Polish Geological Institute
National Research Institute

Polish Geological Survey
Polish Hydrogeological Survey

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

SIEDLCE W

TENDER AREA

GEOLOGICAL PACKAGE ENGLISH ABSTRACT

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

Team leaders:
Piotr SŁOMSKI

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Funded by National Fund
for Environmental Protection
and Water Management

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Warsaw, 2021

1. GENERAL INFORMATION
1.1. LOCATION

The “Siedlce W” tender area of 1200.00 km^2 is located onshore in E Poland, in the concession blocks 216, 217, 236 and 237 (Fig. 1.1). The precise location is defined by geographical coordinates listed below.

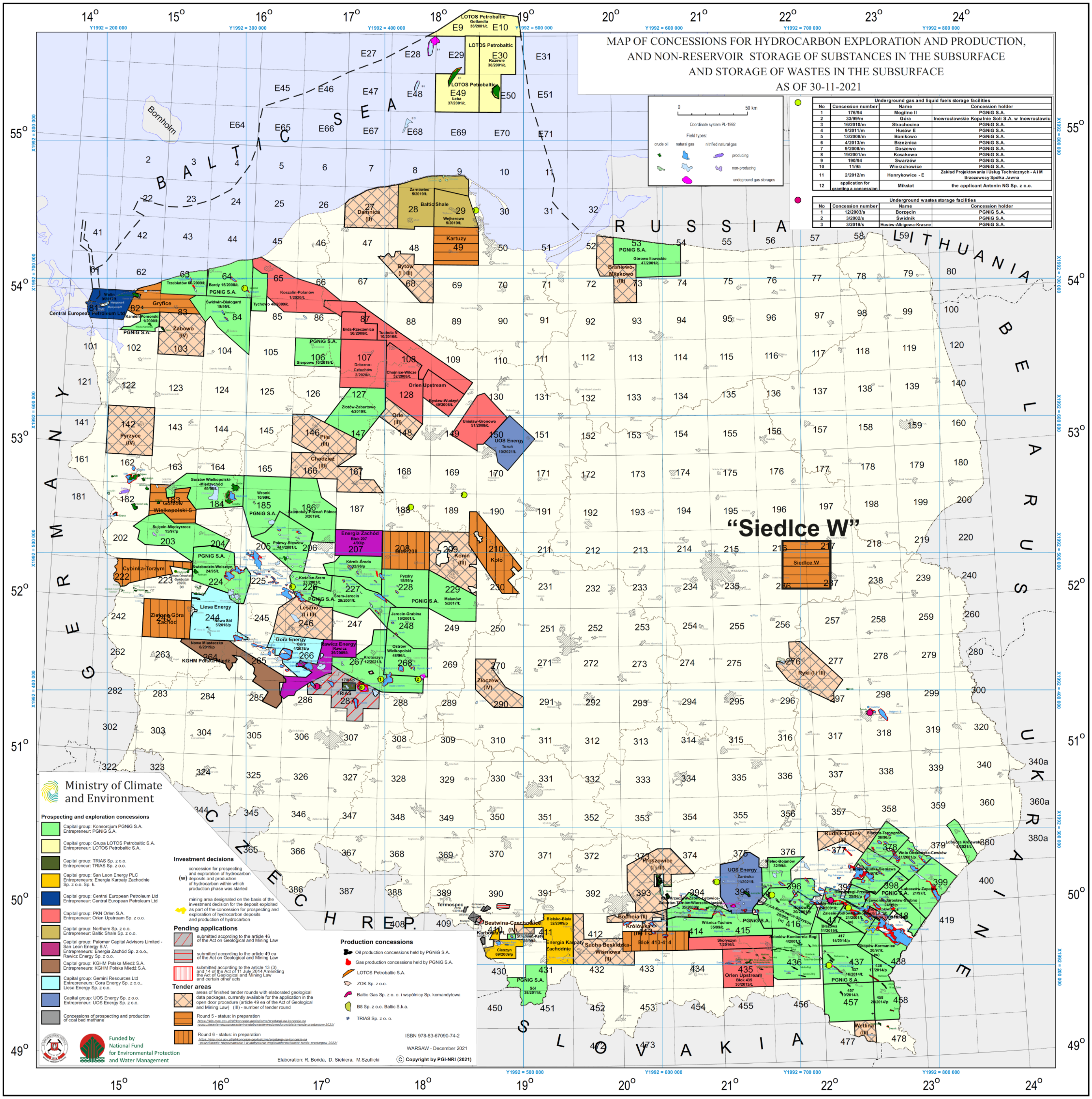
Border points	1992 coordinate system	
	X	Y
1	508667.07	687397.04
2	508667.07	722038.06
3	474026.06	722038.06
4	474026.06	687397.04

Tab. 1.1. Border points coordinates of the “Siedlce W” tender area (Fig. 1.2).

The “Siedlce W” tender area was previously subjected to hydrocarbon prospection and exploration concessions No. 31/2008/p Mińsk Mazowiecki (Mazowia Energy Resources/Exxon Mobil), No. 51/2009/p Wodynie-Łuków (Exxon Mobil/Orlen Upstream), No. 33/2010/p Sokołów Podlaski (Marathon Oil Poland), and No. 35/2010/p Siedlce (Marathon Oil Poland).

No oil and gas fields have been documented up to date within and in the neighborhood of the “Siedlce W” tender area. The main exploration target here is related to unconventional accumulations of gas and oil in the Lower Paleozoic shale formations, as well as to conventional accumulations of oil and gas in the Middle and Lower Cambrian.

→**Fig. 1.1.** Location of the “Siedlce W” 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 30-11-2021.


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 30-11-2021
“Siedlce W”
Siedlce W
BALTIC SEA
RUSSIA
LITHUANIA
BELARUS
UKRAINE
SLOVAKIA
CZECH REP.
GERMANY
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
ISBN 978-83-67090-74-2
WARSAW - December 2021
Elaboration: R. Bońda, D. Siekiera, M.Szuflicki
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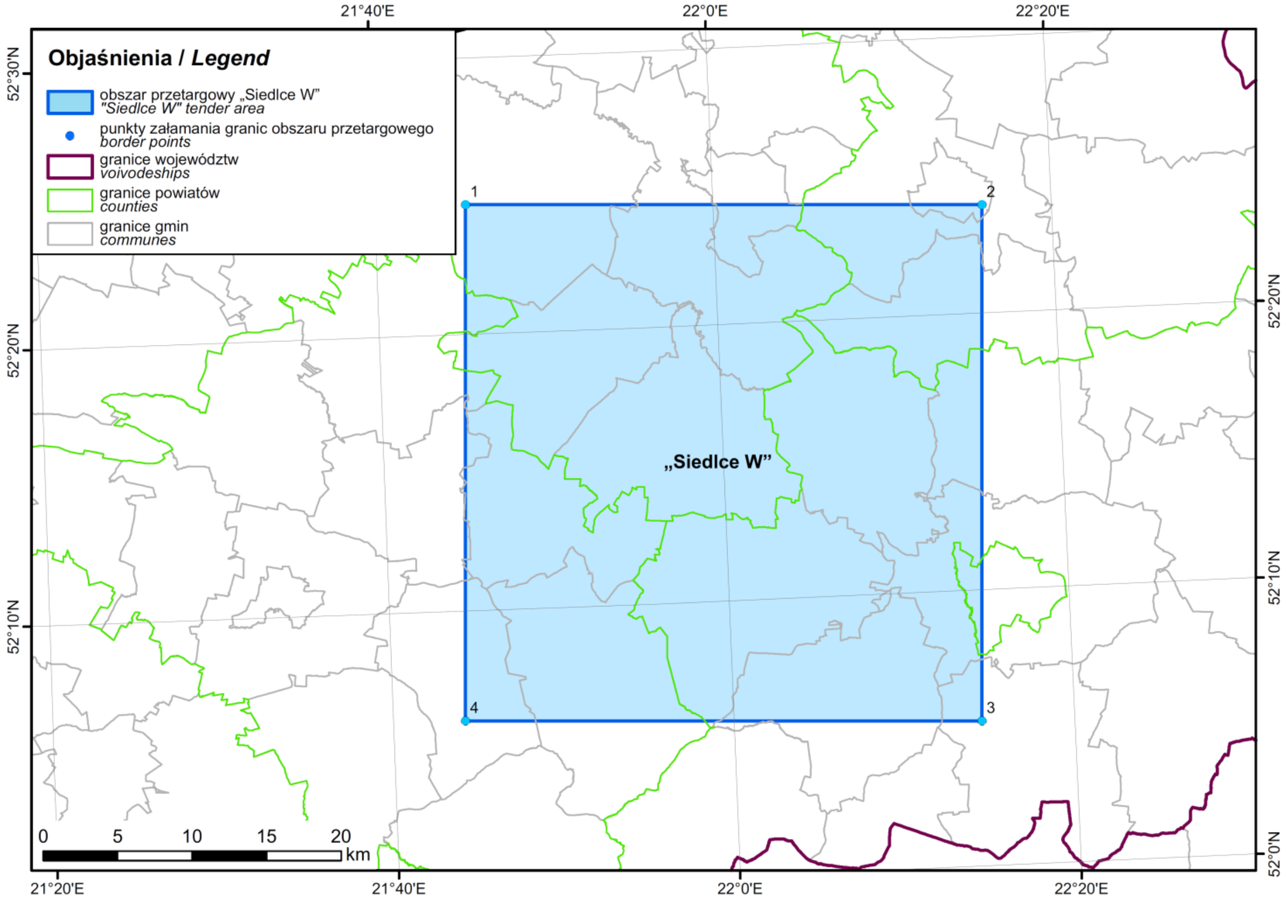

Fig. 1.2. Border points of the “Siedlce W” tender area and location of the hydrocarbon concessions in the neighborhood, as of 30-11-2021 (CGDB, 2021).

1.2. ENVIRONMENTAL CONDITIONS

The “Siedlce W” tender area is located in 20 communes and 1 county town in the Mazowieckie voivodeship. The most important cities are Siedlce and Sokołów Podlaski, which are industrial, administrative, service and educational centers. The road network is well developed. The area is crossed by the A2 highway and the national road No. 2 connecting the eastern and western borders of Poland. Part of the highway A2 is still under construction and will be completed in 2023. The infrastructure is complemented by voivodeship, county and commune roads and railway lines, as well as the electrified double-track line No. 2 and non-electrified single-track line No. 55. The technical infrastructure consists of high voltage power lines and a high-pressure gas transmission pipeline of 700 mm diameter.

The “Siedlce W” tender area is located in the South Podlasie Lowland macroregion, of which 48% is in the "Siedlce Upland, 39% in the Kałuszyn Upland, and 13% in the Węgrów Lowland. In terms of hydrography, the area is located in the Vistula River Basin, within the Liwiec catchment area. In addition, there are numerous canals, drainage ditches, and ponds, and the artificial reservoir of the Lagoon on the Muchawka River. The tender area is located within the boundaries of two principal aquifers, PA 223 (GZWP223) and PA 2151 (GZWP2151).

There are a number of legally protected areas in the “Siedlce W” tender area. Nine nature reserves occupy <1% of its total area, and 2 protected landscape areas, including Siedlecko-Węgrowski PLA and Miński PLA, cover 26% and 14%, respectively. Natura 2000 sites cover 13% of the total area. There are 2 special protection areas, 4 special areas of conservation, 3 ecological areas, and 465 living and inanimate nature monuments as well. The areas of high natural value include also agricultural land of high valuation classes, meadows developed on organic soils, and dense forest complexes partly with the status of protective forests.

There are 95 mineral deposits in the “Siedlce W” tender area including: natural aggregates (92), a quartz sand deposit for the production of cellular concrete (1), a quartz sand deposit for the production of sand-lime brick (1), and a peat deposit (1). Moreover, 4 verified prognostic areas for sands and sand and gravel, as well as 32 prospective areas for sands, sand and gravel, quartz sands and peat, have been designated here.

THE ENVIRONMENTAL CONDITIONS DATASHEET FOR TENDER AREA “SIEDLCE W”				
1.	*LOCATION OF THE TENDER AREA ON THE MAP*	*Name and number of the map sheet at a scale 1: 50 000*	Liw 491, Węgrów 492, Sokołów Podlaski 493, Mińsk Mazowiecki 526, Kałuszyn 527, Mokobody 528, Siedlce Północ 529, Cegłów 562, Latowicz 563, Skórzec 564, Siedlce Południe 565	
2.	*ADMINISTRATIVE LOCATION*	***Voivodeship***	**Mazowieckie**	
		County	**Węgrów**	
		The commune and % of the area within the tendering area	Korytnica (4.80%), Wierzbno (8.35%), Liw (9.03%), Węgrów (1.41%), Grębków (10.89%)	
		County	**Sokołów Podlaski**	
		Commune	Sokołów Podlaski (3.45%), Sokołów Podlaski City (0.29%), Bielany (5.52%)	
		County	**Mińsk Mazowiecki**	
		Commune	Dobre (0.96%), Jakubów (0.34%), Kałuszyn (7.82%), Cegłów (2.33%), Mrozy (8.14%)	
		County	**Siedlce City**	
		Commune	Siedlce (0.55%)	
		County	**Siedlce**	
		Commune	Kotuń (12.52%), Mokobody (9.94%), Siedlce (3.84%), Skórzec (6.74%), Suchożebry (2.32%), Wiśniew (0.76%), Wodynie (<0.0003%)	
3.	*PHYSIOGRAPHIC REGIONALIZATION (after KONDRACKI, 2013 and SOLON et al., 2018)*	*Macroregion*	*Southern Podlasie Lowland (318.9)*	
		Mesoregion	*Kałuszyn Heights (318.92)*	
		Mesoregion	*Węgrów Depression (318.93)*	
		Mesoregion	*Siedlce Heights (318.94)*	
4.	*COORDINATES OF THE TENDER AREA BORDER POINTS*	*PL-1992 coordinate system*	508667.07	687397.04
			508667.07	722038.06
			474026.06	722038.06
			474026.06	687397.04
5.	*SURFACE OF THE TENDER AREA*	[km^2]	1200.00	
6.	*CONCESSION TYPE*		prospecting, exploration and production of hydrocarbons	
7.	*AGE OF HYDROCARBON FORMATION*		Cambrian, Ordovician, Silurian	
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		*Barania Ruda (<1%), Florianów (<1%), Kantor Stary (<1%), Las Jaworski (<1%), Przełom Witówki (<1%), Rogożnica (<1%), Rudka Sanatoryjna (<1%), Stawy Brosz-kowskie (<1%), Torfowisko Jeziorek (<1%)*	
	Landscape Parks		*no*	
	Protected landscape areas		*Miński OChK (14%), Siedlecko-Węgrowski OChK (26%)*	
	Natura 2000, (Special Area of Conservation, SAC)		*PLH080006 Noteć Mouth (3%), PLH080058 Murawy Gorzowskie Reserve (<1%)*	
	Natura 2000 – OSO *Natura 2000, (Special Bird Protection, SPA)*		*PLH140007 Kantor Stary (<1%), PLH140026 Dzwonecznik w Kisielanach (<1%), PLH140032 Ostoja Nadliwiecka (3%), PLH140036 Rogoźnica (<1%)*	
	Natura 2000, (SAC+SPA)		*PLC080001 Warta Mouth (5%)*	
	Nature and landscape complexes		*no*	

THE ENVIRONMENTAL CONDITIONS DATASHEET FOR TENDER AREA "SIEDLCE W"			
	Ecological area	*[yes (quantity) / no]*	3
	Nature monuments		465
	Documentation positions		*no*
9.	*PROTECTED SOIL*	*[yes / no]*	*yes*
10.	*FOREST COMPLEXES*	*[yes / no]*	*yes*
11.	*PROTECTIVE FORESTS*	*[yes (% of the total area / no]*	19.03 km^2 (1.6%)
12.	*CULTURAL HERITAGE FACILITIES* *Archaeological monuments*	*[yes (quantity) / no]*	
		Hillfort	4
		Hamlet	7
		Cemetery	7
		others	*no*
13.	*MAJOR GROUNDWATER RESER-VOIRS*	*[yes (number, name and age of the aquifer) / no]*	*215 Subniecka warszawska Pg-Ng, 2151 Subniecka warszawska (część centralna) Pg-Ng, 223 Dolina kopalna górnego Liwca; Q*
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 (natural aggregates, quartz sands, peat)*
18.	*PROGNOSTIC AND PROSPECTIVE AREAS OF OCCURRENCE OF MINERAL RESOURCES (excluding hydrocarbons)*	*[yes (type of mineral deposit)/ no]*	*yes (sand, sand and gravel, peat)*
19.	*NATURAL GAS PIPELINES*	*[yes / no]*	*yes*
20.	*UNDERGROUND GAS STORAGE*	*[yes / no]*	*no*
21.	*DATE OF THE DATASHEET COM-PLETION*	26.02.2021 r.	
22.	*DATA COLLECTION AND ELABORATION*	Joanna Szyborska-Kaszycka, Dominika Kafara	

Tab. 1.2. The environmental conditions datasheet for the "Siedlce W" tender area.

→**Fig. 1.3.** Environmental map of the "Siedlce W" area.

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

PAŃSTWOWY INSTYTUT GEOLOGICZNY
PAŃSTWOWY INSTYTUT BADAWCZY

Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej

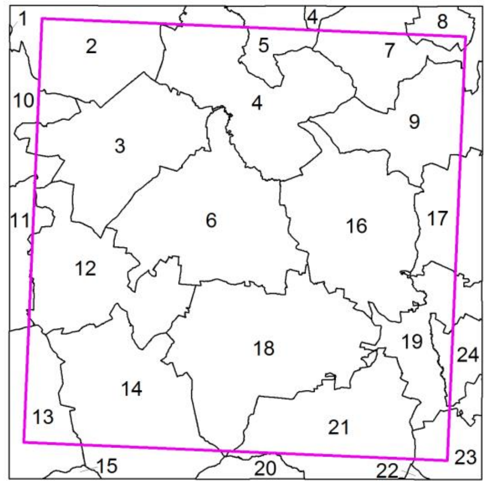
Ministerstwo Klimatu i Środowiska

Mapa środowiskowa obszaru „SIEDLCE W"

Environmental Map of the "SIEDLCE W" area

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

Położenie obszaru na tle podziału administracyjnego
Location of tender area on administrative division map



woj. MAZOWIECKIE
powiat wołomiński
1 – gm. Strachówka
powiat węgrowski
2 – gm. Korytnica
3 – gm. Wierzbno
4 – gm. Liw
5 – gm. Węgrów
6 – gm. Grębków
powiat sokołowski
7 – gm. Sokołów Podlaski
8 – m. Sokołów Podlaski
9 – gm. Bielany
powiat miński
10 – gm. Dobre
11 – gm. Jakubów
12 – gm. Kałuszyn
13 – gm. Cegłów
14 – gm. Mrozy
15 – gm. Latowicz
powiat siedlecki
16 – gm. Mokobody
17 – gm. Suchożebry
18 – gm. Kotuń
19 – gm. Siedlce
20 – gm. Wodynie
21 – gm. Skórzec
22 – gm. Domanice
23 – gm. Wiśniew
powiat Siedlce
24 – m. Siedlce

Położenie obszaru koncesyjnego SIEDLCE W na tle arkuszy mapy 1:50 000
Location of tender area on maps with scale of 1:50 000

Zestawienie danych oraz redakcja komputerowa mapy: *Joanna Szyborska-Kaszycka*
Data compilation and map edition:

Weryfikacja: *Olimpia Kozłowska*
Verification:

Objaśnienia do mapy środowiskowej obszaru „Siedlce W”

Legend of the environmental map of the "Siedlce W" 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

piaski kwarcowe – quartz sands

piaski – sands

torfy – peat

9579 – identyfikator z bazy Midas złoża małokonfliktowego – ID from the MIDAS database of the small environmental conflict

19000 – identyfikator z bazy Midas złoża konfliktowego – ID from the MIDAS database of the environmental conflict

granica złoża – deposit boundary

granica zweryfikowanego obszaru prognostycznego – verified 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

p – punkt niekoncesjonowanej eksploatacji kopaliny (p – rodzaj kopaliny) – point of unlicensed exploitation of a mineral (p - type of mineral)

Symbol kopaliny:
- ż - żwiry – gravels
- pż - piaski i żwiry – sands and gravels
- p - piaski – sands
- pk - piaski kwarcowe – quarz sands
- t - torfy – peat

Symbol jednostki stratygraficznej: Symbol of the stratigraphic unit:
- Q – czwartorzęd – Quaternary
- Ng – neogen – Neogene
- Pg – paleogen – Paleogene

WODY POWIERZCHNIOWE I PODZIEMNE

SURFACE AND UNDERGROUNG WATERS

obszary dolinne zagrożone podtopieniami – valley flood hazard area

granice działu wodnego drugiego rzędu – water divide of second rank

granice działu wodnego trzeciego rzędu – water divide of third rank

granice działu wodnego czwartego rzędu – water divide of fourth rank

215 – granica głównego zbiornika wód podziemnych wraz z jego numerem – principle boundary aquifer with ID number

granica strefy ochrony ujęcia wód – water intake protected area boundary

Q – granica leja depresyjnego wywołanego eksploatacją wód podziemnych (Q – wiek eksploatowanych utworów) – boundary of a cone depression caused by water exploitation (Q – age of exploited rocks)

k/Q – ujęcie wód podziemnych o wydajności 25–50 m^3/h (k – komunalne, p – przemysłowe, Q – wiek ujmowanych utworów) – underground water intake with capacity 25–50 m^3/h (k - municipal, p - industrial, Q - age of exploited rocks)

k/Q – ujęcie wód podziemnych o wydajności ≥ 50 m^3/h – underground water intake with capacity ≥ 50 m^3/h (k - municipal, p - industrial, Q - age of exploited rocks)

OCHRONA PRZYRODY, KRAJOBRAZU I ZABYTKÓW KULTURY

grunty orne (klasy I–IVa użytków rolnych) – arable land (class I-IVa)

łąki na glebach pochodzenia organicznego – meadows on organic soils

lasy – forests

lasy ochronne – protected forests

zieleń urządzona – urban greenery

granice terenów zarządzanych przez Generalną Dyrekcję Lasów Państwowych – boundary of areas managed by General Directorate of the State Forests

granica obszaru chronionego krajobrazu; nazwa obszaru – boundary of protected landscape area; area name

Fn – granica rezerwatu przyrody lub obszaru ochrony ścisłej (os) w obrębie parku narodowego (Fl – florystyczny, Fn – faunistyczny, L – leśny, T – torfowiskowy) – boundary of natural reserve (Fl – floristic, Fn – faunistic, L – forests, T – peat)

granica strefy ochronnej (otuliny) rezerwatu przyrody – boundary of buffer zone of natural reserve

aleja drzew pomnikowych – avenue of monumental trees

PLH140007 – obszary Europejskiej Sieci Ekologicznej Natura 2000; kod obszaru – Natura 2000 ecological network; area code

n – pomnik przyrody żywej (n – liczba obiektów) – animate nature monument (n – 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

geostanowisko o znaczeniu krajowym – geosite of national importance

geostanowisko o znaczeniu lokalnym – geosite of local importance

stanowisko archeologiczne – archeological site

INFORMACJE DODATKOWE

ADDITIONAL INFORMATIONS

granica powiatu – district boundary

granica gminy, miasta – commune or town boundary

A2 – oś autostrady lub drogi szybkiego ruchu – highway or express route

A2 – oś projektowanej autostrady lub drogi szybkiego ruchu – planned highway or express route

SIEDLCE – siedziba urzędu gminy, miasta – commune or town office headquarter

×××××× – sieć gazociągów przesyłowych – natural gas pipeline network

×××××× – sieć elektroenergetyczna najwyższych i wysokich napięć – high-voltage power network

granica obszaru przetargowego – boundary of tender area

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

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

2. GEOLOGY
2.1. GENERAL GEOLOGY AND TECTONICS

The “Siedlce W” tender area is situated within four structural units. These are: East European Craton (EEC) and its sedimentary cover, divided into Caledonian, Laramide and Cenozoic sequences (Żelaźniewicz et al., 2011; Nawrocki and Becker, 2017; Figs 2.1–2.2). In terms of regional sub-Cenozoic geology, the “Siedlce W” tender area is located in the Kościerzyna-Puławy Synclinorium (Figs 2.2–2.6). Below this Permian-Mesozoic structure, the Ediacaran – Silurian succession forms the Podlasie (Caledonian) Syneclise/Depression, located at the western margin of the EEC (Żelaźniewicz et al., 2011; Poprawa, 2019; Podhalańska et al., 2020; Figs 2.2, 2.6, 2.7–2.10). The crystalline basement belongs to the Fennoscandian part of the Baltica palaeocontinent (Bogdanova et al., 2005). The basement is built of Paleoproterozoic granitoids and paragneisses (Krzemińska and Krzemiński, 2017; Figs 2.11–2.12).

The top surface of the crystalline basement, as well as the Lower Paleozoic sedimentary succession, dips to the west. In the same direction, the thickness of the Lower Paleozoic strata increases (Modliński et al., 2010). The basement and its Lower Paleozoic sedimentary cover are cut by several deep reversal faults (Kufrasa et al., 2018; Krzywiec et al., 2018; Fig. 2.6) with the Grójec one as the major fault that runs SW-NE, cutting the NW part of the tender area. The minor faults run SW-NE and NW-SE (Fig. 2.10). The Permian-Mesozoic strata dip gently to the west, and the succession thickness increases in the same direction. Minor faults, which run SW-NE and NW-SE, are observed in the lower part of this succession. The whole “Siedlce W” tender area is covered by the unfolded Cenozoic succession.

The stratigraphy and lithology of sedimentary succession was recognized in several boreholes located in the “Siedlce W” tender area and its close neighborhood. These are: Dobre IG-1, Kałuszyn 1, 2, Polaki 1, Rówce 1, SOK-Grębków-01, Sokołów Podlaski 1, Tłuszcz IG-1 and Żebrak IG-1 (see Fig. 5.1 for location).

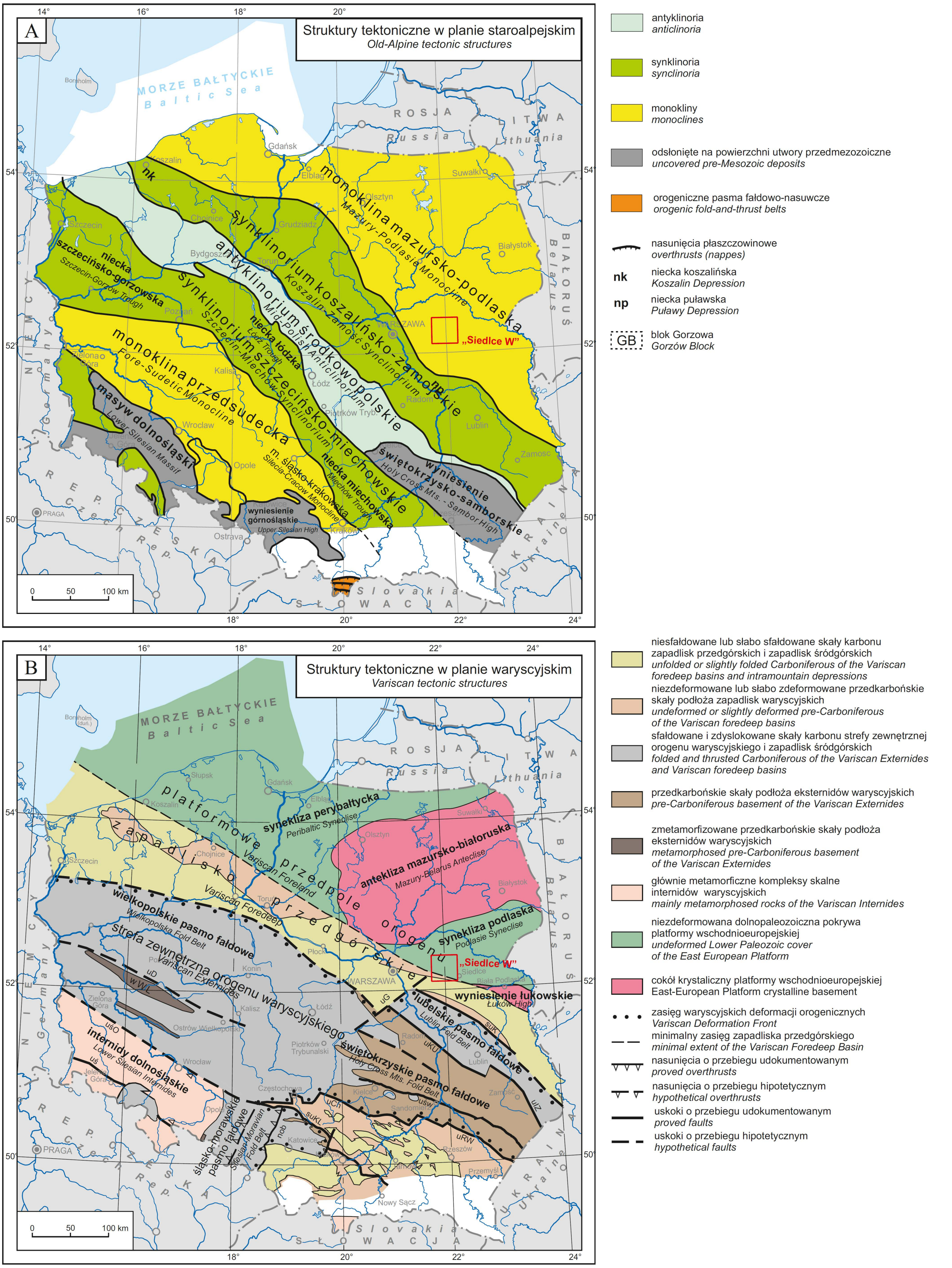


Fig. 2.1. A. Location of the “Siedlce W” tender area in relation to the Old-Apline tectonic structures in the Polish Lowland (Nawrocki and Becker, 2017; modified). **B**. Location of the “Siedlce W” tender area in relation to the Variscan tectonic structures in the Polish Lowland (Nawrocki and Becker, 2017; modified).

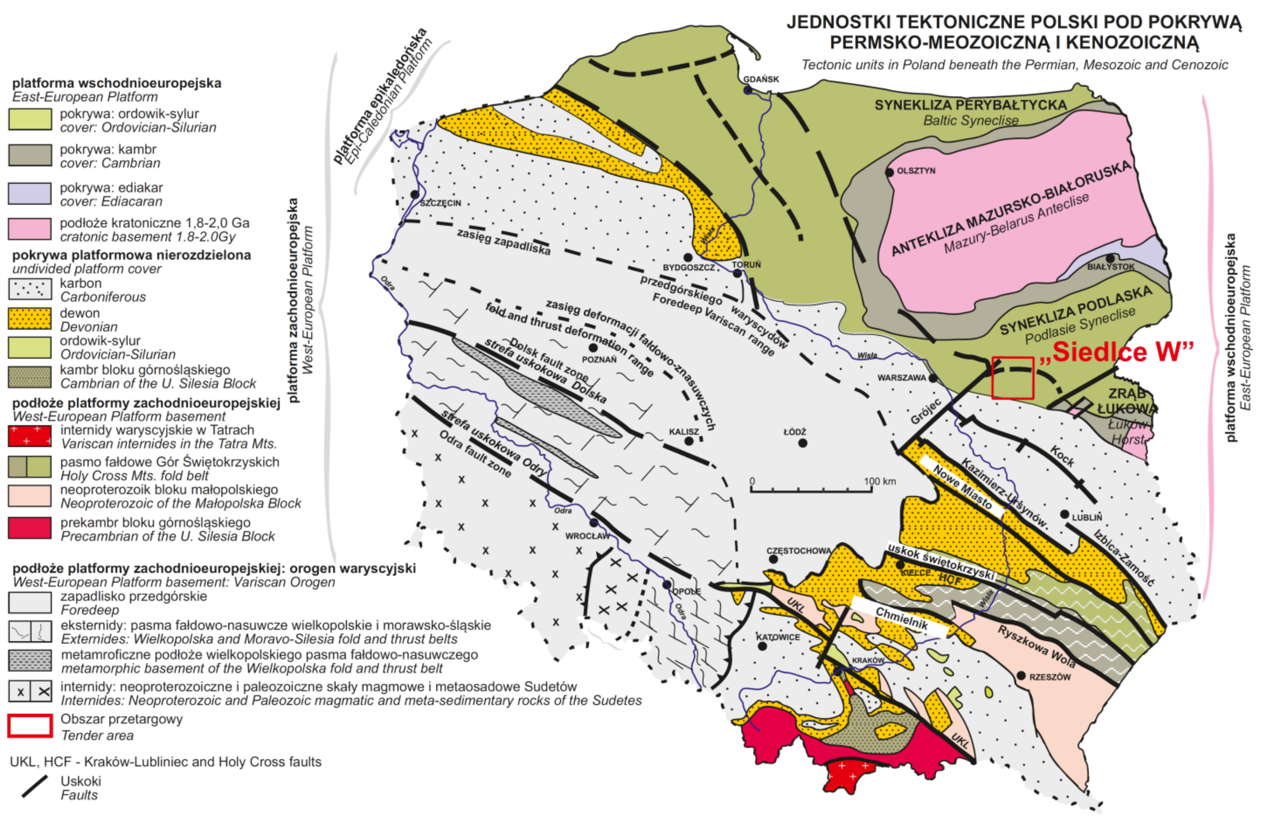


Fig. 2.2. Location of the "Siedlce W" tender area in relation to the main tectonic units in Poland beneath the Permian, Mesozoic and Cenozoic (Żelaźniewicz et al., 2011; modified).

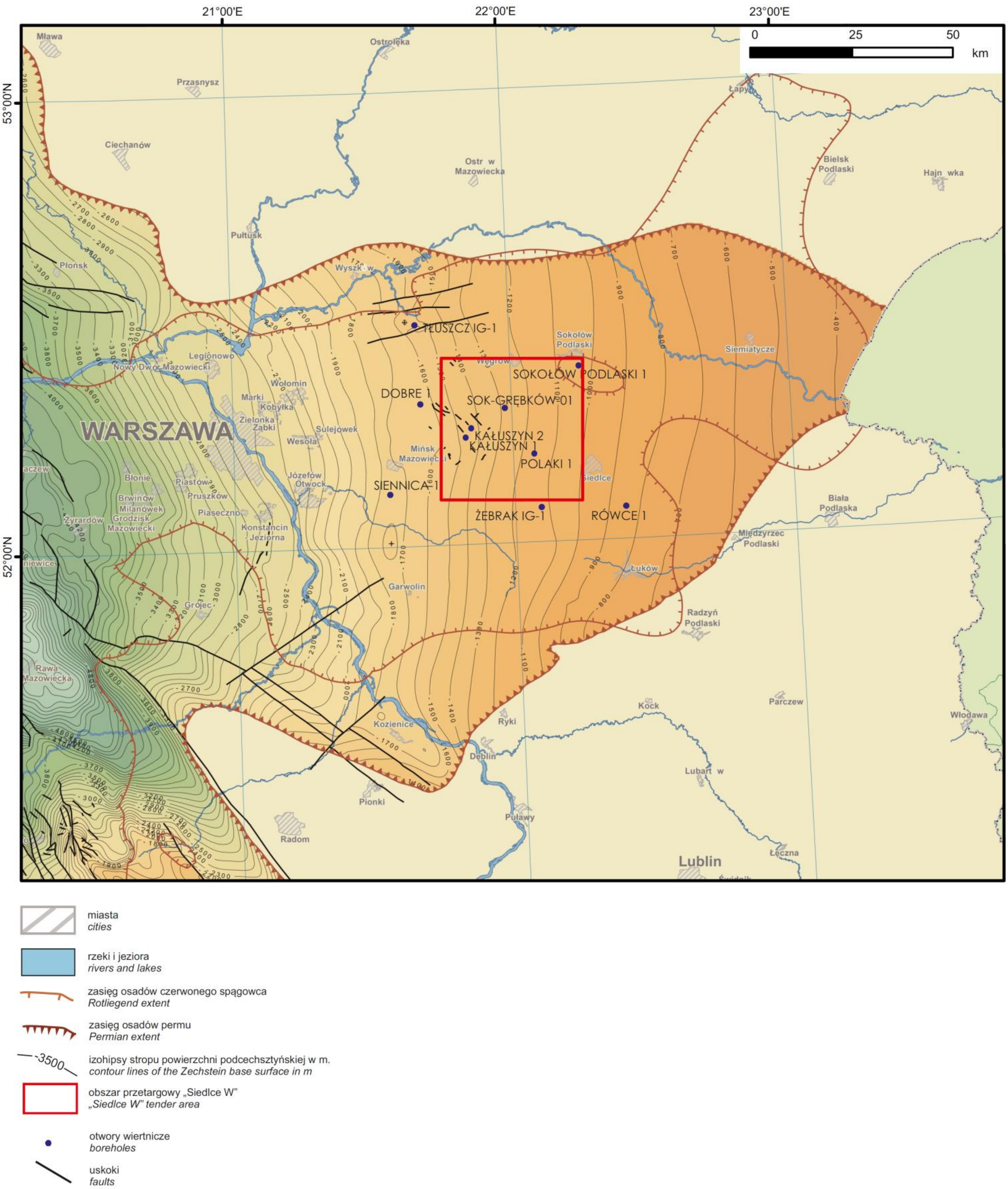


Fig. 2.3. Location of the "Siedlce W" tender area in the structural map of the Zechstein base surface (Kudrewicz, 2008; modified).

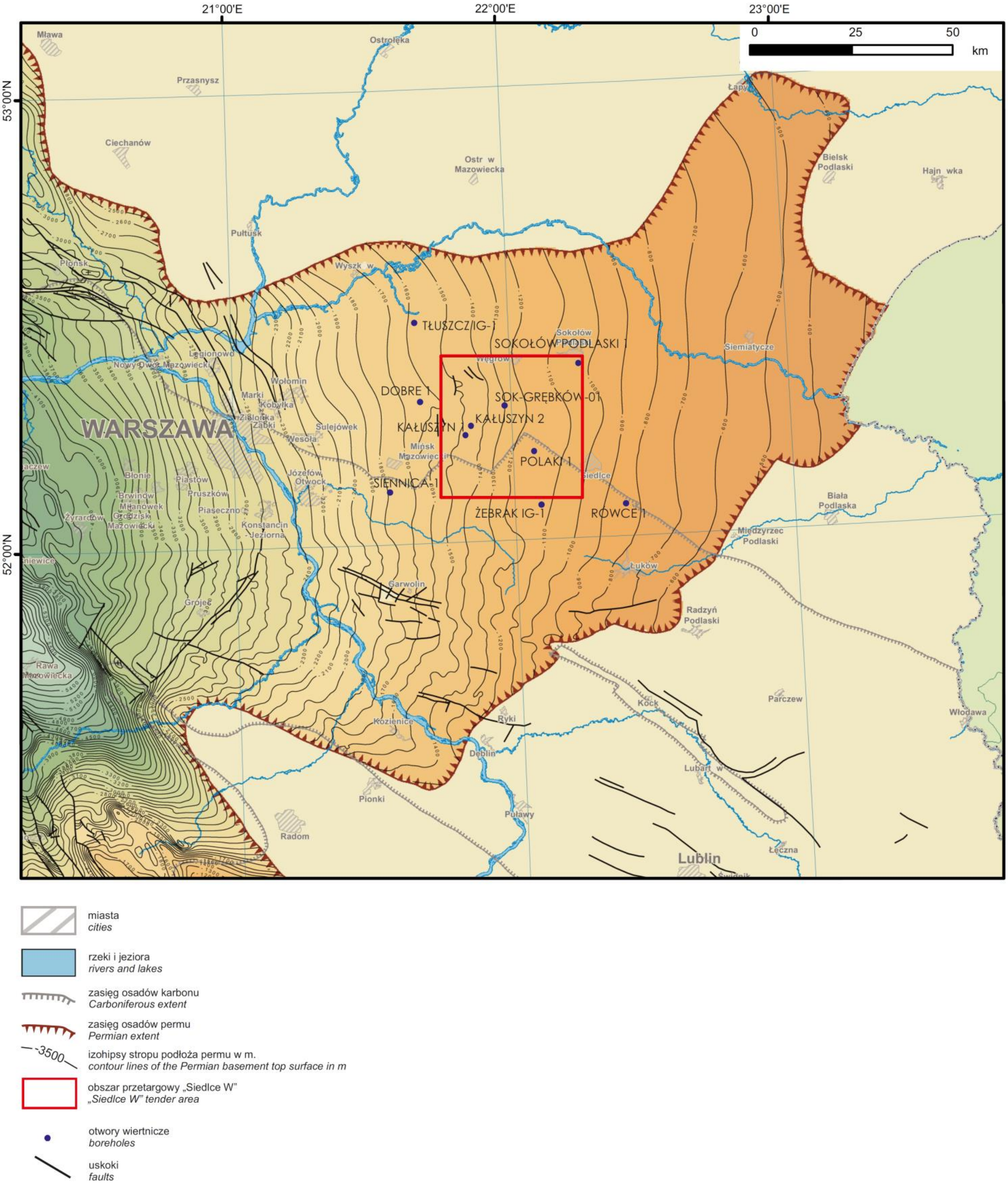


Fig. 2.4. Location of the "Siedlce W" tender area in the structural map of the Permian basement top surface (Kudrewicz, 2008; modified).

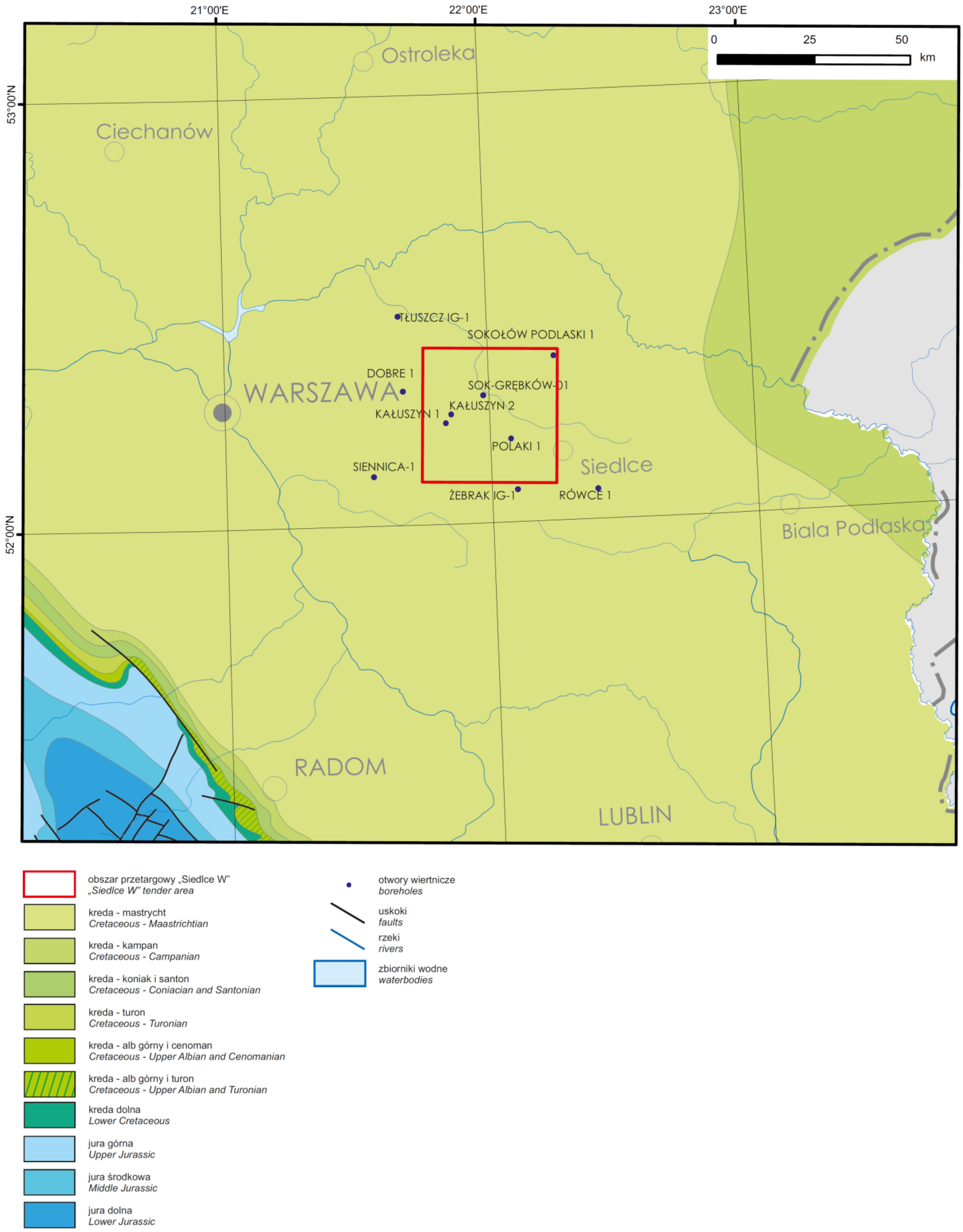


Fig. 2.5. Location of the "Siedlce W" tender area in the geological map of Poland without Cenozoic strata (Dadlez et al., 2000; modified).

