Archaeology Research Grant 2022

Eoin Halpin

Submission Date	Nov 23, 2022 11:16 AM
1. Title:	Mr
First name:	Eoin
Surname:	Halpin
2.	
3. Grant programme	Archaeology Research Grant
4. Year awarded	2022
5. Title of project	Portal tomb construction: Doogort West, Achill Island, Co Mayo
6. Summary of report (Minimum allowed 100 words)	The survey was undertaken in such a way as to allow each of the structural elements to be manipulated separately. Consequently it was possible to re-straighten each of the orthostatic elements and to 'reattach' the two broken pieces of the orthostat located to the northeast of the tomb. With this configuration in place, the cap stone was repositioned on the three highest points of the structure; the top of the main portal stone, the top of the smaller southeast orthostat and on the side of the orthostatic side slab (Figs. 3 - 6). The shape of the capstone, square on three sides with the fourth angled, meant that one of the edges was markedly shorter that the other three. Given these constraints, the modeling suggested that there was only a limited number of positions that the capstone could rest satisfactorily on the underlying orthostsats. When the post-collapse position of the capstone was factored in it was clear that the straight edge of the capstone must have faced west, with the shorter side facing north and the angled side facing east. The possible reconstruction also throws some light on the two outlying stones. That to the northeast, would appear too small and also too far removed to have formed part of the main architecture of the monument. Even if it were taller, the cap stone could not span the required distance between it and the main portal stone to the west. The final potential structural stone lies 1.2 m south, described by de Valera and O'Nuallain as a possible broken back stone 'running askew to the main axis of the chamber, as indicated by the western side, is a set stone, 0•60 m. high, leaning heavily to the north-west'. The fact that the stone leans to the north west could be a product of post collapse dislocation, however if the angle of the lean is projected, it would meet the southern end of the reconstructed capstone, potentially supporting its interpretation as a back stone. The reconstruction was shown to a structural engineer who considered that if the reconstruction was correct and the smaller southeast orthostat were the first to shift inwards and to the west, this would cause the cap stone to shift southeastwards and potentially end up in its current position.

Finally, the survey allowed for each of the stones to be laser printed at a scale of 1:20, which allows for the proposed virtual reconstructions to be tested manually (Fig. 6).

The survey and reconstruction can be accessed via sketchfab on the web using the following links:

The present survey:
https://skfb.ly/ozF7Z The reconstruction:
https://skfb.ly/ozFq8

(Recon)

Please outline the objectives of the project: It was proposed to undertake a detailed laser scan survey of the site, including its component parts and the surrounding area. Each element, some 6 orthostats and the large capstone, lying to the south east, were scanned separately. Uniquely this allowed for the constructional elements of the Portal Tomb to be virtually manipulated individually.
It was clear for an examination of the site, and the various written descriptions, that a number of the orthostats forming the eastern side of the monument have been displaced and now lean up against the apparently in situ orthostats forming the western side of the tomb. In addition it also appeared that the eastern portal stone may have sheared-off close to ground level, with the remaining fragment of the orthostat lying to the north east. Finally, the massive flat capstone was visible, lying some 1.5 m to the southeast.
It was proposed that the resultant laser scan data would allow for theoretical 'reconstruction(s)' to be made. These were reviewed by a structural engineer to comment on stability. An important element of the work was an examination of the processes by which the large capstone, weighing some 5 tons, ended up in its present location.

Please describe the methodology used in conducting the research: A 3D laser scan survey was carried out for accurate 3D geometric capture of the portal tomb structure to include all structural elements. Scans were collected using a Leica Geosystems RTC360 laser scanner. The laser scanner has an effective range of 130m including on board 36 MP 3 camera system capturing 360 imagery in HDR format.
The out puts were a clean up and import point cloud scan data; Construction of 3D model and materials off site; Optimisation of model and split mesh into separate stones; areas of occlusion retextured back onto new mesh and finally live model reconfiguration of stones for reconstruction purposes.

