Strategy for a reassessment of the EGS potential of Europe

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European Economic Interest Group "Heat Mining"

Why a reassessment?

> Why do we need a (re)evaluation of the EGS potential?

- There is no EGS georesource or potential EGS map in Europe
- Hidden resource: heterogeneities – uncertainty - risky
- Quantify the heat in place in several areas or non conventional reservoirs
- Various studies in different countries or areas but need to be harmonized in Europe
- Inform decision makers, politicians, industry, scientists, media

> How evidence the EGS resources in Europe?

- Define existing and innovative EGS concepts/targets
- Take into account technological progresses (binary cycle systems) and the impact in terms of drillable depths
- Needs of regional studies by combining geoscientific and socio-economic data

⇒ Elaborate a series of thematic EGS georesource maps

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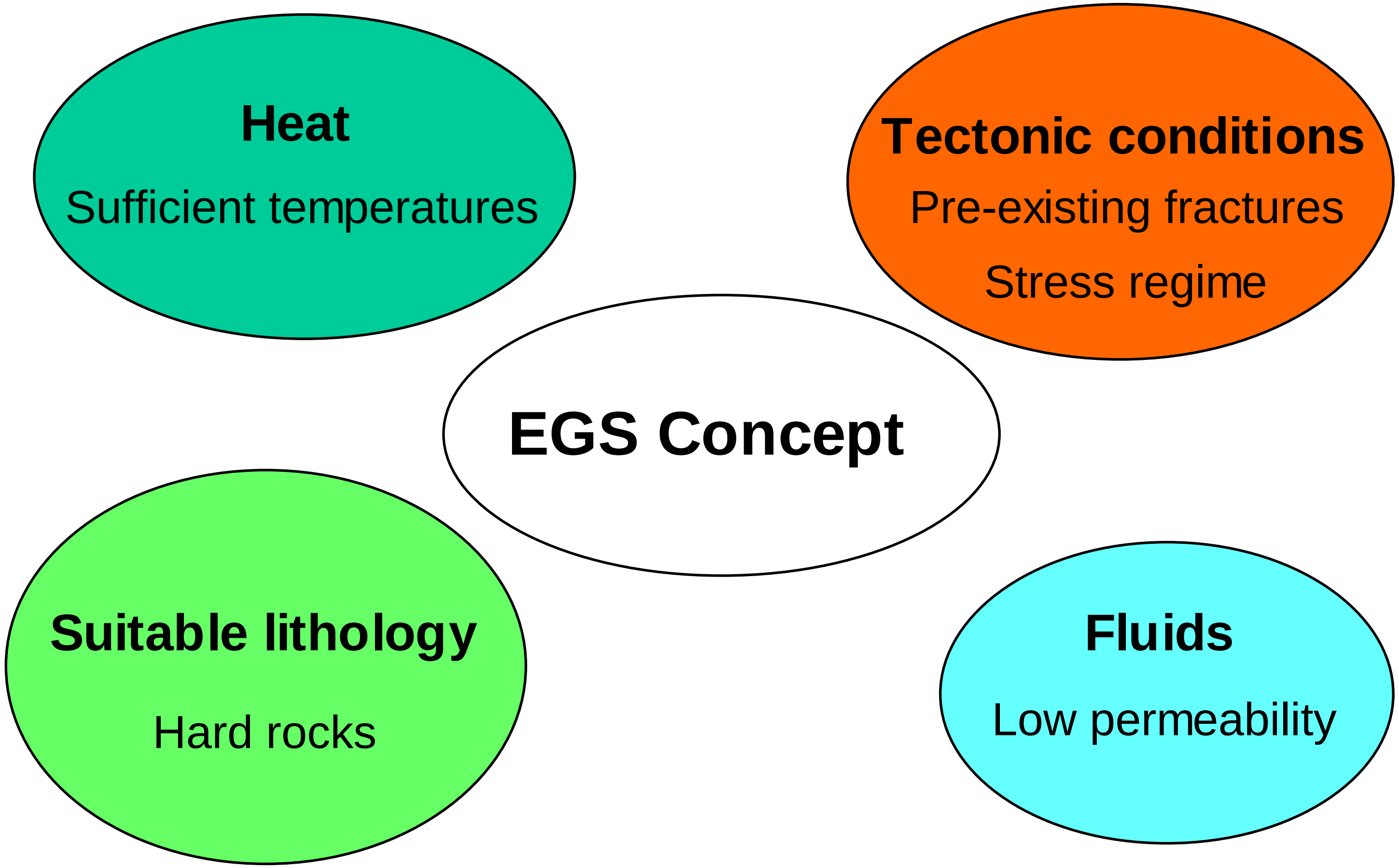
What types of EGS systems?

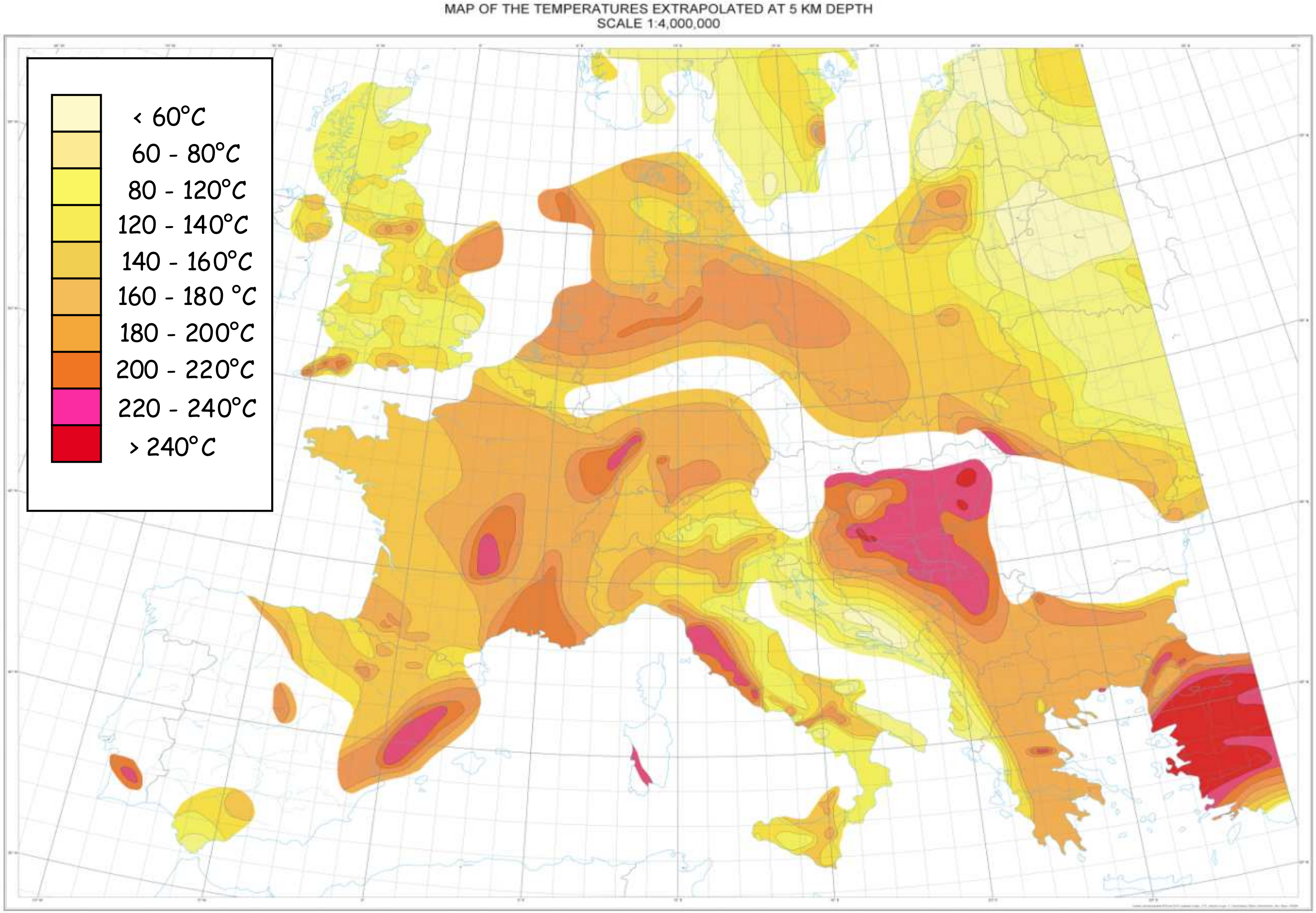
Conduction dominated EGS Low natural permeability			Unproductive hydrothermal systems	Unconventional Geothermal reservoirs
Crystalline-rocks *Radiogenic granites (Variscan belt, Lithuanian basement)* *Active grabens Rhine graben (Soultz, Landau, Basel) Eger graben, Limagne, Catalonia, Sardinia*	**Sediments** *North German basin (Gross Schönebeck)* *Molasse basin (Altheim, Riem, Unterhaching)*	**Metamorphic rocks** *Variscan belt (Urach)* *Tuscany (Larderello)*	**Volcanics areas** *Guadeloupe* *La Réunion* (Indian Ocean) *Iceland, Russia, Greece, Portugal, Turkey, Spain, ….*	**Geopressured reservoirs** *Pannonian Basin* **Supercritical Reservoirs** *Iceland* **Oil/gas fields**

