Polish National Programme on safe CO2 geological storage

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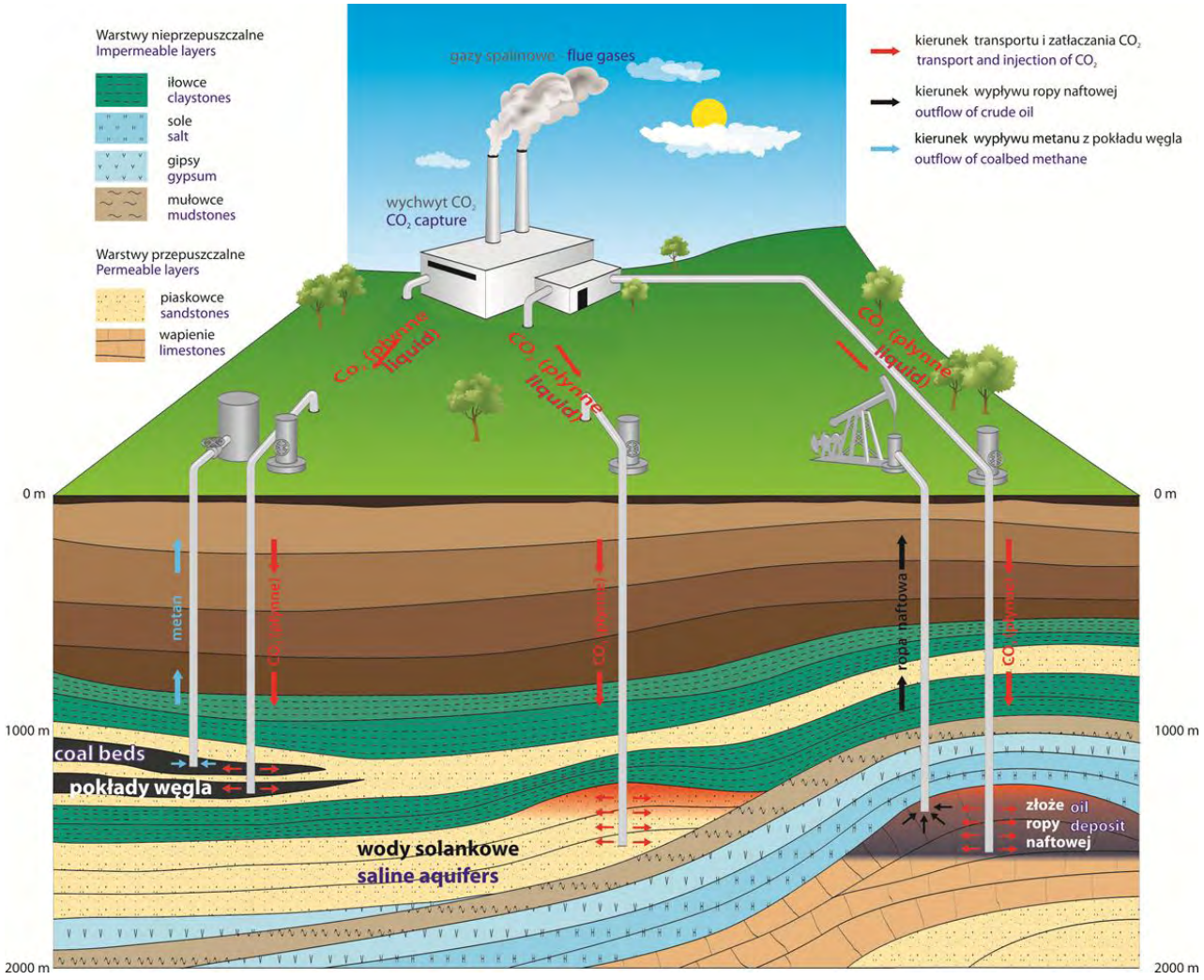
Ordered by (Min. of Environment)

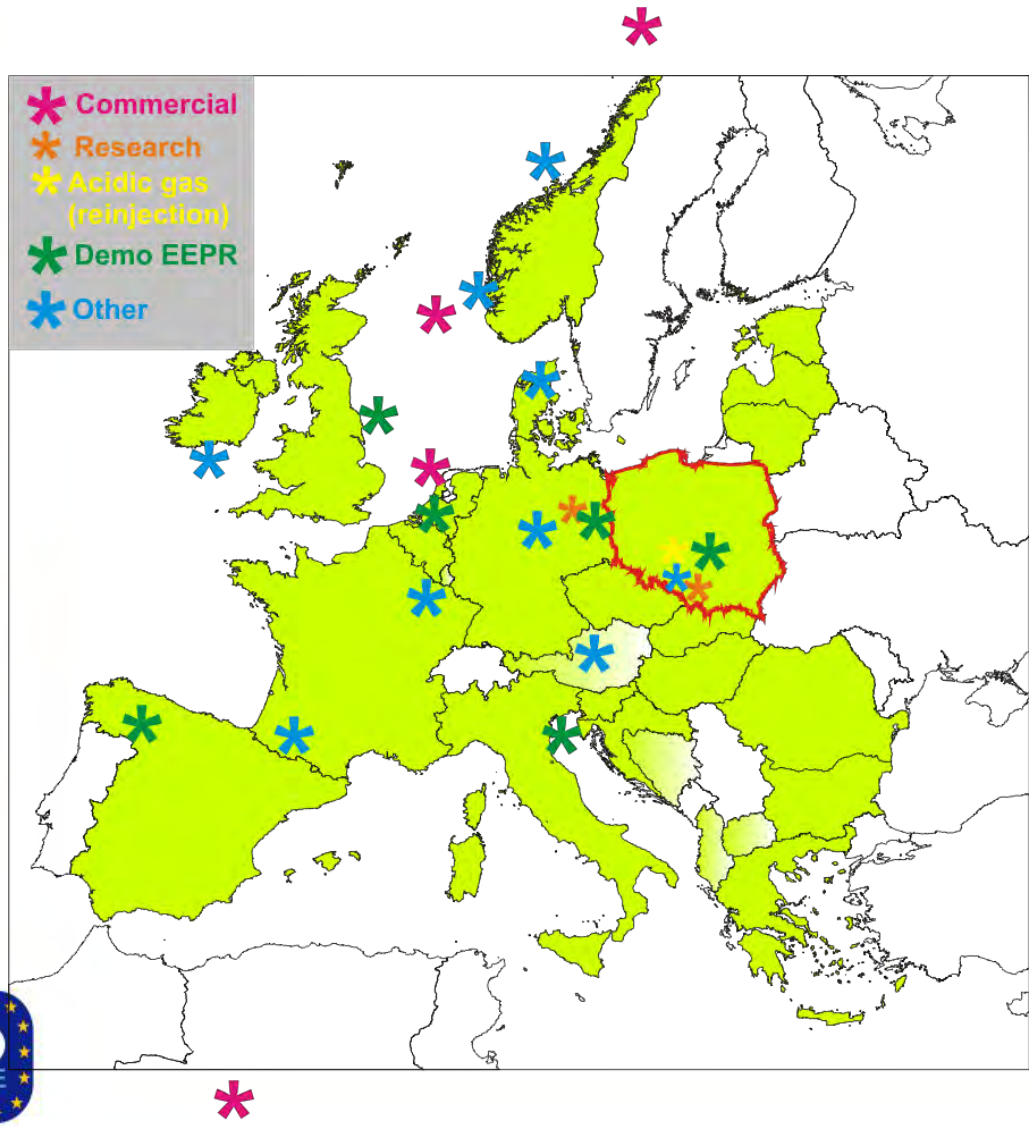
Funding

Sfinansowano ze środków Narodowego Funduszu Ochrony Środowiska i Gospodarki Wodnej

CO2 geological sequestration (CCS)



CO2 storage projects - Poland



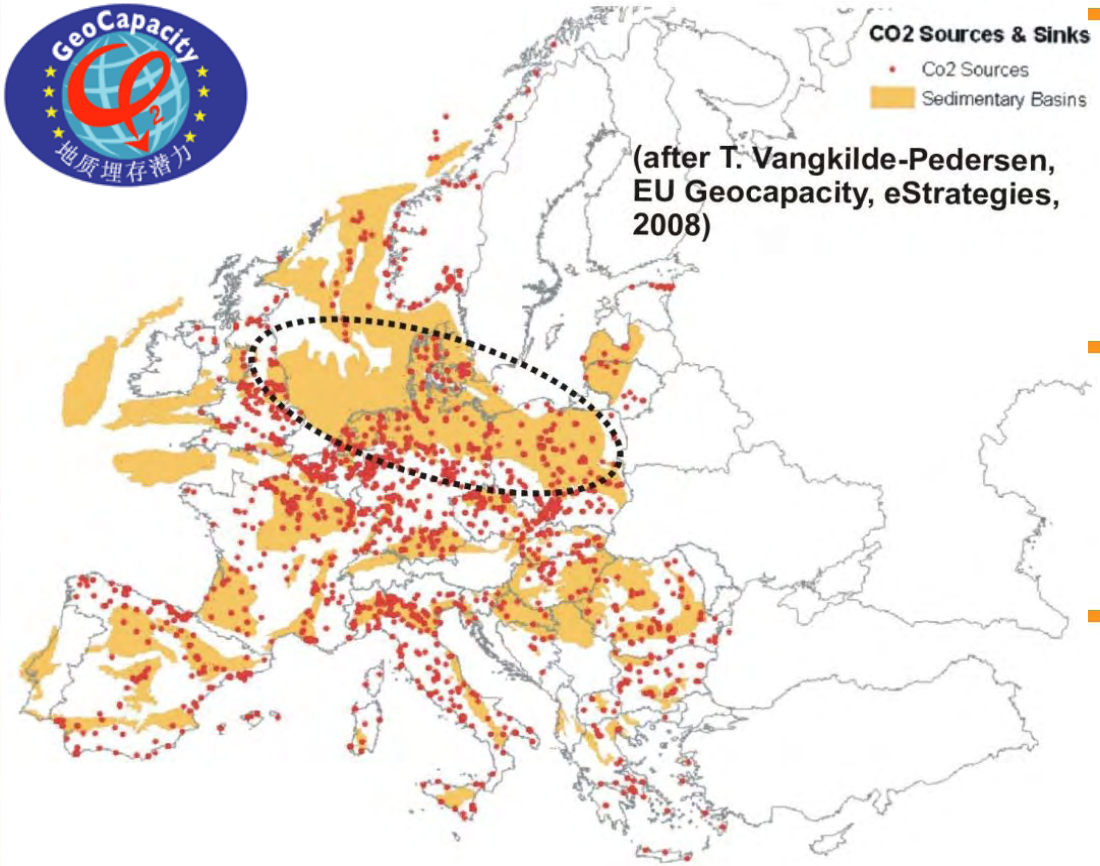
- 1995-..**Borzęcin** gas field (acidic gas – 60% CO2)
- 2004-2008 **Kaniów** coal beds (RECOPOL& MoVeCBM)
- **Bełchatów** demo CCS project (EEPR)
- **Kędzierzyn** demo CCS project planned
- **Regional studies**

