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INQUA-TERPRO PERIBALTIC WORKING GROUP INTERNATIONAL FIELD SYMPOSIUM 2025

"Quaternary Stratigraphy, Paleoenvironments and Geoarchaeology in central Germany"

Book of abstracts

Edited by Andreas Börner & Henrik Rother

25-29th August 2025 Michaelstein Abbey, Germany

Conference schedule - 26th August 2026

08:15 - 08:30 opening session by PWG president and organizing team

08:30 - 10:30 oral presentation – session I

4x 15+4 minutes

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   The process-form imprint of disintegrated ice sheet derived from sedimentological studies, N Poland
2. ***Adrian Hall** and Mikis van Boeckel*
   Glacial sculpting of Precambrian basement in Sweden
3. ***Aleksandra Majecka**, Dorota Nalepka, Mirosława Kupryjanowicz , Wojciech Granoszewski, Anna Hrynowiecka, Irena* Agnieszka Pidek, Magdalena Fiłoc, Małgorzata Malkiewicz, Małgorzata Nita, Bożena Noryśkiewicz, Hanna Winter and Adam Walanus
   The Late Saalian climatic oscillation record from the Polish Lowland in the light of the European evidences
4. ***Małgorzata Pisarska-Jamroży**, Szymon Belzyt, Māris Nartišs, Albertas Bitinas, Barbara Woronko, Alar Rosentau and Szymon Świątek*
   Water-level changes in the Baltic Ice Lake, overloading, and storm activity as causes of sediments liquefaction: A case study from the Sārnate Site, Latvia

5x 12+2 minutes

5. ***Jacek Forysiak,** Mateusz Półciennik and Danuta A. Dzieduszyńska*
   Symptoms of warming at the transition Plenivistulian-Late Vistulian recorded in Polish Lowland sediments
6. ***Joanna Petera-Zganiacz***
   Periglacial structures in fluvial deposits as an important palaeogeographical indicator; a case study from Central Poland
7. ***Monika Niska**, Anna Hrynowiecka, Renata Stachowicz-Rybka, Wojciech Drzewicki, Adam Michczyński, Petra Hajkowa and Krzysztof Stefaniak*
   Mountain regions peat bogs in the light of the results of the Cladocera analysis
8. ***Miglė Paškevičiūtė** and Petras Šinkūnas*
   Sedimentary structures and paleoflow variability patterns in ice-marginal glaciofluvial deposits of Eastern Lithuania
9. ***Michal Šujan**, Albertas Bitinas, Holger Steffen, Laura Gedminienė, Marianna Kováčová, Tomáš Vlček, Rouxian Pan, Andrej Chyba, Oleksiy Davydov, Aldona Damušytė, Jérôme Juilleret, Kishan Aherwar and Barbara Rózsová*
   Tracing the pre-glacial legacy: Evolution of the Daumantai Formation beneath the oldest Quaternary moraines in Lithuania

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11. ***Barbara Woronko**, Zbigniew Zagórski and Michał Cyglicki*
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12. ***Szabolcs, Ákos Fábián***
    Identification and characterisation of buried periglacial polygonal networks in Hungary
13. **Dag Ottesen,** Christine Batchelor, James Kirkham and Julian A. Dowdeswell
    The evolution of the Quaternary North Sea Basin with emphasis on the last three glaciations

5x 12+2 minutes

14. ***Pertti Sarala** and Juha Pekka Lunkka*
    Occurrence of subglacial ring-shaped moraines in Finland
15. ***Przemysław Mroczek**, Nils Andersen, Irena Agnieszka Pidek, Renata Stachowicz-Rybak and Anneli Poska*
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16. ***Dalia Kisielienė** and Vaida Šeirienė*
    Problems in stratigraphy of Late Middle Pleistocene Sediments in Lithuania
17. ***Olga Reutt**, Damian Moskalewicz and Piotr P. Woźniak*
    Local bedrock contribution to geochemistry of glacigenic deposits – case study at Årsdale, Bornholm

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18. ***Marcel Weiss,*** *Andrzej Wiśniewski and Olaf Jöris*
    Continuities and discontinuities in the Upper Pleistocene archaeological record of northern Central Europe
19. **Robert J. Sokołowski**, Henrik Rother, Piotr Moska and Paweł Zieliński
    Correlation of permafrost aggradation episodes in the Polish Lowlands and Saxony-Anhalt based on selected sites

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20. ***Beáta Farkas****, Randall Schaetzl and Barbara Woronko*
    Micromorphological comparison of two relict sand wedge sites and implications for paleoenvironmental conditions
21. ***Jörg Lang****, Anke Bebiolka, Vera Noack, Julia Schütze, Sarah Weihmann and Sonja Breuer*
    Structural control on tunnel-valley formation: Fact or fiction?
22. ***Sanjaya Gurung****, Karol Tylmann and Piotr P. Woźniak*
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23. ***Kajetan K. Ogłaza****, Barbara Woronko, Barbara Rybak-Ostrowska, Mateusz Iskra, Piotr Moska, Arshavir Hovhannisyan, Ara Avagyan and Hakob Simonyan*
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24. ***Edijs Breijers*** *and Hugo Huberts Puriņš*
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22x á 2+1 minutes

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    Microstructural analysis in research of glacigenic sediments deformed by seismic activity – examples from NE Germany and Lithuania
26. ***Piotr Czubla*** *and Dariusz Brykała*
    Erratic boulders as raw material for making rotary querns and millstones in the Southern Baltic Lowlands
27. ***Tiina Eskola****, Juha Pekka Lunkka, Selina Heikura, Pertii Sarala and Niko Putkinen*
    Updated palaeoenvironmental reconstruction using multi-disciplinary methods from an inter-till sequence in a bedrock valley, western Finland
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29. *Łukasz Elwirski and* ***Piotr P. Woźniak***
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30. ***Runa Fälber,*** *Gustav Jungdal-Olesen, Vivi Kathrine Pedersen, Anders Damsgaard, Jan A. Piotrowski,*
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31. ***Jacek Forysiak****, Leszek Marks, Aleksandra Majecka, Łukasz Bujak and Wojciech Włodarski*
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41. ***Joanna Petera-Zganiacz*** *and Danuta A. Dzieduszyńska*
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    The Kalviai diamicton conundrum: Revisiting the presumed oldest Pleistocene till in the Baltic region (Lithuania)
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    Evolutionary model of inland parabolic dunes from the Late Weichselian: Geomorphological and sedimentological records in the central part of European Sand Belt

Excursion Program - Northern and Eastern Harz foreland

August 27, 2025

Stop 1: Devil's Wall ('Teufelsmauer') at Neinstedt / Weddersleben
Stop 2: Sand-gravel pit Drosa (Middle Pleistocene)
Stop 3: Weichselian loess-paleosol sequence at Langenbogen
Stop 4: Geiseltal lignite and late glacial Laacher See Tephra at Krumpa
Stop 5: Copper shale mining history at Wimmelburg

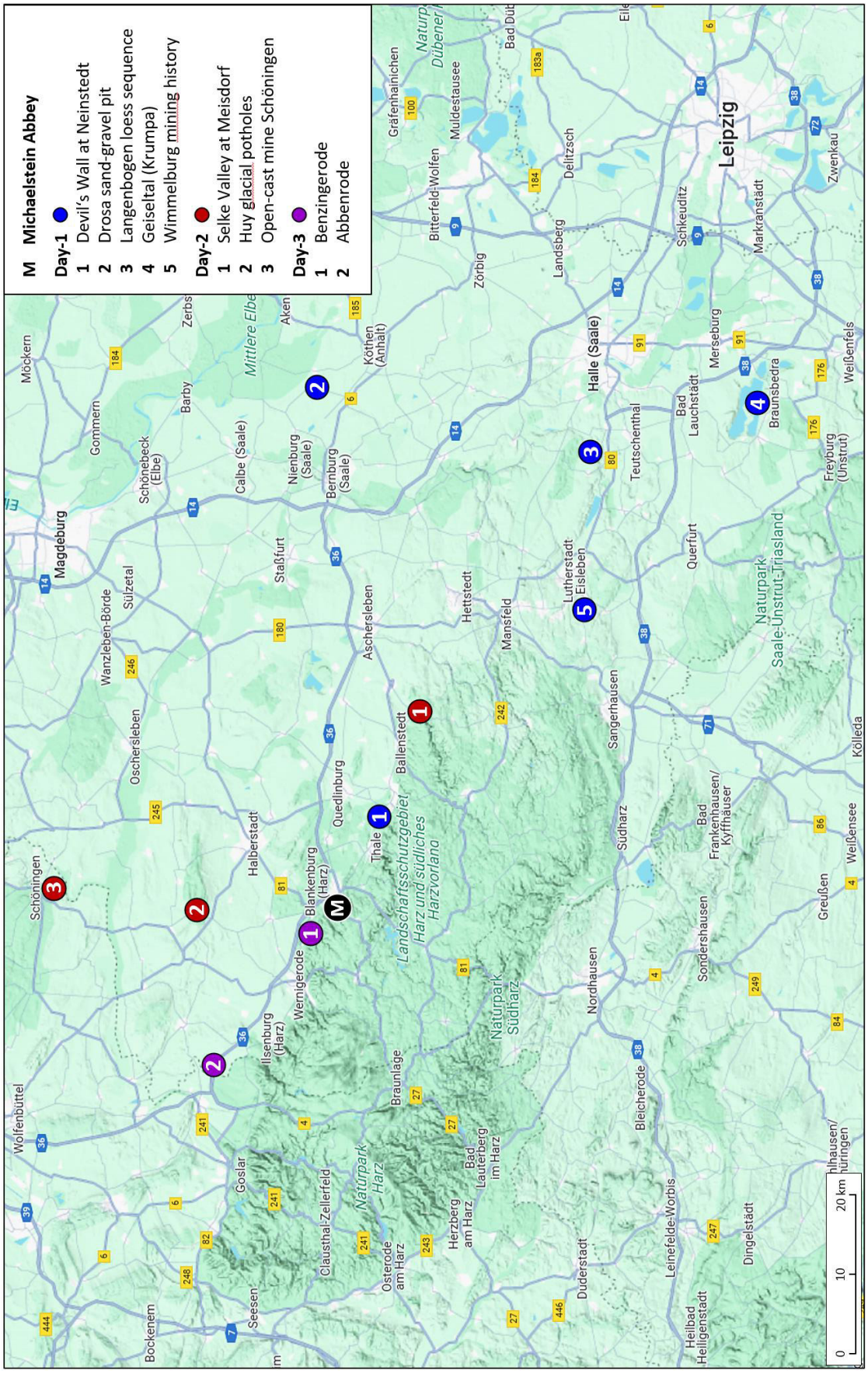
August 28, 2025

Stop 1: Holocene floodplain stratigraphy: Selke River near Meisdorf
Stop 2: Glacial potholes in middle Triassic limestone on the Huy
Stop 3: Pleistocene stratigraphy and Lower Palaeolithic archaeology
in the lignite mine at Schöningen

August 29, 2025

Stop 1: Northern Harz Boundary Fault at Benzingerode
Stop 2: Push moraine and glaciotectonic sequence at Abbenrode

Overview: Excursion route map



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Microstructural analysis in research of glacigenic sediments deformed by seismic activity – examples from NE Germany and Lithuania

Szymon Belzyt[a], Małgorzata Pisarska-Jamrożyb, Emrys Phillips[c] , Barbara Woronko[d] , Aneta Kozłowska[b] and Jan A. Piotrowski[e,f]

[a]Institute of Geological Sciences, University of Wrocław, Wrocław, Poland, szymon.belzyt@uwr.edu.pl;
[b]Institute of Geology, Adam Mickiewicz University, Poznań, Poland;
[c]British Geological Survey, The Lyell Centre, Edinburgh, UK;
[d]Faculty of Geology, University of Warsaw, Warsaw, Poland;
[e]Department of Geoscience, Aarhus University, Aarhus, Denmark;
[f]Faculty of Earth Sciences and Spatial Management, Nicolaus Copernicus University, Toruń, Poland.

The analysis of soft-sediment deformation structures (SSDS) in glaciogenic sediments can be used as a valuable secondary, off-fault indicator of past seismicity associated with glaciations and ice-sheet dynamics. When analyzed at the microstructural level, they significantly complement mesoscale field observations. This study presents micromorphological analyses of liquefaction-induced SSDS from three sites in the southern Baltic region, Dwasieden and Weisser Berg in northeastern Germany, and Dyburiai in northwestern Lithuania, where seismites had previously been identified through mesoscale investigations. At Weisser Berg, deformation reflects repeated seismicity linked to glacioisostatic adjustment during the Late Weichselian glaciation (MIS 2) (Hoffmann and Reicherter, 2012; Pisarska-Jamrożyet al., 2022). At Dyburiai, at least seven seismic events associated with fault reactivation during post-Saalian deglaciation (MIS 5) are inferred (Belzyt et al., 2021). The Dwasieden site records SSDS interpreted as resulting from reactivation of pre-Quaternary faults triggered by the advance of the Fennoscandian Ice Sheet during MIS 2 (Pisarska-Jamrożyet al., 2018, 2019). A total of nine oriented, undisturbed samples were collected from lithologically varied, unconsolidated Pleistocene sediments. Thin sections were prepared and examined to reconstruct the deformation mechanisms and sequences of liquefaction events.

Micromorphological evidence reveals that each seismite layer underwent multiple deformation stages – initial ductile folding, liquefaction with sediment injection, and subsequent brittle faulting. Re-liquefaction features are present, identified by the overprinting of earlier deformation structures by later fluid escape and fracturing events. Heterogeneous deformation intensities observed within individual thin sections highlight the controlling role of sediment composition, grain size contrasts, and impermeable laminae in localizing deformation.

These findings underscore the diagnostic value of micromorphological techniques in recognizing and characterizing seismites in formerly glaciated regions. The staged development of deformation structures provides key insights into intraplate earthquake dynamics and ice sheet–crust interactions during the Late Pleistocene, enhancing reconstructions of past seismic and environmental conditions in formerly glaciated terrains.

References

Belzyt, S., Pisarska-Jamroży, M., Bitinas, A., Woronko, B., Phillips, E.R., Piotrowski, J.A., Jusienė, A., 2021: Repetitive Late Pleistocene soft-sediment deformation by seismicity-induced liquefaction in north-western Lithuania. *Sedimentology 68*, 3033–3056.

Hoffmann, G., Reicherter, K., 2012: Soft-sediment deformation of late Pleistocene sediments along the southwestern coast of the Baltic Sea (NE Germany). *International Journal of Earth Sciences 101*, 351-363.

Pisarska-Jamroży, M., Belzyt, S., Börner, A., Hoffmann, G., Hüneke, H., Kenzler, M., Obst, K., Rother, H.. Van Loon, A.J., 2018: Evidence from seismites for glacioisostatically induced crustal faulting in front of an advancing land-ice mass (Rügen Island, SW Baltic Sea). *Tectonophysics 745*, 338–348.

Pisarska-Jamroży, M., Belzyt, S., Börner, A., Hoffmann, G., Hüneke, H., Kenzler, M., Obst, K., Rother, H., Steffen, H., Steffen, R. and Van Loon, A.J., 2019: The sea cliff at Dwasieden: soft-sediment deformation structures triggered by glacial isostatic adjustment in front of the advancing Scandinavian Ice Sheet. *E&G Quaternary Science Journal 2*, 61–64.

Pisarska-Jamroży, M., Belzyt, S., Börner, A., Hoffmann, G., Kenzler, M., Rother, H., Steffen, R., Steffen, H., 2022: Late Pleistocene earthquakes imprinted on glaciolacustrine sediments on Gnitz Peninsula, Usedom Island (NE Germany). *Quaternary Sciences Reviews 296*, 107807.

Machine Learning for Glacial Landform Detection and Classification: First Insights from Latvia

Edijs Breijers and Hugo Huberts Puriņš

Department of Geography, University of Latvia, Riga, Latvia, edijs.breijers@lu.lv

Glacial landform mapping has long served not only to describe the geomorphological conditions of post-glacial landscapes but also to reconstruct the palaeo-ice dynamics during the last deglaciation. Traditionally, glacial landforms have been delineated manually, initially through field surveys and, more recently, using a geographical information system based interpretation of topographical maps or LiDAR-derived digital elevation models (DEMs) (Lamsters, Zelčs, 2015). Technological advances in machine learning and free and open-source software allow researchers to reduce manual labour and expert bias to a minimum while achieving comparable or even improved accuracy of the resultant landform maps (e.g. Janowski et al., 2022).

As with most supervised classification methods, manually delineated landforms are still required to develop a machine learning framework for glacial landform classification. To mitigate the potential for expert bias not resulting in precise delineations of the landforms, an unsupervised DEM derivative segmentation is introduced with simple linear iterative clustering (Nowosad, Stepinski, 2022). The segmented context-preserving superpixels are overlaid with the manually delineated landforms to construct the training dataset.

In a case study of the Burtnieks drumlin field in the Northern Vidzeme Lowland of Latvia, a binary object-based classification of drumlins was performed using a gradient boosting model. The model's hyperparameters were tuned via a cluster-based spatial cross-validation strategy applied to the DEM-derived feature sets of the superpixels. The model results provide promising first insights into the development of a machine learning framework for glacial landform classification and the benefits of such an approach as opposed to only manually delineating landforms. However, a more nuanced approach is necessary for comprehensive glacial landform mapping across Latvia due to the local and regional variability of the different landforms (e.g. Lamsters et. al., 2021).

This research is funded by the Latvian Council of Science, project "Reconstruction of ice stream dynamics and deglaciation of the SE sector of the Scandinavian Ice Sheet in Latvia", project No. lzp-2024/1-0193.

References

Janowski, L., Tylmann, K., Trzcinska, K., Rudowski, S., Tegowski, J. 2022. Exploration of Glacial Landforms by Object-Based Image Analysis and Spectral Parameters of Digital Elevation Model. *IEEE Transactions on Geoscience and Remote Sensing 60*, 1–17

Lamsters, K., Vītola, Z., Karušs, J., Džeriņš, P., 2021: Evidence of ice streaming and ice tongue shutdown in western Latvia: revealed from the mapping of crevasse-squeeze ridges. *Baltica 33*(1).

Lamsters, K., Zelčs, V., 2015: Subglacial bedforms of the Zemgale Ice Lobe, south-eastern Baltic. *Quaternary International 386*, 42–54.

Nowosad, J., Stepinski, T. F. 2022. Extended SLIC superpixels algorithm for applications to non-imagery geospatial rasters. *International Journal of Applied Earth Observation and Geoinformation 112*, 102935.

Erratic boulders as raw material for making rotary querns and millstones in the Southern Baltic Lowlands

Piotr Czubla[a] and Dariusz Brykała[b]

[a] Department of Geology and Geomorphology, University of Łódź, Poland, piotr.czubla@geo.uni.lodz.pl;
[b] Institute of Geography and Spatial Organization, Polish Academy of Sciences, Toruń, Poland

Querns and/or millstones were essential elements in the functioning of every agricultural community. Large centres of mining and millstone production—such as Niedermendig near Andernach (Rhenish stones), Silesia, and Saxony—developed as early as antiquity and the early Middle Ages. Millstones imported from afar were very expensive; therefore, cheaper substitutes were sought. In the South Baltic Lowlands (SBL), these substitutes were millstones produced locally from available raw materials, namely erratics.

Erratics (erratic boulders) occur in large numbers in glacial and fluvioglacial deposits, especially within the extent of the last Fennoscandian glaciation, and represent a wide variety of petrographic types (e.g., Smed 1994; Schulz 2003; Czubla 2015) with differing technical properties. This diversity allowed for the selection of raw materials with optimal characteristics for millers and stonemasons.

For construction purposes, most types of erratics were used. However, only a few—those characterised by high resistance to abrasion and cracking—were suitable for millstone production. In the area of present-day Poland and Lithuania, these were most often (83%) granitoids with a medium- or coarse-crystalline texture, relatively poor in dark minerals susceptible to weathering. Notably, medium-crystalline granitoids are generally represented among finished millstones, while coarse-crystalline granitoids and pegmatites (2%) occur more frequently as semi-finished products. This may be interpreted as a result of difficulties in processing coarse-crystalline rocks, in which large fragments tended to break off easily along feldspar cleavage planes.

Metamorphic rocks commonly found among erratic boulders—such as gneisses and migmatites—were used for millstone production only in exceptional cases (3%). This was probably due to their high susceptibility to fragmentation along directional textures.

Sandstones and other sedimentary rocks rarely occur as large erratic boulders. Moreover, their technical properties—except in the case of quartzitic sandstones (orthoquartzites)—are generally inferior to those of igneous rocks. Despite this, historical sources indicate that some types, such as sandstones from Silesia and Saxony, were considered valuable raw materials for millstone production. The finished products were then transported over long distances. In the South Baltic Lowlands (SBL), millstones and semi-finished products made of sandstone are relatively rare (7%). This low percentage may be interpreted either as a result of relying solely on local erratic raw material, in which suitably sized sandstone boulders are scarce, or as evidence of the secondary use of worn millstones for producing whetstones or grindstones (e.g., Czubla et al. 2024).

Rotary querns were also occasionally made from Palaeozoic limestones, which occur on Öland and Gotland, as well as in the form of erratics in the SBL. The type of rock alone does not allow for determining the place of production, but archaeological evidence suggests that they most likely originated from the Baltic islands.

Most of the millstones and querns used in the SBL were made from erratic rocks. While the import of roughly processed millstones from quarries in southern Scandinavia cannot be ruled out, it is more plausible that easily accessible local rocks were used instead—especially given that a significant proportion of the analysed objects are semi-finished products which, due to defects, were never completed.

This work was supported by the National Science Centre, Poland (Grant No. 2019/35/B/HS3/03933).

References

Czubla, P., 2015: Eratyki fennoskandzkie w osadach glacjalnych Polski i ich znaczenie badawcze. Wydawnictwo Uniwersytetu Łódzkiego, Łódź, 335 pp.

Czubla, P., Brykała, B., Dąbski, M., Gierszewski, P., Błaszkiewicz, M., Mosakowski, Z., Lamparski, P., 2024: Unobvious geoheritage in sacral buildings: millstones in churches of NE Poland from a geological and geomorphological perspective. *Geographia Polonica 97 (3)*, 327-354, https://doi.org/10.7163/GPol.0282

Schulz, W., 2003: Geologischer Führer für den norddeutschen Geschiebesammler, cw Verlagsgruppe, Schwerin, 508 pp.

Smed, P., 1994: Steine aus dem Norden: Geschiebe als Zeugen der Eiszeit in Norddeutschland. Gebrüder Borntraeger, Berlin–Stuttgart, 194 pp.

Updated palaeoenvironmental reconstruction using multi-disciplinary methods from an inter-till sequence in a bedrock valley, western Finland

Tiina Eskola[a], Juha Pekka Lunkka[a], Selina Heikura[a], Pertii Sarala[a] and Niko Putkinen[b]

[a]Oulu Mining School, University of Oulu, Oulu, Finland, e-mail; tiina.eskola@oulu.fi;
[b]Geological Survey of Finland, Kokkola, Finland

Investigations by the Geological Survey of Finland in Kurikka, western Finland, have provided valuable insights into the stratigraphy and paleoenvironmental history of a geologically complex aquifer system. The multidisciplinary studies have focused on a 1.5-billion-year-old bedrock valley filled with Pleistocene sediments (Hall et al. 2021). The investigations revealed over 10 meter thick organic-rich fine-grained sediments below the Holocene and Late Weichselian sediments. This exceptionally well-preserved sequence was sampled in late 2022 and complemented in early 2025.

