73° GENERAL ASSEMBLY AND INTERNATIONAL SCIENTIFIC CONGRESS OF THE WORLD FEDERATION OF HYDROTHERAPY AND CLIMATOTHERAPY (FEMTEC)THERMALISM IN CHANGING SOCIETIES

THE EUGANEAN GEOTHERMAL BASIN (NE, ITALY): A RICHNESS OF OUR TERRITORY

Prof. Paolo Fabbri

Department of Geosciences - Università di Padova

QUESTIONS

Why is there terrestrial heat

Why was the Euganean area so lucky

What knowledge our conceptual model is based on

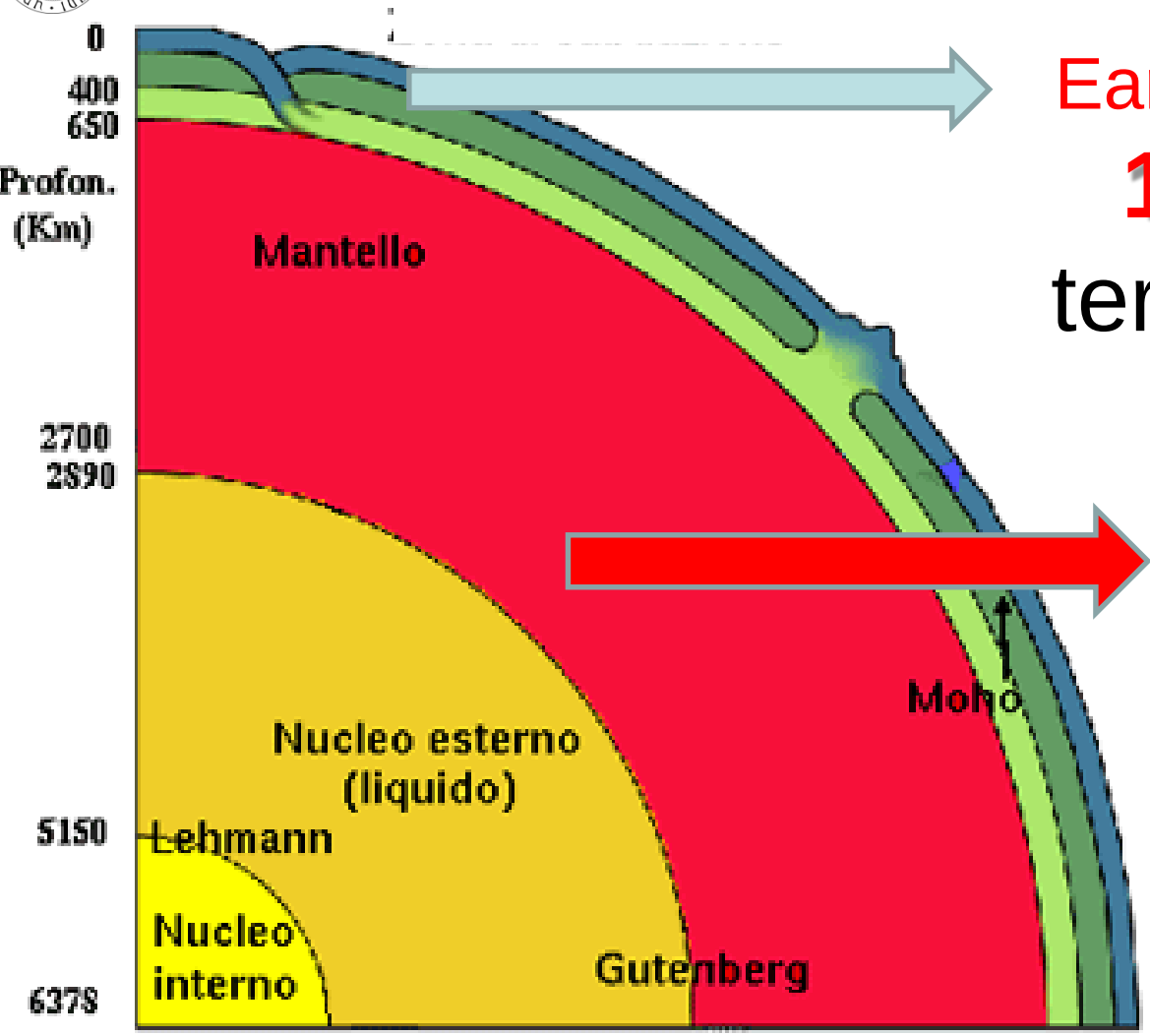
Can we model numerically our conceptual model

Geothermal energy

is the Earth's interior heat

Volcanos
Thermal springs
Fumaroles
Geysers

Thermal water
Peculiar
Renewable energy



Earth crust **(30 km)** Heat

15-20% of total terrestrial heat flux

radioisotopes

Mantle (2890 km) < radioisotopes concentration, but *mass bigger than the crust*

the bottom mantle temperature is estimated of about 4000°C.

HEAT FLUX IN ITALY

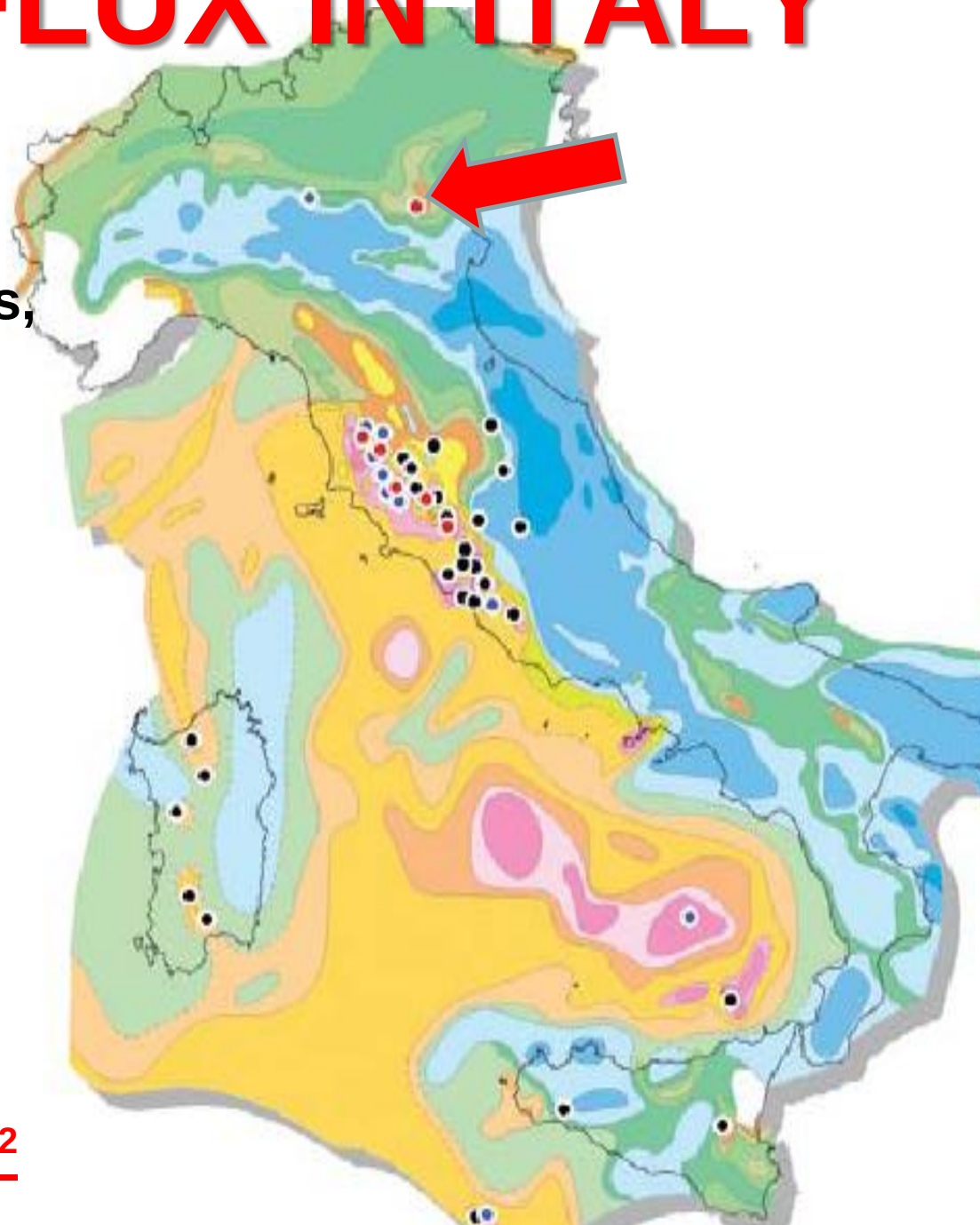
2 areas with different heat flux

1) low - **northern and southern (Alps, Appennines, Adriatic and Jonic areas)**
20 - 80 mW/m²

