National Research Council of Italy

Institute of Geosciences and Earth Resources

Geothermal Data Information & Dissemination

E. Trumpy[1], A. Manzella[1], G. Gola[1], A. Santilano[1], A. Donato[1], S. Botteghi[1], F. Caiozzi[1]

[1] Institute of Geosciences and Georesources – National Research Council of Italy, Via Moruzzi 1 – 56124 PISA, Italy

e.trumpy@igg.cnr.it

Pisa, 10 December 2013

IGG

Geothermal DATA management

Data acquisition and validation

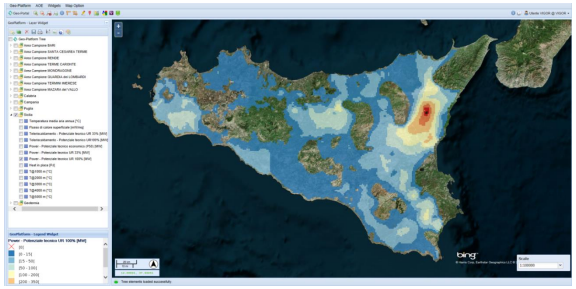
National Geothermal database

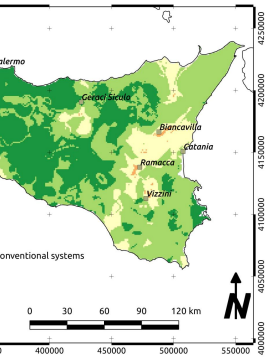
Data Interpretation

Geothermal Potential assessment

Geothermal Favorability

Geothermal Data dissemination





National Research Council of Italy

Institute of Geosciences and Earth Resources

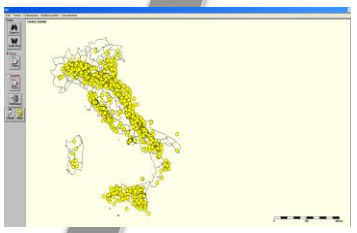
National Geothermal Database

National Geothermal Database

Story

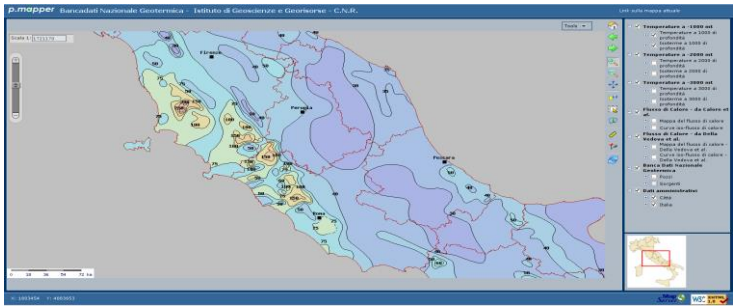
- Was built in 1993 by the International Institute for Geothermal Research in Pisa of the National Research Council at the completion of inventory geothermal resources by CNR, ENEA, ENEL and ENI, under law n°896 of 1986
- Maintained by IGG-CNR and updated since 2001
- Software migration (since 2008) & Data updating (in progress up to now)
- Has been performed a check compatibility with respect to the original data (paper form Inventory of geothermal resources)
- Now we are improving the database functionality with some graphics and analytic features
- Now we are providing information as **OGC** services

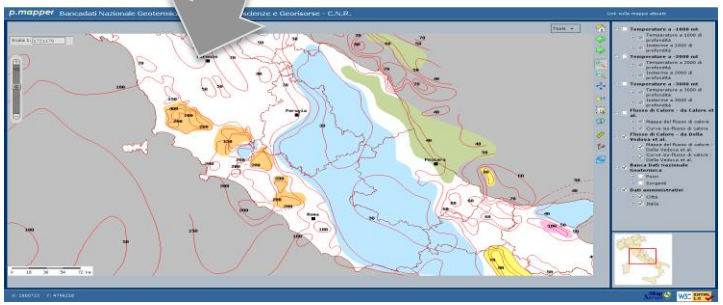
1993



time

2008





National Geothermal Database

References:

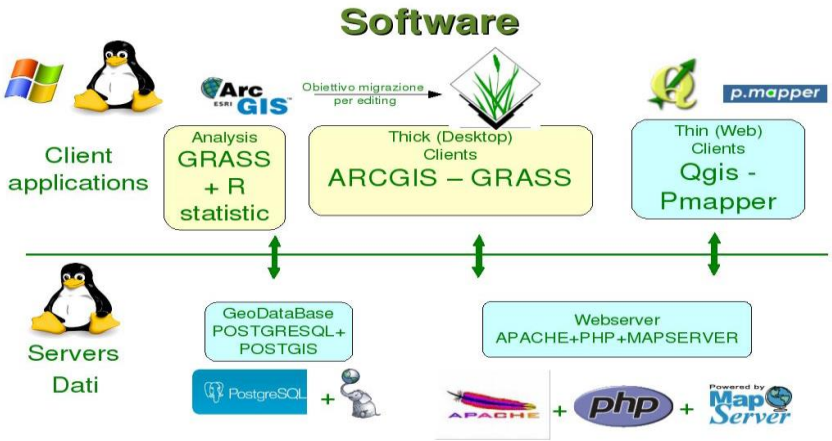
- **ENEL 1987**
- **AGIP bibliography**:
  - ✓ Acque dolci sotterranee – Inventario dei dati raccolti dall'AGIP durante la ricerca di idrocarburi in Italia dal 1971 al 1990
  - ✓ Temperature Sotterranee – Inventario dei dati raccolti dall'AGIP durante la ricerca e la produzione di idrocarburi in Italia – 1977
  - ✓ Aggiornamenti Temperature Sotterranee – Pozzi a Terra – Dicembre 1986, AGIP

- **National Geothermal Resources Inventory** – geothermal wells and Thermal spring 1989
- Economic Development Ministery - UNMIG – **VIDEPI** Project - hydrocarbons wells
- IGG-CNR library: papers, internal reports, ...
- Temperature maps @ various depth (1, 2, 3 km) from Calore et al. 1995 and Della Vedova et al. 2001
- Surface Heat flow maps: from Calore et al. 1995 and Della Vedova et al. 2001

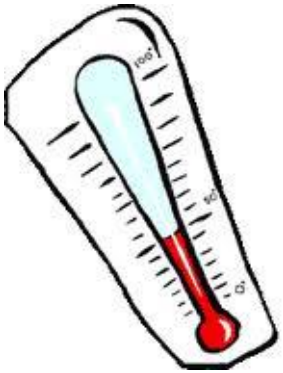
National Geothermal Database

Architectures and capabilities...

- HW – SW platform (data redundancy, informatic security, backup rutine)
- **Open Source platform**
- Database **documentation** (Entity-Relactionship scheme, Logic scheme, Glossary, Metadata ISO19115)
- Temperature and heat flow maps
- Webportal "*GEOTHOPICA*"



- Managment and data storage
- Geographycs and geostatistics analisys
- Visualization and interactivity desktop
- Visualization and interactivity web



National Geothermal Database

How is organized...

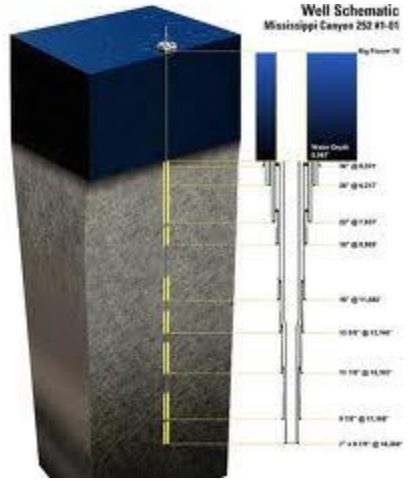
- wells and springs identity

- Chemical, physical and isotopic data of water and gas

- Temperature and deep correlations
- Well stratigraphy
- Well casing and technical profile
- Correlation between vertical and deviated well

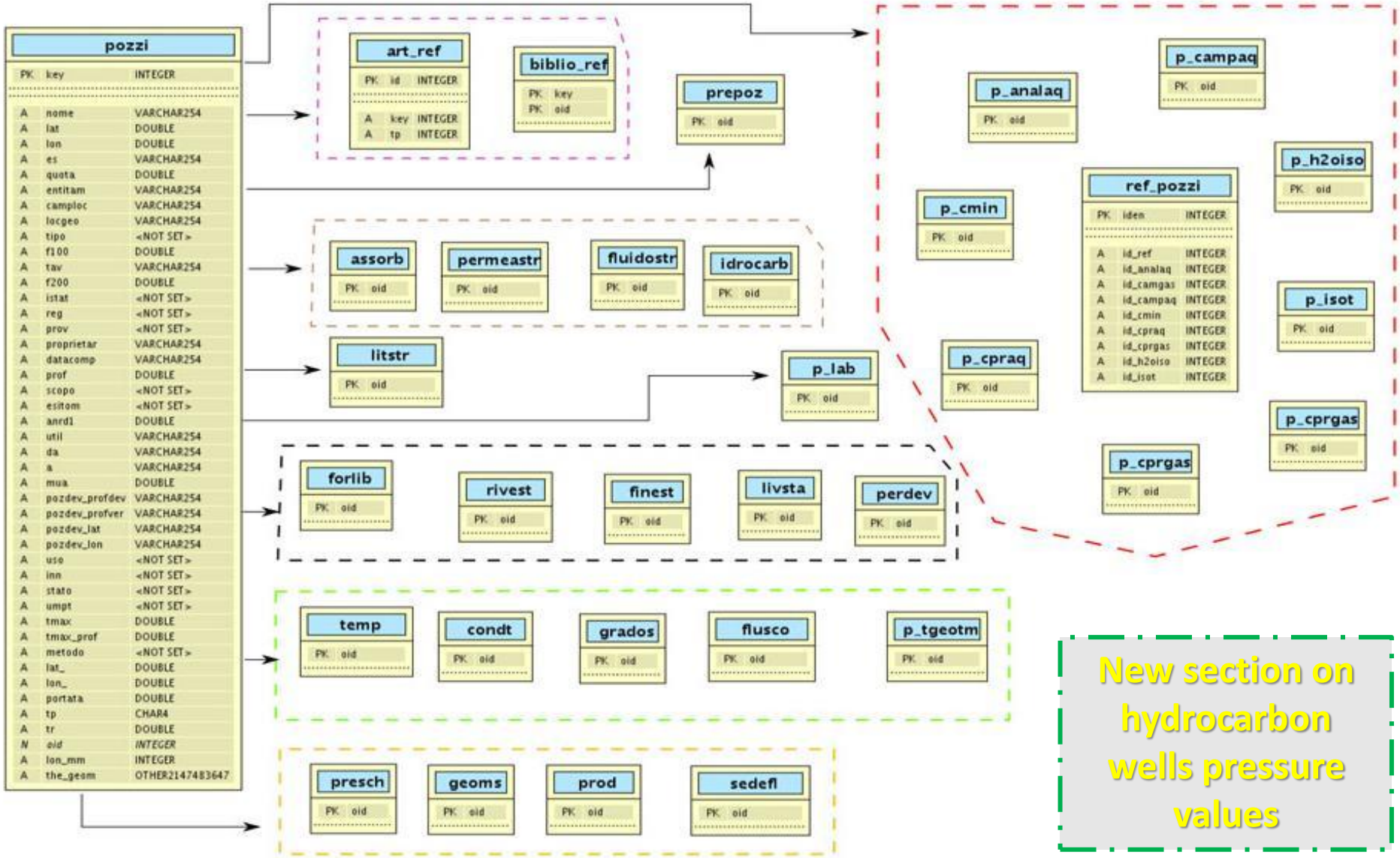
- Temperature gradient and heat flow
- Geothermal Reservoir characteristics
- Well production

- ✓ DST information
- ✓ Physical analysis
- ✓ Chemical Analysis
- ✓ Pressure test and values
- ✓ Thermal facies
- ✓ Well production
- ✓ Mud characteristic
- ✓ Permeability
- ✓ Mineralization in the well



National Geothermal Database

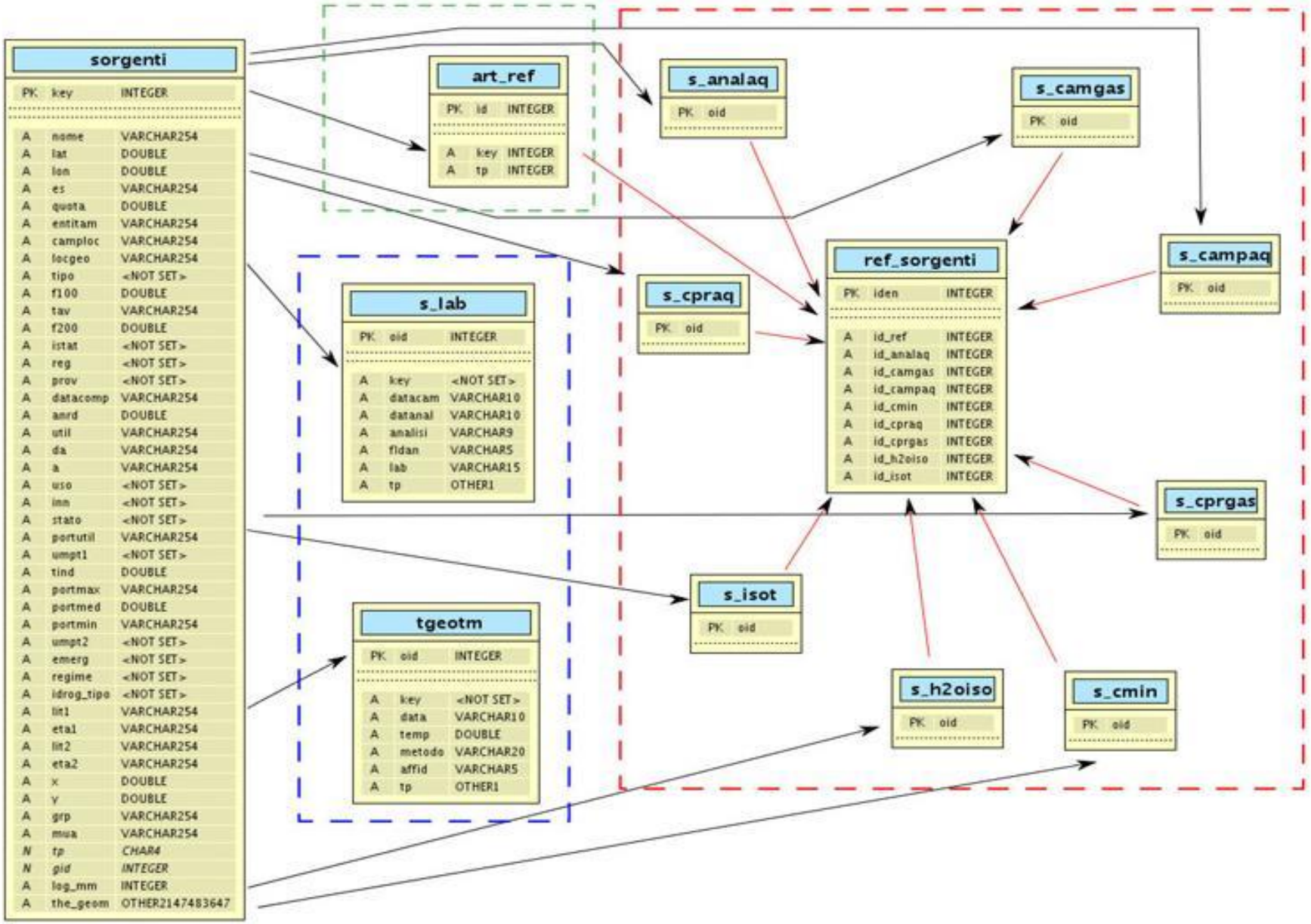
Wells – E-R schema



New section on hydrocarbon wells pressure values

National Geothermal Database

Thermal springs E-R schema



National Geothermal Database

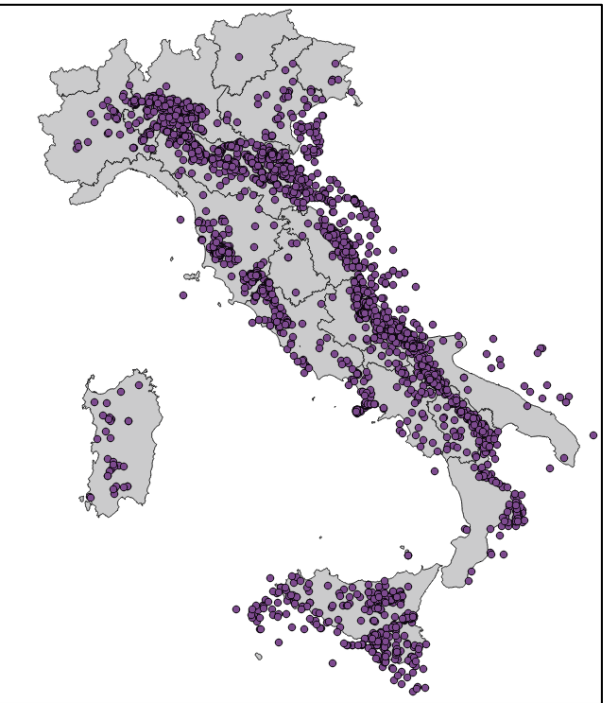
Well data: 3740 (2649)

