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Geophysical Survey of Caerau Hillfort,
Llantrisant, Rhondda Cynon Taff

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Abstract

A geophysical survey (magnetic gradiometry, magnetic susceptibility and ground resistivity) was undertaken of the interior of the hillfort, together with an area outside the hillfort entrance to the east. The interior of the hillfort proved to have been very heavily disturbed by deep ploughing during land "improvements" in the mid-twentieth century, and few distinct ancient features could be discerned, although areas of activity were suggested in a zone immediately inside the ramparts on the northwestern and northern sides. No ancient features were identified outside the fort.

The area between the two ramparts in the area of the entrance (near the southeast angle of the hillfort), however, showed significant magnetic anomalies, including features close to the inner face of the outer rampart which were strongly suggestive of metalworking hearths or furnaces, in an area in which small slag particles were recovered from the surface. A small collection of larger slag pieces from the site, probably collected over twenty years ago, was located in the collections of the Archaeology Section, Cardiff University. These pieces were not closely provenanced, but taken together with the small slag particles retrieved during the geophysical survey, form reasonably strong, although not conclusive, evidence for iron smelting in a non-slag tapping furnace. Evidence for such furnaces has not yet been found in South Wales, although they are becoming well known from North Wales and various parts of England, where they appear as the dominant furnace type in the pre-Roman Iron Age. If this identification can be confirmed by further work, it would give the Caerau Hillfort great regional significance. Iron oxide ores crop out around Mwyndy, 1500m south of the hillfort, and these are known to have been exploited since early in the Roman occupation.

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Background

The survey was undertaken as a contribution to a wider investigation of early mineral exploitation in the Llantrisant area (for published site summaries see Young 2004a-h; Young & Guest 2005; Young & MacDonald 1998).

This project has previously included geophysical survey of the School Lane area (1997), geophysical survey of Mwyndy ironworks site (C16?) (1997), field survey of probable C16 iron-making site at Rhiwsaeson (1998), geophysical and geochemical study of a bloomery site in Cwmnofydd (1999) and geophysical survey of the Pont-y-parc mines (2001 and 2002). Much effort has been focused on a Roman site at Caergwanaf uchaf with geophysical surveys in 2000, 2003 and 2004.

The project has also included excavation of slag dumps associated with a Romano-British smelting site at School Lane, Miskin (Young & Macdonald 1998), evaluative excavations of parts of the Caergwanaf site in 2002 and excavation of areas adjacent to the west gate of the Roman fort at Caergwanaf in 2004.

In addition, fieldwork has contributed to the recording of post-medieval iron-working and iron-smelting sites at Lanelay fach, Hendy isaf and the Afon Clun Mill.

The Caerau hillfort was selected for geophysical survey partly because of a small sample of iron slag

in a collection made by the late Peter Bailes, during his research at Cardiff University. The sample is labelled Caerau Hillfort Llantrisant, and comprises three small pieces of slag. Although the slags are not entirely diagnostic they are probably iron smelting slags, but have a morphology more like slags from a non-slag tapping furnace than slags from the slag tapping furnaces which are the only known form of bloomery furnace in the area.

The survey was undertaken, under the supervision of TY, as a teaching exercise (Module HS23124, Prospecting and Surveying) for the Archaeology Section, Cardiff University, between April 19th and 26th March 2005.

Techniques

The magnetic gradiometer survey was undertaken using a pair of Geoscan fluxgate magnetometers operating in tandem on a CF6 frame. The master gradiometer was an FM256, the slave an FM36. The survey was conducted on 20m grids with a 2m walked traverse interval (1m traverse interval on the combined dataset), walked in parallel and with a 0.25m sample interval (i.e. raw data grid has 1.0 x 0.25m node spacing). Data processing in Geoscan's *Geoplot* software comprised assembly of the composites for each instrument, clipping of the data at an appropriate level, merging the two composites and application of the zero mean traverse function. Data were then exported from *Geoplot* and imported to Golden Software's *Surfer*. The data were gridded by kriging to a node spacing of 0.125m for production of the final images.

The ground resistivity survey was undertaken with a Geoscan RM15 resistivity meter, operating two pairs of mobile electrodes on a PA5 frame, via an MPX15 multiplexer. The mobile electrode pairs had a 0.5m spacing (giving the main component of the response from 0.5-0.7m depth), with 1m between centres, to give a 1m effective traverse interval. Data were collected on 20m grids, walked in zig-zag pattern, with 0.5m sample interval (i.e. raw data grid has 1.0 x 0.5m node spacing). Data processing in *Geoplot* was limited to edge matching grids and removal of any minor data spikes (due to poor electrode contact). Data were exported from *Geoplot* and imported to Golden Software's *Surfer*. The data were gridded by kriging to a node spacing of 0.125m for production of the final image.

The magnetic susceptibility survey employed a Bartington MS2 meter with an MS2d field search coil. Readings were logged 5m survey intervals. Data are recorded on a handheld PC using *Pocket Excel*, with the Excel file then modified to become a *Surfer* ASCII grid file, and interpolated to a node spacing of 1m for imaging.

Surveys were laid-out using a Trimble 4700 GPS system. The basestation was typically located over an arbitrary point, and data logged for three hours on an initial visit. The station coordinates were established by post processing using RINEX and IGS Rapid Orbit corrections. Grids were laid out from pre-planned "round-number" 20m intervals of National Grid, uploaded to the GPS system, with the stakeout undertaken using a Trimble 4700 RTK rover unit with the 4700 base-station repositioned on the same point. The 20m grids were marked by wooden survey pegs. Pegs within areas of poor GPS reception were located using conventional methods using tapes.

