The SCAPE Trust
The University of St Andrews
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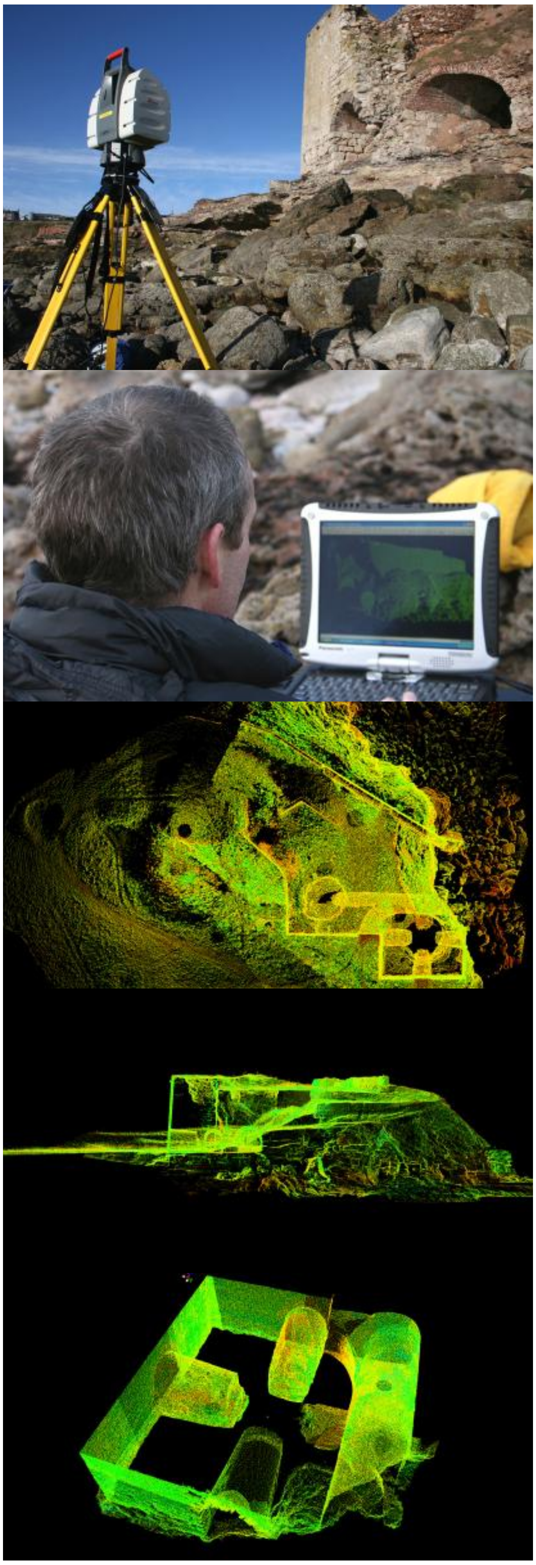
SCAPE
Scottish Coastal Archaeology and the Problem of Erosion



The Eroding Limekilns at Boddin Point, Angus

preservation by digital record

University of St Andrews

Queen's University Belfast

HISTORIC SCOTLAND

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Contents

Figures

Introduction

The remarkable group of 18th century limekilns which stand at the end of the Boddin Point promontory, Angus, are collapsing into the sea as a result of coastal erosion (Figure 1). In order to capture information about the monument before further loss, the kilns were recorded with a terrestrial laser scanner. The resulting digital archive will form the baseline against which future change to the monument can be measured, as well as the basis for innovative presentation of archaeological information.

Background to the project

The limekilns were photographed by John Hume in 1977, at which time the structure was intact (Plate 1). In 2009, a coastal zone assessment survey of Angus was completed by The SCAPE Trust (Dawson *et al*., 2009). This noted that parts of the limekilns had collapsed (Plate 2). The extent of the damage can be clearly seen when the 1977 image is overlain on the more recent photograph (Plate 3).The coastal zone assessment survey report carried a recommendation that the limekilns should be surveyed, as the site was under severe threat from coastal erosion.

In a report to Historic Scotland prioritising action at the 11,500 sites recorded within all of the coastal surveys completed to date (Dawson, 2010), the Boddin Point limekiln was graded as a top priority site requiring action. It was recommended that the site should be surveyed, preferably by laser scanning. The SCAPE Trust submitted a project design to undertake this work in collaboration with the School of Geography, Archaeology and Palaeoecology, Queen's University, Belfast. Historic Scotland funded the survey.

Project aim

The purpose of the project was to use terrestrial laser scanning technology, supported by photography and basic historical research, to create a detailed digital record of the important group of limekilns at Boddin Point that are at high risk of loss from coastal erosion. This resulted in a 3D model of the monument being created, contributing to the 'preservation by record' of the threatened structure. The resulting data will form a baseline against which to measure changes to the monument in the future. The digital data set is extremely flexible and the 3D model can be used to produce cross sections (A-D); virtual representations (Scans1-3); highly accurate plans (Scans4-6); elevations (Scans7-9); and detailed views (Scans10-12). Although the elevations seem almost photographic in nature, they are produced from the point cloud, and so are more akin to rectified photographs as there is no foreshortening affecting the image. The detail of the survey also means that measurements can be taken of any part of the structure, including across cracks in the walls (Scan 10). These measurements can be used for ongoing monitoring.

Methodology

Between February 23rd and February 27th, a team from Queens University, Belfast carried out terrestrial laser scanning of the kilns and their immediate landscape setting (Plates 4 and 5). Data was captured of the external and internal surfaces of the structure with a Leica 3D laser scanner (HDS 3000). The instrument was set up in twenty different positions and over 40 million individual points were recorded. The raw data was processed using the Cyclone software package, which facilitated joining the

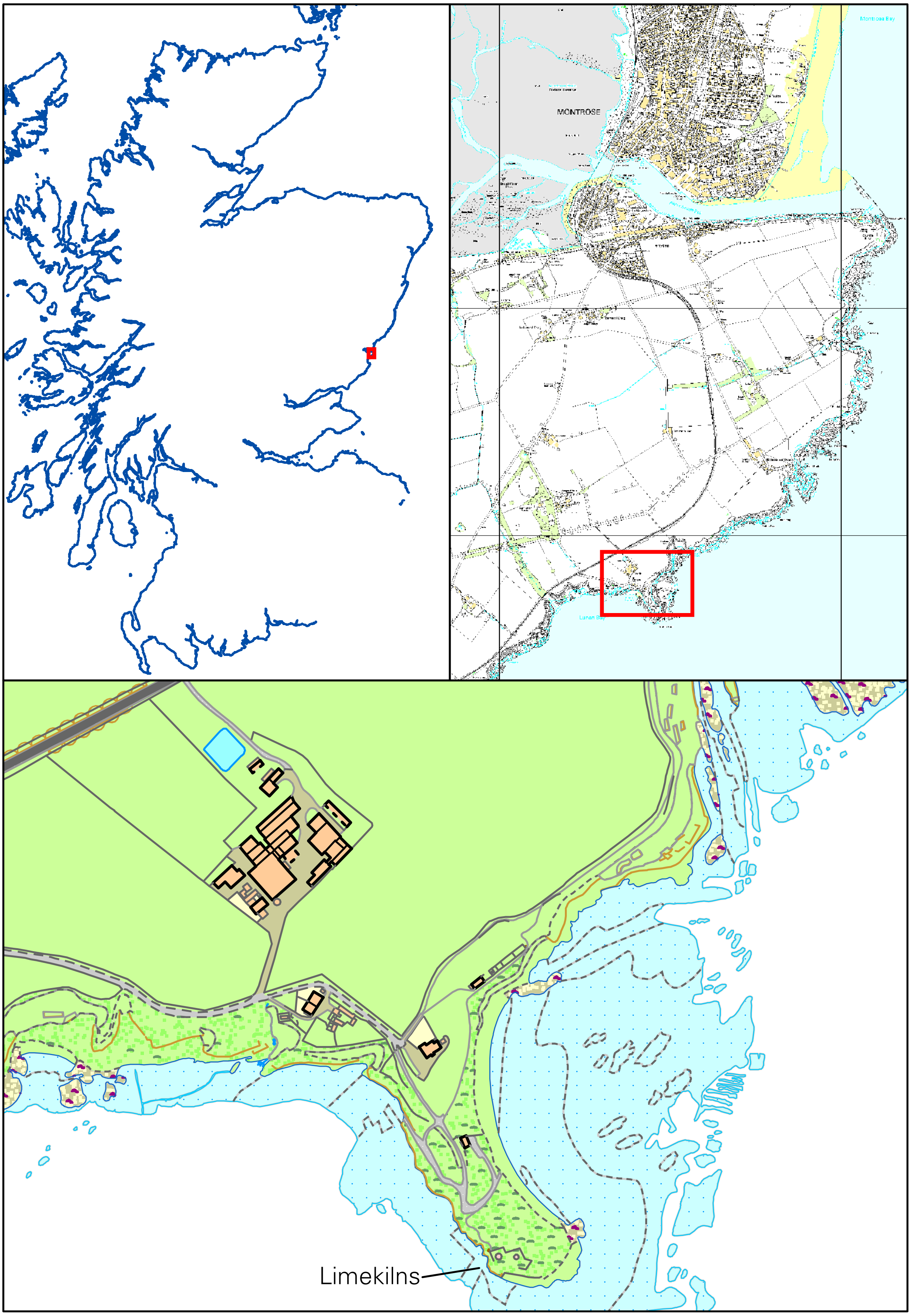

Figure 1. Location Map showing the limekilns at Boddin Point.

individual scans together to produce a point cloud. Further processing was undertaken in Cloudworx and AutoCAD, enabling the production of 2D and 3D elevations, sections, plans and 'fly through' models.