→ Innovative concepts

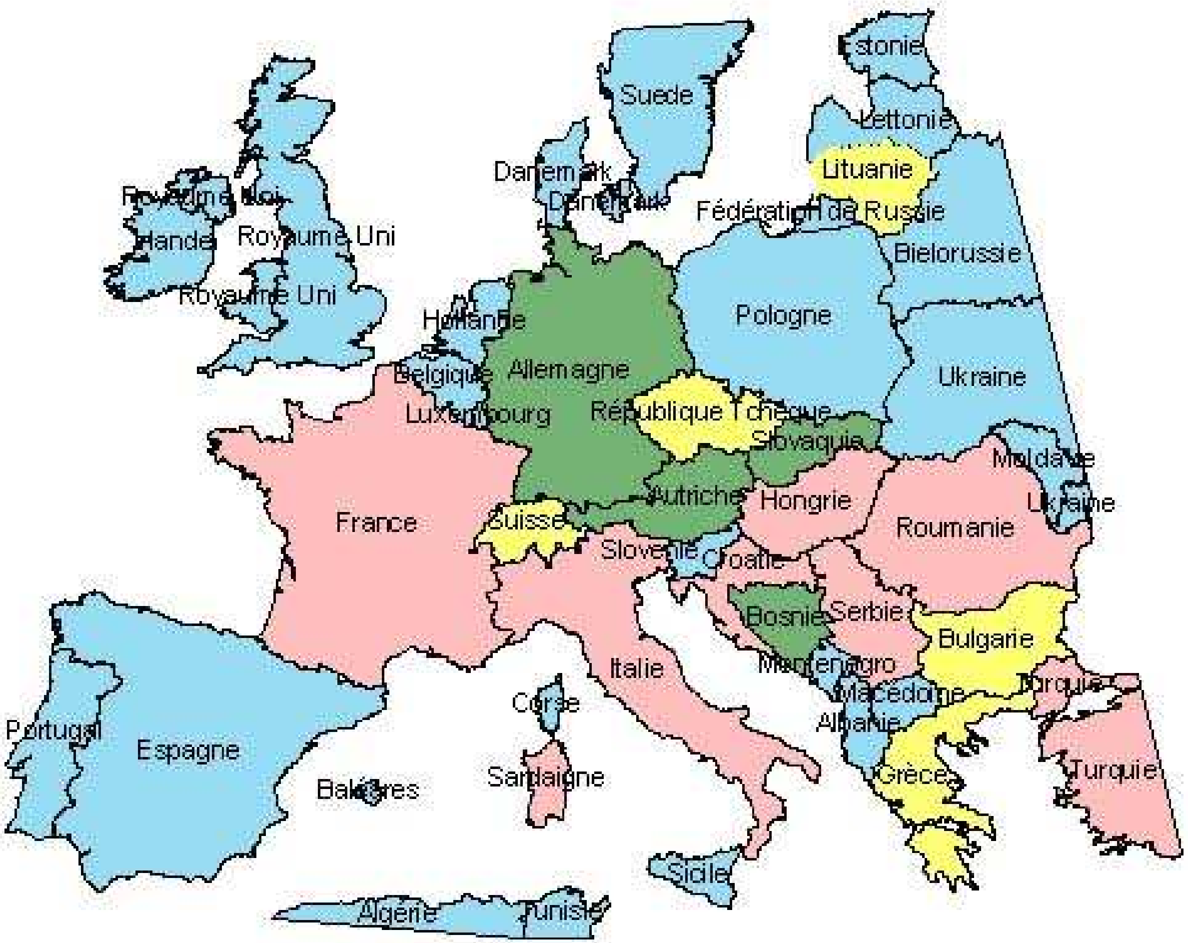
Where are the fractured reservoirs at drillable depths in acceptable tectonic conditions hosted in hard rocks?
What is the energy embedded in such areas?


Heat
Sufficient temperatures
Tectonic conditions
Pre-existing fractures
Stress regime
EGS Concept
Suitable lithology
Hard rocks
Fluids
Low permeability

Deep temperatures in Europe



EGS Potential in Europe



- High HFR potential
- Moderate HFR potential
- Low HFR potential

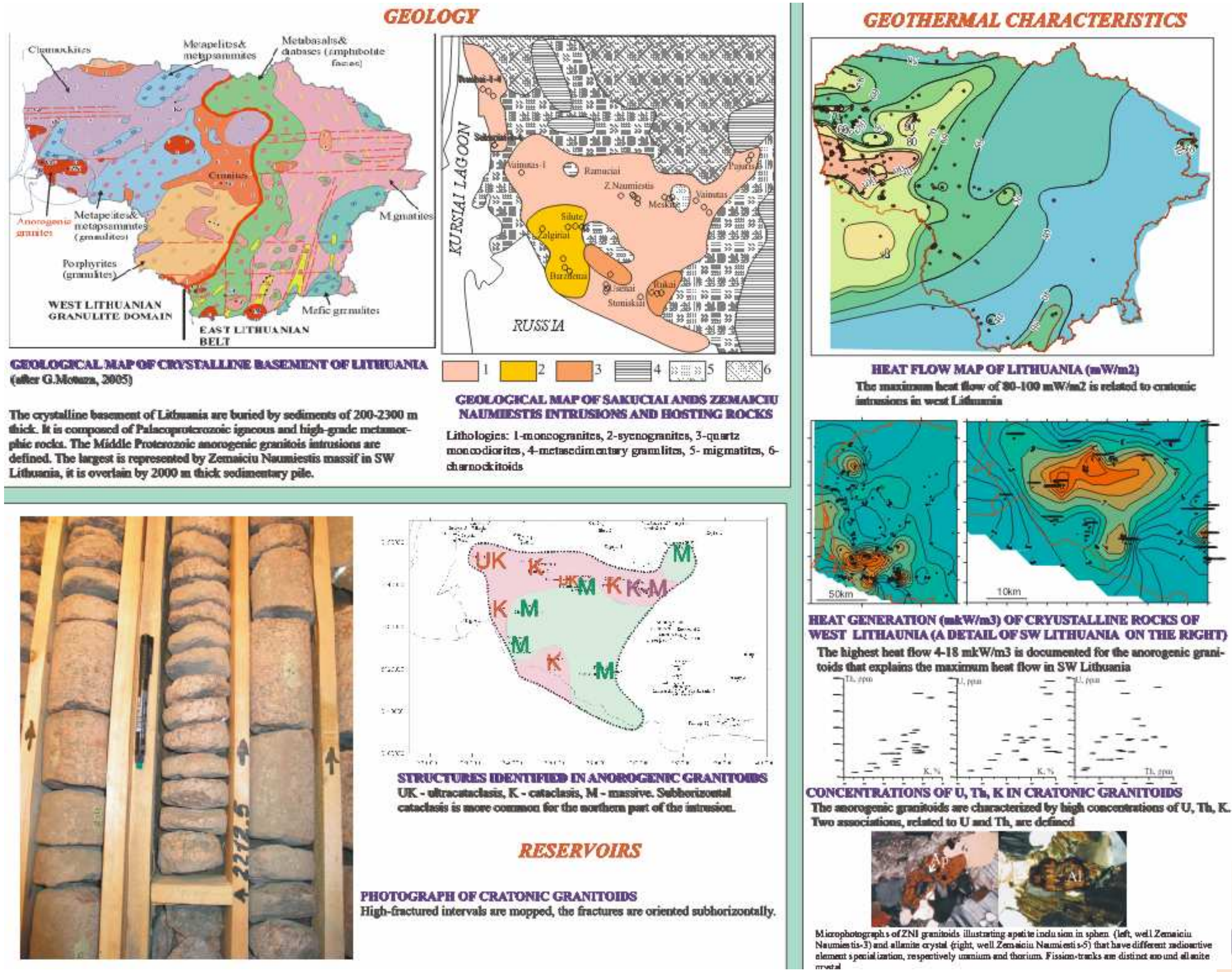
- No calculations but promising HFR potential