Grid locations and the survey coordinate system are shown in Figure 1. The survey exceeded English Heritage (1995) and the Institute of Field Archaeologists (Gaffney & Gater, 1991) guidelines of location of the whole survey to within 1m of the National Grid, and location of points within the survey to within 0.1m with respect to the local grid. Typical surveys are located well within tolerances of 0.1m with respect to the National Grid and points within the grid located to within 0.04m of the local grid.

Both a Nikon DTM330 EDM and the Trimble 4700 RTK system were used to obtain a high quality topographic survey. The principal topographic survey tool is the Trimble 4700 RTK GPS system, with the Nikon EDM used to fill in data in areas of poor GPS reception, particularly under tree cover. Both systems are controlled by dataloggers running Trimble *Survey Controller* software (for this project a TSC1 running Survey Controller v7.7, with calibration files patched to OSTN02 was employed with the GPS, and a TSCc running Survey Controller v10.8, which includes OSTN02, with the EDM). Lower quality (approx. 1m accuracy) survey was also undertaken to map the course of plough furrows across the survey area, using a mapping-grade GPS systems, comprising a Trimble GeoXT (with EGNOS capability) running Survey Supplies *FastMapCE* software. Survey data were assembled and post-processed in Trimble *Geomatic Office* software and exported to *Surfer* for gridding by kriging and imaging.

Results

The survey results are illustrated in figures 1-6, with a summary interpretation given in Figure 7.

Site setting and earthworks (Figure 1)

The hillfort encloses approximately 3.5ha of relatively flat ground on the summit of a hill rising to approximately 167m OD. The geology of the site comprises NNE-dipping sandstones, within the upper part of the Lower Pennant Measures. The summit has a steep scarp slope facing SSW, and the hillfort shows no indications of defences along most of this side. In other directions the land falls more gently outside the hillfort and the defences are mainly closely bivallate, although they vary in detail around the circuit. Additional external counterscarps are seen to the southwest and northeast of circuit. To the north the defences were largely levelled in the 1960s. To the east the presence of an external ditch is uncertain. The surviving earthworks of the defences of the hillfort were described by RCAHMW (1976; pp. 43-44).

To the east of the hillfort a narrow valley rises towards the top of the hill, terminating some 150m east of the hillfort. The northern side of this valley is formed by a prominent south-facing crag of sandstones, which continue westwards, forming a marked topographic feature along the field-boundary east of the hillfort and which continues beneath the eastern defences (about 60m north of the scarp), before becoming more subdued in the hillfort interior.

The intersection of the eastern defences with this natural feature forms a point of complete change in the character of the defences. The large, closely spaced banks north of the crag are replaced by very low banks, possibly without accompanying ditches, to the south. The two banks diverge; the inner curving southwestwards to an incurved entrance just above

the scarp slope and the outer curving outwards slightly to another incurved entrance to the south. The two banks thus enclose a relatively level area of approximately 0.2ha.

The interior of the hillfort rises gently to the summit of the hill and is traversed by two zones of lower ground, each with a tendency to pond water against the eastern defences, and the southern low also has a small pond to the south-west of the summit.

Magnetic gradiometry (Figures 2 and 5)

The magnetic gradiometer results are dominated by intensive parallel lineations in several directions (but particularly orthogonal sets directed towards 108° and 018°). Some of these lineations are still visible as surface furrow features, and they are particularly clearly seen on an aerial photograph from 1946 (Figure 7b). Rather similar anomalies occur in the surveyed area outside the fort to the east

The furrows are cut by a pair of narrow linear features directed towards 096°, which traverse the hillfort in approximate continuation of the line of the field boundary outside to the east. The southern of these two linear anomalies has a strong positive component (particularly towards the east) and corresponds to the position of a significant number of sharp dipolar anomalies indicative of ferrous material. The more northern of the two linear anomalies is dominantly negative, and is more similar to the features produced by ploughing described above. This line can be seen as a fence line on the 1946 aerial photograph (Figure 7b).

Magnetic lineations trending northwest-southeast are less well imaged than the ploughing, and may appear discontinuous. These lineations do not appear to have a single trend, but vary considerably. These features are seen both inside and outside the hillfort, and are interpreted as geological features, probably jointing, but it is possible some of these are minor faults.

Magnetic anomalies running along the earthwork banks in numerous locations also appear to be due to ploughing, and in the south-east corner of the hillfort the ploughing lineations can be seen to extend over the inner bank to the north of the entrances. To the south of a line between the two entrances the ploughing is apparently absent (bedrock is extremely close to surface over much of this area).

In a few areas in the interior of the hillfort the magnetic response is more elevated than elsewhere and some very slight indications of linear features are seen. These are illustrated on the interpretation (Figure 6), but their significance is uncertain because of the intensity of the superimposed ploughing. These possible archaeological features are mainly close to the defences on the northwestern and northern sides of fort. A zone of elevated magnetic response of geological origin lies along the southern side of (i.e. the base of) the northern interval of finer-grained sedimentary rocks (just to the north of N=183200 on eastern side of the hillfort).

In the ploughed area between the two banks north of the entrances there is a cluster of strong magnetic anomalies. A further strong anomaly lies close to the southeast corner of the hillfort. This area is shown in more detail in Figure 5.

