Ancient Monuments Laboratory
Report 3635
QUALITATIVE ANALYSIS OF
SOME SAXON GLASS BEADS FROM
DOVER, KENT

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Pottery & Glass LKC

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Three series of beads were kindly made available for analysis by Mrs L Webster of the Mediaeval and Later Antiquities department of the British Museum. The beads are listed and described in Appendix I where the numbers used in this report are correlated with the excavation numbers. All were examined under a low power microscope and analysed by energy dispersive x-ray fluorescence. For some of the polychrome beads more than one area was analysed in an attempt to separate the different colours. This separation was not complete as the area being analysed was often as large as the bead itself but the variations detected were recorded (see Appendix III).

This report should be read in conjunction with the attached "Notes on the composition of coloured glasses"* which summarise the necessary background information on the production of colour and opacity in glass and the chronological variations that may be inferred from variations in composition.

Technical notes on the analyses

The beads were analysed by x-ray fluorescence using an energy dispersive system. The primary radiation source was an x-ray tube with a rhodium target run at 35 kv; the sample chamber was evacuated to allow detection of elements below atomic number 19 and the fluorescent x-rays were detected by a Si(Li) detector run for a live time of 20 seconds with a photon flux of about 5-10 Kcps.

* see AM Report 3469

Sodium, magnesium and aluminium were effectively not detectable though the first of these elements was almost certainly present in most if not all of the beads and the other two were probably also present in minor amounts. Other elements detected but not appearing in the tables in Appendices II and III include potassium, calcium, strontium and silicon. As the beads were not prepared in any way for analysis it was thought that the potassium levels were not likely to be significant. The figures obtained show small but relatively constant amounts detected so the figures would not have been diagnostic even if they had been meaningful. The calcium figures could not be used as many of the beads had varying amounts of chalk stuck in surface irregularities or in the perforation, ie not all the calcium detected was in the glass.

As the beads were of very variable size, shape and surface texture the absolute peak heights recorded could not usefully be directly compared. To allow approximate comparisons to be made, the readings were normalised by dividing each by the corresponding silicon reading. As a first approximation the proportion of silicon in each bead is constant so this is the most sensible element of those available to use in this way. The only cases where this approximation is less good is where the glass contains major amounts of lead. The colours particularly affected by this are greens and opaque yellows, where the lead figures are enhanced by the way the data has been treated; it does not however materially affect the interpretation given.

The individual peak heights bear no direct relationship to the proportion of that element present as different elements are more or less efficiently excited by the primary x-rays. Eg tin is far less efficiently excited than copper so the figures given in Appendix II and III are consistently lower even when the amounts involved are similar. A fixed proportion of one element will also give varying strength signals depending on the composition of the matrix in which it is present.

The figures given in Appendices II and III should be treated as approximate values as they result from a single measurement of one part of the object only. For this reason fine divisions have been avoided as they would be meaningless; however, broad divisions into groups can be made where the dividing lines used are present/absence or none/some/lots.

The elements recorded in the appendices are titanium (Ti), manganese (Mn), iron (Fe), cobalt (Co), copper (Cu), zinc (Zn), lead (Pb), arsenic (As), tin (Sn) and antimony (Sb). The peak measured was the K_α peak except for lead where the L_α peak was used. Peak heights (normalised to silicon) are given for all elements except cobalt. This is recorded only as detectable/not detectable as the peak overlaps with the iron K_β peak (which is universally present) and is itself very small as the quantities of cobalt necessary to produce a deep colour are minute (see attached "Notes ......"). Most of the elements recorded have an effect on the colour or opacity of the glass (see "Notes ......" for details the exceptions are titanium, which is found in small amounts in much glass, and zinc. It has been suggested that the variations in the amount of titanium present may indicate different sources of silica, one of the glass making raw materials, as titania is found as an impurity in sand (silica) (Spitzer-Aronson, 1979). The zinc appears to have entered these glasses with the copper (see discussion below).

Discussion of Results

The results tabulated in Appendices II and III are given for completeness but a clearer presentation is that of the Figures 1-6, below. The analytical data is considered in isolation as the only archaeological information available was that the beads all came from one pagan Saxon cemetery. Consideration of the analyses in conjunction with archaeological and/or typological data may broaden the conclusions that can be drawn.

