Potential of the recovery of chemical elements from groundwaters in Poland

Lidia Razowska-Jaworek, Marcin Pasternak, Zbigniew Będkowski, Zbigniew Kaczorowski, Irena Wysocka

Polish Geological Institue
National Research Institute
Polish Geological Survey
Polish Hydrogeological Survey

RECOVERY PROJECT (PGI-NRI)

Funds:

In 2017 PGI-NRI received a grant from the National Fund for Environmental Protection and Water Management for a project aimed at showing the feasibility of recovery of mineral resources from groundwaters in Poland

Objectives of the research:

- selection of proper sites
- recognition of the concentration of elements in groundwaters
- evaluation of the possibility of their extraction

Sample locations:

In first step of this projekt We have to choose sampling sites - sites where groundwater is constantly discharged - mine waters, wells exploiting gas and geothermal and medicinal waters

Issues:

Specific technologies for recovery of elements could be used for treatment of mine waters or thermal brines, thus limiting their negative

METHODS

Selection of 67 sites for sampling

- 18 operating and 9 abandoned coal mines
- 3 lignite mines
- 12 geothermal and medicinal water plants
- 9 gas extracting boreholes
- 8 sites of metal ores (copper, zinc and lead, iron, gold)
- 11 other deposits (salt, sulpur, gypsum, uranium)

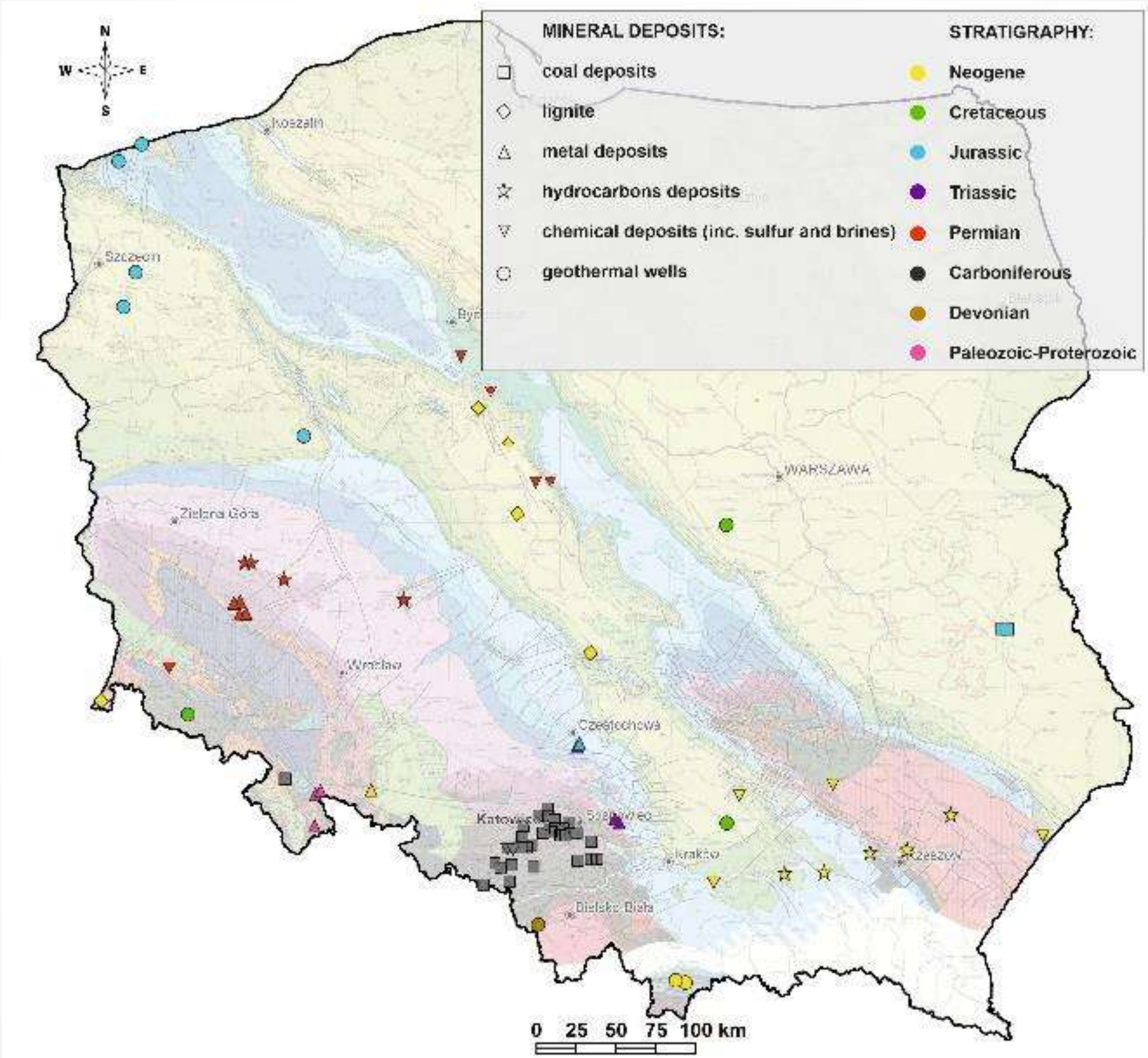
75 water samples & field measurements:

electrolytic conductivity, temperature, pH of waters, as well as obtaining information on hydrogeology, amount of discharged water, etc.

Physico-chemical analyses of water (65 components)

- ICP-OES
- ICP-MS
- ICP-MS + seaFAST-preconcentration system (for REE)
- Ion Chromatography

DOCOMENTATION MAP - DISTRIBUTION OF GROUNDWATER SAMPLES



AFTER SAMPLED WE PERFORM INTERPRETATION

Main assumptions

- concentrations of elements in water are stable and do not change significantly over time
- water discharge does not change significantly with time
- capital and operating costs for each mine/plant were not taken into account
- simplified estimation method was used

$$\mathbf{Zodq = Q * s * 0.001}$$

Zodq – mineral resources for recovery from waters in relation to pumping rate [**kg/a**]
Q – volume of water discharge [m^3/a]
s – content of element in water [mg/L]

$$\mathbf{Zpod = Zodq * e * t_e * 0.001}$$

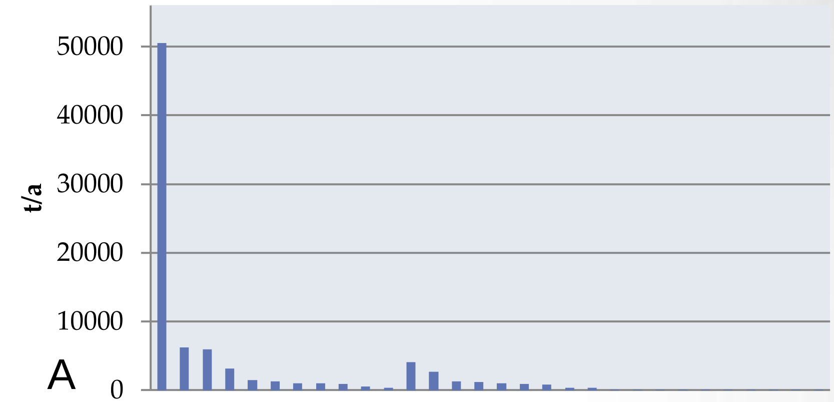
Zpod - mineral resources for recovery from waters in relation to pumping rate taking into account the efficiency - **e** and working time of the installation - $\mathbf{t_e}$ [**t/a**] - **Formula for rought counting.**
e - 80% $\mathbf{t_e}$ - 90%

