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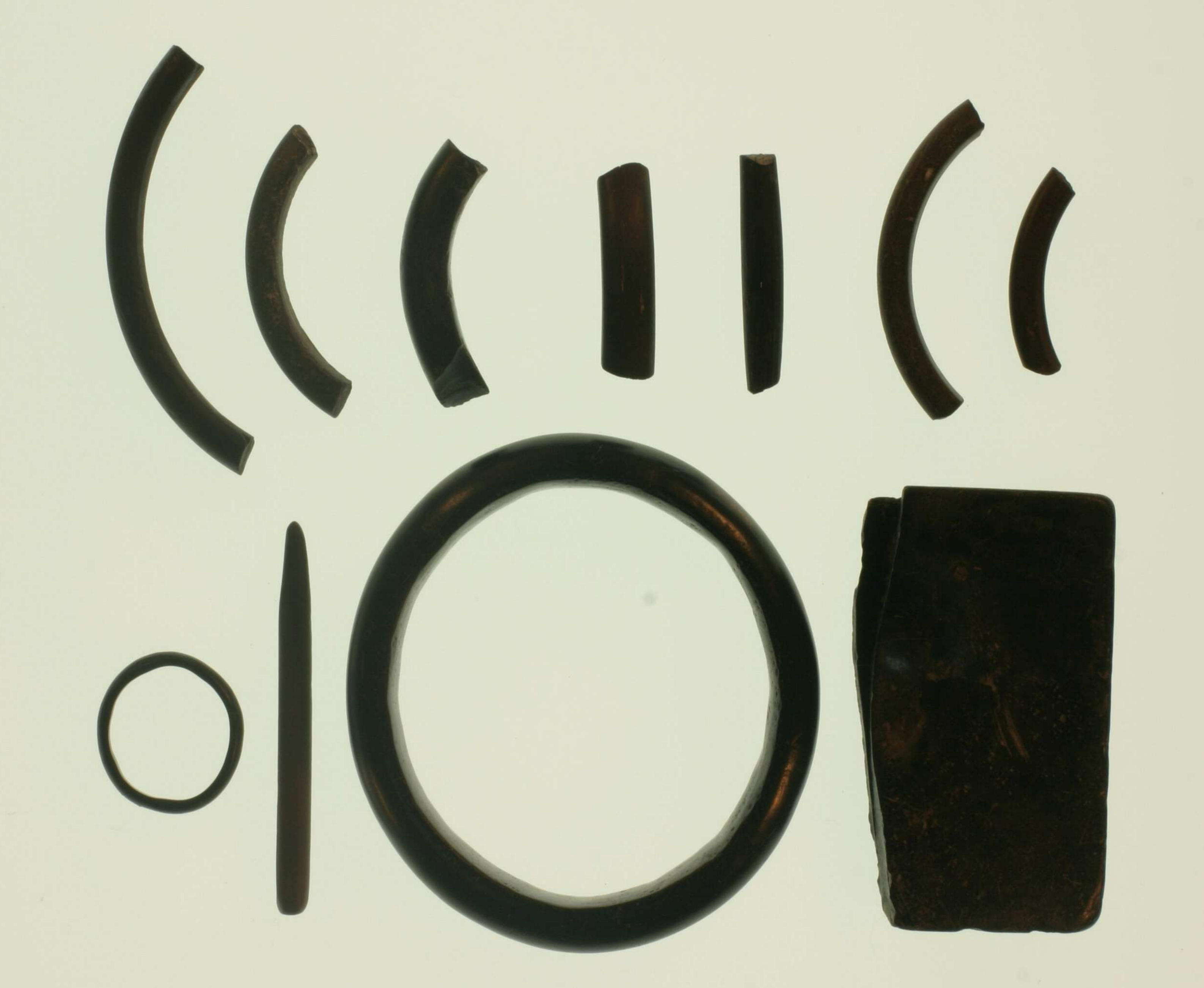
CUMWHITTON, CUMBRIA
ANALYTICAL INVESTIGATION OF JET-LIKE OBJECTS FROM A VIKING CEMETERY

ARCHAEOLOGICAL CONSERVATION REPORT

Sharon Penton



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Summary

This report explores the use of analytical techniques to accurately identify archaeological jet and other jet-like materials. X-radiography, X-ray florescence and Fourier transform spectroscopy were applied in the investigation of two jet-like objects from the Cumwhitton site. Based on this analysis the objects were confirmed to be oil shale, not jet.