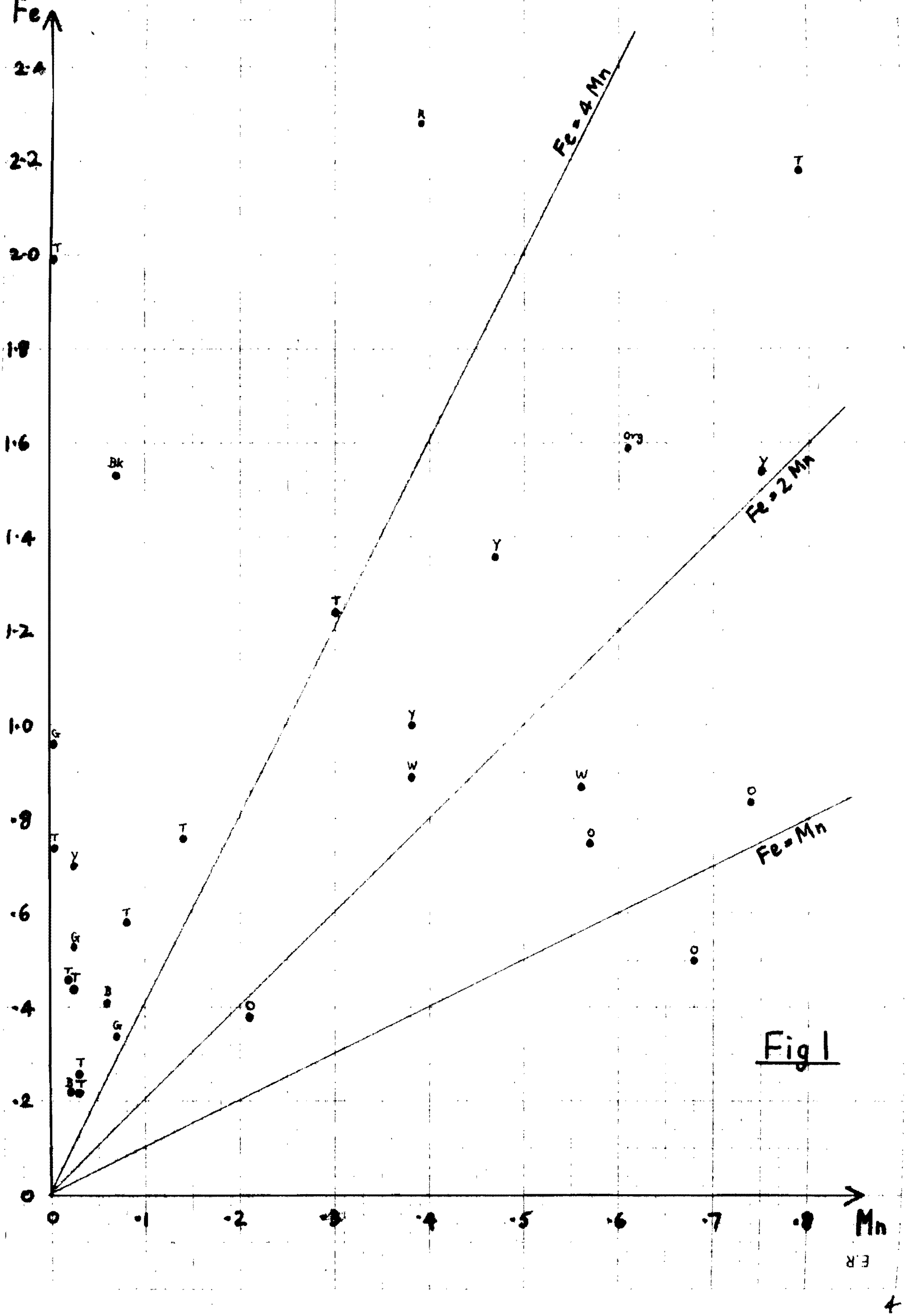


Fig 1

4

The results are considered in two groups; first the monochrome beads where the analytical data relates to a single colour of glass and then the polychrome beads. With these the analyses were not usually of a small enough area to isolate the various colours so the results given in Appendix III are an average for the two or more colours present. This makes the interpretation of the data more complex and the conclusions reached necessarily more tentative.

A. The monochrome beads

A total of 27 beads and one vessel sherd were analysed. These can be divided into 9 colours, some of which are found as both translucent and opaque glass.

Table 1: The monochrome beads

Colour (symbol used in figures)	Opaque	Translucent	Total
Red (R)	1		1
Orange (Org)	1		1
Yellow (Y)	3	1	4
Green (G)	2	1	3
Blue/green and turquoise (T)	3	6	9
Blue (B)		2	2
White (W)	2		2
Black (Bk)		1	1
"Colourless" (O)		4	4

The beads described as blue/green and turquoise were of a range of colours. There is no hard and fast division between these and the green beads, a point which shows up in the Figures. There is also no rigid distinction between opaque and translucent colours as the transparency depends on the thickness of the object, the depth of colour and the presence of opaque inclusions. Many beads which appear opaque in the hand are seen to be translucent with opaque inclusions when examined at low magnifications; this is true of most of the opaque blue and green beads and also, to a lesser extent, the whites and yellows.

With the exception of the vessel sherd (M24), which is of a unique composition and is discussed below, the following general points can be made about the analyses:-

1. Antimony was not detected in any of the beads.

2. Decolourisation was due to the presence of manganese.

3. Opacity was due to copper compounds (red and orange) or tin compounds (other colours).

The lack of antimony is to be expected in a post-Roman context. It does however suggest that none of the beads are re-used Roman ones and that they are not made of reused Roman glass.

This however can really only be taken to apply to the beads where antimony might reasonably be expected ie the opaque whites, yellows, blues and greens and the transparent "colourless" beads. It also assumes an absolute correspondence of antimony with Roman and earlier and lack of antimony with post-Roman glass. While this assumption is generally sound exceptions do exist. Further analyses may clarify the situation.