To the north of the outer entrance there is a scatter of intense dipolar anomalies in the area of the outer bank (the eastern edge of the northern part of the area illustrated in Figure 5); these are interpreted as modern rubbish. Quite distinct from these small, intense anomalies are a series of high but broader anomalies. These anomalies are numbered 1 to 6 on the summary interpretation on figure 5. The peak recorded value for anomalies 1 to 6 are 48, 66, 47, 72, 65 and 53 nT respectively. An irregular zone of raised gradient (maximum recorded 50nT) lies between the northern group of anomalies.

Extensions to the raised magnetic gradient occur in an elongate form in the 108° direction of ploughing, and also slightly in the 018° direction.

Ground resistivity (Figure 3)

The ground resistivity data are slightly striped in a N-S direction, probably due to a slight short leading to imbalance between the readings from two electrode pairs.

The data are dominated by the WNW-directed bedding in the bedrock. This strong geological signal essentially masks any potential signal from smaller archaeological features, although linear negative resistivity anomalies do parallel the ploughing lineation on the southern edge of the hillfort and some linear negative features also appear to accompany the magnetic evidence for a former field boundary across the centre of the fort. The geological setting can be interpreted as intervals dominated by sandstone (and producing a high ground resistivity) alternating with three intervals with a higher mudrock content (producing lower ground resistivity). The main lower resistivity zones also correspond to topographic lows. The geological bedding data are not shown on the interpretation (Figure 6).

The ground resistivity images the hillfort banks as positive resistivity anomalies. The slight negative anomaly on the inner side of the inner bank on the east of the fort may be evidence for some quarrying, but is more likely to represent deeper and damper soil lying against the topographic feature.

The resistivity over the inner entrance forms a rather uniform rectangular area, but does not show the expected pair of features separated by a passageway. It is possible that ploughing and other damage has led to the infill of the passage being little different to the bank, or it may be that the depth of imaging of the resistivity technique is providing results from below the floor of the passageway. The rear face of the rampart appears to continue straight across the line of the inturned entrance, and it is possible that this sharp edge is defined more by 20th century ploughing than by Iron Age structure.

It was hoped that the resistivity survey would shed light on the issue of presence, or otherwise, of ditches in the area of the entrances. Topographic evidence shows a short length of external ditch cutting the bedrock ridge to the north of the gateways, and the resistivity data may provide some evidence this continued southwards, but probably not as far as the outer entrance. The data contain little evidence for a ditch accompanying the inner bank to the northeast of the inner entrance. A small area of negative resistivity anomaly occurs here, but appears on the ground to be associated with a discrete feature, possibly a relatively recent quarry pit.

Magnetic susceptibility (Figure 4)

The magnetic susceptibility meter had some technical problems with maintaining a zero level during the survey and some areas of the data show a "streaking" parallel with the walking direction. This is particularly prominent west of E=306400.

To the east of this line the data are of a rather higher quality. In general the survey shows lower values where the soil cover is likely to have been thickest. Strong anomalies were detected in the area between the ramparts to the north of the outer entrance, and this reflects the slag observed in the topsoil.

In the northeast quadrant of the hillfort some WNW-directed linear anomalies are present. These seem not to be parallel to ploughing features, but are parallel to the bedding of the bedrock as shown by the ground resistivity survey.

The slags

During the survey a very few extremely small pieces of slag were retrieved from the area to the north of the outer entrance. The material was present in small mounds of upcast soil, apparently produced by burrowing or emerging insects, so the size range of material found was extremely limited. Although most of the material was in the form of tiny comminuted debris and not identifiable, the material included some small sub-spheroidal slag particles, a few millimetres in diameter.

The material from Peter Bailes' collection comprises three small slag pieces:

- The largest piece (34.6g) is of a dense slag, in the form of an irregular prill with a smooth surface, which has penetrated between pieces of charcoal (of which moulds remain on the surface of the prill). The slag is slightly vesicular. The piece does not indicate the full size of the charcoal particles but they appear to range up to at least 30mm. This piece has been broken and has been repaired with a glued joint.
- A second piece (19.7g) is of an irregular thin slag sheet, also bearing moulds of charcoal fragments. The lower face of this piece is rusty, presumably indicating it contained metallic iron. There is small piece of vitrified lining (or possibly a small vitrified sandstone clast) attached to the upper surface, and partially broken away during storage.
- The third piece (11.7g) is of a dense, vesicular, well-flowed slag. The upper surface has a small prill of slag, very similar in appearance to that of tapped slag, with a smooth surface and maroonish tinge. Other surfaces show evidence for contact with small charcoal particles and one surface shows a contact with a sandy material (whether wall, soil or sandstone is not clear).

The material in the Bailes collection is not more closely provenanced than "Caerau hillfort, Llantrisant", but given the surface finds of slag adjacent to the hillfort entrance, in conjunction with significant magnetic anomalies, and a lack of similar anomalies elsewhere in the survey area, it seems

highly possible that Bailes' material was derived from this locality.

Discussion

The geophysical survey of the hillfort interior suggests that great damage was done to the site during the 20th century ploughing, which is likely to have disturbed the bedrock over much of the site. The intensity of the geophysical imaging of the ploughing precludes recognition of any smaller archaeological features that may survive. Some small areas of elevated magnetic response hint that some archaeological features/deposits may remain, despite this disturbance; these are seen particularly in a zone close to the inner rampart on the northern and northwestern sides of the hillfort.

The survey adds little to the understanding of the hillfort defences (nor indeed was intended so to do), but the survey does suggest a strong control from the bedrock morphology over the siting and orientation of the inner gateway.