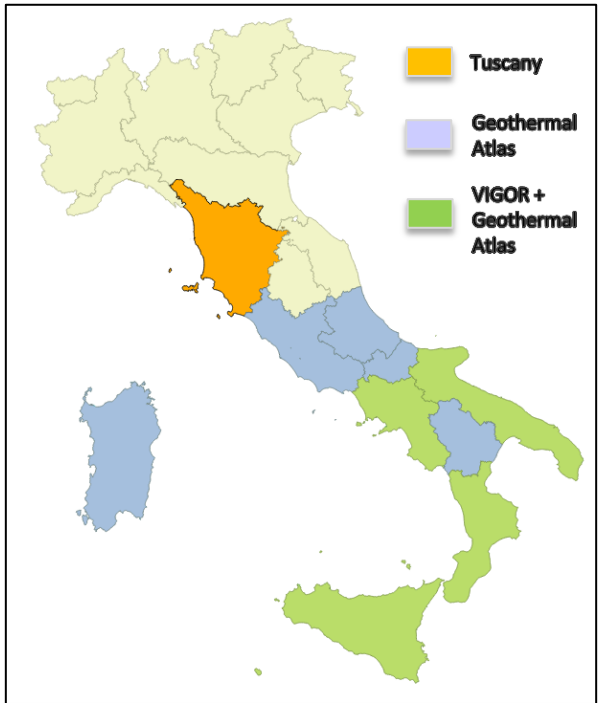
condt	assorb	grados	flusco	geoms	litstr	temp	fluidostr
50	184	1504	1506	504	3485	2724	336

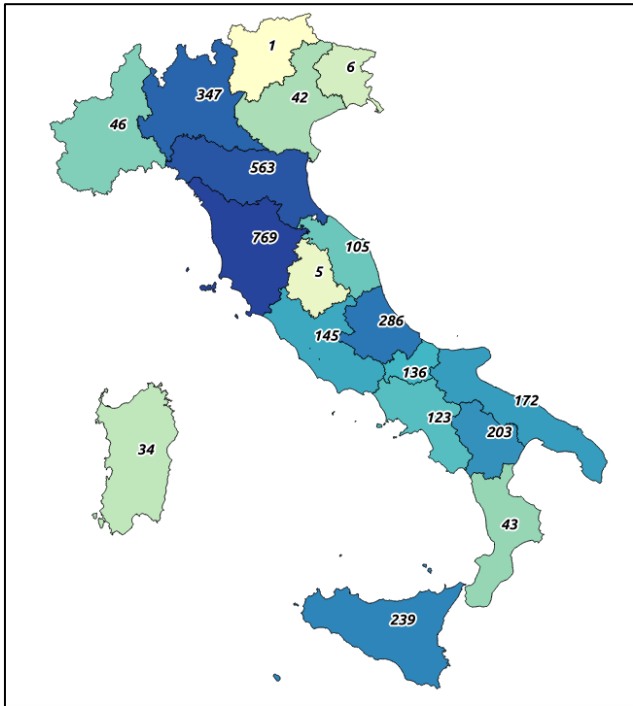
presch	prod	sedefl	tgeotm
252	245	427	28

analaq	cmin	cpraq	cprgas	h2oiso	idrocarb	campaq	p_lab
101	71	83	73	28	41	75	74

finest	forlib	rivest
52	728	1062

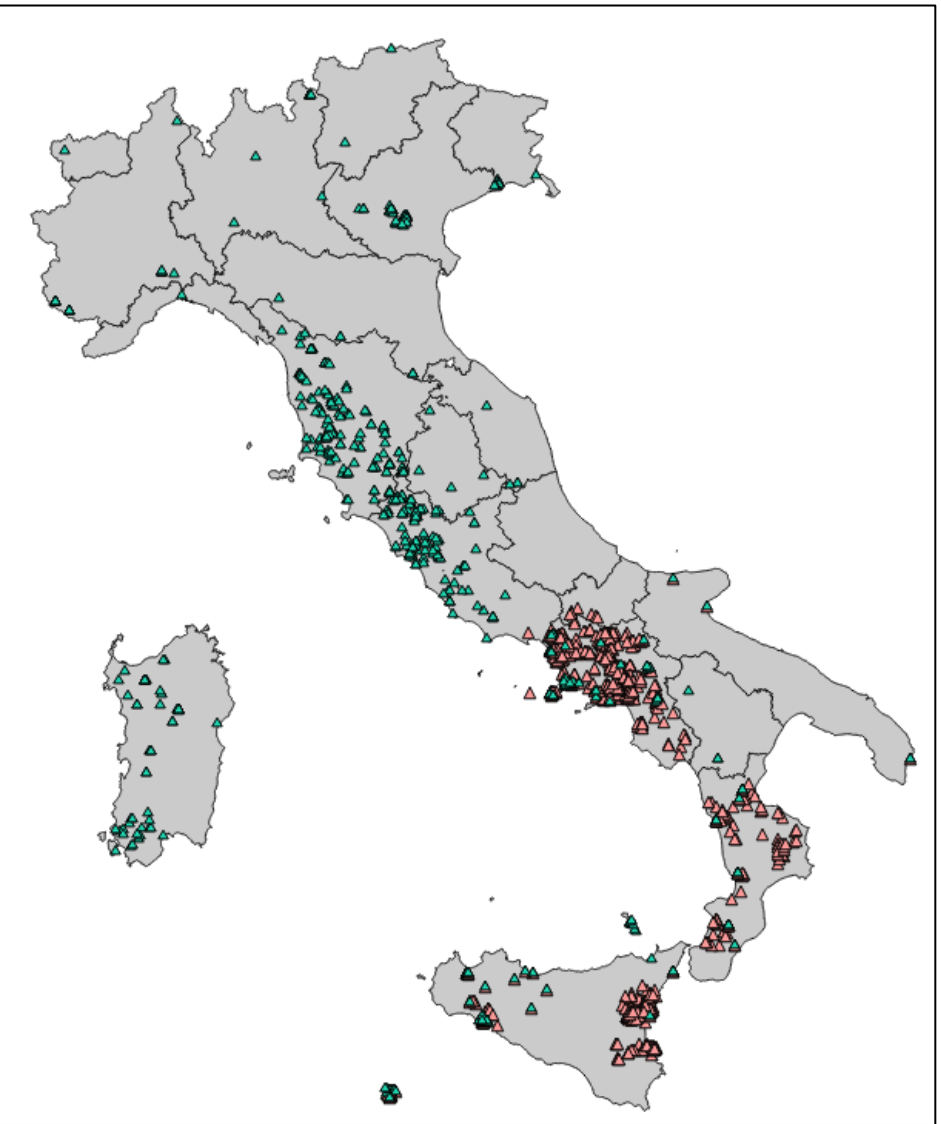






National Geothermal Database

Thermal springs: 589 (460)



analaq	cmin	cpraq	cprgas	h2oiso	isot
475	445	526	124	215	71

campaq	camgas	tgeotm
530	45	153

Thermal springs from letterature: 821 (VIGOR regions)