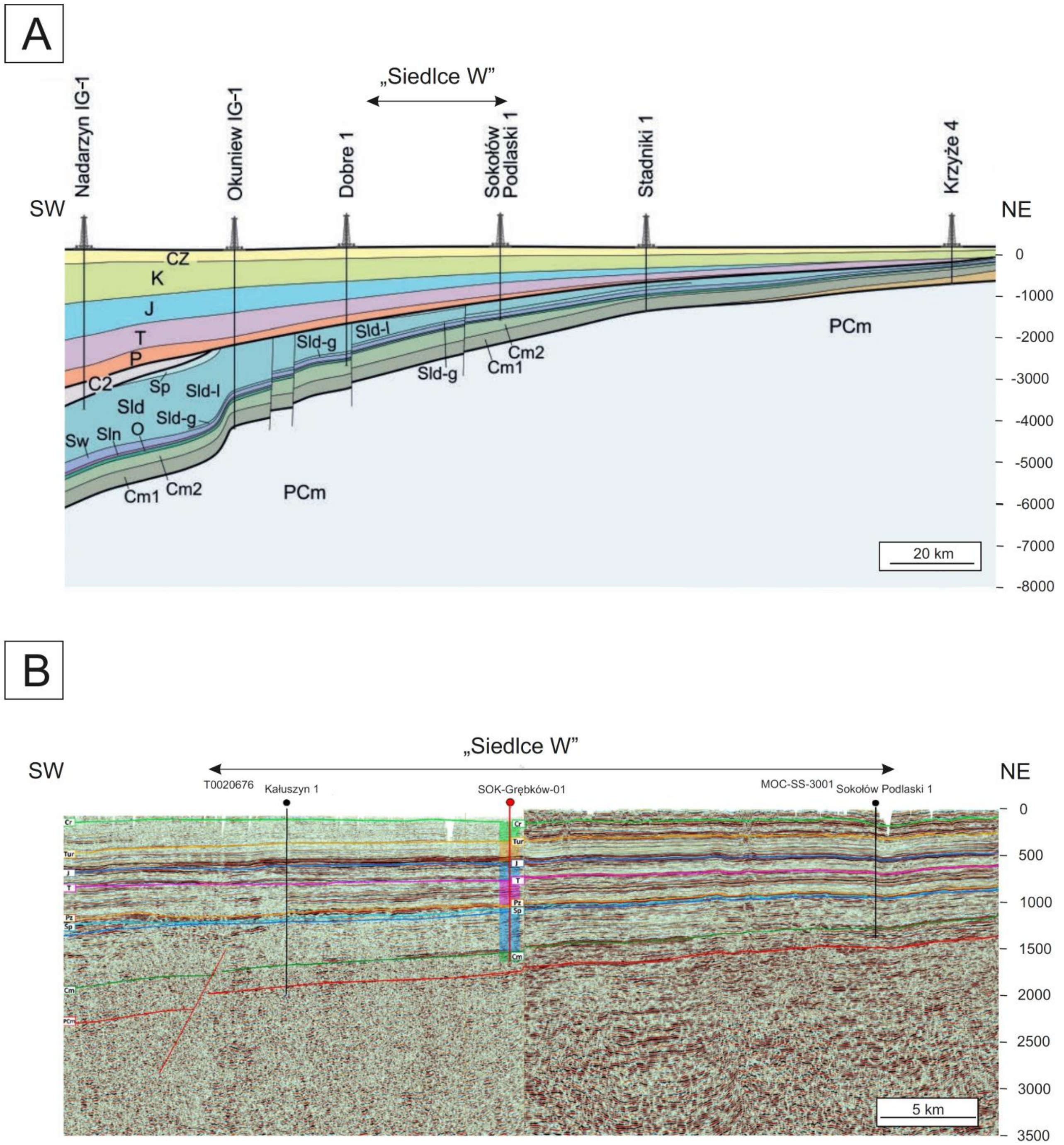


Fig. 2.6.A. Geological cross-section through the Podlasie Syneclise (Poprawa, 2019; modified). **B.** Interpretation of seismic section through the "Siedlce W" tender area (Gliniak et al., 2013; modified). Location of sections in Fig. 2.10; PCm – Precambrian, Cm – Cambrian, Cm1 – Lower Cambrian, Cm2 – Middle Cambrian, O – Ordovician, Sln – Llandovery, Sw – Wenlock, Sld – Ludlow, Sld-g – Gorstian, Sld-l – Ludfordian, Sp – Pridoli, C2 – Upper Carboniferous, Pz – Zechstein, P – Permian, T – Triassic, J – Jurassic, Tur – Turonian, K/Cr – Cretaceous, CZ – Cenozoic.

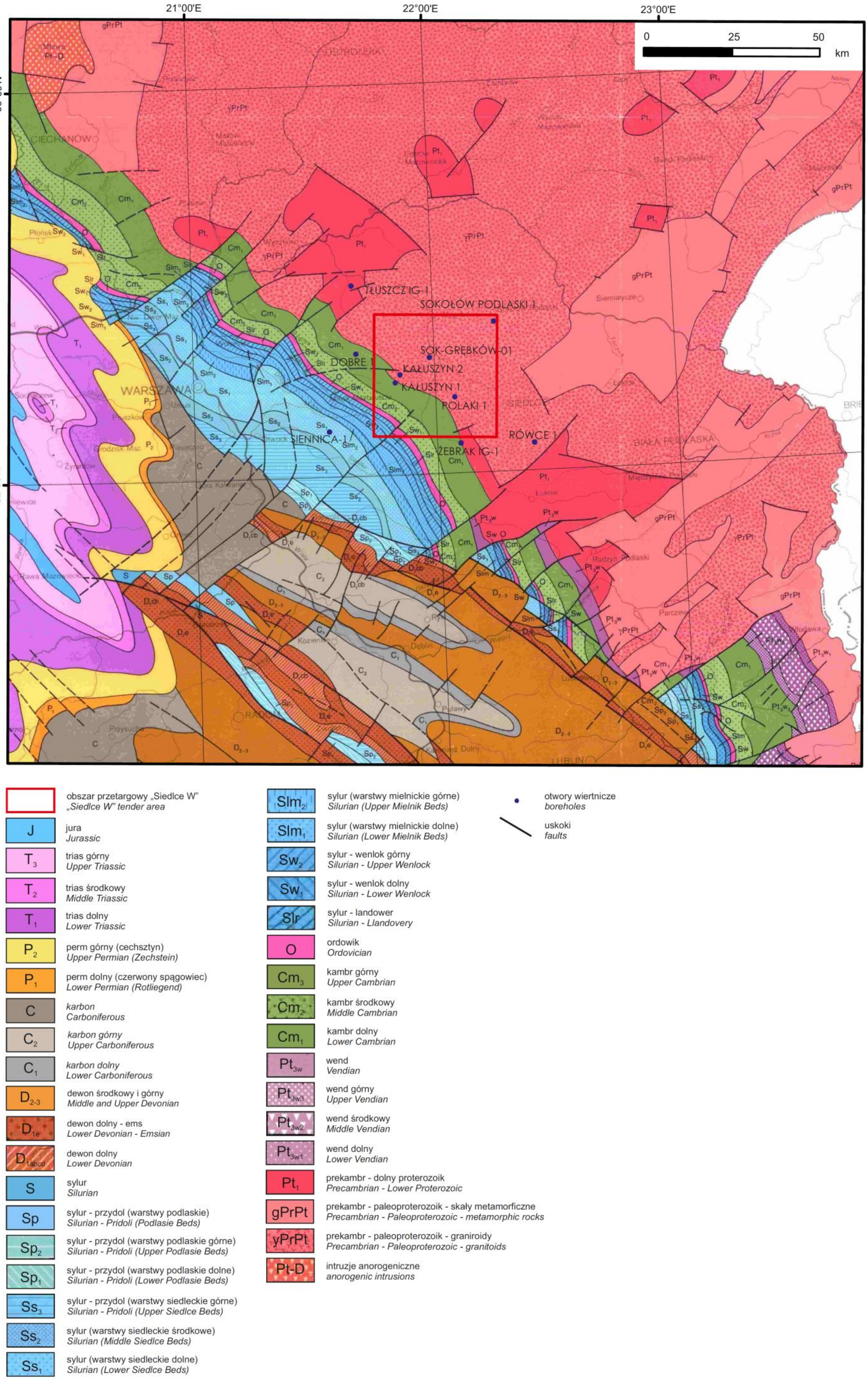


Fig. 2.7. Location of the "Siedlce W" tender area in the geological map of horizontal cutting at 3000 m b.s.l. (Kotański, 1997; modified).

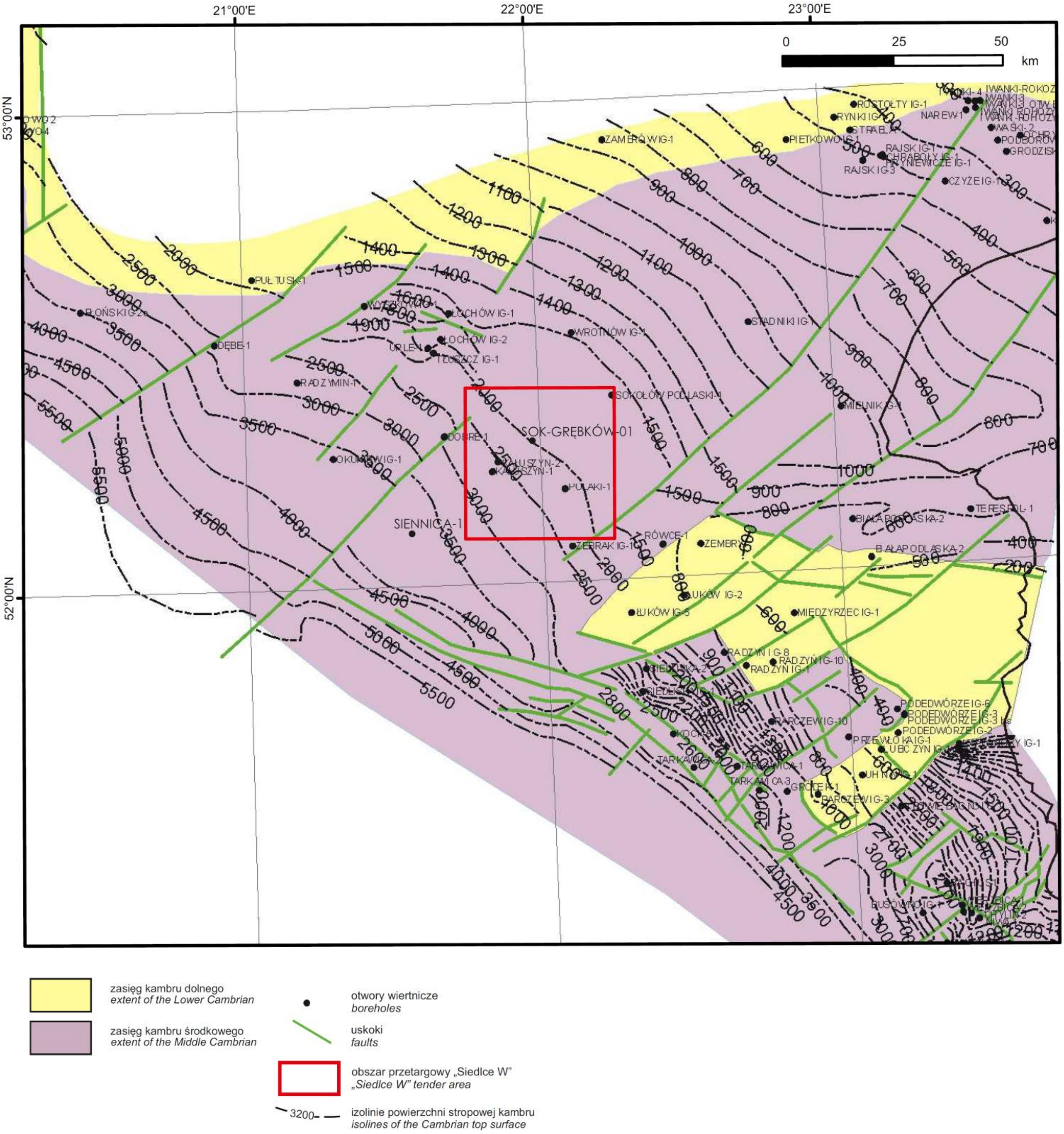


Fig. 2.8. Location of the "Siedlce W" tender area in relation to the structural map of the Cambrian top surface (Poprawa and Kiersnowski, 2010; modified).

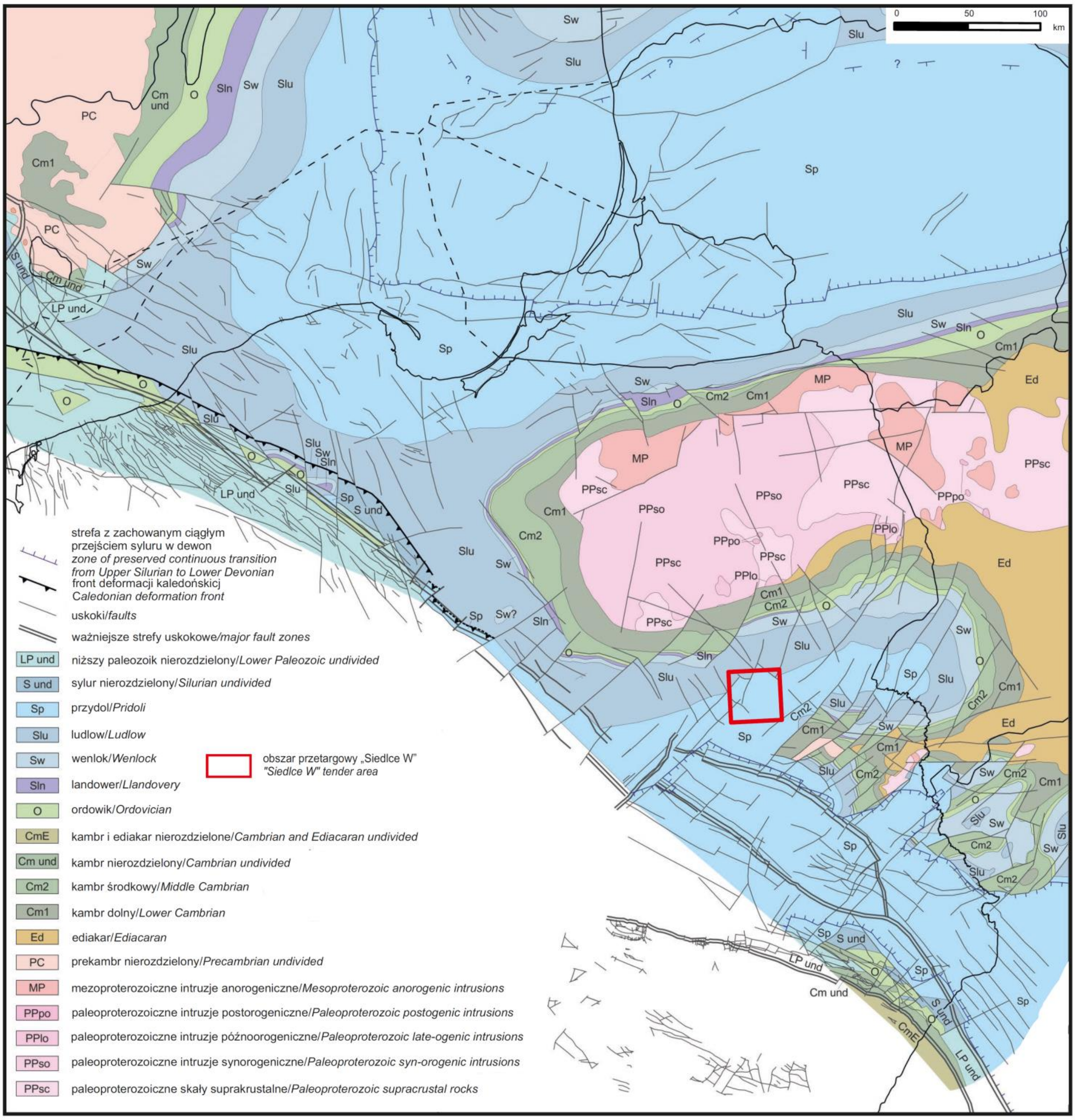


Fig. 2.9. Location of the “Siedlce W” tender area in the geological map of Poland and neighboring countries, without Devonian and yunger strata (Poprawa, 2019; modified).

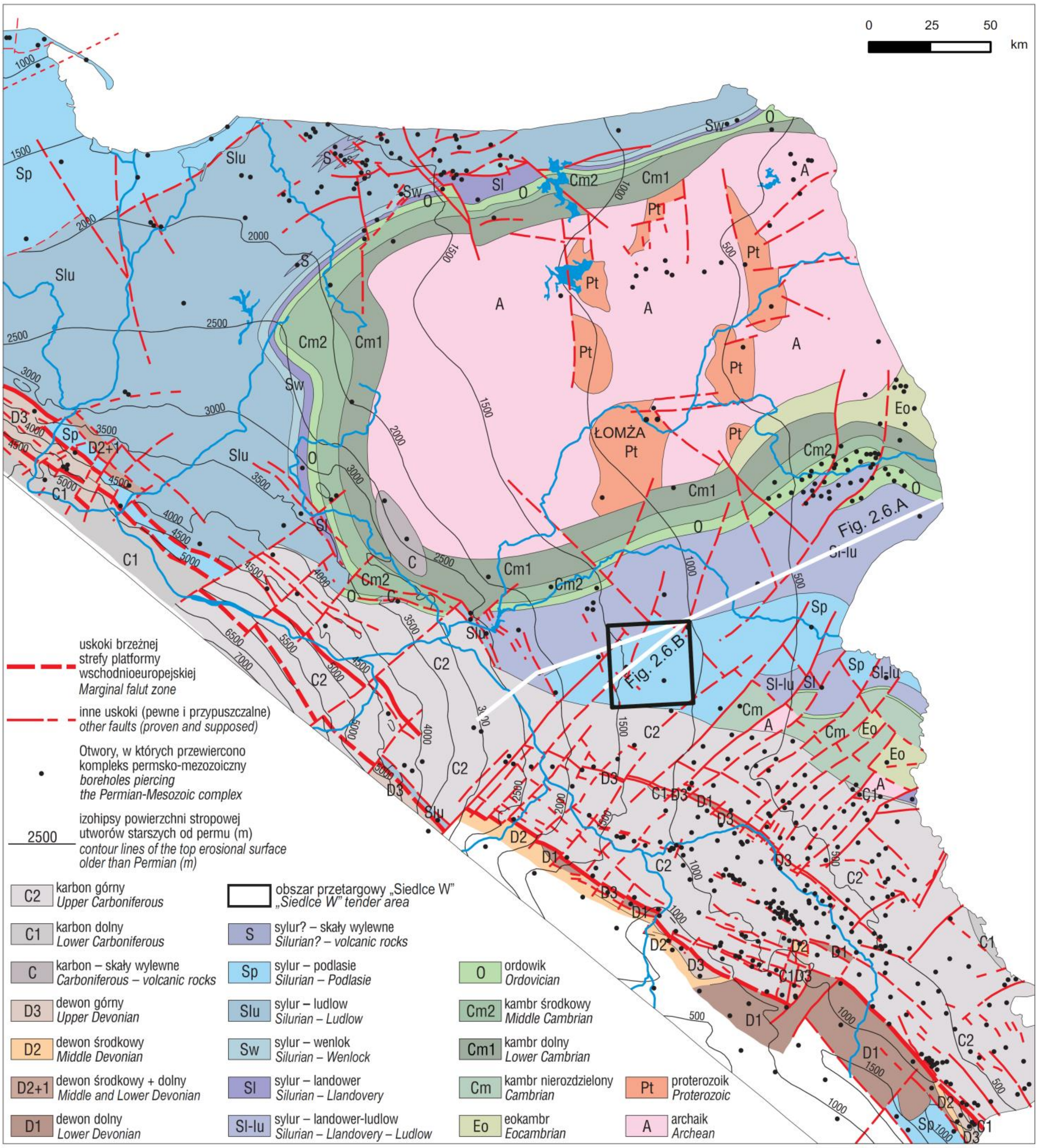


Fig. 2.10. Location of the “Siedlce W” tender area in the map of zones prospective for hydrocarbon exploration in the Middle Cambrian (Stolarczyk et al., 2004; modified).

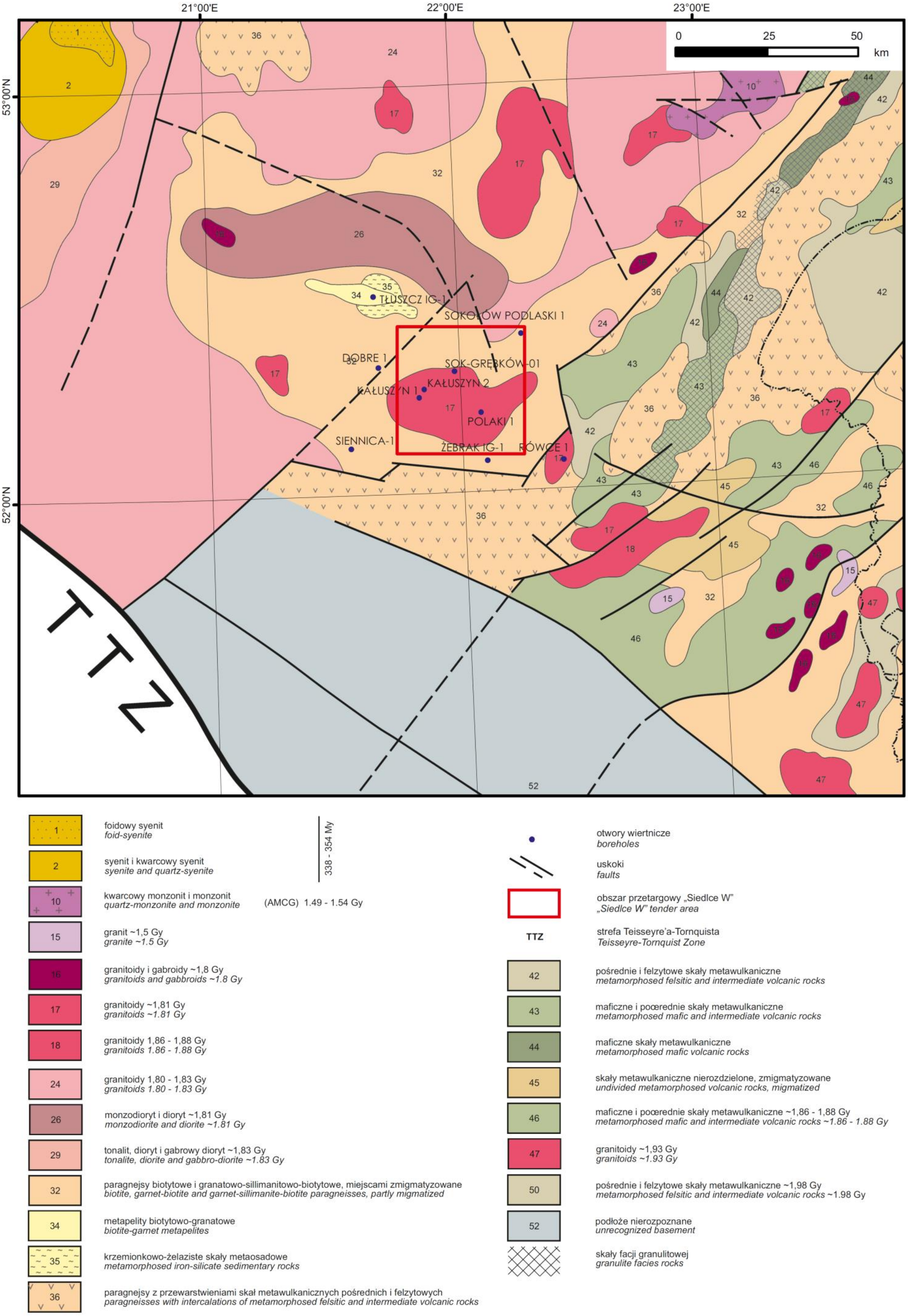


Fig. 2.11. Location of the "Siedlce W" tender area in relation to geological map of the crystalline basement of the East European Craton (Krzemińska and Krzemiński, 2017).

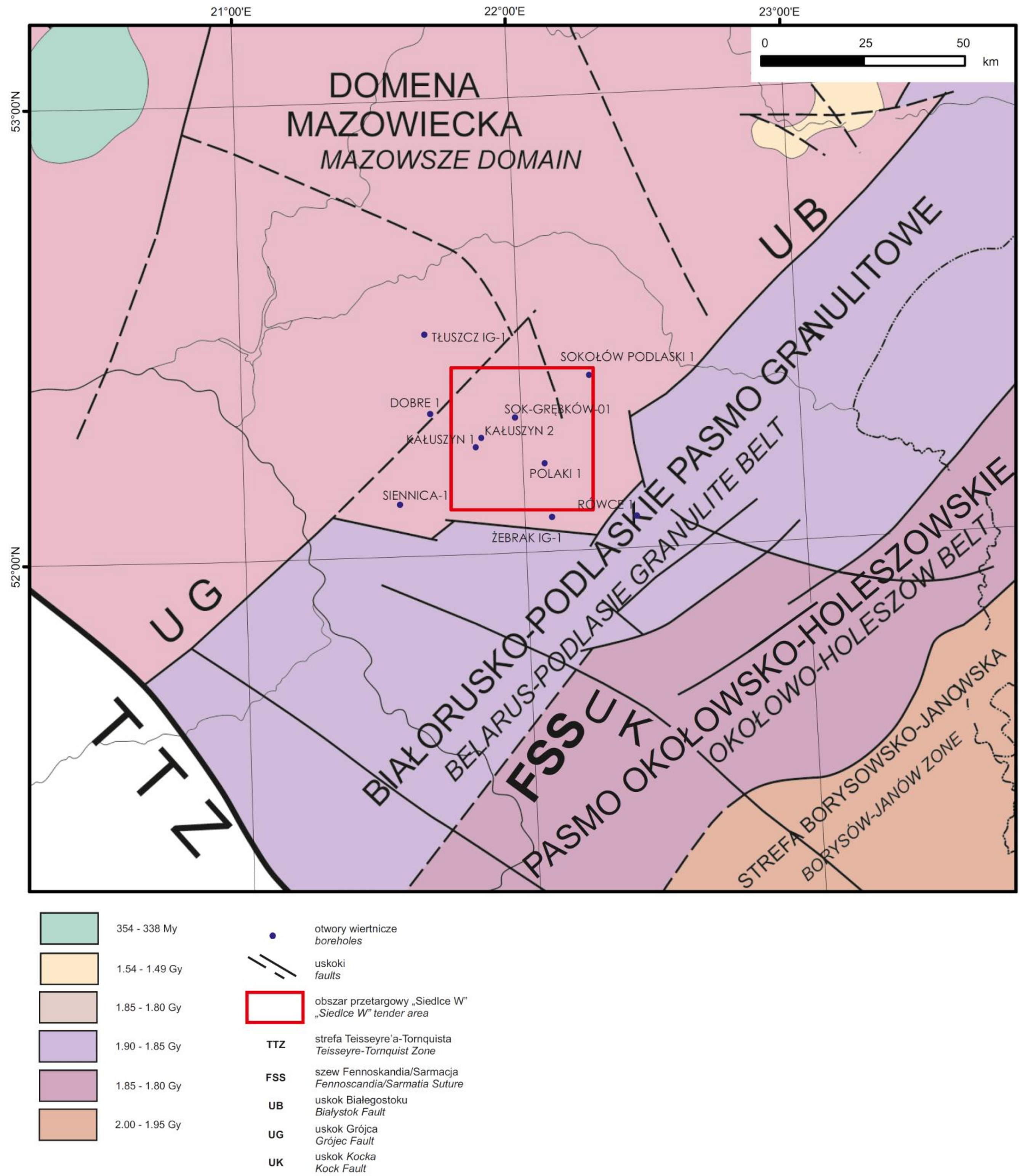


Fig. 2.12. Location of the "Siedlce W" tender area in relation to the crustal structure of the crystalline basement of the East European Craton (Krzemińska and Krzemiński, 2017).

2.2. STRATIGRAPHY
2.2.1. CAMBRIAN

Distribution and thickness

Clastic succession of the Lower and Middle Cambrian was identified in 4 wells located on the line between Kałuszyn and Sokołów Podlaski, as well as in one well located 2 km north of the village of Kotuń. These wells are listed below, with information about the depth interval of the Cambrian succession. However, information from the Kałuszyn 1 and Kałuszyn 2 wells is restricted by investor's rights, therefore it is not presented in detail, and only the depth and stratigraphy at the bottom are given:

- Kałuszyn 1: 3190.0 m, Paleoproterozoic,
- Kałuszyn 2: 2480.0 m, Cambrian,
- SOK-Grębków-01: 2160.0–2243.0 m,
- Sokołów Podlaski 1: 1739.0–1771.0 m,
- Polaki 1: 2198.5–2760.0 m.

According to data from the wells located in the neighborhood (Dobre 1, Żebrak IG-1 Rówce 1), the top of the Cambrian strata was encountered at ca. 1750 m b.g.l. in the north-eastern part and 2800 m b.g.l. in the south-western part of the "Siedlce W" tender area (Fig. 2.15). The top surface of the Cambrian succession was formed by erosion processes during a break in sedimentation before deposition of the Ordovician sediments. In the "Siedlce W" tender area, the average thickness of the Cambrian succession is 570 m, of which the Lower Cambrian is approximately 420 m (Figs 2.16–2.18) thick and the Middle Cambrian, referred to as the Kostrzyń series, is 100–200 m thick (Fig. 2.19).

Lithology and stratigraphy

The Cambrian overlies uncomformably Proterozoic igneous and metamorphic rocks and mostly variously grained Ediacaran rocks. The lithostratigraphic subdivision of the Cambrian in the western slope of the East European Craton has been proposed by Lendzion (1956), and it was later modified many times (Areń and Lendzion 1978; Lendzion 1983; Moczydłowska 1991), which is mentioned in Pacześna (2008). The Cambrian litostratigraphy in the analyzed area is based on the continuous full succession in the Polaki 1, Rówce 1 and Okuniew IG-1 wells (Fig. 2.20), and includes:

Mazowsze series (ca. 200 m)
Polaki 1 2570.0–2772.0 m b.g.l.,
Rówce 1 1860.0–2048.0 m b.g.l.
Kaplonosy and Radzyń series (250–280 m)
Polaki 1: 2290.0–2570.0 m b.g.l.,
Rówce 1: 1610.0–1860.0 m b.g.l.
Kostrzyń series (90–130 m)
Polaki 1: 2200.0–2290.0 m b.g.l.,
Rówce 1: 1481.0–1610.0 m b.g.l.

The Mazowsze series consists of clastic deposits, predominantly quartzitic sandstones with mudstone intercalations. The Kaplonosy and Radzyń series are tripartite, represented by fine and variably grained sandstones in the lower and upper parts of the succession with muddy-sandy sediments in the middle part. The Kostrzyń series belongs to the Middle Cambrian (Jagielska, 1966; Lendzion 1983) and consists of massive fine-grained sandstones with thin mudstone and claystone intercalations.

Petrography

The Middle and Lower Cambrian succession is represented by siliciclastic rocks, which are represented mainly by fine to moderately grained sandstones. These sandstones belong mainly to the quartz arenites group, while in minor cases, they can be described as arkosic arenites or quartz wackes. Cathodoluminescence technique showed that grains are well or very well rounded. The main mineral components are quartz (mainly monocrystalline), feldspar, mica flakes and accessory minerals, i.e. apatite, rutile or zircon. Authigenic quartz is the main type of cement present in the rock samples, although carbonate cement may be also found. Authigenic clay minerals, including illite, kaolinite and chlorite can be found mainly inside pore spaces. The sandstones are interstratified by mudstones and claystones. The framework grains in these rocks are quartz, feldspars, mica, and accessory minerals, similar to those in sandstones. Pyrite, iron oxides and hydroxides, ilmenite and glauconite are noted in significant amounts.

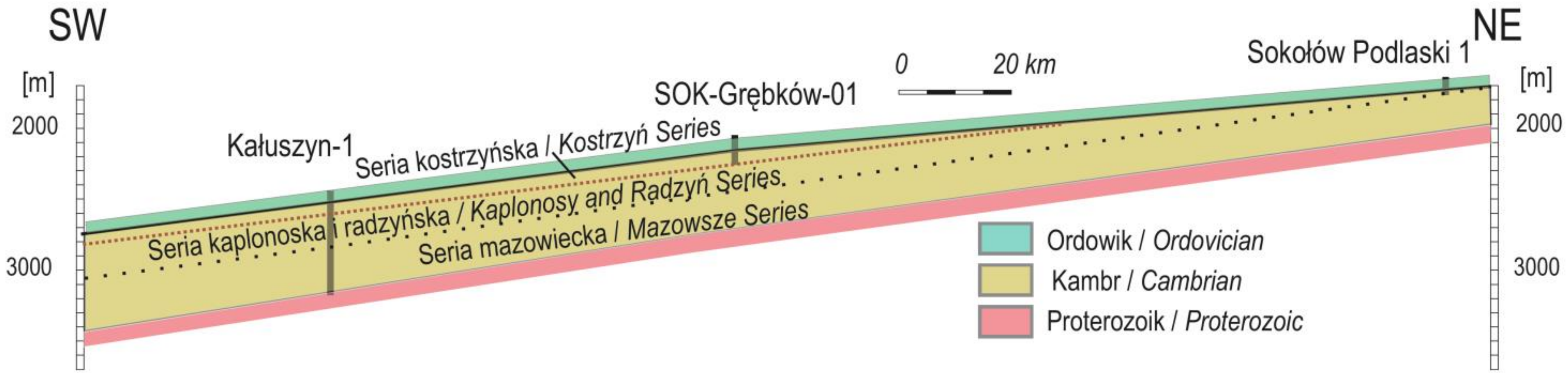


Fig. 2.15. The Cambrian along the Sokołów Podlaski 1 – SOK-Grębków-01 – Kałuszyn 1 line (Monika Jachowicz-Zdanowska, original materials).

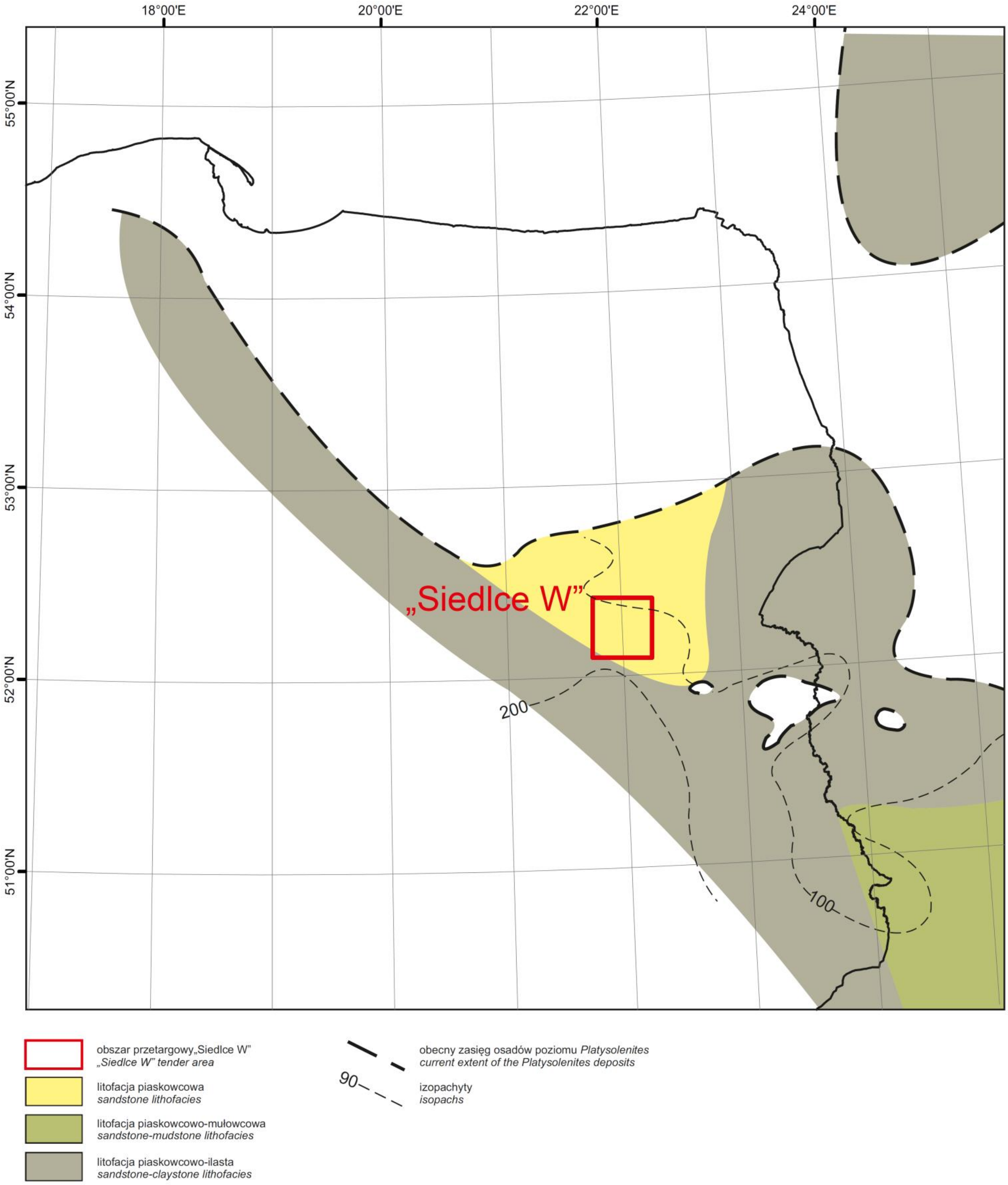


Fig. 2.16. Lower Cambrian lithology and thickness in the “Siedlce W” tender area (*Platysolenites* zone), after Lendzion (1983; modified).

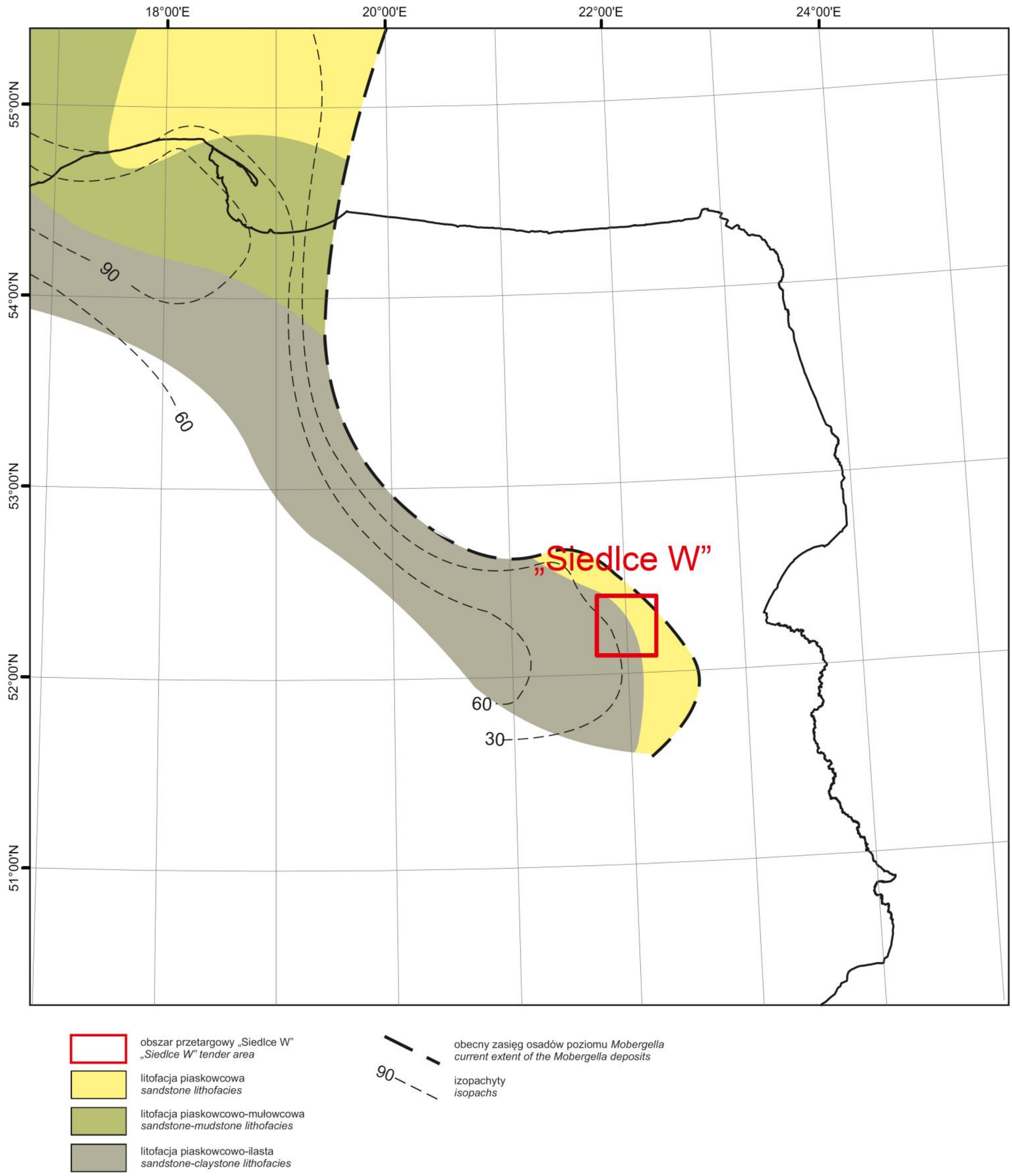


Fig. 2.17. Lower Cambrian lithology and thickness in the "Siedlce W" tender area (*Mobergella* zone), after Lendzion (1983; modified).

