Mapping deep geothermal resources in Europe by European geological surveys using an adapted play-based exploration pyramid within the Horizon Europe co-founded GSEU Project

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The Pan EU Atlas of Sustainable GeoEnergy Capacities

Funded by the European Union

Outlook

1. GSEU project. The Geological for Service for EUROPE
2. What has been done so far and what are the activities of GSEU in the Deep Geo
3. From the Play-based Exploration Pyramid concept to the GSEU approach for Deep Geo
4. Pan-EU Atlas of SGC. Deep geothermal. Published datasets Levels 00, 01, and 02
5. The role of geological surveys in geothermal development
6. Why is the information and knowledge on these issues important for Europe?
7. Accelerate EU, Plan - Creation of an EU-level geological database to accelerate geothermal energy.
8. Summary

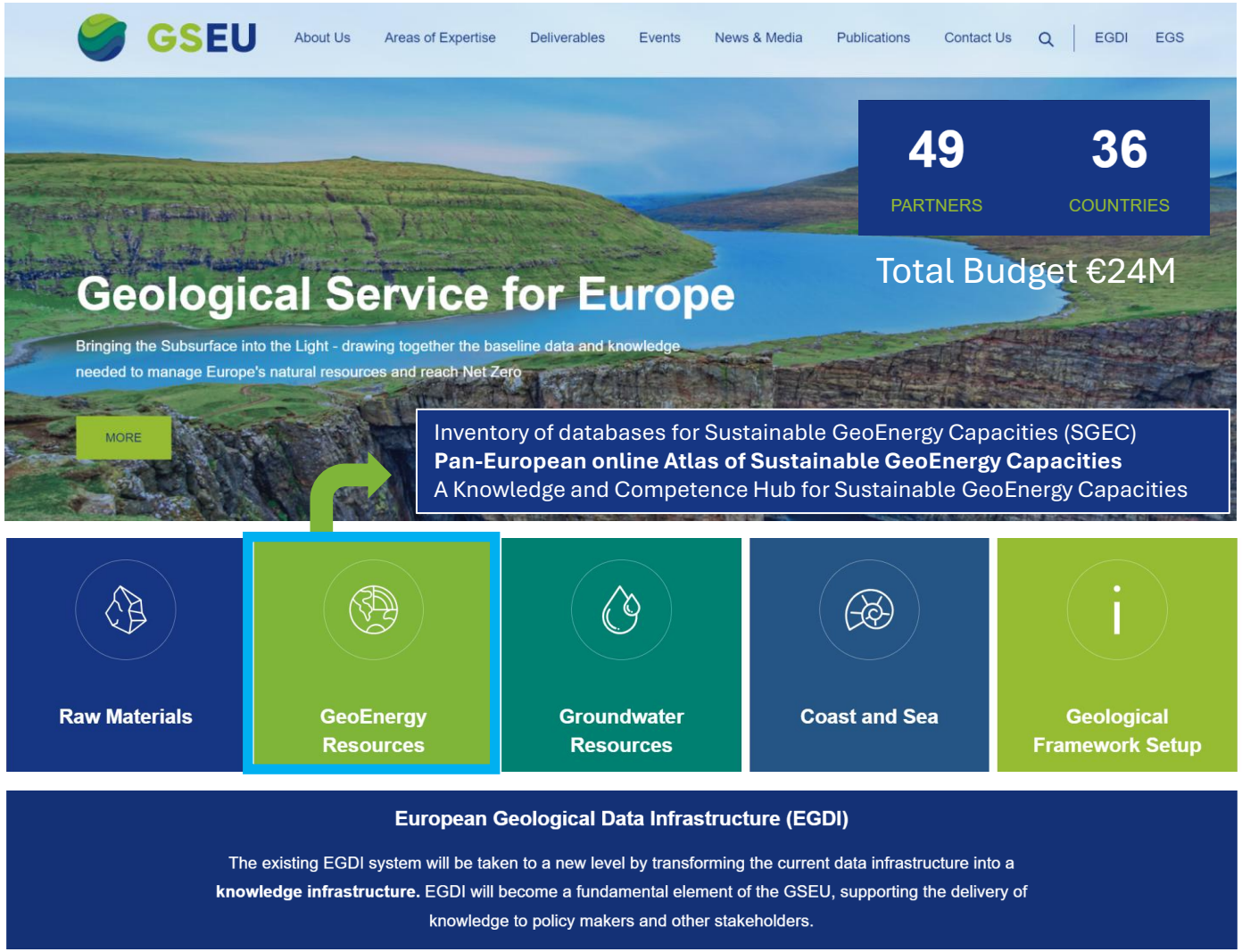
1. GSEU project. The Geological for Service for EUROPE

GSEU is a UE Horizon Europe funded project (Coordination and Support Action) running between 2022-2027, lead by EuroGeoSurveys and 49 partners.

Main goal: to develop and make permanently available a **pan-European geological data infrastructure** and related information services for the sustainable and safe use of our subsurface and its resources.

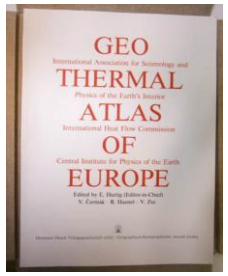
Structured into different Areas of Expertise: Raw Materials, **GeoEnergy Resources**, Groundwater Resources, Coast and Sea, Geological modelling, EGDI.

A **Pan-European online Atlas of Sustainable GeoEnergy Capacities** (geothermal energy resources and subsurface storage capacities for sustainable energy carriers (hydrogen, heat and cold) and sequestration of CO2), with harmonized and generalized maps and databases based on the evaluation and assessment of existing and new data and information.



