# Recent geophysical investigations and LiDAR analysis at the Hill of Slane, Co. Meath

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*The Hill of Slane Archaeological Project (HoSAP)*

## Introduction

This paper details preliminary geophysical investigations undertaken at the motte or mound on the Hill of Slane as part of the wider Hill of Slane Archaeological Project (HoSAP). Archaeological investigation of the site has been identified as a research objective under the Brú na Bóinne World Heritage Site Research Framework (Smyth *et al*. 2009) and has the potential to contribute to academic knowledge and to enhance the hilltop as an amenity for locals and tourists.

The Hill of Slane is an important complex of prehistoric, early medieval and medieval monuments in the townland of Slanecastle Demesne, 500m northwest of the village of Slane. It is strategically located overlooking a key fording point of the River Boyne. It dominates this part of Co. Meath and is visible over a wide area. It is noted for its panoramic views of the surrounding landscape with the Hill of Tara and Skryne visible to the south. The hilltop rises to 158m OD, and its bedrock is comprised of potentially magnetic volcanic

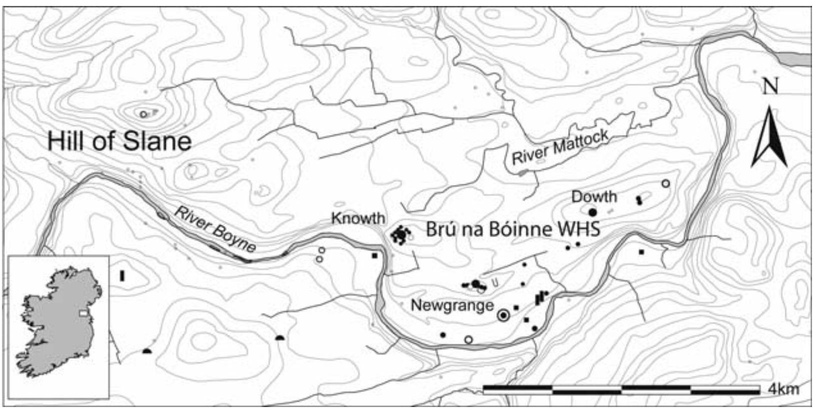


Figure 1: Location of the Hill of Slane.

rocks consisting of bedded felsic tuffs and silt/mudstones intruded by lamprophyre dykes (B. McConnell, Geological Survey of Ireland, 2011, pers comm). The hill lies 3km from the edge of the Brú na Bóinne World Heritage Site buffer zone and both Knowth and Newgrange are visible from the eastern flank of the hill (Figure 1) (see Seaver and Brady 2011).

Physical remains on the site itself include the ruined medieval parish church dedicated to St. Patrick, which is surrounded by a graveyard that is still in use today (Figure 2). Manning has proposed a possible eleventh century date for an early phase of stonework in the north wall of the church (Manning 2008). One of the features within the graveyard is an early medieval gable-shaped shrine. This may date from the seventh century AD and indicates a funerary tradition spanning some 1500 years. It is likely that this was part of the original monastery. The death of Bishop Erc of Ferta fer Feig was recorded in 512 AD (AFM 512). Whether or not this was one and the same place as Slane, the relics of Erc mac Dego were venerated in Slane in the seventh century (Picard 1991, 42). It became the principal church of Northern Brega as well as an important legal centre (Byrne and Francis 1994, 14). It had important national and international connections, with the abbot controlling other monasteries including Louth and northern France by the eighth century (Picard 1991, 45). Ninth or tenth century high cross fragments were discovered in the church fabric while historical references note a round tower and oratory (Harbison 1998, 171; AFM 948, 1028). It remained a significant church site into the twelfth century and therefore a key target for Anglo-Norman settlement (Bhreathnach 1999, 7).

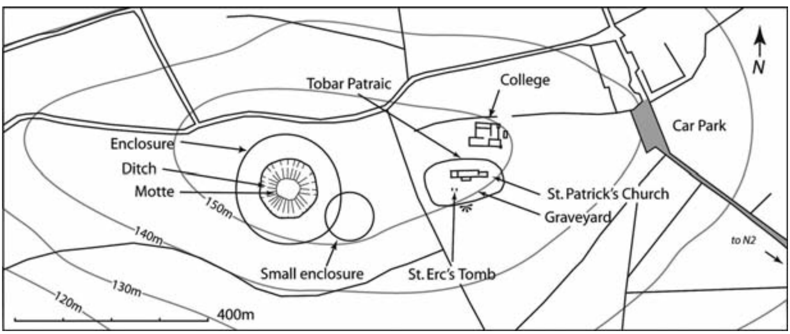


Figure 2: Location of monuments on the Hill of Slane.

To the north of the church and graveyard is the ruin of a building known as the College. This is often mistakenly reported as a friary. This is a multi-period structure the earliest phase of which appears to be a tower house which is referred to as 'the Rectory' in post medieval sources (Cogan 1862-4, i, 286). This was added to in the later fifteenth century to create a chantry college with a claustral arrangement of three ranges of buildings set around an open rectangular cloister. This was rebuilt in the sixteenth century following a bequest by Christopher Fleming for twelve clergy supported by rents of property and houses (Griffiths 1991, 242-243). Rather than being run by religious houses they were established and run by the parish church. An outer gate standing to the east provided access to the complex.

