Typical composition of geothermal fluids at Hungarian concession areas

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University of Miskolc, Faculty of Earth Science and Engineering

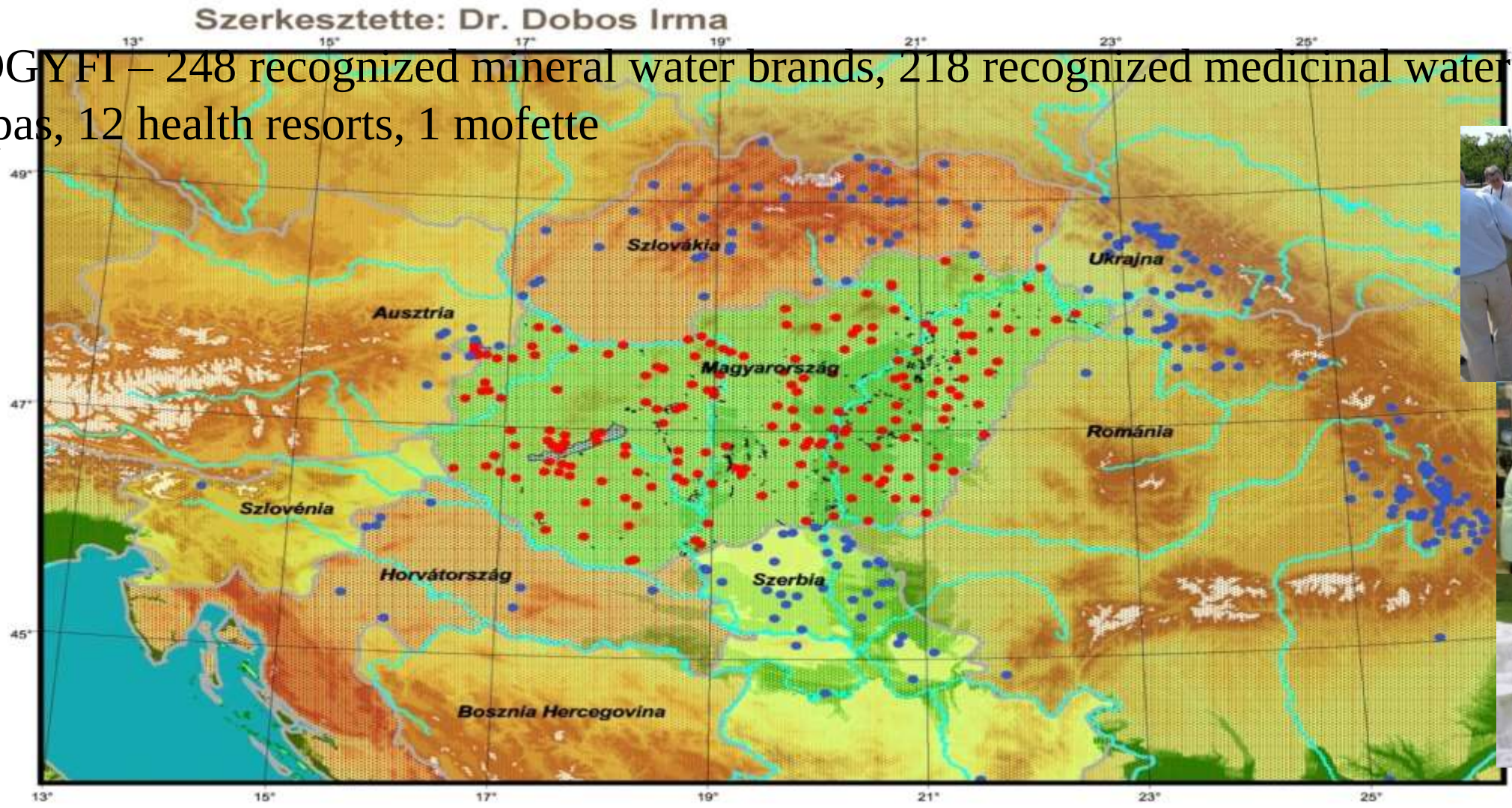
Geochemistry of geothermal fluids workshop

University of Miskolc, October 26-27, 2017

Mineral-, medicinal-, and thermal water resources in Hungary

Favorable conditions in the whole Carpathian Basin – outstanding opportunities in utilization

OGYFI – 248 recognized mineral water brands, 218 recognized medicinal water brands, 67 spas, 12 health resorts, 1 mofette

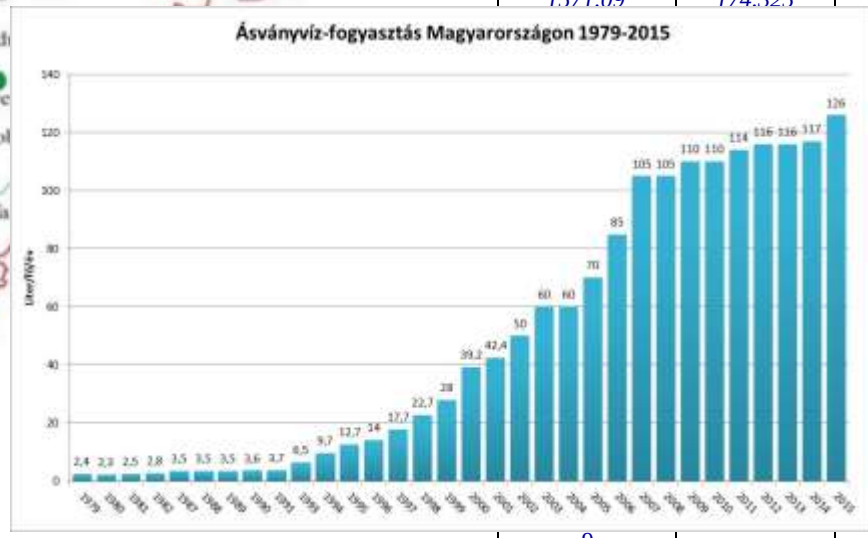


Mineral-, medicinal-, and thermal water resources in Hungary

Around 50 million m^3 /year thermal water production for balneology use

Energetic thermal water production: around 55 million m^3 /year

	Alzalakarosi gyógyfürdő	A mezőkövesdi Zsóry gyógyvíz és Strandfürdő	Tapolcai Barlangfürdő	Tiszaújváros K-50 sz. termálkút	Eger Városi Gyógyfürdő	Hungarospa Gyógyfürdő - Hajdúszoboszló	Egerszalók - Strandfürdő
Kationok	[mg/dm^3]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]
Kálium, K+	58	44	1.9	9.7		11.3	9
Nátrium, Na+	1810	218	7.2	1410	55.7	1530	59.6
						14.8	0.02
						8.6	86
						5.4	19.7
						0.79	0.004
						-	0.001
						0.2	-
						-	< 0,02
						1571.09	*174.325*
						9	-
						3848.42	



Increasing mineral water consumption

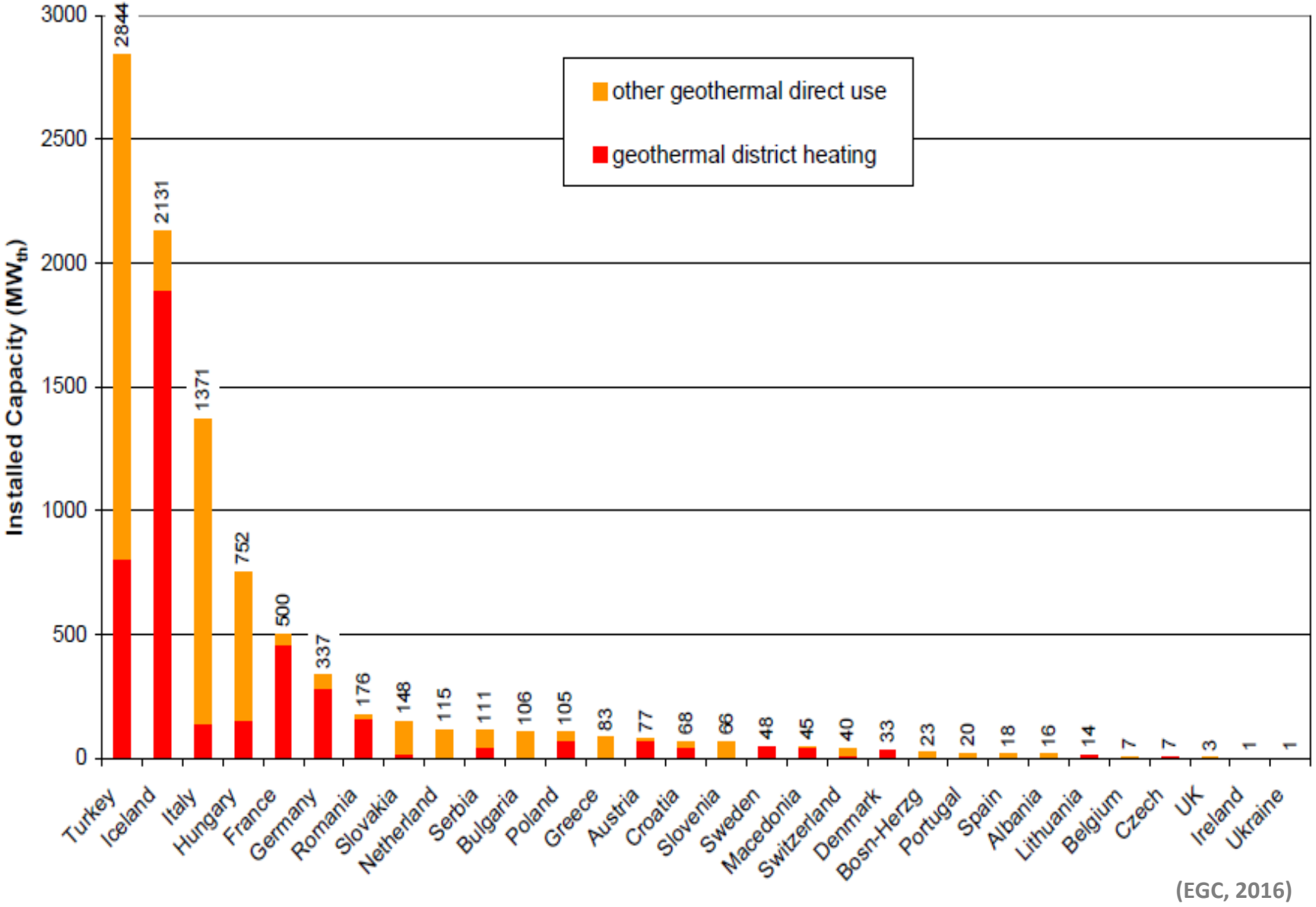
The importance of balneology research at the University of Miskolc

The increasement and sustainable utilization of geothermal energy in Hungary

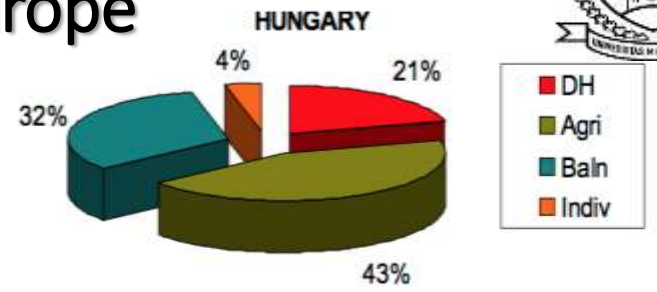
Geothermal community heating: 250 MW capacity (**Miskolc 60 MW , Győr 52 MW**)
Geothermal energy in agriculture: 290 MW capacity
The geothermal potential of the producing medicinal water wells (around 250): 225 MW
Geothermal power plant capacity: one ongoing EGS project, 0 MW_{el}

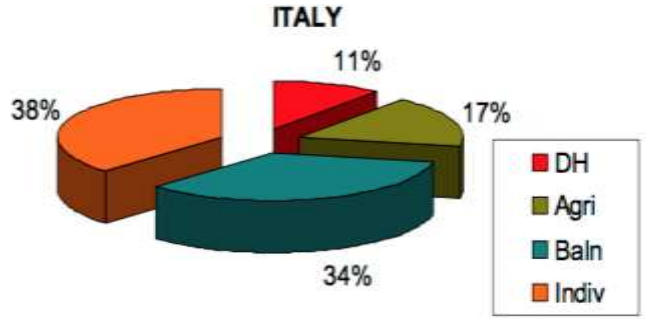
Mainly thermal water related (hydrothermal) projects can be expected in Hungary in the near future – the importance of hydrogeology
Sustainability issues and technical challenges in the main focus of the experts

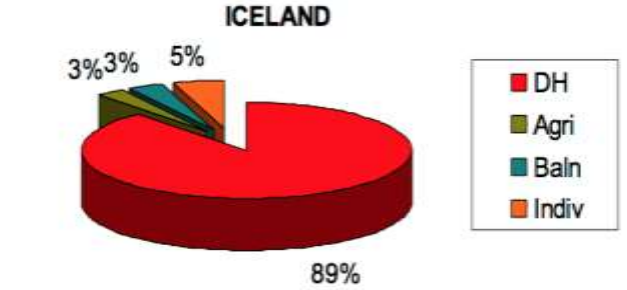
Geothermal heat production in the different countries of Europe

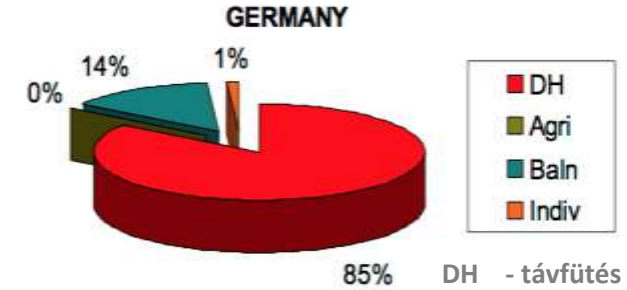


(EGC, 2016)



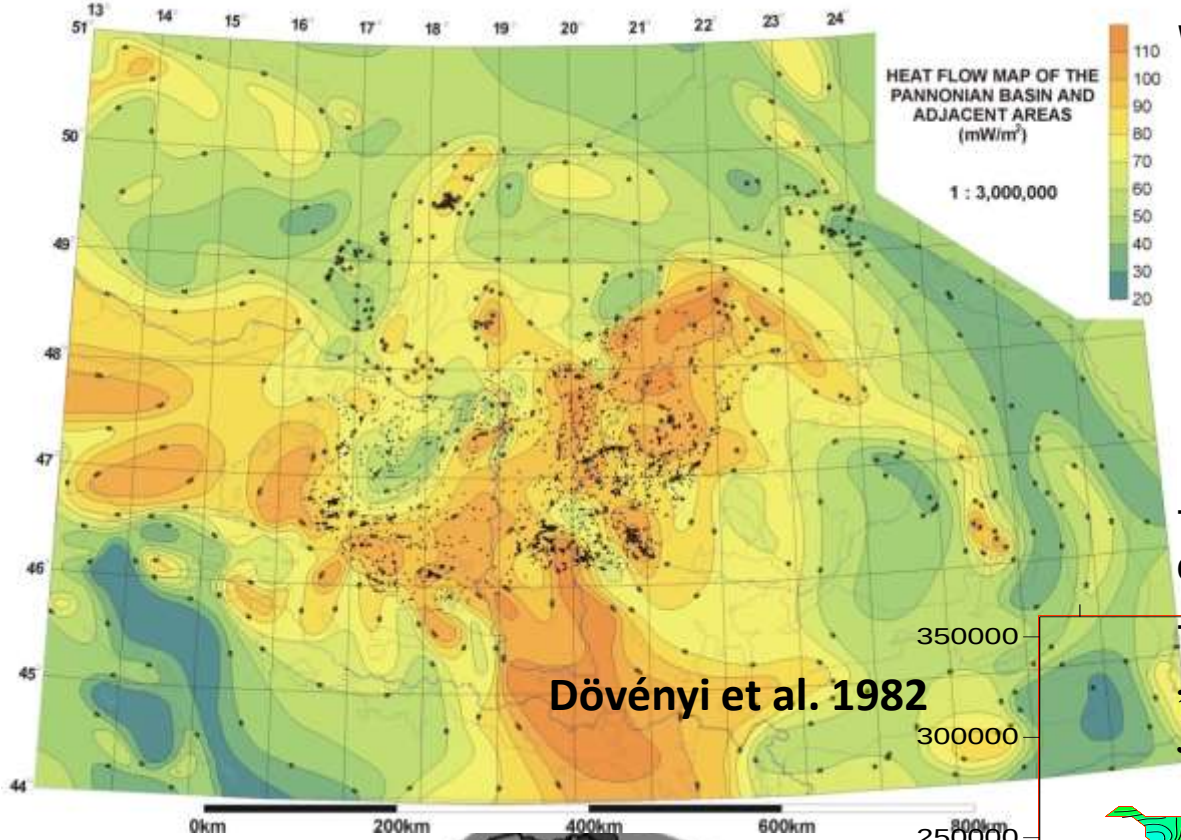




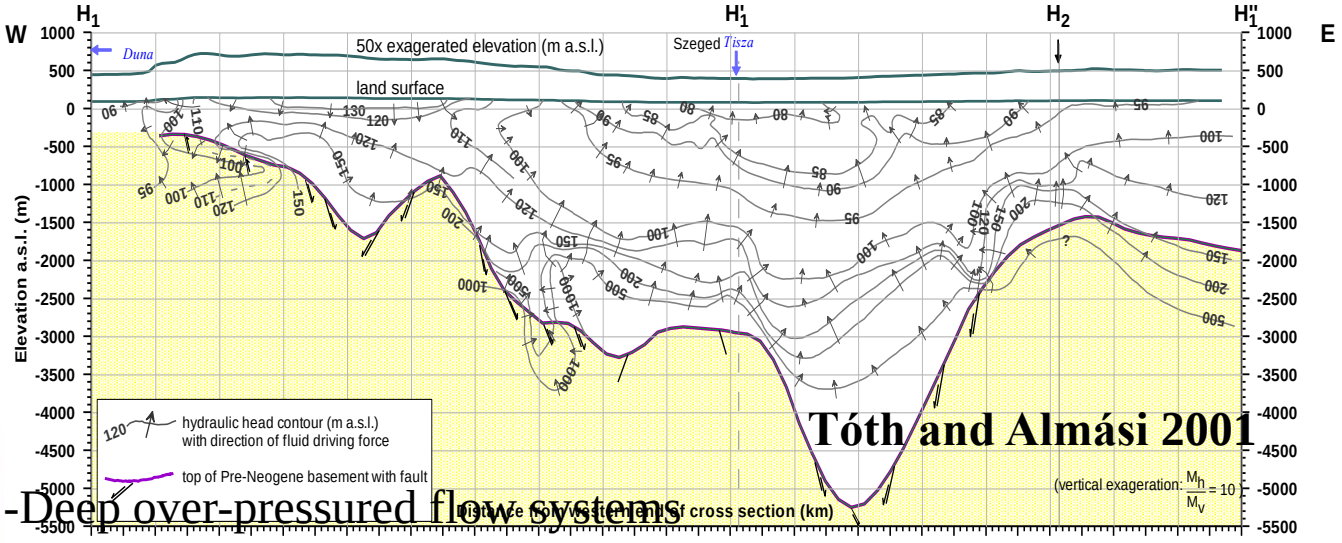


DH - távfütés
Agri - mezögazdaság
Baln - termálfürdök
Indiv – egyéni fütés

Well-known fact – the geothermal energy potential is high in Hungary



Dövényi et al. 1982



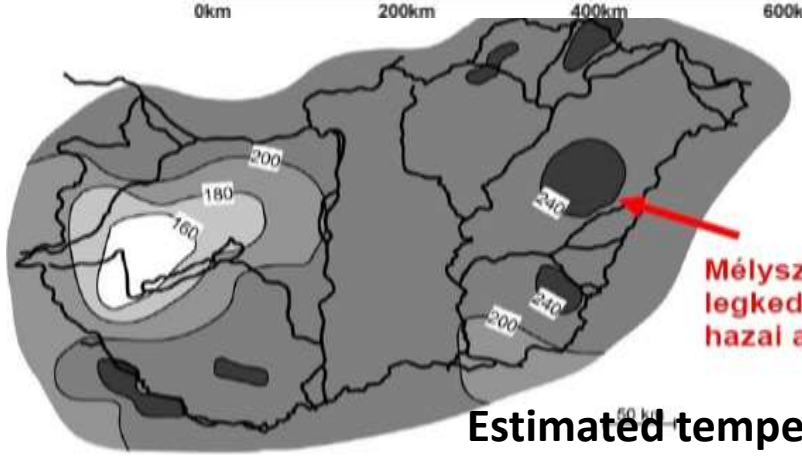
Tóth and Almási 2001

-Deep over-pressured flow systems originated from the Pre-Neogene basement

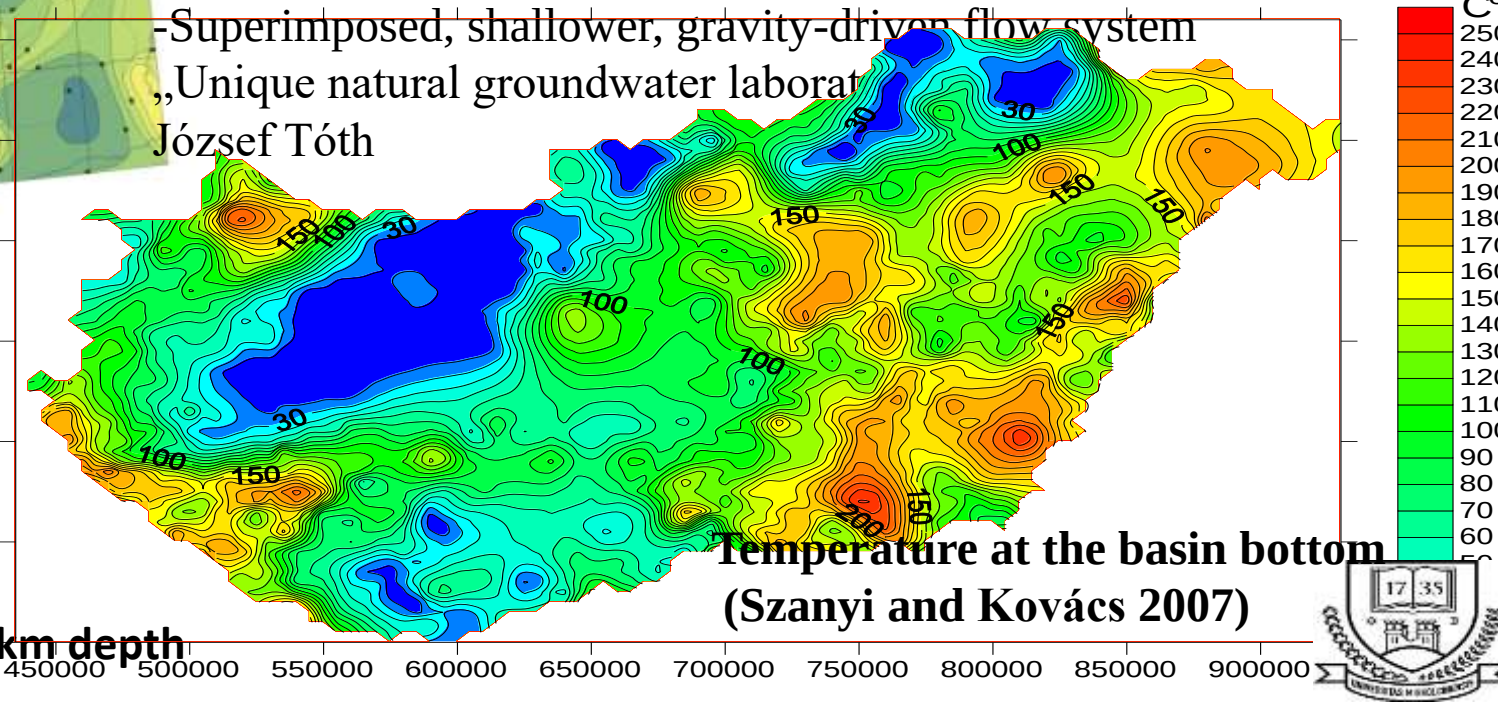
-Superimposed, shallower, gravity-driven flow system