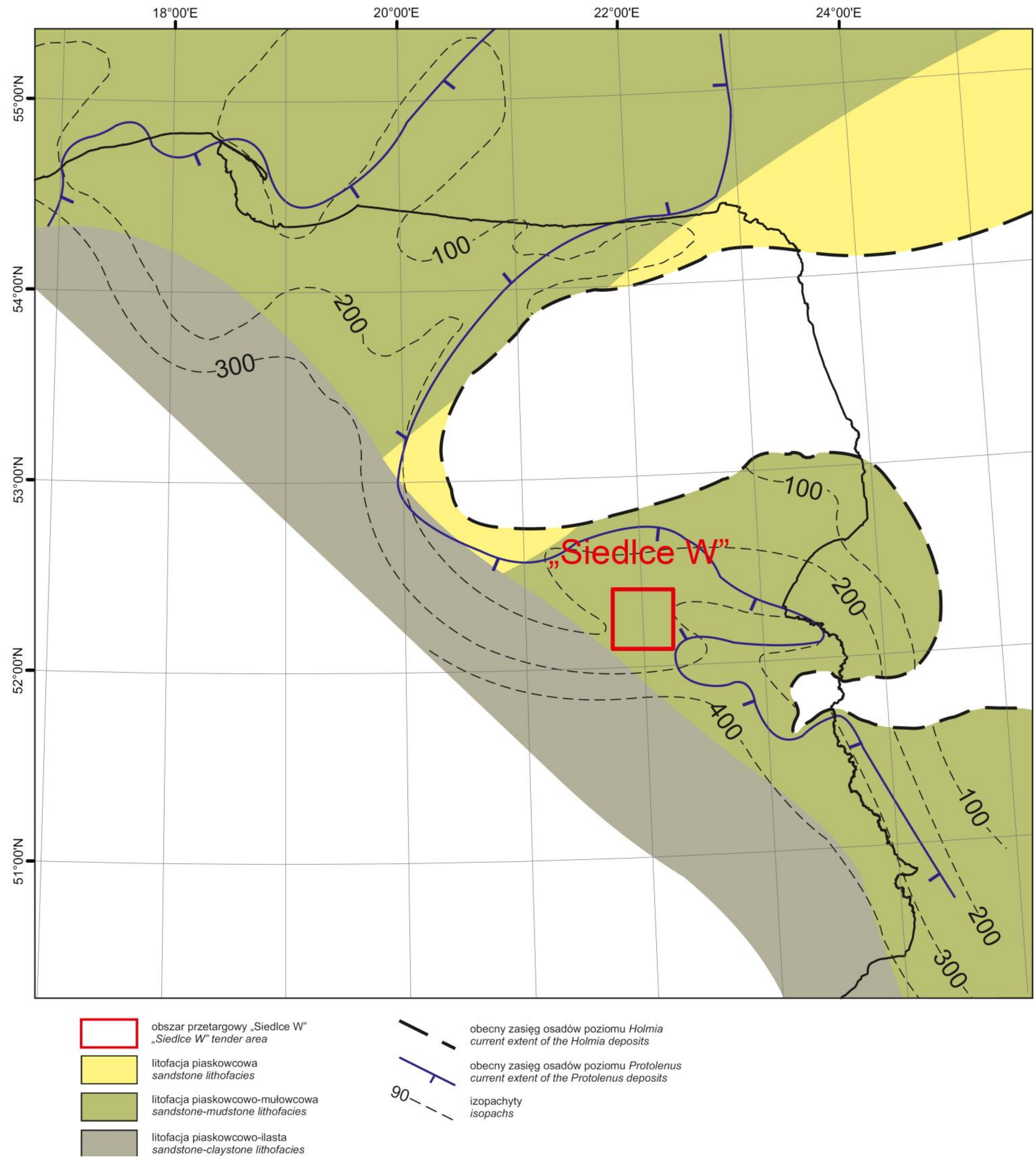


Fig. 2.18. Lower Cambrian lithology and thickness in the "Siedlce W" tender area (*Holmia&Protolenus* zone), after Lendzion (1983; modified).

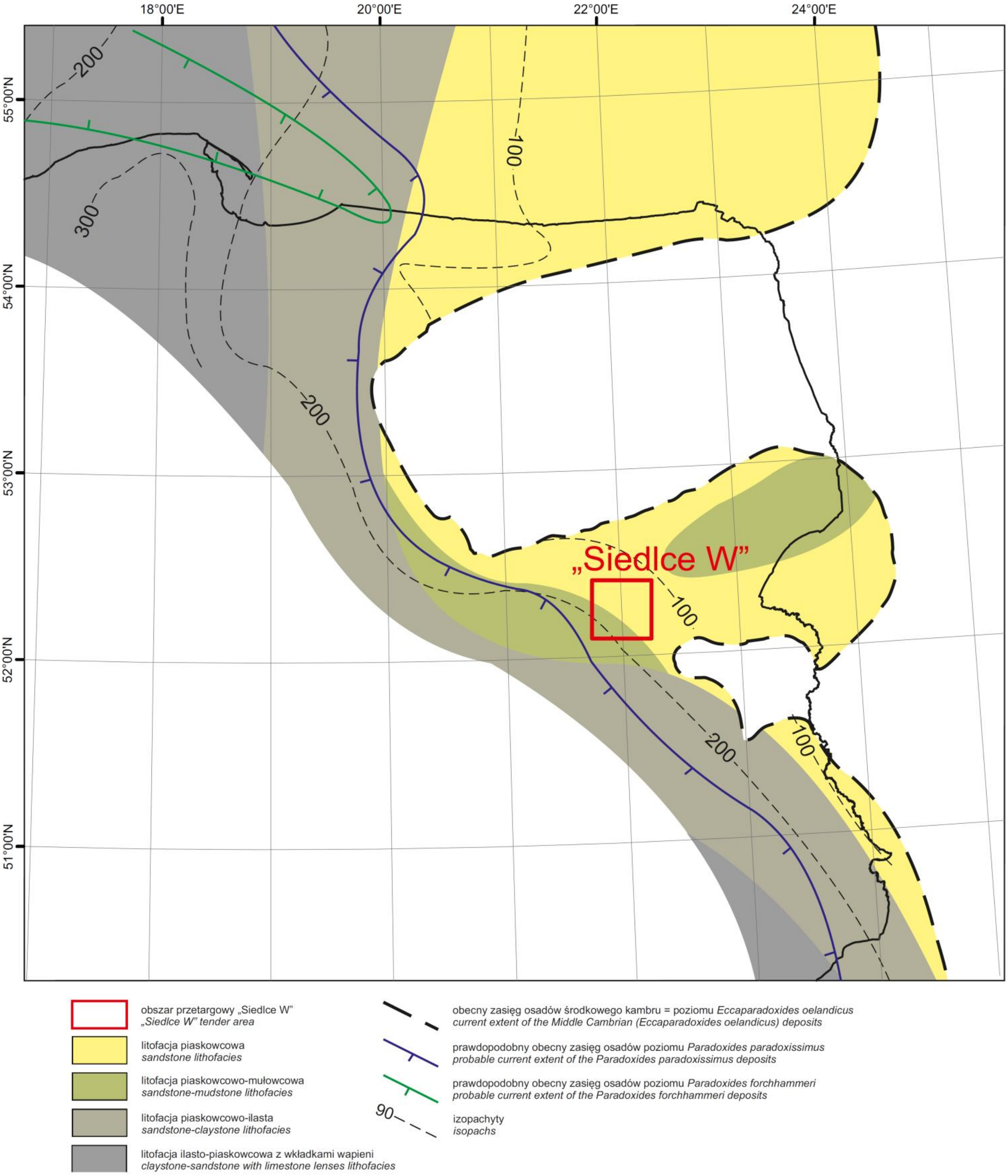


Fig. 2.19. Middle Cambrian lithology and thickness in the "Siedlce W" tender area, after Lendzion (1983; modified).

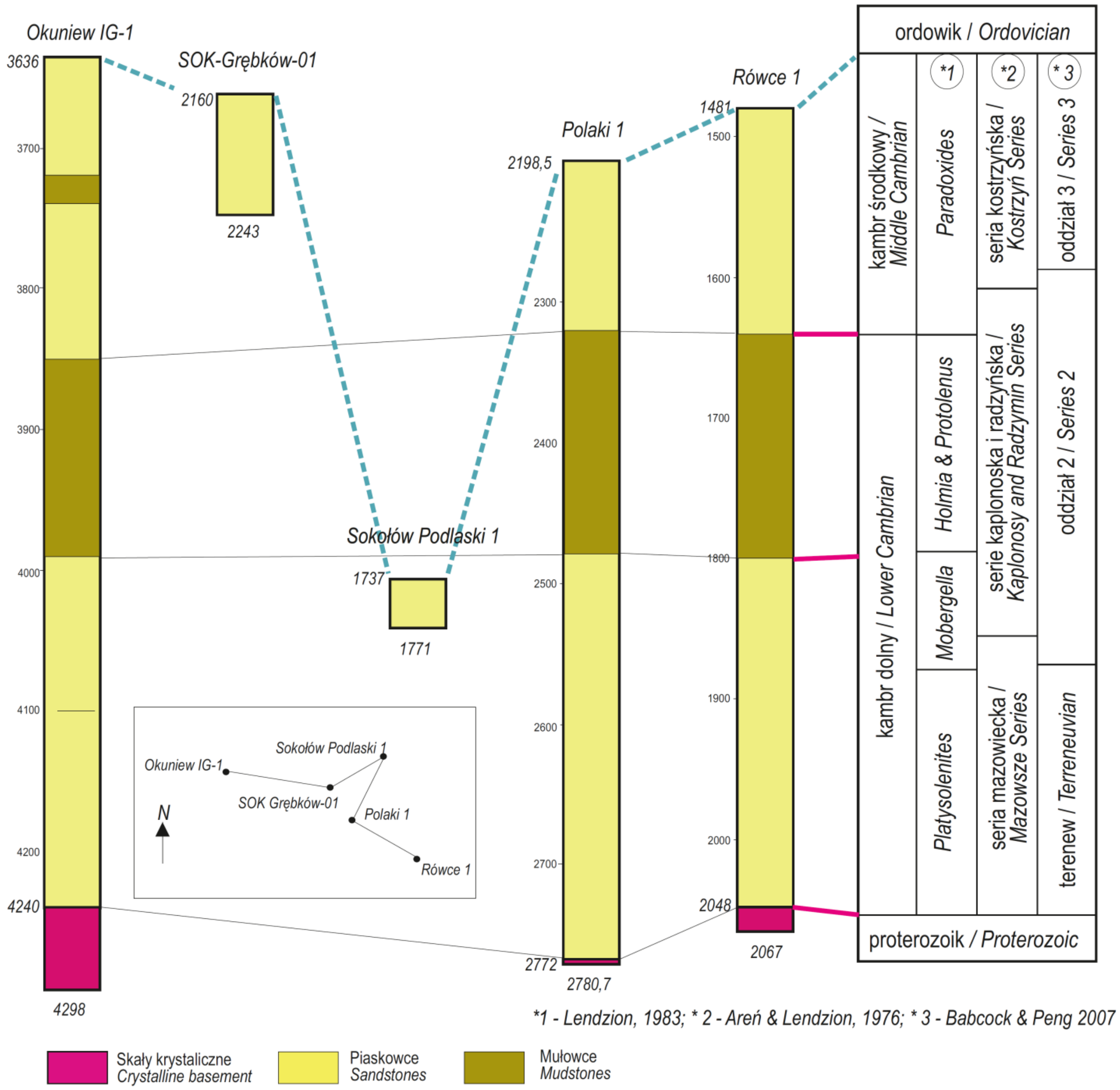


Fig. 2.20. Cambrian lithostratigraphy in the "Siedlce W" tender area (Monika Jachowicz-Zdanowska, original materials).

2.2.2. ORDOVICIAN

Distribution and thickness

The Ordovician has been identified in 5 wells in the "Siedlce W" tender area between Kałuszyn (W), Sokołów Podlaski (NE) and Żebrak (S). In the Żebrak IG-1 well, the Ordovician succession has been particularly well identified due to complete coring (Lendzion, 1975).

The total thickness of the Ordovician succession varies from 26.5 m in the NE to 35.5 in the W part of the analyzed area, but in the Żebrak IG–1 well it is 41.1 m (Gliniak et al., 2013).

The "Siedlce W" tender area is located between the eastern and western parts of the Podlasie Depression/Syneclise. In the western part of the "Siedlce W" tender area, the Ordovician sediments accumulated in a deeper, distal part of the basin. In the eastern part, the Ordovician deposition took place in the proximal part of the basin, characterized by facies and thickness variability (Modliński, 1973, 1982; Modliński and Szymański, 2008;

Kędzior et. al., 2017; Podhalańska, 2017, 2019; Podhalańska et. al., 2020). The depth and thickness of the Ordovician succession in particular wells is as follows:

- SOK-Grębków-01: 2140.0–2160.0 m (Gliniak et al., 2013; modified here as 2130.0–2160.0 m b.g.l.),
- Polaki 1: 2172.0–2198.5 m,
- Sokołów Podlaski 1: 1712.5–1739.0 m,
- Żebrak IG-1: 2359.2–2399.3 m.

Lithology and stratigraphy

In the "Siedlce W" tender area the Ordovician is represented by an almost continuous succession from the Lower Arenig (Floian) to the Upper Ashgill (Hirnantian). The Ordovician succession uncomfornably overlies the Middle Cambrian deposits and is topped by the Silurian (Llandovery). Several formations were distinguished by Modliński and Szymański (2008), later verified by Porębski and Podhalańska (2017, 2019; see Fig. 2.21).

The Ordovician sedimentary succession is represented by calcareous-marly facies with a minor contribution of siliciclastic deposits (see Figs 2.22–2.25).

Rajsko Formation

The Rajsko Formation (Floian) occurs in all wells in the "Siedlce W" tender area, as well as in adjacent areas (Żebrak IG-1 well), with a varying thickness from 0.8 to 1.4 m. The Rajsko Formation is represented by siliciclastic sediments with a substantial content of glauconite.

Pieszkowo Red Limestones Formation

The Pieszkowo Formation (Floian-Dapingian) was recognized in all wells in the "Siedlce W" tender area except in the Sokołów Podlaski 1 well (Modliński and Szymański, 2008). It is composed of limestones, dolomitic limestones and dolomites with a minor amount of glauconite at the base. The total thickness is approximately 5–7.5 m.

Narew Glauconitic Limestones Formation

The Narew Formation (Dapingian) has been distinguished only in the Sokołów Podlaski 1 well (thickness 3.2 m). It is an equivalent of the Pieszkowo Formation (Modliński and Szymański, 2008). The formation is composed of marly limestones and dolomites in the lower part, and organodetrital limestones in the upper part of the succession.

Kielno Limestones Formation

The Kielno Formation of Llanvirin and Caradoc (Darriwilian – lower Sandbian) age has been distinguished in all wells, except in the Sokołów Podlaski 1. It is composed of carbonate deposits, such as limestones, and marly, dolomitic, and organodetritic limestones with minor claystone intercalations and ferrous ooids. Their total thickness ranges from 7.3 to 20 m.

Sasino Claystone Formation

The Sasino Claystone Formation (2.0–7.5 m thick) is composed of fine-grained sediments: dark grey mudstones and claystones with frequent pyrite, and limestone intercalations. Sedimentological analysis shows dominance of lithofacies L-6 (after Feldman-Olszewska and Roszkowska-Remin, 2016) represented by dark-grey non-calcareous bioturbated and unbioturbated claystones. Graptolite dating constrains the age of the formation as the upper Caradoc (upper Sandbian – lower Katian; *Dicranograptus clingani – Climacograptus styloideus* zones).

Włodawka Marl Formation and Widowa Limestone Formation

Both formations have been encountered in the Sokołów Podlaski 1 well with a total thickness of 18.5 m. The Widowa Formation (Lanvrin, Darriwilian) is composed of limestones with ferrous oolites at the base. The Włodawka Formation (Caradoc, Sandbian – lower Katian) is represented by grey and greenish grey marls and claystones.

Kodeniec Limestone Formation and Tyśmienica Marl Formation

The Kodeniec and Tyśmienica formations are present only in the central and western part of the "Siedlce W" tender area. Both formations are represented by a calcareous-marly succession of Ashgill age (upper Katian and Hirnatian). The total thickness of both formations is around several meters.

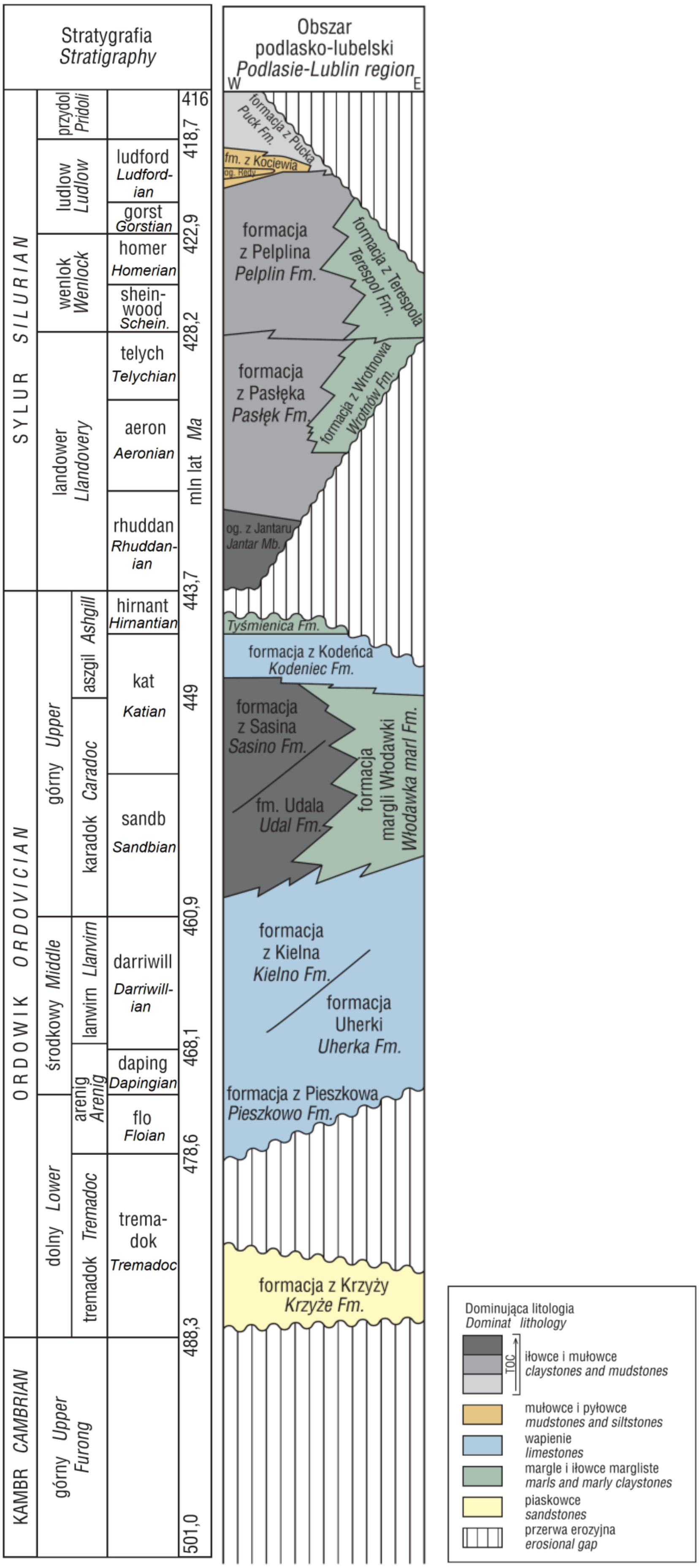


Fig. 2.21. Lower Paleozoic lithostratigraphy in the Podlasie Depression/Syneclise (Podhalańska et al., 2016; modified).

<table>
<tr><th></th><th colspan="6">Depth [m]</th></tr>
<tr><th>Formation</th><th>Kałuszyn 1</th><th>Kałuszyn 2</th><th>Polaki 1</th><th>SOK-Grębków-01</th><th>Sokołów Podlaski 1</th><th>Żebrak IG-1</th></tr>
<tr><td>Tyśmienica</td><td>+</td><td>+</td><td>–</td><td rowspan="2">2130.0–2137.0</td><td>-</td><td>2359.2–2373.3</td></tr>
<tr><td>Kodeniec</td><td>+</td><td>+</td><td>2172.0–2176.0</td><td>-</td><td>2373.3–2375.0</td></tr>
<tr><td>Włodawka</td><td>-</td><td>-</td><td>–</td><td>-</td><td>1716.5–1720.0</td><td>-</td></tr>
<tr><td>Widowo</td><td>-</td><td>-</td><td>–</td><td>-</td><td>1720.0–1735.0</td><td>-</td></tr>
<tr><td>Sasino</td><td>+</td><td>+</td><td>2176.0–2180.0</td><td>2137.0–2139.0</td><td>-</td><td>2375.0–2384.3</td></tr>
<tr><td>Kielno</td><td>+</td><td>+</td><td>2180.0–2193.0</td><td>2139.0–2159.0</td><td>-</td><td>2384.3–2391.6</td></tr>
<tr><td>Narew</td><td>-</td><td>-</td><td>–</td><td>-</td><td>1735.0–1738.2</td><td>-</td></tr>
<tr><td>Pieszkowa</td><td>+</td><td>+</td><td rowspan="2">2193.0–2198.5</td><td>2139.0–2159.0</td><td>-</td><td>2391.6–2398.3</td></tr>
<tr><td>Rajso</td><td>+</td><td>+</td><td>2159.0–2160.0</td><td>1738.2–1739.0</td><td>2398.3–2399.3</td></tr>
</table>

Tab. 2.1. Distribution of the Ordovician formations in the “Siedlce W” tender area (CGDB, 2021; Podhalańska et al. 2016; Modliński and Szymański, 2008); „+” formation is present; „-” formation is absent.

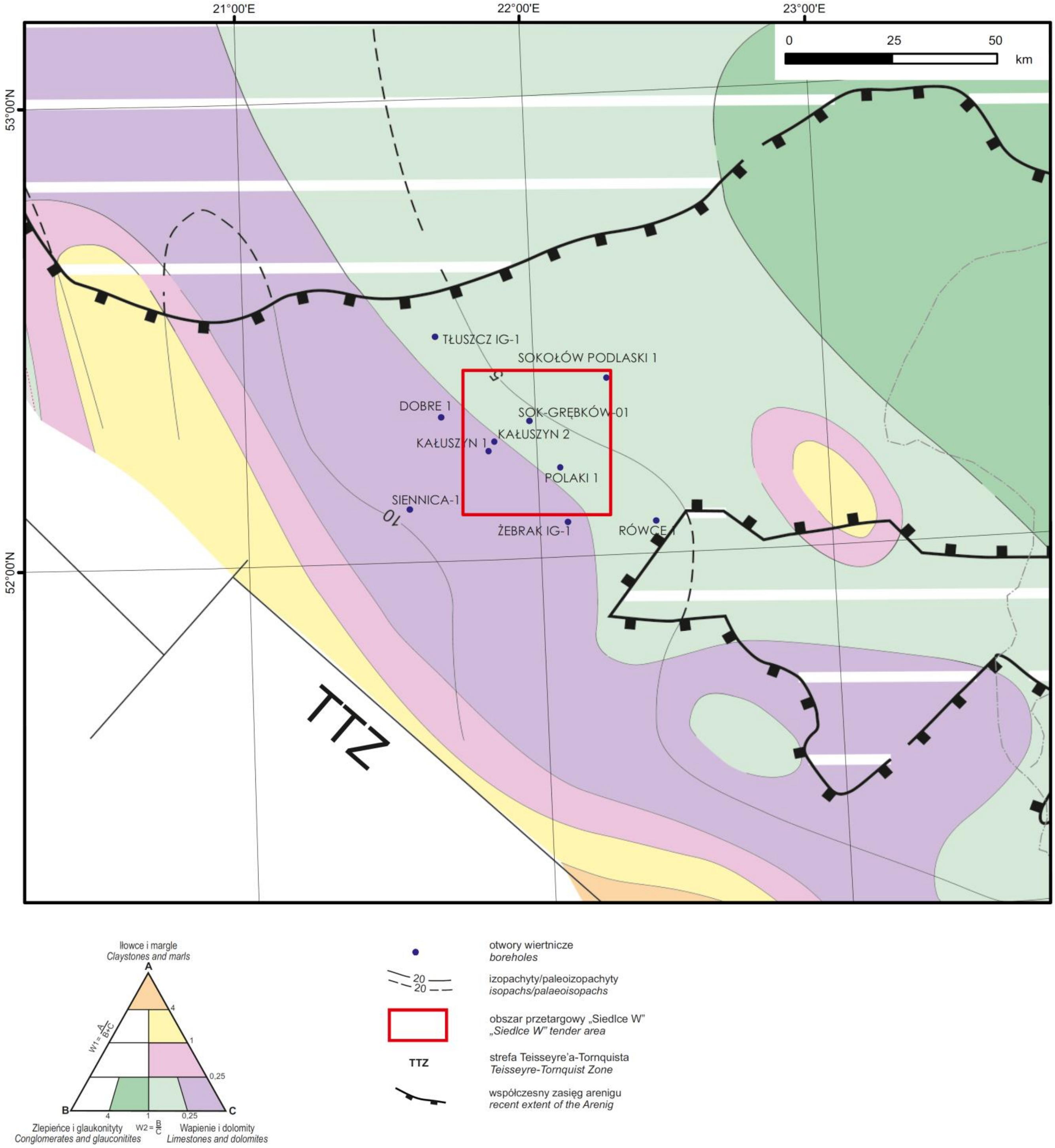


Fig. 2.22. Lithofacies and thickness of the Arenig in the "Siedlce W" tender area, after Modliński et al. (2010; modified).

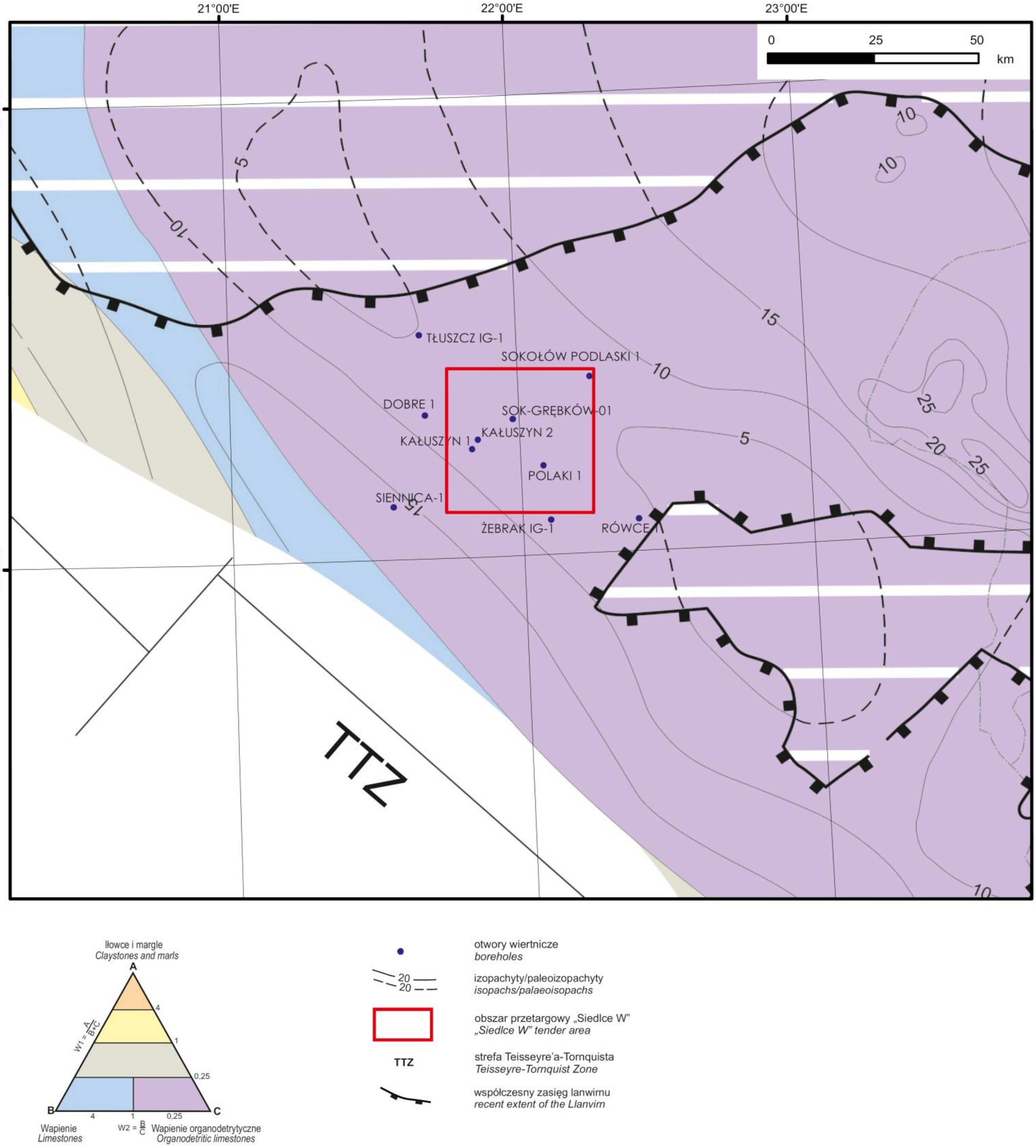


Fig. 2.23. Lithofacies and thickness of the Llanvirn in the "Siedlce W" tender area, after Modliński et al. (2010; modified).

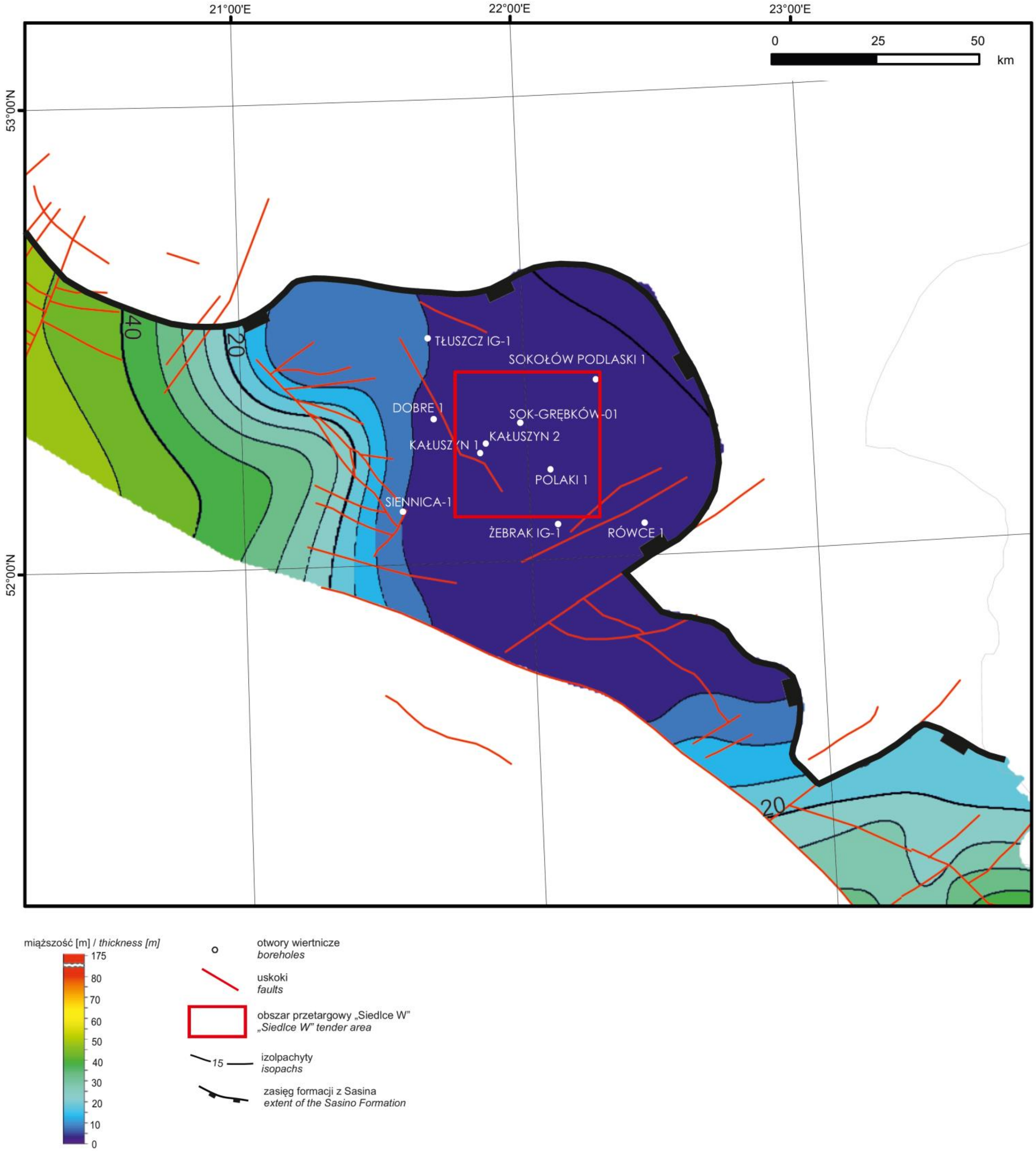


Fig. 2.24. Sasino Formation thickness map in the “Siedlce W” tender area, after Podhalańska et al. (2020; modified).

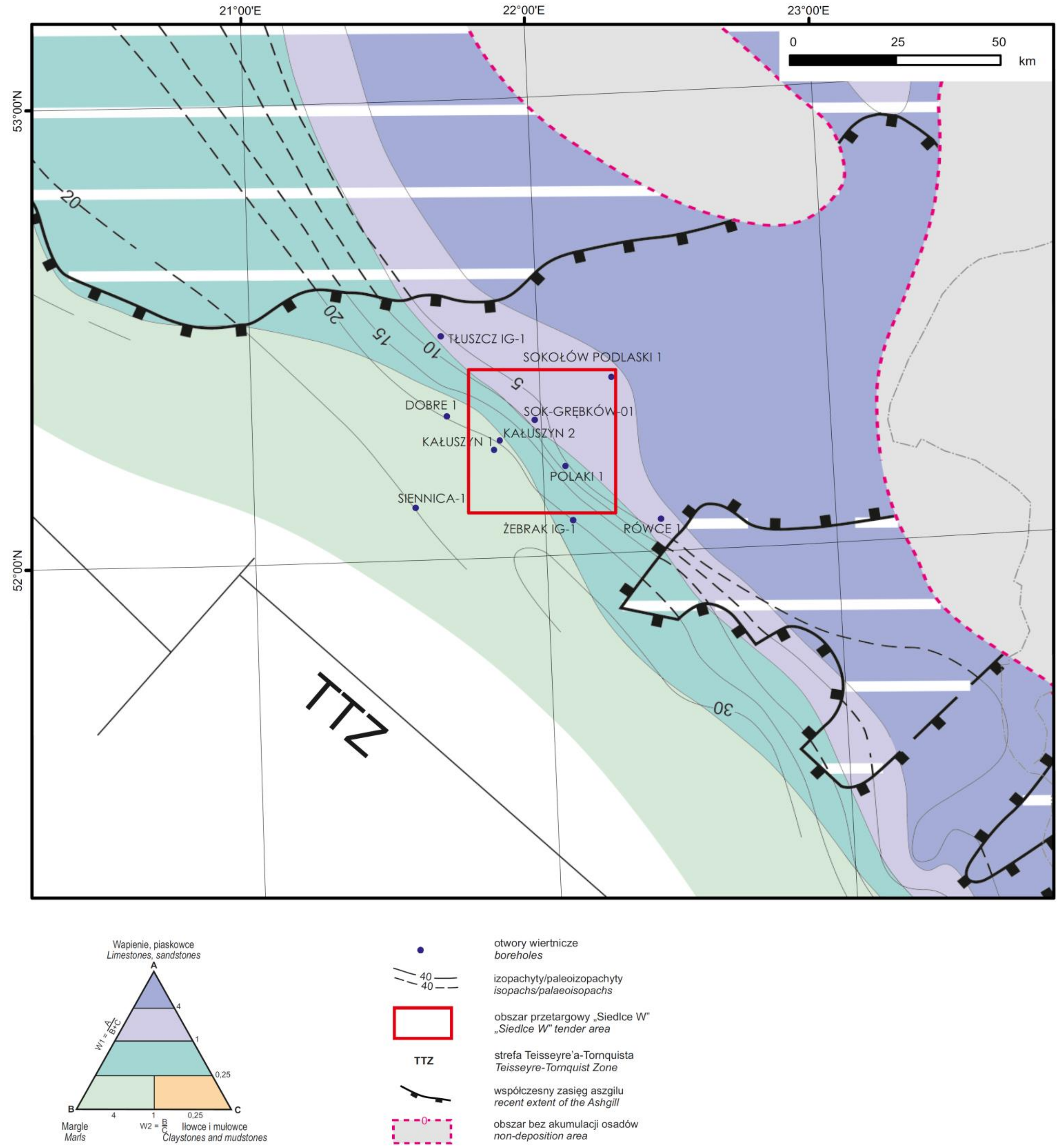


Fig. 2.25. Lithofacies and thickness of the Ashgill in the "Siedlce W" tender area, after Modliński et al. (2010; modified).

2.2.3. SILURIAN

Distribution and thickness

The Silurian was identified in 5 wells in the "Siedlce W" tender area, between Kałuszyn (W), Sokołów Podlaski (NE) and Żebrak (S) (Modliński and Szymański, 1997; Modliński and Podhalańska, 2010; Podhalańska, 2017, 2019).

In the Żebrak IG-1 well, located near the southern border of the analyzed area, the Silurian succession has been particularly well studied due to complete coring (Lendzion, 1975). The thickness of the Silurian succession is much greater than of the Ordovician strata, ranging from 485.5 m in the Sokołów Podlaski 1 to 997.3 m in the Żebrak IG-1 well. The depth of the Silurian succession in particular wells is as follows:

- Kałuszyn 1 – information restricted,
- Kałuszyn 2 – information restricted,
- SOK-Grębków-01: 1452.0–2130.0 m,
- Polaki 1: 1339.0–2172.0 m,
- Sokołów Podlaski 1: 1227.0–1712.5 m,
- Żebrak IG-1: 1360.9–2359.2 m.

Lithology and stratigraphy

The Silurian succession in the Podlasie part of the Baltic-Podlasie-Lublin Basin is divided into 7 formations and 1 member (Podhalańska et al., 2010; Porębski and Podhalańska, 2017, 2019), despite their monotonous lithology (Figs 2.26–2.29). The following units have been identified in the "Siedlce W" tender area (Tab. 2.2):

- Jantar Formation,
- Pasłęk Formation,
- Pelplin Formation,
- Kociewie Formation,
- Puck Formation, including the Reda Member.

Jantar Mudstone Formation

The Jantar Mudstone Formation has been identified in the Kałuszyn 1, SOK-Grębków-01, Polaki 1 and Żebrak IG-1 wells. The formation is composed of black and dark grey bitumionous, intermittently laminated mudstones with pyrite, and interbeds of dark grey calcareous mudstones. The Jantar Formation is characterized by increased values of gamma ray and can be relatively easily identified in the well logs. Sedimentological analysis performed in the Podlasie-Lublin region showed the dominance of lithofacies L-1A/1B (after Feldman-Olszewska and Roszkowska-Remin, 2016), an association of lithofacies consisting of massive claystones and non-calcareous mudstones with rare carbonate laminas and pyrite concretions; occasionally with thin layers of bioturbated deposits. The thickness of the formation in the analyzed and adjacent areas is small and varies from 2.5 m in the Polaki 1 well to 0.2 m in the Żebrak IG-1 well.

The Jantar Formation overlies the Tyśmienica Marl Formation or Kodeniec Limestone Formation of Ashgill age. The upper boundary of the Jantar Formation coincides with the lowest beds of the Pasłęk Formation, represented by greenish-grey bioturbated mudstones. The age of the Jantar Formation in the "Siedlce W" tender area has been determined by graptolite assemblages as the lowest Aeronian (Podhalańska, 2017, 2019).

Pasłęk Claystone Formation

The Pasłęk Claystone Formation is present in the "Siedlce W" tender area and spans the Llandovery – Aeronian – Telychian interval. The formation is developed as thin (milimetre-decimetre) alternations of dark bituminous mudstones and greenish-grey to light-grey, variably bioturbated mudstones. Both types of mudstones are mostly non-calcareous; rarely contain lens and laminas of quartz silt. Those observations have been confirmed by sedimentary studies in the rest of the Podlasie-Lublin region, especially in the Żebrak IG-1 section (Feldman-Olszewska and Roszkowska-Remin, 2016; Podhalańska et al., 2018). The top of the Pasłęk Claystone Formation corresponds to the Llandovery/Wenlock boundary (Porębski and Podhalańska, 2019; Podhalańska, 2017, 2019). The formation thickness varies from 24 m in the SOK-

Grębków -01 to 13.7 m in the Kałuszyn 1 well.

Pelplin Claystone Formation

The dominant lithology of the Pelplin Formation comprises dark grey, often laminated mudstones, interbedded with calcareous-clayey mudstones. In the uppermost part, siliciclastic intercalations of bioclastic limestones and shell detritus is present (Porębski and Podhalańska, 2019). Sedimentary studies show predominance of lithofacies L-4 (after Feldman Olszewska and Roszkowska-Remin, 2016) characterized by black-grey mudstones and laminated claystones. Both the upper and lower boundaries of the formation are transitional. The characteristic feature of the Pelplin Formation is poor variability of lithological, petrographic and sedimentological features, except for the increase in carbonate content towards the east part of the analyzed area (Feldman-Olszewska and Roszkowska-Remin, 2016; Podhalańska et. al., 2018). The thickness of the Pelplin Formation (Wenlock) varies from 63 m in the SOK-Grębków -01 to 87 m in the Polaki 1 well. The age of the formation in the "Siedlce W" tender area has been defined as Wenlock – lower Ludlow (Sheinwoodian – lower Gorstian).

Kociewie Claystone and Mudstone Formation, Puck Claystone and Calcareous Claystone Formation

The Kociewie and Puck formations represent the greatest thickness (500–1000 m) within the Silurian succession (Ludfordian and Pridoli) in the Siedlce W tender area. The Kociewie Formation is composed of massive, laminated calcareous mudstones with siliciclastic and carbonate siltstone intercalations. In the upper part of the Kociewie Formation,

the Reda Member has been distinguished (Modliński et al., 2006). The Puck Formation (upper Ludfordian – Pridoli) consists of mudstones and claystones with mainly benthic fauna. An erosional unconformity marks the transition between the Silurian and Permian or Carboniferous (Polaki 1 and Żebrak IG-1 wells).

	Depth [m]					
Formation	**Kałuszyn 1**	**Kałuszyn 2**	**Polaki 1**	**SOK-Grębków-01**	**Sokołów Podlaski 1**	**Żebrak IG-1**
Kociewie and Puck	+	+	1339.0–2062.0 (Reda Mb: 1915.0–1928.0)	1452.0–2043.0	1227.0–1605.0 (only Kociewie Fm)	1360.9–2274.5 (Reda Mb: 2035.0–2045.0)
Pelplin	+	+	2062.0–2149.0 (Wenlock part)	2043.0–2115.0 (Wenlock part)	1605.0–1691.5 (Wenlock part)	2274.5–2343.0 (Wenlock part)
Pasłęk	+	+	2149.0–2165.0	2115.0–?2130.0	1691.5–1712.5	2343.0–2358.0
Jantar	+	+	2165.0–2172.0	Not identified	-	2358.0–2359.2

Tab. 2.2. Distribution of the Silurian formations in the "Siedlce W" tender area (CGDB, 2021; Podhalańska et al. 2016; Tomczyk, 1975); „+" formation is present; „-" formation is absent.

