Delineation and characterization of geothermal reservoirs in the Southern part of the Pannonian Basin

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GEOTHERMAL RESERVOIR

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Geothermal reservoir: Subsurface 3D space where the rocks contain hot fluidum which can be exploited economically

Approach	*extent of the reservoir*	*characterization*
-geological	geological-hydrogeological units; regional scale	location, geometry, volume lithology, temperature
-economical	thermal energy can exploited economically (local and regional scale)	resource estimation; cost estimation
-engineering	surroundings of wells (local scale)	well test permeability, yield

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DANUBE REGION LEADING GEOTHERMAL ENERGY

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15 partners
from 6 countries
(HU, SLO, HR, SRB, BH, RO)

Project objective:

To increase
the sustainable and
energy-efficient use
of deep geothermal
energy resources
in the heating sector

MBFSZ
GeoZS Geološki zavod Slovenije
TerraTechnik
Zagorska Razvojna Agencija
IGR
Ministry of Foreign Affairs and Trade of Hungary
InnoGeo
Bosnia and Herzegovina Federation of Bosnia and Herzegovina Federal Institute for Geology Sarajevo
MANNVIT
LEA Pomurje
Lokalna energetska agencija za Pomurje
Local Energy Agency Pomurje
HGI 1909
HRVATSKI GEOLOŠKI INSTITUT
CROATIAN GEOLOGICAL SURVEY

METHOD OF DELINEATION AND CHARACTERISATION OF GEOTHERMAL RESERVOIRS (1)

The aim of outlining and characterizingf reservoirs in DARLINGe project:

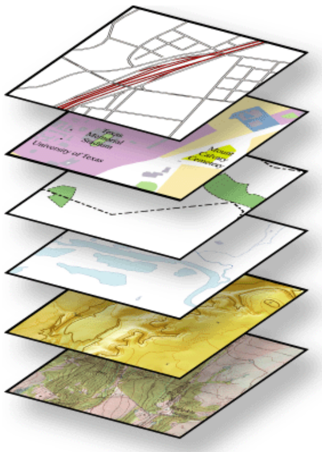
-to identify potential geological/hydrogeological units containing thermal water
-to provide information about utilization possibilities (especially for energy purposes) for stakeholders, decision makers and potential investors

Large scale assessment (1:500 000)

-regional scale → lower resolution → simplifications
(Not suitable for geothermal well design)

