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Geological evaluation of hydrocarbon resources in Poland: concessions for prospection, exploration and exploitation of hydrocarbons – materials for tender procedure (stage III)
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PETROLEUM PROSPECTIVE AREAS IN POLAND 2020

KRYSTIAN WÓJCIK

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A. PREFACE

The petroleum prospective areas in Poland are selected every year since 2015 according to the Polish Geological and Mining Law (Act of 9 June, 2011; Journal of Laws of 2011, No. 163, item 981). Presented here the document is the result of the project financed by the National Found for Environmental Protection and Water Management No. 22.5004.1901.01.1: "Geological evaluation of hydrocarbon resources in Poland: concessions for prospection, exploration and exploitation of hydrocarbons – materials for tender procedure (stage III)".

Four petroleum provinces, divided into subprovinces and regions, are distinguished on the territory of Poland (Fig 1 and 2). This regional subdivison is adopted from the previous assessment of the Petroleum Prospective of Poland (Wójcik et al., 2019, compare to Karnkowski, 1997, 2007), in which individual regional units have been defined, with their boundaries, acreage, petroleum systems and documented oil and gas resources. In terms of content, the information about current hydrocarbon concessions and resources have been updated. Also, the extend of the Eastern Petroleum Province has been slightly modified, so that it includes the area located northeast from the Carpathian Foredeep, where unconventional hydrocarbon accumulations can occur.

The presented document includes:

- description and graphic illustration of the horizons (in stratigraphic order), which are prospective for the occurrence of conventional and unconventional accumulations of oil and gas in Poland, including oil and gas balance resources (Balance… 2019), prognostic resources (Chmieloweic-Stawska and Czekański, 2011; Górecki, 2011; Górecki and Zawisza, 2011; Kwarciński, 2011; Feldman-Olszewska et al., 2020; Hadro and Jureczka, 2020), and production (Balance… 2019) within (section B);
- description and graphic illustration of the areas, which are prospective for oil and gas discoveries in particular petroleum provinces (section C). These areas are selected as potential tender areas for the future licensing rounds for hydrocarbon concessions in Poland, they are free from the other concessions and pending applications, and have the acreage up to 1 200 km^2.

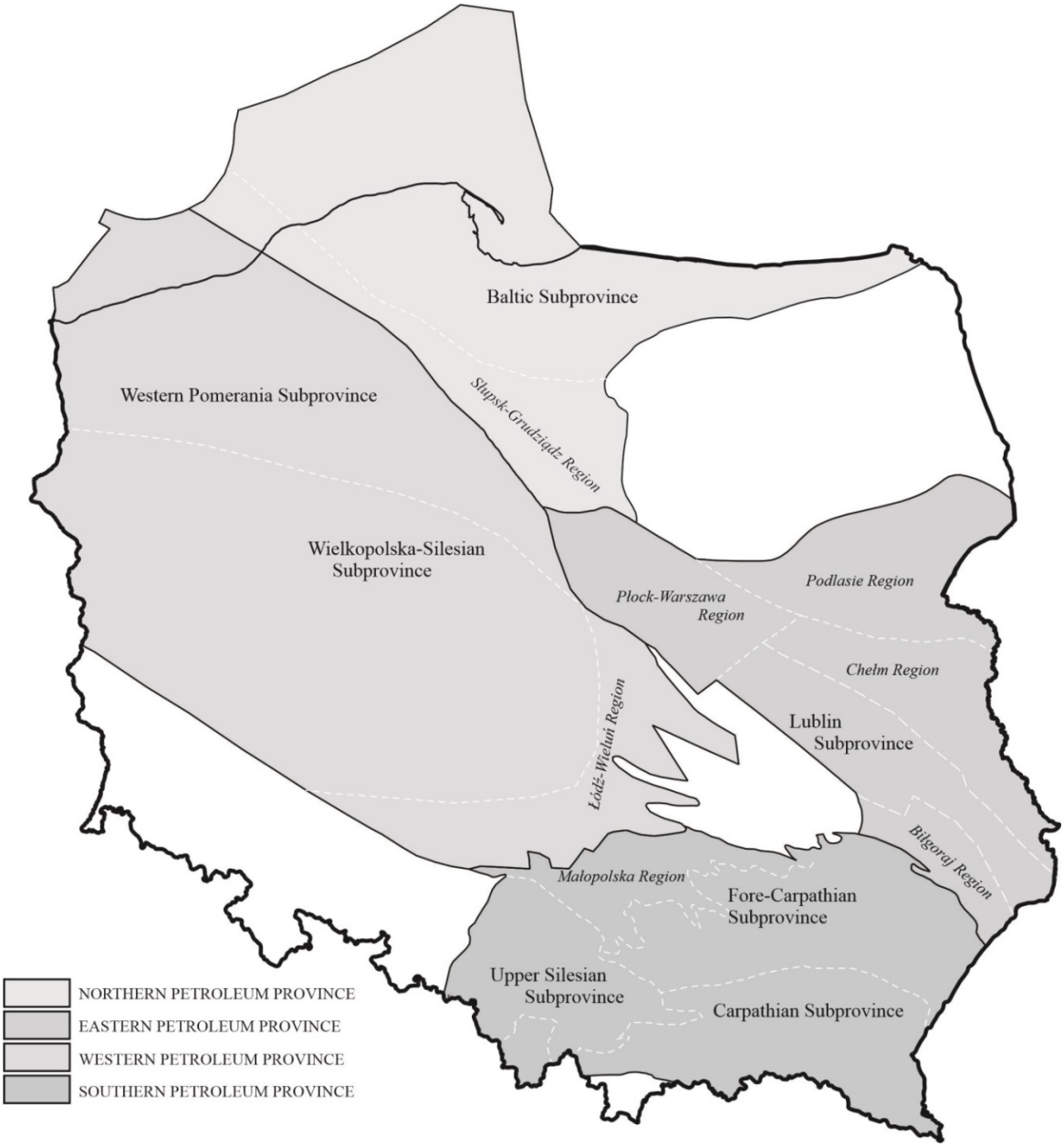

Fig. 1. Petroleum subdivision of Poland – scheme assumed in this study (Wójcik et al., 2019).

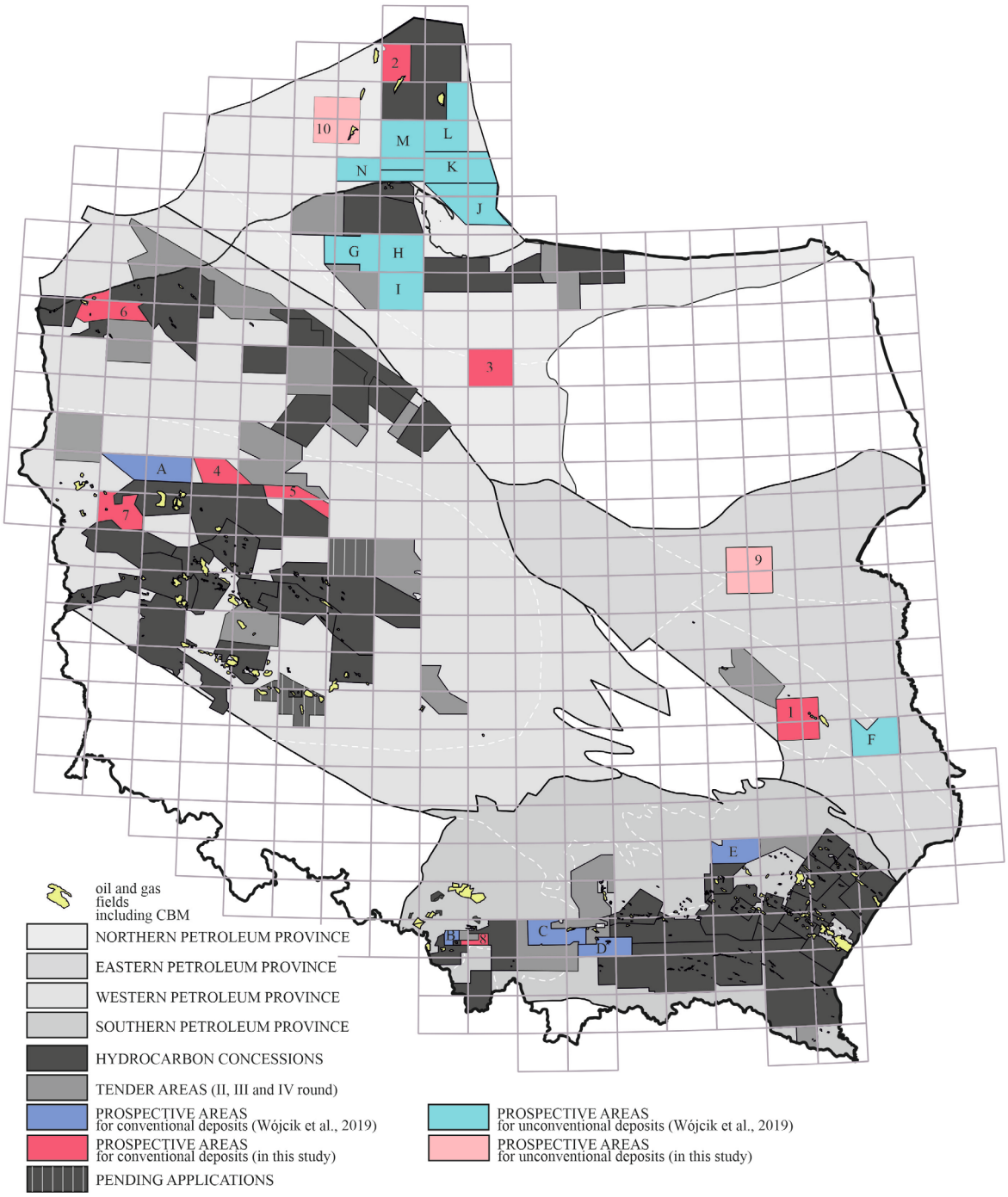

Fig. 2. Petroleum subdivision of Poland (Wójcik et al., 2019) in relation to hydrocarbon concessions and pending applications (as of 31.01.2020), tender areas, oil and gas fields, hydrocarbon concession grid, and prospective areas.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318,
2 – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.

B. PROSPECTIVE HORIZONS
B.1. CONVENTIONAL HYDROCARBON ACCUMULATIONS

B.1.1. CAMBRIAN

Reservoir rocks: Middle Cambrian sandstones (Dębki Formation).

Source rocks: Furongian and Tremadocian claystones of the Piaśnica Formation (Alum Shales), Ordovician claystones of the Sasino Formation, Silurian claystones of the Jantar Formation.

Seal: Furongian, Ordovician and Silurian fine-grained clastic rocks.

Traps: stratigraphic and structural.

Oil and gas fields (as of 31.12.2018):
9 gas fileds and 6 oil fields, including 5 gas fields and 2 oil fields located offshore.

Fields resources (as of 31.12.2018):
4856.77 mln m^3 of natural gas,
6640.61 kt of crude oil.

Production in 2018:
23.85 mln m^3 of natural gas,
192.61 kt of crude oil.

Prospective resources:
onshore (Górecki and Zawisza, 2011; as of 1994):
1300 mln m^3 of natural gas,
1.1 mln t of crude oil;
offshore: not defined.

Prospective zones:

Prospectives for oil and gas exploration in the Cambrian are related to the East European Craton, so also to the areas of the Northern and Eastern Petroleum Provinces. Kotarba (2010a; see also: Kosakowski et al., 2010a, b; Kotarba, 2010b; Więcław et al., 2010a, b; Wróbel and Kosakowski, 2010; Pacześna and Janas, 2020) indicated several offshore zones, which are prospective for exploration for new crude oil, condensate and natural gas accumulations. These are:

(I) zone of migration and accumulation of hydrocarbons;
(II) zone of good prospectives for oil and gas exploration;
(III) zone of medium prospectives for crude oil and condensate, and good for natural gas exploration;
(IV) zone of low prospectives for natural gas exploration.

Outside of them, there is a zone with minimal exploration prospects. These prospective zones are illustrated in Figs 3 and 4, where the location of potential traps is signalized, as well (according to: Pokorski, 2010; Domżalski and Mazurek, 2003).

Prospectives for exploration in the onshore part of the East European Craton were analyzed by Stolarczyk et al. (2004), who distinguished, as follows: highly prospective and prospective zones (II and III in Figs 3 and 4), zone with limited exploration prospectives due to questioned preservation of traps (IV), low prospective zone due to poor reservoir properties of the Cambrian deposits (here not illustrated).

References: Ulmishek, 1990; Witkowski, 1990; Karczewska and Żurawski, 1998; Królicka, 1998; Żurawski, 1998; Jaworowski, 2000; Domżalski and Mazurek, 2003; Domżalski et al., 2004; Stolarczyk et al., 2004; Pokorski and Modliński, 2007; Kosakowski et al., 2010a, b; Kotarba, 2010a, b; Pokorski, 2010; Więcław et al., 2010a, b; Wróbel and Kosakowski, 2010; Górecki, 2011; Pacześna, 2012; Kotarba and Lewan, 2013; Kotarba and Nagao, 2015; Sowiżdżał and Słoczyński, 2016; Yang et al., 2017; Jaśniewicz et al., 2019; Pacześna and Janas, 2020.

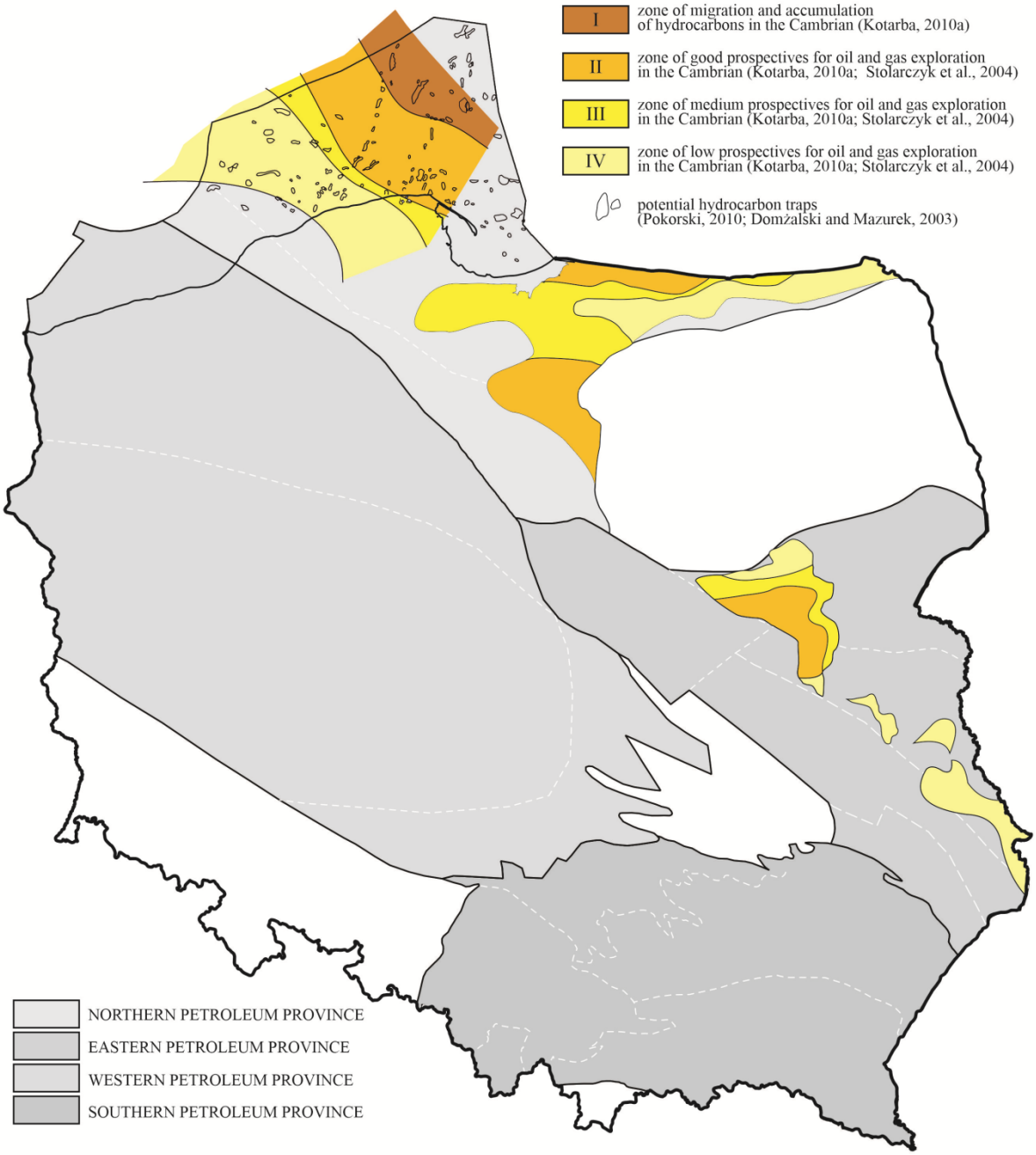

Fig. 3. Zones prospective for oil and gas exploration in the Cambrian (Kotarba, 2010a; Stolarczyk et al., 2004) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019).

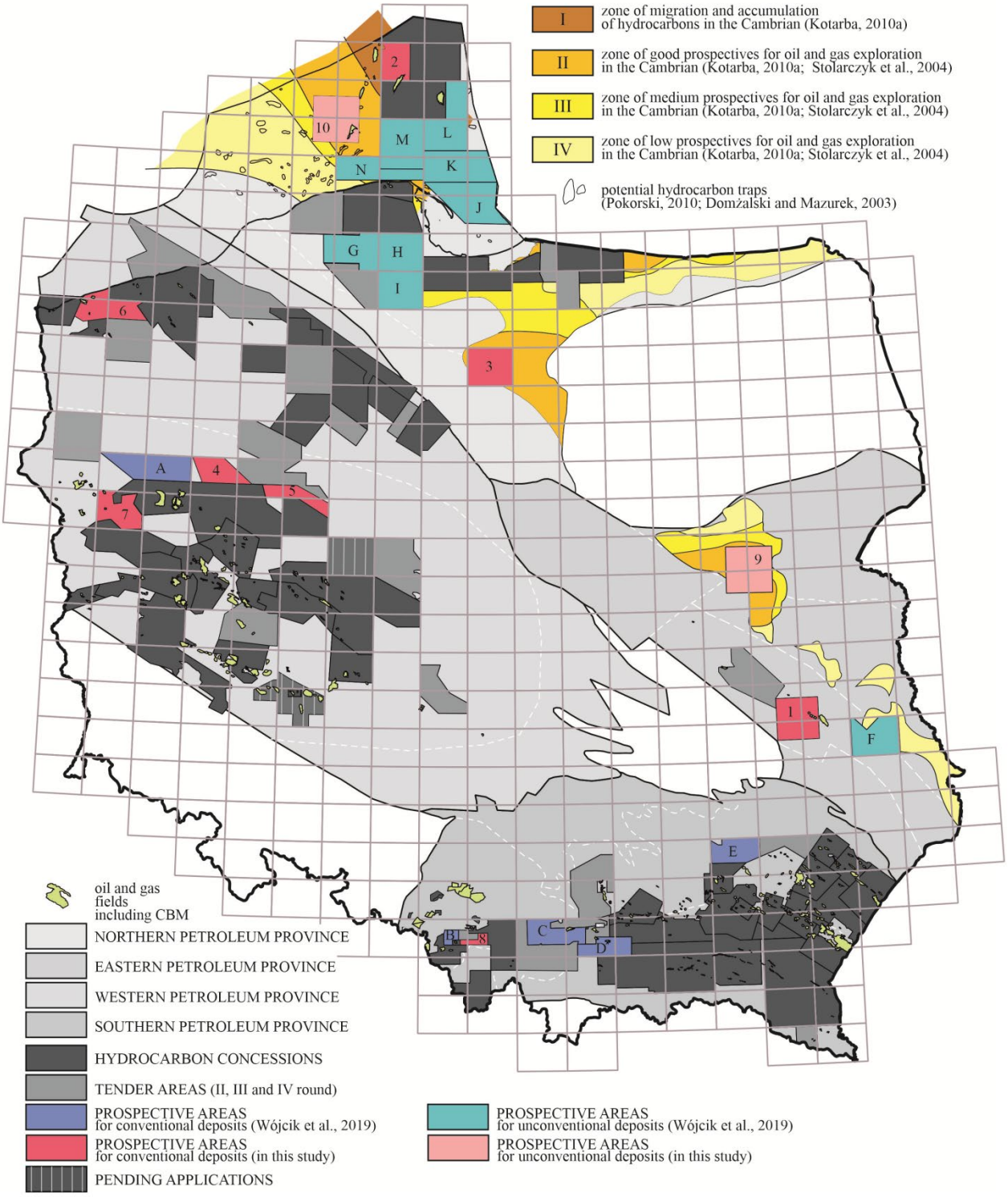

Fig. 4. Zones prospective for oil and gas exploration in the Cambrian (Kotarba, 2010a; Stolarczyk et al., 2004) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318, **2** – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.

B.1.2. DEVONIAN

Reservoir rocks: Givetian carbonate-clastic rocks and Frasnian carbonate rocks in the Western Pomerania Subprovince; Middle Devonian carbonate-clastic rocks of the Terebin Formation, Frasnian carbonate rocks of the Modryń Formation and Famennian carbonate-clastic rocks of the Bychawa Formation in the Lublin Subprovince.

Source rocks: Lower Paleozoic and Devonian fine-grained clastic rocks in the Western Pomerania Subprovince; Lower Paleozoic and Upper Devonian fine-grained clastic rocks in the Lublin Subprovince.

Seal: fine-grained clastic intercalations in the Middle Devonian; Carboniferous fine-grained clastic rocks.

Traps: stratigraphic, structural.

Oil and gas fields (as of 31.12.2018):
3 natural gas fields and 1 oil field in the Lublin Subprovince; no fields in the Devonian of the Western Pomerania Subprovince.

Fieds resources (as of 31.12.2018):
1130.24 mln m^3 of natural gas,
6.82 kt of crude oil.

Production in 2018:
32.49 mln m^3 of natural gas,
0.28 kt of crude oil.

Prospective resources
(Górecki and Zawisza, 2011; as of 1994):
24.8 bln m^3 of natural gas,
15.8 mln t of crude oil in the Lublin Subprovince;
10.2 bln m^3 of natural gas,
6.03 mln t of crude oil in the Western Pomerania Subprovince.

Prospective zones:

Prospectives for oil and gas exploration in the Devonian are related to the Western Pomerania and Lublin Subprovinces (Western and Eastern Petroleum Provinces).

In the Western Pomerania – in its offshore part – Poprawa et al. (2018, compare: Kotarba, 2010a) noticed an exploration potential in the Devonian of the Koszalin-Chojnice zone by analogy with the onshore part, in which accumulations of crude oil and natural gas have recently been discovered near Bajerze and Tuchola (not yet included in the Balance of Mineral Resources... 2019). This discovery confirms prospectivity of the Devonian deposits in the Western Pomerania Subprovince, previously designated by Górecki and Zawisza (2011: Figs 5 and 6).

In the Lublin Subprovince, Narkiewicz et al. (2011) determined the zone of hydrodynamic tightness for the Devonian (i.e. the zone in which Devonian reservoir rocks are sealed). Within, they identified the areas of possible hydrocarbon accumulations (Figs 5 and 6).

References: Burzewski et al., 1998; Grotek et al., 1998; Botor et al., 2002; Antonowicz et al., 2003; Helcel-Weil and Dzięgielowski, 2003; Kotarba et al., 2005; Semyrka et al., 2005; Matyja, 2006, 2008, 2009; Helcel-Weil et al., 2007; Kotarba, 2010a; Górecki, 2011; Górecki and Zawisza, 2011; Narkiewicz et al., 2011; Aleksandrowski and Buła, 2017; Aleksandrowski and Mazur, 2017; Krzywiec et al., 2017a; Tomaszczyk and Jarosiński, 2017; Radkovets et al., 2017; Poprawa et al., 2018; Feldman-Olszewska et al., 2020.

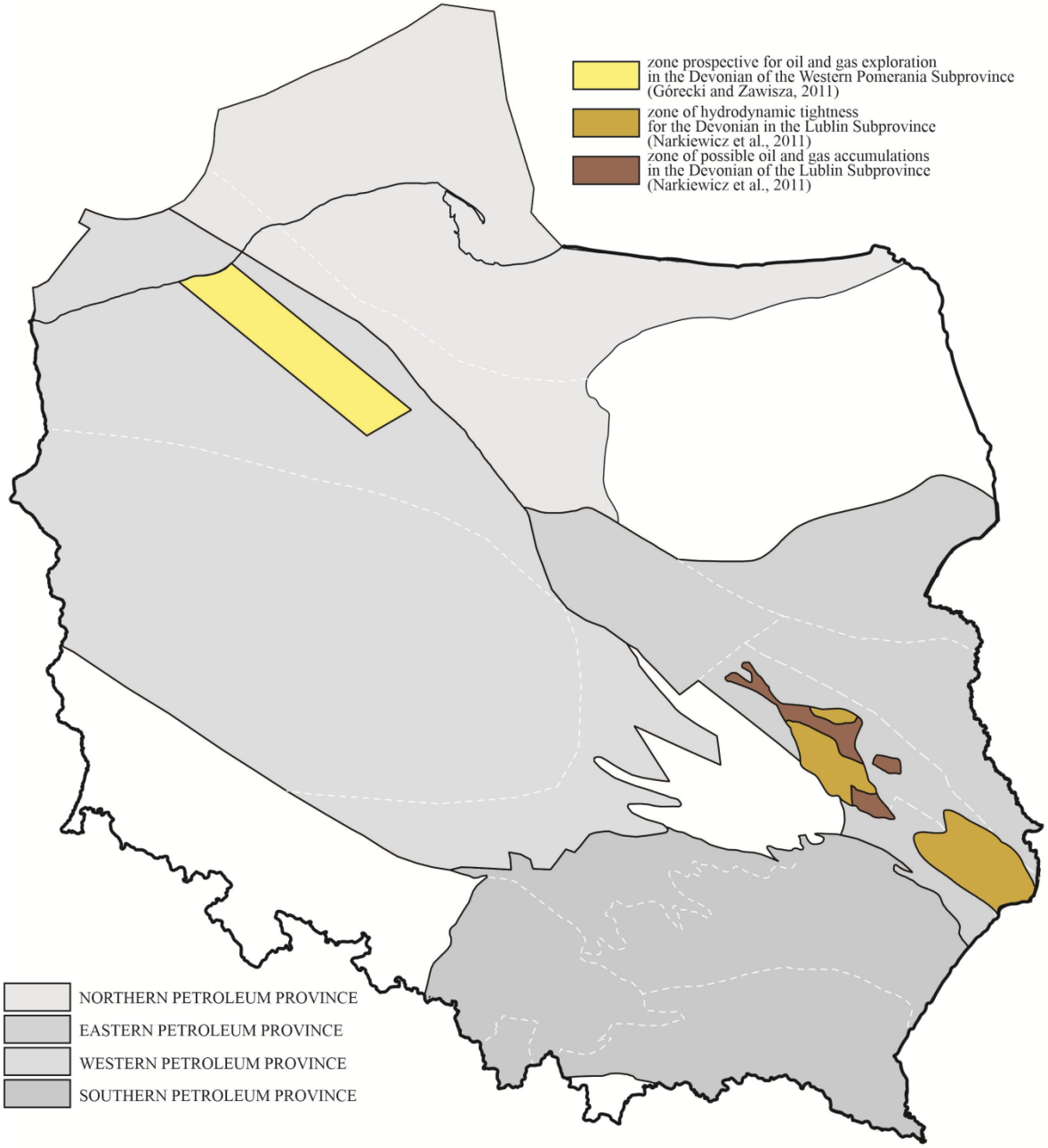

Fig. 5. Zones prospective for oil and gas exploration in the Devonian (Narkiewicz et al., 2011; Górecki and Zawisza, 2011) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019).

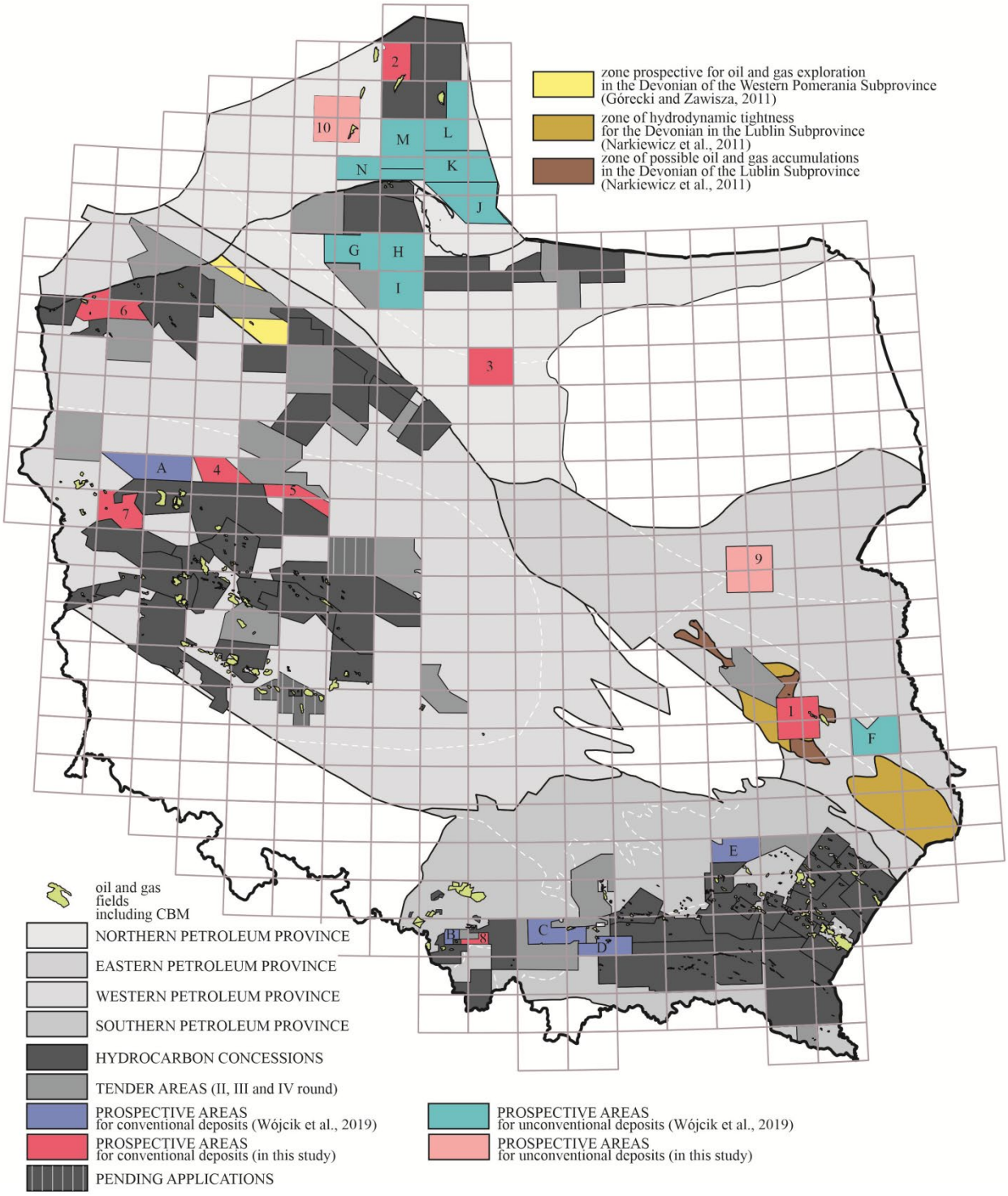

Fig. 6. Zones prospective for oil and gas exploration in the Devonian (Kotarba, 2010a; Stolarczyk et al., 2004) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
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1–10 – areas selected for oil and gas exploration in this study:
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B.1.3. CARBONIFEROUS

Reservoir rocks: Mississippian and Pennsylvanian sandstones in the Western Pomerania Subprovince; sandstones of the Terebin, Dęblin and Lublin Formations in the Lublin Subprovince.

Source rocks: Mississippian and Pennsylvanian fine-grained clastic rockss in the Western Pomerania Subprovince; Mississippian and Pennsylvanian fine-grained clastic rocks of the Huczwa, Terebin and Lublin Formations in the Lublin Subprovince.

Seal: intercalations of fine-grained clastic rock in the Carboniferous, Zechstein evaporites.

Traps: stratigraphic, structural.

Oil and gas fields (as of 31.12.2018):
2 natural gas fields and 1 oil field in the Lublin Subprovince; 8 natural gas fields in the Western Pomerania Subprovince (in one of them production is provided from the Carboniferous and Zechstein Limestone).

Fields resources (as of 31.12.2018):
16 374.25 mln m^3 of natural gas,
86.57 kt of crude oil.