The identification of an area of iron working within the hillfort's entrance complex is extremely interesting and unusual. The limited slag available for study includes Bailes material, with slag prills and blebs penetrating between moderately large charcoal pieces, and the new finds, including small slag spheres. Although neither of these slag morphologies is entirely diagnostic, the two together are suggestive of the slag assemblages commonly encountered in the base of non-slag tapping furnaces. Detailed published accounts of such slag assemblages are largely absent from the literature, but the author has encountered similar material in several unpublished studies.

Similar material has been recovered in England from probably in-situ assemblages, as well as secondary contexts, at the Iron Age site of Hartshill Copse (Young 2004i, 2005a), dated to the 5th or 6th centuries BC. Elsewhere in England a style of Iron Age smelting producing large "furnace bottoms" with large charcoal inclusions is widely recognised, but largely undescribed (but see Clogg 1999, Crew 1995 and Halkon 1997). In Ireland similar material has come from many recently-excavated sites (Young 2003a, c, d and 2005b), most currently lacking radiometric dates but probably ranging from later prehistoric to early medieval in age. In Wales, broadly similar Iron Age examples have been described from Gwynedd by Crew (Bryn y Castell hillfort, Crew 1987; Crawcwellt, Crew 1989, 1998), who subsequently attempted to reproduce the smelting technology (Crew 1991). None of the examples known to the author from Britain is certainly Roman or later. Instead, from the later pre-Roman Iron Age onwards, various forms of slag-tapping furnace seem to become dominant, although the earlier technology remained utilised in Ireland probably until early post-medieval times.

Although an Iron Age date for the smelting activity at Caerau seems likely, there are other possibilities. The controls on situation of bloomeries at various periods are only slowly being determined in Glamorgan, and therefore any interpretation based on site type or location must be tentative. Conditions at Caerau would have been favourable for manually-blown bloomeries: the present site lies only 1500m north of the former outcrop of major iron ore bodies in the area of Mwyndy and the slopes of Caerau Hill are

likely to have been forested in the past, and therefore a potential charcoal source.

The land including the hillfort formed part of the demesnes lands of the lordship of Meisgyn in the 16th century, but its status is slightly unclear. In some documents it appears as forest and in some as pasture. The most likely interpretation would seem to be that this might have been ancient woodland that had become deforested by late medieval times. An unexcavated site at Rhiwsaeson, at the foot of the scarp below Caerau, yields bloomery slag that is chemically similar to that from the much larger site at Mwyndy, close to the ore mines (pers. obs.). The large slag dumps at Mwyndy, are indicative of a large, highly efficient, bloomery, and although not yet dated directly, a later medieval age seems likely on various strands of technological and documentary evidence. The woodland resources of the steep slopes of the Caerau Hill would be very likely to have been the attraction of smelting at Rhiwsaeson. The possibility exists, therefore, that the Caerau Hill itself might have supported bloomery iron-making in medieval times. However, other probable medieval smelting sites in the area seem to be confined to low ground close to water supplies. So far no pre-medieval smelting sites have been located in this area away from the ore outcrops, which are not situated at significant settlement sites.

The location of the iron-making within the hillfort is suggestive of careful placement. The circular anomalies that might represent furnaces are arranged along the rear of the outer rampart. The positioning of bloomery furnaces against a bank (whether natural or artificial) is common occurrence. It is not possible to determine with certainty whether the metalworking activity was contemporary with the hillfort, or whether a convenient flat, but partially enclosed, area was utilised at a later date. However, the very unusual arrangement of the entrance area, with its apparently elaborate, but slight defences compared with the remainder of the circuit, and the strange forecourt area between the defences overlooked by the more substantial defences to the north of the natural crag, all suggest that unusual activity might have been associated with this area.

On balance, the evidence from the slags themselves and from consideration of the site's location, favour, but do not prove, the proposition that the iron-making at Caerau is pre-Roman in date. If this is the case, then Caerau has great significance. There are no pre-Roman iron smelting sites known from South Wales, and very few from Wales as a whole, despite artefact finds suggesting widespread and skilful use of the metal, including the very early material from Lyn Fawr.

Acknowledgements

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Discussions with Professor W Manning about the history of material in the Bales collection in Cardiff University are gratefully acknowledged.

Figure Captions

Figure 1. Topographic survey and survey design. Contours at 5m (green) and 1m (khaki) intervals. Earthworks: grey (banks), blue (ditches). National and site grids indicated. North to top.

Figure 2. Magnetic gradiometer survey. Grey scale: -4nT (black) to +4nT (white). Processing: grids balanced, composites merged, zero mean traverse applied. Data exported to Surfer and kriged to interpolate to 0.125m grid node spacing.

Figure 3. Ground resistivity survey. grey scale: 60Ω (black) to 500Ω (white) measured resistance. Processing: grids balanced. Composite despiked. Data exported to Surfer and kriged to interpolate to 0.125m grid node spacing.

Figure 4. Magnetic susceptibility survey. Colour scale as key. Processing: data collected in Pocket Excel, exported to Surfer and kriged to interpolate to 1.0m grid node spacing.

Figure 5. Magnetic gradiometer survey: detail of area around entrance. Grey scale -10nT (black) to +10nT (white) top and -60nT (black) to +60nT(white) below. Processing as Figure 2. Interpretation: possible furnaces/hearths: white filled features, elevated magnetic response: pink area (with outline around most elevated portion); banks grey and ditches blue fills.