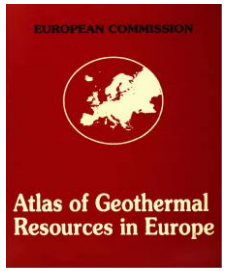
2. What has been done so far and **what are the activities of GSEU** in DG

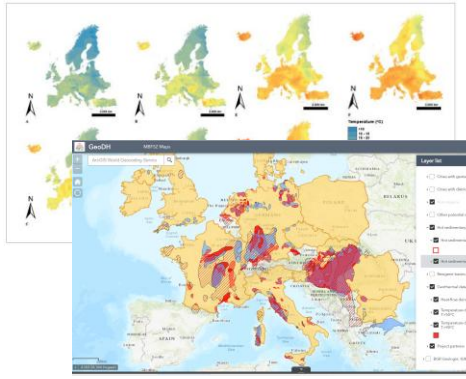
Historic projects



Hurtig et al (1992)

Hurter, S. J. and Haenel, R. (2002)



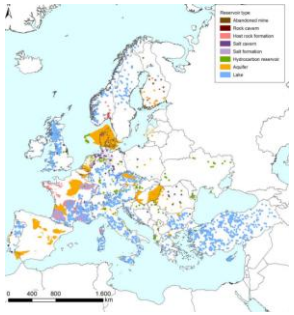


GEO-ELEC

2011-2013

GEODH

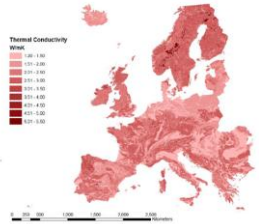
2011-2014



ESTMAP

Energy Storage Mapping And Planning

2015-2016

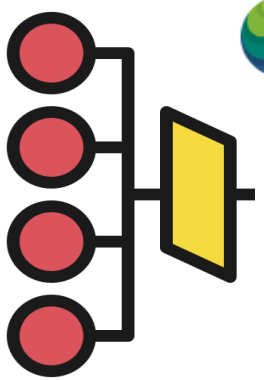


GEOCOND

2017-2021

GSEU's new **Pan-EU Atlas of SGC** takes as its starting point the information from previous EU projects in this topics, **updating, expanding and generating new** information oriented to the end user (for planning, decision-making aid)

1) gathering previous information



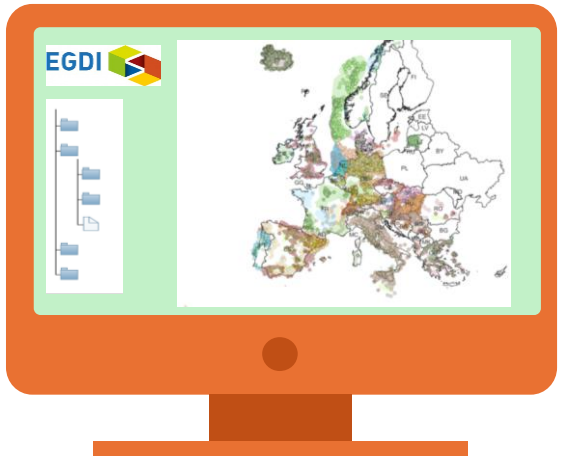
GSEU

GEOLOGICAL SERVICE FOR EUROPE

3) Compilation and publication

2) Updating, expanding and **generating new layers** and guides

The future Pan EU Atlas of Sustainable GeoEnergy Capacities

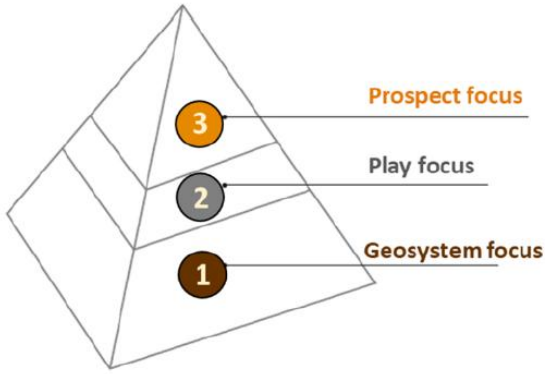


GSEU GEOLOGICAL SERVICE FOR EUROPE

3. From the Play-based Exploration Pyramid concept to the GSEU approach for DG

Play-based Exploration Pyramid concept

(adapted for geothermal, Moeck, 2020)



(Moeck, 2020, modified from Royal Dutch Shell, 2013)

(1) Geological system analysis as a whole
- Plate setting
- Tectonostratigraphic framework
- Geothermal Play identification and typing (Moeck, 2014)

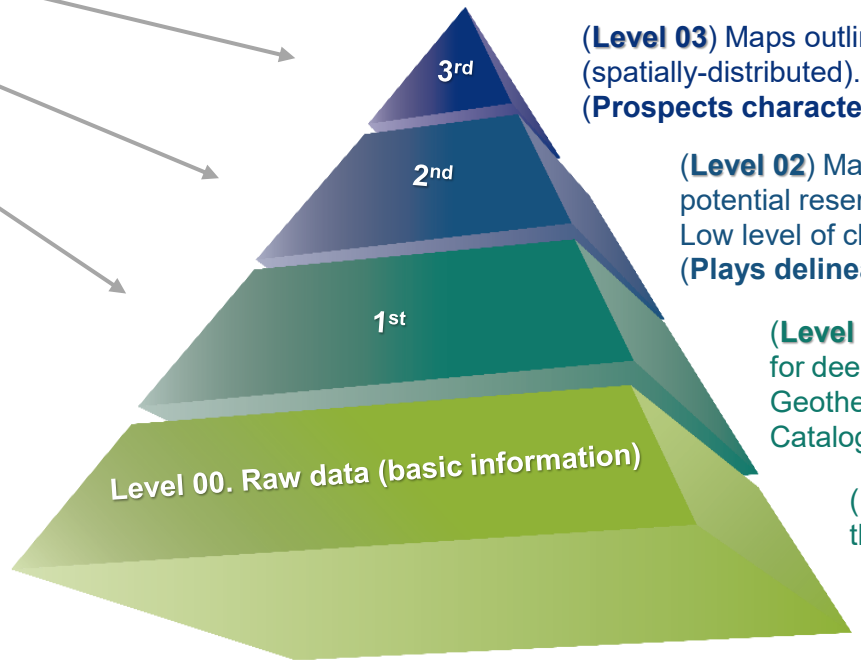
(2) Play focus
- Play level identification (basic characterization)
- Summary of play maps (basic spatial delimitation)
- Prospect selection

(3) Play level analysis in prospect area (local)
- Geophysical evaluation at prospect scale
- Geological (3D) model building
- Play execution activities

GSEU Pan-EU Atlas SGC (Deep Geothermal & MT/HT-ATES)

Concept based on Levels of knowledge

High knowledge / Low coverage



(**Level 03**) Maps outlining and assessing potential reservoirs (spatially-distributed). Medium-high level of characterization (**Prospects characterization at local scale**)

(**Level 02**) Map of global scale outlining and assessing potential reservoirs for geothermal and MT/HT-ATES. Low level of characterization + Catalogue Sheets (**Plays delineation and assessment)**

(**Level 01**) Map of favourable areas at EU scale for deep geothermal prospecting based on Geothermal Plays Types and MT/HT ATES + Catalogue Sheets (**GeoSystems Typing**)