Keywords

Early Medieval
Jet/shale

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Introduction

Since the early 1980's there have been various studies in using analytical techniques to identify jet and other jet-like materials from archaeological sites. Among these studies there have also been attempts at identifying specific characteristics of jet sourced from different areas around the world to determine the possibility of tracking archaeological jet objects to their place of origin. With two objects thought to be jet from the 10th Century Viking cemetery at Cumwhitton in Cumbria, it was decided that some of these techniques could be experimented with and the results compared with the research available. The two objects are a bracelet (SF 792) and finger ring (SF 805) (figure 1).

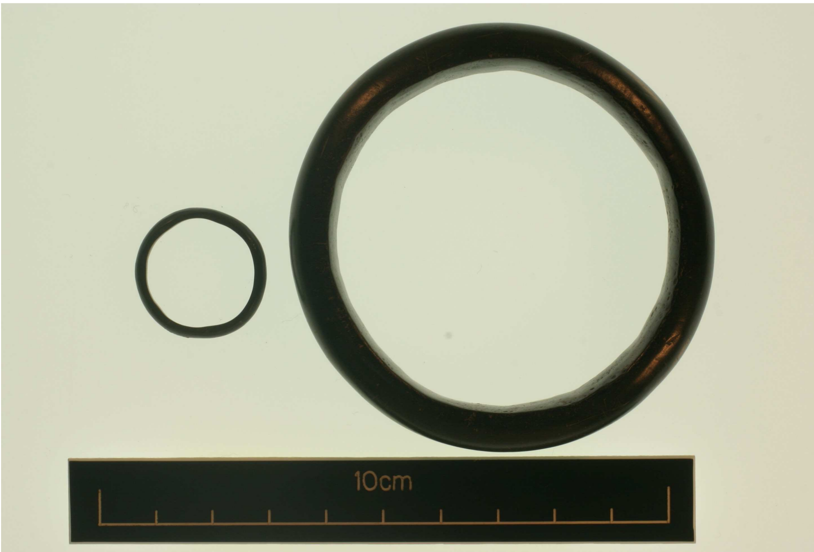

Figure 1. SF 792 and SF 805

After a review of the literature x-radiography, x-ray florescence (XRF) and Fourier-transform infrared spectroscopy (FTIR) seemed the most appropriate techniques to use as they are non-destructive.

Geology

Jet is a type of coal. Like other coal-like materials, is a carbonaceous material of fossilised ancient coniferous wood. The wood is from Jurassic period trees similar to the modern *Araucaria* (monkey puzzle) (Muller 1987). The tissues of these trees mainly consisted of carbohydrates and hydrocarbons, the latter being more resistant to decay.

Jet forms when the wood material mentioned, accumulates in stagnate water with limited oxygen present. Gradually the material is compressed into peat while retaining the wood's structure. Further compression finally leads to the formation of jet (Davis 1993).

Jet looks like a brown coal but when worked and polished it appears as a homogenous black rock with a resinous shine. In some cases it is possible to see the wood structure on the surface though this is best seen through the use of a scanning electron microscope (SEM).

X-radiography

Different types of coal-like materials have different inorganic concentrations. These concentrations affect the material's absorption of x-rays. By x-raying various types of coal-like materials on the same plate using a low voltage it is possible to distinguish between the different types based on the transparency of the object. Shale absorbs the most x-rays and is therefore quite opaque on film. Cannel coals and oil shale are less absorbent and jet and ignites have such a low absorbency they can appear almost completely transparent.

The two possible jet objects from Cumwhitton were placed on a plate alongside other objects from Wroxeter (figures 2 and 3). While none of the objects were completely transparent there are clear variations in the opaqueness of the objects.