Members of The SCAPE Trust joined the survey team, taking digital photographs to record both the process of data capture and to produce an updated record of the eroding structure. Brief historical research of published sources was undertaken to provide background context.

Historical background

The limekilns feature on the First Edition Ordnance survey map of 1865 (Figure 2). Three kiln bowls are depicted (Figure 3) although today, only two of the kilns are upstanding; these are thought to have been constructed *c.* 1750 by Robert Scott of Dunninald. The visible structure consists of a 4-draw kiln and a 3-draw kiln. The third kiln, which is possibly earlier, is now almost completely buried within an earthwork mound (Plates 6 and 7).

The kilns were built during a period when agrarian improvements and enclosure created an enormous demand for lime. 'Liming' or the application of lime to soil was used until the late 19th century to reduce acidity and improve the workability and drainage properties of heavy clay soils.

The Second Statistical Account (revised in 1835) notes that limestone was first extracted from the headland at Boddin in 1696, and it is possible that the buried kiln dates to this period.

Although this date isn't recorded in the First Statistical Account (1791-99), the lime works are mentioned, being regarded as one of the '*advantages'* of the parish as they gave farmers easy access to lime. The Account notes that changes to agricultural practices had started *'about 60 years ago,* [when Mr Scott of Dunninald and his brother] *began gradually to make considerable improvements in the cultivation of their lands. They had plenty of lime within the parish'*.

In 1826, Lyell (p 114) noted that there was a stratum of limestone at Boddin '*which has been long worked, but is now nearly exhausted'*. The Second Statistical Account also records that the limestone was nearly exhausted; adding that the lime workings were abandoned in 1831.

The industrial process

Limekilns transform calcareous rock, usually limestone or chalk (where the raw material is in its insoluble and solid, calcium carbonate state), into calcium oxide or quicklime, also called lump lime because of the lump-form of the product from the kiln. Quicklime reacts with water (in what can be a dangerous and vigorous chemical reaction that generates extreme heat and steam) to produce a fine powder of calcium hydroxide or slaked lime, which can be incorporated into the soil. In practice, the lump lime was transported from the kiln to the fields and dispersed in small heaps and left to slake over time, with the lumps breaking down into a fine powder to be ploughed into the soil (Williams, 2004).

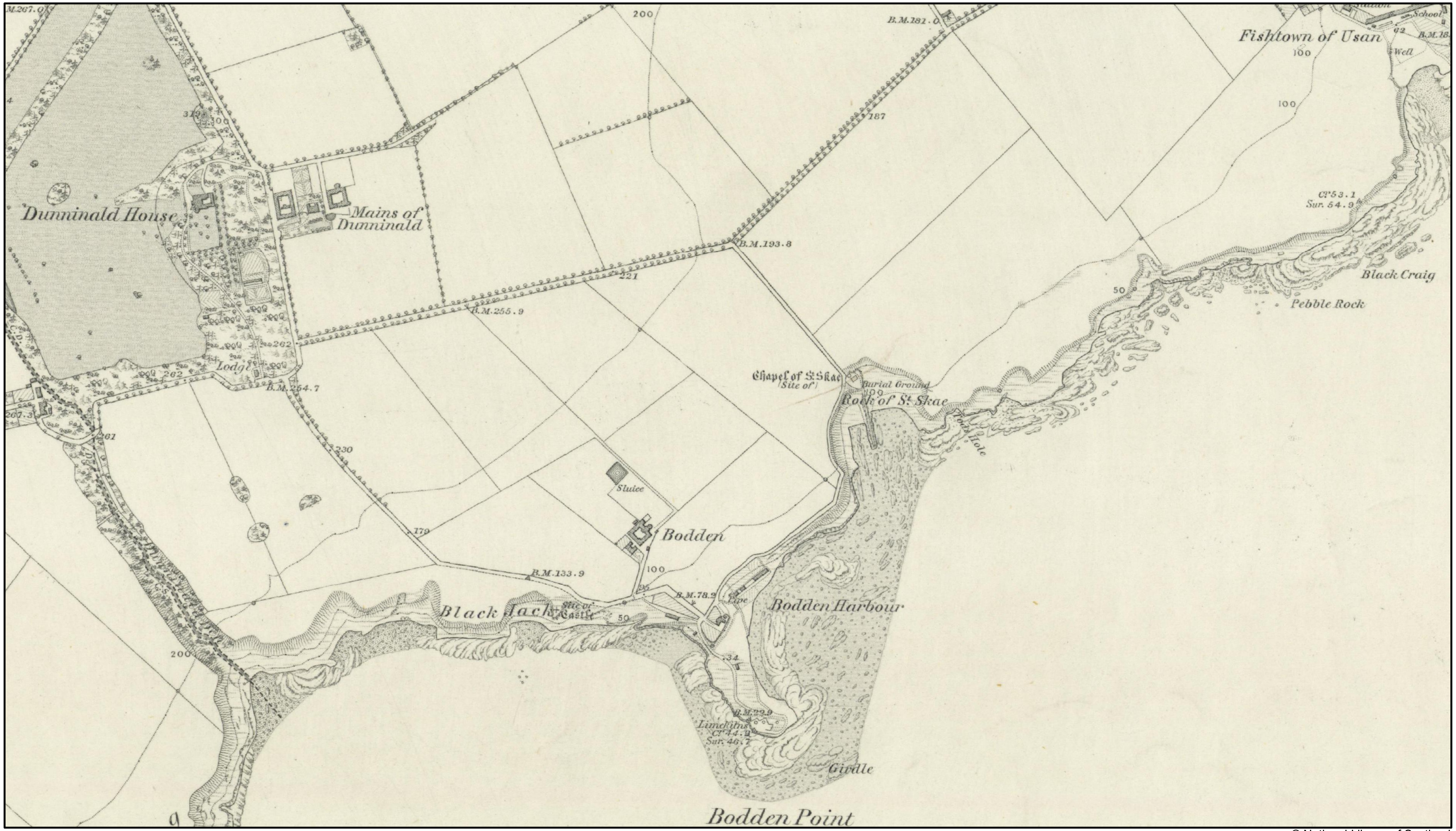

Figure 2. First Edition Ordnance Survey Map showing Boddin Point and its proximity to Dunninald. (scale 1:10,000)

Figure 3. First Ed. OS map showing the limekilns at Boddin, with modern MHWS marked in blue and the cliff top marked in brown. (scale 1:1500)

The situation of the limekiln

Coastal locations for limekilns were favoured because the bulky raw materials, coal and limestone, could be transported in by sea and the resulting product exported out again (Whyte and Whyte, 1991; Williams, 2004). The location of the Boddin Point limekilns is a result of both the geology and the coastal situation. Coal was brought in by ship from central Scotland, and a fault in the Lower Old Red Sandstone volcanic rocks (mid Devonian and Silurian basaltic and andesitic lavas) at Boddin brings down Upper Old Red Sandstone sedimentary mudstones and sandstone rich in 'cornstone', a calcareous concretion formed in the semi-arid conditions of the Late Devonian period (Browne *et al*., 2002). This was the source of the lime burnt in the Boddin kilns (Plate 8).

Coastal erosion at Boddin

The quarrying of the limestone, together with coastal processes, has led to a change in the shape of the promontory. The First Edition Ordnance Survey map (1865) was surveyed after the quarry had ceased to operate. Figure 3 shows the present position of the Mean High Water Springs (MHWS) together with the top of the cliff superimposed onto the 1865 map. It appears that the west coast of the headland has suffered heavy erosion, confirmed by the partial collapse of the limekiln; the destruction of a small fishing harbour to the north; and the exposure of the former road leading down to the limekiln in the coastal section. Changes to the position of the MHWS depicted on the two maps are due to coastal processes rather than quarrying.

Description of the kilns

The kilns at Boddin (Figure 4) are fine examples of continuous draw kilns, with stone-lined burning chambers capable of withstanding continuous firing over a long period (Plates 9, 10 and 11). The 3-draw (kiln 2) and 4-draw (kiln 3) block at Boddin is built at the end of a headland, possibly utilising a pre-existing bank of till and dumped kiln waste. The industrial debris may derive from the earlier kiln (kiln 1) depicted on the First Edition Ordnance Survey map (Figure 3) and just visible on the ground. It is not known how much of the till that makes up the bank is *in situ* or how much has been re-deposited; its origin is possibly the overburden resulting from quarrying operations on the promontory.

