Mapping of geothermal lithium potential in BrineRIS project – final results

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University of Miskolc

GeoLi Networking Event
Wroclaw, 4th December 2024

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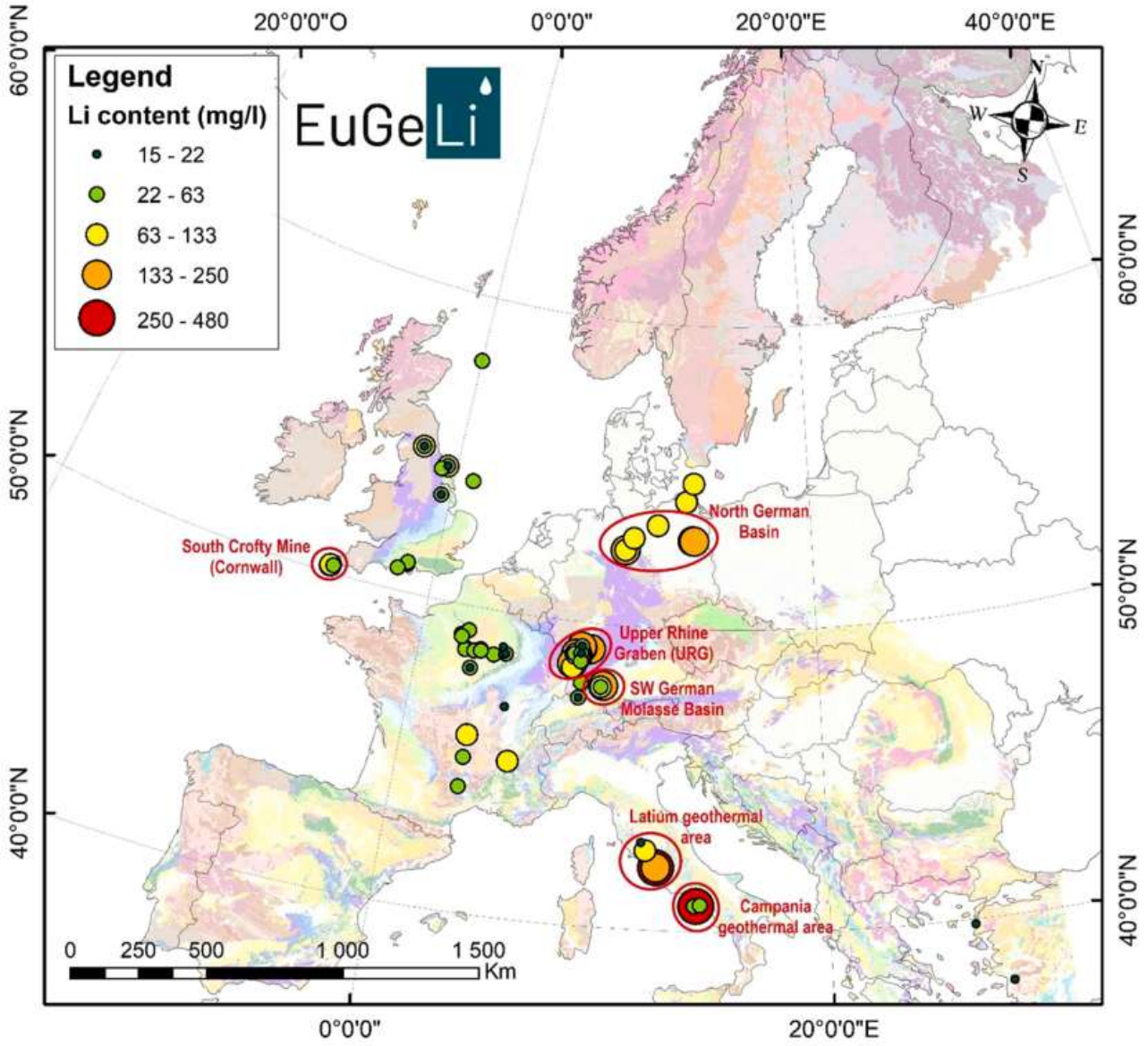
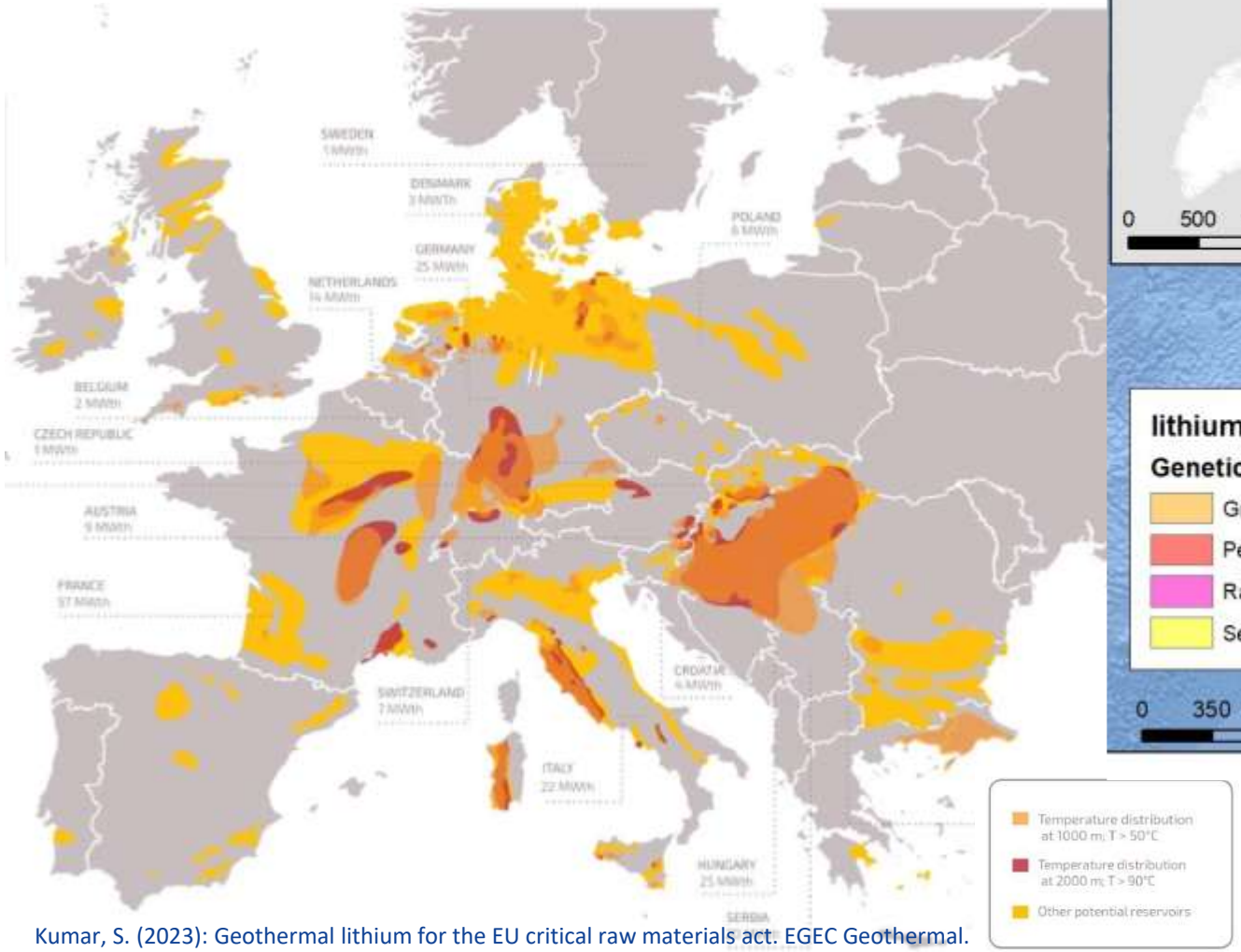
LITHIUM IN BRINES OF EUROPE

- Ultra-high temperature (>300°C): Latium, Campania
- Low to high temperature (120-250 °C): Cornwall, N German Basin, SW German basin, Upper Rhine Graben

