# Lithuanian Subsurface Resources: An Overview

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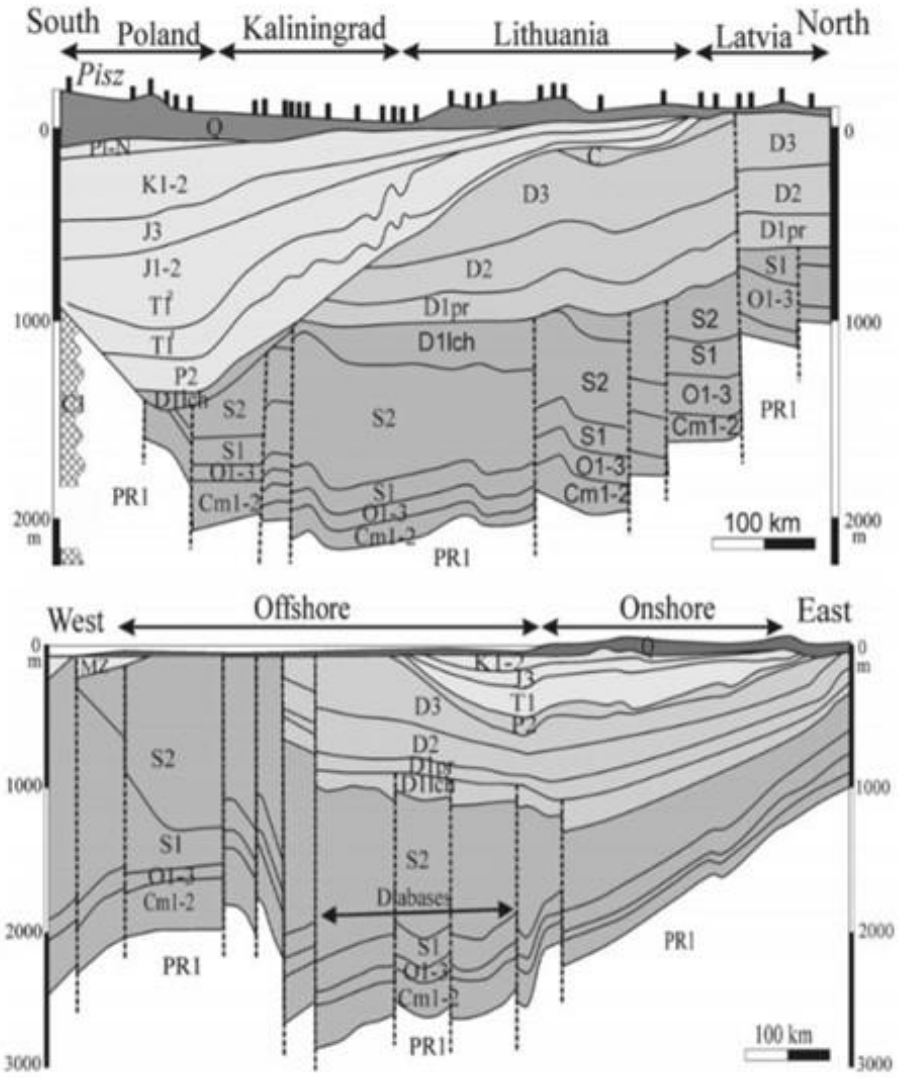
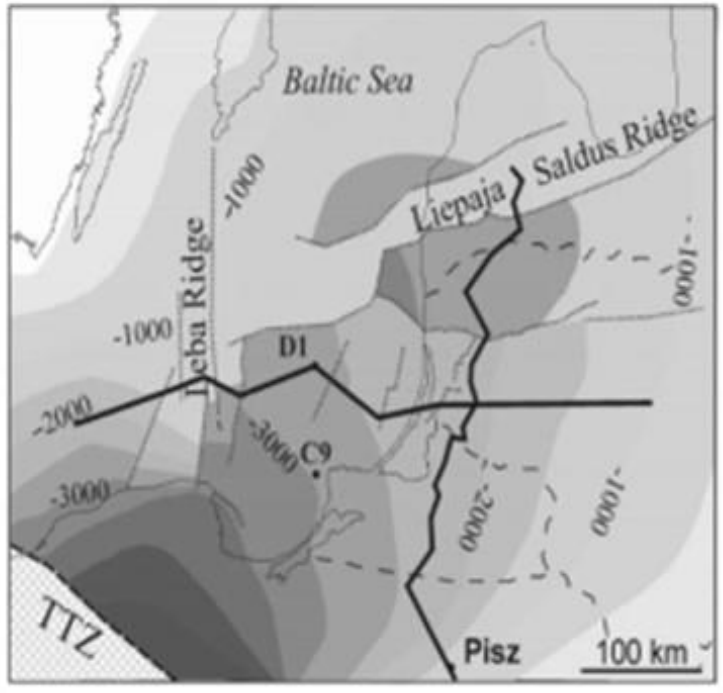
# Baltic syneclise




a

The crystalline basement has a depression with a depth of up to 5 km which is filled with sedimentary rocks.




b

Gediminas Motuza, Saulius Šliaupa and Martin J. Timmerman Geochemistry and 40Ar/39Ar age of Early Carboniferous dolerite sills in the southern Baltic Sea. Estonian Journal of Earth Sciences, 2015, 64, 3, 233–248.

# Exploration of Lithuania's subsurface

- In 1948, signs of oil were discovered in the Vilnius well.
  - Systematic oil searches began in 1958.
- About 30,000 km of 2D seismic has been conducted onshore and 10,000 km offshore.
  - Part of the oil-prospective territory has been explored with 3D seismic work.
- About 500 deep wells have been drilled, most of which reach the crystalline basement.



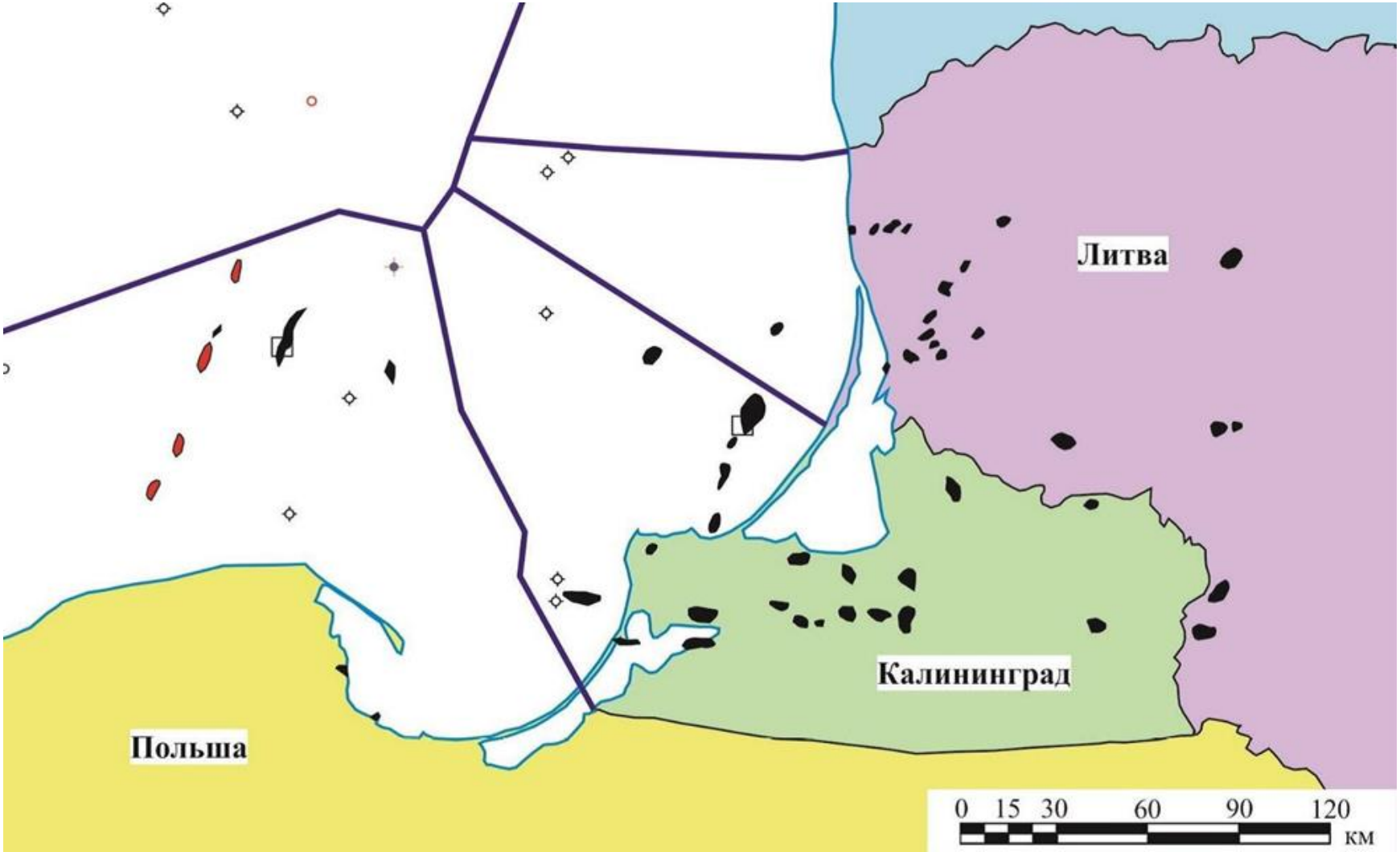

The first hydrocarbons extracted from Silurian shales in (2012-07-24).

**In Lithuania oil is found:**

1. In Cambrian sandstones – oil fields found in Western Lithuania, extraction is underway.
2. In Ordovician and Silurian reefs in the western part of Central Lithuania – small inflows have been obtained. Unfortunately, no oil fields have been found, no extraction.
3. In Silurian, Ordovician, and perhaps Cambrian shales, there are "unconventional" hydrocarbons – shale oil with gas.

Well Pociai-4: a) combustible gas b) oil from Silurian shales.

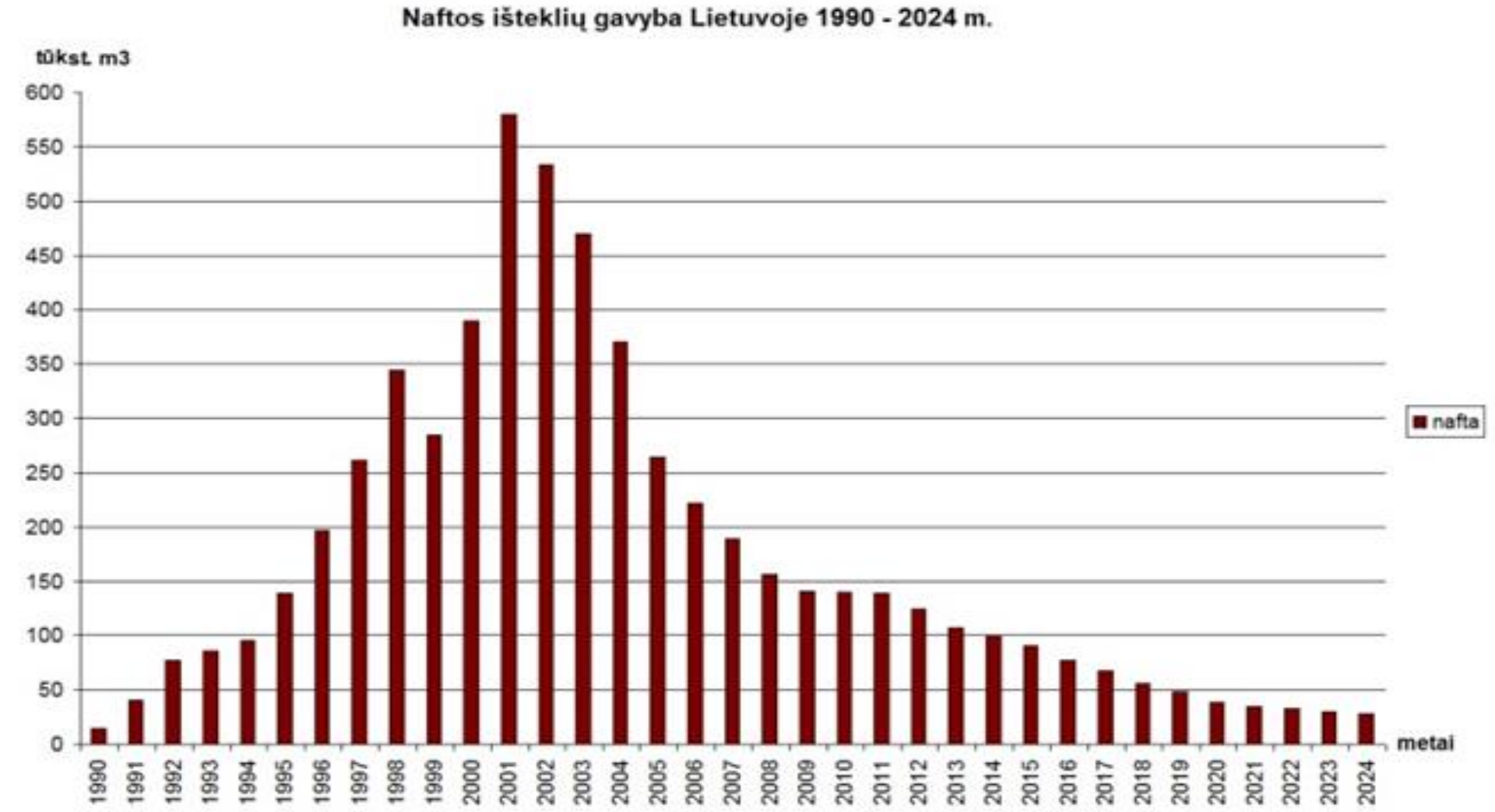

# Oil and gas fields in the Baltic syneclise




Отмас А.А. (старший), Маргулис Л.С., Отмас А.А. ПЕРСПЕКТИВЫ НЕФТЕГАЗОНОСНОСТИ ШЕЛЬФА БАЛТИЙСКОГО МОРЯ. Нефтегазовая геология. Теория и практика.– 2017.- Т.12. - №1.