Estimations of CO2 storage capacity (PL)

Type	*Storage potential, Mt*
CASTOR	**3 752**
EU GeoCapacity	**3 522**
CO2 Atlas of Poland	**8 299**
Cr1, J1, T formations (upper limits)	*~90 000*
Hydrocarbon fields (31 structures)	**764**
Coal seams (selected CBM fields at depth of 1-2 km)	**414**
Coal seams within Polish SCB at depth of 1-2 km	*1 254*
SUM	**5-9.5 Gt**
SUM	*~92 Gt*

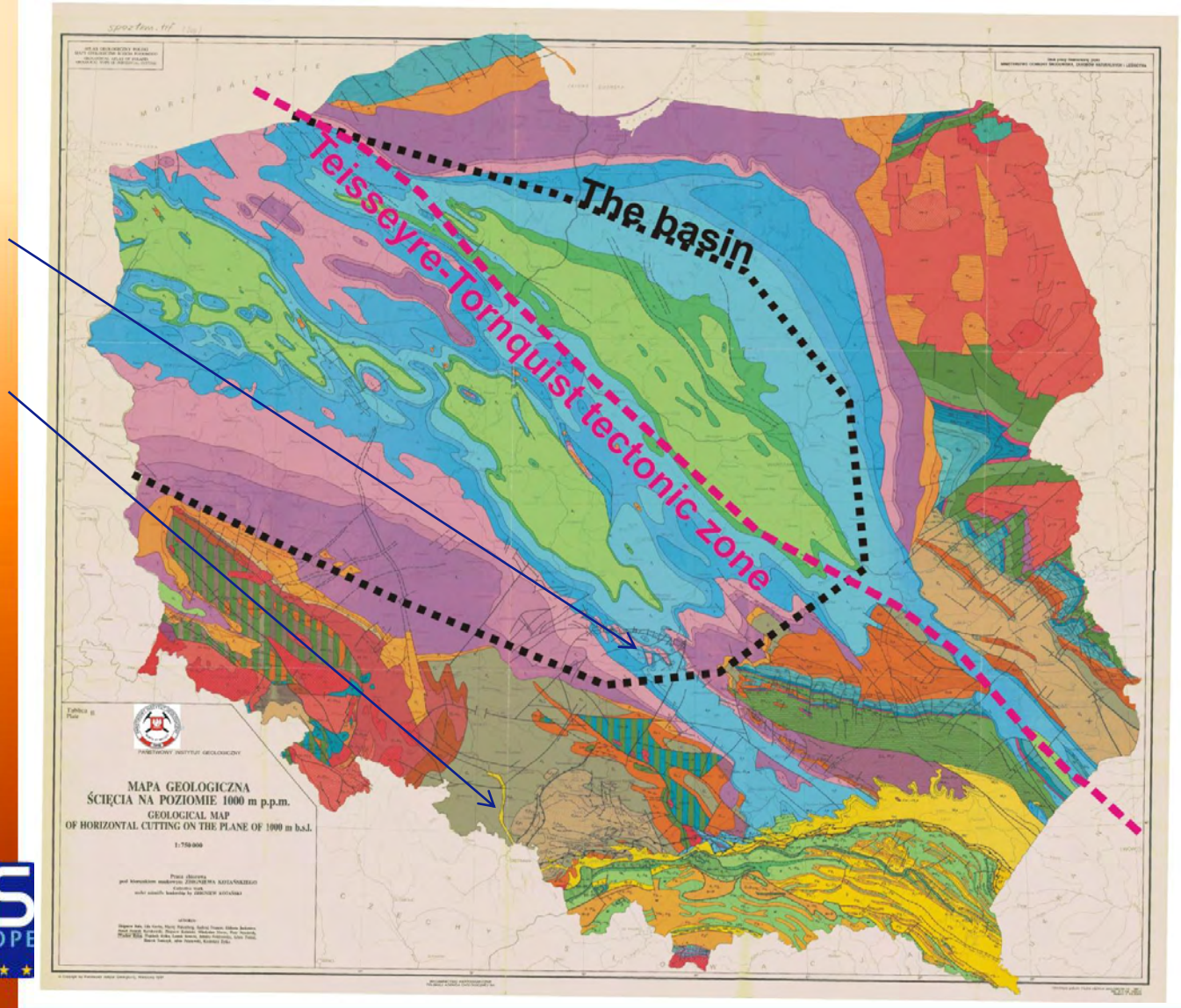
- Saline (Mezozoic) aquifers are of biggest potential and sufficient to store emissions of big plants,
- Hydrocarbon fields (mostly gas) are of small capacity,
- Coal seams (methane recovery) are of local importance (SCB), the technology is not mature yet.

Perspective sedimentary basins



- EU GeoCapacity project mapped perspective sedimentary basins of Europe,
- (southern) Permian-Mezozoic basin is the biggest one,
- It covers a large portion of Poland, so the country (onshore) CO2 storage potential is above the average.

The Polish basin aquifers
(z= 1km; Kotański, 1997)

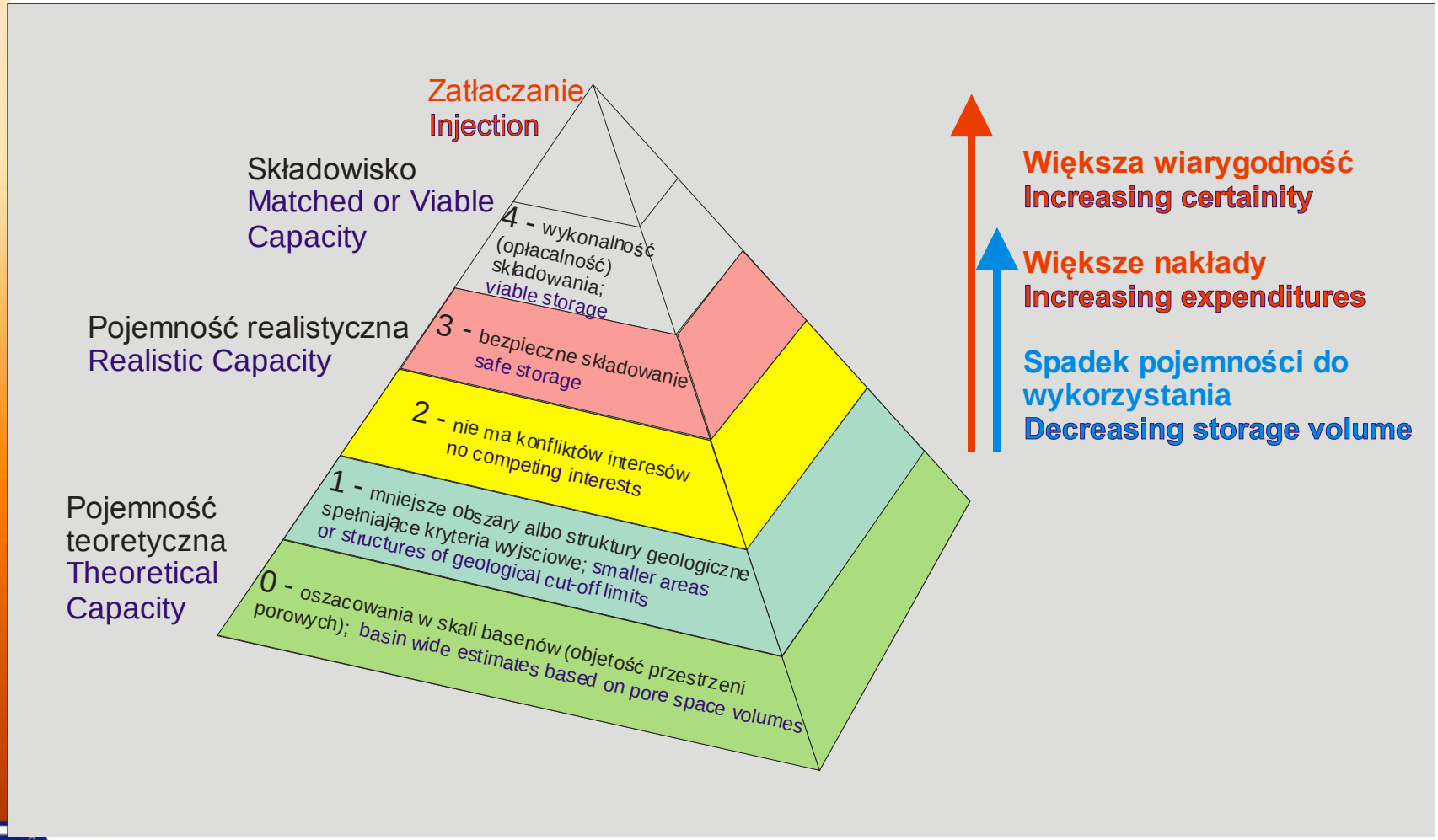


- **Lower Jurassic**
- **Triassic**
- **Lower Cretaceous**

Legal issues

- The Directive on CO2 geological storage is being implemented in Poland;
- The assumptions on relevant amendments of geological and mining law, environmental, economic law, etc., accepted by the Council of Ministers, after a long process of consultations with public and government agendas;
- Now research CO2 injection up to 100 kt per well allowed;
- CO2 storage of over 100 kt will be governed by the geological and mining law (same as, for example, hydrocarbon production) where Ministry of Environment is the authority;
- Storage fee of 1.25 €/t CO2 injected – 60% goes to the commune/municipality where injection is located.

