CHEMICAL ANALYSIS OF LATE MEDIEVAL POTTERY FROM TICKNALL

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Anne Irving selected 44 samples of Late Medieval pottery (Appendix B, Table 1), mainly from Ticknall (Peats Close, Harpur Avenue) and its environs (Hartshorne) in Derbyshire, for chemical analysis by inductively coupled plasma emission spectroscopy (ICP-ES) in the same laboratory (Earth Sciences, Royal Holloway University of London) as was the closely related pottery examined by Vince (2007; see also Vince 2010) (Appendix C, Table 2). Concentrations of 32 elements were determined (Appendix B,Table 1).

The five pottery types are: Coal Measures Whiteware, Coal Measures Purpleware and Coal Measures Orangeware; Midlands Purple and Cistercian ware.

The chemical data set was examined in two ways: with bivariate plots (one element content plotted against another) – not shown here – and by the multivariate technique of principal components analysis (PCA) giving a plot of the first principal components, PC1 and PC2. The data was normalised against the aluminium content to account for the effects of dilution by varying silica content in the fabric; Vince (2007) applied the same procedure to his ICP-ES data set.

Anne Irving posed three questions.

Question 1:

How similar or dissimilar are Vince's Midlands Purple and Cistercian ware found at Peats Close and Church Lane to the same wares analysed here found at Harpur Avenue?

This question was tackled by combining the two data sets and applying PCA. In Fig. 1 (Appendix A) a number of groups are apparent which show small, subtle distinctions in composition:

A: Midlands Purple from both studies
B: 4 Cistercian samples of Vince and 1 of this study
C1: 3 Cistercian samples of Vince and 2 of this study
C2: 2 Cistercian samples of Vince
C3: 2 Cistercian samples of Vince and 1 of this study

It looks likely that the Midlands Purple analysed in the two studies was made in the same or very similar location. There are two outliers in group A: Vince Midlands Purple 3 (TMP3V) is closer to the Cistercian samples in group B, and it differs from Vince Midlands Purple 7 (TMP7V). For Cistercian ware, however, there is a contrasting situation as this ware is distributed across Group B and Groups C1, C2 and C3. Apart from C2, all of these groups (ie B, C1 and C3) include examples from both studies. The members of B are surely different from those of C1 in several elements including Co and Ni which are origin sensitive. At present it is suggested that C1, C2 and C3 have the same general origin but the source of B is somewhat different.

Question 2:
Are the Coal Measure types from Ticknall closer chemically to the Midlands Purple and Cistercian produced in Ticknall or to sherds from one of the known Coal Measures production sites (Rawmarsh, Firsby, Chilvers Coton and Brackenfield)?

Again this question was examined by combining the relevant data sets and applying PCA with the implicit assumption of compatibility of the two data sets. Fig. 2 (Appendix A) shows that Group 1 encompasses the Rawmarsh, Firsby, Doncaster, Rotherham Barnburgh and Croydon samples but overlaps slightly with the Ticknall samples of all types which make up Group 2. Thus the simple answer is that the Coal Measure types from Ticknall are closer chemically to the Midlands Purple and Cistercian produced in Ticknall than to sherds from one of the known Coal Measures production sites. The addition of Vince's Nottingham data expands Group 1 further away from Group 2.

Question 3:
Are the Hartshorne and Ticknall samples indistinguishable?

Fig. 3 (Appendix A) shows the relationship between the samples from Ticknall, Hartshorne and Chilvers Coton. Those from Hartshorne are more uniform than those from Ticknall. The Chilvers Coton samples stand well apart. Comparing Hartshorne and Ticknall alone in Fig. 4 (Appendix A), there is again a spread of Ticknall samples along PC1 contrasting with the variation among the Hartshorne samples which occurs along PC 2; this latter component accounts for a (much) less significant proportion of overall variation in composition. In sum, the samples from the two centres are very similar, only the Harpur Avenue Whitewares and two Harpur Avenue Orangewares being slightly different having higher scores on PC1. This distinction is unlikely to have significance in terms of origin.

ACKNOWLEDGMENTS

The Ticknall Archaeological Research Group (Sue Brown, Janet Spavold and Anne Irving) and Richard Jones would like to acknowledge receipt of a generous grant from the Pilling Bequest (Derbyshire Archaeological Society), without which the following work and article would not have been possible.

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APPENDIX A

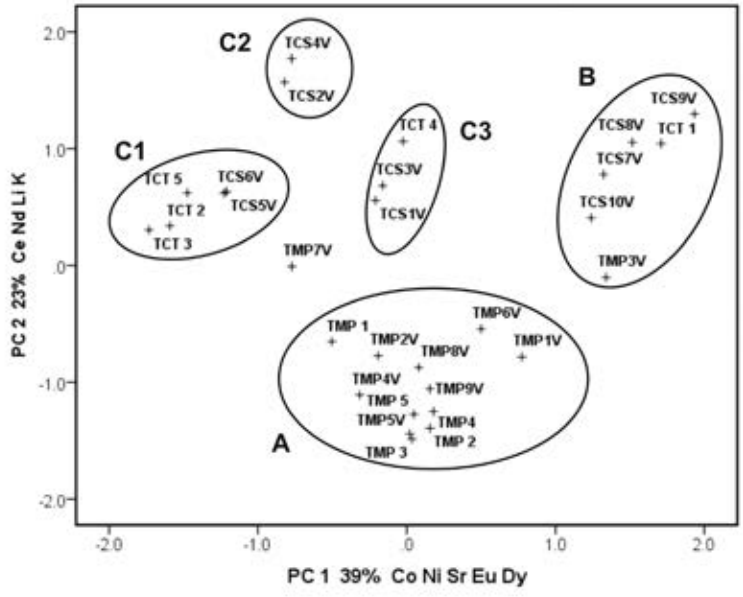

Fig. 1: PC plot of the Al-normalised compositions of Ticknall Midlands Purple (TMP) and Cistercian ware (TCT) of this study and Ticknall Midlands Purple (TMPV) and Cistercian ware (TCSV) of Vince's study.

