Appendix 1: Optically Stimulated Luminescence (OSL) Dating Results from the White Horse and Linear Ditch

by Julie Rees-Jones and Mike Tite

INTRODUCTION

Luminescence is the light given out by crystals on exposure to heat (thermoluminescence) or light (optically stimulated luminescence), due to the release of energy stored in the crystal lattice following exposure to ionising radiation. The luminescence signal of a crystal is proportional to the radiation dose the crystal has received since the zeroing either by heat or by exposure to light and can therefore be used for the dating if the dose rate is known (Aitken 1985).

Sediments can be dated because the optically stimulated luminescence (OSL) of constituent quartz and feldspar crystals will be zeroed when the sediment is exposed to the sunlight at deposition. The sediment then becomes buried and is kept dark. During burial the sediment is exposed to naturally occurring radiation from isotopes in the ground and cosmic radiation; thus the luminescence signal grows. Samples taken for dating are kept dark and the luminescence signal is measured in the laboratory enabling an optical date to be calculated using the formula given below. For further details of the method see Aitken (1998).

$$\text{Age} = \frac{\text{natural luminescence signal}}{\text{luminescence signal per unit dose} \times \text{annual radiation dose}}$$

SEDIMENT

Sediment samples were taken from both the White Horse excavations in 1994 (Fig. 5.9 and Chapter 5) and the linear ditch and rectangular enclosure excavations in 1995 (Fig. 7.4 and Chapter 7). The sediment samples from the White Horse came from the trench at the belly of the Horse. Sample 962a came from 0.4 m below the present ground surface, from a layer of colluvium that overlies one chalk figure and is cut by another later figure above (context 5033). Sample 962b came from 0.6 m further along the section, away from the Horse, and from a colluvial layer underneath all the preserved chalk figures (context 5034).

Four sediment samples were taken from ditches sectioned during the 1995 excavations, one sample being from trench 1, two samples from trench 2 of the linear ditch and a further sample from the ditch of the rectangular enclosure. It proved impossible to date the samples from trench 1 (967a) and the rectangular enclosure (967d) for the reasons set out below. The samples from trench 2 were 967b (context 206) and 967c (context 208), with sample 967b lying stratigraphically above 967c.

MEASUREMENT PROCEDURES

Sample collection and preparation

The sediment samples were taken from the relevant sections using steel cylinders approximately 50 mm diameter and 150 mm long. Immediately upon extraction, the cylinders were capped and wrapped in opaque black plastic to avoid exposure to light. In the laboratory, the samples were prepared under restricted lighting and the ends of the cores that had been exposed to light during collection were removed.

The samples were treated with dilute hydrochloric acid to remove calcium carbonate, hydrogen peroxide to remove any organics and Calgon with ultrasonic treatment to remove clays. The material was then thoroughly rinsed in distilled water and separation of the polymineral fine grains (4–11 μm) was attempted using the appropriate settling time in acetone. Fine grains were successfully separated from sample 962a, 967b and 967c, but in the remaining three samples (962b, 967a, 967d) the fine grains were found to adhere due to the presence of iron oxide coating and calcium carbonate. A further portion of all six samples was then treated with fluorosilicic acid, following the procedure of Rees-Jones (1995), to remove all non-silicate material. This treatment results in a sample that is approximately 95% quartz, allowing comparison of quartz and polymineral dates. Fine grain quartz was then separated again using the appropriate settling time in acetone. Unfortunately, there was insufficient fine grain quartz surviving in samples 967a and 967d after fluorosilicic acid treatment to obtain a viable date.

OSL measurement

The luminescence signals were measured using Elsec optical dating systems. The luminescence signal from the polymineral fractions were measured by exposure to infrared light, which stimulates a luminescence signal only from feldspars (Spooner *et al.* 1990) and the signal from the quartz fractions were measured using green light from an argon ion laser (Huntley *et al.* 1985). A similar measurement procedure was used for both stimulation wavelengths apart from different preheats. A preheat is required to remove the unstable signal, resulting from laboratory irradiation, that is not present in the natural signal.

For the infrared signals a preheat temperature of 160°C was used and a preheat test was carried out to find the appropriate preheat duration. This involved irradiating aliquots with various beta dose (Sr^{90}-Y^{90} source) and making short shine measurements (0.5 s) after preheats of increasing duration. For each preheat time an additive growth curve was constructed and an equivalent dose (the beta dose giving rise to a luminescence signal equivalent to that of the natural signal) calculated. These ED or equivalent dose values increase with preheat time until the time is sufficient to remove all charge unstable over the burial time. The results showed that preheats of 6 h at 160°C were required for samples 962a and 967b and of 4 h for sample 967c. For the quartz signal from all samples a preheat of 5 min at 220°C was used, as specified by Smith *et al.* (1986).

The measurement procedure for dating involved constructing additive alpha and beta growth curves. All aliquots were first normalised by the counts produced from a short shine of infrared or green light applied to the natural signal. Aliquots are then given various alpha or beta doses, preheated and then measured by a 200 s exposure to the stimulation light. The growth curves produced were fitted by a least squares linear fit and extrapolated to give alpha and beta ED values. The alpha ED was used to calculate alpha particle effectiveness at creating a luminescence signal or a-value (see Aitken 1985). This could not be determined for all the quartz fractions due to lack of material. For sample 962a it was assumed to the same value as that for 962b quartz as these were similar samples from the same site. For samples 967b and 967c an average a-value of 0.038 was used. The beta growth curve aliquots, subsequent to measurement, were bleached, re-dosed and used to construct a second growth curve from which the intercept correction (I) associated with supra-linear growth, recuperation of the signal or a residual hard to bleach signal could be determined. This value is used to correct the ED value and give the palaeodose (P), which is the dose the sediment has received since last beached.

Annual radiation dose measurement

The dose rate (ie annual dose) received by the sediment during burial was determined by two independent methods, which agreed with each other. The methods were portable gamma spectrometry and thick source alpha counting with potassium flame photometry. The final dose rate used for age calculation was a combination of both sets of measurements; the total gamma dose rate and the beta dose rate due to uranium and thorium were determined by on site portable gamma spectrometer measurements, which measures gamma rays from a radius of 30 cm. The remaining beta dose rate due to potassium was determined by flame photometry and the alpha dose rate was determined by thick source alpha counting, as alpha particle range is significantly less than that of gamma rays. For the White Horse samples the water content was measured at the time of sampling and found to be 20% of the saturation value despite the fact it was raining at that time. For the Uffington Castle samples the water contents at the time of sampling were between 70 and 90% of the saturation values. A value for the water content of $20 \pm 20\%$ for the White Horse and $60 \pm 30\%$ for Uffington Castle was therefore used to correct the beta and alpha dose rates for absorption of energy by water.

The errors quoted are at the 68% confidence level and include both systematic and random errors from Aitken (1985), with an error of 10% assumed for the dose rate assessment due to systematic errors in equipment calibration.

RESULTS AND DISCUSSION

The measured values for the palaeodose, a-value and dose rates are shown in Table A1.1 together with the dates calculated.

For the samples from trench 2 through the linear ditch, the feldspar dates for both samples are significantly higher than the corresponding quartz dates. Furthermore, these dates are in reverse order to the sample stratigraphy, the dates for sample 967b being higher than those for sample 967c which lay below it in the ditch. Since the quartz signals bleach more rapidly than the feldspar (infrared) signals (Godfrey-Smith *et al.* 1988), these discrepancies strongly suggest that neither sample was fully bleached at deposition and that the ages are all over-estimates of the true ages of the sediments. Of the sample components dated, the quartz component of sample 967c is likely to have come nearest to being completely bleached but was still not necessarily fully bleached at deposition. Therefore, the only inference that can be made from the luminescence dates for these samples is that the final refilling of the ditch must have started sometime after about 400 ± 210 BC, a date that is not inconsistent with the fact that Roman pottery was found in the ditch fill.

In contrast for the White Horse, the feldspar and quartz dates for sample 962a agree with each other within one standard deviation, the latter similarly agreeing with the quartz date for sample 962b. It, therefore, seems probable that the White Horse samples were fully bleached at deposition and the dates obtained are accurate. The assumption is, if anything, strengthened by the fact that, as observed for the Uffington Castle trench 2 ditch samples, failure to achieve full bleaching is clearly revealed through the obvious discrepancy between the dates obtained for the feldspar and quartz components.

The accuracy of the White Horse dates is further reinforced by the agreement in the dose rates as determined by two independent methods (ie portable gamma spectrometry and thick source alpha counting with potassium flame photometry). In addition, since the growth curves for the ED determinations are linear, there is no risk of the age over-estimation that can arise when the growth is exponential. Similarly, there is little likelihood of a lower age as a result of a lower water content, and hence increased dose rate, since the observed water content was already low (20%) at the time of sampling and any possible age over-estimation is covered by the errors (±20%) assumed for the water content. In summary, taking the earliest date as that given by sample 962b from below all the preserved chalk figures and the latest date as that given by sample 962a from above one chalk figure, the luminescence dates for the White Horse suggest and approximate age range of 1380–550 BC for the construction of the first Horse. This range overlaps with the suggested date of 750–650 BC for the construction of the hillfort so that the White Horse and the hillfort could be contemporaneous.

Appendix 2: Sites, Cropmarks and Find Spots in the Vicinity of White Horse Hill – Neolithic to Anglo-Saxon

by Anne Marie Cromarty

(Figs 14.2, 14.3 and 14.6)

SMR PRN (SAM no.)	Area centred NGR Co-ords.	Type	Comments
Neolithic–early Bronze Age			
Long barrows			
7306 f (SAM 21775)	SU 281 853	Excavated and restored earthwork	Two phase chambered long barrow known as 'Wayland's Smithy', kerbed with sarsens in phase 2, sarsen façade at wider southern end (Whittle 1991)
10730 (SAM 21776)	SU 300 866	Excavated and partially restored earthwork	Long mound at White Horse Hill, reused in BA and RB periods (see Chapter 4 this report)
7181	SU 323 834	Earthwork	Lambourn Long Barrow (Wymer 1965–6)
7557 (SAM 12025)	SU 3270 8442	Earthwork and cropmark	Ploughed out but visible as cropmark
7496	SU 335 842	Excavated (site of)	Small long barrow, excavated by E Martin-Atkins in 1852; 4 inhumations and setting of sarsens
Settlement and other features			
13196 (SAM 20602)	SU 2490 9075	Multi-period excavated site	Features of late Mesolithic/early Neolithic transitional date to W of scheduled site, also used in LBA, MIA and LIA/early RB, as well as AS cemetery
	SU 2847 8385	Excavated feature	Grooved Ware pit at Tower Hill (see Chapter 12 this report)
15930	SU 3302 8389	Excavated finds and features	Grooved Ware pit at Sparsholt (Durden 1996)
Lithic scatters and stray finds			
15603	SU 2641 9180		Large flint scatter from fieldwalking
11642	SU 2760 8337		Worked flint
12608	SU 2784 8215		3 flint tools
11643	SU 2824 8085		Flint implement
7909	SU 287 843		Lithic scatter from fieldwalking in area of RB enclosure and settlement
12593	SU 2895 9253 and SU 2893 9256		2 polished stone axes from ploughsoil
7514	SU 2903 9267		Polished flint axe, flint scrapers, cores and struck flints from Little Coxwell hillfort
12216	SU 2928 8655		Conical flint core
7873	SU 301 915		Perforated flint macehead in area of ploughed out barrow
11671	SU 3123 8665		Flint implements and waste material
15573	SU 3268 9358		Concentration of flints from fieldwalking
15574	SU 3309 9357		Flints from fieldwalking, concentration probably resulting from hillwash
15575	SU 3322 9348		Concentration of flints from fieldwalking
15587	SU 335 940		8 flint blades from ploughsoil
15577	SU 336 838		Lithic scatter from fieldwalking
15578	SU 339 844		Lithic scatter from fieldwalking survey
11645	SU 3468 9042		Flint scatters with mainly RB, but also some possible AS and medieval pottery scatter
7935	SU 344 874		Struck flints including axe fragments
7933	SU 349 871		Struck flints

(*Continued*)