„Unique natural groundwater laborat

József Tóth

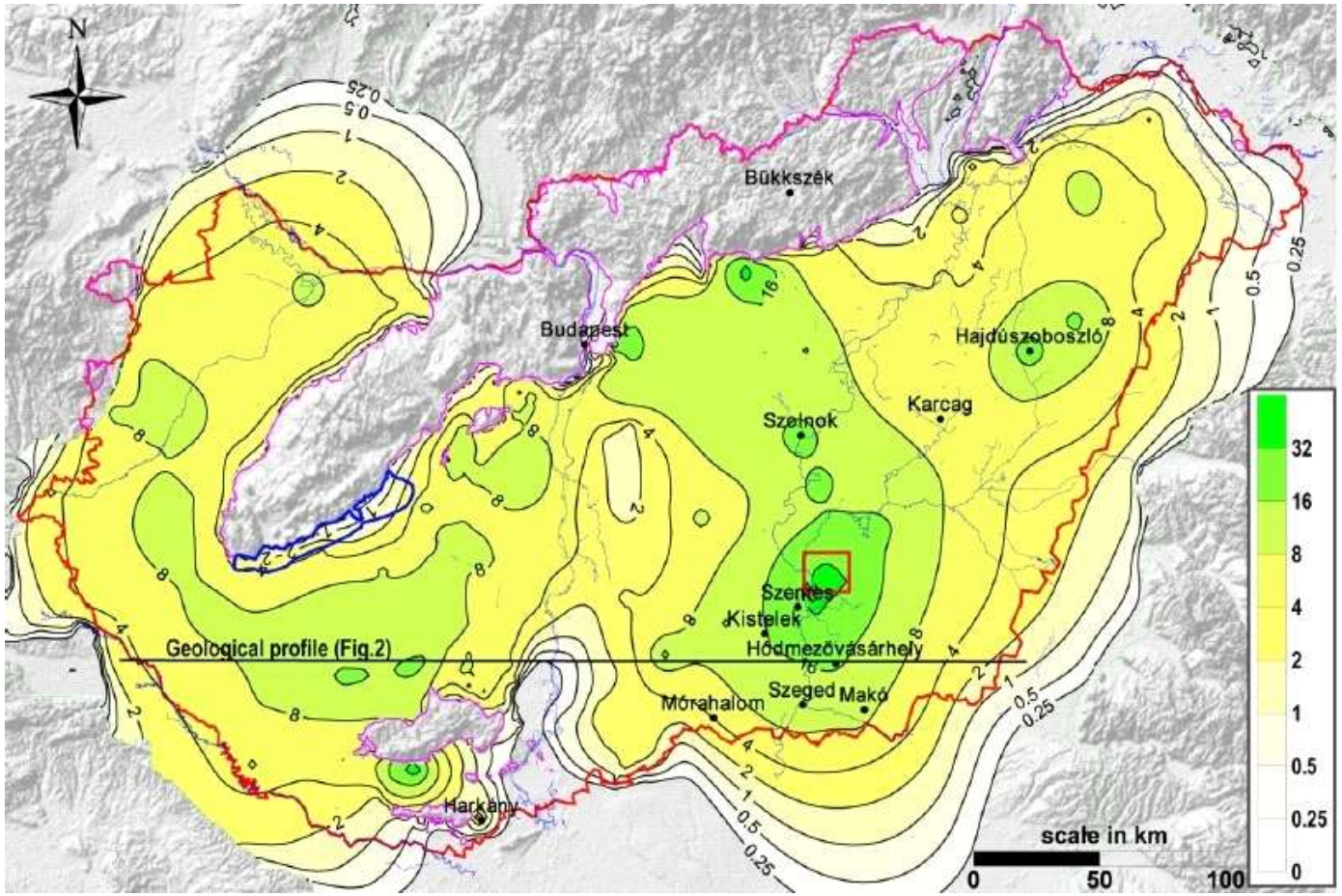


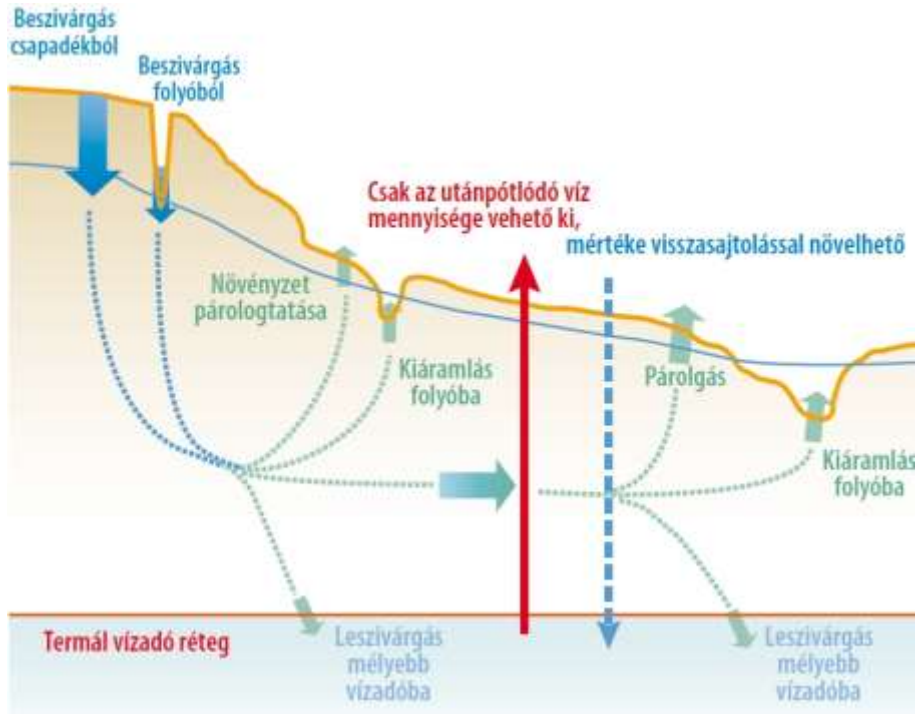
Estimated temperature at 5 km depth



Temperature at the basin bottom (Szanyi and Kovács 2007)

Overproduction of the Upper-Pannonian thermal water aquifers in Hungary





Sustainability aspects

Simulated depressions in the Upper-Pannonian aquifers based the national scale flow modeling - Tóth Gy. 20120

Less than 10 % of the produced thermal water for energy purposes is injected back into the aquifers
Our thermal water resources are not endless

Good example for sustainability – 100 % injection rate into a karst aquifer system

Geothermal Project of Miskolc – well parameters

MAL-PE-01 production well
Depth: 2305 m
Fluid temperature: 105 °C
Yield: 6600-9000 l/min.

MAL-PE-02 production well
Depth : 1514 m
Fluid temperature : >90 °C
Yield: 8 000 l/min.

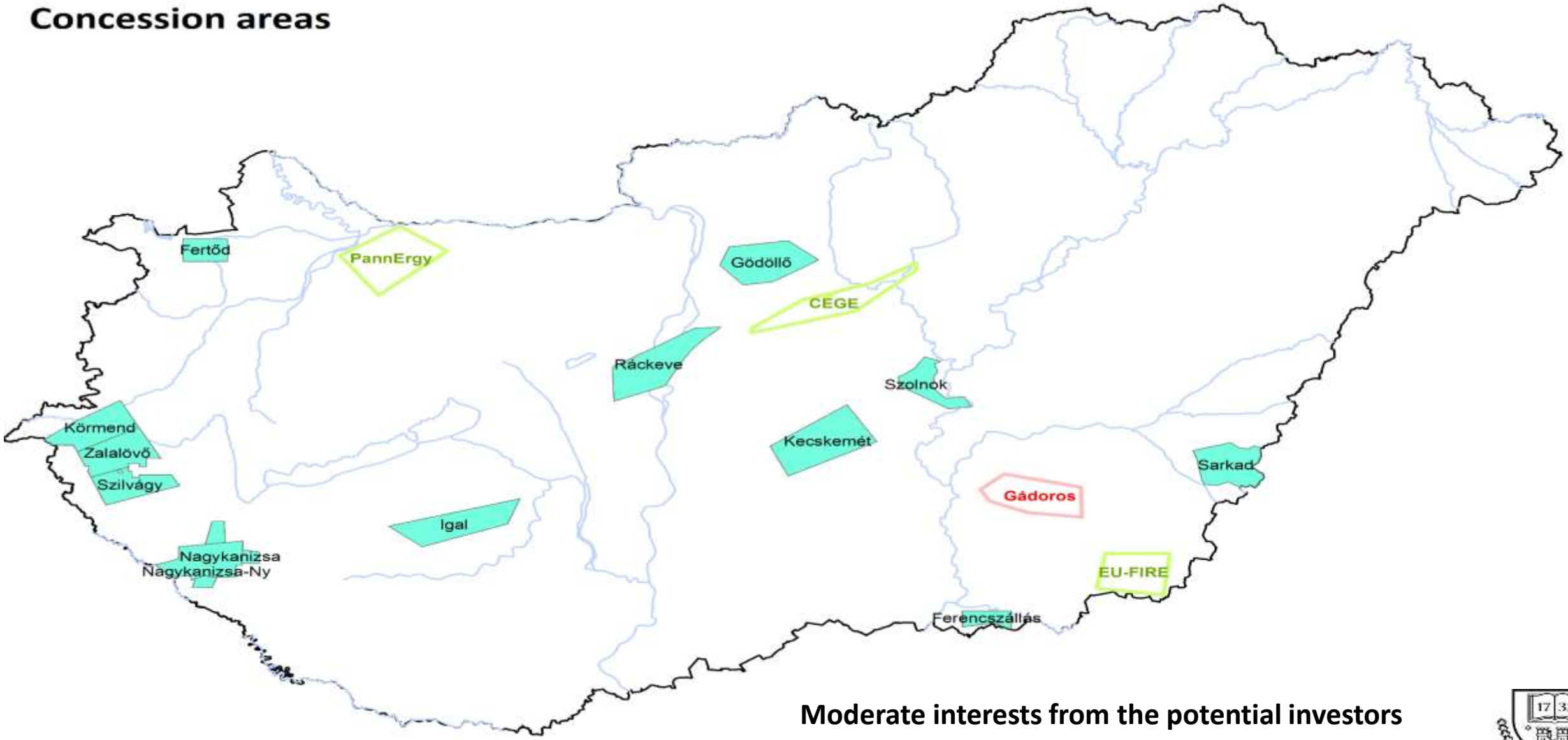
KIS-PE-01 reinjection well
Depth : 1737 m
Receiving capacity: 1600 l/min.

KIS-PE-01B reinjection well
Depth : 1093 m
Receiving capacity : 5600 l/min.

KIS-PE-02 reinjection well
Depth : 1058 m
Receiving capacity : not a final result ~7000 l/min.

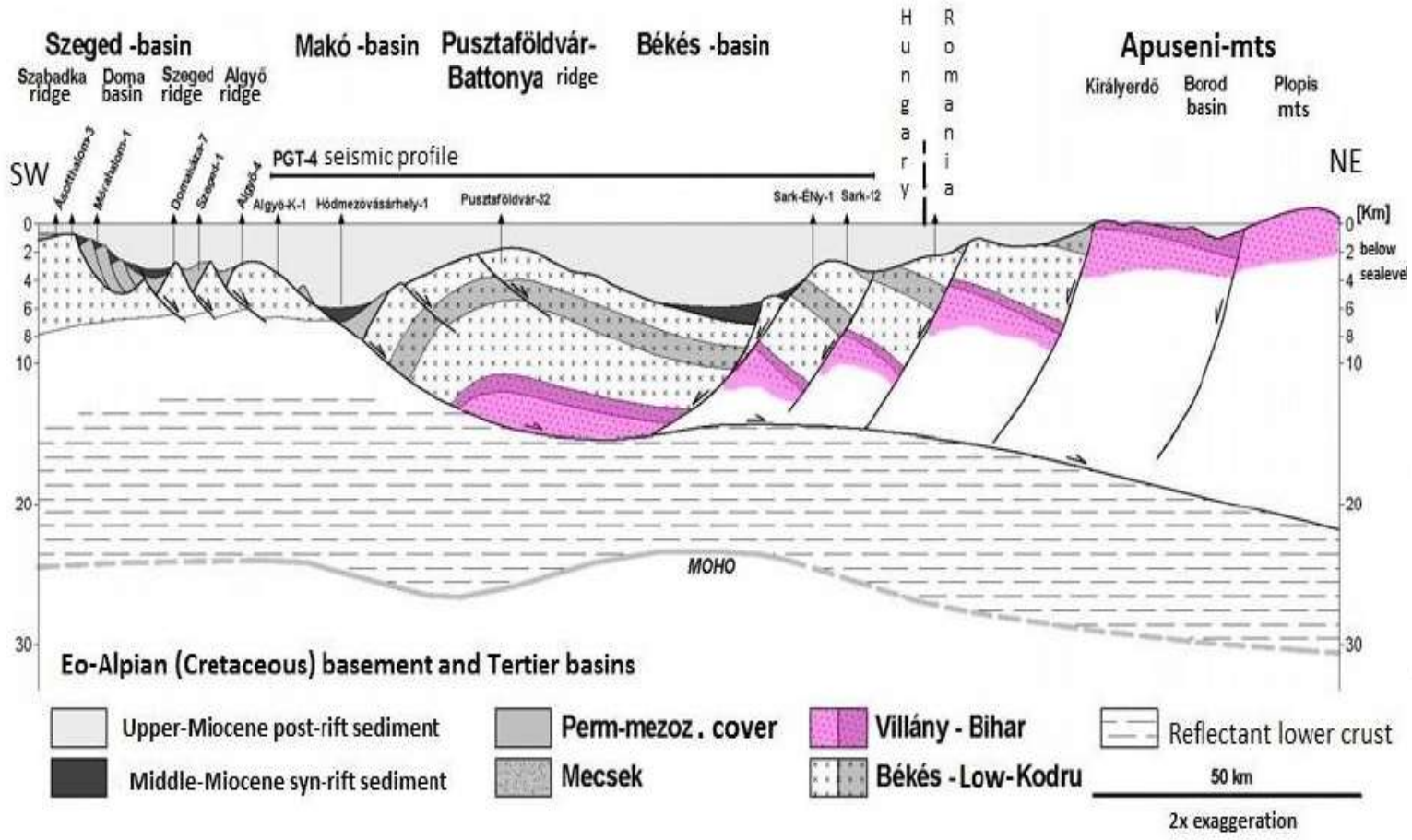
Miskolci Geotermia ZRt - Pannergy
Geothermal community heating: 60 MW capacity

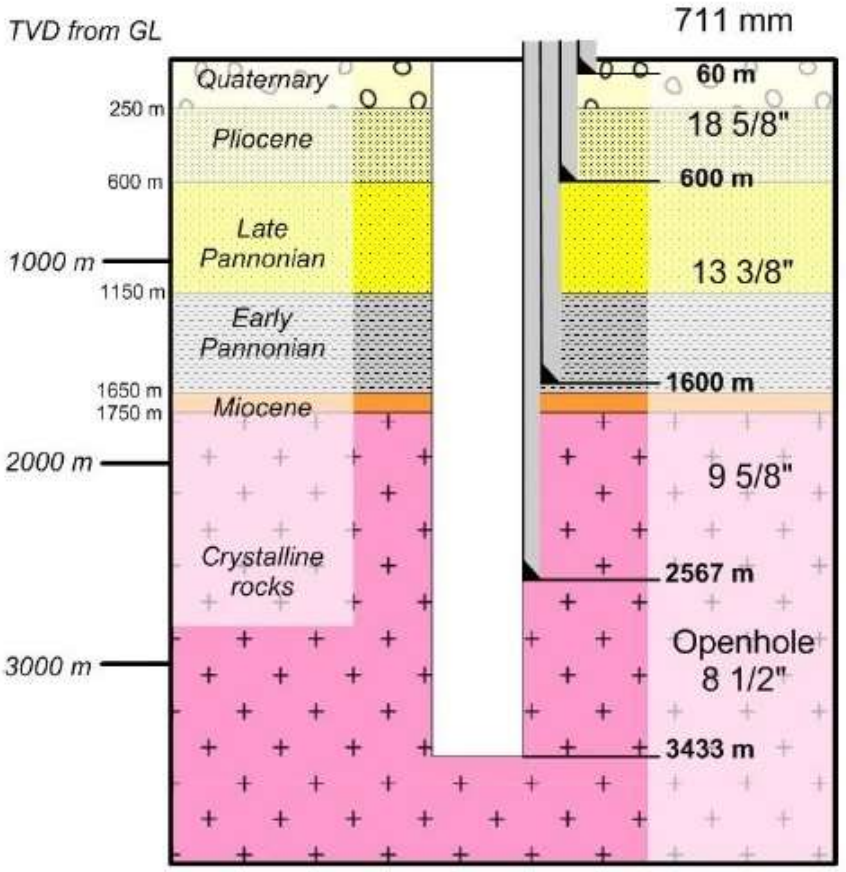
Concession application is required for the geothermal energy utilization bellow the depth of 2500 m in Hungary



Moderate interests from the potential investors

Ongoing concession work by EU-FIRE at Battonya to build the first geothermal power plant in Hungary

