

G E U S



EUROPEAN STORAGE ATLAS MAPPING AND ENSURING EUROPEAN STORAGE POTENTIAL

NIELS POULSEN



"Increasing momentum for CO₂ storage"

11th CO₂GeoNet Open Forum, 9-11 May 2016

EUROPEAN CO₂ STORAGE ATLAS

- Thanks to partners
- The long way to a storage atlas
- Integrating the public available data from former EU and other projects
- CO₂StoP basic facts
- 1st European CO₂ Storage Atlas, challenges
 - Content of atlas,
 - New data, new countries
- The resources are limited, volunteer basis
- The information given and views expressed are those of mine though I'm doing my best to represent 26 CO₂StoP partners and EGS-GEEG





Thanks to partners

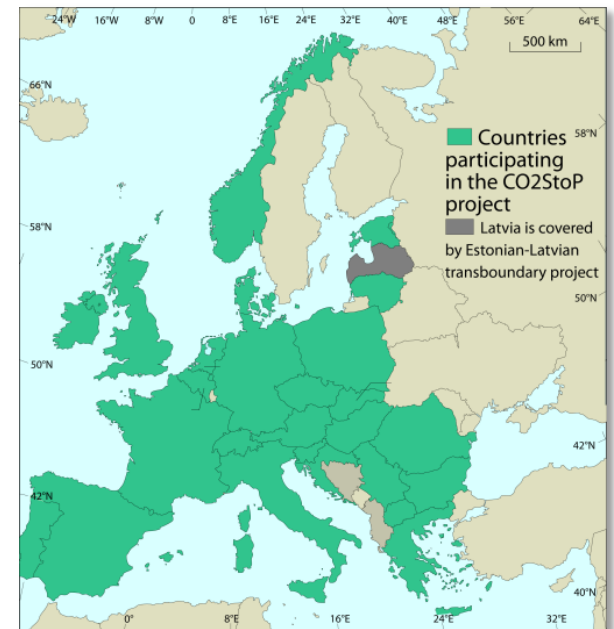
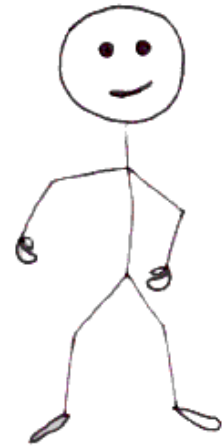
CO₂StoP

- 26 partners and subcontracting partners
- Filip Neele
- Karen Kirk
- Nikki Smith
- Sam Holloway
- Niels Poulsen

TNO



This is
my
thank you
dance!



The long way to 1st European CO₂ storage atlas



1993

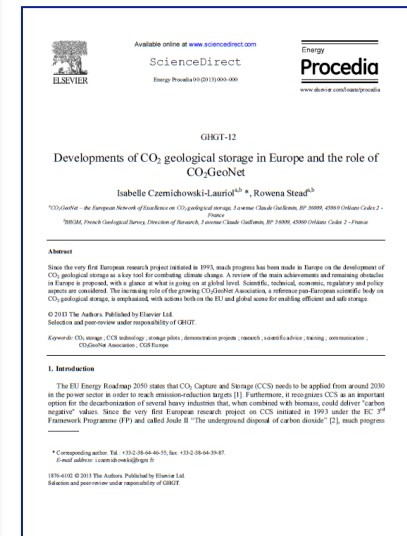
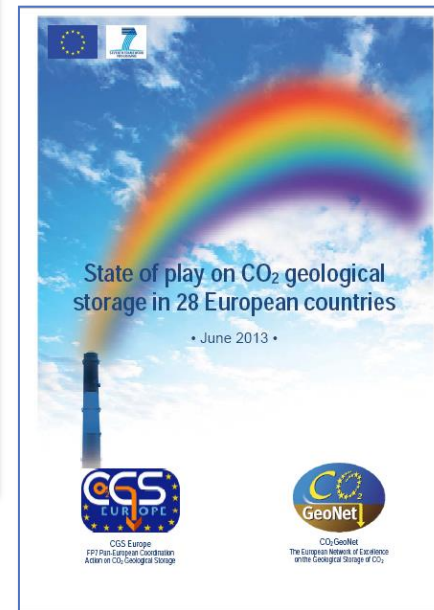
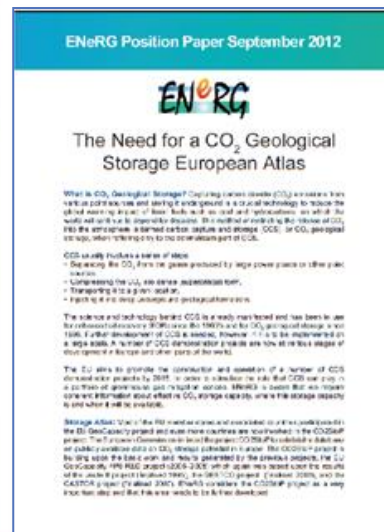
2012



