



February 5-8, 2013
Houston

Lower Paleozoic Shale Gas Resources of Poland - Perspectives and Challenges

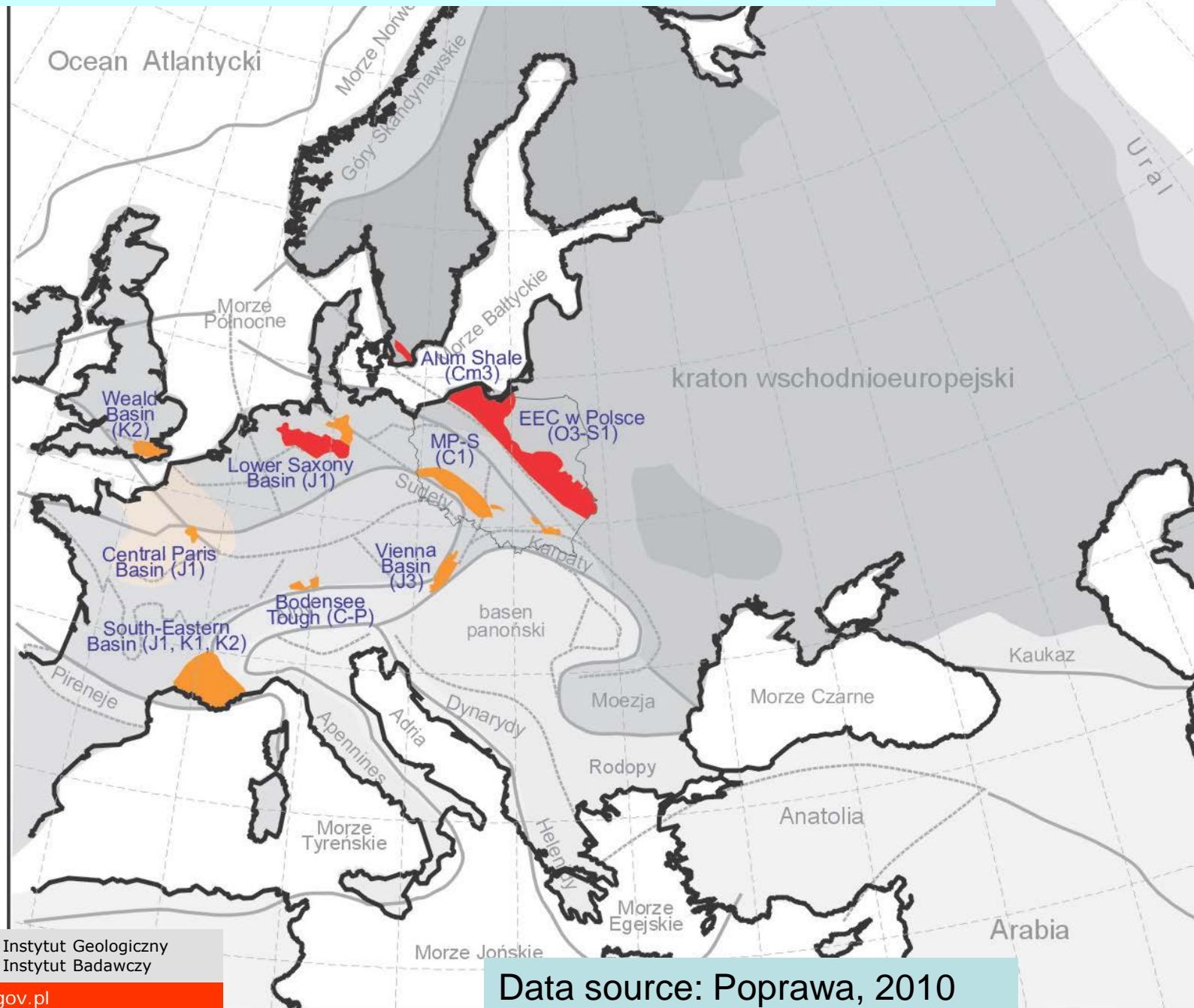
Compilation by Hubert Kiersnowski, PIG – PIB