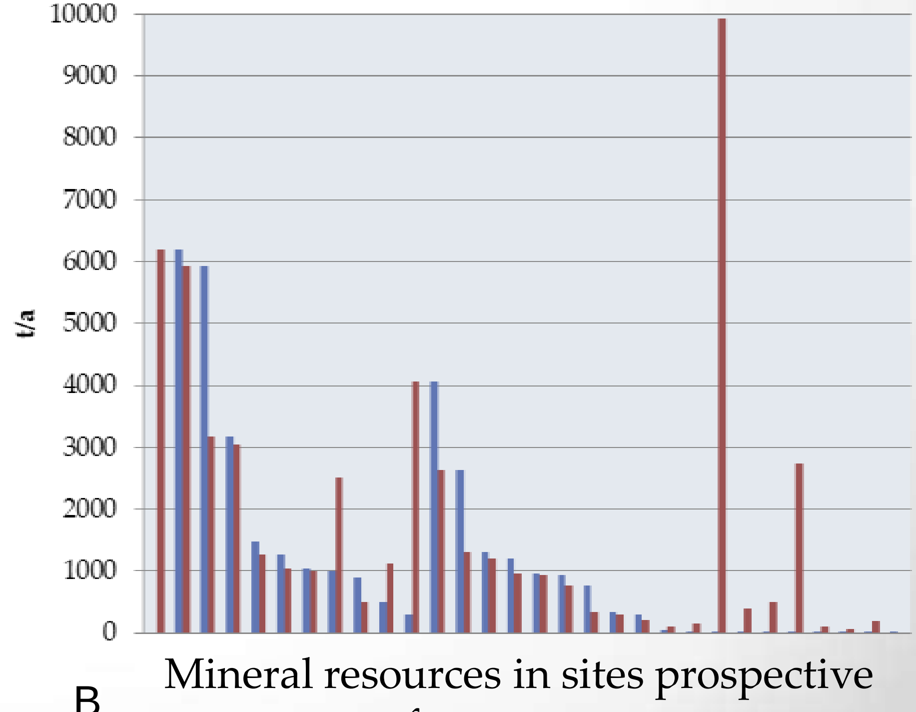
RESULTS OF PROJECT

Mine waters and geothermal brines in Poland - contain resources of valuable elements in very different amounts

In more than half of the sites - content of elements and thus estimated mineral resources - not prospective amounts

Waters in 29 sites contain elevated concentrations of several elements (such as: B, Br, I, K, Li, Mg, Mn) – prospective for recovery; among them 11 sites - the most promising



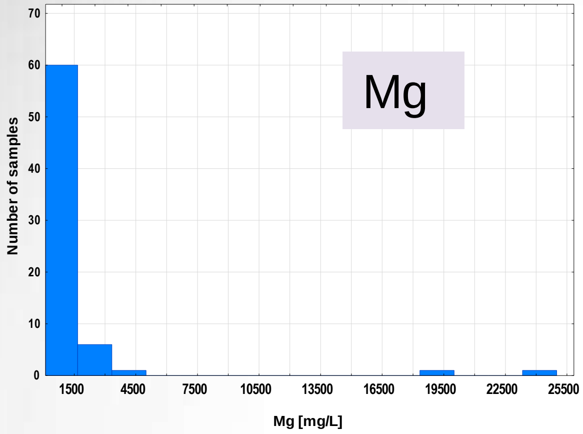


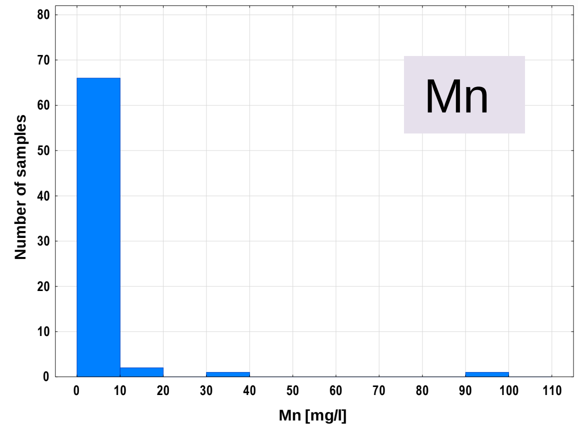
Mineral resources in sites prospective for recovery

