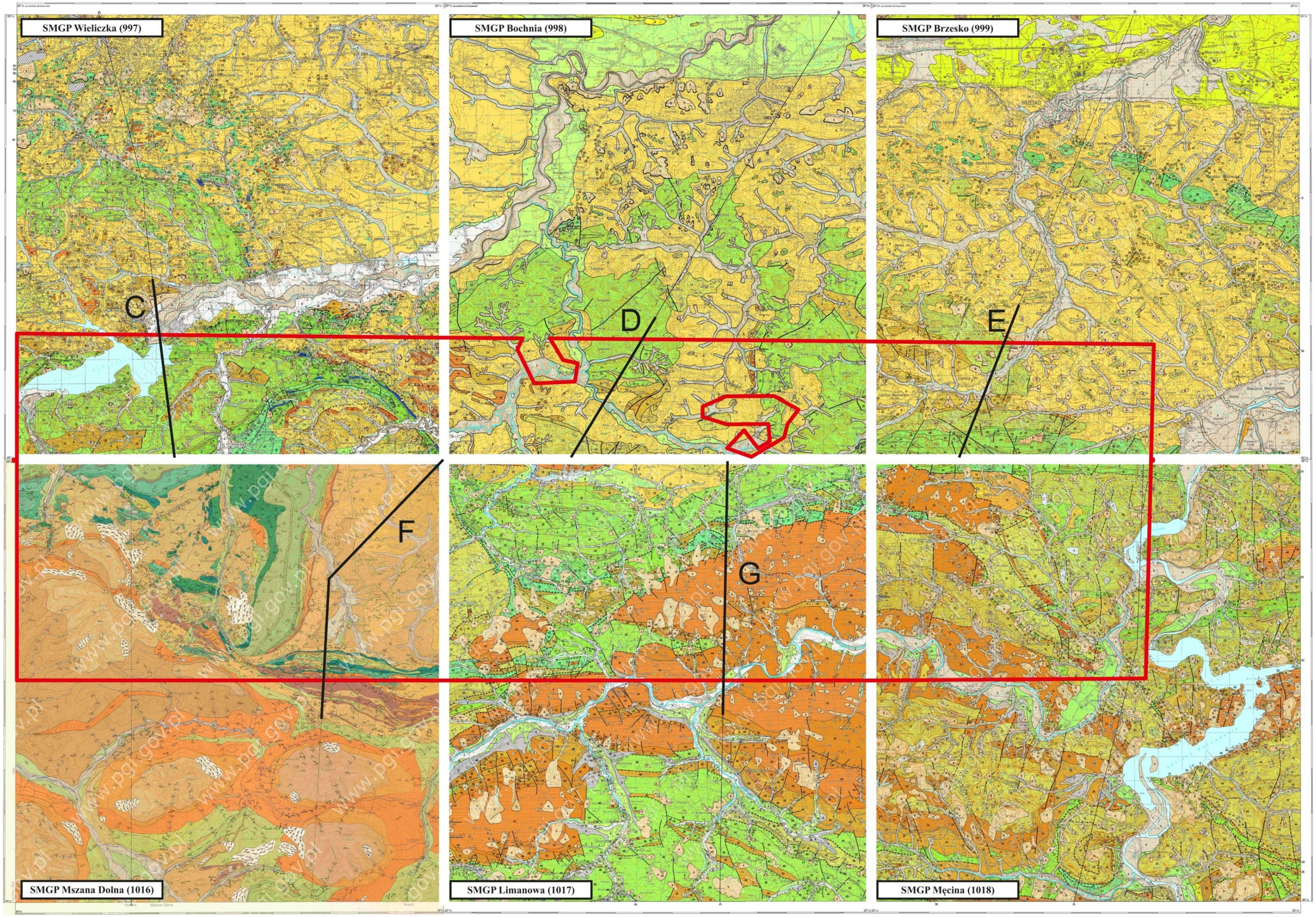
BRZESKO SHEET (Jankowski and Paul, 2007). Holocene: 1–8; **Pleistocene**: 9–15; **Silesian Unit**: 16 – Lower Krosno Beds (Oligocene); 17 – Jasło Limestones (Oligocene); 18 – Menilite Beds (Oligocene); 19 – Ciężkowice Sandstone (Eocene); 20 – Variegated Shales and Hieroglyphic Beds (Paleocene-Eocene); 21–22 – Upper Istebna Beds (Paleocene); 23 – Lower Istebna Beds (Upper Cretaceous–Paleocene); 24–25 – Godula Beds (Upper Cretaceous); 26 – Variegated Shales (Upper Cretaceous); 27 – Lgota Beds (Lower Cretaceous); 28 – Grodziszcze Beds (Lower Cretaceous); 29 – Upper Cieszyn Beds (Lower Cretaceous); **Sub-Silesian Unit**: 30 – Variegated Węglówka Marls (Upper Cretaceous); 31 – Lgota Beds (Cretaceous); 32 – Gaize Beds (Cretaceous); 33 – Upper Cieszyn Beds (Lower Cretaceous); **Skole Unit**: 34 – Krosno Beds (Oligocene); 35 – Menilite Beds (Oligocene); 36 – Variegated Shales (Paleocene-Eocene); 37–39 – Inoceramian Beds (Upper Cretaceous); 40 – Spa Shales (Upper Cretaceous); **Carpathian Foredeep Miocene**: 41 – Grabowiec Beds; 42 – Chodenice Beds; 43 – tuffites; 44 – Evaporite Beds; 45 – Skawina Beds.

MSZANA DOLNA SHEET (Burtan, 1974). Holocene: ${}^{f}Q_{h}$, ${}_{f}Q_{h}^{T}$, ${}_{z}Q$; **Pleistocene**: ${}_{f}Q_{p}$, ${}_{g}Q_{p2}$; **Magura Unit**: OE_{m} – Magura Beds (Paleogene); OE_{pm} – Sub-Magura Beds (Paleogene); E_{h}^{m} – Hieroglyphic Beds (Paleogene); E_{pa}, E_{c}^{m} – Pasierbiec Sandstones (Paleogene); ${}_{pe}E^{m}$ – Variegated Shales (Eocene); Cr_{is}^{m} – Istebna Beds (Upper Cretaceous); Cr_{sz} – Szczawina Sandstones (Ogorzała Sandstones, Upper Cretaceous); Cz_{i}^{m} – Inoceramian Beds (Upper Cretaceous); Cr_{j} – Inoceramian-Biotite Beds (Jaworzynka Beds, Upper Cretaceous); Cr_{k} – Kanina Beds (Upper Cretaceous); ${}_{pe}Cr^{m}$ – Variegated Shales and Marls (Upper Cretaceous); **Southern Fore-Magura Unit**: Olk^{pmS} – Krosno Beds (Paleogene); $Olme^{pmS}$ – Menilite Shales and Ciężkowice Sandstones (Olc^{pmS}, Paleogene); $Olgr^{pmS}$ – Grybów Beds (Paleogene); Pc^{pmS} – dark shales with glauconite sandstone lenses (Paleogene); **Northern Fore-Magura Unit of the Mszany Dolna tectonic window**: Ol_{k}^{pmN}, ${}_{g}Ol_{k}^{pmN}$ – Krosno Beds (Paleogene); **Silesian Unit of the Skrzydlna Bay and Bystre Slice**: ${}_{\text{ł}}Ol_{k}^{sb}$, Ol_{k}^{sb}, ${}_{g}Ol_{k}^{sb}$ – Krosno Beds (Paleogene); Ol_{c}^{sb} – Cergowa type sandstones (Paleogene); Ol_{me}^{sb}, $Ol_{me}^{\text{ś}s}$ – Menilite and Jasło Shales (Paleogene); E_{pme}^{sb}, $E_{pme}^{\text{ś}s}$ – Sub-Menilite Marls (Paleogene); E_{h}^{ss} – Hieroglyphic Beds (Paleogene); ${}_{pe}E$, ${}_{mpe}E^{ss}$ – Variegated Shales (Eocene); $Cr_{i}^{\text{ś}s}$, Cr_{i}^{ssb} – Inoceramian type sandstones and shales (Upper Cretaceous); Cr_{k}^{sb} – Kurów Beds (Lower Cretaceous); **Silesian Unit of the Silesian and Lanckorona facies**: Ol_{k}^{s} – Krosno Beds (Paleogene); Ol_{me}^{s} – Menilite and Jasło Shales (Paleogene); E_{h}^{s} – łup Hieroglyphic Beds (Paleogene); ${}_{pe}E^{s}$ – Variegated Shales (Eocene); E_{c}^{s} – Ciężkowice Sandstones (Paleogene); ${}_{\text{ł}}Pc_{\text{ł}s}$ – Upper Istebna Beds with Variegated Shales smoudges; Pc_{rs} – Upper Istebna Beds (Paleogene); ${}_{\text{ł}}Cr_{is}$ – Lower Istebna Beds with Variegated Shales intercalations (Upper Cretaceous); $Cr_{\text{ł}s}$ – Lower Istebna Beds (Upper Cretaceous); Cr_{gm} – Malinowce Conglomerate (Upper Cretaceous); Cr_{g}, ${}_{pe}Cr_{g}^{s}$ – Godula Beds (Upper Cretaceous); Cr_{j}^{s} – Jasper Beds (Cretaceous); Cr_{m}^{s} – Mikluszowice Hornfelses and Lgota Beds (Cretaceous); Cr_{l}^{s} – Lgota Beds (Lower Cretaceous); Cr_{w}^{s} – Verovice Shales (Lower Cretaceous); Cr_{gr}^{s} – Grodziszcze Beds (Lower Cretaceous); Cr_{c}^{s} – Upper Cieszyn Shales (Lower Cretaceous); **Sub-Silesian Unit of the Wiśniowa and Skrzydlna tectonic window:** $Olme^{ps}$ – Menilite and Jasło Shales (Paleogene); $Epme^{ps}$ – Sub-Menilite Marls (Paleogene); ${}_{\text{ł}z}E$ – green shales with Ankerite concretions (Paleogene); ${}_{mc}E$ – red marls (Paleogene); ${}_{mBa}E$ – variegated marls with barite (Paleogene)' ${}_{pe}E^{ps}$ – Variegated Shales (Eocene); ${}_{mb}E$ – white marls (Paleogene); Pc_{cz} – Czerwin Glauconite Sandstone (Paleogene); CrPg – white marls (Cretaceous-Paleogene); Cr_{sz}^{ps} – Szydłowiec Sandstones (Upper Cretaceous); Cr_{r} – Rybie Sandstones (Upper Cretaceous); Cr_{wg} – Węglówka Variegated Marls (Upper Cretaceous); ${}_{me}Cr$

– marls with exotic rocks (Upper Cretaceous); Cr_{gi} – Inoceramian and Godula Beds (Upper Cretaceous); Cr_{g1} – Lower Godula Beds (Upper Cretaceous); $_{pe}Cr_g^{ps}$ – Variegated Godula Shales (Lower Cretaceous); Cr_j^{ps} – Jasper Beds (Cretaceous); Cr_m^{ps} – Mikluszowice Hornfelses (Cretaceous); $_lCr_l^{ps}$, Cr_l^{ps} – Lgota Beds (Lower Cretaceous); Cr_w^{ps} – Verovice Beds (Lower Cretaceous); Cr_{gr}^{ps} – Grodziszcze Beds (Lower Cretaceous); Cr_c^{ps} – Upper Cieszyn Shales (Lower Cretaceous).

LIMANOWA SHEET (Wójcik et al., 2009). Holocene: 1–6; **Pleistocene**: 7–10; **Transgressive Para-Autochthonous Miocene**: 11; **Sub-Silesian Unit (Lanckorona-Żegocina Unit)**: 12 – shales, marls and sandstones (Upper Cretaceous-Oligocene); 13–14 – Lower Krosno Beds (Oligocene); 15 – Menilite Beds (Oligocene); 16 – Numulitic Conglomerates (Eocene); 17 – Rybie and Rajbrot sandstones (Paleocene); 18 – Variegated Węglówka Marls (Upper Cretaceous-Eocene); 19 – Żegocina Marls (Upper Cretaceous); 21 – Jasienica Marls (Upper Cretaceous); **Silesian Unit**: 22 – Lower Krosno Beds (Oligocene); 23 – Menilite Beds (Oligocene); 24 – Hieroglyphic Beds (Eocene); 25 – Variegated Shales (Eocene); 26 – Upper Istebna Beds (Paleocene); 27–28 – Lower Istebna Beds (Upper Cretaceous–Paleocene); 29 – Godula Shales (Upper Cretaceous); 30 – Godula Beds (Upper Cretaceous); 31 – Variegated Godula Shales (Upper Cretaceous); 32 – Jasper Beds (Cenomanian); 33 – Lgota Beds (Albian-Cenomanian); 34 – Verovice Beds (Barremian-Aptian); 35 – Grodziszcze Beds (Hauterivian); 36 – Grodziszcze and Upper Cieszyn Beds undivided (Valanghinian-Hauterivian); 37 – Upper Cieszyn Beds (Valanghinian-Hauterivian); **Grybów Unit**: 38 – Lower Krosno Beds (Oligocene); 39 – Jasło Shales (Oligocene); 40 – Menilite Beds (Oligocene); 41 – organodetritic limestones (Oligocene); **Magura Unit**: 42 – Małastów/Budzów/Super-Magura Beds (Eocene-Oligocene); 43 – Magura Beds – Wątkowa Sandstones (Eocene-Oligocene); 44 – Zembrzyce Shales – Sub-Magura Beds (Eocene-Oligocene); 45 – Hieroglyphic Beds (Eocene); 46 – Pasierbiec Sandstones (Eocene); 47 – Ciężkowice Sandstones (Eocene); 48 – Variegated Shales (Paleocene-Eocene); 49 – Jaworzynka/Inoceramian Beds (Upper Cretaceous-Paleocene); 50 – Kanina and Hieroglyphic Beds (Upper Cretaceous); 51 – Inoceramian Beds (Upper Cretaceous); **Dukla-Grybów Unit (Słopnice-Obidowa Unit)**: 52 –Krosno Beds (Oligocene); 53 – Grybów Beds (Oligocene); 54 – Rdzawka Beds (Eocene); **Carpathian Foredeep Miocene**: 55 – Skawina Beds.

MĘCINA SHEET (Paul and Jugowiec, 2001). Holocene: 1–9; **Pleistocene**: 10–16; **Transgressive Para-Autochthonous Miocene**: 17–18 – Bela and Iwkowa Formations; **Magura Unit**: 19 – Budzów/Małastów/Super-Magura Beds (Oligocene); 20 – Hornfelses of the Super-Magura Beds (Oligocene); 21 – Magura Sandstones (Oligocene); 22 – Magura Beds (Oligocene); 23 – Zembrzyce Shales – Sub-Magura Beds (Eocene-Oligocene); 24 – Hieroglyphic Beds (Eocene); 25 – Ciężkowice Sandstones (Eocene); 26 – Variegated Shales (Paleocene-Eocene); 27 – Jaworzynka/Inoceramian Beds (Upper Cretaceous-Paleocene); 28 – Kanina and Hieroglyphic Beds (Upper Cretaceous); 29 – Variegated Shales); **Grybów Unit (Michalczowa Unit)**: 30 – Krosno Beds (Oligocene); 31 – Jasło Limestones (Oligocene); 32 – Krosno Beds (Oligocene); 33 – Grybów and Menilite Neds (Oligocene); 34 – Globigerina Marls (Eocene-Oligocene); 36 – Hieroglyphic Beds (Eocene); 37 – Variegated Shales (Eocene); 38 – Jaworzynka/Inoceramian Beds (Upper Cretaceous-Paleocene); **Dukla Unit**: 39–40 – Cergowa and Menilite Beds (Oligocene); 41 – Hieroglyphic Beds (Eocene); **Silesian Unit**: 42 – Krosno Beds (Oligocene); 43 – Jasło Limestones (Oligocene); 44 – Krosno Beds (Oligocene); 45 – Menilite Beds (Oligocene); 46 – Globigerina Marls (Eocene-Oligocene); 47 – Hieroglyphic Beds (Eocene); 48 – Ciężkowice Sandstone (Eocene); 49 – Variegated Shales (Paleocene-Eocene); 50–51 – Upper Istebna Beds (Paleocene); 52–53 – Lower Istebna Beds (Upper Cretaceous–Paleocene); 54–57 – Godula Beds (Upper Cretaceous); 58 – Lgota Beds (Albian-Cenomanian); 59 – Verovice Beds (Barremian-Aptian); 60 – Grodziszcze Beds (Hauterivian-Aptian); 61 – Upper Cieszyn Beds (Beriasian-Hauterivian); **Sub-Silesian Unit (Węglówka facies)**: 62 – Węglówka Variegated Marls (Campanian-Paleocene); **Sub-Silesian Unit (Frydek facies)**: 63 – Rajbrot Sandstones (Paleocene); 64 – Frydek Marls (Campanian-Paleocene); **Carpathian Foredeep Miocene**: 65 – shales, claystones and siltstones (Badenian).


SMGP Wieliczka (997)
SMGP Bochnia (998)
SMGP Brzesko (999)
C
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G
SMGP Mszana Dolna (1016)
SMGP Limanowa (1017)
SMGP Męcina (1018)

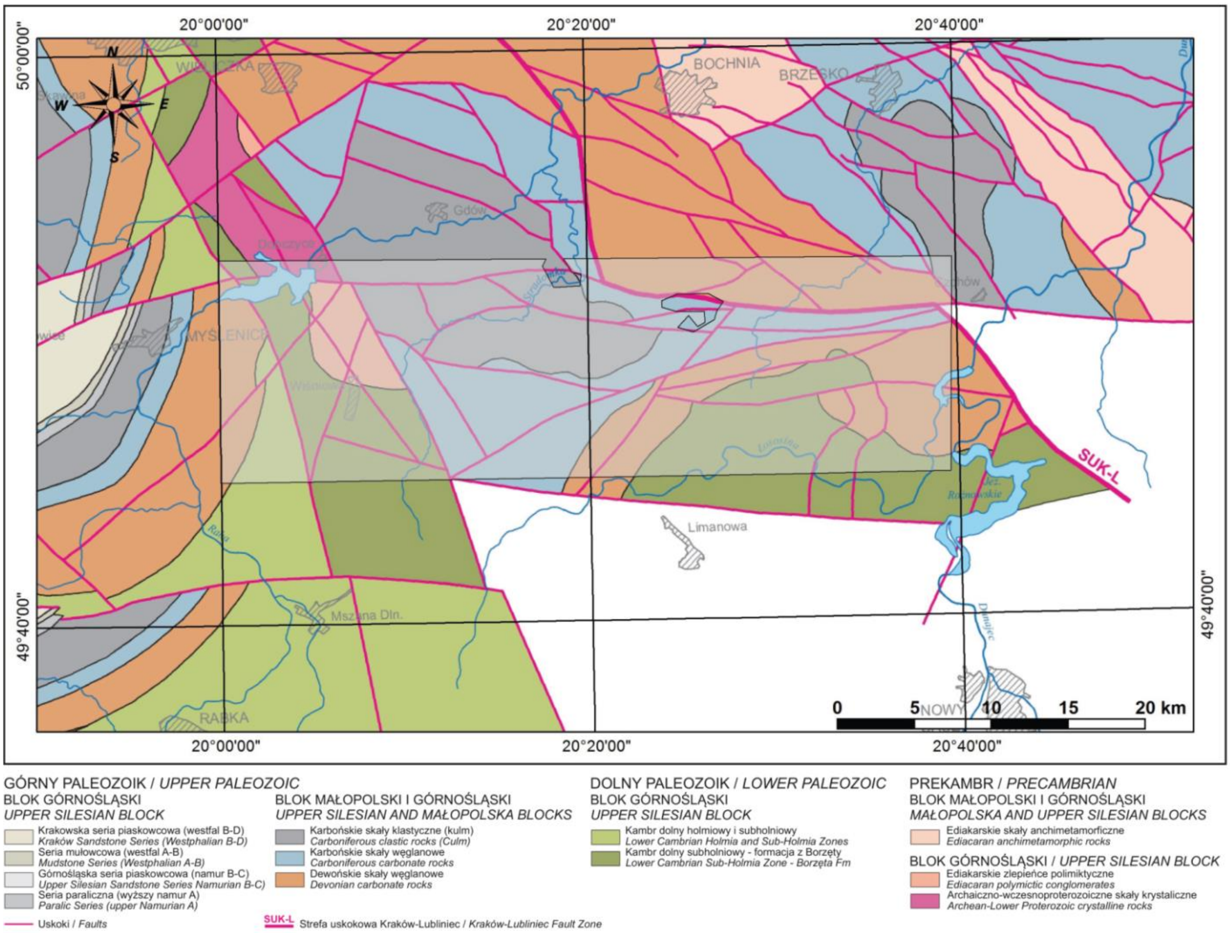


Fig. 2.3. Location of the Block 413-414 on the geological map of the Carpathian basement without strata younger than Carboniferous (Buła and Habryn, 2008).

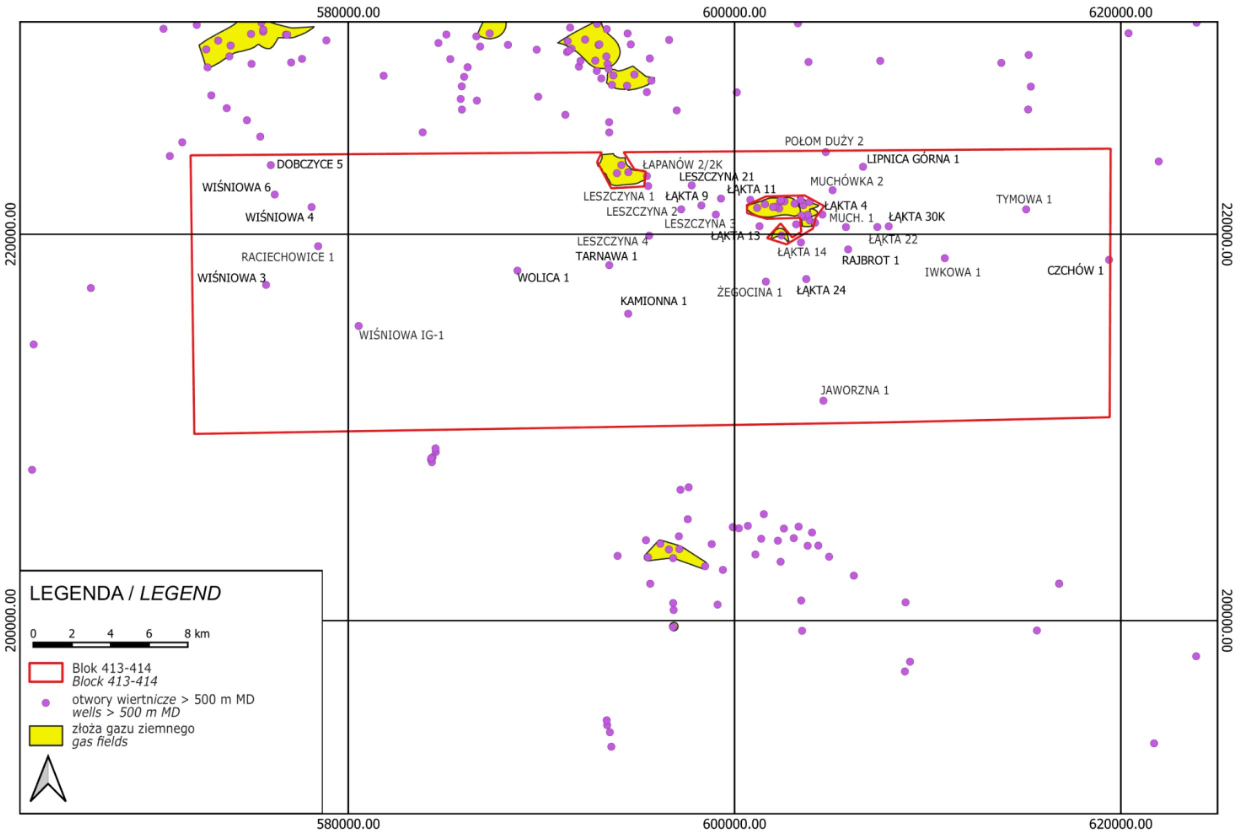


Fig. 2.4. Location of deep wells within the Block 413-414 tender area as crucial for geological characteristics of the area in relation to oil and gas fields.

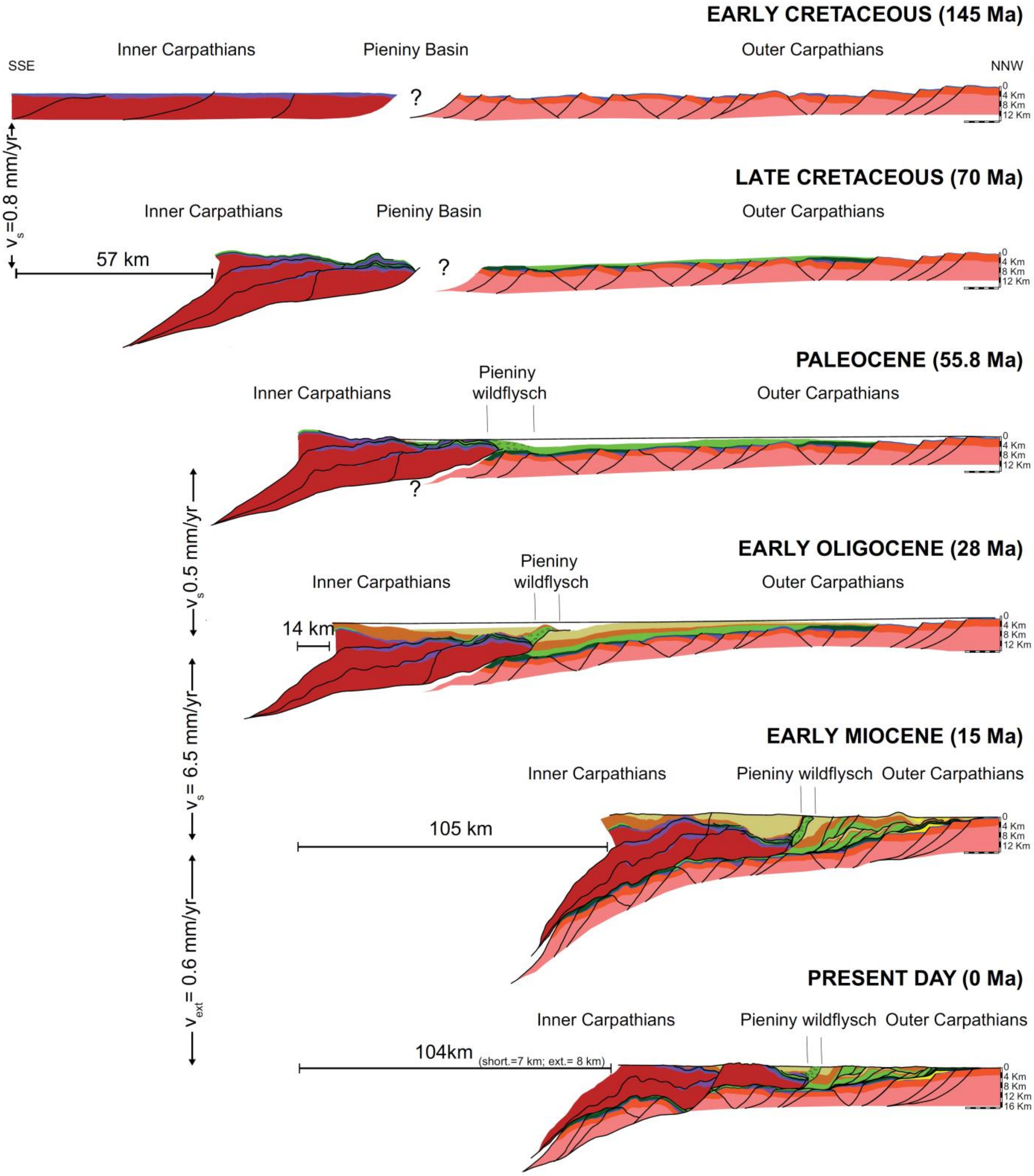


Fig. 2.5. Formation of the Carpathians (Castellucio et al., 2016).

2.2. STRATIGRAPHY
2.2.1. CARPATHIAN BASEMENT

Precambrian

In the western and central part of the tender area, the crystalline Precambrian basement was drilled at a depth of 2290.0 m in the Wiśniowa 6 well. Ediacaran sedimentary rocks – coarse-grained polymictic conglomerates classified as the Potrójna Formation overlie the crystalline rocks in some places, e.g. in the following wells:

- Wiśniowa IG-1: 2770.0–2931.2 m,
- Wiśniowa 3: 2534.0–2613.0 m,
- Wiśniowa 6: 2286.0–2290.0 m,
- Raciechowice 1.

The thickness ranges from 4 to over 161 m.

Cambrian

The Cambrian is represented by the Borzęta Formation, divided into Myślenice, Osieczany and Rajbrot members (Jachowicz-Zdanowska, 2010). It occurs in the western and central part of the tender area, and was recognized in wells (Fig. 2.7):

- Wiśniowa IG-1: 2755.0–2770.0 m,
- Wiśniowa 3: 2509.0–2534.0 m,
- Wiśniowa 6: 2205.0–2286.0 m,
- Rajbrot 1: 4322.0–4948.0 m,
- Rajbrot 2: 3821.0–4158.0 m.

The thickness of the formation ranges from 15 to 626 m.

The Paleozoic and Precambrian top surfaces is illustrated in Fig. 2.6, while the Fig. 2.7 presents a carrent state of their lithostratigraphic subdivision (Jachowicz-Zdanowska, 2010). More details on the Precambrian in the western part of the Carpathians can be found in Wójcik et al. (2017a).

Devonian-Lower Carboniferous carbonate rocks

The Devonian and Lower Carboniferous carbonate rocks lie directly on clastic Cambrian formations (e.g. Rajbrot 1 and Rajbrot 2 wells; Narkiewicz, 2005), which seems quite strange, considering that the beginning of the carbonate sedimentation was not preceded by the stage of shallow marine clastic deposition. Therefore, it seems reasonable to reconsider the stratigraphic position of at least some of the formations classified as Cambrian by Jachowicz-Zdanowska (2010; Fig. 2.7). The Devonian and Lower Carboniferous are overlain by clastic deposits of the upper part of the Carboniferous (Fig. 2.3), or by Permian or Jurassic formations (Fig. 2.10). Sometimes they lie directly below the sub-Miocene erosion surface. Within the tender area, the Devonian and Lower Carboniferous rocks were drilled in the following wells:

- Iwkowa 1: 3206.0?–3228.0 m,
- Rajbrot 1: 3083.0?–4322.0 m,
- Rajbrot 2: 2650.0–3821.0 m,
- Tarnawa 1: 4623.0–5510.0 m,
- Tymowa 1: 3313.0–3740.0 m,
- Żegocina 1.

The thickness of the Devonian and Lower Carboniferous carbonate rocks reaches up to 1239.0 m in the Rajbrot 2 well (Narkiewicz, 2005). The smallest thickness of these deposits is found in the southern part of the Upper Silesian Block, around the Bielsko-Biała Dome, where locally they are completely wedged out. The lack of these deposits in the discussed part of the block may also be the result of the Variscan erosion (Narkiewicz, 2005).

Narkiewicz (2005) developed a lithostratigraphic subdivision of Devonian and Carboniferous carbonate rocks in the Tarnawa 1, Rajbrot 1 and Rajbrot 2 wells, interpreting sedimentary environments and history of diagenesis (cf. Narkiewicz, 1978, 1996, 2001; Tomaś and Zając, 2010). He distinguished from base to top: (1) dolomites and marly limestones with bioturbation, (2) limestones, dolomicrites and dolosparites, (3) nodular and grained limestones, (4) marly horizon, (5) grained limestones and (6) upper limestones and marls. Using conodonts, miospores and foraminiferids, Matyja et al. (2005) developed a biostratigraphy of these deposits. This is, so far, the most complete data on the Devonian and Carboniferous lithology and stratigraphy in the tender area, therefore, we quote the entire 174 volume of the *Prace Państwowego Instytutu Geologicznego* as Appendix 1 to this study.

Carboniferous and Lower Permian clastic rocks

The Lower Carboniferous clastic rocks in the southern part of the Upper Silesian Block are divided into two lithostratigraphic units of the Carboniferous flysch: the Malinowice Beds and the Zalas Beds (Kotas, 1972; 1982a, b; Buła, 2000, 2001; Buła and Krieger, 2004). In the tender area, the Carboniferous is represented only by the Zalas Beds (Buła, 2001), recognized only in the Tarnawa 1 well at depth 4364.0–4623.5 m (259.5 m thick). Trzepierczyńska (2001) included them to the Visean–Namurian A interval basing on miospores. Above (depth 4214.0–4364.0 m; thickness 150.0 m), the Lower Permian sediments occur, which miospore biostratigraphic position was determined by Dybova-Jachowicz and Filipiak (2001).

The extent of the Culm rocks is illustrated in Fig. 2.9. As in the previous section, detailed information on Carboniferous and Lower Permian can be found in the Appendix 1 of this document.

Upper Permian and Permian-Triassic

The Permian and Mesozoic rocks in the Block 413-414 tender area lie unconformably on both Lower and Upper Palaeozoic strata (Figs 2.10–2.11). The Permian and Triassic deposits occur in the so-called Liplas-Tarnawa area. They were drilled in the following wells:

- Leszczyna 1: 2313.0–2410.0 m,
- Leszczyna 4: 2779.0–2850.0 m,
- Rajbrot 2: ?
- Tarnawa 1: 3027.0–4214.0 m,
- Wiśniowa 4: 2490.0–2602.0 m,
- Wolica 1: 3025.0–3177.5 m.

Their thickness is 8.0–1187.0 m. It should be noted, however, that the boundary between Permian-Triassic and Jurassic in the Tarnawa 1 well is a matter of discussion, and, according to Moryc (2014), runs at a depth of 2998.0 m.

The most complete succession of the Permian-Triassic boundary interval was recognized in the Tarnawa 1 well. Kiersnowski (2001; cf. Buła, 2001) separated the part corresponding to the Upper Permian (3705.0–4214.0 m) and Permian-Triassic (3027.0–3705.0 m), interpreting sedimentary environments and reconstructing the tectonic evolution of the basin (see Appendix 1), later criticized by Moryc (2014).