Qualification of CO2 storage potential



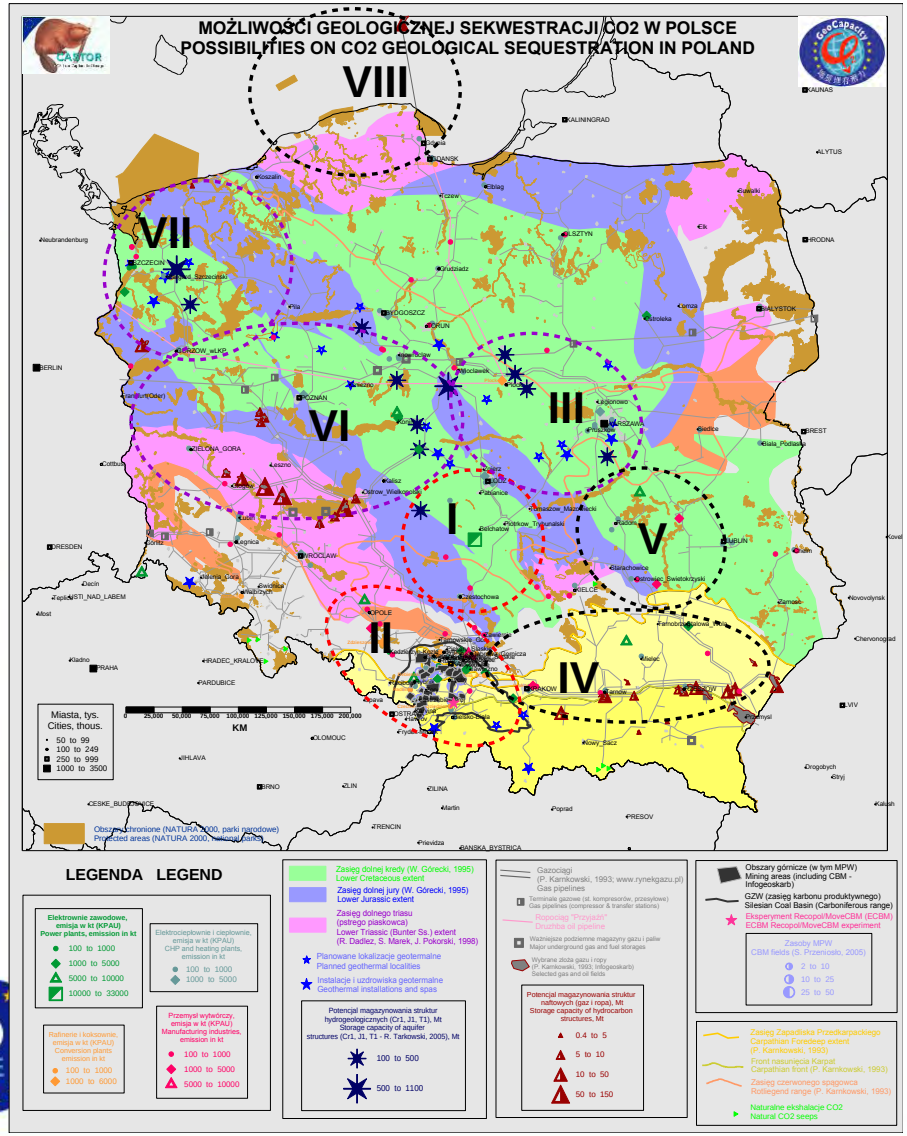
CO2 storage capacity pyramid for the key option - saline aquifers (based on Bachu, 2003 and others)

The Programme

„Assessment of formations and structures for safe CO2 geological storage including monitoring plans”;

- Ordered by Ministry of Environment (=the permiting authority of Directive on geological storage of CO2).
- Conducted by 6 national institutions (PGI-NRI – leader, AGH-UST, CMI, MEERI, O&GI, PBG).
- Timeframe: 10.2008-09.2012; ~80 persons involved;
- Goals:
  - Supporting Polish demo projects,
  - Providing the permitting authority with information necessary for implementing CO2 storage,
  - Cooperation with other stakeholders, R&D organizations.

The scope of the programme (geology)



It covers entire territory of Poland and the Baltic economic zone, but is focused on*:

- regional studies for 8 areas with saline aquifers,
- hydrocarbon fields and coal beds in general,
- case studies for saline aquifer structures (4),
- case studies for hydrocarbon fields (2) and coal beds (1).

reinterpretation of archive data, laboratory analyzes

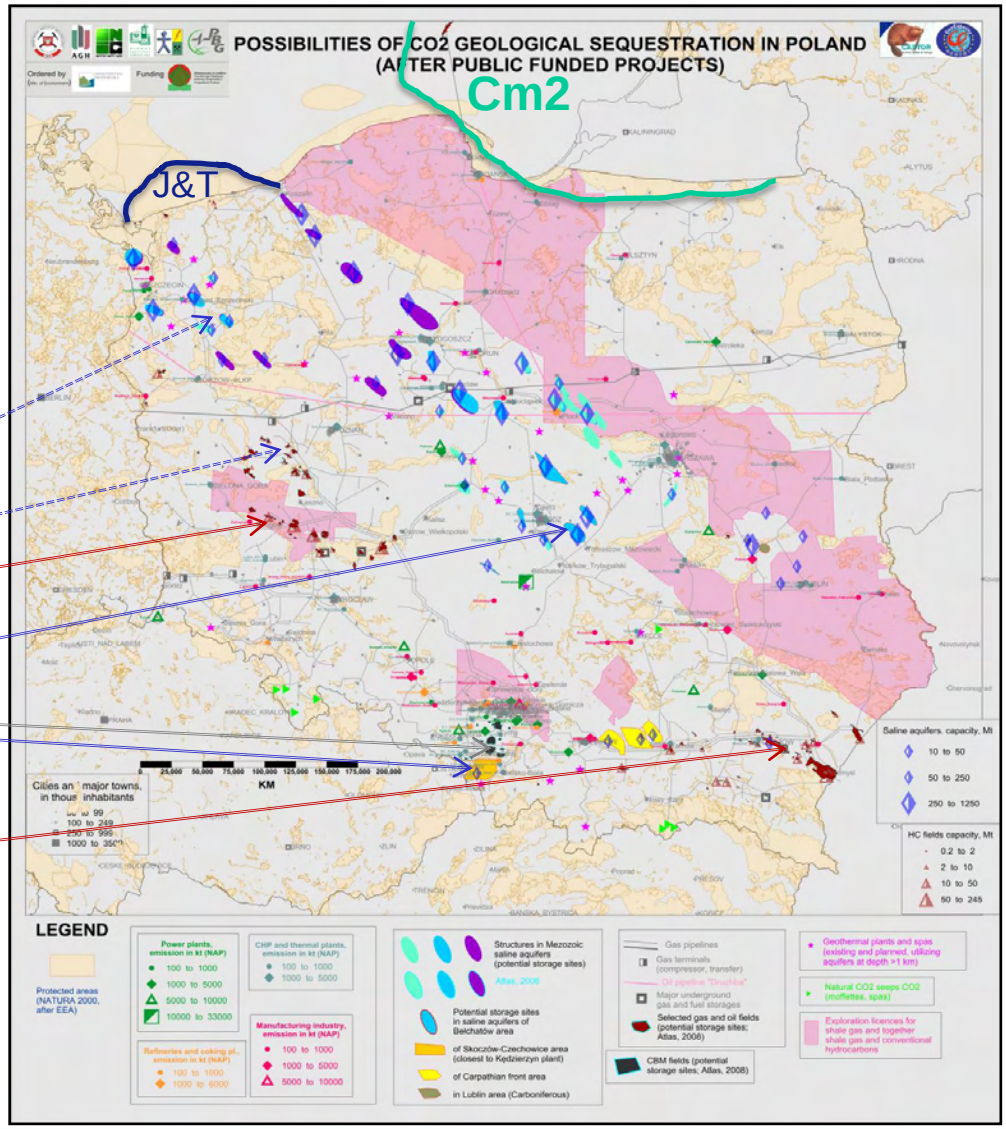
The regional studies

The following geological formations are perspective for the regional study areas of saline aquifers:

- I (central) – Jurassic (J1, J2 sandstones);
- II (S) – Miocene;
- III (central-NE) - Jurassic (J1, J2 sandstones), T, Cr1;
- IV (SE) – Carpathian front foredeep (Cr to Cm);
- V (E) – Carboniferous (C3 sandstones), J, Cm;
- VI (W) – Permian (P1), T, J;
- VII (NW) – Jurassic (J1 sandstones), T3, T1 – a small part offshore;
- VIII (N, incl. offshore area – E part of Polish Baltic economic zone) – Cm2, T.

The progress of the programme (~12-14 Gt)

Case studies in saline, aquifers, hydrocarbon fields and coal beds.

