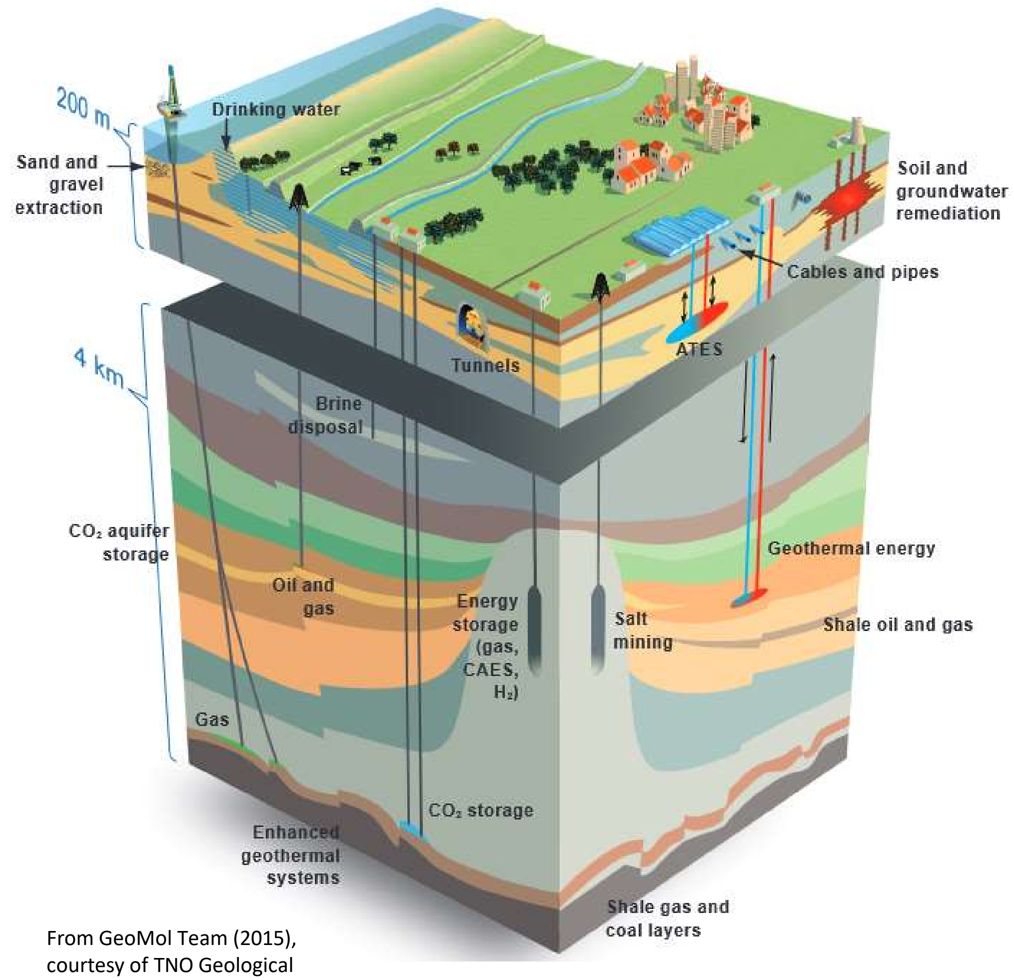
# Unveiling Deep Geothermal Plays in Europe




From GeoMol Team (2015), courtesy of TNO Geological Survey of The Netherlands

**Shallow geothermal** MUSE

**Deep geothermal** HotLime GeoERA

## Mapping and Assessment of Geothermal Plays in Deep Carbonate Rocks

**jointly implemented by:**

Bayerisches Landesamt für Umwelt; HGI Hrvatski Geološki Institut Croatian Geological Survey; Geological Survey Ireland; ISPRA; GeoZS Geološki zavod Slovenije; ICGC Institut Cartogràfic i Geològic de Catalunya; Regione Emilia-Romagna; TNO innovation for life; Baden-Württemberg Regierungspräsidium Freiburg; Czech Geological Survey; gov.mt; Geologische Bundesanstalt; Regione Umbria; vito vision on technology; Arpa Piemonte

