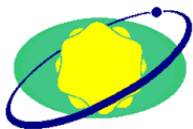


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STU



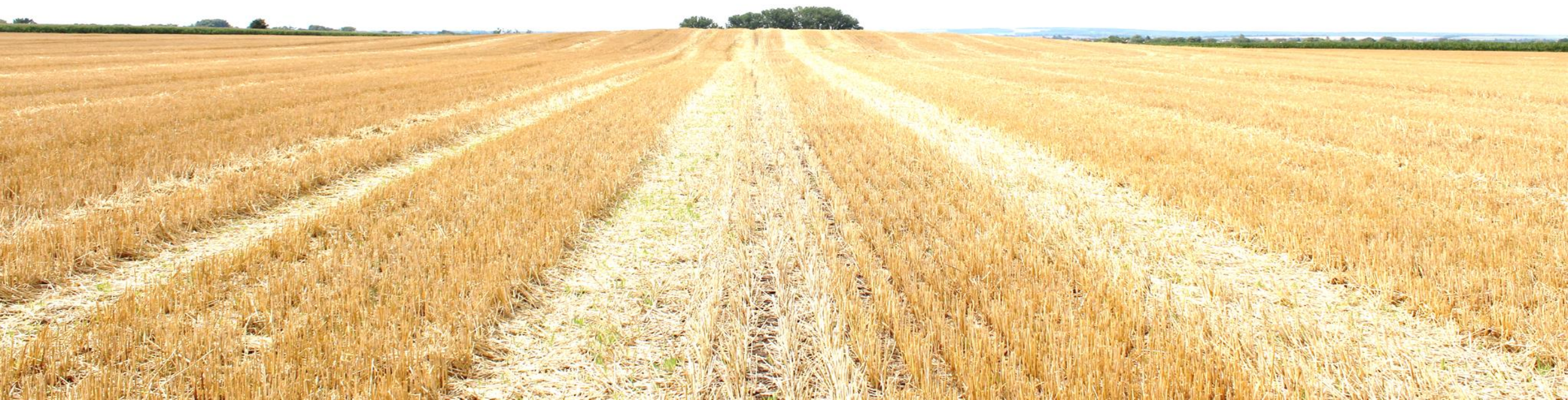
**FYZ
GIS**



HIDDEN IN HILLS

Utilizing LiDAR and historical maps to detect potential burial mounds in lower Hron River catchment

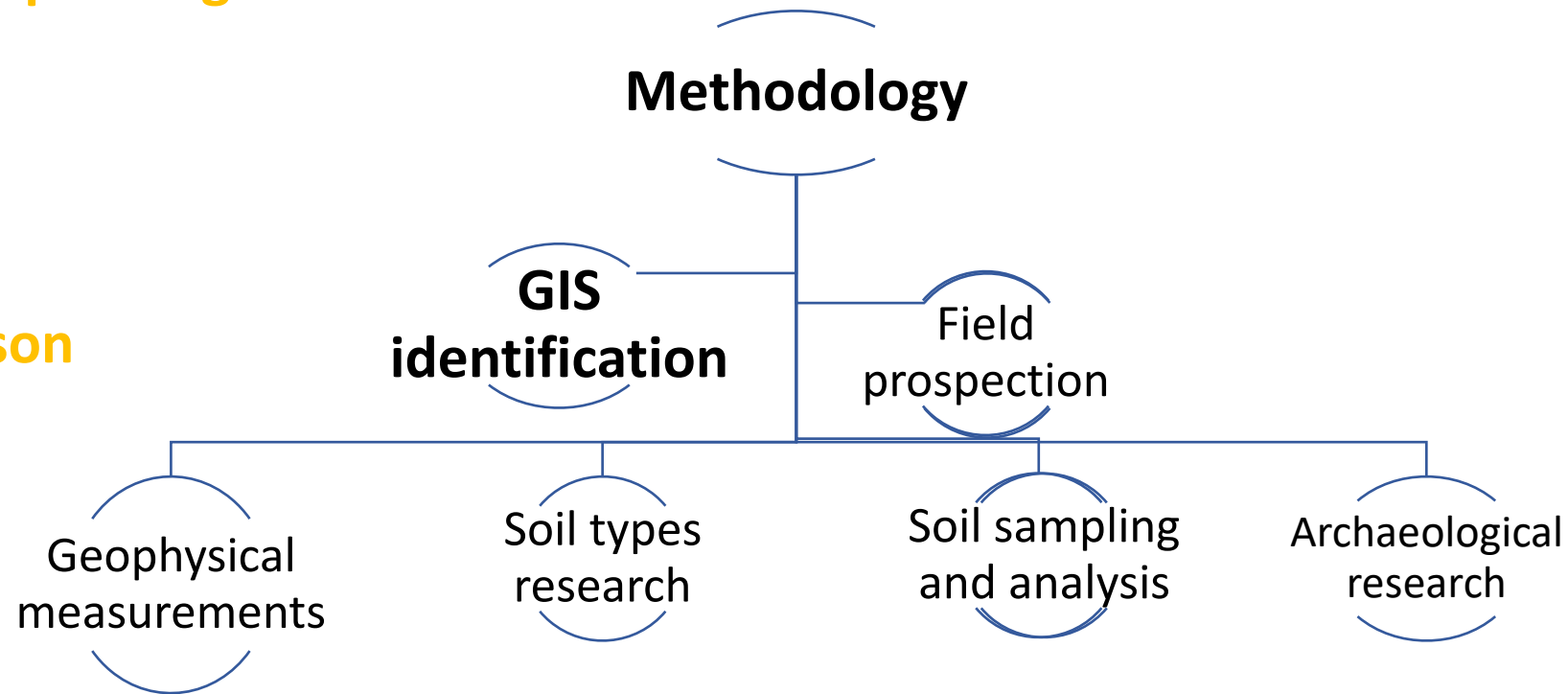
Šárka HORÁČKOVÁ, Tibor LIESKOVSKÝ, Jozef BÁTORA, Adam RUSINKO





Burial mounds and their identification

1. What are burial mounds?
2. How to find them?
3. Hypothesis confirmation pending
4. Testing area
5. Results
6. Further goals
7. Discussion and comparison
8. Conclusions



What are burial mounds?