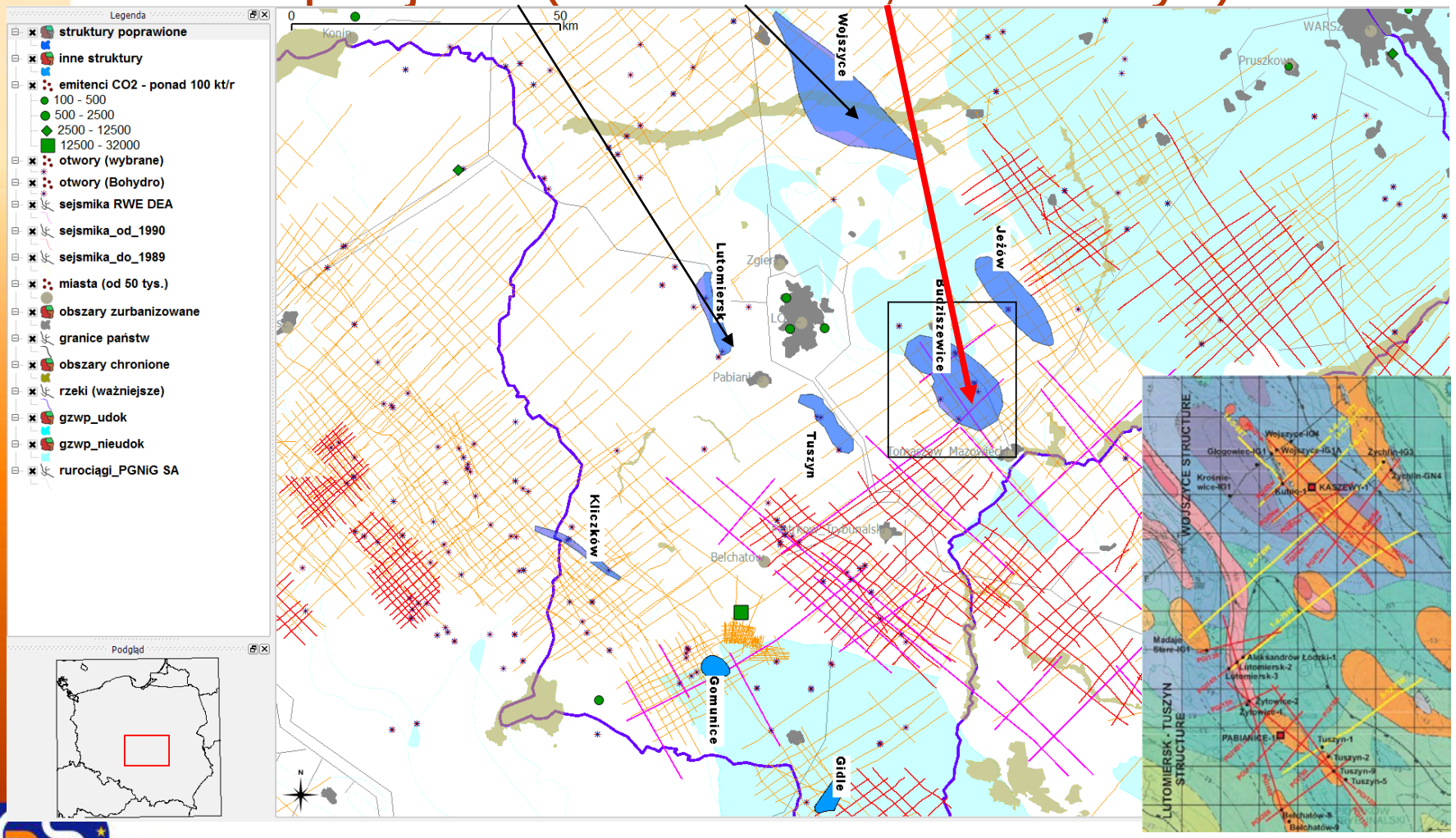


- Central, S, SE and E parts of the country screened and assessed in depth,
- W and NW area in progress,
- N area (incl. a large area offshore) left for 2012.
- Hydrocarbon fields and coal beds in general, assessed.

Site screening/selection criteria (based on CO2STORE guidelines)

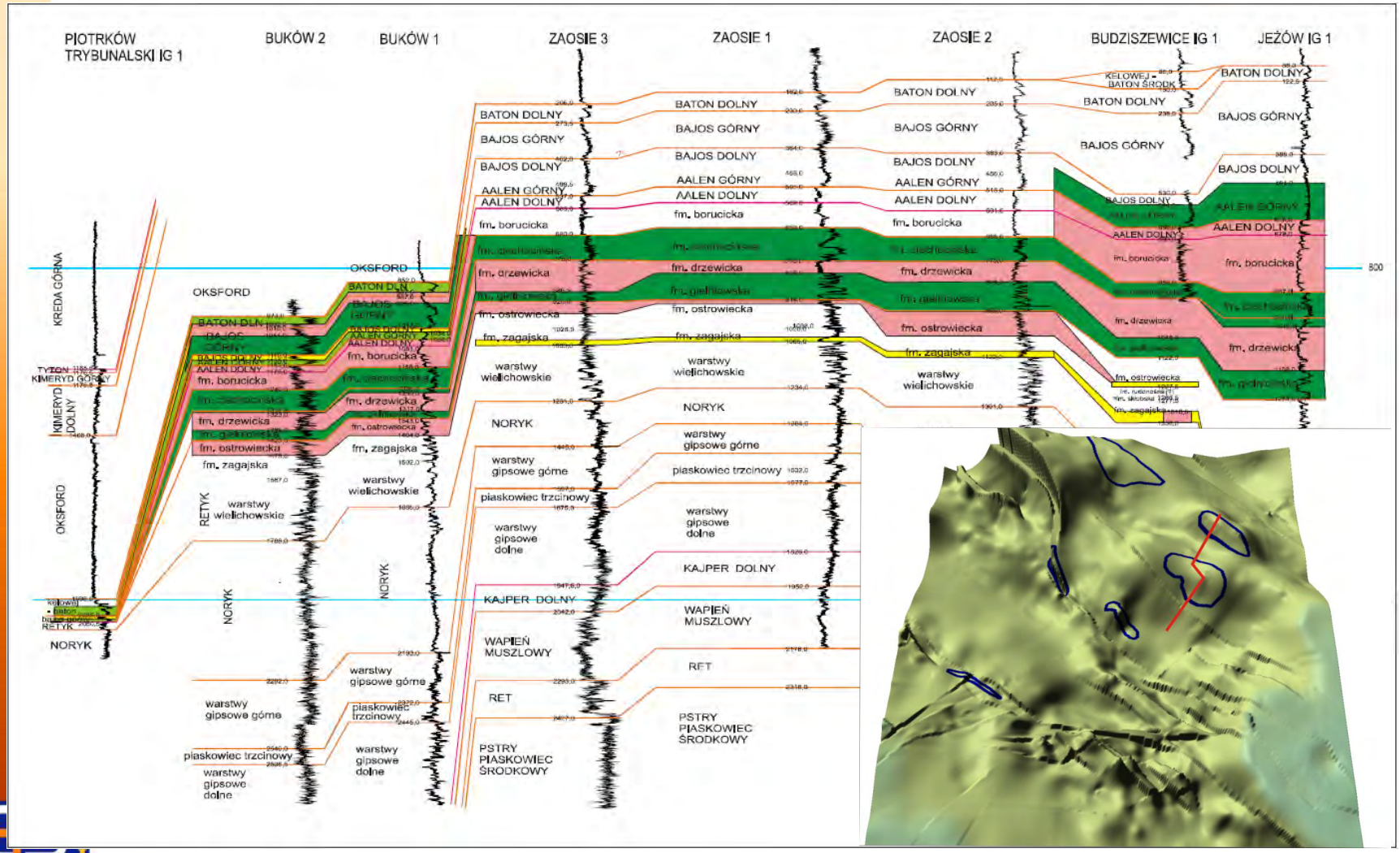
- **Seal thickness:** minimum **50 m,** seal integrity is essential
- **Aquifer depth:** from **800 m** to **2500+ m**
- **Aquifer net thickness:** minimum **20-30 m** (~a single layer)
- **Porosity of the reservoir:** minimum **10%,** preferably **20%**
- **Permeability of the reservoir:** minimum **50-100 mD**
- **Salinity:** minimum **30 g/l**, in case of relic, isolated fluids it might be lower
- **Capillary entry pressure** – is the caprock good enough, impermeable (if K<0.0005-0.005 mD it is likely safe)?
- **<u>Information</u> necessary to evaluate the structure against criteria mentioned above**

Works for area I - 1st Polish demo project (Bełchatów, 1.8 Mt/yr)



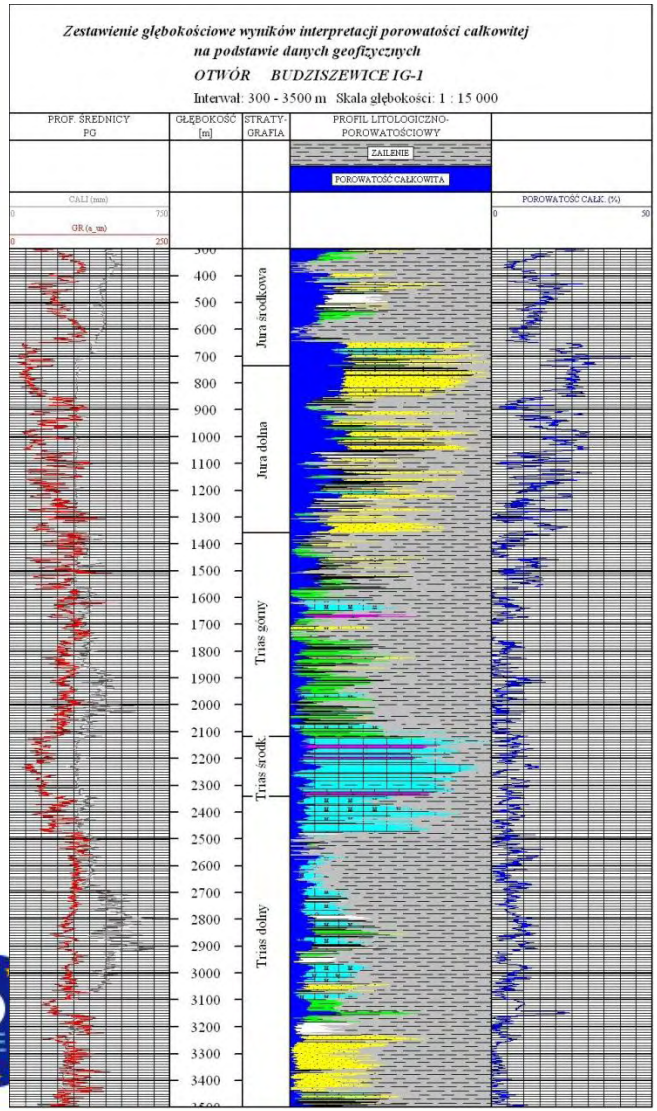
B-Z structure was selected (of sufficient data coverage, though not ideal) and two backup sites/areas were proposed to the investor (PGE).