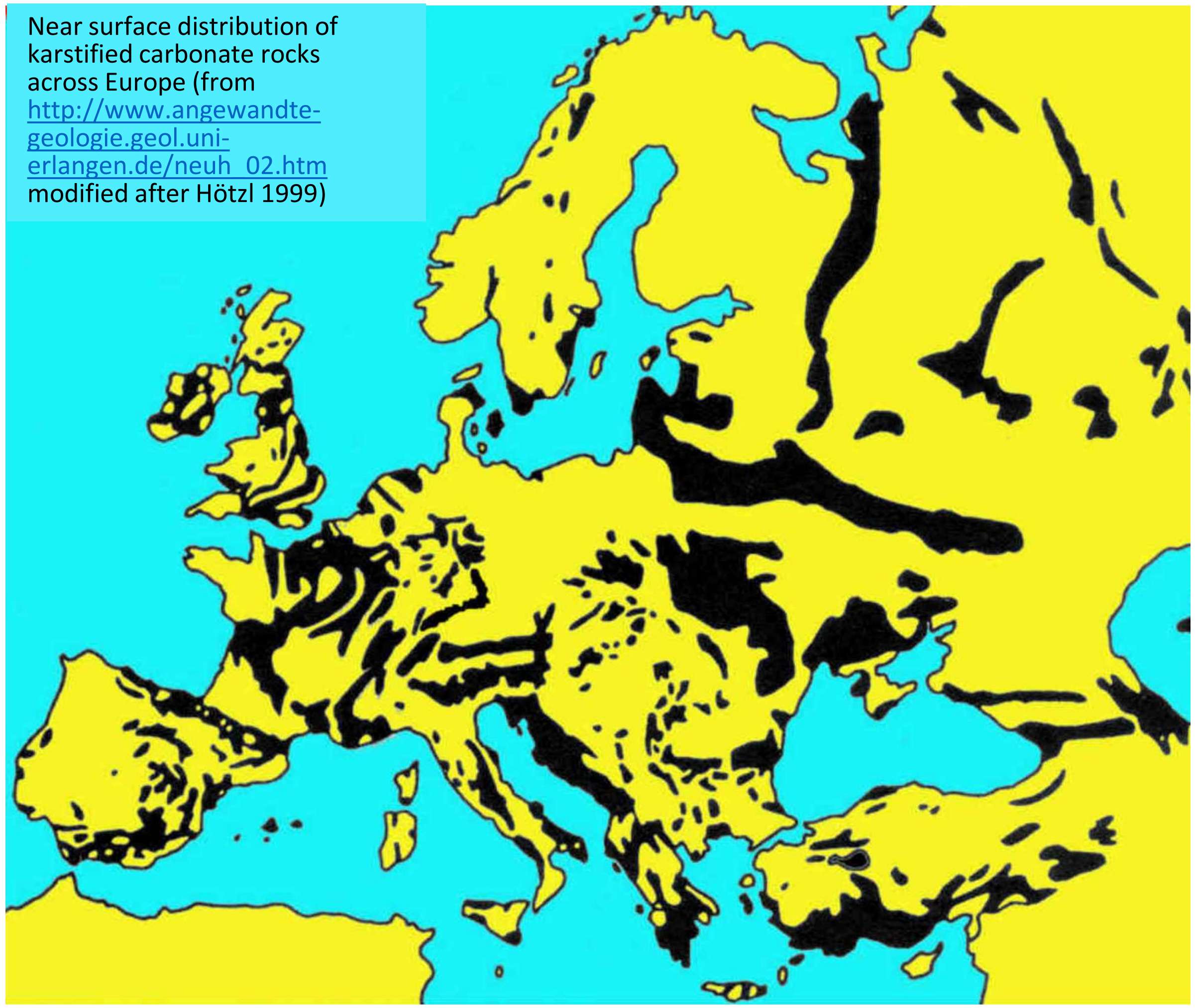
**Presented by Gerold Diepolder (former Project Lead)**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731166

# Mapping and Assessment of Geothermal Plays in Deep Carbonate Rocks

## Rationale

- Exploration and development of the deep subsurface is an acknowledged high-risk investment, particularly in low-enthalpy systems, which require drilling to depths of more than 3 km.
- Carbonate rocks are the most prevalent geothermal aquifers of low-enthalpy systems.
- Across Europe most deep carbonate bedrock has received relatively little attention, because deep carbonate rocks are perceived as 'tight'.
- To de-risk their geothermal exploration requires to improve our understanding of generic geological controls that determine the distribution and technical recoverability of the potential resources.



