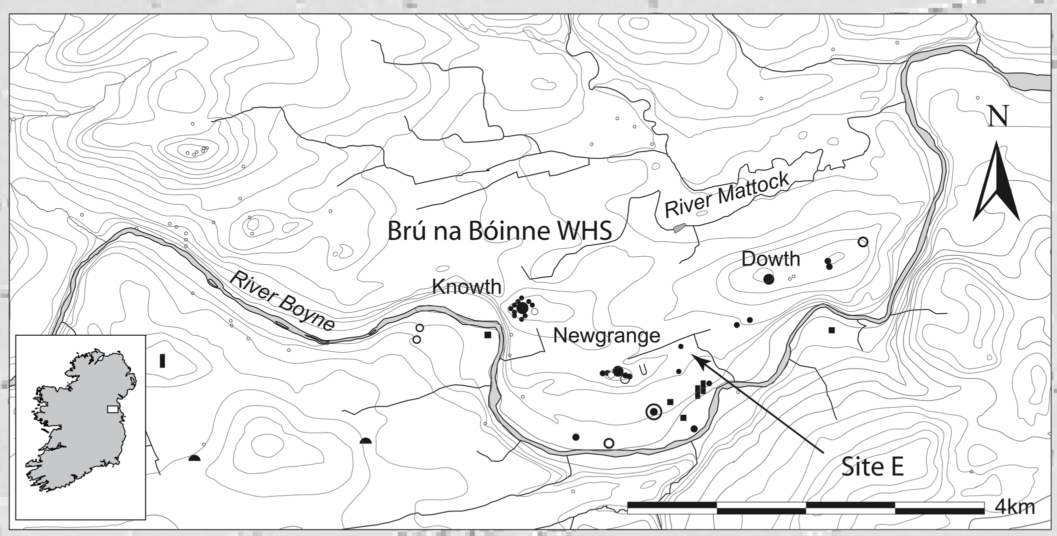
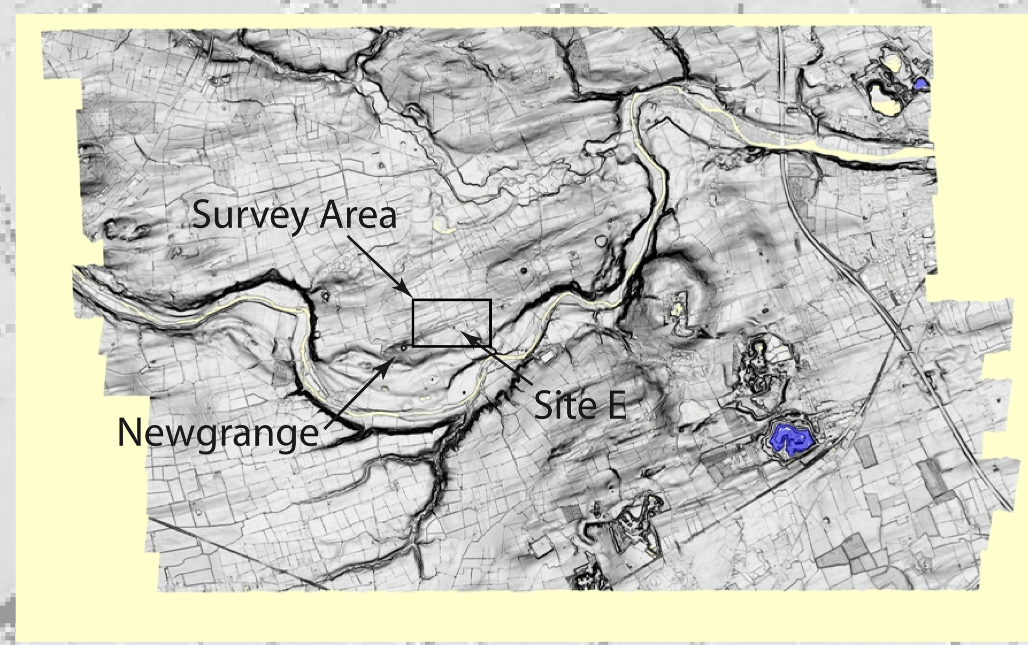
Evaluation of a Multi-Sensor Platform in a Large-Scale Geophysical Survey at Brú na Bóinne World Heritage Site, Ireland