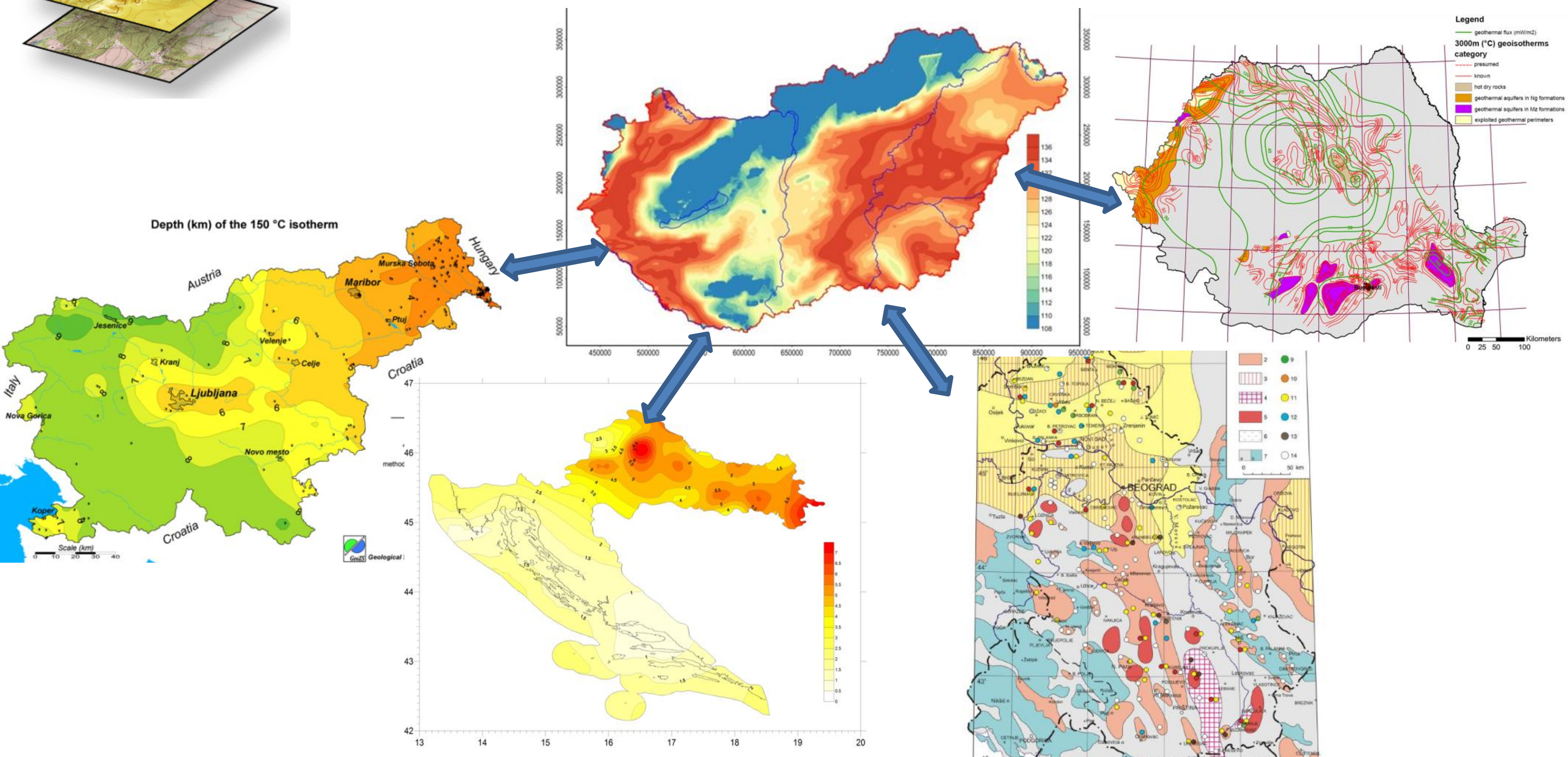
Thermal water: > 30°C

METHOD OF DELINEATION AND CHARACTERISATION GEOTHERMAL RESERVOIRS (2)



Delineation:

Combination of geological and isotherm surfaces
(unique methods in creating harmonized surfaces)



METHOD OF DELINEATION AND CHARACTERISATION GEOTHERMAL RESERVOIRS (3)

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Characterisation:

Temperature categories considering utilization aspects:

- 30°C
- 50°C
- 75°C
- 100°C
- 125°C
- 150°C

Sub-categorization based on hydro-geochemical data

- Hydro-geochemical character of thermal water
- TDS values

Resource estimation

Regional scale → applying statistical method

RESOURCE ESTIMATION

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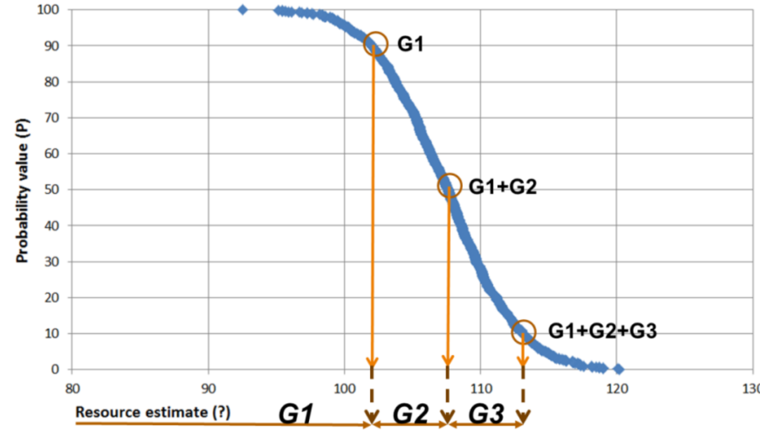
Resource estimation of recoverable thermal energy of the identified reservoirs using probabilistic approach (Monte Carlo simulation): project → regional scale

	Input parameters					Calculated parameters			
	A	B	C	D	E	F	G	H	**I**
	Reservoir area (km^2)	Reservoir thickness (km)	Porosity (V/V)	Reservoir temp. (˚C)	Recovery factor	**Total volume (km^3)**	**Pore volume (km^3)**	**Porosity heat content (PJ)**	**Recove-rable heat (PJ)**
Calculation formula						A*B	C*F	4.187*G*(D-30)	**(H*E)**
MIN									
MAX									

G1: Quantities associated with a high level of confidenece (low estimate – P90)

G2: Quantities associated with a moderate level of confidenece (best estimate – P50)

G3: Quantities associated with a low level of confidenece (high estimate – P10)