analaq	cmin	cpraq	cprgas	h2oiso	isot
495	443	485	122	181	116

campaq	tgeotm
501	41

Tuscany

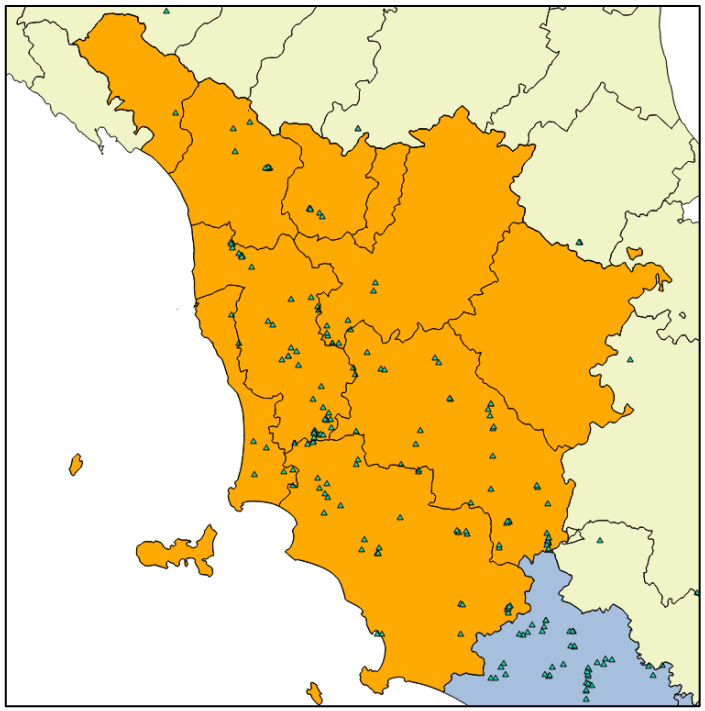
National Geothermal Database

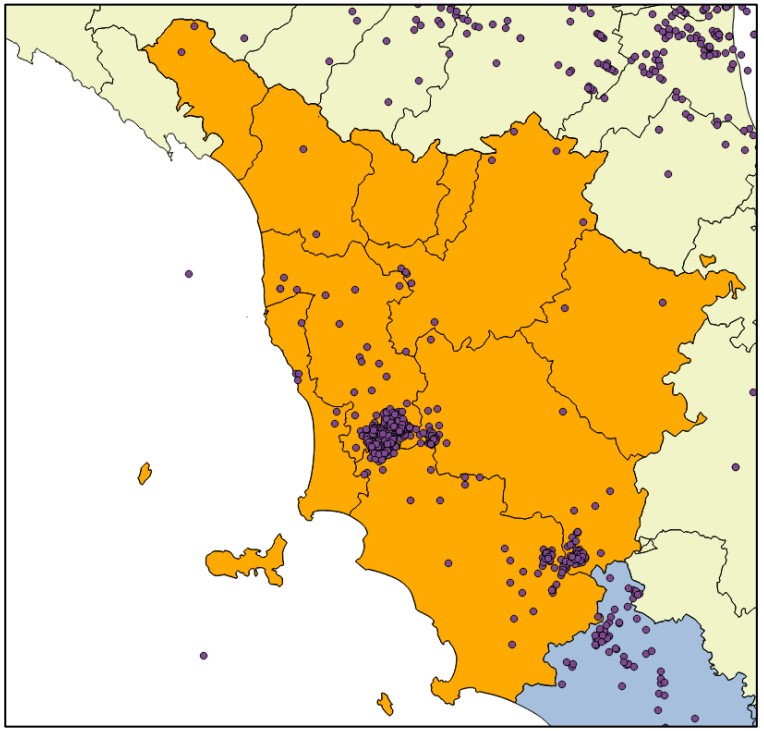
Well data: 771 Tuscany

condt	grados	flusco	geoms	litstr	temp
22	33	33	432	767	490

livsta	presch	prod	sedefl
29	225	210	356

finest	forlib	rivest
19	267	268



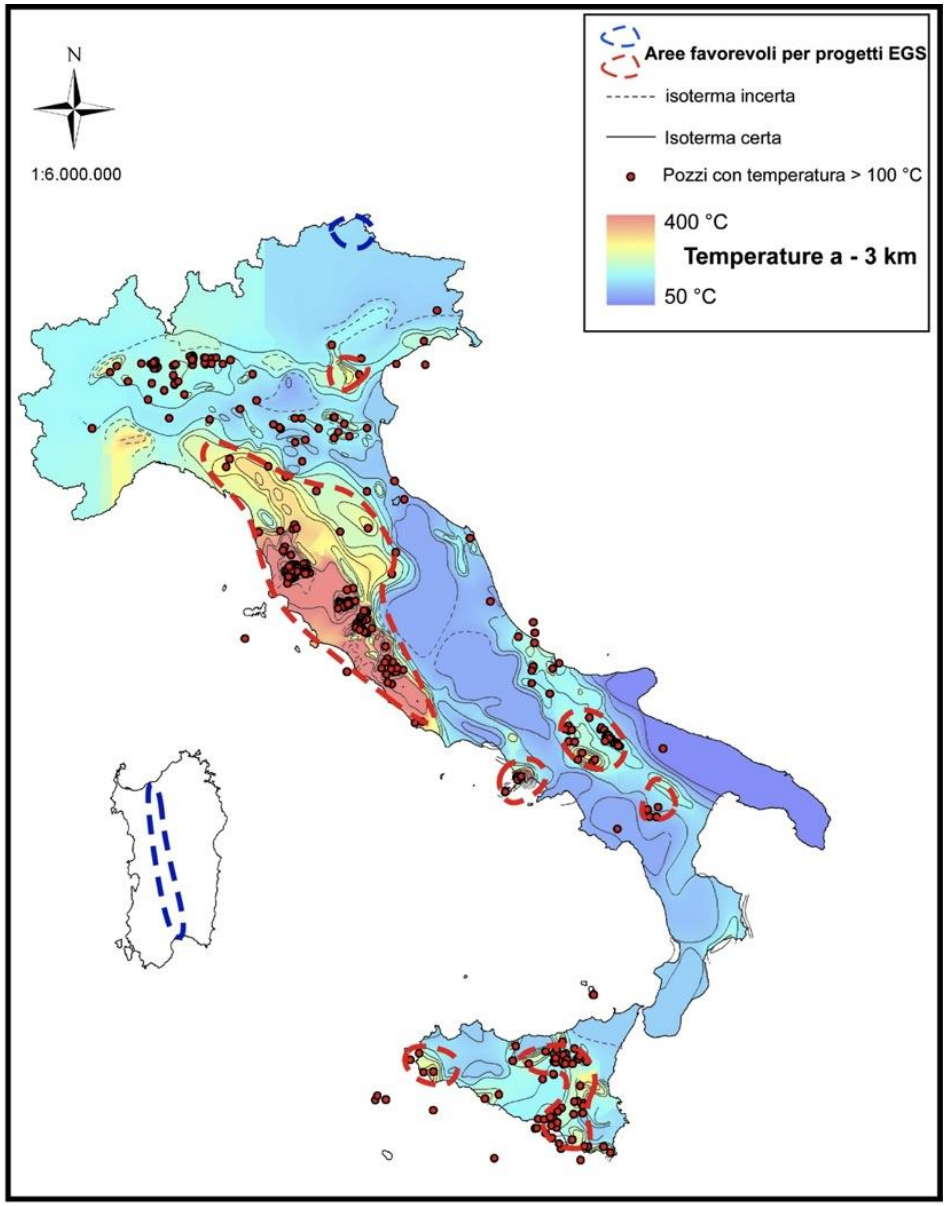


analaq	cmin	cpraq	cprgas	h2oiso	isot
130	127	146	32	59	12

campaq	tgeotm
151	51

National Geothermal Database

Map: Wells with temperature > 100°C



National Research Council of Italy

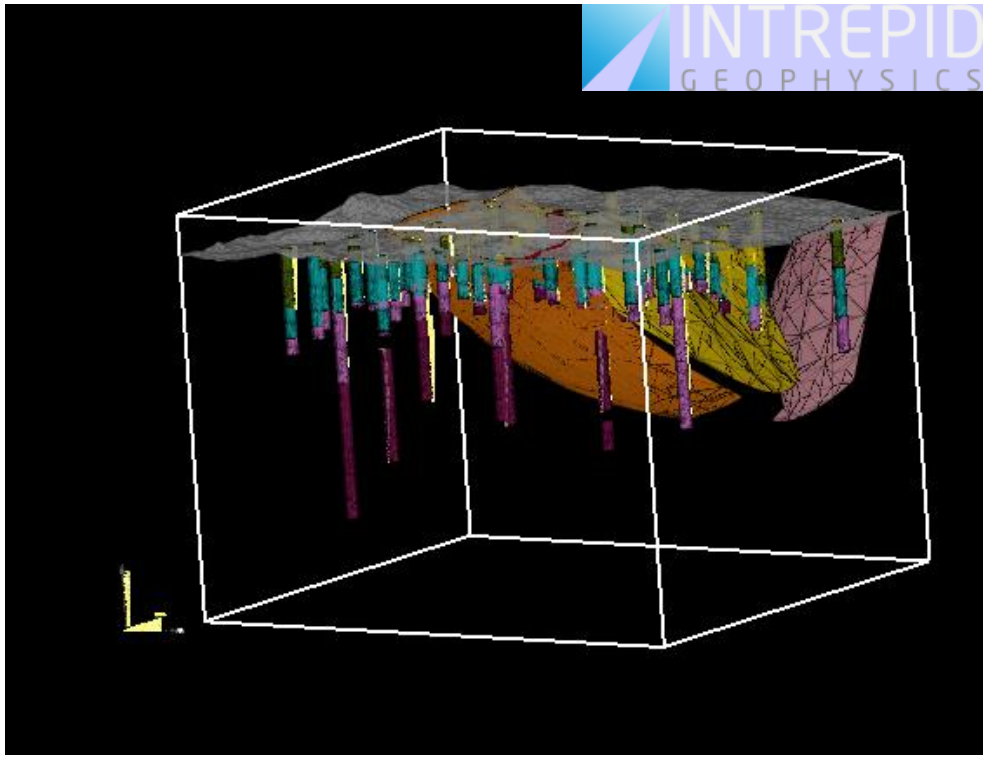
Institute of Geosciences and Earth Resources

Data Interpretation

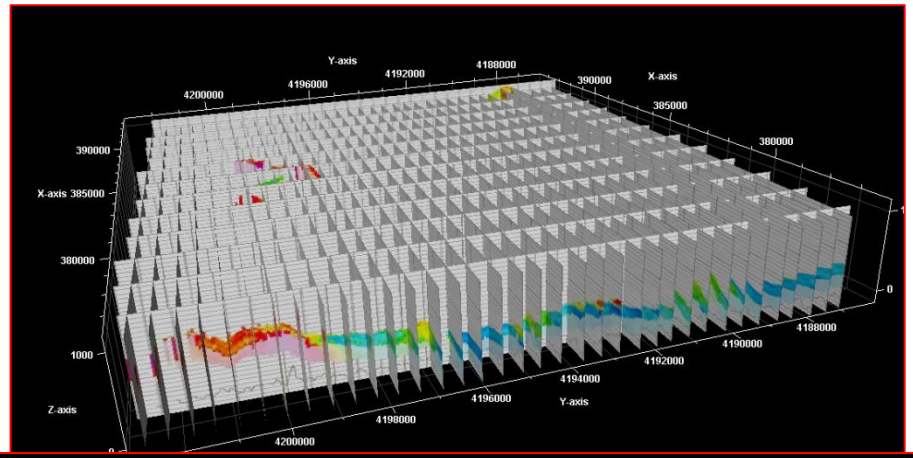
Data Interpretation I

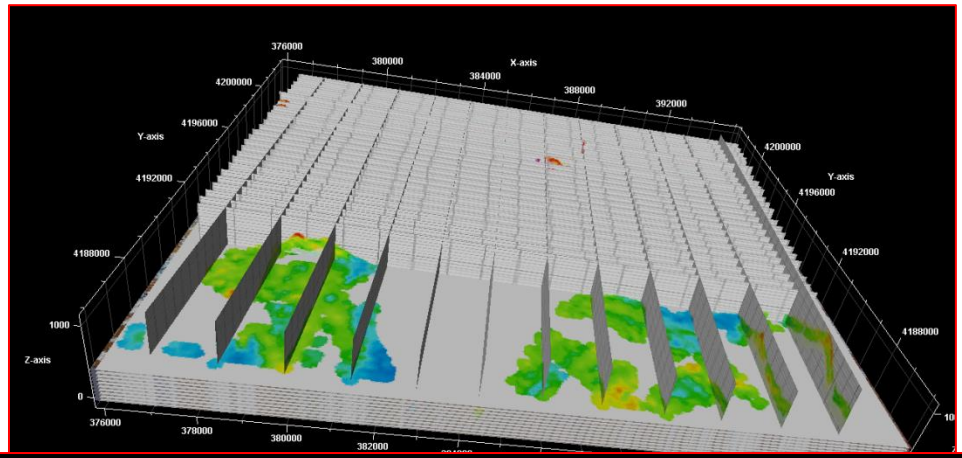
3D geological model

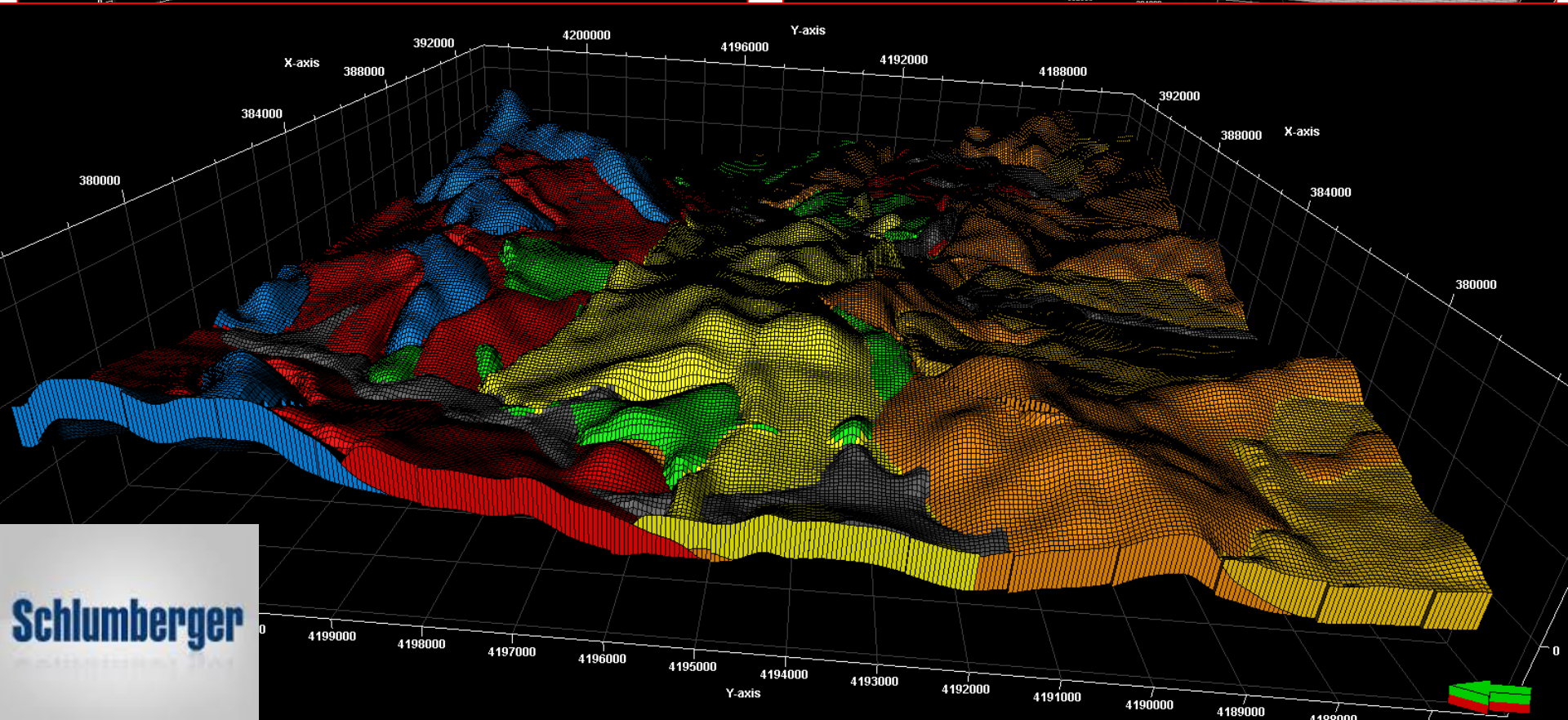
GeoModeller 2013



3D Geological Modeling





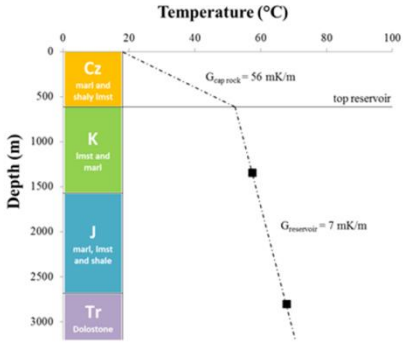


Schlumberger

Data Interpretation II

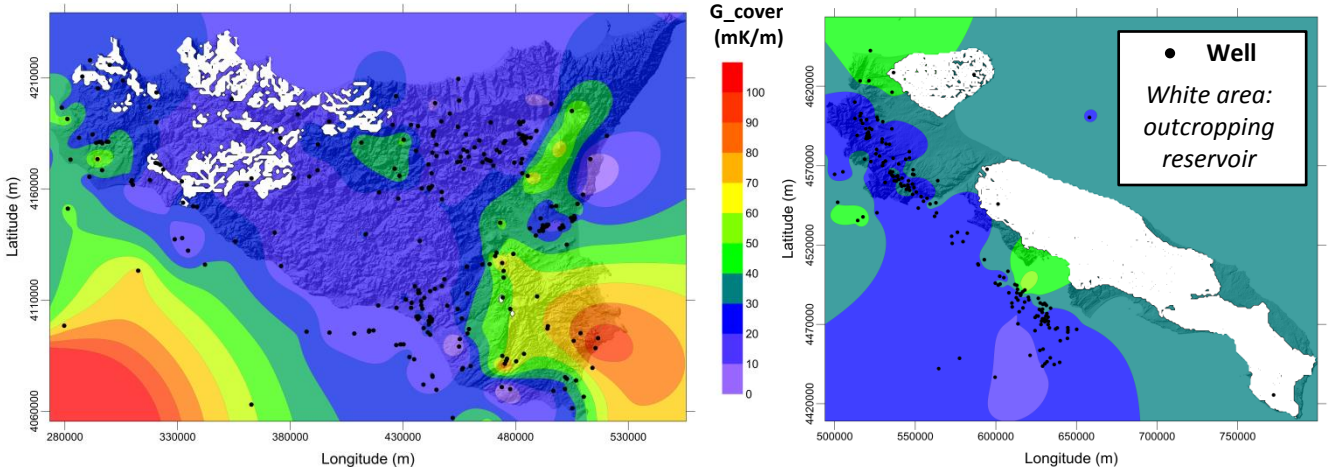
Geothermal Gradients inferred by well data

Temperature data, analysed well-by-well together with lithostratigraphic information, allowed to describe the temperature increase with depth both in the impermeable cap-rock units and in the potential reservoir units

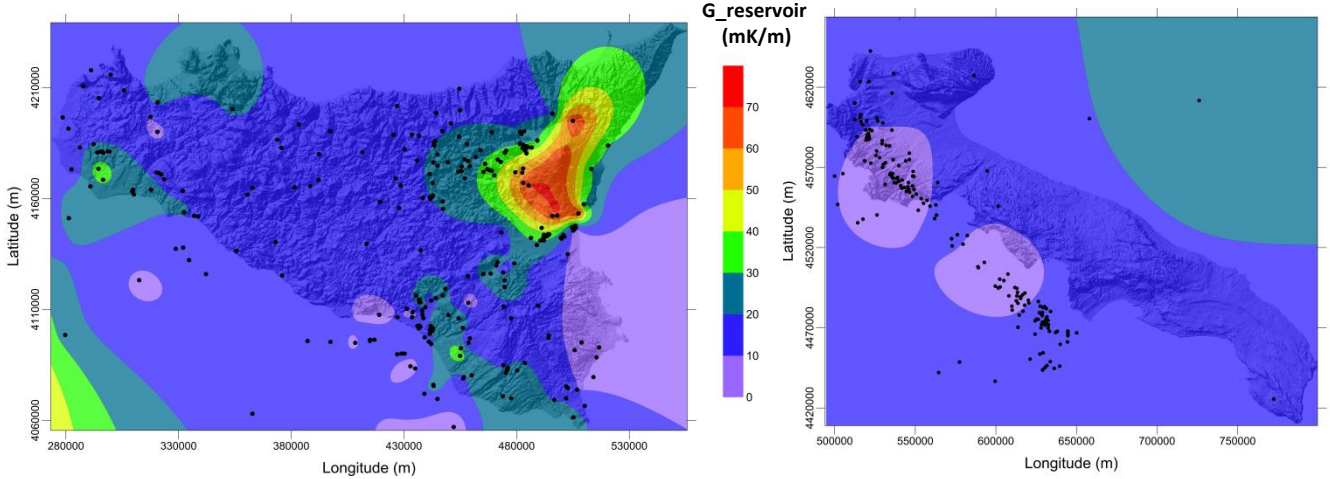


Example: Segesta 1 well (Sicily)