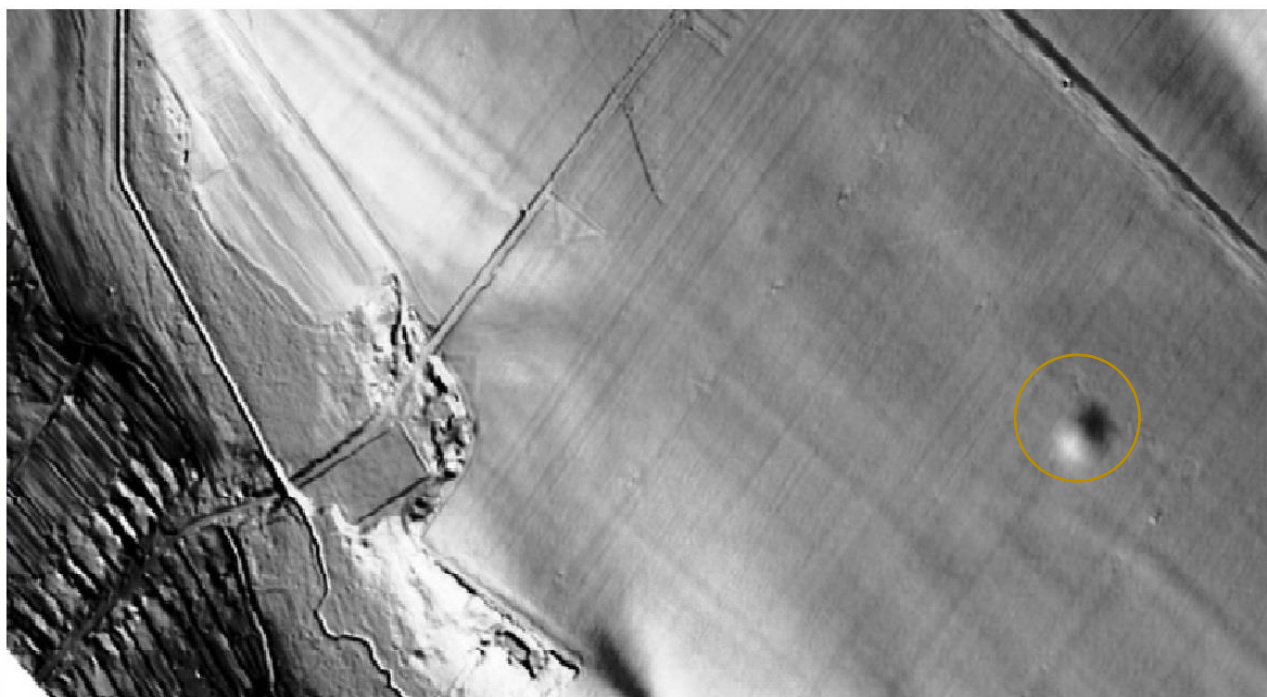
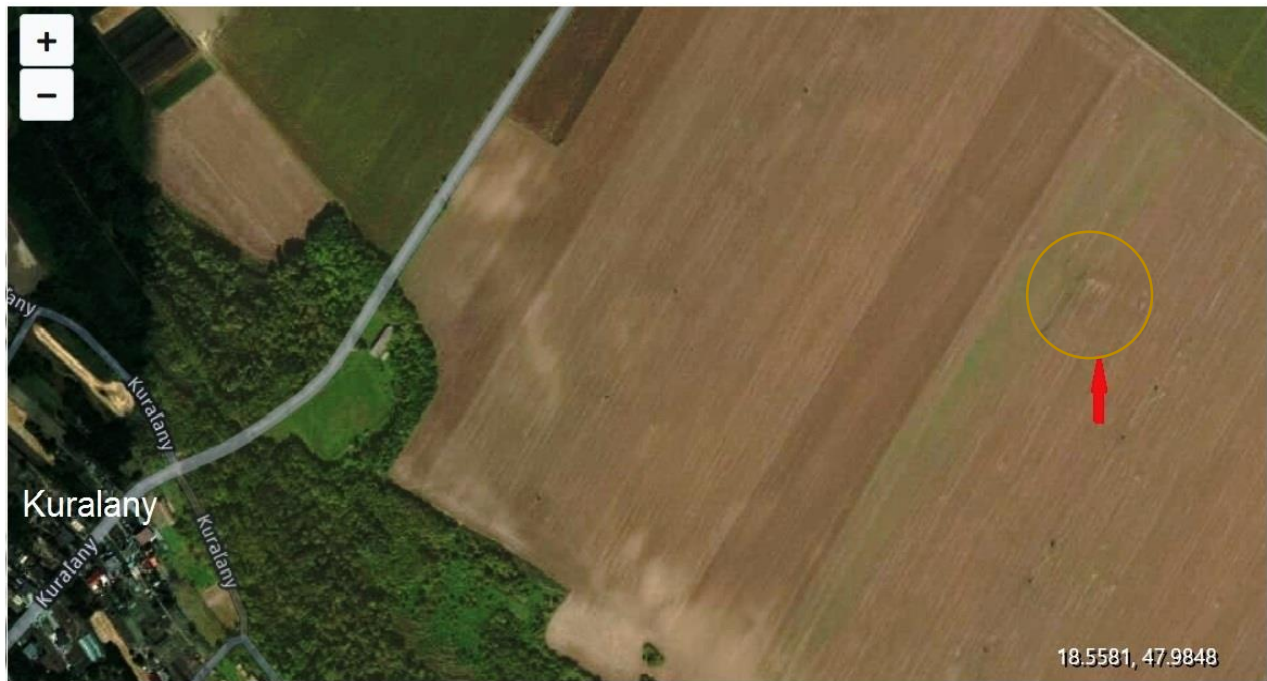


Burial site called Kurgan
in Potisie region
in Hungary
(Peto et al., 2011)

Potential burial site on Danubian lowland (Hron plain)



