INVESTIGATIONS ON THE STUDLAND CIRCLES BY THE DORSET ALUM AND COPPERAS INDUSTRIES PROJECT

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Abstract

Archaeological investigations carried out on behalf of the Poole Harbour Heritage Project examined as series of undated earthworks, known as the Studland Circles, on the South Haven peninsula, Studland. A suggestion that these earthworks were associated with the sixteenth- and seventeenth-century alum and copperas industry in Poole Harbour prompted their exploration as part of the Dorset Alum and Copperas Project. A total of 112 earthwork circles were recorded on Studland Heath and Greenlands Farm. Geophysical and earthwork survey was undertaken on a sample study area on Studland Heath and a single earthwork circle was examined in detail, through excavation and geoarchaeological analyses. This earthwork was shown to have a simple bank built of turf and sand stripped from the interior. No evidence for any activity was recovered from the interior to suggest its function. The earthwork was constructed on a layer of windblown sand, which may be related to sand dune development from the sixteenth to eighteenth centuries. Therefore, it is likely that the earthworks date to the post-medieval period. Although no evidence was recovered for the function of the earthwork circles, an industrial or agricultural function is most probable.

Introduction

The history of Alum and Copperas manufacture in Dorset is little known and poorly understood and it has been argued by Dr William Sheldrick that the beginnings of this industry in the mid-sixteenth century marked the birth of the chemical industry in England (Sheldrick 2006). The Dorset Alum and Copperas Project was set up by the Poole Harbour Heritage Project to investigate the social, economic and historical factors relating to alum and copperas production in Dorset through documentary research and limited archaeological investigation. The archaeological project was supported by English Heritage with the aim of providing data to help characterise the remains of this industry. Three sites were chosen for archaeological investigation at Brownsea Island, Kimmeridge Bay and Studland. All three sites had been suggested as having links with the alum and copperas industry but, in the event, the link was not established to an appropriate degree of certainty and, without a common thread between the three excavations, it has been decided to publish each site separately.

The Studland Circles are a group of enigmatic, mainly circular to sub-circular, earthworks of uncertain date and function. Dr William Sheldrick suggested they may have had a link to alum or copperas production, possibly small extraction sites or areas for the weathering of clay raw material, which he suggested might have been subsequently shipped a short distance across Poole Harbour to Brownsea Island for processing. This latter hypothesis was partly suggested by a 1583 inventory for Okeman's House in Parkstone that listed 'oare reddy digged and caste upp in great heapes above a hundred in number, some bigger than some to lye a seasoning before they come to the working' (Bettey, 1982, 93). In order to explore this hypothesis, the Studland circles were included as part of the Dorset Alum and Copperas Project.

Historical Background

Studland was recorded as a settlement in Domesday held by the Count of Mortain and thirty-two salt pans are mentioned (Morris 1983). Subsequently, the manor was held by the abbey of Tarrant Crawford and after dissolution Studland Manor was granted to Sir George de la Lynde, eventually becoming part of the Bankes estate in 1632. A survey conducted by John Bankes in 1724 recorded the grazing rights and rights of turbary of the thirty-nine tenants of the estate. One of the tenants, Thomas Devers, is recorded as having holdings at South Haven Point, which consisted of a house and garden and a plot of land. He also had the right to cut furze and 2,000 turves from Studland Heath (Papworth 1995, 27).

The Studland Peninsula was considered to be of little agricultural use due to the poor soils. A survey by William Woodward in 1775 describes the area of heathland as 'Waste Ground intermixed with and adjoining to the Heath, mostly consisting of Sand Bank, Flats and Mud many hundred Acres of which have been left by the Sea and become Heath Ground since the Old Survey (1586) was taken. That part of the waste called Little Sea, is yearly growing into Heath,

and the whole will become heath in a few years' (DHC D/BKL). Another survey in 1799 stated that the heathland is 'of little value and the mud part is too sour, low and wet, yet to admit of any use being made of it in Husbandry' (DHC D/BKL).

Enclosure of the heathland on the Studland Estate began in the eighteenth century and by the early nineteenth most of the land had been enclosed. However, this did not prove viable in the long term. One tenant of the Estate had enclosed heath at South Haven Point in the late eighteenth century but his attempt at agriculture proved unsuccessful and by the early nineteenth the land had reverted to common land. A note on the 1810 map of additions to Woodward's survey states: 'This encroachment was taken in by Mr. Hart, now decayed, the fences being down now thrown out to common and deemed as such in 1810' (DHC D/BKL).

There is no record of mineral extraction from the heath before the early nineteenth century although it is likely that there had been local exploitation of the sand, clay and gravel deposits. Exportation of these raw materials from the Studland Peninsula probably commenced by 1810 with the construction of a clay wharf at Red Ord Point (Papworth, 1995, 30).

The area was heavily utilised during the Second World War, particularly in the build-up to D-Day. The area was bombed by German aircraft during their sorties to attack the cordite factory at Holton Heath and bomb craters can still be seen on the Studland Peninsula.

The earliest reference to the Studland circles is by Rev. John H. Austen, who described them as 'Hut Circles' commonly called 'Fairy Rings built by a tribe of Early Britons during the Summer for the purpose of fishing' (Austen 1860). He also described the associated mounds as 'bearing the appearance of graves' but states 'they were probably fire-places' (Austen 1860). The fact that, at this time, there is no local residual knowledge of the purpose of these earthworks suggests they are considerably older than the nineteenth century.

The circles were surveyed by the Royal Commission on Historical Monuments and some limited excavation was undertaken on two circles and a number of mounds in the early 1960s (Bowen & Fowler 1963; RCHME 1970). David Brachi carried out some excavation within the Greenlands farm group in about 1950, and K. Wilson investigated at least one circle (Bowen and Fowler 1963).

The results of the RCHME excavations proved inconclusive with regard to both date and function of the circles. No datable material was recovered and pollen analysis suggested a date range from the Iron Age to AD 1700 (Bowen and Fowler 1963). Any connection with the salt pans recorded in Domesday was dismissed for a number of reasons including distance from the sea, variable impermeability, and the complete lack of evidence for burning. Their use as either grazing plots or arable enclosures was also ruled out as the turf and topsoil had been deliberately dug out of them. One suggestion put forward in the 1940s was that they 'had been dug out some forty years ago as drinking pools for ducks presumably when the water of Little Sea was still saline' (Good, 1971, 374) but, as they appear to have been in existence well before the 1900s, this would seem unlikely. Their identification as hut circles by Austen also seems unlikely, as excavation has revealed a total lack of finds or associated structures. Bowen and Fowler also ruled out any connection with military works as they are randomly spread over the heath and appear 'unmilitary' in fashion. They also ruled out a connection with the copperas industry, as they are 'not convincing […] as pans for the sluicing of iron ore to produce copperas' (Bowen & Fowler 1963, 223).