2009

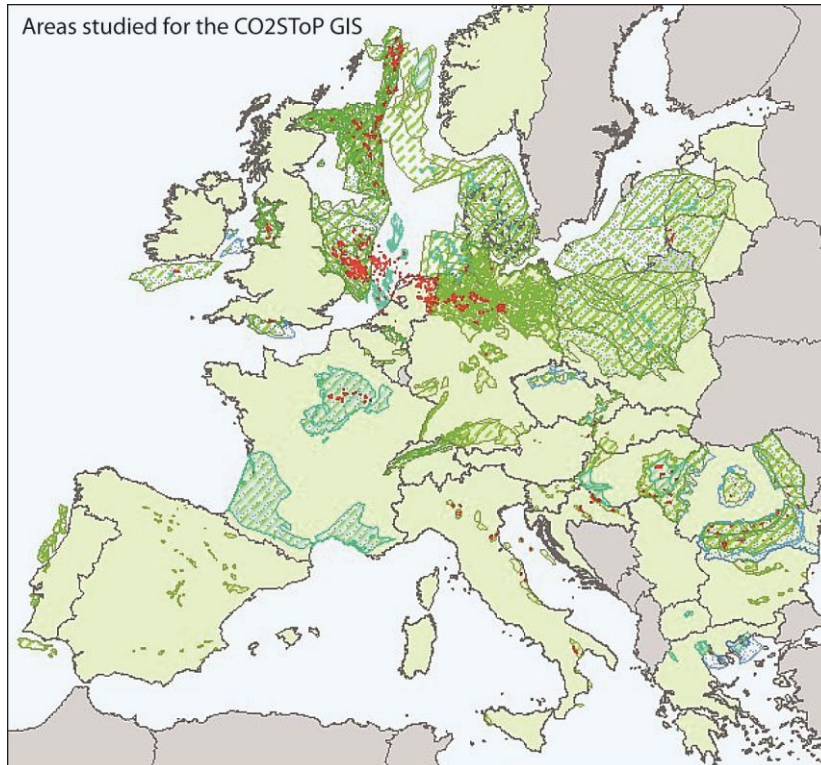
2013

2014

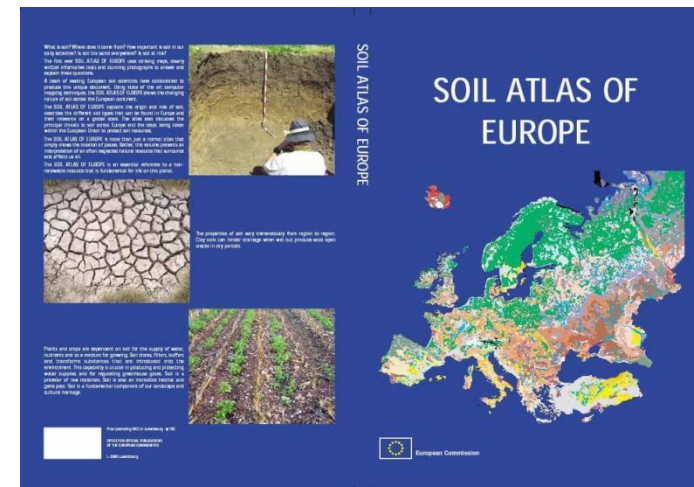
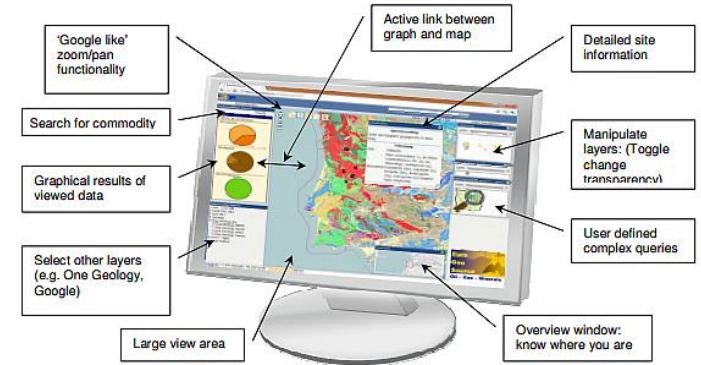


The long way to 1st European CO₂ storage atlas

2014



- = Countries studied
- = Countries not participating in CO2SToP project
- = Aquifer daughter units
- = Hydrocarbon daughter units
- = Storage units
- = Formations



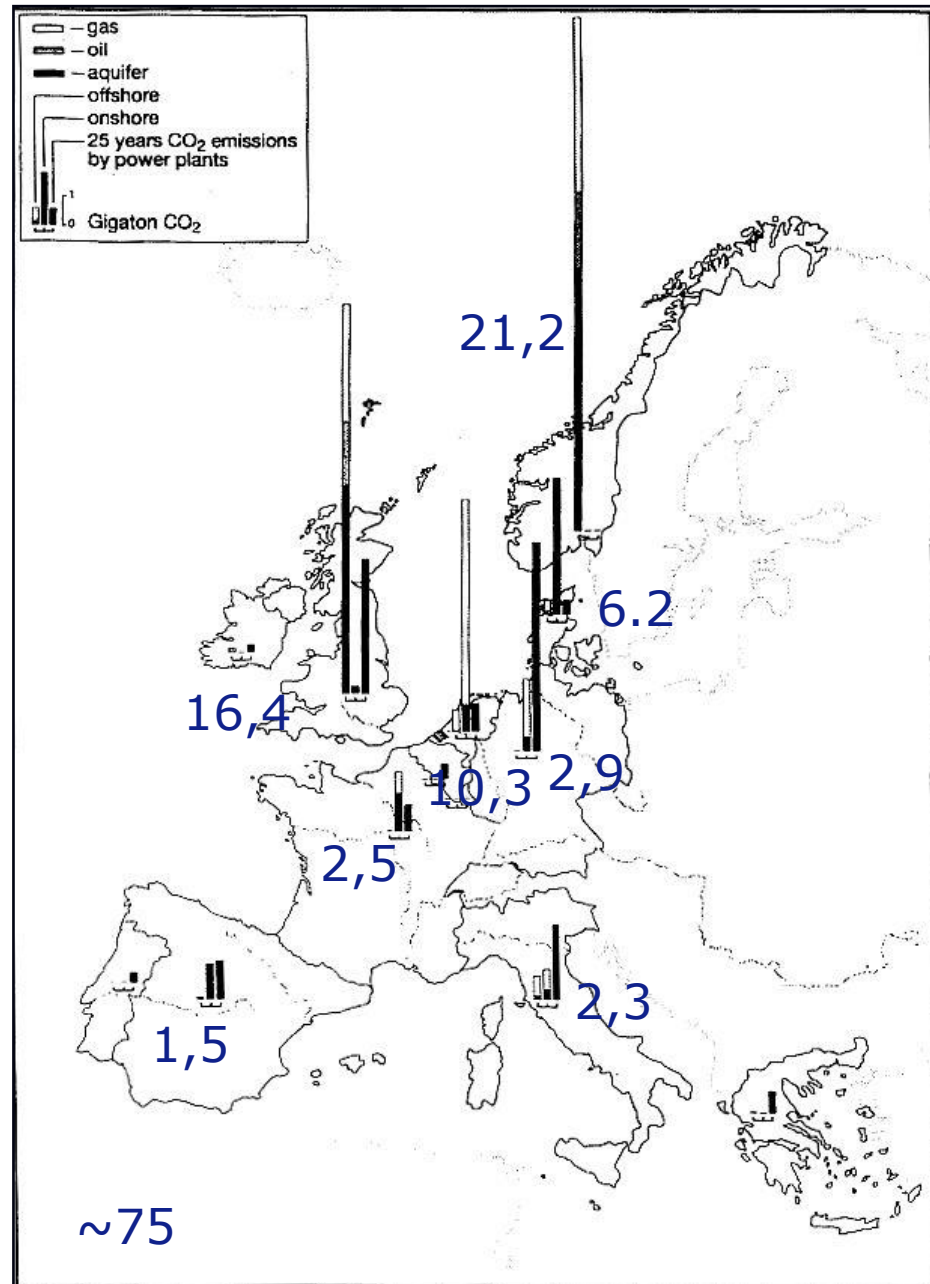


Joule II

CO₂ storage capacity in geological traps for the EU countries and Norway.

→ All figures are in Gt CO₂

The underground disposal of carbon dioxide. *Sam Holloway (editor), 1996.* Final report of the Joule II project No CT92-0031.



Integrating the public available data from former projects into the CO₂StoP GIS database

→ Since the early 1990s



→ **Joule II** finalised 1996

The Joule II project: The underground disposal of carbon dioxide "All Europe"



→ **GESTCO** finalised 2003

Geological Storage of CO₂ from Combustion of Fossil Fuel
Belgium, Denmark, France, Germany, Greece, Netherlands, Norway, UK



→ **Castor** finalised 2006

Bulgaria, Croatia, Czech Rep., Hungary, Poland, Romania, Slovakia, Slovenia



→ **EU GeoCapacity** finalised 2008 (The project was co-funded by the EU within FP6)

Assessing European Capacity for Geological Storage of Carbon Dioxide

Bulgaria, Croatia, Czech Rep., Denmark, Estonia, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, UK, Bosnia-Herzegovina, Albania, FYROM, Luxembourg, Belgium, Norway (25 countries)



→ **CO₂StoP** finalised 2014

Building an aquifer and hydrocarbon field CO₂ storage capacity database for the EC (27 countries)



EU GeoCapacity:

Assess the European Capacity for Geological Storage of Carbon Dioxide.