The bank is retained by substantial stone walls to the south, north and west (Plates 12 and 13). The north wall of kiln 2 is almost 8 metres high, and that of kiln 3 is almost 9 metres.

The burning chambers were built into the bank and dumped material. The bank also gave access, via a ramp which circles around the eastern and southern parts of the structure, to the top of the burning chambers for charging. In a typical draw kiln, the chamber was loaded from the top with alternate layers of limestone and coal in a ratio of three to five parts stone to one of coal. A draught was provided for the fire through the draw holes set into arched recesses in the thick kiln walls (Plate 14). These were connected to the base of the burning chambers and also gave access to moveable iron bars which supported the charge and could be adjusted for drawing off the quick lime. At Boddin, kilns 2 and 3 were connected by an east-west oriented brick-vaulted tunnel which gave access to both burning chambers. This would have allowed the quicklime to be drawn from the bowl in wet weather and would have provided dry storage space for tools, kindling etc. (Plates 15 and 16).

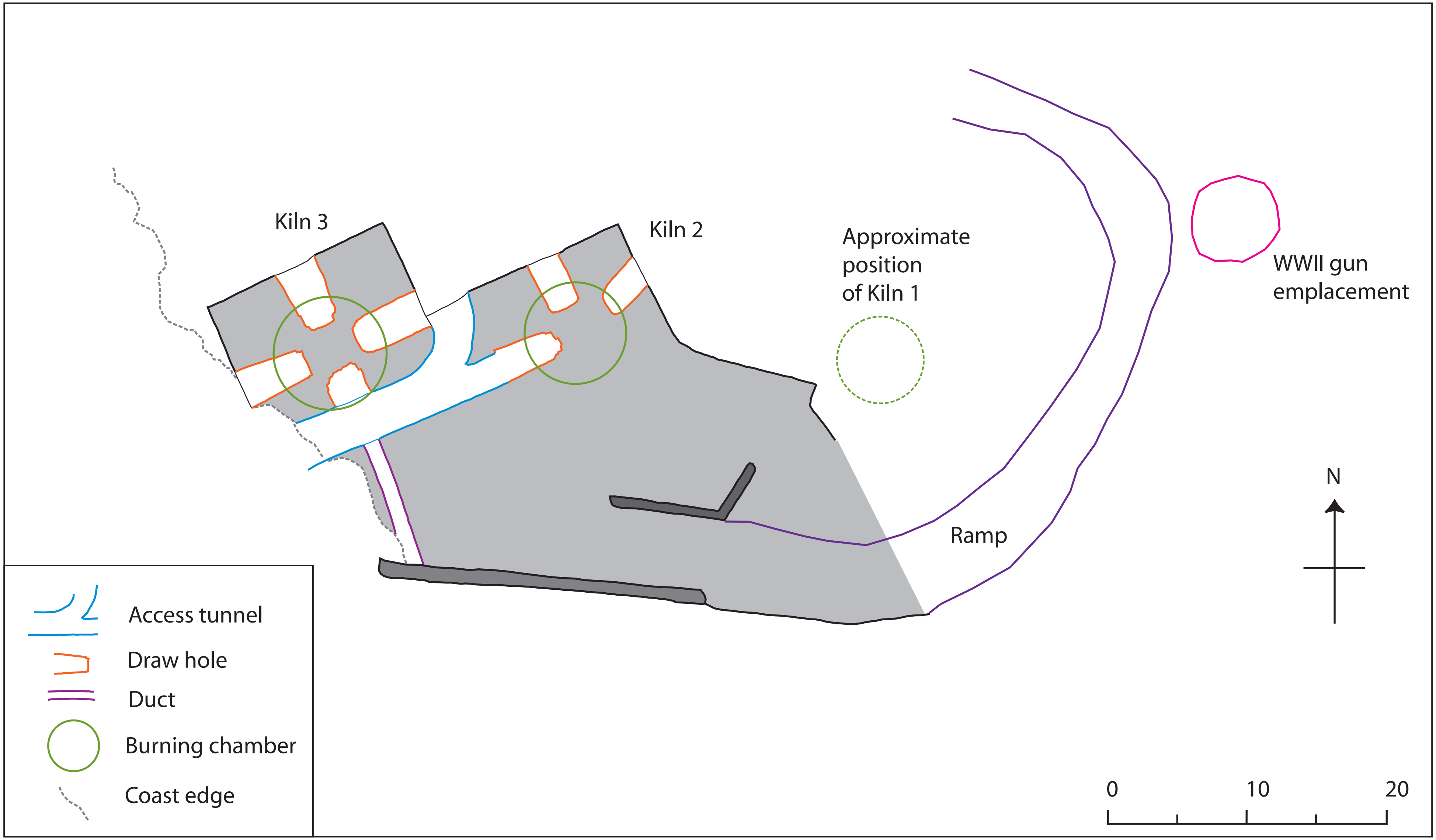

Figure 4. Plan showing principle elements of the limekiln recorded during the survey.

Erosion has led to the collapse of a substantial portion of the southwest quadrant of the structure. At least two thirds of the west wall and the southwest corner of the southern wall of the structure have collapsed exposing the vulnerable rubble and soil core of the monument. Internal structures such as the stone-lined burning chamber of kiln 3; a stone-lined duct (Plate 17); and the brick vaulted interconnecting tunnel are now collapsing. The bedrock platform upon which the whole of the western edge of the monument is constructed comprises a narrow band of sandstone underlain by softer mudstones and siltstones, which are being eroded by wave action leading to significant undercutting of the rock platform. The remainder of the west wall has now been undercut and further collapse of the monument is imminent (Plates 18 and 19).

Results

The survey resulted in a highly detailed point cloud of the Boddin limekilns, containing over 40,000,000 3-dimensional coordinates. The collected data has been used to produce short videos of the site. These include fly-throughs and films showing the extent of the structure at incrementally decreasing and increasing heights above sea level (reducing the full structure down to ground level and then rebuilding it again). The data can also be used to create elevations, plans, cross sections and 3-dimensional images that easily allow the viewer to understand how the limekilns functioned and the relationship between the different elements. A selection of these are illustrated in this report (Cross Sections A-D; Scans 1-12)

The films and still images will be made available via the SCAPE website, and given to Historic Scotland and other relevant heritage agencies as requested. The data has also been offered to CyArk (http://archive.cyark.org/), an organisation that collects digital data about threatened heritage monuments from around the world. Inclusion on CyArk will enable a world-wide audience to learn about the threat to Scotland's coastal heritage from erosion.

Acknowledgements

The SCAPE Trust thanks John Stansfeld of Dunninald for access to the Boddin limekilns and for his interest in the project. The support of Noel Fojut and funding from Historic Scotland enabled the project to take place and is gratefully acknowledged.

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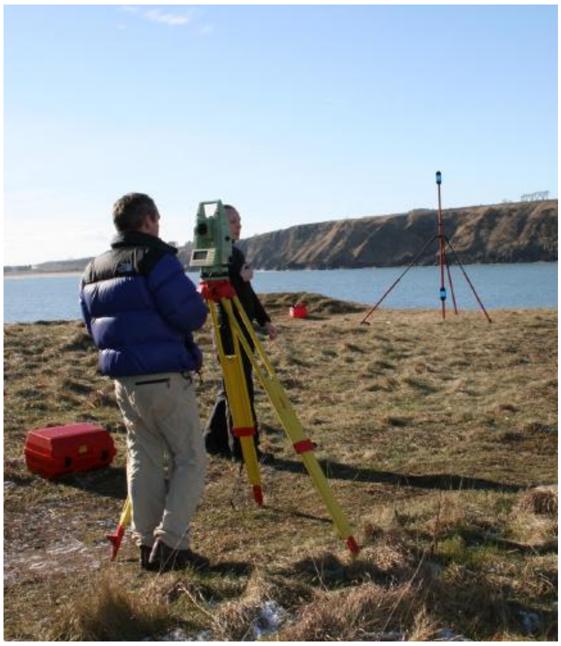
Plates

Plate 1. Boddin limekiln photographed by John Hume in 1977 (copyright RCAHMS)

Plate 2. Boddin limekiln photographed in 2010, showing the collapsed south western corner.

Plate 3. Images taken in 1977 and 2010 (plates 1 and 2) superimposed to show extent of damage to south western corner.



Plates 4a and 4b. Scanning and surveying in progress.