Jurassic

The Jurassic in the Block 413-414 tender area is represented by the Doggerian and Malmian. The Jurassic sediments in the basement of the Carpathian units lie unconformably on the Triassic or on various Paleozoic rocks. The Jurassic forms a continuous sedimentary cover from Wadowice to Rzeszów. The succession is composed of carbonate rocks, which were drilled in the following wells:

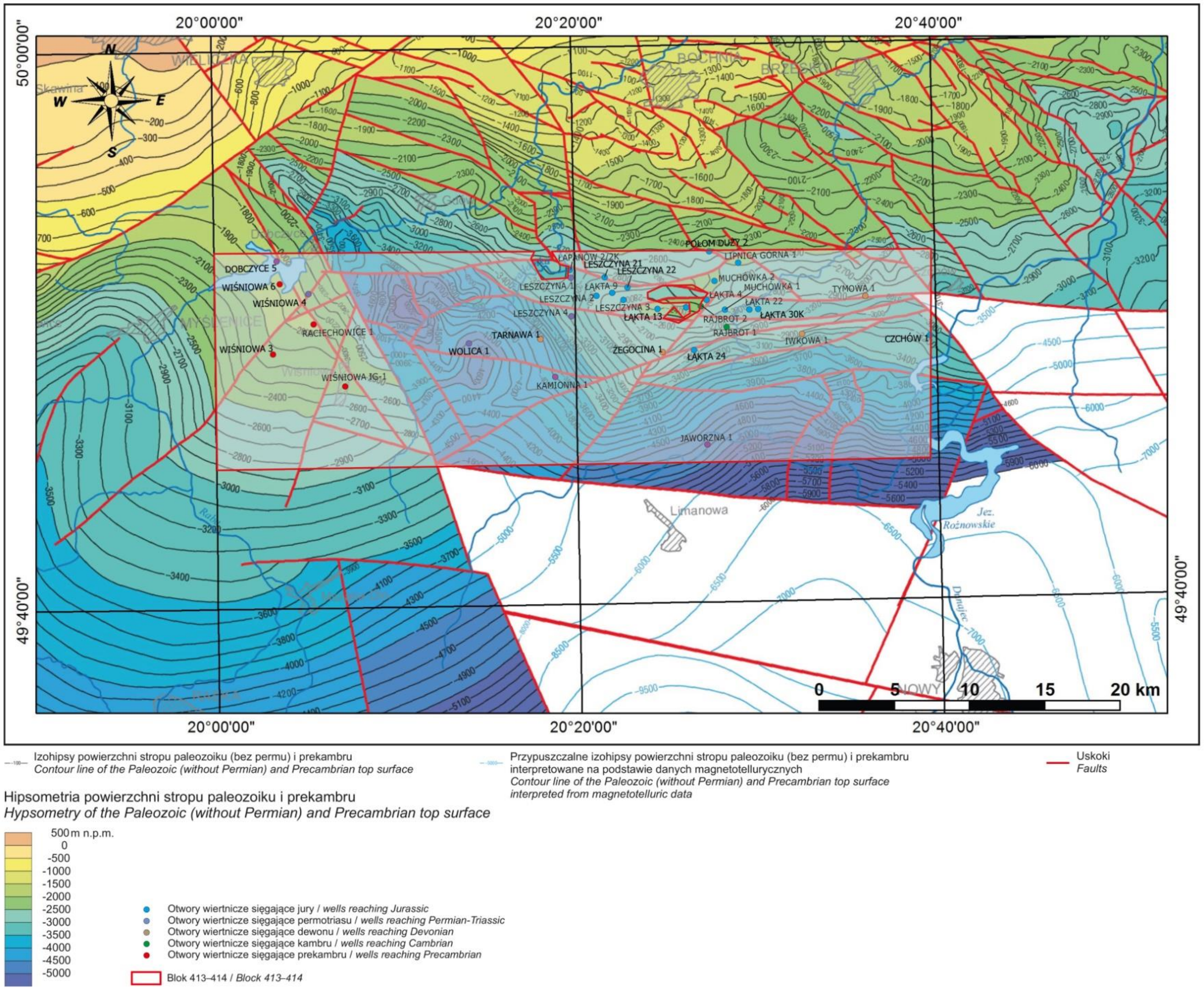
- Czchów 1: 3133.5–3216.0 m,
- Iwkowa 1: 2990.0–3206.0 m,
- Leszczyna 1: 1955.0–2313.0 m,
- Leszczyna 2: 2240.4–2305.0 m,
- Leszczyna 3: 2427.0–2550.0 m,
- Leszczyna 4: 2461.0–2779.0 m,
- Leszczyna 21: 2533.0–2564.6 m,
- Leszczyna 22: 2540.5–2600.0 m,
- Lipnica Górna 1: 2620.0–2710.0 m,
- Łapanów 2/2K: 1927.0–2050.0 m,
- Łąkta 4: 2393.0–2438.8 m,
- Łąkta 9: 2338.0–2382.0 m,
- Łąkta 13: 2406.0–2461.0 m,
- Łąkta 22: 2488.0–2511.0 m,
- Łąkta 24: 3068.0–3150.0 m,
- Łąkta 25: 2412.0–2423.0 m,
- Łąkta 30K,
- Muchówka 1: 2514.0–2620.0 m,
- Muchówka 2.
- Połom Duży 2: 2581.0–2630.0 m,
- Raciechowice 1,
- Rajbrot 1,
- Rajbrot 2,
- Tarnawa 1,
- Tymowa 1: 2703.0–3313.0 m,
- Wiśniowa IG-1: 2648.0–2755.0 m,
- Wiśniowa 3: 2332.0–2509.0 m,
- Wiśniowa 4: 2328.0–2490.0 m,
- Wiśniowa 6: 2093.0–2205.0 m,
- Wolica 1: 2748.0–3025.0 m,
- Żegocina 1.

Cretaceous

The Upper Cretaceous – Cenomanian, Turonian and Senonian deposits occur in the north-western and north-eastern part of the tender area. The Turionian-Senonian deposits are composed of marls, sandy marls, sandstones, conglomerates and claystones. In the Lower Cenomanian there are claystones, mudstones, sandstones, conglomerates, and also marls and cherts (Poprawa and Nemčok, 1989). The extent of the Cretaceous deposits in the Carpathian basement was illustrated by Moryc (2005; Fig. 2.12), however, in the light of current data, the ranges of particular units need to be verified. The following wells drilled the Cretaceous in the tender area:

- Czchów 1: 3120.0–3133.5 m,
- Iwkowa 1: 2841.0–2990.0 m,
- Leszczyna 2: 2225.0–2240.0 m,
- Leszczyna 22: 2511.0–2540.5
- Lipnica Górna 1: 2470.0–2620.4 m,
- Łąkta 9: 2327.0–2338.0 m,
- Łąkta 13: 2383.0–2406.0 m,
- Łąkta 22: 2460.0–2488.0 m,
- Łąkta 25: 2391.0–2412.0 m,
- Muchówka 1: 2494.0–2514 m,
- Muchówka 2,
- Połom Duży 2: 2437.0–2581.0 m,
- Rajbrot 2,
- Tymowa 1: 2660.0–2703.0 m,
- Wiśniowa 6: 2052.0–2093.0 m.

→ **Fig. 2.6.** Hypsometry of the Precambrian and Paleozoic (without Permian) top surface in the Block 413-414 tender area and its neighborhood (Buła and Habryn, 2008) with location of wells that drilled the Carpathian basement.



20°00'00"
20°20'00"
20°40'00"
50°00'00"
49°40'00"
N
S
W
E
WIELICZKA
BOCHNIA
BRZESKO
Limanowa
Jez. Rożnowskie
Dunajec
0
5
10
15
20 km
DOBCZYCE 5
WIŚNIOWA 6
WIŚNIOWA 4
RACIECHOWICE 1
WIŚNIOWA 3
WIŚNIOWA IG-1
WOLICA 1
TARNAWA 1
KAMIONNA 1
ŻEGOCINA 1
ŁAPANÓW 2/2K
LESZCZYNA 21
LESZCZYNA 22
LESZCZYNA 1
LESZCZYNA 2
LESZCZYNA 3
LESZCZYNA 4
ŁAKTA 9
ŁAKTA 4
ŁAKTA 13
ŁAKTA 22
ŁAKTA 30K
ŁAKTA 24
POŁOM DUŻY 2
LIPNICA GÓRNA 1
MUCHÓWKA 2
MUCHÓWKA 1
RAJBROT 2
RAJBROT 1
TYMOWA 1
IWKOWA 1
CZCHÓW 1
JAWORZNA 1
Izohipsy powierzchni stropu paleozoiku (bez permu) i prekambru
Contour line of the Paleozoic (without Permian) and Precambrian top surface
Przypuszczalne izohipsy powierzchni stropu paleozoiku (bez permu) i prekambru interpretowane na podstawie danych magnetotellurycznych
Contour line of the Paleozoic (without Permian) and Precambrian top surface interpreted from magnetotelluric data
Uskoki
Faults
Hipsometria powierzchni stropu paleozoiku i prekambru
Hypsometry of the Paleozoic (without Permian) and Precambrian top surface
500 m n.p.m.
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
-4000
-4500
-5000
Otwory wiertnicze sięgające jury / wells reaching Jurassic
Otwory wiertnicze sięgające permotriasu / wells reaching Permian-Triassic
Otwory wiertnicze sięgające dewonu / wells reaching Devonian
Otwory wiertnicze sięgające kambru / wells reaching Cambrian
Otwory wiertnicze sięgające prekambru / wells reaching Precambrian
Blok 413–414 / Block 413–414

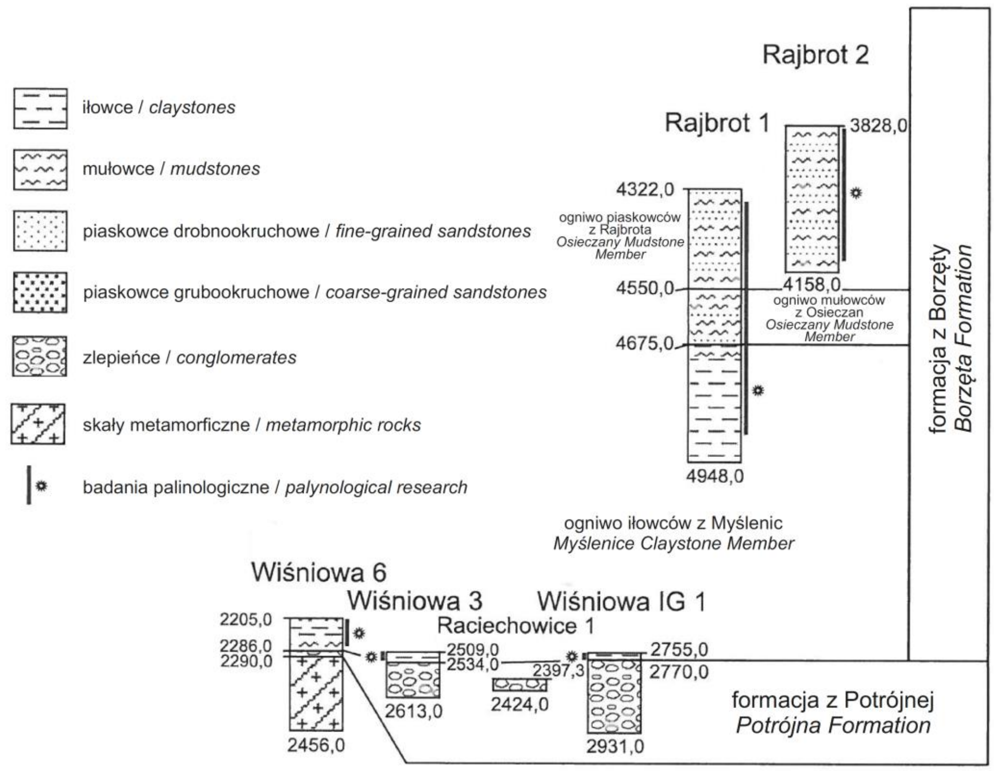
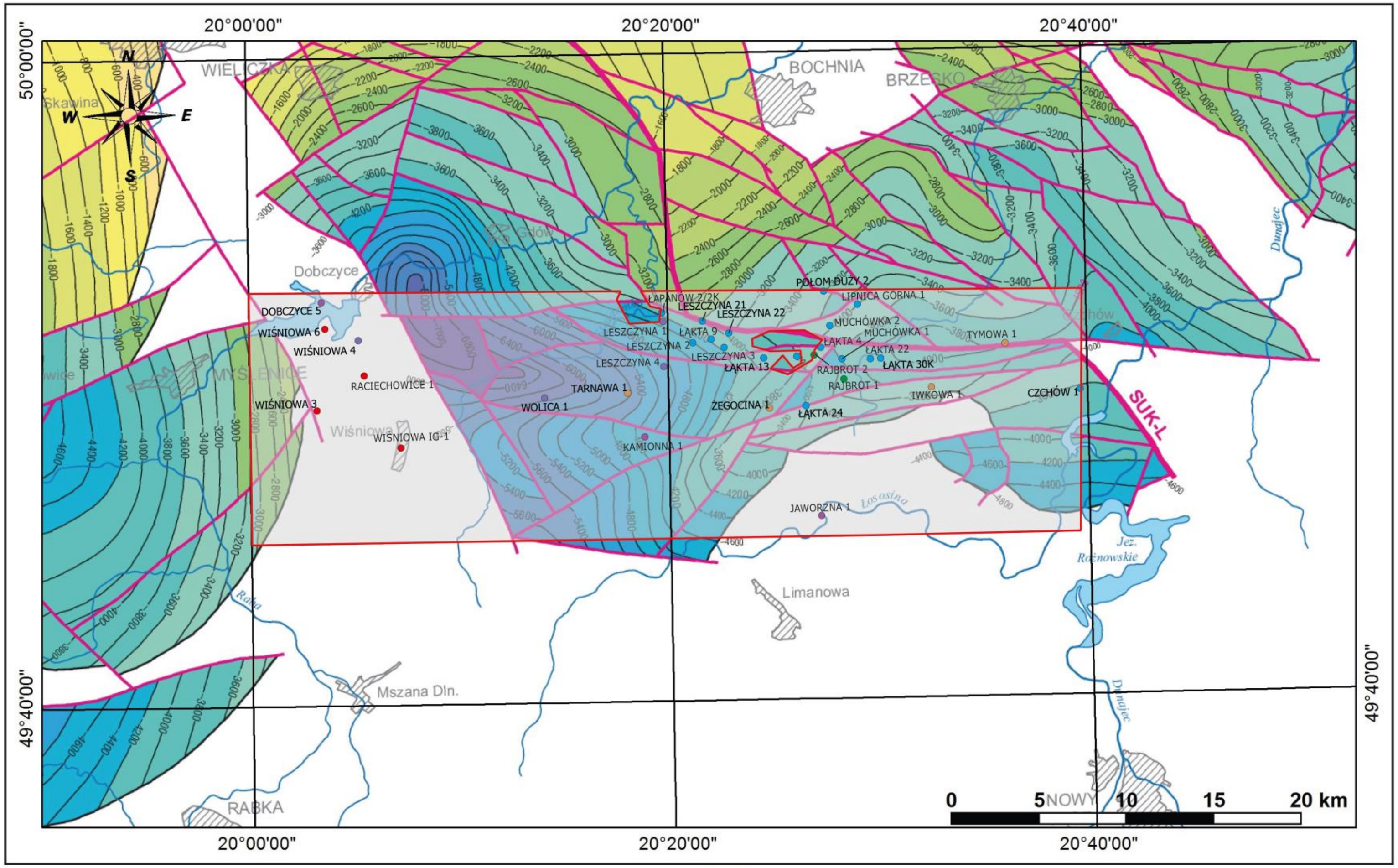


Fig. 2.7. Lithostratigraphy and correlation of the Precambrian and Cambrian deposits in wells located within the Block 413-414 tender area (Jachowicz-Zdanowska, 2010).

→ **Fig. 2.8.** Hypsometry of the Devonian-Carboniferous carbonate complex base surface in the Block 413-414 tender area and its neighborhood (Buła and Habryn, 2008) with location of wells that drilled the Carpathian basement.

→ **Fig. 2.9.** Hypsometry of the Carboniferous clastic complex (Culm) base surface in the Block 413-414 tender area and its neighborhood (Buła and Habryn, 2008) with location of wells that drilled the Carpathian basement.

→ **Fig. 2.10.** Percambrian and Paleozoic (without Permian) overburden in the Block 413-414 tender area and its neighborhood (Buła and Habryn, 2008) with location of wells that drilled the Carpathian basement.



Izohipsy powierzchni spągowej kompleksu dewońsko-karbońskich skał węglanowych
Contour line of the Devonian-Carboniferous carbonate complex base

SUK-L Strefa uskokowa Kraków-Lubliniec
Kraków-Lubliniec Fault Zone

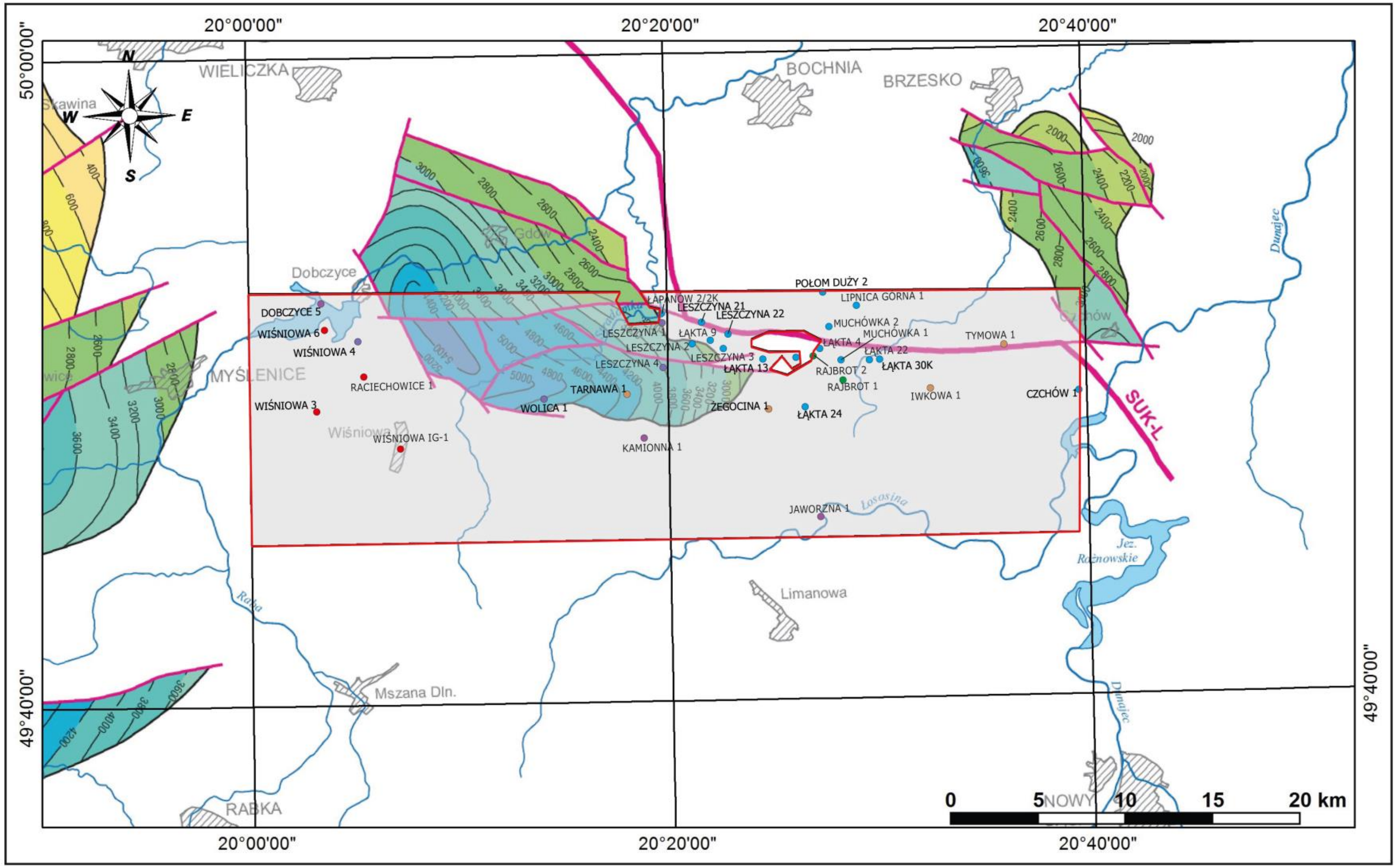
Uskoki
Faults

Hipsometria powierzchni spągowej kompleksu dewońsko-karbońskich skał węglanowych
Hypsometry of the Devonian-Carboniferous carbonate complex base surface

600 m n.p.m.
0
-600
-1200
-1800
-2400
-3000
-3600
-4200
-4800
-5400
-6000
-6600

- Otwory wiertnicze sięgające jury / *wells reaching Jurassic*
- Otwory wiertnicze sięgające permotriasu / *wells reaching Permian-Triassic*
- Otwory wiertnicze sięgające dewonu / *wells reaching Devonian*
- Otwory wiertnicze sięgające kambru / *wells reaching Cambrian*
- Otwory wiertnicze sięgające prekambru / *wells reaching Precambrian*

Blok 413–414 / *Block 413–414*



Izohipsy powierzchni spągowej karbońskiego kompleksu skał klastycznych (kulm)
Contour line of the Carboniferous clastic complex (Culm) base

SUK-L Strefa uskokowa Kraków-Lubliniec
Kraków-Lubliniec Fault Zone

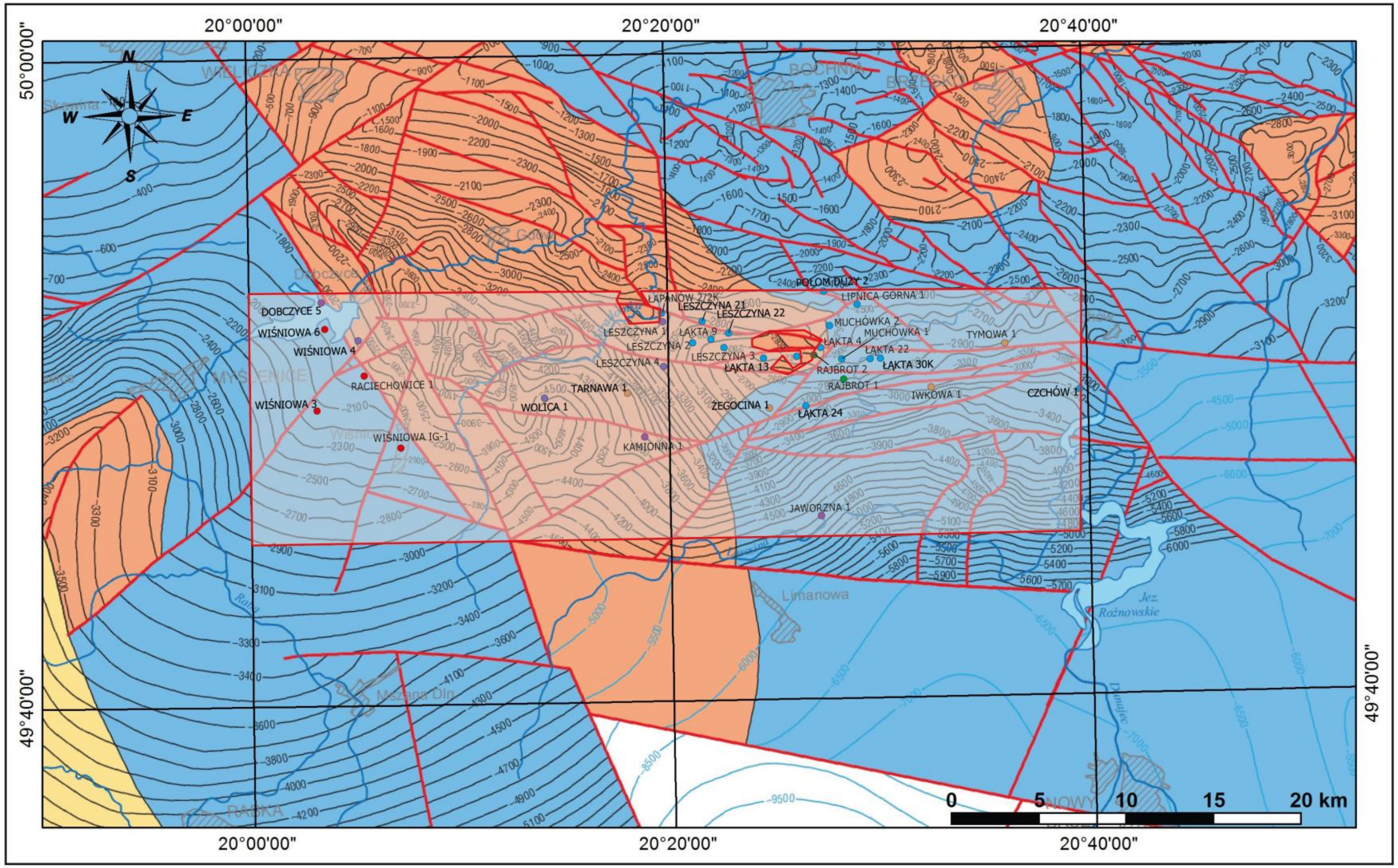
Uskoki
Faults

Hipsometria powierzchni spągowej karbońskiego kompleksu skał klastycznych (kulm)
Hypsometry of the Carboniferous clastic complex (Culm) base surface

600 m n.p.m.
0
-600
-1200
-1800
-2400
-3000
-3600
-4200
-4800
-5400

- Otwory wiertnicze sięgające jury / *wells reaching Jurassic*
- Otwory wiertnicze sięgające permotriasu / *wells reaching Permian-Triassic*
- Otwory wiertnicze sięgające dewonu / *wells reaching Devonian*
- Otwory wiertnicze sięgające kambru / *wells reaching Cambrian*
- Otwory wiertnicze sięgające prekambru / *wells reaching Precambrian*

Blok 413–414 / *Block 413–414*



Izohipsy powierzchni stropu paleozoiku (bez permu) i prekambru
Contour line of the Paleozoic (without Permian) and Precambrian top surface

Przypuszczalne izohipsy powierzchni stropu paleozoiku (bez permu) i prekambru interpretowane na podstawie danych magnetotellurycznych
Contour line of the Paleozoic (without Permian) and Precambrian top surface interpreted from magnetotelluric data

Uskoki
Faults

Blok 413–414 / *Block 413–414*

Nakład na stropie paleozoiku (bez permu) i prekambru
Precambrian and Paleozoic (without Permian) overburden

- Miocen / *Miocene*
- Jura / *Jurassic*
- Permotrias / *Permian-Triassic*

- Otwory wiertnicze sięgające jury / *wells reaching Jurassic*
- Otwory wiertnicze sięgające permotriasu / *wells reaching Permian-Triassic*
- Otwory wiertnicze sięgające dewonu / *wells reaching Devonian*
- Otwory wiertnicze sięgające kambru / *wells reaching Cambrian*
- Otwory wiertnicze sięgające prekambru / *wells reaching Precambrian*

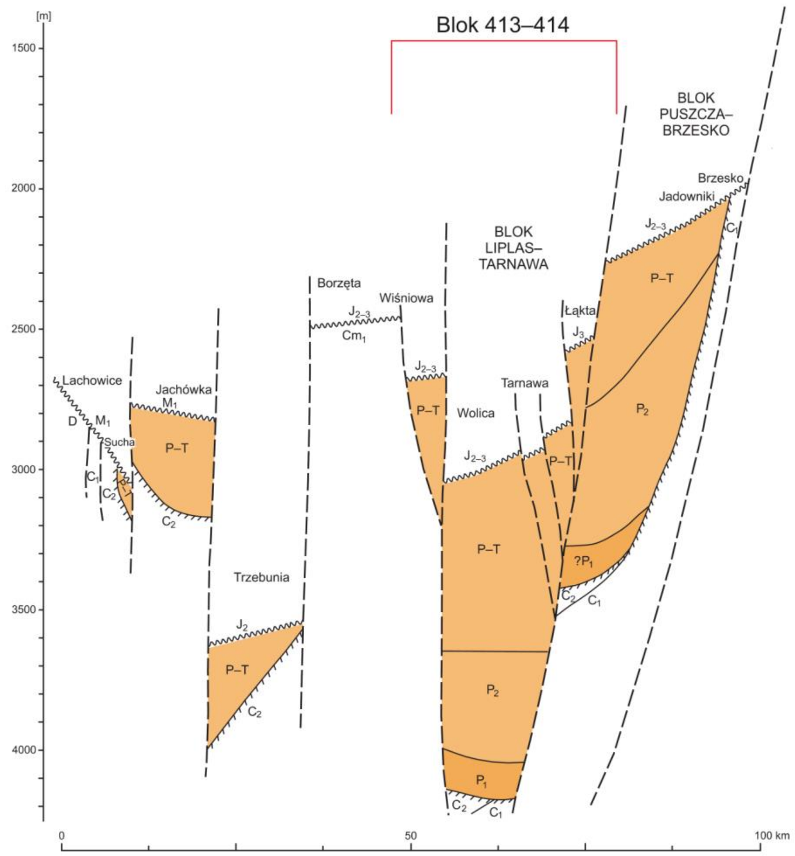


Fig. 2.11. Occurrence of the Permian and Triassic in the Block 413-414 tender area and its neighborhood (Moryc, 2014). M_1 – Lower Miocene, J_3 – Upper Jurassic, J_{2-3} – Middle and Upper Jurassic, P–T – Permian and Triassic, P_2 – Upper Permian, P_1 – Lower Permian, C_2 – Upper Carboniferous, C_1 – Lower Carboniferous, D – Devonian; Cm_1 – Lower Cambrian.

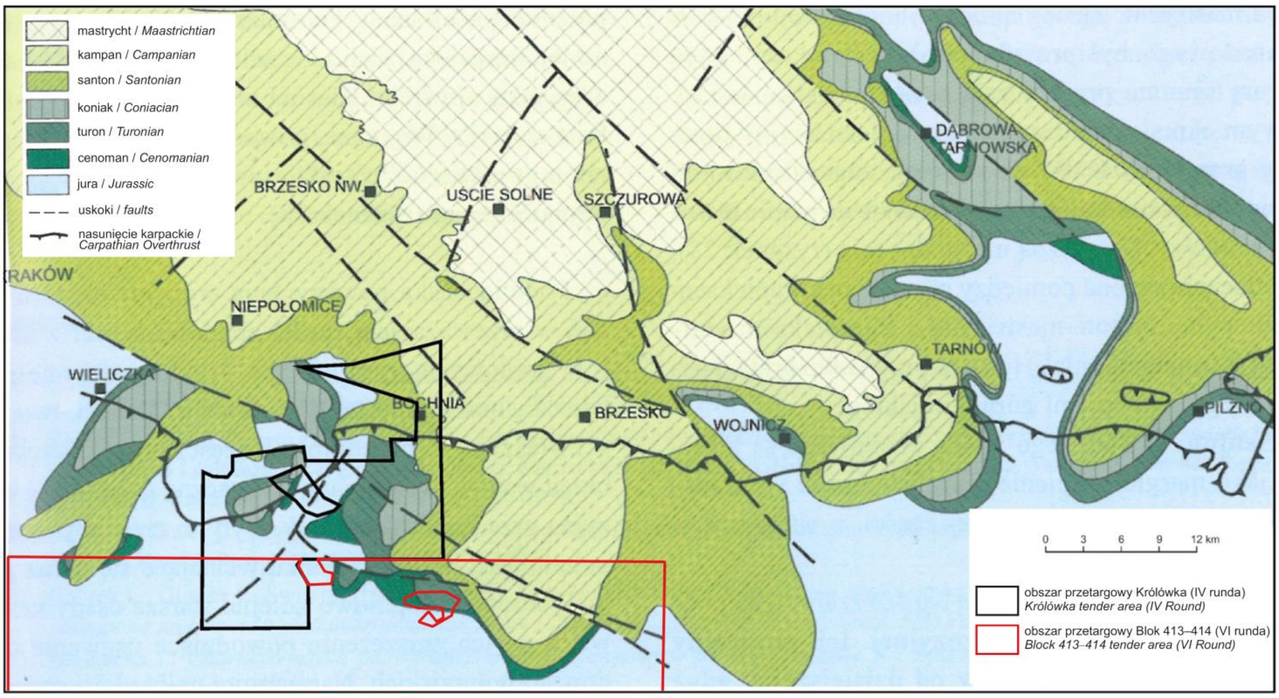


Fig. 2.12. Upper Cretaceous in the Carpathian basement with location of the Block 413-414 and Królówka tender areas (Moryc, 2005). According to the current state of knowledge, the view needs to be verified basing on new wells drilled after 2005.

2.2.2. MIOCENE OF THE CARPATHIAN FOREDEEP

Within the Block 413-414 tender area, the Miocene of the Carpathian Foredeep occurs below the Carpathian flysch as autochthonous and allochthonous deposits. Moreover, in the area of Iwkowa, the Miocene transgressive deposits occur above the flysch.

Transgressive Miocene

In the vicinity of Iwkowa, on the surface or under the thin cover of Quaternary sediments, and especially in the Iwkowa 1 well, the Miocene sediments lie unconformably and transgressively on the Carpathian flysch formations. In the well, they reach a thickness of 555 m. As Paul and Jugowiec (2021) wrote, "*these are grey, marly, soft mudstones with an admixture of pelitic muscovite, with an irregular, flat-textural fissility, with a numerous small molluscs represented by bivalves, rarely gastropods. In the upper part of the succession, they change into soft, grey-blue, marly claystones and mudstones with spherical or lamellar fissility with intercalations or several-metre thick complexes of grey-yellowish, poorly cemented sandstones, usually fine, and rarely medium or coarse-grained, with parallel or diagonal lamination. These sediments include claystone intercalations with flysch pebbles 5–20 cm thick and single blocks of Istebna Sandstones up to l m. ... Redeposited fragments of lignites are often found in the sediments, mainly in the form of brittle xylites. Lignites can form thin intercalations or lenses*".

In the upper part of the succession there are about 200 m thick conglomerate and sandstone complex with intercalations of claystones and mudstones and clays. The conglomerates are formed by flysch rocks, mainly Magura Sandstones in the glauconite facies, less frequently fragments of Miocene algal limestones, soft marls and pieces of lignites. The succession of the transgressive Miocene in the vicinity of Iwkowa has been divided into two – Iwkowa and Bela formations. The transgressive Miocene – mudstones, sand-stones, sands and clays – was also found in the vicinity of Żegocina, although their stratigraphic and tectonic position is currently not clearly defined (Wójcik et al., 2017b).

Allochthonous Miocene

The allochthonous Miocene (Stebnik Unit) in Block 413-414 tender area was drilled in the following wells:

- Lipnica Górna 1: 1575.0–1735.0 m,
- Łąkta 4: 1835.0–1856.0 m,
- Łąkta 9 :1985.0–2036.0 m,
- Muchówka 1: 2060.0–2120.0 m,
- Muchówka 2,
- Rajbrot 1,
- Tarnawa 1.

