

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

Shallow geothermal



Deep geothermal



Mapping and Assessment of Geothermal Plays in Deep Carbonate Rocks

jointly implemented by:

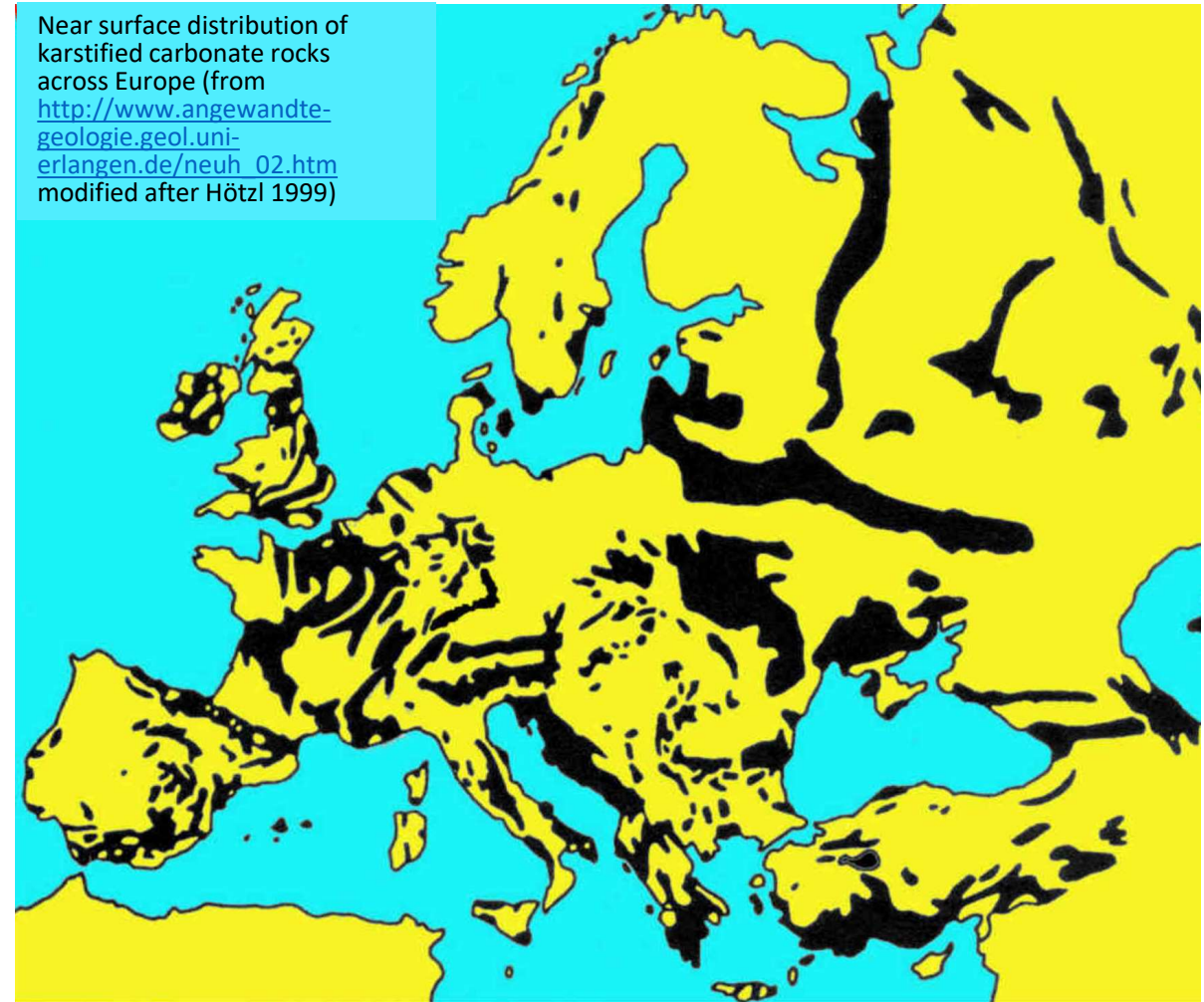


Presented by Gerold Diepolder (former Project Lead)

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.