SMR PRN (SAM no.)	Area centred NGR Co-ords.	Type	Comments
Bronze Age			
Barrows and ring ditches (including examples which may have later origins and other unverified examples)			
12047	SU 2530 8743	Cropmark	Double
11019	SU 256 897	Cropmarks	Three ring ditches, one with linear features running northwards
11006	SU 2637 8326	Cropmark	Ring ditch
10580	SU 264 838	Cropmark	Single ring ditch
12046	SU 2645 8930	Cropmark	Small ring ditch
12036	SU 2675 8923	Cropmark	Small ring ditch
7337	SU 2724 8163	Earthwork	Bowl barrow
7833	SU 2725 8445	Cropmarks earthworks	Four ring ditches
12033	SU 2729 8934	Cropmark	Ring ditch
12035	SU 2738 8895	Cropmark	
7338	SU 2741 8155	Earthwork	Bowl barrow
7879	SU 2744 8890	Cropmark	
12034	SU 2746 8910	Cropmark	Two ring dtches
7517	SU 2755 8382	Site of	Ploughed out barrow, pottery, flint scatter
7340 (SAM 28147)	SU 2758 8102	Earthworks	'Three Barrows'
11000	SU 2760 8096	Cropmark	Ring ditch
9734	SU 2765 8377	Cropmark	Ring ditch
7341	SU 2766 8102	Site of	Opened in 1878, internment found dated to 1600–1200 BC; nothing now visible
11004	SU 2773 8089	Cropmark	Ring ditch
11002	SU 2775 8156	Earthwork	Possible barrow
7332	SU 2778 8237	Site of	Ploughed out possible barrow; Belgic, RB and AS pottery sherds
11003	SU 2782 8395	Cropmark	Ploughed out barrow
12030	SU 2812 9129	Cropmarks	Two ring ditches
9565	SU 2817 8938	Excavated earthwork (site of)	Excavated by E Martin-Atkins; jet ornament, shale ring and bronze pin found indicating reuse in RB or AS period; mentioned in AS charter of AD 955
7869	SU 2818 8417	Earthwork	Possible bowl barrow
12031	SU 2860 9035	Earthwork	Small ring ditch
12023	SU 2860 9233	Earthwork	Round barrow
9739	SU 2869 8448	Earthwork and finds	Possible barrow, with scatter of RB pottery and animal bones
12012	SU 2966 9254	Cropmark	Small ring ditch
12009	SU 2977 8618	Cropmark; excavated	Plough truncated ring ditch, set within RB enclosure and RB inhumation within ditch
9574	SU 2979 8334	Earthwork	Bowl barrow
15998	SU 2999 9065	Cropmark	Ring ditch
10730 (SAM 21776)	SU 300 866	Excavated and partially restored earthwork	Neolithic long mound at White Horse Hill, reused in BA and RB periods (see Chapter 4 this report)
7903 (SAM 21776)	SU 3005 8655	Earthwork	Round barrow on White Horse Hill, reused during AS (see Chapter 4 this report)
7178	SU 3028 8487	Earthwork	Idlebush Barrow; bounds of Uffington attached to 10th-century charter name this barrow as 'hafeceshlæwe' or hawk's barrow (see Hooke 1987 and Chapter 3 this report)
7555	SU 3019 8498	Earthwork	Bowl barrow
11043	SU 3031 8450	Cropmark and earthwork	Plundered barrow
7179	SU 3033 8470	Earthwork	Small disc barrow; bounds of Uffington attached to 10th-century charter name this barrow 'hundes hlæwe' or hound's barrow (see Hooke 1987 and Chapter 3 this report)

(*Continued*)

SMR PRN (SAM no.)	Area centred NGR Co-ords.	Type	Comments
13587	SU 3039 8478	Cropmark ring ditch	Ring ditch
7881	SU 304 846	Earthwork	Small round barrow
11072	SU 3070 8413	Cropmark	Ploughed out
11042	SU 3075 8445	Cropmark	Two ploughed out
10581	SU 313 854	Cropmark	Two ring ditches
10581	SU 314 854	Cropmarks	Ring ditch adjacent to sub-circular feature
12008	SU 3150 8575	Earthwork	Ring ditch
10583	SU 3180 8653	Cropmarks	Two ring ditches
10732	SU 321 856	Cropmark	Two ring ditches
7496	SU 3237 8350	Earthwork (site of)	Ploughed out; part of Seven Barrows barrow cemetery (Case 1956–7)
(SAM 12240)	SU 326 831	Earthwork	Part of Seven Barrows barrow cemetery (Case 1956–7)
(SAM 12277)	SU 326 832	Earthwork (site of)	Two adjacent barrows, parts of Seven Barrows barrow cemetery (Case 1956–7)
7551	SU 3164 8540	Cropmark	Possible barrow
10577	SU 3265 8352	Cropmark	Two conjoining ring ditches may be double barrow, part of Seven Barrows barrow cemetery (Case 1956–7)
(SAM 12239)	SU 327 828	Earthwork	Part of Seven Barrows barrow cemetery (Case 1956–7)
(SAM 12238)	SU 328 825	Earthworks and cropmarks	At least five barrows or ring ditches, parts of the Seven Barrows barrow cemetery (Case 1956–7)
(SAM 12237)	SU 328 827	Earthworks	Two adjacent barrows, parts of Seven Barrows barrow cemetery (Case 1956–7)
7292	SU 3285 8821	Earthwork	Thought to be of RB date by S Piggott, but little dating evidence other than proximity to other RB sites and findspots; may be reused in that period
(SAM 12280)	SU 329 825	Cropmark	Part of the Seven Barrows barrow cemetery (Case 1956–7)
(SAM 12071)	SU 329 829	Earthworks	Group of eight adjacent barrows and one double barrow, forming the main core of the Seven Barrows barrow cemetery (Case 1956–7)
10576	SU 3295 8369	Cropmark	Single ring ditch; part of Seven Barrows barrow cemetery (Case 1956–7)
(SAM 12242)	SU 325 831	Earthwork	Part of Seven Barrows barrow cemetery (Case 1956–7)
7182 (SAM 12241)	SU 325 833	Earthwork	Part of Seven Barrows barrow cemetery (Case 1956–7)
(SAM 12236)	SU 330 826	Earthwork	Part of the Seven Barrows barrow cemetery (Case 1956–7)
15685	SU 3305 8392	Cropmark	Small ring ditch; part of Seven Barrows barrow cemetery (Case 1956–7)
7186	SU 3306 8414	Partially excavated earthwork	Small bowl barrow, now ploughed out; finds of collared urn and LBA pottery
12545	SU 333 848	Cropmark	Part of Seven Barrows group (Case 1956–7)
10578	SU 3387 8558	Cropmark	Two conjoining ring ditches
9593	SU 3403 8426	Earthwork (site of)	Ploughed
7305 (SAM 28192)	SU 3436 8521	Excavated earthwork and finds	Bowl barrow; primary interment consisted of a cremation with much charcoal; flint scraper and arrowhead from mound
12069	SU 3452 9432	Cropmark	Double concentric ring ditch
10578	SU 349 855	Cropmark	Double ring ditch
7240	SU 3510 8518	Earthwork	Bowl barrow
11037	SU 3517 8518	Cropmark	Ring ditch
15685	SU 362 848	Cropmark	Possible round or long barrow
11036	SU 3624 8540	Cropmarks	Two ring ditches
12561	SU 366 841	Cropmark	
7877	SU 367 838	Earthwork (site of)	Ploughed out
11035	SU 3670 8516	Cropmark	Ring ditch
7876	SU 3705 8406	Earthwork	Partially ploughed out
Late Bronze Age			
Settlements and associated features			
15610	SU 2846 8397	Excavated	LBA/EIA transitional settlement at Tower Hill (see Chapter 8 this report)
Not yet on SMR	SU 295 820	Partially excavated	LBA settlement discovered by fieldwalking survey and confirmed by limited excavation at Weathercock Hill; almost ploughed out
10555	SU 3148 8636	Excavated cropmark	Three phase enclosure with limited settlement evidence in interior at Rams Hill; later replaced with larger hillfort (Bradley and Ellison 1975; Needham and Ambers 1994)

(*Continued*)

SMR PRN (SAM no.)	Area centred NGR Co-ords.	Type	Comments
7200 (SAM 28183)	SU 385 845	Excavated	Traces of possible LBA enclosure predating hillfort known as 'Segsbury Camp' or 'Letcombe Castle' (Lock and Gosden 1997 and 1998); *cf* PRN 7841
7841	SU 3878 8448	Cropmark	Enclosure ditch, possibly associated with earlier activity predating hillfort at Segsbury Camp
Boundaries			
9569	SU 2692 8098 to SU 2763 8103	Earthwork linear	Ancient ditch, earthwork facing north typical of OGS Crawford's LBA ranch boundaries
9570	SU 2873 7913 to SU 2920 8290	Earthwork linear	LBA ranch boundary identified by Crawford 1953; nothing identifiable as such now
7547	SU 300 862 to SU 301 856	Earthwork	Linear ditch running south along ridge from Uffington Castle (see Chapter 7 this report)
Finds only			
15610	SU 2846 8397		Bronze metalwork hoard Tower Hill (see Chapter 11 this report)
Not yet on SMR	SU 295 820		Small collection of bronze metalwork from vicinity of settlement at Weathercock Hill
12613	SU 3608 8769		Bronze flanged axe
7887	SU 361 878		LBA pottery
Iron Age			
Hillforts			
7333 (SAM 28163)	SU 277 822	Excavated earthwork	'Alfred's Camp'; massive sarsen built ramparts, features, finds from interior; reused in RB period (Gosden and Lock 1999)
7320 (SAM 28167)	SU 2875 8670	Earthwork	Unexcavated hillfort known as Hardwell Camp
7529	SU 289 928	Earthwork and finds	Little Coxwell hillfort, single rampart and ditch surviving along western side, rest largely destroyed but traceable; earlier reports of double rampart and ditch; IA pottery from interior
7304 (SAM 21778)	SU 300 863	Excavated earthwork	'Uffington Castle' (see Chapter 6 this report)
10556	SU 314 863	Site of	'Rams Hill' ploughed out; partially excavated (Bradley and Ellison 1975; Needham and Ambers 1994)
7200 (SAM 28183)	SU 385 845	Excavated earthwork	Single rampart and ditch hillfort with considerable settlement activity in interior, known as 'Segsbury Camp' or 'Letcombe Castle'; traces of possible LBA enclosure; reused in RB period (Lock and Gosden 1997; 1998)
Other settlement and enclosures			
13196 (SAM 20602)	SU 2490 9075	Multi-period excavated site	MIA settlement, and small LIA/early RB farmstead; also Mesolithic/ Neolithic and LBA as well as AS cemetery
7854	SU 2838 8618	Excavated features and finds	Six pits with pottery, chalk loomweights and animal bone excavated by S Piggott in chalk quarry
Not yet on SMR	SU 295 900	Cropmark	Settlement with numerous annular gullies with internal features and other enclosures and pits
15952	SU 345 933	Multi-period evaluated site	Finds and features, including some RB and medieval
Finds only			
7520	SU 2883 8082		Pottery including RB sherds
9765	SU 2905 8779		Pottery scatter in ploughsoil
7523	SU 2997 8620		Silver coin of Dobunni
7544	SU 301 871		Four pottery sherds from surface of Dragon Hill, also two RB sherds
7851	SU 3015 8630		Shield boss and spearhead with Celtic bronze stud enamelled in red found by labourer digging to SE of Uffington Castle
9461	SU 326 915		Few pot sherds

(*Continued*)

SMR PRN (SAM no.)	Area centred NGR Co-ords.	Type	Comments
9709	SU 373 846		Silver coin found by metal detector
9590	SU 3385 8402		Pottery scatter from ploughsoil
7886	SU 361 878		Pottery including EIA sherds
Romano-British			
Field systems (many may have earlier origins, but included here as the greatest use appears to occur in this period)			
12050	SU 2670 8360	Cropmark	
7342	SU 278 807	Cropmark	
9739	SU 29 83	Cropmark	
12010	SU 2978 8974	Cropmark	
12003	SU 3150 8655	Cropmark and strip lynchets	
12006	SU 318 841	Cropmark	
12005	SU 327 849	Cropmark	With double ditched trackway
12930	SU 337 838	Cropmark	Pre-Roman sherds
9022	SU 340 846	Cropmark	
7559	SU 343 829	Cropmark	
11031	SU 358 838	Cropmark	
9594	SU 379 834	Cropmark	
12004	SU 3170 8550	Cropmark	
Villas and other settlement			
150834	SU 2585 8570	Excavated multi-period site	2nd-century farmstead and associated paddocks, continued use through RB/AS transition; also medieval use
7333 (SAM 28163)	SU 277 822	Earthwork	Villa or temple structure in interior of IA hillfort known as 'Alfred's Camp'
7909	SU 287 843	Excavated settlement site	Polygonal enclosure, holloway, timber fence replaced with sarsens, three phases of occupation from 1st–4th century; ploughed out; pottery from interior; associated field system; also residual lithic scatter
7910	SU 298 830	Earthwork	Sub-rectangular enclosure; area littered with pot sherds, Constantinian coins and a bronze brooch of 1st-century date; field system lynchets also visible around it see PRN 9731
2823	SU 32 88	Place name	Possible villa on basis of place name, and proximity to RB type barrow and finds spots (see PRNs 7894, 9000, 7546 & 7930)
7219 (SAM 251)	SU 3749 8793	Excavated (site of)	Wall, floor, hypocaust, roof tiles, pottery, oyster shells, tesserae and coins; found in 1876 and destroyed by stone robbing
10946	SU 373 882	Cropmarks	Rectangular features, possibly a large building within a big sub-rectangular enclosure; probably associated with PRN 7219
7316	SU 2904 8777	Excavated (site of)	Villa with two tessellated floors, buildings and corridors; three AS inhumations found in corridor (see PRN 9741)
Other enclosures and features			
7332	SU 2778 8237	Site of	Ploughed out possible barrow; Belgic, RB and AS pottery sherds
9739	SU 2869 8448	Earthwork and finds	Possible barrow, with scatter of RB pottery and animal bones
12009	SU 2977 8618	Cropmark; excavated (see Chapter 7 this report)	Rectangular enclosure with adjoining double ditched trackway and central ring ditch; plough truncated; function uncertain; RB inhumation in ring ditch
12007	SU 2984 8385	Cropmark	Double ditched square enclosure, apparently associated with field system but different alignment
7545	SU 302 852	Earthwork (site of)	Rectangular enclosure ditch with outer and inner banks, pottery from interior; separated from north boundary of a field system by massive cross-ridge dyke of unknown date
10557	SU 316 864	Cropmark	Square ditched enclosure butting onto IA hillfort; early RB pottery in ditch fill; two inhumations accompanied with several 5th-century coins in SW; further unaccompanied inhumation in south ditch

(*Continued*)