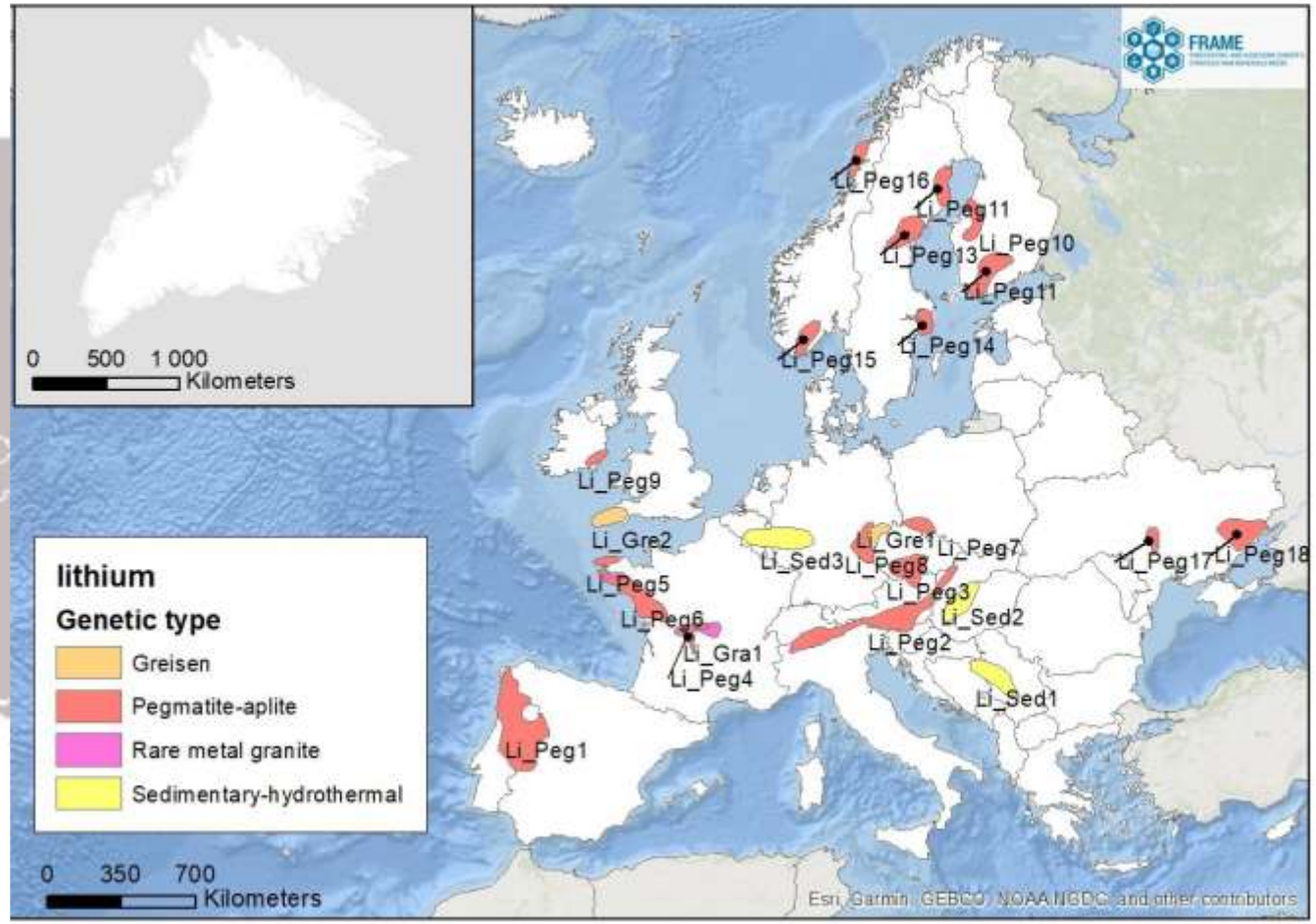


Sanjuan, B., Gourcerol, B., Millot, R., Rettenmaier, D., Jeandel, E. (2020): Geothermal lithium resource assessment in Europe, Eur. EIT Raw Mater. EuGeLi Project, D-0.1 Deliverable, 86 p.

LITHIUM POTENTIAL IN EUROPE



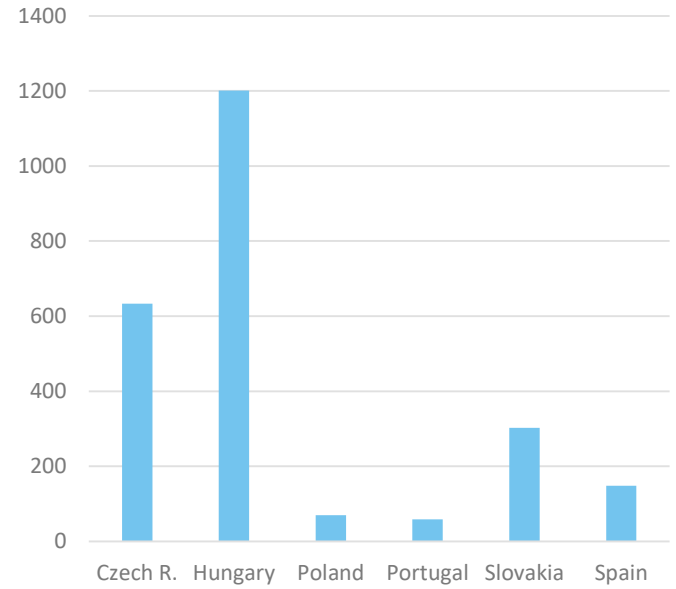
Kumar, S. (2023): Geothermal lithium for the EU critical raw materials act. EGEC Geothermal. www.egec.org/wp-content/uploads/2023/01/Geothermal-minerals-for-the-EU-critical-raw-materials-act.pdf

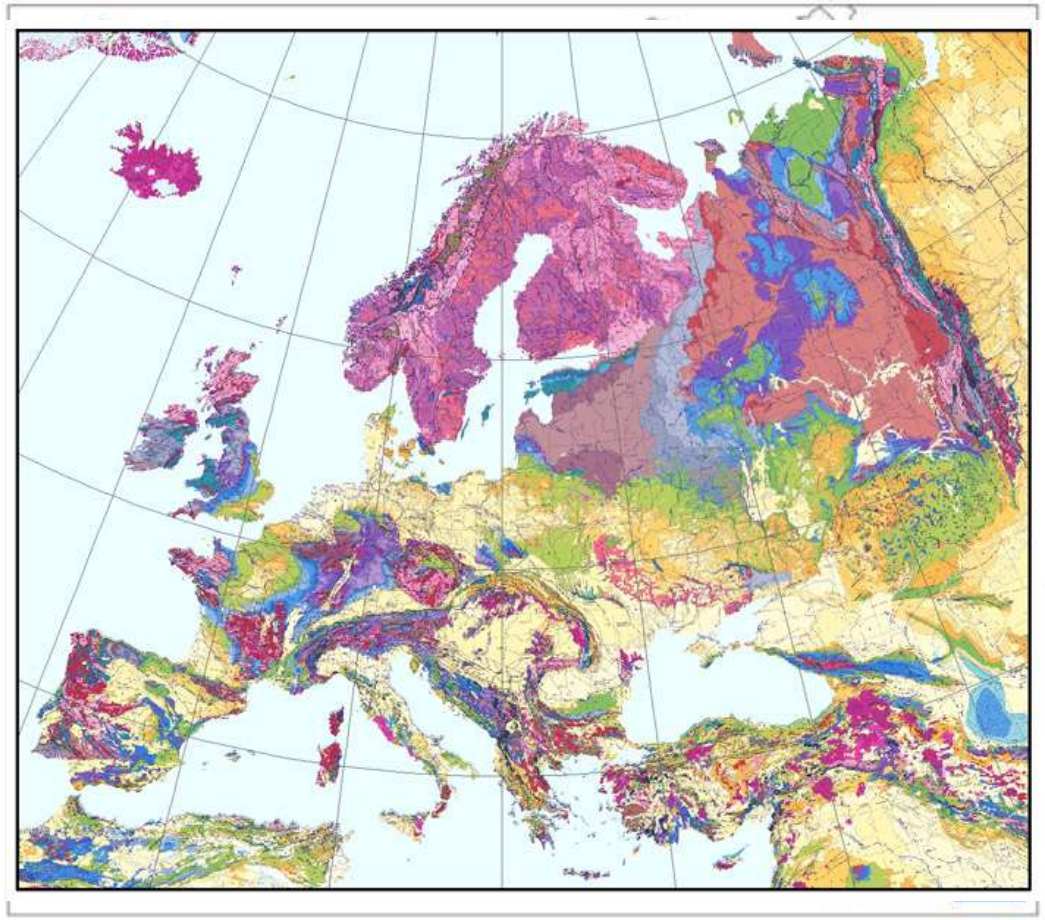


Gautneb, H., Gloaguen, B., Törmänen, T. (2021): Energy critical metals and minerals in Europe; occurrence, types, characteristics, formation, and future potential for European production (report No. D5.3), Forecasting and Assessing Europe's Strategic Raw Materials needs (FRAME)

