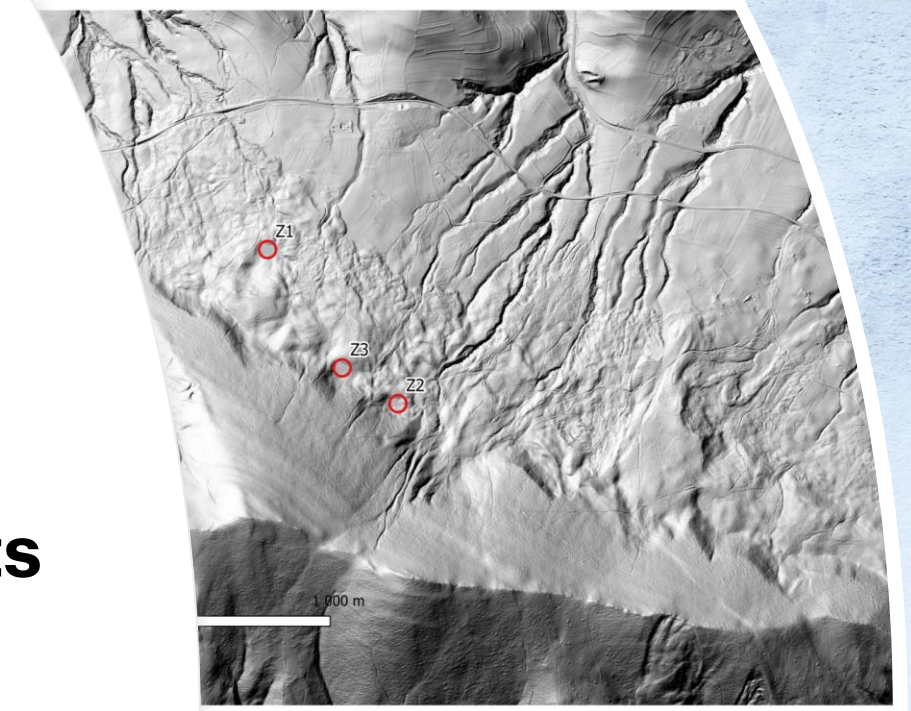
Holocene environmental reconstructions based on organic and mineral deposits of Mt Śnieżnica landslide, Outer Western Carpathians, Poland



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Our main objective is to reconstruct the environmental conditions of Mt Snieznica in the Wyspowy Beskid Mountains based on organic and mineral deposits extracted from the pit formed within the landslide body. We also want to build geochronology based on radiocarbon dating, geochemical properties of sediments, and palaeobotanical evaluation of organic debris found in the peats.

Objectives and research context

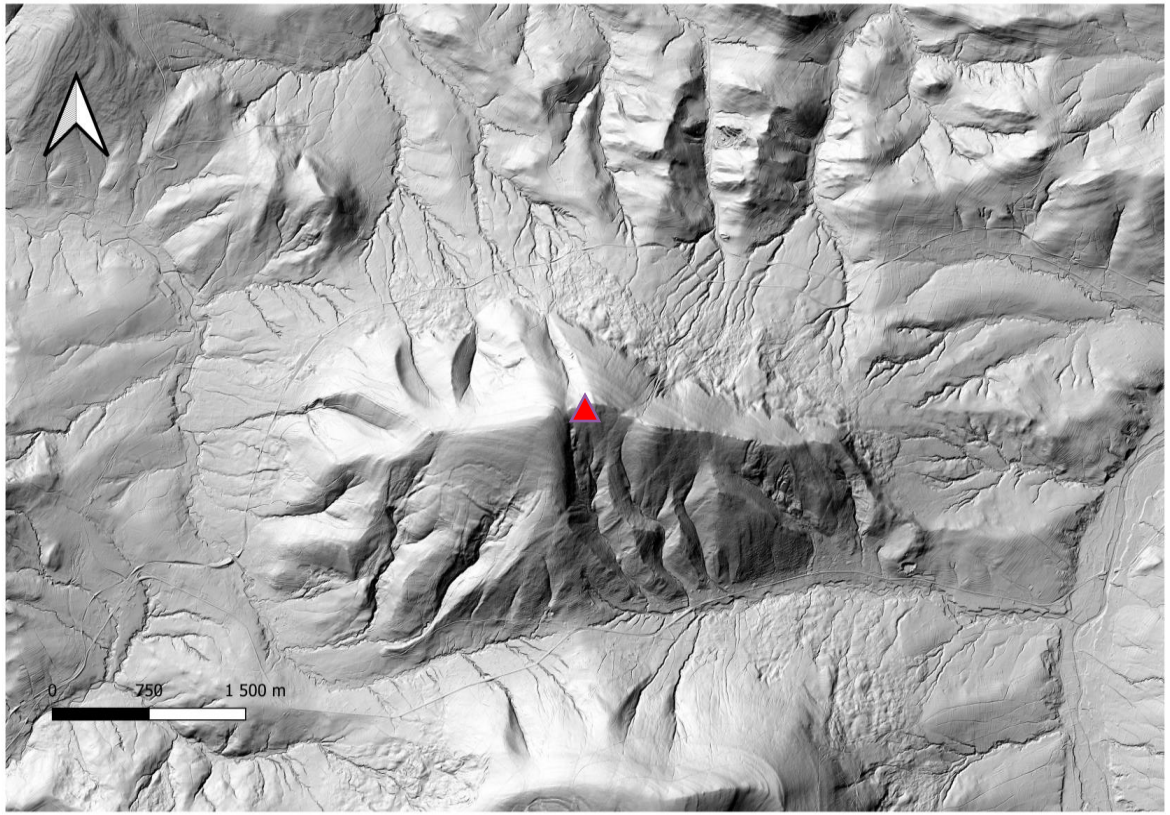
- Study aim: **palaeoenvironment reconstrution based on organo-mineral deposits and radiocarbon dating**

- We study the biggest landslide in the Western Beskidy Mts.
- This landslide has been recognized by the geological survey under the Landslide Counteracting System as still active.