GEOTHERMAL CONDITION AND RESERVOIRS IN THE SOUTHERN PART OF THE PANNONIAN BASIN

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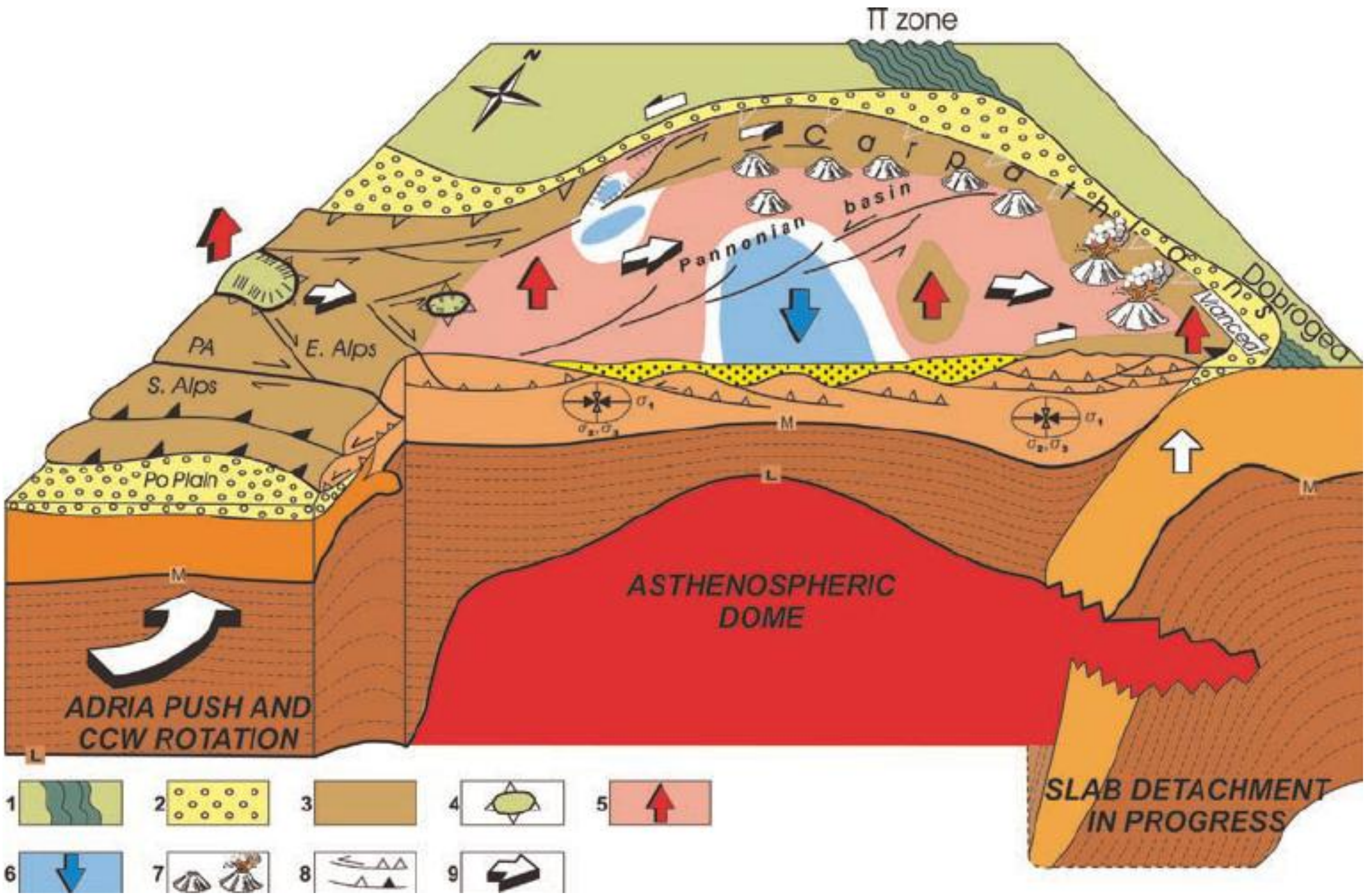
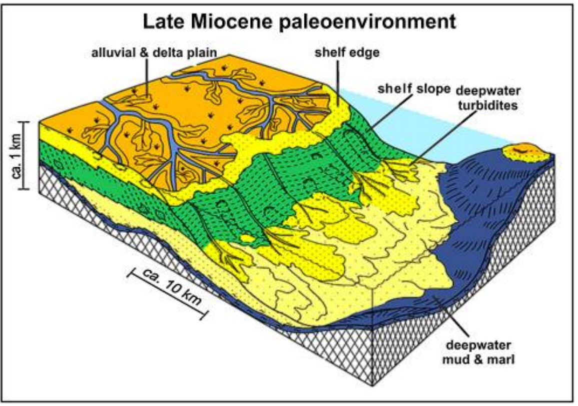
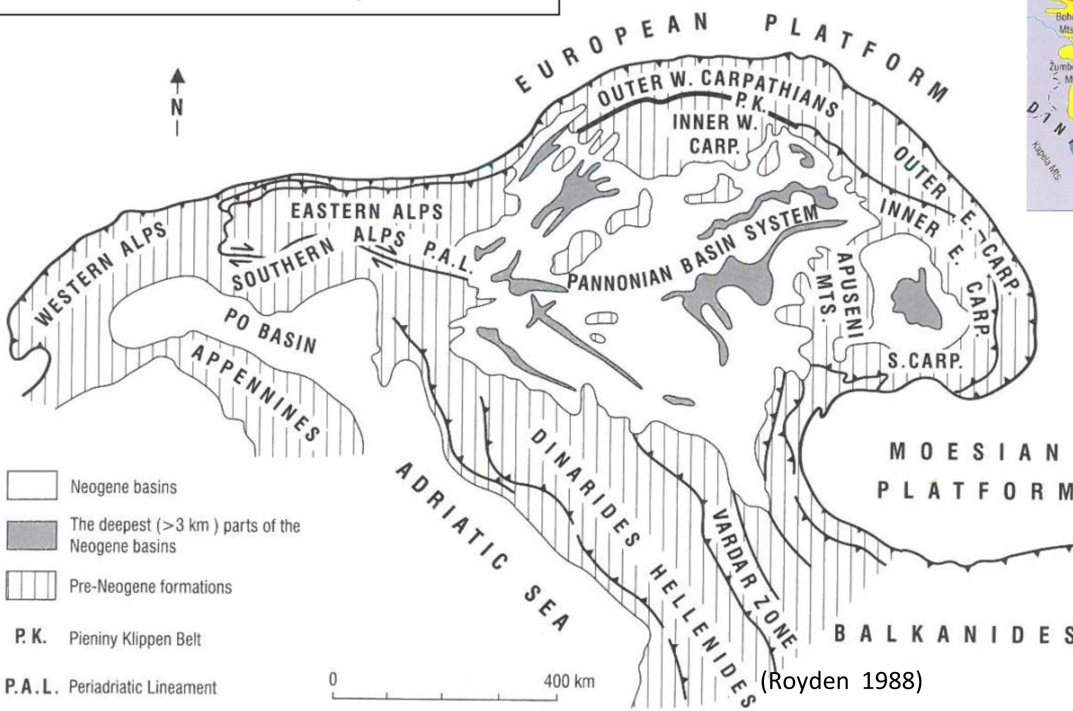