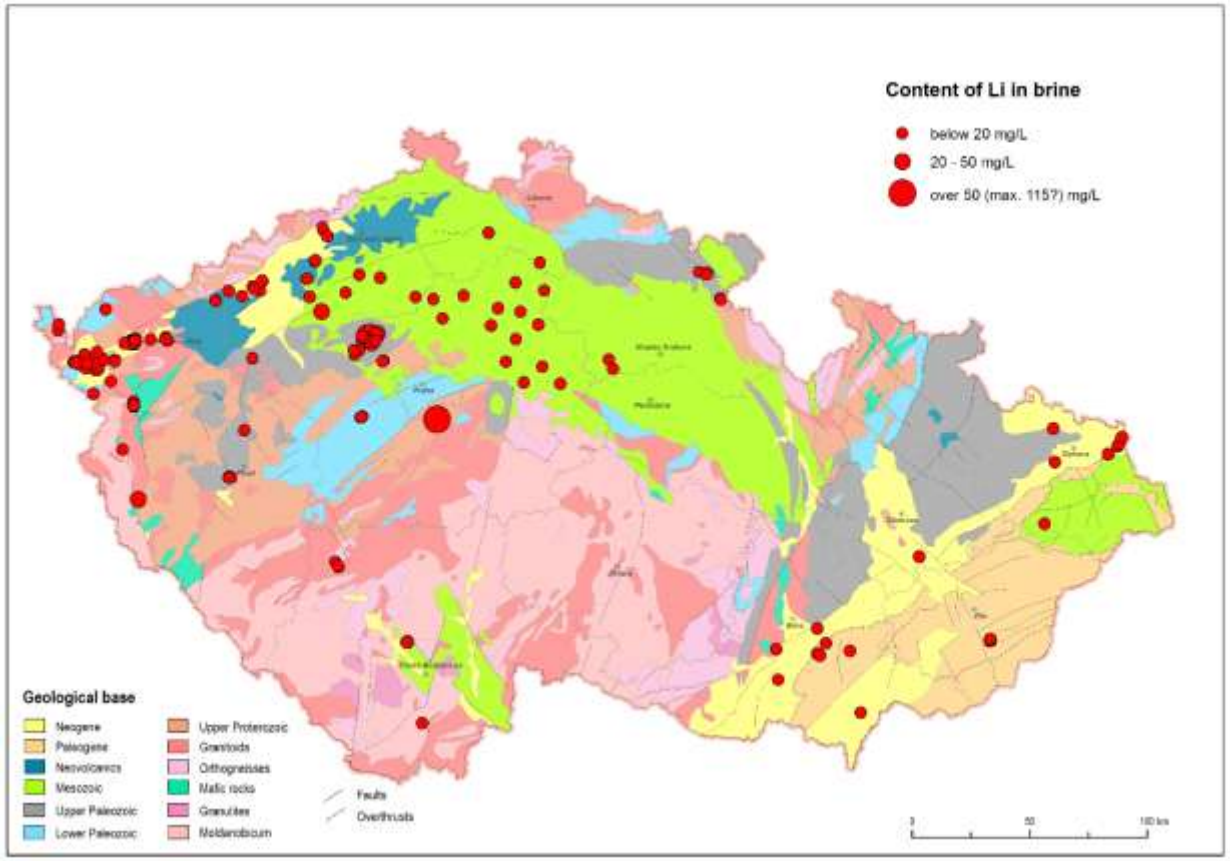
ARCHIVE DATA OF BRINES

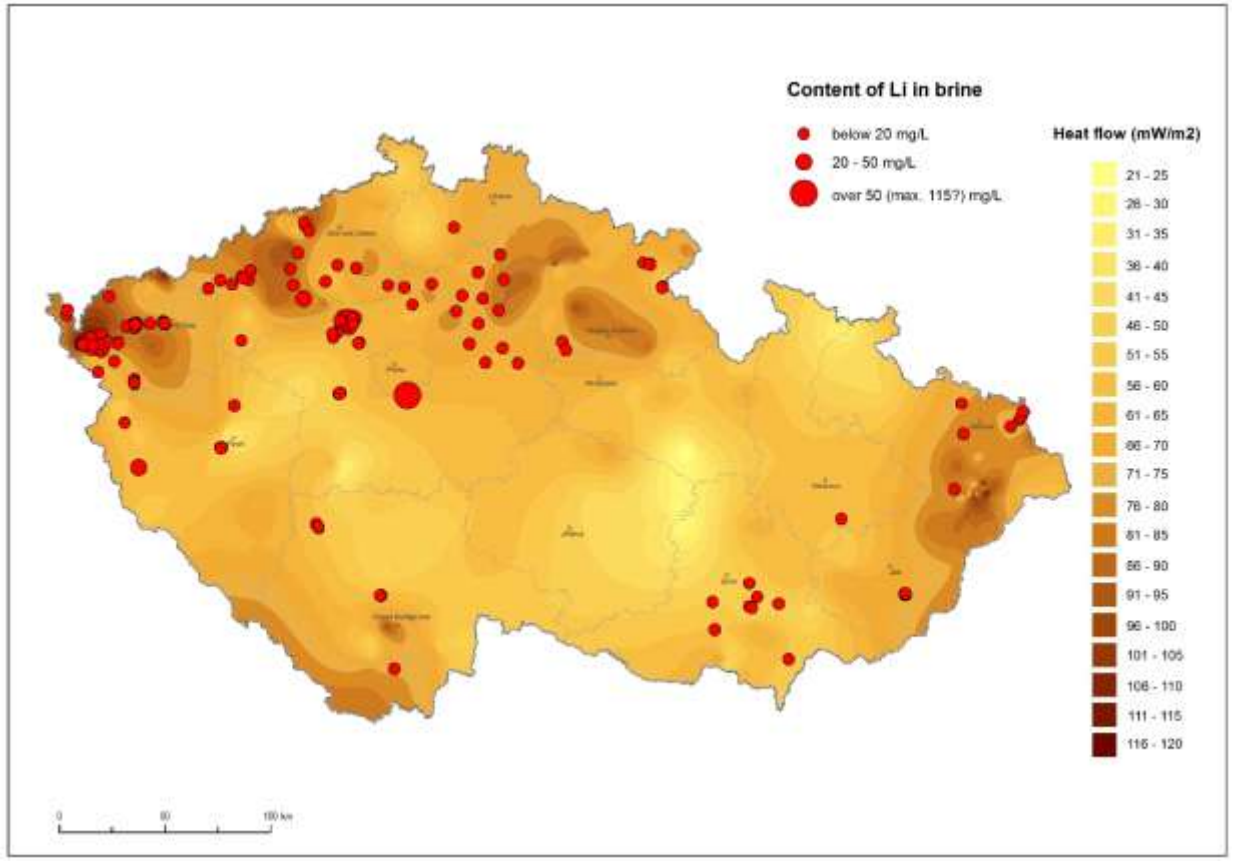
- 6 RIS countries: Mid-Europe and Iberian Peninsula
- Uneven number of records/countries and spatial distribution
- Uneven content of the records from several aspects: analysed components, analythic methods, accuracy, reliability