All the glass contained detectable amounts of iron. Where the colour this imparted to the glass was not going to be masked by another colourant, its effect was meutralised by adding manganese. This is particularly noticeable (see Fig 1) for the "colourless" and white glass (Manganese values greater than half the iron values: $Mn > \frac{1}{2} Fe$) when compared with eg the greens and turquoises (Iron values greater than four times the manganese values: $Fe > 4\ Mn$). The frequency distribution of manganese values (see Fig 2a) suggests that the low values (up to about 0.1 or 0.2) are accidental inclusions, naturally occuring in the glass-making raw materials, while the higher values most probably represent deliberate additions made to the glass.

The presence of tin as an opacifying agent, like the absence of antimony discussed above, is to be expected in post-Roman glass (see "Notes on the composition of coloured glasses"). The presence of small amounts of tin does not usually impart opacity (see Fig 2b) though higher levels may be detected in translucent glass (eg. 3/13). The opacity of the objects marked * in Fig 2b is not due to tin; the two without detectable tin are copper opacified (see below) and the one with very low tin was the vessel sherd which was antimony opacified. It is worth noting that the two low tin opaque beads are both greens and both contain far more lead than the other green bead. Without a larger sample though no firm conclusion can be drawn.

Figure 3 is a plot of tin v. copper values. It shows three distinct groups of points. First, the opaque whites and yellows which have high tin values and zero or virtually zero copper values. This is to be expected as the colour and opacity are due to the presence of lead-tin oxide (yellow) or tin oxide (white). The second group is the greens or blue-greens. Here there seems to be some correlation between the tin and copper suggesting that the tin may have entered the glass along with the copper if the latter was added as an alloy rather