Production in 2018:
926.61 mln m^3 of natural gas,
0.00 kt of crude oil.

Prospective resources
(Górecki and Zawisza, 2011: as of 1994):
13.8 bln m^3 of natural gas,
3.56 mln t of crude oil
in the Lublin Subprovince;
7.42 bln m^3 of natural gas,
2.27 mln t of crude oil
in the Western Pomerania Subprovince.

Prospective zones:
The Carboniferous of the Western Pomerania Subprovince (Western Petroleum Province) and Lublin Subprovince (Eastern Petroleum Province) is considered to be highly prospective for oil and gas exploration.

Górecki and Zawisza (2011) illustrated one prospective zone for exploration in the Carboniferous of the Western Pomerania (Figs 7 and 8). Several natural gas fields, discovered in the vicinity of Gorzysław, Trzebusz, Białogard and Wrzosowo, seem to confirm the hydrocarbon potential of this zone. However, the zone, limited only to the north-western (onshore) part of the Western Pomerania Subprovince, should be extended to the south and east, as the gas accumulations in the Carboniferous were also discovered in Białogard, Daszewo and Wierzchowo.

In the Lublin Subprovince, similar as in the Devonian case, Narkiewicz et al. (2011) documented the zones of hydrodynamic tightness for the Carboniferous (i.e. the zones in which Carboniferous reservoir rocks are sealed). Within, they identified the areas of possible hydrocarbon accumulations (Figs 7 and 8).

References: Burzewski et al., 1998; Grotek et al., 1998; Botor et al., 2002; Antonowicz et al., 2003; Helcel-Weil and Dzięgielowski, 2003; Kotarba et al., 2005; Semyrka et al., 2005; Matyja, 2006; Helcel-Weil et al., 2007; Górecki, 2011; Górecki i Zawisza, 2011; Narkiewicz et al., 2011; Aleksandrowski and Buła, 2017; Aleksandrowski and Mazur, 2017; Krzywiec et al., 2017a; Tomaszczyk and Jarosiński, 2017; Poprawa et al., 2018; Feldman-Olszewska et al., 2020.

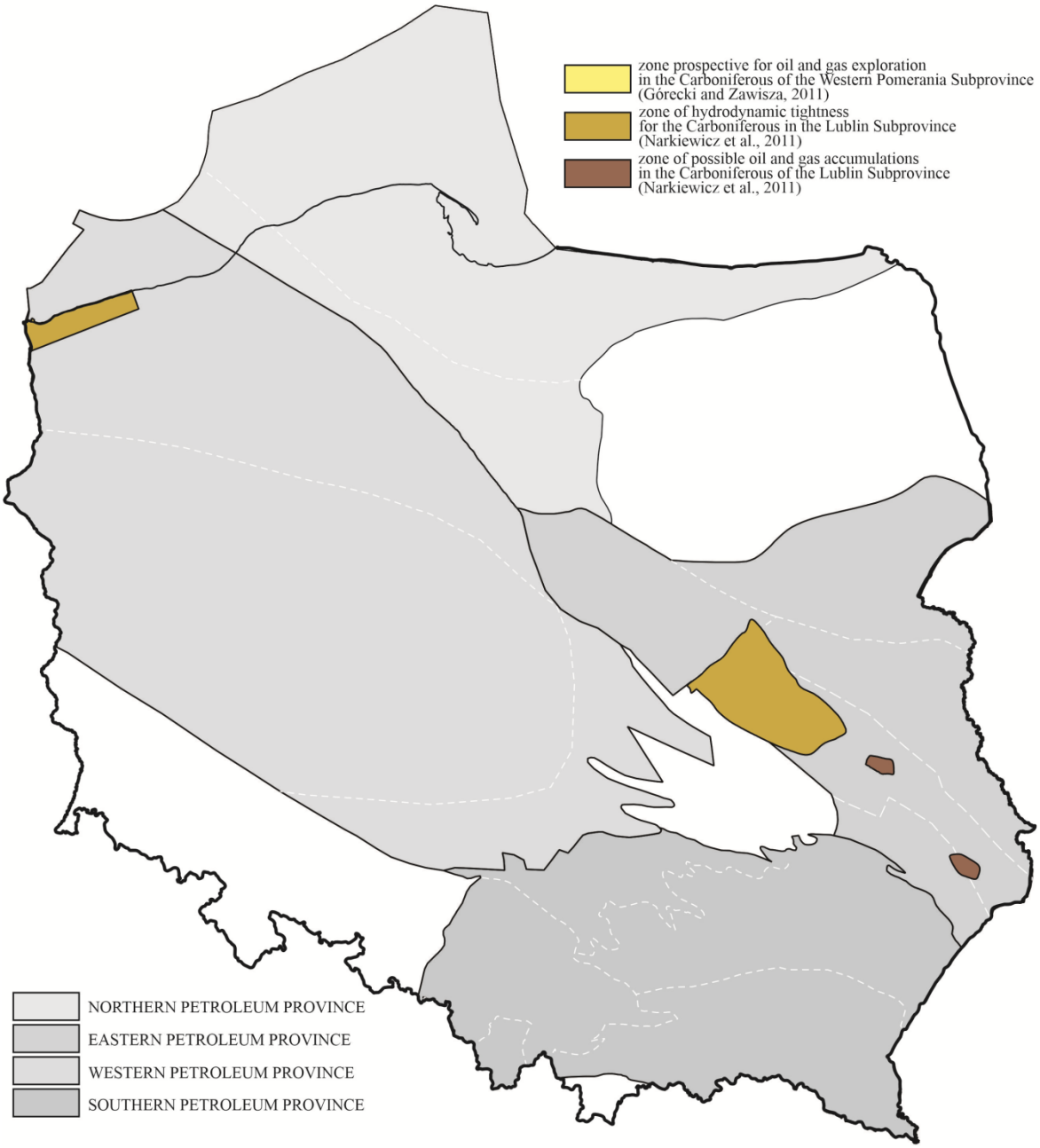

Fig. 7. Zones prospective for oil and gas exploration in the Carboniferous (Narkiewicz et al., 2011; Górecki and Zawisza, 2011) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019).

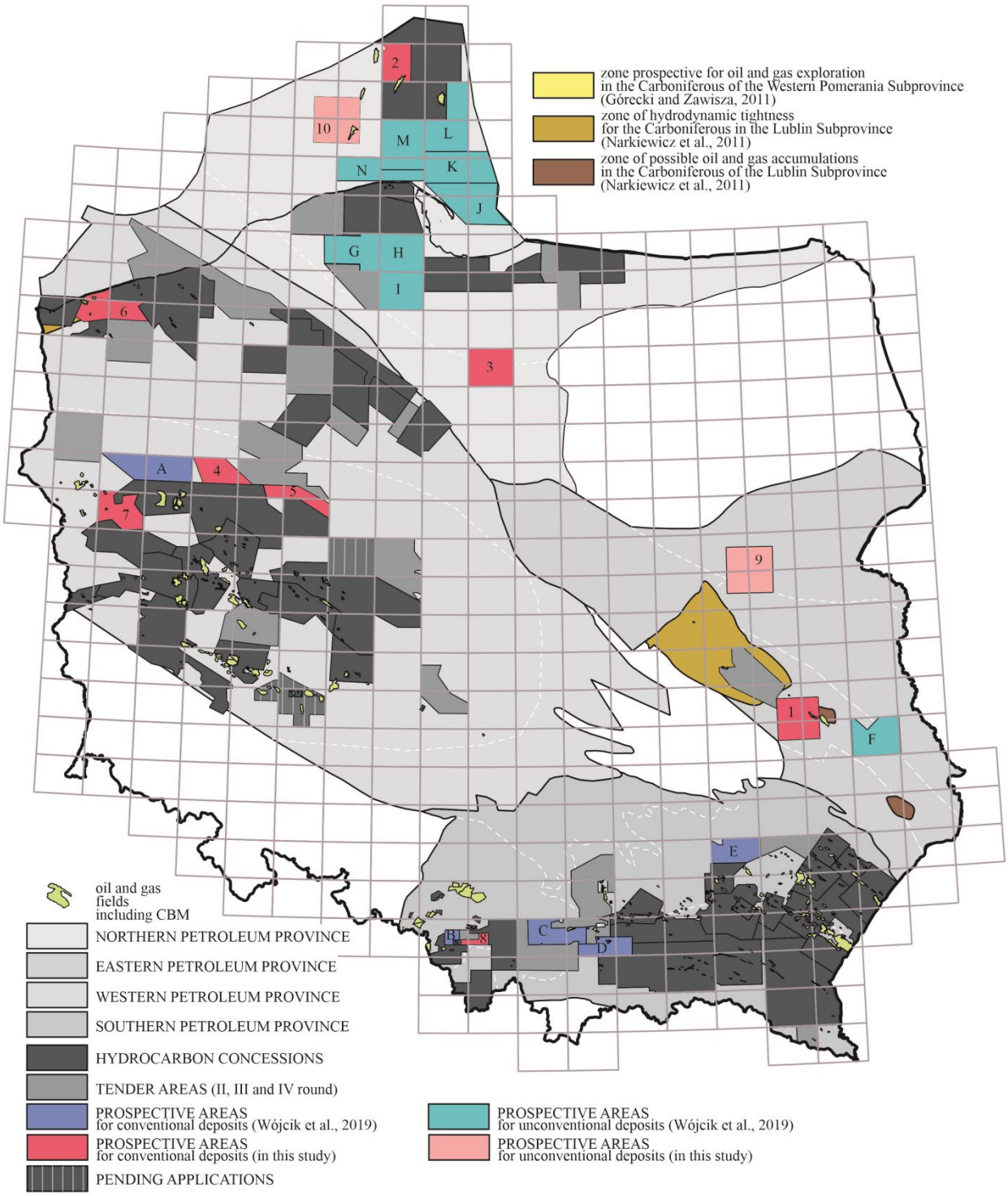

Fig. 8. Zones prospective for oil and gas exploration in the Carboniferous (Kotarba, 2010a; Stolarczyk et al., 2004) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
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1–10 – areas selected for oil and gas exploration in this study:
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B.1.4. PERMIAN – ROTLIEGEND AND ZECHSTEIN LIMESTONE

Reservoir rocks: aeolian and fluvial sandstones, marginal playa-lake sandstones in the Rotliegend; dolomites and limestones in the Zechstein Limestone.

Source rocks: Carboniferous fine-grained clastic rocks.

Seal: Zechstein evaporites.

Traps: stratigraphic, structural.

Oil and gas fields (as of 31.12.2018):

85 fields of natural gas including:

59 fields – Rotliegend,

9 fields – Rotliegend and Zechstein Limestone,

3 fields – Rotliegend and Main Dolomite,

1 field – Carboniferous and Zechstein Limestone,

10 fields – Zechstein Limestone,

3 fields – Zechstein Limestone and Main Dolomite.

In total, natural gas accumulations in the Rotliegend strata occur in 71 fields, while in the Zechstein Limestone – in 23 fields.

Fields resources (as of 31.12.2018):

49 350.42 mln m^3 of natural gas (28 901.40 mln m^3 in the Rotliegend).

Production in 2018:

2 751.69 mln m^3 of natural gas.

Prognostic resources:

1 410 bln m^3 of natural gas (Górecki, 2008; including Rotliegend and Zechstein Limestone)

1 250 bln m^3 of natural gas (Chmielowiec-Stawska and Czekański, 2013; Rotliegend).

Prospective zones:

The Rotliegend and Zechstein Limestone deposits are prospective for natural gas exploration in the Western Pomerania and Wielkopolska-Silesian Subprovinces (Western Petroleum Province).

Chmielowiec-Stawska and Czekański (2013) indicated the northern edge of the Upper Rotliegend Basin (from Kaleń to Świdwin and Łobez), Poznań Basin, and the northern foreland of the Wolsztyn Ridge as the petroleum prospective zones (Figs 9 and 10). Buniak and Nowicka (2013a), as well as Buniak and Kwolek (2013a), illustrated numerous structures in the Upper Rotliegend, which may be treated as potential traps for conventional accumulations (Figs 9 and 10). However, the Zechstein Limestone is in the final stage of hydrocarbon and should be treated rather as an additional horizon during exploration of Carboniferous strata (Chmielowiec-Stawska and Czekański, 2013).

According to Burzewski et al. (2009), the following zones can be considered as the most prospective for natural gas accumulations in the Rotliegend: Mężyk–Objezierze–Września (north-eastern edge of the Upper Rotliegend Basin), Szubin–Byczyna–Kutno (south-western edge of the Upper Rotliegend Basin) and the north-eastern edge of the Wolsztyn Ridge (Figs 9 and 10).

References: Kiersnowski and Buniak, 2006; Górecki, 2008, 2011; Burzewski et al., 2009; Gast et al., 2010; Górecki and Zawisza, 2011; Chmielowiec-Stawska and Czekański, 2013; Buniak and Nowicka, 2013a; Buniak and Kwolek, 2013a; Kiersnowski, 2013, 2020; Feldman-Olszewska et al, 2020.

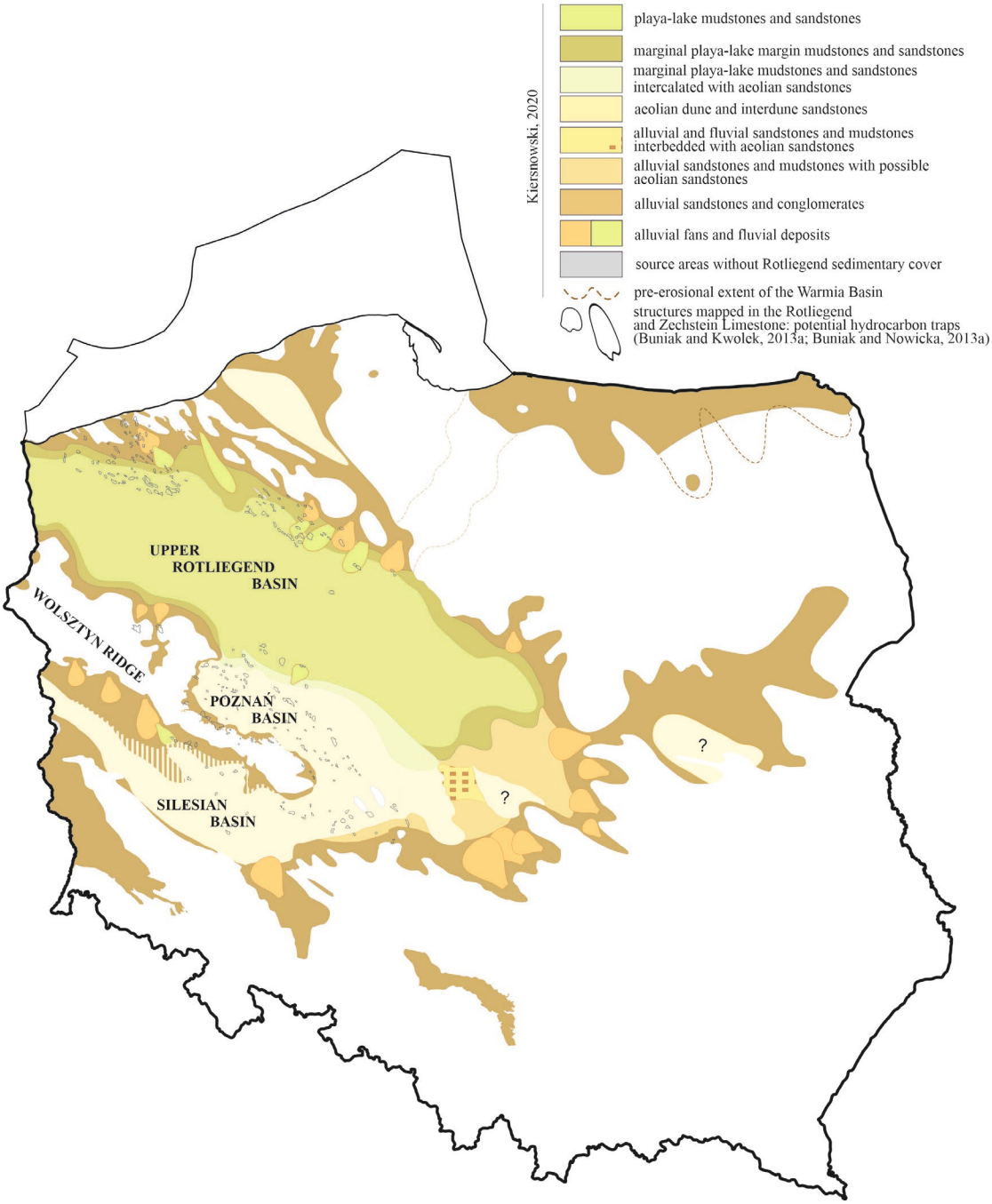

Fig. 9. Paleogeography and lithofacies of the Upper Rotliegend with location of potential traps (Kiersnowski, 2020; traps afret Buniak and Kwolek, 2013a; Buniak and Nowicka, 2013a).

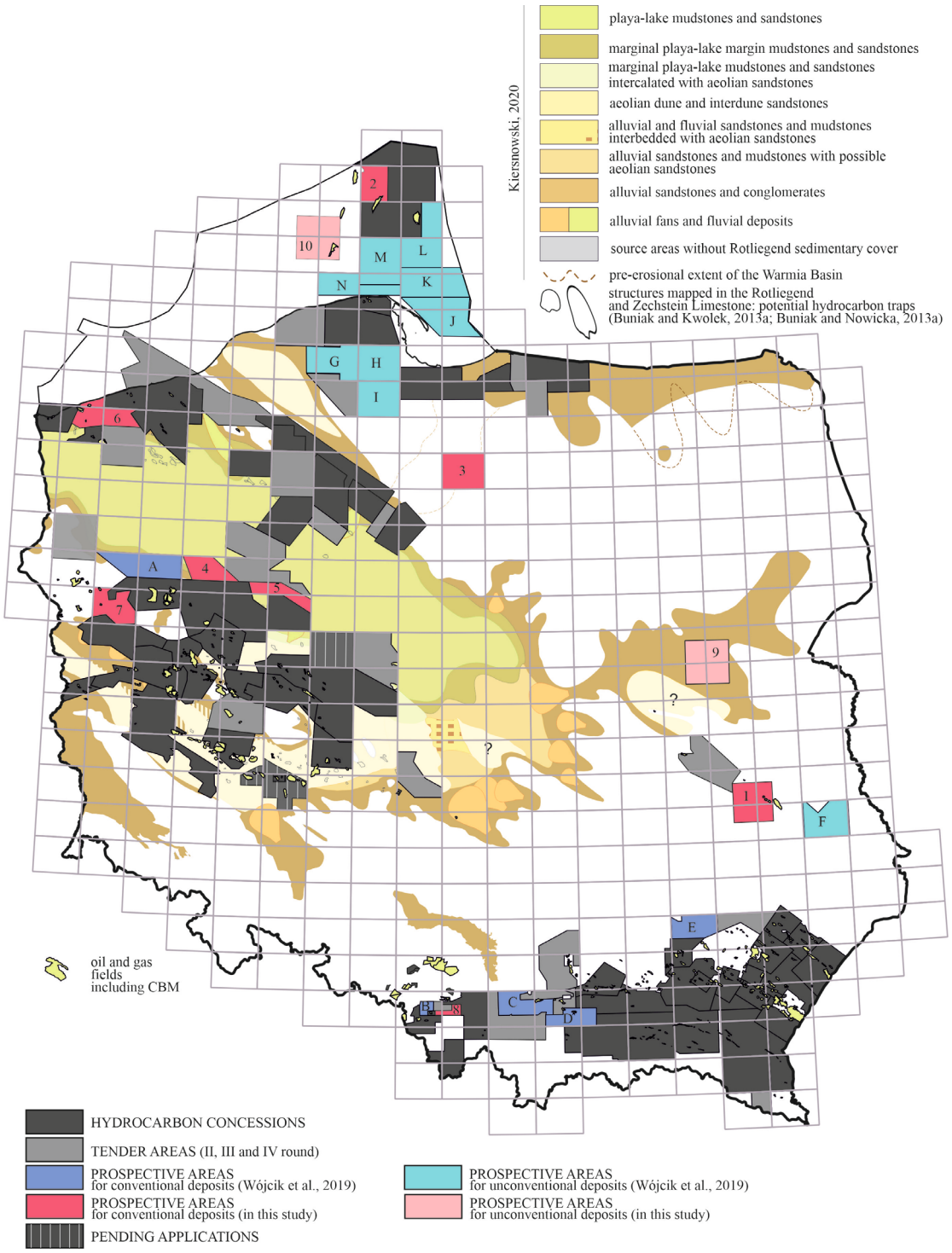

Fig. 10. Paleogeography, lithofacies and potential traps in the Upper Rotliegend (Kiersnowski, 2020; traps afret Buniak and Kwolek, 2013a; Buniak and Nowicka, 2013a) in relation to the hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
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B.1.5. PERMIAN – MAIN DOLOMITE

Reservoir rocks: dolomites and detrital limestones (carbonate platforms and slopes).
Source rocks: biolaminated stromatolitic mudstones and wackstones (lagoons, tidal-flats and carbonate platform slope).
Seal: Zechstein evaporites.
Traps: stratigraphic, structural.
Oil and gas fields (as of 31.12.2018):
58 natural gas fields,
38 oil fields.
Fields resources (as of 31.12.2018):
52 446.17 mln m^3 of natural gas,
15 651.05 kt of crude oil.
Production in 2018:
976.15 mln m^3 of natural gas,
707.78 kt of crude oil.
Prognostic resources:
219 bln m^3 of natural gas,
235 mln t of crude oil
(Górecki and Zawisza, 2011),
100 mln t of crude oil (Chmielowiec-Stawska and Czekański, 2013).
Prospective zones:

The Main Dolomite is prospective for oil and gas exploration in the Western Petroleum Province – in the Western Pomerania and Wielkopolska-Silesian Subprovinces, as well as in the Northern Petroleum Province.

Chmielowiec-Stawska and Czekański (2013) considered the northern and southern edge of the Main Dolomite Basin – the so-called northern and southern carbonate platforms – as prospective for the exploration. The first platform extends through the Western Pomarania and Baltic Subprovinces, while the second one is limited to the Wielkopolska-Silesian Subprovince.

On the northern platform, Chmielowiec-Stawska and Czekański (2013) and Górecki and Zawisza (2011) indicated its western part, extending from the Polish border to the Bydgoszcz, as the most prospective zone, estimating the prognostic resources of crude oil from 10 to 54 mln tons. Buniak and Nowicka (2013b) illustrated here numerous potential traps in the Main Dolomite strata (Figs 11 and 12). The eastern part of the northern platform (located within the Baltic Subprovince) is less promising, and, according to Chmielowiec-Stawska and Czekański (2013), it cannot be treated as the main target during the exploration. Nevertheless, the same authors provide predictable oil resources for this part, estimated at 10 mln tons. Even more – 52 mln tons – are evaluated by Górecki and Zawisza (2011).

The southern platform is promising in its western part, located between the Polish border and Kalisz. Here, Chmielowiec-Stawska and Czekański (2013) and Górecki and Zawisza (2011) indicated the shallow marine carbonate platform, its barriers and slopes, as well as other isolated carbonate platforms and megastructures (Krobielewko, Sulęcin and Chartów) as the most prospective zones. This observations are confirmed by numerous structural objects illustrated by Buniak and Kwolek (2013b; Figs 11 and 12). Prognostic resources of crude oil are estimated here at 100–110 mln tons (Chmielowiec-Stawska and Czekański, 2013; Górecki and Zawisza, 2011). The part of the platform located between Kalisz and the Holy Cross Mountains, where Górecki and Zawisza (2011) estimated oil resources at 19 mln tons, is less promising.

References: Wagner, 1994; Kotarba et al., 1998; Karnkowski, 2000, 2007; Kotarba, 2000; Protas and Wojtkowiak, 2000; Kosakowski et al., 2003; Grotek, 2006; Kotarba and Wagner, 2007; Słowakiewicz and Mikołajewski, 2009, 2011; Czekański et al., 2010; Pletsch et al., 2010; Górecki, 2011; Botor et al., 2013; Buniak and Kwolek, 2013b, 2016; Buniak and Nowicka, 2013b; Chmielowiec-Stawska and Czekański, 2013; Słowakiewicz and Gąsiewicz, 2013; Kosakowski and Krajewski, 2014, 2015; Karnkowski and Matyasik, 2016; Krzywiec et al., 2017b.

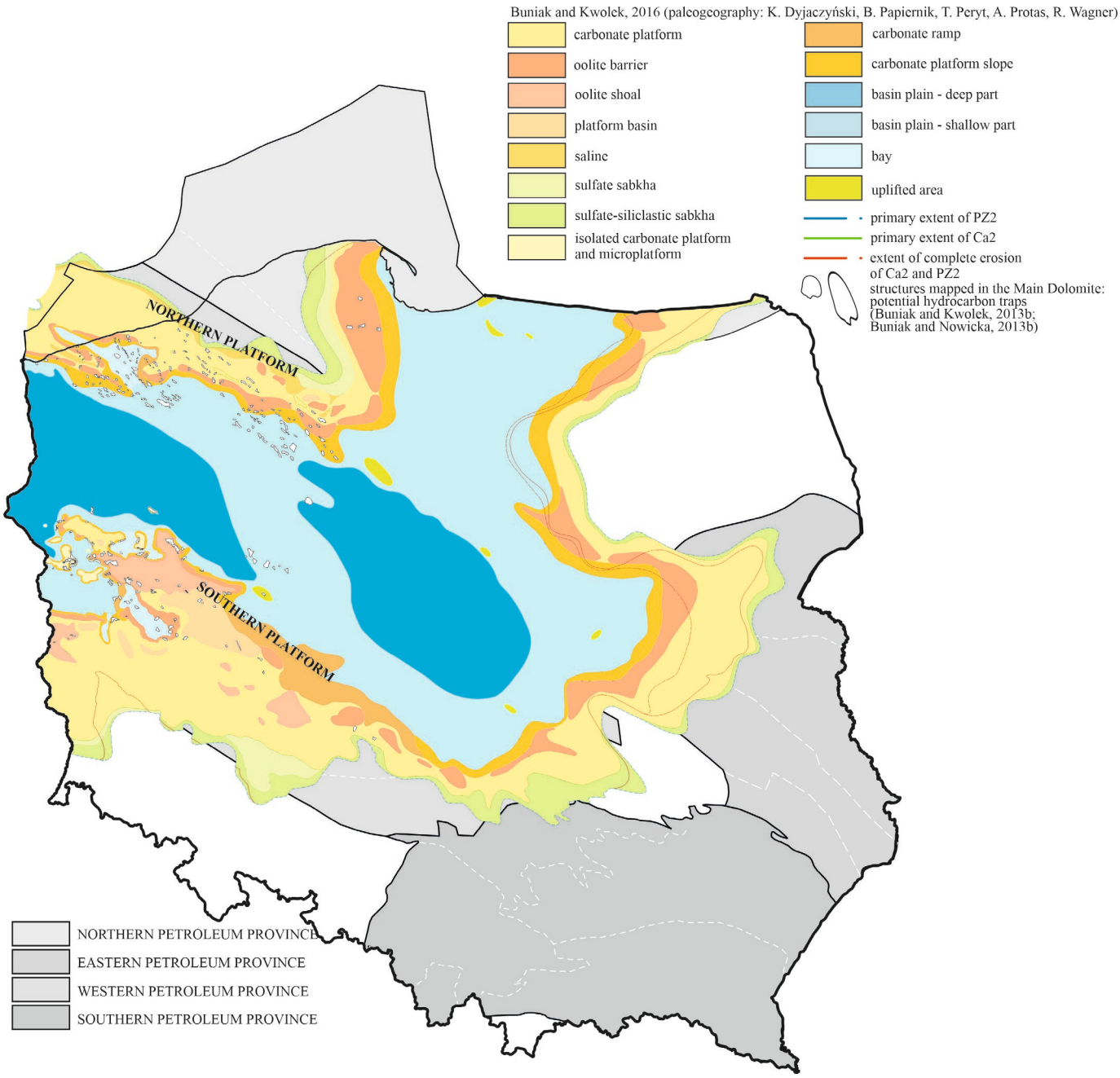

Fig. 11. Paleogeography and facies in the Main Dolomite with location of potential traps (Buniak and Kwolek, 2016; traps after Buniak and Kwolek, 2013b; Buniak and Nowicka, 2013b) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019).

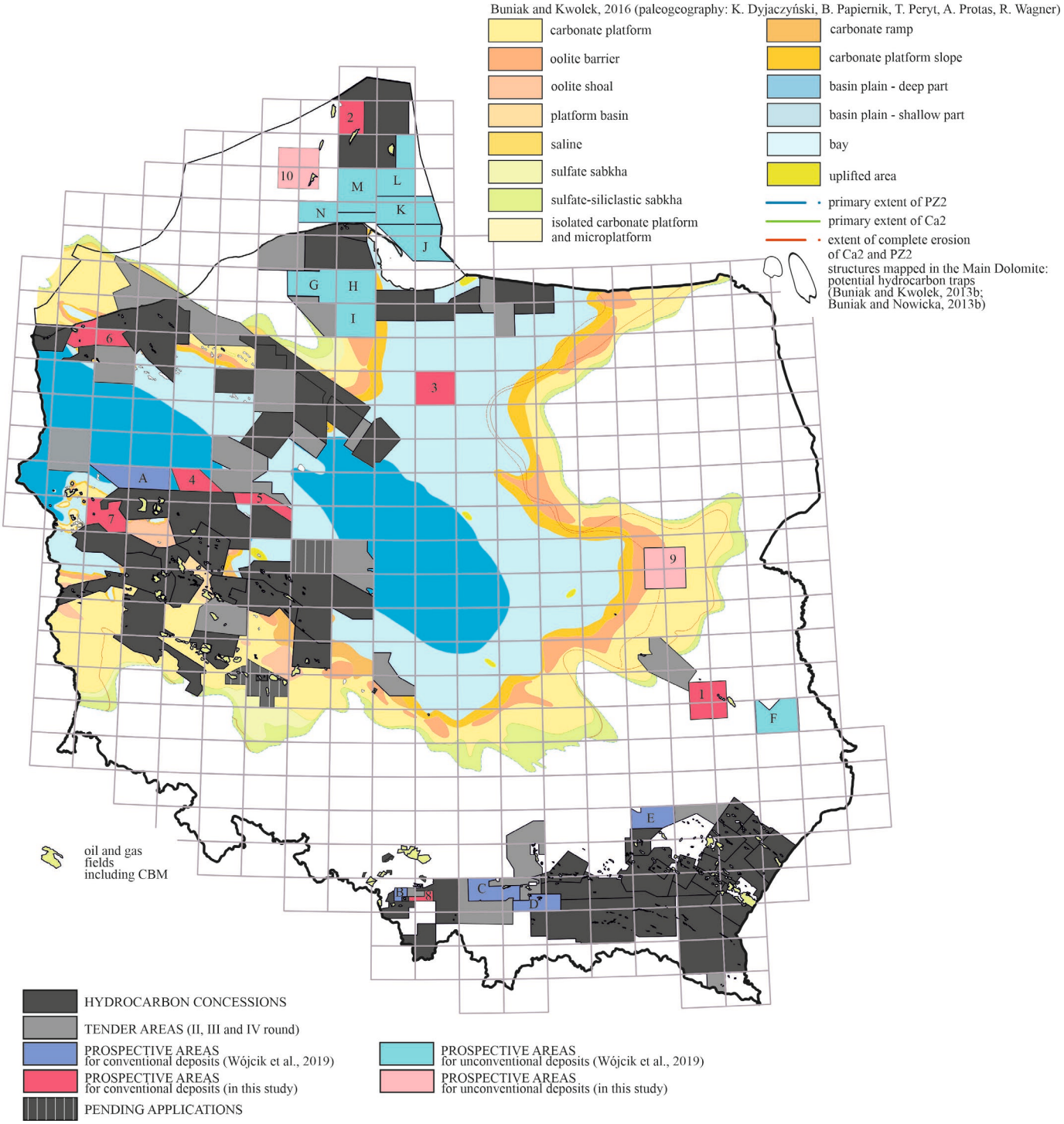

Fig. 12 . Paleogeography and facies of the Main Dolomite with location of potential traps (Buniak and Kwolek, 2016; traps after Buniak and Kwolek, 2013b; Buniak and Nowicka, 2013b) in relation to the hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318, **2** – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.

B.1.6. MESOZOIC OF THE POLISH LOWLAND

Reservoir rocks: Lower Jurassic sandstones (Zagaje, Drzewica, Borucice, Skłoby and Ostrowiec Formations), Middle Jurassic and Lower Cretaceous sandstones (Włocławek and Mogilany Formations), Oxfordian and Tithonian organodetritic and oolitic limestones.

Source rocks: Lower Keuper, Lower and Middle Jurassic and Lower Cretaceous fine-grained clastic rocks.

