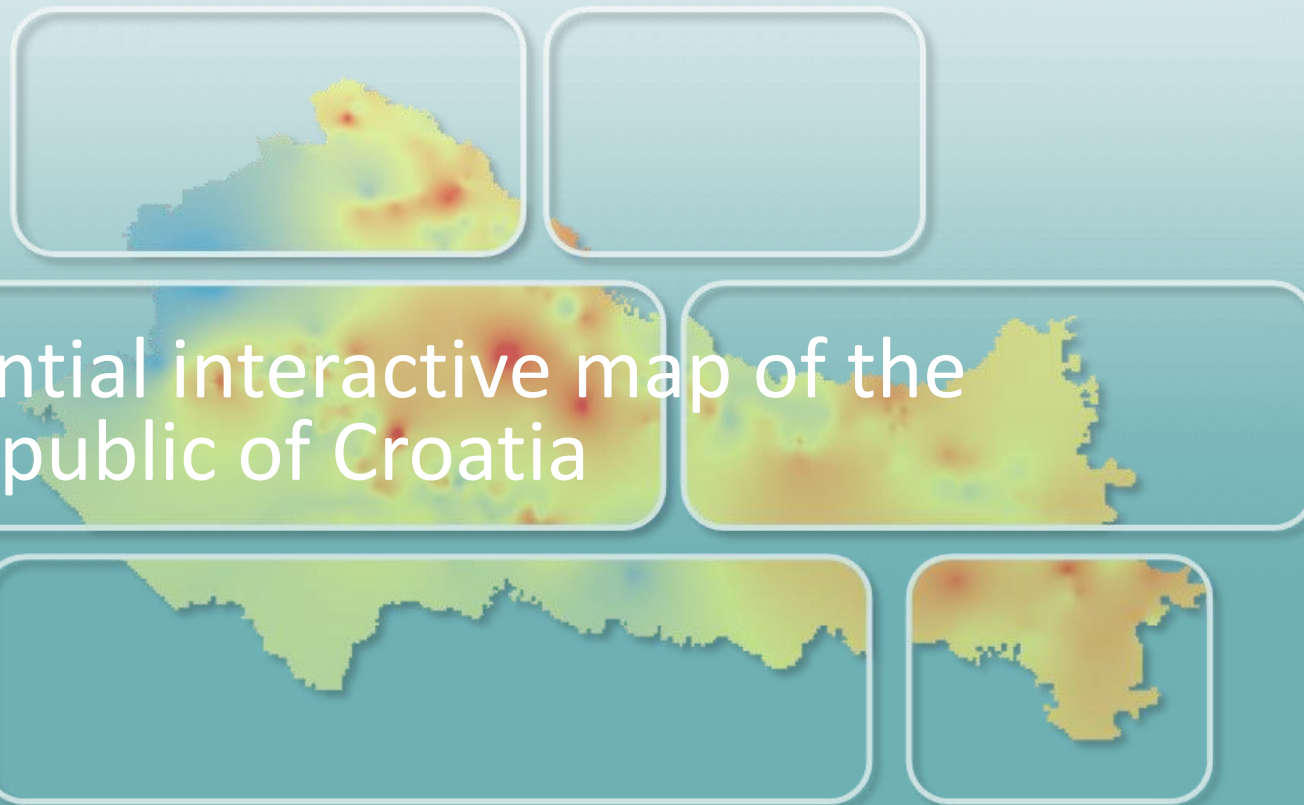


PROJECT

Creating geothermal potential interactive map of the Pannonian Basin in the Republic of Croatia



GEOLOGICAL SETTINGS

The Republic of Croatia is geologically divided into two parts: the Pannonian Basin in the north and the Dinarides in the south.

The northern part of Croatia represents the southwestern margin of the Pannonian Basin, which is characterized by a high geothermal gradient (average $0.05\text{ }^{\circ}\text{C}/\text{m}$).



WHY ONLY PANNONIAN BASIN?

Large numbers of wells drilled in Pannonian basin for hydrocarbon purposes

Geothermal potential has been proved in cca 200 wells

Above-average high geothermal gradient (mean geothermal gradient of Pannonian Basin of Croatia) is 60 % higher than the European average

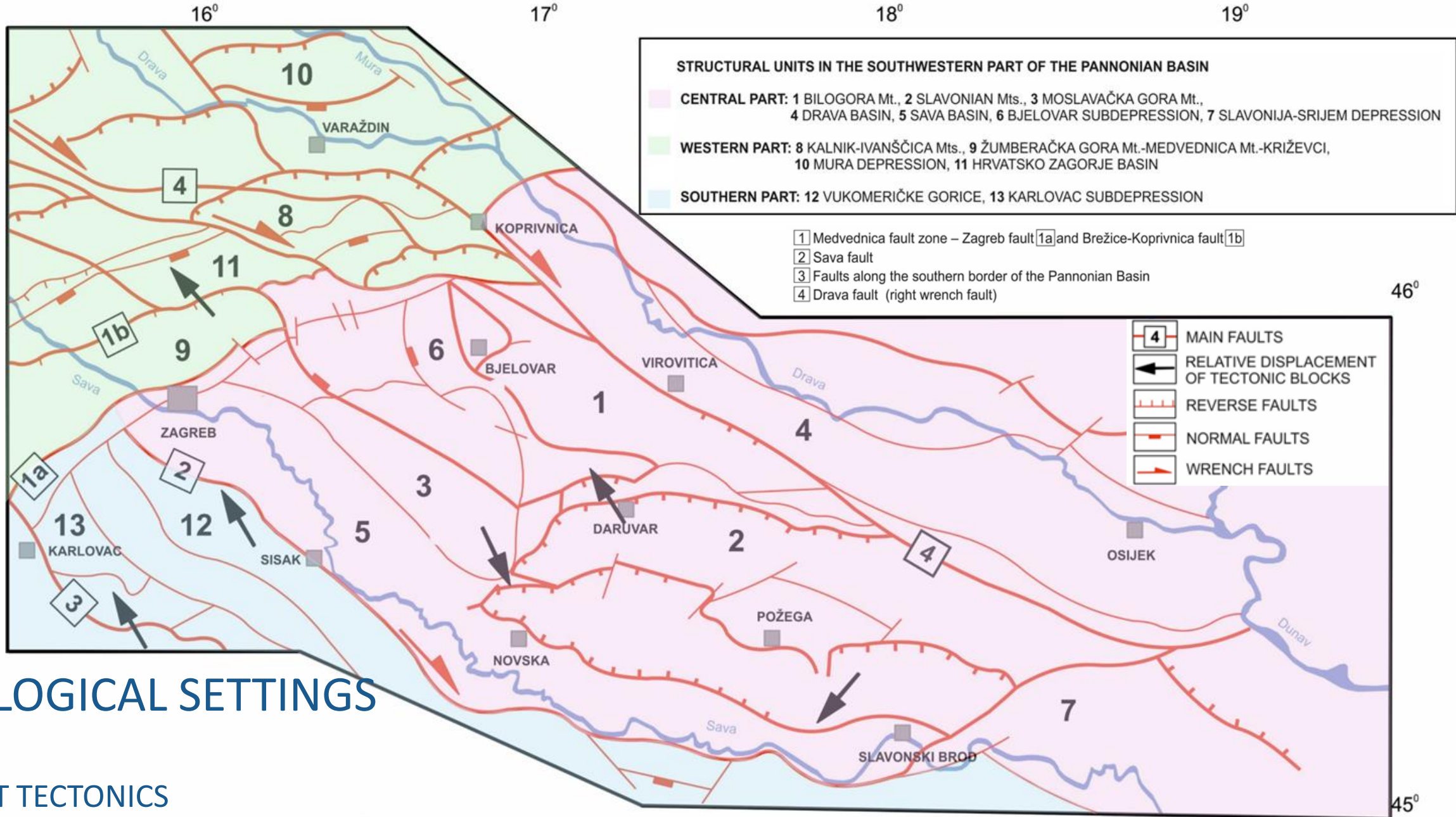
Dinarides have low geothermal potential

Small number of drilled wells in the Dinarides



GEOLOGICAL SETTINGS

RECENT TECTONICS



Structural units and main faults in the southwestern part of Pannonian Basin (modified after Prelogović et al. 1998)