2) high - **Western and Tyrrhenian**
100 - 450 mW/m²

Middle
(100÷150 mW/m²)
In Sicily channel and Sardinia

World average → ***60 mW/m²***



GEOTHERMAL ENERGY UTILISATION

INDIRECT USES

High-temperature resources generally used to produce **electric power**

DIRECT USES

Low-middle temperature resources, different uses

Industrial processes

- greenhouses
- farming
- aquicolture
- space heating

- **salus per aquam (spa) mud-balneotherapy**

income of 300 M €/y in EuGF

COMPONENTS OF A GEOTHERMAL SYSTEM

- **Recharge area** → area of the reservoir recharge

- **Geothermal reservoir** → permeable rocks hosting hot fluids

- ***Heat source***

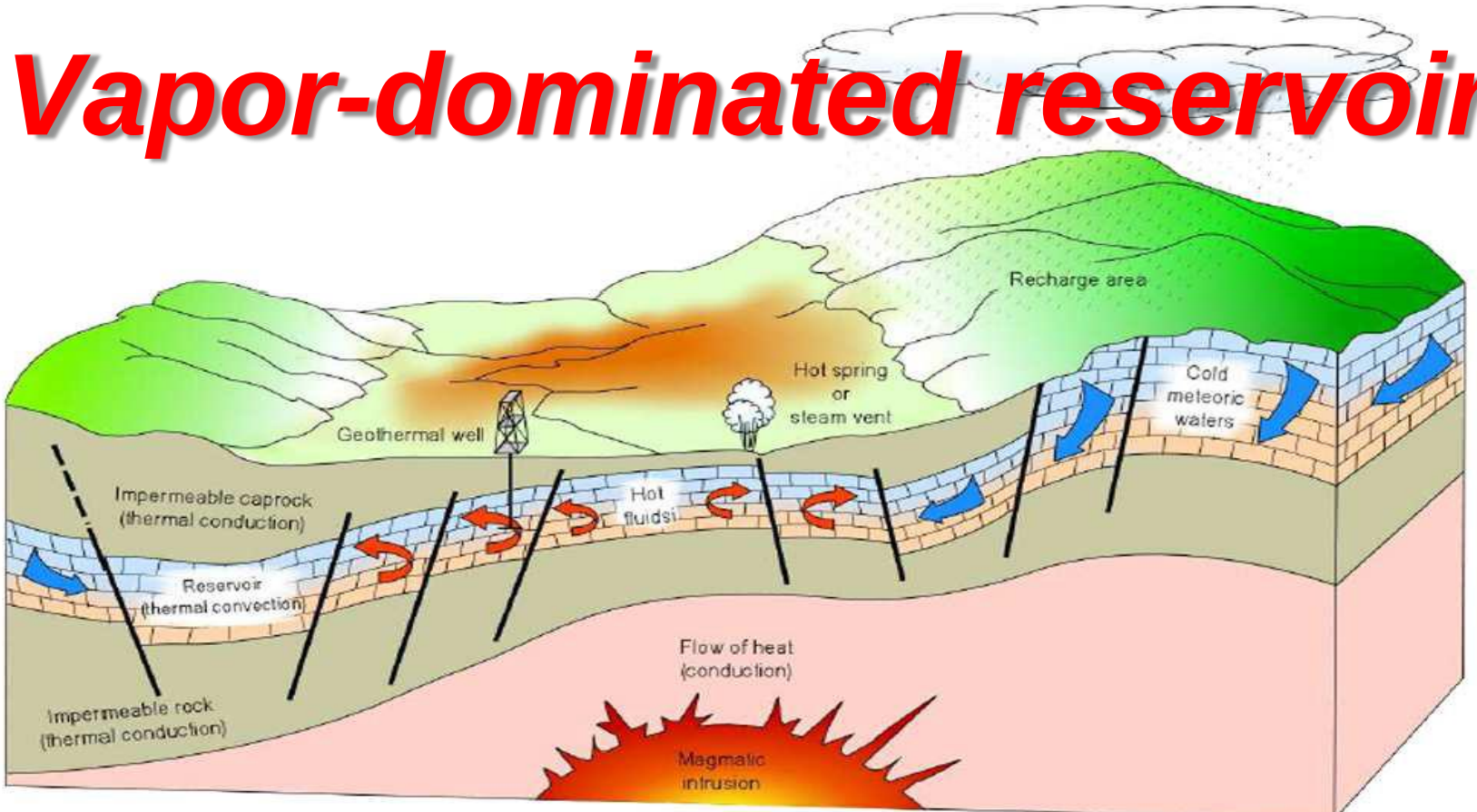
- **Discharge area** →

HEAT SOURCE

Anomalous geothermal flux (magma), reservoir would be geologically shallow

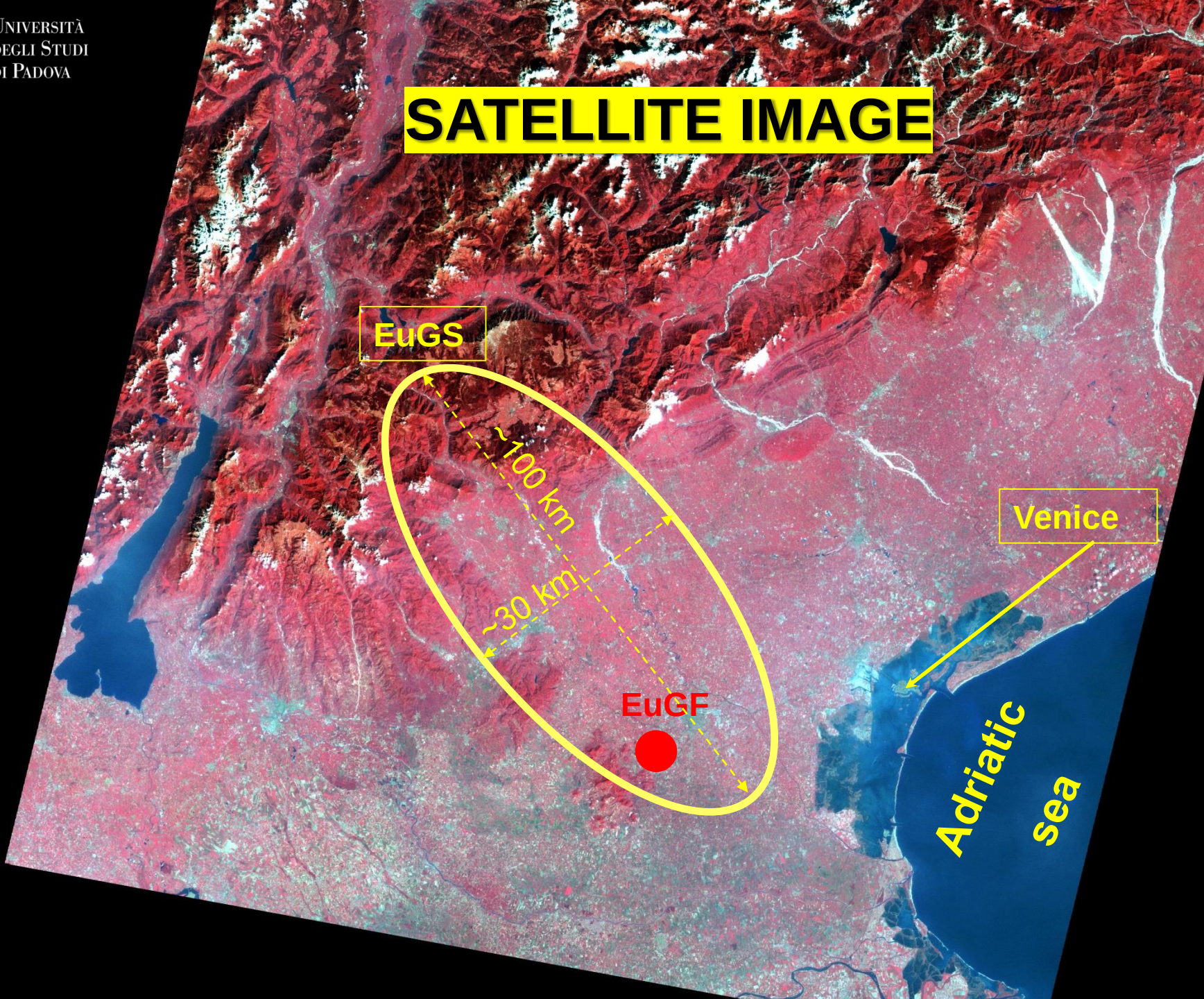
(e.g. **Larderello** **> 600 mW/m²**)

Vapor-dominated reservoir




Veneto
region
EuGS
Castel San
Pietro Terme
Adriatic sea
Tyrrhenian sea
ITALY

SATELLITE IMAGE



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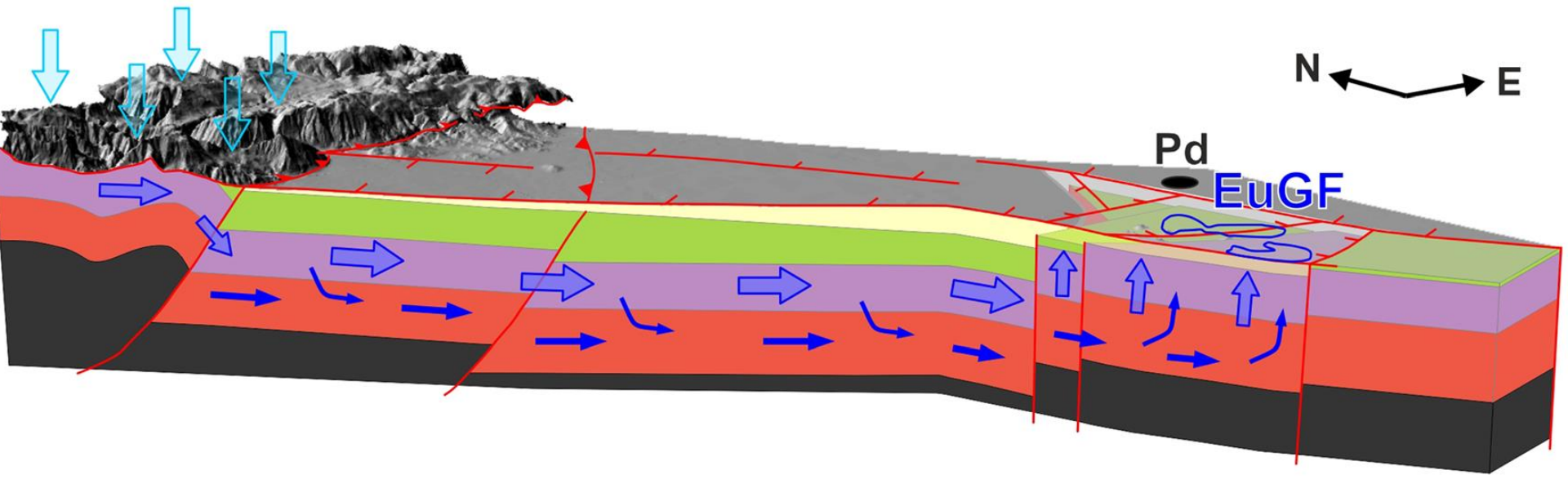
Euganean Geothermal System
CONCEPTUAL MODEL