Autochthonous Miocene

The autochthonous Miocene, similarly to the allochthonous one, is not exposed on the surface in the Block 413-414 tender area. However, these deposits were drilled in numerous wells as one of the main exploration horizons in the region. These are:

- Czchów 1: 3098.5–3122.0 m,
- Dobczyce 5: 1670.0–1912.0 m,
- Iwkowa 1: 2702.0–2841.0 m,
- Leszczyna 1: 1625.0–1955.0 m,
- Leszczyna 2: 1897.0–2225.0 m,
- Leszczyna 3: 1944.0–2427.0 m,
- Leszczyna 4: 2179.0–2461.0 m,
- Leszczyna 21: 1820.0–2531.0 m,
- Leszczyna 22: 1880.0–2511.0 m,
- Lipnica Górna 1: 1735.0–2470.0 m,
- Łapanów 2/2K: 1550.0–1927.0 m,
- Łąkta 4: 1856.0–2393.0 m,
- Łąkta 9: 2036.0–2327.0 m,
- Łąkta 11: 1870.0–2588.0 m,
- Łąkta 13: 1995.0–2383.0 m,
- Łąkta 14: 1905.0–2473.0 m,
- Łąkta 22: 2172.0–2460.0 m,
- Łąkta 24: 2891.0–3068.0 m,
- Łąkta 25: 2008.0–2391.0 m,
- Łąkta 30K,
- Muchówka 1: 2120.0–2494.0 m,
- Muchówka 2,
- Połom Duży 2: 1510.0–2437.0 m,
- Raciechowice 1,
- Rajbrot 1,
- Rajbrot 2,
- Tarnawa 1,
- Tymowa 1: 2538.0–2660.0 m,

- Wiśniowa IG-1: 2268.0–2648.0 m,
- Wiśniowa 3: 2275.0–2332.0 m,
- Wiśniowa 4: 2100.0–2328.0 m,
- Wiśniowa 6: 1867.0–2052.0 m,
- Żegocina 1.

The autochthonous Miocene in the Block 413-414 tender area is poorly recognized. The Miocene succession in the mentioned above wells is most often not stratigraphically subdivided (Figs 2.13–2.14). Only in the Muchówka 2 and Rajbrot 2 wells, the Miocene succession was classified as the Upper Badenian (Muchówka 2) or Upper and Lower Badenian (Rajbrot 2). No evaporitic layers were found anywhere. The Miocene is represented by dark-grey mudstones and claystones, intercalated with light gray quartz-muscovite sandstones. At present, it is not possible to determine whether sandstones form long and continuous layers, but it seems that in a significant part of the succession thin layers of mudstones, claystones and sandstones, partly with heterolithic character, predominate (Figs 2.13–2.14). Assuming the interpretation of lithostratigraphy for the western part of the Carpathian Foredeep (Oszczypko et al., 2006), the described succession probably belongs to the Skawina Formation.

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2.2.3. OUTER CARPATHIAN FLYSCH

Distribution and thickness

Detailed geological investigations of the western part of the Carpathians was made in the 1950s and 1960s, mainly thanks to geological and cartographic works and lithostratigraphic studies by Książkiewicz, summarized in 1972 in a separate volume of the Geology of Poland (Książkiewicz, 1972). In the Block 413-414 tender area, flysch deposits of the Outer Carpathians occur on the surface or under a thin cover of Quaternary deposits. The following tectonic units can be distinguished (from north to south): Silesian, Sub-Silesian and Magura (Żytko et al., 1989; Fig. 2.1). The detailed description of individual lithostatigraphic units, distinguished within these tectonic nappes, can be found in the explanations to the Detailed Geological Map of Poland, 1: 50,000 – Wieliczka (Burtan and Wójcik, 2017), Bohnia (Kopciowski et al., 2017), Brzesko (Jankowski and Paul, 2016), Mszana Dolna (Burtan, 1978), Limanowa (Wójcik et al., 2017b) and Męcina sheets (Paul and Jugowiec, 2021). At this point, we once again refer to our previous studies dedicated to the Sucha Beskidzka-Wiśniowa tender areas (Wójcik et al., 2017a) and Królówka (Jankowski et al., 2018), where you can find a broader description of Outer Carpathian stratigraphy, presented here only briefly.

The Outer Carpathian surface geology in the Block 413-414 tender area is illustrated in Figs 2.1–2.3 and its references. Below is also a list of wells that drilled or pierced flysch deposits in the tender area, with the depth of the bottom of the Outer Carpathians:

- Czchów 1: 3060.0 m,
- Dobczyce 5: 1670.0 m,
- Iwkowa 1: 2702.0 m,
- Jaworzna 1: 3214.1 (not pierced),
- Leszczyna 1: 1625.0 m,
- Leszczyna 2: 1897.0 m,
- Leszczyna 3: 1944.0 m,
- Leszczyna 4: 2179.0 m,
- Leszczyna 21: 1820.0 m,
- Leszczyna 22: 1880.0 m,
- Lipnica Górna 1: 1575.0 m,
- Łapanów 2/2K: 1550.0 m,
- Łąkta 4: 1835.0 m,
- Łąkta 9: 1985.0 m,
- Łąkta 11; 1870.0 m,
- Łąkta 13: 1995.0 m,
- Łąkta 14: 1905.0 m,
- Łąkta 22: 2175.0 m,
- Łąkta 24: 2891.0 m,
- Łąkta 25: 2008.0 m,
- Muchówka 1: 2060.0 m,
- Muchówka 2,
- Połom Duży 2: 1510.0 m,
- Raciechowice 1,
- Rajbot 1,
- Rajbot 2,
- Tarnawa 1,

- Tymowa 1: 2538.0 m,
- Wiśniowa IG-1: 2268.0 m,
- Wiśniowa 3: 2275.0 m,
- Wiśniowa 4: 2100.0 m,
- Wiśniowa 6: 1867.0 m,
- Wolica 1: 2748.0 m,
- Żegocina 1.

Sub-Silesian Unit

The Sub-Silesian (Sub-Silesian/Melange) Unit occurs in the southern part of the tender area in tectonic windows (including Wiśniowa and Skrzydlna windows) along the line of Magura Unit overthrust (Figs 2.–2.2). This unit is represented by Cretaceous and Paleogene deposits, similar in lithology to the Silesian Unit. The succession of the Sub-Silesian Unit is composed of:

1. Upper Cieszyn Shales, Valanghinian–Albian, ~100 m thick.
2. Grodziszcze Beds, Valanghinian–Albian, thickness ~100 m.
3. Verovice Shales, Valanghinian–Albian.
4. Lgota Beds, Aptian.
5. Spotted Shales of the Lgota Beds, Albian–Cenomanian.
6. Mikuszowice Hornfels, Albian–Cenomanian.
7. Jasper Beds, Albian-Cenomanian.
8. Variegated Shales of the Godula Beds, Cenomanian–Senonian.
9. Lower Godula Beds, Cenomanian–Senonian.
10. Godula and Inoceramian Beds, Cenomanian–Senonian, thickness ~~250 m.
11. Gray marls with exotics/Frydek facies, Cenomanian–Senonian, thickness 100 m.
12. Węglówka Variegated Marls, Cenomanian–Senonian.
13. Rybie Variegated Sandstones, Cenomanian–Senonian.
14. Bryozoan-lithothamnium sandstones from Szydłowiec, Cenomanian–Senonian, thickness ~250 m.
15. White Marls, Senonian–Eocene, several meters thick.
16. Glauconite Sandstones from Czerwin, Paleocene.
17. Layered White Marls, Eocene.
18. Variegated Shales, Eocene, thickness ~50–70 m.
19. Red Marls, Eocene.
20. Green shales with ankerite concretions, Eocene.
21. Sub-Menilite Marls, Eocene.
22. Menilite Shales and Jasło Shales, Oligocene.

The Sub-Silesian Unit (usually undivided lithostratigraphically) was detected in the following wells:

- Czchów 1: 2765.0–3060.0 m,
- Iwkowa 1: 2543.0–2702.0 m,
- Leszczyna 1: 1470.0–1625.0 m,
- Leszczyna 2: 1750.0–1897.0 m,
- Leszczyna 4: 2040.0–2179.0 m,
- Łąkta 9: 1640.0–1985.0 m,
- Łąkta 13: 1880.0–1995.0 m,
- Łąkta 14: 1732.0–1905.0 m,
- Łąkta 22: 2066.0–2172.0 m,
- Łąkta 24: 2296.0–2890.0 m,
- Łąkta 25: 1842.0–2008.0 m,
- Muchówka 2,
- Wiśniowa IG-1: 15.0–2268.0 m,
- Wiśniowa 3: 270.0–2275.0 m,
- Wiśniowa 4: 1850.0–2100.0 m,
- Wiśniowa 6: 1312.0–1867.0 m,
- Wolica 1: 2421.0–2748.0 m,
- Żegocina 1.

Silesian Unit

The Silesian Unit occurs in the northern part of the tender area (Figs 2.1–2.2). This unit is represented by Cretaceous and Paleogene deposits:

1. Cieszyn Beds, Beriassian–Hauterivian, thickness ~ 200 m.
2. Grodziszcze Beds, Hauterivian–Albian, thickness ~100 m.
3. Verovice Beds, Hauterivian–Albian, thickness ~80 m.
4. Gaize Beds, Albian, thickness ~50 m.
5. Lower Lgota Beds, Albian, thickness ~200 m.
6. Lower Godula Beds, Turonian–Maastrichtian, thickness ~300 m
7. Godula Beds, Turonian–Maastrichtian, thickness of the Godula Variegated Shales ~60 m.
8. Undivided Godula Beds, Turonian–Maastrichtian.
9. Lower Istebna Beds, Cretaceous–Paleocene, thickness ~80 m.

10. Lower Istebna Beds, Upper Cretaceous–Paleocene, thickness ~1300 m.
11. Lower Istebna Beds, Upper Cretaceous–Paleocene, thickness ~250 m.
12. Upper Istebna Beds, Palaeocene, thickness ~200 m.
13. Upper Istebna Beds, Palaeocene, thickness ~120 m.
14. Variegated Shale, Eocene, thickness ~100 m.
15. Ciężkowickie Sandstones, Eocene, thickness ~80 m.
16. Hieroglyphic Beds, Eocene, thickness may exceed 400 m.
17. Menilite Beds, Oligocene, maximum thickness 100 m.
18. Lower Krosno Beds, Oligocene, maximum thickness ~500 m.

The Silesian Unit was also drilled in the following wells:

- Czchów 1: 10.0–2765.0 m,
- Dobczyce 5: 10.0–1670.0 m,
- Iwkowa 1: 565.0–2543.0 m,
- Jaworzna 1: 2258.0–3214.1 m,
- Leszczyna 1: 15.0–1470.0 m,
- Leszczyna 2: 5.0–1750.0 m,
- Leszczyna 4: 10.0–2040.0 m,
- Leszczyna 21: 0.0–1820.0 m,
- Leszczyna 22: 0.0–1540.0 m,
- Lipnica Górna 1: 10.0–1575.0 m,
- Łapanów 2/2K: 10.0–1550.0 m,
- Łąkta 4: 10.0–1835.0 m,
- Łąkta 9: 15.0–1640.0 m,
- Łąkta 11: 0.0–1870.0 m,
- Łąkta 13: 0.0–1880.0 m,
- Łąkta 14: 0.0–1732.0 m,
- Łąkta 22: 10.0–2066.0 m,
- Łąkta 24: 0.0–2296.0 m,
- Łąkta 25: 0.0–1845.0 m,
- Łąkta 30K,
- Muchówka 1: 0.0–2060.0 m,
- Muchówka 2,
- Połom Duży 2: 0.0–1510.0 m,
- Raciechowice 1,
- Rajbrot 1,
- Rajbrot 2,
- Tarnawa 1,
- Tymowa 1: 8.0–2538.0 m,
- Wiśniowa 3: 0.0–270.0 m,
- Wiśniowa 4: 0.0–1850.0 m,
- Wiśniowa 6: 0.0–1312.0 m,
- Wolica 1: 0.0–2421.0 m,
- Żegocina 1.

Magura Unit

Within the Magura Unit, only the Siary facies zone occurs in the tender area (Fig. 2.1). According to the description of Cieszkowski et al. (2006; see also Wójcik et al., 2017a), the following lithostratigraphic units can be distinguished:

1. Jaworzynka Formation: Biotite Beds (Inoceramian Beds in the biotite facies), Senonian, thickness ~70 m.
2. Jaworzynka Formation: Ropianka Beds (Inoceramian Beds), Senonian–Paleocene, thickness ~150 m.
3. Jaworzynka Formation: Mutne Sandstone Member, Paleocene, thickness ~300 m.
4. Łabowa Formation: Variegated Shales, Paleocene-Middle Eocene, thickness ~120 m.
5. Łabowa Formation: Żurawnica Sandstone Member (Ciężkowice Sandstones), Eocene, thickness of the Żurawnica sandstones is about ~150–300 m.
6. Łabowa Formation: Skawce Sandstone (Pasierba Sandstones?), Eocene, thickness ~200–350 m.
7. Belowesko Formation: Droździna Shales Member (Hieroglyphic Beds), Middle and Upper Eocene, thickness from several to several dozen meters.
8. Maków Formation: Zembrzyce Shales (Sub-Magura Beds), Eocene, thickness from several dozen to about 500 m.
9. Maków Formation: Wątkowa Sandstone Member (Magura Sandstones), Upper Eocene, thickness from several hundred to 1000 m.
10. Maków Formation: Budzów Shales Member (Magura Beds), Upper Eocene, thickness up to 800 m.

The Magura Unit, together with the Sub-Magura Unit, was drilled in the Jaworzna 1 well in the interval 15.0–2258.0 m.

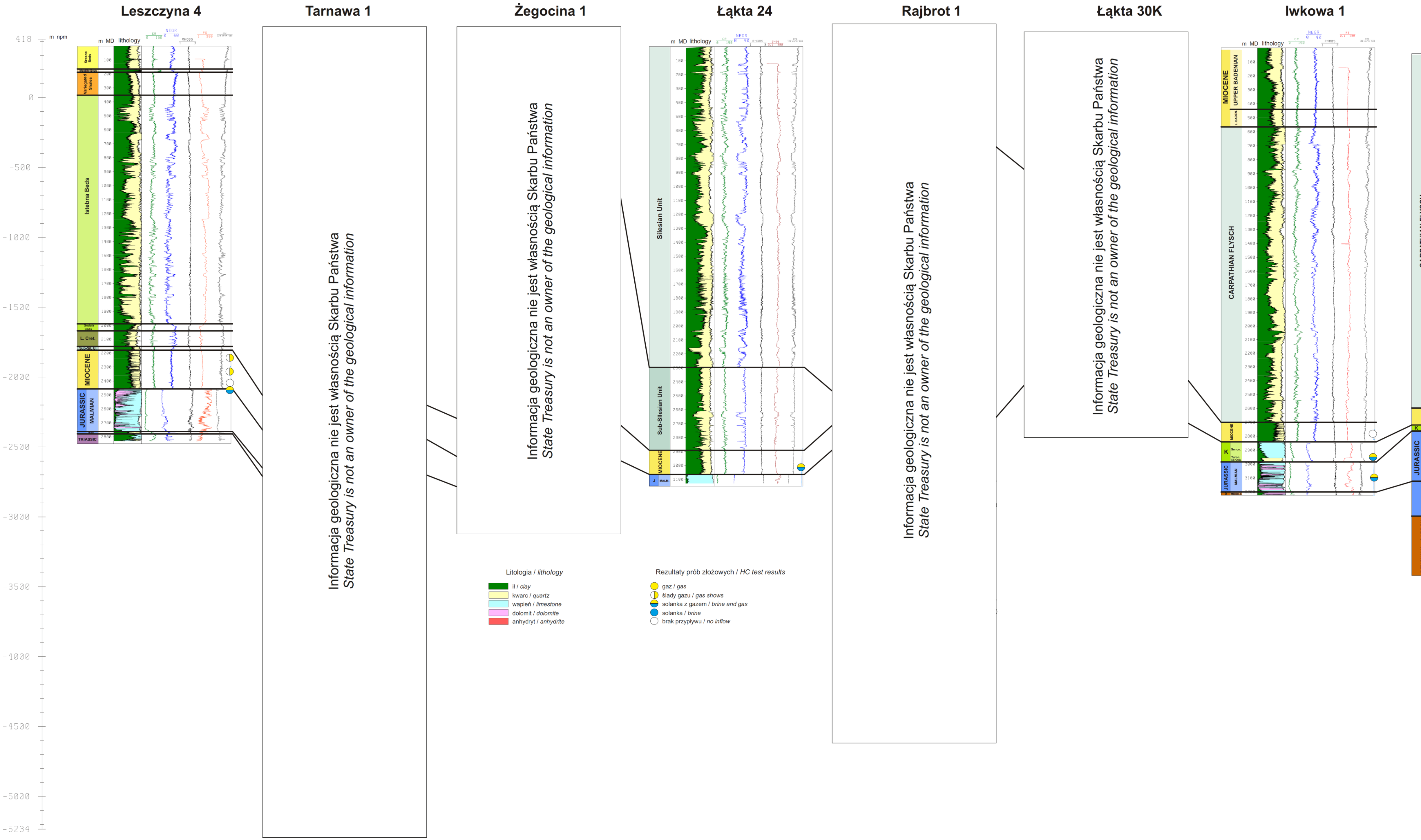


Fig. 2.13. Stratigraphic and geophysical correlation, as well as results of hydrocarbon tests in wells located within the Block 413-414 tender area (Wilk et al., 2013).

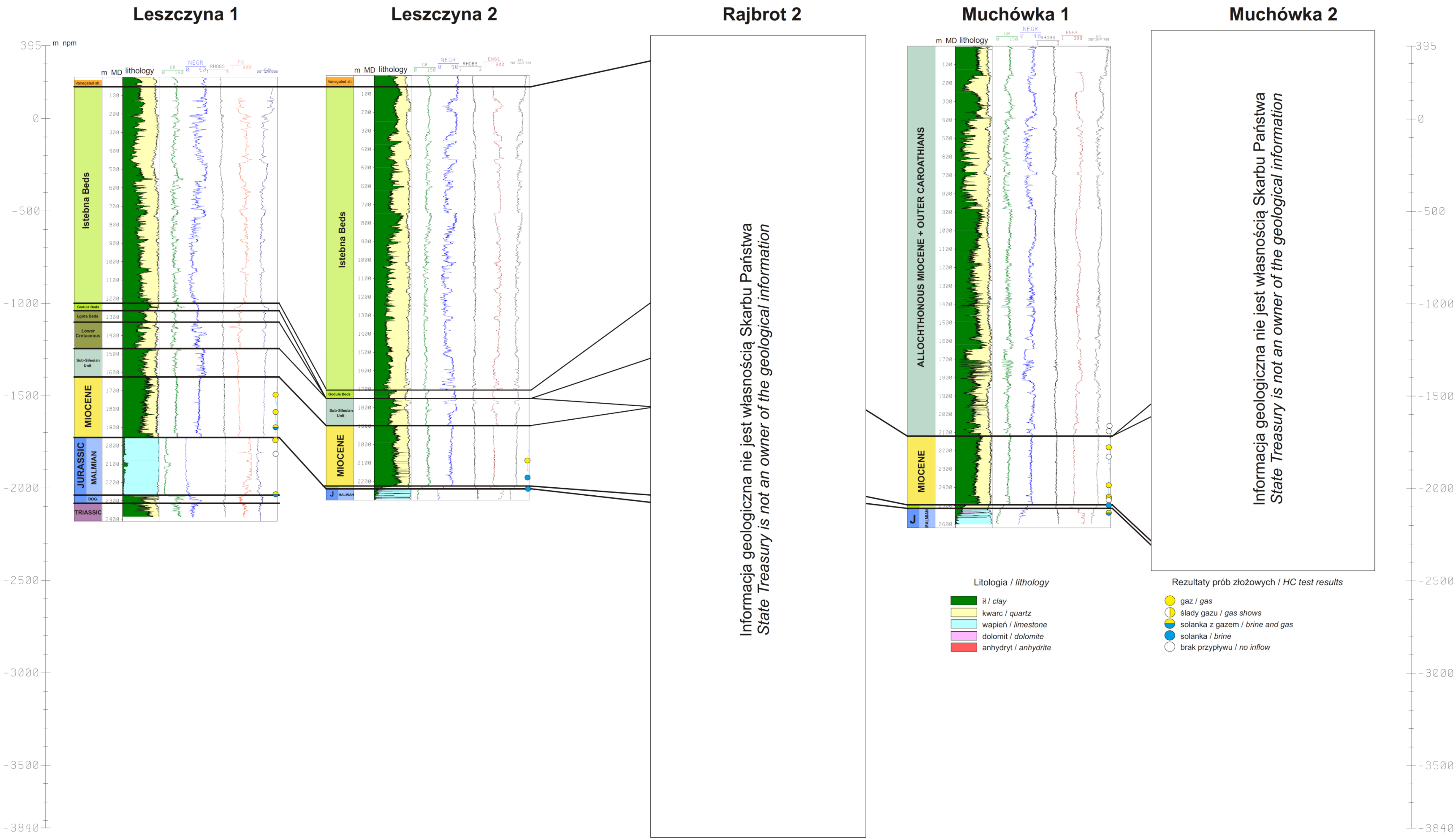


Fig. 2.14. Stratigraphic and geophysical correlation, as well as results of hydrocarbon tests in wells located within the Block 413-414 tender area (Wilk et al., 2013).

2.2.4. CENOZOIC

Based on the Detailed Geological Map of Poland in the scale of 1: 50,000, it can be concluded that the geological basement of the area is heterogeneous. Quaternary deposits cover a smaller part of the area. In the northern part, Quaternary sediments are represented mainly by aeolian deposits from the last glaciation. They are formed as Pleistocene loess and loess-like silts. The thickness of the cover of loess formations is usually several meters. Within the cover, the soils were found, which are marked in the succession with an increased content of humus or silt inserts. Sand intercalations or sand deposits within the dust cover indicate an increase in wind strength during accumulation or the development of slope processes in the periglacial zone. The lithologically discussed sediments are brown-yellow, yellow and yellow-grey dusts, sandy dusts, clays and silty clays. Under the cover of loess in the Raba valley, between Gdów and Niegowa, there are sands and river gravels of terraces 8.0–15.0 m a.l. of the river. In the Raba valley, gravels, sands, clays and river clays were also distinguished – products of terraces reaching 5.0–8.0 m a.l. of the river. They build the so-called rendzina belt (Fig. 2.2).

At the ends of the side valleys, these terraces are overbuilt by alluvial fans. They are composed of gravels and boulders with a diameter of 5–20 cm and sands of various grains, and in the top – clays and sandy clays with a thickness of 1.5–3.0 m.

The southern part of Block 413-414 tender area is characterized by outcrops of older rocks. Only in the south-western part, in the area of Wiśniowa, Zasań and Czerwin, Quaternary clays and rock debris were found. The valleys are filled with Holocene sediments – gravels, sands, floodplain clays. On the slopes, there are landslide colluvia formed from flysch material (Fig. 2.2).

In the south-eastern part of the area, the Quaternary sediments of various origin and thickness lie on the flysch formations. These are fluvial, solifluction-deluvial, colluvial, eluvial, weathered, fluvioglacial sediments, peat soils and calcareous tufa. Very locally, the Quaternary is represented by clays, clays with rock rubble, boulders and colluvial blocks (flysch packages).

2.3. HYDROGEOLOGY

In the regionalization of fresh waters in Poland, the Block 413-414 tender area belongs to the Vistula Province, the Upper Vistula Region, the Outer Carpathians subregion. Groundwater system includes two multiaquifers formation: Quaternary and connected Paleogene-Cretaceous system (Fig. 2.15). Quaternary formations are mainly sands of various granulation and gravel which are associated with river valleys. The average thickness of this aquifer is 5 m. The Quaternary aquifer is fed by direct infiltration of atmospheric precipitation and by infiltration of rivers. In terms of chemistry, the waters of the Quaternary aquifer are of medium quality and are most often of the HCO_3-Ca-Mg and HCO_3-SO_4-Ca-Mg types. Flysch aquifers are associated primarily with the top, cracked part of flysch formations formed mainly in the form of coarse and medium-grained sandstones with shale inserts. They are permeable to a depth of 80–90 m below ground level. The most permeable is the near-surface zone with a thickness of 30–40 m. The average thickness of the aquifer is about 15 m. The waterlogged zone creates a discontinuous aquifer. The flow of groundwater in flysch sediments is towards river valleys. The waters in the flysch formations are of good and very good quality and are characterized by mineralization in the range of 200 to 500 mg/dm^3. Flysch aquifers are characterized by a moderate degree of hazard to groundwater (Fig. 2.16). A very high level of threat includes the Quaternary layers within the valleys of rivers. It is related to the rapid vertical infiltration through the aeration zone and the contamination of rivers by municipal sewage outflows. There are three local groundwater reservoirs in the tender area. These are the local Raba and Stradomka reservoirs and the Istebna layer reservoir (Fig. 2.15). The Raba and Stradomka reservoirs are pore reservoirs developed in Quaternary sediments with waters of II and III quality class. The Istebna groundwater reservoir is a pore-fissure including Quaternary, Palaeogene and Cretaceous sediments. The tender area is located on the border of two balance areas - K-III and K-IV. For the K-III area (2829 km^2) the amount of available resources is 211 200 m^3/24h. For the K-IV area (5194,95 km^2), the amount of available resources is 444 582 m^3/24h.

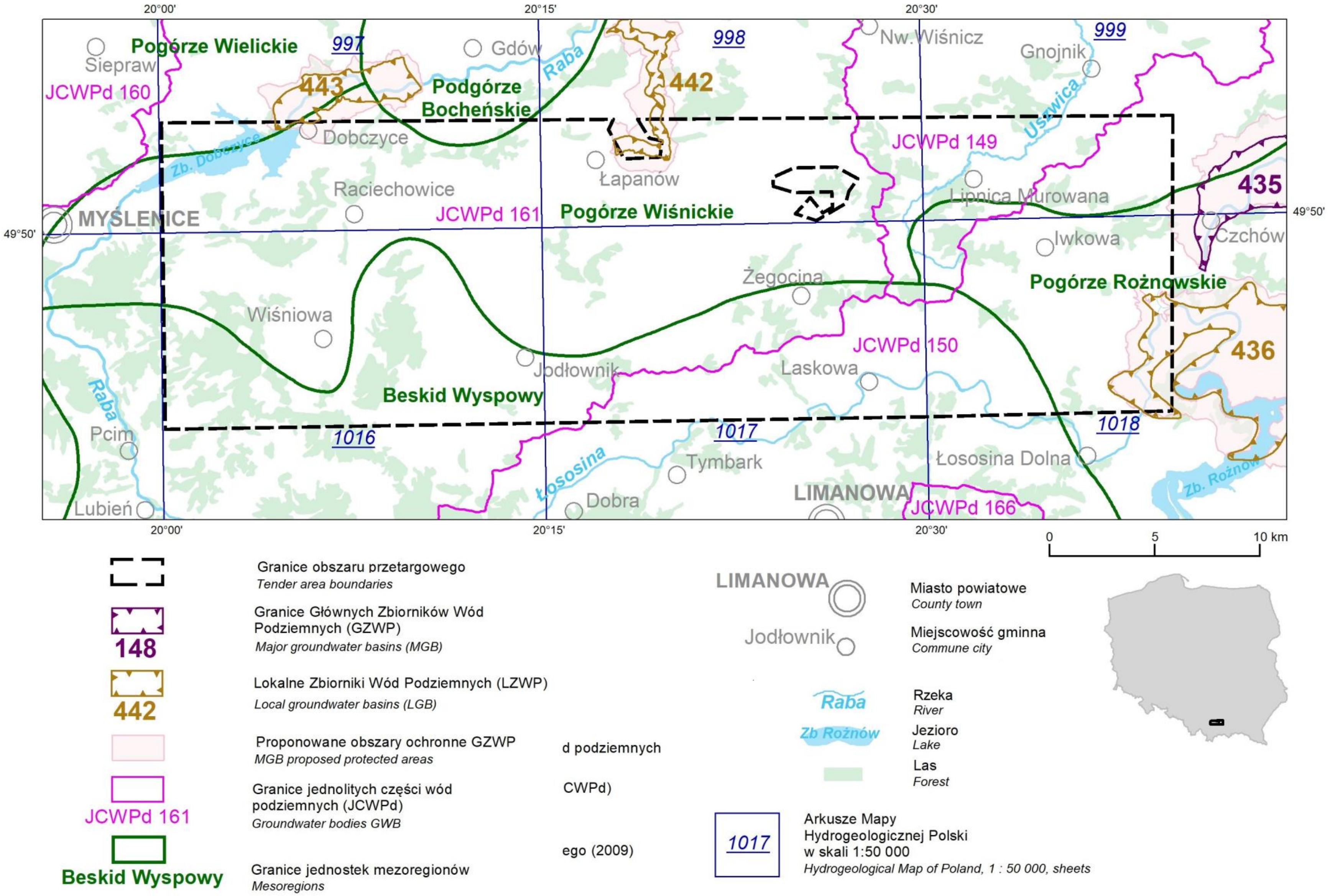


Fig. 2.15. Location of the Block 413-414 tender area on the background of physico-geographic units, Major Groundwater Basins (MGB) and Groundwater Bodies (GBW).

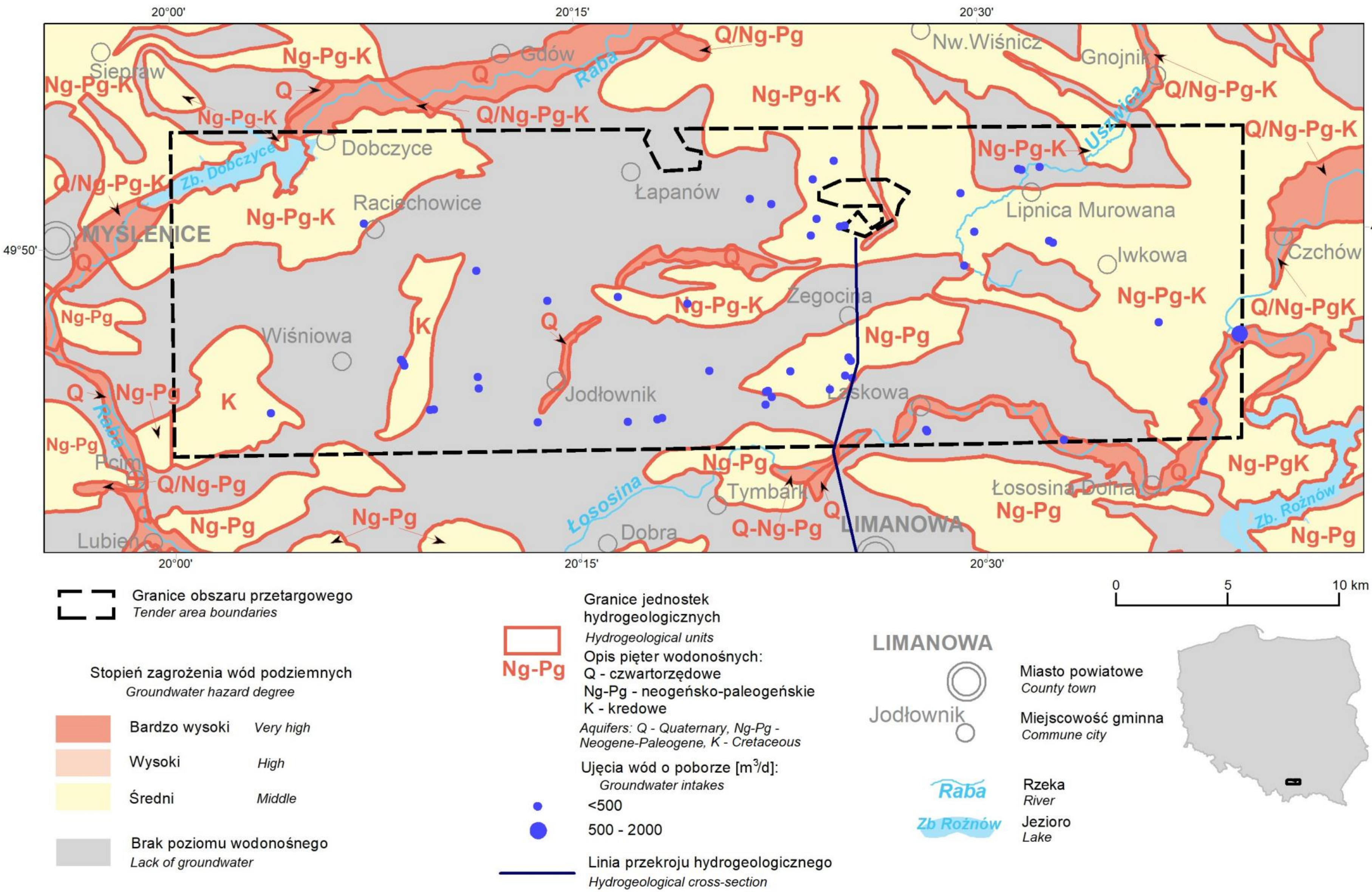


Fig. 2.16. Location of the Block 413-414 tender area on the background of hydrogeological units.

3. PETROLEUM PLAY

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, as well as hydrocarbon characteristics of the Block 413-414 tender area enable to distinguish three separate petroleum plays. They are developed in:

- Paleozoic-Mesozoic Carpathian basement,
- Miocene of the Carpathian Foredeep,
- Outer Carpathian flysch.

The accumulations of hydrocarbons in the Łapanów and Łąkta fields (located within the tender area) are at least partly related to the Mesozoic-Palaeozoic petroleum play. In this case, the Paleozoic-Mesozoic rocks belong to two separate tectonic units: Upper Silesian Block (approx. 85% of the area) and the Małopolska Block (approx. 15% of the area in its NE part). As a consequence, there are differences in thermal maturity and transformation degree of organic matter. The best generation properties are found in the Lower Carboniferous and Middle Jurassic clastic rocks deposited within the Upper Silesian Block. The most promising source rocks in the Małopolska Block are Devonian and Lower Carboniferous carbonate and clastic rocks. Mesozoic clastic and carbonate rocks have the best reservoir properties (porosities in the Cenomanian sandstones of the Łąkta field reach 21% and permeability is up to 1367 mD, while the Upper Jurassic carbonates are characterized by variable values of secondary porosity from several to 20% and permeability exceeding 200 mD). The Devonian and Carboniferous play also a role of potential reservoir rocks (e.g. Rajbrot-2 well and Tarnawa 1 well, in which gasified brine flows and natural gas shows were detected). The Palaeozoic-Mesozoic system is sealed by the Miocene of the Carpathian Foredeep or Senonian marls that lie under the Carpathian overthrust. The seal can also be related to fine-clastic Carboniferous rocks.

The petroleum play developed in the Miocene of the Carpathian Foredeep contains gas generated by biogenic and low-temperature thermogenic processes. Approximately 5 km north to the Block 413-414 tender area, the Grabina-Nieznanowice field was discovered with six horizons of high-methane natural gas accumulations at a depth of 250 to 750 m. The field was discovered in sandstone and mudstone rocks, separated by siltstone and claystone packages. The sand content determines the reservoir properties of these levels (porosity ~4–22%, permeability ~0.002–1.5 D), affecting the production of gas ranging from several to 82 m^3/min. The Miocene part of the Łąkta field is an independent accumulation of high-methane natural gas in sandstones and mudstones with a porosity of 8–12% and a permeability of several mD. Gas production is from 4.25 m^3/min to 99.5 m^3/min from the depth interval 1900–2425 m. In the Miocene succession, there are alternating horizons of fine-clastic rocks enriched in organic matter (they act as both source and sealing rocks) and layers of mudstones and sandstones as collectors.

the oil system in the C

The third petroleum play is developed in the Outer Carpathians. The best source rocks are the Oligocene Menilite Shales, while the Eocene Hieroglyphic Beds and Lower Cretaceous Upper Cieszyn Beds and Grodziszcze Beds of the Sub-Silesian Unit are of minor importance. The reservoir rocks are the Upper Cretaceous-Paleocene Istebna Beds and the Oligocene Krosno Sandstones. There are three fields in close vicinity of the Block 413-414 tender: very small, depleted Skrzydlna oil field (Krosno Sandstones of the Silesian Unit) and Klęczany field (Grybow and Krosno Beds of the Dukla-Grybów Unit), as well as the Słopnice gas-condensate field (Grybow and Krosno Beds of the Dukla-Grybów Unit). The Słopnice field, with a production of approximately 45 million m^3 of gas so far, still has 80 million m^3 of recoverable gas resources. The field is abandoned, however, due to very poor reservoir properties limits the production (porosity: 0.01–2%, permeability up to several mD).