COVER



RESERVOIR

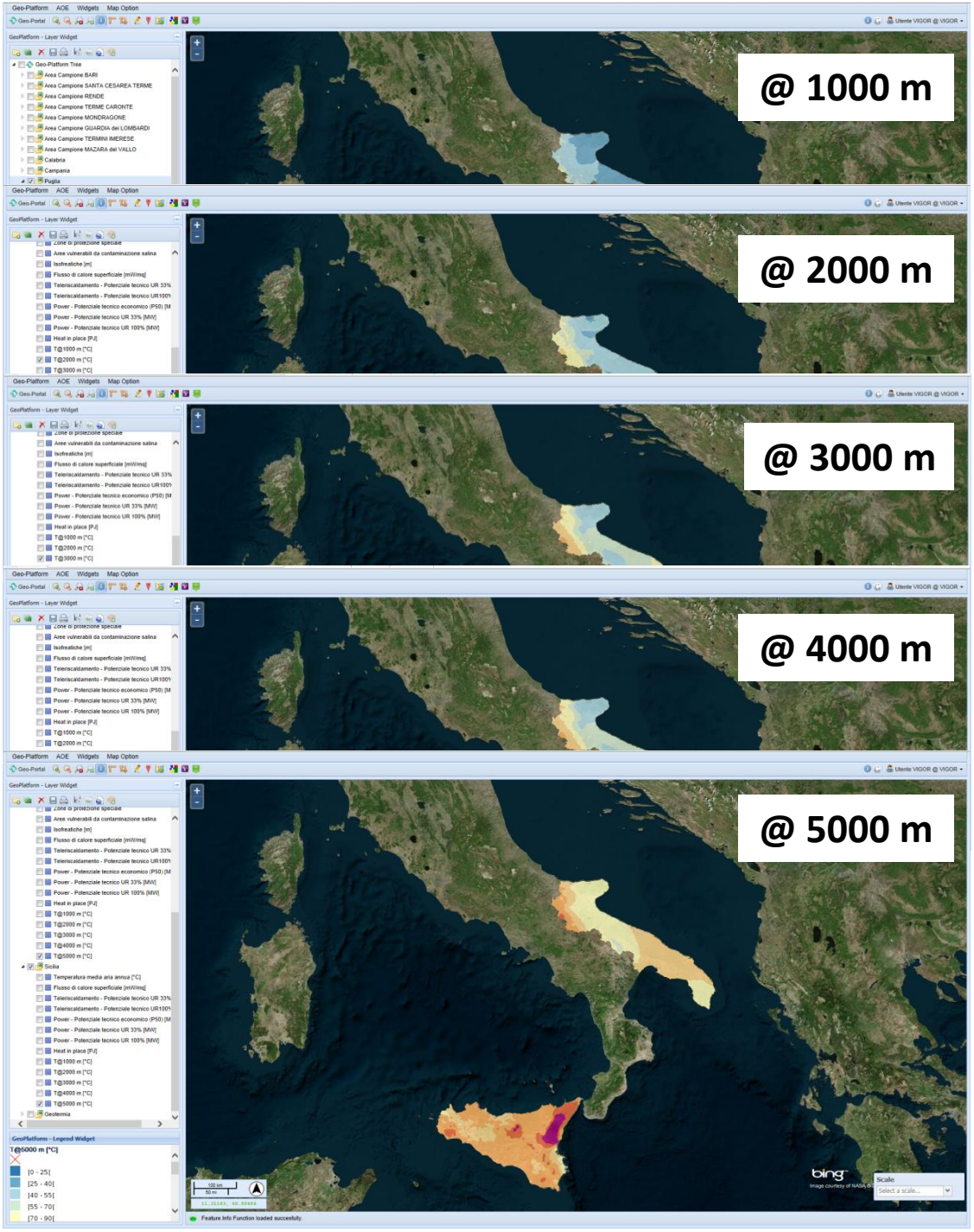


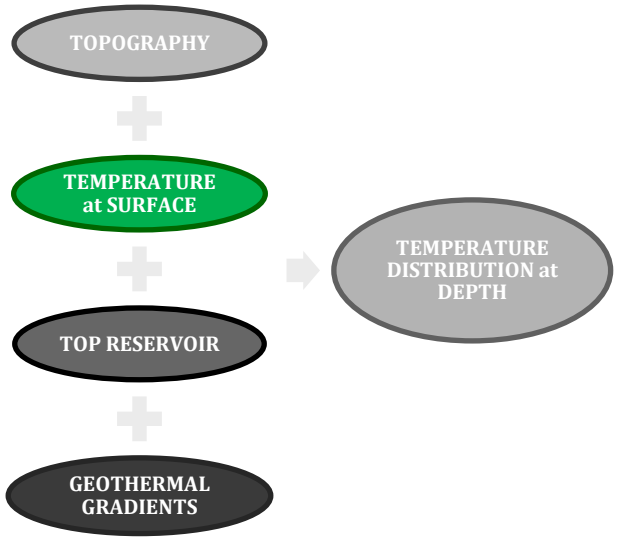
Focusing on conventional hydrothermal systems:

- In the **cap rock** the **high** temperature **gradients** imply a predominance of conductive heat transfer. Sedimentary cover geothermal gradients mimic the underlying geometries of the potential reservoir
- The temperatures in the carbonatic **reservoir** reveal very **low** geothermal **gradients** where the component of convective heat transfer is not negligible

Temperature distribution

www.vigor-geotermia.it/geo-portal/





The newly constructed model of subsurface temperatures down to 5 km depth

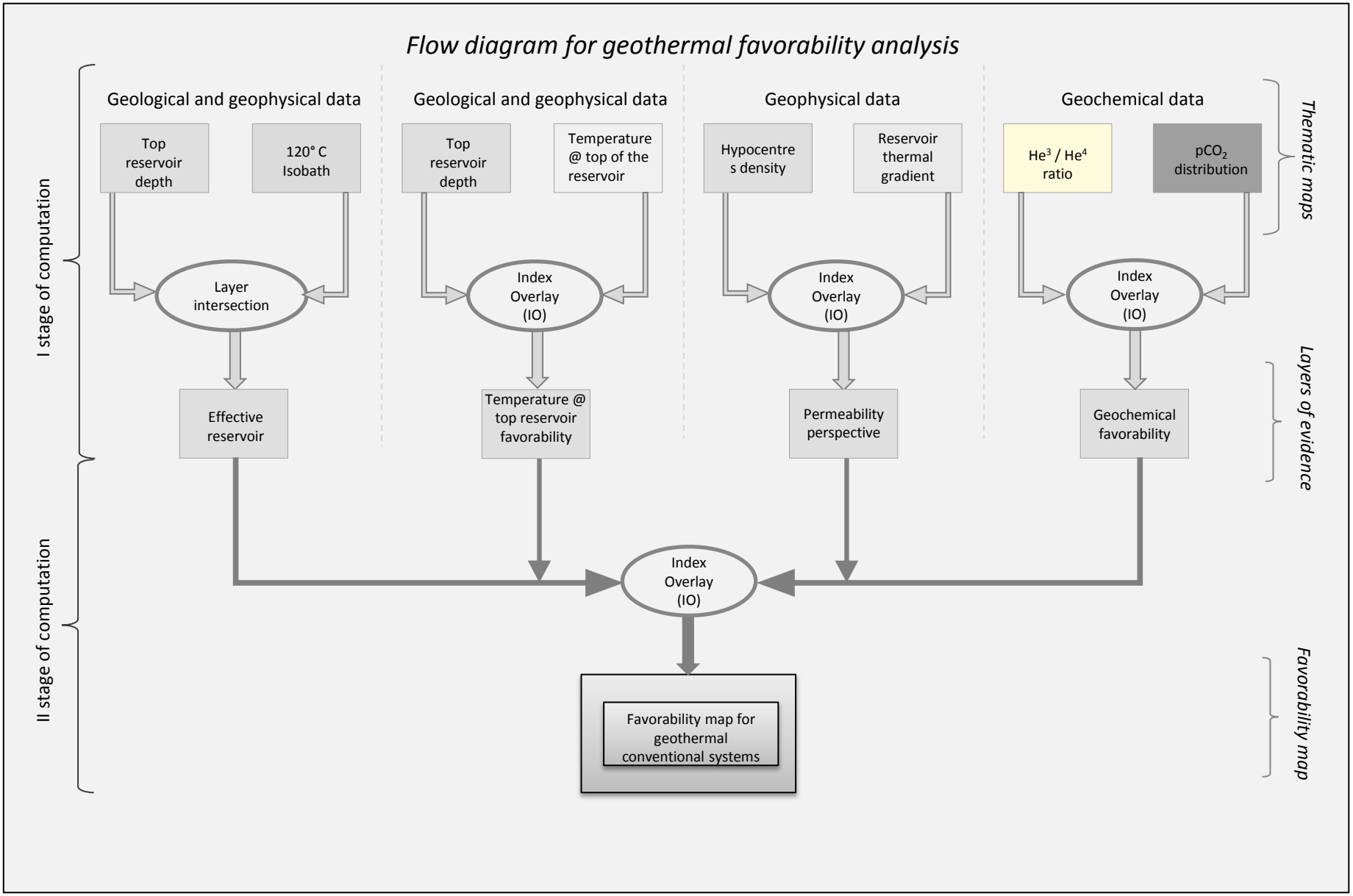
T (°C)

- < 25
- 25-40
- 40-55
- 55-70
- 70-90
- 90-120
- 120-180
- 180-250
- > 250

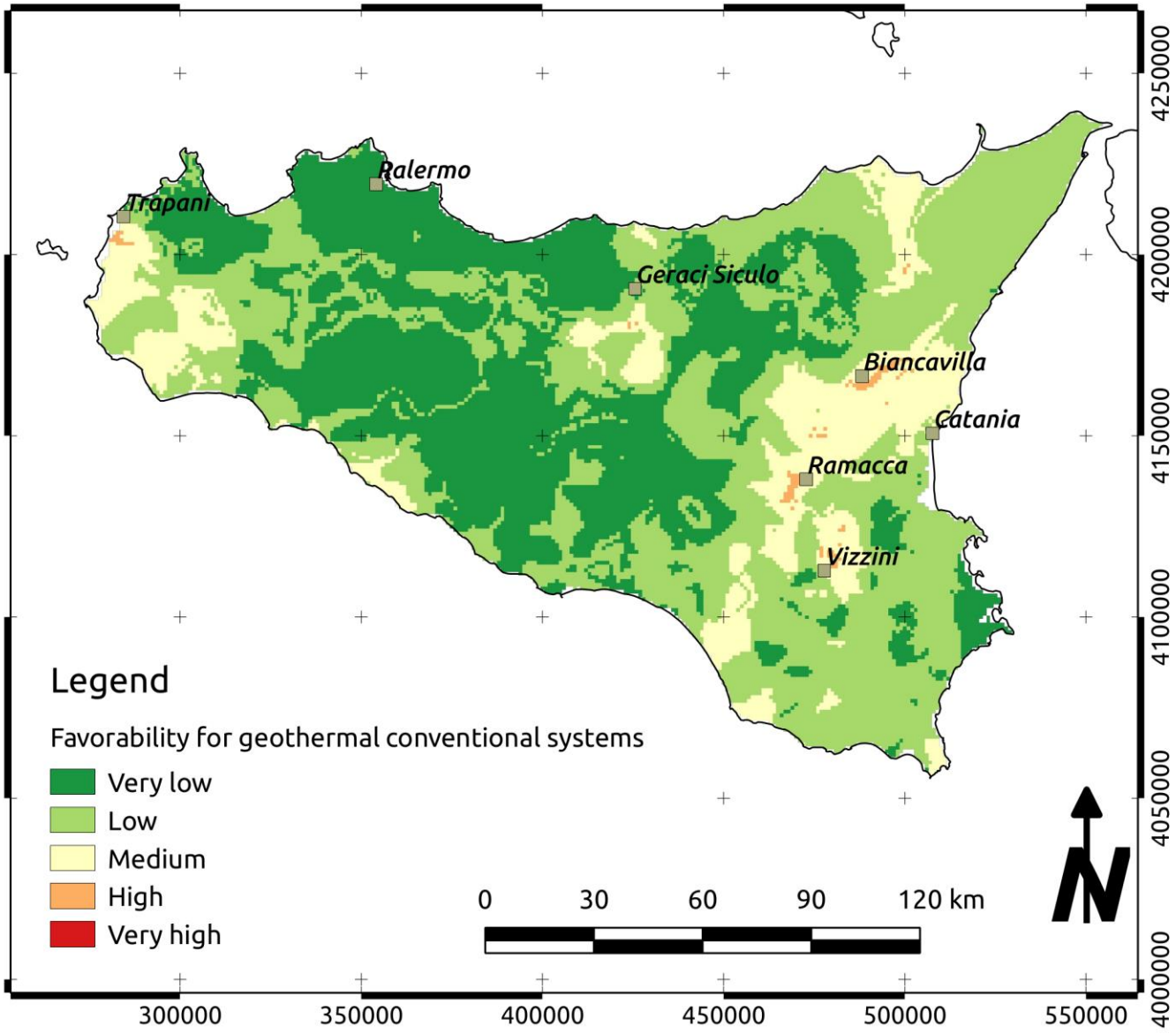
National Research Council of Italy

Institute of Geosciences and Earth Resources

Geothermal Favorability Map


Flow diagram for geothermal favorability analysis
Geological and geophysical data
Geological and geophysical data
Geophysical data
Geochemical data
Top reservoir depth
120° C Isobath
Top reservoir depth
Temperature @ top of the reservoir
Hypocentre s density
Reservoir thermal gradient
He3 / He4 ratio
pCO2 distribution
Thematic maps
I stage of computation
Layer intersection
Index Overlay (IO)
Index Overlay (IO)
Index Overlay (IO)
Effective reservoir
Temperature @ top reservoir favorability
Permeability perspective
Geochemical favorability
Layers of evidence
II stage of computation
Index Overlay (IO)
Favorability map for geothermal conventional systems
Favorability map

Favorability map for Hydrothermal Conventional System in Sicily region



Geothermal ATLAS

National Research Council of Italy

Institute of Geosciences and Earth Resources

Geothermal Potential Assessment

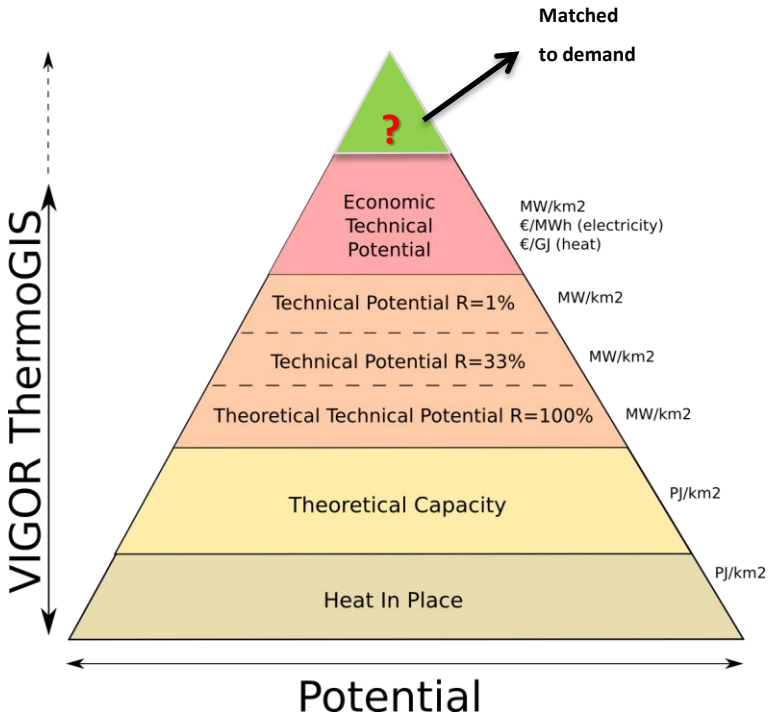
Geothermal Resources Assessment, the case study of VIGOR project