(**Level 00**) Boreholes & wells, thermal spring water data

Low knowledge / High coverage

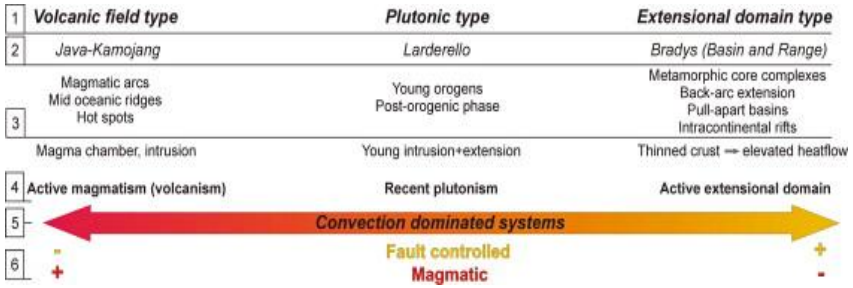
3. From the Play-based Exploration Pyramid concept to the GSEU approach for DG

GSEU Pan-EU Atlas SGC (Deep Geothermal & MT/HT-ATES)

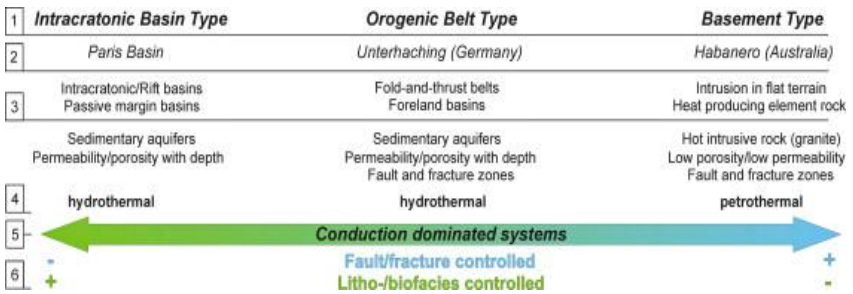
Classification of "Geothermal Plays Types"

(Moeck, 2014, 2015; Moeck et al., 2019)

Convection-Dominated Geothermal Plays (CV)

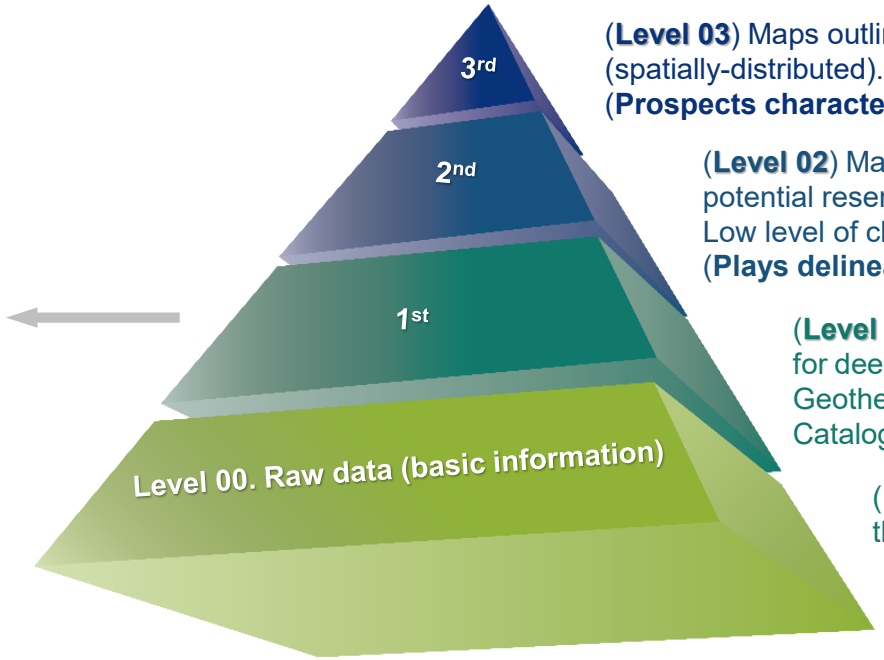


Conduction-Dominated Geothermal Plays (CD)



Concept based on Levels of knowledge

High knowledge / Low coverage



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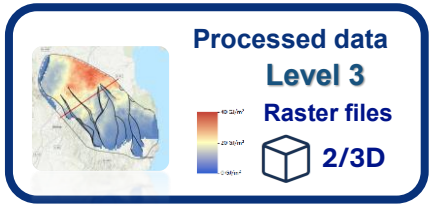
Low knowledge / High coverage

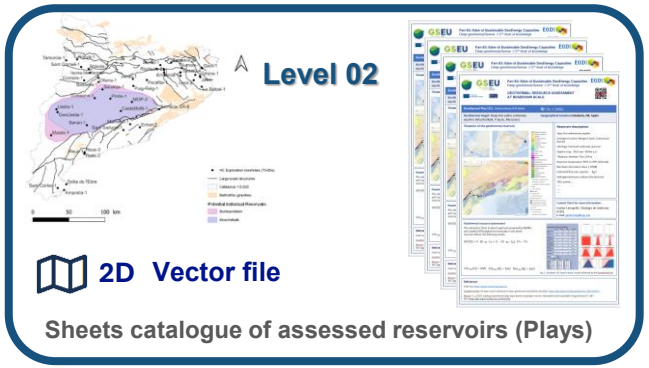
3. From the Play-based Exploration Pyramid concept to the GSEU approach for DG

GSEU Pan-EU Atlas SGC (Deep Geothermal & MT/HT-ATES)

Prospects
(at local scale)

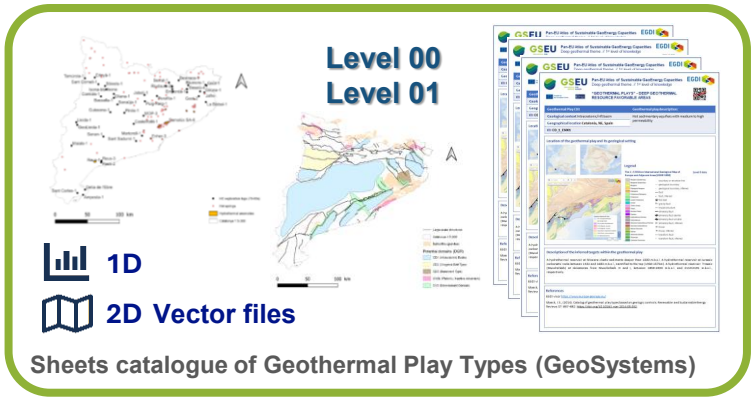


Plays
(reservoirs)