SMR PRN (SAM no.)	Area centred NGR Co-ords.	Type	Comments
10732	SU 3206 8555	Cropmarks	Two ring ditches
7292	SU 3285 8821	Earthwork	Barrow thought to be of RB date by S Piggott, but little dating evidence other than proximity to other RB sites and findspots
7548	SU 3289 8520 and SU 3287 8518	Earthworks and cropmarks	Two bowl barrows with cropmark ditches
12067	SU 3350 8615	Cropmark	Large square, double ditched enclosure; may be associated with the trackway and field systems of PRN 12005
12068	SU 3289 8520	Cropmark	Series of rectilinear enclosures and pits, date uncertain may be IA but nearby RB pottery scatter suggests RB
15952	SU 345 933	Multi-period evaluated site	Finds and features, including some LIA and medieval
7871	SU 3955 8860	Excavated ?road and finds	Large quantity of pottery and eight 4th-century coins
Finds only			
15835	SU 2575 8435		22 pottery sherds mostly early from spoil heap and stripped area of pipeline
11012	SU 2729 8162		Pottery and stone scatter
11013	SU 2783 8227		Pottery and stone scatter including some AS sherds
9565	SU 2817 8938		Jet ornament, shale ring and bronze pin found in barrow excavated by E Martin-Atkins indicating reuse in RB period
7519	SU 2869 8088		Pottery, tile fragments and coin
7945	SU 296 866		Pottery from tractor rut
7544	SU 301 871		Two pottery sherds from surface of Dragon Hill, also four IA sherds
14016	SU 3061 8920		Glass flask
9000	SU 321 878		Pottery and tesserae, from surface collection together with residual flints, AS and medieval pottery
7894	SU 321 880		Pottery
9459	SU 326 915		Large amount 1st–4th-century AD pottery
7930	SU 328 882		Pottery from field near barrow PRN 7292
10725	SU 3379 8527		Pottery scatter
7986	SU 339 933		Spindlewhorl from topsoil over quarry
7560	SU 3429 9388		Bronze skillet, RB and medieval sherds and AS thread picker
7934	SU 344 874		Pottery
9931	SU 344 932		Pottery and bronze ear cleaner
11645	SU 3468 9042		Pottery and flint scatters, mainly RB but also some possible AS and medieval
7936	SU 353 876		Pottery
7539	SU 3581 8904		Pottery from ploughsoil
8792	SU 3595 8763		Quern
7971	SU 360 877		Coin hoard
7888	SU 361 878		Pottery
9708	SU 367 845		Silver coin of AD 367–375
11173	SU 3752 8836		Pottery and shell from fieldwalking
7964	SU 385 845		Coins of Tetricus and Maximilian
Anglo-Saxon			
Cemeteries and individual inhumations			
13196 (SAM 20602)	SU 2490 9075	Multi-period excavated site	In excess of 27 inhumations of 5th–6th-century date, in area used in Mesolithic/Neolithic, LBA, MIA and LIA/early RB
7993	SU 27 90	Excavated	Inhumation in hollow in bedrock, with string of vitreous paste beads
7996	SU 300 885	Inhumation (site of)	Ploughed out inhumation with AS spearhead and knife
7994	SU 348 883	Inhumation	Skeleton found with iron spearhead of probable AS date

(*Continued*)

SMR PRN (SAM no.)	Area centred NGR Co-ords.	Type	Comments
7201	SU 3854 8432	Inhumation and finds	Cist in rampart of Segsbury Castle with fragments of human bone, shield boss, pottery fragments and residual flint scrapers
9741	SU 2904 8777	Inhumations	Three skeletons, thought to be of AS date, found in corridor of RB villa (see 7316)
Boundaries			
9764	Running N from SU 2780 8643	Earthwork	Boundary dyke, referred to as 'Bica's Dyke' in charter of AD 955
Not on SMR		Documentary	Running north from Idlebush Barrow, through Uffington Castle, to the round barrow on White Horse Hill and down across Dragon Hill to the Ickneild Way
Finds only			
7560	SU 3429 9388		Bronze skillet, RB and medieval sherds and AS thread picker
7554	SU 3606 8425		Part of 8th–9th-century spearhead
7855	SU 2838 8618		Pottery from IA pit excavated by S Piggott
9000	SU 321 878		Pottery together with medieval, RB and earlier finds from surface collection
11013	SU 2783 8227		Pottery and stone scatter including some RB sherds Tower Hill brooch

Appendix 3: Geophysical Survey Methodology Employed at White Horse Hill

by Andrew Payne

MAGNETOMETER SURVEY

Magnetometer survey is usually the preferred geophysical technique for the initial location or general planning of buried archaeological sites (English Heritage 1995). Rapid ground coverage (at a rate of around 1.5 ha per day) and the ability under suitable conditions to detect a wide range of archaeological features are the principal advantages of the method over slower techniques such as resistivity and ground radar that are generally employed more selectively.

Magnetometry involves the measurement of local variation in magnetic flux density at close intervals (1.0 m or less) across the ground surface. Magnetometers respond to local modification of the geomagnetic field by magnetic iron oxides in archaeological features, either due to the thermo-remanent effect in fired structures (Aitken 1974) or magnetic susceptibility contrasts between the silting of features and the subsoil into which they are cut (Tite and Mullins 1971). The generally higher magnetism of the topsoil is enhanced by activities associated with human occupation especially burning (Le Borgne 1955; 1960) and when this becomes incorporated in the fills of ditches and pits, detectable magnetic anomalies occur. A magnetic susceptibility contrast can also exist between buried masonry features and the soil enveloping them, often resulting in the detection of walls as low magnetic gradient or negative anomalies. Where the buried masonry has been strongly heated, increasing the magnetism of the stone, the magnetic signature from walls can reverse to a high magnetic gradient positive anomaly. Magnetometers are therefore capable of detecting a wide range of buried archaeological features including silted up ditches and pits, walls constructed from materials with contrasting magnetism to the surrounding soil, fired clay structures and deposits of burnt material.

The magnetometer surveys were carried out with Geoscan FM36 fluxgate gradiometers which incorporate two vertically aligned fluxgates, one situated 0.5 m above the other. The bottom fluxgate was carried at a height of approximately 0.2 m above the ground surface. The FM36 incorporated a built-in data-logger that recorded measurements digitally; these were subsequently downloaded to a portable laptop computer for permanent storage and preliminary processing. Additional processing was performed on return to the AML (now Centre for Archaeology (CfA)) using desktop workstations.

Surveys were based on a grid of 30 m squares laid out using an optical square or electronic total station theodolite. Each 30 m square was surveyed by making successive parallel traverses across it, all parallel to that pair of square edges most closely aligned with the direction of magnetic North. In the case of a standard magnetometer survey each traverse is separated by a distance of 1.0 m from the last; the first and last traverses being 0.5 m from the nearest parallel square edge. Readings are recorded along each traverse at 0.25 m intervals, the first and last readings being 0.125 m from the nearest square edge. Instrument traverses are walked in so called 'zig-zag' fashion, in which the direction of travel alternates between adjacent traverses to maximise survey speed. The magnetometer was always kept facing in the same direction, regardless of the direction of travel to minimise heading error. The readings stored in the magnetometer were recorded to the nearest tenth of a nanotesla (nT – the unit of magnetic flux density) using the 0.1 nT sensitivity setting of the instrument. In cases where a closer reading interval on the ground was required for producing higher resolution images and resolving smaller features, the traverse separation was reduced to half a metre increasing the number of traverses in a 30 m grid square from 30 to 60.

RESISTIVITY SURVEY

Resistivity survey involves the measurement of sub-surface changes in the resistance of the soil to the passage of an electric current injected through the surface of the ground using probes or electrodes. One pair of electrodes is used to measure the potential gradient set up by the passage of a current between two others, enabling the resistance to be derived from Ohm's Law. Variations in the measured resistance reflect the presence of buried archaeological structures such as walls and ditches. Although resistivity is slower than other archaeological prospecting techniques (such as magnetometer survey) due to the requirement to place electrodes in the ground, it is the most suitable and favoured technique for location of buried masonry and stoney layers or surfaces. It is also possible to detect moisture contrasts in buried ditches and other former ground disturbance such as previous archaeological excavation.

Unless otherwise stated in the main report text, resistivity measurements were made with a Geoscan

RM15 constant current earth resistance meter incorporating a built in data-logger, using the Twin Electrode probe configuration (or array) normally with a 0.5 m mobile probe separation. The mobile probe separation conditions the depth of investigation, and therefore in circumstances where deeper buried remains were suspected a 1.0 m probe spacing was used. The wider probe separation gives deeper ground penetration of the current flowing into the soil allowing a greater depth of investigation (in the region of 1.5–2.0 m compared to 0.75–1.0 m for a 0.5 m probe separation).

Readings were normally recorded at 1.0 m intervals along successive 30 m long parallel traverses spaced 1.0 m apart. Each successive instrument traverse was positioned correctly by means of a survey grid of 30 m squares set out with an optical square, total station theodolite or GPS system. Measurements were recorded digitally by the RM15 meter and subsequently transferred to a portable laptop computer for permanent storage and preliminary processing. Additional processing was performed on return to the CfA using desktop workstations.

Appendix 4: The Regional Context of the Animal Bones from Uffington Sites

by Claire Ingrem

IRON AGE

According to Cunliffe (1982), Britain can be divided into five socio-economic regions with White Horse hillfort located in the central southern zone. This is an area characterised by hillforts and farmsteads which developed over a long period of time. Many of the earliest hillforts sprang up in this area and the greatest effects of first millennium changes were also felt here (Darvill 1987). The middle Iron Age saw the development of some hillforts such as Danebury in Hampshire, whilst others went out of use. Evidence from Danebury suggests a highly organised settlement with well laid out roads, houses and demarcated activity areas. Cunliffe proposed that these 'developed hillforts' became centres controlling goods, resources and the division of labour. However, there is little archaeological evidence to suggest the existence of social and economic hierarchies at this time. A more egalitarian view of Iron Age society is taken by Hill (1995) who believes that hillforts complemented Iron Age society but were not necessarily in control of resources. Whichever view is taken, it is likely that exchange networks included the trade in live animals and possibly also joints of meat.

At Uffington, despite the small sample size, the pattern of animal husbandry appears to remain unchanged throughout the Iron Age occupation. Sheep are found in high proportions at most other chalk downland sites including; Danebury (Grant 1984a), Old Down Farm (Maltby 1981a), Winnall Down (Maltby 1985b), Balksbury (Maltby nd) and Maiden Castle (Armour-Chelou 1991). At nearby Liddington hillfort (Hirst and Rahtz 1996), bone fragments from cattle, sheep/goat, pig, horse, dog and red deer were recovered from the principal rampart layer. Again, although the sample size is small, sheep/goat were the most numerous, followed by cattle and pig. At Danebury, Grant (1984a, 506–7) argued that the predominance of sheep is a reflection of the environment. Chalk has poor grassland and scattered water sources, it is therefore less suitable for raising cattle as they require higher quality feed and a greater quantity of water.

As at other Iron Age sites, taking into account disposal and preservation biases, the evidence suggests that complete carcasses were originally present and that the major domestic species were kept on or near the sites. At Winnall Down there was considerable intra-site variability with regard to body part representation, however, differential preservation coupled with cultural practises concerning the treatment of carcasses were considered responsible (Maltby 1985b, 99). At Uffington, similarly most of the variation in body part representation can probably be accounted for by differential disposal and preservation.

A high neonatal mortality was apparent at Danebury (Grant 1984a, 507) and the presence of complete skeletons of neonatal lambs at Old Down Farm and Balksbury suggests that lambing may have taken place at the settlements (Maltby 1981a; nd). The scarcity of neonates during the Iron Age at Uffington is more likely to reflect poor preservation than the absence of breeding stock. Unfortunately, the small sample size renders comparison with contemporary age profiles impossible.

Few Iron Age sites, have produced the remains of immature horse, and so Uffington is not unusual in its lack of young equids. The majority of horses at Danebury (Grant 1984a), Winnall Down (Maltby 1985b), Gussage All Saints (Harcourt 1979a), Maiden Castle (Armour-Chelou 1991) and Old Down Farm (Maltby 1981a) were mature. At Danebury there was a complete absence of neonatal or very young animals in contrast to the evidence for neonatal cattle, sheep and pigs. At Gussage All Saints, this led Harcourt (1979a, 158) to suggest that horses were not bred during the Iron Age but periodically rounded up from wild herds. Alternatively, Grant (1984a, 522) proposed the possibility that specialised breeding sites existed although there was little evidence for this. One recently excavated site which may support this scenario, is Rooksdown (Powell and Clark forthcoming) where there is evidence for animals ranging in age from foetal/neonatal through to adult. There is also evidence for females in contrast to the majority of sites which have been dominated by males. It is therefore quite possible that horses were being bred locally.

Dogs appear to have been kept in small numbers and were probably an occasional source of food. At Balksbury (Maltby nd, 5) and Winnall Down (Maltby 1985b, 103), the deposition of newborn puppies in pits suggests that they were kept on the site and possibly that their numbers were controlled. Cut marks caused by dismemberment is regarded as evidence that dog meat was an occasional dietary supplement. At Guiting Manor Farm (Palmer and Clark nd), butchery was evident on the humerus of a dog although it was not possible to determine if this had been caused by disarticulation or skinning. There were few dog remains at Uffington, other than the discarded skeleton of a severely injured animal and, no evidence of dog butchery.

The hunting of wild animals appears to be of minimal significance during the Iron Age. A few fragments of red and roe deer were recovered from Balksbury (Maltby nd) and Old Down Farm (Maltby 1981a). However, as is the case at Uffington, some of these fragments are antler which could represent the collection of shed antler for working rather than the hunting of wild animals. At Danebury (Grant 1984a, 525–6), although antler seems to have been valued, deer were scarce and other wild animals were extremely rare. Similarly at Owslebury, Maltby (1987, 552) notes that the lack of interest in wild fauna is typical of Iron Age deposits.

A worked roe deer antler was recovered from a chalk pit adjacent to nearby Dragon Hill in 1925 by Stuart Piggott. This antler tool has been made from a complete unshed antler, with the pedicle and main branch removed, the latter at the junction with the first tine. The base had been rounded and the end (of the first tine) was polished. A blade mark is visible where the main branch had been removed. Examples of worked red deer antler points are known from the Iron Age settlement of Gravelly Guy (Boyle and Wait forthcoming), however, there are no known examples made from antler belonging to roe deer. The high degree of smoothness and polish displayed on the point of this implement suggests that it may have been used in the manufacture of textiles (MacGregor 1985).