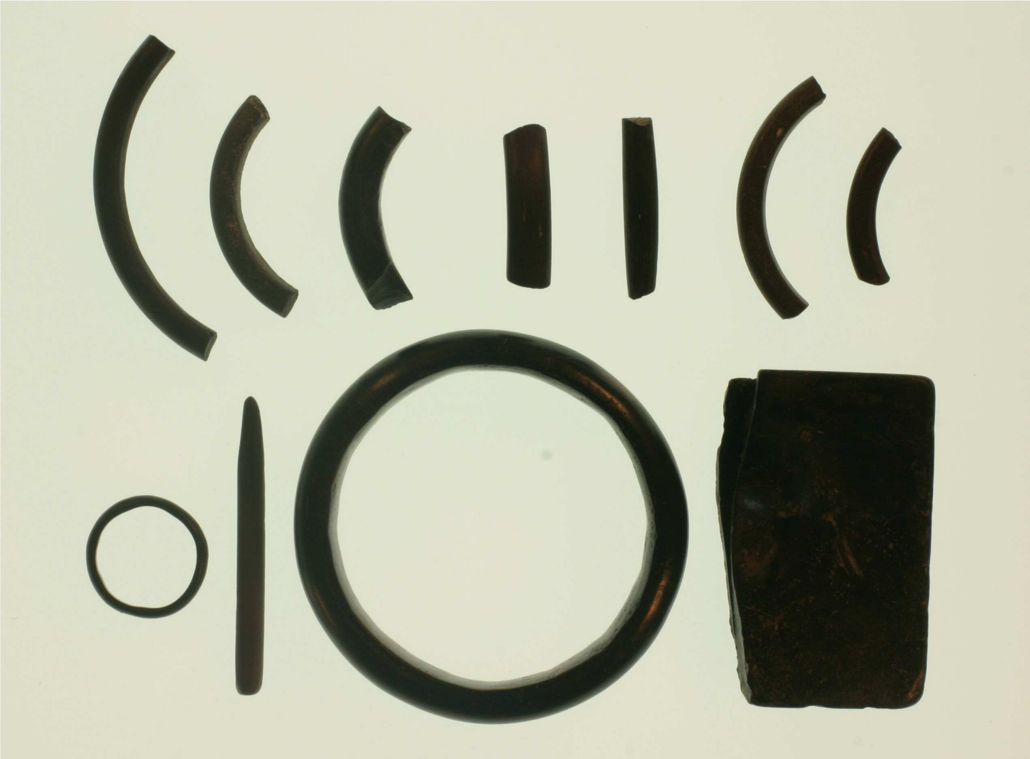

Figure 2. *The two Cumwhitten jet-like objects along side jet-like objects from the Wroxeter site.*