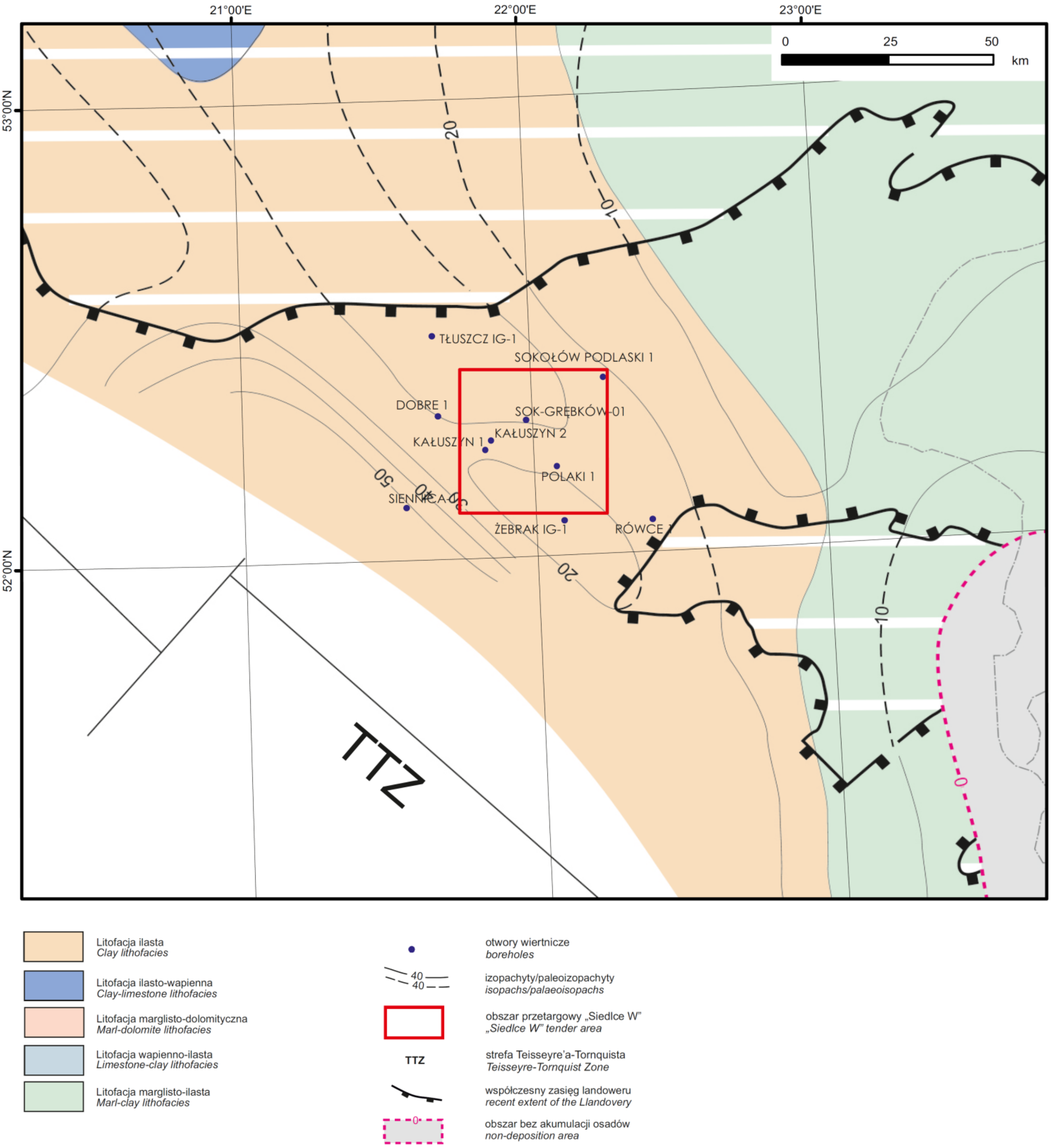


Fig. 2.26. Lithofacies and thickness of the Llandovery in the “Siedlce W” tender area, after Modliński et al. (2010; modified).

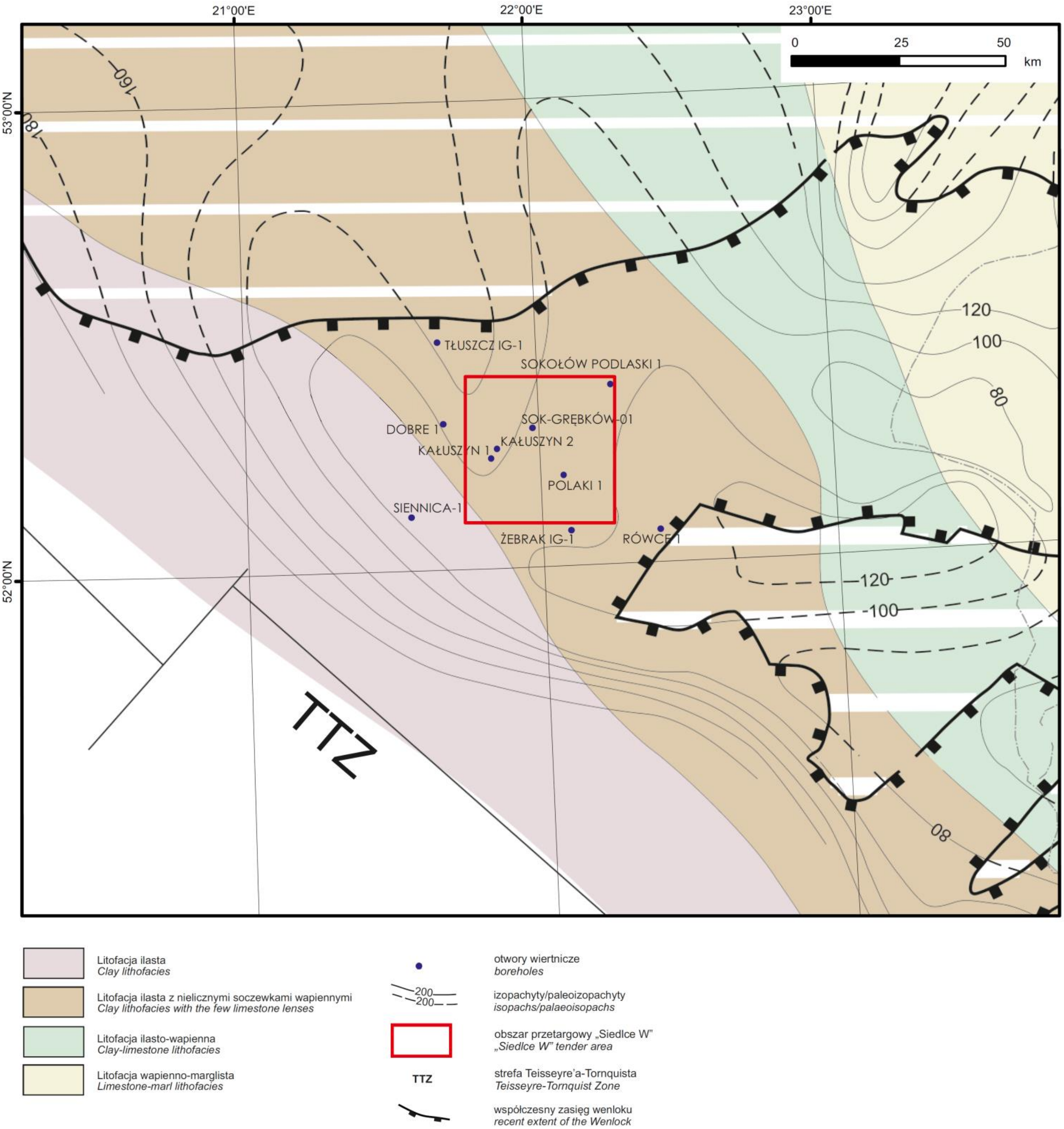


Fig. 2.27. Lithofacies and thickness of the Wenlock in the "Siedlce W" tender area, after Modliński et al. (2010; modified).

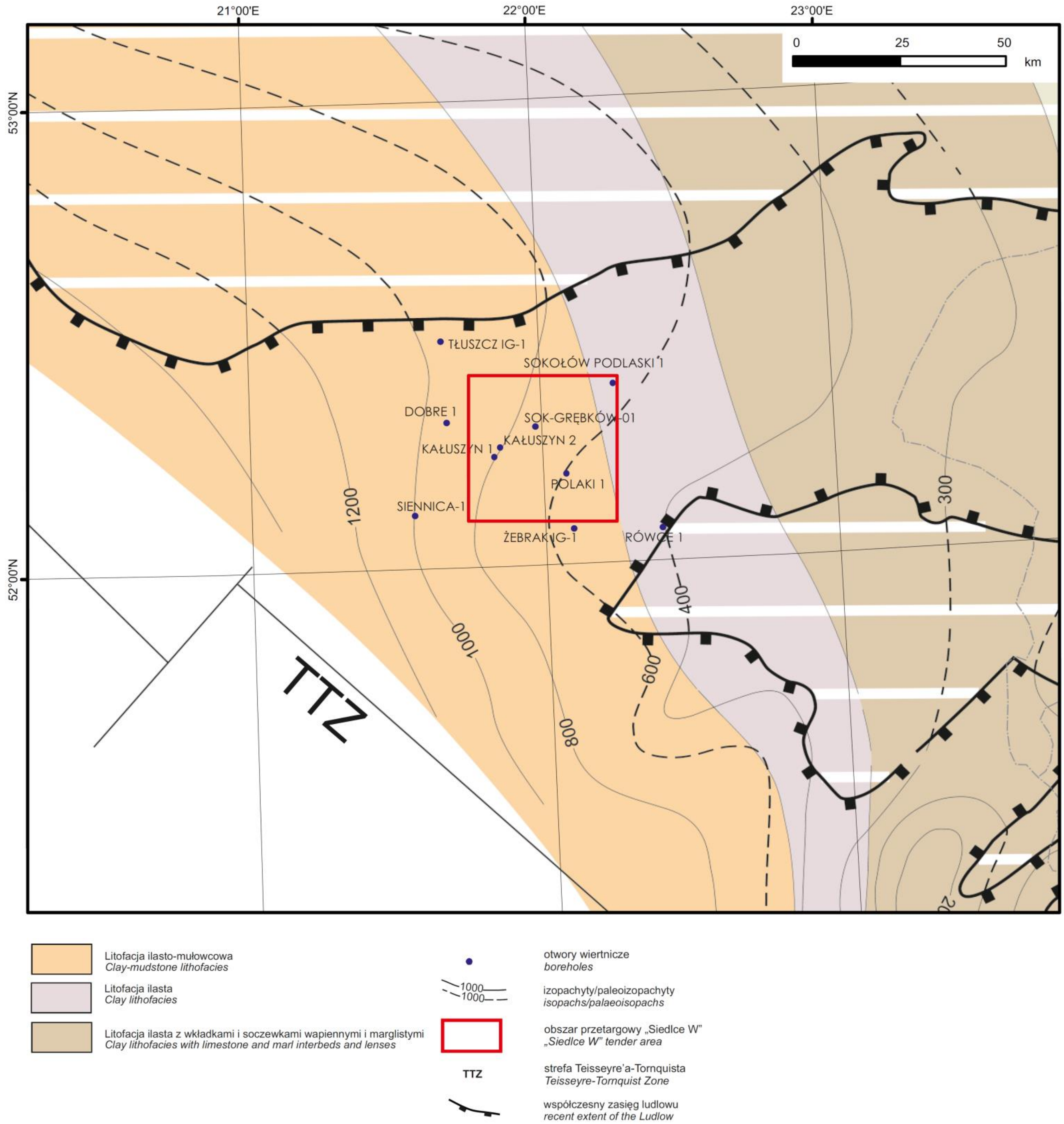


Fig. 2.28. Lithofacies and thickness of the Ludlow in the "Siedlce W" tender area, after Modliński et al. (2010; modified).

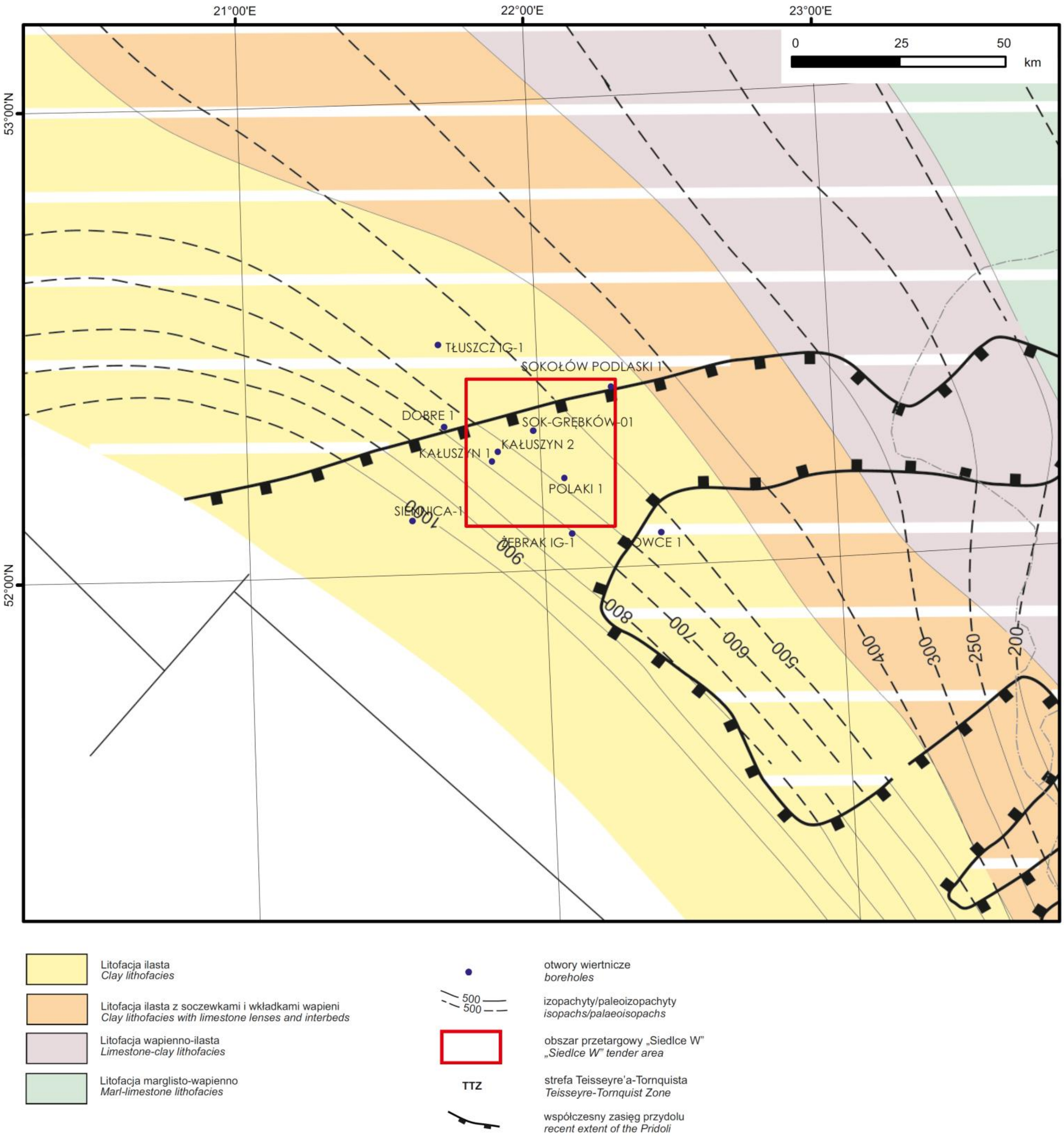


Fig. 2.29. Lithofacies and thickness of the Pridoli in the “Siedlce W” tender area, after Modliński et al. (2010; modified).

Petrography of Ordovician and Silurian sedimentary rocks

The Ordovician and Silurian rocks are in general quite similar and monotonous. They are represented mainly by grey or dark grey claystones and mudstones, often with graptolites. In case of the Ordovician succession, there are additionally thin layers rich in glauconite and carbonate/marly minerals. In the Silurian rocks, the carbonate intervals are sparse, and the succession is dominated by claystones and mudstones. Fine-grained facies are composed of quartz, feldspars, carbonates, mica flakes and clay minerals in different proportions. The mudstones from the Pelplin Formation are mainly argillaceous and indicate continuous, parallel and wavy lamination.

2.2.4. CARBONIFEROUS

Distribution and thickness

The Carboniferous deposits in the “Siedlce W” tender area have been recognized only in one well – Polaki 1 – at a depth of 1335.0–1339.0 m. It seems that the extent of the Carboniferus is limited due to Variscan erosion, and its continuous subcrops occur only in the southern neighborhood of the tender area, reaching 65.9 m in thickness in the Żebrak IG-1 well (depth 1295.0–1360.9 m).

Lithology and stratigraphy

In the Polaki 1 well, the Carboniferous is represented by variegated shales and weathered coarse-grained sandstones and conglomerates with clasts of Silurian shales and claystones. In the upper part of the succession, laminated siltstones and mudstones with siderite concretions and plant detritus appear, as well as claystones with hematite and oolites. Fine-grained sandstones are also present.

2.2.5. PERMIAN – ROTLIEGEND

Distribution and thickness

The Permian Rotliegend deposits occur in 5 wells in the “Siedlce W” tender area, at depths:

- Kałuszyn 1 – information restricted,
- Kałuszyn 2 – information restricted,
- Polaki 1: 1319.0–1335.0 m,
- SOK-Grębków-01: 1436.0–1452.0 m,
- Sokołów Podlaski 1: 1221.0– 1227.0 m.

In the vicinity of the tender area, the Rotliegend has been identified in the following wells:

- Dobre 1: 1801.0–1831.5 m,
- Rówce 1: 980.0–1007.0 m,
- Tłuszcz IG-1: 1665.0– 1667.5 m,
- Żebrak IG-1: 1270.7–1295.0 m.

Lithology and stratigraphy

The Rotliegend thickness varies from 6 m in the NE part of the tender area to 16 m in the Polaki 1 and SOK-Grębków-01 wells, and increases to the S and W.

The Rotliegend is represented by alluvial sandstones and conglomerates composed of granite, quartz, plagioclase and Lower Paleozoic intraclasts. Aeolian sandstones are supposed to occur only in the SW part of the area (Fig. 2.30).

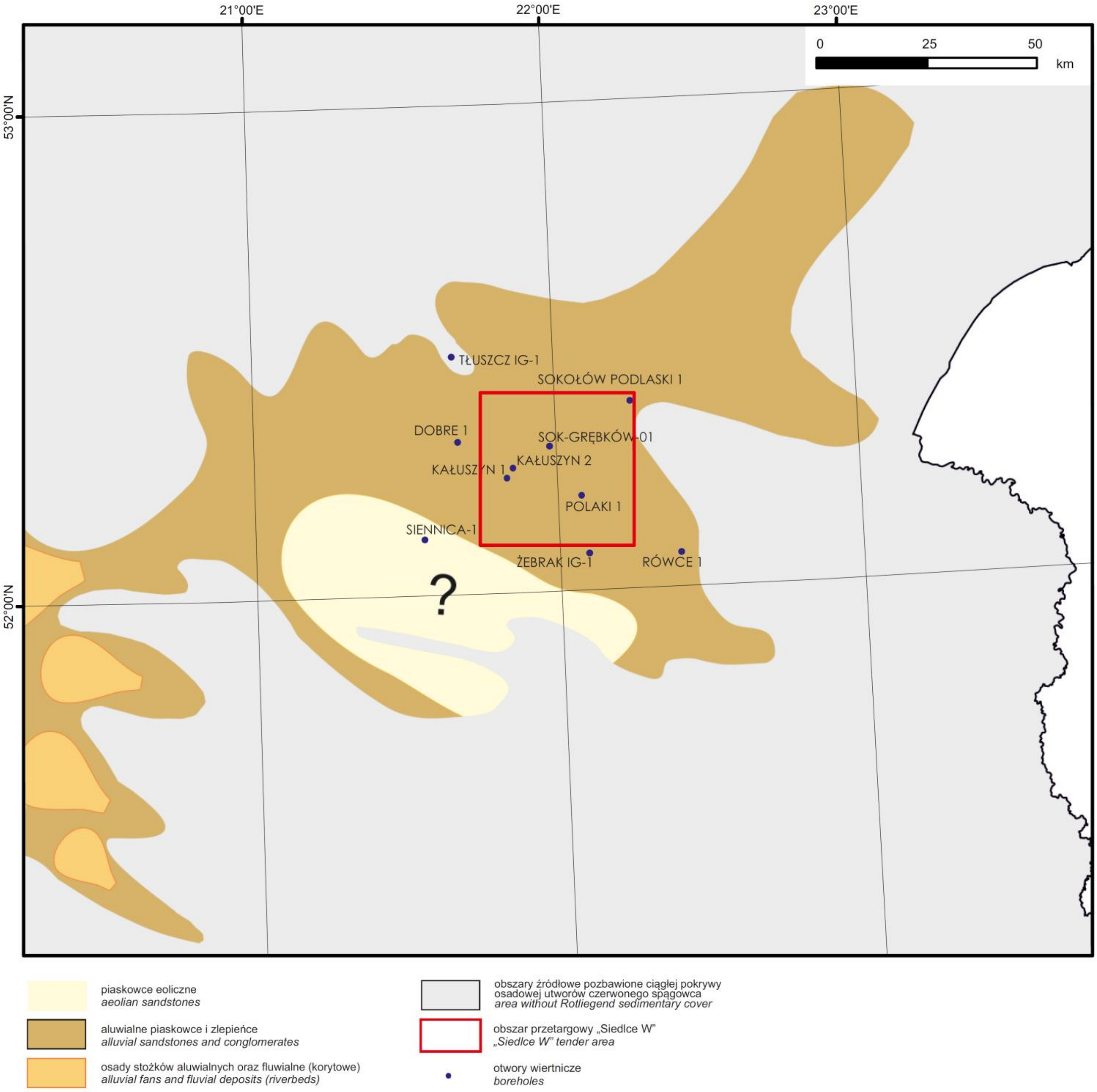


Fig. 2.30. Lithofacies at the top of the Rotliegend in the "Siedlce W" tender area (Kiersnowski et al., 2020; modified).

2.2.6. PERMIAN – ZECHSTEIN

Distribution and thickness

Zechstein deposits occur in the following wells located within and in the vicinity of the tender area, at depths respectively:

- Kałuszyn 1– information restricted,
- Kałuszyn 2 – information restricted,
- Polaki 1: 1241.0–1319.0 m,
- SOK-Grębków-01: 1336.0–1436.0 m,
- Sokołów Podlaski 1: 1160.0–1221.0 m,
- Żebrak IG-1: 1198.5–1270.7 m,
- Dobre 1: 1620.0–1801.0 m,
- Rówce 1: 888.0–980.0 m,
- Tłuszcz IG-1: 1584.5–1665.0 m.

The thickness of the Zechstein ranges from 61 to over 100 m.

Lithology and stratigraphy

The succession is reduced to only PZ1 and PZ2 cyclothems, although the younger Permian sediments have preserved in the neighborhood of the area (Wagner, 1998; Figs 2.37–2.39; Tab. 2.3). The PZ1 cyclothem starts with the Kupferschiefer, covered by the Zechstein Limestone (20–40 m thick). During sedimentation of the Zechstein Limestone, the "Siedlce W" tender area was located at the edge of the Podlasie carbonate platform (Buniak et al., 2013a; Fig. 2.35). The younger PZ1 sediments are composed of anhydrites and, locally, halites. The total thickness of the PZ1 cyclothem is 50–71 m, like in the wells located in the vicinity (Tab. 2.3).

The PZ2 cyclothem starts with the Main Dolomite, locally underlied by terrigenuous series (Tab. 2.3). The Main Dolomite is composed of porous, sometimes cavern dolomites intercalated with grained oncolite dolomites or massive limestones developed in the carbonate platform and oncolite-oolite barier environments (Wagner, 2012; Buniak et al., 2013b; Fig. 2.36). The Main Dolomte thickness varies from 7 m to about 40 m, increasing to 43 m in the Dobre 1 well. According to Buniak et al. (2013 b), there are no prospective structures related to the Main Dolomite in the "Siedlce W" tender area. Moreover, organic matter is scarce and immature for hydrocarbon generation (although hydrocarbon shows were noted in the Sokołów Podlaski 1 well).

<table>
<tr><th rowspan="2">Stratigraphy</th><th>Polaki 1</th><th>SOK–Grębków-01</th><th>Sokołów Podlaski 1</th><th>Dobre 1</th><th>Rówce 1</th><th>Tłuszcz IG-1</th><th>Żebrak IG-1</th></tr>
<tr><th colspan="7">Depth [m]</th></tr>
<tr><td>Top Terrigenuous Series PZt</td><td>–</td><td rowspan="8">1336.0–1436.0 m</td><td>–</td><td>1620.0–1665.0</td><td>888.0–907.5</td><td>1584.5–1587.5</td><td rowspan="8">1198.5–1270.7</td></tr>
<tr><td>Platy Dolomite Ca3</td><td>–</td><td>–</td><td>1665.0–1685.0</td><td>–</td><td>–</td></tr>
<tr><td>Main Dolomite Ca2</td><td>1241.0–1248.0</td><td>1160.0–1171.0</td><td>1685.0–1728.0</td><td>907.5–910.0</td><td>1587.5–1610.5</td></tr>
<tr><td>Terrigenuous Recessive Series T1r</td><td>–</td><td>–</td><td>–</td><td>910.0–915.0</td><td>–</td></tr>
<tr><td>Anhydrite A1</td><td>1248.0–1255.0</td><td>1171.0–1190.0</td><td>1728.0–1795.0</td><td>915.0–964.0</td><td>–</td></tr>
<tr><td>Oldest Halite Na1</td><td>1255.0–1276.5</td><td>–</td><td>–</td><td>–</td><td>1610.5–1665.0</td></tr>
<tr><td>Lower Anhydrite A1d</td><td>1276.5–1308.5</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Zechstein Limestone Ca1, Kupferschiefer T1</td><td>1308.5–1319.0</td><td>1190.0–1221.0</td><td>1795.0–1801.0</td><td>964.0–980.0</td><td>–</td></tr>
</table>

Tab. 2.3. Zechstein distribution in the "Siedlce W" tender area.

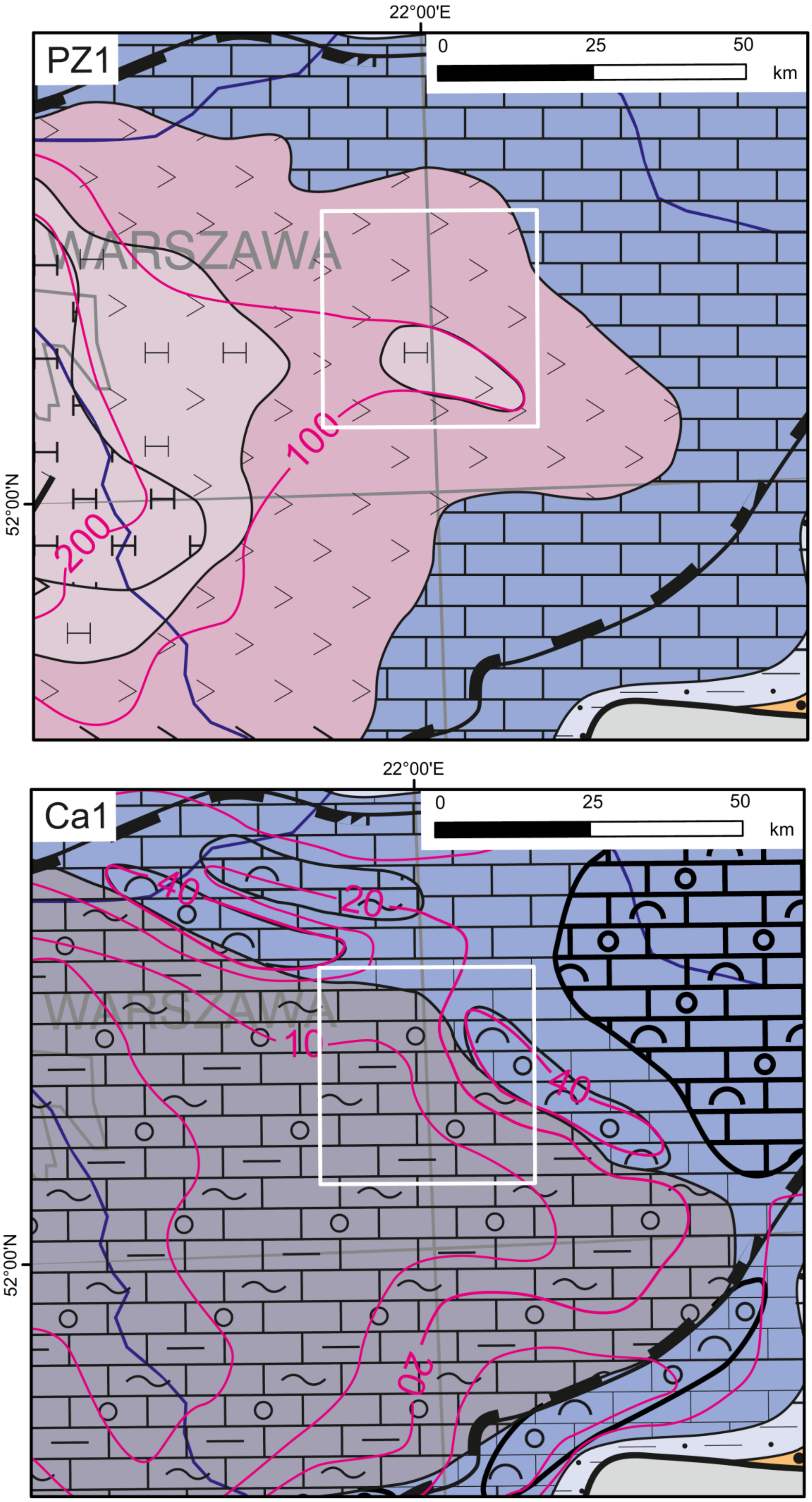
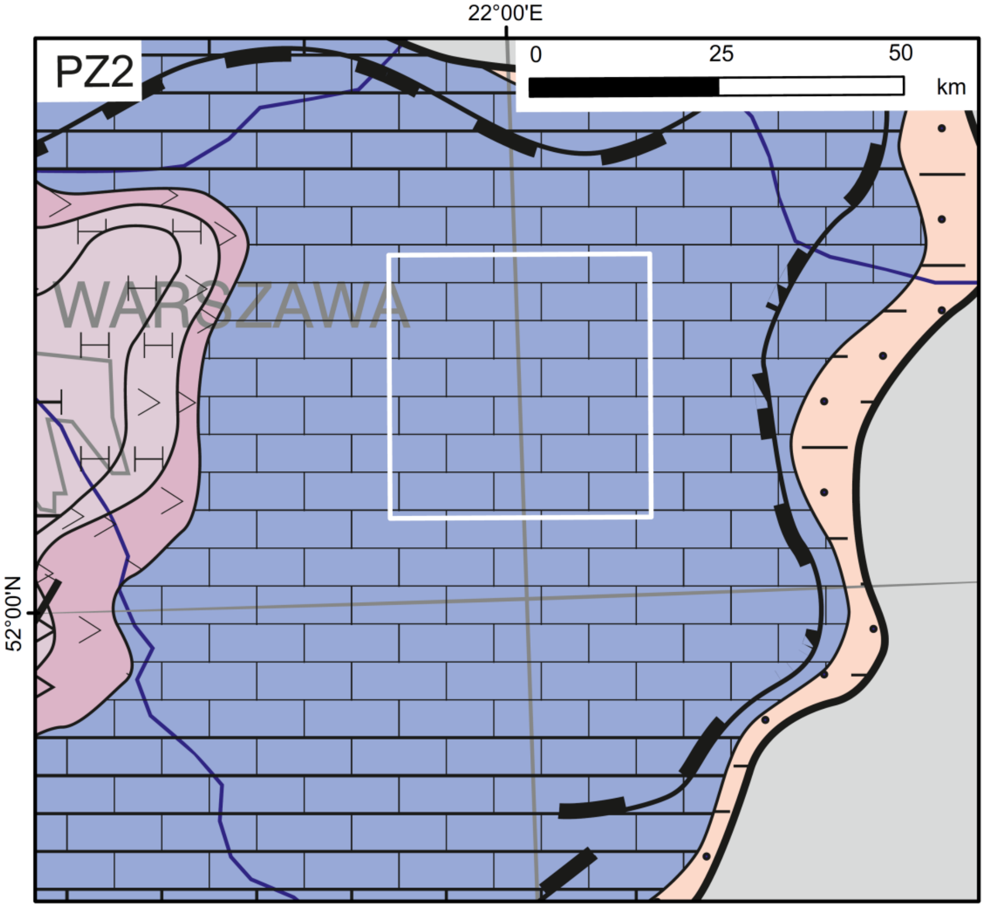


Fig. 2.31. Palaeogeography and thickness of the PZ1 cyclothem and Zechstein Limestone Ca1 in the “Siedlce W” tender area; explanations in Fig. 2.34 (Wagner, 1998; modified).



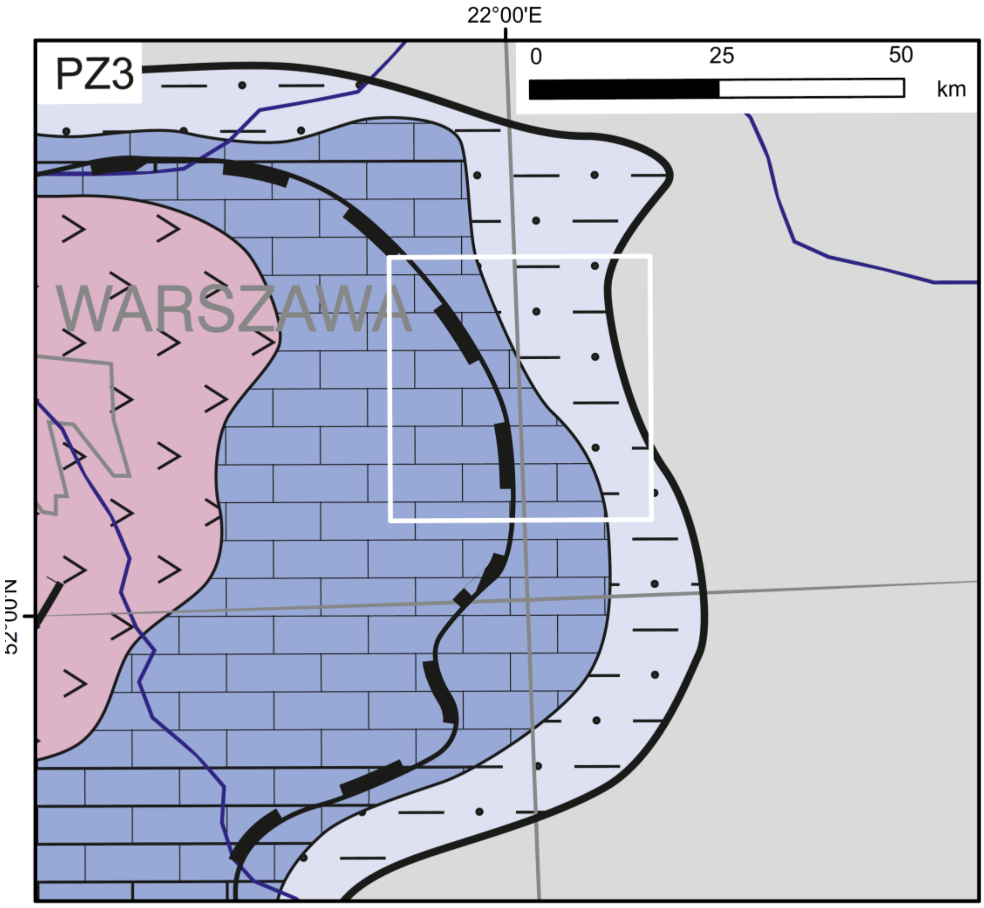


Fig. 2.32. Palaeogeography and thickness of the PZ1 and PZ2 cyclothems in the “Siedlce W” tender area; explanations in Fig. 2.34 (Wagner, 1998; modified).

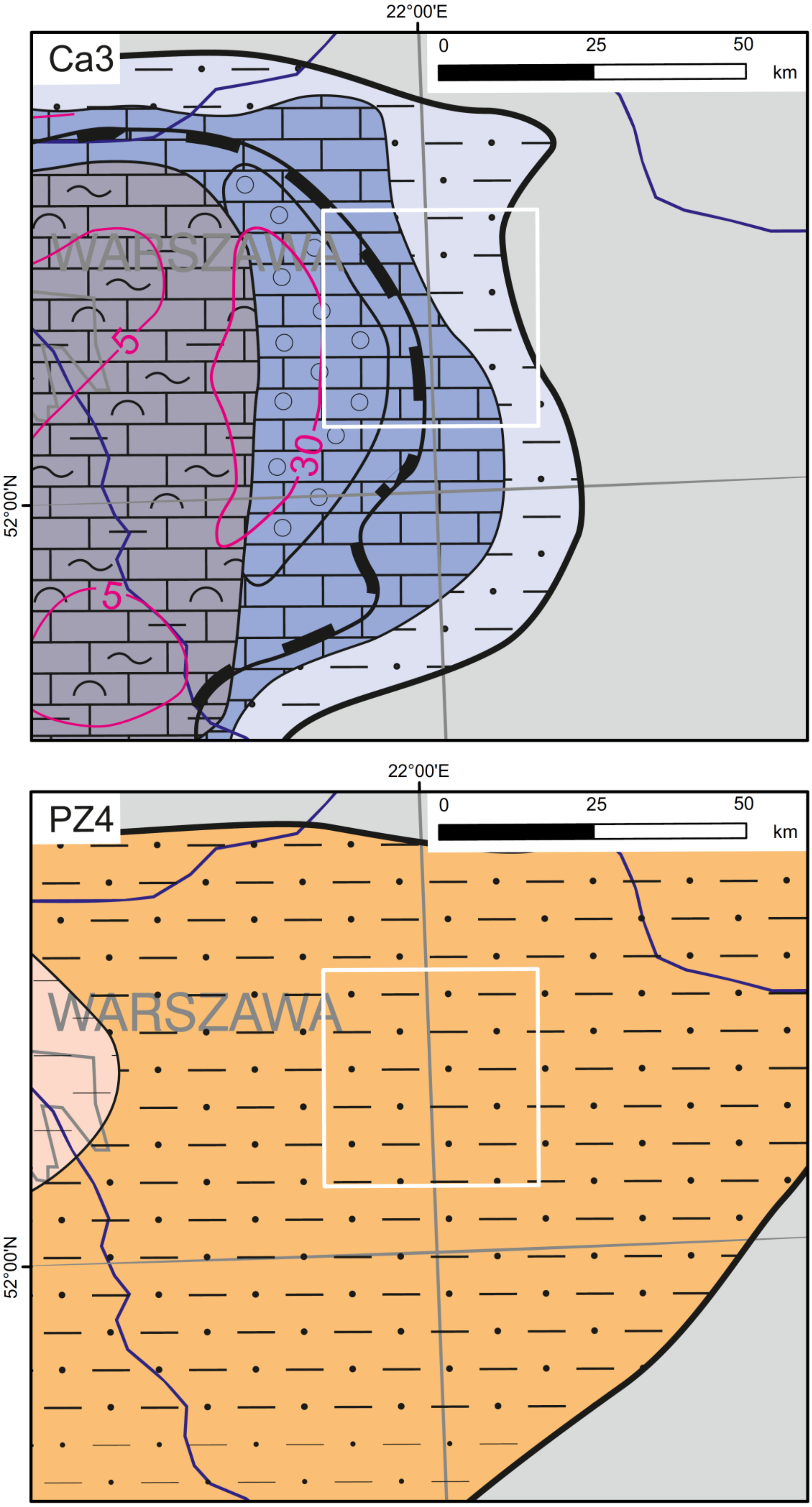


Fig. 2.33. Palaeogeography and thickness of the Platy Dolomite Ca3 and PZ4 cyclothem in the “Siedlce W” tender area; explanations in Fig. 2.34 (Wagner, 1998; modified).

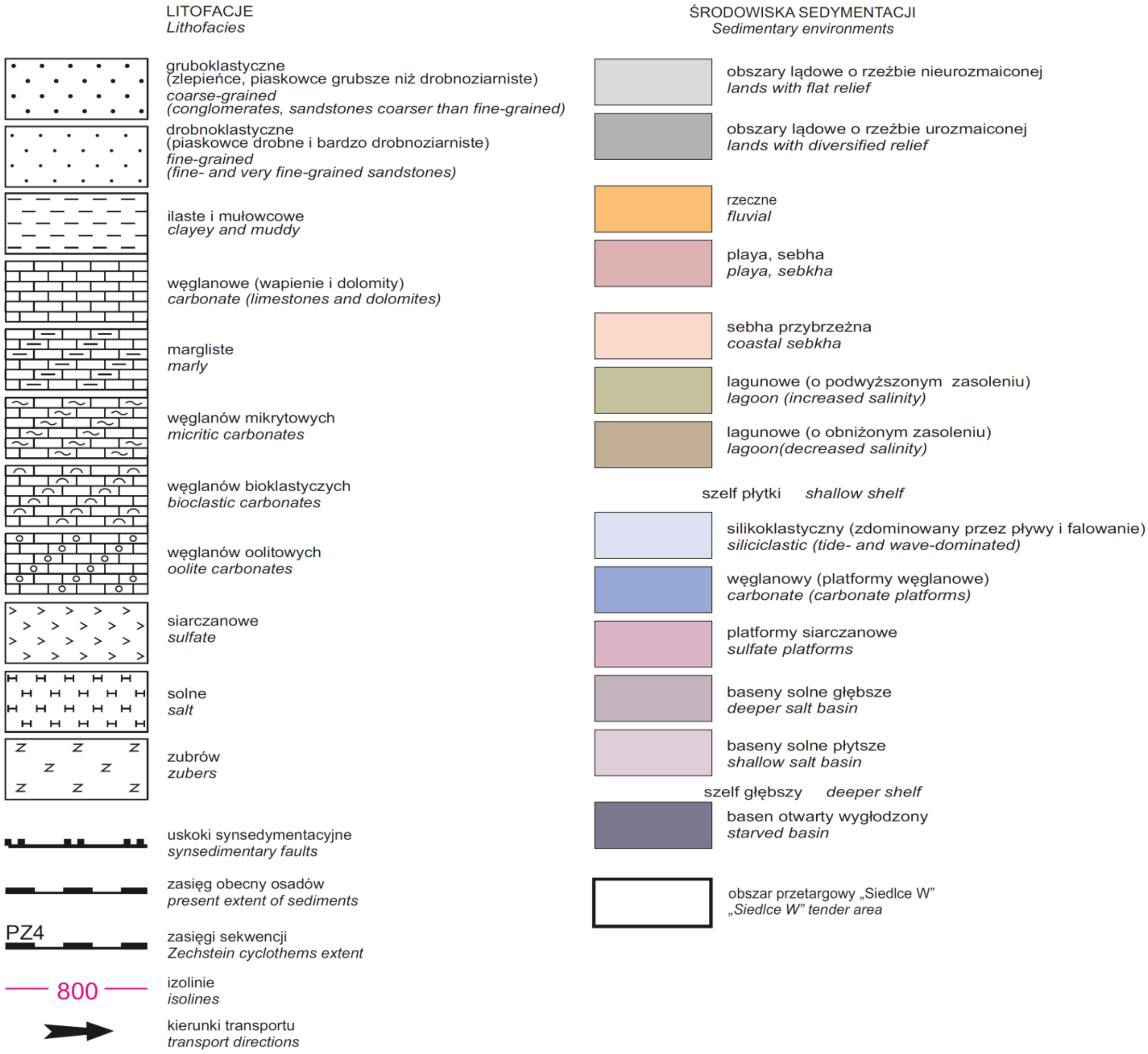


Fig. 2.34. Explanations to Figs 2.31–2.33 (Wagner, 1998; modified).