Genter et al., 2004

Conductive dominated EGS

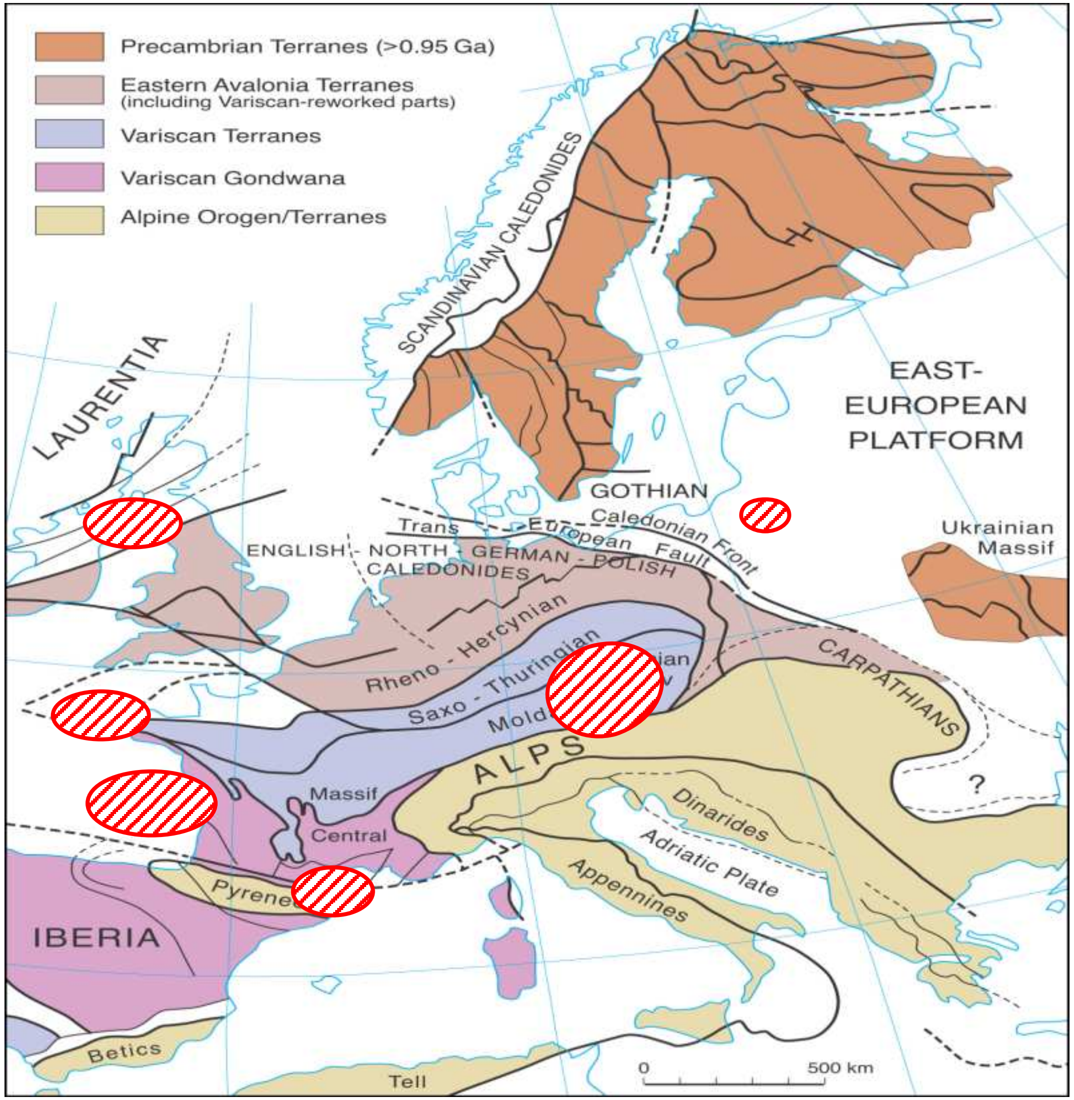
Low natural permeability

Regional scale: deep crystalline rocks in Lithuania



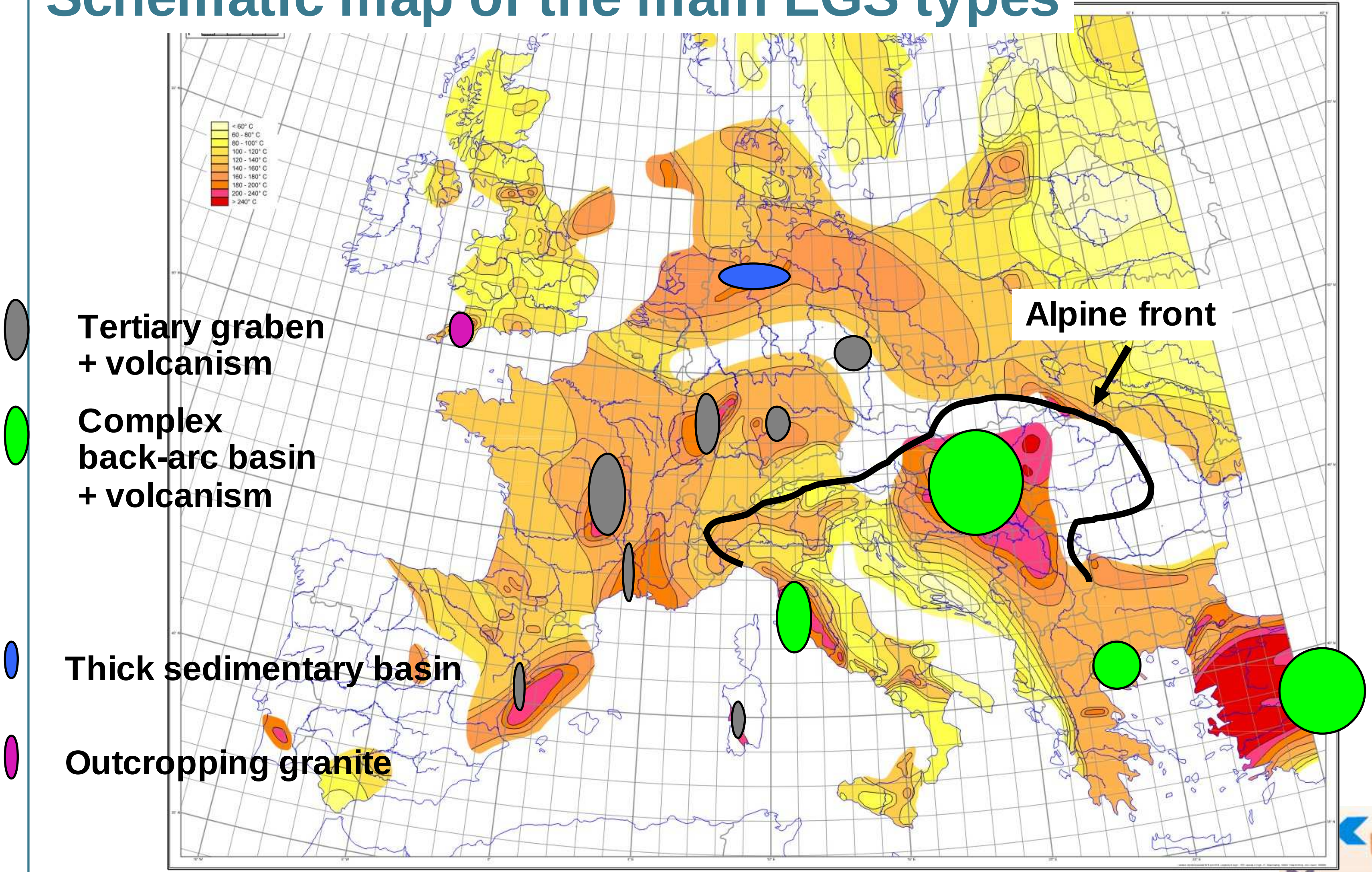
Sliaupia et al., 2006

Potential EGS areas from outcropping granite in Europe



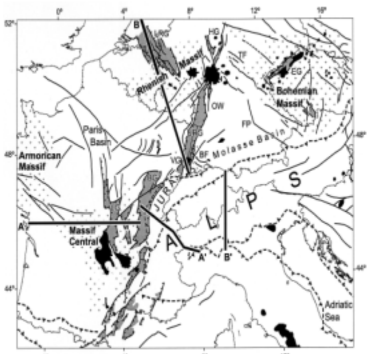
From A. Forster, GFZ, 2006

Schematic map of the main EGS types

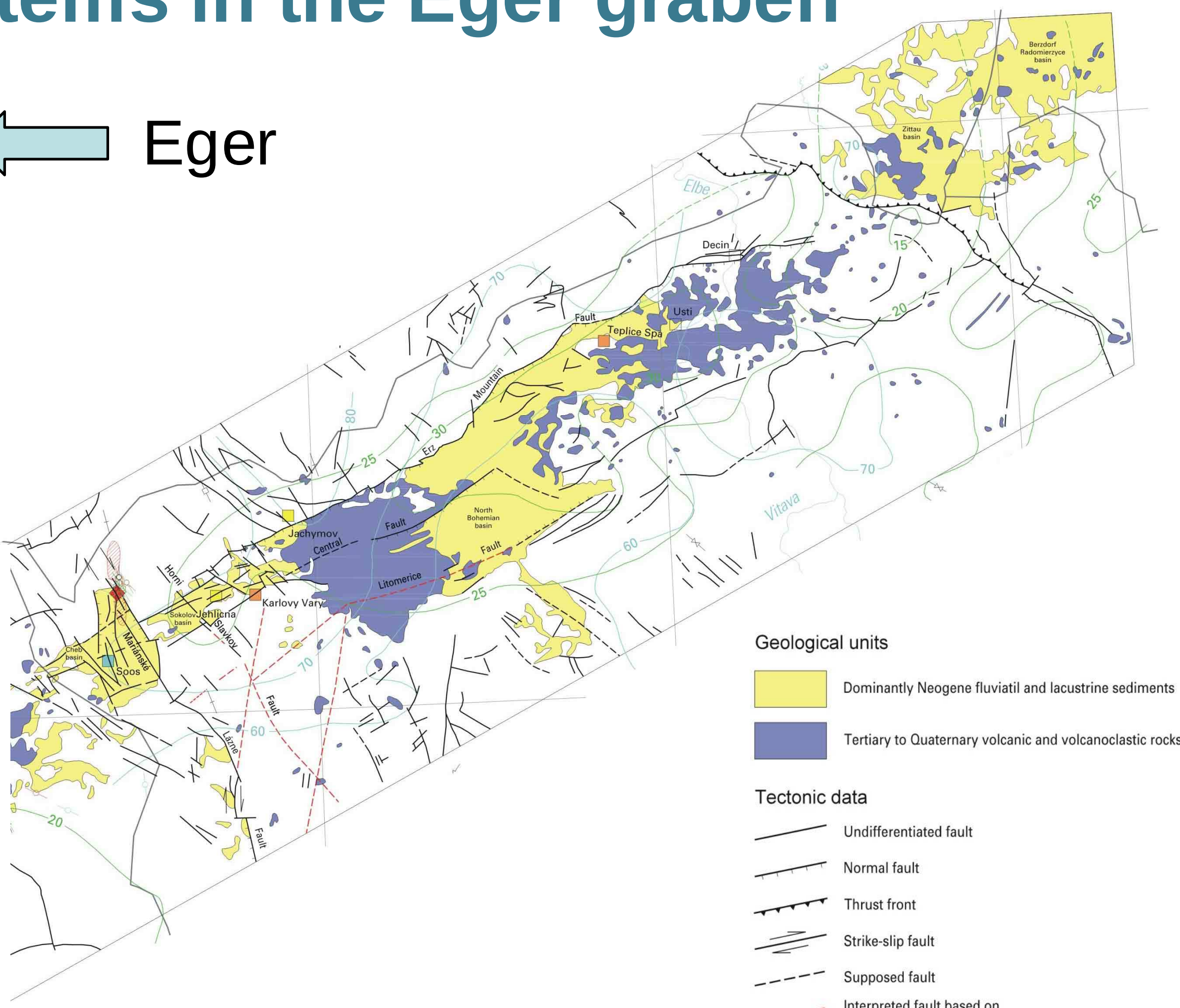


EGS typology in Europe

Fracture systems in the Eger graben



Eger



Thermic data

Isotherms at the depth of 500m b.s.

Isolines of heat flux (mW/m²)

Seismic data

Epicenter of the swarm of December 4 and 5, 1994

Epicenters of earthquakes for the period 1991 - 1994

Thermal springs

No data

T<20°C

20°C<T<45°C

45°C<T<90°C

Geological units

Dominantly Neogene fluviatil and lacustrine sediments

Tertiary to Quaternary volcanic and volcanoclastic rocks

Tectonic data

Undifferentiated fault

Normal fault

Thrust front

Strike-slip fault

Supposed fault

Interpreted fault based on gas measurements

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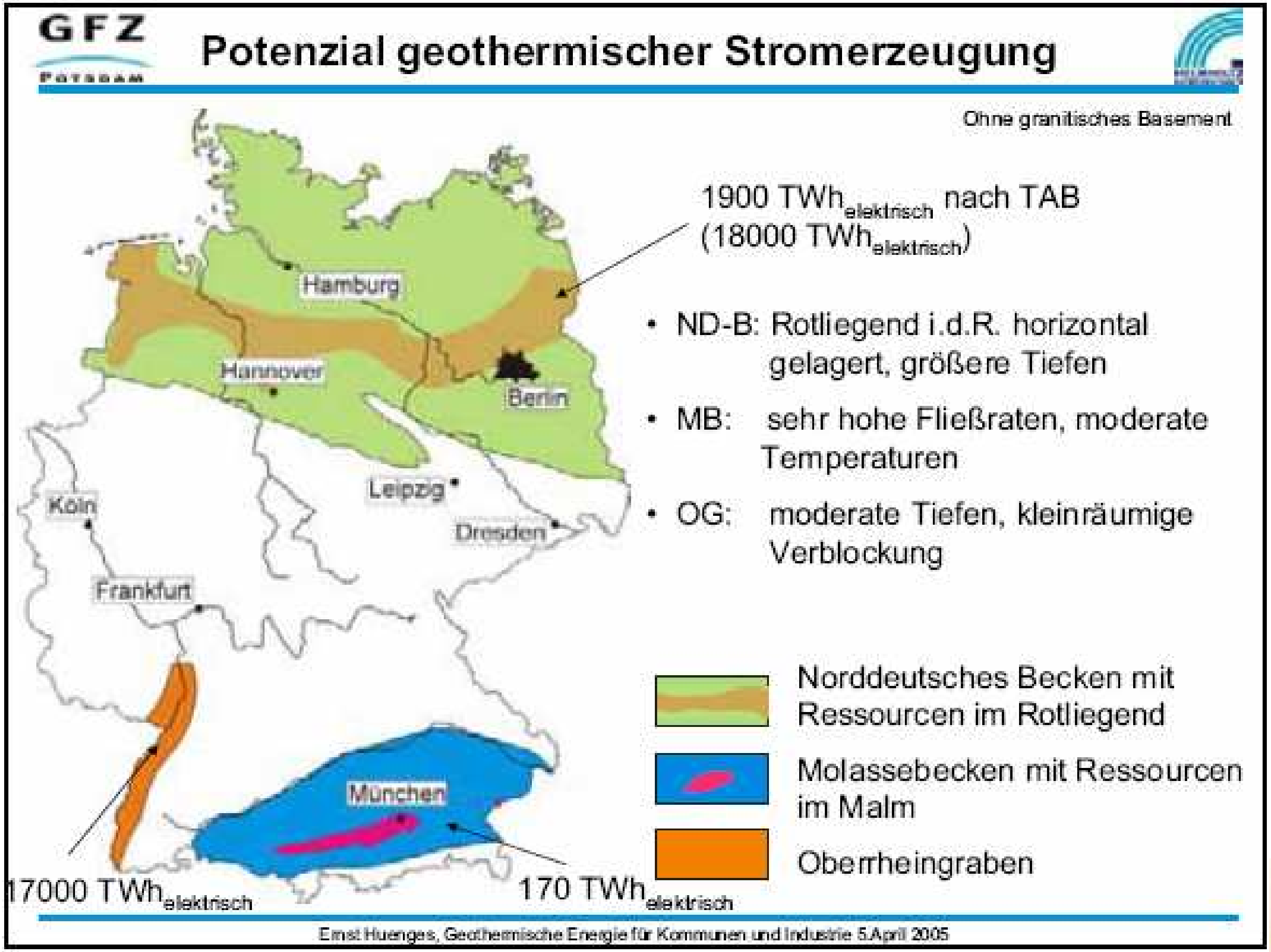
Geothermal potential in Germany