Chronostratigraphic analysis, supported by radiocarbon (AMS) and optically stimulated luminescence (OSL) dating, indicates that these fine-grained, organic-rich sediments accumulated between the Saalian and Middle Weichselian glaciations. Palynological data, particularly pollen analyses, obtained through the LST Fastfloat method (Eskola et al. 2021) further refine the paleoenvironmental framework and highlight vegetational changes over time.

Sediment cores retrieved from depths of 31–43 meters near the Kyrönjoki River reveal that the sequence is dominated by laminated fine-grained sediments, interpreted as varves. These rhythmites are consistently present throughout the core, with synsedimentary deformation structures and dropstones occurring occasionally in the lower units. Preliminary varve counts suggest sedimentation rates ranging from 0.3 to 0.5 mm/year, providing a high-resolution archive of depositional dynamics.

Geochemical and physical proxy data, including portable X-ray fluorescence (pXRF), magnetic susceptibility, and loss-on-ignition analyses, have been carried to assess sediment elemental composition, mineralogy and organic content. All these datasets combined together reflect changes in depositional environment and sediment provenance, input dynamics, and organic accumulation.

References

Eskola T., Kontio R., Lunkka J.P., 2021: Comparison between modified LST Fastfloat and conventional HF methods for pollen preparation in highly minerogenic sediments. *Bulletin of the Geological Society of Finland 93*, 5–18.First author, A.B., Second author, C.D., 2024: Title of paper comes here. *Journal of Geology 15*, 3–17. (Use format style Reference)

Hall A.M., Putkinen N., Hietala S., Lindsberg E., Holma M., 2021. Ultra slow cratonic denutation in Finland since 1.5 Ga indicated by tiered unconformities and impact structures. *Precambrian Research 352*.

Geology, geomorphology and peculiarities of Eidem Lagoon formation (Svalbard archipelago)

Oleksiy Davydov[a,b], Aldona Damušytė[c], Sergej Olenin[d], Andrius Šiaulys[d], Ilya Buynevich[e], Olga Jefanova[a] and Albertas Bitinas[a]

[a]State Scientific Research Institute Nature Research Centre, Vilnius, Lithuania oleksiy.davydov@gamtc.lt, olga.efanova@gamtc.lt, albertas.bitinas@gamtc.lt;
[b]Kherson State University, Kherson, Ukraine, svobodny.polet2012@gmail.com;
[c]Lithuanian Geological Survey, Vilnius, Lithuania, aldona.damusyte@lgt.lt;
[d]Klaipėda University, Klaipėda, Lithuania, sergej.olenin@ku.lt, Andrius.Siaulys@ku.lt;
[e]Temple University, Philadelphia, USA, coast@temple.edu

On the island of West Spitsbergen in the Svalbard archipelago, intense melting of the Eidem Glacier (Eidembreen) forms the new landscape. The latter terrain formation is essentially influenced by the dynamics of the transgressing glacier and the physical-mechanical properties of the rocks of the subglacial substrate, i.e. their resistance to glacial and meltwater erosion. The main scientific interest in the study area is the new lagoon development and the formation of its ecosystem. In order to fully understand these processes, it is also necessary to assess the dynamics of the glacier margin retreat and to reveal the peculiarities of the emerging glaciogenic terrain. One of the most important tasks is to find out how the Eidem Spit – the natural barrier between the ocean and the new lagoon – formed.

A detailed analysis of published geological information and cartographic material has shown that the geological structure of the underlying (pre-Quaternary) bedrock and the sub-Quaternary relief in the vicinity of the Eidem Glacier and the Eidem Lagoon is very complex. The rock mass is divided into blocks by disjunctive tectonic faults, forming various geological structures such as grabens, thrust faults, etc. The lithological composition of the rocks is also very varied, with Neoproterozoic phyllites, quartzites and sandstones, and Paleozoic carbonates and evaporites exposed on the sub-Quaternary surface.

The detailed Quaternary geological-geomorphologic map of the study area shows glacial, fluvioglacial, limnoglacial and marine relief and sediments, varying in lithological composition from fine boulders and gravel to fine sand and silt. The glacial relief is characterized by the ridges of the marginal formations, the plain of the basal moraine and the supraglacial forms of the middle and lateral moraine ridges and the ablation moraine cover. The sandurs are dominating in the fluvioglacial relief. Limnoglacial deposits form several small plains. The marine terrain includes a terrace in the western part of the study area, which is overlain by pre-Quaternary rocks eroded by abrasion processes. The Eidem Spit and the accumulation shoreline along the ocean coast also belong to the marine type of relief.

To clarify the deglaciation dynamics, satellite data were analyzed, and the intensity of gamma-emitting radionuclides was measured along a profile from the ocean coast to the glacier margin. The intensity of Cs-137 was determined in relation to atmospheric nuclear tests, i.e. to clarify how much of the study area was glaciated before the end of the 1960s, when the tests were stopped.

The tectonic structure of the pre-Quaternary rocks, their lithological composition, and the peculiarities of the sub-Quaternary terrain have had a major influence on the morphology and dynamics of the Eidem Glacier and the formation of the Eidem Spit. The polythermal nature of Eidem Glacier results in both surface and subglacial meltwater discharge. The accumulation of glacial and fluvioglacial material at the margin of the glacier during its maximum extent, as well as the transport of fluvioglacial material to the ocean and its subsequent transport along the coast, have had a major influence on the formation of Eidem Spit.

References

Gabrielsen, R. H., Kløvjan, O. S., Haugsbø, H., *et al.* 1992. A structural outline of Forlandsundet Graben, Prins Karls Forland, Svalbard. *Norsk Geologisk Tidsskrift*, 72, 105–120.

Horota, R. K., Senger, K., Rodes, *et al*. 2023. West Spitsbergen fold and thrust belt: A digital educational data package for teaching structural geology. *Journal of Structural Geology*, 167, 104781. https://doi.org/10.1016/j.jsg.2022.104781

Kanat, L., Morris, A. 1988. A working stratigraphy for central western Oscar Il Land, Spitsbergen Norsk Polarinstitutt, Oslo. 27.

Klemsdal, T. 2010. Svalbard and Jan Mayen. In: E. C. F. Bird (Ed.), *Encyclopedia of the World's Coastal Landforms*, 581–588. Springer, Netherlands. https://doi.org/10.1007/978-1-4020-8639-7_99

Olenin S., Šiaulys A., Šaškov A., et al. 2023. Eidembukta Lagoon formation of a novel coastal lagoon ecosystem following glacier retreat. Polar Night Week 2023: posters session; poster RiS-ID 11962.

Schaaf, N.W., Osmundsen, P.T., Van der Lelij, R., *et al*. 2018. Tectono-sedimentary evolution of the eastern Forlandsundet Graben, Svalbard. *Norvegian Journal of Geology*, 100, 1–39.

Tretiakov M.V., Bryzgalo V.A., Rumiantseva E.V., Romashova K.V. 2021. *Freshwater resources of Western Spitsbergen in modern conditions* (long-term studies of the AARI). SPb.: Arctic and Antarctic Research Institute, 2021, 200 p. [In Russian].

Electronic resource: https://toposvalbard.npolar.no/

Electronic resource: https://geokart.npolar.no/geologi/GeoSvalbard/#6/77.959/19.782

Unravelling debrite fabric with computer microtomography: Conclusions from subaqueous fan at the Rzucewo site, Poland

Łukasz Elwirski[a] and Piotr P. Woźniak[b]

[a, b]Department of Geomorphology and Quaternary Geology, University of Gdańsk, Gdańsk, Poland; [b]piotr.wozniak@ug.edu.pl

The study site is located at a coastal bluff of the Baltic Sea in the northern Poland, at Rzucewo village. Analysed debrites were resulted from cohesive flows on a subaqueous fan, in a glaciolacustrine basin, probably during the decay of MIS 4 ice-sheet. The cross-section of the fan along the palaeotransport direction is exposed in the site, what enables tracking clast behaviour during successive stages of debris flow. Following the previous works (Woźniak et al., 2018; Woźniak, Pisarska-Jamroży, 2018; Pisarska-Jamroży, Woźniak, 2019; Elwirski, Woźniak, 2025), the aim of the current research is to investigate the features of debrites using micro-computed tomography (μCT). Among others, use of μCT enables 3D analysis of lithic clasts arrangement, including those of millimetre-size. Clast behaviour regarding its position in the vertical profile of a debrite (the bottom and the top part), the location in the subaqueous fan (the proximal, the medial and the distal part), and the distance from debris-flow head, were studied in scanned debrite monoliths. In addition, the influence of the form of a clast on its susceptibility to reorientation was analysed. Data was collected in separate groups of different clast-size. The results were compared with debrite fabric based on traditional field measurements (Woźniak et al., 2018).

References

Woźniak, P.P., Pisarska-Jamroży, M., 2018. Debris flows with soft-sediment clasts in a Pleistocene glaciolacustrine fan (Gdańsk Bay), Poland. *Catena* 165, 178–191.

Woźniak, P.P., Pisarska-Jamroży, M., Elwirski, Ł., 2018. Orientation of gravels and soft-sediment clasts in subaqueous debrites – implications for palaeodirection reconstruction: case study from Puck Bay, northern Poland. *Bulletin of the Geological Society of Finland* 90 (2), 161–174.

Pisarska-Jamroży, M., Woźniak, P.P., 2019. Debris flow and glacioisostatic-induced soft-sediment deformation structures in a Pleistocene glaciolacustrine fan: The southern Baltic Sea coast, Poland. *Geomorphology* 326, 225–338.

Elwirski, Ł., Woźniak, P.P., 2025. Evolution of lithic clasts in a subaquatic debris flow: Conclusions from the Rzucewo site, Poland. *Sedimentary Geology* 477, 106822.

Construction of hydrostratigraphic grid models for the estimation of subglacial erosion during future glaciations of the North German Basin

Runa Fälber[a], Gustav Jungdal-Olesen[b], Vivi Kathrine Pedersen[b], Anders Damsgaard[c], Jan A. Piotrowski[b,d], Piotr Hermanowski[e], Christian Brandes[a] and Jutta Winsemann[a]

[a]Institut für Erdsystemwissenschaften, Leibniz Universität Hannover, Hannover, Germany;
[b]Department of Geoscience, Aarhus University, Aarhus, Denmark;
[c]Geo (Danish Geotechnical Institute), Brabrand, Denmark,
[d]Faculty of Earth Sciences and Spatial Management, Nicolaus Copernicus University in Toruń, Poland,
[e]Institute of Geology, Adam Mickiewicz University, Poznań, Poland

During the Elsterian glaciation, subglacial tunnel valleys were deeply incised into the subsurface of the Northwest German Basin. These tunnel valleys typically range in depth from 100 to 400 m but can reach depths of more than 500 m. As the BGE (Federal Company for Radioactive Waste Disposal) plans a high-level radioactive waste disposal at depths between 300 and 1500 m, it is important to consider the subglacial erosion potential during future glaciations, in order to ensure a long-term safety of the potential site.

In this project, we first constructed 3D geological subsurface models and currently are carrying out numerical simulations to quantify the meltwater-driven erosive potential during future glaciations in the Northwest German Basin. We are developing and deploying a next-generation dynamical model for subglacial meltwater erosion on soft beds. This hydraulic model, based on principles of dynamical subglacial channel formation and fluvial erosion, is parameterised against tunnel valley formation during past glaciations. Once calibrated, our hydraulic model will estimate meltwater-driven erosion and sediment transport during future glaciations, with particular emphasis on the maximum depth of meltwater erosion.

The hydrostratigraphic 3D reservoir grid models of the Northwest German Basin are used as input for the numerical hydraulic modelling. The lithology and hydrology of the subsurface will considerably influence the location and depth of future tunnel valleys. These hydrostratigraphic 3D subsurface reservoir grid models cover Permian to Cenozoic sediments, have an area of about 40,000 square kilometres and reach a depth of 2,000 metres.

We constructed these 3D subsurface models by using a layered-structural-model and voxel-grid-models approach, enabling us to generate grid models with varying resolution from the same structural model. To build the layered structural model, we utilised existing stratigraphic 3D models (GTA3D, TUNB3D-NI and small-scale regional models) and additional borehole data. The reservoir grids integrate constant permeability values reflecting the hydrogeological properties of the stratigraphic units. This approach facilitates a rapid construction of grid models of different sizes, despite a highly heterogeneous database.

We will compare the outputs of the subglacial erosion modelling with variably resolved grid models to assess the effects of different input data (e.g., lithological data, facies architecture, and related variations in hydrogeological properties). The results are intended to deliver a firm base for future long-term safety considerations of potential repository sites.

Micromorphological comparison of two relict sand wedge sites and implications for paleoenvironmental conditions

Beáta Farkas[a], Randall Schaetzl[b] and Barbara Woronko[c]

[a]Doctoral School of Earth Sciences, University of Pécs, Pécs, Hungary, cmfpr7@pte.hu;
[b]Department of Geography, Environment, and Spatial Sciences, Michigan State University, East Lansing, MI, USA;
[c]Department of Climate Geology, University of Warsaw, Warsaw, Poland

During the Late Pleistocene, permafrost conditions dominated the forelands of the Laurentide Ice Sheet in North America, and the Pannonian Basin in Central Europe. Sand wedges in both these areas confirm the cold, arid climatic conditions at that time. In this study, we compare the micromorphological properties of sand wedge (SW) infillings, particularly micro-scale frost weathering features, to determine the influence of micro-scale frost weathering. Our samples were recovered from SWs and their host materials in Wisconsin, USA and Transdanubia, Hungary.

Grain-size distributions of the sediments were determined using laser diffraction, following standard chemical pretreatment. The morphoscopy of medium sand-sized (250–500 μm) quartz grains was analysed under a binocular microscope, and the surface microtextural characteristics of these same grains from 15 Wisconsin and 15 Hungarian samples were studied using scanning electron microscopy. Fresh conchoidal fractures and breakage blocks were counted as proxies for the degree of frost weathering. Both the Hungarian and Wisconsin SWs are filled with fine sand, although the Hungarian samples are less well-sorted than are the Wisconsin samples. Sand grains in the Wisconsin SWs, as well as their host deposit (glacial outwash) are generally well rounded, assumedly due to their aeolian and glaciofluvial origins.

Conversely, the Hungarian samples exhibited clear differences between the host and the SW infill materials, as the former grains have a subaqueous origin whereas the latter have an aeolian origin. Only a few, frost-related microtextures were identified on the mature grains from Wisconsin, mainly on the convex parts of the grains. The less-mature Hungarian sand grains host more frost-related microtextures, but even then, these characteristics point to only an initial stage of frost weathering. This comparison shows how the different factors (e.g. number of freeze-thaw cycles, grain-size, and other primary, microtextural characteristics) may influence the development of frost-originated microtextures in quartz sands.

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Meltwater runoff during Warta Stadial (Saalian) in central Poland

Jacek Forysiak[a], Leszek Marks[b], Aleksandra Majecka[b], Łukasz Bujak[b] and Wojciech Włodarski[c]

[a]Department of Geology and Geomorphology, University of Łódź, Łódź, Poland, e-mail: jacek.forysiak@geo.uni.lodz.pl;
[b]Department of Climate Geology, University of Warsaw, Warszawa, Poland, e-mail: a.majecka@uw.edu.pl; leszek.marks@uw.edu.pl; l.bujak3@uw.edu.pl;
[c]Faculty of Geographical and Geological Sciences, Adam Mickiewicz University of Poznań, Poland, wojtekw@amu.edu.pl

The drainage system of the Saalian ice sheet during the Warta Stadial has been discussed for several decades. Analysis of archival data and new geological data allow us to join the discussion on the issue of the proglacial water drainage in this time.

Several standstills and local advances occurred during the general ice sheet retreat, among them the Kutno phase. The Kutno end-moraines continue westwards into the Złota Góra Hills complex. The ice sheet blocked the water outflow and a marginal valley, running westwards was formed. The Łowicz-Błonie Plain to the south is built of till and other glacial deposits, with its surface at 100-105 m a.s.l., but dissected by erosional channels, parallel to the marginal valley and filled with glaciofluvial deposits. An ice-dammed lake must have formed periodically within the Warsaw Basin and the Łowicz-Błonie Plain, documented by patches of the Saalian clays, both in the axial part of the Łowicz-Błonie Plain and its higher, marginal parts.

In the Łęczyca and Ozorków areas, a limited water flow towards the west to the Koło Basin probably occurred. There are well-documented traces of the Koźmin ice-dammed lake, correlated with the termination of the Warta Stadial. The ice sheet must have blocked the water outflow towards the northwest. Water could flow from the ice-dammed lake through two or three valleys that cut the Turek Upland, and are generally heading southwest, to the Grabowska Basin.

The Vistula and Odra watershed zone near Łęczyca is a problematic area in the thus outlined scheme of the proglacial drainage during the Warta Stadial. It could have been equally significant already at the termination of the Saalian Glaciation, resulting in separation of the two aforementioned ice-dammed lakes. Its location coincides with the Kłodawa salt structure and in particular, with the NE limb of the related Kłodawa-Łęczyca anticline. The Mesozoic strata recognized in the hinge zone of this anticline are cut by a reverse fault, which originated as a normal fault controlling the vertical movements of the NE hanging wall and the formation of a strongly asymmetric depositional pattern of the syn-kinematic Triassic strata. The resulted significant thickness variation can be observed between the NE and SW limbs of the anticline. The following reverse faulting is associated with the late Cretaceous tectonic inversion and compression. Vertical movements of the NE limb of the anticline were also reactivated in response to the vertical loading by the Pleistocene ice sheets. This is well evidenced by lateral changes in thickness of the Quaternary strata across the hinge zone and the NE limb of the anticline. In particular, glacial tills of the Saalian age, recognized within the glacial upland to the north from the ice-marginal valley, are strongly affected by these changes. However, the tectonic activity across the ice-marginal valley near Łęczyca influenced a thickness reduction of the Quaternary strata and spatially restricted distribution of fluvial and limnic deposits. This allows to state that syn-kinematic erosion could play an important role during meltwater runoff along the ice-marginal valley.

Symptoms of warming at the transition Plenivistulian-Late Vistulian recorded in Polish Lowland sediments

Jacek Forysiak[a], Mateusz Półciennik[b] and Danuta A. Dzieduszyńska[a]

[a]Department of Geology and Geomorphology, University of Łódź, Łódź, Poland, e-mail: jacek.forysiak@geo.uni.lodz.pl; danuta.dzieduszynska@geo.uni.lodz.pl;
[b]Department of Invertebrate Zoology and Hydrobiology, University of Łódź, Łódź, Poland;
e-mail: mateusz.plociennik@biol.uni.lodz.pl

The Upper Plenivistulian ended the period of long-term global glaciation. However, its symptoms are not clearly expressed in the paleoecological record. Climate variability can be well organised according to the scheme used for high-resolution data from a Greenland ice core (Rasmussen et al. 2014). On the border of GS-2a and GS-2b, determined to be 17,400 cal BP), where the $\delta^{18}O$ curve deviates to a value of about -39‰, versus about -44‰ in the central parts of these sub-stadials. Oxygen isotope values suggesting climatic improvement range from about 18,000 to 16,800 cal BP.

A warming in stratigrafical scheme of Polish territory was proposed by Manikowska (1985) based on studies of the dunes at the Kamion site near Wyszogród in the Vistula river valley. There, a humic silt layer is deposited on river sands with silts and has been dated with three radiocarbon datings at from defined 14,590±270 (18157-17477 cal BP) to 13,500±290 (16715-15846 cal BP) (Cichosz-Kostecka et al. 1991). Other data from Central Poland refer to the "Kamion warming", which is placed immediately before the Oldest Dryas. The Polish Lowland is a good area for this type of study because it reflects the influence of periglacial conditions, with evidence of permafrost in both the Plenivistulian and Oldest Dryas (e.g., Dylik 1963, Klatkowa 1996, Dzieduszyńska et al. 2020) and the effects of warm episodes documented already in the 1960s (Wasylikowa 1964). Changes in climatic conditions at the end of the Upper Plenivistulian and in the Late Vistulian, such as an increase in temperature resulting in a thickening of the active permafrost layer (or its local disappearance), as well as changes in the precipitation regime, probably influenced the opportunities for wetlands and shallow lakes to develop in this generally lowland area (Forysiak, Dzieduszyńska, 2024).

Several examples of sites with record of warming at the transition Plenivistulian-Late Vistulian were documented in river valleys, such as Kamion or Ługi (Forysiak et al. 2023), also in peatlands and lacustrine deposits – Żabieniec, Pawłowa. Traces of warmer conditions were reflected in the results of pollen analysis, but also in the analysis of fossil Chironomidae. The remains of species with higher thermal habitat are found beneath layers with a record of cold conditions, correlated with the cooling of the Oldest Dryas.

The studies of a warming at the transition from the Plenivistulian to the Late Vistulian are being implemented in a project undertaken at the University of Lodz: "Was the Kamion Phase the first warming after the Last glacial maximum? – an attempt to explain the se quence of environmental events using paleoecological methods" IDUB UŁ 15/IgB/2024.

References

Cichosz-Kostecka A., Mycielska-Dowgiałło E., Manikowska B., 1991: Late Glacial aeolian processes in the light of sediment analysis from Kamion profile near Wyszogród. *Zeitschrift für Geomorphologie, N. F. Suppl-Bd. 90*, 45–50.

Dylik J., 1963: Nowe problemy wiecznej zmarzliny plejstoceńskiej. *Acta Geographica Lodziensia 17*.

Dzieduszyńska D., Petera-Zganiacz J., Roman M., 2020: Vistulian periglacial and glacial environments in central Poland: an overview. *Geological Quarterly 64(1),* 54–73.

Forysiak J., Dzieduszyńska D., 2024: The Kamion interphase as a warm climatic oscillation during the Plenivistulian/Late Vistulian transition. *Folia Quaternaria 92*, 69-78

Forysiak J., Okupny D., Obremska M., et al., 2023: Changes in habitat conditions in a Late Glacial fluviogenic lake in response to climatic fluctuations (Warta River valley, central Poland). Geological Quarterly 67(1): 1-23.

Klatkowa H., 1996: Symptoms of the per ma frost presence in Middle Poland during the last 150 000 years. Biuletyn Peryglacjalny 35: 45–86.

Manikowska B., 1985: O glebach kopalnych, stratygrafii i litologii wydm Polski środkowej. *Acta Geographica Lodziensia 52.*

Rasmussen S.O., Bigler M., Blockey S.P., et al., 2014: A stratigraphic framework for abrupt climatic changes during the Last Glacial period based on three synchronized Greenland ice-core records: refining and extending the INTIMATE event stratigraphy. *Quaternary Science Reviews 106*, 14–28.

Wasylikowa K., 1964: Vegetation and climate of the Late-Glacial in Central Poland based on investigations made at Witów near Łęczyca. *Biuletyn Peryglacjalny 13*, 261–417.