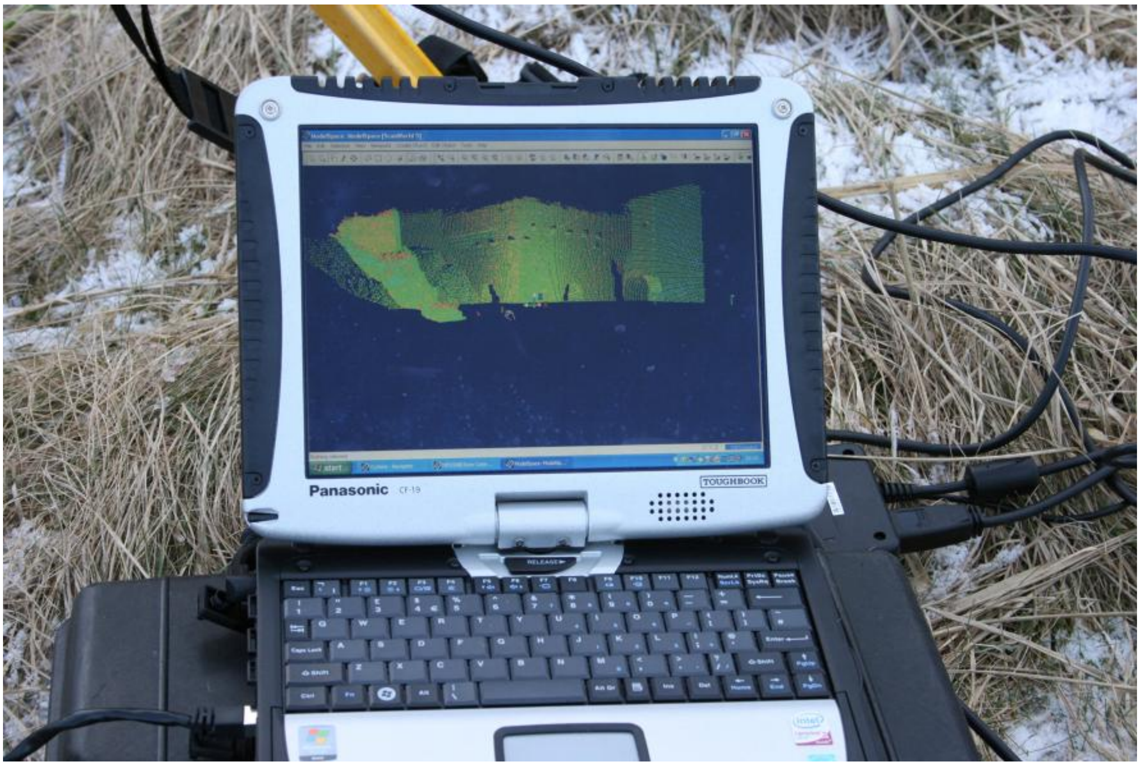


Plate 5. Initial low resolution scan in progress in the field. This is used to define the detailed scan area.

Plate 6. The situation of the limekilns at the end of the Boddin Point promontory. The main block comprises the 3-draw kiln on the left and the larger 4-draw kiln to the right. The probable earlier kiln is buried within the earthwork mound to the left of the main structure.

Plate 7. View of limekilns looking west. The circular depression in the foreground is a 2nd World War feature. The earlier kiln is buried within the earthwork mound in the centre of the picture. The ramp for bringing coal and limestone to the top of the firing bowls can be seen swinging round between these features and along the back of the bank into which the kilns have been constructed.

Plate 8. Exposure of the Upper Old Red Sandstone at Boddin Point, showing cross bedded carbonate rich sandstones and mudstones.

Plate 9. Inside face of the stone-lined burning chamber of the kiln 3 taken from the top of the kiln looking southwest. Also shown is the collapsed southwest corner of the main south retaining wall of the kiln block.

Plate 10. Top of the burning chamber of kiln 2, looking south. The ramp is between the low walls in the right hand corner of the picture.

Plate 11. The internal structure of the kiln block showing the stone-lined burning chamber of kiln 3; the eroding opening of the brick vaulted interconnecting passage between kilns 2 and 3; a collapsed capstone of a stone-lined duct between the inter-connecting passage and the base of the southern retaining wall; and the infill creating the bank into which the kiln stucture has been built. Note the large intact fragment of archway from the eroding passageway in the foreground.

Plate 12. The surviving part of the west elevation of the limekilns showing the western stone-lined draw hole of kiln 3, with the eroding interconnecting passageway to the right. The internal structure of the burning chamber is visible above the draw hole. Note the undercut rock platform upon which this part of the kiln block is built.

Plate 13. View of the southern elevation of Boddin limekilns, looking north. The main seaward retaining wall of the structure is pierced with drainage holes. Turf covered debris from the kilns mixed with redeposited till is piled against the outside face of the wall. Eroded cavities in the soft mudstone of the rock platform have been revetted with sandstone blocks. The eroded opening of the interconnecting passage can be seen in the left of the picture.

Plate 14. Drawhole recess in the north elevation of kiln 3, showing the brick-vaulted roof and stepped arches of the (blocked) drawhole.

Plate 15. Entrance to the interconnecting passage in the north elevation of the kiln block. The eastern drawhole recess of kiln 3 is to the right.

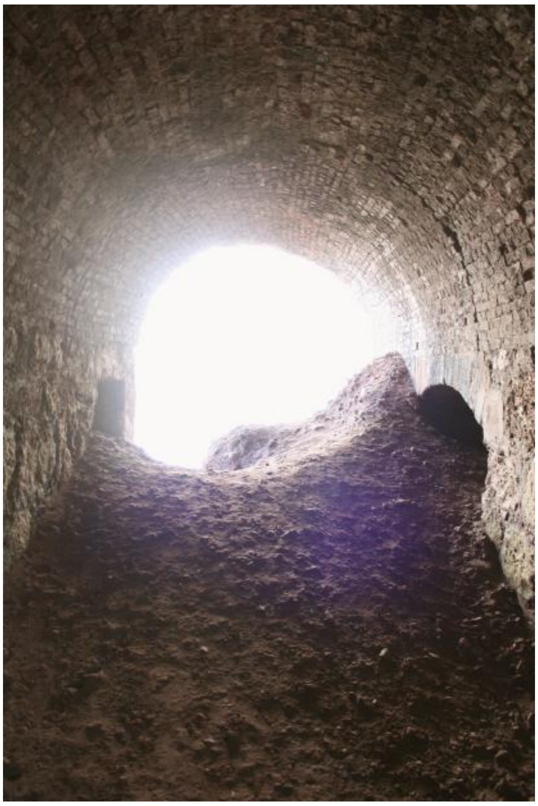


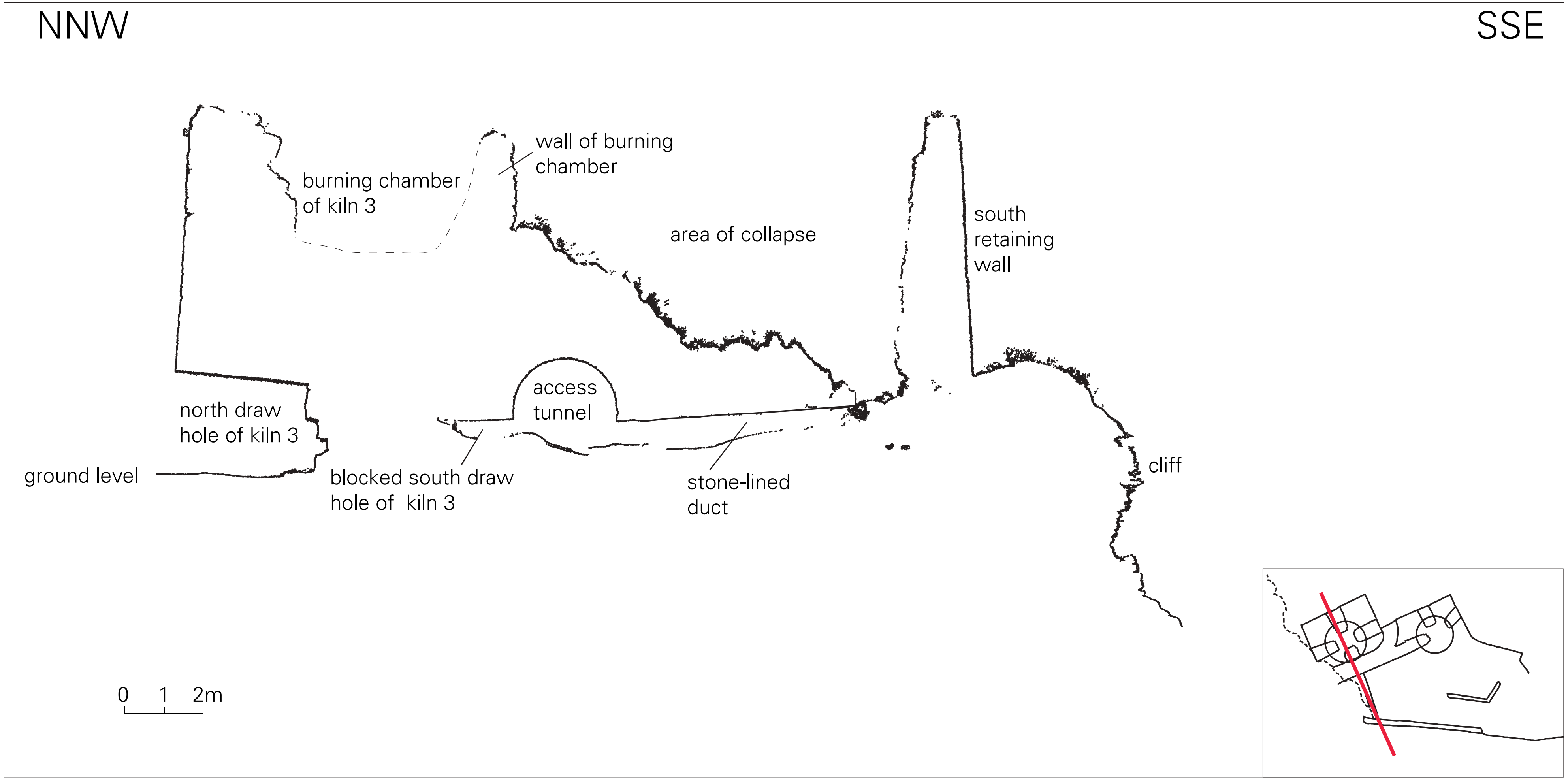
Plate 16. Looking west down the inter-connecting passage towards the collaps-ing western entrance. The opening of the stone-lined duct is visible on the left.

