Groundwater-related environmental phenomena in complex geologic setting of the Tihany Peninsula, Hungary

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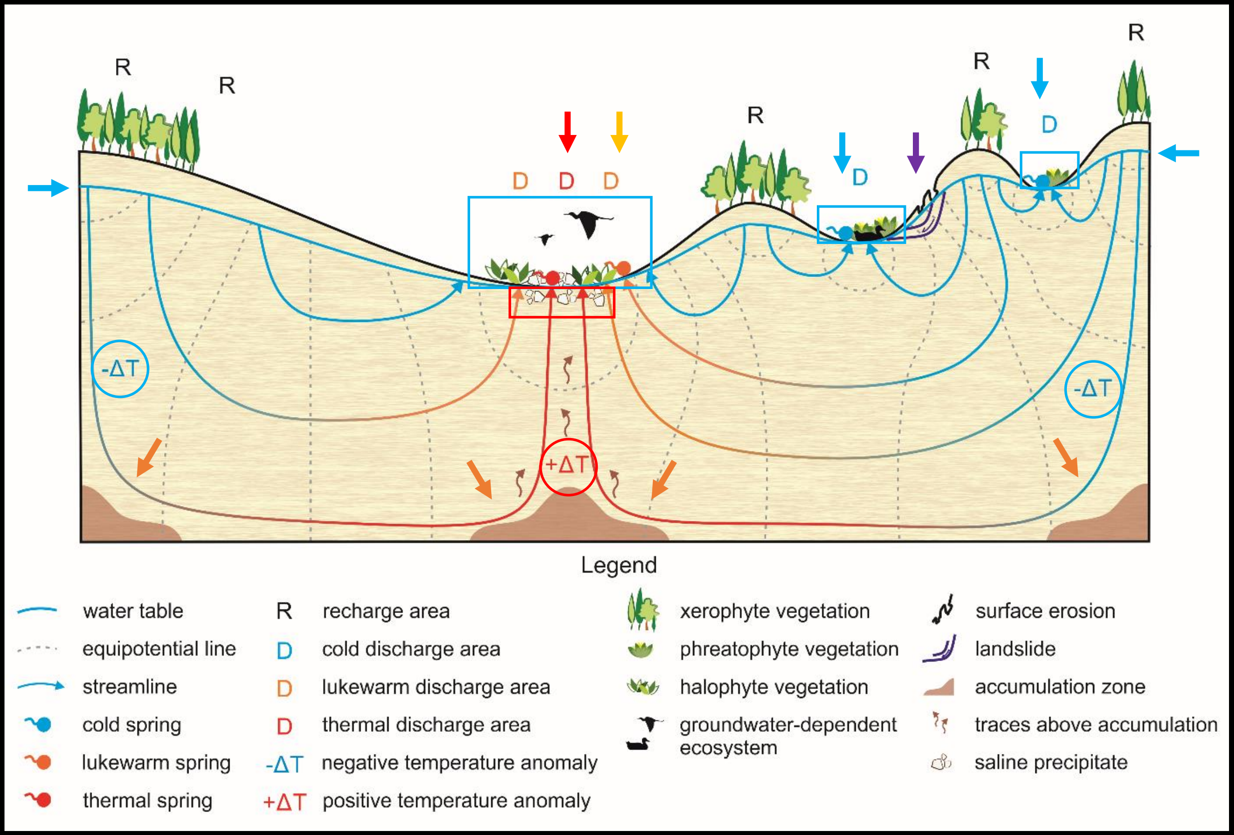
Flowing groundwater as environmental agent



Natural conditions and phenomena due to environmental agency of flowing groundwater in drainage basin (Tóth Á. et al. 2016 modified after Tóth J. 1999)

2. Aims of the study

Natural environmental phenomena

→ **numerical simulation**

Complex geologic framework and/or
A priori information is restricted

→ **geophysical** measurements

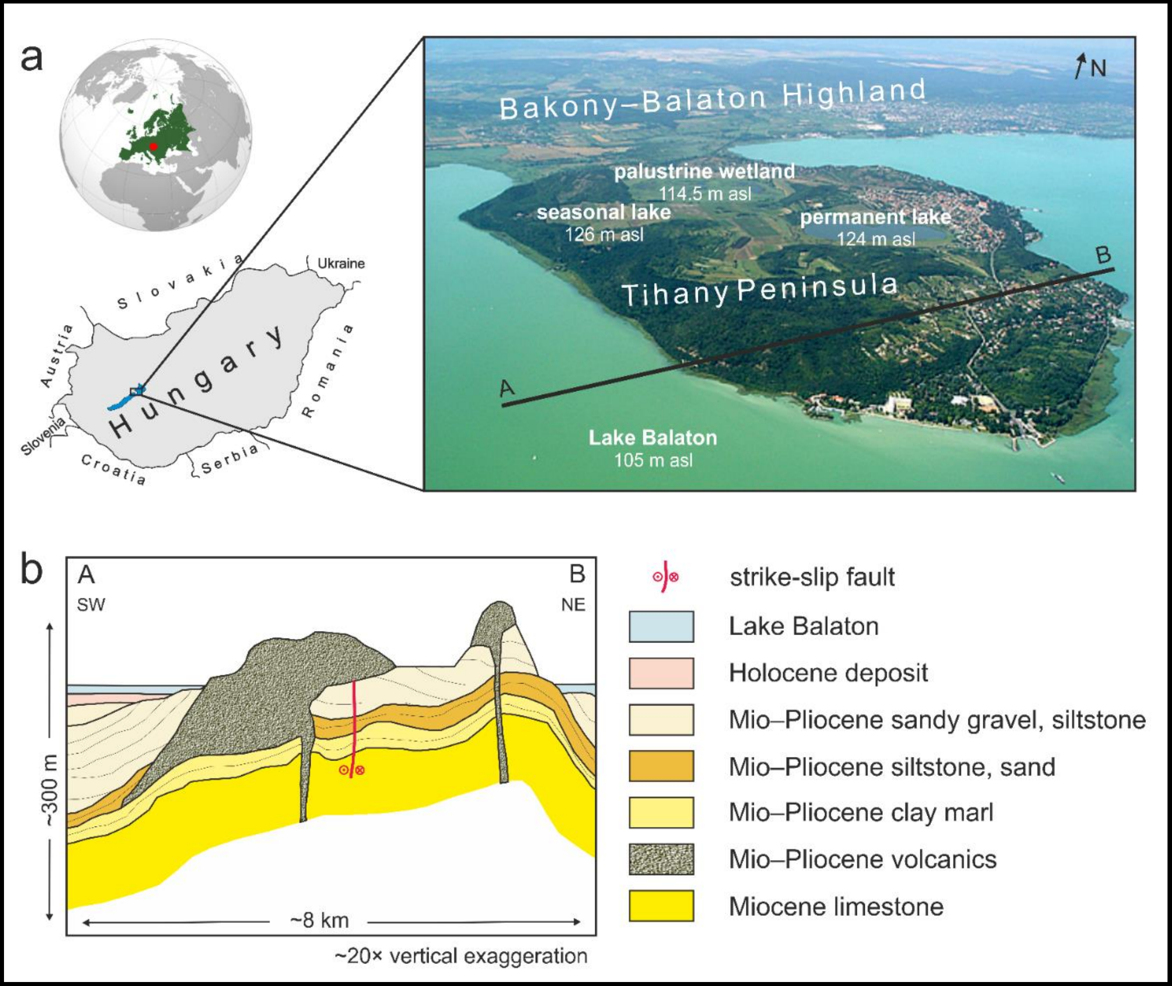
Integrated model construction

→ geologic–hydrogeologic–geophysical data

Groundwater flow model

→ depicting the **hierarchical** flow and **discharge pattern**
→ understanding the **environmental features**
→ revealing the potential effect of **climate change** and **anthropogenic activity**