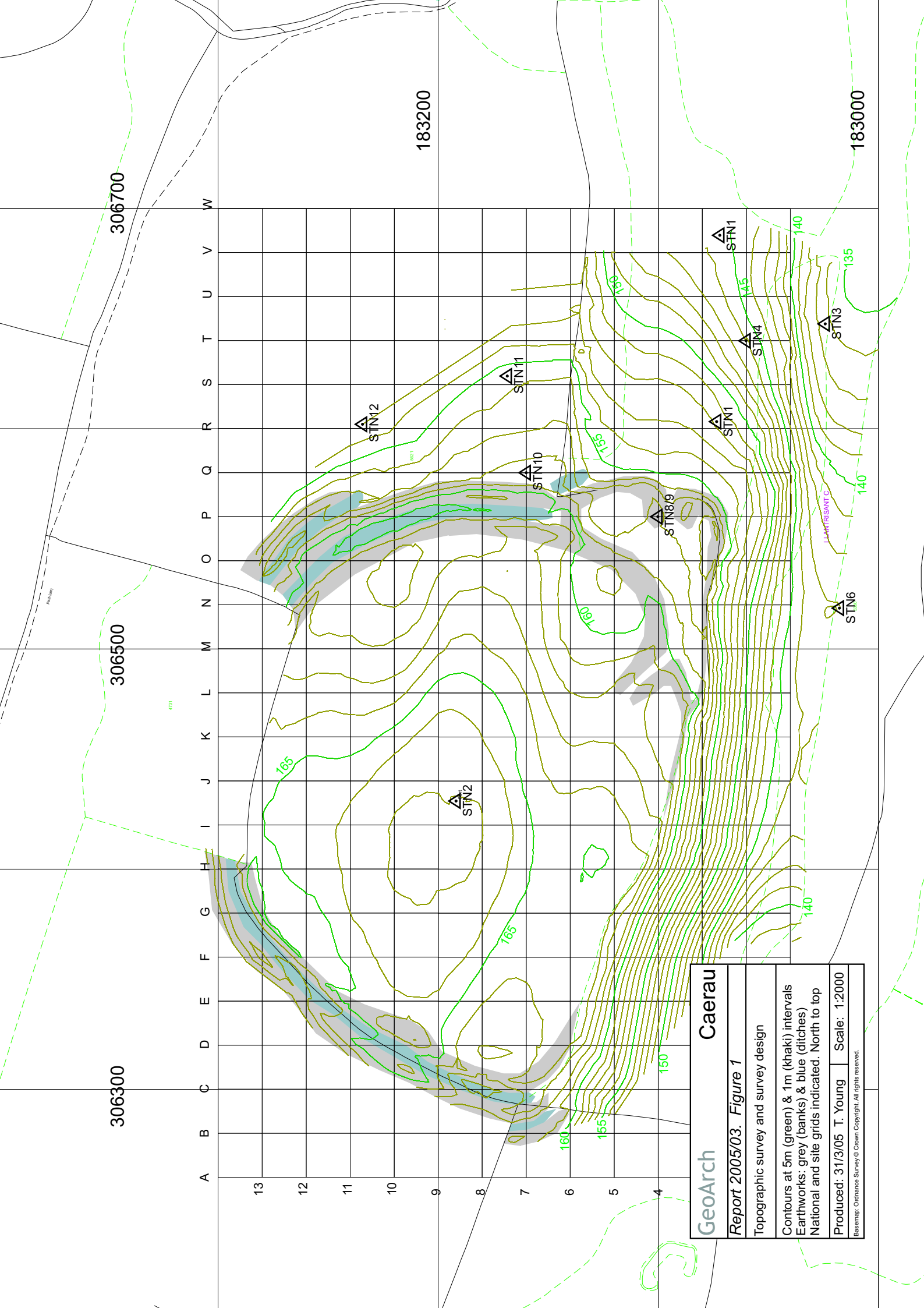
Figure 6. Interpretation. Earthwork features as figure 1, with destroyed parts in dashed lines. Ploughing: green lines, geological jointing: orange lines, pond: blue, damp areas: green, other magnetic features: lineations in red, areas of elevated magnetic response pink, possible furnace/hearth features black linework with white fills, former fenceline: brown line.

Figure 7. Aerial photographs.

- A) 27th February 1968, Fairey, National Coal Board, frame 7862.
- B) 4th December 1946, RAF CPE/UK/1871 frame 4100.

