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Motorized archaeological geophysical prospection for large infrastructure projects – recent examples from Norway

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Introduction

While rescue archaeological investigations and potential subsequent archaeological excavations in relation to large infrastructure development projects are time- and cost-consuming, they provide valuable archaeological source material that otherwise certainly would be neither known nor available. During the past 20 years, exploration archaeology in Norway on previously untouched arable land has traditionally been carried out using topsoil stripping across large areas. Usually, parallel trenches of ca. 2 m width and a distance between 8-12 m from one to another are used to search for potentially present buried archaeological features, and to initially map these. This traditional approach implies that a hardly satisfying percentage of merely 10–15% of the entire areas concerned are actually investigated archaeologically.

Since 2015, the *Norwegian Institute for Cultural Heritage Research* (NIKU) has been using motorized geophysical prospection at a number of large infrastructure development projects in order to supplement and partially replace the traditional archaeological registration approach. The previous and ongoing research collaboration between NIKU and the Vienna based Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (LBI ArchPro) has led to the gathering of essential experience concerning both the organization and realization of large-scale archaeological prospection projects, as well as the efficient processing and handling of the huge amount of data involved and their subsequent archaeological interpretation.

Archaeological structures have shown a rather complicated detectability in Norwegian geological and sedimentological settings, which often are complicated by the presence of a mixture of unsorted glacial moraines, shallow bedrock, and marine or coastal deposits. Therefore, a good understanding of the environmental settings has shown to be crucial to obtain reliable results. Additionally, present buried prehistoric structures in Norwegian soils are often rather small, weakly expressed and thus difficult to detect (minor postholes, pits, ditches), which complicates the situation and limits the chances to detect associated features in the data, or to confidentially interpret the data images. So far, high-resolution GPR prospection has shown the greatest potential to successfully detect and map buried archaeological remains in the investigated study areas. Admittedly, together with the majority of earlier gained prospection experiences, these stem from only a small part of the country, primarily the region of Vestfold County.

Methods

NIKU is utilizing a motorized 16-channel MALÅ Imaging Radar Array with a crossline channel spacing of 10.5 cm and an inline sampling distance of approximately 5 cm at operational speeds of 7km/h and 40Hz sampling frequency. The system allows for an average daily coverage of ca. 3–4 ha. Data processing is carried out with the LBI ArchPro's in-house developed software package ApRadar, and subsequent archaeological data interpretation is carried within ArcGIS using custom built visualization and interpretation toolboxes and geodatabases.

As the outcome of the archaeological investigations have direct impact and consequences for both follow-up archaeological excavations, or the design and definition of development areas, or changes thereto, the underlying investigation and prospection results need to be highly reliable. Therefore, a strategy for further investigations of areas with somewhat unclear prospection results was developed. In the case of a positive geophysical archaeological prospection response in form of clearly identifiable archaeological structures visible in the data (often in the form of remains of burial mounds or distinct settlement patterns) no further measures are necessary. If potentially relevant features are detected but cannot be clearly identified and interpreted (often individual pits that could have different

Figure 1: NIKUs motorized MALÅ MIRA system applied at Marstein, Møre and Romsdal county, Norway.