PSG

POLISH GEOLOGICAL SURVEY

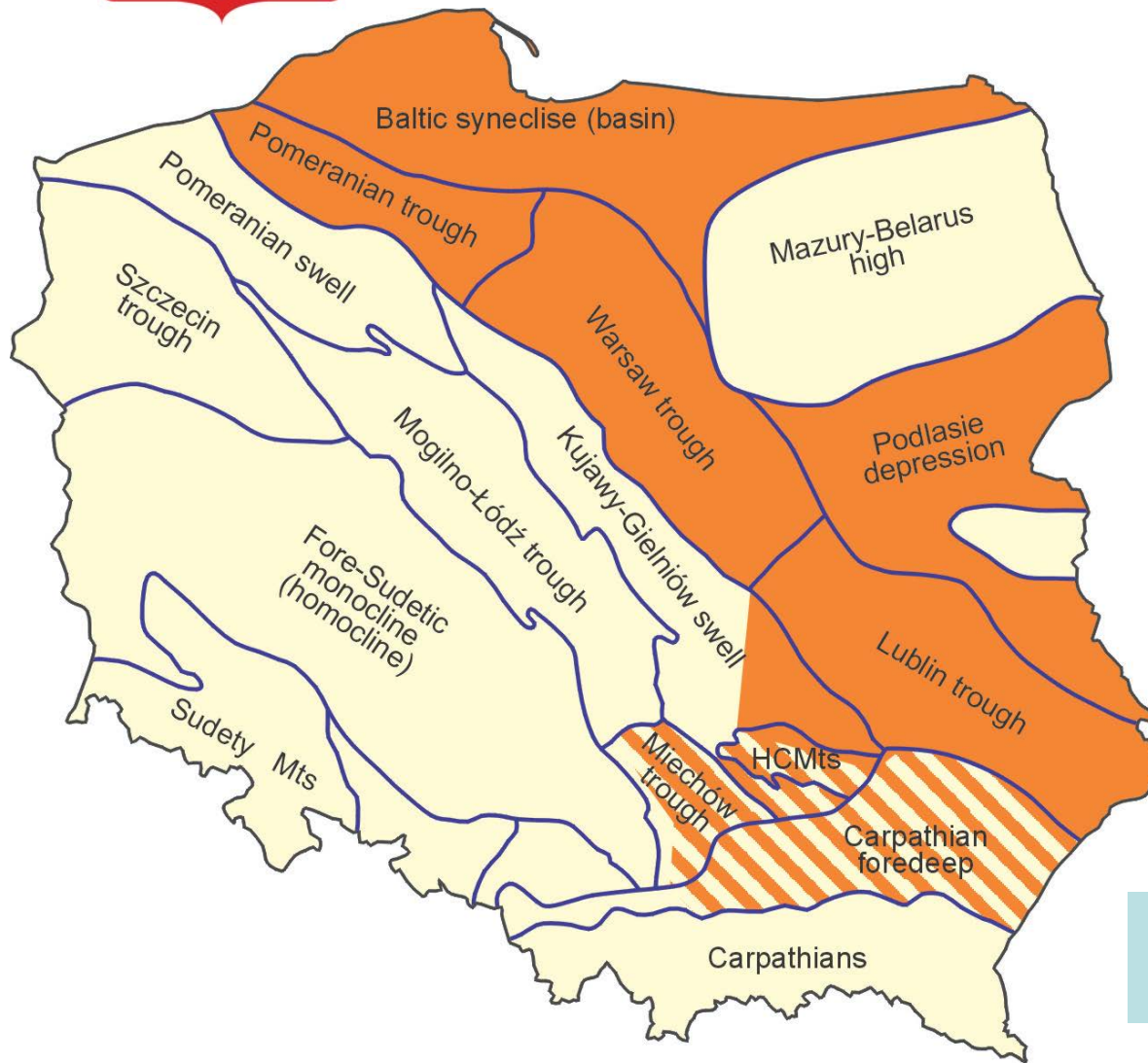


Gas in shales in European sedimentary basins





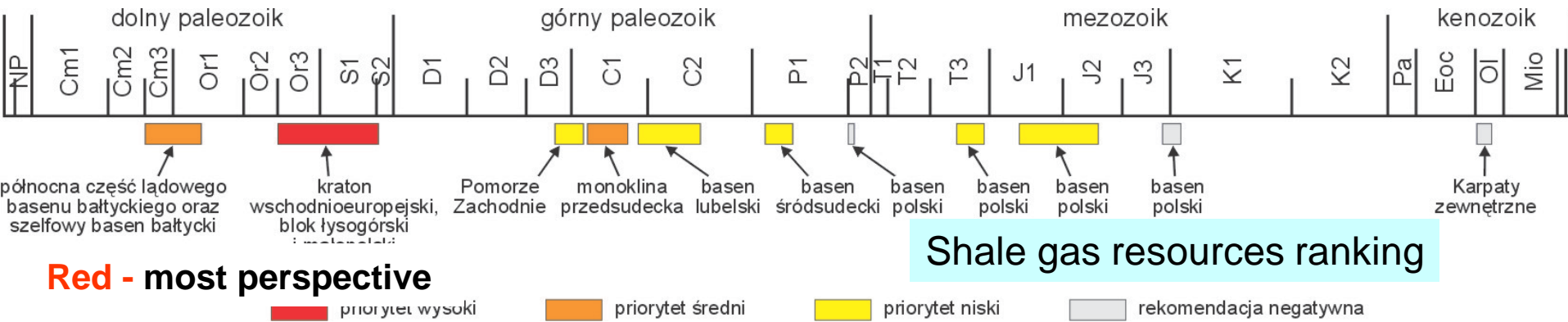
Poland – „unconventional” member of European Union with high potential of unconventional gas resources



O – S shales
geographical
localization

Data source:
Poprawa, Kiersnowski, 2010

Apart from Ordovician and Silurian shale resources, other shale horizons are considering as perspective



Shale gas (shale oil?) – **Upper Ordovician, Silurian**,
 Upper Cambrian? , Upper Devonian ?, Carboniferous?
 and Lower Oligocen, Jurassic – Lowermost Cretaceous?,
 Upper Triassic – Rethian?

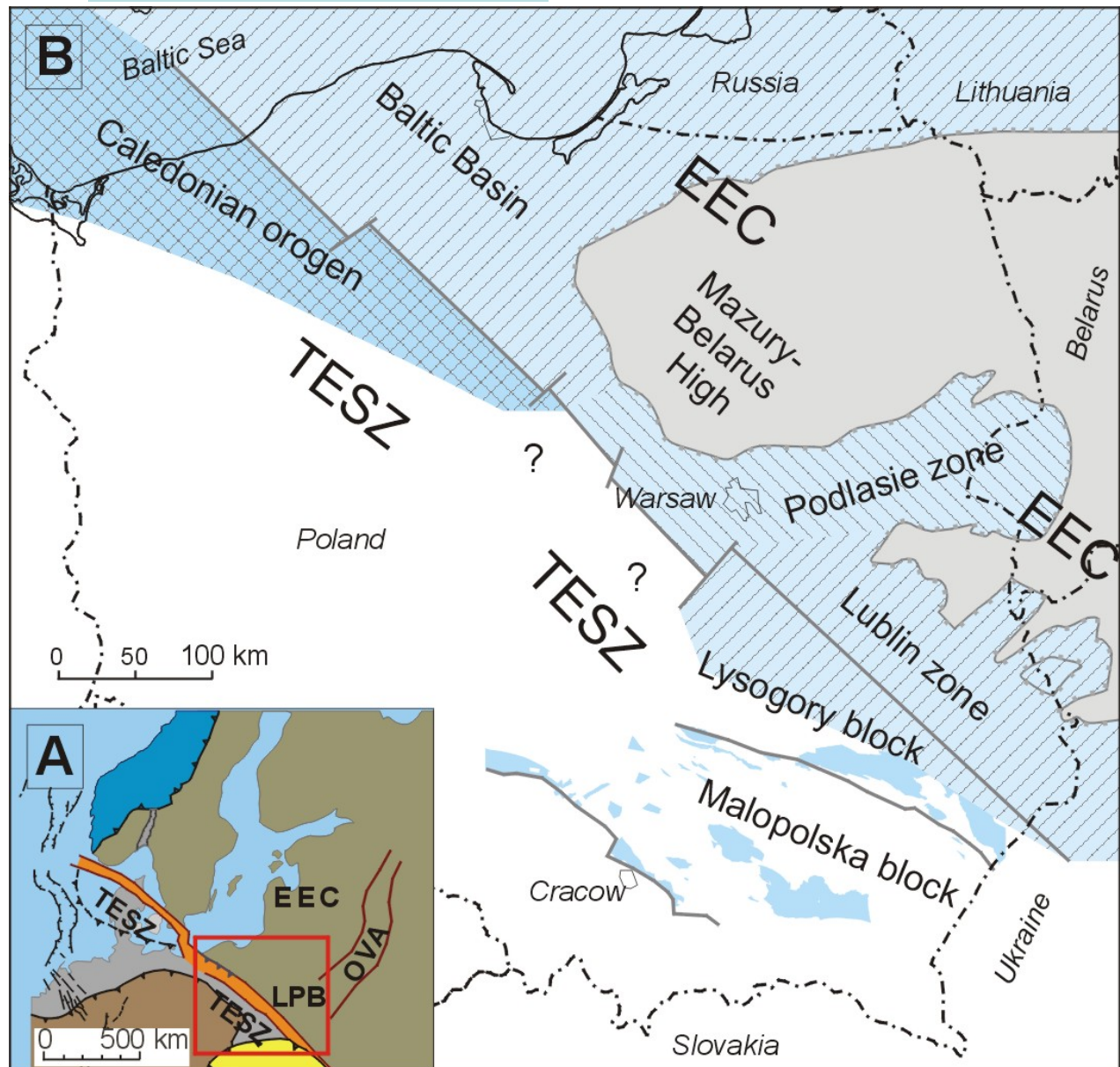




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SHALE GAS

Ordovician and
Silurian
sedimentary
basins in Poland
with high potential
of shale gas
occurrences



after P. POPRAWA



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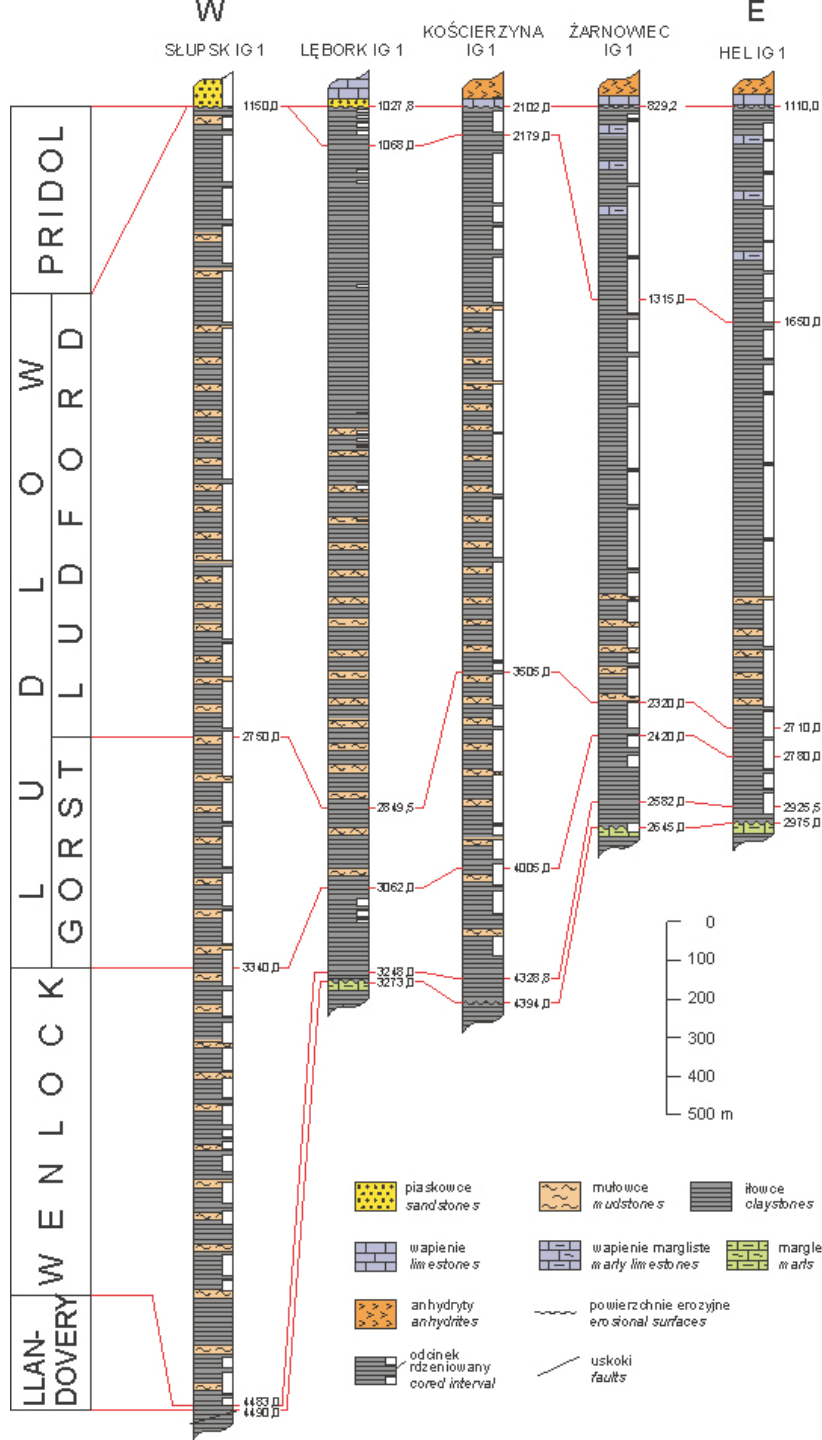