ROMANO-BRITISH

The continued use of the hillfort at Uffington has parallels with other Iron Age sites, both settlement and hillfort, including Winnall Down (Maltby 1985b), Balksbury (Maltby nd), Old Down Farm (Maltby 1981a) and Maiden Castle (Armour-Chelou 1991). The relative proportions of cattle and sheep are often used as an indication of the influence of Romanisation; according to King (1991, 15–20) there is an increase in the numbers of cattle and pigs and a decrease in the numbers of sheep kept throughout the Romano-British period. At Winnall Down (Maltby 1985b, 97–112), Balksbury (Maltby nd), Old Down Farm (Maltby 1981a), Maiden Castle (Armour-Chelou 1991) and Uffington there appears to be little change in species exploitation during this period with the exception of domestic fowl which appears for the first time. At Owslebury (Maltby 1987, 335), Balksbury (Maltby nd, 83) and Maiden Castle (Armour-Chelou 1991) sheep were also the most common species, although generally it is similarly suggested that beef provided the most meat.

Urban settlements in southern England have produced few immature cattle (Maltby 1981b, 179–82) although a higher proportion has been recovered from smaller rural settlements including Balksbury (Maltby nd, 80) and Winnall Down (Maltby 1985b, 110). In contrast, according to Maltby (1981b, 82), the general pattern of sheep mortality during the Romano-British period suggests that they were primarily exploited for meat. At Balksbury (Maltby nd, 85) a greater proportion of second and third year mortalities were recovered from Romano-British deposits than from Iron Age contexts. Similarly, at Uffington, the slaughter of immature sheep suggests that a considerable proportion of sheep were kept to provide meat.

Pigs are generally found in small numbers (Maltby nd, 85; 1981b) although as previously mentioned, the susceptibility of pig bones to destruction makes their relative frequency difficult to estimate. Due to their omnivorous nature pigs can be kept in a wide variety of regimes, they are well suited to deciduous forest and can be fed on surplus whey and waste food. According to Grant (1984a, 518), not only are they efficient producers of first class protein but they can play an important role in cereal cultivation by turning over the soil in their search for roots. Although pigs can be kept in sties and fed waste scraps, it is perhaps more likely that they were allowed to roam freely in a nearby deciduous woodland. Few pigs are kept into adulthood which is to be expected for an animal primarily kept for meat production and which reaches its optimum meat weight before maturity. Pigs would also have provided manure, hide and bristles.

Horse and dog are also generally found in small numbers at sites of this period. Their increase during this period probably reflects the deposition, and subsequent survival, of articulated remains in a pit rather than their actual increase in numbers. Horses were not generally killed until they had reached skeletal maturity. Maltby (nd, 85; 1987, 427) and King (1978, 207–32) also state that horses were generally kept to an old age and were eaten only on a casual basis after a young animal had died.

A small proportion of wild species is usual for sites of this period. King (ibid.) notes that where cervid bones are found, in the vast majority of cases they belong to red deer and suggests that their size makes them the first choice for hunters.

The deposition of the articulated remains of horse and dog is fairly common during the Romano-British period. At Balksbury (Maltby nd, 74), an articulated set of horse metacarpals and a first phalanx were recovered from a pit, whilst six articulated dog bones, a mandible, skull and a set of metacarpals possibly from the same animal were recovered from another pit. At Baldock, Hertfordshire (Chaplin and McCormick 1986) horse bones were present in most of the larger deposits and several partial and complete dog skeletons were recovered. In some, instances a number of related horse bones were present indicating that a portion of the carcass was involved. In 3rd-century deposits the greater part of an old horse was recovered, whilst 4th-century deposits produced the hindquarters, lumbar and thoracic vertebrae, ribs and some teeth of a horse between two and three years old. Two wells also produced the remains of several horses, and one of these, dated to the late 3rd century AD also contained the partial skeleton of a large dog.

There has been much contention in recent years concerning the interpretation of complete skeletons and articulated groups of bones, in particular from Iron Age contexts. At Danebury, Grant (1991) argued that they represented a distinct category of ritual deposit, singled out either by their association with other bones, or the manner and site of deposition. In a study of southern England, Wait (1985) suggested that the animals involved were generally of least economic value to the community and that horse and dog were the most commonly represented. In order to clarify the position Wait (1985) proposed five criteria to aid identification of these 'special animal deposits'. These are that: they comprised parts of the animal not exploited in the normal manner; the number of species represented is not correlated with the number on site; there was a consistency in body part; there was evidence that care was taken in placing the remains; they are found in pits, not ditches which contain more mundane deposits.

The horse and dog remains recovered from the Romano-British pit at Uffington meet these criteria therefore it is possible that some form of continuity existed with regard to 'special deposits', during the Iron Age and Romano-British periods. Some deposits of selected animal remains from the latter period have been interpreted as being of ritual or sacrificial origin. At Chelmsford (Luff 1982, 175–204), an urban settlement dating from the 1st to 4th centuries AD, a well had been recut six times and the shafts contained isolated horse skulls, foetal and young lambs, human bone, raven, cockerel and goose bones. The presence of isolated horse skulls and the overall peculiarities of the assemblage led Luff (1982, 176) to interpret this deposit as 'votive'. At Barton Court Farm, Oxfordshire (Wilson 1986, 8, B12), a pit containing the articulated remains of two matching lower back legs of a horse and the right back leg of a cow was also considered to have clear ritual connotations.

Wilson (1992, 341–9) has argued that quantities of articulated bone could be the result of normal carcass processing activities and that 'special deposits' may only be 'special' as a consequence of their survival. Similarly, Maltby (1985a) also argued that skulls and smaller articulated portions are simply butchery waste. It is therefore apparent that during the Romano-British period a distinction exists between deposits which are simply the result of the burial of ordinary animal casualties and those which possess some form of extraordinary significance associated with ritual practices. This latter group appears to be clearly recognisable by their peculiar content and association with particular features such as wells and foundations. There is little doubt that the horse and dog remains at Uffington are peculiar in content, therefore the possibility that they possess extraordinary significance should not be overlooked.

Appendix 5: Metallurgical Analysis of the Tower Hill Hoard

by Peter Northover

METHODS

All analyses were by electron probe microanalysis using wavelength dispersive spectrometry (WDS). During the course of the analysis programme a new instrument became available which allowed a more convenient analysis of some elements, notably arsenic. The operating conditions were an accelerating voltage of 25/20 kV, a beam current of 30 nA and an X-ray take-off angle of 62/40°. Thirteen elements, as listed in the tables, were analysed using pure element or mineral standards and a counting time of 10 s or 20 s per element. Detection limits were of the order of 100–200 ppm for most elements, the main exceptions being 300–400 ppm for gold and 0.20% for arsenic using the first of the two microprobes. This was a result of the compromises needed with an instrument with a single WDS spectrometer, a Cameca SU, to avoid the well-known interference between the strongest lines in the lead and arsenic spectra, the lead Lα and arsenic Kα lines without frequent crystal changes. Here it was necessary to use the weak arsenic Kβ line. The second instrument, a JEOL 8800, with four spectrometers, allowed the use of the arsenic Lα line under appropriate conditions so that the detection limit could be as low as 200 ppm.

The compositions of the analysed samples from Tower Hill are listed in Table A5.1 and are the means of between three and six analyses per sample, the number of analyses being increased in the more heterogeneous samples; all concentrations are in weight %. Samples Ox 226–269 were analysed with the Cameca SU and in these low arsenic contents are listed as <0.20%, while Ox 201–225, 271–286 were analysed with the JEOL 8800. Table A5.2 shows a comparison between the compositions of two samples analysed in both instruments. With the expected exception of arsenic the agreement is very good.

After analysis the 34 cut samples were examined metallographically in both the as-polished and etched states. The etch used was an acidified aqueous solution of ferric chloride further diluted with ethanol; etches with several different proportions of these ingredients were tried. The metallographic data are tabulated in Table A5.3.

Finally, comparative analytical data, including the results from Figheldean Down and King's Weston Hill, are set out in Table A5.4. These two groups were also analysed with the JEOL 8800 microprobe, while the objects from the Llyn Fawr and Leckwith Moors, Cardiff finds were analysed some years ago with a JXA3A electron microprobe at the University of Wales, Bangor. These analyses were made with a more restricted element set lacking bismuth and sulphur, but multiple analyses have standardised the results for other elements against the other two instruments. While there may be small differences between them, these are no bar to the data from all the instruments being used in a single dataset.

THE ALLOYS

Of the objects analysed, one (92/Ox 204), a hammered rod, can be excluded from the hoard because its composition with 13% zinc cannot be earlier than Roman.

The great majority of the objects were cast in low tin, low to medium lead bronzes. There are one tin content and nine lead contents less than 1%, and just three lead contents over 10%. Reference to the metallography (see below and Table A5.3) demonstrates that some samples showed very considerable segregation of lead and tin, even over a range of 2–3 mm, and there was one clear case of inverse segregation of the αδ eutectoid to the surface (Ox 274, socketed axe 17). Thus it is inevitable that not all the analyses will be truly representative of the alloys cast. Nevertheless, the data in the figures do give a good overall impression of the alloys involved in the Tower Hill metalwork. The bulk of the distribution is very broad and has an outline that suggests the overlapping of two separate distributions, one with a mode of about 4% tin, and the second 6–7%. There is also a small group of higher tin bronzes at 12% and above, and their presence is confirmed by the metallography (esp. Ox 282, a runlet, 42). The lead contents form a rather tighter distribution with a peak at 3% but a long tail towards higher concentrations. Again, based on the metallography, it is probable that not all measured lead contents are representative. Segregation is one cause, but in a number of samples, as indicated by Table A5.3, lead has been lost to corrosion.

To understand the wide spread of alloy contents, especially tin, it was decided to sort the data by category of object. The first level of classification was into axes (complete socketed axes), axe fragments, ornaments, and waste, odd items such as the sheet fragment being excluded from the arguments. Figure A5.1 shows a plot of lead against tin at this level of classification and there is already a degree of separation between groups. In particular, axe fragments tend to have lower tin contents than complete axes although lead contents are similar. Ornamental items show a distribution broadly similar to that of

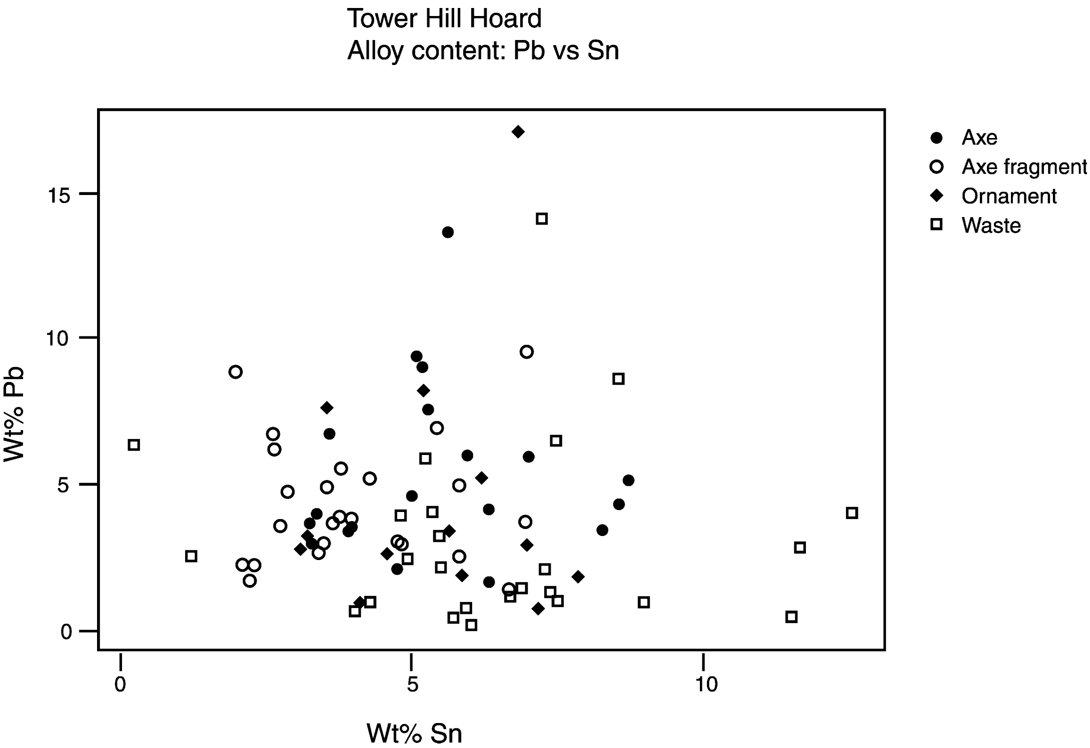


Figure A5.1 Alloying elements in the Tower Hill assemblage: scatter diagram of lead and tin contents for axes, ornaments and waste (data from Table A5.1).

the axes. Finally, apart from a small number of outliers, the waste fragments also have higher tin contents than the axe fragments, one small group having more than any axe or ornament. In general, the waste also has lower lead contents than other items with the same tin contents.

To explore this picture further, each category was examined separately and broken down further where necessary (Fig. A5.2a–c). Figure A5.2a shows a scatter plot of lead against tin for the axes and axe fragments; it divides roughly into two distributions at 4.5% tin, supporting the comments made above about the overall tin distribution. So 6 axes have below 4.5% tin and 14 have above 4.5%, whilst 16 axe fragments are below 4.5% tin and only 8 are above. From this information it can be argued that, given that there is a quantity of unfinished axes in the hoard, the scrap axe fragments were not a major part of the metal supply used for making those axes. This could be the result of the origin of the scrap but more probably represents short-term chronological fluctuations in the components available for making the alloys.