Site Description

Location and Topography

The Studland circles lie in the south-eastern corner of Poole Harbour, on the western side of the South Haven peninsula (Fig. 1). This area is generally fairly flat and low-lying, at a height of between 4-11 m above Ordnance Datum. A single road, Ferry Road, runs northwards along the peninsula and forms an effective eastern edge to the area. The road, in the northern part of its course, broadly follows the line of the original east side of the peninsula. Most of the land east of the road comprises sand dunes, which have formed since the sixteenth century, and the Little Sea, which was open to the sea until the turn of the twentieth century.

The circles fall into two separate groups: a large group to the north on Studland Heath, between Redhorn Quay and Jerry's Point (SZ 025 855 to SZ 029 860); and a small group to the south west adjacent to Greenlands Farm (SZ 021 845) (Figs 1-3). The Studland Heath area covers about 23 hectares and comprises a generally flat area of heathland rising from about 4m above Ordnance Datum to a maximum height of about 11m above OD in the southeast. The Studland Heath area is effectively divided into two distinct

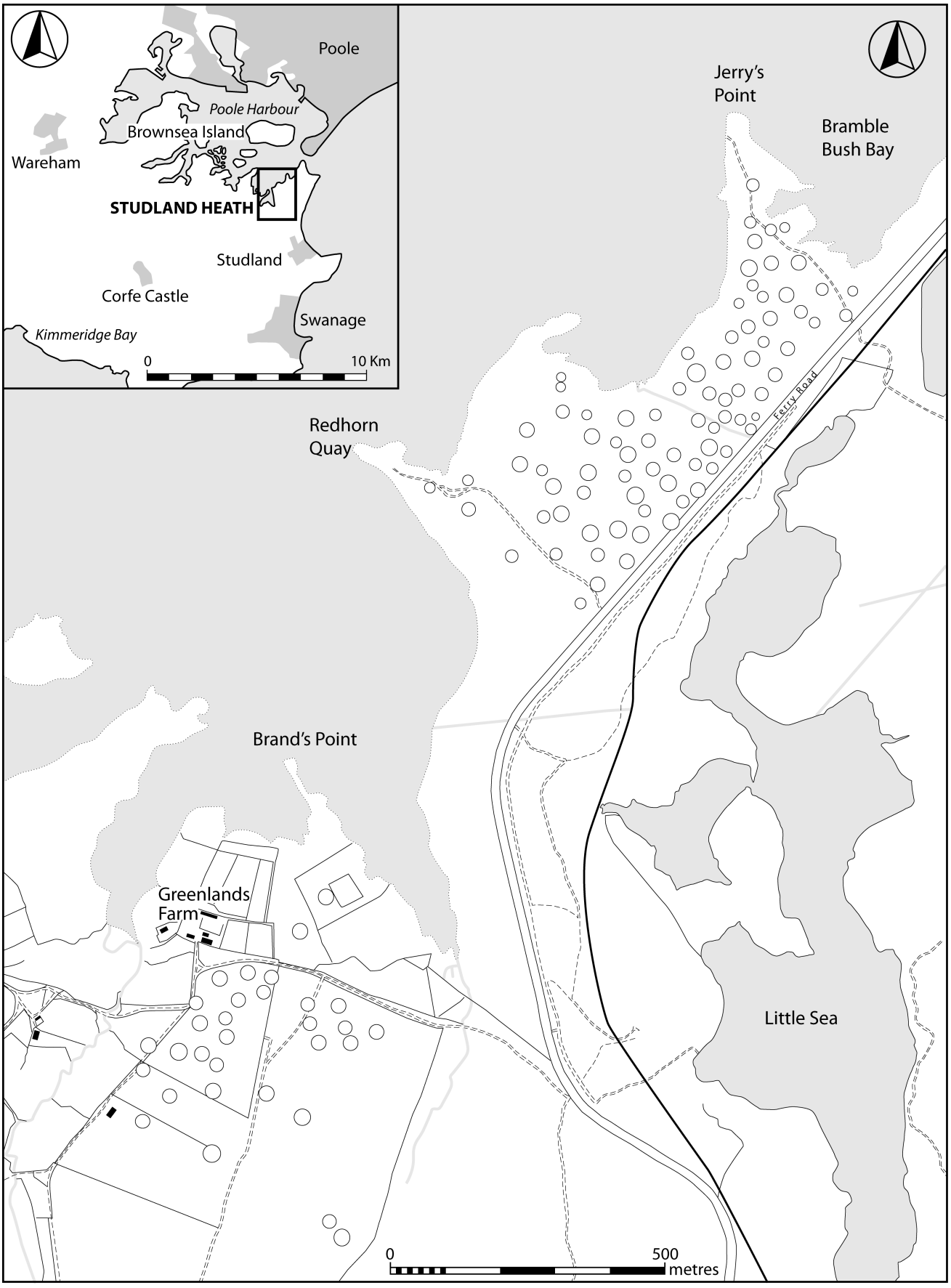

Figure 1: Location plan of the Studland circles.

parts by a bank and ditch earthwork (the 'Boundary Bank'), which runs between SZ 025 856 and SZ 028 855 (Fig. 2). To the north, the vegetation consists mainly of a covering of low heather with occasional pine and silver birch saplings. Tall stands of grass grow in the wetter areas. The eastern part of the area south of the Boundary Bank is similar to the area further north, with low even heather vegetation. However, to the west and south, in the area towards Redhorn Quay, the vegetation is considerably more luxuriant with a dense covering of heather and gorse with some bracken and pine and silver birch trees.

The second group of circles adjacent to Greenlands Farm lies on the edge of improved grassland (Fig. 3). In the 1960s an attempt to convert the marginal heathland into productive farmland had resulted in the levelling of the majority of the banks. The area continued to be ploughed until 1989, after which time it has been maintained as pasture (Papworth 1995, 38). The western part of the area is mainly pasture with a little gorse scrub on the eastern fringe, while to the east the land is covered by gorse scrub, grass, heather and bracken.