Project duration: 3 years (Jan. 2006 – Dec. 2008)

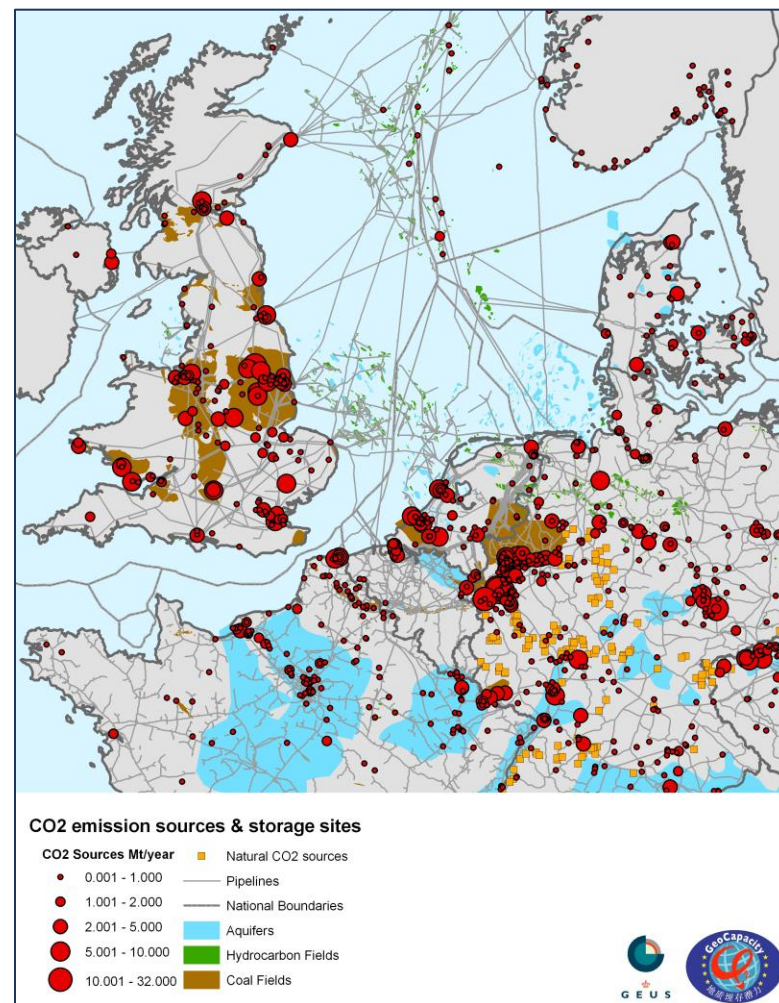
Budget: 10.5 M€ (FP6)

26 Partners from 21 countries

Coordinator: GEUS,

Outcome: provided the data required for the Europe wide adoption of CCS.

- Mapped potential sources and sinks
- GIS and Decision Support System
- Site selection criteria
- Estimated 117 Gt storage
 - 96 Gt in deep saline aquifers
 - 20 Gt in hydrocarbon fields
 - 1 Gt in unmineable coal beds
- Emissions
 - large point sources 1.9 Gt CO₂/year





CO₂StoP basic facts

Project

CO₂StoP is the acronym for the project “CO₂ Storage Potential in Europe.”

Started on January 2012 and ended in March 2014

CO₂StoP was a project funded by the European Commission

- Total eligible costs: >EUR 238,581
- EU contribution: EUR 238,581

Countries

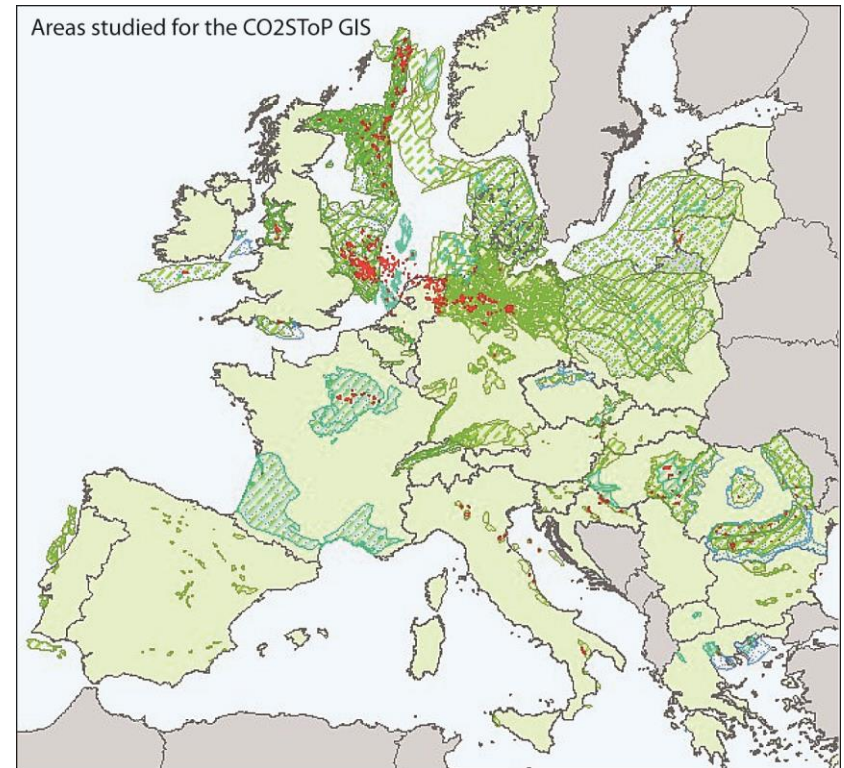
27 countries

Partnership

26 research institutes

Consortium

BGS, GEUS and TNO



- = Countries studied
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- ▨ = Aquifer daughter units
- ▨ = Hydrocarbon daughter units
- ▨ = Storage units
- ▨ = Formations