Figure A.5.2b shows the results for the ornaments and, again, a degree of separation between individual sub-groups can be seen. A wide spread might be expected because of the very heterogeneous nature of the selection of ornamental pieces but this separation by alloy content was not expected. The bracelets range across the whole diagram but the rings fall into two groups, matching a division into plain and 'fancy' rings, the latter being those multiple, pierced or other more complex pieces. The plainer rings have lower alloy contents than the fancy ones although the spread of tin contents is not sufficient to make a major difference in appearance. It would be reasonable to conclude that the two groups might well have been made in different places.

A particularly interesting picture emerges when the waste is examined in the same way (Fig. A5.2c). The waste is divided into sprue (that is, 'casting jets') and 'waste', that is, droplets, runlets, buttons of metal left in crucibles and so on. Here there is a remarkable separation with the 'waste' tending to have much lower lead and a wider range of tin contents than the sprue. The sprue matches most closely a cluster of axes with about 5% tin, but the 'waste' does not match well with any other class of material. Some of the waste (eg Ox 253, no. 76) has had its composition modified by severe oxidation, while some other fragments have marked segregations. Even allowing for this, reference back to Figure A5.2a and b shows that this waste does not compare well with any of the other categories.

IMPURITY PATTERNS

In a situation such as this, where scrap is clearly part of the circulation of metal, analysis of impurity patterns cannot be expected to offer data of direct relevance to the question of provenance. What it can do is help determine whether different categories of material within the find had different histories,

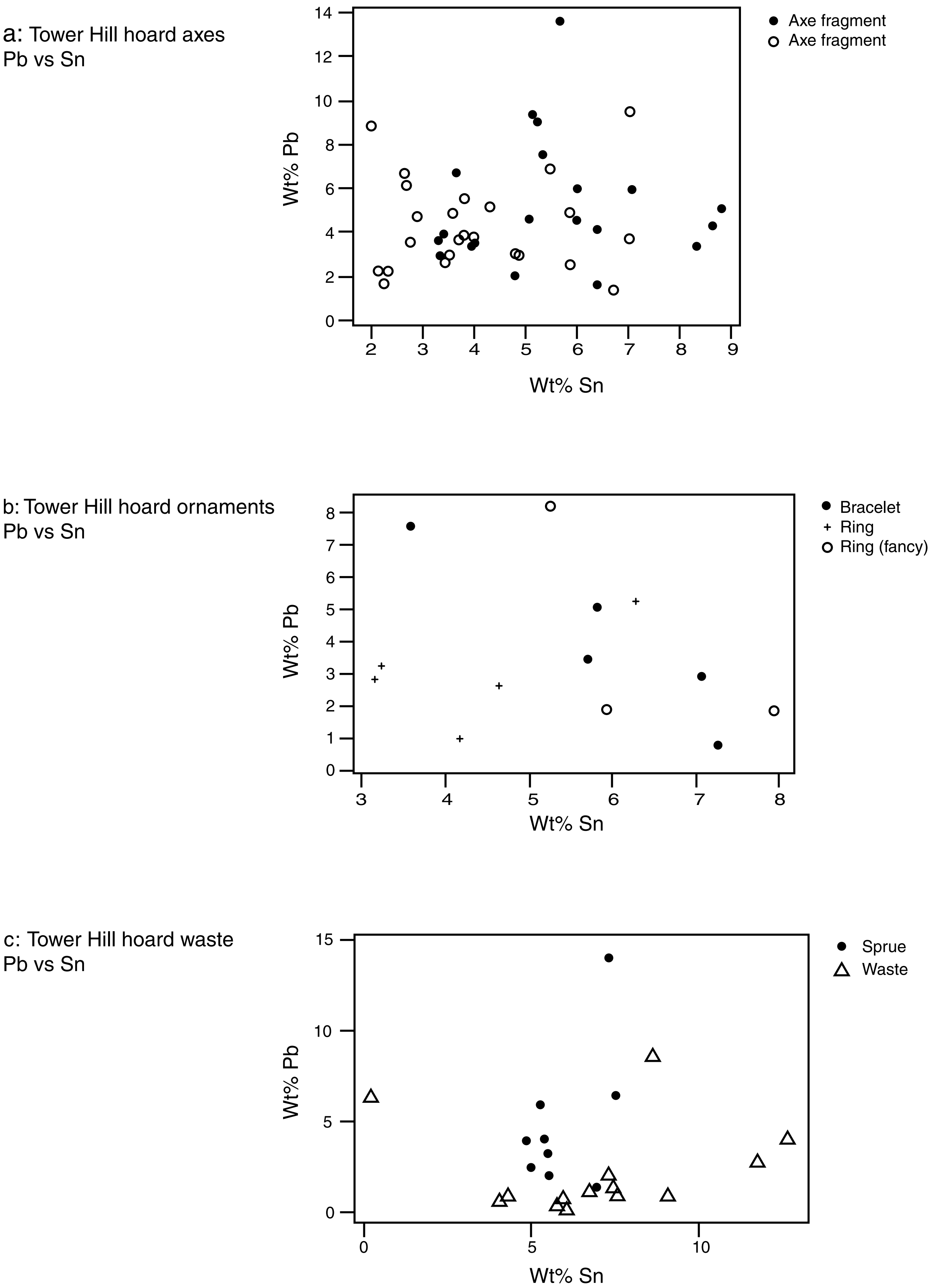


Figure A5.2 Alloying elements in the Tower Hill assemblage: scatter diagrams of lead against tin contents for a) axes, b) ornaments, c) waste (data from Table A5.1).

including the origin of the metal, and, perhaps, suggest the number of sources that might be contributing to the metal supply. As a first step to pursuing this question a principal components analysis was made of the concentrations of tin, nickel, arsenic, antimony and silver (Fig. A5.3a–b). It is clear from the previous section that there are important variations within the distribution of tin contents, but examination of the results of the principal components analysis showed that there were significant variations in the other elements as well. This is most evident in Figure A5.3b (PC3 against PC2) where there is almost total separation between axe fragments and waste, while the differences between complete and fragmentary axes are confirmed. Impurity concentrations as a whole are rather low with the exception of arsenic; of those involved in the principal components analysis the only value above 0.3% is one example for antimony, while arsenic has two above 1%. To try and understand the impurity patterns better a number of bivariate scatter plots was made.

A plot of nickel against antimony for all the bronze was not so informative and is not illustrated; it did show a degree of correlation between the two elements. This is often observed in the analysis of later Bronze Age metalwork in north-western Europe (Bauer and Northover 1998; Cowie *et al.* 1998) and suggests the mixing of two different types of metal, one with a lot more antimony and slightly more nickel than the other. Plots for the individual object classes examined in relation to alloy content are included for nickel against antimony (Fig. A5.4a–c). For the axes and axe fragments (Fig. A5.4a) the broad correlation between the two elements is apparent but there is less differentiation than in the alloy plots between axes and fragments. The only real feature is that the axes extend to lower levels of nickel and antimony than the fragments. There is rather more separation for the ornaments (Fig. A5.4b) but it should be emphasised that we are looking at rather small concentration ranges so the differences may be more apparent than real. The waste offers the clearest outcome: there is a small group of waste with the highest nickel and antimony levels of all. Well separated is a mass with below 0.1% nickel which is plainly divided between 'waste' and sprue. This cluster of points for sprue correlates with that observed in Figure A5.4c for lead and tin and both match a group of axes strongly suggesting that at least some of the sprue relates to the casting of the axes.

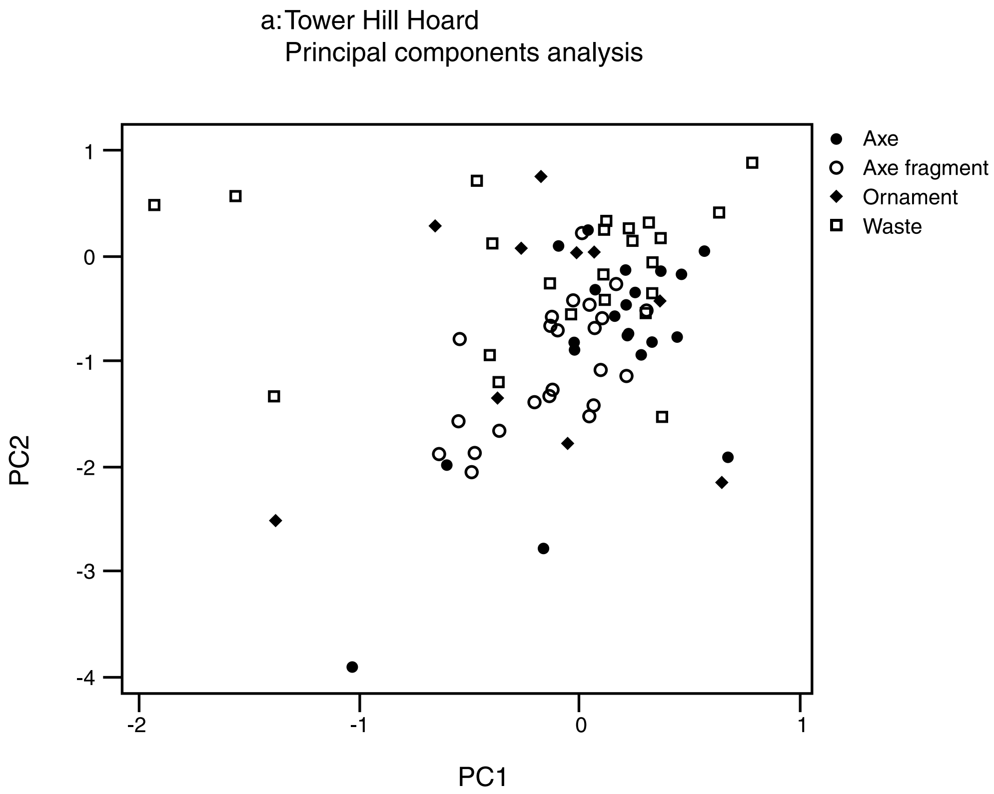
Other elements also require some remark. The implications of the concentration of iron in copper have often been discussed (Craddock 1999) but these discussions have not always covered all the possibilities. Iron may be absent from copper because it was not reduced to the metal in the first place, or because it has been removed, either deliberately by oxidative refining or naturally during repeated recycling. The iron contents in the Tower Hill material are generally extremely low but there is a handful of higher values. Of particular interest is Ox 211 (no. 97), a button of melted metal, which contains 0.21% iron, 0.10% cobalt and 0.28% nickel. The level of cobalt separates this object from all the others analysed; good parallels for this exist on the Continent, notably in Switzerland (Bauer and Northover 1998). There is a very good case for seeing this metal as imported.

The very low iron contents should also be compared with the copper ingots of Ewart Park phase hoards in southern England. While only one hoard combines ingots with axes that relate to the Llyn Fawr period (Roseberry Topping, Schmidt and Burgess 1981) the possibility that this large quantity of metal was still in circulation at the time of Tower Hill cannot be discounted. These ingots have very low iron contents. Analysis of slag trapped in the ingot surfaces demonstrates that this is because iron was not reduced into the metal; a matte smelting process was carried out in such a way that the iron stays in the slag as crystals of magnetite. This is despite conditions sufficiently reducing to leave 2–4% sulphur in the copper. Another feature of these ingots is the low level of antimony and nickel, so that this type of copper could lie at one end of the correlation between nickel and antimony in the Tower Hill impurities.

METALLOGRAPHY

A total of 34 samples were cut and mounted for optical metallography; the results are summarised in Table A5.3 and examples of both typical and unusual microstructures are presented in the plates. The numbers of objects sampled in this way was restricted to preserve a majority of the intact or near intact objects unaltered. The illustrated structures are thus used here as a guide to the others.

Three samples come from unworked cutting edges of axes (Ox 258, Plate A5.4: Ox 274; Ox 284, Plate A5.8), and these are representative of the others. Close to the edge grain sizes are small (100–300 μm) and grains are generally equiaxed; dendrite armspacings are also small, typically 10–15 μm, sometimes less than that. This implies very strongly the use of metal moulds; there is a bronze mould for a not dissimilar axe in the Roseberry Topping hoard (Schmidt and Burgess 1981; Swiss and Ottaway forthcoming). No mould fragment was found at Tower Hill. Two of the structures show significant segregation: Ox 258 has a section much richer in lead and tin than the rest, while Ox 274 shows inverse segregation of the αδ eutectoid to the surface. The latter has been observed to occur during quite rapid freezing (Meeks 1986), while the former may be the result of a local cold shut. When the cutting edges were worked (Ox 255, Plate A5.3; Ox 257) the reductions in thickness from the as-cast state were very heavy; the resulting recrystallised grain sizes were very small but grain growth would have been inhibited by the lead inclusions. The small grain size would have enhanced the hardness and toughness



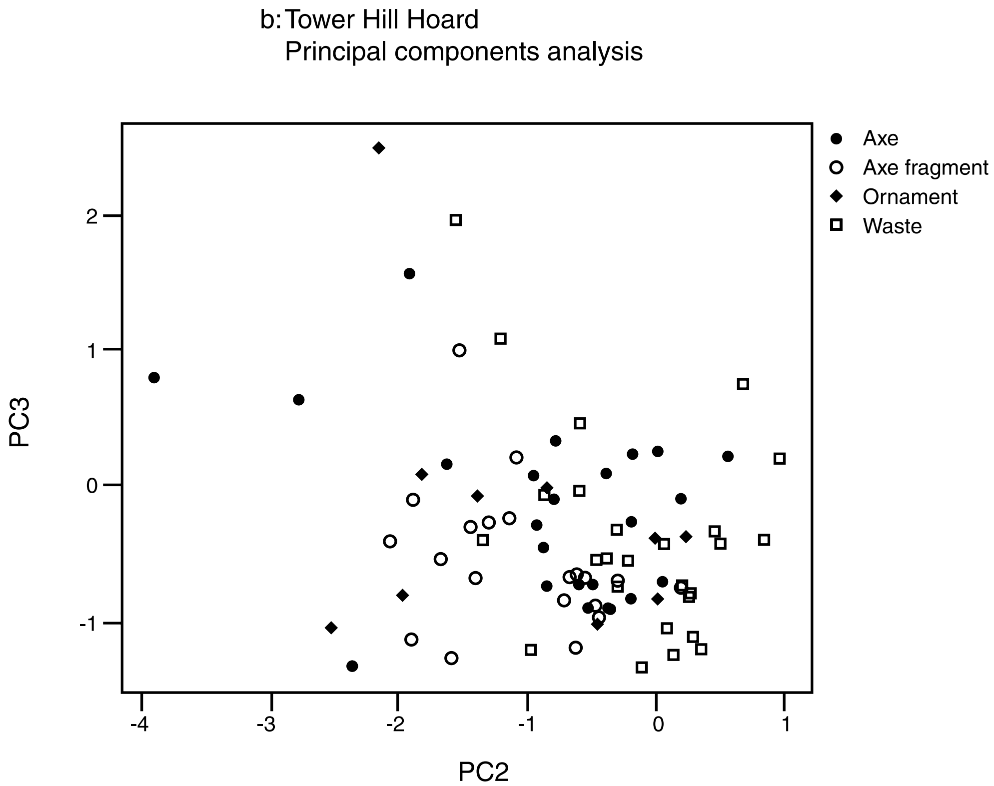


Figure A5.3 Principal components analysis of compositions in the Tower Hill assemblage based on Sn, Pb, Ni, Sb, Ag (data from Table A5.1): a) PC2 vs PC1, b) PC3 vs PC2.