The petroleum plays in the central part of the Carpathians were previously described is geological data packages Sucha Beskidzka-Wiśniowa (Wójcik et al., 2017a) and Krzyżówka (Jankowski et al., 2018) – tender areas dedicated to the previous licensing rounds.

Paleozoic-Mesozoic petroleum play

Source rocks. The main source rocks in the Block 413-414 tender area are found in the Middle and Upper Devonian carbonates, Mississippian carbonate and clastic sediments, as well as in the Middle Jurassic strata (Kotarba et al., 2017). The Middle and Upper Devonian source rocks are developed in carbonate facies, i.e. dolomites, limestones, marls and marly limestones. The TOC is typically below 0.2%. (Kotarba et al., 2014), this classified the Middle and Upper Devonian rocks as having a low hydrocarbon potential, also due to the strong oxidation of organic matter. Oxidation processes took place both at the deposition stage and during the burial. The Middle and Upper Devonian rocks in the Block 413-414 tender area have (according to Kotarba et al., 2017):

TOC = 0.00–2.6% (avg. 0,2%)
Tmax = 428°–466°C (avg. 438°C)
S2 = 0.00–7.4 mg HC/g
PI = 0.01–1.00
HI = 0–367 mg HC/g TOC
Kerogen type: II.

Geochemical investigations of 5 samples from the Upper Devonian carbonate rocks of the Tarnawa 1 well indicate small amounts of dispersed organic matter (TOC up to 0.11%), which means that the sampled intervals are barren (Kotarba et al. , 2001; App. 1).

The Mississipian (Tournaisian–Visean) carbonate rocks are developed as bituminous and organodetritic limestones (Tarnawa 1, Rajbrot 1 and Rajbrot 2 wells). The results of geochemical investigations in the Tarnawa 1 well (12 samples from depth of 4623.1–5006.0 m; Kotarba et al., 2001), indicate small amounts of dispersed organic matter (maximum 0.27% TOC), which is of a marine origin, entering the middle phase of low-temperature thermocatalytic processes (oil window the following parameters were observed:

TOC = 0,00–0.27% (avg. 0,3)
Tmax = 444–452°C (avg. 449°C)
PI = 0.16–0.40 (avg. 0.28)
HI = 100–144 mg HC/g TOC
(avg. 126 mg HC/g TOC)
Ro = 0.78–0.95%
Kerogen type: II, locally II/III.

Additionally, pyrolysis of 2 samples from the Tymowa 1 well (depth 3320.0–3329.0 m) indicate the TOC content in the range of 0.02–0.86%, with Tmax of 422–429°C (Węgrzyn, 2017), which show weak source rocks and immaturity of organic matter.

Clastic rocks of the Mississippian Culm facies (Visean–Namurian A) in the tender area were identified in the Tarnawa 1 well. They are developed as fine- and medium-grained siltstones and sandstones, in places containing intercalations and laminae of humic coal and carbonaceous shale. Kotarba et al. (2014, 2017), based on samples derived from wells located several kilometres north of the tender area, indicate a low and moderate generation potential of Mississippian clastic rocks and immature and mature organic matter in the middle oil window. According to Kotarba et al. (2017), in the vicinity of the tender area, the Mississippian source rocks in the Culm facies are characterized by the following parameters:

TOC = 0.00–2.8%
Tmax = 432–451°C (avg. 441°C)
S2 = 0.33–3.0 mg HC/gRock
PI = 0.03–0.32
HI = 47–116 mg HC/g TOC
(avg. 58 mg HC/g TOC)

Kerogen type: III, locally II/III.

In the Tarnawa 1 well, in the interval of 4365.0–4585.6 m, the Culm deposits contain both dispersed organic matter in claystones and coal intercalations (TOC reaches up to 79.8% by weight), typically terrestrial, gas-forming organic matter predominates, and vitrinite group is typical (Kotarba et al., 2001). A single mudstone sample with a hydrogen index (HI) exceeding 300 mg HC/g TOC indicates the presence of a significant share of exinite macerals with oil-generating properties (Kotarba et al., 2001). Mississippian clastic source rocks in the Tarnawa 1 well are characterized by the following parameters (according to Kotarba et al., 2001):

TOC = 0.53–79.8% (avg. 24.1%)
Tmax = 428–451°C (average 430°C)
PI = 0.03–0.13 (avg. 0.05)
HI = 56–348 mg HC/g TOC
(avg. 177 mg HC/g TOC)
Ro = 0.67–0.71%
Kerogen type: III, locally type II/III.

According to Kotarba et al. (2017), the hydrocarbon potential of the Middle Jurassic strata is variable. The samples with the highest TOC and S2 occur only in the Tarnawa 1 well in brown coal horizons. In other regions, the Jurassic is low in organic matter. Rock-Eval pyrolysis, biomarker distribution, stable carbon isotope composition and elemental composition of kerogen indicate that mixed kerogen type III/II predominates. The Middle Jurassic strata are generally immature or in the early stage of low-temperature thermogenic process. The Middle Jurassic is characterized by the following parameters (Kotarba et al., 2017):

TOC = 0.00–15.7% (avg. 6.5%)
Tmax = 407–430°C (average 421°C)
S2 = 0.22–43.1 mgHC/gRocks
(avg. 22.7 mg HC/g)
PI = 0.02–0.27
HI = 62–467 mgHC/gTOC
(avg. 264 mgHC/gTOC)
Kerogen: type III, locally type III/II.

The hydrocarbon potential of the Middle Jurassic deposits was also analysed by Kosakowski et al. (2012a) in the Tarnawa 1, Rajbrot 1, Rajbrot 2 and Muchówka 2 wells:

TOC = 0.00–14.9% (average 0.2%)
Tmax = 410–430°C (average 423°C)
S1+S2 = 00.4–53.4 mgHC/gRocks
(avg. 22.8) mgHC/gRocks
HI = 121–507 mgHC/gTOC
(avg. 274 mgHC/gTOC)
Kerogen type: III/II
Stage of maturity: immature/early oil window
HC Potential: Poor to Good.

Reservoir rocks: Middle and Upper Devonian carbonate rocks, Mississippian carbonate rocks, Upper Jurassic carbonate rocks, hypothetically Cambrian clastic rocks.

Devonian and Carboniferous carbonate rocks from the Eifelian–Visean interval (limestones and dolomites) were drilled in 6 wells. The most complete succession was found in the Tarnawa 1 well (4623.0–5510.0 m.). Reservoir properties of these rocks resulted from fracturing and karst. Their porositiy ranges from 0.15 to 8.76%, most often in the range of 1–3%, and the maximum permeability was several mD (Baran, 1995; Baran et al., 1998). Referring to other data (see Chapter 5), in the Tymowa 1 and Iwkowa 1 wells the Devonian and Carboniferous carbonate rocks have 0.39–2.72% porosity and permeability <0.01 mD.

The Upper Jurassic rocks (limestones and marls) constitute, next to the Miocene, the most important reservoir horizon in the tender area. Kosakowski et al. (2012b) analysed the Upper Jurassic carbonate rocks between Kraków and Lubaczów, where porosity ranges from 0 to 18.3% (average 1.3%) and permeability ranges from 0 to 436 mD (average 0.01 mD). Good reservoir properties of the Upper Jurassic carbonate rocks are usually the result of karstification and fracturing. Such an example is the Łapanów field, in which the Upper Jurassic has an average porosity of 11.2%, with a permeability of 21–47 mD, and an effective thickness of the saturated horizon is from 12 to 30 m. However, similar carbonate rocks occurring in the vicinity of the Łapanów field have negligible permeability and porosity, which does not exceed 2% (Polakowski, 2011). The Łąkta field, associated with the Upper Jurassic limestones, has porosity from

0.4 to 20.74% and permeability 49 mD (Jawor and Jawor, 1971, 1972). Below (Table 3.1), reservoir properties of the Upper Jurassic carbonate rocks are listed based on data from wells drilled within the tender area (see Chapter 5):

Well name	Samples	Porosity [%]	Permeability [mD]
Czchów 1	3	0.64–0.74	0.0
Iwkowa 1	8	1.43–11.51	0.1–1.7
Leszczyna 1	16	0.17–5.19	0
Leszczyna 3	19	4.36–10.33	1.28–3.32
Leszczyna 4	10	1.04–7.47	0–19.6
Leszczyna 21	3	0–058	–
Leszczyna 22	1	2.24	0
Łapanów 2/2k	13	0.84–5.8	0.001–0.09
Łąkta 4	17	0–6.7	0–1.2
Łąkta 9	1	1.23	0.3
Łąkta 13	2	0.82–0.89	0
Łąkta 22	1	1.33–8.38	0–2.6
Łąkta 24	9	0.98–13.21	0–2.1
Łąkta 25	2	2.43–3.8	0–5.54
Muchówka 1	7	1.71–8.87	0–360.1
Połom Duży 2	2	8.07–10.69	0
Tymowa 1	37	1.74–21.50	<0.01–332.01
Wiśniowa 1	1	1.10	0
Wiśniowa 3	14	0.99–2.71	0
Wiśniowa 4	3	1.5–2.54	0
Wiśniowa 6	20	0.4–1.59	5.2–74.7
Wolica 1	10	0.19–2.94	0–2.6

Tab. 3.1. Porosity and permeability of the Upper Jurassic rocks in the Block 413-414 tender area.

The Cretaceous rocks should also be considered as reservoirs in the Block 413-414 tender area. Their petrophysical characteristics are given in Table 3.2.

Well name	Samples	Porosity [%]	Permeability [mD]
Iwkowa 1	13	7.15–15.92	52.8–554
Leszczyna 2	4	11.16–17.72	13.7–413.5
Lipnica Górna 1	16	0.28–17.79	0–3400.6
Łąkta 9	2	8.72–7.95	5.1
Łąkta 13	5	9.64–11.44	135–706.5
Łąkta 22	7	16.25–18.18	44–119.7
Łąkta 25	11	4.04–14.69	0
Połom Duży 2	13	10.25–20.49	71.2–458

Tab. 3.2. Porosity and permeability of the Cretaceous rocks in the Block 413-414 tender area.

Reservoir rocks potentially also occur in the Cambrian Borzęta Formation, drilled in 5 wells. The reservoir properties of Cambrian sandstones were recognized in the vicinity of Rajbrot, where they may form a potential pore-fissure reservoir, with porosity from 2.81 to 13.6% (average 7.9%) and permeability from 0.001 to 0.52 mD (average 0.001 mD; Kosakowski et al., 2012b). In the Wiśniowa 3 and Wiśniowa 6 wells, the Cambrian reaches a porosity of 0.43–3.15% and a permeability of 0–1.2 mD.

Seal rocks: Culm, Permian-Triassic, Middle Jurassic, autochthonous Miocene of the Carpathian Foredeep and the Outer Carpathian flysch series of the Sub-Silesian and Silesian Units (locally Stebnik Unit) for Devonian and Carboniferous horizons; autochthonous Miocene of the Carpathian Foredeep and Miocene of the Stebnik Unit for Jurassic horizon.

Overburden (approximately 1800–4500 m thick): autochthonous Miocene of the Carpathian Foredeep, folded Miocene of the Stebnik Unit, flysch series of the Sub-Silesian, Silesian and Magura Units.

Shape and size of traps. Structural/anticlinical traps predominate. Traps are related most often with raised blocks of fractured Devonian or Jurassic basement (e.g. Łąkta and Łapanów fields). Potential structures associated with the Jurassic blocks were illustrated in Figs 3.8–3.10. The most important are the Raciechowice, Tymowa, Łososina, Żegocina, Muchówka and Iwkowa elevations.

Age and mechanism of trap formation. The formation of traps was associated with three episodes of tectonic activity. The formation of traps in Devonian and Carboniferous rocks was the result of folding in the Variscan orogeny with formation of their Triassic and Jurassic overburden/sealing. Then, as a result of Laramian folding, at the turn of the Cretaceous and Paleogene, traps were formed in the Jurassic, later sealed with Paleogene and Miocene sediments. The formation of the remaining traps was related to the formation of the Flysch Carpathians, which remodeled the older traps.

Age and mechanism of generation, expulsion, migration and accumulation of hydrocarbons. The processes of hydrocarbon generation in the Paleozoic began at the turn of the Early and Late Cretaceous. The degree of kerogen transformation reached 20%, the source rocks in the zone of their deepest burial entered the main phase of the oil window. The petroleum processes was generally limited to the depth of the source rocks occurring, not exceeding 2500 m. The uplift of the Paleozoic–Mesozoic basement and erosion of the Cretaceous rocks occurred in the Paleogene and lasted until the beginning of the Badenian. During this interval the petroleum processes were slow. Then, when the formation of the foreland depression of the Outer Carpathians began, there was a slight increase in the thermal maturity of the source rocks as a result of the sedimentation of the Badenian and Sarmatian deposits. The degree of kerogen transformation reached only slightly over 30% in the deepest horizons. After the overthrust of the Carpathians onto the autochthonous Badenian and Sarmatian deposits, the kerogen transformation processes clearly intensified as a result of significant burial. The diversity of the thermal regime led to the source rocks reaching different phases of hydrocarbon generation. The highest degree of kerogen transformation, exceeding 90% (wet gas generation phase), was achieved by the source rocks occurring in the south-eastern part of the tender area, where their depth reaches over 5,000 m. The burial and thermal maturity curves, as well as the degree of transformation of the Devonian and Carboniferous source rocks in the tender area, are shown on the example of 1D modelling for the Rajbrot 2 well compared to the Grobla 28 well, located approximately 25 km north of the tender area (Figs 3.1–3.4).

Modelling of petroleum processes in the Paleozoic rocks proves that after the overthrust of the Carpathians, there was a rapid intensification of hydrocarbon generation processes. Therefore, the main phase of hydrocarbon generation was temporally related to the overthrusting, which began around 8 million years ago. If we place the time of the main phase of hydrocarbon generation in the context of the structural evolution of this region, it may indicate the possibility of migration of hydrocarbons from Paleozoic towards higher levels and their accumulation not only in Devonian and Carboniferous reservoir rocks, but also in Mesozoic and Miocene horizons, and even flysch sandstones. The results of modelling of petroleum systems (Wróbel et al., 2016; Sowiżdżał et al., 2015) indicate that the accumulation in the Paleozoic Devonian and Carboniferous reservoir horizons ranges the order of millions of tons, and the zone of the largest accumulations overlaps with the area with the highest TOC values and the highest genetic potential. A characteristic feature is the possible occurrence of hydrocarbons in the vicinity of dislocation zones, which were the main migration paths (Figs 3.5–3.7).

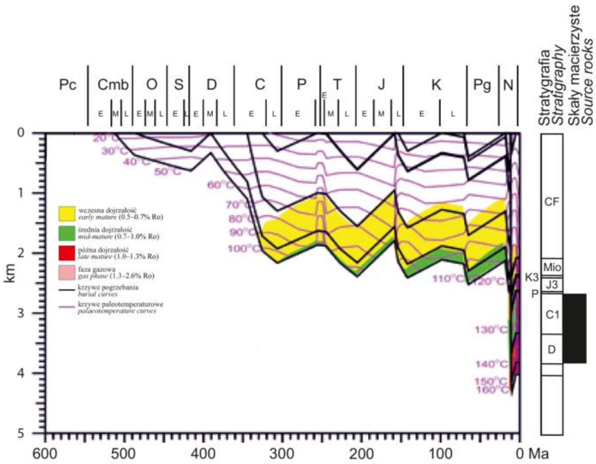


Fig. 3.1. Burial history of the Rajbrot 2 well.:(Wróbel et al., 2016). Well location – Fig. 3.4.

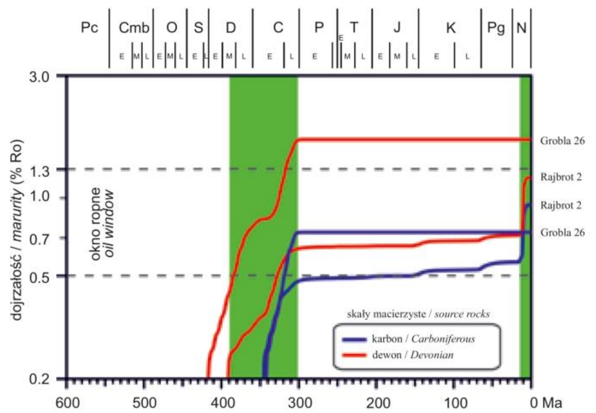


Fig. 3.2. Maturity evolution curves for late Palaeozoic source rocks. Wells location – Fig. 3.4.

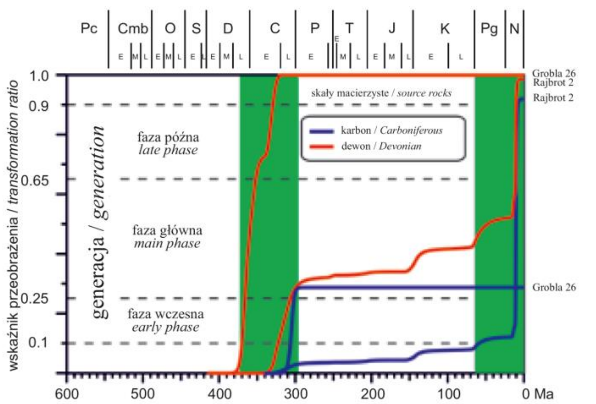


Fig. 3.3. Transformation ratio of kerogen in the late Palaeozoic source rocks. Wells location – Fig. 3.4.

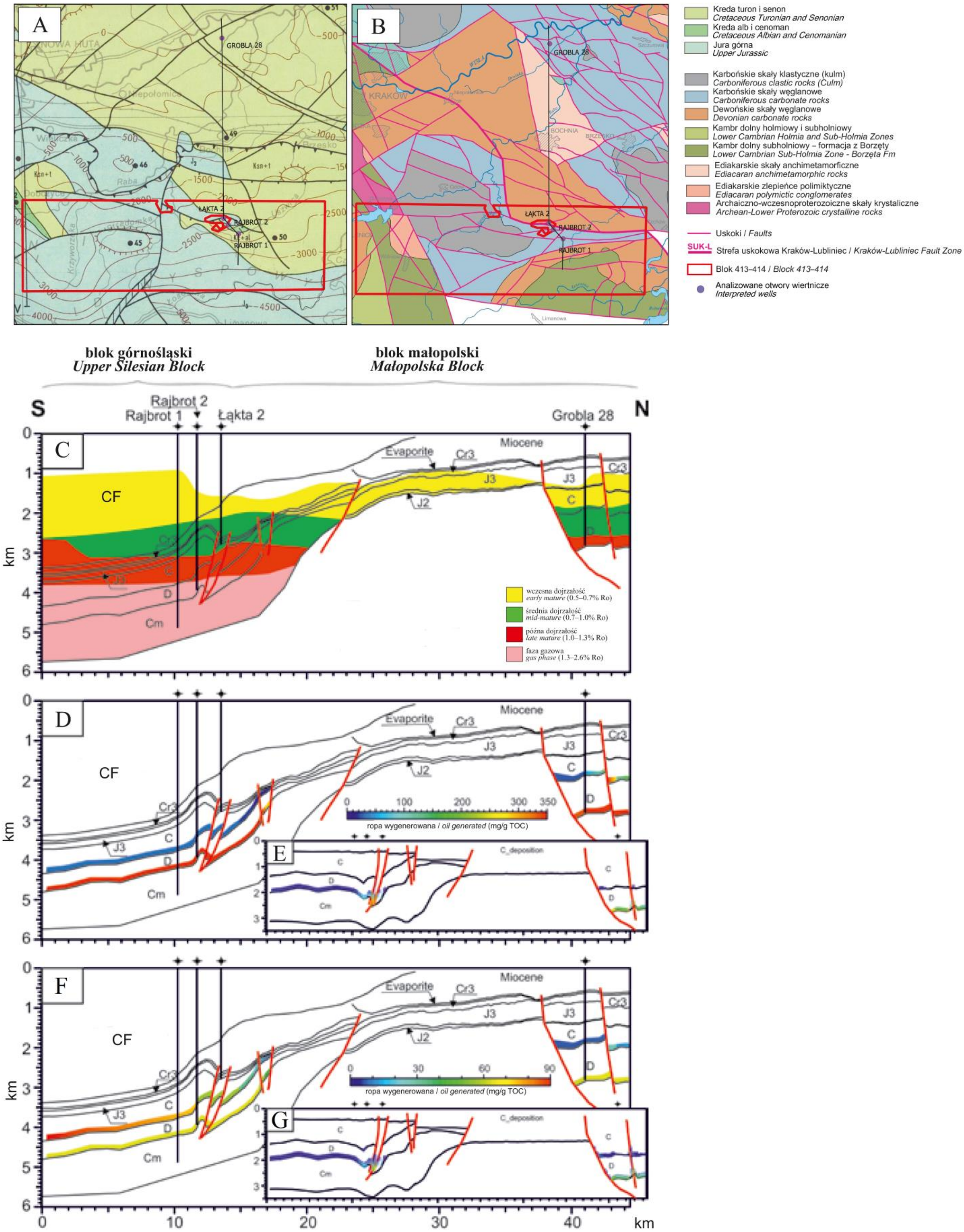


Fig. 3.4. A. Location of the Block 413-414 tender area on the geological map of the top surface of the Mesozoic strata (Poprawa and Nemčok, 1989) with location of the cross-section. **B.** Location of the Block 413-414 tender area on the geological map of the top surface of the Palaeozoic strata (Buła and Habryn, 2008) with location of the cross-section. **C–G.** Maturity schedule along the cross-section (C) and amount of generated oil therein at present (D) and after the Lower Carboniferous deposition (E) as well as amount of generated gas at present (F) and after the Lower Carboniferous deposition (G) along cross-section (Wróbel et al., 2016). Cr – Cretaceous, Cr3 – Upper Cretaceous, Cr1 – Lower Cretaceous, J3 – Upper Jurassic, J2 – Middle Jurassic, T – Triassic, C – Carboniferous, D – Devonian, S – Silurian, O – Ordovician.

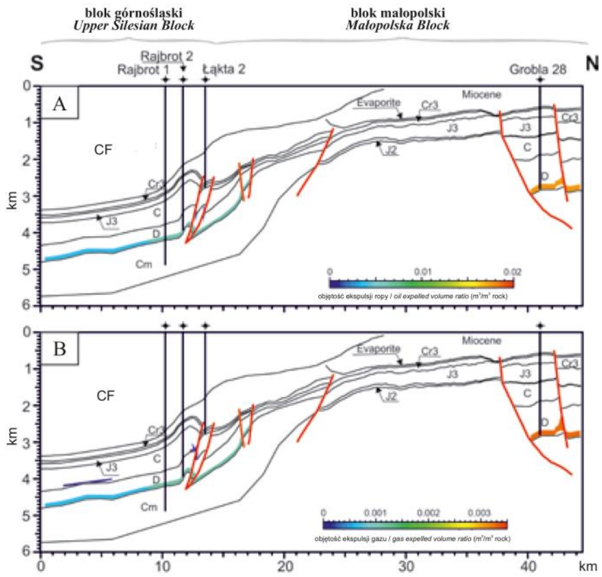


Fig. 3.5. The volume of the oil (A) and gas (B) expulsion along the cross-section (see above).

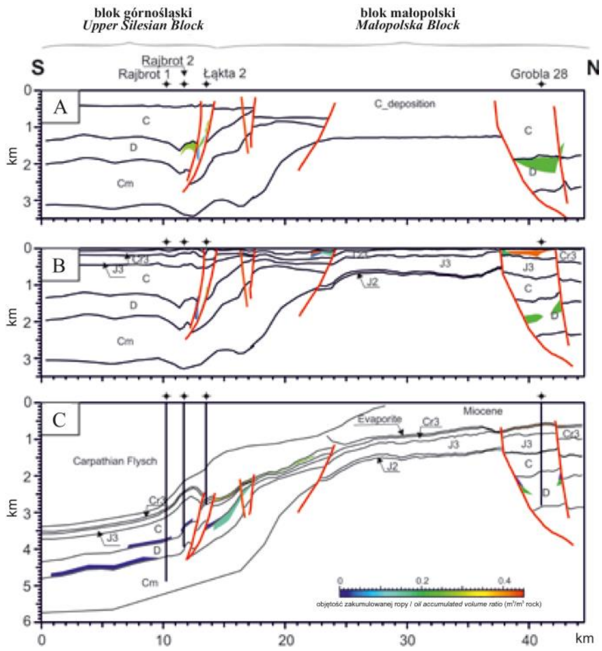


Fig. 3.6. The volume of the oil accumulation along the cross-section (see above) after the Lower Carboniferous deposition (A), in the beginning of the Miocene sedimentation

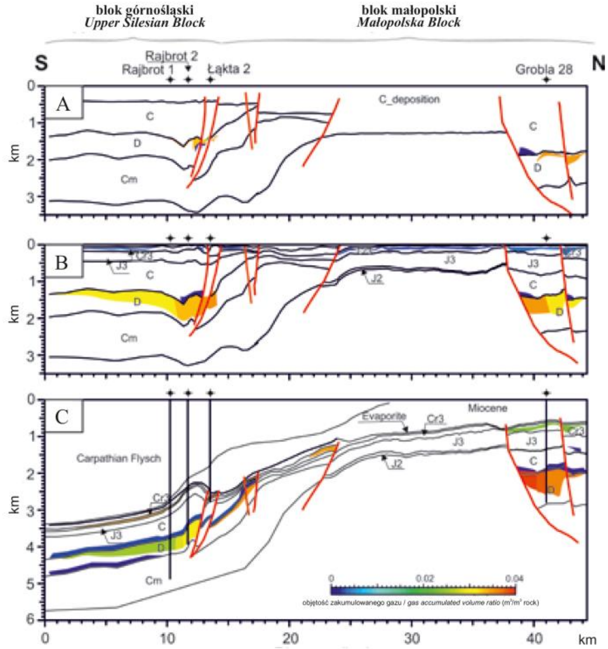


Fig. 3.7. The volume of the gas accumulation along the cross-section (see above) after the Lower Carboniferous deposition (A), in the beginning of the Miocene sedimentation (B) and at present (C).

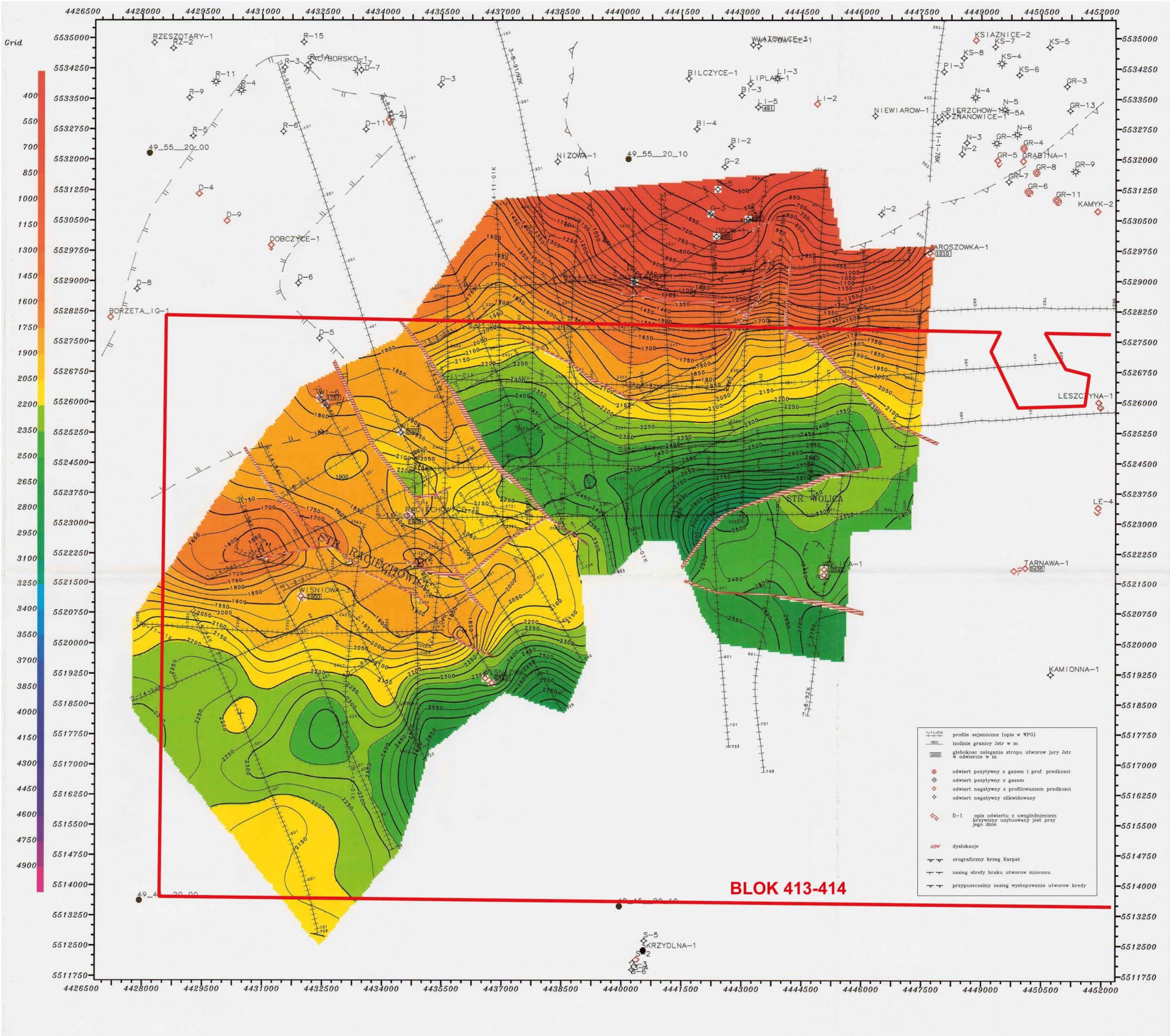


Fig. 3.8. Structural map of the Jstr seismic horizon (top of the Jurassic) in the western part of the Block 413-414 tender area (Jezierska and Keller-Utracka, 2002; in Polish).

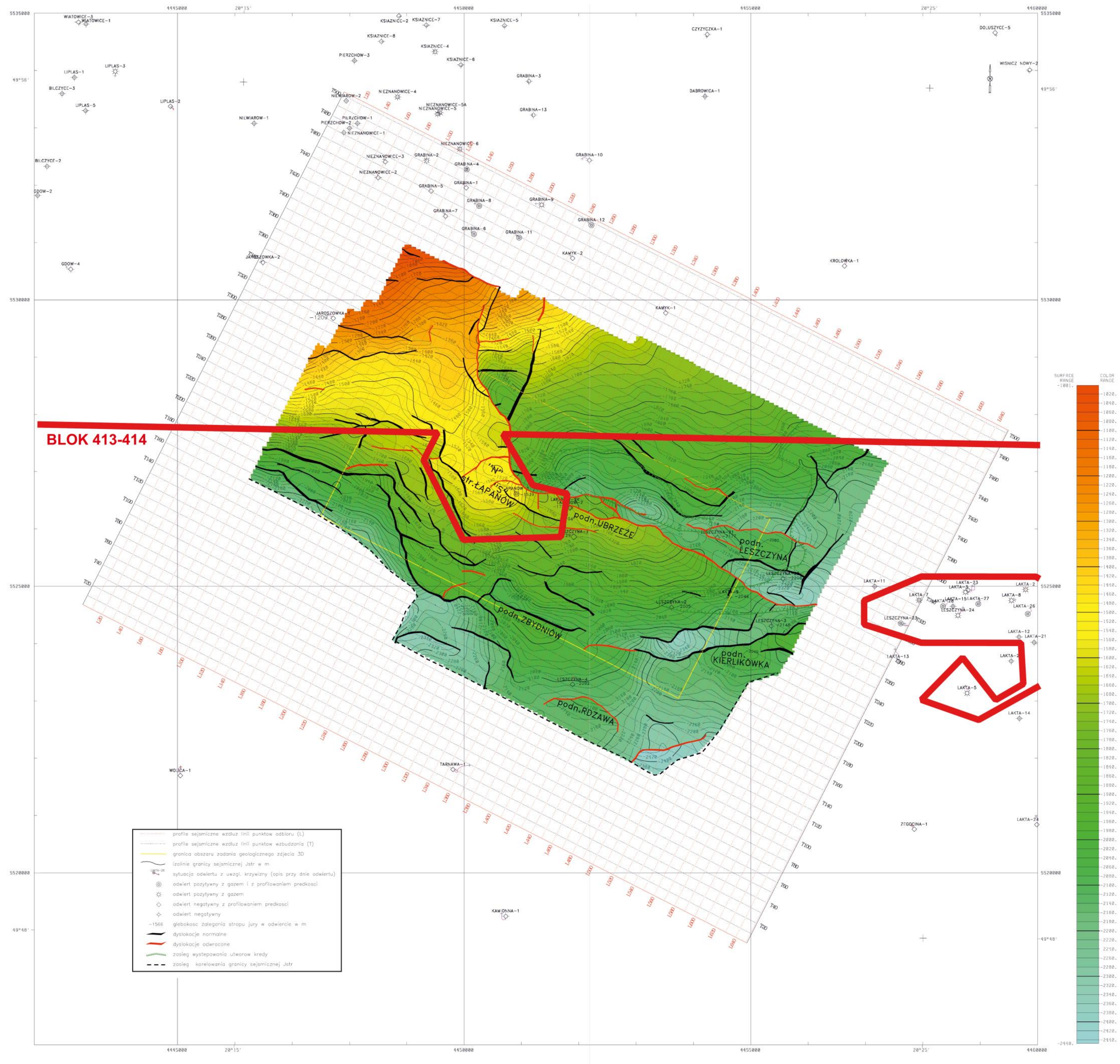


Fig. 3.9. Structural map of the Jstr seismic horizon (top of the Jurassic) in the central part of the Block 413-414 tender area (Zubrzycka et al., 2009; in Polish).