Glaciofluvial landforms of complex origin from the Saalian Glaciation area in Poland

Małgorzata Frydrych

Faculty of of Geographical Sciences, University of Łódź, Łódź, Poland, malgorzata.frydrych@geo.uni.lodz.pl

This study investigates the origin and evolution of complex glaciofluvial landforms, specifically polygenetic eskers, located within the extent of the Saalian Glaciation in Poland. These landforms are characterized by a complex internal structure, reflecting a multi-phase history of formation in both subglacial and supraglacial environments. The research was based on detailed sedimentological and geomorphological analyses of selected eskers located in Poland (Łaszczyn, Rzymsko and Jakubowice sites). The results allowed for the identification of several key stages in esker formation, contributing to the development of a revised model of polygenetic esker evolution. The first stage involved the incision of subglacial tunnel channels due to pressurized meltwater flow beneath the ice sheet. These tunnels, formed under varying hydraulic conditions, eroded into the soft, unconsolidated substrate, creating channels with uneven longitudinal profiles. In the second stage sedimentation began to occur in zones where the energy of the water flow decreased. Accumulation was initiated in expanded sections of the tunnel system or at points where the channel encountered obstacles on the bed. Deposition was primarily governed by hydrostatic pressure and episodic sediment supply, which varied in time and space. High-energy flows transported coarse material, resulting in thick gravelly deposits with large-scale bedding structures. As the third stage progressed, sedimentation intensified and spread along the channel, forming elongated ridges composed of gravel and sand. Vertical and downstream accretion occurred as a result of fluctuating discharge and sediment availability. The nature of the deposits reflected alternations between high- and low-energy conditions, depending on the rate of ice melting and the volume of meltwater inflow. The fourth stage began with the onset of ice-sheet disintegration and the formation of crevasses above the existing subglacial channels. These crevasses allowed the influx of supraglacial material and meltwater, further influencing sedimentation dynamics. Subsequently, in the fifth stage, many of the crevasses expanded into open ice-walled channels. These channels directed meltwater and sediment along the previously formed tunnel paths. The deposits formed during this phase were primarily composed of sand and gravel, reflecting the lower energy conditions. The final stage of landform evolution coincided with the late stages of deglaciation, when the retreat of ice walls and the melting of buried dead ice blocks caused deformation and partial burial of esker ridges. This phase was also characterized by gravitational processes and the accumulation of kame and kettle deposits, which modified the morphology of the eskers and contributed to their present-day complex structure.

Recent progress in studies of the extent and chronology of the Saalian glaciation in Central Europe

Sanjaya Gurung[a], Karol Tylmann[a] and Piotr P. Woźniak[a]

[a]Department of Geomorphology and Quaternary Geology, University of Gdańsk, Poland, sanjaya.gurung@phdstud.ug.edu.pl

This study synthesizes recent developments in understanding of the extent and chronology of the Saalian glaciation in Central Europe, particularly in Germany and Poland. The Saalian, approximately synchronous to Marine Isotope Stage (MIS) 6, is the penultimate glacial cycle of the Pleistocene in continental Europe and is characterized by widespread ice-sheet advances and retreats. Recent studies integrating geomorphological mapping, stratigraphic interpretation of deposits in outcrops and drill cores, and advanced geochronology, namely optically stimulated luminescence (OSL) and cosmogenic nuclide dating, have enhanced regional reconstructions of ice-sheet dynamics. In Germany and Poland, evidences show repeated glacial advances interrupted by interstadials, challenging earlier models for a single uniform glacial event. Despite this progress, uncertainties remain regarding the precise timing of ice maxima, the correlation of terrestrial and marine records, and the drivers of glacial-interglacial transition. This talk highlights the methodological advancement and key findings that contribute to a better understanding of ice margin fluctuations during the Saalian and provides a foundation for future research needs for resolving critical gaps in the Saalian glacial chronology across Central Europe.

Glacial sculpting of Precambrian basement in Sweden

Adrian Hall[a] and Mikis van Boeckel[b]

[a]Institute of Geography, University of Edinburgh, Edinburgh, EH8 9XP, Scotland, UK. adrian.hall@ed.ac.uk;
[b]Earth Surface and Seabed Division, Norges Geologiske Undersøkelse (NGU), Trondheim N-7040, Norway

Few studies deal directly with time as a factor in the development of landscapes and landforms of glacial erosion. Here, we examine how lowland Precambrian shield terrain in southern Sweden has been shaped by glacial erosion from the Fennoscandian Ice Sheet. Our datum is the re-exposed sub-Cambrian basement unconformity, an original smooth, near planar surface, with <5-8 m/km relief over areas of 10^2 km^2. We use projections from beneath Early Palaeozoic outliers and in summit envelope surfaces to reconstruct the original, block faulted form of the sub-Cambrian unconformity surface in Digital Elevation Models. Subtraction of the present basement surface from the modelled former unconformity surface provides estimates of spatially variable depths of glacial erosion. Re-exposure was most recent at sites closest to the present Early Palaeozoic outliers, allowing space-time substitutions to reveal the development of glacial landscapes and landforms through time.

Relative relief, rock surface roughness, and average glacial erosion depths increase along former ice flow lines with increasing distance from Early Palaeozoic outliers. Average glacial erosion depths were 0-10 m close to present outliers and 20-30 m at greater distances. Average glacial erosion in shield rocks was slow (1-2 m per glaciation) and dominated by processes of rock block removal. Incision of rock trenches and overdeepening of rock basins by 10-80 m dominates rock losses and involved selective erosion of major fracture zones. Low hills and rock bumps 0-6 m below the former unconformity surface have classic roche moutonnée forms at Kinnekulle, indicating these typical glacial bedforms do not require deep erosion. At greater distances and after deeper glacial erosion, hill relief increases but strong fracture controls maintain the position and rectilinear planforms of large hills. Glacial streamlining of hills remains weakly developed. The overall trend was for glacial roughening of the original flat unconformity surface, leading to the development of knock-and-lochan terrain typical of glaciated shields, and towards the destruction of the original flat unconformity surface. Current mathematical models of erosion beneath ice sheets based on subglacial sliding laws do not adequately replicate the erosion patterns and morphological changes through time that are documented here.

References

Hall, A. M., M. Krabbendam, M. van Boeckel, K. Ebert, C. Hättestrand and J. Heyman, 2019: The sub-Cambrian unconformity in Västergötland: Reference Surface for Glacial Erosion of Basement. *Technical Report, Svensk Kärnbränslehantering AB*: p 159. SKB TR-19-21.

Hall, A. M. and M. van Boeckel, 2020): Origin of the Baltic Sea basin by Pleistocene glacial erosion. *GFF* **142**(3): 237-252.

The process-form imprint of disintegrated ice sheet derived from sedimentological studies, N Poland

Piotr Hermanowski[a], Mirosław Błaszkiewicz[b], Barbara Woronko[c], Weronika Danel[d] and Mateusz Kramkowski[b]

[a]Institute of Geology, Adam Mickiewicz University, Poznan, Poland, piotr.hermanowski@amu.edu.pl;
[b]Institute of Geography and Spatial Organization of the Polish Academy of Science, Torun, Poland;
[c]Faculty of Geology, University of Warsaw, Warsaw, Poland;
[d]Polish Geological Institute – National Research Institute, Warsaw, Poland;

The landscape of the Central European Lowland was profoundly modified by the last Scandinavian Ice Sheet, which can especially be seen in the palaeo-ice stream areas. However, glacial processes were also active in other areas, although they were dynamically less pronounced. Typically, in such areas, the retreating ice sheet left behind hummocky terrains, which are characterised by various geomorphological features that record processes associated with the downwasting of ice sheets. Common landforms in these areas include ramparts, linear ridges, kettle holes, and ice-walled lake plains. However, the origins of some of these features remain controversial, as they may result from sediment release from stagnant, debris-rich ice or subglacial processes.

This study investigates the landforms in hummocky terrain in north-central Poland. The landforms consist of a circular or oval central part encircled by rim ridges, with a mean ridge height of 1.85 m; the maximum recorded height is 9.21 m (Woronko et al., 2024). Specifically, the internal composition and structures of rim ridges were investigated to uncover their formation mechanisms and infer the sequence of glacial processes.

Sedimentological analyses were conducted in 12 exposures, including excavated trenches, in rim ridges distributed across an extensive hummocky terrain. Each ridge consists predominantly of subglacial traction till interbedded with centimetre-thick fine sand laminae or lenses, indicating episodic basal decoupling and recoupling. Clast fabric measurements reveal a broadly uniform orientation across the study area, often unrelated to the alignment of the ridges themselves. The internal structures consistently show sediments arching into distinct anticlinal forms that mimic the morphology of the rim ridges. Ample evidence suggests that the investigated forms formed in a dead ice environment. It is inferred that water-saturated soft sediments were squeezed into narrow zones between blocks of dead ice due to localised pressure variations. Overall, this study provides insight into the processes in operation during the ice sheet advance and retreat up to its disintegration stage; in the latter, intriguing rim ridges were formed in response to the dynamic interactions between ice, water and sediment. These findings emphasise the critical role of sediment saturation and pore pressure distribution in areas where ice is a key component of the environment.

References

Woronko, B., Danel, W., Błaszkiewicz, M., Hermanowski, P., Juschus, O., Kramkowski, M., Garrett, B., Brauer, A., 2024: Imprint of a dead-ice environment on lidar imagere – Spatial patterns at the last Scandinavian Ice Sheet margin (N Poland). *Geomorphology 466*, 109434.

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Kolga strandplain as an archive of Holocene relative sea level changes and storminess

Triinu Jairus[a], Alar Rosentau[a], Hannes Tõnisson[b], Toru Tamura[c], Ilya Buynevich[d], Tiit Hang[a], Triine Nirgi[a], Art Kristjan Olesk[a], Shinya Sugita[b], Tiit Vaasma[b], Egert Vandel[b], Kadri Vilumaa[b] and Ülo Suursaar[e]

[a]Institute of Ecology and Earth Sciences, University of Tartu, Tartu, Estonia, triinu.jairus@ut.ee;
[b]Institute of Ecology, Tallinn University, Tallinn, Estonia;
[c]Geological Survey of Japan, AIST, Tsukuba, Japan;
[d]Department of Earth and Environmental Sciences, Temple University, USA;
[e]Estonian Marine Institute, University of Tartu, Tallinn, Estonia.

Global warming, sea-level rise, and increasing storminess demand a better understanding of the Earth system. The Holocene coastal formations and sediments found along the non-tidal, uplifting eastern coast of the Baltic Sea provide opportunities to reconstruct pre-instrumental shoreline and storm history. We combined LiDAR-based topographic mapping, sedimentological and magnetic-susceptibility analyses, OSL- and AMS radiocarbon dating, and ground-penetrating radar to reconstruct Holocene sea-level changes and palaeostorminess. The study area, the Kolga ridge–swale system on the southern coast of the Gulf of Finland, spans approximately 3 × 5 km and reaches elevations up to 28 m above sea level. Analysis of the LiDAR topographic model and GPR data reveals more than 120 low ridges with relative heights of 0.2–0.4 m. Among these features, 25 higher ridges (0.5–4 m) were identified. The ridge formations also continue beneath peat layers in older swales. Luminescence dating of coastal sediments shows that the inland, higher-elevation ridges (20–28 m a.s.l.) formed during the Ancylus Lake and Early Littorina Sea stages (11.1–9.6 ka BP). The younger, seaward ridges accumulated during the Littorina Sea's regression over the last 7000 years. Ridge ages and elevations indicate that relative sea-level fall during this interval was nearly linear—averaging 2.7 mm yr^{-1}—and closely matches geoid-referenced land-uplift rates in the Kolga area. We identify 11 prominent ridge clusters in the regression record, suggesting periods of increased storminess (Suursaar et al., 2022). The youngest zone, dated to 540 years ago, corresponds to the Little Ice Age, known for its cold and windy climate (Bond et al., 2001). In Estonia's Saaremaa and Hiiumaa regions, Little Ice Age ridges—often reworked by wind and topped with aeolian deposits— are well documented (Tõnisson & Suursaar, 2020). Comparable ridges dating to ~5.4 ka BP occur at Kolga, Narva-Jõesuu (Rosentau et al., 2013), and Hiiumaa (Suursaar et al., 2022) and are likely linked to a cooler climate. A study of aeolian sand influx in a nearby bog (Vaasma, 2024) identifies multiple storminess peaks, including those at ~4.6, 3.6, and 2.4 ka BP that align with Kolga ridge phases

References

Bond, G., Kromer, B., Beer, J., Muscheler, R., Evans, M. N., Showers, W., Hoffmann, S., Lotti-Bond, R., Hajdas, I., Bonani, G. (2001). Persistent Solar Influence on North Atlantic Climate During the Holocene. Science, 294(5549), 2130–2136.

Rosentau, A., Jõeleht, A., Plado, J., Aunap, R., Muru, M., Eskola, K. (2013). Development of the Holocene foredune plain in the Narva-Jõesuu area, eastern Gulf of Fin land. Geological Quarterly. 57. 10.7306/gq.1077.

Suursaar, Ü.; Rosentau, A.; Hang, T.; Tõnisson, H.; Tamura, T.; Vaasma, T.; Vandel, E.; Vilumaa, K.; Sugita, S. (2022). Climatically induced cyclicity recorded in the morphology of uplifting Tihu coastal ridgeplain, Hiiumaa Island, eastern Baltic Sea. Geomorphology, 404, 108187.

Tõnisson, H., Suursaar, Ü., Rivis, R., Tamura, T., Aarna, T., Vilumaa, K., & Kont, A. (2020). Characteristics and Formation of a Solitary Dune Belt Encountered along the Coast of Estonia. Journal of Coastal Research, 95, 689-694.

Vaasma, T., Vandel, E., Sugita, S., Tõnisson, H., Suursaar, Ü., Kont, A., & Vilumaa, K. (2024). Storminess reconstruction in the northeastern Baltic Sea region over the past 7600 years based on aeolian sand influx into coastal bogs. The Holocene, 35(1), 61-74. https://doi-org.ezproxy.utlib.ut.ee/10.1177/09596836241285783 (Original work published 2025)

Late Pleistocene and Holocene sedimentation peculiarities based on geochemistry of sediments of Lithuania

Donatas Kaminskas[a], Jessica Cindy Same Fakam[b] and Eugenija Rudnickaitė[c]

[a] Department of Geology and Mineralogy, Institute of Geosciences, Faculty of Chemistry and Geosciences, Vilnius University, Vilnius, Lithuania, donatas.kaminskas@gf.vu.lt;
[b] Department of Geology and Mineralogy, Institute of Geosciences, Faculty of Chemistry and Geosciences, Vilnius University, Vilnius, Lithuania, jessica.same@chgf.stud.vu.lt;
[c] Department of Geology and Mineralogy, Institute of Geosciences, Faculty of Chemistry and Geosciences, Vilnius University, Vilnius, Lithuania, eugenija.rudnickaite@gf.vu.lt

The Quaternary period, which was characterized by repeated glaciations and interglacial periods, has resulted in the formation of extensive deposits of sediments with diverse compositions. Glacial sediments are particularly susceptible to intense physical weathering and the mechanical transport of material from a range of bedrock sources. The Quaternary sediments of Lithuania were deposited under the influence of the Scandinavian ice sheet, which advanced and retreated on multiple occasions during the Pleistocene. The sediments range from clay-rich tills deposited directly by the glaciers to well-sorted sands and gravels deposited by meltwater streams and rivers. It is known that rare earth element (REE) distribution in sediments depend on their content in the parent rocks and their distribution in the mineral phases; the ability of secondary minerals formed during the reactions to accommodate REE (Kaminskas et al, 2013). Thus, quantities of REEs may vary depending on transportation and sedimentation. Sources of REEs could be of various origins: suspended river runoff, aeolian dust, glacier runoff, etc.

The principal objective of this thesis is to undertake an analysis of the rare earth element (REE) composition of Quaternary sediments in Lithuania, with a view to identifying any distinctive features that may be attributable to potential environmental influences. The lithological features of these sites could be characterized using the Si and Al oxide ratio which infers the clay content in sediments. For, it is known that the clay content directly influences the distribution and quantities of REEs in sediments (Kaminskas et al., 2013). Several chemical elements ratios were used for sedimentation character, paleoclimate, weathering etc. reconstructions.

The elemental ratios of Sr, Cu, Ti, Al, Rb, Zr, Ce etc. could serve as a compelling instrument in the reconstruction of past environmental conditions like the paleoclimate conditions, weathering intensity, the context of paleo-redox conditions, paleo-hydrodynamics (grain-size analysis). Other elemental ratio proxies such as (Zr+Rb)/(Ca+Mg) and (Si+Al+K+Ti+Na)/(Ca+Mg) are used to infer siliciclastic:carbonate dominance.

References

Kaminskas, D., Bitinas, A., 2013: Rare earth elements of Holocene sediments in the SouthEastern Baltic Region (Nida VI borehole, Lithuania). *Geologija 55* No 1(81), 1–7.

Andronikov A.V., Rudnickaitė E., Lauretta D.S., Andronikova I.E., Kaminskas D., Šinkūnas P., Melešytė M., 2015: Geochemical evidence of the presence of volcanic and meteoritic materials in Late Pleistocene lake sediments of Lithuania*. Q. Int. 386*, 1–12.

Rudnickaitė, E., Same Fakam, J. C., Kaminskas, D. 2024: Rare Earth Elements composition of Quaternary sediments of Lithuania. *INQUA Peribaltic working group international field symposium 2024. Quaternary sediments, landscapes, and early settlement history in Western Estonia, August 27-30, 2024, Pärnu, Estonia : abstract volume. Tartu : Institute of Ecology and Earth Sciences, University of Tartu. 2024*, p. 40. https://inqua-peribaltic.ut.ee/wp-content/uploads/sites/112/PWG2024-Abstract-Volume-2.pdf.

Late Quaternary Meltwater Flow Systems – Traces in Southern Lithuania

Markas Kazlauskas and Petras Šinkūnas

Department of Geology and Mineralogy, Faculty of Chemistry and Geosciences, Vilnius University, Vilnius, Lithuania, markas.kazlauskas@chgf.stud.vu.lt; petras.sinkunas@gf.vu.lt

Lithuania's landscape was largely shaped by glacial processes during the last glacial period, leaving behind distinct landforms and sedimentary structures. This study investigates the impact of climate change after Last Glacial Maximum on the landscape and sedimentation in southern Lithuania, with a focus on interpreting glacial meltwater paleoflows through their geomorphic and sedimentary records. Key research objectives include identifying the sources, directions, and dynamics of meltwater flows and assessing their geomorphological significance.

A combination of fieldwork, sedimentological analysis, and spatial data interpretation was employed. Excavation sites revealed high-energy glaciofluvial deposition, including features characteristic of both dune and antidune sedimentation. Digital Elevation Models (DEMs) supported these findings, indicating two dominant meltwater flow directions: one from the north, linked to subglacial outburst floods, and another from the east. Landforms exhibit an east–west orientation with southern curvature, reflecting directional erosion by meltwater.

The results highlight the complex interplay of depositional environments, where glaciofluvial processes were the primary force shaping the investigated landforms and the broader outwash plain. Sedimentary evidence points to fluctuating conditions, including abrupt inputs from high-energy events. Field investigations were undertaken jointly with Nicolaus Copernicus University.

Chronostratigraphy of Weichselian Deposits from Coastal Cliffs of Schleswig-Holstein (northern Germany): Insights from OSL-Dating

Michael Kenzler[a], Kay Krienke[a] and Frank Preusser[b]

[a]State Office of the Environment Schleswig- Holstein (LfU), Flintbek, Schleswig- Holstein, Germany, michael.kenzler@lfu.landsh.de;
[b]Institute of Earth and Environmental Sciences, University Freiburg, Freiburg, Germany

Based on the Weichselian stratigraphic scheme of Schleswig-Holstein (northern Germany), five distinct formations exist that are related to advances of the Fennoscandian Ice Sheet (Livingstone et al. 2015). The oldest, the Ellund-Fm. is correlated to a supposed mid-Weichselian ice advance (Preusser 1999, Stephan 2003). A reliable age assessment of the Ellund advance is still missing. Nevertheless, there are contemporaneous suggested ice advances in Denmark (Ristinge-Adv., Houmark-Nielsen 2010) and north-east Germany (Warnow-Adv., Müller 2004).

The four younger Weichselian formations of Schleswig-Holstein (Brügge-Fm., Blumenthal-Fm., Bordesholm-Fm., and Wandelwitz-Fm.) all belong chronologically to Marine Isotope Stage 2 (MIS 2, 29-12 ka) ice advances. In this context, an important question of the study presented here is to what extent these Weichselian formations can be found at cliff sections of Schleswig-Holstein and whether they can be age constrained by optically stimulated luminescence dating (OSL). For this purpose four cliff sections located along the Baltic Sea coast of Schleswig-Holstein were chosen and investigated by geological methods. Beside a detailed sedimentological logging, a total of 12 luminescence samples were taken from mostly glacifluvial deposits that framing subglacial traction tills (Fig. 1).

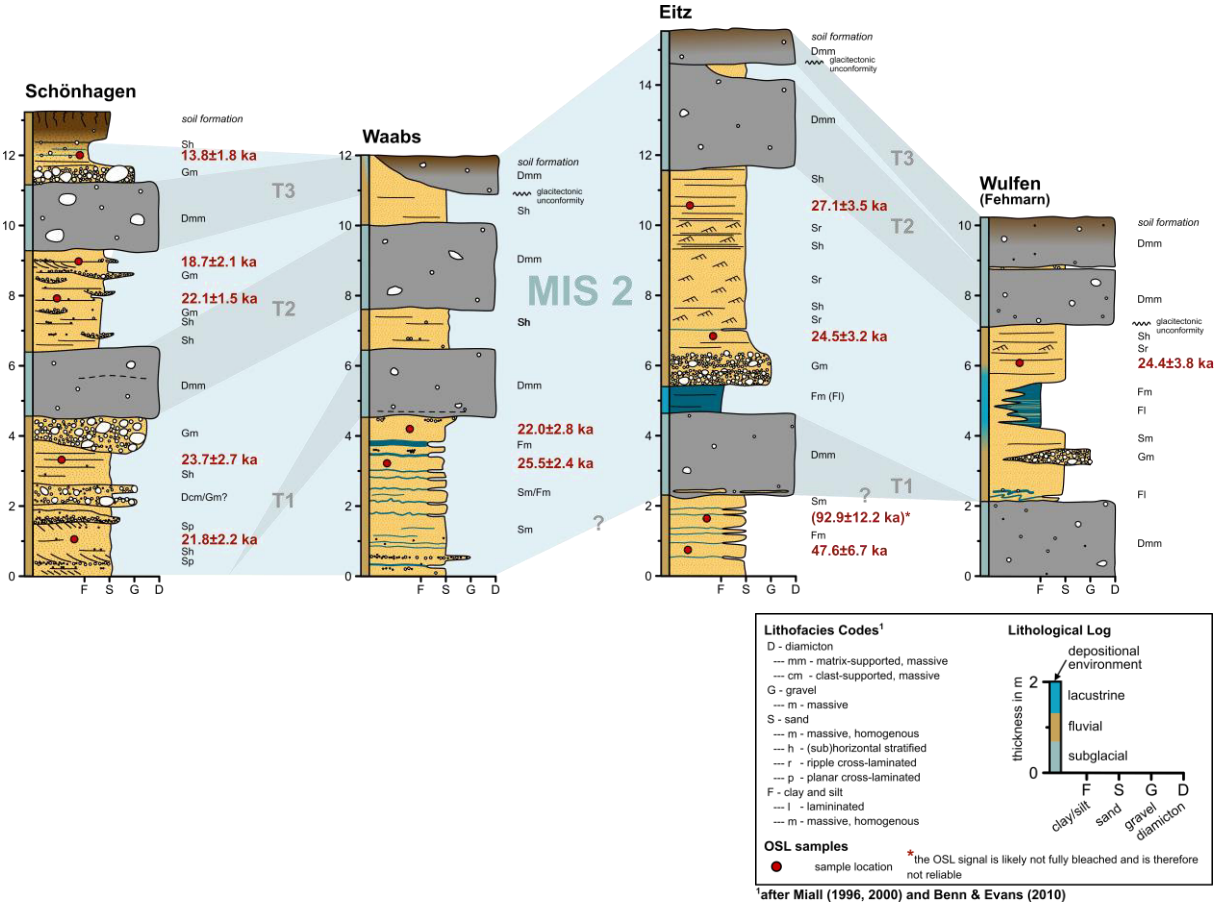

Fig. 1: Standard profiles of the investigated cliff sections, with OSL ages and correlations based on the lithological and chronological findings.