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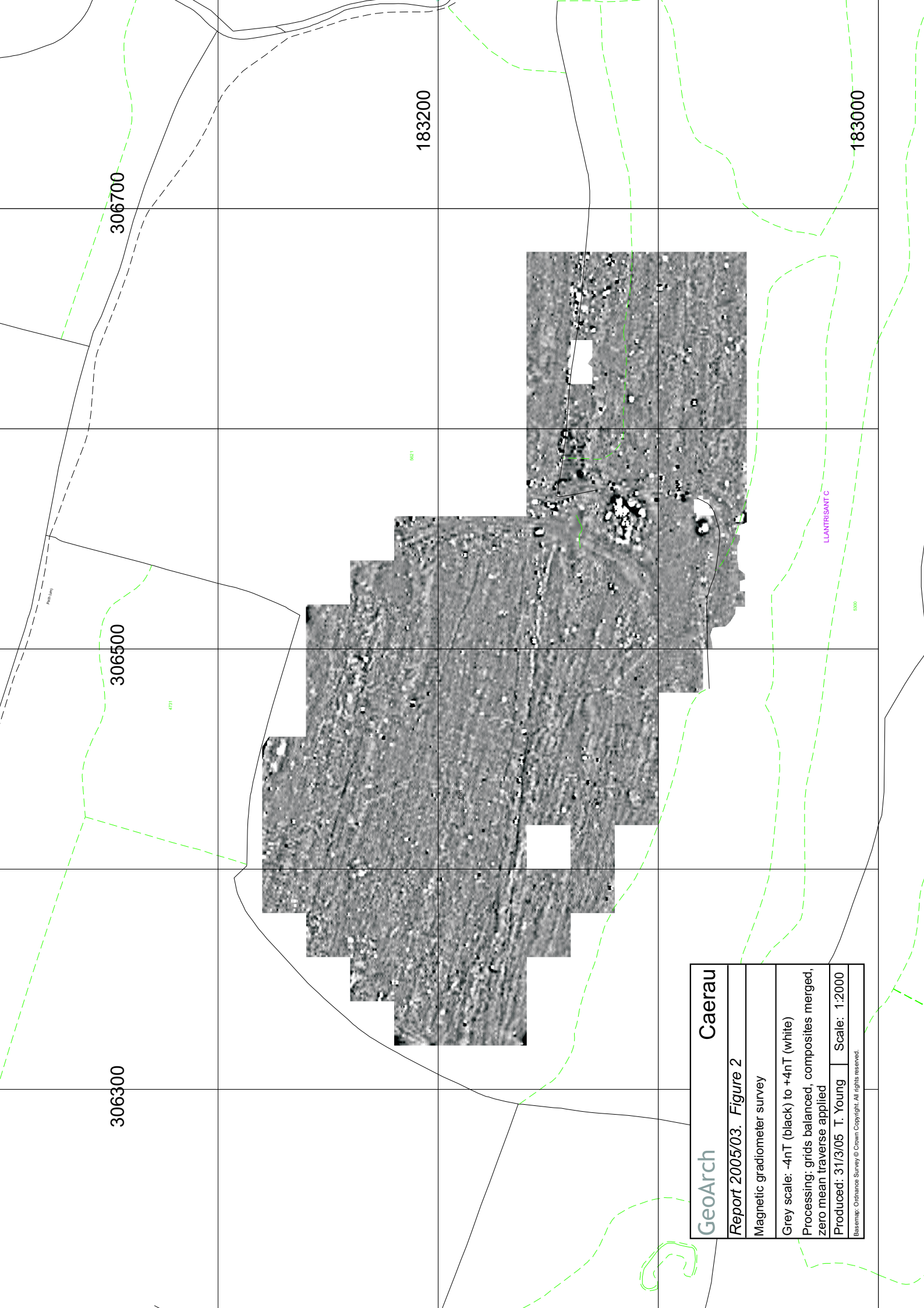
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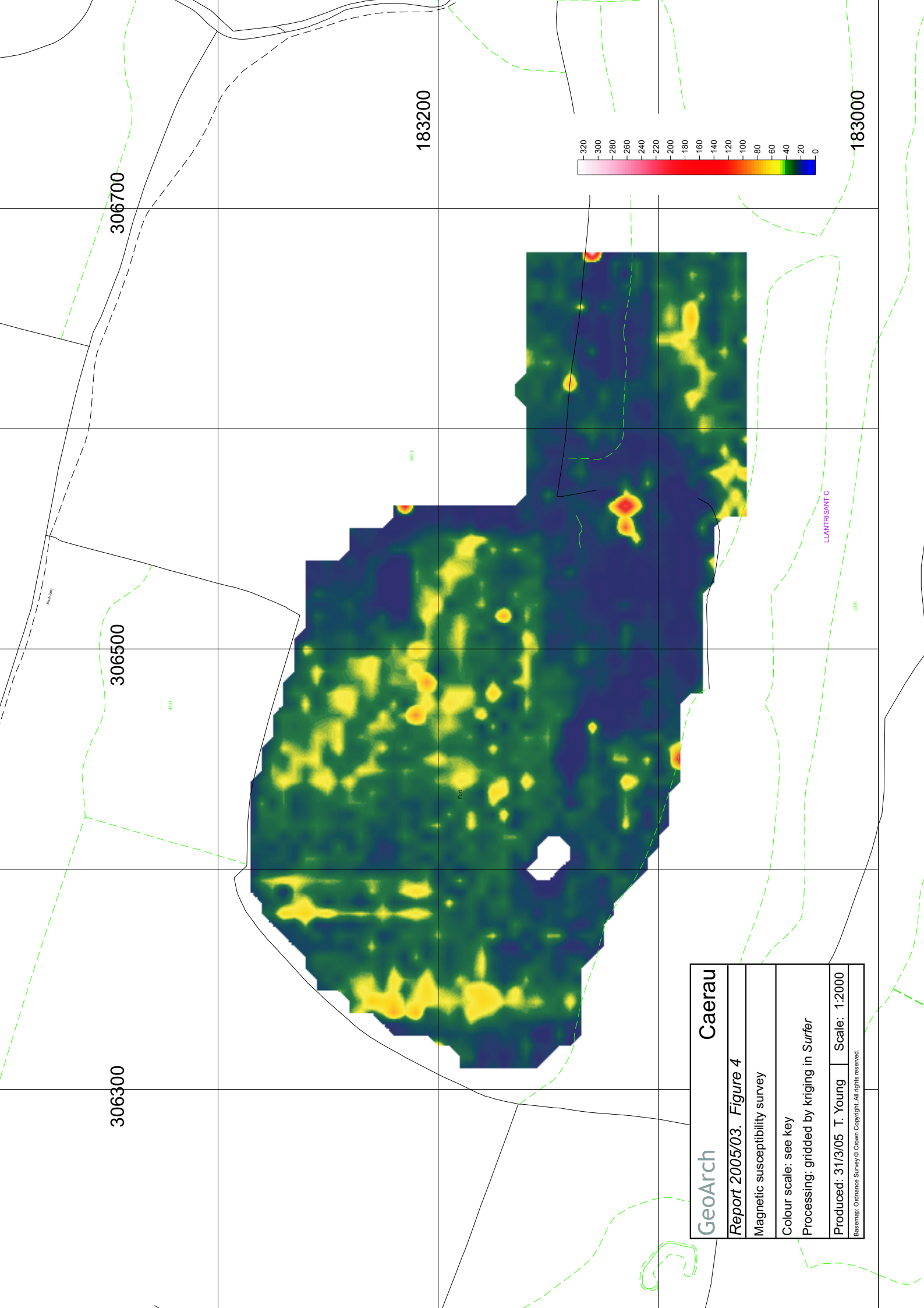
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Report 2005/03. Figure 1	
Topographic survey and survey design	
Contours at 5m (green) & 1m (khaki) intervals	
Earthworks: grey (banks) & blue (ditches)	
National and site grids indicated. North to top	
Produced: 31/3/05 T. Young	Scale: 1:2000
<small>Basemap: Ordnance Survey © Crown Copyright. All rights reserved.</small>	



