

Thermal water depletion and its impact on drinking water

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Outline

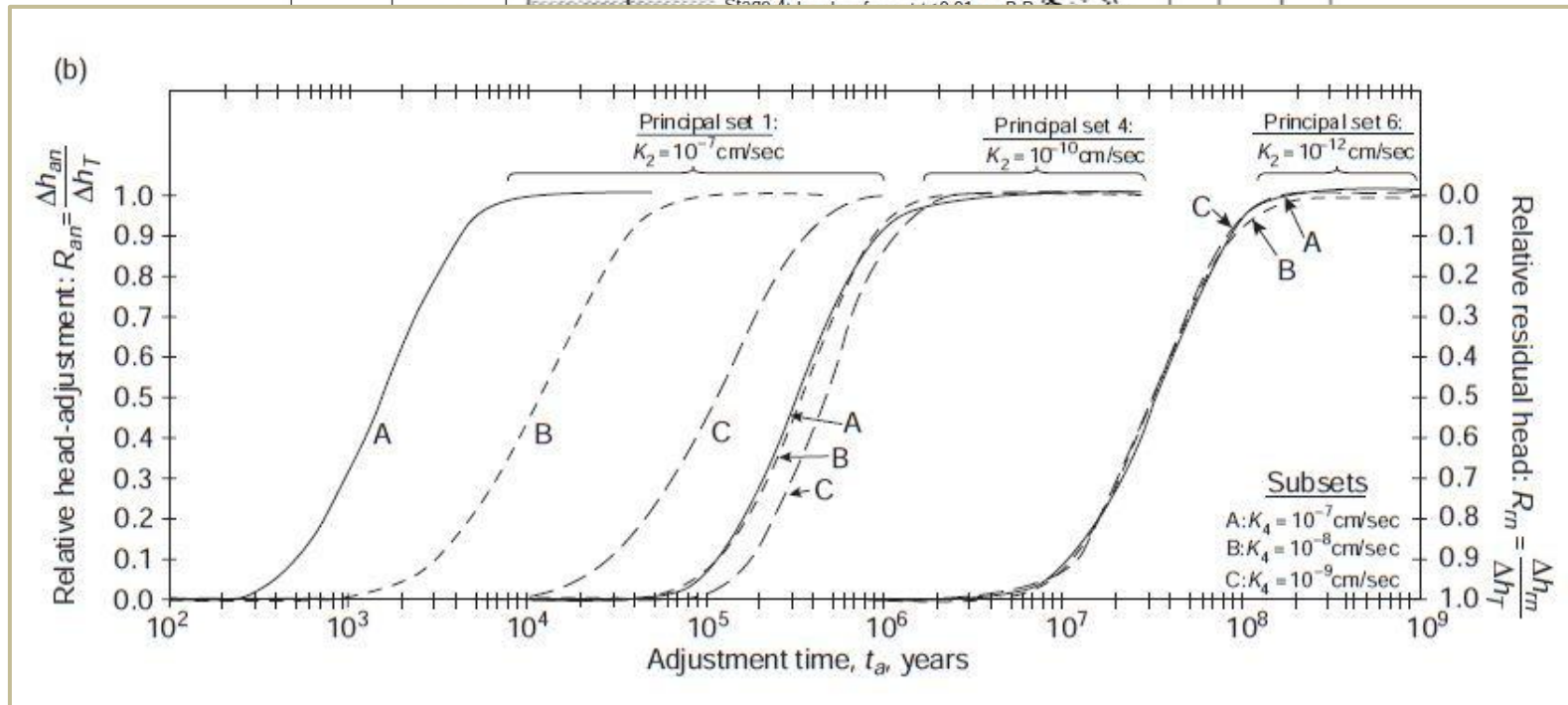
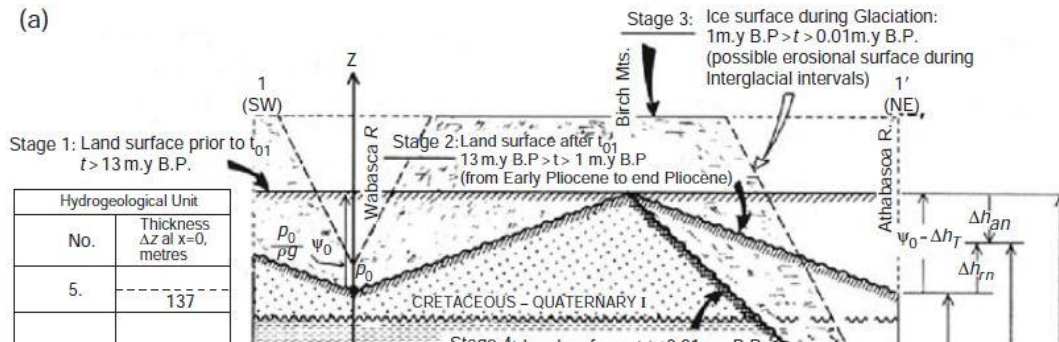
- **hydraulic continuity**
- **field tests**
- **numerical calculations**
- **conclusions**