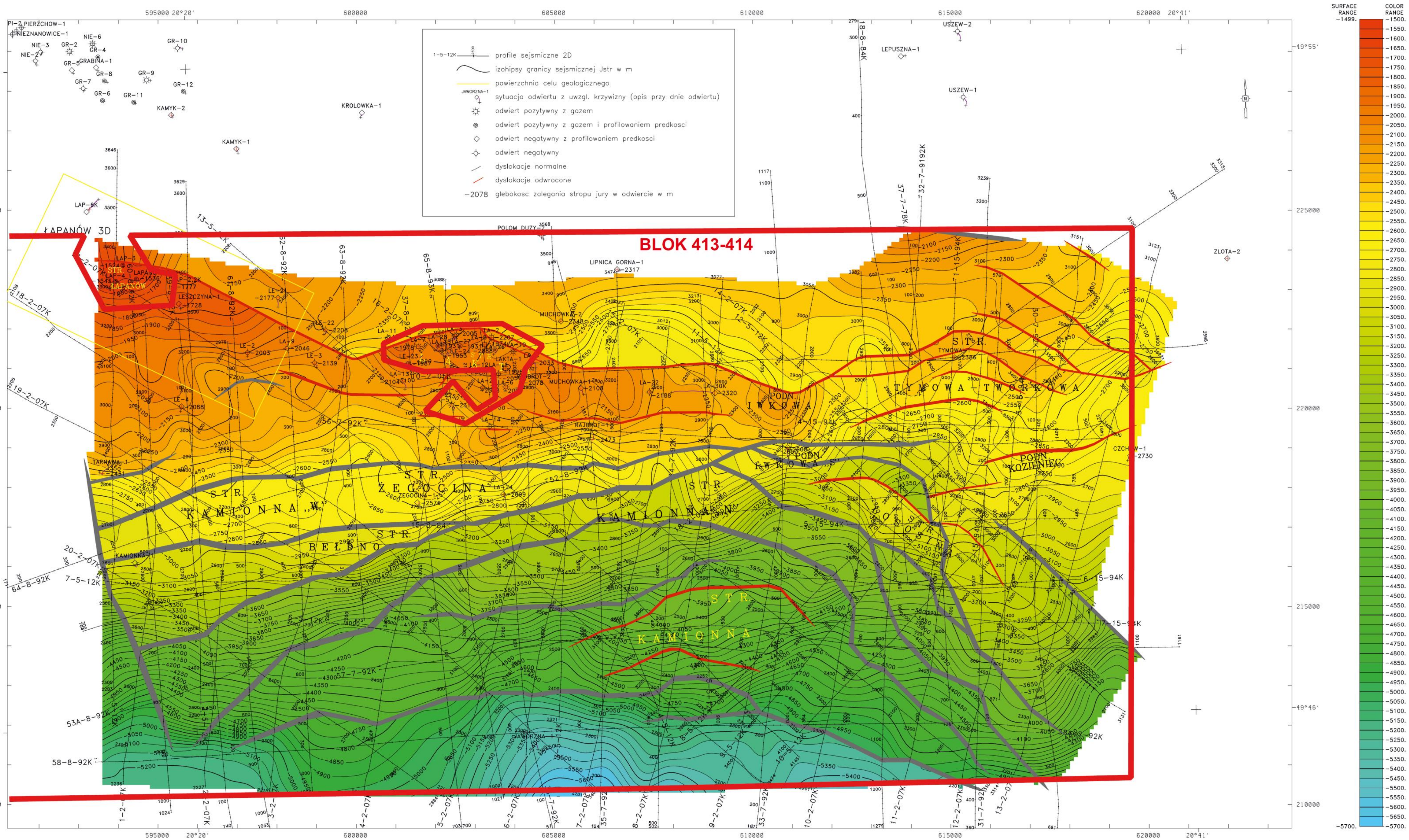


Fig. 3.10. Structural map of the Jstr seismic horizon (top of the Jurassic) in the eastern part of the Block 413-414 tender area (Wilk et al., 2013; in Polish).

Miocene petroleum play

Source rocks. The petroleum play in the autochthonous Miocene of the Carpathian Foredeep was developed in detail mainly for the eastern part of the basin, where the Upper Badenian and Sarmatian rocks were analysed in terms of their generation potential. The most important data covering the tender area can be found in Kosakowski et al. (2020), including the results from the Tymowa 1 and Łapanów 2 wells. This study indicates that the total organic carbon (TOC) content is about 0.5–0.7% wt., and locally up to 1% wt. The kerogen in the Badenian and Lower Sarmatian interval is terrestrial type III and locally mixed type II-III, which influenced the relatively low hydrocarbon potential, confirmed by the hydrogen index values, which are generally below 100 mg HC/g TOC (Kosakowski et al., 2020).

The thermal maturity of the organic matter (Rock-Eval, Tmax, vitrinite reflectance, and biomarkers) indicates the early stages of the oil window with an increasing tendency towards the southwest, where the Badenian and Lower Sarmatian interval occurs under the Carpathian thrust (Kosakowski et al., 2020). A summary of the organic geochemistry investigations performed for the Tymowa 1 and Łapanów 2 wells can be found in Tab. 3.3.

The natural gas accumulations in the Foredeep are the result of microbial processes (Kotarba, 2011; Kotarba et al., 2011). Locally, an admixture of thermogenic gases generated from deeply buried rocks is also possible (Kosakowski et al., 2020).

Well name	Samples	Depth	TOC	Tmax	S2	HI	PI
		[m MD]	[%]	[C]	mg HC/gRock	mg HC/gTOC	
Tymowa 1	4	2605–2614	0.13–0.65 (0.32)	423–428 (425)	0.33–1.13 (0.66)	173–253 (222)	0.13–0.35 (0.24)
Łapanów 2	10	1999–2003	0.47–0.68 (0.61)	425–430 (428)	0.60–0.85 (0.68)	93–131 (112)	0.14–0.38 (0.25)

Tab. 3.3. Autochthonous Miocene source rocks characteristics in the tender area and in its vicinity (Węgrzyn, 2017). Average values are given in brackets.

Reservoir rocks: sandstones and sands of the Upper Badenian and Lower Sarmatian. In the Block 413-414 tender area, a separation of allochthonous and autochthonous Miocene has been made only in a few wells, therefore the whole succession is characterized in terms of reservoir properties (see Chapter 2). The occurrences of natural gas fields in the neighborhood of the tender area – Łapanów, Łąkta – proof good reservoir potential of Miocene deposits. The Łąkta field consists of 3 horizons, each with a thickness of 13 to 37 m. The porosity of sandstones in these horizons ranges from 9.9 to 12.5%, and the permeability ranges from 0 to 40 mD (Jawor and Jawor, 1971, 1972). However, it will be a challenge to recognize if the sandstone lithosomes continue in the tender area. The characteristics of the Miocene rocks in terms of their reservoir properties are presented in Tab. 3.4.

Well name	Samples	Porosity [%]	Permeability [mD]
Dobczyce 5	11	1.34–5.99	0.0
Iwkowa 1	2	0.82–2.08	–
Leszczyna 1	7	3.23–4.64	0
Leszczyna 2	6	3.15–7.62	0–44.8
Leszczyna 3	13	2.83–17.22	0
Leszczyna 4	12	2.53–10.74	0
Leszczyna 21	16	2.48–7.55	0–6.7
Leszczyna 22	34	0.88–8.51	0
Lipnica Górna 1	15	2.63–11.39	0–84
Łąkta 4	31	0–6.59	0–2.7
Łąkta 9	12	2.59–6.25	–
Łąkta 11	25	2.35–10.16	0–2.5
Łąkta 13	5	2.7–7.16	0
Łąkta 14	32	0.67–2.6	0–5.1
Łąkta 25	13	1.35–11.22	0
Połom Duży 2	24	3.6–16.27	0–40.7
Tymowa 1	17	4.13–11.78	<0.01
Wiśniowa 1	5	4.10–10.57	0
Wiśniowa 3	4	0.67–3.04	0
Wiśniowa 4	5	1.36–4.7	0–4.4
Wiśniowa 6	7	0.36–10.56	0–68.8

Tab. 3.4. Petrophysical properties of the autochthonous Miocene in the Block 413-414 tender area.

Seal: numerous layers of claystone within the autochthonous Miocene succession; Stebnik, Sub-Silesian and Silesian Units above the top erosional surface of the autochthonous Miocene.

Overburden rocks: folded Miocene of the Stebnik Unit under the Carpathian overthrust and Sub-Silesian and Silesian Units.

Age and mechanism of trap formation. Multi-horizontal stratigraphic traps, related to the lateral pinch-out of reservoir layers, were formed and filled during the deposition of Miocene sediments. The stratigraphic traps related to unconformities occurring at the base and within the Miocene are synsedimentary in nature. Compaction anticlines developed above the basement were formed during the Miocene deposition, but their final shape was formed during the compaction and diagenesis processes enhanced by the thrusting of the Outer Carpathians. Traps related to unconformities at the top of the Miocene, as well as structural traps formed by folding, were created during the overthrusting, especially in the vicinity of the basement highs.

Shape and size of the traps. The most common are structural traps developed as compaction anticlines above the elevations of the Paleozoic and Mesozoic basement. The seal for compaction anticlines is made of impermeable clastone layers, which even several dozen centimetres thickness is sufficient to effectively seal gas accumulation (Myśliwiec, 2004a). The compaction anticline is a trap for the Łąkta gas field. The second type of structural traps are folds associated with the overthrust of the Silesian, Sub-Silesian and Stebnik Units. These types of gas accumulations are isolated by the overthrust surface or impermeable flysch rocks and limited by a gas/water contour. A common type of traps in the Miocene are stratigraphic associated with unconformities. These traps often wedge out on the sub-Miocene unconformity surface or slopes of the basement elevations (Myśliwiec, 2004b). They are difficult to recognize using seismic survey and in most cases are recognized only in wells.

The potential traps detected by seismic surveys at the Miocene top surface in the Block 413-414 tender area are illustrated in Figs 3.11–3.12. The most important of them are the Raciechowice A, B and C structures, as well as Łąkta north and Tymowa highs.

Age and mechanism of hydrocarbon generation and accumulation. Numerous studies indicate that natural gas in the autochthonous Miocene of the Carpathian Foredeep was generated by microbiological processes, and only occasionally by low-temperature thermogenic processes (Kotarba, 2011; Kotarba et al., 2011; Myśliwiec, 2004a, 2004b; Kotarba and Koltun, 2006; Kosakowski al., 2020). Methane generation was mainly achieved by reducing carbon dioxide in the marine environment. Additionally, ethane was also produced in an amount of one molecule per 1,000 methane molecules (Kotarba, 2011). Some of the ethane, similarly to propane, butane and pentanes, was a product of low-temperature thermal transformations of organic matter. Rhythmic and cyclic sedimentation of claystones and sandstones in the Miocene basin of the Carpathian Foredeep and very similar sedimentation rates (1,500 m/million years in the Late Badenian and 5,000 m/million years in the Sarmatian) facilitated the intensive generation of microbial methane and ethane, as well as the almost simultaneous formation and filling multi-horizon stratigraphic traps (Kotarba, 2011). The greatest intensity of microbial methane generation occurred at a depth of 900–1500 m below the seabed, the presence of significant amounts of methanogenic and methylotrophic bacteria in reservoir waters may suggest that the generation process continues to this day (Kotarba, 2011; Kotarba et al., 2011). Taking into account the great depth of the Miocene in the tender area, it seems that it is also possible to generate hydrocarbons through low-temperature thermogenic processes. They could have started after the Carpathian overthrusting and may continue to this day.

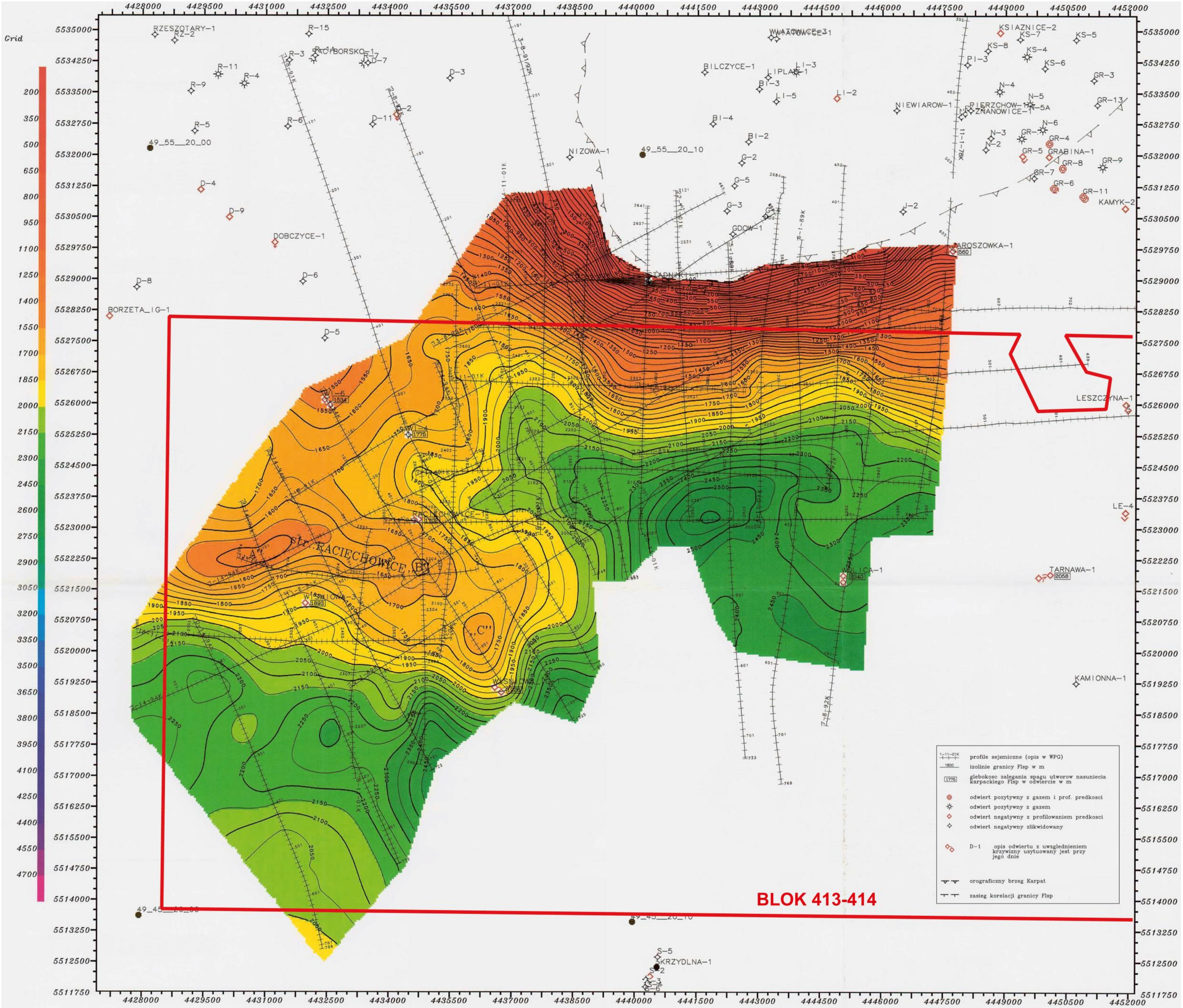


Fig. 3.11. Structural map of the Flsp surface (base of the Carpathian overthrust = top of the autochthonous Miocene) in the western part of the Block 413-414 tender area (Jezierska and Keller-Utracka, 2002; in Polish).

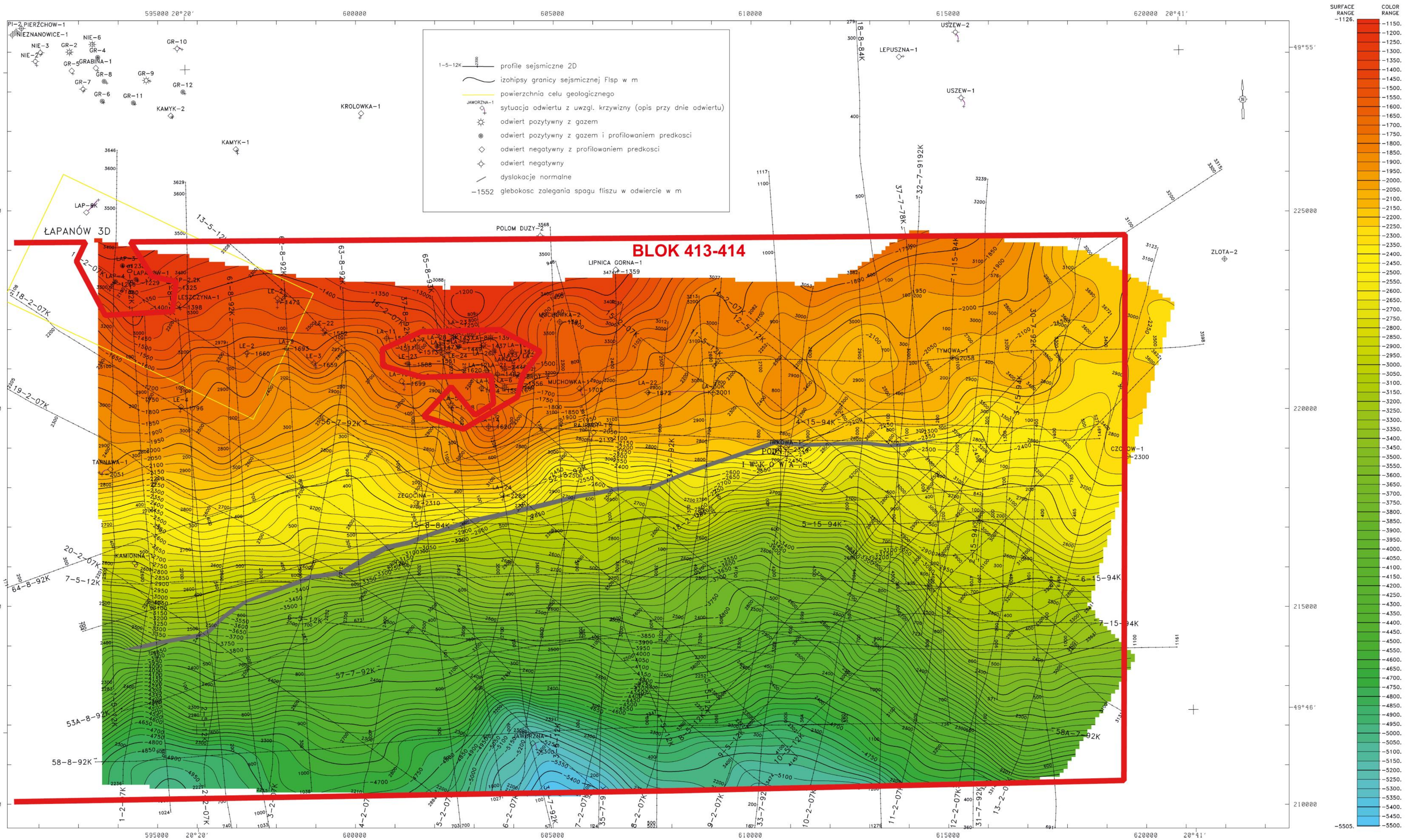


Fig. 3.12. Structural map of the Flsp surface (base of the Carpathian overthrust = top of the autochthonous Miocene) in the eastern part of the Block 413-414 tender area (Wilk et al., 2013; in Polish).

Carpathian petroleum play

Source rocks (Silesian Unit). In the Silesian Unit, source rocks occur in the Menilite, Istebna and Lgota Beds.

The Menilite Beds (Oligocene) have the highest TOC and the best hydrocarbon potential in the Silesian Unit although only two samples from the surface outcrops were analysed (Kotarba et al., 2017). Biomarker and aromatic hydrocarbon indicates that the maturity corresponds with the initial stage of low-temperature thermogenic processes (Kotarba et al., 2017). Geochemical characteristics and hydrocarbon potential of the Menilite Beds are as follows (Kotarba et al., 2017):

TOC = 2.0–7.2%
Tmax = 428–436°C
S2 = 2.5–7.8 mg HC/g
PI = 0.02–0.03
HI = 109–126 mg HC/g TOC
Kerogen type: III.
Maturity: low or immature.

The Istebna Beds (Upper Cretaceous to Paleocene) contain source rocks of poor potential for hydrocarbon generation, with the following geochemical characteristics and hydrocarbon potential (Kotarba et al., 2017):

TOC = 0.19–1.97% (avg. 1.05%)
Tmax = 431–435°C (avg. 433°C)
S2 = 0.38–0.89 mg HC/gRock
(av. 0.84 mg HC/gRock)
PI = 0.01–0.06
HI = 16–51 mg HC/g TOC
(avg. 32 mg HC/g TOC)
Kerogen type: III, locally III/II.
Maturity: low.

The Lgota Beds (Upper Cretaceous–Paleocene) have also poor hydrocarbon potential. Geochemical characteristics are as follows (Kotarba et al., 2017):

TOC = 0.01–1.22% (av. 0.15%)
Tmax = 427–433°C (av. 429°C)
S2 = 0.14–1.04 mg HC/g
(av. 0.47 mg HC/g)
PI = 0.02–0.16
HI = 37–239 mg HC/g TOC
(av. 65 mg HC/g TOC)
Kerogen type: III/II and II/III.
Maturity: low or immature.

Source rocks (Sub-Silesian Unit). Upper Cieszyn Beds and Grodziszcze Beds.

The Cieszyn Beds (Lower Cretaceous) contain source rocks of poor to moderate potential for hydrocarbon generation, with the following geochemical characteristics (Kotarba et al., 2017):

TOC = 0.79–1.63% (av. 1.07%)
Tmax = 425–438°C (av. 437°C)
S2 = 0.5–2.23 mg HC/gRock
(av. 1.6 mg HC/gRock)
PI = 0.06–0.11
HI = 57–230 mg HC/g TOC
(av. 140 mg HC/g TOC)
Kerogen type: III, locally III/II.
Maturity: low to immature.

The Grodziszcze Beds (Lower Cretaceous) have poor to moderate hydrocarbon potential. Geochemical characteristics and hydrocarbon potential as follows (Kotarba et al., 2017):

TOC = 0.19–1.38% (av. 0.94%)
Tmax = 424–438°C (av. 437°C)
S2 = 0.16–2.37 mg HC/g
(av. 1.43 mg HC/g)
PI = 0.04–0.06
HI = 59–231 mg HC/g TOC
(av. 151 mg HC/g TOC)
Kerogen type: III.
Maturity: low to immature.

Reservoir rocks (Magura Unit): Due to the surface exposition and generally very poor reservoir properties, the Magura Unit only serves as a sealing horizon for the deeper flysch formations of the Silesian and Sub-Silesian Units. Possible accumulation of hydrocarbons in the Magura Unit could be considered in the Inoceramian and Ropianka Beds. In the tender area, the reservoir properties of the Magura Unit were carried out only in the Jaworzna 1 well (Tab. 3.5).

Well name	Stratigraphy	Samples	Porosity [%]	Permeability [mD]
Jaworzna 1	Sub-Magura Beds	13	0.27–9.37	0
	Variegated Shales	1	3.22	0

Tab. 3.5. Petrophysical characteristics of the Magura Unit in the Block 413-414 tender area.

Reservoir rocks (Silesian Unit). Reservoir rocks occurring in the Silesian Unit are the most promising among the others Carpathians tectonic units. Accumulations are expected in the Krosno Beds and sandstones of the Menilite Beds, as evidenced by the Skrzydlna field (currently depleted) discovered to the south of the tender area. In this field, crude oil was exploited from several horizons of the Krosno and Menilite Beds, located at depths from 370 to 1260 m below sea level. Production was from 0.2 to 1.4 t/day. However, the best reservoir properties in the Silesian Unit seem to be occurred in the sandstones of the Istebna Beds. Tab. 3.6 presents the petrophysical characteristics of the most important reservoir horizons in the Silesian Unit, based on data from wells drilled within the tender area.

Well name	Stratigraphy	Samples	Porosity [%]	Permeability [mD]
Wolica 1	Krosno Beds	9	0.74-5.99	0–1.2
Czchów 1	Istebna Beds	11	2.15–15.19	0
Leszczyna 1		5	3.73–11.94	0–26.8
Leszczyna 2		4	8.53–12.75	0–4.6
Leszczyna 4		10	1.35–18.51	0–5.9
Lipnica Górna 1		3	5.2–11.19	0–76.6
Łąkta 4		2	1.09–1.72	–
Muchówka 1		1	10.92	0
Połom Duży 2		1	0.78	–
Wiśniowa 6		1	0.69	0
Wolica 1		3	1.51–10.32	0–2
Jaworzna 1	Istebna and Godula Beds	1	–	–
Czchów 1	Godula Beds	1	6.69	0
Muchówka 1		1	6.16	0
Czchów 1	Lgota, Verovice and Grodziszcze Beds	2	2.26–4.49	0
Leszczyna 1	Verovice Beds	1	4.32	0
Iwkowa 1	Lower Cretaceous	2	6.42–6.57	–
Jaworzna 1		35	0.23–5.69	0
Lipnica Górna 1		2	0.08–5.02	–
Muchówka 1		4	0.22–6.11	0
Połom Duży 2		3	0.15–0.59	0
Wiśniowa 6		2	0.48–0.61	0

Tab. 3.6. Petrophysical characteristics of the Silesian Unit in the Block 413-414 tender area.

Reservoir rocks (Sub-Silesian Unit). Hydrocarbon shows in the Sub-Silesian Unit were observed in the Wiśniowa 3 well at a depth of 2115.0–2205.0 m in the Upper Cretaceous and Paleogene deposits (Tab. 3.7).

Well name	Samples	Porosity [%]	Permeability [mD]
Leszczyna 3	1	6.07	–
Łąkta 24	2	1.06–1.44	0
Wiśniowa 3	5	3.5–7.15	0
Wiśniowa 6	2	0.57–3.3	–

Tab. 3.7. Petrophysical characteristics of the Sub-Silesian Unit in the Block 413-414 tender area.

Seal: impermeable fine-clastic flysch deposits: Inoceramian Beds, Hieroglyphic Beds, Variegated Shales, Menilite Beds, Krosno Beds in all tectonic units. The sealing in flysch is very variable and relatively weak, which is largely related to the tectonic style of deformations and contact of reservoirs with the surface. The sealing is better in deeply buried intervals.

Type of traps: hydrocarbon accumulations in the Outer Carpathians most often occur in multilayered structural or structural-stratigraphic traps with complex geometry (Wdowiarz, 1960; Poprawa and Machowski, 2010). Lithological traps are associated with lateral wedging out of reservoir horizons (e.g. Ciężkowice Sandstones, Istebna Sandstones). Structural traps are often steep, imbricated folds that are thrusted over each other (Karnkowski, 1993).

Age and mechanism of hydrocarbon generation, migration and accumulation. Due to the occurrence of source rocks in several different levels in the Silesian and Sub-Silesian Units, as well as different degree of their burial, it is difficult to determine one universal scenario for generating hydrocarbons in the Carpathian petroleum play. The most likely process is the synorogenic generation and expulsion of hydrocarbons before the end of thrusting movements and several remigration of hydrocarbons continuing to the present time. Hydrocarbons were generated already in the sedimentary stage during the existence of the Carpathian basins, but the most important generation impulse occurred in the Early Miocene in synorogenic conditions. As a result, before the final folding took place, hydrocarbons remigrated several times within the Carpathian units, and modern oil spills indicate that these processes are still continuing. Maćkowski and Kuśmierek (1995) defined the start time of hydrocarbon generation in the Carpathian units as: 41–14 My for the Upper Cretaceous-Paleocene deposits, 9–14.6 My for the Lower Oligocene deposits, and 52–13.7 My for the Lower Cretaceous deposits. Generational model (Poprawa and Machowski, 2010) indicates that the Upper Cretaceous reached the highest degree of maturity and thermal transformation (2.5% Ro and 90% on the TR scale) at a depth below 6000 m, the mass of generated hydrocarbons does not exceed 2 Mt/km^2 with low hydrogen index values (100 mg HC/g TOC), the efficiency of hydrocarbon expulsion has a coefficient >0.6 at depths below 5000 m. The Lower Cretaceous reached the highest degree of maturity (>2% Ro) and thermal transformation (>90 %) at depths >6000 m, the mass of generated hydrocarbons exceeds 6 Mt/km^2 with a hydrogen index value HI >200 mg HC/g TOC, the hydrocarbon expulsion efficiency coefficient is the highest (above 0.8) below 6000 m. Studies of the molecular and isotopic composition of gas in the Carpathian units in the vicinity of the tender area indicate the presence of gases of both bacterial and thermogenic origin (Kotarba et al., 2021) related to type III/II kerogen and II/III of thermal maturity from the entire range of the oil window.

4. HYDROCARBON FIELDS

Three hydrocarbon fields have been documented in the close neighborhood of the Block 413-414 tender area (Fig. 4.1). These are:

- Łapanów natural gas field
  (GZ 12078; Figs 4.2–4.3, Tab. 4.1);
- Łąkta natural gas field
  (GZ 4597; Figs 4.4–4.7, Tab. 4.2);
- Słopnice natural gas field
  (GZ 4596; Figs 4.8–4.10, Tab. 4.3).

→ **Fig. 4.1.** Hydrocarbon fields in the neighborhood of the Block 413-414 tender area.

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

Blok 413 - 414

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*
- obszary górnicze wyznaczone dla złóż węglowodorów / *mining areas assigned for hydrocarbon fields*
- granice gmin / *commune border*
- granice powiatów / *county border*

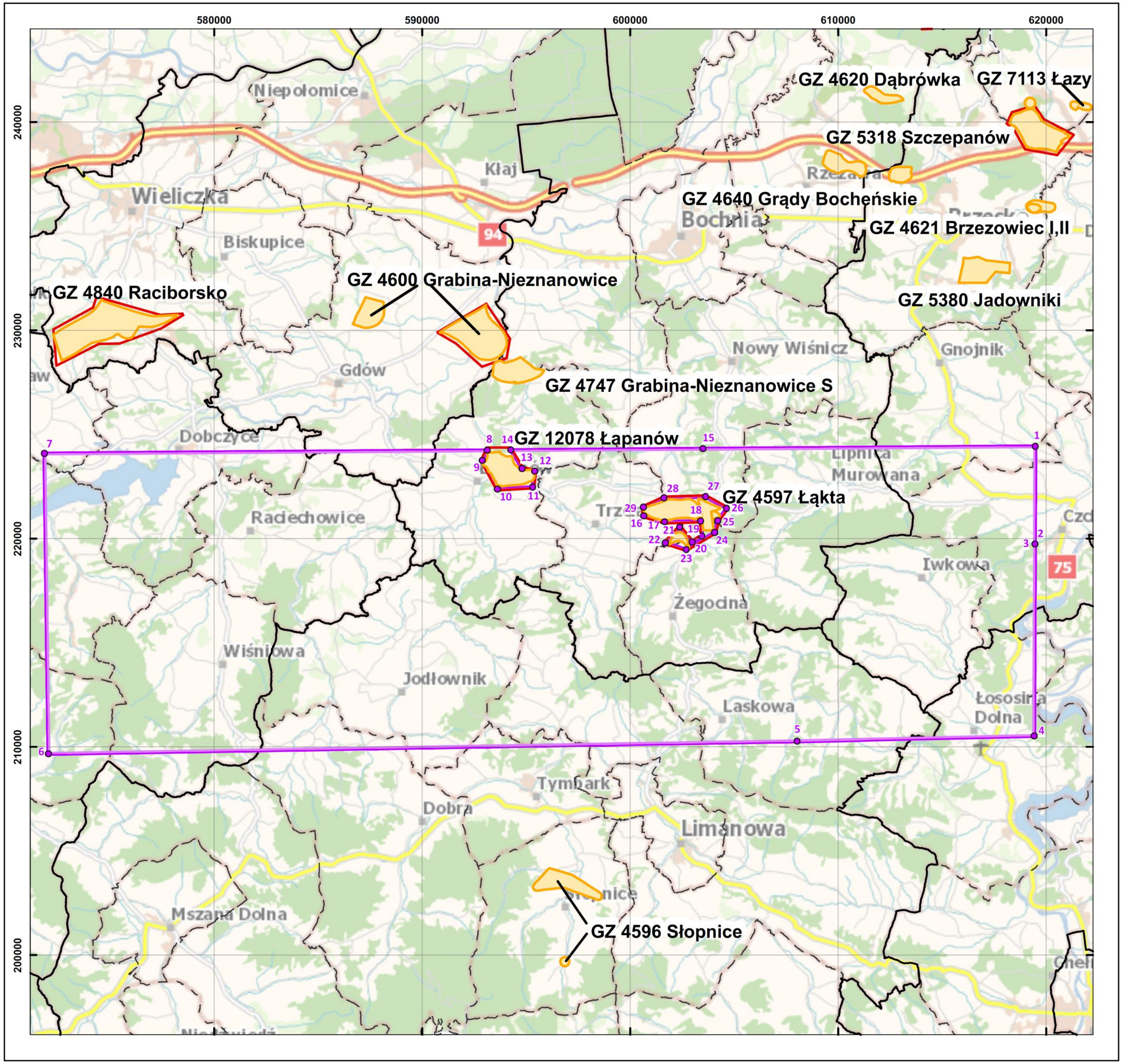
Współrzędne punktów wyznaczających granice obszaru przetargowego, ukł. wsp. PL-1992
Coordinates determining the borders of tender area, coordinate system PL-1992

Nr punktu / *Point No*	X	Y	Nr punktu / *Point No*	X	Y
1	224429,40	619471,74	z wyłączeniem poligonu zdefiniowanego punktami 16-29/ *excluding the polygon defined by points No 16-29*		
2	219734,09	619456,21	16	221091,02	600645,13
3	219733,92	619454,87	17	220797,73	601652,77
4	210523,09	619421,78	18	220844,14	603391,19
5	210260,58	608022,58	19	220125,97	603450,34
6	209660,93	572015,80	20	219833,40	602978,16
7	224085,46	571823,28	21	220557,32	602379,11
8	224239,14	593113,46	22	219798,82	601679,44
9	223753,00	592883,00	23	219475,76	602687,75
10	222376,00	593612,00	24	220292,07	604055,74
11	222475,00	595313,00	25	220865,93	604200,42
12	223236,00	595405,00	26	221457,15	604634,48
13	223368,00	594800,00	27	222010,11	603619,97
14	224247,38	594254,96	28	221956,85	601621,88
15	224314,01	603486,16	29	221510,53	600634,09

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)



Łapanów natural gas field

The total field acreage: 245.0 ha
Depth: from 1,791.5 to 1,930.0 m
Stratigraphy: Lower Jurassic
Resources:
The primary exploitable anticipated economic resources (as of 2010):
325.00 MCM of natural gas in cat. C
The exploitable anticipated economic resources as of 31 XII 2022:
270.61 MCM of natural gas in cat. C
The economic resources in place as of 31 XII 2022:
270.59 MCM of the natural gas economic resources in place in cat. C
81.02 MCM of the natural gas subeconomic resources in place in cat. C
The production in 2022:
0.12 MCM of natural gas in cat. C

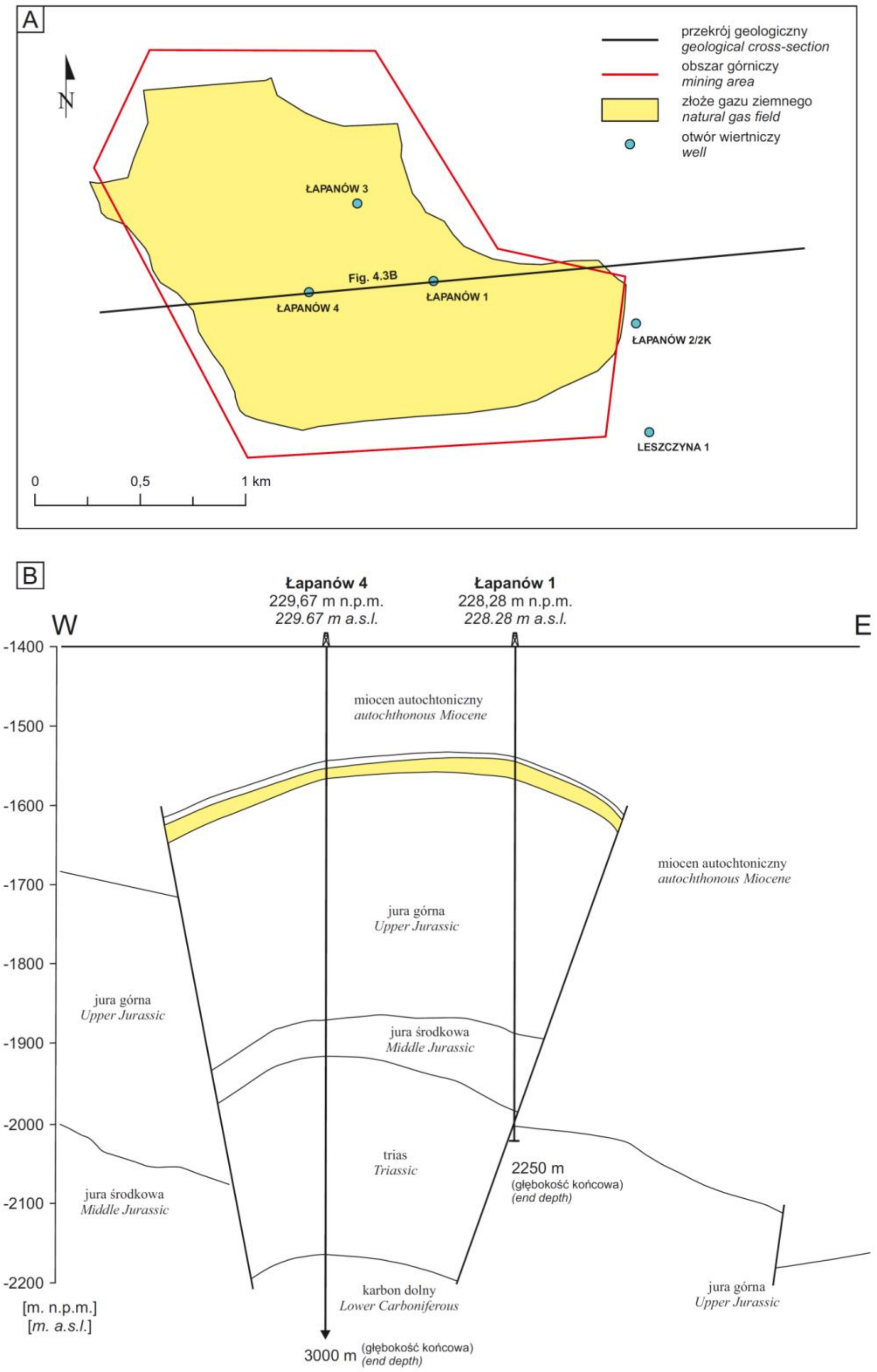


Fig. 4.2. A. Location of the wells drilled in the Łapanów natural gas field and its neighborhood (CGDB, 2023). **B.** Geological cross-section through Łapanów natural gas field (Polakowski, 2011).