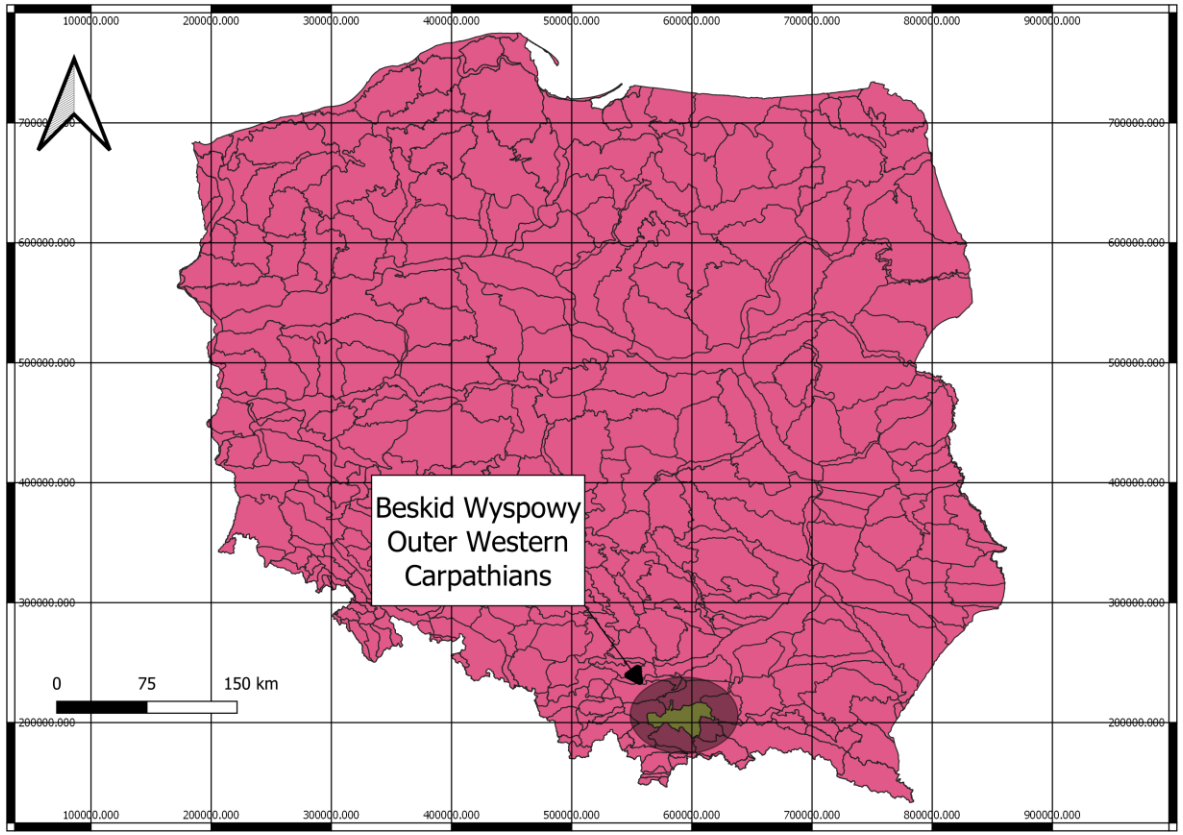
The Wyspowy Beskid Mountains belong to the Outer Western Carpathians. The area under consideration is on the north-eastern side of Mt Snieznica, an isolated mountain massif reaching 1,006 meters above sea level.

Study area

Mt Śnieżnica (1,006 m asl)



Poland

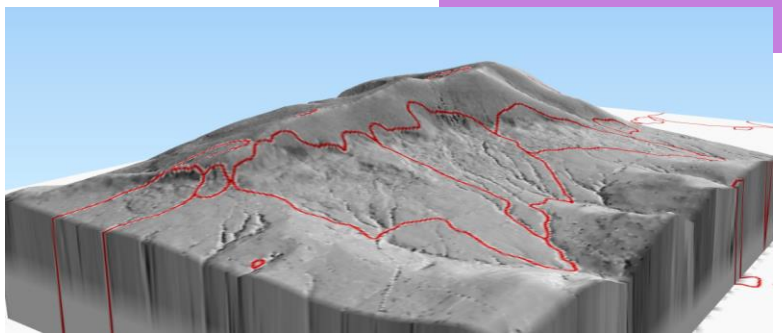


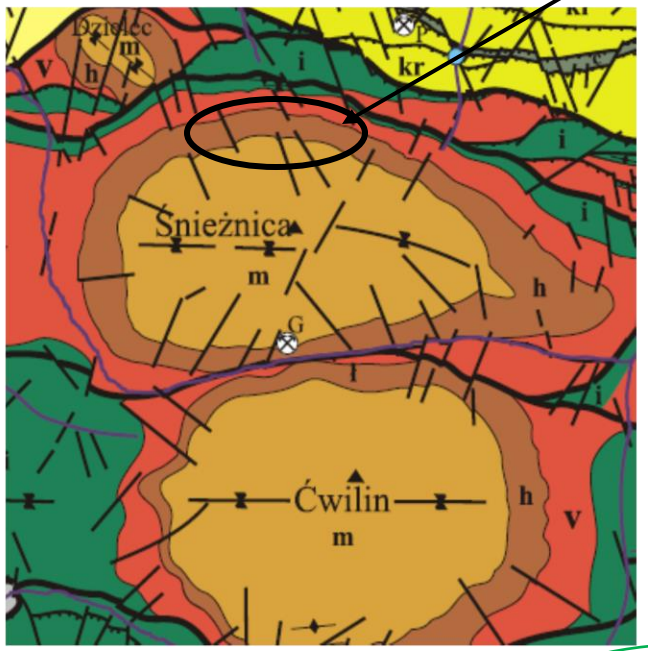
Geologically, the area belongs to the Magura Nappe, and it is built of thick and thin-bedded sandstones overlying shales and sandstones.

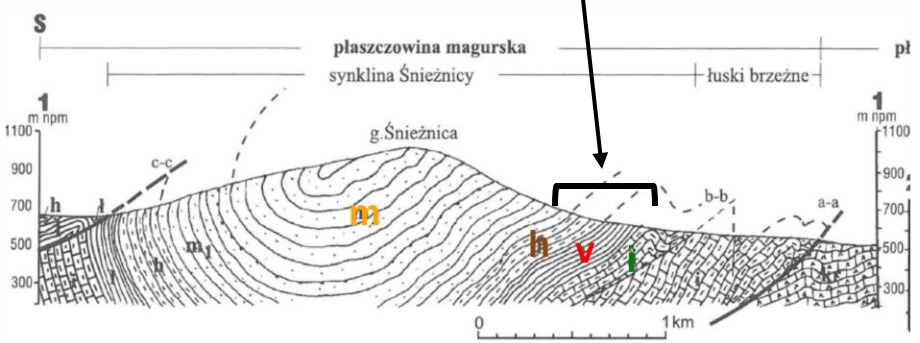
Study area

Mt Śnieżnica landslide

Geology



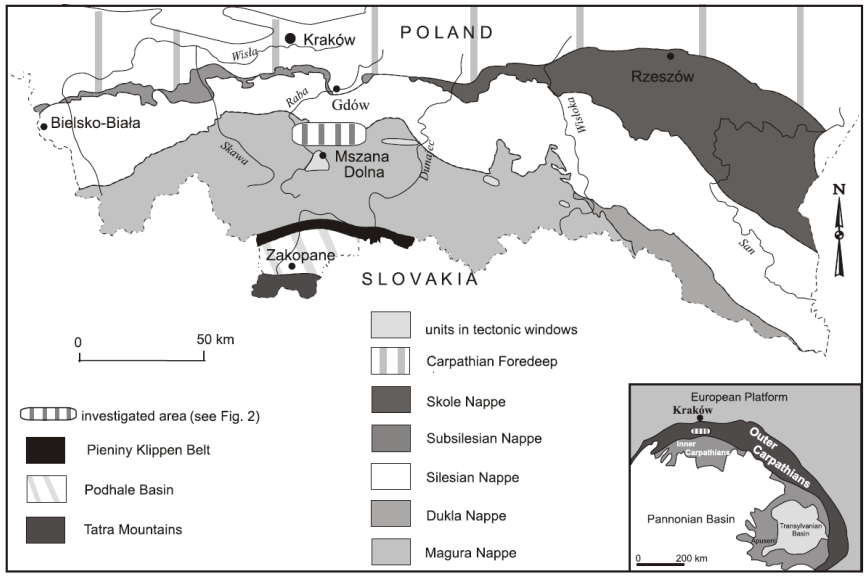




Beskid Wyspowy Subunit:

- m – Magura Beds
- h – Hieroglyphic Beds
- v – Variegated Shales
- i – Inoceramian Beds

thrust of Magura Nappe
other thrusts within Magura Nappe
anticlines axis
synclines axis
faults
reverse faults



Magura Beds (Upper Eocene-Oligocene) – thick-bedded sandstones

Hieroglyphic Beds (Middle-Upper Eocene) – thin-bedded sandstones

Variegated Shales (Lower?-Middle Eocene)