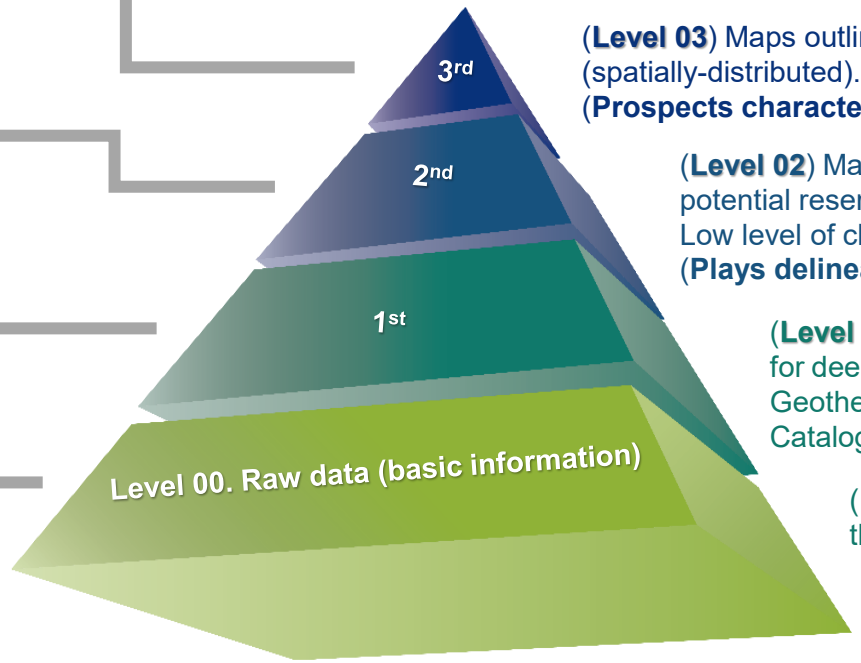
Boreholes & Thermal Springs

Geothermal Play Types regions



Concept based on Levels of knowledge

High knowledge / Low coverage



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(**Level 00**) Boreholes & wells, thermal spring water data

Low knowledge / High coverage

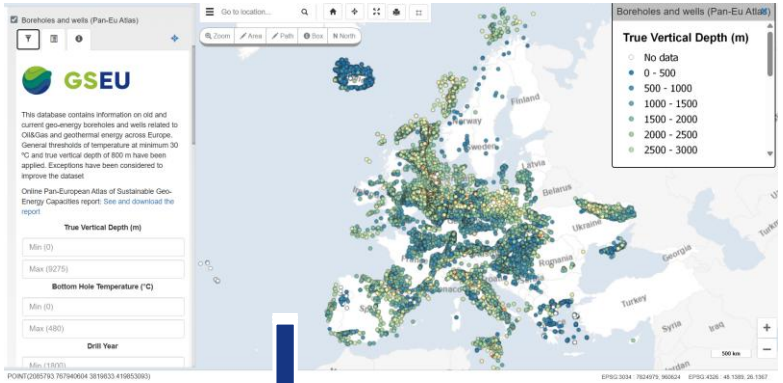
4. Pan-EU Atlas of SGC. Deep geothermal: Levels 00 and 01

Level 00

Boreholes and wells

(O&G, geothermal, mining, water resources…)

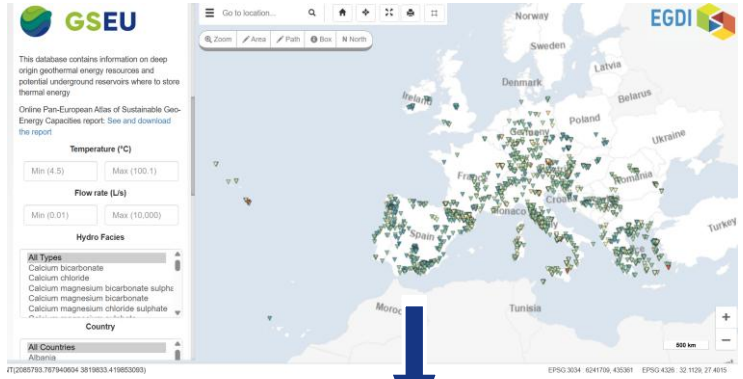
Data useful for Deep Geothermal and Geo Storage (CO_2, H_2, CAES, ATES) purposes



Attribute table

Thermal springs

(Natural outflow water 5ºC higher than the mean air annual temperature)

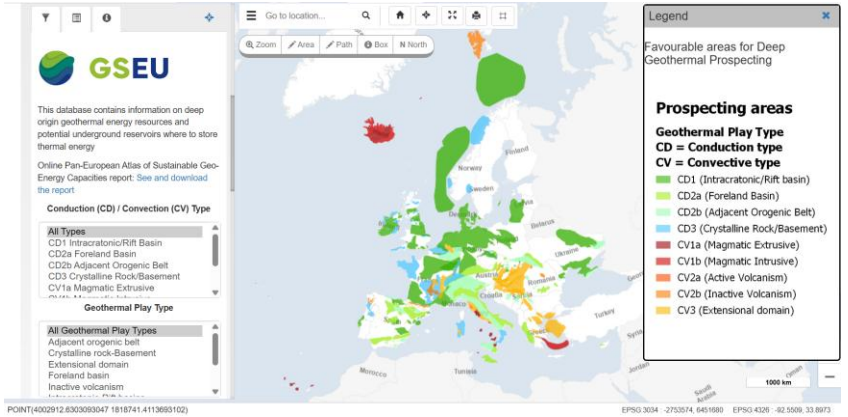


Attribute table

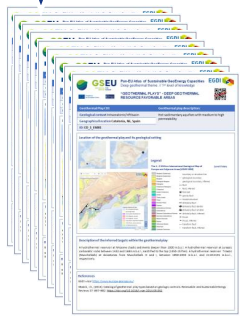
Level 01

Geothermal Plays Types at Pan-EU scale

(Favourable geological settings for geothermal exploration)



*Catalogue of accessible factsheets of **Geothermal Play Type** across EU containing the description*



Attribute table

4. Pan-EU Atlas of SGC. Deep geothermal: Levels 00 and 01

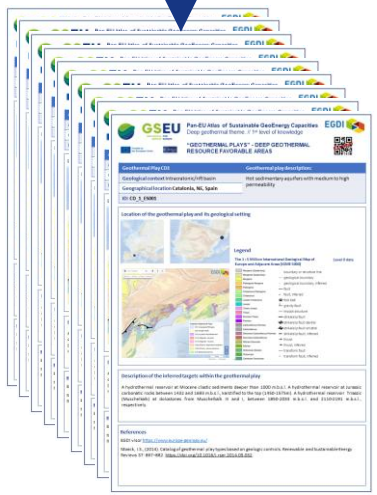
Version v1.0 Pan-EU Atlas (April 2025)

