CONSEQUENCES OF MINE DEPRESSURISATION ON A REGIONAL CARBONATE AQUIFER, TATA, HUNGARY

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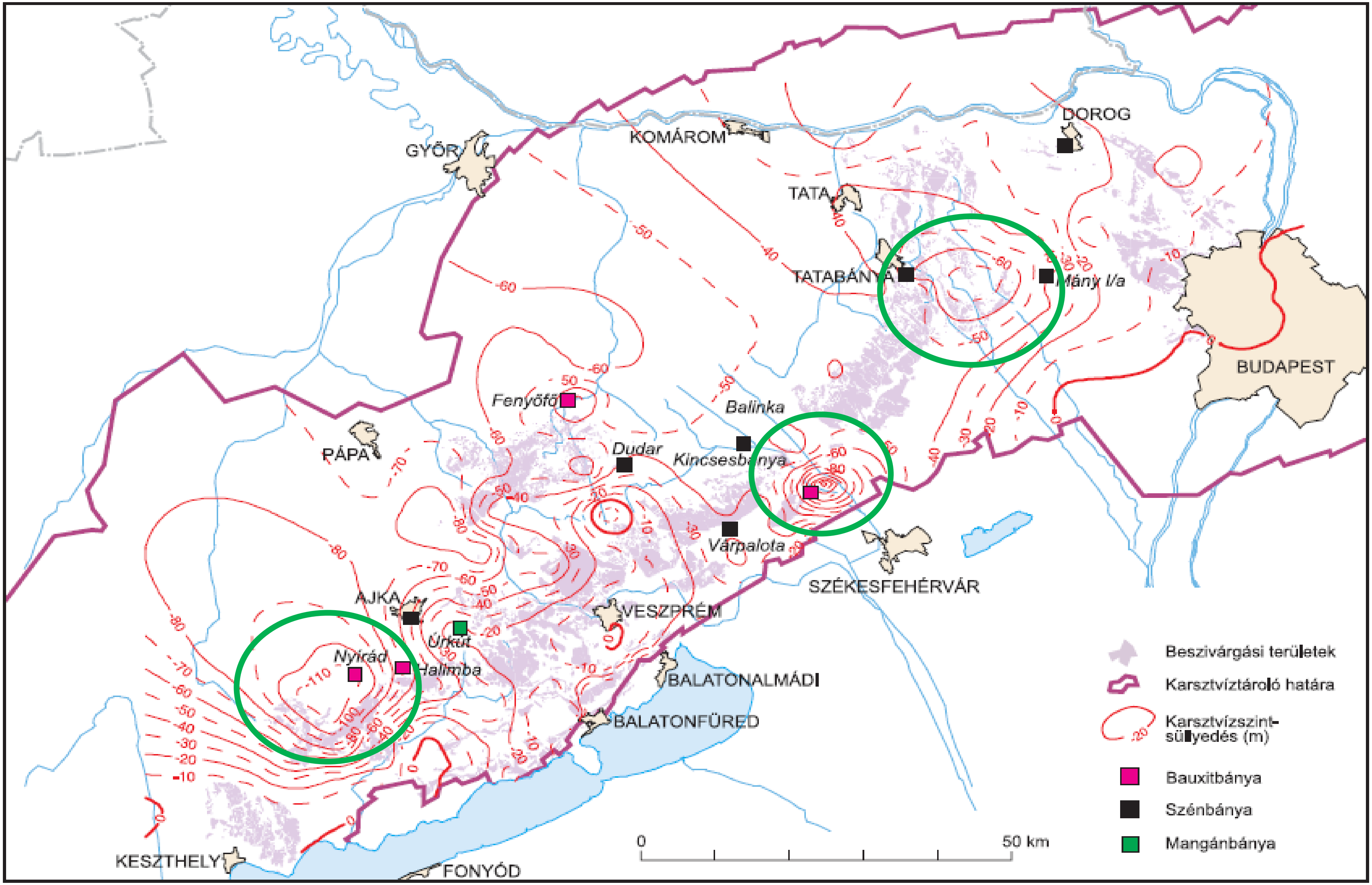
43rd IAH CONGRESS, Montpellier, 27/09/2016

General background

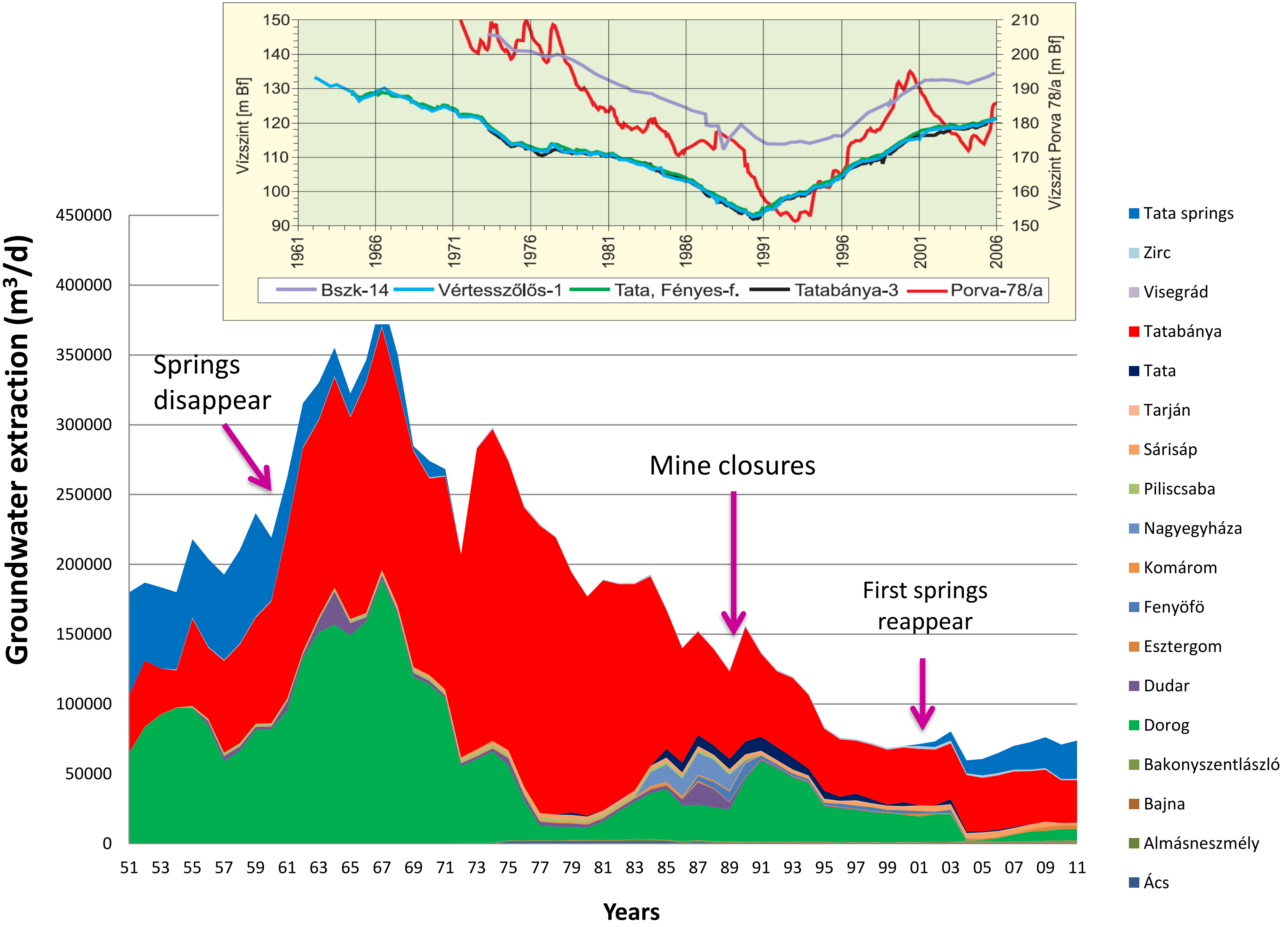
- Effects of mine dewatering on the karst water levels
  - 10 billion m^3 of water extracted between 1950-1990 @ 700 m3/min)
  - 40m depression in the Tata area
  - Springs disappear between 1961-65
  - Water resources reorganised (bore installation, distant resources)
- Settlement development in 1970’s in affected areas
- Mine closures in early 1990’s → groundwater recovery (1 m/y) → Reactivation of springs
- Geotechnical and environmental problems (flooded basements, water seepages, contamination, etc.)
- Goals:
  - Prediction of karst water recovery
  - Prediction of spring locations and time of reappearance
  - Hydrochemical characterisation