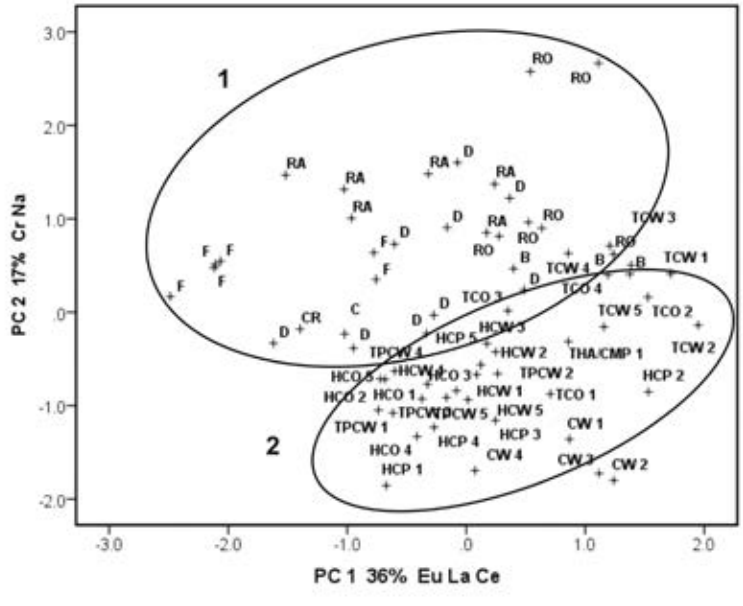

Fig. 2: PC plot of the Al-normalised compositions of Ticknall Midlands Purple (TMP), Cistercian ware (TCT), Hartsholme CM Whiteware (HCM), Hartsholme CM Purple (HCP), Harpur Avenue CM Orangeware (TCO), Chilvers Coton CM Whiteware (CW) of this study and of Vince's Coal Measures ware from Rawmarsh (RA), Firsby (F), Rotherham (RO), D (Doncaster), Barnburgh (B) and Croydon (CR).).

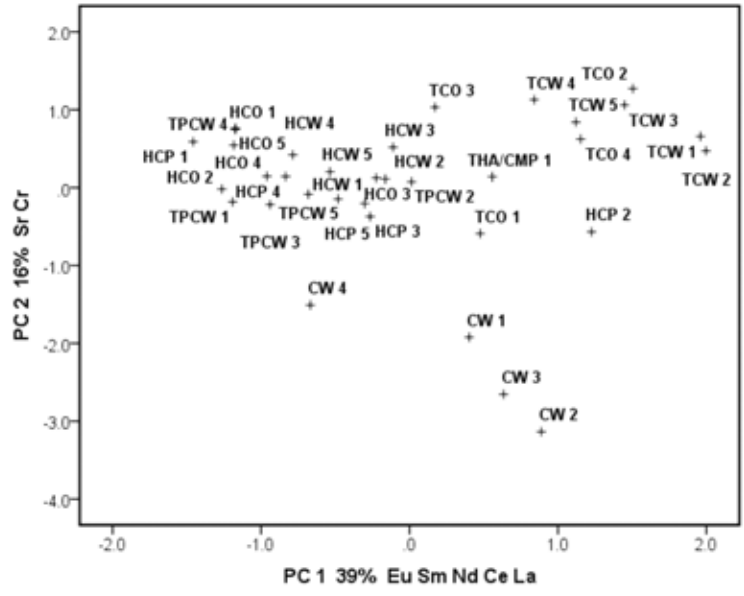

Fig. 3: PC plot of the Al-normalised compositions of samples from Hartshorne, Ticknall and Chilvers Coton (CW).

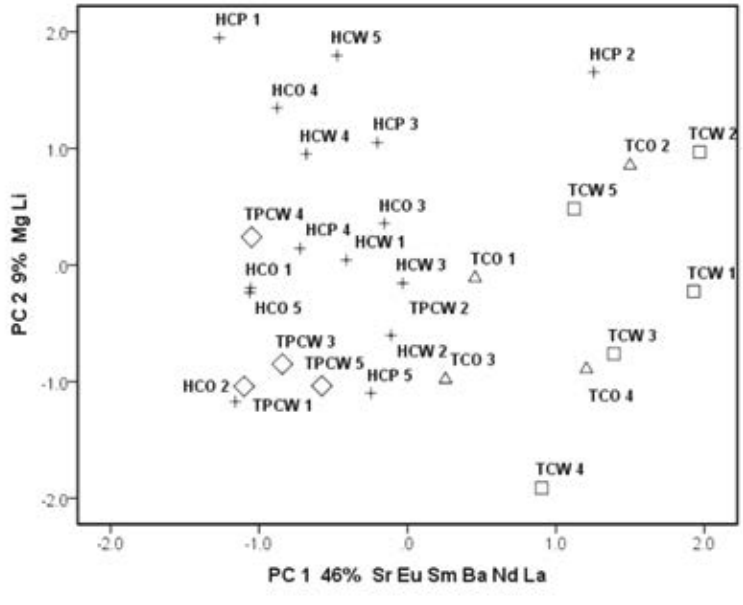

Fig. 4: PC plot of the Al-normalised compositions of samples from Hartshorne and Ticknall. Harpur Avenue Whiteware (square), Harpur Avenue Orangeware (triangle), Peats Close Whiteware (diamond). The Hartshorne samples are all indicated with +.

