

## **1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)**

**Project title: Multiple glacial lake-outburst floods in north-eastern Poland and their contribution to the development of the Biebrza-Narew ice-marginal valley during the last glaciation**

### **1.1. Project goals**

- recognition and typology of landforms indicative of glacial lake-outburst floods (GLOFs) on the Augustów and Kurpie Plains;
- identification of the number of GLOF events, sources of floodwaters and outflow directions;
- quantitative characteristics of floodwater outflow;
- interpretation of depositional environment of sediments forming bedforms evolved due to multiple GLOFs;
- paleogeographic reconstruction of the evolution of the Biebrza-Narew ice-marginal valley and its importance for the development of the European valley system at the decline of the Weichselian glaciation, with particular emphasis on the role of multiple GLOFs in north-eastern Poland, their dynamics and the variable direction of floodwater outflows in the watershed area between western and eastern European valley systems.

### **1.2. Outline**

Recently, the results of geomorphological research in north-eastern Poland indicate the need for a far-reaching verification of views on the development of the initial segment of the European valley system in the context of identifying glacial lake-outburst floods (GLOFs), which significantly fed this system during the last glaciation, reaching discharges up to 2 million m<sup>3</sup>/s (Weckwerth, et al. 2019; 2022, 2024). The significant contribution of GLOFs in forming the European valley system can be recognized through investigations of morphology and sediments of outwash contacting the initial segment of the European valley system, i.e. the Biebrza-Narew ice-marginal valley. Taking these facts into account, the research project assumes (1) identification of the morphology, geological structure and origins of landforms created by the GLOFs on the Kurpie and Augustów Plains, floodwater outflow magnitude, the number of GLOF events and palaeoflow directions, and (2) recognition of the palaeogeography of the watershed zone dividing the western and eastern European valley systems, and the contribution of GLOFs occurring in NE Poland in their evolution during the Weichselian glaciation. This means that the project has supra-regional importance, intending to resolve the role of multiple GLOFs in meltwater distribution towards two major river systems, one of which fed the Bay of Biscay while the second the Nemunas River system. It will also help us understand the processes by which such floods transport and deposit sediments, and the research results will subsequently allow us to determine the possible influence of a sudden massive supply of meltwaters to the Atlantic Ocean, which may have caused changes in the circulation of its waters and on the course of global climate changes.

### **1.3. Work plan**

**Phase 1:** Review of the current knowledge on the geomorphology and geology of the Kurpie and Augustów and Plains and Pleistocene and contemporary GLOFs, preparing digital elevation models based on LIDAR data, collecting geological and geomorphological data collection and determination of test fields. **Phase 2:** geomorphological mapping of GLOF-related landforms and analysis of their geomorphometric parameters; palaeohydraulic calculations; identification of floodwater sources and outflow directions; typology of GLOF-related bedforms using the techniques exploring the naturally occurring groups within a data set; interpretation and publishing the research results. **Phase 3:** geomorphological, sedimentological, geophysical investigations at key sites (e.g., identifying the

sedimentary successions of GLOF-related bedforms and collecting sediment samples for further laboratory analysis; investigations using ground-penetrating radar), laboratory analysis (e.g. grain-size distributions and analysis of particle surface morphology in microscale – manual and automatic); interpretation and publishing the research results. **Phase 4:** synthetic works and qualitative and semi-quantitative analyses of the discharge phases related to multiple GLOFs; processing and synthesising research results to realize the main project goal, which involves the model of ice-marginal valley development and the role of multiple GLOFs in the formation of the European valley system at the decline of the Weichselian glaciation; publishing the research results.