Parameter	Minimum value	Maximum value	Average value	Unit	Comments
primary reservoir pressure	---------	---------	18.280	MPa	
depth of underlying water	---------	---------	---------	m	lack of
effective reservoir thickness	---------	---------	11.300	m	
porosity	---------	---------	11.200	%	
permeability	21.720	46.910	---------	mD	
reservoir temperature	---------	---------	57.330	°C	
chemical type of reservoir water	---------	---------	---------	–	Cl-Ca brine (metamorphosed relict brine)
production conditions	---------	---------	---------	–	expansive
hydrocarbons saturation factor	---------	---------	0.740	–	
production factor	---------	---------	0.800	–	
absolute efficiency V_{abs}	100.000	233.700	---------	Nm^3/min	
permitted efficiency V_{dozw}	15.000	33.000	---------	Nm^3/min	
oil exponent	1.000	24.430	---------	g/Nm^3	
water exponent	---------	---------	---------	g/m^3	not stated
sand encroachment	---------	---------	---------	%	not stated
quality parameters of natural gas (main raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
combustion heat	38.480	40.650	39.950	MJ/Nm^3	
calorific value	34.630	36.210	35.920	MJ/m^3	
C_2H_6 content	0.988	1.054	1.030	% v/v	
CH_4 content	89.496	95.445	93.040	% v/v	
carbon dioxide content	0.001	0.211	0.090	% v/v	minimum value of < 0,001% v/v
H_2 content	0.000	1.358	0.139	% v/v	
He content	0.002	0.022	0.015	% v/v	
N_2 content	2.506	6.686	4.217	% v/v	
hydrogen sulfide content	---------	---------	---------	% v/v	lack of
heavy hydrocarbons C_{3+} content	23.840	53.680	39.700	g/m^3	

Tab. 4.1. Parameters of Łapanów natural gas field and quality parameters of the raw material (MIDAS, 2022).

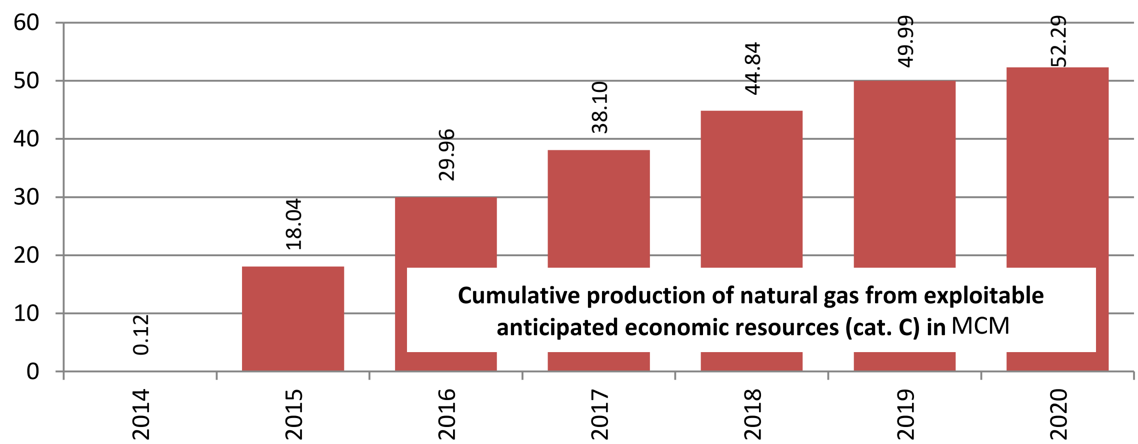


Fig. 4.3. Graph of natural gas production from Łapanów field (MIDAS, 2022).

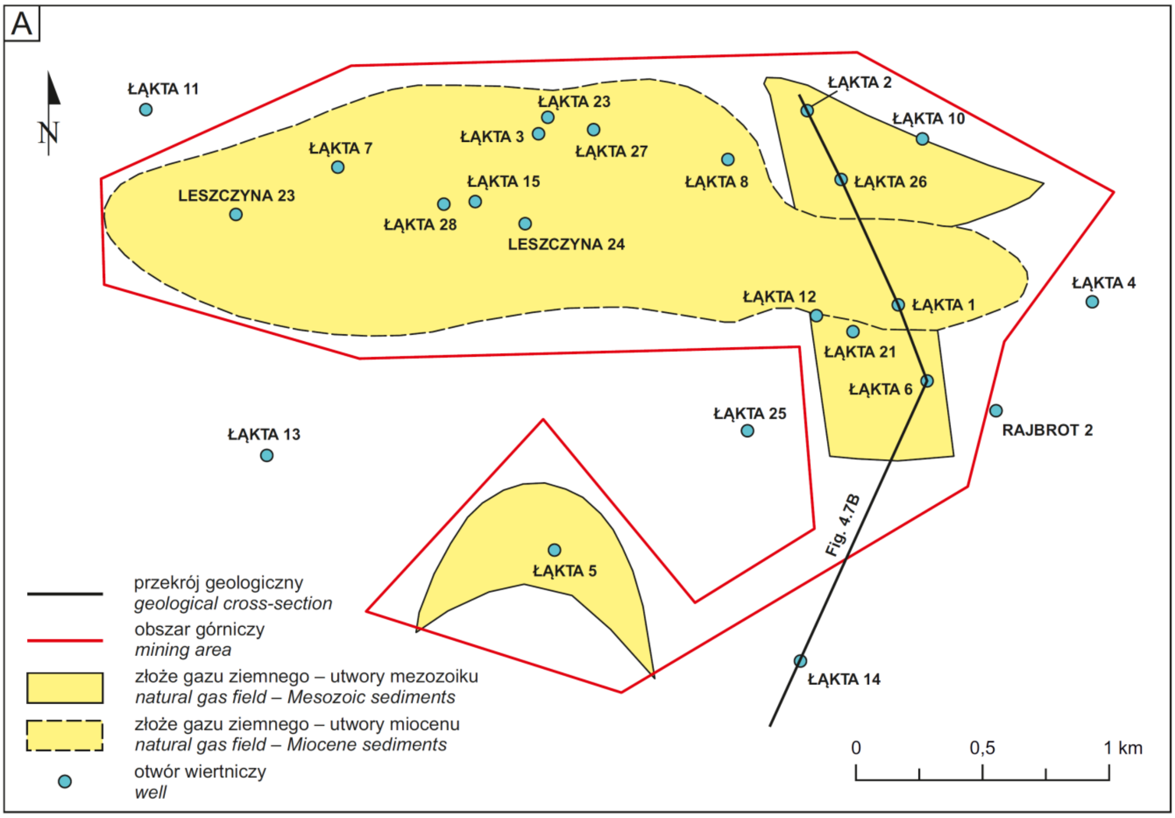
Łąkta natural gas field

The total field acreage:
Mesozoic (Cenomanian) – 216.3 ha
Mesozoic (Upper Jurassic) – 219.1 ha
Miocene horizon I – 35.0 ha
Miocene horizon II (Łąkta 10) – 21.0 ha
Miocene horizon II (Łąkta 5) – 30.5 ha
Miocene horizon III – 66.5 ha

Depth: (average)
Mesozoic (Cenomanian) – 2,290.0 m
Mesozoic (Upper Jurassic) – 2,290.0 m
Miocene horizon I – 1,900.0 m
Miocene horizon II (Łąkta 10) – 2,030.0 m
Miocene horizon II (Łąkta 5) – 2,220.0 m
Miocene horizon III – 2,260.0 m

Stratigraphy: Upper Jurassic, Upper Cretaceous/Cenomanian, Neogene/Miocene

Resources:
The primary exploitable anticipated economic resources (as of 1990):
lack of documented primary resources
The exploitable anticipated economic resources as of 31 XII 2022:
70.45 MCM of natural gas in cat. A and B (Miocene horizon)
13.60 MCM of natural gas in cat. C (Miocene horizon)
108.04 MCM of natural gas in cat. A (Cenomanian and Upper Jurassic)
4.58 kt of condensate in cat. A
The economic resources in place as of 31 XII 2022:
21.44 MCM of the natural gas economic resources in place and 60.78 MCM of the natural gas sub-economic resources in place in cat. A and B (Miocene horizon)
10.43 MCM of the natural gas economic resources in place and 27.64 Mm^3 of the natural gas sub-economic resources in place in cat. C (Miocene horizon)
551.62 MCM of the natural gas sub-economic resources in place in cat. A (Cenomanian and Upper Jurassic),
lack of condensate economic and sub-economic resources in place
The production in 2022:
1.85 MCM of natural gas in cat. A and B (Miocene horizon)
0.51 MCM of natural gas in cat. C (Miocene horizon)
natural gas from the Mesozoic horizon (Cenomanian and Upper Jurassic) was not a subject of exploitation
condensate was not a subject of exploitation



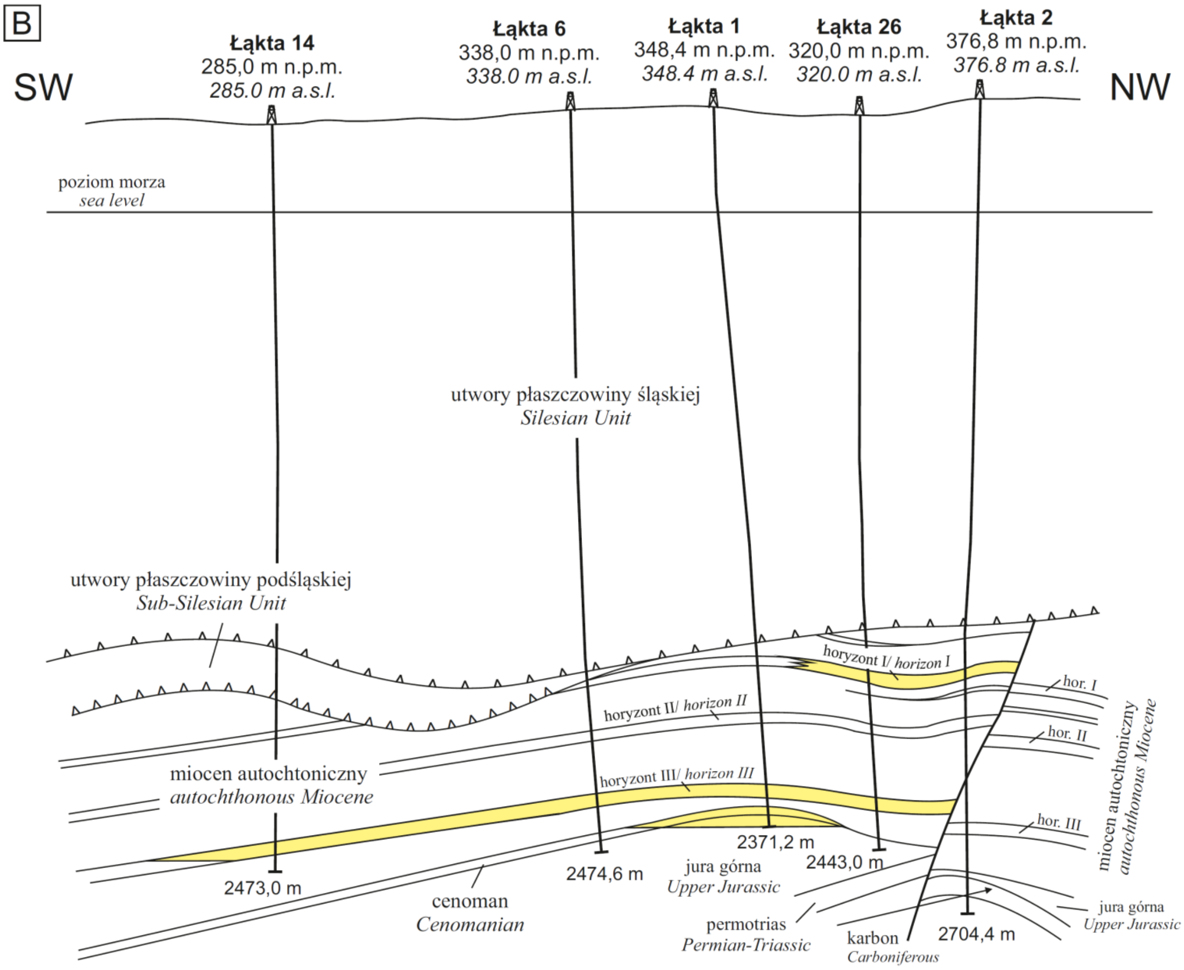


Fig. 4.4. A. Location of the wells drilled in the Łąkta natural gas field and its neighborhood (CGDB, 2023). **B.** Geological cross-section through Łąkta natural gas field (Dusza and Dudek, 1991).

Parameter	Minimum value	Maximum value	Average value	Unit	Comments
current pressure	---------	---------	11.870	MPa	Miocene field (horizon II, Łąkta 10 well)
current pressure	---------	---------	12.850	MPa	Miocene field (horizon II, Łąkta 5 well)
current pressure	---------	---------	20.910	MPa	Mesozoic field (Cenomanian)
current pressure	---------	---------	4.600	MPa	Miocene field (horizon III)
current pressure	---------	---------	20.910	MPa	Mesozoic field (Upper Jurassic)
current pressure	---------	---------	6.850	MPa	Miocene field (horizon I)
bottom pressure P_{ds}	---------	---------	14.620	MPa	Miocene field (horizon I)
bottom pressure P_{ds}	---------	---------	19.700	MPa	Miocene field (horizon III)
bottom pressure P_{ds}	22.320	23.580	---------	MPa	Mesozoic field (Cenomanian)
bottom pressure P_{ds}	---------	---------	15.770	MPa	Miocene field (horizon II, Łąkta 5 well)
bottom pressure P_{ds}	---------	---------	16.660	MPa	Miocene field (horizon II, Łąkta 10 well)
wellhead pressure P_{gs}	---------	---------	16.380	MPa	Miocene field (horizon III)
wellhead pressure P_{gs}	18.390	19.220	---------	MPa	Mesozoic field (Cenomanian)
wellhead pressure P_{gs}	---------	---------	13,230	MPa	Miocene field (horizon II, Łąkta 5 well)
wellhead pressure P_{gs}	---------	---------	14.120	MPa	Miocene field (horizon II, Łąkta 10 well)
wellhead pressure P_{gs}	---------	---------	12,360	MPa	Miocene field (horizon I)
primary reservoir pressure	---------	---------	14.620	MPa	Miocene field (horizon I)
primary reservoir pressure	---------	---------	16.660	MPa	Miocene field (horizon II, Łąkta 10 well)
primary reservoir pressure	---------	---------	23.580	MPa	Mesozoic field (Upper Jurassic)
primary reservoir pressure	---------	---------	19.700	MPa	Miocene field (horizon III)
primary reservoir pressure	---------	---------	15.770	MPa	Miocene field (horizon II, Łąkta 5 well)
primary reservoir pressure	---------	---------	23.580	MPa	Mesozoic field (Cenomanian)
effective reservoir thickness	0.000	72.400	31.100	m	Mesozoic field (Upper Jurassic)
effective reservoir thickness	1.000	20.000	11.800	m	Mesozoic field (Cenomanian)
effective reservoir thickness	---------	---------	10.500	m	Miocene field (horizon II, Łąkta 10 well)
effective reservoir thickness	---------	---------	13.630	m	Miocene field (horizon I)
effective reservoir thickness	---------	---------	13.650	m	Miocene field (horizon III)
effective reservoir thickness	---------	---------	13.760	m	Miocene field (horizon II, Łąkta 5 well)
reservoir thickness	---------	---------	25.000	m	Miocene field (horizon II, Łąkta 10 well)
reservoir thickness	---------	---------	36.700	m	Miocene field (horizon III)
reservoir thickness	0.000	84.400	48.100	m	Mesozoic field (Upper Jurassic)
reservoir thickness	1.000	20.000	11.800	m	Mesozoic field (Cenomanian)
reservoir thickness	---------	---------	29.000	m	Miocene field (horizon I)
reservoir thickness	---------	---------	32.000	m	Miocene field (horizon II, Łąkta 5 well)

effective porosity	---------	---------	9.900	%	Miocene field (horizon II, Łąkta 10 well)
effective porosity	---------	---------	11.530	%	Miocene field (horizon I)
effective porosity	---------	---------	4.870	%	Mesozoic field (Upper Jurassic)
effective porosity	---------	---------	11.230	%	Miocene field (horizon III)
effective porosity	---------	---------	13.280	%	Mesozoic field (Cenomanian)
effective porosity	---------	---------	12.500	%	Miocene field (horizon II, Łąkta 5 well)
permeability	0.000	40.000	---------	mD	Miocene field (horizon III)
permeability	0.000	40.000	---------	mD	Miocene field (horizon II, Łąkta 5 well)
permeability	0.000	40.000	---------	mD	Miocene field (horizon II, Łąkta 10 well)
permeability	---------	---------	364.900	mD	Mesozoic field (Cenomanian)
permeability	0.000	40.000	---------	mD	Miocene field (horizon I)
permeability	---------	---------	48.900	mD	Mesozoic field (Upper Jurassic)
reservoir temperature	---------	---------	336.300	°K	Miocene field (horizon II, Łąkta 5 well)
reservoir temperature	---------	---------	337.700	°K	Miocene field (horizon III)
reservoir temperature	---------	---------	325.900	°K	Miocene field (horizon I)
reservoir temperature	---------	---------	338.700	°K	Mesozoic field (Upper Jurassic)
reservoir temperature	---------	---------	330.000	°K	Miocene field (horizon II, Łąkta 10 well)
reservoir temperature	---------	---------	338.700	°K	Mesozoic field (Cenomanian)
calorific value	---------	---------	6,836.500	Kcal/Nm^3	
production conditions	---------	---------	---------	–	Miocene field (horizon II, Łąkta 5 well), expansive
production conditions	---------	---------	---------	–	Miocene field (horizon II, Łąkta 10 well), expansive
production conditions	---------	---------	---------	–	Miocene field (horizon I), expansive
production conditions	---------	---------	---------	–	Miocene field (horizon III), expansive
production conditions	---------	---------	---------	–	Mesozoic field (Cenomanian), spring-waterdrive mechanism
hydrocarbons saturation factor	---------	---------	0.800	–	Miocene field (horizon II, Łąkta 5 well)
hydrocarbons saturation factor	---------	---------	0.900	–	Mesozoic field (Upper Jurassic)
hydrocarbons saturation factor	---------	---------	0.800	–	Miocene field (horizon I)
hydrocarbons saturation factor	---------	---------	0.800	–	Miocene field (horizon II, Łąkta 10 well)
hydrocarbons saturation factor	---------	---------	0.900	–	Mesozoic field (Cenomanian)
hydrocarbons saturation factor	---------	---------	0.800	–	Miocene field (horizon III)
production factor	---------	---------	0.750	–	Miocene field (horizon II, Łąkta 5 well)
production factor	---------	---------	0.650	–	Mesozoic field (Upper Jurassic)
production factor	---------	---------	0.750	–	Miocene field (horizon II, Łąkta 10 well)

production factor	---------	---------	0.750	–	Miocene field (horizon III)
production factor	---------	---------	0.800	–	Mesozoic field (Cenomanian)
production factor	---------	---------	0.750	–	Miocene field (horizon I)
absolute efficiency V_{abs}	---------	---------	4.250	m^3/min	Miocene field (horizon II, Łąkta 10 well)
absolute efficiency V_{abs}	---------	---------	9.200	m^3/min	Miocene field (horizon II, Łąkta 5 well)
absolute efficiency V_{abs}	20.000	30.000	---------	m^3/min	Miocene field (horizon III)
absolute efficiency V_{abs}	116.000	3,239.000	---------	m^3/min	Mesozoic field (Cenomanian)
absolute efficiency V_{abs}	---------	---------	99.500	m^3/min	Miocene field (horizon I)
permitted efficiency V_{dozw}	---------	---------	14.000	m^3/min	Miocene field (horizon I)
permitted efficiency V_{dozw}	---------	---------	2.000	m^3/min	Miocene field (horizon II, Łąkta 10 well)
permitted efficiency V_{dozw}	---------	---------	6.000	m^3/min	Miocene field (horizon II, Łąkta 5 well)
permitted efficiency V_{dozw}	2.000	15.000	---------	m^3/min	Miocene field (horizon III)
permitted efficiency V_{dozw}	50.000	260.000	---------	m^3/min	Mesozoic field (Cenomanian)
quality parameters of natural gas (main raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
density	---------	---------	0.634	–	Mesozoic field (Cenomanian), in regard to air
density	---------	---------	0.577	–	Miocene field (horizon III), in regard to air
density	---------	---------	0.571	–	Miocene field (horizon II, Łąkta 5 well), in regard to air
density	---------	---------	0.569	–	Miocene field (horizon II, Łąkta 10 well), in regard to air
density	---------	---------	0.569	–	Miocene field (horizon I), in regard to air
calorific value	---------	---------	9,040.000	kcal/m^3	Mesozoic field (Cenomanian)
calorific value	---------	---------	8,572.000	kcal/m^3	Miocene field (horizon II, Łąkta 10 well)
calorific value	---------	---------	8,558.000	kcal/m^3	Miocene field (horizon III)
calorific value	---------	---------	8,506.000	kcal/m^3	Miocene field (horizon II, Łąkta 5 well)
calorific value	---------	---------	8,572.000	kcal/m^3	Miocene field (horizon I)
C_2H_6	---------	---------	3.210	% v/v	Mesozoic field (Cenomanian)
C_2H_6	---------	---------	0.645	% v/v	Miocene field (horizon III)
C_2H_6	---------	---------	0.672	% v/v	Miocene field (horizon II, Łąkta 5 well)
C_2H_6	---------	---------	0.459	% v/v	Miocene field (horizon II, Łąkta 10 well)
C_2H_6	---------	---------	0.459	% v/v	Miocene field (horizon I)
CH_4	---------	---------	89.710	% v/v	Mesozoic field (Cenomanian)
CH_4	---------	---------	97.120	% v/v	Miocene field (horizon II, Łąkta 5 well)
CH_4	---------	---------	96.510	% v/v	Miocene field (horizon III)

CH_4	---------	---------	99.061	% v/v	Miocene field (horizon I)
CH_4	---------	---------	98.061	% v/v	Miocene field (horizon II, Łąkta 10 well)
heavy hydrocarbons C_{3+} content	---------	---------	82.000	g/m^3	Mesozoic field (Cenomanian)
heavy hydrocarbons C_{3+} content	---------	---------	17.950	g/m^3	Miocene field (horizon III)
heavy hydrocarbons C_{3+} content	---------	---------	9.640	g/m^3	Miocene field (horizon II, Łąkta 5 well)
heavy hydrocarbons C_{3+} content	---------	---------	9.300	g/m^3	Miocene field (horizon I)
heavy hydrocarbons C_{3+} content	---------	---------	9.300	g/m^3	Miocene field (horizon II, Łąkta 10 well)
quality parameters of natural gas (main raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
specific gravity	---------	---------	0.752	g/cm^3	average specific gravity in temperature of 20°C; Mesozoic field (Cenomanian)
viscosity	0.897	1.237	---------	cSt	in temperature of 20°C; Mesozoic field (Cenomanian)
oil fraction content	---------	---------	89.000	% v/v	up to 180°C; Mesozoic field (Cenomanian)
oil fraction content	---------	---------	99.800	% v/v	up to 300°C; Mesozoic field (Cenomanian)

Tab. 4.2. Parameters of Łąkta natural gas field and quality parameters of the raw material (MIDAS, 2022).

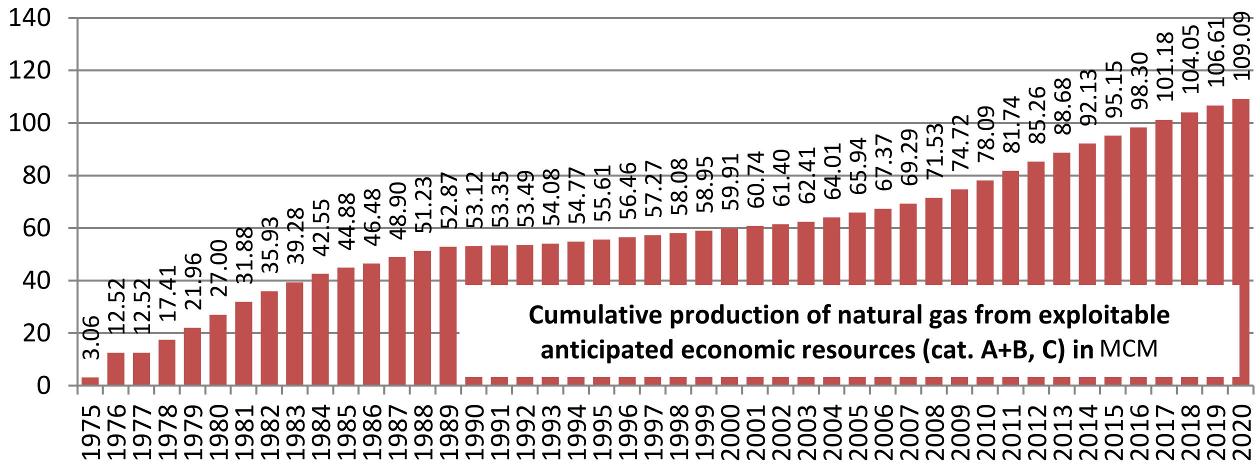


Fig. 4.5. Graph of natural gas production from the Miocene horizons of Łąkta field (MIDAS, 2022).

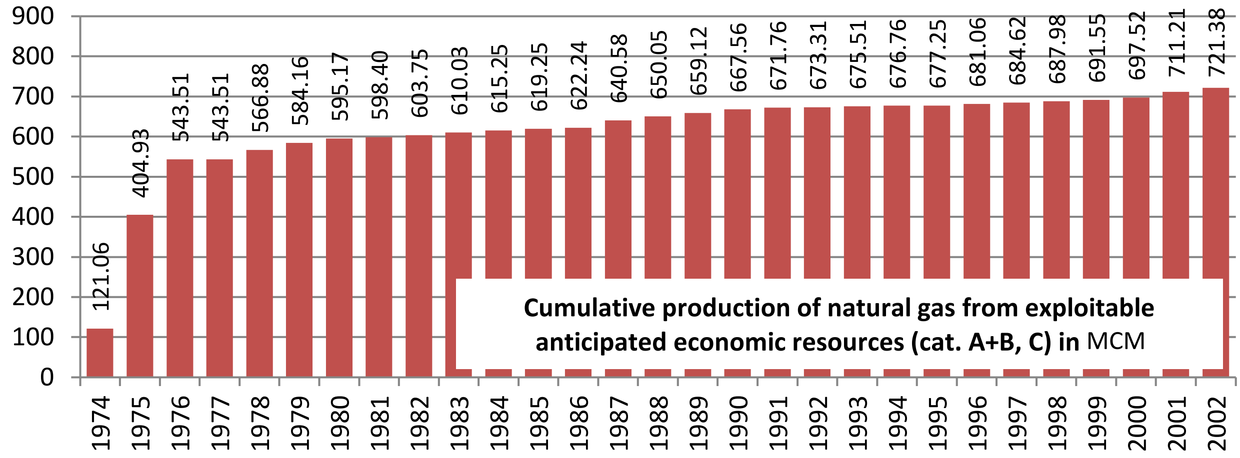


Fig. 4.6. Graph of natural gas production from the Mesozoic horizons of Łąkta field (MIDAS, 2022).

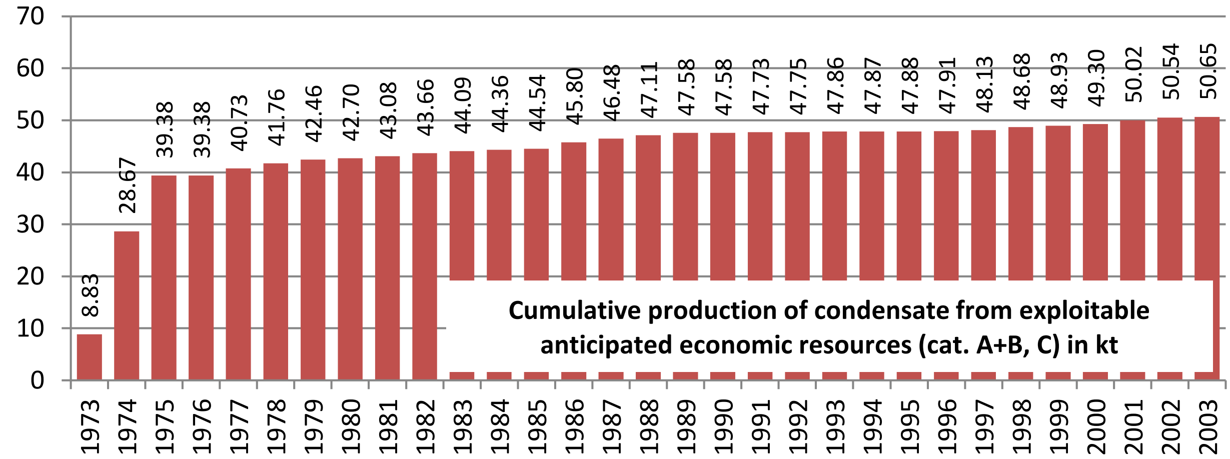


Fig. 4.7. Graph of condensate production from Łąkta field (MIDAS, 2022).

Słopnice natural gas field

The total field acreage: 235.0 ha
Depth: from -1,518.0 m do -2,640.0 m a.s.l.
Stratigraphy: Eocene and Oligocene (Krosno, Grybów and Menilite-Krosno BEDS)
Resources:
The primary exploitable anticipated economic resources (as of 2012):
42.02 MCM of natural gas in cat. A and 80.00 MCM of natural gas in cat. C
0.5 kt of condensate in cat. A and 1.5 kt of condensate in cat. C
The exploitable anticipated economic resources as of 31 XII 2022:
80.00 MCM of natural gas in cat. C
1.5 kt of condensate in cat. C
The economic resources in place as of 31 XII 2022:
lack of natural gas economic and subeconomic resources in place
lack of condensate economic and subeconomic resources in place
The production in 2022:
lack of production, exploitation of field ended on September 30, 2012

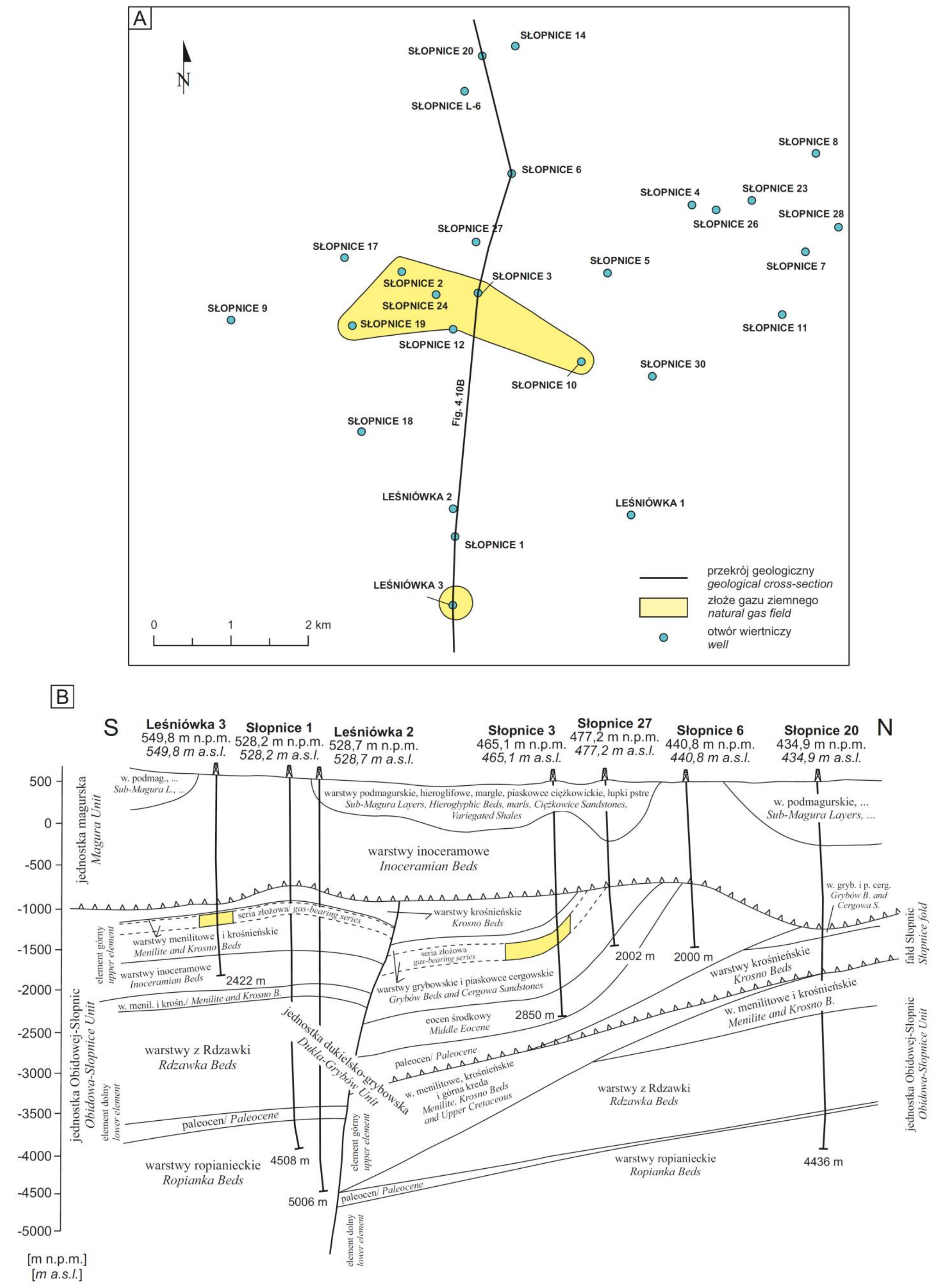


Fig. 4.8. A. Location of the wells drilled in the Słopnice natural gas field and its neighborhood (CGDB, 2023). **B.** Geological cross-section through Słopnice natural gas field (Przybyła, 2013).

