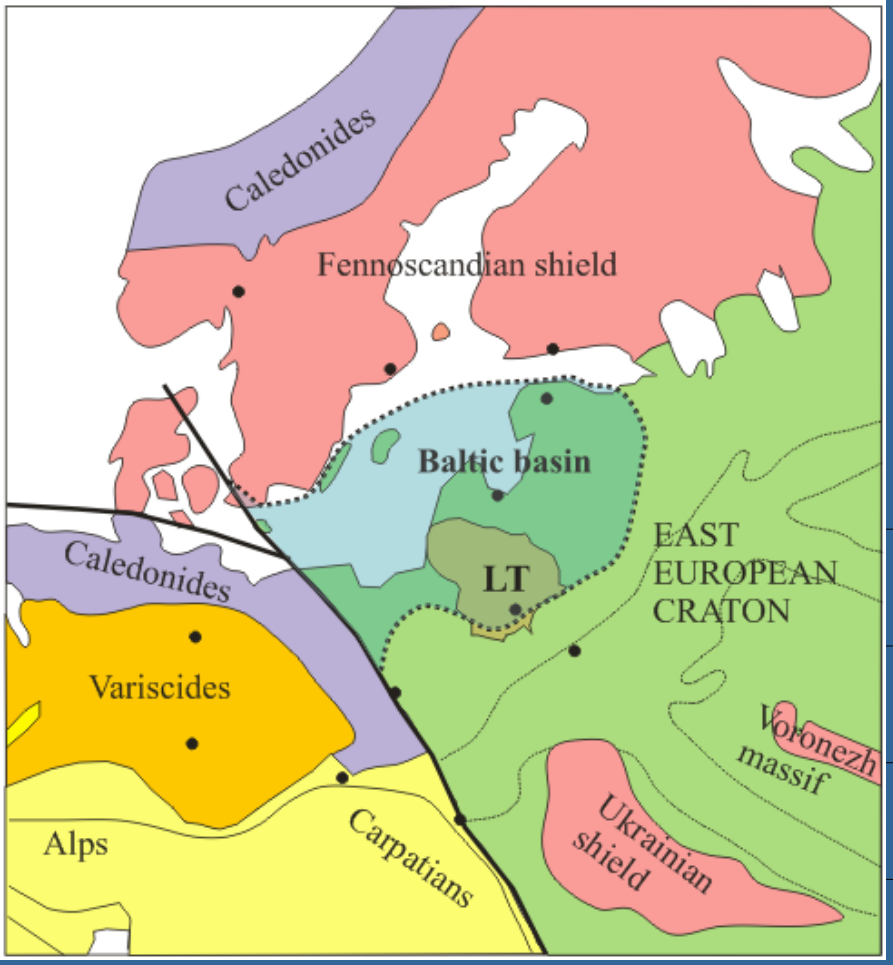
Saulius Sliaupa
Rasa Sliaupiene

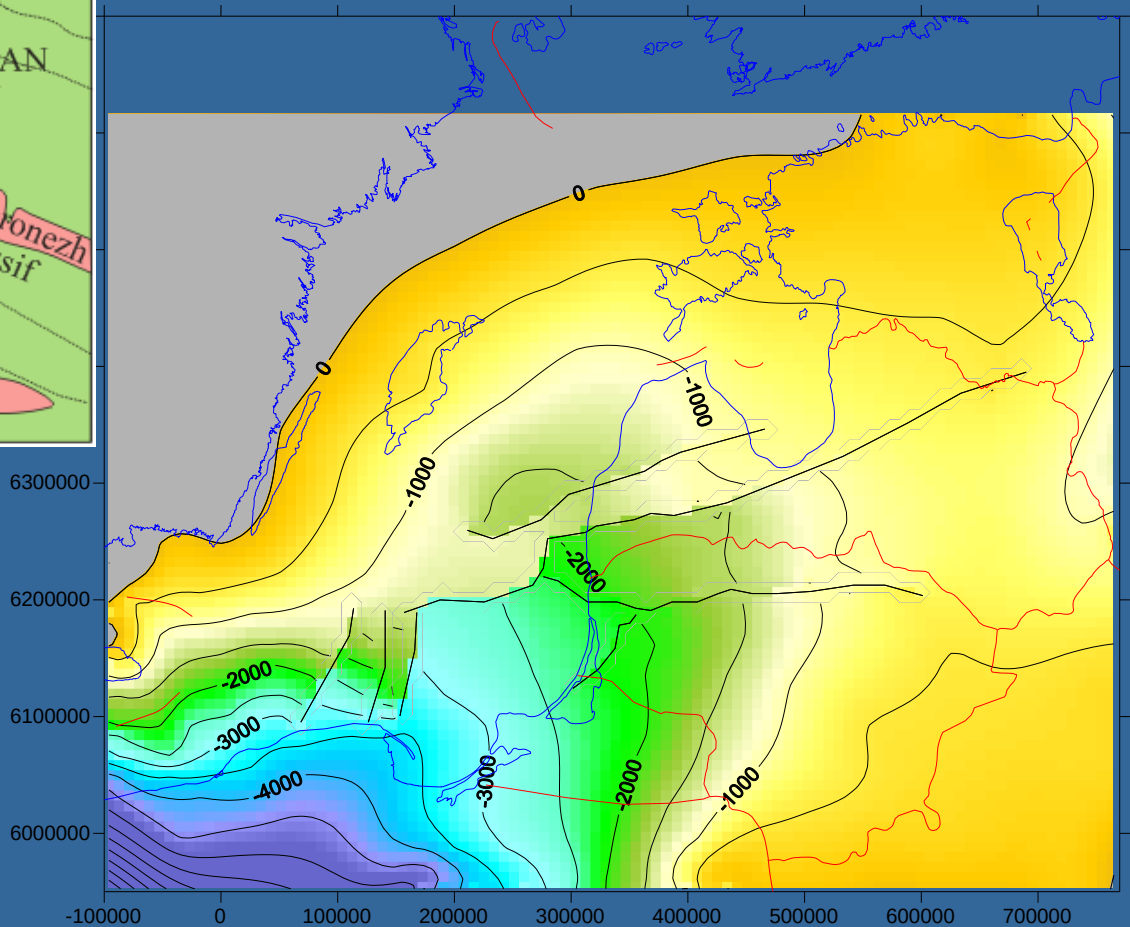
Nature Research Centre

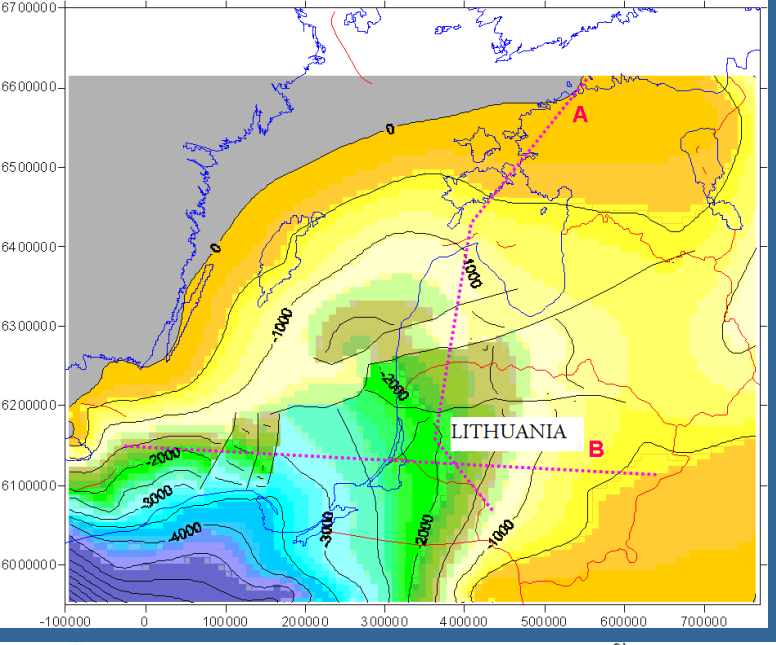
Lithuanian CO_2–EOR and CO_2 storage project

Tectonic scheme

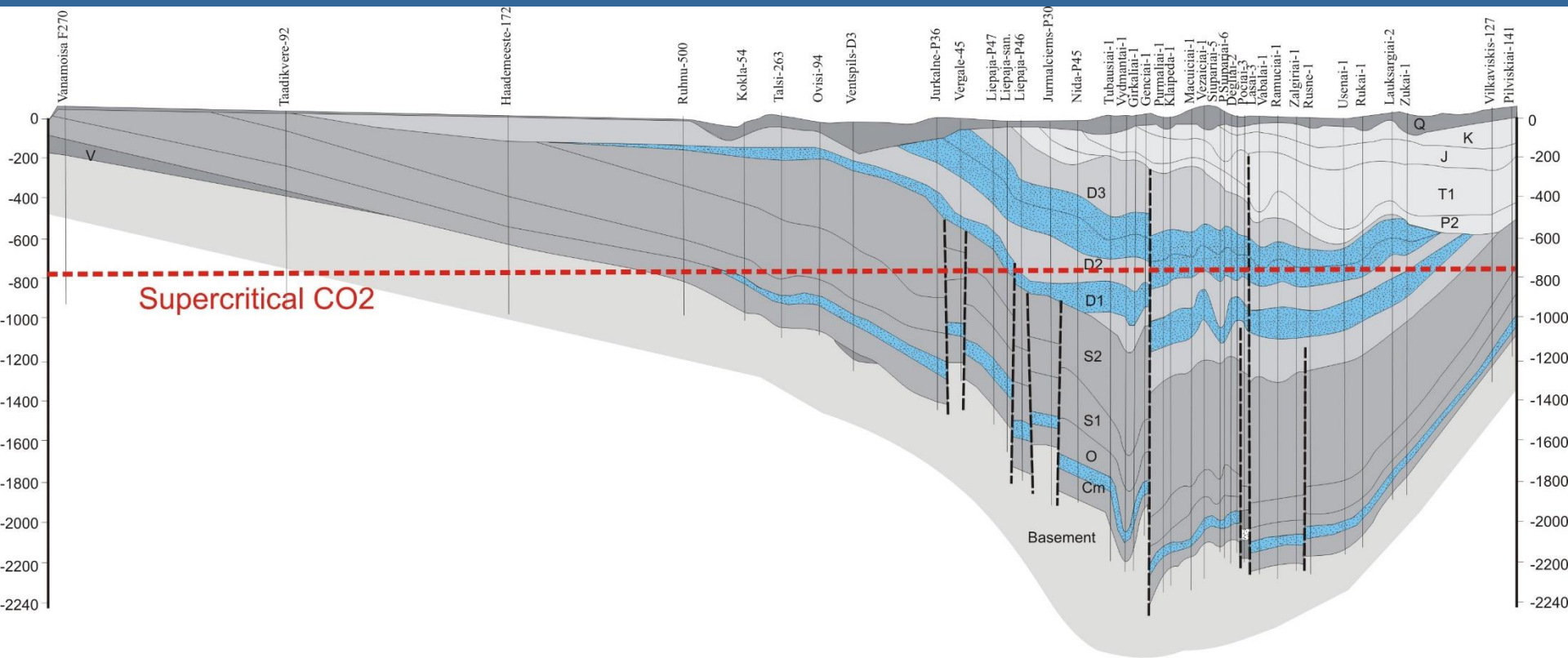


Depths of the crystalline basement

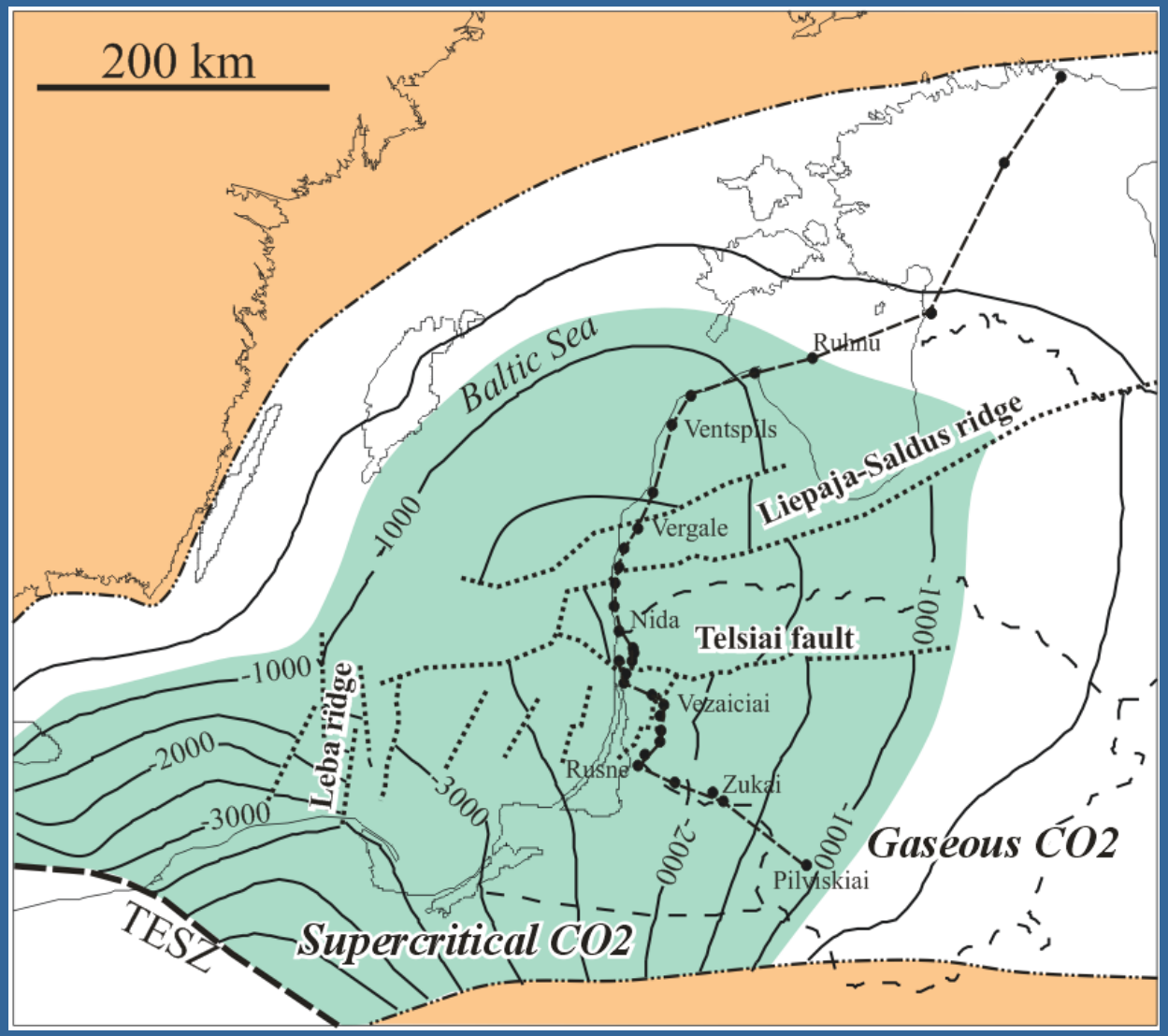




Cross section across the Baltic basin, north-south

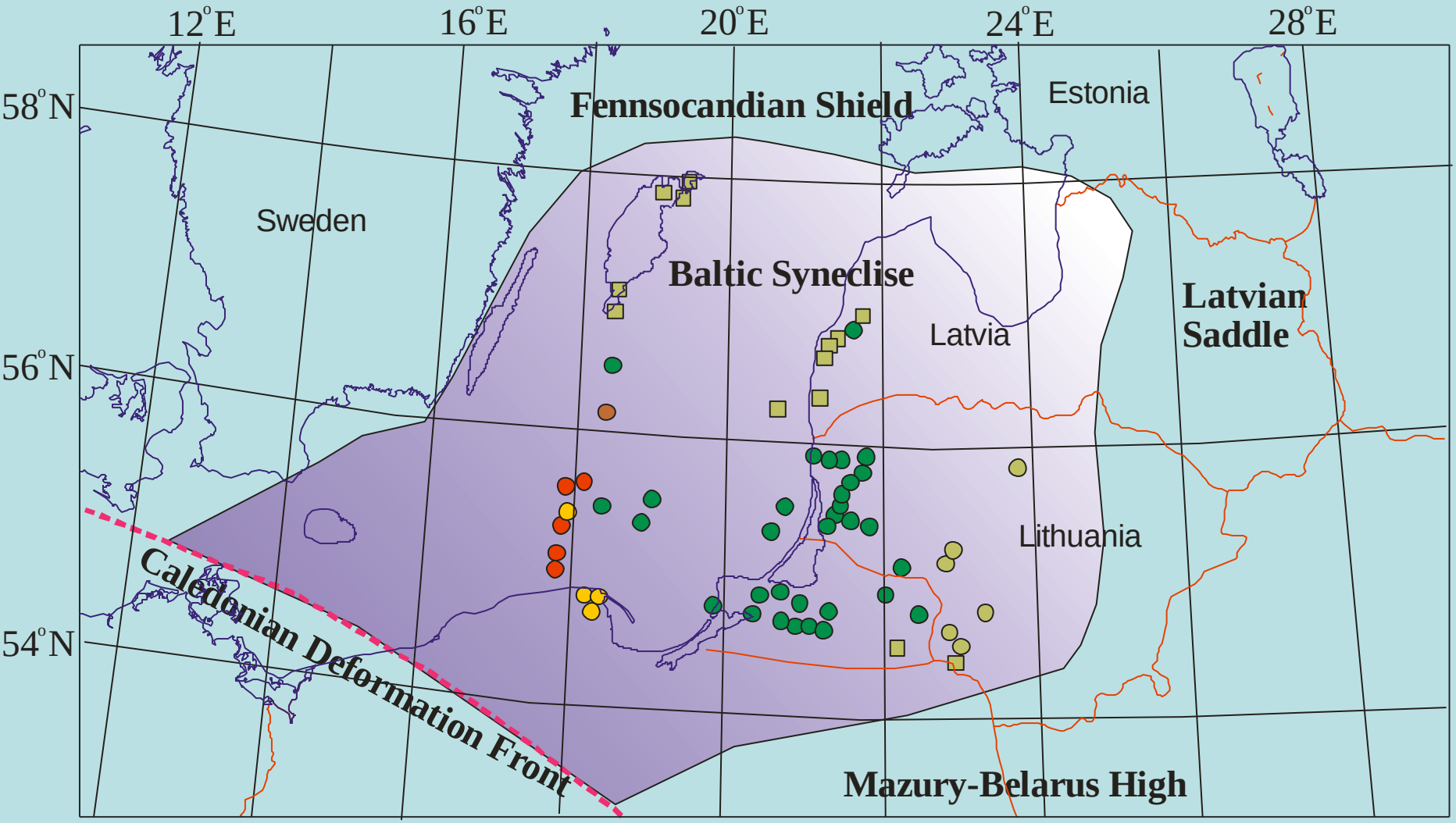


Prospective saline aquifers of the Baltic region



Cambrian aquifer

Oil fields of the Baltic basin



Cambrian sandstone reservoirs

- *Oil field, tested discovery*
- *Light oil field, tested discovery*
- *Gas field, tested discovery*
- *Gas discovery (non tested)*