Seal: Upper Cretaceous rocks?

Traps: stratigraphic, structural.

Oil and gas fields: none.

Fields resources: none.

Production in 2018: none.

Prognostic resources:

11.25 bln m^3 of natural gas,
4.99 bln t of crude oil,
including:
1.89 bln m^3 of natural gas,
0.64 mln tons of crude oil,
in the Trassic strata;
9.36 bln m^3 of natural gas,
4.35 mln tons of crude oil,
in the Jurassic strata.

Prospective zones:

The Mesozoic succession of the Polish Lowland is prospective for hydrocarbon exploration in the Northern, Western and Eastern Petroleum Provinces. Unfortunately, no oil and gas fields have been decumented here, so far, although hydrocarbon shows have been noticed in numerous wells.

Górecki and Zawisza (2011) considered the Central Poland as prospective for hydrocarbon exploration (Figs 13 and 14), as the Jurassic successions seems to be particulary promising.

Feldman-Olszewska et al. (2020) indicated the Ponętów – Koło, Damasławek – Uniejów, Rogoźno – Kłecko – Janowiec and Lipno – Sochaczew zones as the most important for further exploration. These zones extend the area indicated by Górecki and Zawisza (2011) towards the north-west and south-east.

References: Burzewski et al., 1990; Nowicki et al., 1990; Bachleda-Curuś et al., 1992; Grotek, 2006; Więcław, 2016; Feldman-Olszewska et al., 2020.

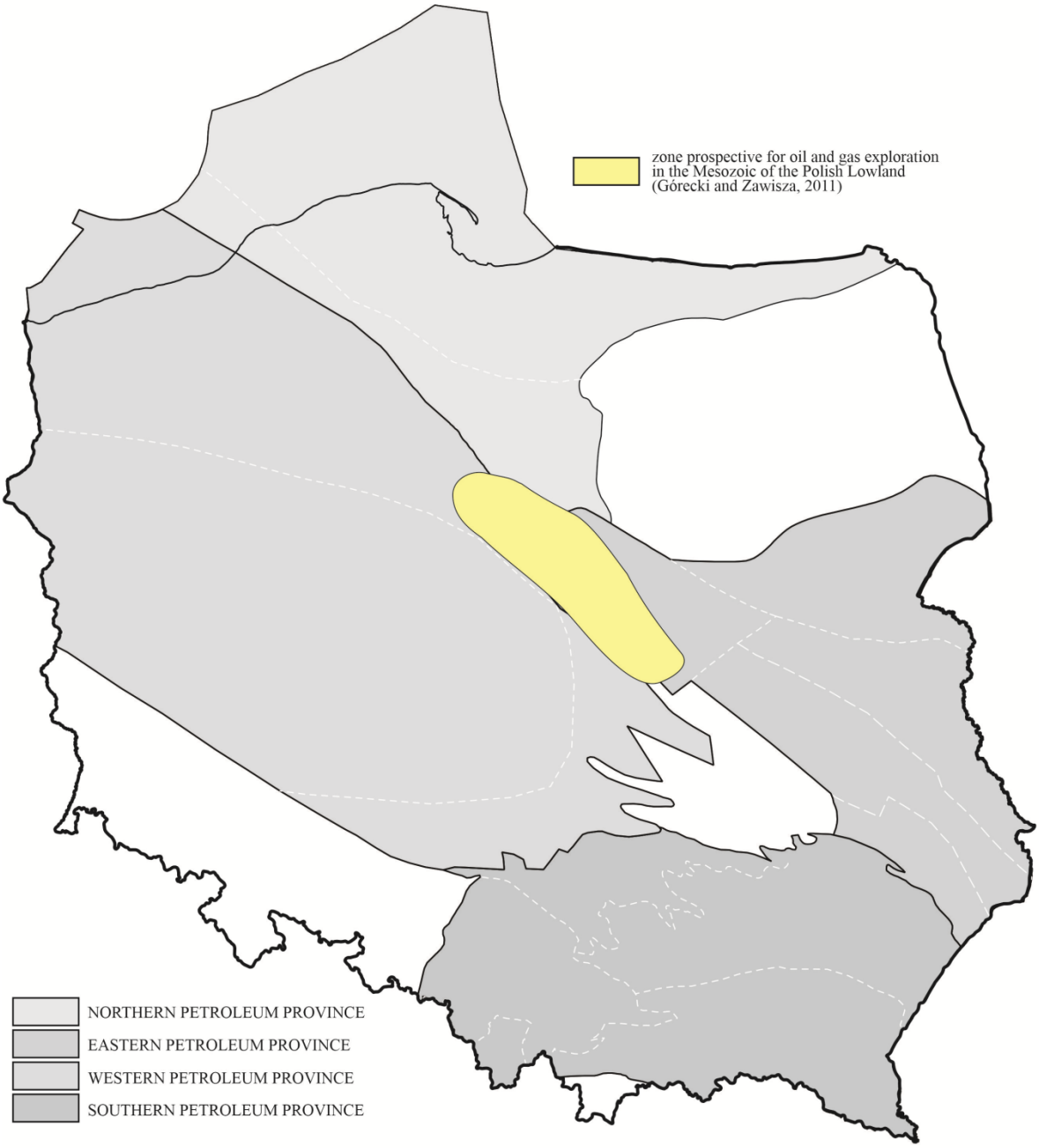

Fig. 13. Zones prospective for oil and gas exploration in the Mesozoic of the Polish Lowland (Górecki and Zawisza, 2011) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019).

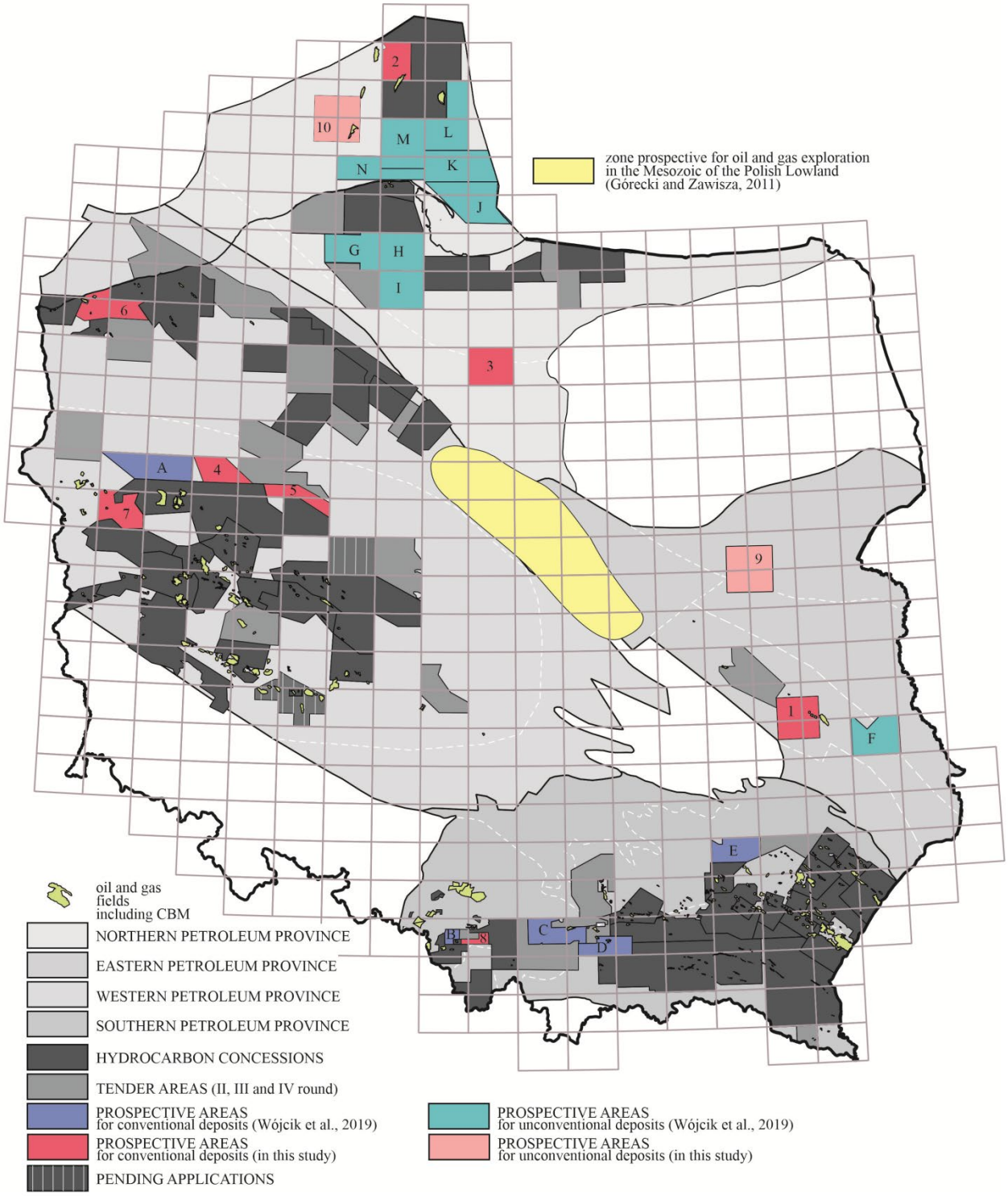

Fig. 14. Zones prospective for oil and gas exploration in the Mesozoic of the Polish Lowland (Górecki and Zawisza, 2011) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
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B.1.7. BASEMENT OF THE CARPATHIAN UNITS

Reservoir rocks: Precambrian, Cambrian, Lower Devonian, Lower Carboniferous and Upper Cretaceous sandstones; Devonian, Carboniferous, Upper Jurassic and Upper Cretaceous carbonate rocks.

Source rocks: Middle and Upper Devonian, Upper Jurassic carbonate rocks; Ordovician, Silurian, Devonian, Carboniferous and Middle Jurassic fine-grained clastic rocks.

Seal: Miocene of the Carpathian Foredeep, intercalations of fine-grained clastic rocks within Paleozoic-Mesozoic successsions.

Traps: stratigraphic, structural, structural-stratigraphic.

Oil and gas fields (as of 31.12.2018):

20 natural gas fields, including 9 fields producing from the Miocene and Paleozoic-Mesozoic basement;

10 oil fields, including 2 fields producing from the Miocene and Paleozoic-Mesozoic basement.

Fields resources (as of 31.12.2018):

4 325.55 mln m^3 of natural gas
(1 465,10 mln m^3 without Miocene fields),
461.18 kt of crude oil
(447.40 kt without Miocene fields).

Production in 2018:

267.34 mln m^3 of natural gas
(46.51 mln m^3 without Miocene fields),
15.17 kt of crude oil
(13.57 kt without Miocene fields).

Prognostic resources: undefined.

Prospective zones:

Oil and gas prospectives in the Precambrian and Paleozoic-Mesozoic succession in the basement of the Carpathian Units (Outer Carpathians and Carpathian Foredeep) is confirmed by numerous fields discovered. However, due to a depth, these horizons are usually treated as an additional exploration target.

Poprawa et al. (2010) indicated low and medium prospective zones for hydrocarbon exploration in the basement of the Outer Carpathians (Figs 15 and 16) based on residual geochemical data and preliminary analyses of petroleum system. Kotarba et al. (2011b) identified 7 areas, in which the hydrocarbon generation and expulsion processes from the Palezozoic and Mesozoic rocks in the basement of the Carpathian Foredeep and northern part of the Outer Carpathians occured most intensively. These areas should be considered as the most prospective for future oil and gas exploration (Figs 15 and 16).

References: Gliniak et al. 2001; Maksym et al., 2001, 2003; Kotarba et al., 2003, 2004a, b, c, 2011a, b, 2017; Gliniak and Urbaniec, 2005; Moryc, 2004, 2006; Myśliwiec et al., 2006; Buła and Habryn, 2008, 2011; Kotarba, 2011; Kosakowski and Wróbel, 2011, 2012; Kosakowski et al., 2011, 2012a, b, c; Więcław et al., 2010a, b, 2011, 2012; Wróbel et al., 2012, 2016.

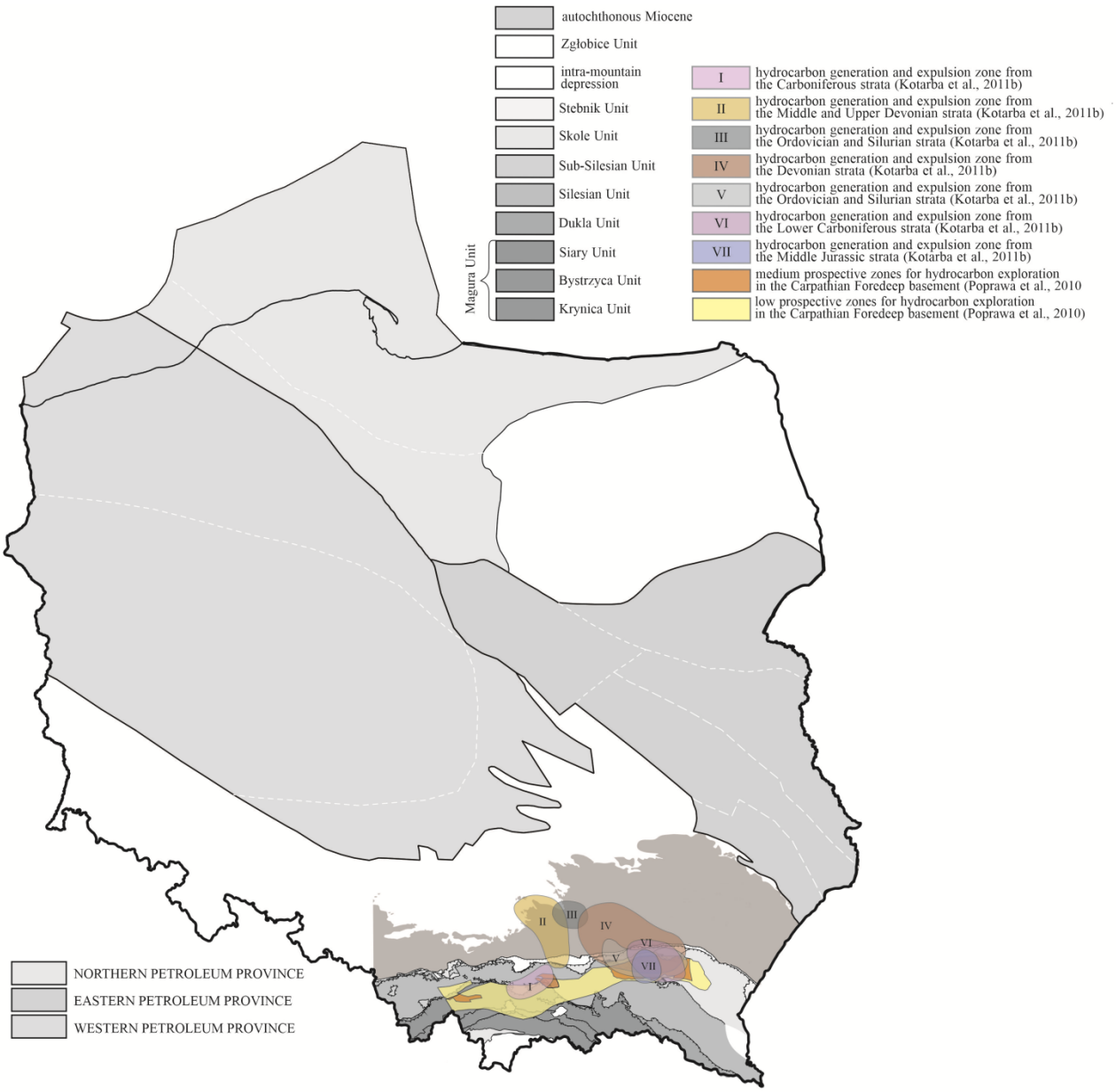


Fig. 15. Zones prospective for oil and gas exploration in the basemet of the Carpathians and Carpathian Foredeep (Poprawa et al., 2010; Kotarba et al., 2011b) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019).

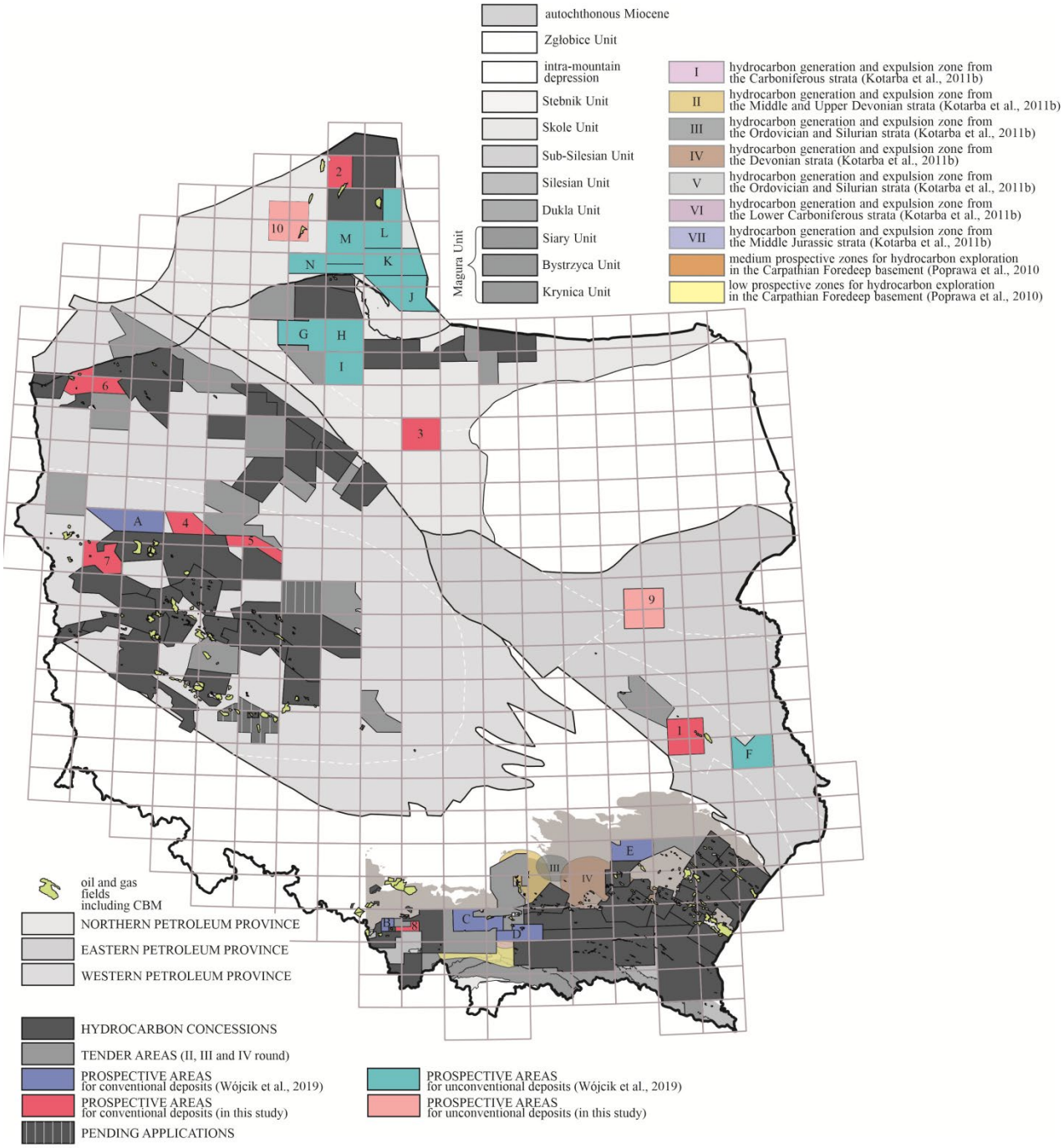


Fig. 16. Zones prospective for oil and gas exploration in the basemet of the Carpathians and Carpathian Foredeep (Poprawa et al., 2010; Kotarba et al., 2011b) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318, **2** – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.

B.1.8. OUTER CARPATHIANS

Reservoir rocks: Krosno beds, Kliwa, Magdalena and Cergowa sandstones of the Menilite beds, Ciężkowice sandstones, lower and upper Istebna sandstones, Godula sandstones, Inoceramus beds, Węglówka marls, Lgota beds, Grodziszcze sandstones.

Source rocks: Menilite shales, Inoceramus beds, Istebna shales, Wierzowice shales, Spas shales, Cieszyn shales.

Seal: fine-grained clastic rocks of the flysh successions.

Traps: stratigraphic, structural, structural-stratigraphic.

Oil and gas fields (as of 31.12.2018):
34 natural gas fields;
29 oil fields.

Fields resources (as of 31.12.2018):
1 134.87 mln m^3 of natural gas,
709.56 kt of crude oil.

Production in 2018:
31.00 mln m^3 of natural gas,
20.73 kt of crude oil.

Prognostic resources:
43.49 bln m^3 of natural gas,
16.30 mln t of crude oil
(Pawlewicz, 2006);
30.6 bln m^3 of natural gas,
124.2 mln t of crude oil
(Feldman-Olszewska et al., 2020).

Prospective zones:

The results of deep wells drilled in the eastern part of the Carpathians indicate that structural elements located at depths below 3000 m bsf have the best and probably primary reservoir properties. However, these elements are still poorly recognized within the flysch succession. Prospectives for hydrocarbon exploration even in deeper structures, reaching the depths up to 4500 m bsf, are particularly related to the Sub-Silesian, Silesian and Skole Units (Dziadzio et al., 2006a, b; Feldman-Olszewska et al., 2020).

The deeper part of the Carpathians (1000–3000 m bsf) was noted as prospective by Poprawa et al. (2010), who emphasized the hydrodynamic tightness of potential reservoir horizons, high geochemical quality of source rocks and increased thermal maturity. Prospective zones for the hydrocarbon exploration in the deeper part of the Carpathians, illustrated by Poprawa et al. (2010) can be found in Figs 17 and 18.

The shallower part of the Carpathians (0–1000 m bsf) is well recognized in terms of geology and petroleum systems. Poprawa et al. (2010) indentified 2 zones – of medium and low prospectives, respectively (Figs 19 and 20). The first one is related to these strata, which occur below the Magura Unit, where source rocks have high thermal maturity and high content of organic matter, while the seal is well preserved. To the north, the thermal maturity decreases and the seal rocks occur only locally.

References: Kotarba, 1992; Kuśmierek, 2004; Oszczypko, 2004, 2006; Dziadzio, 2006; Dziadzio et al., 2006a, b; Kotarba and Koltun, 2006; Matyasik, 2006; Matyasik and Dziadzio, 2006; Pawlewicz, 2006; Ślączka et al., 2006; Czopek et al., 2009; Kosakowski et al., 2009; Poprawa et al., 2010; Górecki and Zawisza, 2011; Kotarba et al., 2014; Matyasik et al., 2015; Golonka et al., 2017; Feldman-Olszewska et al., 2020.

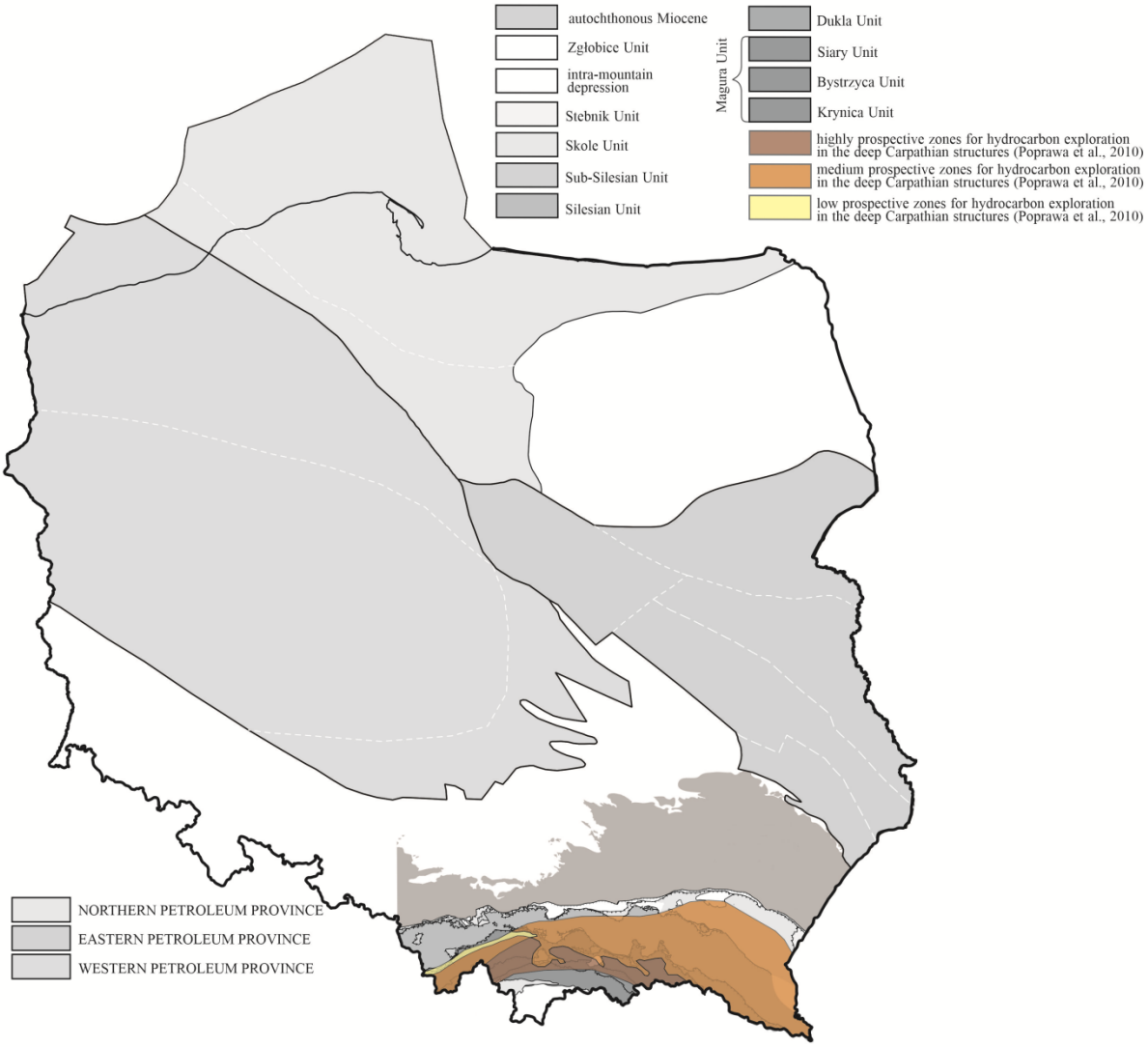


Fig. 17. Zones prospective for oil and gas exploration in the deep Carpathian structures (Poprawa et al., 2010) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019).

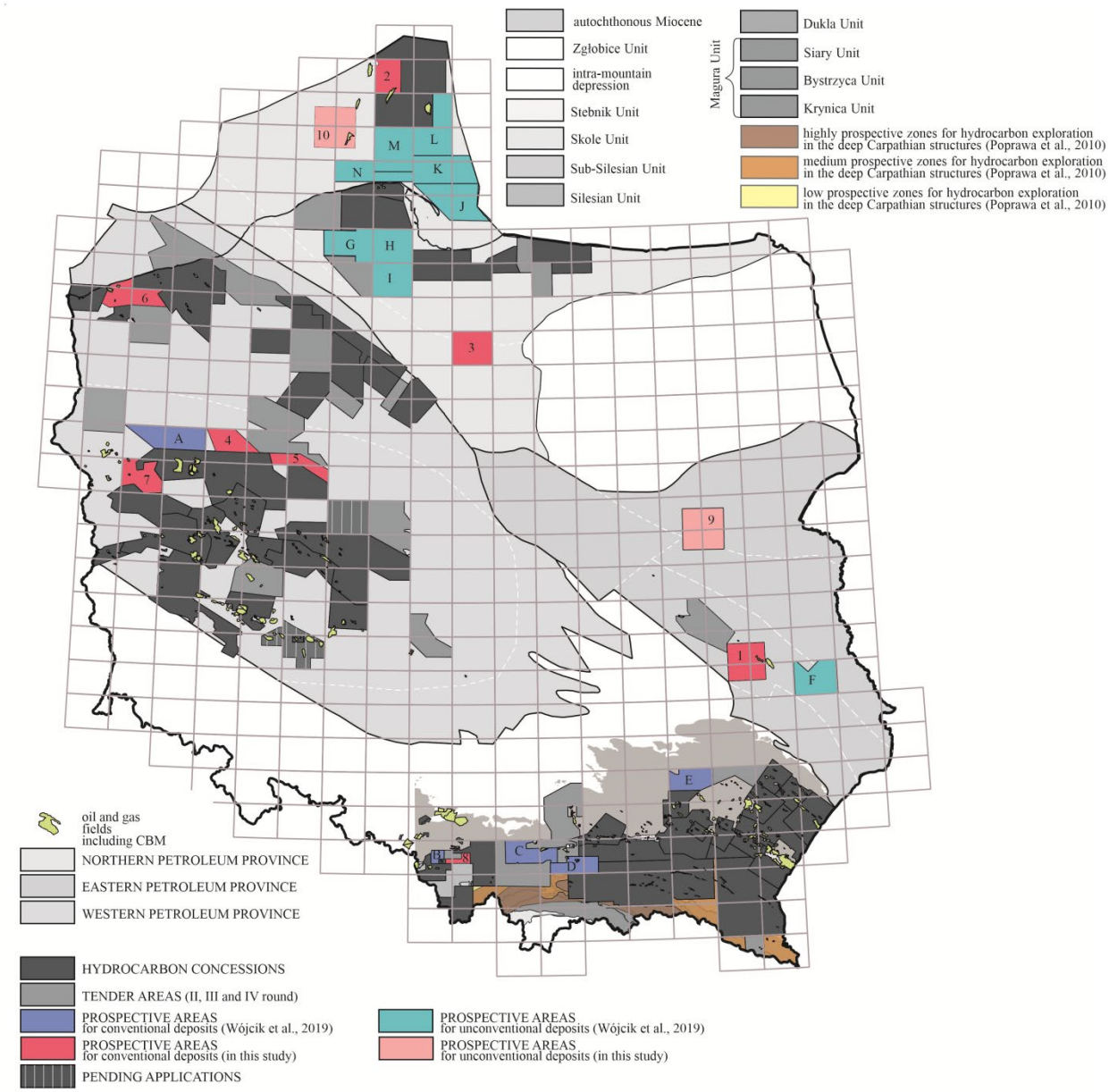


Fig. 18. Zones prospective for oil and gas exploration in the deep Carpathian structures (Poprawa et al., 2010) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318, **2** – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.

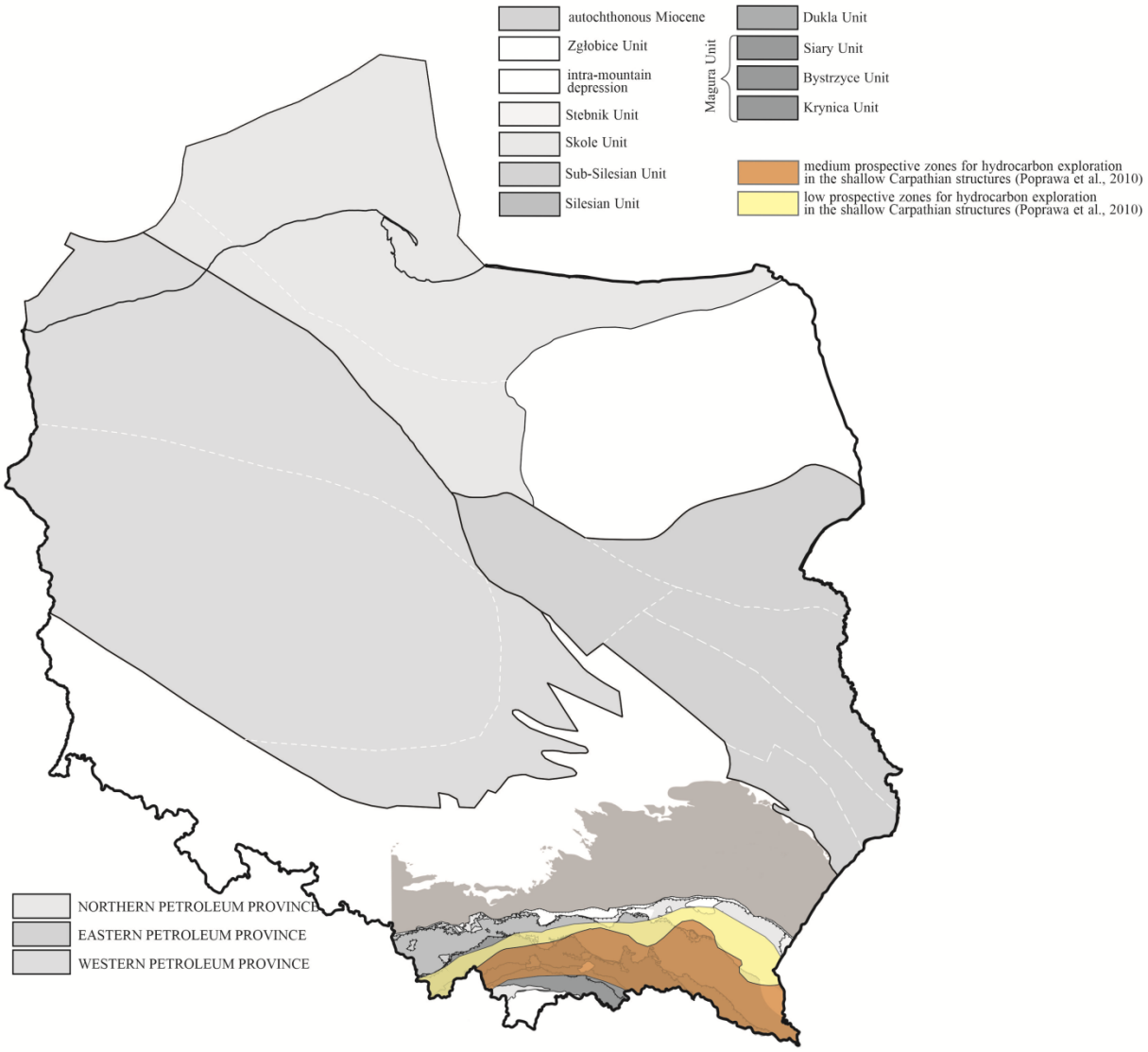


Fig. 19. Zones prospective for oil and gas exploration in the shallow Carpathian structures (Poprawa et al., 2010) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019).