Plate 17. View down the stone-lined duct running between the central interconnecting passage and the base of the south retaining wall. The fallen capstone is in the background. Taken from inside the interconnecting passage looking south.

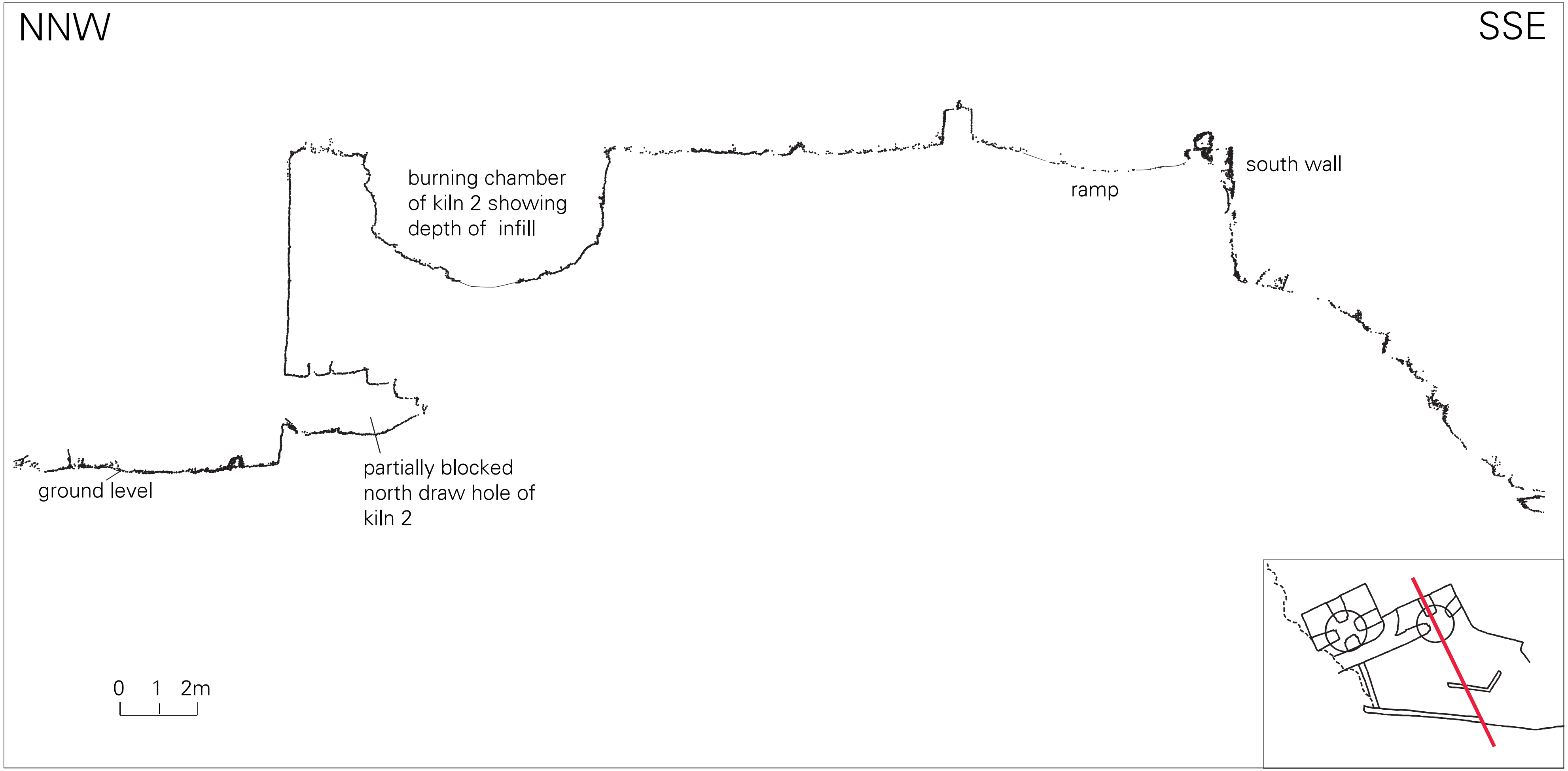
Plate 18. The collapsing western side of the kiln block showing undercutting of the rock platform.

Plates 19a and 19b. Two views of the vulnerable western side of the kiln structure taken at higher and lower states of the tide, looking southeast. The rock platform underlying the remaining northwest corner of kiln 3 has been undercut and the collapse of this part of the monument could occur at any time.