3. Study area



Topographic and geologic characteristics of the study area
(a) Aerial photo of the Tihany Peninsula, Hungary, Europe
(b) Geology along the cross section indicated in (a) (after Sacchi et al., 1999)
(Tóth Á. et al. 2016)

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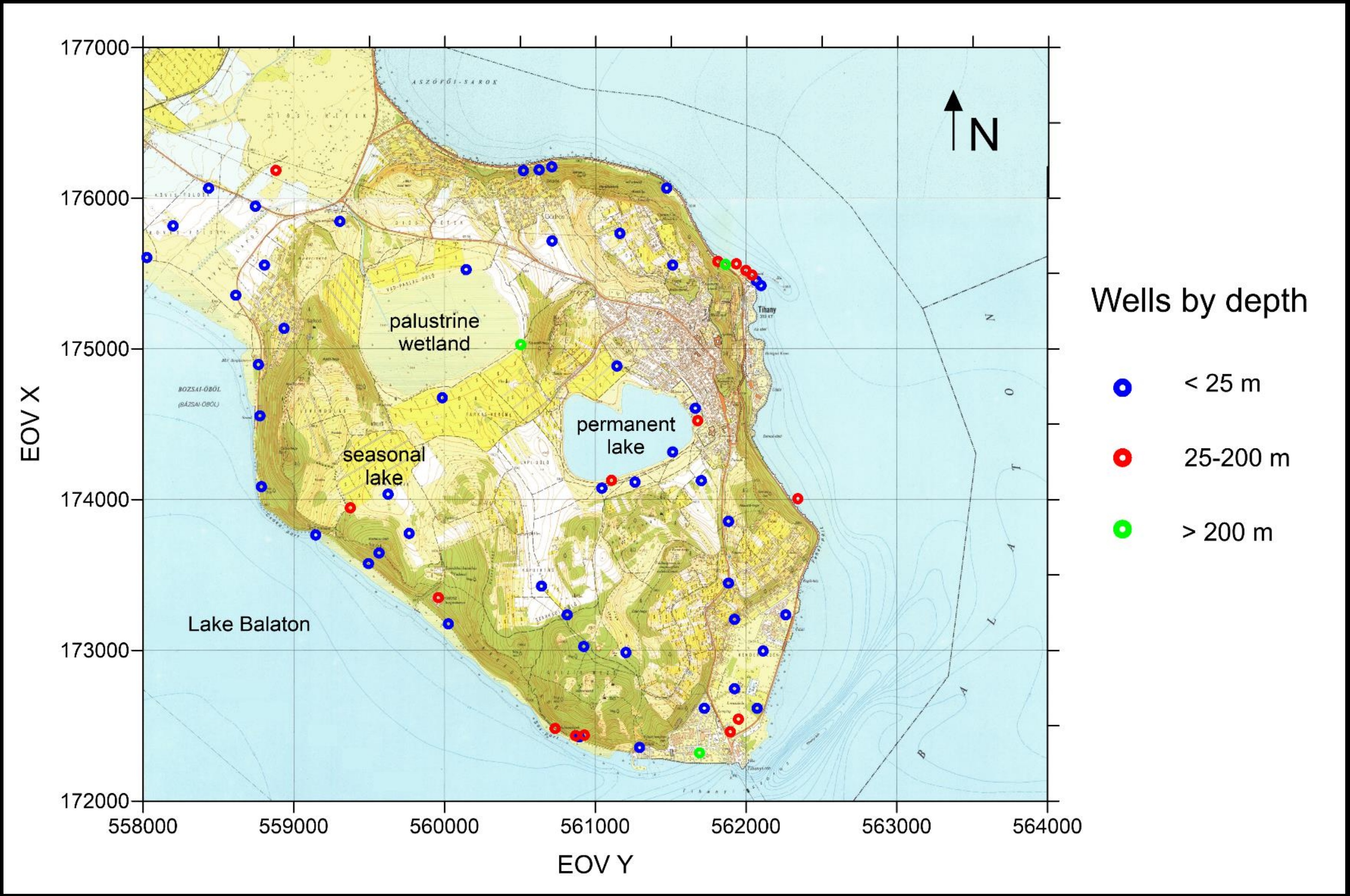
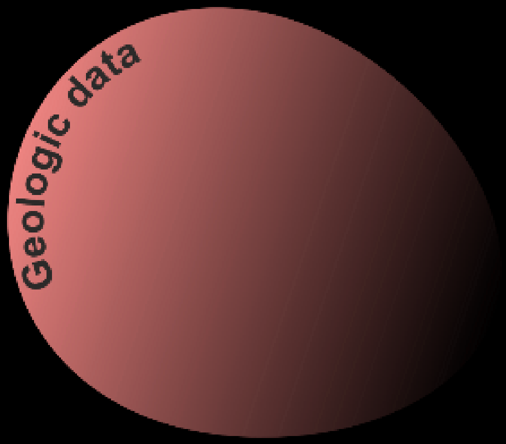


Spatial distribution of wells of the Tihany Peninsula

3. Workflow

Geologic data:

- volcanological studies
- geologic maps, sections
- boreholes



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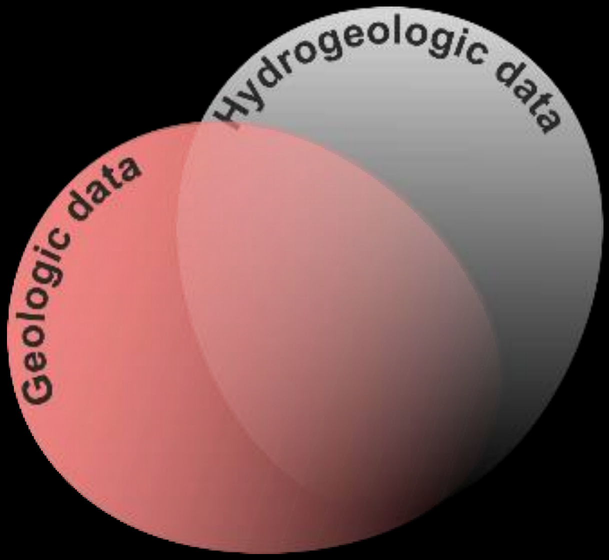

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Hydrogeologic data:

- pumping test
- water level
- potentiometers

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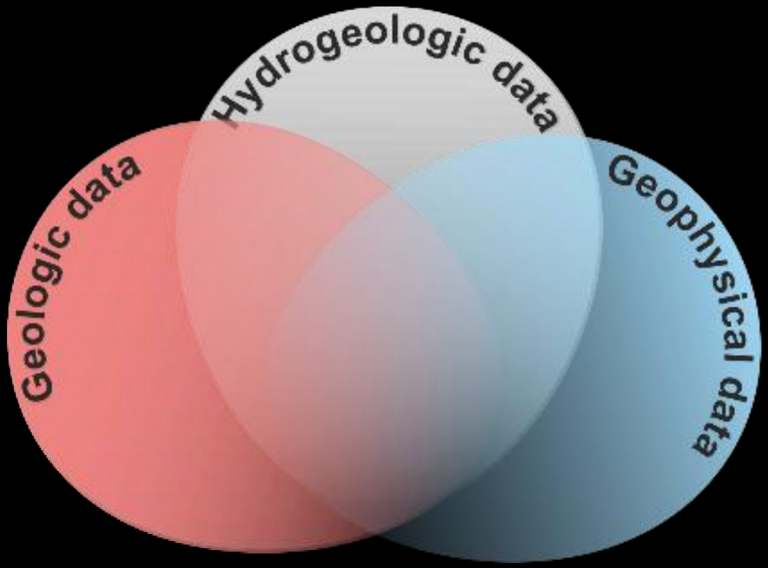

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Geophysical data:

- gravity
- geomagnetics
- reflection seismics
- electromagnetics

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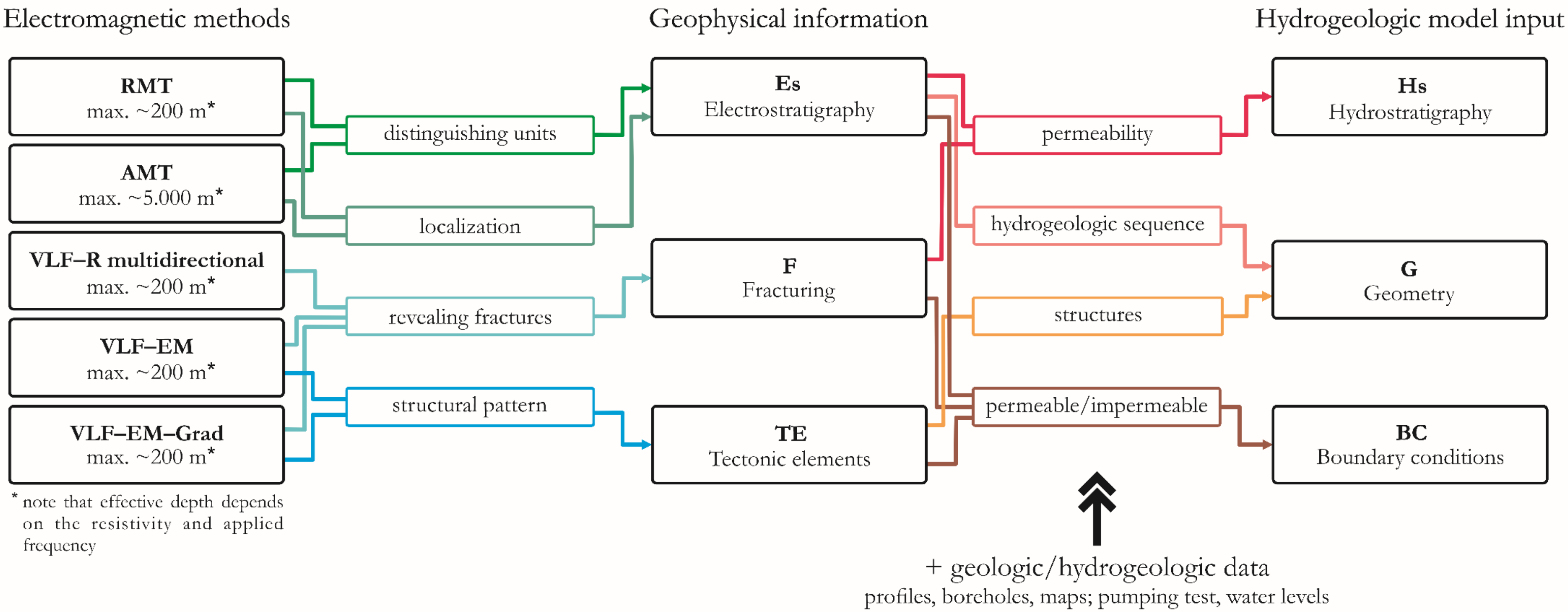

Flow chart of the applied scheme from applied electromagnetic methods via geophysical information to groundwater flow model input (Tóth Á. et al. 2016)

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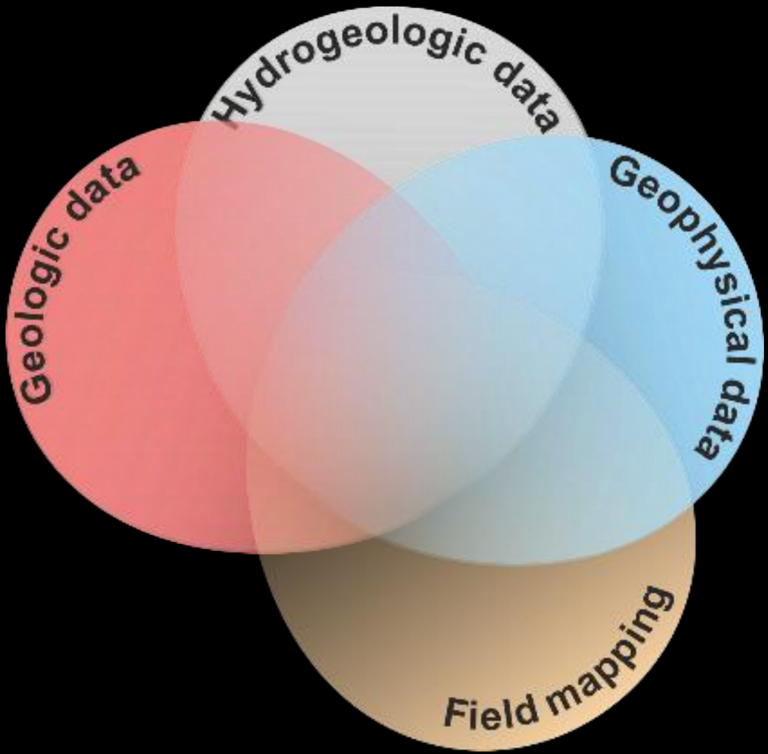

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Field mapping:
- vegetation
- slope instability
- springs