PROJECT TEAM

LUKA ARAS

PROJECT MANAGER

**ANA
BELJAN**

FINANCIAL COORDINATOR

**ANA
PETROVIĆ**

PUBLIC PROCUREMENT
COORDINATOR AND LEGAL
LEGISLATION

**LJILJANA
ZORNJAK**

MEMBER OF THE TEAM IN
THE FIELD OF RESERVOIR
ENGINEERING AND
GEOTHERMAL WORKS

**ZORICA
KUREŠIĆ**

MEMBER OF THE TEAM IN
THE FIELD OF RESERVOIR
ENGINEERING AND
GEOTHERMAL WORKS

**BARBARA
GLUHAK
POPOVIĆ**

MEMBER OF THE GEOLOGY
TEAM

**KRISTINA
NOVAK
ZELENIKA**

MEMBER OF THE GEOLOGY
TEAM

**IGOR
TURČIN**

MEMBER OF THE GIS
ENVIRONMENT TEAM

**IVANA
MIJIĆ**

MEMBER OF THE INFORMATION
AND VISIBILITY TEAM



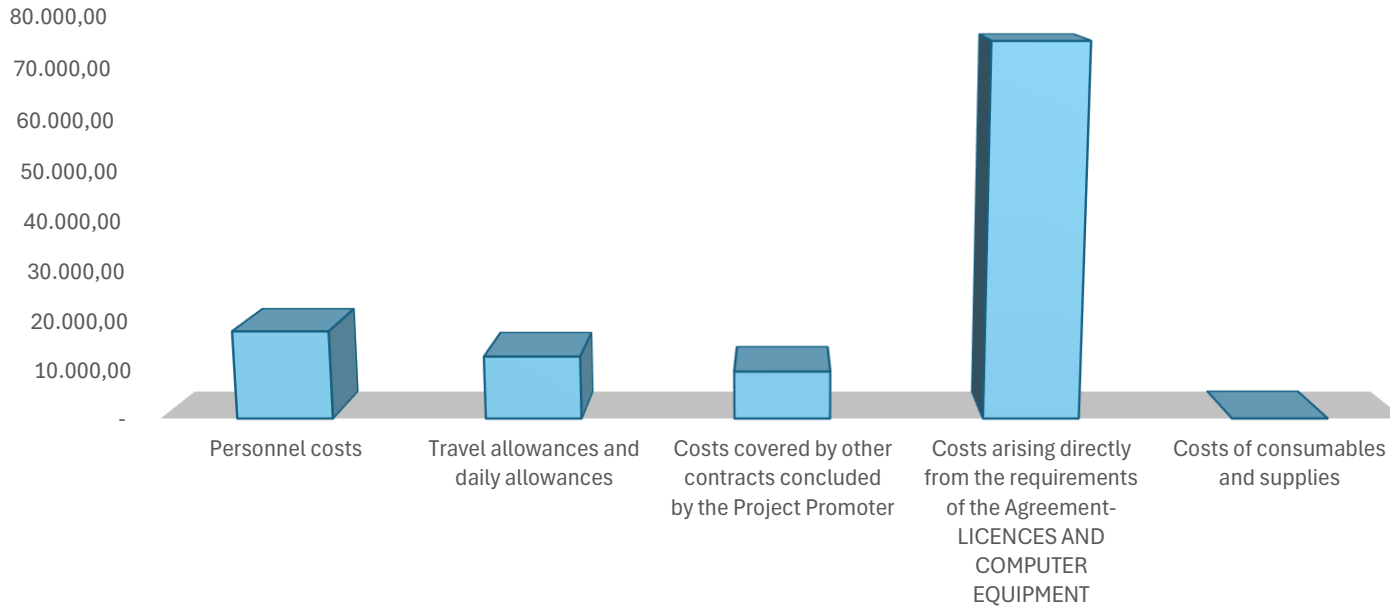
FINANCE

PROJECT COST

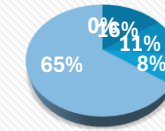
115,398.04 EUR

PROJECT COSTS BY TYPE

■ REALIZED GRANTS



SHARE BY TYPES OF COSTS



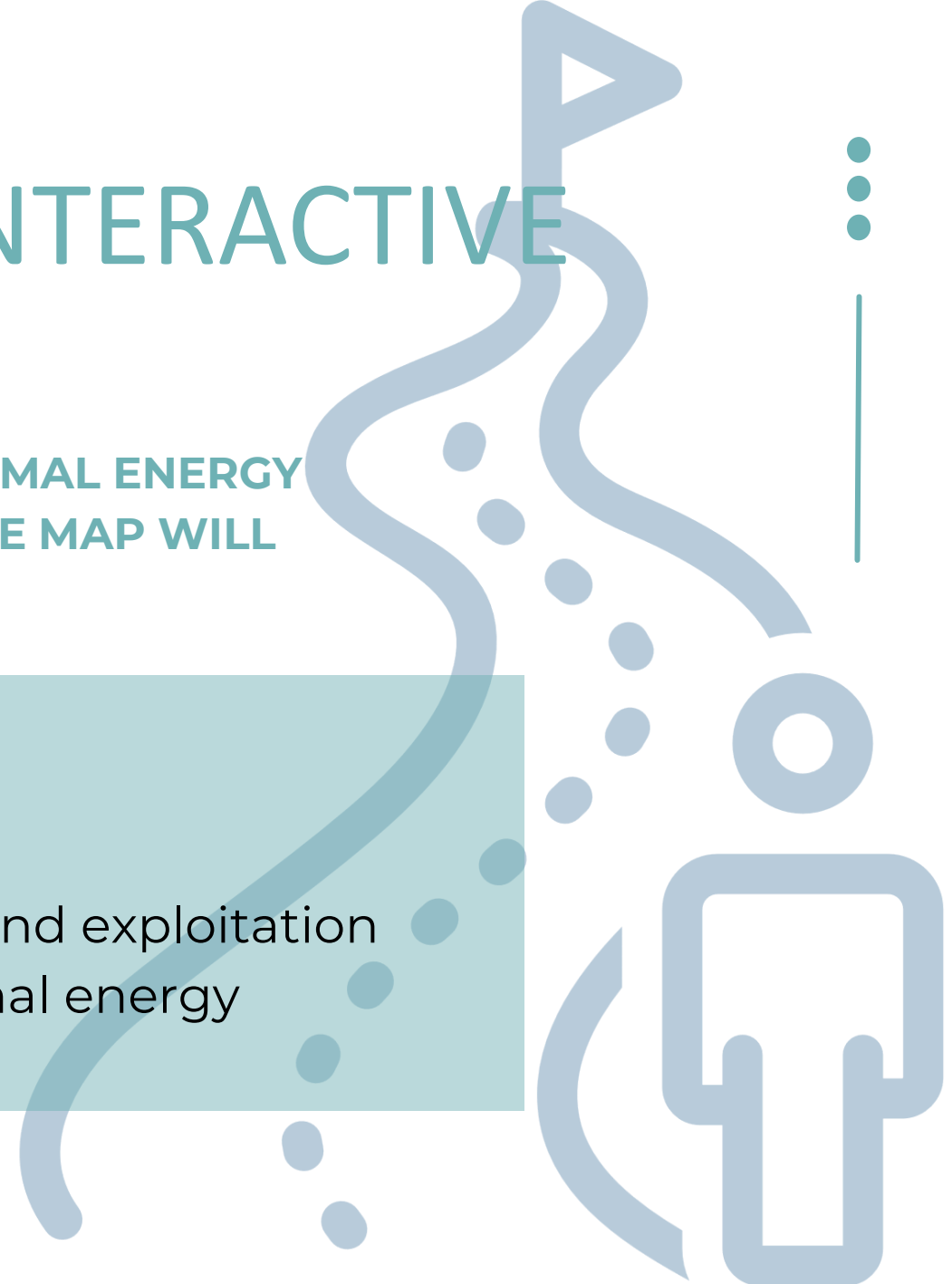
- Personnel costs
- Travel allowances and daily allowances
- Costs covered by other contracts concluded by the Project Promoter
- Costs arising directly from the requirements of the Agreement-LICENCES AND COMPUTER EQUIPMENT

PROJECT OBJECTIVE – INTERACTIVE MAP

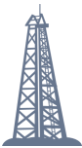
- TO STRUCTURE A DATABASE OF DEEP GEOTHERMAL ENERGY ON THE BASIS OF WHICH A UNIQUE INTERACTIVE MAP WILL BE MADE AND PUBLICLY PUBLISHED

Encompasses:

- Display of **well data**
- Geothermal gradient **map**
- **Display** of exploration blocks and exploitation fields boundaries for geothermal energy purpose



