



Ordered by
(Min. of Environment)



MINISTERSTWO
ŚRODOWISKA

Funding



Finansowano ze środków
Narodowego Funduszu
Ochrony Środowiska i
Gospodarki Wodnej

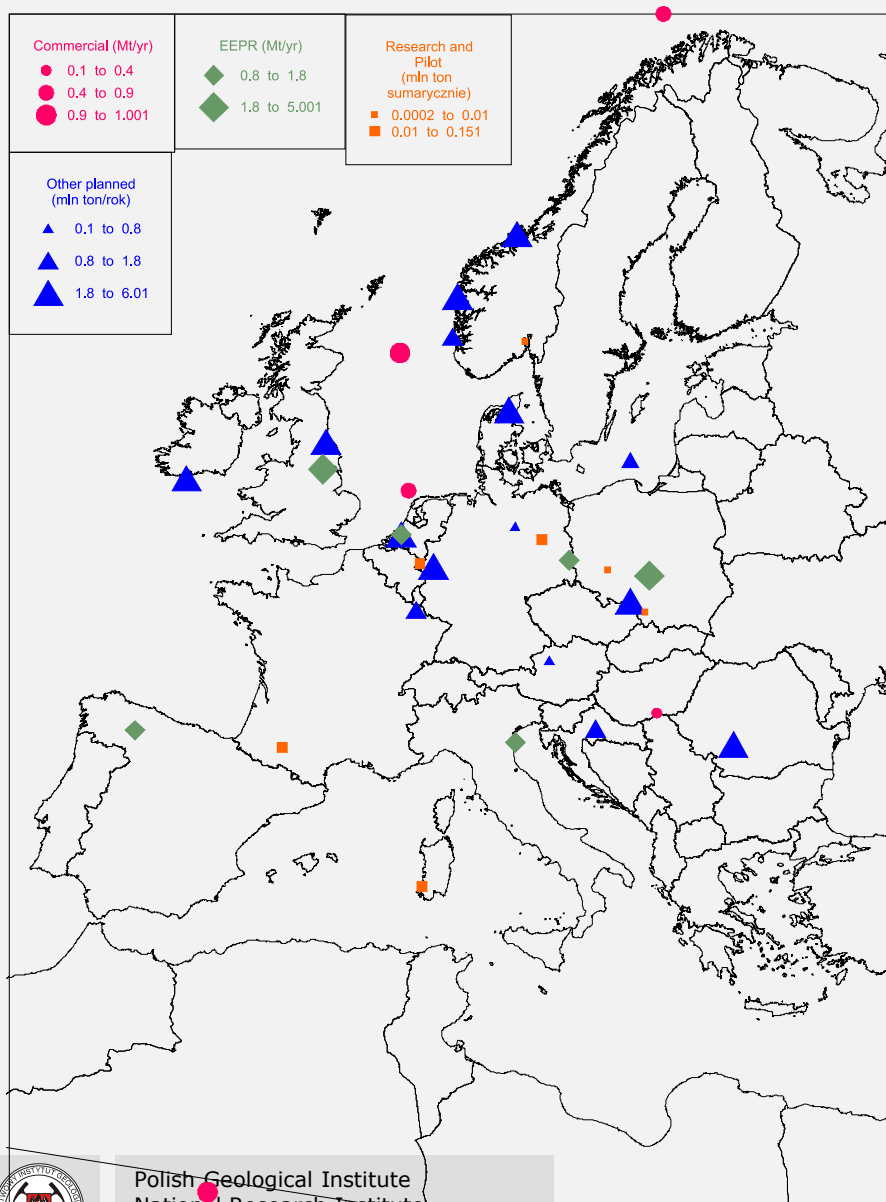


STORAGE POTENTIAL OF POLAND (THE BALTIC BASIN)

**Adam Wójcicki & Jolanta Paczeńska,
PGI-NRI**

..... Espoo, 23.05.2013

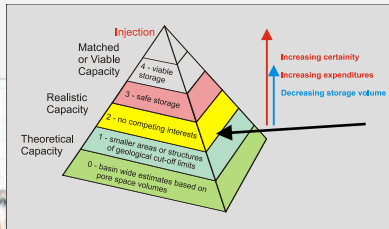
CO2 storage projects – Poland and Europe



- ➔ 1995-.. **Borzęcín** gas field (acidic gas – 60% CO₂; INiG, POGC)
- ➔ 2004-2008 **Kaniów** coal beds (RECOPOL& MoVeCBM; CMI)
- ➔ **Bełchatów** demo CCS project (EPR funding; PGI-NRI involvement; cancelled)
- ➔ Pilot project on injection into Jurassic aquifer (same as for Bełchatów demo site) – research permit granted in 2011
- ➔ **Kędzierzyn** demo CCS project cancelled (to be relocated?)
LOTOS EOR? (ECO₂ project)
- ➔ New power blocks – CCS ready to be proven
- ➔ Regional studies



Estimations of CO2 storage capacity (PL)*



<i>Type</i>	<i>Storage potential, Mt</i>
CASTOR EU GeoCapacity CO2 Atlas of Poland <i>Cr1, J1, T formations (upper limits)</i>	3 752 3 522 8 299 ~90 000
Hydrocarbon fields (31 structures)	764
Coal seams (selected CBM fields at depth of 1-2 km) <i>Coal seams within Polish SCB at depth of 1-2 km</i>	414 1 254
SUM <i>SUM</i>	5-9.5 Gt ~92 Gt

- ➔ Saline (Mezozoic) aquifers are of biggest potential and sufficient to store emissions of big plants,
- ➔ Hydrocarbon fields (mostly gas) are of small capacity,
- ➔ Coal seams (methane recovery) are of local importance (SCB), the technology is not mature yet.



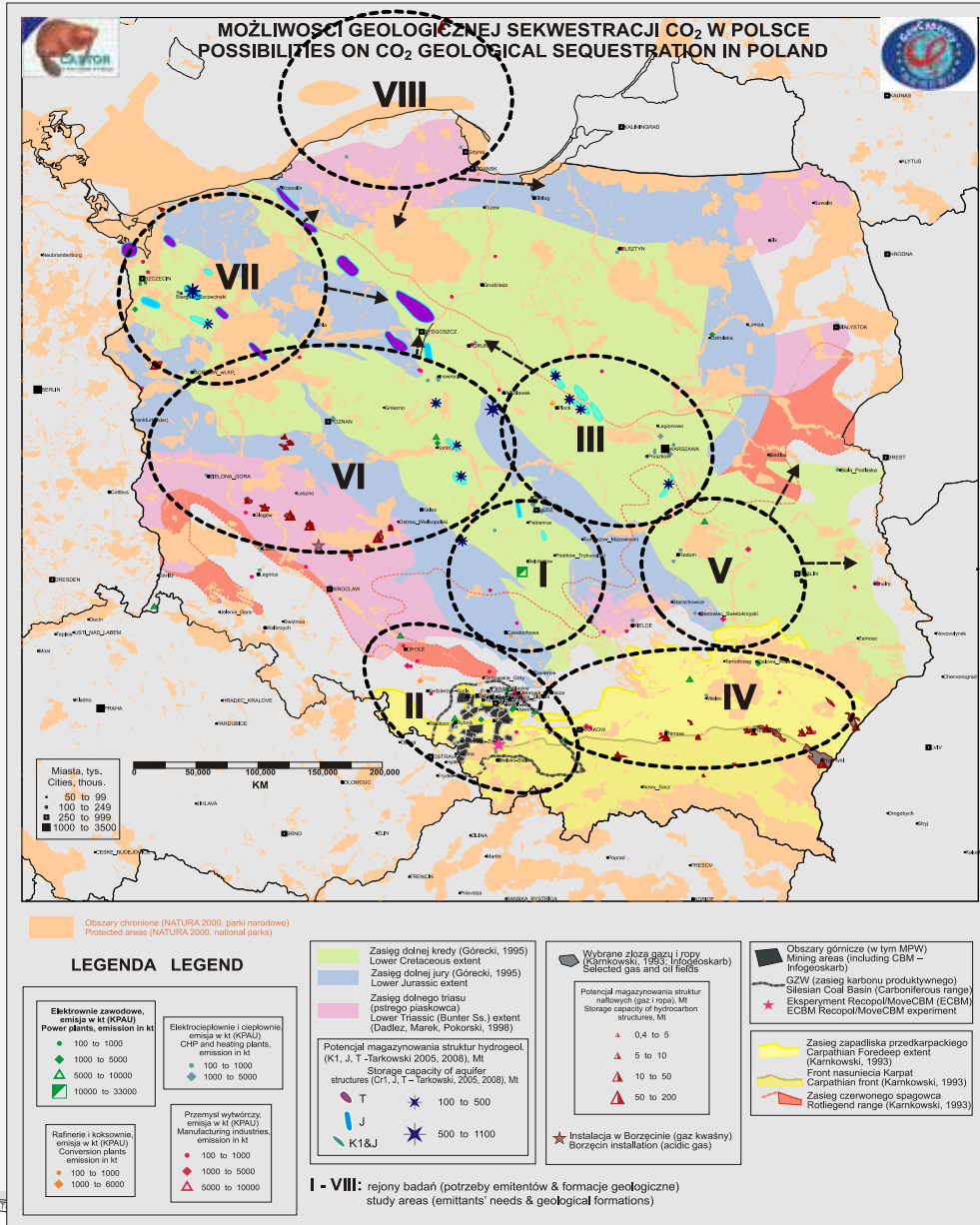
The Programme

„Assessment of formations and structures for safe CO2 geological storage including monitoring plans“;