## The Motte

The focus of the work described here was on the mound located at the western end of the Hill of Slane complex (Figure 2). This is classified as a motte in the archaeological inventory of County Meath and Urban Survey (Moore 1987; Bradley 1984). These features were built in some numbers in the late twelfth century by the Anglo-Normans as earth and timber castles and many became manorial centres and lordly residences. Although a very impressive feature measuring *c*.7m high above surrounding ground level and with a diameter of *c*.45m at the base, few of the many visitors to the site realise that it exists as it is located on private land. It is also hidden by a dense covering of mature trees and is completely invisible from all but a short distance away. The monument is flat-topped and the summit has a diameter of 20m north-south by 23m east-west. There is low stone walling a few courses high evident on the edge of the summit, especially along the north side. The monument is surrounded by a ditch, 4m to 5m wide and 2m deep which is rock-cut in places, particularly on the south eastern side. Herity has compared this motte to several other large mounds such as that at Rathcroghan, given its proximity to adjacent possible ring-barrows and has suggested that it may be a significant early ritual centre (Herity 1993).

An unusual feature of the motte on the Hill of Slane is that it is located centrally within a circular enclosure *c*.120m in diameter (Figure 2; Plate 1). Although motte castles often had baileys in the form of earthwork enclosures or timber palisades, these were normally attached to the base of the motte. An example built by the Flemings can be seen at Drumconrath (Seaver 2005, 94). The enclosure on the Hill of Slane takes the form of an inner bank up to 1.5m high with an outer ditch maybe 60cm deep, although undoubtedly deeper when originally cut. Along the northern side of the enclosure, its form is different and its topographical expression is as a 'step' feature terraced into the natural slope. The line of the enclosure is most indistinct along its eastern side where there appears to be a series of low earthworks. To the southeast of the motte a smaller circular enclosure *c.*25-30m in diameter is overlain by the large enclosure surrounding the motte. This indicates a clear relationship between the two features with the small enclosure being earlier in date than the large enclosure. It has been suggested that this may be a barrow (Herity 1993).

## Historical references to the motte castle

Although Muirchú and Tíreachán, St Patrick's hagiographers, describe the lighting of the Paschal Fire at *Fertae Fer Feicc* (the Grave Mound of the Men of Feicc), it is unclear that this was on the Hill of Slane (Swift 1996). Early medieval mounds, churches and forts were, however, often connected with legal centres or places of judgement (ibid) and just such a tradition is connected with the mound at Slane.

The earliest reference to a mound which is definitely at Slane is a reference to the feature called *Dumha Sláine* in the metrical Dindsenchas. In a twelfth-century poem in this source we are told that Sláine, a king and judge of the Fir Bolg, died and was buried on *Druim Fuar* in a great mound called *Dumha Sláine* (CELT 2005, Poem 77). This story links the mound to themes of kingship and judgement.

The Barony of Slane was granted by Hugh de Lacy to Richard le Fleming who established a centre there at *Dumhach Sláine*, and also set up a centre at Knowth. We know from *The Song of Dermot and the Earl* that this was a motte: '*Un mote fist cil jeter*' (Mullally 2002, 134-135). A number of annalistic sources mention that a castle was constructed at *Dumhach Sláine*. This was destroyed in 1176 by Maol Sheachlainn Ó Lochlainn, king of Cinéal Eóghain with the reported deaths of five hundred people (ÓhInnse 1947, 63; AFM, 1176). This has sometimes been taken to refer to Knowth, where an Anglo-Norman fortification was excavated although a separate reference in 1176 clearly refers to a castle at *Cnogba* or Knowth (Kenny 2008, 137).

All barony centres in the medieval Liberty of Meath contained an earthwork castle, a church and in many cases a borough. Slane is unlikely to have differed and as in many other cases, this may have been built over a complex monument which may have prehistoric origins (Seaver 2005). It seems most likely that the location of le Fleming's motte and the *Dumhach Sláine* are on the Hill of Slane. The word *Dumhach* itself is usually employed to refer to a burial mound. The parish church was built on the location of the ecclesiastical site and while a later stone medieval castle was built on the riverside on the location of the present Slane Castle, it is highly likely that the initial fortification was built at this strategic and politically significant site. It is interesting that le Fleming followed a deliberate strategy in the construction of his stronghold at Knowth in appropriating an existing mound and modifying it. The reference to the *Dumhach Sláine* suggests that he may have followed the same strategy for the construction of his centre at Slane.

Thus, it seems certain that the first castle at Slane, le Fleming's motte, was built overlying an important prehistoric site close to the medieval parish church.

## Research question

Although the mound on the Hill of Slane appears in its present form to conform to the morphology of an Anglo-Norman earth and timber motte castle, as discussed above, a number of factors suggest that it may incorporate an earlier prehistoric burial mound. Given the proximity of the hill to the Brú na Bóinne passage tomb cemetery, it is possible that the *Dumhach Sláine* might have been a passage tomb. The Hill of Slane is a very prominent landmark and provides a similar location to many prominently located passage tomb sites outside Brú na Bóinne. The initial aim of the HoSAP was to investigate this possibility using non-invasive methods. The techniques most suited to addressing this question in this case were Electrical Resistivity Tomography (ERT), earth resistance and topographic survey. This strategy has proved to be highly effective in examining the internal structure and evolution of the large mound at Rathcroghan (Waddell *et al*. 2009).

## Fieldwork

In August 2010, the overall site was being used for pasture with the area immediately surrounding the mound and its inner and outer ditches vegetated with bushes and mature trees. The outer edge of the inner ditch was largely obscured by bushes and the flanks

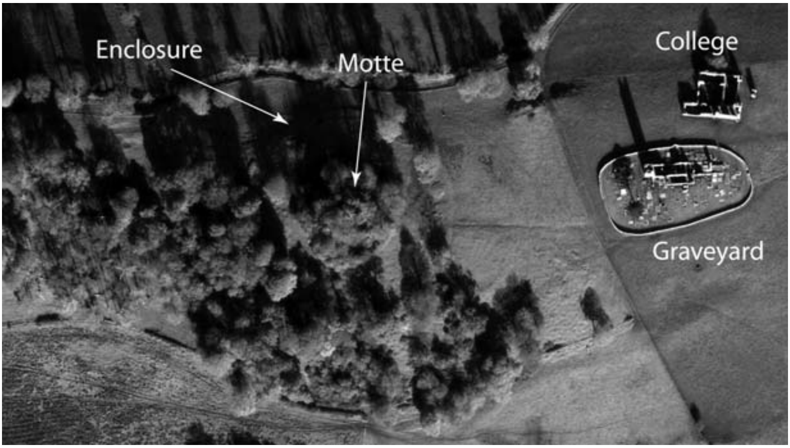


Plate 1: Aerial photograph of the Hill of Slane (OSi).

of the mound had a heavy growth of vegetation (Plate 1). The summit of the mound was covered in light scrub with a number of mature trees.