Geomorphological history of the Studland Peninsula

The underlying geology of Studland Heath comprises the Broadstone Clay Member of the Poole Formation, overlain by wind-blown sands.

Three different dune ridges have been identified on the eastern side of the South Haven peninsula. The development of these dune systems was reconstructed by Diver (1933) based on old maps and Admiralty Charts. The oldest of these dunes (Third Ridge) is thought to have started accumulating as marine sand before the start of the seventeenth century and was fully developed by 1721 (Diver 1935; Wilson 1960). The two other dune formations, Second Ridge and First Ridge, are considerably younger. The Second Ridge is thought to have formed at the eastern extremity of the peninsula and did not connect with the Third Ridge until the eighteenth century (Wilson 1960). The First Ridge is the youngest and formed in the early nineteenth century.

Tentative analysis of the organic matter content of the soils of both the Third Ridge and the Studland Heath (Wilson 1960) indicated that the soils of Studland Heath may have started forming at least 300 years ago, and it was thought possible, though not proven, that the sand from the Third Ridge is of the same age and source as the sand underlying Studland Heath.

Methods

The investigations comprised an initial baseline and walkover survey followed by detailed geophysical and earthwork survey, sample excavation and geoarchaeological recording and sampling of the soils and sediments of one of the circles.

The baseline survey started by examining the published RCHME survey, the vertical aerial photograph data, in particular the 1947 RAF vertical photographs, and the LiDAR data from the Channel Coast Observatory (www.channelcoast.org). All visible earthworks were plotted on a map, which formed the basis for a condition survey undertaken during the winter of 2008 and spring 2009. Each earthwork circle was recorded in the field using a standard pro forma sheet.

The results of the baseline survey enabled a representative detailed study area to be defined. The 100 m by 100 m study area was centred on SZ 02890 85775 (Fig. 2). This study area formed the basis for further geophysical and earthwork survey and a single earthwork circle (SH10) was selected for excavation.

The geophysical survey comprised electrical resistance and magnetic surveys undertaken by ArchaeoPhysica Ltd over the detailed survey area. The magnetic survey was undertaken with a Geometrics G858 Magmapper caesium magnetometer along lines 1.0 m apart. The electrical resistance survey was undertaken with a Geoscan Research RM15 0.5 m twin probe on a 1.0 m by 0.5 m grid (Roseveare 2009).

The earthwork survey was undertaken in May 2009 by Mark Corney within the detailed survey area using a Total Station survey system (Fig. 4). The ground conditions were generally good with good light and an even low cover of heathers averaging 10 cm high.

The archaeological investigation was undertaken in September 2009. A single trench (Trench 1) measuring 21 m by 1 m was excavated across the circle SH10 down to the top of the windblown sand (Figs 4-5). The western end of the trench was extended to expose a 3 m by 3 m area in the centre of the circle. Two one metre square sondages were dug through the windblown sand down onto the underlying natural clay layer.

The geoarchaeological recording was undertaken by Dr Clare Wilson, SBES, University of Stirling. The soils and deposits were examined and described following Hodgson (1976). A Bartington MS2 meter and MS2-F field probe were used to investigate patterns of magnetic susceptibility in the field in order to investigate potential burning and buried soils.

Undisturbed samples were taken through the bank and the buried soils beneath and also through the possible buried soil profile outside the circle.

Samples for OSL dating were taken through the circle centre, bank, turves and buried soil using sealed copper tubes driven into the section face. An assessment of their relative dates and potential for further dating was made at the University of Stirling using a portable OSL designed by SUERC with SUERC luminescence analysis software (Sanderson and Murphy 2010). Unfortunately, due to a lack of luminescence, no dates were obtained from these samples.