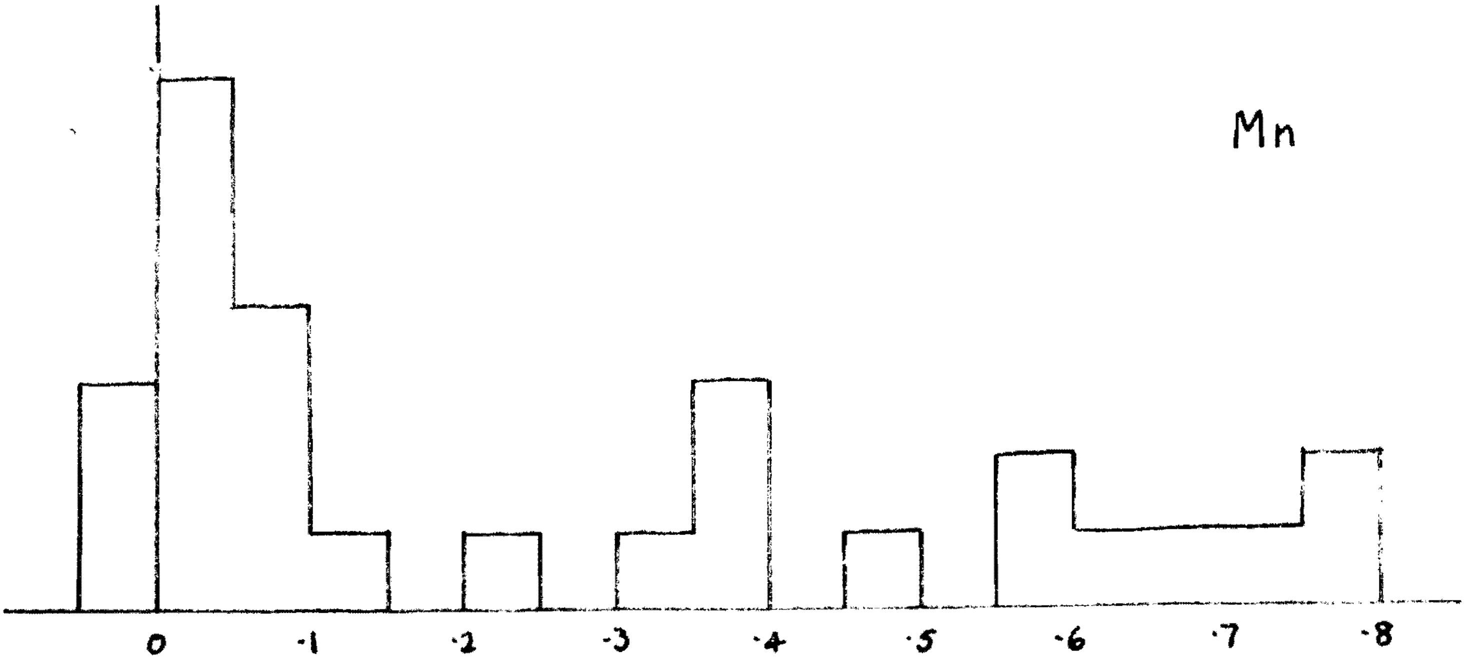


Fig 2a

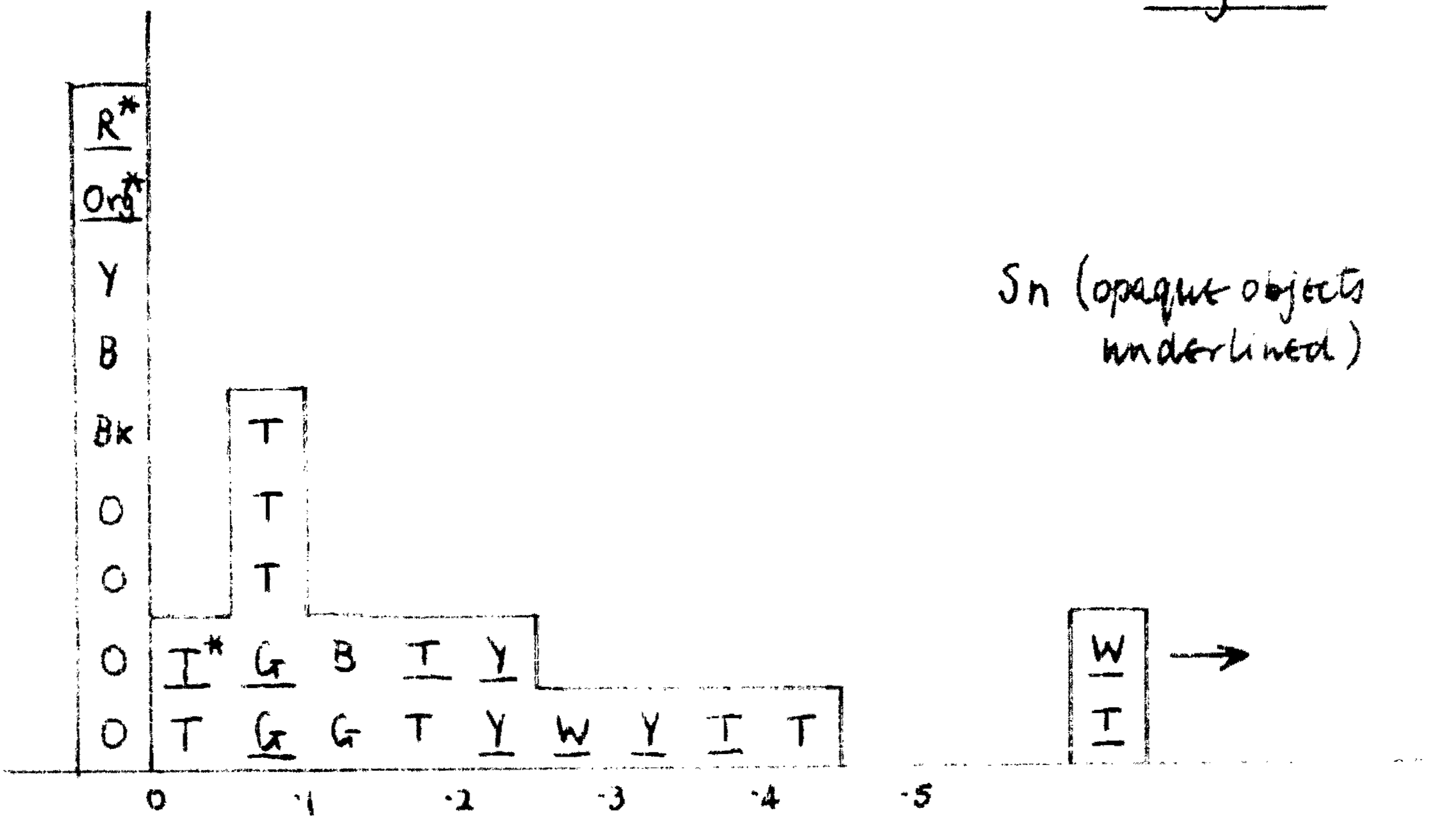


Fig 2b

Vertical scale is frequency (no. of examples).
Squares to the left of the zero line represent objects
the element was not detectable
See text (above) for explanation of

