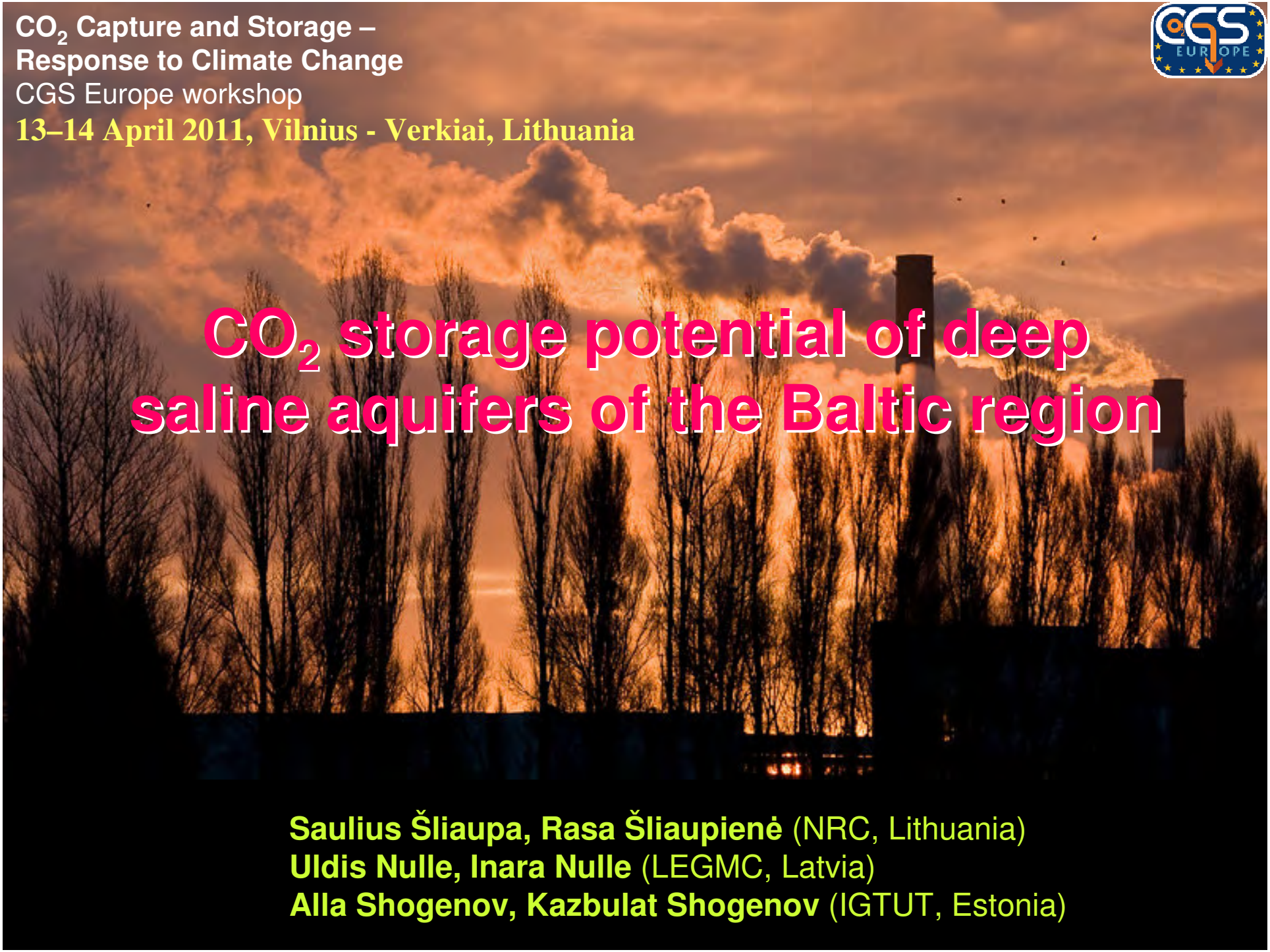
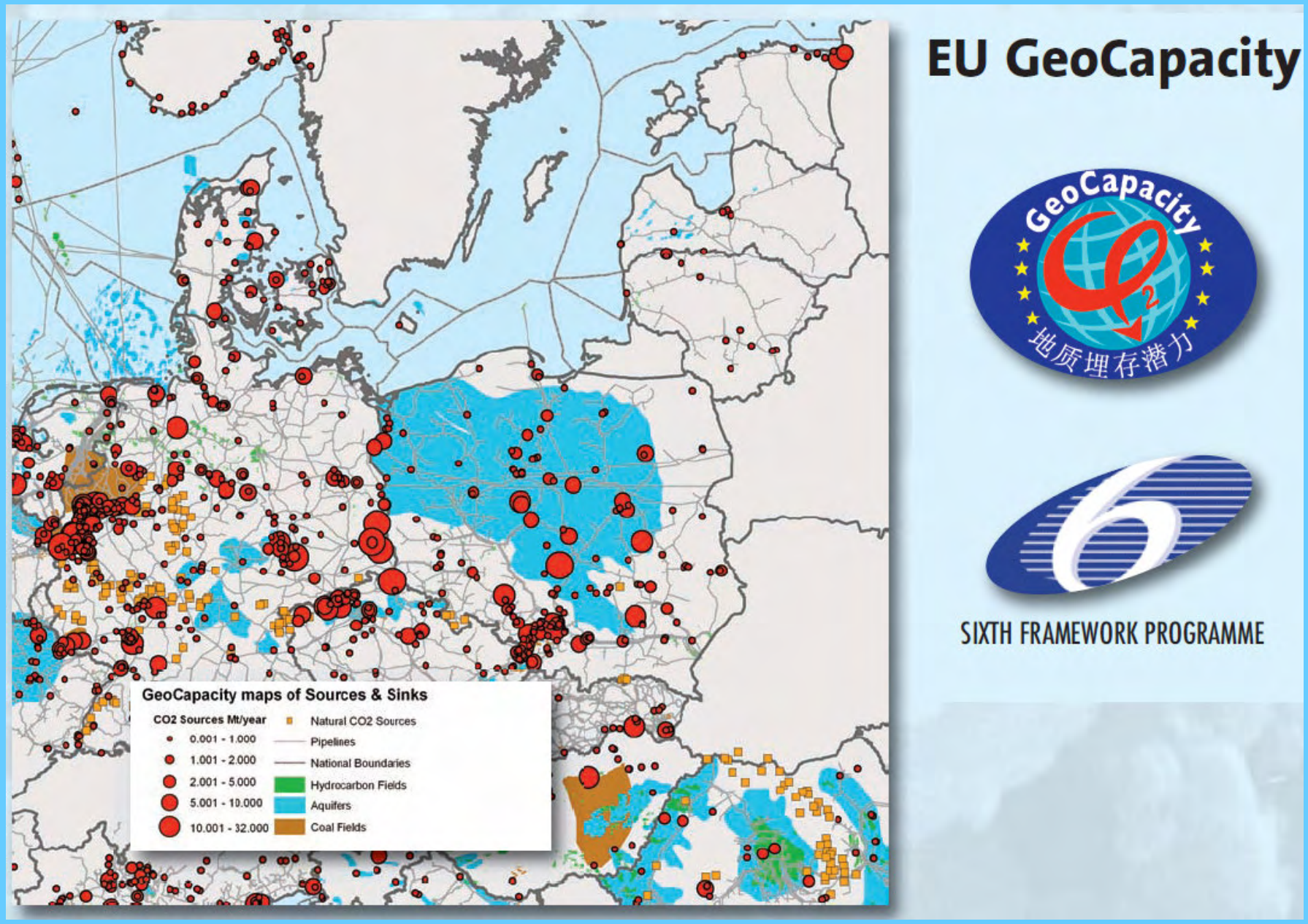


CO_2 Capture and Storage – Response to Climate Change
CGS Europe workshop
13–14 April 2011, Vilnius - Verkiai, Lithuania

CO_2 storage potential of deep saline aquifers of the Baltic region

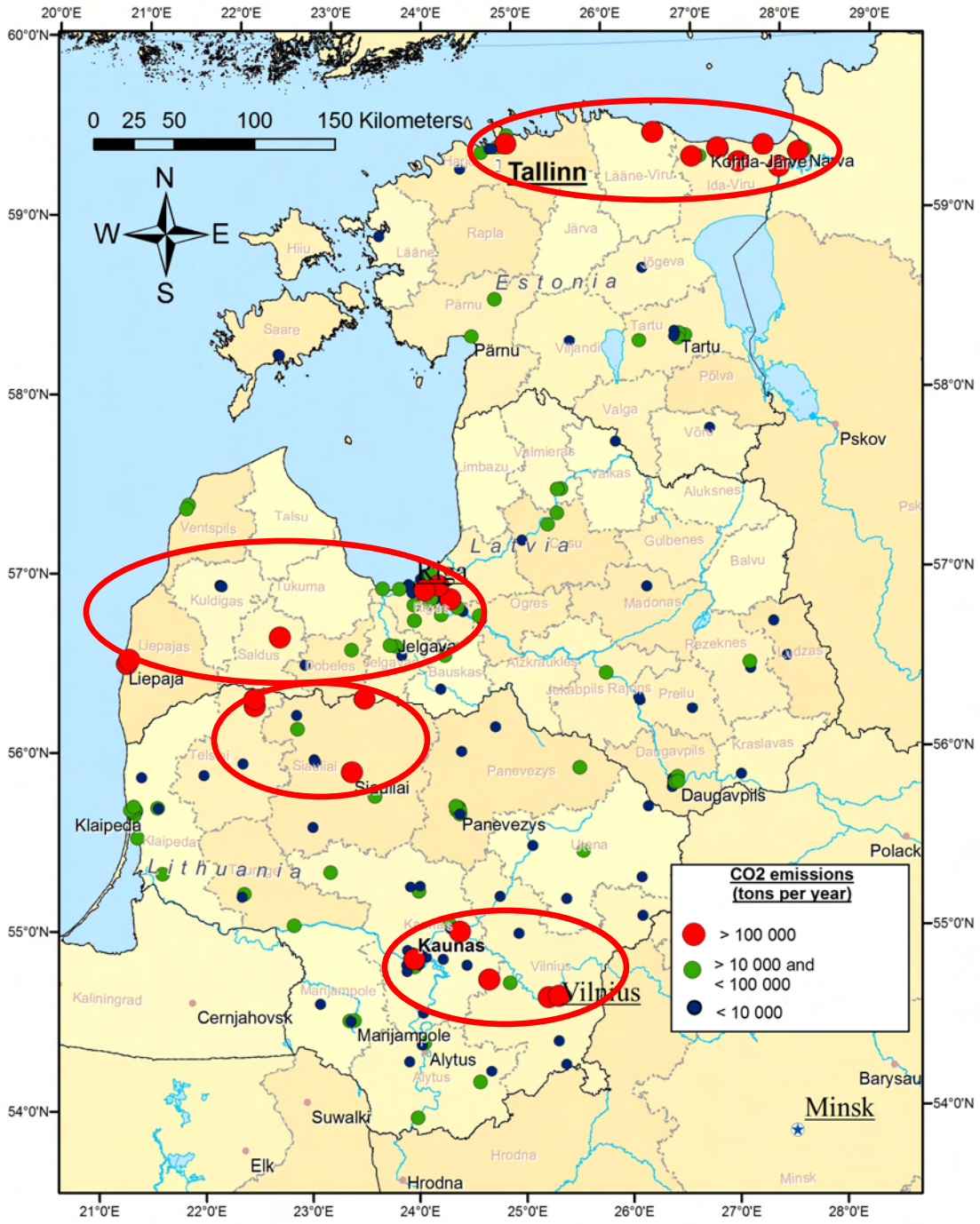
Saulius Šliaupa, Rasa Šliaupienė (NRC, Lithuania)
Uldis Nulle, Inara Nulle (LEGMC, Latvia)
Alla Shogenov, Kazbulat Shogenov (IGTUT, Estonia)

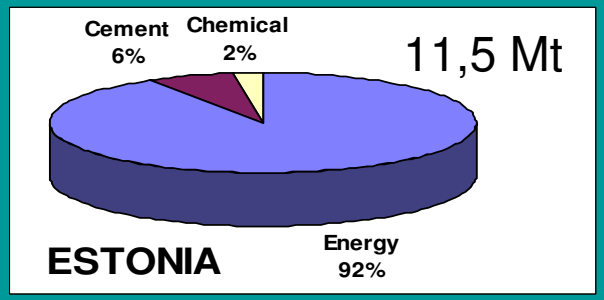
EU GeoCapacity

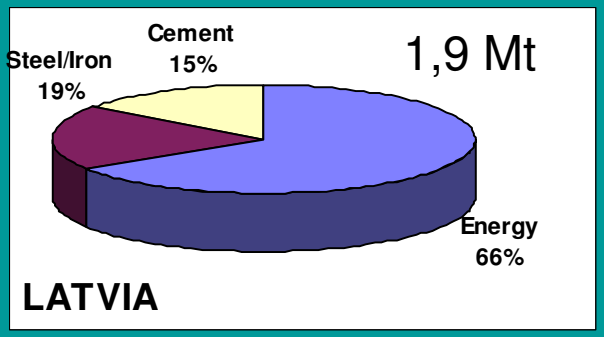


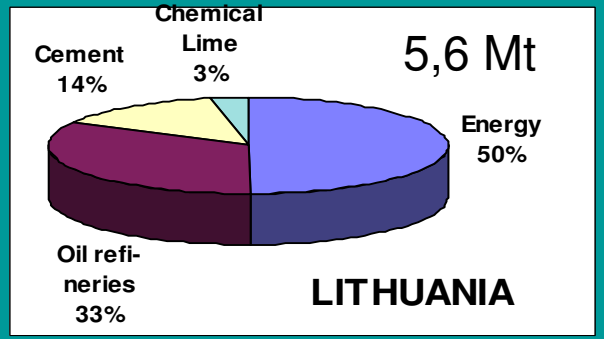
SIXTH FRAMEWORK PROGRAMME

Major CO_2 sources in the Baltic region









CO_2 sources registered in EU ETS in 2005 and 2007

Big sources (>100 000 tonnes CO_2)				All registered in ETS sources		
Year	2005/2007			2005/2007		2005
	Million tonnes	Number of sources	Share in all ETS emissions, %	Million tonnes	Number of sources	ETS share in total GHG emissions
Estonia	11.5/ 14.5	9/9	91.3/94.6	12.6/15.3	41/47	59.3
Latvia	1.9/1.9	6/5	63.8/65.7	2.98/2.89	89/89	26.7
Lithuania	5.6/4.8	9/9	84.8/80	6.6/6	89/93	32.5

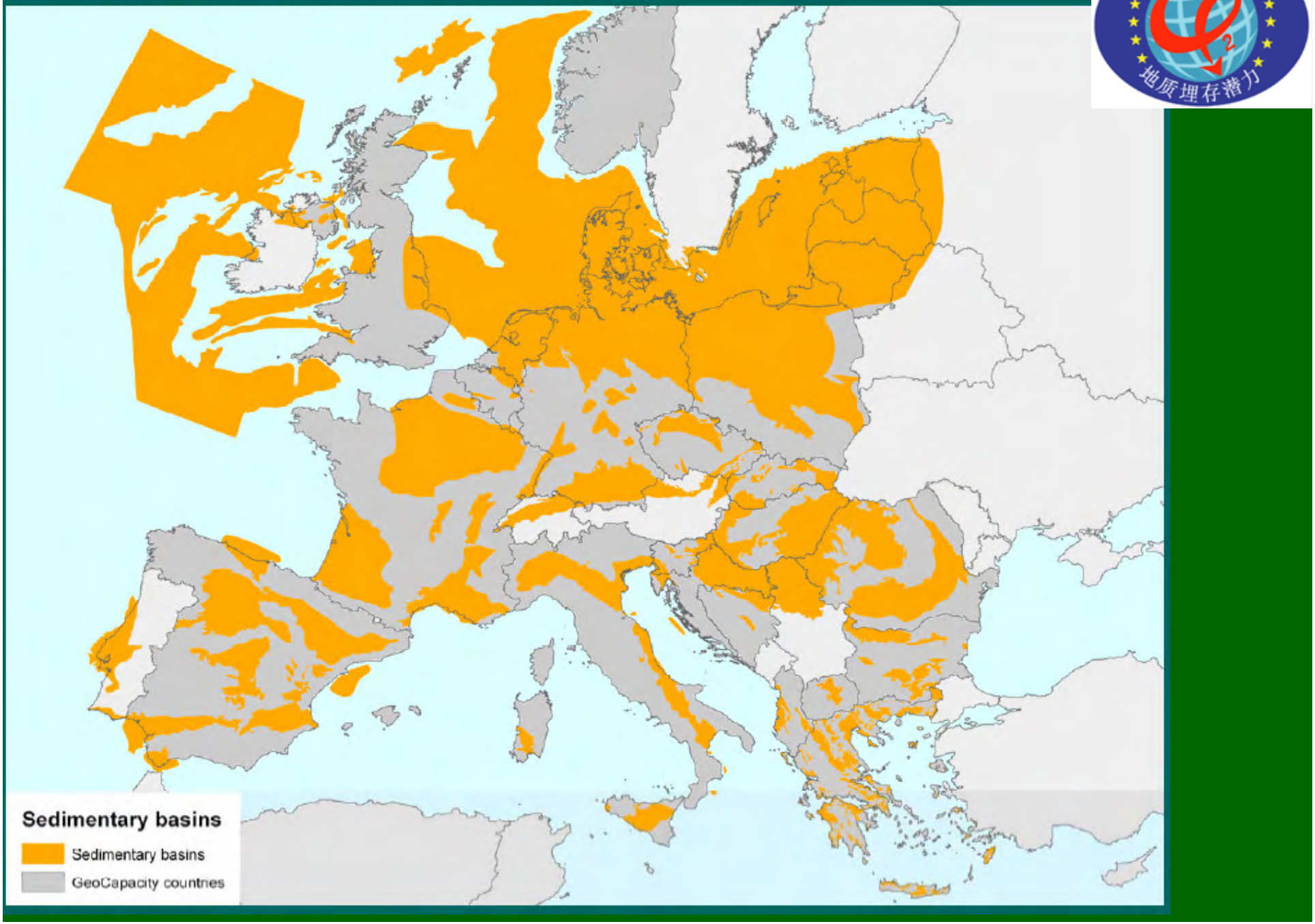
Total greenhouse gas (GHG) emissions and CO_2 emissions per capita.