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Magnetic gradiometer survey	
Grey scale: -4nT (black) to +4nT (white)	
Processing: grids balanced, composites merged, zero mean traverse applied	
Produced: 31/3/05 T. Young	Scale: 1:2000
<small>Basemap: Ordnance Survey © Crown Copyright. All rights reserved.</small>	



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Ground resistivity survey	
Grey scale: 60Ω (black) to 500Ω (white) measured resistance	
Processing: grids balanced, composite despiked	
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<small>Basemap: Ordnance Survey © Crown Copyright. All rights reserved.</small>	



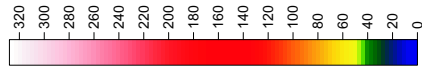
306300

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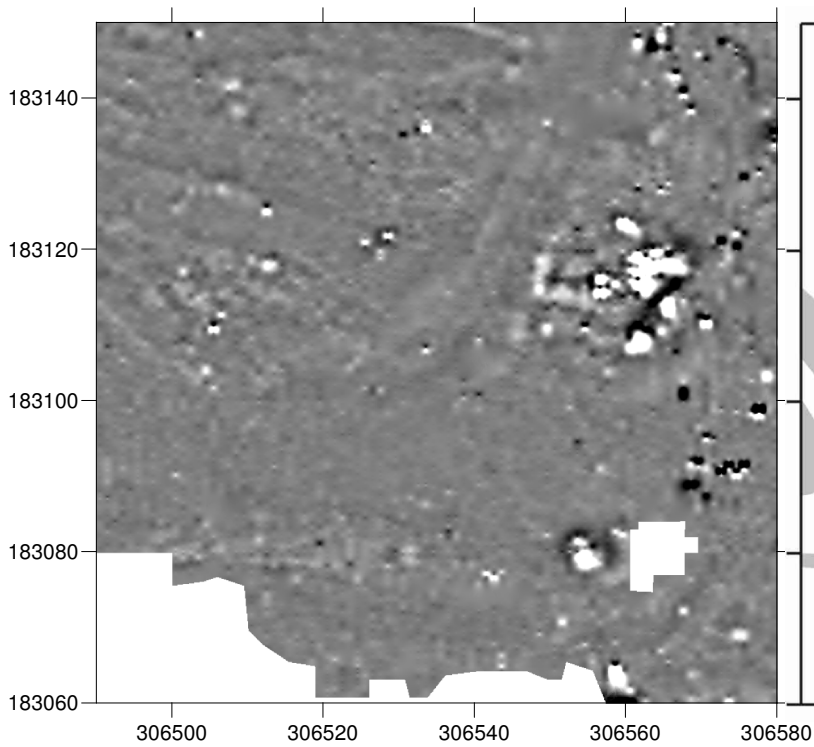
306700