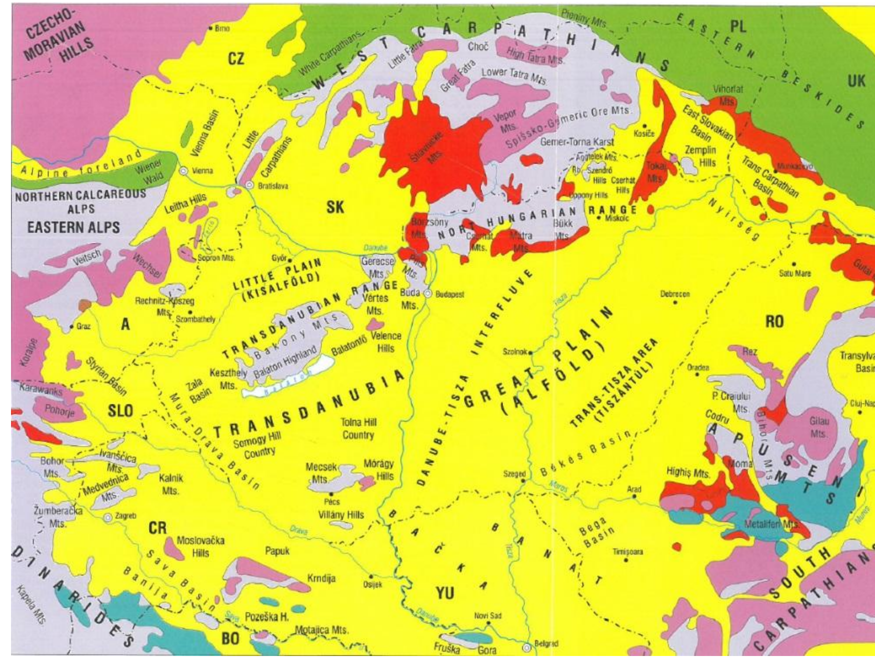
(Horváth et al. 2015)

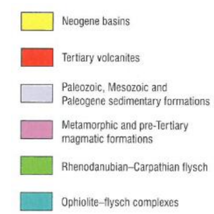
COMPLEX GEOLOGICAL STRUCTURE



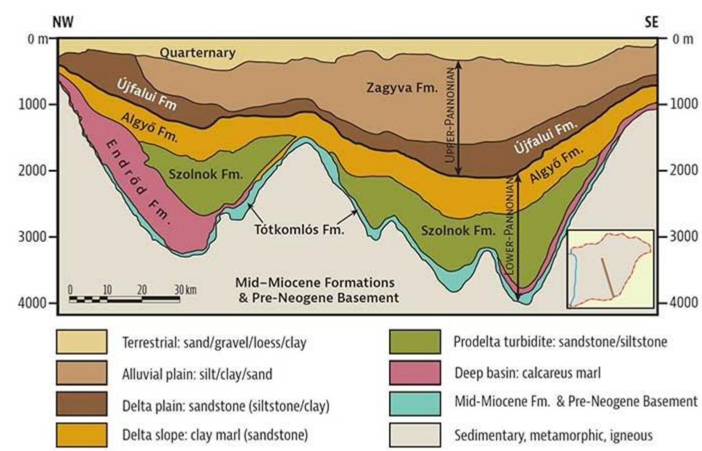


(Royden 1988)





(Haas 2010)



OUTLINING OF GEOTHERMAL RESERVOIRS

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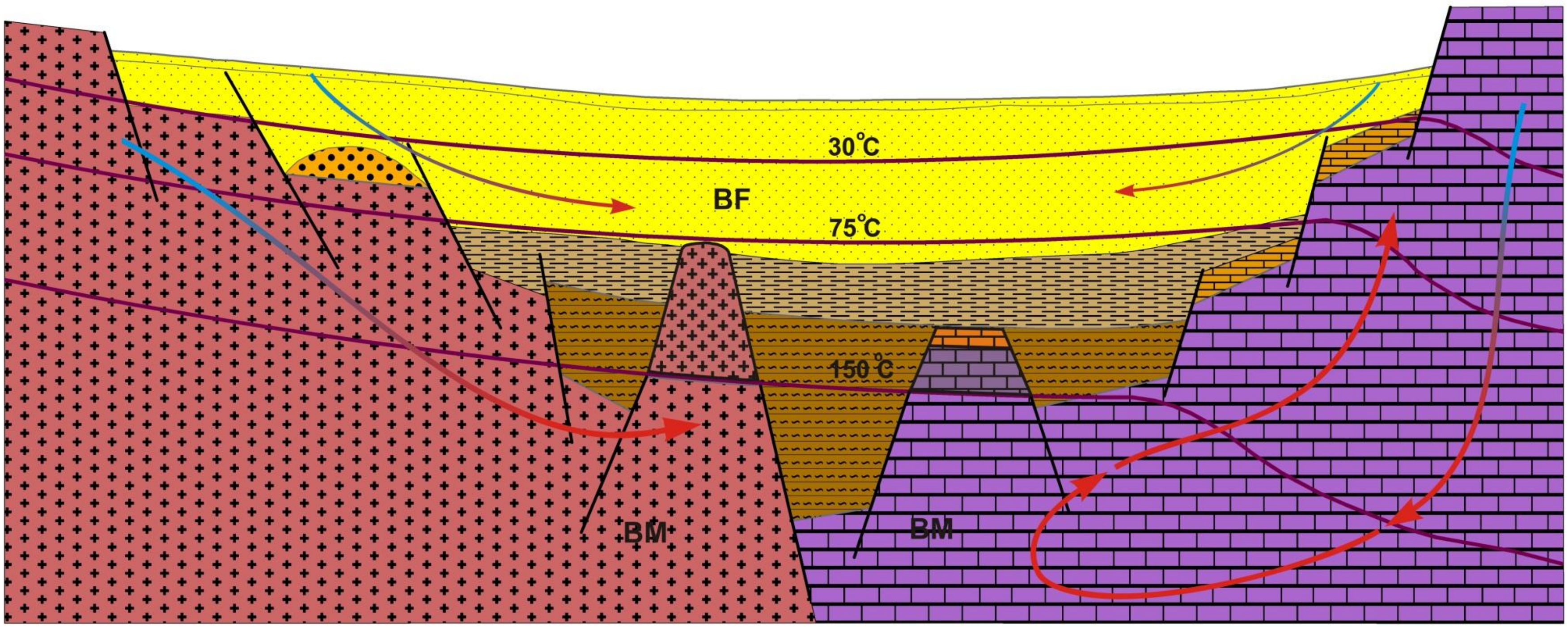
Applying simplifications for determining harmonized reservoirs →