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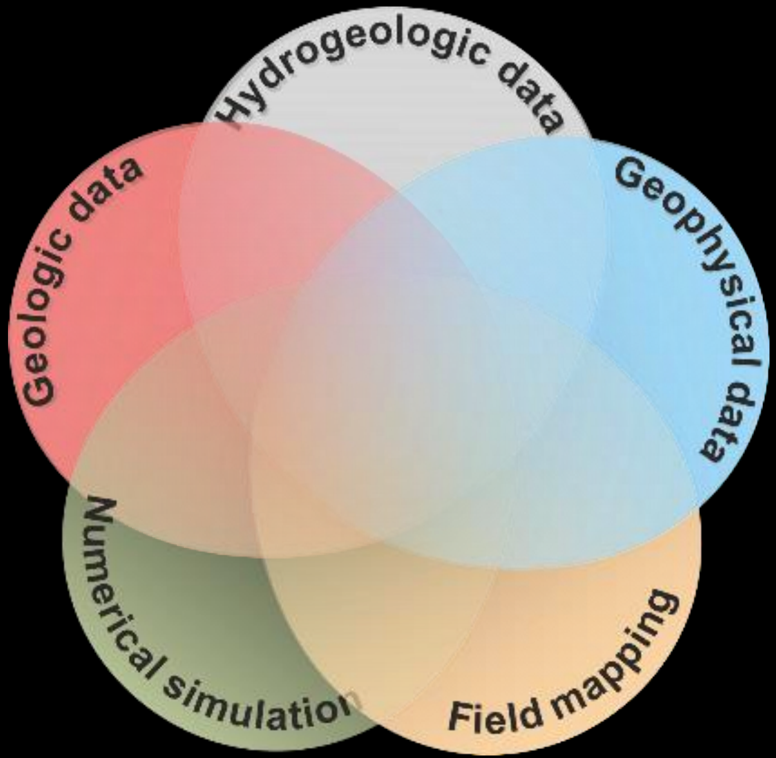

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Numerical simulation:
- groundwater flow pattern
- groundwater flow systems
- hydraulic connection

Field mapping:
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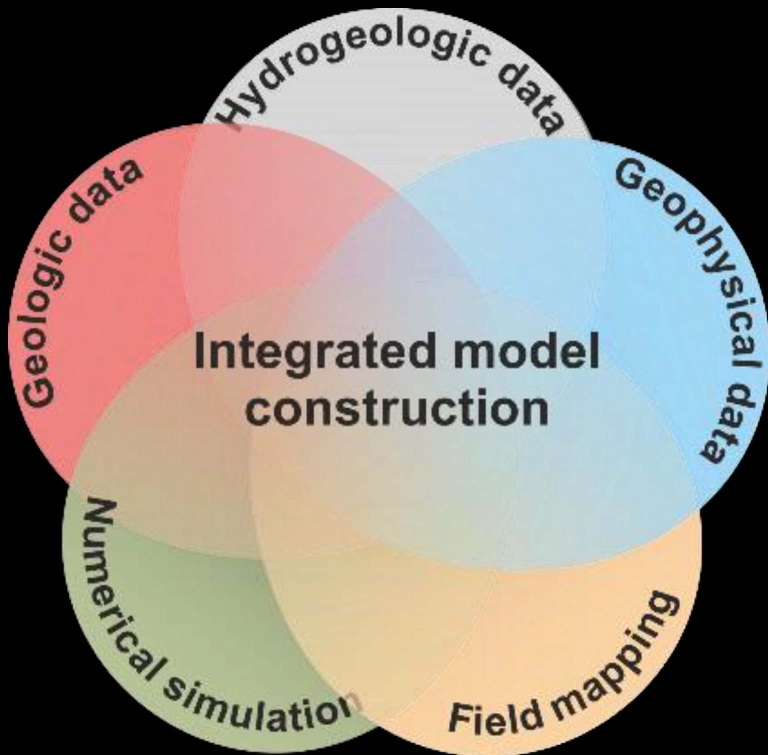