Huenges et al., 2005

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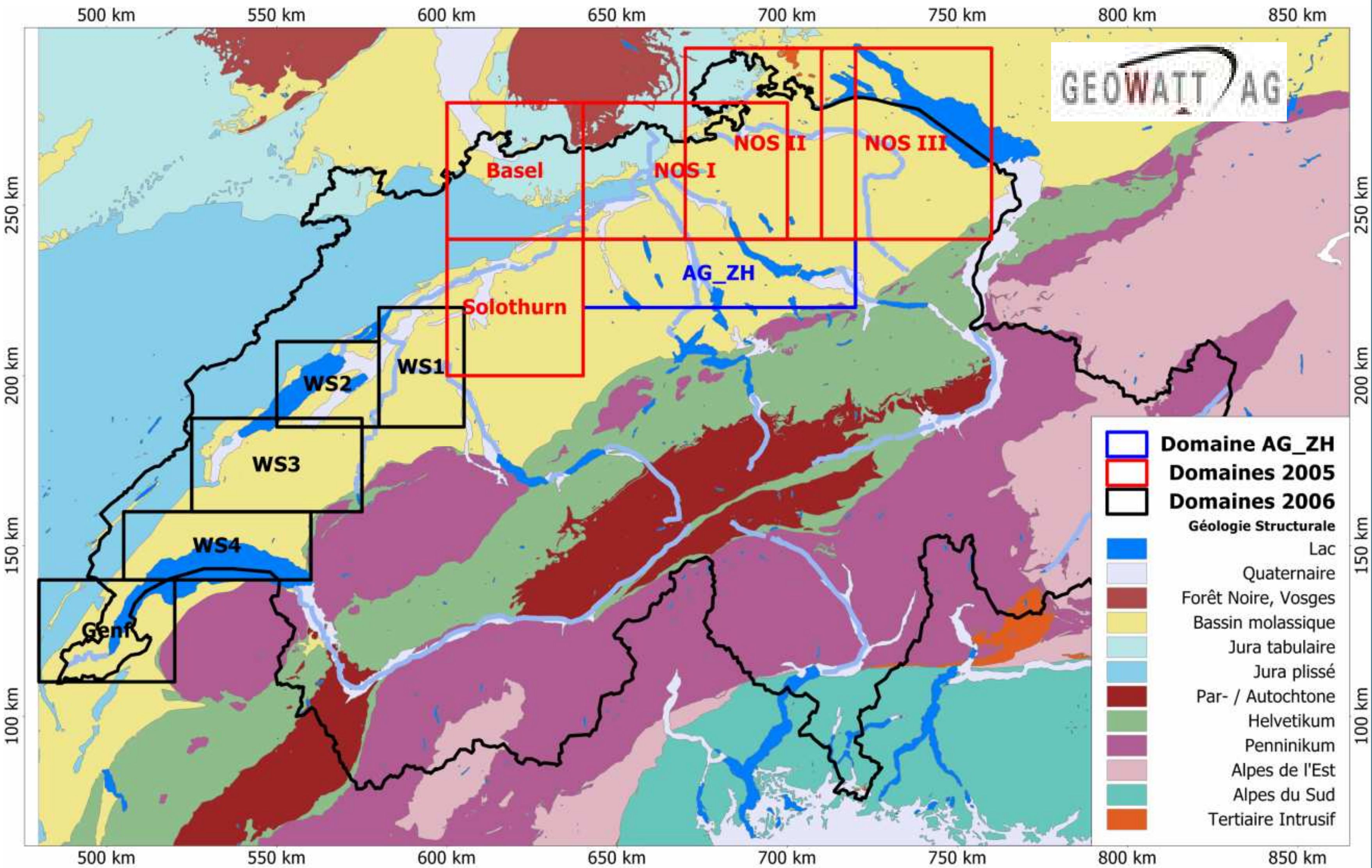
Investigation of National Swiss Geothermal Resources



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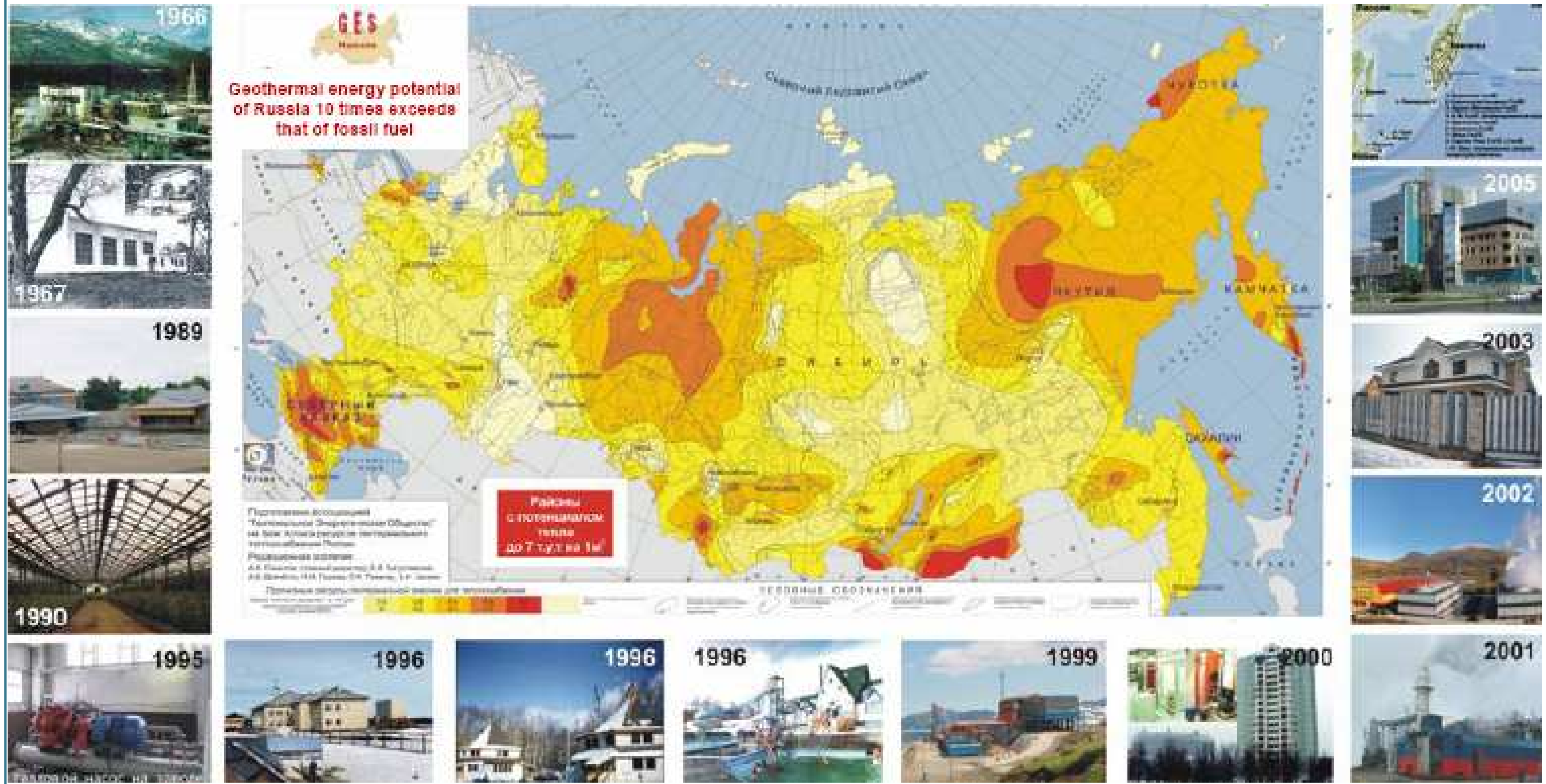
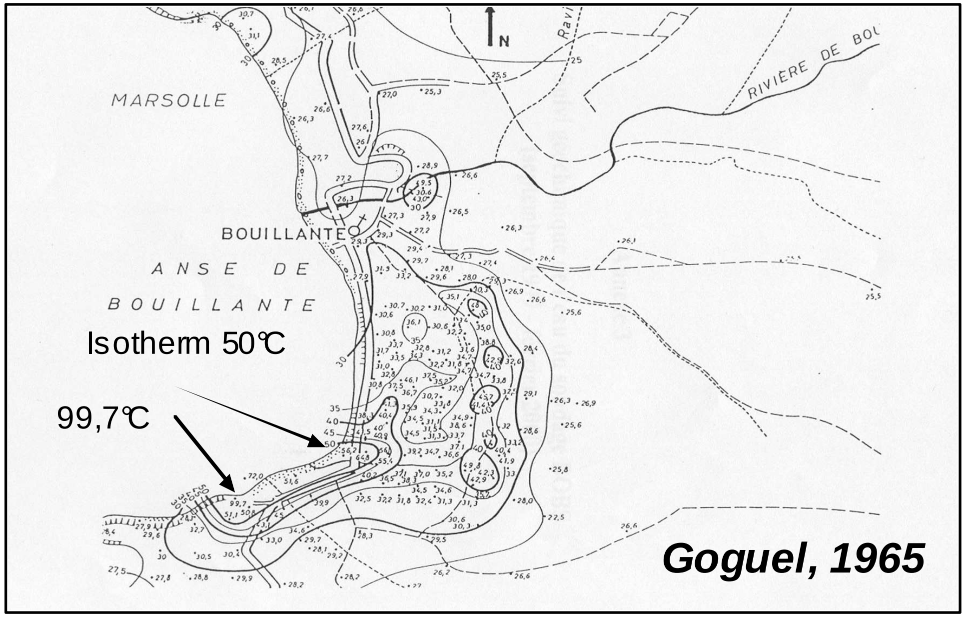
Unproductive hydrothermal systems