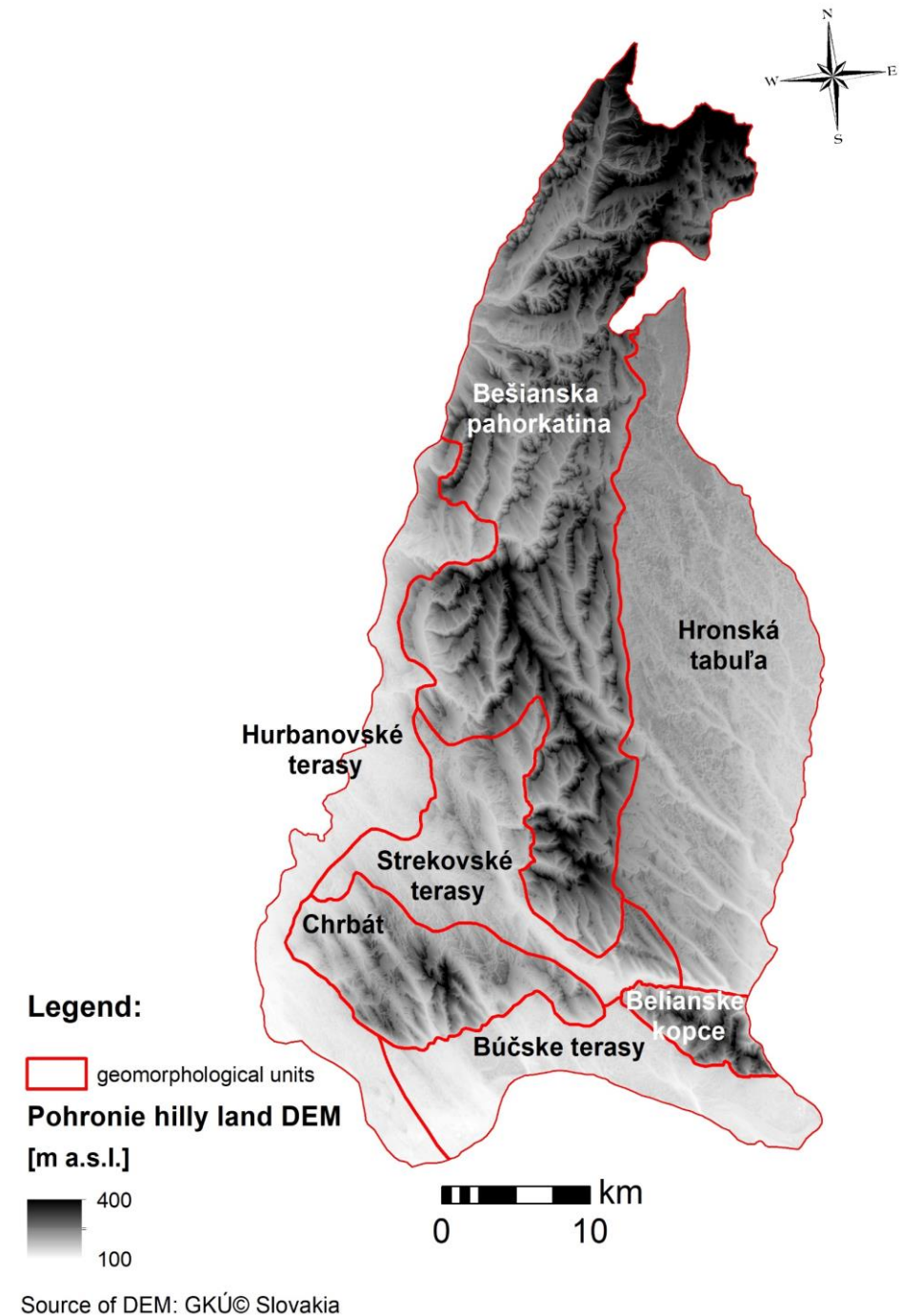
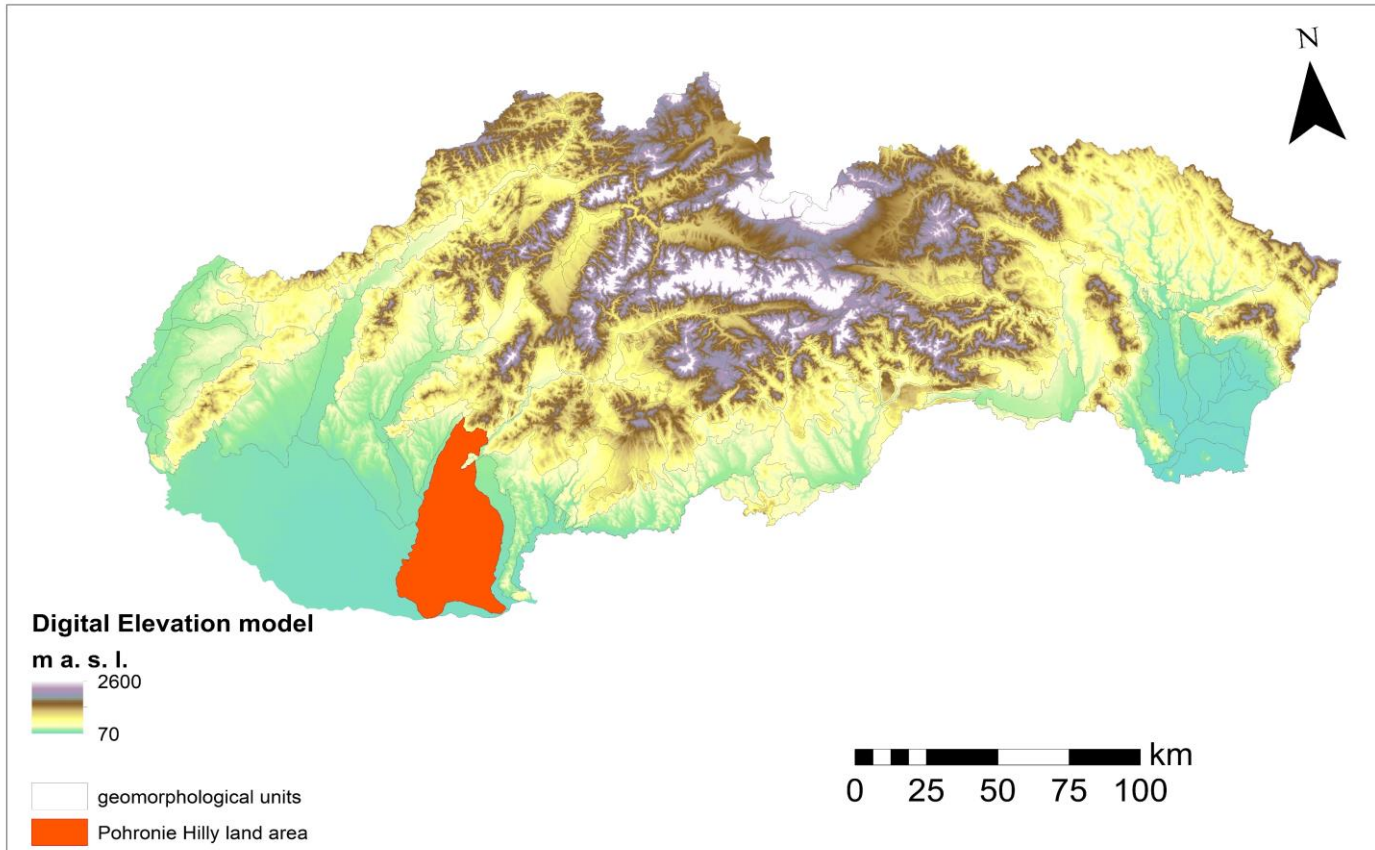
How can we find them?



Hron plain (Danubian lowland)

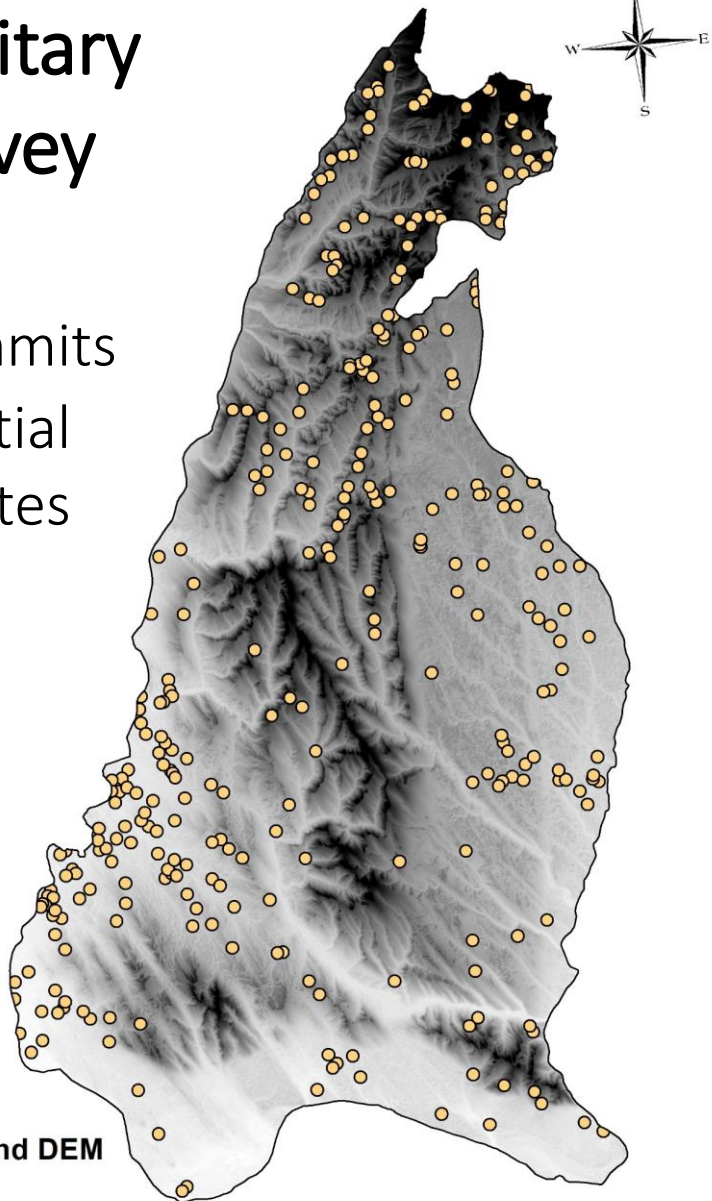
*Suspected similar culture as in Hungary
(Potisie region)*

– *unconfirmed in Slovakia*



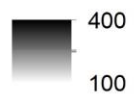
I. Military Survey

316 summits
= potential
burial sites



Legend:

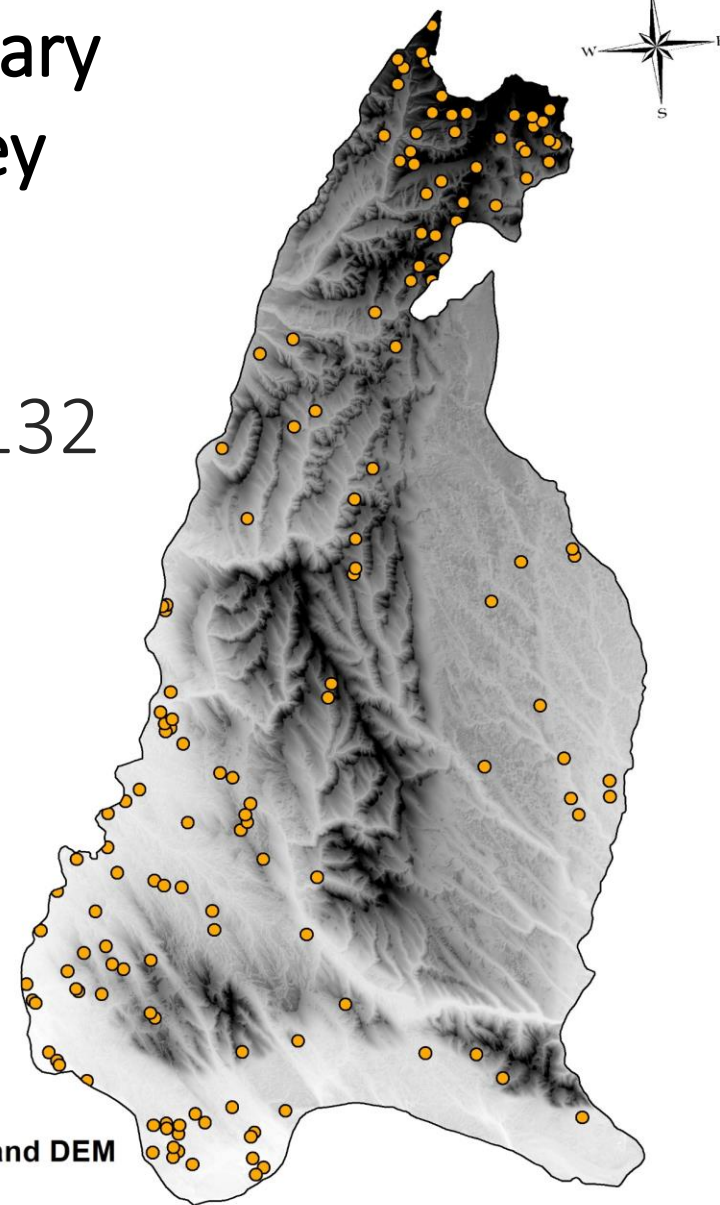
Pohronie hilly land DEM
[m a.s.l.]



Source of DEM: GKÚ© Slovakia

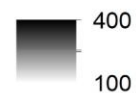
II. Military Survey

132



Legend:

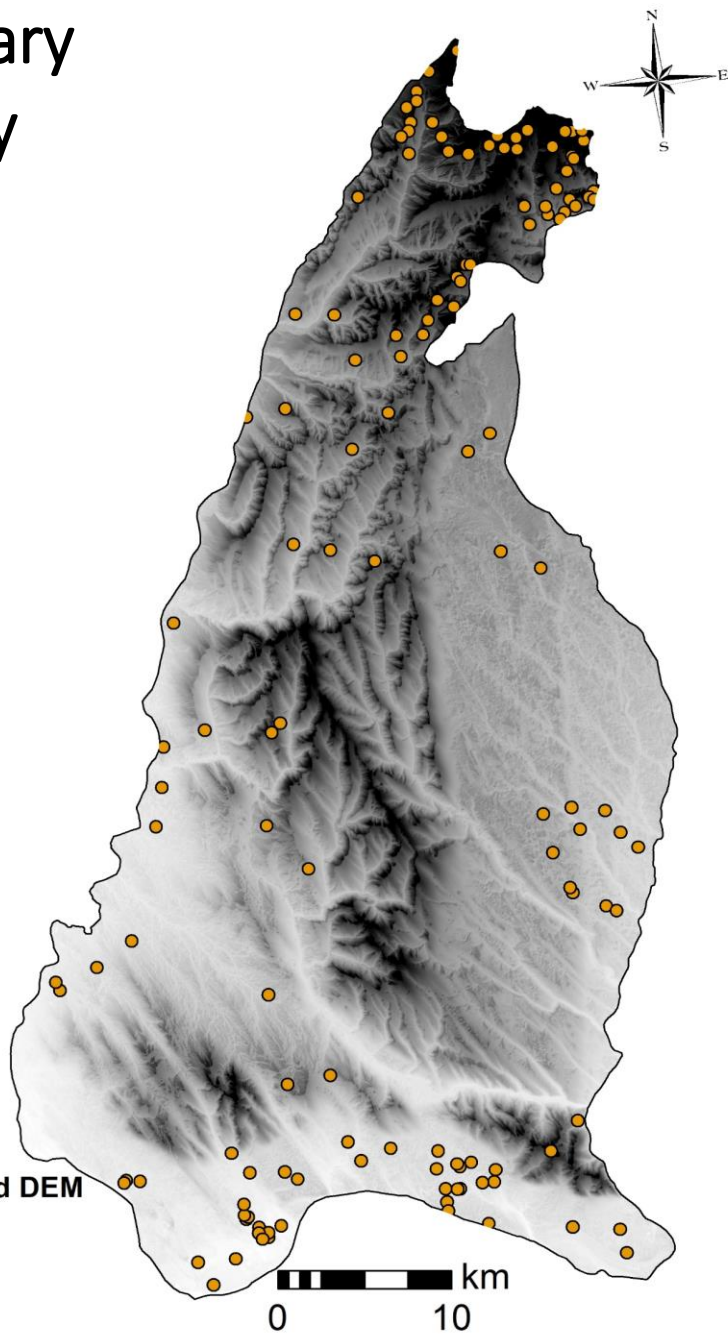
Pohronie hilly land DEM
[m a.s.l.]



Source of DEM: GKÚ© Slovakia

III. Military Survey

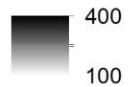
132



Legend:

Pohronie hilly land DEM

[m a.s.l.]