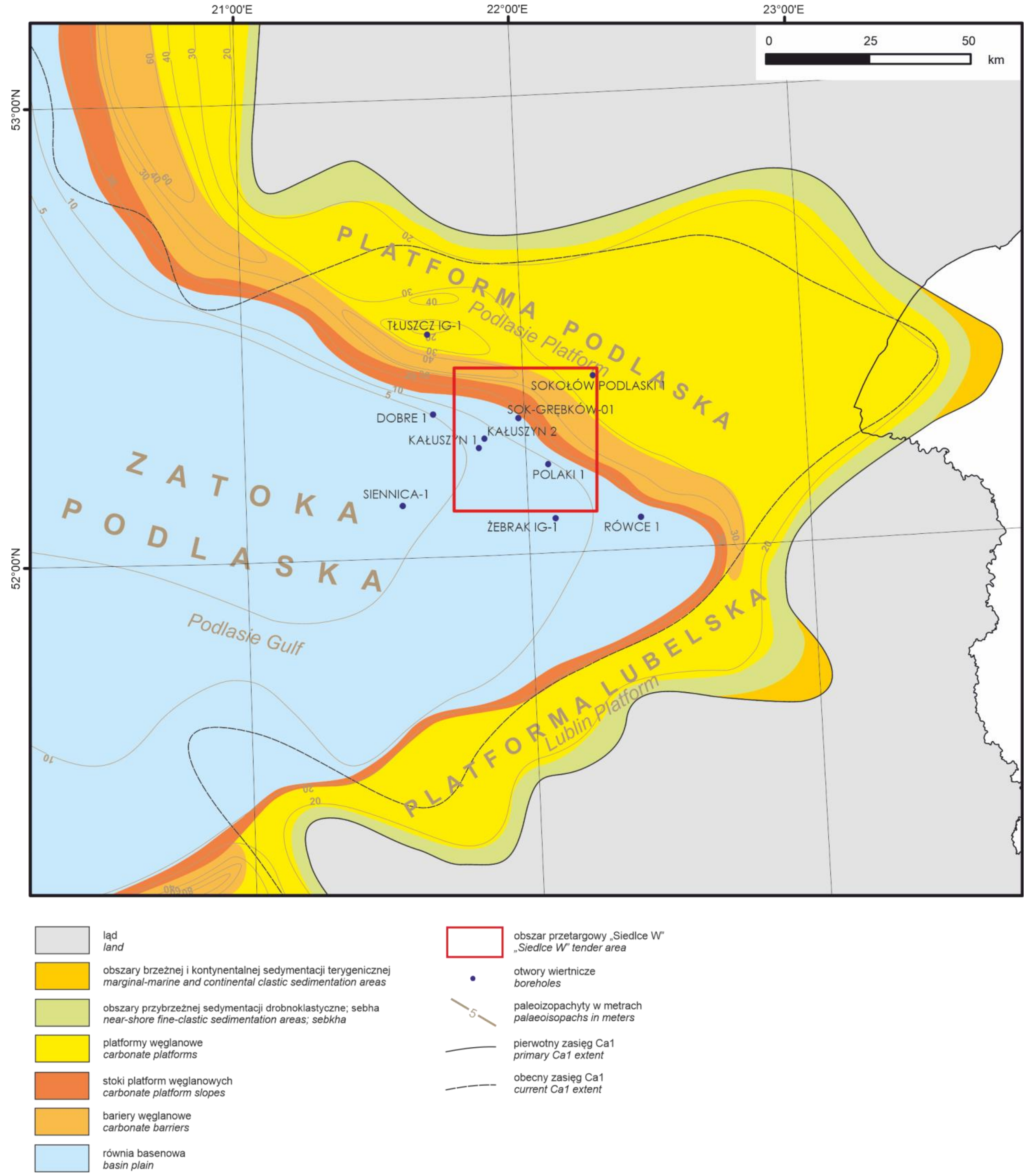


Fig. 2.35. Palaeogeography and thickness of the Zechstein Limestone Ca1 in the "Siedlce W" tender area (Buniak et al., 2013a; modified).

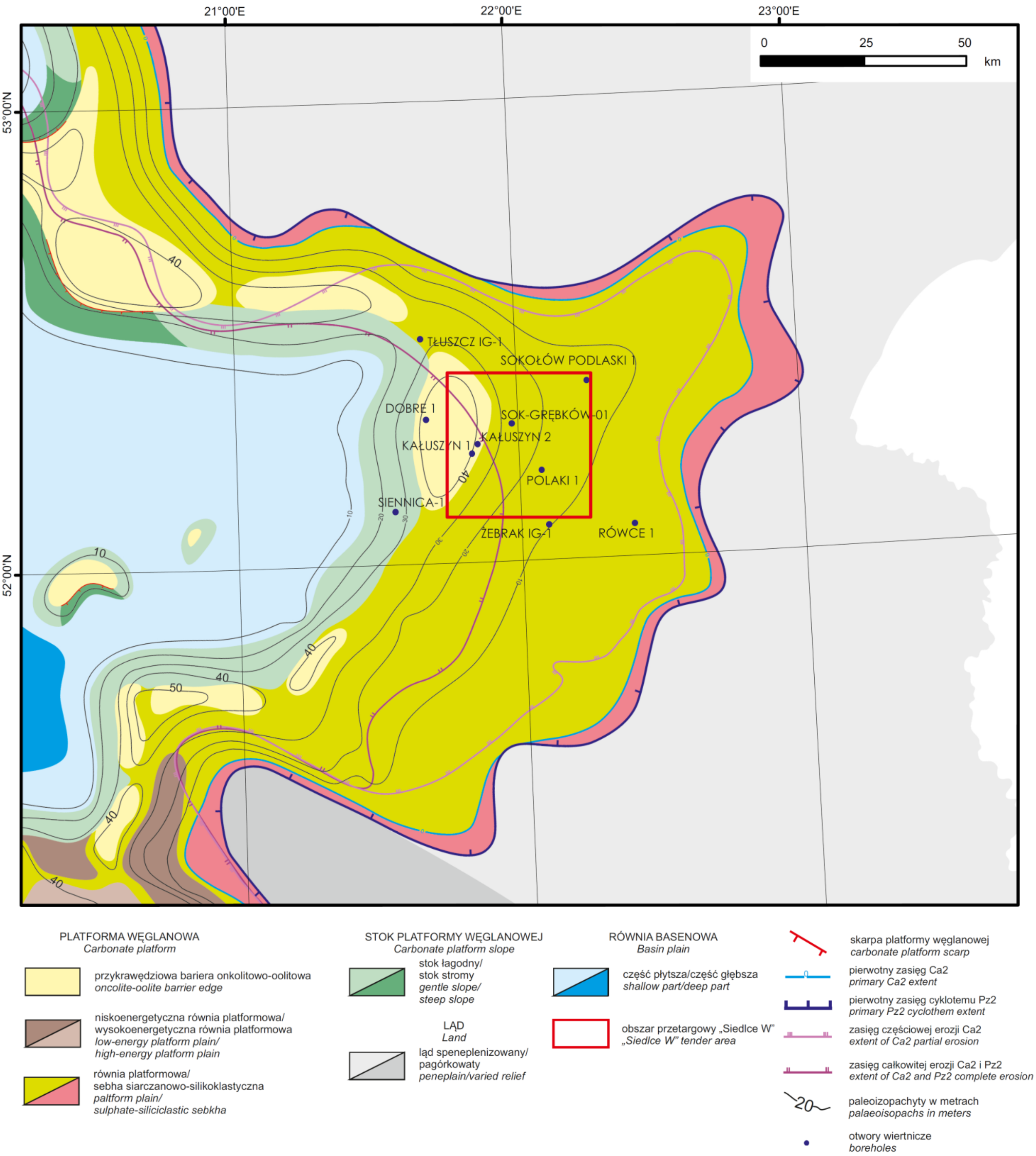


Fig. 2.36. Palaeogeography and thickness of the Main Dolomite Ca2 in the "Siedlce W" tender area (Wagner, 2012).

2.2.7. TRIASSIC

Distribution and thickness

The Triassic deposits were recognized in the following wells in the “Siedlce W” tender area and in the vicinity:

- Kałuszyn 1 – information restricted,
- Kałuszyn 2 – information restricted,
- Polaki 1: 914.5–1241.0 m,
- SOK-Grębków-01: 991.0–1336.0 m,
- Sokołów Podlaski 1: 870.0–1160.0 m,
- Dobre 1: 1247.0–1620.0 m,
- Rówce 1: 765.0–88.0 m,
- Tłuszcz IG-1: 1171.1–1584.5 m,
- Żebrak IG-1: 914.2–1198.5 m.

The thickness of the Triassic succession is from 284.3–290.0 m in the S and W part of the area to over 400 m in the Kałuszyn region. Because the Triassic is of no petroleum importance, its lithology and stratigraphy are not described in detail.

2.2.8. JURASSIC

Distribution and thickness

In the “Siedlce W” tender area and in the vicinity, the Jurassic deposits were recognized in the following wells:

- Kałuszyn 1 – information restricted,
- Kałuszyn 2 – information restricted,
- Polaki 1: 654.0–914.5 m,
- SOK-Grębków-01: 716.0–991.0 m,
- Sokołów Podlaski 1: 631.5–870.0 m,
- Dobre 1: 815.0–1247.0 m,
- Rówce 1: 555.0–765.0 m,
- Tłuszcz IG-1: 775.0–1171.1 m,
- Żebrak IG-1: 625.0–914.2 m.

The thickness of the Jurassic succession ranges from 238.5 m in the NE part of the area to 432 m in the Dobre 1 well. Due to the lack of petroleum importance, the lithology and stratigraphy of the Jurassic sediments are not described in detail.

2.2.9. CRETACEOUS

Distribution and thickness

The Cretaceous deposits in the “Siedlce W” tender area and in its close neighborhood were recognized in the following wells, at depths respectively:

- Kałuszyn 1 – information restricted,
- Kałuszyn 2 – information restricted,
- Polaki 1: 200.5–654.0 m,
- SOK-Grębków- 01: 223.0–716.0 m,
- Sokołów Podlaski 1: 225.0–631.5 m,
- Dobre 1: 267.5–815.0 m,
- Rówce 1: 149.0–555.0 m,
- Tłuszcz IG-1: 208.6–775.0 m,
- Żebrak IG-1: 193.0–625.0 m.

The Cretaceous thickness ranges from 406.0 m in the Rówce 1 well to 566.4 m in the Tłuszcz IG-1 well. The lithology and stratigraphy of the Cretaceous sediments are not described in detail due to the lack of petroleum prospectivity.

2.2.10. CENOZOIC

Distribution and thickness

The Cenozoic sediments occur in the followng wells, at depths respectively:

- Kałuszyn 1 – information restricted,
- Kałuszyn 2 – information restricted,
- Polaki 1: 0–200.5 m,
- SOK-Grębków-01: 0–223.0 m,
- Sokołów Podlaski 1: 0–225.0 m,
- Dobre 1: 0–267.5 m,
- Rówce 1: 0–149.0 m,
- Tłuszcz IG-1: 0–208.6 m,
- Żebrak IG-1: 0–193.0 m.

The maximum thickness of the Cenozoic deposits in the "Siedlce W" tender area and its neighborhood reaches 267.5 m. The hydrogeological importance of the Cenozoic sediments is shortly summarized in Chapter 2.3

2.3. HYDROGEOLOGY

The "Siedlce W" tender area is located in the water regions of the Bug (97.2% of the area) and the Middle Vistula (2.8% of the area). It belongs to the groundwater bodies (JCWPd) Nos 55, 66 and 54 (Figs 2.37–2.38). The area is drained by the Liwiec and Kostrzyń rivers, their tributaries: Struga, Witówka, Gawroniec, Świdnica, Kałuska; Czerwonka and Muchawka, and other minor watercourses.

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

The near-surface water-bearing horizon (upper layer) occurs in sand and gravel deposits mainly of river accumulation (valleys of the Liwiec and Kostrzyń rivers) and in fluvioglacial sands from the period of the North Polish and locally Middle Polish glaciations. It occurs at depth ranges from 5 to 50 m b.g.l. The aquifer thickness is from several to 20 m (locally up to 30 m). The potential discharge of a well varies from 10 to 70 m^3/h. It is commonly exploited in the discussed area and the major intakes are located in Siedlce (Sekuła I), Kałuszyn and Piaseczno.

The intertill water-bearing horizon occurs in sandy and sandy-gravel deposits of the Middle Polish Glaciations. It is found at a depth of about 10–100 m b.g.l. Its thickness ranges from several to more than 30 m. The potential discharge of a well is from 10 to 80 m^3/h. It is intensely exploited in the Polków-Sagały, Garczyn Duży and Grębków intakes.

The subtill water-bearing horizon occurs in depressions of the sub-Quaternary surface. It is composed of sand and sand-gravel deposits of the South Polish Glaciation, the Augustów Interglacial and locally the Narew Glaciation. Locally, it is in hydraulic contact with the intertill or Neogene-Paleogene water-bearing horizons, forming the joint Quaternary-Neogene-Paleogene aquifer. It is found at a depth of about 50–80 m b.g.l. (locally 20–40 m b.g.l.). The thickness of this horizon is about 10–40 m (locally up to 90 m near Wyszków).

Apart from the Quaternary water-bearing horizons, water is also found in Pliocene, Oligocene and Miocene sand deposits. The Miocene and Oligocene water-bearing horizons, locally in direct hydraulic contact, are of utility importance. They usually occur at depths of 50–150 m b.g.l. and their average thickness is from 10 to 50 m. Water from Miocene deposits is exploited by the city of Siedlce (Sekuła II water intake).

The degree of hazard for groundwater ranges from high to low and very low (Fig. 2.37–2.38).

There are three main groundwater reservoirs (GZWP) within the "Siedlce W" tender area: GZWP No. 223 Górny Liwiec Burried Valley – a documented Quaternary reservoir, and two Neogene-Paleogene undocumented reservoirs: GZWP No. 215 – Subniecka Warszawska and GZWP 2151 – Subniecka Warszawska – central part. Groundwater intakes are located mainly in the eastern part of the area. They abstract water from the main groundwater aquifers. Within the boundaries of the “Siedlce W” tender area, two zones of protection for the groundwater intakes have been established: Sekuła I in Siedlce and Kałuszyn.

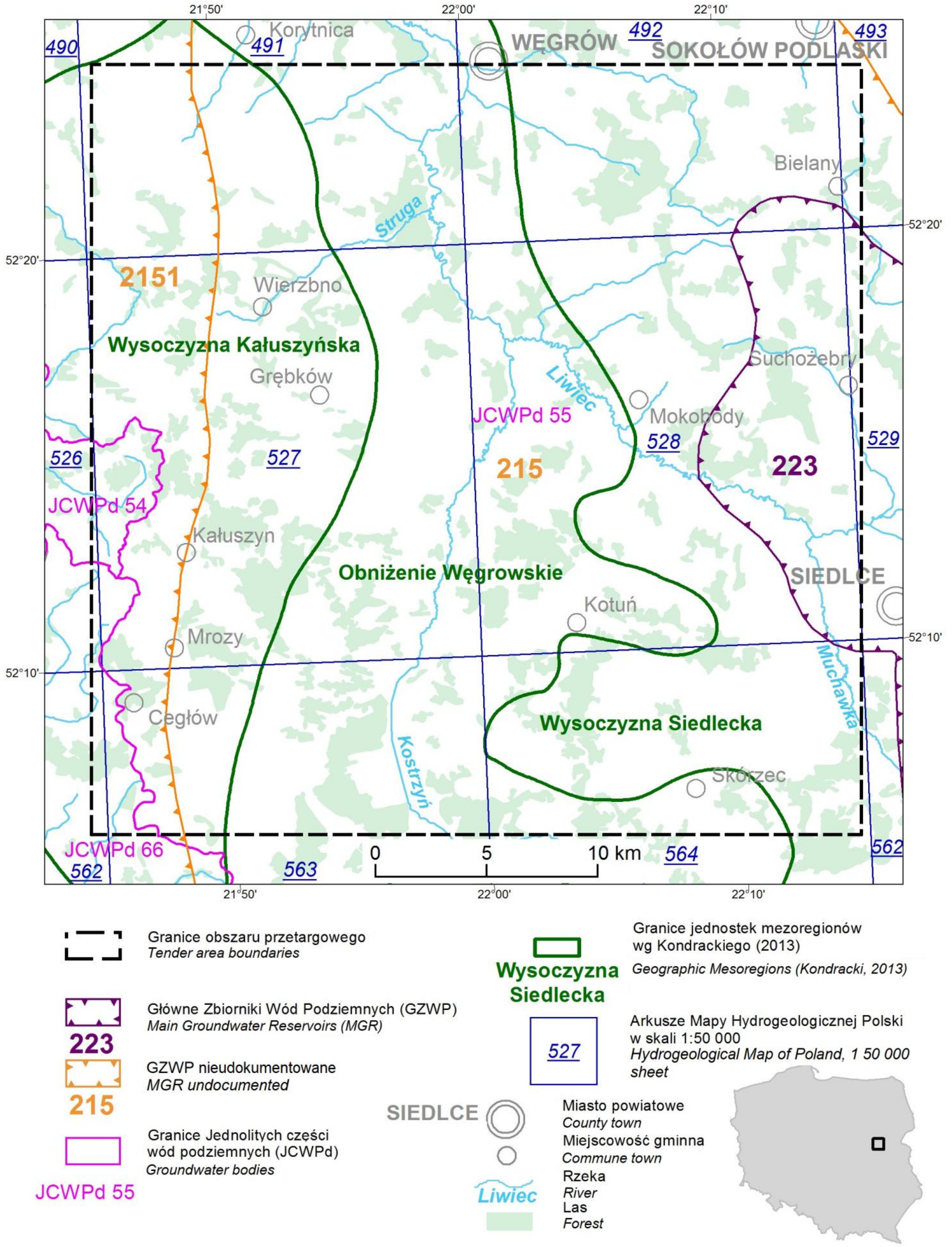


Fig. 2.43. Location of the "Siedlce W" tender area in the map of the geographic regions, main groundwater reservoirs, and groundwater bodies.

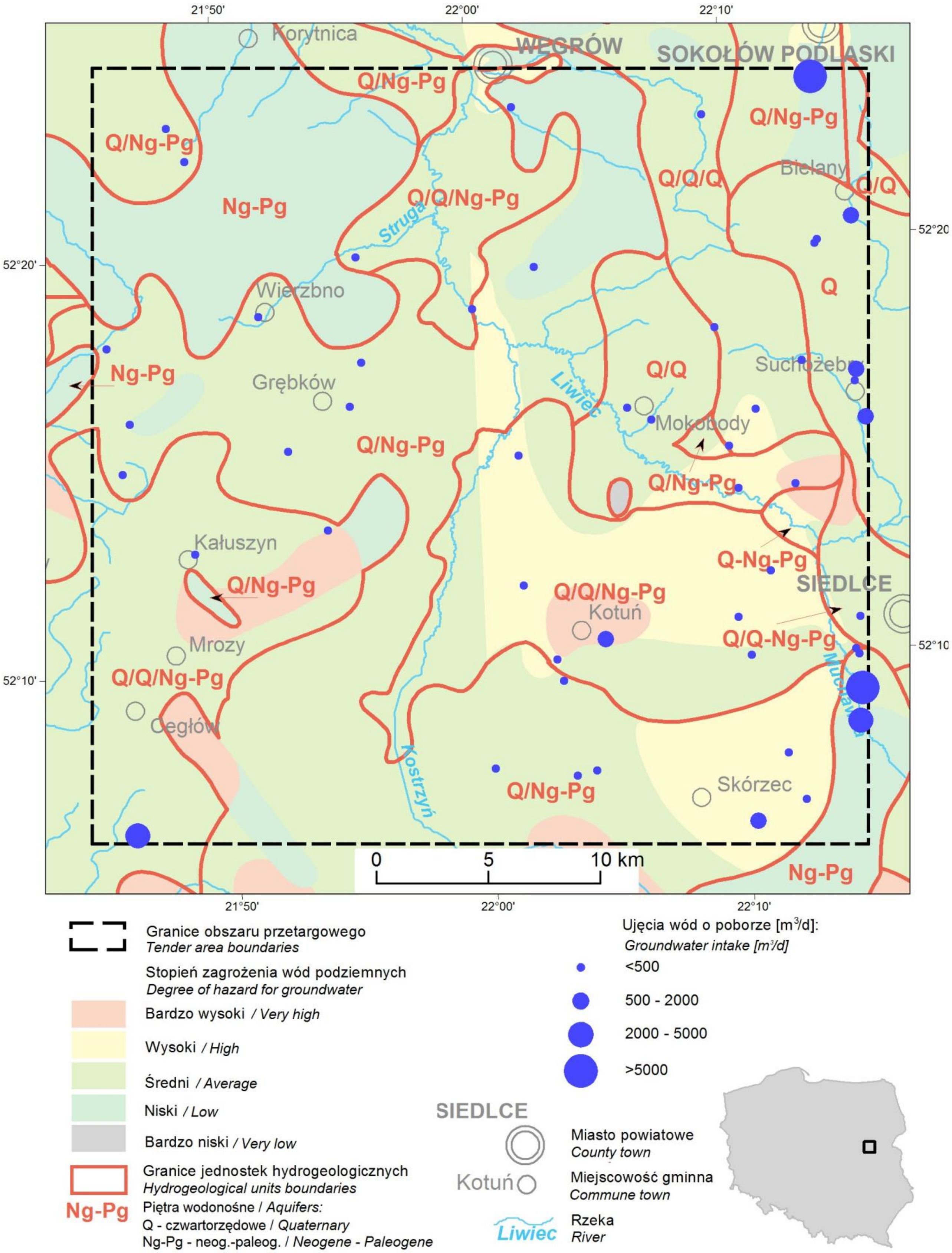


Fig. 2.37. Location of the “Siedlce W” tender area in relation to the hydrogeological unit boundaries.

3. PETROLEUM PLAY

3.1. GENERAL CHARACTERISTICS

The petroleum play is a term that joins geological structures and processes, which together lead to the formation of hydrocarbon deposits. The main elements of the petroleum play are 1) source rocks, 2) reservoir rocks, and 3) seal. In case of the conventional petroleum plays, a petroleum trap is another important element. The essential issue for each petroleum play is the appropriate time-placed set of processes including hydrocarbon generation, expulsion and migration. The coincidence between geological elements and processes mentioned above may result in creation of hydrocarbon deposits (Dembicki, 2017; Magoon and Dow, 1994).

In the "Siedlce W" tender area, we can distinguish two petroleum plays:

- conventional petroleum play, including the Middle Cambrian succession and selected Ordovician and Silurian horizons;
- unconventional petroleum play located in the lower part (Wenlock) of mudstone of the Pelplin Formation.

In case of conventional petroleum system, the Ordovician and Silurian rocks enriched in organic matter, which may be regarded as source rocks, belong to the Pelplin Formation (Wenlock part), Pasłęk Formation (upper part), as well as the Jantar and Sasino formations. The Middle Cambrian sandstones are the possible reservoir rocks, since the lateral connection between them and younger rocks was possible during the Variscan evolution of the sedimentary basin (Stolarczyk et al., 2004). The thick series of low-permeable Ordovician and Silurian strata plays also a role of a seal.

The unconventional petroleum play is located in the lower (Wenlock) part of the Pelplin Formation mudstones. The succession can be regarded as source rocks, reservoir rocks and self-sealing rocks (Zhao et al., 2016). Therefore, in this text, all potential source rocks will be described together in Chapter 3.2, reservoir rocks from the conventional play (Middle Cambrian sandstones) will be discussed in Chapter 3.3, while their seal will be shortly described in Chapter 3.4. The next one – Chapter 3.5 will be devoted to the characteristics of the unconventional oil play in the Pelplin Formation (excluding the issues of rock source rocks). Issues related to the generation, migration and expulsion of hydrocarbons will be discussed in Chapter 3.6.

There are five wells in the "Siedlce W" tender area: Kałuszyn 1, Kałuszyn 2, Polaki 1, SOK-Grębków-01 and Sokołów Podlaski 1. Since the data collected in the Kałuszyn 1 and 2 wells are the property of the investor, the results from these wells will not be presented here. In order to provide better information and regional context perspective, this text will additionally use data from selected wells located near the borders of the tender area, which are the Dobre 1, Rówce 1, Żebrak IG-1 and Tłuszcz IG-1 wells.

3.2. SOURCE ROCKS

Ordovician and Silurian fine-grained clastic rocks

The most promising rocks in terms of hydrocarbon source in the "Siedlce W" tender area and its neighborhood are the mudstones from the lower part of the Pelplin Formation, the upper part of the Pasłęk Formation, and mudstones representing the Sasino and Jantar formations (Podhalańska et al., 2018; Papiernik et al., 2019; Porębski and Podhalańska, 2019; Stolarczyk et al., 2004).

Silurian rocks

The thickness of the Wenlock in the "Siedlce W" area varies from ca. 75 to 87 m. However, the thickness of rocks in which TOC content is equal or greater than 1.5% is slightly smaller and do not exceed 70 m (Fig. 3.1). In the "Siedlce W" area, there is a local increase in

TOC content among the mudstones from the Pelplin Formation. The median of TOC in these rocks is never less than 1.25 %. (Fig. 3.2; Podhalańska et al., 2020).

The values of TOC and other geochemical parameters measured for the Pelplin Formation mudstones (Wenlock part) are presented in the Tab. 3.1. The highest TOC amounts were noticed in the SOK-Grębków-01 well (average 1.86%) and Tłuszcz IG-1 well (1.3 %). The pyrolysis analyses from the SOK-Grębków 01 and Tłuszcz IG-1 wells pointed to the presence of type II/II kerogen, and the hydrogen index (HI) average is 286 mg HC/g TOC and 294 mg HC/g in these wells, respectively (Tab. 3.1). The thermal maturity of the Wenlock in the Podlasie Syneclise/Depression changes from the early oil window level in the east to the gas window in the west (Fig. 3.1; Kiersnowski and Dyrka, 2013; Papiernik et al., 2019; Podhalańska et al., 2018). The value of thermal maturity for rocks in the prevailing part of the "Siedlce W" area and its vicinity oscillate around the early oil window level (average Tmax in wells SOK-Grębków-01 and Tłuszcz-IG1 equal 438–440 °C).

The Pelplin mudstones are underlain by the grey and dark grey claystones belonging to the Llandovery Pasłęk Formation. The TOC content in this formation represents values from 0.09 to 3.02 wt%. in the SOK-Grębków -01 well and up to 1.59 wt% in the Tłuszcz IG-1 well. However, the TOC content is elevated mainly in the upper part of the Llandovery succession in the described region.

The layer enriched in organic matter contains kerogen, which can be classified as type II/III or III types. The thermal maturity is at the oil window level (Tab. 3.2).

The mudstones from the Jantar Formation are typically black graptolitic shales. Although the thickness of the Jantar mudstones in the region does not exceed 5 m (Fig. 3.3), the amount of the TOC in the "Siedlce W" area and its vicinity displays very high values (Fig. 3.4; Podhalańska et al., 2018, 2020). In the Tłuszcz IG-1 well, the average TOC content in the Jantar Formation rocks is about 9.7%, while the maximum value is 17.4% (Poprawa and Kiersnowski, 2010). The kerogen type in the Jantar mudstones is mainly of type II or type II/III. In the eastern part of the tender area, the thermal maturity of organic matter indicates the level of oil window, and it grades towards the wet gas window to the west (Fig. 3.5).

Ordovician rocks

The total thickness of the Sasino mudstones (Caradoc) in the "Siedlce W" area is up to ca. 11 m (Fig. 3.6). The TOC median is up to 1 wt% in the described area (Fig. 3.7). In most of the tender area, the Sasino Formation mudstones indicate the level of thermal maturity corresponding to oil window; however, in the south-western part, the maturity grows to the wet gas window level (Fig. 3.8) (Kiersnowski and Dyrka, 2013; Papiernik et al., 2019; Podhalańska et al., 2018). Rock Eval pyrolysis parameters indicate that kerogen type III dominates in the described rocks (Podhalańska et al., 2018).

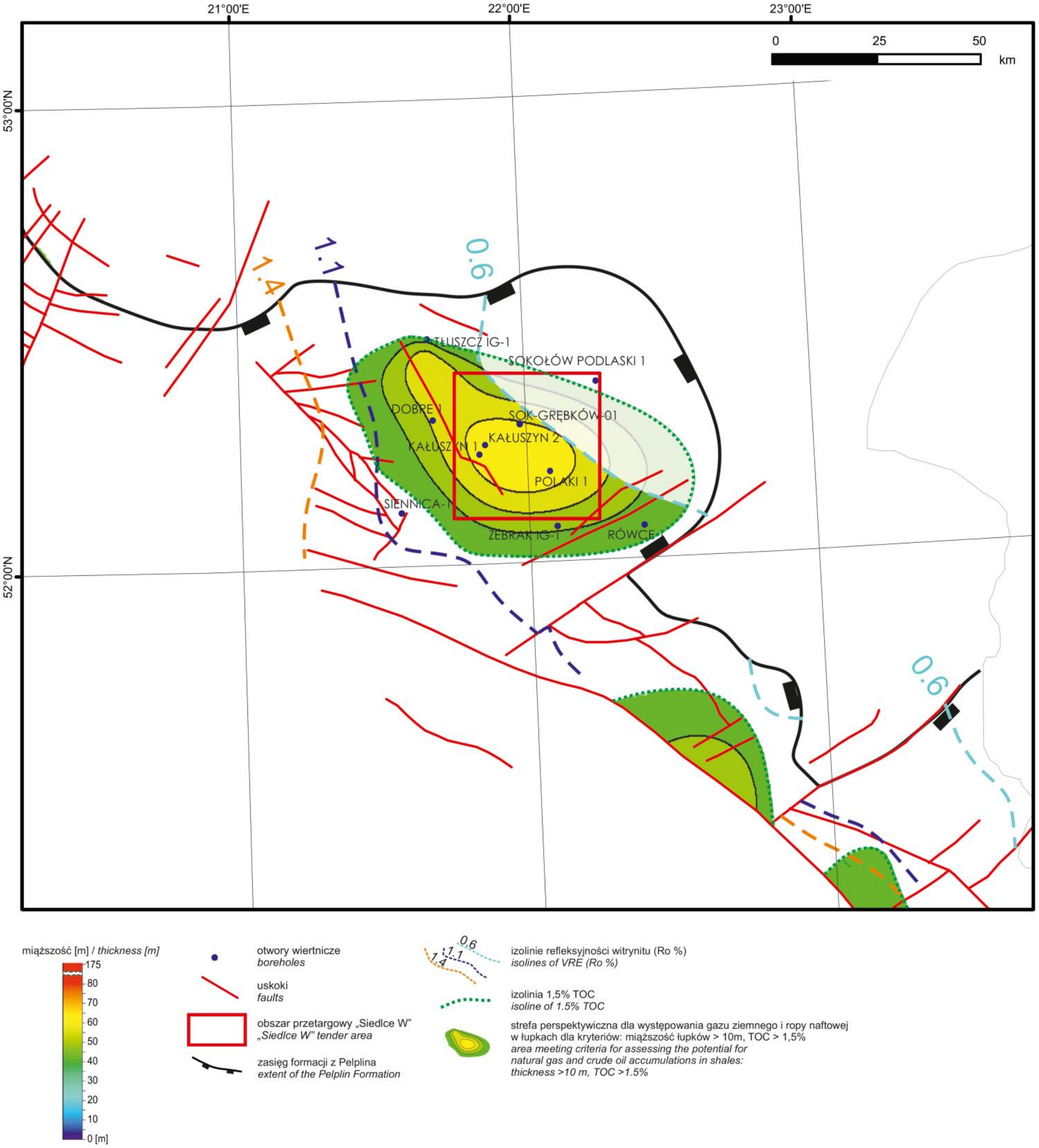


Fig. 3.1. Location of the "Siedlce W" tender area in relation to prospective zone for unconventional hydrocarbon accumulations in the Pelplin Formation (Podhalańska et al., 2020; modified).

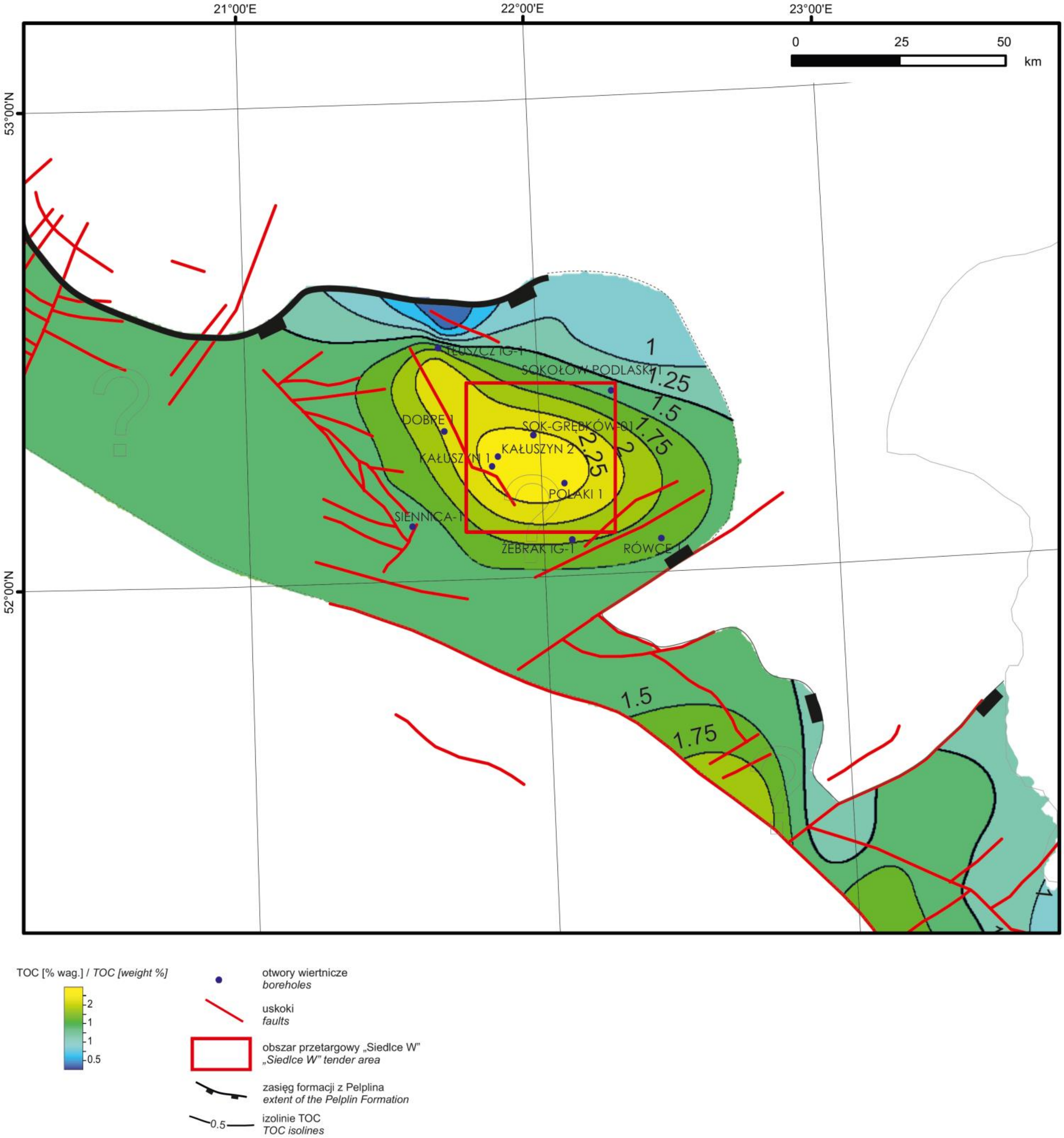


Fig. 3.2. TOC content in the Pelplin Formation and its stratigraphic equivalents in the "Siedlce W" tender area and its vicinity (Podhalańska et al., 2020; modified).

Rock-Eval pyrolysis	SOK-Grębków-01* Min.–Max. (average)	Tłuszcz IG-1 Min.–Max. (average)	Żebrak IG-1** Min.–Max. (average)
TOC [wt%]	0.20–3.13 (~ 1.86)	0.2–3.05 (~ 1.29)	0.16
T_{max} [°C]	438–444 (~ 440)	421–446 (~ 438)	327
S1 [mg HC/ gRock]	0.18–0.84 (~ 0.54)	0.06–0.89 (~ 0.42)	0.04
S2 [mg HC/gRock]	2.00–10.31 (~ 5.85)	0.18–11.21 (~ 4.05)	0.12
HI [mg HC/gTOC]	179–399 (~ 286)	27–404 (~ 294)	76
PI	0.06–0.12 (~ 0.09)	0.06–0.48 (~ 0.12)	0.26
Kerogen type	II/III	II/III	-

Tab. 3.1. Geochemical parameters of mudstones from the Wenlock part of the Pelpin Formation in the "Siedlce W" tender area and its vicinity (Gliniak et al., 2013; Podhalańska et al., 2018). * – pyrolysis analysis was conducted only for the sample with TOC amount greater than 1 wt%; ** – only one sample was analyzed in this well.

Rock-Eval pyrolysis	SOK-Grębków-01* Min.–Max. (average)	Tłuszcz IG-1 Min.–Max. (average)
TOC [wt%]	0.09–3.02 (~0.96)	0–1.59 (~0.59)
T_{max} [°C]	442–443 (~442)	385–477 (~432)
S1 [mg HC/ gRock]	0.33–0.79 (~0.49)	0.03–0.37 (~0.14)
S2 [mg HC/ gRock]	3.39–12.41 (~6.74)	0.06–4.13 (~1.3)
HI [mg HC/gTOC]	235–411 (~296)	58–276 (~182)
PI	0.06–0.09 (~0.07)	0.07–0.37 (~0.17)
Kerogen type	II/III	III, II/III

Tab. 3.2. Geochemical parameters of the Pasłęk Formation in the "Siedlce W" tender area (Gliniak et al., 2013; Podhalańska et al., 2018). * – pyrolysis analysis was conducted only for the samples with TOC amount greater than 1 wt%.

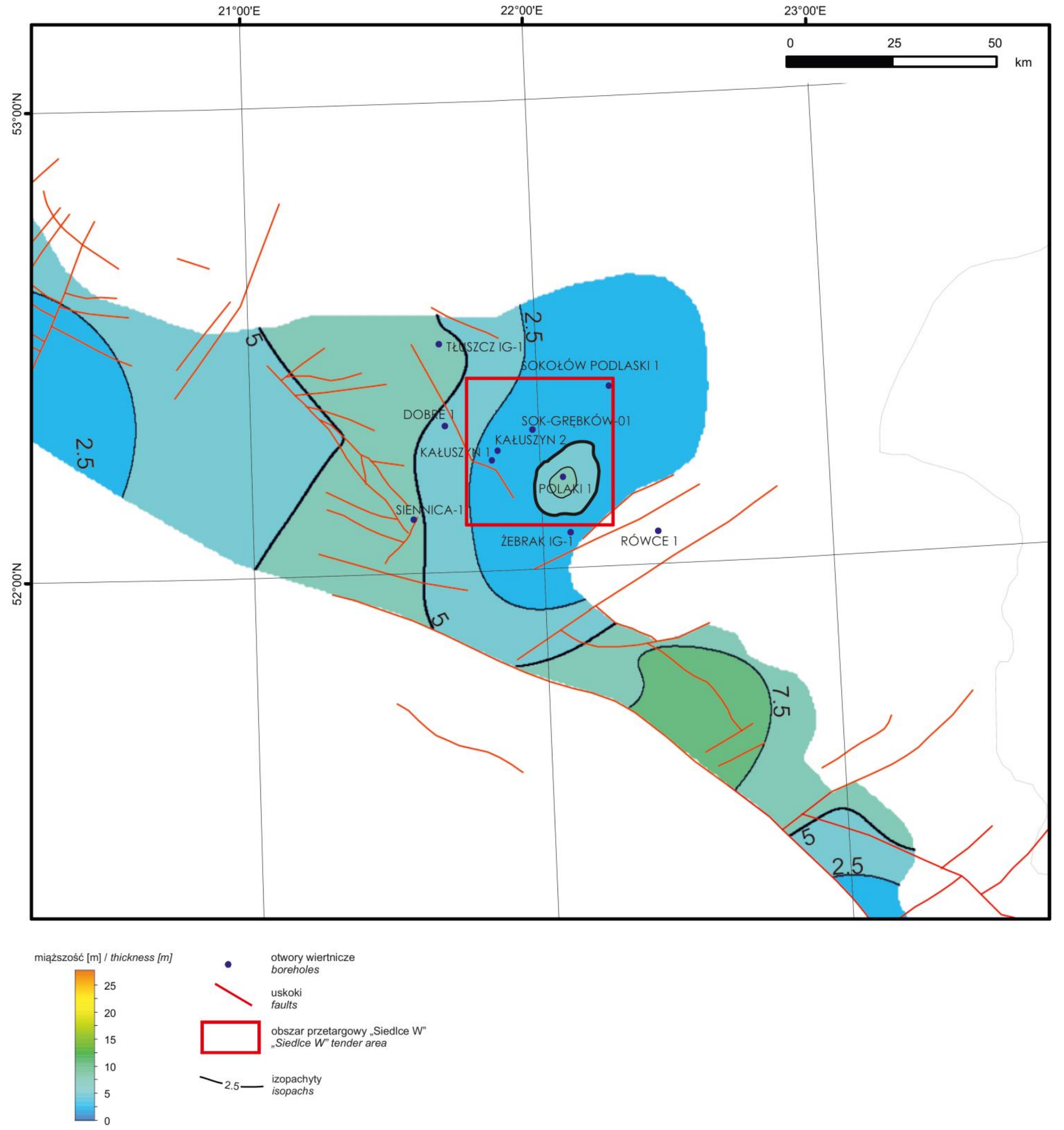


Fig. 3.3. Thickness of the Jantar Formation and its stratigraphic equivalents in the "Siedlce W" tender area and its vicinity (Podhalańska et al., 2020; modified).