Volcanic areas

Geothermal in Russia (Povarov, 2006)

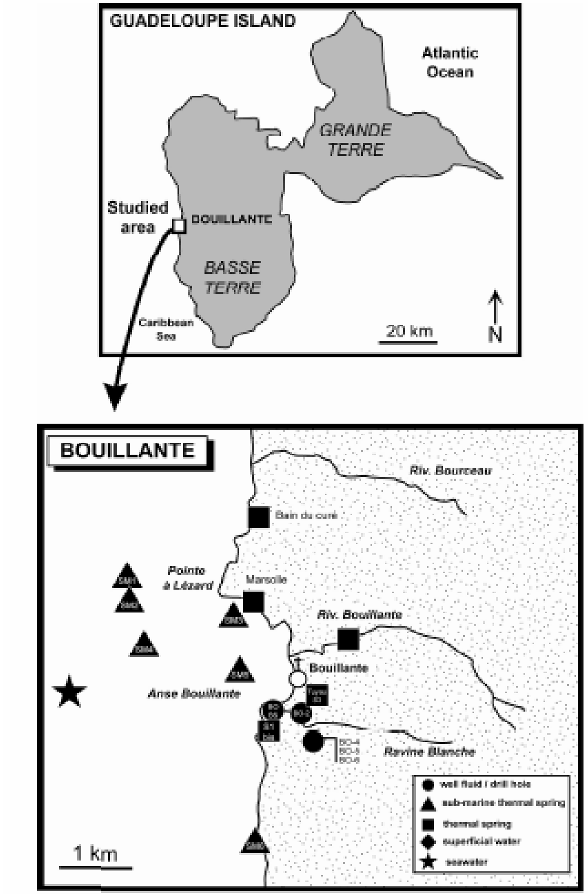


Hot areas around hydrothermal systems in Guadeloupe (Bouillante)



Goguel, 1965

Temperatures measured at 2 m depth



Sanjuan et al., 2007

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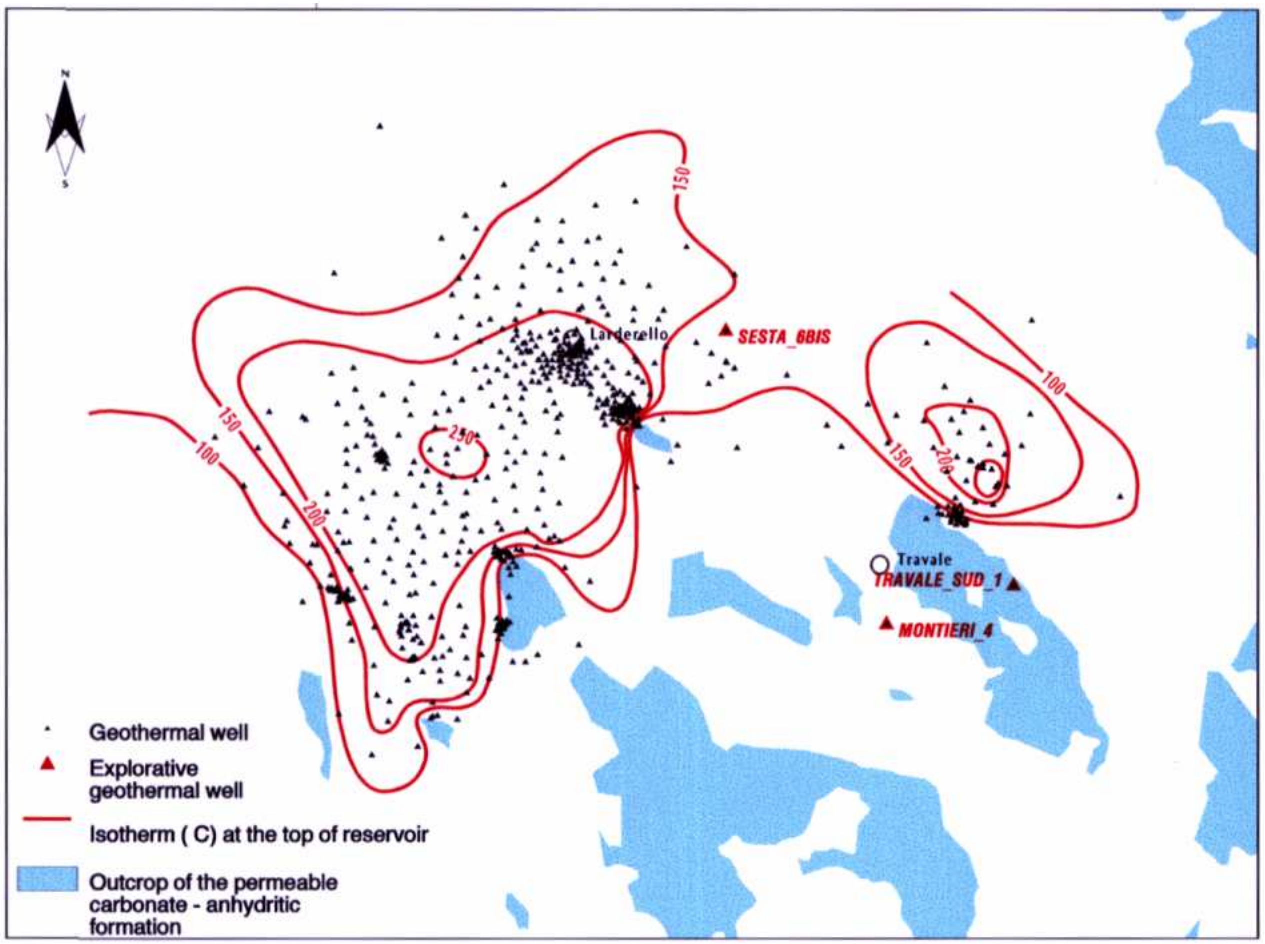
Temperatures at depth in Larderello (Tuscany)