Parameter	Minimum value	Maximum value	Average value	Unit	Comments
current pressure	---------	---------	12.170	MPa	Leśniówka 3 well, 2003
current pressure	---------	---------	4.060	MPa	Słopnice 2 well, 1990
current pressure	---------	---------	6.570	MPa	Słopnice 10 well, 1996
current pressure	---------	---------	3.910	MPa	Słopnice 3 well, 1999
current pressure	---------	---------	6.640	MPa	Słopnice 19 well, 2008
current pressure	---------	---------	1.730	MPa	Słopnice 24 well, 1999
primary reservoir pressure	---------	---------	19.240	MPa	Słopnice 10 well
primary reservoir pressure	---------	---------	17.390	MPa	Słopnice 2 well
primary reservoir pressure	---------	---------	34.030	MPa	Słopnice 19 well
primary reservoir pressure	---------	---------	13.460	MPa	Słopnice 24 well
primary reservoir pressure	---------	---------	23.780	MPa	Słopnice 3 well
primary reservoir pressure	---------	---------	17.860	MPa	Leśniówka 3 well
depth of underlying water	---------	---------	---------	m	not stated
effective reservoir thickness	2.000	6.000	---------	m	
porosity	1.060	3.630	---------	%	
permeability	0.000	2.700	---------	mD	
mineralization degree of formation water	---------	---------	6.000	g/l	
reservoir temperature	---------	---------	47.850	°C	Słopnice 2 well
reservoir temperature	---------	---------	74.850	°C	Słopnice 10 well
reservoir temperature	---------	---------	40.850	°C	Słopnice 3 well
reservoir temperature	---------	---------	66.850	°C	Słopnice 19 well
reservoir temperature	---------	---------	51.850	°C	Leśniówka 3 well
chemical type of formation water	---------	---------	---------	–	Cl-Na
production conditions	---------	---------	---------	–	expansive
production factor	---------	---------	0.800	–	
absolute efficiency V_{abs}	---------	---------	10.400	Nm^3/min	
absolute efficiency V_{abs}	4.700	37.000	14.000	m^3/min	primary
permitted efficiency V_{dozw}	2.100	12.000	6.000	m^3/min	primary
oil/condensate exponent	---------	---------	3.580	g/m^3	Leśniówka 3 well
oil/condensate exponent	---------	---------	15.250	g/m^3	Słopnice 19 well
oil/condensate exponent	---------	---------	0.000	g/m^3	Słopnice 24 well
oil/condensate exponent	---------	---------	10.870	g/m^3	Słopnice 2 well
oil/condensate exponent	---------	---------	18.560	g/m^3	Słopnice 3 well
oil/condensate exponent	---------	---------	3.750	g/m^3	Słopnice 10 well
water exponent	0.000	50.800	33.250	g/m^3	in the last year of exploitation
quality parameters of natural gas (main raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
calorific value	26.680	44.220	39.080	MJ/m^3	
C_2H_6	0.190	14.350	5.550	% v/v	
CH_4	63.860	98.960	88.330	% v/v	

CO_2	0.000	3.900	0.560	% v/v	
He	0.000	0.020	0.004	% v/v	
N_2	0.350	30.550	2.170	% v/v	
H_2S	---------	---------	---------	% v/v	does not occur
heavy hydrocarbons C_{3+} content	2.200	169.470	81.720	g/m^3	
quality parameters of oil/condensate (accompanying raw material)					
Parameter	**Minimum value**	**Maximum value**	**Average value**	**Unit**	**Comments**
density	0.719	0.760	---------	g/cm^3	
naphtha fraction content	58.000	83.000	---------	% v/v	
oil fraction content	14.000	28.000	---------	% v/v	

Tab. 4.3. Parameters of Słopnice natural gas field and quality parameters of the raw materials (MIDAS, 2022).

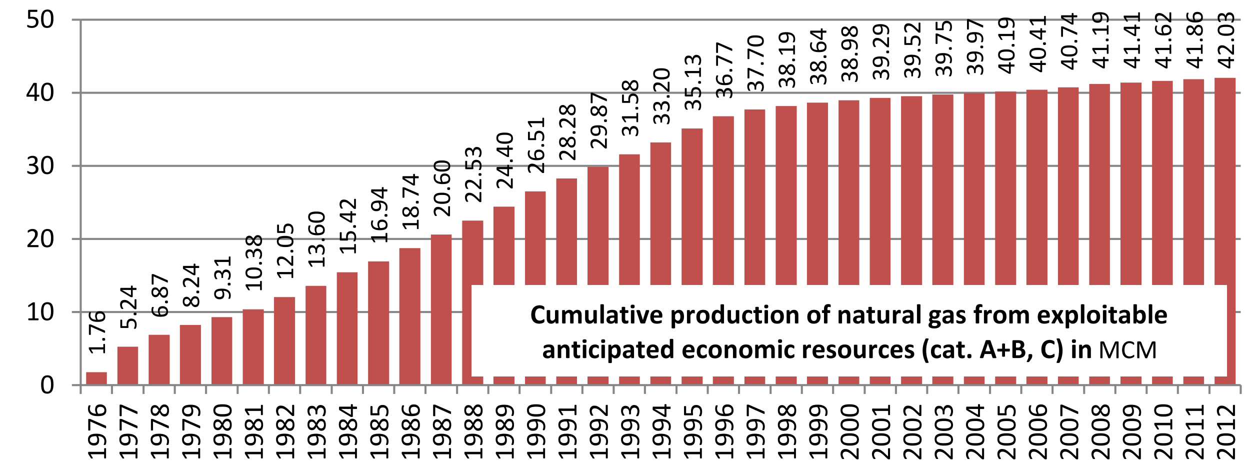


Fig. 4.9. Graph of natural gas production (main raw material) from Słopnice field (MIDAS, 2022).

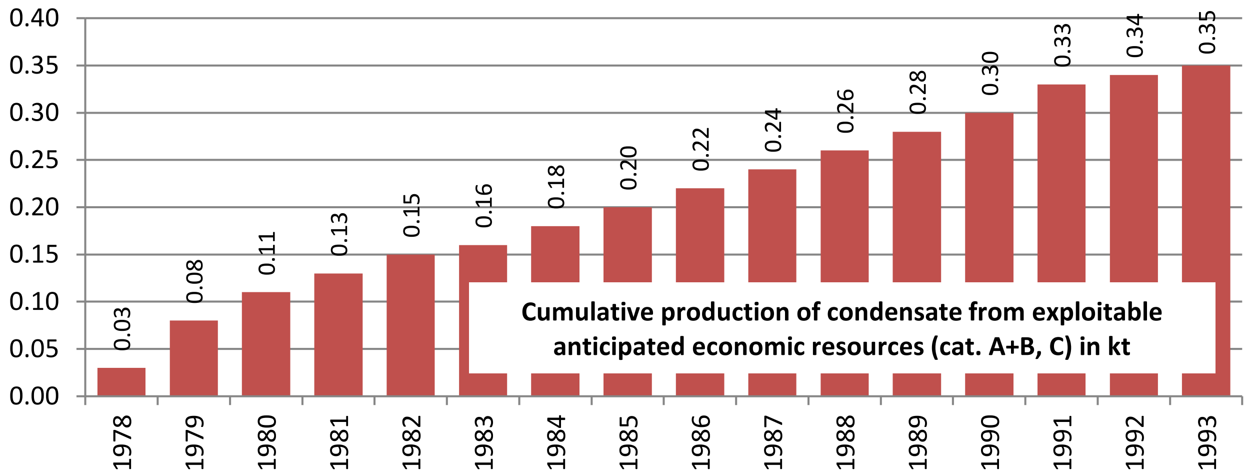


Fig. 4.10. Graph of condensate production (accompanying raw material) from Słopnice field (MIDAS, 2022).

5. WELLS

The following deep wells (>500 m MD) reached the prospective intervals in the Block 413-414 tender area:

Well name	Year	HC concessions (after 1994)	Owner	Depth [m]	Stratigraphy at the bottom
CZCHÓW 1	1974		State Treasury	3216.0	Jurasic
DOBCZYCE 5	1972		State Treasury	1912.0	Autochthonous Miocene
IWKOWA 1	1974		State Treasury	3228.0	Carboniferous-Devonian
JAWORZNA 1	1973		State Treasury	3214.1	Silesian Unit
KAMIONNA 1	1974		State Treasury	2566.9	Silesian Unit
LESZCZYNA 1	1972		State Treasury	2410.0	Permian-Triassic
LESZCZYNA 2	1973		State Treasury	2305.0	Jurasic
LESZCZYNA 3	1973		State Treasury	2550.0	Jurasic
LESZCZYNA 4	1973		State Treasury	2850.0	Permian-Triassic
LESZCZYNA 21	1974		State Treasury	2564.6	Jurasic
LESZCZYNA 22	1972		State Treasury	2600.0	Jurasic
LIPNICA GÓRNA 1	1972		State Treasury	2710.0	Jurasic
ŁAPANÓW 2/2K	2007	25/2001/p Myślenice-Limanowa-Czchów	State Treasury	2050.0	Jurasic
ŁĄKTA 4	1973		State Treasury	2438.8	Jurasic
ŁĄKTA 9	1978		State Treasury	2382.0	Jurasic
ŁĄKTA 11	1974		State Treasury	2588.0	Autochthonous Miocene
ŁĄKTA 13	1979		State Treasury	2461.0	Jurasic
ŁĄKTA 14	1978		State Treasury	2473.0	Autochthonous Miocene
ŁĄKTA 22	1973		State Treasury	2511.0	Jurasic
ŁĄKTA 24	1974		State Treasury	3150.0	Jurasic
ŁĄKTA 25	1976		State Treasury	2423.0	Jurasic
ŁĄKTA 30K	1995	13/92/p	PGNiG S.A.	2746.4	Jurasic
MUCHÓWKA 1	1972		State Treasury	2620.0	Jurasic
MUCHÓWKA 2	1991		PGNiG S.A.	2804.0	Jurasic
POŁOM DUŻY 2	1973		State Treasury	2630.0	Jurasic
RACIECHOWICE 1	1996	3/96/p	PGNiG S.A.	2424.0	Precambrian
RAJBROT 1	1992	13/92/p	PGNiG S.A.	4948.0	Cambrian
RAJBROT 2	1993	13/92/p	PGNiG S.A.	4185.0	Cambrian
TARNAWA 1	1996	13/92/p	PGNiG S.A.	5510.0	Cambrian
TYMOWA 1	2011	25/2001/p Myślenice-Limanowa-Czchów	State Treasury	3740.0	Lower Carboniferous
WIŚNIOWA IG-1	1964		State Treasury	2931.2	Precambrian
WIŚNIOWA 3	1982		State Treasury	2613.0	Precambrian
WIŚNIOWA 4	1973		State Treasury	2602.0	Permian-Triassic
WIŚNIOWA 6	1973		State Treasury	2456.0	Precambrian
WOLICA 1	1977		State Treasury	3177.5	Permian-Triassic
ŻEGOCINA 1	1994	13/92/p	PGNiG S.A.	3509.0	Carboniferous

Location of the above-mentioned wells is presented in Fig. 5.1. Their general characteristics are shortly summarized in Tab. 5.1. 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.

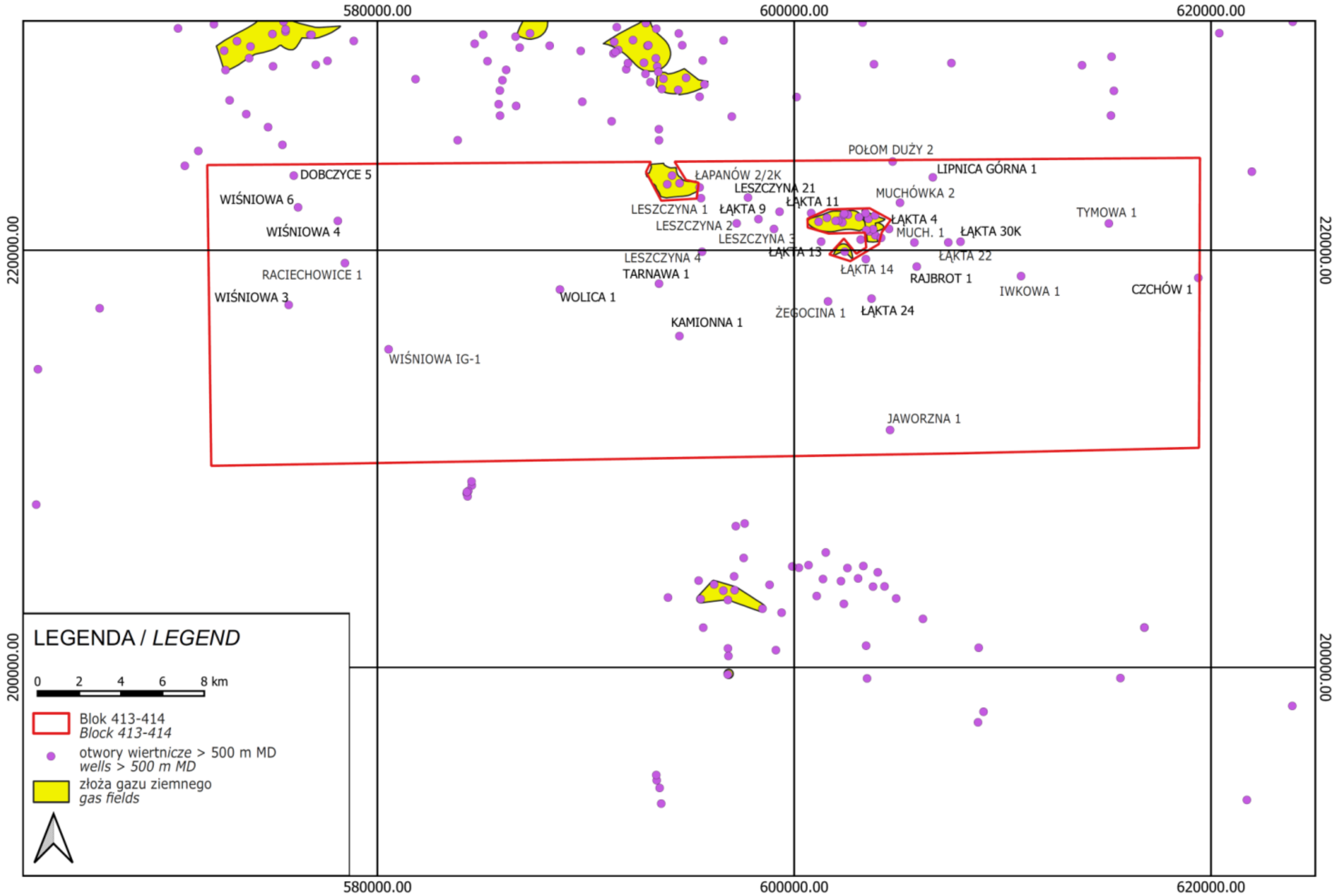


Fig. 5.1. Deep wells (>500 m MD) located within the Block 413-414 tender area and in its close neighborhood.

TRATIGRAPHY		Czchów 1 top – bottom [m]		Dobczyce 5 top – bottom [m]		Iwkowa 1 top – bottom [m]		Jaworzna 1 top – bottom [m]		Kamionna 1 top – bottom [m]		Leszczyna 1 top – bottom [m]		Leszczyna 2 top – bottom [m]	
Quaternary				0.0	10.0	0.0	10.0	0.0	15.0			0.0	15.0	0.0	5.0
Transgressive Miocene						10.0	565.0								
Magura Unit								15.0	1537.0						
Fore-Magura Unit								1537.0	2258.0						
Silesian Unit	*Krosno Beds*														
	Menilite Beds														
	Variegates Shales											15.0	55.0		
	Istebna Beds	0.0	1899.0	10.0	976.0			2258.0	2520.0	0.0	573.0	55.0	1225.0	5.0	1705.0
	Godula Beds	1899.0	1949.0	976.0	1090.0			2520.0	2634.0	573.0	1440.0	1225.0	1327.0	1705.0	1750.0
	L. Cretaceous	1949.0	2765.0	1090.0	1670.0	565.0	2543.0	2634.0	3214.1	1440.0	2566.9	1327.0	1470.0		
Sub-Silesian Unit		2765.0	3060.0			2543.0	2702.0					1470.0	1625.0	1750.0	1900.0
Stebnik Unit															
Autochthonous Miocene		3060.0	3120.0	1670.0	1912.0	2702.0	2841.0					1625.0	1955.0	1900.0	2225.0
Carpathian basement	Senonian	3120.0	3131.0												
	Turonian					2841.0	2990.0							2225.0	2232.5
	Cenomanian													2232.5	2240.4
	Jurassic	3131.0	3216.0			2990.0	3206.0					1955.0	2313.0	2240.4	2305.0
	Permian-Triassic											2313.0	2410.0		
	Upper Permian														
	Lower Permian														
	Upper Carboniferous														
	Lower Carboniferous														
	Middle and Upper Devonian					3206.0	3228.0								
	Lower Devonian														
	Lower Paleozoic														
	Precambrian														

TRATIGRAPHY		Leszczyna 3 top – bottom [m]		Leszczyna 4 top – bottom [m]		Leszczyna 21 top – bottom [m]		Leszczyna 22 top – bottom [m]		Lipnica Grn. 1 top – bottom [m]		Łapanów 2/2K top – bottom [m]		Łąkta 4 top – bottom [m]	
Quaternary		0.0	10.0	0.0	5.0					0.0	10.0	0.0	10.0	0.0	10.0
Transgressive Miocene															
Magura Unit															
Fore-Magura Unit															
Silesian Unit	*Krosno Beds*			5.0	165.0			0.0	520.0						
	Menilite Beds			165.0	188.0										
	Variegates Shales			188.0	352.0										
	Istebna Beds	10.0	1272.0	352.0	1990.0	0.0	1365.0	520.0	1238.0	10.0	942.0	10.0	1550.0	10.0	1560.0
	Godula Beds	1272.0	1650.0	1990.0	2040.0	1365.0	1545.0	1238.0	1540.0	942.0	1022.0			1560.0	1603.0
	L. Cretaceous	1650.0	1944.0	2040.0	2052.0	1545.0	1820.0	1540.0	1880.0	1022.0	1575.0			1603.0	1835.0
Sub-Silesian Unit				2052.0	2179.0										
Stebnik Unit										1575.0	1735.0			1835.0	1856.0
Autochthonous Miocene		1944.0	2427.0	2179.0	2461.0	1820.0	2533.0	1880.0	2513.4	1735.0	2470.0	1550.0	1927.0	1856.0	2393.0
Carpathian basement	Senonian									2470.0	2530.0				
	Turonian									2530.0	2535.0				
	Cenomanian							2513.4	2545.0	2535.0	2620.4				
	Jurassic	2427.0	2550.0	2461.0	2779.0	2533.0	2564.6	2545.0	2600.0	2620.4	2710.0	1927.0	2038.0	2393.0	2438.8
	Permian-Triassic			2779.0	2850.0										
	Upper Permian														
	Lower Permian														
	Upper Carboniferous														
	Lower Carboniferous														
	Middle and Upper Devonian														
	Lower Devonian														
	Lower Paleozoic														
	Precambrian														

TRATIGRAPHY		Łąkta 9 top – bottom [m]		Łąkta 11 top – bottom [m]		Łąkta 13 top – bottom [m]		Łąkta 14 top – bottom [m]		Łąkta 22 top – bottom [m]		Łąkta 25 top – bottom [m]		Łąkta 24 top – bottom [m]	
Quaternary		0.0	15.0							0.0	10.0				
Transgressive Miocene															
Magura Unit															
Fore-Magura Unit															
Silesian Unit	*Krosno Beds*			0.0	1133.0	0.0	635.0					0.0	55.0		
	Menilite Beds			1133.0	1165.0	635.0	655.0								
	Variegates Shales			1165.0	1370.0	655.0	848.0	0.0	595.0			55.0	140.0		
	Istebna Beds	15.0	1445.0			848.0	1230.0	595.0	1206.0	10.0	1373.0	140.0	1098.0	535.0	825.0
	Godula Beds	1445.0	1578.0	1370.0	1405.0	1230.0	1495.0	1206.0	1307.0	1373.0	1447.0	1098.0	1300.0	825.0 445.0	900.0 535.0
	L. Cretaceous	1578.0	1640.0	1405.0	1870.0	1495.0	1880.0	1307.0	1732.0	1447.0	2066.0	1300.0	1845.0	900.0 0.0	2296.0 445.0
Sub-Silesian Unit		1640.0	1985.0			1880.0	1995.0	1732.0	1905.0	2066.0	2175.0	1845.0	2008.0	2296.0	2890.0
Stebnik Unit		1985.0	2036.0												
Autochthonous Miocene		2036.0	2327.0	1870.0	2588.0	1995.0	2383.0	1905.0	2473.0	2175.0	2463.0	2008.0	2391.0	2890.0	3070.0
Carpathian basement	Senonian														
	Turonian	2327.0	2330.0			2383.0	2390.0					2391.0	2393.0		
	Cenomanian	2330.0	2338.0			2390.0	2406.0			2463.0	2491.0	2393.0	2412.0		
	Jurassic	2338.0	2382.0			2406.0	2461.0			2491.0	2511.0	2412.0	2423.0	3070.0	3150.0
	Permian-Triassic														
	Upper Permian														
	Lower Permian														
	Upper Carboniferous														
	Lower Carboniferous														
	Middle and Upper Devonian														
	Lower Devonian														
	Lower Paleozoic														
	Precambrian														

TRATIGRAPHY		Muchówka 1 top – bottom [m]		Połom Duży 2 top – bottom [m]		Tymowa 1 top – bottom [m]		Wiśniowa IG-1 top – bottom [m]		Wiśniowa 3 top – bottom [m]		Wiśniowa 4 top – bottom [m]		Wiśniowa 6 top – bottom [m]		Wolica 1 top – bottom [m]	
Quaternary						0.0	8.0	0.0	15.0								
Transgressive Miocene																	
Magura Unit																	
Fore-Magura Unit																	
Silesian Unit	*Krosno Beds*															0.0	738.0
	Menilite Beds																
	Variegates Shales															738.0	880.0
	Istebna Beds	0.0	895.0	0.0	982.0					0.0	270.0	0.0	1530.0	0.0	640.0	880.0	2421.0
	Godula Beds	895.0	1303.0	982.0	1105.0	8.0	2538.0					1530.0	1536.0	640.0	729.0		
	L. Cretaceous	1303.0	2083.0	1105.0	1510.0							1536.0	1830.0	729.0	1312.0		
Sub-Silesian Unit								15.0	2268.0	270.0	2275.0	1830.0	2100.0	1312.0	1867.0	2421.0	2748.0
Stebnik Unit		2083.0	2120.0														
Autochthonous Miocene		2120.0	2494.0	1510.0	2437.0	2538.0	2660.0	2268.0	2648.0	2275.0	2332.0	2100.0	2328.0	1867.0	2052.0		
Carpathian basement	Senonian			2437.0	2474.0												
	Turonian	2494.0	2495.0			2660.0	2695.0										
	Cenomanian	2495.0	2514.0	2474.0	2581.0	2695.0	2703.0							2052.0	2096.0		
	Jurassic	2514.0	2620.0	2581.0	2630.0	2703.0	3313.0	2648.0	2755.0	2332.0	2509.0	2328.0	2490.0	2096.0	2205.0	2748.0	3025.0
	Permian-Triassic											2490.0	2602.0				
	Upper Permian															3025.0	3177.5
	Lower Permian																
	Upper Carboniferous																
	Lower Carboniferous					3313.0	3740.0										
	Middle and Upper Devonian																
	Lower Devonian																
	Lower Paleozoic							2755.0	2770.0	2509.0	2534.0			2205.0	2286.0		
	Precambrian							2770.0	2931.2	2534.0	2613.0			2286.0	2456.0		

Tab. 5.1. Summary of stratigraphy with prospective exploration horizons in the wells located within the Block 413-414 tender area. Data from wells: Łąkta 30K, Muchówka 2, Raciechowice 1, Rajbrot 1, Rajbrot 2, Tarnawa 1, Żegocina 1 belongs to the Investor and cannot be published here.

6. SEISMIC SURVEYS

LIN E NAME	YEAR	PROJECT	CONCESSIONS (after 2001)	OWNER	LENGTH [km]
9-5-74K	1974	Limanowa-Nowy Sącz		State Treasury	7.58
9-3-74K	1974	Myślenice-Sucha-Rabka			12.50
1-5-75K	1975	Słopnice-Nowy Sącz			3.38
5-35-75K	1975				11.99
1-3-75K	1975	Sucha-Rabka-Nowy Targ			8.84
2-3-75K	1975				10.05
3-3-75K	1975				15.11
38-7-77K	1977	Bochnia-Czchów-Pilzno			3.91
37-7-78K	1978				12.41
11-1-78K	1978	Żywiec-Wadowice-Gdów			4.85
8-1-78K	1978				6.04
K0050178	1978				9.53
K0120178	1978				2.77
12-8-83K	1983	Wiśniowa-Łąkta			17.58
6-8-83K	1983				8.17
8-7-83K	1983				9.71
13-8-84K	1984				16.37
15-8-84K	1984				16.71
16-8-84K	1984				4.34
17-8-84K	1984				8.38
18-8-84K	1984				9.38
7-8-84K	1984				8.26
20-8-85K	1985	Tuchów-Kowalowy			4.77
38-8-86K	1986	Wiśniowa-Łąkta			2.36
39-8-86K	1986				4.17
40-8-85/86K	1986				4.38
41-8-86K	1986				8.09
41A-8-86K	1986				9.42
42-8-86K	1986				4.09
43-8-86K	1986				3.64
42-1-88K	1988	Niepołomice-Gdów-Myślenice			3.32
48-1-88K	1988				24.16
10-1-89K	1989	Dobczyce-Gdów-Wolica		ORLEN S.A.	12.48
10A-1-89K	1989				13.82
5-1-89K	1989				10.86
6-1-89K	1989				11.53
48-1-89K	1989	Skoczów-Wadowice-Sucha			3.83
11-8-91K	1991	Dobczyce-Gdów-Wolica			13.48
12-8-91K	1991				9.00
1-8-91K	1991				11.39
3-8-91K	1991				6.72
32-7-91K	1991	Myślenice-Limanowa-Czchów			14.06
11A-8-92K	1992	Dobczyce-Gdów-Wolica			10.27
21-8-92K	1992				4.30
22-8-92K	1992				6.85
23-8-92K	1992				6.91
2-8-92K	1992				7.08
4-8-92K	1992				8.98
7-8-92K	1992				10.07
30-7-92K	1992	Myślenice-Limanowa-Czchów			11.86
31-7-92K	1992				7.69
33-7-92K	1992				14.11
34-7-92K	1992				8.78
35-7-92K	1992				14.23

36-7-92K	1992				11.88
37-8-92K	1992				11.01
38A-7-92K	1992				2.95
38B-7-92K	1992				9.59
39-8-92K	1992				12.71
41-8-92K	1992				8.50
42-8-92K	1992				6.79
43-8-92K	1992				8.58
44-8-92K	1992				5.66
45-8-92K	1992				10.60
46-8-92K	1992				8.15
48-8-92K	1992				7.39
51-8-92K	1992				8.45
52-8-92K	1992				13.34
52A-8-92K	1992				15.28
53-8-92K	1992				6.29
53A-8-92K	1992				5.90
56-7-92K	1992				19.59
57-7-92K	1992				19.84
58-8-92K	1992				19.92
58A-7-92K	1992				7.76
59-8-92K	1992				7.89
60-8-92K	1992				12.42
61-8-92K	1992				13.04
62-8-92K	1992				13.83
63-8-92K	1992				9.76
8-8-92K	1992				10.40
9-8-92K	1992				26.21
65-8-93K	1993				11.84
10-14-94K	1994				8.39
1-14-94K	1994				11.47
2-14-94K	1994				12.89
3-14-94K	1994				14.36
4-14-94K	1994				10.31
5-14-94K	1994				6.38
64-8-92K	1994				19.15
1-15-94K	1995				9.83
2-15-94K	1995				8.41
3-15-94K	1995				8.35
4-15-94K	1995				7.78
5-15-94K	1995				7.01
6-14-94K	1995				9.61
6-15-94K	1995				5.23
7-14-94K	1995				8.80
7-15-94K	1995				8.67
8-14-94K	1995				10.50
9-14-94K	1995				11.39
16-11-01K	2001	Raciechowice-Stadniki	3/96/p Wiśniowa-Rachiechowice, 3/99/p Wysoka-Łapanów		5.07
18-11-01K	2001				5.04
20-11-01K	2001				5.17
22-11-01K	2001				4.69
24-11-01K	2001				4.78
3-11-01K	2001				7.18
5-11-01K	2001				8.70
7-11-01K	2001				14.00
9-11-01K	2001				14.70
10-11-01K	2002			State Treasury	7.53
11-11-01K	2002				6.02
12-11-01K	2002				8.08
14-11-01K	2002				5.02

15-11-01K	2002				7.50
8-11-01K	2002				7.57
16-1-04K	2004	Kamyk-Niepołomice	35/99/p Wiśnicz-Tuchów, 39/99/p Wysoka-Łapanów, 17/2001/p Gdów-Cichowa-Bochnia, 25/2001/p Myślenice-Limanowa-Czchów		9.96
17-1-04K	2004				16.96
2-1-04K	2004				2.97
3-1-04K	2004				3.97
4-1-04K	2004				6.12
5-1-04K	2004				6.33
6-1-04K	2004				4.69
7-1-04K	2004				3.03
8-1-04K	2004				3.35
9-1-04K	2004				6.49
10-2-05K	2005	Wiśnicz	35/99/p Wiśnicz-Tuchów, 39/99/p Wysoka-Łapanów, 25/2001/p Myślenice-Limanowa-Czchów		17.34
1-2-05K	2005				8.28
17-2-05K	2005				15.37
18-2-05K	2005				13.70
20-2-05K	2005				3.68
2-2-05K	2005				7.82
3-2-05K	2005				8.16
4-2-05K	2005				8.06
5-2-05K	2005				8.16
6-2-05K	2005				8.32
7-2-05K	2005				8.11
9-2-05K	2005				16.27
10-2-07K	2007	Tarnawa-Czchów	35/99/p Wiśnicz-Tuchów, 39/99/p Wysoka-Łapanów, 25/2001/p Myślenice-Limanowa-Czchów		14.41
11-2-07K	2007				15.13
1-2-07K	2007				12.51
12-2-07K	2007				14.67
13-2-07K	2007				10.73
14-2-07K	2007				13.94
15-2-07K	2007				17.32
16-2-07K	2007				17.76
17-2-07K	2007				19.81
18-2-07K	2007				19.26
19-2-07K	2007				21.57
20-2-07K	2007				10.49
21-2-07K	2007				2.21
2-2-07K	2007				12.90
23-2-07K	2007				2.76
3-2-07K	2007				13.24
4-2-07K	2007				12.71
5-2-07K	2007				12.35
6-2-07K	2007				14.08
7-2-07K	2007				13.62
8-2-07K	2007				14.39
9-2-07K	2007				14.32
K0190311	2011	brak danych	brak danych		6.15
K0200311	2011				6.25
KE430311	2011				14.57
10-5-12K	2012	Kamionna-Łososina	25/2001/p Myślenice-Limanowa-Czchów		11.96
11-5-12K	2012				11.54
12-5-12K	2012				11.12
13-5-12K	2012				19.33
1-5-12K	2012				9.51
2-5-12K	2012				12.09
3-5-12K	2012				12.25
4-5-12K	2012				11.31
5-5-12K	2012				9.56
6-5-12K	2012				11.41
7-5-12K	2012				24.25

8-5-12K	2012				14.32
9-5-12K	2012				14.14
				State Treasury	1005.06
				ORLEN S.A.	791.73

Tab. 6.1. 2D seismic surveys (lines longer than 2 km) within the Block 413-414 tender area.

NAME	YEAR	CONCESSIONS (after 2001)	OWNER	ACREAGE [km^2]
Łapanów 3D	1999	39/99/p Wysoka-Łapanów, 25/2001/p Myślenice -Limanowa-Czchów	State Treasury	55.28

Tab. 6.2. 3D seismic surveys within the Block 413-414 tender area.