	Total GHG emissions			CO_2 emissions per head	
	In CO_2 equivalents, million tonnes		Reduction compared to 1990, %	Tonnes CO_2/capita	Place in world rate
Year	1990	2006		2004	
Estonia	41.6	21.4	54.6	14.1	16
Latvia	26.4	11.6	56	3.87	90
Lithuania	49.4	23.2	53	3.07	100

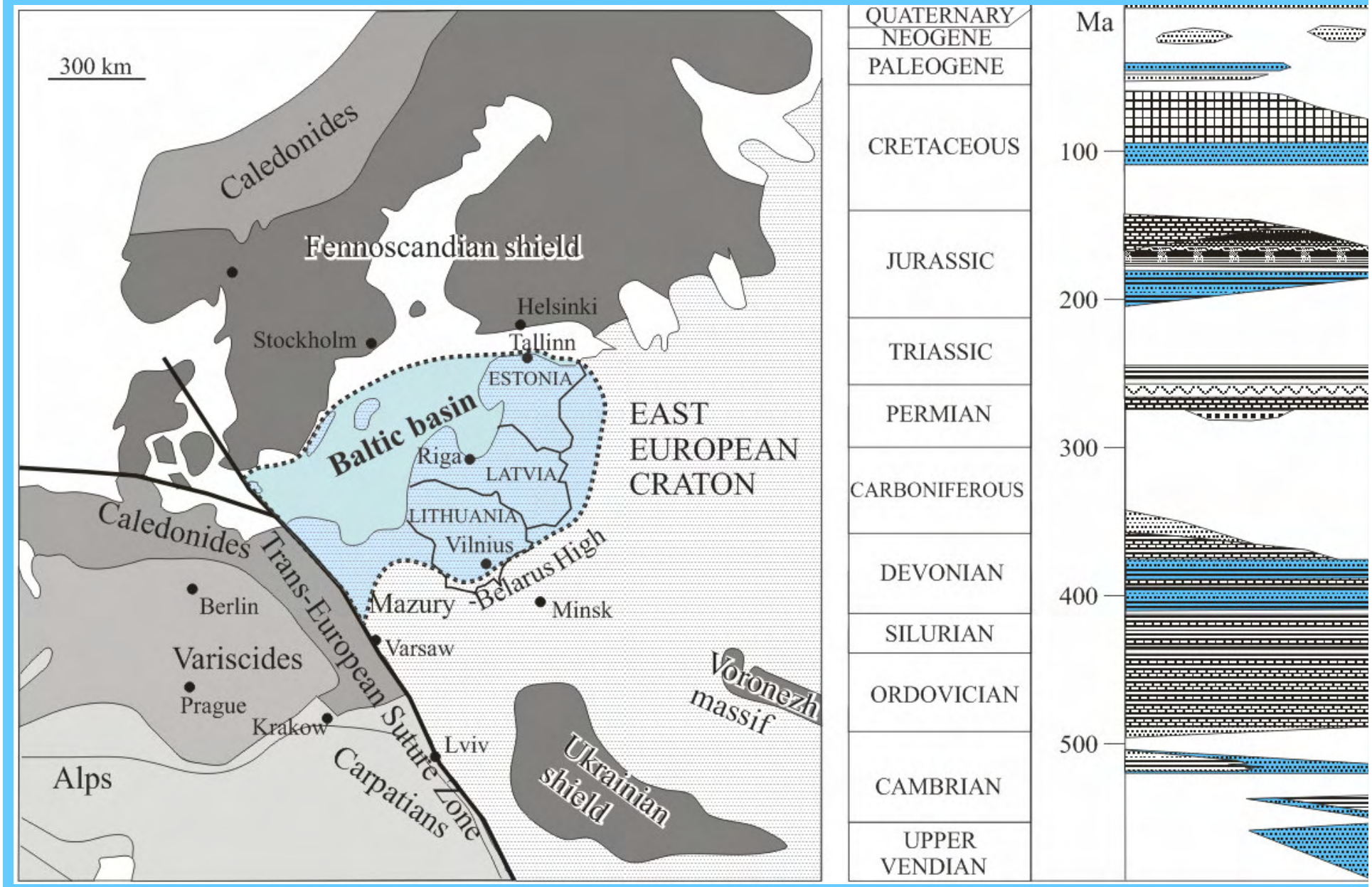
Share of sectors (%) in greenhouse gas (GHG) emissions in countries.

Emissions	Estonia	Latvia	Lithuania
Energy (fuel combustion and emissions from fuels in all sectors, including transport) Fuel combustion in transport	89 10	72 27.5	58 18.2
Agriculture	5.7	17.7	17.9
Industrial processes	2.7	2.5	16.6
Waste	2.5	7	6.8