VIGOR ThermoGIS works both in **2D** and in **3D**

- Data input are the **result** of a team specialists: geologist, hydro-geologist, geo-chemist, geophysicists, ...
- **Volumetric** method assessment
- Include **montecarlo** calculation to incorporate the effects of **uncertainty**
- Output maps: **temperature maps** @ various depth, **technical potential** for power and heat applications

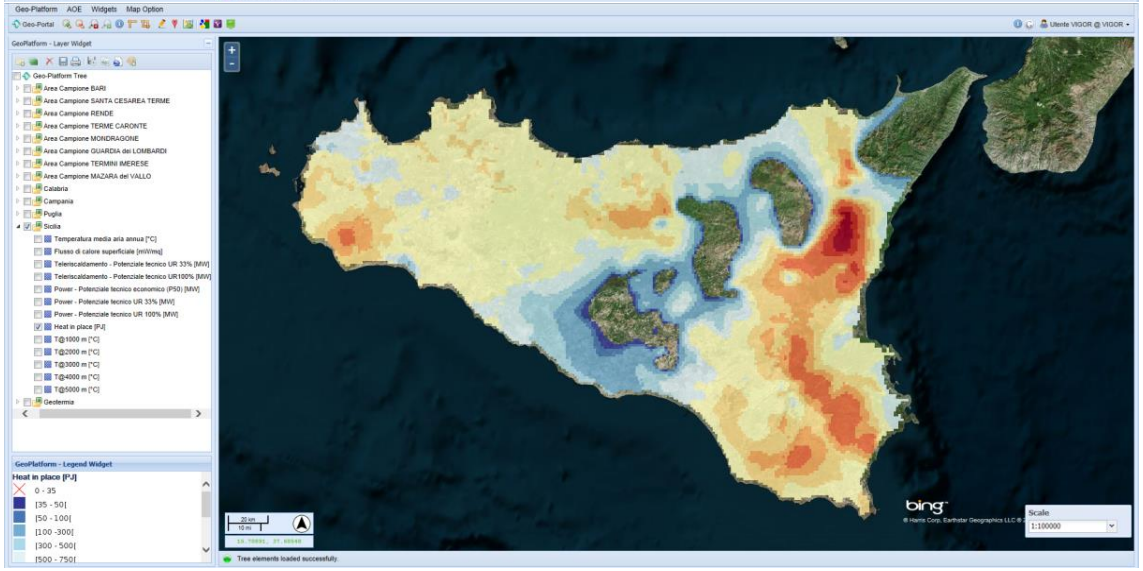
VIGOR ThermoGIS

- ✓ Economic technical potential (**MW/km2**, potential with a threshold, **LCOE** < =200 €/MWh for power and 9€/GJ for heat)
- ✓ Technical potential for different Ultimate Recovery factor (**MW/km2**)
- ✓ Theoretical Capacity for specific technologies (H x efficiency, **PJ/km2**)
- ✓ Heat in place, maximum thermal energy extractable from the reservoir (**PJ/km2**)



Heat in place

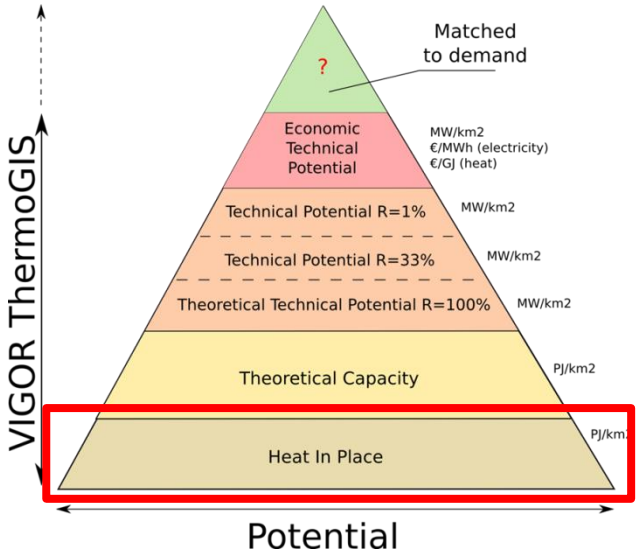
The HIP is computed as the maximum of the thermal energy available in the reservoir.
The computation for each voxel is:



$$HIP\ [PJ] = V \times (\rho c)_{rock} \times (T - T_o) 10^{-15}$$

HIP (PJ)

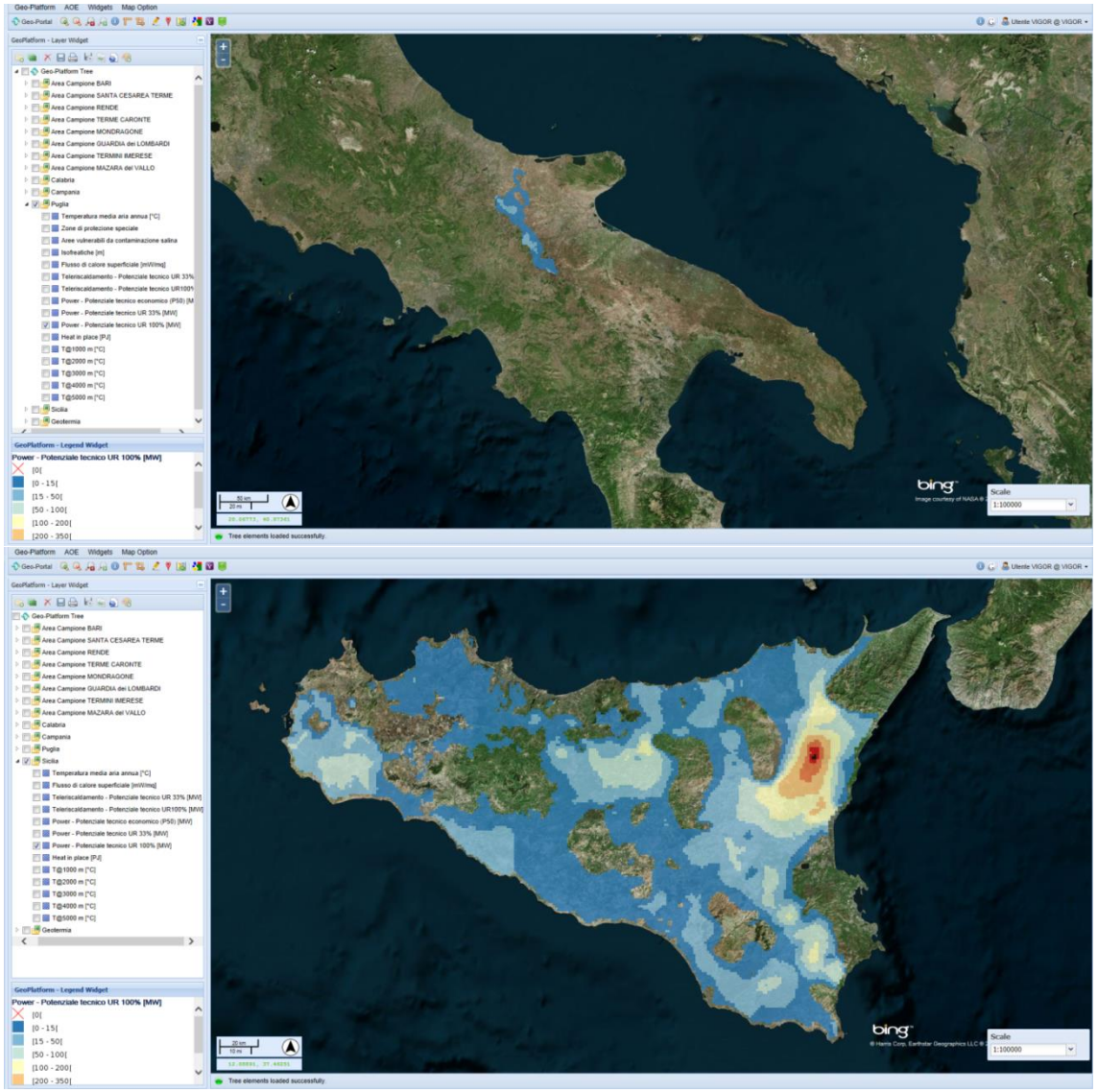
- < 50
- 50-300
- 300-500
- 500-750
- 750-1000
- 1000-1250
- 1250-1500
- 1500-2000
- > 2000



From Theoretical capacity to Technical potential

The theoretical capacity (TC) is given by the HIP used by the application and efficiency (η) and by the re-injection temperature.

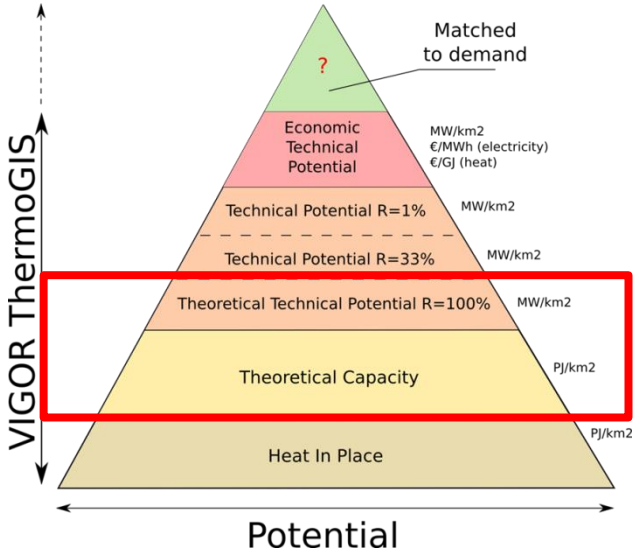
The technical potential (TP) shows the expected geothermal energy extractable [MW] and assumes that the resources will be exploited for a period of 30 years.



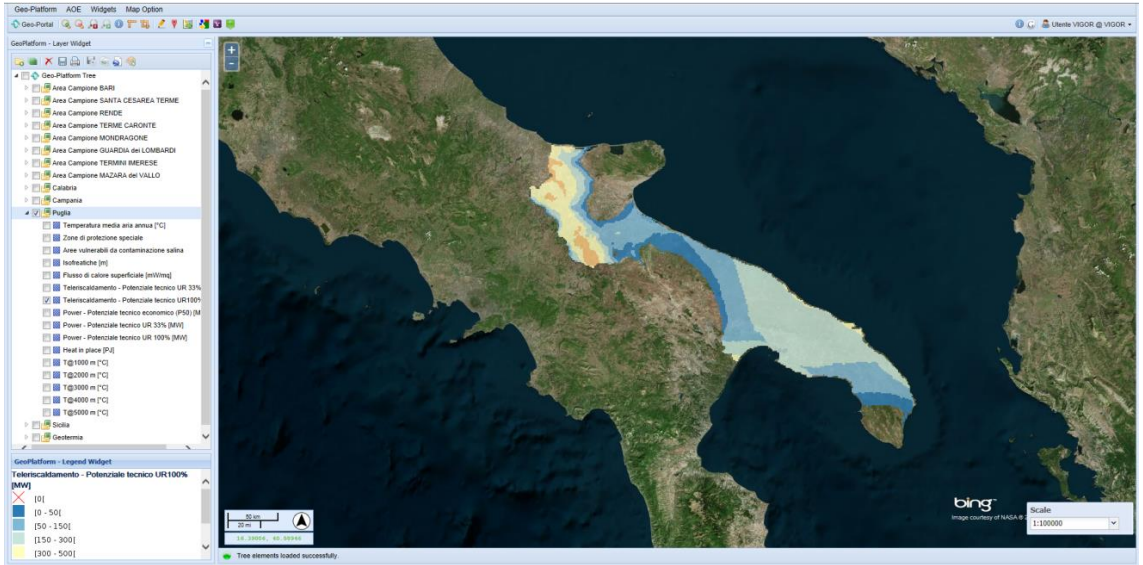
	Power (Binary plant)
Minimum Temperature	120 °C
Re-injection Temperature	97 °C

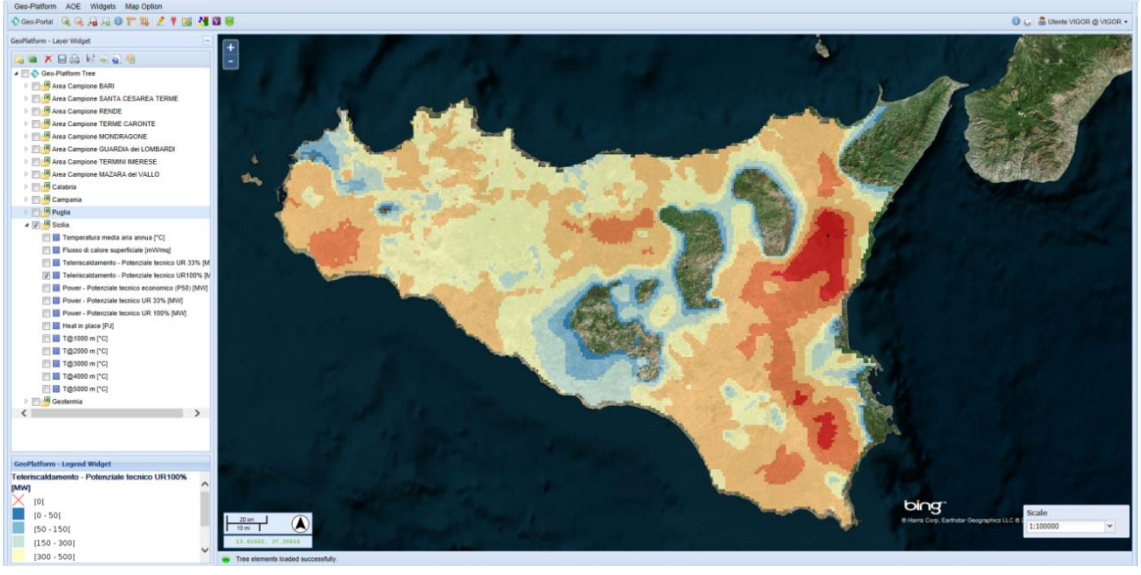
TP (MW)

- < 15
- 15-50
- 50-100
- 100-200
- 200-350
- 350-500
- > 500



From Theoretical capacity to Technical potential

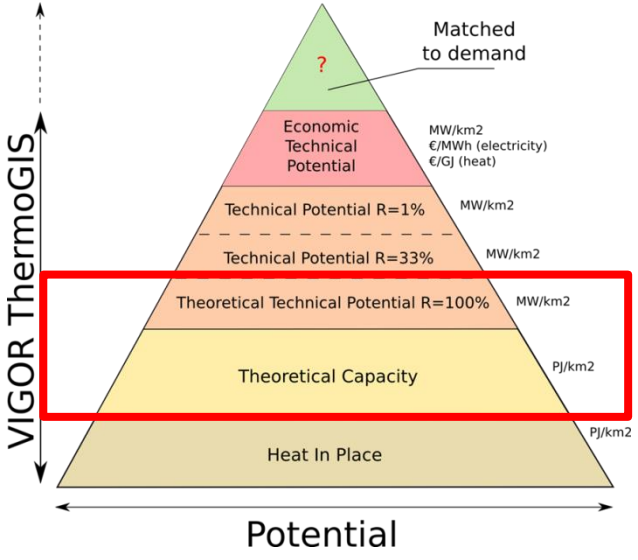




	District heating and cooling
Minimum Temperatura	80 °C
Re-injection Temperature	40 °C

TP (MW)