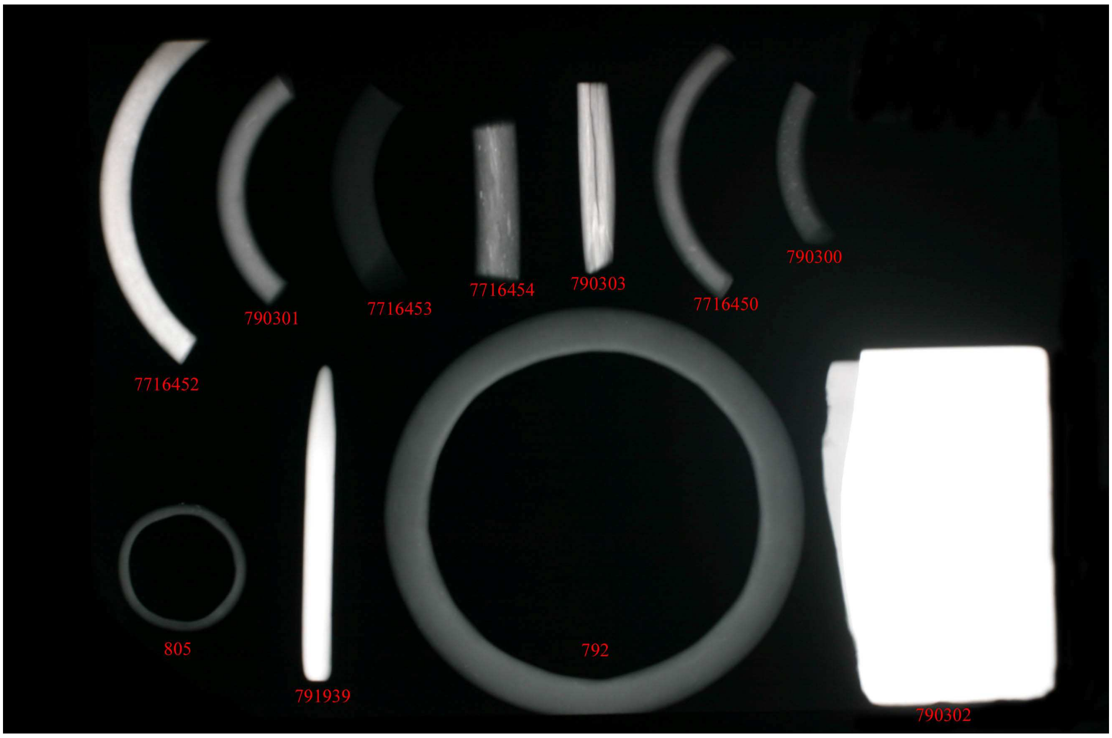

Figure 3. X-radiograph of the two Cumwhitton jet-like objects with jet-like objects from Wroxeter, small finds numbers in red

7716453 is nearly completely transparent suggesting this might in fact be jet. 790302, 7716452,791939, and 790303 represent the other end of the scale being virtually opaque. The rest, including the two Cumwhitton objects, are somewhere in between. There are further differences visible between the homogeneity of the materials, most notably with 7716454, 790303 and 790300.

When compared with these other coal-like materials the two objects from Cumwhitton do not appear to be jet. Nor are they shale. From the x-radiograph it can be concluded that these objects are composed of a homogenous material with a less organic concentration than jet, probably cannel coal or oil shale.

XRF

With the x-radiograph results in mind the next step was to see what the XRF analysis would make of these objects. Based on a review of the literature available XRF analysis is another successful way of identifying jet. Three previous studies compared the elemental concentrations of geological jet, lignite, cannel coal and shale samples (Pollard, et al 1981; Davis 1993; Hunter, et al 1993). These studies show that elemental concentrations can be used to differentiate jet from non-jet.

A list of elements indicative of different types of coals was compiled based on the studies mentioned (Table 1). Each object was then analysed using an EDAX-EAGLE II x-ray florescence spectrometer and scanned twice to compare results using a low and high current. For scan 'a' the machine was set to 40 kV and 250 mA and for scan 'b' the setting was adjusted to 46 kV and 0.3 mA. As there were no geological samples available for calibrating the machine it is not possible to calculate the exact amount of an element present in parts per million (ppm). Instead the weight percentages are given to compare the differences in relative concentrations of the elements (Table 2).

Table 1. Elemental trends of the different coal-like materials based on the studies using geological samples by Pollard, Bussel and Baird (1981) and Hunter, McDonnell. Pollard, Morris and Rowlands (1993).

element	ppm	material
Fe	< 600	Jet
	1600-1800	Lignite
	>5000	Shale and Cannel coal
K	<600	Jet and lignite
	400-1000	Cannel coal
	> 1000	Shale
Ti	> 1000	Jet
Sr	<50	Jet and cannel coal
Cr	< 40	Possible Jet
V	presence	Possible jet
Zr	presence	Possible jet
Zn	Presence	Possible jet
Pb	Presence	Possible shale
Rb	Presence	Possible shale
Al	High	Shale
Si	High	Shale
Ca /Cu	variable	Too variable for archaeological material