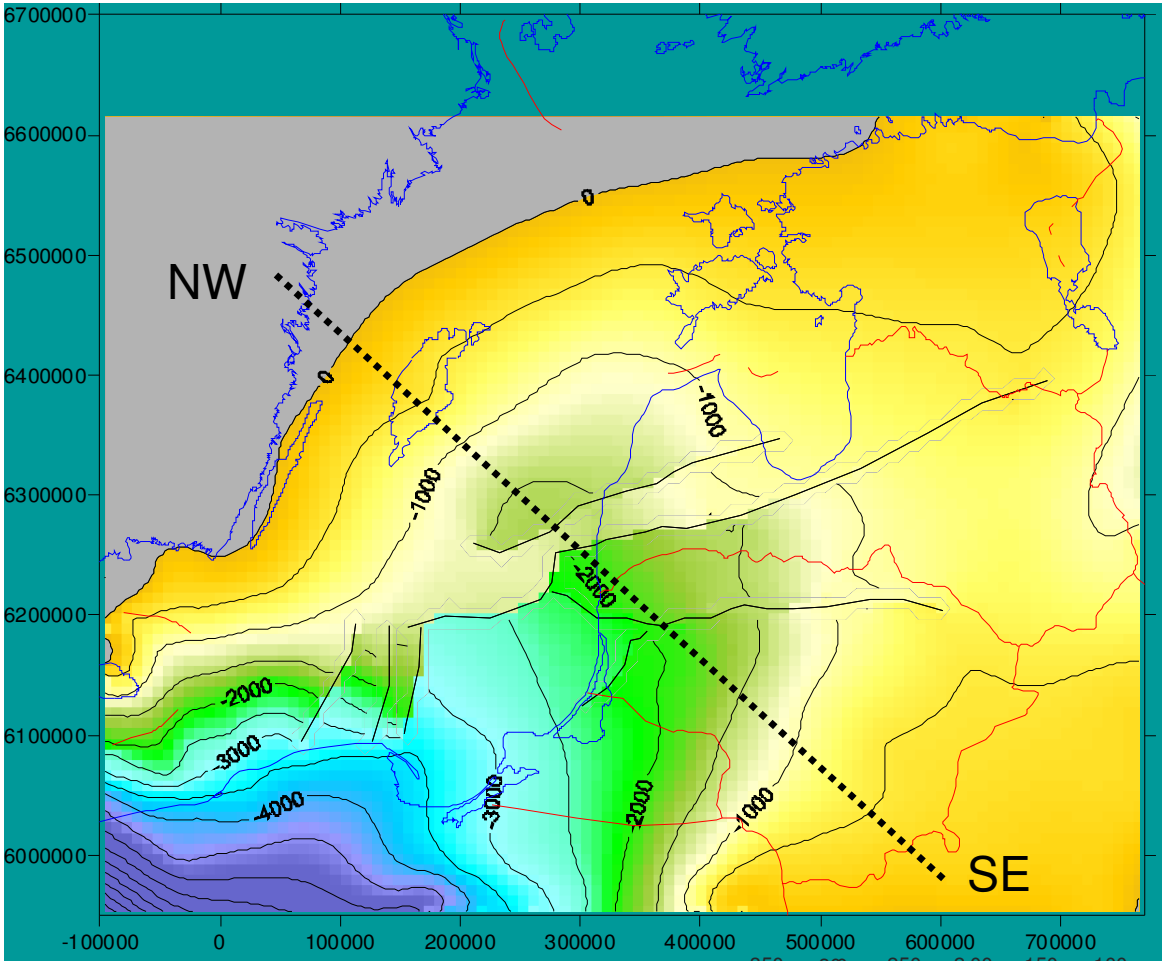
Sedimentary basins of Europe

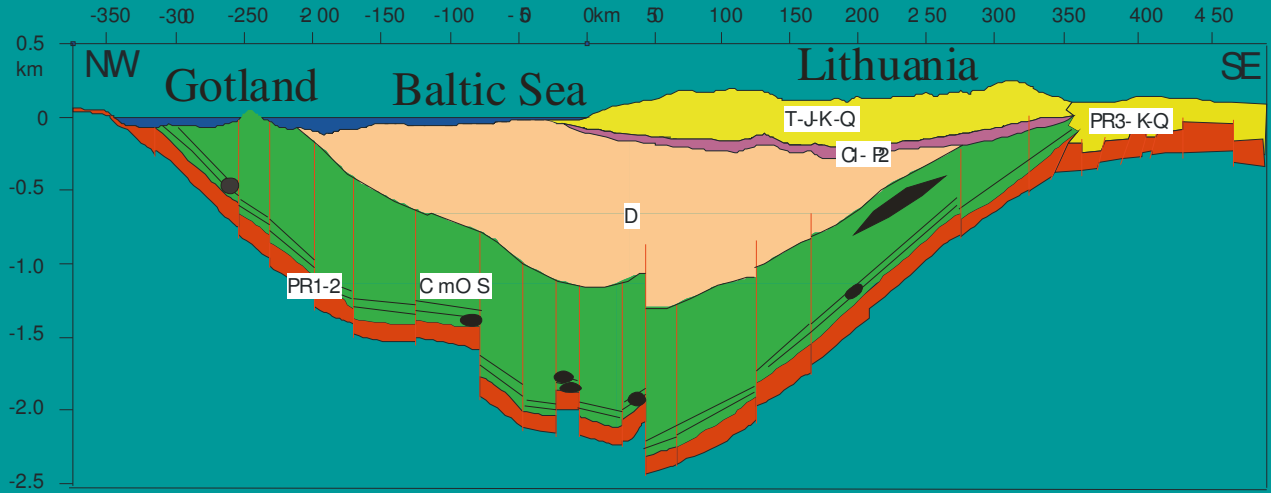


Tectonic framework of Europe



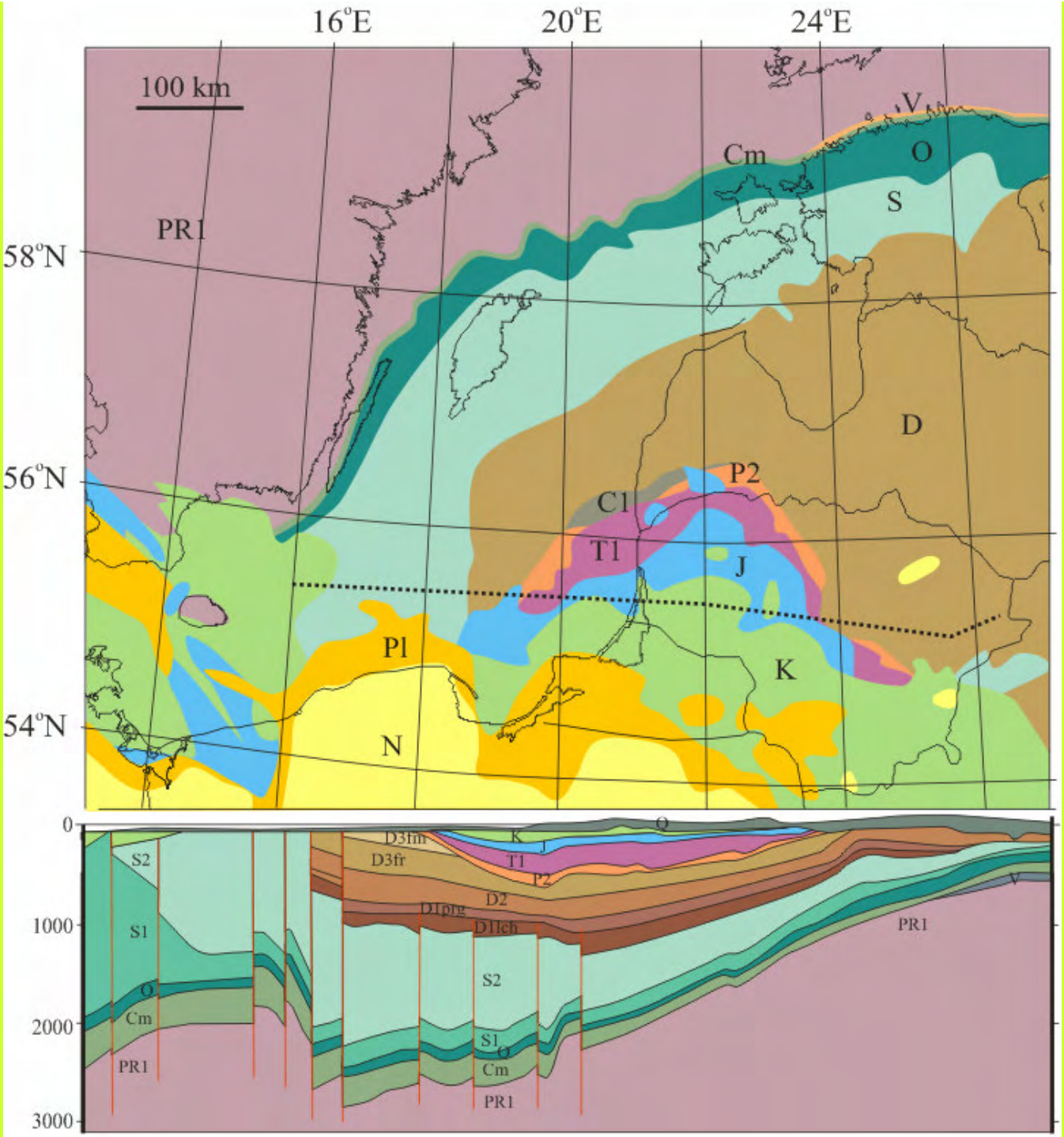
Baltic basin

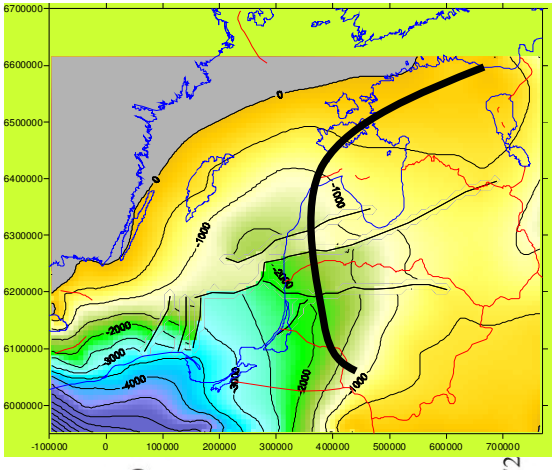




Pre-Quaternary geological map

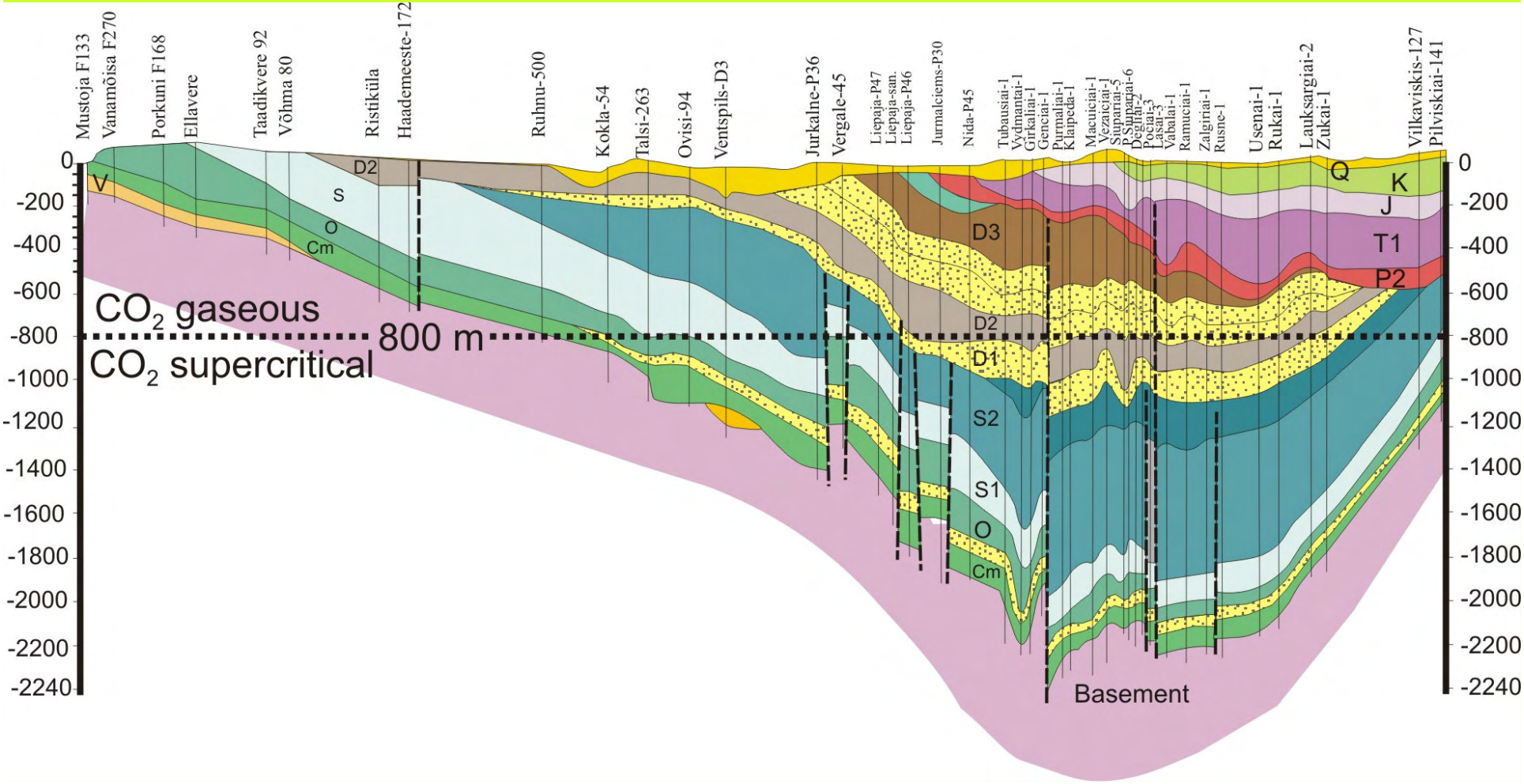
Cross-section



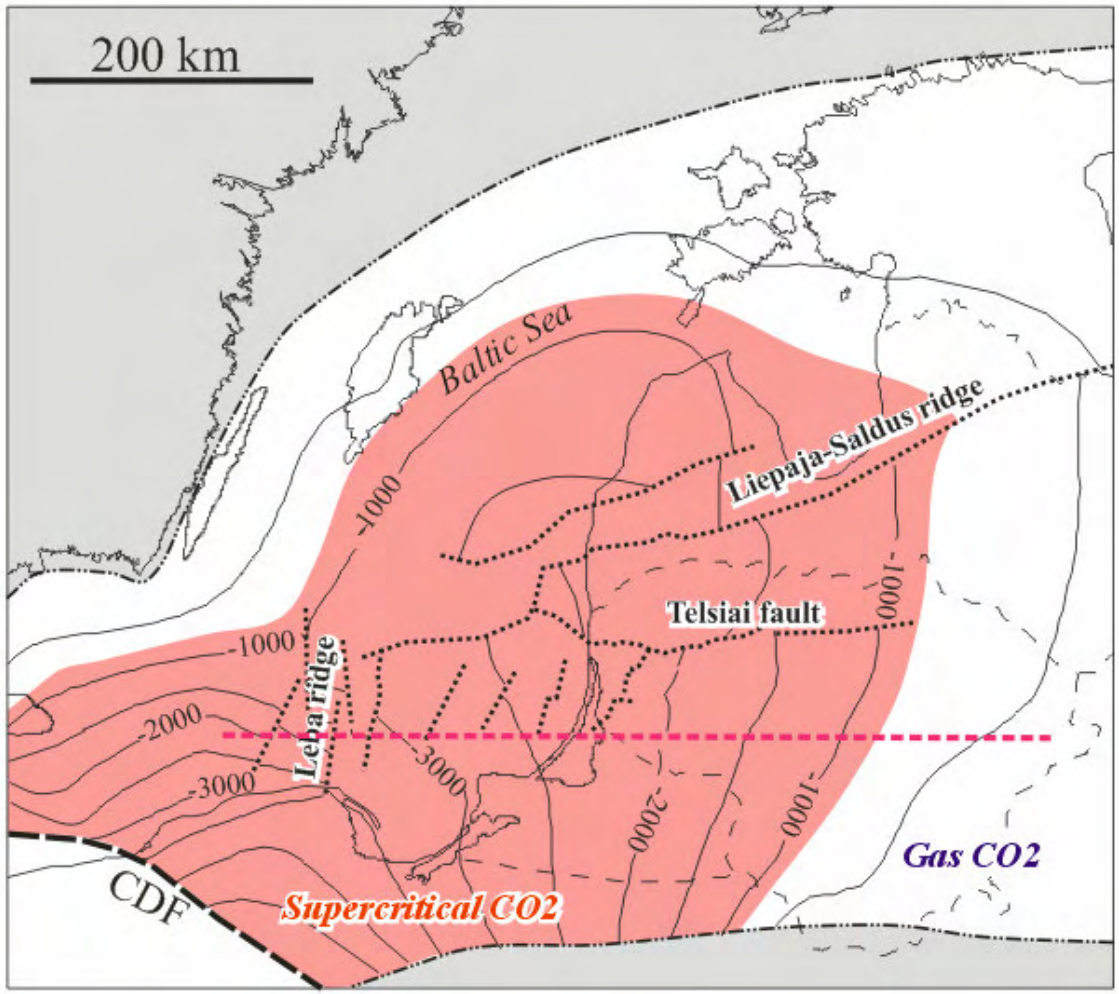


Geological cross-section North-South

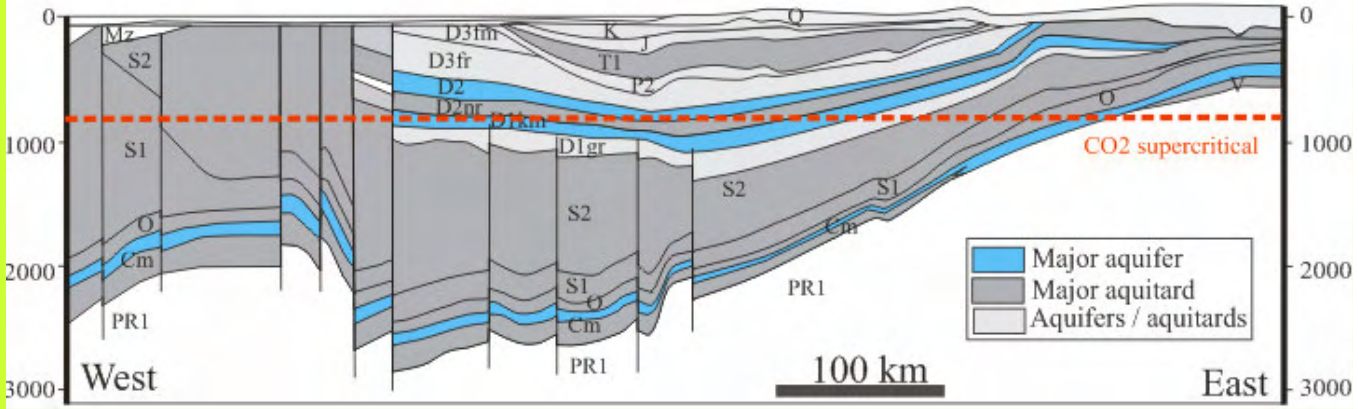
Major aquifers are shown in yellow



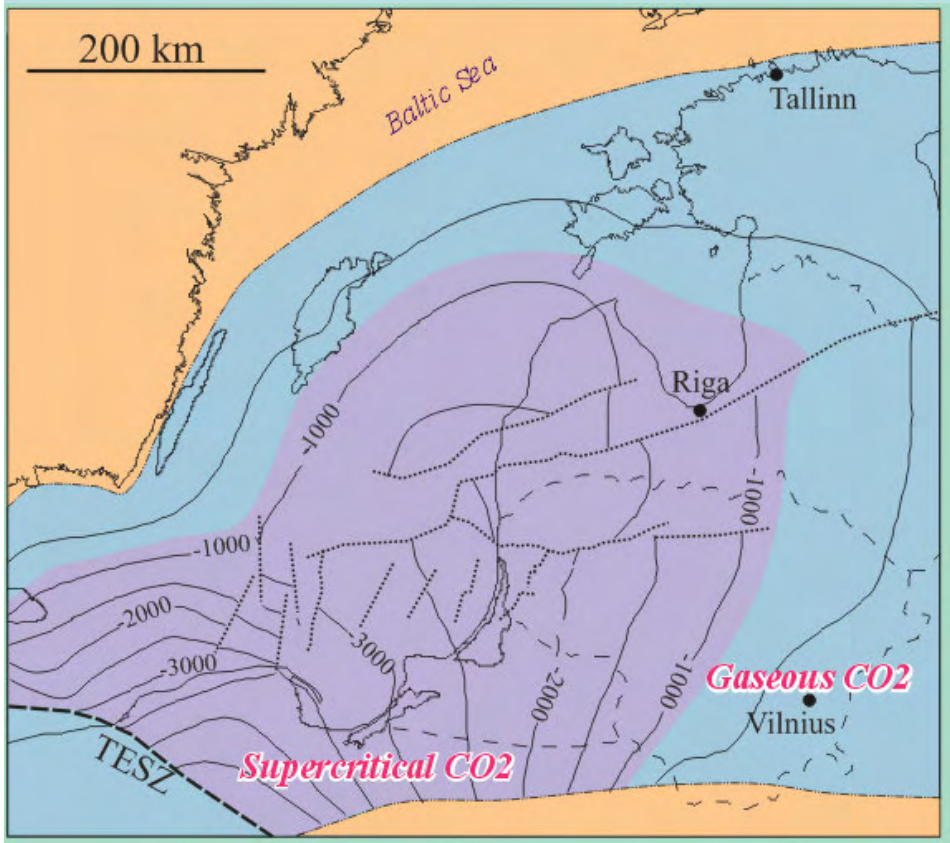
Top of Cambrian reservoir



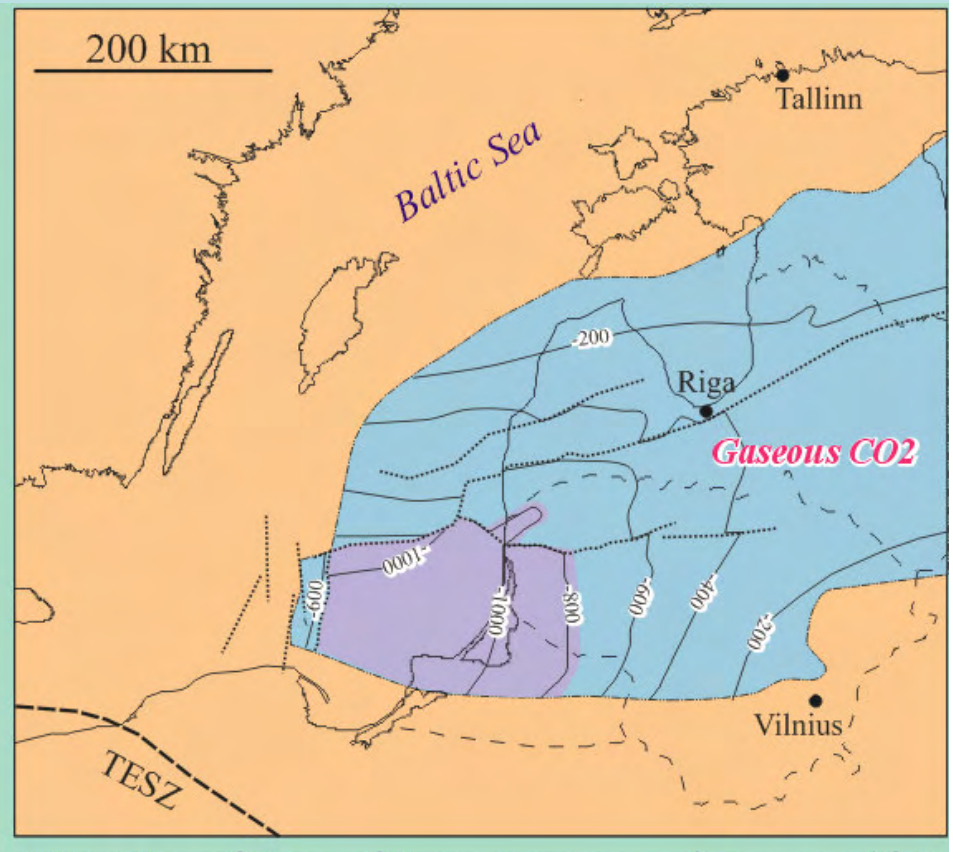
Geological cross section W-E



Avaluation of the CO2 storage capacity of the Baltic basin

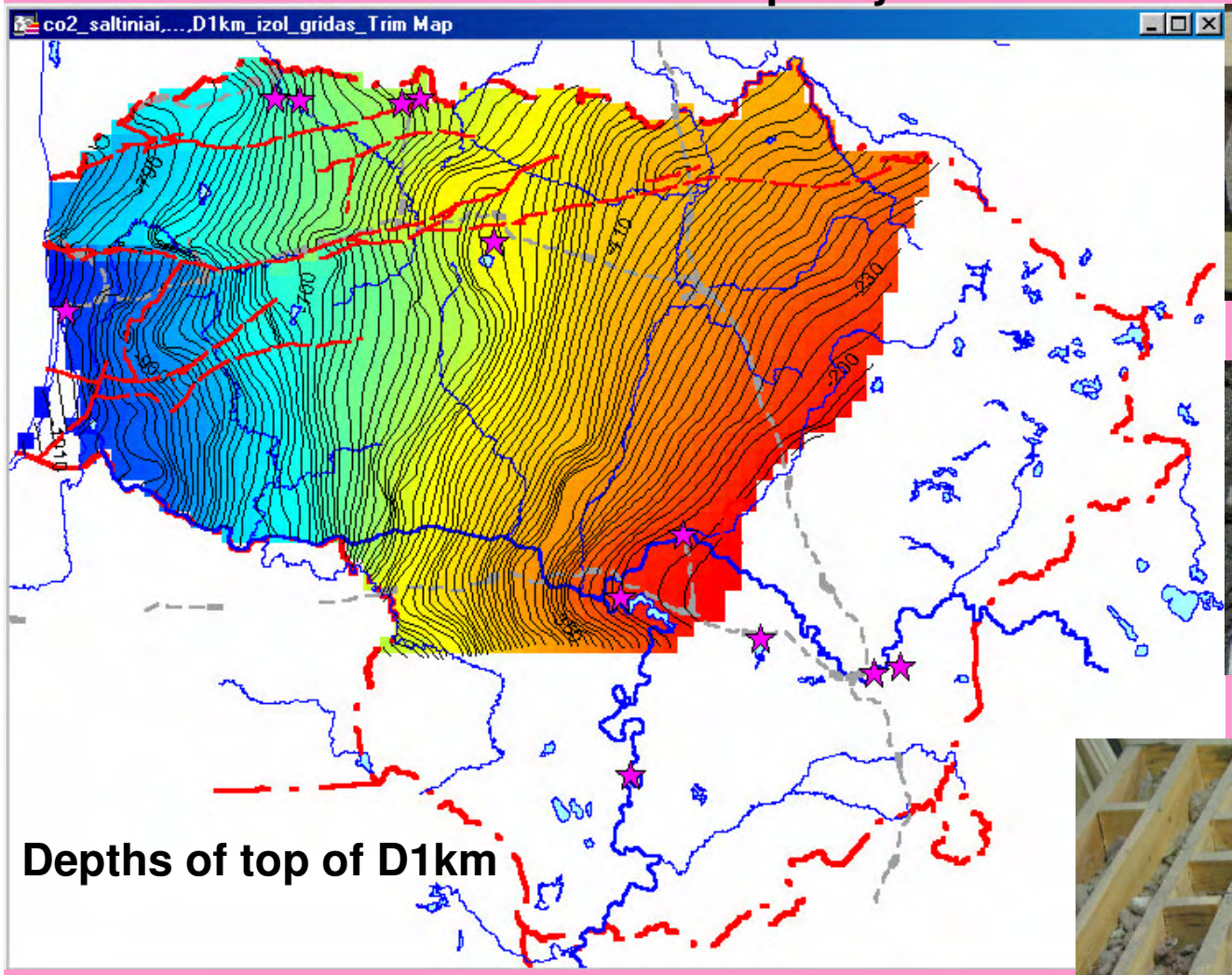


Depths of top of Cambrian aquifer