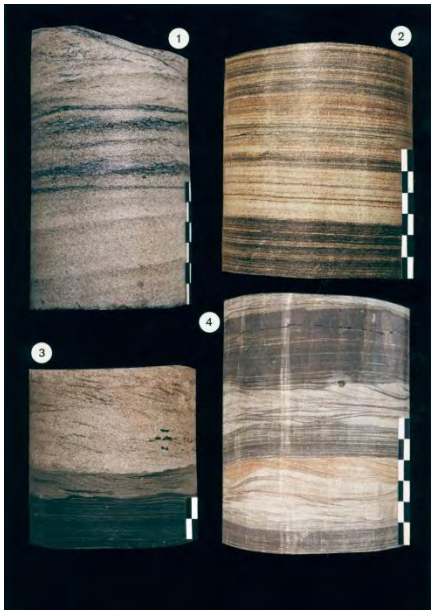
Well correlation and aquifer mapping

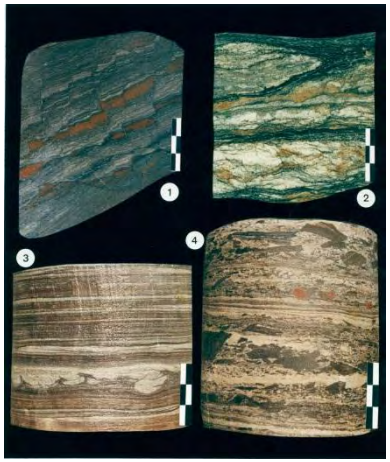


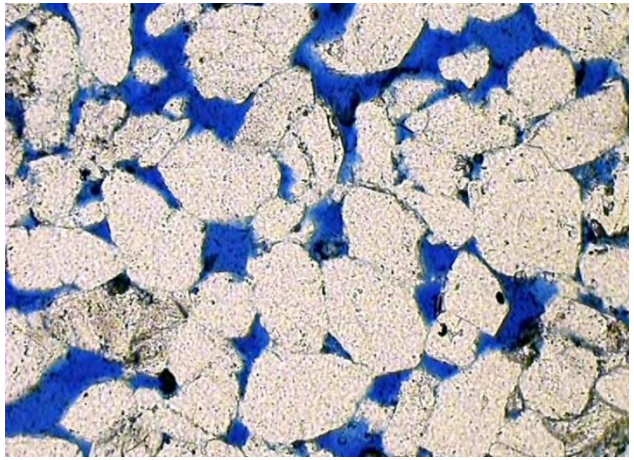
J1 caprock and aquifer formations within the supercritical range

Well data analyzes (6 wells within B-Z structure)