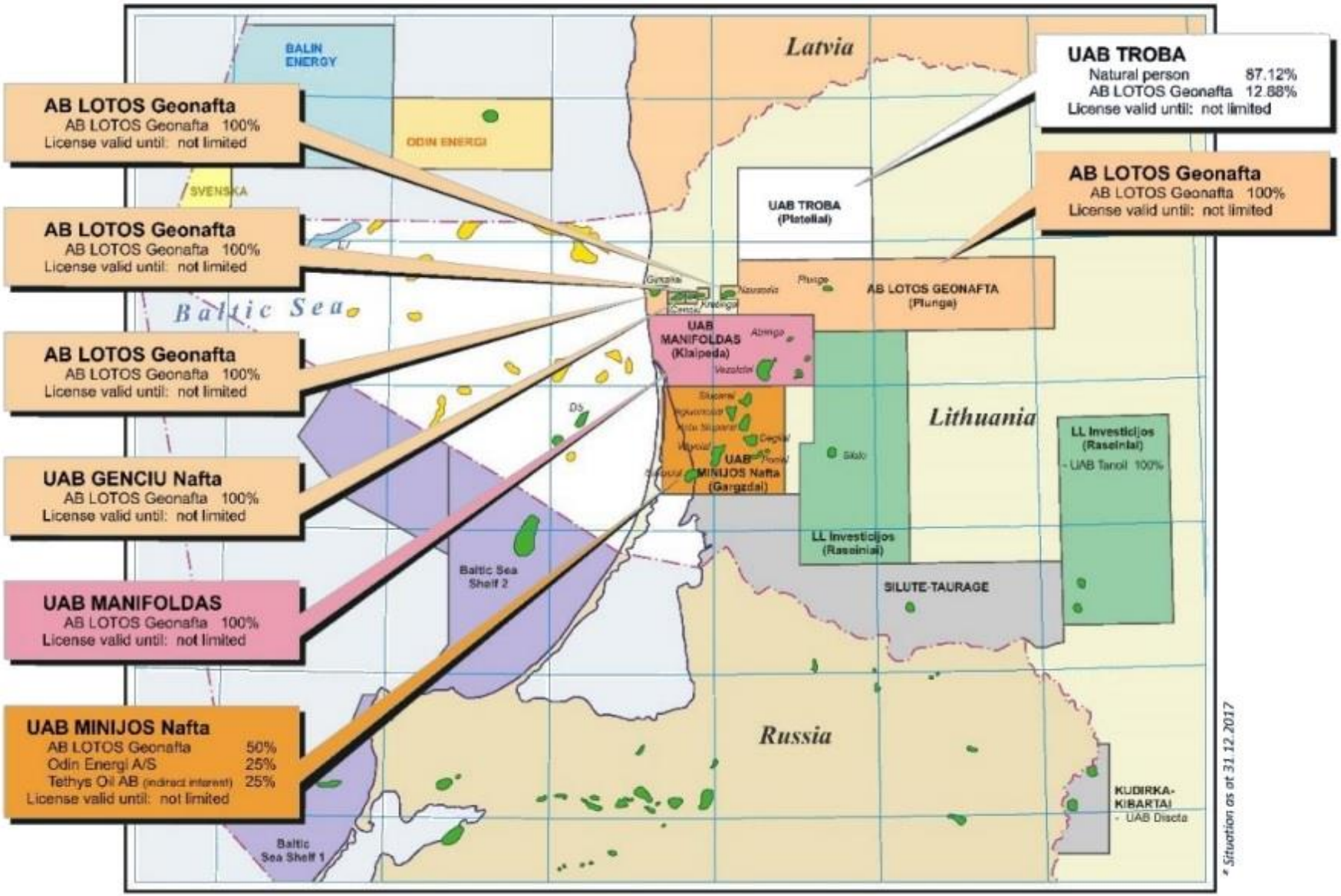
Ordovician carbonate reservoirs

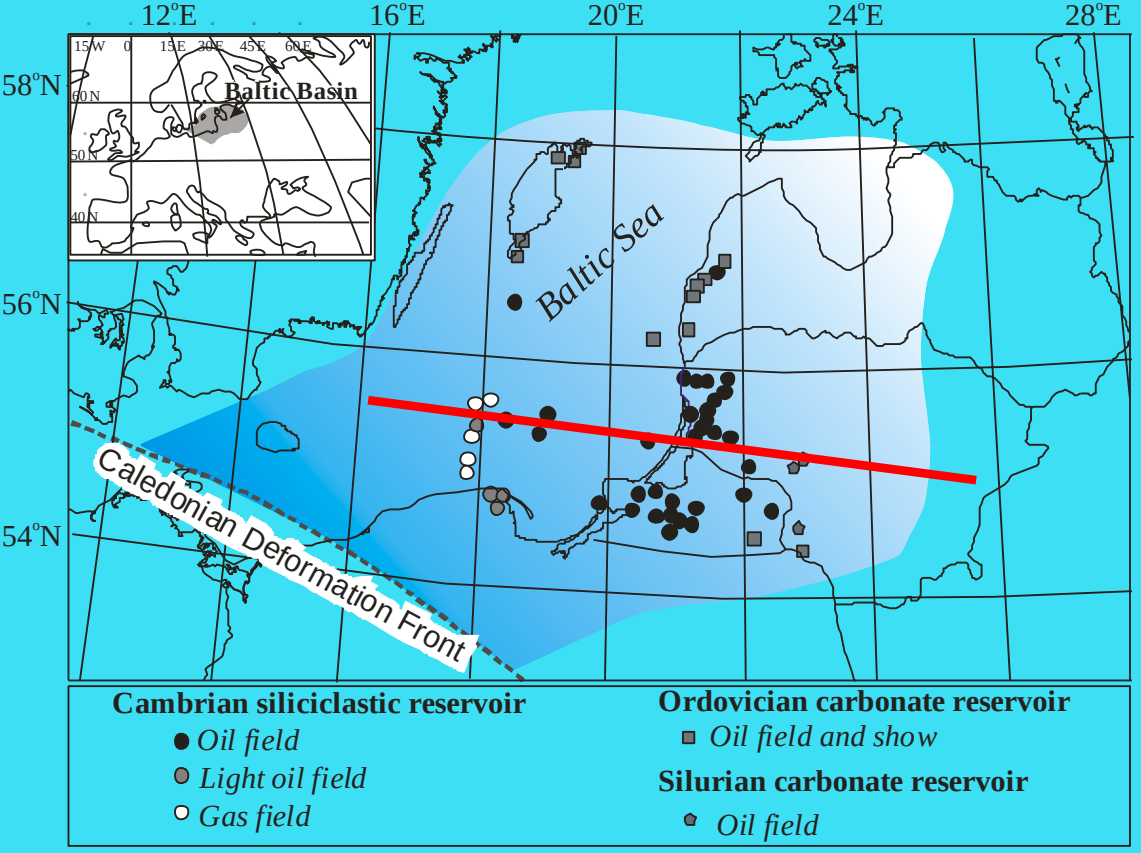
- *Oil field, tested discovery*

Silurian Carbonate reservoirs

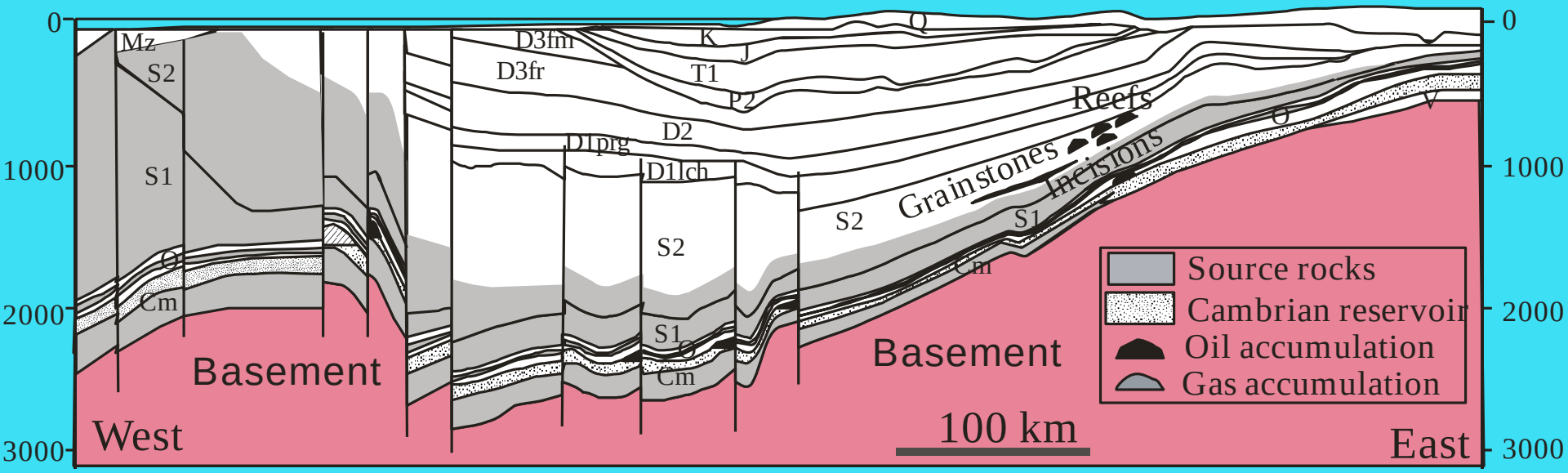
- *Oil field, tested discovery*

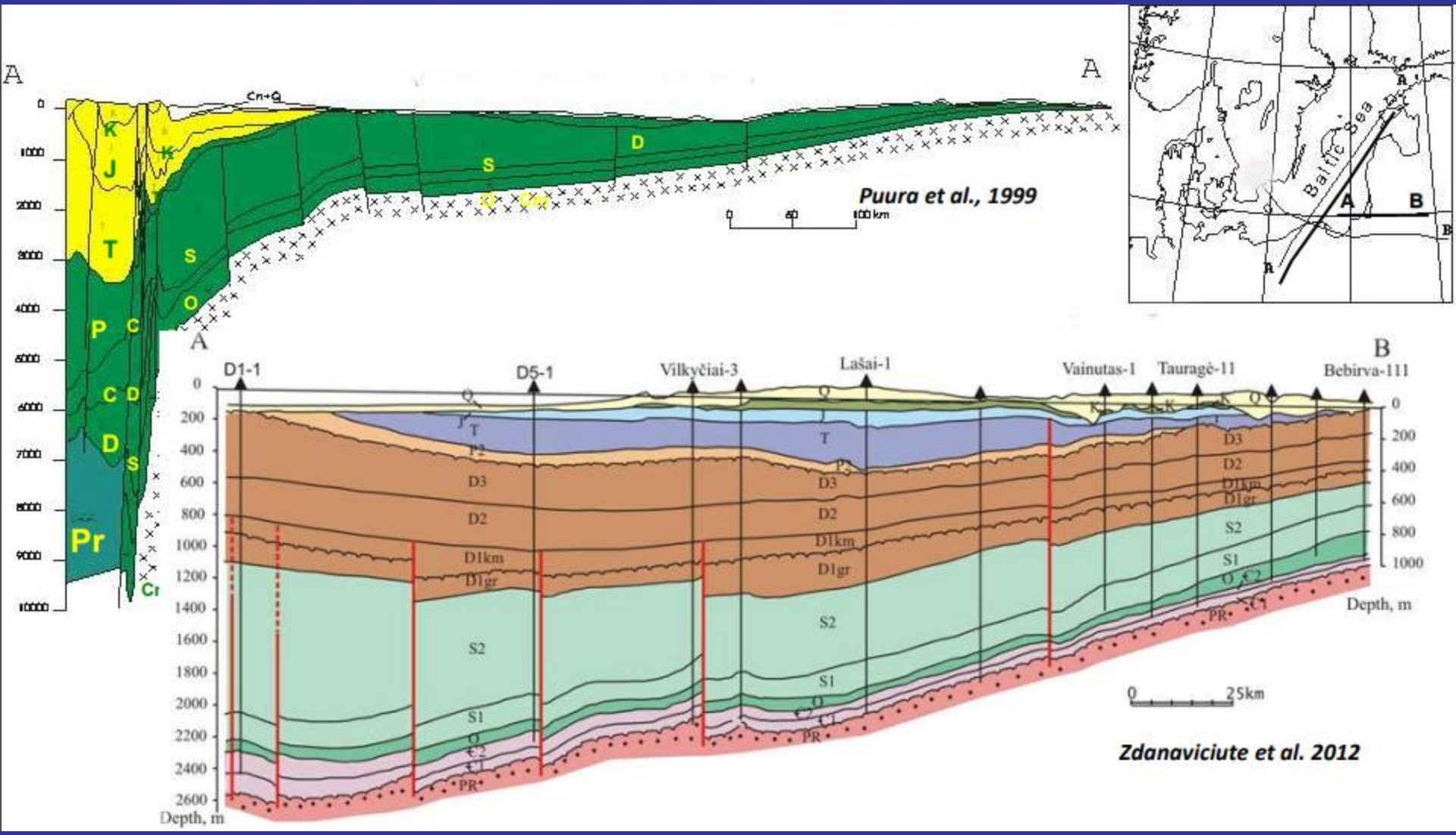
Licences held by AB LOTOS Geonafta Group as at December 31st 2017