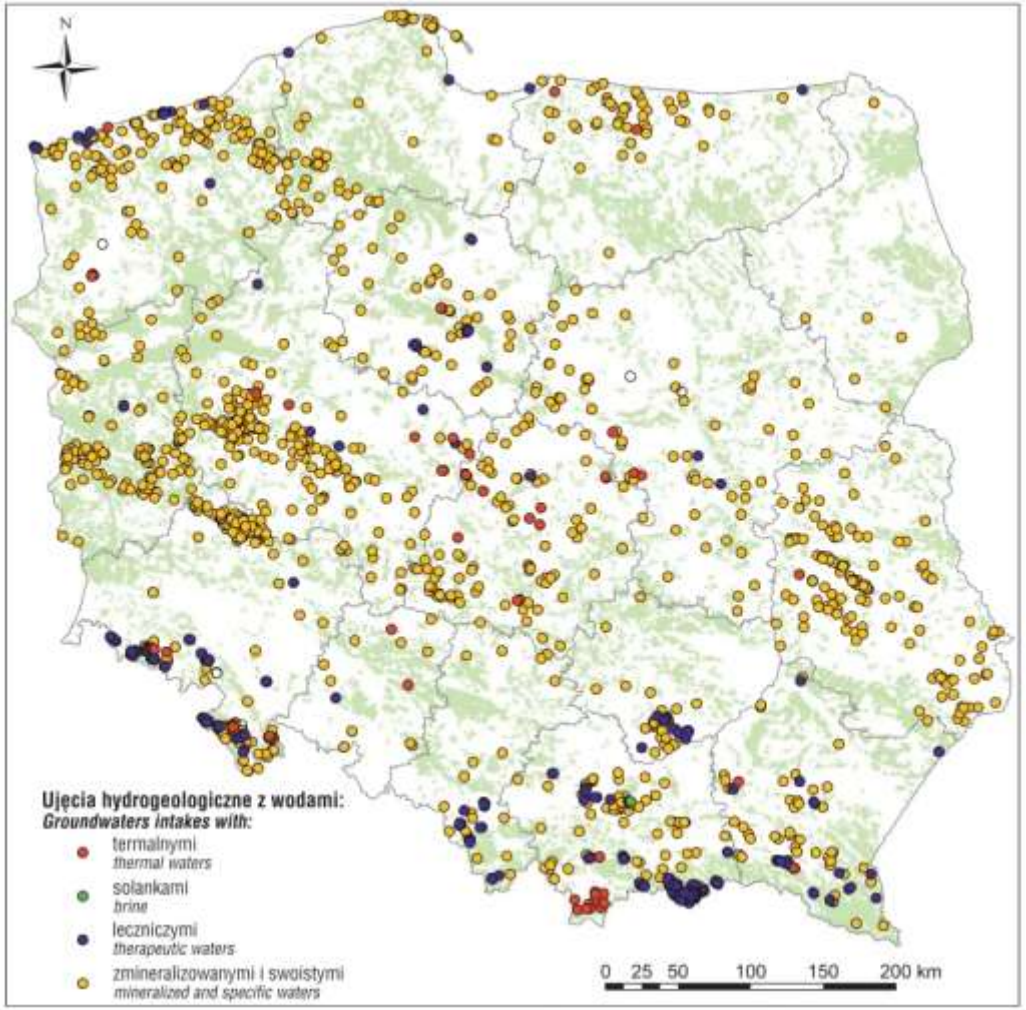


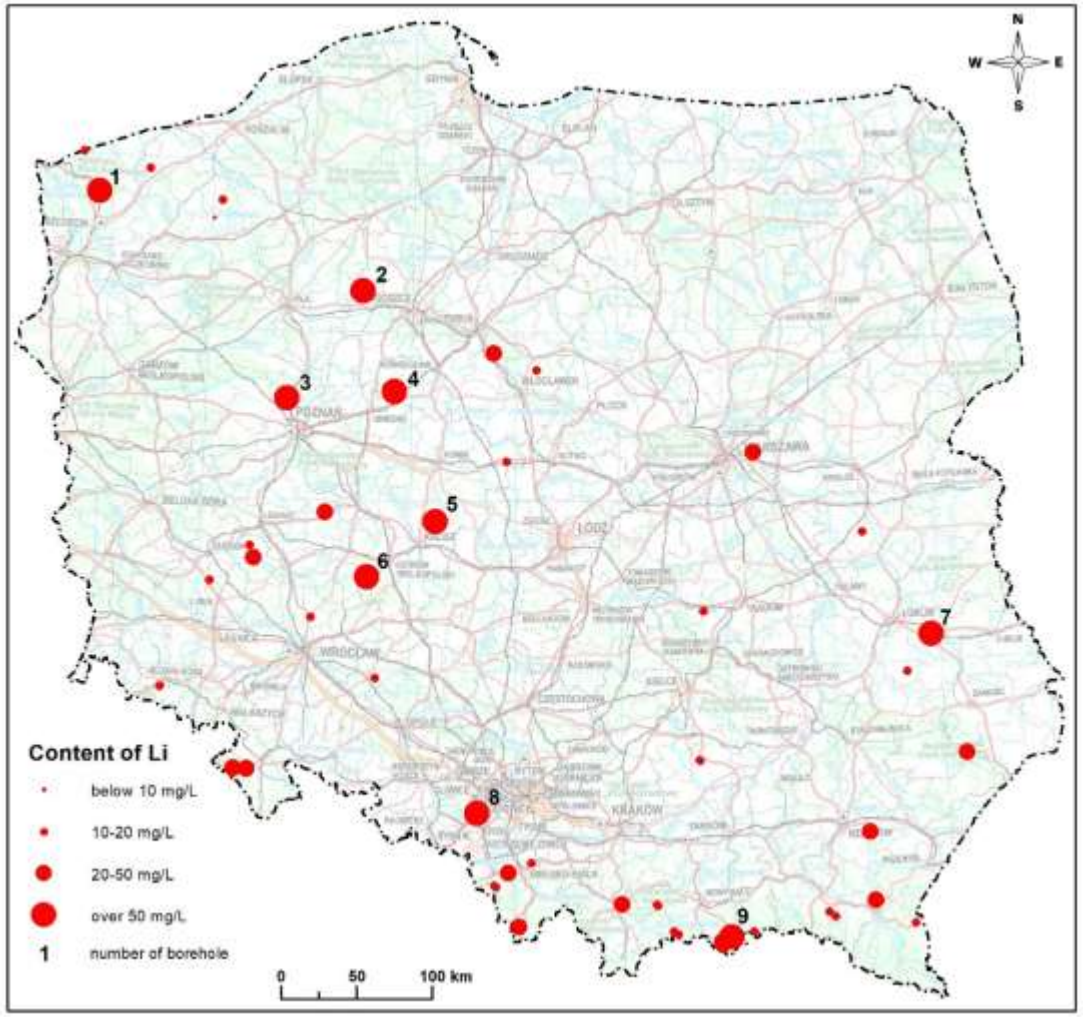
BRINES IN THE CZECH REPUBLIC



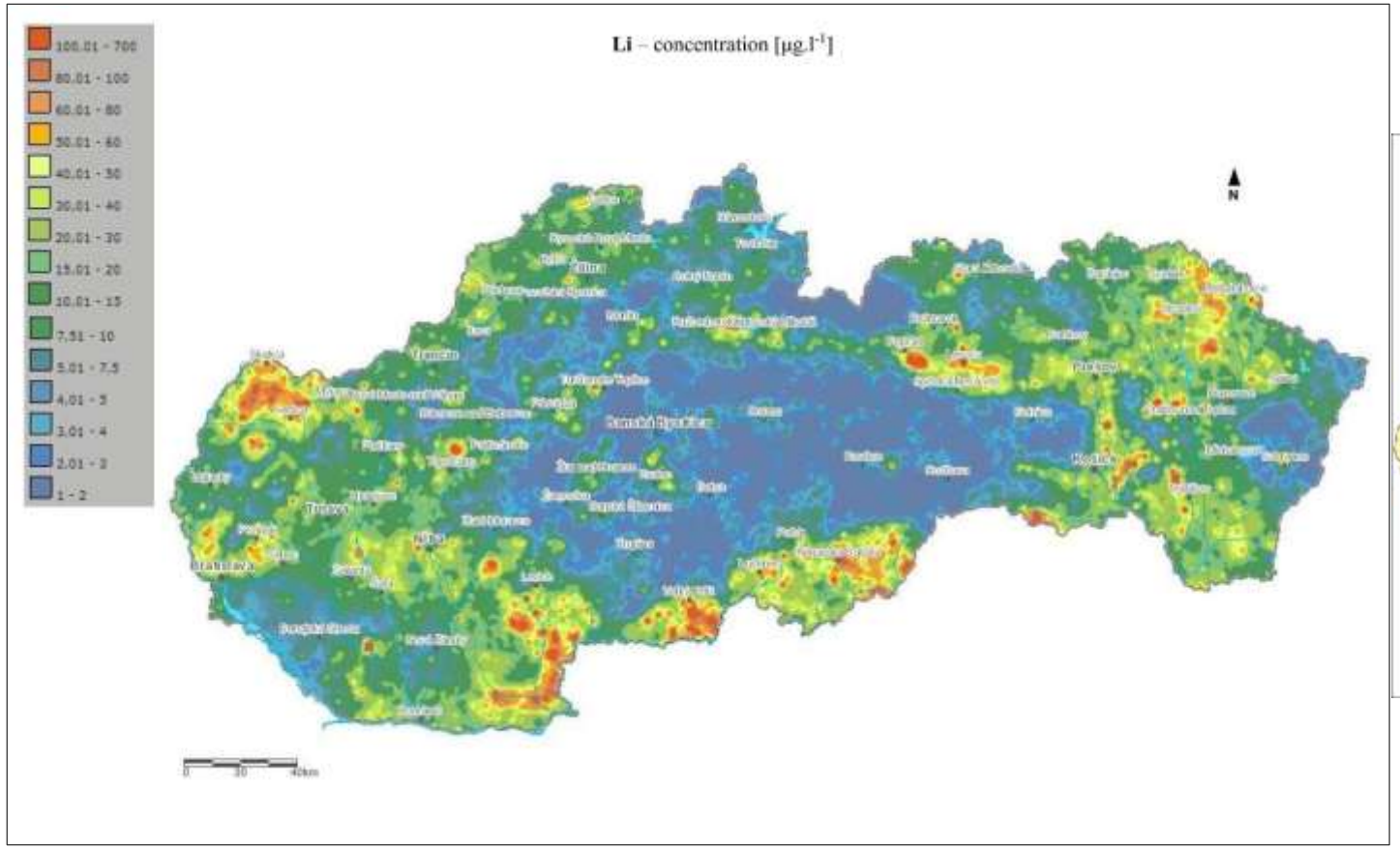


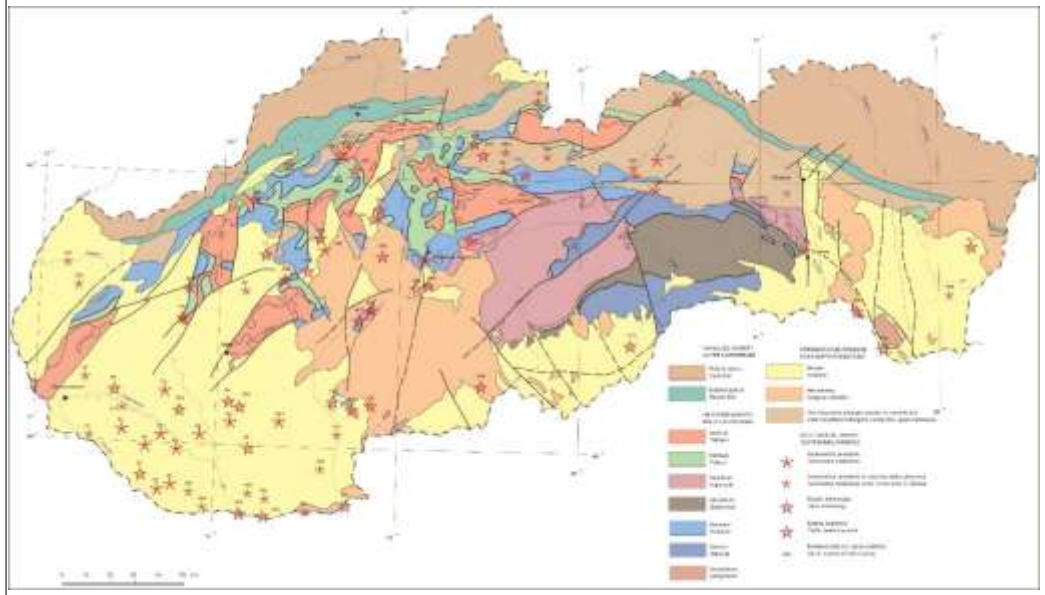
BRINES IN POLAND





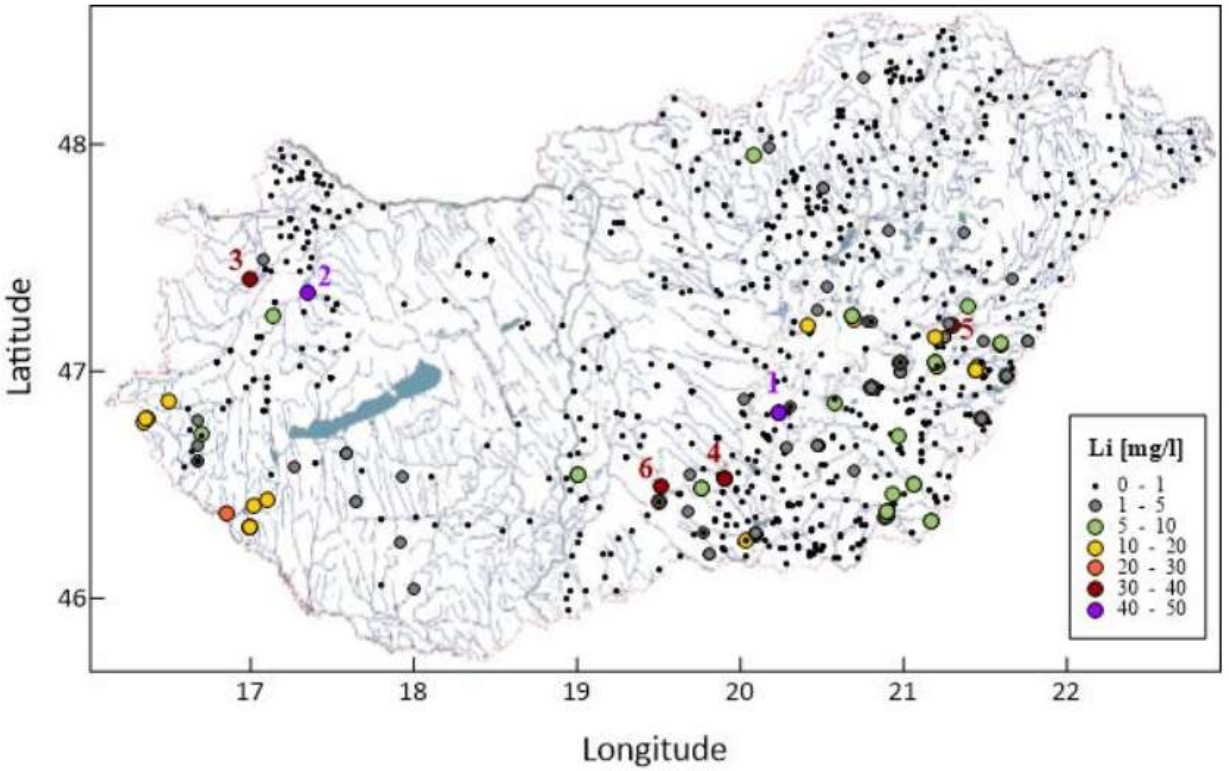
BRINES IN SLOVAKIA

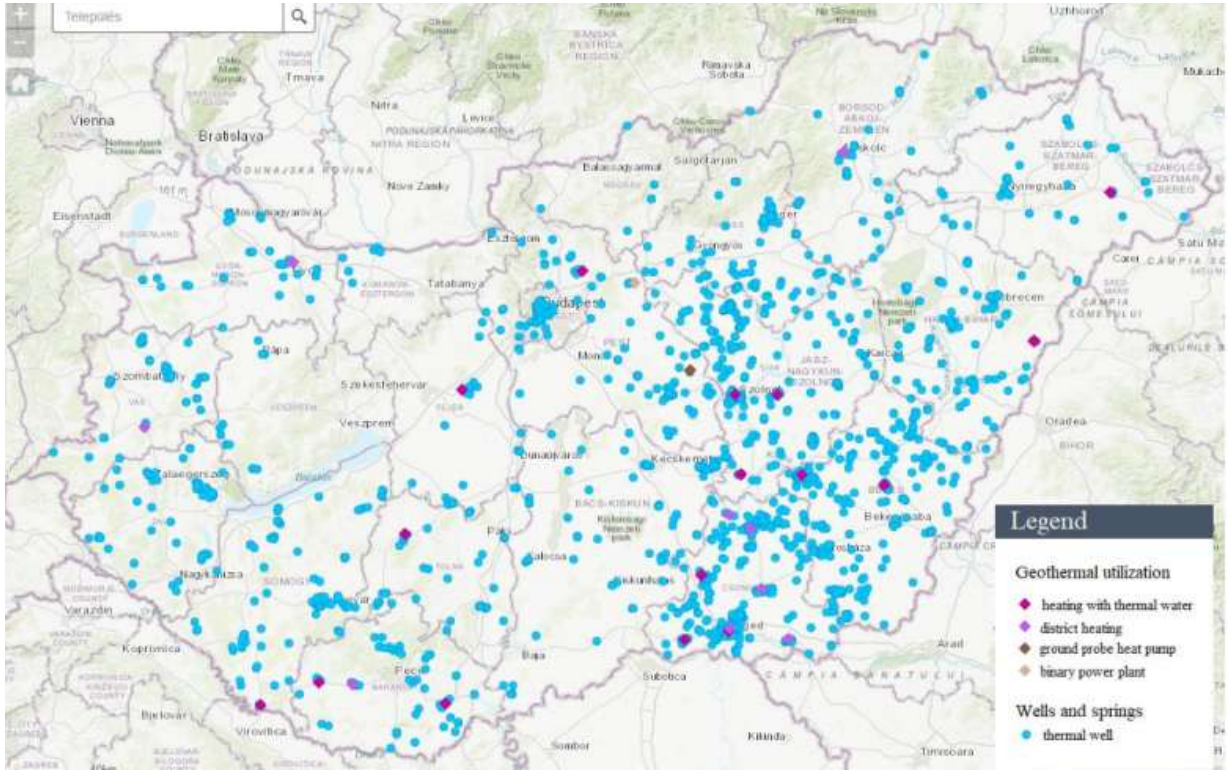