183200

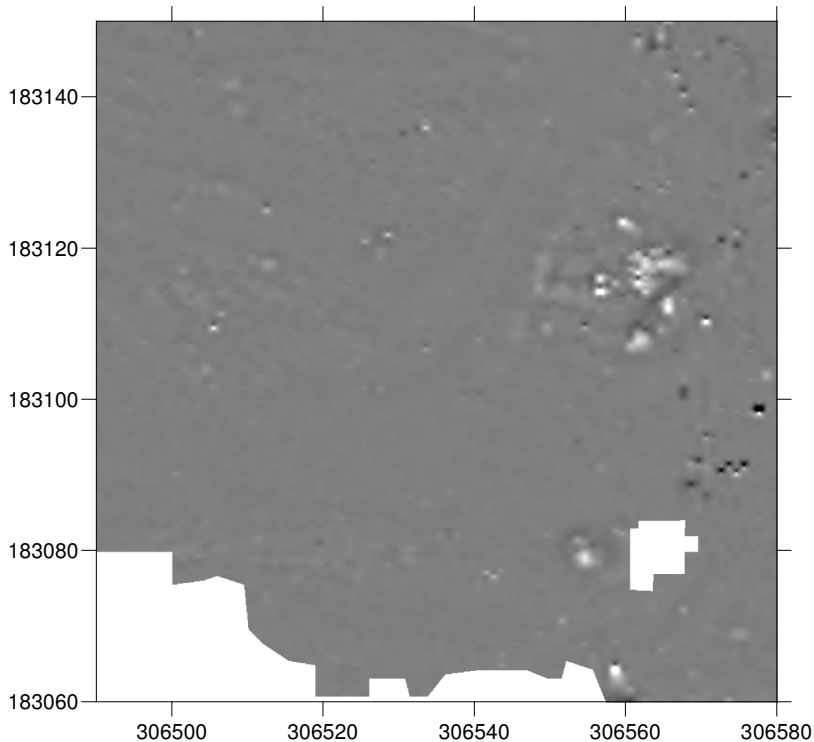
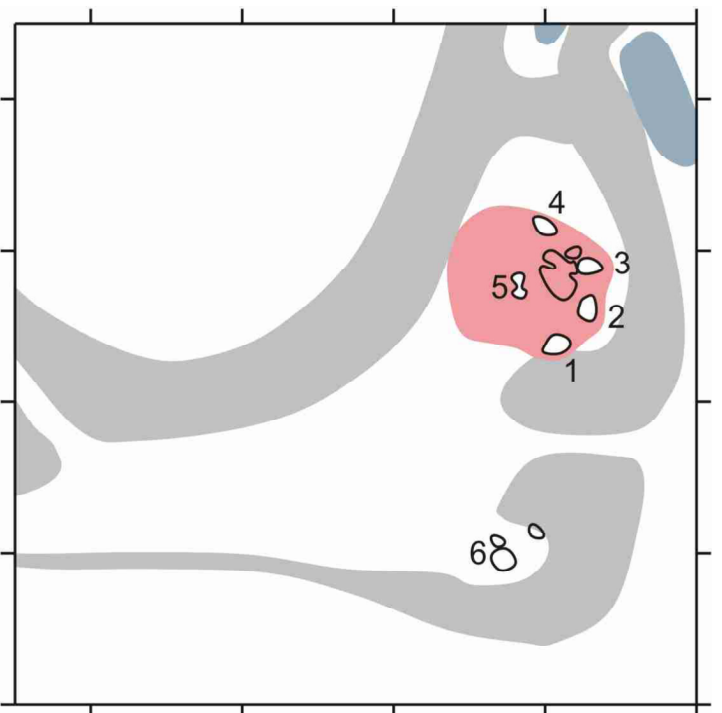
183000



GeoArch	Caerau
Report 2005/03. Figure 4	
Magnetic susceptibility survey	
Colour scale: see key	
Processing: gridded by kriging in Surfer	
Produced: 31/3/05 T. Young	Scale: 1:2000
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-10nT black
to
+10nT white



-60nT black
to
+60nT white

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<i>Report 2005/03. Figure 5</i>	
Magnetic gradiometer survey: detail	
Grey scale: -10nT (black) to +10nT (white) top -60nT (black) to +60nT (white) below	
Processing: as figure 2	
Produced: 31/3/05 T. Young	Scale: 1:1000

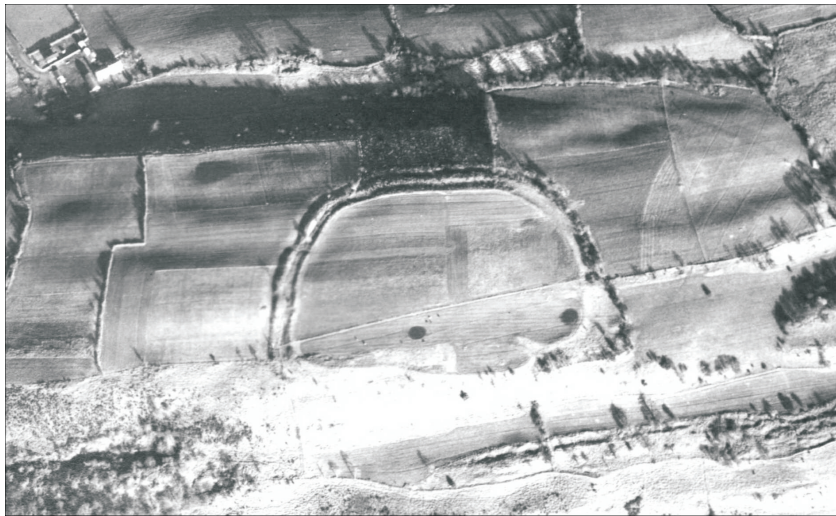


GeoArch	Caerau
Report 2005/03. Figure 6	
Interpretation	
Earthwork features as Fig. 1 with missing parts in dashed lines. Ploughing: green lines, geological features: orange lines, pond: blue, damp areas: green, magnetic features: red and open circles, former fenceline: brown line.	
Produced: 31/3/05	T. Young
Scale: 1:2000	
<small>Basemap: Ordnance Survey © Crown Copyright. All rights reserved.</small>	

a



b



GeoArch	Caerau
<i>Report 2005/03. Figure 7</i>	
Aerial photographs	
a. 27th February 1968. Fairey, National Coal Board, frame 7862	
b. 4th December 1946. RAF CPE/UK/1871 frame 4100	
Produced: 04/10/05 T. Young	

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