Legend

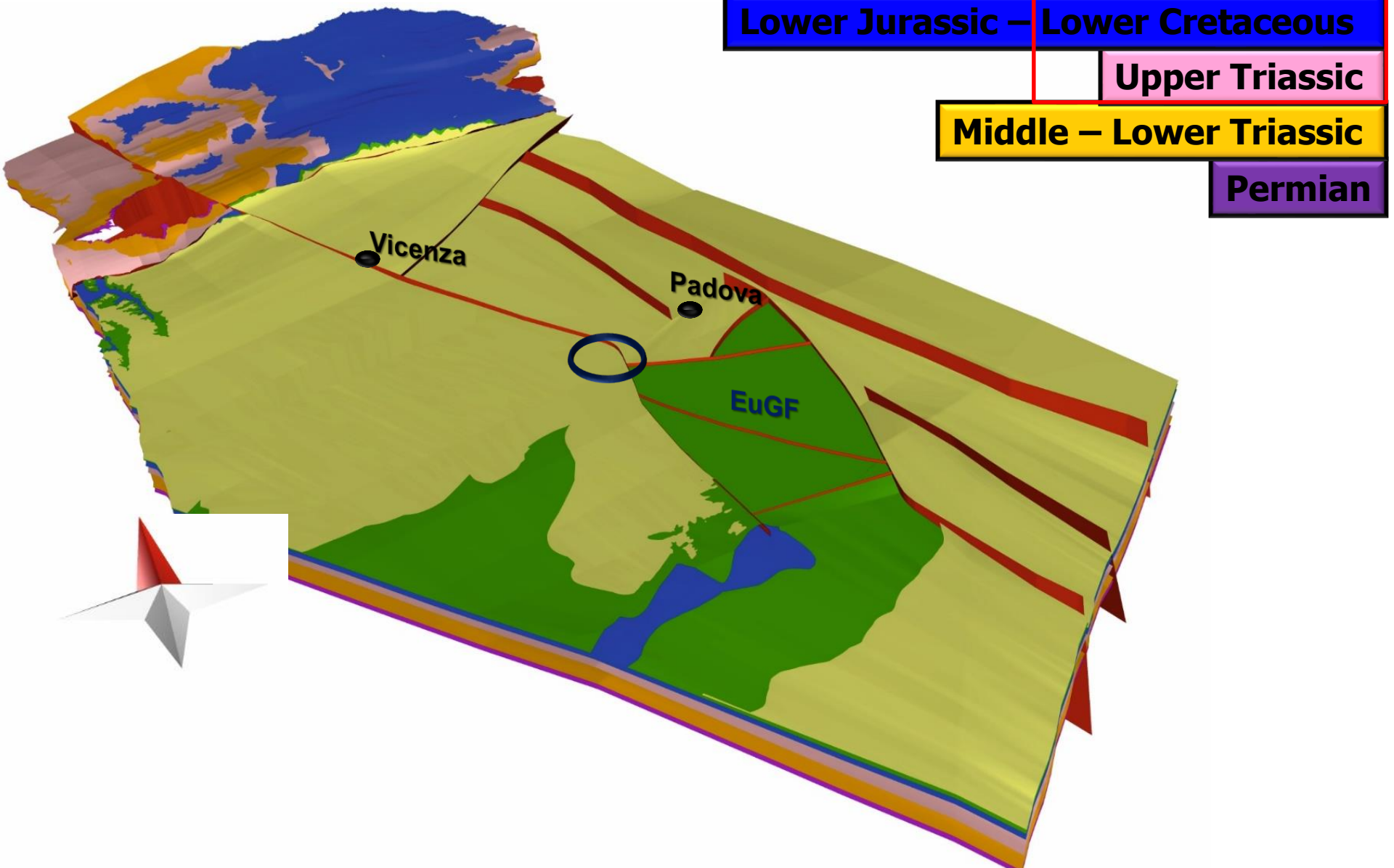
- Pliocene - Pleistocene
- Early Cretaceous - Miocene
- Late Triassic - Early Cretaceous
- Early Permian - Middle Triassic
- pre - Permian
- High angle fault
- Thrust fault
- Precipitation
- Principal fluid flow
- Secondary fluid flow



Geothermal Flux 90-100 mW/m^2

Geothermal Flux 80-70 mW/m^2

GEOLOGICAL MODEL



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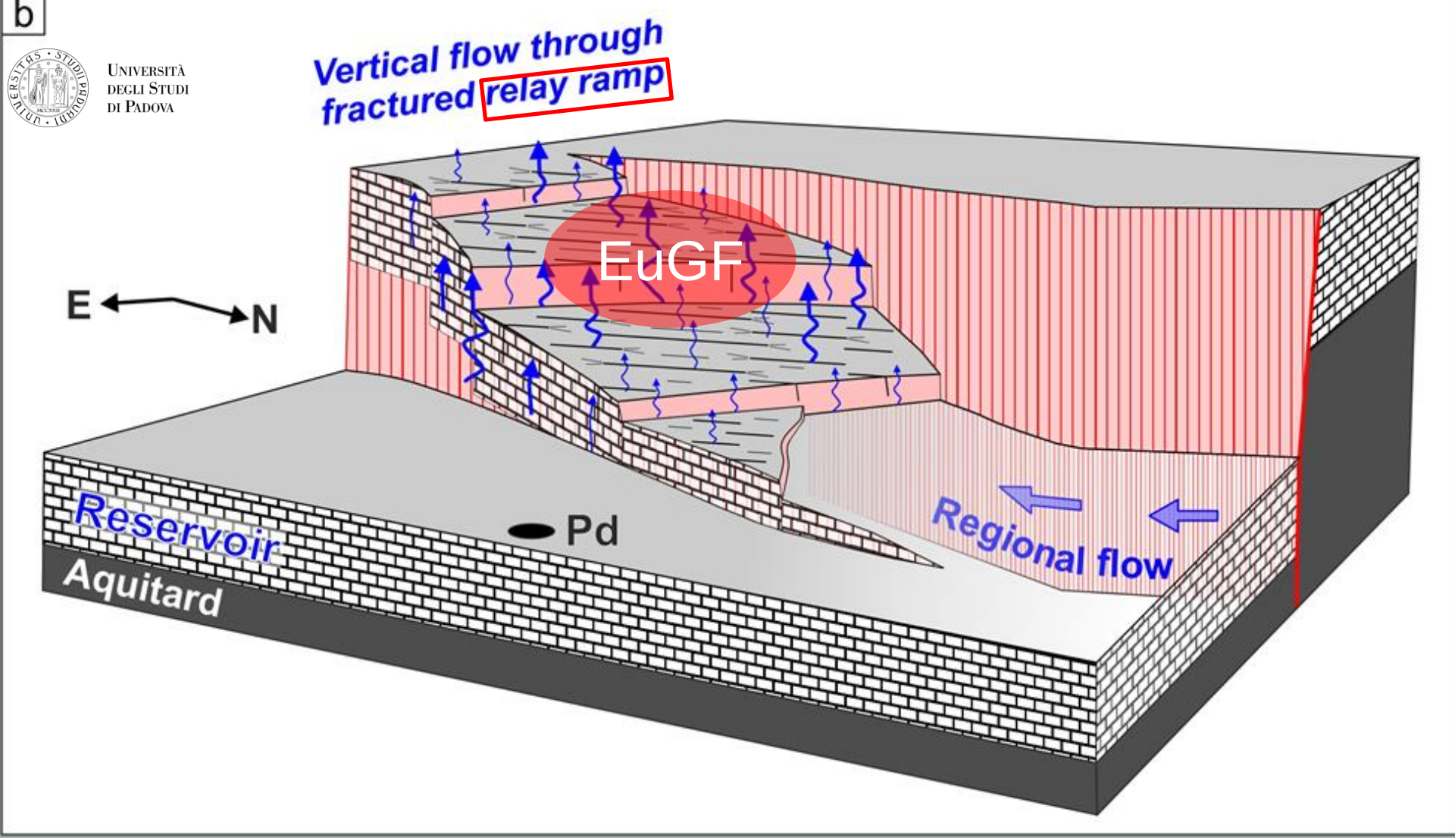
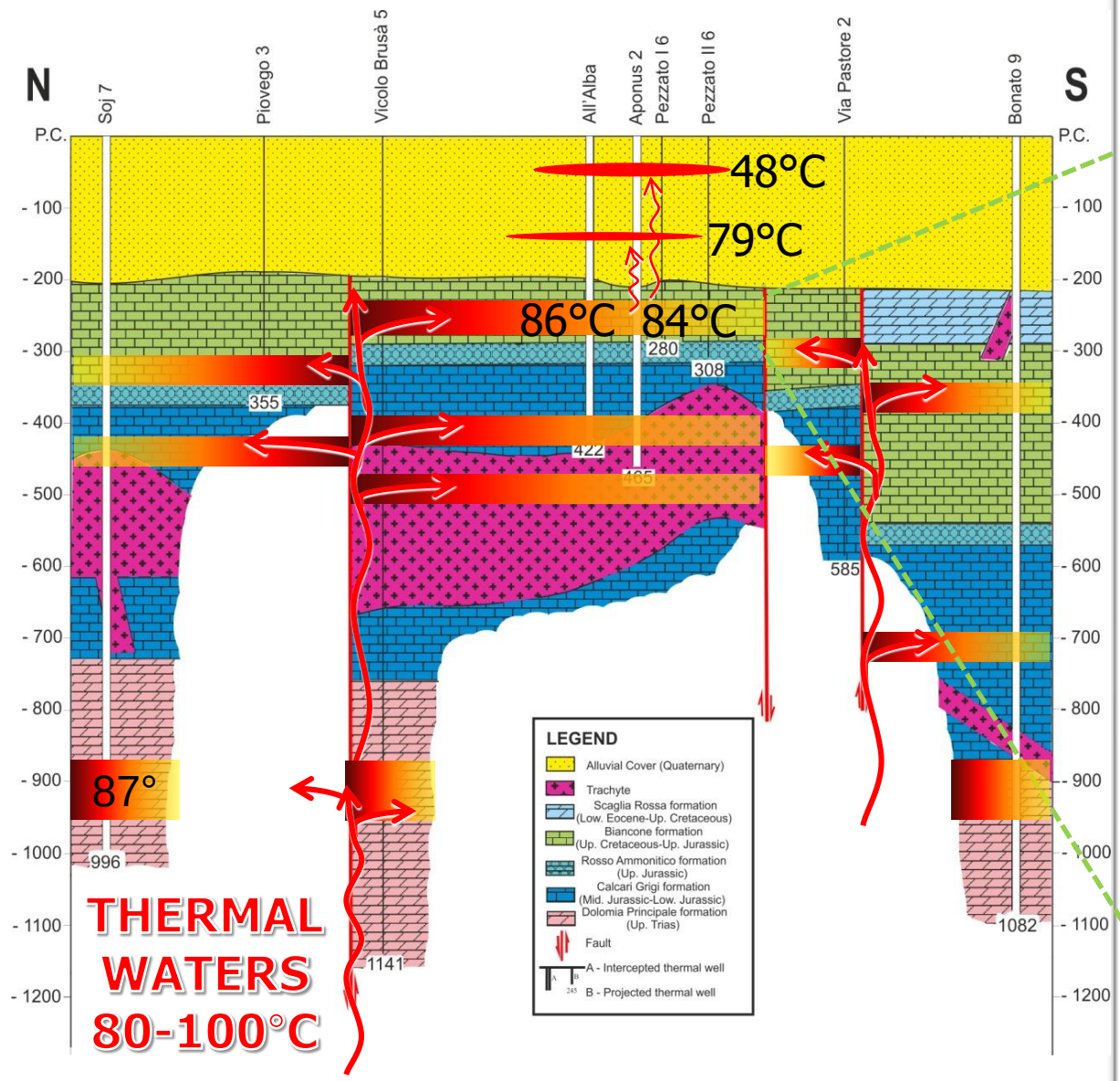