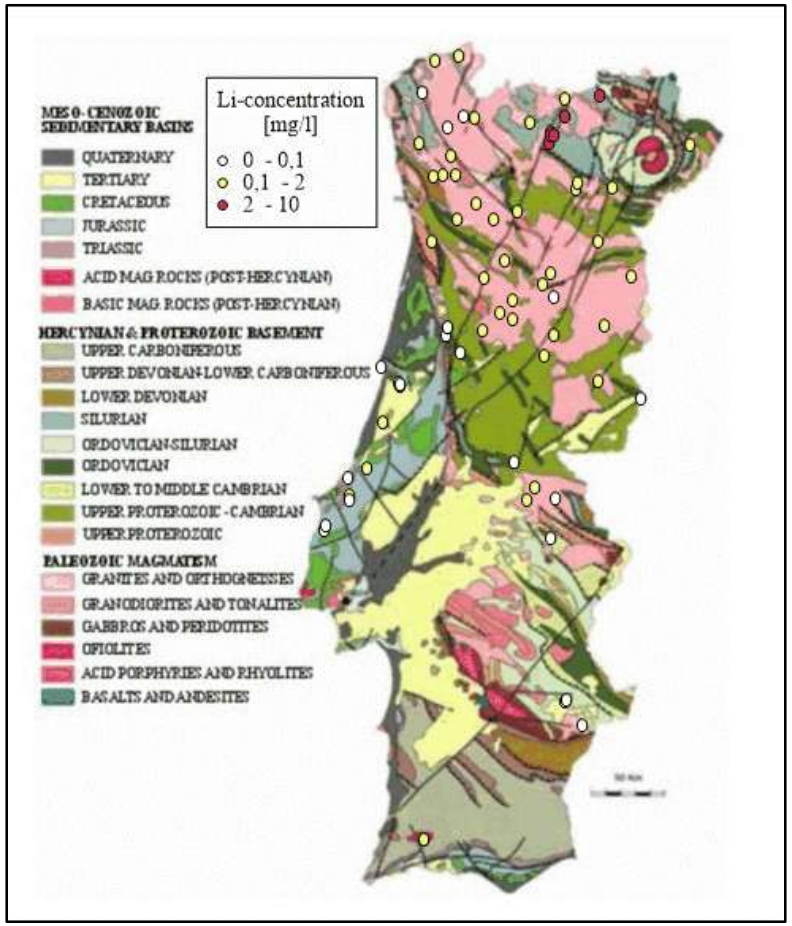
Rapant, S., Vrana, K., Bodiš, D., Doboš, V., Hanzel, V., Kordík, J., Slaninka, I., Repčoková, Z., Zvara, I. (1996) Geochemický atlas Slovenskej republiky, časť I: Podzemné vody. [Geochemical Atlas of Slovakia, Part I: Groundwater]. Geological Survey of Slovak Republic, Bratislava. 127 p. http://apl.geology.sk/atlaspv/