- < 15
- 15-50
- 50-100
- 100-200
- 200-350
- 350-500
- > 500



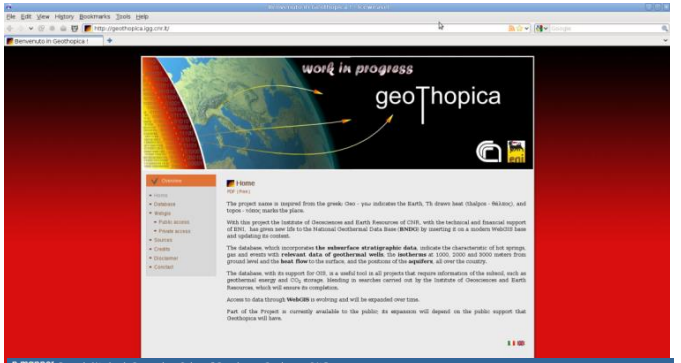
National Research Council of Italy

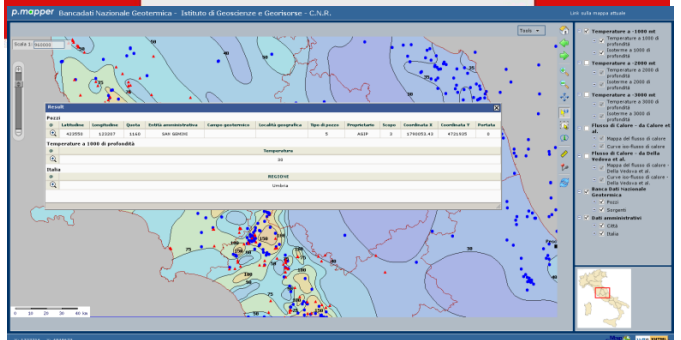
Institute of Geosciences and Earth Resources

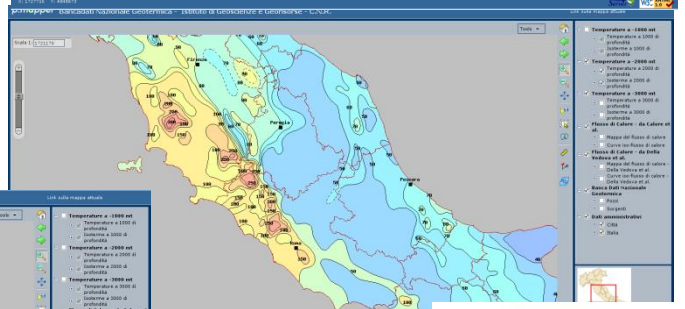
Geothermal Data Dissemination

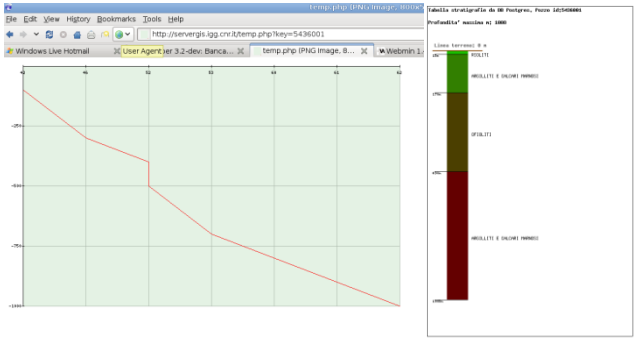
http://geothopica.igg.cnr.it

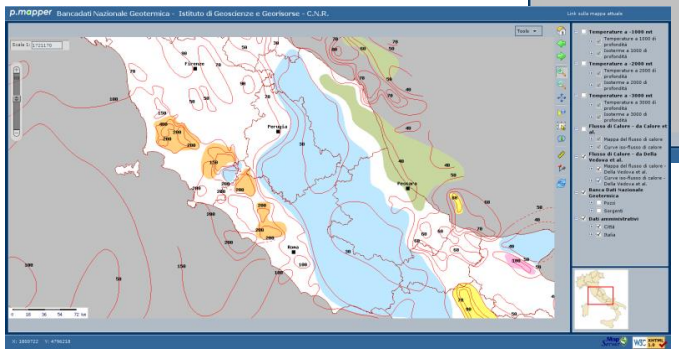
- The **Geothopica** web portal makes available some information from the National Geothermal database. Users can access to data and maps on the basis of the data policy access.
- Within the portal a **webGIS** tool allows the viewing of the **temperature maps** at 1, 2, 3 km depth and the **surface heat flow** map of Italy.
- The **location** of geothermal wells and thermal spring are available.
- The portal will be implemented soon with analytics capabilities as well as chart and reports that allow a quick and effective analysis of the data stored in.











//

Recent Changes

- added: today | yesterday | last 7 days | since last login
- edited: today | yesterday | last 7 days | since last login
- published in: 2012 | 2011 | 2010 | 2009

Most recently added publications:

Catalano, R., Merlini, S, Sulli, A. (2002). The structure of western Sicily, central Mediterranean. *petroleum geoscience*, *8*, 7–18.

Polemio, M., Limoni, P. P., Mitolo, D., & Virga, R. (2006). Il degrado qualitativo delle acque sotterranee pugliesi. *Giornale di Geologia Applicata*, (3), 25–31.

Polemio, M., & Casarano, D. (2008). Climate change, drought and groundwater availability in southern Italy. In W. Dragoni, & B. S. Sukhija (Eds.), *Climate Change and Groundwater* (Vol. 288, pp. 39–51). London: The Geological Society.

Polemio, M., Dragone, V., & Limoni, P. P. (2008). Salt contamination of Apulian aquifers: spatial and time trend. In *1st SWIM-SWICA meeting (19th SWIM & 3rd SWICA jointed meeting)* (pp. 115–121). Cagliari.

Polemio, M., & Casarano, D. (2008). Climate change, drought and groundwater availability in southern Italy. In W. Dragoni, & B. S. Sukhija (Eds.), *Climate Change and Groundwater* (Vol. 288, pp. 39–51). London: The Geological Society.

Polemio, M., Dragone, V., & Limoni, P. P. (2008). Salt contamination of Apulian aquifers: spatial and time trend. In *1st SWIM-SWICA meeting (19th SWIM & 3rd SWICA jointed meeting)* (pp. 115–121). Cagliari.

Polemio, M., Casarano, D., & Limoni, P. P. (2009). Karstic aquifer vulnerability assessment methods and results at a test site (Apulia, southern Italy). *Natural Hazards and Earth System Sciences*, *9*(4), 1461–1470.

Show My Group:

(no groups available) | Show

Recall My Query:

(no queries available) | Go | Edit

Fill-in instructions

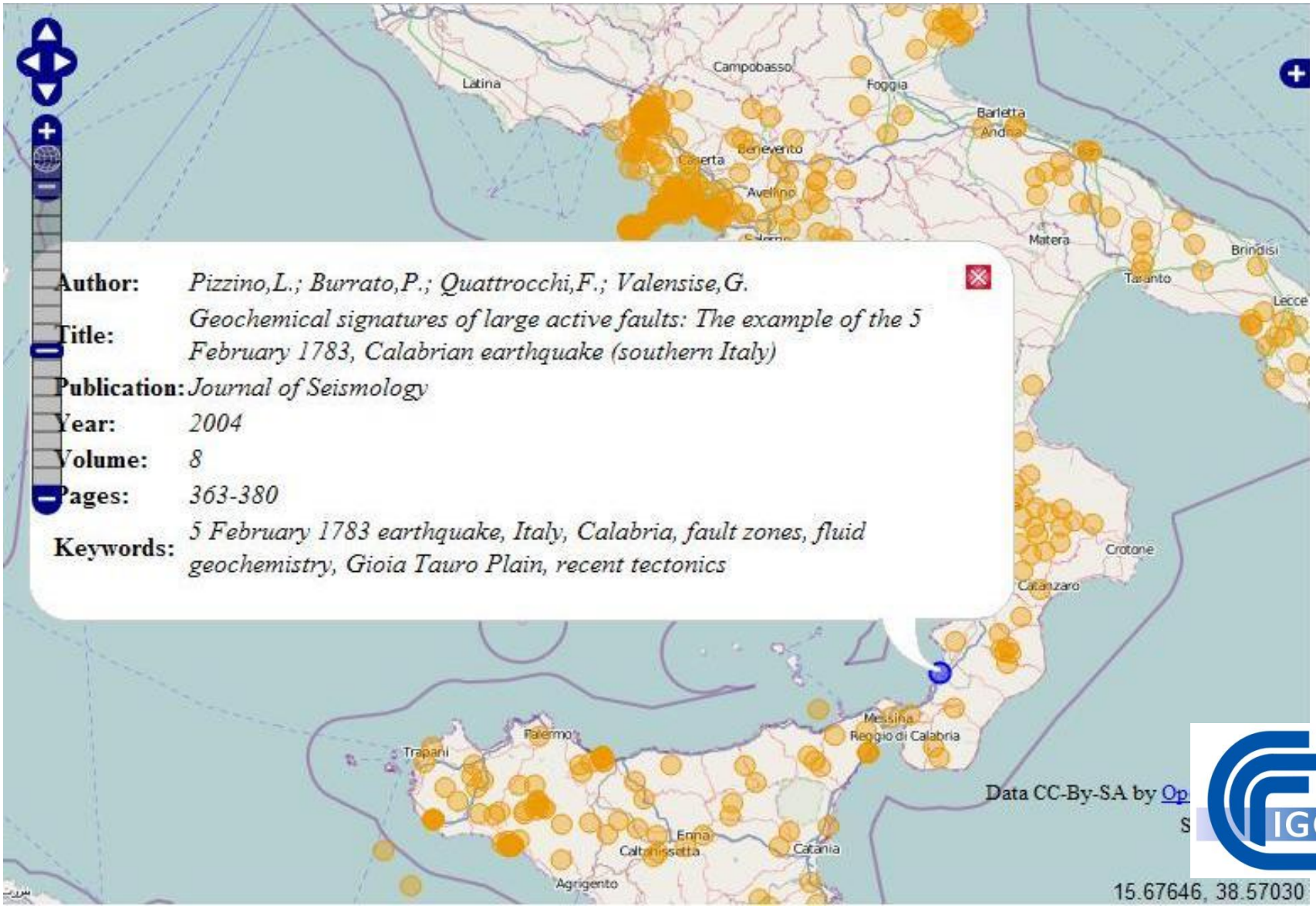
Here you can find a keynotes list to compile the forms of VIGORBIB How to fill-in

About

This literature database is maintained by the Institute for Geosciences and Earth Resources (IGG). You're welcome to send any questions or suggestions to our feedback address. The database is powered by refbase, an open source database front-end for managing scientific literature & citations.

GEOVIGORBIB

Papers located for VIGOR project



The web-oriented framework of the world geothermal production database: a business intelligence platform for wide data distribution and analysis

Eugenio Trumpy[1], Ruggero Bertani[2], Adele Manzella[1], Marietta Sander[3],

[1] Institute of Geosciences and Georesources – National Research Council of Italy, Via Moruzzi 1 – 56124 PISA, Italy

[2] ENEL Green Power, Italy

[3] International Geothermal Association (IGA), Secretariat c/o Bochum University of Applied Sciences, Germany

e.trumpy@igg.cnr.it

Global Geothermal Energy Database - IGA

Database content:

- ✓ IGA periodically collect geothermal data
- ✓ Every 5 years for World Geothermal Congress countries provide an update on national geothermal use (power and direct use)

http://www.geothermal-energy.org/ IGA web site

→ Geothermal energy

→ Geothermal energy database

User: visitor – Password: visitor

The GGED was developed by the IGA in cooperation with the Institute of Geoscience and Earth Resources (CNR), Italy.
Updates are conducted by the CNR following the regular content update of IGA.

Global Geothermal Energy Database - IGA

Database contents:

- ❑ Geothermal fields (location – field owner – geothermal plants)
- ❑ Geothermal plants (typology – plant owner - turbine)
- ❑ Turbine (installed and running capacity [MWe] – produced energy [GWh] – status - COD)
- ❑ Direct use of the heat (type of use – installed capacity [MWth] – annual production [TJ/year])

Typology of plants

- Binary
- Single flash
- Double flash
- Back pressure
- Dry steam
- Hybrid

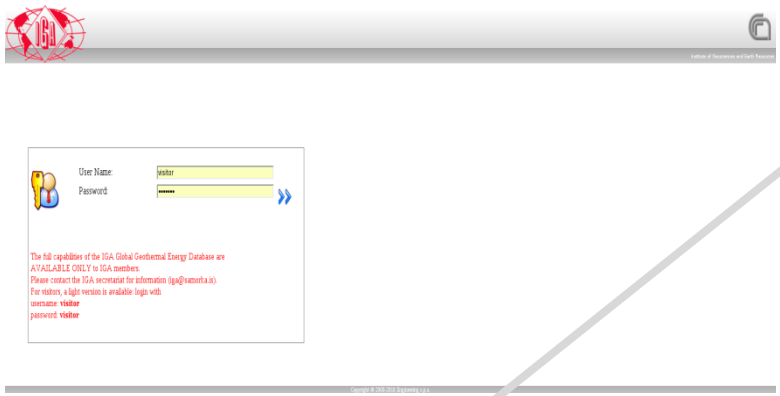
Category of uses

- Individual space heating
- District heating
- Air conditioning (cooling)
- Greenhouse
- Fish farming
- Animal farming
- Agricultural drying
- Industrial process heat
- Snow melting
- Bathing and Swimming
- Geothermal heat pumps
- Other uses

Global Geothermal Energy Database - IGA

The web application allows the login for two kinds of user:

- ✓ i) igamember
- ✓ ii) visitor



Menu

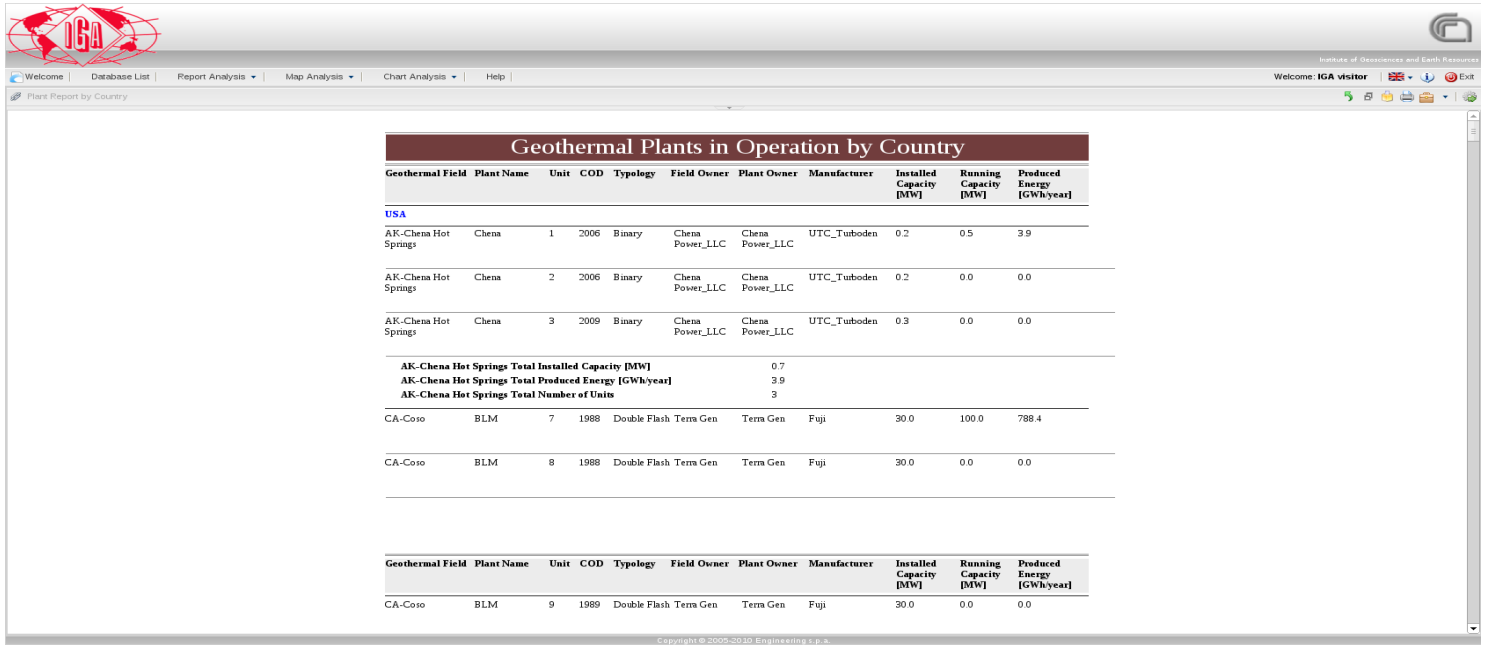
- ✓ Database list (only for igamember)
- ✓ Report analysis
- ✓ Map analysis
- ✓ Chart analysis
- ✓ help

