

Multi-proxy palaeoenvironmental study of the Lipsk archaeological site (north-eastern Poland)

In recent years, interdisciplinary research combining various fields of science has gained increasing importance. By integrating knowledge from biology, chemistry, and archaeology, we can better understand past environments and how humans may have influenced them. These interdisciplinary studies are referred to as archeometric research.

Particularly fascinating are studies conducted in areas where, in addition to archaeological sites, natural archives also exist, such as peatlands. Those ecosystems have a unique ability to preserve traces of the past. Due to their constant water saturation, plant remains are not fully decomposed because of the lack of oxygen, which is necessary for the bacteria that break down organic matter. Since peat layers accumulate over hundreds, even thousands of years, they accumulate valuable paleoenvironmental data in the form of, e.g. **plant fossils** informing of the plants that grew at a given time, and consequently, the climatic, hydrological, and environmental conditions of this time **and fragments of charred wood** serving as combustion traces. Peatlands act as natural archives of environmental data that we can study today to understand how the landscape has changed over hundreds and thousands of years.

However, due to the condition of the peat, sometimes plant remains are not visible or easily recognisable. In such cases, advanced chemical techniques come to the rescue. These methods allow us to extract molecules from the peat that are invisible to the naked eye, chemical traces of the previous environmental states. Groups of such substances (known as markers) form a unique chemical profile of past environmental conditions, revealing information about the climate, water levels, types of vegetation, and even whether fires may have occurred in the area. One of the most commonly used groups of vegetation markers are **n-alkanes**, which are linear organic chemical compounds. The length of such compound is often characteristic of a specific group of plants (e.g., aquatic plants or terrestrial plants), and sometimes even for a particular family (e.g., *Ericaceae*). On the other hand, more complex **Polycyclic Aromatic Hydrocarbons (PAHs)** are used as markers for the combustion process. The ratios between PAHs in a sample allow for the analysis of potential combustion conditions and the sources of burned matter.

Ideal conditions for such research exist in Lipsk, located in north-eastern Poland, where traces of ancient human settlement have been discovered. A particularly large number of archaeological finds at this site are associated with the Neman culture, which inhabited the north-eastern part of Europe between the second half of the 6th millennium to the 2nd millennium BC. The Neman culture combined a traditional hunter-gatherer lifestyle with more advanced elements characteristic of the Neolithic period, such as pottery production. For a long time, it was believed that representatives of this culture had little impact on their surrounding environment. However, this view is increasingly being challenged. Moreover, archaeological investigations conducted last year revealed evidence of Final Palaeolithic settlement in the deeper sediment layers of the site. In light of these archaeological findings, a particularly compelling question emerges: **despite their nomadic way of life, did these prehistoric cultures leave a detectable imprint in the profile of environmental markers preserved within the peat layers?** Drawing on available archaeological knowledge and performing multi-proxy analyses of the chemical and biological composition of nearby peat deposits, **the project aims to investigate vegetation changes and fire frequency in the vicinity of the Lipsk archaeological site.**

The research involves collecting peat cores near the archaeological site, containing all available sediment layers, including those from the Neman culture times. The cores will be divided into smaller segments, which will undergo a series of chemical and biological analyses. The content of selected markers will be examined, both visible to the naked eye (plant fossils and fragments of charred wood), as well as detected using advanced laboratory techniques (n-alkanes and PAHs). Selected samples will be sent for radiocarbon dating to determine their age. This will allow us to reconstruct how the environment surrounding the archaeological site changed over different periods.

The results will provide a better understanding of the history of the unique archaeological site in Lipsk and its surrounding area. We will be able to determine whether, and potentially how, human activity left its imprint on the peat sediments. This offers an opportunity to look into the past, not only through the lens of human influence but also in terms of environmental changes.