A reconnaissance survey using a differential global positioning system (dGPS) was carried out to make an outline map of the motte, motte summit and inner ditch. The ditch could not be surveyed due to the vegetation cover causing loss of the dGPS signal. The outer edge of the ditch defined by bushes was mapped where a dGPS signal could be obtained.

## Geophysical surveys

*Earth resistance survey*

The survey was carried out with a TRS/CIA 0.5m twin-probe array on a 0.5m x 0.5m grid. The estimated depth of investigation is 0.5m. The approximate 20m x 20m survey area was difficult to survey with light scrub and mature trees. The rough nature of the terrain has introduced some spurious 'noise' into the data.

There is a relatively large range in the resistance values measured reflecting the nature of the terrain and obstacles such as tree roots. The data have been clipped to between 215 and 600 Ohms to remove extreme values. After clipping there is an overall coherent image that can be interpreted in terms of possible sub-surface features. The data and the main features recognised are shown in Figure 3A.

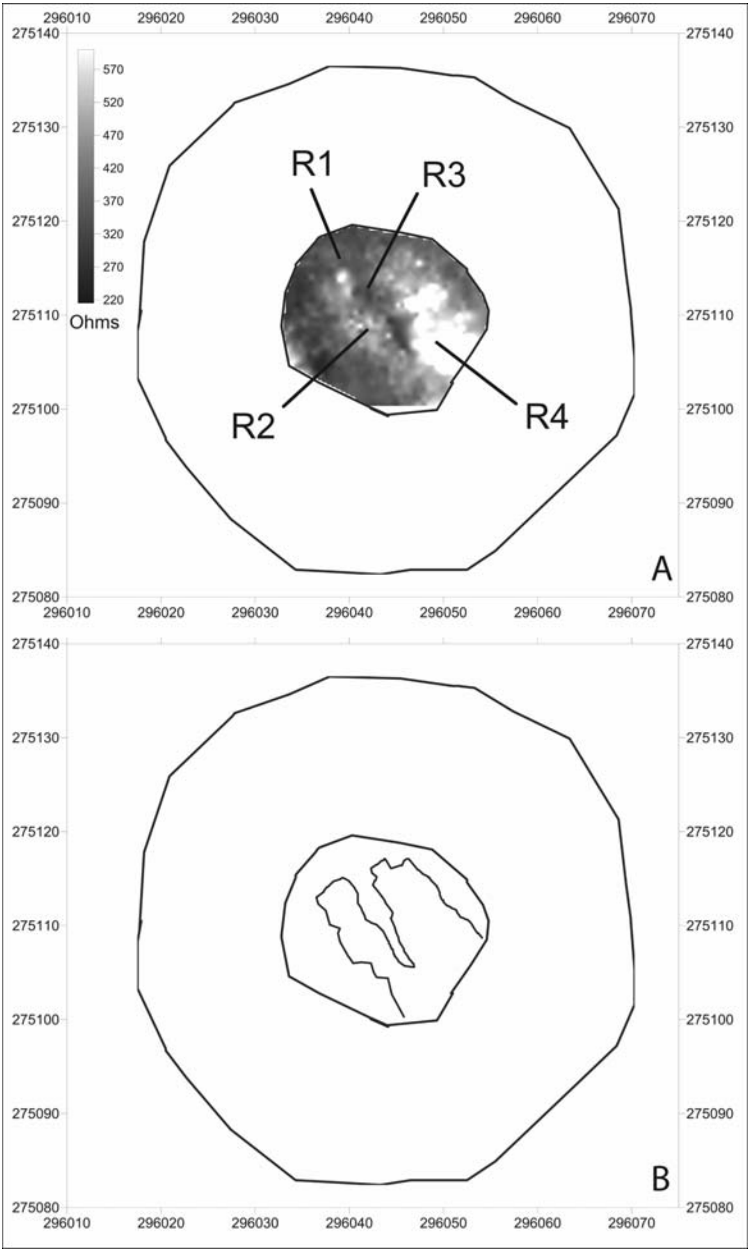


Figure 3: Earth resistance data on the motte summit with main interpreted features(A); schematic diagram of main earth resistance feature (B)

There are four main features seen in the data: R1 indicates the low resistance clays which are found on the periphery of the summit. R2 is a higher resistance 'limb' some 4m wide and 17m long which could be drier or stonier ground. R3 is a distinct, 2m wide zone of low resistance to the northeast of R2. This could be clay or wetter ground. R4 is a wider 'limb' of higher resistance some 5.5m wide and approx 17m long lying to the northeast of R2 and R3. This has a much higher resistance than R2 and may represent more rocky ground, especially at its southeast end at the edge of the summit.

Figure 3B gives the approximate outline of features R2, R3 and R4 which describe the footprint of an overall high resistance feature cut by a narrow low resistance zone. The higher resistance 'limbs' described above could be straight or curving. If they are straight they could form a stone or rocky foundation or a platform measuring approximately 11.5m x 17m. If they are curving they may represent the remnants or footprint of a cairn.