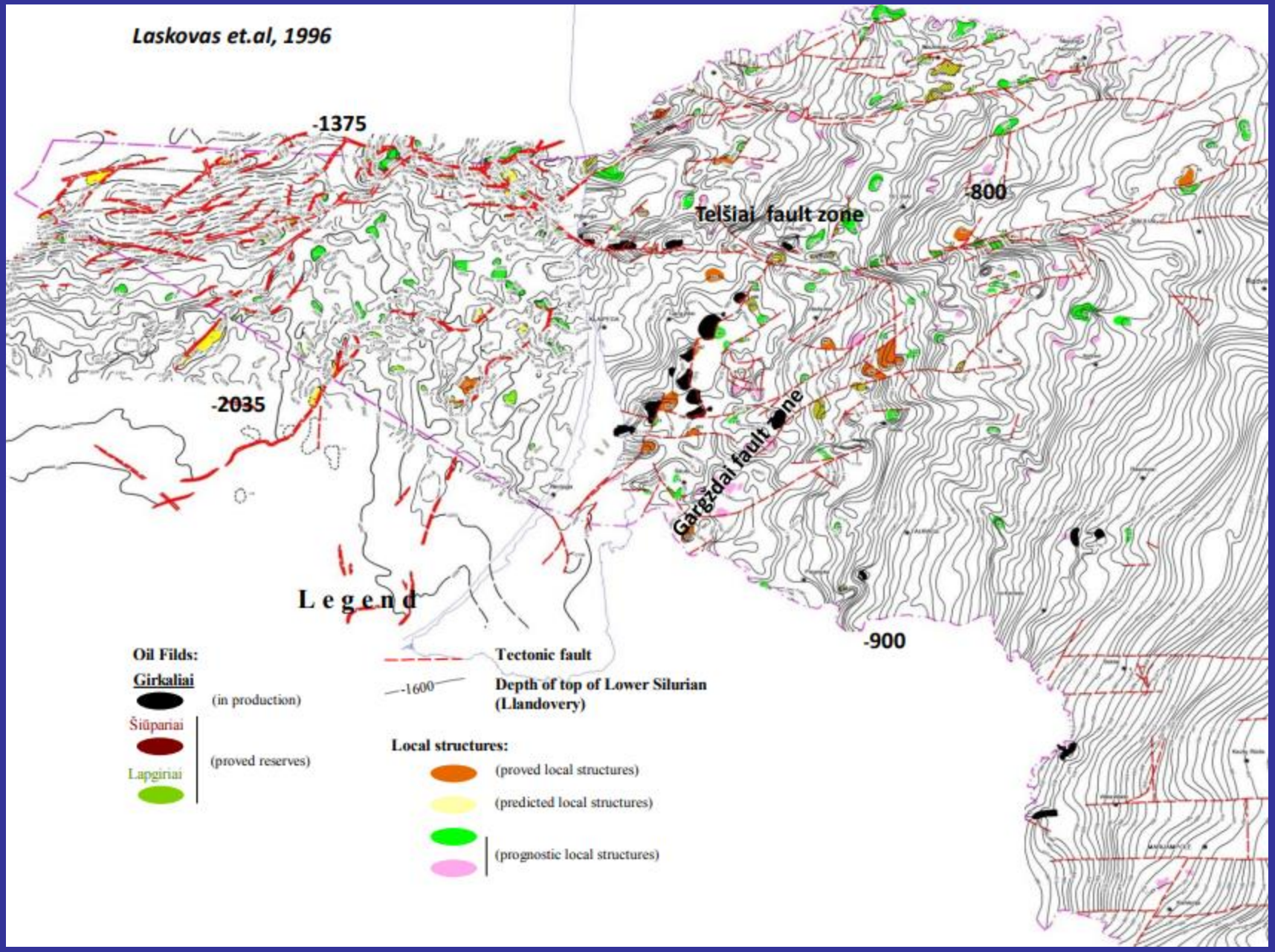


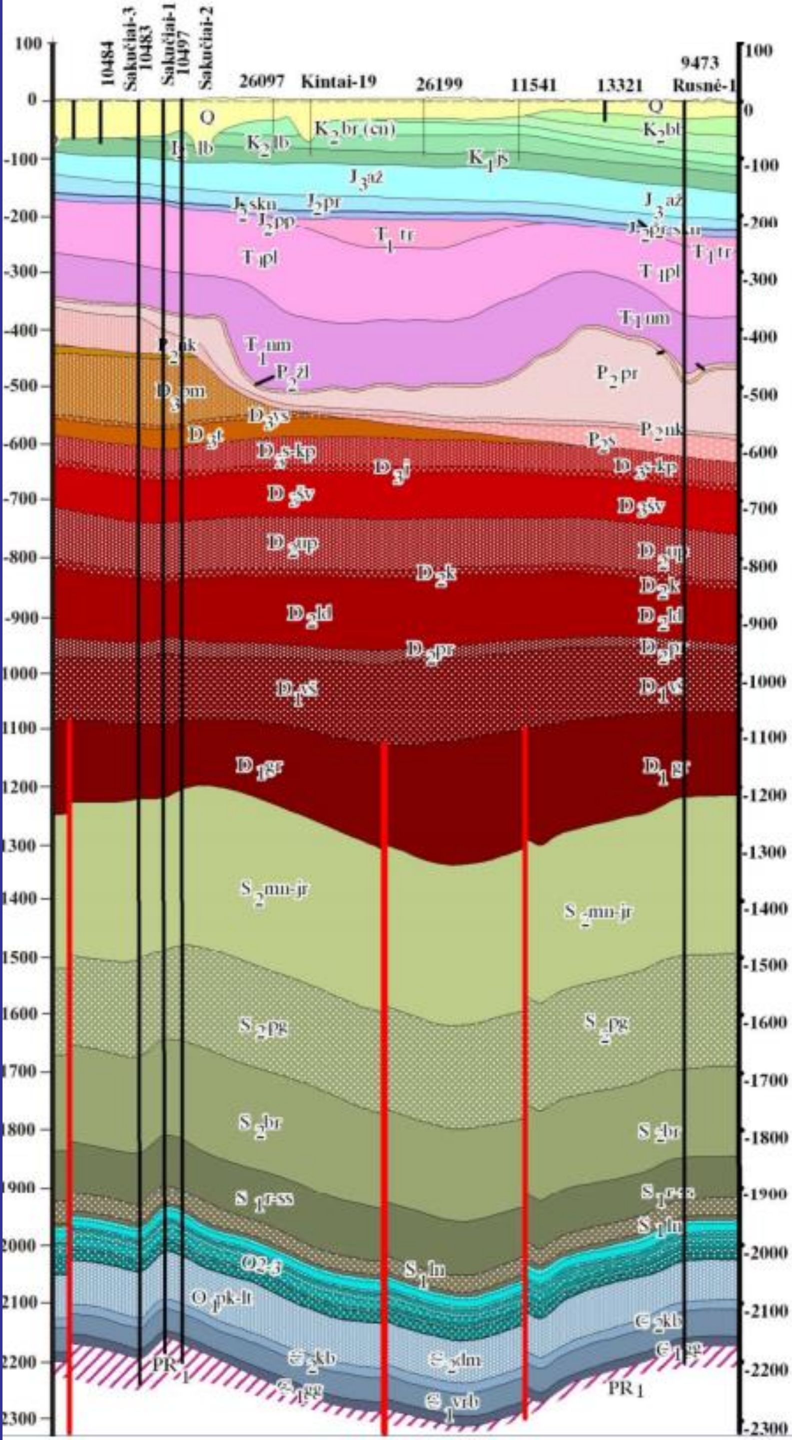


Regional cross-section



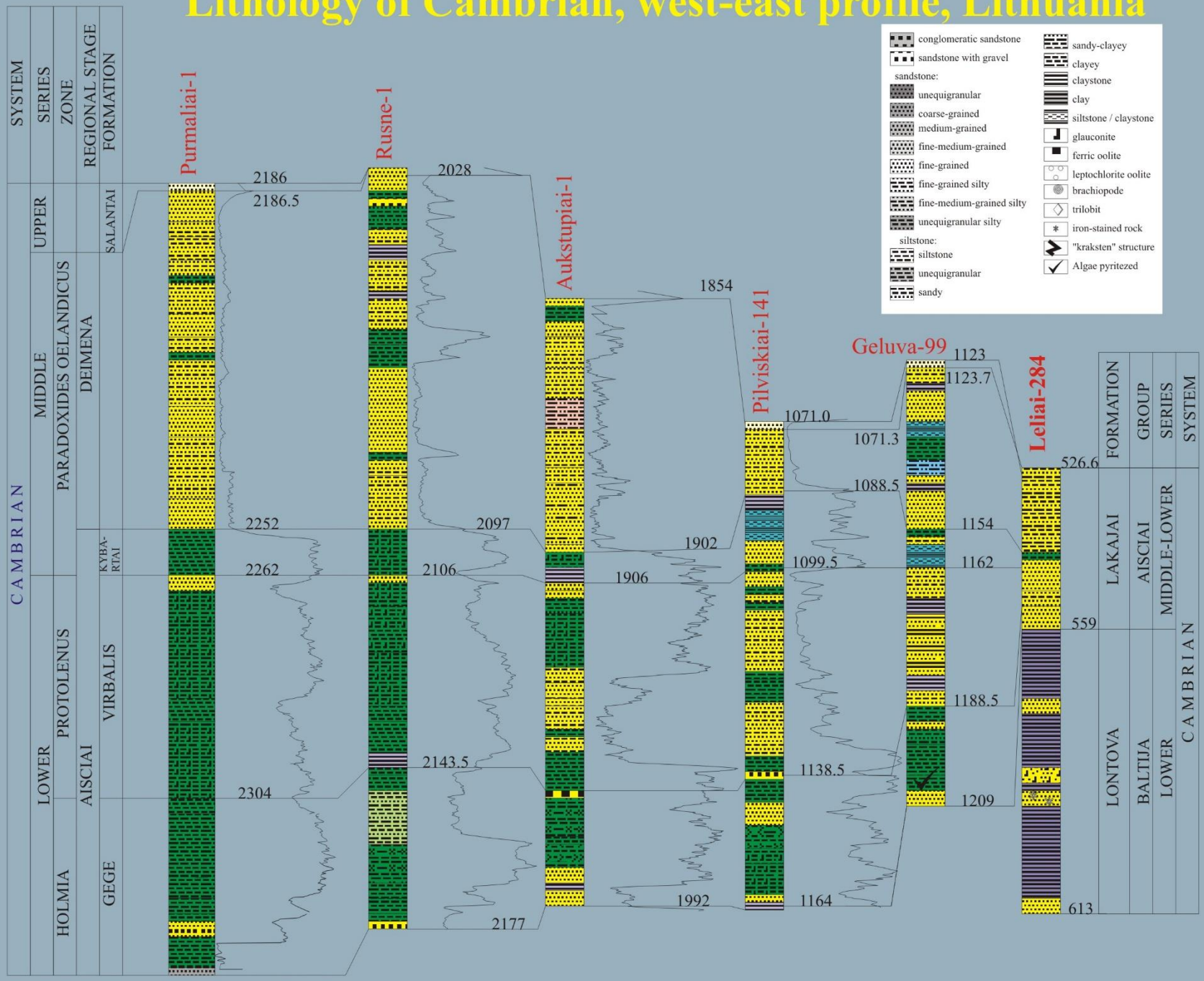

A
A
Cn→Q
K
J
T
P
C
D
S
O
Pr
Cr
Puura et al., 1999
Baltic Sea
A
B
A
B
D1-1
D5-1
Vilkyčiai-3
Lašai-1
Vainutas-1
Tauragė-11
Bebirva-111
Q
T
P2
P1
D3
D2
D1km
D1gr
S2
S1
O
€2
€1
PR
Depth, m
0
25km
Zdanaviciute et al. 2012


Laskovas et.al, 1996
-1375
-2035
-800
-900
Telšiai fault zone
Gargždai fault zone
Legend
Oil Filds:
Girkaliai
(in production)
Šiūpariai
Lapgiriai
(proved reserves)
Tectonic fault
-1600
Depth of top of Lower Silurian (Llandovery)
Local structures:
(proved local structures)
(predicted local structures)
(prognostic local structures)

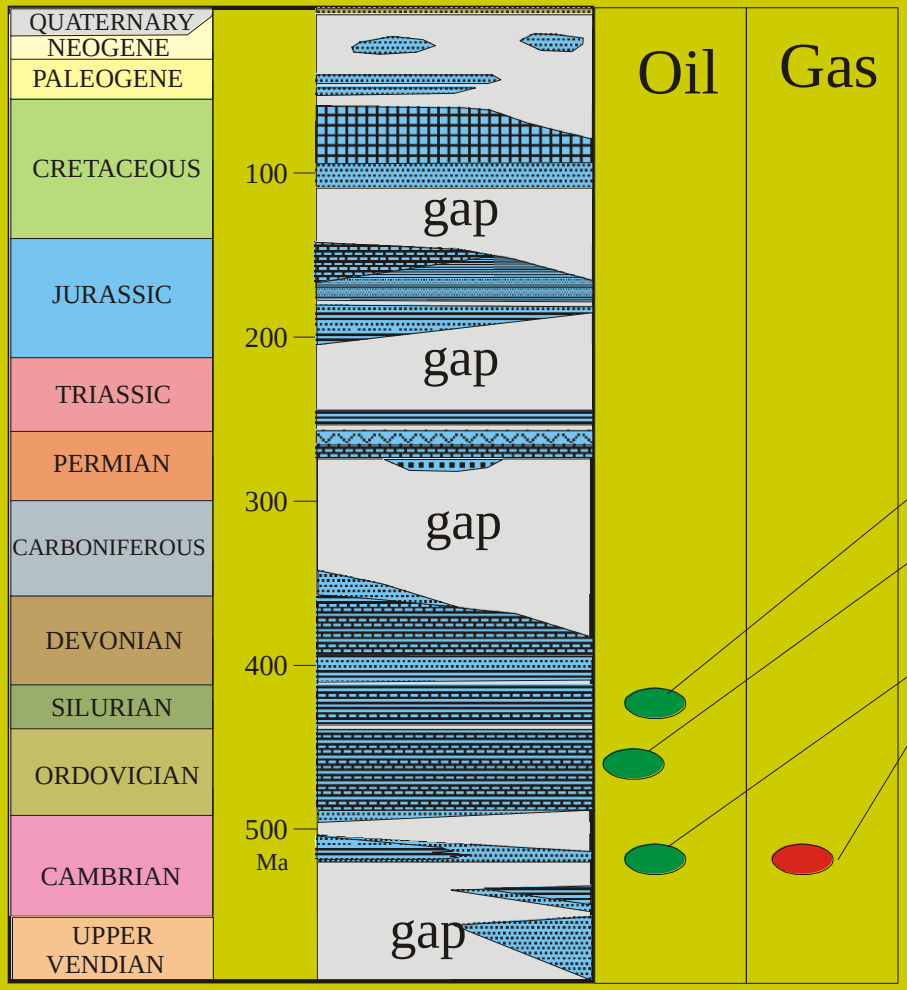


10484
Sakučiai-3
10483
Sakučiai-1
10497
Sakučiai-2
26097
Kintai-19
26199
11541
13321
9473
Rusnė-1
Q
K2br (cn)
K2lb
K2bl
K1js
J3až
J2skn
J2pr
J2pp
T1tr
T1pl
T1nm
P2nk
P2žl
P2pr
P2s
D3pm
D3ys
D3t
D3s-kp
D3į
D3šv
D2up
D2k
D2ld
D2pr
D1vš
D1gr
S2mn-jr
S2pg
S2br
S1r-ss
S1ln
O2-3
O1pk-lt
Є2kb
Є2dm
Є1vrb
Є1gg
PR1
100
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
-1200
-1300
-1400
-1500
-1600
-1700
-1800
-1900
-2000
-2100
-2200
-2300