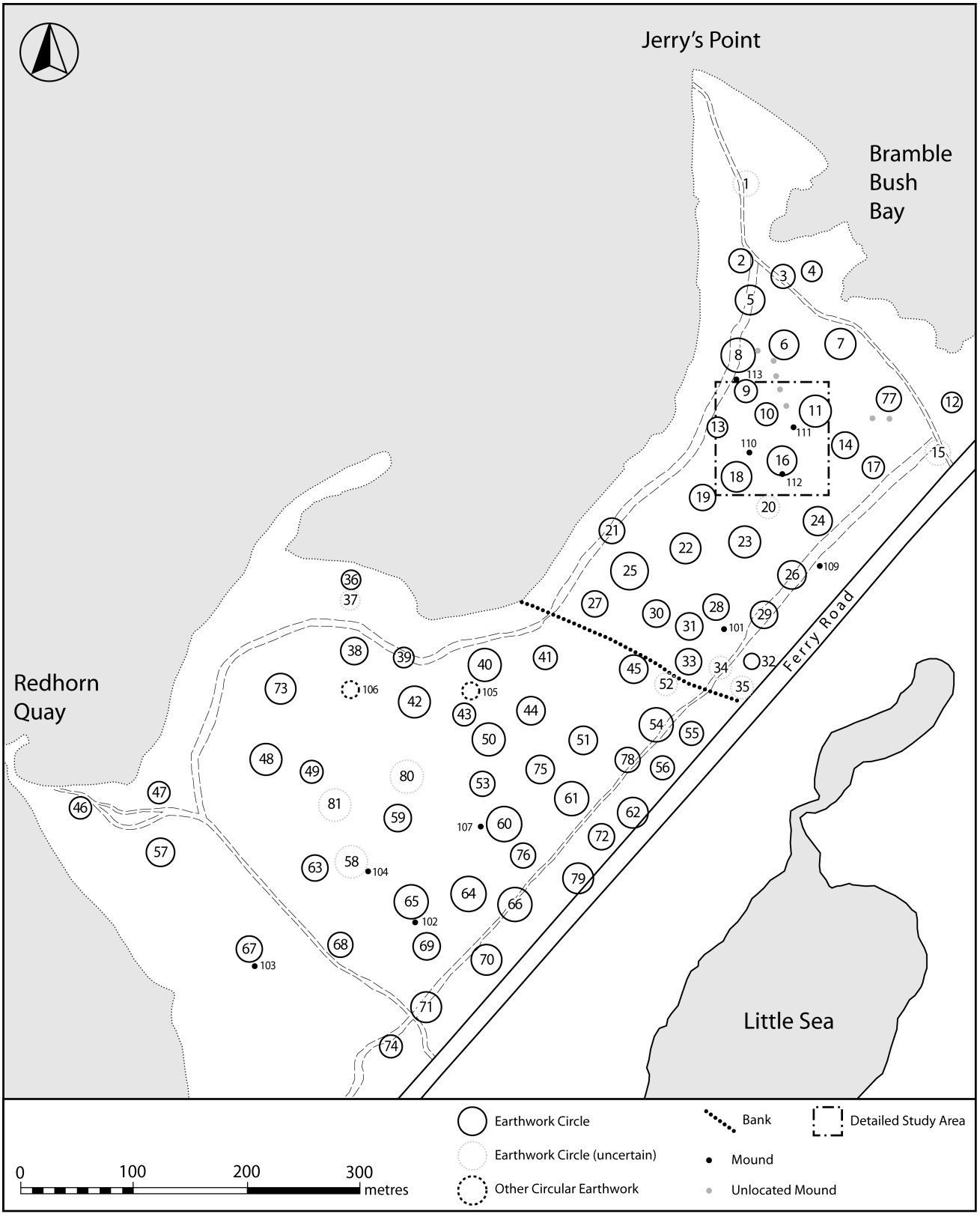

Figure 2: Plan of earthwork circles and other features on Studland Heath, showing the location of the detailed study area.

Studland Circles Location and Form

The two groups of circles on Studland Heath and at Greenlands Farm are separate, located over 800 m apart, but both areas are on broad flat topography (Fig. 1). The distribution of earthwork circles on Studland Heath is confined to an area between Jerry's Point to the north and Redhorn Quay to the south, occupying the widest part of the peninsula to the east of Ferry Road (Fig. 2). The circles appear to be irregularly spaced across the whole of this area, with no uniformity in their position and with a varying distance between each circle. The density of the circles appears to tail off towards the south and west.

Studland Heath

Eighty-one circles were identified from aerial photographs and RCHME survey and each given a number with the prefix SH (for Studland Heath). Five circles could not be located on the ground, probably due either to very dense vegetation cover (in the case of circles SH01, SH37, SH58) or to ground disturbance associated with the widening of Ferry Road (SH15, SH35). The minimal surviving remains of the earthwork banks of three others (SH20, SH34, SH52) made the determination of their precise location impossible to plan accurately.

The circles are all broadly similar in form, comprising a simple low bank with a spread, eroded, profile enclosing a circular or near circular interior. The interiors of the circles are generally slightly below the surrounding ground surface and are either perfectly flat, in some cases clearly deliberately terraced into the slope (for example SH10), or have an almost flat, slightly dished, profile. At least eight of the circles have breaks in the bank (for example SH07, SH16). The gaps are of variable width and do not appear to have any preferred orientation. It is unclear whether these are original features or later breaches, though, generally, a later breach seems more likely. The diameter of the earthwork circles, measured from the highest points of the banks, ranges in size from between 14.5 m to 33 m. The majority of the circles are between 21 and 26 m across. There is no observable pattern in the distribution of the different sizes of earthwork circles.

Six mounds of varying shape and size were recorded by the survey, but others may still survive masked by dense vegetation. The RCHME, for example, records five mounds adjacent to circles SH08-SH10 and two south of SH77 (RCHME 1970), which were not recognised in the field (Fig. 2). The mounds are fairly low features, up to about 0.8 m in height and measure between 3-5 m across. They generally lie adjacent to the earthwork circles, but the relationship between them is unclear, though Circle SH09 has a mound on top of the bank.

A single linear earthwork was recorded. This is the 'Boundary Bank', a sinuous earthwork bank that crosses Studland Heath in a WNW-ESE direction from the shoreline to Ferry Road. The bank is about 2.5 m wide and over 1m high. A small stream runs along the southern side and there is a suggestion of a small silted ditch on the northern side. The date and precise function of this feature are not known, but it may be associated with the attempt to enclose the land in the eighteenth century and which had been abandoned by 1810 (Papworth, 1995, 39). To the south of the Boundary Bank, are two earthworks (SH105, SH106), which do not fit neatly into the categories above. SH105 is a circular feature between 15-18 m in diameter. Unlike the circles described above, the whole of the area is raised above the surrounding ground level. About 100m to the west, SH106 is a circular depression in the ground and there does not appear to be any surrounding bank.

There are very few direct physical relationships between the features. None of the earthwork circles intersect each other, although SH03 and SH04 appear to touch. A single mound lies on the bank of circle SH09, indicating it is later. The other mounds mainly lie adjacent to the circles and may be later also. Two circles (SH33, SH45) are immediately adjacent to the Boundary Bank. In both cases the Boundary Bank appears to be later than the circles.

Greenlands Farm

The circles adjacent to Greenlands Farm are all in poor condition; many are largely ploughed out and survive as very slight earthworks, or are badly affected by rabbit and root damage. The RCHME record the existence of only six circles (RCHME 1970), but a total of 31 circles (GF01-GF14) was identified on the ground during the survey. Another six (GF15-GF20) were subsequently identified in the LiDAR data (Fig. 3).

The earthworks at Greenlands Farm comprise primarily circular enclosures, with one possible mound on the bank of GF13. The poor condition of these earthworks makes detailed analysis of their form difficult. However, the best preserved (GF13, GF14) indicate this group was similar in form to those on Studland Heath, with their interiors levelled and slightly terraced and simple low banks. No definite

gaps were identified in the banks, but the full circuit of all the earthworks could not be traced due to the density of the vegetation.

Unlike Studland Heath, the diameters of the circles in the Greenlands Farm area are all very similar, at an average of 27 m. The exceptions to this are the smallest, but best preserved, GF13, which has a diameter of approximately 20 m and the largest, GF04, with a diameter of 31 m.

Detailed Survey and Investigation on Studland Heath

The baseline survey enabled the selection of a more detailed study area for further intensive investigation. A detailed study area 100 m by 100 m centred on SZ

Figure 3: Plan of the earthwork circles at Greenlands Farm.

02890 85775 was defined, partly because it contained some well-preserved circles, both with and without gaps in the banks, and a series of mounds. The whole of this detailed study area was investigated by geophysical and earthwork survey and one circle (SH10) was selected for excavation.

Earthwork survey

The detailed survey area included the earthwork remains of six circular or sub-circular enclosures (SH09, SH10, SH11, SH13, SH16 and SH18), four low mounds and four depressions (Fig. 4). The enclosures are defined by a low bank with no trace of a ditch and are in varying states of preservation ranging from very good to fragmentary.