Groundwater drawdown in 1990, caused by mining



Csepregi 2007

Mine dewatering and recovery

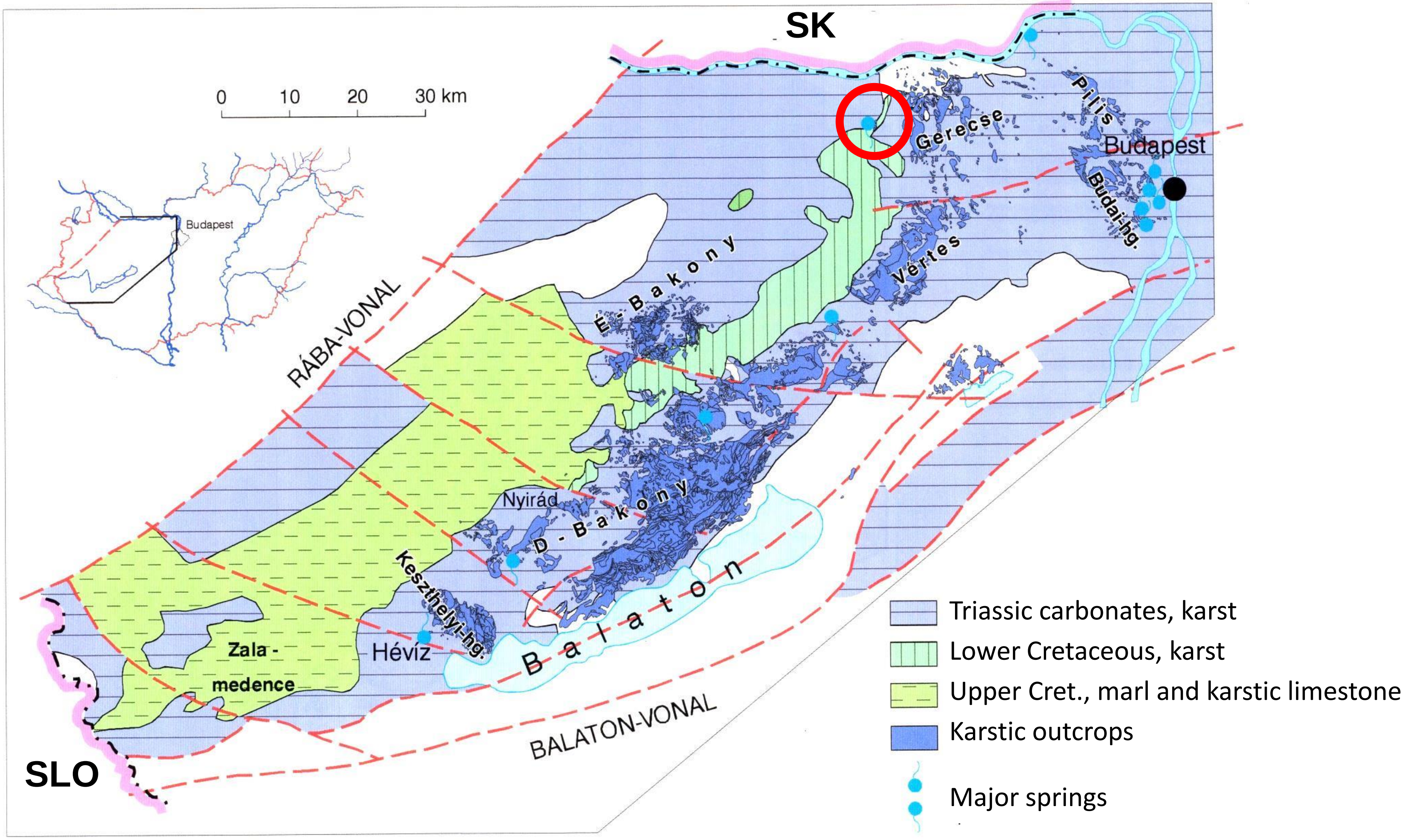


Springs disappear

Mine closures

First springs reappear

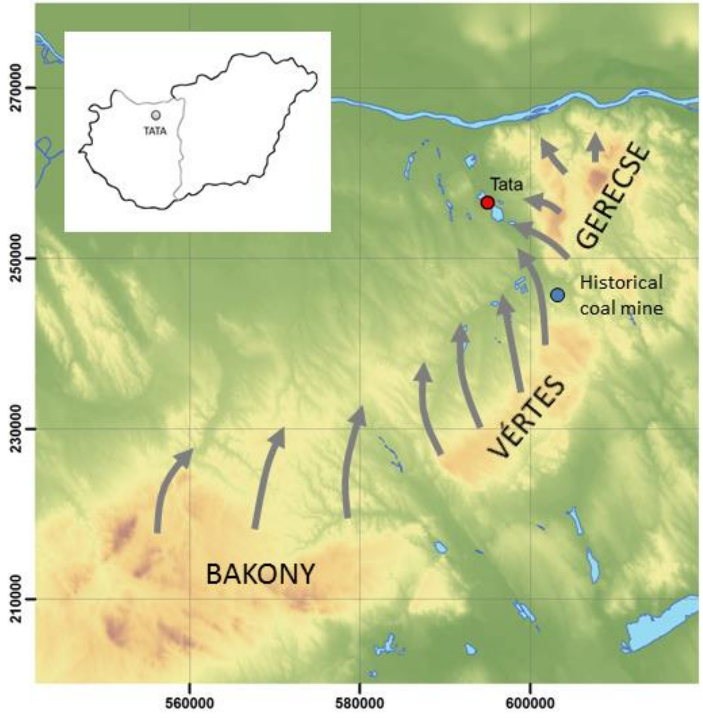
General geology of the Transdanubian aquifer system



