Britannia 45 (2014)

A LATE ROMAN MILITARY BURIAL FROM THE DYKE HILLS, DORCHESTER ON THAMES, OXFORDSHIRE

By Paul Booth

SUPPLEMENTARY MATERIAL

APPENDIX 1: ANALYSIS OF THE BUCKLE AND END PLATE

By Andrew Shortland[1]

The buckle and end plate are each made up of three separate pieces of metal. The buckle consists of the D-frame, decorated with incised triangular depressions with terminal beast heads with possible inlaid eyes and a more lightly decorated outer border; the pin, with decorative snake heads and central circular decorations; and the top plate, where the belt would have attached to the buckle, with incised triangular depressions matching the D-frame, incised inlays and plain border. The end plate is made up of the top plate, which forms most of the front of the piece and carrying the main decoration with inlays, echoing the top plate of the buckle; a tubular strip, which marks the very end of the end plate and is a single piece of metal bent over joining top plate to back plate; and the back plate, which is a distinctive colour from the rest of the buckle and contains parallel rows of small holes drilled into it – perhaps hinting that this piece is reused from another object. In addition, various rivets survived which were used to hold the different components together.

Each of the components of the buckle (FIG. 11) and end plate (FIG. 12) were analysed in a Seiko bench top XRF, working at 45kV and maximum current for the detector, usually around 1000um. Multiple points were analysed on all the six pieces of metal that make up the objects, plus the rivets and the inlays. The spot size for most of the analyses was set at 1.5 mm square, but where small features were observed, this was reduced to 0.5 mm or, rarely, 0.2 mm. Analysis time was 50 seconds. The results of the XRF are presented as spectra (see examples in FIGS 16 and 17), which are then processed by using the automatic background correction and peak area calculation. This gives counts per second for each element, which can be linked with appropriate copper-alloy standards to approximate percentage composition for some elements. The peaks measured were chosen to minimise overlap between peaks of different elements, but this was not always possible.

[1] Cranfield University.

RESULTS OF ANALYSIS

TABLE 1: XRF RESULTS BY PIECE, EXPRESSED IN COUNTS PER SECOND

	no.	Ca Ka	Ti Ka	Fe Ka	Cu Ka	Zn Kb	As Kb	Ag Ka	Sn Ka	Pb Lb	Au La
Buckle pin											
buckle central dot 1 0.5 mm D focus	1	445	4	1981	52313	498	9	nd	300	231	nd
buckle central ring1 0.5 mm D focus	2	621	18	861	59381	526	20	nd	334	188	nd
buckle central triangle 1 0.5 mm D focus	3	489	22	686	60809	422	13	nd	288	140	nd
buckle dolphin spot 1 0.5 mm D focus	8	589	20	781	56683	386	11	nd	313	176	nd
buckle snake head 1 1.2 mm S focus	19	841	15	1624	110031	616	34	nd	495	289	nd
buckle snake head 2 1.2 mm D focus	20	803	29	1740	108894	614	35	nd	555	355	nd
buckle pin reverse 1 0.5 mm D focus	11	1236	25	1122	44434	842	26	nd	399	423	nd
Buckle top plate											
buckle top plate 1 1.2 mm D focus	21	1015	33	1999	101844	1128	41	nd	354	334	nd
buckle chip carving 1 1.2 mm D focus	4	612	24	1673	104812	828	26	nd	292	214	nd
buckle chip carving with fill 2 1.2 mm D focus	5	351	46	2124	111074	424	11	nd	275	220	nd
Buckle D-frame											
buckle D-frame 1 1.2 mm D focus	6	1034	30	2192	94581	787	45	nd	759	4112	nd
buckle D-frame 2 0.5 mm D focus	7	518	12	1076	49253	386	14	nd	393	1904	nd
buckle right beast head 1 0.5 mm D focus	17	803	15	1330	36203	605	25	nd	405	2831	nd
Rivets											
buckle rivet 1 0.5 mm D focus	18	245	16	376	77564	212	17	nd	59	201	nd
end plate back plate rivet 2 1.2 mm S focus	24	146	50	682	124194	49	13	nd	76	182	nd
end plate back plate rivet1 1.2 mm S focus	25	179	59	895	124893	29	18	nd	90	161	nd
End Plate back plate											
end plate back plate 1 1.2 mm S focus	22	1475	51	775	119483	35	79	nd	1127	544	nd
end plate back plate 2 1.2 mm S focus	23	1446	46	511	119599	58	86	nd	998	475	nd
End Plate top plate											
end plate chip carving 1 1.2 mm S focus	26	1308	38	2300	100136	1097	62	nd	360	453	nd
end plate chip carving 2 1.2 mm S focus	27	1302	31	2483	105358	805	35	nd	273	273	nd
end plate edge 1 1.2 mm S focus	28	566	32	1278	105733	913	26	nd	232	163	nd
end plate top plate panel 1 1.2 mm S focus	33	1203	35	1994	105749	704	48	nd	311	281	nd
end plate top plate panel 2 1.2 mm S focus	34	1401	44	2324	105233	768	56	nd	345	357	nd
End Plate tubular strip											
end plate tubular strip 1 1.2 mm S focus	29	1771	43	2873	105236	679	68	nd	395	399	nd
end plate tubular strip 2 1.2 mm S focus		1192	49	2412	108930	392	59	nd	439	370	nd
Inlays											
buckle left beast eye 1 0.5 mm D focus	9	63	nd	750	50542	68	18	1870	244	2659	nd
buckle right beast eye 1 0.5 mm D focus	15	23	nd	242	33205	329	37	3196	363	1744	nd
buckle right beast eye ring 1 0.5 mm D focus	16	76	69	181	17733	126	64	4564	499	605	tr
buckle pin triangle 1 0.5 mm D focus	12	247	22	709	21768	1002	89	4871	527	105	211
buckle left beast triangle 1 0.5 mm D focus	10	88	nd	250	16445	627	291	5429	608	618	760
end plate ridge inlay 3 with plate 0.5 mm S focus	32	587	nd	1188	37116	891	312	10155	1248	395	676
end plate ridge inlay 2 with plate 0.5 mm S focus	31	511	nd	1992	44976	469	261	10391	1153	1862	425
end plate ridge inlay 1 50kV 0.5 mm S focus	30	238	nd	333	7076	1229	565	14529	1544	161	1305
buckle ridge inlay 3 0.2 mm D focus	14	nd	nd	48	702	Nd	Nd	353	36	61	nd
buckle ridge inlay 2 0.2 mm D focus	13	nd	nd	44	529	Nd	Nd	361	39	55	nd