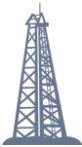
NATIONAL WELL DATABASE



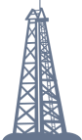
Total well number > 3500



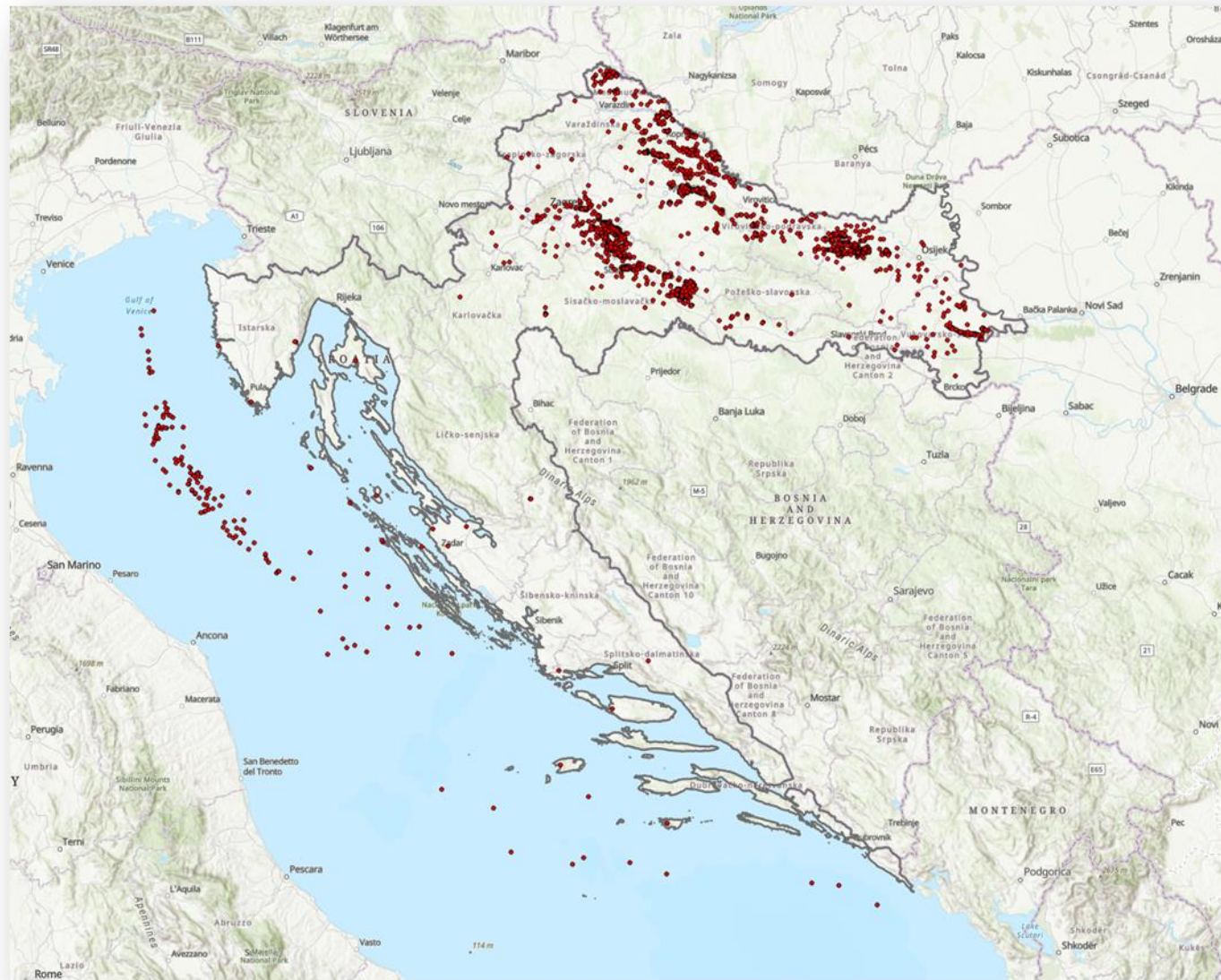
Adriatic Offshore > 180



Dinarides = 24



Pannonian Basin > 3300

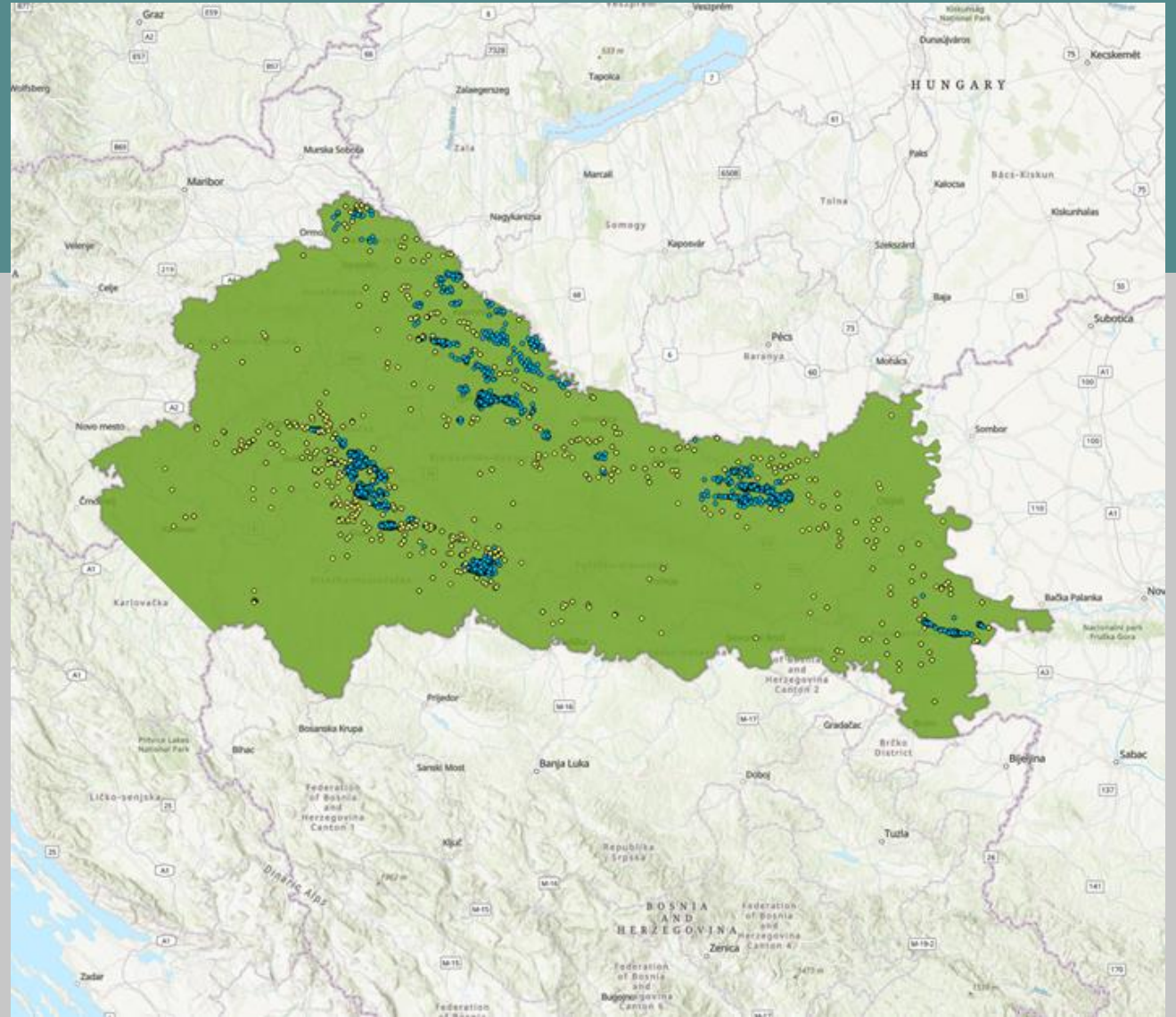


TEMPERATURE - DATA COLLECTION

- Total Numbers of wells in Pannonian Basin > 3300
- Reviewed 2723 wells
- 562 wells outside of HC exploitation fields
- 2161 are inside HC exploitation fields

Temperature data source :