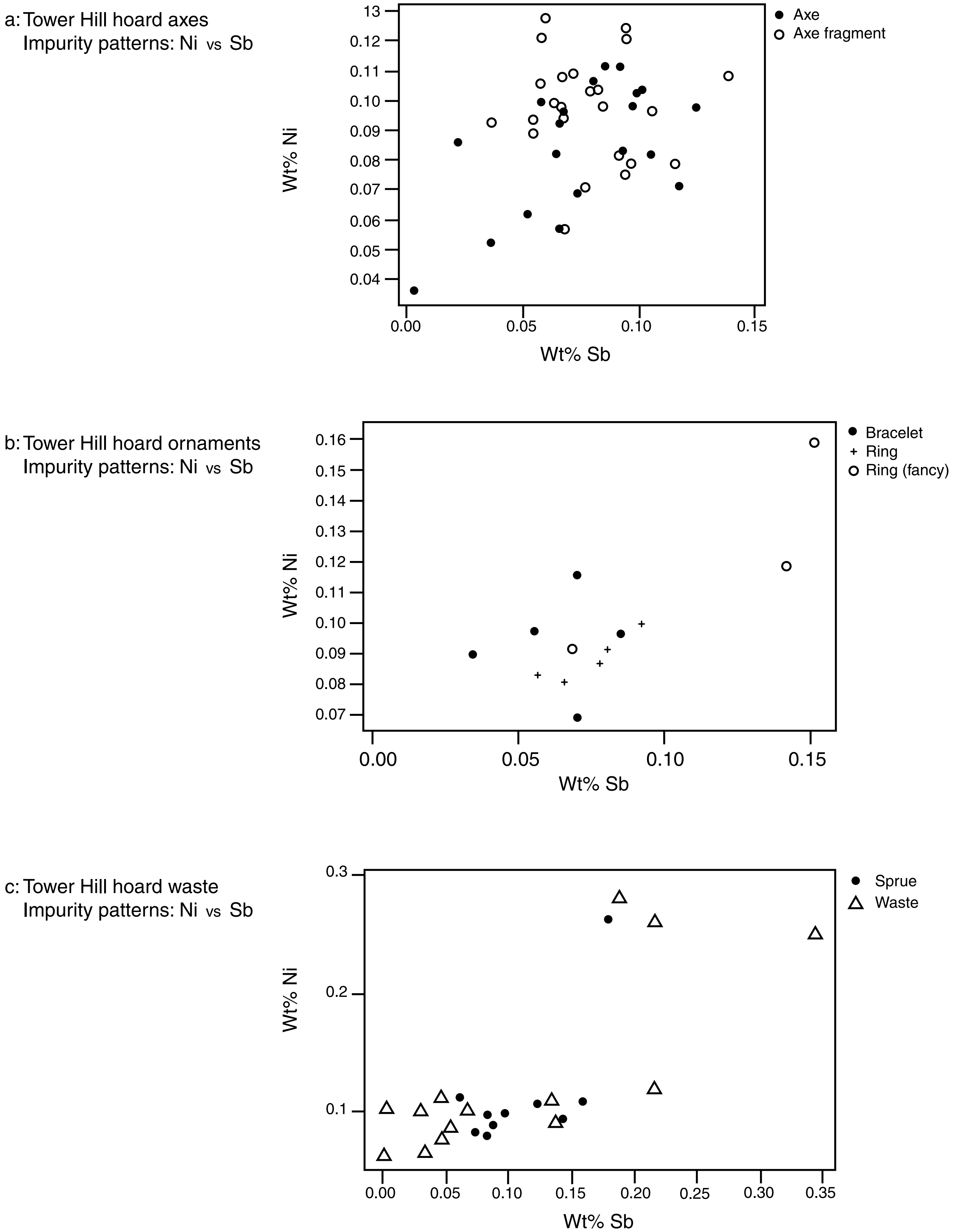


Figure A5.4 Impurities in the Tower Hill assemblage: scatter diagrams of nickel against antimony contents for: a) axes, b) ornaments, c) waste (data from Table A5.1).

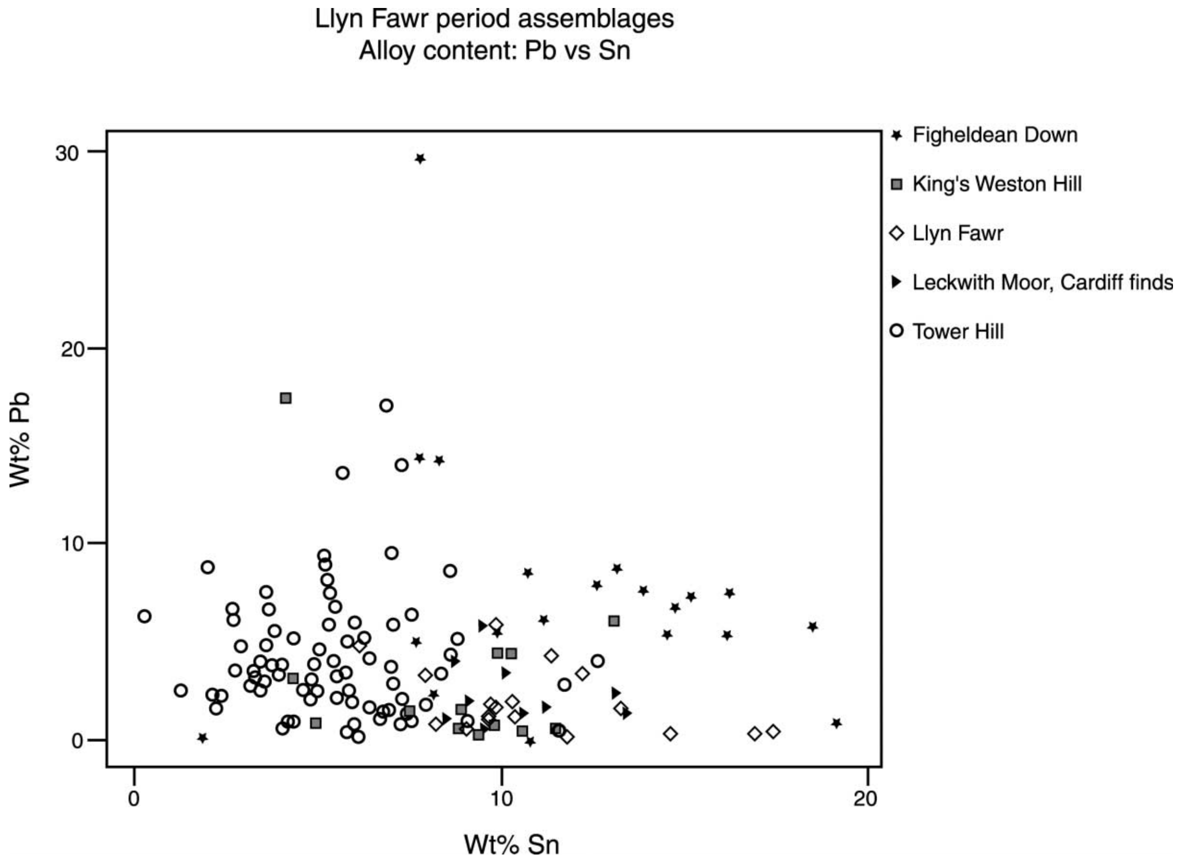


Figure A5.5 Alloying elements in Llyn Fawr period assemblages: scatter diagram of lead and tin contents for axes, ornaments and waste (data from Table A5.4).

of the cutting edges; useful when tin contents were relatively low and lead contents relatively high. In one case some deformation of the very edge was observed, obscured by etching, but indicative of some use of the blade.

Where axe fragments were examined (for example, Ox 251, Plate A5.1; Ox 262; Ox 275, Plate A5.6), they might be in the as-cast state (Ox 251) or show signs of working and annealing, or just of cold work. In the former case it is usually where areas of the body have been affected by the working of the blade, in the latter possibly the deformation occurred when the axe was broken up.

Bronze waste, spilled in or around the hearth, or sprue, some of the last metal to freeze and where dross might collect, can offer some varied microstructures (*cf* Fasnacht and Northover 1991). This is unsurprising because of the wide range of cooling rates encountered and Tower Hill is no exception. For example, both Ox 259 and Ox 282 (Plate A5.7), exhibit marked changes in cooling rate during their formation. Both have coarse structures indicative of slow freezing rates but they were then both rapidly cooled, with in Ox 259 quenched γ phase being retained in the high-tin interdendritic material. In Ox 282 the quenching has been from the β phase region and a β martensite structure has resulted. This, to the best of the writer's knowledge, is the oldest example of such a structure yet identified but is in fact of minimal significance as it is not in an artefact. Other waste and sprue has a simple cast structure but even here there may be complications. The sprue fragment Ox 272 (Plate A5.5) has areas freezing at different rates. Depending how the object was poured conditions in the sprue cup or runner bush might be quite complex so it is difficult to predict any structure. Finally, when metal falls in an oxidising part of the hearth the metal itself may become oxidised (Ox 253, Plate A5.2). The equilibrium condition of bronze freezing with an excess of oxygen is to form a mixture of copper, cuprite (Cu_2O) and cassiterite (SnO_2); this piece is different with many large cassiterite crystals of typical form in an homogenised bronze matrix. Such material is not generally recovered for reuse and is good evidence for metalworking activity on a site (Northover 1987b).

The crumpled sheet fragment is badly corroded (Ox 254) has large homogenised grains with numerous slip traces; the sheet has probably been exposed to heat (perhaps in use if from a vessel), and when scrapped the sheet was crumpled up, hence the deformation markings.

Only two ornaments were examined metallographically (Ox 267–68) and both show rapidly cooled microstructures, possibly implying a metal or stone mould.

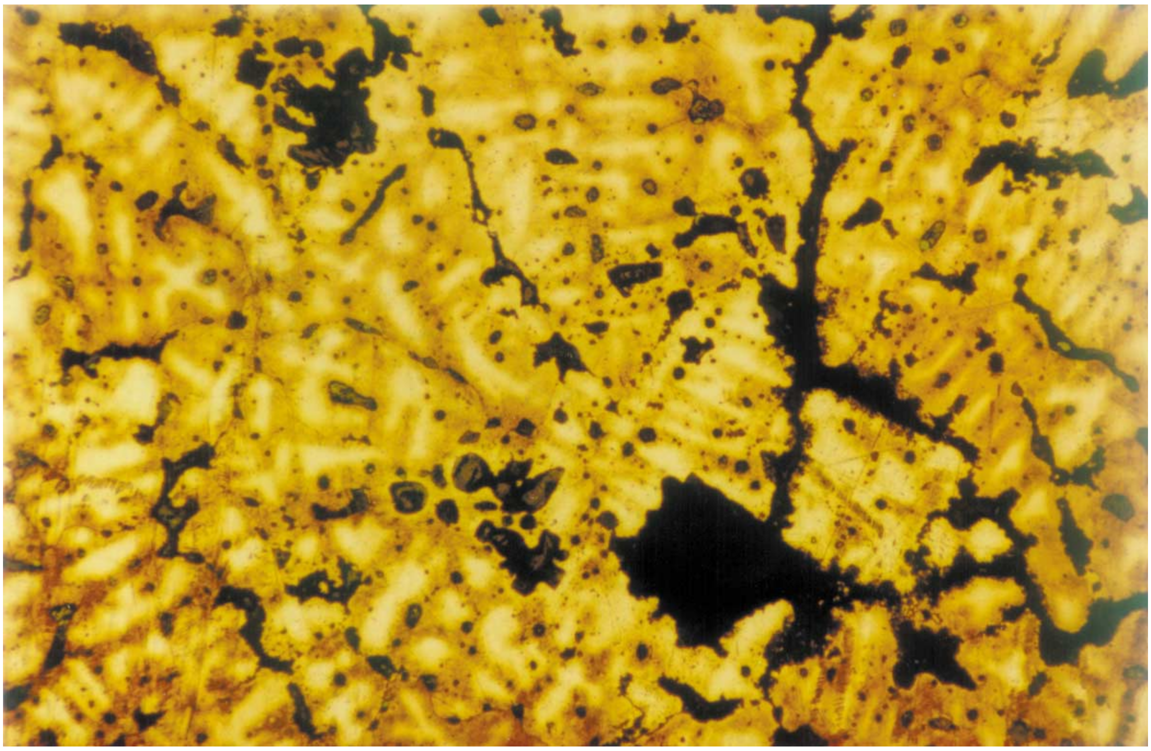


Plate A5.1 Ox 251, cast structure with intergranular and interdendritic corrosion with lead also attacked, etched, ×250.