10. Please outline the findings of your research and/or milestones achieved

The survey was undertaken in such a way as to allow each of the structural elements to be manipulated separately. Consequently it was possible to re-straighten each of the orthostatic elements and to 'reattach' the two broken pieces of the orthostat located to the northeast of the tomb. With this configuration in place, the cap stone was repositioned on the three highest points of the structure; the top of the main portal stone, the top of the smaller southeast orthostat and on the side of the orthostatic side slab (Figs. 3 - 6). The shape of the capstone, square on three sides with the fourth angled, meant that one of the edges was markedly shorter that the other three. Given these constraints, the modeling suggested that there was only a limited number of positions that the capstone could rest satisfactorily on the underlying orthostsats. When the post-collapse position of the capstone was factored in it was clear that the straight edge of the capstone must have faced west, with the shorter side facing north and the angled side facing east.
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The reconstruction was shown to a structural engineer who considered that if the reconstruction was correct and the smaller southeast orthostat were the first to shift inwards and to the west, this would cause the cap stone to shift southeastwards and potentially end up in its current position.
Finally, the survey allowed for each of the stones to be laser printed at a scale of 1:20, which allows for the proposed virtual reconstructions to be tested manually.
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11. a) Please provide details of the dissemination of the outcomes from this project (inc. publications, presentations, outreach, media etc.) including details of any social media/web platforms used to publicise this project

It is proposed to submit at minimum two articles, one to Archaeology Ireland and one to the Journal of Archaeological Science. I would also intent to give a talk to the Achill Historical and Archaeological Society. The final reconstructions will also be added to the proposed virtual visitor experience being developed by Tandem Design of Holywood, Co Down for the Slievemore Heritage trail, due to open in May 2022.

b) No. of Academic Papers/articles published:

2

c) No. of Lectures given/outreach events involved in:

1

15. How did the award enhance your professional development (e.g. in terms of specific opportunities, opportunities for enhancing skills, collaborations with others etc.)?	Great to work with the survey team - hope to expand this model of working into other sites and in other areas of the country
16. What plans (if any) do you have to further your proposal/project?	see above - in discussions with other stakeholders for a roll out of the reconstructions of other archaeological sites

Portal Tomb Construction
Doogort West
Slievemore, Achill Island, Co Mayo

Eoin Halpin

With contributions from
Ciara McManus, Conor Graham & Andrew Castle

Royal Irish Academy 2022 Archaeology Research Grants

Acadamh Ríoga na hÉireann
Royal Irish Academy

Acknowledgements

Research reported in this publication was funded by the ***Royal Irish Academy***.

My thanks also go to the land owner Irene Appelbe, without whose permissions and support this survey would not have been possible. Also to Tommy 'Coleman' Gallaher, the farmer, who put up with the numerous requests for access and facilitated the survey at every turn.

Thanks also go to Ciara McManus of *FarrimondMcManus ltd* and Conor Graham who undertook the survey efficiently and professionally and to Andrew Castle of *Pivotal Animations* who took the survey data and produced the wonderful graphics.

Portal tomb construction: Doogort West, Achill Island, Co Mayo

1. Introduction

The aim of the project was to investigate the processes of portal tomb construction via non-invasive methodologies with particular reference to the Doogort West site (MO024-021021-).

Plate 1. General view of site from the southeast showing remains of possible cairn on the east side

The monument was described in the Survey of the Neolithic Tombs of Ireland (de Valera and O'Nuallain 1964 pp 60-61) as lying immediately south of the old road leading to Slievemore village. It stands at the upper edge of the arable land on the lower slopes of Slievemore (Fig. 1; Plate 1). To the north the land gives way to a tract of summer pasturage beyond which the steeper slopes of the mountain commence. A small stream runs down the hillside to a point just north of the monument and becomes diverted along the line of the old road.

The tomb is very damaged. It consists of the ruins of a chamber orientated roughly north-south (Fig. 2). The grass-grown remains of a cairn are present at the east side of the chamber. Three fences join at the tomb. The first is the southern boundary of the old road and it runs east-west across the northern edge of the cairn. The second, which incorporates the west side of the chamber, runs north-south to meet the first. The remnants of the third fence can be traced running from the west to join the second fence 6·00 m. south of the road fence.

Plate 2. West facing elevation

Two slabs forming the west side of the chamber remain in situ (Plate 2). The northern is a fine tall portal stone 2.30 m. high. It leans slightly to the east. It tapers from 1.30 m. long at the base to 0·25 m. at the top.