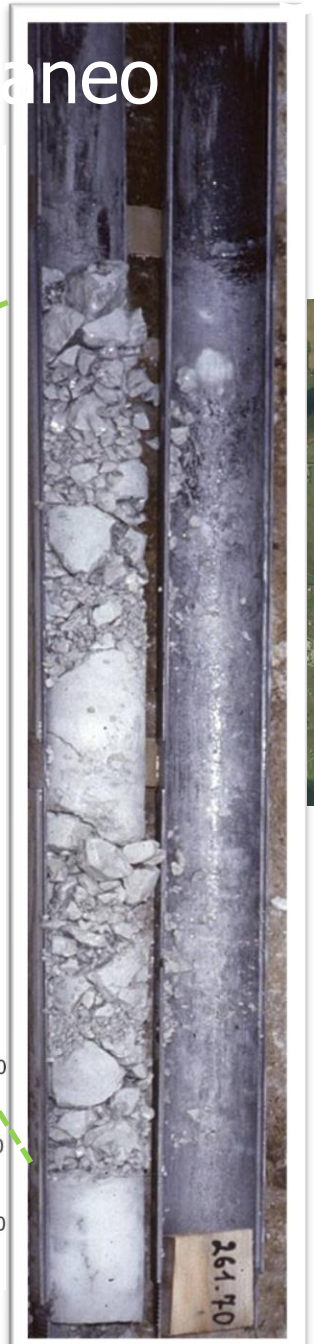
MONTIRONE SPRING

(early 1900)

ABANO TERME (Padova) - Fonte principale Termale - Estrazione del fango da porsi nelle vasche di deposito

CONCEPTUAL MODEL OF THE EuGF





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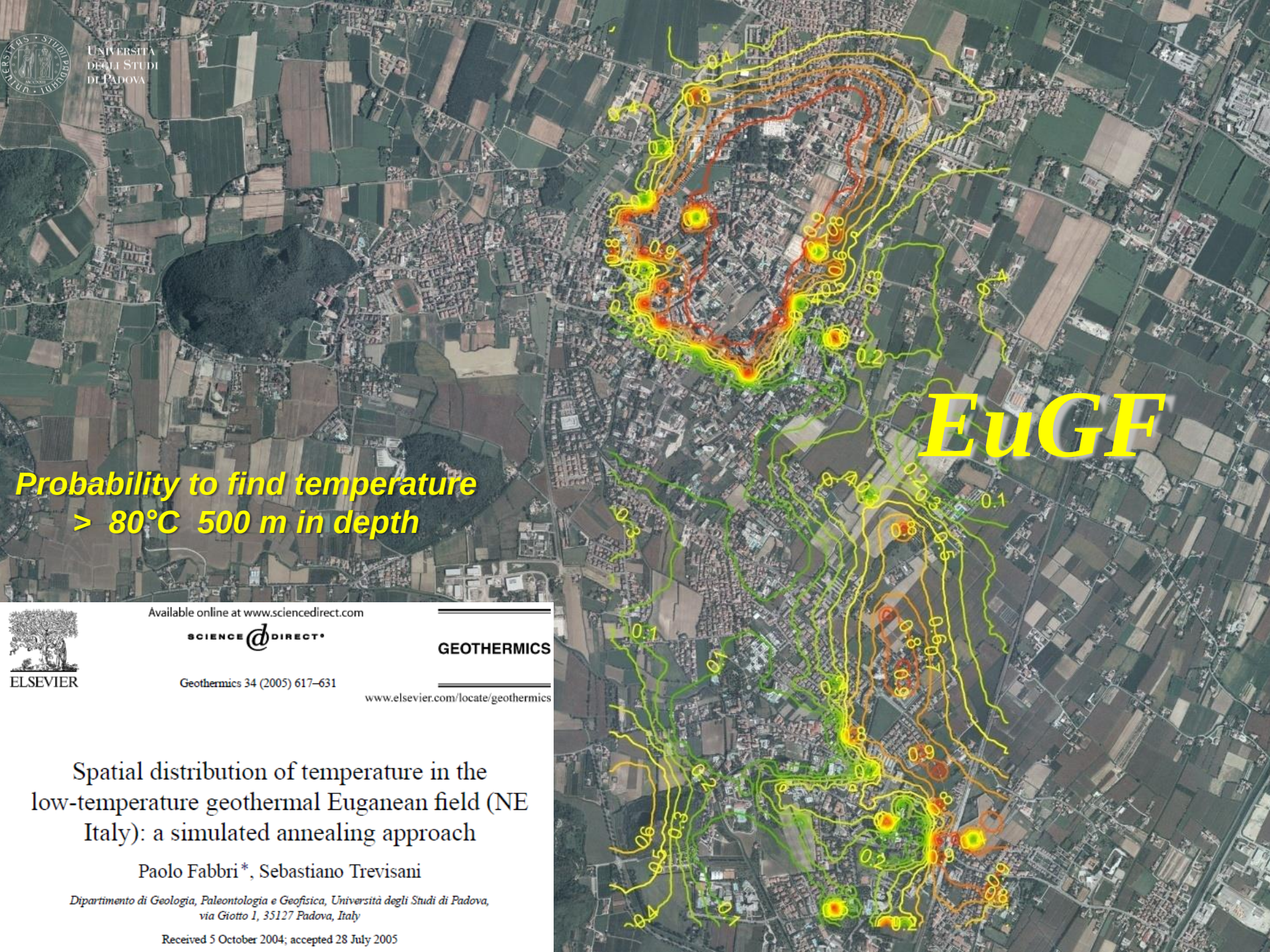
MINING CLAIMS DISTRIBUTION IN EUGANEAN GEOTHERMAL FIELD (EuGF)

170 wells

40 M L/day

138 mining claims



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Geothermics 34 (2005) 617–631
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Spatial distribution of temperature in the low-temperature geothermal Euganean field (NE Italy): a simulated annealing approach

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THERMAL WATER EXPLOITATION IN EuGF

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2017

Geothermics

journal homepage: www.elsevier.com/locate/geothermics

Monitoring, utilization and sustainable development of a low-temperature geothermal resource: A case study of the Euganean Geothermal Field (NE, Italy)

Paolo Fabbri[a,b], Marco Pola[a,b,*], Leonardo Piccinini[a,b], Dario Zampieri[a,b], Aldo Roghel[c], Nico Dalla Libera[a]

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1900

38 springs

8 Abano Terme

22 Montegrotto Terme

8 Battaglia Terme & Galzignano Terme

1953 → **31** (1 Abano Terme, 22 Montegrotto Terme e 8 Battaglia & Galzignano Terme)