# Lithuanian oil production

- 1990 – 2024 ~5.6 mln. m³ of oil was extracted.
  - The balance of recoverable resources at the end of 2024 amounted to ~2.1 mln. m³.
  - 7 percent less was extracted in 2024 than in 2023.
- Currently, oil is extracted from 11 fields.

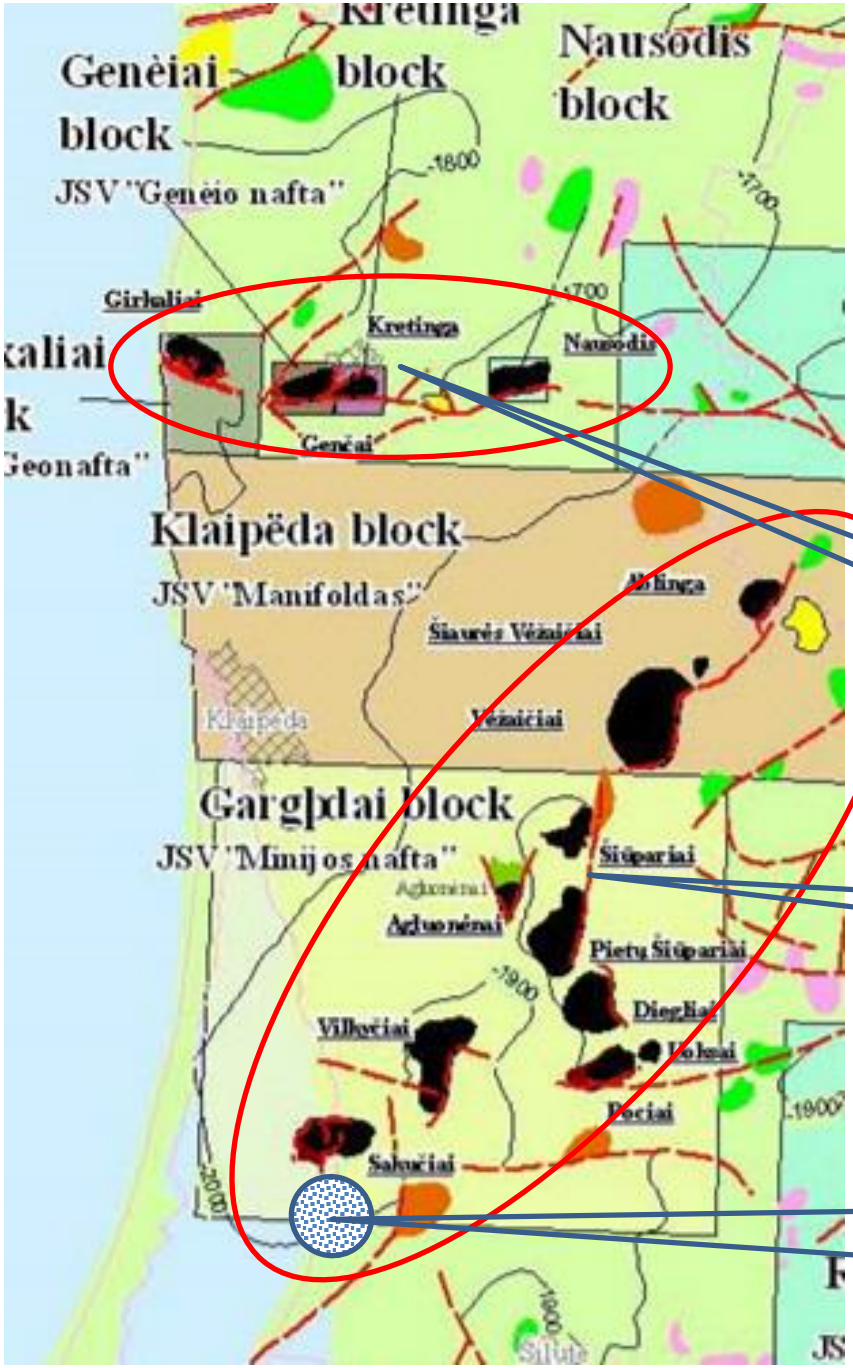



With time the oil was replaced by water and now
there is less than 4 $m^3$ of oil in every 100 $m^3$ of liquid produced.

# Oil production map

Onshore, traditional hydrocarbons are extracted from Cambrian sandstones in the **Telšių Volas** and **Gargždai Uplift Zone**.

In the southern part of the latter, the Kintai structure is ready for drilling.

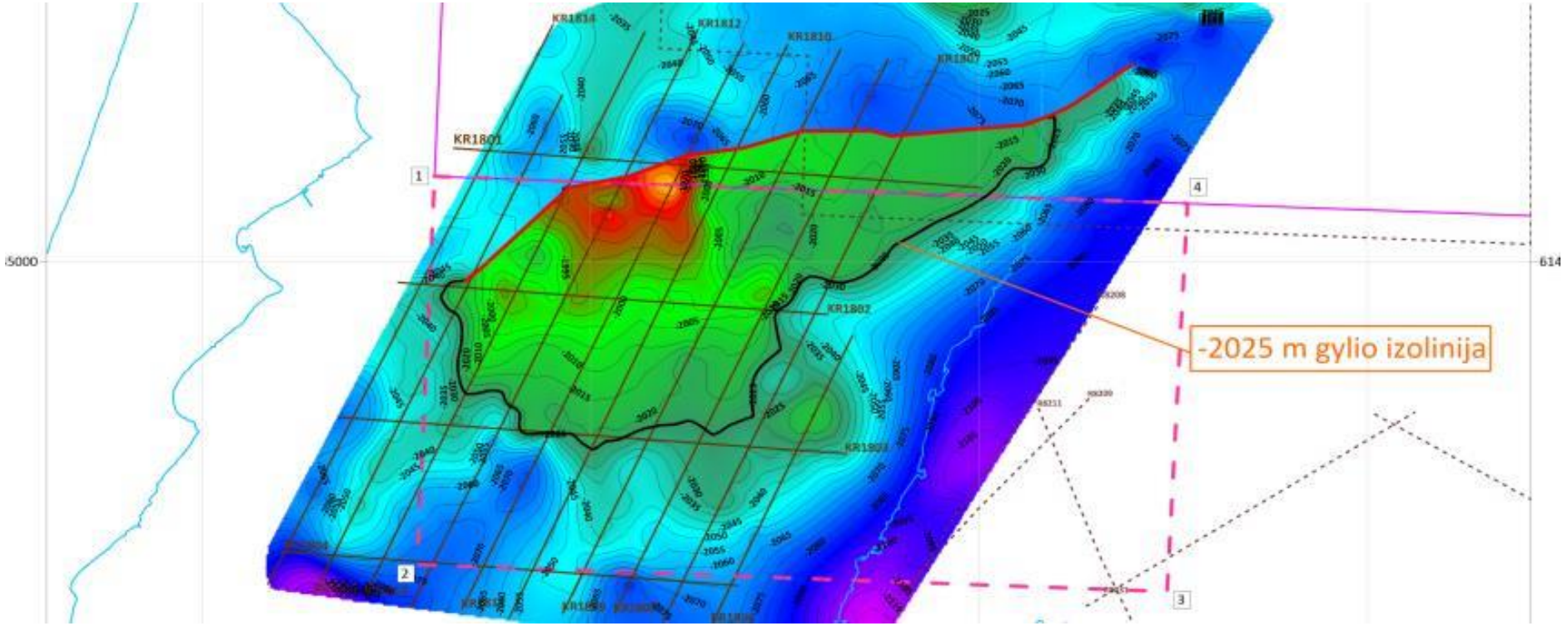



Telšių Volas (scarp)

Gargždai Uplift Zone

Kintai structure has been studied with 2D and 3D seismic work. It is ready for drilling.

Kintai structure is ready for drilling, but due to the opposition of local residents, drilling is not taking place.
Geological resources in the structure are estimated at 4.5 (1.5) mln. $m^3$.



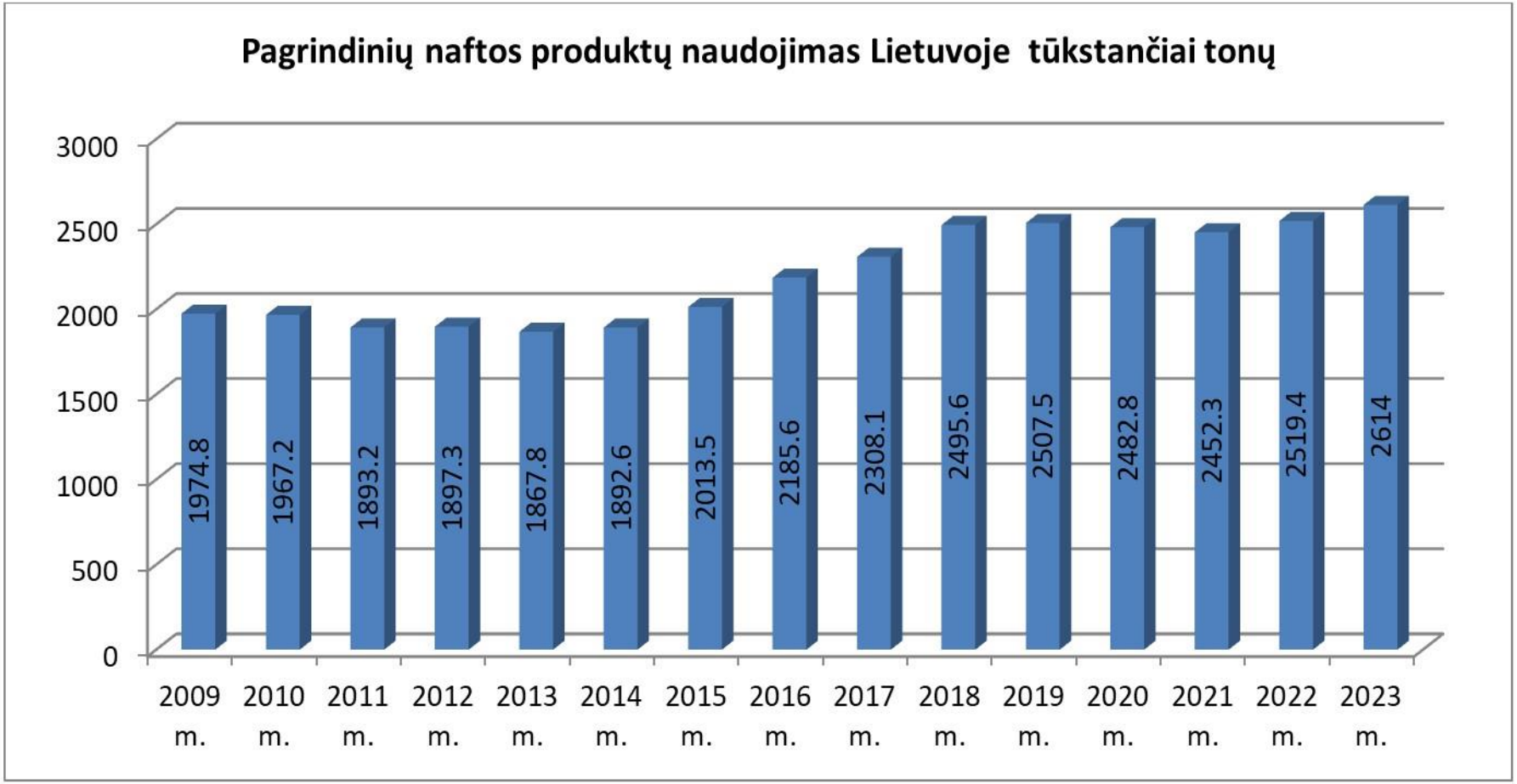

At current oil prices, state revenue in the form of royalties alone would be about 70 million euros.