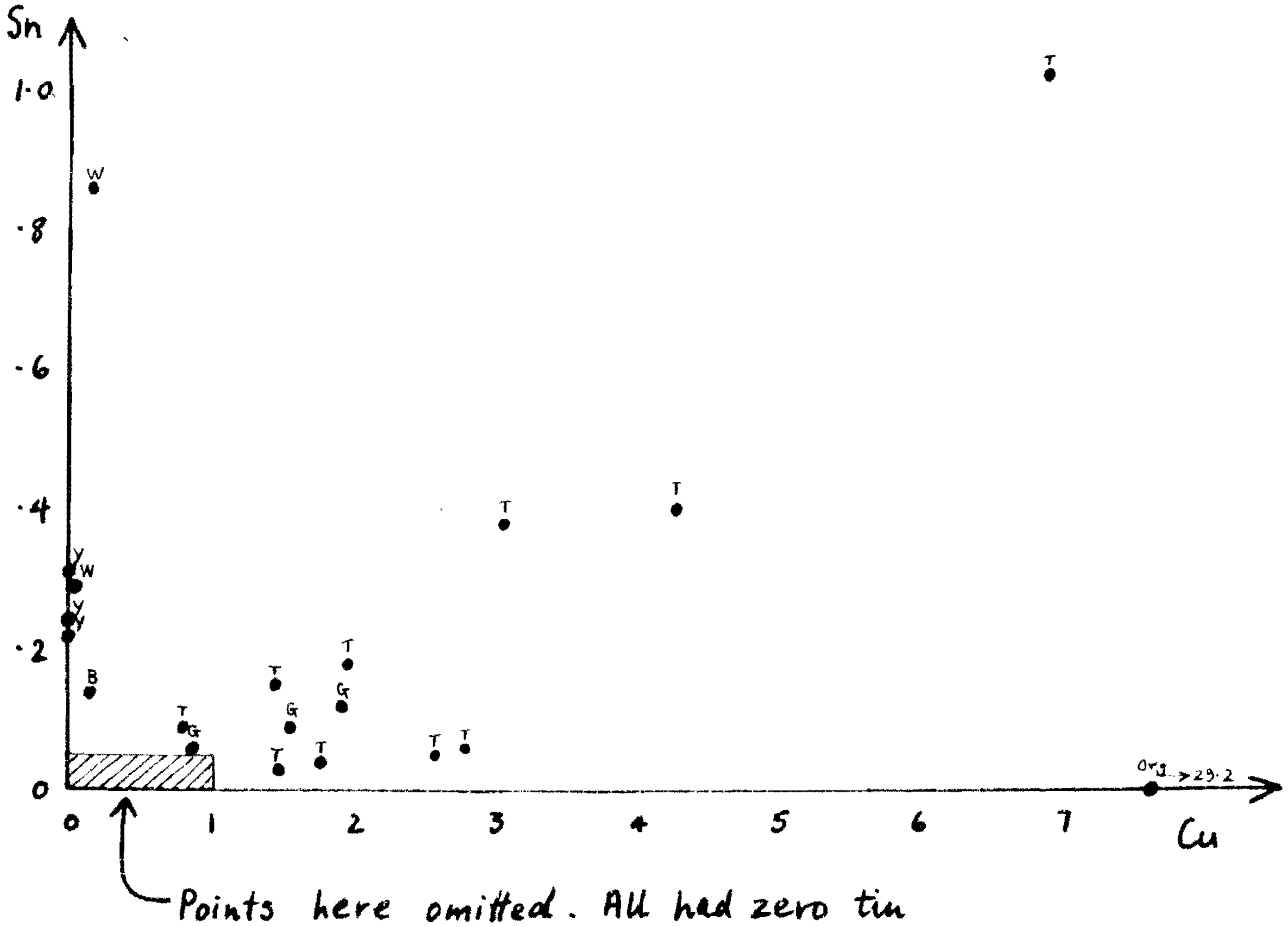


Fig 3

than as pure copper. Whether the glass ended up opaque or translucent may have been chance, depending on the overall level of additions. The third group is the glass with low levels of copper and zero tin which comprises the black, red and "colourless" beads as well as the transparent yellow (which should perhaps be considered as high-iron "colourless" rather than as yellow).