The southeastern corner of the feature has a much higher resistance which might indicate more stone or rock in this area. The function of the narrow resistance zone is uncertain in the case of a rectangular foundation or platform. It should be noted that the ground in part of this narrow zone has been dug out in recent times. In the case of a possible footprint of a cairn, the narrow low resistance zone perhaps could be an entrance or passage aligned northwest-southeast. It is interesting to note that if the overall feature is circular in nature, it is situated centrally on the summit.

*Electrical resistivity tomography (ERT) survey*

The survey was carried out using a Campus Geopulse Resistance meter controlled by software running on a laptop computer. An Imager cable with 25 takeouts was connected to the resistance meter. The cable was arranged in a Wenner array with a 3m electrode separation. This was specified in order to investigate the internal area of the core and base of the mound from the summit through 8m of overlying material. The software controlled the data acquisition which enabled data to be collected to six levels equating to a modelled depth of 9m. Four sections were surveyed across the motte and its surrounding ditch, the locations of which are indicated in Figure 4. A total station was used to collect topographic data, referenced to an arbitrary height datum of 100m, at 1m intervals along each ERT section.

Each ERT section was modelled using the RES2DINV software package (Loke 2011; Loke and Barker 1996) to produce a pseudosection with draped topography. There is an x2 vertical exaggeration on each modelled section. The spaceform and severe topography has introduced distortion to varying degrees in the modelled sections but the general resistivity variation and distribution is valid. The RMS (Root Mean Square) error indicated on each modelled section is a measure of the goodness of fit of the model to the field data. The RMS error is the result of a statistical analysis and displays the distribution of the percentage difference between the measured field data and calculated apparent resistivity values in the modelled pseudosection. Values less than 5 being good, 5 to 10 generally being acceptable and greater than 10 being marginal.

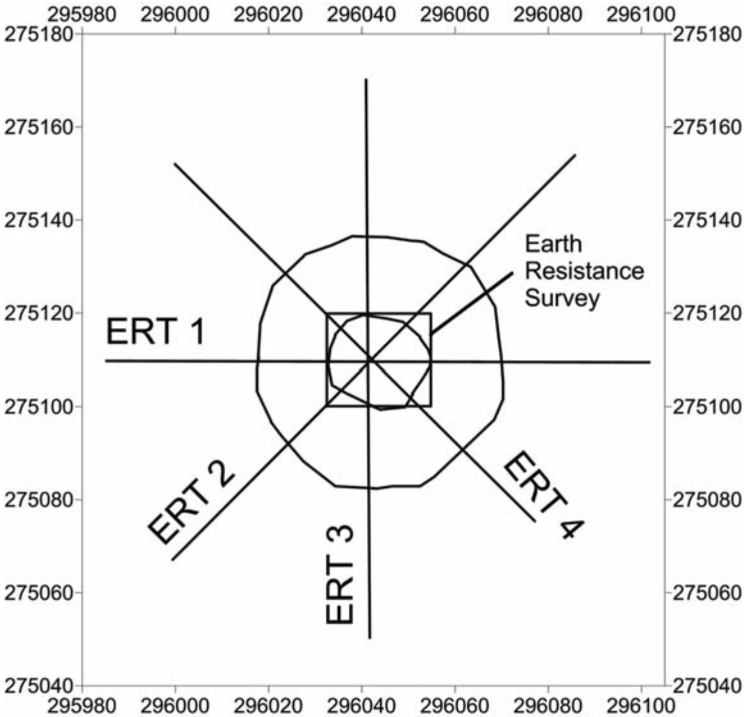


Figure 4: Outline of the outer edge of the inner ditch and flat summit of the motte based on dGPS reconnaissance mapping and the location of the earth resistance and ERT surveys.