- Basin-fill reservoirs
- Basement reservoirs



CREATING GEOLOGICAL SURFACES (1)

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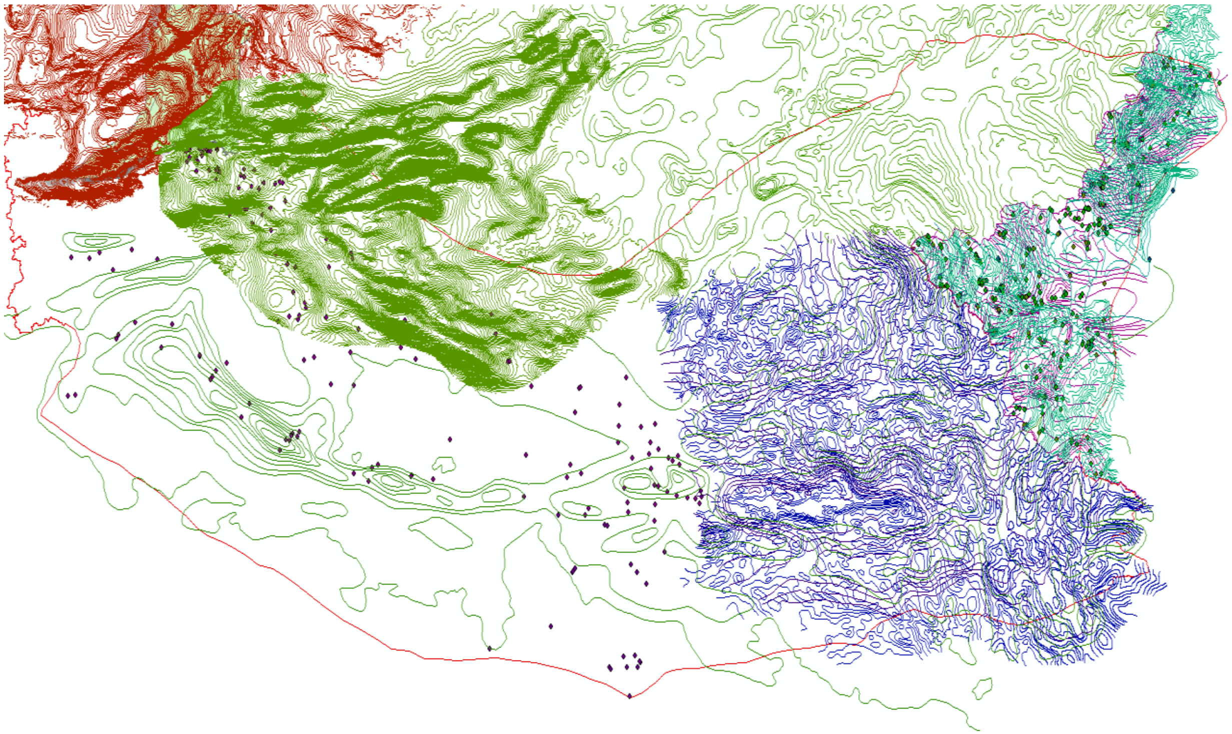
- Different formats of geological data in each partner country
- Harmonization of geological surfaces on workshops
- 3D geological model (JEWEL)



CREATING GEOLOGICAL SURFACES (2)