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STRATIGRAPHY AND LITHOLOGY

Occurrence of **dark shales** in the **Silurian** of selected sections of the northern Poland
(after Podhalańska, Modliński, 2006)

Huge shale thickness (in some cases over 3000 m), but only selected units has promising potential



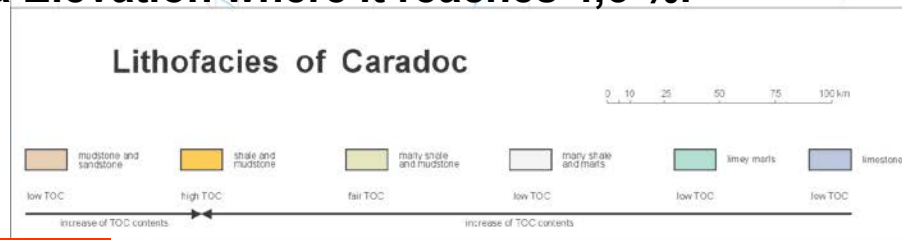


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Thickness of the Upper Ordovician shale increases from the east towards the west and north-west: in the Baltic Basin onshore from 3,5 m to 37 m and offshore from 26,5 m to 70 m (Modliński & Szymański, 1997), while in the Podlasie Depression and the basement of Płock-Warszawa Trough from 1,5 m to 52 m (Modliński & Szymański, 2008).

Upper Ordovician (Caradoc) Lithofacies – north-east Poland and southern Baltic Sea

In the central part of the Baltic Basin for the individual wells **the average TOC contents** of this shale formation ranges from 1 % to 3 % (Poprawa, 2010b; Kowalski et al., 2010). In the western and central part of the Podlasie Depression the average TOC contents of the Upper Ordovician shale is equal to 1 % to 1,25 %, while in the basement of Płock-Warszawa Trough it ranges between 2,1 to 3,76 % TOC. In the Lublin region the average TOC of these sediments is lower than 1%. The average TOC contents of the Ashgill deposits usually is below 0,5 %, except of the Łeba Elevation where it reaches 4,5 %.



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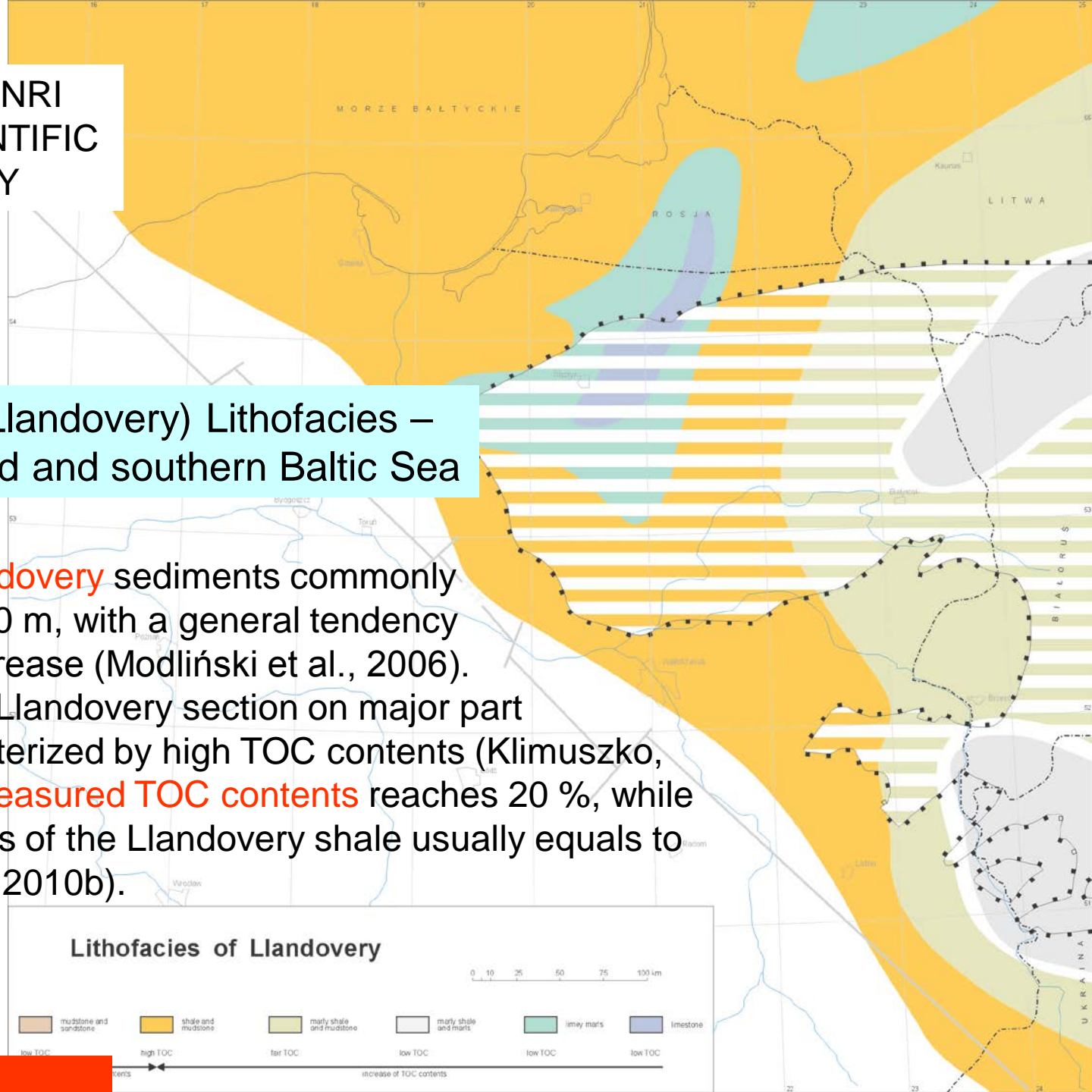




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Lower Silurian (Llandovery) Lithofacies – north-east Poland and southern Baltic Sea

Thickness of the Llandovery sediments commonly ranges between 20-70 m, with a general tendency for the westwards increase (Modliński et al., 2006). The lower part of the Llandovery section on major part of the basin is characterized by high TOC contents (Klimuszko, 2002). The highest **measured TOC contents** reaches 20 %, while average TOC contents of the Llandovery shale usually equals to 1 % to 3% (Poprawa, 2010b).



Lithofacies of Llandovery



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









Perspective areas of Lower Palaeozoic Dark Shales from the East European Craton in Poland



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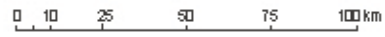
Thickness of the Wenlock section is significantly varies laterally from less than 100 m in the eastern part of the Podlasie Depression (SE) and Lublin region, to more than 1000 m in the western part of the Baltic Basin (NW).

-  Clay-silt lithofacies
-  Clay lithofacies
-  Clay lithofacies with sparse limestone interbeds and lenses
-  Clay-limestone lithofacies
-  Limestone-marly lithofacies
-  Wenlock isopachs
-  Wenlock recent extent
-  Teisseyre-Tornquist zone deep fractures

Average TOC contents in a range of 1 % to 2 % are characteristic to the Wenlock sediments in the eastern Baltic Basin, as well as in a part of Podlasie/Depression and Lublin region. In a remaining part of the discussed area average TOC contents of the Wenlock is less than 1 %.