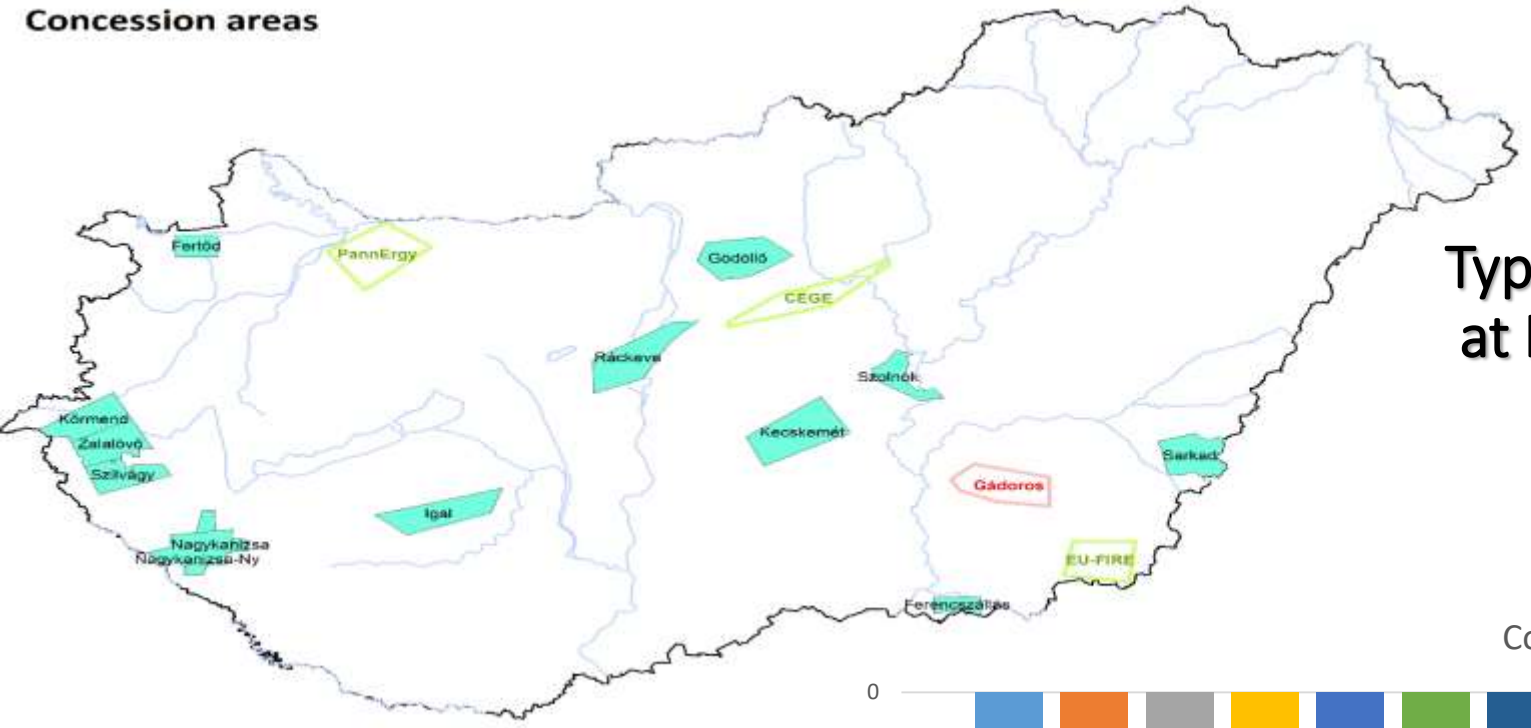




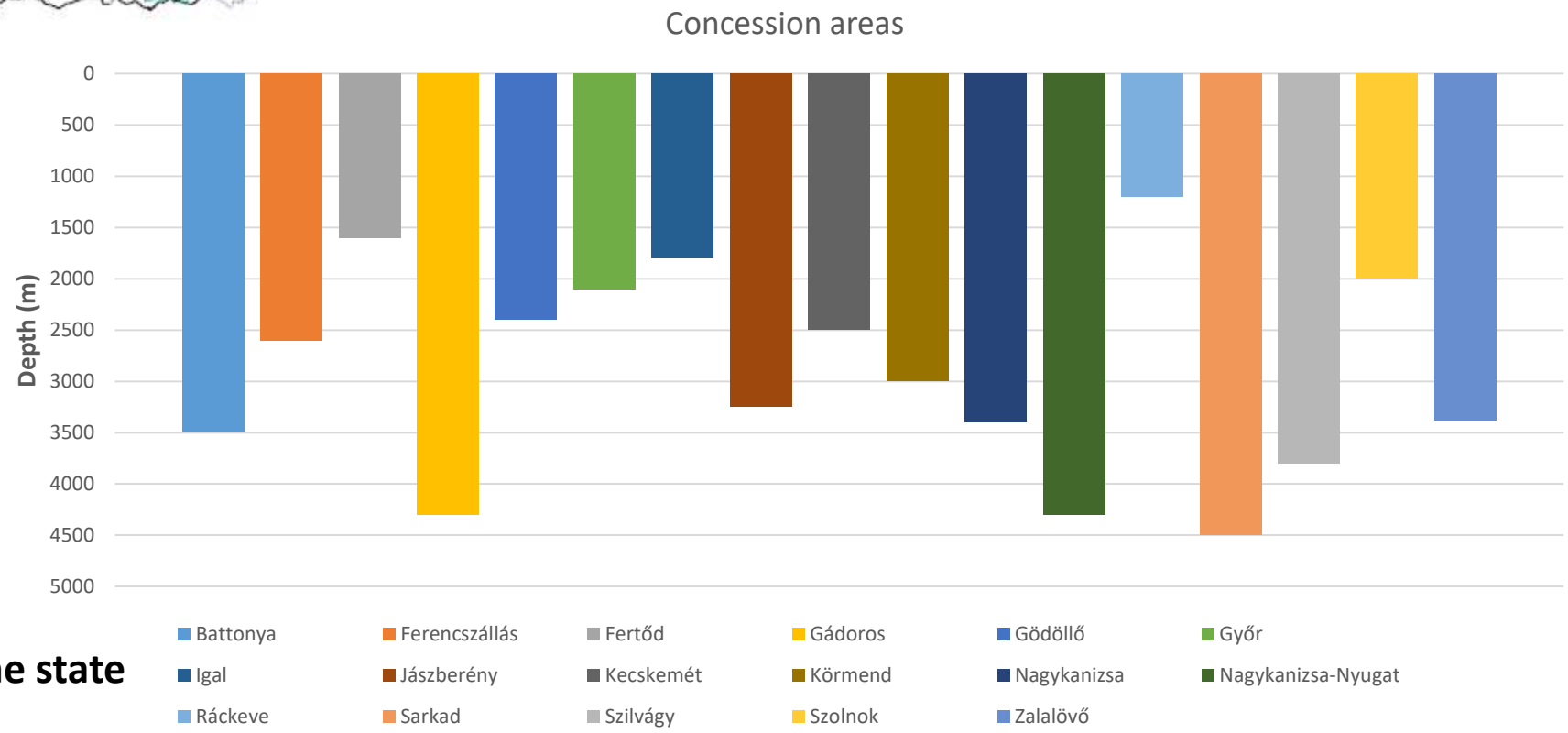
EGS geothermal power plant is proposed

Binary ORC geothermal power plant – around 9 MWe

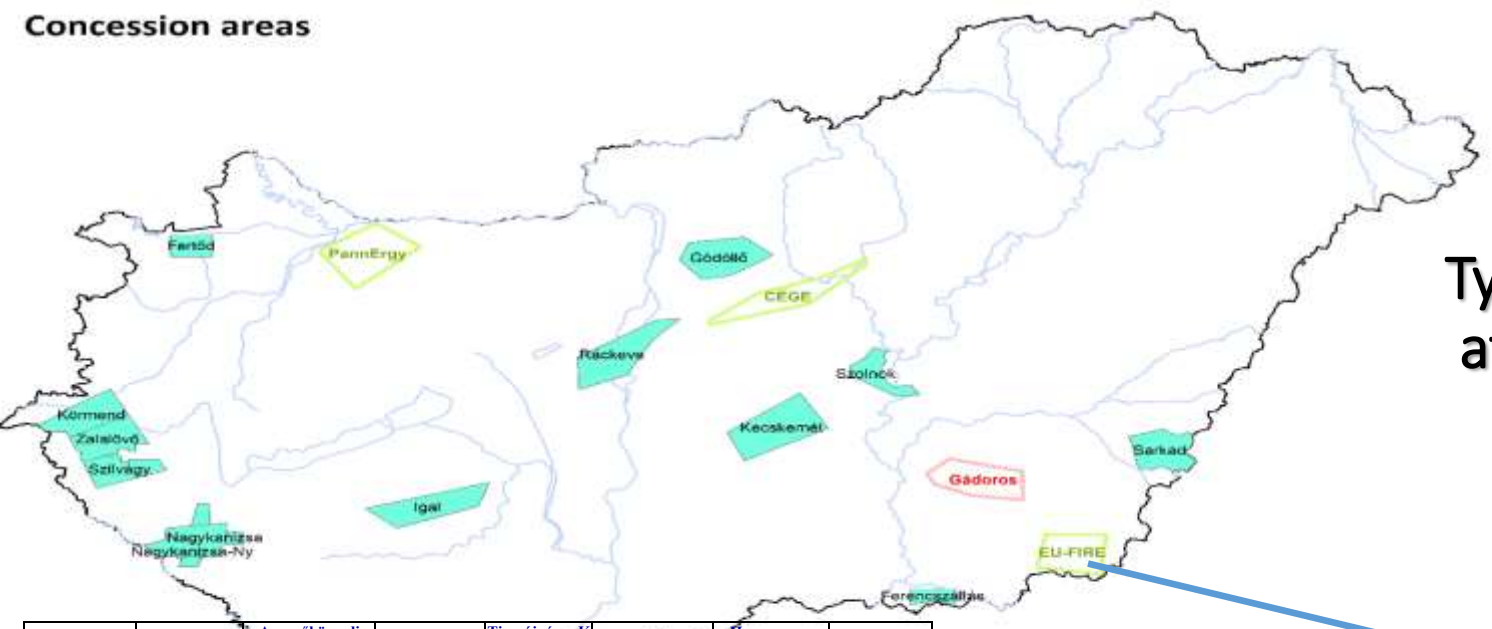
Ádám László 2017.



Typical composition of geothermal fluids at Hungarian concession areas



17 different areas are delineated by the state



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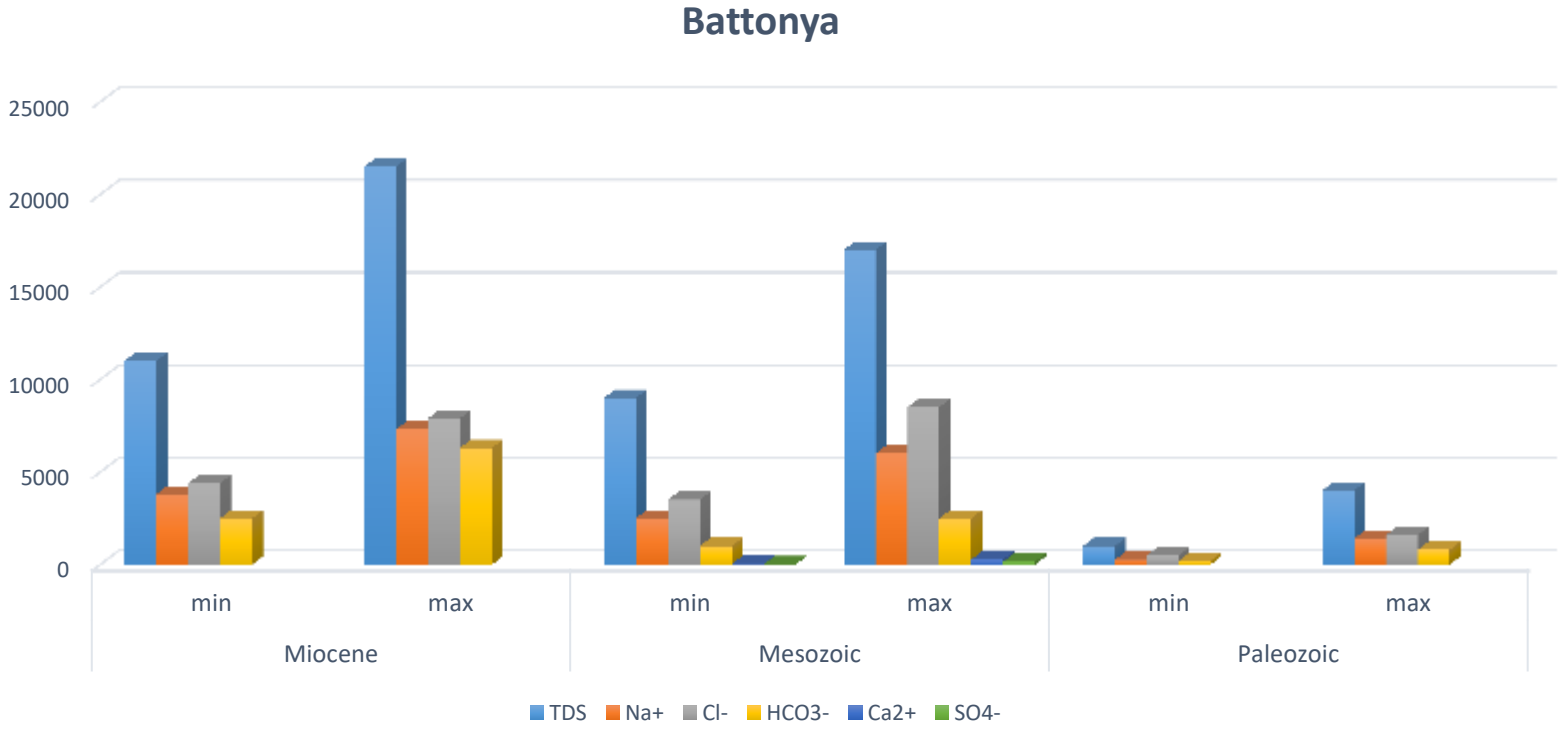
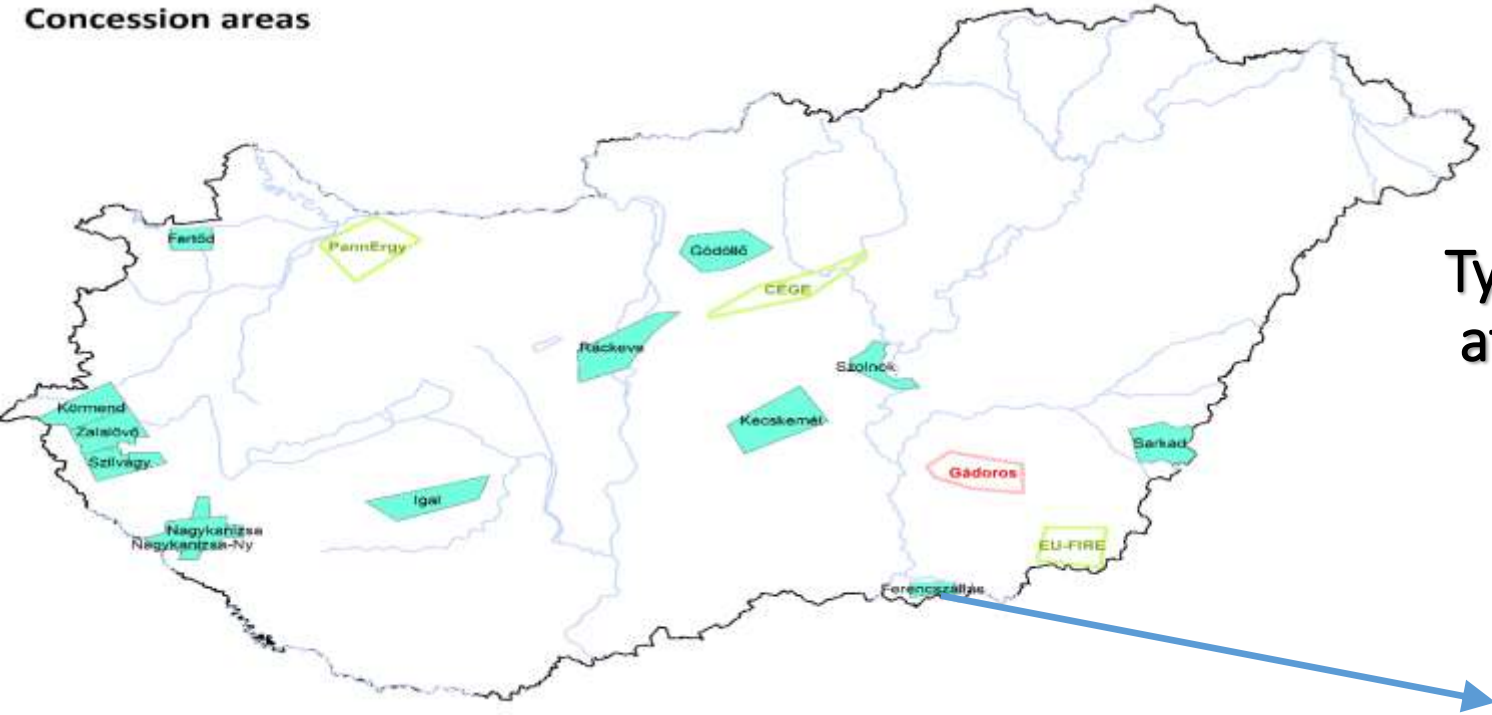
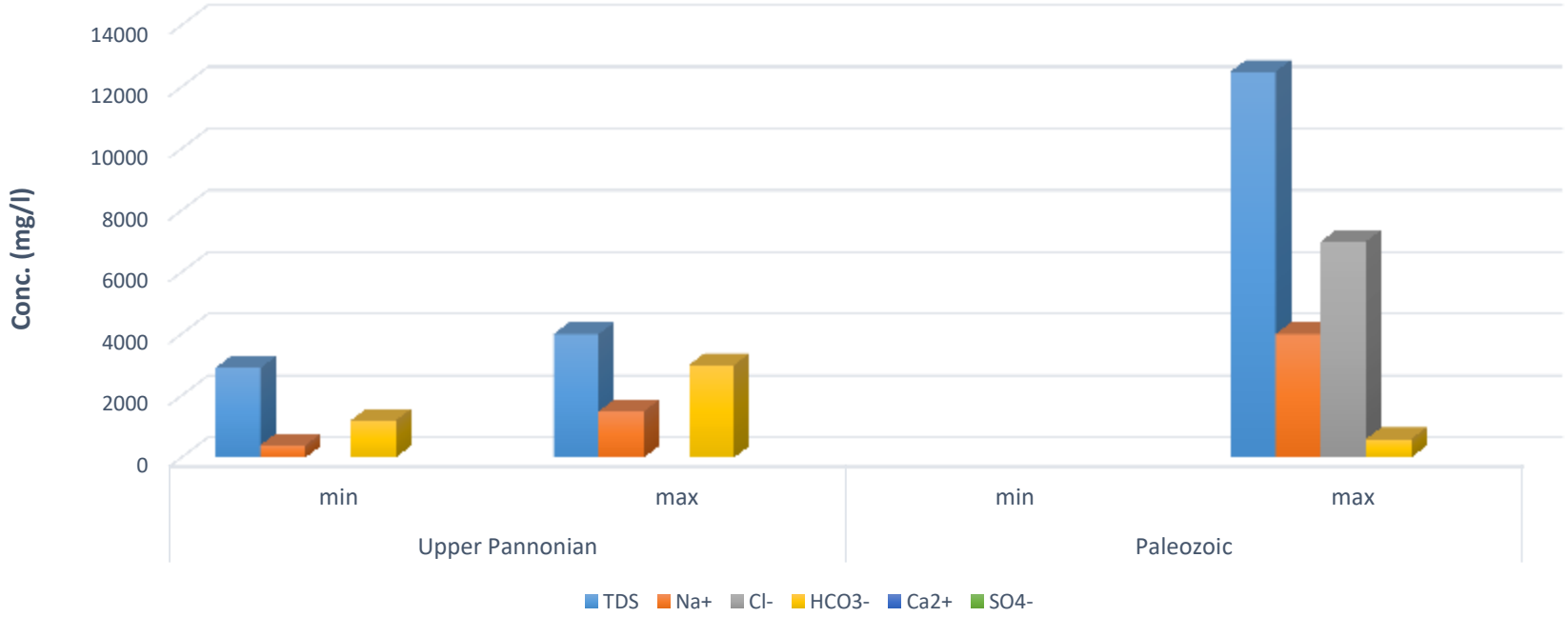
Kationok	[mg/dm^3]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]
Kálium, K+	58	44	1.9	9.7		11.3	9
Nátrium, Na+	1 810	218	9.2	1410	55.7	1530	59.6
Ammónium, NH_4^+	12	4.9	-	11.3	0.85	14.8	0.02
Kalcium, Ca^{2+}	136	370	101	13	151.7	8.6	86
Magnézium, Mg^{2+}	47,5	52	11.9	6.4	15.6	5.4	19.7
Vas, Fe^{2+}	0,15	0.26	-	0.08	2.14	0.79	0.004
Mangán, Mn^{2+}	-	0.18	-	-	0.11	-	0.001
Lítium, Li^+	-	1.58	-	0.2	-	0.2	-
Alumínium, Al^{3+}	-	-	-	-	-	-	< 0,02
Kationok összesen:	*2016*	*690.92*	*124*	*1450.68*	*226.1*	*1571.09*	*174.325*
Anionok							
Nitrát, NO_3^-	-	<1,00	1.3	-	Nem mutatható ki	-	1.2
Nitrit, NO_2^-	-	<0,02	-	-	Nem mutatható ki	-	-
Klorid, Cl^-	2 420	244	8	1128	20	1495	18.5
Bromid, Br^-	6,5	1.43		2.3	0.22	9.8	-
Jodid, J^-	5,4	0.19		1.2	0.022	5.5	-
Fluorid, F-	1,4	4.5		0.91	0.7	1.7	-
Szulfát, SO_4^{2-}	121	17	5	-	50	37	67.7
Hidrogén-karbonát, HCO_3^-	1 650	1620	366	1920	586	1790	320
Szulfid, S^{2-}, S^{3-}	2,9	14.6	-	-	2.4	0.16	-
Foszfát, PO_4^{3-}	0,12	2.4	-	0.32	-	0.25	-
Karbonát, CO_3^{2-}	-	-	-	-	-	9	-
Anionok összesen:	*4191*	*1904.12*	*380.3*	*3052.73*	*659.342*	*3348.41*	-

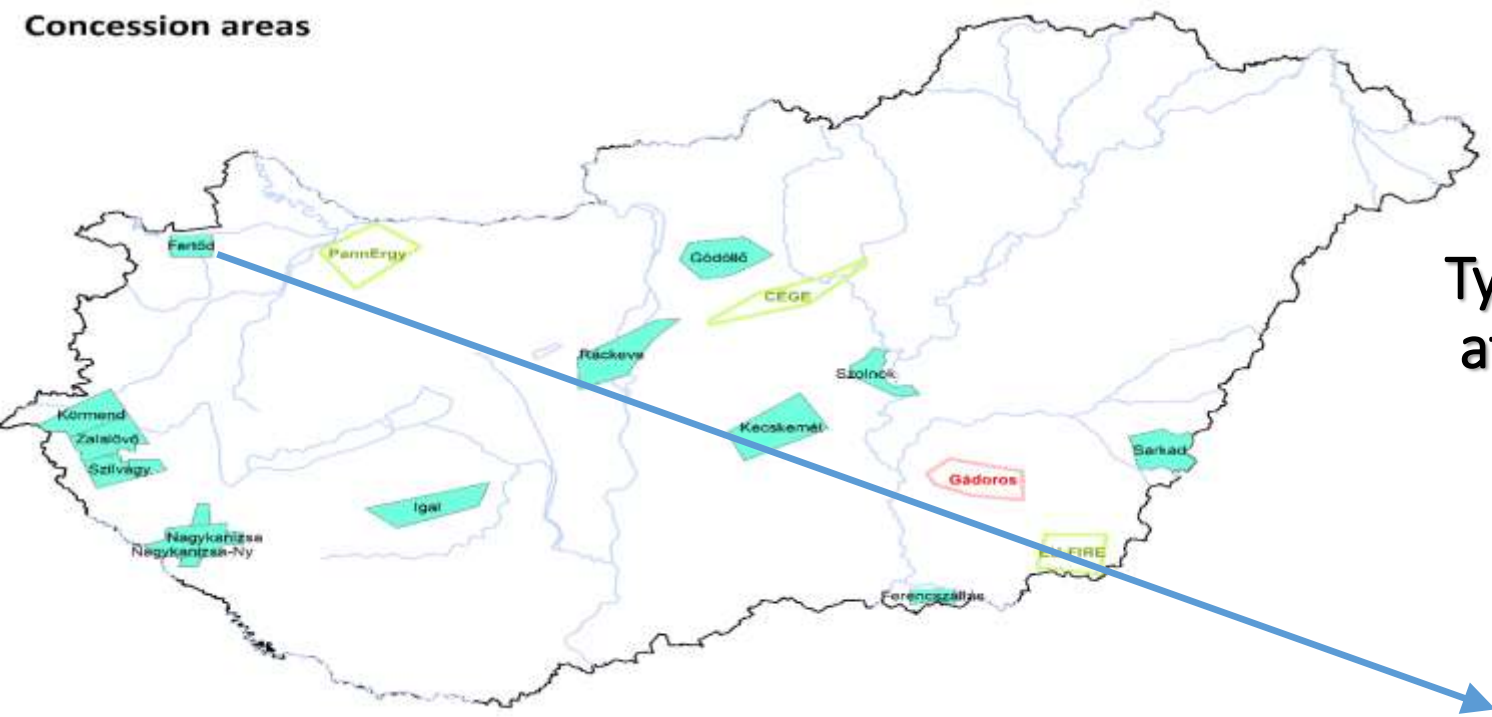




Typical composition of geothermal fluids at Hungarian concession areas

Ferencszállás





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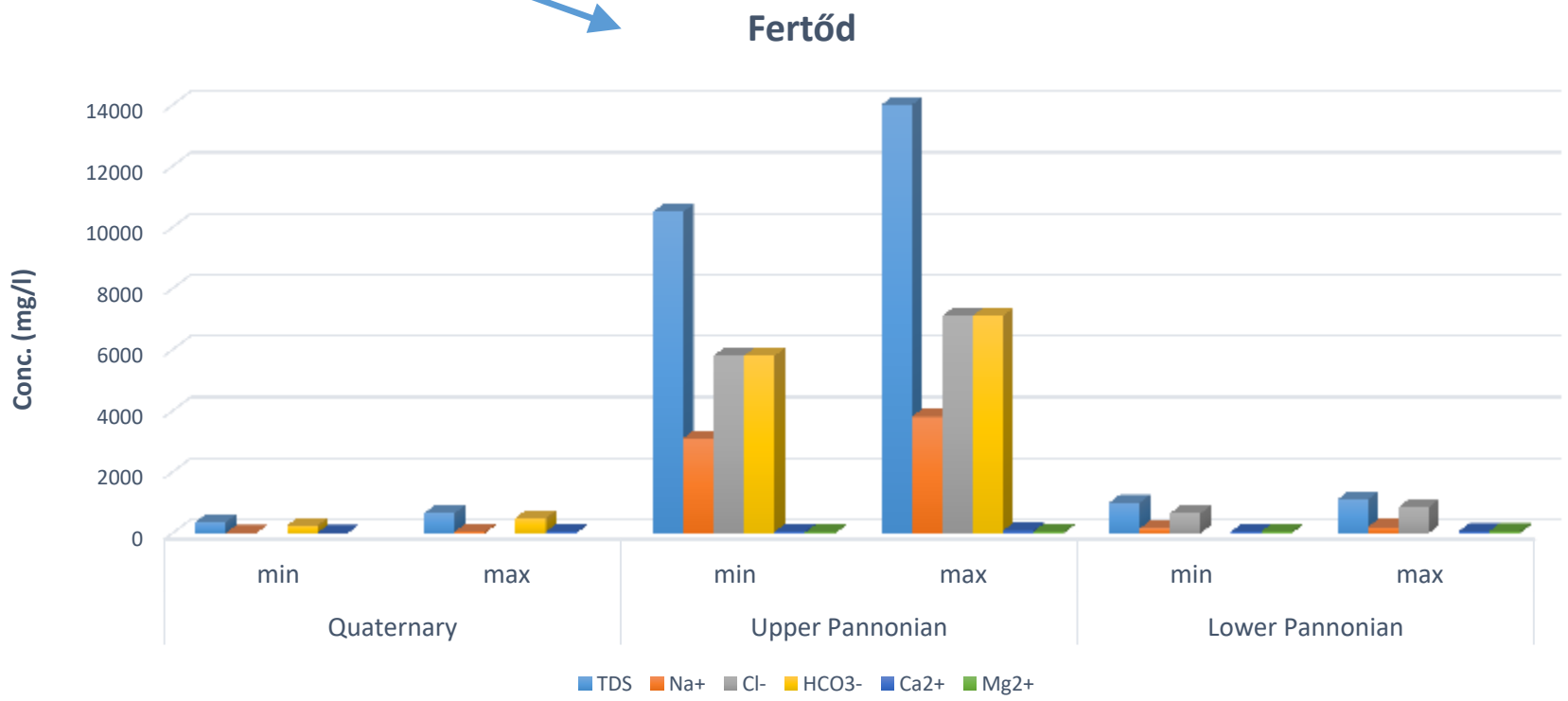