- Ordered by Ministry of Environment (=the permitting authority of Directive on geological storage of CO2).
- Conducted by 6 national institutions (PGI-NRI – leader, AGH-UST, CMI, MEERI, O&GI, PBG).
- Timeframe: 10.2008-09.2012; ~80 persons involved;
- Goals:
 - Supporting Polish demo projects,
 - Providing the permitting authority with information necessary for implementing CO2 storage,
 - Cooperation with other stakeholders, R&D organizations.



The scope of the programme (geology)



It covers entire territory of Poland and the Baltic economic zone, but is focused on*:

- ➔ regional studies for 8 areas with saline aquifers,
- ➔ hydrocarbon fields and coal beds in general,
- ➔ case studies for saline aquifer structures (4),
- ➔ case studies for hydrocarbon fields (2) and coal beds (1).

reinterpretation of archive data, laboratory analyzes



Site screening/selection criteria (based on CO2STORE guidelines)

- **Seal thickness:** minimum **50 m**, the seal integrity is essential
- **Aquifer depth:** from **800 m** to **2500+ m**
- **Aquifer net thickness:** minimum **20-30 m** (~a single layer)
- **Porosity of the reservoir:** minimum **10%**, preferably **20%**
- **Permeability of the reservoir:** minimum **50-100 mD**
- **Salinity:** minimum **30 g/l**, in case of relic, isolated fluids it might be lower
- **Capillary entry pressure** – is the caprock good enough, impermeable?
- **Information necessary to evaluate the structure against criteria mentioned above**



The regional studies

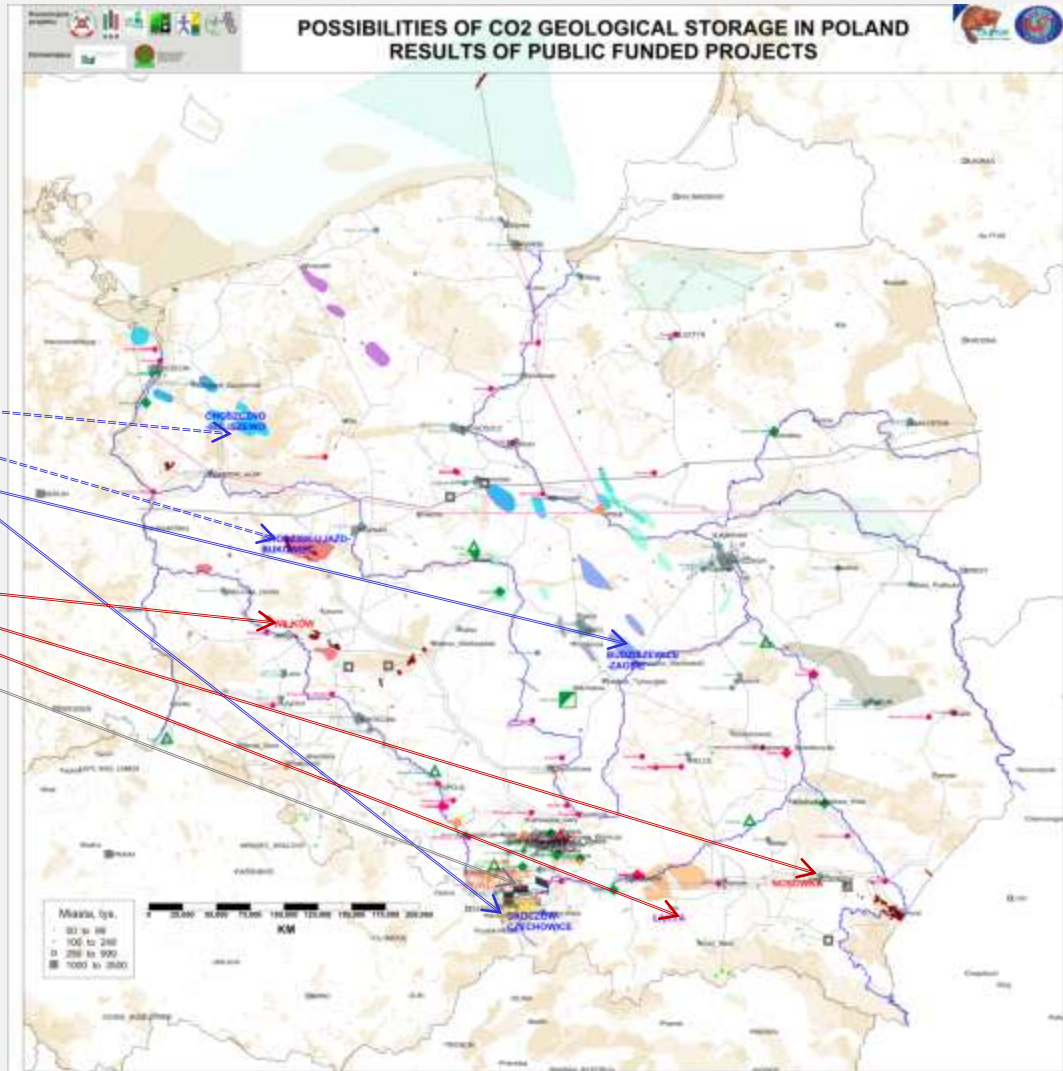
The following geological formations are perspective for the regional study areas of saline aquifers:

- I (central) – Jurassic (J1, J2 sandstones), T;
- II (S) – Lower Miocene;
- III (central-NE) - Jurassic (J1, J2 sandstones), Cr1,T;
- IV (SE) – Carpathian front foredeep (J to Cm basement);
- V (E) – Carboniferous (C3 sandstones), Cm;
- VI (W) – Permian (P1), T, J;
- VII (NW) – Jurassic (J1 sandstones), T3, T1 – a small part offshore;
- VIII (N, incl. offshore area – E part of Polish Baltic economic zone) – Cm2.



The outcome of the programme

- ➔ Regional studies being completed;
- ➔ Case studies (4 structures in saline aquifers, one oil, two gas fields, one CBM area).
- ➔ Estimated realistic/effective storage capacity for Poland is about 15 Gt (saline aquifers >92%, hydrocarbon fields 7%, coal beds <1%); about 94% onshore