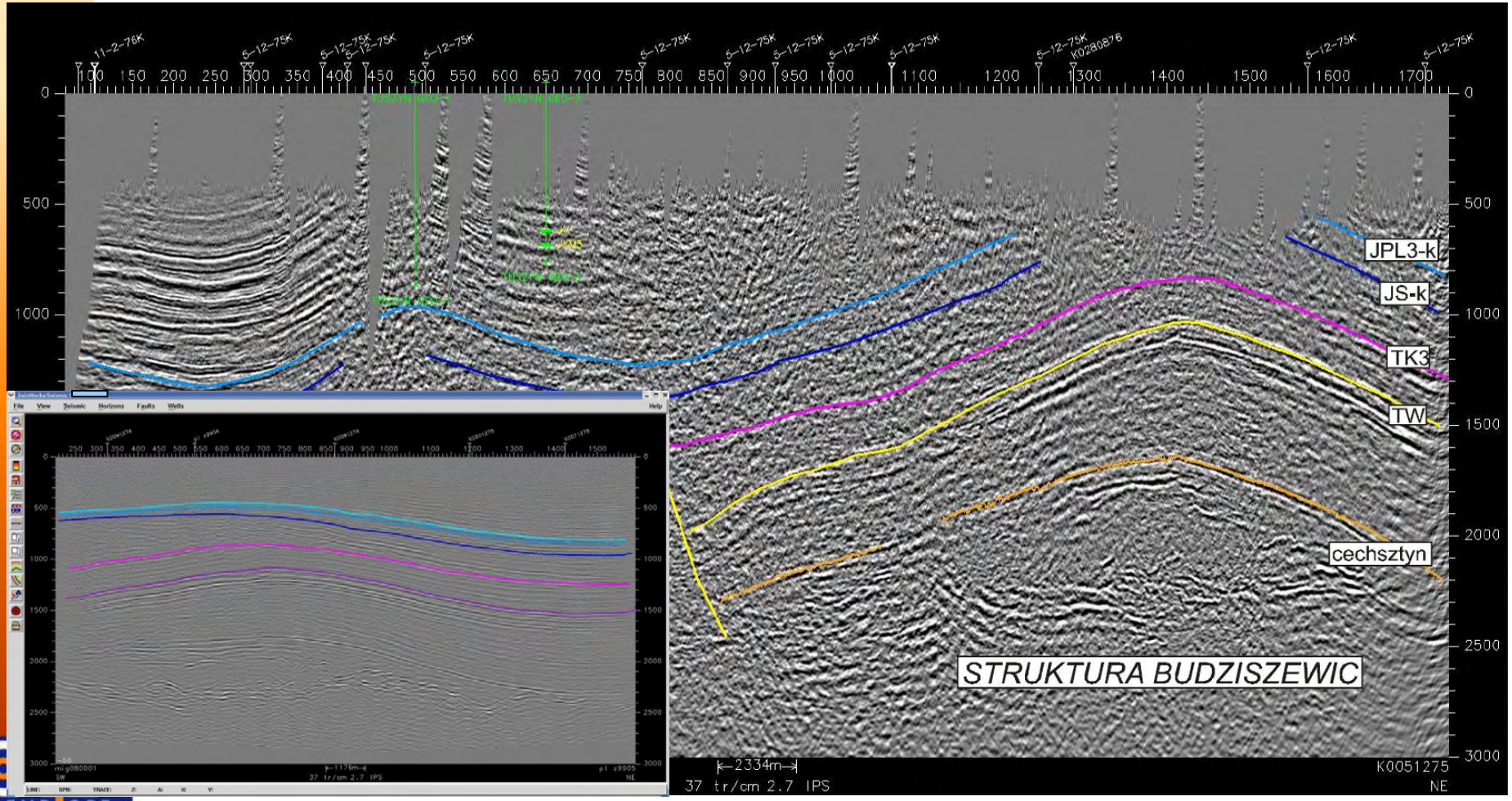




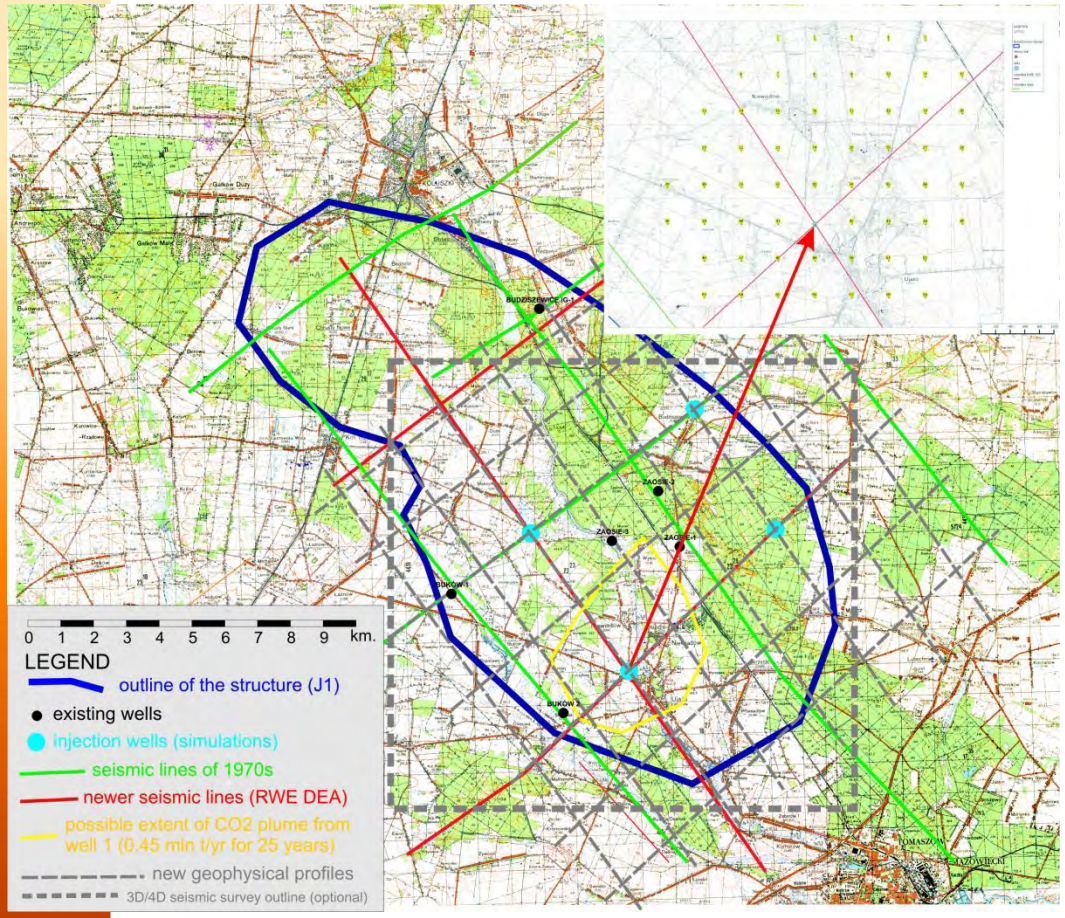


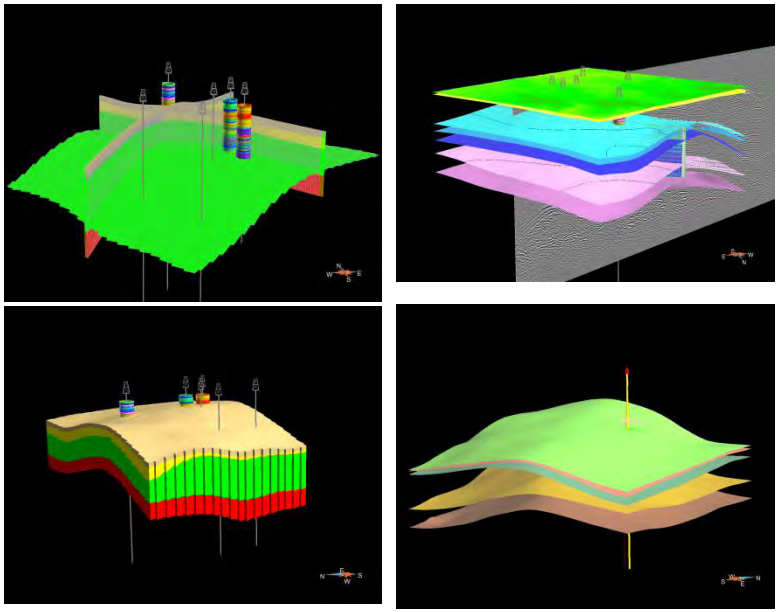


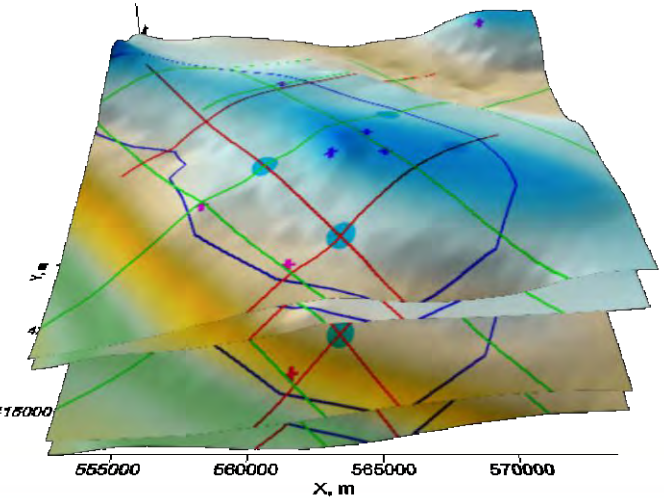
2-D seismic for the site (17 old lines, 3 newer)



The site model and proposed surveys
(site characterization and baseline monitoring)



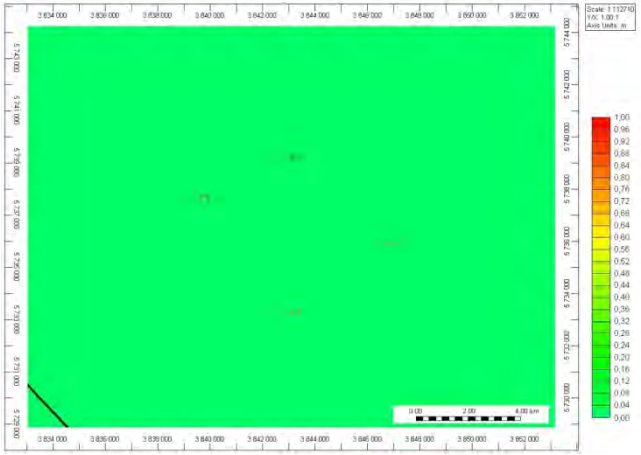


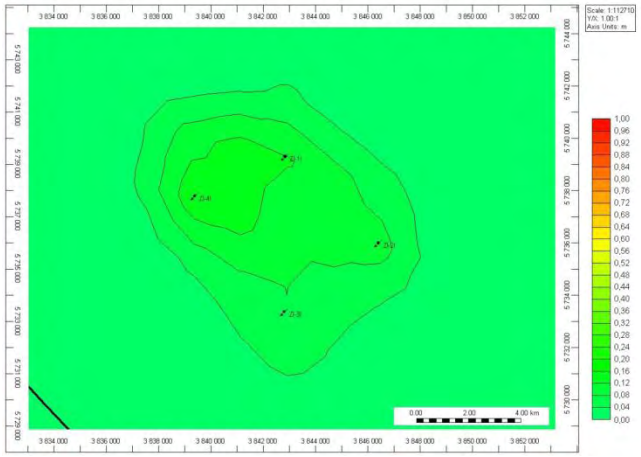


Static capacity (J1) – 370 Mt
(Bełchatów needs 45 Mt; Kędzierzyn 35 Mt)

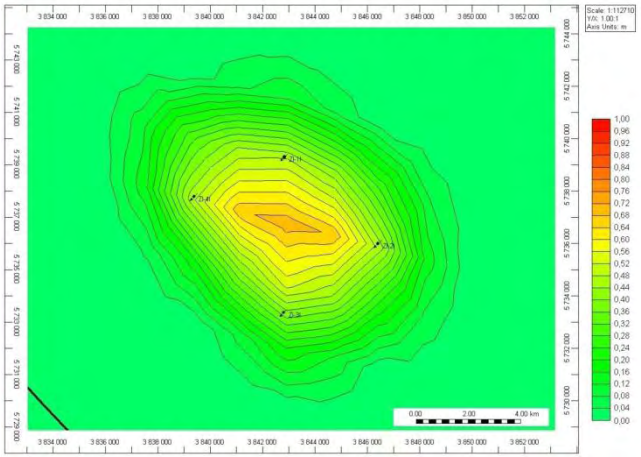
Injection simulations (AGH-UST) of J1

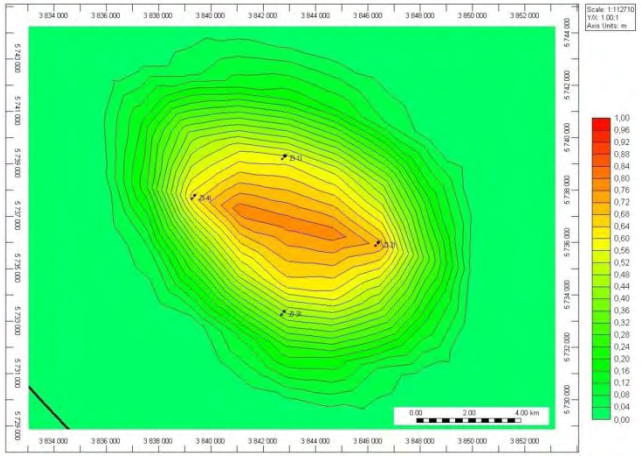
(0, 5, 20 y. of injection; 25 y. after; storage capacity 100-500 Mt)





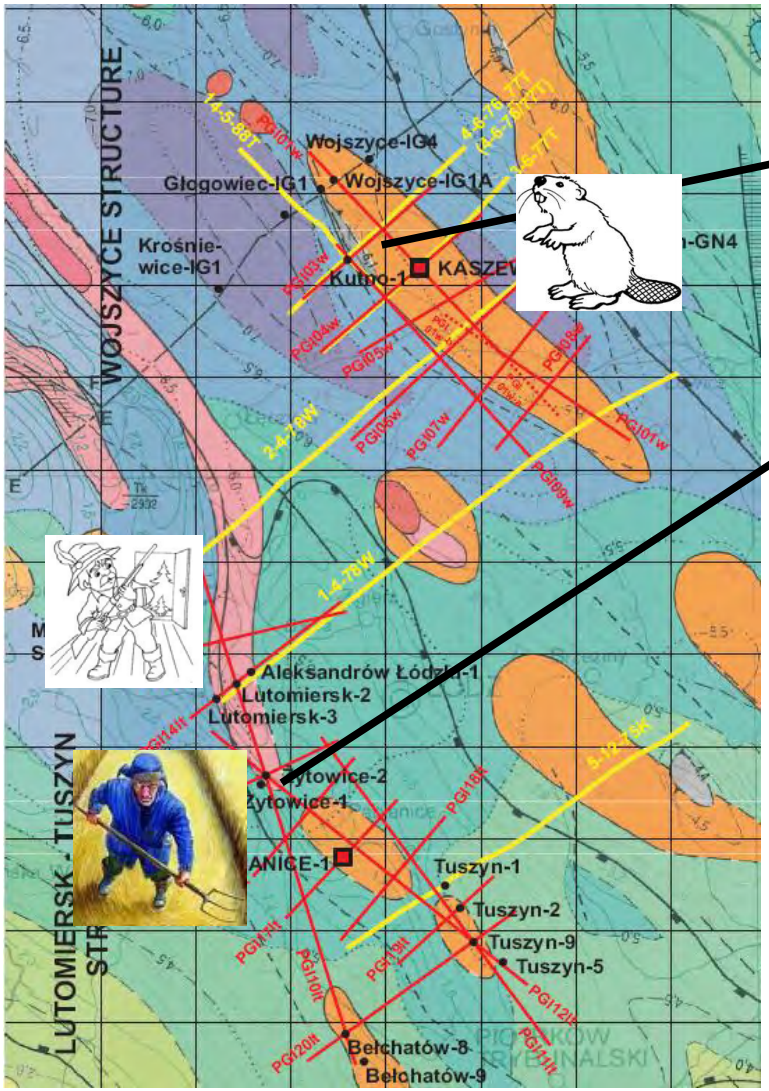
CO2 na plume area ~14 x 14 km (max.)