Depths of top of Lower Devonian aquifer

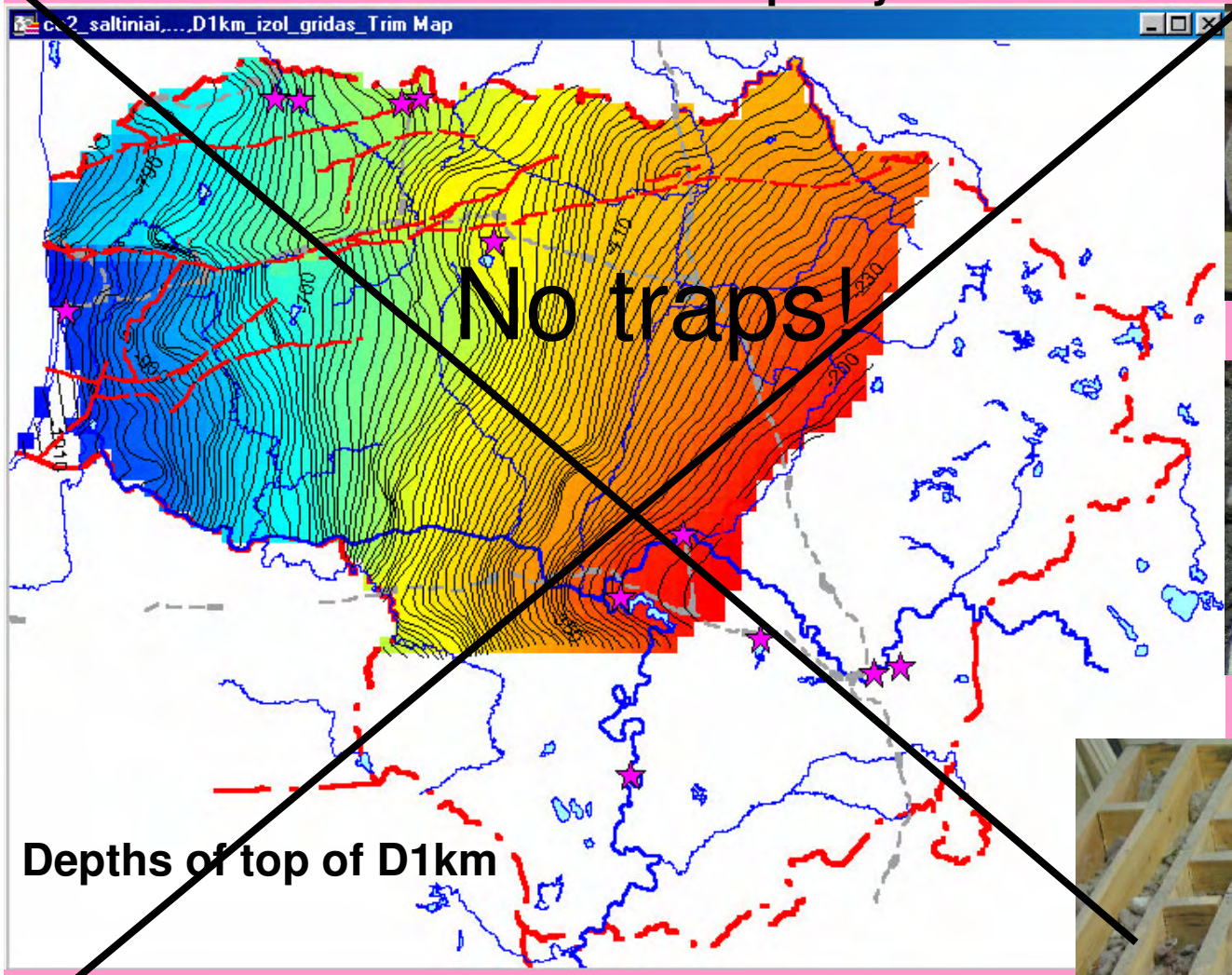
Lower Devonian D1km reservoir capacity



Depths of top of D1km

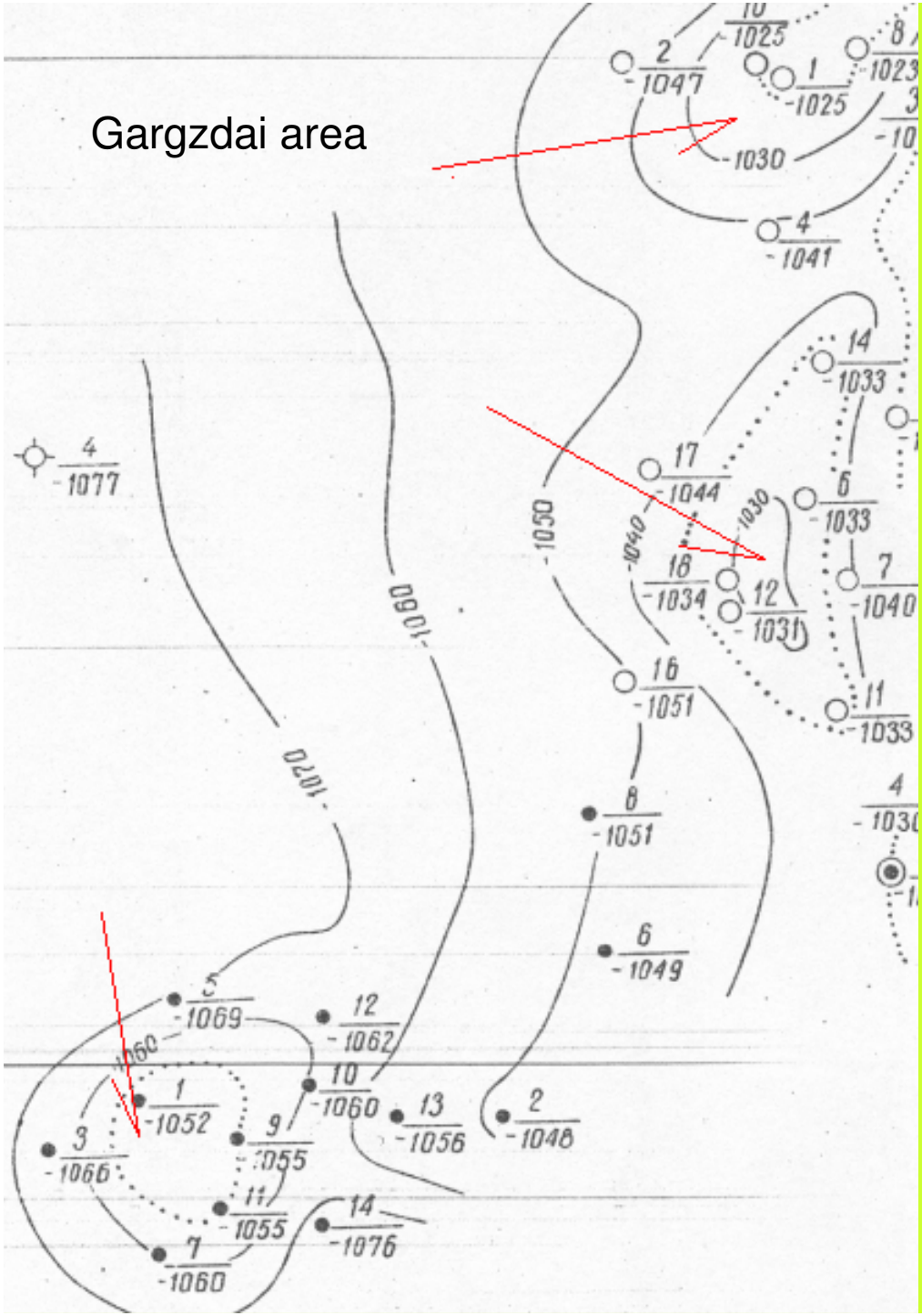
Average thickness – 150 m
Average porosity 26%
Average permebility 2-4 D
Net-to-gross 0.65
Composition quartz with minor feldspar (10-15%)

Lower Devonian D1km reservoir capacity



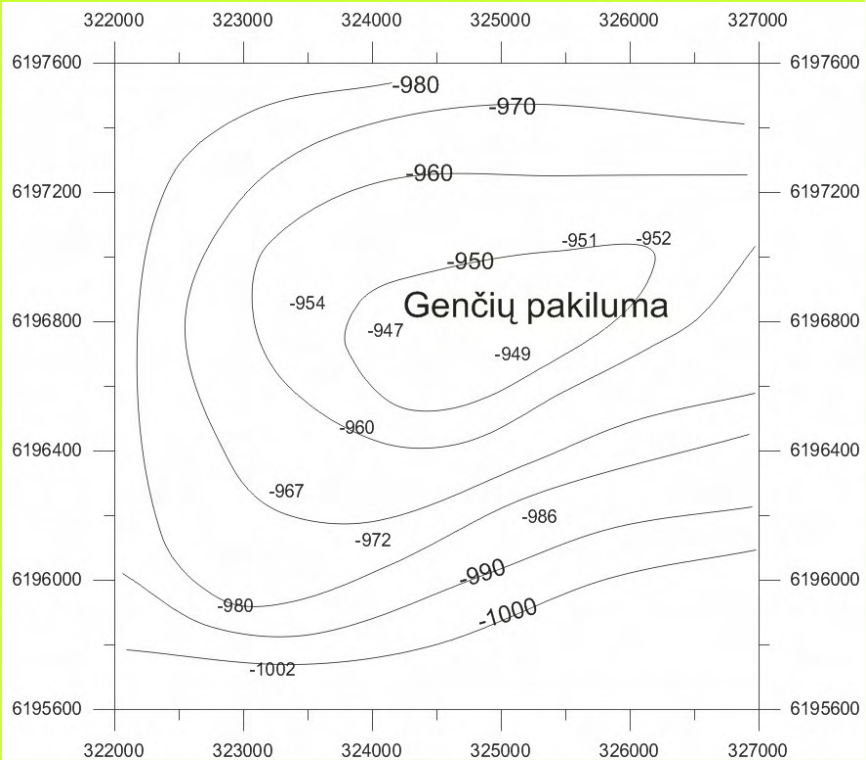
Depths of top of D1km

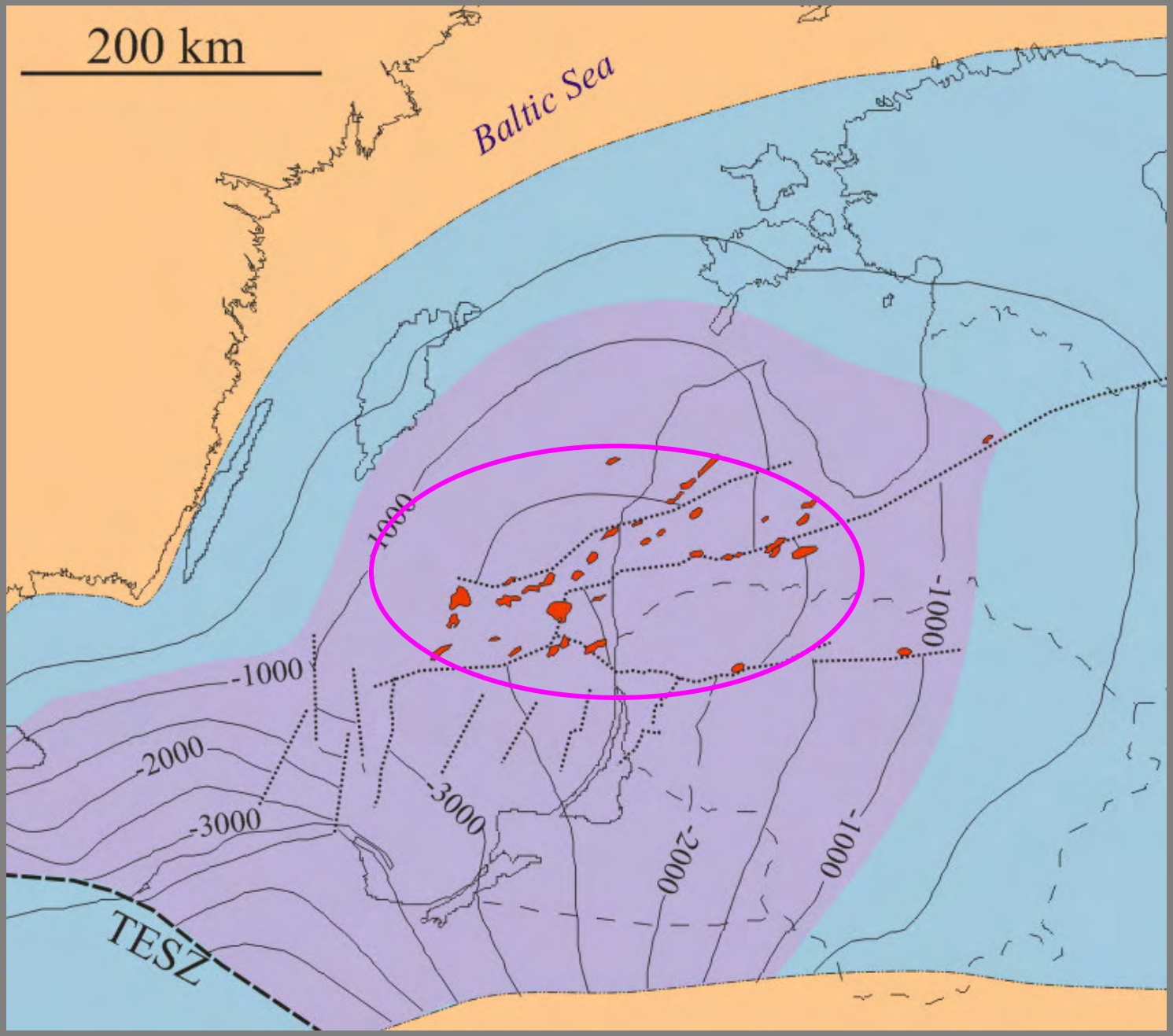
Average thickness – 150 m
Average porosity 26%
Average permebility 2-4 D
Net-to-gross 0.65
Composition quartz with minor feldspar (10-15%)



Structural map of top of D1 reservoir, west Lithuania

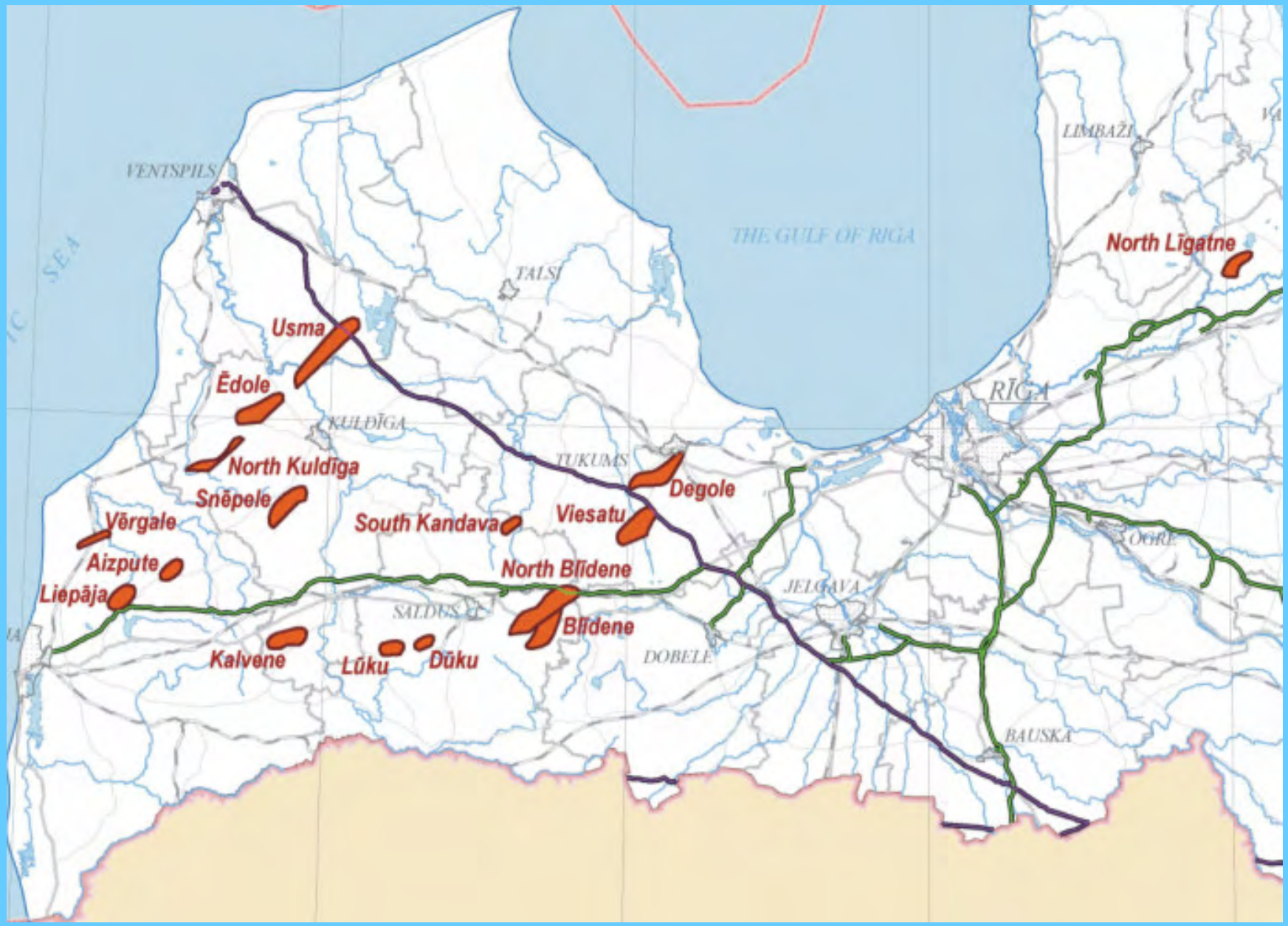
Structures are of very low amplitude (a dozen to a few dozens of meters)