Sample		Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	Cu	Li	Sc	V	Y	Cr	Co	Ni	Zn
HCW 1	Hartshorne Coal measure whiteware	25.8	4.6	0.9	0.1	0.1	2.3	0.99	0.05	0.02	36.1	354.0	22.9	152.8	33.5	99.2	14.6	45.5	59.3
HCW 2		20.0	2.9	0.7	0.1	0.1	1.8	0.98	0.05	0.01	33.2	353.6	17.5	149.0	21.8	90.6	9.3	38.5	61.9
HCW 3		22.7	4.1	0.8	0.2	0.2	2.0	0.90	0.05	0.05	45.3	319.4	20.5	154.2	22.6	101.6	14.7	39.2	90.8
HCW 4		24.4	4.4	0.9	0.1	0.2	2.5	0.76	0.06	0.01	47.4	368.1	20.3	136.9	29.0	86.7	13.8	56.5	71.4
HCW 5		26.0	3.6	1.1	0.4	0.1	2.6	0.70	0.10	0.02	42.0	418.7	21.8	168.3	31.2	93.5	28.2	78.1	72.5
HCP 1	Hartshorne Coal measure purpleware	27.1	3.8	1.0	0.1	0.1	2.4	0.81	0.06	0.01	40.6	518.2	22.0	156.7	32.8	96.2	12.2	50.7	51.8
HCP 2		21.4	4.8	0.9	0.1	0.2	2.2	0.84	0.08	0.03	39.0	335.7	21.0	141.9	40.7	83.4	16.5	43.2	78.4
HCP 3		25.1	4.7	0.9	0.1	0.1	2.5	0.95	0.06	0.03	38.7	375.5	22.1	148.6	41.1	89.2	21.1	45.4	83.4
HCP 4		24.5	4.6	0.8	0.1	0.1	2.3	0.93	0.06	0.02	29.4	362.8	20.1	144.5	29.7	87.1	12.1	43.8	62.1
HCP 5		23.9	5.5	0.8	0.2	0.1	2.1	0.97	0.08	0.02	47.6	312.2	20.4	142.6	21.2	91.9	11.7	46.3	73.8
HCO 1	Hartshorne Coal measures Orangeware	25.3	4.4	0.9	0.1	0.2	2.0	0.99	0.05	0.02	33.5	371.7	20.3	122.8	30.3	104.0	15.3	57.4	78.1
HCO 2		26.0	4.3	0.8	0.2	0.1	1.9	0.91	0.06	0.03	39.0	313.6	22.3	119.7	26.7	95.7	9.9	43.2	52.1
HCO 3		24.3	5.7	0.9	0.1	0.2	2.5	0.93	0.06	0.02	38.5	318.6	19.8	131.5	31.7	82.6	14.4	47.1	64.4
HCO 4		28.2	3.9	1.0	0.2	0.2	2.4	0.75	0.05	0.01	62.2	457.3	22.0	125.6	34.3	92.4	17.6	72.6	85.5
HCO 5		24.9	5.3	0.9	0.2	0.1	2.2	0.97	0.05	0.02	44.1	281.1	18.9	108.6	29.8	95.1	15.8	50.9	82.6
TCO 1	Harpur Avenue Coal measures Orangeware	22.7	4.3	0.8	0.3	0.1	1.9	0.90	0.15	0.11	61.6	333.7	20.0	130.5	38.0	88.0	16.1	52.0	80.3
TCO 2		23.4	6.4	0.9	0.6	0.2	2.1	0.90	0.39	0.09	32.3	295.3	22.0	153.8	31.7	104.8	26.3	84.1	229.8
TCO 3		23.4	5.4	0.8	0.4	0.2	2.2	0.96	0.95	0.04	35.4	287.8	20.7	167.0	26.9	108.5	11.6	40.8	106.2
TCO 4		19.6	5.5	0.7	0.7	0.2	2.0	0.69	1.72	0.02	84.3	176.4	17.3	132.9	24.6	98.5	12.1	62.6	131.8

Table 1: Results of analysis of Ticknall samples selected for this study.

Pottery analysed by ICP-ES and ICP-MS. Al to Mn are expressed as weight % element oxide, the remainder as parts per million of element

Sample		Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	Cu	Li	Sc	V	Y	Cr	Co	Ni	Zn
CW 1	Chilvers Coton Coal measures whiteware	26.5	3.2	0.8	0.2	0.1	2.1	1.13	0.05	0.01	81.2	241.1	23.6	188.7	47.5	89.8	25.0	59.0	132.9
CW 2		26.4	3.3	0.8	0.2	0.1	2.3	0.97	0.06	0.01	69.5	168.7	24.1	192.7	47.6	80.6	16.0	49.0	106.9
CW 3		25.5	3.7	0.8	0.2	0.1	2.0	0.93	0.05	0.02	101.4	262.8	25.4	188.4	42.1	80.3	27.5	67.6	58.0
CW 4		24.5	2.3	0.7	0.2	0.1	1.7	1.09	0.04	0.01	84.8	276.0	23.9	185.3	35.3	76.2	16.2	52.3	64.8
TMP 1	Harpur Avenue Midlands Purple	23.6	5.1	0.9	0.4	0.2	2.4	0.92	0.18	0.03	57.0	299.1	21.1	143.3	26.7	95.5	17.9	65.2	173.9
TMP 2		27.4	7.0	1.0	0.2	0.2	2.6	1.32	0.06	0.04	50.4	410.6	26.2	181.7	36.4	161.1	22.8	84.0	95.3
TMP 3		29.6	4.5	1.0	0.2	0.2	2.5	1.31	0.06	0.02	45.3	500.6	27.6	183.7	49.8	127.2	18.6	64.6	69.4
TMP4		27.1	5.5	1.1	0.2	0.2	2.6	1.24	0.06	0.03	47.9	427.1	25.5	174.4	31.8	128.7	23.9	76.0	73.9
TMP 5		25.1	8.7	1.0	0.2	0.2	2.6	1.18	0.10	0.03	95.9	339.9	25.6	176.4	38.7	123.9	14.9	60.5	71.8
THA/ CMP 1	Harpur Avenue Coal measures Purpleware	25.5	6.6	1.0	0.2	0.1	2.5	1.24	0.06	0.03	44.3	394.7	24.4	171.2	34.9	118.1	19.8	65.8	97.4
TCT 1	Harpur Avenue Cistercian	17.9	6.1	0.8	0.2	0.1	2.2	1.15	0.06	0.02	31.1	218.3	19.2	127.3	44.7	102.7	20.3	66.5	55.4
TCT 2		17.0	7.0	1.3	0.1	0.2	3.9	0.72	0.08	0.03	18.5	62.1	15.1	112.5	14.6	68.0	7.6	26.0	57.6
TCT 3		16.5	6.9	1.1	0.1	0.2	3.7	0.71	0.09	0.02	13.6	68.5	13.9	110.1	12.5	65.9	6.5	25.8	52.1
TCT 4		15.8	5.5	0.8	0.2	0.1	2.9	0.91	0.08	0.03	30.9	123.0	15.1	106.7	30.0	72.6	9.3	30.7	45.3
TCT 5		16.5	7.2	1.2	0.2	0.2	3.9	0.73	0.07	0.03	26.3	64.3	14.5	110.5	14.0	66.8	8.7	23.5	50.0
TPCW 1	Peats Close Coal measures Whiteware	28.8	4.2	0.9	0.1	0.1	2.2	1.06	0.08	0.02	31.2	381.3	23.8	159.3	31.2	105.4	9.5	43.7	59.4

Table 1: Results of analysis of Ticknall samples selected for this study.