Conor Brady[1], Ian Hill[2], Kevin Barton[3], Liam Williams[2] & Martin Krajňák[4]

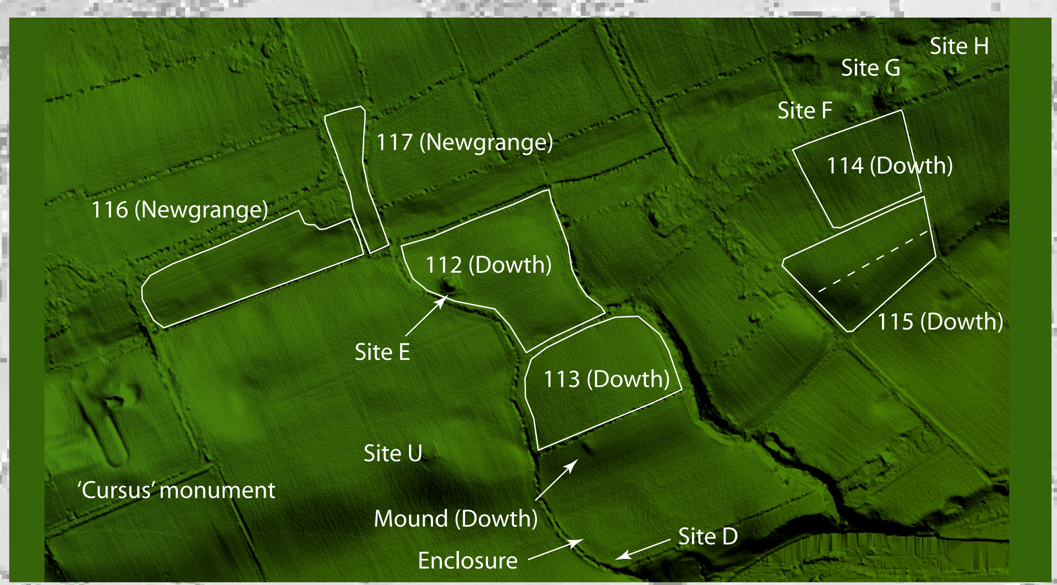




Brú na Bóinne, has been an important ritual, social and economic centre for thousands of years. It was designated a UNESCO World Heritage Site (WHS) in 1993. Although extensive research has been undertaken, this has focused on the excavation of and geophysical survey of some monuments. Little extensive systematic field survey of the wider landscape has taken place. We still lack an in-depth understanding of the site's broad range of archaeological monuments, spanning over 6,000 years from the Neolithic passage tombs to the Battle of the Boyne (AD 1690) battlefield, and the landscape and communities that shaped them. *RIGHT*: Worldview-2 panchromatic image of Brú na Bóinne with the location of the survey area, Site E and Newgrange Passage Tomb (Data courtesy of Digital Globe).

The Brú na Bóinne Research Framework document (Smyth et al. 2009) has advocated a shift in research focus away from sites and towards landscape. It is in this area that remote sensing techniques have an important role. The current project addresses this aim and is field testing a range of geophysical techiques that will be used in a large-scale systematic remote sensing survey and will be integrated with other remote sensing datasets. *ABOVE*: Slope-shaded LiDAR image. (Data courtesy of Meath County Council and the Discovery Programme)

Survey Area



Equipment - Geophysical Exploration Equipment Platform (GEEP)