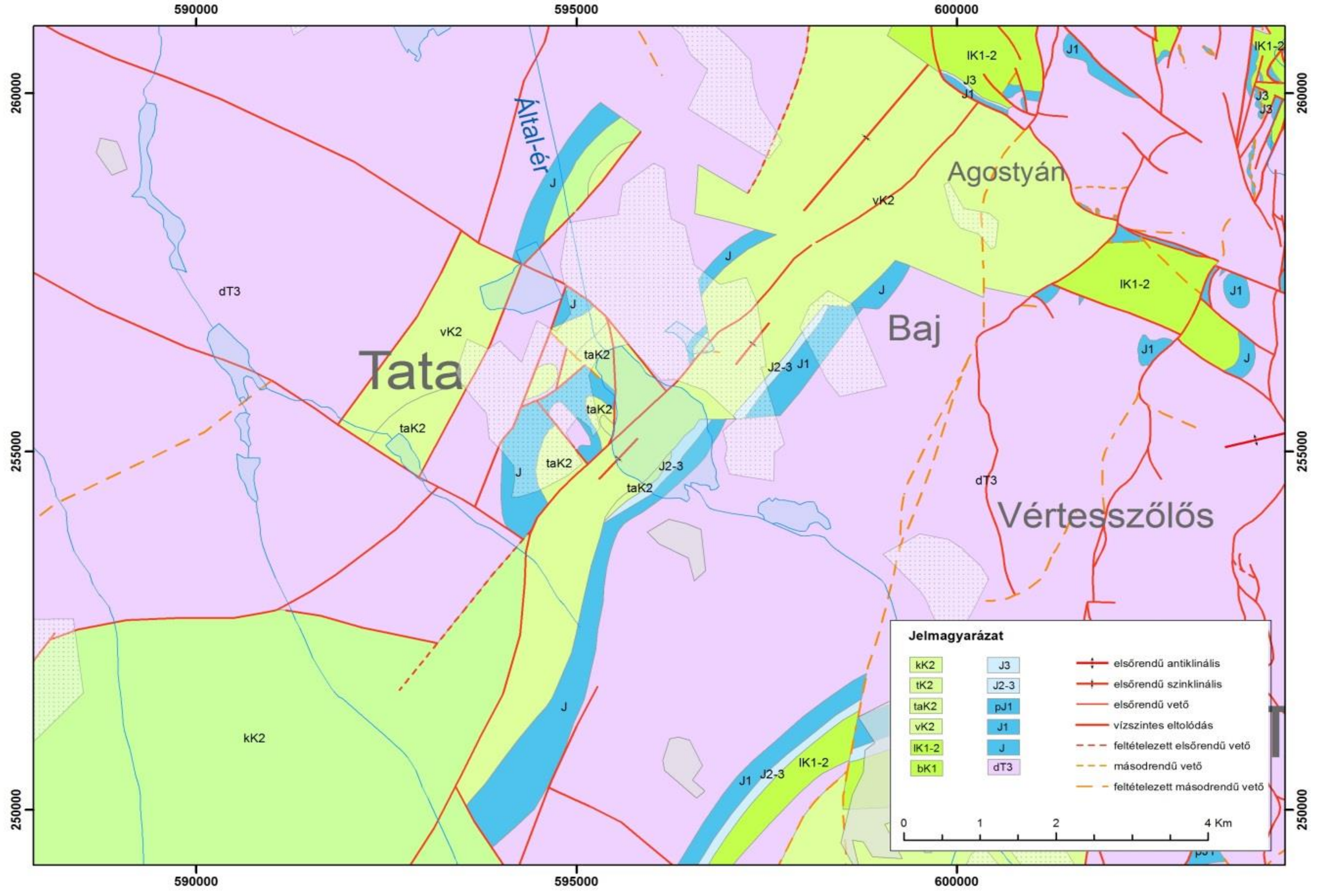
Geological conditions

- Triassic aquifer (>1000 m): Hauptdolomite, Dachstein Limestone
- Miocene confining layers: Száki marls (abscent at Kálvária hill)
- Quaternary shallow aquifers: Alluvial gravel, sand
- Intermediate aquifer: Pliocene Somlói Formation
- Springs located along faultlines
- Major outlet of the Transdanubian aquifer system

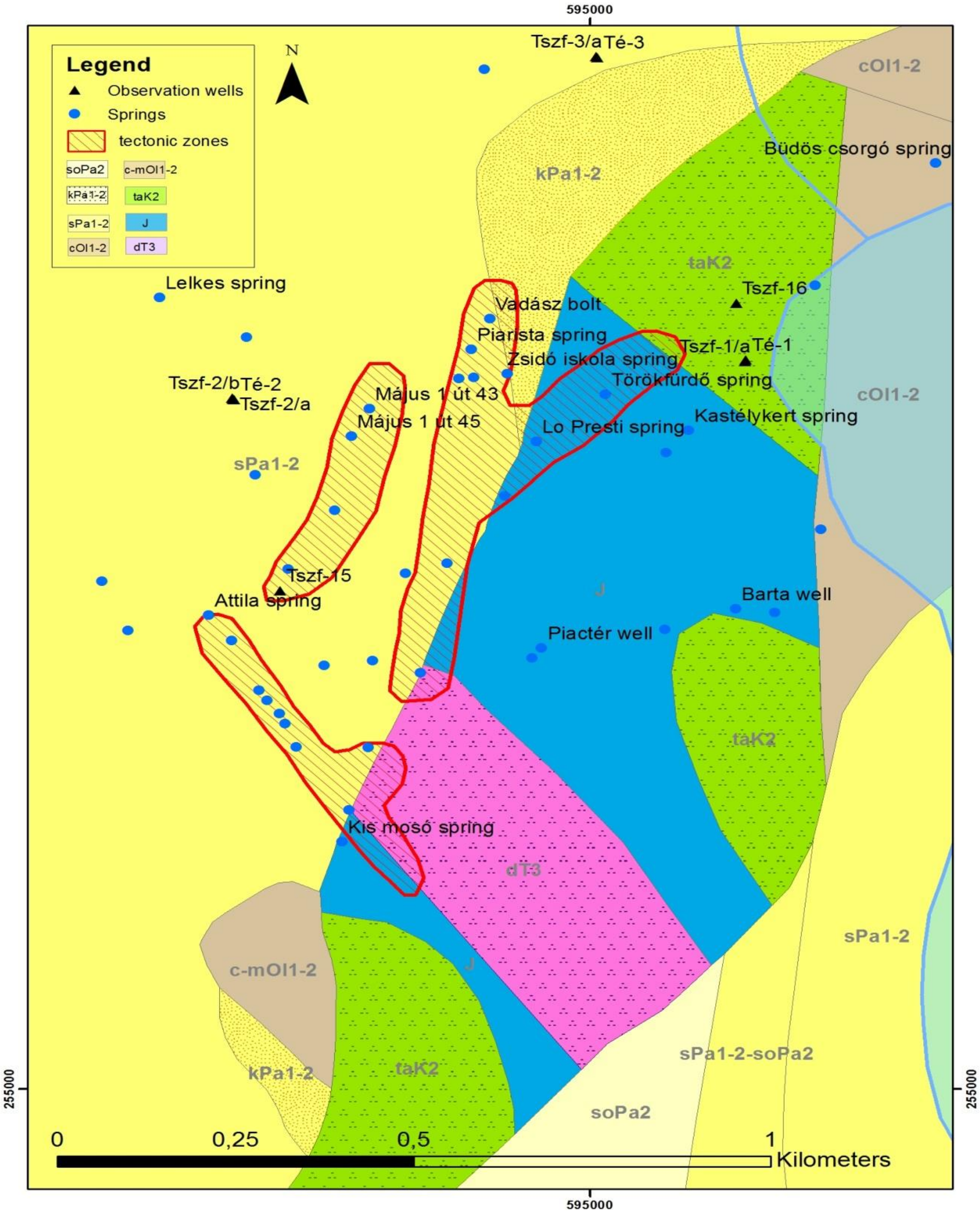
- Erosion base: Által stream
- Recharge area: Gerecse W, Vértes S, Bakony SW
- Q=76,000-156,000 L/min (Sárvári 1990, Horusitzki 1923)
- Flat gradient: i=0,001-0,0005
- T= 15-22 C°
- H=137 mASL at the moment
- Before mining H=140 m