Glacial sediments of MIS 2, and thus of the Upper Weichselian have been dated at all four outcrops (Fig. 1). So far, there is no evidence for the near-surface occurrence of Saalian deposits at the investigated cliff sections. The youngest till, which mostly overlies the older deposits with an unconformaty, is assigned to the Young Baltic advance (Stephan 2001) and correlated with the deposits of the Mecklenburg phase (17-15 ka, Litt et al. 2007). An assignment of the underlying till to the Pomeranian phase (Blumenthal advance) or older Weichselian glacial advances is to be clarified by further investigations.

In addition to the ages of the Upper Weichselian, an age of the Middle Weichselian (MIS 3, 57-29 ka) was determined in one case in lying (glaci?)-fluvial sand deposits at the cliff of Eitz. This age classification is to be verified by further dating and investigations of the depositional environments.

References

Houmark-Nielsen, M, 2010: Extent, age and dynamics of Marine Isotope Stage 3 glaciation in the southwestern Baltic Basin. *Boreas 39*, 343–359.

Litt, T., Behre, K.-E., Meyer, K.-D., Stephan, H.-J., Wansa, S., 2007. Stratigraphische Begriffe für das Quartär des norddeutschen Vereisungsgebietes. *E&G Quaternary Science Journal 56, 1/2*, 7–65.

Livingstone, J.S., Piotrowski, J.A., Bateman, M.D., Ely, J.C. Clark, C.D., 2015: Discriminating between subglacial and proglacial lake sediments: an example from the Dänischer Wohld Peninsula, northern Germany. *Quaternary Science Reviews 112*, 86–108.

Müller, U., 2004: Weichsel-Frühglazial in Nordwest-Mecklenburg. *Meyniana 56*, 81–115.

Preusser, F., 1999: Lumineszenzdatierung fluviatiler Sedimente: Fallbeispiele aus der Schweiz und Norddeutschland. *Kölner Forum für Geologie und Paläontologie Vol. 3,* 1–63, Köln.

Stephan, H.-J., 2003: Zur Entstehung der eiszeitlichen Landschaft Schleswig-Holsteins. *Schriften des Naturwissenschaftlichen Vereins für Schleswig-Holstein, 67*, 101–118, Kiel.

Stephan, H.-J., 2001: The Young Baltic advance in the western Baltic depression. *Geological Quarterly 45/4*, 359–363.

Problems in stratigraphy of Late Middle Pleistocene Sediments in Lithuania

Dalia Kisielienė and Vaida Šeirienė

Department of Quaternary Research, State Scientific Research Institute Nature Research Centre, Vilnius, Lithuania,
e-mail dalia.kisieliene@gamtc.lt ; vaida.seiriene@gamtc.lt

Multiproxy studies carried out in Lithuania in the last decades have made it possible to refine the stratigraphy of many Late Middle Pleistocene sections and to correlate them with those of adjacent European countries. However, the most problematic part of this period are strata laying between the Butėnai (Holsteinian) and Merkinė (Emmian) Interglacials which correlated with the Saalian Complex and linked to MIS 6 - 10 (Hughes et all, 2019). In Lithuania they are represented by Žemaitija (Drenthe) and Medininkai (Warthe) tills and the Snaigupėlė Interglacial sediments (Šeirienė & Bitinas, 2024).

Here we focus on the analysis of Snaigupėlė Interglacial sediments that are tentatively attributed to discussed time frame. There are known eight sites of this type of interglacial sediments in Lithuania. Their characterization is generally based on palaeobotanical data, and geological conditions of occurence. Also some dates derived using different dating methods (TL, 230U/Th, and OSL) are available. The sedimentary sections best representing this interglacial, such as the Snaigupėlė-705 borehole, the Snaigupėlė and Buivydžiai outcrops, show a characteristic succession of vegetation with specific differences that distinguish them from other interglacials. They are visible in the palynological diagrams: all broad-leaved trees (except *Carpinus*) appear simultaneously; *Tilia* culminates earlier than in the Merkine (Eemian) Interglacial; *Quercus* peaks twice: at the beginning of the climatic optimum and at the beginning of *Carpinus* expansion; *Larix* is present up until the climatic optimum; *Abies* is not represented (Kondratienė, 1996). Attempts to correlate vegetation succession in Lithuanian region with that in the northern and central Europe have revealed some similarities with the Schöningen/Lublinian Interglacial (Kondratienė & Damušytė 2009; Šeirienė et al. 2019). Data on the macroremains of plants show that the number of extinct species in the interglacial flora of Snaigupėlė is significantly higher than in the interglacial flora of Merkinė (Emmian), suggesting that the former is more archaic. The extinct species like *Caulinia lituanica* Rišk. and *Carpinus betuloides* Wieliczk., which were recovered from the Snaigupėlė Interglacial sediments are absent in the sediments of other interglacials and can therefore be used for correlation. Several sections with finds of these species are known in the territory of Belarus and Russia (Velichkevich & Sanko, 1993). The diatom floras of the Snaigupėlė and Buivydžiai outcrops also contain several extinct species. Species *Cyclotella comta* var. *lichvinensis* and *Stephanodiscus* aff. *tenuis* f. *minor* can be used as age indicators as they became extinct at the end of the Middle Pleistocene (Šeirienė & Bitinas, 2024).

Attempts to date the sediments of the Snaigupele Interglacial have not always clarified their chronostratigraphy. Conflicting absolute age determinations and ambiguous interpretations of other proxy data leave the issue open for further debate and studies.

References

Hughes, P. D., Gibbard, P. L., Ehlers, J. 2020. The “missing glaciations” of the Middle Pleistocene. *Quaternary Research 96,* 161 - 183.

Kondratienė, O. 1996: The Quaternary Stratigraphy and Paleogeogra phy of Lithuania Based on Paleobotanic Studies. 213 pp. Academia, Vilnius (in Russian with English summary)

Kondratienė, O. & Damušytė, A. 2009: Pollen biostratigraphy and environmental pattern of Snaigupėlė Interglacial, Late Middle Pleistocene, western Lithuania. *Quaternary International 207*,4–13.

Šeirienė, V. & Bitinas, A. 2024 (October): Stratigraphy of Late Mid-Pleistocene in Lithuania: the current status and issues. *Boreas 53*, 562–576.

Šeirienė, V., Šinkunas, P., Stančikaitė, M., Kisielienė, D. & Gedminienė, L. 2019: Late Middle Pleistocene interglacial sediments from Buivydžiai site, eastern Lithuania: a problem of chronostratigraphic correlation. *Quaternary International 534*,18–29.

Velichkevich, F. Y. & Sanko, A. F. 1993: The Vitebsk interglacials of Belarus. *Stratigraphy. Geological correlation. 1 (3),* 120-124. (in Russian)

Late-Glacial and Early Holocene Cladocera Assemblages: Insights into Paleoenvironmental Changes in Southern Lithuania

Gražyna Kluczynska[a], Miglė Stančikaitė[a] and Žana Skuratovič[a]

[a]State Scientific Research Institute Nature Research Centre, Akademijos Str. 2, LT-08412 Vilnius, Lithuania

The Late Glacial and Early Holocene represent significant periods of climatic transition that strongly influenced environmental and ecological conditions. As sensitive bioindicators, cladocerans provide valuable insights into past hydrological and climatic conditions. By analyzing their fossil remains, shifts in species composition and diversity can be studied, reflecting changes in water temperature, nutrient levels, and habitat structure. These findings offer crucial insights into the dynamics of aquatic ecosystems during postglacial periods.

The subject of our research — the Čepkeliai Bog (southern Lithuania) — is the largest wetland complex in Lithuania, located in the marginal area of the surface affected by the Late Weichselian Glaciation (Bitinas, 2012), near the border between Lithuania and Belarus. The research focuses on the temporal dynamics of subfossil Cladocera assemblages and reconstructed environmental conditions. Cladoceran analysis was conducted on 126 samples taken from a depth interval of 706–1490 cm. The sediment sequence examined in this study spans the Late Glacial and Early Holocene. Cladocerans are represented in the sediments by remains of both planktonic (Daphniidae, Bosminidae) and littoral (Chydoridae, Sididae) forms.

This study analyzes the Cladocera remains and changes in their dynamics within the study basin during the period from approximately 13,200 to 8,100 cal yr BP. The aim is to reconstruct palaeoenvironmental conditions and assess the palaeoecology of the catchment. During the initial sedimentation phase, cladoceran abundance was low, and planktonic species dominated, suggesting a deep-basin character at that time. Around 13,000 cal yr BP, a rapid increase in littoral species accompanied by a decline in planktonic species indicates basin shallowing and changes in habitat structure. The low abundance of cladocerans around 12,850 cal yr BP reflects prevailing unfavourable environmental conditions, while the predominance of cold-tolerant species indicates low temperatures and oligotrophic conditions. Around 12,600 cal yr BP, rising water levels and an increase in planktonic species are observed, although trophic levels remained low. Since 12,000 cal yr BP, littoral species have predominated, with species composition reflecting a warmer, wetter climate, coastal vegetation development, and mesotrophic conditions. The changes in cladoceran species composition around 10,600 cal yr BP suggest a shift in trophic dynamics. An increase in planktonic species around 10,200 cal yr BP indicates a rise in water levels associated with a wetter climatic phase. A substantial increase in the number of subfossil cladoceran species around 9000 cal yr BP points to the expansion of the macrophyte zone and the formation of shallower habitats. Additionally, the prevalence of thermophilic and acid-tolerant species is linked to a warming climate and a possible decline in pH.

References

Bitinas, A., 2012. New insights into the last deglaciation of the south-eastern flank of the Scandinavian Ice Sheet. Quat. Sci. Rev. 44, 69-80.

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Long-term carbon accumulation in northern boreal peatlands – the role of the basin bathymetry

Seija Kultti[a], Niina Kuosmanen[a], Suvi Erhovaara[b], Kirsti Korkka-Niemi[a,b], Annika Åberg[a,b] and Olli Nurmilaukas[b]

[a]Department of Geosciences and Geography, Faculty of Science, University of Helsinki, P.O. Box 64, (Gustaf Hällströmin katu 2), 00014 Helsinki, Finland, seija.kultti@helsinki.fi,
[b]Geological Survey of Finland GTK, Water and Mining Environment Solutions, Vuorimiehentie 5, P.O. Box 96, FI-02151 Espoo, Finland

Boreal peatlands are essential in global carbon dynamics, acting as both sinks and sources. The groundwater-dependent, nutrient-rich sloping fen is a typical peatland type in northeastern Finland, especially in Kuusamo region. To better understand the long-term carbon dynamics of these ecosystems, we studied Puukkosuo that is a sloping fen located in the carbonate bedrock area of the northern boreal zone.

We collected four peat cores from across the site, which were radiocarbon dated to establish chronological control and calculate the peat accumulation rate. We analyzed peat characteristics, including composition, degree of humification, bulk density, and carbon content, to explore the peatland's development and long-term carbon storage during the Holocene. Using radiocarbon dates, bulk density, and carbon content, we calculated the long-term carbon accumulation. To examine how basin bathymetry influences peatland development and carbon storage, we modeled the 3D structure of the Puukkosuo basin using Leapfrog Geo software (Seequent), based on a dense network of ground-penetrating radar (GPR) profiles (5.5 km) across the peatland and reference peat stratigraphy.

The records cover the past 9,000 Cal BP of peatland development and carbon accumulation. The results indicate that the carbon accumulation rate in the basal part of the basin surpasses remarkably the average rate in the northern boreal zone, while the surface layer shows typical carbon accumulation values. Although changes in accumulation rates vary between cores, they occur at the same altitudinal level of the basin but not at the same chronological level. We conclude that bathymetry, rather than the accumulation period and climate, has been the primary factor controlling major carbon accumulation patterns. Therefore, when using point-specific data for calculating regional and/or global carbon storage, it is important to understand the basin bathymetry to avoid overestimation of carbon storage.

Preliminary results of high-resolution LiDAR mapping of glacial landforms in Latvia

Kristaps Lamsters[a], Edijs Breijers[b], Hugo Huberts Puriņš[b], Normunds Stivriņš[a,c], Kristaps Rendinieks[a] and Izolde Ivanova[b]

[a]Department of Geology, University of Latvia, Riga, Latvia, kristaps.lamsters@lu.lv;
[b]Department of Geography, University of Latvia, Riga, Latvia;
[c]Department of Geology, Tallinn University of Technology, Tallinn, Estonia

The study of glacial landforms in Latvia and the Baltic region has a history spanning more than a century pioneered by Professor Konstantin Grewingk of the University of Tartu, a geologist who conducted the first geological investigations of Latvian from the perspective of glacial theory in 1879 (Grewingk, 1879). Subsequent key studies by Doss and Hausen published in 1910 and 1913 recognized and mapped drumlin fields in the lowlands of northern Lithuania, the Linkuva and other terminal moraines, eskers in the Central Latvian Lowland, ice-dammed lake plains, and ice-marginal positions. The foundations of glaciotectonics in Latvia were established largely due to the work of A. Dreimanis (1935). In the 1960s, glacial landforms were mainly studied and mapped to infer glacier flow directions. A key method that emerged at this time was the analysis of pebble orientation in tills (Spriņģis et al., 1963). In the 1970s and 1980s, researchers began to focus on specific glacial features, such as refining the mapping and correlation of ice-marginal features (Āboltiņš, 1970). With the availability of large-scale topographic maps, more detailed mapping of glacial landforms in Latvia was conducted shortly before and after the restoration of Latvian independence (e.g. Zelčs, 1993).

Between 1999 and 2003, for the first time, the ArcInfo software was used to develop a digital map of glaciotectonic formations and a database of ice flow indicators. This database included 3,633 directional elements, comprising measurements of till macrofabric, glacial striation and glaciotectonic structure measurements, longitudinal axes of glacial flow-related landforms and indirect indicators such as tunnel valleys and esker and kame chains (Dzelzītis et al., 2004). These features were digitized from 1:50,000 and 1:75,000 scale topographic maps. Based on these studies, a map depicting the flow directions of major ice streams, lobes, and tongues in Latvia was developed (Zelčs, Markots, 2004) enabling correlation of ice-margin positions with those in neighboring countries (Zelčs et al., 2011). In the second decade of the 21st century, geomorphologists began using GIS tools to identify and delineate glacial landforms in a digital environment, although large-scale topographic maps continued to serve as the primary data source (e.g. Lamsters, Zelčs, 2015). The nationwide airborne laser scanning of Latvia was completed in 2019. Consequently, it was only in the third decade of the 21st century that the mapping of glacial landforms began using 1-meter resolution digital elevation models (DEMs) derived from LiDAR data and demonstrating that the high-resolution elevation model enables unprecedented detail in the identification and mapping of glacial landforms, including discovering new features as, for example, crevasse-squeeze ridges (Lamsters et al., 2021).

In 2025, a research project was launched with an aim to reconstruct the dynamics and deglaciation of the southeastern sector of the Scandinavian Ice Sheet in Latvia. The mapping of glacial landforms is being conducted from high-resolution LiDAR-derived DEMs to evaluate the behavior of major ice streams and lobes, subglacial processes, and the retreat patterns of the ice margin. Initially, the landform mapping is being conducted manually. A database including several tens of thousands of landforms such as subglacial bedforms, crevasse-squeeze ridges, eskers, tunnel valleys, end moraines is being prepared. Subsequently, the resulting database will be used to train machine learning models, leading to the development of an automated methodology for glacial landform mapping.

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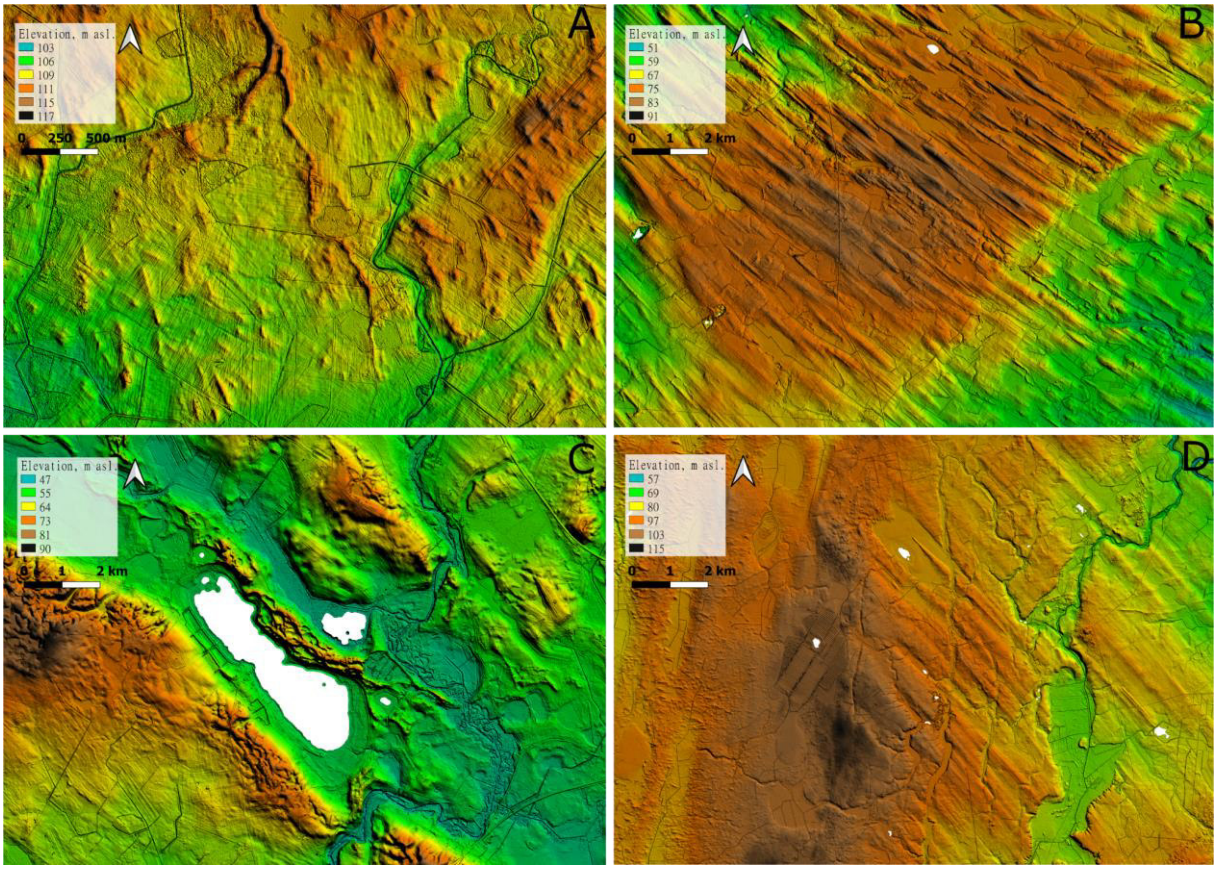

Figure 1. Examples of glacial landforms in Latvia. 1-m-resolution LiDAR DEM at the background. A: crevasse-squeeze ridges (CSRs) in the Eastern Latvian Lowland. B: Burtnieks drumlin field in the Northern Vidzeme Lowland. C: Multi-crested esker in tunnel valley, Idumeja Upland D: Examples of surging ice lobe landscapes. From the left: CSRs superimposed on N-S oriented MSGLs, shear margin moraine (blackish), NW-SE oriented MSGLs cut by proglacial drainage valley in the Eastern Kursa Upland.

References

Āboltiņš, O., 1970: Marginal formations of Middle Latvian tilted plain and their correlation to Linkuva (North Lithuanian) end moraine. *In*: Danilans I. (ed.), *Problems of Quaternary geology*, V, 95-107. Riga, Zinatne (in Russian, English summary).

Dreimanis, A., 1935: The rock deformations, caused by inland ice, on the left bank of Daugava at Dole Island, near Riga in Latvia. Riga, Gulbis, 30 pp (in Latvian with English summary).

Dzelzītis, J., Markots, A. Zelčs, V., 2004: Database and map of Late Weicshselian directional ice-flow features of Latvia. In International Field Symposium on Quaternary Geology and Modern Terrestrial Processes, Western Latvia, September 12-17, 2004: Abstracts of Papers and Posters. Riga, University of Latvia.

Grewingk, C., 1879: Erläuterungen zur zweiten Ausgabe der geognostischen Karten Liv-, Est- und Kurlands. Dorpat: Verlag der Dorpater Naturforscher Gesellschaft, 123 s.

Lamsters, K., Vītola, Z., Karušs, J., Džeriņš, P., 2021: Evidence of ice streaming and ice tongue shutdown in western Latvia: revealed from the mapping of crevasse-squeeze ridges. *Baltica*, *33*(1).

Lamsters, K., Zelčs, V., 2015: Subglacial bedforms of the Zemgale Ice Lobe, south-eastern Baltic. *Quaternary International*, *386*, 42–54.

Spriņģis, K., Konshin, G.I., Savvaitov, A.S., 1963: Data concerning pebble orientation and changes of the ice movement direction of the Valdaian glaciation. *In*: Danilans, I. (ed.), *Questions of Quaternary Geology*, II, 35-43. Riga, Zinatne (in Russian, English summary).

Zelčs, V., 1993: Glaciotectonic landforms of divergent type glaciodepressional lowlands. *Dissertation work synthesis*. University of Latvia, p 105.

Zelčs, V., Markots, A., 2004: Deglaciation history of Latvia. In Ehlers, J., Gibbard, P. L. (eds.), *Extent and Chronology of Glaciations, v.1 (Europe)*. Elsevier, The Netherlands [etc.], pp. 225–244.

Zelčs, V., Markots, A., Nartišs, M., Saks, T., 2011: Pleistocene Glaciations in Latvia. In Ehlers, J., Gibbard, P.L., Hughes P.D. (eds.), *Quaternary glaciations – extent and chronology: A Closer Look*, vol. 15. Elsevier, Amsterdam, pp. 221–229.