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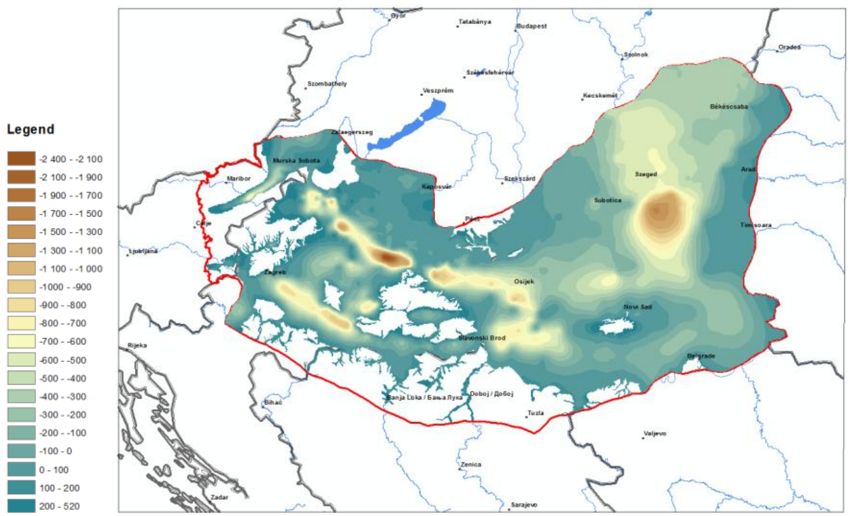
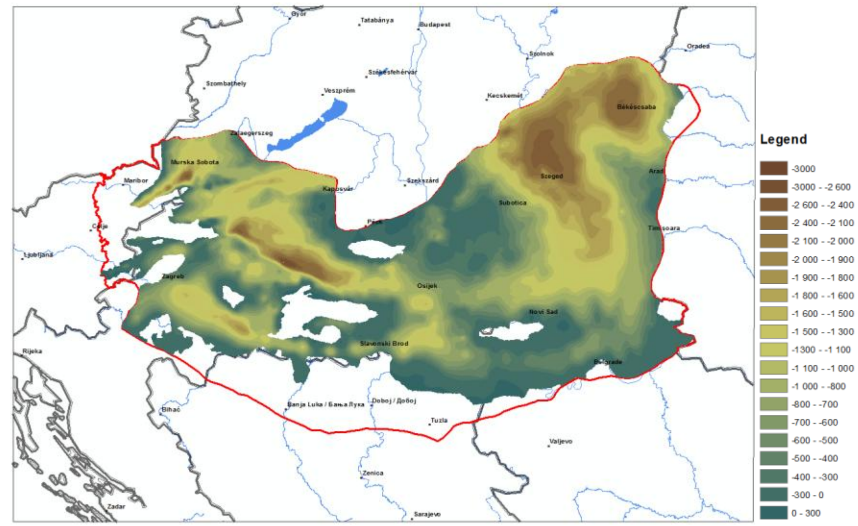
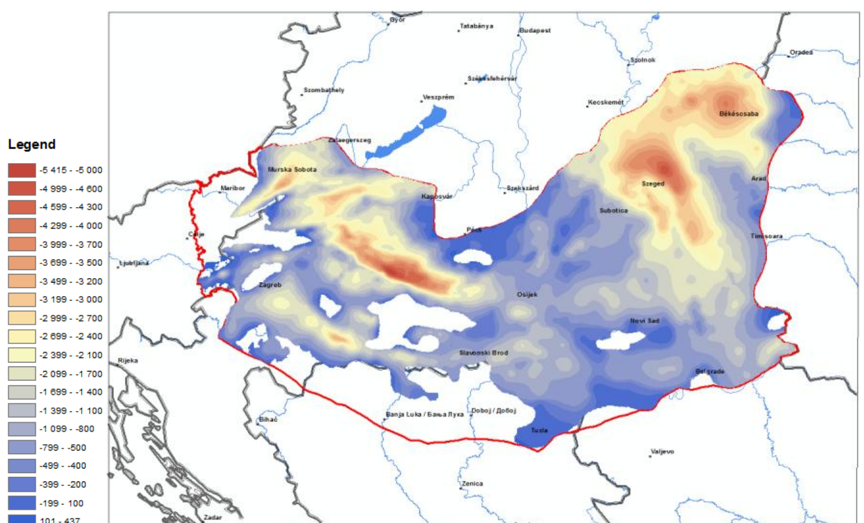
Top of Basinfill Reservoir (BF)



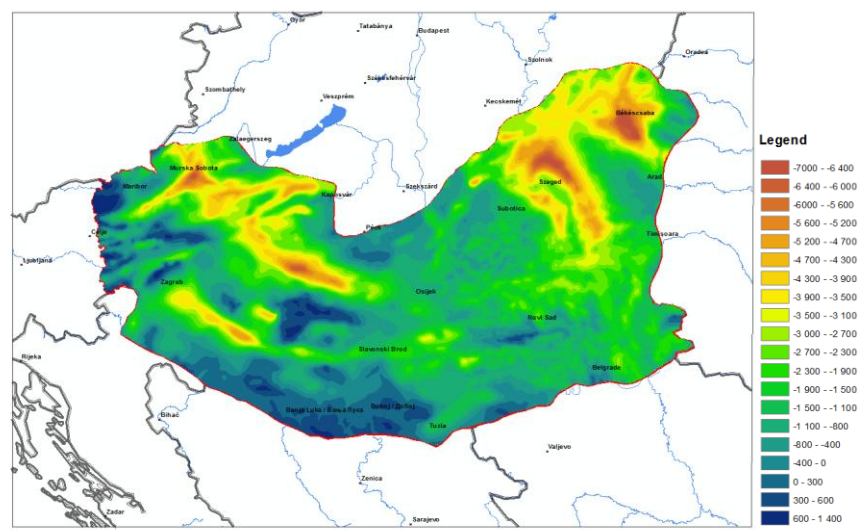
Bottom of Basin-fill Reservoir (BF)



Bottom of Pannonian sediments



Top of Basement Reservoir (BM)