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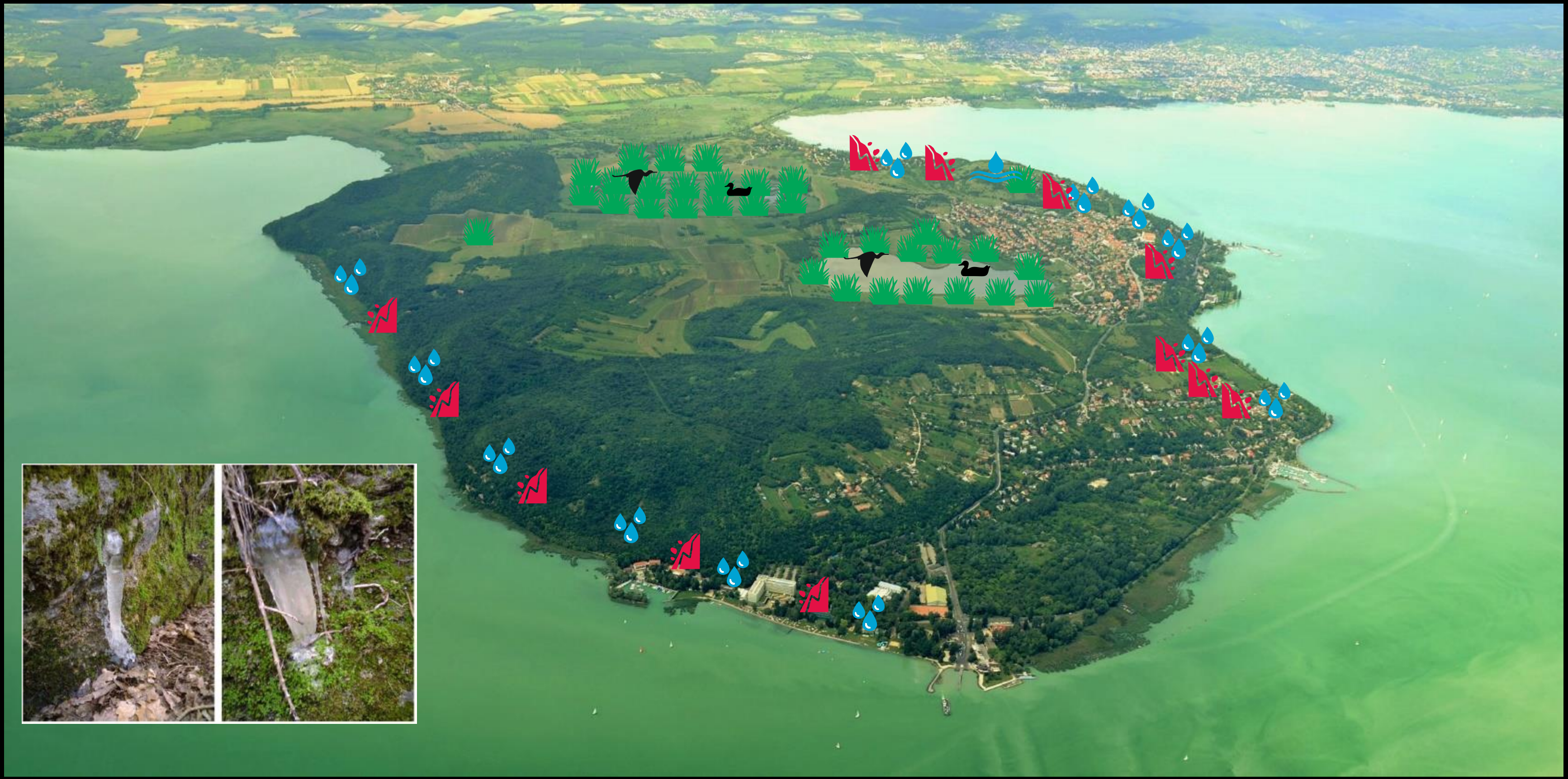
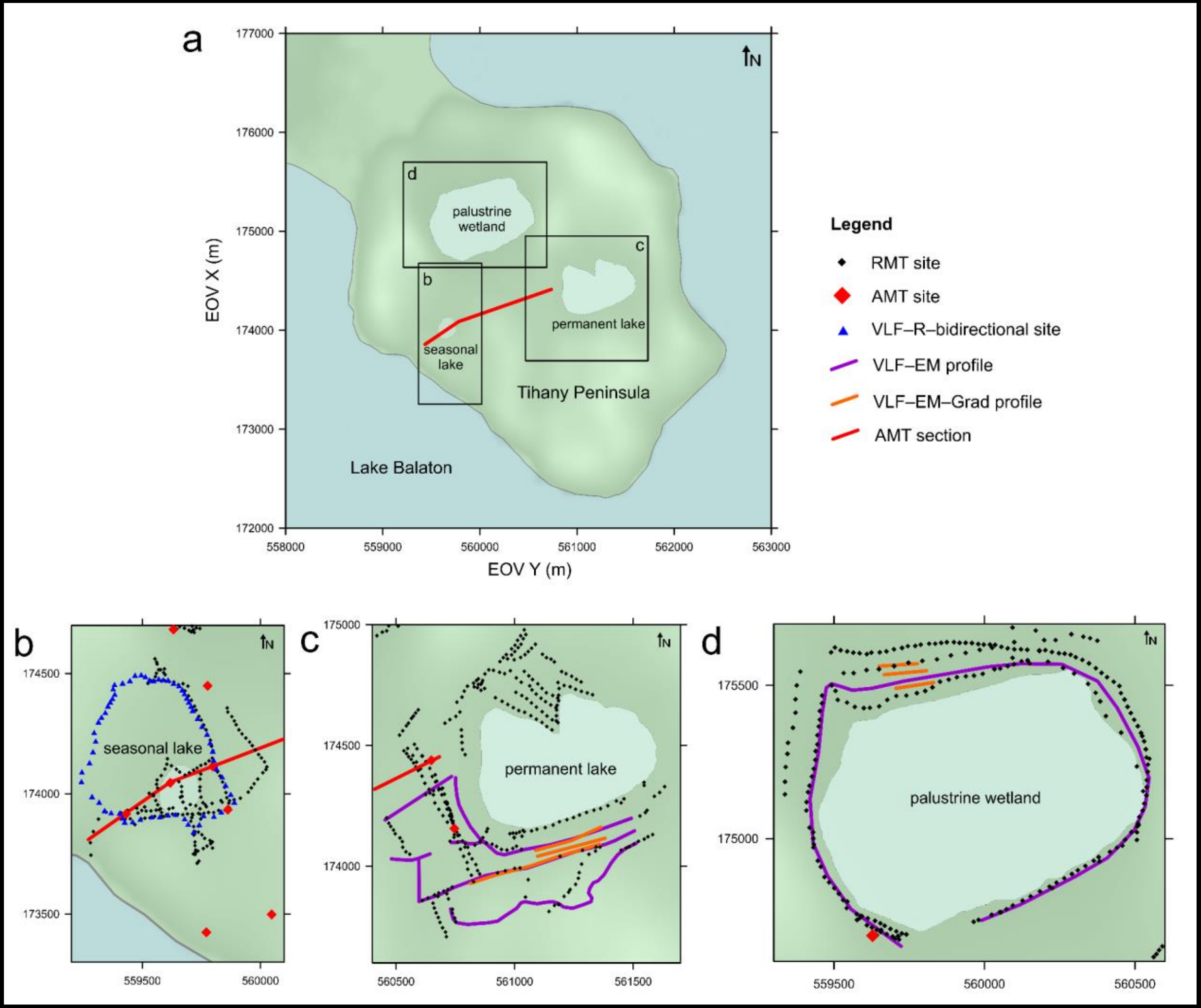
4. Results – Field mapping



Aerial photo of the Tihany Peninsula with the imprints of flowing groundwater

4. Results – Geophysical prospecting



Location of the geophysical measurements. (a) Schematic map of the Tihany Peninsula as a reference for b–d. Measurement sites in the vicinity of (b) the seasonal lake, (c) the permanent lake, (d) the palustrine wetland (Tóth Á. et al. 2016)

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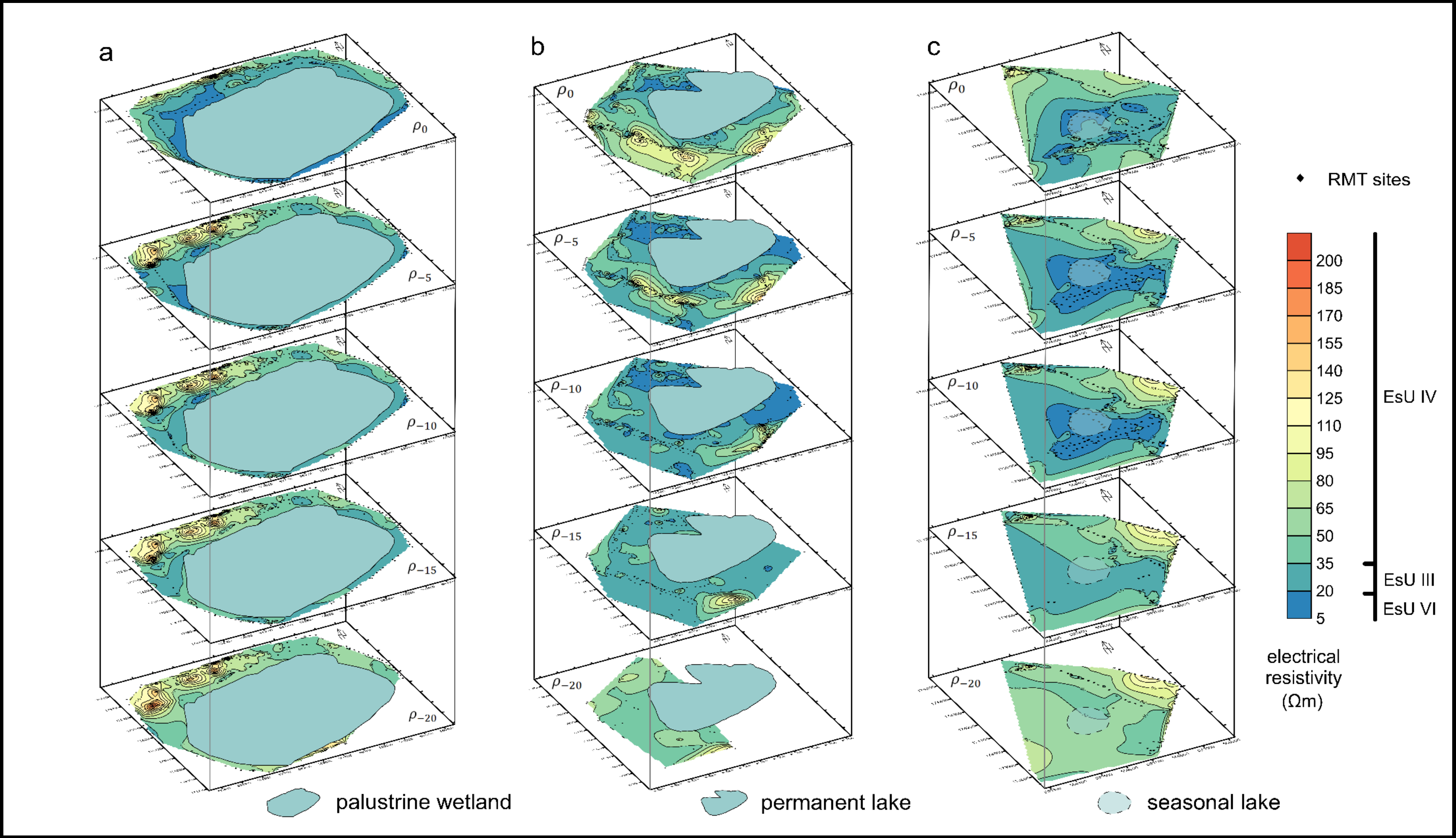