Structural control on tunnel-valley formation: Fact or fiction?

Jörg Lang[a], Anke Bebiolka[a], Vera Noack[a], Julia Schützke[b], Sarah Weihmann[b] and Sonja Breuer[a]

[a]Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover, Germany, Joerg.Lang@bgr.de;
[b]Lehrstuhl für Endlagersicherheit (ELS), RWTH Aachen, Aachen, Germany

Subglacially incised tunnel valleys may attain depths of almost 600 m, for example in the North German Basin. Characteristic features of tunnel valleys include undulating basal profiles, abrupt terminations and steep flanks, all indicative of subglacial formation by pressurised meltwater discharge. Tunnel-valleys fills represent important archives of past glaciations and may provide important groundwater reservoirs. Furthermore, tunnel-valley incision beneath potential future ice sheets is regarded as a major challenge for the long-term safety of radioactive waste repositories, as the incision may reach depths under consideration for such repositories. Therefore, an understanding of the controlling factors of tunnel-valley formation is an important contribution to long-term safety assessments.

Tunnel-valley formation is primarily controlled by climatic and glaciological factors. Furthermore, regional geological features, e.g. faults and salt structures, have been suggested as controlling factors for tunnel-valley formation. To improve the understanding of the impact of regional geological structures on tunnel-valley incision, we compare the distribution and orientations of buried Pleistocene tunnel valleys in the North German Basin to regional geological features, such as basin geometry and infill, faults and salt structures. Our analysis shows that deep tunnel valleys are restricted to areas with thick erodible Cenozoic deposits. The correlation between the trends of tunnel valleys, faults and salt structures varies between the analysed regions. The orientations of tunnel valleys commonly follow the trends of faults and salt structures in regions where the structural trend is NNW-SSE to E-W and ice-flow directions were approximately parallel to this trend. However, correlations are rarely observed if the regional structural trend is NW-SE to WNW-ESE and ice advances occurred thus normal or oblique to the regional fault trend. Faults active under the present-day stress field typically are NNW-SSE to NE-SW trending normal faults. Therefore, neotectonically active faults were probably favourably oriented to promote subglacial incision (Lang et al. 2025).

Knowing the impact of the underlying geology on subglacial incision can provide an idea of areas with an increased risk of subglacial incision and thus help in long-term safety assessments. However, the presence and orientations of faults and salt structures alone do not provide consistent indicators for the locations of future tunnel-valley incision (Lang et al. 2025).

References

Lang, J., Bebiolka, A, Noack, V., Schützke, J., Weihmann, S., Breuer, S., 2025: The impact of the structural framework of the North German Basin on Pleistocene tunnel-valley for-mation. *Boreas.* DOI: https://doi.org/10.1111/bor.12694

Formation and infilling of Middle Pleistocene buried valleys in the Subhercynian Basin (Germany)

Jörg Lang[a] and Jutta Winsemann[b]

[a]Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover, Germany, Joerg.Lang@bgr.de;
[b]Institut für Erdsystemwissenschaften, Leibniz Universität Hannover, Hannover, Germany

The Subhercynian Basin was overridden by the Middle Pleistocene Elsterian and Saalian ice sheets. Both glaciations led to the formation of deep erosional valleys that are now completely or partially infilled. The processes of valley formation and infilling, however, were very different.

During the Elsterian glaciation, a subglacial tunnel valley was incised into the poorly consolidated infill of the western rim syncline of the Helmstedt-Staßfurt salt wall near Schöningen. The tunnel valley trends NNW-SSE, is 3.5 km long, 850 m wide and up to 45 m deep. The subglacial origin of the tunnel valley is indicated by its abrupt terminations and undulating basal profile. The glacigenic tunnel-valley fill comprises coarse- and fine-grained meltwater deposits and till (Lang et al. 2012). After the Elsterian glaciation, a lake remained in the underfilled the tunnel valley and acted as an interglacial depocentre. Lacustrine deposits consist of a fine-grained delta that was shed into the lake from the west. Numerous Palaeolithic artefacts have been recovered from the lacustrine succession, including the famous Schöningen hunting spears. The distribution of the archaeological sites can be explained by the lateral and vertical stacking of the deltaic deposits, which was controlled by lake-level changes (Lang et al. 2015). During the subsequent Saalian glaciation, the remnant tunnel valley was completely infilled and buried by meltwater deposits and till. Tunnel-valley incision was probably fostered by the poorly consolidated Cenozoic infill of the rim syncline in contrast to the surrounding Mesozoic rocks.

The Middle Pleistocene glaciations were characterised by the formation of extensive ice-dammed lakes due to the blockade of the drainage pathways by the ice-sheet margin. Ice-margin retreat re-opened the drainage pathways, causing high-magnitude lake-drainage events. In the Subhercynian Basin a prominent east-west trending valley, the so-called Große Bruch, is incised that crosscuts all underlying structural trends. This trench-like channel is 40 km long, 2 to 3 km wide and 20 to 60 m deep. At the western termination of the valley, a deep scour indicates erosion by northwards-directed flow. The valley is incised into Early Saalian fluvial deposits, suggesting a formation during the Saalian glaciation. The main valley fill comprises sand, pebbly sand and gravel, with intercalations of locally organic-rich mud. The Große Bruch is interpreted as eroded by outburst floods from ice-dammed lakes farther to the east, which had volumes of up to 224 km³ (Lang et al. 2019). Further evidence of outburst floods is provided by scours, streamlined hills and flood-related deposits along the likely flood pathway. The incision of the Große Bruch valley strongly affected the regional drainage system by providing an efficient drainage pathway. The trench-like channel initiated by the lake-outburst flood became a crucial part of the ice-marginal drainage and subsequent fluvial system.

References

Lang, J., Winsemann, J., Steinmetz, D., Polom, U., Pollok, L., Böhner, U., Serangeli, J., Brandes, C., Hampel, A., Winghart, S., 2012: The Pleistocene of Schöningen, Germany: a complex tunnel valley fill revealed from 3D subsurface modelling and shear wave seismics. *Quaternary Science Reviews 39*, 86-105.

Lang, J., Böhner, U., Serangeli, J., Polom, U., Winsemann, J. (2015) The Middle Pleistocene tunnel valley at Schöningen as a Paleolithic archive. *Journal of Human Evolution 89*, 18-26.

Lang, J., Alho, P., Kasvi, E., Goseberg, N., Winsemann, J., 2019: Impact of Middle Pleistocene (Saalian) glacial lake-outburst floods on the meltwater-drainage pathways in northern central Europe: insights from 2D numerical flood simulation. *Quaternary Science Reviews 209*, 82-99.

The Late Saalian climatic oscillation record from the Polish Lowland in the light of the European evidences

Aleksandra Majecka[a], Dorota Nalepka[b], Mirosława Kupryjanowicz[c], Wojciech Granoszewski[d], Anna Hrynowiecka[e], Irena Agnieszka Pidek[f], Magdalena Fiłoc[c], Małgorzata Malkiewicz[g], Małgorzata Nita[h], Bożena Noryśkiewicz[i], Hanna Winter[j] and Adam Walanus[k]

[a]Department of Climate Geology, University of Warsaw, Żwirki and Wigury 93, 02-089 Warszawa, Poland, a.majecka@uw.edu.pl
[b]W. Szafer Institute of Botany Polish Academy of Sciences, Lubicz 46, 31-512 Kraków, Poland, d.nalepka@botany.pl
[c]Faculty of Biology, Department of Palaeobiology, University of Białystok, K. Ciołkowskiego 1J, 15-425 Białystok, Poland, m.kupryjanowicz@uwb.edu.pl, m.filoc@uwb.edu.pl
[d]Polish Geological Institute- National Research Institute, Skrzatów 1, 31-560 Kraków, Poland, wojciech.granoszewski@pgi.gov.pl
[e]Polish Geological Institute - National Research Institute, Marine Geology Branch, Kościerska 5, 80-328 Gdańsk, Poland, ahry@pgi.gov.pl
[f]Institute of Earth and Environmental Sciences, Maria Curie-Sklodowska University, al. Krasnicka 2 d, 20-718 Lublin, Poland, irena.pidek@mail.umcs.pl
[g]Institute of Geological Sciences, University of Wroclaw, Cybulskiego 34, 50-205 Wroclaw, Poland malgorzata.malkiewicz@uwr.edu.pl
[h]Faculty of Natural Sciences, Institute of Earth Sciences, University of Silesia in Katowice, Będzińska 60, 41-200 Sosnowiec, Poland, malgorzata.nita@us.edu.pl
[i]Department of Geomorphology and Palaeogeography of the Quaternary, Faculty of Earth Sciences, Nicolaus Copernicus University, Lwowska 1, 87-100 Toruń, Poland, norys@umk.pl
[j]Puławska 109b/139, 02-707, Warszawa, hwin1@o2.pl
[k]Janowa Wola 10/15, 30-550 Kraków, Poland, a@adamwalanus.pl

The Saalian Glaciation represents the marine isotope stage MIS 6 (Shackelton et al., 2002) preceding the last Eemian Interglacial (MIS 5e). In the actual Polish stratigraphy, the younger part of the Saalian is referred to the Warta stadial of the Odranian Glaciation (Marks et al., 2016, 2018), correlates with MIS 6a within the Penultimate Glacial Maximum. The name Late Saalian is used for define the decline of the Warta stadial (cf. Railsback et al., 2015).

Globally documented records from various sedimentary environments indicate that the end of the Late Saalian was marked by warm conditions interrupted by a sudden cold, dry interval at the Saalian–Eemian boundary (e.g. Heinrich, 1988). The climatic oscillations during the Late Saalian in the rank of interstadial/stadial (Zeifen/Kattegat) had been documented in Zeifen in southern Germany which the name 'Zeifen Interstadial' is derived (Jung et al., 1972; Beug, 1973; Grüger, 1979). Floristic succession related to Late Saalian had been continually documented in Europe in numerous profiles (e.g. Woillard, 1979; Menke & Tynni, 1984; Novenko et al.,2005; Beets et al., 2006; Börner et al., 2018).

The record of floristic succession from the Late Saalian has also been documented in over 50 pollen profiles from the Polish Lowland. The outlined picture of climatic oscillations in the Late Saalian on the example of selected archival profiles shows the diversity in the pollen picture of this period. The initial vegetation was represented by mosaic of tundra and cold steppe communities. Climatic amelioration is expressed in various ways, by increased biodiversity, higher pollen frequency resulting from improved vegetation conditions or the appearance of sparse pine-birch boreal forest communities (Majecka et al., 2022). The deterioration of conditions at the boundary of the interglacial might be expressed in various ways, by the coexistence of forest and open park tundra communities, lithological change, signals indicating progressive aeolization or erosion. With the support of other palaeobiological, lithological and geochemical evidence from recent studies, we indicate certain evidence of the occurrence of the Late Saalian interstadial-stadial climatic oscillation on the Polish Lowland. Based on additional proxies, it is necessary to retrace the Late Saalian/Eemian interglacial boundary, which could be more indicative than the pollen record.

References

Beets, D.J., Beets, C.J., Cleveringa, P., 2006. Age and climate of the late Saalian and early Eemian in the type-area, Amsterdam basin, The Netherlands. *Quaternary Science Reviews 25*, 876–885.

Beug, H. J., 1973. Die Bedeutung der interglazialen Ablagerungen von Zeifen und Eurach (Oberbayern, BRD) für die Vegetationsgeschichte der Eem-Warmzeit am Nordrand der Alpen. In: *Palynology of the Pleistocene and Pliocene* (ed. V. Gritschuk), 7–13.

Börner, A., Hrynowiecka, A., Stachowicz-Rybka, R., Niska, M., Moskal-del Hoyo, M., Kuznetsov, V., Maksimov, F., Petrov, A., 2018. Palaeoecological investigations and 230Th/U dating of the Eemian Interglcial peat sequence from

Neubrandenburg-Hinterste Mühle (Mecklenburg-Western Pomerania, NE Ger many). *Quaternary International 467*, 62–78.

Grüger, E., 1979. Spatriss, Riss/Würm und Frühwürm am Samerberg in Oberbayern - ein vegetationsgeschichtlicher Beitrag zur GIiederung des Jungpleistozäns. *Geologica Bavaria 80*, 5–64.

Heinrich, H., 1988. Origin and consequencesof cyclic ice rafting in the northeast Atlantic Ocean during the past 130,000 years. *Quaternary Research 29*, 142–152.

Jung, W., Beug, H.J., Dehm, R., 1972. Das Riss-Würm Interglazial von Zeifen, Landkreis Laufen a.d Salzach. Abhandlungen der Bayerischen Akademie der Wissenschaften, *Mathematisch Naturwissenschaftliche Klasse, Neue Folge 151*, 1–131.

Majecka, A., Wachecka-Kotkowska, L., Krzyszkowski, D., Malkiewicz, M., Mirosław-grabowska, J., Niska, M., Rzodkiewicz, M., Myśkow, E., Tomaszewska, K., Wieczorek, D., Raczyk, J., 2022. Environmental changes during the MIS 6a–MIS 5e transition: the Parchliny 2016 profile, central Poland. *Geological Quarterly 66,* 31.

Marks, L., Dzierżek, J., Janiszewski, R., Kaczorowski, J., Lindner, L., Majecka, A., Makos, M., Szymanek, M., Tołoczko-Pasek, A., Woronko, B., 2016. Quaternary stratigraphy and palaeogeography of Poland. *Acta Geologica Polonica 66*, 410–434.

Marks, L., Karabanov, A., Nitychoruk, J., Bahdasarau, M., Krzywicki, T., Majecka, A., Pochocka-Szwarc, K., Rychel, J., Woronko, B., Zbucki, £., Hradunova, A., Hrychanik, M., Mamchyk, S., Rylova, T., Nowacki, Ł., Pielach, M., 2018. Revised limit of the Saalian ice sheet in central Europe. *Quaternary International 478*, 59–74.

Menke, B., Tynni, R., 1984. Das Eeminterglazial und das Weichselfrühglazial von Redestall/Dithmarschen und ihre Bedeutung für die mitteleuropäische Jungpleistozän-Gliederung. *Geologische Jahrbuch, Ser. A, 76*, 3–120.

Novenko, E.Y., Velichko, A.A., Suganova, S., Junge, F.W., Boettger, T. 2005.Dynamics of vegetetion at the Late Pleistocene glacial/interglacial transition (new data from the center ohe East European Plain). *Polish Geological Institute Special Papers, 16*, 77–82.

Railsback, L.B., Gibbard, P.L., Head, M.J., Voarintsoa, N.R.G., Toucanne, S., 2015. An optimized scheme of lettered marine isotope substages for the last 1.0 million years, and the climatostratigraphic nature of isotope stages and substages. *Quatenary Sci ence Reviews 111*, 94–106.

Shackleton, N.J., Chapman, M.R., Sanchez Goni, M.F., Pailler, D., Lancelot, Y., 2002. The classic Marine Isotope Substage 5e. *Quaternary Research 58*, 14–16.

Woillard, G.M., 1979. The last interglacial-glacial cycle at Grande Pile in North eastern France. *Bull. Soc. Belge Geol. 88*, 51–69.

Contrasting hydrological regimes in two neighbouring Eemian palaeolakes of Central Poland: sedimentary, isotopic and pollen-based insights

Przemysław Mroczek[a], Nils Andersen[b], Irena Agnieszka Pidek[a], Renata Stachowicz-Rybka[c] and Anneli Poska[d]

[a]Institute of Earth and Environmental Sciences, Maria Curie-Skłodowska University, Lublin, Poland, przemyslaw.mroczek@mail.umcs.pl;
[b]Leibniz-Labor für Altersbestimmung und Isotopenforschung der Christian Albrechts-Universität zu Kiel, Kiel, Germany;
[c]W. Szafer Institute of Botany Polish Academy of Sciences, Kraków, Poland;
[d]Department of Geology, School of Science, Tallinn University of Technology, Tallinn, Estonia

This study presents a multi-proxy reconstruction of environmental and climatic changes during the Eemian Interglacial (MIS 5e), based on sedimentary archives from two palaeolakes—Kozłów (hydrologically open) and Struga (closed)—located 10 km apart in the Garwolin Plain. While a summary of the key results was previously published by Mroczek et al. (2025), this contribution expands on that framework by incorporating additional granulometric and palaeobotanical data, alongside new interpretations of hydrological dynamics and climate variability.

Both sites preserve thick biogenic successions exceeding 6 m in depth, subdivided into regional pollen assemblage zones (RPAZs) and subzones, enabling high-resolution correlation with other European records. High-resolution palynological analyses revealed complete forest succession, including thermophilous taxa such as Tilia tomentosa, Hedera helix, and Carpinus betulus, supporting detailed climate reconstructions. Plant macroremain analysis provided further insights into shoreline vegetation and lake-level fluctuations, identifying taxa such as Najas marina, Trapa natans, and Phragmites australis.

Grain size analysis revealed distinct sedimentary dynamics. At Kozłów, average grain size progressively increases upwards, with sorting values indicating a transition from stable lacustrine to more dynamic fluvial deposition. Upper subzones (E5–E7) are characterised by a marked increase in sand-sized fractions and the presence of grains >2 mm, suggesting episodic high-energy inflow, likely linked to catchment runoff or seasonal flooding. Parameters such as U-ratio and grain size index point to enhanced hydrodynamic activity, consistent with isotopic evidence for riverine influence.

In contrast, the Struga profile displays greater textural variability, reflecting alternating phases of depositional energy. Lower subzones exhibit fine, well-laminated silts, while upper intervals show abrupt increases in sand content, coupled with poor sorting and fluctuating kurtosis values. These changes reflect unstable hydrological conditions typical for a closed-basin lake responding sensitively to regional P/E balance. The observed granulometric heterogeneity complements the isotopic and biotic proxies, confirming dynamic lacustrine processes modulated by hydrological isolation.

Stable carbon and oxygen isotope analyses of bulk carbonates revealed systematic differences: Kozłów exhibited elevated and relatively stable $\delta^{18}O$ values, with low covariance between $\delta^{18}O$ and $\delta^{13}C$, consistent with an open lake influenced by river inflow and evaporative enrichment. In contrast, Struga showed strong $\delta^{13}C$–$\delta^{18}O$ covariance and wider isotopic ranges, indicating prolonged water residence times and strong control by the P/E ratio.

Reconstructions using the PPPbase model and indicator species analysis revealed distinct thermal and hydrological phases. Warm and wet conditions during the Carpinus-dominated phase (E5) were followed by cooling and drying trends in the coniferous phases (E6–E7). Notably, isotope data and diatom-based lake-level reconstructions from Struga closely tracked regional climate variability. Quantitative estimates indicate mean July temperatures reaching ~21 °C and annual precipitation exceeding 1200 mm during the climatic optimum, followed by a marked drop in both parameters during the terminal Eemian.

Our results demonstrate how local hydrological and geomorphological settings modulate sedimentary and geochemical signals in lake basins. While Kozłów reflects hydrodynamic instability and evaporative overprinting, Struga preserves a more climatically sensitive signal. This dual-site perspective offers new

insights into the temporal and spatial variability of the Eemian in Central Europe and provides a valuable framework for comparative interglacial studies.

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References

Mroczek, P., Andersen, N., Stachowicz-Rybka, R., Poska, A., Żarski, M., Nitychoruk, J., Suchora, M., Kultys, K., Pidek, I.A., Bober, A., 2025: Climatic and geological controls on the hydrological response of two neighbouring Eemian palaeolakes (Central Poland): A multi-proxy study. *Catena* 109039, 1–25. https://doi.org/10.1016/j.catena.2025.109039

Mountain regions peat bogs in the light of the results of the Cladocera analysis

Monika Niska[a], Anna Hrynowiecka[b], Renata Stachowicz-Rybka[c], Wojciech Drzewicki[d], Adam Michczyński[e], Petra Hajkowa[f] and Krzysztof Stefaniak[g]

[a]Institute of Geography, Pomeranian University in Słupsk, 76-200 Słupsk, monika.niska@upsl.edu.pl
[b]Marine Geology Branch Polish Geological Institute - National Research Institute, 80-328 Gdańsk, Poland ahry@pgi.gov.pl
[c]W. Szafer Institute of Botany, Polish Academy of Sciences, 31-512 Kraków; k.stachowicz@botany.pl
[d]Institute of Geological Sciences, University of Wrocław, 50-204 Wrocław, Poland wojciech.drzewicki@uwr.edu.pl
[e]Institute of Physics, Centre for Science and Education, Silesian University of Technology, 44-100 Gliwice;
[f]Department of Botany and Zoology, Faculty of Sciences, Masaryk University, 611-37 Brno, Czech Republic
[g]Department of Palaeozoology; Faculty of Biological Sciences, University of Wrocław, 50-335 Wrocław, Poland, krzysztof.stefaniak@uwr.edu.pl

All mires, including the ombrotrophic peat bogs, represent valuable and rare habitats that host specific and diversified biota specialised to the permanently wet and nutrient-extremely-poor environment (Spitzer and Danks 2006). Unfortunately, mires belong to the most endangered habitats. Because of their sensitivity to any changes in the water regime and degree of threats, they are considered to be EU priority habitats. Knowledge about the Quaternary history of mires is important for understanding their current functioning and threats. Mires are also very exceptional because they are natural past archives. Sadzonki peatbog (1230 m. asl.) is located at the Śnieżnik Massif on the border between the Czech Republic and Poland. The second peatbog – Bór na Czerwonem (about 500 m asl) – today surrounded by reserve care was a part of a large complex of peat bogs, which in the past filled the Orava-Nowy Targ Basin and, as a consequence of expansive human management, almost disappeared. Both peat bogs were subjected to comprehensive multiproxy studies covering both the current state of the peat bog and its history. Among the paleolimnological analyses, there was also an analysis of fossil remains of Cladocera. Cladocera are typical representatives of lake zooplankton and constitute an excellent tool for lake study. In peatbogs, they usually appear in the initial period associated with water accumulation and also in wet periods. However, there are factors limiting Cladocera succession as the lack of open water and a typical littoral zone, fluctuation of water level and pH, in the case of mountain peat bogs, the altitude above sea level, which is a limit for many species (Rybak and Błądzki, 2010). The subfossil Cladocera fauna of deposits from a 2,000-year time span of the Sadzonki profile is represented only by 7 species belonging to the family Chydoridae. The dominant species became those with the highest resistance: Alonella excisa and Chydorus sphaericus. Similarly, in the Bór na Cerwonem, the remains of only 5 Cladocera species were recorded. This group included again *Ch.Spaericus, A.excisa*, and *A. guttata* and *A.exigua* in wetter periods. Interestingly, in the sediments correlated with the Boreal period, a unique species Rhynchotalona latens appeared, belonging to the smallest and rarest Cladocera species known from N Finland from fossil sites and at contemporary sites in the taiga (NW Russia and N Finland). This species is considered a glacial relic (Ibragimova et al. 2024), it prefers acidic, shallow humotrophic lakes typical.

Despite the low frequency of Cladocera in the peatbog, the mere appearance could be an important indicator of a higher water level. Changes in species composition provide information about small changes in the ecosystem due to climate change, human activity and environmental evolution. A higher pH results in an increase in the number of species and attendance, e.g., *A.guttata*, *Acroperus harpae*, chenges in conductivity – the appearance of *Alonella exigua* and higher water level - *Alona quadrangularis*. The presence of a larger number of ephiphia may indicate worsening conditions. In summary, Cladocera can provide valuable data and be a useful tool to study peatbog.