Sample		Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	Cu	Li	Sc	V	Y	Cr	Co	Ni	Zn
TPCW 2		26.3	5.6	1.0	0.2	0.1	2.2	1.03	0.11	0.03	44.1	354.3	25.4	145.9	30.0	111.1	14.2	61.5	68.5
TPCW 3		27.2	3.8	0.8	0.1	0.1	2.3	1.01	0.09	0.02	33.0	369.1	23.2	172.8	28.1	104.8	10.0	43.1	59.6
TPCW 4		21.3	2.2	0.8	0.2	0.2	1.9	1.12	0.08	0.02	15.4	374.9	18.0	112.0	20.2	74.9	6.5	24.7	53.5
TPCW 5		26.4	3.9	0.9	0.1	0.1	2.3	1.05	0.06	0.01	31.9	338.4	24.2	193.4	32.8	120.8	10.0	42.1	57.1
TCW 1	Harpur Avenue coal measures Whiteware	21.4	4.9	0.8	0.6	0.2	2.3	1.02	1.16	0.13	36.7	249.8	19.7	125.5	35.4	118.8	22.8	72.2	106.8
TCW 2		21.1	4.1	0.9	0.5	0.2	1.9	1.03	0.63	0.07	36.7	317.1	20.6	149.1	32.1	99.8	22.2	76.2	107.1
TCW 3		18.9	4.5	0.8	0.5	0.1	1.7	0.94	0.87	0.11	29.8	271.4	17.1	119.9	18.1	86.7	21.1	63.9	114.4
TCW 4		22.0	7.3	0.7	0.6	0.2	2.1	1.11	1.47	0.11	17.3	269.0	21.1	166.9	29.2	118.8	17.4	45.3	65.8
TCW 5		22.9	4.9	0.9	0.5	0.2	1.8	0.96	0.89	0.05	36.9	390.2	21.6	165.7	30.0	108.6	26.5	85.3	56.9

Sample		As	Rb	Sr	Zr *	Cd	Ba	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb
HCW 1	Hartshorne Coal measure whiteware	5.8	129.8	85.7	223.7	0.23	491.5	55.8	100.2	49.4	8.5	1.72	4.7	2.8	167.0
HCW 2		6.6	73.0	74.5	192.6	0.10	592.5	48.2	87.8	39.9	6.6	1.34	3.7	2.1	176.3
HCW 3		9.5	92.6	80.9	163.9	0.10	736.8	50.2	92.5	43.8	7.3	1.54	3.8	2.4	136.4
HCW 4		8.4	118.8	77.8	147.8	0.51	476.0	49.6	87.3	39.9	6.7	1.44	4.6	2.4	222.7
HCW 5		11.4	123.2	95.7	161.6	0.10	471.3	55.5	98.8	46.8	8.0	1.70	4.5	2.5	135.7
HCP 1	Hartshorne Coal measure purpleware-ware	11.6	122.7	86.1	206.3	0.08	760.5	49.5	85.9	37.4	6.2	1.42	4.8	3.1	210.0
HCP 2		10.0	114.0	106.3	208.3	0.10	1623.1	56.4	102.8	48.1	8.2	2.06	6.0	3.3	643.1
HCP 3		14.4	134.4	97.3	186.2	0.62	583.8	54.9	98.5	46.2	7.7	1.68	4.8	3.5	105.9

Table 1: Results of analysis of Ticknall samples selected for this study.

Sample		As	Rb	Sr	Zr	Cd	Ba	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb
HCP 4		9.4	113.2	89.3	199.0	0.13	501.7	55.3	98.7	43.5	7.0	1.49	4.3	2.6	111.8
HCP 5		13.0	91.3	93.7	156.2	0.20	600.6	56.7	108.6	52.2	8.6	1.74	4.1	2.5	194.8
HCO 1	Hartshorne Coal measures Orangeware	14.1	101.6	90.4	196.0	0.14	540.9	52.0	85.8	35.6	5.4	1.20	4.0	2.4	200.9
HCO 2		13.4	88.2	92.3	191.1	0.16	465.0	57.4	101.5	43.1	6.6	1.38	3.7	2.3	349.6
HCO 3		10.8	122.9	87.3	134.7	0.54	538.0	56.1	104.1	49.2	8.3	1.80	4.8	2.4	80.6
HCO 4		16.6	112.6	99.3	159.1	0.16	809.7	54.5	99.6	46.1	8.0	1.79	5.1	3.4	144.5
HCO 5		21.2	104.8	80.9	149.6	0.61	492.4	49.0	83.8	36.9	5.9	1.25	4.1	2.3	1879.2
TCO 1	Harpur Avenue Coal measures Orangeware	13.3	89.3	89.9	163.4	0.43	684.9	55.9	112.9	53.0	8.8	1.83	4.5	2.3	211.9
TCO 2		10.4	116.6	136.1	186.1	0.22	1711.0	55.5	99.7	50.7	8.7	2.11	5.5	2.6	97.6
TCO 3		27.8	93.3	119.2	213.1	1.43	1872.4	51.5	91.8	43.0	7.1	1.75	4.1	2.4	2843.9
TCO 4		23.8	78.7	123.8	173.3	0.70	1658.4	47.6	86.4	38.9	6.3	1.60	4.1	2.6	4439.1
CW 1	Chilvers Coton Coal measures whiteware	7.1	94.9	74.2	223.4	0.08	898.2	63.7	114.6	55.1	9.7	2.16	6.6	3.8	604.1
CW 2		3.7	100.9	54.9	216.4	0.06	438.5	74.5	138.3	70.6	12.4	2.67	7.6	4.1	1147.6
CW 3		5.1	90.8	52.6	217.0	0.06	421.4	60.4	112.4	58.5	10.8	2.42	7.1	3.8	425.2
CW 4		4.0	78.1	46.8	211.7	0.07	463.3	46.3	85.7	40.9	7.1	1.59	4.9	2.8	885.0
TMP 1	Harpur Avenue Midlands Purple	8.1	116.8	128.2	174.4	0.14	1353.9	55.4	102.8	51.7	8.8	2.05	5.4	2.7	3023.2
TMP 2		9.1	129.7	101.4	242.6	0.35	866.6	60.5	110.4	50.4	7.9	1.83	5.5	3.5	55.1
TMP 3		8.2	127.1	116.1	266.6	0.13	680.9	73.9	131.7	60.1	9.6	2.11	6.1	3.8	166.0

Table 1: Results of analysis of Ticknall samples selected for this study.

