

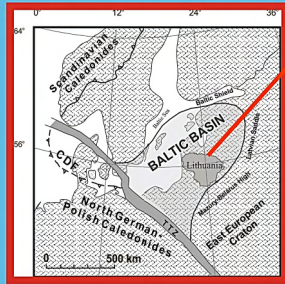
Geological and tectonic structure of Lithuania: implications for CO₂ storages

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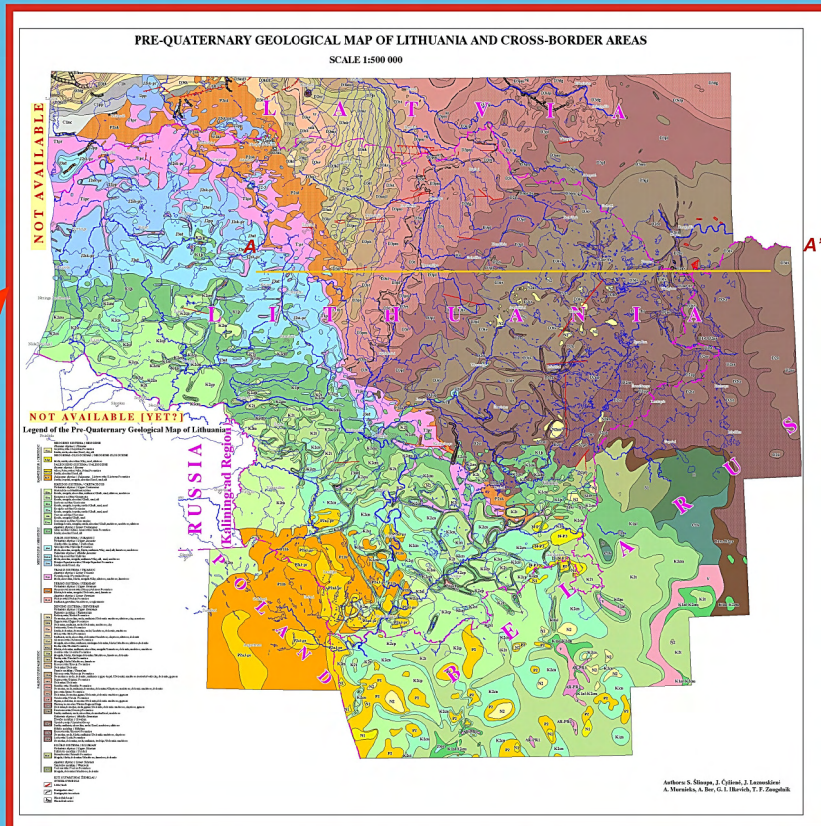
INTRODUCTION

The Baltic Sedimentary Basin (BB) is a Phanerozoic sedimentary basin, situated on the western margin of the East European Craton (EEC). It was initiated during the latest Vendian-Early Cambrian times and then underwent the main episode of subsidence in Silurian-Early Devonian.

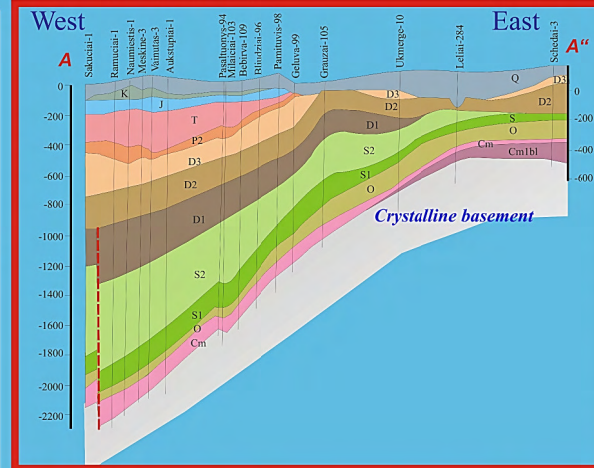


The regional tectonic framework of the study area: CDF - Caledonian Deformation Front; TTZ - Tornquist-Teisseyre Zone (modified after Lazauskiene et al., 2002).

Lithuania covers the major part of BB. Strongly faulted, displaced crystalline basement gradually submerges SW from 200 to ~2300 m. The crystalline basement is strongly faulted - two dominating families of reverse faults, oriented WSW-ENE and SSW-NNE can be distinguished: the former are transpressional and the latter are compressional faults mainly.