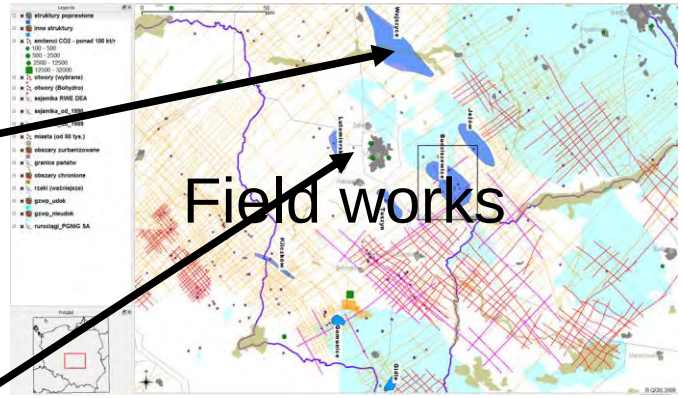




Field works of PGE Bełchatów

(the backup structures; not a part of the programme)





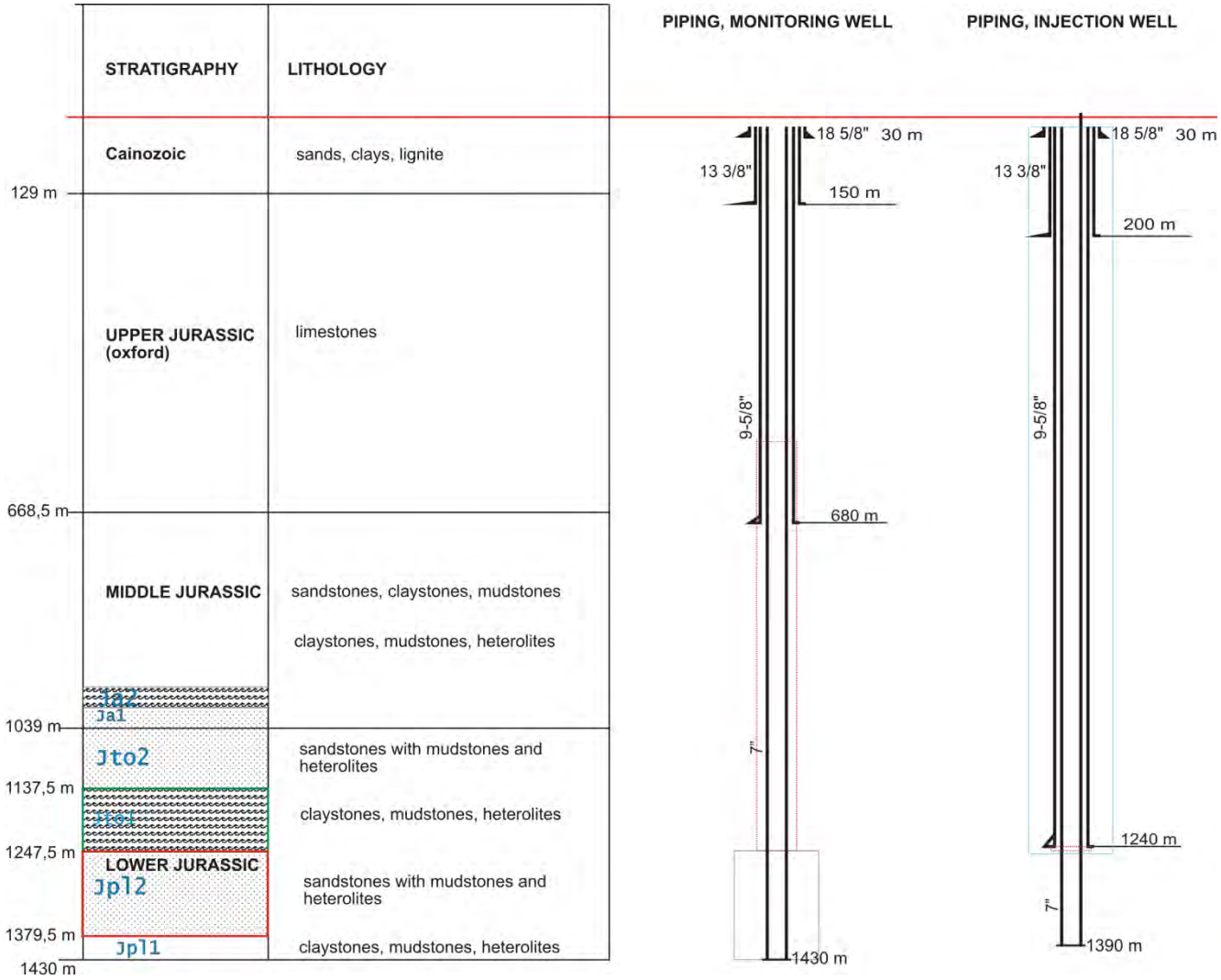
- The backup sites were explored (2D seismic, 2 wells) and models are being constructed,
- In NE there is nature protected area – longer approval procedures,
- In SW public opposition encountered (an NGO), a few lines relocated.

Pilot injection project
(another initiative; not a part of the programme)

An initiative of Ministry of Environment, funded by an association of Polish power plants.

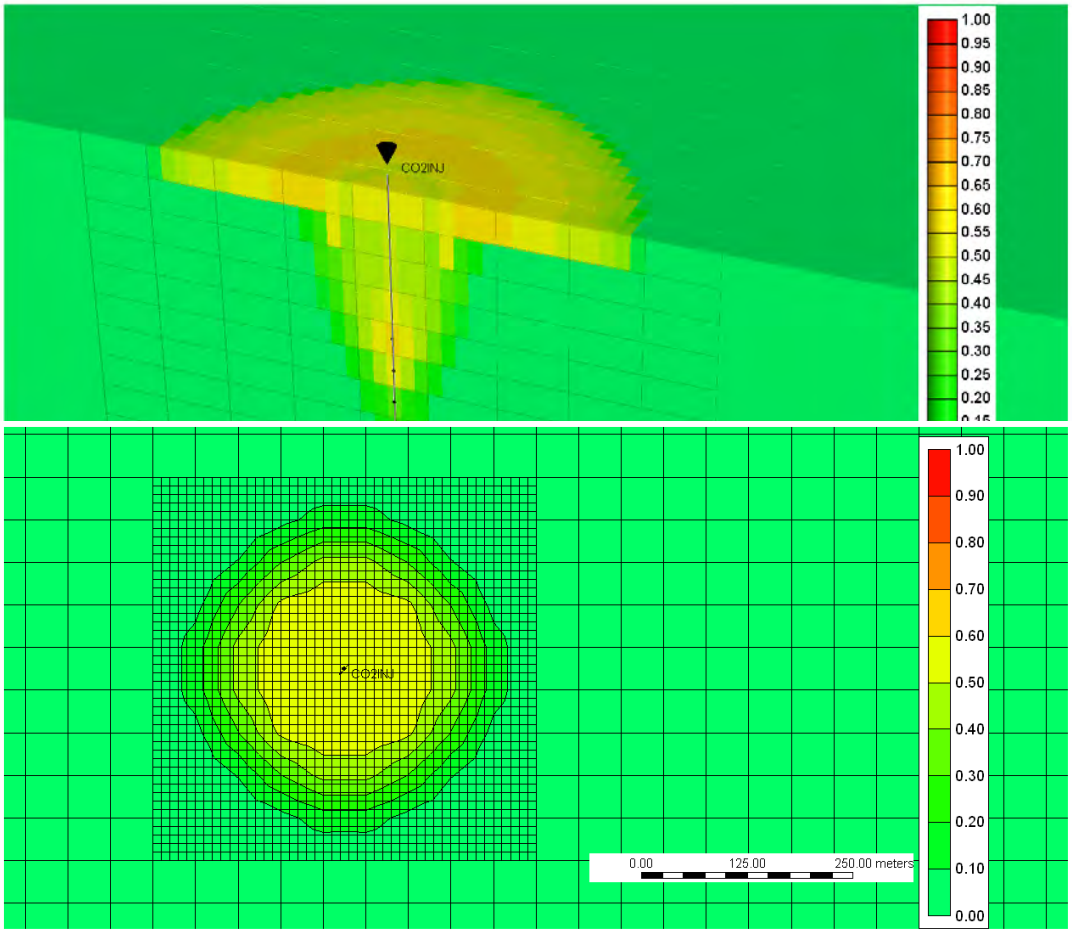
- Location in central Poland, not far from the demo site(s)
- J1 (Jpl) aquifer as for demo site(s)
- Duration – 3 years
- One injection well, one observation well (~1400 m)
- Reservoir properties – effective porosity likely 20%; permeability 200-500 mD; temperature 45 C; pressure ~12.5 MPa
- Goal – to evaluate injectivity of J1 aquifer
- Amount of CO2 injected – 27 kt within 2 years
- Project status – contract ready for signing, land being purchased, geological study evaluated by experts of Ministry of Environment
- Project starts within several weeks