**Gentvilas Simonas Member of Parliament since 2016, Minister of the Environment from 2020 to 2024.**

https://osp.stat.gov.lt/ "As oil resources dwindle, its extraction in Lithuania may be stopped". 2021-07-30. Internet link accessed 2025-03-20.

- "Oil production will definitely not be encouraged. We are satisfied with the noticeable natural decrease in the production of these resources and the ministry is considering the possibility of completely ceasing its production on land" said the head of the ministry.
- S. Gentvilas admitted that the ministry is considering the possibility of demanding from Russia to pay for the oil extracted from the D6 field, which is being exploited in the Kaliningrad region, right next to the border with Lithuania.

# Oil production increased by 1% in the world in 2013-2023*, while in Lithuania the usage of petroleum products increased by 40% during the same period**.




* OPEC Annual Statistical Bullet in 2024 https://publications.opec.org/asb/chapter/show/123/2113/2117.

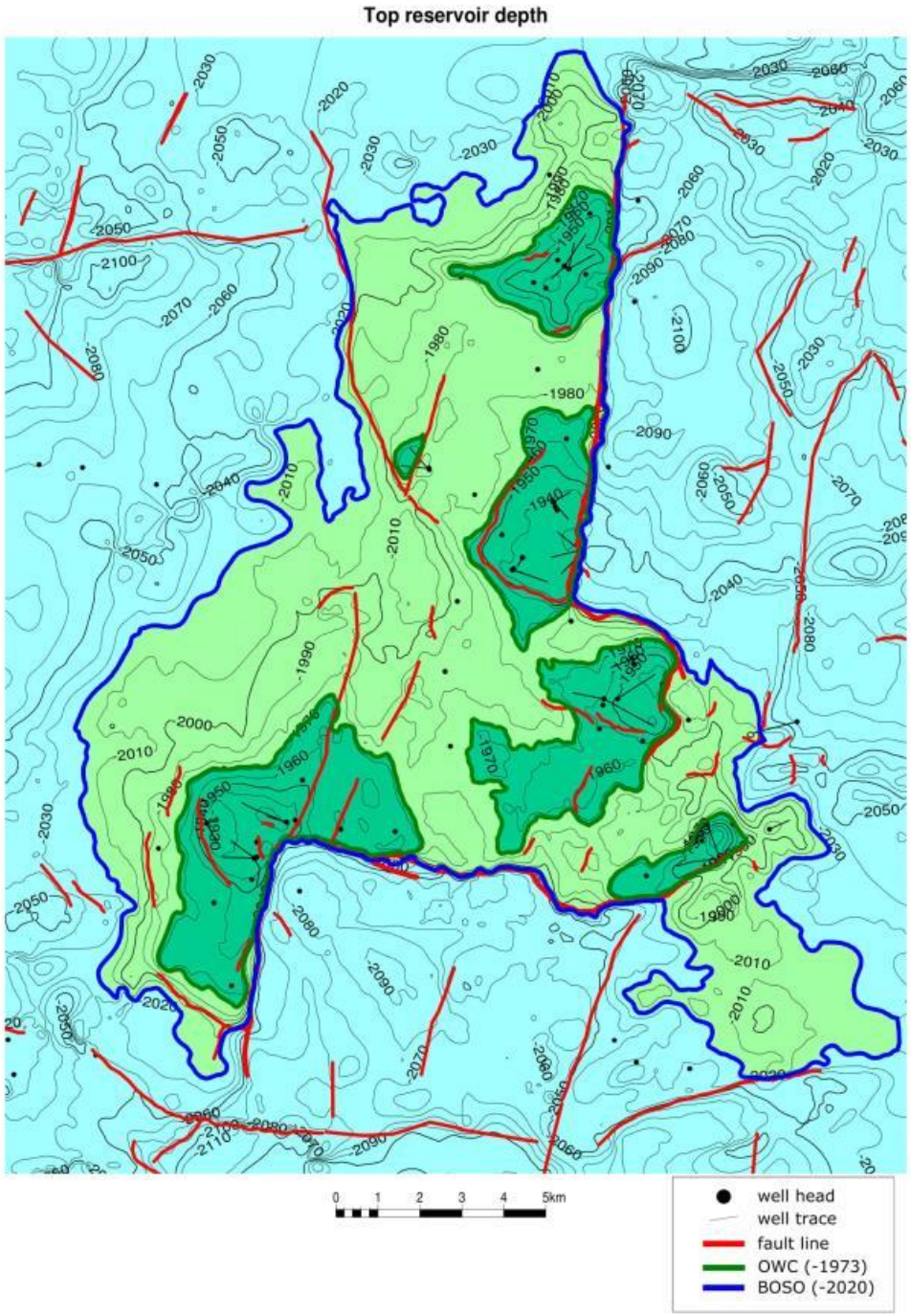
** Lithuanian Ministry of Energy, e-link accessed on 2025-03-18. https://enmin.lrv.lt/lt/veiklos-sritys-3/nafta/ . Update date: 2024-11-12.

# Is there still any oil left in the depths of Lithuania?

Baltic Sea,

Gargždai Uplifts (transitional zone),

Shales.




# Transition zone in Gargždai uplifts

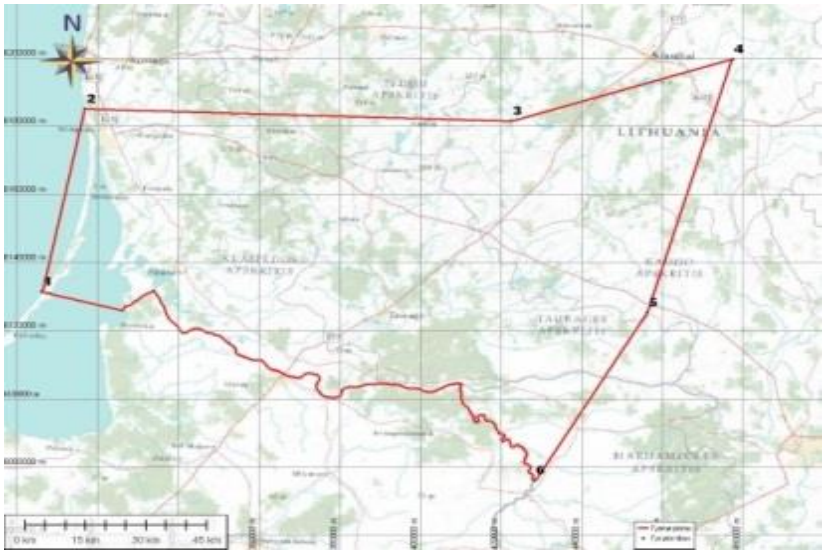
- Dark green fields – the main oil resources located above the average depth of the VNK (1973 m).
  - Their total area is 51 $km^2$.
  - Contains 12.7 mln. $m^3$ of oil.
- Light green field – residual oil field in the transition zone in the interval [1973 m – 2020 m].
  - Its area reaches 250 $km^2$.
  - Contained 125.6 mln. $m^3$ of oil.

# Transition zone in Gargždai uplifts

- Transition zone oil can be **extracted by applying tertiary recovery methods**.
  - Methods that change the properties of fluids and/or their relationship with reservoir rocks (**reducing oil viscosity**, **changing wettability**).
- Laboratory and field studies have shown that **$CO_2$ injection is effective** in the Cambrian reservoir.
  - If the ban on $CO_2$ injection is lifted, we could **additionally extract 10% of oil** from the Gargždai Uplifts area with a pronounced transition zone,
  - This would be equivalent to 13.8 mln. $m^3$ of oil or **635 mln. euros in royalty tax to the state**.

# Shale oil

- The red line marks the area where UAB “Minijos nafta” has assessed the potential of Silurian oil-generating rocks.
  - **Geological oil resources** in an area of ~4,000 km$^2$ may reach **~5.6 billion m$^3$**.
- According to O. Zdanavičiūtė’s* 2013 calculations:
  - The minimum oil resources in Western Lithuania in the Ordovician and Lower Silurian 1143 km$^2$ are 3.7 billion m$^3$,
  - The maximum – 5691 km$^2$ 18.3 billion m$^3$.




* In the study "Genesis of shale geological formations and hydrocarbon extraction: impact on the environment and human health" Compiled by prof. habil. dr. Algimantas.

# Shale oil

Serious intentions to explore the potential of unconventional hydrocarbons were met with an enormous resistance and further research into these hydrocarbons was halted.


# Shale oil

- Even the Lithuanian Academy of Sciences Commission was of no help, which assessed the importance of using the hydrocarbon potential from the depths of the country for energy and economy and "came to the following conclusions: **shale gas exploration in the depths of the Lithuanian earth is possible.**"*
- Having banned the exploration of our own shale hydrocarbon resources, we bring them from other countries (especially gas from USA), although at a steeper price.

* Report of the LMA Shale Gas Assessment Commission. Compiled by Algimantas Grigelis, 2013-03-18. 

# The Baltic Sea

- The oil potential of the Baltic Sea began to be studied purposefully in 1975, with the establishment of a joint Soviet, Polish and East German company “Petrobaltic“.

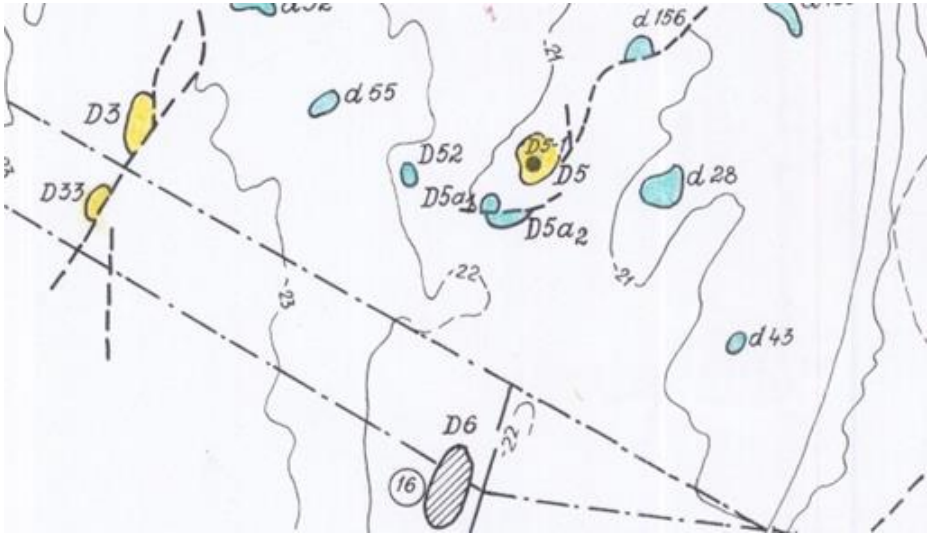
- After the restoration of independence, no oil exploration was carried out on the Lithuanian shelf.
  - The only exception was the seismic work of Minijos Nafta in the Kuršiai Lagoon, which clarified the structure of the **Sakučiai oil field** and discovered the **Kintai structure**. Oil in the Sakučiai field is being produced by drilling from the shore.