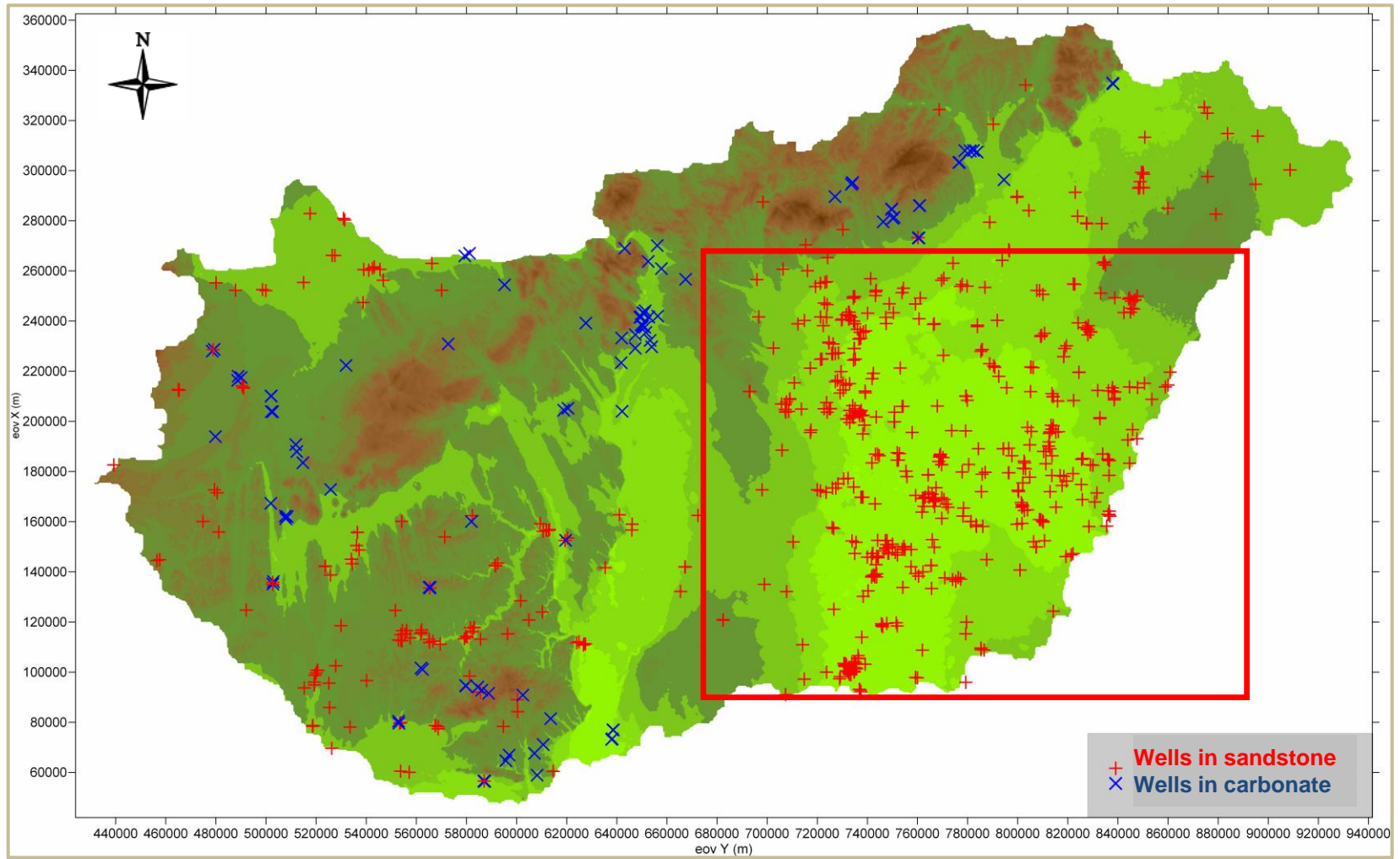
Principle of hydraulic continuity



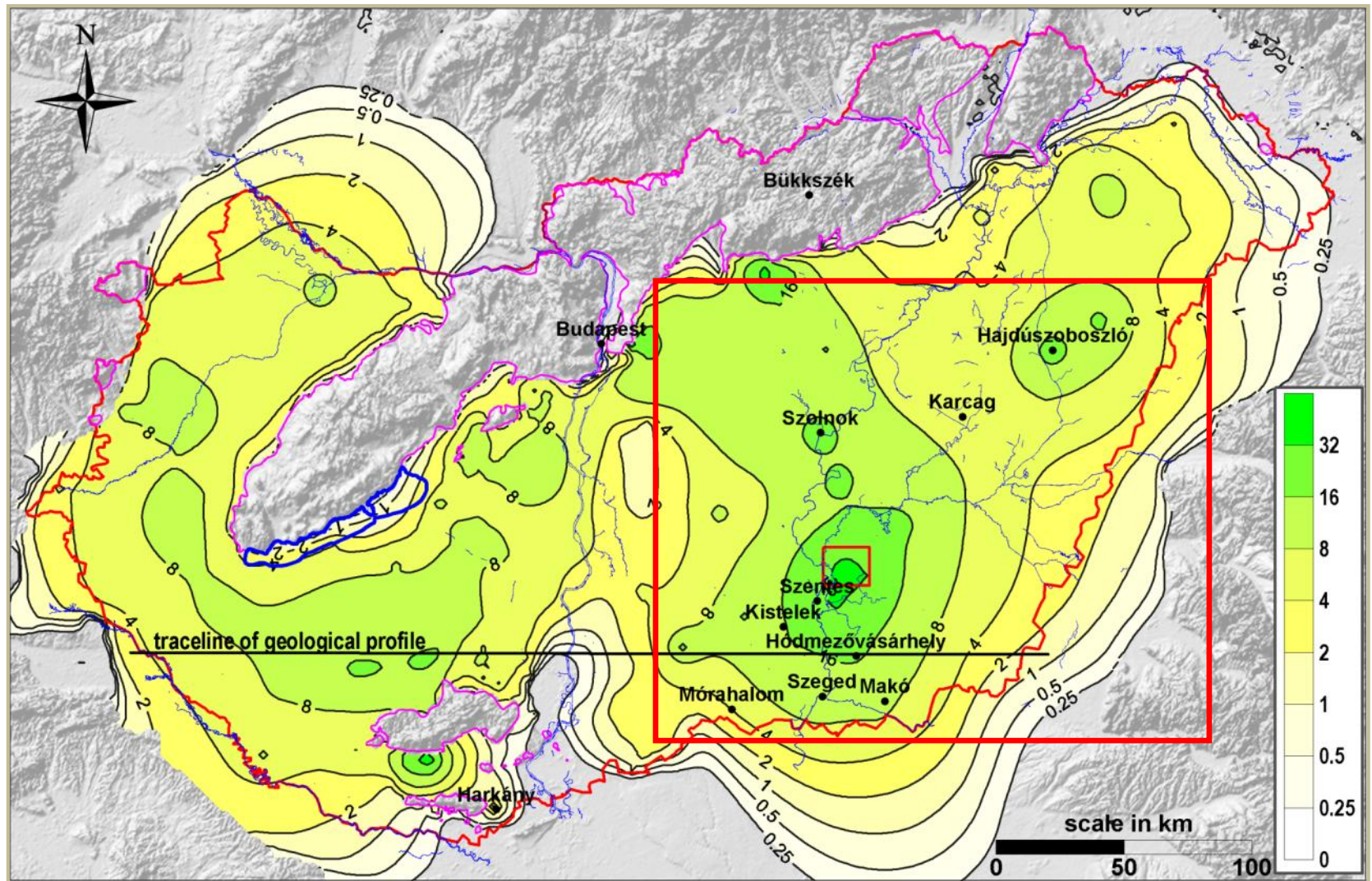
Calculated times for pore-pressure adjustment on geological time scale (Tóth and Millar, 1983)