Table 2. XRF results for SF 792, 805 and 7716453

element	SF 792 scan a	SF 805 scan a	7716453 scan a
Fe	21.65	5.69	7.62
K	5.17	2.5	4.34
Ca	16.53	0.67	7.69
Ti	2.08	2.4	28.44
Sr	0.21	0.02	0.3
Cr	0.11	0.1	0.58
V	0.25	0.16	5.67
Zr	0.21	0.02	1.75
Zn	0.53	0.03	1.26
Cu	0.45	0.19	0.28
Pb	0.67	0.13	0.72
Rb	0.29	0.02	0.19
Mo	0.1	0	0.09
Al	25.5	35.09	34.94
Si	25.87	52.99	6.13

element	SF 792 scan b	SF 805 scan b	7716453 scan b
Fe	22.17	5.53	7.49
K	5.15	2.39	4.42
Ca	16.08	0.57	7.57
Ti	1.95	2.37	28.18
Sr	0.22	0.01	0.29
Cr	0.24	0.05	0.62
V	0.36	0.18	5.49

Zr	0.16	0.02	1.56
Zn	0.3	0.02	1.4
Cu	0.67	0.02	0.59
Pb	0.25	0.12	1.44
Rb	0.22	0.01	0.06
Mo	0	0.01	0
Al	23.85	35.2	34.2
Si	28.38	53.32	6.72

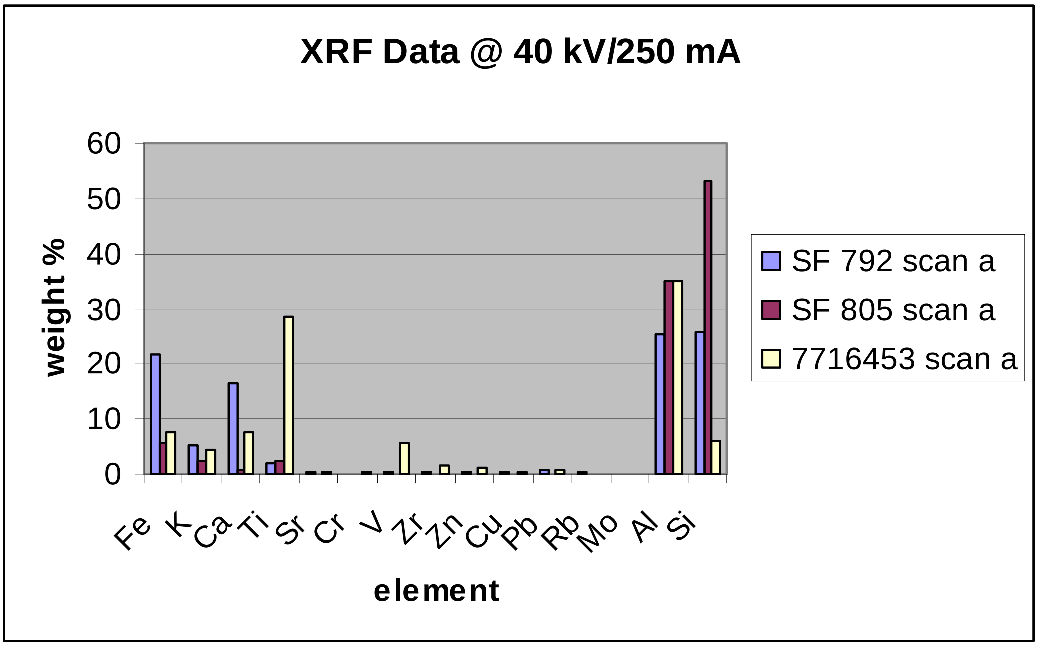

Figure 4. Graph of the XRF data collected on the three objects at 40 kV and 250 mA