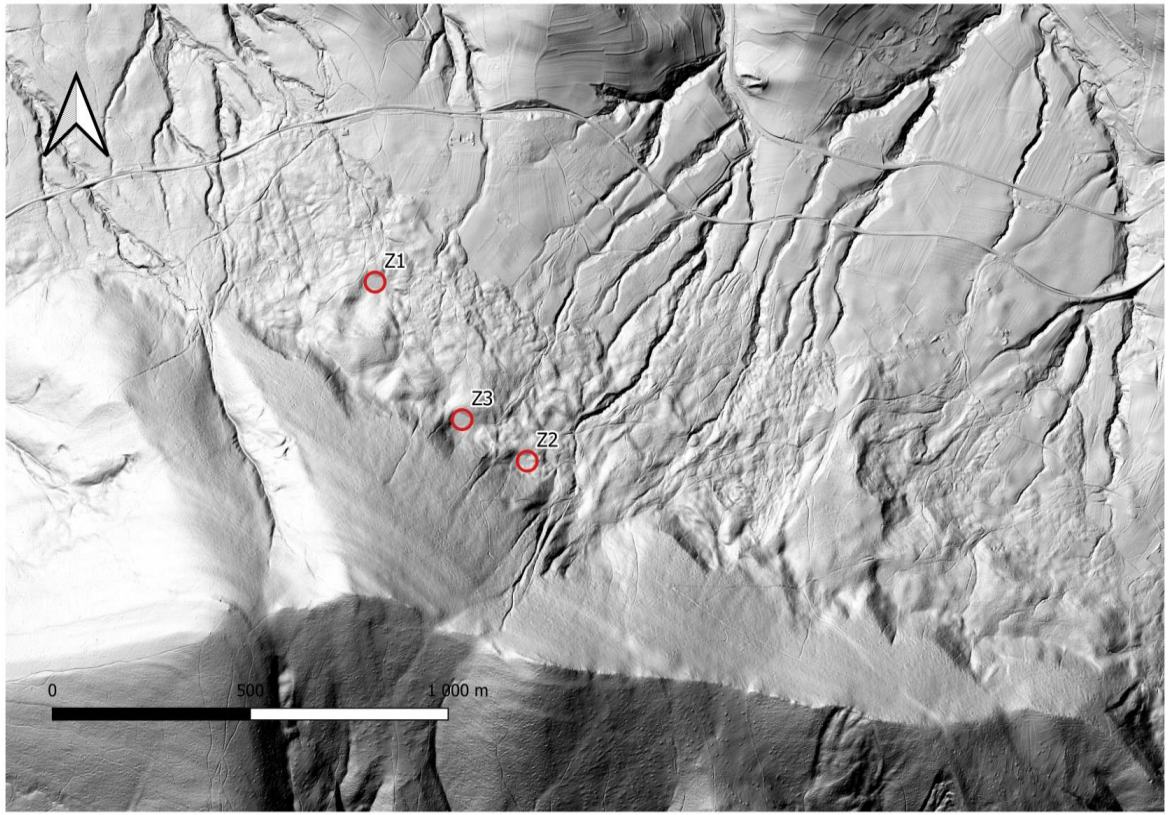
Inoceramian Beds (Senonian-Paleocene) – shales/thin-bedded sandstones

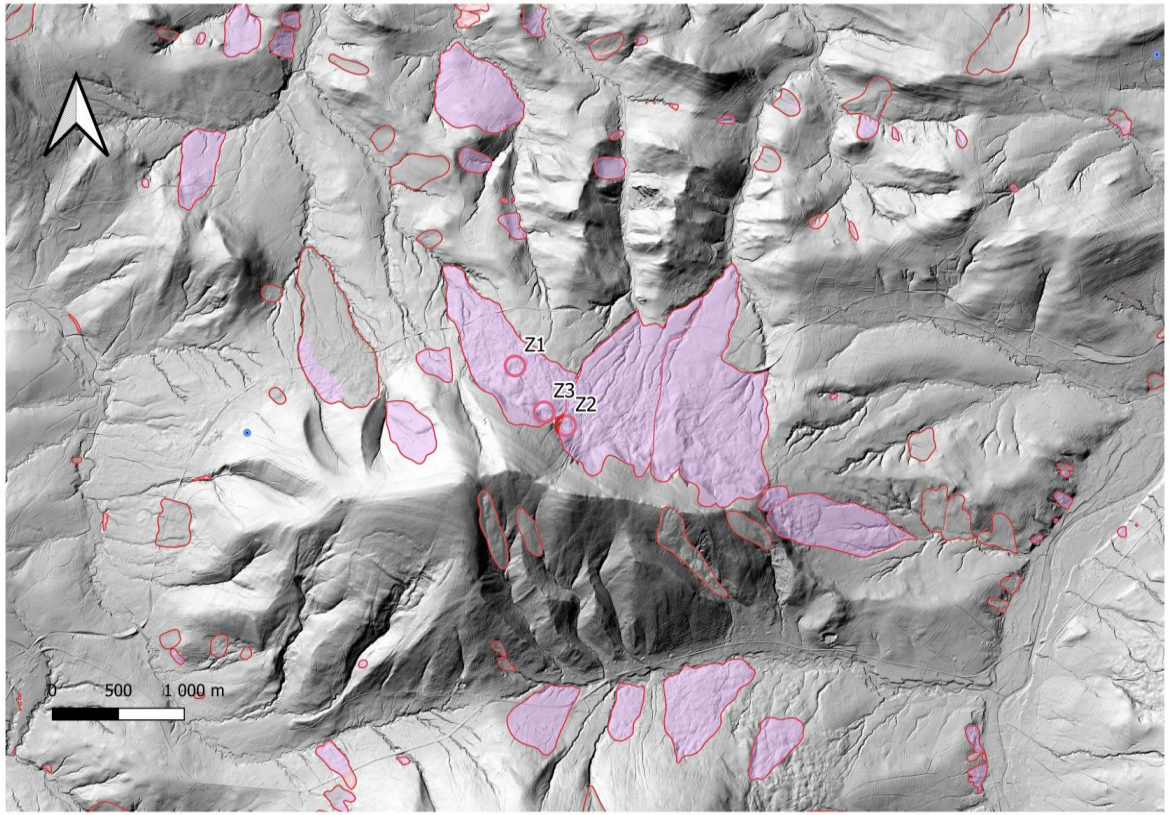
Konon, 1997, 2001

The landslide body is 2.5 kilometers long in its upper part and around 1 kilometer wide from the upper edge to the lower limit of the accumulation zone. The area features hilly topography, typical for landslide bodies of complex origin, and in places, it is dissected by the first-order streams. There is high contrast between the geomorphology of the northern and southern slopes of Mt Snieznica.