Near surface distribution of karstified carbonate rocks across Europe (from http://www.angewandte-geologie.geol.uni-erlangen.de/neuh_02.htm modified after Hötzl 1999)

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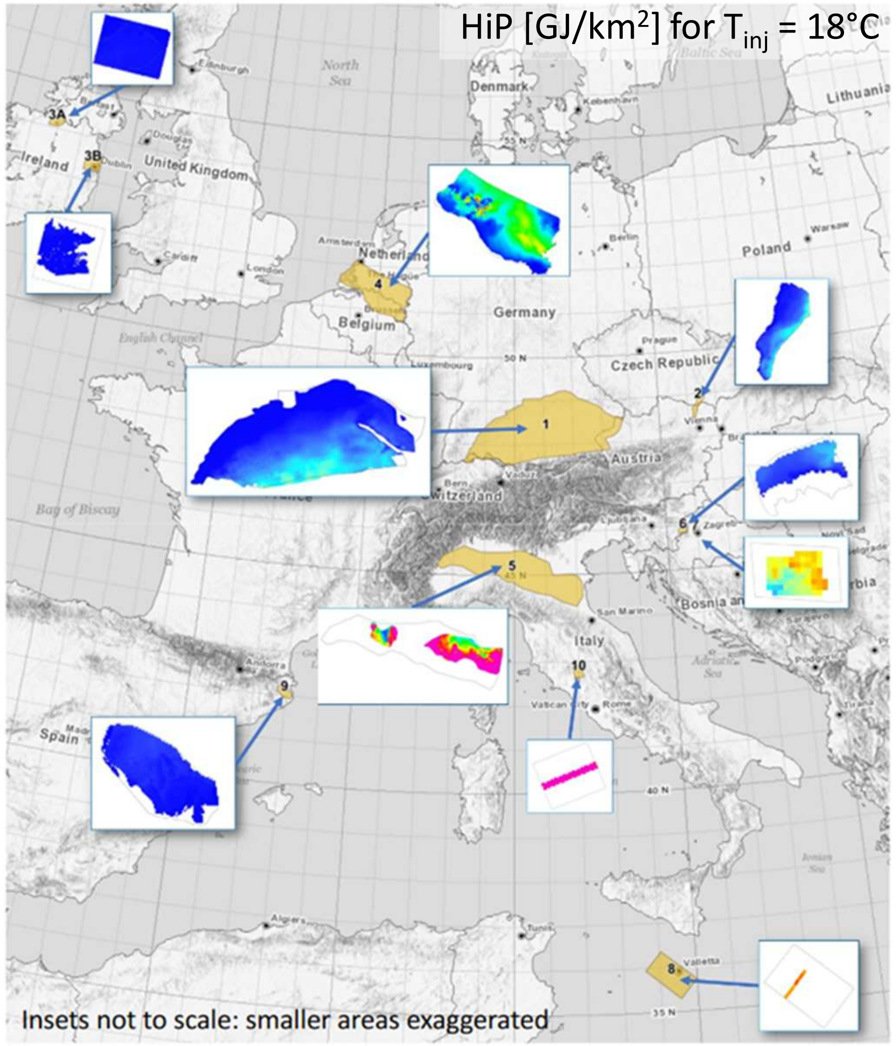
# Mapping and Assessment of Geothermal Plays in Deep Carbonate Rocks


Few hard data at great depth. Need of

- **C**ross-fertilization: sharing knowledge and experience
- **C**omparison of well-investigated and underexplored areas
- **C**onsistent characterization and assessment using **c**ommon parameters
- **C**oherent best practice applicable in all areas

➢ **C**onsistent representation for easy comparability of results

➢ Collation and **c**ombination of results for a comprehensive knowledge base beneficial also beyond the 11 Case Study Areas

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# Geothermal base assessment: Heat in Place

Consistent assessment using common parameters - Coherent best practice applicable in all areas