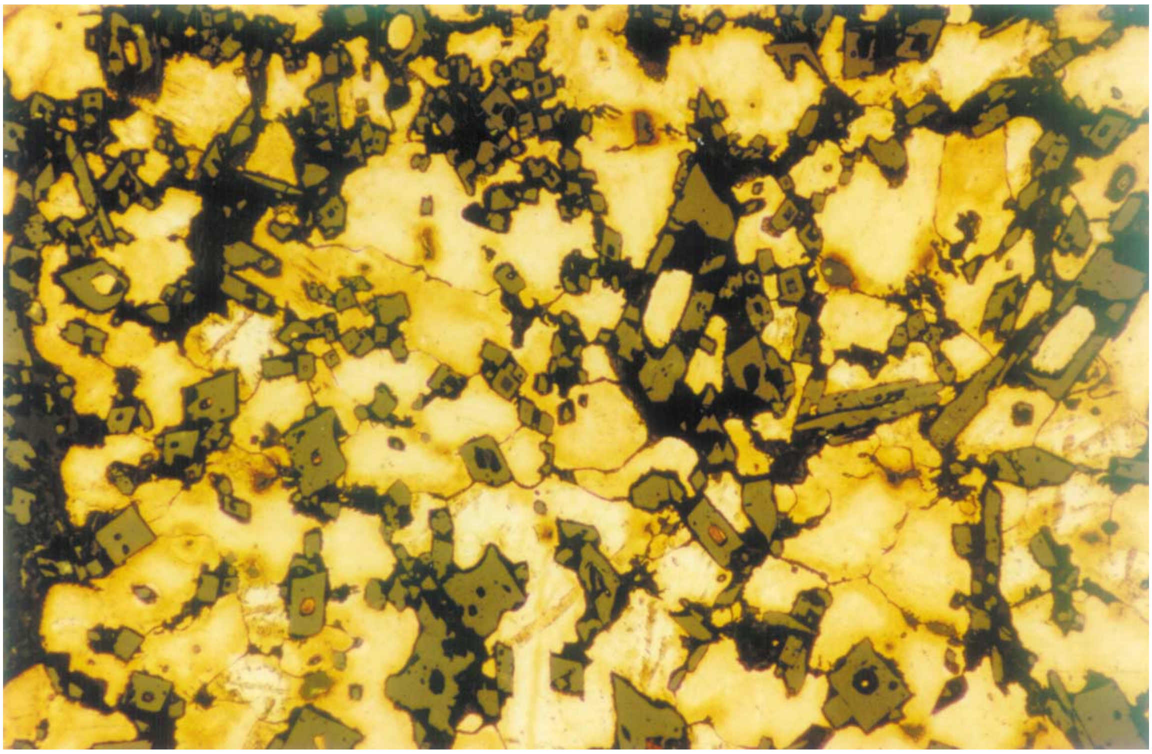


Plate A5.2 Ox 253, oxidised bronze with large crystals of cassiterite, etched, ×125.

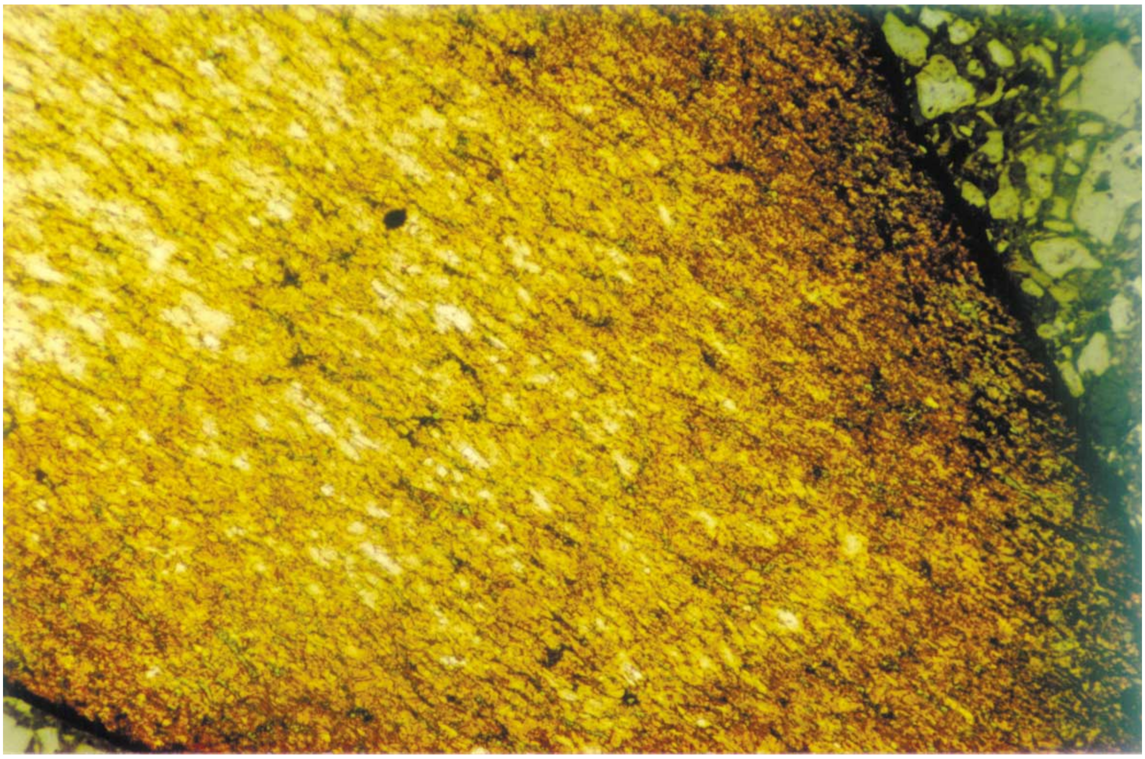


Plate A5.3 Ox 255 heavily deformed leaded bronze in axe cutting-edge, with very fine recrystallised microstructure, etched, ×250.

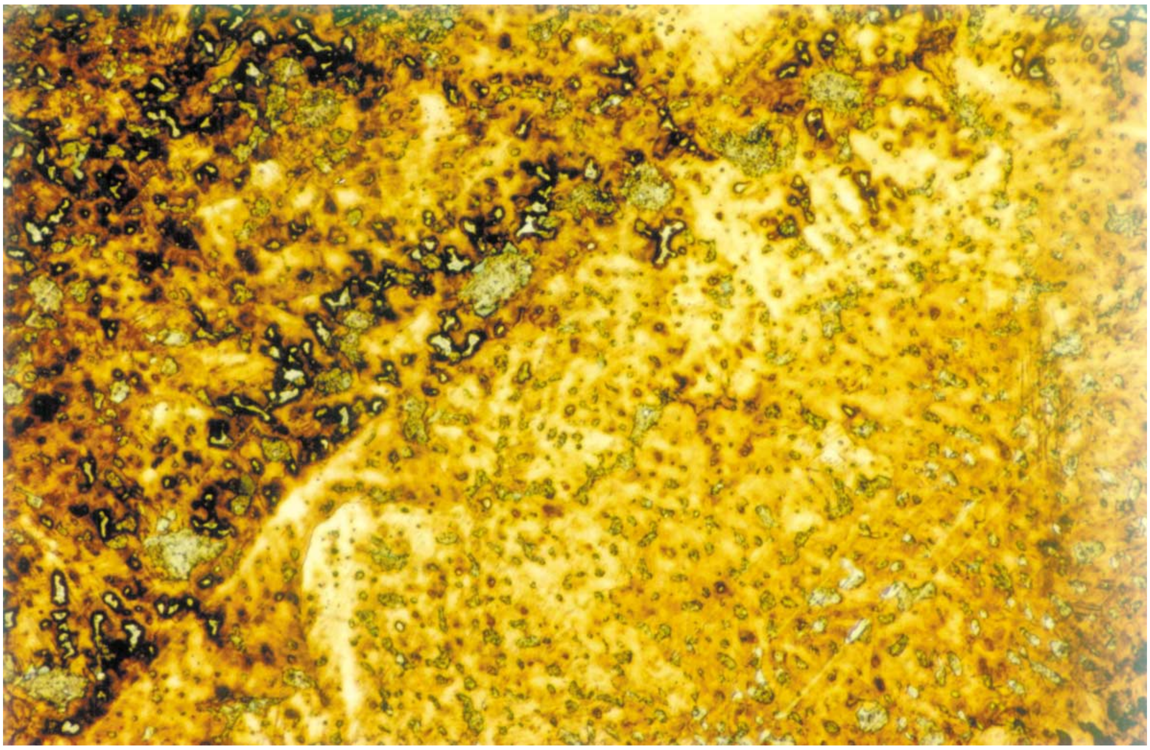


Plate A5.4 Ox 258, cast structure with severe segregation of lead and tin, etched, ×250.

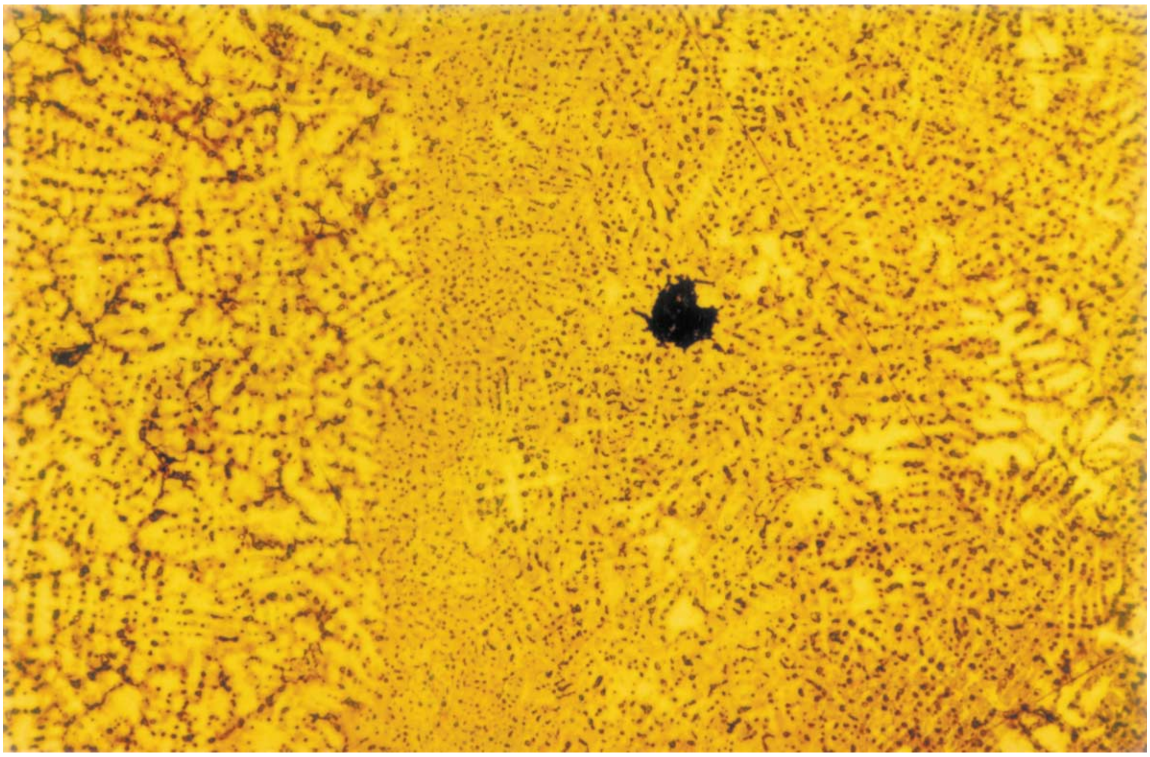


Plate A5.5 Ox 272, cast structure with two markedly different cooling rates, etched, ×250.

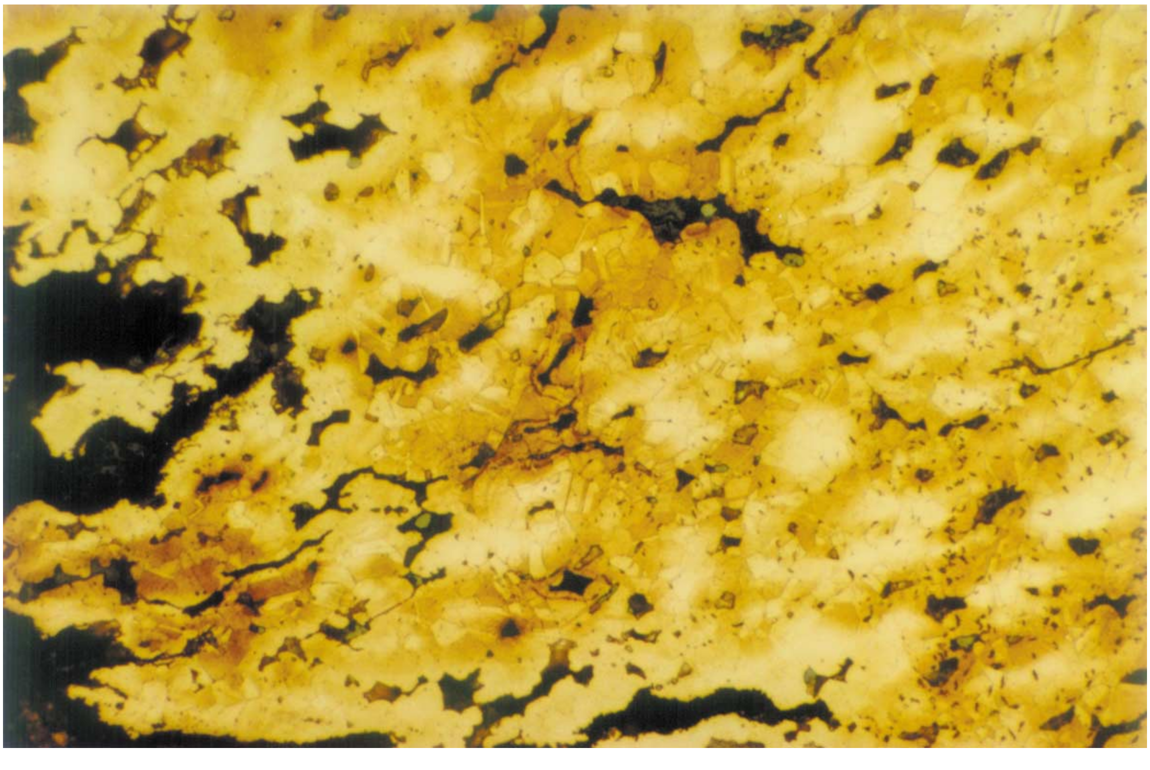


Plate A5.6 Ox 275, partially recrystallised, deformed cored structure with severe corrosion, etched, ×625.