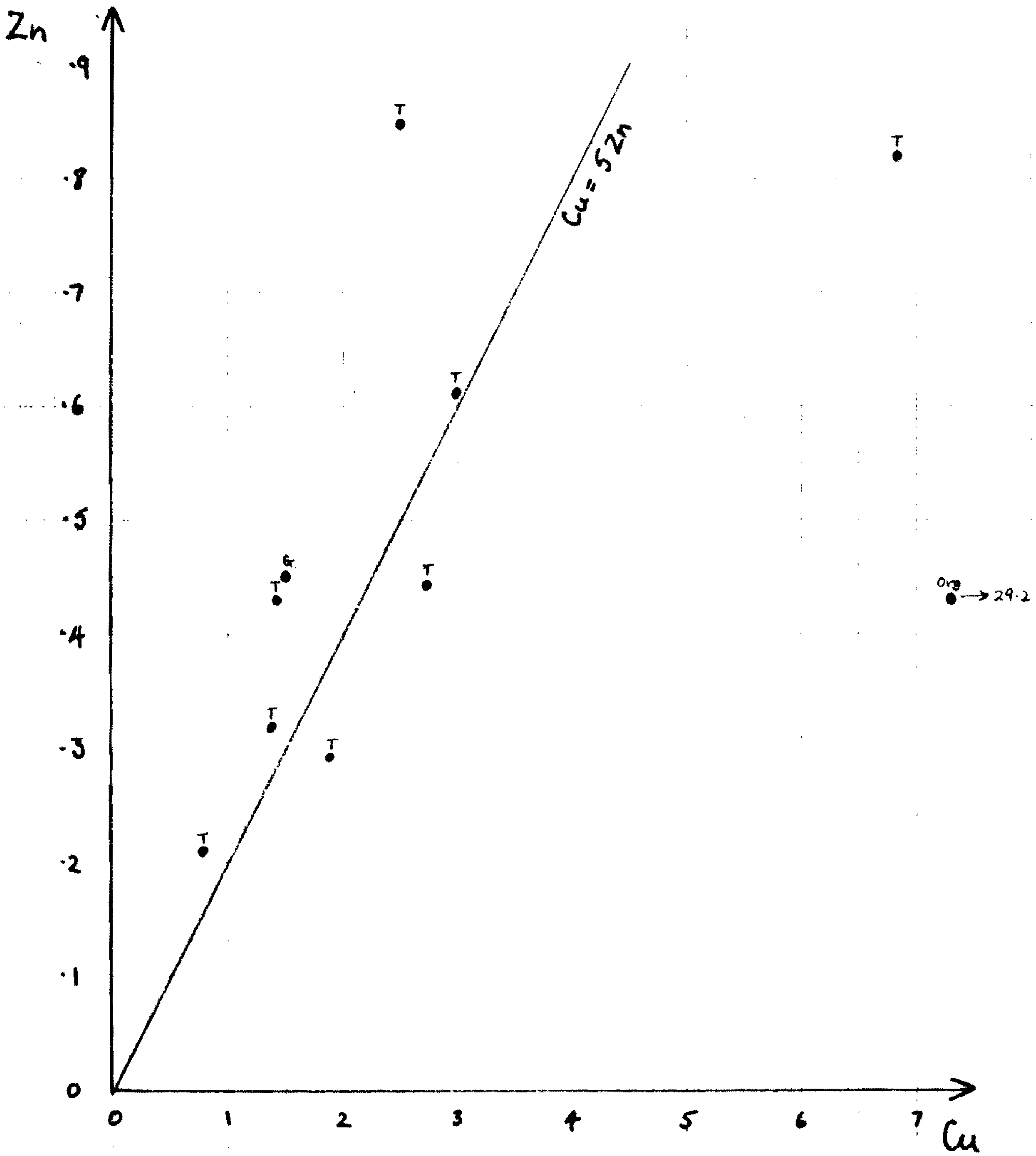
The copper v. zinc plot (Fig. 4) also shows positive correlation which suggests the zinc entered the glass with the copper. The relative amounts of copper and zinc suggest alloys with about 15-20% zinc. There are also a few beads with significant amounts of copper but no detectable zinc (M1, M6, M12, M24, 3/13).

In some cases there are significant amounts of both tin and zinc present so the metals used to give the copper colour to the glass must have varied, with pure copper, brass, bronze and gunmetals all being used. There is not enough data available on the use of the different copper alloys in the Saxon period to allow any deductions to be made from this observation.

Consideration of Fig. 5 (lead v. copper) shows three groups of points. The first is the opaque yellows with high lead and no detectable copper, the second the points with significant amounts of copper and variable lead levels and the final group comprises those glasses with very low levels of both copper and lead (whites, blues, black and "colourless").

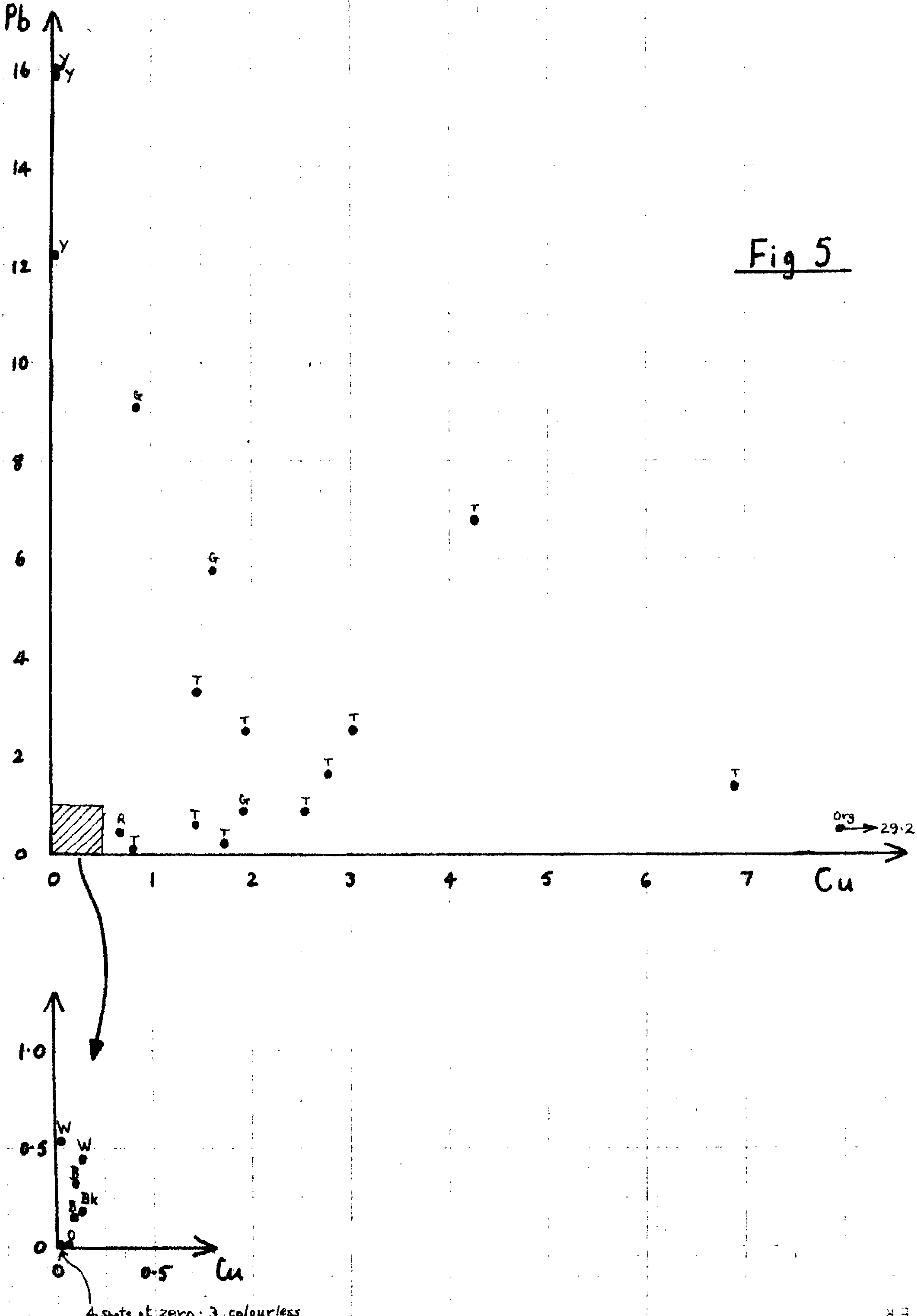
The yellows contain very much more lead than the whites which are otherwise similar to them in composition. This suggests that the whites and yellows were made separately although white can be produced by overheating yellow (see attached "Notes ....").