Plate 3 South facing elevation

Plate 4. The possible backstone back right with the apparently broken orthostat front left

The second slab, which forms the main part of the chamber side, overlaps the portal stone slightly at the west. It is 1·75 m. high. The top edge is thin and slopes fairly regularly from north down to south. It leans rather more heavily eastwards than the portal stone, which it almost touches.

Plate 5 The possible backstone from the east and the straight edge of the probable roofstone

Leaning against the east side of this slab is a stone 1·90 m. high (Plate 3). It too tapers, from 1·00 m. long at the base to 0·35 m. near the top. It may not be in situ, but its shape suggests that it may have

formed a pair with the portal stone. It would seem, however, too low, unless it has lost part of its base. If it is, in fact, a portal stone it seems to be considerably out of position.

About 1·20 m. south of the last and running askew to the main axis of the chamber, as indicated by the western side, is a set stone, 0·60 m. high, leaning heavily to the north-west (Plates 4 and 5). Its top edge is irregular and appears to have been damaged. The function of this stone is not altogether certain but it may well be the backstone of the chamber.

2·50 m. east of the portal stone the base of a set slab protrudes 0·25 m. from the ground (Plate 4). Its function is not clear. It can scarcely be the base of a portal stone as the gap of 2·50 m. between it and the surviving portal would be unusually wide. Just east of this is a slab 1·15 m. high which leans heavily to the east. Its edges are rounded. It is probably the stone referred to by O'Donovan of which 'an impious miller commenced to make a millstone.' Its original function is unknown.

A large prostrate stone lying on the cairn at the south-east is very probably the displaced roof stone (Plate 1). It is 2·75 m. in maximum dimension. Its north-west edge shows a clean break which looks comparatively recent (Plate 5). De Valera and O'Nualain were informed locally that the slab was fractured by the lighting of a bonfire upon it and that the detached portion was used as a lintel in a nearby house (see front cover). The stone is 0.45 m. thick at its north-east corner, and tapers to 0·20 m.

2. Survey proposal

Following a successful application to the *Royal Irish Academy 2022 Archaeology Research Grants*, it was proposed to undertake a detailed laser scan survey of the site, including its component parts and the surrounding area. Each element, some 6 orthostats and the large capstone, lying to the south east, were scanned separately. Uniquely this allowed for the constructional elements of the Portal Tomb to be virtually manipulated individually.

It was clear for an examination of the site, and the various written descriptions, that a number of the orthostats forming the eastern side of the monument have been displaced and now lean up against the apparently *in situ* orthostats forming the western side of the tomb. In addition it also appeared that the eastern portal stone may have sheared-off close to ground level, with the remaining fragment of the orthostat lying to the north east. Finally, the massive flat capstone was visible, lying some 1.5 m to the southeast.

It was proposed that the resultant laser scan data would allow for theoretical 'reconstruction(s)' to be made. These were reviewed by a structural engineer to comment on stability. An important element of the work was an examination of the processes by which the large capstone, weighing some 5 tons, ended up in its present location.

Site survey

A 3D laser scan survey was carried out for accurate 3D geometric capture of the portal tomb structure to include all structural elements. Scans were collected using a Leica Geosystems RTC360 laser scanner. The laser scanner has an effective range of 130m including on board 36 MP 3 camera system capturing 360 imagery in HDR format.

The majority of the data collection was registered using targeted controlled scans utilising a combination of Leica HDS Planar and Tilt & Turn 3" and 6" targets. These were augmented with Visual Alignment registrations in those areas of the structure where access to place targets were not possible (e.g. height restrictions / poor/unstable ground conditions etc). The exported results of any