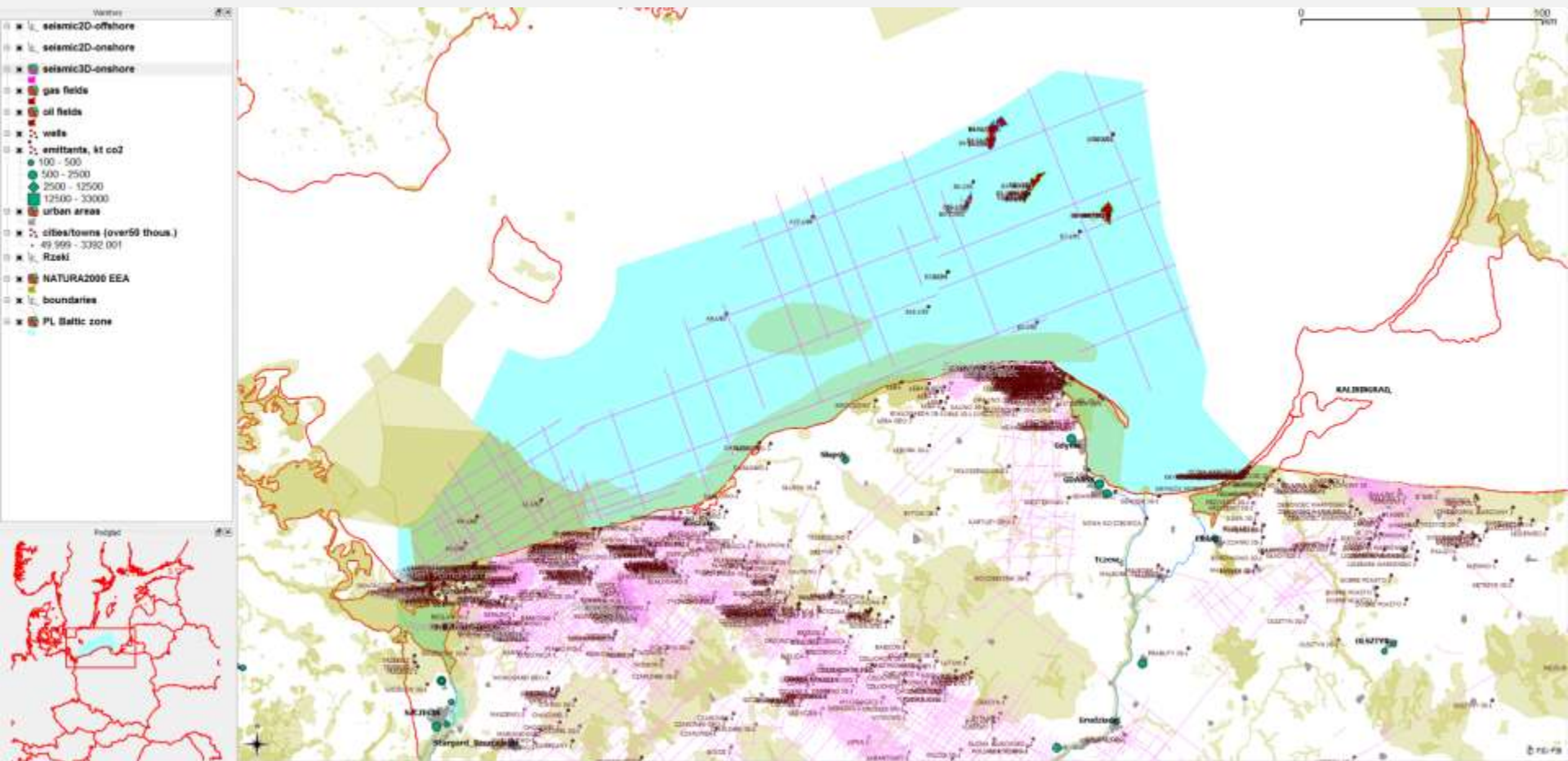
Case studies in saline, aquifers, hydrocarbon fields and coal beds.

LEGEND

<p>Power plants (NATURA 2000, after EEA)</p> <ul style="list-style-type: none"> 100 to 1000 1000 to 10000 10000 to 100000 	<p>CO2 and hydrocarbon fields (NATURA 2000, after EEA)</p> <ul style="list-style-type: none"> 100 to 1000 1000 to 10000 	<p>Structures in saline aquifers of Mesozoic (G1, J2, T1, T2, T3) (potential storage sites)</p> <ul style="list-style-type: none"> Structures (potential storage sites) in saline aquifers in Białystok area Site in Skoczów-Czerwony area and structures in west (Mazowiec) Site on the carpathian front (basement) Lignite perspective area (Carboniferous) 	<p>SALINE AQUIFER STRUCTURES</p> <ul style="list-style-type: none"> Capillary saline aquifers offshore and onshore Structure in Permian (P1/P2/P3) saline aquifer 	<ul style="list-style-type: none"> Deep position Shallow position Water table/ground (oil and gas) storage Selected hydrocarbon fields (potential storage sites) CBM fields (potential storage sites) Storage CO2 capacity (Gt/Gha, 2000)
--	---	---	--	---

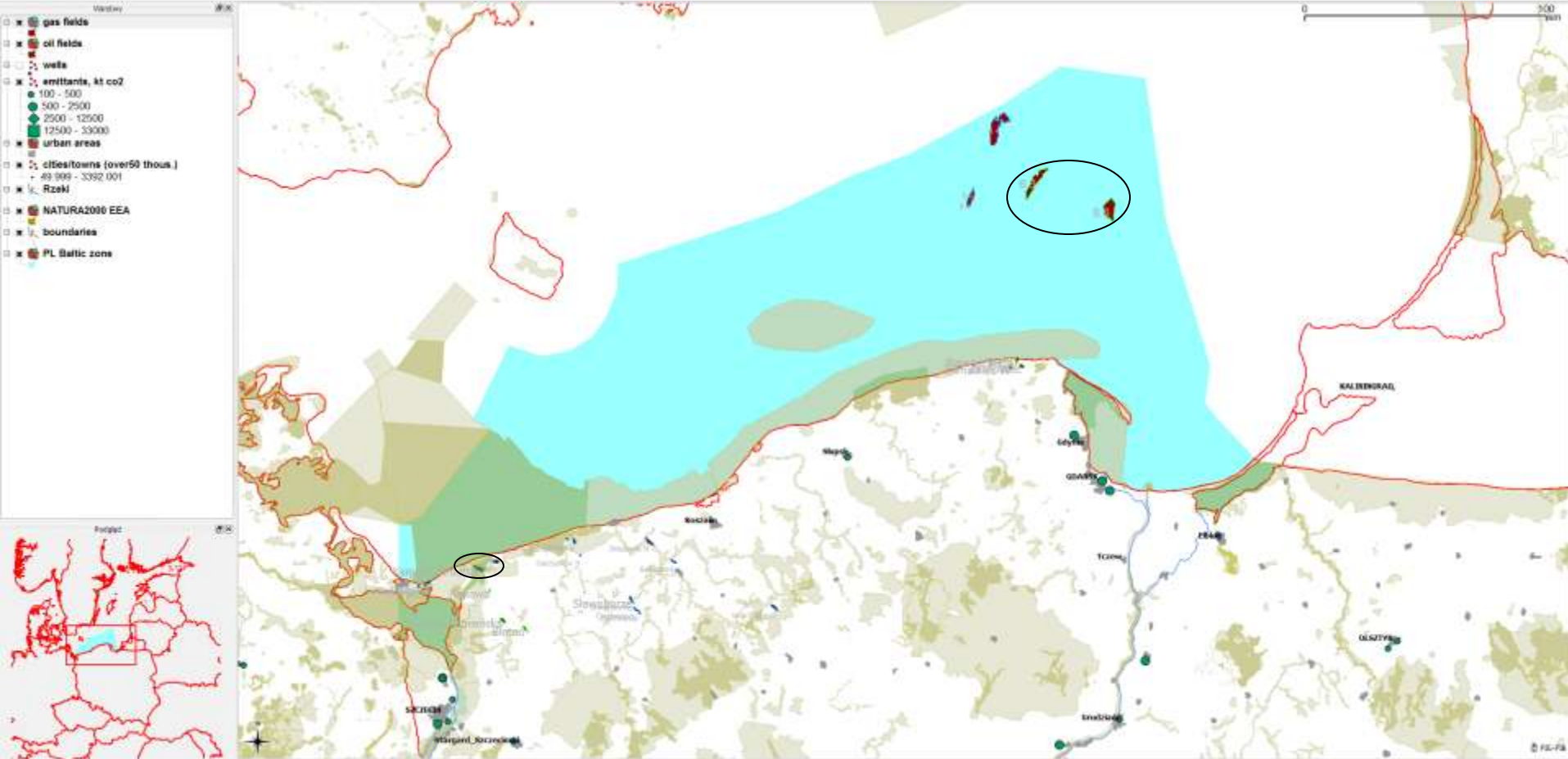


The Baltic basin – data available



The distribution of wells onshore and offshore is uneven, depending on exploration programmes of POGC (onshore) and Petrobaltic (offshore). Same refers to seismic – Petrobaltic lines are mainly of 1980 and 90s (Anolik et al., 2008), POGC onshore of various vintages.

