The internal structure of the Galtrim motte, County Meath, as revealed by ground-penetrating radar and electrical resistivity geophysical techniques

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Introduction

A motte is a flat-topped mound built by the Normans following the invasion circa. 1170. Its purpose was defensive, to protect against the local people whose land had been seized. It provided a local elevated vantage point from which the surroundings could be viewed. Mottes are often, though not always, associated with a bailey, an enclosed courtyard area that housed animals and soldiers. There are about 50 such mottes in County Meath with approximately 35 per cent being associated with baileys. Today most mottes in County Meath are grassed over and little information can be obtained about their internal structure. Were they constructed with a core of boulders at their centre, onto which soil was packed, or are they composed mainly of soil, or was a ring of stones first constructed around their base? Archaeological excavations can answer these questions but in the process the motte itself would be destroyed. In this study, two non-invasive, non-destructive geophysical techniques were employed, resistivity and ground-penetrating radar, in order to obtain information about the internal structure of the Galtrim motte.

The Galtrim motte (Irish Grid Reference: 286170 252090) is located 7 kilometres SE of Trim at the junction of three roads, Fig. 1. It is built on the Galtrim moraine. The moraines in County Meath are generally aligned NE-SW and record the position of a temporarily stabilised ice margin during the Quaternary.[1] The moraine at Galtrim consists of a sinuous ridge of cobbles, boulders and sand which in places is up to 5 metres high. The motte is slightly elliptical in shape and trends NW-SE. It was built on top of the moraine and thus stands approximately 8 metres higher than the surrounding fields.

Figure 1. Location map of Galtrim motte and location of survey lines.

Geophysical techniques

Geophysical techniques allow us to image the subsurface using a non-invasive, non-destructive approach. Various techniques exist, two of which are employed in this study: ground-penetrating radar (GPR) and resistivity.

Ground-penetrating radar (GPR) is an electromagnetic geophysical technique which can, under certain circumstances, provide a very detailed image of the subsurface. In essence, GPR consists of transmitting electromagnetic pulses into the ground and measuring the signals that are reflected back from subsurface interfaces or bodies and the times at which these signals are acquired at the receiver. The GPR data were collected with a Sensors & Software pulseEKKO 100 system operating at a frequency of 200 MHz. A high voltage electrical pulse is sent from the control console

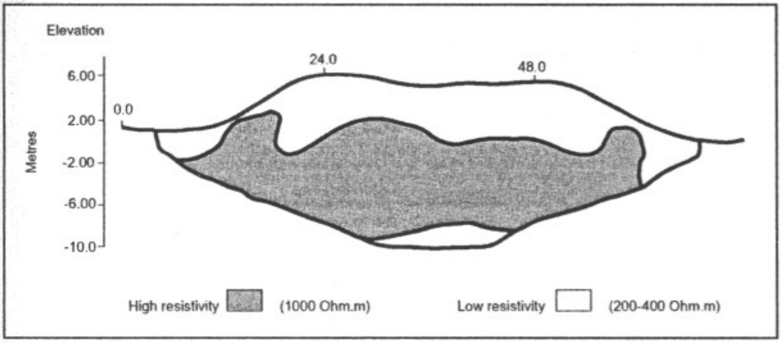

Figure 2. Resistivity traverse line 1.

to the transmitter by means of fibre optic cable, and the pulse is injected into the ground via the transmitter antenna which has a designated central operating frequency of 200 MHz. As the input energy wave travels down it encounters discontinuities in the subsurface such as changes in rock type, water content or grain size and a fraction of the input energy is reflected back towards the surface. The receiver records the reflected signal and the results are shown on a display. The data are stored digitally on a computer which also contains the software programs used to control the collection of the data and also the processing of the radar data.

The resistivity of a substance is effectively a measure of how easy (or difficult) it is to pass an electric current through it. It depends to a large extent on the amount of water present and the porosity and permeability of the subsurface. Rocks like limestone typically have resistivity values of > 2000 ohm m whereas wet soils are generally less than about 100 ohm m.

The resistivity data were collected using Campus Geopulse 2D electrical imaging equipment. Two dimensional electrical imaging allows the acquisition of apparent resistivity variations in both the vertical and horizontal directions. Electrical imaging was undertaken using an insulated multi-core cable with a number of fixed interval take-off points to which electrodes are connected. The cable is connected to the resistivity meter which in turn is connected to a laptop computer which contains the relevant software to run the process. In order to determine how the true resistivity varies with depth the data were modelled using the inversion program RES2DINV.