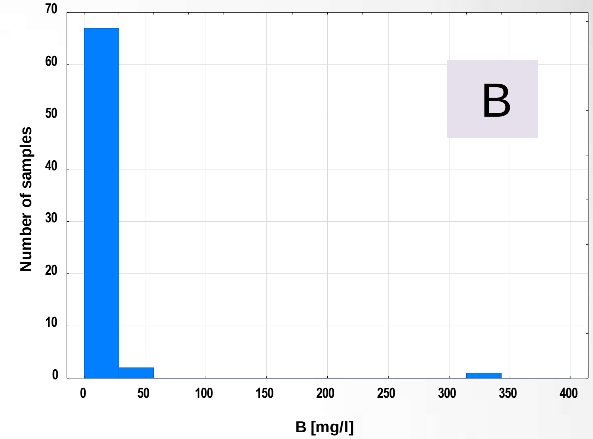
MAJOR COMPONENTS OF ALL WATER SAMPLES

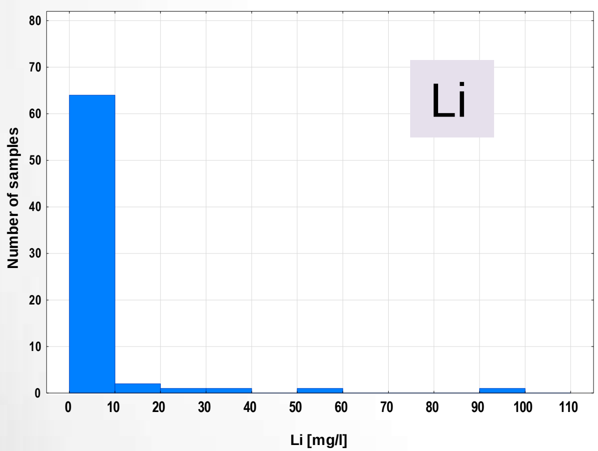
Component	Unit	Range of values	Average	Median	Standard deviation	Number of samples
pH		4.50 – 8.59	7.16	7.36	0.79	70
Total Dissolved Solids	g/L	0.16 – 463	59.0	10.9	94	70
Electrolytic conductivity	mS/cm	0.19 – 1114	81.3	17.3	160	70
HCO_3^-	mg/L	24 – 2171	345	253	332	70
Cl	g/L	0.003 – 305	35.4	4.8	59	70
SO_4^{2-}	mg/L	0.68 – 3610	745	467	815	70
Ca	mg/L	6.6 – 62900	3191	367	9286	70
Na	g/L	0.002 – 127	16.7	3.13	26	70

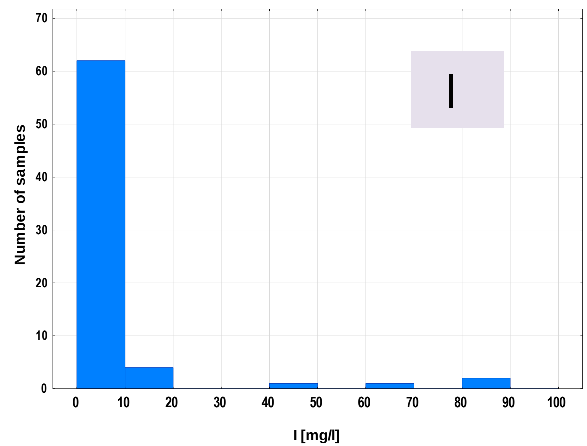
CONCENTRATION OF ELEMENTS IN SAMPLED WATERS