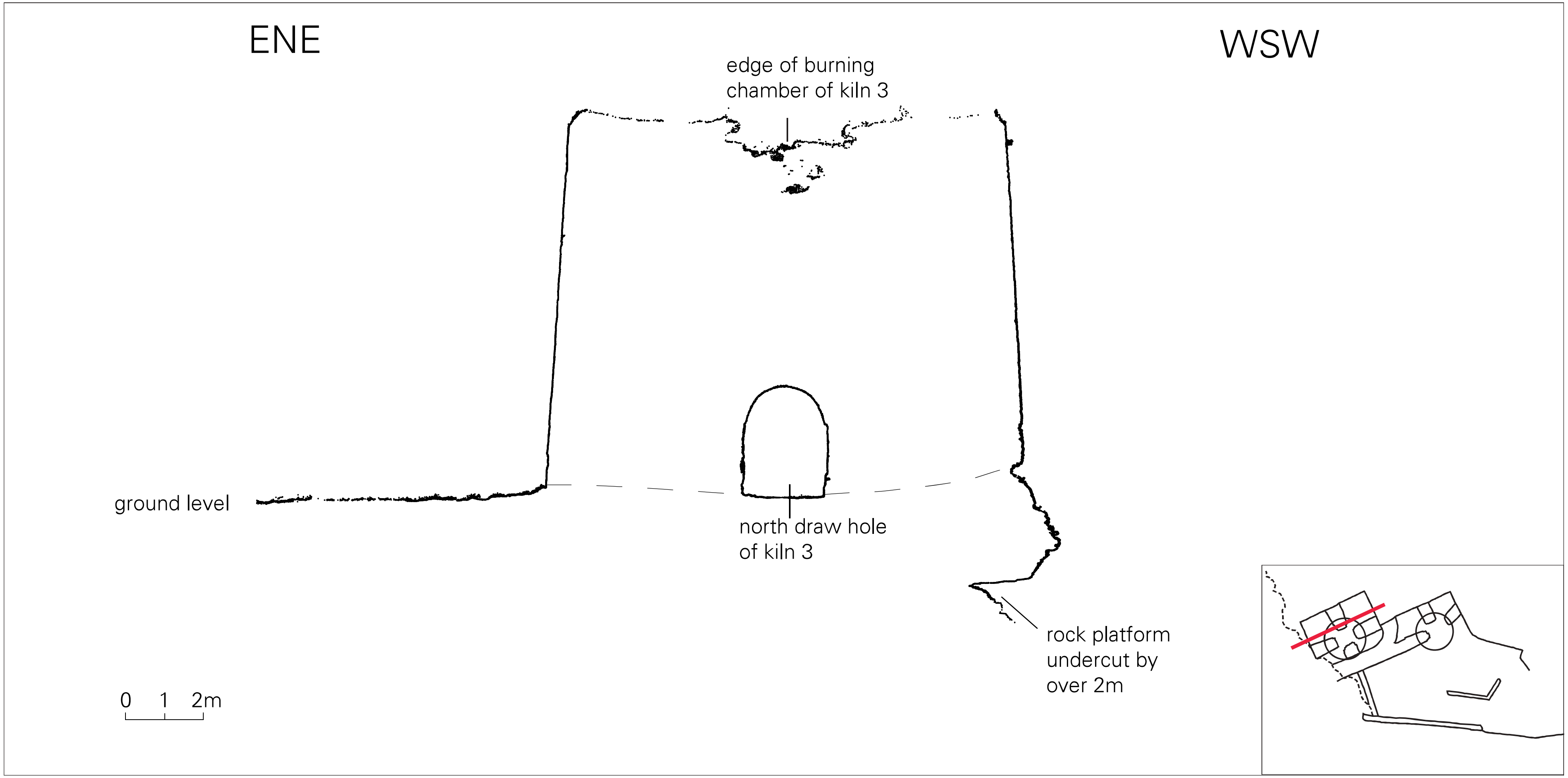
Cross sections



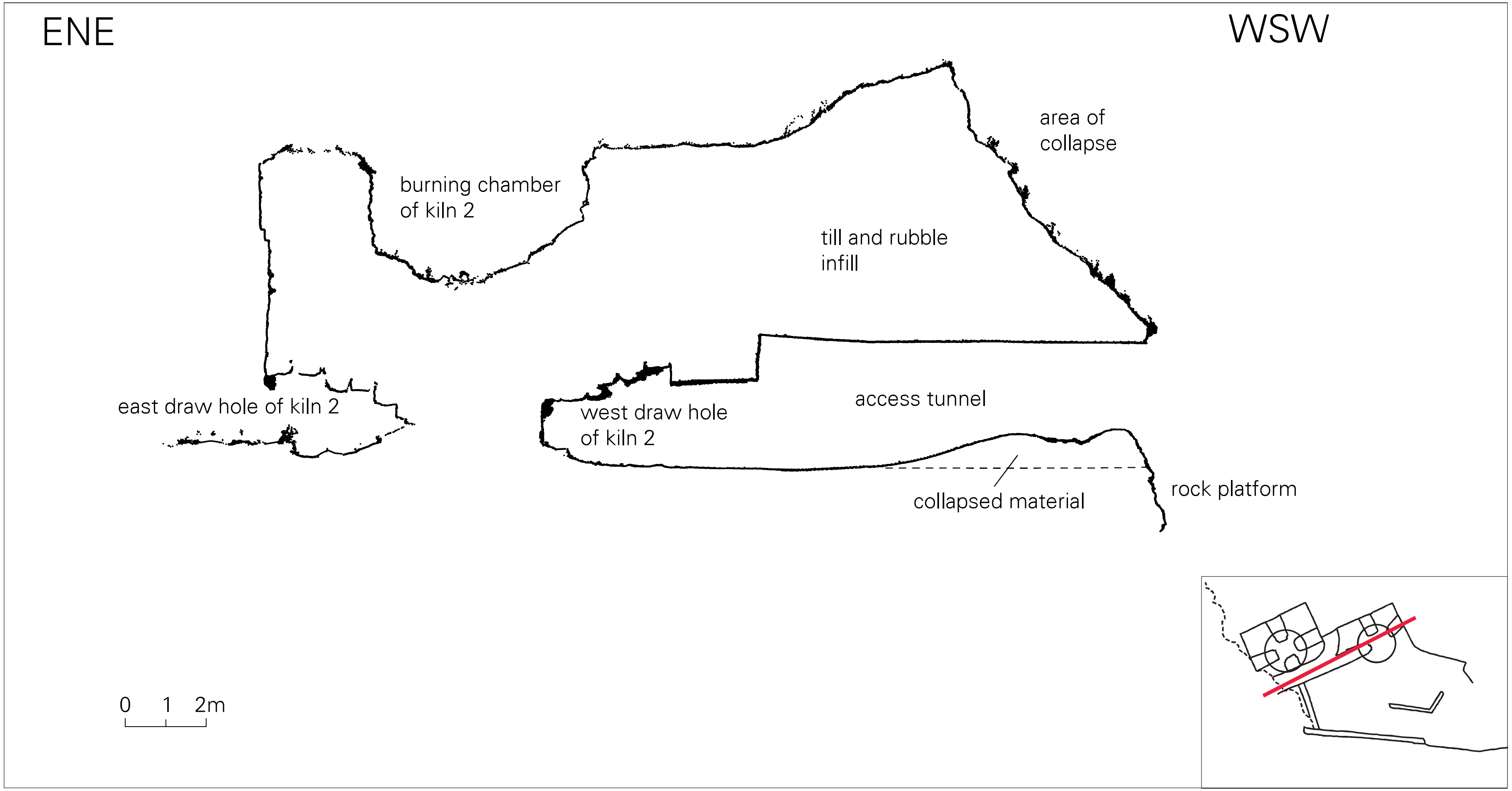
Cross section A. Raw view of north-south section through the limekiln structure generated from scanning data



Cross section B. Raw view of north-south section through the limekiln structure generated from scanning data

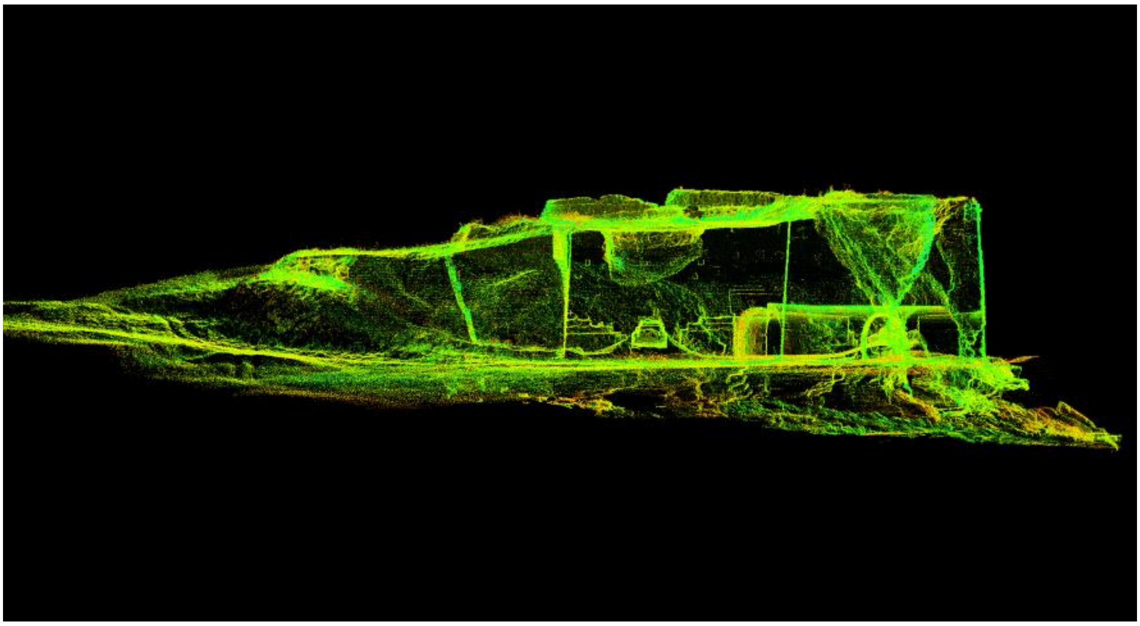


Cross section C. Raw view of east-west section through kiln 3 showing undercutting of rock platform below west wall

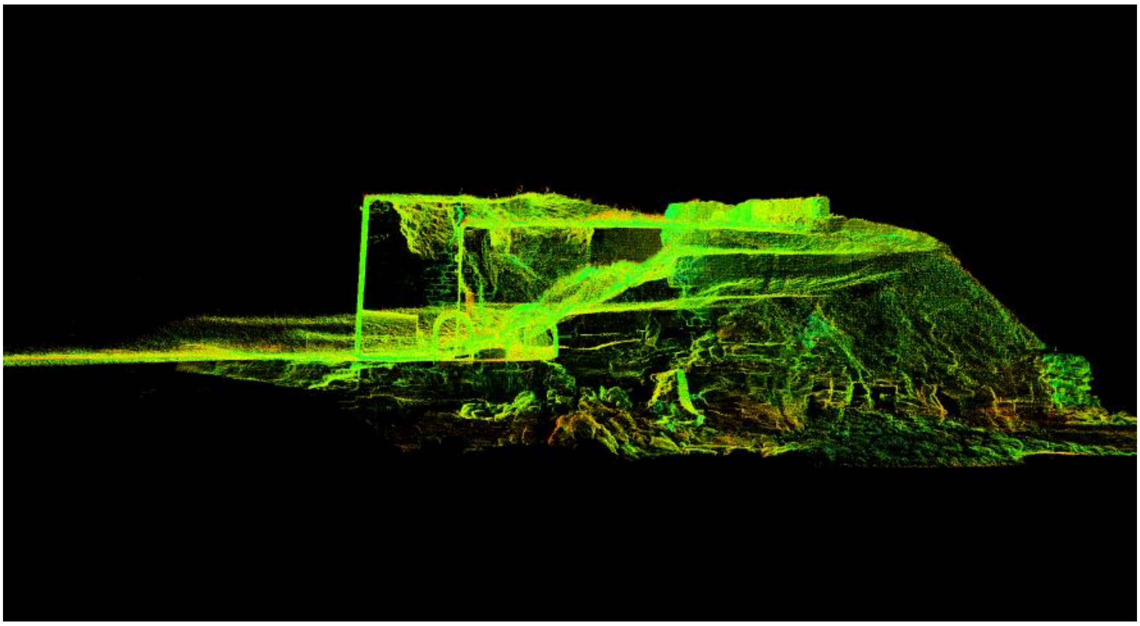


Cross section D. Raw view of east-west section through access passage and across kiln 2