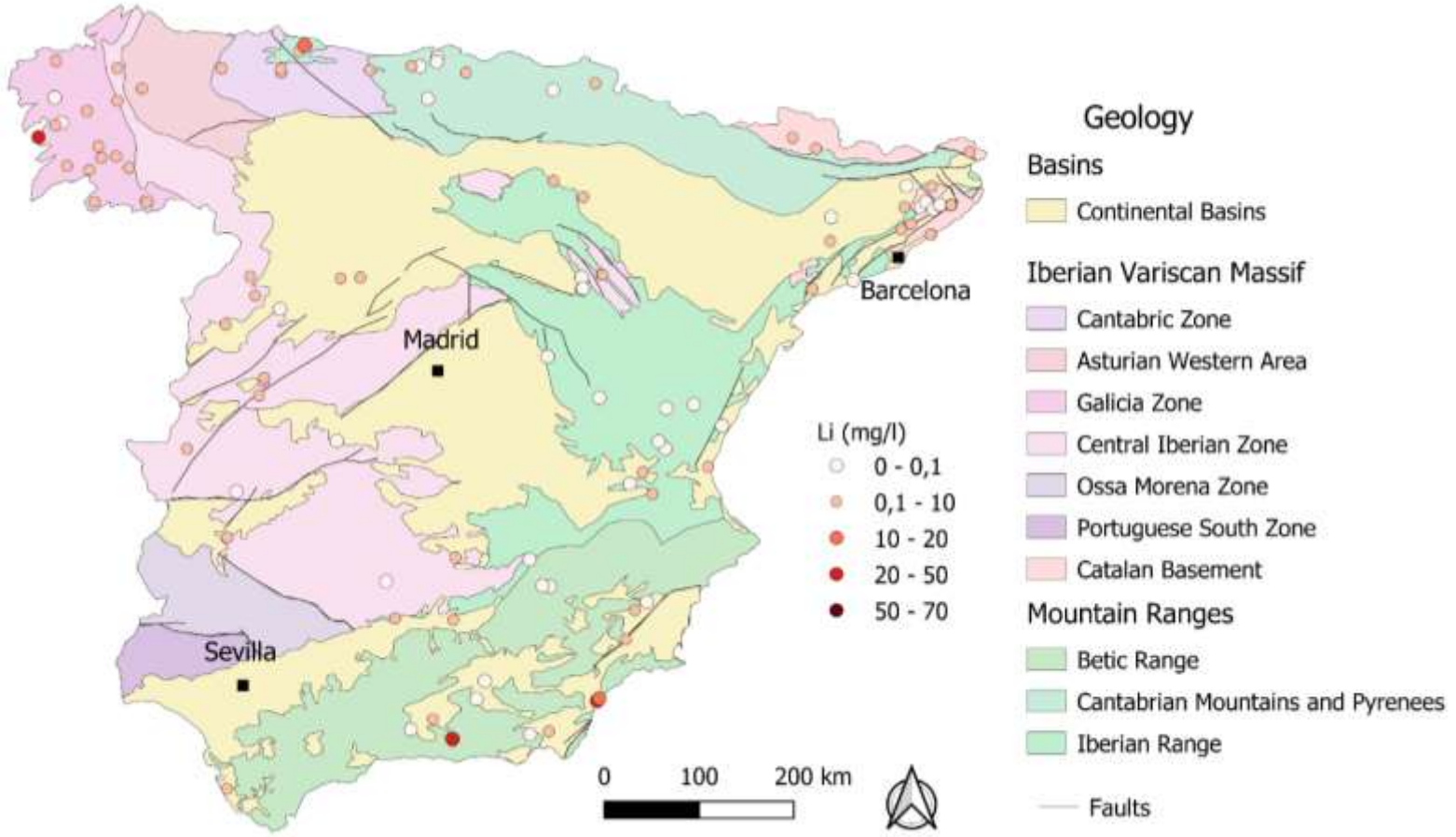
BRINES IN HUNGARY





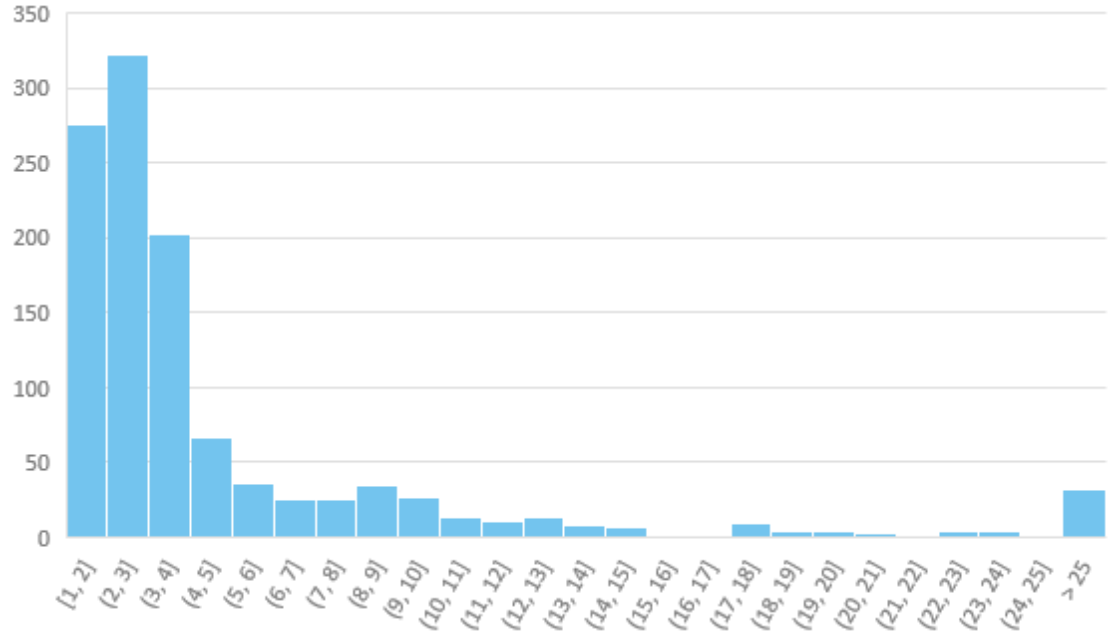
BRINES OF THE IBERIAN PENINSULA

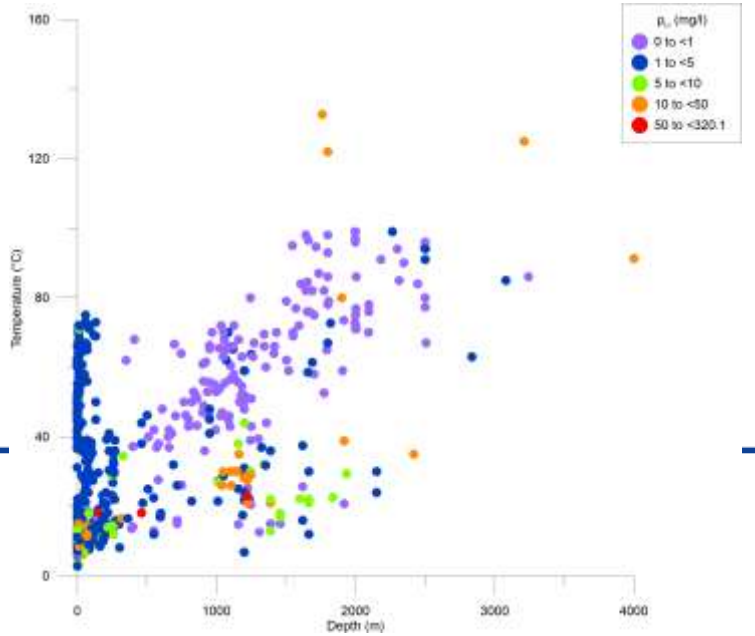




ARCHIVE DATA OF BRINES

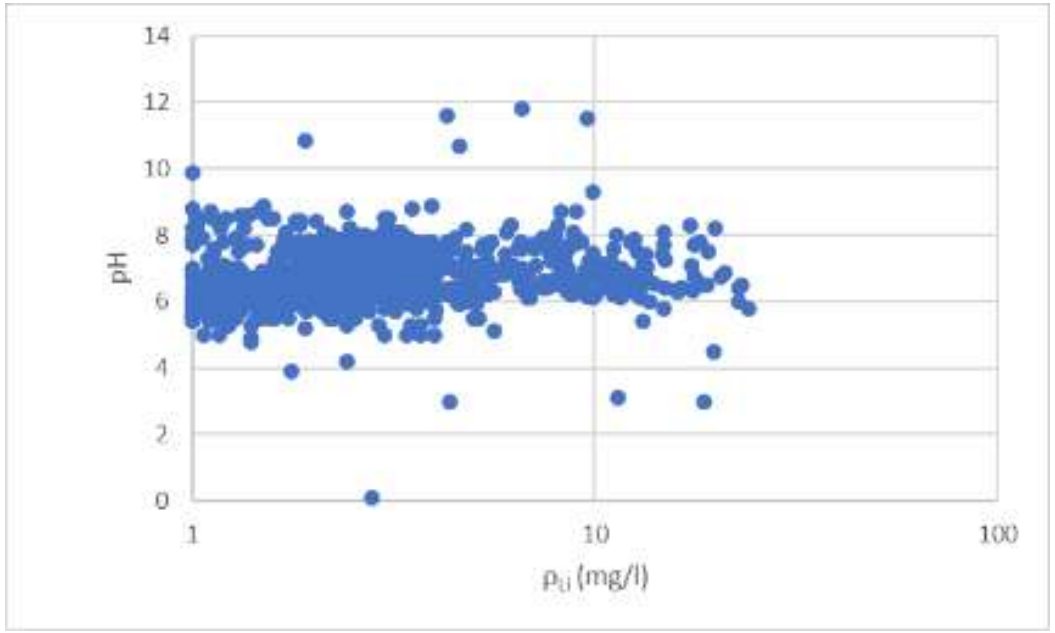
- Focus: utilized geothermal brines containing lithium
- Brines from various depth and temperature
- 1134 records with Li concentration > 1 mg/l
- More than 90% Li c. < 10 mg/l
- 32 records with Li c. > 25 mg/l
- 896 records with complete data of
  Li, Ca, Mg, Na, K, NH_4^+, Cl, HCO_3^-, SO_4^{2-}
- Low number of records with trace elements
- No anion concentrations from Spain and Portugal

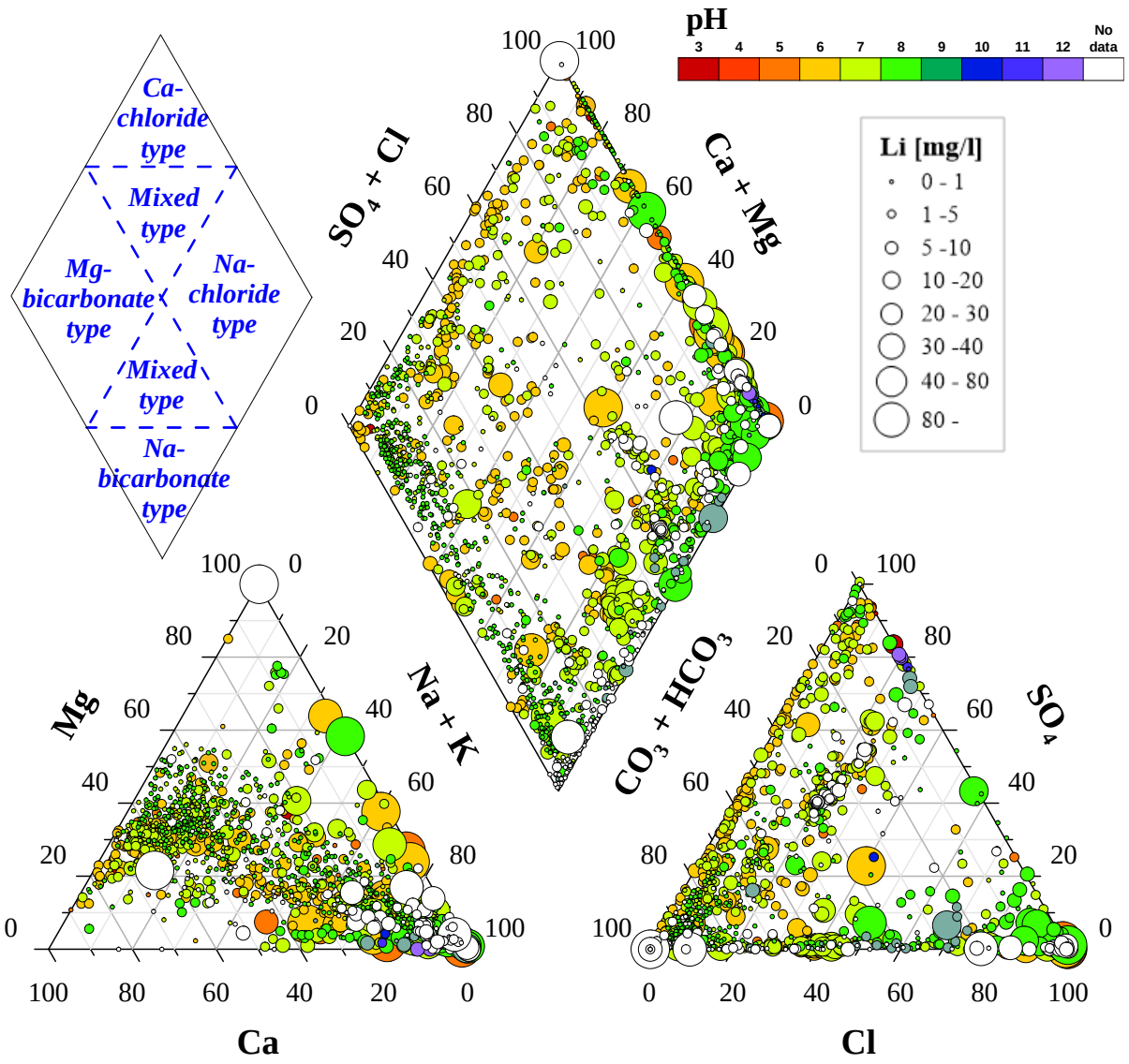




CHEMICAL COMPOSITION OF THE BRINES

- Mid-Europe only