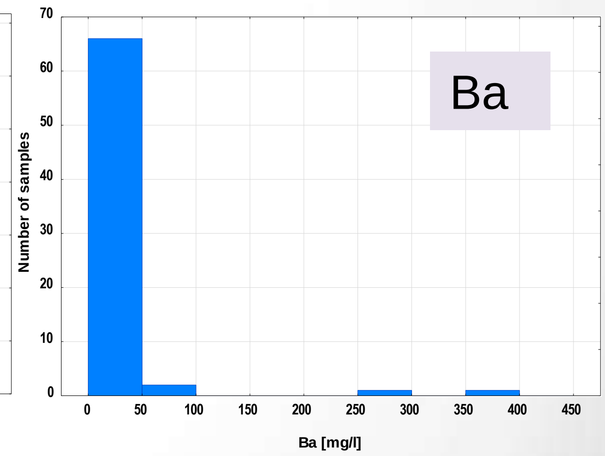




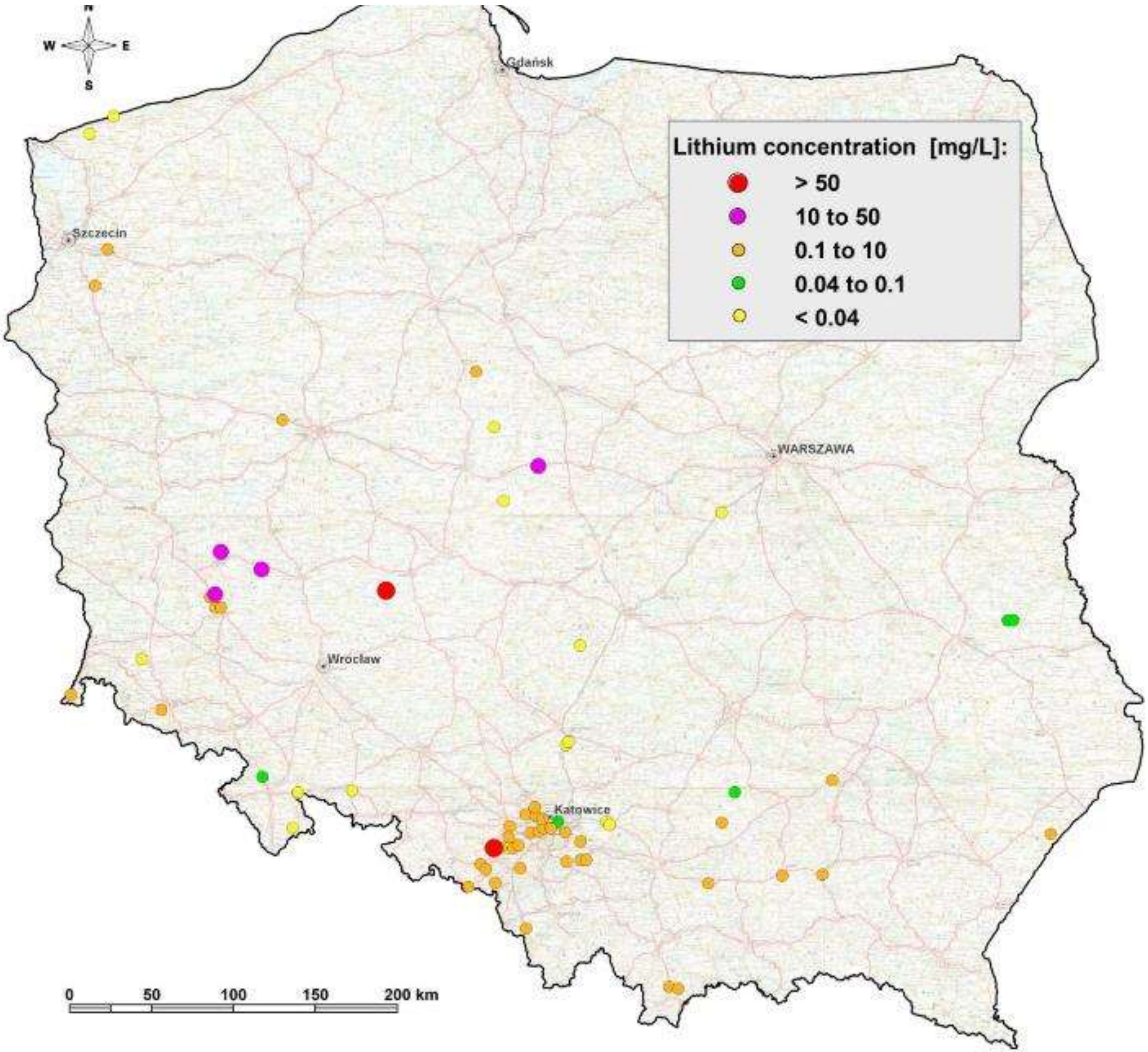








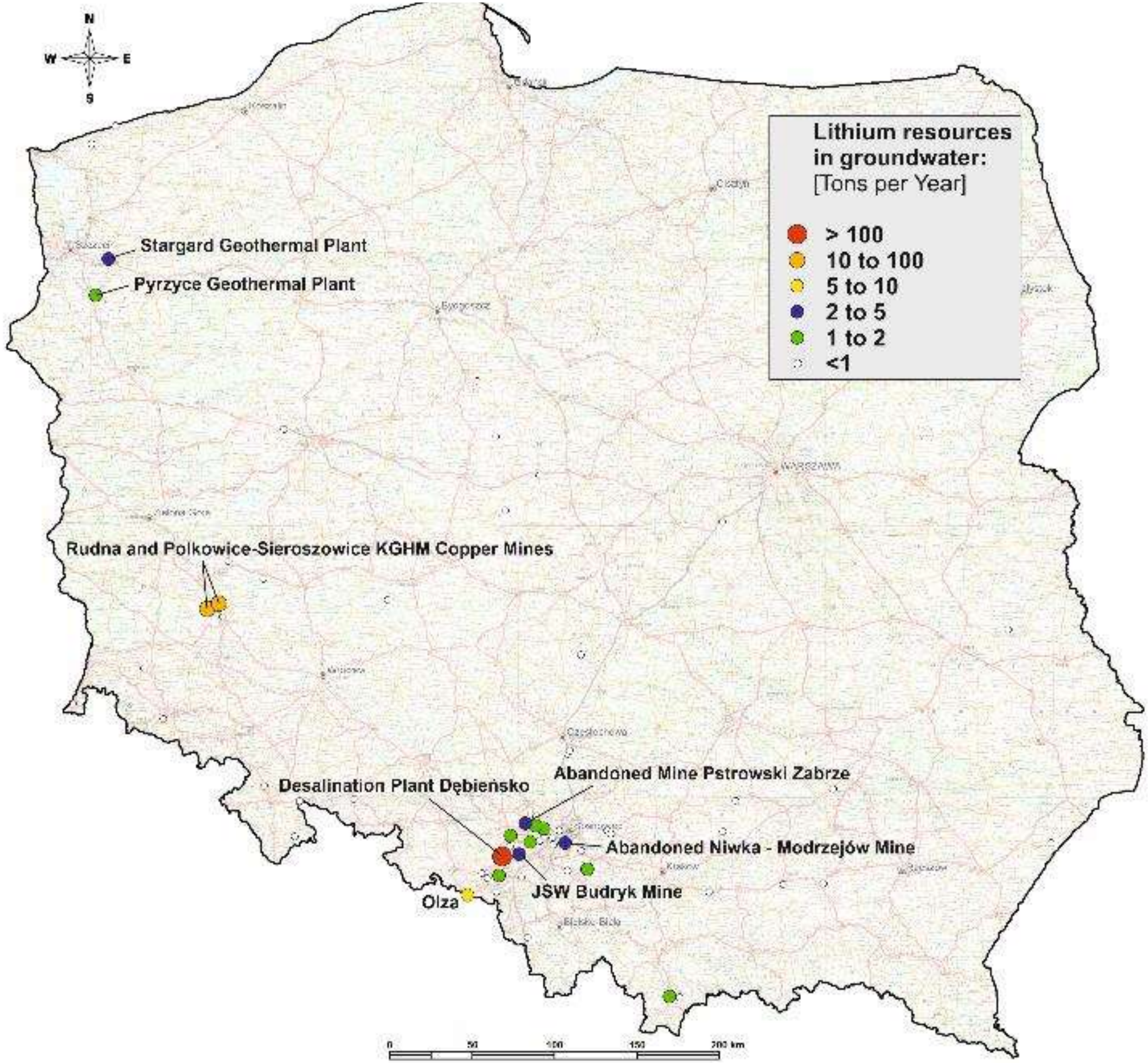
Li CONCENTRATION in GROUNDWATER SAMPLES



CALCOLATION OF 70 SAMPLING SITES

Element	K	Mg	I	Br	B	Ba	Fe	Mn	Li	SiO_2	Sr	F	Zn	Cs	Sum REE
	Resources [t/a]														[kg/a]
Sum	23 610	63 639	221	4 144	272	166	121	303	244	2 517	2 132	65	94	3.27	142
Maximum	11239	36329	164	2081	81	57	20	91	104	487	546	14	35	1.9	29.0
Average	357	935	10	84	5.0	3.2	2.3	11	5.0	46	33	2.5	4.1	0.05	1.1
Median	3.0	127	0.9	10	0.5	0.8	0.5	1.3	0.6	16	6.4	1.4	0.3	0.003	0.02
	Concentration [mg/L]														[mg/L]
Average	695	1 587	5.8	172	9.6	12.6	15.2	3.1	4.9	17.7	1030	1.2	0.53	0.096	1.0
Median	64.3	174	0.05	11.6	2.11	0.1	0.17	0.58	0.61	11.8	8.76	0.12	0.01	0.004	0.18
Maximum	26 600	52 800	90	4 400	340	387	195	91	100	95	1 950	12.0	14.1	4 530	29