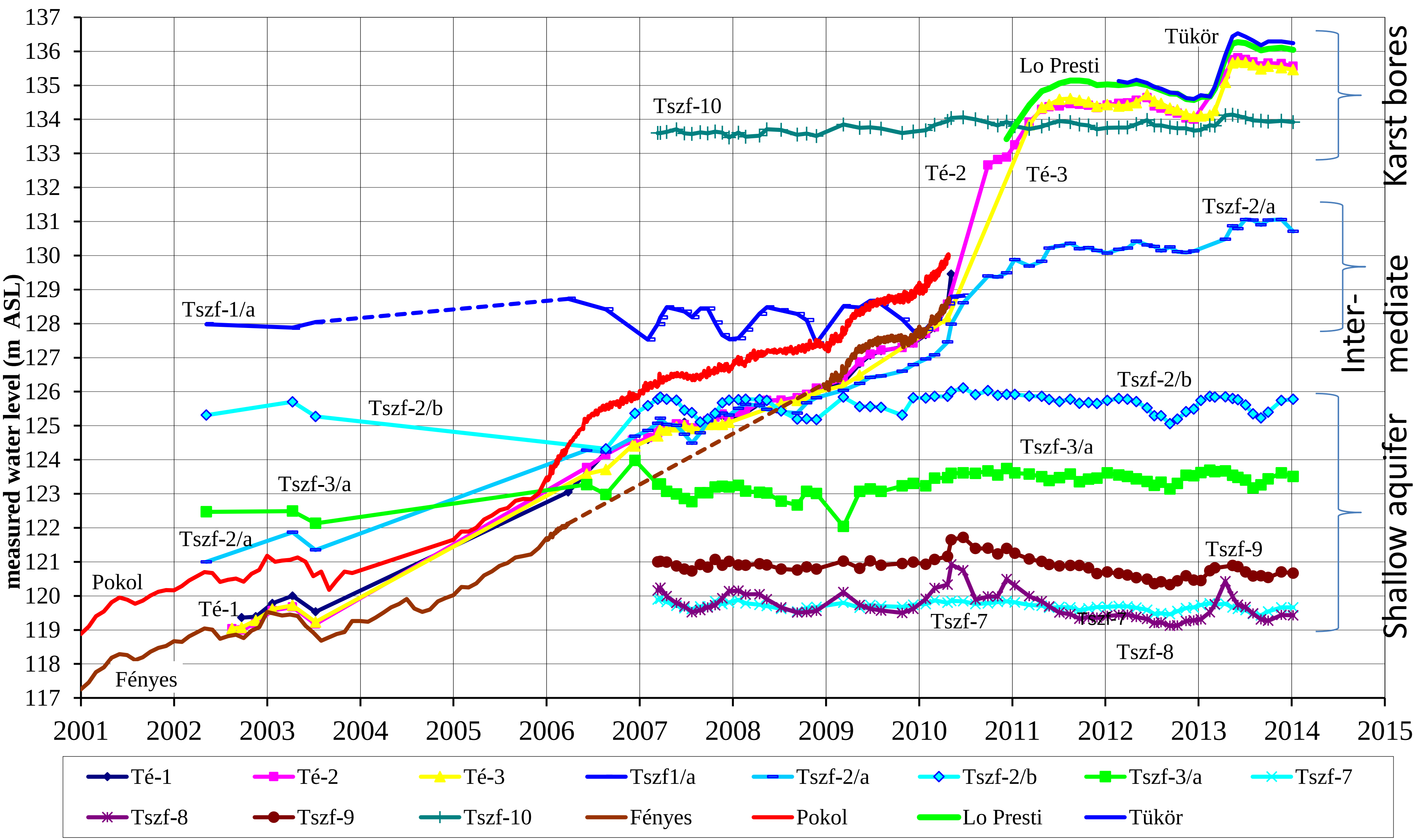
Mesosoic basement



Tectonic control

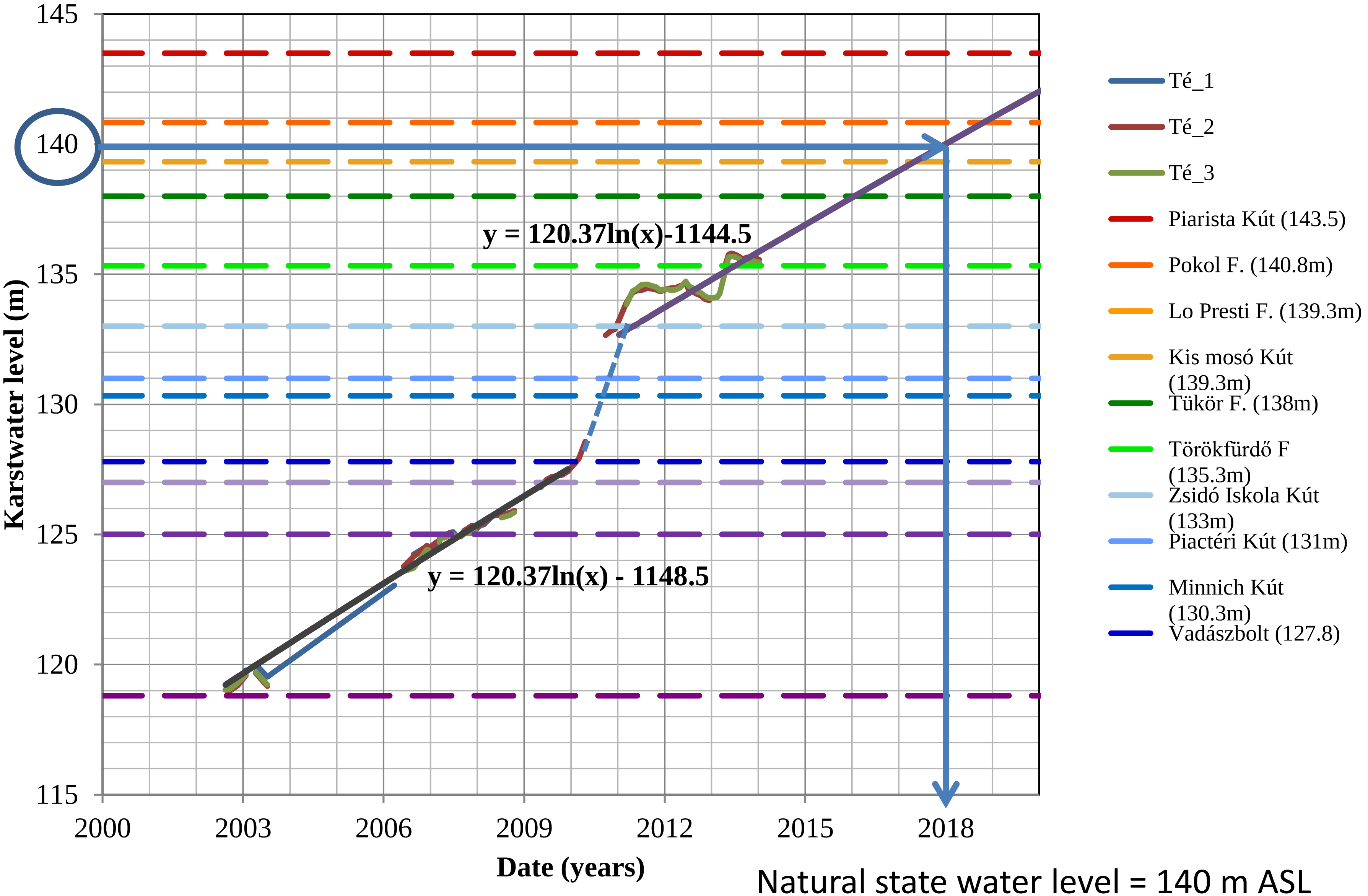


Water level monitoring around Tata



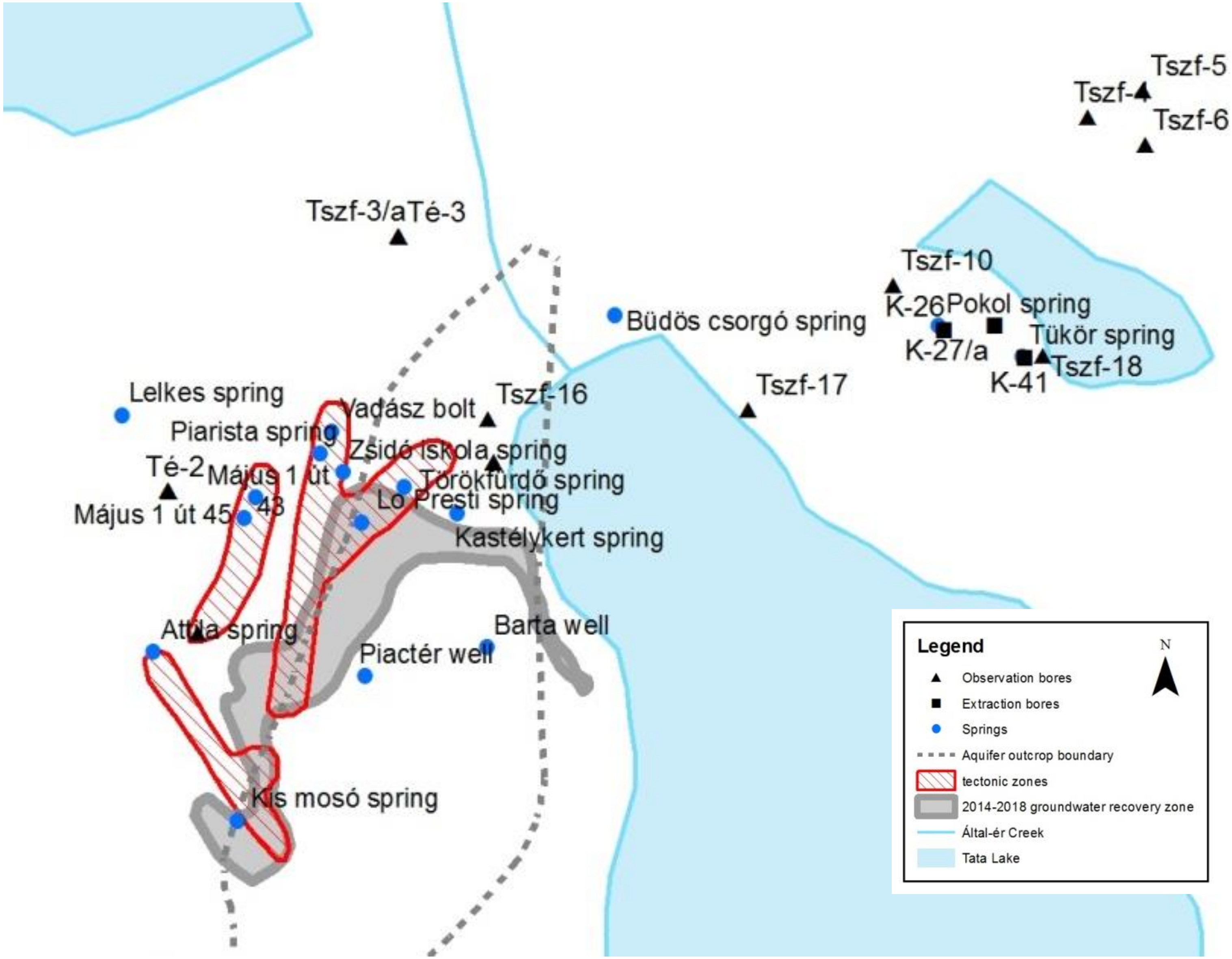
Groundwater level prediction

Logarithmic recovery based on Cooper-Jacob (1946) assumption

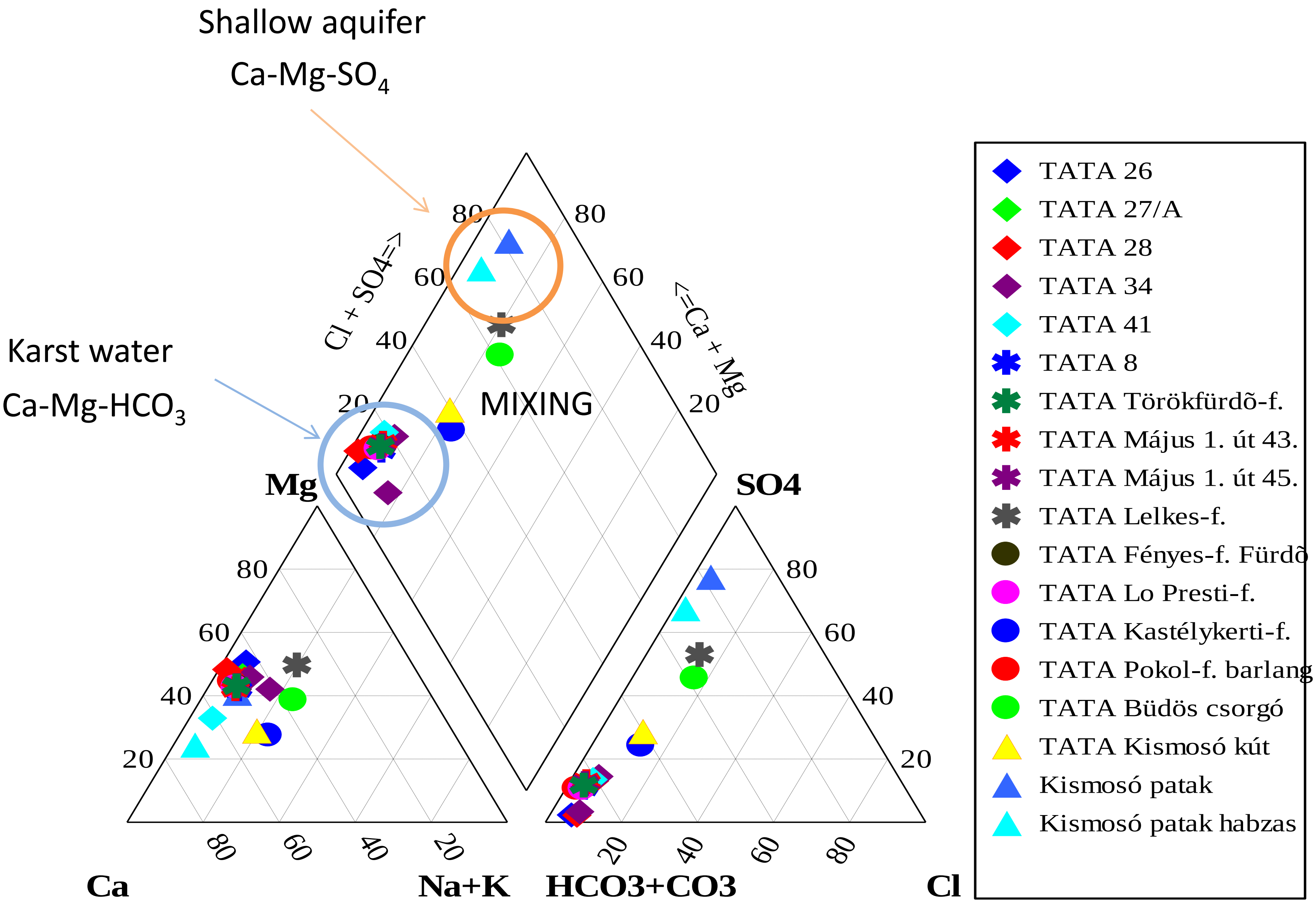


Natural state water level = 140 m ASL

Risk zones


Tszf-5
Tszf-4
Tszf-6
Tszf-3/aTé-3
Tszf-10
K-26
Pokol spring
Büdös csorgó spring
Tükör spring
K-27/a
Tszf-18
K-41
Tszf-17
Lelkes spring
Vadász bolt
Tszf-16
Piarista spring
Zsidó iskola spring
Té-2
Május 1 út 43
Törökfürdő spring
Lo Presti spring
Május 1 út 45
Kastélykert spring
Attila spring
Barta well
Piactér well
Kis mosó spring
Legend
N
▲ Observation bores
■ Extraction bores
● Springs
Aquifer outcrop boundary
tectonic zones
2014-2018 groundwater recovery zone
Által-ér Creek
Tata Lake