Lithology of Cambrian, west-east profile, Lithuania

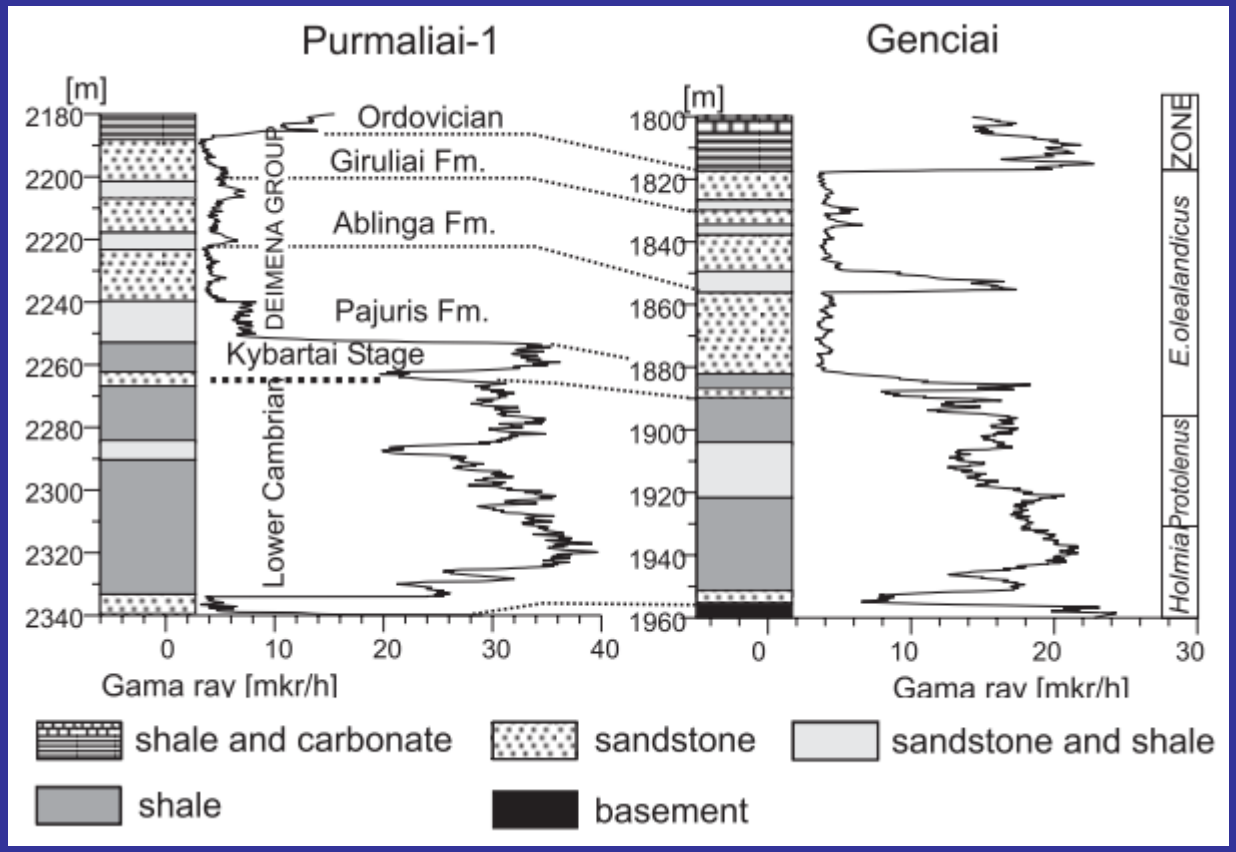


Chronostratigraphy of Lithuania

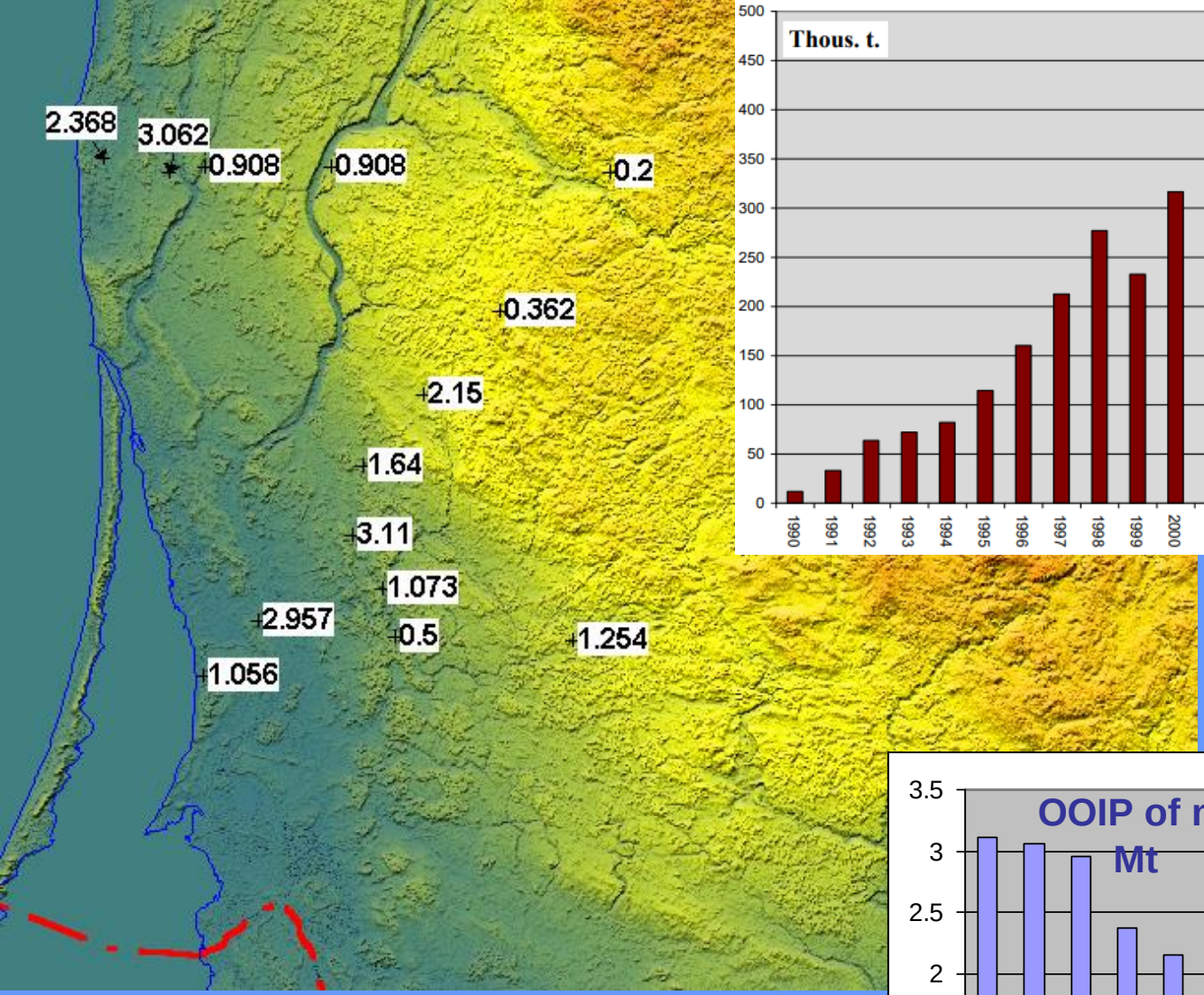


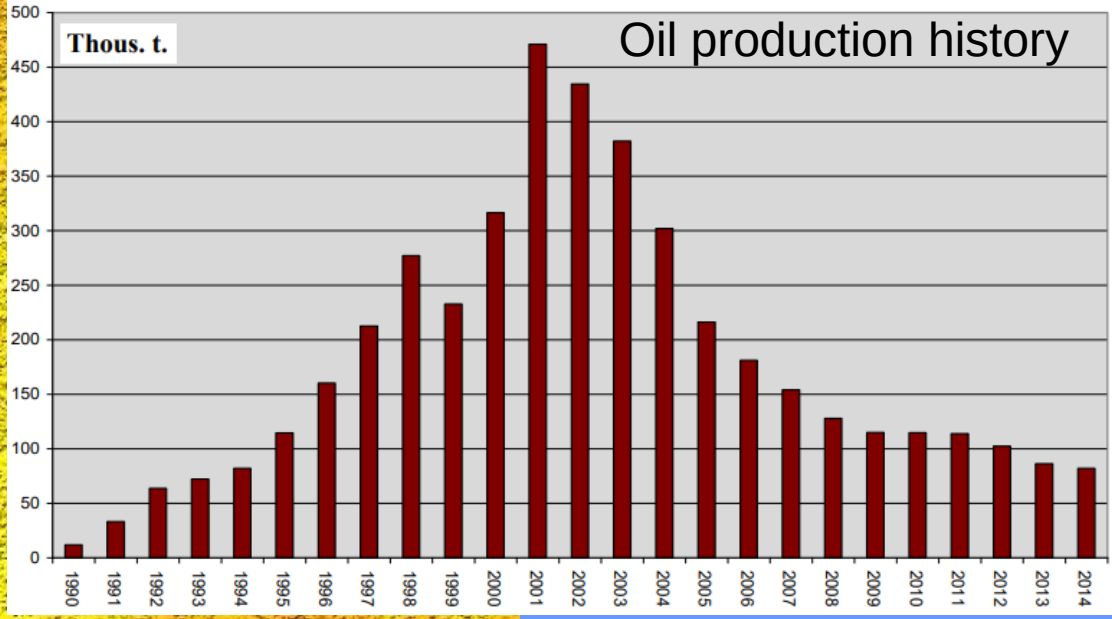
Petroleum plays

- Silurian Play
- Ordovician Play
- Cambrian Play



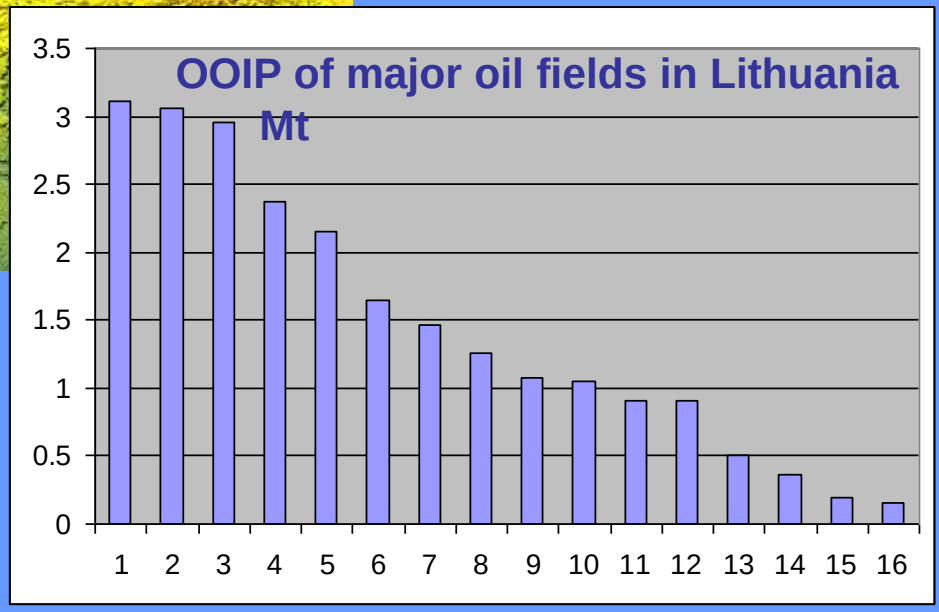
Gamma-ray logs and stratigraphic correlation of the Cambrian strata, West Lithuania

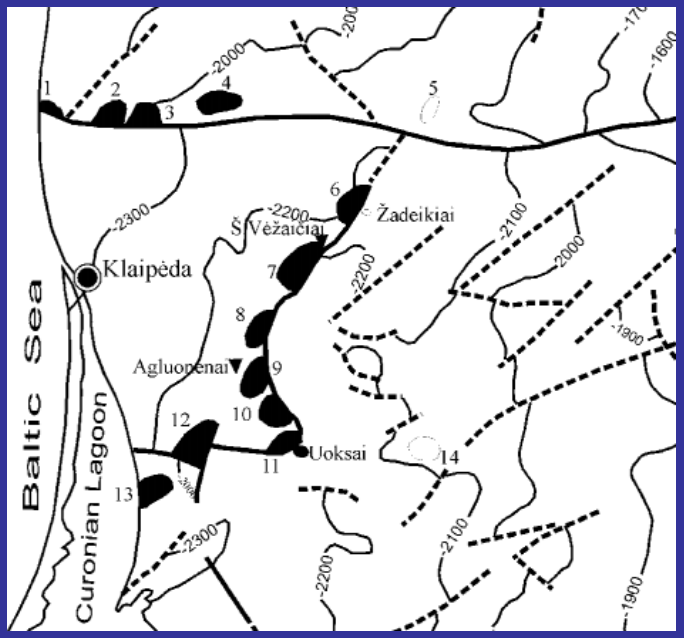




OOIP (mln.t) of oil fields of Cambrian reservoir

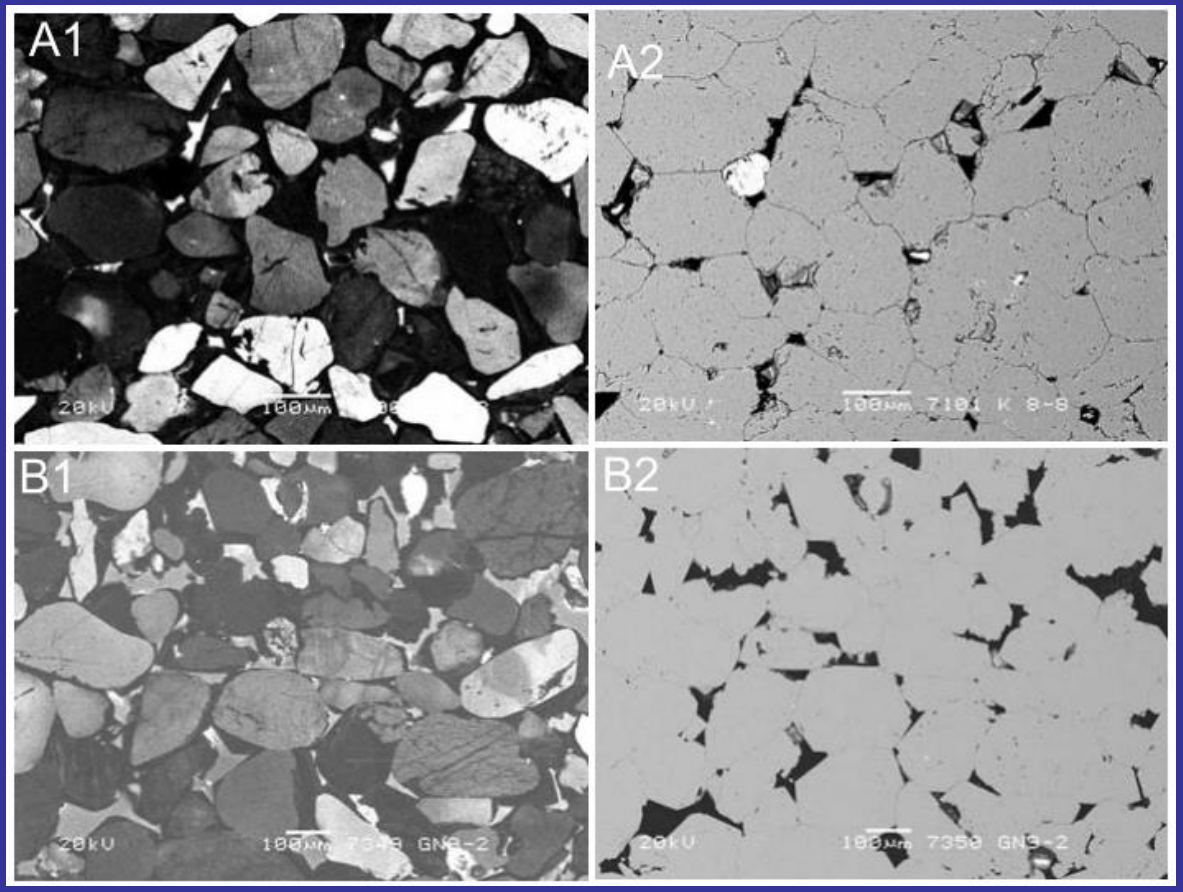
Total storage capacity 5.6 Mt





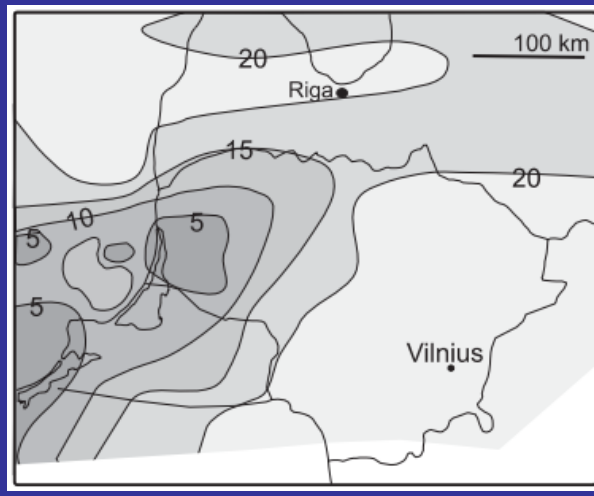
Physical properties of Lithuanian oil (example)

Well	Sampling interval, m	Age	Gravity, kg/m^3	Kinematic viscosity, 10^{-6} m^2/s	Saturated vol. %*	Arom. vol. %*	Polars vol. %*	Saturated / Arom.	Asphaltene, %	Boiling point, C° (b. p.)	Fraction b. p.-150 C°, volume %	Fraction b. p.-200 C°, volume %
Agluonėnai-2	1996–2030	E_2dm	803.6	6.0	57.0	29.0	10.0	1.96	4.0	43	30	45
Uoksai-1	2187–2200	E_2dm	814.8	7.09	65.6	23.9	8.3	2.74	2.2	85	18	30
Antkoptis-1	1900–2003	E_2dm	814	7.41	72.9	22.3	5.1	3.26	–	78	16	24
Žadeikiai-1	1985–1992	O_1pk	853.2	20.03	43.4	39.0	13.4	1.11	1.2	66	14	20

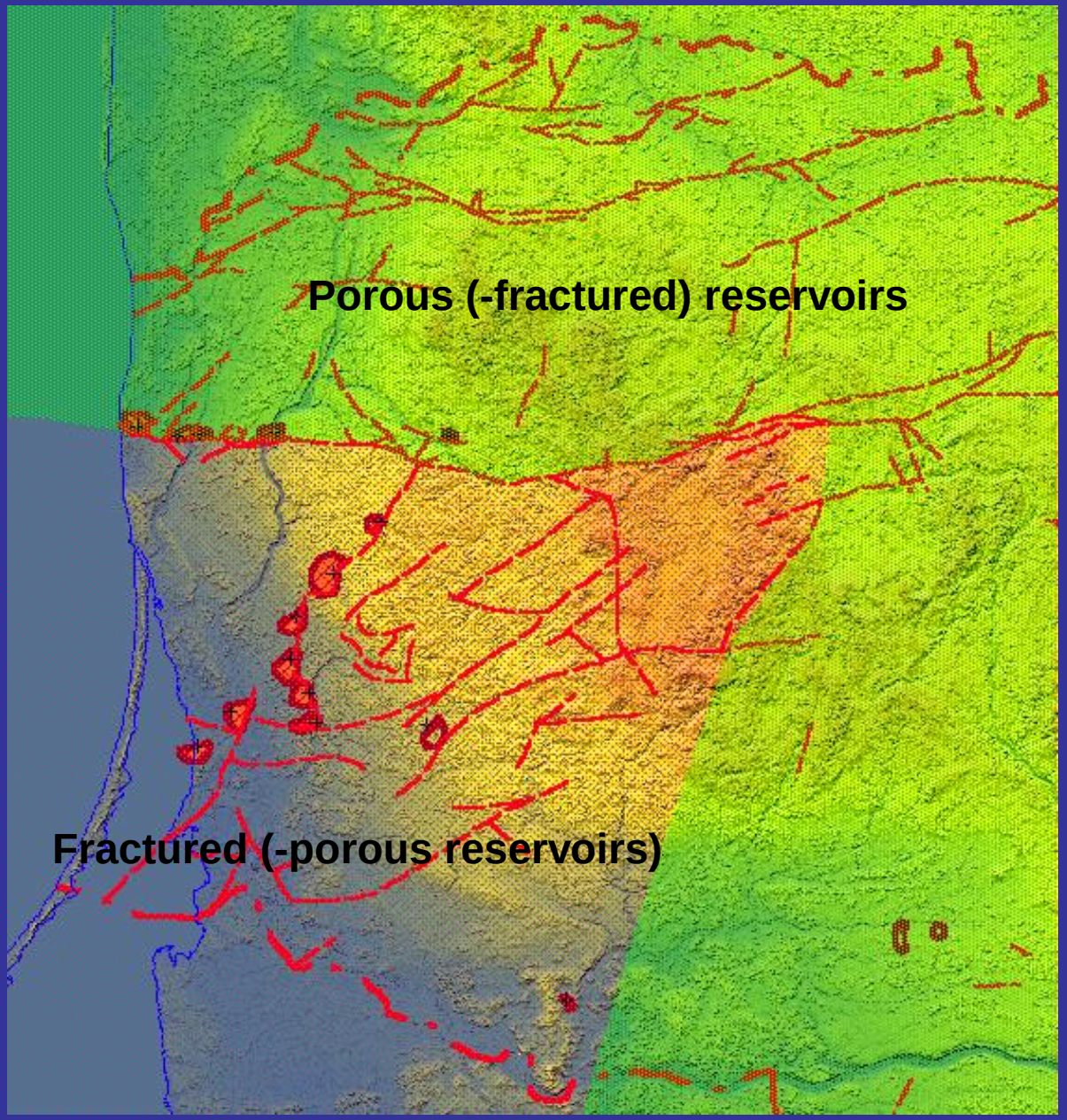


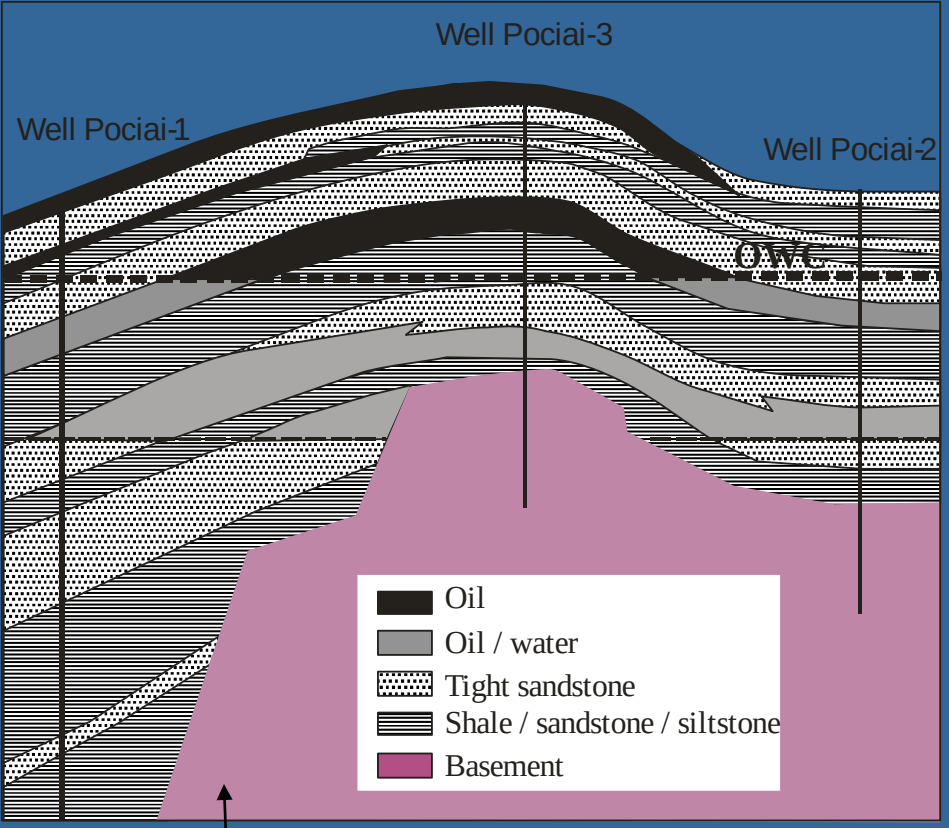
CL and BSE micrographs of Cambrian sandstones A – Kretinga oil field, depth 1560, porosity 6%; B-Genciai oil field, depth 1830 m, porosity 10%)