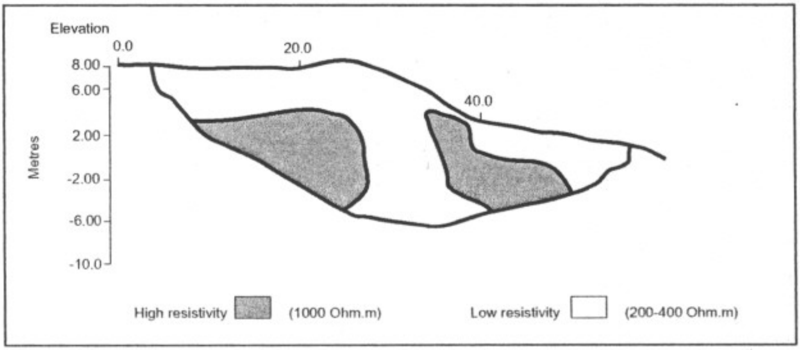

Figure 3. Resistivity traverse line 2.

Resistivity results

A number of electrical resistivity images were obtained for the Galtrim motte – see Fig. 1 for location. The simplified results of these electrical resistivity surveys are shown in Figures 2 and 3. The NW-SE traverse illustrates two distinct zones of resistivity, an upper one with low resistivity values and a lower one of high resistivity values. Similar results were obtained on the second resistivity traverse taken on a NE-SW trend, Fig. 3. The lower zone is associated with resistivity values of around 1000 ohm m and are typical values for the rock-cored moraine.[2] However, the lower value for the motte, circa 200 ohm m, is typical for soil and earth. Thus the resistivity data indicate that the motte, although situated on the moraine, is not formed of morainic material but has been constructed from fine-grained soil. Other traverses on top of the motte again indicate that it is formed mainly of earth though the presence of a few stones cannot be discounted. Interestingly, both traverses indicate the existence of high resistivity material at the base of the flanks of the motte (at 12-15 m and 57-60 m on Fig. 2 and at 36-39 m on Fig. 3). This suggests that the motte may have been built by first constructing an annular ring of stones, boulders and packed earth (high resistivity) about a metre high to form a retaining wall for the earth from which the motte was mainly constructed. Detailed shallow resistivity surveying indicates high values of resistivity in a small area on the eastern side of the motte which may indicate the subsurface presence of a structure.

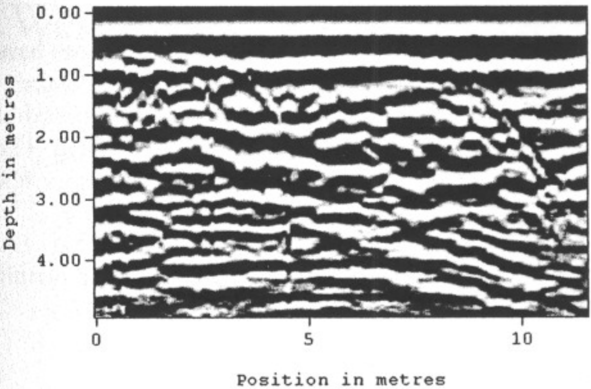

Figure 4.
Radar line 4.

Ground-penetrating radar results

Two radar traverses were taken on the motte (see Fig. 1 for locations). The results are shown in Figs. 4 and 5. Radar data indicate that the subsurface of the motte is composed in the main of undulatory reflectors. Large stones and boulders act as point sources on radar images and consequently produce hyperbolic inverted U responses.[3] These are mainly absent from the profiles (one can be observed at 12 m on Fig. 5). Radar images of the glacial Galtrim moraine are different from the motte and they yield noisy data because of extensive signal scattering and the overlapping of numerous hyperbolae. At one location the reflectors on Fig. 5 (in the 15-22 m range) are quite chaotic and differ from others on the radar profiles suggesting that this area has been disturbed.

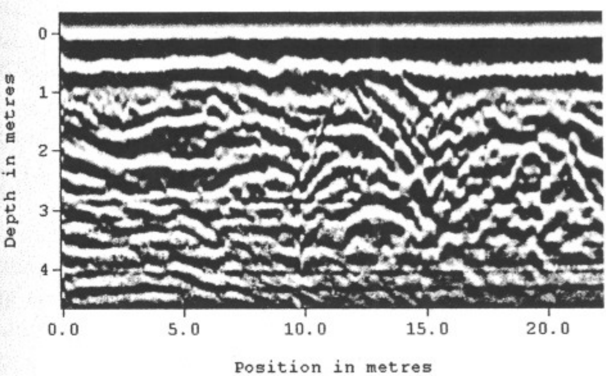

Figure 5.
Radar line 5.

Conclusions

Resistivity and ground-penetrating radar geophysical techniques have provided useful information on the internal structure of the Galtrim motte. The resistivity data show that the motte is not composed of the same material as the glacial moraine on which it is situated. The data suggest that the motte is formed mainly of soil with very few large stones except possibly in an annular ring around its base. The ground-penetrating radar profiles support the view that the composition of the motte is unlike the moraine. It is formed mainly of sub-horizontal compacted soil layers.

REFERENCES

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3. Gibson, P. J. and George, D. M. 2004. *Environmental applications of geophysical surveying techniques*. Nova Science Publishers, Inc., New York. ISBN 1-59033-782-4.