Wenlock lithofacies and thickness map

after P. POPRAWA

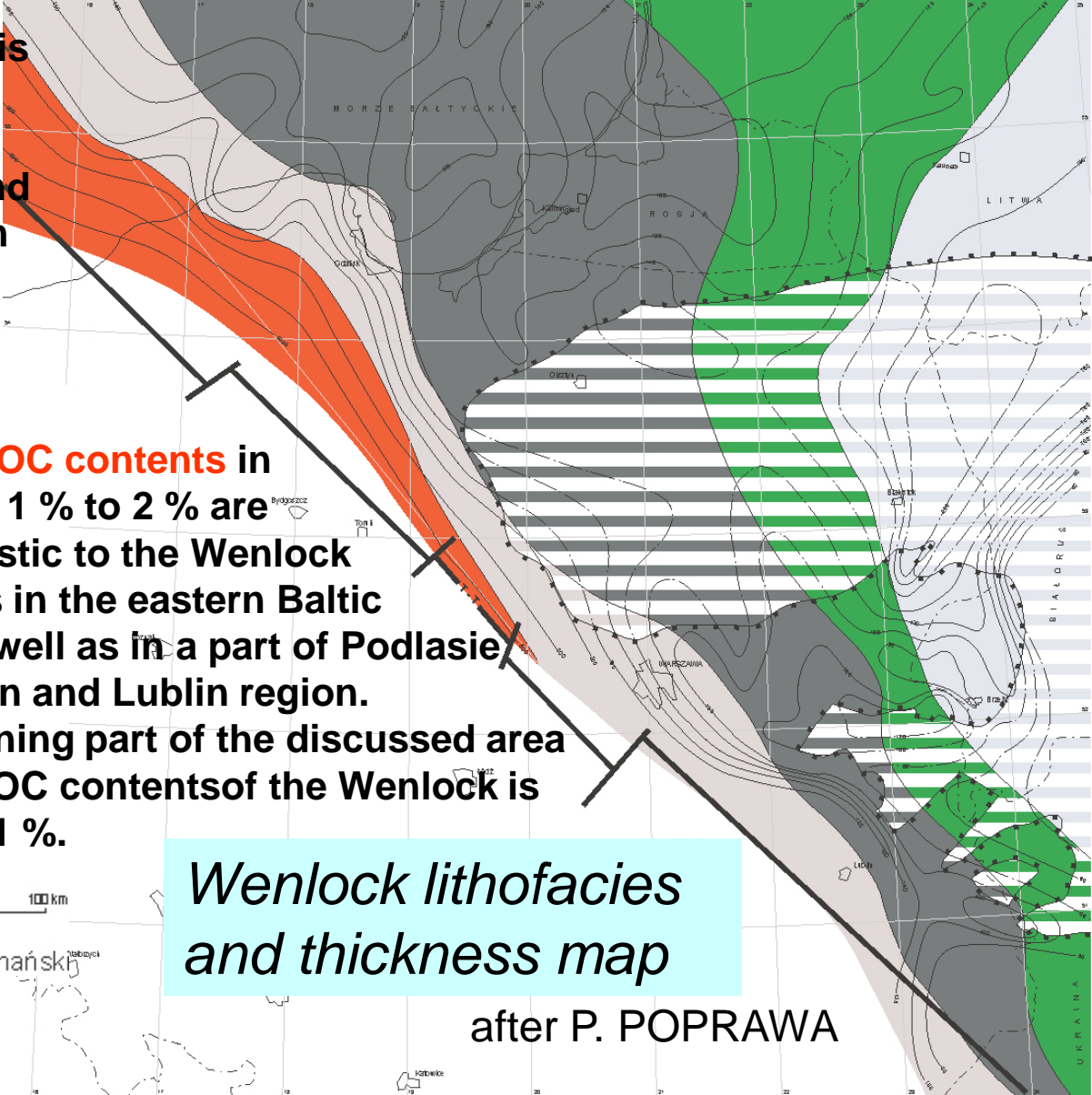


Z. Modliński, T. Podhalańska, B. Szymański



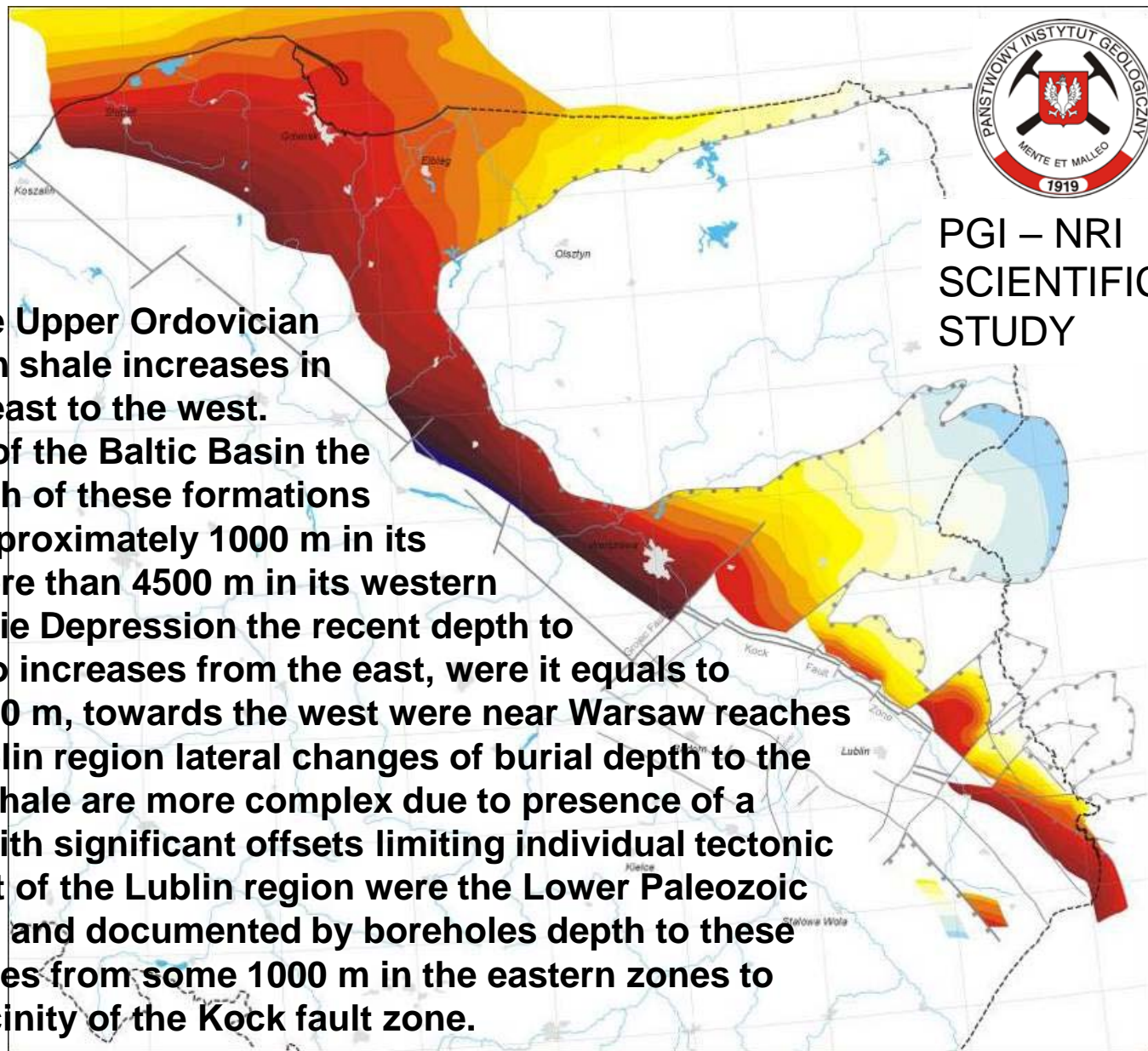
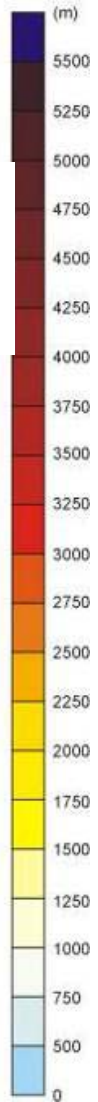
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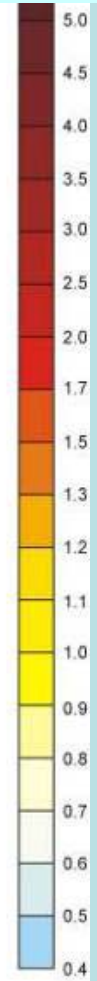
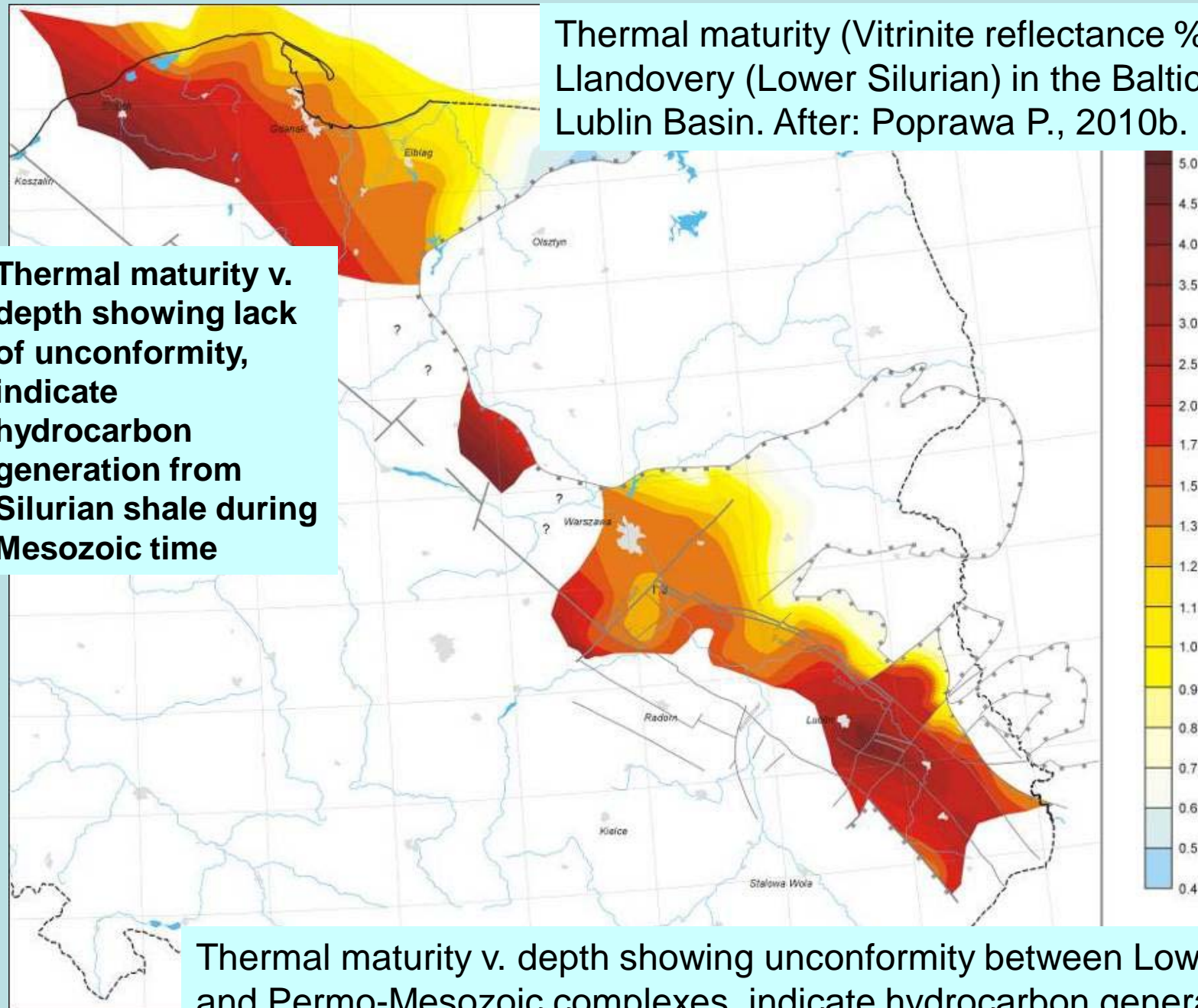
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Burial depth of the Upper Ordovician and Lower Silurian shale increases in General from the east to the west. In the Polish part of the Baltic Basin the Recent burial depth of these formations increases from approximately 1000 m in its eastern part to more than 4500 m in its western part. In the Podlasie Depression the recent depth to this formation also increases from the east, where it equals to approximately 5000 m, towards the west where near Warsaw reaches 4000 m. In the Lublin