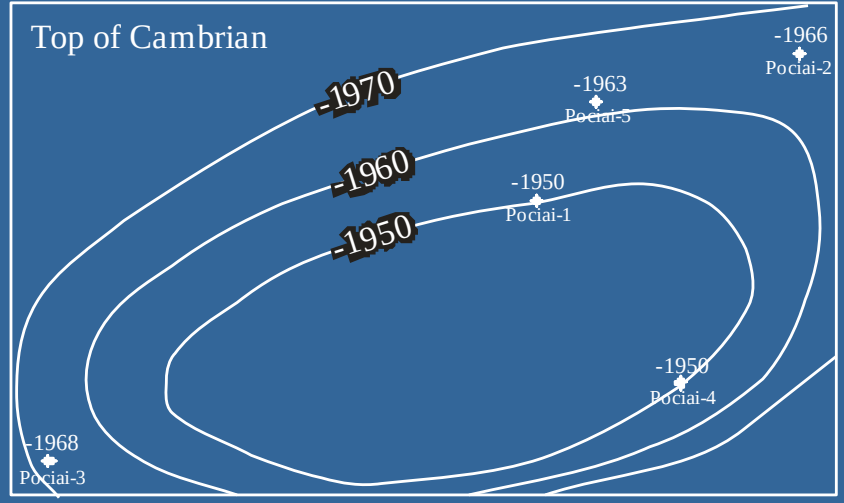
Average porosity of Cm sandstones

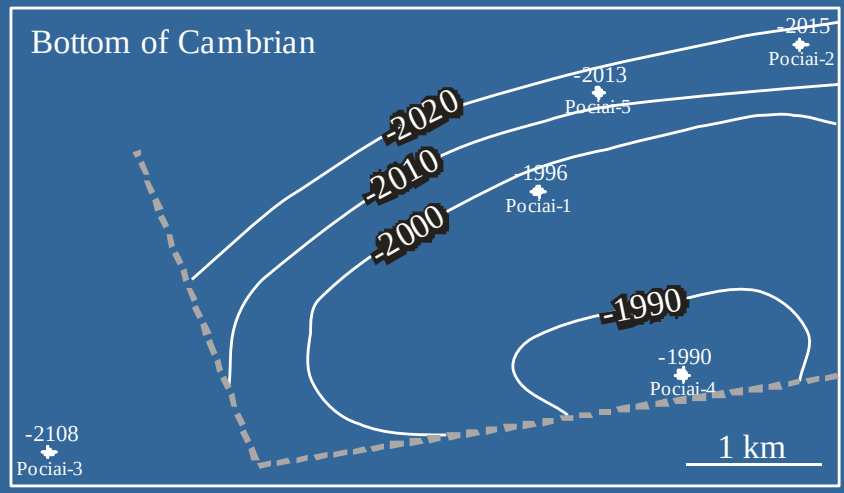


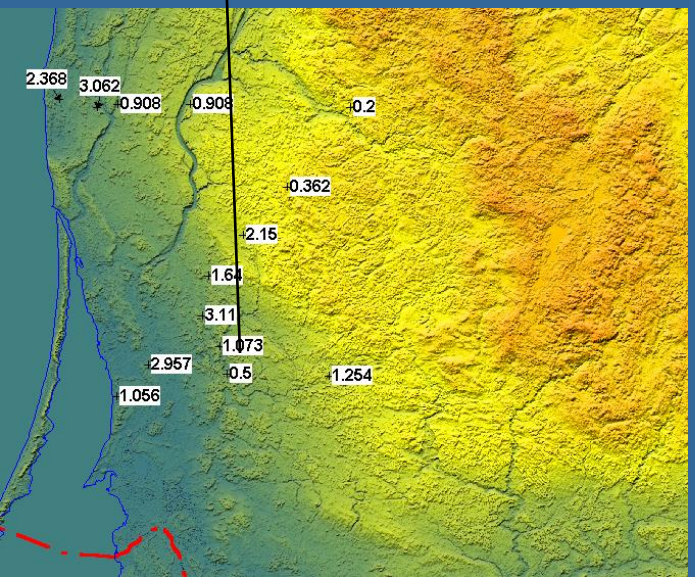
Reservoir types of Middle Cambrian











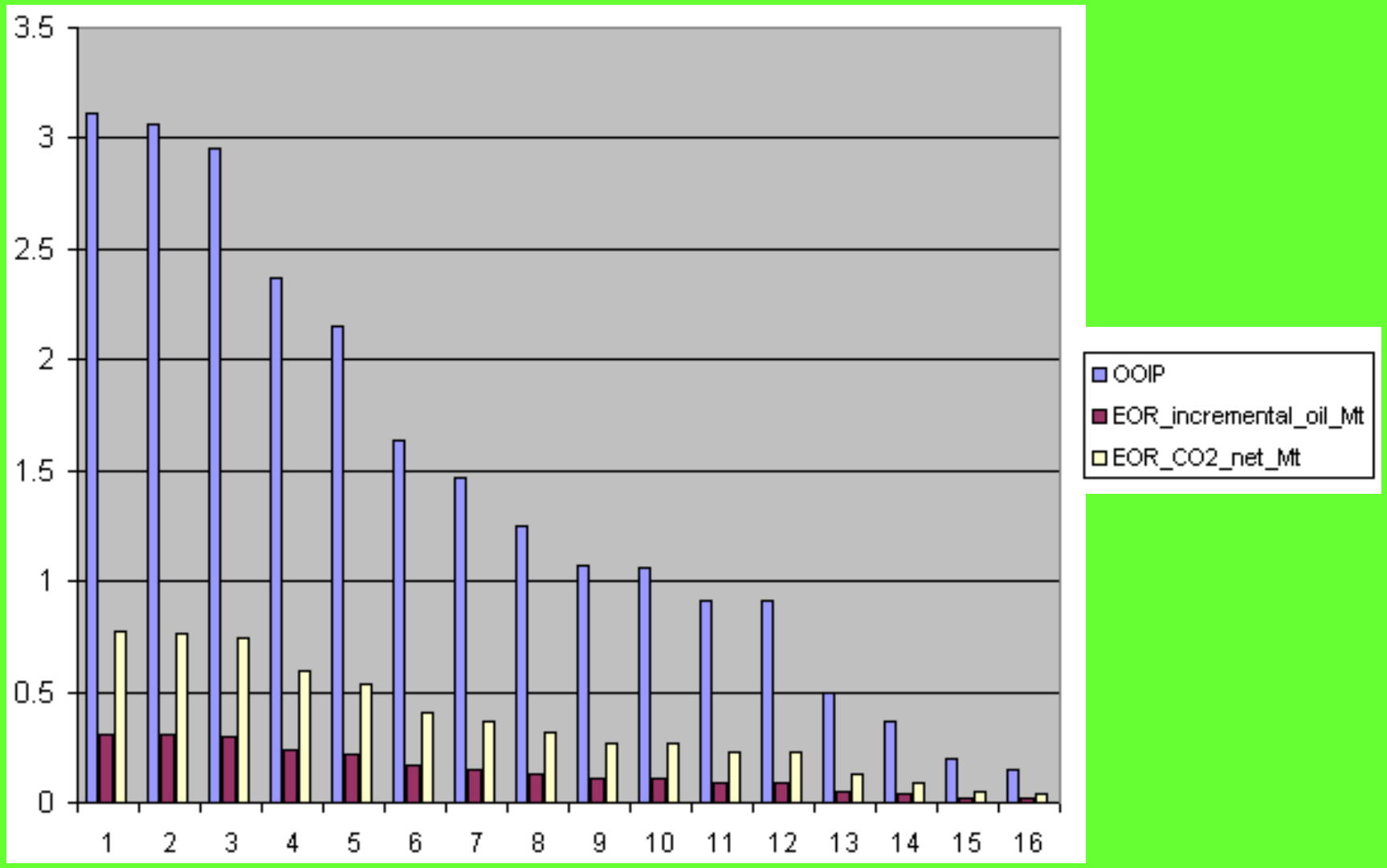
POCIAI OIL FIELD, WEST LITHUANIA

CO_2-EOR/Sequestration Potential

Rule-of-Thumb Approach (historical experience)

- Incremental Oil Recovery (% OOIP)
  - 8-16 %
- Gross CO_2 Utilization (Mcf/Bbl)
  - 5-10 Mcf/Bbl
- Net/Gross Utilization Ratio (fraction)
  - 0.5

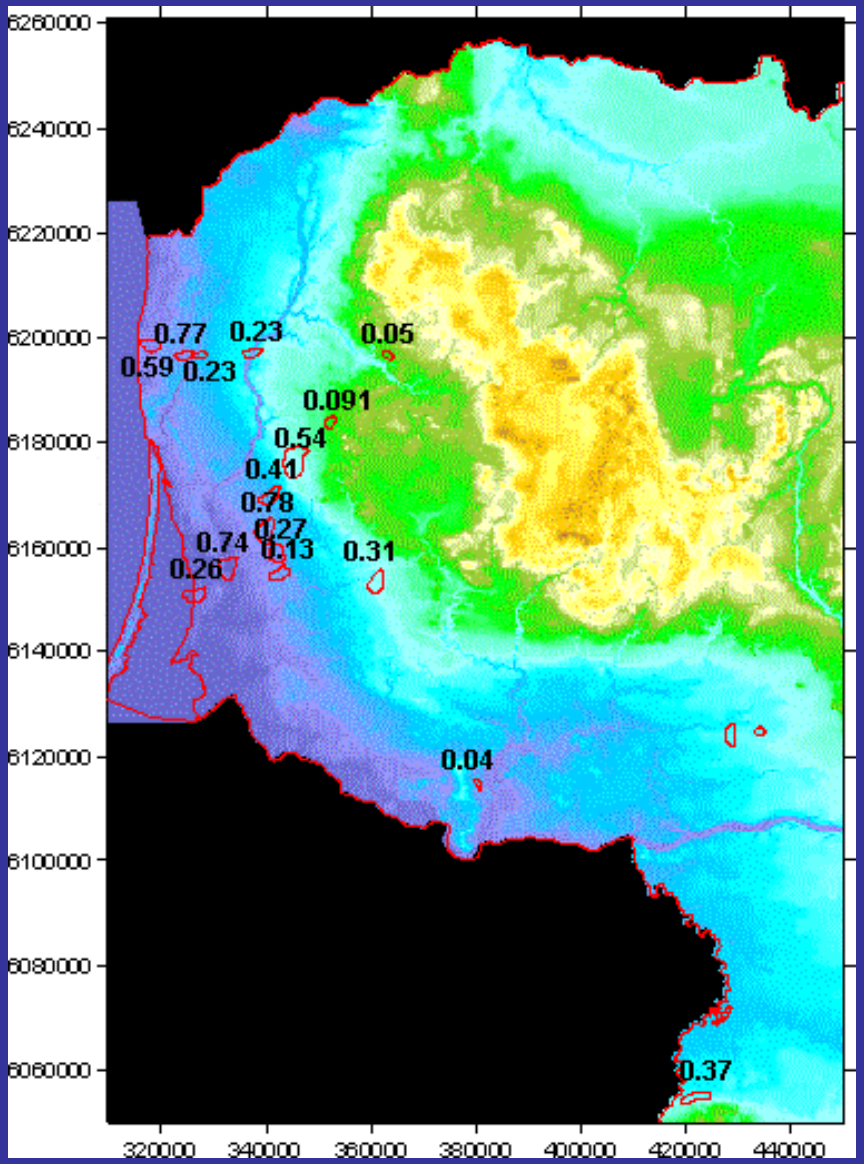
EOR POTENTIAL IN LITHUANIA
(Rule-of-Thumb Oil Recovery)



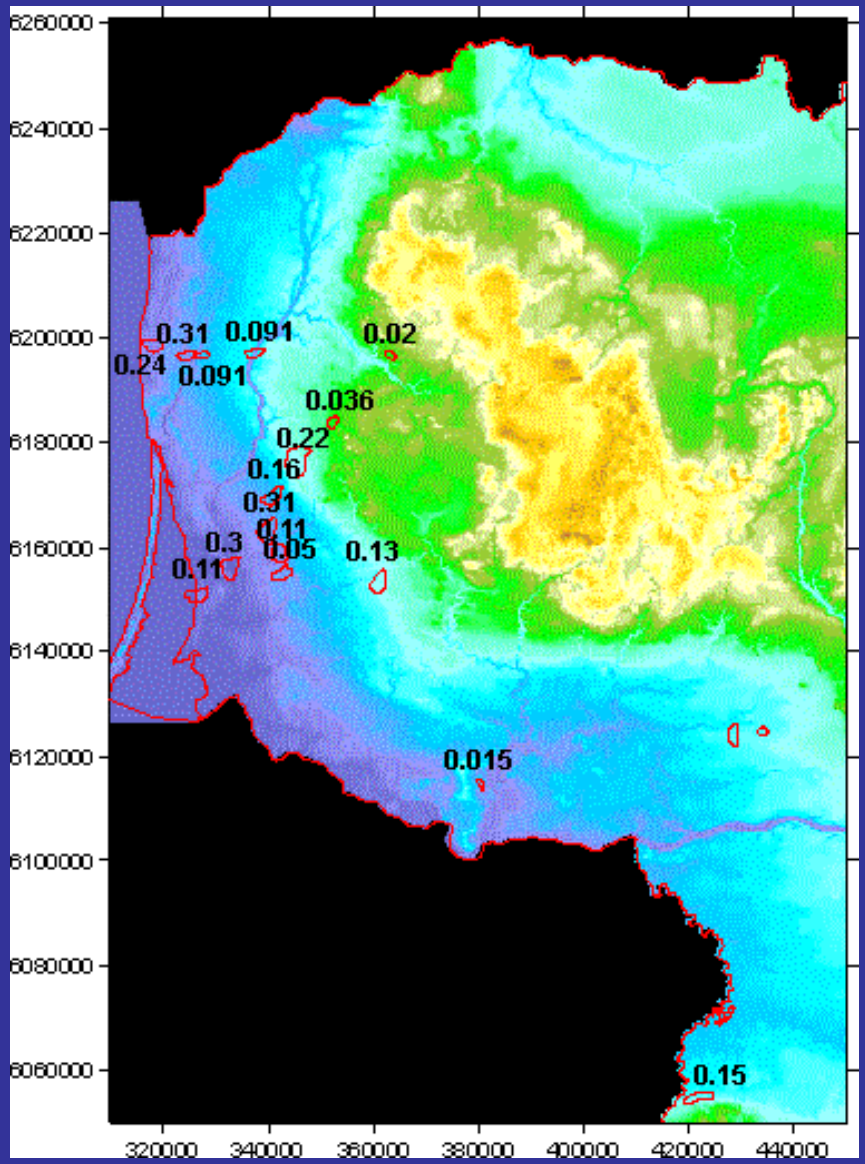
EOR CO_2 **net** potential volume **5.8** Mt