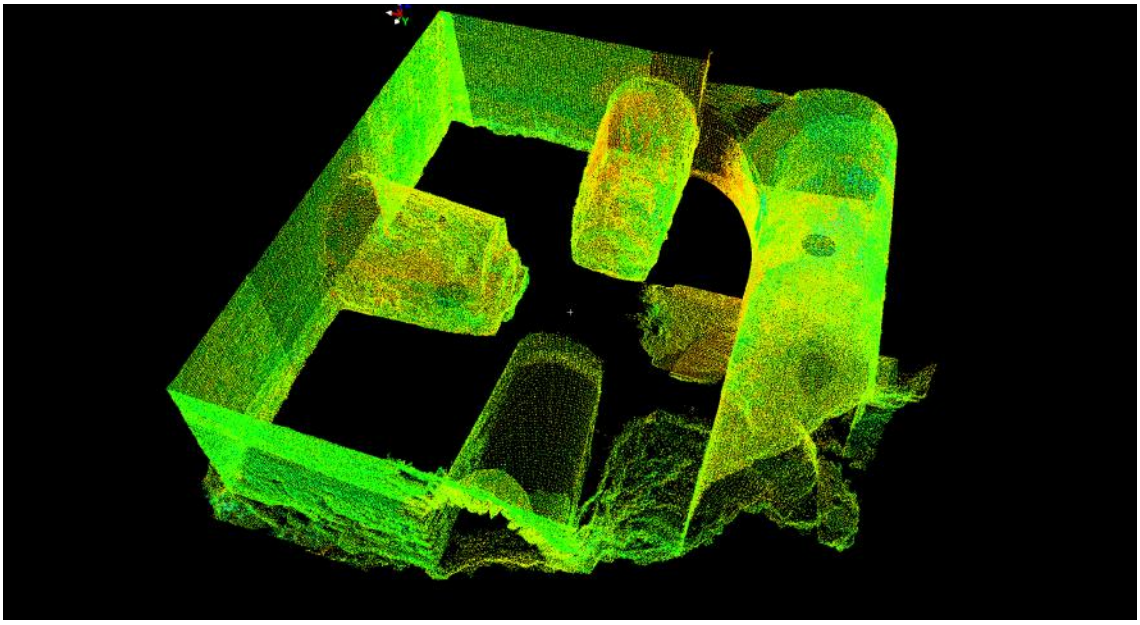
Scans



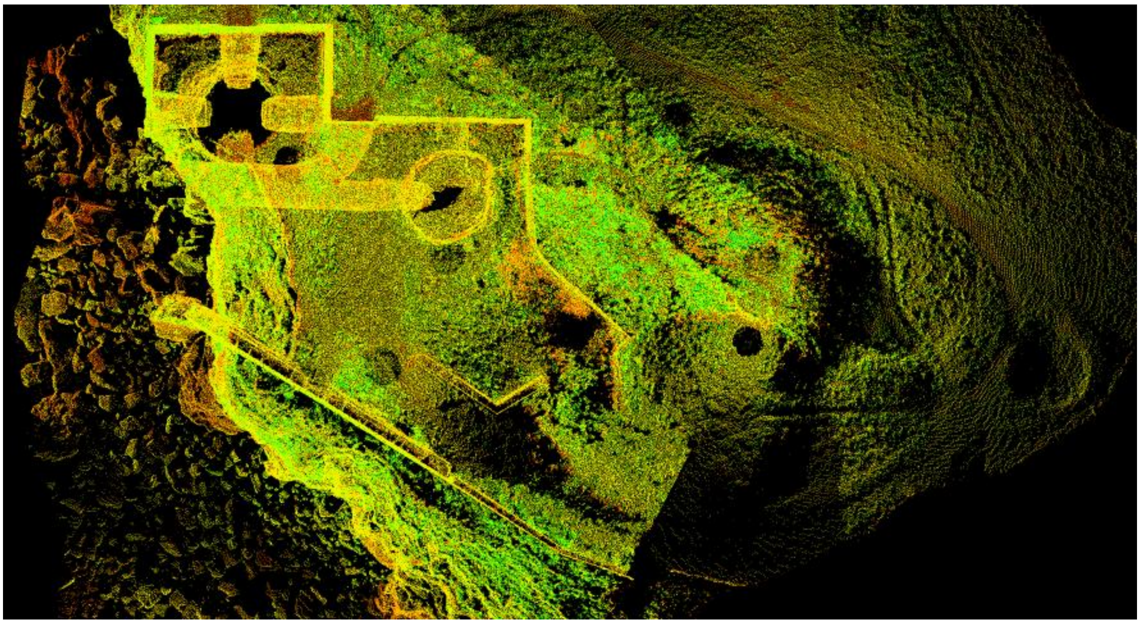
Scan 1. 3-dimensional ‘transparent’ view of Boddin limekilns looking SE. Kiln 2 is on the left, kiln 3 on the right. The relative positions of internal structures such as the partially blocked burning chambers; draw holes; and central access tunnel can be seen. The extent of the blocking of the burning chambers is also clearly visible.



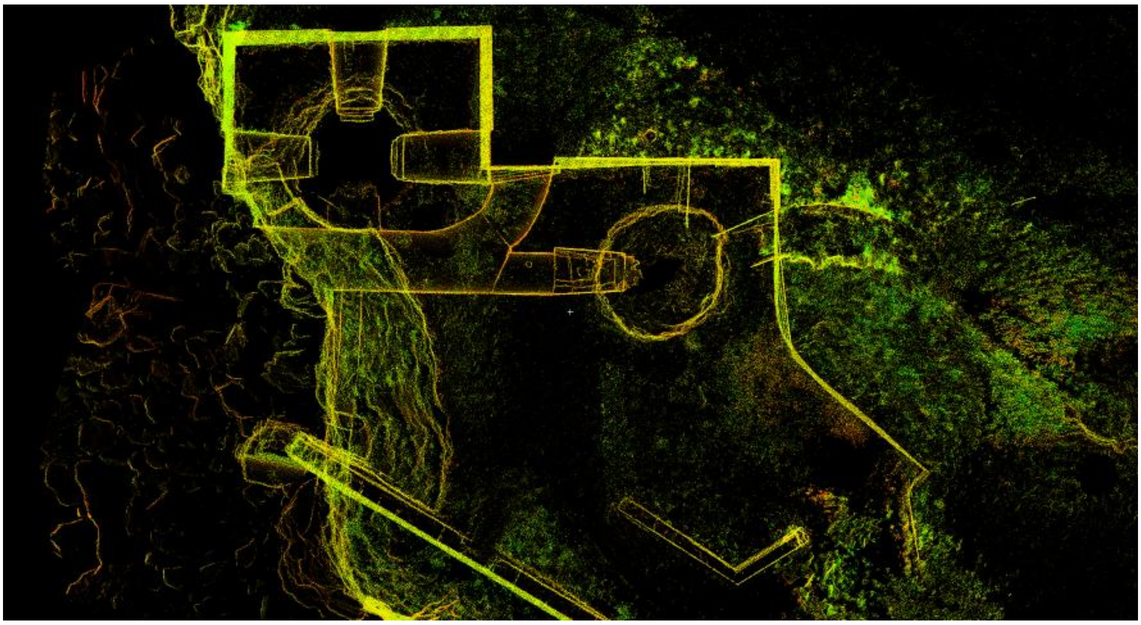
Scan 2. 3-dimensional ‘transparent’ view of the limekiln looking ENE. Kiln 3 is to the left. Note the tumbled fragment of the brick arch of the access tunnel in the foreground.