Collezione Giancarlo Ercolin 1950

EXPLOITATION *Abano Terme*

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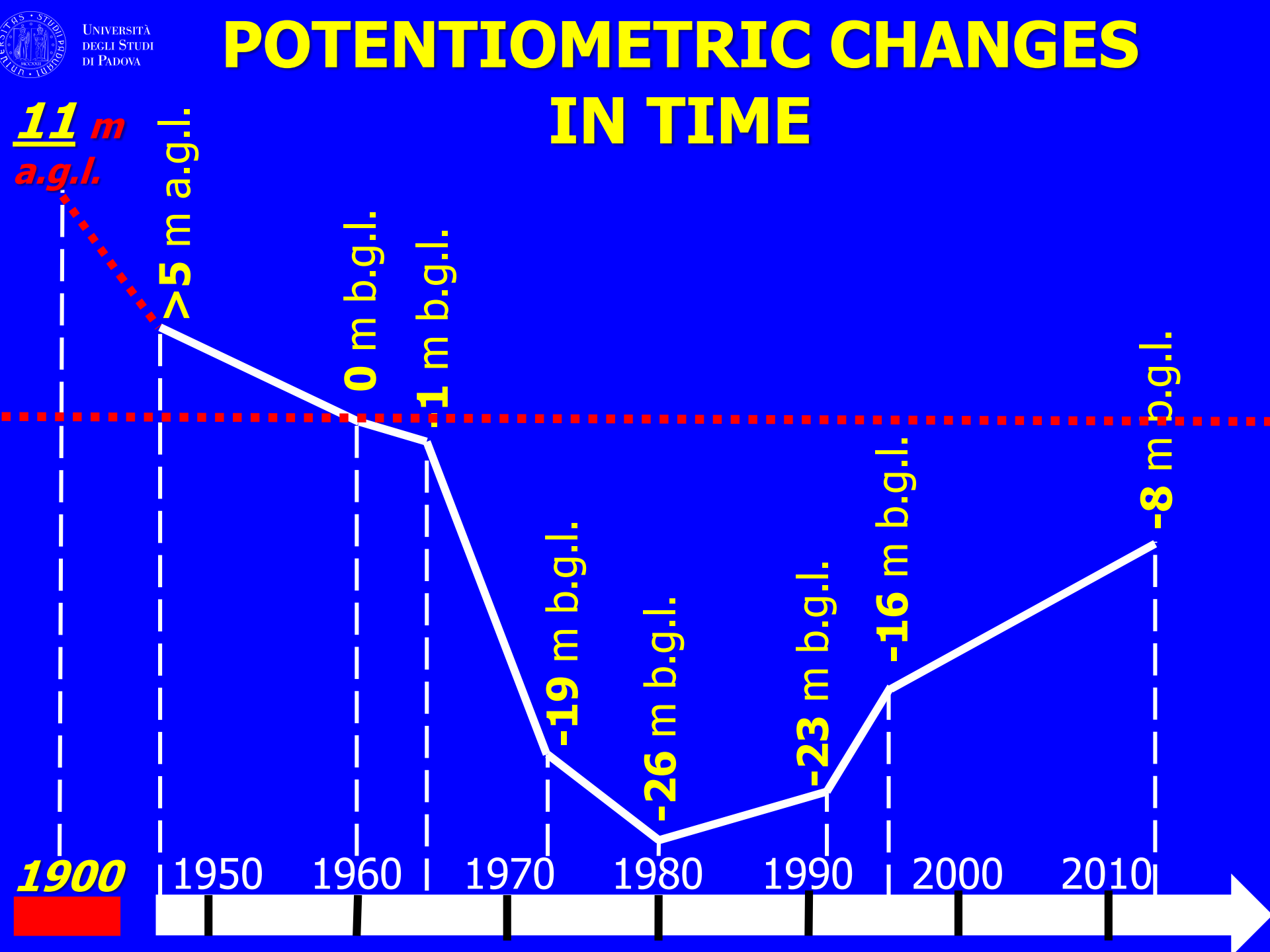
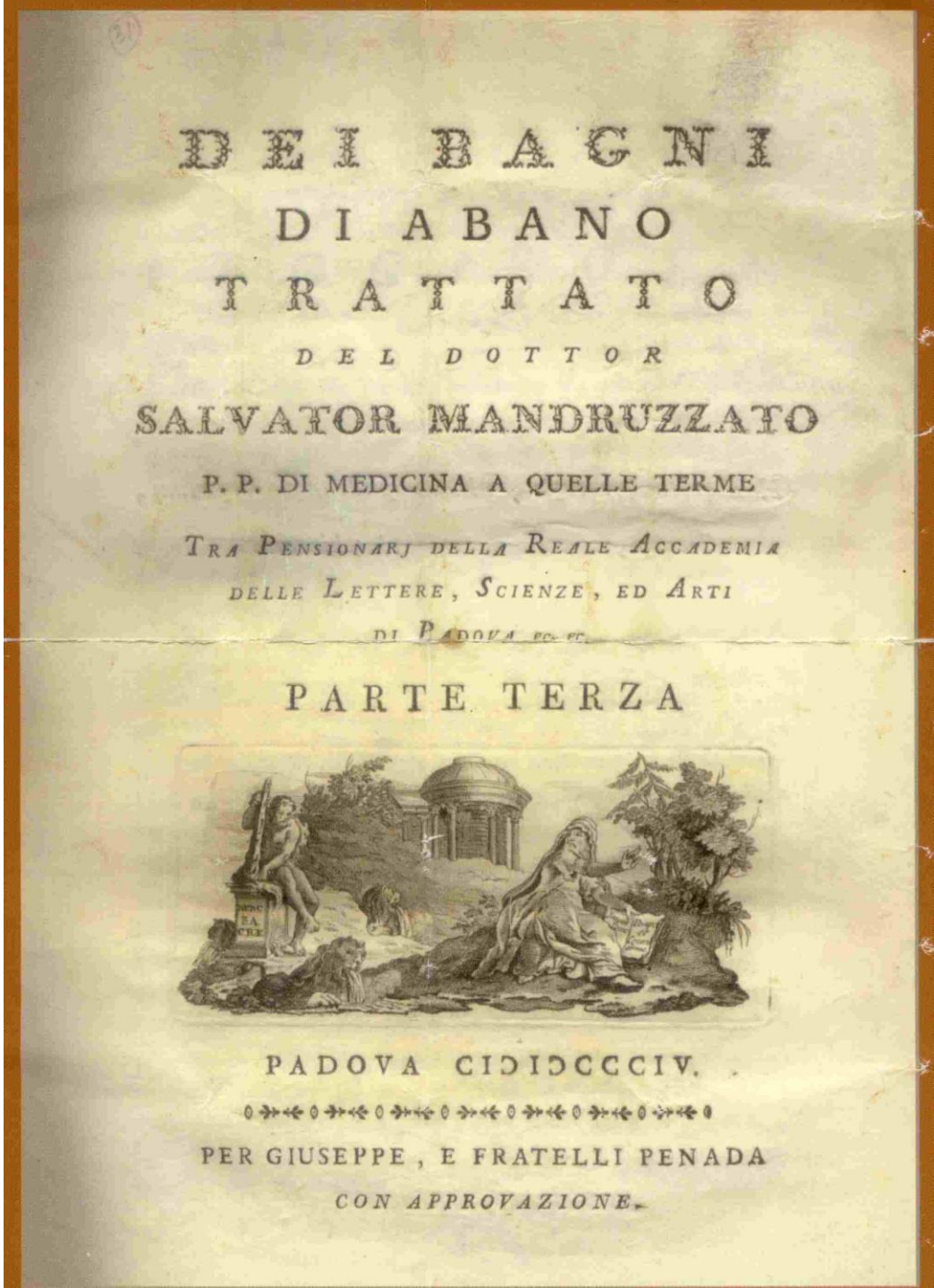
POTENTIOMETRIC CHANGES IN TIME



HYDRO-GEOCHEMISTRY (1804)

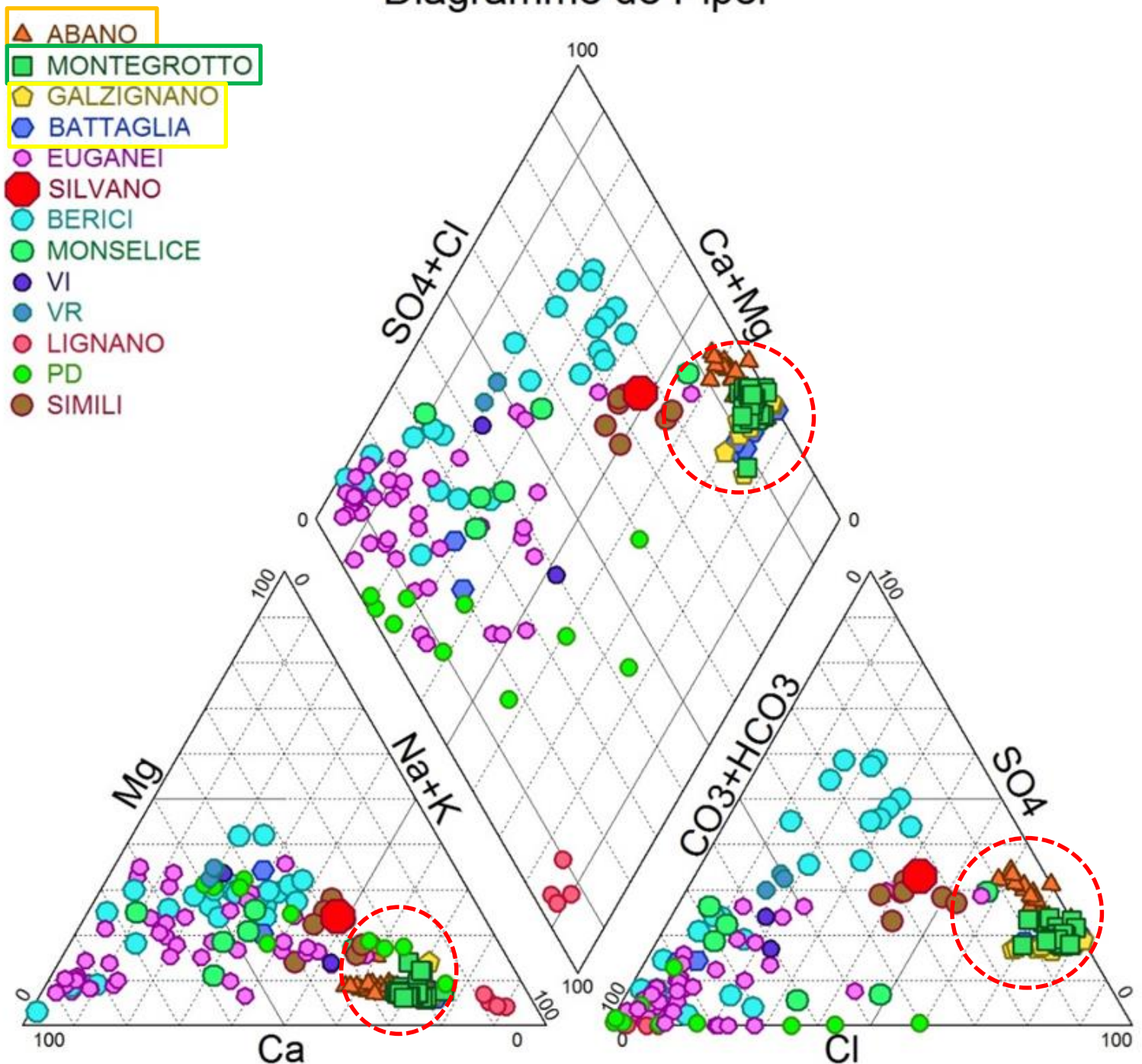


DEI BAGNI
DI ABANO
TRATTATO
DEL DOTTOR
SALVATOR MANDRUZZATO
P. P. DI MEDICINA A QUELLE TERME
TRA PENSIONARJ DELLA REALE ACCADEMIA
DELLE LETTERE, SCIENZE, ED ARTI
DI PADOVA &c. &c.
PARTE TERZA

PADOVA CIↃIↃCCCIV.

PER GIUSEPPE, E FRATELLI PENADA
CON APPROVAZIONE.