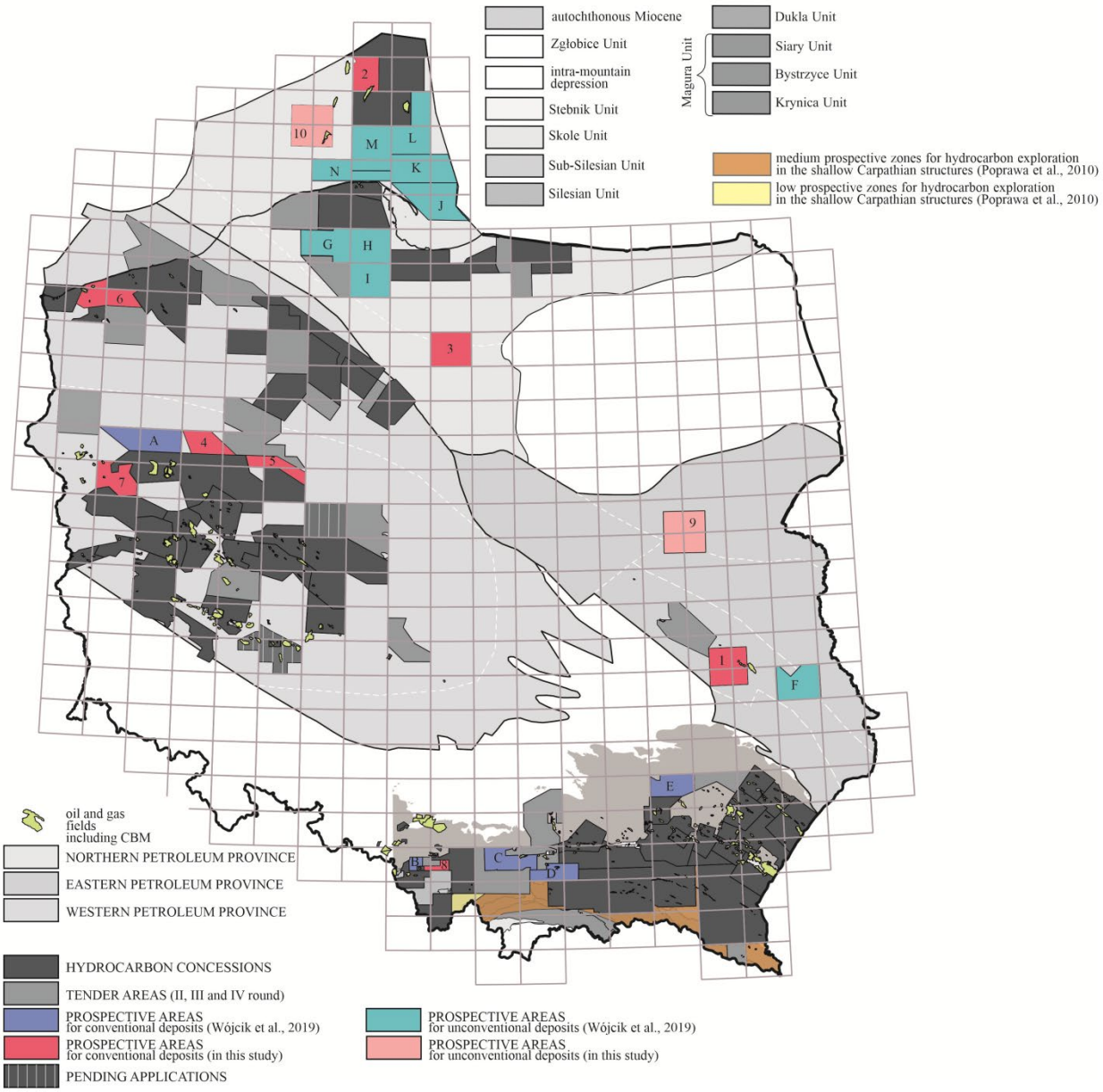


Fig. 20. Zones prospective for oil and gas exploration in the shallow Carpathian structures (Poprawa et al., 2010) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318, **2** – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.

B.1.9. CARPATHIAN FOREDEEP

Reservoir rocks: sandstones and mudstones of the autochthonous Miocene; heterolithic series.

Source rocks: interbeds of claystones and mudstones in the autochthonous Miocene successions; Paleozoic-Mesozoic basement.

Seal: fine-grained clastic rocks within autochthonous Miocene successions of the inner and outer part of the Carpathian Foredeep; Outer Carpathian flysch succession for the inner part of the Carpathian Foredeep.

Traps: stratigraphic, structural (including compactional anticlines, fault-related anticlines, thrust-related anticlines), structural-stratigraphic, hybrid.

Oil and gas fields (as of 31.12.2018):
95 natural gas fields
(including 9 fields producing from the Miocene of the Carpathian Foredeep and from the basement);
3 oil fields
(including 2 fields producing from the Miocene of the Carpathian Foredeep and from the basement).

Fields resources (as of 31.12.2018):
31 654.49 mln m^3 of natural gas
(28 809.02 mln m^3 without the basement),
13.78 kt of crude oil.

Production in 2018:
1 239.94 mln m^3 of natural gas,
(1 019.11 mln m^3 without the basement),
1.60 kt of crude oil
(0.00 kt without the basement).

Prognostic resources:
100 bln m^3 of natural gas
(Górecki and Zawisza, 2011).

Prospective resources:
300 bln m^3 of natural gas
(including unconventional accumulations; Górecki, 2012),
2 250 bln m^3 of natural gas
(genetic potential of the Miocene strata at the contact zone between the Carpathian Foredeep and Carpathians; Sowiżdżał et al., 2017).

Prospective zones:

Prospectives for exploration of natural gas in the Carpathian Foredeep, both in its outer and inner part (below the Carpathian Overthrust), are related not only to the conventional accumulations of biogenic gas in structutal and stratigraphic traps, but also to the hybrid-type concentrations, which become the most significant, nowdays. These are also saturated with high-quality natural gas, and, after fracturing, they provide extra productive horizons.

In the case of the conventional exploration, Górecki and Zawisza (2011) calculated the probability of new gas fields discover in the Carpathian Foredeep, also in its part below the Carpathian Overthrust (Figs 21 and 22). The most promising zone is located between Rzeszów and the eastern Polish border.

Almost in the same area, Sowiżdżał et al. (2017) and Słoczyński et al. (2019) identified the most prospective zone for unconventional/hybrid exploration: it extends from the westernmost Husów wells to the eastern Polish border. Around Przemyśl, the highest values of generated natural gas, as well as significant amount of hydrocarbons accumulated in mudstones-claystones horizons and in conventional traps, were obtained.

References: Myśliwiec, 2004a, 2004b; Myśliwiec et al., 2006; Oszczypko, 2006; Oszczypko et al., 2006; Kotarba and Pluta, 2009; Kotarba, 2011; Kotarba and Peryt, 2011; Kotarba et al., 2011a; Górecki, 2012; Krzywiec et al., 2012; Sowiżdżał et al., 2017, Słoczyński et al., 2019.

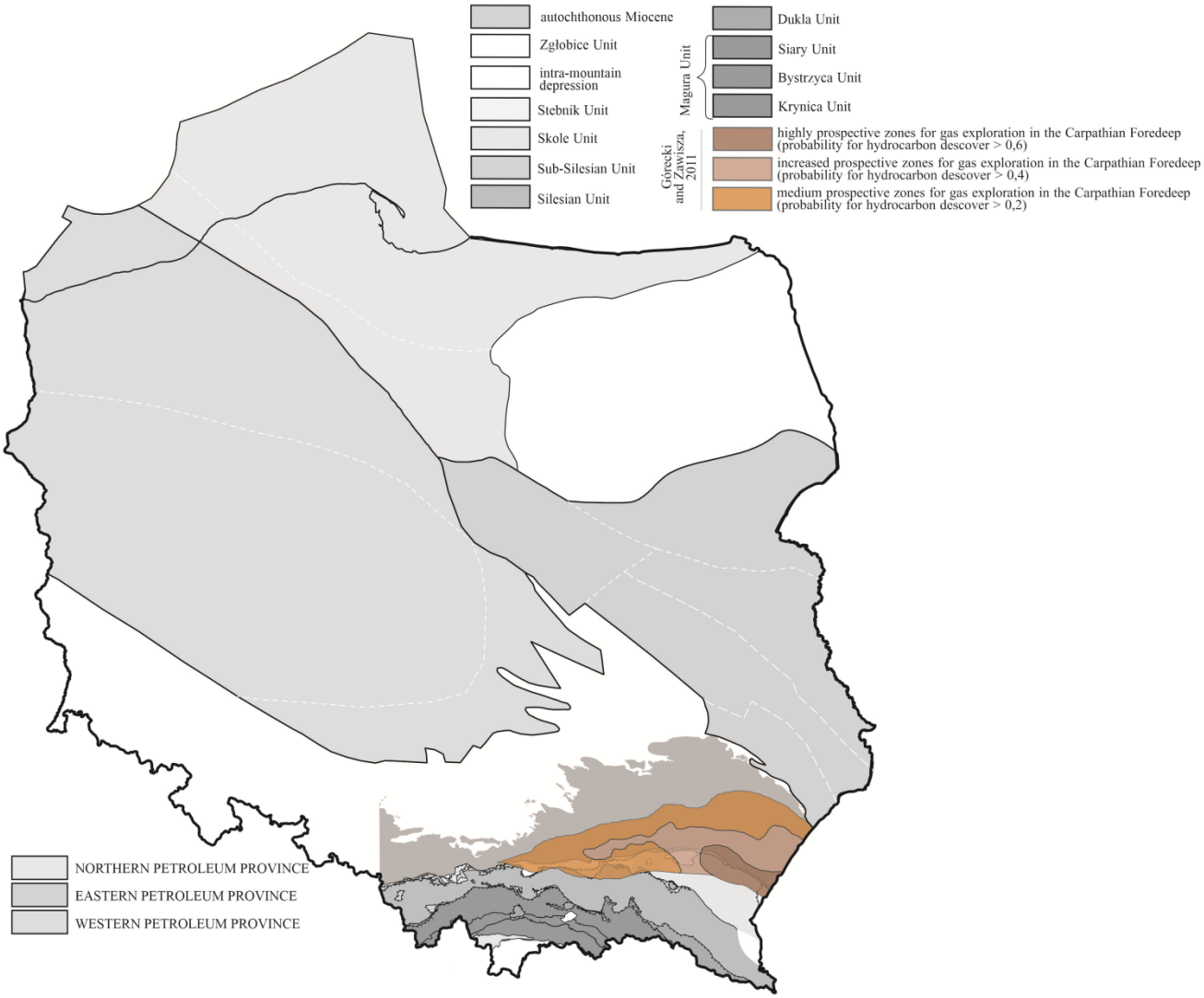


Fig. 21. Zones prospective for gas exploration in the Carpathian Foredeep (Górecki and Zawisza, 2011) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019).

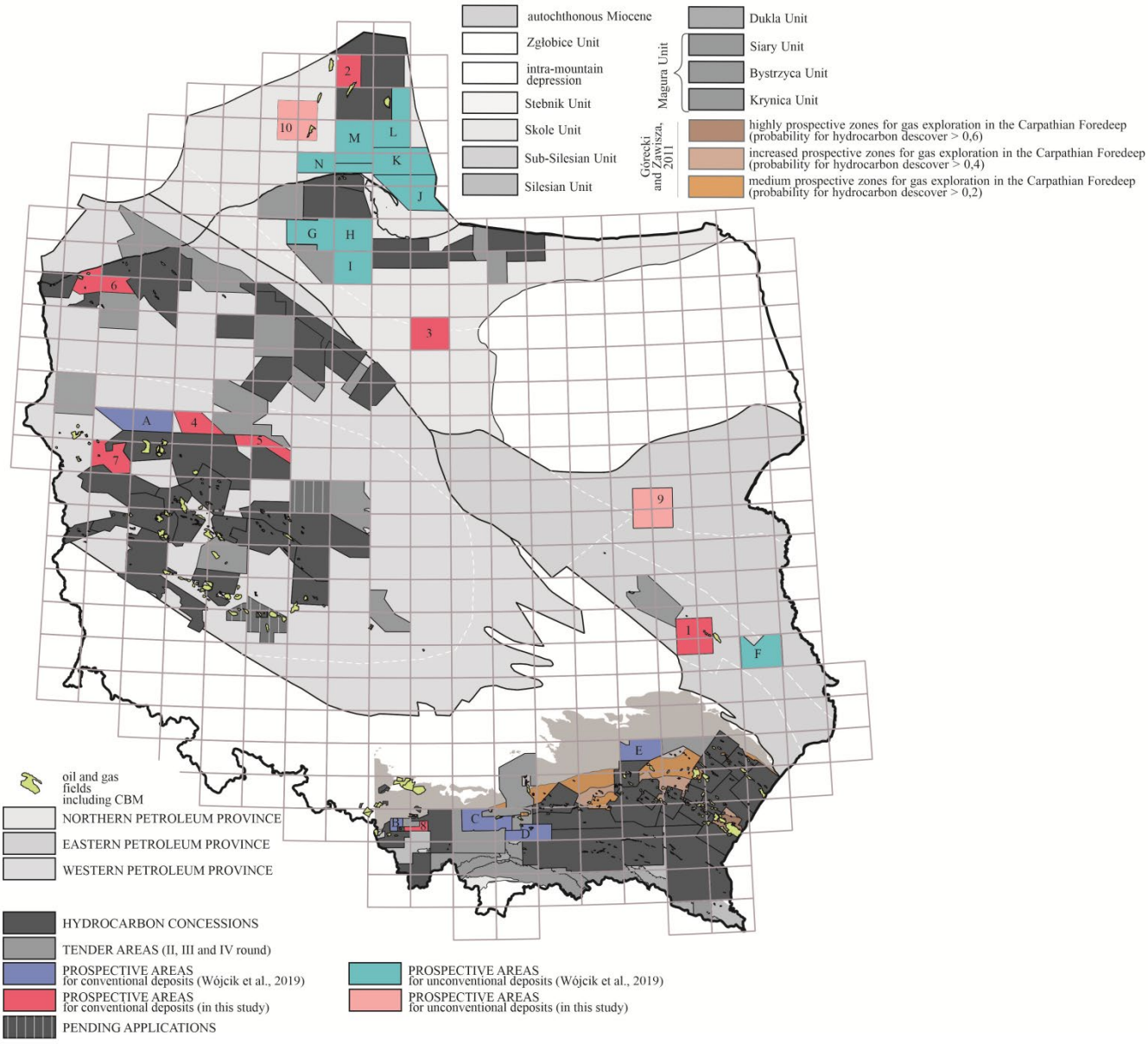


Fig. 22. Zones prospective for gas exploration in the Carpathian Foredeep (Górecki and Zawisza, 2011) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318, **2** – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.

B.2. UNCONVENTIONAL HYDROCARBON ACCUMULATIONS

B.2.1. COAL BED METHANE

Reservoir rocks: coal beds.
Source rocks: coal beds.
Traps: stratigraphic/unconventional.
Gas fieds (as of 31.12.2018):
65 fields.
Fields resources (as of 31.12.2018):
102 021.34 mln m^3 of natural gas.
Production in 2018:
320.94 mln m^3 of natural gas.
Prognostic resources:
1.69 bln m^3 of natural gas as co-occurring raw material,
69.33 mld m^3 of natural gas as main raw material
(Kwarciński, 2011).
Prospective resources:
52.79 bln m^3 of natural gas as main raw material
(Kwarciński, 2011).
Prospective zones:
The criteria, which define the coal bed methane as the main raw material determine the maximum depth of exploration of 1500 m bsf, minimum methane content >4.5 m^3/Mg daf and minimum thickness of a coal bed 0.6 m. In the case, when the coal bed methane is the co-occurring raw material – minimum methane content is ≥2.5 m^3/Mg daf and minimum thickness of the coal bed is 0.1 m.

Hadro and Jureczka (2020) defined the prognostic resources of the coal bed methane as the resources of co-occurring raw material documented in D category in hard coal deposits. Consequently, the prospective are the resources of coal bed methane, when it is the main raw material.

Hadro and Jureczka (2020; compare Kwarciński, 2011) indicated prospective zones for the occurrence of the coal bed methane as the main raw material in the Upper Silesian Coal Basin, Lublin Coal Basin and Lower Silesian Coal Basin (Figs 23 and 24). The prospective resources are 94.33 bln m^3 (USCB), 15.19 lbn m^3 (LCB) and 1.75 bln m^3 (LSCB), respectively.

References: Kotarba and Pluta, 2009; Kwarciński, 2011; Jureczka, 2013, 2017a, 2017b; Hadro and Jureczka, 2020.

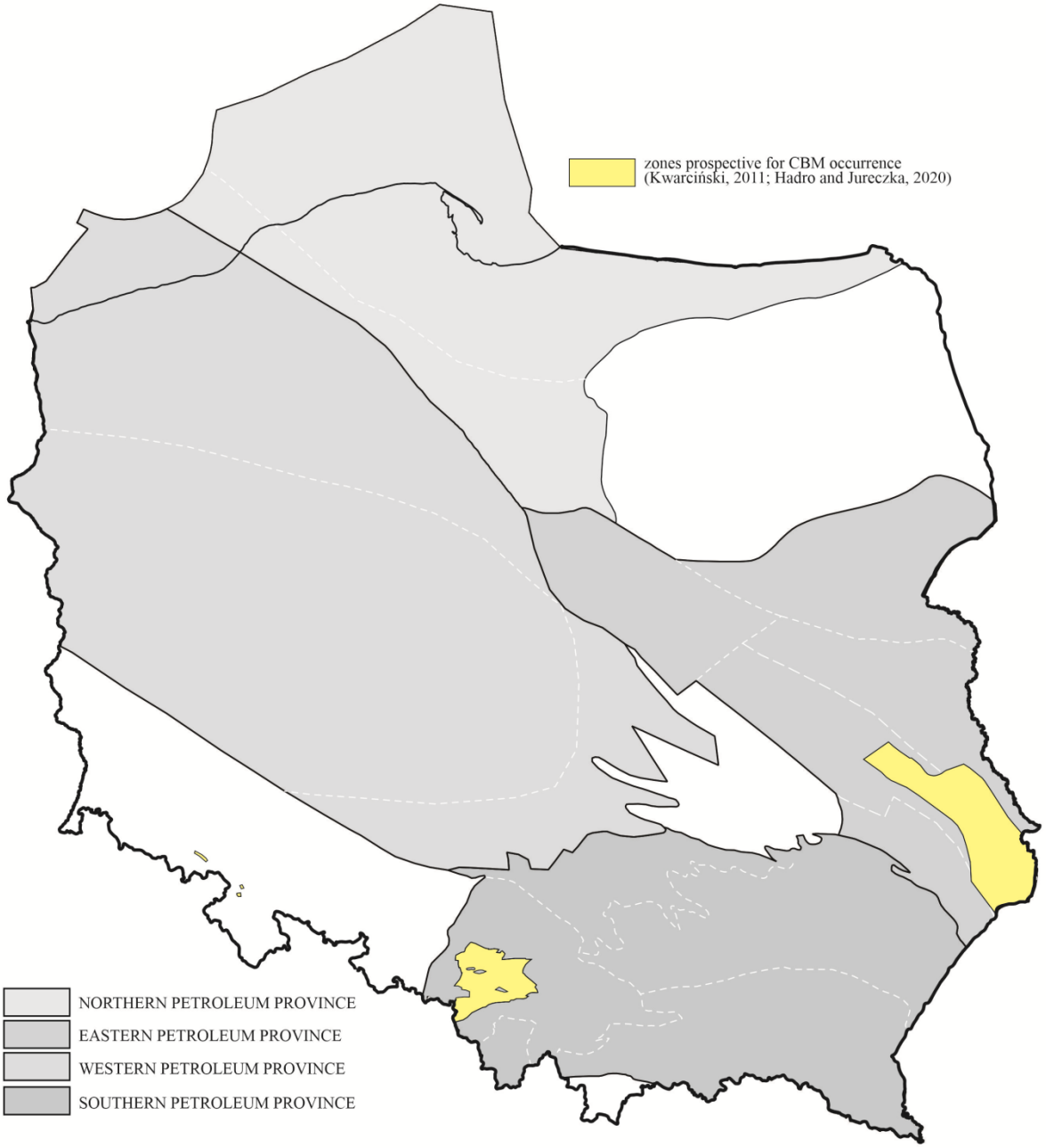


Fig. 23. Zones prospective for CBM exploration (Hadro and Jureczka, 2020) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019).

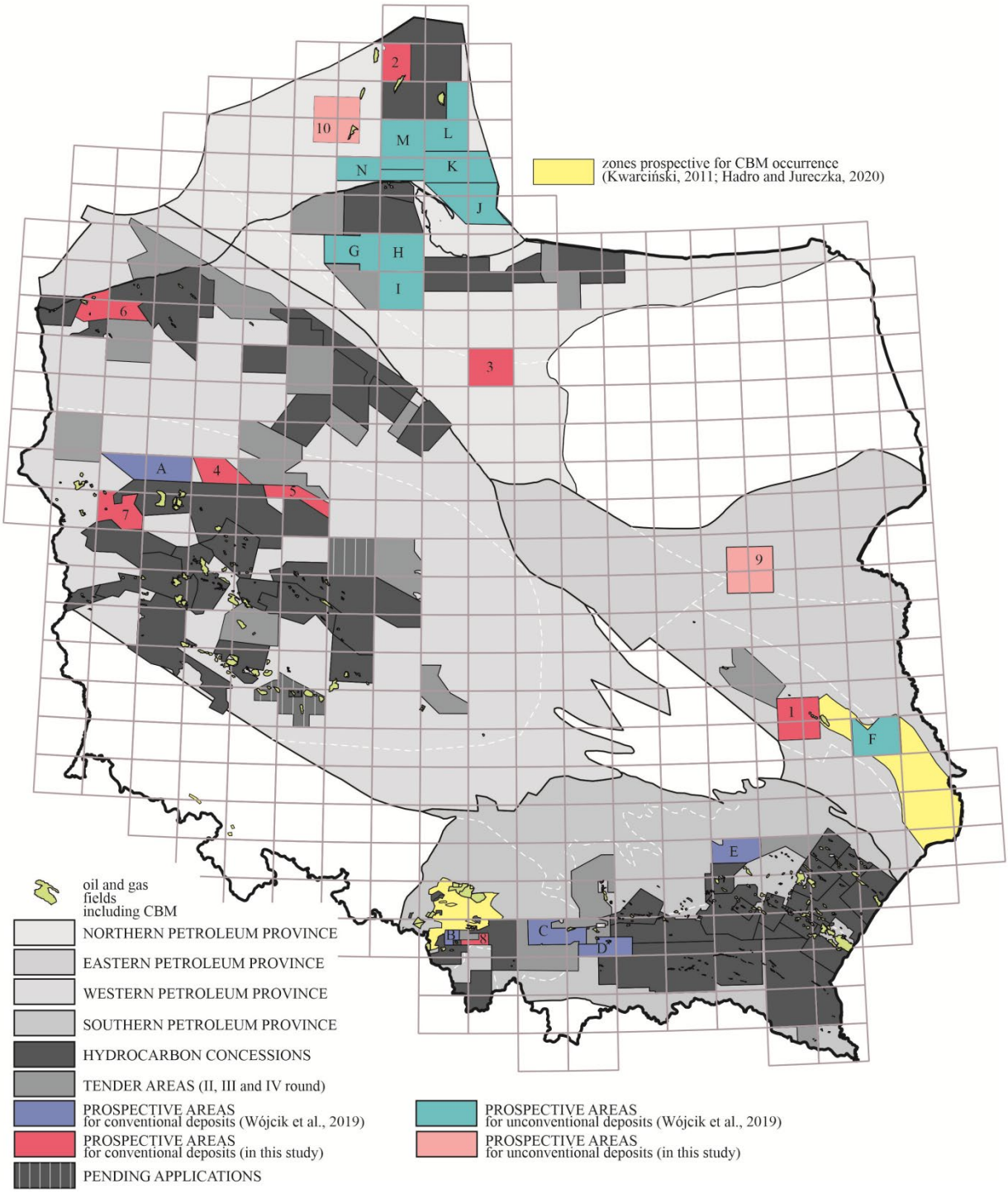


Fig. 24. Zones prospective for CBM exploration (Hadro and Jureczka, 2020) in relation to the Petroleum Provinces in Poland (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318, **2** – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.

B.2.2. TIGHT GAS

Reservoir rocks: aeolian sandstones of the central part of the Polish Rotliegend Basin, Carboniferous sandstones of the Fore-Sudetic Monocline, Cambrian sandstones of the Baltic Basin (Dębki, Biała Góra and Łyna Formations); Istebna, Inoceramus and Krosno sandstones in the Carpathians.

Source rocks: Carboniferous shales and Lower Paleozoic fine-grained clastic rocks of the Polish Lowland; Spas shales, Lower Cretaceous shales and Menilite shales in the Carpathians.

Traps: continuous/unconventional.

Oil and gas fields (as of 31.12.2018):
none.

Prognostic resources:
1.528–1.995 bln m^3 of natural gas (Wójcicki et al., 2014).

Prospective zones:

The criteria defining tight gas accumulations include low (but not zero) <0.1 mD permeability, total porosity >3% and effective porosity >2%, formation water saturation <60%, clay content <55% and its compaction and consolidation. The rock complex should be homogenous with high volume, extent and sufficient thermal maturity. The key factors are also the presence of increased gas pressure, source rocks and occurrences of conventional accumulations within the same petroleum system.

Wójcicki et al. (2014) indicated three zones, which are the most promising for tight gas accumulations in the Polish Lowland (in the Northern and Western Petroleum Provinces), providing their estimated resources. These are: the Rotliegend sandstones of the Poznań-Kalisz zone (with prognostic resources up to 345 and 812 trillion m^3, calculated for the depth interval 5500–6000 m and 5100–6000 m b.g.l.), Carboniferous sandstones of the Wielkopolska-Silesian Subprovince (with prognostic resources 1145 bln m^3, calculated for the depth interval 1800–3500 m b.g.l.) and Cambrian sandstones of the Baltic Basin (in which tight oil can also occure, and the prognostic resources of tight gas were estimated at 38 bln m^3 for the depth interval 2800–3100 m).

In the Outer Carpathians, prospective for tight gas accumulations are Istebna, Inoceramus and Krosno sandstones in the eastern part of the Orogeny, where accumulations are expected at the depths 3000–4000 m b.g.l. (Kuśmierek and Semyrka, 2003; Poprawa et al., 2010). The main problem there is low quality of source rocks.

Zones prospective tight gas exploration are illustrated in Figs 25 and 26.

References: Kuśmierek et al., 2001; Kuśmierek and Semyrka, 2003; Machowski and Kuśmierek, 2008; Poprawa and Kiersnowski, 2008; Buniak et al., 2009; Kiersnowski et al., 2010; Poprawa et al., 2010; PGNiG, 2012; Chmielowiec-Stawska and Czekański, 2013; Wójcicki et al., 2014, 2020.

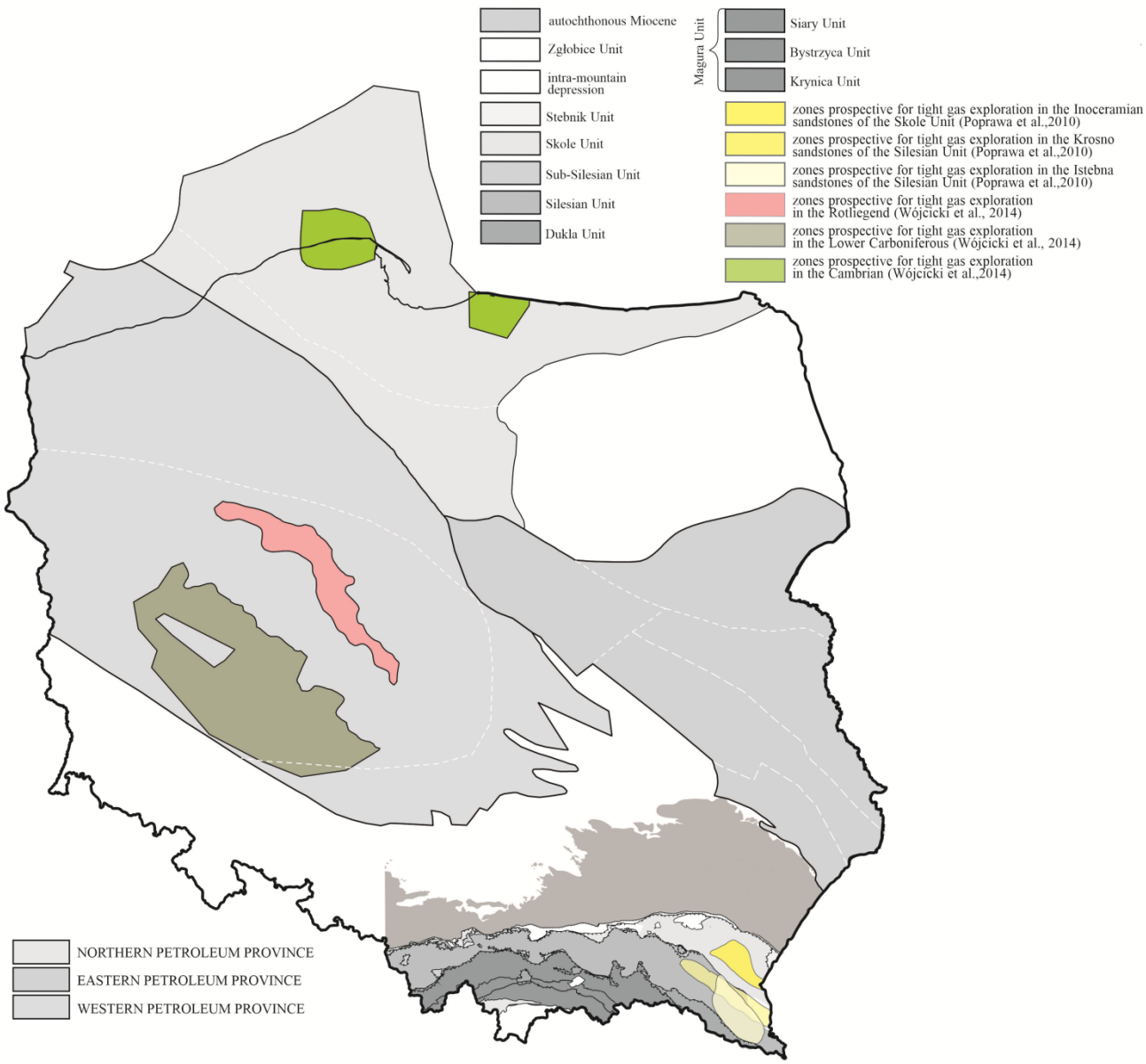


Fig. 25. Zones prospective for tight gas exploration in the Polish Lowland (Wójcicki et al., 2014, 2020) and in the Carpathians (Poprawa et al., 2010) in relation to the Petroleum Provinces of Poland (Wójcik et al., 2019).