GEOLOGICAL SETTING

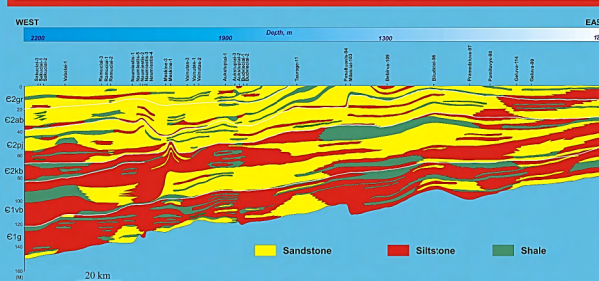
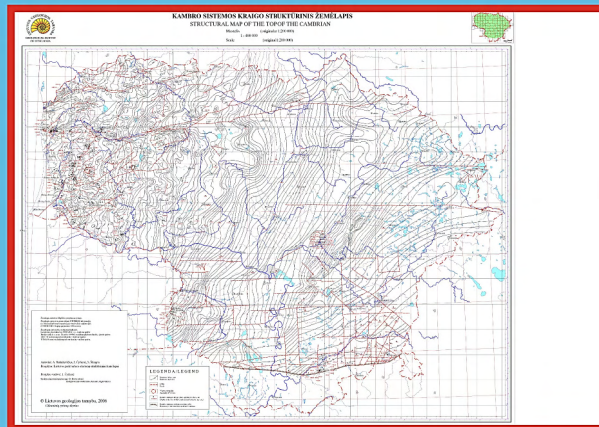
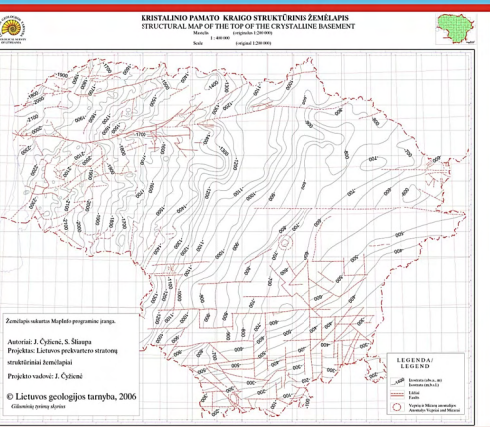
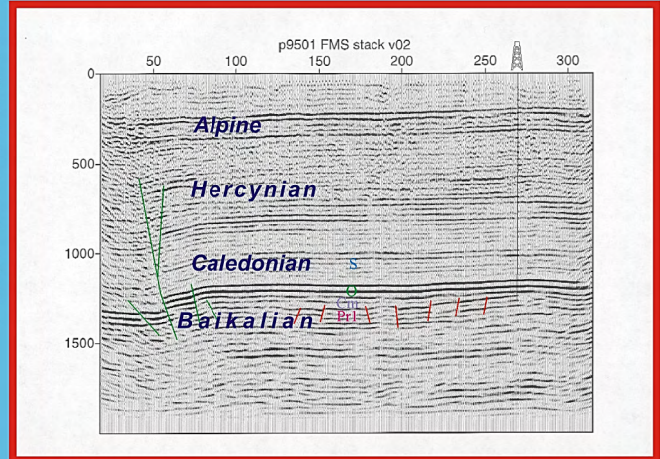


Geological cross-section Lithuanian onshore (see left figure for location; modified after Sliupa, Lazauskiene)

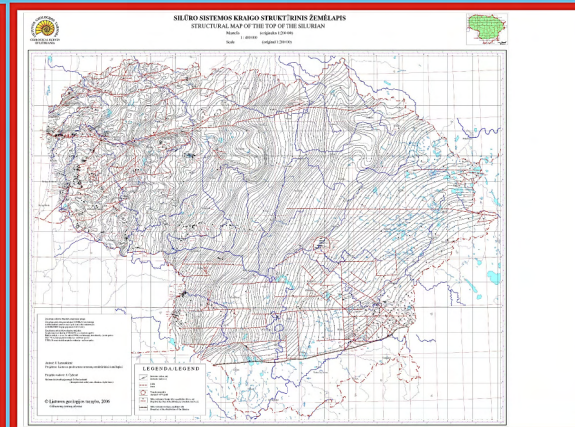
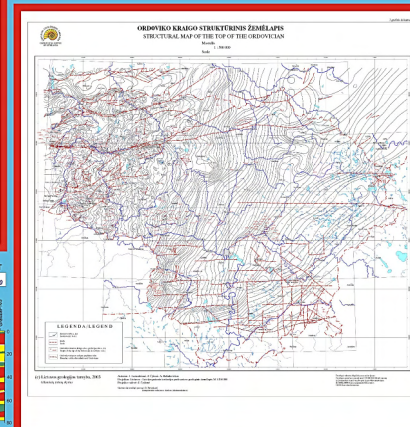
The distribution of sedimentary cover is related to the structure of the crystalline basement - sedimentary succession is represented by all the Phanerozoic strata and Quaternary that overlie the deeply eroded surface of crystalline basement. The most complete ~2 km section is in W Lithuania. Palaeozoic-Cainozoic successions are covered by 0.5-10 to 300 m Quaternary. Only Quaternary, Neogene, Cretaceous, Jurassic and Devonian sediments crops out at the surface. The older Silurian and Devonian sediments are distributed in the east, while youngest Neogene-Paleogene strata were mapped in the SW part of Lithuania. Sub-Quaternary relief of the area is highly dissected by palaeoincisions with altitudes from 90-100 m above to ~30-70 m below sea level.