targeted scans and visual registration scans were supplied as metadata. This would quantify the accuracy and precision of the scanner on the day. The locations of each scanner setup and Total Station Control Setup were supplied as part of the metadata report.
The RTC360 has a maximum scan rate of 2 million points per second with a 3D accuracy of 5.3mm at 40m. Scan density (resolution) of this project was 5mm @ 10m allowing for a maximum scan density of 3-5mm at 10m through the course of each scan. Average scan density was therefore a minimum 3mm given the maximum feature and scene range during the survey was <30m (range noise at 50m c.2mm).
As 3D laser scanning is a 'line of site' survey process it is unrealistic to state that no 'data voids' will be present in the dataset. The survey endeavoured to reduce voids to a minimum through careful placement and multiple scanner setups, which required the removal as much temporary obstructions as possible including vegetation.
The on board digital camera was utilised as a means of capturing digital imagery for record purposes and to allow for RGB to be mapped to the Point Cloud. In-scene point-cloud control was supplied by a combination of EDM target survey and RTK GPS measurements to the Irish Grid coordinate system (IG75, OD Belfast), connected to the OSNI active GPS network via the Smartnet Network RTK GPRS service.
Survey Post Processing
The point-cloud data processing and registration used the Leica Cyclone Register 360 and Core software package. Point Cloud registration was completed using in scene targets as a default (3" and 6") and via 'cloud to cloud' registration where it was not possible to control the scan setups via targets, EDM control or scanner traverse/resection. 'Visual Alignment' was utilised in these cases. The Visual Alignment process used multiple passes over the global overlapping scan data to accurately and precisely register non-targeted scans at accuracies equivalent to RMS errors calculated for targeted scans. A full registration error report was generated and submitted as part of this process. Cyclone's Point Cloud Engine (PCE) intelligent management of point cloud database negates the requirement for data duplication via 'overview' scans.
A fully registered (to IG grid and datum, RGB), full density dataset in PCE format accessible via a free copy of 'Cyclone Viewer' OR Autodesk ReCap format, was generated. Users can define the 'visual density' of individual scans and the fully registered point cloud within the software based on the available specifications of the host PC. Overlapping scans contain valuable metric information, surface geometry and Scan to Scan registration information and are not removed by default. Cyclone PCE uses a process of 'Overlap Point Averaging' to greatly reduce the number of duplicate coordinates in scan overlaps without affecting global cloud density at overlap. This processing step was supplied to the PCE database and applied to the export of the archive format database. As part of the processing process the point cloud was 'cleaned' of any extraneous data collected.
Survey outputs
3D Modelling output and 3D Digital Output
Project requirements included;

- Clean up and import point cloud scan data
- Construct 3D model and materials of site
- Optimise model and split mesh into separate stones
- For areas of occlusion it will be necessary to project textures back onto new mesh
- Teams meeting for live model reconfiguration of stones for reconstruction purposes.

The 3D point cloud was exported as an x/y/z co-ordinate file and imported into Agisoft Metashape modelling software to create a 3D mesh and textures for rendering and visualisation. Model and

textures were exported into AutoDesk 3DS Max as an object to allow for cleaning up the mesh model and separation of assets before optimisation and manual occlusion reconstruction. Optimized 3D models were exported back into Metashape to reproject textures onto a new mesh and back into 3DS Max to finalise any amendments and prepare the model for manipulation.

3. Existing research

A number of interesting works have been published in recent years which deal with the question of the construction of Portal Tombs (Kytmannow 2008; McSporran et al 2013; Lynch 2014; Mercer 2015; Cummings & Richards 2021; Connolly 2021). The best understood method, highlighted by Cummings & Richards in their work on Garn Turne, south west Wales and again by Connolly in Killaclohane, Co Kerry, is where a large stone is selected and raised up *in situ*, eventually to form the capstone to the monument. This method of construction leaves a tell-tale stone-pit under the monument, outlining the original position of the capstone.

Clearly the other construction method would have involved the erection of the constituent elements, side stones, portal stones, back stones etc prior to the placement of the capstone. In Tirnony Co Derry, McSparron suggested that the construction of the tomb took place in a series of distinct steps, each of which, according to Mercer (p 137-139), might have had some ritual significance. There is good survival of the various constructional elements in the Doogort tomb. It is well described by de Valera and O'Nuallain (p 60-61), however they pose a series of questions about the surviving remains, wondering if the leaning eastern 1.9 m high tapered stone is the other portal stone, stating 'if it is a portal stone it seems to be considerably out of position' and they are not clear what the function of the 1.5 m high slab 'which leans heavily to the east'. Finally they note 'the large prostrate stone lying on the cairn at the south east…very probably the displaced roofstone'.

The unique approach to the present research design is that through existing non-invasive survey techniques the constituent stones of the monument can be individually manipulated and a virtual examination of the possible original construction can take place.