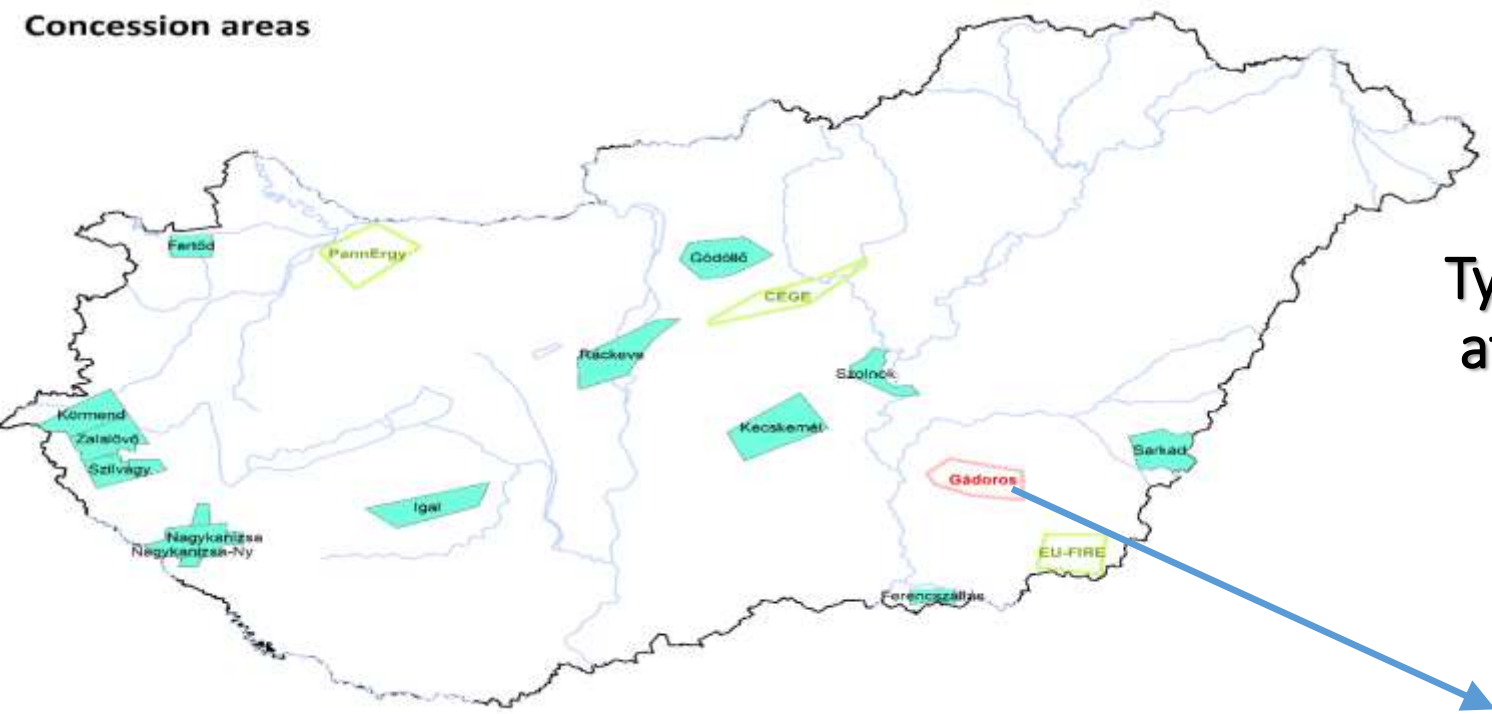

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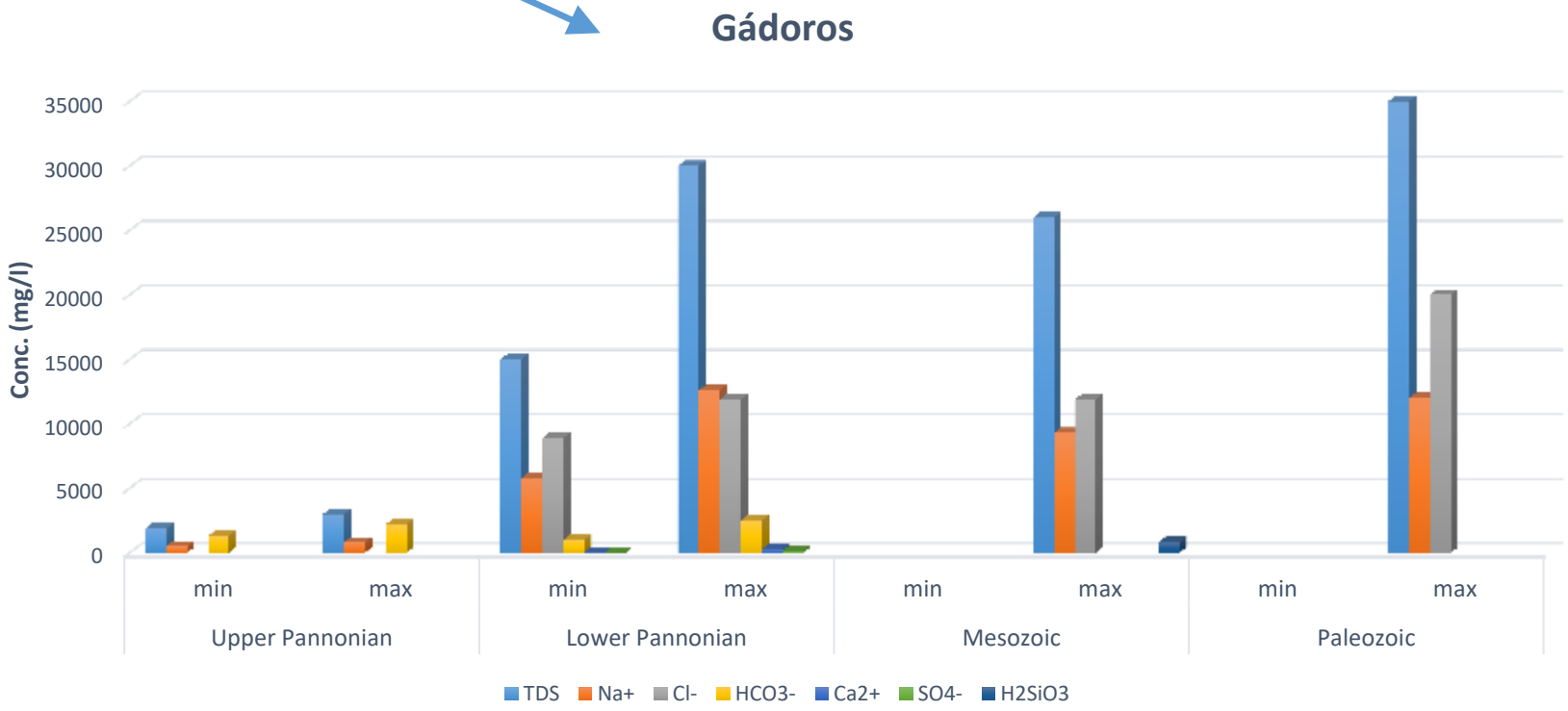

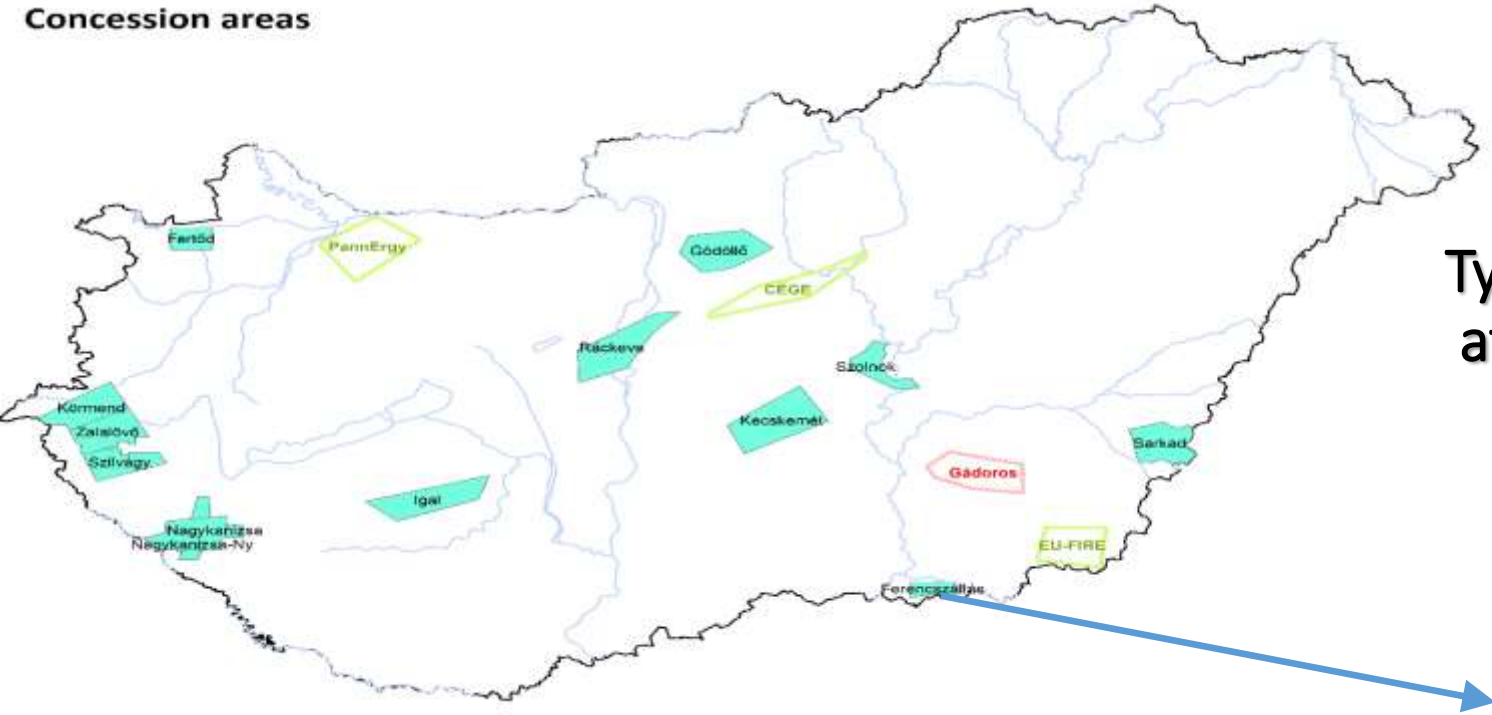

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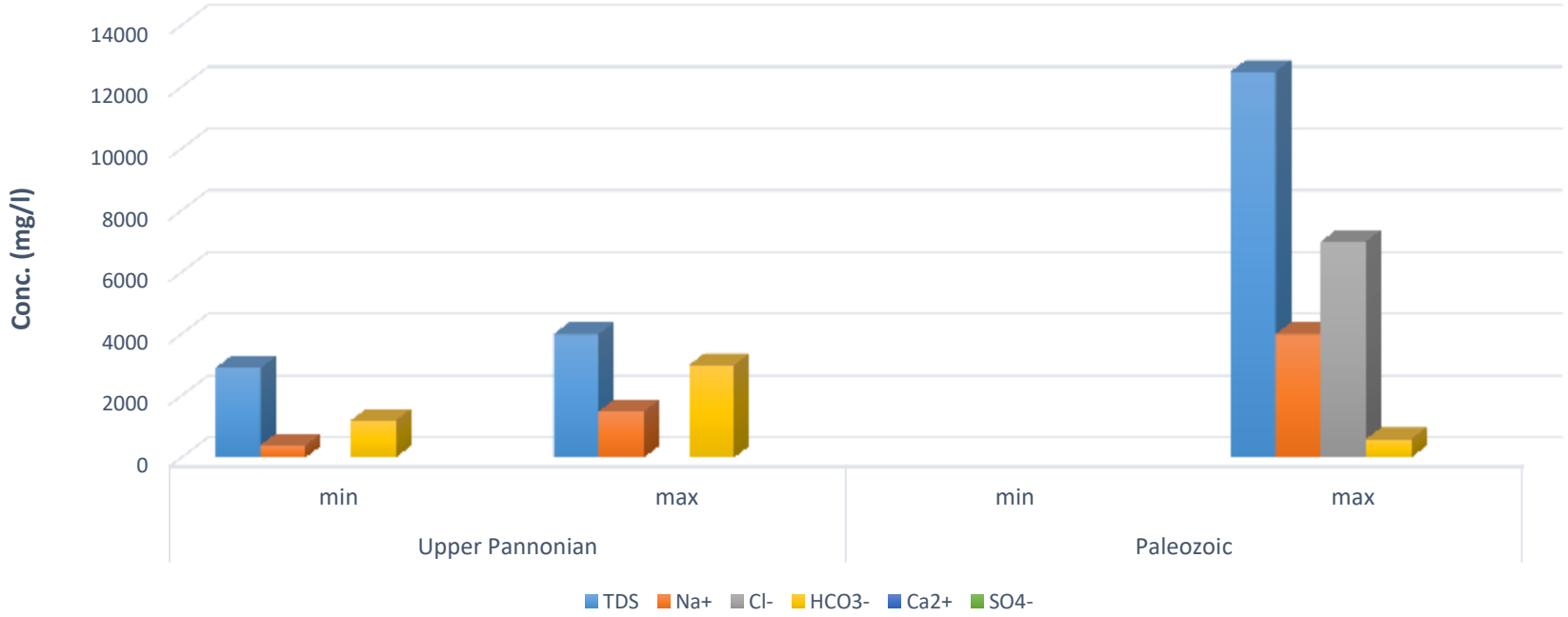

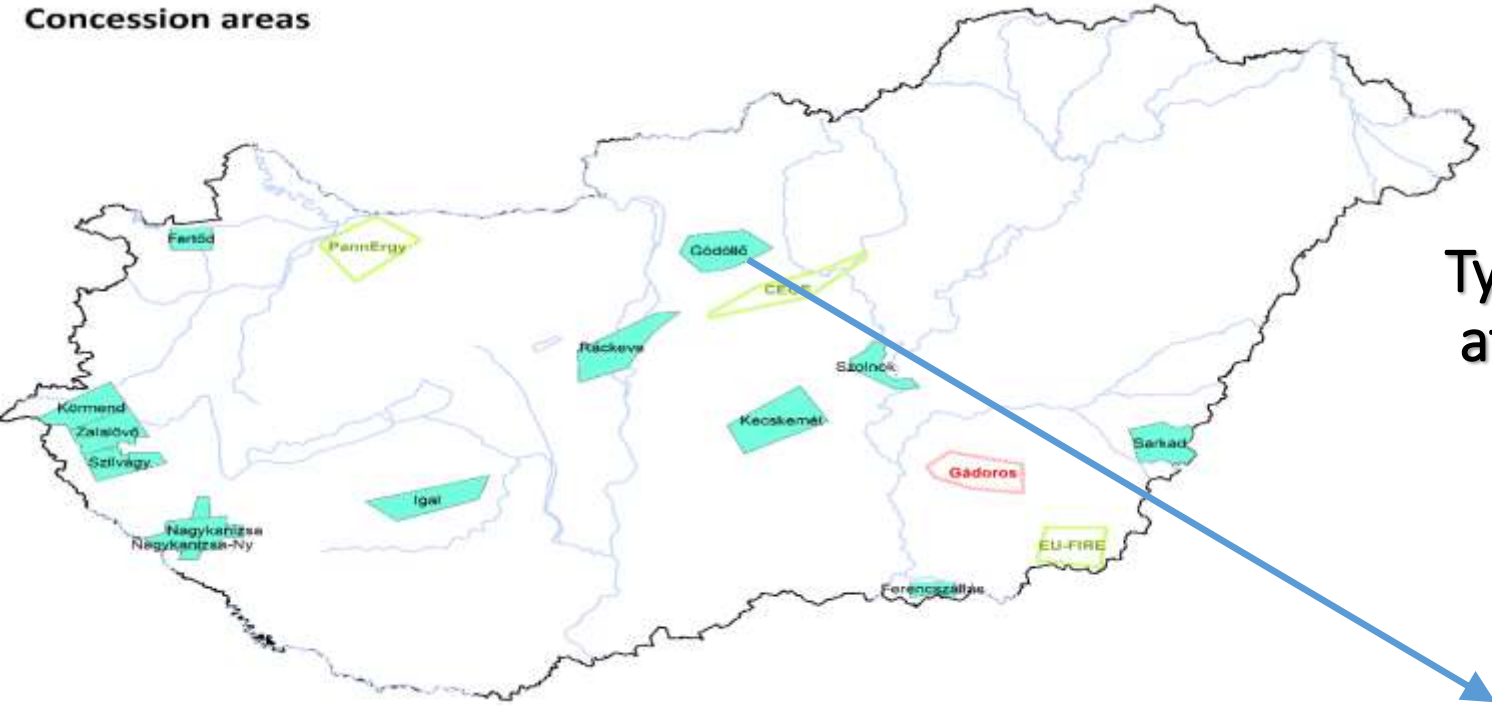

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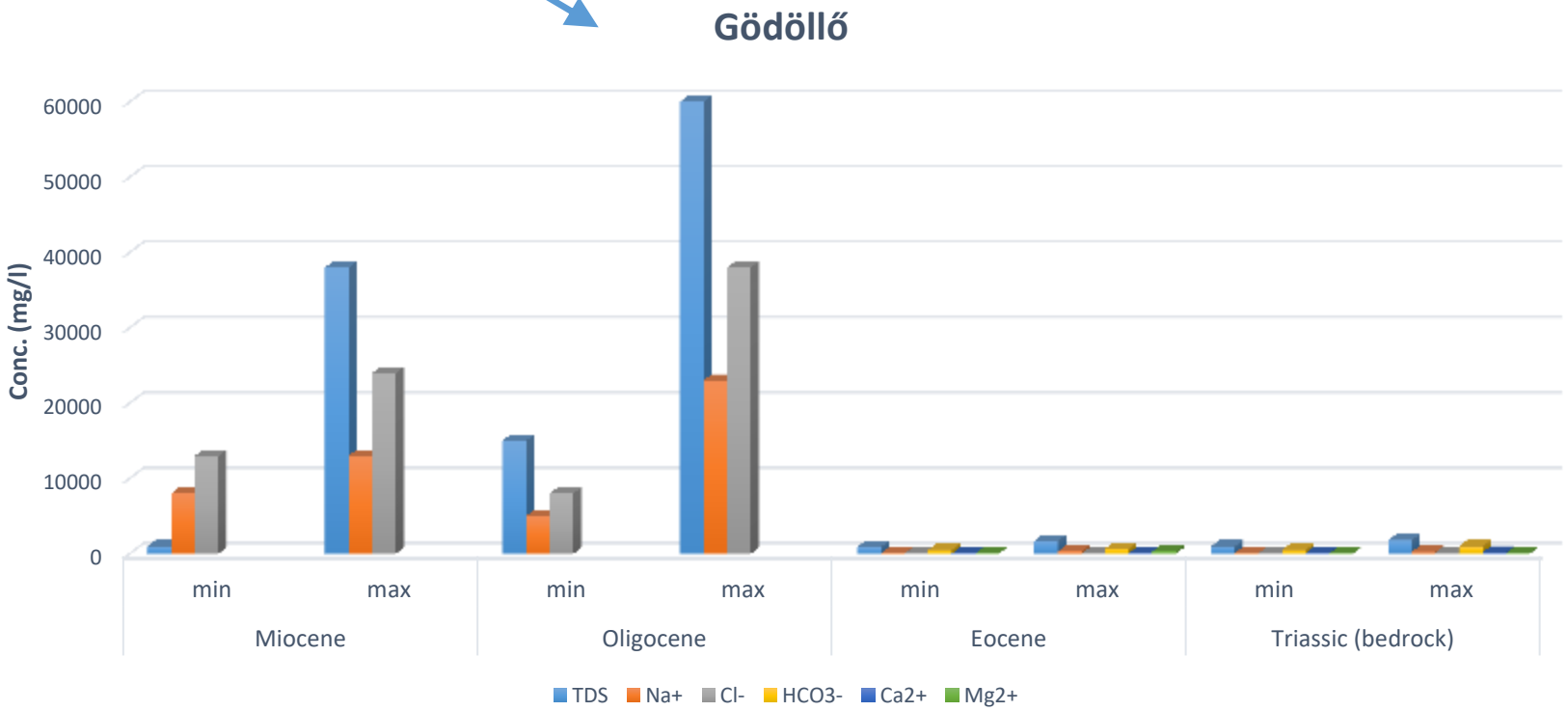