- ✓ Logged in user
- ✓ Log out

Global Geothermal Energy Database - IGA

Report analysis:

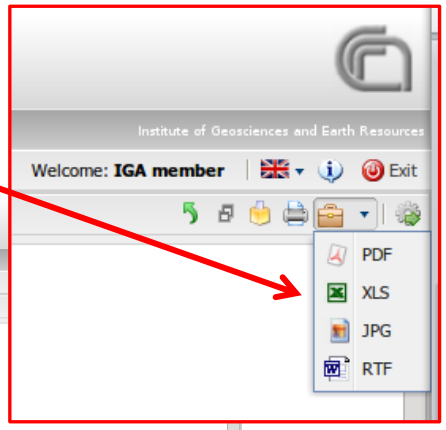
- ✓ Geothermal plants in operation by country
- ✓ Geothermal plants in operation by category
- ✓ Geothermal plants by their operative status
- ✓ Geothermal plants in operation by country and by their operative status
- ✓ Geothermal plants in operation and planned by country
- ✓ Geothermal plants by GEA code
- ✓ Direct use by country
- ✓ Direct use by category
- ✓ Direct use by GEA code



Global Geothermal Energy Database - IGA

Report analysis

Export menu



Welcome | Database List | Report Analysis | Map Analysis | Chart Analysis | Help

Plant Report Future

Geothermal Field	Plant Name	Unit	COD	Typology	Status	Field Owner	Plant Owner	Manufacturer	Installed Capacity [MW]	Running Capacity [MW]
Travale-Radicondoli	Rancia	1	1986	Dry Steam	in operation	Enel Green Power	Enel Green Power	Ansaldo_Tosi	20.0	18.0
Travale-Radicondoli	Rancia 2	1	1988	Dry Steam	in operation	Enel Green Power	Enel Green Power	Ansaldo_Tosi	20.0	18.0
Travale-Radicondoli	Travale 3	1	2000	Dry Steam	in operation	Enel Green Power	Enel Green Power	Ansaldo_Tosi	20.0	19.0
Travale-Radicondoli	Travale 4	1	2002	Dry Steam	in operation	Enel Green Power	Enel Green Power	Ansaldo_Tosi	40.0	39.0
Travale-Radicondoli Total Installed Capacity [MW]						200.0				
Travale-Radicondoli Total Number of Units						8				
Italy Total Installed Capacity [MW]							922.5			
Italy Total Units							36			

Geothermal Plants in Operation and Planned by Country

Query Grand Total - Installed Capacity [MW]	922.5
Query Grand Total - Units	36

Report title

Geothermal field subtotal

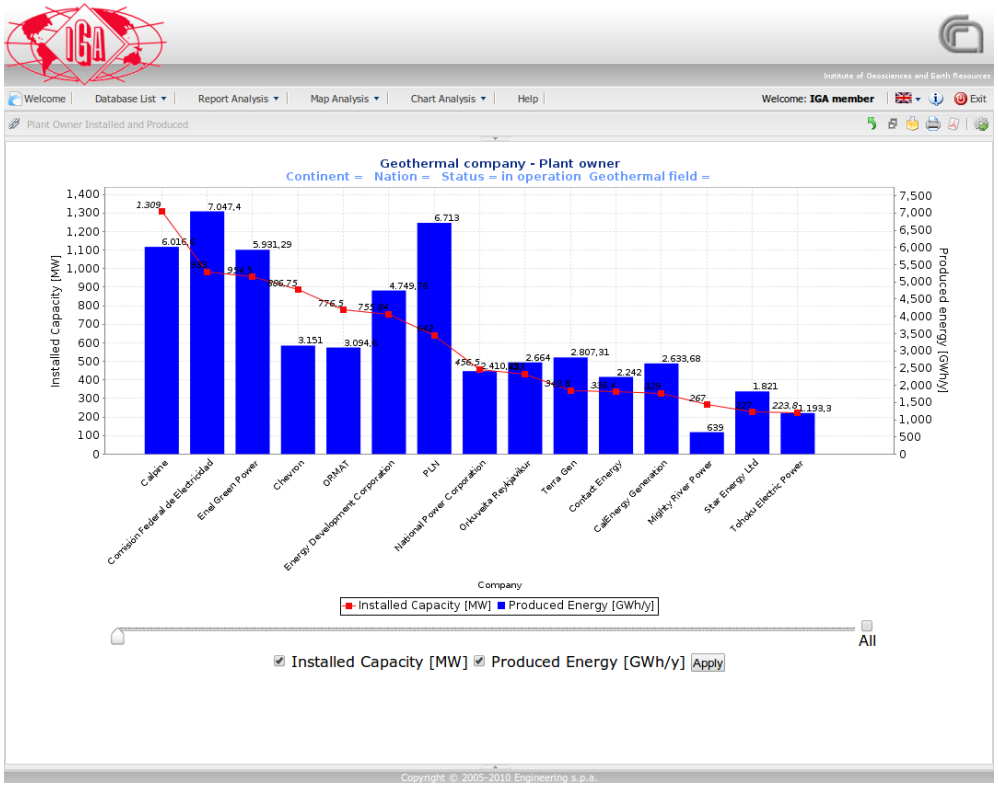
Country subtotal

All selected countries subtotal

Global Geothermal Energy Database - IGA

Chart analysis:

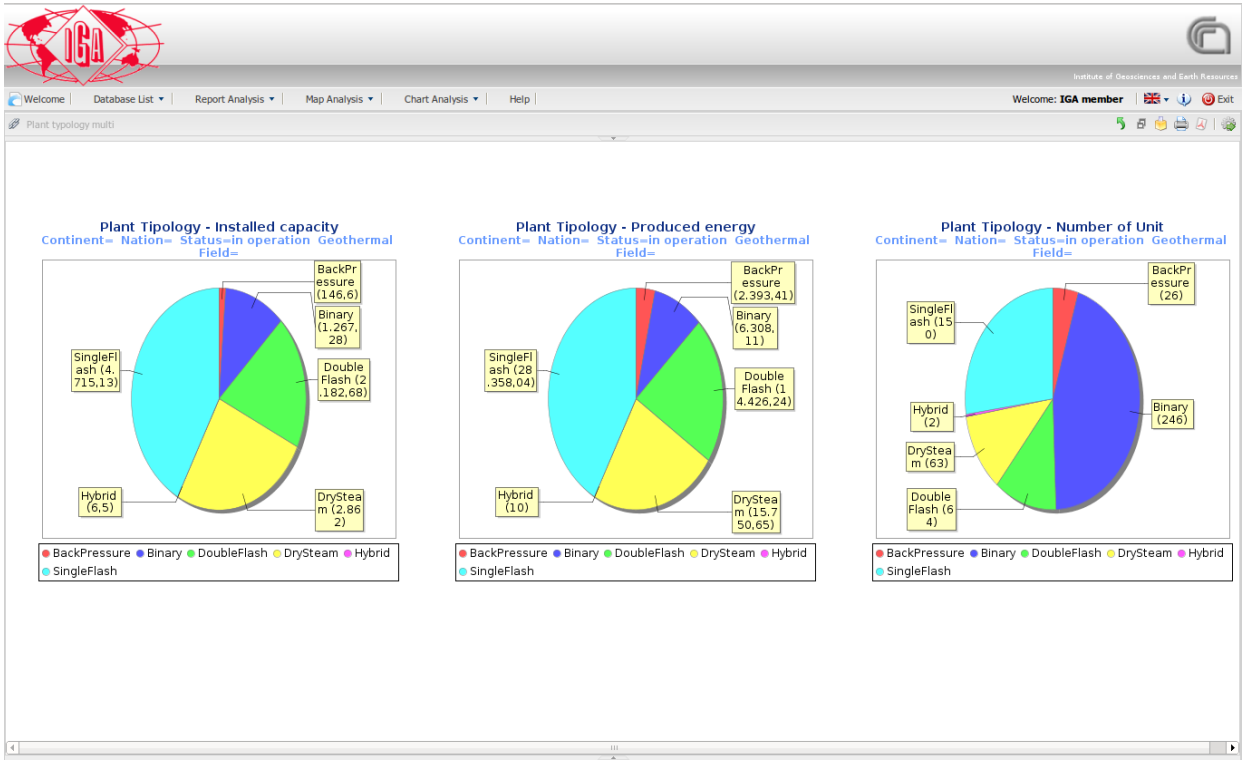
- ✓ Geothermal company – Plant owner by country, by status and by geothermal field (bar chart)
- ✓ Geothermal company – Field owner by country, by status and by geothermal field (bar chart)
- ✓ Manufacturer by country and by status (bar chart)
- ✓ Country by continent and by status(bar chart)



Global Geothermal Energy Database - IGA

Chart analysis:

- ✓ Plant category by country, by status, by geothermal field (pie charts)
- ✓ GEA code installed capacity and produced energy by status (bar chart)
- ✓ Category of direct use by country (pie chart)



Global Geothermal Energy Database - IGA

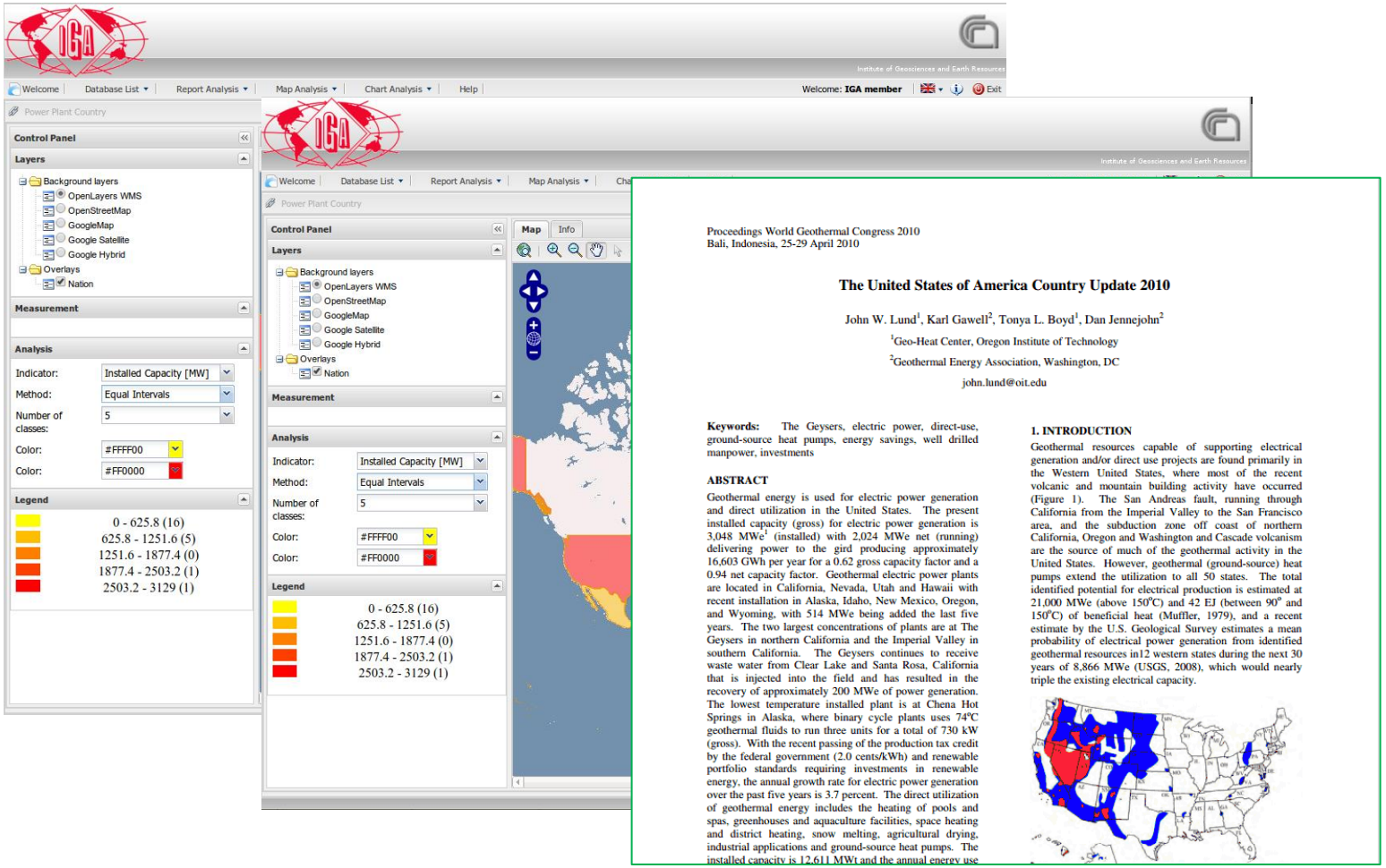
Maps analysis:

- ✓ Power plant by country

Global Geothermal Energy Database - IGA

Maps analysis:

✓ Power plant by country



Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

The United States of America Country Update 2010

John W. Lund[1], Karl Gawell[2], Tonya L. Boyd[1], Dan Jennejohn[2]
[1]Geo-Heat Center, Oregon Institute of Technology
[2]Geothermal Energy Association, Washington, DC
john.lund@oit.edu

Keywords: The Geysers, electric power, direct-use, ground-source heat pumps, energy savings, well drilled manpower, investments

ABSTRACT

Geothermal energy is used for electric power generation and direct utilization in the United States. The present installed capacity (gross) for electric power generation is 3,048 MWe[1] (installed) with 2,024 MWe net (running) delivering power to the gird producing approximately 16,603 GWh per year for a 0.62 gross capacity factor and a 0.94 net capacity factor. Geothermal electric power plants are located in California, Nevada, Utah and Hawaii with recent installation in Alaska, Idaho, New Mexico, Oregon, and Wyoming, with 514 MWe being added the last five years. The two largest concentrations of plants are at The Geysers in northern California and the Imperial Valley in southern California. The Geysers continues to receive waste water from Clear Lake and Santa Rosa, California that is injected into the field and has resulted in the recovery of approximately 200 MWe of power generation. The lowest temperature installed plant is at Chena Hot Springs in Alaska, where binary cycle plants uses 74°C geothermal fluids to run three units for a total of 730 kW (gross). With the recent passing of the production tax credit by the federal government (2.0 cents/kWh) and renewable portfolio standards requiring investments in renewable energy, the annual growth rate for electric power generation over the past five years is 3.7 percent. The direct utilization of geothermal energy includes the heating of pools and spas, greenhouses and aquaculture facilities, space heating and district heating, snow melting, agricultural drying, industrial applications and ground-source heat pumps. The installed capacity is 12,611 MWt and the annual energy use