EOR prospects

EOR net CO2, Mt



EOR incremental oil, Mt

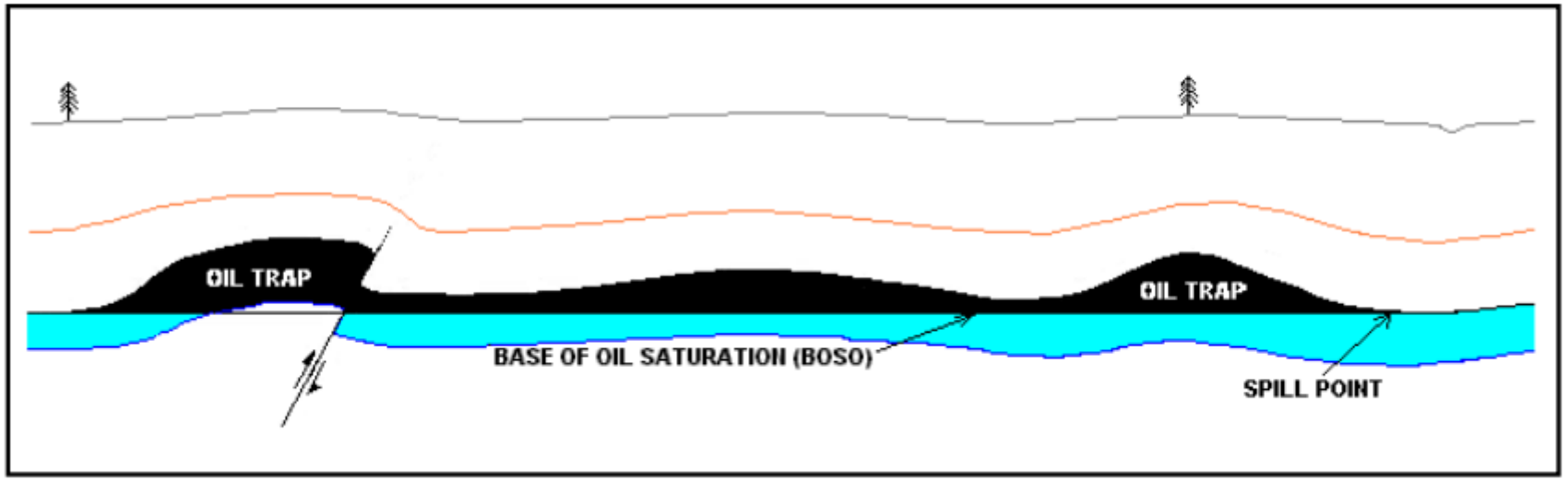


RESIDUAL OIL ZONE

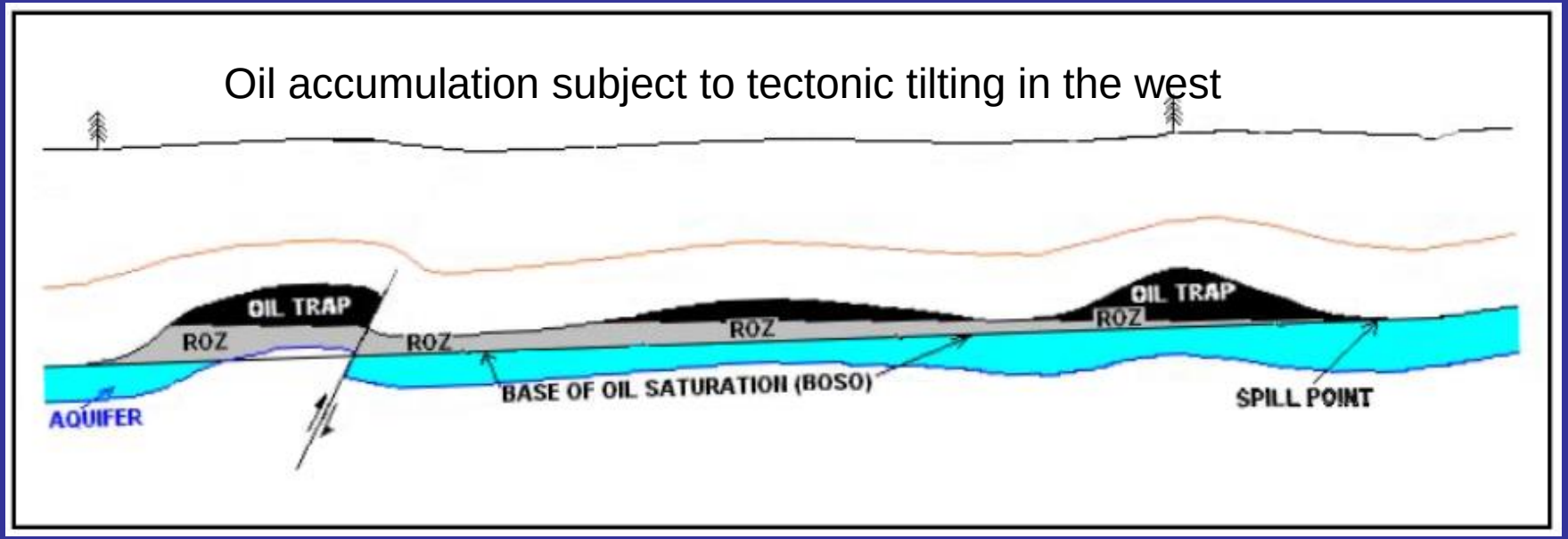
W

Original oil accumulation

E

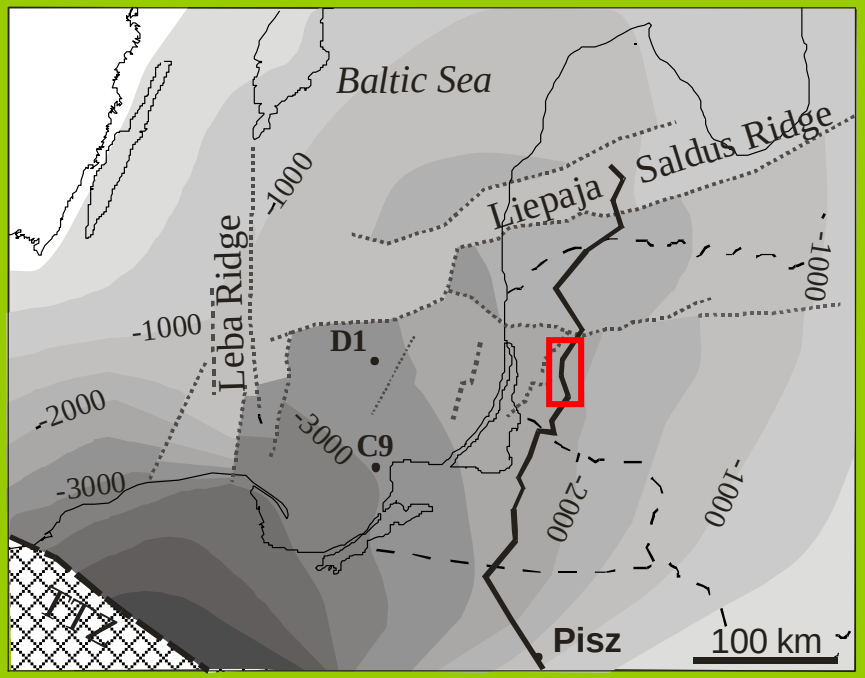


Oil accumulation subject to tectonic tilting in the west



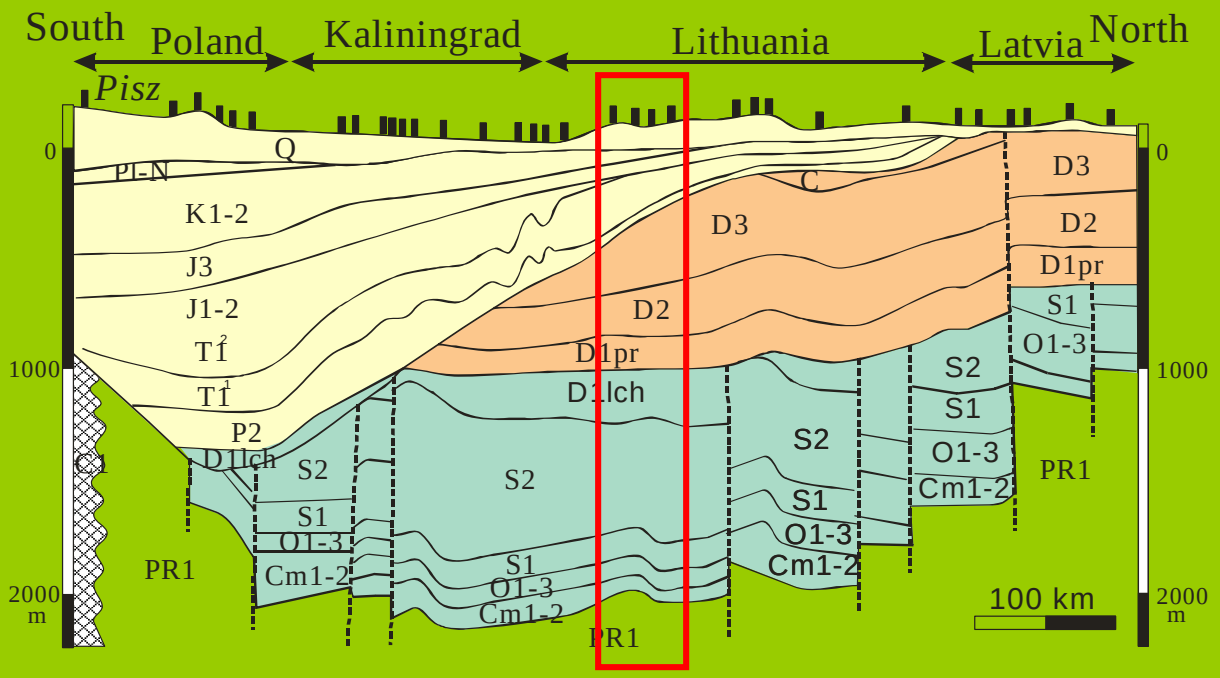
Melzer Consulting

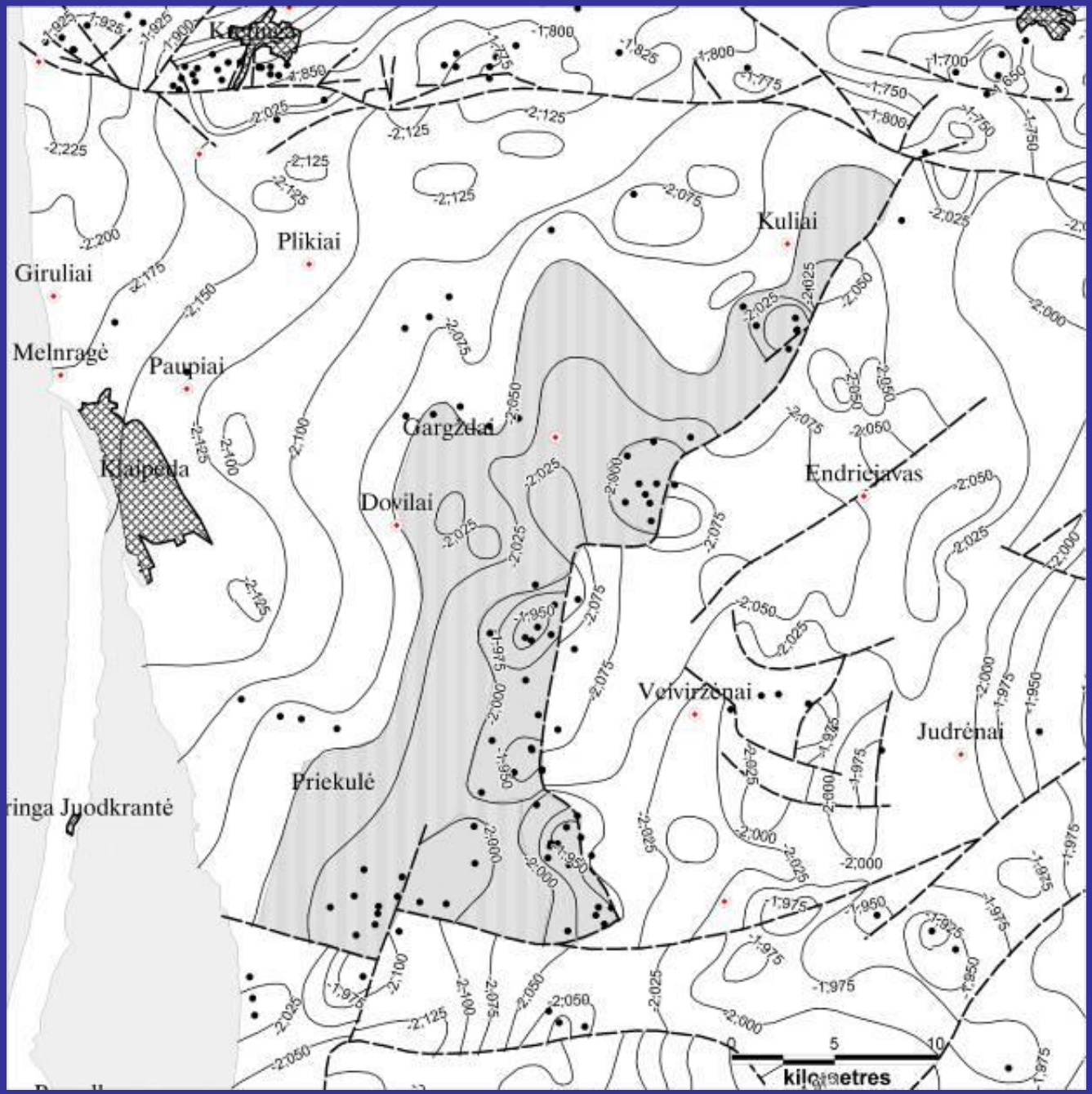
Bottom of Cambrian



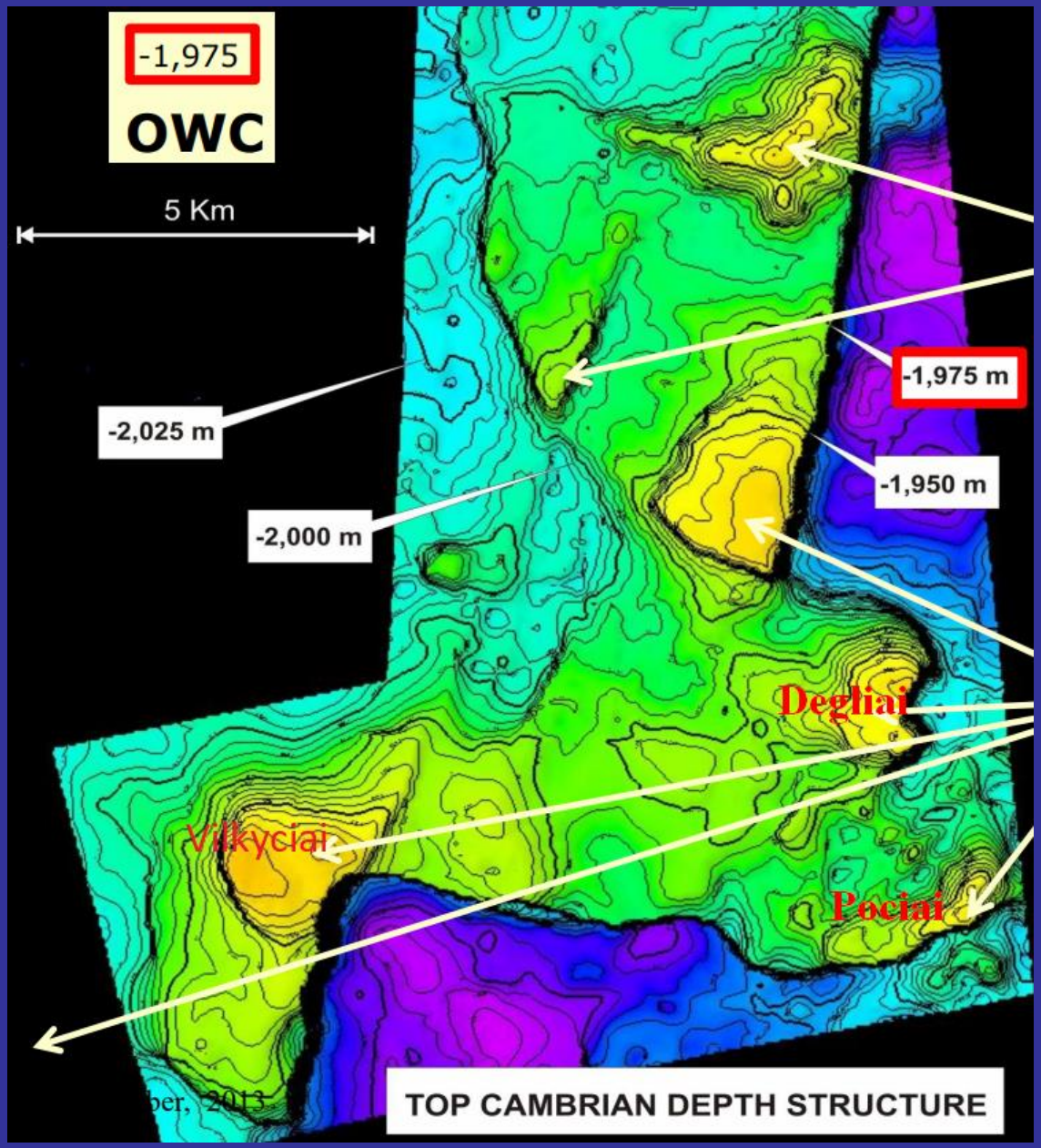
Profile

Major oil accumulation took place during the Late Devonian-Early Carboniferous, it was succeeded by intense uplift in the south during the Late Carboniferous-Early Permian, that inversed to subsidence since the Late Permian





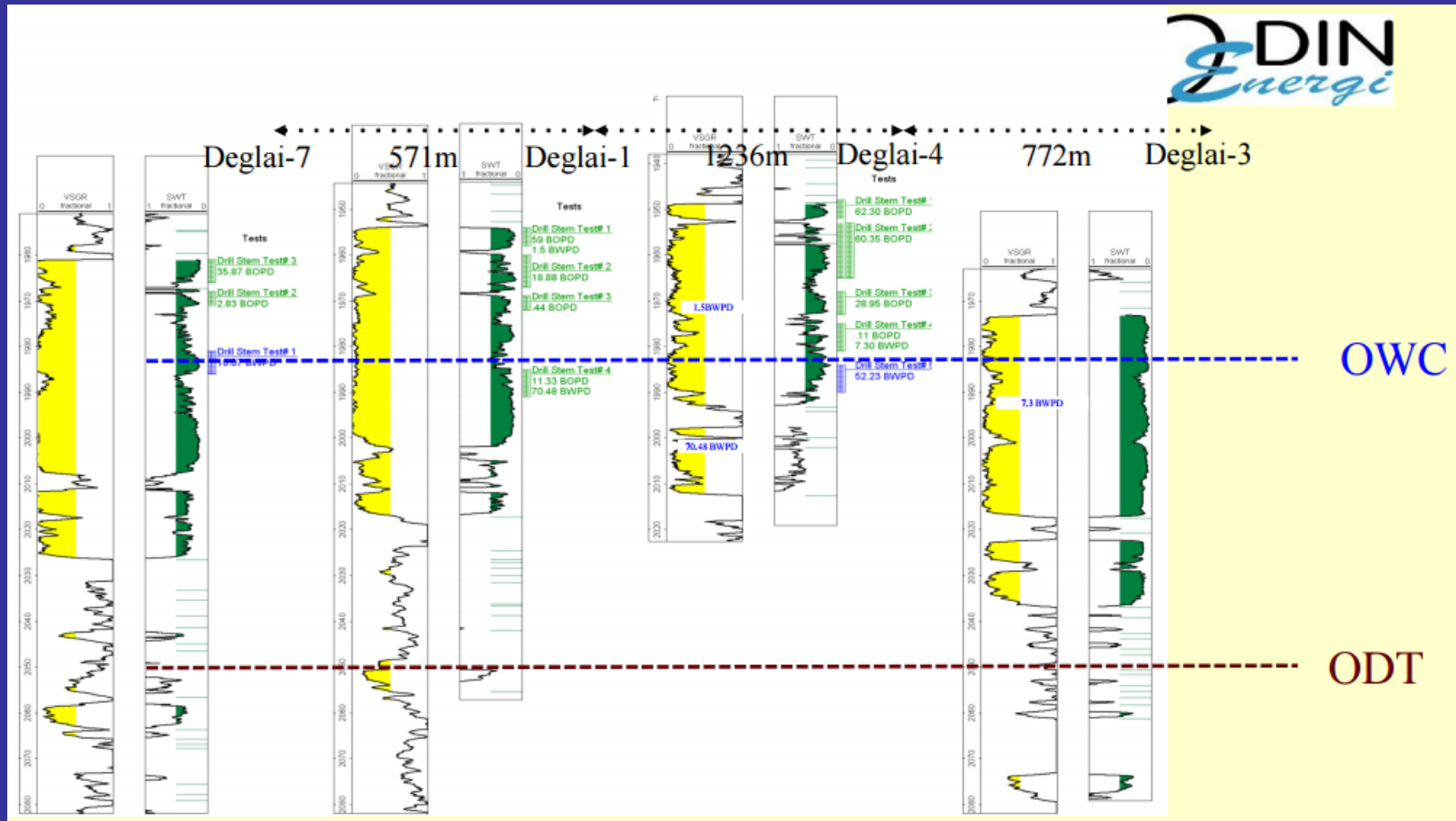
Gargzdai oil zone



Structural map of the Middle Cambrian sandstone reservoir, Gargzdai oil zone. 3D seismic survey. Oil accumulations are confined to the structural uplifts

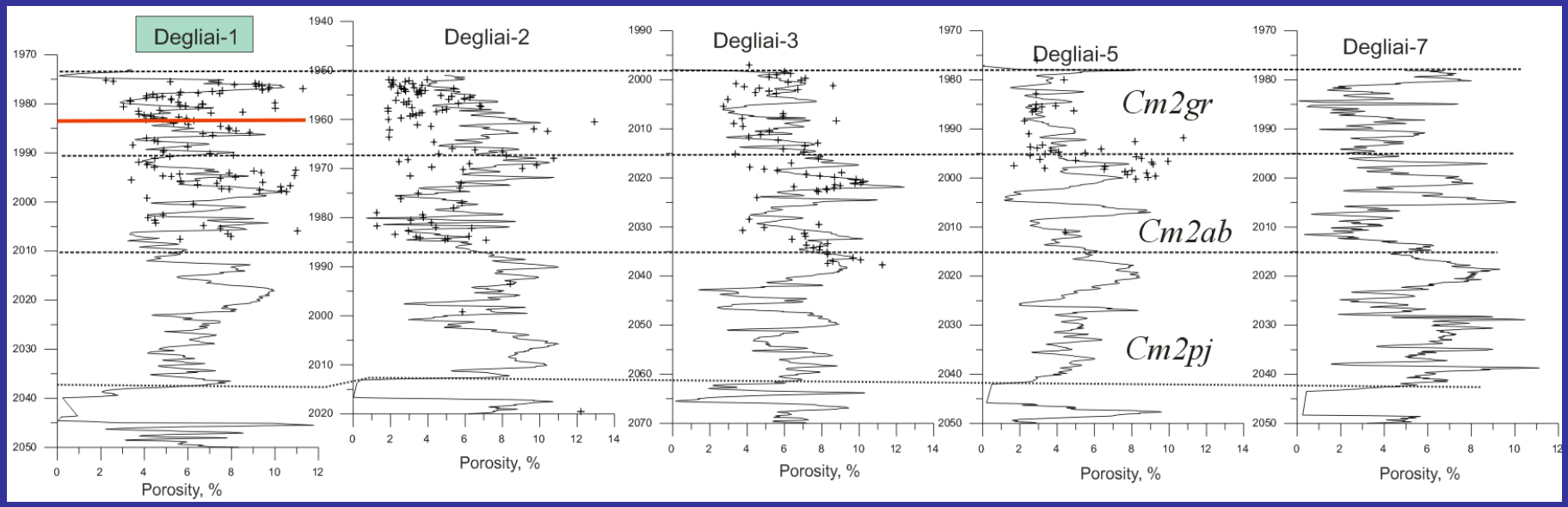
OWC selected at –1970m on basis well flow tests but oil is seen down to -2040m with oil saturations of 40-60%