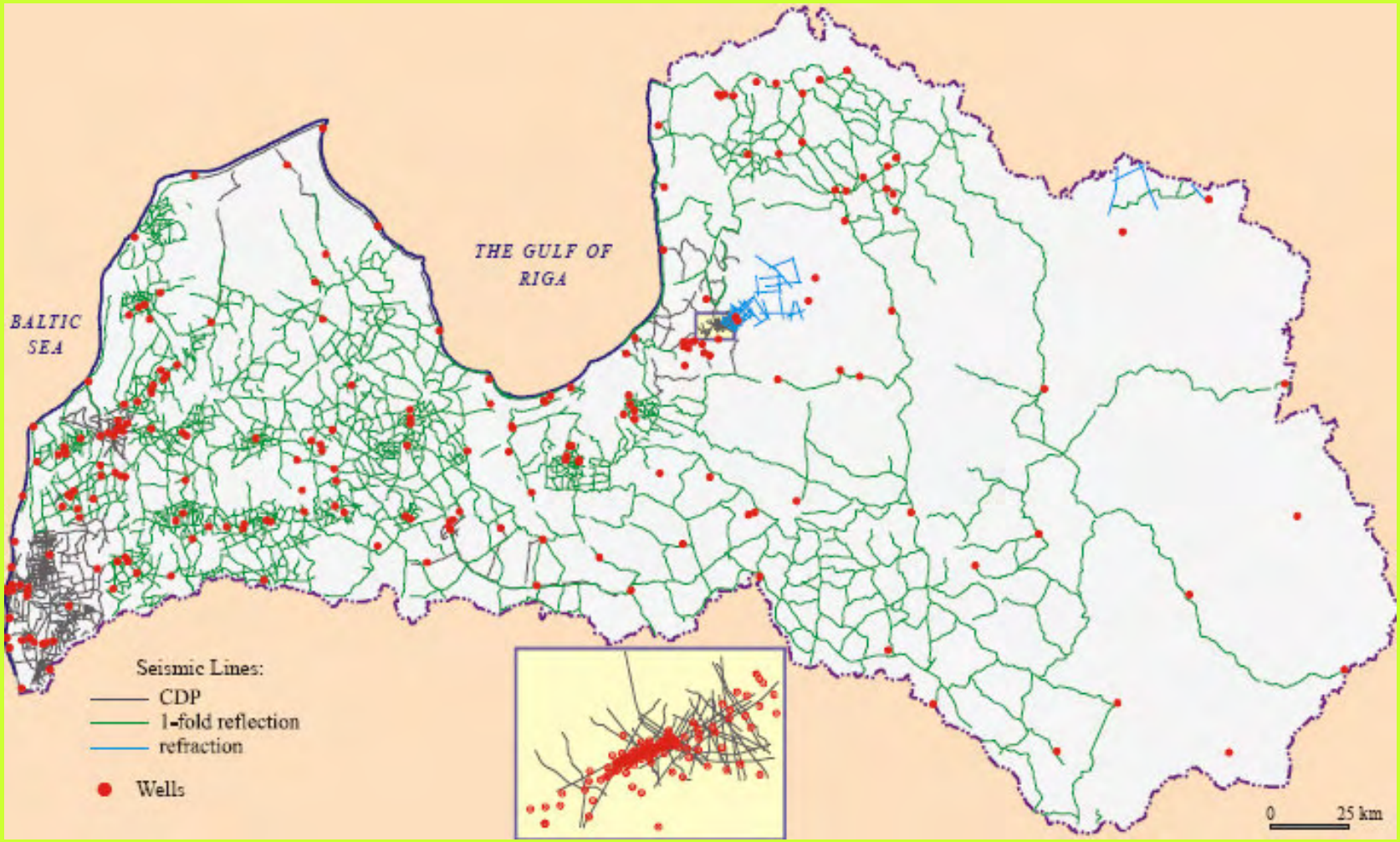




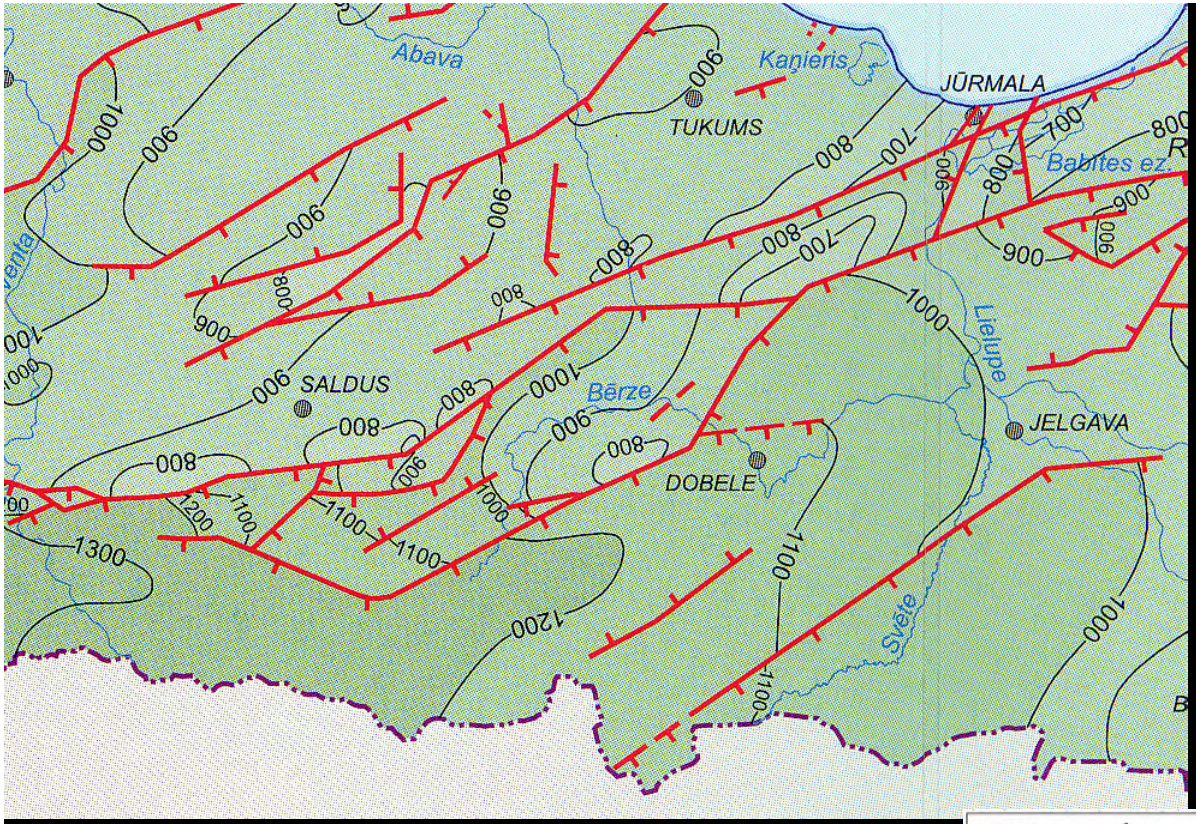
Major Cambrian aquifer saline water structures (34 in total)

Tectonic structures potential for CO2 storage, Latvia



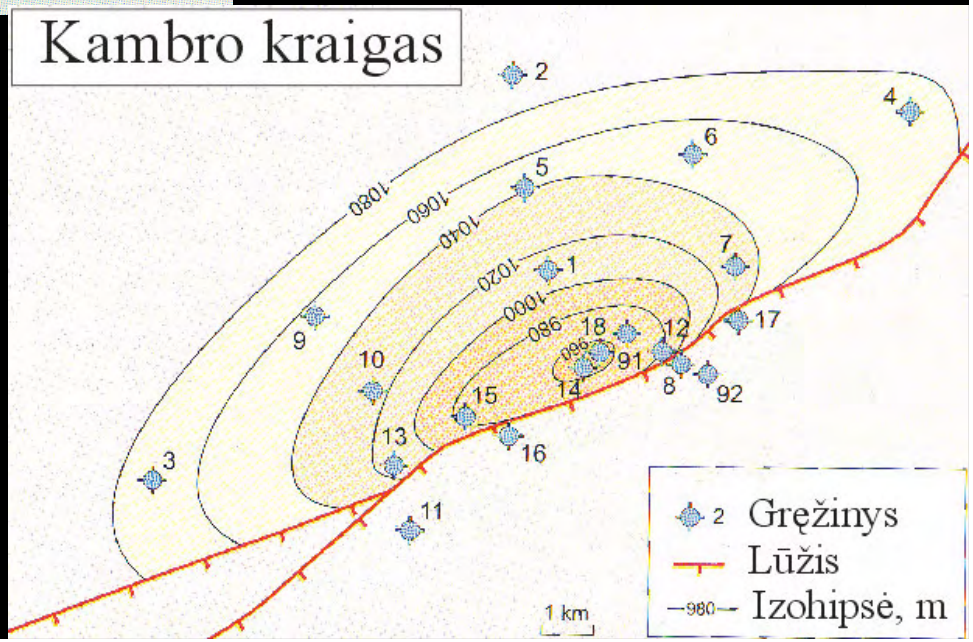


Seismic coverage of the Latvian territory. Green is one-fold reflection, blue – refraction, black – CDP



Dobele structure

Tectonic Map of central Latvia

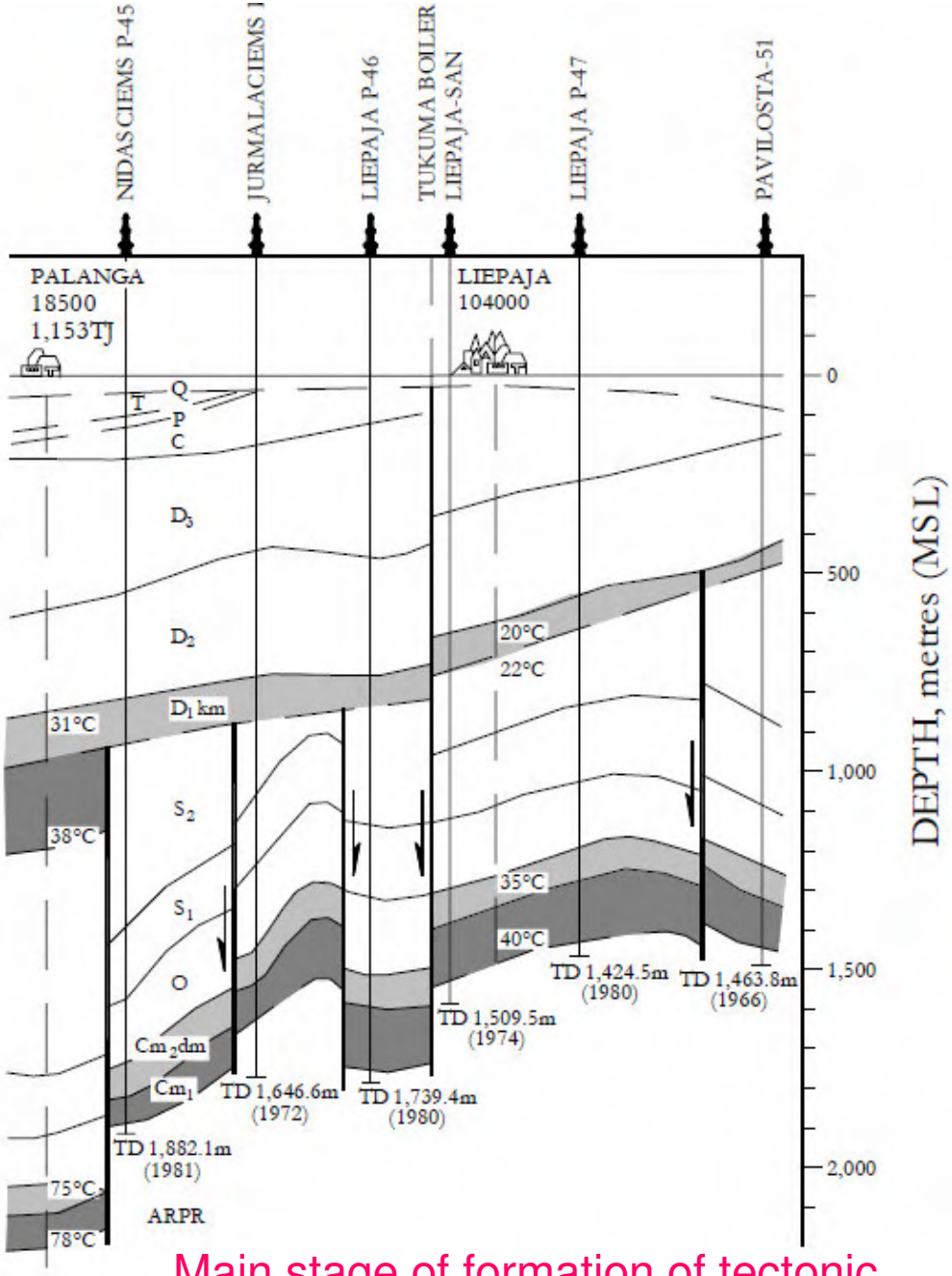


Q	Quatemary
K	Cretaceous
J	Jurassic
T	Triassic
P	Permian
D3	Upper Devonian
D2	Middle Devonian
D1km	Lower Devonian Kemeri Formatio
D1gr	Lower Devonian Gargzdai Formatio
S2	Upper Silurian
S1	Lower Silurian
O	Ordovician
Cm2dm	Middle Cambrian Deimena Format
Cm1	Lower Cambrian
ARPR	Archean/Proterorozoic Basement

Aquifer zone of primary Interest

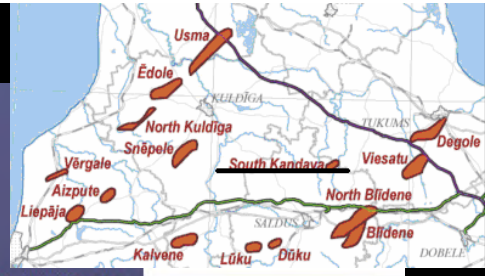
Aquifer of secondary Interest

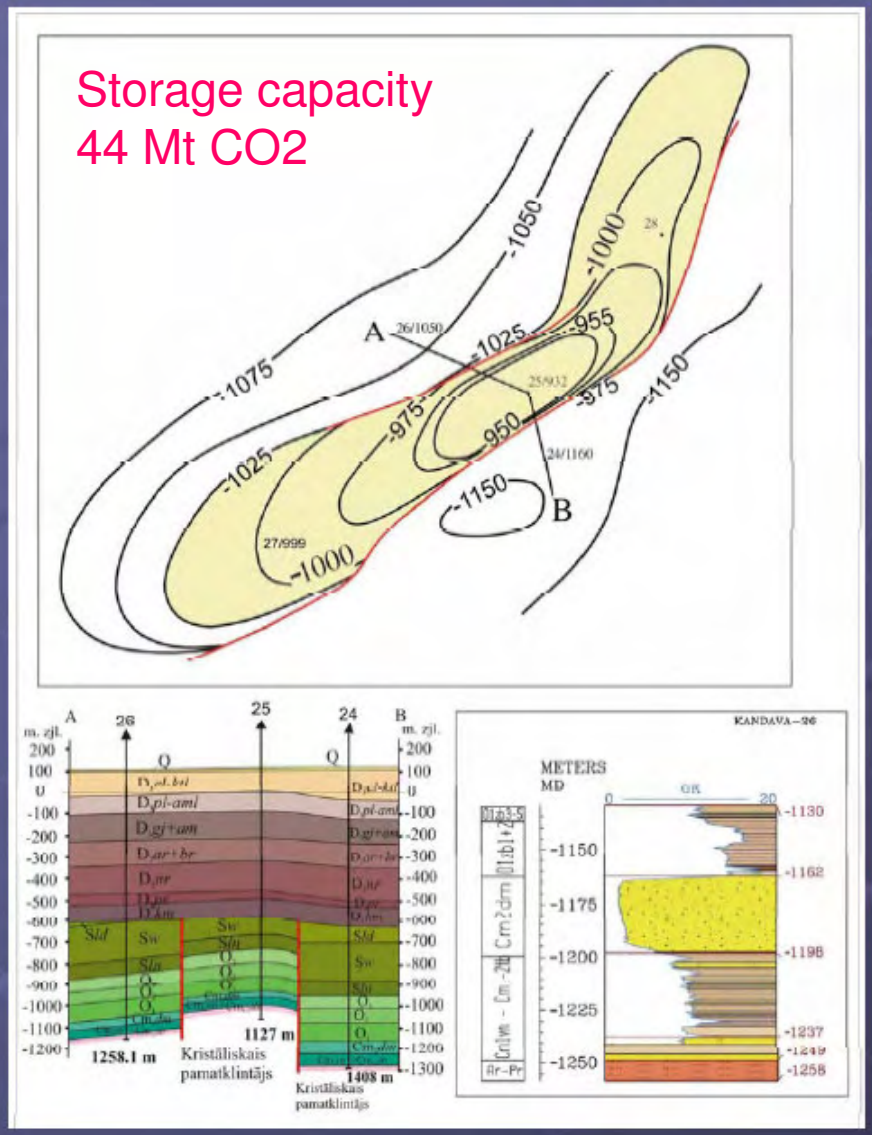
Well control



Main stage of formation of tectonic structures was end S2-earliest D1

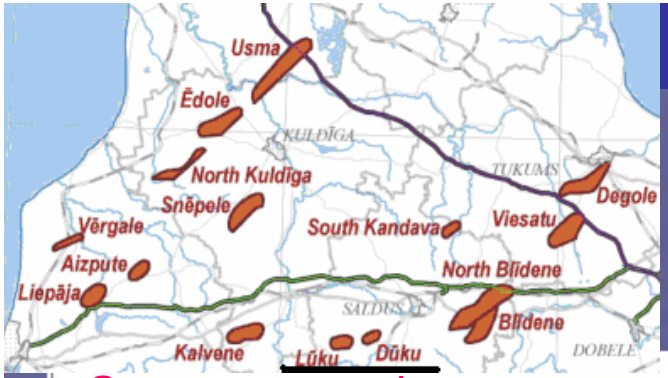
South Kandava



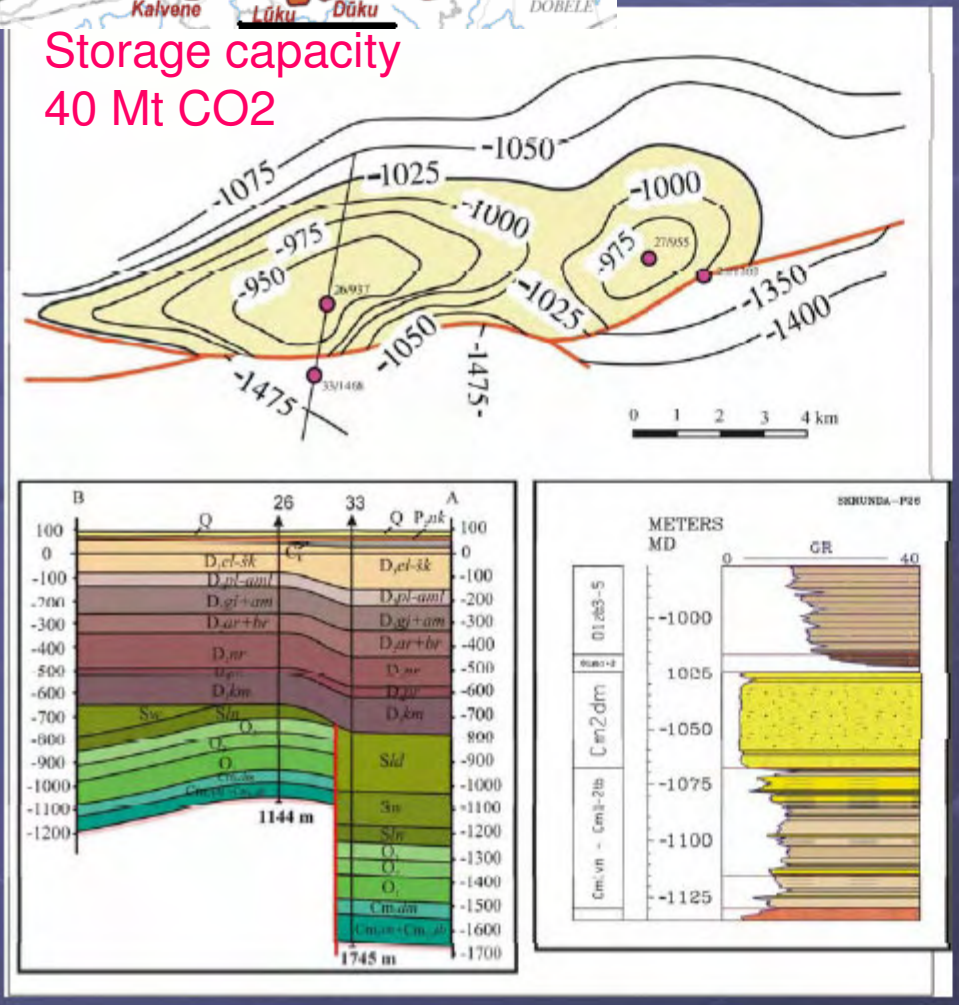


- These structures were determined by seismic investigations and studied by four (Luku-Duku) and five (South Kandava) boreholes.
- South Kandava is brachyanticlinal fold structure of north-eastern stretching located in the centre of Latvia.
- The south-eastern and north-western flanks of the brachyanticlinal fold are bounded by faults.
- Its area is about 69 km2, thickness of reservoir is 25-36 m.
- The top of reservoir rocks represented by sandstones of the Middle Cambrian Deimena Formation located at the depth of 1053 m. They covered by argillaceous rocks of Lower Ordovician Zebrus Formation.