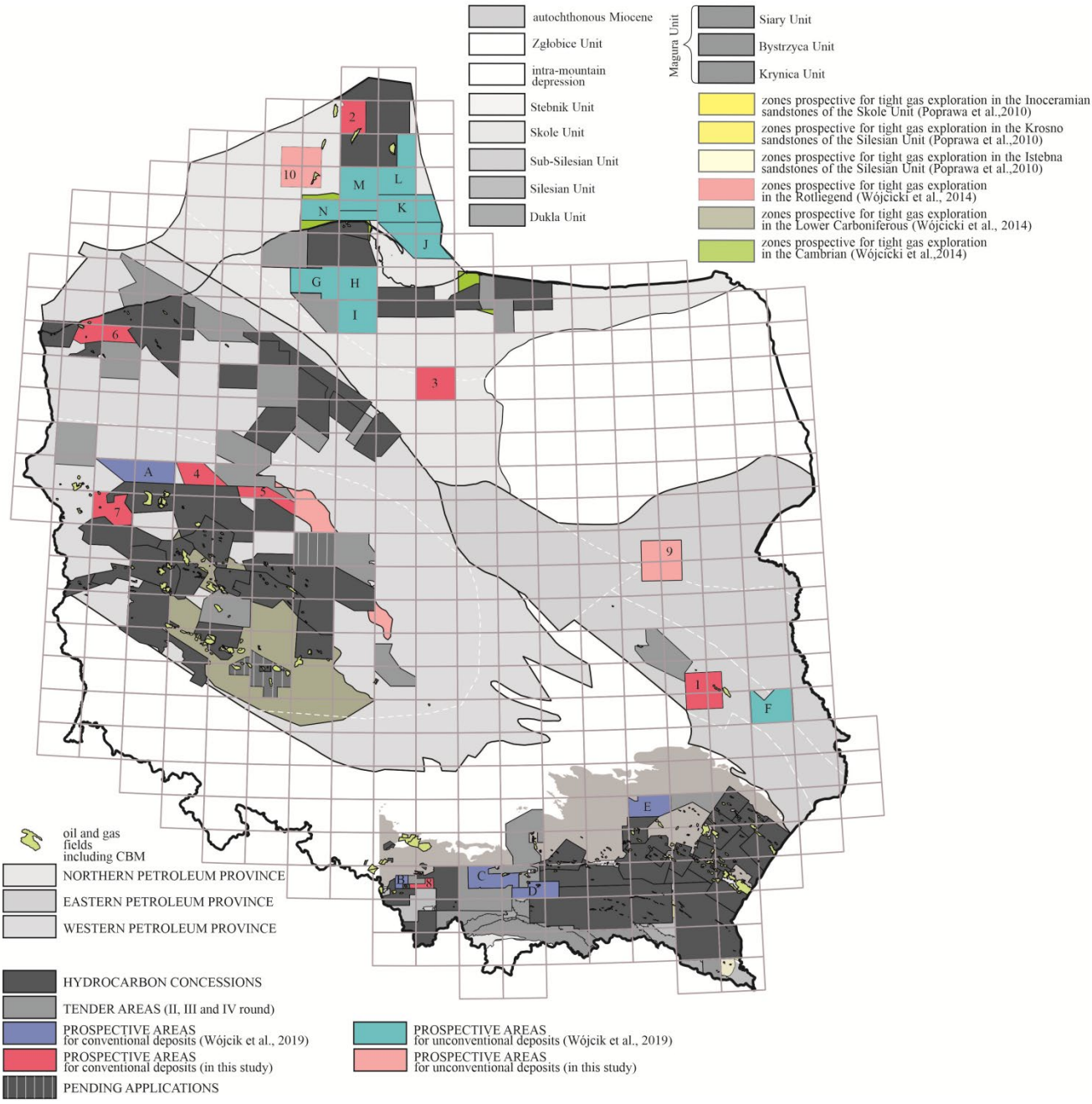


Fig. 26. Zones prospective for tight gas exploration in the Polish Lowland (Wójcicki et al., 2014, 2020) and in the Carpathians (Poprawa et al., 2010) in relation to the Petroleum Provinces of Poland (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318, **2** – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.

B.2.3. SHALE GAS AND SHALE OIL

Reservoir rocks: Lower Paleozoic shales (Piaśnica, Sasino, Jantar and Pelpin Formations) in the Baltic Basin; Menilite beds in the Outer Carpathians.

Traps: continuous/unconventional.

Oil and gas fields (as of 31.12.2018): none.

Prognostic resources:

3.19–9.80 trl m^3 of natural gas,
2.23-3.62 bln m^3 of crude oil
(Wójcicki et al., 2017).

Prospective zones:

The criteria, which are used to define the zones prospective for shale-gas and shale-oil exploration include average TOC value >2%, total thickness of individual shale horizons >15 m and average gas saturation >1.5 m^3/Mg. Also important is thermal maturity of organic matter – the succession of rocks should be in gas or oil window.

According to this, Podhalańska et al. (2018) described zones prospective for shale-oil and shale-gas exploration for four formations of the Lower Paleozoic of the East European Craton: Furongian-Lower Tremadocian Piaśnica Formation, Caradocian and locally Upper Lanvirnian Sasino Formation, Lower Llandovey Jantar Formation and Wenlock Pelplin Formation. The first three are prospective in the Baltic Subprovince – both in its onshore and offshore part, while the last is also prospective in the Eastern Petroleum Province (Figs 27 and 28). Each formation is an individual and isolated horizon of shale rocks.

Wójcicki et al. (2017) presented slightly different appproch, treating the Lower Paleozoic shale rocks as the one exploration horizon, showing two possible variants of prospective zone extent (Figs 29 and 30). The first one (the variant with cut-off criteria) assumed a minimum total thickness of shales with TOC >1.5% not less than 10 m and minimum total gas content 0.5 m^3/t. The second variant (optimal criteria) limited prospective zone to the areas, in which TOC is above 2.0%, shales thickness is not less than 15 m and minimum total gas content is above 1.5 m^3/t.

In the Carpathians, as prospective for shale gas exploration should be considered the Lower Oligocene Menilite shales, which occur below the Magura Unit overthrust. Here, they note the highest thermal maturity (Poprawa et al., 2010). However, complicated tectonics may limit the drilling of horizontal wells and fracturing.

References: Kuśmierek, 1995; Kuśmierek et al., 2001; Dziadzio and Matyasik, 2004; Świerczewska, 2005; Botor et al., 2006; Modliński et al., 2006; Kosakowski et al., 2009; Poprawa et al., 2010, 2018; Więcław et al., 2010a, 2010b; PGI-NRI, 2012; Kiersnowski and Dyrka 2013; Wójcicki et al., 2015, 2016, 2017, 2020; Kosakowski et al., 2016; Podhalańska et al., 2018; Porębski and Podhalańska, 2019, Papiernik et al., 2019.

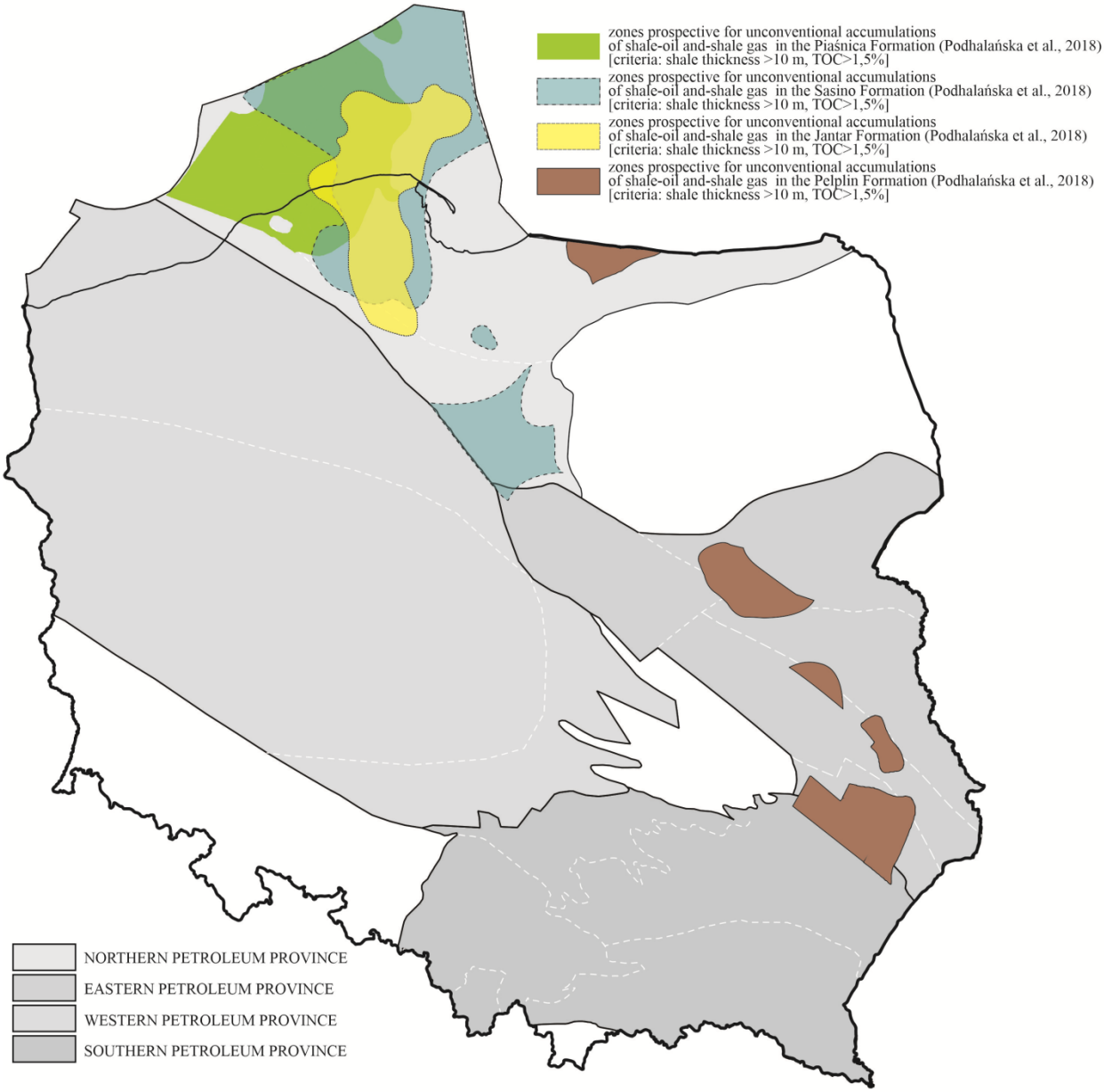


Fig. 27. Zones prospective for shale-oil and shale-gas exploration in the Lower Paleozoic of the East European Craton (Podhalańska et al., 2018) in relation to the Petroleum Provinces of Poland (Wójcik et al., 2019).

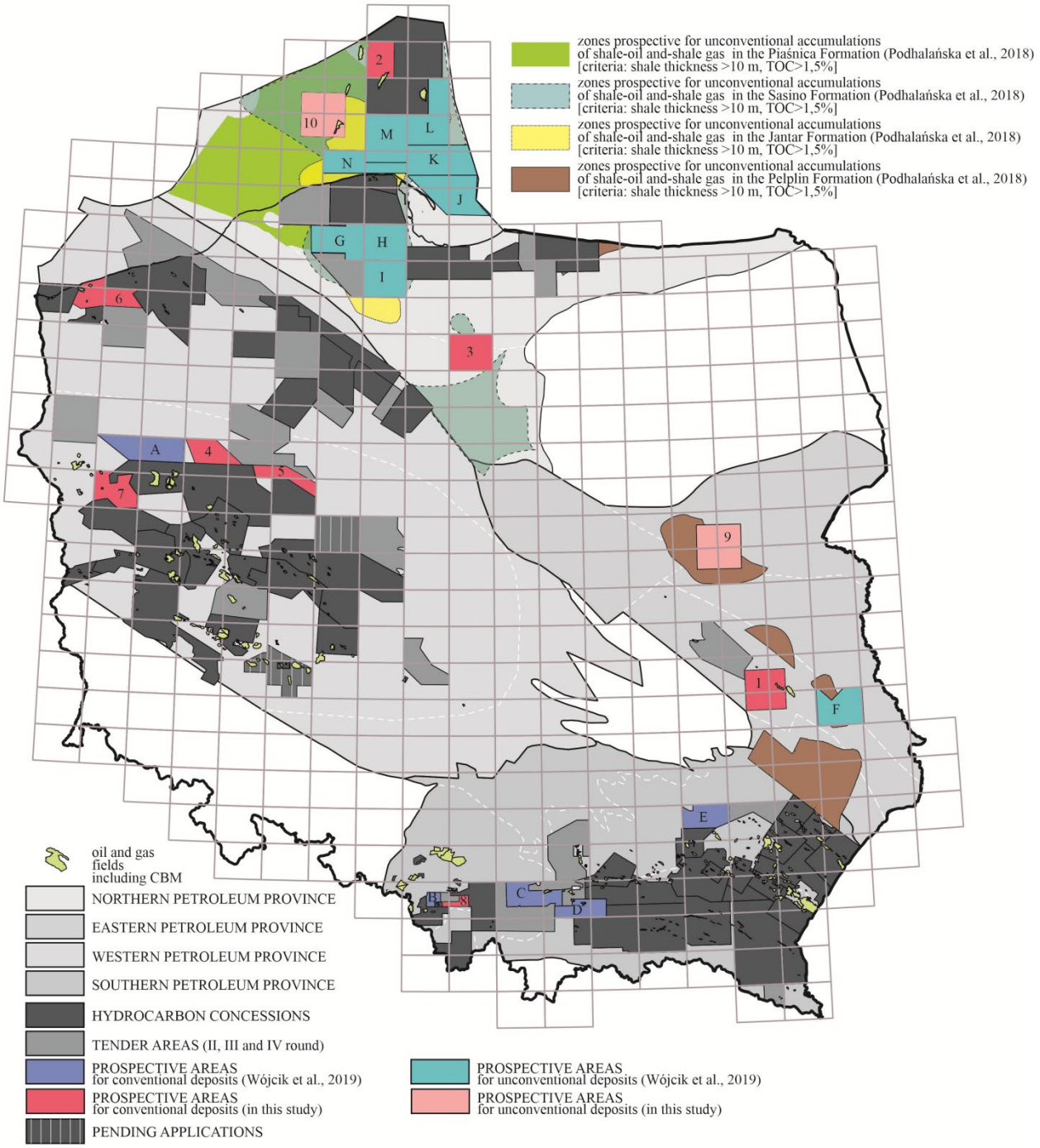


Fig. 28. Zones prospective for shale-oil and shale-gas exploration in the Lower Paleozoic of the East European Craton (Podhalańska et al., 2018) in relation to the Petroleum Provinces of Poland (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318, **2** – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.

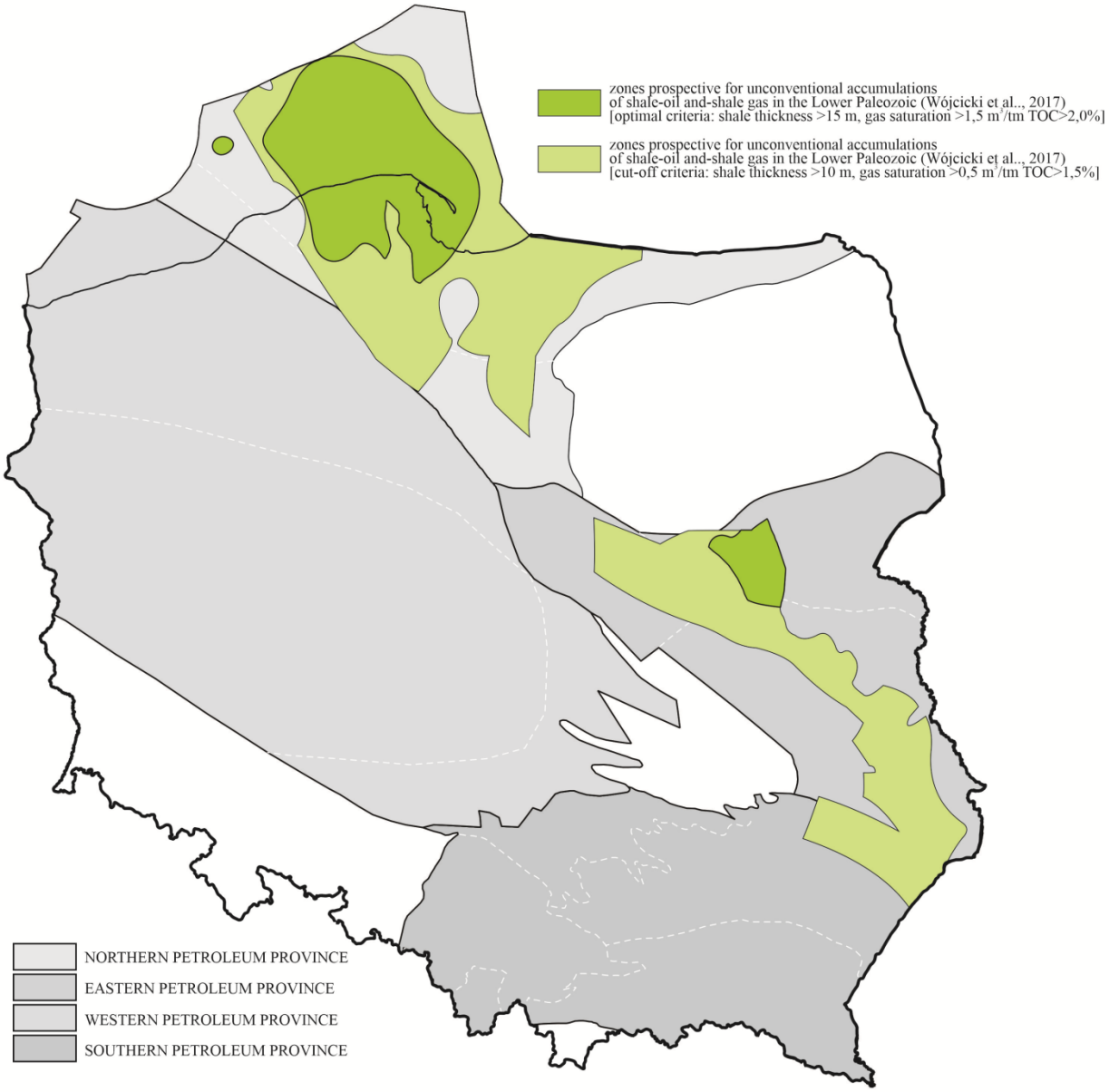


Fig. 29. Zones prospective for shale-oil and shale-gas exploration in the Lower Paleozoic of the East European Craton (Wójcicki et al., 2017) in relation to the Petroleum Provinces of Poland (Wójcik et al., 2019).

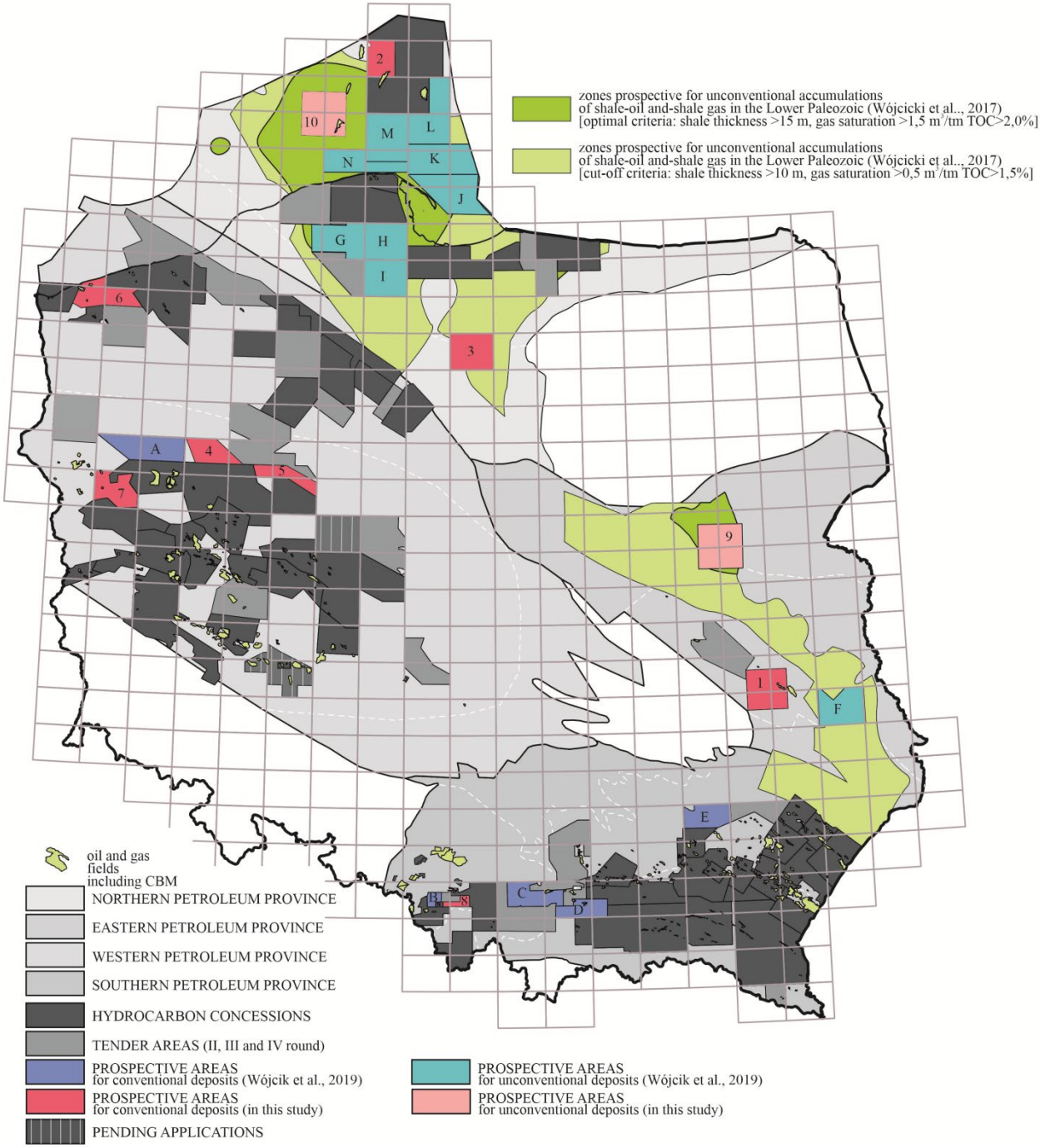


Fig. 30. Zones prospective for shale-oil and shale-gas exploration in the Lower Paleozoic of the East European Craton (Wójcicki et al., 2017) in relation to the Petroleum Provinces of Poland (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318, **2** – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.

C. PROSPECTIVE AREAS
C.1. CONVENTIONAL HYDROCARBON ACCUMULATIONS

C.1.1. BLOCK 297/318

Location: **onshore** (Fig. 31)
Petroleum Province: **Eastern**
Concession blocks: **297, 298, 317, 318**
Border points coordinates:

Border points	PL 1992	
	X	Y
1	368572.23	757156.61
2	367137.54	725912.77
3	398381.37	724478.08
4	399816.07	755721.92
excluding the area bound by the following points:		
5	384242.72	751312.11
6	384456.41	751456.81
7	384617.73	751366.47
8	384743.40	751280.34
9	384846.58	751173.79
10	385041.54	750905.13
11	384718.66	750664.99
12	384422.33	751043.70
13	384242.72	751312.11
14	385534.90	749882.14
15	384713.72	751720.54
16	383123.40	754521.37
17	384257.68	755076.28
18	384992.00	754350.34
19	385235.64	753057.14
20	386453.28	751405.00
21	386567.89	750483.21
22	385534.90	749882.14

Acreage: **971.11 km^2**

Prospection and exploration concessions in the neighborhood: **none**.

Main exploration target:
Devonian and Carboniferous (conventional)

- type of expected fields: conventional for oil and gas;
- reservoir rocks: Middle Devonian clastic and carbonate rocks, Carboniferous clastic rocks;
- depth of reservoir rocks: 1000–4100 m;
- source rocks: Lower Paleozoic, Devonian, Mississippian and Pennsylvanian fine-grained clastic rocks and carbonate rocks;
- seal: fine-grained clastic intercalations within the Devonian and Carboniferous succession;
- trap types: stratigraphic, structural, mixed.

Wells >500 m MD: **62**.

Well name	Depth [m MD]	Stratigraphy at the bottom
ABRAMÓW 5	3009.0	Famennian
ABRAMÓW 6	2706.0	Famennian
ABRAMÓW 7	2311.0	Famennian
ABRAMÓW 8	3320.0	Famennian
ABRAMÓW 9	3300.0	U. Devonian
BEŁŻYCE 2	3054.0	Famennian
BEŁŻYCE 3	3154.0	Devonian
BISKUPIE 1	1900.0	Devonian
CIECIERZYN 1	4002.0	Eifelian
CIECIERZYN 2	3808.0	Devonian
CIECIERZYN 3	4032.0	Eifelian
CIECIERZYN 4	4119.0	Eifelian
CIECIERZYN 5	4080.0	Eifelian
CIECIERZYN 6	4065.0	Devonian
CIECIERZYN 7	4100.0	Eifelian
CIECIERZYN 8	4126.0	Eifelian
CIECIERZYN 9	3875.0	Givetian
GLINNIK 2	2464.0	Famennian
GLINNIK 6	2380.0	Devonian
LUBLIN	855.0	Jurassic
LUBLIN 40 M OD DLN.BYSTRZYCY	786.0	Cretaceous
LUBLIN IG-2	2102.0	Serpukhovian
ŁĘCZNA IG-26	1695.8	Carboniferous
NASUTÓW 1	2331.0	U. Devonian
NASUTÓW 3	2002.0	Carboniferous
NASUTÓW 5	2280.0	U. Devonian
NIEDRZWICA 3	3301.0	U. Devonian
PLISZCZYN 1	4510.0	M. Devonian
PUŁAWY IG-2	2198.0	Carboniferous
RADAWIEC MAŁY 1	4370.0	Emsian
RADAWIEC MAŁY 2	4290.0	L. Devonian
RUDNIK 1	1265.0	Carboniferous
RUDNIK 2	1405.0	Carboniferous
ŚWIDNIK-2	2040.4	Famennian
ŚWIDNIK 3	2203.0	Famennian
ŚWIDNIK 4	2105.0	Famennian

ŚWIDNIK-5	1802.5	Famennian
ŚWIDNIK 6	2201.1	Famennian
ŚWIDNIK-7	2185.5	Famennian
ŚWIDNIK-8	3300.0	U. Devonian
ŚWIDNIK-9	1126.0	Carboniferous
ŚWIDNIK-10	1213.0	Carboniferous
ŚWIDNIK-11	1500.0	Carboniferous
ŚWIDNIK-12	1320.0	Carboniferous
ŚWIDNIK-13	1115.0	Carboniferous
ŚWIDNIK 14	1596.0	Famennian
ŚWIDNIK-15	1116.0	Carboniferous
ŚWIDNIK-16	1563.0	Devonian
ŚWIDNIK-17	1116.0	Carboniferous
ŚWIDNIK-18	1137.0	Carboniferous
ŚWIDNIK 19	1120.0	Carboniferous
ŚWIDNIK 20	1129.0	Carboniferous
ŚWIDNIK-21	1125.0	Carboniferous
ŚWIDNIK 22	1616.0	U. Devonian
TRZEŚNIÓW 1	1850.0	Devonian
WILCZOPOLE 1	1656.0	Famennian
WILCZOPOLE-2	2725.4	Emsian
ZEMBORZYCE 1	3004.0	Famennian
ZEMBORZYCE 2	3173.0	U. Devonian
ZEMBORZYCE 3	3001.0	U. Devonian
ZEMBORZYCE 4	3001.5	Famennian
ZEMBORZYCE 5	3003.0	Famennian

Seismic survey:

2D: 146 seismic lines of total length of 1571.57 km,

3D: 1 seismic survey.

Year	Number of lines/ seismic project	Owner
1975	2 lines/ Minkowice-Świdnik 2D	State Treasury
1976	1 line/ Rów Lubelski 2D	State Treasury
1976	3 lines/ Tłuszcz-K.-Włodawa 2D	State Treasury
1979-1981	22 lines/ O. Lubelskie-Bychawa 2D	State Treasury
1979-1992	111 lines/ Tłuszcz-Dęblin-Lublin 2D	State Treasury/ PGNiG S.A.
1997	2 lines/ Radom-Lublin 2D	PGNiG S.A.
1997	1 line/ Radom-Zamość 2D	PGNiG S.A.
2012	1 line/ PolandSPAN	State Treasury
2013	3 lines/ Bełżyce 2D	State Treasury
2018	Lublin 3D	State Treasury

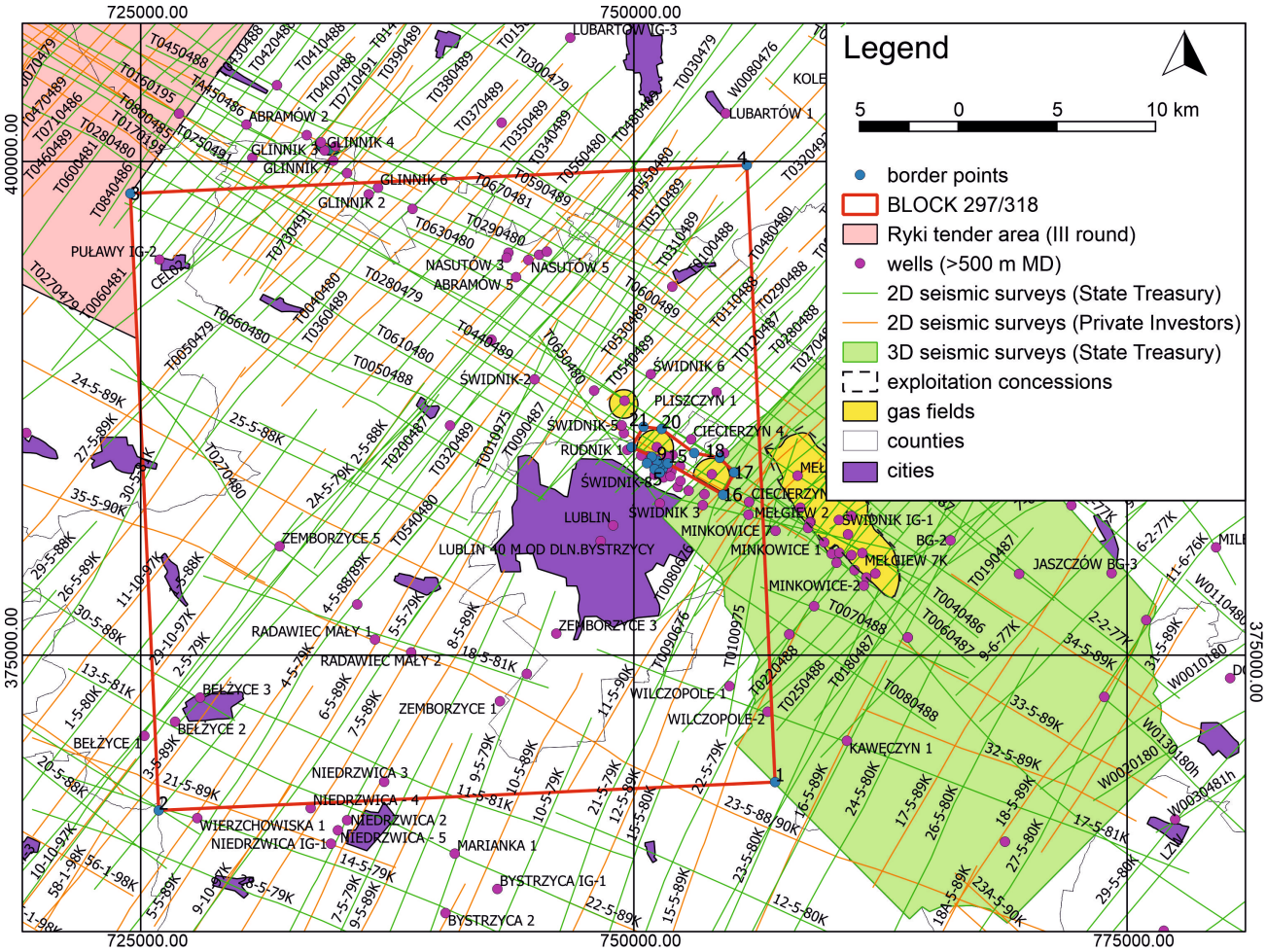
Oil and gas fields discovered in the area and in the neighborhood (analogues for further exploration): **3**.