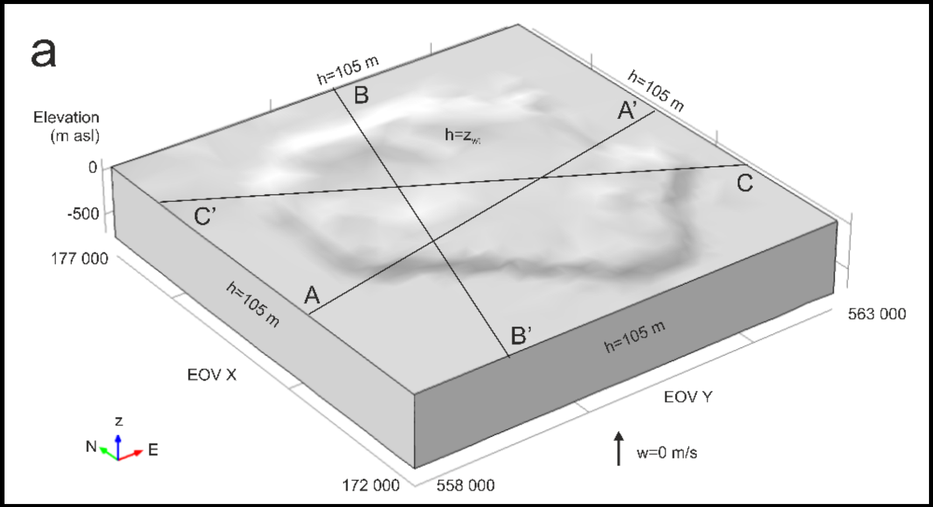
Resistivity maps indicating electrostratigraphic units based on RMT measurements for (a) the palustrine wetland, (b) the permanent lake, and (c) the seasonal lake (Tóth Á. et al. 2016)