References:

Ibragimova A.G, Gusarov A.V., Frolova, L.A., 2024: Rhynchotalona latens (Sarmaja-Korjonen, Hakojärvi et Korhola 2000) (Crustacea, Anomopoda, Chydoridae) in Lacustrine Sediments of European Russia. *Quaternary* 7: 14.

Rybak, J. I., Błędzki, L. A., 2010: Freshwater planktonic crustaceans: identification key.(Słodkowodne skorupiaki planktonowe). *Wydawnictwo Uniwersytetu Warszawskiego* 268.

Spitzer, K., Danks, H. V., 2006: Insect biodiversity of boreal peat bogs. *Annual review of entomology* 51(1), 137-161.

Archaeoseismology: The Impact of Earthquakes on Settlement in the Aras River Valley (Armenia)

Kajetan K. Ogłaza[1], Barbara Woronko[2], Barbara Rybak-Ostrowska[2], Mateusz Iskra[3], Piotr Moska[4], Arshavir Hovhannisyan[5], Ara Avagyan[5] and Hakob Simonyan[6]

[1]University of Warsaw, Doctoral School of Exact and Natural Sciences, Stefana Banacha 2c, 02-097 Warsaw, Poland
[2]University of Warsaw, Faculty of Geology, Żwirki i Wigury 93, 02-089 Warsaw, Poland
[3]University of Warsaw, Polish Centre of Mediterranean Archaeology, Tyniecka 69, 00-838 Warsaw, Poland
[4]Institute of Physics, Division of Geochronology and Environmental Isotopes, Silesian University of Technology, Konarskiego 22B str., 44-100, Gliwice, Poland
[5]National Academy of Sciences of Armenia, Institute of Geological Sciences, 24a Baghramyan avenue, 0019 Yerevan, Armenia
[6]Yerevan State University, Faculty of History, 1Alex Manoogian, 0025 Yerevan, Armenia

The area of Argishtikhinili located in the eastern part of the Sardarapat Ridge in the southern Armenia provides evidence of active faulting recorded presently and in the historical times (Karakhanian et al., 2004; Karakhanian and Abgaryan, 2004). Deformation of the area resulted from collision of the Arabian and Eurasian tectonic plates. The N-S shortening of the area was primarily accommodated by thrusting and strike-slip faulting (Dewey et al. 1986). The Sardarapat Ridge defines the WNW-ESE-trending local dextral strike-slip Sardarapat Fault belonging to the network of the NW-SE trending large active faults, bordering pull-apart structure, which outline the Ararat Volley.

The Argishtikhinili exposure reveals the presence of faults and liquefaction features within the deposits of the dammed lake formed as a result of a local earthquake. The lake deposits are cut by network of faults. The lake existed from 92 to 24 ka. Analysis of kinematic indicators on exposed slickensides indicates reverse displacement along NNW-SSE and NW-SE trending faults, and strike-slip displacement along NW-SE trending faults. The liquefaction features occurring in close vicinity of the faults indicates water saturation of deposits during deformation. Such features are commonly considered as a result of earthquakes of M>5 (Machette, 2000).

References:

Dewey J.F., Hempton M.R., Kidd W.S.F., Saroglu F., Şengör A.M.C., 1986 Shortening of continental lithosphere: the neotectonics of Eastern Anatolia a young collision zone. In: Coward, M. P. & Ries, A. C. (eds), 1986, Collision Tectonics, Geological Society Special Publication, 19, 3-36.

Karakhanian A. and Abgaryan Y., 2004 Evidence of historical seismicity and volcanism in the Armenian Highland (from Armenian and other sources). Annals of Geophysics, 47, 793-810.

Karakhanian A.S, Trifonov W.G., Philipc H., Avagyana A., Hessamid K., Jamalie F., Bayraktutanf M.S., Bagdassariana H., Arakeliana S., Davtiana V., Adilkhanyan A., 2004 Active faulting and natural hazards in Armenia, eastern Turkey and northwestern Iran. Tectonophysics, 380, 189– 219.

Machette, M.N. 2000. Active, capable, and potentially active fault—A paleoseismic perspective. Journal of Geodynamics, 29, 387–392.

The evolution of the Quaternary North Sea Basin with emphasis on the last three glaciations

Dag Ottesen[a], Christine Batchelor[b], James Kirkham[c] and Julian A. Dowdeswell[d],

[a]Geological Survey of Norway, Trondheim, Norway;
[b]Department of Geography, University of Newcastle, Newcastle, UK;
[c]British Antarctic Survey, Cambridge, UK;
[d]Scott Polar Research Institute, University of Cambridge, Cambridge, UK

More than 1000 m of Quaternary sediments exist over large areas of the Norwegian continental shelf. Here, we summarise the large-scale history of the Quaternary North Sea Basin (NSB) (52-62°N) (Ottesen et al., 2018). The central and southern NSB (52-59°N) was infilled mainly by fluvial and distal-marine sediments, whereas the northern NSB (59-62°N) was infilled mainly by glacial sediments (glacigenic debris flows) during the Early Pleistocene.

One single Early Pleistocene ice advance into the central NSB occurred c. 1.1 Ma and deposited a more than 100 m thick till package over a large area (> 10 000 km^2).

Higher in the stratigraphy, an Upper Regional Unconformity is present over the entire NSB. In the central and southern NSB, this surface separates underlying sediments with a fluvial/marine character from overlying sediments with a more glacial character. The URU is multi-aged, but most of this surface was probably formed during the third last glaciation (the Elsterian on land in northern Europe). In the northern NSB, the URU represent a transition from mainly glacigenic debris-flows below to more flat-lying units such as tills, sometimes linked to glacial erosional surfaces with glacial lineations, above. A complex pattern of tunnel valleys cut through these sediments and sometimes also into the older sediments.

The Norwegian Channel was carved out by the recurring Norwegian Channel Ice Stream during the last few glaciations. Towards the shelf break, the North Sea Fan extends into the deep Norwegian Sea and was built up from high rates of glacigenic debris-flow delivery onto the continental slope (up to 1500 m in thickness).

Examples of the seismic stratigraphy of the NSB will be presented, together with some of the key scientific questions that still need to be resolved.

References:

Ottesen, D., Batchelor, C.L., Dowdeswell, J.A., Løseth, H., 2018: Morphology and pattern of Quaternary sedimentation in the North Sea Basin (52-62°N). Marine and Petroleum Geology 98, 836-859.

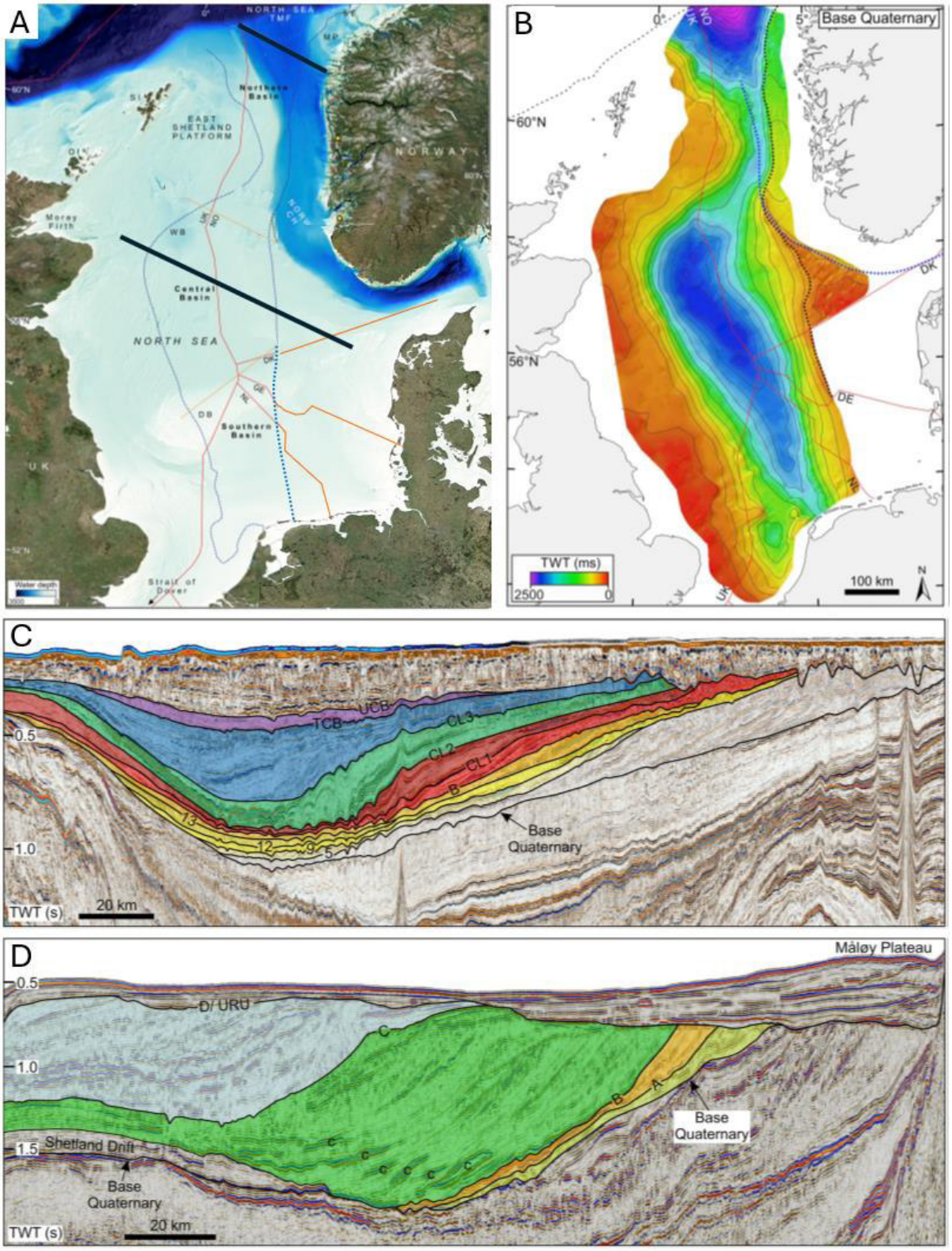

Figure 1. A) Modern bathymetry of the North Sea with the outline (500 m depth contour) of the buried Quaternary Basin. B) The base of the Quaternary NSB. C) Seismic profile across the central NSB. D) Seismic profile across the northern NSB (from Ottesen et al., 2018).

Sedimentary structures and paleoflow variability patterns in ice-marginal glaciofluvial deposits of Eastern Lithuania

Miglė Paškevičiūtė and Petras Šinkūnas

Institute of Geosciences, Faculty of Chemistry and Geosciences, Vilnius University, Vilnius, Lithuania, migle.paskeviciute@chgf.stud.vu.lt;

This study focuses on sedimentary structures within glaciofluvial deposits formed in the ice-marginal zone during the Baltija (Pomeranian) Stage of the Nemunas (Weichselian) Glaciation in Eastern Lithuania, aiming to reconstruct paleoflow variability. This is crucial for reconstructing and interpreting glacial retreat dynamics, as well as understanding mechanisms driving these related processes. The investigated sections are located in sand and gravel pits across the Utena and Molėtai districts, within a geomorphologically complex segment of the ice-marginal zone.

The methodology included detailed sediment facies analysis and systematic documentation of sedimentary structures, such as planar and trough cross-bedding, rhythmic gravel–sand alternations, clast imbrication, and erosional boundaries. The sedimentary structures were documented by creating schematic sedimentary logs from profiles at multiple investigation sites, combined with photographs and paleoflow direction measurement. The sedimentary facies analysis was complemented by borehole data and surface models derived from the LiDAR-based high-resolution (1m) digital terrain model (DTM-LT-1m) used to assess slope gradients and spatial relationships between glaciofluvial sediment bodies and landforms shaped by ice-marginal and proglacial processes.

Preliminary observations indicate variability in flow regimes and sediment supply across different sections, suggesting localized hydrodynamic conditions influenced by ice-margin retreat dynamics and meltwater drainage pathways. Despite some distinct similarities in sedimentary structures and texture across different study sites, lateral facies changes reflect spatial heterogeneity in depositional processes within the ice-marginal glaciofluvial system.

These preliminary findings contribute to understanding sedimentary processes and palaeohydrological dynamics operating at the ice margin during late Weichselian deglaciation, highlighting the distinct origins of glaciofluvial plains formed by proglacial meltwater flow and their spatial embedding within moraine-dominated ice-marginal landforms in Eastern Lithuania.

Periglacial structures in fluvial deposits as an important palaeogeographical indicator; a case study from Central Poland

Joanna Petera-Zganiacz

Department of Geology and Geomorphology, University of Lodz, Łódź, Poland, joanna.petera@geo.uni.lodz.pl

Periglacial structures, such as ice wedges casts, sand wedges or large involutions are an important indicator of the presence of permafrost (Goździk, 1973; Vandenberghe, 1988; Vandenberghe, Pissart, 1993). These structures formed differently on plateaus and in river valleys. In case of river valleys, the dynamics of the fluvial environment contributed to the specific and multi-level development of periglacial structures. In the serve climatic conditions of the Plenivistulian in the old-glacial zone, aggradation dominated in river valleys, which resulted in river valleys becoming a valuable archive of symptoms of the periglacial environment.

The research was conducted in the Warta River valley, over 20 km south of the Last Glacial Maximum. The research material was collected from the walls of the Adamów opencast of the no longer operating Adamów Brown Coal Mine.

The Plenivistulian sediments are represented by alluvia reaching a thickness of 20 m. They were deposited in the environment of a low-energy sand-bottomed braided river. The results of OSL dating indicate that these sediments were formed at the turn of the Middle and Upper Plenivistulian. The alluvia contain thin layers of mineral-organic sediments with a significant spread, which are evidence of the basins functioned on floodplains. The age determinations of these sediments using the 14C method, in most cases, gave results that form a logical sequence with the results of OSL dating (Petera-Zganiacz et al., 2024).

The recorded periglacial structures are epigenetic and syngenetic pseudomorphoses after ice wedges of small width, which were formed in a few levels. Initial thermal contraction cracks with primary sand filling were also observed. The levels from which the ice wedges developed were involved in involutions of various scales. Of particular paleogeographic importance were flat-bottomed involutions, the presence of which provides important clues as to the characteristics of the active layer of permafrost.

The river waters caused thermokarst processes and had influenced melting of ice. Aggradational tendencies in the river valley limited the formation of wide wedges. Such conditions were conducive to the formation of syngenetic ice wedges. The formation of many levels with periglacial structures does not have to be an indicator of climate change, but can be a derivative of the dynamics of the fluvial environment.

References

Goździk, J.S., 1973: Geneza i pozycja stratygraficzna struktur peryglacjalnych w Środkowej Polsce. *Acta Geographica Lodziensia, 31*, 1–117.

Petera-Zganiacz, J., Brzozowicz, D., Pawłowski, D., Kaczmarek, P., 2024: Fluvial processes under late Pleni-Weichselian environmental conditions: a case study from the Warenka site in central Poland. *Geologos, 30(2)*, 81–94.

Vandenberghe, J.,1988: Cryoturbations. (In:) Clark, M.J. (Ed.), Advances in Periglacial Geomorphology. Wiley, Chichester, 179–198.

Vandenberghe, J., Pissart, A., 1993: Permafrost changes in Europe during the last glacial. *Permafrost and Periglacial Processes, 4*, 121–135.

Transformation of natural relief of a post-mining area – the Anthropocene determinant?

Joanna Petera-Zganiacz[a] and Danuta A. Dzieduszyńska[b]

[a]Department of Geology and Geomorphology, University of Lodz, Łódź, Poland, joanna.petera@geo.uni.lodz.pl
[b]Department of Geology and Geomorphology, University of Lodz, Łódź, Poland,danuta.dzieduszyńska@geo.uni.lodz.pl

The strong activation of human pressure on the natural environment is marked since less than 100 years. The proposed but unconfirmed unit called the Anthropocene has its beginnings in the 1950s. It is associated with nuclear weapons testing and the presence of anthropogenic mineral markers in geological sediments. In the field of Earth sciences, the Anthropocene is studied in various aspects, including anthropogenic geomorphological changes (Brown et al., 2017; Brandolini et al., 2020; Cendrero et al., 2022). The transformation of landforms is particularly visible in the areas of open-pit mining during the exploitation and subsequent reclamation.

The presented study is based on observation carried out in the post-mining area of the Lignite Mine (Central Poland, Warta River valley in the Koło Basin section), which was active in the years 1959-2021 (Orlikowski, Szwed, 2011). The Miocene age lignite deposits was lying in horizons with a thickness of up to 11 m, between 21 and 47 m below ground level. They were covered with Quaternary glacial, glaciofluvial and fluvial deposits. Mining activities were carried out in a few opencasts. The outcrops included in the research were located within the low and high terraces of the Warta valley, locally covered by aeolian sand.

The reclamation of post-mining areas is the appearance of new elements of landscape with a specific, artificial internal structure (Petera-Zganiacz, Dzieduszyńska, 2024). The terrace surface was replaced by anthropogenic plain, which did not cause any significant physiographic changes. However, the newly created surface was devoid of natural features, such as swellings or concavities of various origins (e.g. fluvial, aeolian, biogenic) that make up the geomorphic diversity of natural plains. Shapes of convex forms created from dumps are far from natural. The formation of anthropogenic forms activated natural morphogenetic processes such as landslides. The shaping of artificial reservoirs in post-mining excavations and filling them with water led to the creation of an anthropogenic lake district with quite large and deep lakes. The result of such activities is the creation of a new geomorphological landscape as a determinant of the Anthropocene.

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References

Brandolini, P., Cappadonia, Ch., Luberti, G.M., Donadio, C., Stamatopoulos, L., Di Maggio, C., Faccini, F., Stanislao, C., Vergari, F., Paliaga, G., Agnesi, V., Alevizos, G., Del Monte, M., 2020: Geomorphology of the Anthropocene in Mediterranean urban areas. *Progress in Physical Geography, XX(X),* 1–24.

Brown, A.G., Tooth, S., Bullard, J.E., Thomas, D.S.G., Chiverrell, R.C., Plater, A.J., Murton, J., Thorndycraft, V.R., Tarolli, P., Rose, J., Wainwright, J., Downs, P., Aalto, R., 2017: The geomorphology of the Anthropocene: emergence, status and implications. *Earth Surface Processes and Landforms, 42*, 71–90.

Cendrero, A., Remondo, J., Beylich, A.A., Cienciala, P., Forte, L.M., Golosov, V.N., Artyom, V. Gusarov, A.V., Kijowska-Strugała, M., Laute, K., Li, D., Navas, A., Soldati, M., Vergari, F., Zwoliński, Z., Dixon, J.C., Knight, J., Nadal-Romero, E., Płaczkowska, E., 2022: Denudation and geomorphic change in the Anthropocene; a global overview. *Earth-Science Reviews 233*, 104186.

Orlikowski, D., Szwed, L., 2011: Zagospodarowanie terenów pogórniczych KWB „Adamów" SA w Turku – krajobraz przed rozpoczęciem działalności górniczej i po jej zakończeniu. *Górnictwo i Geoinżynieria, 35,3*, 225–240.

Petera-Zganiacz, J., Dzieduszyńska, D., 2024: Przemiany rzeźby terenu w obszarze poeksploatacyjnym – wyznacznik antropocenu? *Acta Geographica Lodziensia, 116*, 71–78.

Anthropopressure recorded in the beachrocks

Małgorzata Pisarska-Jamroży and CEMENT team

Institute of Geology, Adam Mickiewicz University, Poznań, Poland, pisanka@amu.edu.pl

Beachrocks are coastal sedimentary formations that undergo rapid cementation, appearing as small patches or extensive outcrops stretching hundreds of metres or more (e.g., Vousdoukas et al., 2005). Their high porosity allows for the entrapment of various materials, including sand, gravel, archaeological artefacts such as pottery fragments, and modern debris like cans and plastic litter (e.g., Kelletat, 2006). In tropical and subtropical zones, rapid cementation promotes the incorporation and preservation of such materials within the rock matrix. Recent human activity has led to the formation of novel rock types, including plastistones, hybrid rocks composed of natural material and melted plastic, first documented by Santos et al. (2022) on Trindade Island in the South Atlantic.

Preliminary observations from Seychelles, Sri Lanka and Oman have identified beachrocks with embedded plastic waste along parts of the Indian Ocean coastline. The research will focus on three sites influenced by monsoon-driven ocean currents, which facilitate long-distance transport of floating plastics. It is proposed that plastic incorporation modifies the beachrocks' geochemical and physical properties, potentially affecting their resistance to weathering and long-term stability.

References

Kelletat, D., 2006: Beachrock as sea-level indicator? Remarks from a geomorphological point of view. *Journal of Coastal Research* 22, 1558–1564.

Santos, F.A., Diório, G.R., Guedes, C.C.F., Fernandino, G., Giannini, P.C.F., Angulo, R.J., de Souza, M.C., César-Oliveira, M.A.F., Santos Oliveira, A.R.S, 2022: Plastic debris forms: Rock analogues emerging from marine pollution. *Marine Pollution Bulletin* 182, 114031.

Vousdoukas, M.I., Velegrakis, A.F., Karambas, T., Valais, G., Zarkoyiannis, S., 2005: Morphodynamics of beachrock-infected beaches: Vatera Beach, NE Mediterranean. In: Sanchez-Arcilla, A. (Ed.), 5th International Conference on Coastal Dynamics, Barcelona, 12 pp.

Water-level changes in the Baltic Ice Lake, overloading, and storm activity as causes of sediments liquefaction: A case study from the Sārnate Site, Latvia

Małgorzata Pisarska-Jamroży[a], Szymon Belzyt[b], Māris Nartišs[c], Albertas Bitinas[d], Barbara Woronko[e], Alar Rosentau[f] and Szymon Świątek[a]

[a]Institute of Geology, Adam Mickiewicz University, Poznań, Poland, pisanka@amu.edu.pl;
[b]Institute of Geological Sciences, University of Wrocław, Poland;
[c]Faculty of Geography and Earth Science, University of Riga, Latvia;
[d]Nature Research Centre, Vilnius, Lithuania; [e]Faculty of Geology, University of Warsaw, Poland;
[f]Department of Geology, University of Tartu, Estonia

Investigations of liquefaction features within sedimentary records provide crucial information on past deformation processes and environmental conditions. This research focuses on soft-sediment deformation structures resulting from liquefaction, identified in Late Pleistocene nearshore sediments at the Sārnate site in western Latvia, deposited during the Baltic Ice Lake. A combination of sedimentological, microstructural, and geochronological methods was employed to interpret the depositional environment and determine the timing of deformation episodes.

Environmental changes associated with the Baltic Ice Lake, particularly the transition from deeper to shallower aquatic conditions at Sārnate, were likely driven by drainage events. These changes probably increased pore-water pressures within the heterolithic sequence of alternating coarse- and fine-grained sediments, heightening their susceptibility to liquefaction. Deformation of the water-saturated nearshore deposits appears to have been primarily initiated by overloading, where unevenly applied vertical stress destabilised the underlying layers. Storm surges and wave activity likely acted as additional contributing factors, amplifying the deformation processes.