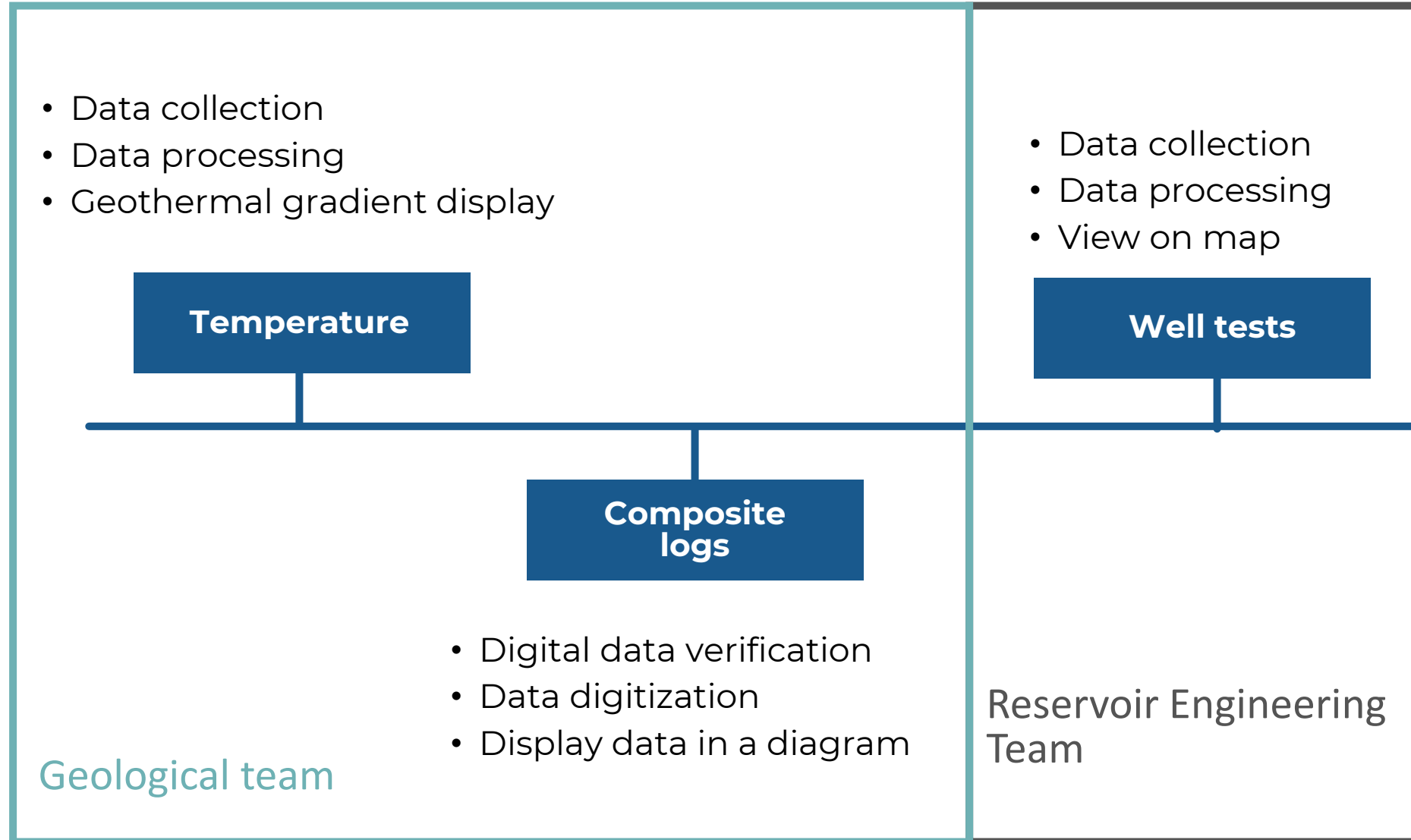
- Temperature curves
- Logging records
- Well log headers
- Other documents





METHODOLOGY

Display of relevant well data



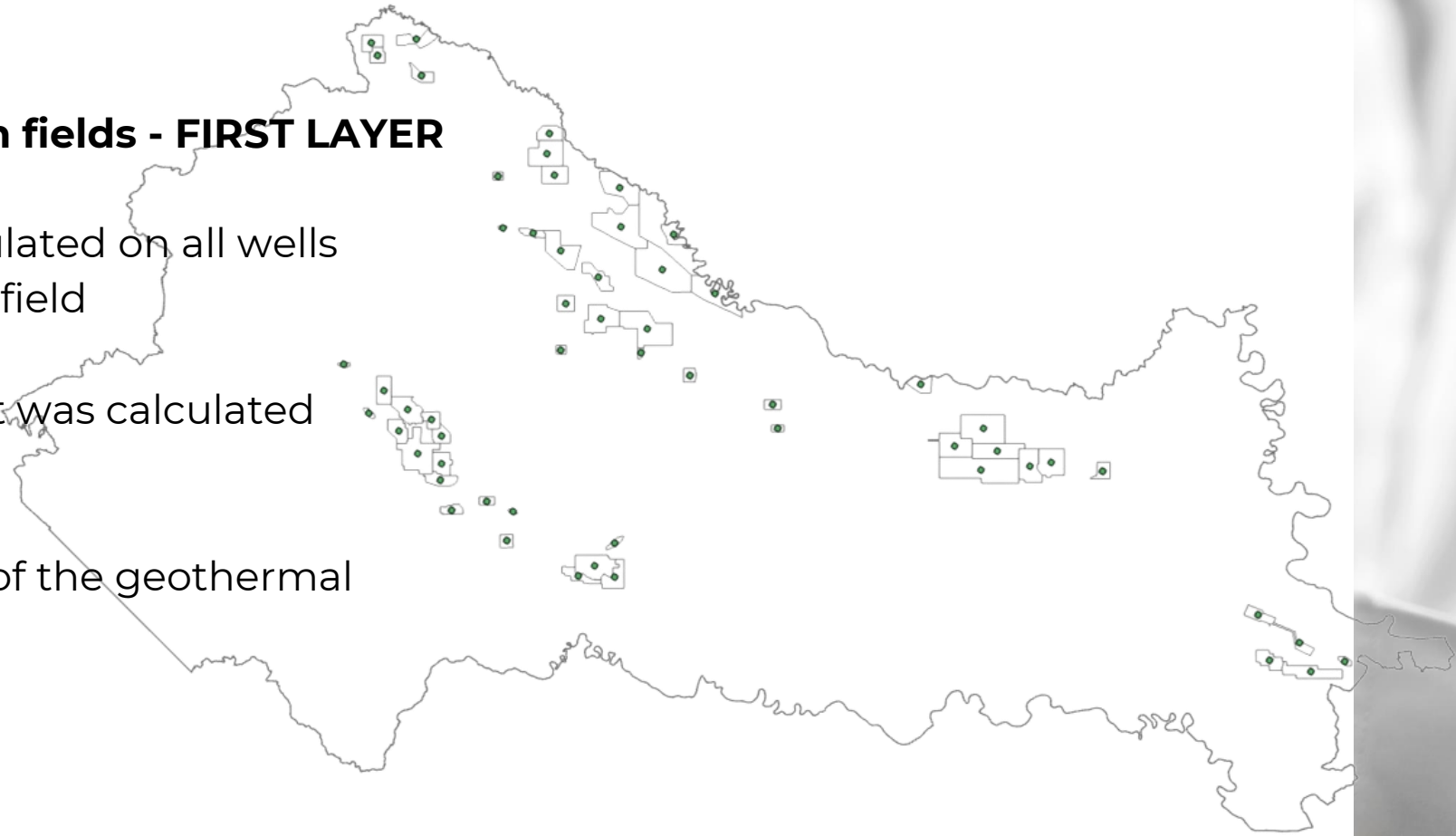
DATA PROCESSING

1. Wells inside HC exploitation fields - FIRST LAYER

Geothermal gradient was calculated on all wells located within the exploitation field

The mean value of the gradient was calculated for each exploitation field

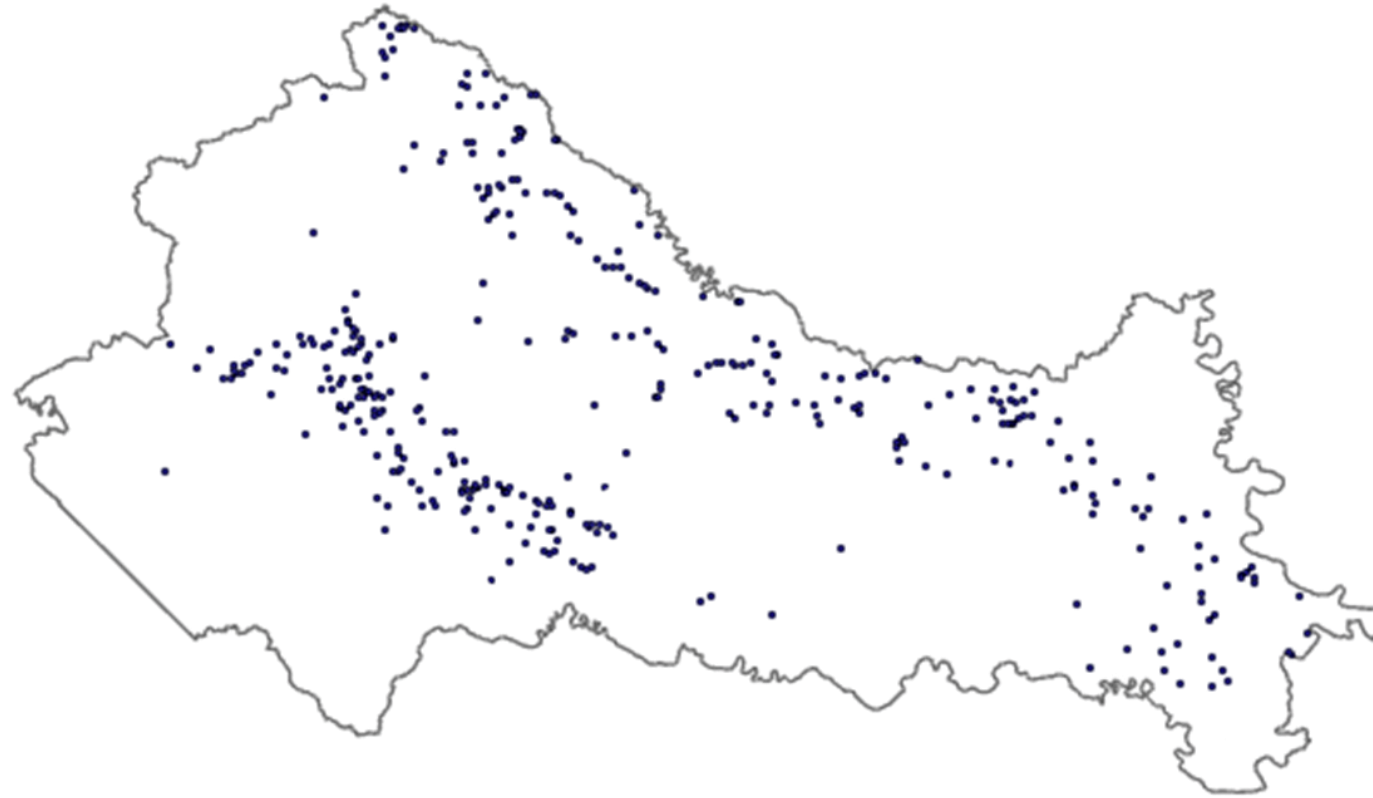
With this data, the calculation of the geothermal map was entered