Field name	Type	Crude oil resources [kt]	Natural gas resources [mln m^3]
Ciecierzyn	GAS		413.59
Glinnik	OIL/GAS	6.82	0.52
Mełgiew A i B	GAS		716.13

*as of 31.12.2018 (Balance...2019)

Hydrocarbon prospective assessment/exploration potential:

The proposed area is located within the Lublin Fold Belt (Lublin Subprovince). Seismic structures mapped within the Devonian and Carboniferous succession in the vicinity of documented oil and gas fields – Ciecierzyn, Glinnik, Mełgiew A and B, Minkowice and Świdnik – prove the potential of the block for further exploration. The area is also located within the Lublin 3D seismic survey, which indicates that the structures related to the Mełgiew fields continue to the NW (Fig. 31). However, the attention of investors should be directed to the western neighborhood of the mentioned Lublin 3D survey, where the Devonian and Carboniferous rocks are in the zone of hydrodynamic tightness (Narkiewicz et al., 2011; Figs 5–8).



EASTERN PETOLEUM PROVINCE

Fig. 31. Border points and boundaries of the BLOCK 297/318 in relation to hydrocarbon concessions (as of 31.01.2020), tender areas, wells >500 m MD, seismic surveys, and oil and gas fields (CBDG, 2020).

C.1.2. BLOCK E29

Location: **offshore** (Fig. 32)
Petroleum Province: **Northern**
Concession blocks: **E29**
Border points coordinates:

Border points	PL 1992	
	X	Y
1	876574.60	458040.80
2	848761.00	457773.50
3	848826.70	452017.13
4	853791.90	455653.20
5	852797.40	451864.40
6	850273.80	449048.80
7	848868.00	448376.70
8	849011.67	436849.07
9	870473.10	437153.10
10	871718.00	437810.70
11	872066.40	439561.80
12	873724.90	439457.80
13	876179.84	437240.47
14	876828.45	437249.82

Acreage: **556.88 km^2**

Prospection and exploration concessions in the neighborhood: Łeba No. 37/2001/Ł (LOTOS Petrobaltic S.A), Gotlandia No. 36/2001/Ł (LOTOS Petrobaltic S.A), Rozewie No. 38/2001/Ł (LOTOS Petrobaltic S.A).

Main exploration target:
Middle Cambrian sandstones (conventional)

- type of expected fields: conventional for crude oil and condensate;
- reservoir rocks: Middle Cambrian sandstones;
- depth of reservoir rocks: 1400–1800 (?) m;
- source rocks: Lower Paleozoic shales, especially Upper Cambrian, Ordovician and Lower Silurian claystones;
- seal: Middle and Upper Cambrian claystones and mudstones, Ordovician mudstones;
- trap types: stratigraphic, structural and mixed.

Additional exploration target:
Cambrian and Ordovician claystones and mudstones (unconventional shale-oil and shale-gas)

- type of expected fields: unconventional for crude oil and condensate;
- source rocks: Upper Cambrian and Lower Ordovician bituminous claystones (Sasino Formation);
- depth of reservoir rocks: 1000–1100 m;
- trap types: unconventional/continuous.

Wells: No wells have been drilled in the area, 28 wells are located in the neighborhood.

Well name	Depth [m MD]	Stratigraphy at the bottom
B3-13/97	1850.0	Middle Cambrian
B3-17/96	1835.0	Middle Cambrian
B3-15B/96	1748.0	Middle Cambrian
B3-Z3/97	2505.0	Middle Cambrian
B3-Z1/97	2683.0	Middle Cambrian
B3-Z7/98	3403.0	Middle Cambrian
B3-Z5N/98	2491.0	Middle Cambrian
B3-21/2006	1717.0	Middle Cambrian
B3-13A/98	1781.0	Middle Cambrian
B3-1/81	1790.0	Precambrian
B3-4/91	1520.0	Middle Cambrian
B3-5/93 (K)	1875.0	Lower Cambrian
B3-6/92	1510.0	Middle Cambrian
B4-1/81	1507.0	Precambrian
B4-N1/2001	1286.0	Middle Cambrian
B3-3/81	1603.0	Cambrian
B3-2/81	1800.0	Precambrian
B4-2A/02	1212.5	Middle Cambrian
B3-8/97	1502.8	Middle Cambrian
B3-15/96	1850.0	Middle Cambrian
B3-7/94	1840.0	Middle Cambrian
B3-10/95 (K)	1815.0	Middle Cambrian
B3-11/95 (K)	1738.0	Middle Cambrian
B3-16/96 (K)	1687.0	Upper Cambrian
B3-9/95	1532.0	Middle Cambrian
B3-4B/97	1490.0	Middle Cambrian
B3-Z4/97	2592.0	Middle Cambrian
B3-14/98	1807.6	Middle Cambrian

Seismic: There is no complete digital data and metadata in CBDG about seismic surveys in the area. In analog form, they are available at NAG.

Oil and gas fields discovered in the area and in the neighborhood (analogs for further exploration): **3**.

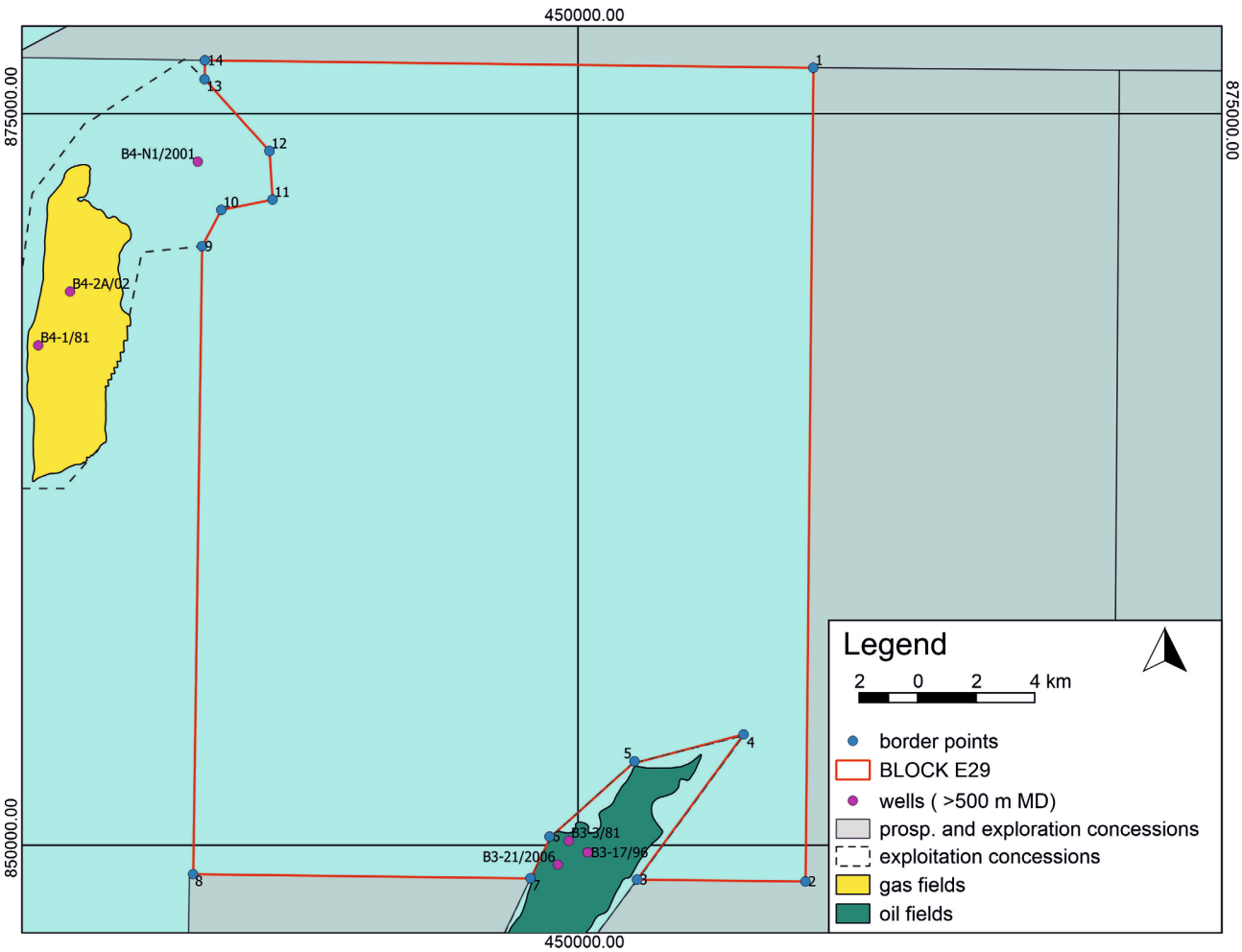
Field name	Type	Crude oil resources [kt]	Natural gas resources [mln m^3]
B3	OIL	2074.84	
B6	GAS		1792.85
B4	GAS		2014.20

*as of 31.12.2018 (Balance...2019)

Hydrocarbon prospective assessment/exploration potential:

At least 3 potential structural traps for hydrocarbon accumulations were mapped in the Middle Cambrian of the area (Kotarba, 2010a, b; Więcław et al., 2010a, b). The results of seismic investigations of bottom sediments and geochemical studies of water composition showed correlation of hydrocarbon content (including methane, higher alkanes) with the detected deeper geological structures, especially in fault zones (Domżalski et al., 2004). In addition, the exploration potential is indicated by the results of organic matter composition: in the Upper Cambrian – sample from the B4-N1/2001 well (at the depth 1192.0–1197.0 m) – total organic carbon content (TOC) is 13%, while HI parameter is 364 mg/g TOC (Podhalańska et al., 2018).

In terms of unconventional exploration, the Piaśnica Formation seems to be prospective on a relatively small area. Nevertheless, the average TOC content is 10–11%, while S1 parameter showed 2 mg HC/g of rock, which proves good source of rocks properties (samples analysed in selected nearby boreholes). On the other side, the Block E29 is located in the prospective zone for shale-gas and shale-oil exploration in the Sasino Formation. The TOC content is probably around 3%. Geochemical parameters (S1, S2, OSI; RockEval measurements) show early thermal maturity and source properties at medium-level (Podhalańska et al., 2018).



NORTHERN PETROLEUM PROVINCE

Fig. 32. Border points and boundaries of the BLOCK E29 in relation to hydrocarbon concessions (as of 31.01.2020), tender areas, wells >500 m MD, and oil and gas fields (CBDG, 2020).

C.1.3. BLOCK 111

Location: **onshore** (Fig. 33)
Petroleum Province: **Northern**
Concession blocks: **111**
Border points coordinates:

Border points	PL 1992	
	X	Y
1	626114.67	500000.00
2	653919.70	500000.00
3	654035.68	532960.81
4	626230.97	533156.18

Acreage: **919.19 km^2**

Prospection and exploration concessions in the neighborhood: none.

Main exploration target:
Middle Cambrian sandstones (conventional)

- type of expexted fields: conventional for wet gas;
- reservoir rocks: Middle Cambrian sandstones;
- depth of reservoir rocks: 3500–3900 m;
- source rocks: Lower Paleozoic shales, especially Upper Cambrian claystones, Ordovician and Lower Silurian mudstones;
- seal: Middle and Upper Cambrian claystones and mudstones, Ordovician mudstones;
- trap types: stratigraphic, structural, mixed.

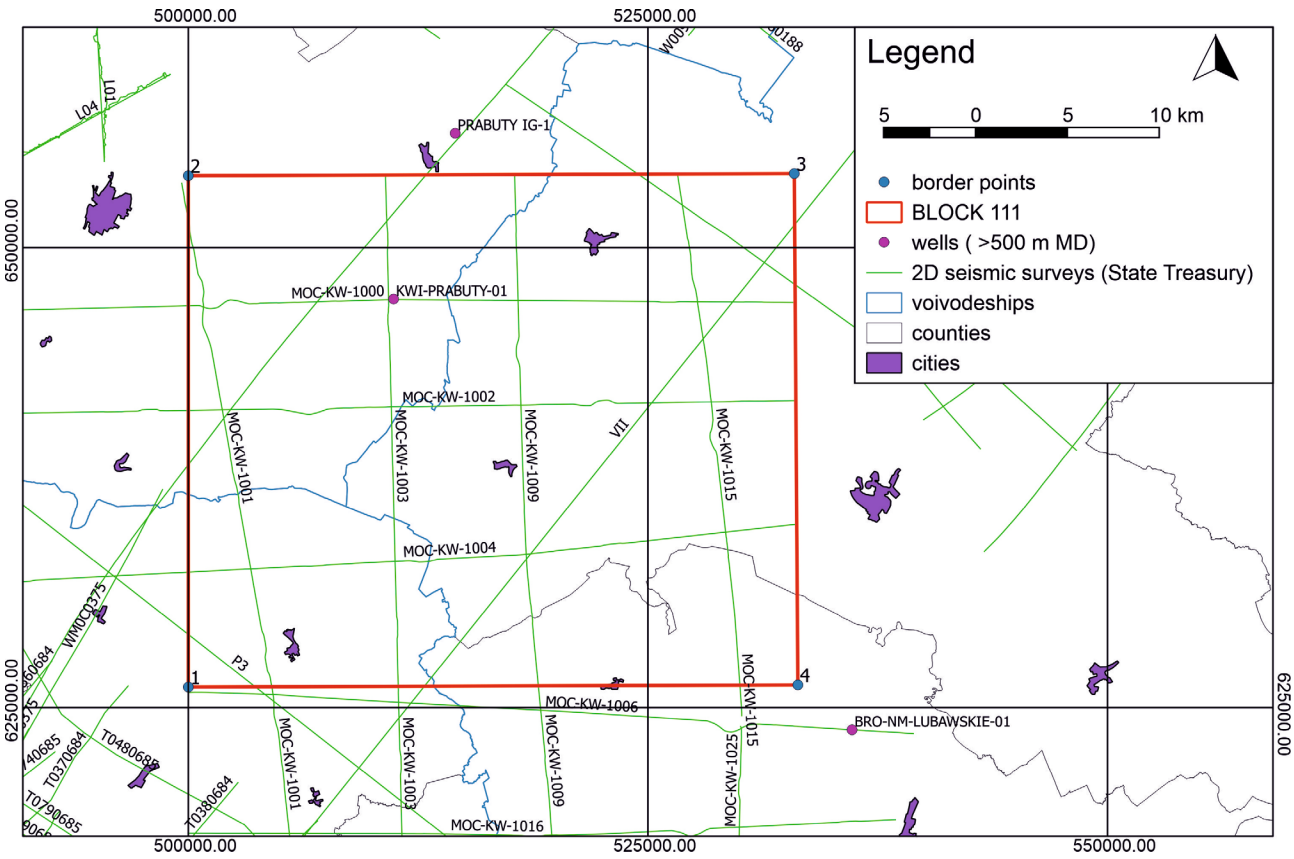
Wells: **1** well KWI-Prabuty-01 (depth 3713.2 m) reaching the Cambrian.

Seismic:
2D: 9 linesof total length of 245.78 km.

Year	Line name	Owner
1973	VII 2D	State Treasury
1997	P3 2D	State Treasury
2012	MOC-KW-1000 2D	State Treasury
2012	MOC-KW-1001 2D	State Treasury
2012	MOC-KW-1015 2D	State Treasury
2012	MOC-KW-1002 2D	State Treasury
2012	MOC-KW-1003 2D	State Treasury
2012	MOC-KW-1004 2D	State Treasury
2012	MOC-KW-1009 2D	State Treasury

Oil and gas fields discovered in the area and in the neighborhood (analogues for further exploration): **none**.

Hydrocarbon prospective assessment/exploration potential:
The porosity of the Middle Cambrian sandstones is 2–10%, usually 5–10% (Stolarczyk et al., 2004). Increasing porosity correlates with increasing permeability, as well, while silification processes are developed only in small scale. The Cambrian deposits of the Block 111 are sealed by Ordovician and Sillurian shales. As the area is located in the Olsztyn Ridge, it is also more likely that lateral hydrocarbon migration from the younger Ordovician and Sillurian source rocks may have occurred.



NORTHERN PETROLEUM PROVINCE

Fig. 33. Border points and boundaries of the BLOCK 111 in relation to hydrocarbon concessions (as of 31.01.2020), tender areas, wells >500 m MD, seismic surveys, and oil and gas fields (CBDG, 2020).

C.1.4. BLOCK 165/166

Location: **onshore** (Fig. 34)
Petroleum Province: **Western**
Concession blocs: **165, 166**
Border points coordinates:

Border points	PL 1992	
	X	Y
1	574045.01	315521.35
2	573815.18	321798.39
3	554529.78	342286.09
4	554868.38	331517.04
5	554827.12	331515.49
6	555840.26	305867.90
7	574717.49	298754.62

Acreage: **553.27 km^2**

Prospection and exploration concessions in the neighborhood: Wronki No. 10/99/Ł (PGNiG S.A), Szamotuły-Poznań Północ No. 3/2019/Ł (PGNiG S.A.).

Main exploration target:
Rotliegend
(conventional and unconventional)

- type of expected fields: conventional for natural gas, unconventional for tight gas;
- reservoir rocks: aeolian and fluvial sandstones;
- depth of reservoir rocks: below 4700 m (4300–4500 m in the Obrzycko-Człopa area);
- source rocks: Lower Carfoniferous claystones and mudstones (Culm facies);
- seal: Zechstein evaporites;
- trap types: stratigraphic, structural, unconventional/continuous (diagenetic).

Wells >500 m MD: **5**.

Well name	Depth [m MD]	Stratigraphy at the bottom
KUŹNICA ŻELICH.-1*	1910.0	Upper Triassic
HUTA SZKLANA 1*	3129.0	Upper Triassic
HUTA SZKLANA 2	2200.0	Permian
SZAMOTUŁY GEO-21	800.4	Upper Jurassic
SZAMOTUŁY GEO-27	732.1	Jurassic

*wells located in the neighborhood

Seismic:
2D: 32 lines of total length of 242.11 km.

Year	Number of lines/ seismic project	Owner
1977-1978	8 lines/ Czarnków-P.-Strzelno 2D	State Treasury
1979	2 lines/ Piła-Bydgoszcz 2D	State Treasury
1980	15 lines/ Radęcin-M. Goślina 2D	State Treasury
1983	2 lines/ Wałcz-Gołańcz 2D	State Treasury
1984	1 line/ Chociwel-Czaplinek 2D	State Treasury
1985	3 lines/ Nucl. Power P. Warta 2D	State Treasury
1997	1 line/ Polonaise'97	State Treasury

Oil and gas fields discovered in the area and in the neighborhood (analogues for further exploration): **none**.

Hydrocarbon prospective assessment/exploration potential:

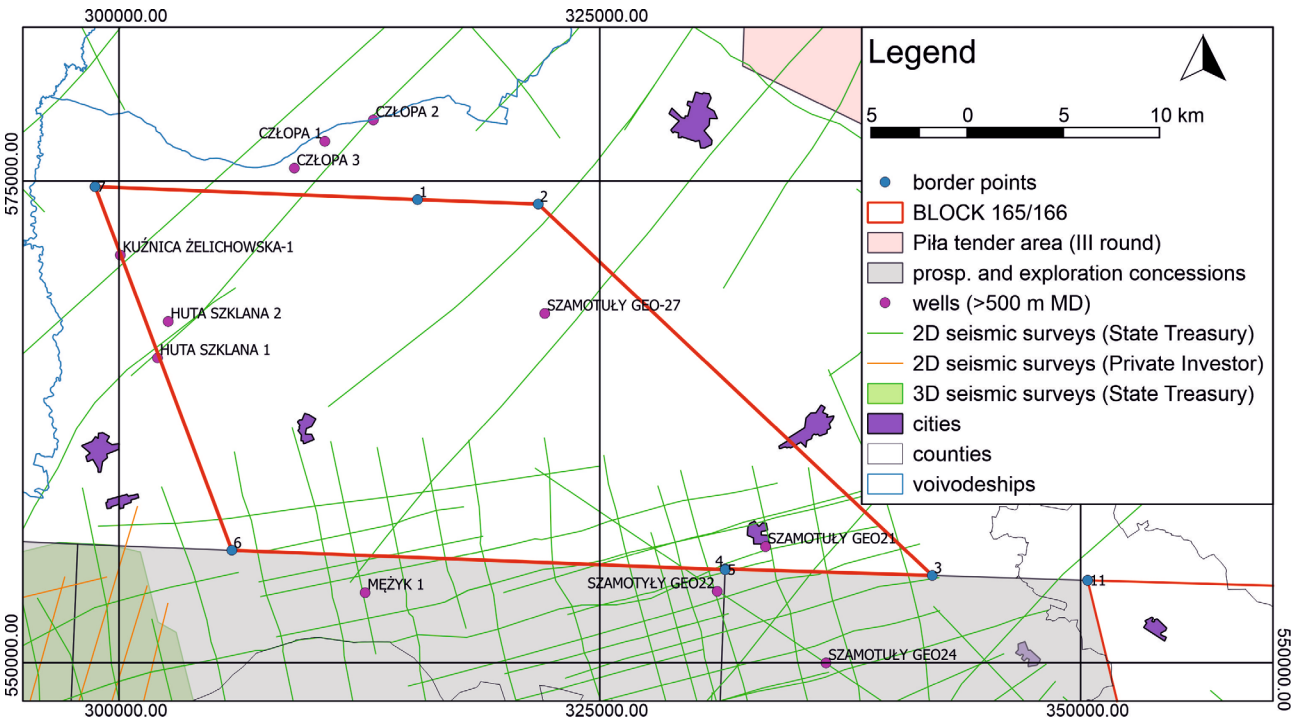
The area is located in the Upper Rotliegend Basin, north-east from the Grotów-Chrzypsko High. According to the previous facies-paleogeographic models, the Upper Rotliegend is here developed in playa-lake facies of the Noteć Formation. In the south-western part of the area, alluvial deposits of the sedimentary basin edge can also occur (as in the Mężyk 1 well, which is located in the close southern vicinity of the Block 165/166). The playa-lake deposits are probably underlied by aeolian sandstones. Below, the volcanics of the Lower Rotliegend and Lower Carboniferous source rocks occur.

The aeolian sandstones of the Noteć Formation may have a reservoir potential. They are sealed by playa sediments, but an intraformational seal of lithological or diagenetic character can also occur.

The chemical compositions of hydrocarbons obtained from wells in the Rotliegend deposits show the decreasing trend

of methane content towards the north – centre of the Rotliegend Basin. In the Block 165/166, the methane content can oscillate between 40 and 80%, while the nitrogen is expected in reversed proportions.

The tectonic structure of the Block 165/166 is the key for further exploration. In the north-estern part of the block, the Drawno-Golęczewo tectonic zone occurs. It is characterized by the multi-stage structural evolution during the Permian and Mezosoic. Numerous salt pillows and diapirs are related to the zone, forming potential structural traps. The elevated blocks, sealed along faults, form another type of structural traps. One of them is located in the area, being probably related to the Obrzycko-Golęczewo High. In addition, the results of the 2D and 3D seismic surveys of the Golęczewo area show that the occurence of secondary gas traps in the Lower Triassic sandstones (sealed by overthrusted Zechstein evaporites) should be considered.



WESTERN PETROLEUM PROVINCE

Fig. 34. Border points and boundaries of the BLOCK 165/166 in relation to hydrocarbon concessions (as of 31.01.2020), tender areas, wells >500 m MD, seismic surveys, and oil and gas fields (CBDG, 2020).

C.1.5. BLOCK 166/187

Location: **onshore** (Fig. 35)
Petroleum Province: **Western**
Concession blocks: **166, 167, 187**
Border points coordinates:

Border points	PL 1992	
	X	Y
1	553847.28	365311.06
2	553596.00	375549.53
3	540674.67	398723.18
4	534495.27	398594.59
5	529747.47	398495.79
6	529829.16	398372.08
7	544249.21	376171.46
8	544545.39	365052.07
9	544581.77	365053.08
10	544970.04	352638.19
11	554275.83	350362.87

Acreage: **454.04 km^2**

Prospection and exploration concessions in the neighborhood: Szamotuły-Poznań Północ No. 3/2019/Ł (PGNiG S.A.), Murowana Goślina-Kłecko No. 10/2007/Ł (PGNiG S.A.).

Main exploration target:
Rotliegend
(conventional and unconventional)

- type of expected fieds: conventional for natural gas; unconventional for tight gas (Basin Centered Gas System);
- reservoir rocks: aeolian sandstones and secondary fluvial sandstones;
- depth of reservoir rocks: below 4700 m;
- source rocks: Upper and/or Lower Carboniferous claystones and mudstones (Culm facies);
- seal: Zechstein evaporites;
- trap types: stratigraphic, structural, unconventional/continuous (diagenetic).

Additional exploration target:
Carboniferous sandstones
(conventional)

- type of expected fields: conventional for natural gas;
- reservoir rocks: Carboniferous sandstones;
- source rocks: Carboniferous fine-grained clastic rocks;
- trap types: structural.

Wells >500 m MD: **4**.

Well name	Depth [m MD]	Stratigraphy at the bottom
GOŚCIEJEWO-1	1537.0	Jurassic
GOŚCIEJEWO-2	1692.5	Jurassic
LUDOMY 1*	1509.0	Upper Triassic
SZAMOTUŁY 13	1103.7	Jurassic

*wells located in the neighborhood

Seismic:
2D: 17 lines of total length of 1571.57 km.

Year	Number of lines/ seismic project	Owner
1974	1 line/ Deep S. Soundings PAS	State Treasury
1976-1977	6 lines/ Czarnków-P.-Strzelno 2D	State Treasury
1980-1981	7 lines/ Radęcin-M. Goślina 2D	State Treasury
2011	3 lines/ Gniezno-Ślesin 2D	State Treasury

Oil and gas fields discovered in the area and in the neighborhood (analogues for further exploration): **none**.

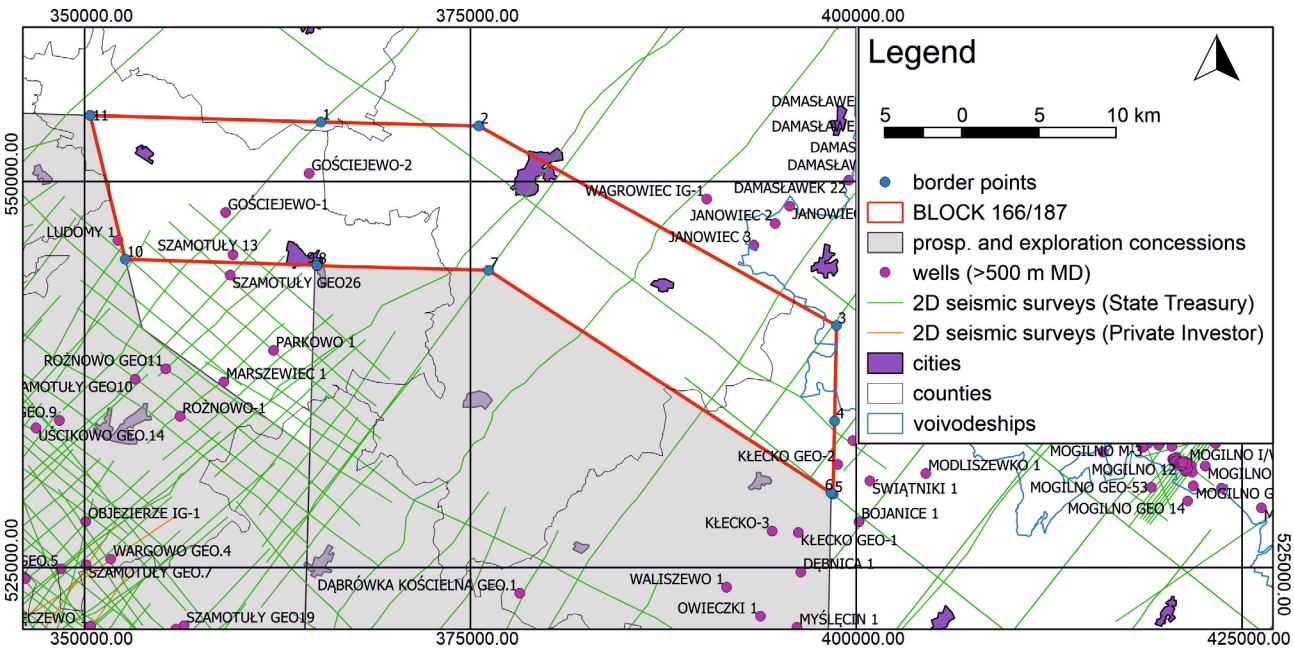
Hydrocarbon prospective assessment/exploration potential:
The area is located in the Upper Rotliegend Basin, northeast from the elevated Obrzycko and Siekierki Highs. According to the previous facies-paleogeographic models, the Upper Rotliegend is here developed in playa-lake facies of the Noteć Formation, while aeolian sandstones are probably developed below. Below, the Lower Rotliegend volcanics and Lower and ?Upper Carboniferous source rocks occur.

The aeolian sandstones of the Noteć Formation may have a reservoir potential. They are sealed by playa sediments, but an intraformational seal of lithological or diagenetic character can also occur. However, the results of the Kłecko 1 well (PGNiG S.A., completed in 2019), located in

the eastern part of the neighboring Murowana Goślina-Kłecko concession, have a great importance for further interpretations.

The chemical compositions of hydrocarbons obtained from wells in the Rotliegend deposits show the decreasing trend of methane content towards the north – centre of the Rotliegend Basin. In the Block 165/166, the methane content can oscillate between 40 and 80%, while the nitrogen is expected in reversed proportions.

The tectonic structure of the Sub-Permian basement, which is still poorly recognized, is the key for further exploration. Faults related to the tectonic edge of the Obrzycko High (elevation) may occur in the western part of the Block 166/187. In the central part, the tectonic block built of Carboniferous rocks and sealed by Zechstein evaporates is postulated. If seismic analysis confirm its exsistence, then traps for gas accumulations may be found at the top of the Carboniferous succession. In addition, the tectonic edge of this block can be associated with numerous structural traps developed in the Carboniferous and Rotliegend.



WESTERN PETROLEUM PROVINCE

Fig. 35. Border points and boundaries of the BLOCK 166/187 in relation to hydrocarbon concessions (as of 31.01.2020), tender areas, wells >500 m MD, seismic surveys, and oil and gas fields (CBDG, 2020).

C.1.6. BLOCK 62/83

Location: **onshore** (Fig. 36)
Petroleum Province: **Western**
Concession blocks: **62, 82, 83**
Border points coordinates:

Border points	PL 1992	
	X	Y
1	691055.17	219674.19
2	692737.14	221619.12
3	693771.09	224785.26
4	695846.05	233241.52
5	697800.71	239098.78
6	689034.77	237808.88
7	688700.54	245043.47
8	687684.41	264181.99
9	684723.09	259134.45
10	673948.18	266614.09
11	675598.09	237055.20
12	673865.95	223383.30
13	673409.40	219824.29
14	677185.11	213499.78
15	687174.95	217946.87
16	685637.43	221987.20
17	688367.49	223047.42
18	689636.16	219042.50
excluding the area bound by the following points:		
19	679335.20	223870.95
20	679746.86	224268.31
21	679040.45	224478.55
22	678251.69	224485.63
23	678251.81	224056.04

Acreage: **747.58 km^2**

Prospection and exploration concessions in the neighborhood: Trzebiatów No. 60/2009/Ł (PGNiG S.A.), Świdwin-Białogard No. 18/95/Ł (PGNiG S.A.), Kamień Pomorski No. 1/2000/Ł (PGNiG S.A.), Wolin No. 9/2017/Ł (Central European Petroleum Ltd).

Main exploration target:
Main Dolomite
(conventional)
- type of expected fields: conventional for oil and gas;
- reservoir rocks: Main Dolomite carbonate rocks;
- depth of reservoir rocks: 2300–3500 m;
- source rocks: microbial and clayey deposits enriched in organic matter in the Main Dolomite;
- seal: Zechstein evaporites;
- trap types: stratigraphic, structural, mixed.

Additional exploration target I:
Rotliegend sandstones
(conventiona)
- type of expected fields: conventional for natural gas;
- reservoir rocks: aluvial sandstones, marginal playa-lake sandstones;
- source rocks: Carboniferous fine-grained clastic rocks;
- trap types: stratigraphic, structural, mixed.

Additional exploration target II:
Carboniferous sandstones
(conventional)
- type of expected fields: conventional for natural gas;
- reservoir rocks: sandstones, sandy conglomerates;
- trap types: stratigraphic, structural, mixed.

Wells >500 m MD: **38**.