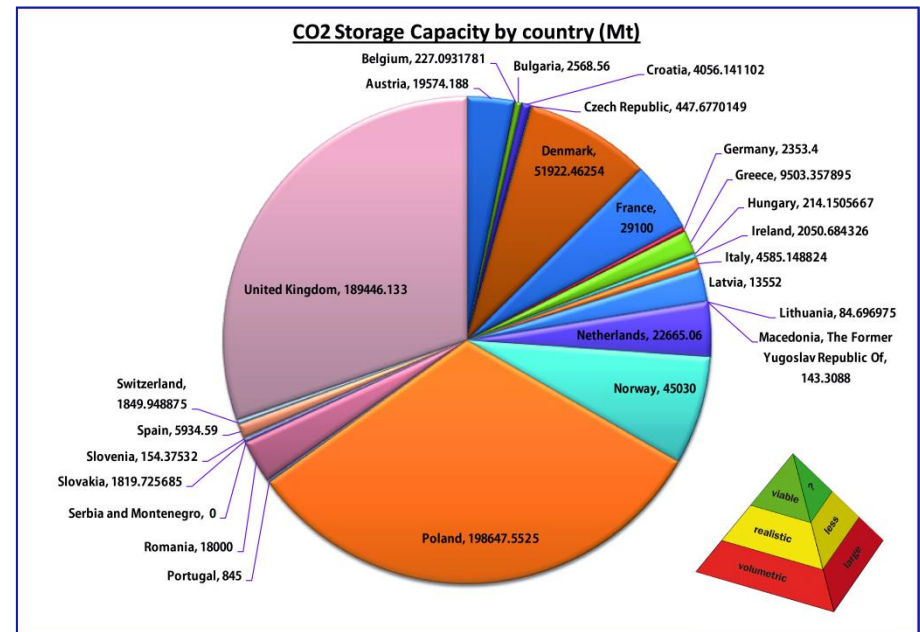




CO₂Stop: Assessment of the CO₂ storage potential in Europe

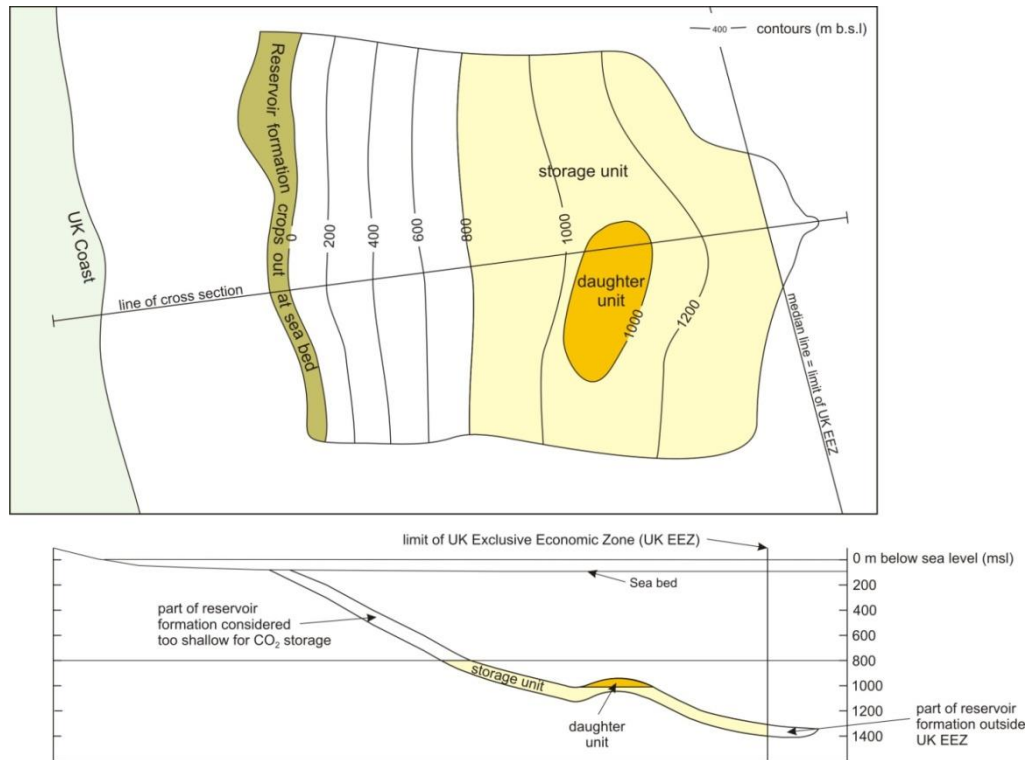
Outcome

- Database of CO₂ storage locations throughout Europe
- Public available data
- The CO₂StoP database paint a broad picture,
- but also identify the gaps in our knowledge
- It marks rather the beginning of atlases with resource estimation, and certainly not the end.
- The database is housed by the Joint Research Centre - European Commission, Petten





Storage formation contains structural reservoirs (traps)



Method assumes different (higher) storage efficiency in trap than in rest of formation.

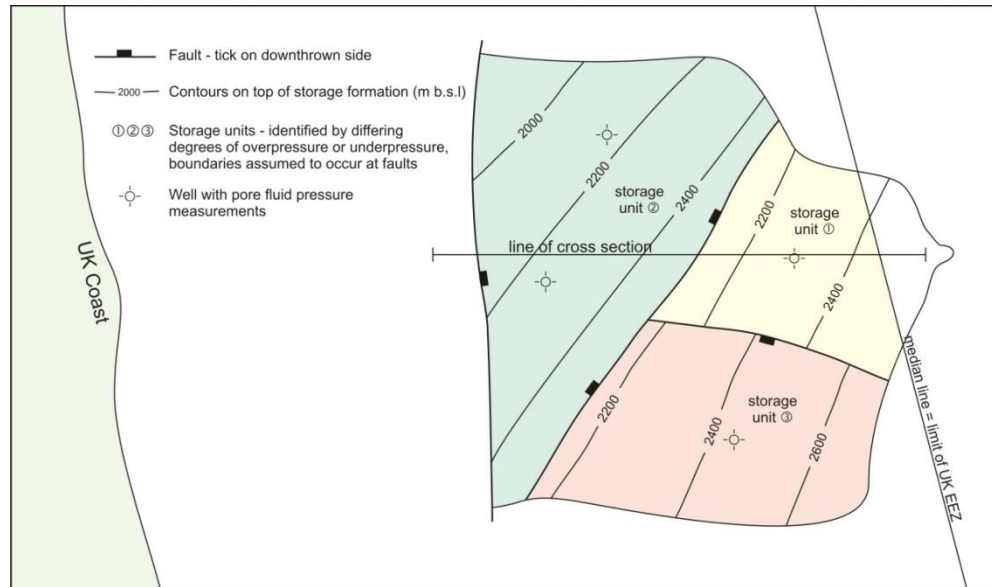
Calculation varies depending on whether parent unit has closed or open boundaries.

(Fig. after Gammer et al. 2011)

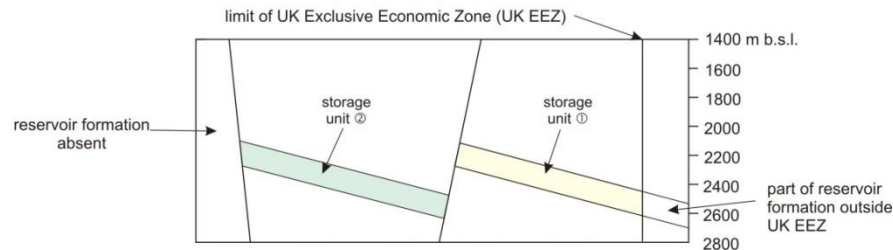




Aquifer consists of compartments (units) with closed boundaries



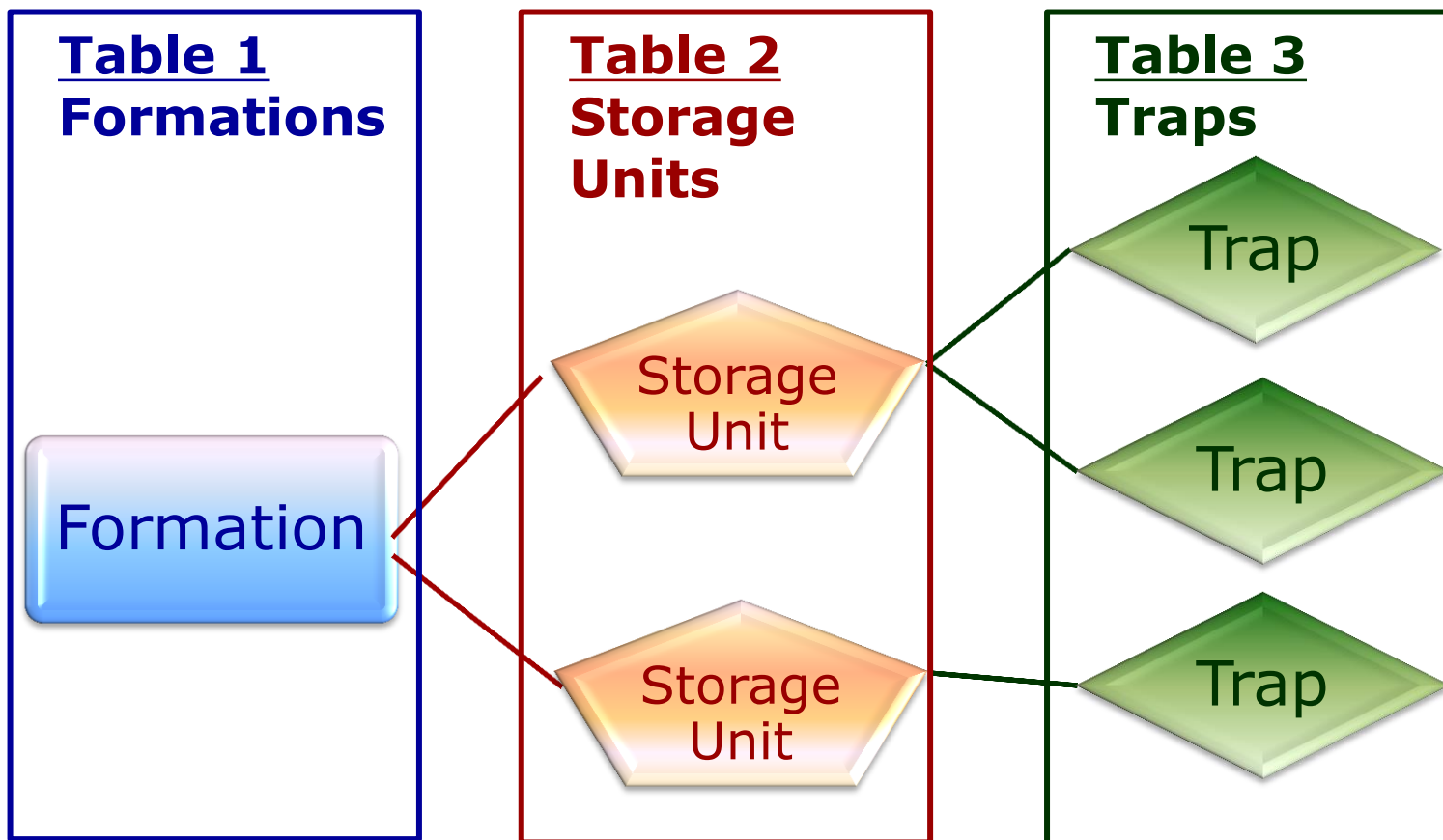
Storage capacity is the mass of CO₂ that could be stored in available space at limiting pressure