Volumetric Heat in Place (HIP) developed by the United States Geological survey (USGS) and reported by Muffler & Cataldi (1978) and later revisions and reformulations (e.g. Garg & Combs 2010, 2011, 2015)

$$HIP\,[GJ] = \underbrace{h \cdot A}_{\text{volume}} \cdot \underbrace{(T_{prod} - T_{inj})}_{\text{productive temp interval}} \underbrace{[(1 - \Phi)\, c_{pr} \cdot \rho_r + \Phi \cdot c_{pw} \cdot \rho_w]}_{\text{mean reservoir properties: matrix / pore ratio} \times \text{physical properties}}$$

**Basic reservoir parameters:**

- Extension and thickness
- Temperature distribution
- Formation permeabilty
- Rock properties

**Available from:**

Extension and thickness, Temperature distribution: WP2: Mapping and characterization

Formation permeabilty, Rock properties: Mainly literature values (few measurements)

**Applied for two $T_{inj}$:**

18°C mean ambient +10°C (Limberger et al. 2018)

50°C usual re-injection T after power production

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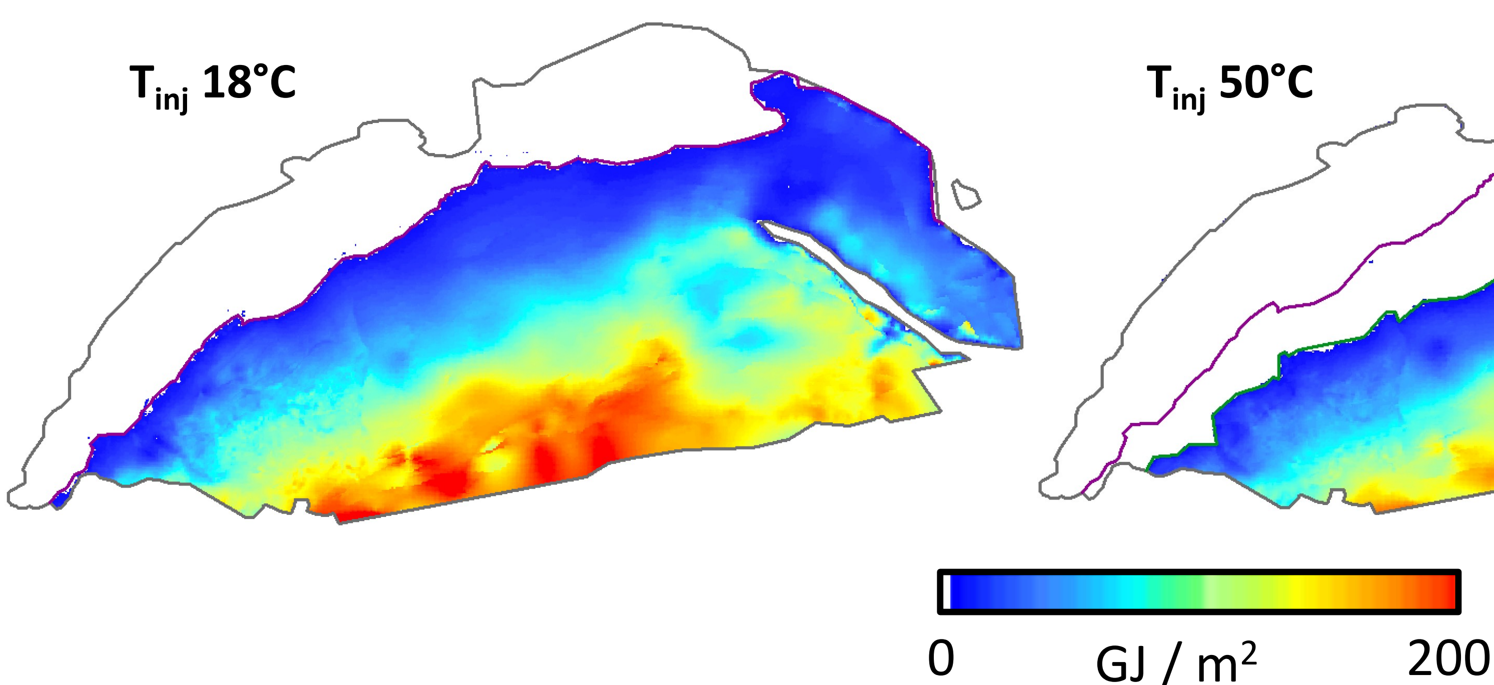
# Geothermal base assessment: Heat in Place