4. Significance of project

Studies of Irish Portal Tombs have either been through excavation (for example: Cooney 1997; McSporran et al 2013; Lynch; 2014; Connolly 2021;) or through field work and survey (for example de Valera & O'Nuallain 1964; Kytmannow 2008; Mercer 2015). The significance of the present proposal is that it has the potential to combine both of these approaches, undertaking a detailed laser scan survey of the monument and to manipulate the orthostatic elements, without the need to undertake physical excavation, leading to a proposed archaeological reconstruction.

This approach has been used in a limited way previously on Poulnabrone (Lynch p 178), where a laser scan undertaken by the Discovery Programme digitally maneuvered the subsidiary capstone back to what is considered to be it's original position. The present proposal will be the first time this method will be employed to digitally maneuver the majority of the constituent elements to arrive at a considered reconstruction of the tomb.

If successful, the methods employed on the Doogort Tomb can be transferred to other collapsed and / or disturbed monuments, allowing for reconstructions to be proposed for these monuments also. One of the major benefits of this approach is that the monument remains untouched with reconstructions taking place virtually and additionally, because it all takes place digitally, the various options for the reconstructions can be explored and shared quickly and efficiently and can easily include the input of other experts, for example structural engineers. Moreover, because the project

outputs are digital, these can easily be shared on social media to inform and engage as wide an audience as possible.

5. Survey results

The survey was undertaken on 5th August 2022 by Ciara McManus of *FarrimondMcManus* and Conor Graham, with the results processed and graphics and models produced by Andrew Castle of *Pivotal Animations.*

Prior to the survey, a number of presumptions were made, firstly that the majority of the constructional elements of the portal tomb were extant and, perhaps most significantly, that the large flat stone, lying to the southeast of the orthostatic elements, represented the capstone. It was also presumed that its present location derived from its collapse from the tomb. De Valera and O'Nuallain, in their 1964 survey, thought so, noting that 'it is very probably the displaced roof stone'.

Plate 6 Detail of lichen growth on straight face of cap stone

This roof stone has been the subject of some speculation. De Valera and O'Nuallain noted that it's 'north-west edge shows a clean break which looks comparatively recent', going on to relate a local story which recounted 'that the slab was fractured by the lighting of a bonfire upon it and that the detached portion was used as a lintel in a nearby house.' As part of the preparatory work to the present survey, the family of the owners of the 'nearby house' (see front cover) who are also the owners of the land on which the portal tomb is situated, were interviewed and while being aware of the story, are adamant that no structural elements of the tomb were used in the construction of their ancestral home. While it is not entirely conclusive, an examination of the ruined remains of the house, which is located some 15 m to the northwest of the portal tomb, did not reveal any stones, lintels or otherwise, which would fit the profile of the capstone. It is also noteworthy that the exposed 'clean break' as described by de Valera and O'Nuallain, is not really that clean at all. The exposed surface of the break is in fact covered in a variety of lichen species (Plate 6), some of which are notoriously slow growing, which are unlikely to have colonised the face of the stone had the

break occurred when the nearby house was built sometime in the early 19th century. It therefore must be concluded that the roof stone in its present state has remained unaltered since it was used in the construction of the portal tomb.

In regards to the other constructional elements, it was clear that the 1.9 m high tapered southeast orthostat had tipped significantly to the west, coming to rest on the large flat orthoststic slab which forms the western side of the tomb. De Valera and O'Nuallain considered that this tapered orthostat 'may not be in situ', because its shape suggested that it may have formed a pair with the main portal stone. However, they noted that it was a much smaller stone that the main 2.3 m high portal stone, and postulated that the difference in height might be accounted for by the potential loss of part of its base. As there was no surface evidence for this stone either being broken or being ex-situ, it seemed simpler and more straightforward to consider that at least its base was in its original position.