# The Baltic Sea

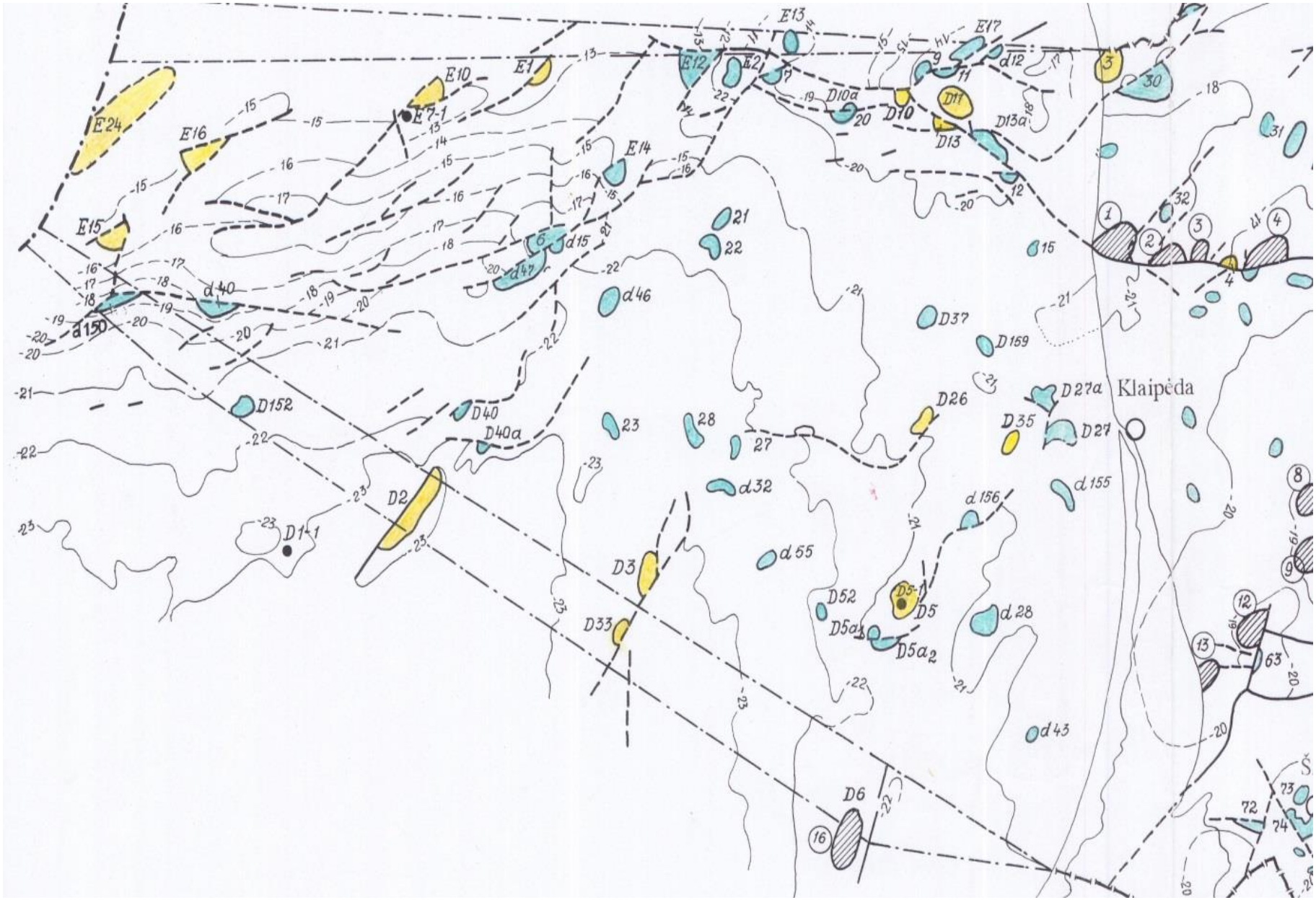
- Total oil resources were estimated in 1996, and were calculated in the Lithuanian offshore at about **85 mln. m³**.
- However, fields *have* been found **next to the southern border of our economic zone** with the initial recoverable oil resources of **40 mln. m³**.
- Geological resources are at least twice as large, so they should be about **100 mln. m³**.

**We can expect oil resources and fields of similar size on the Lithuanian Baltic Sea shelf.**

- *We can expect deposits and oil resources of similar size on the Lithuanian Baltic Sea shelf.*
- Lithuanian shelf:
  - 1 well in D5 has been drilled, which yielded **5.7 m$^3$/day** of oil flow from Cambrian sandstones. Unfortunately, this structure has not been studied further.
  - The structure D3 may be similar to D33, with similar resources, or even form a single field.

# Petrobaltic's discovered promising oil structures



# State plans

- The Government of the Republic of Lithuania, by Resolution No. 789 of 29 September 2021, approved the GENERAL PLAN OF THE TERRITORY OF THE REPUBLIC OF LITHUANIA until 2030.
- The first point states that it establishes "mandatory provisions for the use of the state territory":
  - 16.5. To develop marine and sea-related activities, [...] extraction of minerals.
  - 465. To carry out the use of hydrocarbon resources (oil) by applying the best environmental and risk management practices of the European Union, taking into account environmental pollution, climate change and other problems. To provide for the regulation of the development of oil resources in the offshore part, in coordination with other activities.
  - 569. The search, exploration and extraction of oil and other subsoil resources is possible in the entire water area, with the exception of extraction activities in the coastal zone, protected areas, port roads, and territories of natural and cultural heritage objects.

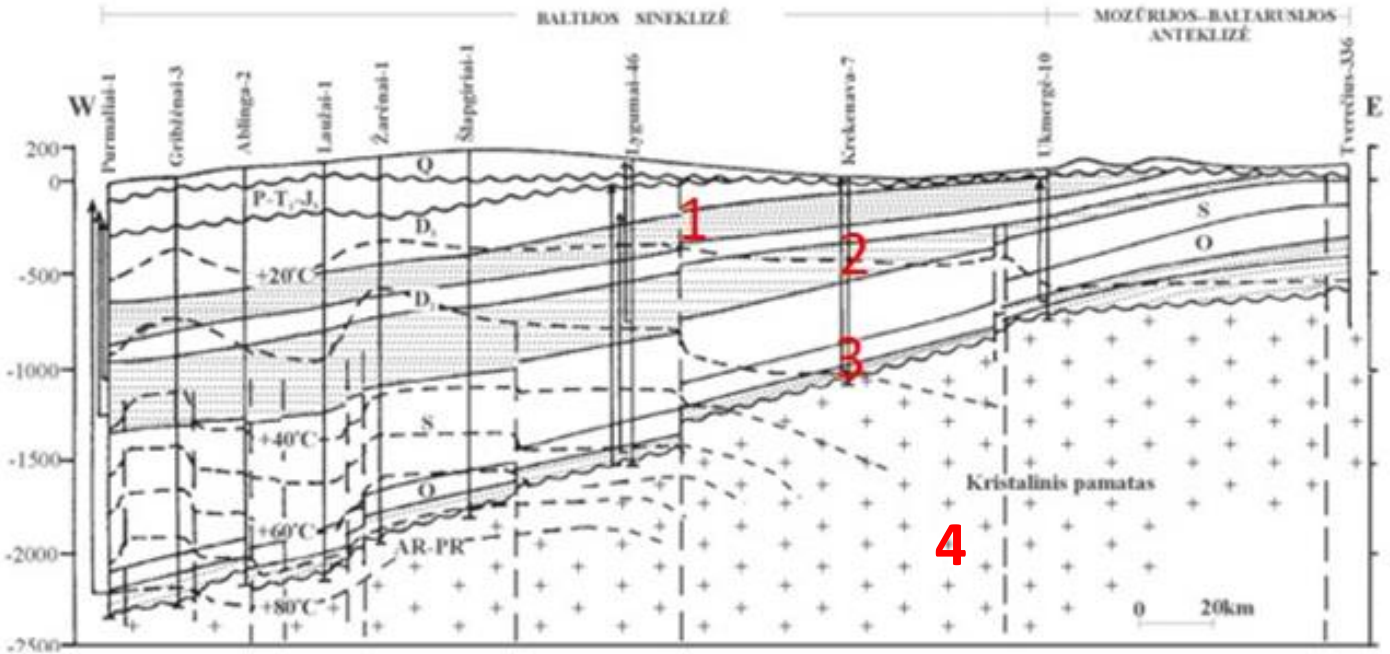
* Translated to English

# State plans and State losses

- The cost is not known for the preparation of the General Plan for the Territory of the Republic of Lithuania, approved by the Government of the Republic of Lithuania on September 29, 2021, Resolution No. 789.
- But if the "mandatory provisions on the use of state territory" were implemented, the state would receive about **423 million euros royalty** from offshore oil production.

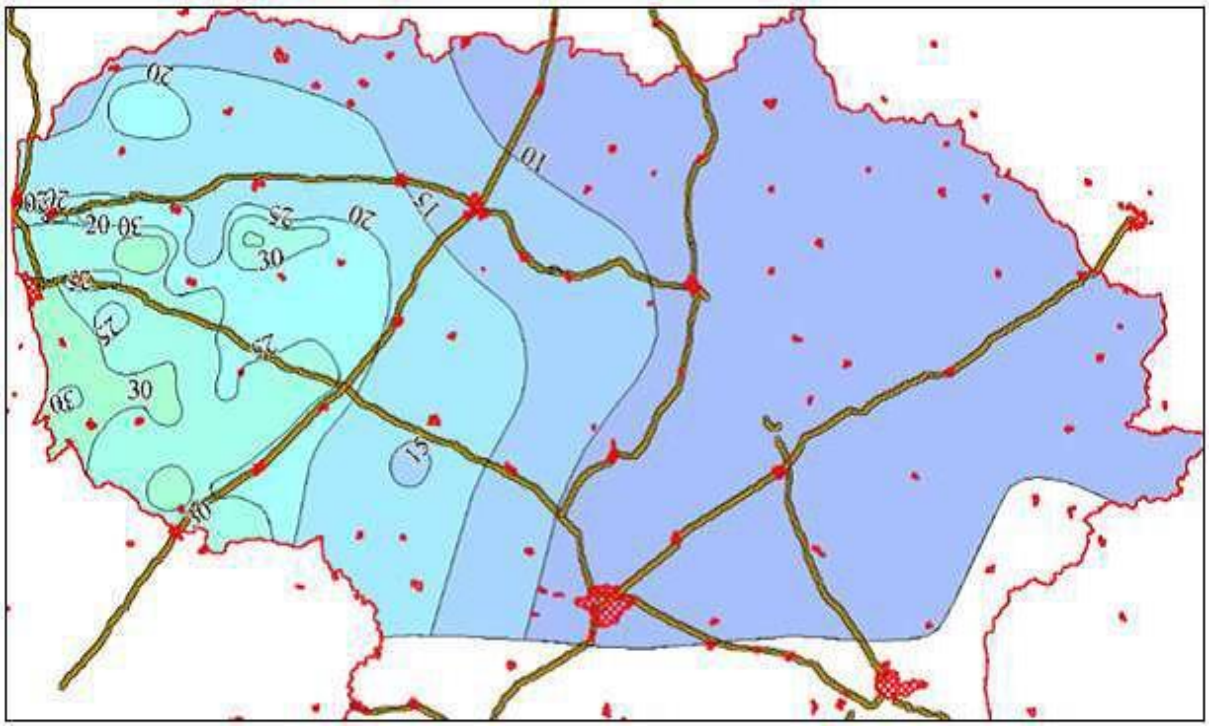
# Geothermal

- Oil exploration and production has provided crucial knowledge about the heat in the depths of the Lithuanian subsurface.
- Geothermal energy can be extracted from these layers:
  1. Upninkai – Šventoji aquifer,
  2. Gargždai – Kemeri aquifer,
  3. Cambrian aquifer,
  4. Hot crystalline basement rocks.




Geothermal heat in Lithuania: an ecological, renewable type of energy. Povilas Suveizdis, Vita Rastenienė, Geografijos metraštis vol. 38(1), 2005.

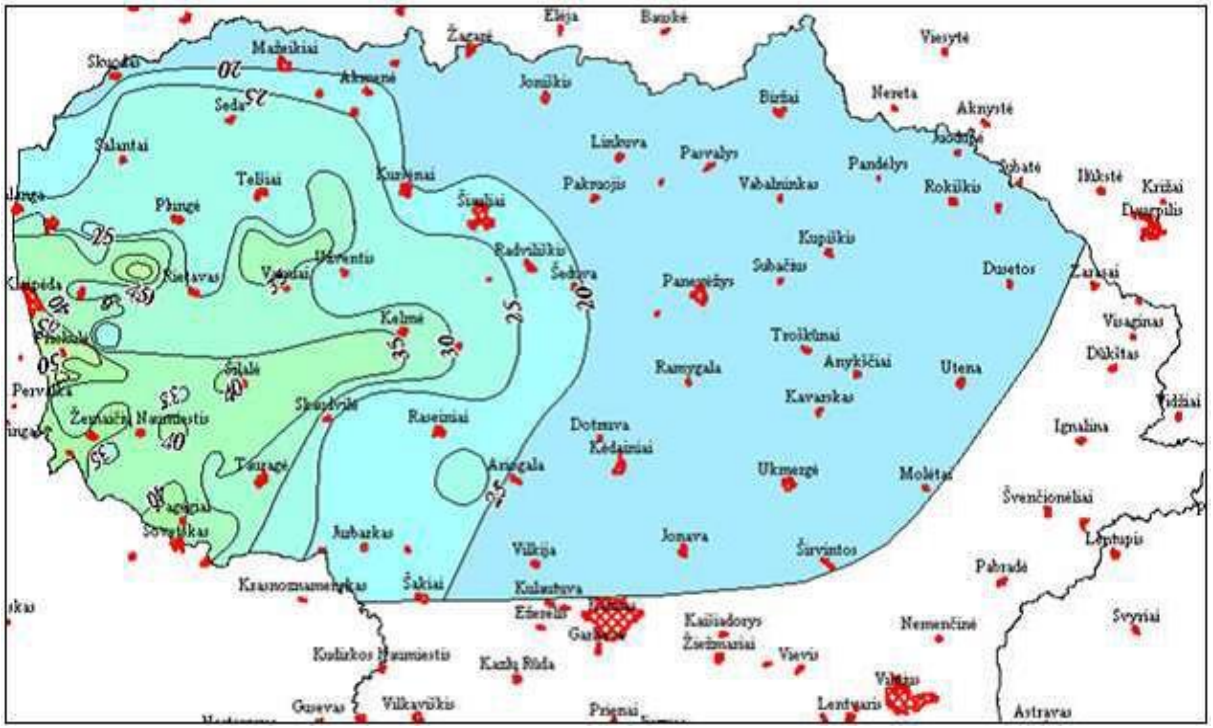
# Aquifer surface temperature of the Šventoji-Upninkai complex.