(Fig. after Gammer et al. 2011)



Database Structure





- ☒ Layers
 - ☒ DK_aquifers
 - ☐ Frederikshavn_Forma
 - ☐ Haldager_Formation
 - ☐ Gassum_Formation
 - ☐ Skagerrak_Formation
 - ☐ Bunter_Formation

Traps



- ☒ Layers
 - ☐ DK_aquifers
 - ☐ Frederikshavn_Forma
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 - ☒ Gassum_Formation
 - ☐ Skagerrak_Formation
 - ☐ Bunter_Formation

Formation



Identify

Identify from:

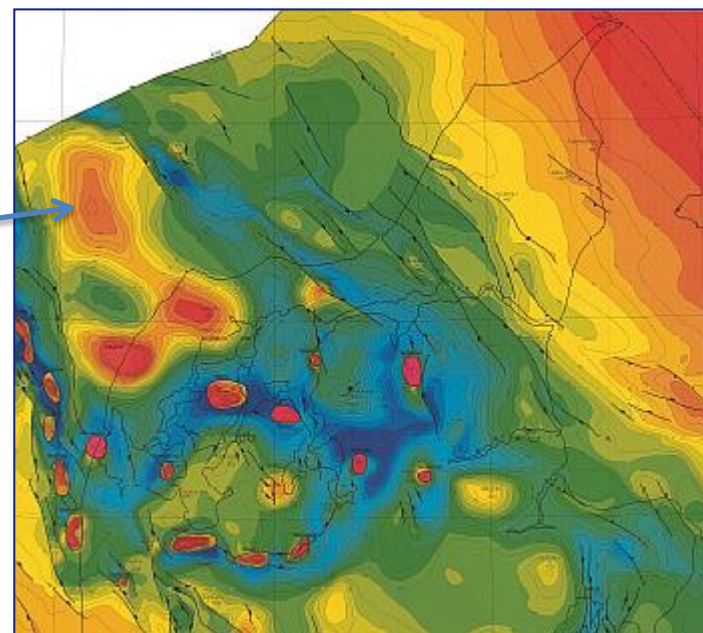
☒ Gassum_Formation
72264,5754843

Location: -570.799,845 6.664.073,485 Meters

Field	Value
FID	0
Shape	Polygon
Area	72264,5754843541
Polygon_ID	DK_F_20120905113052957

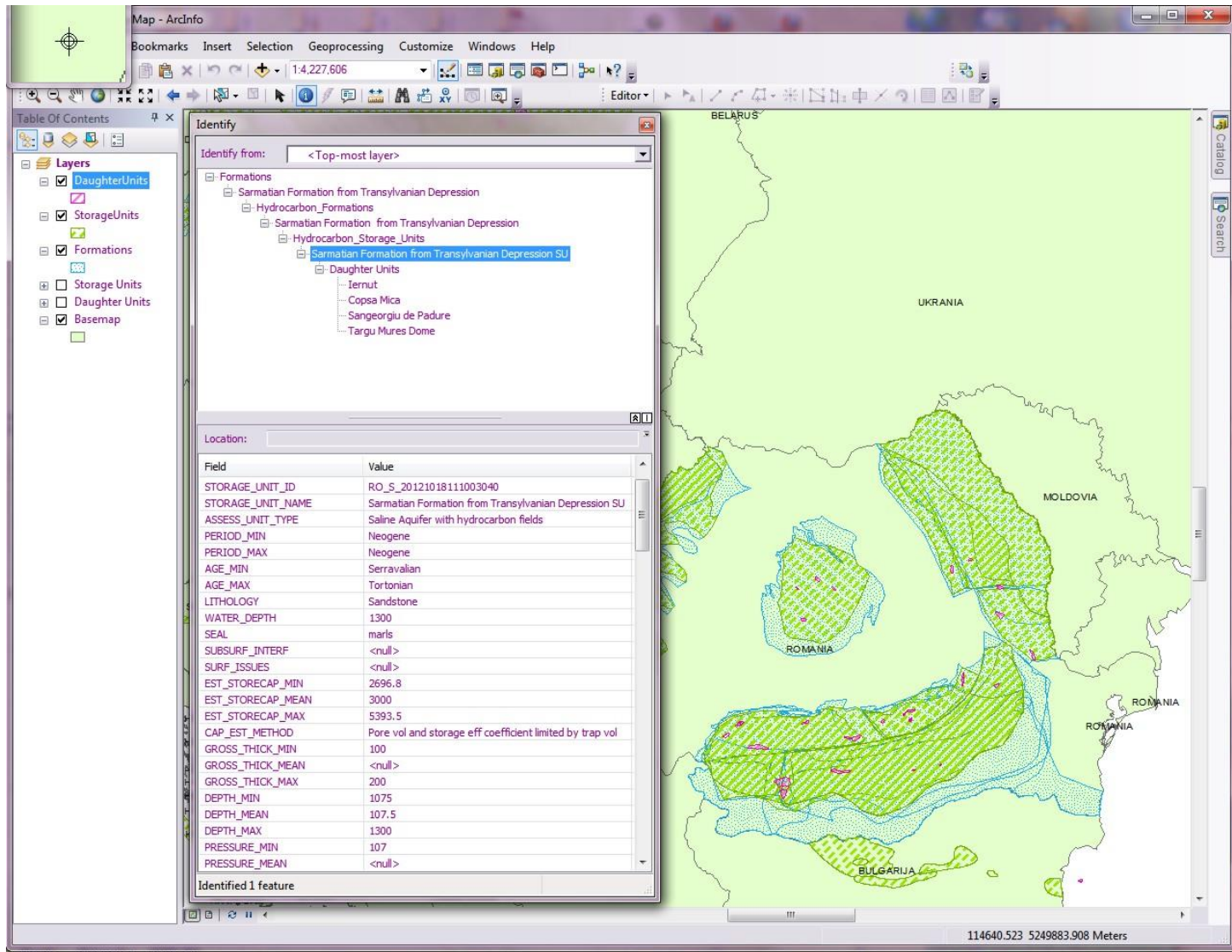
Identified 1 feature

- ☐ Frederikshavn_Forma
- ☐ Haldager_Formation
- ☒ Gassum_Formation
- ☐ Skagerrak_Formation
- ☐ Bunter_Formation