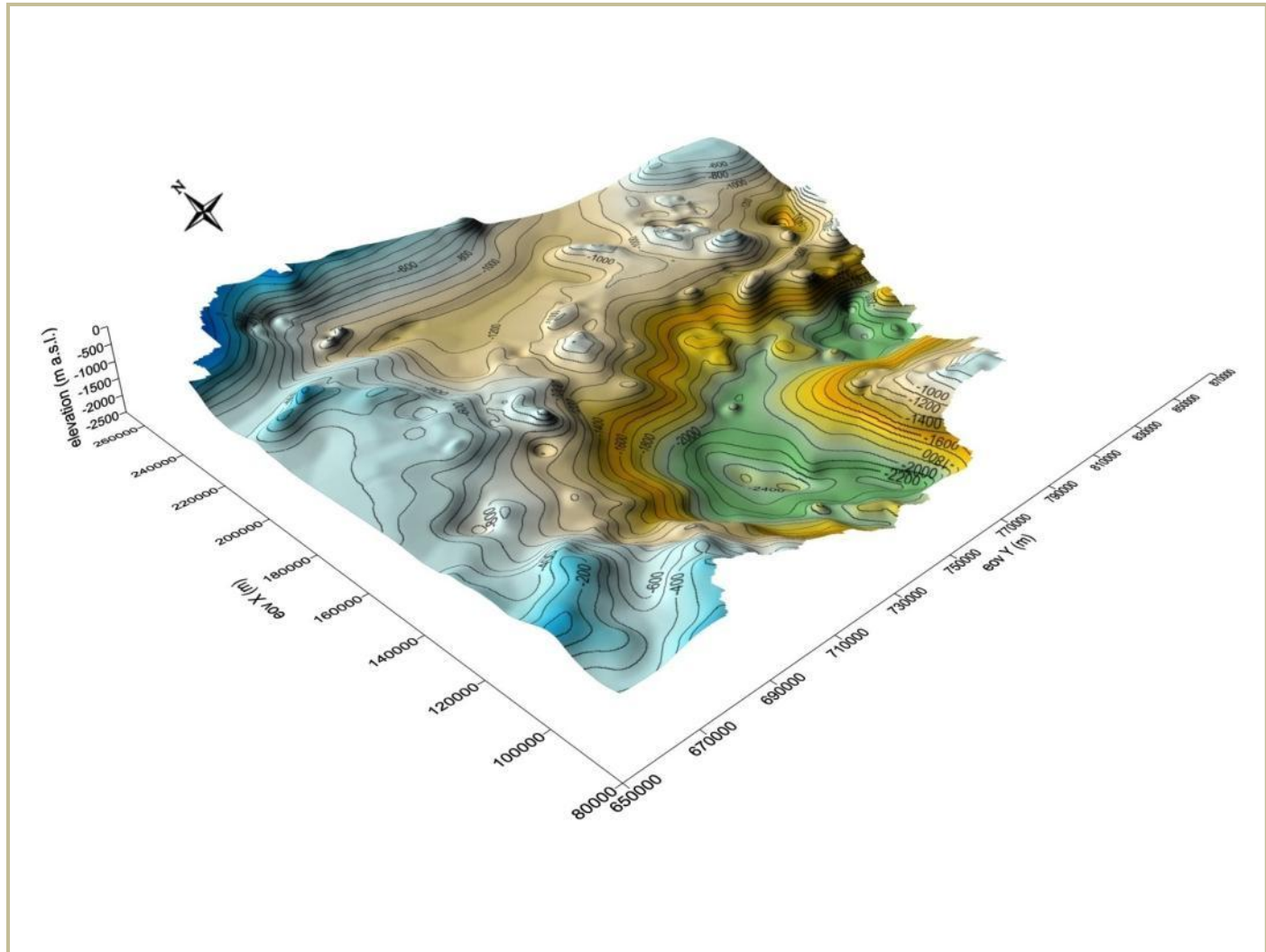
Locations of thermal wells in Hungary



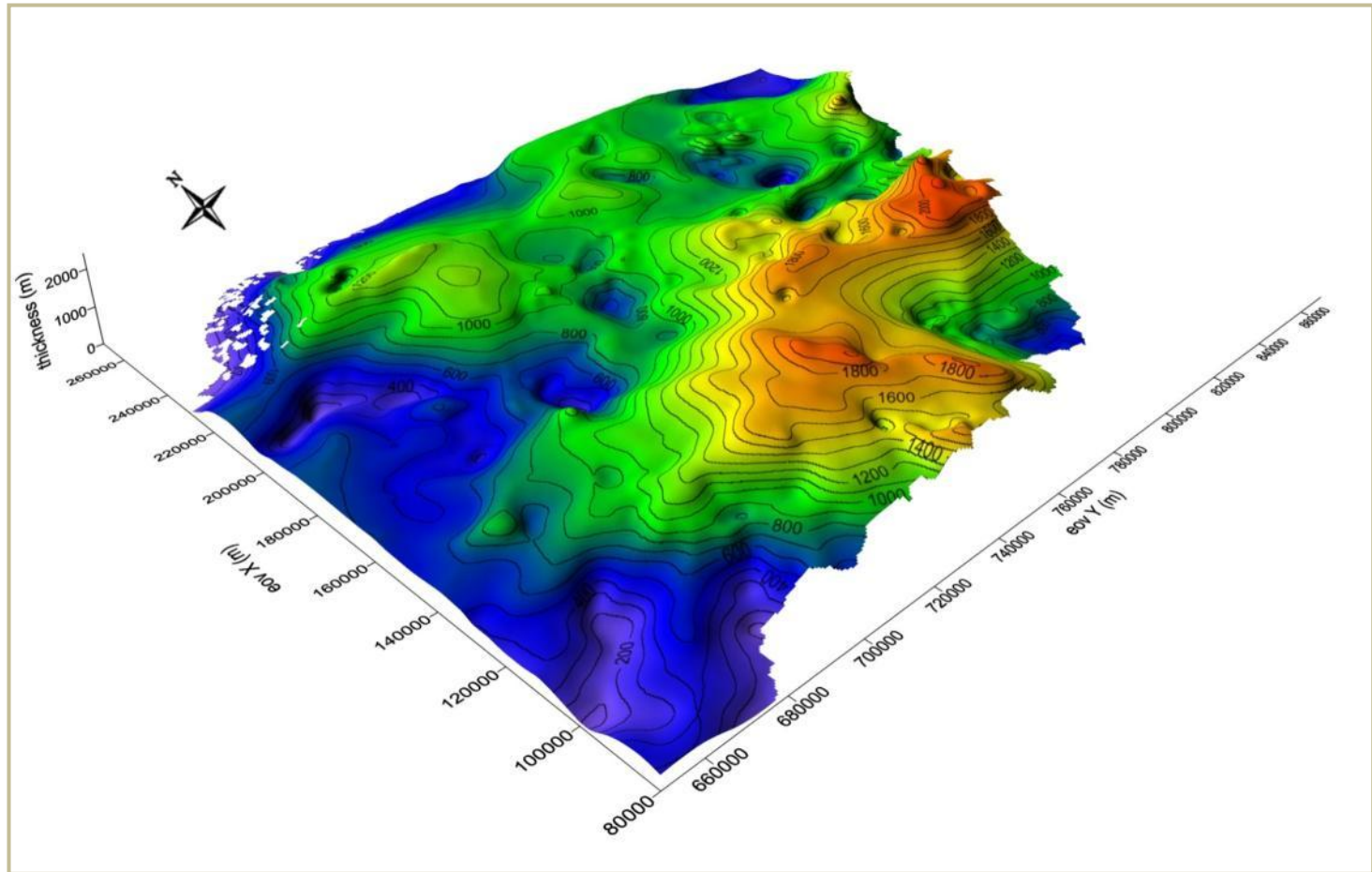
The calculated drawdown at the bottom of the Upper Pannonian sequences (György Tóth, 2009)