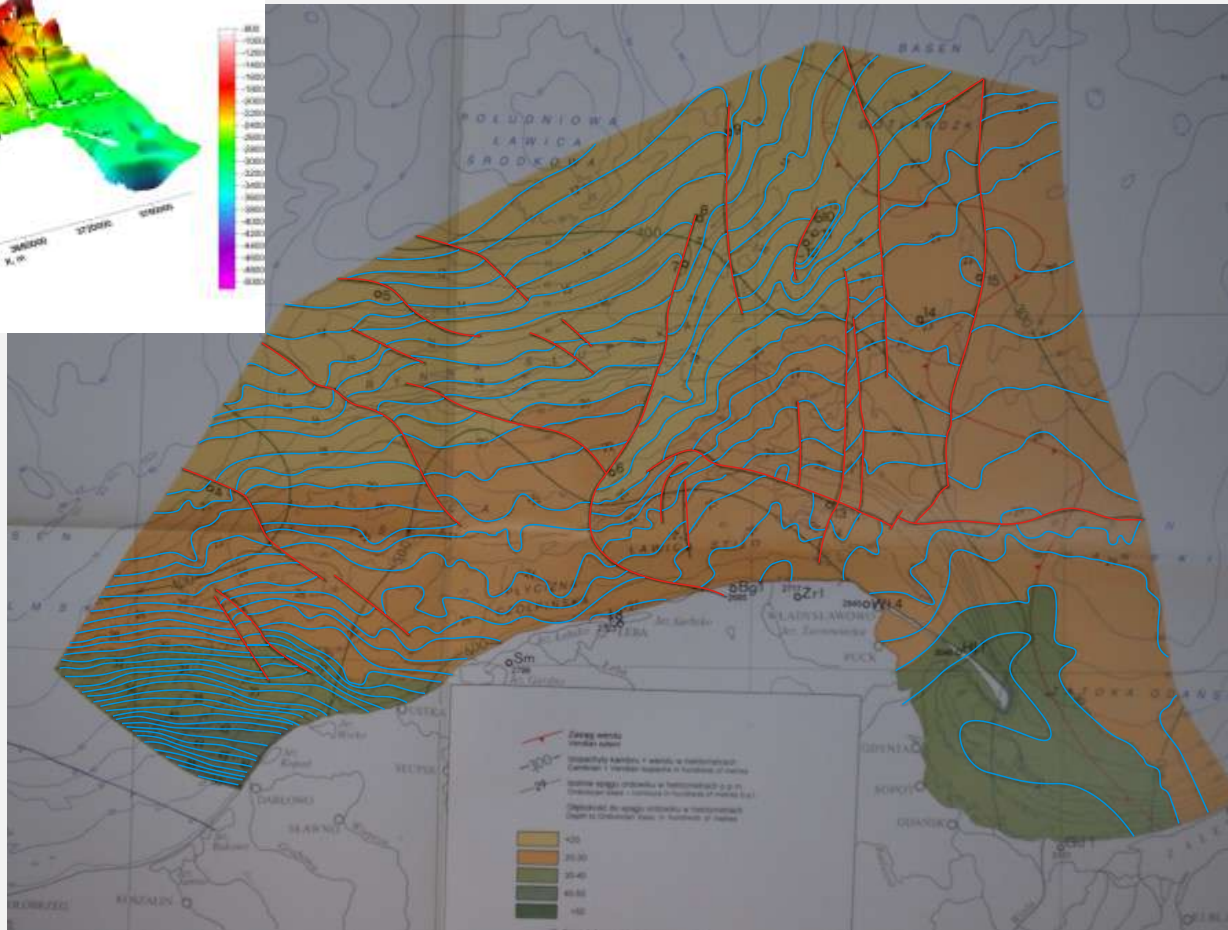
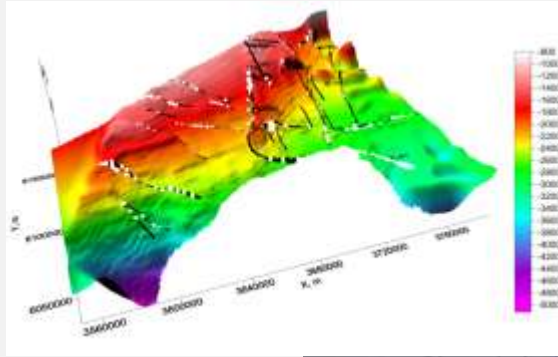
The Baltic basin - hydrocarbons



There are a couple of hydrocarbon fields in Polish part of the Baltic Basin considered as CO₂ storage sites. These are B3 and B8 in NE offshore area and Kamień Pomorski in west. Storage capacities of these fields are of 2-7 Mt. Other fields are smaller and/or not developed yet.



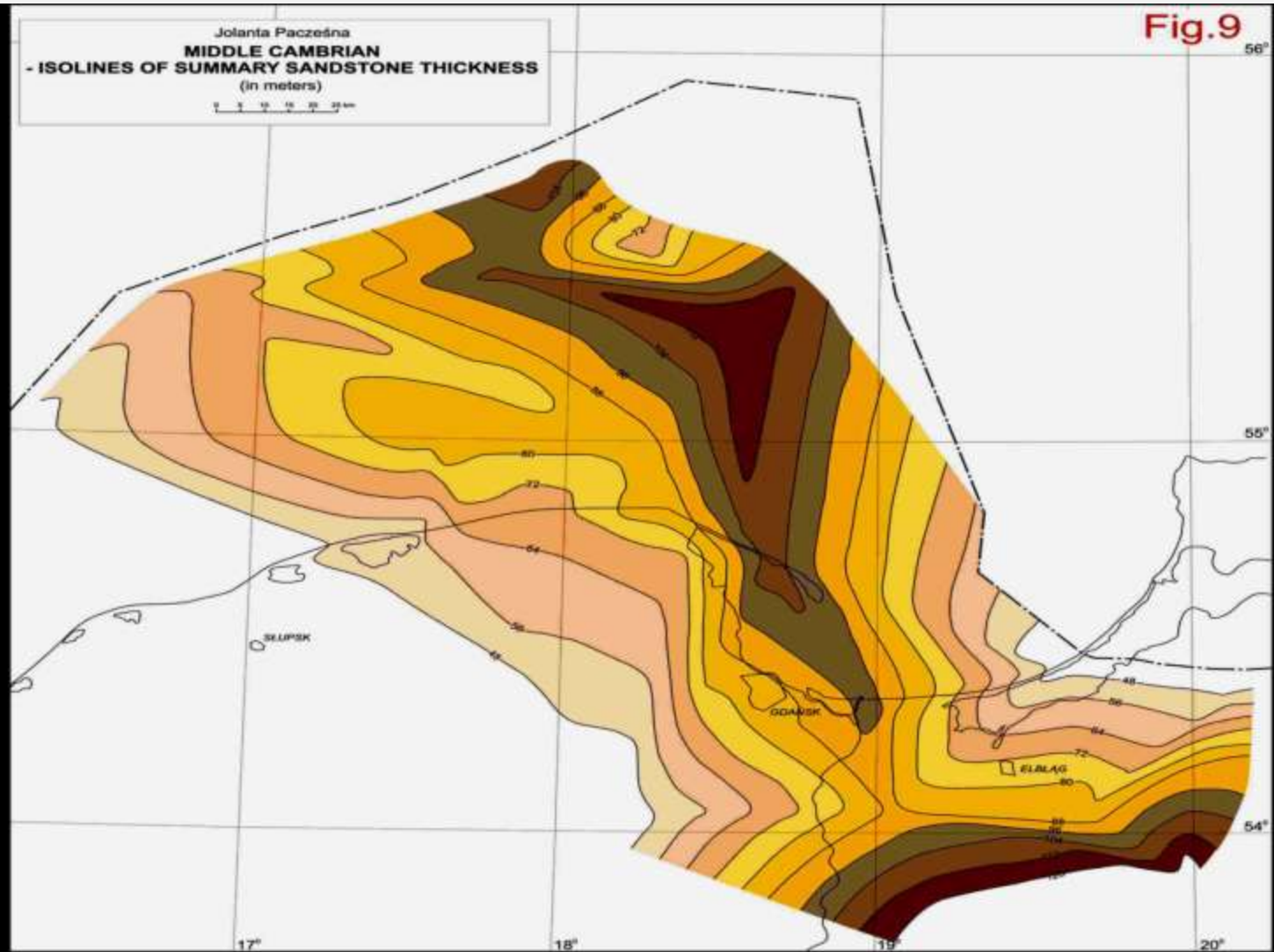
The (available) offshore area



Map of the top of Cambrian/floor of Ordovician. The Cambrian aquifer is secondary to Jurassic onshore, but not so bad within 1,3-2 km depth range (in oil fields in eastern part average porosity is up to 10% and permeability 60-100 mD; some sandstone beds reach 20% porosity) but with compartments. Realistic storage capacity ~ **0.9 Gt** (sweep efficiency 2%).