- The waters of the complex are suitable for heating swimming pools, fishing, and balneological purposes.
- Projects are being prepared in Klaipėda to use the 30 °C brines of the Šventoji-Upninkai complex for heating hotels and balneological purposes.

"Explanation and justification of the potential of geothermal energy resources in the Western Lithuanian region, and possibilities for their use for energy production", Saulius Šliaupa, et al. Applied scientific research, Institute of Geology and Geography 2008

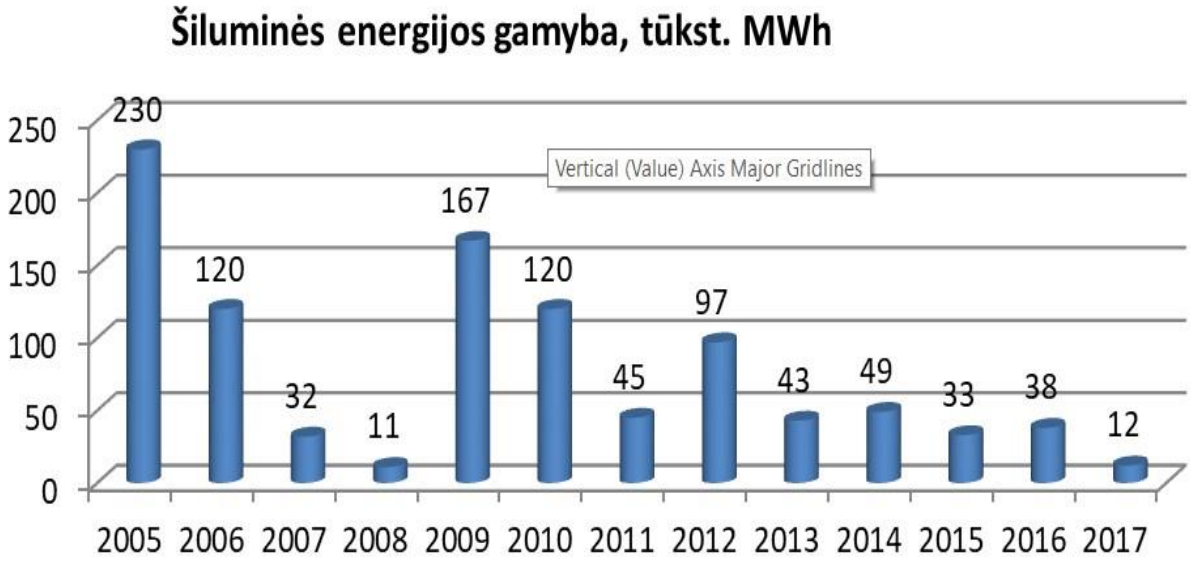
# Aquifer surface temperature of the Gargždai-Kemeri complex.




- Klaipėda Geothermal Station used the waters of this complex for city heating.
- Klaipėda University scientists had prospective results in cultivating shrimp and trout using the waters of this complex; they have found positive effects on human treatment and rehabilitation as well.

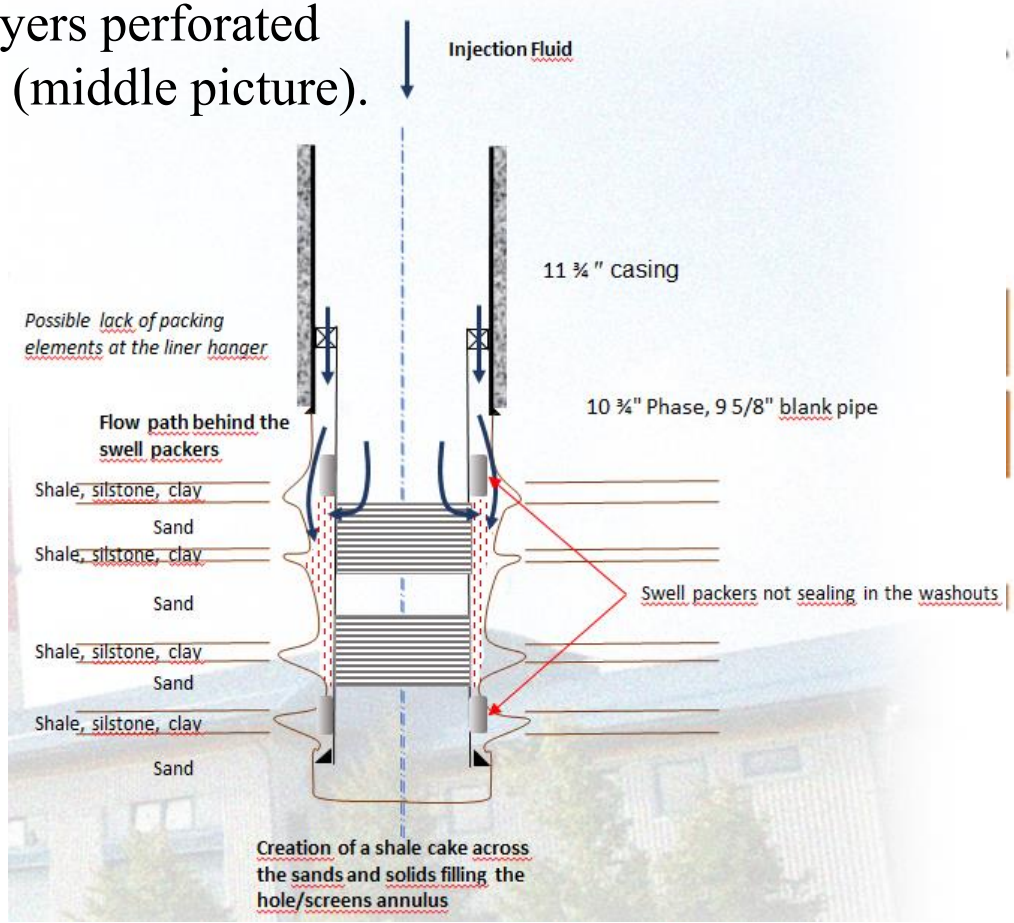
"Explanation and justification of the potential of geothermal energy resources in the Western Lithuanian region, and possibilities for their use for energy production", Saulius Šliaupa, et al. Applied scientific research, Institute of Geology and Geography 2008

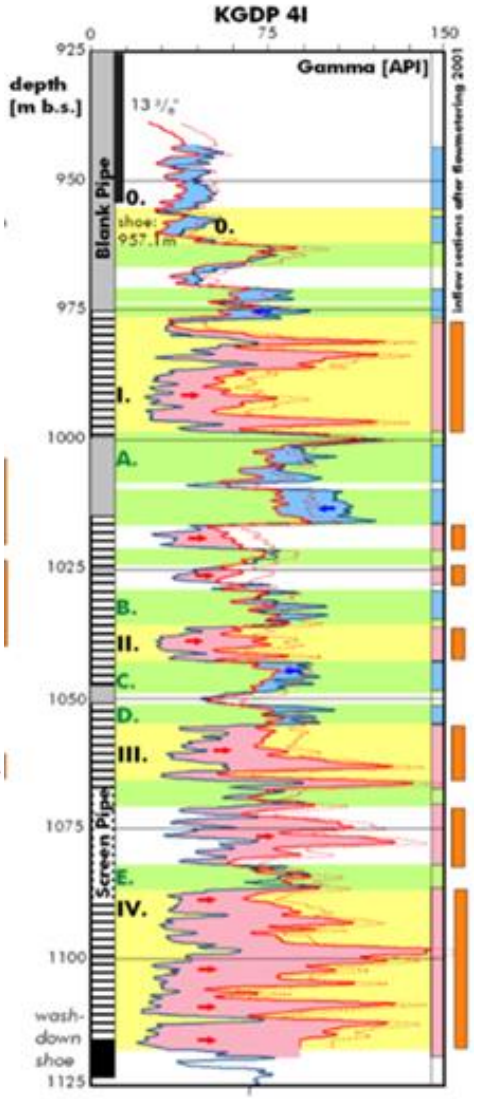
- Klaipėda geothermal station has encountered various technical and bureaucratic difficulties.
- The main technological problem is the decrease in the acceptability of injection wells.
- It seems that the reasons are already clear. The desire of the current city authorities to revive the station's work is encouraging.




- The injected water washes the clayey interlayers, the clays form a clay film and make injection difficult (picture on the left).
- In the right picture, the blue line is gamma measurements in 1998, the red line is in 2008.
- To improve injection, protective columns must be inserted instead of filter columns, cemented and only targeted clean sandstone layers perforated for injection (middle picture).

Death by Injection: Reopening the Klaipėda Geothermal Cold Case, Frédéric Guinot & Serge Marnat, Klaipėda Geothermal Conference January 17, 2024



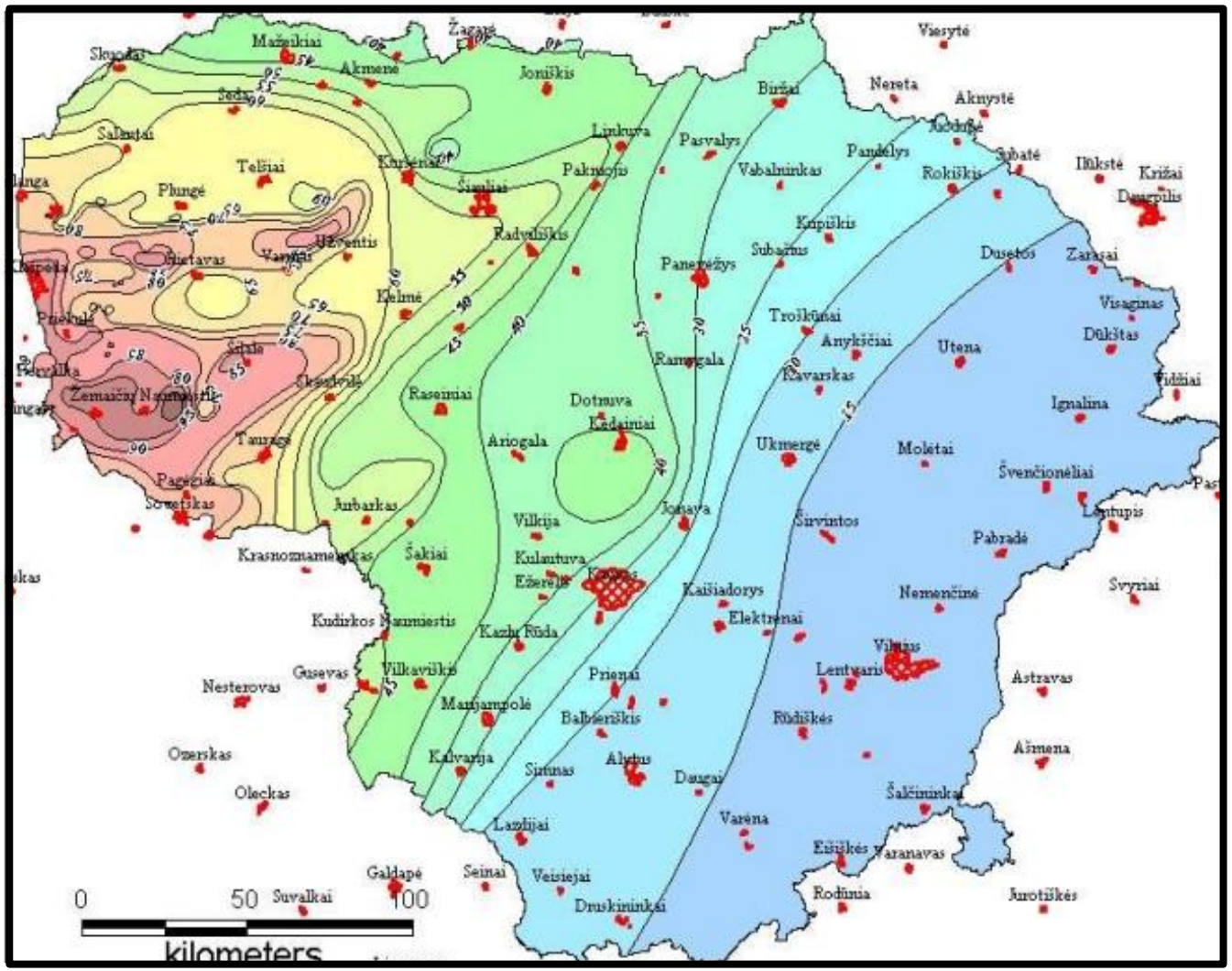
# Brackish water aquaculture

- The Fisheries and Aquaculture Laboratory of the Marine Research Institute of Klaipėda University is conducting research on the **development of brackish water aquaculture**.
- Experiments are being conducted with **shrimp and rainbow trout**. For these studies, specially prepared brine is used from the **Middle-Lower Devonian complex**, extracted in the wells of the geothermal power plant.
- Head of the Fishery and Aquaculture Laboratory of the Marine Research Institute, Dr. Nerijus Nika: "The geothermal resources of Western Lithuania are highly mineralized, their composition is very close to the composition of the sea, therefore it can potentially become an excellent source of salt for the development of brackish water aquaculture in the Baltic Sea region."