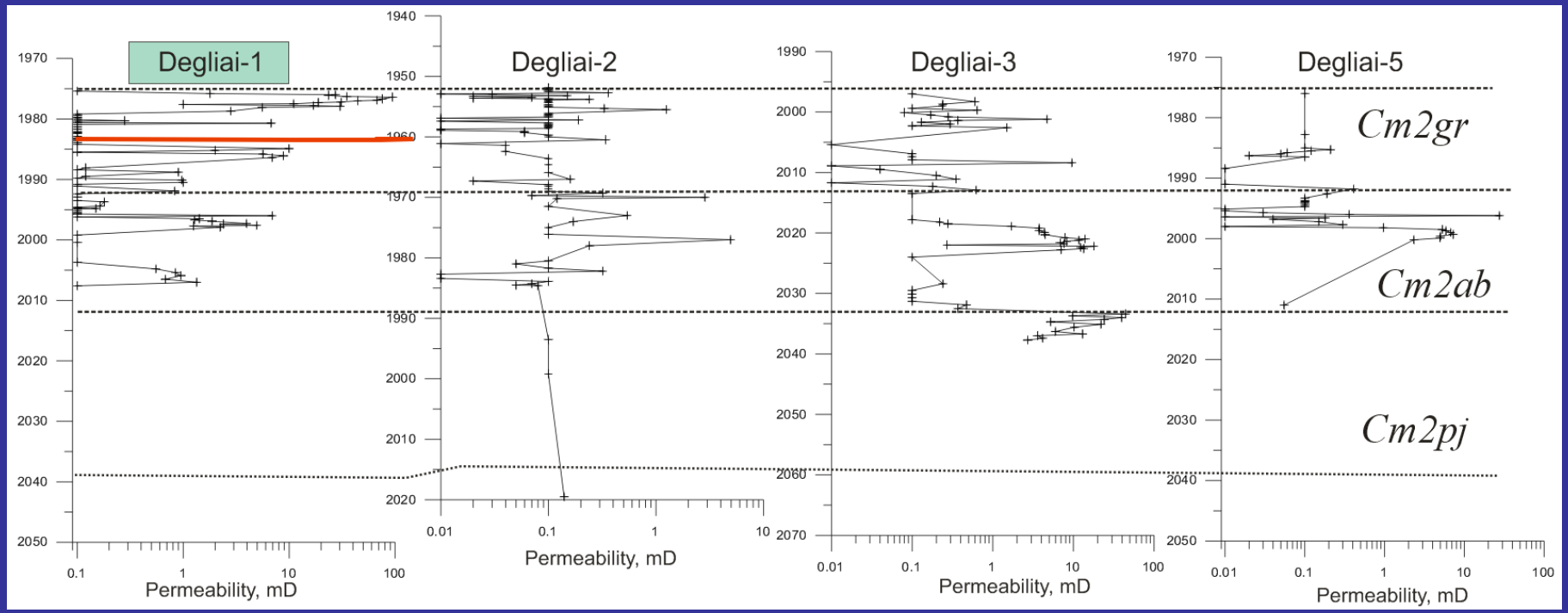
- Injected 1,000 tons CO2 into Degliai-1 producing zone
- Produced oil back
- Producing approximately 1 ton (7 barrels) of oil per ton of CO2 produced



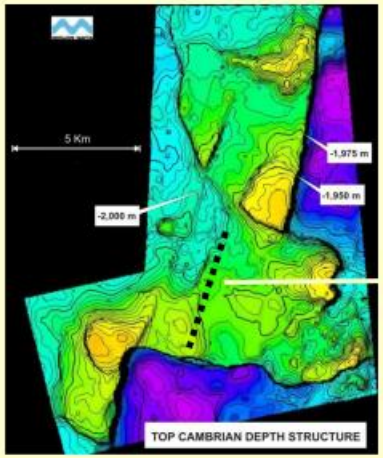
OWC selected at –1970m on basis well flow tests but oil is seen down to -2040m with oil saturations of 40-60%.

Reservoir properties of the Degiliai oil field

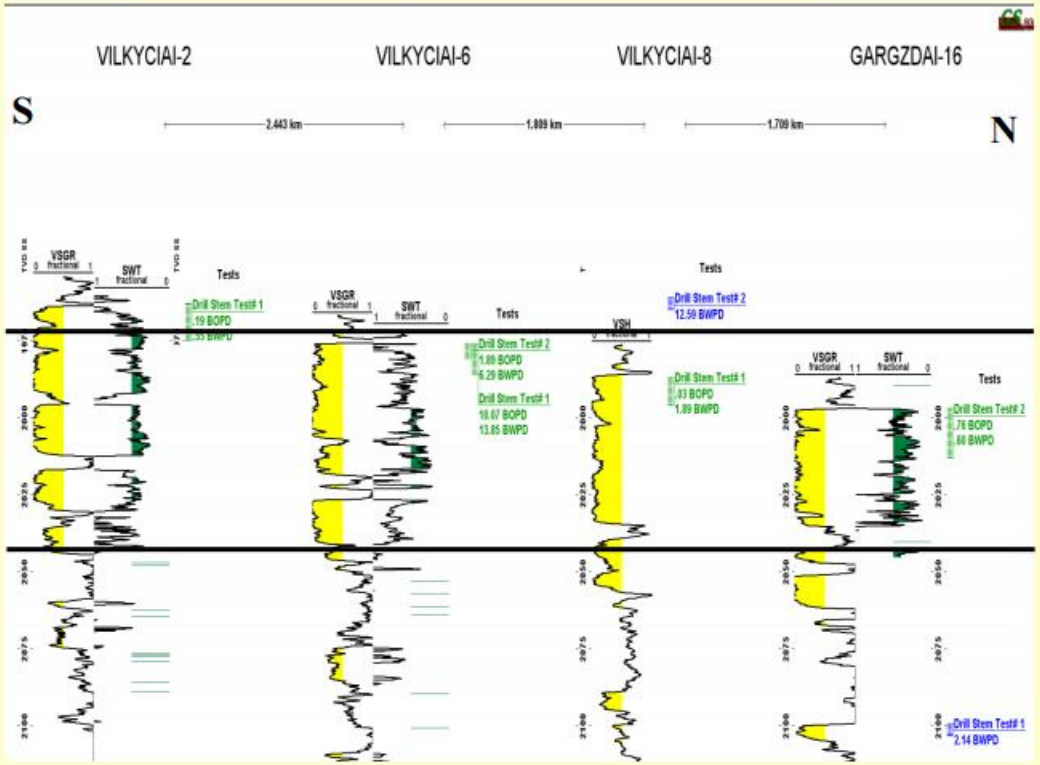




THICK RESIDUAL OIL ZONE EXISTS IN LITHUANIA



CROSS-SECTION BELOW; ALL RESERVOIRS BELOW OWC

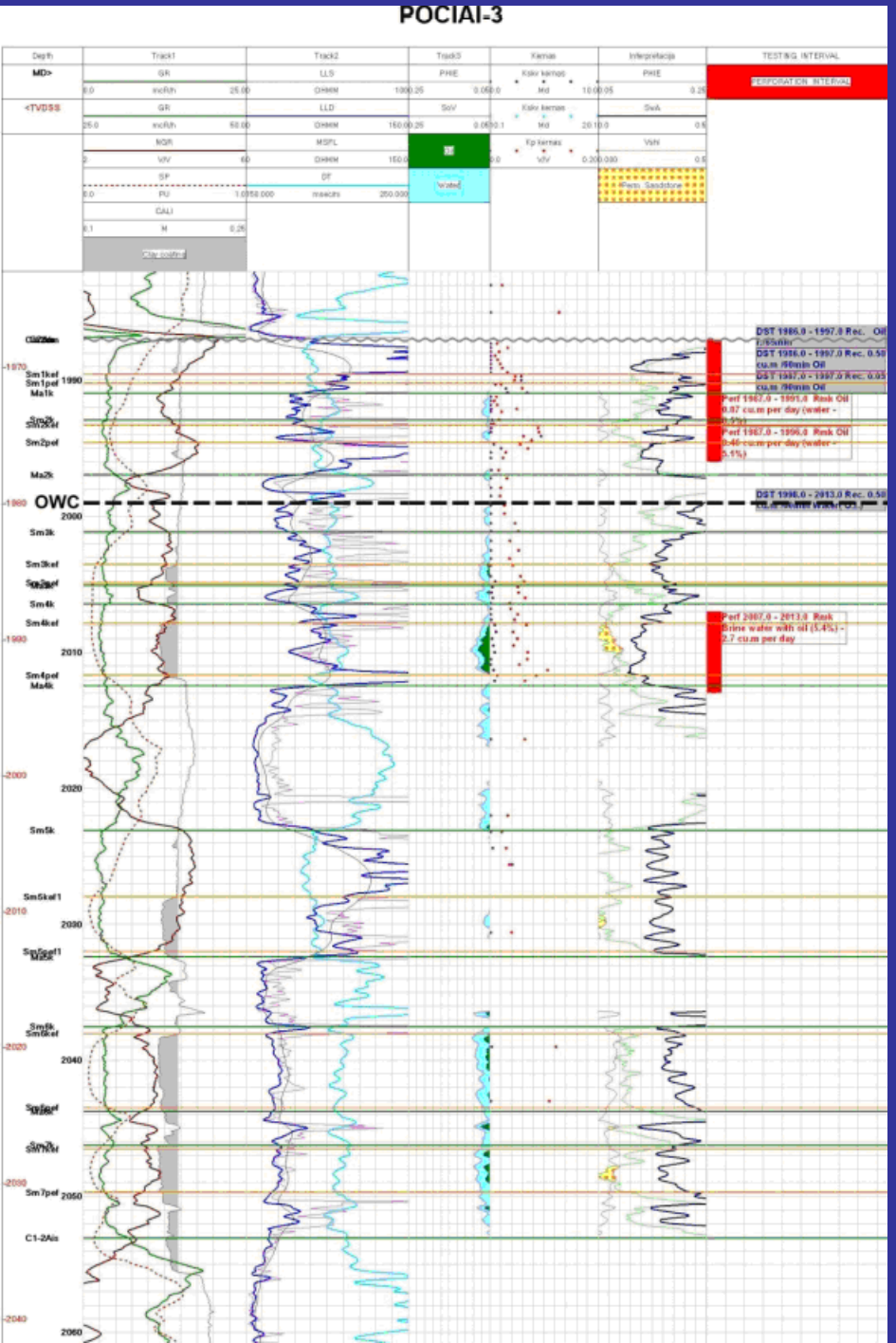


OIL-WATER-CONTACT –1,973

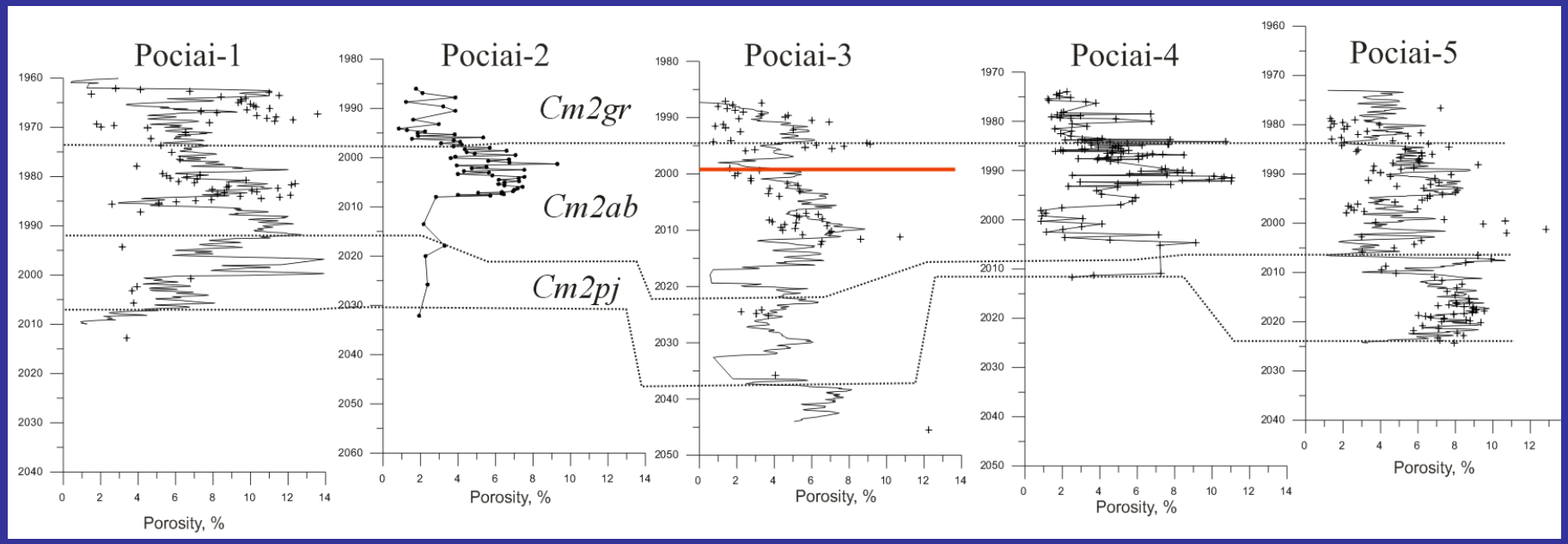
65 m RESIDUAL OIL ZONE (ROZ)

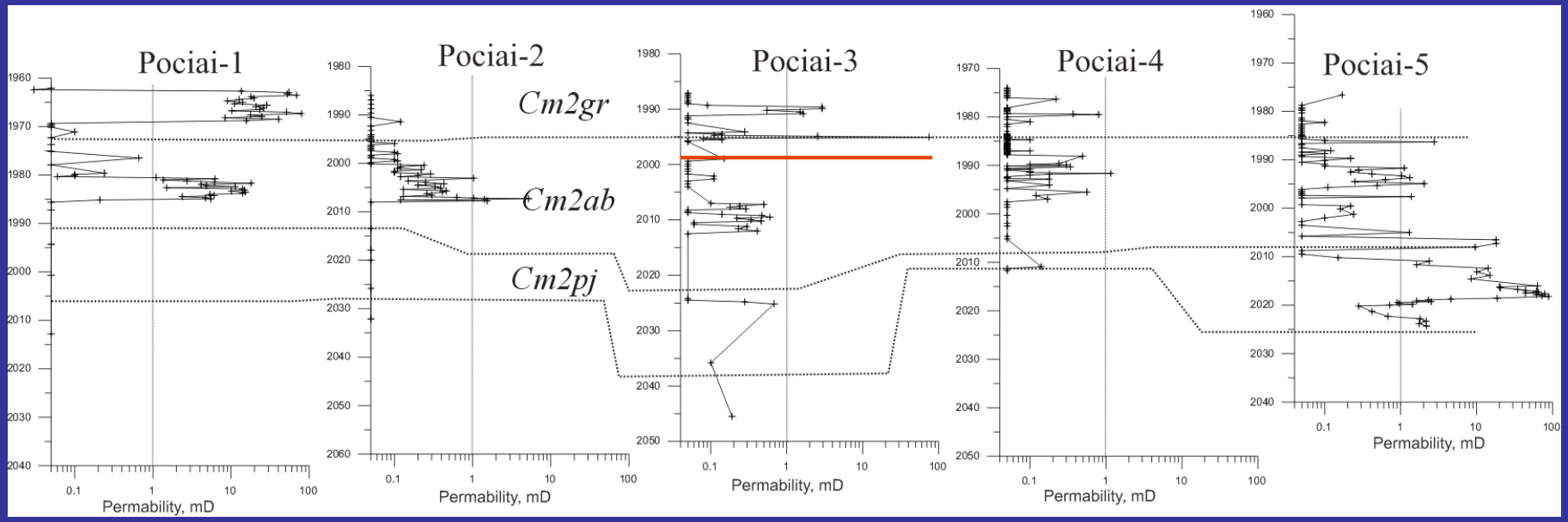
BASE of OIL SATURATION ("BOSO") –2,040

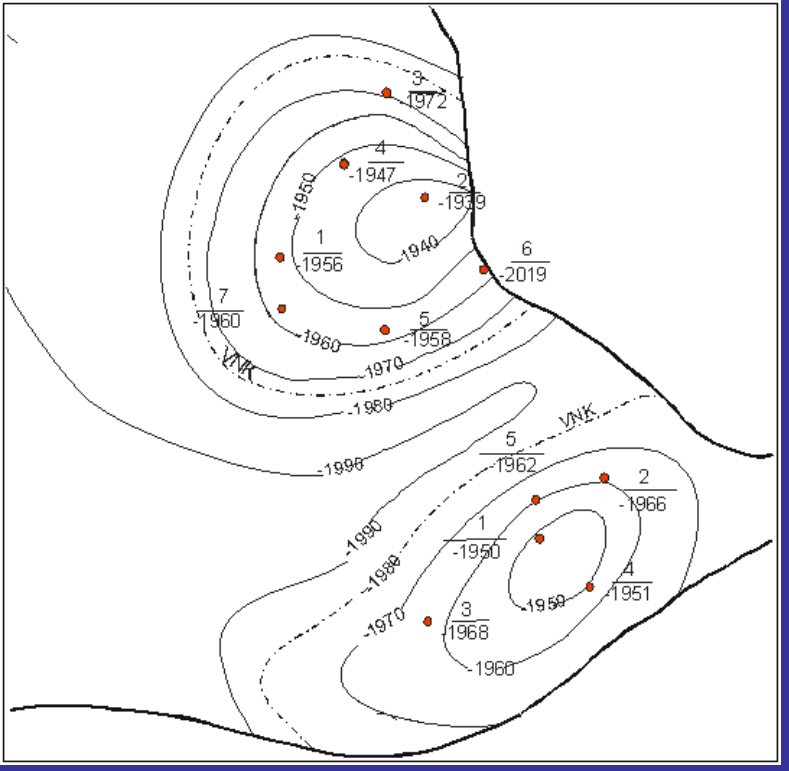
December, 2013

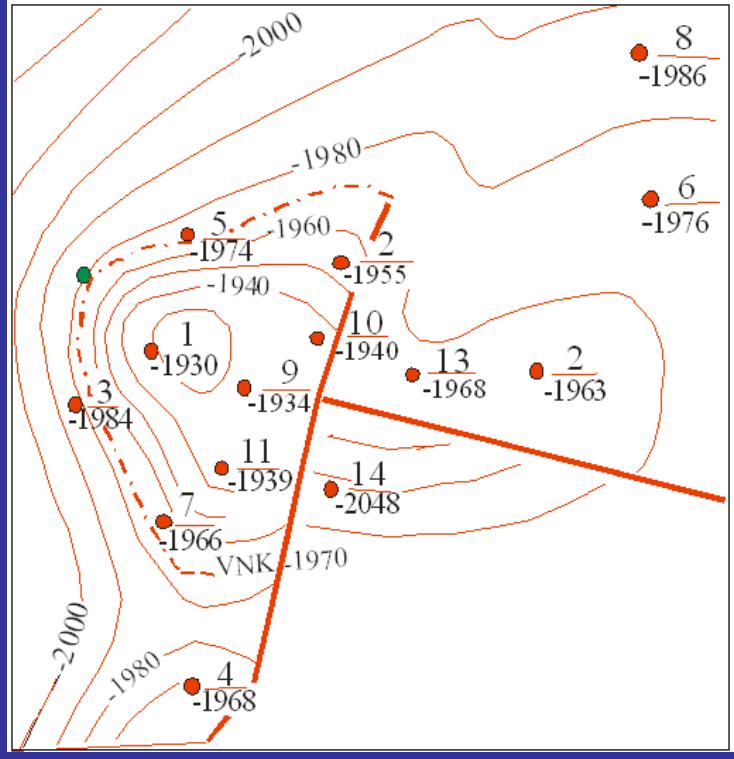


- Test produced well for 6 months—2-3 bpd Injected 500 tons in ROZ • Shut in for 1 month and produce back