The copper containing colours are the red, orange, blue/greens and greens. The opaque reduced colours (red and orange) are low in lead. The orange contains far more copper than the red but is otherwise very similar. The low lead/low copper



Points with zinc below 0·2 omitted

Fig 4



Pb
16
14
12
10
8
6
4
2
0
Y
Y
Y
G
G
T
Gr
R
Org
29·2
0
1
2
3
4
5
6
7
Cu
1·0
0·5
W
W
B
B
Bk
O
0
0·5
Cu
4 spots at zero: 3 colourless
1 yellow

Fig 5

red is probably comparable to Hughes' (1972) "less brilliantly coloured" reds where the colour is thought to be due to finely divided metallic copper rather than cuprous oxide though Bateson and Hedges (1975) saw cuprous oxide crystals even in their low copper red enamels. The high level of copper in the orange bead is in agreement with the findings of Biek et al (1980) and Bateson and Hedges (1975) for orange enamels.

The oxidised copper colours (blue/green and green) also contain significant amounts of iron (see Fig. 6); in fact there seems to be some correlation between the copper and iron as though more copper was added to glass containing higher levels of iron to mask the iron colour. In alkali glass copper gives a turquoise -blue colour but in a lead glass gives a true green. It is not surprising therefore that the higher lead levels in copper containing glasses in Fig 5 are greens. The low lead green (M6) is relatively high in iron so it is probably this element that is dominant in producing the colour noted.

The separation of the blues from the blue/greens is slightly surprising. It has been suggested (Bateson and Hedges 1975, Biek et al 1980) that blue enamels owe most of their colour to copper though they appear a true "cobalt blue" colour. Here the two blue beads (M18 and M19) contain only very low levels of cobalt (see attached "Notes ....") but they contain virtually no copper so their colour is unlikely to be significantly affected by it.

The black glass is not, as might be supposed, all the left-overs melted up together. Apart from its high iron content which gives the colour it is most closely comparable with the "colourless" glass. The "colourless", the transparent yellow and the black can best be seen as a progression containing increasing amounts of iron though otherwise similar.