Temperature at the top of the upper reservoir

Barelli et al., 1995

Unconventional geothermal reservoirs

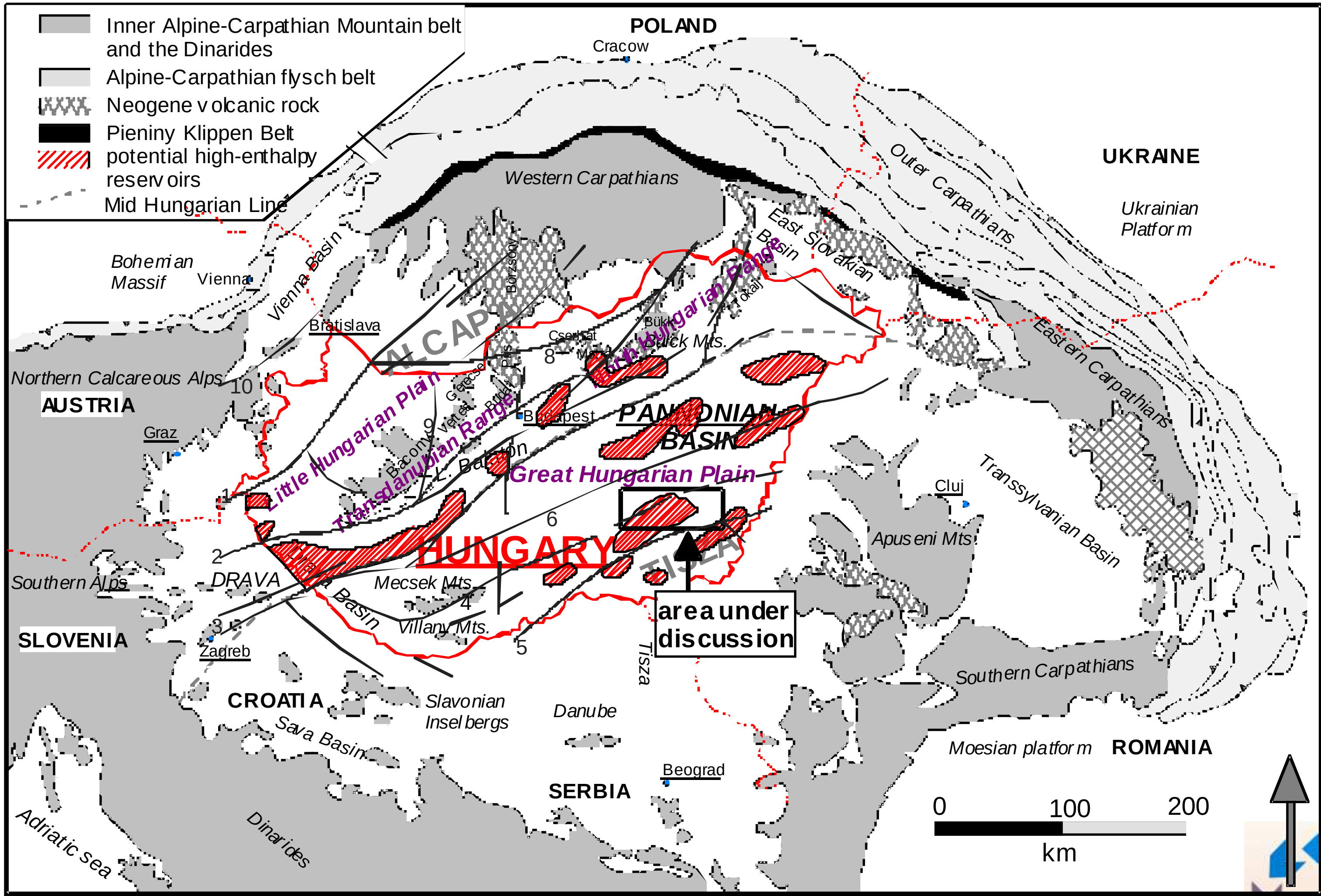
Geopressured reservoirs

Pannonian basin

Supercritical reservoirs

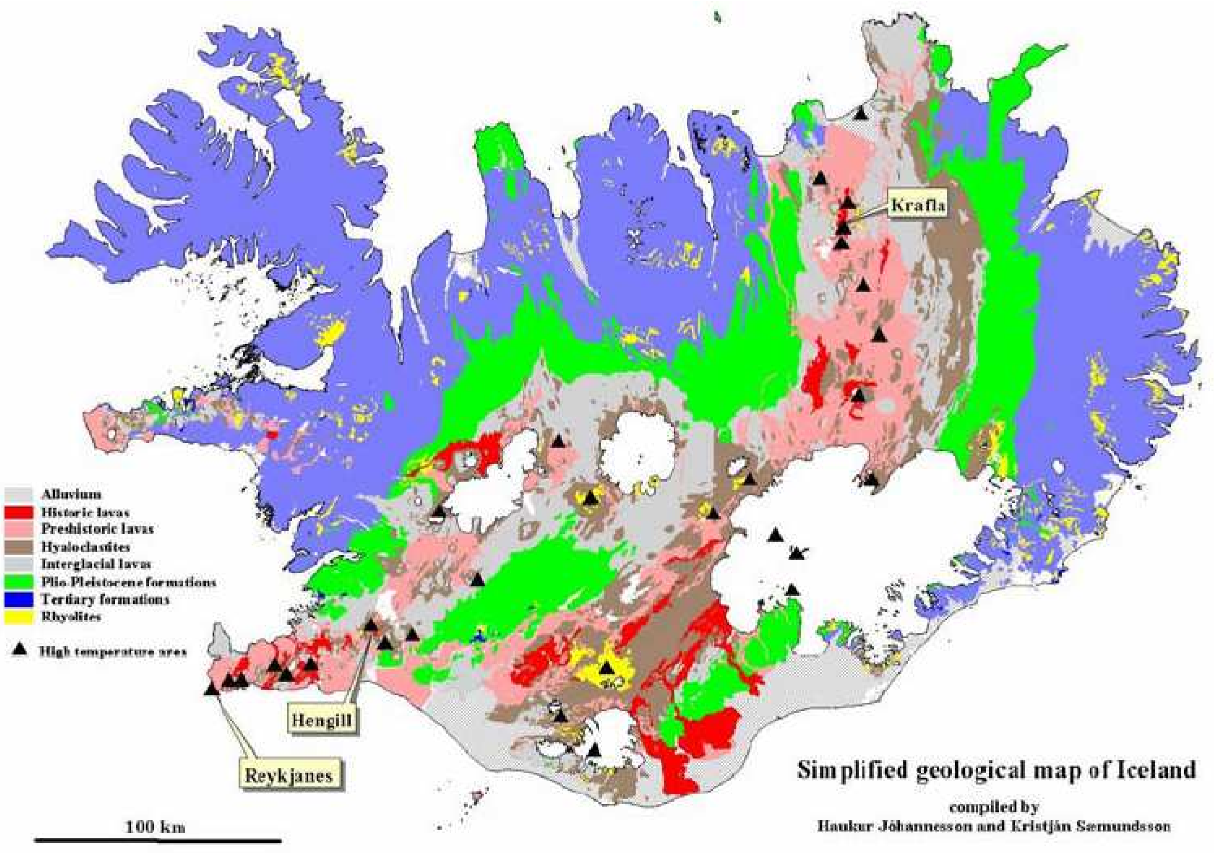
Icelandic reservoirs

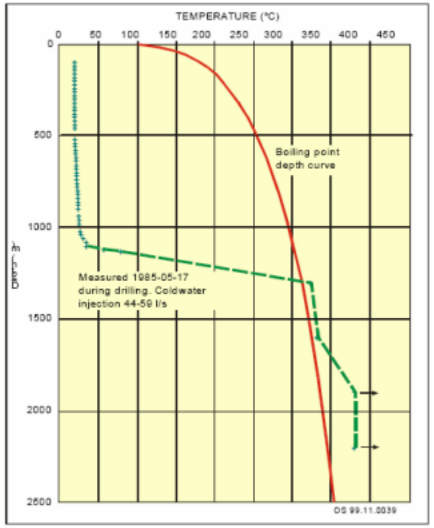
High enthalpy reservoirs in Hungary

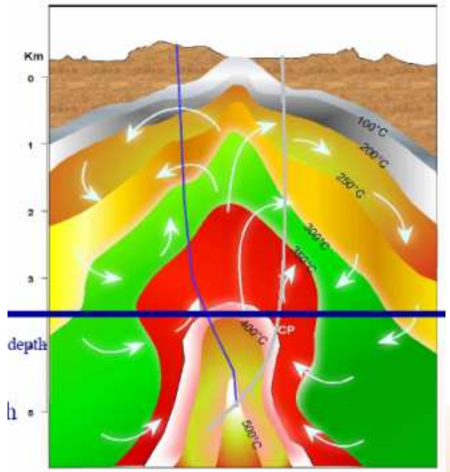


Wolfgramm, 2006

Supercritical reservoirs in Iceland







Isor, 2007

Georesource strategy

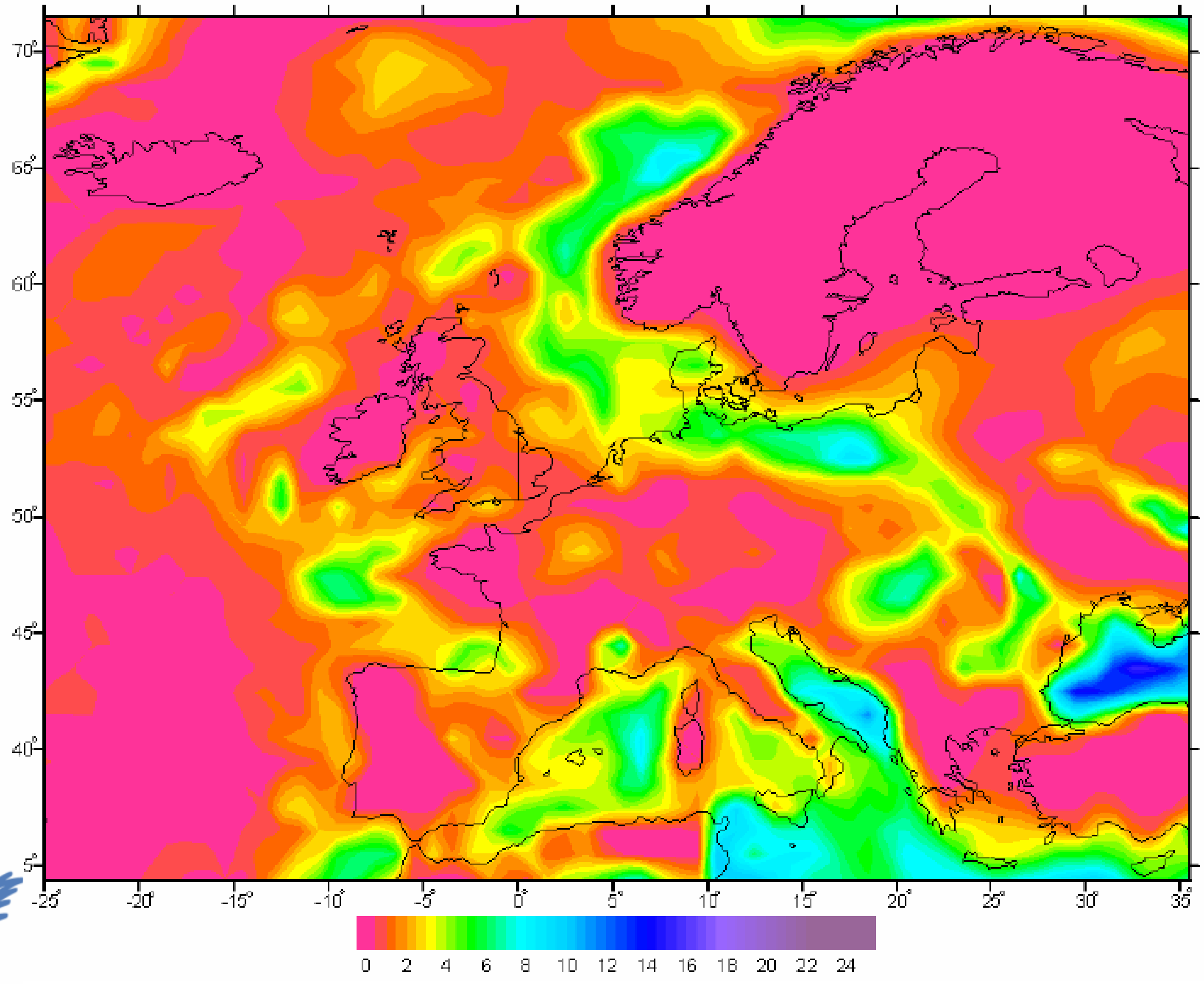
> **Explore new EGS concepts/targets**

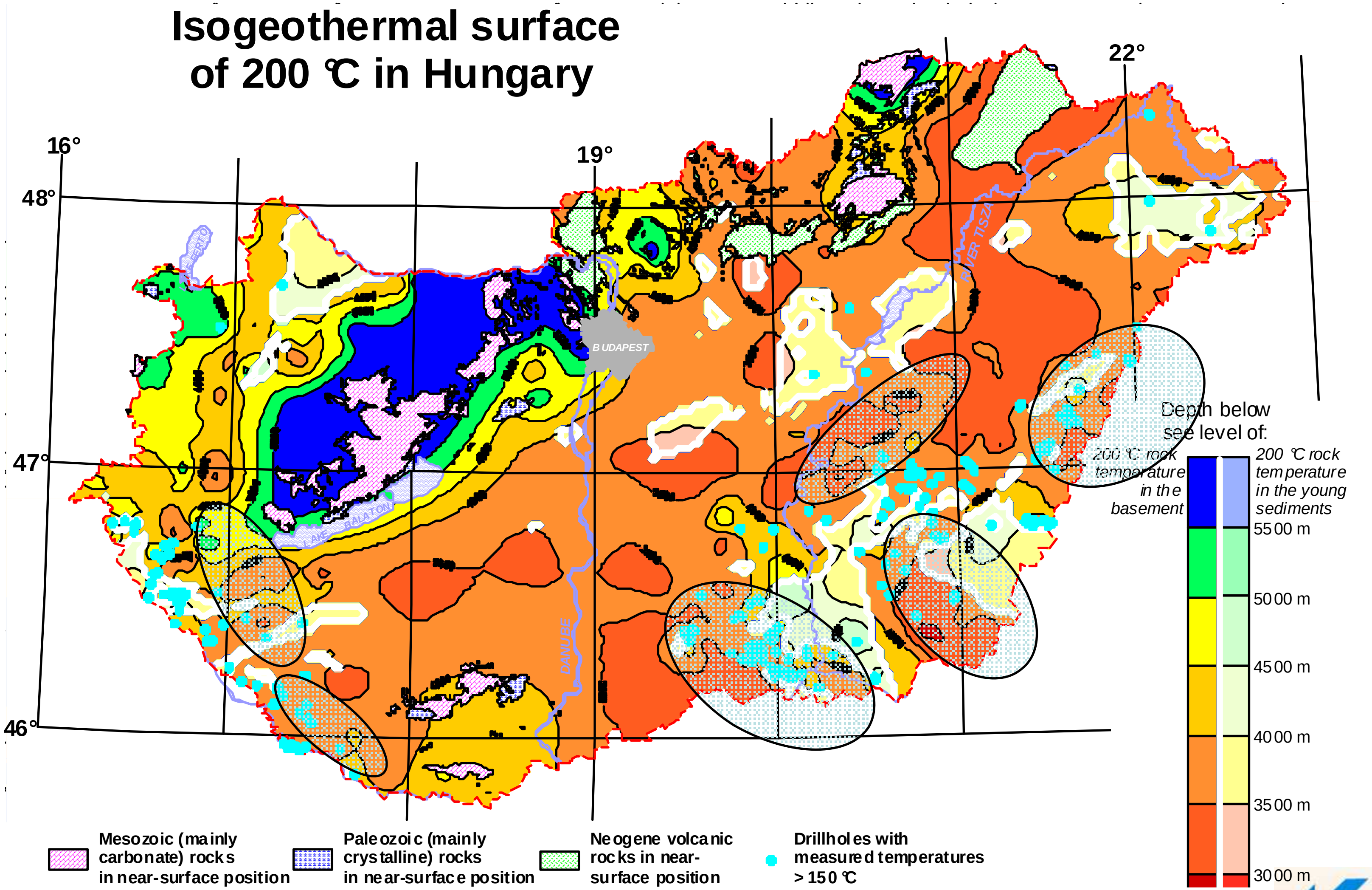
- Ex. The limit between the post Paleozoic sedimentary cover and the basement in western Europe
- Hidden granites, Oil/gas fields, border of conventional fields, ….
- Improve tools for quantifying the geothermal potential
- Combination with socio-economic needs