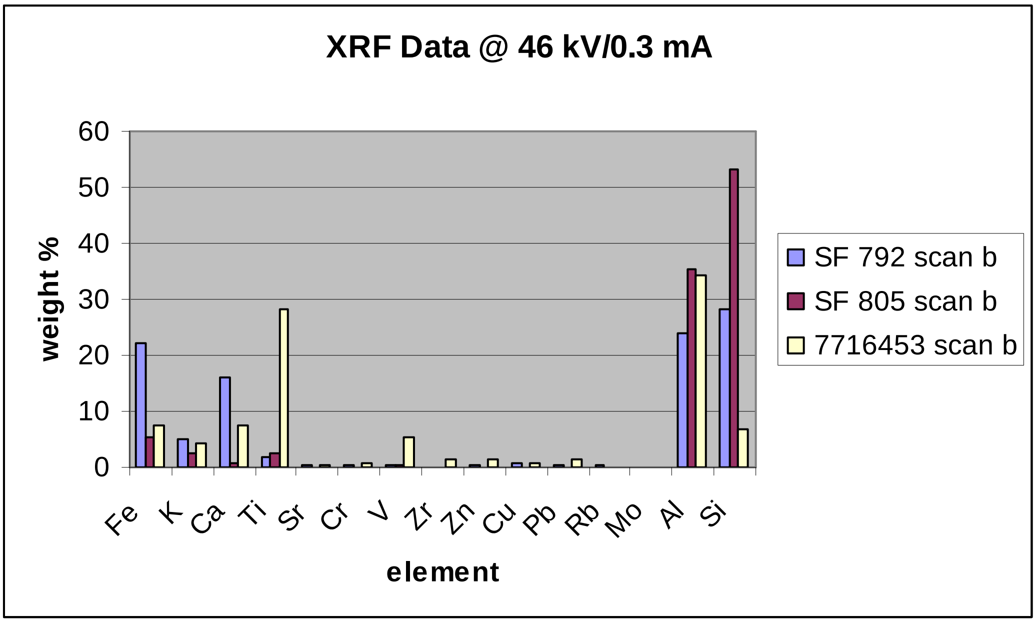

Figure 5. Graph of the XRF data collected on the three objects at 46 kV and 0.3 mA

Both SF 805 and 7716453 have comparatively low iron concentrations. However, 7716453 has much higher concentrations of titanium, vanadium, zircon, and zinc all of which suggests the material is jet and while its concentrations of aluminum are similar to those of the other two objects it has a significantly lower silica concentration.

All three objects displayed the presence of lead and rubidium but these measurements were miniscule and could have resulted from surface contamination of the objects or leaching of these elements into the material during burial.

The information gathered in this part of the investigation further supports the conclusion that SF 792 and 805 are not jet but may be a cannel coal or oil shale. It also shows that while this technique is useful in discriminating between jet and non-jet materials, at least in this situation there are too many variables to say this is an appropriate method for linking the material to its source.

FTIR

Thus far, FTIR seems to be the best technique for identifying the source of materials. Watts and Pollard have performed studies using FTIR to evaluate its reliability for differentiating between the coal types and identifying a jet object's source (Watts and Pollard, 1998). After comparing various geological jet samples from multiple sources they were able to identify unique spectral characteristics between the different coals and their sources.