Luku-Duku

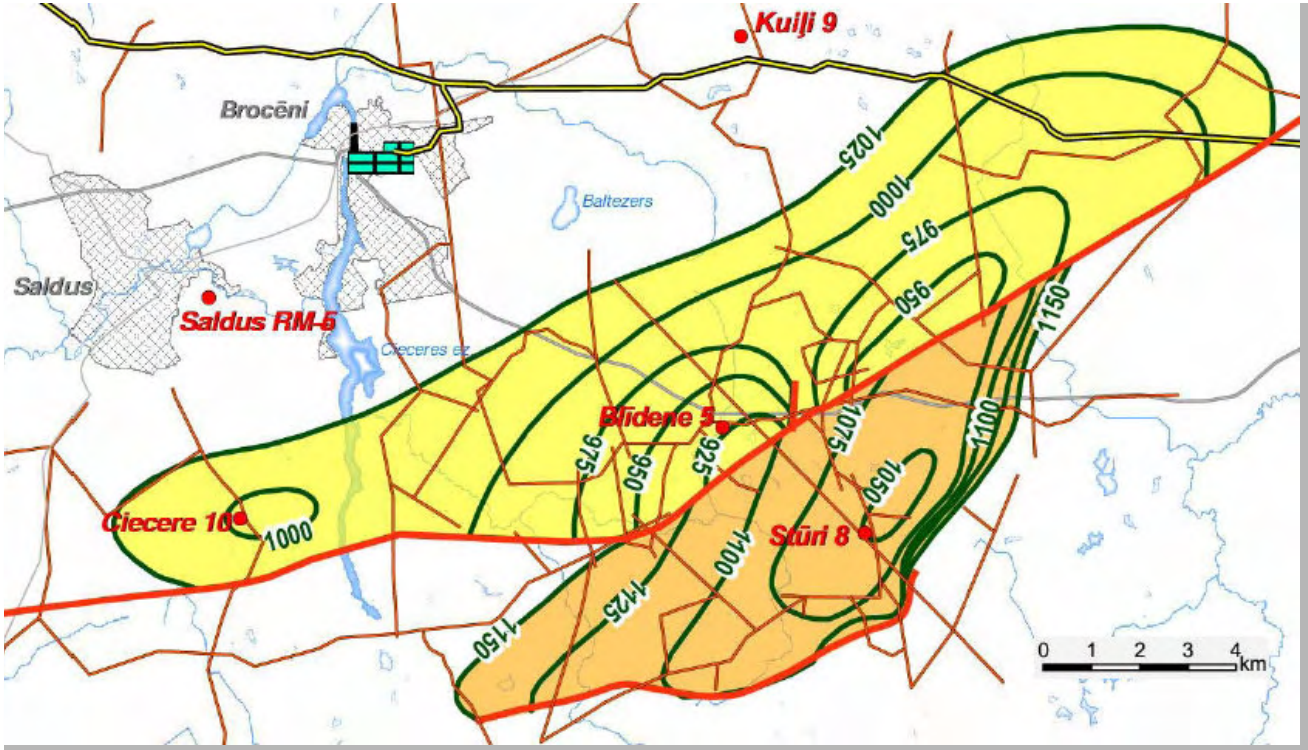


Storage capacity
40 Mt CO2



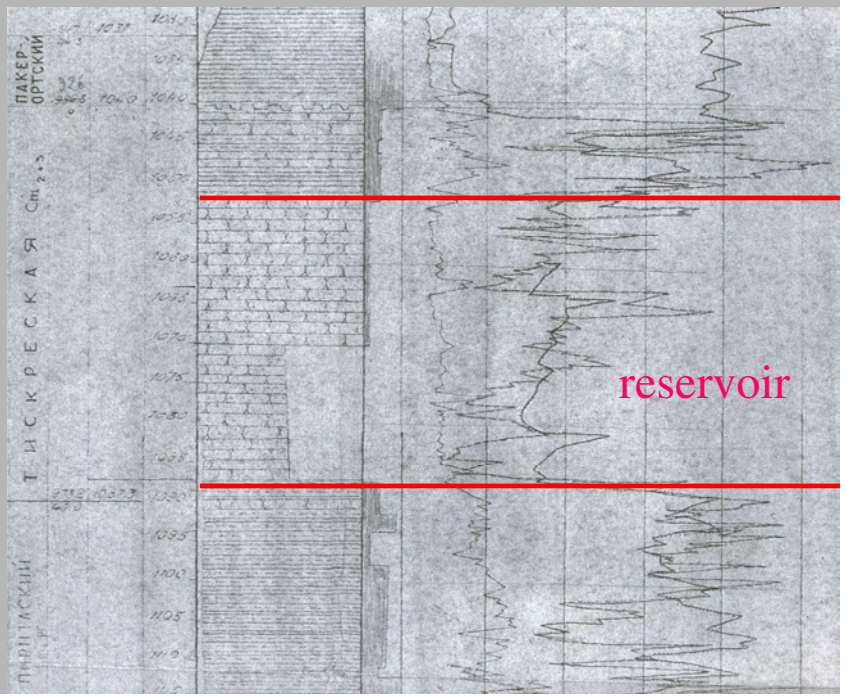
- Luku-Duku (Figure 3.6) is situated within the tectonically dislocated zone Saldus-Sloka-Inčukalns high. The Luku-Duku local high is near-fault brachyanticlinal fold. Its area is about 50 km2, thickness of reservoir rocl is 45 m, their top depth is 1024 m. Reservoir rocks are represented by sandstones of Middle Cambrian Deimena Formation. They covered by argillaceous rocks of Lower Ordovician Zebrus Formation.

Sink name	Luku-Duku	S.Kandava
Depth (m) (from the earth surface)	1024	1053
Current reservoir pressure (bar)	113	114
Maximum reservoir pressure (bar)	155	156
Reservoir radius (km)	8	5
Trap radius (km)	8	5
Reservoir thickness (m)	45	28
Porosity (%)	22	20
Net-gross *(aquifers only)*	0.8	0.8
Reservoir temperature (°C)	19	11
Permeability (mD)	>200-300	300
Well radius (m)	0.15	0.15
Storage capacity ($MtCO_2$)		
in Geocapacity database	40.2	44
Well injection rate (Mt/yr)	2	2
Storage efficiency factor (%)		
Aquifers : fraction of		
available total pore space	40	40



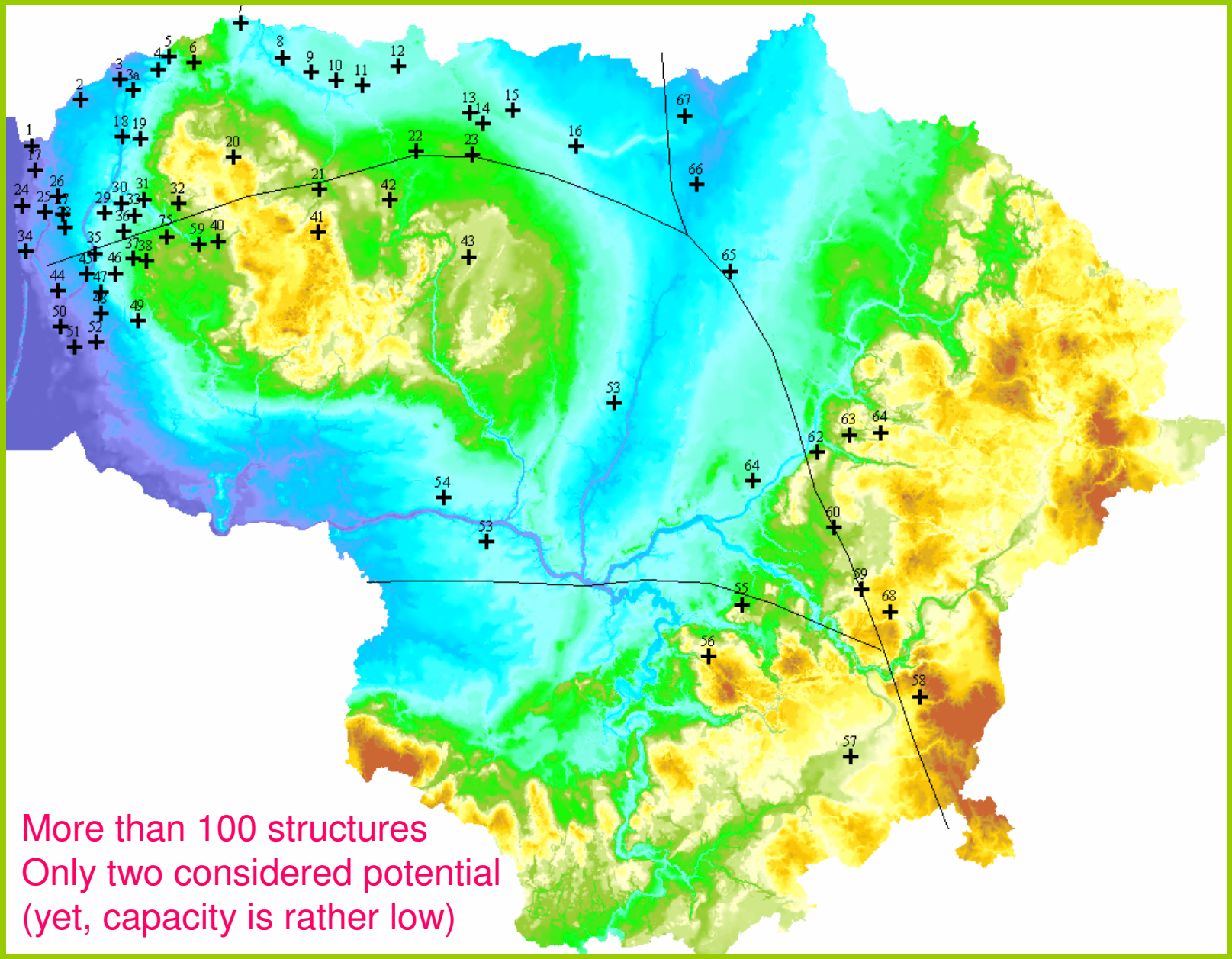
. Blidene and North Blidene structures, top of Cambrian

Storage capacity
58+74 Mt CO2



Lithology of Cambrian of well Blidene-5

Identified local uplifts in Cambrian reservoir, Lithuania

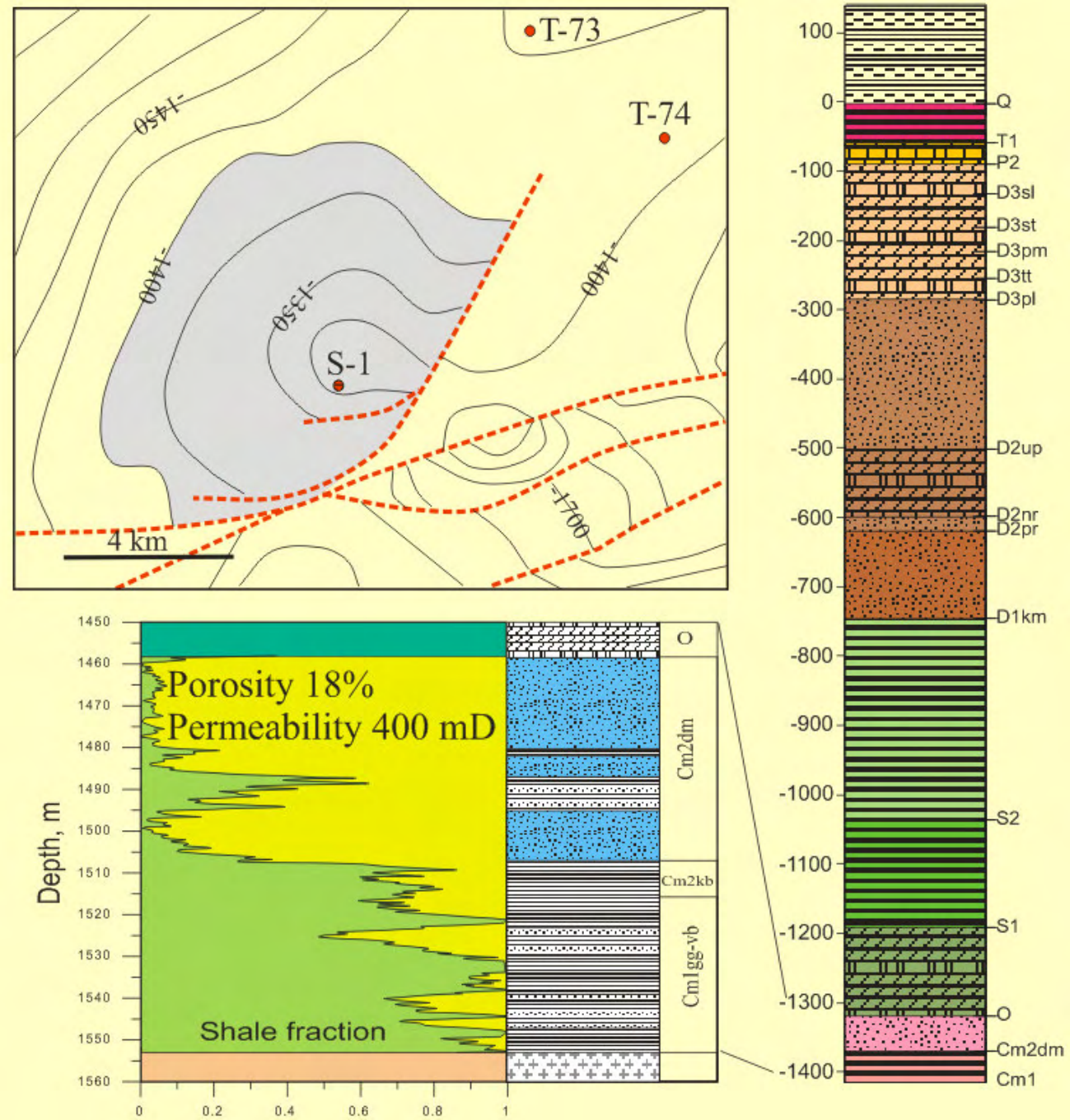


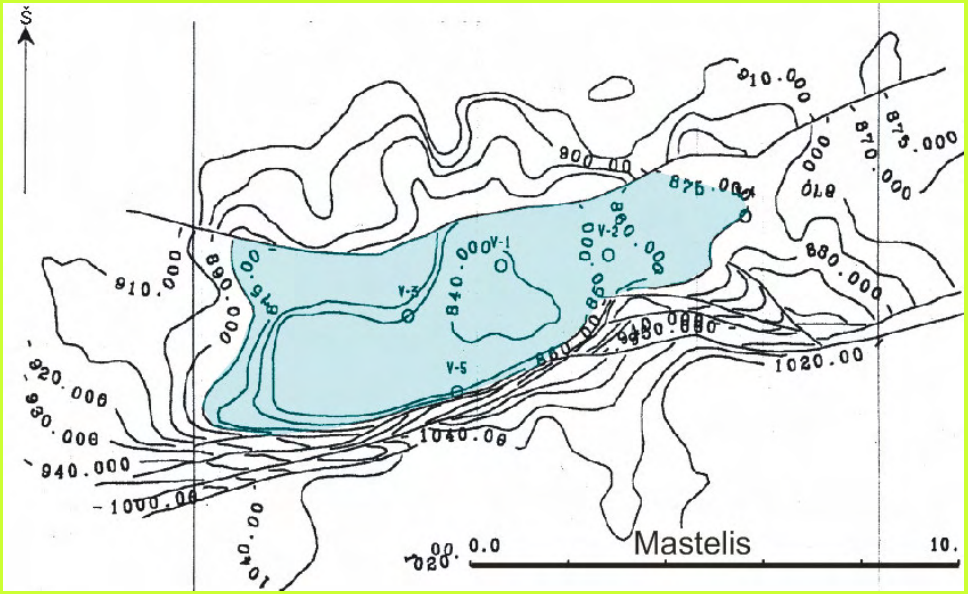
More than 100 structures
Only two considered potential
(yet, capacity is rather low)

Syderiai uplift,
West Lithuania

Storage capacity 22 Mt CO2

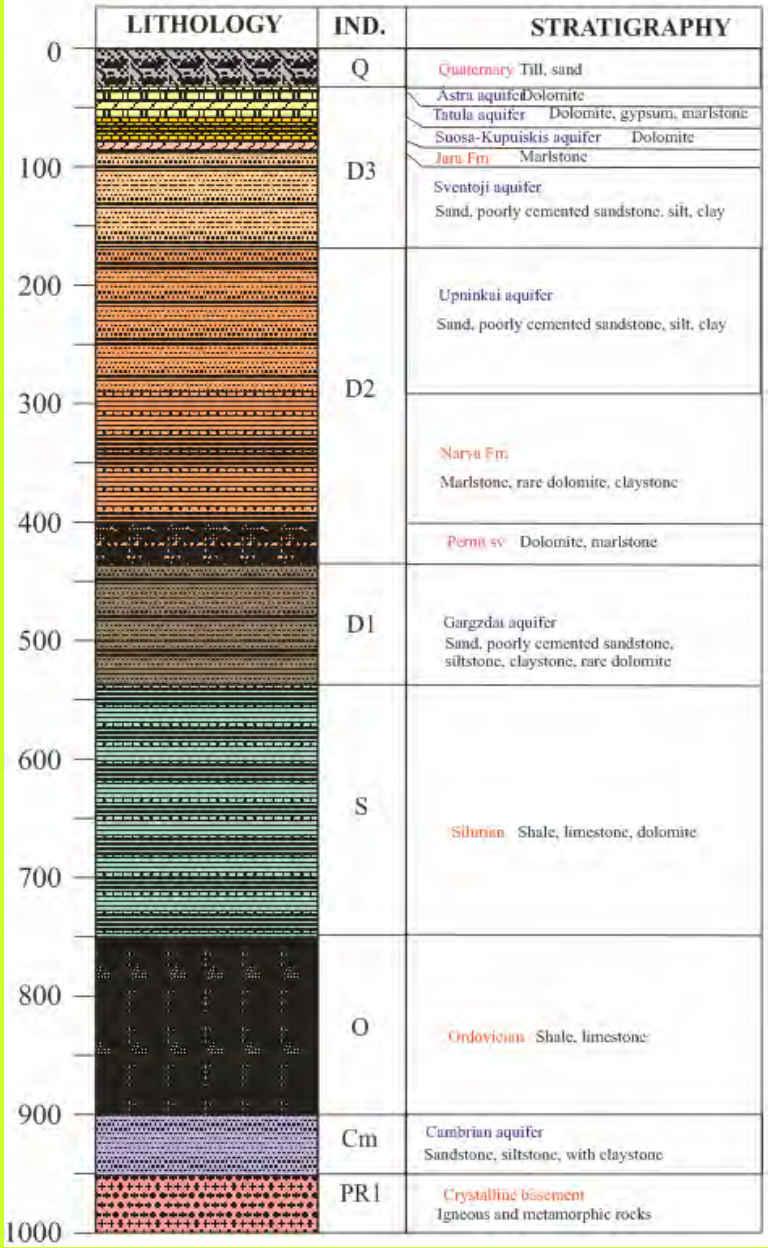
Excellent cap rock
Good reservoir properties
Favorable depth



