IN SEARCH OF HIDDEN CHAMBERS AT NEWGRANGE PASSAGE TOMB

Kevin Barton, Roman Pašteka, Palo Zahorec, Juraj Papčo and **Conor Brady** describe the first use of microgravity on a passage tomb in Ireland.

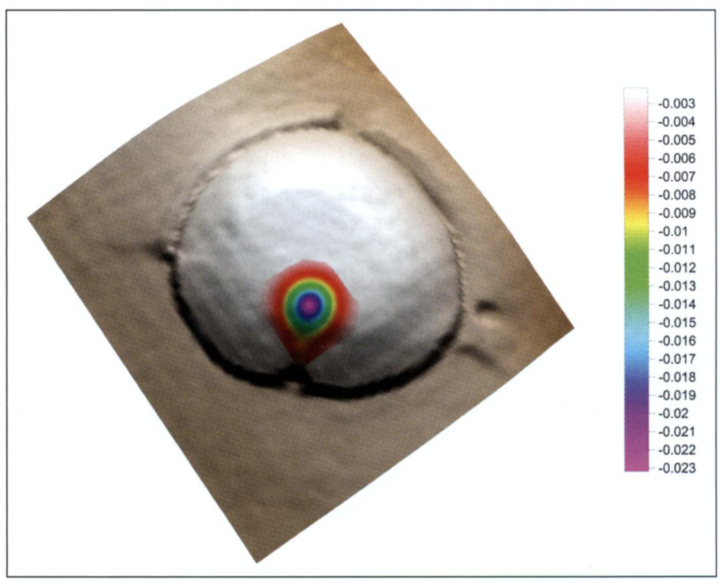
The possibility that further chambers exist within the Newgrange passage tomb has been a subject of interest since the excavations of Professor Michael O'Kelly. Multiple passageways and chambers exist at Site 1 at Knowth and also at Dowth; could there be hidden cavities or chambers at Newgrange that could be detected using geophysical techniques?

One such geophysical technique is microgravity, which found hidden cavities in the Great Pyramid at Giza in Egypt (Lakshmanan and Montlucon 1987). The technique measures variation in subsurface density, with anomalous microgravity values being detected over low-density, air-filled cavities which have a significant volume and shallow depth. A microgravity survey at Newgrange was part of a 2011 funding application to the Irish National Strategic Archaeological Research (INSTAR) programme administered by the Heritage Council. It was not funded, however, owing to a drastic cut in the INSTAR budget.

Roman Pašteka, a partner in the INSTAR application, has successfully carried out microgravity surveys to detect the presence of medieval crypts (Pašteka and Zahorec 2000; Pašteka *et al.* 2007). There has been little research into the use of microgravity to detect chambers in mounds, owing to their generally small size, but the situation as regards the mounds at Brú na Bóinne is different. The major chambers have quite large dimensions, thus enhancing the detection capability of microgravity. As part of the INSTAR application a computer simulation to predict the gravity anomaly over the Newgrange chamber was carried out (Fig. 1). This simulation showed that the calculated effect on gravity of the chamber volume together with its depth within the mound would produce a measurable negative gravity anomaly—purple, blue and green colours in Fig. 1.

Such was the research potential of using microgravity at Newgrange and other sites that Roman Pašteka obtained research funding in Slovakia. The microgravity survey, using state-of-the-art gravity meters, was carried out as an international collaboration project in October 2011. The key objective of the pilot survey was to investigate the potential of the microgravity method in the initial detection of the known chamber and subsequently in searching for possible hidden chambers.

Initial field measurements (Pl. 1) were made over and in the vicinity of the known chamber along lines perpendicular to the main axis of the passageway. The lines were 2m apart, and automated



Top: **Pl. 1—Collecting gravity data and their location and elevation over the chamber at Newgrange passage tomb. Site Z is in the background** (Conor Brady).