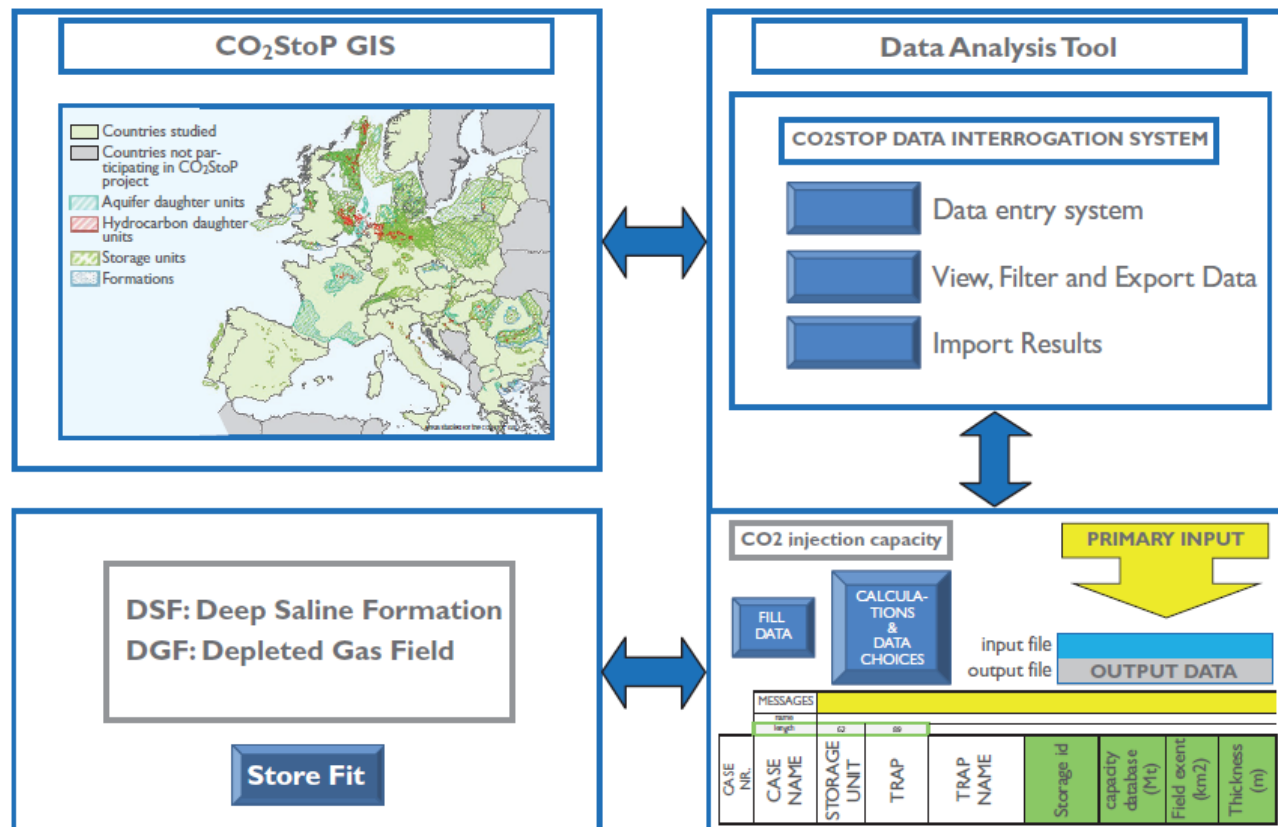
Data linked to polygons in the GIS





Database interrogation tool

- The CO₂StoP tools established probabilistic estimates of the CO₂ storage resource in Europe and calculation of injection rates



1st European CO₂ Storage Atlas

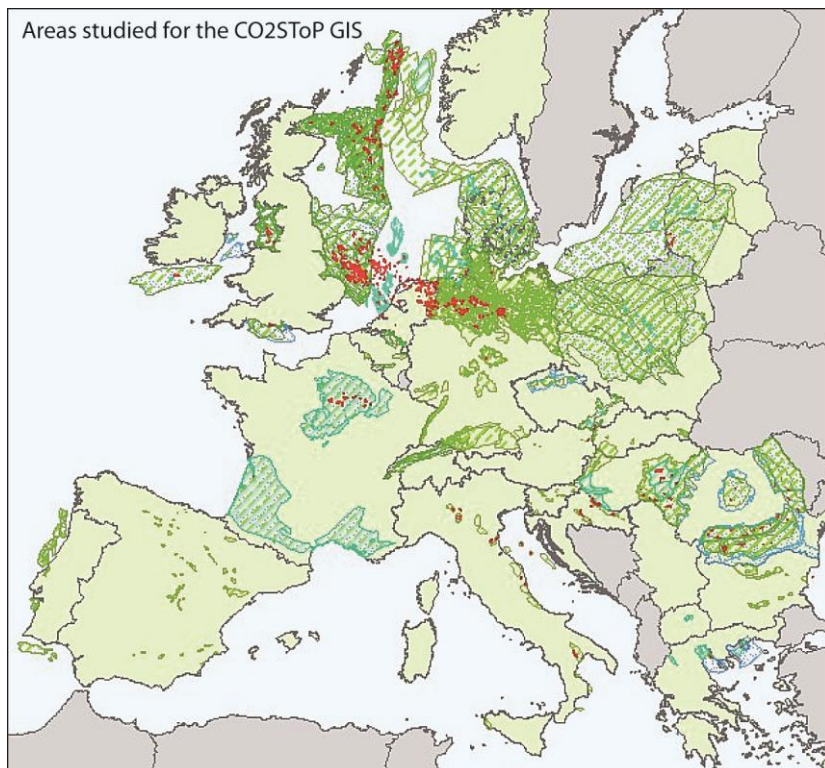
- Develop a first CO₂ Storage Atlas for EU, to be **built on** the foundations of the **CO₂STOP** database (owned by JRC)
- JRC believes it is **now or** it will not be possible before a good number of years.
- Publishing the atlas now is needed as a **follow up** on the outcomes from the **COP21**