Circle SH09 has an external diameter of 20 m with a 3.5 m wide bank standing up to 0.4 m high and is best preserved around the south-eastern arc. A north-facing gap, 5 m wide, appears to be original, with a well defined terminal on the east side. The west side of the gap is overlain by an oval mound, 9 m by 5 m and a maximum height of 0.7 m. The western arc of the enclosure is less well-preserved, only surviving to an average height of 0.25 m.

Circle SH10 has an external diameter of 26m and is best preserved around the southern and eastern arcs where it survives to a maximum height of 0.5 m. To the north-west, the bank is only 0.2 m high and may have been subject to localised damage or erosion. The interior of the enclosure is slightly 'dished' with the centre being approximately 0.15 m lower than the periphery.

Circle SH11 is the least well-preserved enclosure within the detailed sample area, comprising a pair of detached arcs of low banks on the east and west. The reconstructed original external diameter is approximately 29 m with the surviving bank having a maximum width of 6 m and a maximum height of 0.25 m. Breaks in the circuit to the north and south are 10 m and 18 m wide respectively.

Circle SH13 has an external diameter of 27 m and is a well-preserved earthwork, without an entrance or original break in the circuit. It stands to a maximum height of 0.5 m and is 6 m wide on the southern arc. On the north, east, and west, the width of the mound averages 4.5 m and stands up to 0.4 m high.

Circle SH16 is poorly preserved with an external diameter of 31.5 m. The enclosure bank is breached by opposed breaks to the east and west; neither appears to be an original feature. The northern arc is a low, spread bank 7.5 m wide and 0.3 m high. The southern arc is more substantial being 6 m wide and 0.5 m high. It is overlain by an oval mound measuring 15 m by 10 m and 0.85 m high.

Circle SH18 is the best-preserved example within the detailed survey area with an external diameter of 32.5 m and a 5 m wide original gap on the north side. The bank averages 5.5 m in width and 0.65 m high, rising to 0.75 m on the inner face of the southern arc. The interior profile is slightly 'dished' with the centre being approximately 0.15 m lower than the periphery.

Only two of the circles (SH08 and SH18) have what may be regarded as original gaps in their circuits and these are both oriented to the downslope side, towards Poole Harbour. In both cases the gaps are 5 m wide. It is clear that not all the earthwork circles were provided with gaps; the relatively well-preserved SH10 and SH13 still feature full circuits, whilst damage to SH11 and SH16 makes their status less certain. However, observation within the sample survey area and beyond suggests a preference for original gaps to be on the northern arc. On this basis it is possible that SH16 was originally an uninterrupted circuit whilst the original condition of SH11 remains unknown.

The lack of a ditch, external or internal, suggests that the circles were created by scraping surrounding soil. Examination of the earthwork profiles, showing the interiors to be slightly lower than the surrounding land, strongly suggests that material was scraped from the interior of each circle.

In addition to the low mounds overlying SH09 and SH16, two further mounds were recorded. Between SH10, SH11 and SH16 is a long, low mound 19 m long, 7 m wide at the north end and tapering to 4 m at the south end. It stands to a maximum height of 0.3 m. Eight metres north-east of SH18 is a circular mound 10 m in diameter and 1.0 m high. Three metres south of the mound is an ovoid depression measuring 7.5 m by 6 m with a maximum depth of 0.5 m. The function of the mounds is unknown. They have varying plans and profiles and two actually overlie enclosure banks demonstrating that they post-date the construction of the circles. SH09 and SH16.

Between SH9 and SH13 is a pair of steep-sided pits approximately 5 m in diameter. Their full depth could not be ascertained, as they are water-filled. From their appearance they are most likely craters of military origin. A similar interpretation is probable for a 2 m diameter water-filled pit within the western