Sample		As	Rb	Sr	Zr	Cd	Ba	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb
TMP4		6.2	133.4	108.3	240.0	0.1	643.1	65.6	117.6	52.6	8.3	1.8	5.9	3.9	76.7
TMP 5		9.8	126.9	97.2	241.5	0.20	834.3	57.1	104.4	49.1	8.0	1.87	5.9	3.9	1470.0
THA/ CMP 1	Harpur Avenue Coal measures Purpleware	12.7	124.7	99.3	267.6	0.30	883.1	60.2	110.9	51.6	8.2	1.95	5.7	3.6	761.6
TCT 1	Harpur Avenue Cistercian	6.4	111.0	61.3	179.8	0.07	494.0	56.4	109.4	58.0	10.5	2.34	7.0	3.6	11372.4
TCT 2		10.7	144.1	162.2	148.7	0.08	544.2	45.4	82.0	36.5	4.9	0.93	2.3	1.8	3449.9
TCT 3		11.5	145.9	171.3	140.6	0.09	581.1	42.6	80.3	35.1	4.7	0.89	2.4	1.5	964.8
TCT 4		9.5	121.2	129.5	176.8	0.11	661.9	48.6	90.0	44.0	7.2	1.56	4.9	2.9	16435.5
TCT 5		10.7	144.8	163.3	149.1	0.09	560.3	45.8	81.9	36.4	5.1	0.92	2.3	2.2	2434.2
TPCW 1	Peats Close Coal measures Whiteware	3.6	102.0	106.2	189.0	0.09	568.5	67.2	116.4	50.0	7.6	1.55	4.2	2.9	197.0
TPCW 2		6.6	c	105.5	266.2	0.14	740.8	64.6	114.2	50.6	8.1	1.76	4.7	3.5	224.6
TPCW 3		8.0	106.8	104.8	186.9	0.16	793.5	63.2	110.0	48.0	7.4	1.60	4.9	2.7	196.5
TPCW 4		5.2	80.7	78.3	170.4	0.10	737.0	41.6	78.6	35.0	5.4	1.10	3.0	2.8	385.8
TPCW 5		13.0	111.5	98.1	206.3	0.21	700.0	61.2	106.6	47.9	7.6	1.62	4.2	2.6	172.7
TCW 1	Harpur Avenue coal measures Whiteware	11.0	102.1	143.5	202.0	0.49	1945.3	56.1	101.4	52.6	9.5	2.37	5.3	2.9	138.6
TCW 2		9.1	101.9	137.3	163.6	0.36	1676.1	57.1	103.5	53.4	9.5	2.28	5.3	2.7	185.2
TCW 3		9.7	89.8	118.1	115.6	0.64	1439.0	50.6	93.2	46.5	8.3	1.90	3.7	1.8	65.6
TCW 4		25.9	82.5	137.7	225.4	0.86	1988.5	50.5	89.5	41.0	7.0	1.79	4.1	2.9	100.1
TCW 5		19.9	82.8	125.8	188.8	0.4	1410.7	56.3	104.0	49.5	8.6	2.0	4.7	2.6	260.6

Table 1: Results of analysis of Ticknall samples selected for this study.

locality	tsno	cname	Number in Fig. 1 or 2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	Ba	Co	Cr	Cu	Li	Ni
Ticknall	V4266	MP	TMP1V	25.89	7.65	1.1	0.18	0.16	2.52	1.22	0.08	0.037	874	23	136.8	69	427	69
Ticknall	V4267	MP	TMP2V	22.62	6.9	1.13	0.22	0.17	2.92	1	0.09	0.035	1307	17	122.4	30	289	62
Ticknall	V4268	MP	TMP3V	25.71	4.74	1.05	0.18	0.17	2.55	1.15	0.06	0.025	991	22	118.8	81	463	68
Ticknall	V4269	MP	TMP4V	22.15	4.94	1.23	0.16	0.16	2.87	1.03	0.06	0.032	1239	15	108	34	262	40
Ticknall	V4280	MP	TMP5V	21.72	5.21	0.78	0.12	0.13	2.16	1.02	0.05	0.017	773	14	114	31	300	33
Ticknall	V4281	MP	TMP6V	16.95	5.21	0.68	0.11	0.11	1.8	0.92	0.04	0.016	817	15	86.4	37	245	37
Ticknall	V4282	MP	TMP7V	20.99	7.23	1.76	0.36	0.18	3.56	0.69	0.06	0.054	829	17	92.4	38	148	52
Ticknall	V4283	MP	TMP8V	19.25	5.35	0.78	0.23	0.13	2.03	0.93	0.05	0.022	934	17	92.4	40	302	48
Ticknall	V4284	MP	TMP9V	22.03	7.44	0.86	0.15	0.14	2.13	1.03	0.06	0.033	1415	19	112.8	48	301	56
Ticknall	V4270	CSTN	TMC-SV1	16.58	7.14	0.98	0.21	0.16	2.91	0.86	0.06	0.029	715	14	86.4	23	132	35
Ticknall	V4271	CSTN	TMC-SV2	16.95	7.12	1.23	0.23	0.2	3.76	0.76	0.09	0.069	676	13	76.8	18	65	37
Ticknall	V4272	CSTN	TMC-SV3	14.59	6.36	0.73	0.2	0.14	2.22	0.76	0.07	0.016	530	11	81.6	17	87	30
Ticknall	V4273	CSTN	TMC-SV4	15.66	6.41	1.22	0.19	0.32	3.48	0.72	0.08	0.051	598	11	78	20	77	33
Ticknall	V4274	CSTN	TMC-SV5	16.67	7.11	1.19	0.15	0.2	3.74	0.79	0.06	0.031	557	10	75.6	20	71	25
Ticknall	V4275	CSTN	TMC-SV6	15.32	6.54	1.09	0.13	0.19	3.45	0.69	0.06	0.03	532	11	70.8	25	65	26
Ticknall	V4276	CSTN	TMC-SV7	19.55	5.22	0.94	0.22	0.13	2.44	1.2	0.04	0.027	490	23	105.6	19	249	74
Ticknall	V4277	CSTN	TMC-SV8	17.38	7.74	0.72	0.15	0.11	1.92	1.13	0.05	0.012	600	17	97.2	26	159	51
Ticknall	V4278	CSTN	TMC-SV9	19.32	5.34	0.92	0.19	0.14	2.31	1.23	0.04	0.024	639	24	106.8	23	257	73
Ticknall	V4279	CSTN	TMC-SV10	19.75	4.6	0.96	0.21	0.15	2.45	1.19	0.05	0.023	461	24	106.8	20	245	82