This study highlights the significant influence of local sedimentary characteristics on liquefaction potential and the resulting deformation styles. The findings provide valuable insights into the formation of non-seismic SSDS in nearshore environments and offer an important reference point for interpreting similar features in formerly glaciated regions.

A 3D modelling framework for elucidating the complex depositional history of the Kurikka buried valley

Niko Putkinen[a], Annika K. Åberg[b], Adrian Hall[c] and Juha Pekka Lunkka[d]

[a]Water and Mining Environment Solutions, Geological Survey of Finland, Kokkola, Finland, niko.putkinen@gtk.fi;
[b]Water and Mining Environment Solutions, Geological Survey of Finland, Espoo, Finland;
[c]Institute of Geography, University of Edinburgh, Edinburgh, UK;
[d]Oulu Mining School, University of Oulu, Oulu, Finland

The Kurikka aquifer system, located in western Finland, constitutes a groundwater reservoir of regional significance. This aquifer system is situated within a network of valleys interpreted to have formed between the Palaeoproterozoic (~1.5 Ga) and the Pleistocene. These valleys are infilled by a sedimentary succession exceeding 70 meters in mean thickness, comprising tills, sands, gravels, and fine-gained and organic-rich sediments deposited during the Middle and Late Pleistocene.

Over the past 15 years, comprehensive investigations involving borehole drilling (211 pcs), geophysical surveys, sedimentological analyses, and luminescence dating have elucidated the complex stratigraphy of the valley fill. An integrated workflow, incorporating geological and downhole geophysical data including resistivity, magnetic susceptibility, natural gamma, and gamma-gamma density measurements, from approximately 85 boreholes, along with seismic reflection profiling, has been employed to construct a three-dimensional hydrostratigraphic model. This model is supported by the interpretation of approximately 1412 km of geological cross-sections.

Hydrostratigraphic model bases on the valley-fill sequence model including 18 identified unconformity-bounded depositional systems. It reflects multiple episodes of sediment accumulation primarily during the penultimate glaciation. This stratigraphic record represents one of the most detailed reconstructions of the central Fennoscandian Ice Sheet (FIS) history currently available.

The modelling approach developed for the Kurikka system offers a transferable framework for the assessment of groundwater systems in other parts of Finland. It holds particular relevance for evaluating the potential impacts of future climate change on subsurface water resources.

Local bedrock contribution to geochemistry of glacigenic deposits – case study at Årsdale, Bornholm

Olga Reutt[a], Damian Moskalewicz[a] and Piotr P. Woźniak[a]

[a]Department of Geomorphology and Quaternary Geology, University of Gdańsk, Gdańsk, Poland,olga.reutt@phdstud.ug.edu.pl

The geochemical composition of glacial deposits may reflect the signature of local bedrock, serving as a potential indicator of past glacial dynamics (Farmer & Licht, 2016) and sediment provenance (Wittkop et al., 2020). Understanding these bedrock-till geochemical interactions can help in understanding ice-flow pathways, sediment transport mechanisms, and post-depositional alterations occurring during glacial and interglacial periods. Numerous studies conducted in diverse glaciated terrains underline the significance of bedrock lithology as one of the key controls influencing till geochemistry, emphasizing its use in Quaternary geological reconstructions, paleoenvironmental analyses, and mineral exploration strategies (e.g., Boston et al., 2010; McClenaghan et al., 2013; Valkama et al., 2021).

Bornholm, located in the southwestern Baltic Sea, exhibits a complex geological setting shaped by multiple Quaternary glaciations interacting with Precambrian crystalline bedrock. This study assesses the influence of local bedrock, specifically the Svaneke Granite, on the geochemical characteristics of till at Årsdale in eastern Bornholm. The Svaneke Granite is a coarse- to medium-grained granite primarily composed of potassium feldspar, plagioclase, quartz, biotite, hornblende, and accessory minerals including titanite, apatite, epidote, and fluorite (Micheelsen, 1961). Biotite within this granite is frequently altered to chlorite and iron oxides.

To investigate the contribution of local bedrock to till geochemistry, we applied an integrated methodological approach combining geochemical, petrographic, and geophysical techniques. Systematic sampling was carried out at 10 cm intervals along a vertical sedimentary profile at the Årsdale site. Bulk geochemical composition was determined using ICP-OES, while micro-XRF spectroscopy was applied to selected gravel-size fractions to evaluate element distributions within coarse material. Complementary petrographic analyses of gravel fractions (2–4 mm and 5–10 mm) were conducted to identify lithological components. To supplement laboratory results, in situ geophysical measurements were performed using handheld gamma-ray spectrometry (hGRS), providing vertical profiles of K, U, and Th concentrations, along with total gamma-ray (API) values. These data offer additional context for interpreting geochemical trends within the profile. Statistical analyses, including multivariate techniques, were used to explore patterns in elemental associations and to distinguish potential provenance signals. Furthermore, geochemical signatures of the till samples were compared to upper continental crust (UCC) reference values, enabling the assessment of elemental enrichment or depletion relative to a global compositional baseline. This framework enables us to explore general trends in elemental composition potentially linked to local bedrock and to assess vertical variability within the Årsdale till profile. Our preliminary interpretation underscores the value of high-resolution geochemical datasets for reconstructing the interactions between glacial, bedrock lithology, and sediment deposition processes.

References

Boston, C. M., Evans, D. J. A., Cofaigh, C. Ó., 2010: Styles of till deposition at the margin of the Last Glacial Maximum North Sea lobe of the British–Irish Ice Sheet: An assessment based on geochemical properties of glacigenic deposits in eastern England. *Quaternary Science Reviews*, *29*(23–24), 3184–3211.

Farmer, G. L., Licht, K. J., 2016: Generation and fate of glacial sediments in the central Transantarctic Mountains based on radiogenic isotopes and implications for reconstructing past ice dynamics. *Quaternary Science Reviews*, *150*, 98–109.

McClenaghan, M. B., Plouffe, A., McMartin, I., Campbell, J. E., Spirito, W. A., Paulen, R. C., Garrett, R. G., Hall, G. E. M., 2013: Till sampling and geochemical analytical protocols used by the Geological Survey of Canada. *Geochemistry: Exploration, Environment, Analysis*, *13*(4), 285–301.

Valkama, M., Sundblad, K., Korkka-Niemi, K., 2021: Metal anomalies in till in the Sarvlaxviken area, Lovisa, southern Finland. *Geochemistry*, *81*(4), 125788.

Wittkop, C., Bartley, J. K., Krueger, R., Bouvier, A., Georg, R. B., Knaeble, A. R., St. Clair, K., Piper, C., & Breckenridge, A., 2020: Influence of provenance and transport process on the geochemistry and radiogenic (Hf, Nd, and Sr) isotopic composition of Pleistocene glacial sediments, Minnesota, USA. *Chemical Geology*, *532*, 119390.

Occurrence of subglacial ring-shaped moraines in Finland

Pertti Sarala and Juha Pekka Lunkka

Oulu Mining School, University of Oulu, Finland (corresponding author pertti.sarala@oulu.fi)

There are several areas in northern and eastern Finland where relatively small, semi-linear to ring-shaped moraines occur. These moraines, named Pulju moraines in Finland, have been mapped, and investigated using Light Detection and Ranging (LiDAR) imagery interpretation and using sedimentological methods. The ring-shaped, linear, and non-linear Pulju moraines are typically superimposing the different glacigenic features.

Pulju moraines were first described by Kujansuu (1967) from around Pulju village, NW Finnish Lapland, which gave the name to this moraine type. Based on earlier observations, these moraines were found especially north of the late Weichselian ice-divide zone in Enontekiö, Inari and northern Kittilä (Aartolahti 1974, Aario 1990, Johansson & Nenonen 1991). The Pulju moraines occur and/or are best preserved in the supra-aquatic area typically close to ice-divide zone or at the interlobate zones of the Fennoscandian paleo-ice sheet.

Recent landform mapping indicates that Pulju moraines occur as fields where individual moraine ridges occur as various types of horseshoe-shaped features, 1-5 metres high and 25-100 m in diameter. For example, in the Kemijärvi and Salla areas south from the latest ice divide zone, Pulju moraines occur as a distinct moraine field with hundreds of individual landforms (Korkala 2020). There are also typically separate linear and non-linear moraine ridges between the ring-type moraine features and in places there seems to be a continuum from ridge-shaped into ring-shaped moraines. Stratigraphy shows that Pulju moraines are composed of 2-3 subglacial sandy till units with strong till clast fabrics orientation parallel to last ice flow direction. The moraines seem to have been formed in supra-aquatic areas void of major subglacial glaciofluvial landforms such as eskers but relatively close to ice interlobate area between the ice lobes in central Lapland and eastern Finland. In places, the ring-shaped moraines are superimposed by the streamlined moraines such as drumlins and flutings.

In SE Finland, some ring-ridge moraine fields occur between the former Lake District Ice lobe and the Karelian Ice Lobe adjacent to the interlobate complex. Moraines in this area cover more than 300 km^2 on both sides of the interlobate formation. The moraines are composed of sandy till. Their shape varies from ring-shaped to straight ridge-type moraines, commonly 1-3 metres high. In places, Pulju moraines are overlain by fluted surfaces, indicating partial deformation and morphological re-modification. Thus, this indicates the origin to be in the subglacial conditions under influence of fractional, moving ice sheet both in the last ice-divide zone and the interlobate areas.

References

Aario, R., 1990: Morainic landforms in northern Finland. In: Aario, R. (ed.) Glacial heritage of northern Finland. III International Drumlin Symposium, excursion guide. *Nordia tiedonantoja A1*, 13-26.

Aartolahti, T., 1974: Ring ridge hummocky moraines in northern Finland. *Fennia 134*, 21 p.

Johansson, P., Nenonen, J., 1991: Till stratigraphical studies in the Pulju area in northern Finland. Geological Survey of Finland, *Special Paper 12*, 131-134.

Korkala, H.-M., 2020: Pulju-moreenit Suomen Keski- ja Itä-Lapissa. MSc thesis, University of Oulu, 161 p.

Kujansuu, R., 1967: On the deglaciation of western Finnish Lapland. *Bulletin de la Commission géologique de Finlande 232*, 98 p.

Refining the timing of Elsterian and Saalian ice advances into northern Central Europe

Niklas von Soest[a], Neda Rahimzadeh[b], Debra Colarossi[c], Falko Malis[d,a], Tobias Lauer[e], Yvonne Spychala[f], Christian Brandes[a], Runa Fälber[a], Sumiko Tsukamoto[b,e] and Jutta Winsemann[a]

[a]Institute of Earth System Sciences, Leibniz Universität Hannover, Hannover, Germany, von-soest@geowi.uni-hannover.de;
[b]LIAG Institute for Applied Geophysics (LIAG), Hannover, Germany;
[c]Department of Geography and Earth Sciences, Aberystwyth University, Aberystwyth, Wales;
[d]LBEG, State Authority of Mining, Energy and Geology, Hannover, Germany;
[e]Department of Geosciences, Eberhard Karls Universität Tübingen, Tübingen, Germany;
[f]Geological Institute, RWTH Aachen University, Aachen, Germany

The timing, number and extent of Elsterian and Saalian ice advances into northern Central Europe are still a matter of debate. In this study, we summarize the current state of knowledge on the age of the Middle Pleistocene ice advances and provide new luminescence ages of meltwater deposits.

25 samples for luminescence dating were taken from five different Saalian ice-marginal positions and Elsterian tunnel-valley fills in northern Germany. Ice-marginal sediments are commonly transported in a highly dynamic setting and such sediments may have been insufficiently bleached. Therefore, both multiple- and single-grain luminescene dating of feldspar minerals were performed for all samples. To obtain a non-fading signal, a two-step post-infrared IRSL (pIRIR) protocol with second high-temperature IR stimulation (i.e., 290 and/or 275 °C) was applied.

The sampled Elsterian deposits consist of fine-grained subaqueous fan and delta deposits, which were deposited in glacial lakes and underfilled tunnel valleys during ice-margin retreat. The estimated luminescence ages allow a tentative correlation with MIS 12. However, the samples from the Elsterian tunnel valley fills are commonly not well bleached and partly in saturation, likely caused by erosion of older deposits and subsequent re-deposition.

The sampled Saalian deposits comprise glaciofluvial, glaciolacustrine and glacial-lake outburst flood sediments. The estimated luminescence ages of these deposits imply several ice advances during MIS 8 and MIS 6.

Reference

von Soest, N., Rahimzadeh, N., Calorossi, D., Malis, F., Lauer, T., Spychala, Y., Brandes, C., Fälber, R., Tsukamoto, S., Winsemann, J. (in prep): Refining the timing of Elsterian and Saalian ice-advances into northern Germany: sedimentological analysis and single-grain luminescence dating of glaciotectonic complexes and tunnel-valley fills.

Correlation of permafrost aggradation episodes in the Polish Lowlands and Saxony-Anhalt based on selected sites

Robert J. Sokołowski[a], Henrik Rother[b], Piotr Moska[c] and Paweł Zieliński[d]

[a] Department of Geophysics, Faculty of Oceanography and Geography, University of Gdansk, Poland
[b] State Office for Geology and Mines Saxony-Anhalt (LAGB), Halle, Germany
[c] Institute of Physics, Centre for Science and Education, Silesian University of Technology, Gliwice, Poland
[d] Institute of Earth and Environmental Sciences, Maria Curie-Skłodowska University, Lublin, Poland

The cooling of the climate during the Pleistocene resulted, among other things, in the formation of ice sheets and their transgression into the European Lowlands. However, if we take into account the entire period of glaciation, cool and cold conditions prevailed for most of the time without the presence of ice sheets. These conditions were conducive to the formation of permafrost.

Periglacial structures are widely accepted evidence of the presence of permafrost. These are primarily frost wedges (pseudomorphs after ice wedges and sand wedges), load-cast structures, and polygonal grounds. Their frequency and size indirectly reflect the duration and degree of climate cooling. Their presence has been confirmed in many places in the Polish part of the European Lowlands and in typical outcrops in Saxony-Anhalt in Germany.

The age of periglacial structures was mainly based on optically stimulated luminescence dating. The use of this method of age determination made it possible to verify and determine both the time of formation of the host sediments and the age of the structures themselves. Statistical analysis indicates that, at the time of the study, most periglacial structures were formed in the period preceding the transgression of the Scandinavian Ice Sheet during the last (MIS 2) and previous glaciation (MIS 6a). It is worth noting that periglacial structures formed during the early and middle Weichselian (Vistulian) glaciation have been dated. New results from river terraces in Saxony-Anhalt are particularly important. They indicate a younger age (early Weichselian) of both periglacial structures and, in part, host sediments. However, this issue requires further research.

The Kalviai diamicton conundrum: Revisiting the presumed oldest Pleistocene till in the Baltic region (Lithuania)

Michal Šujan[a,b], Albertas Bitinas[a], Rouxian Pan[b], Andrej Chyba[c], Oleksiy Davydov[a], Aldona Damušytė[d], Kishan Aherwar[b] and Barbara Rózsová[b]

[a]Laboratory of Quaternary Research, Nature Research Centre, Vilnius, Lithuania, michal.sujan@gamtc.lt; [b]Department of Geology and Paleontology, Faculty of Natural Sciences, Comenius University Bratislava, Slovakia; [c]Institute of Chemistry, Slovak Academy of Sciences, Bratislava, Slovakia; [d]Lithuania Geological Survey, Vilnius, Lithuania

Knowledge of the temporal and spatial evolution of past ice sheets is essential for understanding the climate system and for generating robust climate predictions. However, information on Early Pleistocene glaciations remains scarce. The Baltic Highlands in Lithuania preserve a valuable archive of up to 250 m-thick Quaternary succession, which includes the Kalviai diamicton near its base (Guobytė and Satkūnas 2011). The sedimentological interpretation of this 2–3 m, locally up to 6.5 m thick sandy loam with only 3–8% gravel content is controversial, as its occurrence is spatially limited and known only from boreholes. Moreover, unlike all overlying, younger tills, it lacks carbonates in the matrix. As the Kalviai diamicton may represent the oldest Pleistocene glaciation in the Baltic region, this study aims to clarify the depositional processes of this stratigraphic unit. 13 specimens of undisturbed core material were collected from Kalviai, with an additional 6 specimens obtained from the overlying Elsterian diamictons for comparison, whose glacial origin is confirmed by correlation with surface exposures. The specimens were impregnated with epoxy resin, polished for meso-scale observations, and thin sections were prepared for micromorphological analysis.

The Elsterian diamicton cores exhibit a massive structure with faint banding. Bands are subhorizontal, inclined up to 20°. The texture is homogeneous, with evidence of microshears and grain-contact crushing. In contrast, the Kalviai diamicton is dominated by plastic deformation structures, such as folds and flame structures. Some include deformed clasts of irregular shape, resembling mud balls. The microstructure also shows features such as boudinage and flame structures. Although some deformation could potentially be attributed to drilling disturbance in the unconsolidated mud, the relatively deep burial depth (90–170 m) would likely have consolidated the sediment. Furthermore, such deformation features are absent in the overlying Elsterian diamicton, suggesting that the structures in the Kalviai unit are primary. Additional support comes from personal observations by co-author A. Bitinas, who reports the undisturbed nature of the cores recovered during drilling. Altogether, the deformation structures observed in the Kalviai diamicton suggest its origin as a cohesive debris flow, rather than as a glacial till (*sensu* Menzies 2022).

The CosmoLith project is caried out under the “New Generation Lithuania” plan (Nr. 10-036-T-0008) financed under the European Union economic recovery and resilience facility NextGenerationEU.

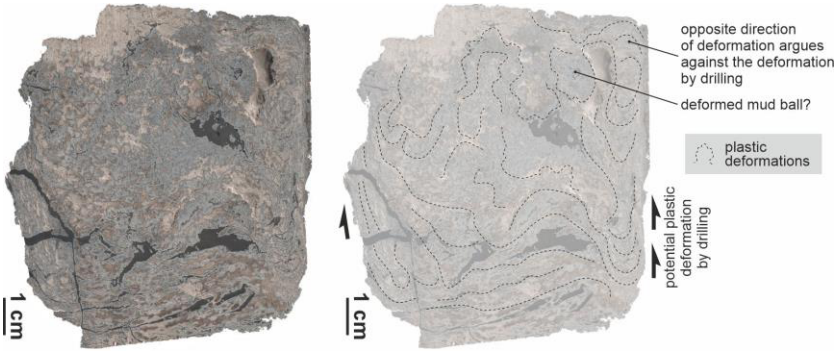

Fig. 1. A Kalviai diamicton well-core example with plastic deformations (well 129, depth 171,7 m). The cross-section is parallel with the core axis.

Refefrences

Guobytė, R., Satkūnas, J., 2011: Pleistocene Glaciations in Lithuania. In: Ehlers, J., Gibbard, P.L., Hughes, P.D., (Eds.), *Developments in Quaternary Sciences* 15, 231–246.

Menzies, J., 2022. Differentiation of diamictons (glacigenic – non-glacigenic) using microstructure abundancies and types. *Proceedings of the Geologists' Association* 133, 603–615.

Tracing the pre-glacial legacy: Evolution of the Daumantai Formation beneath the oldest Quaternary moraines in Lithuania

Michal Šujan[a,b], Albertas Bitinas[a], Holger Steffen[c], Laura Gedminienė[a], Marianna Kováčová[b], Tomáš Vlček[b], Rouxian Pan[b], Andrej Chyba[d], Oleksiy Davydov[a], Aldona Damušytė[e], Jérôme Juilleret[f], Kishan Aherwar[b] and Barbara Rózsová[b]

[a]Laboratory of Quaternary Research, Nature Research Centre, Vilnius, Lithuania, michal.sujan@gamtc.lt;
[b]Department of Geology and Paleontology, Faculty of Natural Sciences, Comenius University Bratislava, Slovakia;
[c]Lantmäteriet, Geodetisk Infrastruktur, Gävle, Sweden;
[d]Institute of Chemistry, Slovak Academy of Sciences, Bratislava, Slovakia;
[e]Lithuania Geological Survey, Vilnius, Lithuania;
[f]Luxembourg Institute of Science and Technology (LIST), Belvaux, Luxembourg

The Daumantai Formation is considered the youngest pre-glacial stratigraphic interval preserved beneath the oldest Pleistocene glacial diamictons in the Baltic Highlands, eastern Lithuania (Bitinas et al. 2015). This study is motivated by the high potential of the Daumantai Fm. to provide valuable insights into the paleoenvironmental evolution preceding the first advance of continental ice sheets to the region. Several outcrops in the Šventoji River valley offer good vertical exposures of the formation, while the Anykščiai quarry allows for detailed sedimentological observations of along-bed variability and spatial stratal stacking patterns.

The lowermost part of the exposed succession comprises a heterolithic interval, including symmetrical ripples and organic mud preserved both as in situ layers and intraclasts. It was deposited in a lacustrine environment, possibly during the Miocene–Pliocene, as suggested by palynological spectra indicating a subtropical climate. The overlying unit consists of cross-stratified very coarse to coarse sands, interpreted as deposits of a perennial river channel. Above the cross-stratified sands lies an overbank horizon composed of stratified to massive sandy mud, showing evidence of soil redeposition and containing frequent charcoal fragments. These fragments also occur in the lower portion of a second cross-stratified sandy unit, again interpreted as fluvial channel deposits. The upper fluvial unit includes frost-related deformation structures. A striking feature is the change in palaeotransport direction, confirmed at several sites: from southeastward in the lower fluvial unit to northwestward above the overbank horizon in the second fluvial unit. The upper fluvial unit is covered by tills.

The potential cause of this major change in the depositional system was further explored using ICEAGE normal-mode modelling software (Kaufmann 2004), which simulates glacial isostatic adjustment. We tested three ice sheet extents: (1) the late Gauss and (2) early Matuyama extents from Batchelor et al. (2019), and (3) an additional, larger ice sheet reaching ~150 km northwest of the study area. A 285,000-year modelled scenario included four glacial cycles of ice growth, deglaciation, and ice-free periods, with 40 kyr and 100 kyr periodicities and increasing magnitude. The modelling results indicate that the forebulges of the two smaller ice sheets induced southeast-trending slopes in the area of the Daumantai Fm., while the largest ice sheet generated a 0.0015° slope tilting toward the northwest. These initial modelling results suggest that the observed paleoenvironmental changes could be linked to lithospheric deformation driven by isostatic adjustment to distant ice loading. Upcoming research aims to validate the potential impact of such topographic tilting on river network reorganization.

The postdoctoral project CosmoLith is caried out under the “New Generation Lithuania” plan (Nr. 10-036-T-0008) financed under the European Union economic recovery and resilience facility instrument NextGenerationEU.

References

Batchelor, C.L., Margold, M., Krapp, M., Murton, D.K., Dalton, A.S., Gibbard, P.L., Stokes, C.R., Murton, J.B., Manica, A., 2019. The configuration of Northern Hemisphere ice sheets through the Quaternary. *Nature Communications* 10, 3713.

Bitinas, A., Katinas, V., Gibbard, P.L., Saarmann, S., Damušytė, A., Rudnickaitė, E., Baltrūnas, V., Satkūnas, J., 2015. The problem of the lower boundary of the Pleistocene in Eastern Lithuania. *Quaternary International* 386, 89–101.