Pilot injection project
profile and design of the wells

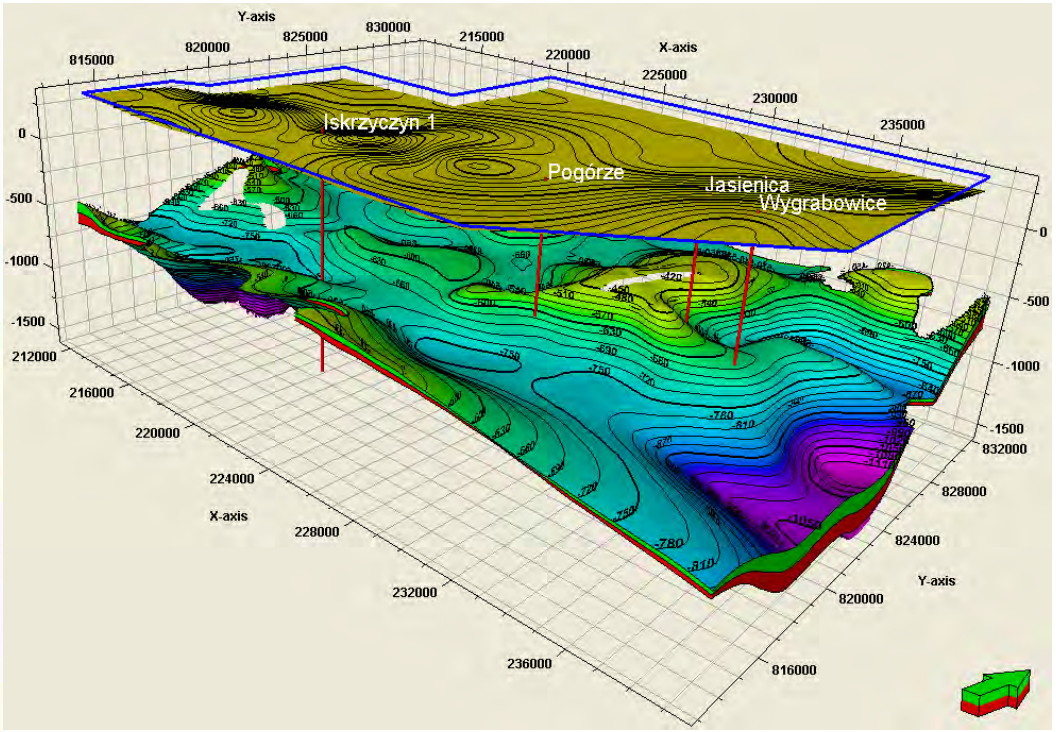


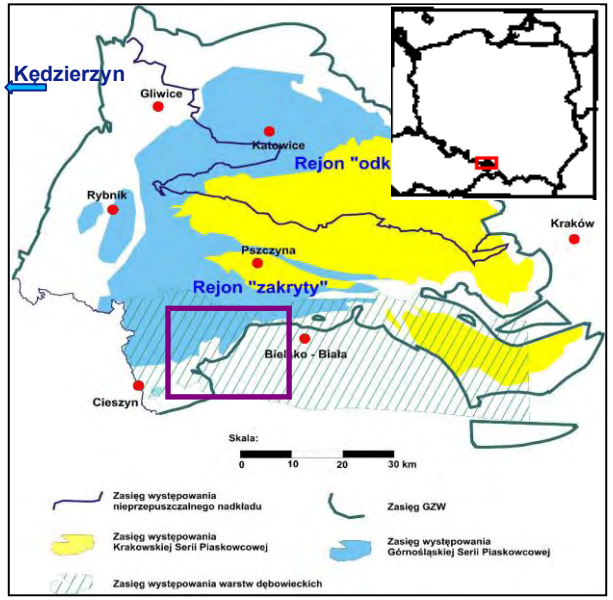
Pilot injection project

injection simulations (AGH-UST) – the CO2 plume range practically stabilizes after two year injection stops (~200 m radius)



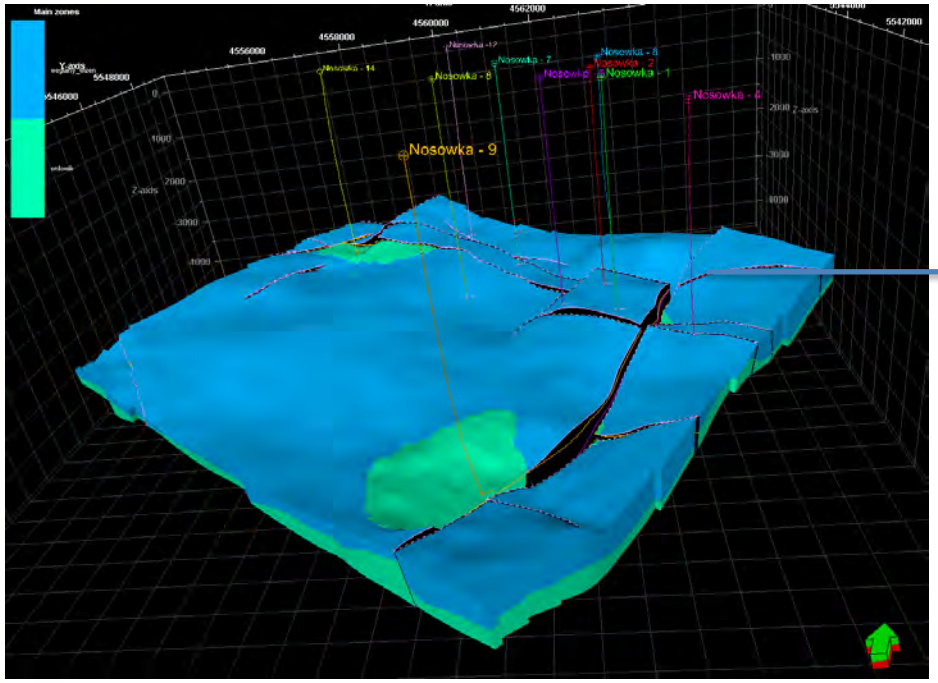
Works for area II – 2nd Polish demo project
(Kędzierzyn, 1.4 Mt/yr; PGI US & CMI)

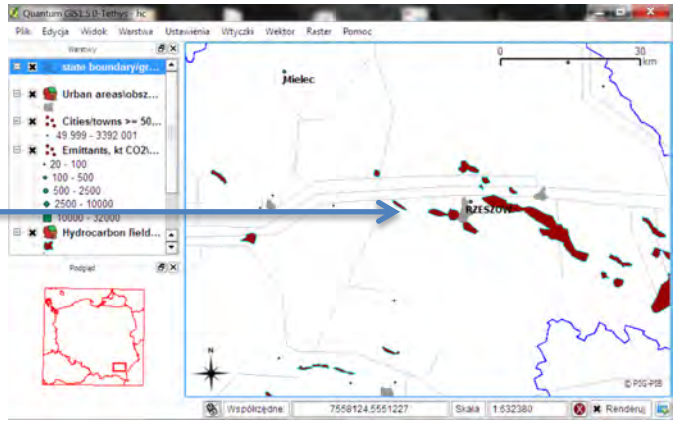




- Principal aquifer – dębowieckie beds of Lower Miocene + basement (zamarskie beds, Upper Carboniferous),
- Insufficient storage capacity – 25 Mt after injection simulations (at least 35 Mt required),
- Other options considered – gas fields NW of Wrocław and saline aquifers in central Poland (200 km distance).

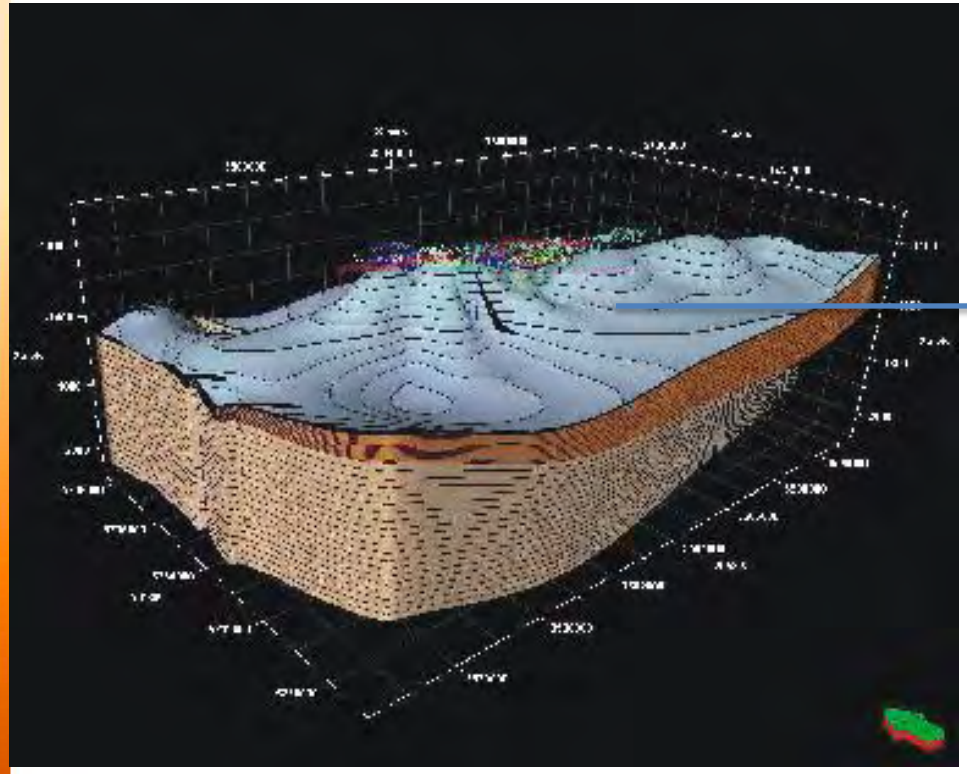
Hydrocarbon fields
(Nosówka oil field in SE Poland; O&GI/INiG)

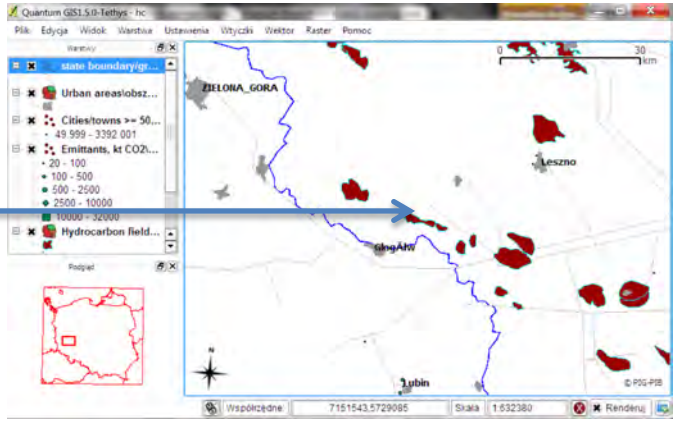




- Reservoir – C1 (Visean)
- Caprock – Lower Miocene
- OOiP 4.5 mln t; OGiP 0.585 bln m3
- UR of oil 0.9 mln t, gas 0.117 bln m3

Hydrocarbon fields
(Wilków gas field in W Poland; AGH-UST)





- Reservoir – P1 (Rotliegend)
- Caprock – Zechstein
- OGiP 5.5 bln m3; UR 4.4 bln m3
- Storage capacity 14-20 Mt

Conclusions

Ongoing research of the National Programme and previous projects provide the following conclusions:

- CO2 storage capacity of Poland is sufficient (equals 50-70 years of emissions listed in ETS);
- The most of storage potential is located onshore (>90%), offshore mostly in E Baltic area;
- The best aquifers are of Mezozoic formations (especially J1, to lesser extent T3&T1; Cr3 is not always safe)
- Case study of B-Z structure (the 1st Polish CCS demo) provided promising results and such structures are a quite numerous – J1 injectivity shall be proven by a field experiment
- Miocene aquifers are not so good, as well as (likely) C1.
- Hydrocarbon fields and coal beds are of limited storage capacity, same in case of EHR potential.

Thank you for your attention:

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