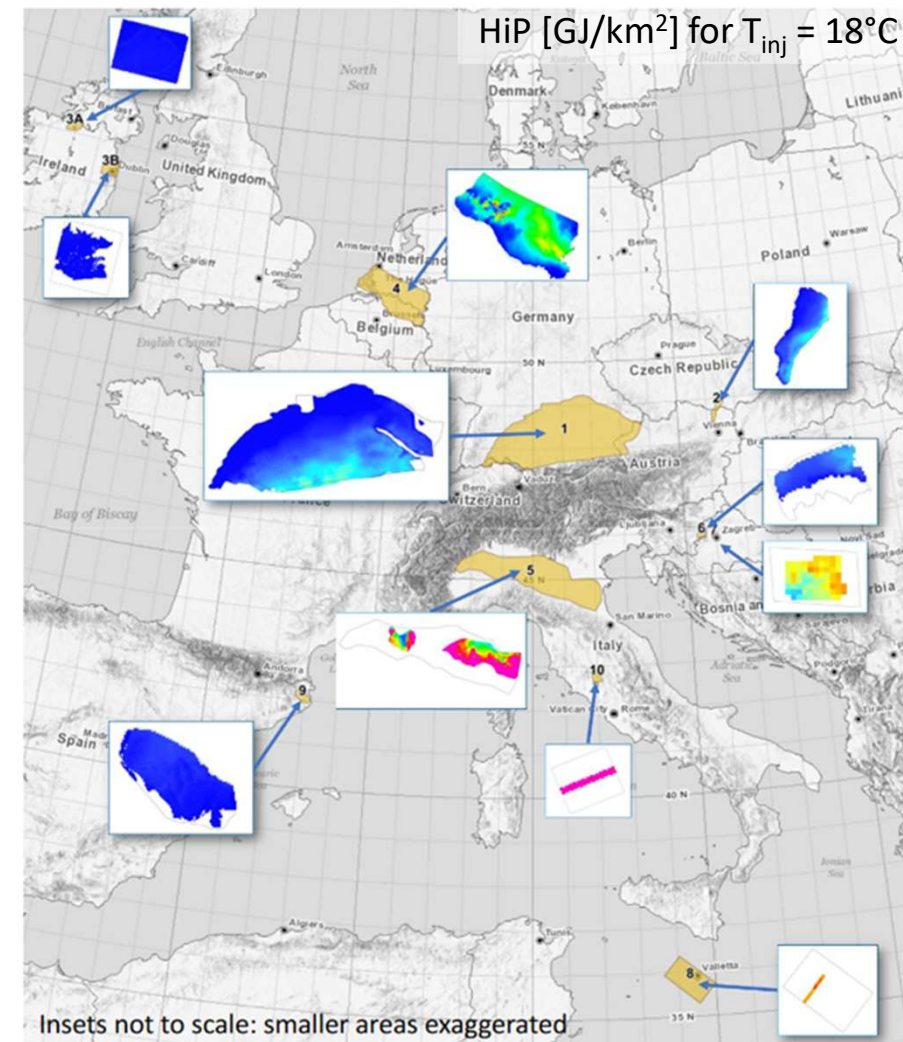


Mapping and Assessment of Geothermal Plays in Deep Carbonate Rocks



Few hard data at great depth. Need of

- **Cross-fertilization:** sharing knowledge and experience
- **Comparison** of well-investigated and underexplored areas
- **Consistent** characterization and assessment using common parameters
- **Coherent** best practice applicable in all areas
- **Consistent** representation for easy comparability of results
- **Collation and combination** of results for a comprehensive knowledge base beneficial also beyond the 11 Case Study Areas



Insets not to scale: smaller areas exaggerated

Unveiling Deep Geothermal Plays in Europe

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)

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

Basic reservoir parameters:

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

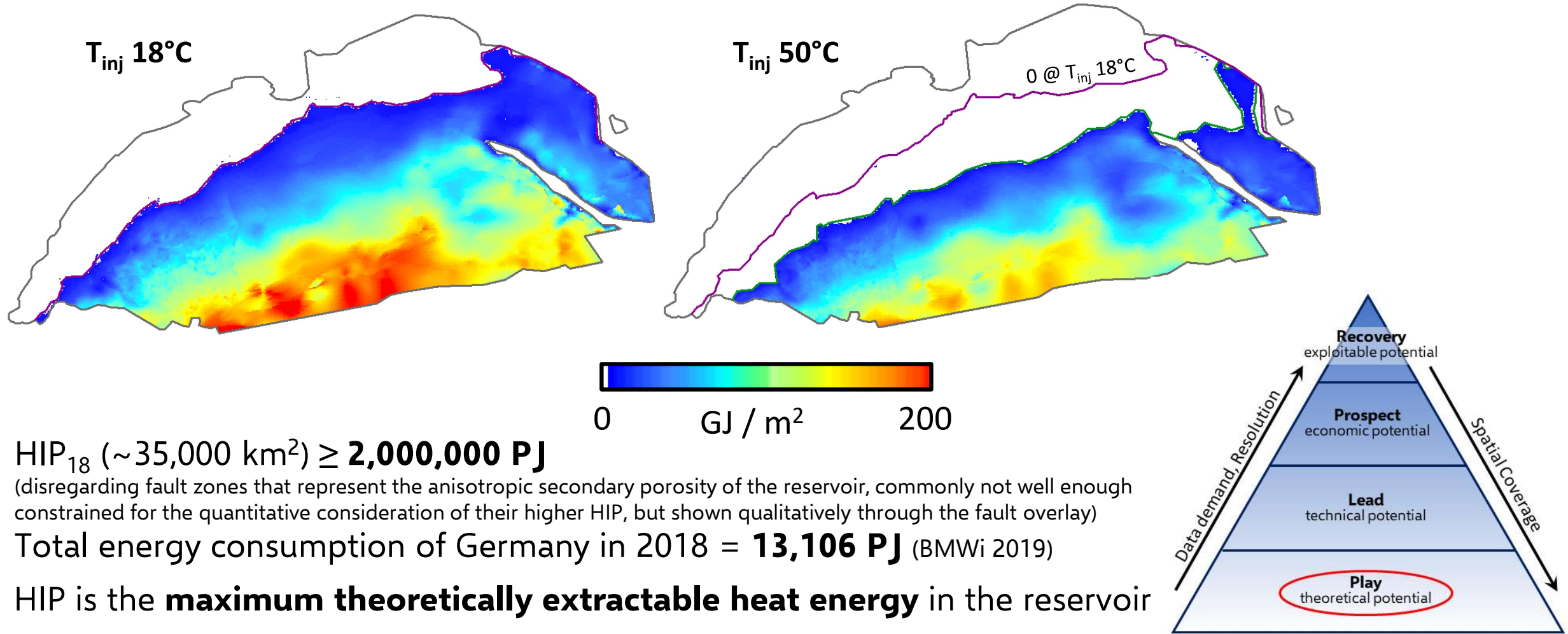
Available from:

- WP2: Mapping and characterization
- 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

Geothermal base assessment: Heat in Place



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



GeoE.171.007

Report on play and prospect evaluation
in HotLime's case study areas.

HotLime Deliverable 3.1
pooling D3.1.1, D3.1.2, D3.1.3 and D3.1.4

2021-03-31

HotLime Deliverable # / WP / due month	D3.1 / WP3 / M30
Dissemination Level	Public
Partner / Person in charge	TNO / J. G. Veldkamp
Authors	See Imprint
Approved	TNO / G. W. Diepolder, PI
Submitted to MT	

Factsheet Faults

It is generally acknowledged that the groundwater yield in carbonate rock reservoirs only to a negligible extent depends on the primary rock porosity (matrix permeability) but principally is controlled by faults, fractures, and karst conduits. The groundwater flow in carbonate reservoirs thus is governed by the fracture and fault network. Accordingly, as opposed to porous rocks systems, carbonate plays are highly anisotropic and heterogeneous, and mapping the fault network is the prime goal at the forefront of any hydrogeothermal exploration. This is also because the structural inventory is the only subsurface feature that can be reliably assessed by geophysical surveys, before drillings are carried out; however, on a larger scale only (cf. Diepolder & GeoERA Team 2015).

The vast majority of basin faults in HotLime's Case Study Areas are blind faults, 3D modelled based on evidence of seismic surveys and rare deep drillings. Tectonic boundaries featuring westerly 10 m, likewise soft links between faults, e.g. relay ramps and < 1% commonly are subseismic in legacy surveys and detectable only in seismic projects that have been carried out in few focus areas only. The in HotLime's maps, thus, represents the seismically resolvable portions of. Actually, the hydraulically effective area can be much larger, in length as res 1 and 2), than indicated by the slip surface trace in the maps.