# Balneology

- The impact of Lower-Middle Devonian brines on human health was studied by Lolita Rapolienė, Doctor of Biomedical Sciences, Klaipėda University Rector, Doctor of Biomedical Sciences Artūras Razbadauskas, and Klaipėda University Professor in the Field of Medical Technologies Arvydas Martinkėnas.
- In 2012, the research used brine from the geothermal power plant well 2P from a depth of 1135 m. The **total mineralization of geothermal water is 108 g/l, pH 6.07**. Research has shown that 108 g/l. water, diluted with sea or fresh water, is suitable and effective:
  - Up to ≈ 15 g/l is suitable for swimming pools, general rehabilitation, recreation, children;
  - Up to ≈ 20 g/l is suitable for skin diseases, cardiovascular diseases, digestive system diseases, endocrinological diseases;
  - Up to ≈ 40 g/l is suitable for inflammatory bone and muscle diseases, nervous system diseases, respiratory diseases, urogenital diseases, recovery from stress and body training;
  - Up to ≈ 60 g/l is suitable for - degenerative musculoskeletal diseases, orthopedic diseases, chronic degenerative diseases, chronic fatigue and stress, recovery from injuries or illnesses (Rapolienė, 2015).

# Aquifer surface temperature of the Cambrian complex




"Explanation and justification of the potential of geothermal energy resources in the Western Lithuanian region, and possibilities for their use for energy production", Saulius Šliaupa, et al. Applied scientific research, Institute of Geology and Geography 2008

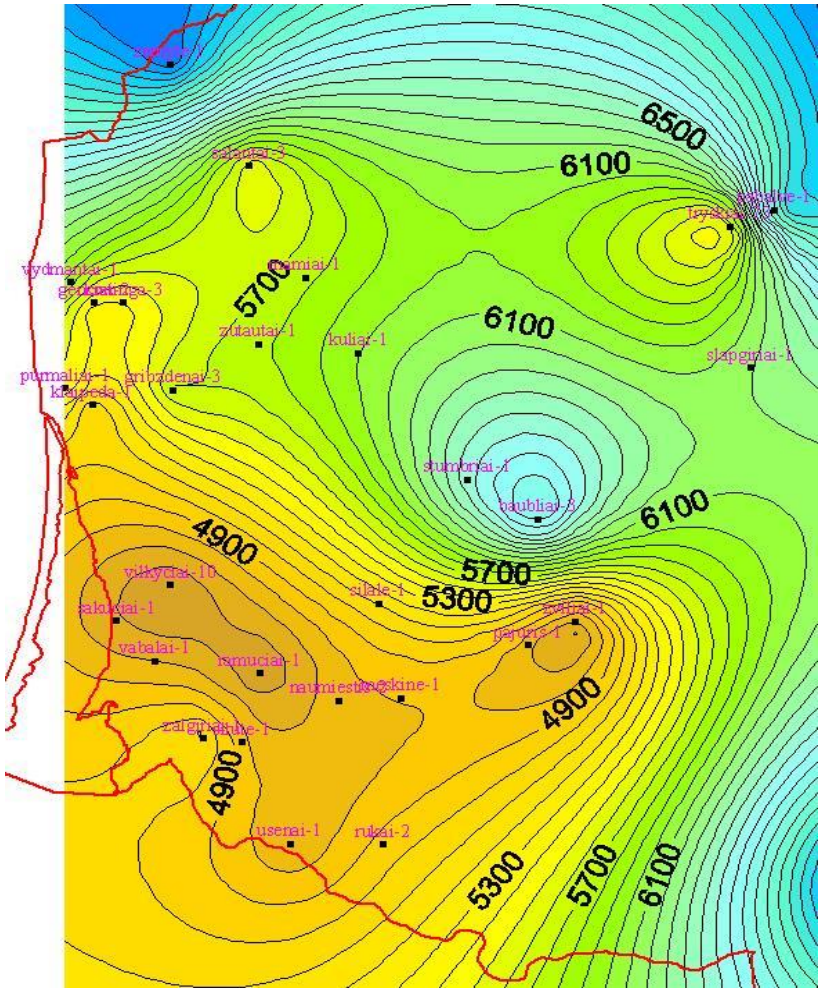
# Cambrian aquifer

- Cambrian horizon sandstones in Western Lithuania are saturated with high mineralization brines up to 200 g/l, **containing important trace elements** – bromine 1109 mg/l, iodine 3.5 mg/l (well Žalgiriai-1).
- The use of the Cambrian aquifer horizon for energy purposes is complicated by **poorer reservoir properties in the hottest zone**. However, by applying modern capabilities (**horizontal drilling**, **hydraulic fracturing of rocks)**, large hot water production and injection flows are possible: current V9+V18 extraction is 450$m^3$/day and V16 injection is the same.
- In Central, Northern and Eastern Lithuania, where temperatures are <50 °C, **large flows are possible without additional stimulation**.
- By using existing oil wells and infrastructure, **it is possible to obtain a good economic effect** by absorbing geothermal energy.

# Use of dry crystalline bedrock heat

- In the Vydmantai-1 well, a temperature gradient of **2.5˚C/100 m** was determined in Vydmantai-1 well at crystalline rock level:
  - Every 1000 m, we can expect a 25 ˚C higher temperature.
  - At a depth of **3100 meters**, we can expect a temperature of brines to reach 100 ˚C.

Isotherm 150 ˚C depth map




Saulius Šliaupa, “Giluminės geotermijos geologinės prielaidos Lietuvoje”, 2019. GTC pranešimas Geotermijos asociacijai.

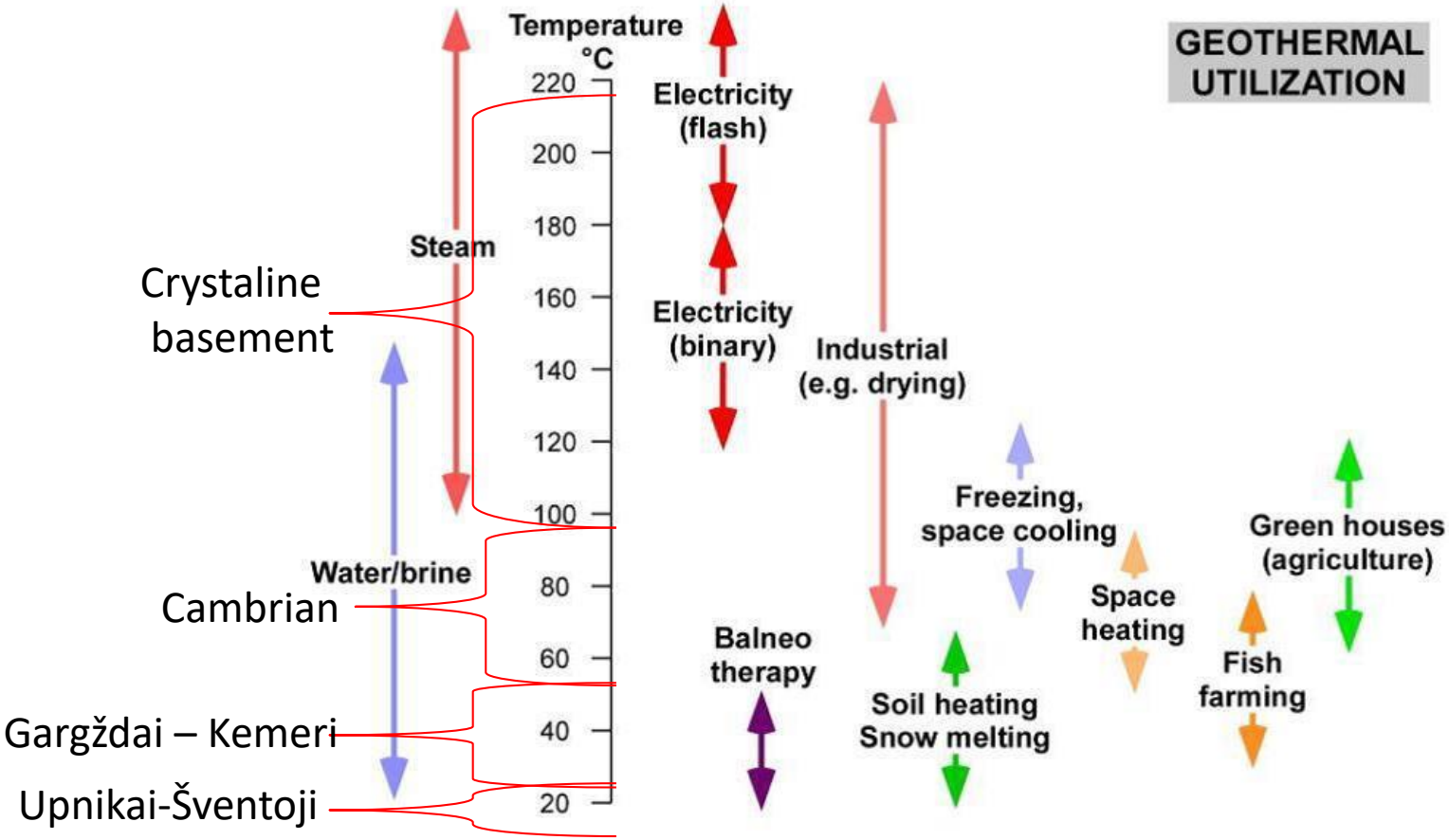
# Use of dry crystalline bedrock heat

- By creating **artificial fractures** at a depth of 4-5 km, we can get steam to the surface by circulating water and **produce electricity**.
- The **drilling of wells of such depth** as well as fracturing are technologies well widely used in oil industry.
- **Such plans are being nurtured**, and the possibilities of implementing them near Klaipėda, Gelgaudiškis, and Tauragė are being considered.

# Use of dry crystalline bedrock heat

- Such projects can **generate electricity**, **provide thermal energy** and **act as energy storage**, which would help "**balance**" the energy produced by solar and wind power plants:
  - Pumping fluid into artificial fractures in the event of a surplus of solar/wind electricity,
  - Releasing the pumped fluid to the surface to turn steam turbines and producing electricity in the absence of sun and wind.