Diagramme de Piper



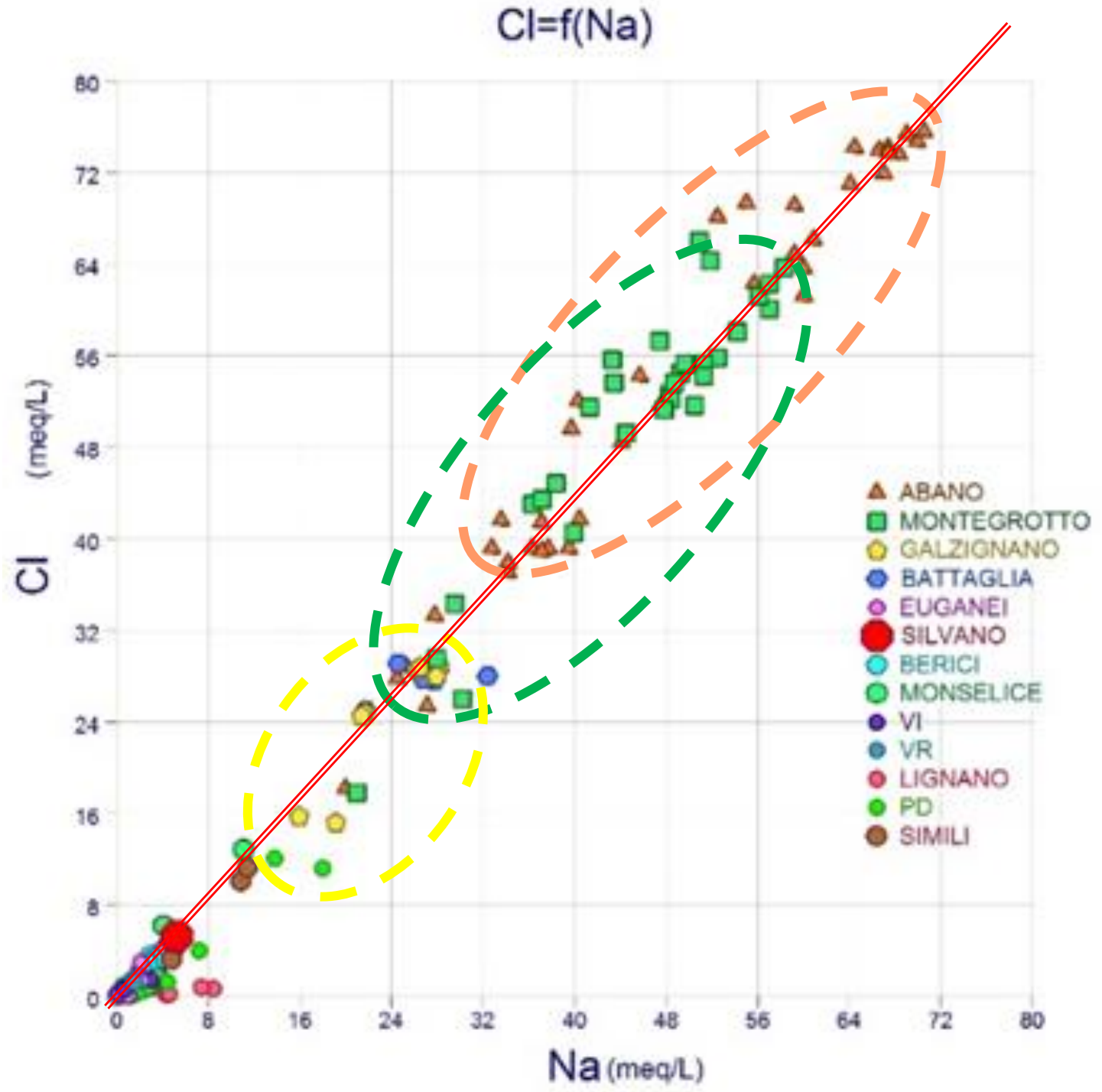
HYDROGEOCHEMITRY OF THERMAL WATERS

- **70% Na e Cl**
- **High values SO_4, HCO_3 Ca e Mg, SiO_2**

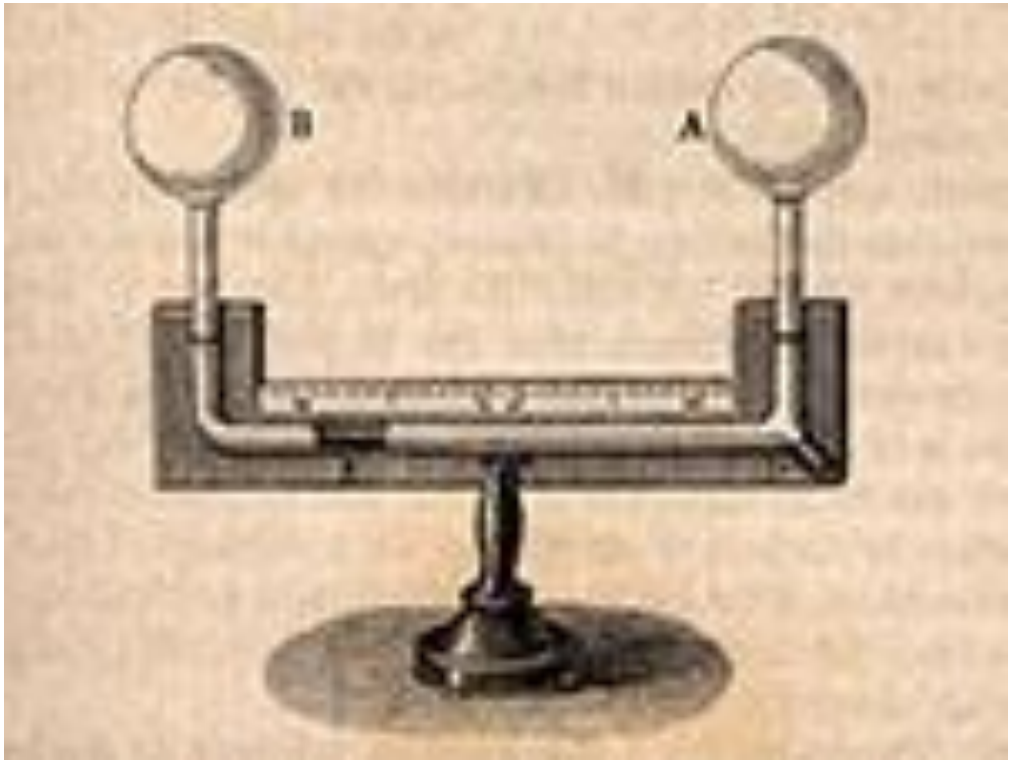
- **Abano fluids** temperature between 75°< T < 87° C and T.D.S. between 3000 < T.D.S. < 6000 mg/L;

- **Montegrotto fluids** temperature between 70°< T < 80° C , T.D.S. between 2000 < T.D.S.<4000 mg/L;

- **Battaglia-Galzignano fluids** temperature between 60°< T< 75° C, T.D.S. between 1500 < T.D.S.< 3000 mg/L


Cl=f(Na)
Cl (meq/L)
Na (meq/L)
0
8
16
24
32
40
48
56
64
72
80
ABANO
MONTEGROTTO
GALZIGNANO
BATTAGLIA
EUGANEI
SILVANO
BERICI
MONSELICE
VI
VR
LIGNANO
PD
SIMILI

GEOTHERMOMETERS



SiO_2 ~ 90-100 °C

Na-K

Na-K-Ca ~ 130-150°C

GAS IN WATER

GAS GEOCHEMISTRY

- N_2 ranging between 70% and 90%
- High value of He
- Ar in atmospheric percentage
- Some hydrocarbon (CH_4, C_2H_6)
- Low value of H_2

ISOTOPIC GEOCHEMISTRY

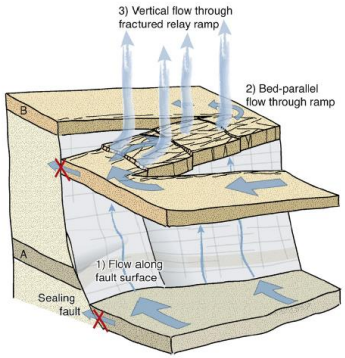
• RADIOISOTOPES

- **^{3}H** analysis suggest residence time of waters **more** than 60 years

- Some **^{14}C** analysis suggest fluids with some thousand years. But there are some problems due to the presence of limestones in reservoir

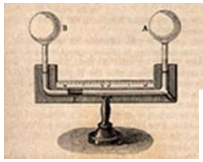
- Modest concentration in **U** and high ratios of $^{234}U/^{238}U$ in travertine, indicating a deep circulation of fluids and their high residence time into the reservoir