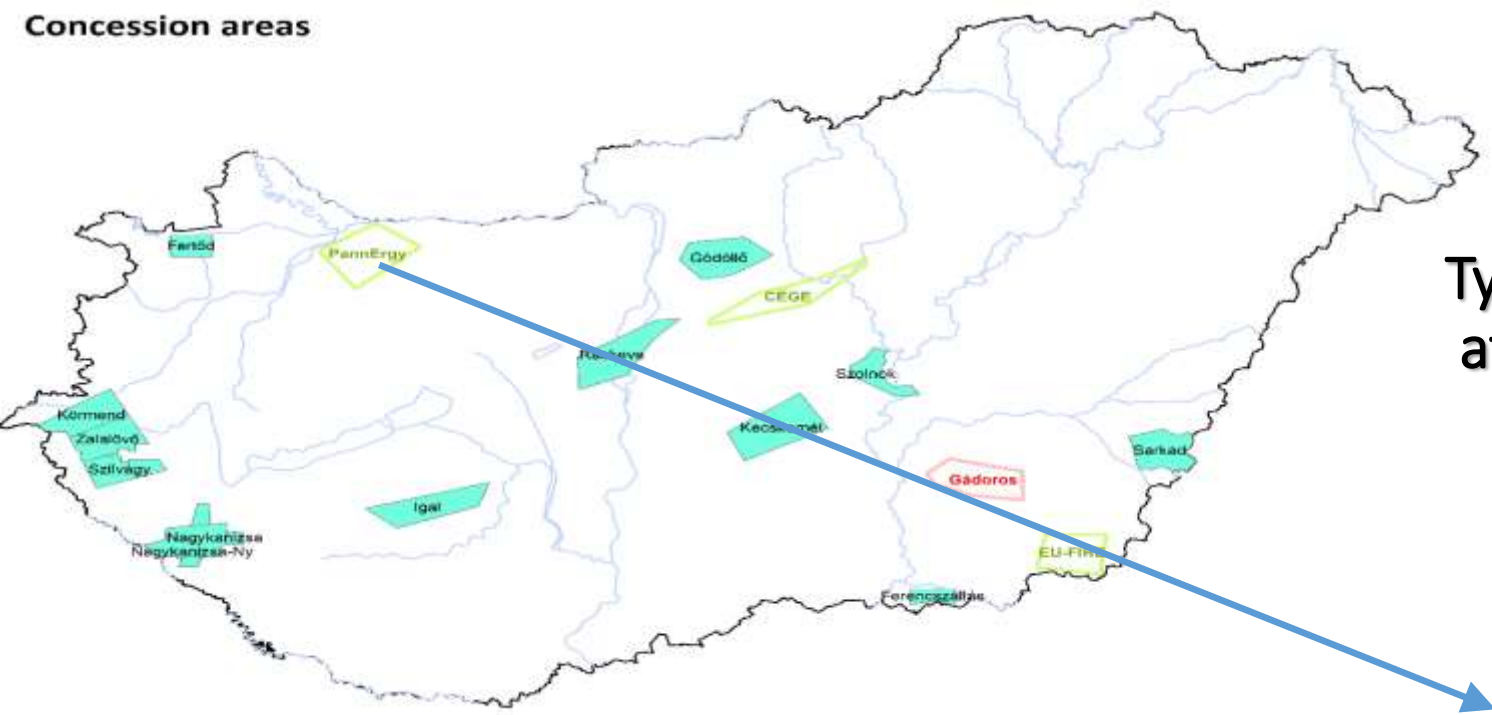

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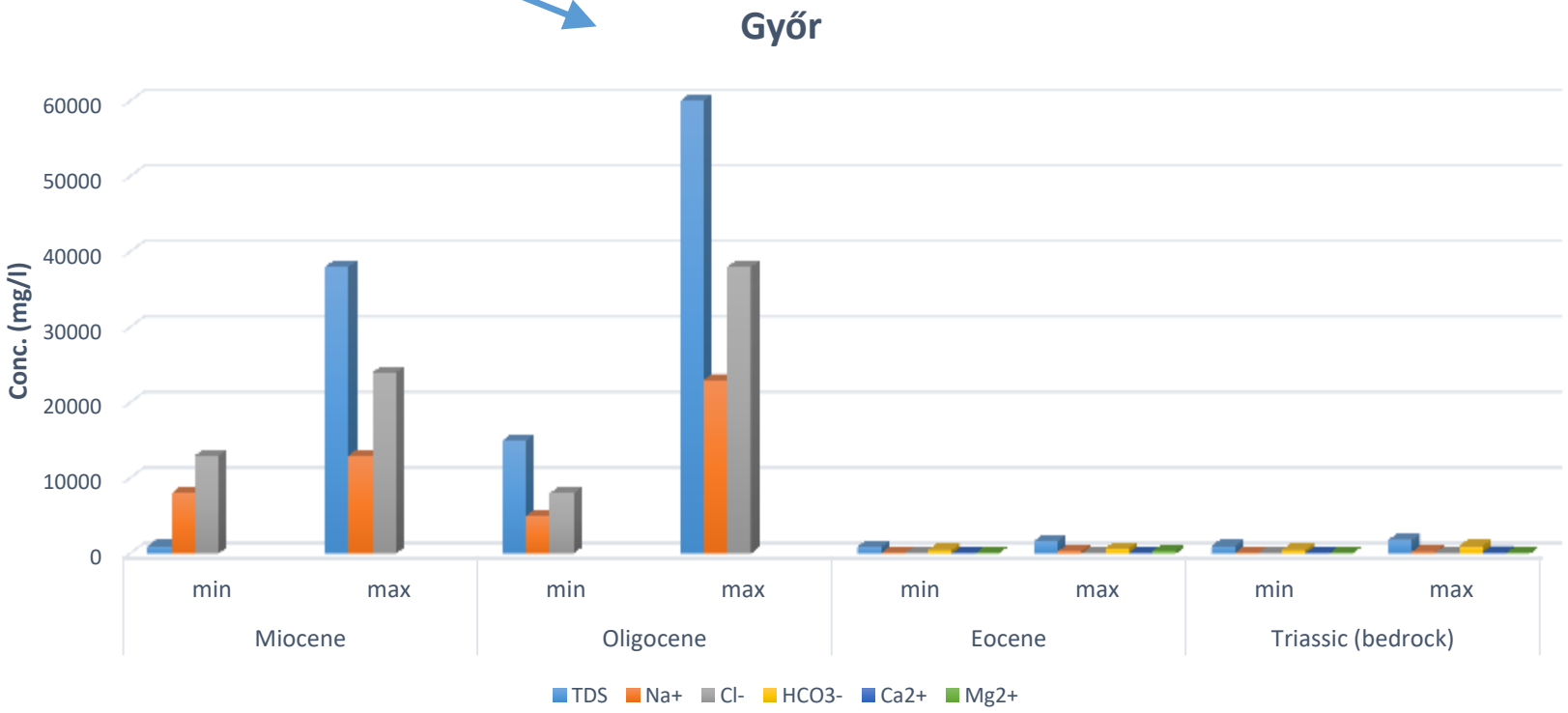

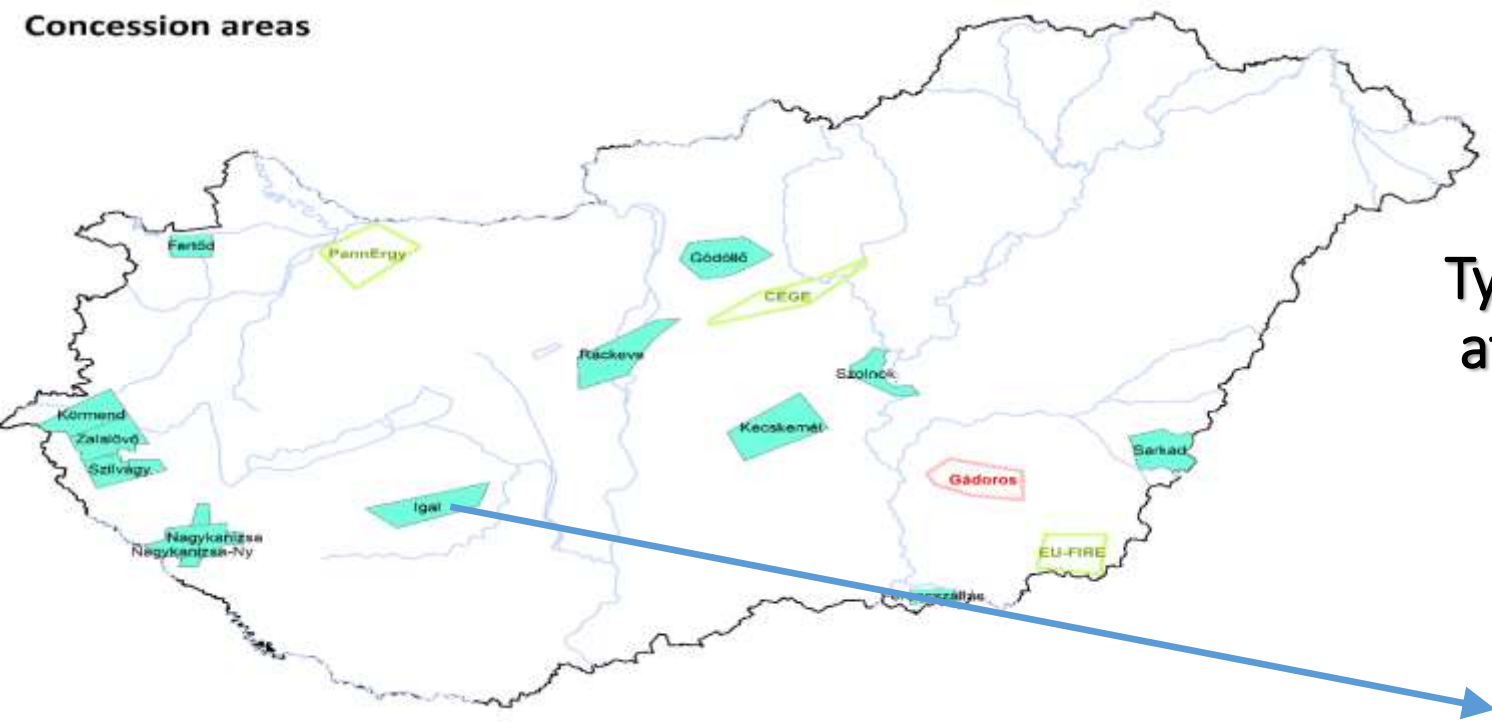

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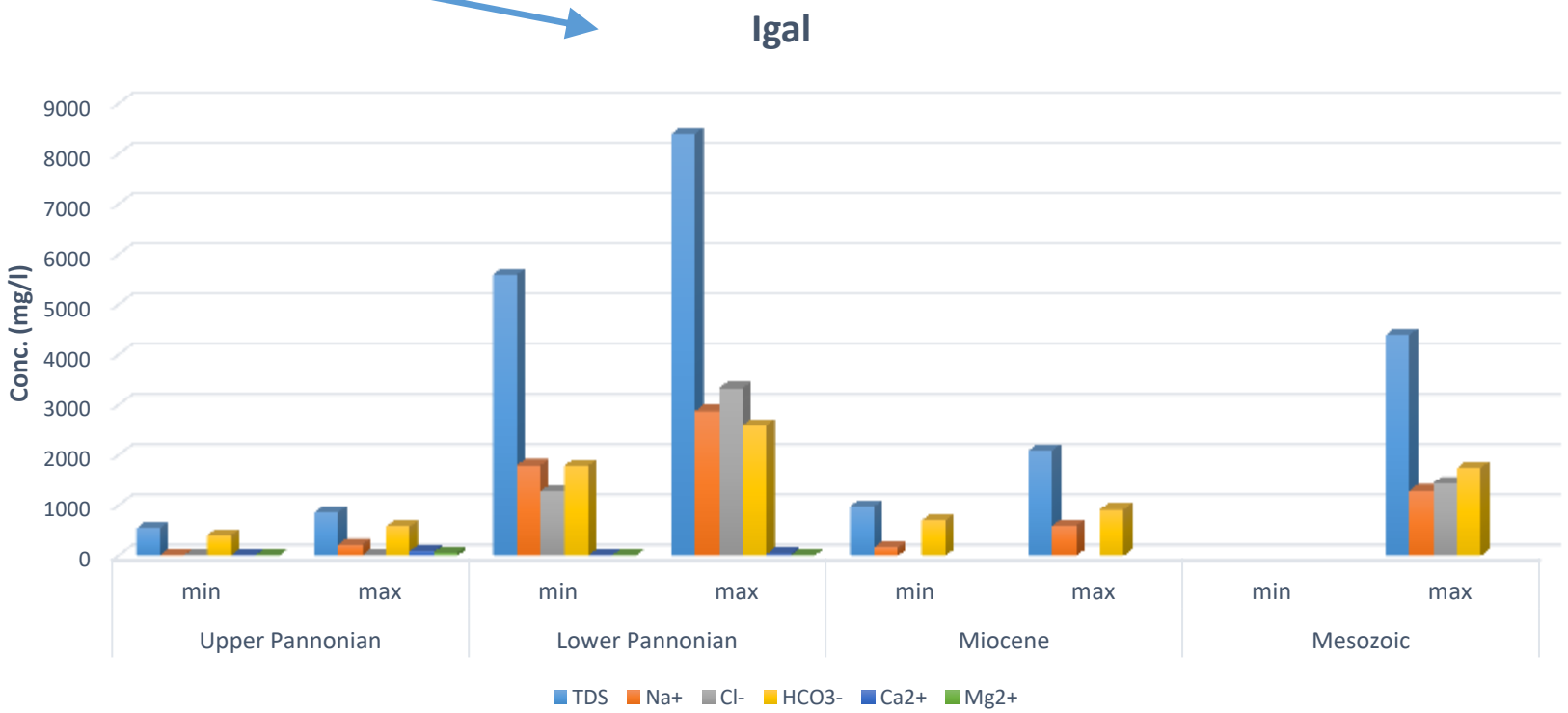

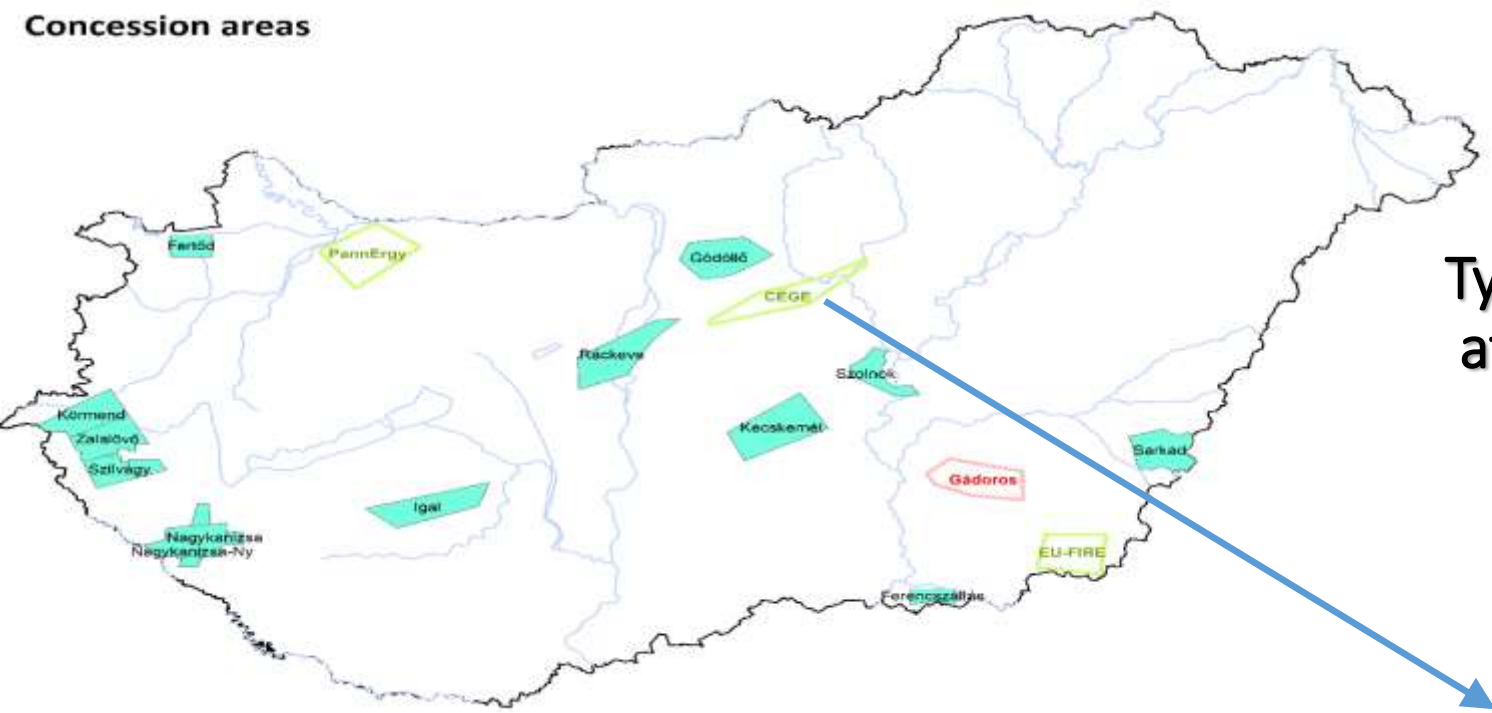

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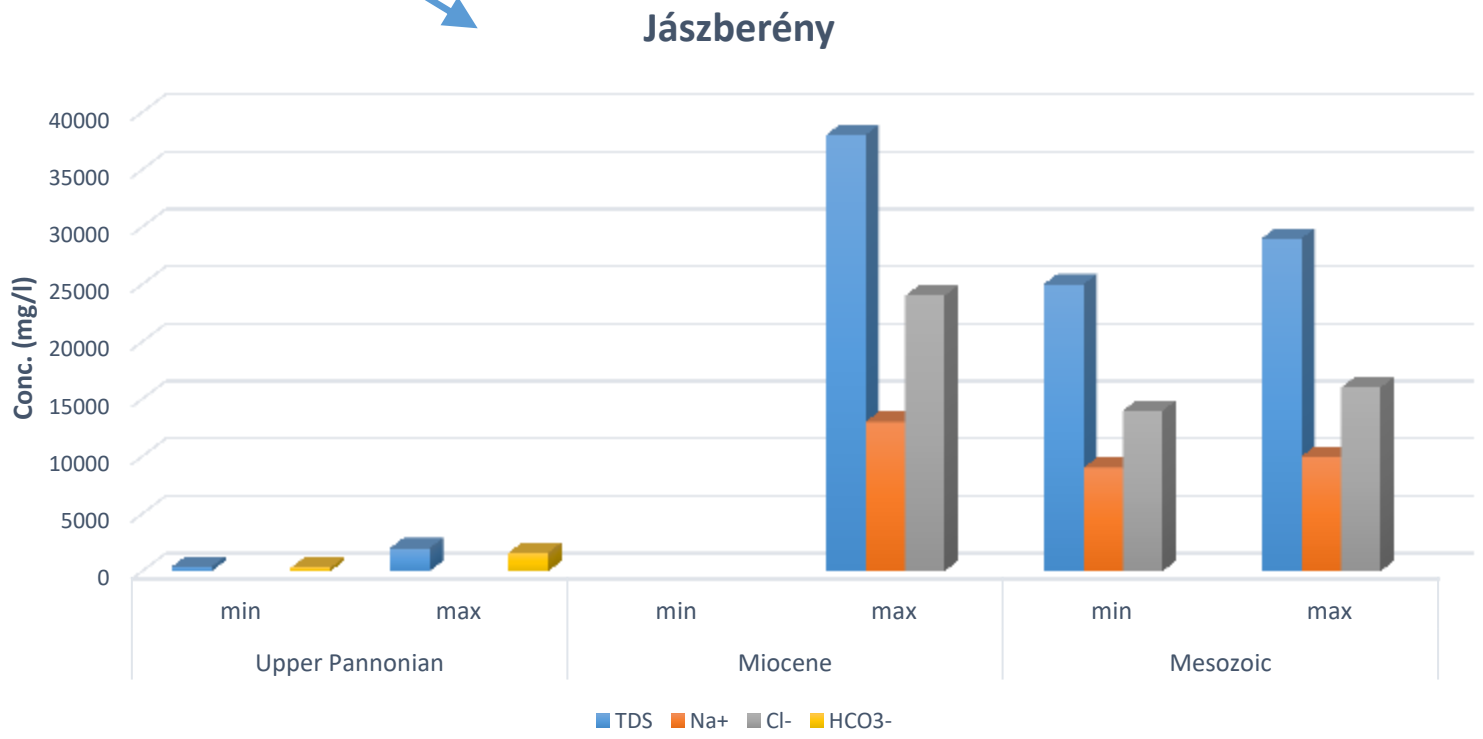