Study area

Geomorphology

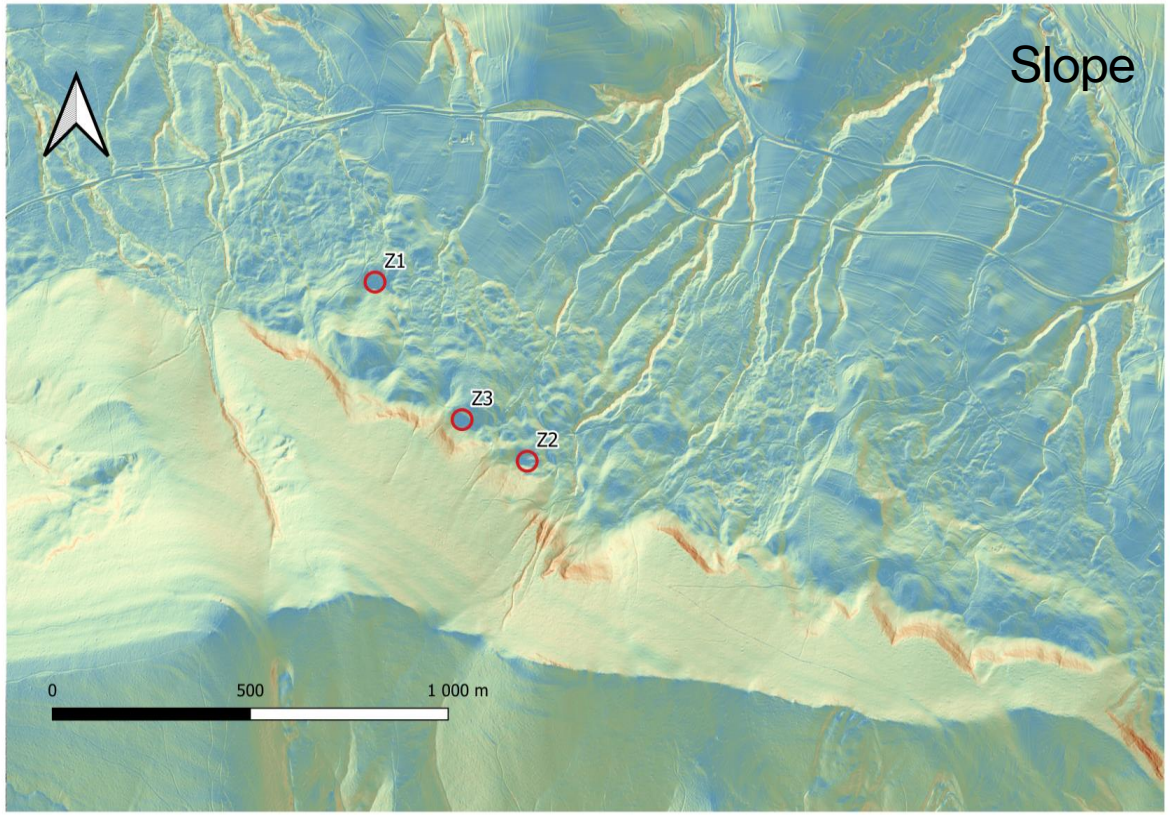


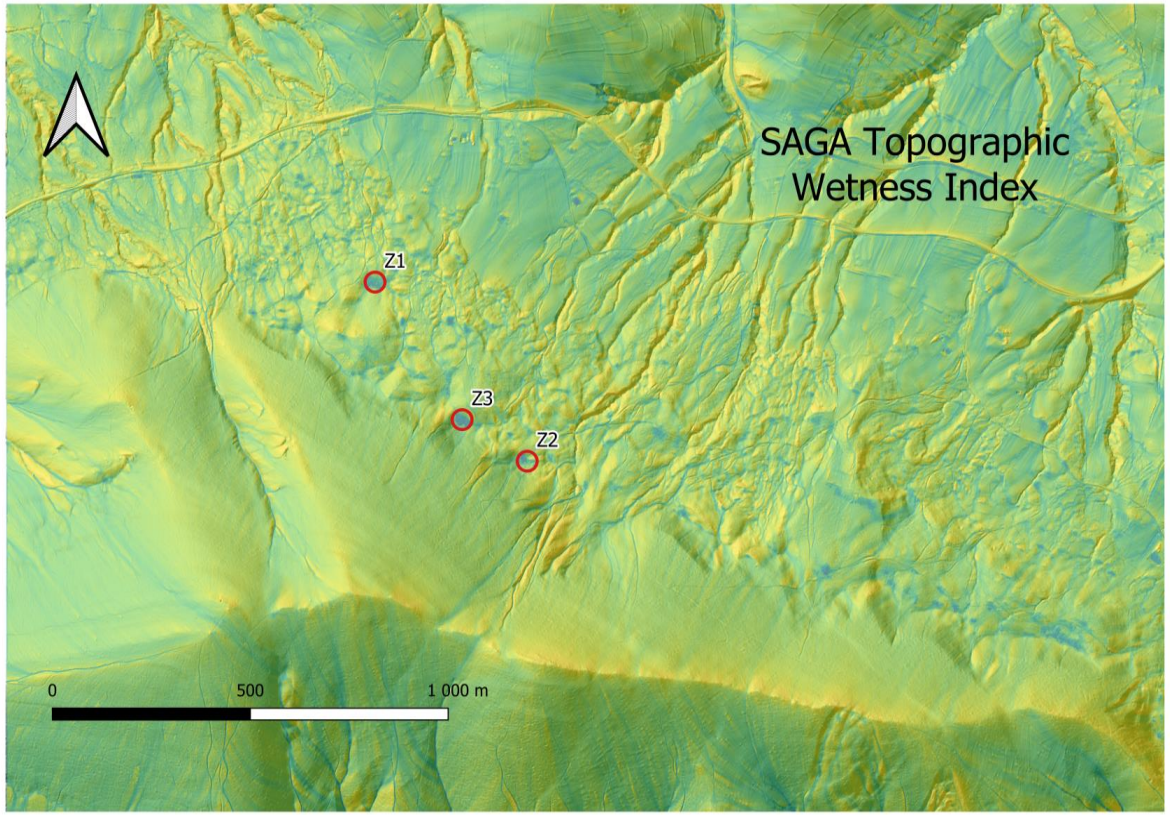


Slope surface model and topographic wetness index highlight differences in hillslope topography between the undisturbed main slope of Mt Snieznica, the landslide body that is highly complex in terms of slope and wetness index, and the foreland of the landslide body that features smooth topography dissected by several streams.