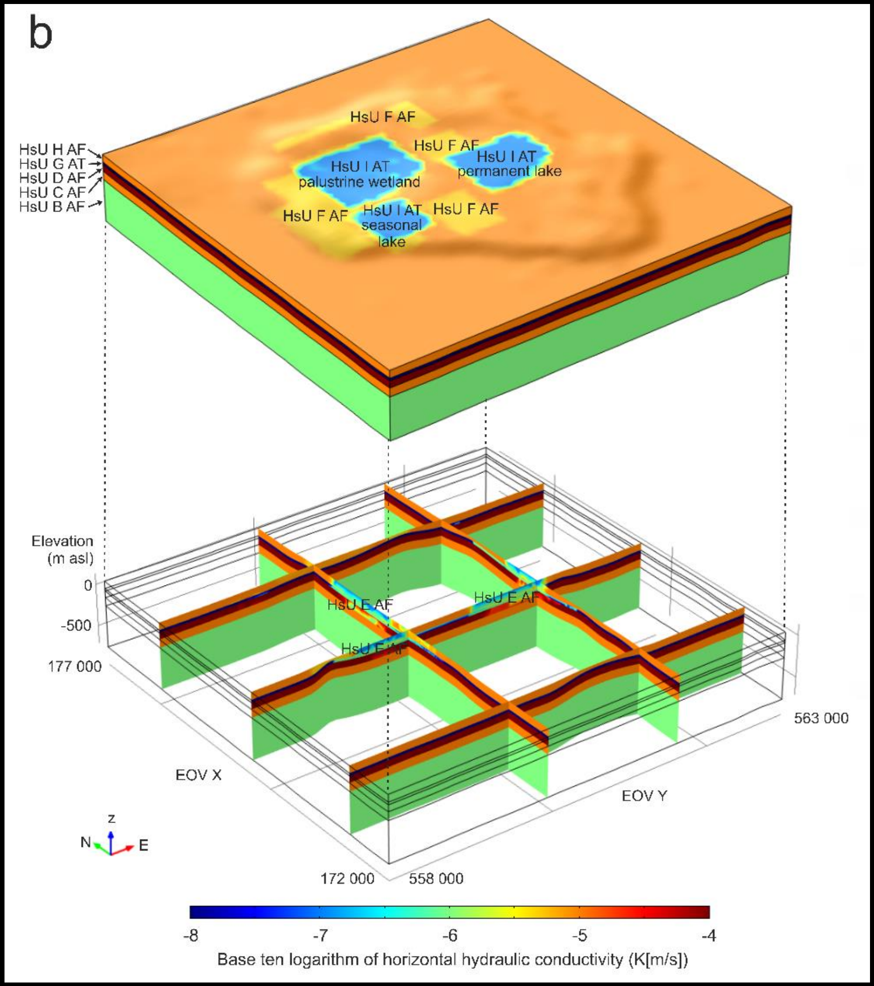
4. Results – Groundwater flow model

Lithostratigraphic Unit				Electrostratigraphic Unit		Hydrostratigraphic Unit				
ID	**lithology**	**age**	**depositional environment**	**ID**	**electrical resistivity ρ (Ωm)**	**ID**	**thickness d [m]**	**horizontal hydraulic conductivity K_h [m/s]**	**vertical hydraulic conductivity K_v [m/s]**	**effective porosity Φ [%]**
LsU 11	deposit	Holocene	shallow lacustrine	**EsU VI**	<20	**HsU I AT**	10–15	10^{-7}	10^{-8}	15
LsU 10	clastic deposit	Pleisto–Holocene	deluvial, proluvial, eluvial	n.a.	n.a.					
LsU 9	sandy gravel, siltstone	Mio–Pliocene	delta plain			**HsU H AF**	90	10^{-5}	10^{-6}	10
LsU 8	siltstone, sand	Mio–Pliocene	delta plain	**EsU V**	~20					
LsU 7	clay marl	Mio–Pliocene	shallow lacustrine			**HsU G AT**	30	10^{-8}	10^{-9}	5
LsU 6	basaltic tuff	Mio–Pliocene	maar volcano	**EsU IV**	>35	**HsU F AF**	max. 60	$5 \cdot 10^{-6}$	$5 \cdot 10^{-7}$	10
LsU 5	pyroclastics	Mio–Pliocene	maar volcano	**EsU III**	20–35	**HsU E AF**	max. 200	10^{-6}	10^{-7}	10
LsU 4	limestone	Miocene	shallow marine	**EsU II**	60–80	**HsU D AF**	80	10^{-4}	10^{-5}	20
LsU 3	limestone, dolomite, marl	Triassic	carbonate platfrom, lagoon, shelf			**HsU C AF**	100	10^{-5}	10^{-6}	15
LsU 2	sandstone	Permian	alluvial fan	**EsU I**	>100	**HsU B AF**	500	10^{-6}	10^{-7}	10
LsU 1	shale	Silurian	hemipelagic marine	n.a.	n.a.	**HsU A AT**	500	10^{-9}	10^{-10}	5

Integration of lithostratigraphic, electrostratigraphic and hydrostratigraphic information: units and their characteristics of the Tihany Peninsula based on boreholes, seismic section, electromagnetic survey, pumping tests and literature data (Tóth Á. et al. 2016)

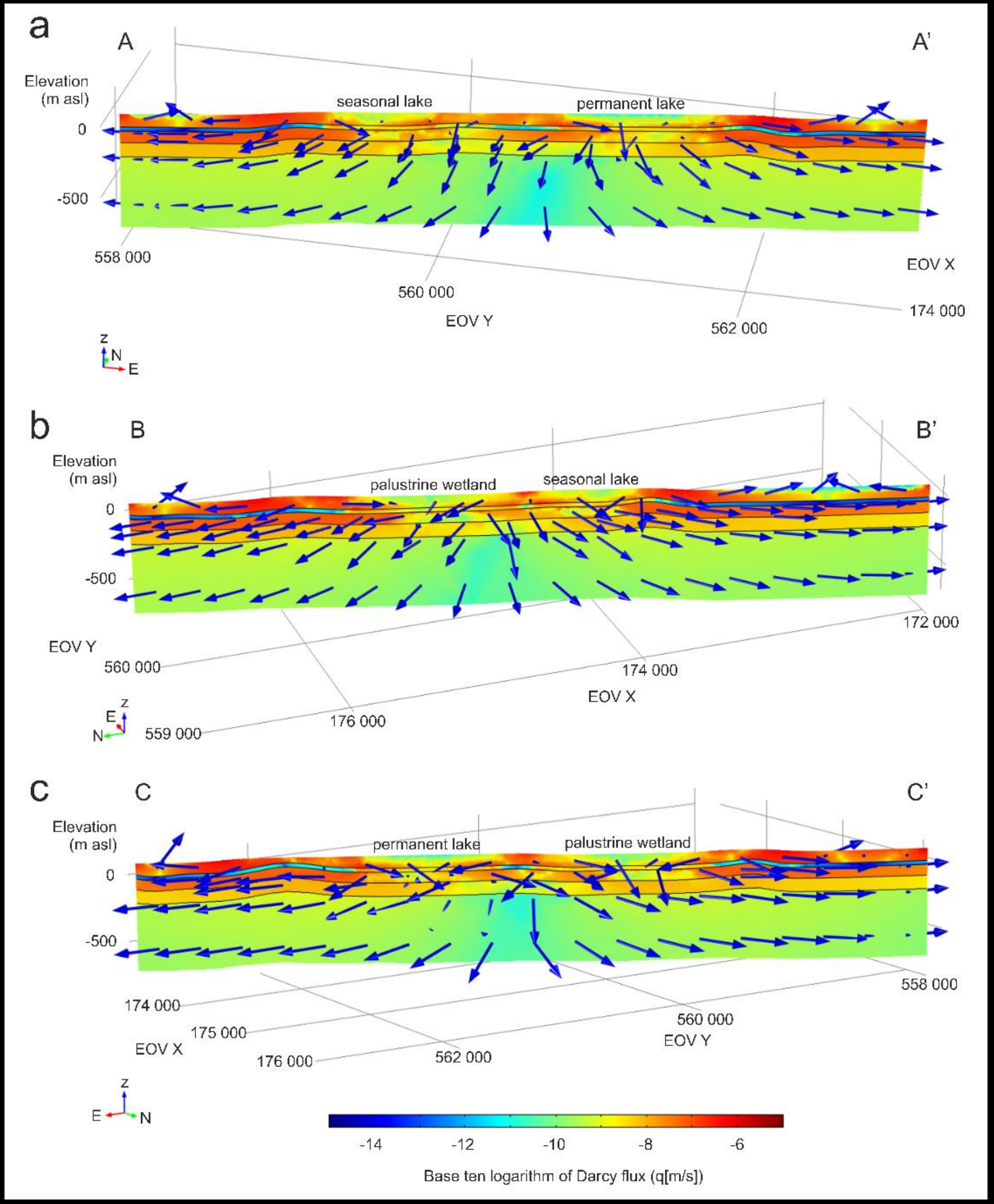
4. Results – Groundwater flow model

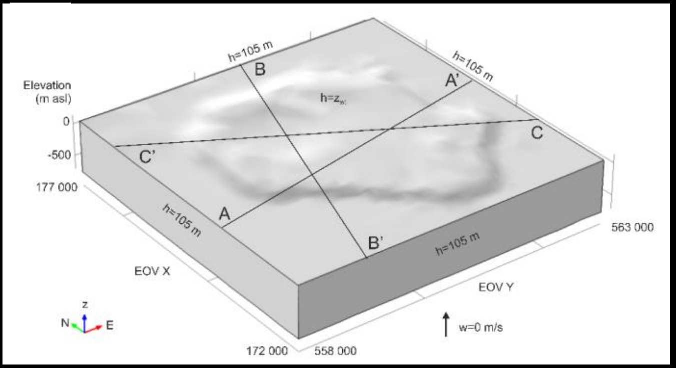




Numerical simulation input of the hydrogeologic model
(a) Boundary conditions and tracks of 2D cross sections
(b) Hydrostratigraphic units and their geometry on block and fence diagram
(Tóth Á. et al. 2016)