> **We need boreholes**

> **We need EGS sites in various contexts**

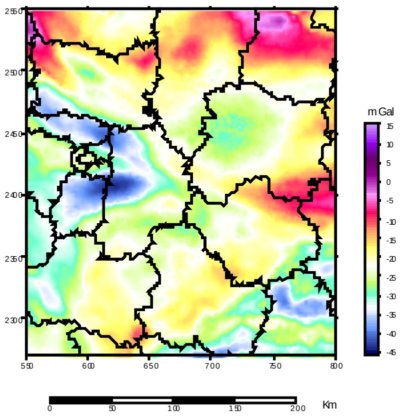
Thickness of the sediments (Tesauro et al., 2006)



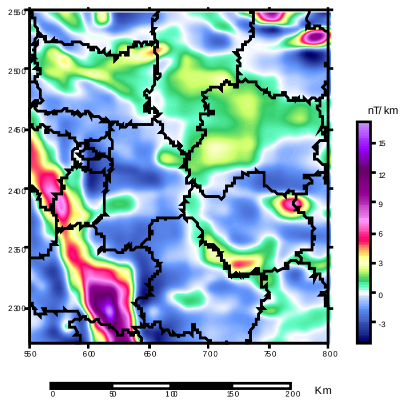


From P. DÖVÉNYI (ELTE Budapest, Hungary) & L. RYBACH (GEOWATT AG Zürich, Switzerland), Orléans ENGINE launching Conference, February 2006

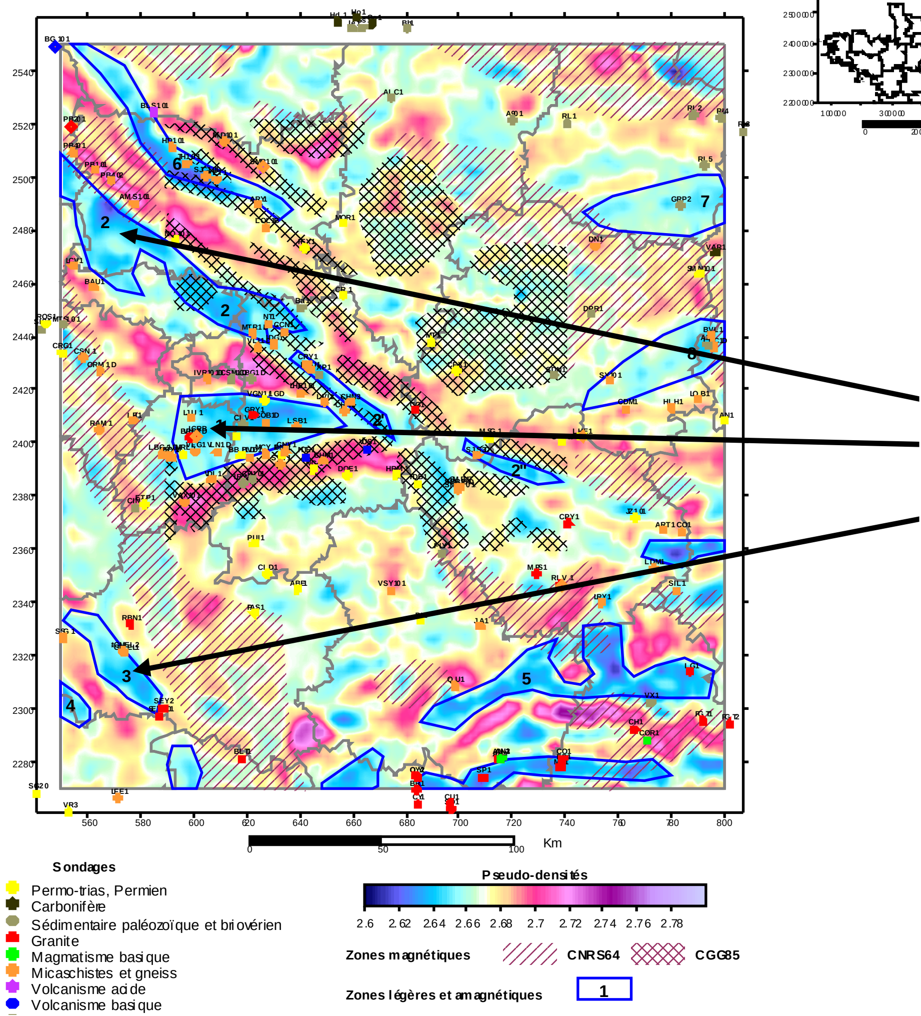
Paris basin: Gravi-Magnetic data



Bouguer anomaly

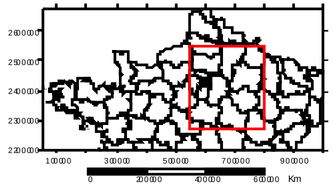


Magnetic data vertical gradient



Granites

Planche 3 - Synthèse
Interprétation gravimétrique et magnétique combinée et nature du socle



Debeglia, 2005

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Quantity the geothermal potential

> Heat in Place

$$E_{HIP} = \rho c_P \cdot V \cdot (T_{prod} - T_{reinj})$$

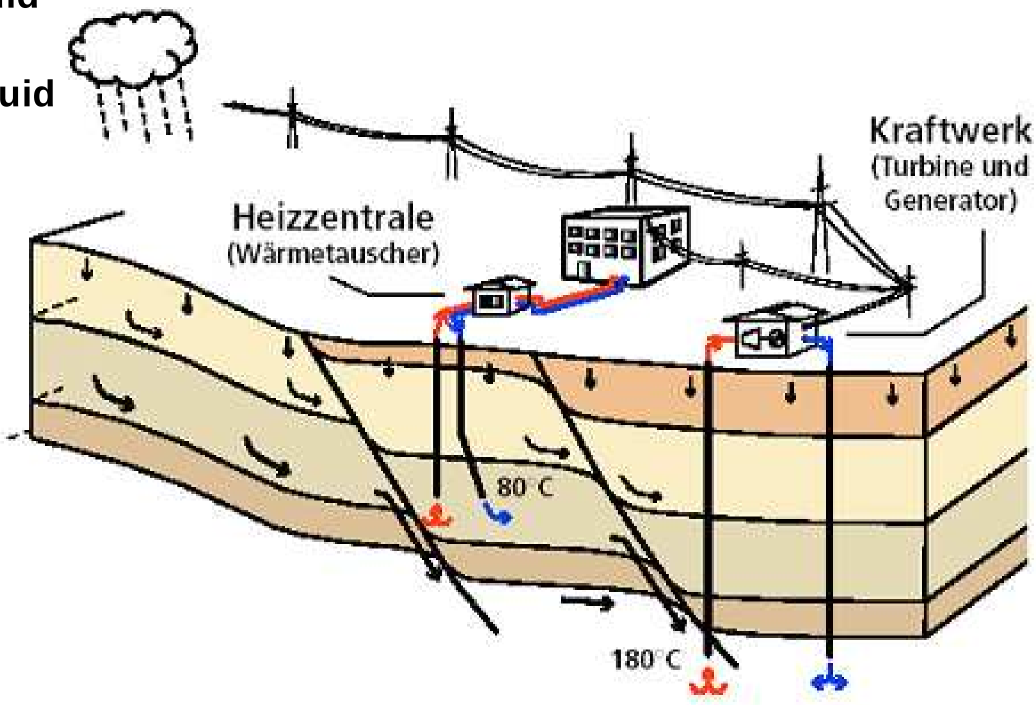
- > ρc_P specific heat capacity of rock [J m^{-3} K^{-1}],
- > V Volume of resource [m^3],
- > T_{prod} Temperature of produced fluid [°C]
- > T_{reinj} Temperature of re-injected fluid [°C].

> Transient Production

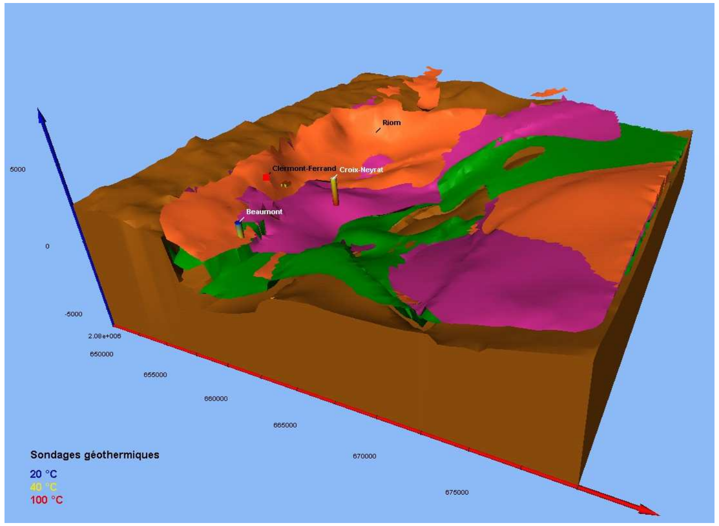
$$E_{ut} = \int_{\Delta t} p_{th} \cdot dt$$

$$= \int_{\Delta t} (\rho c_P)_f \cdot Q \cdot (T_{prod} - T_{reinj}) \cdot dt$$

- > $(\rho c_P)_f$ specific heat capacity of fluids [J m^{-3} K^{-1}] Q produced flow rate [m^3 s^{-1}].