CONCEPTUAL MODEL IN A NUTSHELL IS BASED ON

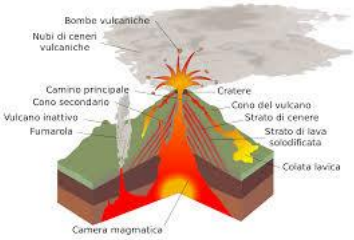


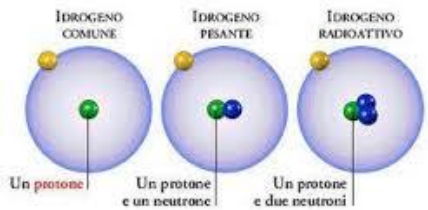
- Geo-structural situation

Thickness of sedimentary cover



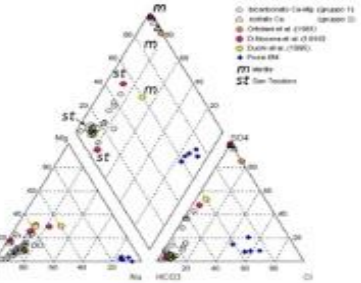
- Geothermometers



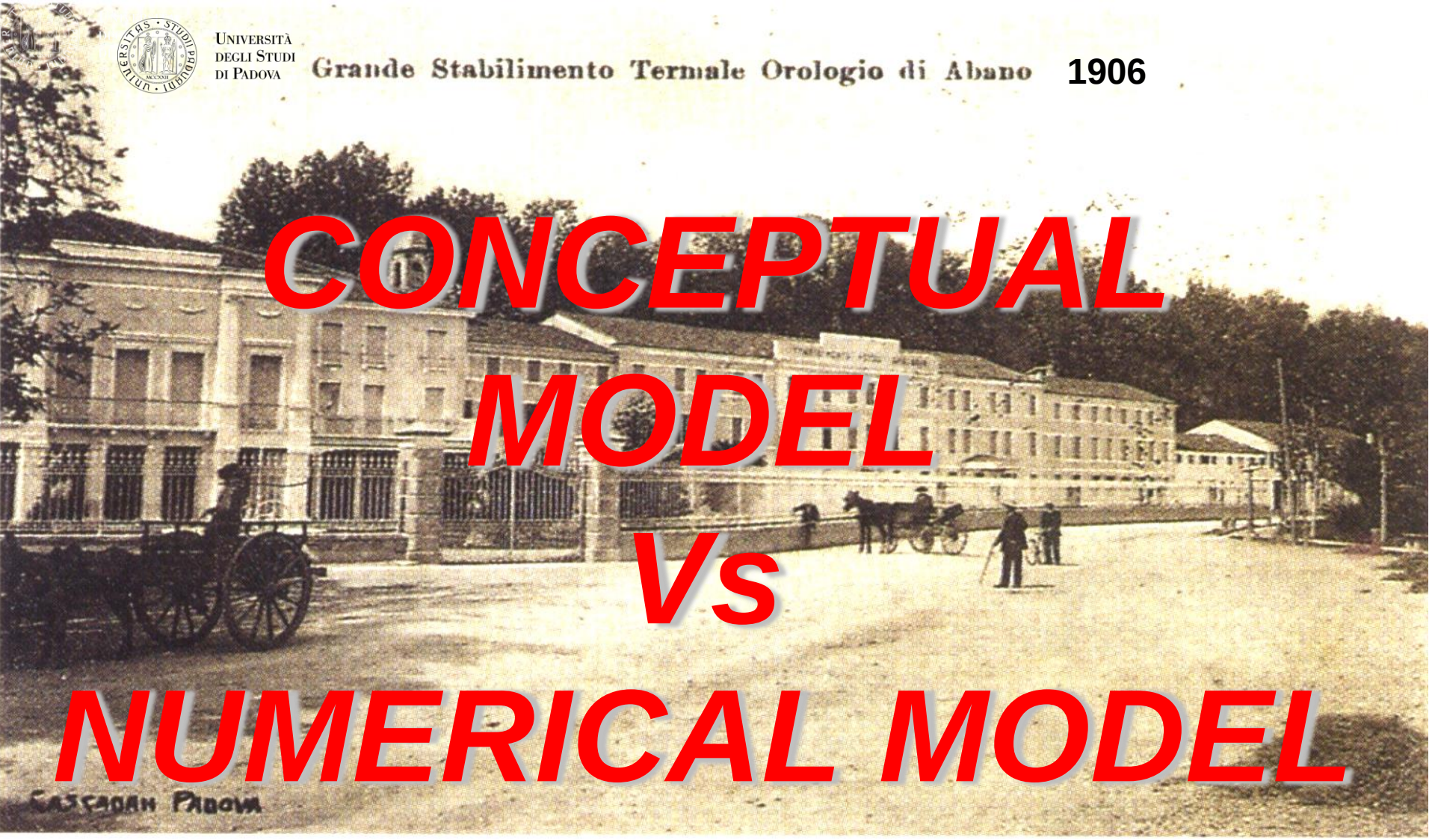


- Volcanic rock age (K/Ar)
- Stable isotopes

- Recharge volumes
- Permeability of rechearge area
- Radioisotopes



- Hydrochemical stability of fluids



Stabilimento Termale Orologio (1906)

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FIRST 3D MODEL 2020

AGU ADVANCING EARTH AND SPACE SCIENCE

Check for updates

JGR Solid Earth

RESEARCH ARTICLE
10.1029/2019JB017394

Key Points:

- Fracturing related to local extension by fault interaction in a convergent regional setting controls fluid flow in a geothermal system
- Numerical simulations corroborate the impact of structural process driving a local increase in convection and the rising of thermal waters
- Convection enhanced by fracturing can result in temperature values profitable for energy production in low-temperature geothermal resources

Fault Control on a Thermal Anomaly: Conceptual and Numerical Modeling of a Low-Temperature Geothermal System in the Southern Alps Foreland Basin (NE Italy)

Marco Pola[1], Mauro Cacace[2], Paolo Fabbri[3,4], Leonardo Piccinini[3,4], Dario Zampieri[3,4], and Filippo Torresan[3]

[1]Croatian Geological Survey, Zagreb, Croatia, [2]Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Telegrafenberg, Potsdam, Germany, [3]Department of Geosciences, Università degli Studi di Padova, Padova, Italy, [4]Geothermal System Hydrostructures (GSH), Interdepartmental Centre "Giorgio Levi Cases" for Energy Economics and Technology, Università degli Studi di Padova, Padova, Italy

Environ Geochem Health
https://doi.org/10.1007/s10653-021-01028-4

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ORIGINAL PAPER

SECOND 3D MODEL 2022

Numerical modeling as a tool for evaluating the renewability of geothermal resources: the case study of the Euganean Geothermal System (NE Italy)

Filippo Torresan · Leonardo Piccinini · Mauro Cacace · Marco Pola · Dario Zampieri · Paolo Fabbri

UNSTRUCTURED MESH

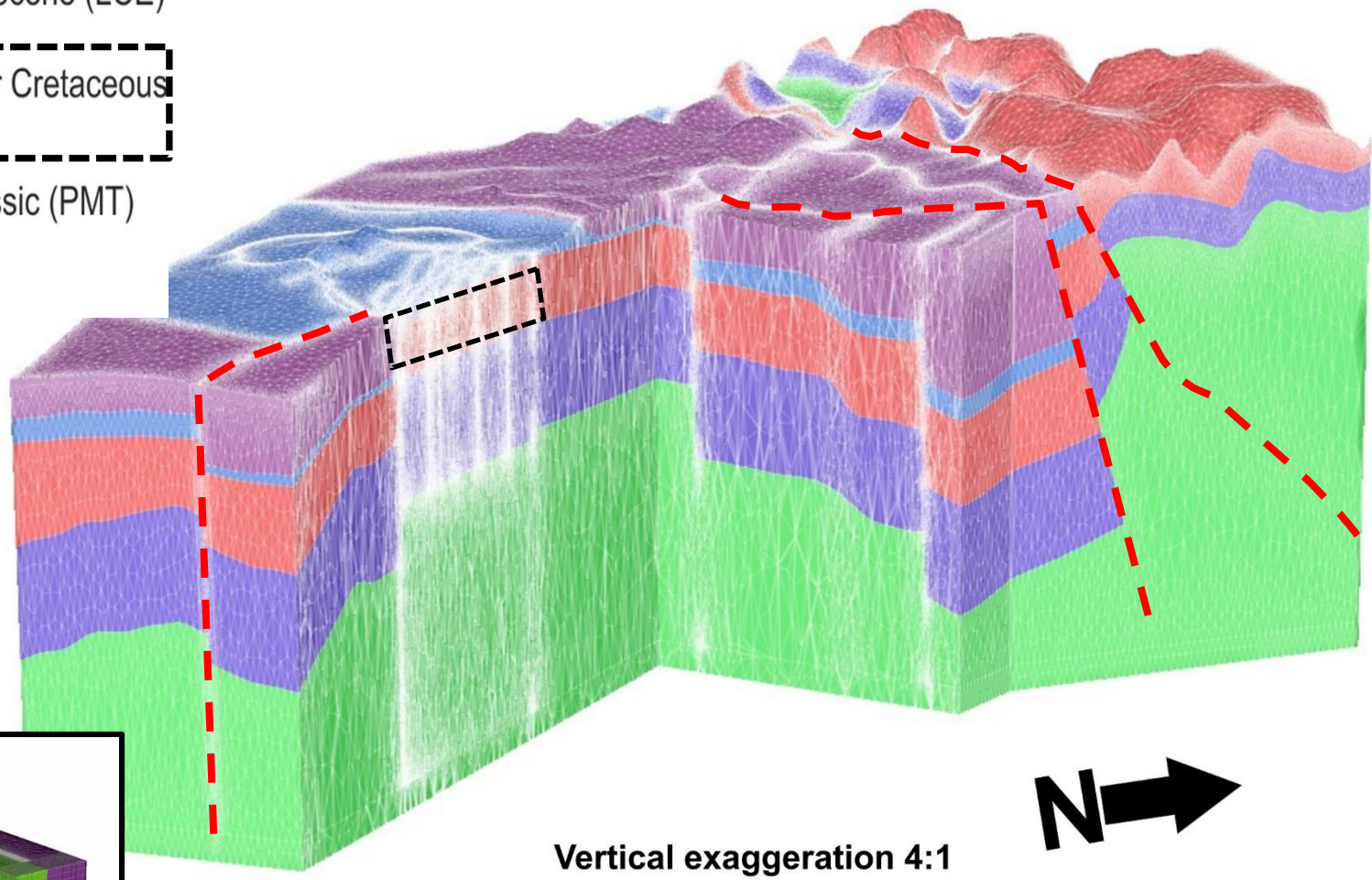
Eocene - Miocene (EM)

Lower Cretaceous - Eocene (LCE)

Upper Triassic - Lower Cretaceous (UTLC)

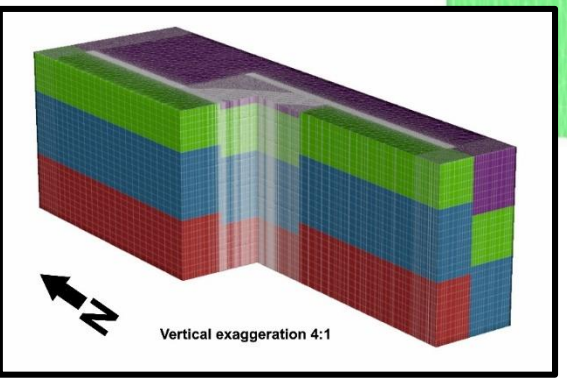
Permian - Middle Triassic (PMT)

Pre-Permian (PP)