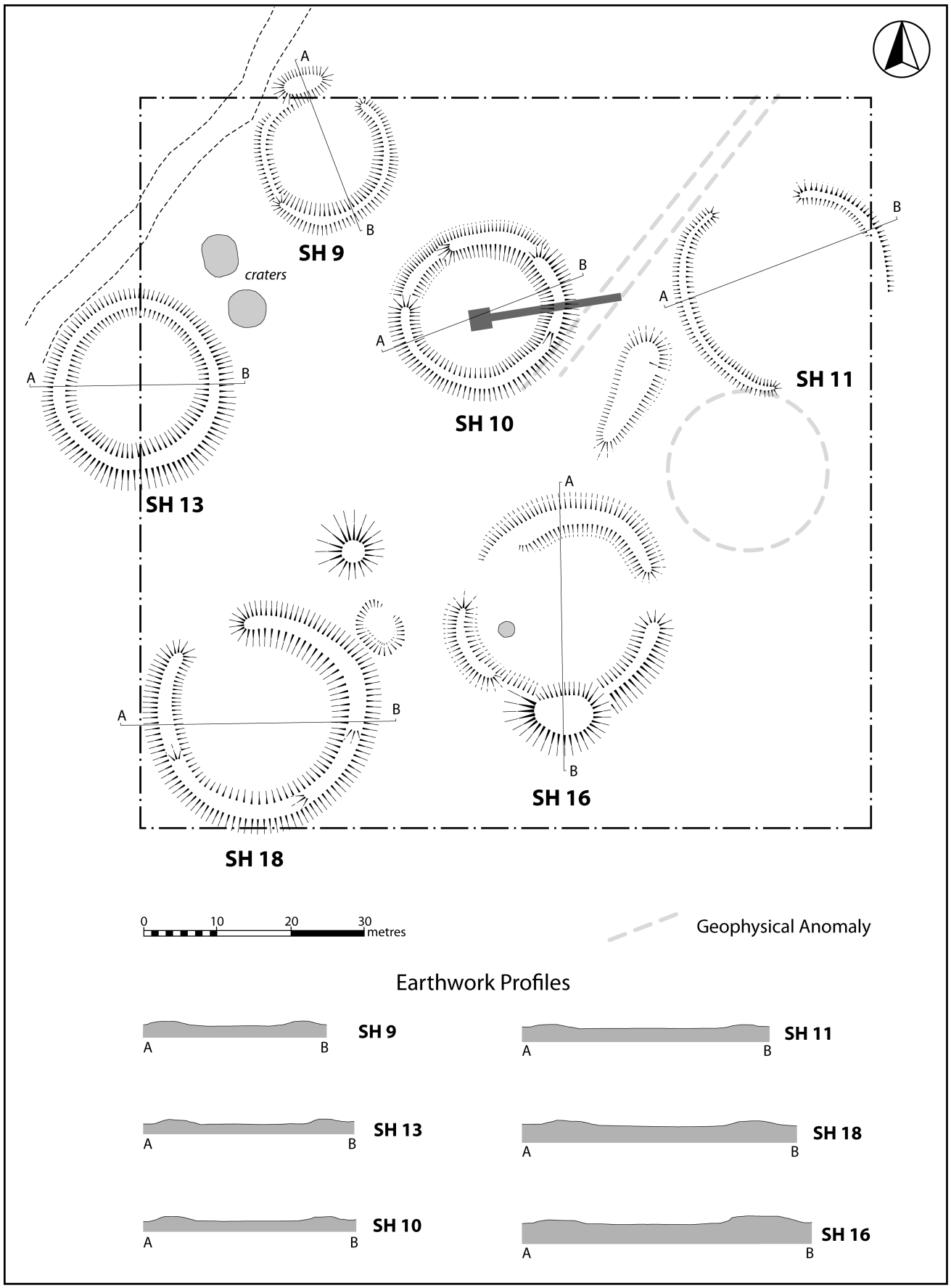

Figure 4: Earthwork survey of detailed study area, showing geophysical anomalies and location of excavation trench.

arc of SH16.

Geophysical Survey

Ten geophysical anomalies were identified but most do not appear to be archaeologically significant (Roseveare 2009). There was little correlation between the earthworks and the geophysical disturbances indicating that the earthworks are ephemeral surface features. A weak annular low-resistance arc coincided with the bank of circle SH10, perhaps due to deeper topsoil or turf. An area of reduced resistance was associated with the interior of SH11, suggesting this circle was capable of holding water.

An annular electrical resistance anomaly between SH11 and SH16 may indicate the site of a former earthwork circle, now no longer visible on the surface (Fig. 4), but it is unclear why this should be manifest as a change of resistance when the surviving rings are not.

A narrow linear band of elevated resistance aligned NE-SW was identified running close to the north-west quadrant of circle SH11 and the south-east quadrant of SH10 and may mark a possible path or former boundary. Other anomalies were probably formed by buried ferrous objects or variations in the natural deposits.

Excavation

Circle SH10 (centred on SZ 02885 85796) has an external diameter of 26 m and is best preserved around the southern and eastern sectors, where it survives to a maximum height of 0.5 m. To the northwest, the bank is only 0.2 m high and may have been subject to localised damage or erosion. The interior of the enclosure is slightly dished, with the centre being approximately 0.15 m lower than the periphery. The trench was cut from the centre across the most well-preserved part of the bank to the east (Fig. 4).

The excavation revealed that the earthworks were relatively superficial and of simple construction, overlying a layer of natural wind-blown sand (103). The bank was constructed of cut turves (104), stacked inverted on the old ground surface (105/106), with the remaining loose spoil cast up onto the top of the turf stack. It was clear that there had been some erosion of the bank material and on the inner face of the bank was a wedge of pale off-white sand (112), possibly a truncated remnant of the original upcast sand or erosion of loose sand from the bank. Originally, the turf

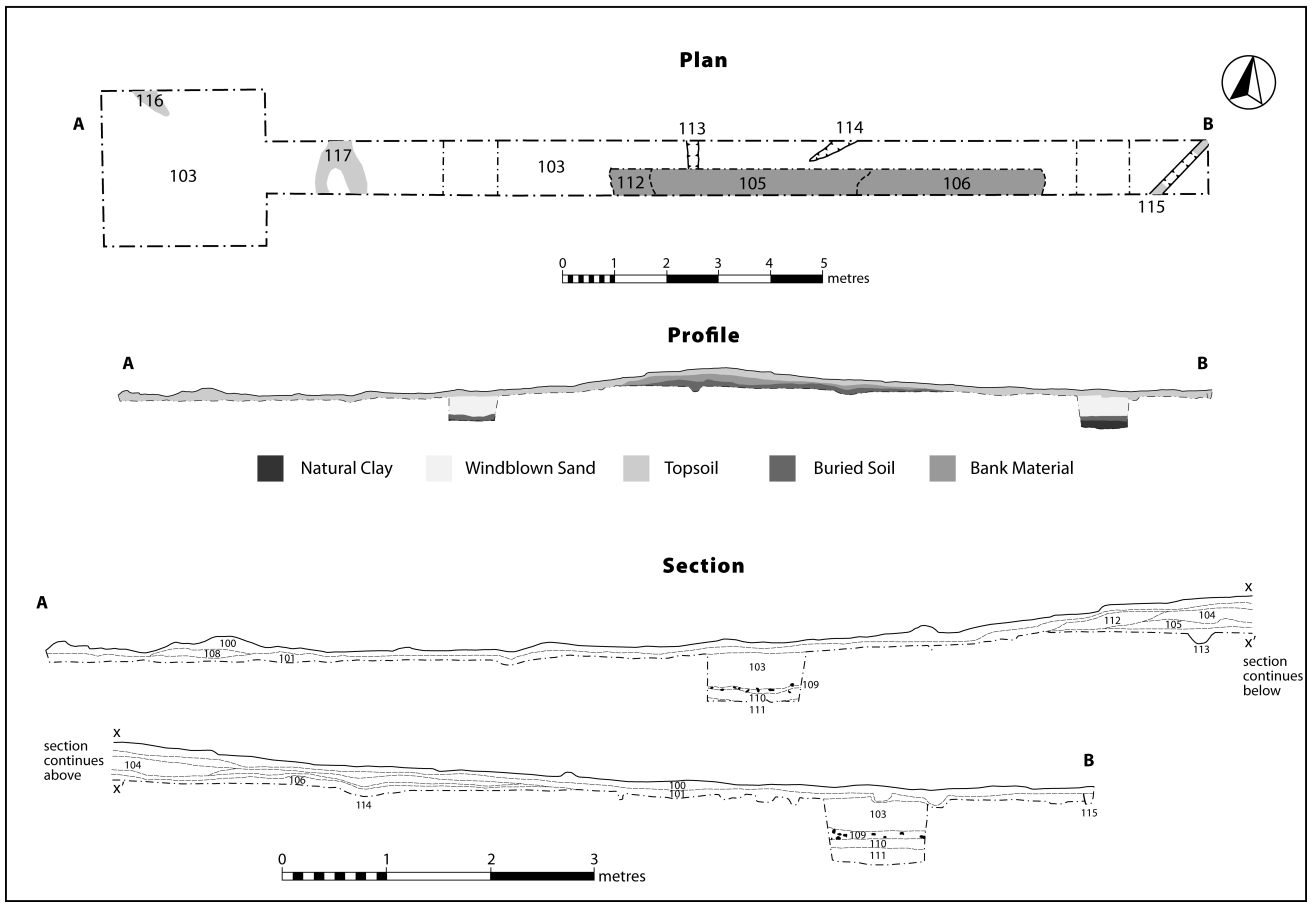

Figure 5. Plan and section of excavation trench through circle SH10

bank would have stood significantly higher than the surviving earthworks suggest but, whilst individual decomposed turves could be seen in the excavated section (Fig. 5), the bank's original profile could not be reconstructed.