STRUCTURAL- SEDIMENTARY COMPLEXES

Based on the tectonic events, structure of the crystalline basement, thickness, stratigraphic completeness of the sedimentary cover and the facies the sedimentary succession is subdivided into Baikalian, Caledonian, Hercynian and Alpine structural-sedimentary complexes. All the complexes are separated by unconformities that represents periods of non-deposition and erosion.



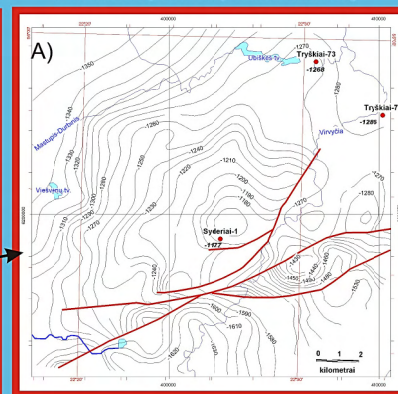
The Cambrian sediments of Baltic Basin were deposited in a shallow marine environment. The thickness of the Cambrian succession in Lithuania range from several meters in the east to 175 m in the west. Lithologically the succession comprises alternating quartz arenite sandstones, siltstone and shales with different proportions across the basin. A number of economically important hydrocarbon reservoirs occur in the Cambrian succession of the Lithuania onshore and offshore.



The most prospective formation for geological storage of CO₂ is the Cambrian reservoir. The capacities of more than 100 Cambrian local uplifts identified in Lithuania were evaluated recently (Šliaupa et al., 2005). The two largest Vaskai and Syderiai aquifer structures can storage 3.5 and 5.4 Mt of CO₂ respectively (Sliupa et al., 2008).

Structural framework of Syderiai (a) and Vaskai (b) structures

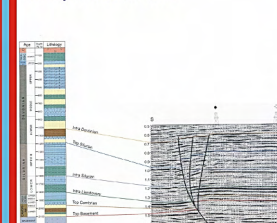
Structural map of the top of the Llandovery



Area of structure - 10.5 sq.km
amplitude - 35 m
bulk volume - 183.75 mln.cq.m
total porosity - 14%
net pore volume - 18.0 mln.cq.m

Area of structure - 25.0 sq.km
amplitude - 40 m
bulk volume - 500.0 mln.cq.m
total porosity - 22%
net pore volume - 39.6 mln.cq.m

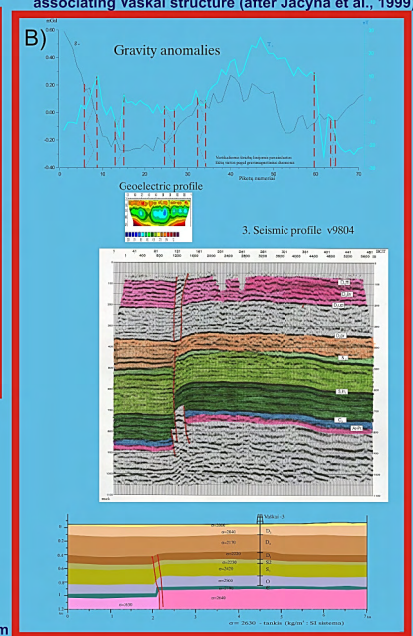
Depth structure map of the Lithuanian onshore Girkaliai Oil Field; exhibiting the top Cambrian level



Girkaliai oil field; in production from 1994
~65% of recoverable oil resources produced
area of structure - 10.8 sq.km
amplitude - 60 m
bulk volume - 54.0 mln.cq.m
total porosity - 8.5%
net pore volume - 3.02 mln.cq.m