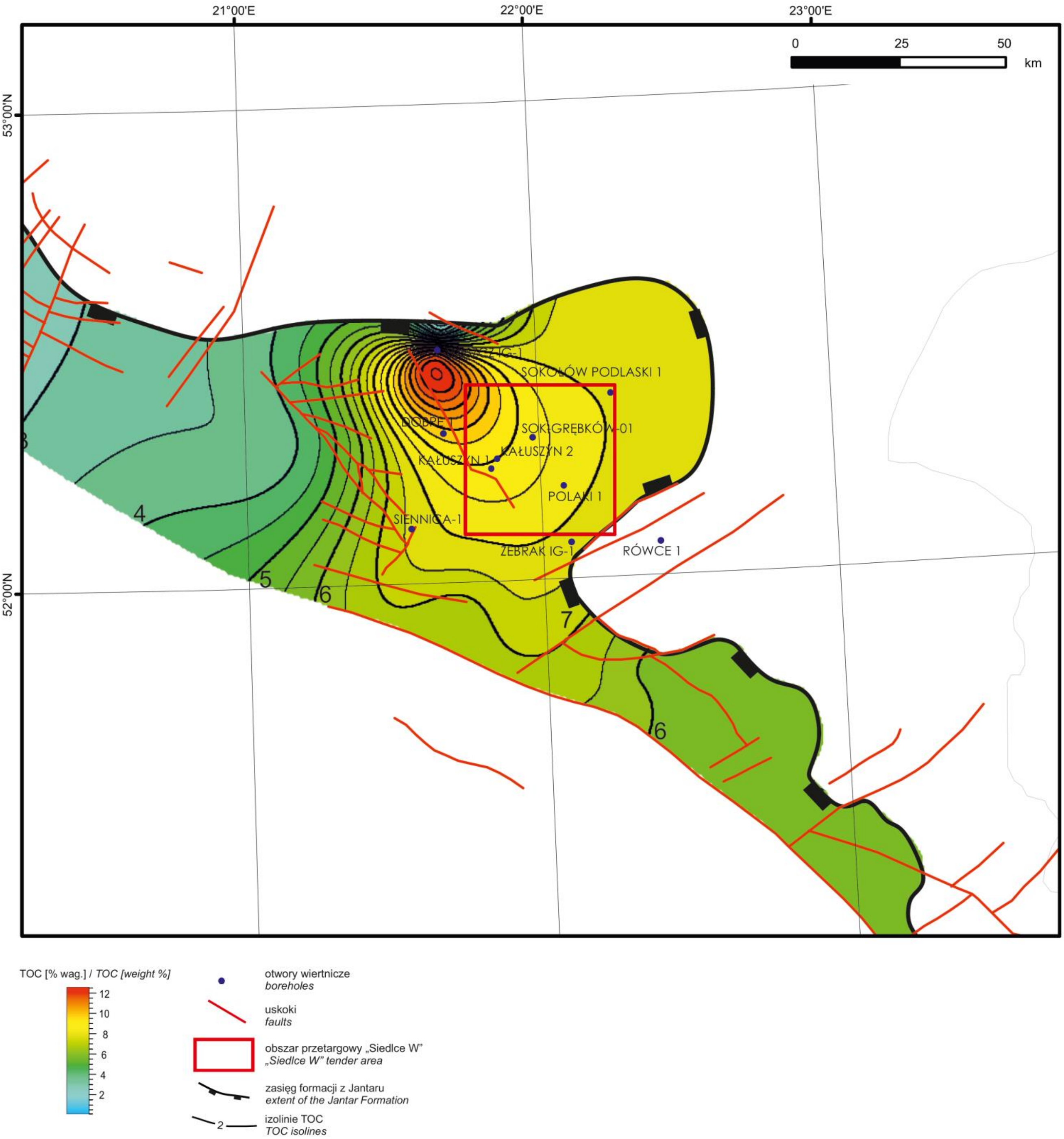


Fig. 3.4. TOC content in the Jantar Formation and its stratigraphic equivalents in the "Siedlce W" tender area and its vicinity (Podhalańska et al., 2020; modified).

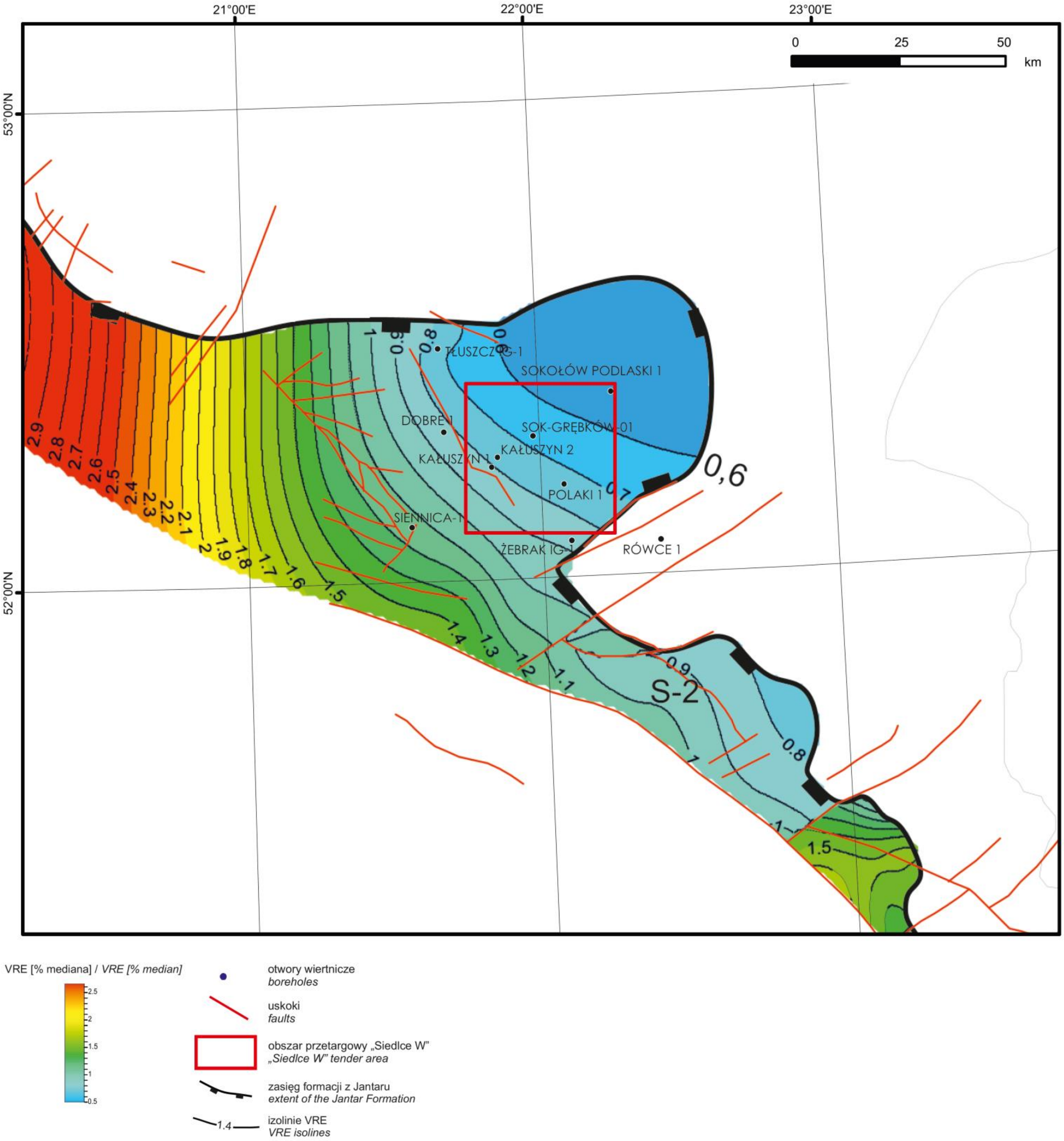


Fig. 3.5. Thermal maturity of the Jantar Formation and its stratigraphic equivalents in the "Siedlce W" tender area and its vicinity (Podhalańska et al., 2020; modified).

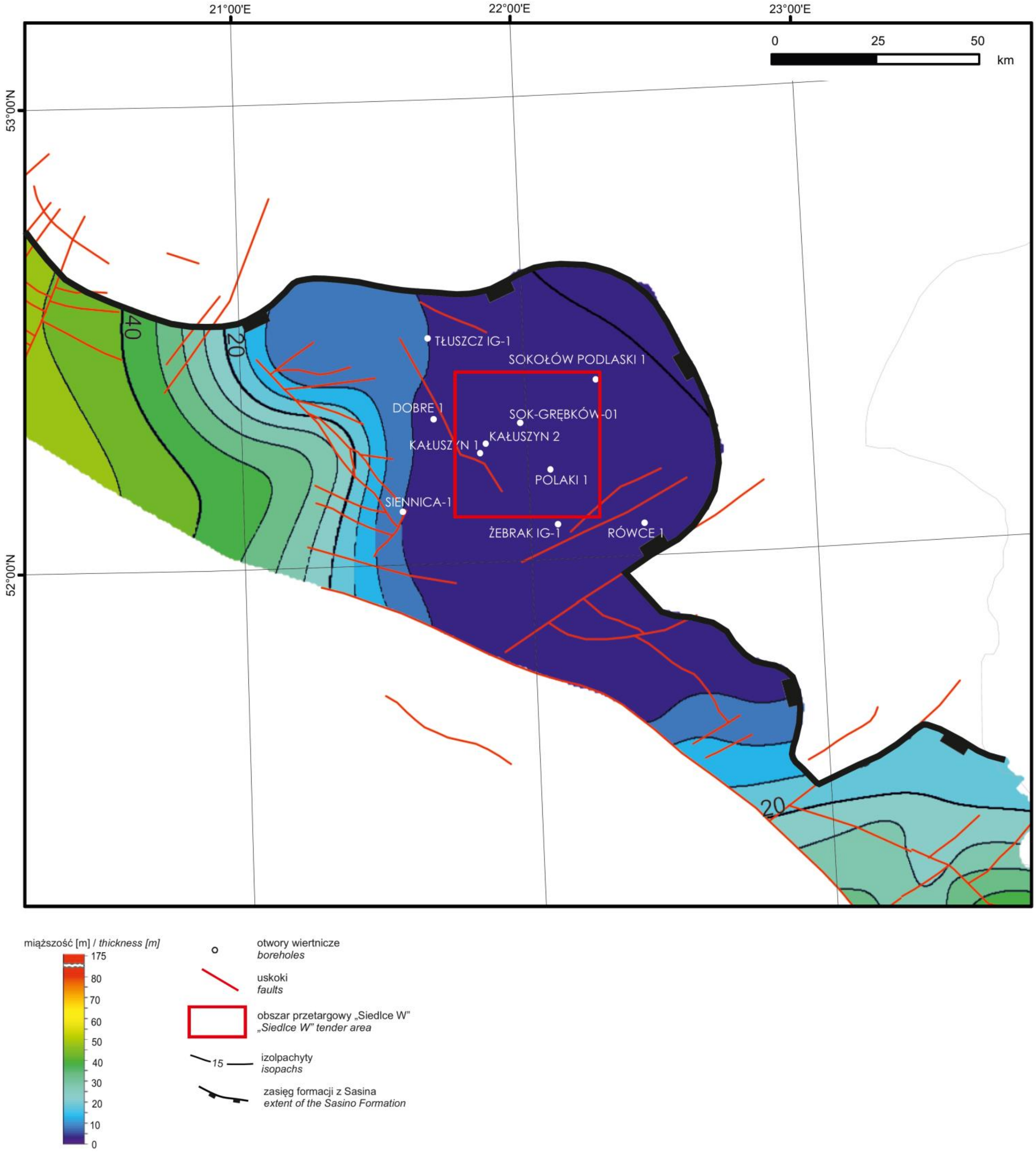


Fig. 3.6. Thickness of the Sasino Formation and its stratigraphic equivalents in the "Siedlce W" tender area and its vicinity (Podhalańska et al., 2020; modified).

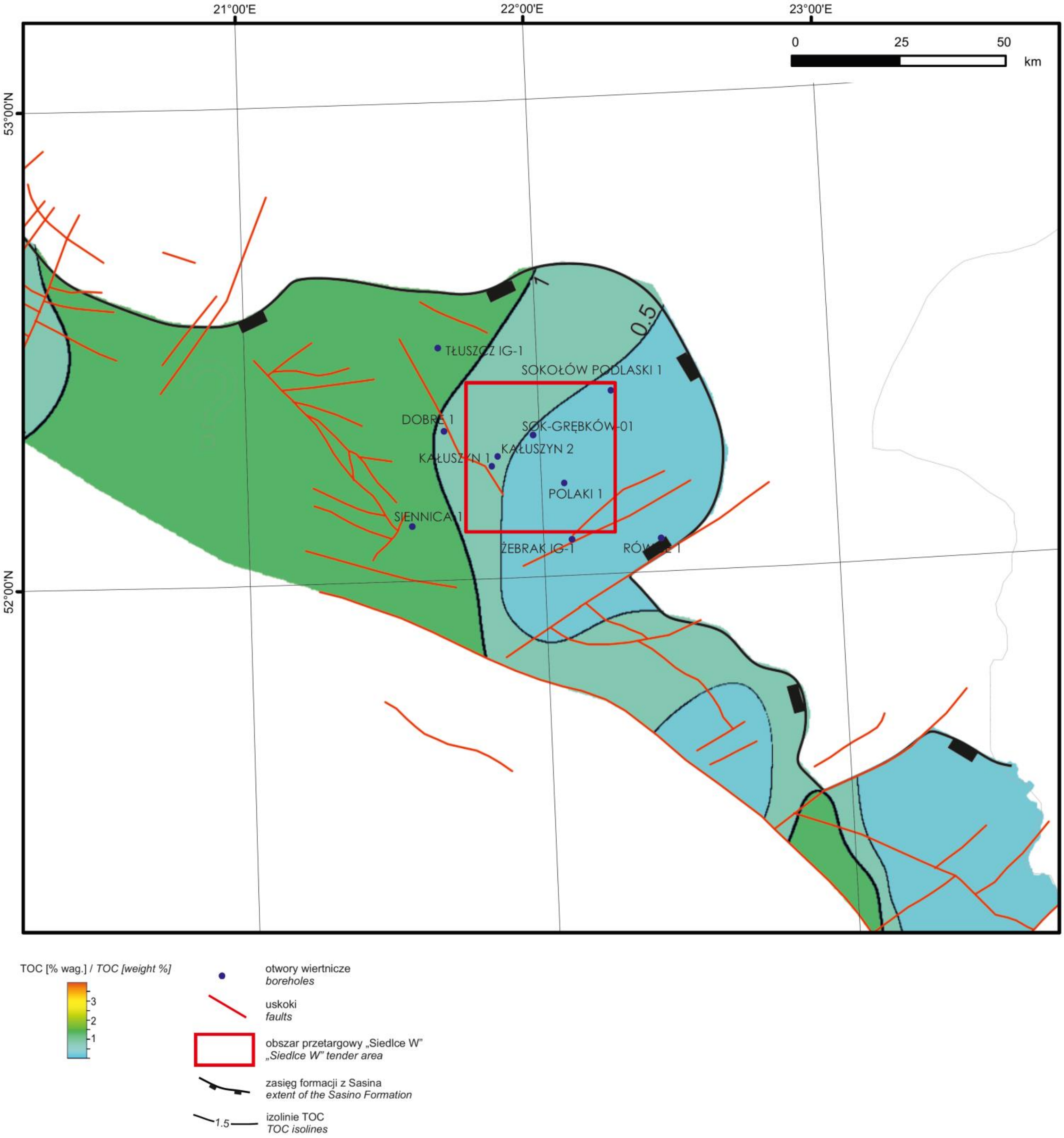


Fig. 3.7. TOC content in the Sasino Formation and its stratigraphic equivalents in the "Siedlce W" tender area and its vicinity (Podhalańska et al., 2020; modified).

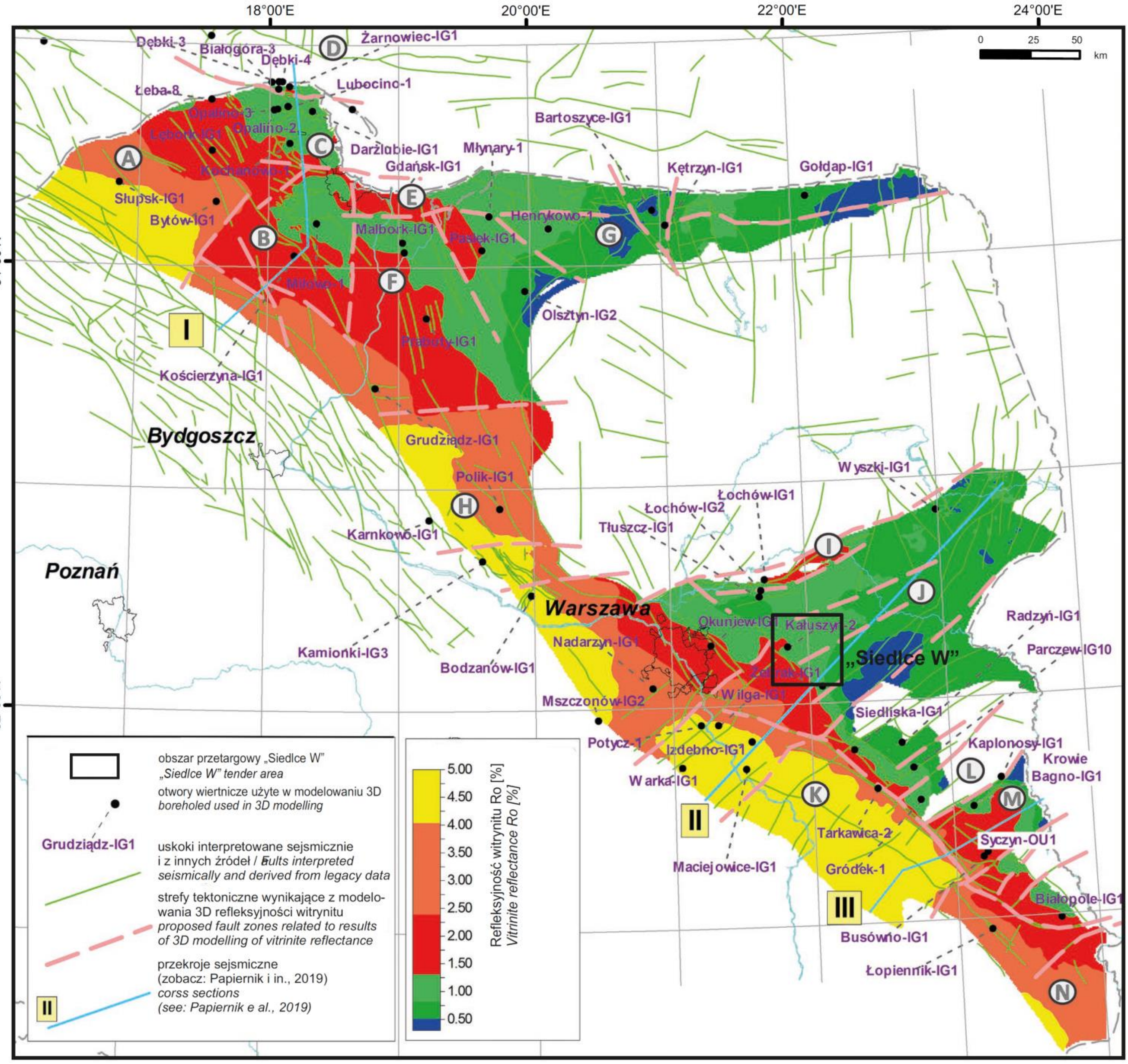


Fig. 3.8. Thermal maturity of the Caradoc Sasino Formation in Poland (Papiernik et al., 2019; modified).

3.3. CONVENTIONAL PLAY – RESERVOIR ROCKS

Lower and Middle Cambrian sandstones

Thickness:

Middle Camrbian ~100–200 m, increasing to SW.

Depth to the top:

1739.0 m – Sokołów Podlaski 1 well,
2198.5 m – Polaki 1,
2159.3 m – SOK-Grębków-01.

Stolarczyk et al. (1997) distinguished two potential reservoir horizons in the Podlasie Syneclise/Depression: B3 – covering the Lower Cambrian sandy complex, and D – covering the Middle Cambrian sandstones. Both horizons are represented by fine- and medium-grained, almost monomineral sandstones composed of quartz arenites, usually with a small amount of cement. Nevertheless, the Middle Cambrian sedimentary rocks have the greatest reservoir significance, and only these are described in this paragraph, except for the Sokołów Podlaski 1 well, where only Lower Cambrian sandstones are present in the succession.

The "Siedlce W" tender area is located on the Siedlce palaeoelevation (Stolarczyk et al., 2004), which means, according to Sikorska (1998), that the processes of diagenesis and silicification are less advanced here, in contrast to the regions buried to greater depths. The diagenesis had a crucial impact on the pore system evolution. The first stage of silicification stabilized the framework of the sandstones, which later enabled the preservation of porosity during intensified Silurian and Devonian subsidence (Sikorska, 1998). The second, post-Silurian stage of silicification did not cause severe porosity reduction in the elevated areas.

The Middle Cambrian sandstones have good reservoir properties. In most parts of the "Siedlce W" area, the porosity of sandstones ranges from 5 to 15% (Fig. 3.9; Stolarczyk et al., 2004). It is also important that the permeability in these sediments usually increases with the porosity (Stolarczyk et al., 2004). The porosity and permeability measurements for the Cambrian sandstones are summarized in Tabs 3.3–3.4.

Referring to the hydrochemical features of the Middle Cambrian sandstones, the brines contain mainly chlorine, calcium and sodium. The Cambrian aquifers are recharged mainly by the water from the Mazury – Suwałki High (Bojarski and Sadurski, 2000; Stolarczyk et al., 2004). The total mineralization of the brines in the "Siedlce W" afrea represents values from 100 to 250 g/l and a regional trend of mineralization growth towards the SW can be seen (Bojarski and Sadurski, 2000; Stolarczyk et al., 2004).

Waters from Cambrian rocks were not analyzed in the Sokołów Podlaski 1 and Sok-Grębków-01 wells. In the Polaki 1 well, an interval of 2304.8–2358.0 m was sampled. The analysis indicated that the fluid was a mixture of drilling mud filtrate and Cl-Ca-Na brine, with the pH equal to 7.5 and the following composition: 91.6 g/l of Cl^-; 0.17 g/l HCO_3^-; 32.7 g/l Ca_2^+, and 0.34 of g/l Mg_2^+.

In the Sokołów Podlaski 1 well, no formation tests have been conducted in the Cambrian interval. In the Sok-Grębków-01 well, the presence of gas in the drilling mud was recorded; its greatest amounts were measured in the Ludlow-Cambrian interval (Tab. 3.5). In the Polaki 1 well, one well test in the Middle Cambrian formations was performed (in the interval 2252.3–2304.8), and the brine flow was obtained with a rate of 748.8 m^3/day, and the permeability of 350 mD was estimated. No symptoms of bitumens were noted; however, small amounts of bitumens (about 0.01%) were detected in the Middle Cambrian samples after extraction with chloroform.

Gaseous brine inflows were also observed in the Middle Cambrian and Lower Cambrian intervals in the Kałuszyn 1 and Kałuszyn 2 wells located in the central part of the "Siedlce W" area. Hydrocarbon symptoms were also recorded in the wells near the tender area:

- the flows of gasified brine were recorded in Lower Cambrian rocks in the Tłuszcz IG-1 well,
- traces of oil in the cracks were observed at the top of the Cambrian (interval 2399.0–2425.0 m) in the Żebrak IG-1 well; extraction with chloroform showed a bitumen content between 0.1–0.2%,

• similar amounts of extracted bitumens were also obtained in the Dobre 1 well.

Well	Number of samples	Stratigraphy	Depth [m]	Porosity [%] Min.–Max. (average)	Permeability [mD] Min.–Max. (average)
Polaki 1	3	Middle Cambrian	2198.5–2334.5	2.9– 9.1 (6.8)	350[1]
	7	Lower Cambrian	2334.5–2760.0	1.6–12.6 (7.1)	-
SOK-Grębków-01	3	Middle Cambrian	od 2159.3	7.5–13.7 (10.9)	1–187 (95.9)
	-	Lower Cambrian	-	-	-
Sokołów Podlaski 1	-	Middle Cambrian	-	-	-
	20	Lower Cambrian	1739.0–1771.0	5–14 (10.4)	-
Rówce 1	23	Middle Cambrian	1481.0–1608.0	1.8–15.9 (10.9)	0.04–340 (88)
	22	Lower Cambrian	1608.0–2048.0	1–12.4 (4.9)	0–3.2 (0.3)
Żebrak IG-1	13	Middle Cambrian	2399.3–2472.2	2–8 (7)	-
	-	Lower Cambrian	-	-	-

Tab. 3.3. Porosity and permeability in the Cambrian according to the final well reports (Garbacik, 1973; Gliniak et al., 2013; Kiełbasa and Kowalska-Łącka, 1972; Kowalska-Łącka and Jagiełło, 1971; Lendzion and Wszeborski, 1963; CGDB, 2021).

Well	Number of samples	Depth [m]	Helium porosity [%] Min.–Max. (average)	Total porosity NMR [%] Min.–Max. (average)	Effective porosity NMR [%] Min.–Max. (average)	Unreducted water [%] Min.–Max. (average)	Permeability [mD] Min.–Max. (average)
Rówce 1	7	1481.0–1608.0	10.6–14.8 (13)	10.5–14.9 (12.9)	10.5–14.8 (12.9)	0–0.34 (0.09)	34.5–160.8 (90.3)
Tłuszcz IG-1	2	1990.7–2125.3	10.9–18.7 (15.6)	15.6–21.6 (18.6)	-	-	-

Tab. 3.4. Helium porosity and NMR-technique pore-measurement in the Cambrian sandstones in the Rówce 1 and Tłuszcz IG-1 wells (Podhalańska et al., 2016).

Depth [m]	Stratigraphy	Gas composition from the drilling mud							
		Total gas [ppm]	C1 [ppm]	C2 [ppm]	C3 [ppm]	iC4 [ppm]	nC4 [ppm]	iC5 [ppm]	nC5 [ppm]
1350.0–1445.0	Permian	80	80						
1446.0–1554.0	Permian – Silurian	2930	790	320	300	120	180		
1555.0–1614.0	Ludlow	480	190	70	50				
1615.0–1820.0		2980	700	320	330	80	250		
1821.0–2170.0	Ludlow – Cambrian	29510	8910	3470	3170	340	1370	240	220
2171.0–2243.0		1890	1070	220	160	30	130		

Tab. 3.5. Composition of gas from the drilling mud in the Sok-Grębków-01 well (Gliniak et al., 2013)

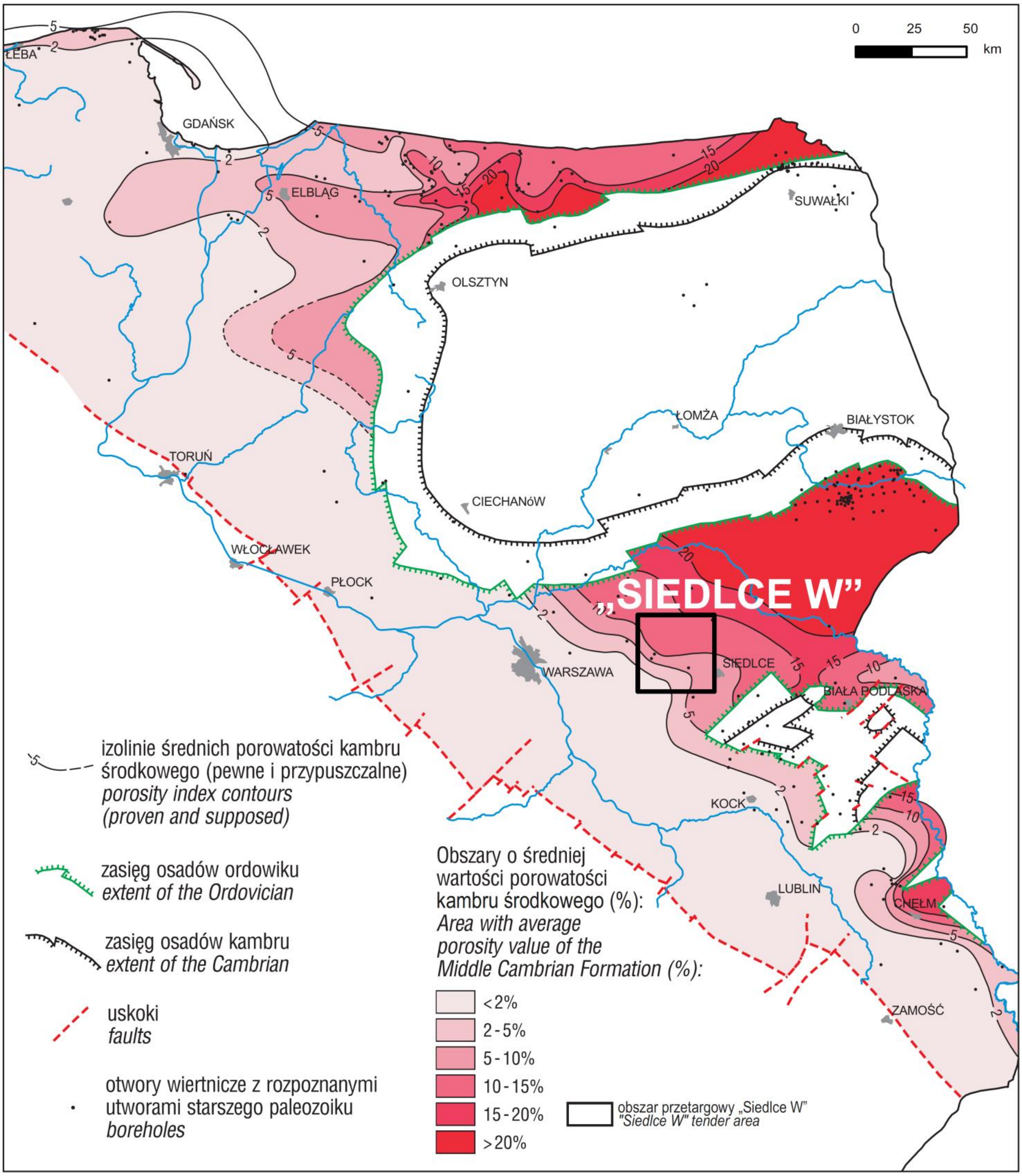


Fig. 3.9. Porosity in the EEC Middle Cambrian sandstones (Stolarczyk et al., 2004; modified).

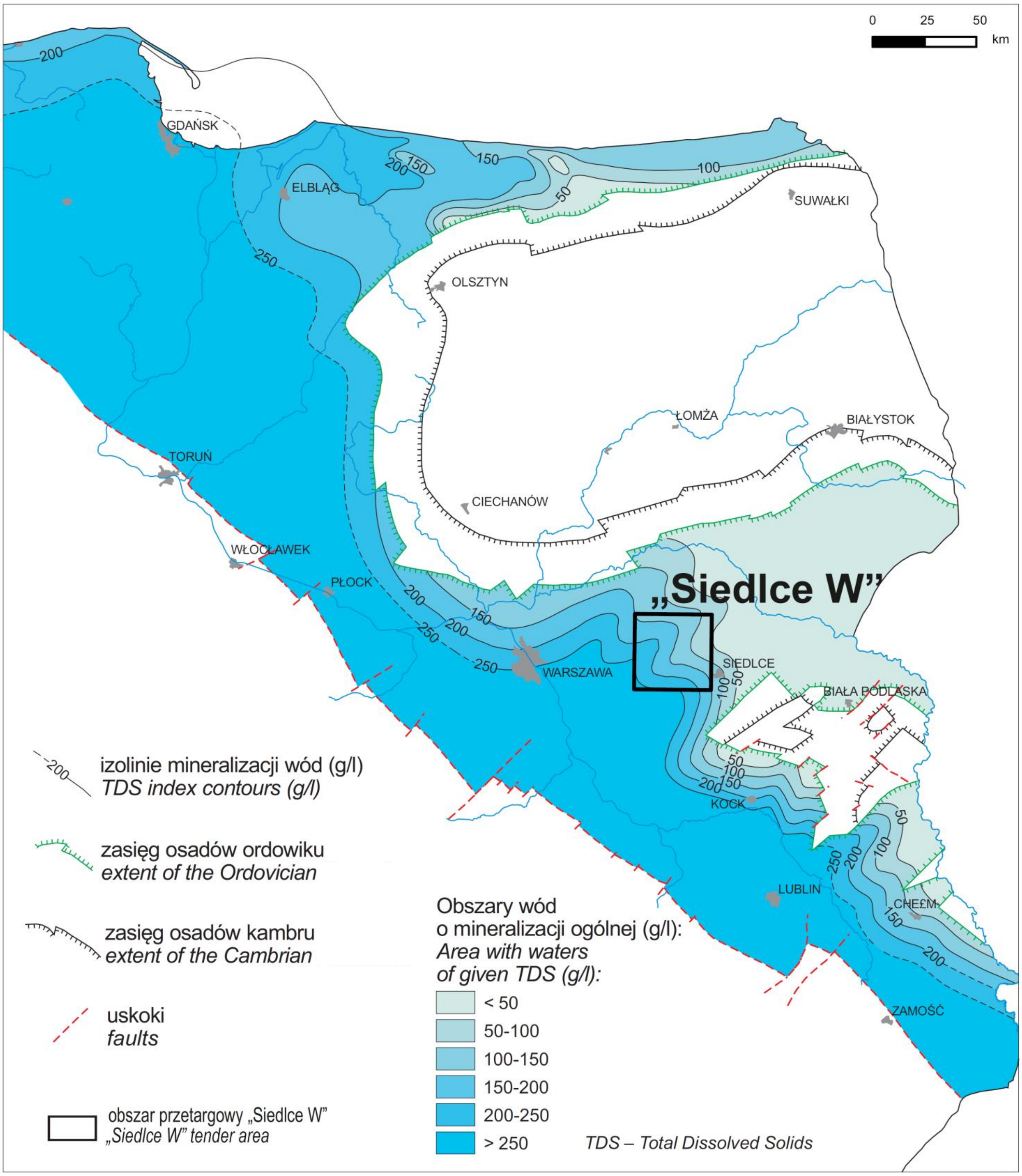


Fig. 3.10. Total mineralization in brines in the EEC Middle Cambrian sandstones (Stolarczyk et al., 2004; modified)

3.4. CONVENTIONAL PLAY – SEAL

The Cambrian sandstones in the "Siedlce W" tender area are sealed by the thick succession of fine-grained Ordovician and Silurian sedimentary rocks, which were described in details in chapters 2.2 and 2.3. Good isolation of the Cambrian rock is confirmed by high values of total mineralization of Cambrian brines, which falls in the range between 100 and 250 g/l (Fig. 3.10; Stolarczyk et al., 2004).

3.5. UNCONVENTIONAL PLAY

Pelplin mudstone Formation

Thickness:

from ~70–85 m within the "Siedlce W" tender area to ~112 m in the Rówce 1 well

Depth to the top:

1605.0 m – Sokołów Podlaski 1,
2062.0 m – Polaki 1,
2043.0 m – SOK-Grębków-01.

Detailed analysis of the Ordovician and Silurian sedimentary rocks deposited in the Baltic-Podlasie-Lublin Basin was carried out at the Polish Geological Institute – National Research Institute in the years 2015-2018 to estimate their prospectivity in terms of unconventional oil and gas accumulations (Podhalańska et al., 2016, 2018). As a result, four prospective zones were determined, in which the criteria (at least the minimal values) presented in Tab 3.6 are fulfilled (Podhalańska et al., 2020; Wójcicki et al., 2017).

One of the prospective zones was identified and determined in the lower part (Wenlock) of the Pelplin Formation. The "Siedlce W" tender area covers a large part of the zone east of Warsaw (Fig. 3.1). The porosity and permeability of the Pelplin Formation mudstones in the "Siedlce W" tender area and its vicinity have not yet been thoroughly investigated by using a consistent set of laboratory methods. The porosity values available in the reports from the Sokołów Podlaski 1 and Żebrak IG-1 wells are in the range from 3 to 7%, with the average values of 5.2 and 4.3%, respectively. In the SOK-Grębków-01 well, the porosity of Wenlock mudstones (gas-filled porosity, TRA method) ranges from 2.1 to 3.1%, while the average is 2.6% (Tab. 3.7). Additionally, in the Tłuszcz IG-1 and Żebrak IG-1 wells, porosity was measured using both helium porosity and nuclear magnetic resonance technique (NMR, Tab. 3.8). The range of helium porosity variations in these wells is from 0.9 to 12%, while the NMR total porosity varies from 9.3 to 16.8%. In NMR measurements, the Kp1 component corresponds to porosity developed within clay minerals and the Kp2 component corresponds to capillary and free water. The Kp2 z values can be treated as an effective porosity.

The number of porosity measurements for the Pelplin Formation mudstones is not large; however, taking into account the homogeneity of this lithostratigraphic unit, in case of mineral composition and structural and textual features (see Chapter 2.3 and Podhalańska et al., 2018), it may be assumed that the measurements given above are representative of the entire formation. The sediments in the Pelplin Formation are also very uniform in terms of their geomechanical parameters. The brittleness factor ranges from 0.55 to 0.6. The values of dynamic Young's modulus measured parallel to the layers vary within 65 GPa, and the Poisson's ratio is 0.235. The median of measurements of these parameters in the direction perpendicular to the layers is 41.6 GPa and 0.22, respectively (Podhalańska et al., 2018). It means that the discussed rocks are susceptible to hydraulic fracturing. Due to their homogeneity, in the case of fracturing treatments, there is no concern about extinguishing the generated fractures.

The well tests in most cases did not provide positive results in the "Siedlce W" area and its surroundings. Only in the SOK-Grębów-01 well, analyses of gas content in the drilling fluid were carried out, which showed that its highest concentrations were in the Wenlock interval, where the average C1–C3 gas volumes (methane, ethane, propane) vary within about 0.2925–0.58% for C1, 0.1376–0.2% for C2 and 0.1425–0.19% for C3 (Gliniak et al., 2013). Additionally, gas desorption was performed from the cores taken from the interval representing the Wenlock mudstones. These tests showed a diverse composition of desorbed and residual gas. In the Żebrak IG-1 well, extraction with chloroform showed that the Wenlock rocks contain from 0.029 to 0.22% of bitumens (Lendzion, 1975).

The sealing is ensured not only by the lower part of the Pelplin mudstone itself but also by low permeable, adjacent Ludlow layers. These sediments are included in the upper part of the Pelplin Formation and the Kociewie Formation. Their thickness in the "Siedlce W" ranges from about 378 m (in the Sokołów Podlaski 1 well), through about 591 m (in the SOK-Grębków 1 well). In the SW part some of them probably exceed about 650 m (in the Dobre-1 well, located to the west of the Siedlce area).

Criteria	Ro [%]	TOC [wt%]	Thickness	Porosity filled with movable hydrocarbons	Brittleness (quartz, feldspars and carbonates)	Total desorbed gas	OSI	Reservoir pressure
Optimal value	-	>2%	>15 m	>2%	≥65%	≥1.5 m^3/t	>100	above the hydrostatic pressure
Minimal value	≥0,6 <3,5	>1,5%	≥10 m	-	≥40%	≥0.5 m^3/t	>50	-

Tab. 3.6. Boundary criteria for oil and gas effective accumulations in shales, after Wójcicki et al. (2017).

Well	Number of samples	Depth [m]	Porosity [% vol.] Min.–Max. (average)	Permeability [mD] Min.–Max. (average)
Sokołów Podlaski 1	6	1605.0–1691.5	3–7 (5.2)	-
Żebrak IG-1	13	2274.5–2343.0	3–6 (4.3)	-
SOK-Grębków-01	14	2043.0–2115.0	2.1–3.1 (2.4)	6.3E-07–1.5E-05 (5.2E-06)

Tab. 3.7. Results of porosity and permeability measurements in selected wells from the "Siedlce W" tender area and its vicinity (Gliniak et al.,2013; Lendzion and Wszeborski, 1963; Kowalska-Łączka and Jagiełło, 1971; CGDB, 2021).

Well	Number of samples	Depth [m]	Helium porosity [%] Min.–Max. (average)	Total porosity NMR [%] Min.–Max. (average)	Effective porosity NMR [%] Min.–Max. (average)	Unreducted water [%] Min.–Max. (average)	Permeability [mD] Min.–Max. (average)
Tłuszcz IG-1	12	1803.0–1929.0	5.3–10.2 (8.5)	9.2–16.2 (13.3)	4.3–11.6 (9)	3.9–5 (4.3)	0–1.26 (0.19)

Tab. 3.8. Helium porosity and NMR porosity results for the Wenlock samples from the Tłuszcz IG-1 well (Podhalańska et al., 2016).

3.6. GENERATION, MIGRATION AND ACCUMULATION OF HYDROCARBONS

Introduction

Fine-grained sedimentary rocks representing the Sasino Formation (Caradoc), Jantar and Pasłęk formations (Llandovery) and Pelpin Formation (Wenlock part) are regarded as the potential source rocks for hydrocarbons in the Middle Cambrian sandstones. On the other hand, the Pelplin mudstones play the role of source, reservoir and sealing rock in the unconventional, shale-type petroleum play. The Ordovician and Silurian rocks have a common history of subsidence and diagenesis (Botor et al., 2019a; Poprawa, 2010). Therefore, also the processes of hydrocarbon generation took place in these rock in a similar time interval and according to the same pattern (Botor et al., 2019b). Hence, the processes of hydrocarbons generation will be described together for both petroleum plays, while the migration and accumulation in the conventional system will be considered later.

Generation and expulsion of hydrocarbons

The studies of burial and thermal history suggest that the early Paleozoic sedimentary rocks in the Podlasie Syneclise/Depression have already reached a maximal range of temperatures between the Late Silurian and Late Carboniferous/Early Permian period (Botor et al., 2017; 2019a, b; Podhalańska et al., 2018). The process of hydrocarbon generation, which took place between the Late Silurian and the end of the Carboniferous, was interrupted due to the Variscan inversion of the basin. After that, the Paleozoic sedimentary succession was generally cooling down (Botor et al., 2017). The kerogen transformation ratio (TR) in the Ordovician and Silurian rocks is shown in Fig. 3.11. The expulsion of hydrocarbons took place with only a small delay after the generation processes (up to a few million years; Figs 3.12– 3.13). The results provided by Botor et al. (2019 a, b) allow us to estimate that within the “Siedlce W” tender area, the oil expulsion from the Caradoc rocks was between 0 and 50 Mton/km^2/Ma, while the gas expulsion reached the value of 20 Mton/km^2/Ma (Fig. 3.12A and Fig. 3.13A). In the case of the Llandovery rocks, the gas expulsion rate was determined at ca. 10 Mton/km^2/Ma (Fig. 3.12B and Fig. 3.13B). Although the highest rates of oil and gas expulsion were estimated westwards from the “Siedlce W” tender area, the reservoir properties of the Cambrian sandstones located to the west from the “Siedlce W” are getting worse. Moreover, the depth of their deposition also increases in the west direction. It cannot be excluded that the hydrocarbons, which have been generated west from the Siedlce region, later migrated east, also toward the “Siedlce W” area, where the Cambrian sandstones are at a smaller depth and have better reservoir properties. In terms of the potential presence of unconventional deposits within the Pelplin Formation, it is worth noting that the Pelplin Formation mudstones are characterized by uniformity of the mineral composition and geomechanical features, which is rarely found among this type of rock and may have a positive impact on the fracturing processes.

The age and mechanism of hydrocarbon migration in the conventional petroleum play

The “Siedlce W” tender area lies within the Siedlce palaeoelevation (Fig. 3.14), which is characterized by an increase in the thickness of the Middle Cambrian sandstones and a reduction of the Ordovician succession (Stolarczyk et al., 1997, 2004). Tomczykowa and Tomczyk (1979) observed lithological differences and a thickness reduction in Silurian rocks in this region, which suggests that local structural forms could have formed relatively early, before the hydrocarbon generation phase. This may have enabled lateral contacts between Cambrian rocks and younger strata, which could later facilitate the migration of hydrocarbons.

Finally, the migration of hydrocarbons to the Cambrian reservoir rocks in the area of the western edge of the EEC, including in the “Siedlce W” tender area, became possible as a result of the post-Sylurian changes in the structural arrangement of the Lower Paleozoic sedimentary rocks (Stolarczyk et al., 2004). These structural changes were induced by the compressive stress related to Caledonian and

Variscan movements (Dadlez, 1998; Poprawa, 2019). The stresses arranged along the SW-NE direction created conditions for the formation of hydrocarbon traps parallel to the EEC edge (Fig. 3.15). The migration could take place especially in the regions where Cambrian sandstones show high porosity and permeability.

Traps

The current state of recognition of the deep geological structure in the “Siedlce W” area does not allow for a precise description of potential hydrocarbon traps. However, by the analogy to the regions, where hydrocarbon deposits in the Cambrian rocks have been discovered earlier (i.e. the Łeba High or places located north of the Polish borders), it may be assumed that the traps can be of lithological and structural types (Stolarczyk et al., 2004).