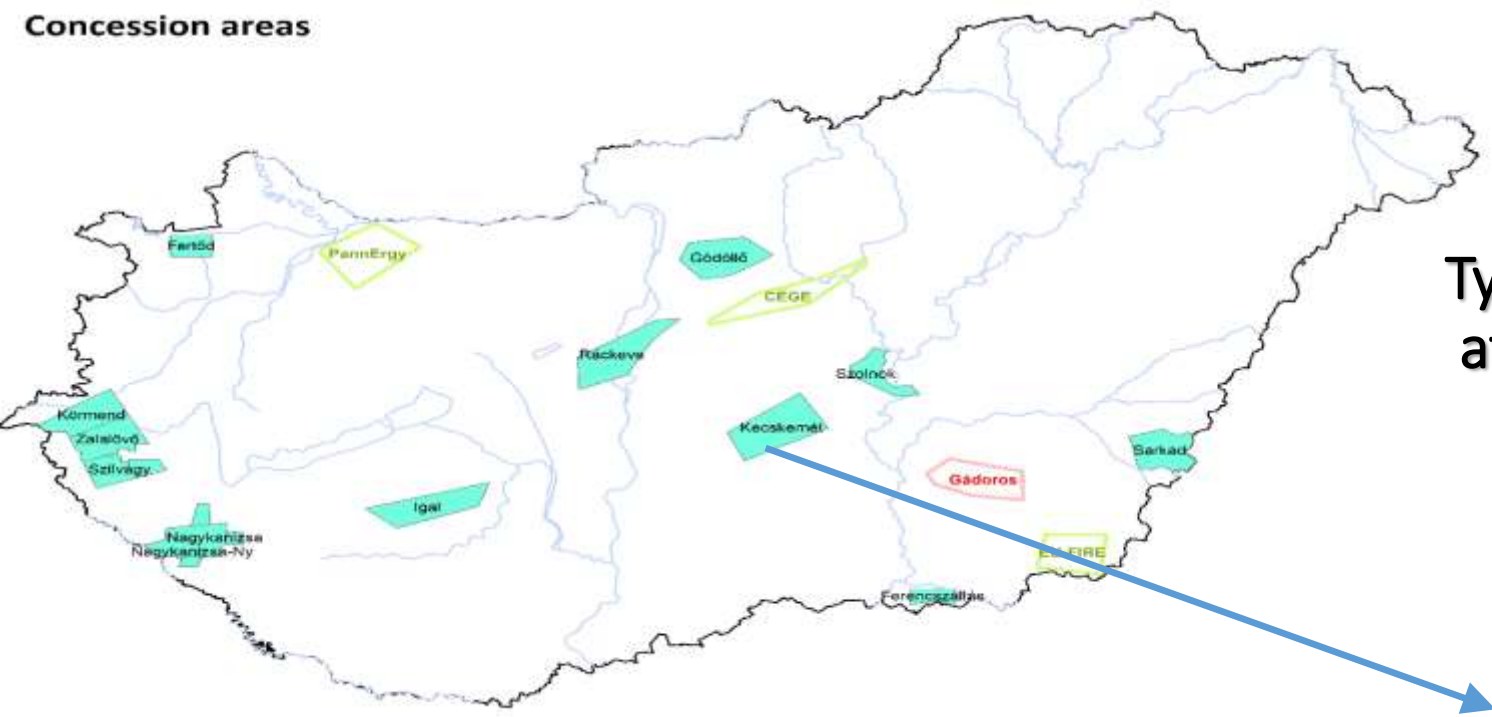

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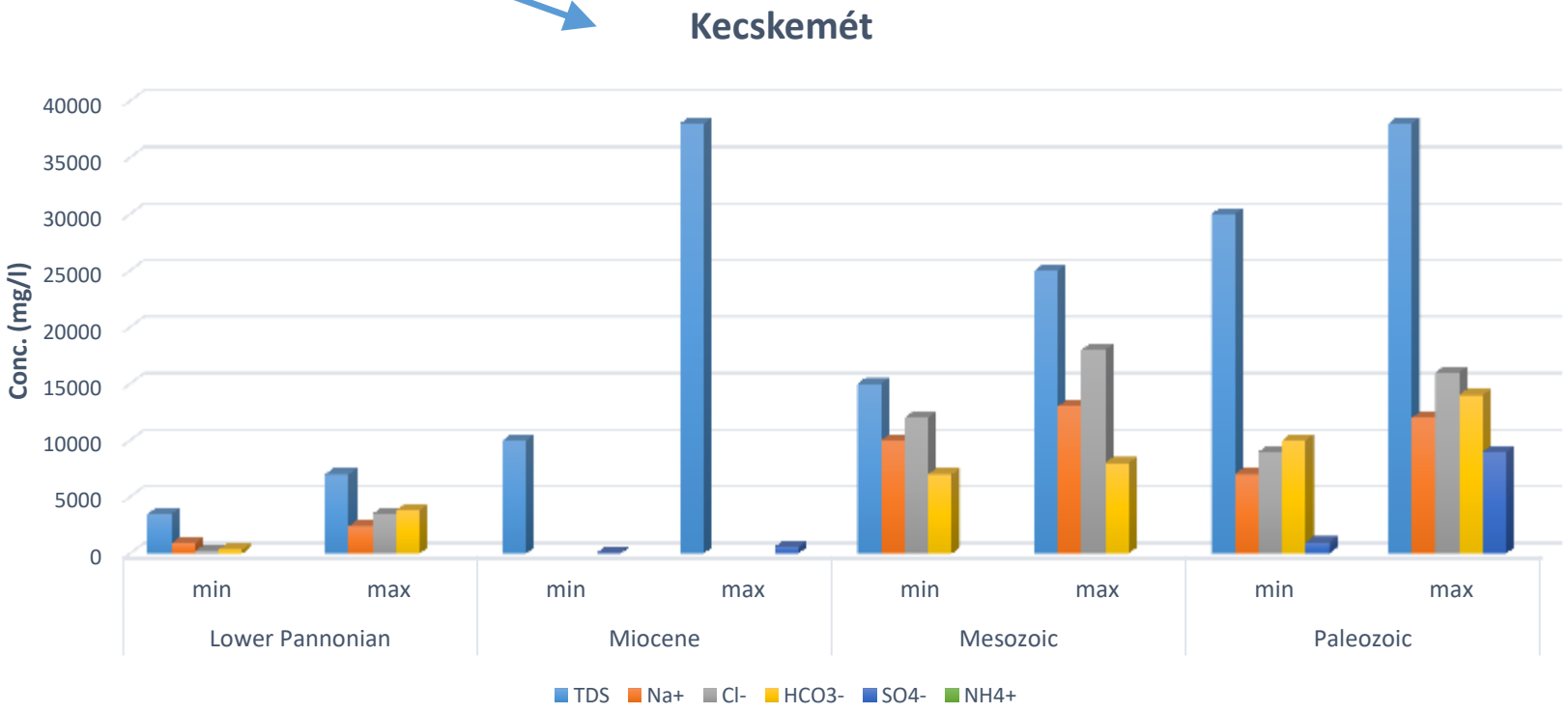

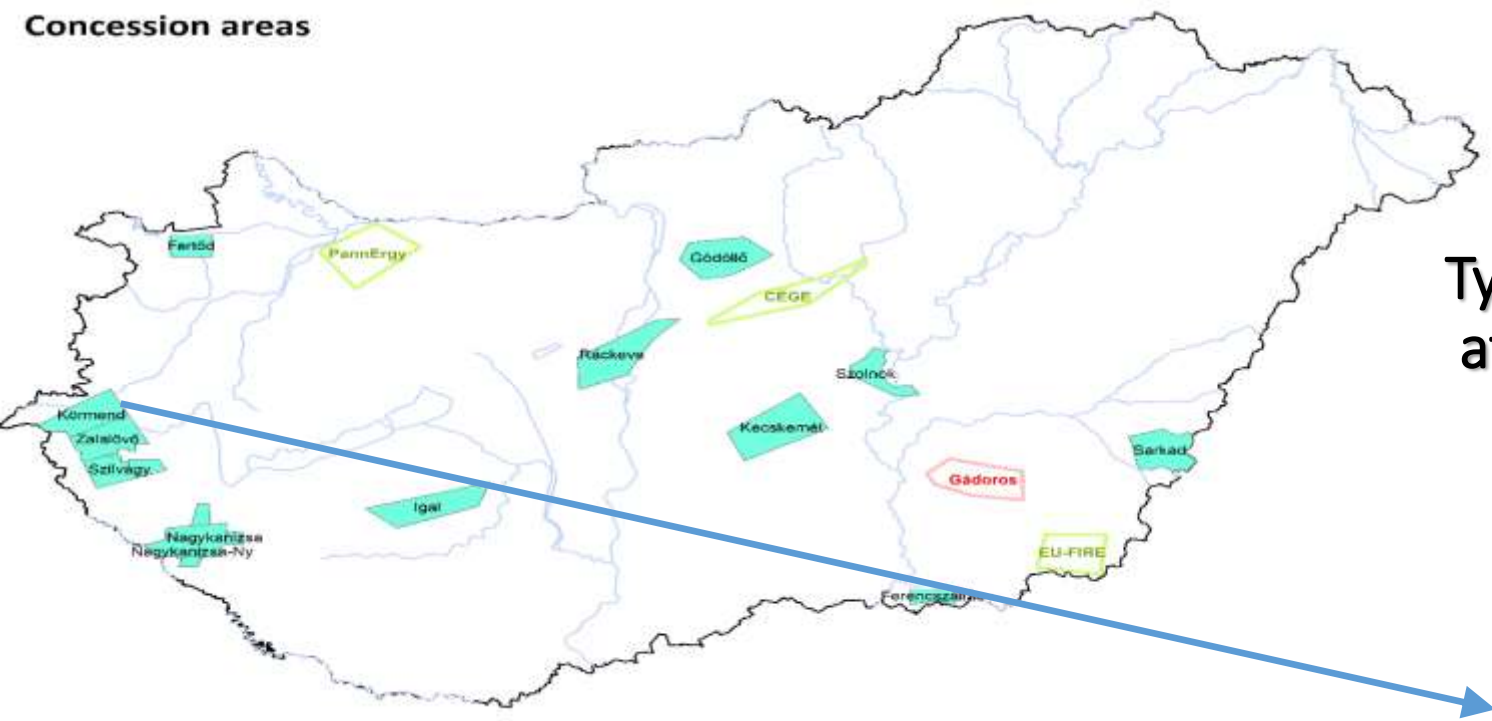

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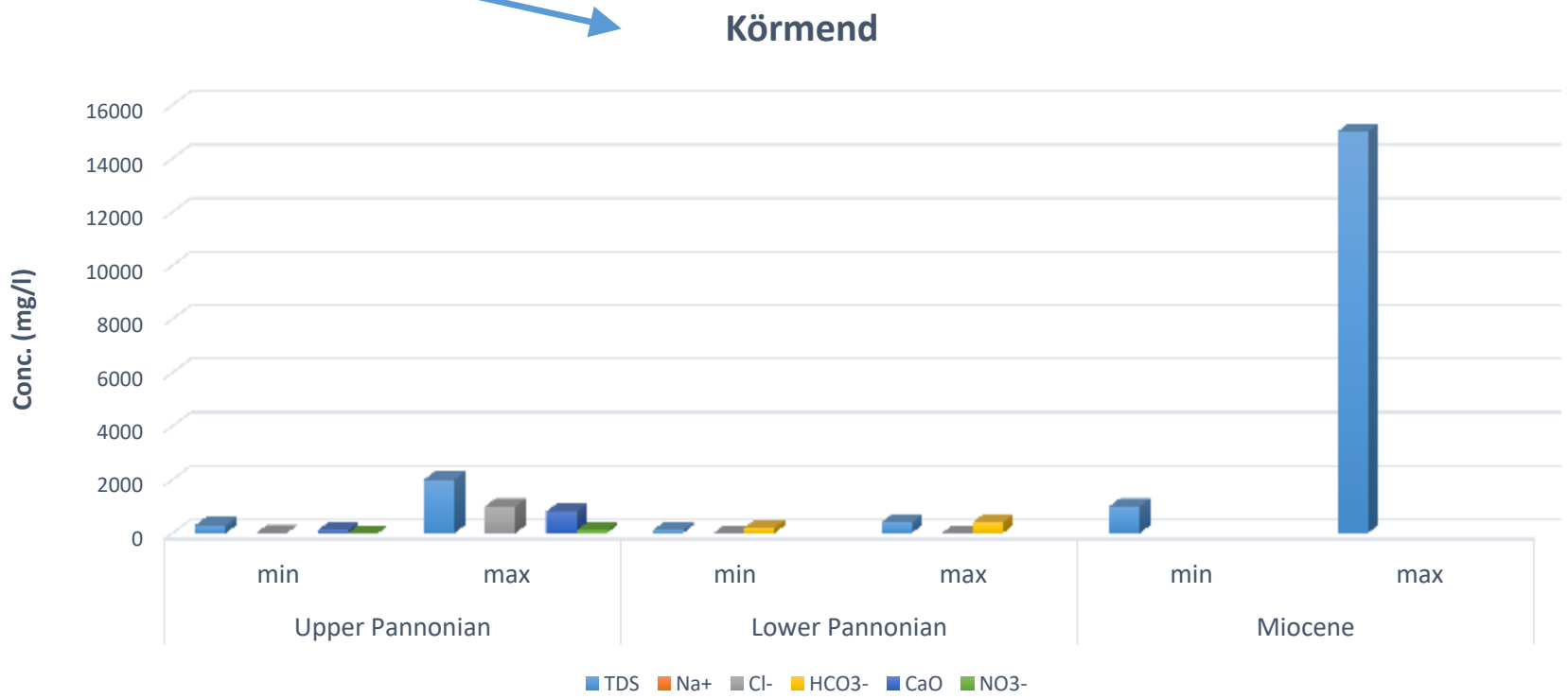

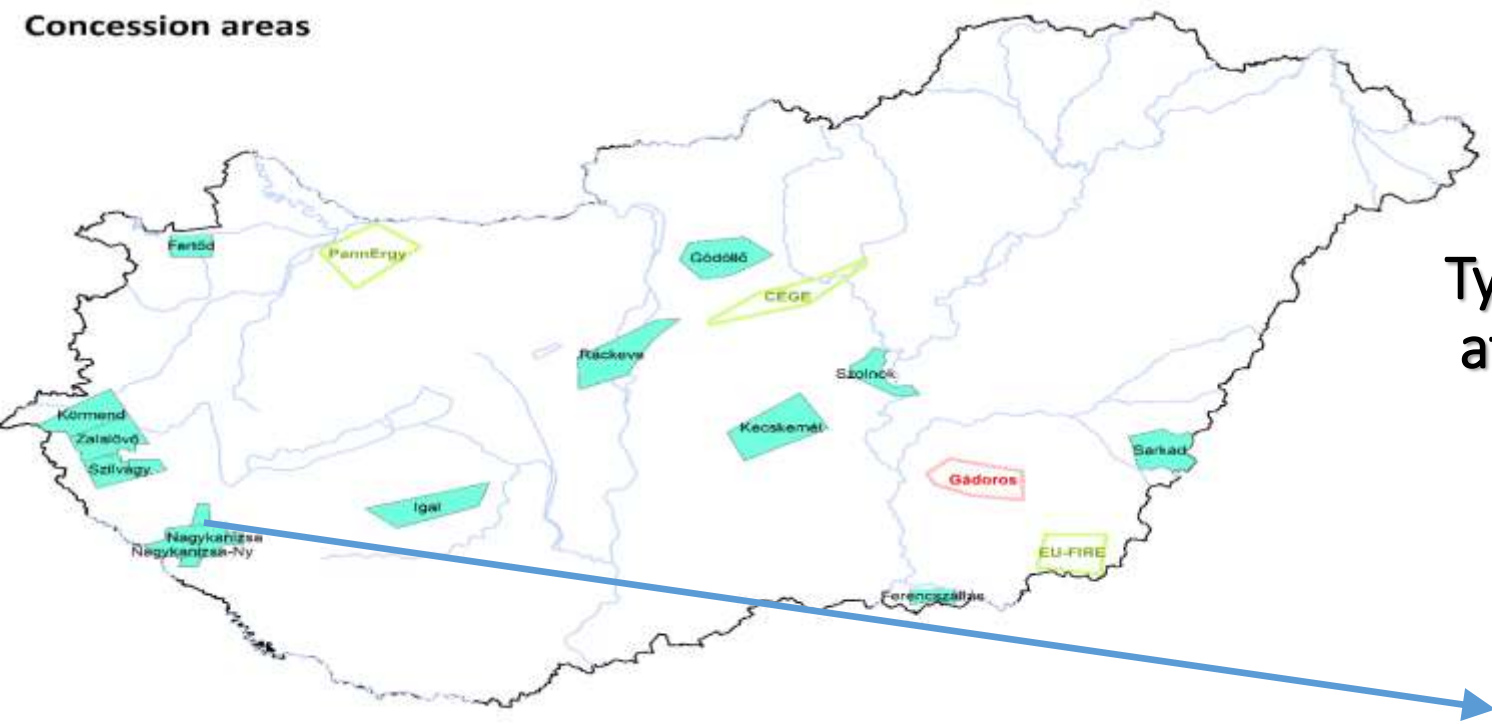

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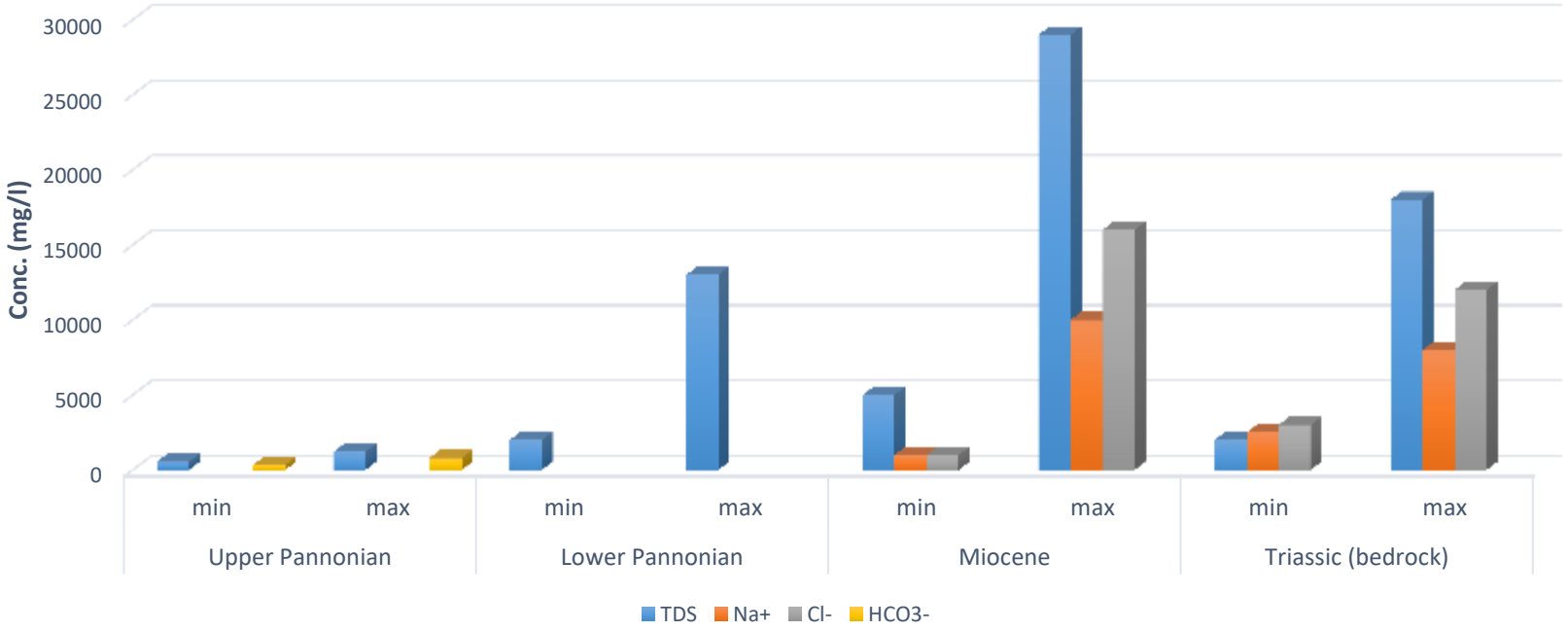
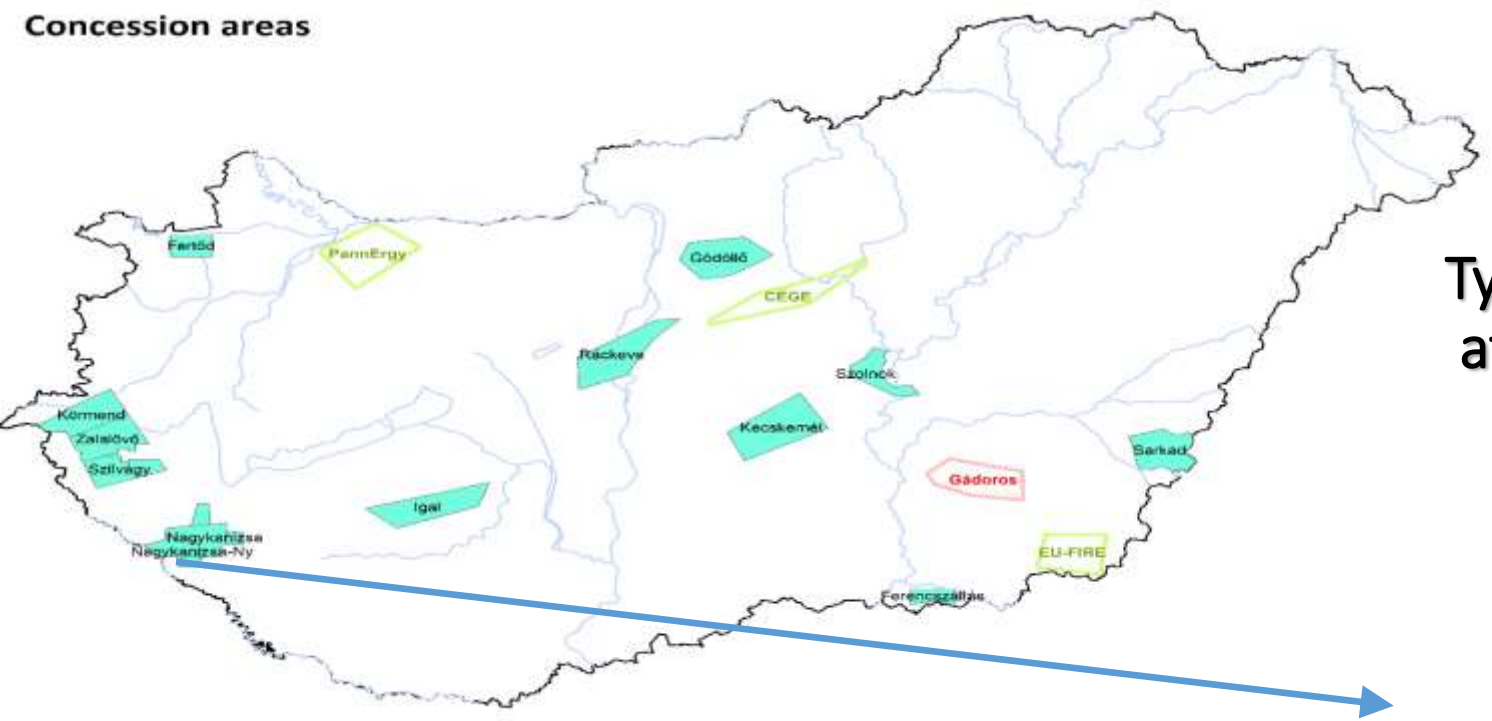
Nagykanizsa