N

Vertical exaggeration 4:1



MIKE Powered by DHI FEFLOW

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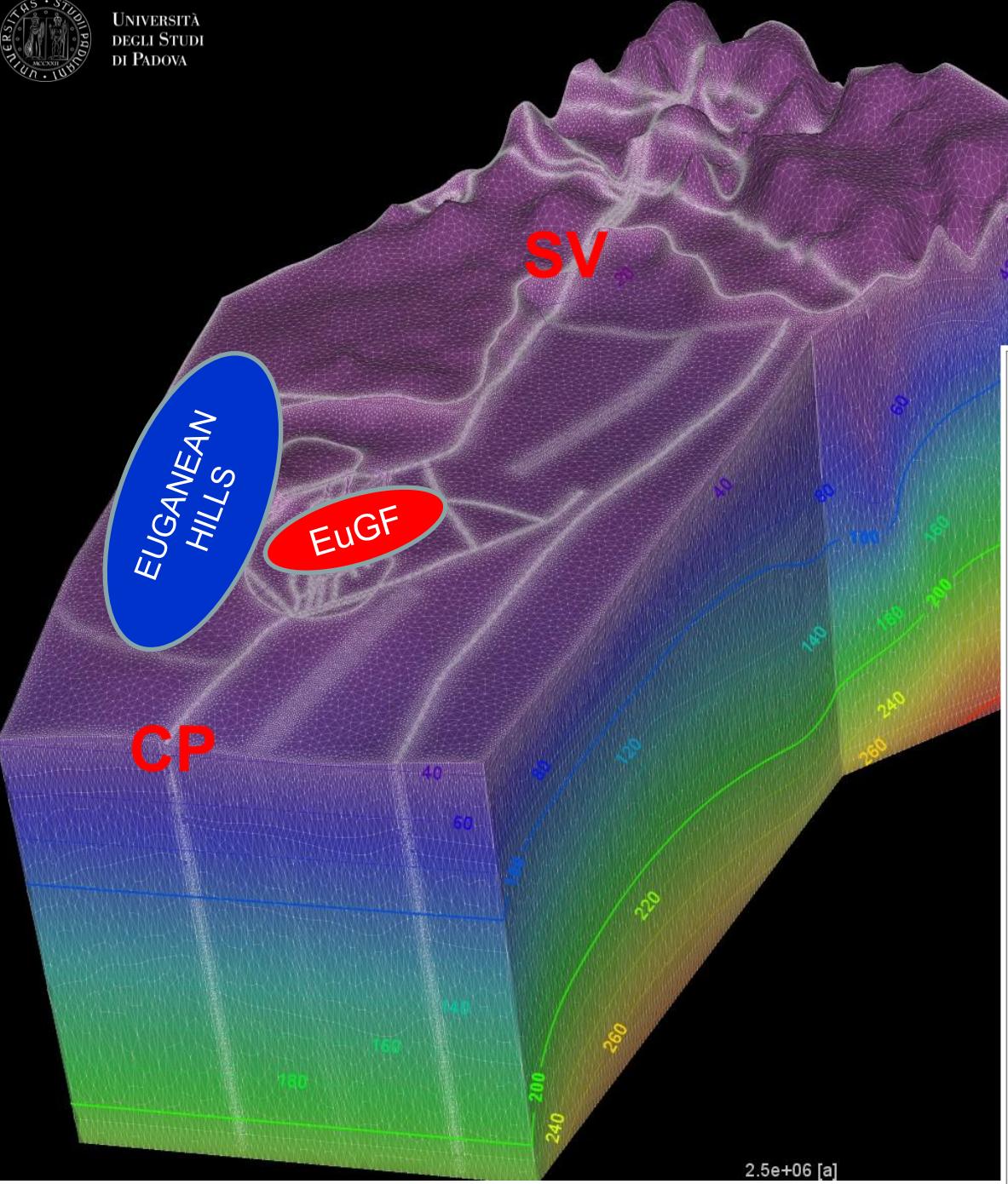
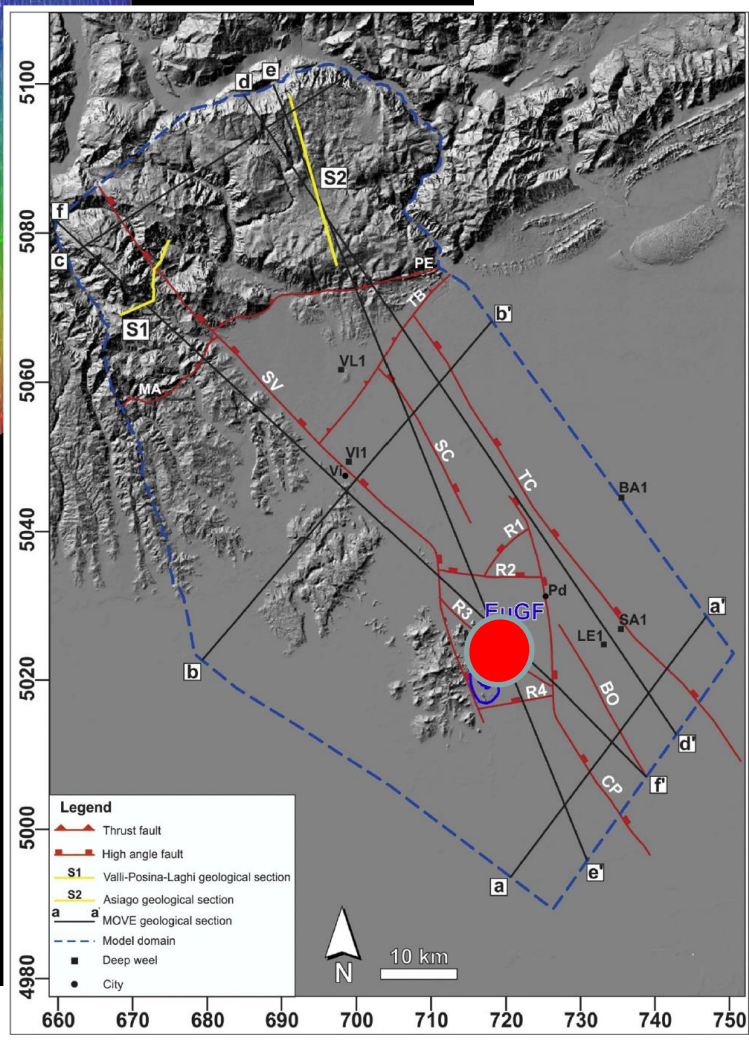
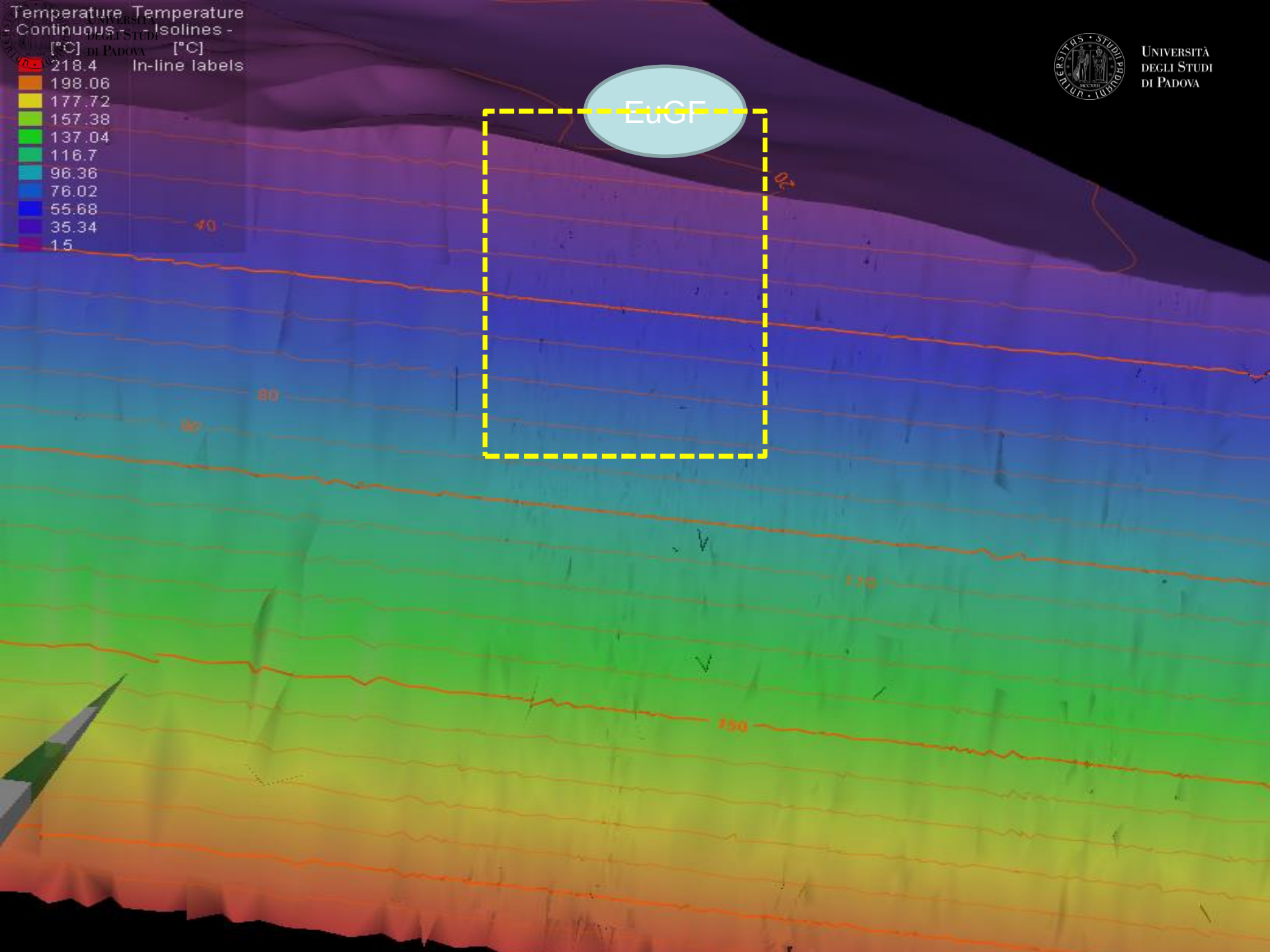
50 x 115 x 9 km
5.2 M elem
2.5 My






Temperature Temperature
- Continuous - - Isolines -
[°C] [°C]
218.4 In-line labels
198.06
177.72
157.38
137.04
116.7
96.36
76.02
55.68
35.34
15
EuGF
40
80
120
150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THIS IS EUGANEAN TREASURE

Thanks for your attention!

https://it.wikipedia.org/wiki/Bacino_Termale_Euganeo