The interior, formed by the upper surface of the natural wind-blown sand (103), contained only occasional root disturbances and/or animal burrows (116, 117) filled with humic soil. No trace of any internal structures or features was found and no indication of significant trampling or disturbance in the interior of the circle. There was no enhancement of magnetic susceptibility either inside circle SH10 or within its bank, which suggests an absence of both *in situ* burning and redeposited burnt material associated with the structure.

Following disuse of the earthwork, both the interior and bank were re-colonised by heathland plant species, resulting in the formation of a secondary humic podzol (100/101). The only find recovered was a single flint flake from this podzol.

Some modern impacts to the site were recorded. A single tyre rut (115) was seen at the east end of the site and another possible wheel-impaction (114) was seen more faintly on a similar alignment *c.* 6 m to the west. This appears to be in the same position as a linear geophysical anomaly tentatively identified as a track (Fig. 4). An old root channel (113) was recorded in the clean sand (103) beneath the bank.

Geoarchaeological investigation

The local soils are mapped as belonging to the Sollom 2 soil association (National Soil Resources Institute, 2012) formed on Tertiary blown sand deposits. These humic podzol soils have low fertility and are subject to seasonal flooding waterlogging due to fluctuating groundwater levels (National Soil Resources Institute 2012).

Field examination revealed the natural soil beneath the monument to consist of an organic Ah horizon (100) and a grey sandy Ea horizon (101) that have developed in a wind blown sand (103). The sand buries a sequence of two humic horizons (109 and 110) that could either represent a buried soil (bA soil horizon) formed in the Eocene Bagshot sand clays below (111) or be redeposited humic material washed down through the sand (a Bh soil horizon).

The section in the centre of the circle is similar to that of the natural soil profile other than the Ea horizon (101) is less well developed suggesting that the modern topsoil in the centre of the circle has had less time to develop. Together with the thinning of the sand in the centre of the circle this suggests a phase of truncation involving the stripping of the topsoil and sand in the construction of the circle.

The humic podzol soil formed in the bank (100 and 101) was slightly less developed than in the 'natural' soil profile outside the circle. The lateral extent of the sand toward the outer edge of the bank suggests considerable spreading of the material as a result of erosion. Towards the base of the sand irregular organic lenses were similar in composition to the buried soil (105) and were interpreted as turves stripped from the centre of the circle. The buried soil contexts (105 and 106) extended below the bank and merged with the modern topsoil (101) on the outer edge. However, on the inner edge, the buried soil fades away and doesn't meet the modern topsoil, consistent with the turf having been stripped from the centre of the circles during construction.

The bank appears to represent an inversion of the local soil profile and have been formed when first the turf and then sand was stripped from the centre of the circle and piled at the edge forming the bank and a clean sandy surface in the centre. The podzol profile on the bank is not fully developed, and whilst this cannot be quantified, it does suggest the stabilisation here is in the order of centuries rather than millennia.

Micromorphological analysis

A series of four thin sections were produced from the bank of circle SH10 and a further two from context 109 and 110 from outside of the circle. These showed the sand to be dominated by sub-rounded and sub-angular quartz grains that were randomly oriented and showed no size differentiation, consistent with the suggestion of them being wind-blown.

The nature of the organic material (reddish brown and dark brown, amorphous, cellular and tissue organic matter with evidence of mite, enchytraeid (wire worm) and rare earthworm excrements) in the modern soil, buried soil and turves is very similar, suggesting a comparable landscape at the time the circle was constructed to that which exists today. There was no evidence in the distribution of roots and organic matter for the deliberate placement of the turves. Instead there is a tentative suggestion (deposits showed evidence of post-deposition bioturbation) that some turves were placed vegetation upwards and some root upwards.

The thin section through context 109 revealed this to consist of translocated amorphous organic matter and clay (homogeneous, amorphous orange brown organic matter with oriented clay coatings around voids) that are consistent with this being the Bh/Bs horizon of the modern humic podzol soil. However, in the top of context 110 is a layer of mid to dark brown amorphous and cellular organic matter and ovoid excremental pedofeatures that are consistent with a buried soil. As such, these contexts appear to represent both the original land surface (pre-sand deposition (context 103)) and translocated organic matter associated with the modern land surface and podzolic soils.

Examination with oblique incident light revealed no evidence of burnt material in either the natural soils or through the bank of the circle.

Discussion

The current survey has substantially increased the number of earthwork circles known on Studland Heath and at Greenlands Farm. Both these areas have a similar low-lying almost flat topography and in both areas, the earthworks were constructed in sand deposits. The circles appear to have a random distribution in these areas, between 15 m and 550 m from the current shoreline of Poole Harbour. The circles are not regularly distributed and there is a variation in concentration across the areas, with little apparent relationship to this shoreline. On Studland Heath, the circles become less dense towards the south and west. At Greenlands Farm, the circles appear to have a similar density and irregular distribution to Studland Heath, though the agricultural history of this area means that further earthworks are likely to have been completely obliterated by ploughing. Although some circles are situated close together, none of the circles intersect and all remain discrete earthworks, suggesting they were all built within a relatively restricted time period with the existing circles still in use, or still visible, when a new circle was constructed. In contrast the 'Boundary Bank' earthwork appears to have been built over the edge of two circles.