Of the other elements, the main 2.3 m high portal stone, while clearly in situ, did exhibit a slight lean from the vertical to the east, as did the large flat orthostatic slab lying against it to the south. Two further earthfast stones were noted in the vicinity and appear to be part of the construction of the tomb. The first, located roughly 1.2 m to the south of the monument, stands some 0.6 m in height. De Valera and O'Nuallain noted that 'its top edge is irregular and appears to have been damaged' but suggested that it might mark the location of a back-stone to the chamber, however there was nothing to indicate how tall this stone may once have been. The other stone is located some 2.5 m east of the main portal stone. It stands a mere 0.25 m high and according to de Valera and O'Nuallain, the 2.5 m wide gap would be 'unusually wide' if it were to be interpreted as the remains of the other portal stone. This view is supported by Kytmannow's survey where she notes that the distance between portals ranges from as little as 0.4 m to 1.95 m with an average of 0.88m (p 40). An examination of the exposed surface of this low stone and the base of the larger 1.15 m long stone lying immediately to the east, suggests that the two fragments may originally have part of a single orthostat.

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6. References

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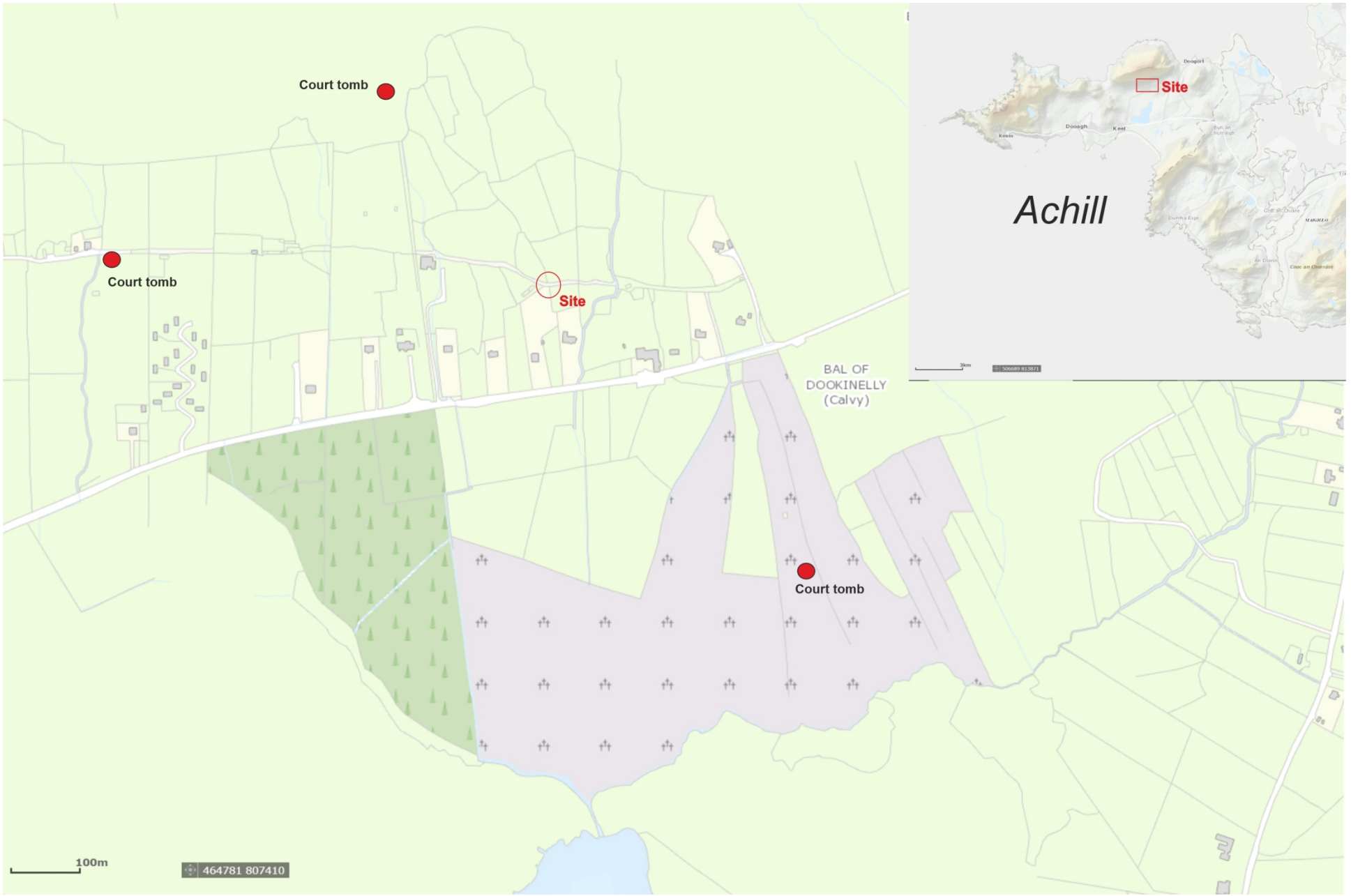
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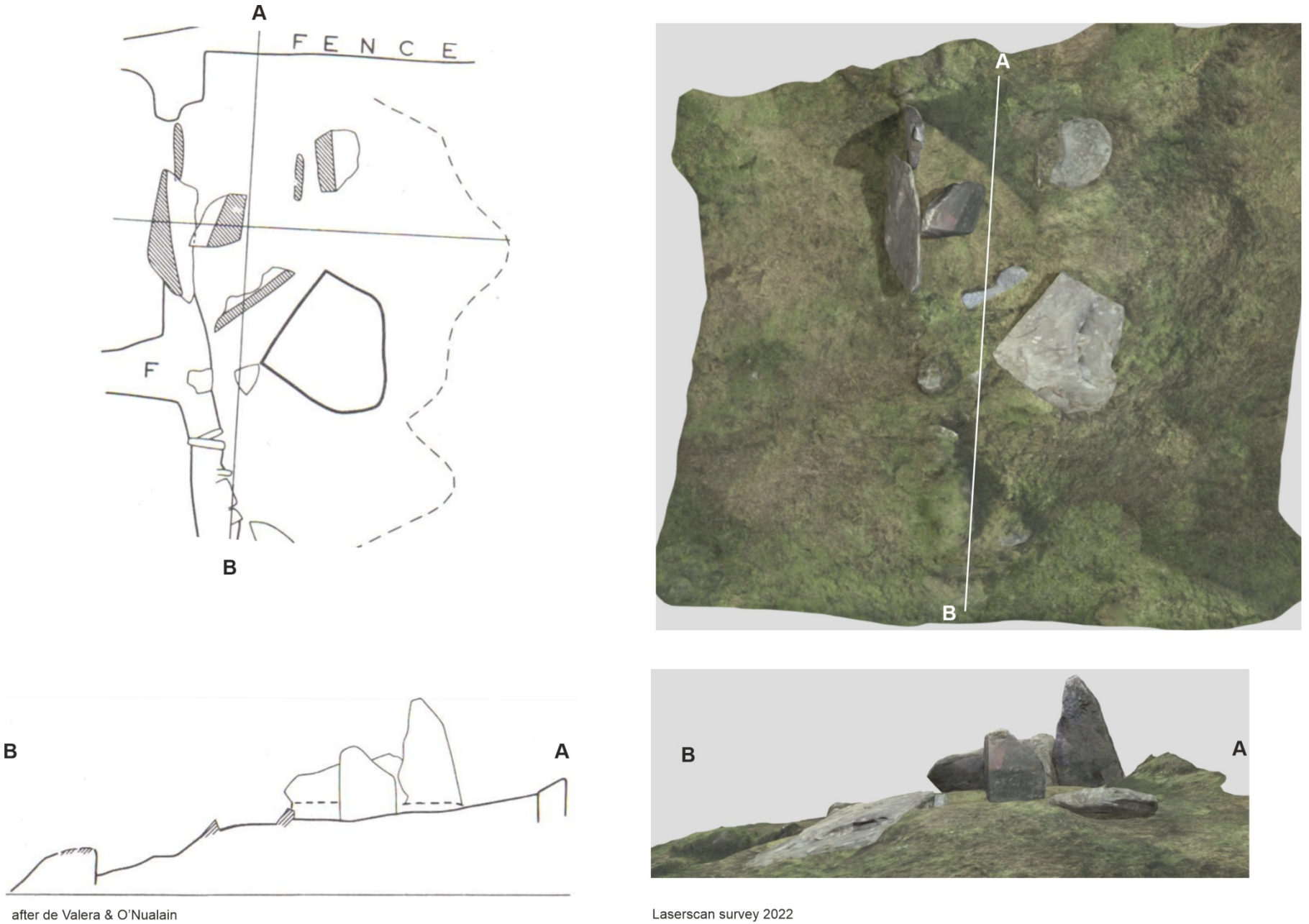

after de Valera & O'Nualain

Laserscan survey 2022

Fig. 2 Plans and elevations of the existing site from 1964 on left and 2022 on right