Version v2.0 Pan-EU Atlas (May 2026) **update!**

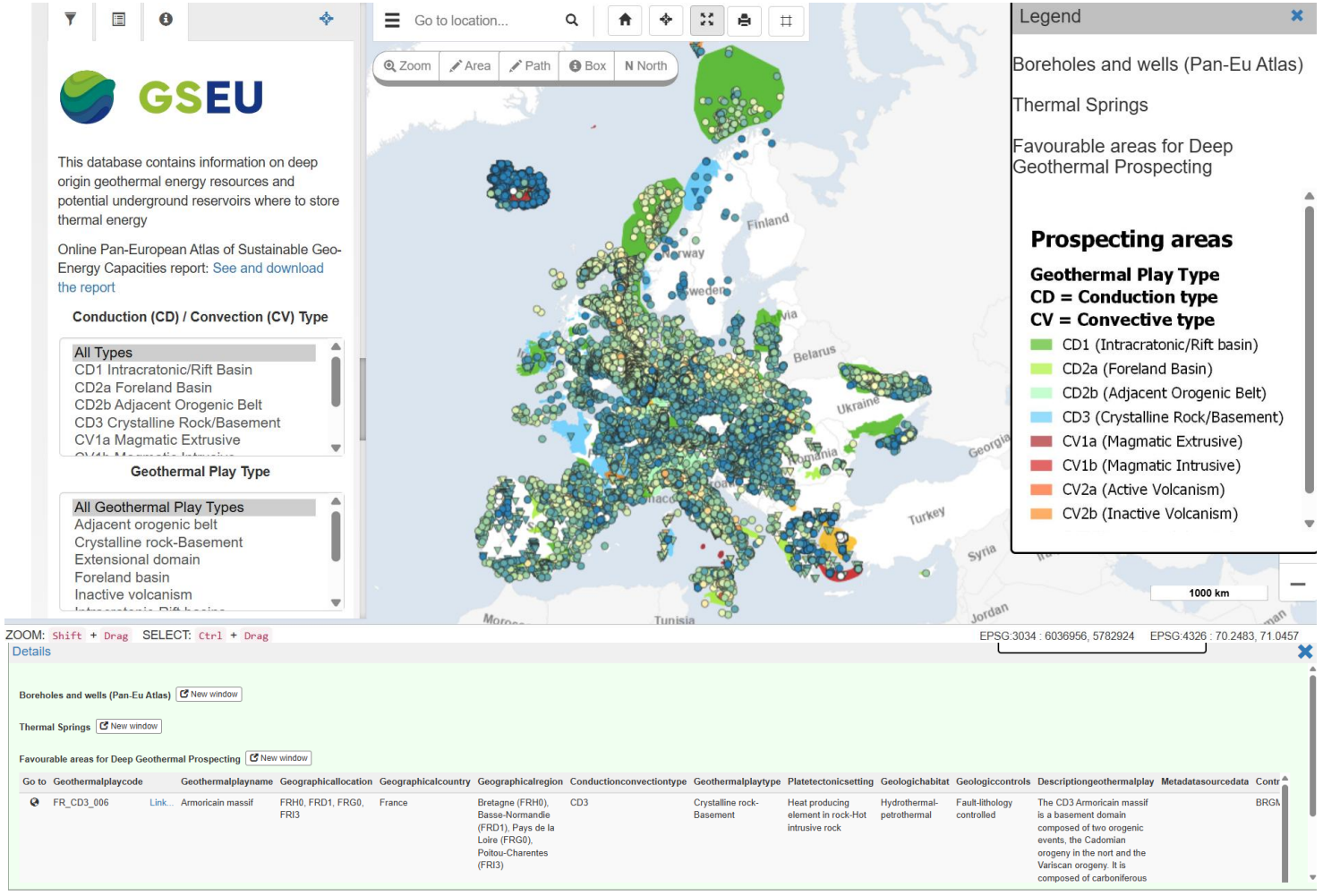
(Level 00) **Boreholes & wells, thermal spring water data**

55.117 boreholes &wells

(Level 01) **Map of favourable prospecting areas at EU scale + Catalogue Sheets**



376 SHEETS describing the "Geothermal Plays Types" across EU



https://maps.europe-geology.eu/

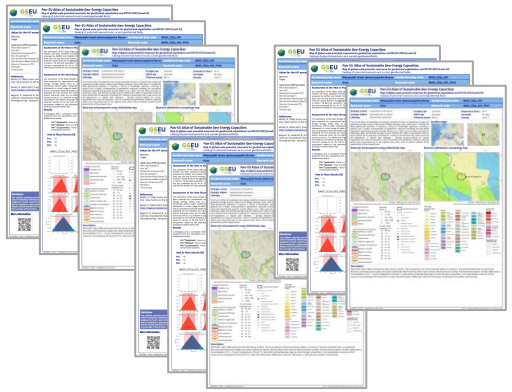
4. Pan-EU Atlas of SGC. Deep geothermal: Levels 02