DATA PROCESSING

2. Wells outside exploitation fields - SECOND LAYER

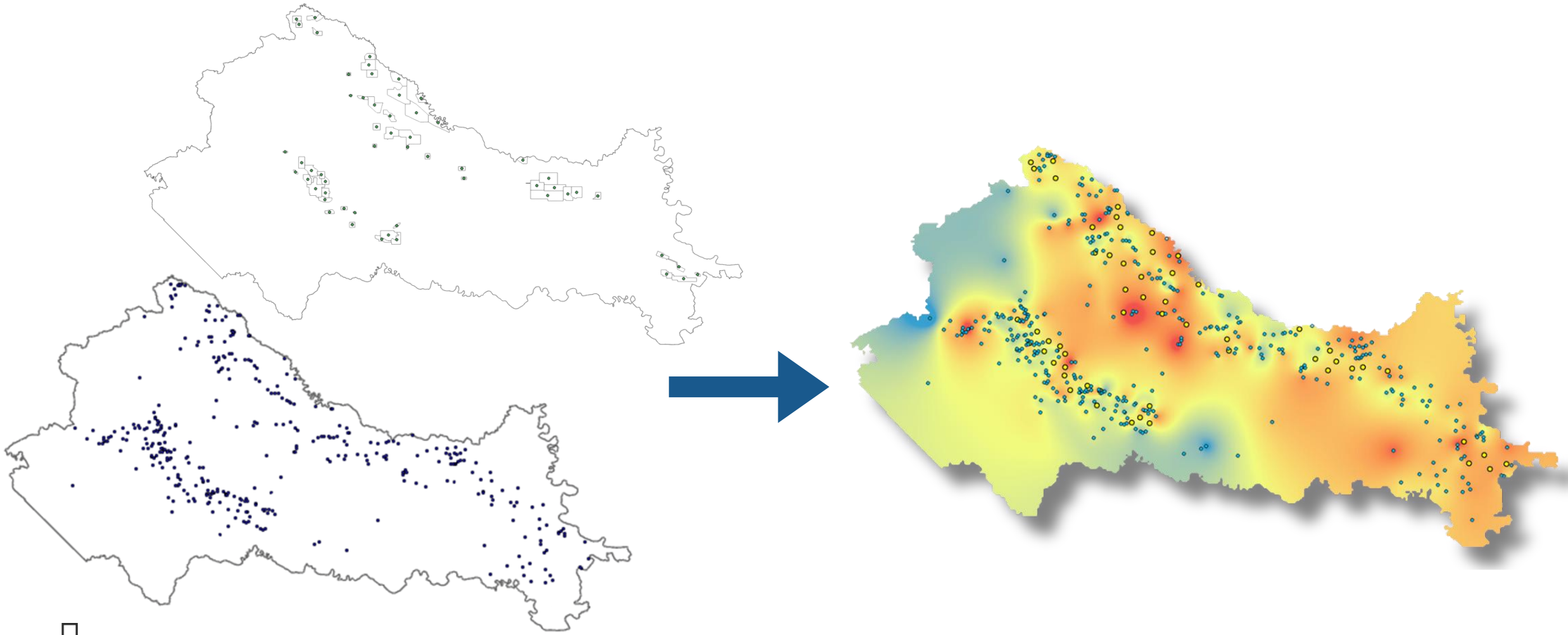


Geothermal gradient is calculated on 379 wells

All those wells are entered for calculation geothermal map

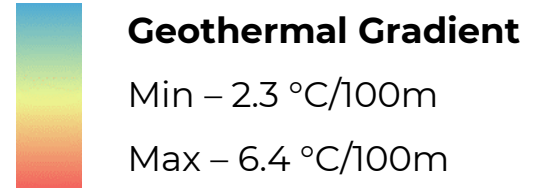
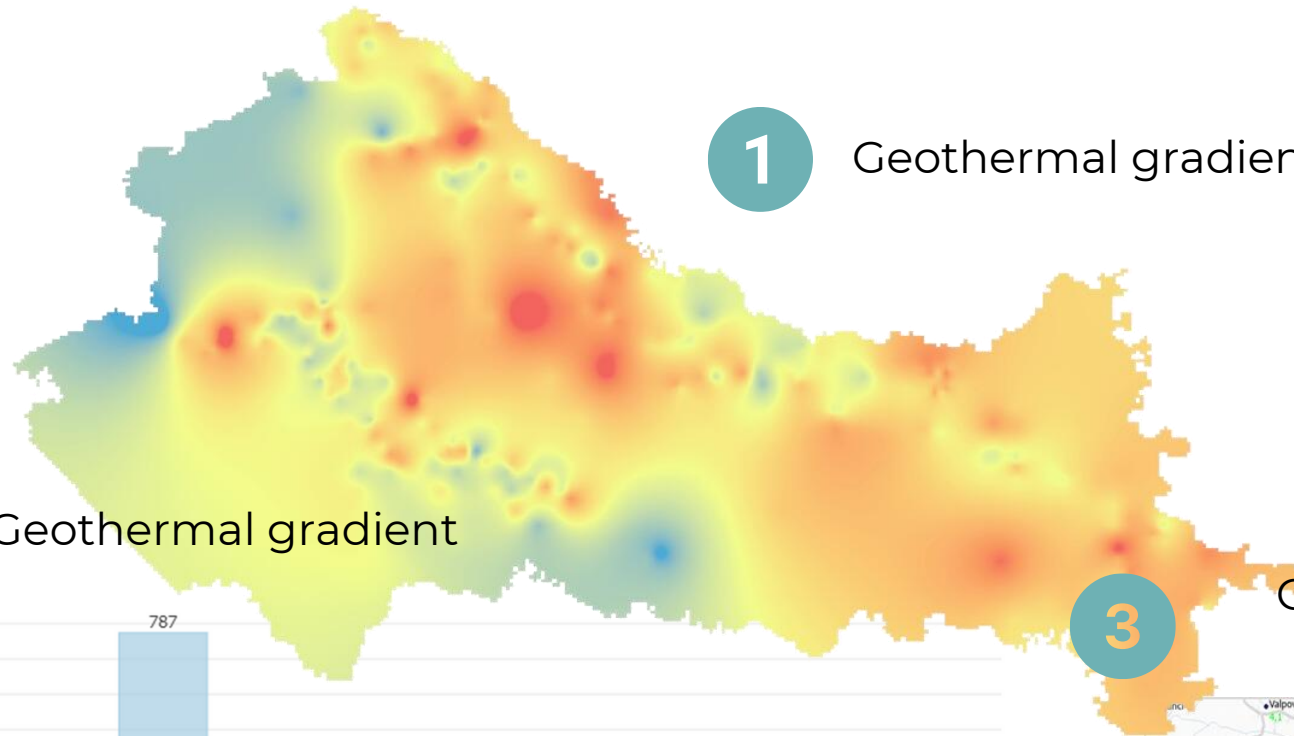
GEOHERMAL MAP DISPLAY