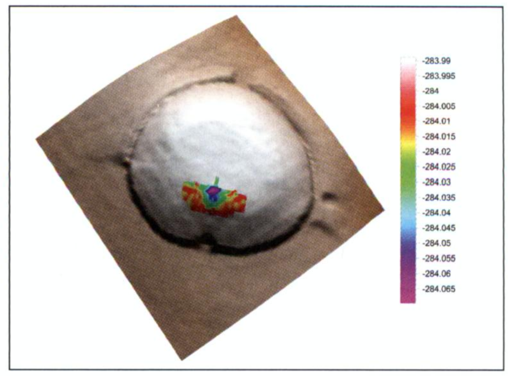
Above: **Fig. 1—3D LiDAR model draped with a simulation of the predicted gravity anomaly over the known chamber in Newgrange passage tomb. Units: milliGals (1mGal = 10^{-5}m×s^{-2}).**

readings lasting one minute were taken at 1m intervals. The horizontal and vertical position of each of the 149 measurement points was precisely determined using a combination of differential GPS and laser tachymetry methods. Gravity meters are very sensitive to vibrations and/or oscillations. Frequent strong winds at the time of survey required special wooden windshields to be used to protect the instruments from wind gusts, and each measurement was verified by repeat readings. The average error from repeated and independently controlled measurement points was ±15mGals. This is relatively high but acceptable in the case of this survey.

The data were processed to remove the effects of elevation, tidal variation, topography, latitude and instrument drift. The removal of the effect of surrounding topography on the measurements was greatly facilitated by the availability of high-resolution (0.5m x 0.5m) LiDAR digital elevation data. The output of the processing was a gravity anomaly map, draped on a 3D model made from the LiDAR data (Fig. 2), which presents the properties and geometry of subsurface inhomogeneities. The map shows a well-developed negative anomaly (a gravity low) over the centre of the chamber—purple, blue and green colours in Fig. 2. The size of the anomaly at its centre is several times larger than the precision of the instrument and also the average error of the instruments. The existence of the passageway cannot be detected. Its dimensions are too small and its depth too large for the detection capability of the microgravity method.

Further microgravity measurements were made on the mound and in the chamber (Pl. 2) in order to seek further anomalies and to refine the gravity model of the known chamber. The data are being processed and will be interpreted in conjunction with complementary geophysical techniques. Further results will be available in 2012.

Below: **Pl. 2—Locating gravity measurements in the chamber at Newgrange passage tomb** (Igor Murin).



Right: **Fig. 2—3D LiDAR model draped with the measured gravity anomaly over the chamber area of Newgrange passage tomb. Units: milliGals (1mGal = 10^{-5}m×s^{-2}).**

We are very optimistic about the capability of the microgravity technique to detect an unknown chamber of similar dimensions to that at Newgrange and are exploring the possibilities of further collaboration.

What is microgravity?

The microgravity method measures very small variations in the Earth's gravity field caused by small variations in subsurface density or mass. This variation of mass causes changes in the gravitational attraction of a very sensitive weight housed within a gravity meter. The degree of attraction is a measure of the very small change in gravity caused when the instrument is moved over areas of low and high subsurface density.

We normally use a highly approximated value for gravity of 9.81m×s^{-2}. To measure the effect of a small change in gravity caused by a low-density air-filled cavity or chamber we have to measure changes in gravity to the eighth decimal place, i.e. 9.81000000m×s^{-2}. The unit of measurement is the microGal, where 1mGal = 0.00000001m×s^{-2}. State-of-the-art relative gravity meters can measure changes in the gravity field with a precision of approx. ±5mGals. With such precise instruments, cavities with anomalous gravitational effect above 10mGals (taken in absolute value) can be detected. ■

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References

Lakshmanan, J. and Montlucon, J. 1987 Microgravity probes the Great Pyramid. *Geophysics: The Leading Edge of Exploration* **6** (1), 10–17.

Pašteka, R. and Zahorec, P. 2000 Interpretation of microgravimetrical anomalies in the region of the former church of St Catherine, Dechtice. *Contributions to Geophysics and Geodesy* **30** (4), 373–87.

Pašteka, R., Terray, M., Hajach, M. and Pašiaková, M. 2007 Microgravity measurements and GPR technique in the search for medieval crypts: a case study from the St Nicholas Church in Trnava, SW Slovakia. In 'Proceedings of the 7th International Conference on Archaeological Prospection'. *Štúdijné Zvesti Archeologického Ústavu SAV* **41**, 222–4.