ANALYSIS OF MEDIEVAL HUMAN BONE FOR MANGANESE CONTENT BY X-RAY MICROANALYSIS USING A SCANNING ELECTRON MICROSCOPE

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Introduction

During archaeological excavations, it is not uncommon for a staining of artefacts to be observed, in particular the staining of bone material. Darkening of artefacts may be associated with fire; however in cases where fire is not evident opinion on the cause of this staining appears inconsistent.

Whilst manganese oxides are frequently given to be the cause of “blackened” staining, the origins of the manganese oxide are rarely considered. Other causes of staining are acknowledged though are rarely given and so while it seems that causes of the staining are accepted, these are rarely tested for.

Bacteria have been suggested as facilitators in the deposition of manganese upon bone surface and lichen growth found to correspond to the patchy appearance associated with staining. A number of studies have suggested pH and soil type to be important predisposing factors for the accumulation of staining however little work has been done on this. It has been suggested that alkalinity of clays/loamy soils provide favourable conditions for surface coating development but again little work has been done to show this.

It appears widely accepted that while staining may be a result of the presence of manganese, this is not the only component of the stain material. Numerous cases suggest that the stain is also a result of the presence of iron, and it is also noted that the presence of staining may be associated with the presence of heavy metals, such as strontium, barium and lead, though no real trends appear to have been found connecting the elevated concentrations of these to the increased staining of material.

“Promising trends” have been documented as being observed with relation to the presence of organic grave goods, with wood and leather grave goods in particular being mentioned as being potentially related to the staining process, however this has not been further expanded upon and little research has gone into this.

It is clear that while many cases of bone staining have occurred and been documented, little research has gone into the cause of this staining and while little analysis appears to have been done on these stains, the common consensus appears to be that staining of bone is caused by the presence of manganese, possibly also in the presence of iron. Analysis of stained and unstained medieval human bones excavated from Hulton Abbey (Staffordshire, UK) was performed by X-Ray microanalysis and comparisons made to try to ascertain possible factors affecting staining.

Prepared bone samples on aluminium stubs with Silver DAG

Analysis

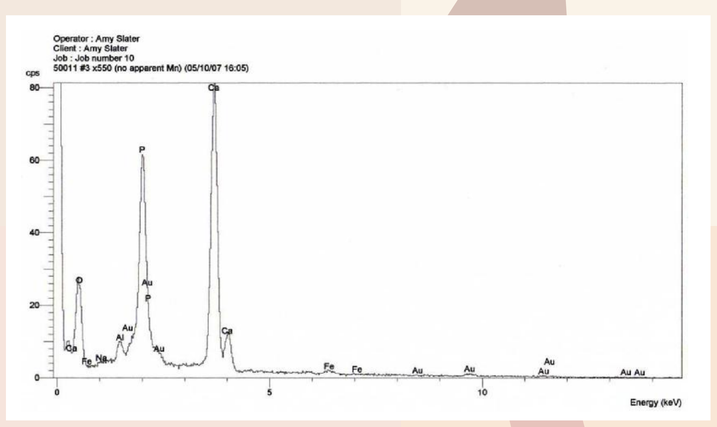
Analysis of the samples was performed using a JEOL JSM-820 Scanning Electron Microscope coupled with a Pixie 3000 digital scan generator. The Scanning Electron Microscope was calibrated against a cobalt standard, and so for this analysis the principle peak for manganese was given to occur at 5.9075 keV.

Although preferable; and whilst possible using this technique, the equipment used was not equipped to perform quantitative analysis of the samples and as such the elemental analysis performed was, strictly speaking, qualitative. However by minimising the number of variables during analysis it was possible to give an indication of relative elemental concentration, enabling comparison of concentrations between stained and unstained material.

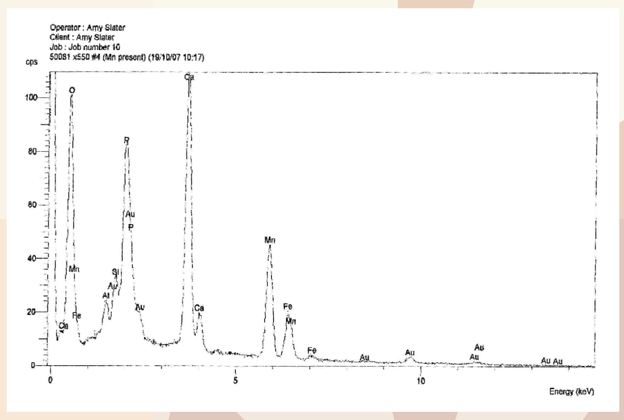
The analysis itself was performed using a magnification of 550 and acceleration voltage of 17 keV. Working distance was set between 39 and 44mm and a minimum of 4 results were taken for each sample. As it could be suggested that peak intensity indicates relative concentration, by measuring the height of the principle manganese peak and subtracting an approximate background it was possible to give the data numerical values.