# Geothermal energy areas

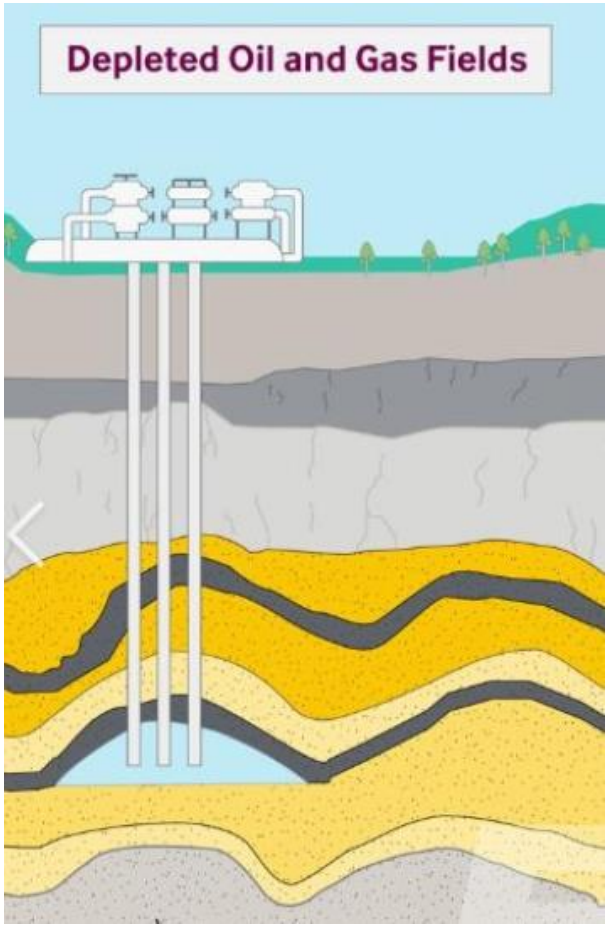


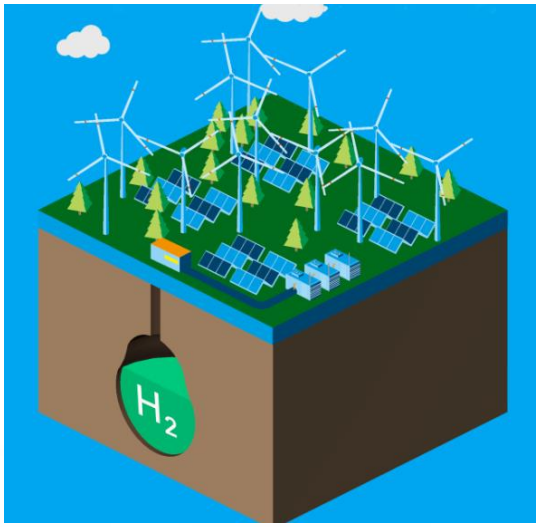

According to Limbergeret al. (2018) demonstrated by Gudni Axelsson in the presentation “Geothermal Worldwide, in Iceland, and Geothermal Training for the Future of Geothermal Energy”, Klaipėda. Geothermal Association Conference, Klaipėda 2024-01-17.

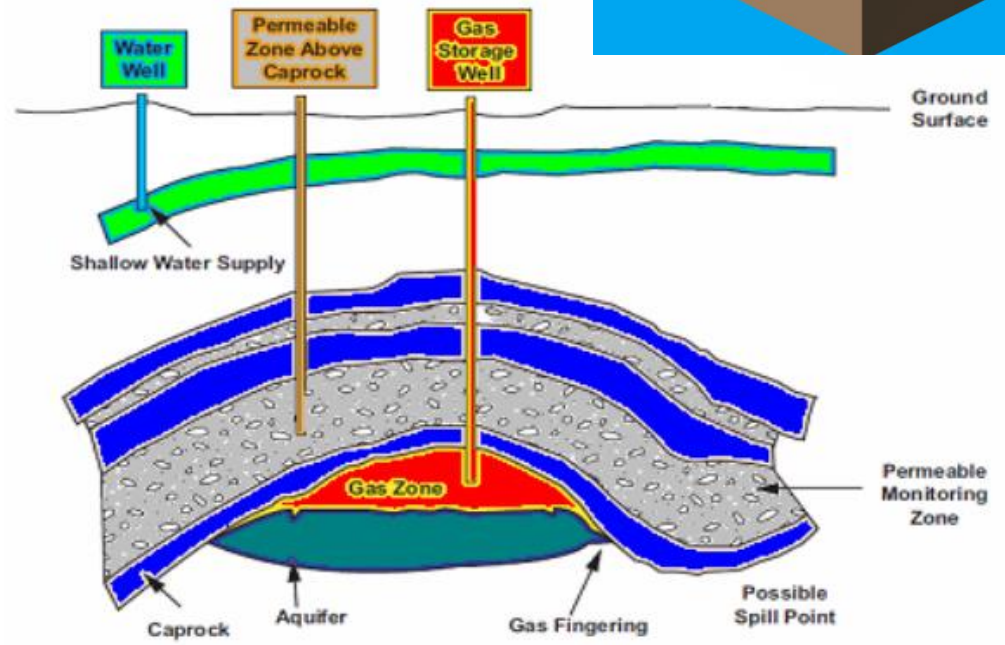
# Caverns

- The Law on the Subsurface states that “Caverns in the subsurface are natural cavities in rocks, their layers, and artificial cavities formed during the extraction of minerals or specially installed”.
- Natural caverns are pores between grains of sand or sandstone, various voids, cavities formed due to the dissolution of minerals, rock fractures, and various combinations of these things.
- Just as large buildings that store various valuables are assets, so too could the **caverns in the subsoil be valuable assets** of the subsoil.

- These caverns can store various gases:
  - Hydrocarbon gases ($CH_4$, $C_2H_6$, $C_3H_8$, etc.)
  - Carbon dioxide ($CO_2$)
  - Hydrogen ($H_2$)

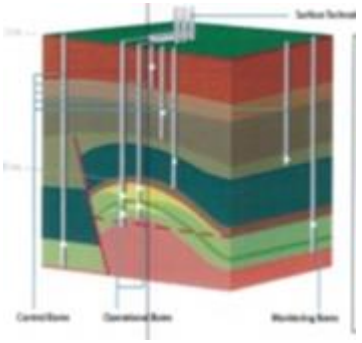


# Gas storage facilities

We have a liquefied gas terminal – we bring it, but we pump it to Latvia, Inčukalns, then back to our consumers.



The National Energy Independence Strategy writes about increased risks, the need for the resilience of energy systems, threat prevention and crisis preparedness.

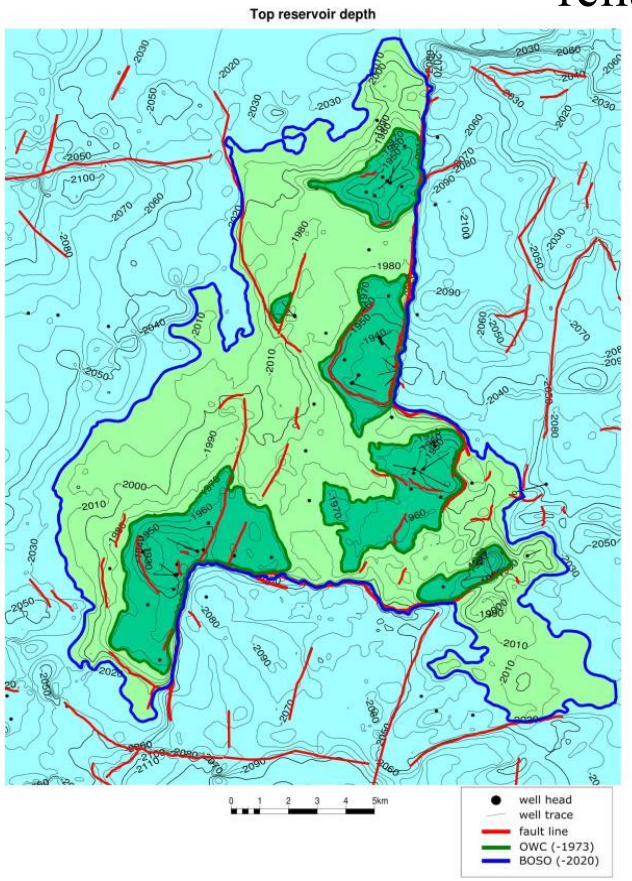
However, it is limited only to natural gas reserves stored in the Latvian underground natural gas storage, although Lithuania has good conditions for installing gas storage facilities.

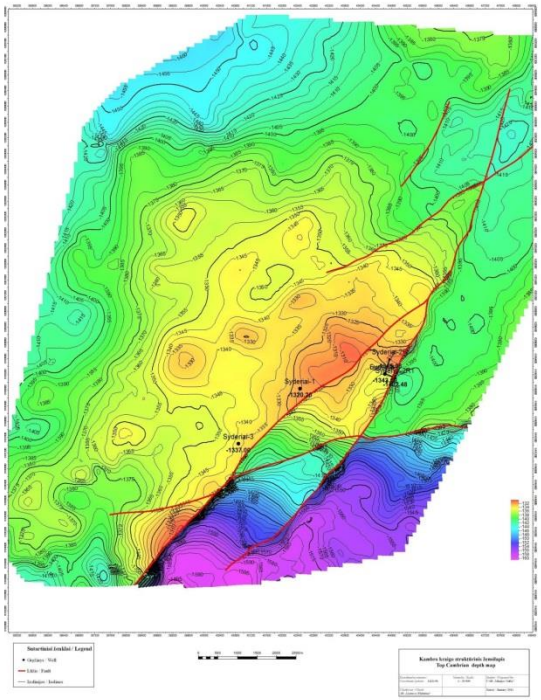
If we were to install them, we would be both safer and would have economic benefits.

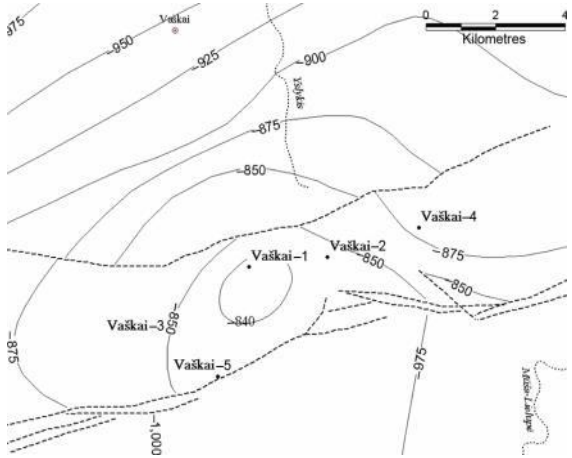
# Gas storage facilities

- Gargždai Uplifts Zone – 18 billion $m^3$, working capacity **9 billion $m^3$**.
- Syderiai structure – 4.5 billion $m^3$, working capacity **2.25 billion $m^3$**.
- Vaškai structure – 2.6-3.4 billion $m^3$, working capacity **1.5 billion $m^3$**.

Can be installed in **depleted oil or gas structures** or **similar structures** (although there was no oil or gas in them), but their confinement has been reliably determined by research.

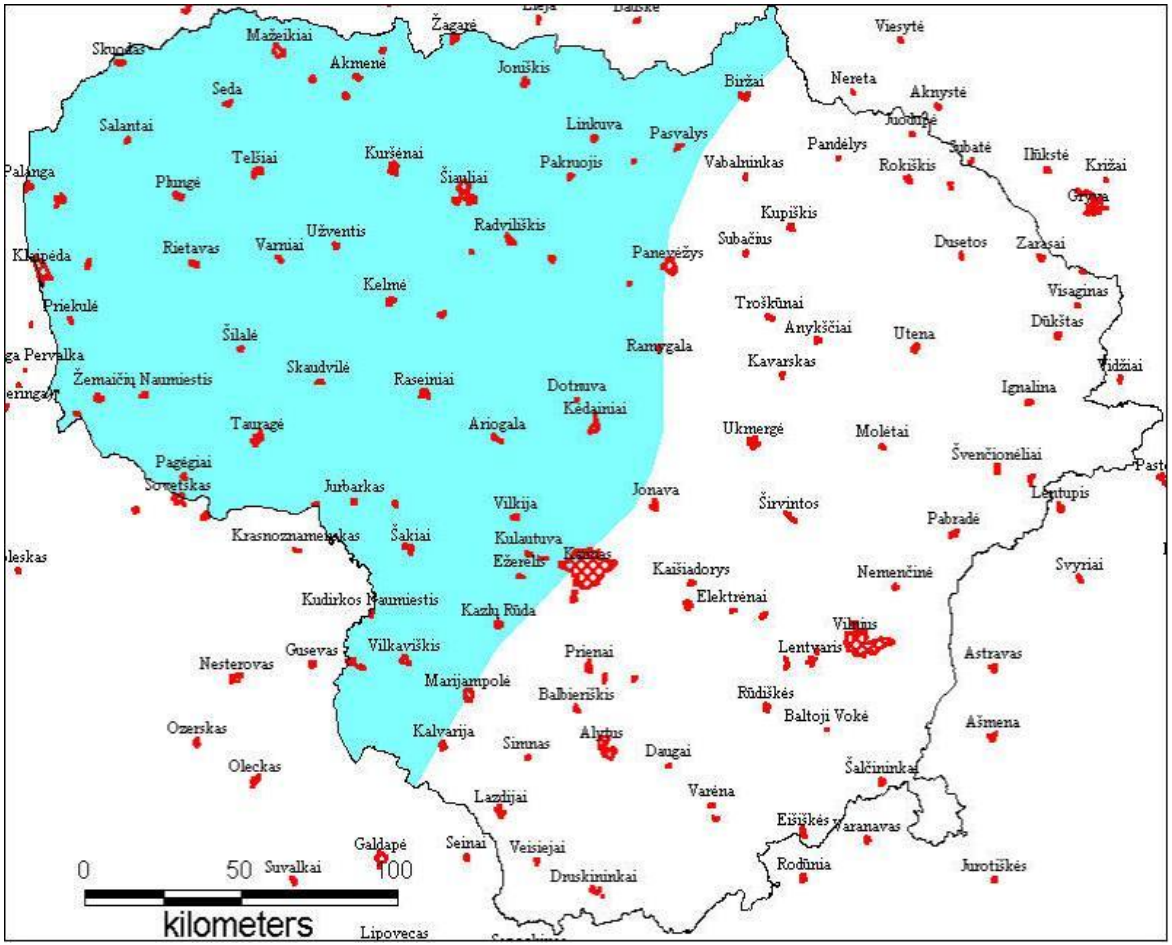


# Carbon dioxide

- Caverns suitable for storing natural gas are excellent for storing $CO_2$ as well.
- According to thermobaric characteristics, the most favorable conditions are in the Cambrian aquifer.
- The critical isotherm of 32 °C coincides with the pressure mark of 78 bar, and with the depth mark of 850 m above sea level. The entire western part of Lithuania is promising in this aspect - here carbon dioxide in the Cambrian reservoir will be in a supercritical (liquid) state.