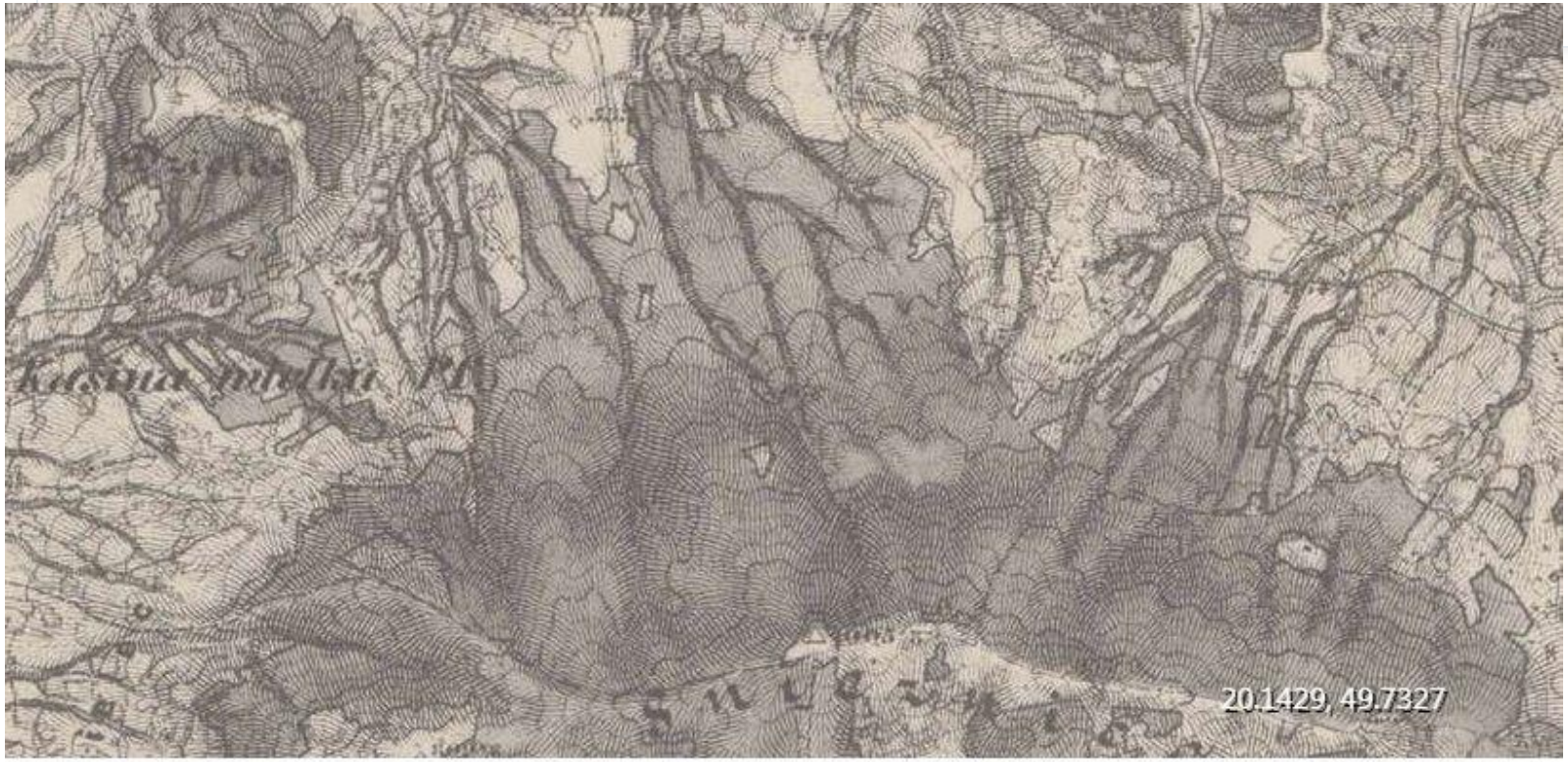
Study area

Geomorphology



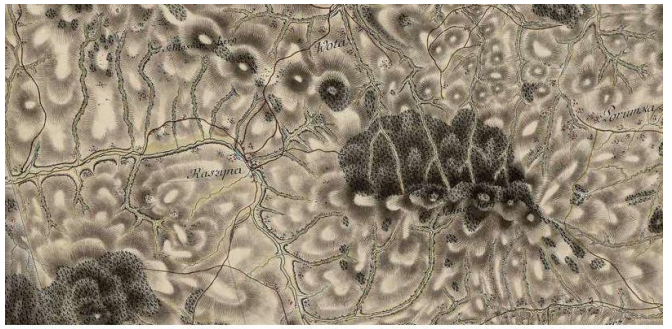


Historical context



Europe in the XIX. century (with the Third Military Survey)

Galicia and Bucovina (1861–1864) - Second military survey of the Habsburg Empire



Galizien und Lodomerien (1779–1783) - First Military Survey

Habsburg Empire (1869-1887) - Third Military Survey (1:75000)

https://mapire.eu/

Historical maps show the area under investigation was still forested at the end of the 18th century. This might suggest unfavorable conditions for settlement and agricultural activity at that time in this area.

For sampling, we selected three sites. The sampling was done with a peat sampler. The cores were 10 cm in diameter and up to 4.4 meters long. The laboratory analyses included: bulk density, measurements of terrigenous and biogenic silicon dioxide, calcium carbonate, total organic carbon content, and other compounds. For the AMS radiocarbon dating, we selected 20 pieces of plant tissue.

Methods

1. After finding and examining 20 pits, three were selected for detailed analyses.
2. For core extraction a peat sampler was used.
3. The cores were 10 cm in diameter and up to 4.4 m deep.
4. Laboratory analyses included: bulk density measurement, geochemical analyses (organic matter, SiO2ter, SiO2biog, CaCO3, TOC, TIC, C, N, S, Na, K, Mg, Ca, Fe, Mn, Cu, Zn, and Pb contents) of biogenic deposits (405 samples), AMC radiocarbon dating of plant tissue (20 pieces), macroscopic charcoal (420 samples each representing 1 cm slice of the core)

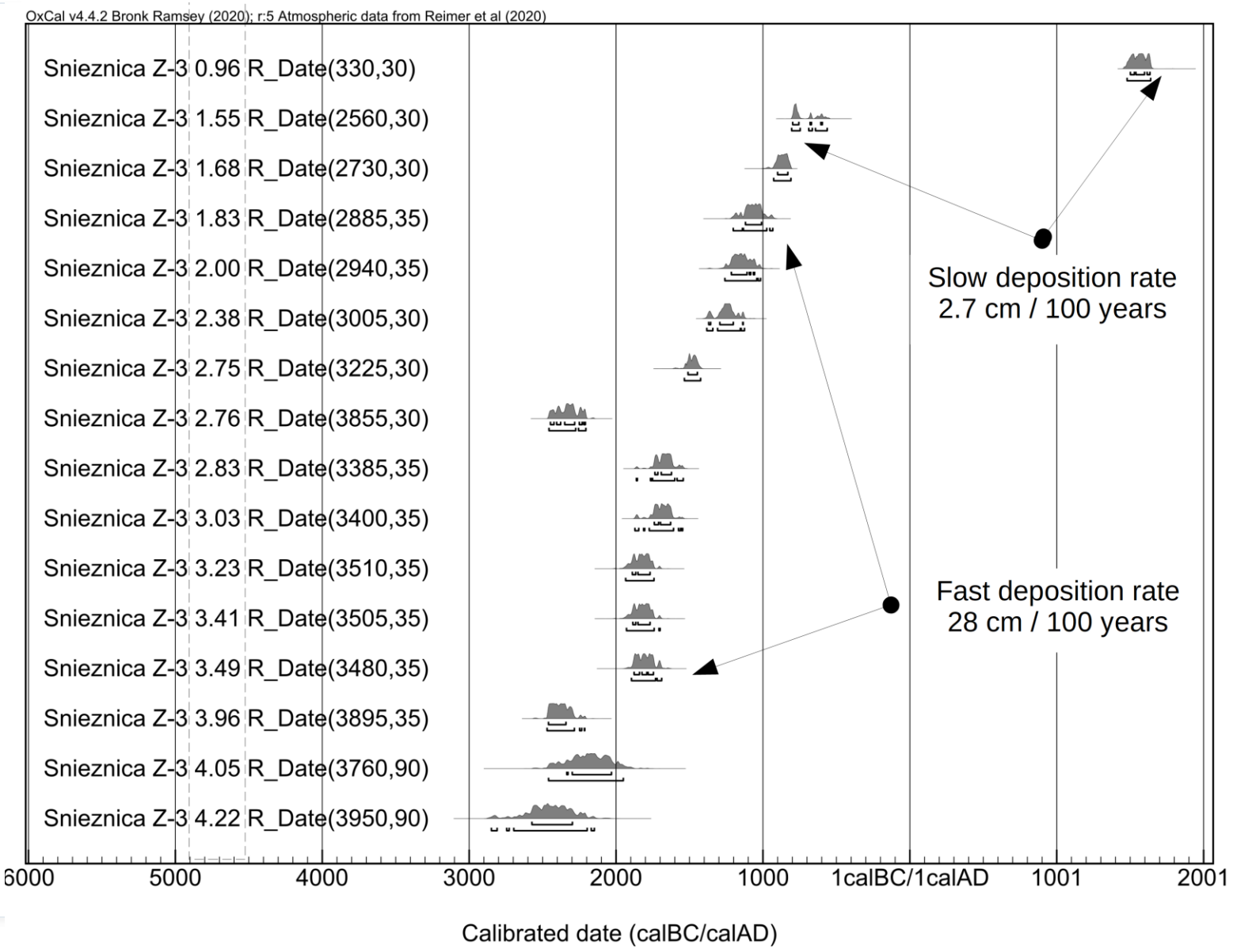
Results 1

- Because this is an ongoing project, so far we were able to analyze one core. For the first stage of the study we have chosen the deepest core reaching 4.4 meters. The study site where this core was extracted is in the upper part of the landslide, at the bottom of the steep slope. The core was marked as Z3.