Combine those two layers with data using Spatial Analysis module geothermal map was created

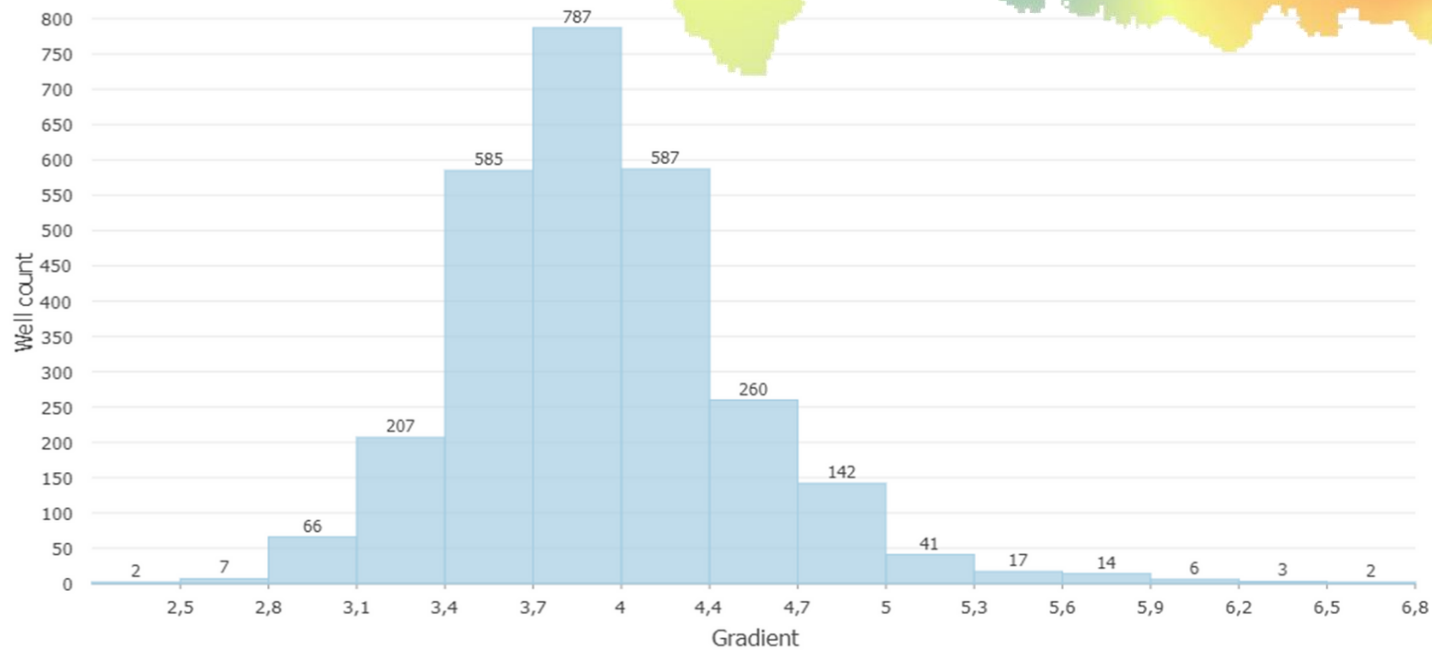


RESULTS

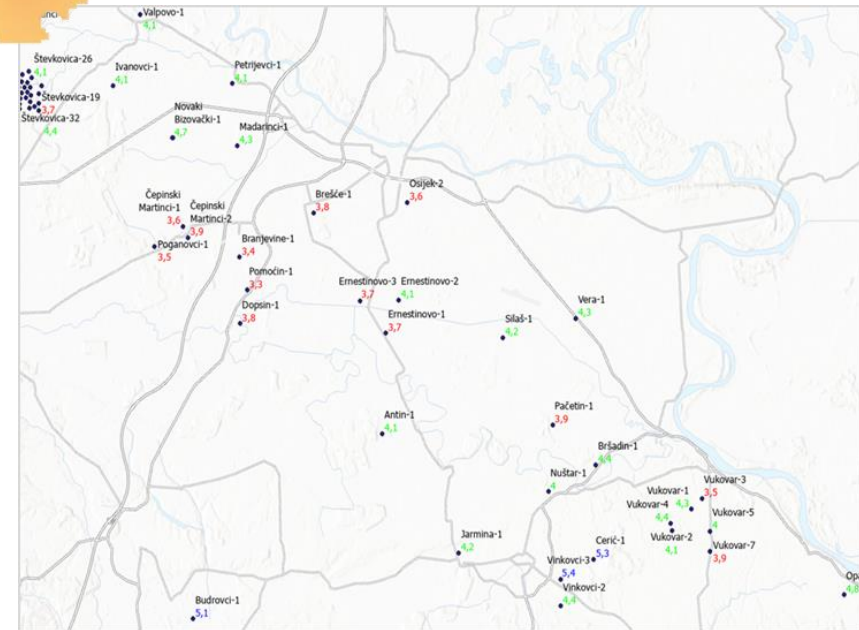
1 Geothermal gradient map



2 Distribution of Geothermal gradient

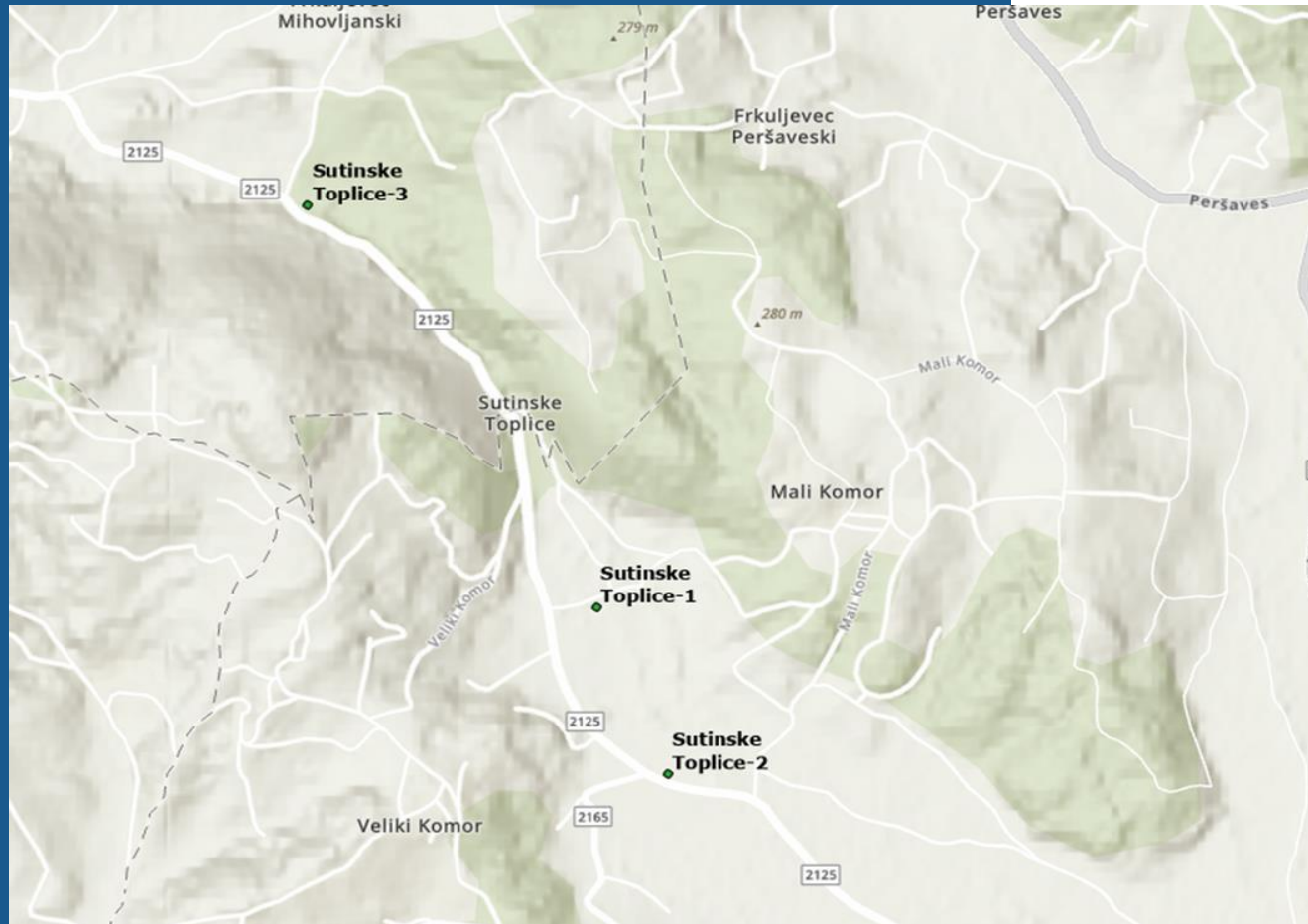


3 Geothermal gradient at the bottom of each well



Example Well comparison

Well Name	Total Depth (m)	Max temp (°C)	Grad (°C/100m)
Sutinske Toplice-1	247	25,9	6,07
Sutinske Toplice-2	680	24	1,91
Sutinske Toplice-3	385	29	4,68