The National Energy Independence Strategy, paragraph 194, table 5 (resolution of the Seimas of the Republic of Lithuania, 2024) shows the forecasts for carbon dioxide capture in Lithuania

| | 2030 m. | 2040 m. | 2050 m. |
|---|---|---|---|
| **Fossil fuel carbon capture forecast (carbon dioxide source – the largest GHG emitters participating in the Lithuanian ETS - Achema, Mažeikių nafta and Akmenės cementas)** | 0 | 2,4 | 1,0 |
| **Biogenic carbon capture forecast (carbon source – biomethane production, waste incineration, biofuel production and/or use)** | 0,2 | 3,5 | 2,4 –3,5 |
| **Total, million tons per year** | **0,2** | **5,9** | **4** |

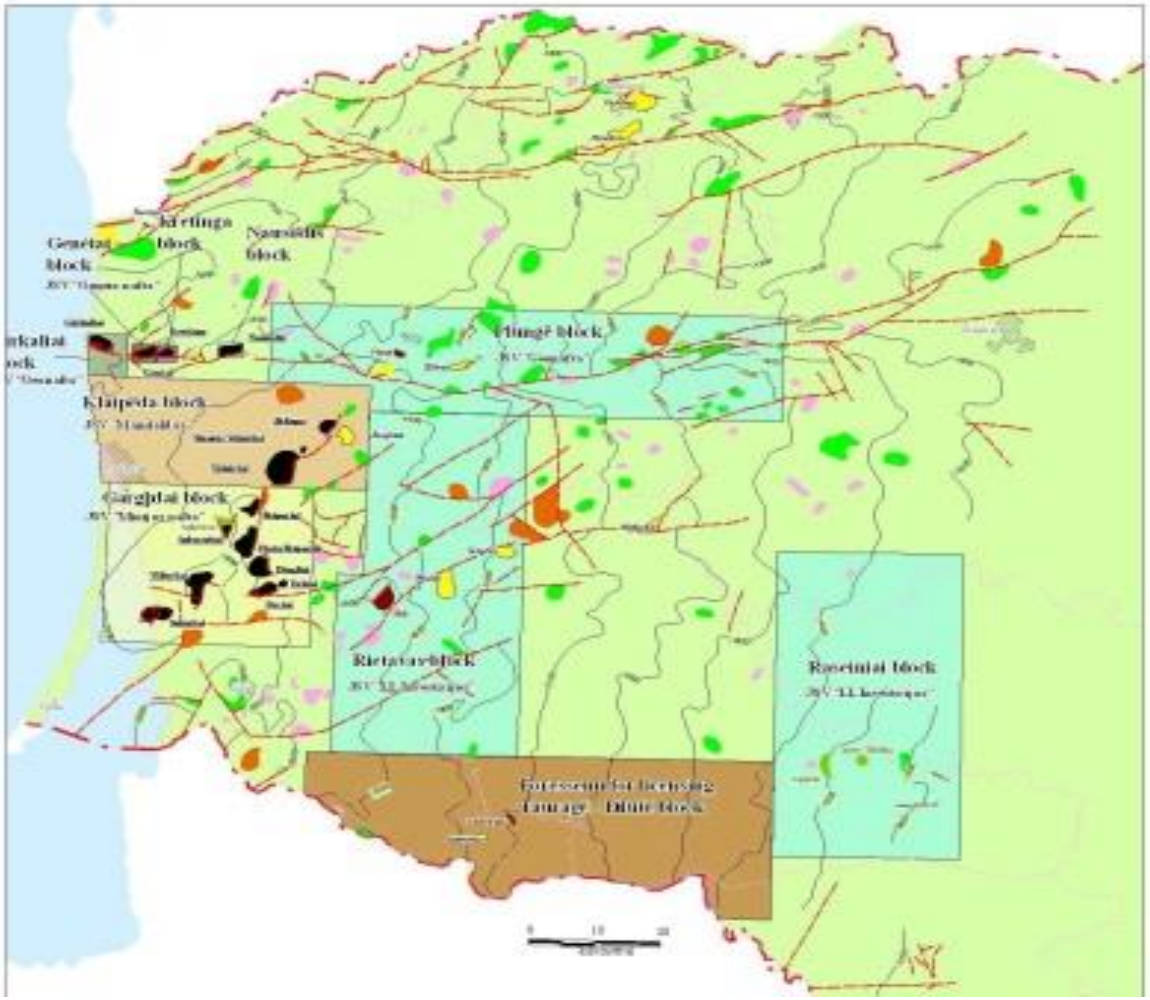
All of these quantities can be safely stored in Lithuania, in geological structures of the Cambrian reservoir.

# $CO_2$ storage sites

- The most suitable for $CO_2$ storage sites:
  - Vaškai – capacity >8.8 mln. t (new wells are needed).
  - Syderiai – capacity 49.1 mln. t (wells can be restored/adapted).
  - Gargždai Uplift Zone up to 100 mln. t (wells can be adapted).
- This gives a total of 157.9 mln. t
  - Or > 25 years of planned maximum collection.

**What's next?**

# Structures galore!




Closed structures in the Cambrian reservoir in Western Lithuania:

- Black color – containing oil resources (oil fields)
- Other color – different structures according to the degree of exploration (reliability).

"Oil and natural gas in the depths of the Lithuanian earth", habil. dr. Onytė Zdanavičiūtė, Institute of Geology and Geography of the Lithuanian Technical University, presentation 2012.

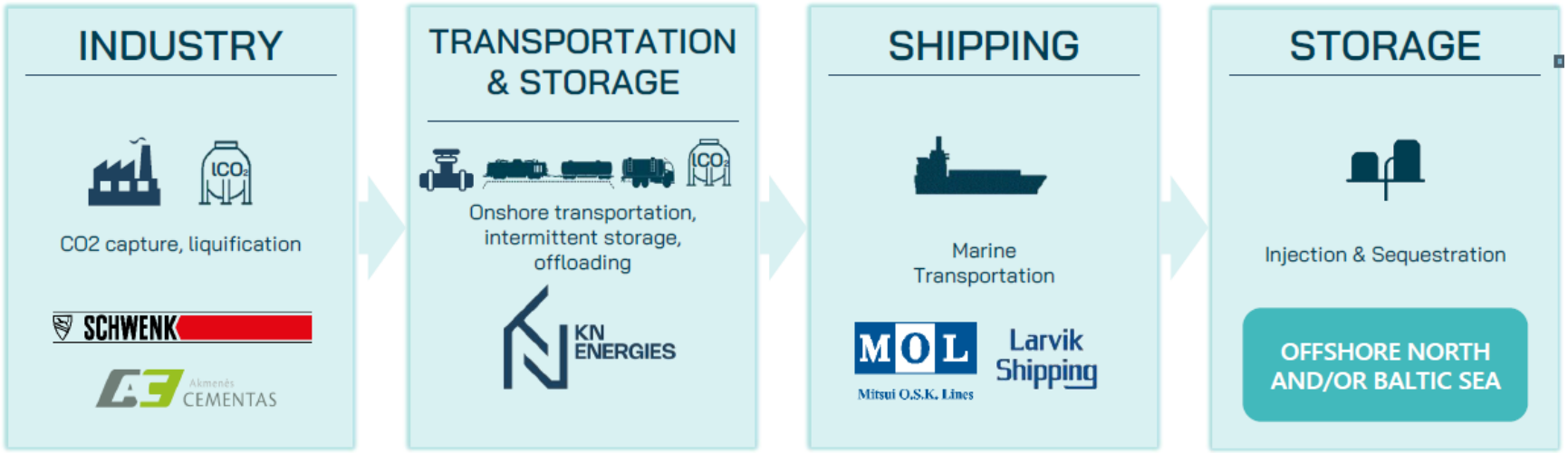
# The eternal question – What to do?

**AGREEMENT**
**ON THE ESTABLISHMENT AND COOPERATION OF THE LITHUANIAN PLATFORM FOR CARBON DIOXIDE COLLECTION, TRANSPORTATION, STORAGE AND USE**
**29 October 2024**
**Vilnius**

- **Institutions:**
  - Ministry of Energy of the Republic of Lithuania,
  - Ministry of Economy and Innovation of the Republic of Lithuania,
  - Ministry of Environment of the Republic of Lithuania,
- **And other parties:**
  - Lithuanian Confederation of Industrialists,
  - Kaunas University of Technology,
  - Vilnius Gediminas Technical University,
  - Klaipėda University,
  - Lithuanian Energy Institute,
  - AB "KN Energies",
  - AB "Amber Grid",
  - AB "Achema",
  - AB "Akmenės cementas".
- ***Signed an agreement to transport $CO_2$ out of Lithuania.***

In other words – completely write off the potential of local reservoirs.


# Lithuanian national strategy for energy independency in practice. Companies' strategical and practical approach



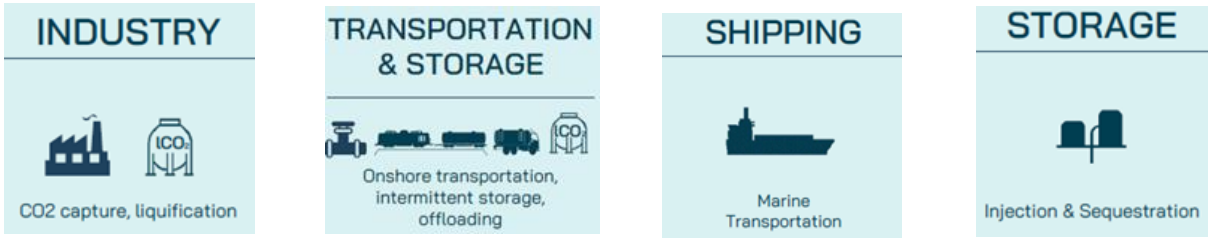

The project has held PCI from 2023 (Projects of Common Interest)

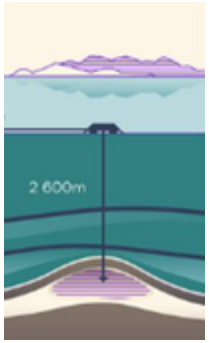
The Final Investment Decision (FID) is scheduled for 2027.

The Commercial Operations Date (COD) is targeted for 2030.

# For comparison – two chains

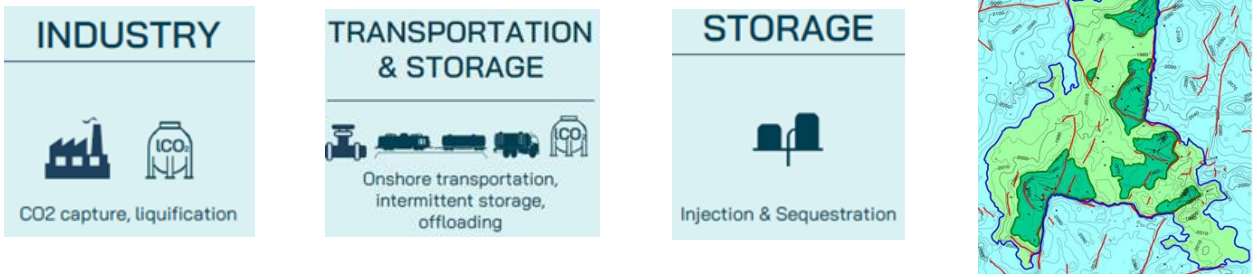
1. From collection to KN Energy ~300 km, stored in the port, loading onto ships to Oygarden ~1500 km, unloading to temporary storage,
100 km by pipeline to the injection well.




Norway,
Northern Lights

2. From collection to Vilkyčiai ~300 km, unloading to temporary storage,
0.1-10 km pipeline to injection well






Lithuania,
Gargždai Uplifts Zone

# Quiz time: Which is better – a long or short chain?

**Hint: it’s the short one.**

**Thank you for your attention**