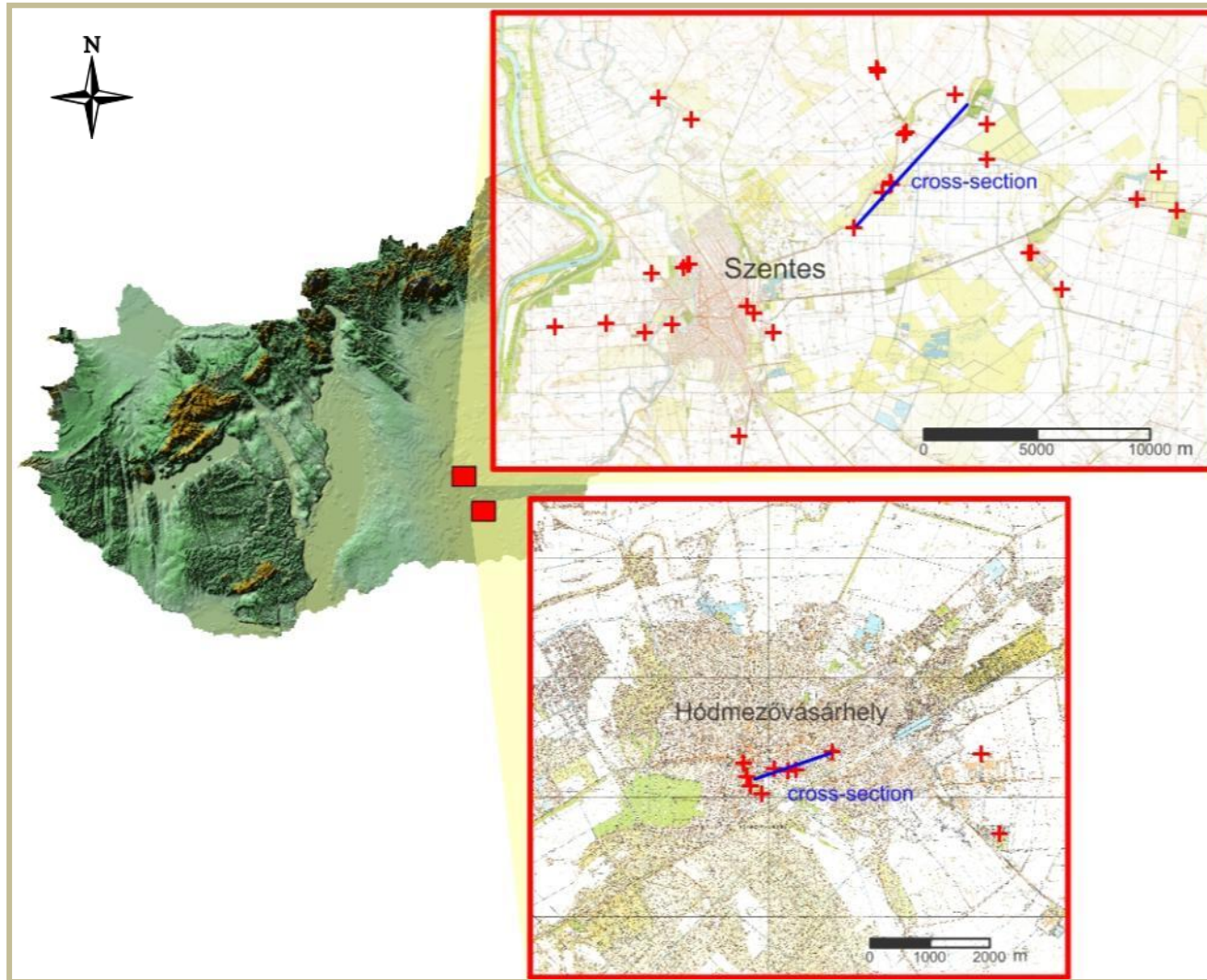
Bottom of the Upper Pannonian strata



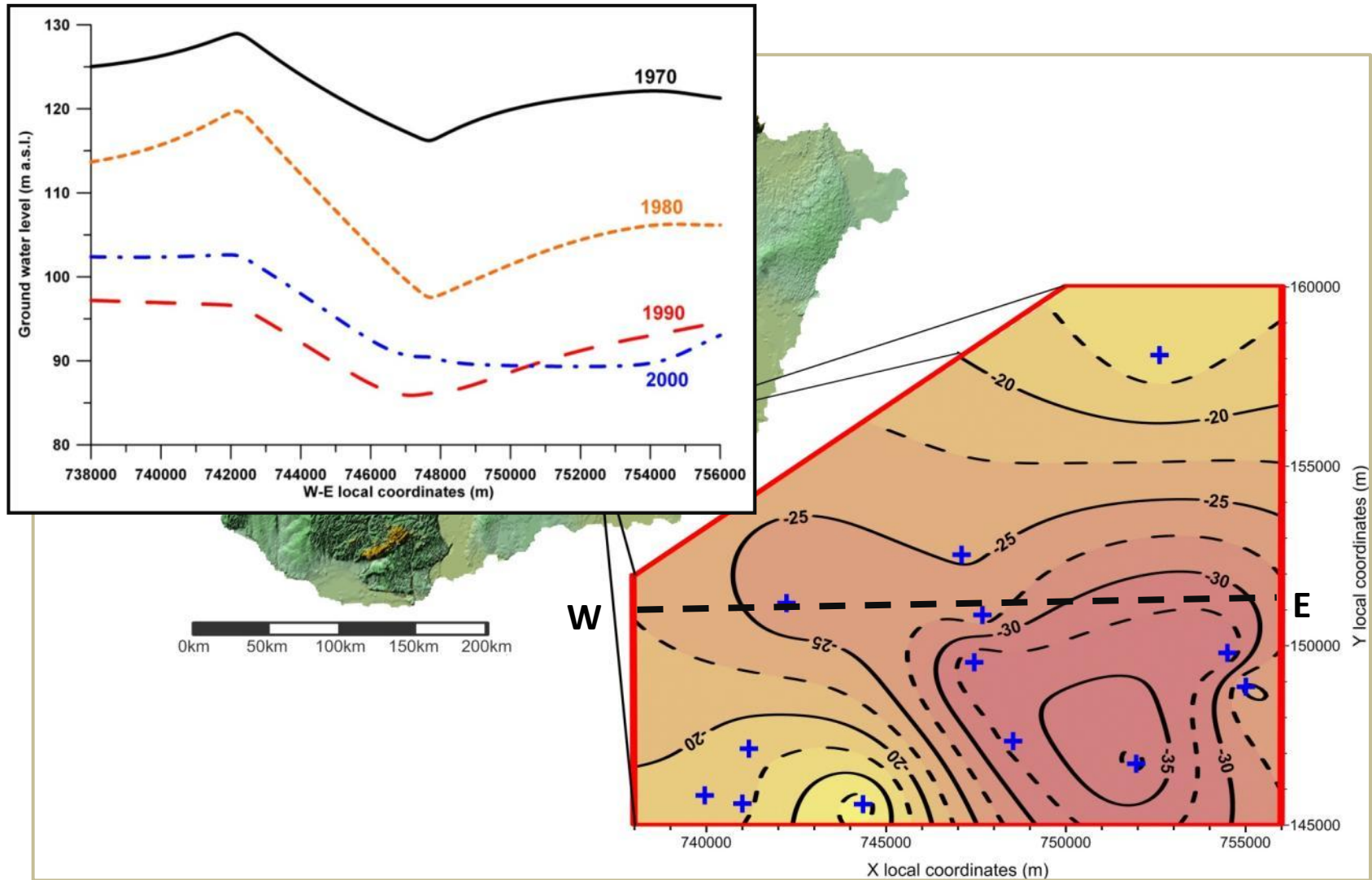
Thickness of the Upper Pannonian strata



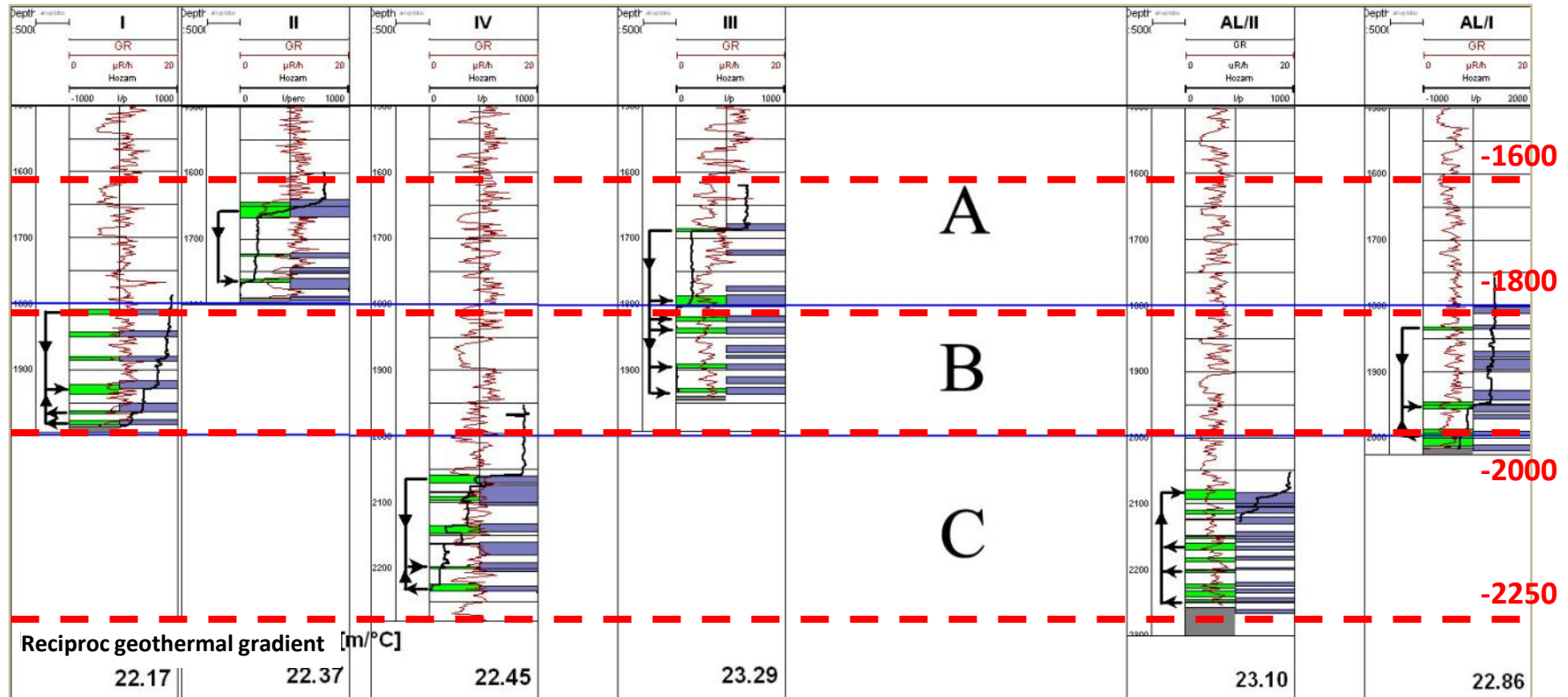