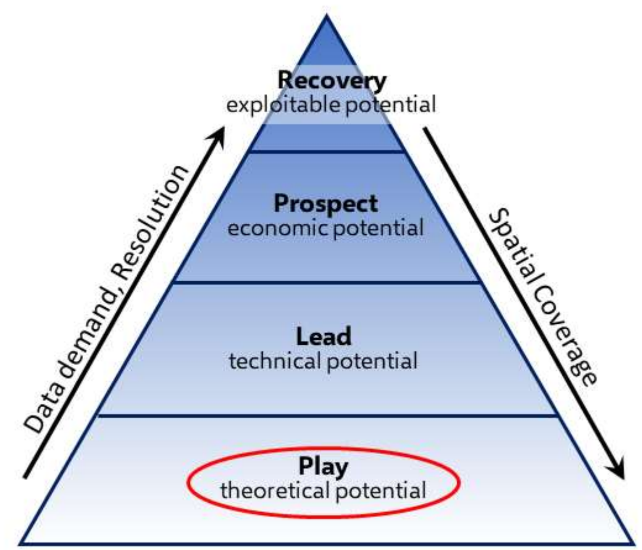



$HIP_{18}$ (~35,000 km²) ≥ **2,000,000 PJ**

(disregarding fault zones that represent the anisotropic secondary porosity of the reservoir, commonly not well enough constrained for the quantitative consideration of their higher HIP, but shown qualitatively through the fault overlay)

Total energy consumption of Germany in 2018 = **13,106 PJ** (BMWi 2019)

HIP is the **maximum theoretically extractable heat energy** in the reservoir

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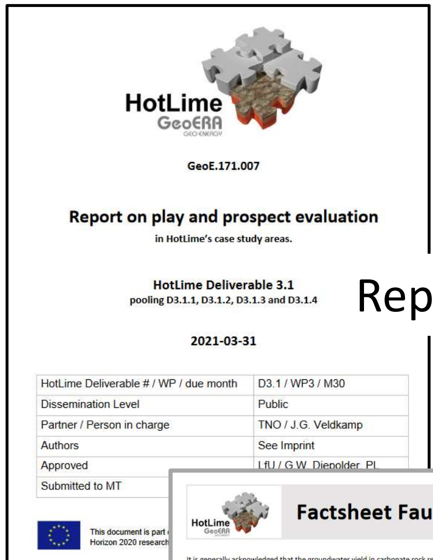
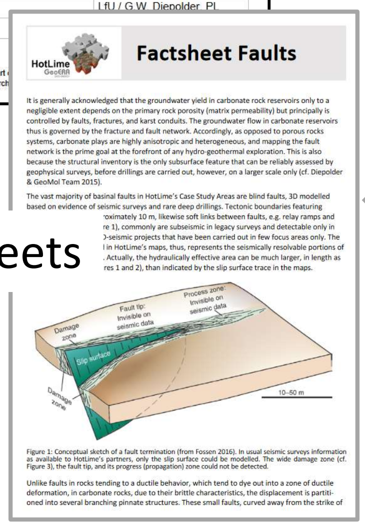
# Unveiling Deep Geothermal Plays in Europe