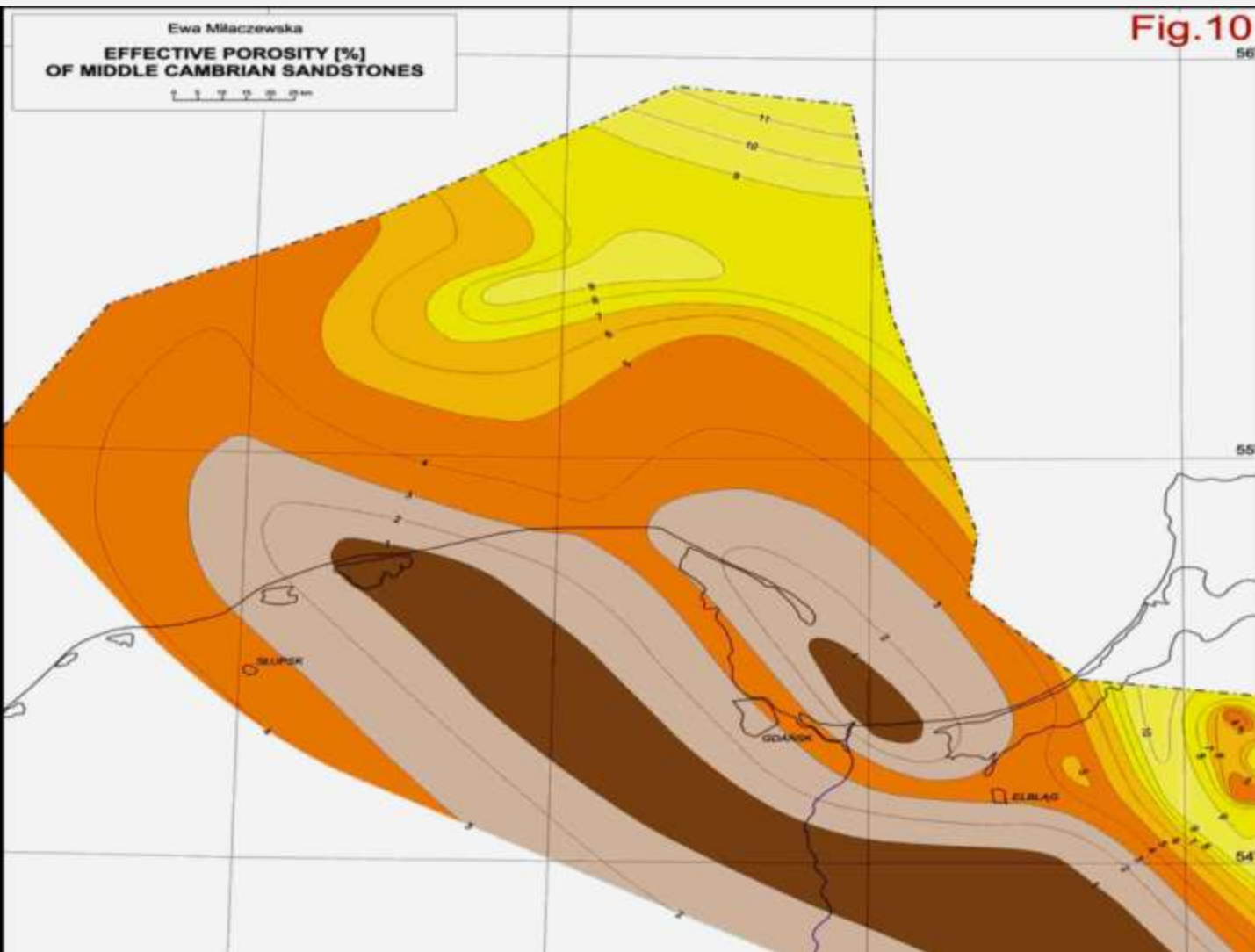


Thickness of the Middle Cambrian aquifer



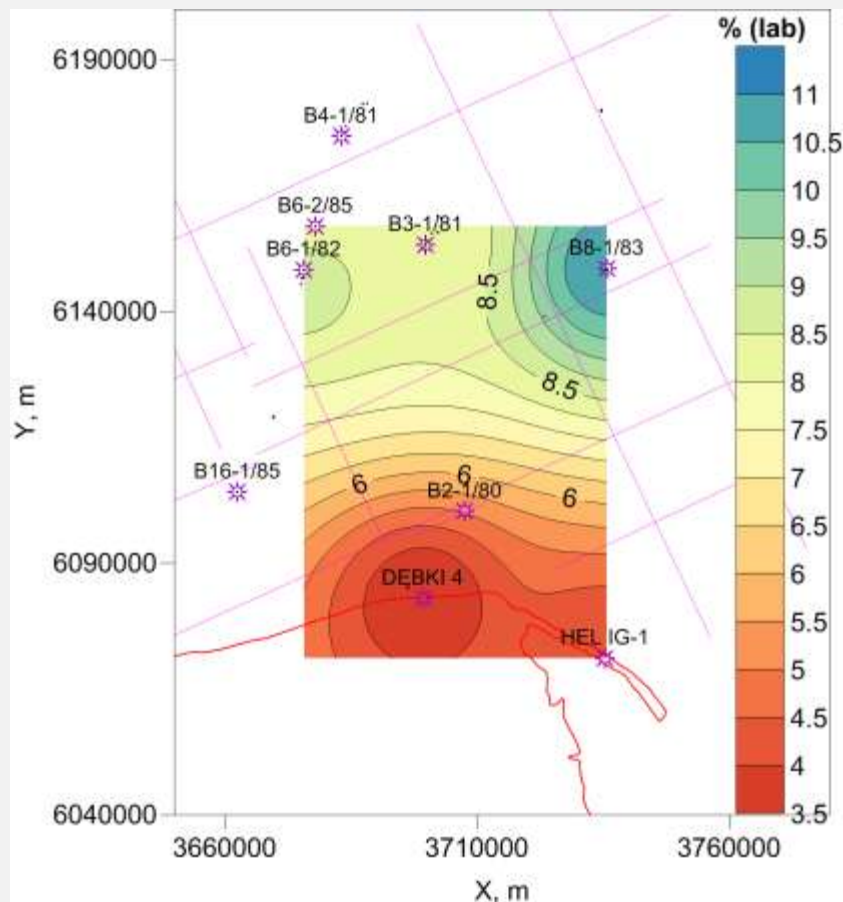
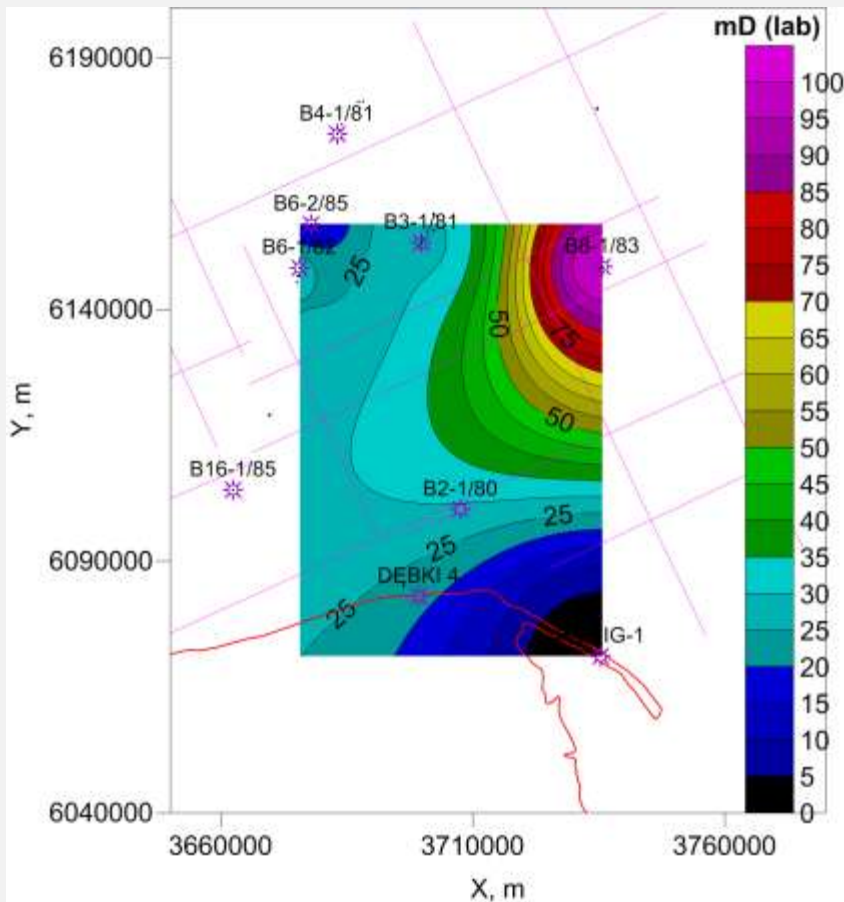
Map of present thickness of the Cambrian aquifer.