Table 2: Alan Vince's ICP-MS data used in this study.

Al to Mn are expressed as weight % element oxide, the remainder as parts per million of element

locality	tsno	cname	Number in Fig. 1 or 2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	Ba	Co	Cr	Cu	Li	Ni
Firsby	AG282	CMW	F	21.39	3.69	0.56	0.21	0.16	1.53	0.93	0.09	0.12	348	8	122	37	111	50
Firsby	AG283	CMW	F	23.26	3.04	0.59	0.27	0.19	1.48	1	0.08	0.03	447	6	131	29	193	53
Firsby	AG284	CMW	F	24.36	3.41	0.73	0.19	0.24	2.28	1.06	0.09	0.05	506	8	134	64	267	62
Firsby	AG285	CMW	F	24.17	3.32	0.57	0.15	0.17	1.46	0.94	0.08	0.04	322	4	129	23	126	40
Firsby	AG286	CMW	F	23.8	5.09	0.67	0.17	0.23	1.82	0.98	0.1	0.08	488	12	123	41	258	70
Firsby	AG287	CMW	F	24.41	4.64	0.61	0.22	0.22	1.53	0.97	0.11	0.04	373	6	135	32	186	58
Rawmarsh	AG294	CMW	RA	22.67	5.53	0.95	0.31	0.26	2.62	0.88	0.11	0.03	485	6	118	39	367	39
Rawmarsh	AG295	CMW	RA	20.98	4.06	0.81	0.17	0.23	2.16	0.91	0.1	0.04	458	8	112	40	227	54
Rawmarsh	AG296	CMW	RA	25.82	4.67	0.97	0.16	0.26	3.08	0.9	0.11	0.02	546	5	129	38	424	40
Rawmarsh	AG297	CMW	RA	20.09	5.44	0.78	0.19	0.21	2.19	0.76	0.11	0.04	429	7	111	37	185	44
Rawmarsh	AG298	CMW	RA	21.73	5.28	0.89	0.13	0.22	2.65	0.91	0.13	0.03	455	6	126	37	141	38
Rawmarsh	AG299	CMW	RA	24.89	3.54	0.94	0.16	0.26	3.16	0.93	0.11	0.02	570	5	126	45	381	38
Doncaster	CMF01	CMW	D	23.01	4.1	0.58	0.15	0.21	1.83	0.99	0.07	0.06	450	36	123	35	224	56
Conis-brough	CMF02	CMW	D	25.22	3.3	0.61	0.1	0.15	1.62	1.06	0.06	0.02	346	13	146	33	139	52
Barnburgh	BNB001	CMW	B	22.85	3.98	0.86	0.39	0.26	2.44	1.05	0.12	0.04	770	16	112	95	256	62
Barnburgh	BNB002	CMW	B	21.65	4.46	0.76	0.34	0.24	2.46	0.93	0.11	0.05	755	19	122	71	241	51
Rotherham	CAN001	CMW	RO	24.78	3.9	0.84	0.12	0.25	2.32	0.94	0.12	0.04	468	15	130	48	403	64
Rotherham	RAW001	CMW	RO	25.91	3.4	1.2	0.19	0.26	2.86	0.96	0.1	0.04	554	19	135	79	429	80
Rotherham	RAW002	CMW	RO	20.56	4.99	0.77	0.16	0.22	2.5	0.87	0.08	0.04	431	18	119	39	237	42
Rotherham	RAW003	CMW	RO	20.44	5.42	1.38	0.17	0.22	3.47	0.93	0.11	0.05	472	18	137	29	82	59
Rotherham	RAW004	CMW	RO	21.7	5.14	1.46	0.16	0.23	3.63	0.94	0.11	0.03	462	20	133	33	93	59

Table 2: Alan Vince's ICP-MS data used in this study.