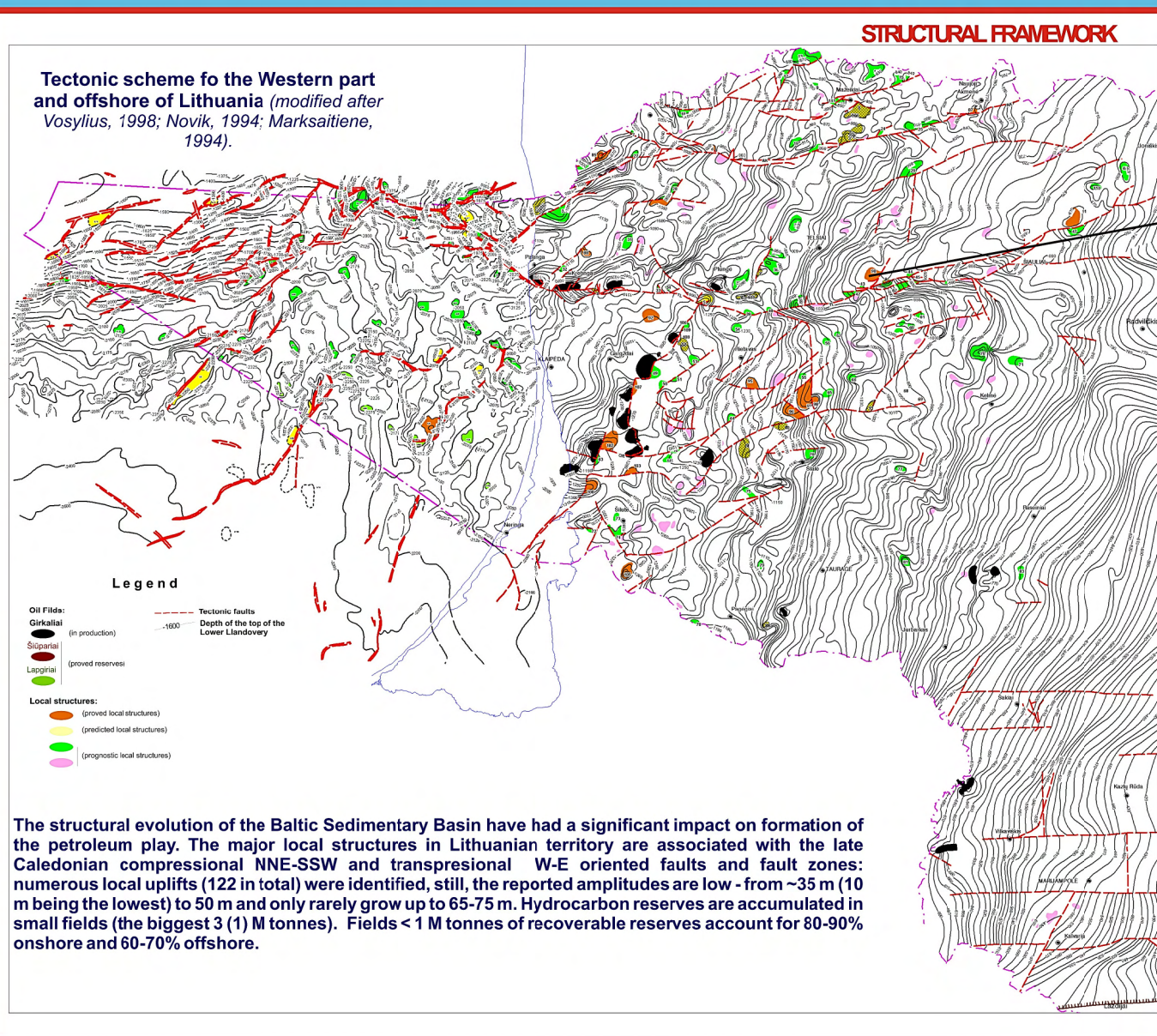
Undrilled onshore Cambrian local structure P17
area of structure - 1 sq.km
amplitude - 10-15 m
total porosity - 8.0%

Combined geophysical study of the Telsiai Fault and associating Vaskai structure (after Jacyna et al., 1999)



Depleted Cambrian siliciclastic oil reservoirs are attractive as CO₂ storage locations

The Cambrian oil-bearing structures are commonly as large as 3x5 sq.km x 20-40 m. Twelve oil fields are presently producing; three small oil fields already depleted and three oil fields almost depleted (~90% of recoverable oil resources are produced). The size of oil fields ranges from 16,000 t to 1,297,000 t of the recoverable oil. The storage potential of the largest oil fields in West Lithuania reaches two Mt of CO₂. The total potential in Lithuania is estimated at 7.6 Mt of CO₂, which is just a little more than the annual stationary CO₂ emissions of the country (Sliupa et al., 2008).



The structural evolution of the Baltic Sedimentary Basin have had a significant impact on formation of the petroleum play. The major local structures in Lithuanian territory are associated with the late Caledonian compressional NNE-SSW and transpresional W-E oriented faults and fault zones: numerous local uplifts (122 in total) were identified, still, the reported amplitudes are low - from ~35 m (10 m being the lowest) to 50 m and only rarely grow up to 65-75 m. Hydrocarbon reserves are accumulated in small fields (the biggest 3 (1) M tonnes). Fields < 1 M tonnes of recoverable reserves account for 80-90% onshore and 60-70% offshore.