Note: Zn Kb and Au La interfere making the Zn count inaccurate when Au is present; As Kb and Au Lb interfere making As inaccurate when Au is present; Ag Kb and Sn Ka interfere making Sn inaccurate when Ag is present. These values are highlighted in red. ‘nd’ – not detected, ‘tr’ – trace.

DISCUSSION

A fundamental question for the analysis was whether the six components of the buckle were made from the same pieces of metal or multiple pieces of different metals. The regular holes in the back plate of the end plate suggested that it might have been reused scrap, which should therefore have a different composition to the other pieces. The best way to compare the pieces is to look at the ratio of counts for various elements present. These are shown in FIGS 13–15. Owing to the problems that might be observed in the preferential concentration of certain elements in the surface layers, plus the possibility of weathering and surface accretions, only the very clear differences can be used to differentiate the pieces. The two main pieces, the top plates of both the buckle and the end plate, cannot be distinguished analytically, with relatively low tin and some zinc and lead, as can be seen in the figures. This is good evidence that they may have been made from the same piece of metal, which might have been chosen so that the colours of the two pieces that would be most visible matched. The buckle D-frame and buckle pin are very similar to each other, but somewhat distinct from the two top plates, especially in tin content. However, the D-frame has much more lead than the pin, strongly suggesting that they are different to each other and to the top plates. The end plate tubular strip falls between the two groups, but in many ways appears similar to the top plates, and it is reasonable to conclude that it may be part of this piece of metal as well. However, the back plate of the end plate is very distinct. It has very low zinc, and high tin, putting it in a new category. This supports the idea that it might have been a reused piece. The rivets are very variable in zinc composition, but have very little tin, making them a fairly pure copper alloy, rather than a bronze.

Comparison with copper-alloy standards run under the same conditions allows some cautious absolute figures to be put onto the amount of the various elements present in the metals. It should be emphasised that these are only a guide. With the information above and these calibrations, the following different metal types can be determined: Type A – consisting of the buckle top plate, the end plate top plate and the tubular strip (although this is slightly different), each of which is a copper alloy with traces of zinc (<0.2% Zn), significant tin (2–5% Sn) and some lead (0.5–1.5% Pb); Type B – present only in the buckle pin, which is a copper alloy with traces of zinc (<0.2% Zn), mostly higher tin (5–6% Sn) and some lead (about 1.0% Pb); Type C – the buckle D-frame, again with traces of zinc, higher tin (5–6% Sn) and high lead (>10%Pb, potentially much greater); Type D – which is the end plate back plate, with lower zinc, high tin (perhaps 10% Sn) and some lead (around 1.0% Pb). The final type, Type E, consists of the rivets, which are variable in zinc and lead, but have low levels of tin (<1.0% Sn).

There was a suggestion that the triangular cell decoration of the buckle and end plate might have been shaped that way in order to receive an inlay of some sort. However, analysis in the triangular recesses showed no evidence of inlay or any securing pastes or glue. There is no evidence, therefore, that these areas were inlaid. However, there is evidence that the borders to these triangular areas were inlaid with another metal that appears more silvery under the microscope. Analysis of the inlays shows that they are rich in copper, silver, lead and sulphur, and some also have gold (see FIG. 16). There appears to be some variety in the composition of the inlays, with the possibility of two different sorts being used, one in the end plate with relatively high Ag/Cu count ratios, traces of gold and higher sulphur and lead, and one in the buckle, which is the opposite (FIG. 17). The analysis showed no evidence of sulphur enrichment in areas of the bronze or other surface treatment which might suggest that the bronze was deliberately darkened in order to allow the inlays to stand out.

CONCLUSIONS

Analysis of the Dyke Hills buckle and end plate has shown some clear patterns. It is evident that the compositions of the front plates of both buckle and end plate and perhaps the tubular strip of the end plate are consistent with them being made from the same piece of bronze, with traces of zinc and relatively low tin and some lead. The fact that the same piece of metal might have been chosen may be because it was desired that these pieces should appear the same, as changes in composition might affect the colour. In contrast, the pin and D-frame are slightly different, especially in tin content, which appears to be significantly higher. The D-frame also has a high lead content, which might have been added to make the metal easier to cast. Perhaps the complex shape of the D-frame was cast in a particular metal that would be better for this piece, or maybe it is simply chance that a relatively high lead piece was chosen for this component. The last major piece of metal, the back plate of the end plate, is very distinctive, with high tin like the D-frame, but little zinc. This supports the idea that this piece may have been reused.