## The HotLime Geothermal Atlas – the all-in-one hyperlinked synopsis of HotLime's results & more

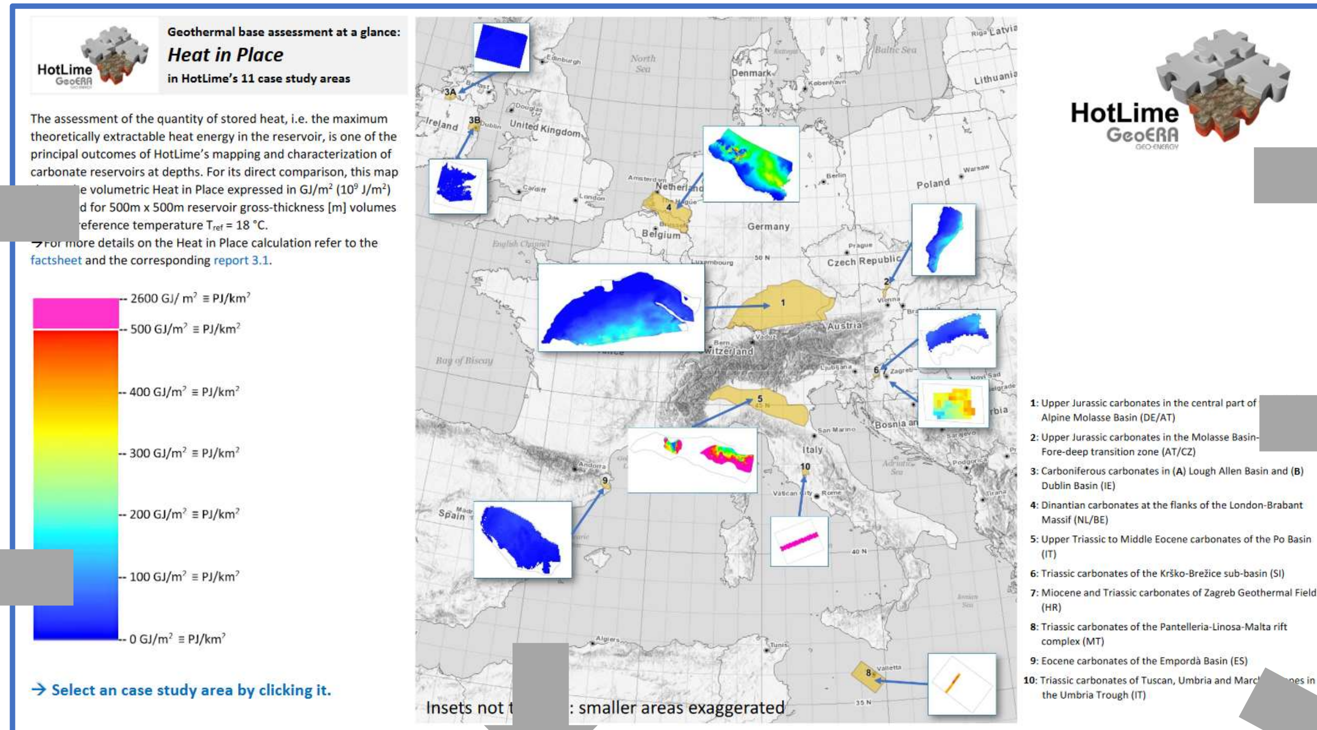
https://repository.europe-geology.eu/egdidocs/hotlime/hotlime_geothermal_atlas.pdf