Skeleton	Peak Height of Sample/mm				
	1	2	3	4	5
HA06	--	**	18	35	5
50001	1	1	1.5	1.5	--
50011	*1.5*	*3.5*	*--*	*1*	*1.5*
50042	0.5	--	8.5	2.5	--
50058	*9*	*0.5*	*4.5*	*17*	*2.5*
50074	*2*	*1*	*3*	*7*	*4*
50080	*2*	*7.5*	*4*	*9*	*--*
50081	31	16	14	37	37

** Whilst it was considered a possibility that manganese may be present at the threshold of detection, it was not possible to differentiate between any potential peak and the background “noise” and as such a value was not determined for this sample.



Spectral analysis of and area of



Spectral analysis of an area of “unstained” bone

Discussion

Of the eight samples analysed, only five of the thirty-eight spectra recorded did not show characteristic manganese peaks, and for some there was a degree of uncertainty for this as it was considered possible that manganese levels may be slightly too low to detect with any degree of confidence.

The results of this analysis show that manganese presence does not guarantee staining, suggesting that other factors must be taken into consideration. It seems likely that the manganese present in the staining is in a different form than that present on the surface of unstained bone. As all of the samples were excavated from a localised area of relatively similar soil, it would seem that other factors affect the staining process. The age of the burials was not determined and this may be a factor if staining is affected by the development of ferromanganese nodules, which is a seasonal process.

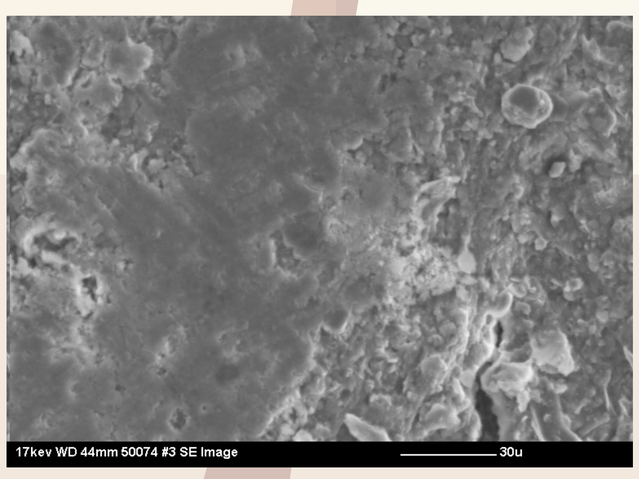
To test the theory that the observed staining occurs when manganese is in a different state than that which is detected on the unstained material, X-Ray powder diffraction could be used to determine the crystalline structure of the manganese compounds and thus determine whether or not the staining is principally composed of Birnessite, as is thought to be the case.

While it seems likely that organic grave finds may promote staining, the process itself appears to occur naturally.

Whilst the overall composition of stain deposits seems to be relatively similar regardless of location, the locality of minerals will obviously affect stain composition to an extent, although for the most part the staining process itself seems to be very similar. While manganese does appear to be a significant component of stain deposits, it seems to provide an even bigger role in the surface coating of unstained bone and so detection of manganese alone is not an indication of bone staining.

Skeleton Number	Documented as blackened?	Approximate age	Gender	Burial Location	Clay Type	Finds	Analysis Number (Mn content)				
							#1	#2	#3	#4	#5
HA06	No	17-25 years	♀	Chancel	Not specified	Wrapped in rushes	Absent	Maybe	Present	Present	Present
SK50001	No	adult	Probably ♂	South transept	Mixed, cutting natural	None documented	Slight	Slight	Slight	Slight	Not evident
SK50011	*Yes*	*35-45 years*	♂	*Crossing*	*Mixed, with occasional sandstone fragments*	*Wand, wood fragments. Amber bead within grave fill*	*Present*	*Present*	*Not apparent*	*Some*	*Present*
SK50042	No	25-35 years	♀	North transept	Mixed	None documented	Small	Not detected	Present	Present	--
SK50058	*Yes*	*18 months*	*Indeterminate*	*Nave and Aisles*	*Not specified*	*None documented*	*Present*	*Small*	*Present*	*Present*	*present*
SK50074	*Yes*	*25-35 years*	*Probably♂*	*Nave and Aisles*	*Not specified*	*None documented*	*Present*	*Present*	*Present*	*Present*	*present*
SK50080	*Yes*	*25-35 years*	♀	*Nave and Aisles*	*Not specified*	*None documented*	*Present*	*Present*	*Present*	*Present*	--
SK50081	No	25-35 years	♂	Nave and Aisles	Not specified	None documented	Present	Present	Present	Present	Present

All Archaeological data taken from Klemperer, W.D. and Boothroyd, N, 2004. *Excavations at Hulton Abbey, Staffordshire 1987-1994* Leeds, UK: Maney Publishing. ISBN 1-904-350-3005



Bone surface under Scanning Electron Microscope

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