Well name	Depth [m MD]	Stratigraphy at the bottom
BENICE 1	3247.0	Permian
BENICE 2	2916.0	Permian
BENICE 3	2842.0	Permian
BENICE 4K	2732.5	Permian
BROJCE IG-1	4252.0	Givetian
CHOMINO-1	2750.0	Upper Permian
DOBROPOLE 1	2883.0	Permian
DUSIN 1	2662.5	Permian
GOSTYŃ 2	3447.0	Westphalian
GOSTYŃ IG-1	2133.4	Middle Triassic
GRYFICE 1	3367.0	Permian
GRYFICE 2	3415.0	Lower Permian
GRYFICE 3	3190.0	Permian
JARSZEWO 1	2998.7	Permian
KALEŃ 1	3232.0	Carboniferous
KAM. POMORSKI	580.0	Jurassic
KAM. POMORSKI 3	2405.0	Upper Permian
KAM. POMORSKI 7	3410.0	Westphalian
KAM. POMORSKI 13	2672.0	Permian
LASKA 2	3583.0	Visean
MECHOWO IG-1	1347.0	Upper Triassic
REKOWO 2	3141.5	Permian
REKOWO 3	2697.0	Permian
REKOWO 4	2736.0	Permian
REKOWO 6	2746.0	Permian

SKARCHOWO 1	2667.0	Permian
STRZEŻEWO 1	4521.0	Givetian
ŚWIERZNO 1	3103.0	Permian
ŚWIERZNO 2	2772.2	Permian
ŚWIERZNO 4	3238.5	Famennian
ŚWIERZNO 5	2883.6	Permian
ŚWIERZNO 9	2774.7	Permian
TRZĘSACZ GT-1	1224.5	Triassic
WRZOSOWO 1	3305.0	Westphalian
WRZOSOWO 2	3127.3	Westphalian
WRZOSOWO 3	3255.0	Westphalian
WRZOSOWO 8	3310.0	Westphalian
WRZOSOWO 9	3198.0	Westphalian

Seismic:

2D: 116 lines of total length of 1035.70 km,
3D: 3 seismic surveys.

Year	Number of lines/ seismic project	Owner
1976	8 lines/ Gorzysław-Petrykozy 2D	State Treasury
1976	2 lines/ Wysoka Kamieńska 2D	State Treasury
1979	10 lines/ Wysoka Kam.-Białogard 2D	State Treasury
1980	13 lines/ Wysoka Kam.-Białogard 2D	State Treasury
1981	23 lines/ Wysoka Kam.-Białogard 2D	State Treasury
1982	19 lines/ Wysoka Kam.-Białogard 2D	State Treasury
1983	10 lines/ Wysoka Kam.-Białogard 2D	State Treasury
1996	3 lines/ Jarkowo-Piaski 2D	PGNiG S.A.
1997	8 lines/ Jarkowo-Piaski 2D	State Treasury
1999	2 lines/ K. Pom.-Gryfice-Trzeb. 2D	PGNiG S.A.
2000	3 lines/ K. Pom.-Gryfice-Trzeb. 2D	PGNiG S.A.
2002	2 lines/ Piaski-Resko 2D	State Treasury
2006	13 lines/ Rybokarty-Komorowo 2D	State Treasury
1997	Świerzno 3D	PGNiG S.A.
2018	Jarkowo 3D	State Treasury
2018	Moracz 3D	State Treasury

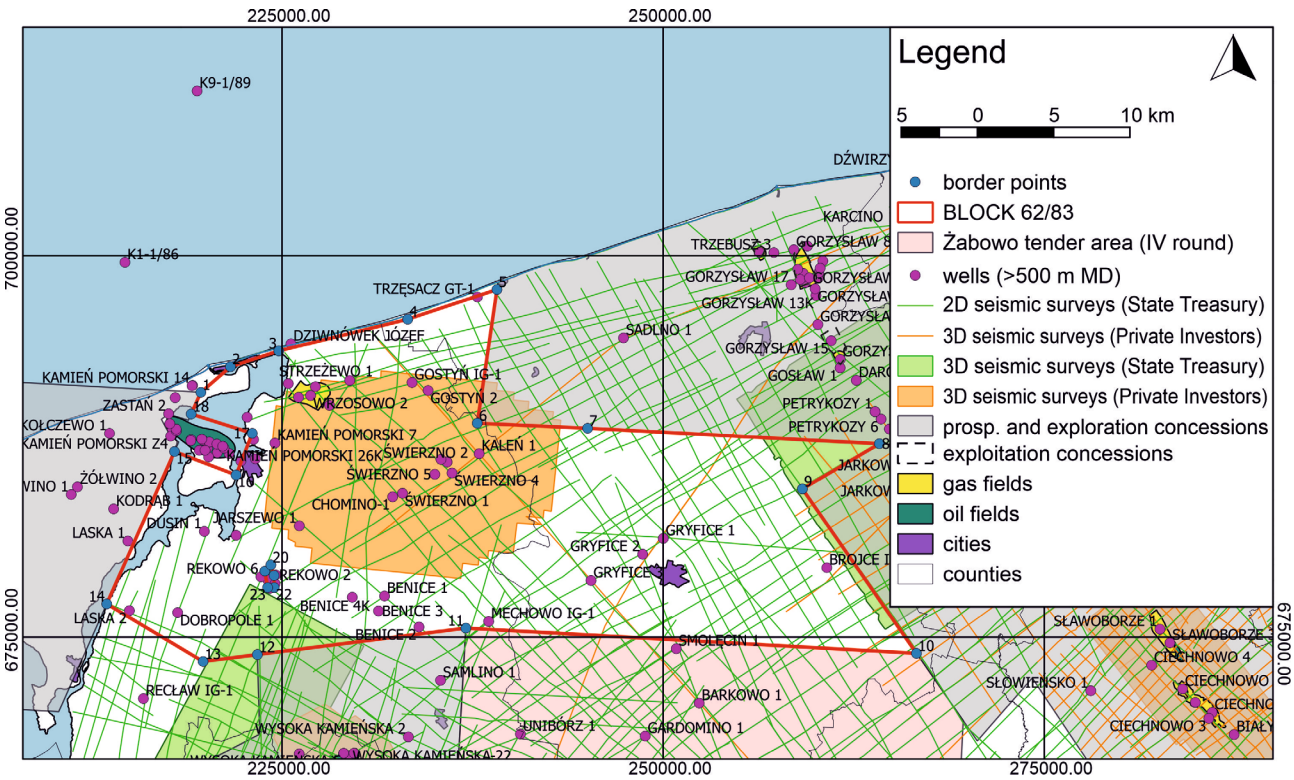
Oil and gas fields discovered in the area and in the neighborhood (analogues for further exploration): **16**.

Field name	Type	Crude oil resources [kt]	Natural gas resources [mln m^3]
Białogard	GAS	-	28.50
Błotno	GAS/RN	7.9	1.92
Ciechnowo	GAS	-	8.70
Daszewo N	GAS	-	928.20
Daszewo N	GAS/OIL	4.27	928.20
Gorzysław N	GAS	-	289.61
Gorzysław S	GAS	-	417.88
Kamień Pomorski	GAS/OIL	5.49	9.14
Międzyzdroje E	GAS	-	300.00
Międzyzdroje W	GAS	-	300.00
Przytór	GAS	-	360.00
Rekowo	GAS/OIL	1.37	0.27
Sławoborze	GAS/OIL	4.28	53.98
Trzebusz	GAS	-	2.55
Wrzosowo	GAS	-	600.00
W. Kamieńska	GAS/OIL	12.29	2.47

*as of 31.12.2018 (Balance...2019)

Hydrocarbon prospective assessment/exploration potential:

The Block 62/83 is located in the north-western part of the Mid-Polish Anticlinorium. Numerous structures – potential traps – mapped in the Rotliegend and Main Dolomite deposits, as well as numerous oil and gas fields discovered in the neighborhood (including the one – Wrzosowo field – documented within the Block), prove that the area is highly prospective for further exploration.



WESTERN PETROLEUM PROVINCE

Fig. 36. Border points and boundaries of the BLOCK 62/83 in relation to hydrocarbon concessions (as of 31.01.2020), tender areas, wells >500 m MD, seismic surveys, and oil and gas fields (CBDG, 2020).

C.1.7. BLOCK 183

Location: **onshore** (Fig. 37)
Petroleum Province: **Western**
Concession blocks: **183**
Border points coordinates:

Border points	PL 1992	
	X	Y
1	549450.19	244711.63
2	546785.65	241113.57
3	540242.75	241894.16
4	540873.53	247572.85
5	546430.59	247861.28
6	547712.18	259199.82
7	540414.53	256580.45
8	531745.15	262931.15
9	531753.26	263057.74
10	521496.05	262559.19
11	521556.67	262436.44
12	521365.66	247695.31
13	528872.38	239725.61
14	528621.24	236900.92
15	527049.18	228863.08
16	540948.98	229635.49
17	547125.25	229978.70
18	550209.91	230150.11
excluding the area bound by the following points:		
19	537338.87	235938.86
20	537381.70	235451.89
21	537161.68	235262.61
22	536191.17	234978.91
23	535945.30	236140.79
24	536032.11	236456.84
25	536631.59	236671.44
26	537053.67	236400.94

Acreage: **692.13 km^2**

Prospection and exploration concessions in the neighborhood: Gorzów Wlkp.-Międzyrzecz No. 69/98/Ł (PGNiG S.A.), Sulęcin-Międzyrzecz No. 15/97/p (PGNiG S.A.).

Main exploration target:
Main Dolomite (conventional)

- type of expected fields: conventional for oil and gas;
- reservoir rocks: Main dolomite carbonate rocks;
- depth of reservoir rocks: 2700–3500 m;
- source rocks: microbial and clayey deposits enriched in organic matter in the Main Dolomite successions;
- seal: Zechstein evaporites
- trap types: stratigraphic, structural.

Wells >500 m MD: **18**.

Well name	Depth [m MD]	Stratigraphy at the bottom
BACZYNA 1	3204.0	Permian
BACZYNA-2	3167.0	Upper Permian
BRZOZOWA 1	3218.0	Permian
CIECIERZYCE 1	3092.0	Upper Permian
CIECIERZYCE 1K	3006.8	Upper Permian
DZIERŻÓW 1K	3031.9	Upper Permian
DZIERŻÓW 1K-BIS	3034.1	Upper Permian
JENINIEC 4	3290.0	Permian
JEŻYKI 1	3401.0	Permian
LUBNO 1	3217.0	Upper Permian
MASZKÓW 1	3168.0	Permian
PŁONICA 1	3353.0	Permian
RACŁAW 1K	3256.0	Upper Permian
STANOWICE 1	3200.0	Upper Permian
STANOWICE 2	3200.0	Upper Permian
STANOWICE 3	3261.0	Upper Permian
WĘDRZYN 1	3170.0	Permian
WĘDRZYN 5	3210.0	Permian

Seismic:
2D: 153 lines of total length of 1573.68 km,
3D: 6 seismic surveys.

Year	Number of lines/ seismic project	Owner
1975	3 lines/ Międzyrz.-Nowy Tomyśl 2D	State Treasury
1976	2 lines/ Kostrzyń-Skwierzyna 2D	State Treasury
1976	2 lines/ Skwierzyna-Nowa Sól 2D	State Treasury
1977	6 lines/ Sulęcin-Świebodzin 2D	State Treasury
1978	11 lines/ Kostrzyn-Gorzów Wlkp. 2D	State Treasury
1978	10 lines/ Myślibórz-Krzyż 2D	State Treasury
1984	2 lines/ Chociwel-Czaplinek 2D	State Treasury
1987	1 line/ Chojna-G. Wlkp.-S. Kr. 2D	State Treasury
1987	1 line/ Kostrzyn 2D	State Treasury
1988	6 lines/ Chojna-G. Wlkp.-S. Kr. 2D	State Treasury

1989	6 lines/ Chojna-G. Wlkp.-S. Kr. 2D	PGNiG S.A.
1990	8 lines/ Chojna-G. Wlkp.-S. Kr. 2D	PGNiG S.A.
1991	1 line/ Chojna-G. Wlkp.-S. Kr. 2D	PGNiG S.A.
1992	1 line/ Chojna-Myśl.-G. Wlkp. 2D	PGNiG S.A.
1993	2 lines/ Chojna-G. Wlkp.-S. Kr. 2D	PGNiG S.A.
1993	1 line/ Chojna-Myśl.-G. Wlkp. 2D	PGNiG S.A.
1993	6 lines/ Dzied.-G. Wlkp.-L. 2D	PGNiG S.A.
1994	19 lines/ Dzied.-G. Wlkp.-L. 2D	PGNiG S.A.
1994	1 line/ Sulęcin-Międzyrzecz 2D	PGNiG S.A.
1995	24 lines/ Dzied.-G. Wlkp.-L. 2D	PGNiG S.A.
1995	6 lines/ Sulęcin-Międzyrzecz 2D	PGNiG S.A.
1996	11 lines/ Dzied.-G. Wlkp.-L. 2D	PGNiG S.A.
1996	3 lines/ Sulęcin-Międzyrzecz 2D	PGNiG S.A.
1997	7 lines/ Sulęcin-Międzyrzecz 2D	PGNiG S.A.
1998	7 lines/ Dzied.-G. Wlkp.-L. 2D	PGNiG S.A.
1999	4 lines/ Międzyrzecz-Międzych. 2D	PGNiG S.A.
2000	2 lines/ Międzyrzecz-Międzych. 2D	PGNiG S.A.
1997	Dzieduszyce-Stanowice 3D	PGNiG S.A.
2000	Gorzów Wlkp.-Santok 3D	PGNiG S.A.
2001	Nowa Wieś-Templewo 3D	PGNiG S.A.
2005	Wędrzyn 3D	State Treasury
2013	Sulęcin-3D	State Treasury
2019	Maszków-Bolemin 3D	State Treasury

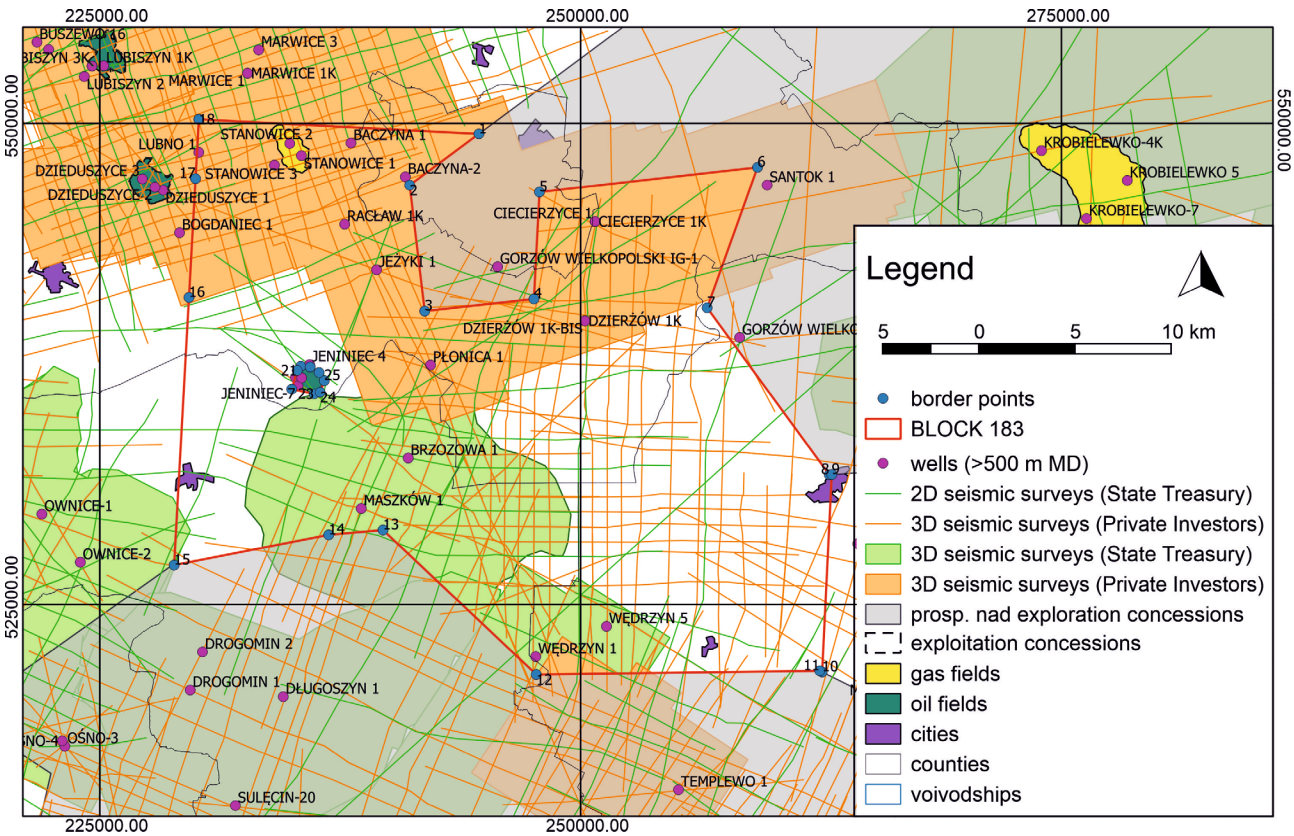
Oil and gas fields discovered in the area and in the neighborhood (analogues for further exploration): **9**.

Field name	Type	Crude oil resources [kt]	Natural gas resources [mln m^3]
Stanowice	GAS	-	602.03
Międzychód	GAS	-	4160.44
Jeniniec	GAS/RN	5.67	0.78
Dzieduszyce	GAS/RN	461.09	65.97
Lubiszyn	GAS/RN	4.11	1.06
BMB	GAS/RN	5873.30	2216.83
Gajewo	GAS/RN	29.04	10.91
Lubiatów	GAS/RN	3516.84	882.78
Grotów	GAS/RN	1708.68	845.48

*as of 31.12.2018 (Balance...2019)

Hydrocarbon prospective assessment/exploration potential:

The area is located in the Gorzów block, as a part of the Wolsztyn Ridge. For this reason, there are no Rotliegend deposits at the basement. The main exploration target is related to the Main Dolomite. Numerous structures – potential traps – and one gas field (Stanowice) are documented, which, together with numerous oil and gas fields in the neighborhood, prove the area is highly prospective for further exploration.



WESTERN PETROLEUM PROVINCE

Fig. 37. Border points and boundaries of the BLOCK 183 in relation to hydrocarbon concessions (as of 31.01.2020), tender areas, wells >500 m MD, seismic surveys, and oil and gas fields (CBDG, 2020).

C.1.8. BLOCK 410/411

Location: **onshore** (Fig. 38)
Petroleum Province: **Southern**
Concession blocks: **410 i 411**
Border points coordinates:

Border points	PL 1992	
	X	Y
1	222190.12	494662.22
2	222189.30	499916.20
3	222293.28	507622.86
4	226943.36	507622.42
5	227019.95	514380.11
6	218499.11	514622.35
7	218493.73	500124.08
8	218475.55	494761.25

Acreage: **106.52 km^2**

Prospection and exploration concessions in the neighborhood: Strumień-Kęty No. 20/99/Ł (PGNiG S.A.), Cieszyn No. 69/2009/p (Energia Karpaty Zachodnie), Bielsko-Biała No. 32/2009/p (Energia Karpaty Zachodnie) and Bestwina-Czechowice tender area dedicated to IV licensing round for hydrocarbon concessions in Poland.

Main exploration target:
Autochthonous Miocene of the Carpathian Foredeep (conventional and unconventional/hybrid)

- type of expected fields: conventional gas fields; unconventional/hybrid gas fields;
- reservoir rocks: Miocene sandstones; heterolitic interbes within the Miocene successions;
- depth of reservoir rocks: 100–300 m;
- source rocks: claystones and mudstones interbeds in the Miocene successions;
- seal: fine-grained clastic rocks within the Miocene successtion; fine-grained flysch successions of the Carpathians;
- trap types: stratigraphic, structural, mixed, unconventional/continuous.

Additional exploration target:
Paleozoic basement of the Carpathian Foredeep (conventional)

- type of expected fields: conventional for natural gas;
- reservoir rocks: Cambrian and Lower Devonian sandstones, Upper Devonian and Lower Carboniferous limestones and dolomites, Upper Carboniferous sandstones;
- depth of the reservoir rocks: 400–1000 m;
- source rocks: Upper Devonian and Lower Carboniferous fine-grained clastic and carbonate rocks, Upper Carboniferous coal beds;
- seal: Carboniferous fine-grained clastic rocks for the Devonian and Carboniferous traps; fine-grained clastic rock intercalations within the Carboniferous succession;
- trap types: stratigraphic, structural.

Wells >500 m MD: **16**.

Well name	Depth [m MD]	Stratigraphy at the bottom
BIELSKO-1	1203.0	Carboniferous
BIELSKO-3	1098.0	Carboniferous
BIELSKO 4	2006.1	Devonian
KĘTY SL-1	705.0	Miocene
KĘTY 1	1360.0	Carboniferous
KĘTY-2	1192.0	Carboniferous
KĘTY 3	1494.1	Carboniferous
KĘTY 4	1002.0	Carboniferous
KĘTY 5	1002.0	Carboniferous
KĘTY 7	1756.0	Precambrian
KĘTY 8	1466.0	Devonian
KĘTY 9	1984.0	Devonian
KĘTY-11	1000.0	Carboniferous
KOZY MT-3	1500.0	Cambrian
MIĘDZYRZECZE 1	1443.6	Carboniferous
POGÓRZ 5	802.5	Miocene

Seismic:
2D: 18 lines of total length of 323.8 km.

Year	Seismic project	Owner
1988	4 lines/ USCB 2D	State Treasury
1990-1991	14 lines/ Skoczów-Wadow.-Sucha 2D	PGNiG S.A.

Oil and gas fields discovered in the area and in the neighborhood (analogues for further exploration): **4**.

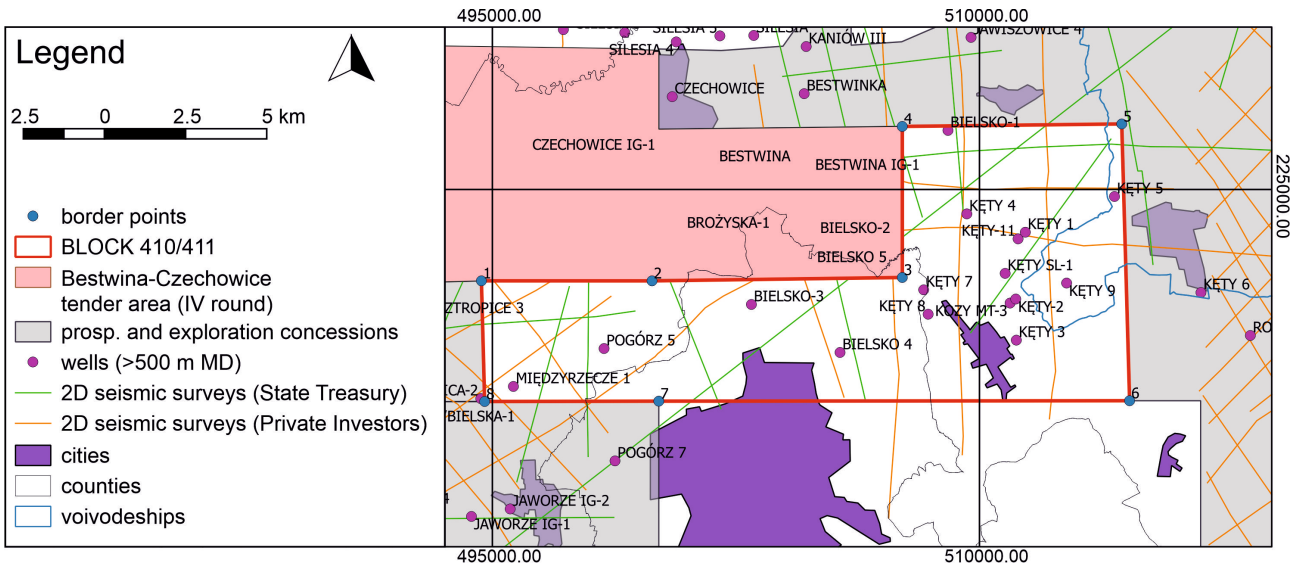
Field name	Type	Crude oil resources [kt]	Natural gas resources [mln m^3]
Dębowiec Śląski	GAS	-	29.65
Kowale	GAS	-	80.91
Pogórz	GAS	-	11.80
Lachowice-Stryszawa	GAS	-	240.00

*as of 31.12.2018 (Balance… 2019)

Hydrocarbon prospective assessment/exploration potential:

The Block 410/411 is located in the Upper Silesian Subprovince of the Southern Petroleum Province. The Carpathian Orogeny is represented here by the Sub-Silesian and Silesian units. At the front of the Carpathians, the autochthonous Miocene successions of the Carpathian Foredeep occurs. The basement of the Carpathian Units is built of the Upper Silesian Block, composed of Proterozoic crystalline basement and Paleozoic sedimentary cover.

The area is medium prospective in terms of oil and gas exploration. The hydrocarbon shows were noted in the Miocene, Carboniferous and Devonian strata in the Bielsko 3, Bielsko 4, Kęty 4, and Kęty 9 wells, while gas inflows were documented in the Kęty 1 and Kęty SL-1 wells. However, they did not have the character of commercial accumulations.



SOUTHERN PETROLEUM PROVINCE

Fig. 38. Border points and boundaries of the BLOCK 410/411 in relation to hydrocarbon concessions (as of 31.01.2020), tender areas, wells >500 m MD, seismic surveys, and oil and gas fields (CBDG, 2020).

C.2. UNCONVENTIONAL HYDROCARBON ACCUMULATIONS

C.2.1. BLOCK 216/237

Location: **onshore** (Fig. 39)
Petroleum Province: **Eastern**
Concession blocks: **216, 217, 236, 237**
Border points coordinates:

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

Acreage: **1200.00 km^2**

Prospection and exploration concessions in the neighborhood: **none**

Main exploration target:
Mudstones of Pelplin Formation (unconventional for shale-oil and shale-gas)
- type of expected fields: unconventional for oil, condensate and gas;
- reservoir rocks: mudstones of the Pelpin Formation;
- depth of reservoir rocks: 2200–2700 m;
- trap types: unconventional/continuous.

Additional exploration target:
Middle Cambrian sandstones (conventional)
- type of expected fields: conventional for oil, condensate and gas;
- reservoir rocks: Middle Cambrian sandstones;
- depth of reservoir rocks: 1700–2600 m;
- source rocks: Lower Paleozoic shales, especially Upper Cambrian claystones, Ordovician and Lower Silurian mudstones;
- seal rocks: Middle and Upper Cambrian claystones, Ordovician mudstones;
- trap types: stratigraphic, structural, mixed.

Wells >500 m MD: **5**.

Well name	Depth [m MD]	Stratigraphy at the bottom
Kałuszyn 1	3190.0	Paleoproterozoic
Kałuszyn 2	2480.0	Cambrian
Polaki 1	2780.7	Proterozoic
Sok-Grębków-01	2243.0	Cambrian
Sokołów Podlaski 1	1771.0	Cambrian

Seismic:
2D: 52 lines of total length of 196.30 km.

Year	Line name	Owner
1976	T0020676	State Treasury
1991	T0200591	PGNiG S.A.
1991	T0210591	PGNiG S.A.
1991	T0220591	PGNiG S.A.
1991	T0230591	PGNiG S.A.
1991	T0190591	PGNiG S.A.
1991	T0270591	PGNiG S.A.
1991	T0260591	PGNiG S.A.
1991	T0280591	PGNiG S.A.
1991	T0250591	PGNiG S.A.
1991	T0240591	PGNiG S.A.
1992	T0440592	PGNiG S.A.
1992	T0410592	PGNiG S.A.
1993	T0530493	PGNiG S.A.
1993	T0540493	PGNiG S.A.
1993	T0550493	PGNiG S.A.
1993	T0560493	PGNiG S.A.
1993	T2620493	PGNiG S.A.
1993	T0520493	PGNiG S.A.
1993	T0500493	PGNiG S.A.
1993	T0580493	PGNiG S.A.
1993	TA620493	PGNiG S.A.
1993	T0680493	PGNiG S.A.
1993	T0690493	PGNiG S.A.
1993	T0700493	PGNiG S.A.
1993	T0710493	PGNiG S.A.
1993	T0720493	PGNiG S.A.
1993	T0750493	PGNiG S.A.
1993	T0760493	PGNiG S.A.
1993	T0780493	PGNiG S.A.
1993	T0670493	PGNiG S.A.
1993	T0640493	PGNiG S.A.
1993	T0650493	PGNiG S.A.
1993	T0510493	PGNiG S.A.

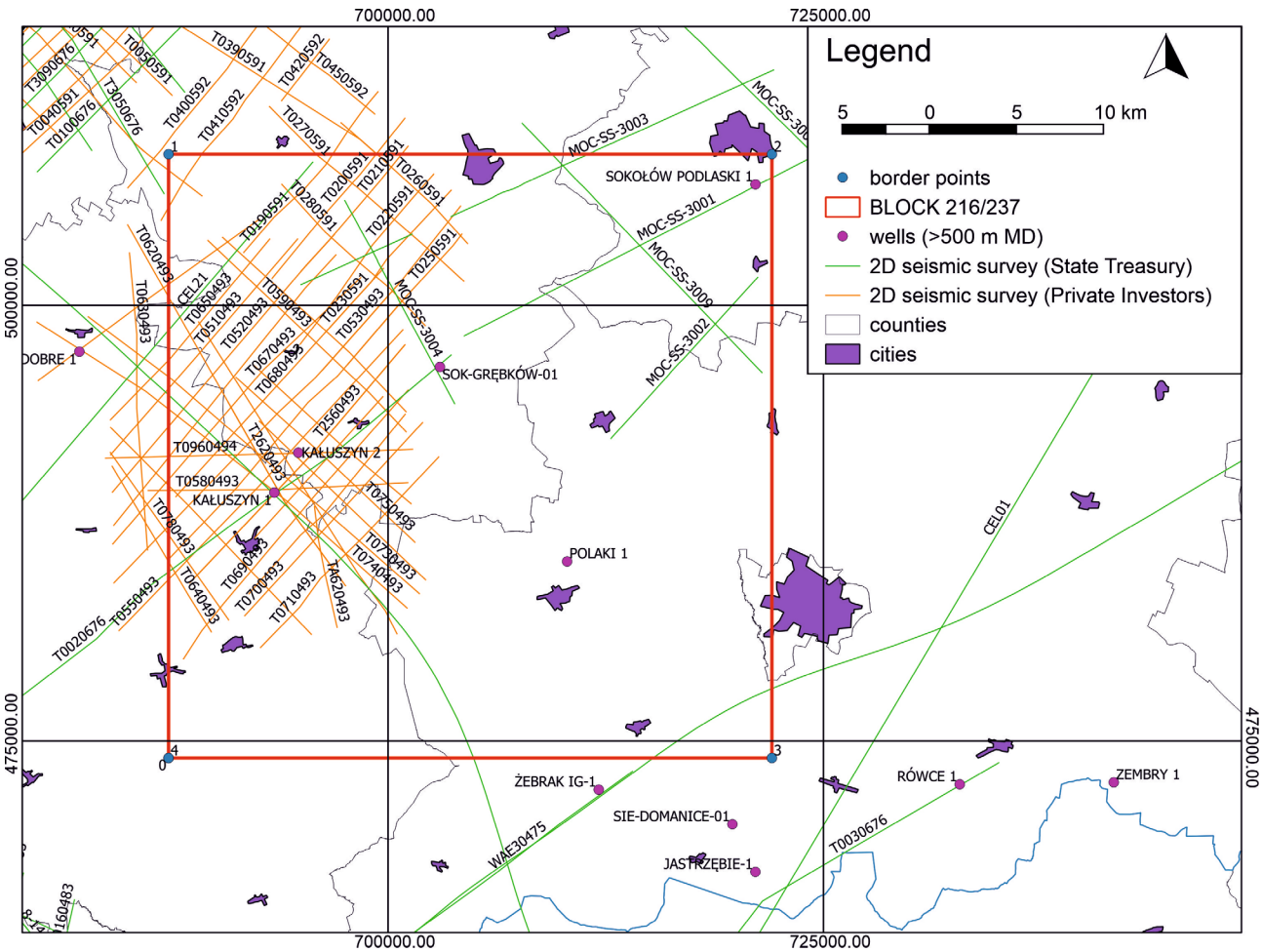
1993	T0740493	PGNiG S.A.
1993	T0570493	PGNiG S.A.
1993	T0590493	PGNiG S.A.
1993	T0600493	PGNiG S.A.
1993	T0610493	PGNiG S.A.
1993	T0770493	PGNiG S.A.
1993	T0620493	PGNiG S.A.
1993	T2560493	PGNiG S.A.
1993	T0730493	PGNiG S.A.
1993	T0660493	PGNiG S.A.
1993	T0790493	PGNiG S.A.
1994	T0960494	PGNiG S.A.
2000	CEL21	State Treasury
2011	MOC-SS-3009	State Treasury
2011	MOC-SS-3001	State Treasury
2011	MOC-SS-3004	State Treasury
2011	MOC-SS-3013	State Treasury
2011	MOC-SS-3002	State Treasury
2011	MOC-SS-3003	State Treasury

Oil and gas fields discovered on in the area and in the neighborhood (analogues for further exploration): **none**.