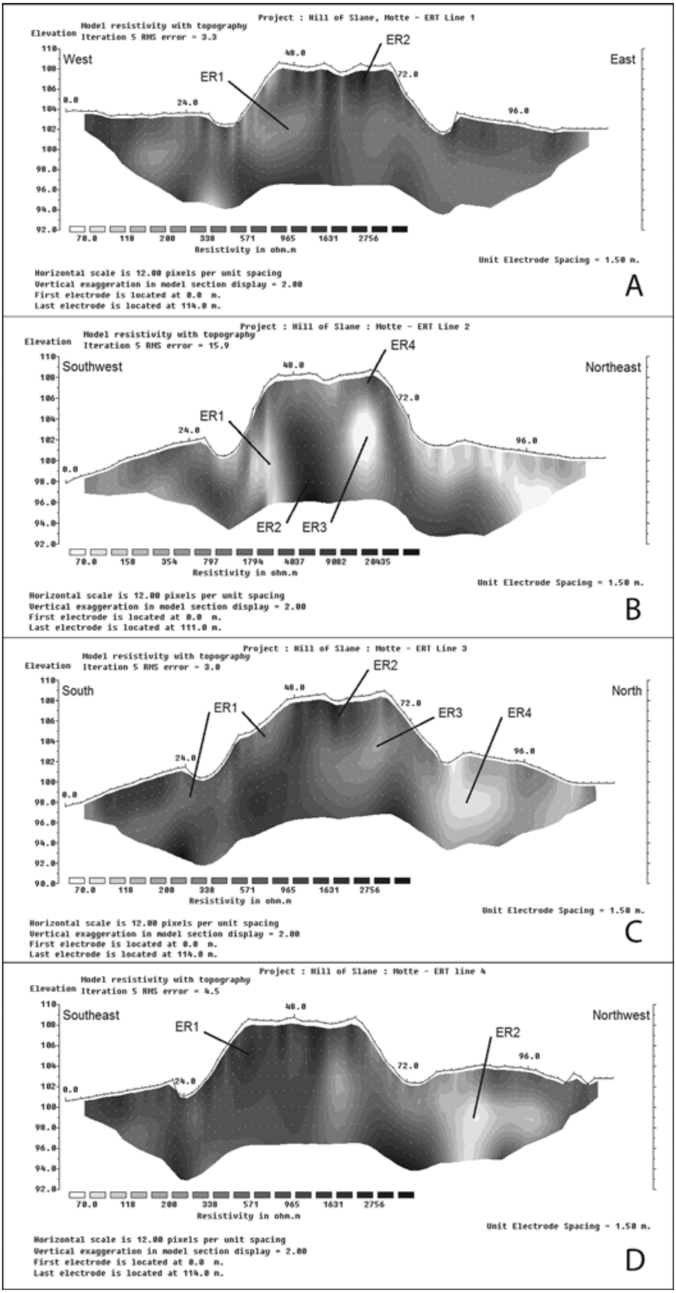


Figure 5: Modelled pseudosection for ERT 1 with indicated main features (A); modelled pseudosection for ERT 2 with indicated main features (B); modelled pseudosection for ERT 3 with indicated main features (C); modelled pseudosection for ERT 4 with indicated main features (D).

The modelled pseudosection for ERT 1 with indicated main features is shown in Figure 5A. ER1 shows a zone of the western sector of the motte to have predominantly low resistivity, likely due to clay. ER2 shows higher resistivity generally to east of the summit with a modelled thickness of perhaps 3m. This correlates with the higher earth resistance measurements from the summit (Figure 3A) which have been interpreted to be due to a stony and/or rocky sub-surface.

The modelled pseudosection for ERT 2 with indicated main features is shown in Figure 5B. This pseudosection has severe topography with near-vertical faces on the motte resulting in a model with high RMS error and distorted resistivity distribution. ER1 shows a thin, low resistivity zone on the southwestern face of the motte, likely due to clay. ER2 is a narrow zone of high resistivity that extends to the 'core' which may be related to bedrock beneath this area of the motte. ER3 shows a zone of low resistivity in the 'core' which may be due to clay. ER4 is a small area of higher resistivity. This correlates with the earth resistance results from the summit (Figure 3A) which have been interpreted to be due to a stony and/or rocky sub-surface.

The modelled pseudosection for ERT 3 with indicated main features is shown in Figure 5C. ER1 indicates lower resistivity areas associated with the ditch and southern face of the motte. ER2 is a higher resistivity zone on the summit. This correlates with the earth resistance results which have been interpreted to be due to a stony and/or rocky sub-surface. ER3 is a lower resistivity zone, likely due to clay, which extends inwards from the northern face of the motte. ER2 may be cut or excavated into this clay zone. ER4 is a significant area of low resistivity to the north of the motte and is likely be due to a substantial clay deposit.

The modelled pseudosection for ERT 4 with indicated main features is shown in Figure 5D. ER1 is a higher resistivity zone on the summit. This correlates with the earth resistance results which have been interpreted to be due to a stony and/or rocky sub-surface. ER2 is a zone of low resistivity material to the northwest of the motte and is likely to be due to a clay deposit.

The ERT sections do not indicate a cairn buried in the core of the motte, but there are indications of high resistivity bedrock under the motte. To the northwest, north and northeast of the motte there seems to be lower resistivity material perhaps indicating significant clay deposits. The southerly areas from the motte have higher resistivity and may be the source area for the clay component of the motte if its removal has exposed higher resistivity sediments and/or bedrock. If this is the case the ditch may be rock-cut along parts of its southerly circuit. The higher resistivity associated with generally the centre and southeast area of the summit is intriguing when the earth resistance data is taken into account. There could be a foundation or footprint of a structure which could be rectangular or circular in form. The possibility is for a building or a cairn with a possible passageway.

## Airborne LiDAR survey

Although there are LiDAR elevation data available for the Brú na Bóinne World Heritage Site commissioned by Meath County Council with the assistance of the Discovery Programme, the zone surveyed did not include the Hill of Slane. Separate LiDAR elevation data available from Ordnance Survey Ireland (OSi) were acquired by the project. The survey was flown by OSi in Autumn 2010 and processed in Spring 2011. The data supplied are on a 0.5m x 0.5m grid and cover a 1km x 1km area enclosing the Hill of Slane. Each data point is referenced in the Irish National Grid (ING) and elevations are relative to the OSi Malin Head datum. The data were supplied in Digital Terrain Model (DTM) format which is also known as 'bare earth' format in that specific data processing has been carried out to remove the effect of vegetation and foliage as far as possible. This is particularly important in the case of the survey over the motte where there is dense vegetation obscuring the view of the morphology of the motte and its ditches (Plate 1).

*Preliminary maps and images*

Some preliminary processing has been undertaken to make maps and images. Figure 6A is a topographic contour map of the area of motte with inner and outer ditches. The motte and the general form of the inner ditch are apparent but the outer ditch is not seen. In order to extract more information from the LiDAR dataset further processing has been carried out to produce the shaded topographic relief image shown in Figure 6B.