Location of the investigated areas



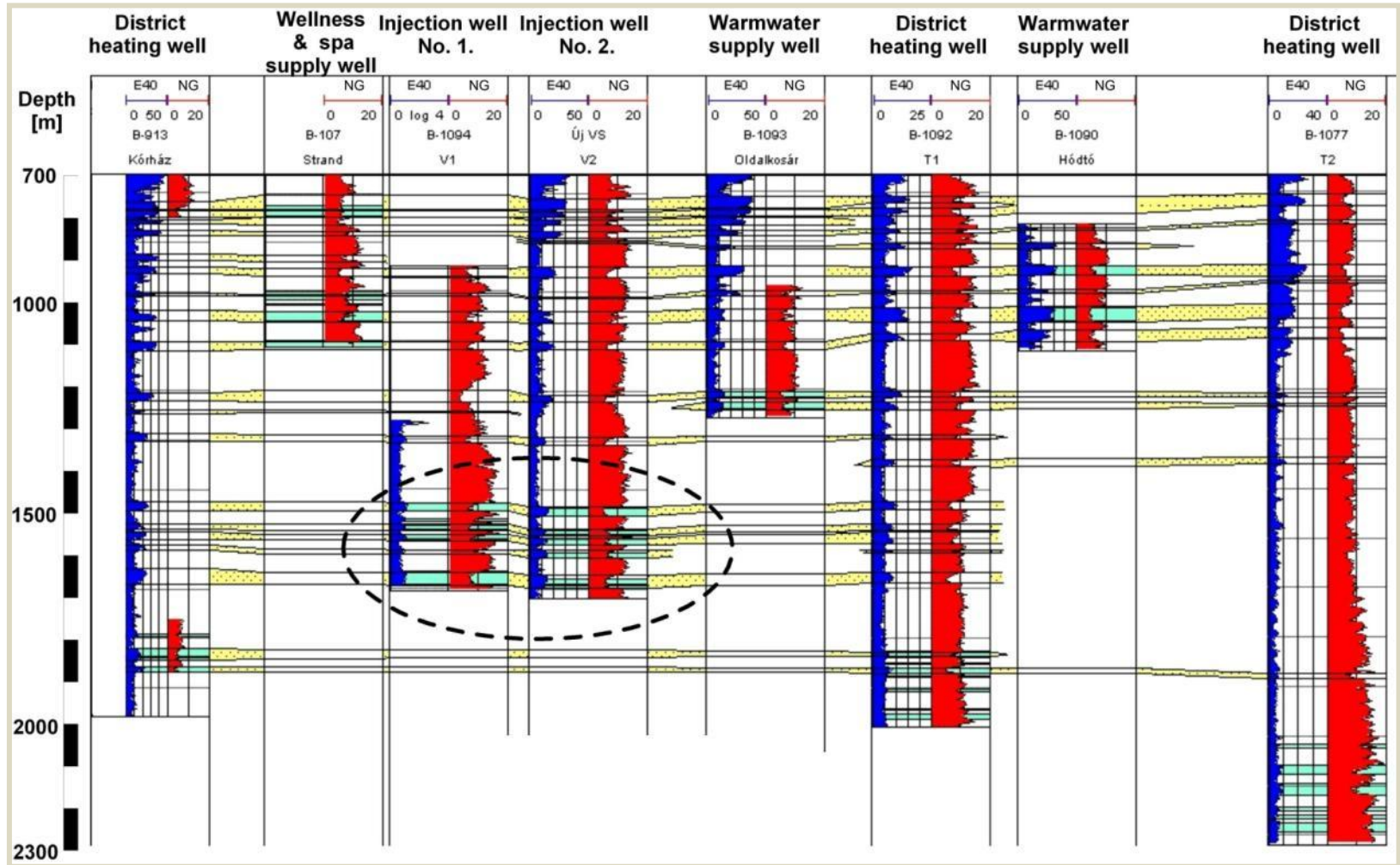
The calculated drawdown at the bottom of the Upper Pannonian sequences with wells in Szentes site