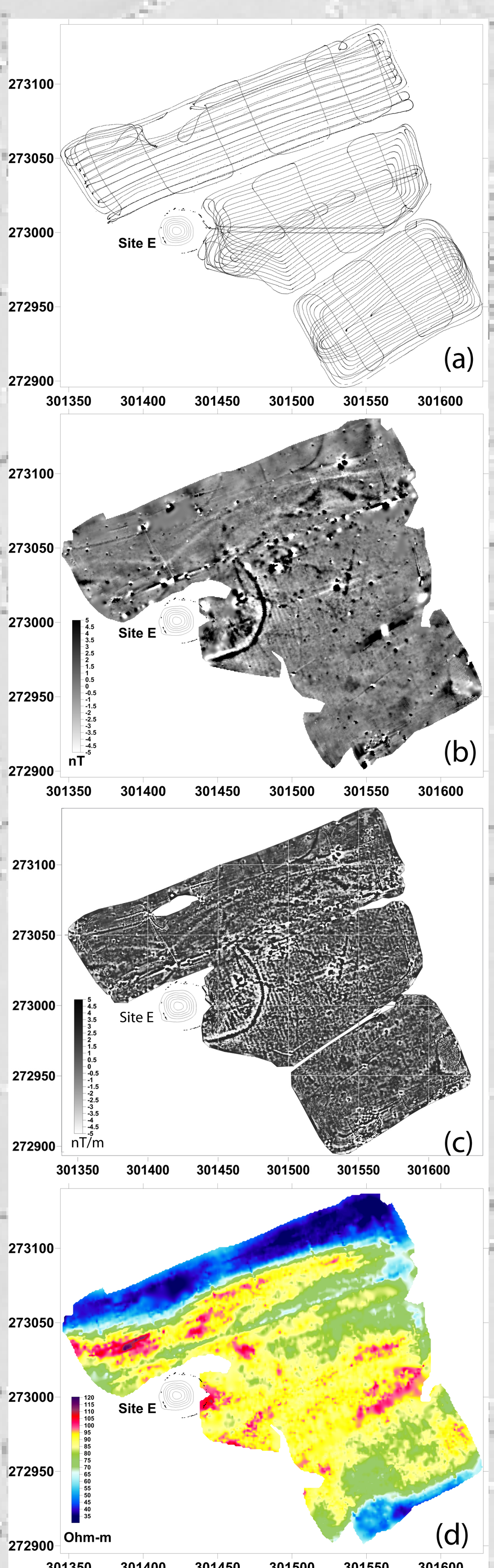
The GEEP system comprises a tractor unit with datalogger and Wi-Fi antenna. The sled is configured with 4x caesium vapour sensors spaced 1m apart, a centrally mounted DualEM 421S 6-receiver coil EM system, GPS antenna and 3-axis compass. Data are transmitted in real time via the Wi-Fi link from the tractor unit to a datalogger in the trailer unit for quality control.

Survey Analysis

Field Number	Magnetic Readings	Conductivity Values	Survey Time (minutes)	Area (hectares)
112	130,000	65,000	220	2.956
113	180,000	90,000	152	2.600
114	108,000	54,000	89	1.809
115	90,000	45,000	77	0.940
116	160,000	80,000	136	2.695
117	60,000	30,000	48	0.684
Totals	728,000	364,000	722	11.684

The GEEP successfully completed the survey of 6 fields (above) with the results from Field 112 presented below. Data acquisition was c. 1 ha per hour compared to 1 to 2 ha per day with a hand-carried magnetometer.