4. Results – Groundwater flow model

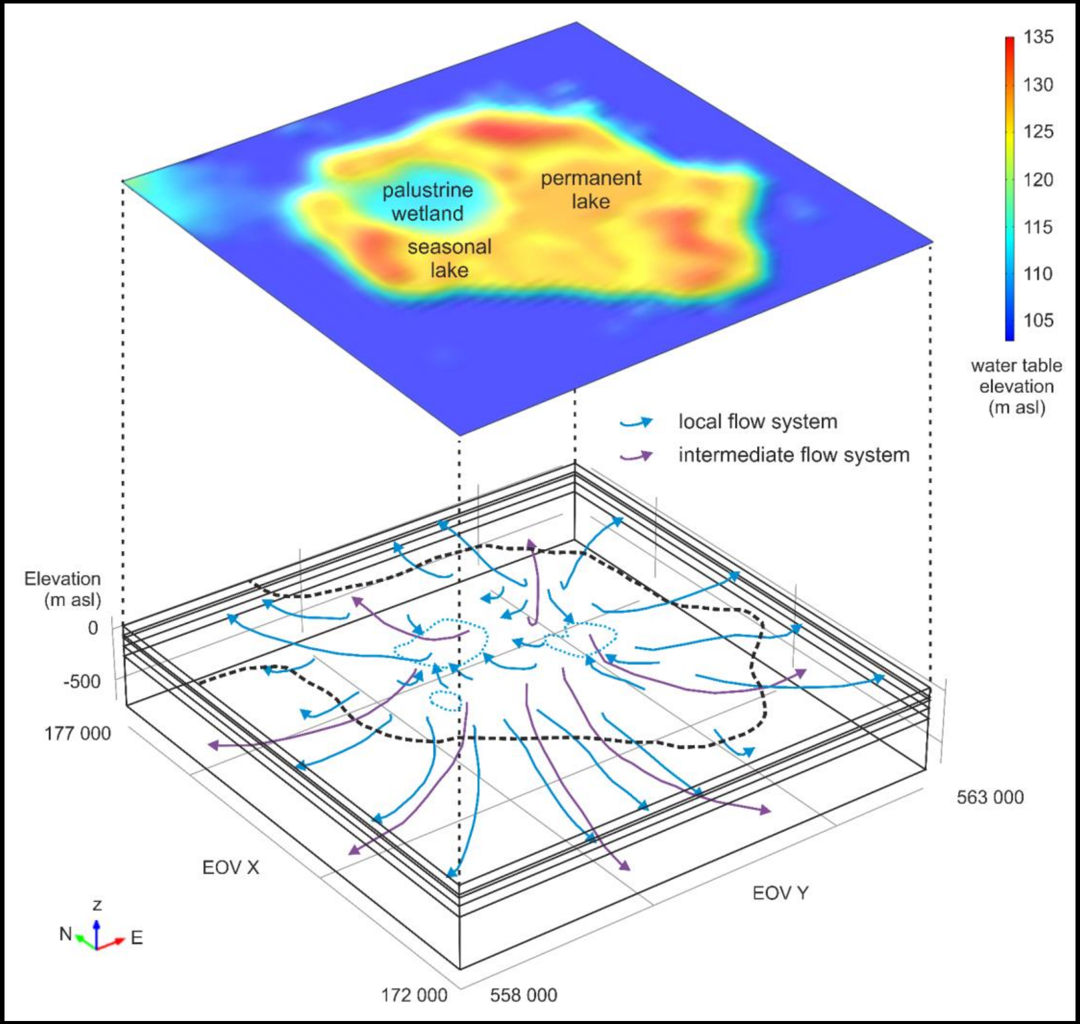




Simulated flow field along 2D cross sections displaying intensity of flow by colours, and direction of flow by normalised 3D vectors for
(a) seasonal lake–permanent lake,
(b) palustrine wetland–seasonal lake,
(c) permanent lake–palustrine wetland

Boundaries of regional hydrostratigraphic units (B AF, C AF, D AF, G AT and H AF) are indicated. (Tóth Á. et al. 2016)

4. Results – Groundwater flow model



Hierarchical interpretation of simulated gravity-driven flow field displaying local and intermediate flow systems with their characteristic flow lines (Tóth Á. et al. 2016)

5. Discussion

Aerial photo of the Tihany Peninsula with the imprints of flowing groundwater

5. Discussion

Human impact

→ **water demand** cannot be supplied

→ high potential of **contamination**

Climate change

→ **local flow systems** mostly affected

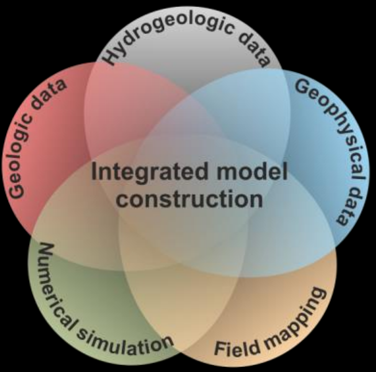
→ wetlands are **extremely vulnerable**

Water management and policy

Thank you for your attention! Questions?

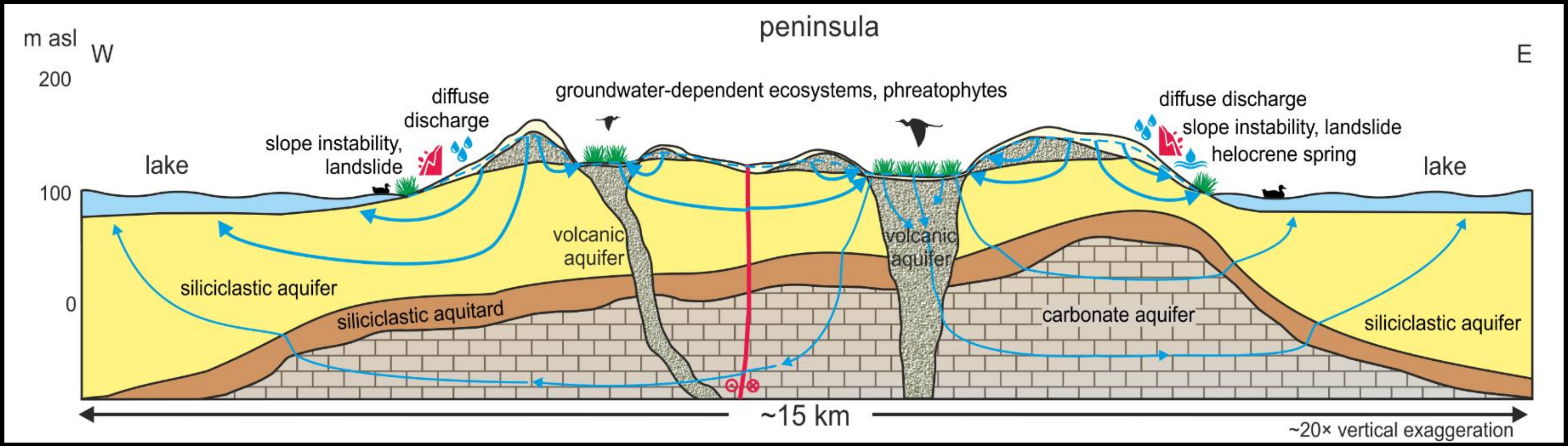
6. Conclusion

Scheme of **integrated model** construction



Groundwater flow pattern of a **geologically complex** area

Environmental imprints of groundwater



This lecture was based on:
Tóth Á, Havril T, Simon Sz, Galsa A, Monterio Santos F, Müller I, Mádl-Szőnyi J 2016: Groundwater flow pattern and related environmental phenomena in complex geologic setting based on integrated model construction
Journal of Hydrology 539, pp. 330-344