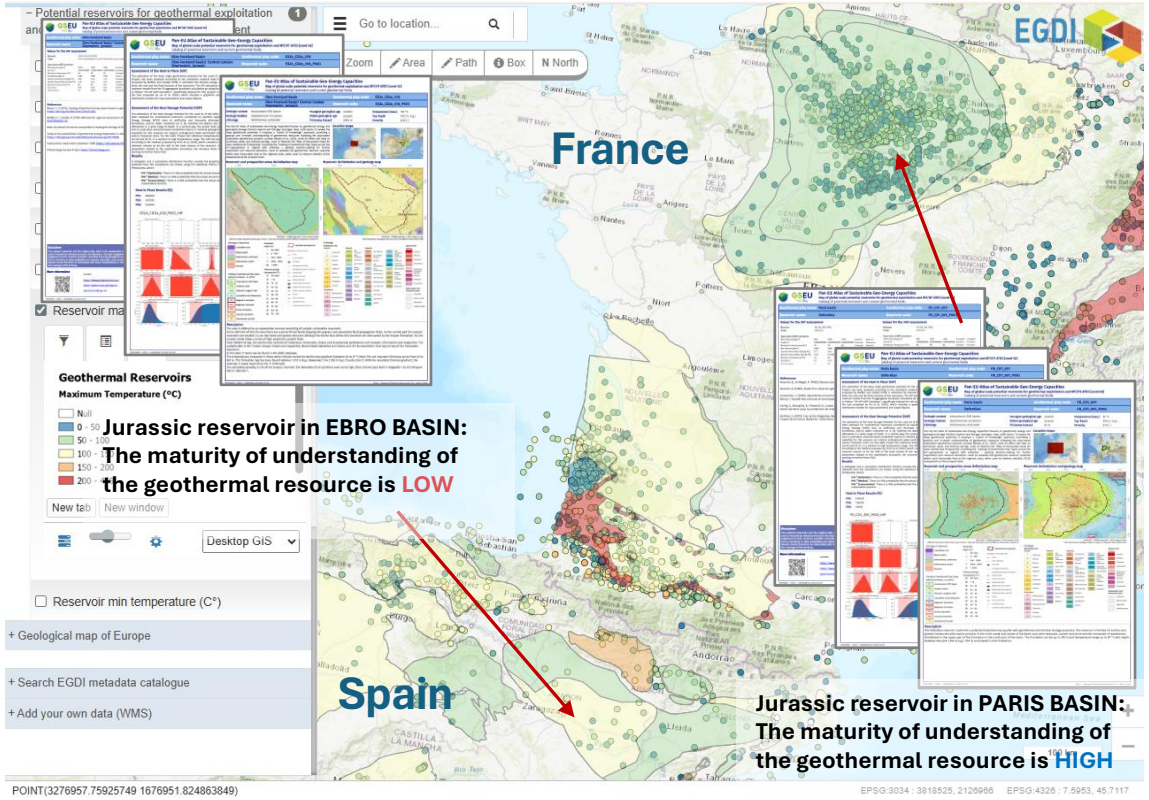
(Level 02) **Map of Identified and Broadly Assessed Potential Natural Reservoirs for Deep Geothermal Energy and MT/HT ATES across Europe** – v1.0 (May 2026).

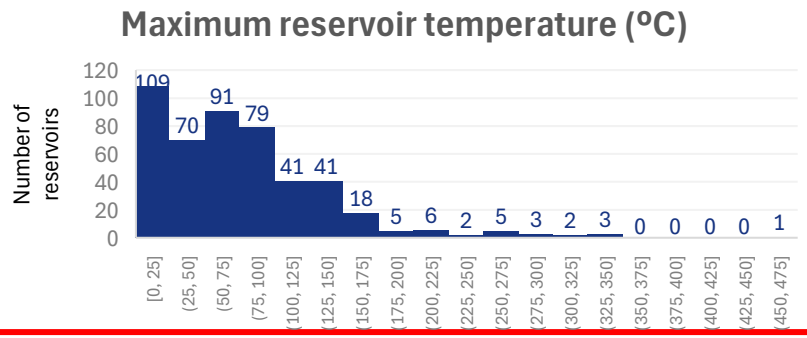
- 540 geothermal reservoirs identified across the European Union (v1.0); further expansion planned.
- 358 reservoirs (66%) assessed using HIP and HSP methodologies.
- Mapped attributes: max/min temperature, top/bottom depth, max/min thickness, average porosity, and lithology.
- Downloadable 3–4-page factsheets with maps, assessments, and references.

https://maps.europe-geology.eu/

540 SHEETS describing the "Broadly Assessed Potential Natural Reservoirs for Deep Geothermal Energy and MT/HT ATES " across EU