#### **1.4. Literature (max. 10 listed, as a suggestion for a PhD candidate)**

- Baker, V.R., 1973. Paleohydrology and sedimentology of the Lake Missoula flooding in eastern Washington. *Geol. Soc. Am. Spec. Pap.* 144, 1–79.
- Carling, P.A., 2013. Freshwater megaflood sedimentation: What can we learn about generic processes? *Earth-Science Rev.* 125, 87–113.
- Høgaas, F., Longva, O., 2016. Mega deposits and erosive features related to the glacial lake Nedre Glomsjø outburst flood, southeastern Norway. *Quaternary Science Reviews* 151, 273–291.
- Lang, J., Le Heron, D.P., Van den Berg, J.H., Winsemann, J., 2021. Bedforms and sedimentary structures related to supercritical flows in glaciogenic settings. *Sedimentology* 68, 1539–1579.
- Maizels, J., 1997. Jokulhlaup deposits in proglacial areas. *Quaternary Science Reviews* 16, 793–819.
- Russell, A.J., Roberts, M.J., Fay, H., Marren, P.M., Cassidy, N.J., Tweed, F.S., Harris, T., 2006. Icelandic jökulhlaup impacts: Implications for ice-sheet hydrology, sediment transfer and geomorphology. *Geomorphology* 75, 33–64.
- Weckwerth, P., Kalińska, E., Wysota, W., Krawiec, A., Adamczyk, A., Chabowski, M., 2022. What does transverse furrow train in scabland-like topography originate from? The unique records of upper-flow-regime bedforms of a glacial lake-outburst flood in NE Poland. *Quaternary International* 617, 40–58.
- Weckwerth P., Kalińska E., Wysota W., Krawiec A., Alexanderson H., Chabowski M., 2024. Evolutionary model for glacial lake-outburst fans at the ice-sheet front: development of meltwater outlets and origins of bedforms. *Geomorphology* 453: 1-28.
- Weckwerth, P., Wysota, W., Piotrowski, J.A., Adamczyk, A., Krawiec, A., Dąbrowski, M., 2019. Late Weichselian glacier outburst floods in North-Eastern Poland: Landform evidence and palaeohydraulic significance. *Earth-Science Rev.* 194, 216–233.
- Zieliński, T., 1993. *Sandry Polski północno-wschodniej – osady i warunki sedymentacji*. Uniw. Śląski, Katowice, 96.

#### **1.5. Required initial knowledge and skills of the PhD candidate**

The following initial knowledge and skills are required for the proposed project:

- fluvial and glaciogenic landforms development and their sedimentary successions;
- sedimentary processes and their mechanisms;
- experience in geomorphic analysis of landforms using GIS tools and LIDAR data;
- labwork experience in samples preparation, especially in grain-size analysis;
- light microscopy experience in the analysis of shape and surface of sediment particles;
- experience in automated shape particle analysis;
- experience in scientific work (in the field of geomorphology) and writing scientific articles published in journals indexed on Web of Sciences;
- communication skills, experience and ability to work in the research teams.

### **1.6. Expected development of the PhD candidate's knowledge and skills**

The PhD student will gain knowledge in the field of:

- glacial and fluvial geomorphology, especially in terms of processes associated with extreme and catastrophic glacial events in the last European glaciation;
- erosional and accumulation processes of the GLOFs, the scale and duration of their discharge in NE Poland and the origins of meltwaters;
- geology and sedimentology of sediments of bedforms originated from GLOFs,
- the impact of a dramatic influx of large quantities of meltwaters into the Atlantic ocean on global climate changes in the Late Weichselian. Another overarching aspect of the project is that it will investigate the influence of glacial megafloods on the development of the European valley system.

The PhD student will acquire the skills of analytical thinking and also skills related to an innovative methodological approach involving multifactor and semi-quantitative modelling of glaciogenic processes, landforms evolution and sediments deposition, and identifying unambiguous morphological evidence of glacial lake-outburst floods, which has never previously been identified in the European Lowlands. These skills are related to geomorphometric analysis of landforms, palaeohydraulic calculations of palaeoflows, experimenting with a large sampling dataset, lithofacies analysis of sediments and interpreting the results, advanced statistical analyses and quantitative and qualitative assessment of morphogenetic processes.