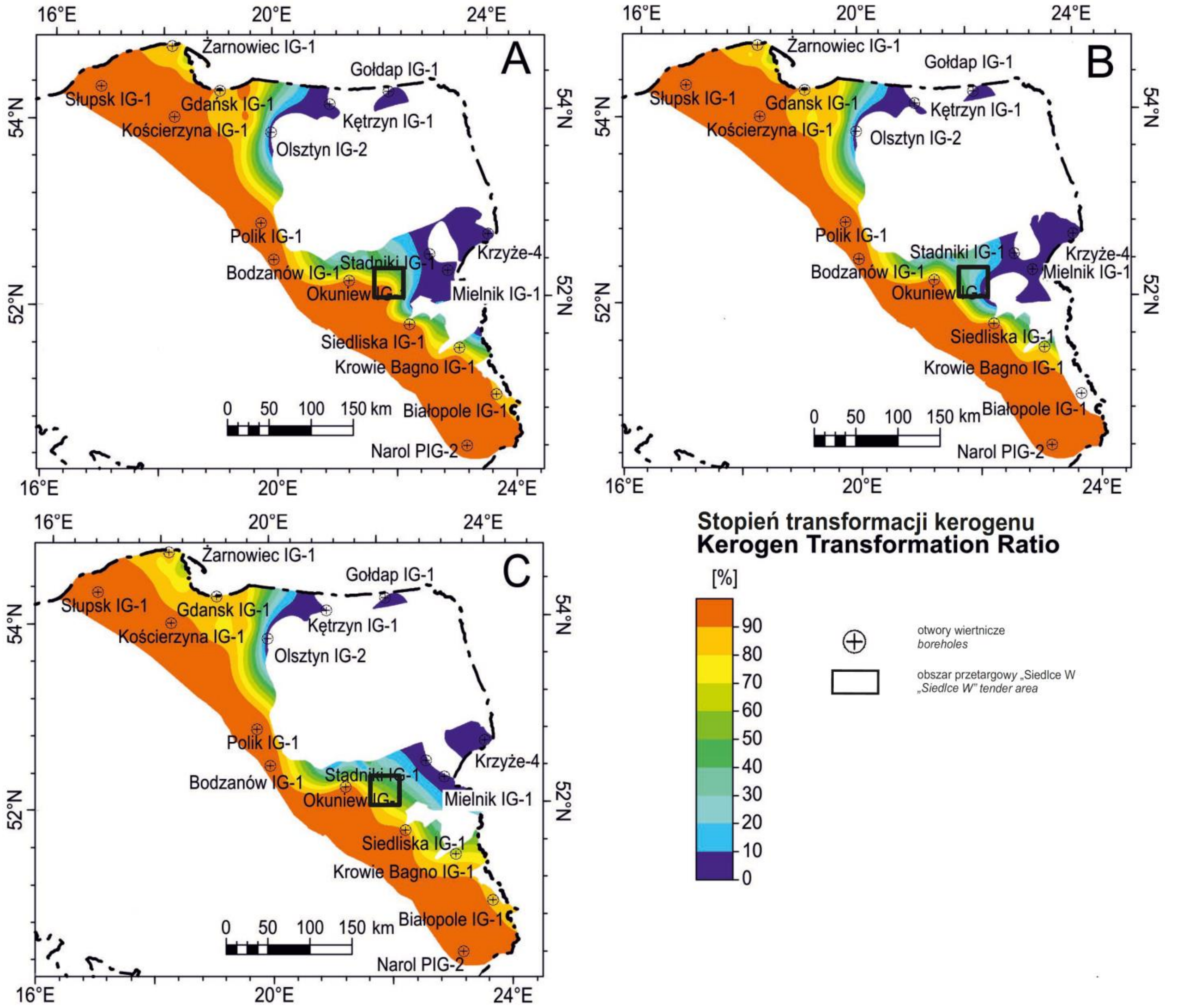


Fig. 3.11. Location of the "Siedlce W" area in the map of kerogen transformation (TR) distribution: (A) Caradoc, (B) Llandovery, and (C) Wenlock (Botor et al., 2017, 2019a; modified).

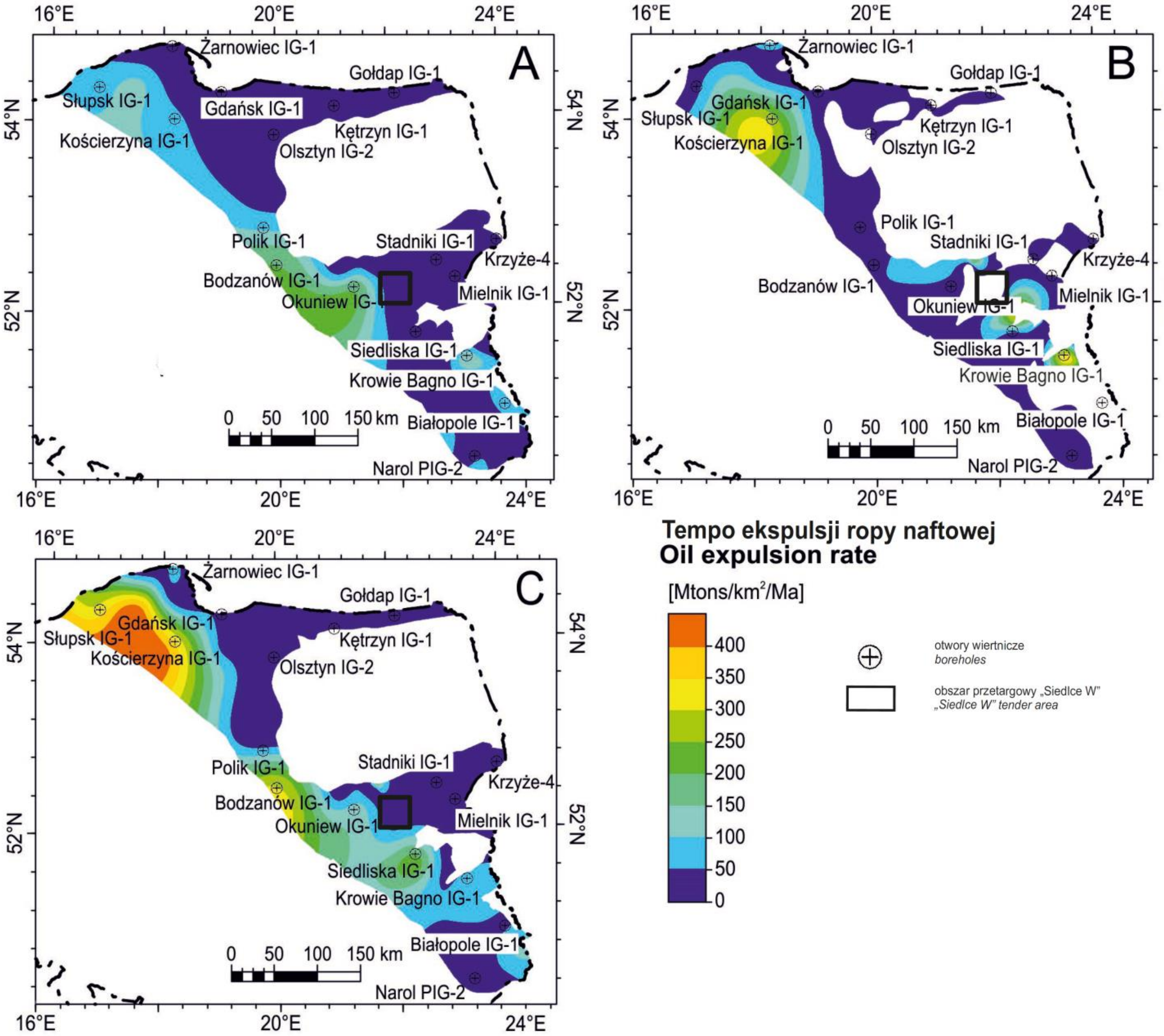


Fig. 3.12. Location of the "Siedlce W" area in the map of oil expulsion rate: (A) Caradoc, (B) Llandovery, and (C) Wenlock (Botor et al., 2017, 2019a; modified).

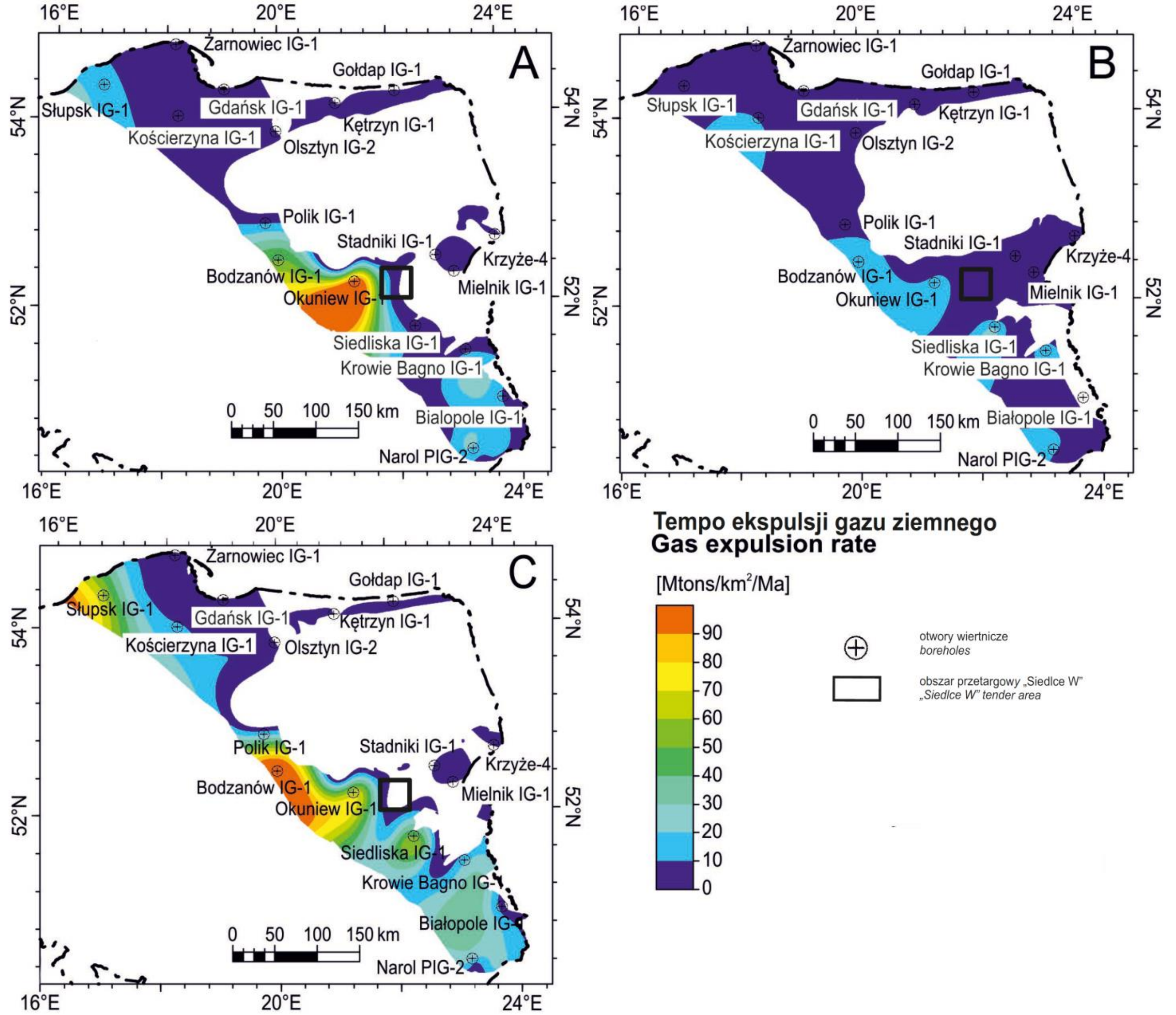


Fig. 3.13. Location of the "Siedlce W" area in the map of gas expulsion rate: (A) Caradoc, (B) Llandovery, and (C) Wenlock (Botor et al., 2017, 2019a; modified).

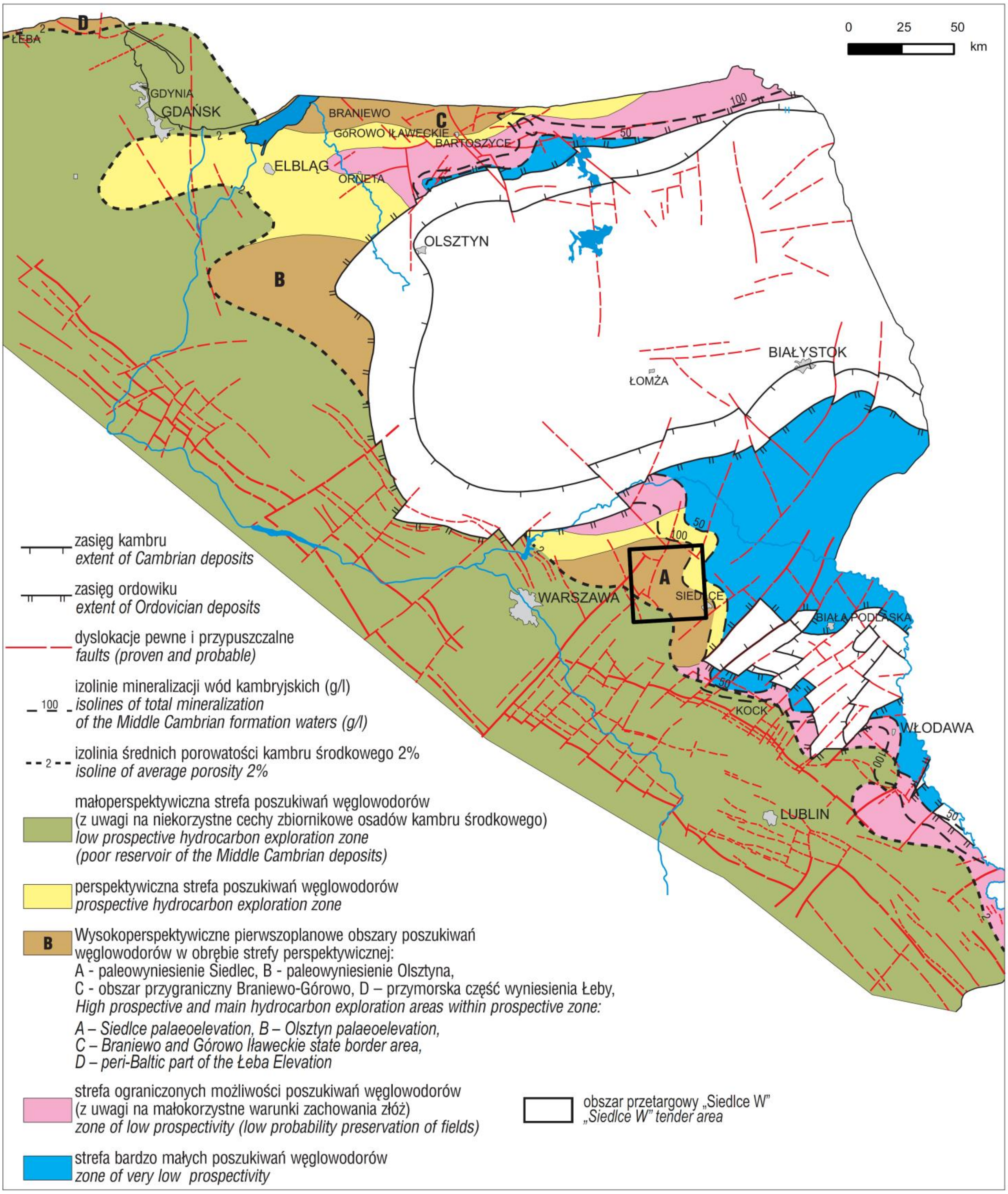
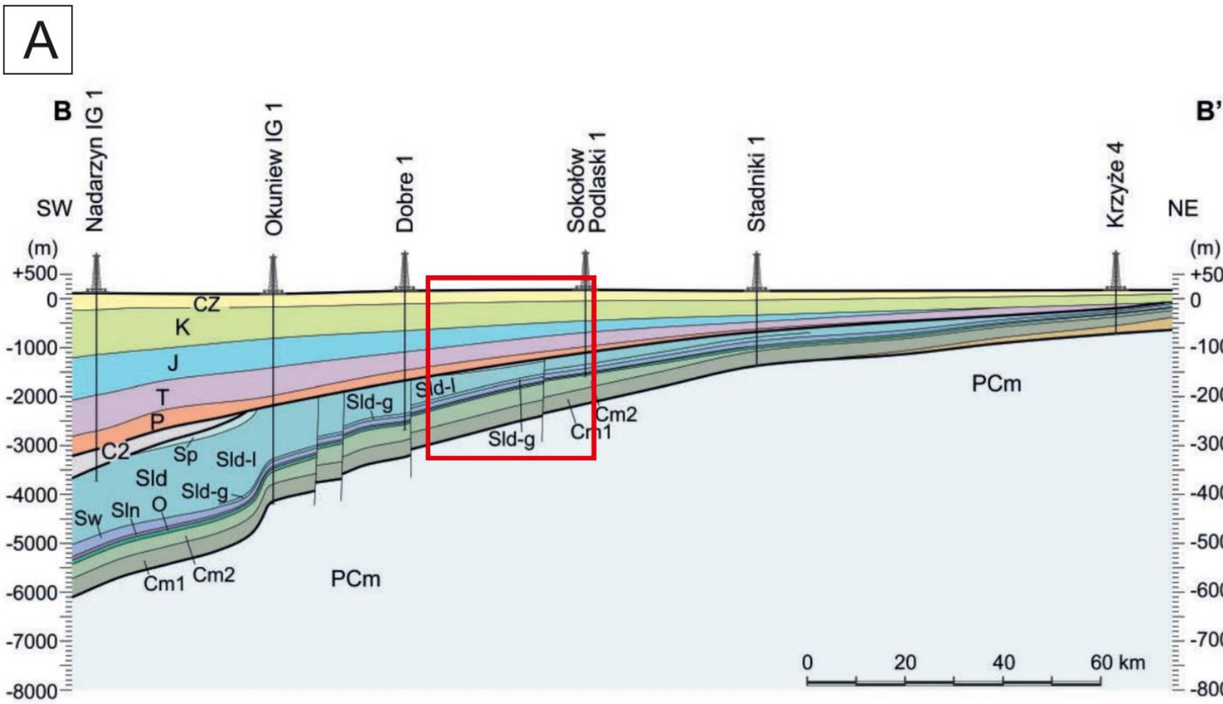
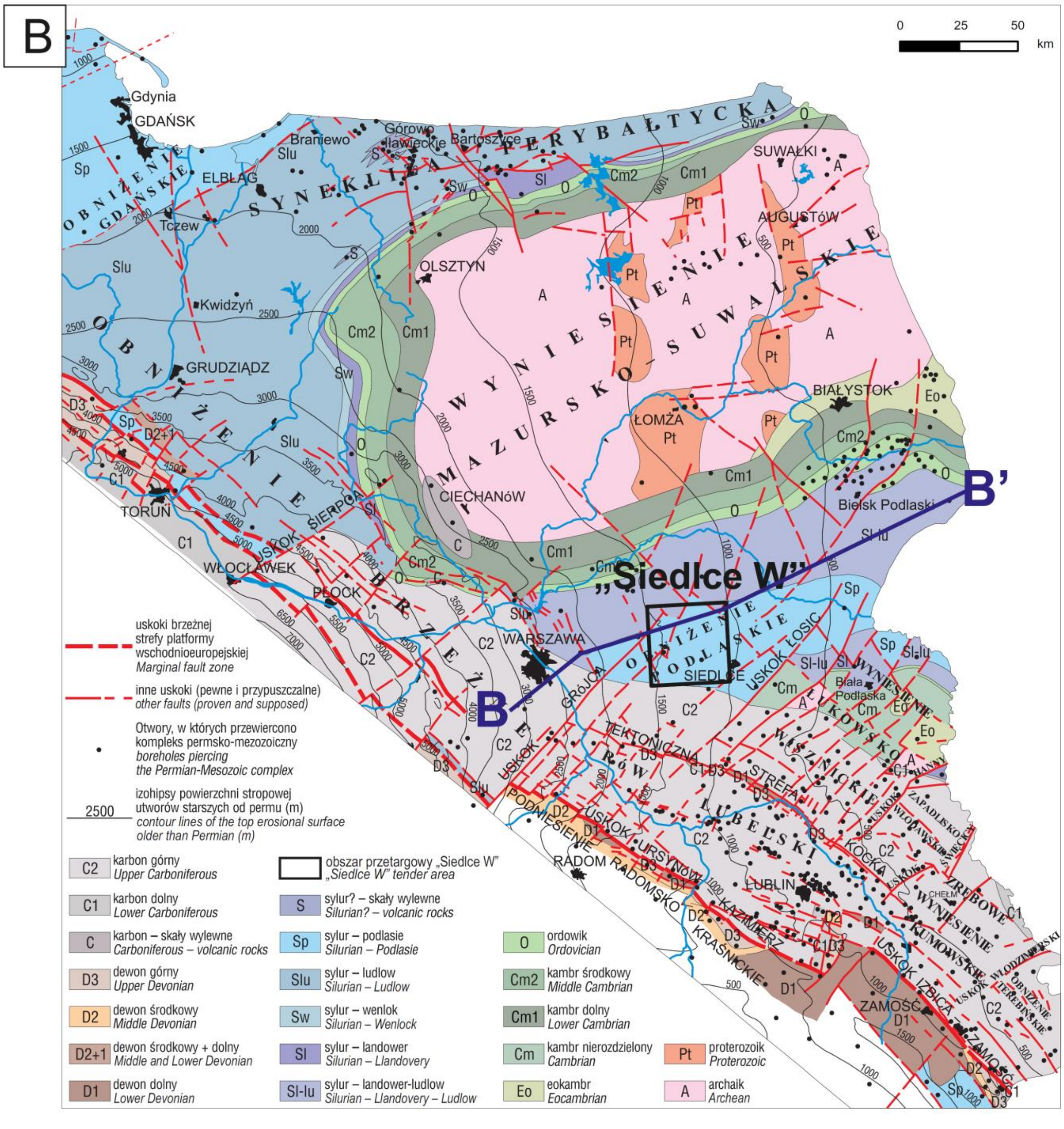


Fig. 3.14. Low, moderate and highly prospective zones for hydrocarbons exploration in the Middle Cambrian in NE Poland (Stolarczyk et al., 2004).

→**Fig. 3.15. A.** The B-B' cross-section through the Podlasie Syneclise/Depression (Poprawa, 2019). PCm – Precambrian, Cm1 – Lower Cambrian, Cm2 – Middle Cambrian, O – Ordovician, Sl – Silurian (Llandovery), Sw – Silurian (Wenlock), Sw-s – Silurian (Wenlock, Sheinwoodian), Sw-h – Silurian (Wenlock, Homerian), Sld – Silurian (Ludlow), Sld-g – Silurian (Ludlow, Gorstian), Sld-l – Silurian (Ludlow, Ludfordian), Sp – Silurian (Pridoli), C2 – Pennsylvanian, P – Permian, T – Triassic, J – Jurrasic, K – Cretaceous, CZ –Cenozoic. **B.** Location of the B-B' cross-section in the geological-structural map of the EEC without Permian and younger sediments (Stolarczyk et al., 2004).


A
B
B'
SW
NE
Nadarzyn IG 1
Okuniew IG 1
Dobre 1
Sokołów Podlaski 1
Stadniki 1
Krzyże 4
(m)
+500
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
CZ
K
J
T
P
C2
Sp
Sld
Sld-l
Sld-g
Sw
Sln
O
Cm1
Cm2
PCm
0
20
40
60 km


B
0
25
50
km
„Siedlce W"
B
B'
Gdynia
GDAŃSK
ELBLĄG
Tczew
Kwidzyń
GRUDZIĄDZ
TORUŃ
WŁOCŁAWEK
PŁOCK
WARSZAWA
OLSZTYN
CIECHANÓW
ŁOMŻA
SUWAŁKI
AUGUSTÓW
BIAŁYSTOK
Bielsk Podlaski
SIEDLCE
Biała Podlaska
RADOM
LUBLIN
ZAMOŚĆ
SYNEKLIZA PERYBAŁTYCKA
WYNIESIENIE MAZURSKO-SUWALSKIE
OBNIŻENIE PODLASKIE
OBNIŻENIE GDAŃSKIE
uskoki brzeżnej strefy platformy wschodnioeuropejskiej
Marginal fault zone
inne uskoki (pewne i przypuszczalne)
other faults (proven and supposed)
Otwory, w których przewiercono kompleks permsko-mezozoiczny
boreholes piercing the Permian-Mesozoic complex
2500
izohipsy powierzchni stropowej utworów starszych od permu (m)
contour lines of the top erosional surface older than Permian (m)
C2 karbon górny Upper Carboniferous
C1 karbon dolny Lower Carboniferous
C karbon – skały wylewne Carboniferous – volcanic rocks
D3 dewon górny Upper Devonian
D2 dewon środkowy Middle Devonian
D2+1 dewon środkowy + dolny Middle and Lower Devonian
D1 dewon dolny Lower Devonian
obszar przetargowy „Siedlce W"
„Siedlce W" tender area
S sylur? – skały wylewne Silurian? – volcanic rocks
Sp sylur – podlasie Silurian – Podlasie
Slu sylur – ludlow Silurian – Ludlow
Sw sylur – wenlok Silurian – Wenlock
Sl sylur – landower Silurian – Llandovery
Sl-lu sylur – landower-ludlow Silurian – Llandovery – Ludlow
O ordowik Ordovician
Cm2 kambr środkowy Middle Cambrian
Cm1 kambr dolny Lower Cambrian
Cm kambr nierozdzielony Cambrian
Eo eokambr Eocambrian
Pt proterozoik Proterozoic
A archaik Archean

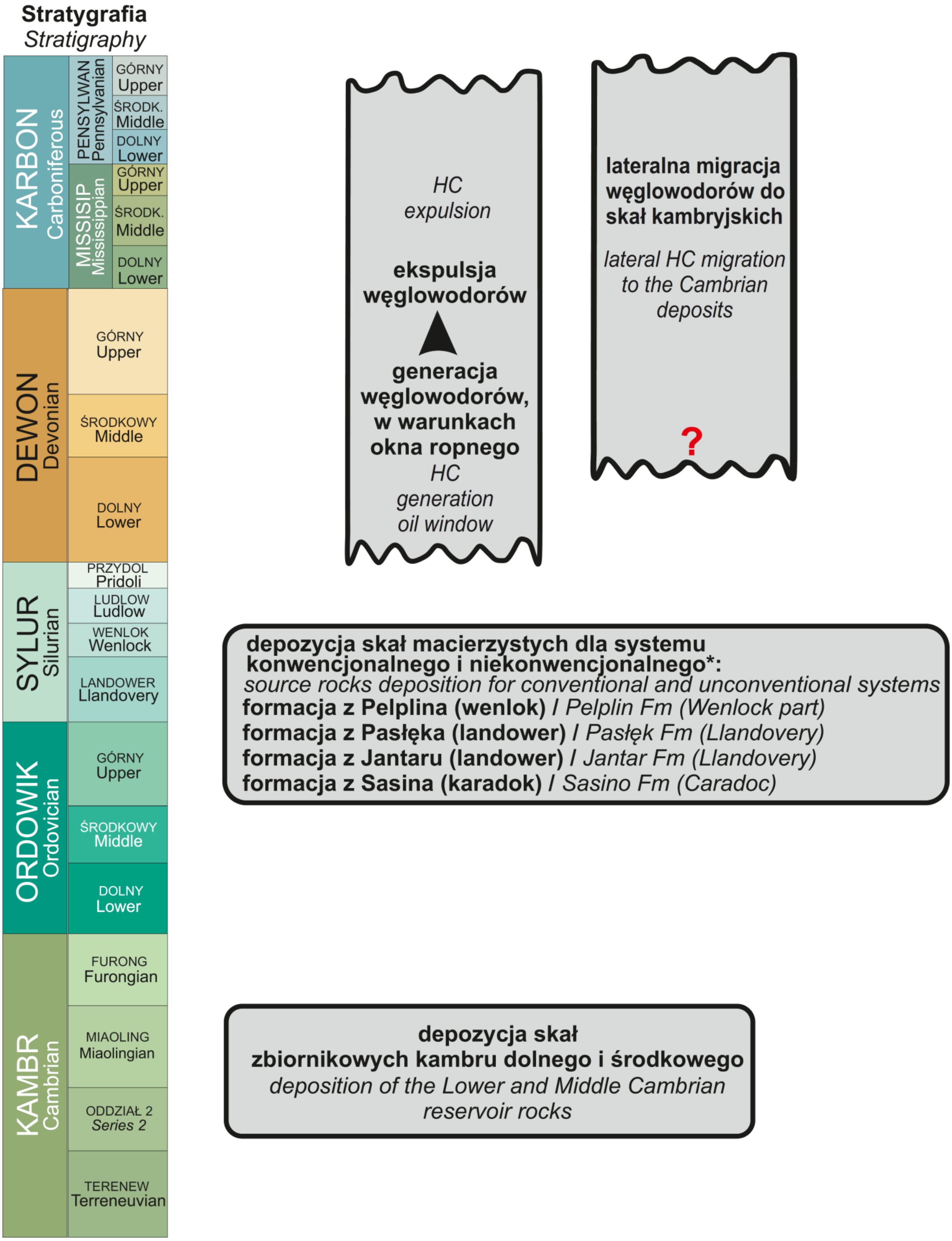


Fig. 3.16. Scheme of the main elements of both conventional and unconventional petroleum plays in the “Siedlce W” tender area.

4. HYDROCARBON FIELDS

Neither conventional nor unconventional oil and gas fields have been documented within the "Siedlce W" tender area and in its vicinity. Some analogues related to the conventional accumulations in the Middle Cambrian – Żar-nowiec, Dębki and Białogóra fields - are lo-cated in northern Poland. The detailed descriprion of these accumulations can be found at, e.g.:
https://bip.mos.gov.pl/fileadmin/user_upload/bip/koncesje_geologiczne/ogloszenia/przetargi_weglowodorowe/runda_3_2018/pakiety_2/PDG%20WEJHEROWO.pdf

5. WELLS

Five wells deeper than 500 m MD reached the prospective intervals in the „Siedlce W" tender area, and another four wells, which pierced the Lower Paleozoic, are located in the neighborhood:

Well name	Year	Owner	Concession (for wells after 1994)	Depth [m]	Stratigraphy at the bottom
POLAKI 1	1971	State Treasury		2780.7	Proterozoic
SOK-GRĘBKÓW-01	2013	State Treasury	Sokołów Podlaski 33/2001/p	2243.0	Cambrian
SOKOŁÓW PODLASKI 1	1968	State Treasury		1771.0	Cambrian
KAŁUSZYN 1	1992	PGNiG S.A.		3190.0	Proterozoic
KAŁUSZYN 2	1995	PGNiG S.A.	Kałuszyn-Dobre-Wierzbno 76/92/p	2480.0	Cambrian
Wells located in the neighborhood of the tender area					
DOBRE 1	1968	State Treasury		2841.9	Middle Cambrian
RÓWCE 1	1973	State Treasury		2067.0	Precambrian
TŁUSZCZ IG-1	1963	State Treasury		2953.8	Proterozoic
ŻEBRAK IG-1	1953	State Treasury		2472.2	Middle Cambrian

Location of the above-mentioned wells is presented in Fig. 5.1. Their general characteristics, including hydrocarbon shows and inflows, as well as petrophysical properties of gas-and-oil-bearing intervals, are shortly summarized in Tab. 5.1. The Polaki 1 well is illustrated in Fig. 5.2 as an example.

The original data from 7 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 5th tender round.

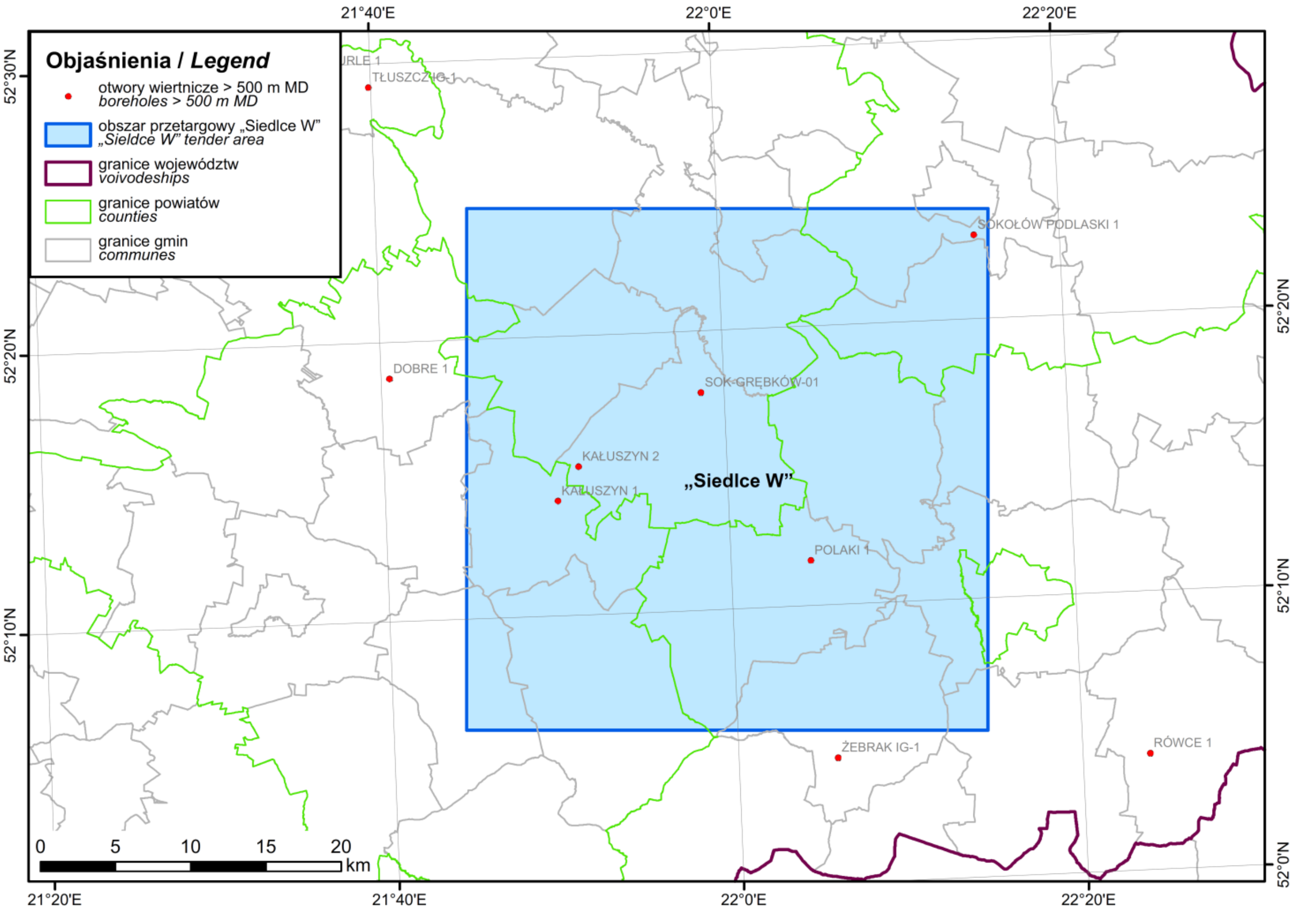


Fig. 5.1. Deep wells (>500 m MD) located within the "Siedlce W" tender area and in its close neighborhood.

→ **Tab. 5.1.** Summary of stratigraphy, petrophysical properties, hydrocarbon shows, hydrocarbon inflows, and geophysical measurements in deep wells located within the "Siedlce W" tender area and in its close neighborhood.

STRATIGRAPHY	POLAKI 1 Depth from [m]	Depth to [m]	1971 Average porosity [%]/ Average permeability [mD]	HC Inflow	SOK GRĘBKÓW-01 Depth from [m]	Depth to [m]	2013 Average porosity [%]/ Average permeability [mD]	TOC [%]
Caenozoic	0	200.5			0	223.0		
Cretaceous	200.5	654.0			223.0	716.0		
Jurassic	654.0	914.5			716.0	991.0		
Triassic	914.5	1241.0			991.0	1336.0		
Permian	1241.0	1335.0			1336.0	1452.0		
Transitional Terrigenous Series PZt								
Platy Dolomite Ca3								
Main Dolomite Ca2	1241.0	1248.0						
Recessive Terrigenous Series T1r								
Upper Anhydrite A1g	1248.0	1255.0						
Upper Oldest Halite Na1g	1255.0	1276.5						
Lower Anhydrite A1d	1276.5	1308.5						
Zechstein Limestone Ca1 and Kupferschiefer T1	1308.5	1319.0						
Rotliegend	1319.0	1335.0	7.48/-	Brine and drilling fluid	1436.0	1452.0		
Carboniferous	1335.0	1339.0						
Silurian	1339.0	2172.0			1452.0	2130.0		
Kociewie Fm	1339.0	2062.0			1452.0	2043.0		
Puck Fm								
Pelplin Fm	2062.0	2149.0			2043.0	2115.0		1.86
Pasłęk Fm	2149.0	2165.0			2115.0	2130.0		0.61
Jantar Fm	2165.0	2172.0						
Ordovician	2172.0	2198.5			2130.0	2159.3		
Kodeniec Fm and Tyśmienica Fm	2172.0	2176.0			2130.0	2137.0	4.61/0.00-0.01	0.15
Stadniki Fm								
Prabuty Fm								
Sasino Fm	2176.0	2180.0			2137.0	2138.0		
Kielno Fm	2180.0	2193.0						
Pieszkowo Fm and Rajsko Fm	2193.0	2198.5			2138.0	2160.0		
Krzyże Fm								
Middle Cambrian	2198.5	2334.5	6.8/-	Brine and drilling fluid	2160.0	2243.0	10.95/95.86-99.96	0.08
Lower Cambrian	2334.5	2760.0	7.11/-					
Proterozoic	2760.0	2780.7						

STRATIGRAPHY	SOKOŁÓW PODLASKI 1 Depth from [m]	Depth to [m]	1968 Average porosity [%]/ Average permeability [mD]	HC Inflow	DOBRE 1 Depth from [m]	Depth to [m]	1968 Average porosity [%]/ Average permeability [mD]	HC Inflow
Caenozoic	0	225.0			0	267.5		
Cretaceous	225.0	631.5			267.5	815.0	15.7/-	
Jurassic	631.5	870.0		Water	815.0	1247.0	30.28/254.70	Brine
Triassic	870.0	1160.0		Water and brine	1247.0	1620.0		
Permian	1160.0	1227.0			1620.0	1831.5		
Transitional Terrigenous Series PZt					1620.0	1665.0		
Platy Dolomite Ca3					1665.0	1685.0		Brine
Main Dolomite Ca2	1160.0	1171.0	18.77/185.93	Brine	1685.0	1728.0	20.82/36.17	
Recessive Terrigenous Series T1r								
Upper Anhydrite A1g					1728.0	1735.0		
Upper Oldest Halite Na1g								
Lower Anhydrite A1d	1171.0	1190.0			1735.0	1795.0		
Zechstein Limestone Ca1 and Kupferschiefer T1	1190.0	1221.0	16.13/11.0		1795.0	1801.0		Brine
Rotliegend	1221.0	1227.0			1801.0	1831.5	13.17/94.79	
Carboniferous								
Silurian	1227.0	1712.5		no inflow	1831.5	2690.0		Brine
Kociewie Fm	1227.0	1605.0						
Puck Fm								
Pelplin Fm	1605.0	1691.5						
Pasłęk Fm	1691.5	1712.5						
Jantar Fm								
Ordovician	1712.5	1739.0		no inflow	2690.0	2731.0		
Kodeniec Fm and Tyśmienica Fm					2690.0	2708.0		
Stadniki Fm								
Prabuty Fm								
Sasino Fm					2708.0	2712.5		
Kielno Fm					2712.5	2725.5		
Pieszkowo Fm and Rajsko Fm	1738.2	1739.0			2725.5	2731.0		
Krzyże Fm								
Middle Cambrian	1739.0	1771.0			2731.0	2841.9		
Lower Cambrian								
Proterozoic								

STRATIGRAPHY	RÓWCE 1 Depth from [m]	Depth to [m]	1973 Average porosity [%]/ Average permeability [mD]	HC Inflow	TŁUSZCZ IG-1 Depth from [m]	Depth to [m]	1963 Average porosity [%]/ Average permeability [mD]	TOC [%]	ŻEBRAK IG-1 Depth from [m]	Depth to [m]	1953 Average porosity [%]/ Average permeability [mD]	TOC [%]
Caenozoic	0	149.0			0	208.6			0	193.0		
Cretaceous	149.0	555.0			208.6	775.0			193.0	625.0		
Jurassic	555.0	765.0			775.0	1171.1		0.44	625.0	914.2		
Triassic	765.0	888.0			1171.1	1584.5		0.48	914.2	1198.5		
Permian	888.0	1007.0			1584.5	1667.5			1198.5	1295.0		
Transitional Terrigenous Series PZt	888.0	907.5										
Platy Dolomite Ca3												
Main Dolomite Ca2	907.5	910.0										
Recessive Terrigenous Series T1r	910.0	915.0										
Upper Anhydrite A1g	915.0	920.0										
Upper Oldest Halite Na1g												
Lower Anhydrite A1d	920.0	964.0										
Zechstein Limestone Ca1 and Kupferschiefer T1	964.0	980.0										
Rotliegend	980.0	1007.0	27.06/-		1665.0	1667.5			1270.7	1295.0		
Carboniferous	1007.0	1008.0							1295.0	1360.9		
Silurian	1008.0	1454.0	1.03-7.07/0.00		1667.5	1960.0			1360.9	2359.2	0.03-8.61/-	0.1-0.63
Kociewie Fm												
Puck Fm												
Pelplin Fm					1667.5	1929.0	8.46-0.85/0.19-0.79	0.94-1.29				
Pasłęk Fm					1929.0	1954.0	6.26/0.28	lut.18				
Jantar Fm					1954.0	1960.0						
Ordovician	1454.0	1481.0			1960.0	1990.7	4.19/-	0.34	2359.2	2399.3	1.22/-	0.19-0.22
Kodeniec Fm and Tyśmienica Fm									2359.2	2375.0		
Stadniki Fm	1454.0	1459.5										
Prabuty Fm					1960.0	1964.7						
Sasino Fm	1459.5	1463.0			1964.7	1980.0			2375.0	2384.3		
Kielno Fm	1463.0	1475.5		Brine with oil and gas	1980.0	1985.0			2384.3	2391.6		
Pieszkowo Fm and Rajsko Fm	1475.5	1480.8			1985.0	1990.7			2391.6	2399.3		
Krzyże Fm	1480.8	1481.0										
Middle Cambrian	1481.0	1608.0	12.89/90.33		1990.7	2125.3	13.29/12.65	0.05	2399.3	2472.2		
Lower Cambrian	1608.0	2048.0		no inflow	2125.3	2497.6						
Proterozoic	2048.0	2067.0			2497.6	2953.8						