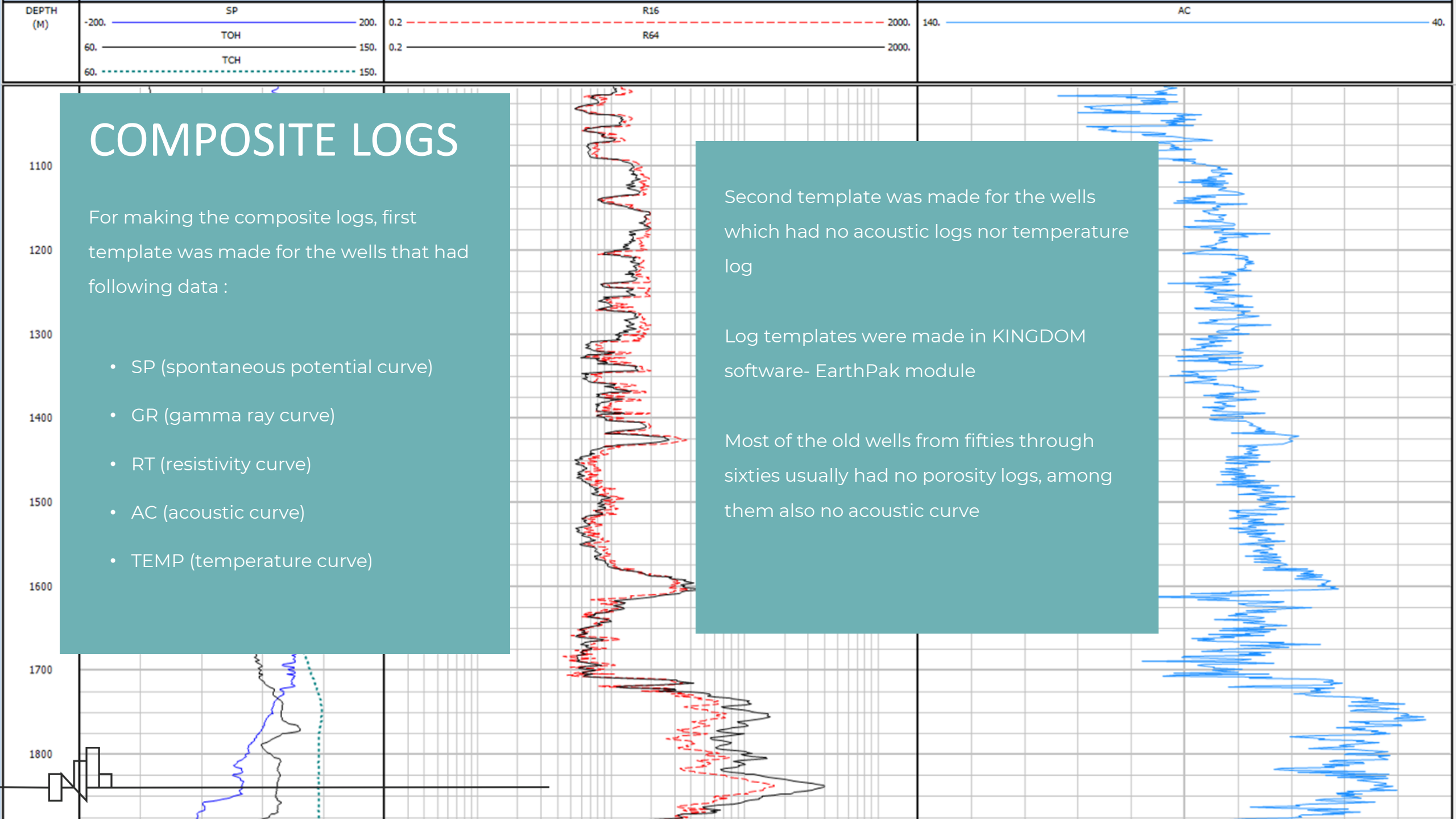
TESTING DATA

Collected data:

- Trajectory of the well
- Well test type, year
- Interval of the tested reservoir
- Geological formation
- Effective thickness (if applicable)
- Testing results (inflow (m³/d, l/s), pwf, k(mD), Skin, duration)
- Water analysis (yes/no)
- Pressure measurements
- Temperature readings

Well Name	Abbrev	Trajectory	Well Test	Year	Top depth	Bottom depth	Formation	Effect Thickness (m)	Water inflow (m ³ /d)	Testing duration (h)	Orifice (mm)	pwf (bar)	Water Production (m ³ /d)	Water Production (l/s)	Permeability k (mD)	SKIN/D	Salinity (g NaCl)	Measured Depth (m)	Initial Pressure (measured) (bar)	Measured (m ²)	Initial temperature (measured) (°C)	Max. well Depth (m)	Max. Temperature (log)	Water analysis (YES/NO)
Andrilovac 1	An 1	Vertikalna	DST 2	1971	1626	1638	pješčenjak	12	0.9	1.23	6.5	13.03	17.56	0.20	1.032	50.209		1637.5	141.14		2277.4	94	NO	
Babina Greda 1	Bag 1	Vertikalna	DST 1	1984	1571.15	1585	laporoviti vapnenac	13.85	12	0.283	9.52	58.74	149.80	1.73	4.48	1.26	4.299		1584	110	3802	161	YES	
Babina Greda 1	Bag 1	Vertikalna	DST 3	1984	1752.7	1768	dolomitno breča	15.3	16.1	2.32	9.52	170.218	166.55	1.93	14.78		3.89	1747	171.09	1766	112	3802	161	YES
Babina Greda 1	Bag 1	Vertikalna	OI	2002	1768	3802	breča	2034				170.03	1176.00	13.61	485.5	0.8	3.65	1750	170	1750	121.1	3802	161	YES
Banov Dol 1	Bd 1	Vertikalna	DST 2	1982	3342	3415	breča	73	1	11.08	9.52	25.78	2.17	0.03		2.282			152	3545	155		YES	
Banov Dol 2	Bd 2	Vertikalna	DST 2	1982	1372.6	1393	skriljavec	20.4	1.5	0.75	9.52	18	48.00	0.56	0.249		4.007	1393		1393	90	2211	91	YES
Banova Jaruga 2	Bj 2	Vertikalna	OI	1968	885	887	laporovita glina	2	11	16			16.50	0.19								2970.6	120	NO
Banova Jaruga 2	Bj 2	Vertikalna	OI	1968	768	770	glina	2	4.7	13				0.10								2970.6	120	NO
Banje Solo 1 Alfa	Bs 1AL	Usmjerena	DST 3	1988	1343.5	1400	pješčenjak	56.5	3.3	4	9.52	50.695	19.52	0.23	0.92908	0.88409	0.1017	1380	144.25	1335.6	68.3	2458	106	YES
Batina 1	Bt 1	Vertikalna	OI	1968	3040	3095	pješčenjak	55	17.7	16			26.55	0.31			6.9					3212.5	122	YES
Batina 1	Bt 1	Vertikalna	OI	1972	3031.5	3033.5	pješčenjak	2	24.8	24			24.80	0.29			17.9					3212.5	122	YES
Benkovića 1	Ben 1	Vertikalna	DST 1	1992	1134.3	1151	pješčenjak	16.7	4.35	2.2	9.52	55.94	47.45	0.55	0.97	0.14	0.559	1143	111.66	1148	54.4	1240	57.2	YES
Bockovići 1	Bc 1	Vertikalna	DST 1	1984	2548.9	2561	vapnenac	12.1	20	2	9.52		240.00	2.78	19.68		0.913					3102	138	YES
Branjvine 1	Bnj 1	Vertikalna	DST 1	1987	1561	1639	breča konglomerat	78	9.5	1.883	9.52		133.83	1.55	1.83	1.21	6.691		1537.67		97	2603	99	YES
Breckovljani 3	Bl 3	Vertikalna	DST 2	1971	1696.7	1705	lapor	8.3	1	1	6.35	183	24.00	0.28	37.32		22.05					1933.6	78	NO
Brežće 1 Alfa	Brt 1AL	Usmjerena	DST 3	1976	2005	2085	lapor breča, vapneni konglomerat	80	5	1.116	9.52	75.17	66.87	0.77	37.32	0.77		2012.8	217.64			2281	93	YES
Brežće 1 Alfa	Brt 1AL	Usmjerena	DST 4	1976	2270	2281	konglomerat	11	2	2.26	9.52	29.03	15.90	0.18	0.47	0.874	45.05	2281	182.99			2281	93	YES
Brežnica 1	Bz 1A	Vertikalna	DST 1	1983	1099.9	1114	dijabaz	14.1	9.9	1.66	9.52	56.18	151.67	1.76	63.65	4.24	4.271	1114	110.63	1112	61.1	1662	108	YES
Brežnica 1 Alfa	Bz 1A	Usmjerena	DST 2	1983	1225	1237	konglomerat	32	10.6	2.083	9.52	100.826	127.64	1.48	78.178	5.937	4.066	1237	105.87	1235.2	73	1245	71	YES
Brdadin 1	Brd 1	Vertikalna	DST 2	1984	1305.6	1326	konglomerat	20.4	9.6	3	9.52	109.69	106.97	1.24	12.39	1.34	5.323		1325	76.7	2232	110	YES	
Brdadin 1	Brd 1	Vertikalna	DST 4	1984	1619	1635	skriljavec	16	1.15	2.15	9.52	15.37	13.10	0.15	2.097	7.39	7.507					2232	110	YES
Brdadin 1	Brd 1	Vertikalna	DST 5	1984	1726.8	1736	raspućani dolomit	9.2	15.6	2	9.52	148.89	268.00	3.10	63.21	24	7.61			1735	107.2	2232	110	YES
Brdadin 1 Alfa	Brd 1AL	Usmjerena	DST 2	1984	1648.81	1673	breča	24.19	14.5	2	9.52	152.62	174.00	2.01	75.2	38.4	6.318	1645.01	152.62	1670	101.5	1825		YES