Water chemistry of springs



Shallow aquifer

Ca-Mg-SO_4

Karst water

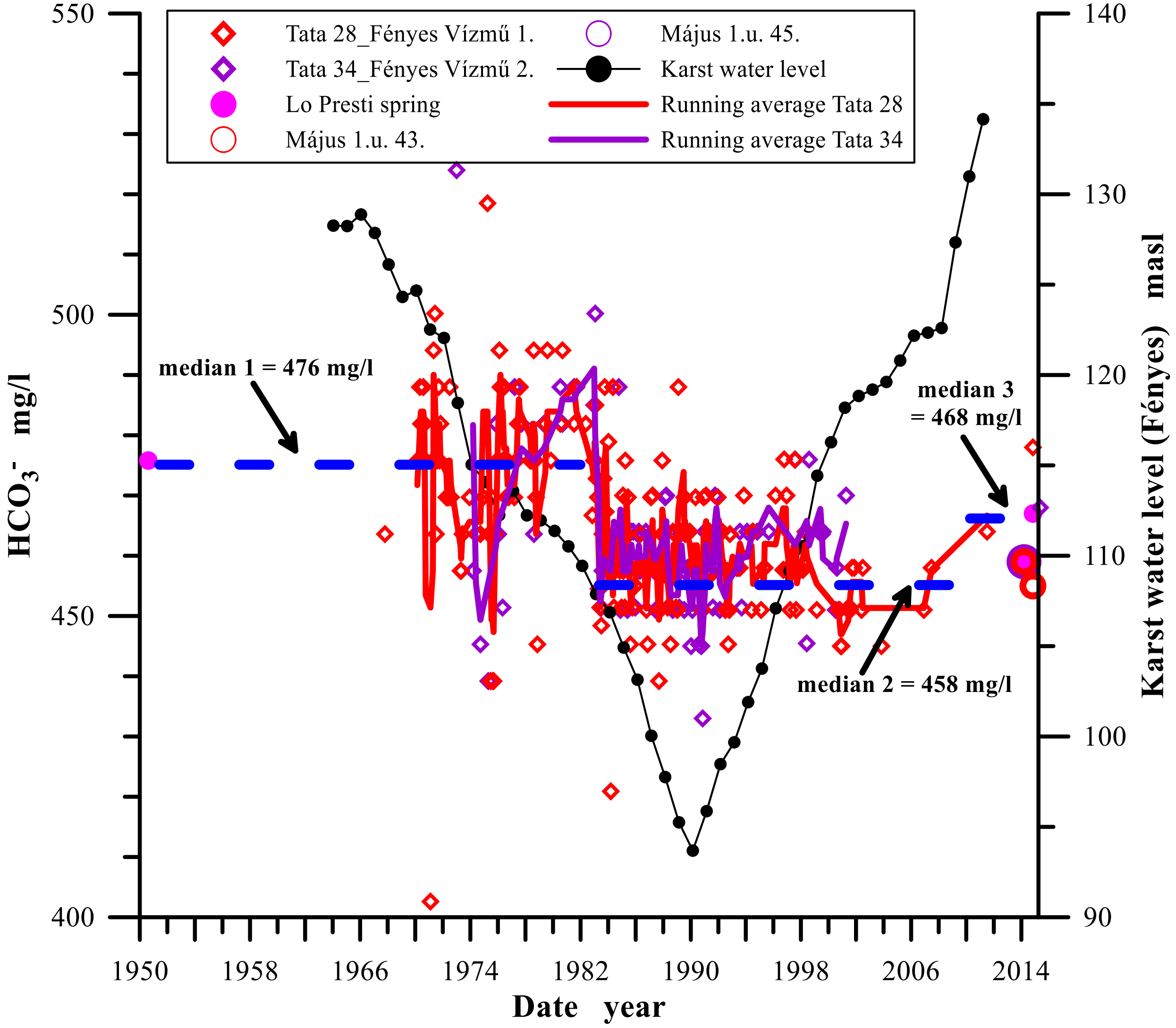
Ca-Mg-HCO_3

MIXING

Hydrochemical properties

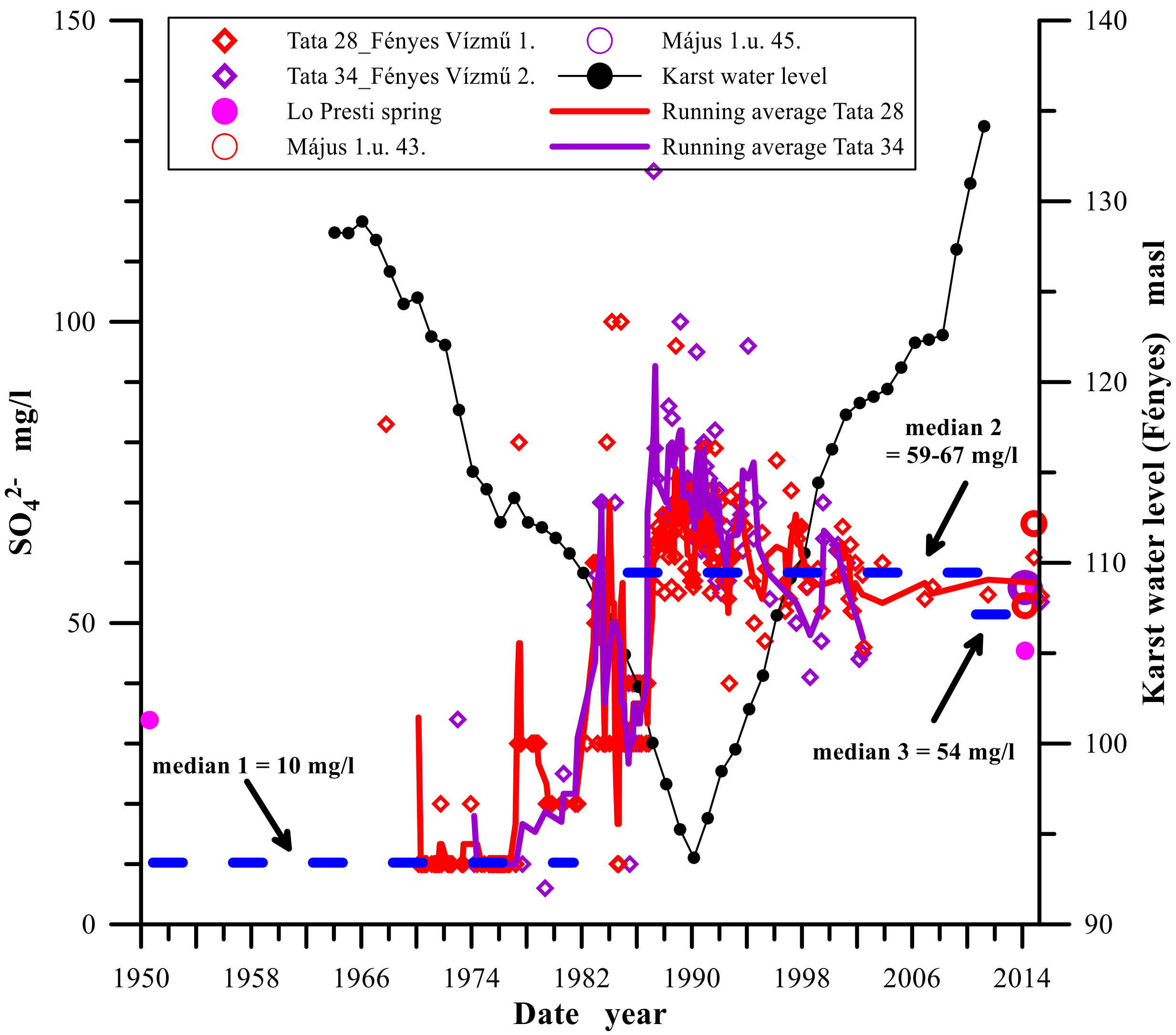
- Karstwater: Ca-Mg-HCO_3 water type → Dolomitic aquifer
- Karstwater: Fényes-forrás, Lo Presti forrás, Törökfürdő forrása, Pokol forrás, Zsidó iskola kútja, a Május 1. út 43 és 45,
- Kastélykert spring and Kismosó well: Ca-Mg-HCO_3-SO_4 water type → local contamination (Nitrate) / mixing with shallow gw
- Lelkes spring and Büdös spring: Mg-Ca-SO4-HCO3 water type
- Shallow gw (TSZF): Diverse chemical composition, mainly Ca-Mg-$HCO_{3-}SO_4$ water type
- Shallow gw chemistry reflects geology and contamination (Nitrate)

Changes of bicarbonate concentrations



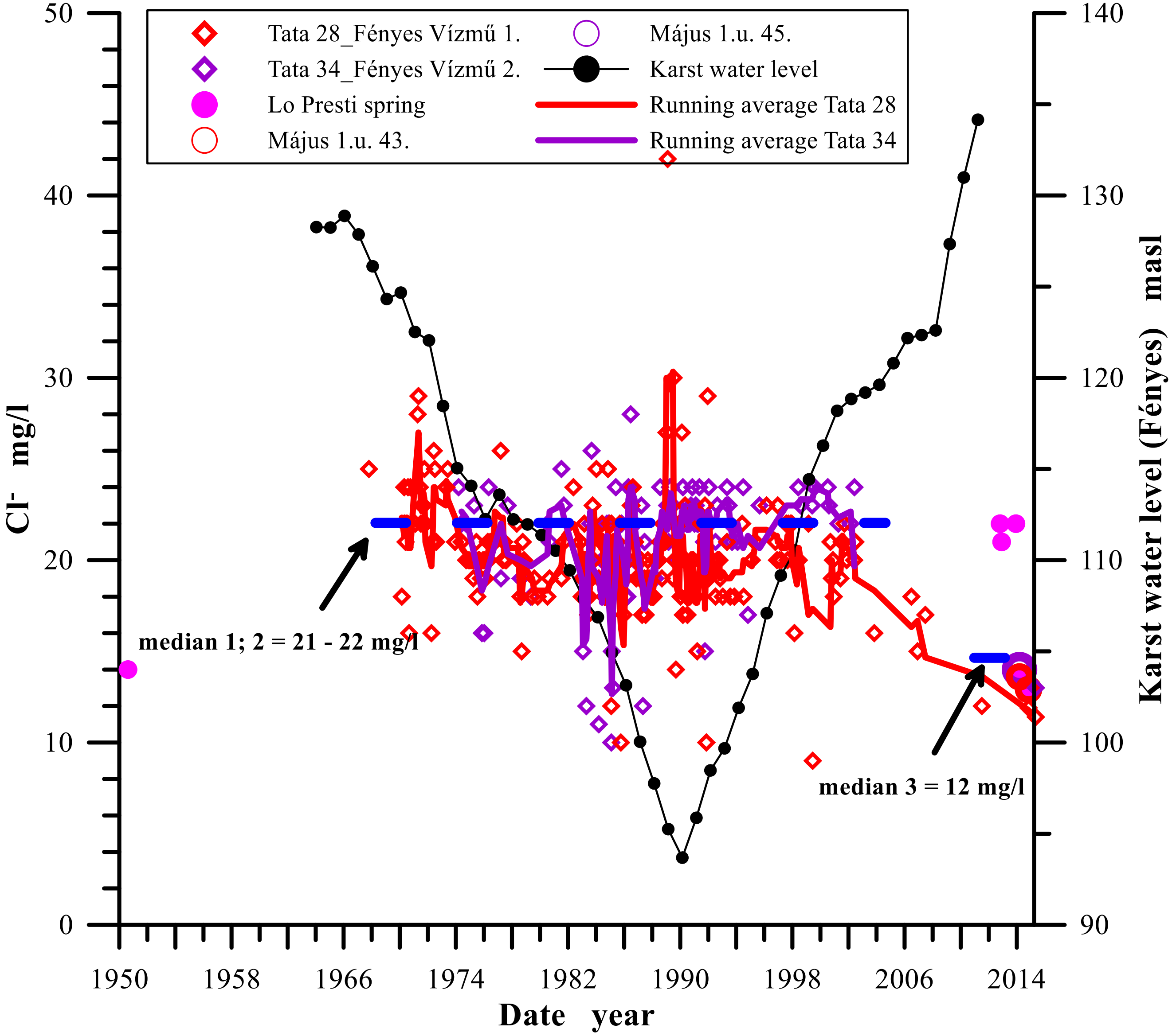
- Decreasing from 1983 to 2004, then rising