AMS radiocarbon dating shows that the oldest plant tissue, an isolated seed of a black elder, has a radiocarbon age of 3,950 years before present. It means this plant decayed between 2,700 and 2,200 before Christ. Thus it is more or less the beginning of the Subatlantic stage of the Holocene. Based on the radiocarbon age, we can distinguish two periods of contrasting deposition rate. The fast deposition rate of 28 cm per 100 years was found between 3,480 and 2,885 years before present, and a slow deposition rate of 2.7 cm per 100 years was found between 2,560 and 330 years before present.

- The oldest plant tissue (seed of *Sambucus nigra* – black elder) was dated on 3950±90 years BP.
- The youngest plant tissues (seed and needles of Abies alba – silver fir) was dated on 330±30 years BP.

Results 2

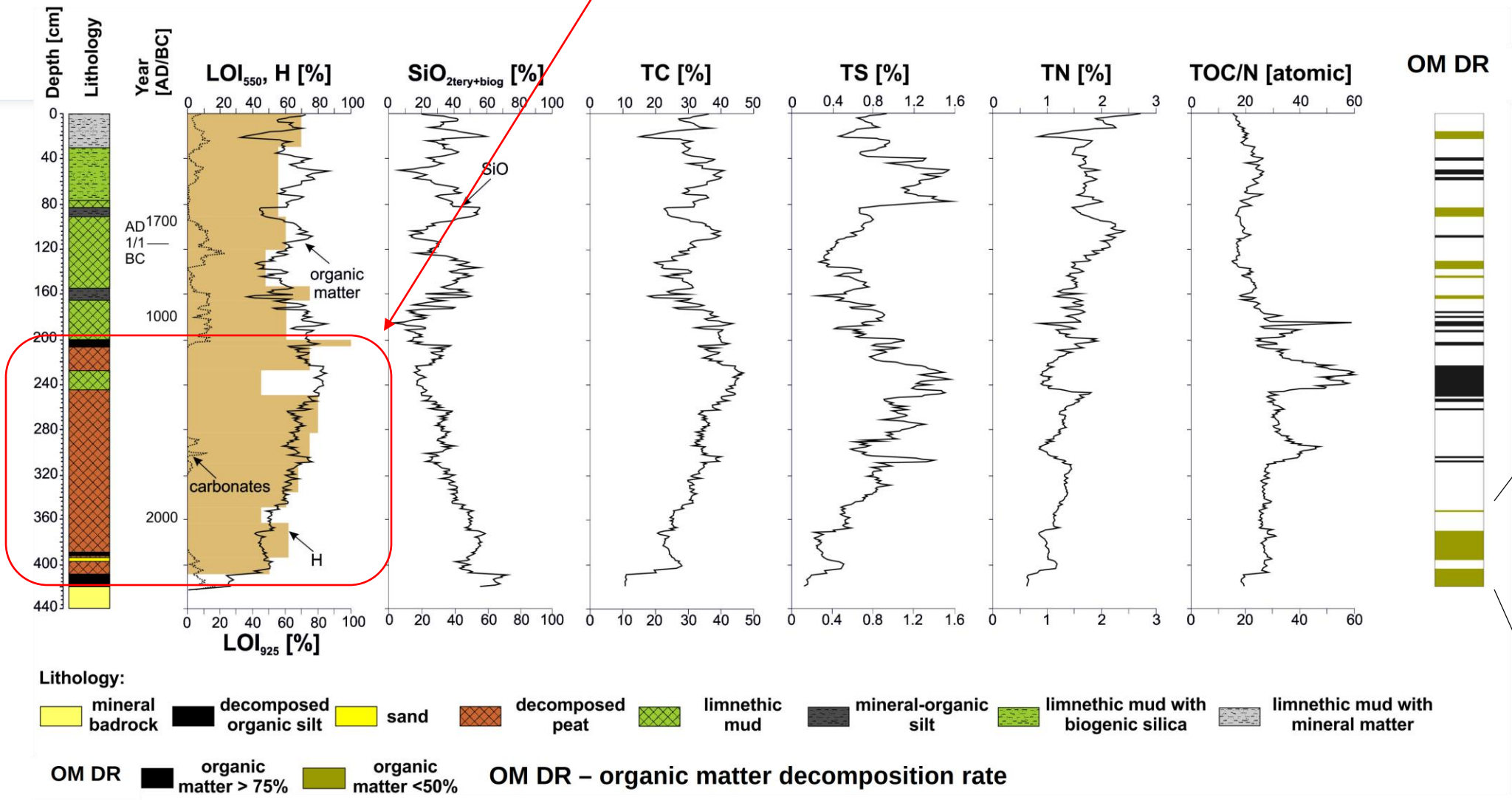


Radiocarbon dating was made in Poznan Radiocarbon Laboratory (https://radiocarbon.pl/en/)

Results 3

Geochemical profile Z3 features an apparent dichotomy. In the lower part, from 420 to 200 cm, peat deposits in different degrees of decomposition dominate. The contribution of organic matter grows continuously up to the maximum level slightly above 80%.

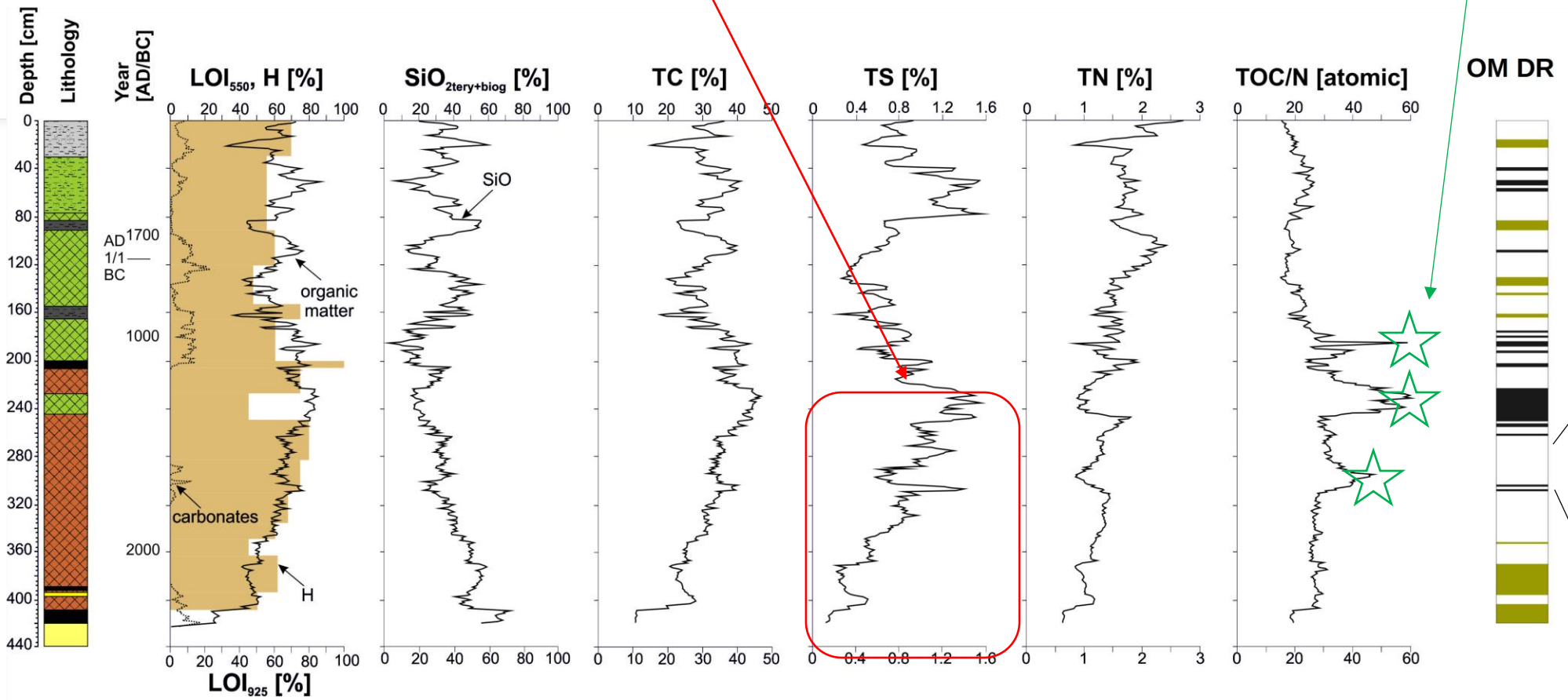
Peat deposits dominate
Continuous increase of organic matter content