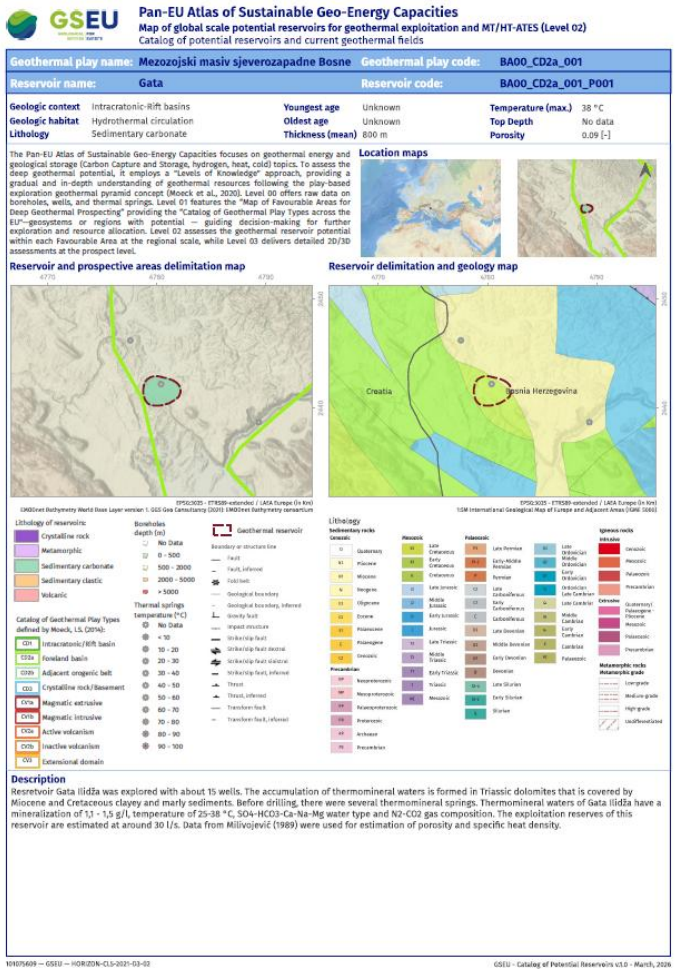


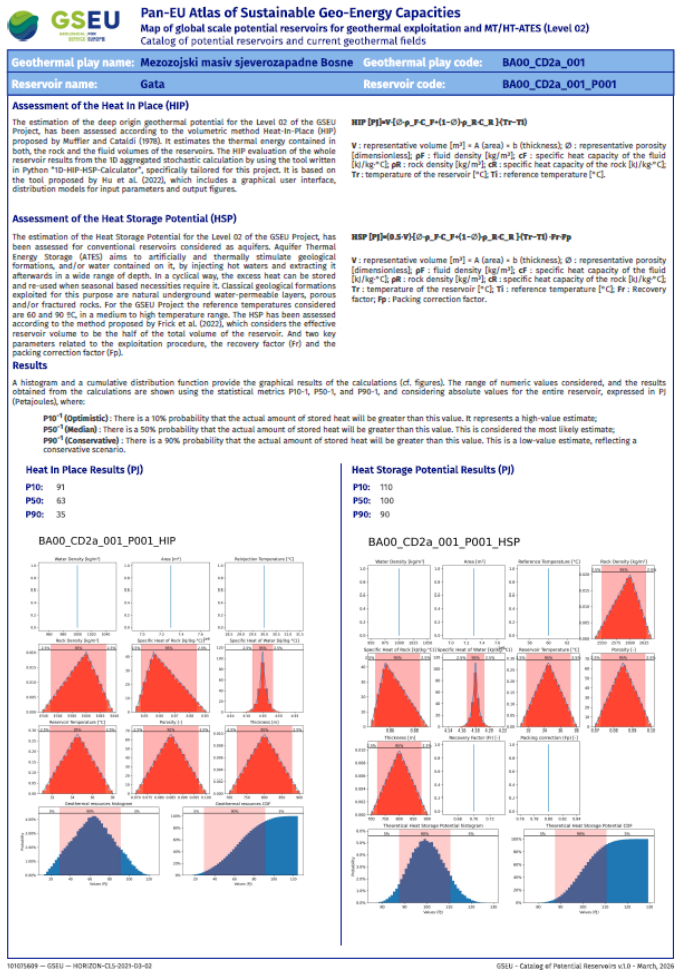
Histograms for attributes

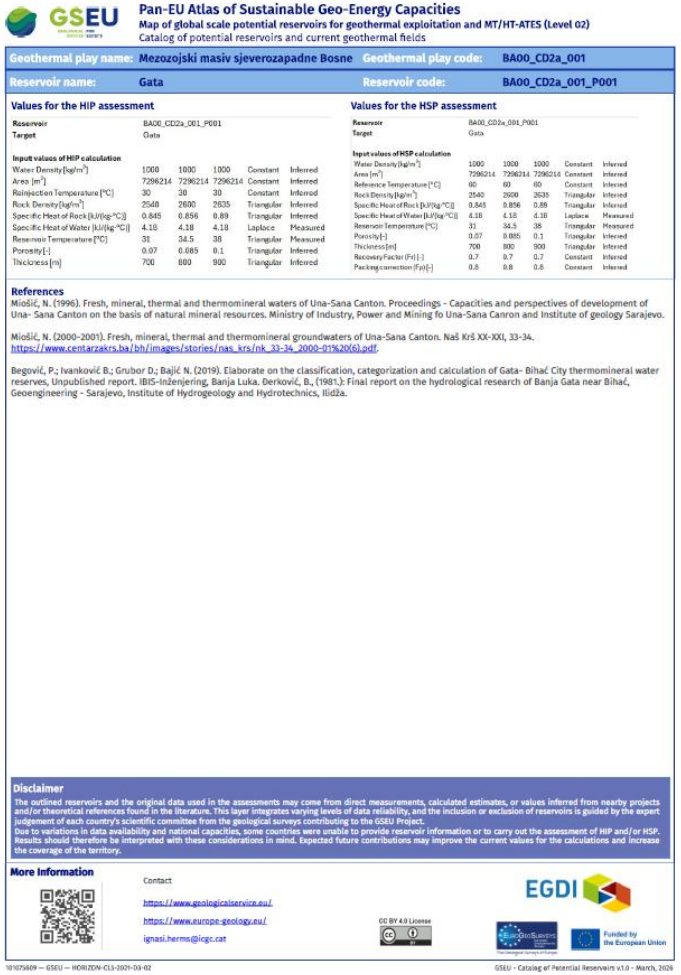
4. Pan-EU Atlas of SGC. Deep geothermal: Levels 02

Downloadable 3 - 4-page factsheets with maps, assessments, and references.

540 SHEETS describing the "Broadly Assessed Potential Natural Reservoirs for Deep Geothermal Energy and MT/HT ATES " across EU