Changes of sulphate concentrations



- Rising from 1978 till 1990, then falling

Changes of chloride concentrations

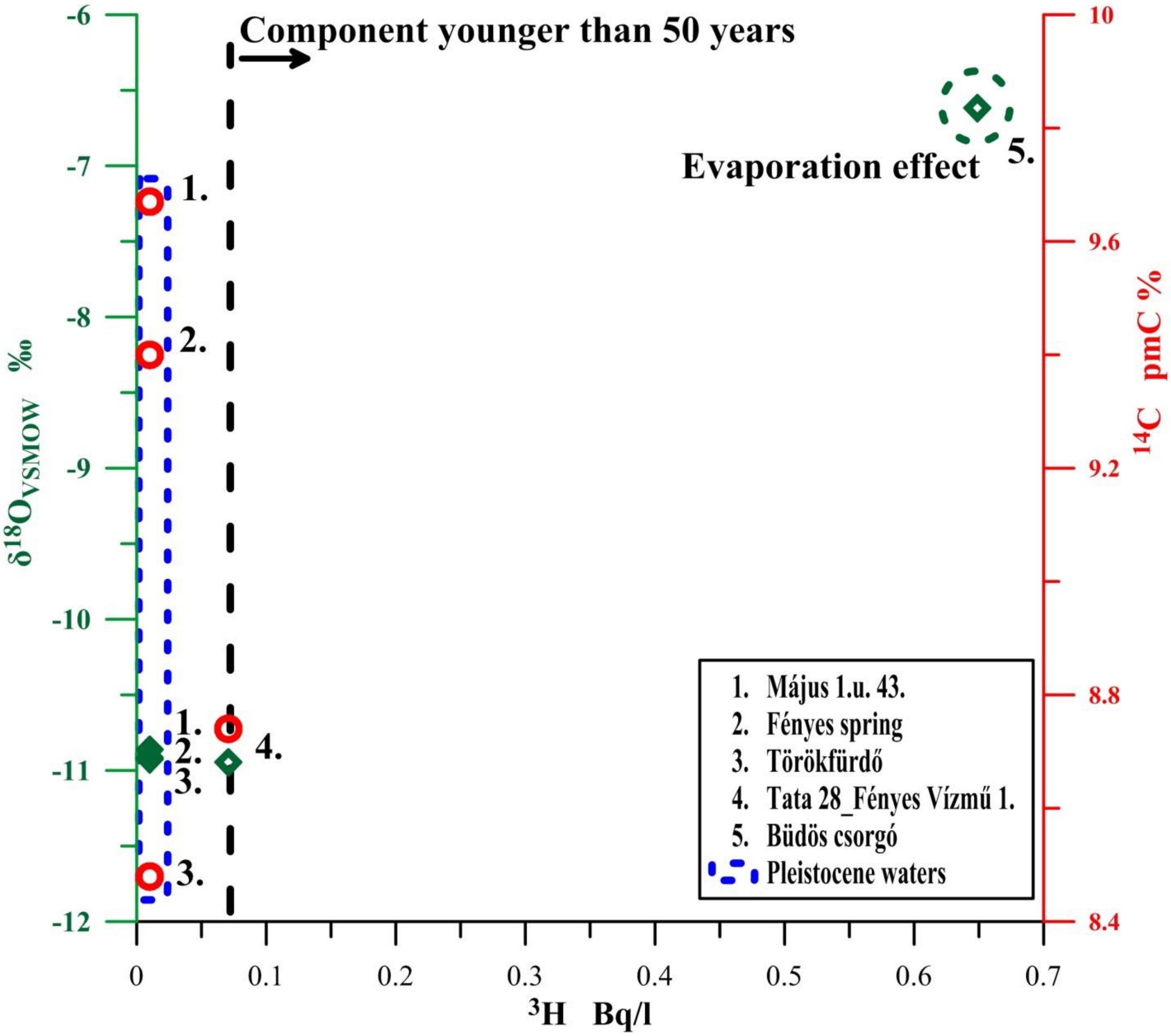


- Stable till 2002, then falling

Temporal hydrochemical variations

- Hydrochemical response of the groundwater system given to large-scale aquifer dewatering.
- Concentration rebound at mid-2000’s → hydrochemical recovery of the groundwater system.
- HCO_3 concentration decreases in response to gw extraction, increases during recovery.
- SO_4 concentration increases in response to gw extraction, decreases during recovery.
- Cl concentration stable during extraction, decreases during recovery.
- Delay of 10-20 years between dewatering changes and hydrochemical changes.
- Hydrochemical changes presumably caused by the reversal of hydraulic gradients and the subsequent changes in regional flow directions (NE ↔ SW).