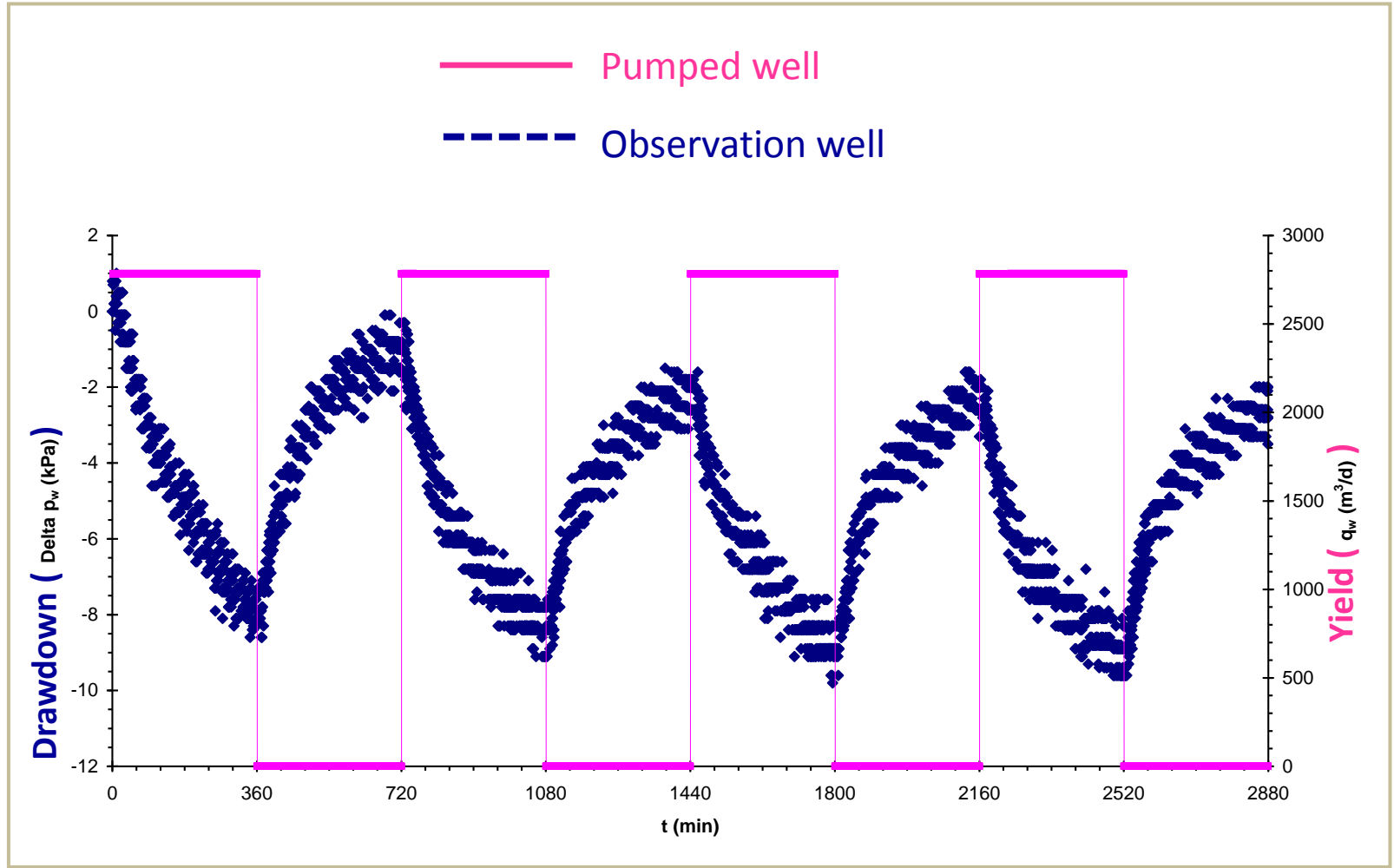
Well logs in Szentes area



Geophysical cross-correlated profiles in the Hódmezővásárhely area

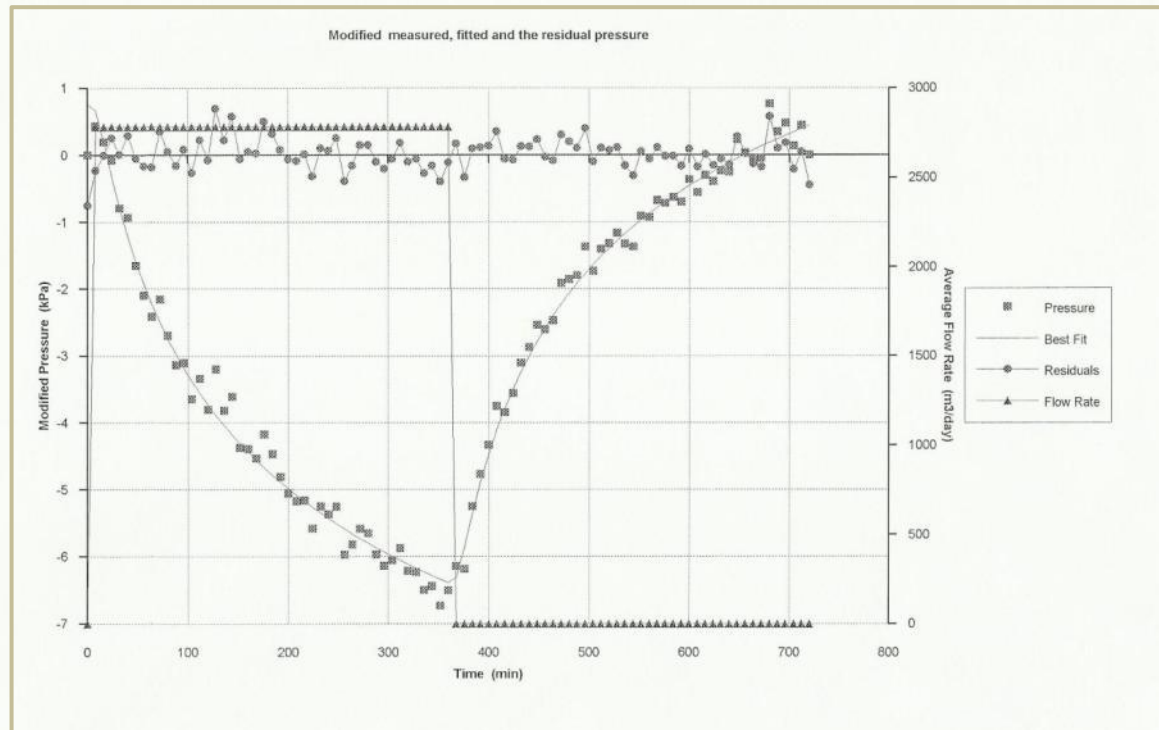


Pulsation test (4 times every 6 hours)



Score of Pulsation test analysis

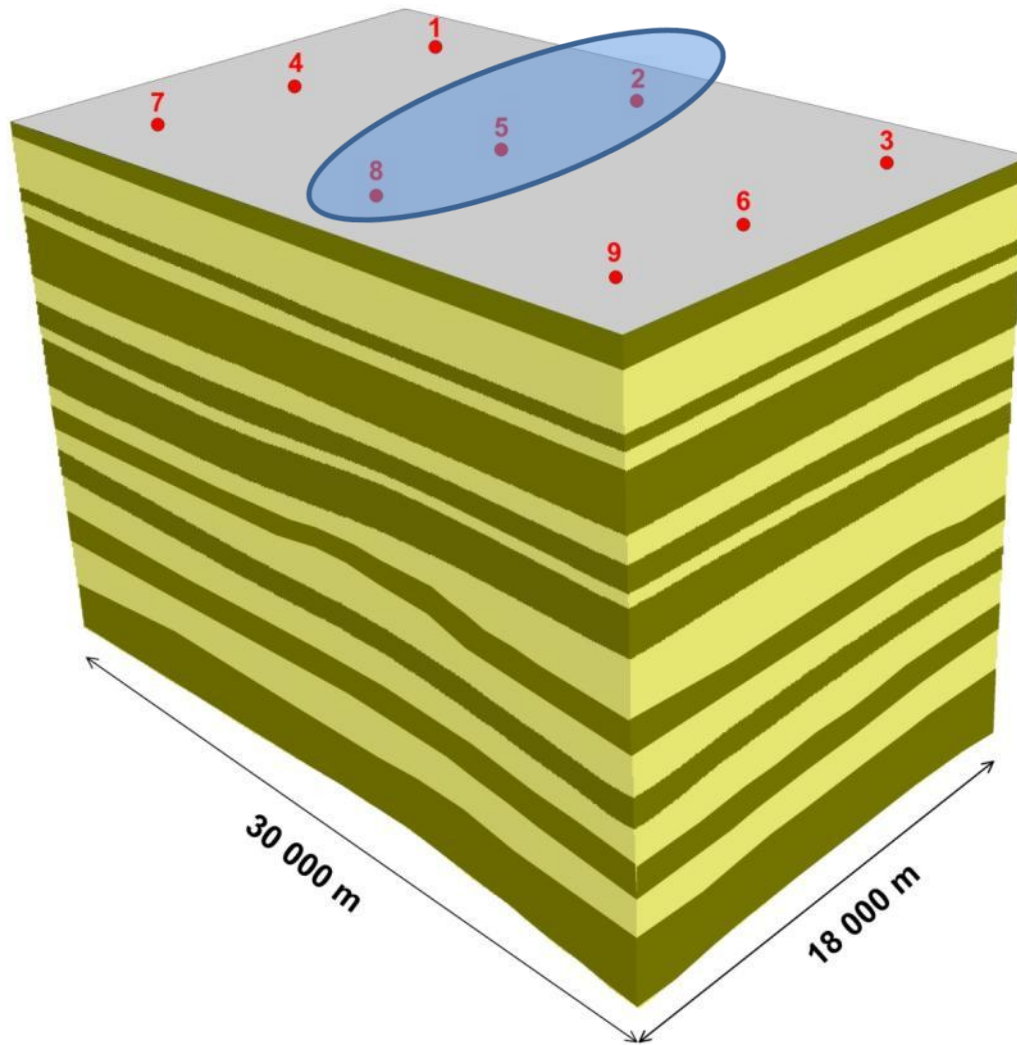
<i>Parameter</i>	<i>Unit</i>	<i>Value</i>
Transmissivity (T)	m ² /d	654
Storage coefficient (S)	-	432·10 ⁻⁶
Leakage factor	%	8