Kaufmann, G., 2004. Program Package ICEAGE, Version 2004. Institut für Geophysik der Universität Göttingen, 40 pp (Manuscript).

Identification and characterisation of buried periglacial polygonal networks in Hungary

Szabolcs, Ákos Fábián[a]

[a]Department of Physical and Environmental Geography, University of Pécs, Pécs, Hungary, fasaaa.t.jpte@pte.hul

Polygonal vegetation and soil patterns, commonly referred to as crop marks, are found in various locations across the lowlands of northwest Hungary. In Central Europe, these buried networks were predominantly formed due to past periglacial processes (Ewertowski et al., 2017). High-resolution satellite imagery and orthophotos from the Lechner Centre (Hungary), along with profiles of both active and abandoned gravel pits, furnish significant insights into the existence of these buried landforms. In addition to analysing existing imagery, drone orthophotos were acquired, and field excavations were performed in the gravel pits to examine the sediments under controlled laboratory conditions. The polygonal networks are typically covered by 0.3 to 0.5 m of Holocene sediments and recent soil, and the V-shaped cracks are filled with poorly sorted, aeolian fine sand (Blott & Pye, 2001). Laser diffraction grain size analysis of 378 samples collected from these polygons reveals that only four samples exhibited moderate sorting, while 28 samples were classified as very poorly sorted. The polygons generally possess a diameter ranging from 15 to 25 meters, exhibit five to seven edges, and have depths from 1.5 to 3 meters, with an average width of approximately 1 meter. According to optically stimulated luminescence measurements (Farkas et al., 2023), these formations were created at the end of the Last Glacial Maximum or during the colder phases of the Greenland Stadial 2.1a-b, approximately 15,000 to 22,000 years ago. These structures likely represent thermal contraction cracks, commonly known as relict sand-wedge polygons, and they are among the southernmost occurrences of the late Pleistocene "permafrost" zone in Europe (Bertran, 2022). The host sediment of these polygonal cracks is an alluvial fan complex with fluvial gravel and sand of the Rába and tributaries, created in the early to middle Pleistocene. The most typical pattern is an irregular non-orthogonal polygon with a relatively small diameter. A comprehensive study of these features provides valuable insights into the surface evolution processes during the late Pleistocene, a period marked by significant climatic transformations.

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References

Bertran, P., 2022: Distribution and characteristics of Pleistocene ground thermal contraction polygons in Europe from satellite images. *Permafrost and Periglacial Process*es *33,* 99–113.

Blott, S.J. and Pye, K. 2001: GRADISTAT: a grain size distribution and statistics package for the analysis of unconsolidated sediments. *Earth Surface Processes and Landforms 26,* 1237–1248.

Ewertowski, M.W., Kijowski, A., Szuman, I., Tomczyk, A.M., and Kasprzak, L., 2017: Low-altitude remote sensing and GIS-based analysis of cropmarks: classification of past thermal-contraction-crack polygons in central western Poland. *Geomorphology 293,* 418–432.

Farkas, B., Sipos, G., Bartyik, T., Józsa, E., Czigány, S., Balogh, R., Varga, G., Kovács, J., & Fábián, S.Á. (2023). Characterization and mapping of MIS-2 thermal contraction crack polygons in Western Transdanubia, Hungary. *Permafrost and Periglacial Processes 34,* 417–427.

Dynamic oscillations of the last palaeo-ice margin on the northern coast of Poland: lesson from landform analysis and ^{10}Be surface exposure dating

Karol Tylmann[a], Damian Moskalewicz[a], Vincent Rinterknecht[b], Piotr P. Woźniak[a], Aleksandra Bielicka-Giełdoń[c] and ASTER Team[b]

[a]Department of Geomorphology and Quaternary Geology, University of Gdańsk, Poland, k.tylmann@ug.edu.pl;
[b]Aix Marseille University, CNRS, IRD, INRAE, CEREGE, France;
[c]Department of General and Inorganic Chemistry, University of Gdańsk, Poland

This study presents newly acquired data on glacial landforms, derived from high-resolution Digital Elevation Model (DEM) analysis and ^{10}Be surface exposure dating of erratic boulders, conducted in northern Poland. The objective was to reconstruct the main positions of the ice margin and determine the timing of ice margin fluctuations during the final phase of deglaciation. A total of 715 glacial landforms were mapped, comprising 274 moraine ridges, 68 subglacial lineations, 74 overridden moraines, 52 eskers, 169 kames, 14 hummocky moraine zones, 47 subglacial valleys, 5 subglacial meltwater corridors (SMCs), and 12 ice-marginal valleys. Surface exposure dating was performed on nine erratic boulders, yielding ^{10}Be ages ranging from 2.2 ± 0.3 ka to 17.8 ± 1.8 ka, with the most consistent results falling between 12.5 ± 1.1 ka and 17.8 ± 1.8 ka. The findings indicate that the ice sheet experienced dynamic behavior marked by episodes of retreats, stagnations, and re-advances. Contrary to earlier interpretations identifying the Gardno moraines as a continuous ice-marginal belt associated with the final Pleistocene re-advance in the Polish Lowland, our results reveal that these features represent varied ice-marginal landsystems. They reflect spatially and temporally discontinuous dynamics of specific ice streams or lobes, with the main ice margin positions dated to approximately 17.5 to 15 ka.

Continuities and discontinuities in the Upper Pleistocene archaeological record of northern Central Europe

Marcel Weiss[a], Andrzej Wiśniewski[b] and Olaf Jöris[c,d]

[a]Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt - Landesmuseum für Vorgeschichte, Halle (Saale), Germany, mweiss@lda.stk.sachsen-anhalt.de;
[b]University of Wrocław, Institute of Achaeology, Wrocław, Poland, andrzej.wisniewski@uwr.edu.pl;
[c]Leibniz-Zentrum für Archäologie, MONREPOS Archaeological Research Centre and Museum for Human Behavioural Evolution, Neuwied, Germany, olaf.joeris@leiza.de;
[d]Institute of Ancient Studies, Johannes Gutenberg University Mainz, Germany.

The Upper Pleistocene archaeological record of the peribaltic region of northern Central Europe – here defined as the area south of the Baltic and north of the main southern-peribaltic watershed, east of the Weser and west of the Bug rivers – is characterized by a highly uneven distribution of sites across time and space. This fragmentary record results to some degree from a combination of changing climatic and environmental conditions which impacted the preservation of sites in relation to strongly changing sedimentation regimes. On the other hand, the discontinuous archaeological record does result from changing demographies showing that human presence in the region was not continuous over lengthy periods of time, and that the region was repeatedly abandoned and void of hominin occupation, followed by periods of often rapid reoccupation (Fig. 1).

The compiled data presented here allows to conclude that Neanderthals expanded equally far north as, later on, Upper Palaeolithic modern humans did. However, early modern human occupation in the Pericbaltic can be traced even during much of MIS 3 which was not as mild as the preceding MIS 5. The coldest phases of the Last Glacial cycle, i.e., MIS 4 and most of MIS 2, appear to have not allowed a sustainable living in the region.

Even though it is highly likely that Early Weichselian Neanderthals expanded much further north, these potential traces have been fully erased by later erosional events in the forefield of the advancing ice shields of the Weichselian. It is not before the Late Palaeolithic (LP) that archaeological sites can be traced all across the northern peribaltic lowlands.

References

Jöris, O., Neruda, P., Wiśniewski, A., & Weiss, M., 2022. The Late and Final Middle Palaeolithic of Central Europe and Its Contributions to the Formation of the Regional Upper Palaeolithic: a Review and a Synthesis. Journal of Paleolithic Archaeology, 5(1), 17. https://doi.org/10.1007/s41982-022-00126-8

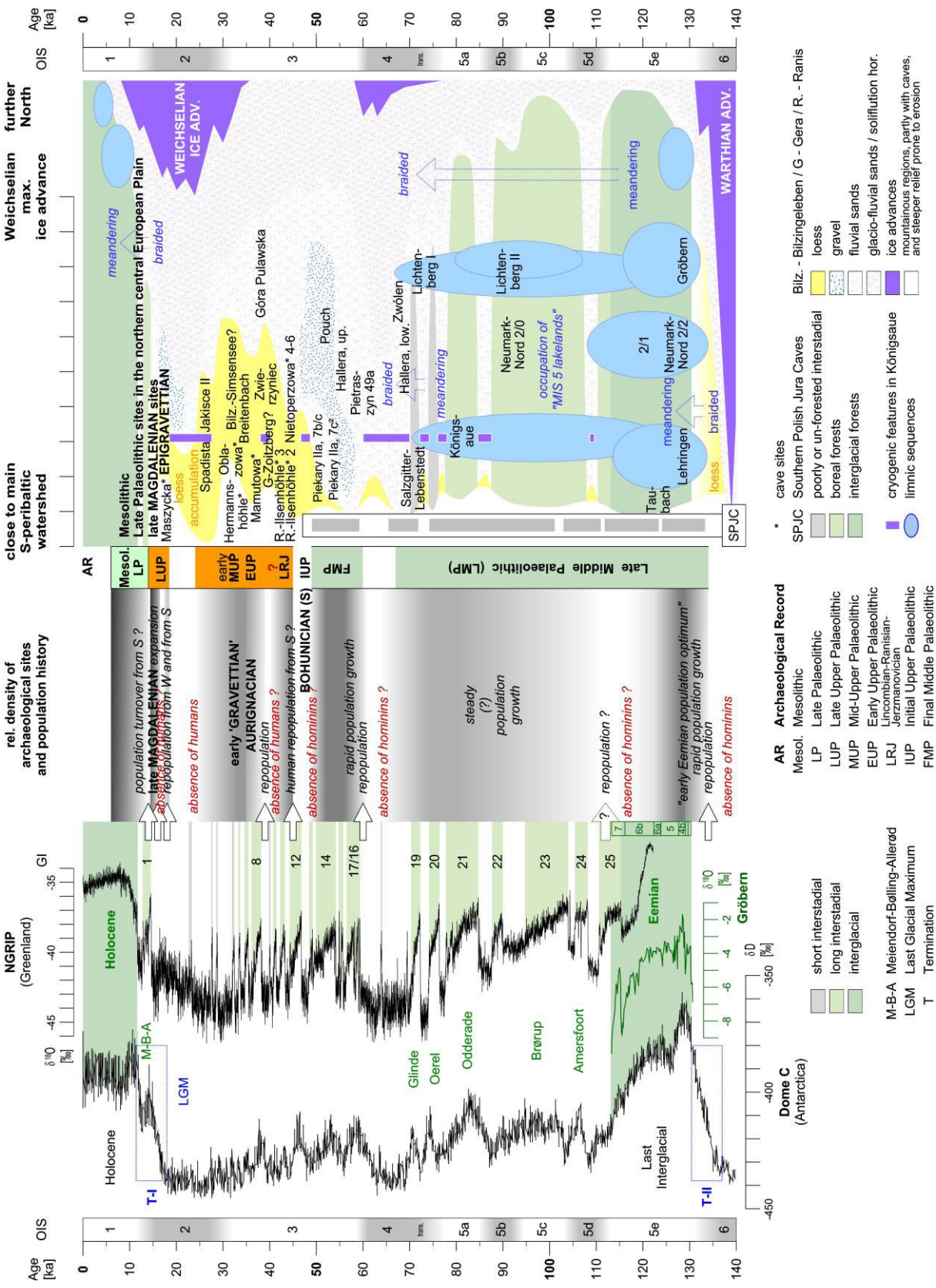


Fig.1. Synthetic and schematic overview of chronostratigraphy of climatic and environmental conditions, sedimentological regimes, the archaeological record and population dynamics.

Soil-development differentiation across a glacial–interglacial cycle, Saalian upland, E Poland

Barbara Woronko[1], Zbigniew Zagórski[2] and Michał Cyglicki[1]

[1]University of Warsaw, Faculty of Geology, Żwirki i Wigury 93, 02–089 Warsaw, Poland
[2]Warsaw University of Life Science, Nowoursynowska 166, 02-787 Warsaw, Poland

Moraine uplands located within the extent of the Saalian ice sheet (MIS 6) in Poland are formed of glacial diamicton and represent relatively flat terrain. These moraines must have undergone a long evolution since their formation (c. 130 ka BP). Gilewska (1991) calls them "periglacial denudation plains", which clearly indicates the important role of periglacial processes in their formation. Periglacial processes operating in the rhythmic glacial–interglacial cycles resulted in the development of polygenetic soils on the surfaces of the moraine plateaus.

An example of such soils are three soil pedons that developed on glacial diamicton at the Koczery site (E Poland). A wide range of analyses of the physical and chemical properties of these soils was performed. The obtained results indicate that the studied profiles represent the Planosol. Three stages of soil development were distinguished, which refer to the environmental changes that took place in the study area. Stage I is correlated with the warm period of the Eemian interglacial, when the development of Luvisol took place. Stage II is associated with the Vistulian glaciation (MIS 2). Processes such as frost weathering, development of sand-wedge casts, formation of aeolian pavement, accumulation of cover sands, and erosion of the upper part of the Eemian soil took place under permafrost conditions. Stage III correlated with a temperate climate of the Holocene.

The pedogenic processes that occurred in the cover sand deposits were followed by the eluviation processes. In such environmental settings, ice wedges constituted the spaces for the vertical migration of water, base components and iron. Reduced permeability of the sediments in the bottommost part of ice wedges favoured the formation of a gleyic horizon. Consequently, ice wedges became the ice-wedge transit corridors.

References

Gilewska, S., 1991. Rzeźba. In: Starkel, L. (Ed.), Geografia Polski. Środowisko przyrodnicze, PWN, Warszawa, pp. 243–288.

Evolutionary model of inland parabolic dunes from the Late Weichselian: Geomorphological and sedimentological records in the central part of European Sand Belt

Paweł Zieliński[a], Michał Łopuch[b], Robert J. Sokołowski[c] Marta Kondracka[d] Przemysław Mroczek[a], Natalia Piotrowska[e], Anna Hrynowiecka[f], Marcin Krawczyk[b], Agnieszka Szymak[e], Jerzy Raczyk[b], Zdzisław Jary[b], Jacek Skurzyński[b], Grzegorz Poręba[e], Konrad Tudyka[e] and Piotr Moska[e]

[a] Institute of Earth and Environmental Sciences, Maria Curie-Skłodowska University, Lublin, Poland, pawel.zielinski@mail.umcs.pl;
[b] Institute of Geography and Regional Development, University of Wrocław, Wrocław, Poland;
[c] Department of Geophysics, Institute of Oceanography, University of Gdansk, Gdynia, Poland;
[d] Institute of Earth Sciences, University of Silesia, Sosnowiec, Poland;
[e] Institute of Physics, Centre for Science and Education, Silesian University of Technology, Gliwice, Poland,
[f] Polish Geological Institute – National Research Institute, Marine Geology Branch, Gdańsk, Poland

Parabolic dunes are the most common aeolian landforms in temperate regions, yet they are also found across almost all climatic zones, from subarctic areas to tropical coastlines. This broad distribution indicates that their formation is not just climate-controlled, but strongly influenced by both local and regional environmental factors. The key controls include wind direction and velocity, the sand supply, the nature of vegetation cover, and moisture conditions — encompassing both air humidity and substrate moisture. Parabolic dunes may originate as primary deflation forms surrounding a deflation basin, or develop secondarily through the transformation of transverse or barchanoid dunes, where the arms become stabilized by vegetation while the dune nose remains active. Under certain conditions, these forms may continue to evolve — becoming fully stabilized, reactivated, eroded, or transformed into other dune types.

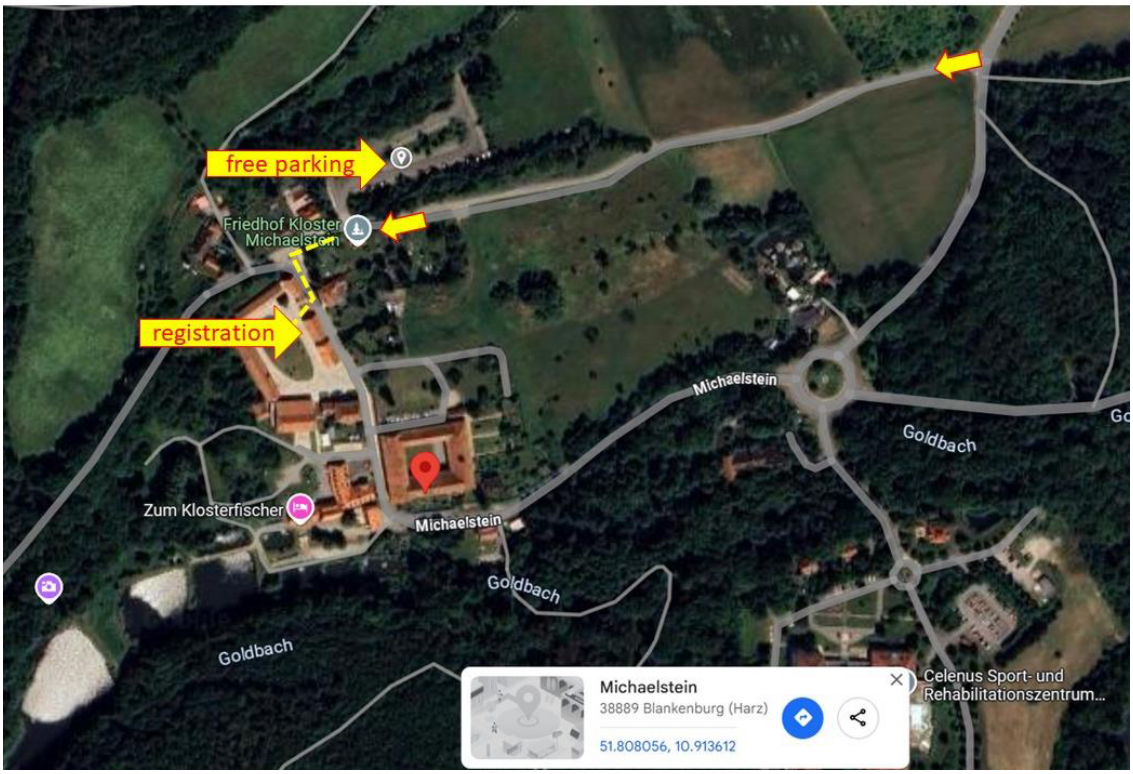
The aim of this study is to present an evolutionary model for parabolic dunes in the central European Sand Belt (ESB) during the Late Weichselian, with particular emphasis on morphological variability and transformation stages in relation to environmental controls. The proposed model is intended as a tool for reconstructing paleoenvironmental conditions in the periglacial zone of the last glaciation.

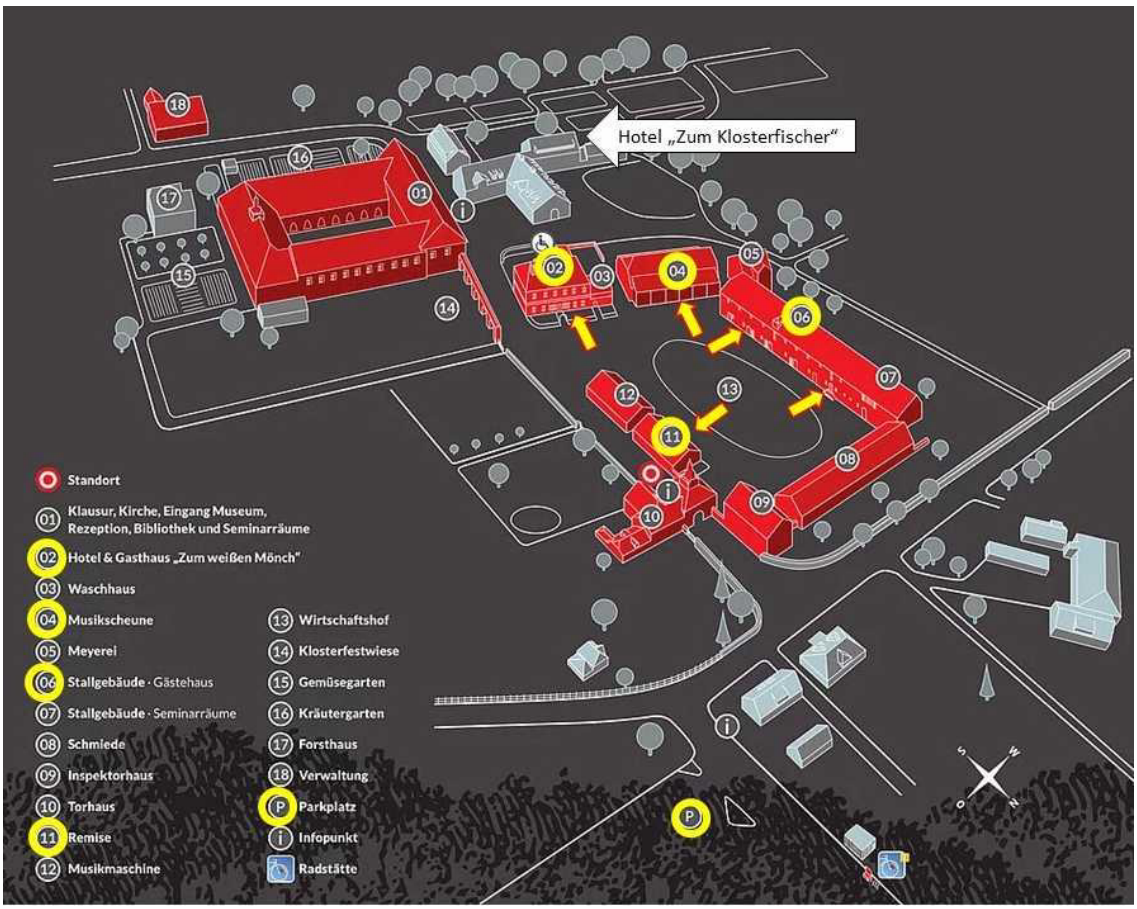
The research includes several sites from the Polish part of the ESB, representing morphologically diverse parabolic dunes, both simple and compound. An integrated methodological approach was used, including: (1) GIS-based analysis of high-resolution, LiDAR-derived elevation models; (2) ground-penetrating radar (GPR) profiling; (3) lithofacial analysis of aeolian sediments and underlying deposits (including measurements of directional sedimentary structures); (4) pedological analysis of buried soils; (5) palynological analysis; (6) basic sedimentological analyses (grain size distribution, morphoscopy, heavy mineral content); and (7) OSL and AMS radiocarbon dating.

The proposed model demonstrates that the development and evolution of parabolic dunes are controlled by the interplay of several key environmental factors: (1) wind regime — specifically unimodal direction and velocity; (2) availability of sand and the proximity of sediment source areas; (3) vegetation dynamics and type, which are themselves controlled by temperature and moisture conditions; and (4) substrate lithology, which determines the hydrogeological regime.

Parabolic dunes therefore serve as sensitive indicators of past environmental conditions, with their morphology and internal structure preserving valuable records of landscape change during the transition from the Pleistocene to the Holocene.

Location maps Michaelstein abbey





#12 = restaurant (breakfast+dinner); # 04 = presentation hall;

#11 = Remise (registration +evening sessions); # 05+06 = accomodation; P = parking zone