Isotope geochemical characteristics



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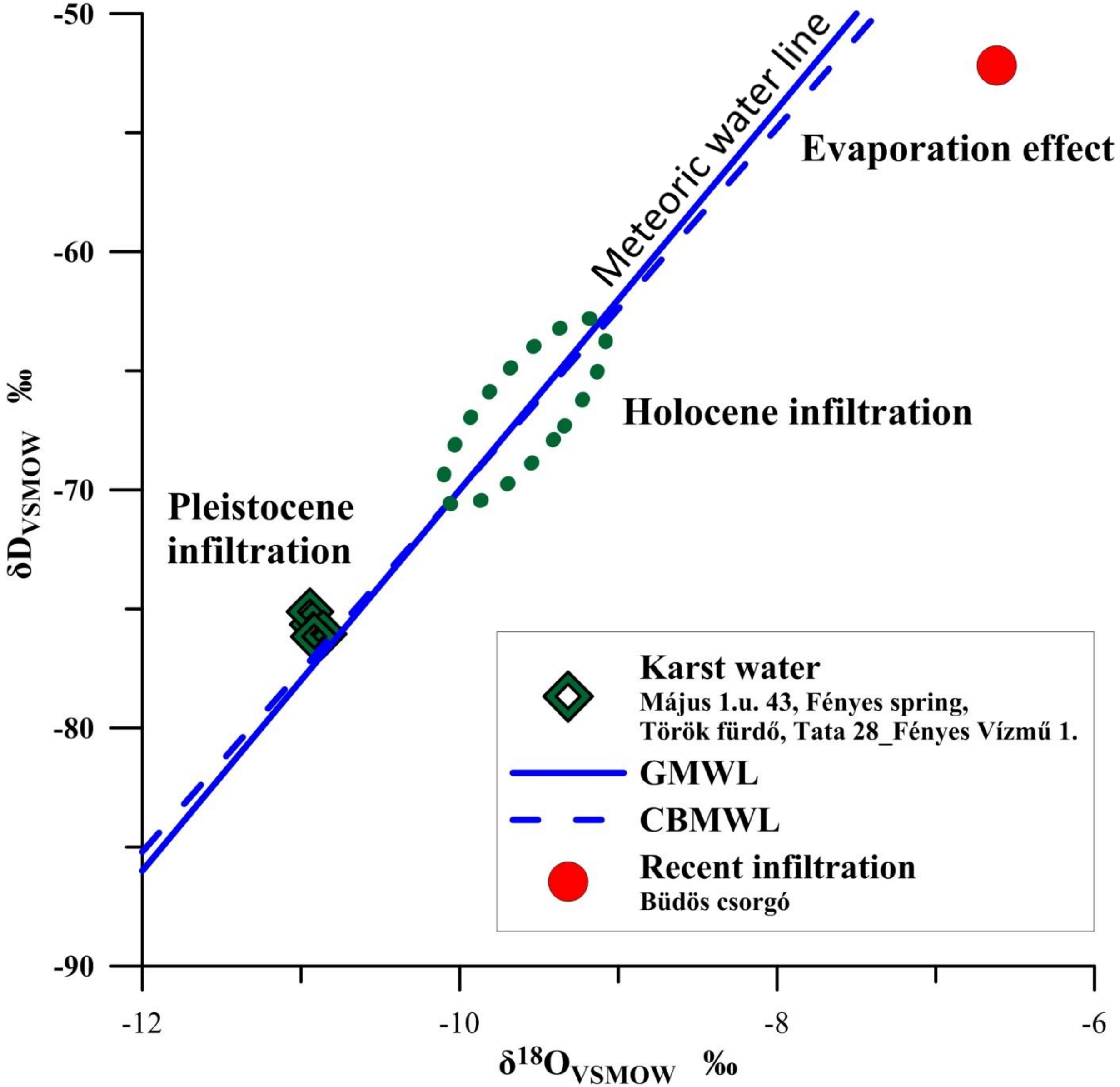
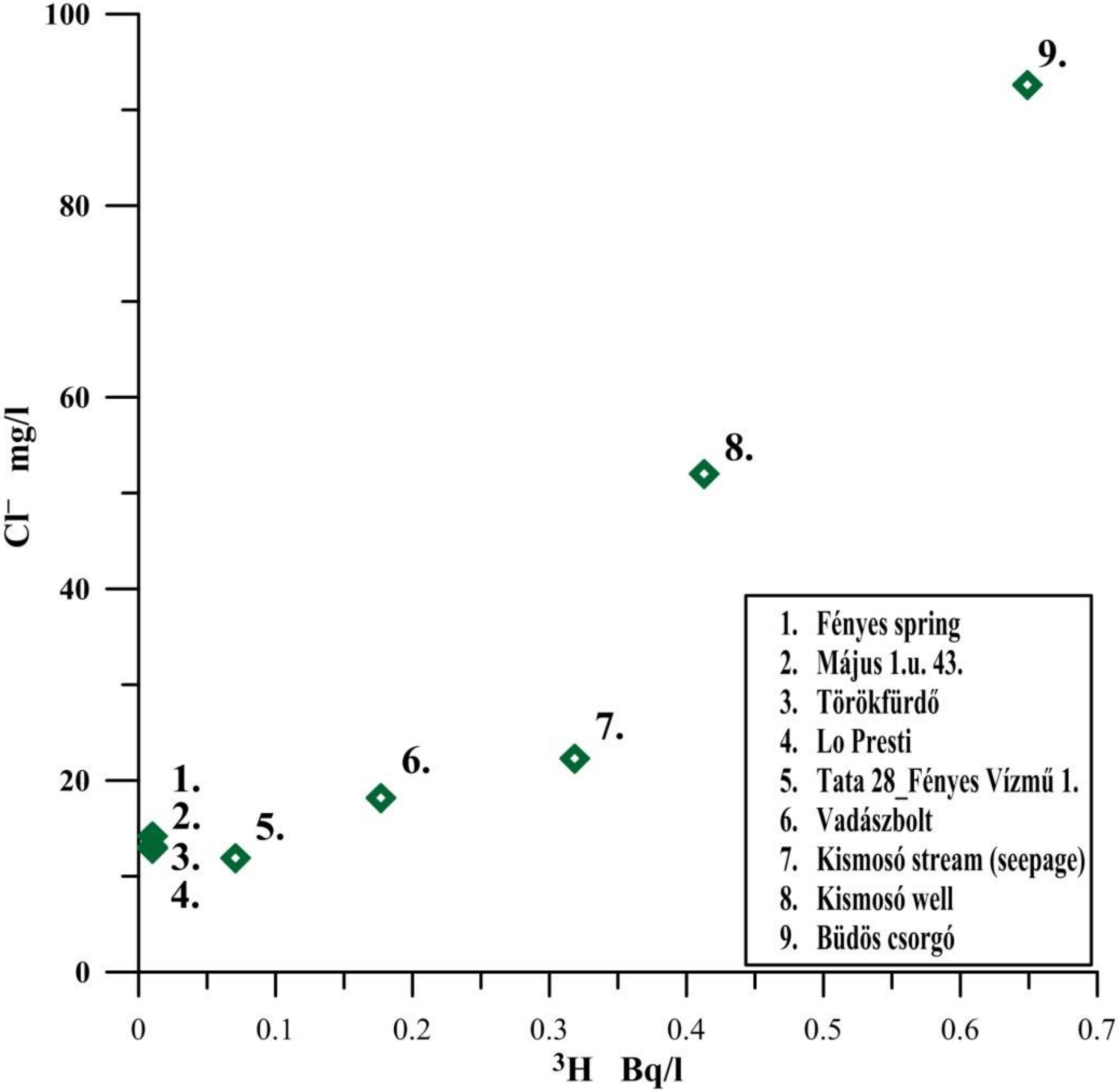


Isotope geochemical characteristics

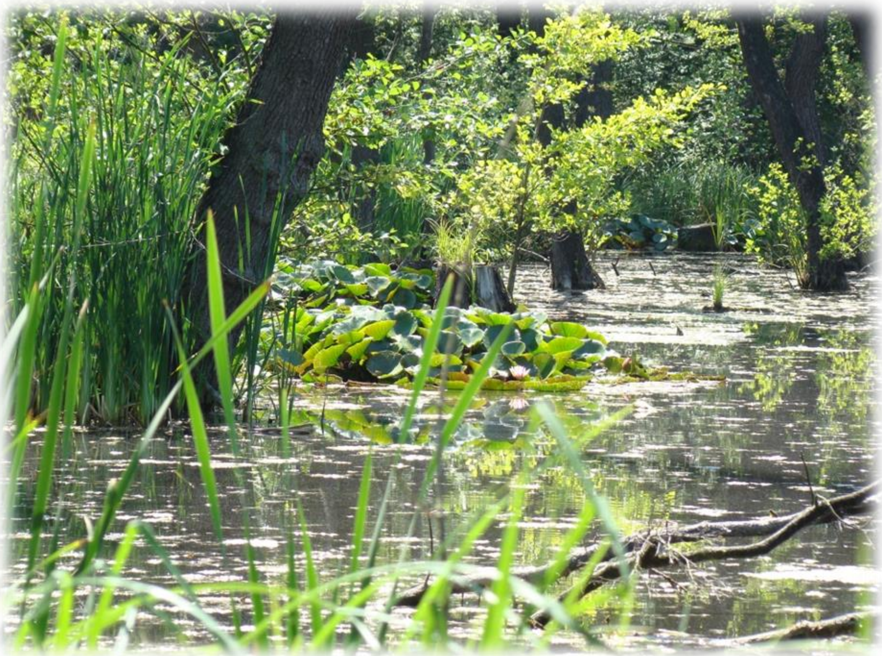


Isotope geochemical characteristics

- Karstwater <0,5 TU → No components younger than 50 yrs
- Radiocarbon ages calculated by the Carbon-13 correction between 11800 -13100 years.
- Karstwater: Pleistocene recharge
- Kismosó well and Büdös well: recent infiltration
- Parallel increase in ^{3}H and Cl indicates mixing with shallow gw

Summary

- Mine dewatering related to bauxite and coal mining from the beginning of the 1950’s
- 1970’s significant settlement developments → environmental problems
- Spring located along tectonic zones, confining layers not „impermeable”
- Since the late 90’s the karst water table has risen by more than 40 metres in the Tata area
- Further spring reactivation until 2018, and further water level rise predicted
- Hydraulic recovery by ~2018, geochemical recovery takes long time
- Drawdown and recovery → changes in flow directions → hydrochemical changes
- 10-20 yrs lag of chemical changes compared to extraction/recovery
- Most springs discharge karstwater. Kastélykerti spring, Kismosó well, Vadászbolt → mixing with shallow groundwater. Büdös csorgó kút → atypical chemistry, isolated shallow aquifer
- Pleistocene infiltration of karst waters
- Rising karst water level – „good” for ecosystems, „bad” for constructed environment
- Complex settlement planning and development should be based on regional hydrogeological understanding and on hydrogeological models



Thanks for your attention!