PulsEx - Pulse Interference Test Analysis



Numeric model

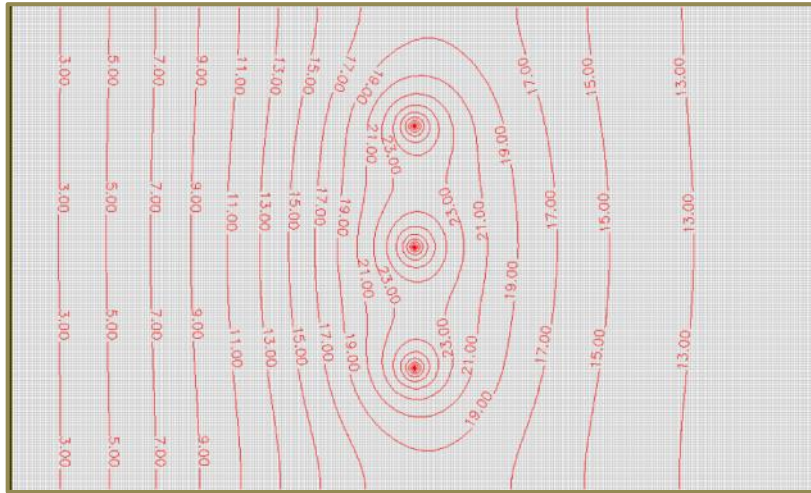


No	Hydraulic conductivity [m/d]		Effective porosity
	Horizontal	Vertical	
1.	3	0.3	0.15
2.	1	0.1	0.1
3.	3	0.3	0.15
4.	1	0.1	0.1
5.	2	0.2	0.12
6.	0.05	0.005	0.05
7.	1.5	0.15	0.1
8.	0.05	0.005	0.05
9.	1	0.1	0.08
10.	0.001	0.0001	0.05
11.	1	0.1	0.12
12.	0.001	0.0001	0.05
13.	0.6	0.06	0.1175
14.	0.001	0.0001	0.05
15.	1.5	0.15	0.115
16.	0.001	0.0001	0.05
17.	0.8	0.08	0.1125

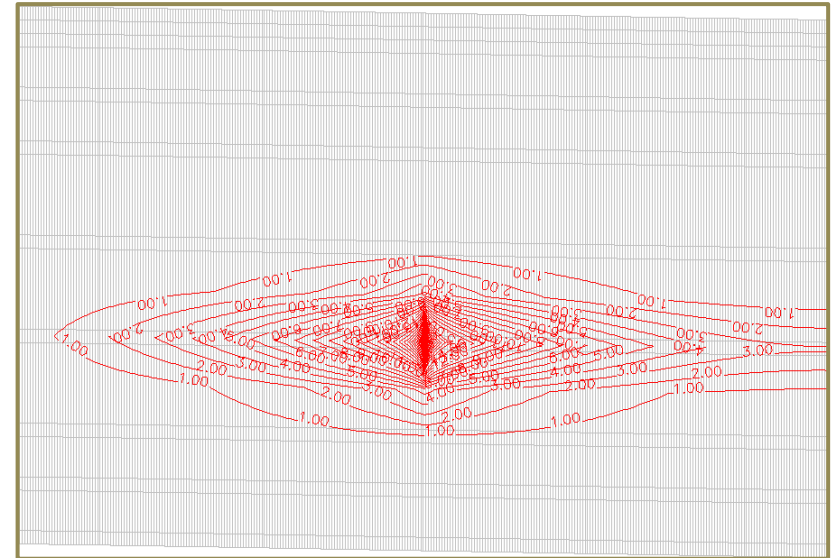
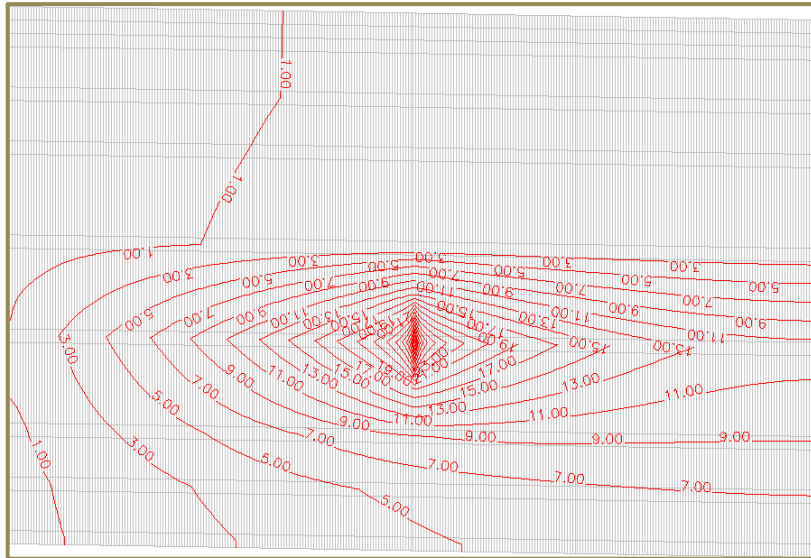
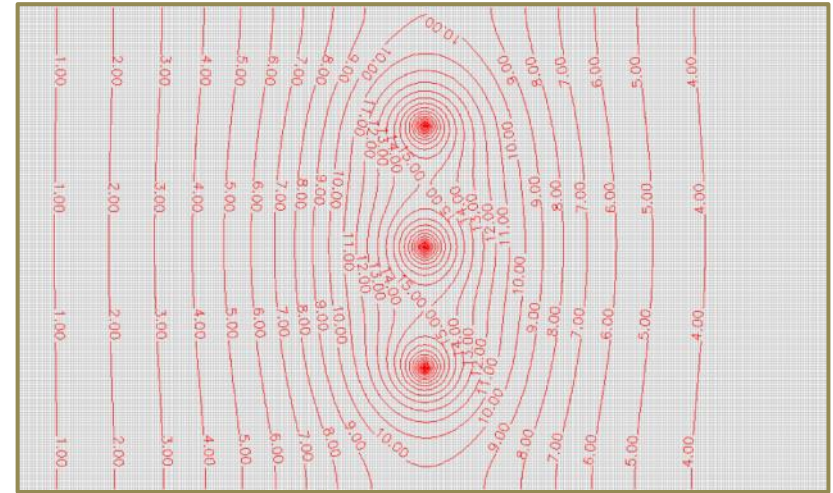