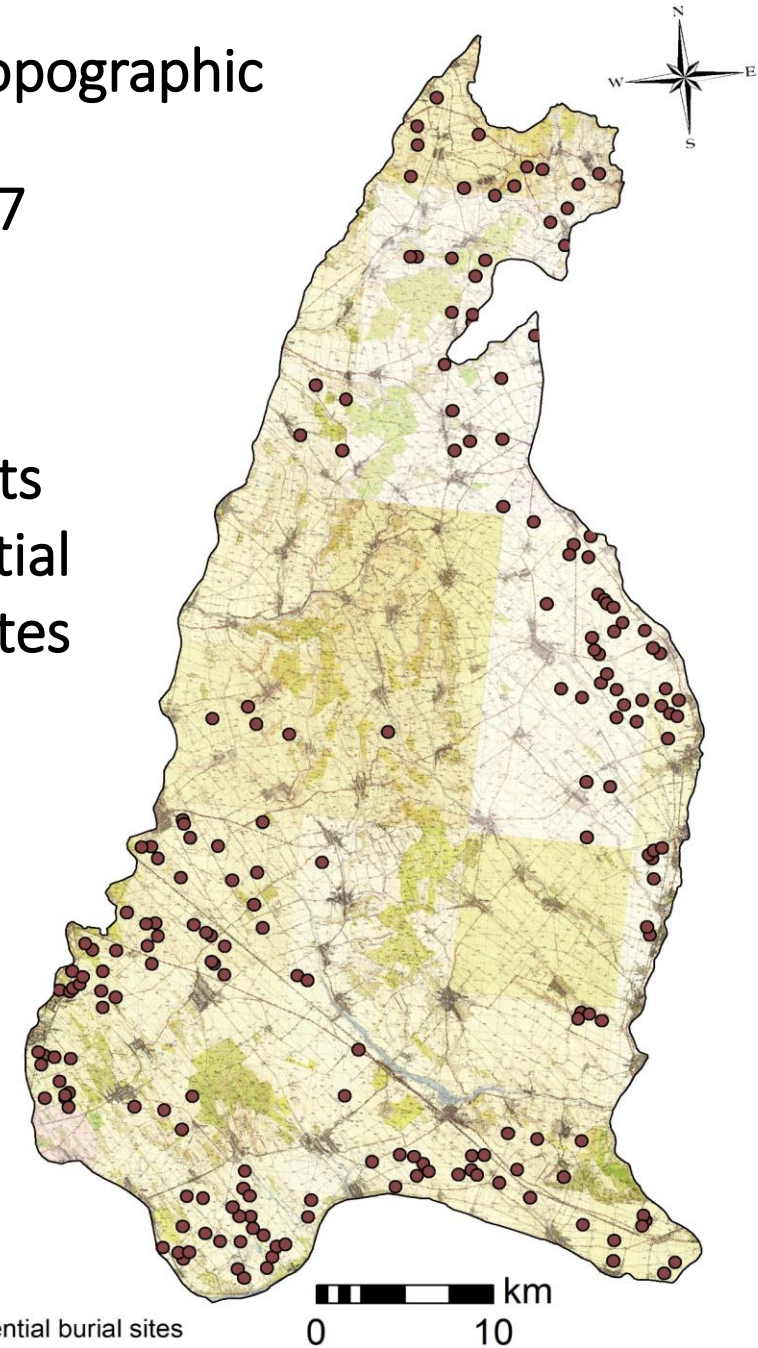


Source of DEM: GKÚ© Slovakia

Military topographic maps 1952-1957

215

summits
= potential
burial sites



Legend:

● summits - potential burial sites



Source of topographic maps: SEA© Slovakia

DEM from LiDAR (GKÚ Slovakia)

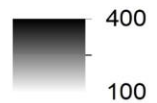
124

Legend:

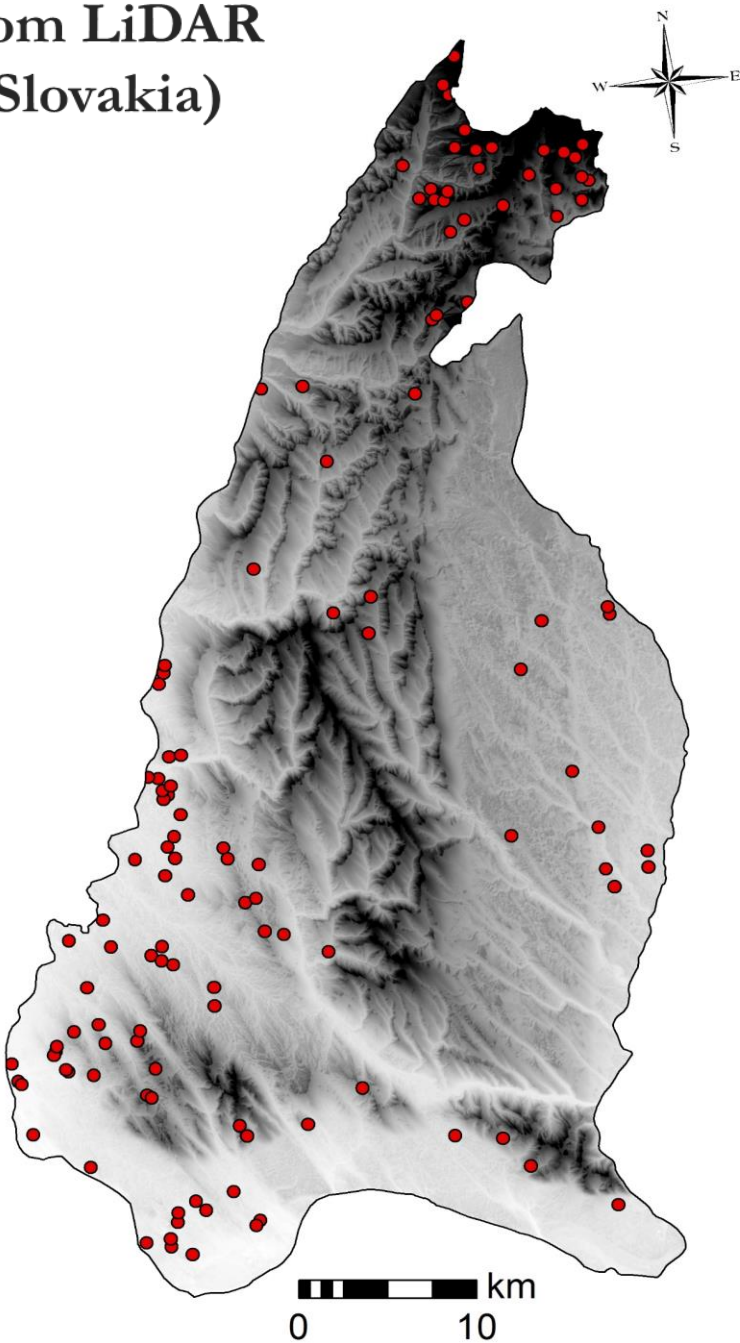
- summits on current DEM

Pohronie hilly land DEM

[m a.s.l.]



Source of DEM: GKÚ© Slovakia



Processed DEM (T. Lieskovský)

89

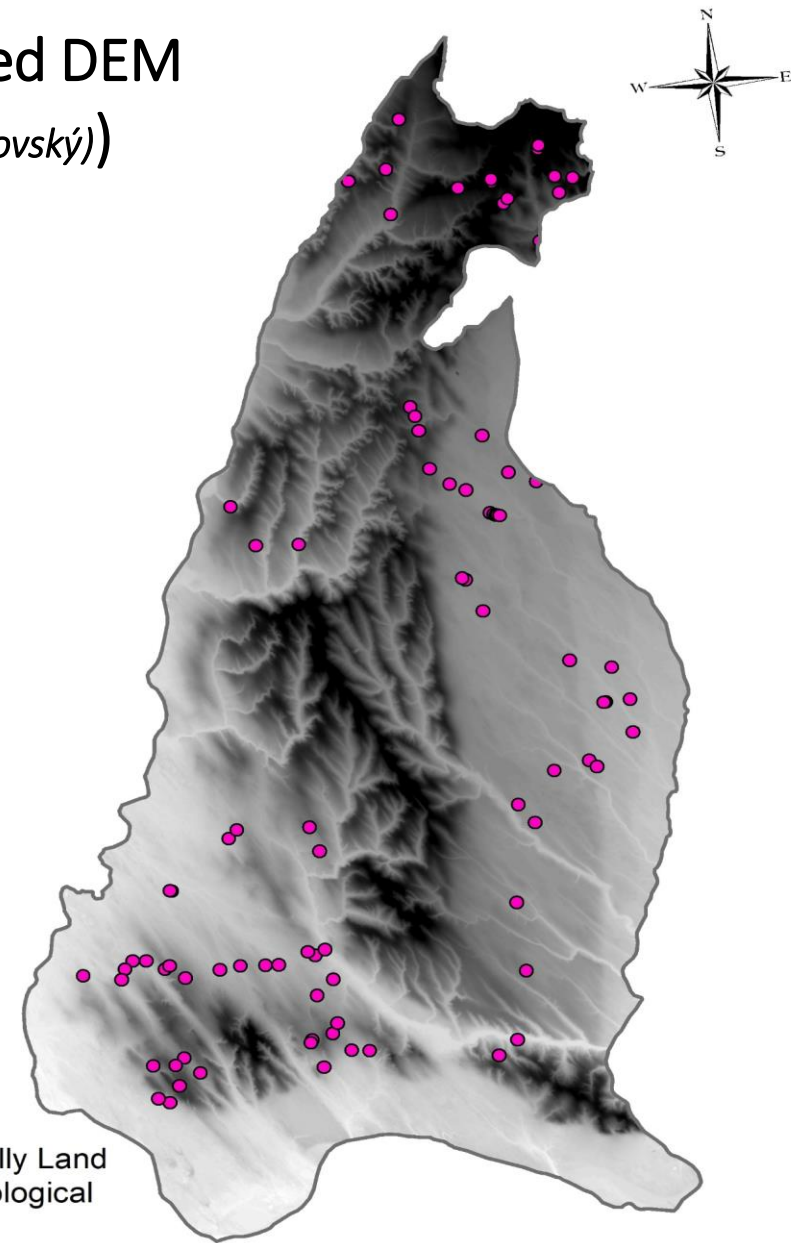
Legend:

- ▭ Pohronie Hilly Land (geomorphological border)

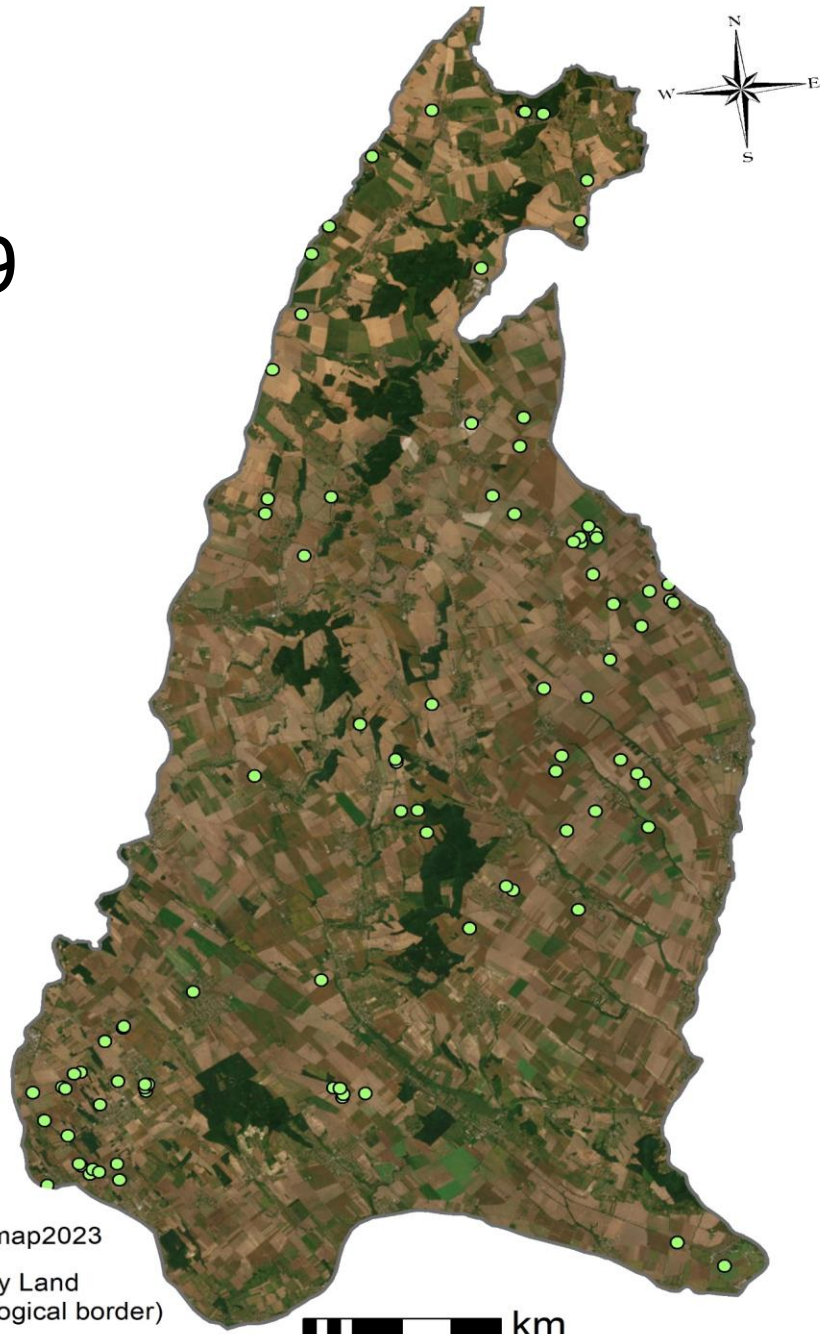
- summits - potential burial sites



Source of DEM: GKÚ© Slovakia and processed by
Department of Global Geodesy STU



89



Legend:

 mohylybasemap2023

 Pohronie Hilly Land
(geomorphological border)

ArcGIS Basemap ©

0 10 km



0 1 km

ArcGIS Basemap ©

Hypothesis confirmation pending



- **These landforms are possible to detect and identify using available LiDAR data quite precisely**
- The questions remain:
 - **Why are they seen differently on different maps?**
 - **How much more than 200 years of tillage destroyed them?**
 - **Is it possible that soil properties influence their visibility only on some Orthophotomaps?**
 - **Is it possible that some type of automated classification would bring better results?**
- **Field research prospection showed – the soil properties of these sites are different than the surroundings,**
 - characteristic black soil (chernozem layer) such as in Hungary – anthropogenic soil horizon between A/B (Barczy et al., 2006)
 - **However how to distinguish it on other brown soils???**
 - **Is it even possible without full archaeological prospection to identify if the hill is burial site?**



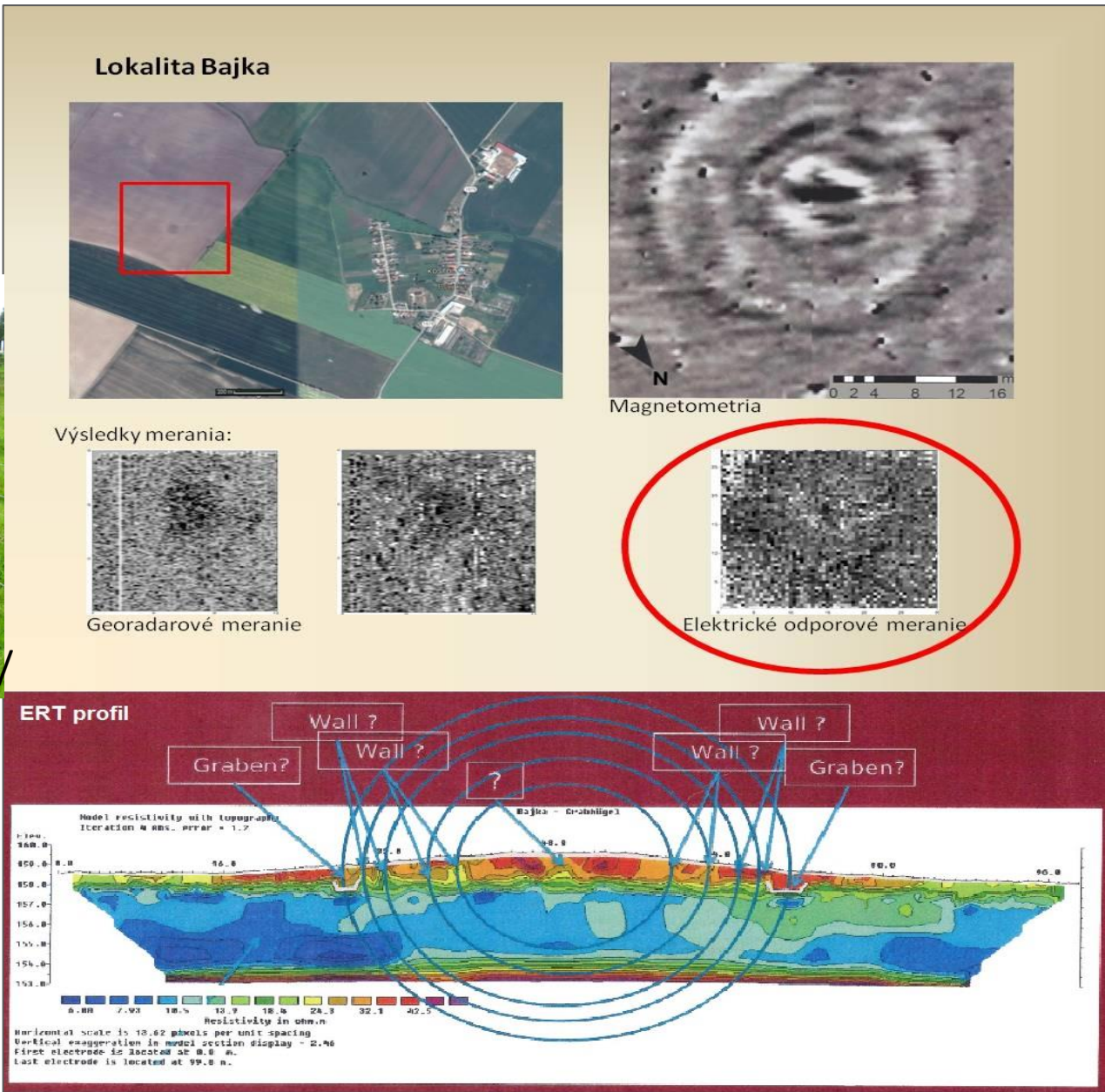
Further GOALS:

- 1. To create an initial database of summits with highest potential for field prospection using different maps, historical sources, studying historical names of the hills and comparing it to precise LiDAR data.**
- 2. To establish a methodology for burial sites identification during field prospection and soil analysis.**
- 3. Compare the possibilities of automated identification to the manual identification from LiDAR for larger area?**

Geophysical prospection

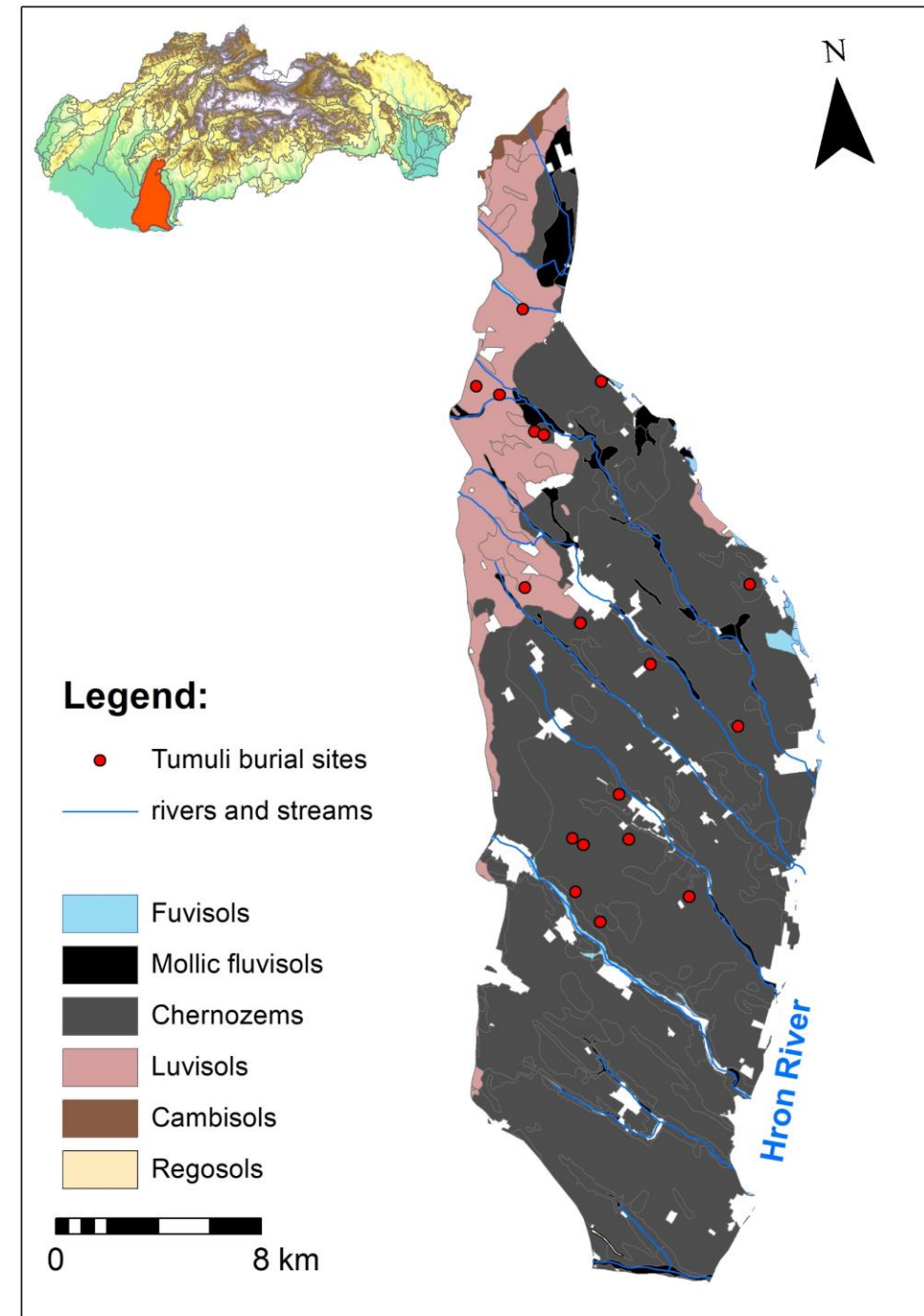


<https://cherishproject.eu/cy/tool-kit/geophysical-survey/>



Soil types research and sampling

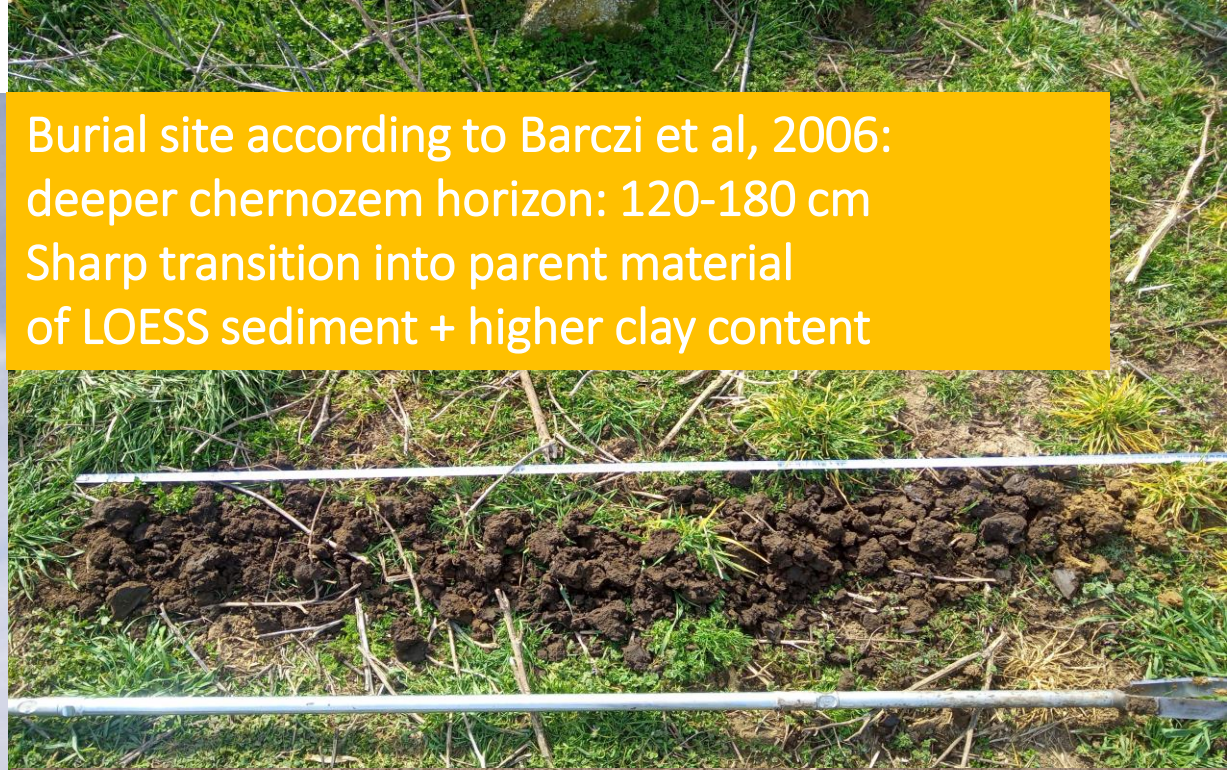
- Selected 18 summits – highly suspected burial sites on the Hron plain
- Looking for anthropogenic soil horizon
 - microfossils – bones, metal objects, cutlery, charcoals
 - **black, clustic horizon** on chernozem soils such as found in Hungary on similar sites (Barczi et al., 2006)