CREATING ISOTHERM SURFACES

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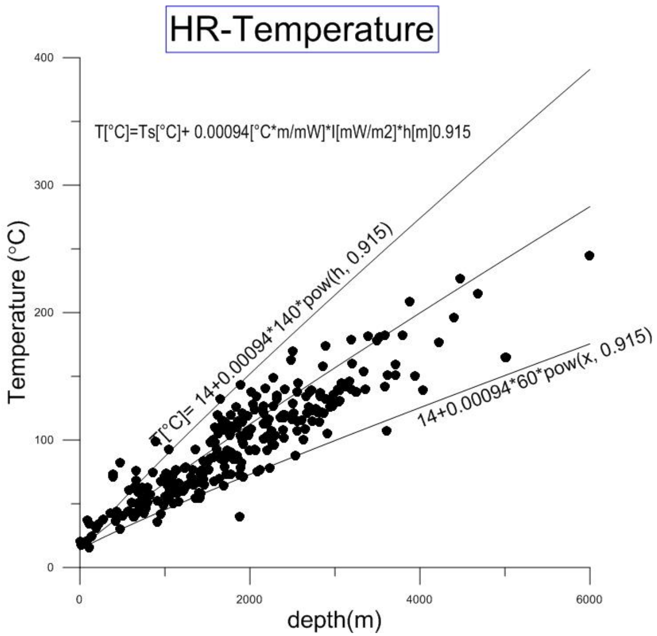
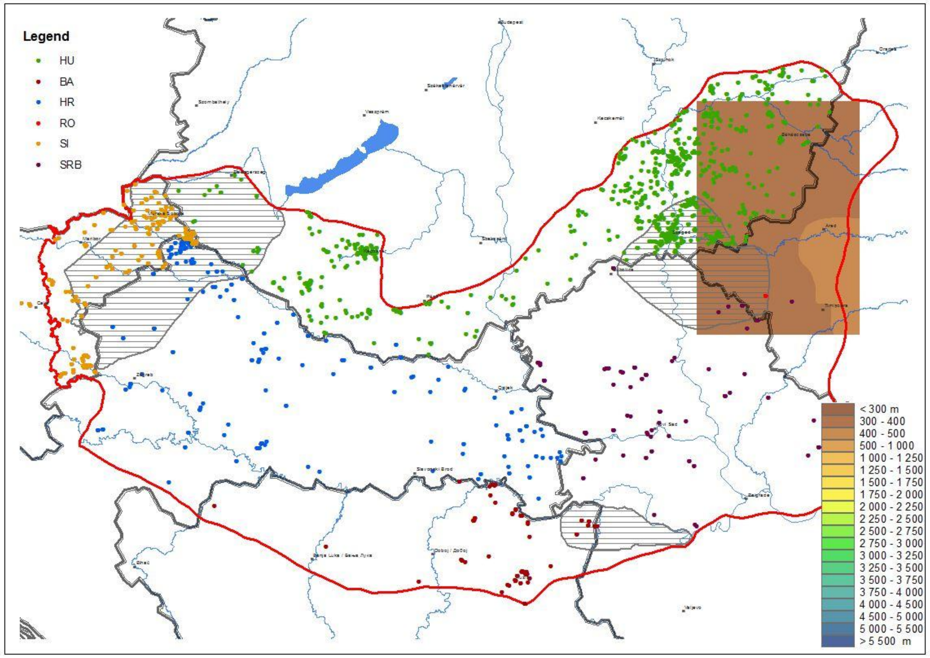


Temperature measurement data have high degree of uncertainity

Unfavourable spatial distribution of temperature data



Applying a simplified conductive model → Regional estimation of temperature surfaces

CREATING ISOTHERM SURFACES (2)

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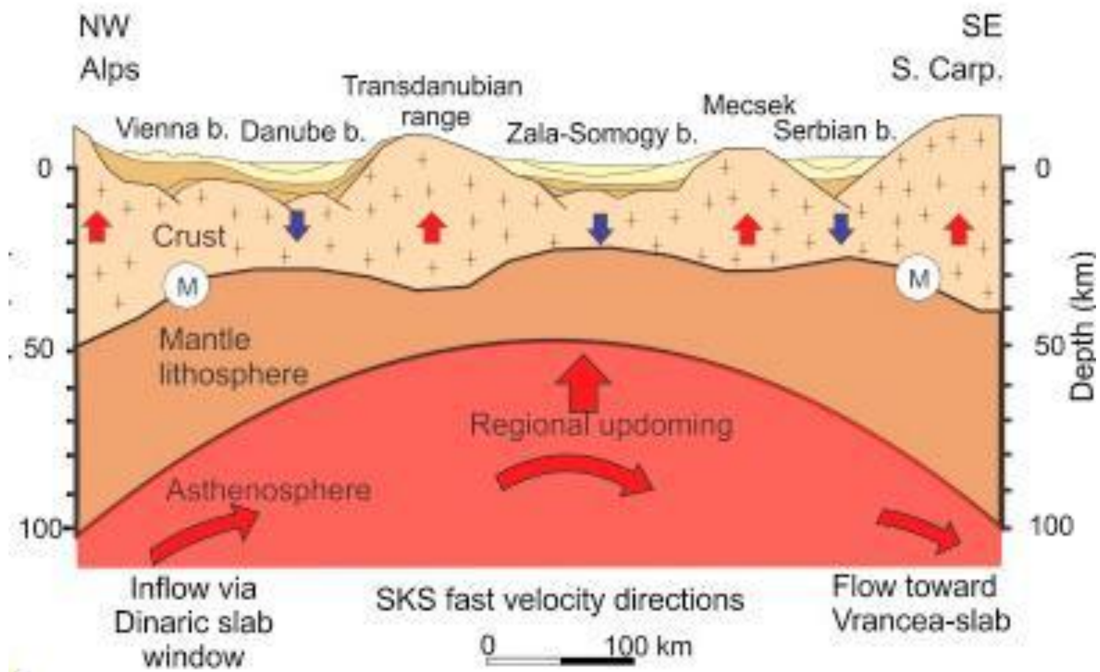
Basic assumptions of the simplified conductive geothermal model:

- Favourable geothermal condition of the Pannonian Basin is due to thinning of the lithosphere
- The thinning of the lithosphere is the result of the thinning of the lower crust. Therefore the depth of the Pannonian Basin is proportional to the rate of thinning.
- The temperature is constant at the basement of the crust (T=1000°C)
- Heatflow is constant in the basement (effect of radioctive decay is neglected), so the temperature of the basement surface can be calculated
- Heat conductivity of the basin fill sediments depends on porosity. Variation of porosity is the function of depth (increasing with depth)



(Horvath et al. 2015)

$I\{mW/m^2\}=989/((\mathbf{20000*(1+exp(-x/1800))})/2.5e3+0.00094*x^{0.915})$

$\mathbf{T\{C\}=T_s+0.00094*I\{mW\}*H^{0.915}}$

I = heatflow; X= depth of the basin; **T_s**= surface temperature

Isoterm surfaces compared to temperature measurements

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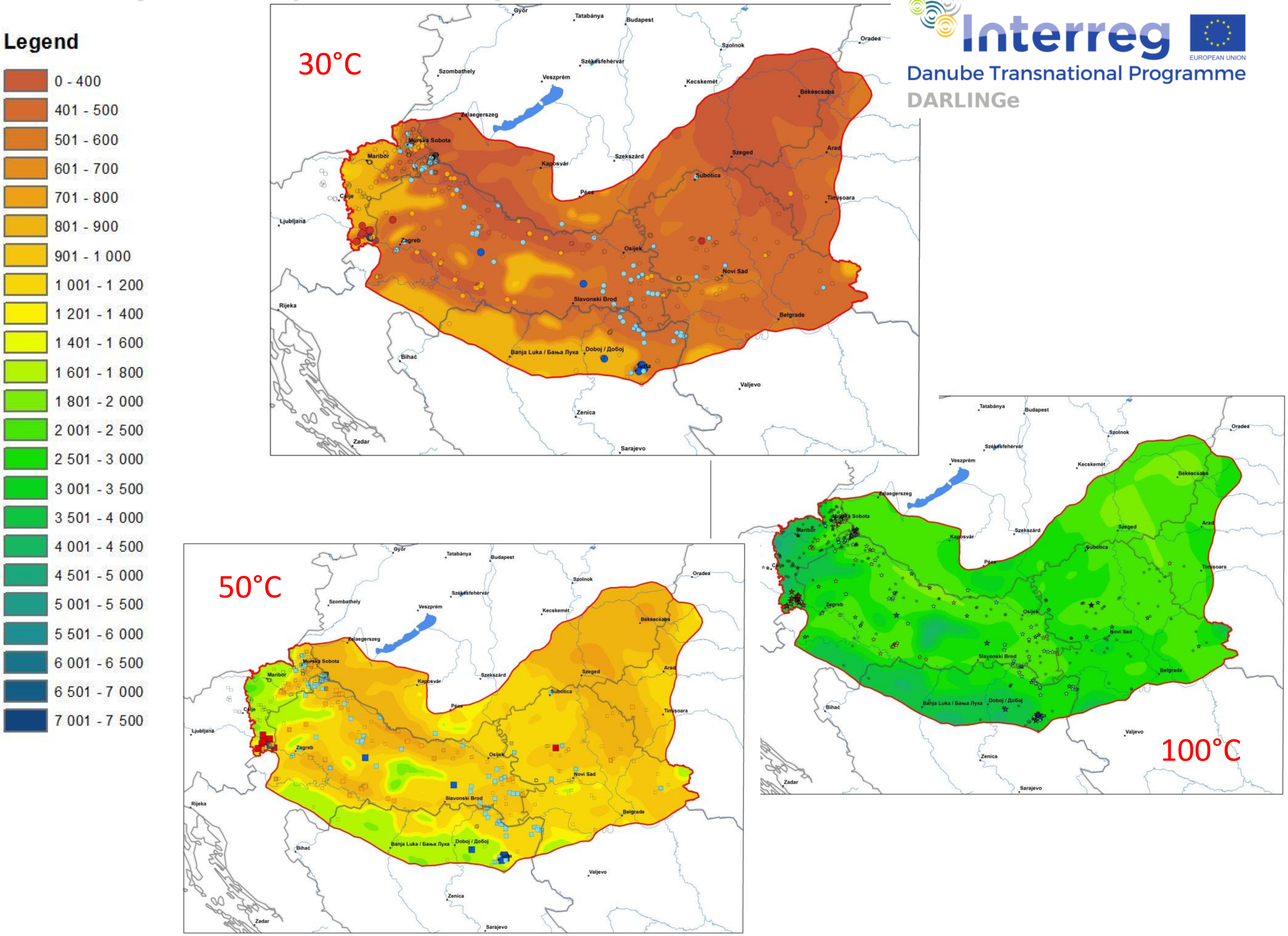

CONCLUSION

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- Aim of delineation of reservoirs in the DARLINGe project is to provide information about utilization possibilities for stakeholders, decision makers and potential investors
- Regional scale assesement can be done applying simplifications:
  – selected reservoir types
  – harmonization of geological and geothermal information
  – creating isotherm surfaces applying simplified conductive model
- Characterization of reservoirs acording to temperature and hydro-geochemical behavior
- Applying probabilistic approach in resource estimation

Transboundary geothermal reservoirs can be delineated and characterized in regional scale applying common methodology in 6 countries


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Thank you for your attention!