Reservoir properties of the Cambrian aquifer



Map of effective porosity of the Cambrian aquifer.

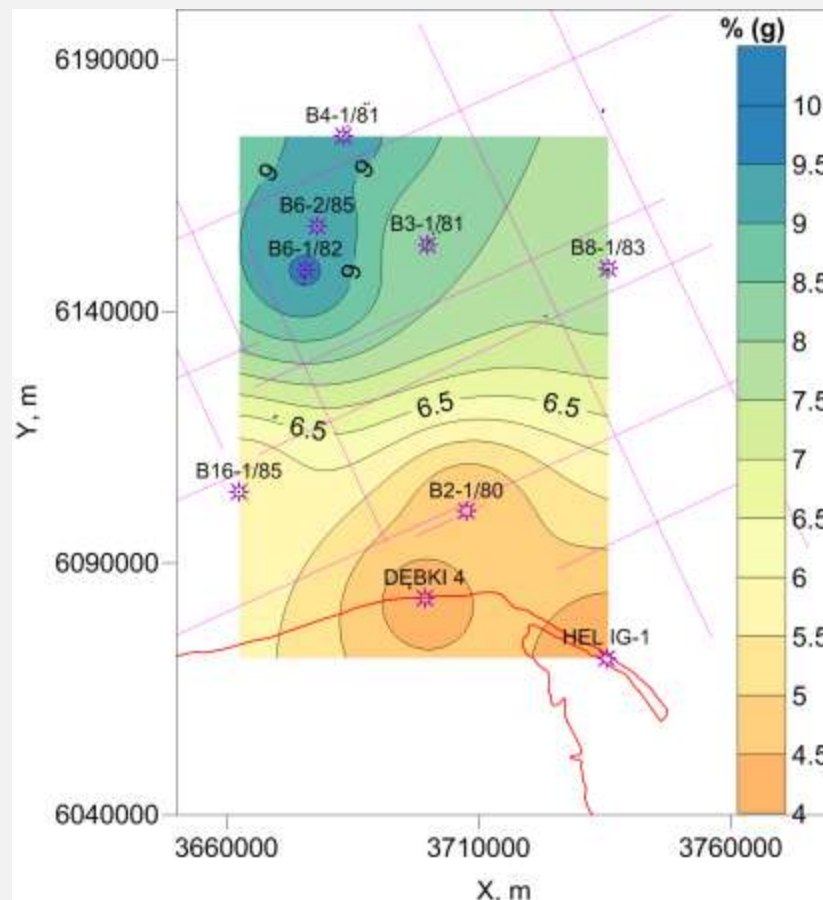
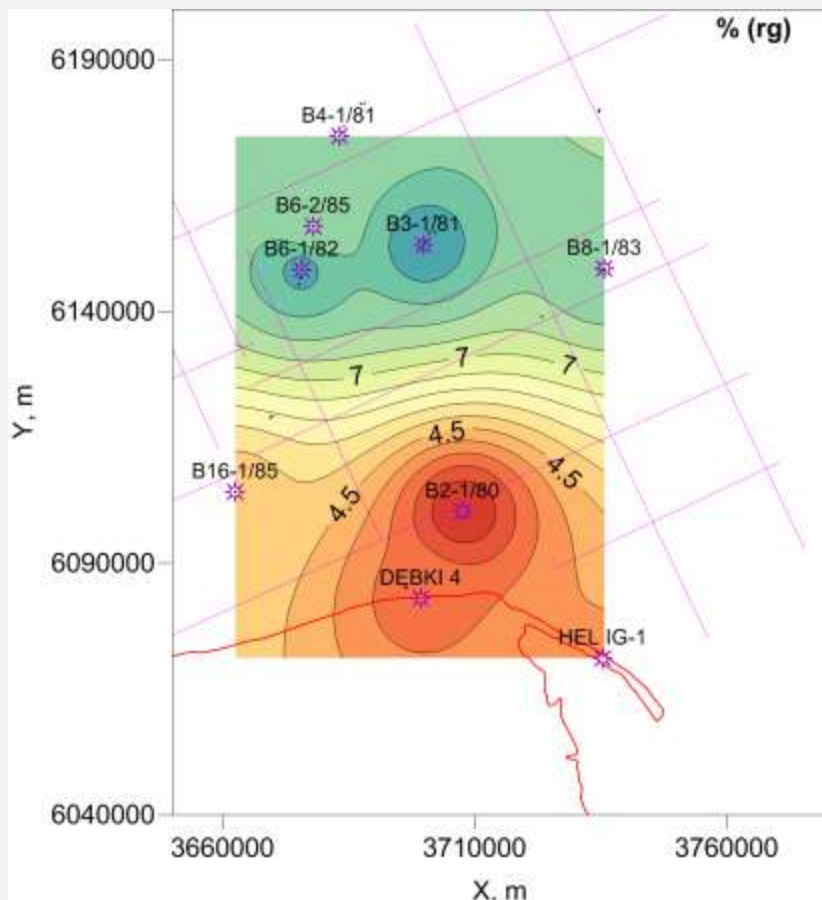
Reservoir properties of the Cambrian aquifer



Maps of permeability and effective porosity of the Cambrian aquifer after laboratory measurements.