region lateral changes of burial depth to the Lower Paleozoic shale are more complex due to presence of a system of faults with significant offsets limiting individual tectonic blocks, In this part of the Lublin region where the Lower Paleozoic section is reached and documented by boreholes depth to these sediments increases from some 1000 m in the eastern zones to 3000-3500 m in vicinity of the Kock fault zone.

Burial depth of the bottom of Llandovery (Lower Silurian) in the Baltic-Podlasie-Lublin Basin. After: Poprawa P., 2010b.

Thermal maturity (Vitrinite reflectance %Ro) of the Llandovery (Lower Silurian) in the Baltic-Podlasie-Lublin Basin. After: Poprawa P., 2010b.



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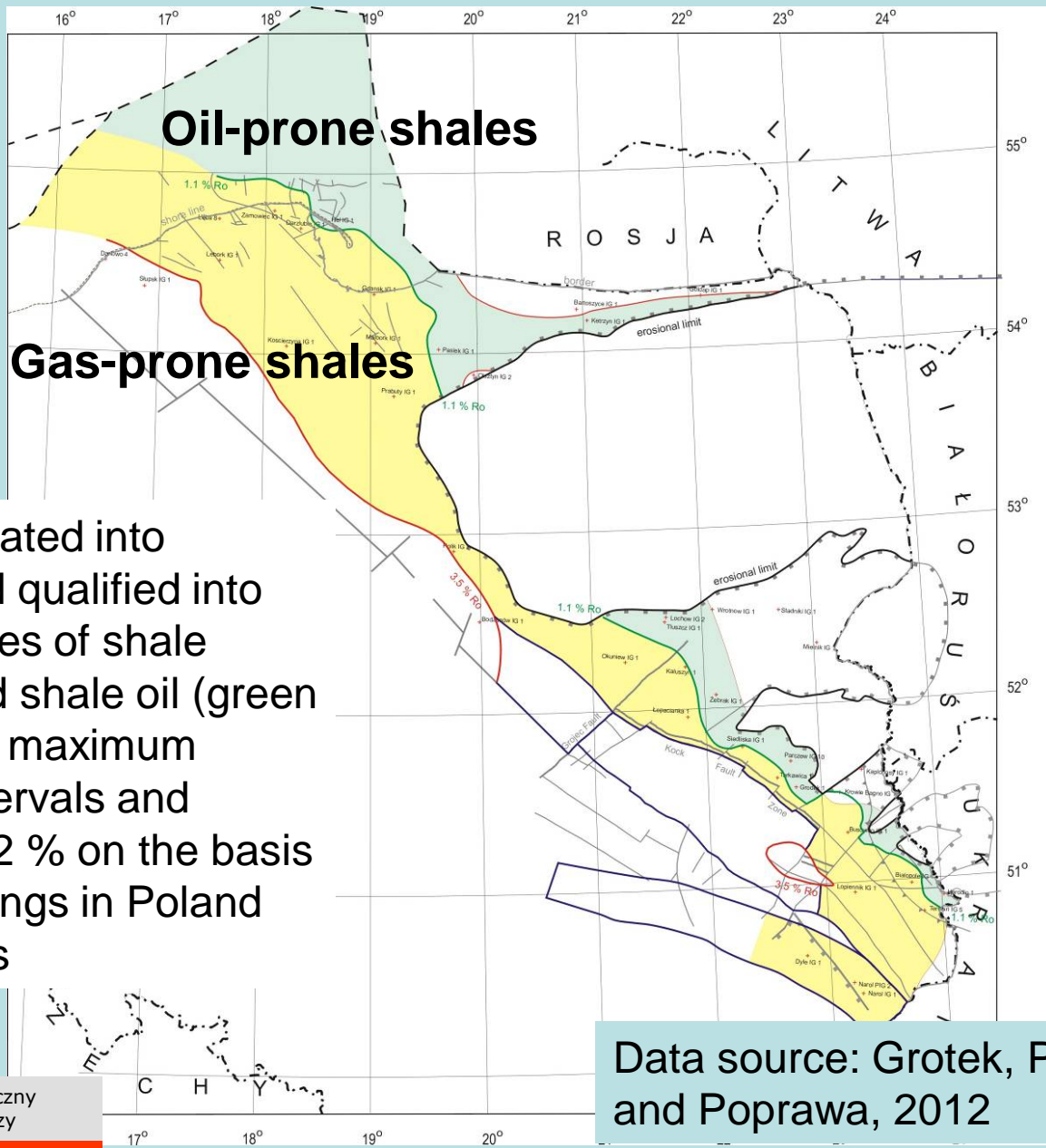
Thermal maturity v. depth showing lack of unconformity, indicate hydrocarbon generation from Silurian shale during Mesozoic time