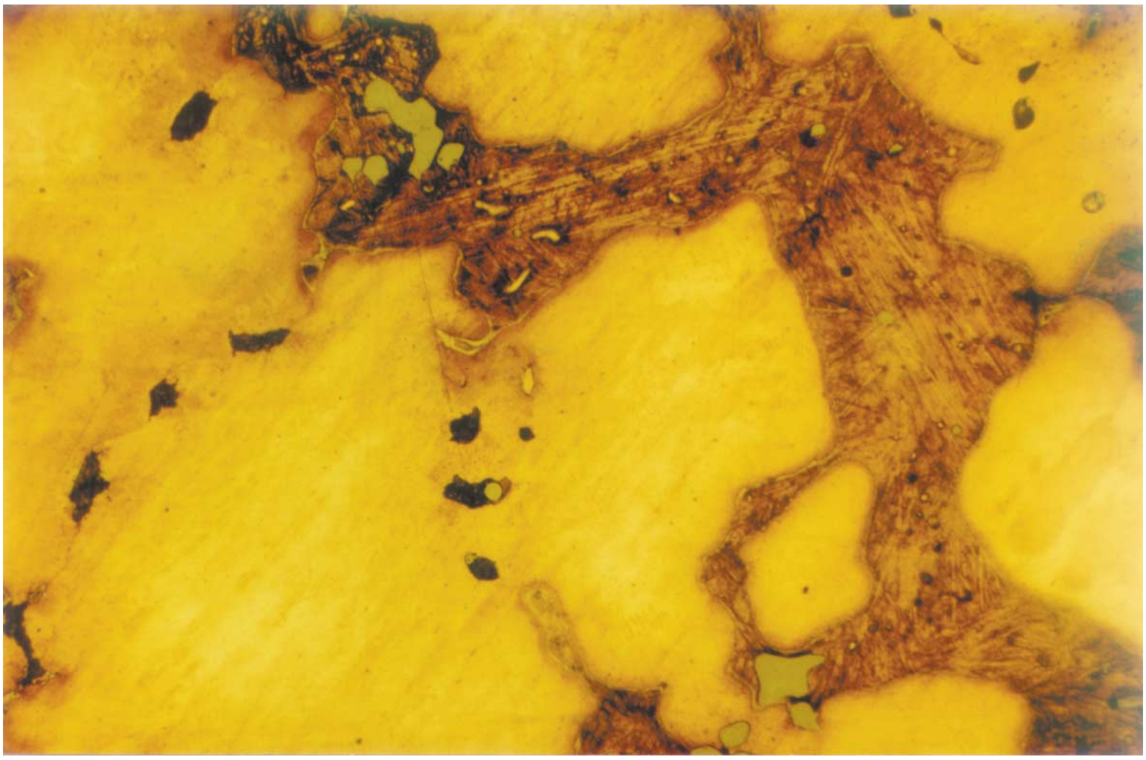


Plate A5.7 Ox 282, detail of martensite structure, etched, ×625.

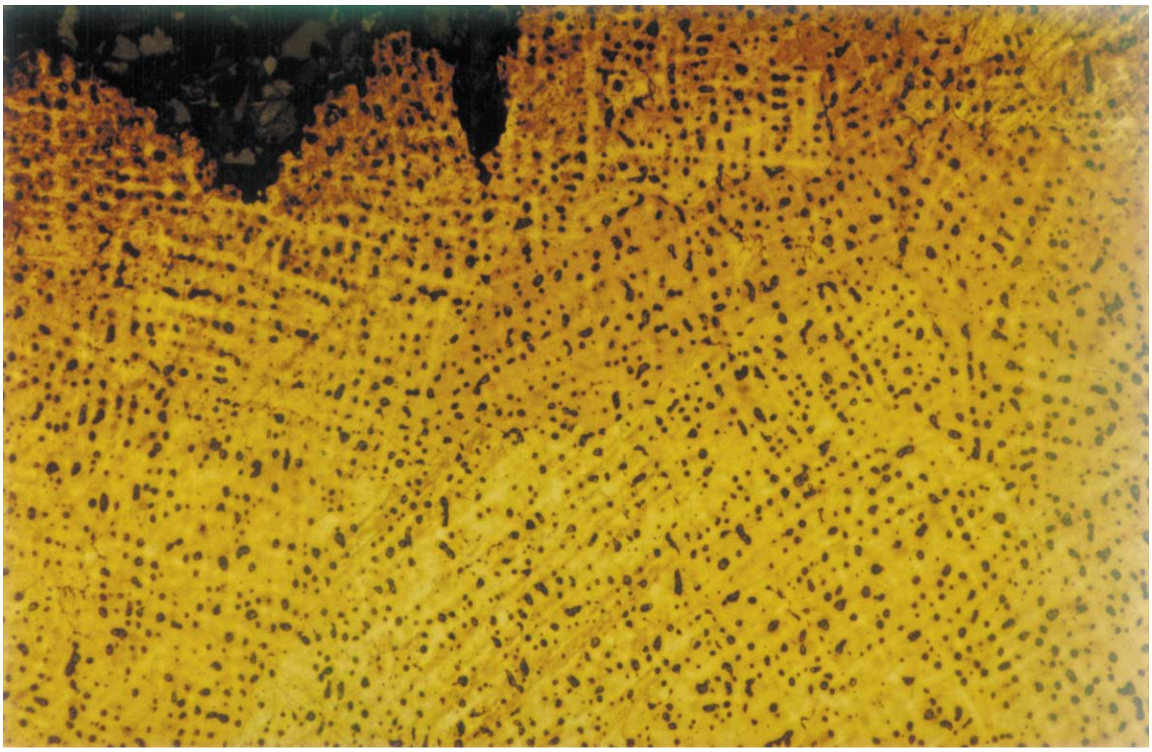


Plate A5.8 Ox 284, typical chill cast structure in as-cast axe cutting-edge, etched, ×250.

Many of the samples were quite severely corroded. In the cast or only moderately altered structures corrosion was often along as-cast grain boundaries with some interdendritic attack, particularly where lead particles were located. Where objects had been cold worked and annealed, especially with a fine grain size, corrosion was much restricted and in the form of pitting with only slight intergranular attack.

Appendix 6: White Horse Hill and Oral History

by Christine Finn

White Horse Hill means different things to different people who use it in different ways
(Miles and Palmer 1995, 373)

INTRODUCTION

This account draws together a number of different perspectives – among them those of children, American visitors and pensioners – which, it is hoped, will add something to a general discussion about the site and its landscape in a contemporary context. The term 'oral history' is used here to describe what can perhaps best be called a knee-jerk reaction to the White Horse and Uffington hillfort. It is basically 'pers. comm.' evidence, gathered by the writer over five years of talking to non-archaeologists about their feelings. The methodology, as it can be said to exist, is interview and casual chat. Purists may regard this as highly non-scientific, but it relates to an area of anthropological fieldwork technique, while allowing a range of voices to be heard in a relaxed, non-academic, setting.

CHILDREN

I visited Uffington Primary School and talked to pupils there, in general terms about archaeology. They had already thought about the subject as part of their classroom activities. I prompted some discussion by asking them questions about their relationship to the site. Had they visited it recently? Had older members of their families talked to them about their memories of it when they were young? Had they heard about the custom of wishing on the eye for good luck? Some had, indeed, visited the White Horse to stand on the eye and make a wish, and they had heard their grandparents talk about this custom. They were excited about the site and regarded it as special. They would miss it if they could not go to it. They were keen for it to be kept open to visitors.

AMERICAN STUDENTS

This was a category which proved surprising in the strength of their reaction to the site. The group of six High School students, aged 16 and 17, were on a month-long American summer-school programme, based in Oxford at Lady Margaret Hall. They were being taught 'Archaeology and Anthropology' as a major (four hours a day) by the writer, who had devised the course and included a visit to the White Horse as part of teaching landscape archaeology. In the classroom, the group had sometimes seemed unclear about the relevance of getting into a landscape to appreciate a site, and in the minibus appeared to have only limited interest in the excursion.

However, once at White Horse Hill, they were transformed. Nearly all ran across to Dragon Hill to view the site from another perspective, and they happily sat quietly and listened to stories about the Hill in its literary and historical context. I suggested they might like to write down their impressions, and this caused a couple of students to wander off alone. This, it transpired, was part of their process of coming to terms with the site. When the accounts were discussed in class the next day, the superlatives were extraordinary from a group which was well financed and often well-travelled. One student was moved to declare White Horse Hill the best place he had ever been in his life; 'Awesome' was a regular description, while one of the most moving testimonies in class was given by a teenage boy more used to wandering alone through miles of woodland and plain in his home state. He had found his British experience disheartening and often depressing 'because you have no space'. He came back from Uffington with a different view, and a greater understanding of how lived landscape evolved and ways in which it can be negotiated.

SENIOR CITIZENS

I spoke to a number of local people in Uffington, about the importance of the White Horse in their lives. While these were emphatic about its special quality, it was the oral testimony of a number of older people, which stayed in my mind, and reinforced, with the children's feelings, the enduring nature of the site. One older lady said she always turned to look at the White Horse if she was travelling in a bus or car; even if it was not visible, she felt moved to acknowledge it. Another said she arranged her room so that she sat facing the site, and she said that this was typical in the village. The White Horse, in this context, became part of their personal vista, interestingly even if it was not actually within view it was 'part of the furniture', an extension of the home and very much a part of their own landscape. Asking how they would feel if it were not there seemed a strange question in this context, as it was quite often 'not there', as in out of sight. It was recognised that the Uffington hillfort, and the White Horse in particular, was so much a part of their village life, that it was difficult to contemplate daily life without it.

VISITORS

These ranged in profile from overseas visitors who were visiting the site as part of a general tour of the Oxford area, to those, from Britain or abroad, who specifically came up to the site. In the latter case, I spoke with a couple from America who had read about the White Horse in a book on sacred sites and related it to Stonehenge and Chaco Canyon, in the American south-west, as being of special spiritual significance. They were at Uffington hillfort at the time of excavation and so were especially thrilled to have an opportunity to discuss finds and to put the site into an archaeological perspective. They found the site as uplifting and fascinating as they had expected, and appeared truly delighted to have made the journey – or a quasi-pilgrimage, perhaps – to walk a landscape hitherto seen on photographs. Much the same feelings came from a number of other local visitors, their 'use' of the site was more pragmatic, and extended beyond walking the hillfort and White Horse Hill, to sit and admire the view. A number regularly came to fly kites, walk the dog, or have a picnic – the site being an extension of their own, commonly accessible, landscape.

CUSTODIANS

People given the responsibility of looking after the site, notably those employed by the National Trust, had a range of unattributed anecdotes concerning the way visitors related to the White Horse. I was told of numerous visits to the Horse's eye to lay flowers after a wedding, both Christian and pagan, things left at the site and Wayland's Smithy, such as coins and candles, various processions, and occasional disrobing. It became apparent that the site, in line with a number of others associated with folklore, attracted a following with its own distinct material culture.

ARTISTS

This is a cover-all term for those I spoke to who said they found the site inspirational. They ranged from artists who either came to paint at the site, or who incorporated the White Horse into their work in a studio; poets, following the lead of notables such as Sir John Betjeman, who lived nearby; and writers, including one who had enjoyed the site as a child and had produced a BBC Radio 4 play featuring the site and recorded there. While these were able to show work, it seemed that the 'inspiration' nature of the site was apparent in most of the interviews conducted. Ambivalence was rarely detected.

CONCLUSION

As stated at the outset, this gathering of ideas and reactions is intended to open up discussion about the way people spoke of their responses to the site and its landscape. The emotions explored relate to things and events remembered, as folk-memory and generational memory which may be passed down, seen in the case of Uffington pensioners and children, and which may have nostalgic embellishment, and immediate reaction while at the site, or in view of it; and recent memory, as in the discussion among the American High School students in class next day.

The publicity given to the site outside the Uffington area, either through archaeological publications or art and writing inspired by the White Horse, has drawn visitors for various reasons. It is apparent that the site forms part of a set of 'sacred' places, which have been appropriated in a 'New Age' sense, as part of an approach to a special landscape, which is at the same time communal. On the other hand, it is obvious that, as Miles and Palmer contend, White Horse Hill means different things to different people. It is both part of Uffington's community, as well as being particular to its villagers who can both associate with certain shared family events, such as weddings, or more closely, with the lives of individuals. What is less clear is whether the site is made special by this attachment, or has acquired its potency by being special in its own right.