Suspected burial site
near Tekovské Lužany village



Burial site according to Barczy et al, 2006:
deeper chernozem horizon: 120-180 cm
Sharp transition into parent material
of LOESS sediment + higher clay content



Normal finding: 30-60 cm transition into
parent material of LOESS sediment



Collected samples

- 14 sites - summits
- 32 soil probes
- ~250 samples
- to be continued 10/2023

Summit no.	Amount of soil probes	samples	Anthropo/extended black horizon	Extracted charcoals	Bones/cutlery /metal objects
1. Bajka	5	✓	✓	✓	x
2. Tek.Lužany 1	3	✓	✓	✓	x
3. Želiezovce	3	✓	✓	✓	✓
4. Želiezovce 2	2	✓	x	x	✓
5. Tek.Lužany 2	4	✓	x	x	x
6. Tek.Lužany 3	2	✓	✓	n/a	n/a
7. Nýrovce 1	2	✓	x	n/a	n/a
8. Nýrovce 2	1	x	✓	x	x
9. Vinodol	1	✓	x	n/a	n/a
10. Čaka 1	2	✓	✓	n/a	n/a
11. Čaka 2	2	✓	x	n/a	n/a
12. Hronovce	1	x	x	n/a	n/a
13. Veľká Máňa	3	x	x	x	x
14. Fitvár	1	x	x	x	x

Macrofossil analysis of soil samples near Tekovské Lužany village



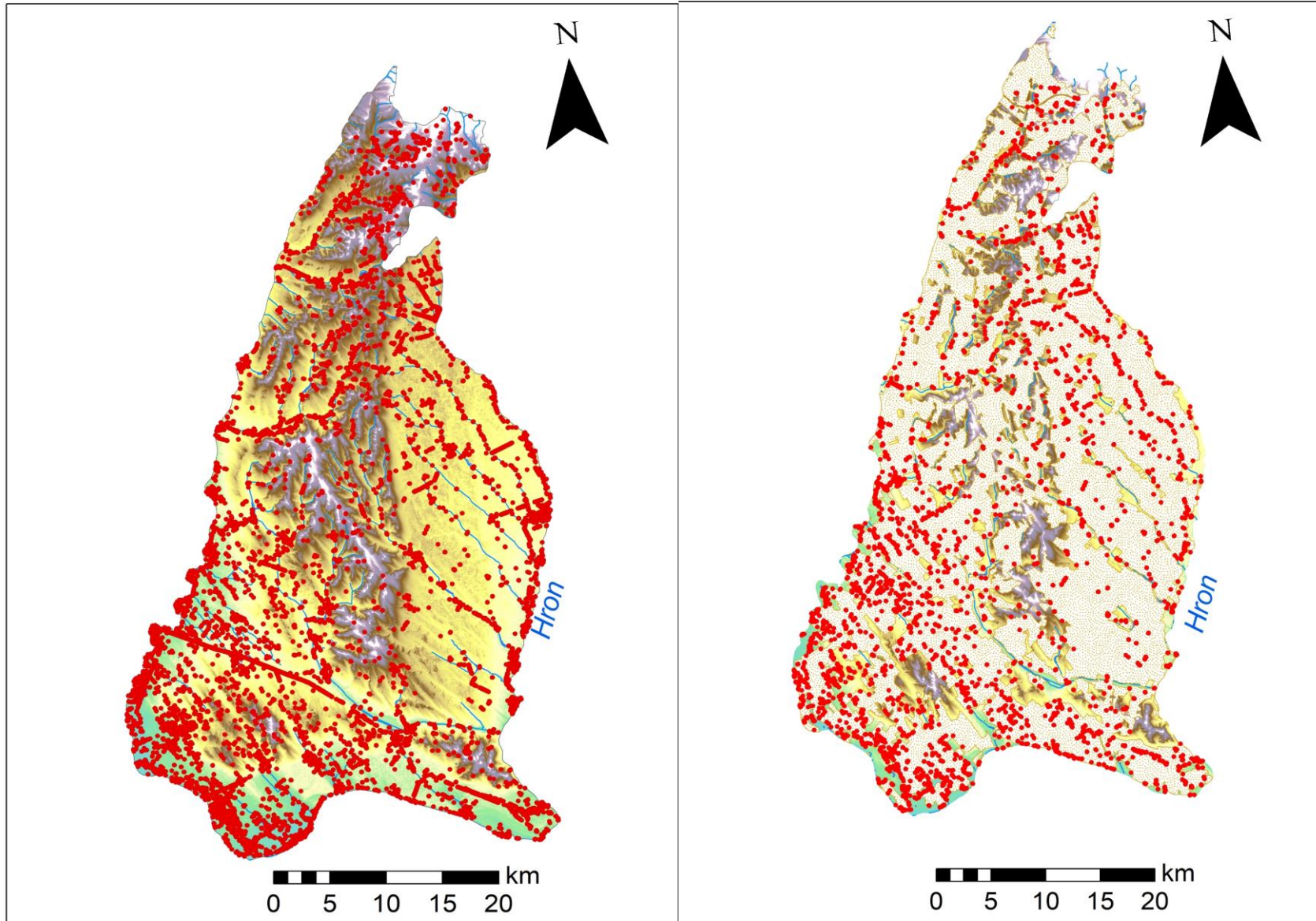
Charcoals after decantation with H₂O₂



Probably this burial site is not Kurgan but Medieval

AMS ¹⁴ C Lab Code	Sample prep. Nr.	Sample ID/name	Sample material	C Yield (%)	Conventional ¹⁴ C age (yrs BP) (± 1σ)	Calibrated calendar age (cal AD/BC) (2σ)
DeA-41387	I/3339/1	Bajka_1_SarHor	charred plant matter	60.2	1424 ± 23	cal AD 599 - 654

Semi-automated classification
GRASS GIS – r.geomorphon



- Available DEM from GKU LiDAR data used as base
- Prepared polygon of agricultural land
 - Separation only for this area
- Manual removal of line features – roads

Conclusions



AIM1 - done

- These landforms such as summits are possible to define and identify using available LiDAR data
 - Different results prospecting different GIS open source maps (cadastral, historical, orthophotomaps) - important for comparison, but for initial database the most precise data are the best input
 - **Initial database formed – potential burial sites**

AIM 2 – to be continued

- **Methodology for burial verification still in process – soil analysis**
 - chemical components analysis, phosphorus, pH, etc.) and radiocarbon dating of found charcoals – inconclusive, magnetic susceptibility measurements inconclusive, relying on geophysical research so far
 - **It is not going to be so easy, probably needs time-consuming field prospection**

AIM 3 – still to be done

- Comparison with automated identification
 - **very different and too many mistakes and summits provided** – for now not possible, maybe with deep-learning and further specific morphometric parameters identified that are similar in each burial site (**after methodology verification**)

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