Next steps

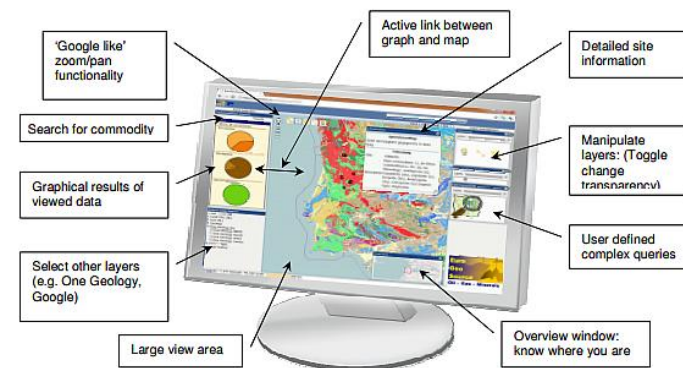
1st European CO₂ storage atlas

2014

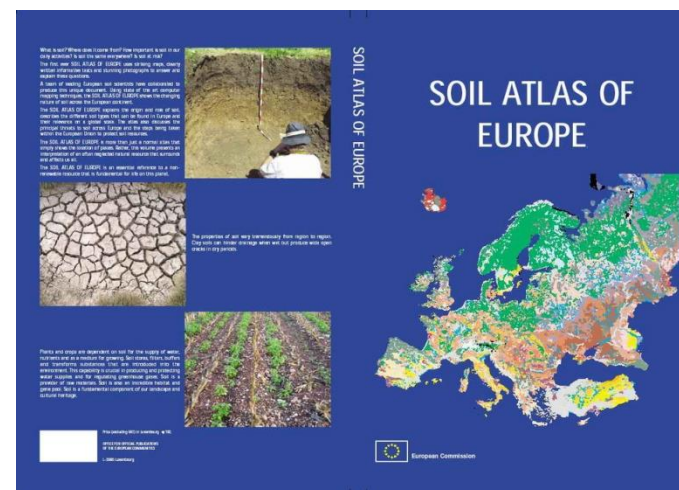


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November 2016



2017





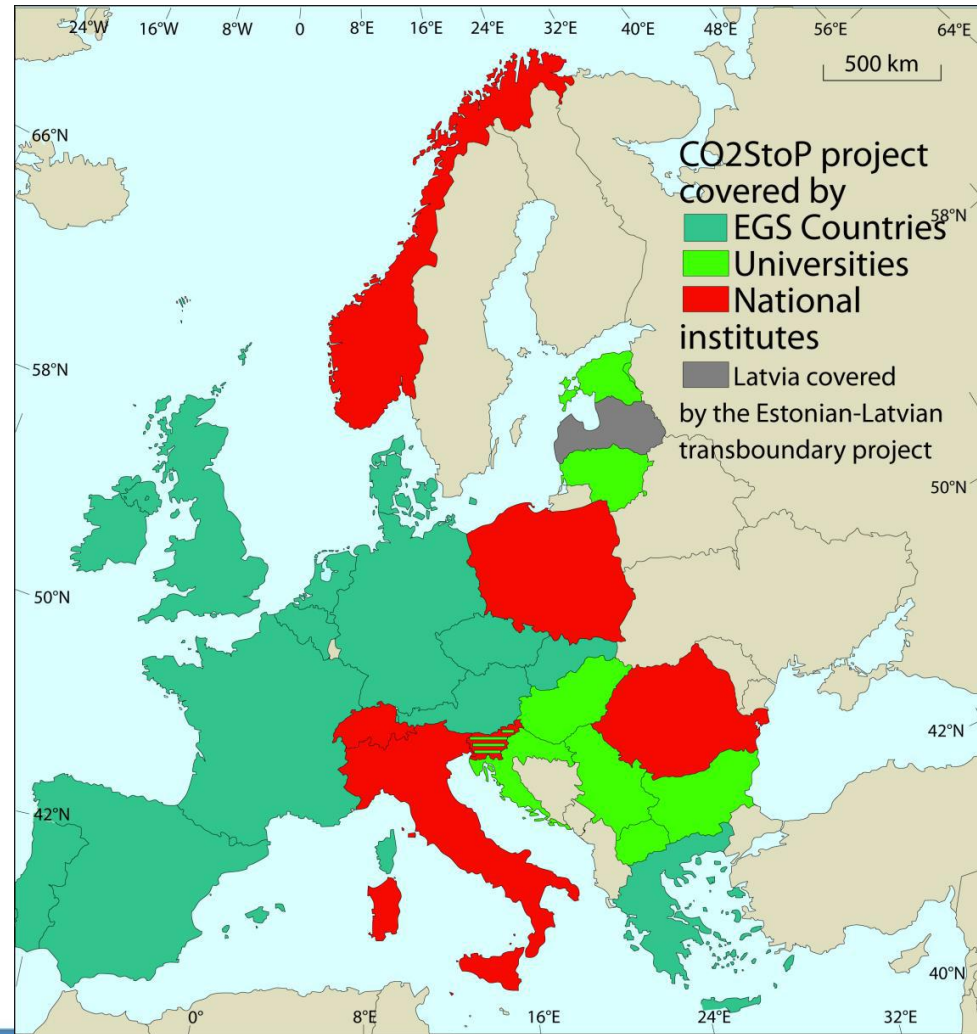
Text for online and publishes atlases

The resources are limited.

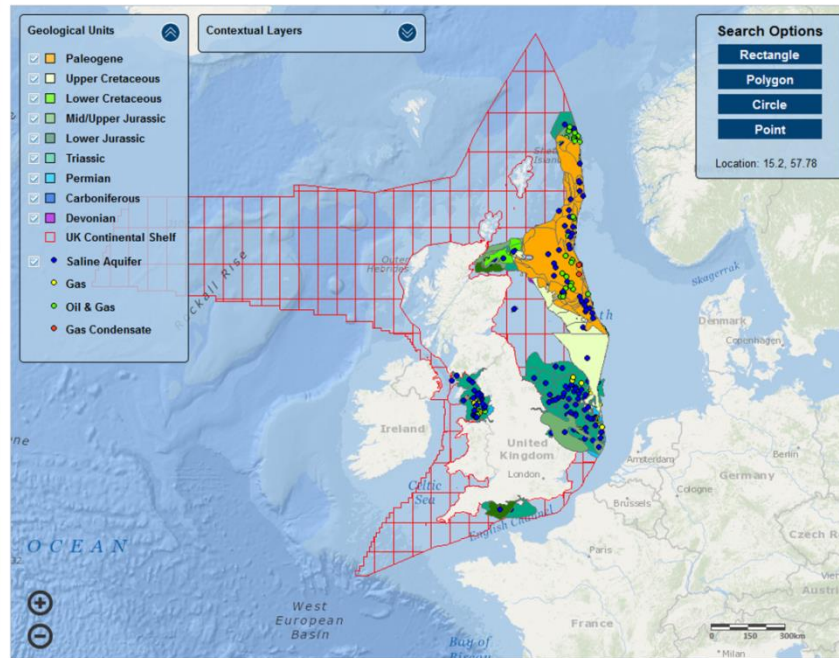
Mainly volunteer basis

Text needed and good to have.

- ➔ What is CCS
- ➔ CO₂GeoNet
- ➔ Geological description of geological basins and formations
- ➔ CO₂StoP partners & EuroGeoSurveys GeoEnergy Expert Group
- ➔ Methodology
- ➔ is already available in the CO₂StoP report
- ➔ Give reference for new, more and better information like the CO₂Stored or NORDICCS.
- ➔ Relevant partnerships, countries



CO₂Stored Interactive Map and database



Unit Designate	Select One	Age	Select One
Group	Select One	Unit ID	
Formation	Select One	Maximum Water Depth [m]	
Member	Select One	Permeability [mD]	
Area	Select One	Porosity [fraction]	
Storage Unit Type	Select One	CO ₂ Theoretical Capacity [10 ⁶ t]	

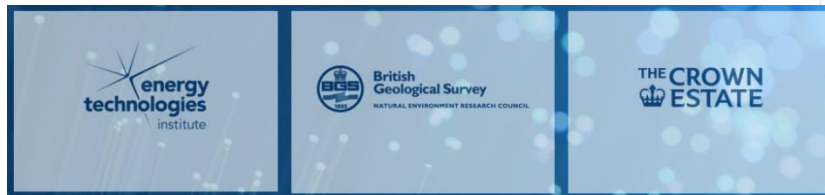
Capacity Data Results

Description	Units	Measurements
Total Number of Storage Units		574
Number of Storage Units With Results		505
Preliminary Overall Theoretical Capacity (P90)	[10 ⁶ Tonnes]	62845
Preliminary Overall Theoretical Capacity (P50)	[10 ⁶ Tonnes]	69172
Preliminary Overall Theoretical Capacity (P10)	[10 ⁶ Tonnes]	75499