Reservoir properties of the Cambrian aquifer

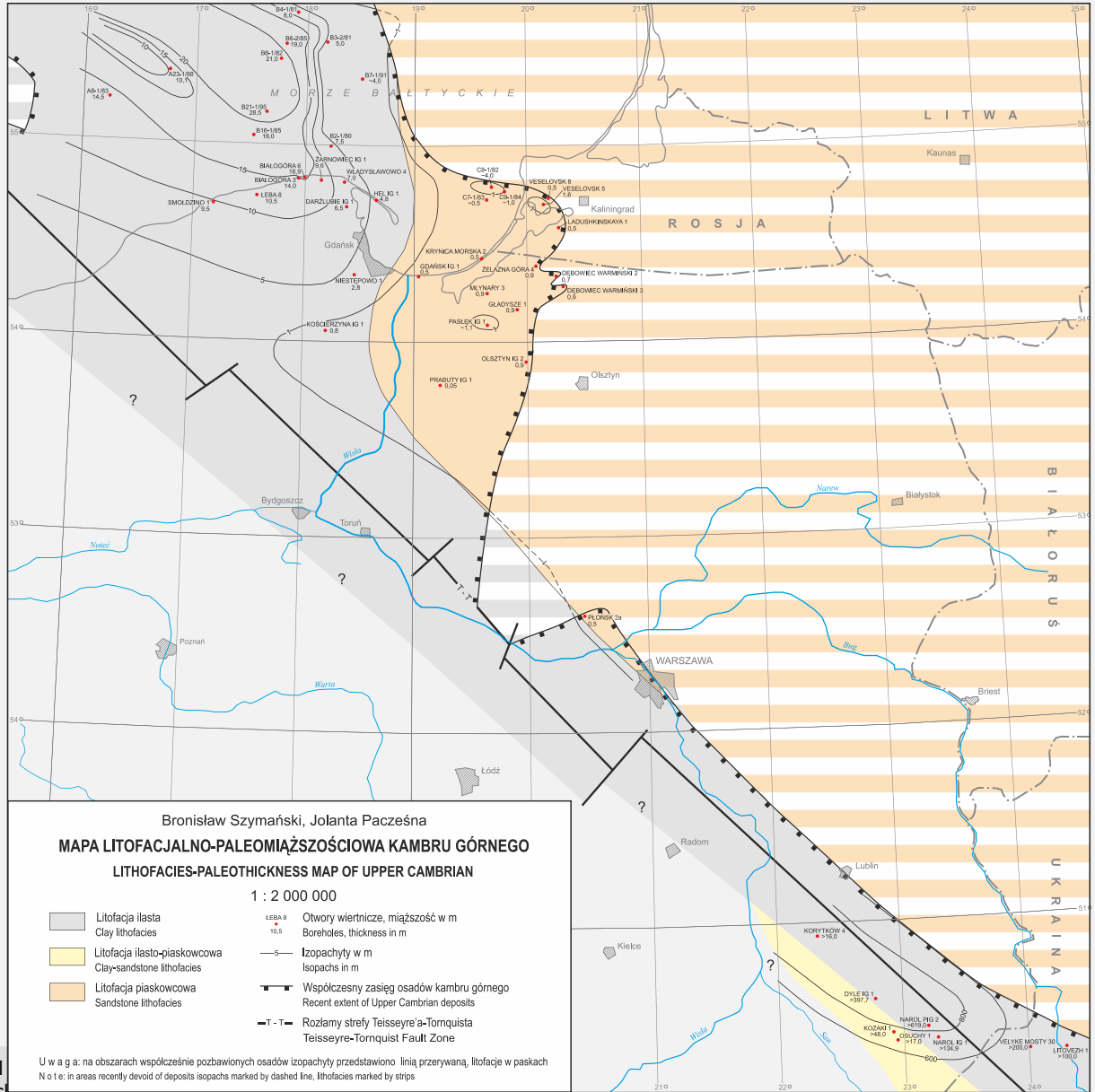


Maps of porosity of the Cambrian aquifer after laboratory measurements of gas&oil and gas filtration space (AGH – archive report).



The regional seal – Upper Cambrian (of insufficient thickness)

Tablica 5
Plate 5



Bronisław Szymański, Jolanta Paczeńska

MAPA LITOFACJALNO-PALEOMIĄSZOŚCIOWA KAMBRU GÓRNEGO
LITHOFACIES-PALEOTHICKNESS MAP OF UPPER CAMBRIAN

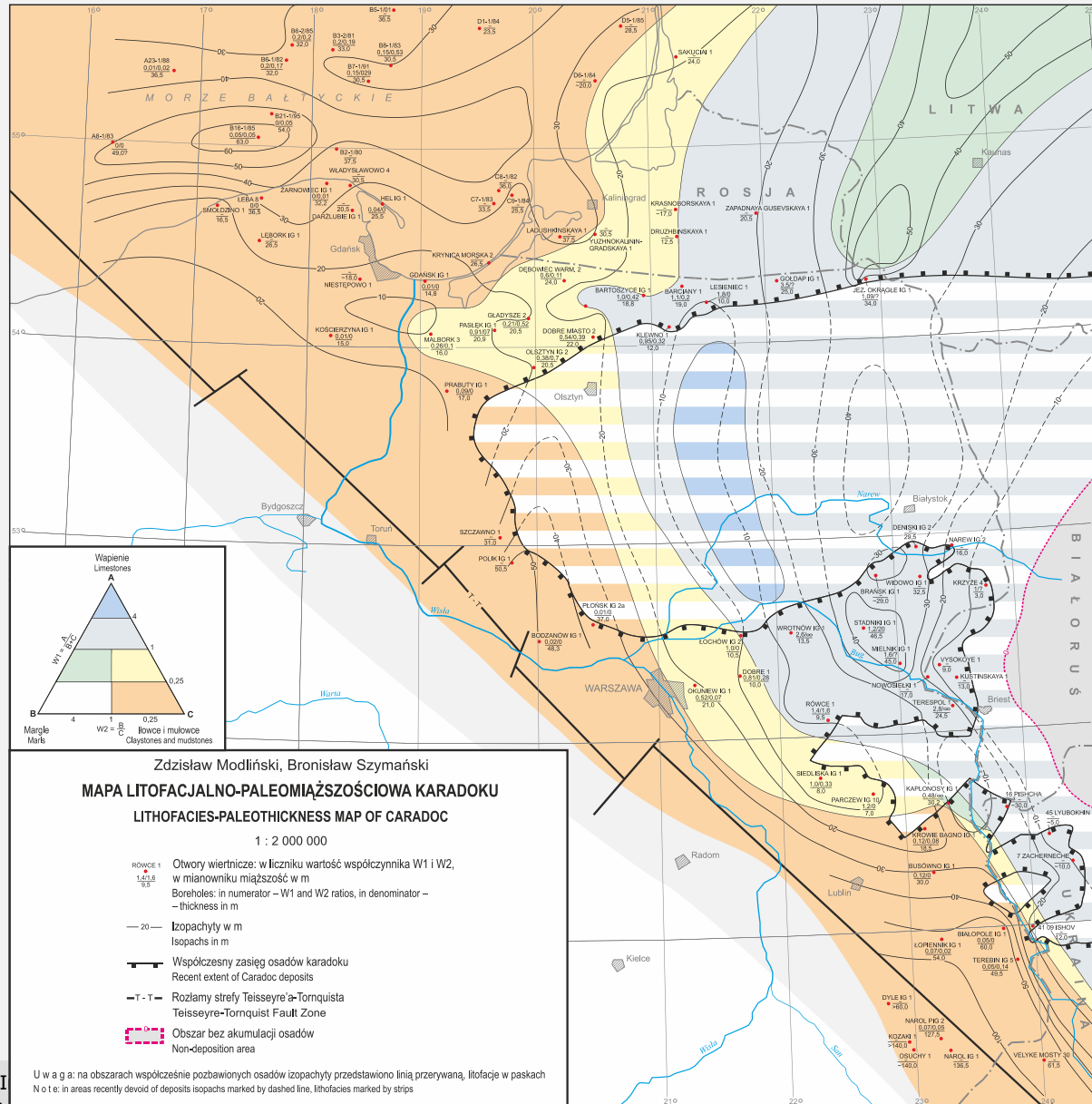
1 : 2 000 000

	Litofacja ilasta	LEBA 8	Otworki wiertnicze, miąższość w m
	Litofacja ilasto-piaskowcowa	10,5	Boreholes, thickness in m
	Litofacja piaskowcowa	—	Izopachy w m
	Sandstone lithofacies	—	Isopachs in m
			Współczesny zasięg osadów kambru górnego
			Recent extent of Upper Cambrian deposits
			Rozłamy strefy Teisseyre'a-Tornquista
			Teisseyre-Tornquist Fault Zone

U w a g a: na obszarach współcześnie pozbawionych osadów izopachy przedstawiono linią przerywaną, litofacje w paskach
 Note: in areas recently devoid of deposits isopachs marked by dashed line, lithofacies marked by strips