Hydrocarbon prospective assessment/exploration potential:

On the Block 216/236 (especially in the Grębków region), the Pelpin Formation has the highest total organic carbon content (TOC), exceeding 2%. The S1 parameter (RockEval measurements) oscillates around 0.5 mg HC/g of rock, while the values of S2 are estimated between 5 and 6 mg HC/g of rock, which suggest well generation potential. The Pelpin Formation is homogeneous in terms of geochemical parameters. The Brittle Index value oscillate between 0.55 and 0.6. The Young modulus value, measured parallel to the layers, oscillate around 65 GPa, and the Poisson's ratio equals 0.235. The perpendicular measurements equal 41.6 GPa and 0.22, respectively. These results allow to state that the rocks of the Pelplin Formation are susceptible to hydraulic fracturing (Podhalańska et al., 2018).

For the Middle Cambrian sandstones, the median porosity oscillates between 10 and 15%, but usually equals 5–10% (Stolarczyk et al., 2004). It is also important that together the increasing porosity, the permeability increases, as well. The Cambrian is covered by the succession of Ordovician and Silurian fine grained and impermeable rocks. However, lateral migration of hydrocarbons generated in the Ordovician and Silurian source rocks to the Cambrian sandstones, could occur, as well.



EASTERN PETROLEUM PROVINCE

Fig. 39. Border points and boundaries of the BLOCK 216/237 in relation to hydrocarbon concessions (as of 31.01.2020), tender areas, wells >500 m MD, seismic surveys, and oil and gas fields (CBDG, 2020).

C.2.2. BLOCK E47/E68

Location: **offshore** (Fig. 40)
Petroleum Province: **Northern**
Concession blocks: **E47, E48, E67, E68**
Border points coordinates:

Border points	PL 1992	
	X	Y
1	838328.87	386543.02
2	838328.87	421184.04
3	803687.85	421184.04
4	803687.85	386543.02
excluding the area bound by the following points:		
5	813471.25	420164.47
6	816839.72	415926.85
7	815336.01	415029.62
8	812566.50	414286.20
9	810795.46	413993.77
10	806263.07	411963.49
11	806234.72	413495.76
12	806987.77	414385.78
13	811128.19	417093.52

Acreage: **1168.00 km^2**

Prospection and exploration concessions in the neighborhood: **none**.

Main exploration target:
Cambrian and Ordovician claystones and mudstones (unconventional for shale-oil and shale-gas)

- type of expected fields: unconventional for oil, condensate and gas;
- reservoir rocks: Upper Cambrian and Lower Ordovician bituminous claystones (Piaśnica Formation), Middle and Upper Ordovician mudstones (Sasino Formation);
- depth of reservoir rocks: 1600–2000 m;
- trap types: unconventional/continuous.

Wells >500 m MD: **5**.

Well name	Depth [m MD]	Stratigraphy at the bottom
B21-2/2014	1905.0	Middle Cambrian
B21-3/2015	1830.0	Middle Cambrian
B21-1/95	2277.0	Precambrian
*B6-1/82	1868.5	Precambrian
*B6-3/2002	1555.5	Precambrian

*wells located in the neighborhood

Seismic:
There is no complete digital data and metadata in CBDG about seismic surveys in the area. In analogue form, they are available at NAG.

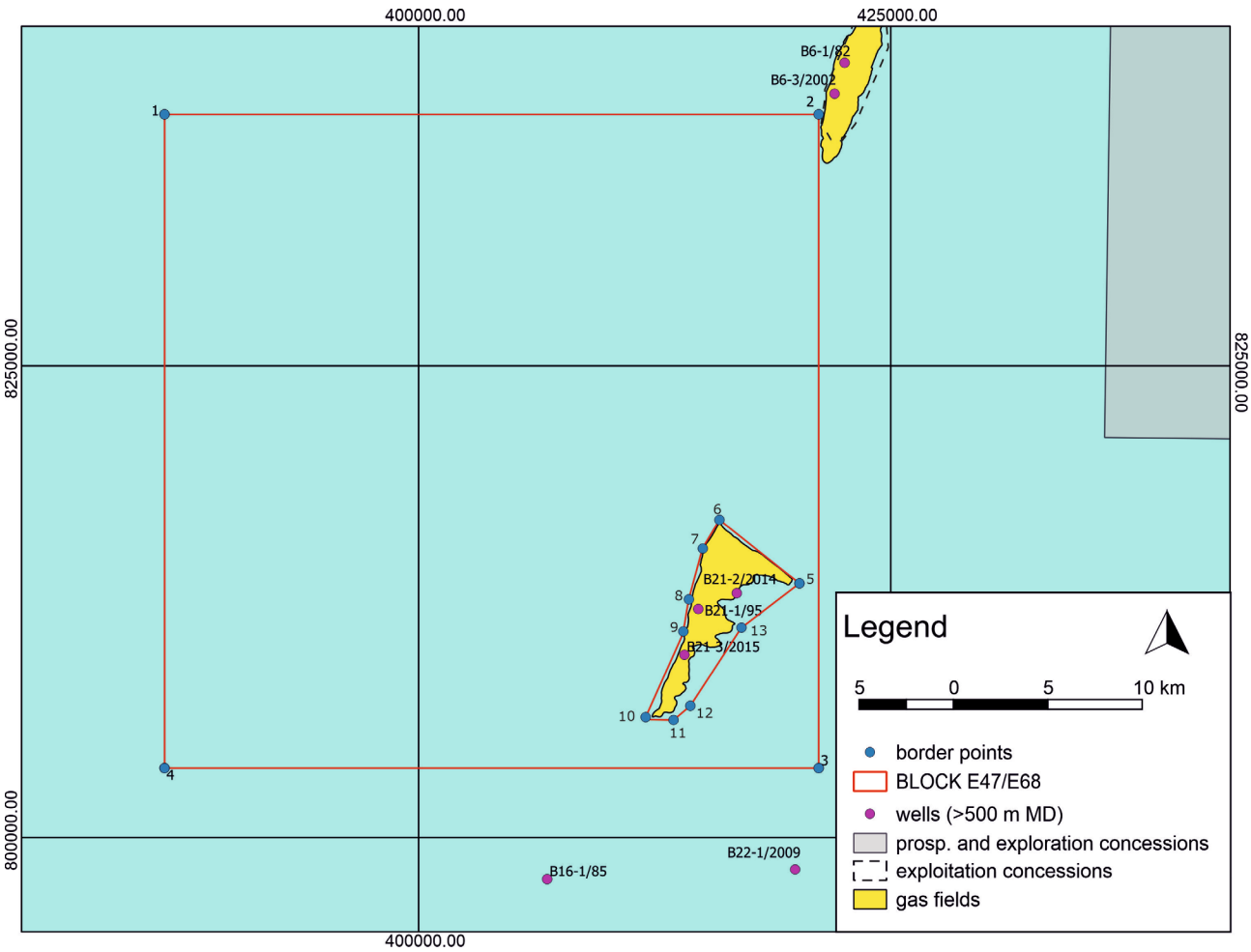
Oil and gas fields discovered in the area and in the neighborhood (analogues for further exploration): **2**.

Field name	Type	Crude oil resources [kt]	Natural gas resources [mln m^3]
B6	GAS	-	1792.85
B21	GAS	-	275.00

*as of 31.12.2018 (Balance...2019)

Hydrocarbon prospective assessment/exploration potential:
High TOC content (from 5 to 12%, with increasing values ~7–9% in the B6 and B21 fields) is characteristic for the claystones of the Piaśnica Formation. Geochemical parameters (OSI, S1, S2, HI; RockEval measuremets) suggest the rocks have high generation potential. In the B21 field, the highest values of desorbed and total gas were noted, >2m^3/t and >3.5m^3/t, respectively. The median porosity of samples from the B21-2/2014 well is 8.21%. The total porosities, measured in samples from the B21-2/2014 and B21-1/95 wells, are 4.7% and 3.43%, respectively. The brittle index values are relatively high and oscillate around 0.5–0.6 (Podhalańska et al., 2018).

The TOC values, measured for the mudstones of the Sasino Formation, are between 1.5 and 3.5%, while the median is around 1.5–2.5%. Geochemical analysis of samples derived from the B21-1/95, B21-2/2014, and B21-3/2015 wells, show the OSI parameter 50–60 mg HC/g TOC. However, the S2 parameter, which varies from 2 to 8, indicates the formation has still generation potential. The S1 parameter values are from 1.5 to 3 mg HC/g of rock. The median of the total porosity is 7.86% and 7.27% for effective porosity.



NORHERN PETROLEUM PROVINCE

Fig. 40. Border points and boundaries of the BLOCK E47/E68 in relation to hydrocarbon concessions (as of 31.01.2020), tender areas, wells >500 m MD, and oil and gas fields (CBDG, 2020).

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E. LIST OF THE PROSPECTIVE AREAS

PETROLEUM PROSPECTIVE AREAS IN POLAND 2020 (this paper; Figs 41 and 42)

Conventional oil and gas fields as main targets:

BLOCK 297/318
BLOCK E29 – *OFFSHORE*
BLOCK 111
BLOCK 165/166
BLOCK 166/187
BLOCK 62/83
BLOCK 183

Unconventional oil and gas fields as main targets:

BLOCK 216/237
BLOCK E47/E68 – *OFFSHORE*

PETROLEUM PROSPECTIVE AREAS IN POLAND 2019 (Wójcik et al., 2019; Figs 41 and 42)

Conventional oil and gas fields as main targets:

Gorzów Wielkopolski
Chybie
Kalwaria Zebrzydowska-Dobczyce
Żegocina
Nowa Dęba

Unconventional oil and gas fields as main targets:

Rejowiec Fabryczny
Sierakowice
Kartuzy
Nowa Karczma
Hel – *OFFSHORE*
Jastarnia – *OFFSHORE*
Łeba S – *OFFSHORE*
Rozewie S – *OFFSHORE*
Władysławowo – *OFFSHORE*

TARGET – CONVENTIONAL OIL AND GAS FIELDS

PETROLEUM PROSPECTIVE AREAS IN POLAND 2020 (this paper)								
No.	**Name**	**Acreage [km^2]**	**Petroleum Province**	**Target UC - unconventional C - conventional**		**No.**	**X**	**Y**
							PL 1992	
1	BLOCK 297/318	971.11	Eastern PP	C	Devonian and Carboniferous clastic and carbonate rocks	1	368572.23	757156.61
						2	367137.54	725912.77
						3	398381.37	724478.08
						4	399816.07	755721.92
						excluding the area bound by the following points:		
						5	384242.72	751312.11
						6	384456.41	751456.81
						7	384617.73	751366.47
						8	384743.40	751280.34
						9	384846.58	751173.79
						10	385041.54	750905.13
						11	384718.66	750664.99
						12	384422.33	751043.70
						13	384242.72	751312.11
						14	385534.90	749882.14
						15	384713.72	751720.54
						16	383123.40	754521.37
						17	384257.68	755076.28
						18	384992.00	754350.34
						19	385235.64	753057.14
						20	386453.28	751405.00
						21	386567.89	750483.21
						22	385534.90	749882.14
2	BLOCK E29	556.88	Northern PP *OFFSHORE*	C	Middle Cambrian sandstones	1	876574.60	458040.80
						2	848761.00	457773.50
						3	848826.70	452017.13
						4	853791.90	455653.20
						5	852797.40	451864.40
						6	850273.80	449048.80
						7	848868.00	448376.70
				UC (shale)	Lower Paleozoic shales	8	849011.67	436849.07
						9	870473.10	437153.10
						10	871718.00	437810.70
						11	872066.40	439561.80
						12	873724.90	439457.80
						13	876179.84	437240.47
						14	876828.45	437249.82
3	BLOCK 111	919.19	Northern PP	C	Middle Cambrian sandstones	1	626114.67	500000.00
						2	653919.70	500000.00
						3	654035.68	532960.81
						4	626230.97	533156.18
4	BLOCK 165/166	553.27	Western PP	C	Rotliegend sandstones	1	574045.01	315521.35
						2	573815.18	321798.39
						3	554529.78	342286.09
						4	554868.38	331517.04
				UC (tight)	Rotliegend sandstones	5	554827.12	331515.49
						6	555840.26	305867.90
						7	574717.49	298754.62
5	BLOCK 166/187	454.04	Western PP	C	Rotliegend sandstones	1	553847.28	365311.06
						2	553596.00	375549.53
						3	540674.67	398723.18

						4	534495.27	398594.59
						5	529747.47	398495.79
				UC (tight)	Rotliegend sandstones	6	529829.16	398372.08
						7	544249.21	376171.46
						8	544545.39	365052.07
						9	544581.77	365053.08
						10	544970.04	352638.19
						11	554275.83	350362.87
6	BLOCK 62/83	747.58	Western PP	C	Main Dolomite	1	691055.17	219674.19
						2	692737.14	221619.12
						3	693771.09	224785.26
						4	695846.05	233241.52
						5	697800.71	239098.78
						6	689034.77	237808.88
						7	688700.54	245043.47
						8	687684.41	264181.99
				C	Rotliegend sandstones	9	684723.09	259134.45
						10	673948.18	266614.09
						11	675598.09	237055.20
						12	673865.95	223383.30
						13	673409.40	219824.29
						14	677185.11	213499.78
						15	687174.95	217946.87
						16	685637.43	221987.20
				C	Carboniferous sandsones	17	688367.49	223047.42
						18	689636.16	219042.50
						excluding the area bound by the following points:		
						19	679335.20	223870.95
						20	679746.86	224268.31
						21	679040.45	224478.55
						22	678251.69	224485.63
						23	678251.81	224056.04
7	BLOCK 183	692.13	Western PP	C	Main Dolomite	1	549450.19	244711.63
						2	546785.65	241113.57
						3	540242.75	241894.16
						4	540873.53	247572.85
						5	546430.59	247861.28
						6	547712.18	259199.82
						7	540414.53	256580.45
						8	531745.15	262931.15
						9	531753.26	263057.74
						10	521496.05	262559.19
						11	521556.67	262436.44
						12	521365.66	247695.31
						13	528872.38	239725.61
						14	528621.24	236900.92
						15	527049.18	228863.08
						16	540948.98	229635.49
						17	547125.25	229978.70
						18	550209.91	230150.11
						excluding the area bound by the following points:		
						19	537338.87	235938.86
						20	537381.70	235451.89
						21	537161.68	235262.61
						22	536191.17	234978.91
						23	535945.30	236140.79
						24	536032.11	236456.84

						25	536631.59	236671.44
						26	537053.67	236400.94
8	BLOCK 410/411	106.52	Southern PP	C/UC (hyb.)	autochthonous Miocene of the Carpathian Foredeep	1	222190.12	494662.22
						2	222189.30	499916.20
						3	222293.28	507622.86
						4	226943.36	507622.42
				C	Devonian and Carboniferous of the Carpathian basement	5	227019.95	514380.11
						6	218499.11	514622.35
						7	218493.73	500124.08
						8	218475.55	494761.25

TARGET – UNCONVENTIONAL OIL AND GAS FIELDS

PETROLEUM PROSPECTIVE AREAS IN POLAND 2020 (this paper)								
No.	**Name**	**Acreage [km^2]**	**Petroleum Province**	**Exploration target: UC - unconventional C - conventional**		**No.**	**X**	**Y**
							PL 1992	
9	BLOCK 216/237	1200.00	Eastern PP	UC (*shale*)	Lower Paleozoic shales	1	508667.07	687397.04
						2	508667.07	722038.06
				C	Middle Cambrian sandstones	3	474026.06	722038.06
						4	474026.06	687397.04
10	BLOCK E47/E68	1168.00	Northern PP *OFFSHORE*	UC (*shale*)	Lower Paleozoic shales	1	838328.87	386543.02
						2	838328.87	421184.04
						3	803687.85	421184.04
						4	803687.85	386543.02
						excluding the area bound by the following points:		
						5	813471.25	420164.47
						6	816839.72	415926.85
						7	815336.01	415029.62
						8	812566.50	414286.20
						9	810795.46	413993.77
						10	806263.07	411963.49
						11	806234.72	413495.76
						12	806987.77	414385.78
						13	811128.19	417093.52

TARGET – CONVENTIONAL OIL AND GAS FIELDS

PETROLEUM PROSPECTIVE AREAS IN POLAND 2019 (Wójcik et al., 2019)								
No.	**Name**	**Acreage [km^2]**	**Petroleum Province**	**Target UC - unconventional C - conventional**		**No.**	**X**	**Y**
							PL 1992	
A	Gorzów	1015.06	Western PP	C	Main Dolomite	1	578050.68	231703.41
						2	574775.40	298543.71
						3	556156.87	297853.03
						4	558082.24	256367.92
B	Chybie	100.70	Southern PP	C	autochthonous Miocene of the Carpathian Foredeep	1	222153.81	493303.33
						2	222035.78	488885.90
						3	218455.96	488980.84
						4	218434.63	482690.08
				C	Devonian and Carboniferous of the Carpathian basement	5	226659.30	482557.17
						6	228475.40	483189.30
						7	229417.61	483167.35
						8	229422.37	493418.39
C	Kalwaria Zebrzydowska-Dobczyce	615.82	Southern PP	C	Istebna and Ciężkowice sandstones of the Outer Carpatihans	1	234844.36	560392.57
						2	230642.81	560453.66
						3	230896.96	571608.57
						4	230992.76	574100.13
						5	230011.54	572315.44
						6	228395.66	572458.46
						7	229408.06	574430.69
						8	229434.99	575429.65
						9	230147.53	577410.08
						10	230743.62	578393.80
				C	autochthonous Miocene of the Carpathian Foredeep	11	230687.12	577395.51
						12	231067.40	576041.64
						13	231446.80	585909.50
						14	231619.15	587161.05
						15	230387.33	586612.41
						16	230574.94	585908.57
						17	230006.10	585907.97
						18	219097.84	585896.39
						19	219005.58	580176.25
				C	Precambrian sandstones, Middle Devonian carbonates, Lower Carfoniferous and Upper Jurassic carbonates	20	221144.84	580743.36
						21	221028.90	577051.28
						22	218918.27	574085.44
						23	218677.07	553795.86
						24	219634.17	553786.28
						25	218661.71	552238.18
						26	218462.26	543731.87
						27	227842.28	543481.10
						28	237088.56	543233.92
						29	237383.66	566195.31
						30	236207.60	566125.53
D	Żegocina	480.49	Southern PP	C	Istebna and Ciężkowice sandstones of the Outer Carpathians	1	224429.40	619471.74
						2	219993.39	619456.98
						3	219830.52	619456.53
						4	219734.09	619456.21
						5	219733.96	619456.22
						6	219733.95	619456.07
						7	219733.92	619454.87
						8	214616.64	619436.49
						9	210523.09	619421.78
						10	209976.71	594697.07

				C	autochthonous Miocene of the Carpathian Foredeep	11	209794.17	580172.71
						12	219005.58	580176.25
						13	219097.84	585896.39
						14	219222.83	593635.80
						15	222376.00	593612.00
						16	222475.00	595313.00
						17	223236.00	595405.00
						18	223368.00	594800.00
						19	224307.00	594218.00
				C	Precambrian sandstones, Middle and Upper Devonian carbonates, Lower Carfoniferous and Upper Jurassic carbonates, Cretaceous sandstones and sands	20	224314.01	603486.16
						21	224429.40	619471.74
						22	221109.37	600644.87
						excluding the polygon defined by points:		
						23	220816.08	601652.51
						24	220862.49	603390.93
						25	220125.97	603450.34
						26	219833.40	602978.16
						27	220557.32	602379.11
						28	219798.82	601679.44
						29	219475.77	602687.75
						30	220292.07	604055.74
						31	220865.93	604200.42
						32	221457.15	604634.48
						33	222010.11	603619.97
						34	221956.85	601621.88
						35	221510.53	600634.09
E	Nowa Dęba	584.17	Southern PP	C	autochthonous Miocene of the Carpathian Foredeep	1	296831.15	712681.39
						2	282871.88	713244.88
						3	278512.41	703100.24
						4	278002.46	677845.11
				C	Precambrian and Lower Cambrian sandstones	5	294522.05	677289.44
						6	291497.74	682596.08
						7	291459.64	685 375.92
						8	295800.79	685256.08
						9	296510.27	704411.18

TARGET – UNCONVENTIONAL OIL AND GAS FIELDS

PETROLEUM PROSPECTIVE AREAS IN POLAND 2019 (Wójcik et al., 2019)								
No.	**Name**	**Acreage [km^2]**	**Petroleum Province**	**Target UC - unconventional C - convetional**		**No.**	**X**	**Y**
							PL 1992	
F	Rejowiec Fabryczny	896.33	Eastern PP	UC (shale)	Lower Paleozoic shales	1	384719.21	799654.16
						2	385544.79	813899.18
						3	357769.83	815600.98
						4	355745.40	780547.43
						5	366856.82	779942.57
						6	371470.35	779691.43
						7	383524.22	779035.27
						8	383992.00	781307.00
						9	375496.00	790915.00
G	Sierakowice	926.732	Northern PP	UC (tight)	Lower and Middle Cambrian sandstones	1	715916.10	395018.18
						2	736654.49	394914.17
						3	736415.47	403325.65
						4	735907.85	421189.09
				UC (shale)	Lower Paleozoic shales	5	737990.19	421224.49
						6	737770.93	435133.01

						7	709994.91	434842.34
						8	710216.13	420752.34
						9	715477.11	420841.77
H	Kartuzy	898.424	Northern PP	UC (shale)	Lower Paleozoic shales	1	709648.50	467438.93
						2	709994.91	434842.34
				UC (tight)	Lower and Middle Cambrian sandstones	3	737770.93	435133.01
						4	737259.22	467502.29
				C	Lower and Middle Cambrian sandstones	5	720 361.13	467514.79
I	Nowa Karczma	906.099	Northern PP	UC (shale)	Lower Paleozoic shales	1	709648.50	467438.93
						2	695454.92	467338.43
				UC (tight)	Lower and Middle Cambrian sandstones	3	681841.49	467242.03
						4	682184.52	434676.55
				C	Lower and Middle Cambrian sandstones	5	709994.91	434842.34
J	Hel	1196.982	Northern PP *OFFSHORE*	UC (tight)	Lower and Middle Cambrian sandstones	1	774588.93	521368.50
						2	756267.53	520183.94
						3	743956.47	532324.66
				C	Lower and Middle Cambrian	4	744586.66	498099.45
						5	760779.19	482224.42
						6	774536.10	467893.14
K	Jastarnia	1146.388	Northern PP *OFFSHORE*	UC (tight)	Lower and Middle Cambrian sandstones	1	774588.93	521368.50
						2	774536.10	467893.14
						3	784245.44	467962.51
				C	Lower and Middle Cambrian sandstones	4	797561.64	468057.76
						5	797604.00	500000.00
						6	797622.74	514122.38
L	Rozewie S	1187.822	Northern PP *OFFSHORE*	UC (shale)	Lower Paleozoic shales	1	848587.35	500000.00
						2	797604.00	500000.00
				UC (tight)	Lower and Middle Cambrian sandstones	3	797561.64	468057.76
						4	820859.70	468098.90
				C	Lower and Middle Cambrian sandstones	5	820774.10	483986.60
						6	848587.40	484086.60
						7	848562.20	494611.90
M	Łeba S	1172.924	Northern PP *OFFSHORE*	UC (shale)	Lower Paleozoic shales	1	797561.64	468057.76
						2	784245.44	467962.51
				UC (tight)	Lower and Middle Cambrian	3	784298.35	435921.59
						4	821201.40	436324.10
				C	Lower and Middle Cambrian sandstones	5	820859.70	468098.90
N	Władysławowo	822.213	Northern PP *OFFSHORE*	UC (shale)	Lower Paleozoic shales	1	793990.87	404079.74
						2	793419.95	436021.08
				UC (tight)	Lower and Middle Cambrian sandstones	3	784298.35	435921.59
						4	784245.44	467962.51
				C	Lower and Middle Cambrian sandstones	5	776119.74	467904.45
						6	776205.60	403698.83

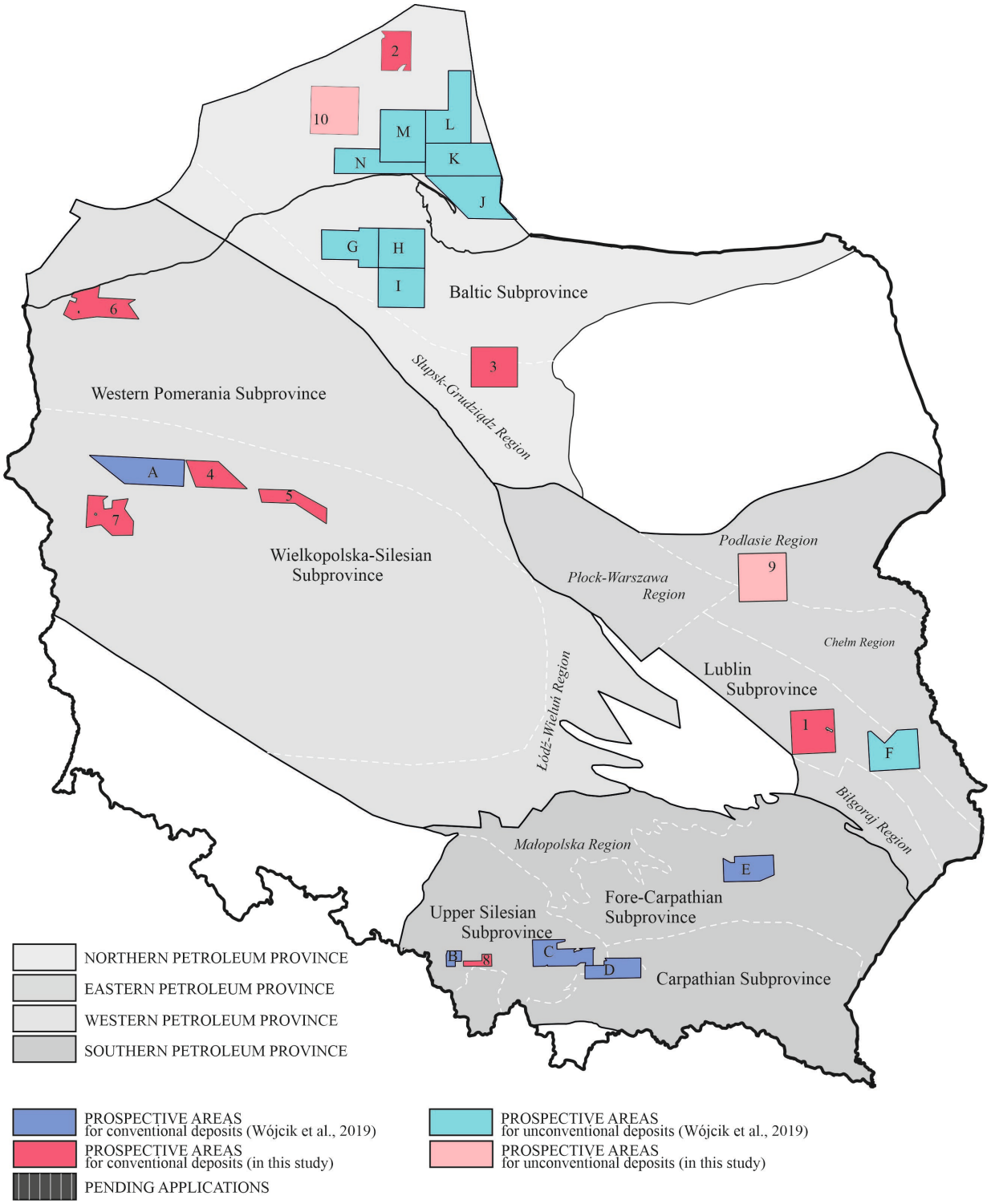

Fig. 41. Areas prospective for oil and gas exploration in Poland in relation to petroleum provinces, subprovinces and regions (Wójcik et al., 2019).

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318, **2** – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.

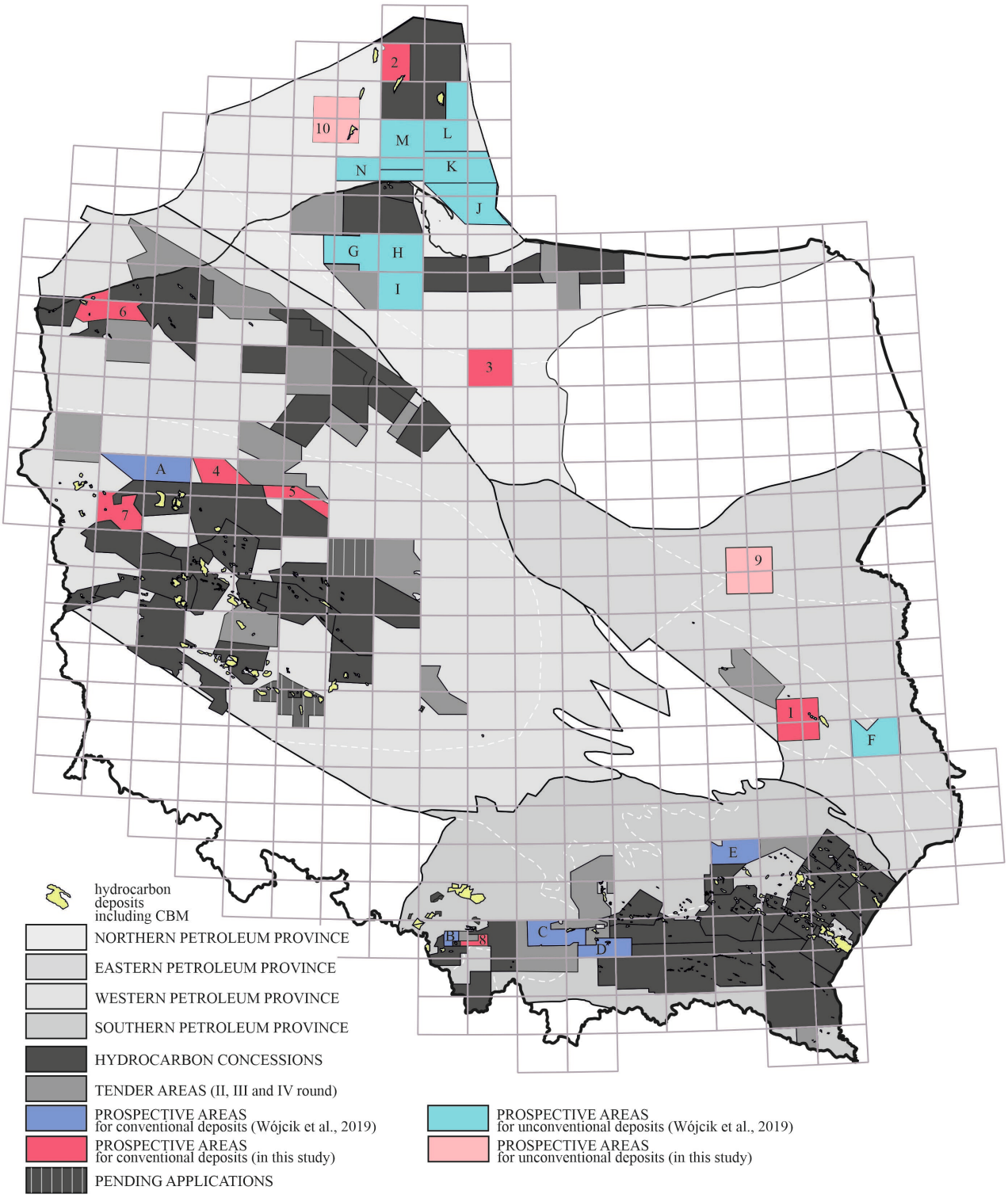

Fig. 42. Areas prospective for oil and gas exploration in Poland in relation to petroleum provinces, subprovinces and regions (Wójcik et al., 2019), hydrocarbon concession and pending applications (as of 31.01.2020), tender areas, oil and gas fields, and hydrocarbon concession grid.

A–N – areas selected for oil and gas exploration in 2019 (Wójcik et al., 2019):
A – Gorzów Wielkopolski, **B** – Chybie, **C** – Kalwaria Zebrzydowska-Dobczyce, **D** – Żegocina, **E** – Nowa Dęba, **F** – Rejowiec Fabryczny, **G** – Sierakowice, **H** – Kartuzy, **I** – Nowa Karczma, **J** – Hel, **K** – Jastarnia, **L** – Łeba S, **M** – Rozewie S, **N** – Władysławowo.

1–10 – areas selected for oil and gas exploration in this study:
1 – Block 297/318, **2** – Block E29, **3** – Block 111, **4** – Block 165/166, **5** – Block 166/187, **6** – Block 62/83, **7** – Block 183, **8** – Block 410/411, **9** – Block 216/237, **10** – Block E47/E68.