There is no evidence of deliberate inlaying in the triangular depressions in both the buckle and end plate. It seems likely that they were intended for decoration as they appear, rather than to receive another inlay. However on the ridges between these pieces there are inlaid strips, high in copper and silver, often with sulphur and gold. These are consistent with niello, and it may be that the buckle and end plate are slightly different in the compositions of the nielli used in them.

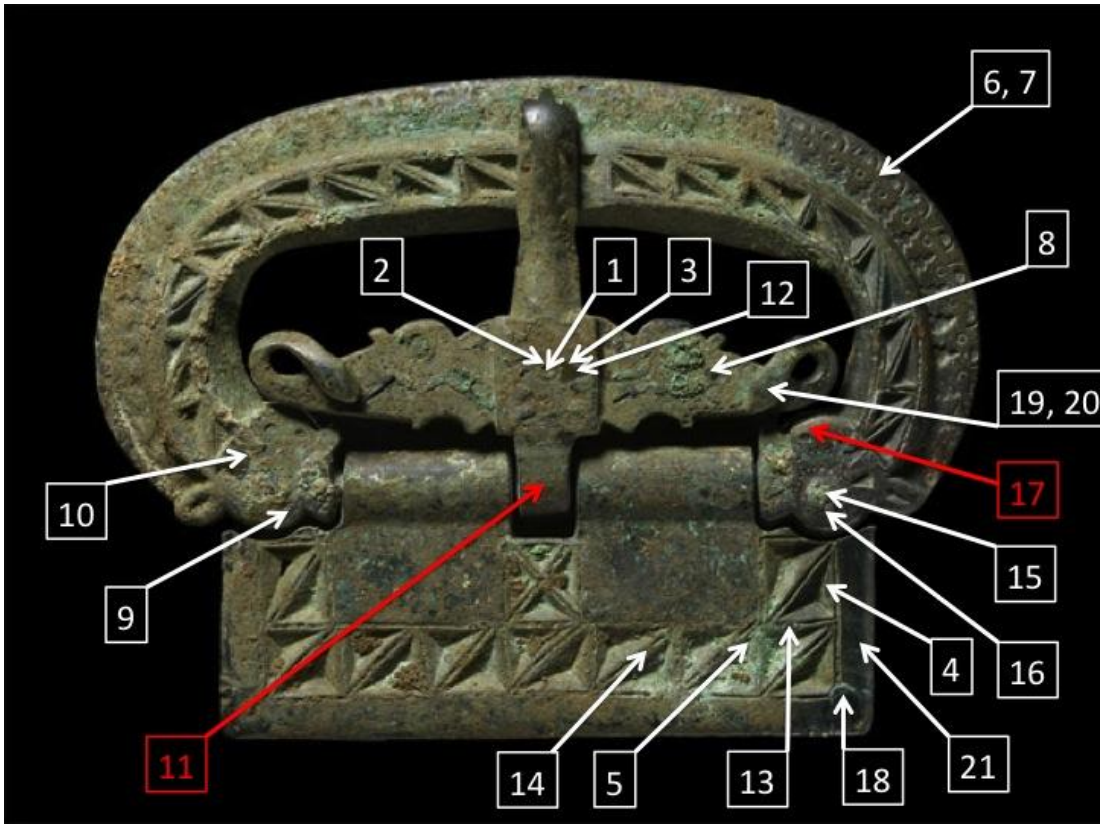


FIG. 11. Buckle from the front, showing D-frame, pin and top plate. White numbers show analysis spots on this, the front surface, red shows area where an analysis was made on the corresponding back surface.