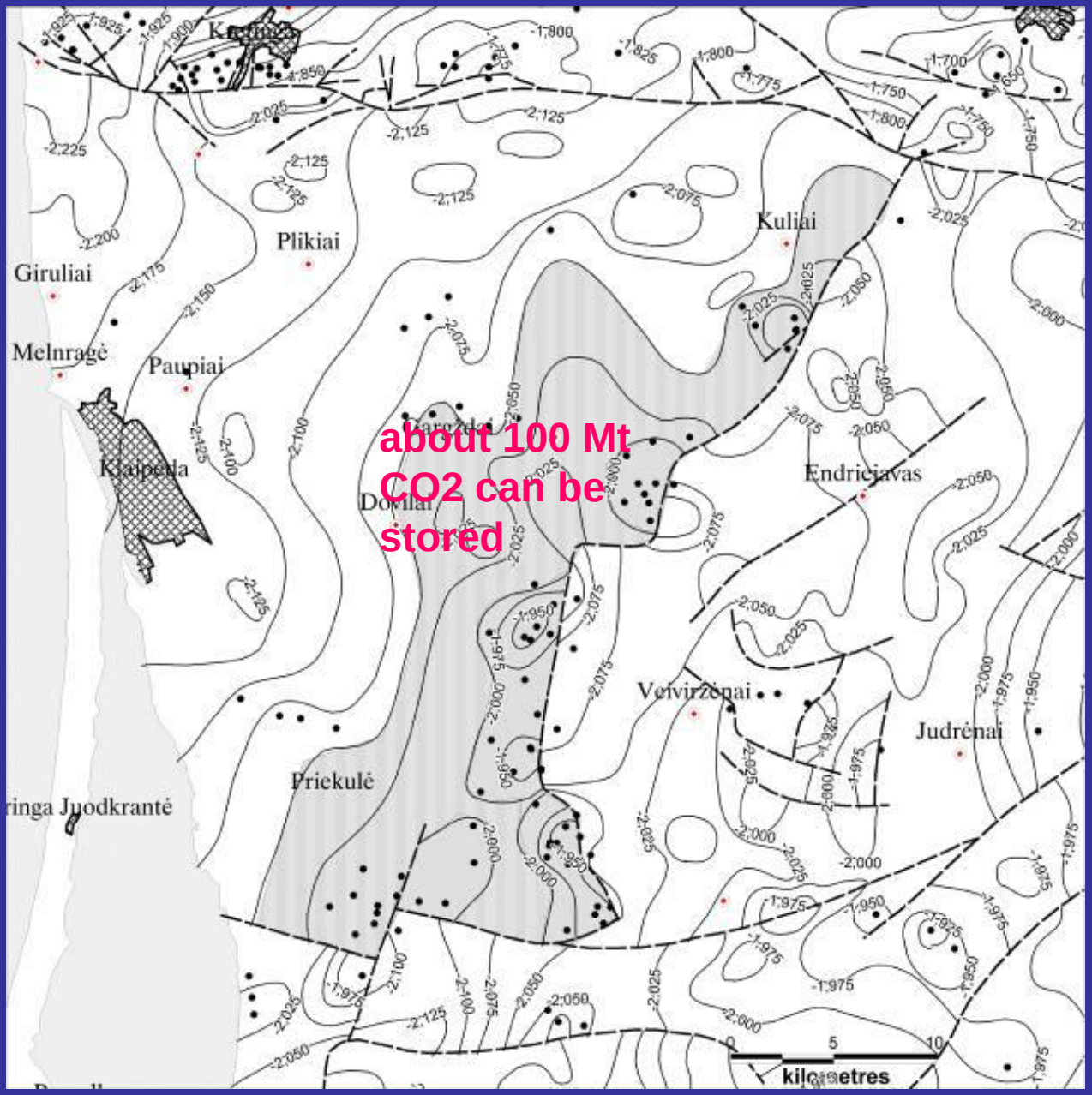

Pociai-1
Pociai-2
Pociai-3
Pociai-4
Pociai-5
Cm2gr
Cm2ab
Cm2pj
Porosity, %


Pociai-1
Pociai-2
Pociai-3
Pociai-4
Pociai-5
Cm2gr
Cm2ab
Cm2pj
Permability, mD

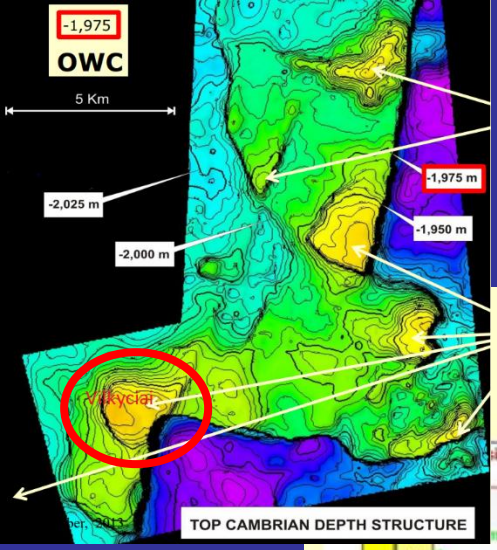




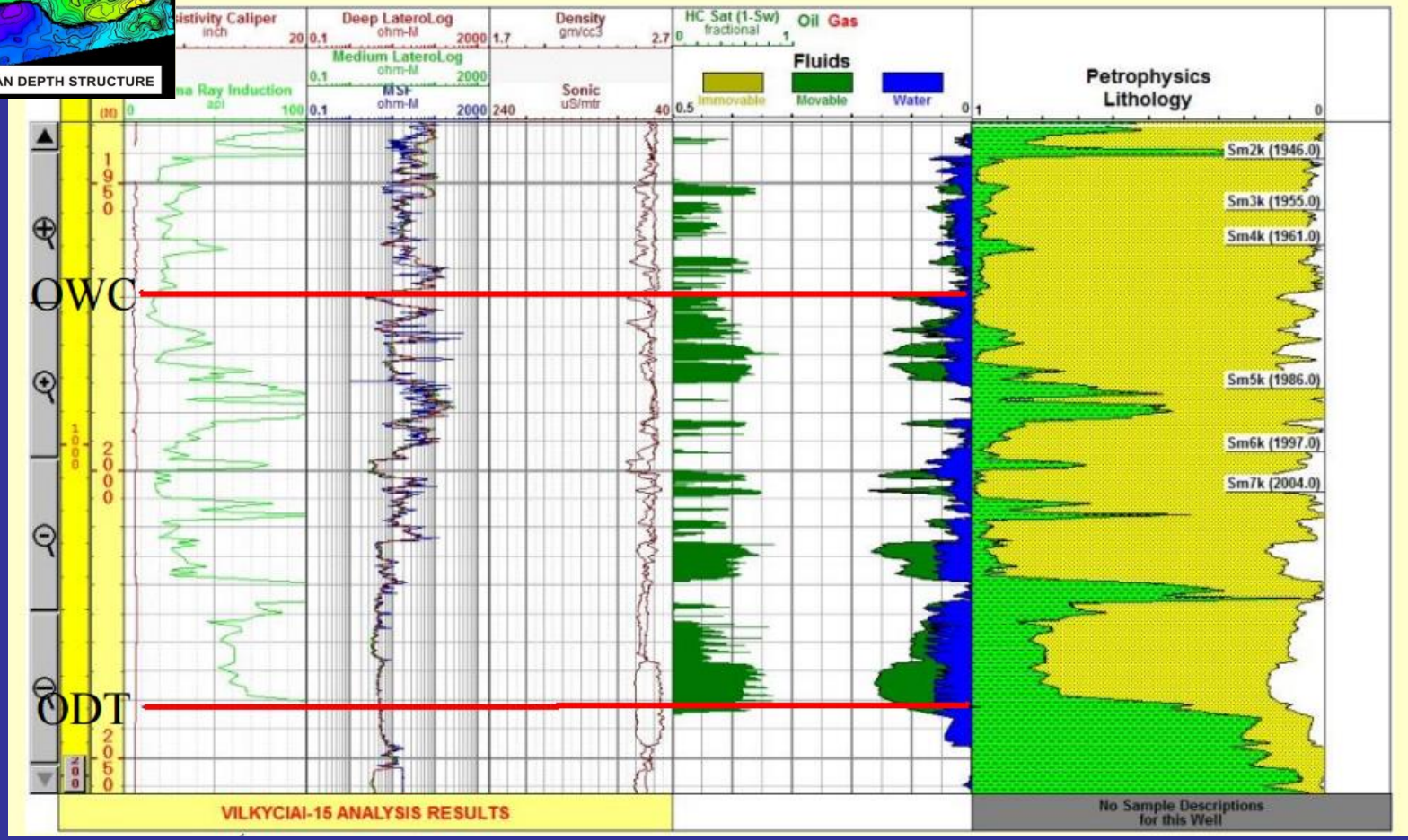
Structural maps of Degliai and Pociai (left) and Vilkyciai (righgt) oil fields, top of Cambrian reservoir (m), before 3D seismic survey



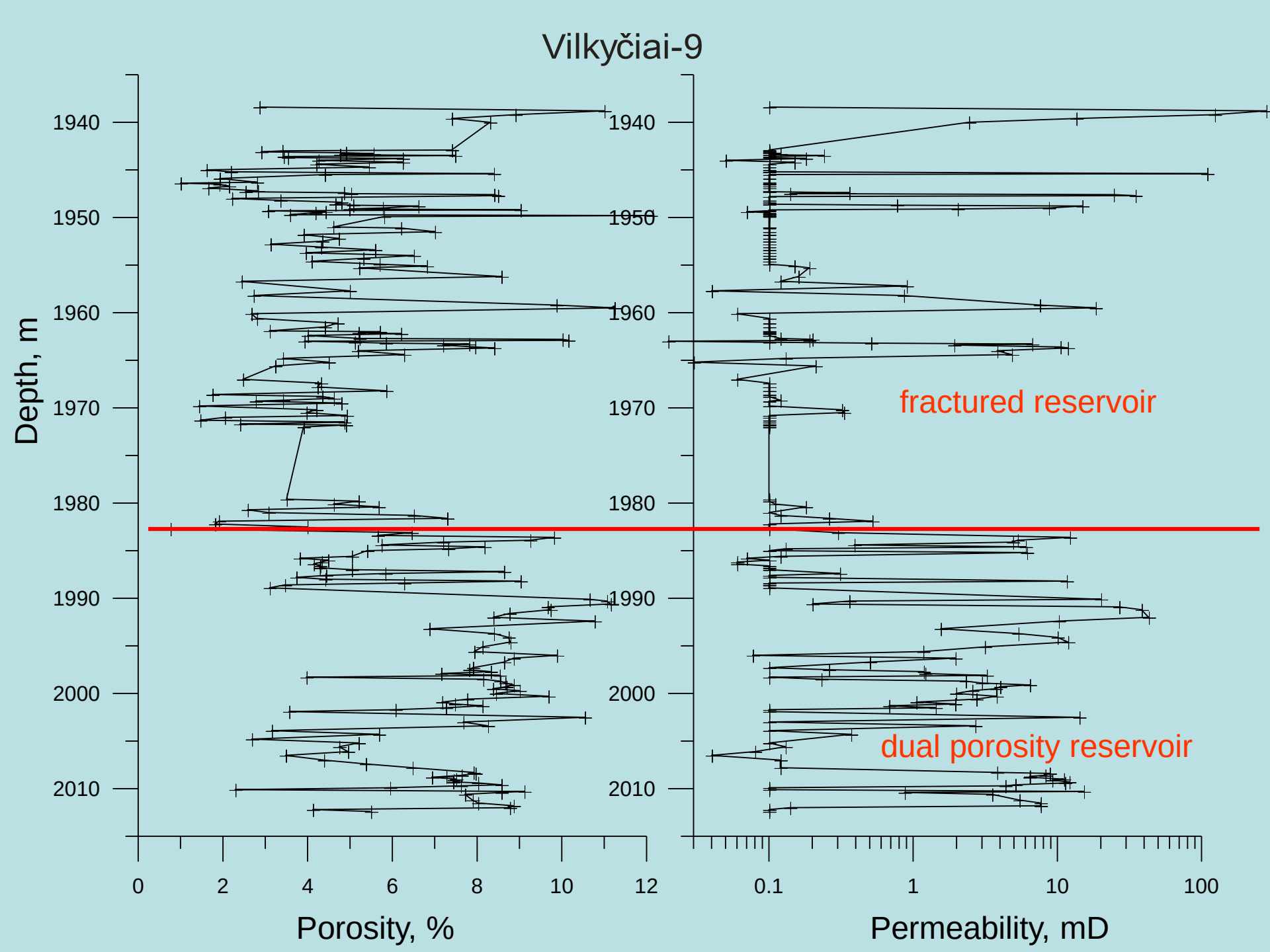
Structural map of top of Cambrian. Shaded area shows Gargždai elevation



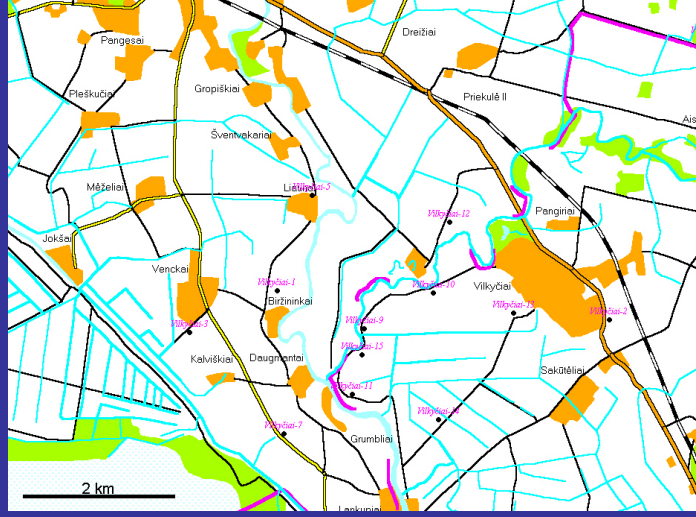
Vilkyciai-15

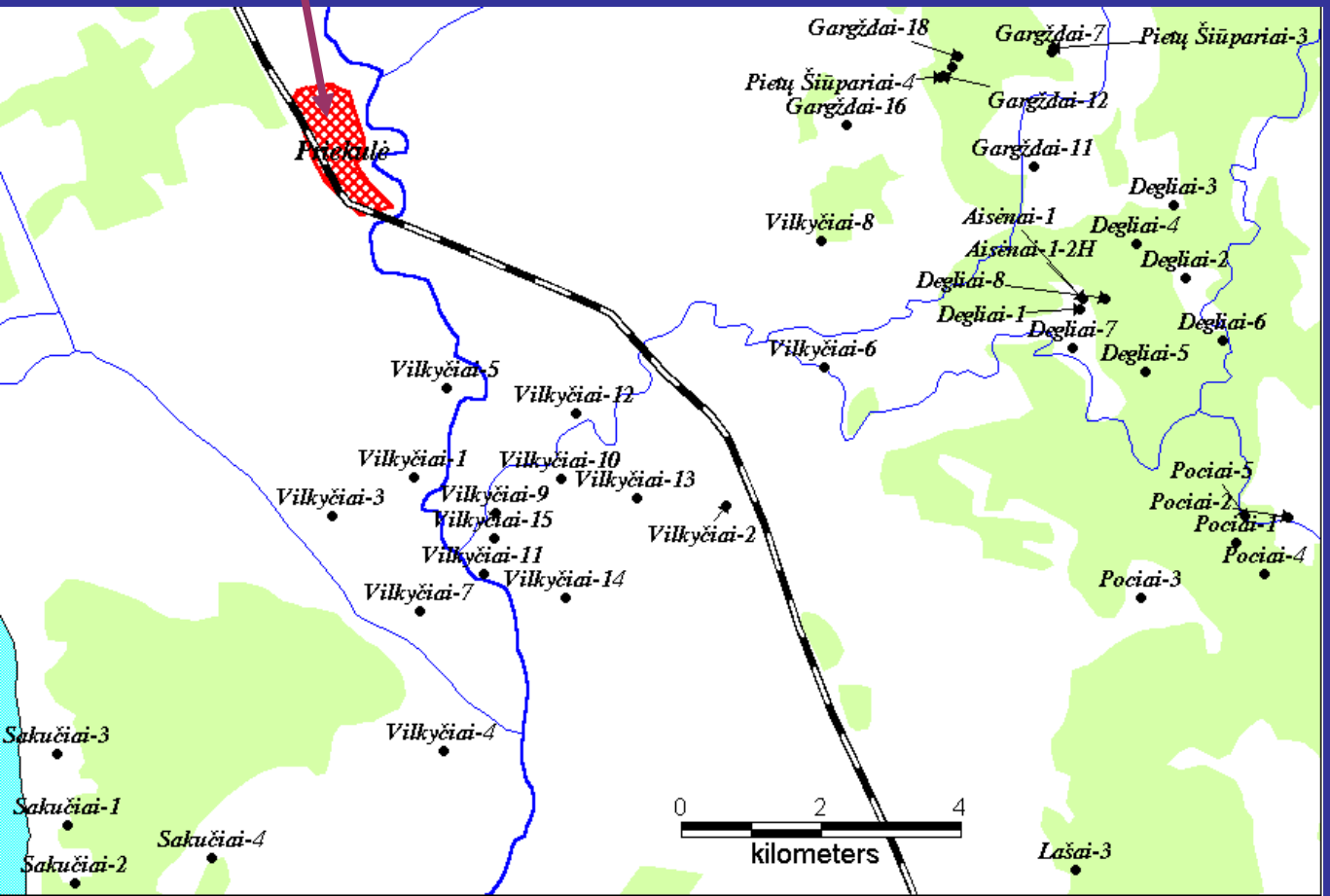


http://www.co2conference.net/wp-content/uploads/2013/12/15-Haselton-Exploiting-the-ROZ-in-Lithuania-new-new.pdf


Vilkyčiai-9
Depth, m
1940
1950
1960
1970
1980
1990
2000
2010
0
2
4
6
8
10
12
Porosity, %
0.1
1
10
100
Permeability, mD
fractured reservoir
dual porosity reservoir

Priekule,
1256 population





CO2 sourcing from “Achema” AB fertilizers producing company