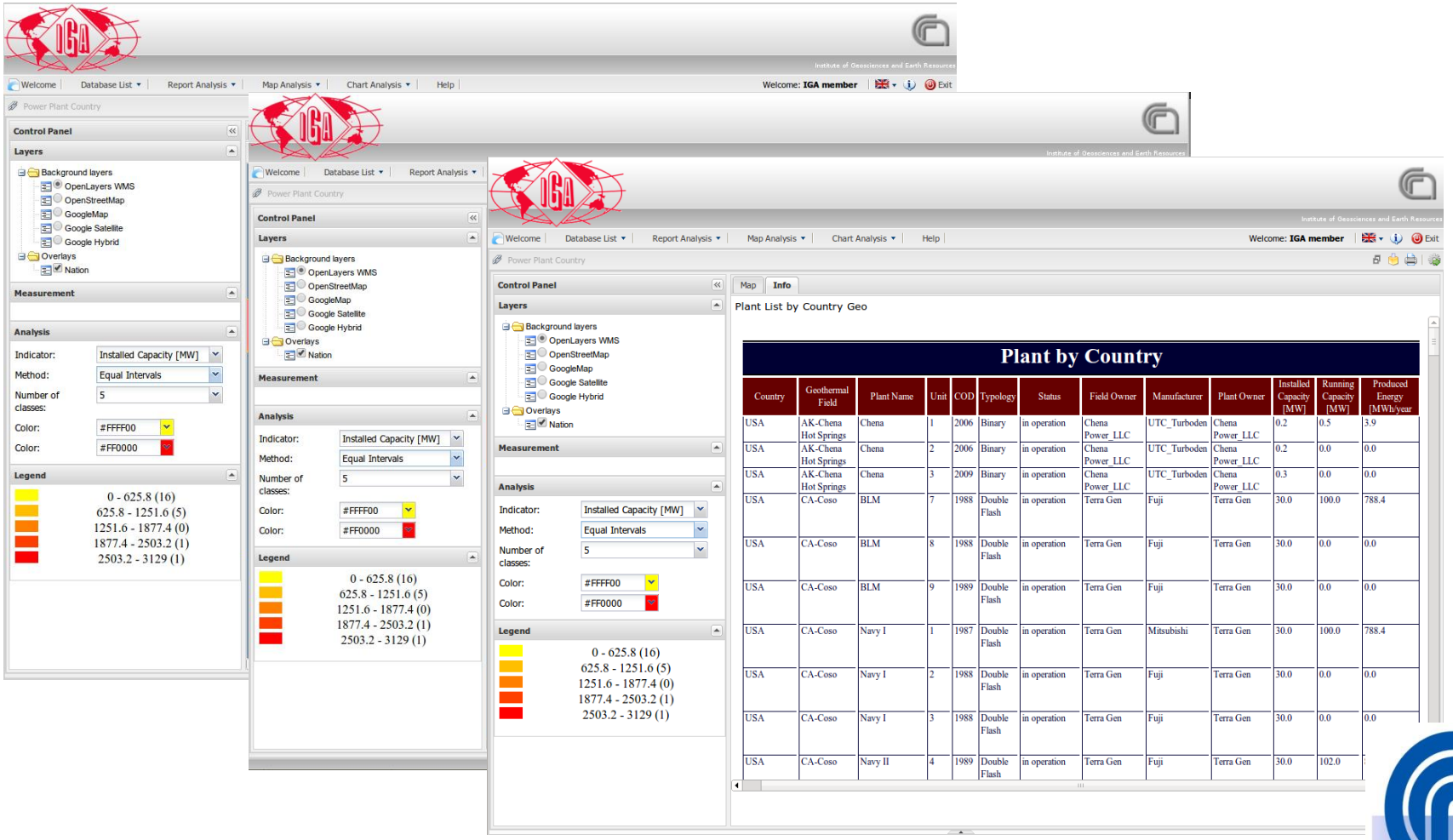
1. INTRODUCTION

Geothermal resources capable of supporting electrical generation and/or direct use projects are found primarily in the Western United States, where most of the recent volcanic and mountain building activity have occurred (Figure 1). The San Andreas fault, running through California from the Imperial Valley to the San Francisco area, and the subduction zone off coast of northern California, Oregon and Washington and Cascade volcanism are the source of much of the geothermal activity in the United States. However, geothermal (ground-source) heat pumps extend the utilization to all 50 states. The total identified potential for electrical production is estimated at 21,000 MWe (above 150°C) and 42 EJ (between 90° and 150°C) of beneficial heat (Muffler, 1979), and a recent estimate by the U.S. Geological Survey estimates a mean probability of electrical power generation from identified geothermal resources in12 western states during the next 30 years of 8,866 MWe (USGS, 2008), which would nearly triple the existing electrical capacity.

Global Geothermal Energy Database - IGA

Maps analysis:

✓ Power plant by country



Country	Geothermal Field	Plant Name	Unit	COD	Typology	Status	Field Owner	Manufacturer	Plant Owner	Installed Capacity [MW]	Running Capacity [MW]	Produced Energy [MWh/year]
USA	AK-Chena Hot Springs	Chena	1	2006	Binary	in operation	Chena Power_LLC	UTC_Turboden	Chena Power_LLC	0.2	0.5	3.9
USA	AK-Chena Hot Springs	Chena	2	2006	Binary	in operation	Chena Power_LLC	UTC_Turboden	Chena Power_LLC	0.2	0.0	0.0
USA	AK-Chena Hot Springs	Chena	3	2009	Binary	in operation	Chena Power_LLC	UTC_Turboden	Chena Power_LLC	0.3	0.0	0.0
USA	CA-Coso	BLM	7	1988	Double Flash	in operation	Terra Gen	Fuji	Terra Gen	30.0	100.0	788.4
USA	CA-Coso	BLM	8	1988	Double Flash	in operation	Terra Gen	Fuji	Terra Gen	30.0	0.0	0.0
USA	CA-Coso	BLM	9	1989	Double Flash	in operation	Terra Gen	Fuji	Terra Gen	30.0	0.0	0.0
USA	CA-Coso	Navy I	1	1987	Double Flash	in operation	Terra Gen	Mitsubishi	Terra Gen	30.0	100.0	788.4
USA	CA-Coso	Navy I	2	1988	Double Flash	in operation	Terra Gen	Fuji	Terra Gen	30.0	0.0	0.0
USA	CA-Coso	Navy I	3	1988	Double Flash	in operation	Terra Gen	Fuji	Terra Gen	30.0	0.0	0.0
USA	CA-Coso	Navy II	4	1989	Double Flash	in operation	Terra Gen	Fuji	Terra Gen	30.0	102.0	

National Research Council of Italy

Institute of Geosciences and Earth Resources

What we are working on

National Geothermal database

- Data **checking** and **updating**
- **New** data insert
- **Metadata cataloguing** , ONLINE **CSW** service
- Publishing information by **WMS** – **WFS** services
- Implementing **analysis** tools

Towards a multipurpose platform...

VIGOR
Valutazione del potenzIale Geotermico delle regiOni ConveRgenza

Ministero dello Sviluppo Economico – CNR DTA

ATLANTE – Geotermico
Caratterizzazione, classificazione e mappatura di risorse geotermiche convenzionali e non-convenzionali per produzione di energia elettrica nelle regioni del Mezzogiorno d'Italia
CNR DTA

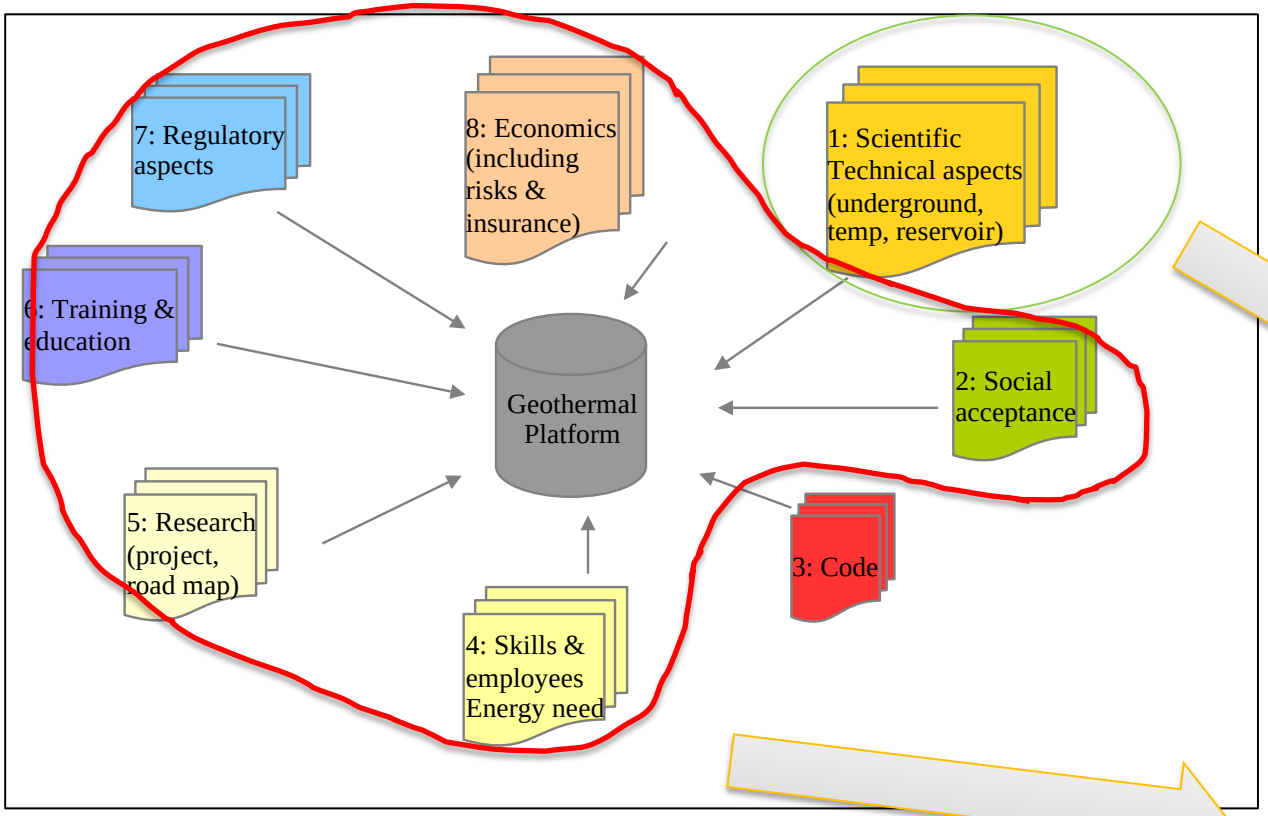
Geothermal ERA-NET

SEVENTH FRAMEWORK PROGRAMME

GEO-ELEC
Supported by INTELLIGENT ENERGY EUROPE

IGG

Towards a Geothermal European Information Platform EGIP – content

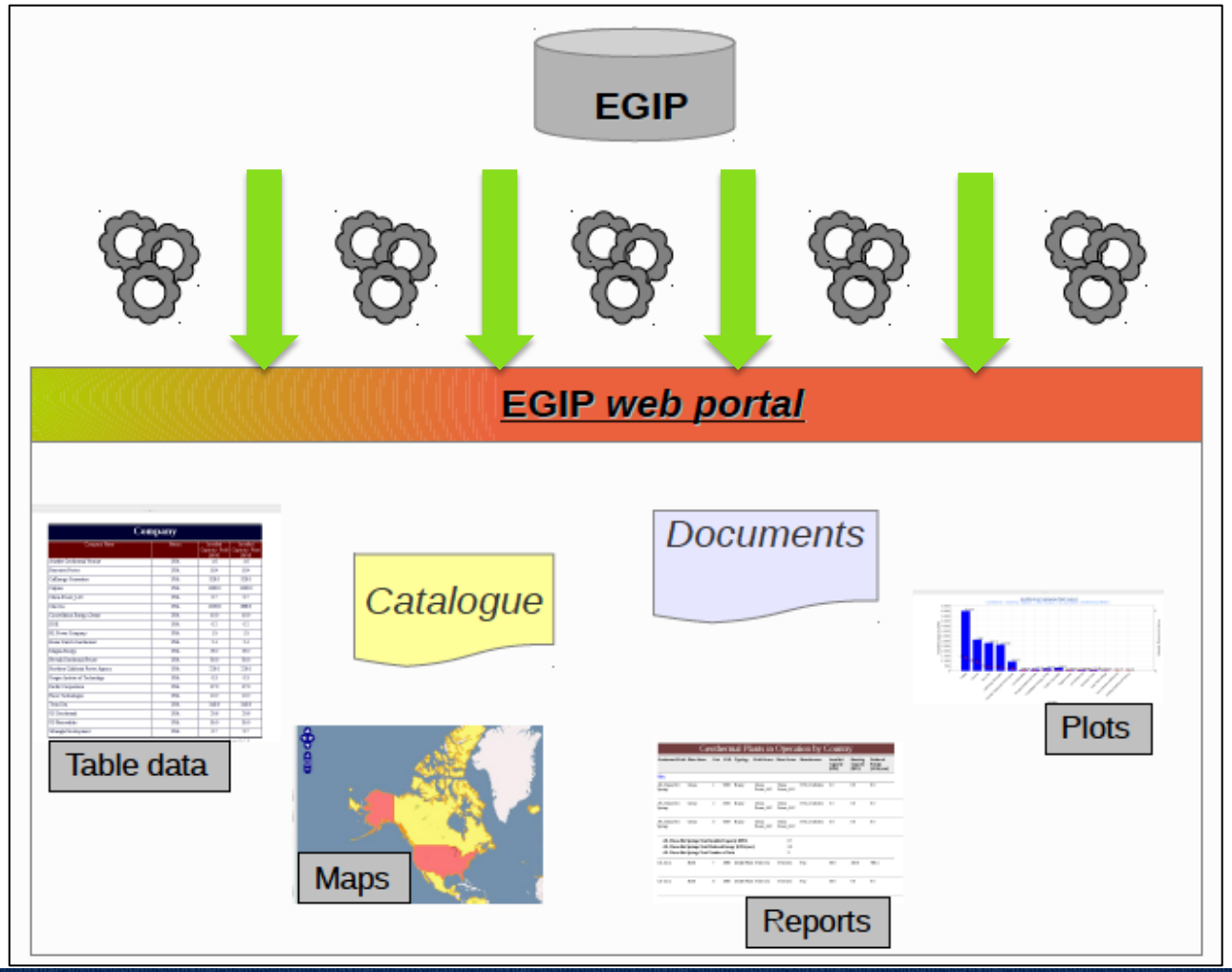


Widely distributed Structured information

Widely distributed Un-Structured information, always documents – Not yet included into any Database

Towards a Geothermal European Information Platform
EGIP – functionalities

EGIP tools have to guarantee a 360° data browsing (e.g., browsing from a catalogue to a document, from a document to a tabled info or spatial data) and **allowing a deep survey into the geothermal knowledge**.



- http://geothopica.igg.cnr.it
- www.vigor-geotermia.it
- http://mezzogiorno.cnr.it
- www.geothermal-energy.org

Thank you