- High Li concentration typically occurs in Na-chloride type, neutral brines





CORRELATIONS OF THE CHEMICAL COMPONENTS

- Heterogeneous dataset with a low number of outliers, possibly inaccurate numbers
  - ✓ Robust index: **rank correlation**
- Spearman correlation coefficient:
  1. Converting actual concentration values to rank variables
  2. Calculating Pearson (linear) correlation coefficients for the rank variables
- Calculation was repeated by excluding outliers above 50, 25 and 10 mg/l lithium

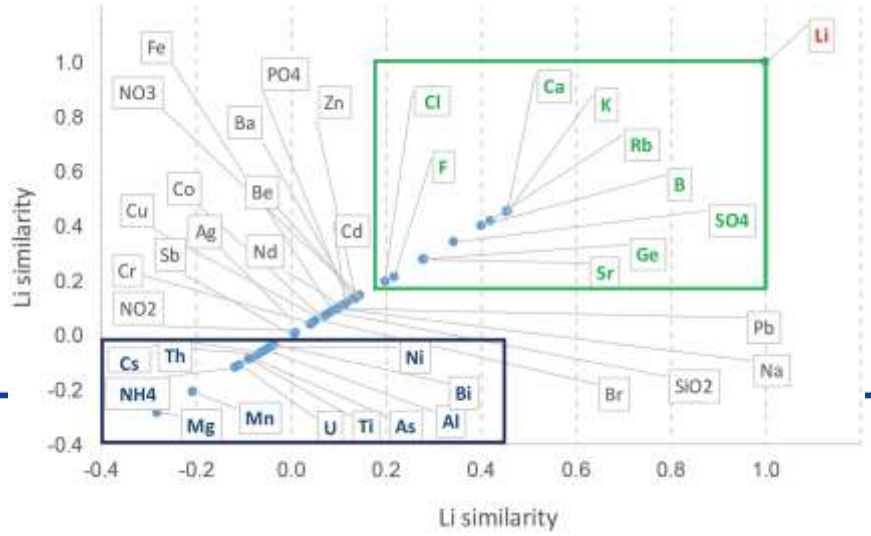
$$r_s = \rho\left[\,\mathrm{R}[X],\mathrm{R}[Y]\,\right] = \frac{\mathrm{cov}\left[\,\mathrm{R}[X],\mathrm{R}[Y]\,\right]}{\sigma_{\mathrm{R}[X]}\ \sigma_{\mathrm{R}[Y]}},$$