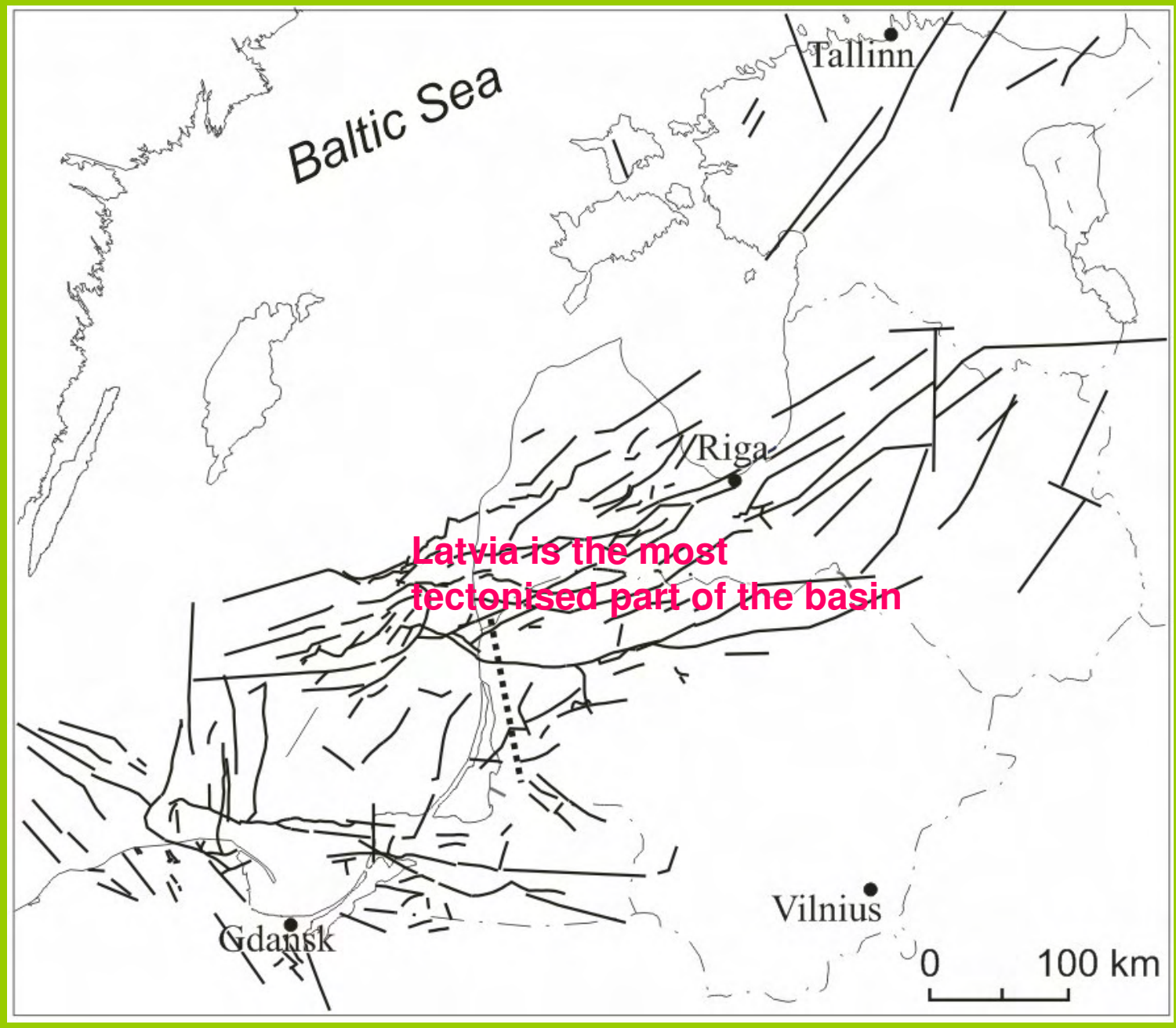


Vaskai structure, depths of top of Cambrian

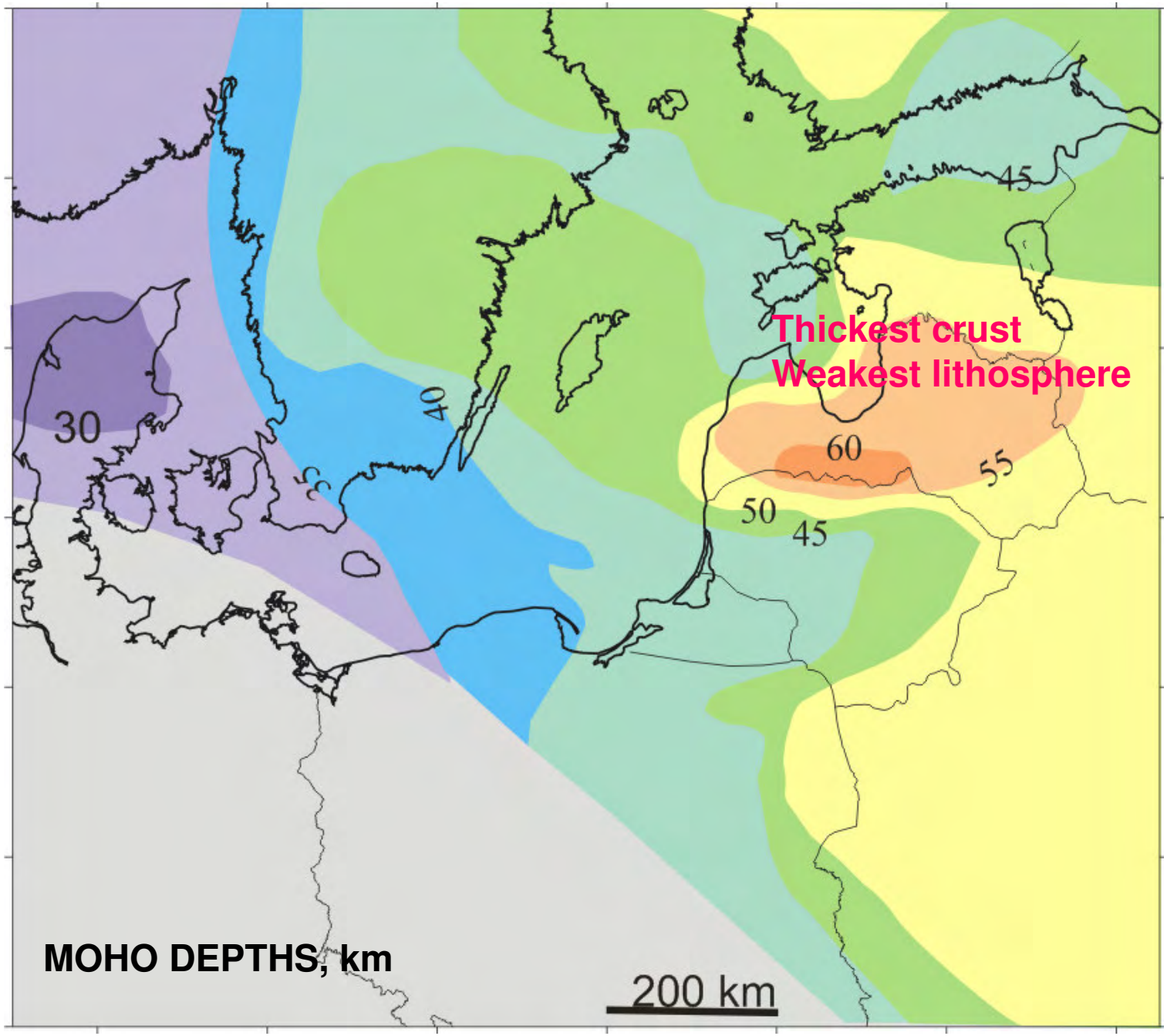
Storage capacity 8 Mt
CO2



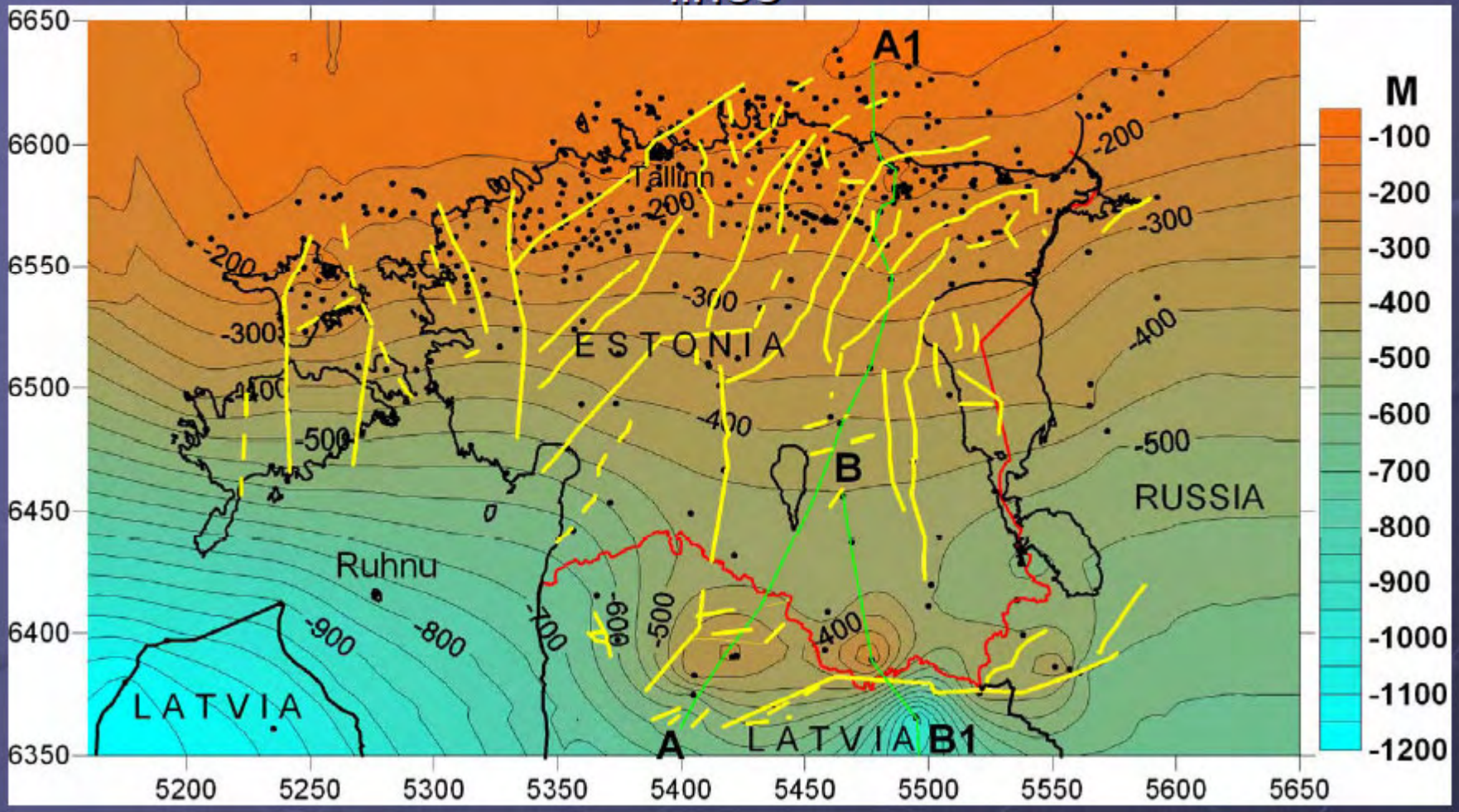
Stratigraphy of the Vaškai structure

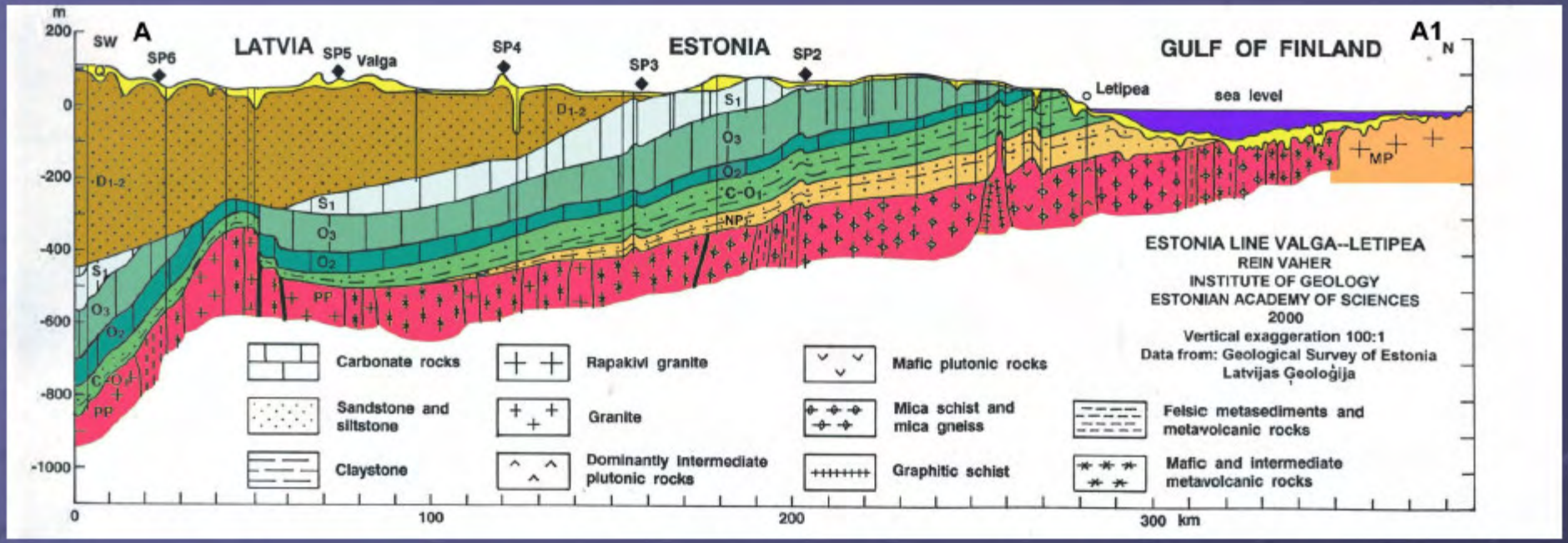


Major faults of the sedimentary cover


Thickest crust
Weakest lithosphere
30
40
35
45
60
55
50
45
MOHO DEPTHS, km
200 km

Top of the Precambrian basement is shown by contours. Flexures above the basement fault are shown by yellow lines

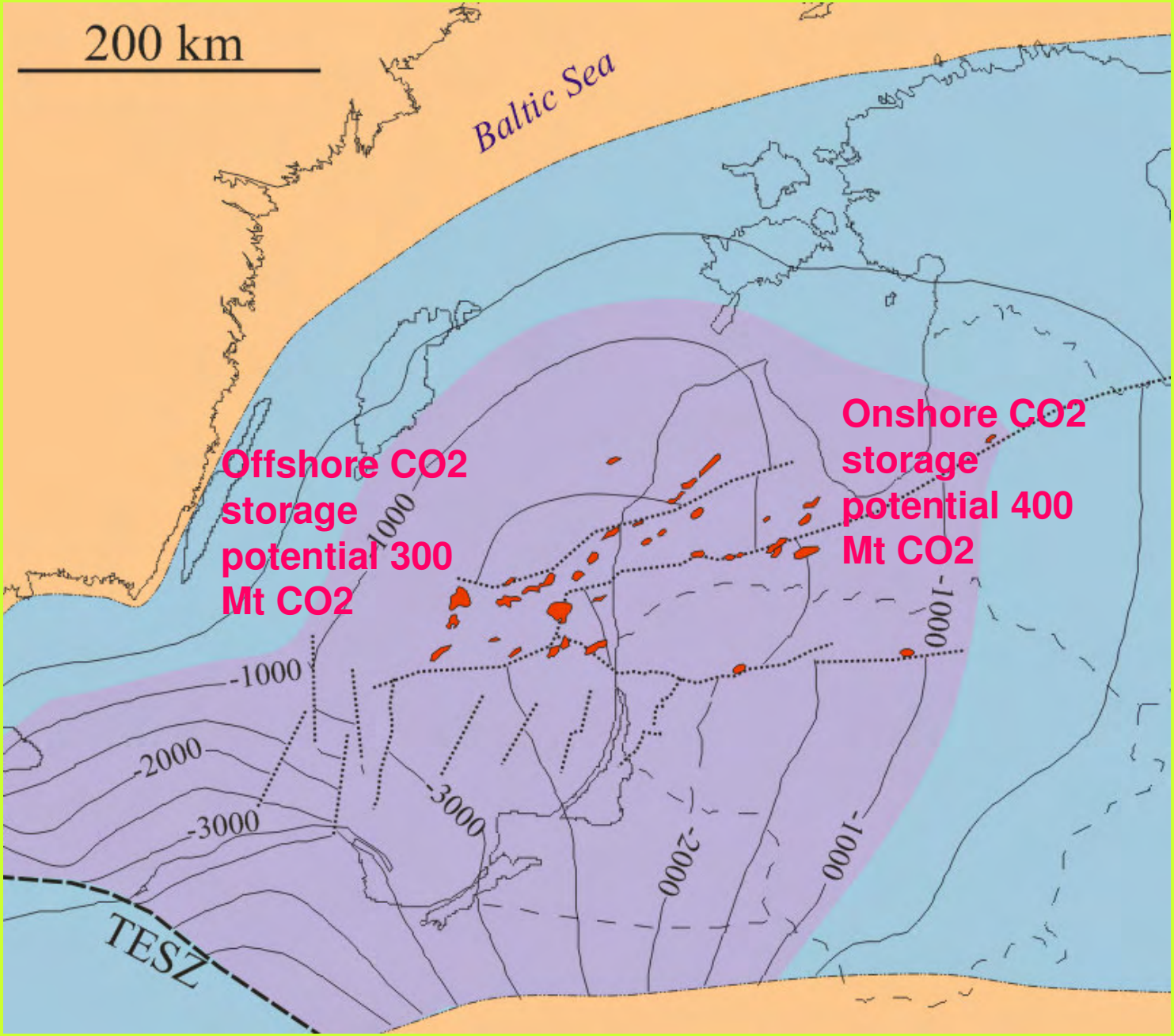




Section along Valga-Letipea line is modified after Puura & Vaher, 1997.