Thermal maturity v. depth showing unconformity between Lower Paleozoic and Permo-Mesozoic complexes, indicate hydrocarbon generation from Silurian shales during Variscan burial stage (Carboniferous)



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Upper Ordovician – Lower Silurian Shales



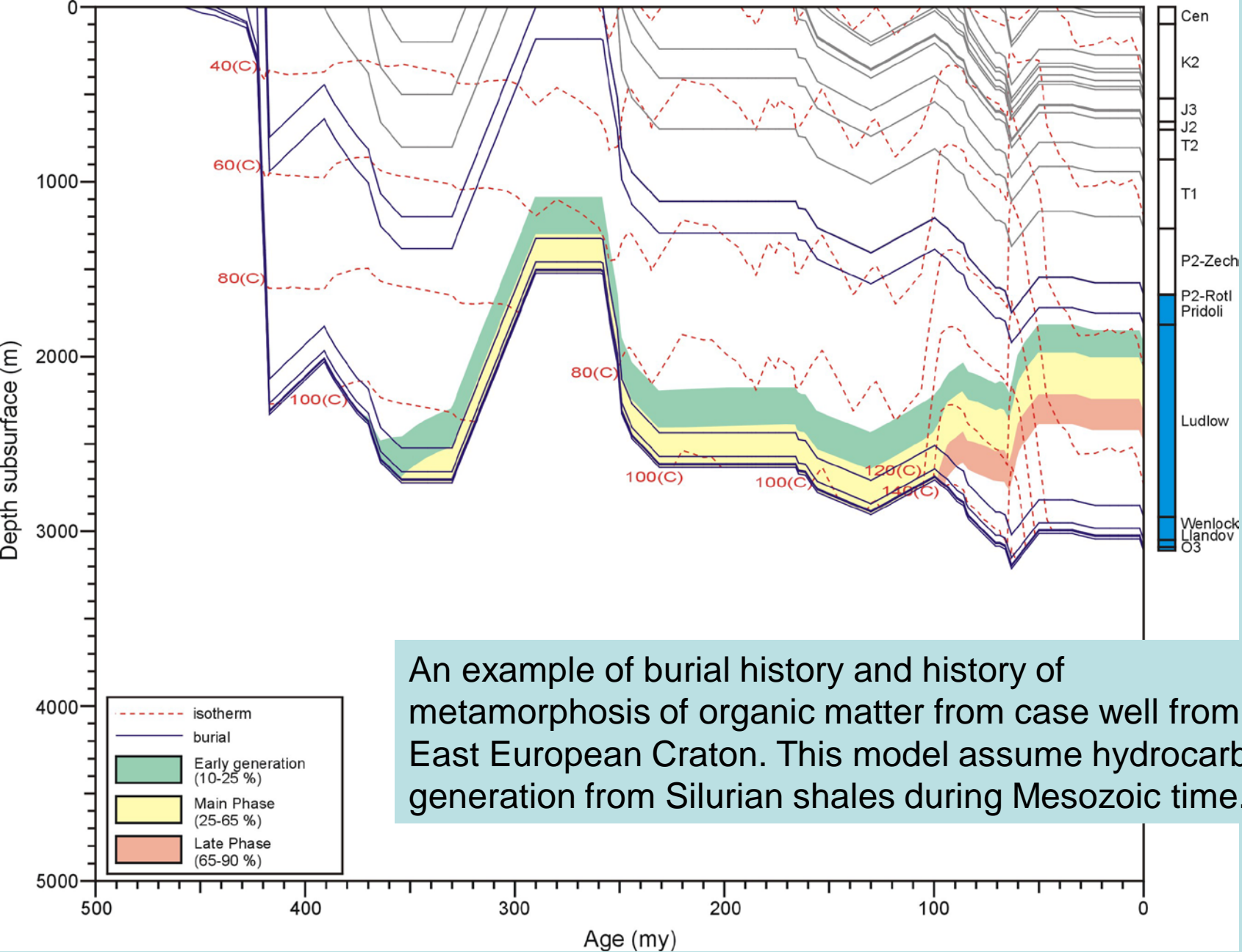
The acreage incorporated into assessment units and qualified into calculation of resources of shale gas (yellow color) and shale oil (green color) in a model with maximum thickness of shale intervals and with TOC contents > 2 % on the basis of 39 exploratory drillings in Poland from 1950-1990 years

Data source: Grotek, Poprawa and Poprawa, 2012



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An example of burial history and history of metamorphosis of organic matter from case well from East European Craton. This model assume hydrocarbons generation from Silurian shales during Mesozoic time.





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Lower Paleozoic geological profile from East European Craton (N-E Poland) (A – Lublin Basin; B -- Baltic Basin), with indicated complexes of maximal potential of unconventional gas accumulations in Ordovician – Silurian shales



Depression the average TOC contents of the Upper Ordovician shale is equal to 1 % to 1,25 %, while in the basement of Płock-Warszawa Trough it ranges between 2,1 to 3,76 % TOC. In the Lublin region the average TOC of these sediments is lower than 1 %. The average TOC contents of the Ashgill deposits usually is below 0,5 %, except of the Łeba Elevation where it reaches 4,5 %.

Data source: Poprawa, 2010



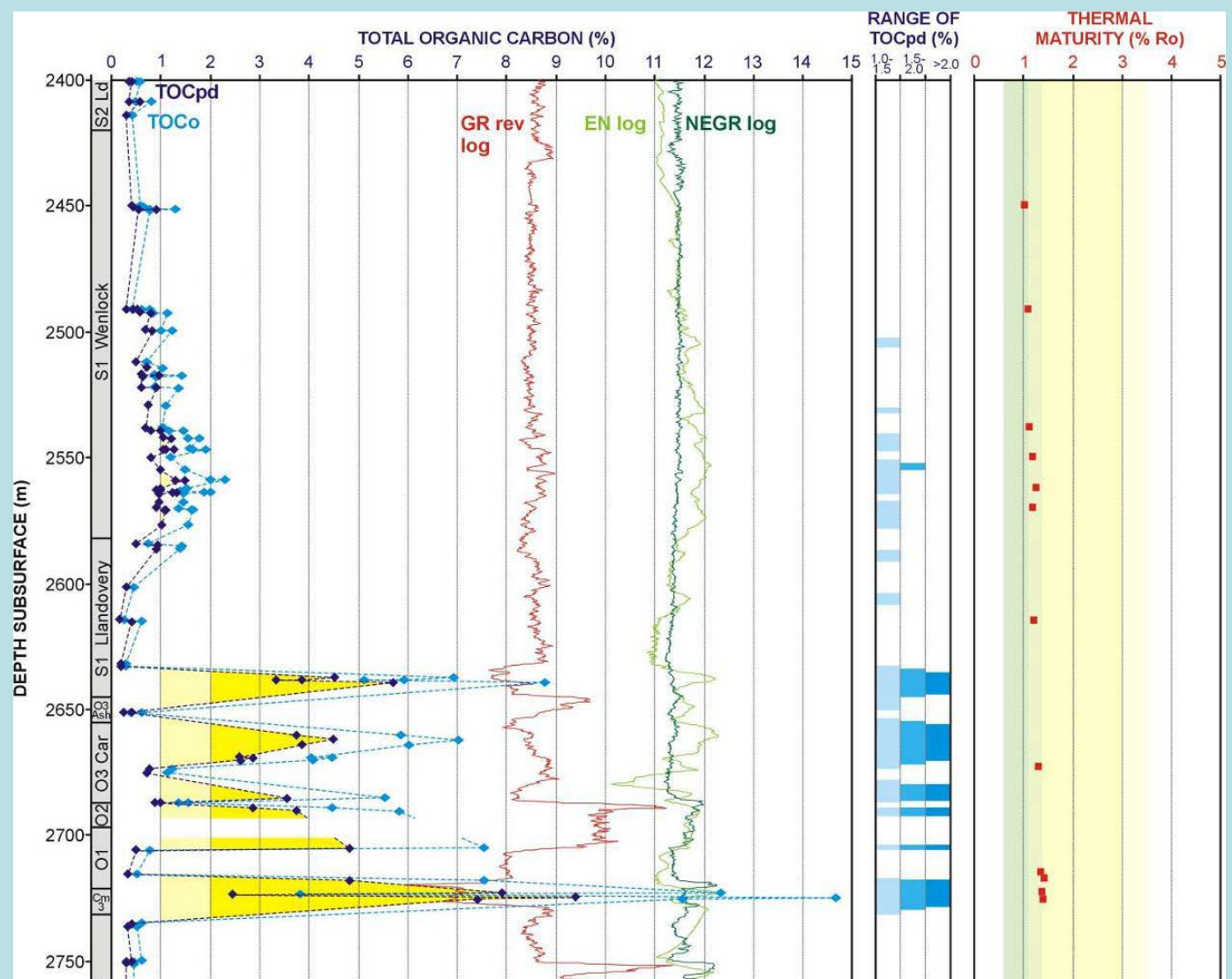
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Data source:
Poprawa, 2012