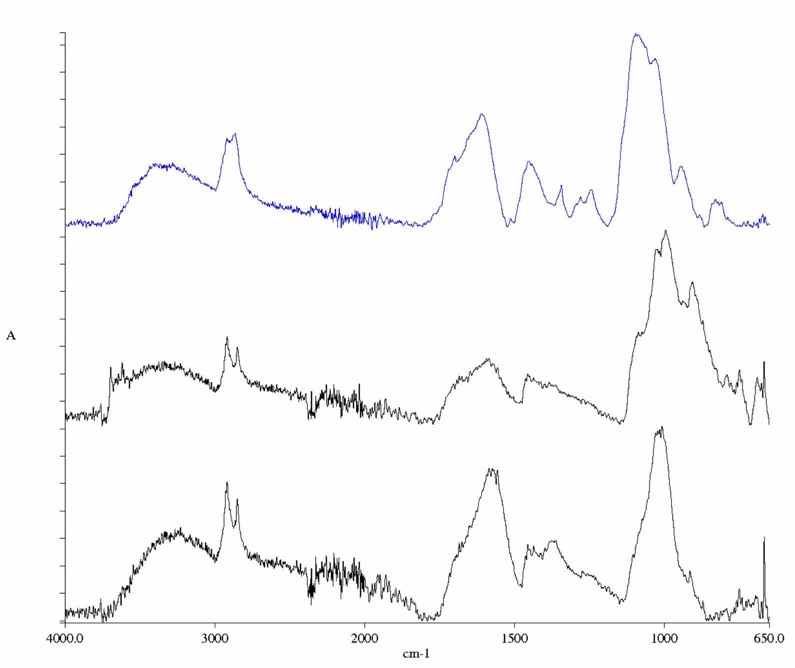

Figure 6. XRF spectra of SF 792 (bottom), SF 805 (centre), and 7716453 (top)

The spectra above (figure 6) were compared with those collected by Watts and Pollard; the best match was concluded to be oil shale. 'Oil shale' can be any sedimentary rock with a carbon concentration of more than 10% (Watts and Pollard 1998). The characteristic absorbance peaks for oil shale have been circled on the spectra for the Cumwhitton objects in figure 7 below.

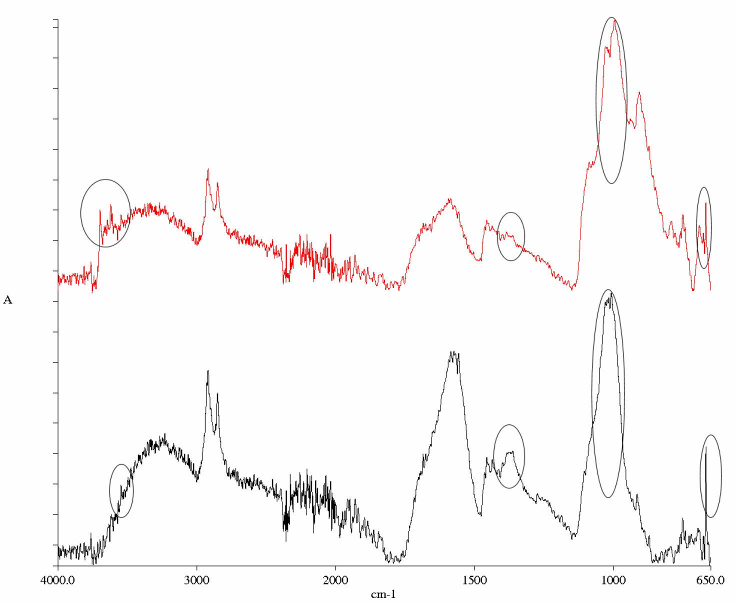

Figure 7. FTIR spectra for SF 792 (bottom and SF 805 (top) with characteristic oil shale peaks circled

Though not as apparent in the SF 792 spectra, the spectra for SF 805 clearly has a sharp O-H absorption peak near 3700 cm-1. There are also sharp silicate absorption peaks around 1400 cm-1, 1000 cm-1 and 670 cm-1.

The FTIR spectra for 7716453, not only confirms the material is jet but suggests it could be a Whitby jet because of the combination of aromatic and aliphatic absorption peaks (figure 8). The aromatic peaks include a C-H stretch around 3100 cm-1 a sharp C=C stretch at around 1600 cm-1 and C-H deformations between 900 and 700 cm-1. The aliphatic absorption peaks include a C-H deformation at around 1400 cm-1. Thus, FTIR is confirmed here to be a reliable technique for identifying the source of the material.