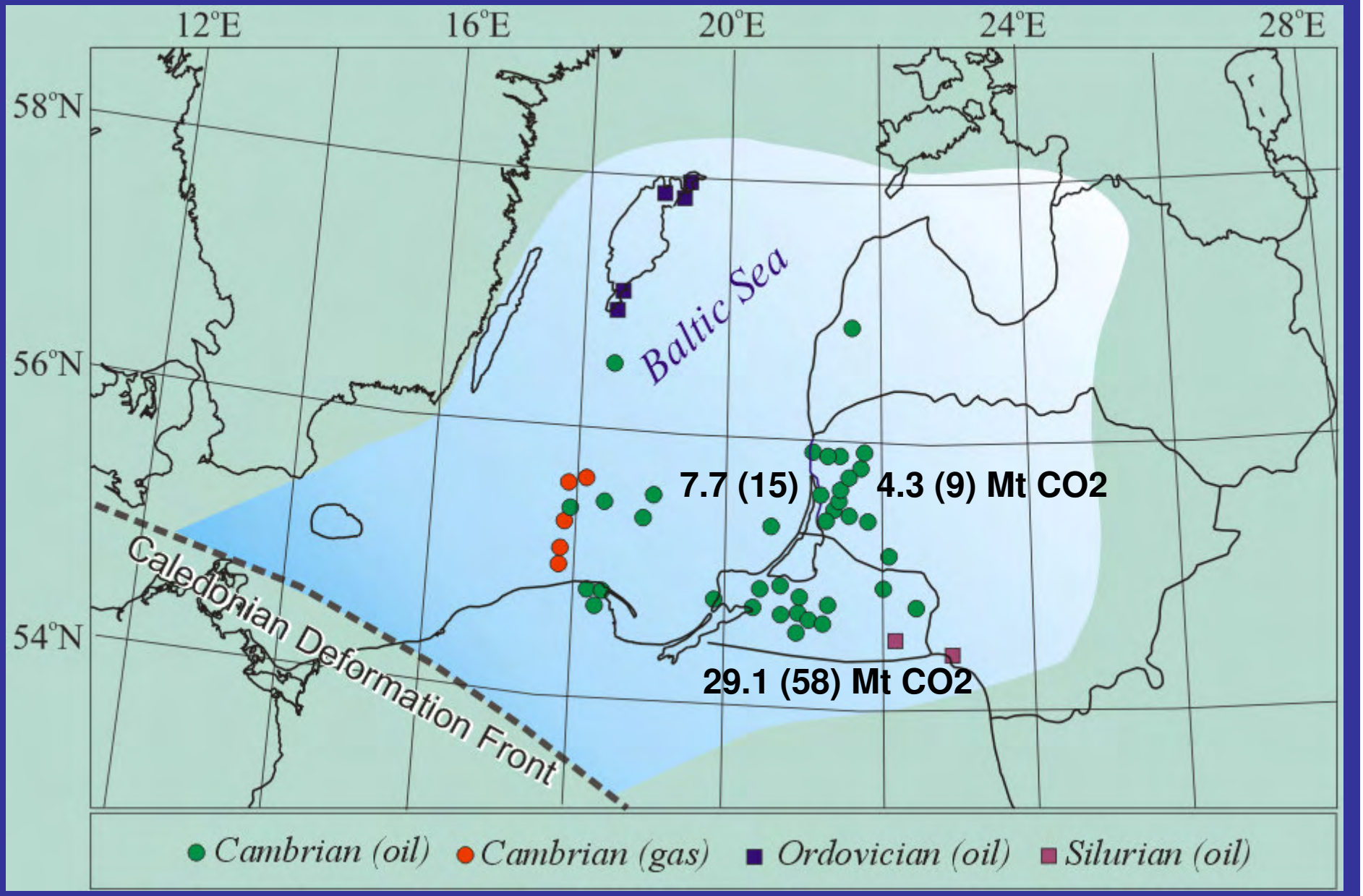
♦ – seismic shortpoint, Q – Quaternary, D – Devonian, O – Ordovician,

C – Cambrian, V – Vendian, PR – Palaeoproterozoic basement.



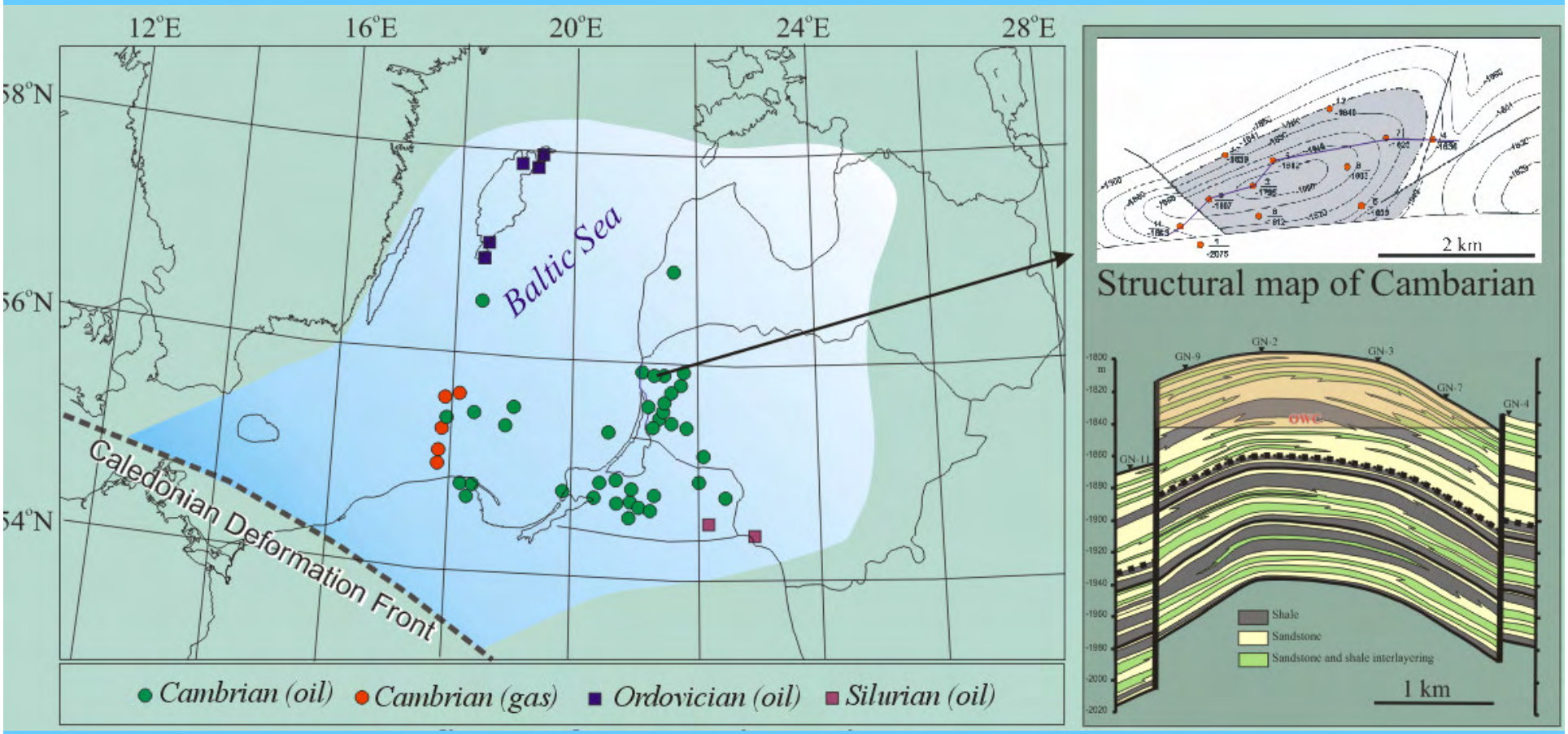
Major Cambrian aquifer saline water structures (34 in total)

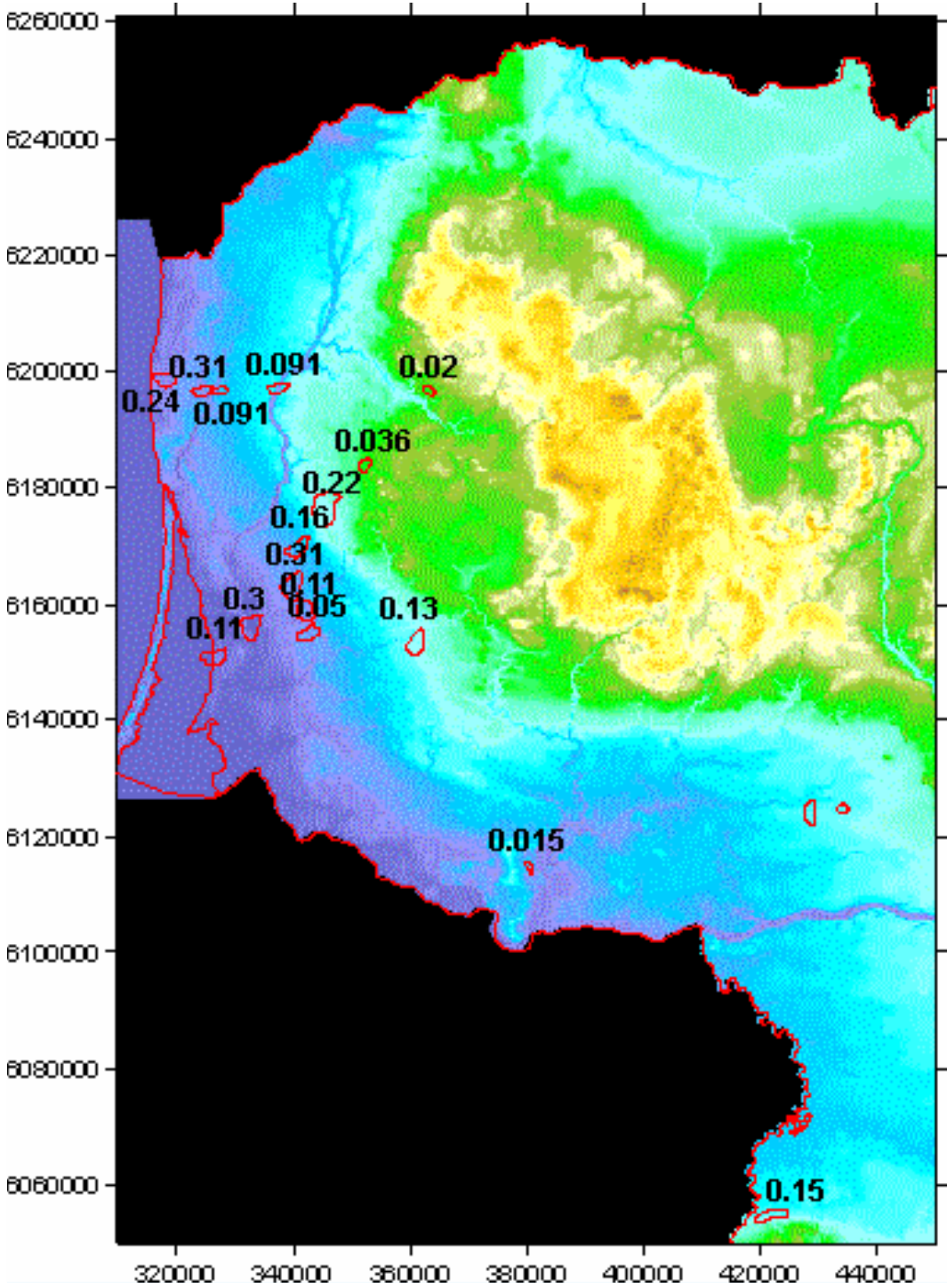
ALTERNATIVE STORAGE TECHNIQUES?



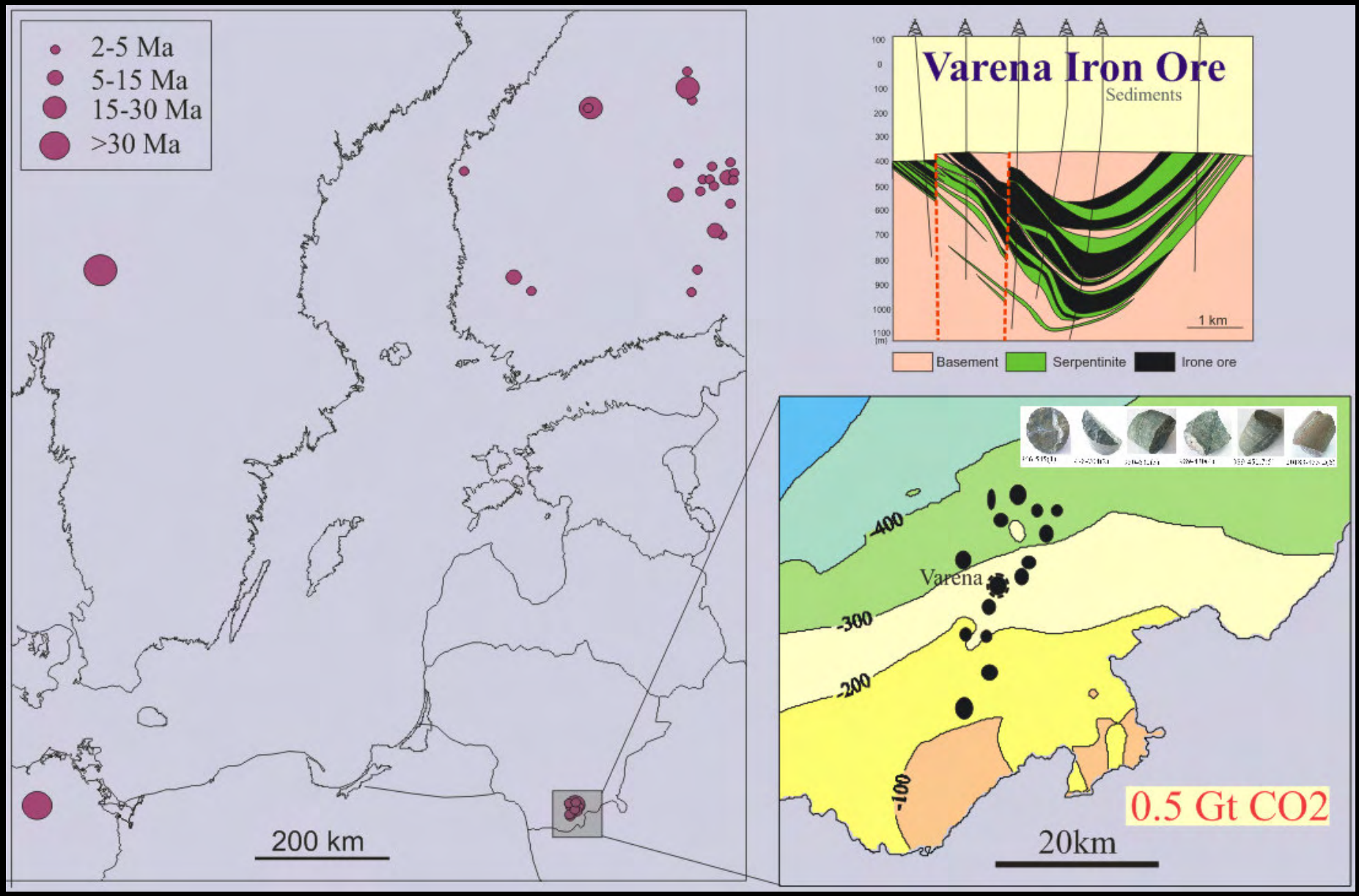
Oil and gas fields of the Baltic basin and CO2 EOR (net-gross)

Oil fields are confined to small Cambrian structures





EOR incremental oil, Mt



CO2 carbonation potential in Baltoscandian region

CONCLUSIONS

Only Cambrian deep saline aquifer is considered as the prospective reservoir for CO_2 storage

Baltic sedimentary basin comprises prospective structural traps as large as up to 58+74 Mt CO_2.

The total storage capacity is estimated 400 Mt CO_2 onshore and 300 Mt onshore (the latter estimate is rough)

It covers more than 40 years emissions from major CO_2 source (350 years of needs of Latvia)

All the potential (structural) traps of deep saline aquifers is confined to Latvian territory with only little capacity estimated in Lithuania and no prospects in Estonia

CO_2 storage capacity of oil fields is negligible; EOR economy does not seem viable in Lithuania oil fields, while there is a good potential in adjacent Kaliningrad and Polish oil fields.

Carbonation has a large potential, but technologies are at only early stage of development.