The data have been illuminated from the northwest at 45 degrees above ground level. Features such as the motte and both the inner and outer ditches are now apparent with the addition of the smaller enclosure partially intersected by the outer ditch. There is a hint that this feature is cut by the outer ditch implying that it is older than the ditch. There are areas in the image where detail is missing e.g. the summit of the motte and the area to the southwest of it. This is due to the vegetation being too dense for the LiDAR signal to penetrate

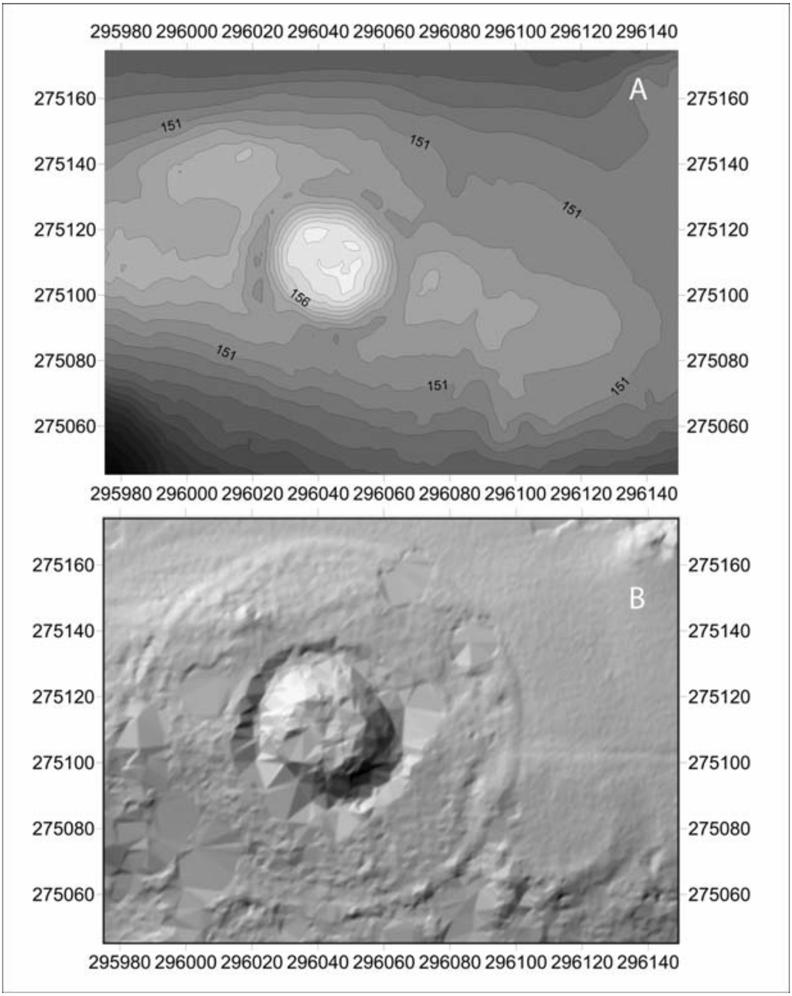


Figure 6: Topographic contour map of the motte with inner and outer ditches (A); shaded topographic relief image of the motte with inner and outer ditches (B). Both based on OSi LiDAR data.

and provide a coherent return signal. Overall, considering the degree of vegetation cover, the LiDAR image is very good. The data have been further processed to produce a pseudo-3D model of the motte in the landscape. The image has been made by draping the shaded relief image on the topography itself. Figure 7 shows the data illuminated from the southwest and viewed from the northeast and shows the distinctive morphology of the motte, its ditches and the smaller enclosure lying to the southeast.

The availability of the LiDAR data now makes it possible to provide more quantifiable data on the morphology of the motte and surrounding features. Figure 8 is drawn from the shaded topographic relief image of Figure 6B and is a schematic drawing of the outlines of the base of the motte, the outer ditch and the small enclosure. The measured east-west diameters of the base of the motte, the outer ditch and the small enclosure are 45m, 120m and 36m respectively. The image of the edge of the small enclosure is not particularly sharp and its circumference needs to be further investigated in the field. The circle represents what may be the summit of the feature.

*Improving the LiDAR coverage*

The degree of LiDAR coverage in the more heavily vegetated areas of the motte and its environs has resulted in somewhat degraded images with lack of archaeological detail. This can be improved by in-filling missing data where possible using a total station. An area to the east of the motte (Figure 6B) was selected for a trial topographic survey. The survey was carried out to provide a dataset which can be compared to the LiDAR data over the same area. The survey was carried out in a relatively dense area of vegetation and collected

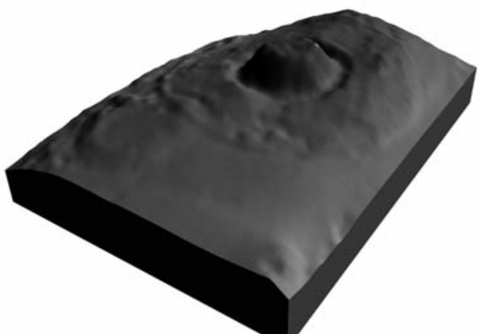

Figure 7: Pseudo-3D model of the motte in the landscape. Derived from LiDAR data and viewed from the northeast.

ground elevations on a 3m x 3m paced grid. Measurement locations were recorded in the Irish National Grid using control stations set up using a dGPS. An arbitrary elevation datum of 100m was used in the survey. In order to compare the datasets the ground heights were converted to the Malin Head datum. This was accomplished by comparing height differences between the coincident west-east ground and LiDAR profiles shown in Figures 9A and 9B. For data for the area to the east of ING 296080E, which had no tree canopy, the average difference of the ground elevation from the LiDAR elevation data was found to be –50.5m and this was added to each measurement in the ground elevation dataset.

The ground and the LiDAR data were interpolated onto regular grids and further processed to produce shaded topographic relief images (Figures 9A and 9B). The illumination is from the west at 30 degrees above ground level. Here, the location of the inner and outer ditches is well defined in the shaded relief images despite the vegetation cover.