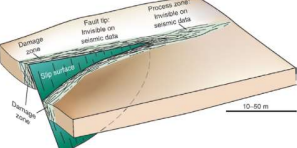
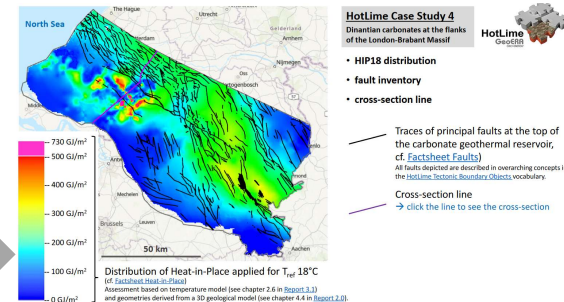
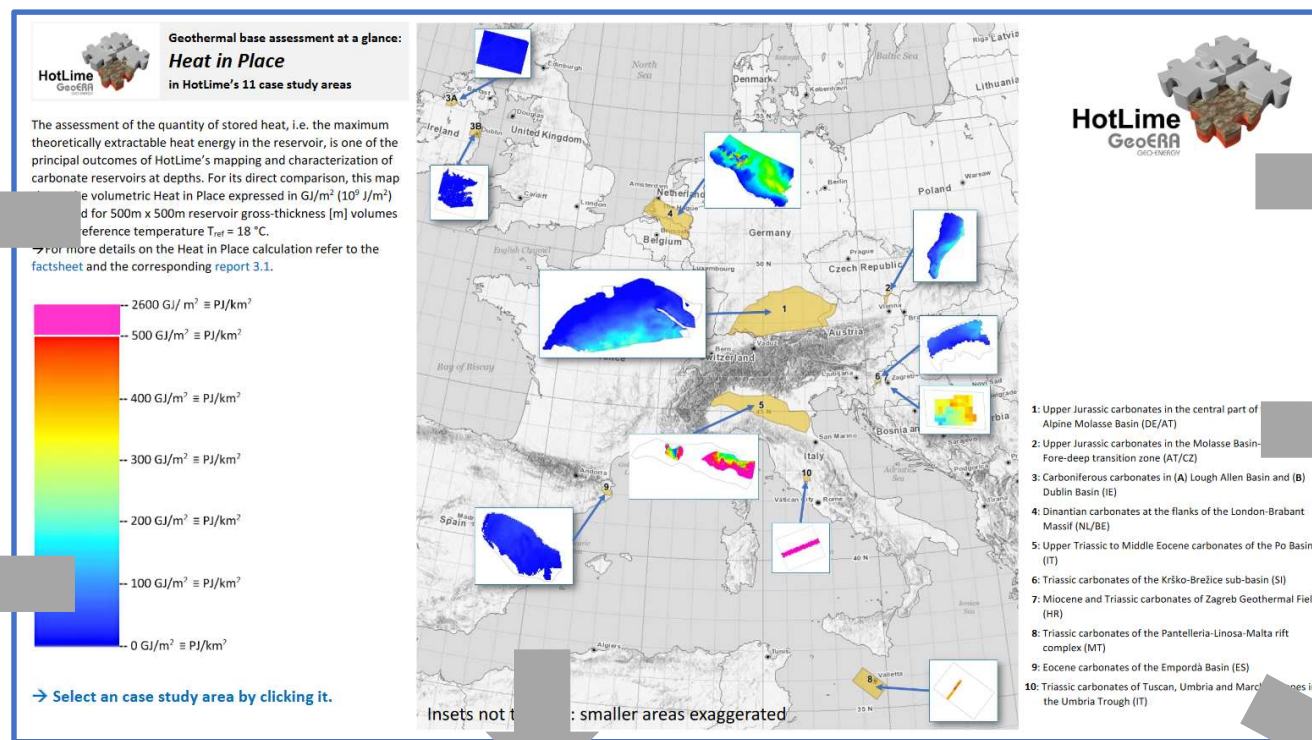


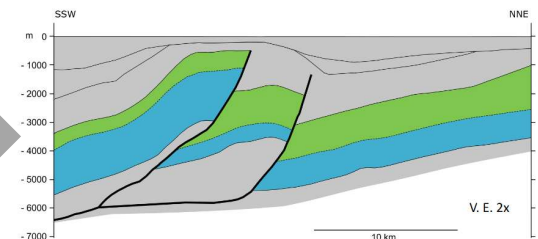
Figure 1: Conceptual sketch of a fault termination from Fossen (2016). In usual seismic surveys information is available to HotLime's partners, only the slip surface could be modelled. The wide damage zone (cf. Figure 3), the fault tip, and in (grey) (preparation) zone could not be detected.

Unlike faults in rocks tending to a ductile behavior, which tend to die out into a zone of ductile deformation, in carbonate rocks, due to their brittle characteristics, the displacement is partitioned into several branching private structures. These small faults, curved away from the strike of

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



Various thematic maps



Click a feature (fault, unit) to retrieve more information

Cross-sections

Unterhaching Fault System

<https://data.europe-geology.eu/egdidocs/hotlime/faults/3459>

Unterhachinger Störungssystem Unterhachinger Fault System

Notation: DE-BY-1083 LU-BY-1083

Northward facing structure consisting of three main faults, in sections split up into or subdividing in horizontal slip structures, forming a northwestern elevated ramp and a southeastern graben structure. The complete fault network of Unterhaching Fault System represents the target structure of several successful geothermal exploitations, featuring some of the most prolific deep geothermal installations in the Greater Munich Area.

Concept relations

broader Berg-Pöding Train of Faults
narrower Pfaffenberg-Baldern Fault, Taufkirchen-Parndorf Fault, Unterhaching Fault

Download: 1251 TL

HotLime Mapping and Assessment of Geothermal Plays in Deep Carbonate Rocks

Map layers in EGD I GIS Viewer

Metadata in EGD I Metadata Catalogue

SKOS vocabs

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



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/>