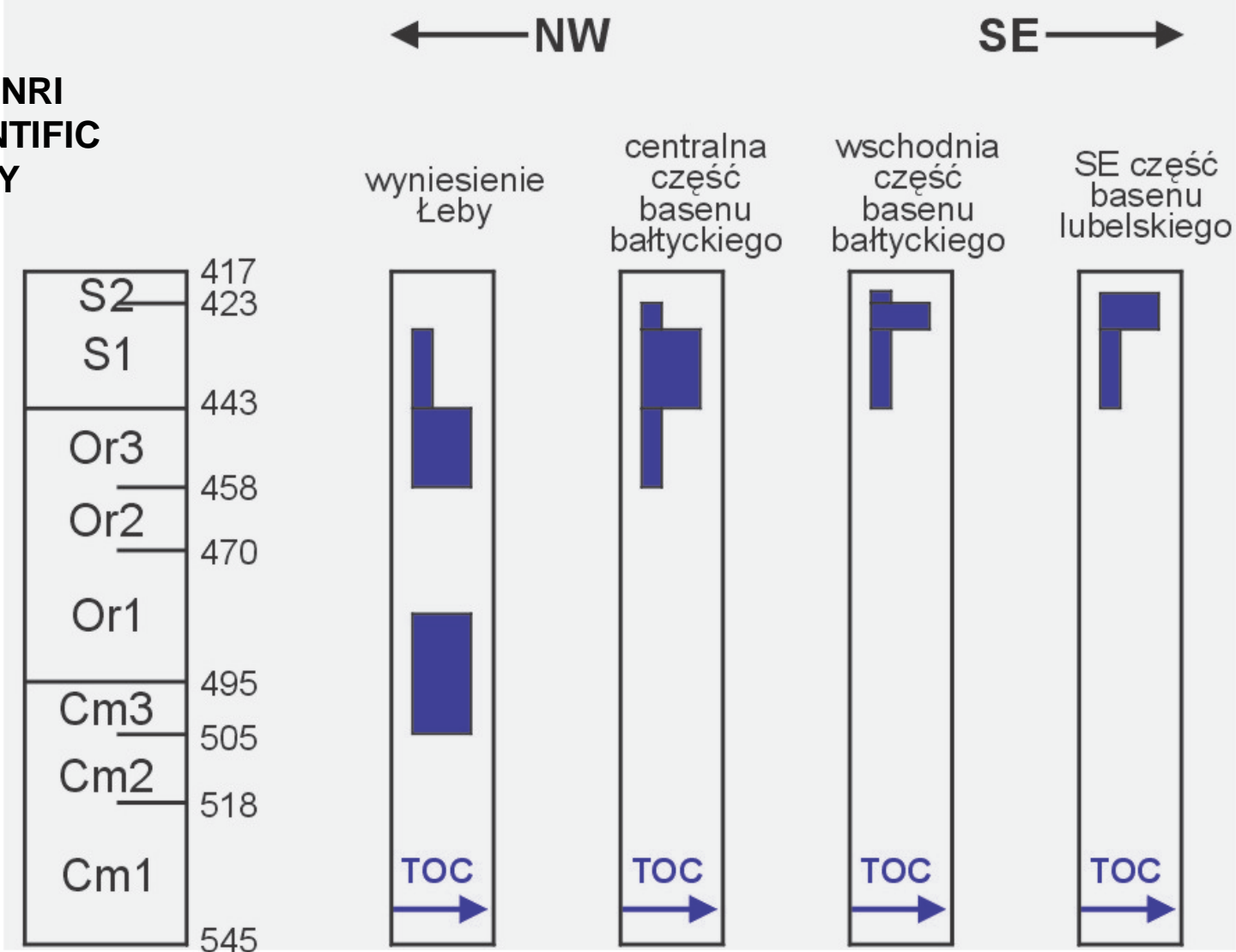
Compilation of geological, geochemical and geophysical data, characterizing shale gas/oil potential of the Lower Paleozoic shale interval in a given exemplary well from the Baltic Basin (Żarnowiec IG 1). TOCpd – measured present day TOC contents. TOCo – reconstructed original TOC contents. GR – gamma ray (increasing towards left-hand side). EN, EL – resistivity log (increasing towards right-hand side). NEGR –neutron log (increasing towards right-hand side)



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STUDY FOR
TRACING SHALE
HORIZONS
REACH IN
ORGANIC
MATTER –
SWEET SPOTS

after P. POPRAWA

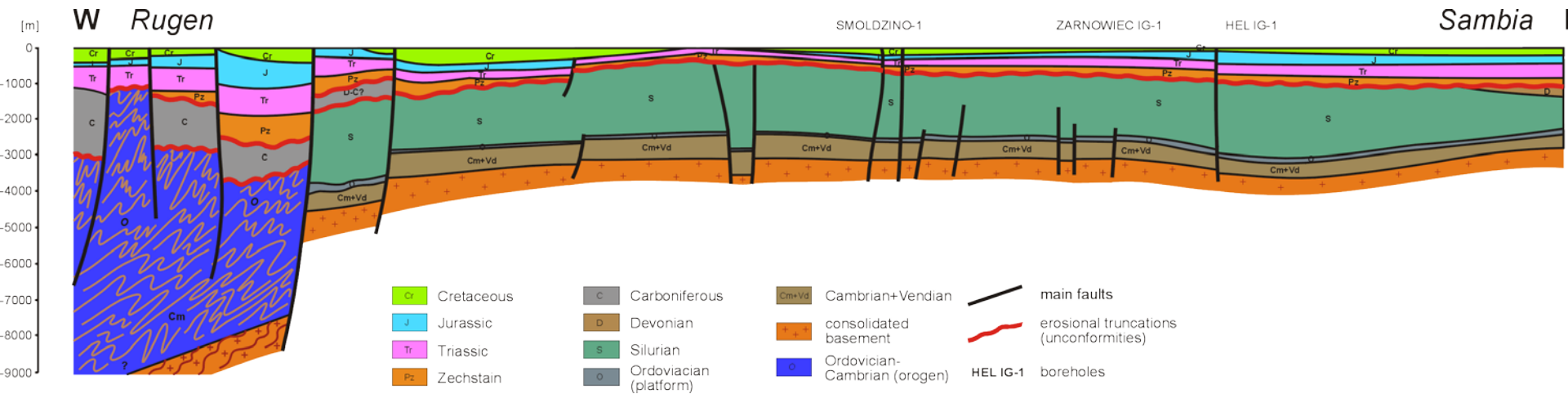


High TOC differences within Lower Paleozoic deposits of East European Craton (N-E Poland).





Dark green – Silurian deposits, mostly dark shales



Simplified cross-section across Baltic Basin (E-W) showing relatively simple tectonic frame-work, favourable for shale gas exploration and production (Witkowski, 1989).