Minimum	0.9	2.9	0.05	0.05	0.005	0.001	0.005	0.001	0.005	2.5	0.045	0.05	0.02	0.025	<DL
Number of samples	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70

MOST INTRESTING FOR RECOVERY - LITHIUM



SITES WITH RESOURCES PROSPECTIVE TO RECOVERY

Site, plant/mine	Water type	Elements with recovery potential	Discharge thousand, m^3/a	Sum of resources, t/a
Desalination Plant Dębieńsko	Mine waters - brines	Mg, K, Br, Sr, I, Li, Ba, F	2 630	50 554
Rudna KGHM Copper Mine	Mine waters - brines	Mg, K, Br, Sr, B, Li, SiO_2, I	5 490	6 205
Góra Salt Mine	River waters - pumped into salt structure	K, Mg, Br, Sr, B, I	4 470	5 926
Mine Waters Collector Olza	Mine waters	Mg, K, Br, Sr, SiO_2, I, Li	7 360	3 175
Stargard Geothermal Plant	Geothermal brines	Mg, K, Sr, Br, SiO_2, B	1 680	1 465
Abandoned Mine Pstrowski Zabrze	CNMW (Circa-Neutral Mine Waters)	Mg, K, SiO_2, Br, Sr, B	7 950	1 274
Abandoned Mine Siemianowice	CNMW	Mg, K, SiO_2, Br, B, Sr	7 230	1 035
Abandoned Mine Saturn Czeladź	CNMW	Mg, K, SiO_2, Fe, Mn, Sr	13 140	999
Pyrzyce Geothermal Plant	Gethermal brines	Mg, K, Sr, Br, SiO_2, B	1 050	885
Abandoned Mine Gliwice	CNMW	Mg, K, Br, SiO_2, Sr	2 290	499

CONCLUSIONS

Mine waters, geothermal brines, brines from gas extraction wells in Poland - contain resources of valuable minerals of very different amounts

in 29 sites (out of 67 examined) - elevated content of several elements

in 11 most prospective sites - total amount of mineral resources which could be recovered from waters - ca. **72 000 t/a**

if successfully recovered – potential additional income for mining and geothermal industries

The most promising - Desalination Plant (of mine waters) Dębieńsko

- the highest resources of elements to be recovered
- 6 elements in concentration perspective for recovery **(Mg, K, Br, I, Li, Sr)**