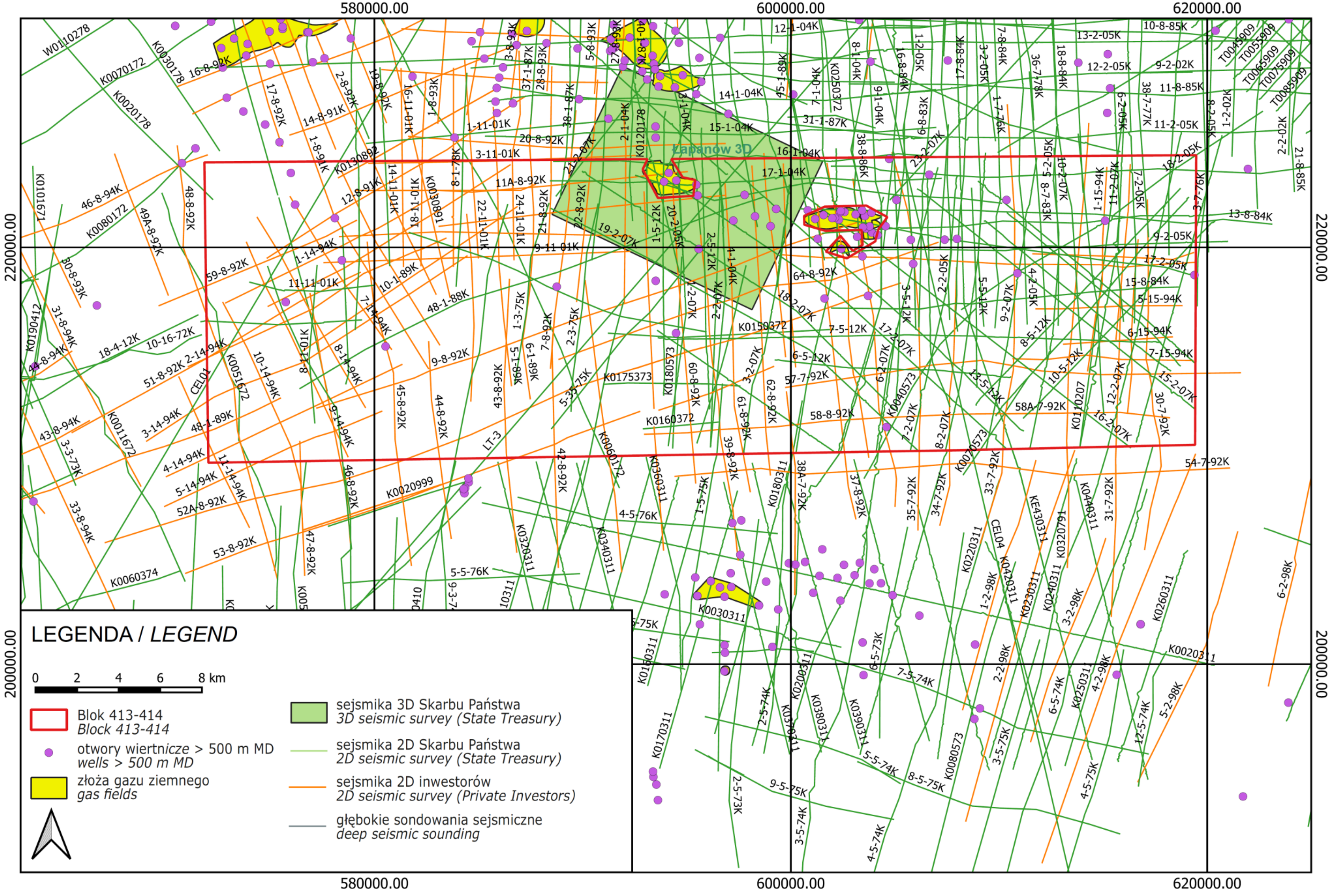


Fig. 6.1. Seismic survey within and in the neighborhood of the Block 413-414 tender area (CGDB, 2023).

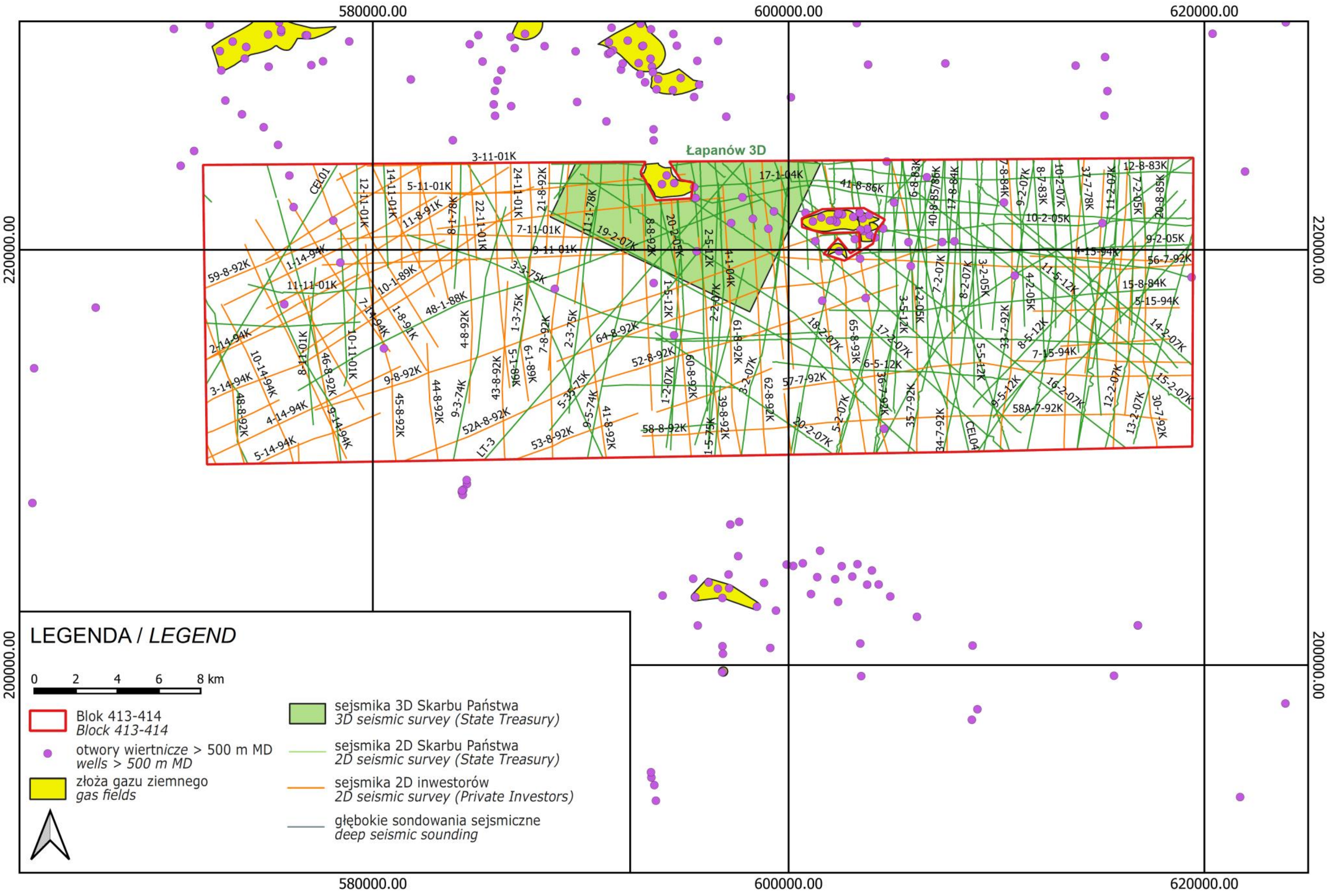


Fig. 6.2. Seismic survey within the Block 413-414 tender area (CGDB, 2023).

7. GRAVIMETRY, MAGNETOMETRY AND MAGNETOTELLURICS

7.1. GRAVIMETRY

Semidetailed gravimetric surveys in the Block 413-414 tender area and in its close neighbourhood were collected with a point density ca. 4 points/km^2 (Fig. 7.1). All data are available in the CGDB (2023). There are 2672 data points within the tender area (Fig. 7.1) coming from the Western Carpathians survey (Reczek, 1978a). Two modern detailed surveys were collected in the Block 413-414 tender area. The Raciechowice-Stadniki survey (Ostrowski et al., 2002) at the west, collected along profiles with 100 m step as well as in an irregular net of points, with density of 9–10 stations/km^2. The Tarnawa-Łąkta-Czchów detailed survey (Ostrowska et al., 2006) at the east was collected along profiles with 250 m step and in an irregular net too. Królikowski and Petecki (1995) proposed a division of Poland into several gravity regions. Thus, the Block 413-414 tender area is placed within south margin of Szczecin-Mogilno-Miechów Low (Fig. 7.2). It is adjacent to the south with the Carpathian Low, the margin of which is visible at the SE-corner of the Fig. 7.2. As a part of comprehensive interpretation of Carpathians geophysical image (Lemberger et al., 2007), the residual anomaly map with approximate tracking depth of the range 0–6 km b.s.l. was performed (Fig. 7.3), which reflects structure of sub-Neogene basement.

7.2. MAGNETOMETRY

Airborne magnetic survey in the Carpathians and Carpathian Foredeep was performed at the level of 250 m a.g.l. (Wasiak, 1982). There are 4981 data points along 19 profiles within the Block 413-414 tender area. Because of strong artificial noise and its attenuation in the process of data processing, only blurred image of magnetic field was obtained. A ground, semidetailed survey of the total magnetic field intensity was conducted in the Block 413-414 tender area (Kosobudzka and Wrzeszcz, 2005). The survey has an average density of 2 stations/km^2. All data are available in the CGDB (2023). There are 1998 data points within the Block 413-414 tender area (Fig. 7.4). An image of magnetic anomalies presented on Fig. 7.5 is taken from magnetic map of Carpathians (Lemberger et al., 2007). Petecki and Rosowiecka (2017) divided the Magnetic map of Poland into several regions with different magnetic characteristic. The Block 413-414 tender area is located within the Upper Silesia-Małoposka domain (USMd). This domain is characterized by mild intensity of magnetic field with a few regional positive anomalies. The Block 413-414 tender area lies in the north-west branch of the Nowy Sącz regional anomaly, which is related to the Precambrian basement of Western Carpathians.

7.3. MAGNETOTELLURICS

Location map of magnetotelluric surveys in the Block 413-414 tender area is presented in Fig. 7.6. Some of them were performed in the 80-ties of 20th century (Święcicka-Pawliszyn, 1984 and 1986; Molek and Oraczewski, 1987) and as a result a depth map of flysch consolidated basement was developed. The next study (Mazurek et al., 2001) had a similar goal. The field work was carried out along five measurement lines, three of which pass through the tender area in question. More detailed Raciechowice-Stadniki survey (Stefaniuk et al., 2002) was collected along 6 lines with a total length of 40.8 km, and it was the first survey with the use of CPMT (MT continuous profiling) method in the Carpathians. The last survey within the Block 413-414 tender area is Tarnawa-Łąkta-Czchów survey (Ostrowska et al., 2006). 45 soundings along 3 profiles were performed. Based on the combined gravimetric-magnetotelluric interpretation, the resulting structural-tectonic map was prepared.

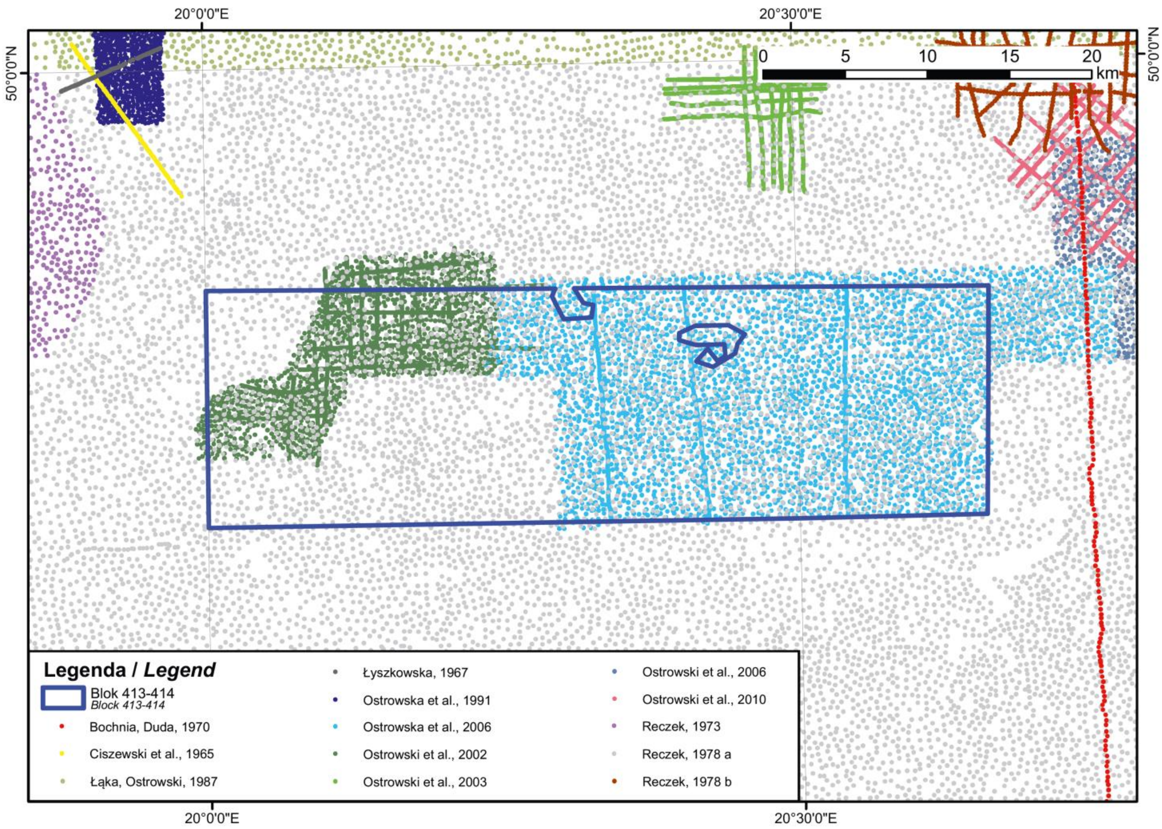


Fig. 7.1. Distribution of gravimetric measurements in the Block 413-414 tender area (based on CGDB, 2023).

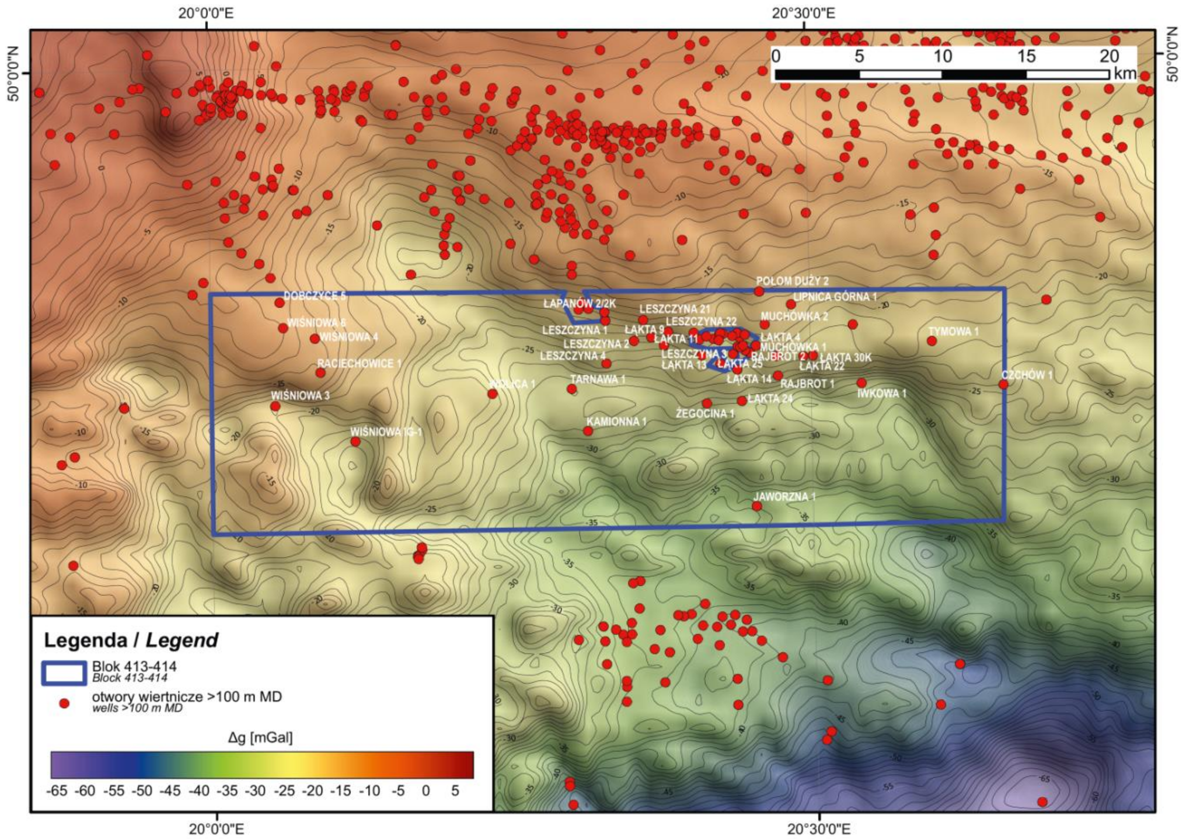


Fig. 7.2. Location of the Block 413-414 tender area on the Bouguer gravity anomaly map of Poland (Królikowski and Petecki, 1995).

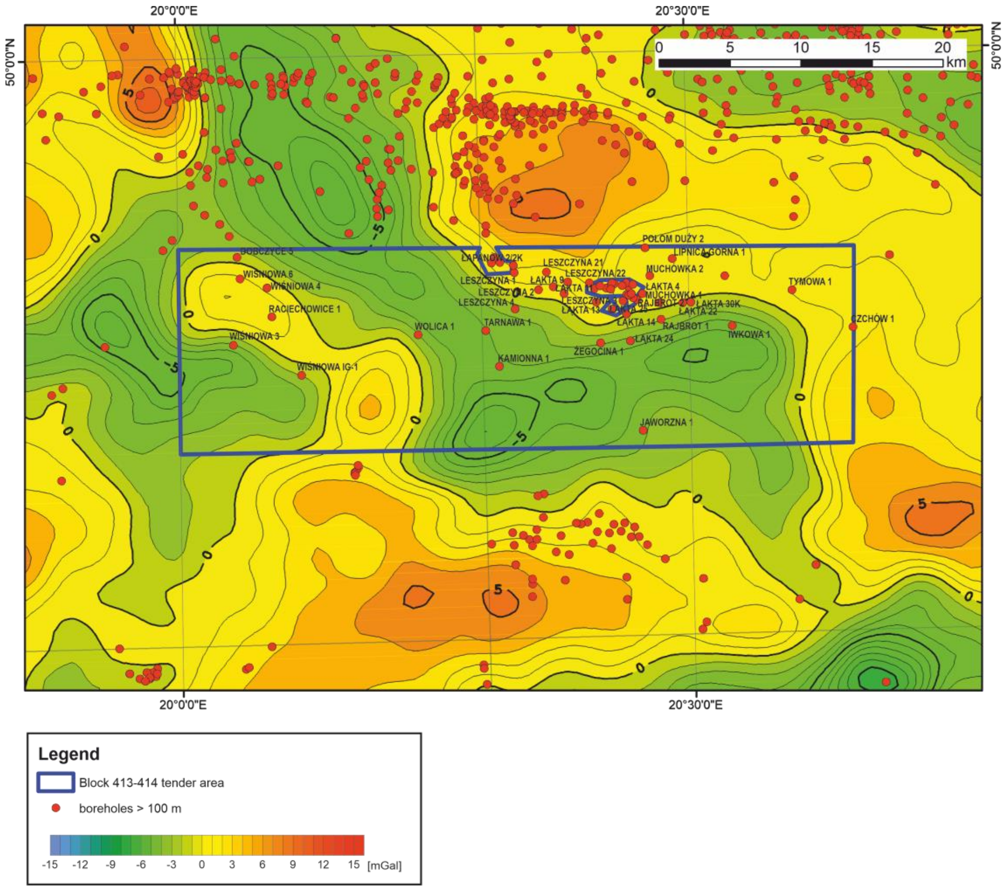


Fig. 7.3. Gravity residual anomalies map as a result of frequency filtering with approximate tracking depth in the range from 0 km to 6 km (Lemberger et al., 2007)

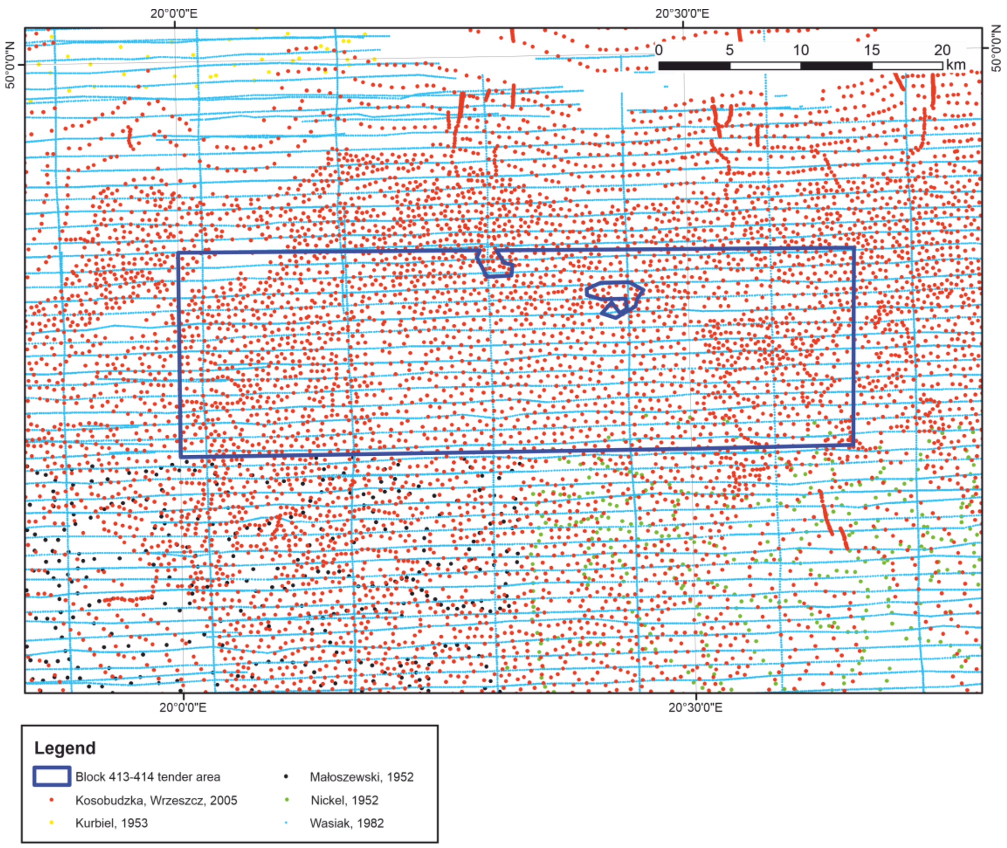


Fig. 7.4. Distribution of magnetic stations in the Block 413-414 tender area (based on CGDB, 2023).

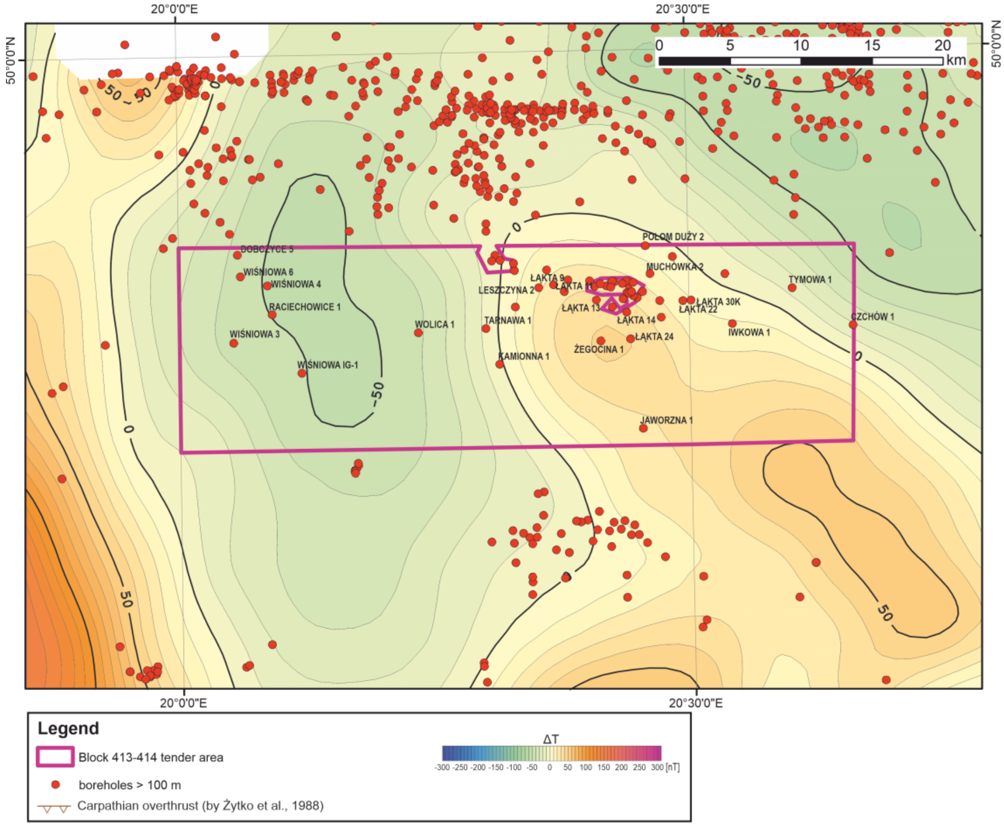


Fig. 7.5. Location of the Block 413-414 tender area on the magnetic anomaly map (Lemberger et al., 2007, modified).

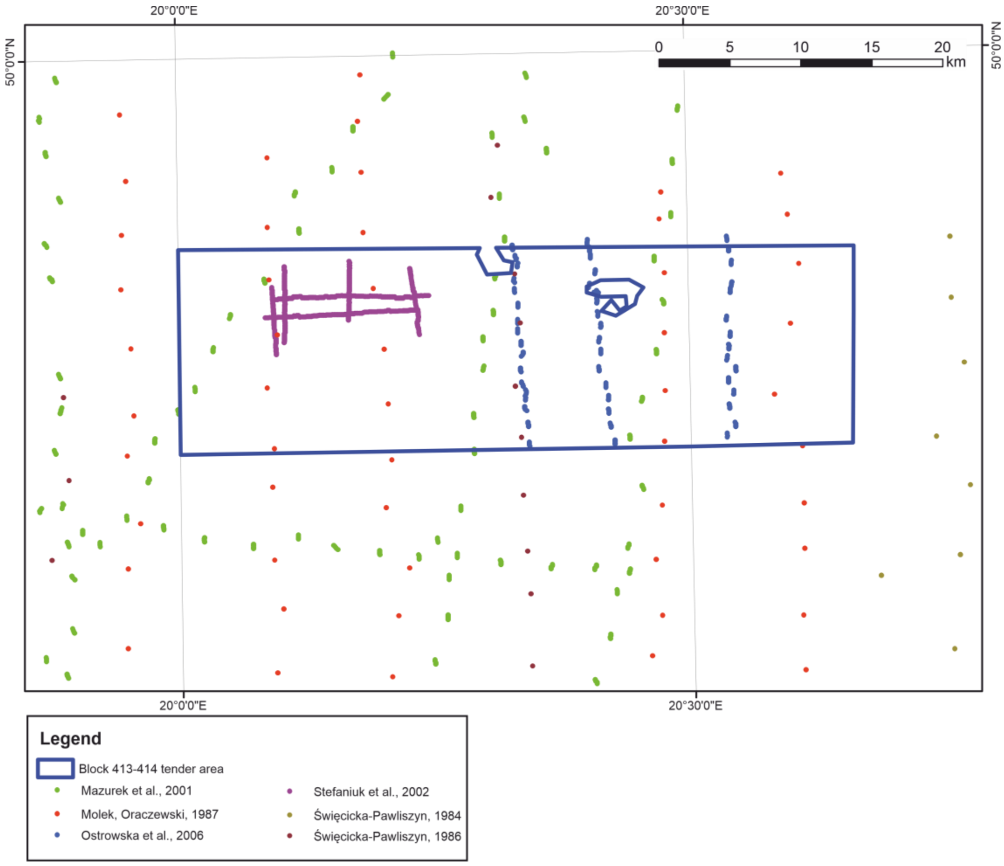


Fig. 7.6. Distribution of magnetotelluric surveys in the Block 413-414 tender area (based on CGDB, 2023).

8. SUMMARY CHART

<table>
<tr><td rowspan="4">General information:</td><td>Tender area:</td><td>BLOCK 413-414</td></tr>
<tr><td>Location:</td><td><u>Onshore</u>
<u>Hydrocarbon concession blocks</u>: 413, 414
<u>Administrative location</u>: Voivodeship Małopolskie, Bochnia county, communes: Nowy Wiśnicz (2.02%), Łapanów (6.50%), Lipnica Murowana (7.65%), Trzciana (6.35%), Żegocina (5.06%);
Brzesko country, communes: Iwkowa (7.08%), Gnojnik (1.60%), Czchów (4.54%)
Limanowa country, communes: Jodłownik (10.44%), Laskowa (7.23%), Dobra (1.40%), Tymbark (0.37%), Limanowa (5.95%)
Myślenice country, communes: Pcim (1,79%), Wiśniowa (8.66%), Dobczyce (5.34%), Raciechowice (9.17%), Siepraw (0.21%), Myślenice (4.70%)
Nowy Sącz country, communes: Łososina Dolna (2.86%), Gródek nad Dunajcem (0.16%)
Wieliczka country, commune: Gdów (0.92%)</td></tr>
<tr><td>Concession type:</td><td>prospection and exploration of hydrocarbon deposits
and production of hydrocarbons from a deposit</td></tr>
<tr><td>Time:</td><td>concession for 30 years, including:
prospection and exploration phase (5 years),
production phase – after investment decision</td></tr>
<tr><td colspan="2">Participation:</td><td>winner of the tender 100%</td></tr>
<tr><td colspan="2">Acreage [km^2]:</td><td>666.20</td></tr>
<tr><td colspan="2">Accumulation type:</td><td>conventional oil and gas fields</td></tr>
<tr><td colspan="2">Petroleum plays:</td><td>I – Outer Carpathians
II – autochthonous Miocene of the Carpathian Foredeep
III – Paleozoic-Mesozoic basement</td></tr>
<tr><td colspan="2">Reservoir rocks:</td><td>I – Krosno, Menilite, and Istebna Beds of the Silesian Unit
II – Upper Badenian and Lower Sarmatian sands and sandstones
III – Middle and Upper Devonian, Carboniferous and Jurassic carbonate rocks, hypothetically (Pre)Cambrian clastic rocks</td></tr>
<tr><td colspan="2">Source rocks:</td><td>I – Menilite, Istebna, and Lgota Beds of the Silesian Unit
Cieszyn and Grodziszcze Beds of the Sub-Silesian Unit
II – Upper Badenian and Lower Sarmatian fine-grained clastic rocks
III – Middle and Upper Devonian carbonate rocks, Carboniferous and Middle Jurassic carbonate and clastic rocks</td></tr>
<tr><td colspan="2">Seal rocks:</td><td>I – impermeable fine-grained clastic flysch formations: Inoceramian and Hieroglyphic Beds, Variegated Shales, Menilite and Krosno Beds
II – numerous layers of claystones within the autochthonous Miocene succession, rocks of the Stebnik Unit or the Sub-Silesian and Silesian Units above the top surface of the autochthonous Miocene
III – Culm, Permian-Triassic, Middle Jurassic, autochthonous Miocene and the Outer Carpathian series of the Sub-Silesian and Silesian Units (locally Stebnik Unit) for reservoirs in the Devonian and Carboniferous; autochthonous Miocene and Stebnik Unit for Jurassic reservoirs</td></tr>
<tr><td colspan="2">Trap type:</td><td>I – structural, structural-stratigraphic
II – structural (compactional anticlines, folds related to overthrusts), stratigraphic (related to wedging out and unconformities)
III – structural (Carpathian basement uplifted blocks, anticlines)</td></tr>
<tr><td colspan="2">Oil and gas fields:</td><td>Łapanów, Łąkta, Słopnice</td></tr>
<tr><td colspan="2">Seismic surveys (owner):</td><td>1974 Limanowa-Nowy Sącz, 1 line (State Tresaury)
1974 Myślenice-Sucha-Rabka, 1 line (State Tresaury)
1975 Słopnice-Nowy Sącz, 2 lines (State Tresaury)
1975 Sucha-Rabka-Nowy Targ, 3 lines (State Tresaury)
1977 Bochnia-Czchów-Pilzno, 2 lines (State Tresaury)
1978 Żywiec-Wadowice-Gdów, 3 lines (State Tresaury)
1983-1986 Wiśniowa-Łąkta, 16 lines (State Tresaury)
1985 Tuchów-Kowalowy, 1 line (State Tresaury)
1988 Niepołomice-Gdów-Myślenice, 2 lines (State Tresaury)
1989 Skoczów-Wadowice-Sucha, 1 line (ORLEN S.A.)
1989-1992 Dobczyce-Gdów-Wolica, 15 lines (ORLEN S.A.)
1991-1995 Myślenice-Limanowa-Czchów, 53 lines (ORLEN S.A.)</td></tr>
</table>

	2001-2002 Raciechowice-Stadniki, 15 lines (State Tresaury, ORLEN S.A.) 2004 Kamyk-Niepołomice, 10 lines (State Tresaury) 2005 Wiśnicz, 12 lines (State Tresaury) 2007 Tarnawa-Czchów, 22 lines (State Tresaury) 2012 Kamionna-Łososina, 12 lines (State Tresaury) 2008 Łapanów 3D, 55.28 km^2 (State Tresaury)
Wells (depth):	CZCHÓW 1 (3216.0 m) DOBCZYCE 5 (1912.0 m) IWKOWA 1 (3228.0 m) JAWORZNA 1 (3214.1 m) KAMIONNA 1 (2566.9 m) LESZCZYNA 1 (2410.0 m) LESZCZYNA 2 (2305.0 m) LESZCZYNA 3 (2550.0 m) LESZCZYNA 4 (2850.0 m) LESZCZYNA 21 (2564.6 m) LESZCZYNA 22 (2600.0 m) LIPNICA GÓRNA 1 (2710.0 m) ŁAPANÓW 2/2K (2050.0 m) ŁĄKTA 4 (2438.8 m) ŁĄKTA 9 (2382.0 m) ŁĄKTA 11 (2588.0 m) ŁĄKTA 13 (2461.0 m) ŁĄKTA 14 (2473.0 m) ŁĄKTA 22 (2511.0 m) ŁĄKTA 24 (3150.0 m) ŁĄKTA 25 (2423.0 m) ŁĄKTA 30K (2746.4 m) MUCHÓWKA 1 (2620.0 m) MUCHÓWKA 2 (2804.0 m) POŁOM DUŻY 2 (2630.0 m) RACIECHOWICE 1 (2424.0 m) RAJBROT 1 (4948.0 m) RAJBROT 2 (4185.0 m) TARNAWA 1 (5510.0 m) TYMOWA 1 (3740.0 m) WIŚNIOWA IG-1 (2931.2 m) WIŚNIOWA 3 (2613.0 m) WIŚNIOWA 4 (2602.0 m) WIŚNIOWA 6 (2456.0 m) WOLICA 1 (3177.5 m) ŻEGOCINA 1 (3509.0 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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