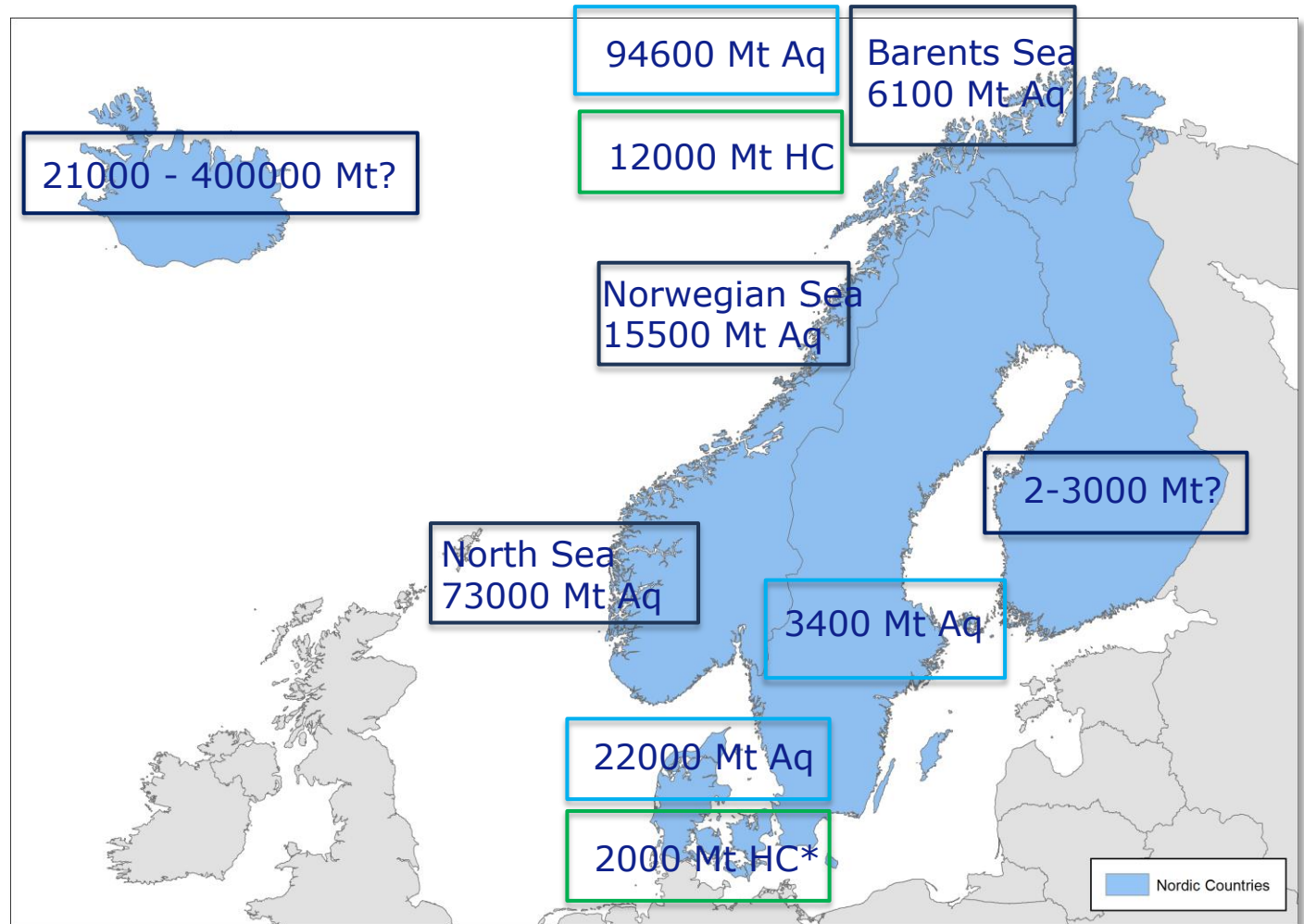
Storage Unit Results (574)

Unit ID	Description	Area	Unit Designate	Lat	Lon
1.000	Cormorant_009_14	Northern North Sea	Saline Aquifer	59.55	1.78
2.000	Cormorant_009_09	Northern North Sea	Saline Aquifer	59.24	0.26

CO₂Stored project partners



NORDICCS: Total Nordic CO₂ storage capacity mapped until 2015



Providing digital data to the Nordic CO₂ Storage Atlas



ICELANDIC INSTITUTE OF NATURAL HISTORY



NORWEGIAN PETROLEUM
DIRECTORATE

NORDICCS project partners



SINTEF

NORCEM

HEIDELBERGCEMENT Group



CHALMERS



NTNU – Trondheim
Norwegian University of
Science and Technology



Statoil



Orkuveita
Reykjavíkur



GEUS

SGU

Sveriges geologiska undersökning
Geological Survey of Sweden

VATTENFALL



IVL

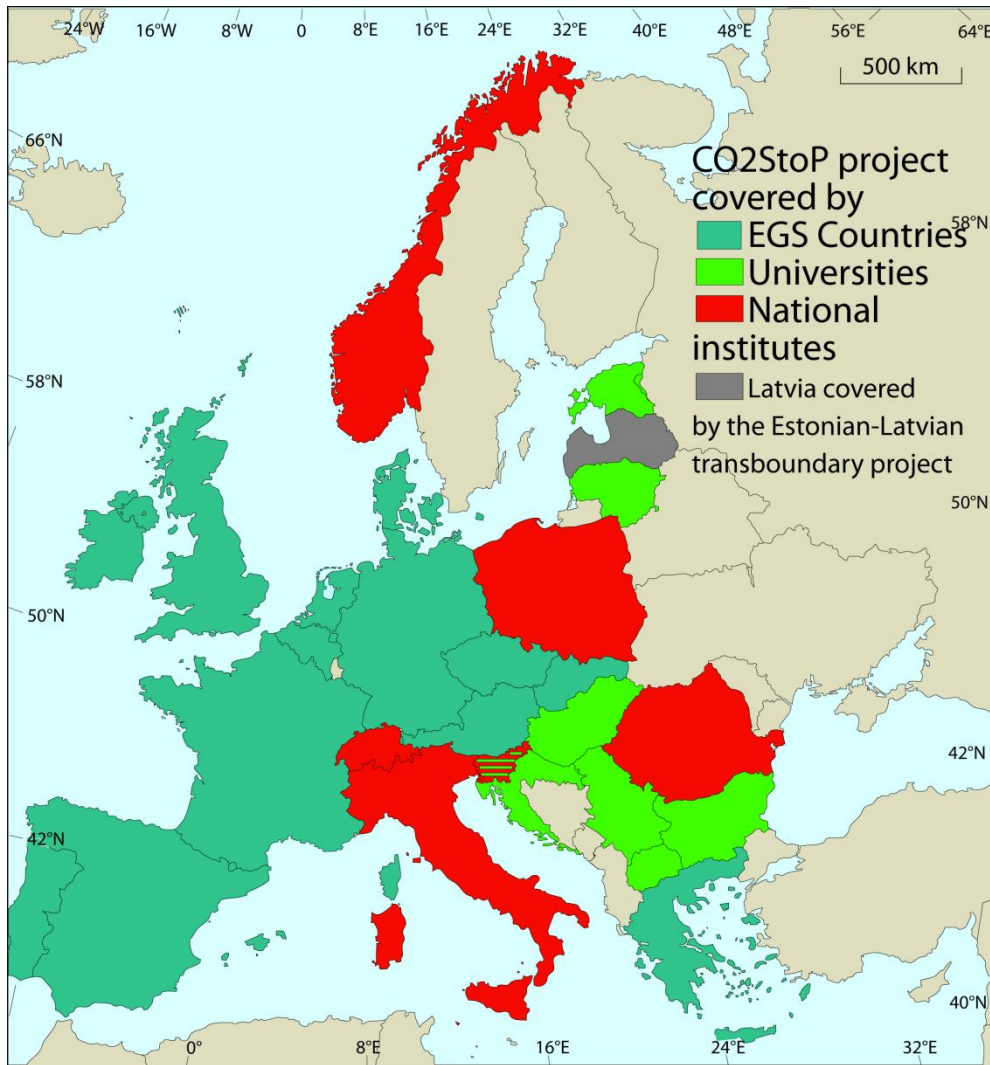
Swedish Environmental
Research Institute

Produced with support from the NORDICCS Centre, performed under the Top-level Research Initiative CO₂ Capture and Storage program, and Nordic Innovation.
The authors acknowledge the following partners for their contributions:
Statoil, Gassco, Norcem, Reykjavik Energy, CO₂ Technology Centre Mongstad, Vattenfall and the Top-level Research Initiative (Project number 11029).





Atlas: growing variety of partners



- **EU GeoCapacity**
- **ENeRG**
- **CGS Europe**
- **CO₂GeoNet Association**
 - **Universities**
 - **Research Institutes**
 - **National Agencies**
 - **EuroGeoSurveys**