Tertiary graben in France: Limagne resource analysis



Genter et al., WGC05, 2005

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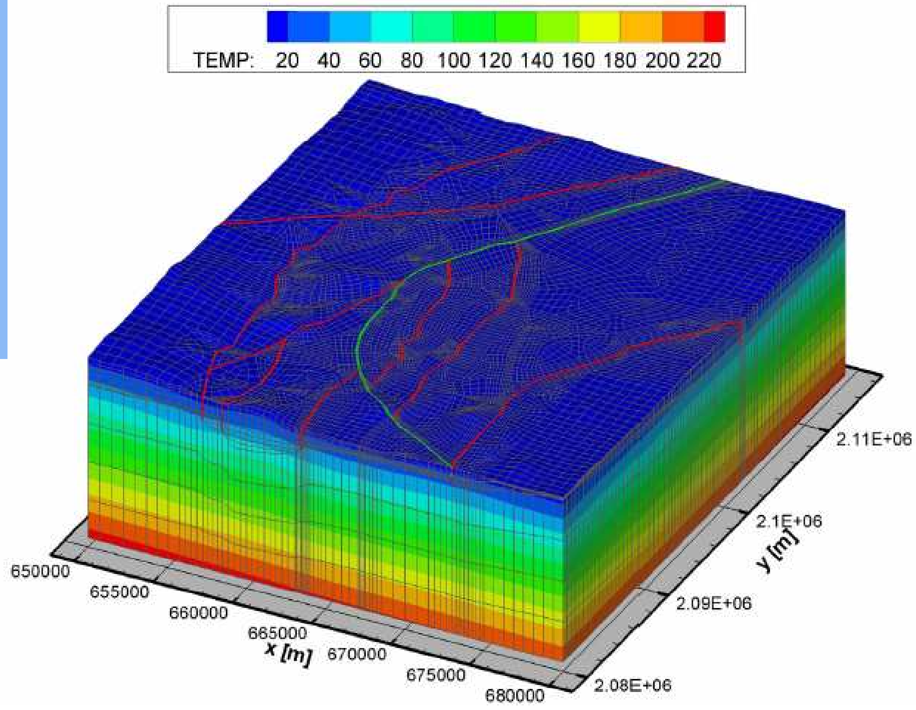
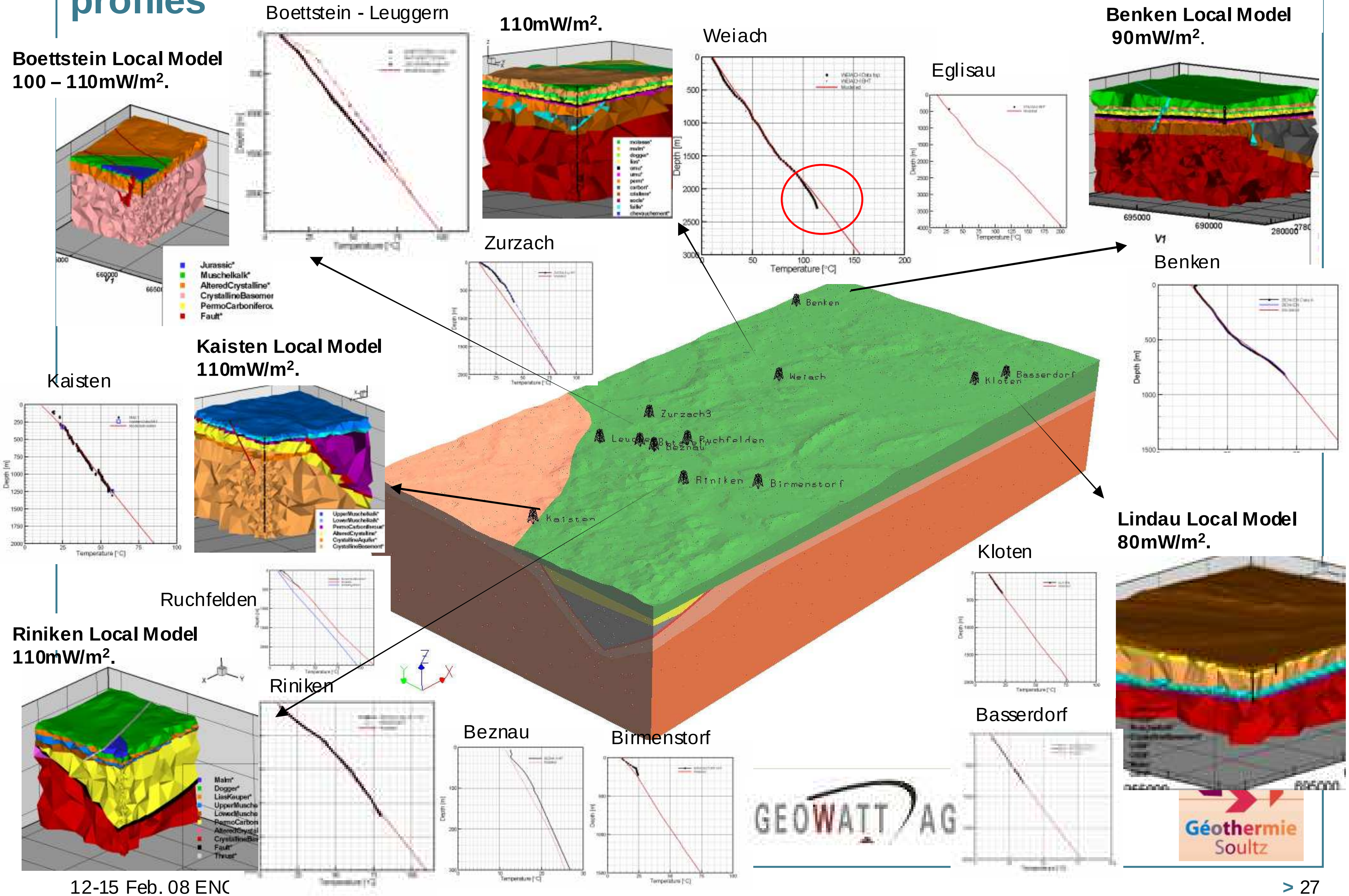


Baujard et al., Vilnius, 2008

Clastic reservoir potential

Example of current potential analysis calibrated on thermal profiles



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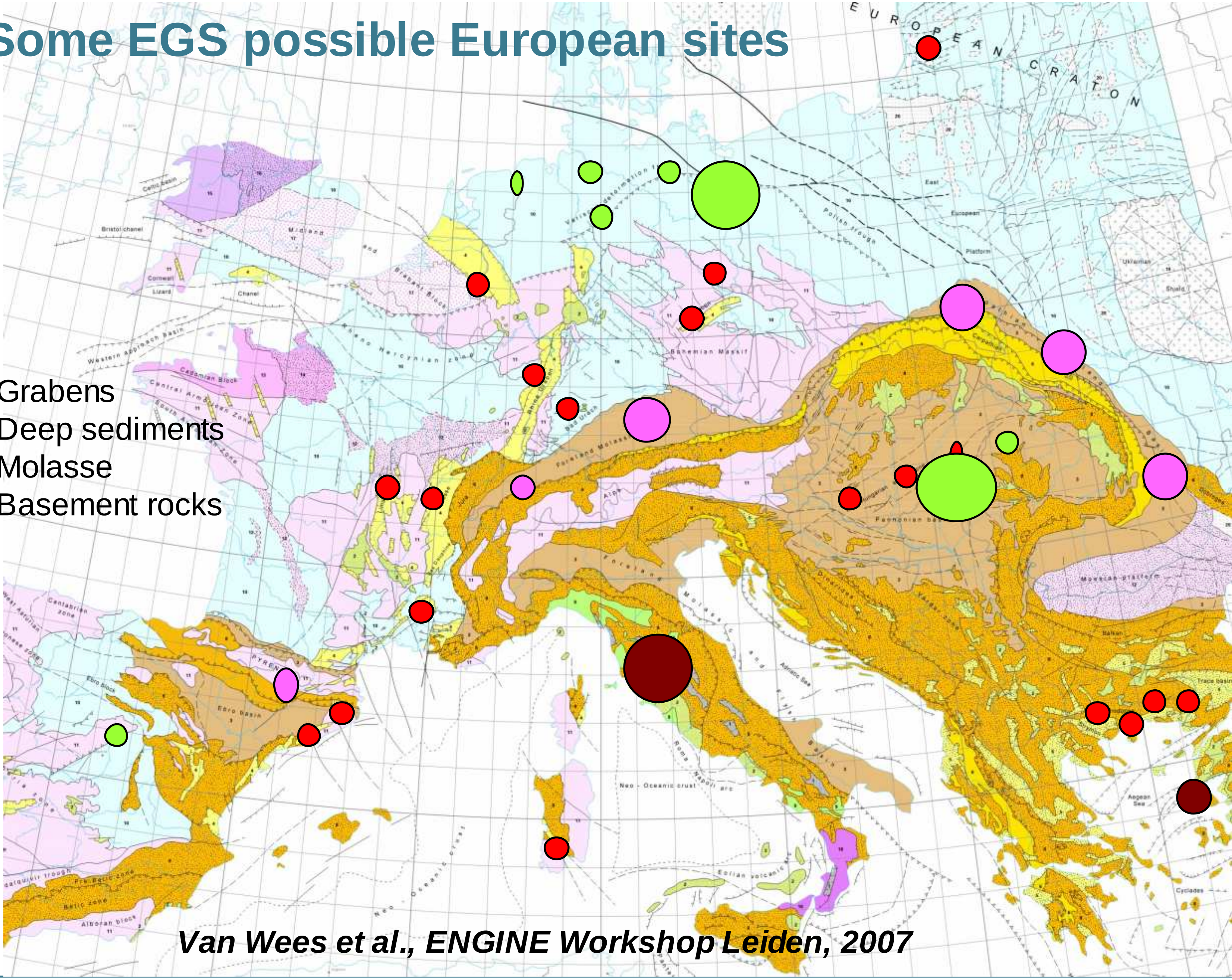
Some EGS possible European sites



- Grabens
- Deep sediments
- Molasse
- Basement rocks

Van Wees et al., ENGINE Workshop Leiden, 2007

Conclusion

Innovative EGS concepts integrating socio-economic demand but also new technologies (exploration, drilling, exploitation)

Documents able to map the main features of those innovative EGS concepts

Boreholes for calibrating and for testing those concepts

Improve tools (GIS, 3D, Resource analysis)