	POLAKI 1	SOK GRĘBKÓW-01	SOKOŁÓW PODLASKI 1	DOBRE 1	RÓWCE 1	TŁUSZCZ IG-1	ŻEBRAK IG-1
GEOPHYSICS	mPO: 252–2771 m; mPSr: 2150–2290 m; PG: 10–2738 m; PK: 25–2775 m; PNG: 10–2738 m; PO: 7–2771 m; POs: 500–1377 m; PS: 7–2771 m; PSr: 7–2540 m; PT: 30–1823 m; PT: 1700–2776 m; Tx2: 20–2720 m; TW: 20–2720 m; Tr_PW1: 285–2735 m; Tr_PW2: 285–2735 m; Tr_PW3: 285–2735 m; Tr_PO: 285–2735 m; DT_VSP: 20–2720 m.	GR_WS: 25–2216 m; PSr: 326–2240 m; RHOB_WS: 329–2234 m; DRHO_WS: 329–2234 m; DTC_WS: 329–2224 m; NPHI_WS: 329–2231 m; PEF_WS: 329–2234 m; PS: 329–2235 m; RDEEP_WS: 329–2234 m; RMED_WS: 329–2234 m; RSHAL_WS: 329–2234 m; DSL: 325–2243 m; XMAC: 325–2243 m; WGI: 325–2243 m; TTRM: 325–2243 m; CN: 325–2243 m; ZDL: 325–2243 m; HDIL: 325–2243 m; FLEX: 1534–2243 m; STAR: 1534–2243 m; CBIL: 1534–2243 m; VSP: 1534–2243 m.	mPO: 475–1765 m; PG: 4–1765 m; PGaz: 1400–1482 m; PK: 25–1600 m; PNG: 4–1765 m; PO: 0–1765 m; PS: 0–1765 m; PSr: 0–1040 m; PT: 12–1300 m; Tx2: 20–1420 m; TW: 20–1420 m; Tr_PW1: 85–1435 m; Tr_PW2: 110–1435 m; Tr_PW3: 85–1435 m; Tr_PO: 85–1435 m; DT_VSP: 20–1420 m.	mPO: 299–2760 m; PA: 30–2625 m; PG: 17–2770 m; PGaz: 1804,5–1836,5 m; PK: 25–2750 m; PNG: 17–2770 m; PO: 10–2760 m; PS: 10–2758 m; PSr: 10–2750 m; PT: 12–1650 m; Tx2:–20–2640 m; TW:–20–2640 m; Tr_PW1:–94–2644 m; Tr_PW2:–94–2644 m; Tr_PW3:–94–2644 m; Tr_PO:–94–2644 m; DT_VSP:–20–2640 m.	mPO: 300–2060 m; PG: 980–2060 m; PGG: 1405–2060 m; PK: 275–2050 m; PNG: 980–2060 m; PO: 300–1855,5 m; POg: 1500–2060 m; PS: 300–2060 m; PSr: 300–2060 m; Tx2: 20–2000 m; TW: 20–2000 m; Tr_PW1: 26–2001 m; Tr_PW2: 76–1776 m; Tr_PO: 26–2001 m.	mPO: 1330–2313 m; mPSr: 234–2313 m; PG: 0–2685 m; PK: 1350–2500 m; PNG: 197–2685 m; PO: 1350–1794,75 m; POpl: 30–2313 m; PS: 234–2585 m; PSr: 0,25–2585 m; PT: 5–2689 m; Tx2: 20–2620 m; TW: 20–2620 m; Tr_PW1: 40–2638 m; Tr_PW2: 15–2638 m; Tr_PW3: 65–2638 m; Tr_PO: 15–2638 m; DT_VSP: 20–2620 m.	mPSr: 2123–2416 m; PG: 5–2442 m; PK: 300–2425 m; PNG: 0–2170 m; PO: 40–1136,75 m; POpl: 20,25–1149,5 m; PS: 38,25–2416 m; PSr: 0,25–2444 m; PT: 14,25–2435,75 m; Tr_PW1: 48–2398 m; Tr_PW2: 98–2373 m; Tr_PW3: 173–2348 m; Tr_PO: 48–2398 m.
DOCUMENTATIONS	Kądzioła, A., Madej, H. 1971. Polaki 1 well velocity report. ŚPR/464, Arch. PGNiG S.A, Warsaw. [In Polish]	Gliniak, P., Purchla, J., Hoffmann, A., Pachciarek, T., Popczyk, R., Schnabel, W., Starzec, K., Szotek, A., Wójcik, I. 2013. Concession N. 33/2010/p "Sokołów Podlaski" final report. Inv. 787/2014, Arch. CAG PIG, Warsaw. [In Polish]	Kowalska-Łącka, M., Jagiełło, D. 1971. Sokołów Podlaski 1 well report. Inv. 110507, Arch. CAG PIG, Warsaw. [In Polish]	Krach, B., Madej, H. 1968. Dobre 1 well velocity report. ŚPR/243, Arch. PGNiG S.A, Warsaw. [In Polish]	Garbacik, Z. 1973. Rówce 1 well report. Inv. 117855, Arch. CAG PIG, Warsaw. [In Polish]	Areń, B. 1966.Tłuszcz IG-1 well report. Inv. 69444, Arch. CAG PIG, Warsaw. [In Polish]	Krach, B., Sacharanowa, A. 1958. Żebrak IG-1 well velocity report. Ż9 VS, Arch. CAG PIG, Warsaw. [In Polish]
	Kiełbasa, H., Kowalska-Łącka, M. 1972. Polaki 1 well report. Inv. 114081, Arch. CAG PIG, Warsaw. [In Polish]		Połtowicz, M., Mach, R. 1970. Sokołów Podlaski 1 well velocity report. ŚPR/384, Arch. PGNiG S.A, Warsaw. [In Polish]	Stolarczyk, J., Kowalska-Łącka, M., Pyk, B., Kruczak, E. 1970. Dobre 1 well report. Inv. 108040, Arch. CAG PIG, Warsaw. [In Polish]	Kocoń, S., Madej, H. 1973. Rówce 1 well velocity report. R92 VS, Arch. CAG PIG, Warsaw. [In Polish]	Areń, B. 1974. Profile głębokich otworów wiertniczych Instytutu Geologicznego. Tłuszcz IG-1, 13. [In Polish]	Lendzion, K. 1956. Żebrak IG-1well report. Inv. 9264,4034/39, Arch. CAG PIG, Warsaw. [In Polish]
					Podhalańska, T. et al. 2018. Inv. 9051/2019, Arch. CAG PIG, Warsaw. [In Polish] ?	Podhalańska, T. et al. 2016. Inv. 4878/2016, Arch. CAG PIG, Warsaw. [In Polish]	Lendzion, K. 1975. Żebrak IG-1. Profile głębokich otworów wiertniczych Instytutu Geologicznego, 28. [In Polish]
						Podhalańska, T. et al. 2018. Inv. 9051/2019, Arch. CAG PIG, Warsaw. [In Polish] ?	Lendzion, K., Wszeborski, A. 1963. Żebrak IG-1 well final report. Inw. 51766, Arch. CAG PIG, arsaw. [In Polish]
						Poprawa, P., Kiersnowski, H. 2010. Inv. 2439/2011 Arch. CAG PIG, Warsaw. [In Polish] ?	Podhalańska, T. et al. 2016. Inv. 4878/2016, Arch. CAG PIG, Warsaw. [In Polish]
						Sawaryn, M. 1963. Tłuszcz IG-1 well velocity report. T18 VS, Arch. CAG PIG, Warsaw. [In Polish]	Podhalańska, T. et al. 2018. Inv. 9051/2019, Arch. CAG PIG, Warsaw. [In Polish] ?
							Poprawa, P., Kiersnowski, H. 2010. Inv. 2439/2011 Arch. CAG PIG, Warsaw. [In Polish] ?

	hydrocarbon shows

CBIL: circumferential borehole imager log; CN: compensated neutron log; DRHO_WS: high-valued density correction log; DSL: spectra gamma ray log; DT_VSP: acoustic log; DTC_WS: compressional waves sonic log; FLEX: spectroscopy log; GR_WS: gamma ray log; HDIL: high-definition induction log; mPO: micro resistivity log; mPSr: caliper micrologi; NPHI_WS: neutron-porosity log; PA: acoustic log; PEF_WS: photo electric factor log; PG: gamma-ray log; PGaz: gas log; PGG: gamma-gamma density log; PK: deviation log; PNG: neutron-gamma log; PO: electrical survey (resistivity log); POg: electric log lateral device; POpl: mud resistivity log; POs: symmetric resistivity log; PS: spontaneous potential log; PSr: diameter; PT: temperature log; RDEEP_WS: deep reading resistivity measurement; RHOB_WS: bulk density log; RMED_WS: medium deep reading resistivity measurement; RSHAL_WS: shallow reading resistivity measurement; STAR: simultaneous acoustic and resistivity imager; Tr_PO: velocity survey, observed average time; Tr_PW1: velocity survey, observed travel time of SP1; Tr_PW2: velocity survey, observed travel time of SP2; Tr_PW3: velocity survey, observed travel time of SP3; TTRM: temperature/tension/mud resistivity log; TW: velocity survey, interpolated time; Tx2: velocity survey, doubled interpolated time; VSP: vertical seismic profile; WGI: diameter; XMAC: cross-multipole array acoustic log; ZDL: bulk density log.

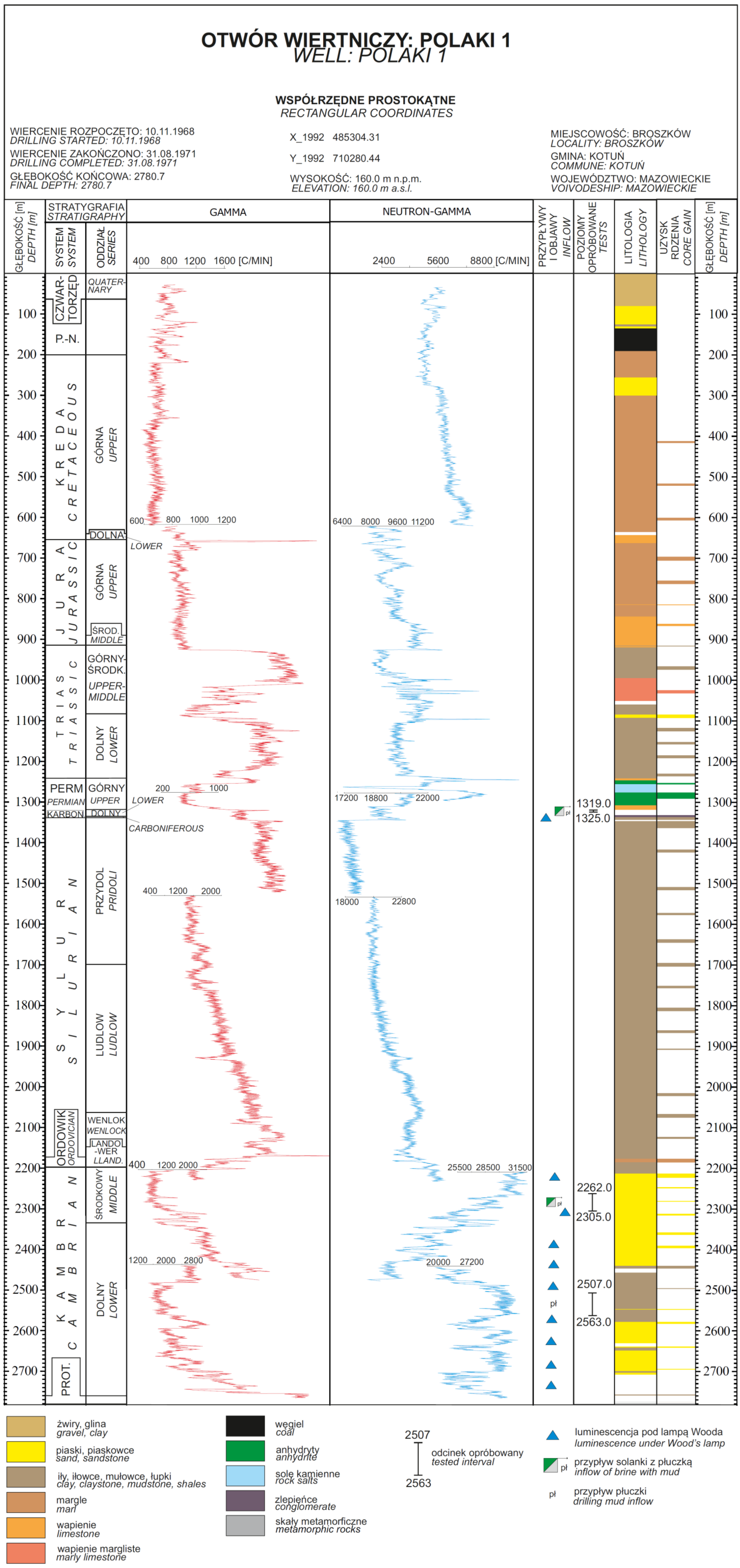


Fig. 5.2. Stratigraphy, lithology and selected well logs in the Polaki 1 well according to Kiełbasa and Kowalska-Łącka (1972). PROT. – Proterozoic, P.-N. – Paleogene and Neogene.

6. SEISMIC SURVEYS

The “Siedlce W” area is covered by a relatively evenly distributed grid of seismic profiles only in its western and north-western parts (Figs 6.1-6.2). Most of the data were acquired in the early 1990s and belong to the Investor (Tab. 6.1; CGDB, 2021). The remaining single profiles are located, among others, in the north-eastern part of the area. They were acquired in 2011 on the order of the Marathon Oil Company Poland. Within the borders of the tender area there are also 2 profiles collected in 2012 within the framework of the Poland Span project. These are regional data, and parts of the profiles cross the south-eastern and south-western regions of the area.
Additionally, within the tender area, there is a part of the CEL21 profile carried out within the CELEBRATION 2000 deep seismic sounding project. Due to the research specificity, resolution and range, they are not used in hydrocarbon exploration.

Siesmic lines	Year	Survey	Region	Concession (for surveys after 2001)	Owner	Length [km]
T0020676	1976	Tłuszcz – Kock – Włodawa	Tłuszcz – Kock – Włodawa		State Treasury	20.46
T0190591	1991	Tłuszcz – Dęblin – Lublin	Liw		Private Investor	7.62
T0200591	1991	Tłuszcz – Dęblin – Lublin			Private Investor	9.29
T0210591	1991	Tłuszcz – Dęblin – Lublin			Private Investor	8.85
T0220591	1991	Tłuszcz – Dęblin – Lublin			Private Investor	12.43
T0230591	1991	Tłuszcz – Dęblin – Lublin			Private Investor	10.95
T0240591	1991	Tłuszcz – Dęblin – Lublin			Private Investor	12.31
T0250591	1991	Tłuszcz – Dęblin – Lublin			Private Investor	9.94
T0260591	1991	Tłuszcz – Dęblin – Lublin			Private Investor	7.3
T0270591	1991	Tłuszcz – Dęblin – Lublin			Private Investor	11.18
T0280591	1991	Tłuszcz – Dęblin – Lublin			Private Investor	11.56
T0410592	1992	Tłuszcz – Dęblin – Lublin	Tłuszcz		Private Investor	3.6
T0440592	1992	Tłuszcz – Dęblin – Lublin			Private Investor	2.42
T0500493	1993	Kałuszyn – Dobre – Wierzbno	Kałuszyn – Dobre – Wierzbno		Private Investor	6.4
T0510493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	11.33
T0520493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	14.54
T0530493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	19.48
T0540493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	20.08
T0550493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	19.65
T0560493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	18.11
T0570493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	10.95
T0580493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	13.75
T0590493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	15.82
T0600493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	13.19
T0610493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	21.22
T0620493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	19.22
T0640493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	4.72
T0650493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	9.05
T0660493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	15.08
T0670493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	16.01
T0680493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	17.71
T0690493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	20.11
T0700493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	15.07
T0710493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	14.99
T0720493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	14.53
T0730493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	19.04
T0740493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	17.83
T0750493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	13.96
T0760493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	12.03
T0770493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	11.84
T0780493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	5.97
T0790493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	13.67
T2560493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	18.35
T2620493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	12.51
TA620493	1993	Kałuszyn – Dobre – Wierzbno			Private Investor	7.04
T0960494	1994	Kałuszyn – Dobre – Wierzbno			Private Investor	14.02
MOC-SS-3001	2011	Sokołów Podlaski		Sokołów Podlaski 33/2010/p, Siedlce 35/2010/p	State Treasury	19.86
MOC-SS-3002	2011	Sokołów Podlaski			State Treasury	12.5
MOC-SS-3002	2011	Siedlce 2D	Siedlce		State Treasury	1.21
MOC-SS-3003	2011	Sokołów Podlaski			State Treasury	8.66
MOC-SS-3004	2011	Sokołów Podlaski			State Treasury	13.25
MOC-SS-3008	2011	Siedlce 2D	Siedlce		State Treasury	17.66
MOC-SS-3009	2011	Sokołów Podlaski			State Treasury	17.38
MOC-SS-3009	2011	Siedlce 2D	Siedlce		State Treasury	0.82
MOC-SS-3013	2011	Sokołów Podlaski			State Treasury	7.00
MOC-SS-3015	2011	Siedlce 2D	Siedlce		State Treasury	13.67

PL1-1100	2012	PolandSPAN			State Treasury	27.51
PL1-5200	2012	PolandSPAN			State Treasury	7.91
					Total:	
					State Treasury	167.89
					Private Investor	584.72

Tab. 6.1. List of 2D seismic surveys within the “Siedlce W” tender area.

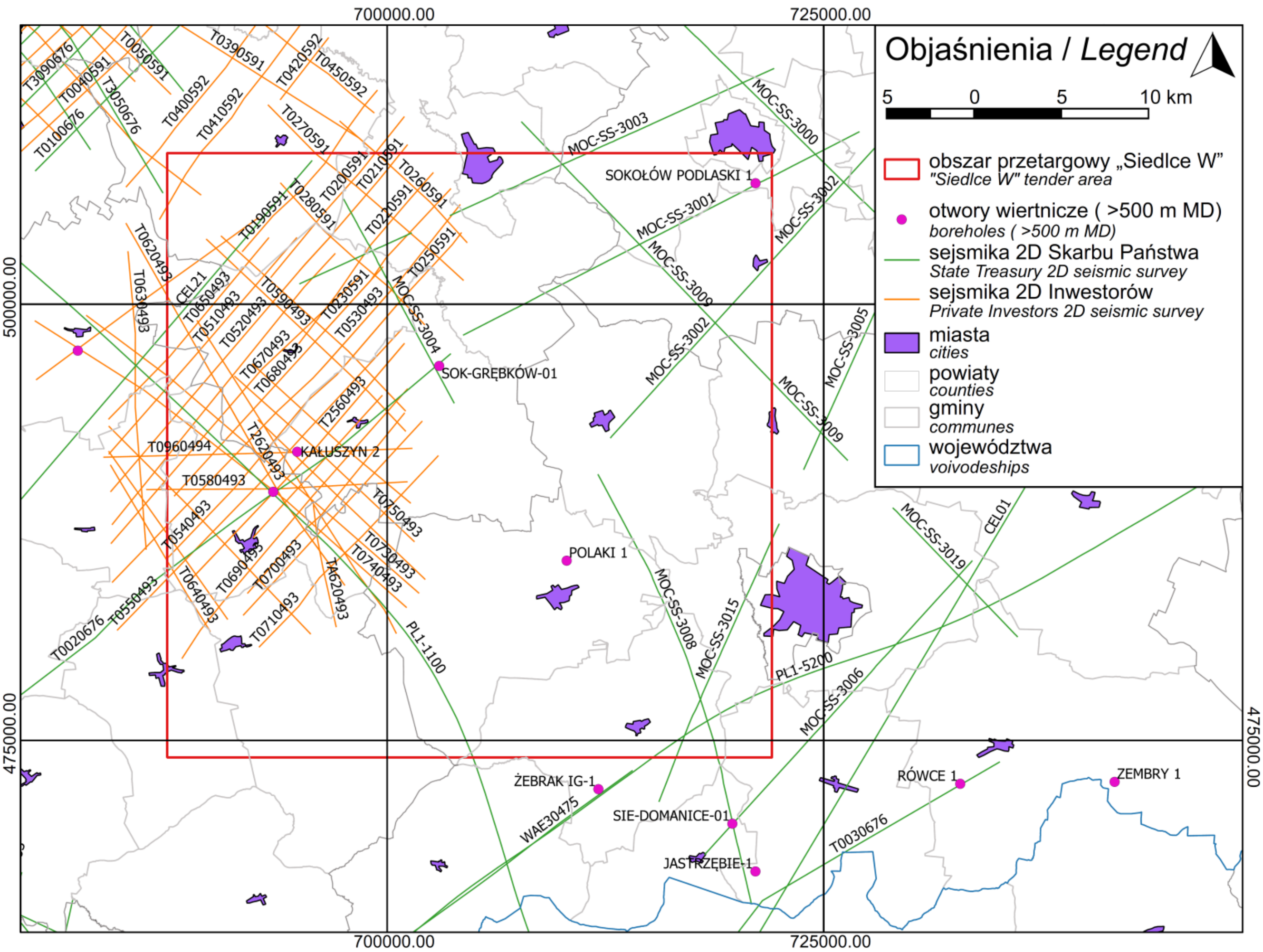


Fig. 6.1. Seismic surveys within the “Siedlce W” tender area and in its neighborhood, and location of deep wells (CGDB, 2021).

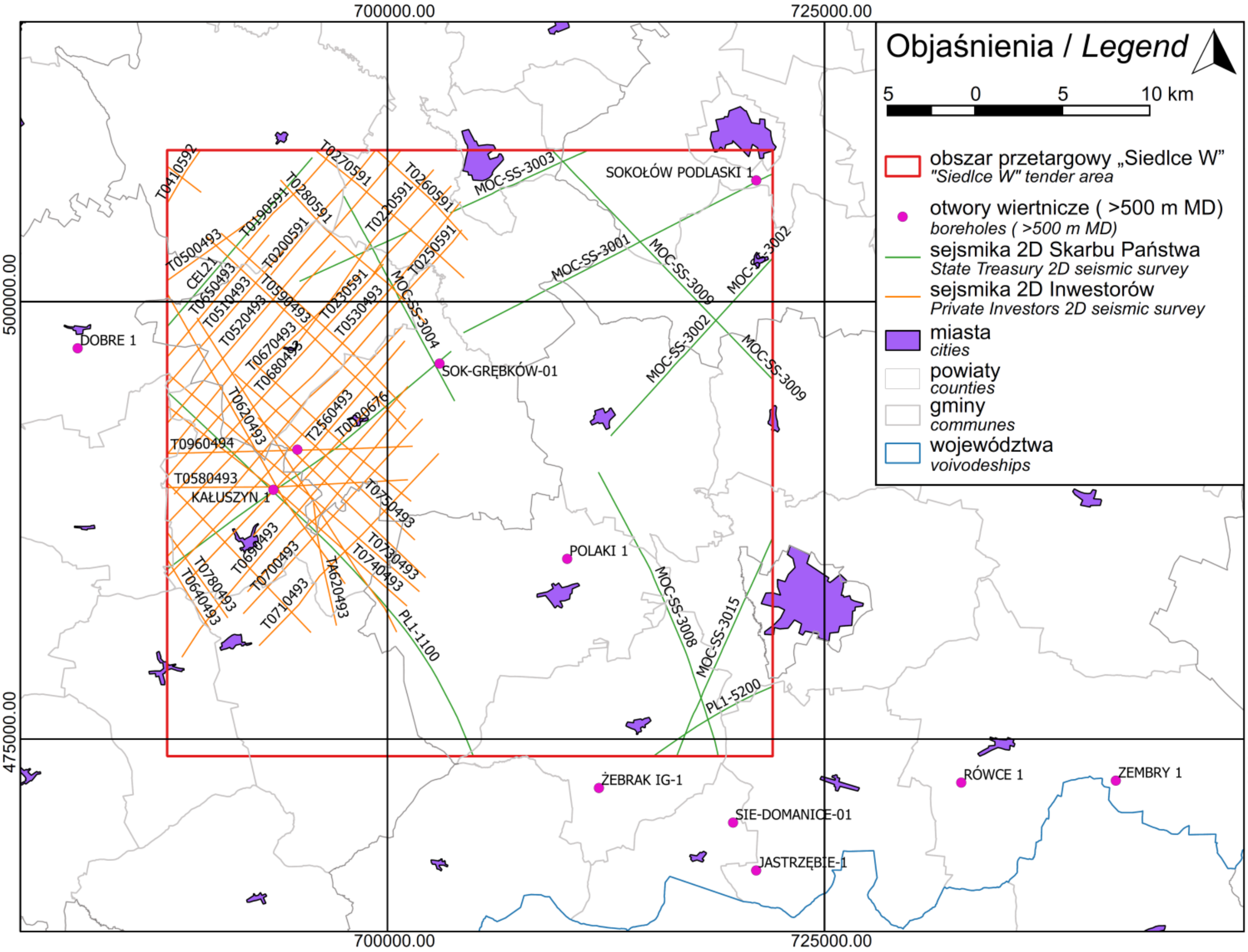


Fig. 6.2. Seismic surveys within the “Siedlce W” tender area, and location of deep wells (CGDB, 2021).

7. GRAVIMETRY, MAGNETOMETRY AND MAGNETOTELLURICS

7.1. GRAVIMETRY

Two semidetailed gravimetric surveys were collected in the “Siedlce W” tender area and in its close neighborhood (Fig. 7.1). There are 546 data points within the tender area, coming from the “Margin zone of Mazury – Suwałki Massif” survey (Lisowski, 1985), collected with a point density of 2.5 stations/km^2. The remaining part of the area is covered by the Podlasie Depression survey (Moryto et al., 1973) with a slightly lower density of points (2 stations/km^2, 2062 data points in total). From the south, the “Siedlce W” tender area borders with the Kock – Łęczna survey (Kruk, 1962) and Lublin region survey (Wasiak, 1968), and from the east with the Siemiatycze – Łuków – Włodawa survey (Bandura and Cieśla, 1985). No detailed survey (whether scattered or profiled) has been documented in the tender area.

Królikowski and Petecki (1995) proposed a division of Poland into several gravity regions. Thus, the “Siedlce W” tender area is placed in the northern part of the Podlasie – Lublin Low – so-called Białystok Depression, which should be related to the Mazowsze granitoid massif (Fig. 7.2).

7.2. MAGNETOMETRY

A semidetailed ground survey of the total magnetic field intensity was conducted in the “Siedlce W” tender area (Kosobudzka, 2002). The survey has an average density of 2 stations/km^2. All data are available in the CGDB (2021). There are 1755 data points within the “Siedlce W” tender area (Fig. 7.3). Taking measurements in the south-western quarter of the area was completely impossible due to the level of electromagnetic noise from the Warsaw agglomeration.

An image of magnetic anomalies presented in Fig. 7.4 is taken from a magnetic map of Poland (Petecki and Rosowiecka, 2017). The map is divided into several regions with different magnetic characteristics. The “Siedlce W” tender area is located within the Mazowsze domain (Md) which is characterized by a negative low amplitude anomaly and corresponds mainly to granitoids and paragneisses (Williams et al., 2009; Krzemińska and Krzemiński, 2017). Strong positive anomalies to the east and south of the “Siedlce W” tender area belong to the so-called Podlasie zone (Pz), which is characterized by a set of several belt-shaped anomalies, which delineate the Belarus – Podlasie Granulite (BPGB) and Okolovo – Holeszów (OHB) belts (Krzemińska and Krzemiński, 2017).

7.3. MAGNETOTELLURICS

No magnetotelluric survey was performed within and in the vicinity of the “Siedlce W” tender area.

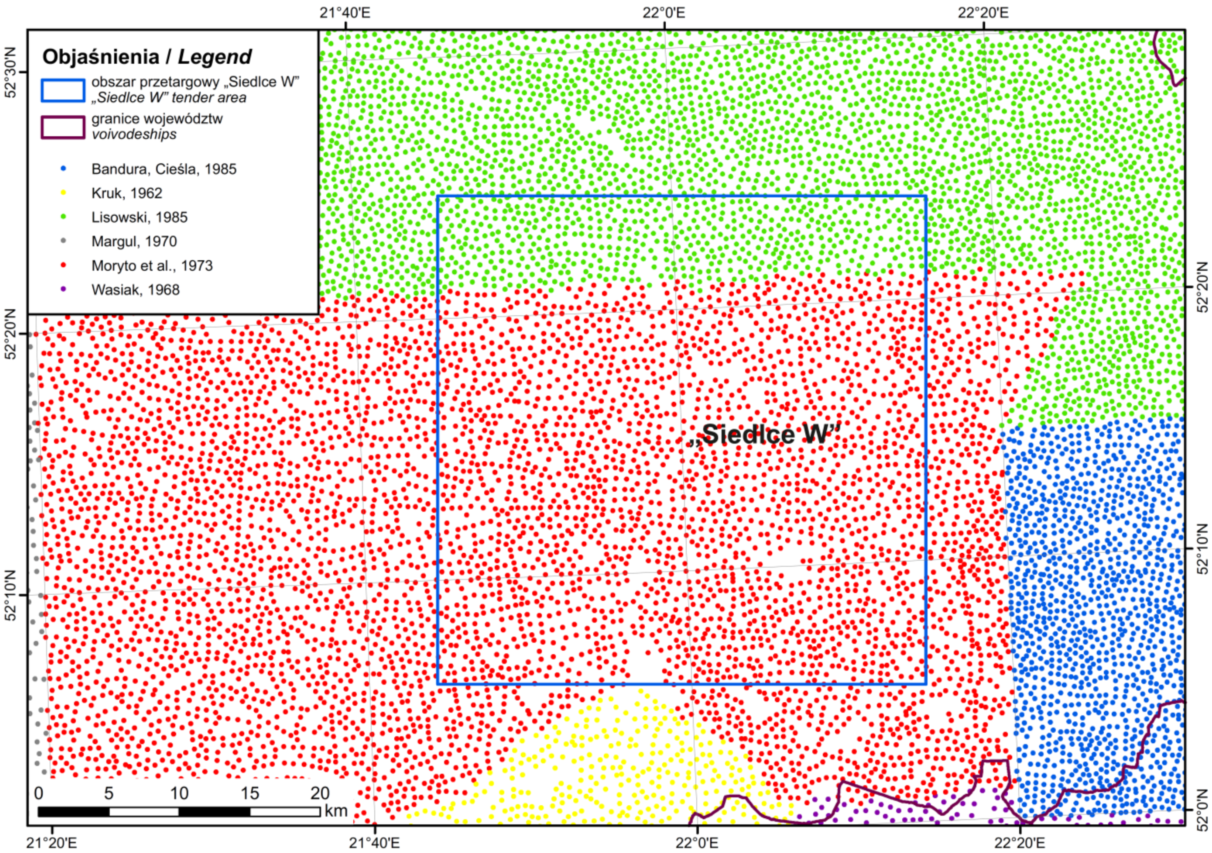


Fig. 7.1. Distribution of gravimetric measurements in the "Siedlce W" tender area (based on CGDB, 2021).

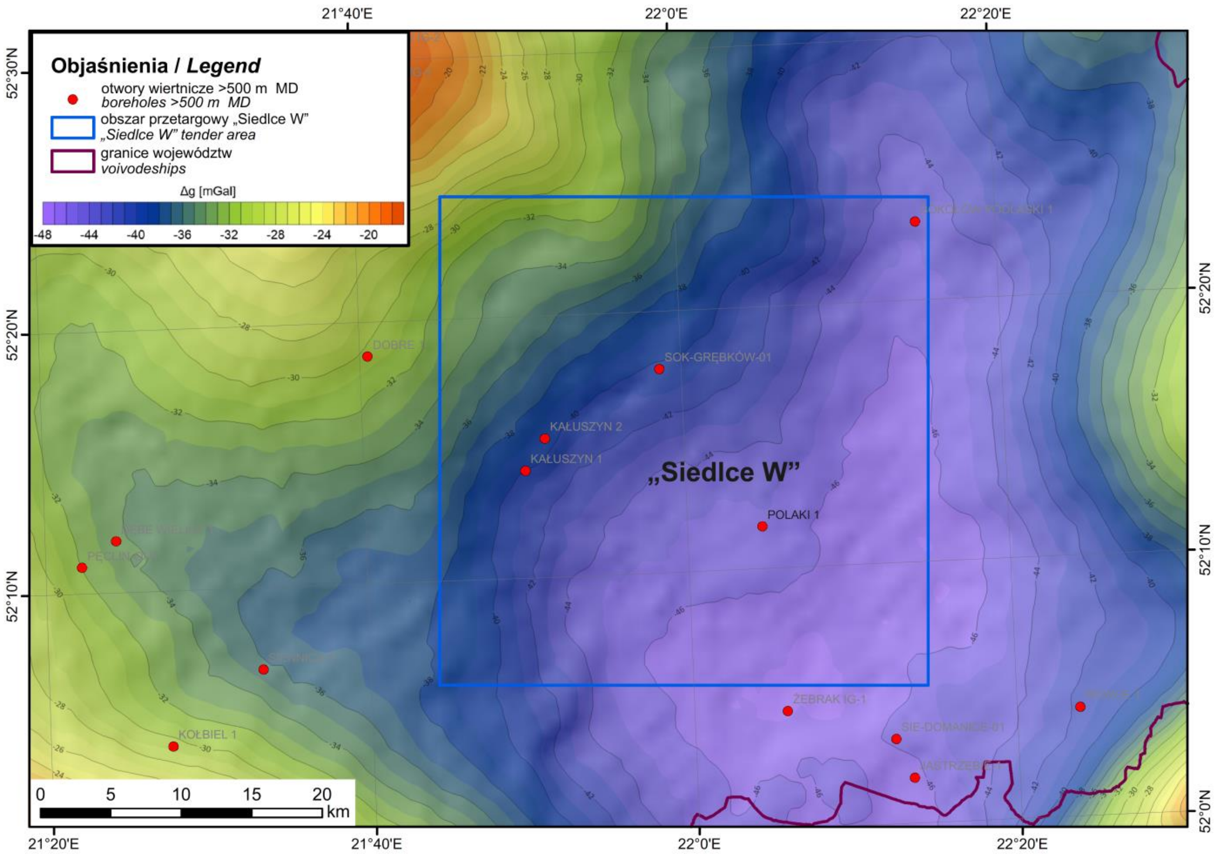


Fig. 7.2. Location of the "Siedlce W" tender area in the Bouguer gravity anomaly map of Poland.

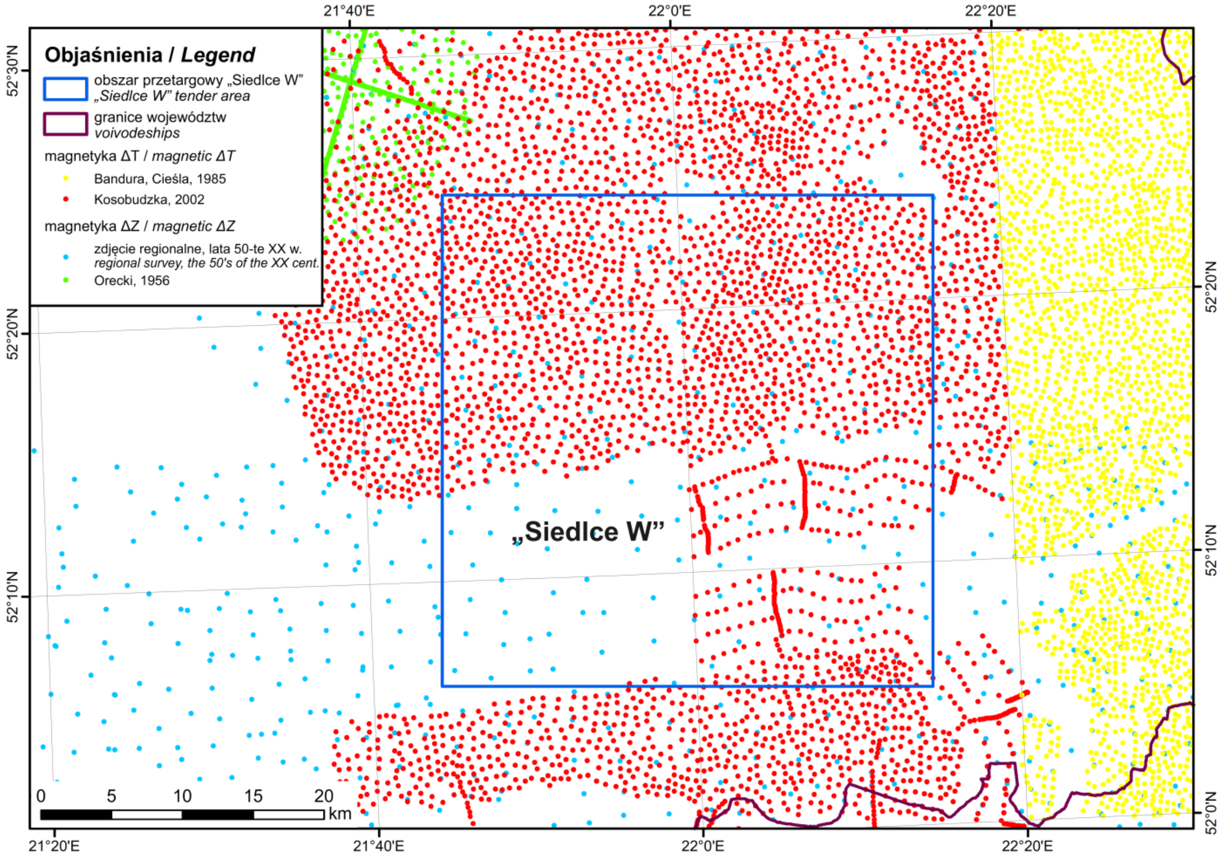


Fig. 7.3. Distribution of magnetic stations in the "Siedlce W" tender area (based on CGDB, 2021).

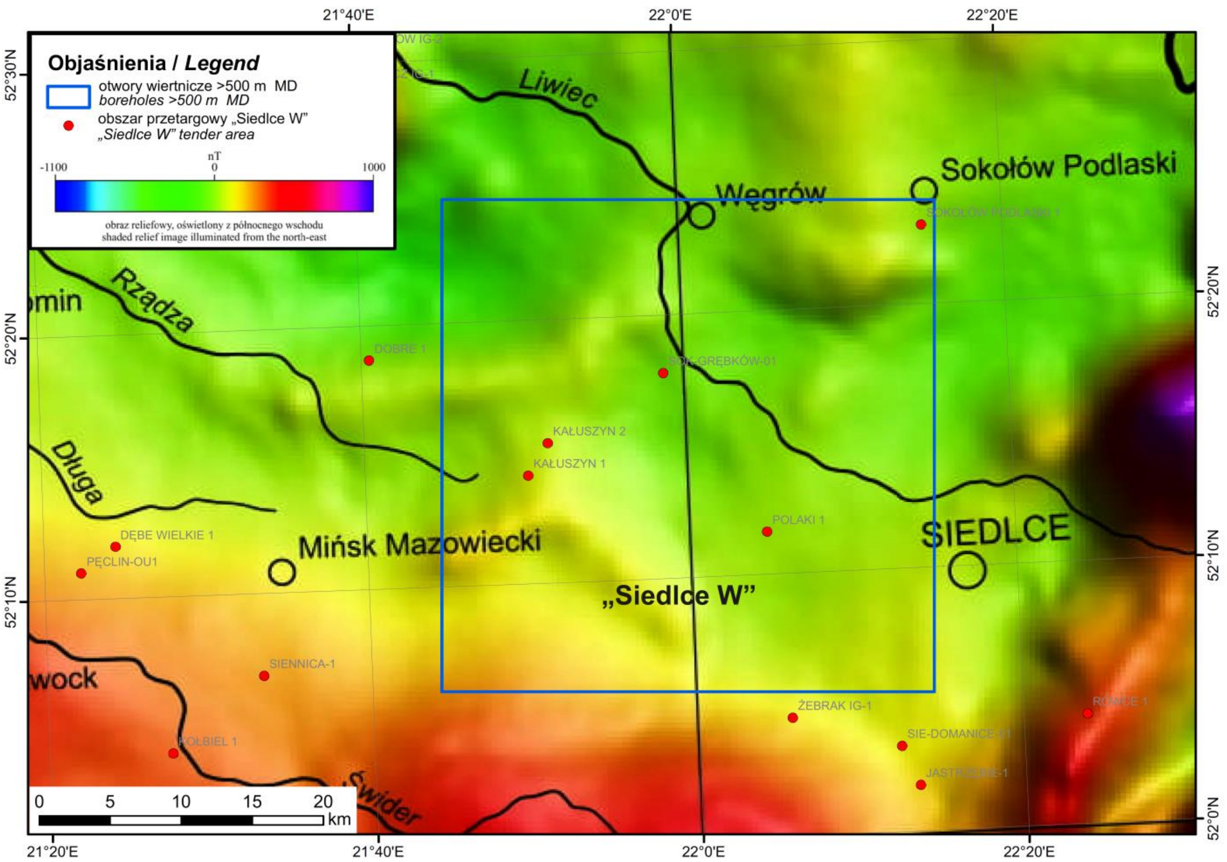


Fig. 7.4. Location of the "Siedlce W" tender area in the magnetic anomaly map of Poland (Petecki and Rosowiecka, 2017).

8. SUMMARY CHART

General information:	**Tender area:**	**"SIEDLCE W"**
	Location:	Onshore Hydrocarbon concession blocks: 216, 217, 236, 237 Administrative location: Mazowieckie Voivodeship, Węgrów county, communes: Korytnica (4.80%), Wierzbno (8.35%), Liw (9.03%), Węgrów (1.41%), Grębków (10.89%); Sokołów Podlaski county, communes: Sokołów Podlaski (3.45%), Sokołów Podlaski City (0.29%), Bielany (5.52%); Mińsk Mazowiecki county, communes: Dobre (0.96%), Jakubów (0.34%), Kałuszyn (7.82%), Cegłów (2.33%), Mrozy (8.14%); Siedlce City county, commune: Siedlce City (0.55%); Siedlce county, communes: Kotuń (12.52%), Mokobody (9.94%), Siedlce (3.84%), Skórzec (6.74%), Suchożebry (2.32%), Wiśniew (0.76%), Wodynie (<0.01%)
	Concession type:	prospection and exploration of hydrocarbon deposits and production of hydrocarbons from a deposit
	Time:	concession for 30 years, including: prospection and exploration phase (5 years), production phase – after investment decision
Participation:		winner of the tender 100%
Acreage [km^2]:		1200.00
Accumulation type:		conventional for oil and gas unconventional for shale oil and shale gas
Structural stages:		Cenozoic Laramide Caledonian Precambrian
Petroleum plays:		I. Lower Paleozoic (Lower and Middle Cambrian) conventional petroleum play II. Lower Paleozoic unconventional (shale gas/shale oil) petroleum play
Reservoir rocks:		I. Lower and Middle Cambrian sandstones II. Silurian (Wenlock) fine-grained clastic rocks
Source rocks:		I. Ordovician and Silurian fine-grained clastic rocks (Caradoc, Sasino Formation; Llandovery, Jantar and Pasłęk formations; Wenlock, Pelplin Formation) II. Silurian fine-grained clastic rocks (Wenlock, Pelplin Formation)
Seal rocks:		I. Ordovician and Silurian fine-grained clastic rocks II. Silurian fine-grained clastic rocks
Trap type:		I. structural, lithological, stratigraphic, mixed II. continuous
Oil and gas fields in the neighborhood:		none
Seismic surveys (owner):		1976 Tłuszcz – Kock – Włodawa 2D, 1 line (State Treasury) 1991 Tłuszcz – Dęblin – Lublin 2D, 10 lines (Private Investor) 1992 Tłuszcz – Dęblin – Lublin 2D, 2 lines (Private Investor) 1993 Kałuszyn – Dobre – Wierzbno 2D, 32 lines (Private Investor) 1994 Kałuszyn – Dobre – Wierzbno 2D, 1 line (Private Investor) 2011 Sokołów Podlaski 2D, 6 lines (State Treasury) 2011 Siedlce 2D, 4 lines (State Treasury) 2012 Poland SPAN, 2 lines (State Treasury)
Wells (depth):		Polaki 1 (2780.7 m), SOK-Grębków-01 (2243.0 m), Sokołów Podlaski 1 (1171.0 m), Kałuszyn 1 (3190.0 m), Kałuszyn 2 (2480.0 m), Dobre 1 (2841.9 m), Rówce (2067.0 m), Tłuszcz IG-1 (2953.8 m), Żebrak IG-1 (2472.2 m)

Possible minimum work program for the prospection and exploration phase

- Archival data reinterpretation and analysis
- Conducting seismic survey 2D (150 km SP) or 3D (50 km^2)
- Drilling of one well of max. depth 3500 m TVD reaching the Cambrian deposits with oligatory coring of prospective intervals

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