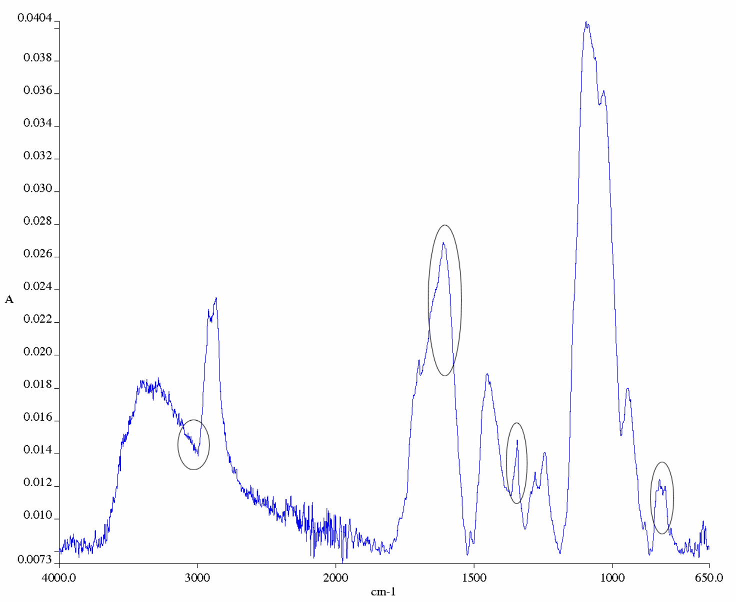

Figure 8. FTIR spectra of 7716453 with characteristic Whitby jet peaks circled

Conclusion

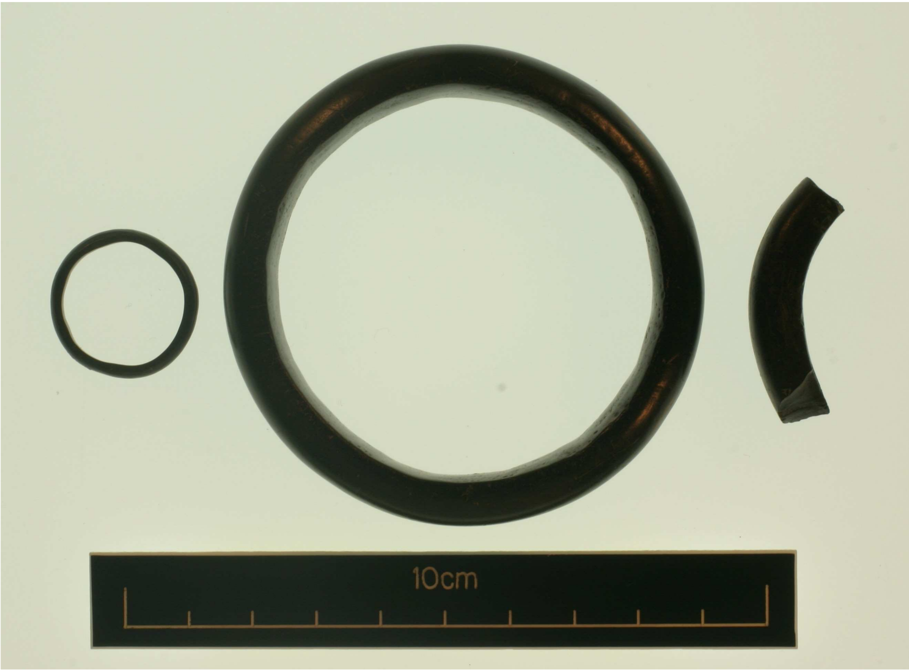

Figure 9. SF 805 (left), SF 792 (centre) and 7716453 (right)

Figure 9 shows the two Cumwhitton objects beside the confirmed jet object from Wroxeter. With the naked eye it is almost impossible to distinguish the difference between these materials but as this report demonstrates it is possible to do so using analytical techniques. However, it seems that no single technique on its own can give an absolute accurate identification when dealing with archaeological materials as they present too many variables that are not accounted for. In this instance the results from all three methods applied were considered before a confident identification could be made. More research about the deterioration of jet and other jet-like materials in the burial environment is needed before the techniques discussed can be made more reliable.

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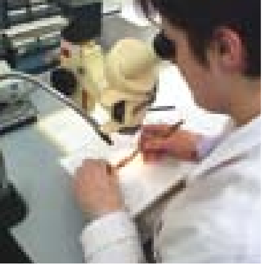
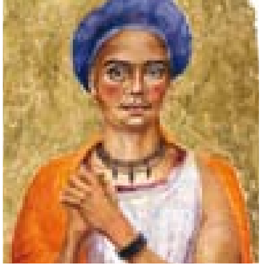



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