SPEARMAN COEFFICIENTS

		Major elements								*Complex ions*						*Halogens*			
		Ca	Na	Mg	K	Si	Mn	Fe	Al	HCO_3^-	SO_4^{2-}	NH_4^+	PO_4^{3-}	NO_3^-	NO_2^-	Cl^-	F^-	Br^-	I^-
Number of data		*1105*	*1104*	*1099*	*1071*	*891*	*839*	*885*	*303*	*1034*	*1015*	*736*	*577*	*510*	*242*	*1049*	*659*	*353*	*306*
rank correlation	All	0.20	0.52	0.08	0.52	-0.11	0.09	0.06	0.07	0.28	-0.04	0.31	0.01	0.04	0.19	0.48	0.09	0.58	0.54
	ρ_{Li}<50	0.19	0.52	0.07	0.51	-0.11	0.08	0.06	0.07	0.29	-0.03	0.30	0.00	0.04	0.19	0.47	0.08	0.58	0.53
	ρ_{Li}<25	0.19	0.50	0.06	0.49	-0.12	0.08	0.05	0.04	0.30	-0.02	0.26	-0.01	0.04	0.20	0.45	0.10	0.58	0.50
	ρ_{Li}<10	0.17	0.45	0.07	0.44	-0.09	0.04	0.04	-0.08	0.25	0.11	0.18	-0.01	-0.01	0.16	0.41	0.10	0.59	0.50

		Trace elements																	
		Zn	Sr	Cu	As	Pb	Ni	U	Ti	Be	Cr	Ba	Co	Mo	B	Ag	V	Cs	Rb
Number of data		*483*	*380*	*300*	*280*	*208*	*208*	*193*	*132*	*131*	*130*	*120*	*111*	*105*	*78*	*75*	*43*	*39*	*30*
rank correlation	All	0.29	0.22	0.23	0.14	0.12	0.21	-0.03	-0.04	0.04	-0.16	0.30	0.17	-0.08	0.43	-0.09	0.02	0.70	0.41
	ρ_{Li}<50	0.28	0.20	0.22	0.14	0.10	0.20	-0.04	0.00	0.05	-0.16	0.28	0.15	-0.04	0.38	-0.03	0.02	0.63	0.36
	ρ_{Li}<25	0.28	0.17	0.21	0.15	0.07	0.20	-0.04	0.04	0.03	-0.16	0.25	0.15	-0.01	0.35	0.03	0.02	0.60	0.36
	ρ_{Li}<10	0.26	0.10	0.14	0.16	-0.03	0.16	-0.13	0.13	0.07	-0.21	0.14	0.15	0.05	0.20	-0.11	-0.02	0.43	0.28

Differences from other European brines with Li concentration higher than 15 mg/l:
Pearson coefficients from Gourcerol et al (2024): Atlas of lithium geothermal fluids in Europe (Geothermics 119, 102956)

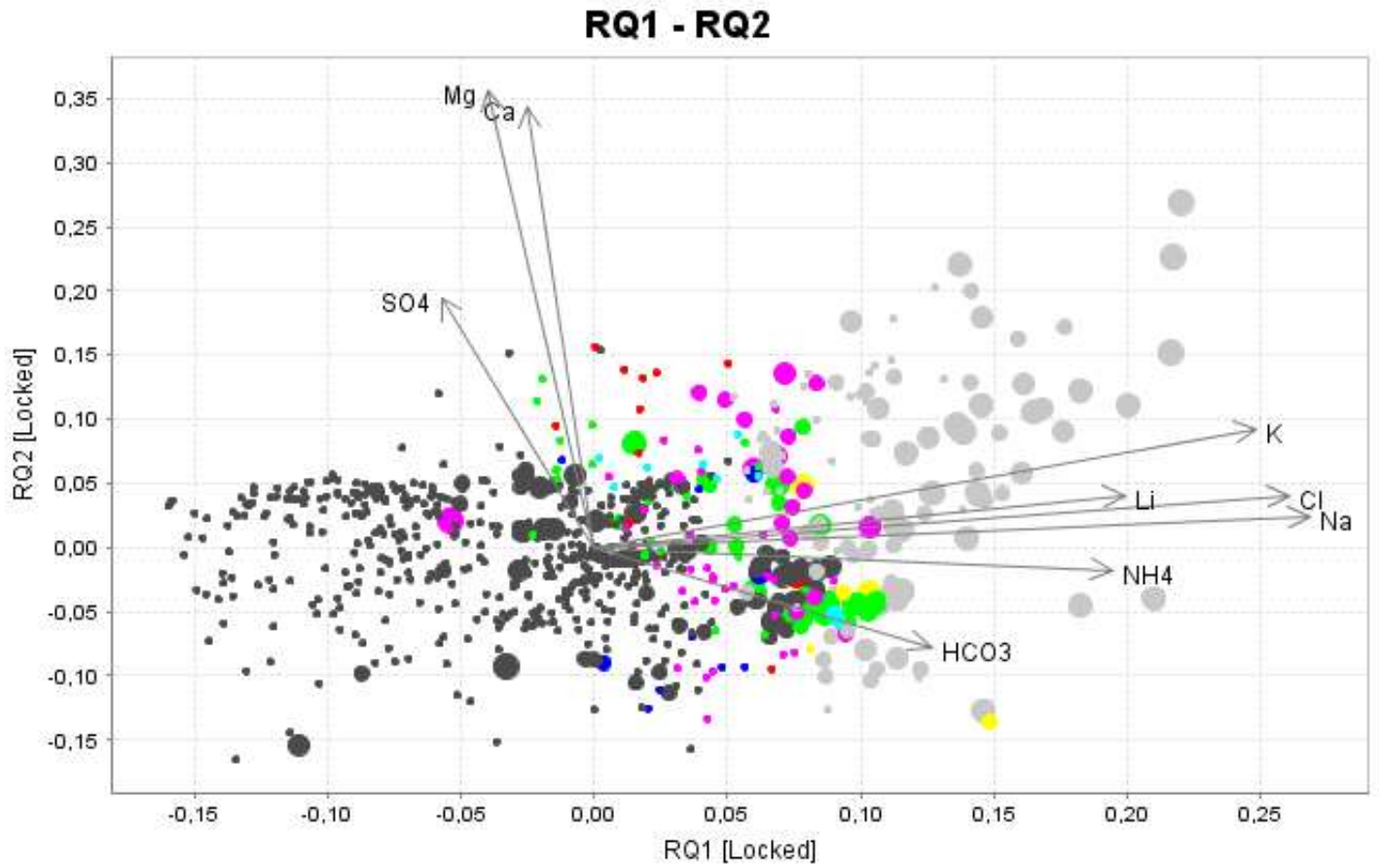


PRINCIPAL COMPONENT ANALYSIS

PCA biplot –clusters and loadings

- For 9 chemical components with complete data in 896 records of the database (Mid-Europe only)
- PC1: 41% and PC2: 20,7%
- Circle diameters are proportional with Li concentration

None meet RGB criteria	☑
Na > 80.0%	☑
K > 80.0%	☑
Cl > 80.0%	☑
K > 80.0% Cl > 80.0%	☑
Na > 80.0% Cl > 80.0%	☑
Na > 80.0% K > 80.0%	☑
Na > 80.0% K > 80.0% Cl > 80.0%	☑



SUMMARY

- Results relevant for brines with low (1-10 mg/l) Li concentrations
- NaCl type, neutral brines tend to contain relatively high lithium concentration
- Correlated elements: potassium (+ caesium and rubidium), sodium; chlorine, iodine, bromine; boron
- Corresponding to general trends in sedimentary formation waters
- Weak correlations? Calcium and hydrogen carbonate; strontium and barium; ammonium

THANK YOU FOR YOUR ATTENTION!

And for the co-workers participating in the data collection and compiling the presented results:

- Csilla Balassa, Viktor Mádai, Felicitász Velledits / UM - University of Miskolc
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- Pál Csicsák / Rotaqua Ltd.
- Lidia Razowska-Jaworek, Marcin Pasternak / PGI - Polish Geological Institute
- Daniel Marcin, Zuzana Kollová, Peter Malík, Jaromír Švásta, Juraj Michalko, Natália Bačová / SGIDS - State geological institute of Dionýz Štúr, Slovakia

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Connecting matters

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