Field 112 Magnetic and Electromagnetic Data



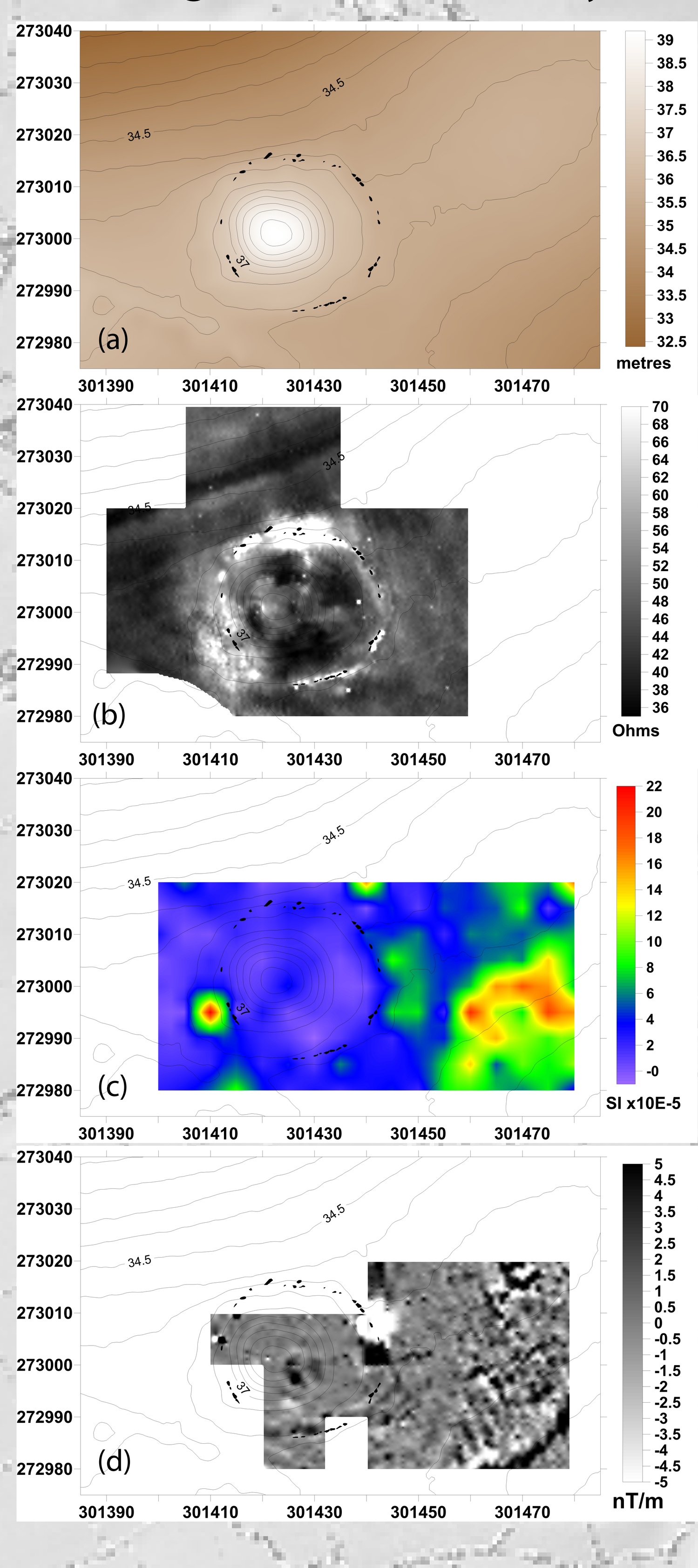
(a) Total field magnetic data are collected along 4 continuous tracks 1m apart with a sampling interval of c. 0.4m.

(b) The data from all 4 magnetometer sensors are combined to produce a total field magnetic map.

(c) These data (b) are filtered to produce the vertical derivative data which is comparable to the data collected by magnetic gradient systems such as the Bartington Grad601-2. The derivative (or gradient) data emphasize short wavelength anomalies from shallow near-surface sources. These magnetic data clearly indicate multi-phase archaeological activity focused on Site E.

(d) EM data are collected synchronously with the magnetic data along tracks 4m apart with a c. 0.4m sampling interval. They have a much lower spatial resolution than the magnetic data, but show the relationship of the archaeology to the soil, subsoil and shallow bedrock geology. The data at a nominal depth of 2m are displayed as resistivity values in Ohm-m. Low resistivity (blue) alluvium is evident at the north and south of the survey area with sub-parallel higher resistivity bands representing glacially derived sediments.

Site E Topography, Earth Resistance, Magnetic Susceptibility and Magnetic Gradiometry