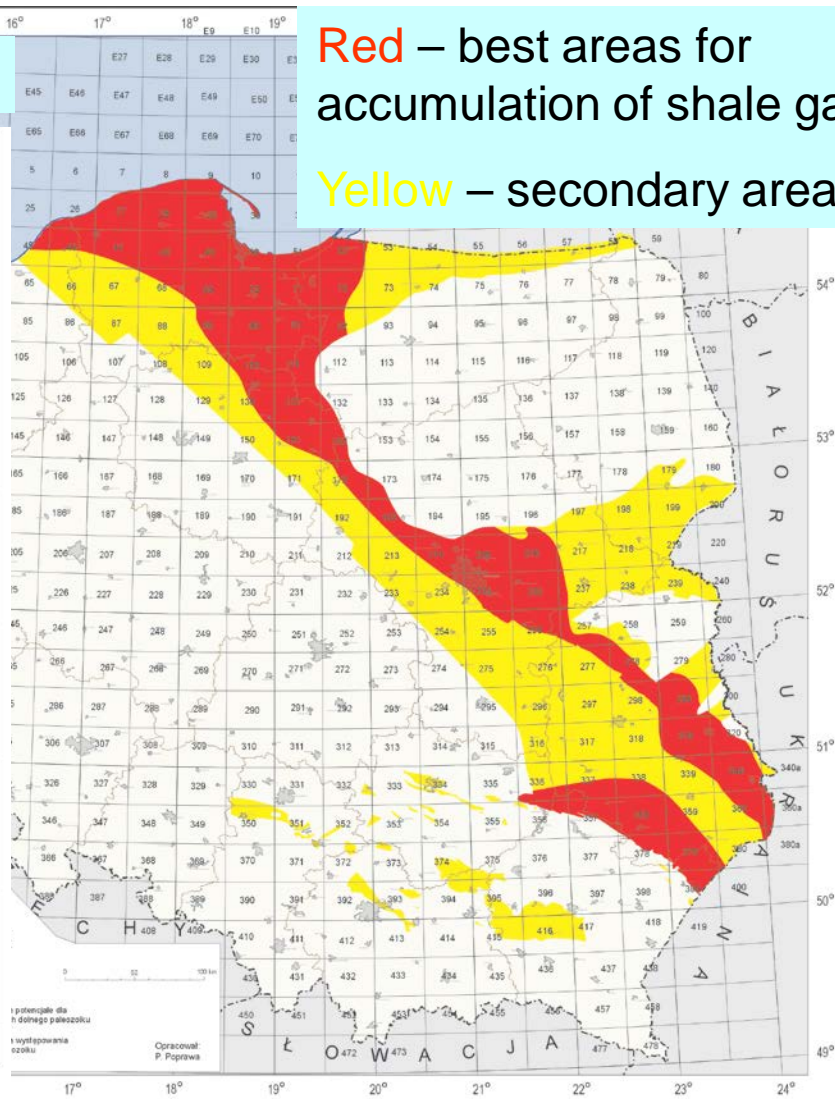
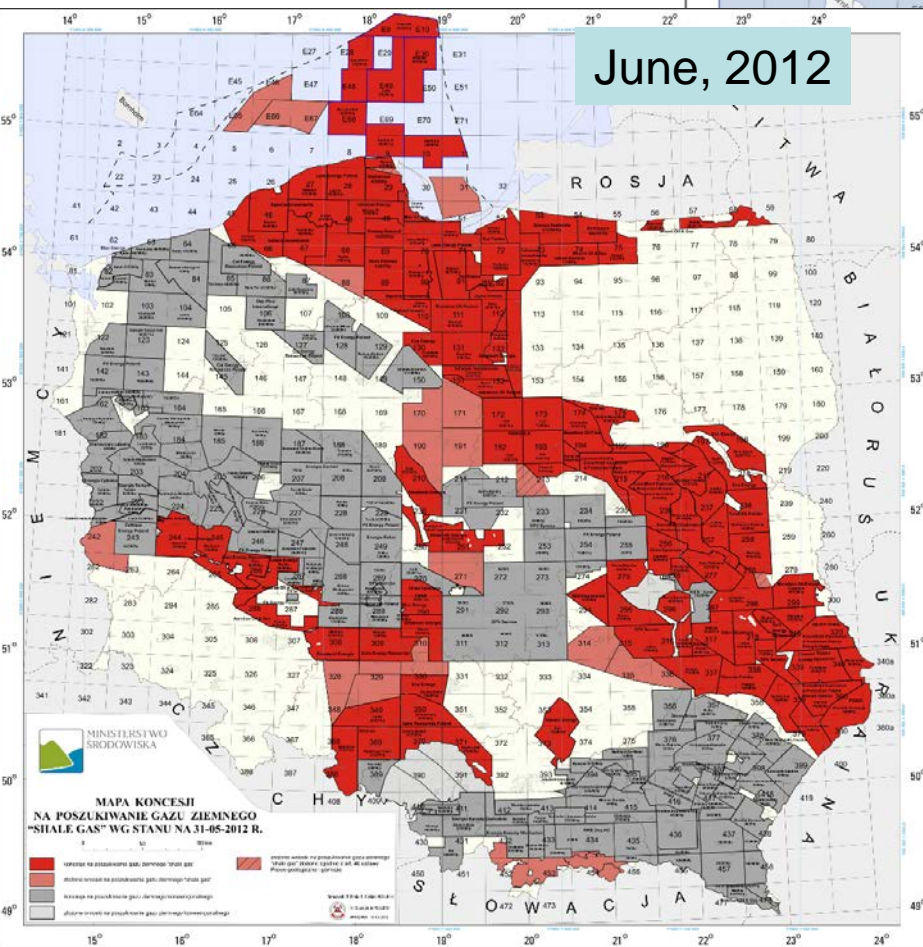
AREA OF DISTRIBUTION OF LOWER PALEOZOIC SHALES IN POLAND

Licenses blocks for shale gas prospecting

June, 2012

Red – best areas for accumulation of shale gas

Yellow – secondary areas



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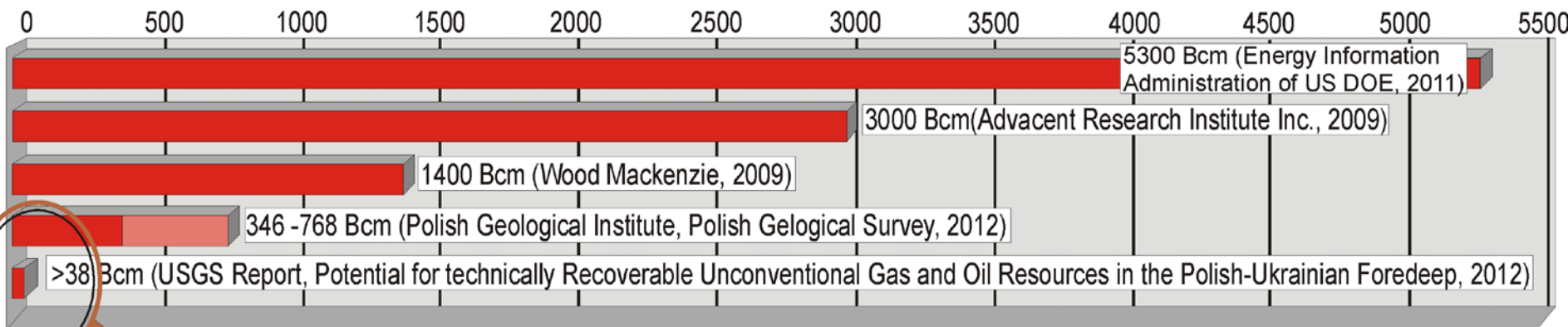
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Data source: Ministry of Environment

How great are unconventional gas resources of Poland?

No reliable estimate of the resources yet exists...

SHALE GAS RECOVERABLE RESOURCES



We still don't know. Is the Polish Ordovician-Silurian Shale Gas Basin a honey barrel or just honey smell?

SHALE GAS

Shale gas recoverable resources of the **onshore and offshore** Baltic – Podlasie – Lublin Basin

Basin is estimated for maximum: **1920 Bcm (1,92 Tcm)**. Taking into account constraints on key parameters of the calculations the higher probability range of **recoverable shale gas resources** is: **346 - 768 Bcm**

Source: ASSESSMENT OF SHALE GAS AND SHALE OIL RESOURCES OF THE LOWER PALEOZOIC BALTIC-PODLASIE-LUBLIN BASIN IN POLAND. First Report by P. Poprawa, 2011



Thank you