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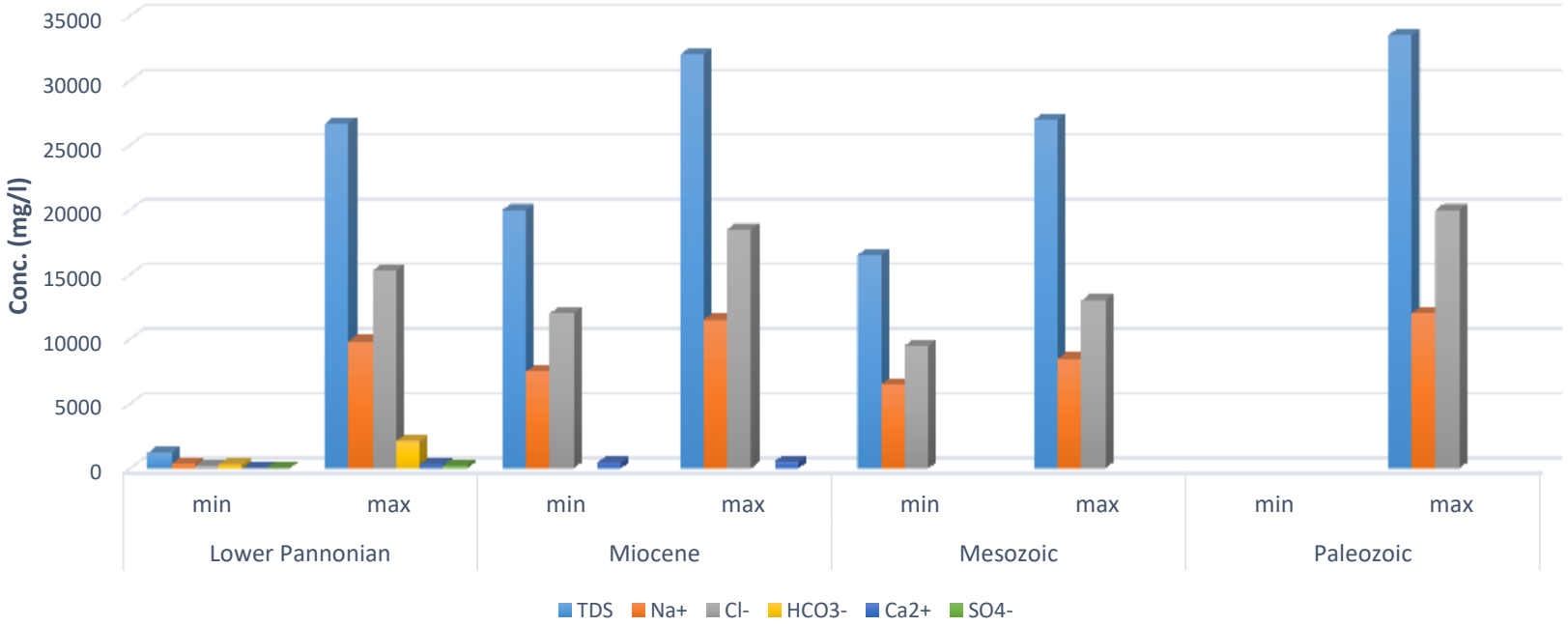
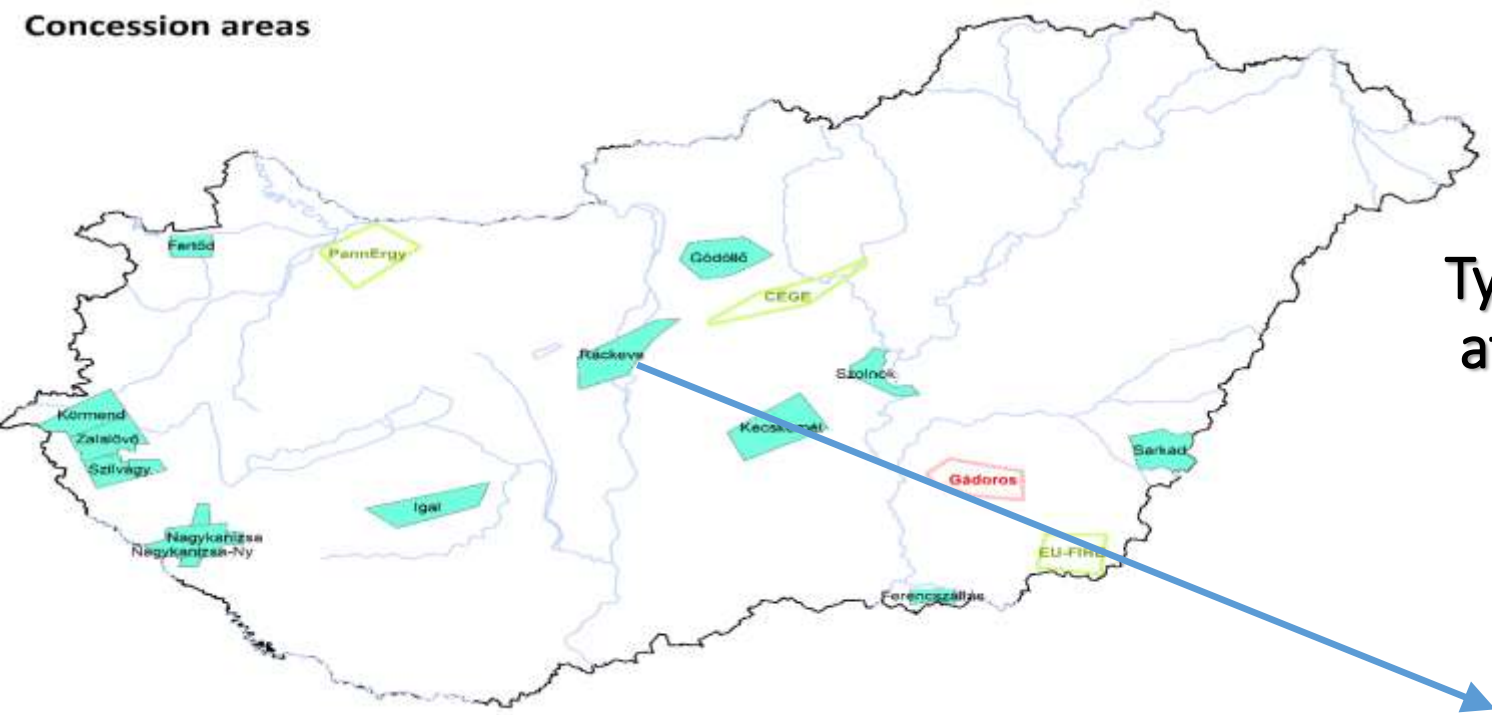
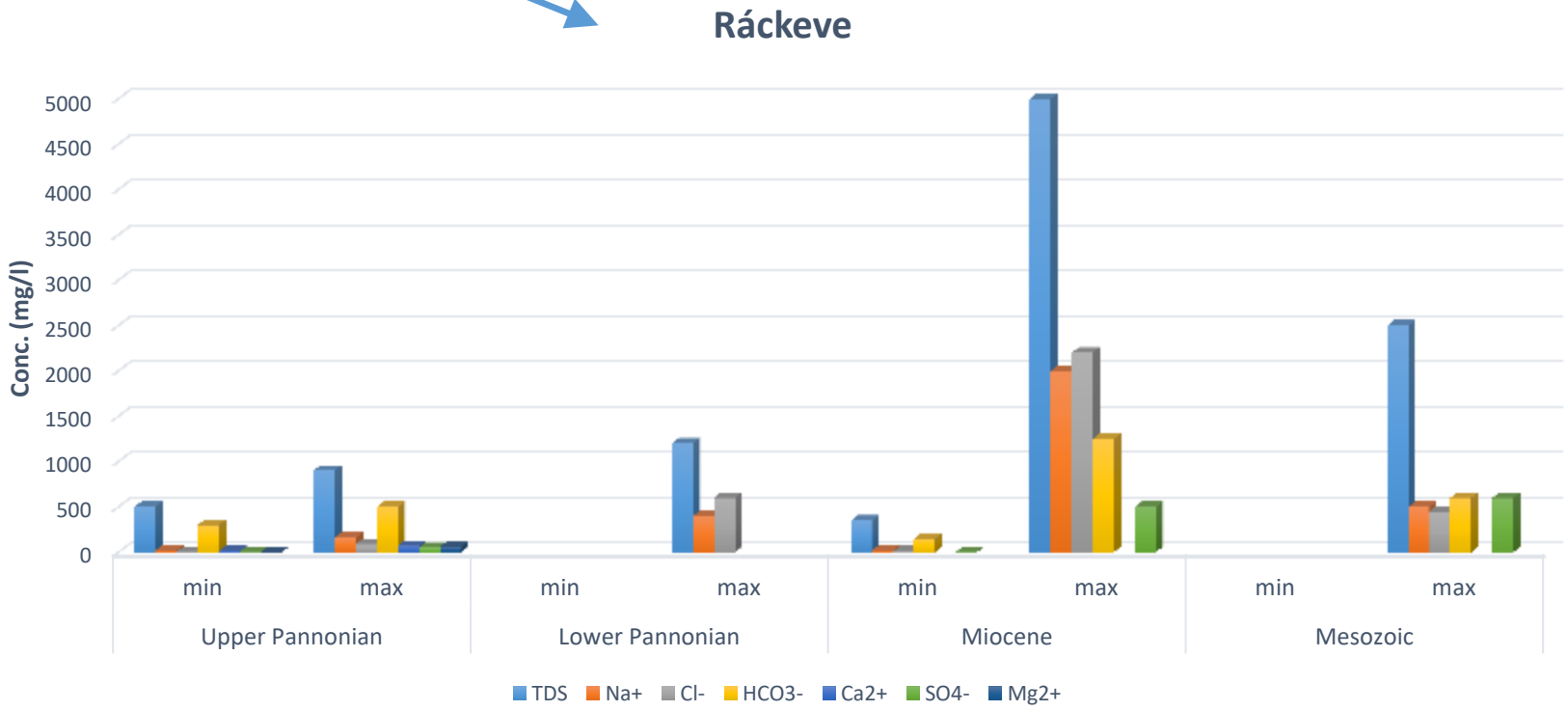
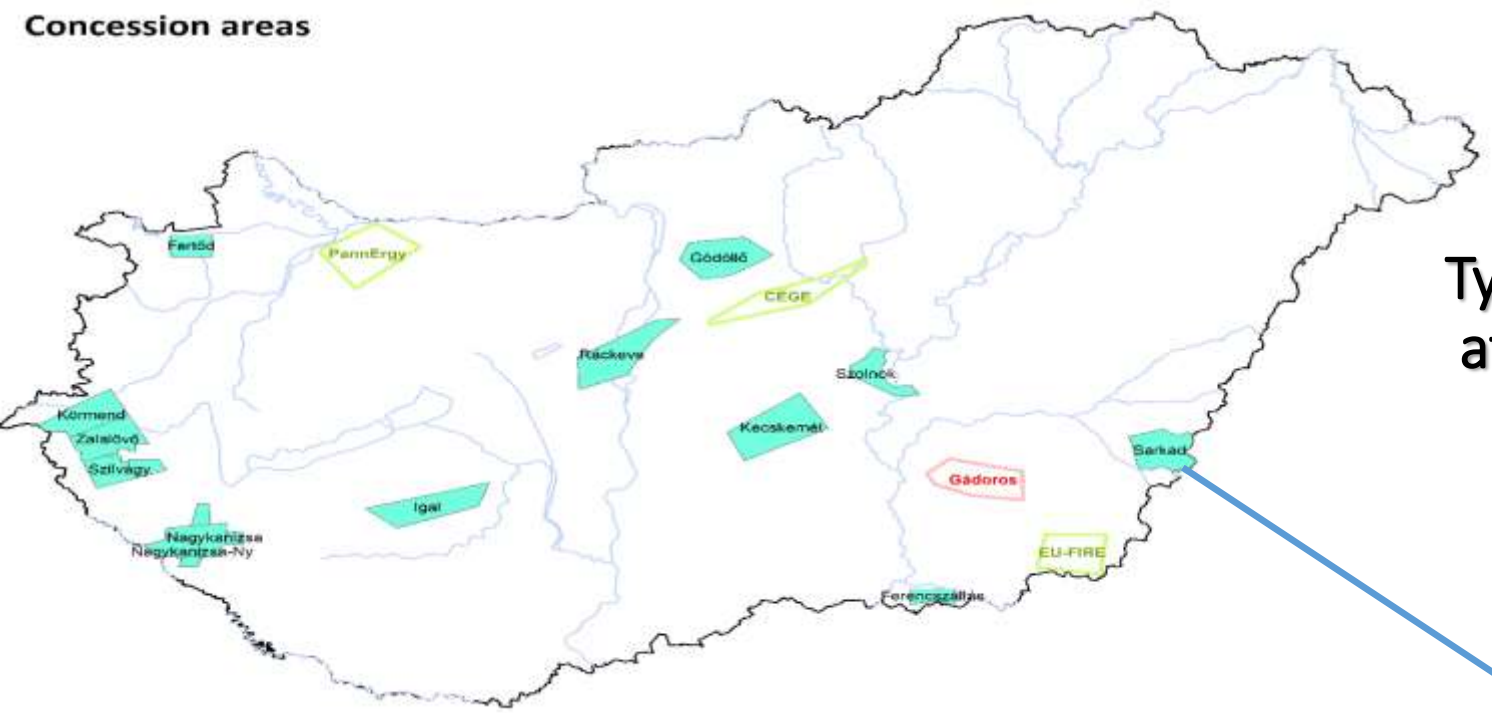
Nagykanizsa-Nyugat



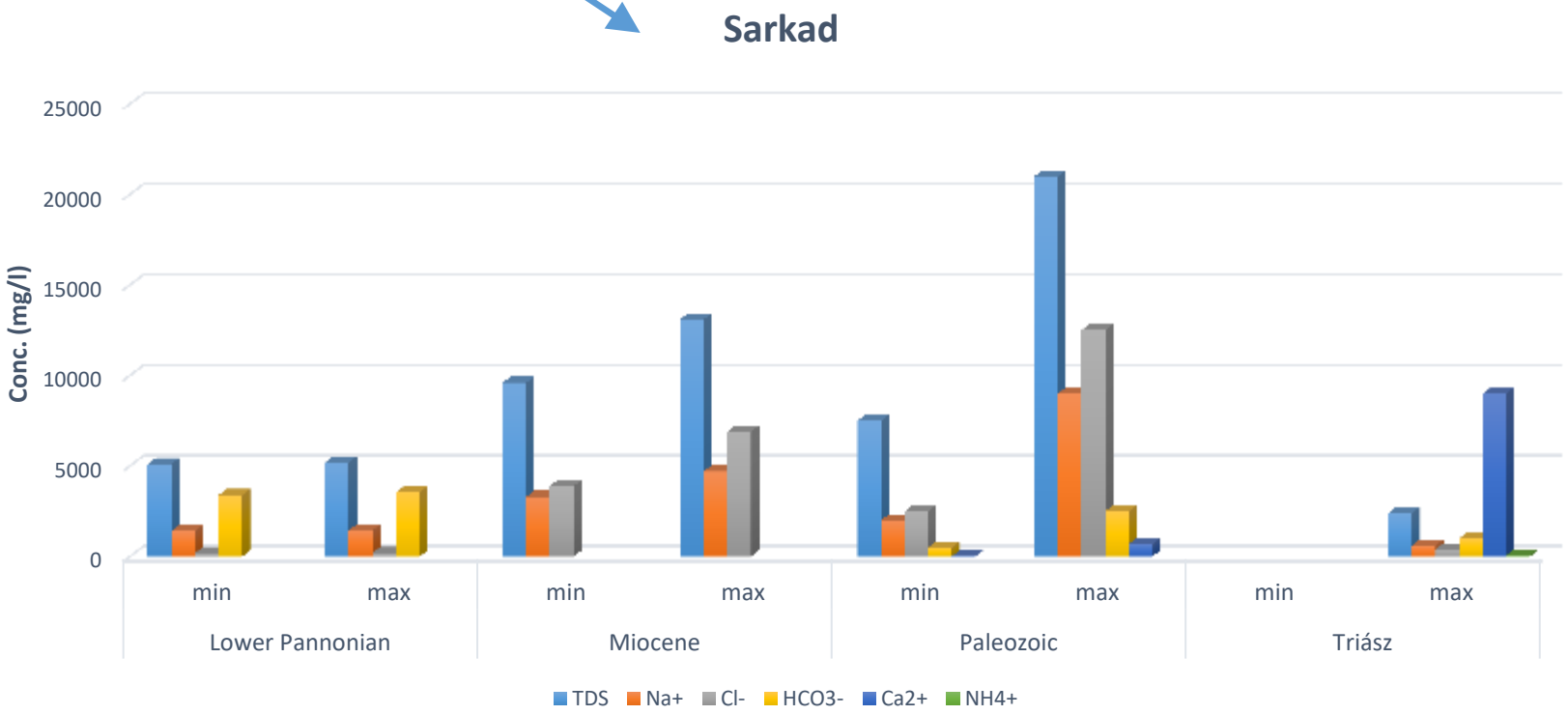


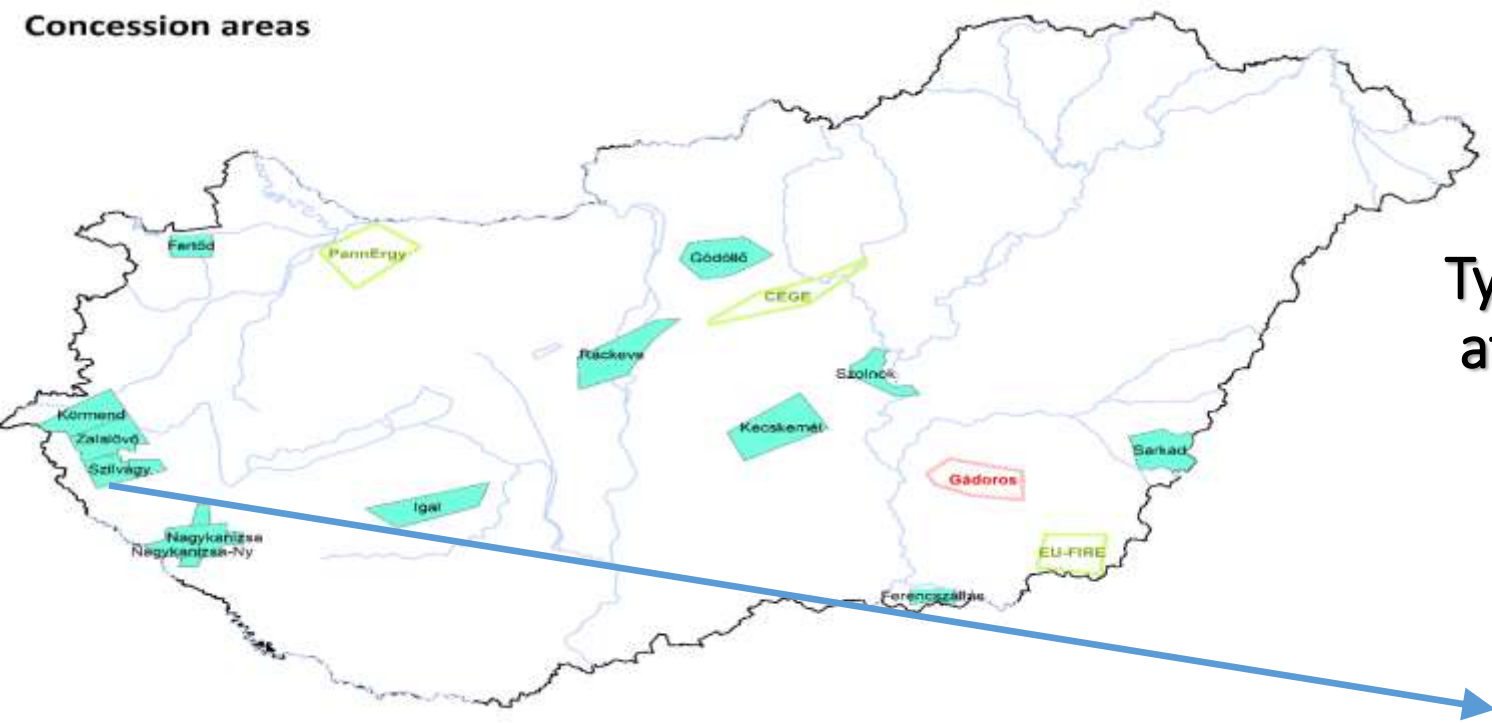
Typical composition of geothermal fluids at Hungarian concession areas





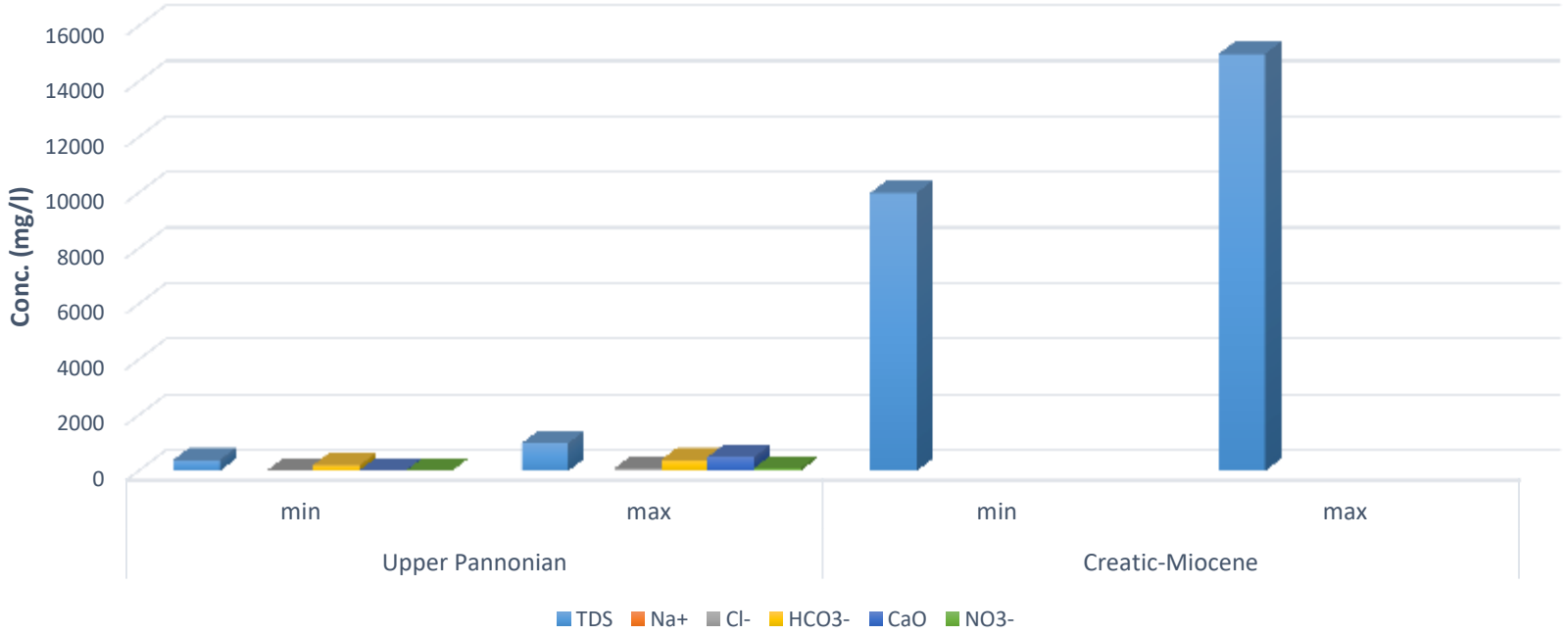
Typical composition of geothermal fluids at Hungarian concession areas