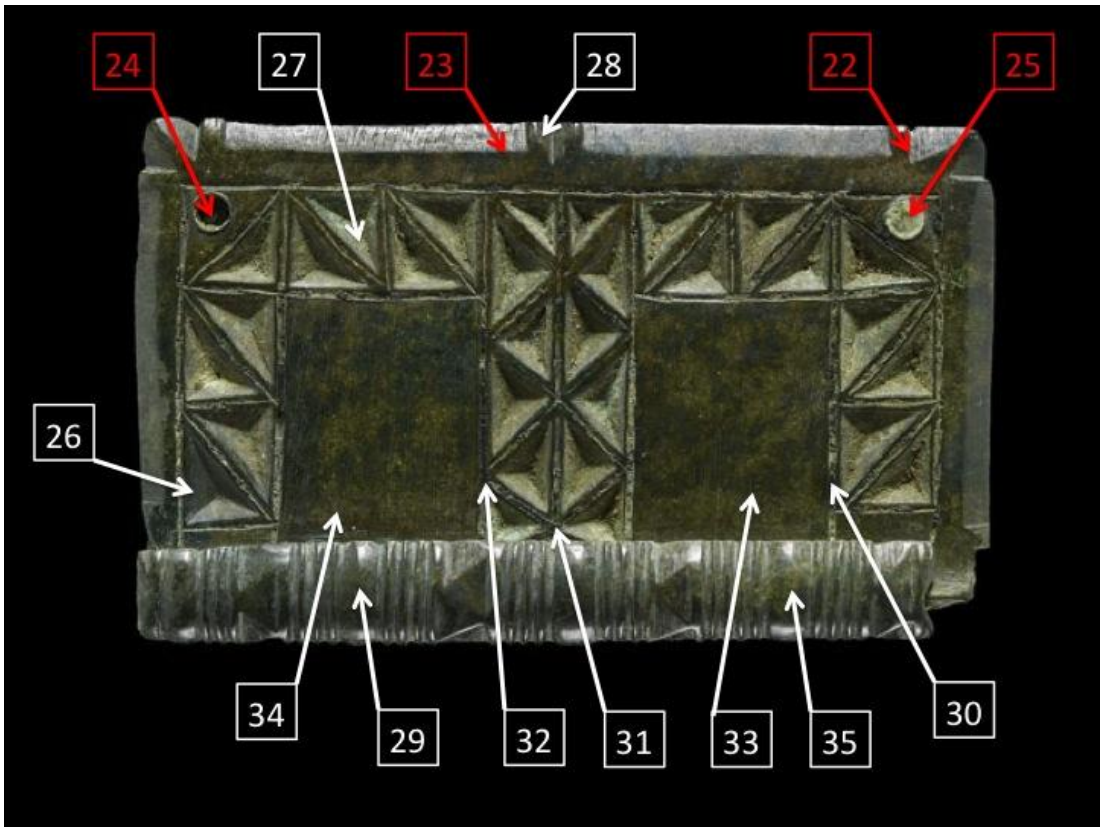
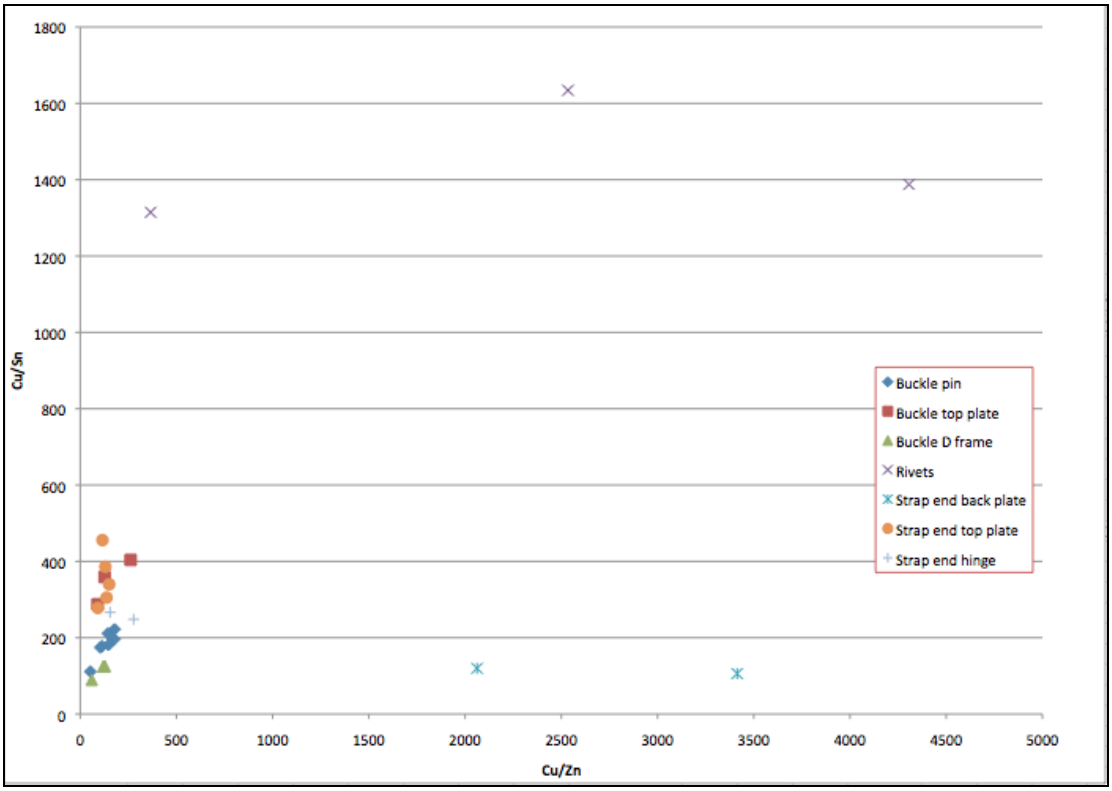


FIG. 12. End plate from the front, showing top plate and tubular strip (bottom). White numbers show analysis spots on this, the front surface, red shows area where an analysis was made on the corresponding back surface.