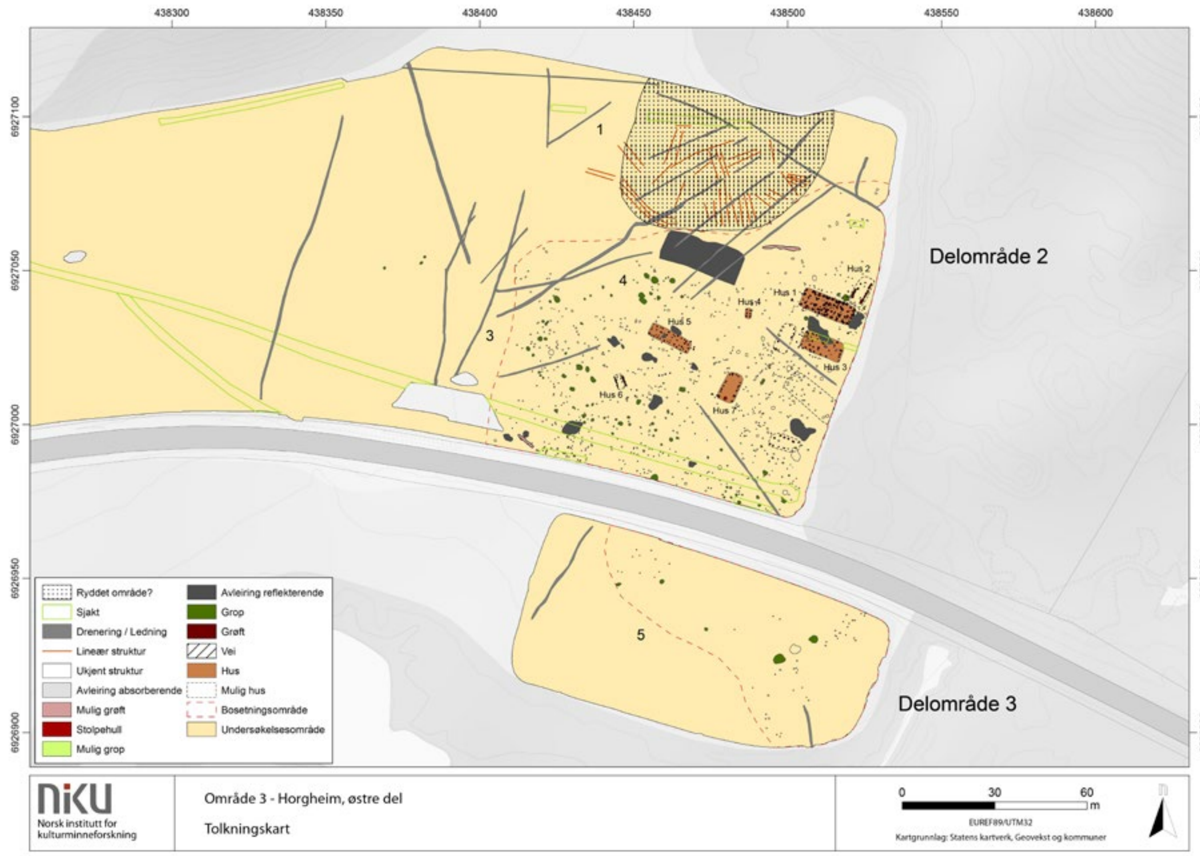

Figure 2: Archaeological interpretation of a detected settlement area at Horgheim, Møre and Romsdal. A large number of single pits and postholes as well as a number of clearly identified three-aisled post building could be detected and mapped.

causes) small, targeted test trenches are used in order to clarify the archaeological relevance of the detected structures. Areas that do not show any archaeological or potentially archaeological features are most difficult to deal with, as the absence might be due to a limited detectability (principle of negative evidence). These areas might be subjected to larger test-trenching in order to reliably determine the presence of absence of archaeological remains.

Large-scale Infrastructure Development Projects

NIKU is currently involved in several large-scale railroad and road development projects taking place throughout Norway. We will present geophysical archaeological prospection results from a new double-track intercity railroad development project underway in Vestfold County, as well as from road construction projects in Rogaland and Møre and Romsdal counties.

The planned development area of the intercity railroad track in Vestfold, which stretches over 24 km and includes over 100 ha of arable land, will be completely investigated using high-resolution GPR surveys. To this day (February 15th 2017) about 55 ha have been surveyed using GPR, while the remaining areas are scheduled to be covered over the course of winter and spring 2017. The project area is situated in the vicinity of previous large-scale prospection projects conducted in the framework of the LBI ArchPros Case Study Vestfold, and the available experience led to the decision with the awarding authority to apply GPR prospection as the main investigation and registration method within this project. Results from the first survey campaign in autumn 2016 resulted in a minor number of actual archaeological findings, which were directly used to refine the planned course of the railroad track in order to avoid costly large-scale archaeological excavations.

GPR prospection in the framework of the highway construction in Rogaland and Møre and Romsdal were carried out as part of a collaboration project conducted together with the Norwegian Public Road Administration. The goal of this project is to evaluate the potential of large-scale GPR prospection for archaeological surveys in other parts of Norway and under different geological and sedimentological settings. The pilot project in Rogaland is situated in a coastal area and its geological background comprises exclusively unsorted moraine material. First results show that the prevailing geology is very much complicating the detectability of archaeological features. Prospection data analysis in combination with corresponding test trenching is ongoing.

In contrast to the rather poor results from Rogaland, the first large-scale prospection datasets generated in Møre and Romsdal County show a large number of clearly identifiable archaeological structures. The survey areas located in the valley of Romsdal are situated on top of sandy, fluvial deposits. A wide range of archaeological features ranging from individual postholes, entire building structures, larger settlement areas, and mound cemeteries could be detected.

Results

The ongoing transition towards a standardized application of geophysical archaeological prospection methods in Norwegian exploration archaeology is facilitated by the earlier standardized use of topsoil stripping as a method for archaeological registrations consequently applied in development projects. High-resolution motorized GPR prospection offers a great potential for time and cost-efficient non-invasive surveys and is therefore well appreciated amongst contractors. Frequently, archaeologists used to the traditional way of archaeological investigations are somewhat more sceptical to the geophysical prospection approach. However, with an increasing number of reliable archaeological results to show for the method, it is gaining increasing acceptance and demand is increasing.

First analysis shows that cost savings of the order of up to 70% can be achieved by the use of geophysical prospection methods compared to systematic topsoil stripping. However, potentially necessary further test trenching is not yet included in this calculation since its extent heavily depends on the outcome of the geophysical prospection.

The actual organization and realization of large-scale geophysical prospection in the framework of large infrastructure projects, usually within a very limited timeframe, has proven to be challenging. A large number of different parties are involved in the process, and a good communication and reporting strategy is essential: local heritage authorities are responsible for fulfilling the obligation for archaeological assessment and investigation of any area affected (§9, Norwegian cultural heritage law). Local or national museums are responsible for follow-up archaeological excavations, and thereby the clearing of the areas. National heritage authorities are responsible for general review and approval of all measures. Furthermore, the interest and priorities of the contracting authorities, independent consultants, and last but not least, a large number of individual land owners need to be considered.

Additionally, a growing interest in further use of the acquired geophysical data, aside of archaeology, was registered. Information about mapped utilities, drainage systems, depth to solid bedrock and old river and creek systems is increasingly requested and can be of direct use in the planning process of infrastructure development projects.