Figures 10A and 10B show smoothed coincident topographic profiles from the LiDAR and ground surveys respectively. The outer ditch lies just east of ING 296090E in this area and is not apparent

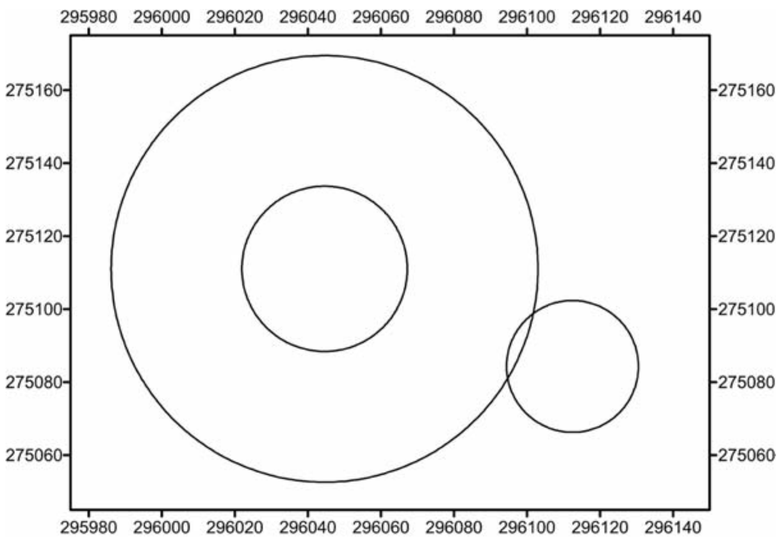


Figure 8: Schematic outlines of the base of the motte, outer ditch and small enclosure based on LiDAR data.

in the LiDAR profile (Figure 10A). In this area its form seems to be a low profile bank without a ditch and in the ground survey profile the feature is more clearly discernible as a bank (Figure 10B). The LiDAR profile lacks detail when compared with the ground survey profile due to the degree of vegetation coverage in the inner ditch and in the immediate vicinity of the motte, i.e., west of 296090E. This is particularly noticeable when comparing the profiles of the inner ditch near ING 296070E.

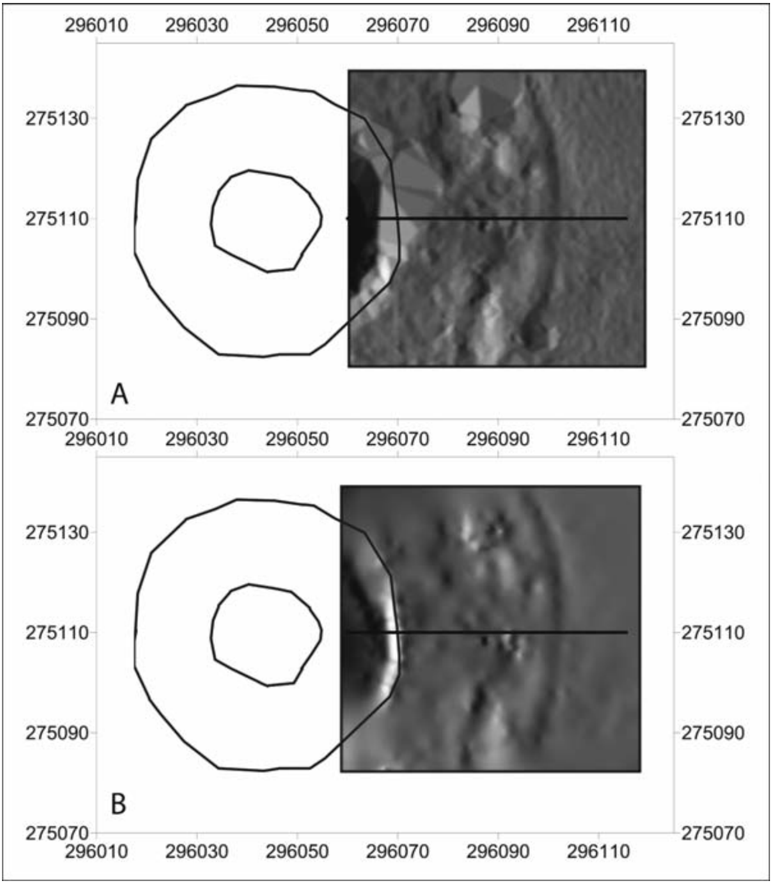


Figure 9: Shaded topographic relief image based on LiDAR data of an eastern sector of the inner and outer ditches with location of profile 10A (A); shaded topographic relief image based on total station data of an eastern sector of the inner and outer ditches with location of profile 10B (B).

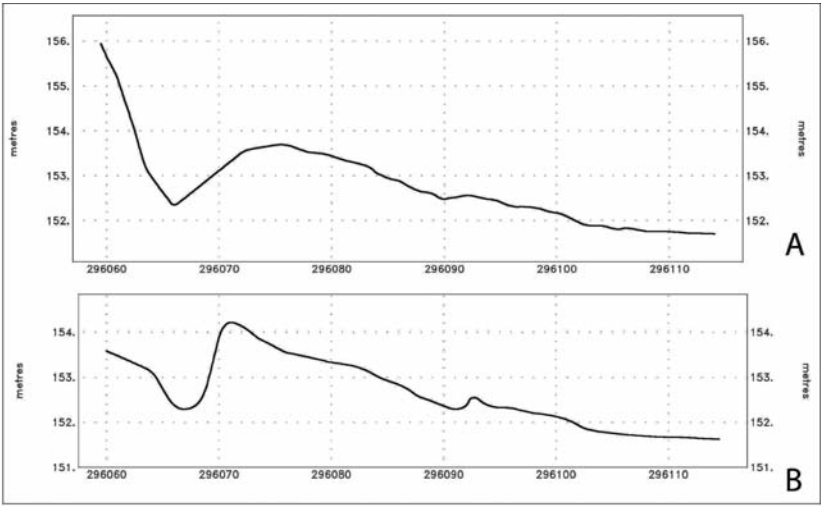


Figure 10: Topographic profile on OSi datum derived from LiDAR data. (A); topographic profile on OSi datum derived from total station data (B).