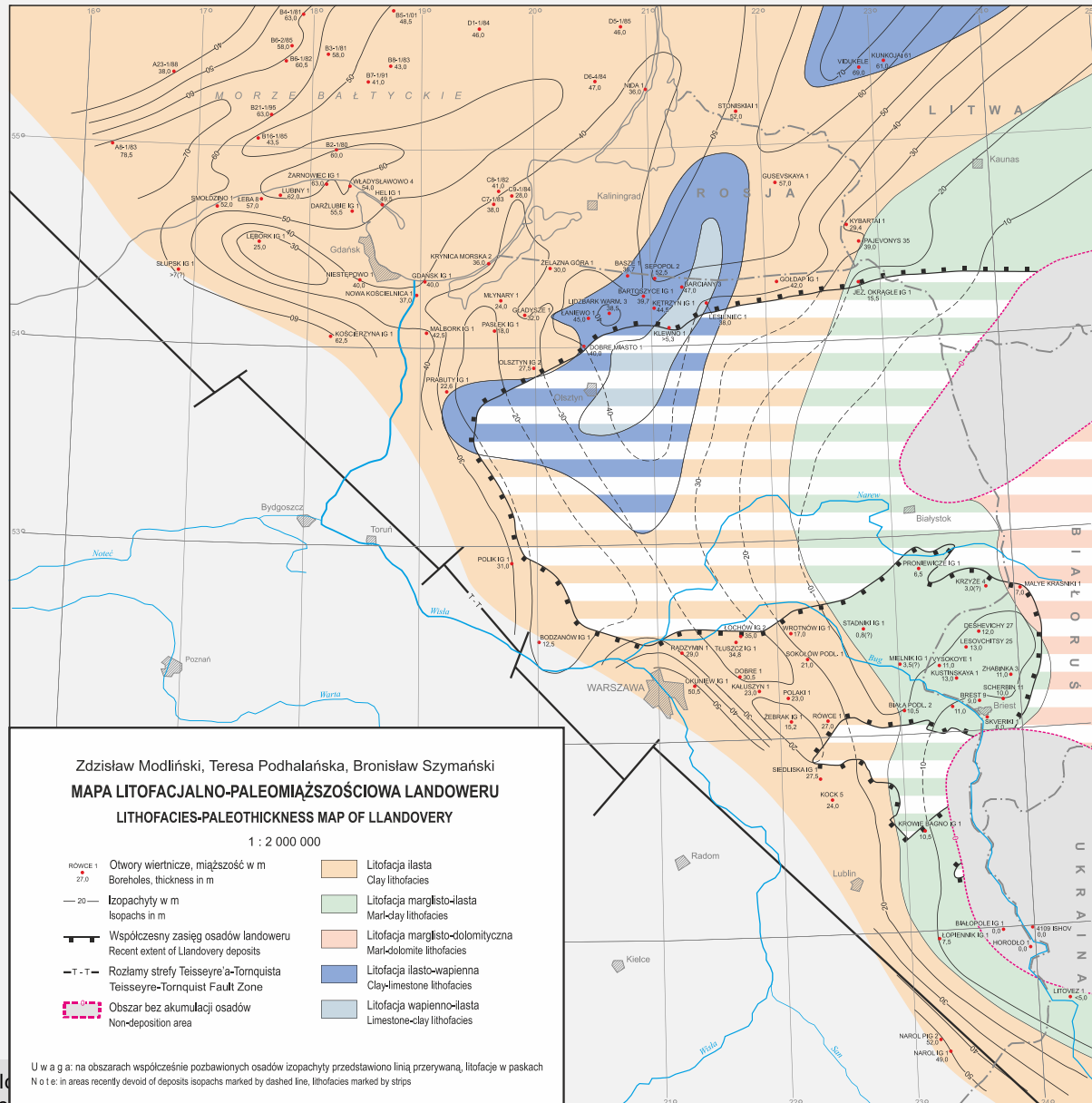


The regional seal – Caradoc (of sufficient thickness)



The regional seal – Llandovery (of sufficient thickness)

Tablica
Plate 11



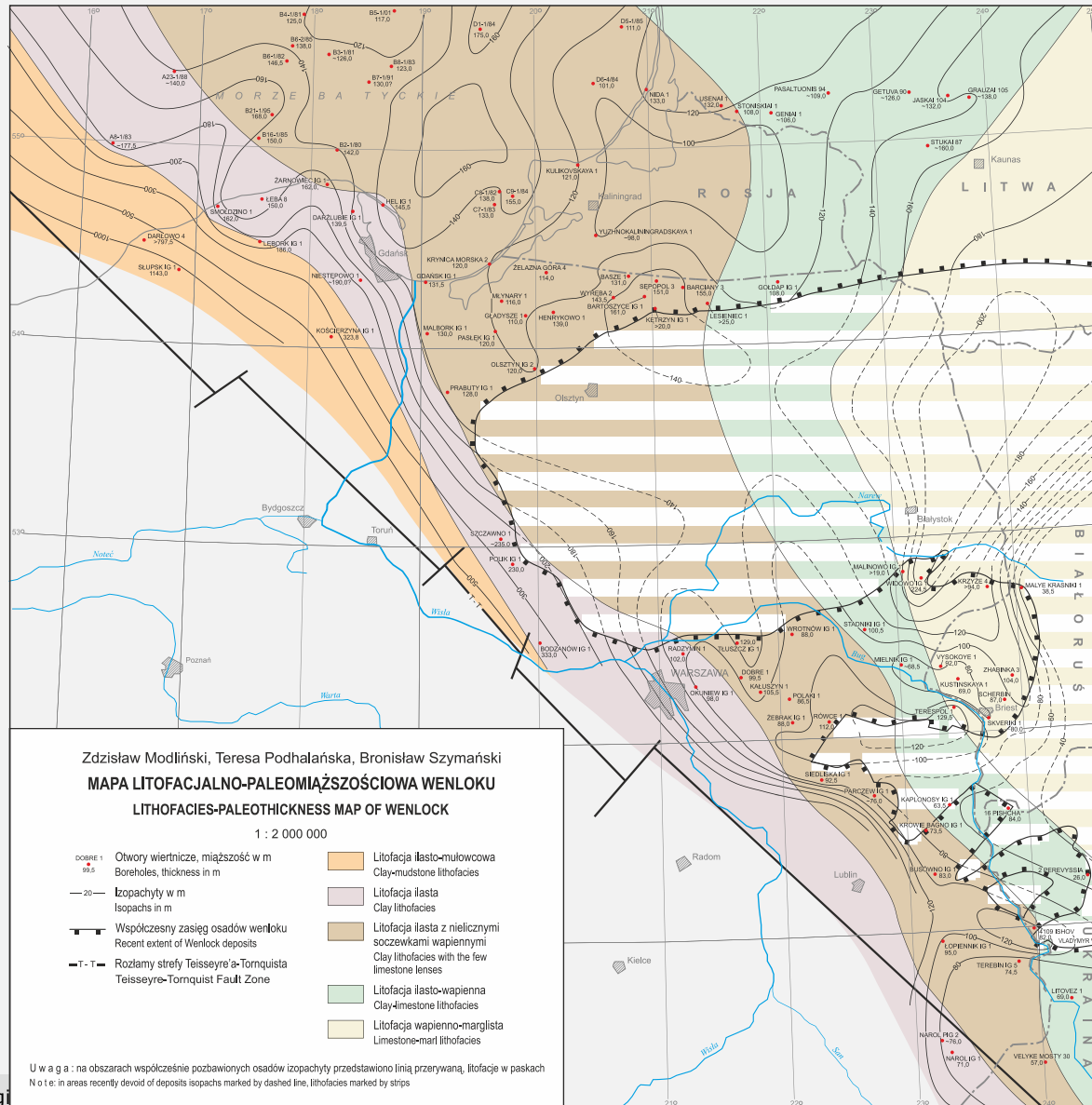
Polish Geological Institute
 National Research Institute

Redaktorzy wydawnictwa: Janina Małecka, Andrzej Szewczyk

© Copyright by Państwowy Instytut Geologiczny—Państwowy Instytut Badawczy, Warszawa 2010

The regional seal – Wenlock (of sufficient thickness)

Tablica 12
Plate



Polish Geological
National Research Institute

www.pgi.gov.pl

Conclusions

Studies of the National Programme and other projects can provide the following conclusions on Polish part of Baltic basin:

- In area VII (NW Poland) structures in Jurassic and Triassic aquifers make up about 3 Gt capacity. Offshore part of VII is small and excluded because of NATURA2000.
- In area VIII Cambrian aquifer is perspective, both offshore and onshore. Offshore area has in average a relatively poor reservoir properties (though there are hydrocarbon fields) and capacity 0.9 Gt, onshore part south of Russian border has far better properties but the area is smaller, so its capacity is similar, of at least 0.8 Gt.



Conclusions

Studies of the National Programme and other projects can provide the following additional conclusions on the selected area of Polish economic zone of Baltic:

- Offshore data (wells, seismic) are of LOTOS-Petrobaltic but those older than 1989/90 are state owned – in both cases approval of respective owners is needed to use data in new projects.
- Caprock includes Upper Ordovician claystones of sufficient thickness (~50 m) and a far thicker Silurian complex (minimum 150 m) but O3/S1 formations are perspective for unconventional hydrocarbon resources.



The new project (for Ministry of Environment)

„A detailed assessment of areas perspective for CO2 storage on the area of Polish economic zone of Baltic Sea”(2014-2016)

The Workpackages of the project:

- Data acquisition, database construction;
- Static (structural-parametric) models of the storage complex (including analyzes of rock samples);
- Dynamic simulations for the storage sites;
- Risk identification and risk management plans;
- Monitoring programme for the storage sites;
- A prefeasibility study for the storage sites;
- Coordination, information strategies, dissemination of results.





Thank you for your attention:

www.pgi.gov.pl



Polish Geological Institute
National Research Institute

www.pgi.gov.pl