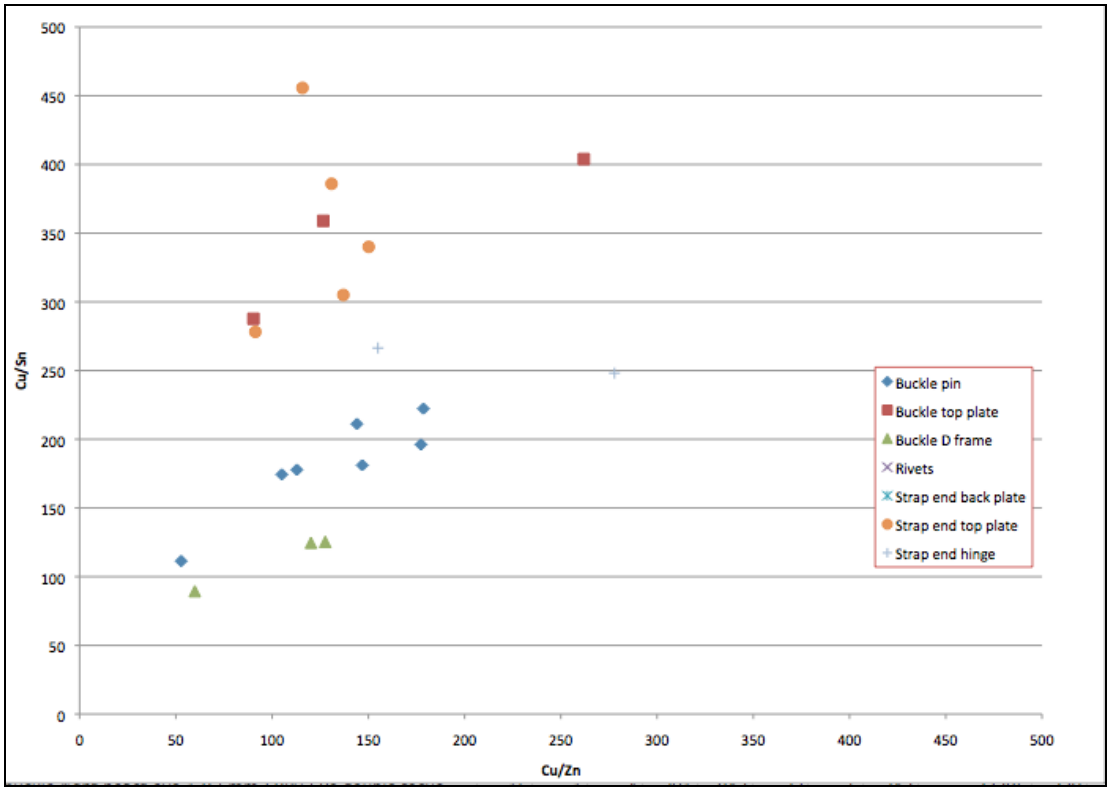


FIG. 13. Cu/Sn against Cu/Zn expressed as counts, on two different scales, the lower showing detail of the main clusters.

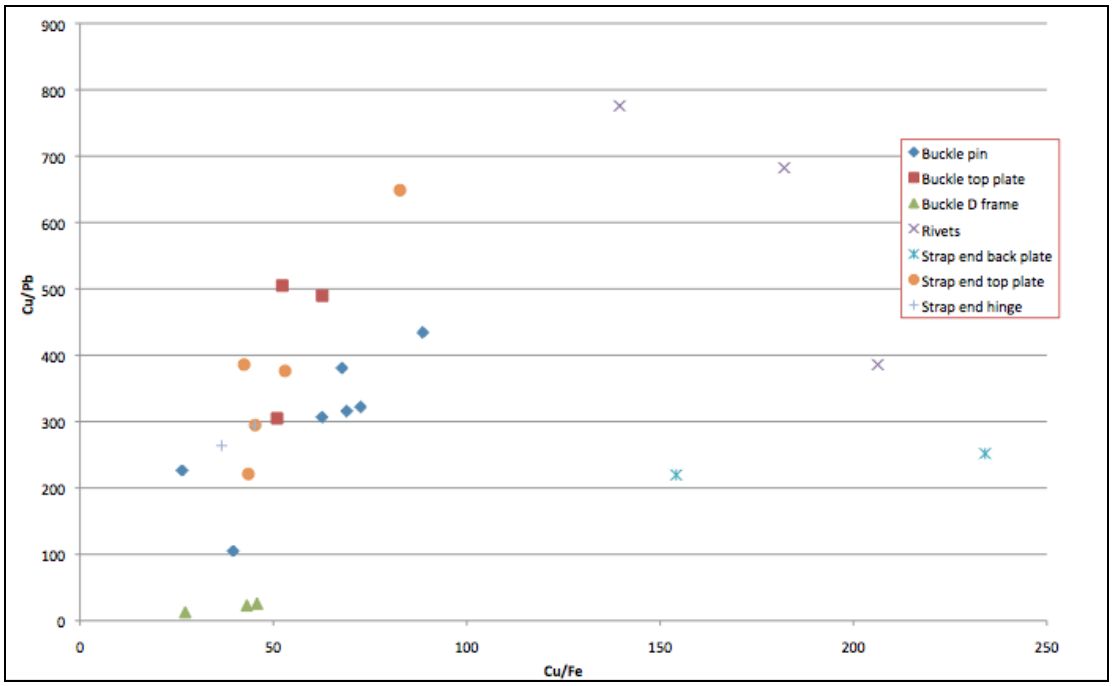


FIG. 14. Cu/Pb against Cu/Fe expressed as counts.