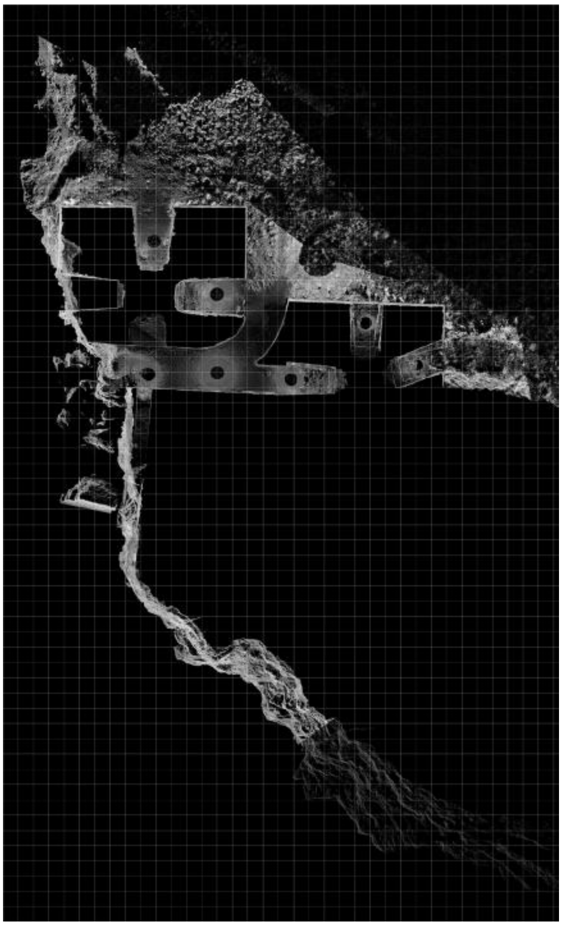
Scan 3. 3-dimensional view of the internal structure of kiln 3 showing the four draw holes; and the interconnecting passage to the right, looking NE.



Scan 4. Plan of Boddin limekilns generated from all data points. The small black circles are artefacts of the scanning process and indicate the set up position of the scanner.

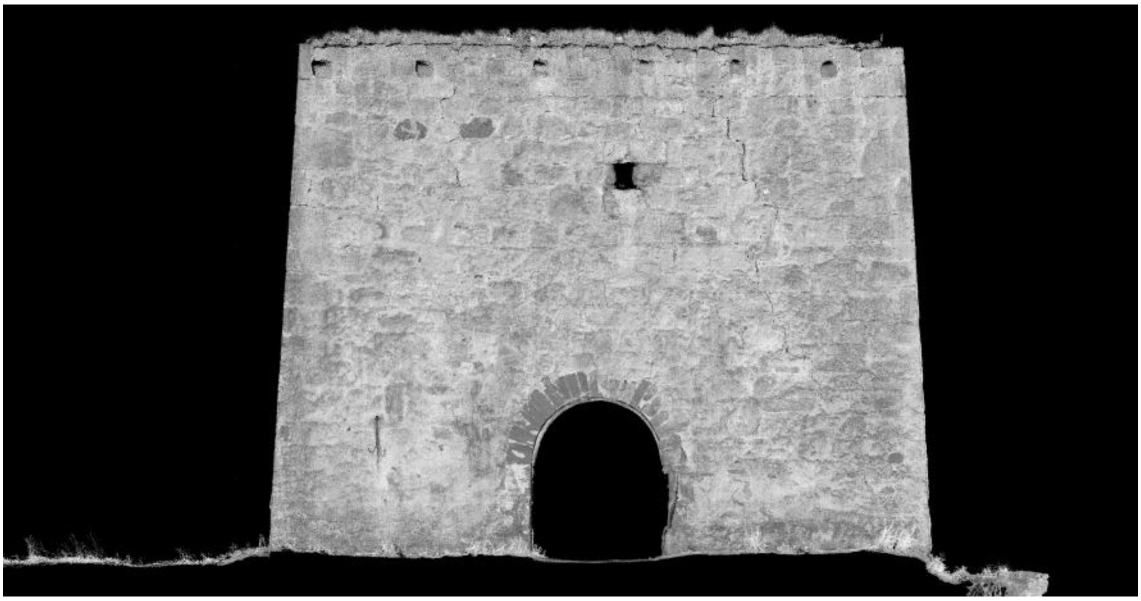


Scan 5. Plan of Boddin limekilns generated with selected data points to highlight structures in outline.



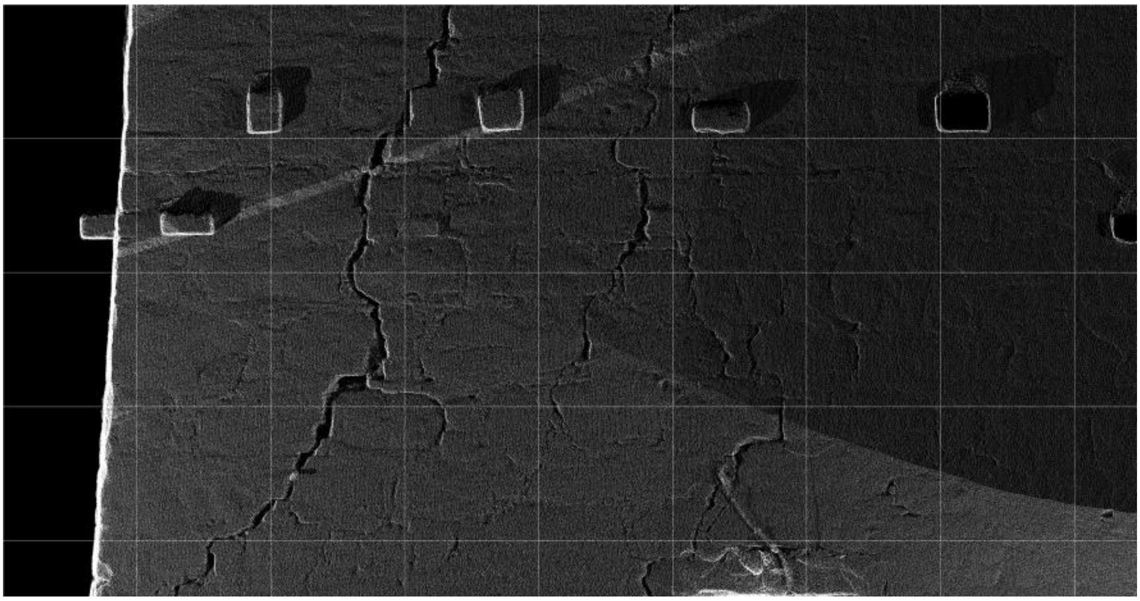
Scan 6. Horizontal slice through the main kiln block to generate a plan view of the internal structure of kilns 2 and 3. The black circles are artefacts of the scanning process.

Scan 7. Digital elevation of the north face of the kiln block. Kiln 2 is on the left and kiln 3 is on the right. The entrance to the cental access tunnel lies between them.



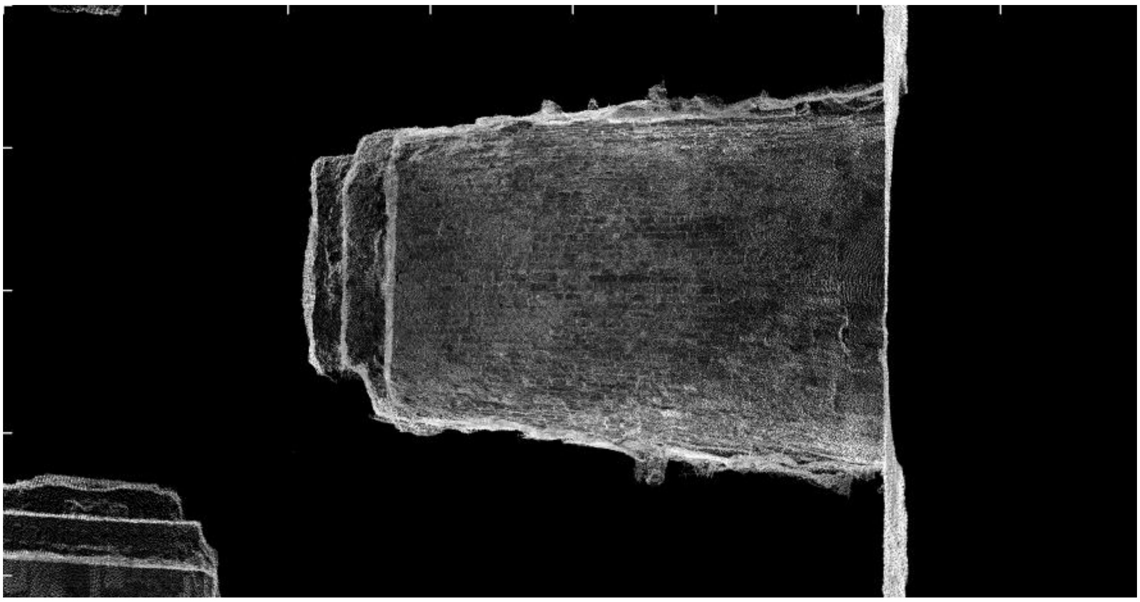
Scan 8. Detailed digital elevation of the north wall of kiln 3, showing a major crack at the northwest corner caused by undercutting of the rock platform upon which this side of the kiln is constructed.

Scan 9. South retaining wall of the Boddin limekilns, looking NE.



Scan 10. Detail of part of the eastern elevation of kiln 3, showing cracks within the wall.

Scan 11. Detail of the interior of the east draw hole of kiln 3, looking W.



Scan 12. Detail of the north draw hole of kiln 4, from above.