Results 4

Continuous increase of sulfur content
Deteriorating oxygen conditions

High values of TOC/N ratio indicate terrestrial origin of organic matter

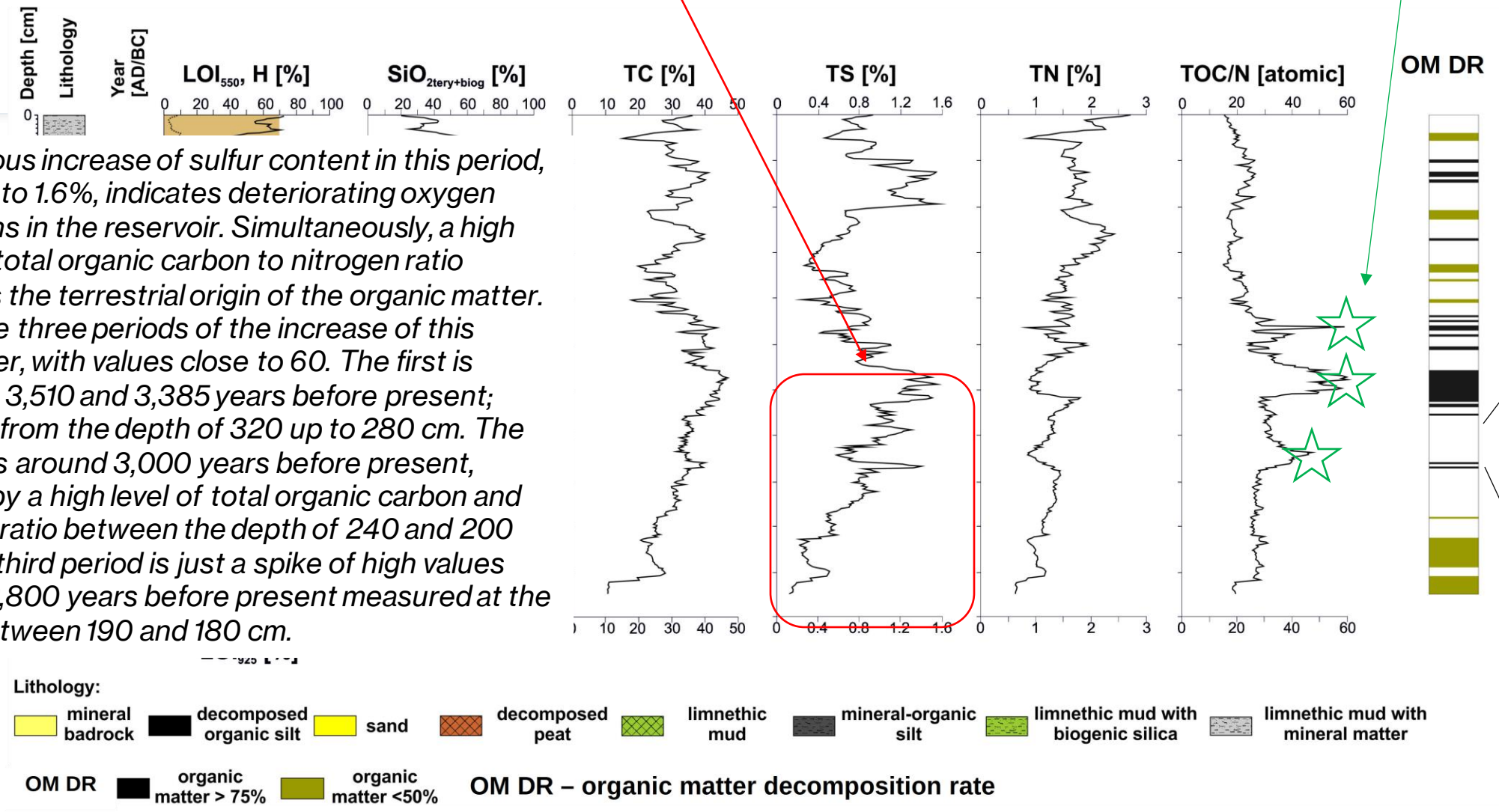


Results 4

Continuous increase of sulfur content
Deteriorating oxygen conditions

High values of TOC/N ratio indicate terrestrial origin of organic matter

Continuous increase of sulfur content in this period, from 0.5 to 1.6%, indicates deteriorating oxygen conditions in the reservoir. Simultaneously, a high value of total organic carbon to nitrogen ratio indicates the terrestrial origin of the organic matter. There are three periods of the increase of this parameter, with values close to 60. The first is between 3,510 and 3,385 years before present; samples from the depth of 320 up to 280 cm. The second is around 3,000 years before present, marked by a high level of total organic carbon and nitrogen ratio between the depth of 240 and 200 cm. The third period is just a spike of high values around 2,800 years before present measured at the depth between 190 and 180 cm.