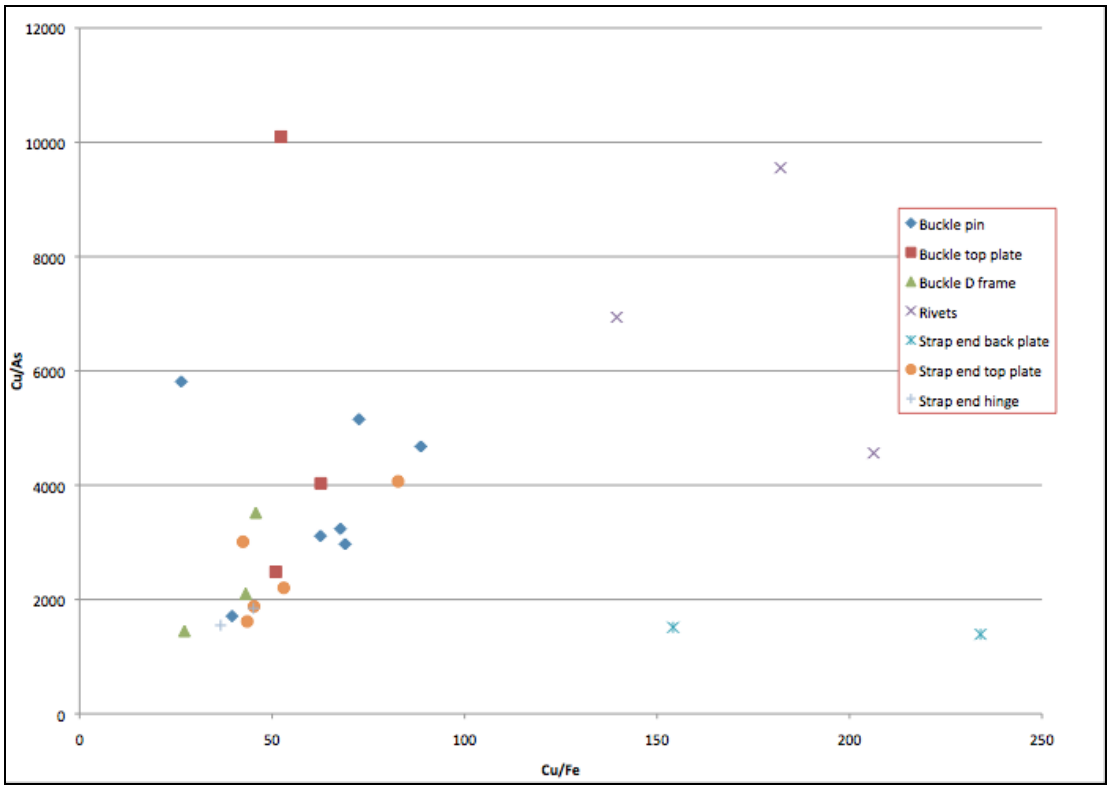


FIG. 15. Cu/As against Cu/Fe expressed as counts.

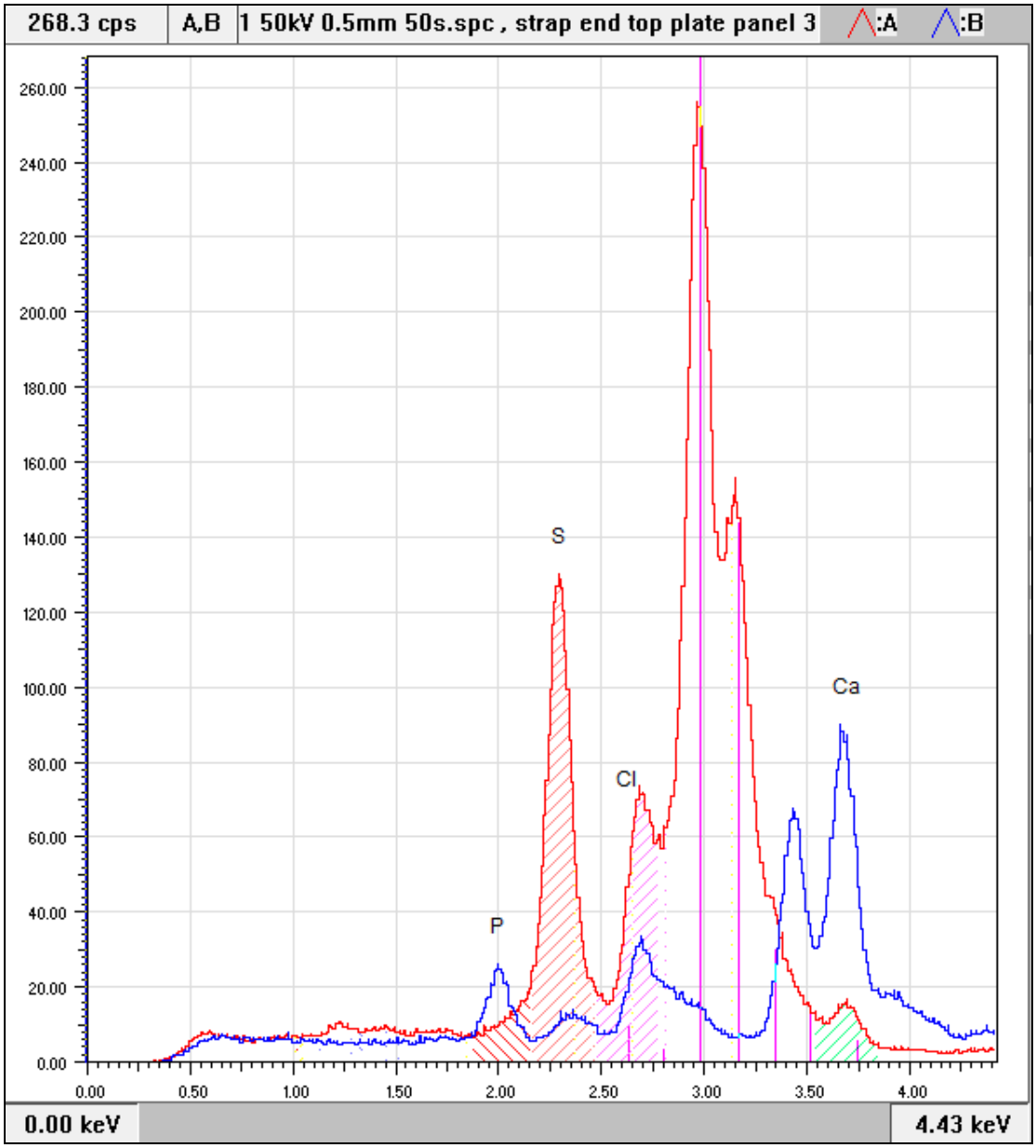


FIG. 16. Comparison of spectra for end plate ridge inlay I (red) and End Plate top plate 1 (blue), clearly showing high S levels in the inlay. The major peaks at just under 3.00 and 3.20 are Ag L lines.