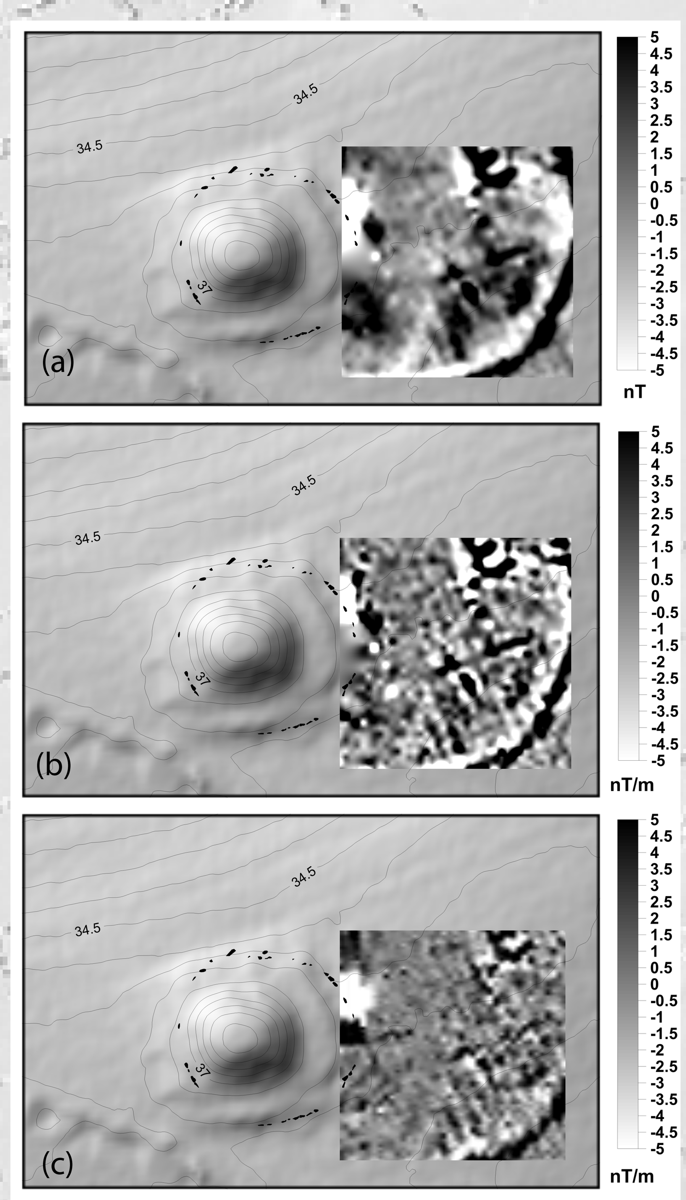
(a) Airborne LiDAR data, collected on a 1m x 1m grid, have been contoured to show the topographic contours of the Site E mound. The 35 visible stones surrounding the mound have been mapped and show the centre of the stone circle is offset c. 5m to the east from the centre of the mound. This may indicate the mound and the stone circle were not constructed at the same time.

(b) Earth resistance data collected with a twin-probe array on a 0.5m x 0.5m grid show the surface of the mound has a variable resistance distribution. The summit has a higher resistance indicating a drier, compacted composition while the steep sides have a low resistance possibly due to a wetter clay composition. There are a number of discrete high resistance anomalies in the circumference of the stones which may indicate places where stones have been removed.

(c) Volume specific magnetic susceptibility measurements made with a 0.18m diameter fieldloop on a 5m x 5m grid show low enhancement over the mound and its immediate vicinity. Isolated single point anomalies are due bare soil disturbed by livestock. There is a significant area of enhancement to the east and southeast of the mound. This correlates with the archaeological features seen in the magnetic gradiometry data (d).

(d) Vertical magnetic gradient measurements made on a 1m x 0.25m grid using a twin gradiometer array with fluxgate sensors spaced 1m vertically apart, show the area of the mound to be magnetically quiet. A large anomaly at the northeast of the stone circle is due to a metal sign. The area to the east of the mound shows a northwest to southeast linear overprint due to cultivation. In the southeast of the survey area there is a curvilinear positive gradient anomaly which is due to a ditch. The area of cultivation and the ditch correlate with the area of enhancement seen in the magnetic susceptibility data.

Comparison of Bartington Vertical Gradient Data with GEEP Vertical Derivative Data



Results from a comparison of magnetic data collected near Site E using the GEEP with caesium vapour sensors and a hand-carried Bartington dual fluxgate gradiometer; (a) GEEP Total Field data, (b) GEEP Vertical Derivative data and (c) Bartington Vertical Gradient data. There is good correlation between the data collected with the vertical derivative data showing better resolution of features.

Reference: Smyth, J., Brady, C., Chadwick, J., Condit, T., Cooney, G., Doyle, I., Guinan, L., Potterton, M., Stout, G. and Tuffy, C. 2009. Brú na Bóinne World Heritage Site Research Framework. Dublin: The Heritage Council.

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1. Humanities and Social Sciences Research Centre, Dundalk Institute of Technology, Ireland; 2. Department of Geology, University of Leicester, England; 3. Landscape and Geophysical Services, Claremorris, Co. Mayo, Ireland; 4. Comenius University, Bratislava, Slovakia.

Background Image: Brú na Bóinne Lidar. Courtesy of Meath County Council, Discovery Programme