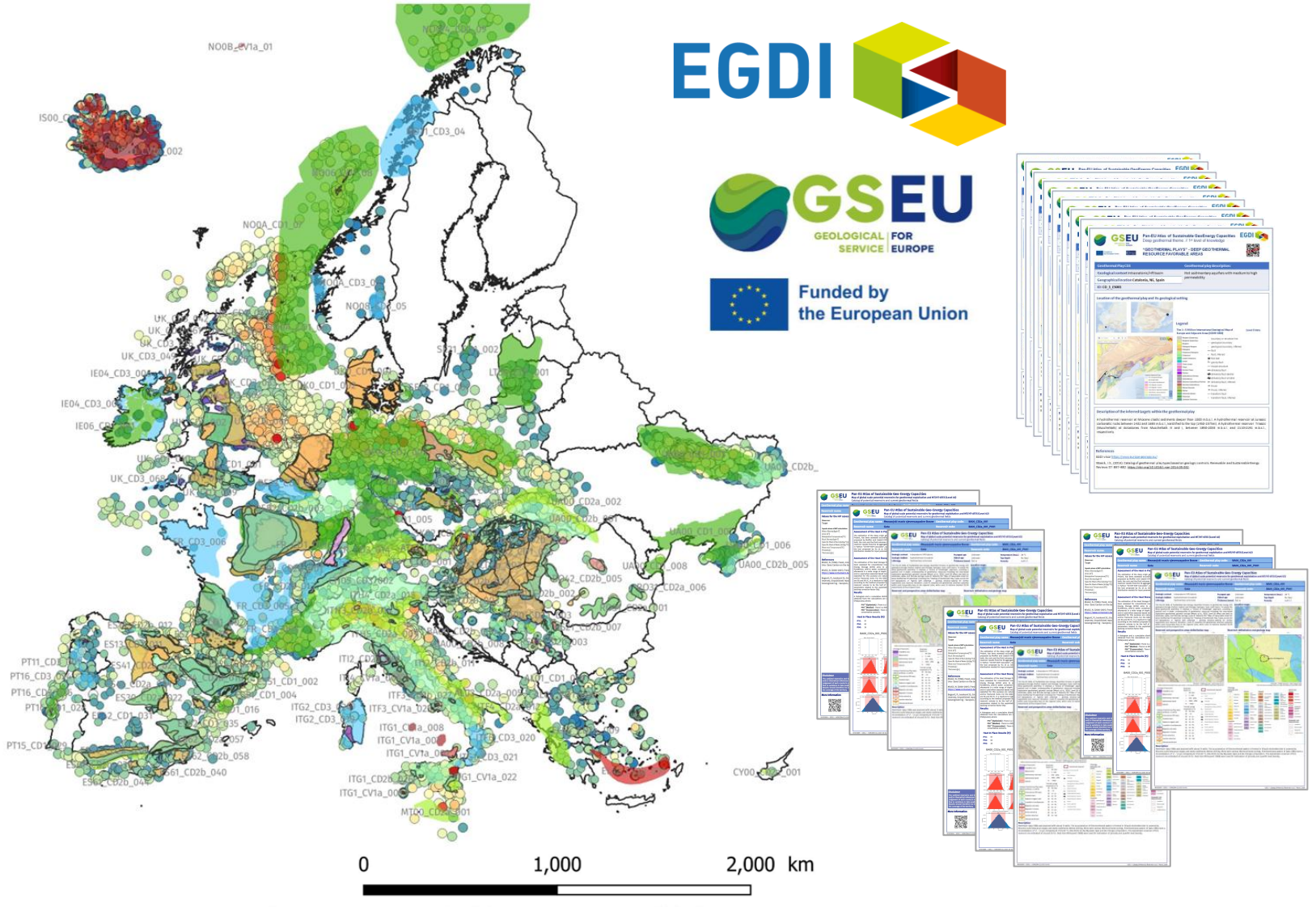




4. Pan-EU Atlas of SGC. Deep geothermal

The GSEU's PanEU-Atlas of SGC provide information and knowledge in a standardized and harmonized way at EU level, so it will support the dissemination, the awareness and the development of Europe's geothermal energy sector

https://maps.europe-geology.eu/



5. The role of geological surveys in geothermal development

The EuroGeoSurveys ten-year SRIA

It focusses on geoscientific data, information, and knowledge of the subsurface to address EU and global challenges

Develop and deliver geological data and expertise to support national authorities in transitioning from petroleum exploration and production to **deploying renewable energy** (e.g., geothermal, geological storage capacities for hydrogen, compressed air, heat and cold and CO_2)

Develop public databases and atlases indicating harmonized cross-border potential for renewable technologies at European scale. **Collaboration** under the HE GSEU project

Support capacity building, scientific networking, and joint responses to EU and interregional calls for project proposals. Collaboration through pan-European expert groups (including CO2GeoNet, ZEP, EERA CCS JP, and EuroGeoSurveys Geoenergy Expert Group)

GOAL: Energy Transition & Decarbonization

- Priority ETD1 – Develop and deploy "Pan-EU Information and Decision Support Systems" to accelerate deployment of geothermal systems; with different topics

  - Fit-for-purpose digital geological data, for techno-economical evaluations, for de-risking schemes, etc.

EU Geothermal Action Plan

6. **Why** is the information and knowledge on these issues important for Europe?

European Parliament

EU Parliament resolution (01/2024)

EU Council conclusions (12/2024)

European Commission

Geothermal Action Plan

8 Key Pillars:

- Target
- Finance
- Permitting
- Value Chain
- **Data Availability**
- Planning
- Flagship initiatives
- Industrial Alliance

EuroGeoSurveys — The Geological Surveys of Europe

Long-term establishment of a Geological Service for Europe (GSE)

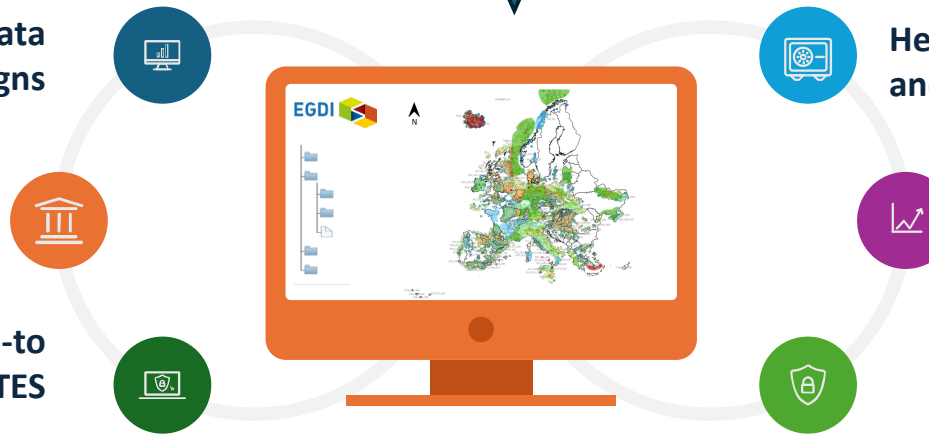
GSE

Through the **European Geological Data Infrastructure** (EGDI) platform, geological data, assessed information and subsurface predictive models will be centralized and available.

Mapping global- scale resource-potential areas to new data acquisition through targeted exploration campaigns

Information for decision-making aid to formulate supportive policies and streamlining permitting procedures

Identification renewables 'go-to areas' for geothermal and UTES



Helping planning for heating and cooling and investing for power generation projects

To underpin risk-schemes mitigation strategies

To geographically assist technological adaptation based on potential

Integration and harmonised subsurface data and expertise
pan-European geothermal information system

7. The PanEU Atlas of SGC in the framework of the new “AccelerateEU Plan”

The key role of the GSEU geothermal DDBB

- The European Commission launched the **AccelerateEU Plan** on 22 April 2026, recognizing geothermal energy as essential for EU energy security, economic resilience, and climate action
- The plan highlights geothermal energy as a versatile renewable source for electricity, heating, and cooling that can replace imported fossil fuels with clean and affordable energy
- The **AccelerateEU Plan** outlines a series of measures that, among them: ***creating an EU-level database of geological data*** focused to speed-up the deployment of geothermal energy projects across the whole of the EU

- This underlines the strategic importance of the **Pan-EU Atlas of GSEU database** structure and the need to secure its long-term maintenance, together with its continuous enrichment with new data

GSEU GEOLOGICAL SERVICE FOR EUROPE

8. Summary

The **GSEU project:**

- Creates the base structure for the **Pan-European Atlas for Sustainable GeoEnergy Capacities**. The deep geothermal part It is based on an adapted Play-based Explorarion pyramid concepts.
- The **Pan EU Atlas for SGC** published into EGDI complements, expand and update the coverage provided by previous EU projects, whose geographic scope was only partial, or the data are not updated and was not harmonized.
- It will be further developed in the future within the framework of a permanent **Geological Survey for Europe**, **incorporating also information from other relevant past EU-funded R+I projects**
- The broader vision is for EGDI to become the European reference infrastructure for geothermal data sharing and preservation, supporting geothermal deployment through harmonized and standarized datasets, improved subsurface knowledge, and pan-European information and decision-support services developed together with the European geothermal community, a *European Investment Opportunities Atlas for Geothermal Energy*

Thank you for your attention!

Dr. Ignasi Herms

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EuroGeoSurveys

Head of the Area of Geological Resources
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EuroGeoSurveys European Geoscience for Society
The Geological Surveys of Europe