Fig. 3 Reconstruction of site, east facing elevation

Fig. 4 Reconstruction of site, north facing elevation

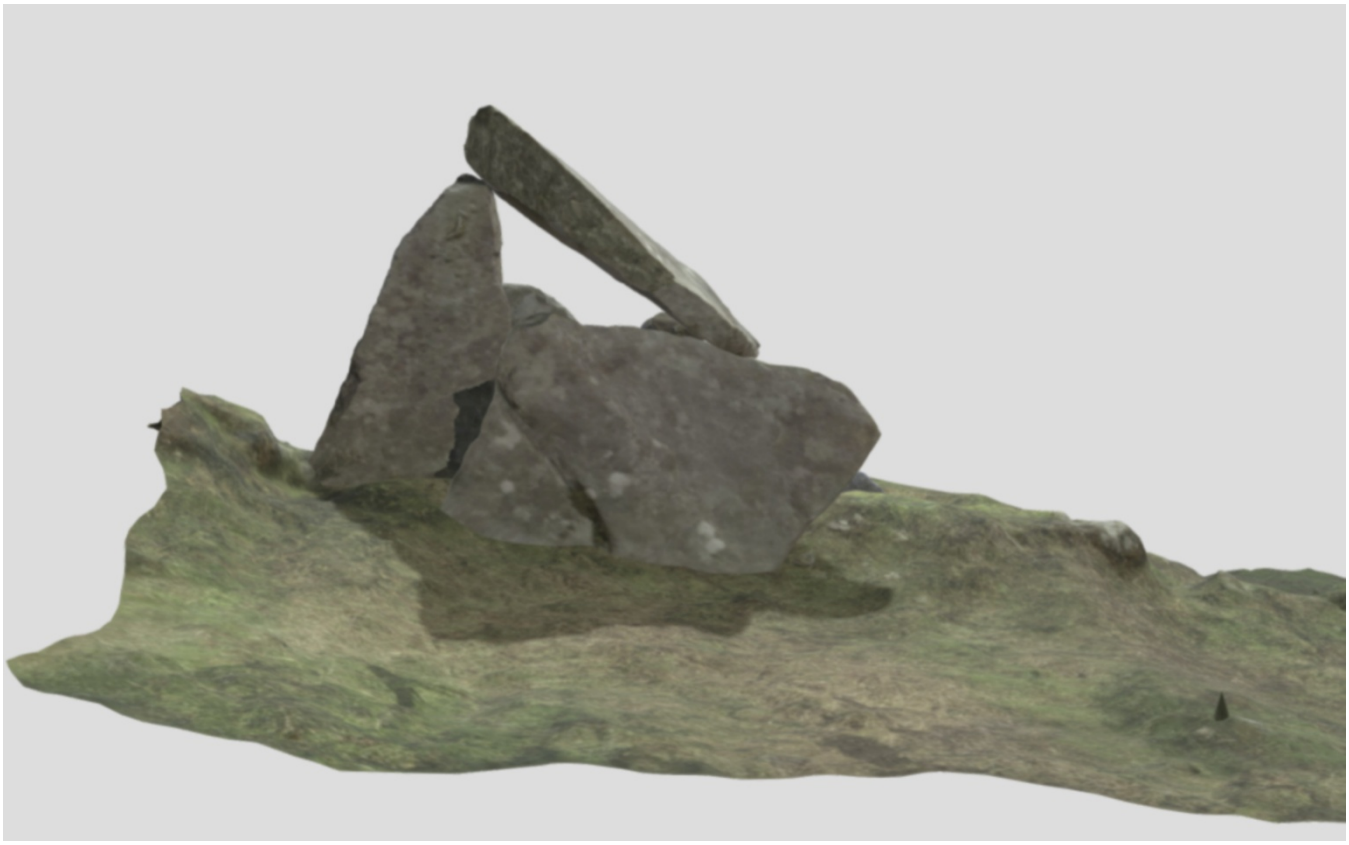

Fig. 5 Reconstruction of site, west facing elevation

Fig. 6 Reconstruction of site, south facing elevation

Fig. 7 Laser printed structural elements at 1:20 scale