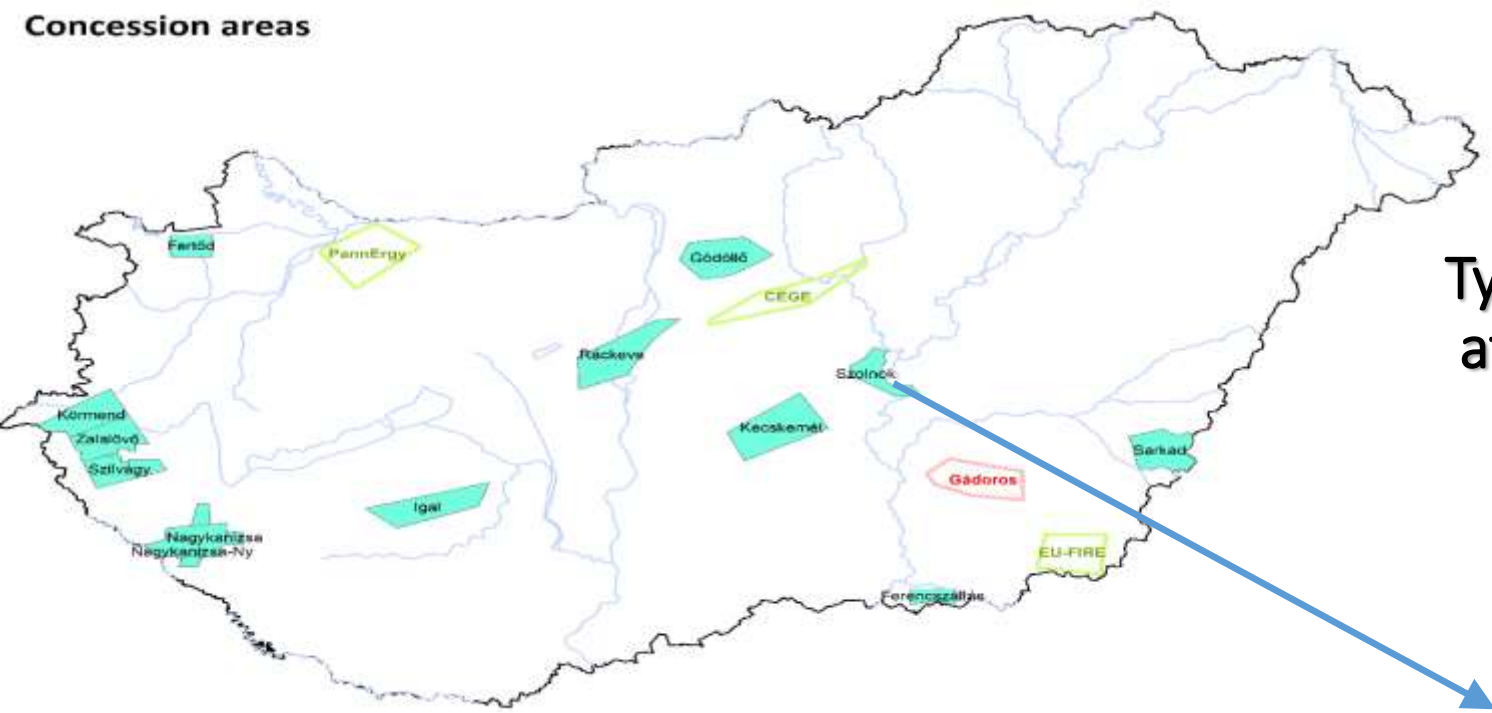




Typical composition of geothermal fluids at Hungarian concession areas

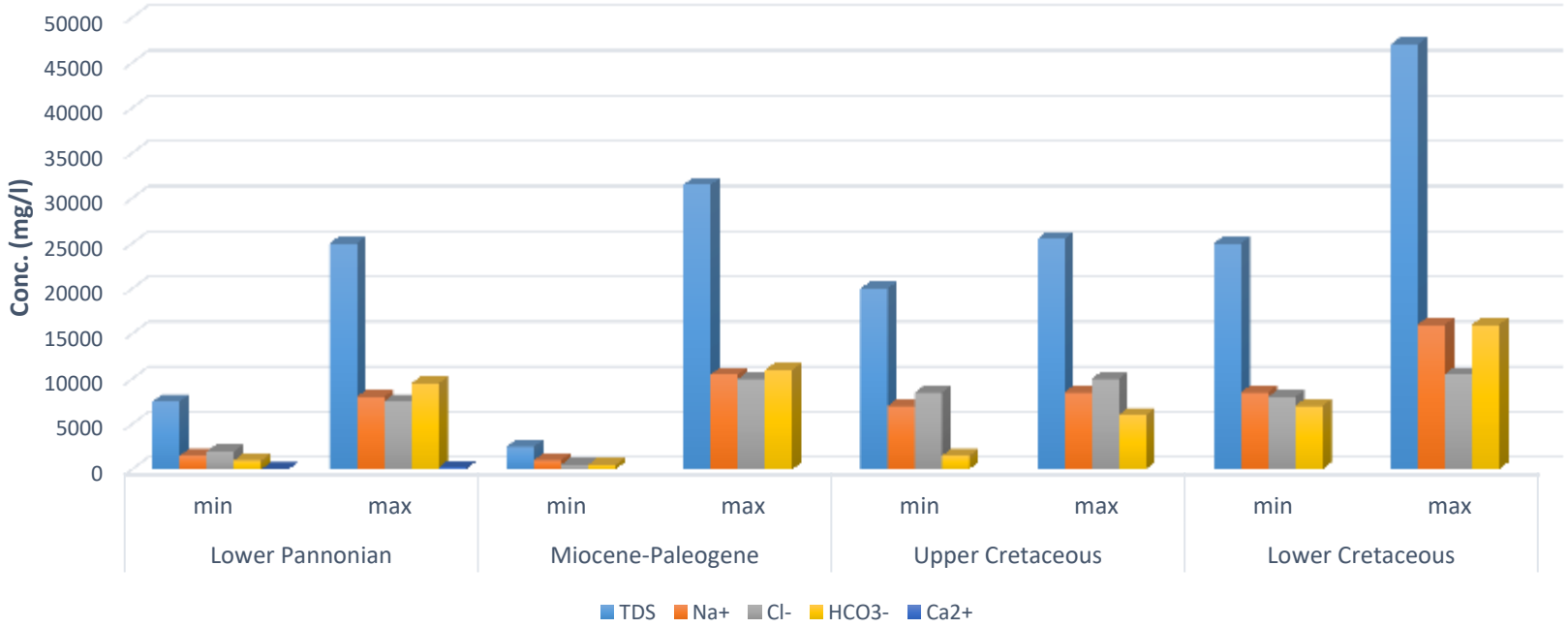
Szilvágy

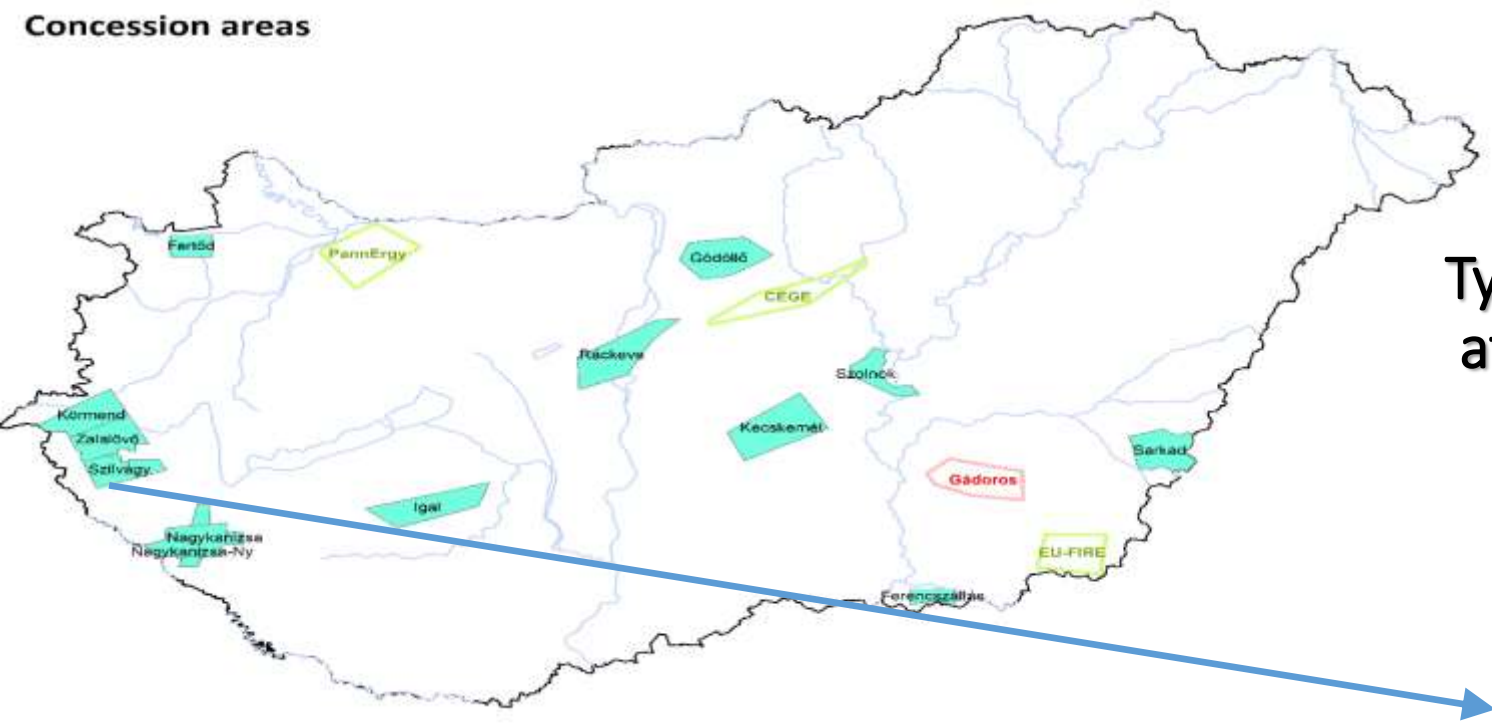




Typical composition of geothermal fluids at Hungarian concession areas

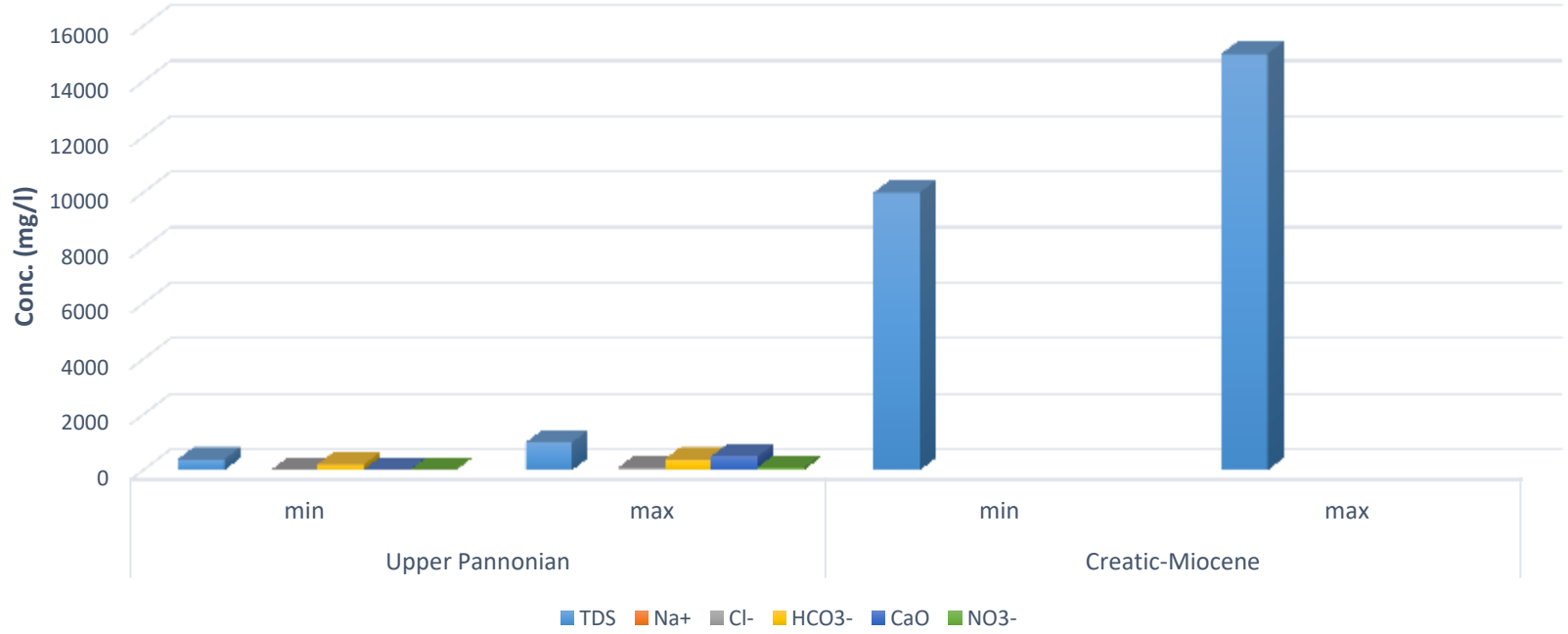
Szolnok





Typical composition of geothermal fluids at Hungarian concession areas

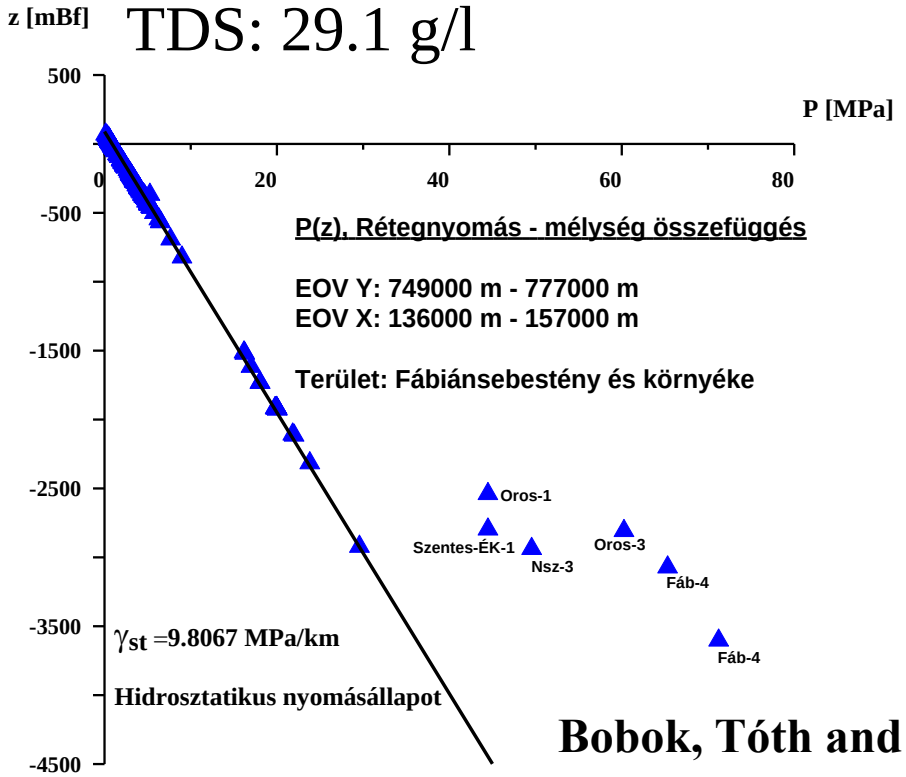
Zalalövő



Corrosion and scale problems because of the geothermal fluid compositions

Innovative complex scientific and engineering solutions are required to combat against nature extremes (the example of Fábiánsebestény, 1985)

Blowout depth: 3684 m
Temperature: 190.5 ^{0}C
Formation pressure: 712.26 bar
TDS: 29.1 g/l



Fáb-4. 1986. water sample

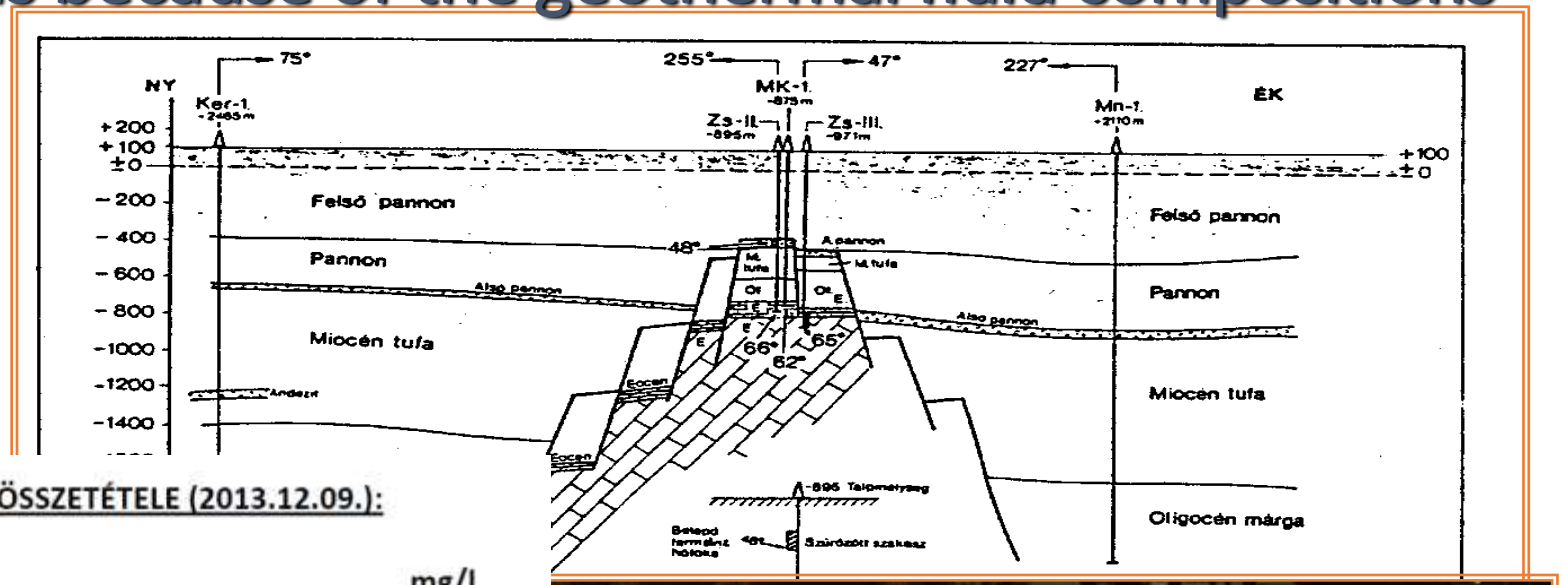
pH	7,70
Total hardness	991,04 g CaO/m^3
NaCl	**25,04** g/l
$Ca(HCO_3)_2$	0,82g/l
$CaSO_4$	0,02 g/l
$CaCl_2$	1,33 g/l
$NaHCO_3$	0,00 g/l
Na^+	**9852,19 mg/l**
K^+	410,00 mg/l
Ca^{2+}	**616,17** mg/l
Mg^{2+}	55,15 mg/l
NH_4^+	14,02 mg/l
Fe^{2+} (Al^{3+})	13,99 mg/l
Cl^-	**16039,60 mg/l**
HCO_3^-	615,65 mg/l
SO_4^{2-}	11,50 mg/l
Br^-	4,300 mg/l
J^-	8,40 mg/l
HBO_2	780,74 mg/l
H_2SiO_3	820,95 mg/l
TDS	**29,1 g/l**

Bobok, Tóth and Szűcs 2008

Corrosion and scale problems because of the geothermal fluid compositions

Mezőkövesd, Zsóry spa

Hydrodynamic relationship with the Bükk thermal karst systems



GYÓGYVÍZ ÖSSZETÉTELE (2013.12.09.):

Kationok:	**mg/l**
Kálium	43,00
Nátrium Na+	212,60
Kalcium Ca2+	345,00
Magnézium Mg2+	65,00
Mangán Mn2+	0,19
Vas Fe2+	0,1
Kationok összesen:	***665,89***

Anionok:	**mg/l**
Nitrát NO3-	<1,00
Nitrit NO2-	4,61
Klorid Cl-	219,00
Szulfát SO42-	15,00
Hidrogén-karbonát HCO3-	1623,00
Anionok összesen:	***1847,61***

Anionok – Kationok összesen:	**2513,5**

Photos: Dr. Lénárt László

Corrosion and scale problems because of the geothermal fluid compositions

Mezőkövesd, Zsóry spa

Conclusions

Concurrent thermal water production in Hungary – balneology and geothermal energy utilization
Valuable but not endless thermal water resources
Diverse water chemistry – advantages in balneology
Challenges in geothermal energy utilization – corrosion, scales and other technical problems

Water – gas – rock framework interactions, pressure and temperature conditions – hydrogeochemistry
No generalized solutions – locally specified technical solutions – chemicals (inhibitors), magnetic methods, etc.