Reports

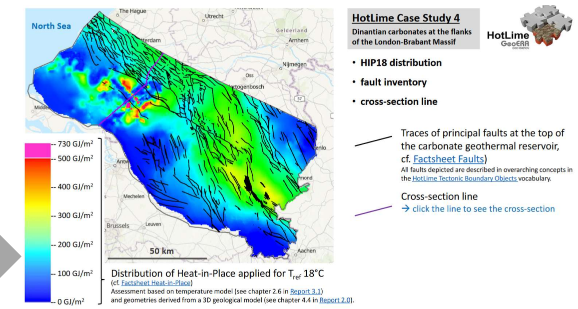



Factsheets

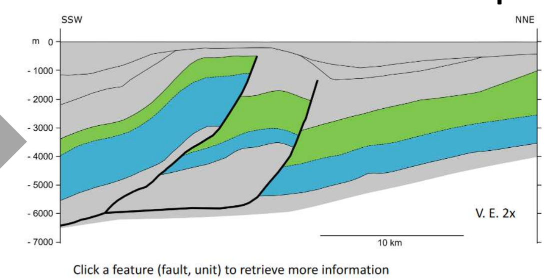



Map layers in EGDI GIS Viewer

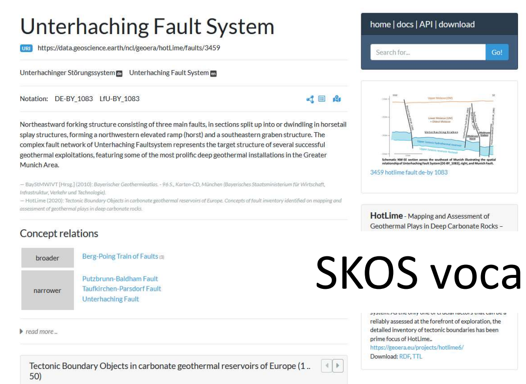
Metadata in EGDI Metadata Catalogue




Various thematic maps




Cross-sections




SKOS vocabs

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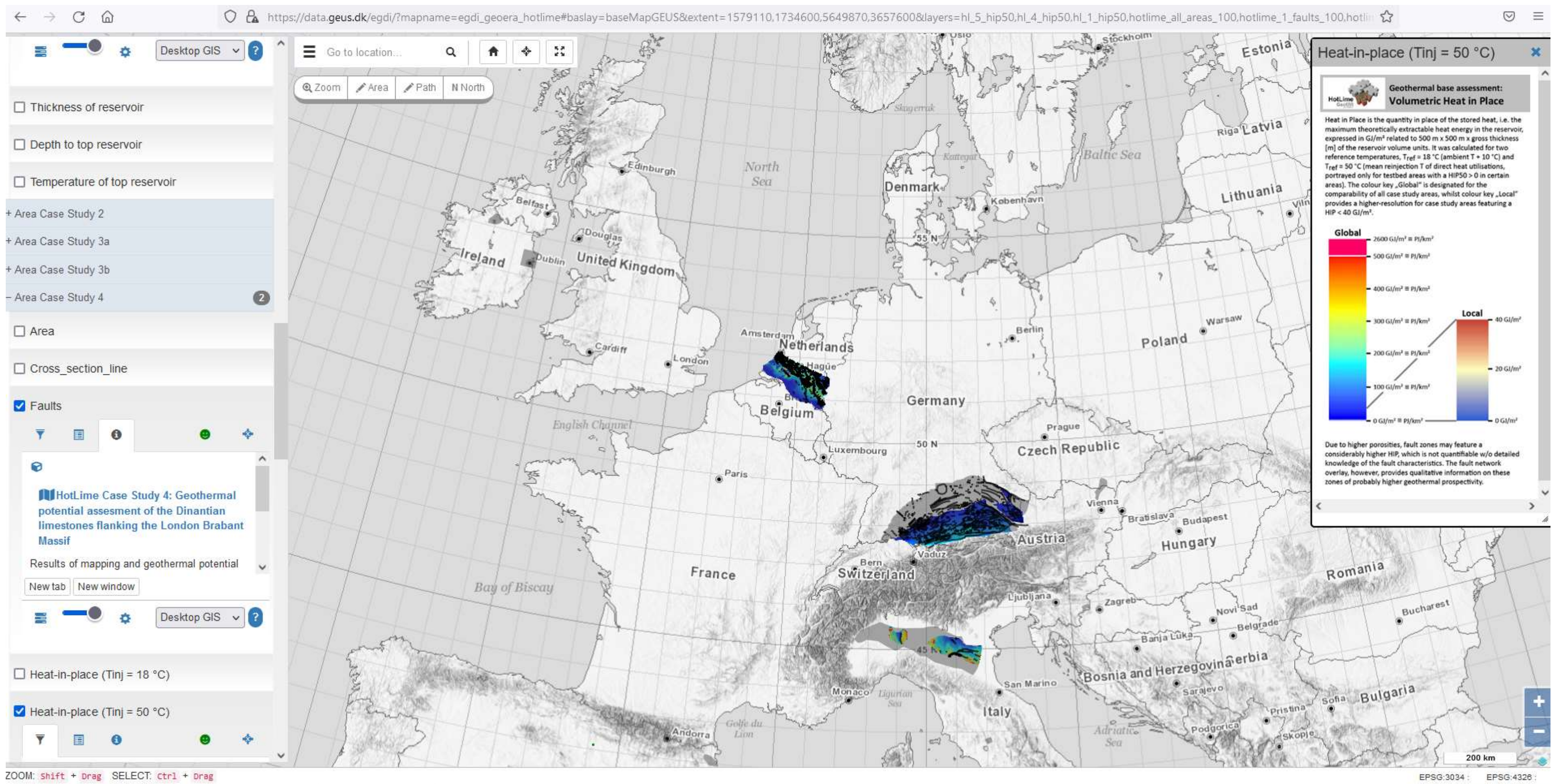
# Unveiling Deep Geothermal Plays in Europe

## The HotLime GIS Viewer as part of EGDI

All spatial information of the HotLime Geothermal Atlas as georeferenced map layers

- downloadable,
- combinable,
- underpinned by vocabs & metadata.




Explore all HotLime products under [https://geoera.eu/projects/hotlime6/](https://geoera.eu/projects/hotlime6/)

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