The earthwork enclosures are broadly similar in form and construction, with a circular earthen bank of stacked turf cut from the interior, which is either flat, occasionally terraced into the slope, or very slightly dished. On present evidence, it is unclear whether this represents a real distinction of type or is simply a product of weathering. The circles have a range of different sizes between 14.5 m and 33 m, forming a normal distribution with a mean of 25 m, which, taken together with the lack of apparent difference in form between the smallest and largest circles, suggests that size was not a critical factor. Ten of the circles on Studland Heath have gaps in their circuit. In three examples (SH08, SH18, SH 49) the gap could be original, but in the remainder they appear to be a result of later disturbance. No circles at Greenlands Farm had evidence for breaks in their circuit.

No direct dating evidence for the circles was obtained, but a likely date between the late sixteenth and the eighteenth century can be deduced from the geoarchaeological analyses and the relationship with other earthwork features. The circles on Studland Heath were constructed on a layer of blown sand that has been tentatively associated with the Third Ridge dune development. This dune ridge is thought to have started accumulating before the start of the seventeenth century and was fully developed by 1721 (Wilson 1960). If this association is correct then the start of dune development in the sixteenth century provides a *terminus post quem* for the construction of the circles. The character of the soil over circle SH10 suggests that it had developed over centuries rather than millennia, which would fit with this chronology.

The Boundary Bank earthwork does not respect the circles and appears to be later. This bank can be related to the attempt to enclose the heath for agriculture in the late eighteenth century, which provides a *terminus ante quem* for their construction and use. This would also be consistent with Rev. John H Austin's lack of knowledge of their function and use in the mid nineteenth century.

Although, a post-medieval date for the circles seems likely, no documentary sources referring to their construction and use have been found and no evidence was obtained from the current investigations to provide positive identification of their purpose. It is easier to dismiss earlier hypotheses about the use of the circles, than it is to identify their actual function.

Firstly, there is no evidence that the circles were related to alum and copperas manufacture. Although the dating suggested above would fit with the period of alum and copperas production in Poole Harbour, it is difficult to see what function they would have performed in the manufacturing process. The form of the earthworks makes it clear that they were not extraction sites for ferruginous materials in the clay, as they were constructed in blown sands, not clay

deposits, and there is no evidence for disturbance by quarrying within the interior of any of the surviving circles. The suggestion that they were sites for the weathering of clays for copperas production has also been disproved by the absence of any trace of clay within the excavated circle SH10 and the lack of any remnant clay dumps or disturbance caused by the removal of clay from the interior of any of the circles. It also seems highly unlikely that clay would be moved from one part of Poole Harbour to another for no apparent benefit to the manufacturing process. The circles themselves do not cluster close to the shoreline or any likely landing place. It is much more probable that the clays were weathered adjacent to the extraction pits as detailed in the 1583 inventory from Okeman's House in Parkstone (Bettey 1982, 93), quoted above.

Bowen and Fowler (1963) considered a number of possible functions for the circles, including salt pans, ponds, grazing plots, arable enclosures and military works, but none were considered plausible. The current work confirms their conclusions. The suggestion that the circles were associated with medieval saltworking has been disproved, both on the grounds that the circles appear to be significantly later in date, and by the evidence obtained by the recent work that has demonstrated the circles were not deliberately constructed to hold brine, as their interior was formed in the blown sand deposit, and there was absolutely no trace of burning in or near the earthworks, which would be expected if the brine was being boiled to evaporate the water to produce salt.

The suggestion that they were constructed as ponds for livestock also can be rejected on the grounds of the permeability of the interior of the circles. Although a number of circles regularly retain water, this appears to be a result of localised poor drainage rather than a deliberate attempt at creating a pond. The suggestion that they were used as grazing plots or arable enclosures is contra-indicated by their method of construction by stripping the turf/soil from the interior to construct the encircling banks. Finally the suggestion that the earthworks were either hut circles or military installations seems unlikely given the lack of finds and other traces of habitation.

This leaves a number of possible uses for the circles that cannot be proved or disproved on current evidence. It has been suggested that the circles may be bee gardens (Gordon Le Pard, pers. comm.), in which bee skeps could be kept protected against stock (Sumner 1923). A series of bee garden earthworks have been identified, clustered on the heathland of the New Forest and some have been excavated, but no internal structural features or artefacts were found (Passmore 1981; 1983). Documentary evidence suggests these bee gardens may date from the seventeenth to nineteenth centuries. The majority are rectangular or subrectangular, with a ditch and low bank, but some circular examples are known on Dur Hill Down, surviving as low spread banks about 10 m in diameter with no entrances (Smith, 1999, 42). These are smaller than the Studland circles, which appear to be much larger than necessary for keeping bee skeps. The New Forest bee gardens are mentioned in documentary sources, but no reference to beekeeping has yet been found in the historical sources for Studland.

Another possible use for the circles could be for processing seaweed for manure. Seaweed collected from the beach may have been laid out within the circles to rot before being used on fields or gardens. The 1799 Survey of Studland makes reference to the use of seaweed to improve the fertility of the generally poor quality land of the Studland: 'there is an opportunity of adding to the composts as much Sea Weed as may be wanted at little expense, which when rotted with Earth and Dung, would prove highly beneficial to these Lands, sufficient proof of the efficacy of this Manure is seen in the Common Corn Land, where it is used with good success.' (DHC D/BKL)

Concentrations of earthwork circles have been recorded elsewhere, but none has been securely dated or their function identified. A series of over seventy circular earthworks have been recorded on Sopley Common, Hurn, Christchurch, one of which has been excavated and a relatively recent date and a possible forestry management function proposed, though no evidence of date or function was recovered (Woodward 1978). These circles are smaller (around 10 m diameter) and the earthwork bank is constructed from material dug from an internal ditch, rather than from stripping the interior of the enclosure, so are not directly analogous to the Studland circles. In north-east Wiltshire, there is a group of over forty earthwork enclosures known as the Highworth Circles. These are undated, but it has been proposed they were associated with medieval stock practises (Pugh and Critall 1957; Gingell 1981). These earthworks are of a different scale and form to the Studland circles, with an internal ditch and external bank forming a circular to sub-rectangular enclosure between 40 and 90 m in diameter, so again are not really analogous.

In conclusion, the Studland circles remain enigmatic

— their function is still unknown, but an industrial or agricultural purpose appears most probable. It is unlikely that archaeology alone can answer this question, given the almost complete lack of finds or evidence for activity found to date. The current work has provided the most complete distribution plan of these enclosures, revealing detailed information on their form and construction and providing convincing evidence for a post-medieval date, most probably the seventeenth or eighteenth century. It is possible that evidence for their use may survive in the documentary sources of this period.

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