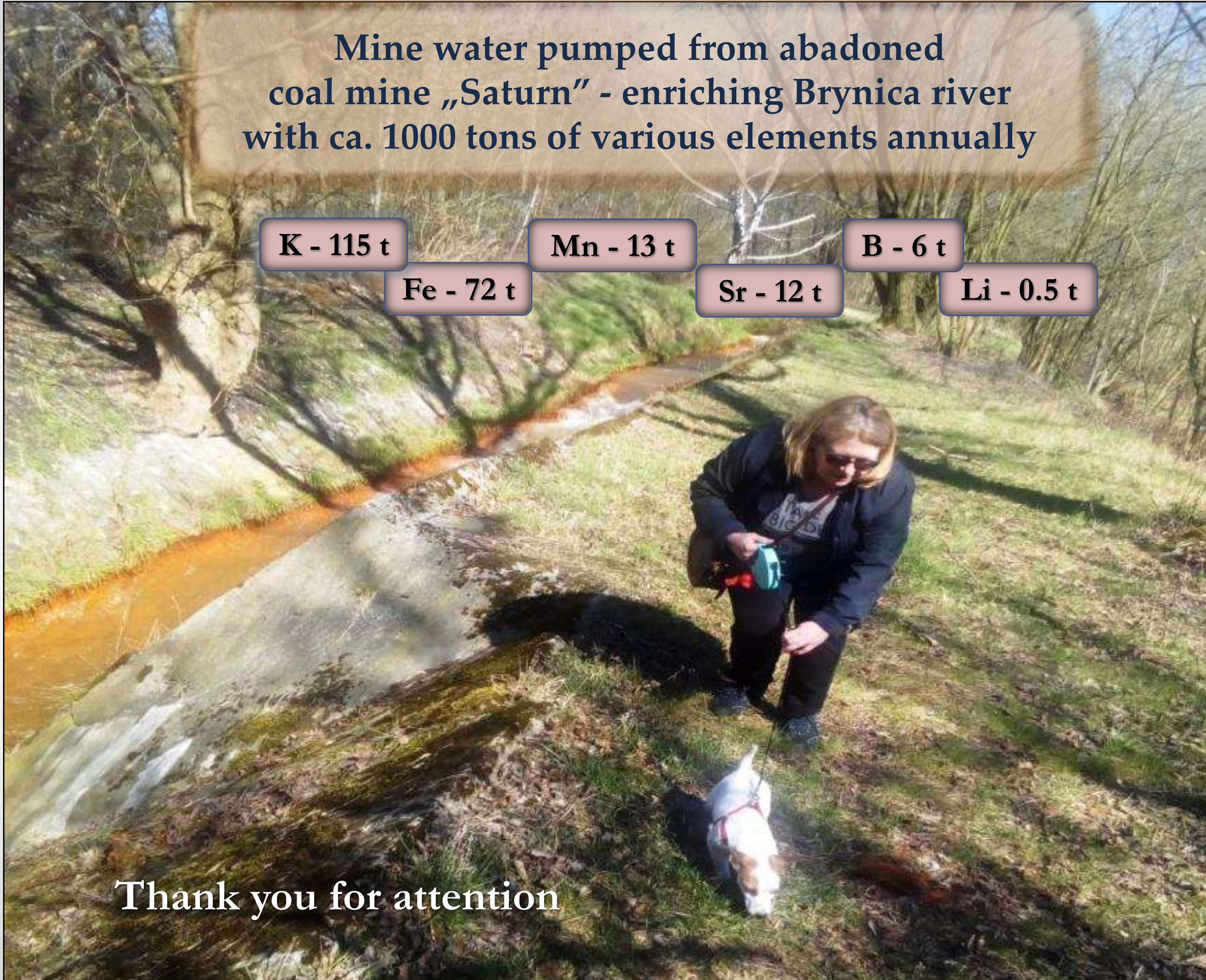
CONCLUSIONS

Recovery and reuse of chemical elements from mine waters & geothermal brines have the potential to:

- decrease Poland reliance on primary resources & import
- reduce unwanted dispersion of some potentially harmful elements into the environment
- reduce disposal or treatment costs
- decrease risk of future environmental obligations for wastewater generators

The recovery of elements from mine waters or geothermal brines is a technology of the 21st century and has something of ***alchemy* -** where thousands of tons of **harmful substances** can be transformed in tons of **valuable mineral resources**

Mine water pumped from abadoned coal mine „Saturn” - enriching Brynica river with ca. 1000 tons of various elements annually



Thank you for attention