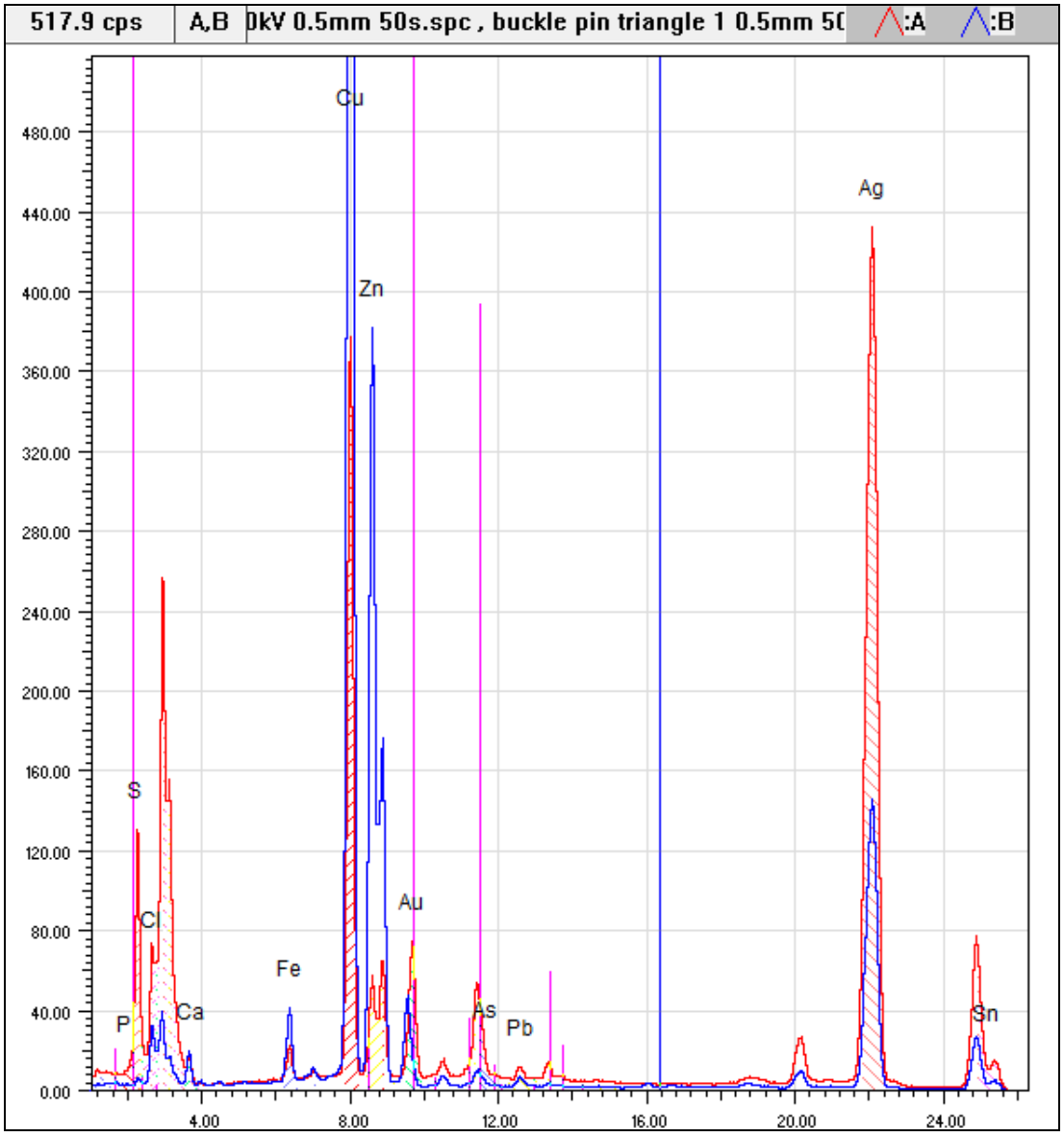


FIG. 17. Comparison of spectra for end plate ridge inlay I (red) and buckle central triangle 1 (blue), clearly showing high S levels in the end plate inlay, but not the buckle and very different Cu to Ag ratios.

APPENDIX 2: STRONTIUM AND OXYGEN ISOTOPE ANALYSIS OF TOOTH ENAMEL FROM AN INDIVIDUAL FROM DYKE HILLS

By Jane Evans[2]

INTRODUCTION

The right maxillary 2nd molar from the Dyke Hills skeleton was received by NERC Isotope Geosciences Laboratory for isotope analysis. Strontium and oxygen isotope analysis was requested to place constraints on his childhood origin with the aim of testing whether he was of British origin or not.