locality	tsno	cname	Number in Fig. 1 or 2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	Ba	Co	Cr	Cu	Li	Ni
Rotherham	RAW005	CMW	RO	24.55	3.32	1.12	0.27	0.28	2.75	1	0.16	0.03	516	14	130	55	278	70
Rotherham	RAW006	CMW	RO	23.1	3.82	0.91	0.14	0.27	2.56	0.96	0.11	0.06	466	21	123	50	347	72
Croydon	V2219	CMW?	CR	23.74	5.25	0.74	0.31	0.18	2.22	0.91	0.15	0.025	344	13	115	70	146	34
Doncaster	V4207	CMW	D	23.14	4.28	0.85	0.26	0.28	2.42	1.05	0.15	0.043	533	15	104	38	235	48
Doncaster	V4208	CMW	D	23.15	3.49	0.85	0.24	0.27	2.52	1.01	0.15	0.024	511	14	93	41	182	46
Doncaster	V4209	CMW	D	25.35	3.38	0.63	0.09	0.24	2.19	1.02	0.07	0.024	401	15	97	28	181	40
Doncaster	V4210	CMW	D	23.33	2.5	0.89	0.25	0.28	2.63	1.02	0.1	0.03	602	15	84	34	186	45
Doncaster	V4211	CMW	D	24.11	2.98	0.59	0.1	0.22	2.25	1.13	0.07	0.027	416	16	98	27	117	36
Doncaster	V4197	CMW	D	24.64	4.63	0.72	0.24	0.24	2.06	0.99	0.08	0.054	540	28	90	44	281	66
Doncaster	V4199	CMW	D	23.87	3.67	0.65	0.18	0.21	1.93	1.04	0.12	0.035	479	16	84	32	283	52
Doncaster	V4203	CMW	D	23.97	2.46	0.57	0.18	0.2	1.61	1.09	0.06	0.019	362	15	89	23	228	40
Doncaster	V4204	CMW	D	21.96	4.44	1.03	0.2	0.29	3	0.97	0.14	0.032	552	15	90	38	143	44
Doncaster	V4856	CMW	D	24.3	4.44	0.6	0.15	0.21	1.7	0.91	0.15	0.044	389	12	100	24	172	35
Doncaster	V4855	CMW	D	20.95	3.95	0.75	0.17	0.27	2.45	0.9	0.07	0.025	464	11	81	41	288	36
Doncaster	V4865	CMW	D	18.95	6.16	0.74	0.17	0.29	2.61	0.87	0.06	0.033	423	11	97	29	119	23
Nottingham	AG208	NOTG		21.58	5.91	1.72	0.42	0.26	4.23	0.87	0.15	0.04	559	14	99	15	122	70
Nottingham	AG209	NOTG		20.36	4.56	1.54	0.43	0.23	3.91	0.9	0.14	0.03	550	12	96	15	111	63
Nottingham	AG210	NOTG		21.44	4.69	1.63	0.26	0.26	4.04	0.93	0.12	0.03	531	12	105	18	131	73
Nottingham	AG211	NOTG		20.98	4.78	1.65	0.5	0.27	4.11	0.86	0.14	0.03	545	12	116	31	127	67
Nottingham	AG212	NOTG		20.26	7	1.7	0.61	0.25	3.81	0.88	0.16	0.06	594	17	96	28	103	73
Nottingham	AG275	NOTG		22.63	3.15	1.29	0.53	0.26	4.36	0.77	0.21	0.02	661	8	116	631	140	46
Nottingham	AG276	NOTG		23.17	2.78	1.35	0.29	0.26	4.44	0.8	0.11	0.02	642	9	116	20	192	44

Table 2: Alan Vince's ICP-MS data used in this study.

locality	tsno	cname	Number in Fig. 1 or 2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	Ba	Co	Cr	Cu	Li	Ni
Nottingham	AG277	NOTG		23.21	2.66	1.39	0.39	0.28	4.42	0.79	0.14	0.02	637	9	118	23	174	47
Nottingham	AG278	NOTG		21.82	2.53	1.29	0.32	0.26	4.18	0.76	0.11	0.02	628	8	110	21	168	47
Nottingham	AG279	NOTG		20.25	2.58	1.14	0.25	0.25	4.09	0.7	0.13	0.03	581	9	101	23	141	42
Nottingham	AG280	NOTG		21.22	2.83	1.16	0.22	0.24	4.15	0.76	0.1	0.02	603	8	105	29	150	41
Nottingham	AG281	NOTG		22.74	2.62	1.39	0.23	0.28	4.37	0.84	0.11	0.02	614	10	114	115	169	45

Table 2: Alan Vince's ICP-MS data used in this study.

locality	tsno	cname	Number in Fig. 1 or 2	Sc	Sr	V	Y	Zr	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb
Ticknall	V4266	MP	TMP1V	28	95	177	48	214	62	115	65	10.0	2.1	6.8	4.5	277
Ticknall	V4267	MP	TMP2V	23	144	169	30	116	51	88	52	6.7	1.4	3.9	3.3	132
Ticknall	V4268	MP	TMP3V	26	102	160	56	129	77	144	80	14.5	3.0	8.5	4.6	121
Ticknall	V4269	MP	TMP4V	22	101	144	29	93	49	75	50	7.2	1.5	3.8	2.9	119
Ticknall	V4280	MP	TMP5V	22	88	160	26	99	50	74	51	6.3	1.4	4	3	1301
Ticknall	V4281	MP	TMP6V	16	72	108	24	81	45	79	46	7.2	1.5	3.8	2.4	232
Ticknall	V4282	MP	TMP7V	20	106	134	26	68	46	85	47	7.3	1.7	3.8	2.7	81
Ticknall	V4283	MP	TMP8V	18	85	129	22	77	48	76	48	7.2	1.5	3.4	2.3	381
Ticknall	V4284	MP	TMP9V	22	86	153	31	96	53	88	54	7.0	1.6	4	3	308
Ticknall	V4270	CSTN	TMC-SV1	17	125	113	24	166	46	78	46	7.1	1.2	3.1	2.1	158
Ticknall	V4271	CSTN	TMC-SV2	15	176	111	24	86	46	77	47	8.4	1.6	4	2.7	251
Ticknall	V4272	CSTN	TMC-SV3	14	94	94	16	54	42	68	42	7.1	1.4	2.3	1.7	459
Ticknall	V4273	CSTN	TMC-SV4	16	163	108	21	74	46	81	46	7.2	1.3	3	2.4	470
Ticknall	V4274	CSTN	TMC-SV5	14	171	108	19	86	44	73	43	5.4	1.0	2.2	2.4	8246
Ticknall	V4275	CSTN	TMC-SV6	13	162	100	16	81	41	73	40	4.6	0.9	1.7	2	4137
Ticknall	V4276	CSTN	TMC-SV7	19	71	127	31	81	59	110	60	12.3	2.4	5	2.8	4236
Ticknall	V4277	CSTN	TMC-SV8	18	63	117	35	85	56	99	58	10.3	2.2	5.6	3.1	732

Table 2: Alan Vince's ICP-MS data used in this study.