Drawdown (m) while pumping 11 layer

Steady state condition

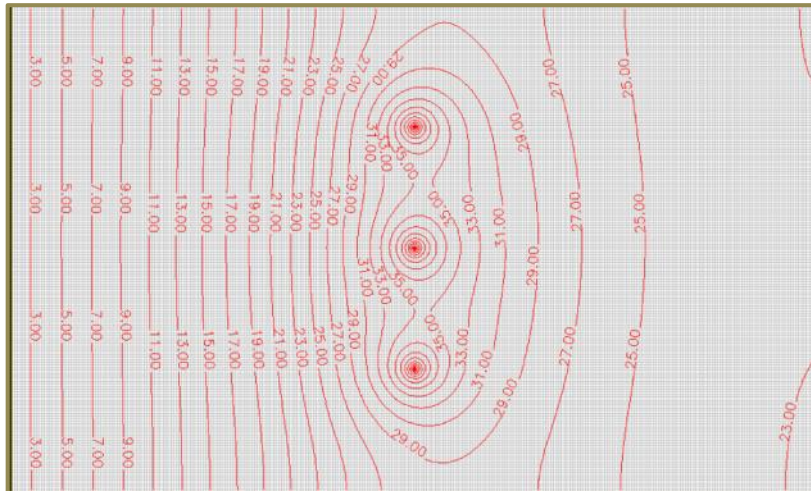


50 years operation

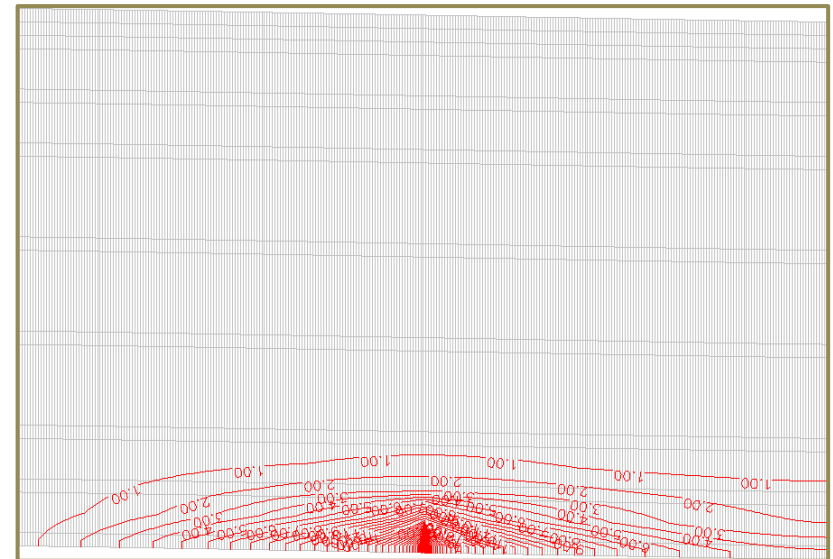
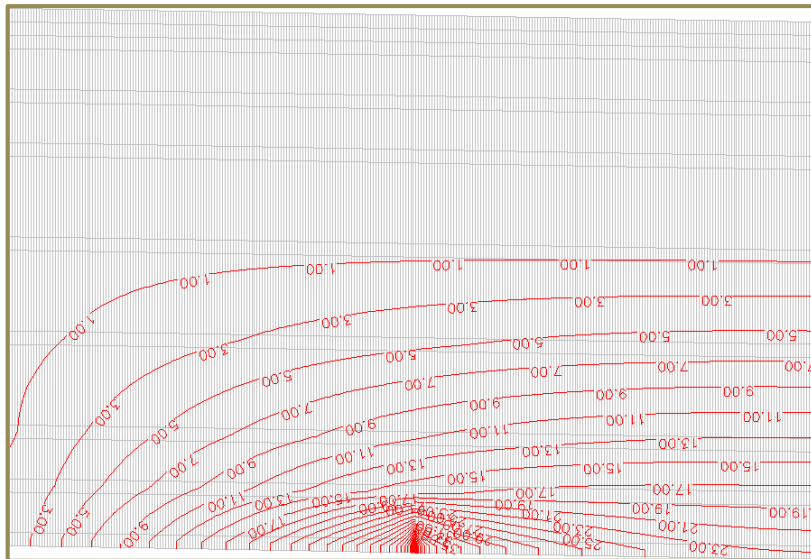
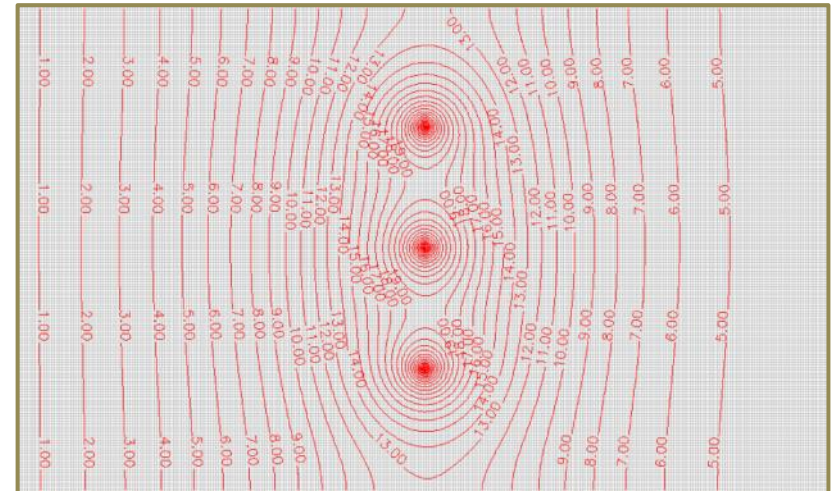


Drawdown (m) while pumping 17 layer

Steady state condition



50 years operation

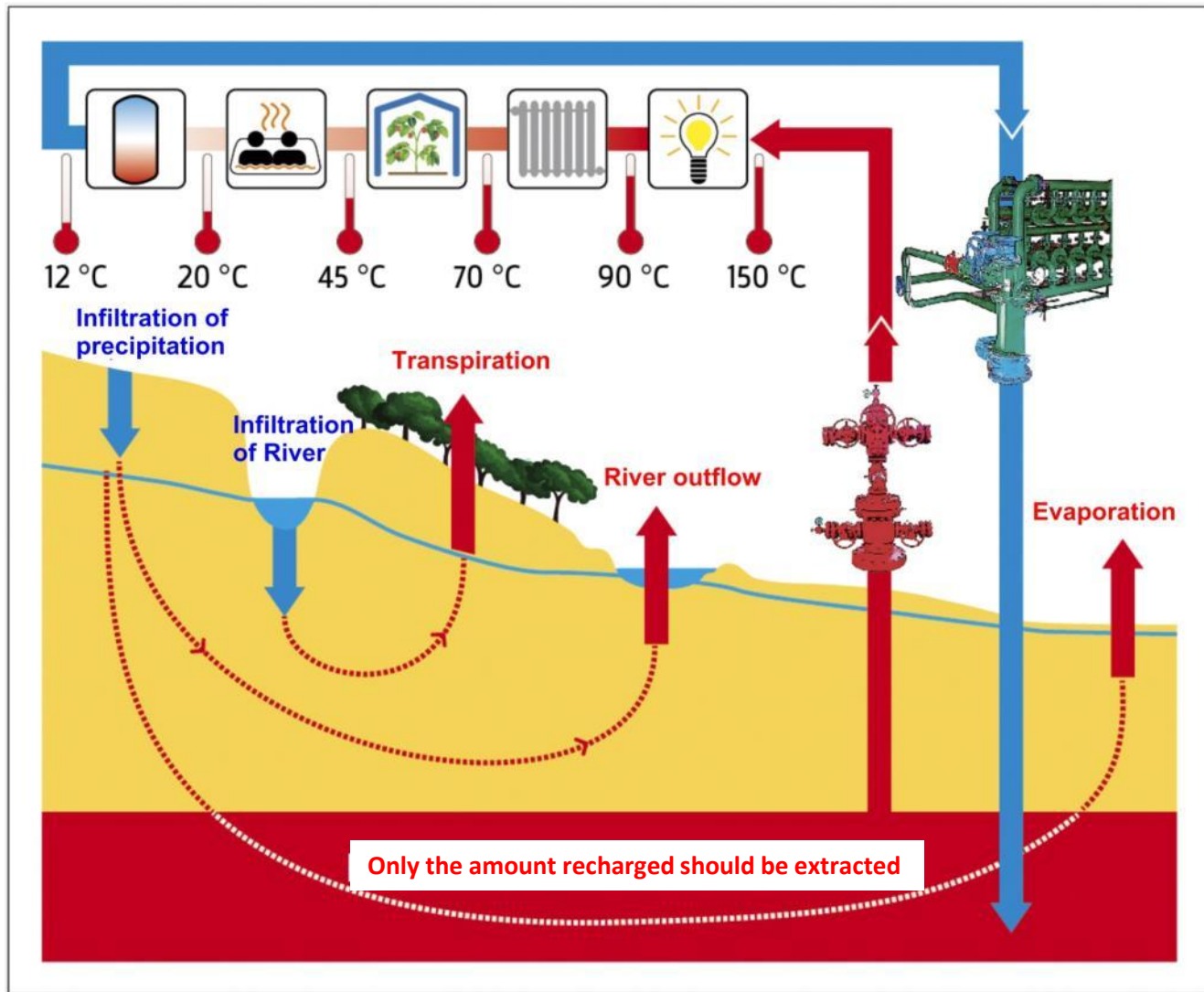


Effect of thermal water withdrawal on the whole model domain

No	K_h [m/d]	Maximum drawdown in pumped layer [m]	Maximum drawdown in shallow groundwater (1st layer) [m]
11 layer	1	37.81	2.07
13 layer	0.6	55.67	1.12
15 layer	1.5	27.84	0.78
17 layer	0.8	48.68	0.67



Optimal use of thermal water



Conclusion

- The calculations and test results show that geothermal operation in the area has long term hydraulic effect on the aquifer not just horizontally, but vertically
- In case of making sustainable river basin management plan one needs to consider thermal water withdrawal
- Both theoretical studies and field experience clearly demonstrate that reinjection is an essential part of sustainable field management. Without reinjection, only a small fraction of the thermal energy available in the reservoir can be recovered





Thank you!