METHOD

The available enamel surface of the tooth was abraded to a depth of >100 microns using a tungsten carbide dental burr and the removed material discarded. Thin enamel slices were then cut from the tooth using a flexible diamond edged rotary dental saw. All surfaces were mechanically cleaned with a tungsten carbide burr to remove adhering dentine. The resulting samples were transferred to a clean (class 100, laminar flow) working area for further preparation. In a clean laboratory, the samples were first washed in high purity acetone to remove any grease that might have come from handling the enamel. Then the sample was cleaned ultrasonically in high purity water, rinsed, dried and then weighed into pre-cleaned Teflon beakers. The samples were mixed with ^{84}Sr tracer solution and dissolved in Teflon distilled 8M HNO_3. Strontium was collected using Dowex resin columns. Strontium was loaded onto a single Re Filament with TaF following the method of Birck,[3] and the isotope composition and concentrations were determined by Thermal Ionisation Mass spectroscopy (TIMS) using a Thermo Triton multi-collector mass spectrometer. The international standard for $^{87}Sr/^{86}Sr$, NBS987, gave a value of 0.710251 ± .000005 (n=19, 2ς) during the analysis of these samples. Blank values were in the region of 100pg.

For the isotopic analysis of carbonate oxygen approximately 2 milligrams of prepared enamel was loaded into a glass vial and sealed with septa. The vials are transferred to a hot block at 90°C on the GV Multiprep system. The vials are evacuated and 4 drops of anhydrous phosphoric acid are added. The resultant CO_2 was collected cryogenically for 14 minutes and transferred to a GV IsoPrime dual inlet mass spectrometer. The resultant isotope values are treated as a carbonate. $\delta^{18}O$ is reported as per mil (‰)($^{18}O/^{16}O$) normalized to the PDB scale using a within-run calcite laboratory standard (KCM) calibrated against SRM19, NIST reference material and were converted to the SMOW scale using the published conversion equation of Coplen: SMOW=(1.03091 x $\delta^{18}O_{VPDB}$) +30.91.[4] The carbonate oxygen isotope (SMOW scale) composition is converted to phosphate oxygen isotope composition using the recently published equation of Chenery *et al*.[5] Drinking water values are then derived using equation 4 from Daux *et al*.[6] Analytical reproducibility for this run of laboratory standard calcite (KCM) is 0.11‰ (1 σ, n=7) for $\delta^{18}O_{SMOW}$ and ± 0.04‰ (1s, n=7) for $\delta 13C_{PDB.}$

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2 British Geological Survey, NERC Isotope Geosciences Laboratory.

3 Birck 1986.

4 Coplen 1988.

5 Chenery *et al*. 2012.

6 Daux *et al*. 2008.

Reproducibility of human dental enamel is best estimated from duplicate pair analysis at ± 0.16‰ (1s).[7]

RESULTS

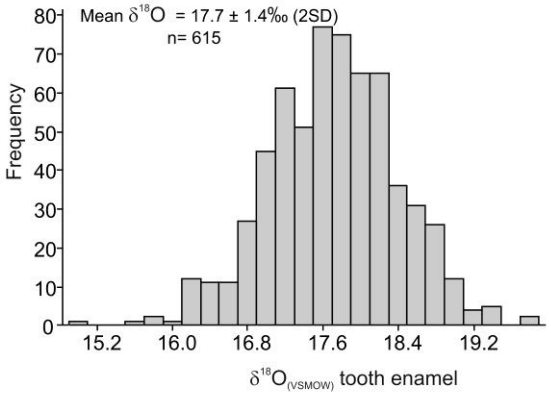
TABLE 2. STRONTIUM, OXYGEN AND CARBON ISOTOPE COMPOSITION OF TOOTH ENAMEL FROM THE TOOTH ENAMEL.

sample	$\delta^{13}C_{PDB}$	$\delta^{18}O_{PDB}$	$\delta^{18}O_C$ ‰ VSMOW	$\delta^{18}O_P$ ‰ VSMOW	Drinking water*	Sr ppm	$^{87}Sr/^{86}Sr$
Dyke Hills	-16.49	-7.53	+23.15	14.2	-12.7	109	0.709314

* Drinking water values are calculated using equation 4 from Daux *et al*. (2008). The 1s errors on the drinking water values are estimated at ± 0.7.

DISCUSSION

The graph below summarises $\delta^{18}O_P$ ‰ $_{VSMOW}$ data from 615 samples of archaeological human tooth enamel[8] and shows that the phosphate oxygen value from this individual's tooth enamel ($\delta^{18}O_P$ ‰ $_{VSMOW}$ =14.2) is well below values typical for the UK. The value is at the lower end of compositions found in a mass execution pit interpreted to be 'Vikings' of Scandinavian origin,[9] but the strontium isotope composition of 0.70932 rules out areas of ancient geology such as inland Baltic shield (Norway, Sweden and Finland).



In conclusion, the individual is unlikely to have spent his childhood in Britain. He comes from an area where drinking water has a value of circa -12.7 ±0.7 (1s). This is consistent with northern Scandinavia and areas of Eastern Europe.[10] The strontium isotope compositions suggest either a coastal region or one of Mesozoic to Recent geology.

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7 Chenery *et al*. 2012.

8 Evans *et al*. 2012.

9 Chenery *et al*. in press.

10 See GNIP http://www-naweb.iaea.org/napc/ih/documents/userupdate/Waterloo/index.html#Europe.

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