## Discussion

*Internal structure of the motte*

The ERT survey successfully imaged the general internal structure of the motte. Even though there is distortion in the modelled pseudosections due to topographic effects there does not appear to be any significant coherent feature in all the pseudosections that could represent a mound or cairn that pre-dates the motte. There appears to be a degree of internal variation within the motte which could be related to its construction, augmentation or repair. It should be noted that where significant zones of high resistivity are found in modelled ERT pseudosections it is not possible to differentiate between likely stone features such as cairns and air-filled cavities.

The dataset collected needs to be compared and further interpreted with the results from excavated mottes which reveal their construction detail. There are anomalous features at the extremities of the ERT pseudosections perhaps associated with the outer ditch/bank. These need to be correlated with detailed topographic data.

*The summit of the Mound*

The earth resistance survey has imaged possible features on the summit of the motte. The ERT data provide confirmation that these features have some depth. The form and function of the features is not clear; they may be related to building foundations or a summit cairn. Further more detailed work will be necessary to more clearly define the nature of this feature.

*LiDAR data*

It is clear from the preliminary images produced that LiDAR data can be used in the interpretation and presentation of visible and hitherto obscured monuments and also the landscape of the Hill of Slane. Further work is necessary to refine the images produced in conjunction with the results of archaeological and geophysical survey on the Hill of Slane. Although the full potential of the LiDAR data is limited by the degraded coverage caused by vegetation, trial topographic survey has been used successfully to fill in areas missed by the LiDAR survey. Use of the LiDAR data has allowed for the first time successful imaging of the morphology of the motte, surrounding bank and ditch and the small enclosure. It has also demonstrated the topographical relationship between the latter two features.

The outer bank and ditch have particular similarities to a similar monument at Mountfortescue 6km to the north (de Paor and Ó hEochaidhe 1956). Here, a circular enclosure defined by a low bank and external ditch, with a diameter of *c.*164m contains a low flat-topped mound *c.* 12m in diameter and *c.* 1m high (Moore 1987). Given the proximity of this monument to the Slieve Breagh complex, it seems likely that this may be a barrow. The striking similarity of the form and scale of the two enclosures perhaps suggests that the feature described in the historical sources as *Dumhach Sláine* may be a low barrow feature rather than a passage tomb.

## Conclusions

The results of the ERT survey in this particular situation were inconclusive in identifying an earlier phase in the construction of the motte. However, if a mound had originally stood on the site which was later modified by the Anglo-Normans, the survey data indicate that this is unlikely to have been a significant stone cairn like the major mounds at Newgrange, Dowth and Knowth in Brú na Bóinne. Nonetheless, it is still possible that there was a smaller earthen mound on the site which was constructed of soil dug in its immediate vicinity. It is possible that such a monument was in the passage tomb tradition as earthen mounds are known in the Brú na Bóinne area. If this were the case and, if the motte is largely of earthen construction, then there would be no clearly discernible contrast between the material used in the two phases of activity and certainly not discernible by the ERT technique used in the survey.

On the other hand, if the analogy with the circular enclosure at Mountfortescue is correct then any mound that may have stood within the enclosure on the Hill of Slane may have been a relatively small feature, similar to the 1m high mound at Mountfortescue. A feature of this scale located beneath the motte on the old ground surface is unlikely to produce an anomaly detectable by the ERT technique, especially given the relatively coarse 3m electrode spacing necessitated by the height of the motte. However, given the nature of the historical references and the fact that a mound feature is named in these sources, this suggests that the feature may have originally been a significantly more prominent a landmark than the Mountfortescue mound.

It is also possible that the motte was not constructed over an existing mound and that the *Dumhach Sláine* is, in fact, the small enclosure feature on the south eastern side of the motte. This feature may be the remains of a barrow as suggested by Herity and it is also possible that it was once a more prominent feature (Herity 1993). The possibility of this feature being prehistoric is also suggested by the topographic superposition of the large enclosure which, on the basis of the analogy with the Mountfortescue enclosure, is likely to be prehistoric.

There are a number of high resistivity zones within the motte which have presently been interpreted as being due to stone or rock, e.g. feature ER2 on line ERT 2 (Figure 6B). An alternative interpretation would be that this or other similar features could be air-filled cavities. A recent experimental microgravity survey at Newgrange Passage Tomb (Barton *et al.* 2011) was successful in detecting the known chamber which is a large air-filled cavity. Further investigation of the motte using microgravity may reveal more detail on its inner construction.

Follow-up investigation of the high resistance feature on the summit of the motte might help in interpretation and help to confirm whether this is a medieval or earlier feature. Close-spaced ERT lines with a 1m electrode separation would equate to a 3m depth of investigation and could be used here to generate a 3D model of the anomaly.

Comparative data from other mounds would be useful to contextualise the data collected on the Hill of Slane. Sites that could be investigated might include some of the unexplored mounds in the Brú na Bóinne area or Millmount in Drogheda which, like the Hill of Slane has early mythology associated with it. Data from other motte sites in the Meath area would also be useful.

In relation to the LiDAR data, its acquisition was a major benefit to the interpretation of the topographical relationship between the enclosure around the mound and the smaller enclosure feature. The LiDAR data indicate that the small enclosure predates the construction of the large enclosure. The particular difficulties created by the dense vegetation cover reduce the utility of the data. It has been demonstrated here through the trial topographic survey that vegetated areas that remain unsurveyed by the LiDAR survey can be filled in using ground survey methods. However, this increases the costs involved to the project in terms of time and use of equipment and is not ideal. Organisations conducting LiDAR surveys should take account of the time of year when flights are scheduled, making every effort to plan flights during the winter months when vegetation cover is normally at a minimum. This would not only enhance the archaeological value of LiDAR datasets by ensuring optimum visibility of low-relief features and vegetated areas but would also be good practice.

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