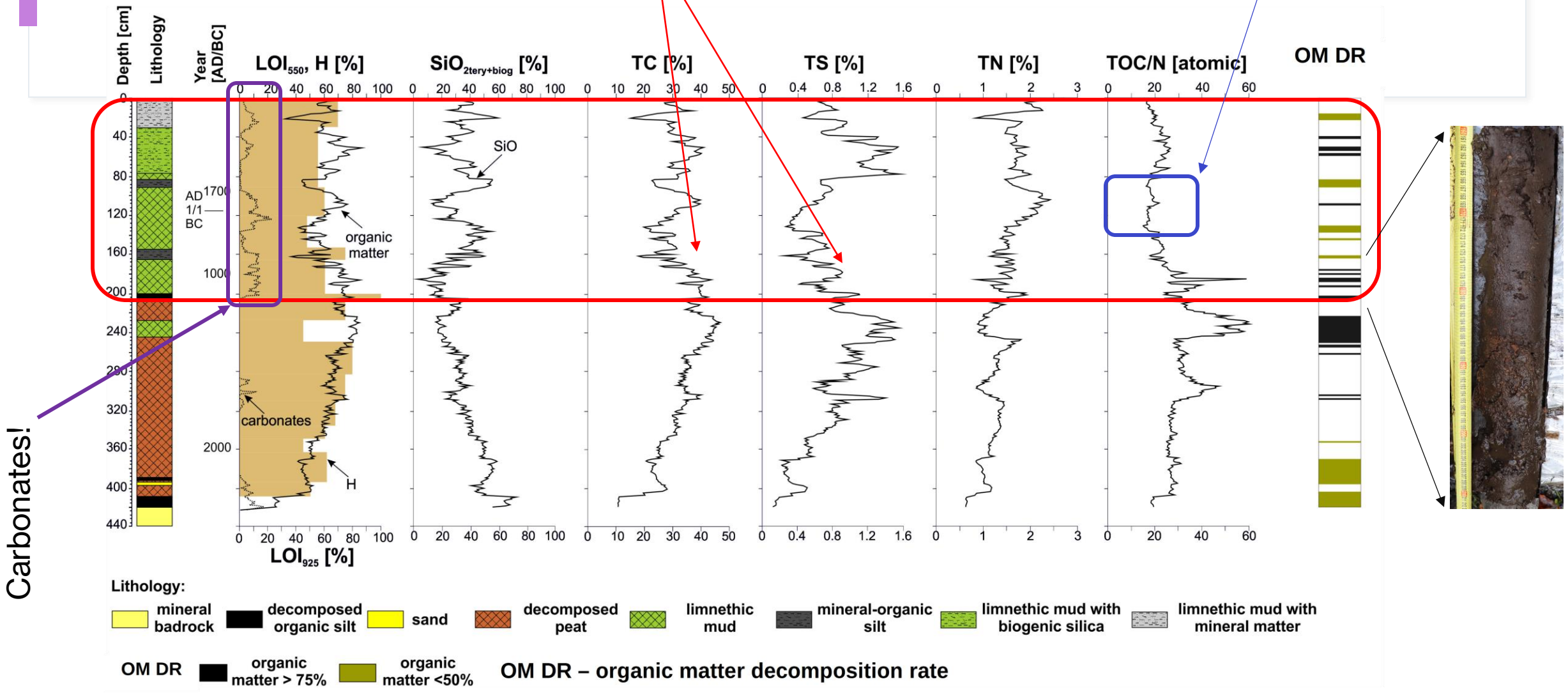


Results 5

Decreasing concentration of carbon and sulfur

Aquatic origin of organic matter

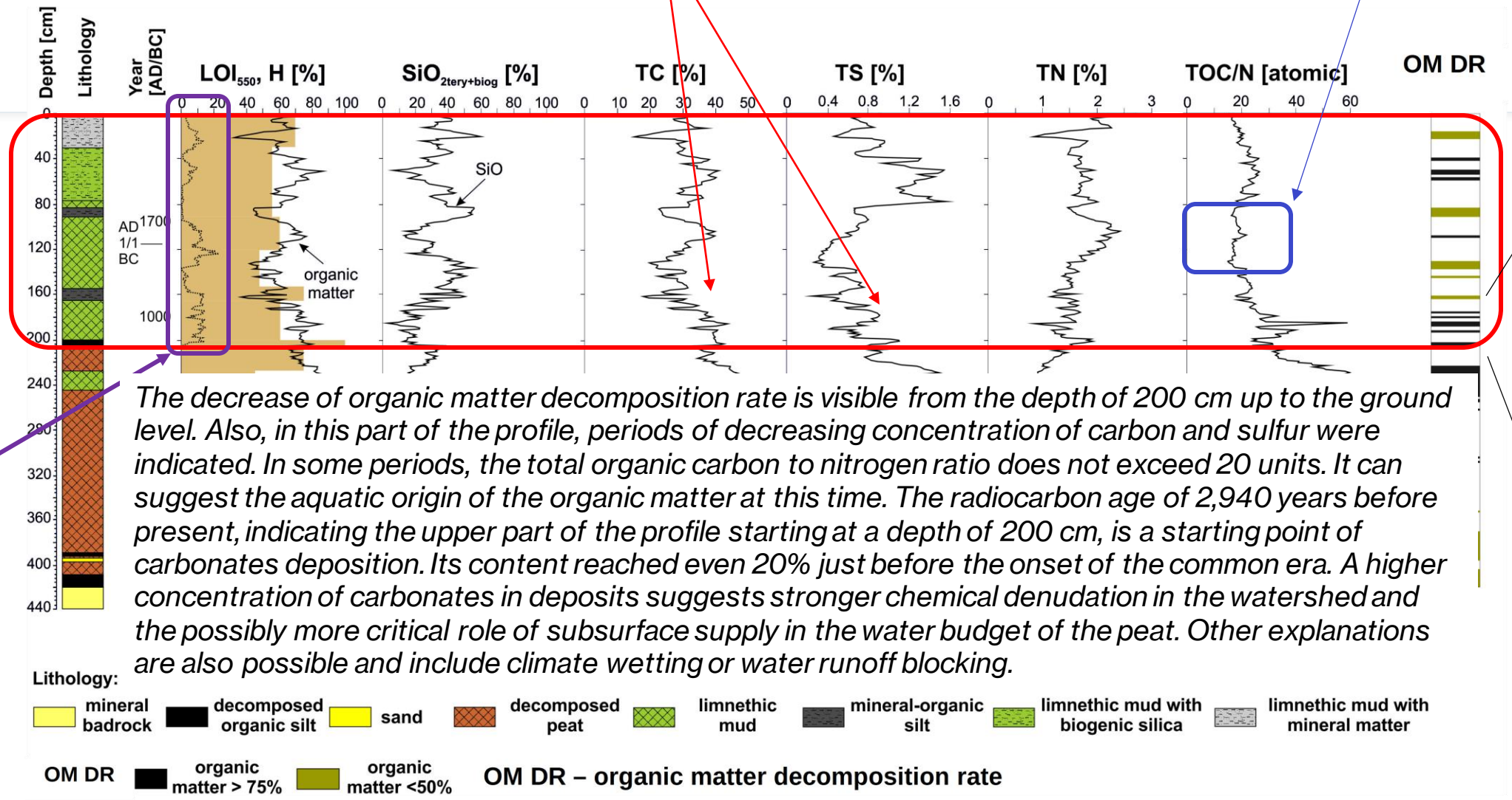
Carbonates!



Results 5

Decreasing concentration of carbon and sulfur

Aquatic origin of organic matter



The decrease of organic matter decomposition rate is visible from the depth of 200 cm up to the ground level. Also, in this part of the profile, periods of decreasing concentration of carbon and sulfur were indicated. In some periods, the total organic carbon to nitrogen ratio does not exceed 20 units. It can suggest the aquatic origin of the organic matter at this time. The radiocarbon age of 2,940 years before present, indicating the upper part of the profile starting at a depth of 200 cm, is a starting point of carbonates deposition. Its content reached even 20% just before the onset of the common era. A higher concentration of carbonates in deposits suggests stronger chemical denudation in the watershed and the possibly more critical role of subsurface supply in the water budget of the peat. Other explanations are also possible and include climate wetting or water runoff blocking.

Carbonates!

Discussion and conclusions

- The peat profile analyzed in this project features a weak record of intensified landslide, or more generally, hillslope processes.
- This can be an outcome of local geological structure and stable water retention conditions that favour biogenic sedimentation.
- It is important to resolve the origin of significant change in lithology of deposits and their chemical content at the time of 1,200 years before the Common era; at the depth of 200 cm.

References

- Konon, A., 1997. Tektonika masuwy Śnieżnicy i jej przedpola (Beskid Wyspowy, płaszczowina magurska). Przegląd Geologiczny 45, 10, 1001-1007.
- Konon, A., 2001. Tectonics of the Beskid Wyspowy Mountains (Outer Carpathians, Poland). Geological Quarterly 45, 2, 179-204.

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