COMPOSITE LOGS

For making the composite logs, first template was made for the wells that had following data :

- SP (spontaneous potential curve)
- GR (gamma ray curve)
- RT (resistivity curve)
- AC (acoustic curve)
- TEMP (temperature curve)

Second template was made for the wells which had no acoustic logs nor temperature log

Log templates were made in KINGDOM software- EarthPak module

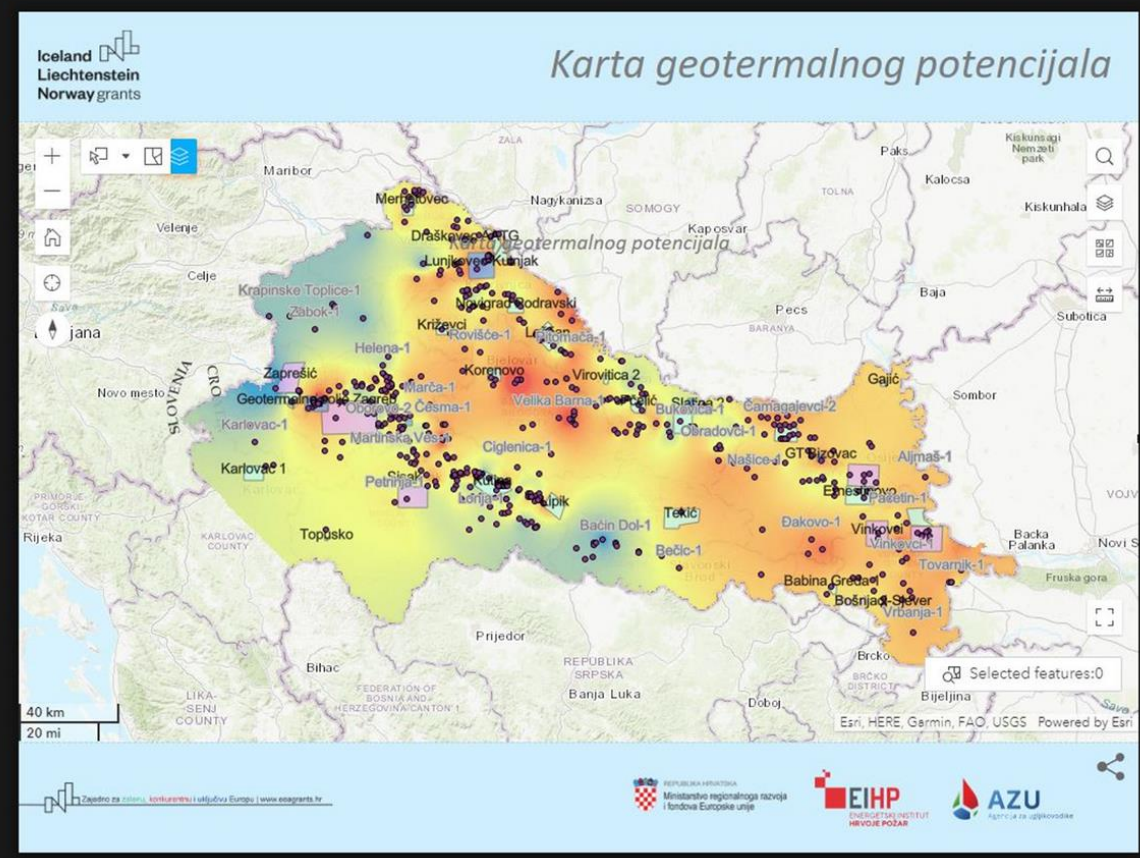
Most of the old wells from fifties through sixties usually had no porosity logs, among them also no acoustic curve

Page Window

Page 1

Outline

- Header
 - EEA
 - Text 1
- Footer
 - Share
 - EEA_grants
 - AZU
 - EIHP
 - Image 1
- Body
 - Karta



Karta

Content Style Action

Initial view

Default

Custom

Modify

Tools

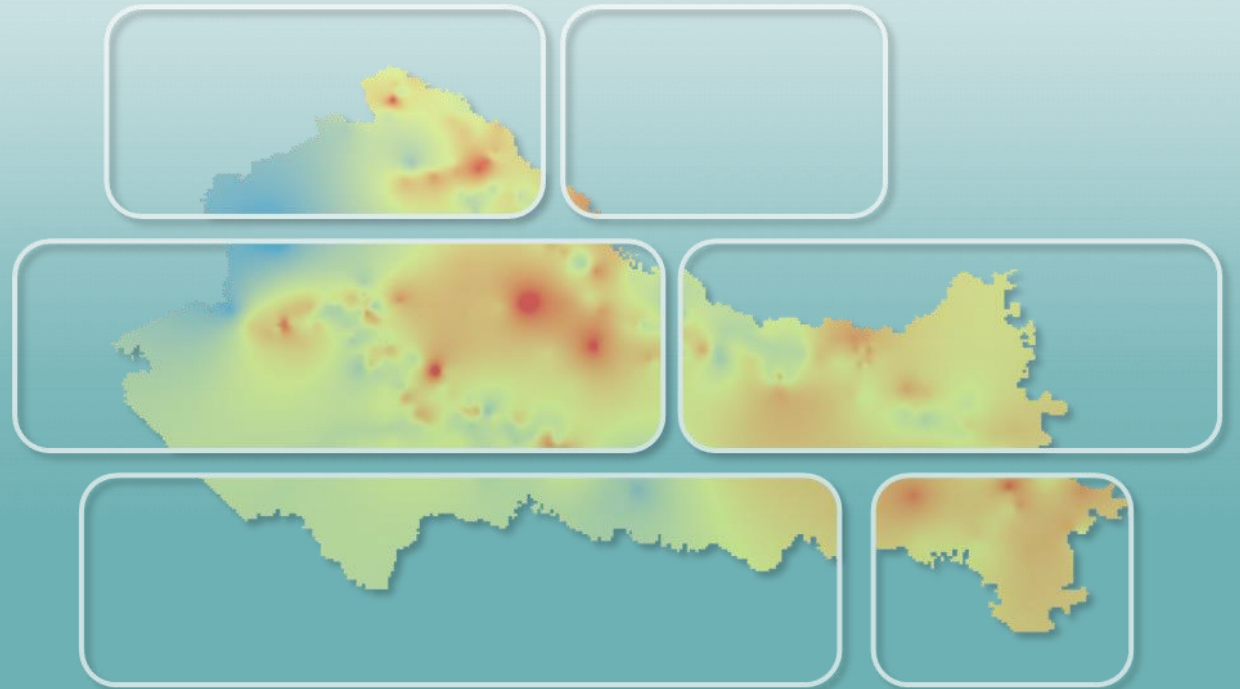
- Zoom
- Home
- Navigation
- Locate
- Compass
- Search
- Layers
- Basemap
- Measure
- Fullscreen
- Scale bar
- Select

Tools layout

Large and medium size

DEMO

(Final web GIS application-
as of April 2024)



THANK YOU FOR YOUR ATTENTION!