locality	tsno	cname	Number in Fig. 1 or 2	Sc	Sr	V	Y	Zr	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb
Ticknall	V4278	CSTN	TMC-SV9	19	71	127	41	97	62	126	65	12.9	2.8	6.9	3.5	987
Ticknall	V4279	CSTN	TMC-SV10	20	66	128	29	94	56	97	58	11.1	2.2	5.2	2.9	13534
Firsby	AG282	CMW	F	16	58	109	11	50	26	51	19	3.9	0.5	1.1	0.9	
Firsby	AG283	CMW	F	18	71	127	10	53	28	54	22	4.4	0.6	1	0.9	
Firsby	AG284	CMW	F	22	106	160	22	92	38	74	31	6.2	1	2.7	2	
Firsby	AG285	CMW	F	17	66	121	10	38	32	58	21	4.1	0.6	0.8	0.8	
Firsby	AG286	CMW	F	21	108	143	25	60	42	77	29	5.7	1	2.9	2.1	
Firsby	AG287	CMW	F	18	70	139	12	47	33	62	22	4.3	0.6	1.1	0.9	
Rawmarsh	AG294	CMW	RA	18	113	133	10	70	33	61	21	4.6	0.7	0.9	0.8	
Rawmarsh	AG295	CMW	RA	20	109	155	26	72	44	86	37	7.2	1.1	3.3	2.1	
Rawmarsh	AG296	CMW	RA	23	164	169	18	58	45	88	35	6.9	1.1	1.9	1.3	
Rawmarsh	AG297	CMW	RA	18	116	149	14	63	41	82	32	6.9	1.1	2	1.1	
Rawmarsh	AG298	CMW	RA	20	185	148	30	72	44	89	37	8.1	1.3	4.1	2.4	
Rawmarsh	AG299	CMW	RA	21	200	168	15	54	40	77	33	6.6	1	1.8	1.4	
Doncaster	CMF01	CMW	D	19	88	129	22	57	39	73	41	12.2	1.2	4.3	2.4	
Conis-brough	CMF02	CMW	D	21	65	140	19	40	44	74	45	13.4	1.0	3.6	2.2	
Barnburgh	BNB001	CMW	B	22	126	168	28	73	56	102	58	17.3	1.8	5.5	3.1	
Barnburgh	BNB002	CMW	B	21	124	170	25	64	51	96	53	15.8	1.5	4.9	2.8	

Table 2: Alan Vince's ICP-MS data used in this study.

locality	tsno	cname	Number in Fig. 1 or 2	Sc	Sr	V	Y	Zr	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb
Rotherham	CAN001	CMW	RO	23	150	196	23	67	57	108	58	6.9	2.0	4.6	2.1	
Rotherham	RAW001	CMW	RO	27	193	196	32	93	64	116	66	8.6	2.4	5.7	2.8	
Rotherham	RAW002	CMW	RO	19	111	145	23	75	46	85	47	3.5	1.7	4.3	2.2	
Rotherham	RAW003	CMW	RO	19	124	138	18	110	52	98	52	6.6	1.6	3.5	1.9	
Rotherham	RAW004	CMW	RO	19	140	138	16	106	51	92	51	4.8	1.6	3.2	1.4	
Rotherham	RAW005	CMW	RO	23	120	177	28	80	51	91	52	6.6	1.6	4.5	2.4	
Rotherham	RAW006	CMW	RO	22	122	169	22	105	54	99	54	6.1	1.8	3.8	2.1	
Croydon	V2219	CMW?	CR	17	56	99	21	67	29	62	30	4.9	1.2	3.3	2.1	
Doncaster	V4207	CMW	D	20	128	181	16	59	46	76	46	8.5	1.7	2.7	1.8	
Doncaster	V4208	CMW	D	21	126	150	25	70	46	81	47	8.9	1.6	3.5	2.4	
Doncaster	V4209	CMW	D	22	98	146	18	46	43	68	43	5.7	1.2	2.4	2	
Doncaster	V4210	CMW	D	19	130	146	18	64	43	74	43	7.7	1.4	2.4	1.7	
Doncaster	V4211	CMW	D	21	104	139	14	44	42	66	42	6.3	1.1	2.3	1.6	
Doncaster	V4197	CMW	D	23	105	143	23	58	45	73	45	7.2	1.3	3.3	2.1	
Doncaster	V4199	CMW	D	20	79	135	20	51	40	64	40	6.3	1.2	2.7	1.9	
Doncaster	V4203	CMW	D	20	67	136	20	34	37	59	37	6.3	1.0	2.4	2	
Doncaster	V4204	CMW	D	21	131	141	21	83	45	82	45	8.6	1.7	3	2.2	
Doncaster	V4856	CMW	D	19	68	132	15	38	39	68	39	5.2	0.6	2.2	1.7	
Doncaster	V4855	CMW	D	19	117	149	27	54	46	86	47	8.7	1.6	3.8	2.7	
Doncaster	V4865	CMW	D	17	94	124	17	49	38	70	38	6.9	1.1304	2.2	1.9	
Nottingham	AG208	NOTG		22	145	143	22	92	51	96	38	7.2	1.1	2.7	1.7	

Table 2: Alan Vince's ICP-MS data used in this study.

locality	tsno	cname	Number in Fig. 1 or 2	Sc	Sr	V	Y	Zr	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb
Nottingham	AG209	NOTG		21	132	141	23	87	50	96	39	7.2	1.2	2.8	1.8	
Nottingham	AG210	NOTG		20	135	157	22	95	49	97	38	7.3	1.2	2.7	1.8	
Nottingham	AG211	NOTG		20	143	154	16	134	51	96	38	6.9	1.1	2.1	1.2	
Nottingham	AG212	NOTG		21	137	140	20	113	49	95	37	7.8	1.3	2.9	1.3	
Nottingham	AG275	NOTG		22	256	155	16	92	48	88	37	5.9	1	1.9	1.4	
Nottingham	AG276	NOTG		22	250	153	13	59	49	94	41	6.4	0.9	1.6	1.1	
Nottingham	AG277	NOTG		22	236	156	13	62	49	92	39	6.4	0.9	1.5	1.2	
Nottingham	AG278	NOTG		21	216	142	18	60	47	90	38	6.3	0.9	2.1	1.5	
Nottingham	AG279	NOTG		19	217	137	14	91	42	81	35	6	0.8	1.8	1.3	
Nottingham	AG280	NOTG		19	235	135	14	86	45	87	38	6.3	0.9	1.6	1.2	
Nottingham	AG281	NOTG		21	248	143	18	79	47	91	40	6.3	0.9	2	1.6	

Table 2: Alan Vince's ICP-MS data used in this study.