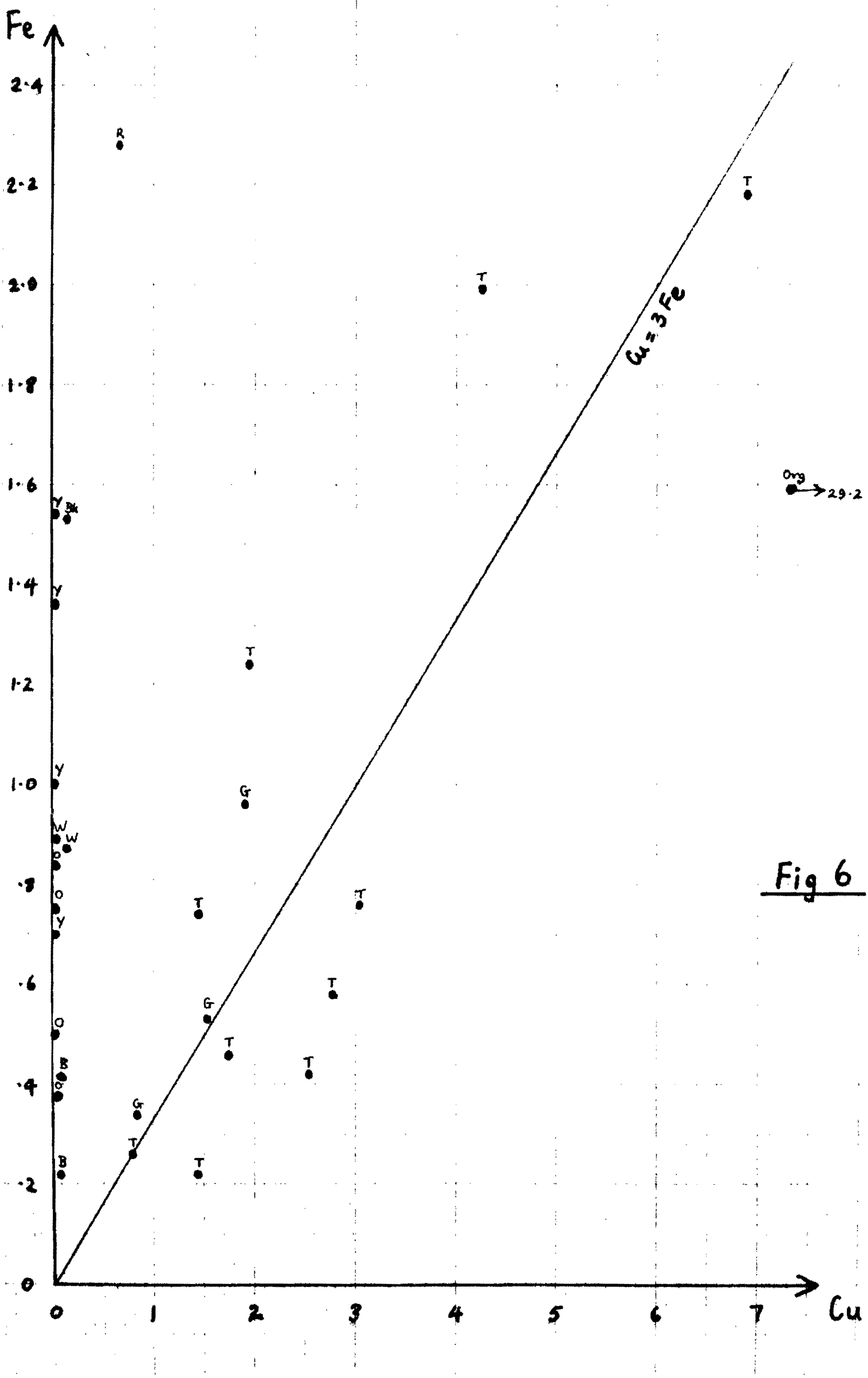


Fig 6

The vessel sherd (M24) was in many ways of a typical composition for its colour. However there were two quite atypical elements detected. One was antimony and the other arsenic. The tin present was not there in sufficient quantities to produce the opacity noted so this must be due to the antimony and/or arsenic. Antimony is a common opacifying agent in Roman and earlier times but arsenic is far less commonly reported; Turner and Rooksby (1959) have noted it, but only in 17th century AD and later glass.

B. The polychrome beads

The analytical data for these has been treated in the same way as that from the monochrome beads. However it cannot be so simply interpreted as most of the analyses include more than one colour of glass (see Appendix III for details). In most cases the figures are what would be expected from a mixture of the two (or more) colours present, based on a consideration of the results for the monochrome beads. In these cases no further comments have been made. The rest of the results are discussed below together with notes on how some of the more complex beads were made.

P1: The main point here is the presence of antimony, acting as the opacifying agent. The relatively high iron figure may be due in part to soil caught in the fissures in the glass.

P3: Possible traces of antimony but the opacity of the white is due to the tin.

P5: The white is antimony opacified.

P7: The white trail is not combed but was applied as an undulating spiral round the bead.

P8: White trail combed. Yellow applied after white.

P15: The blue was applied after the red. The "white" bulk glass is actually almost colourless. The opacity is due to masses of tiny bubbles; no truely opaque inclusions were noted. Although possible traces of tin and antimony were noted, neither were present in sufficient amounts to produce opacity or, in the case of the antimony, to have had any very real decolourising effect.

P17: Red spots probably applied before white trails as the spots look as though they are marvered in while the trails are not.

P18: The antimony here is unexpected, the more so because the glass is neither opaque nor colourless. The red also contains more lead than most of the other red glass.

P19: The pink/purple/brown colour of the "colourless" translucent glass is due to the presence of manganese in larger quantities than necessary to produce truely colourless glass. The bead was made by rolling up a slab and fusing the ends together.

P20: This bead was made in the same way as P19. The manganese level is higher than in the monochrome turquoise beads.

P21: As expected the copper and lead levels are lower for the blue than the green glass.

P23: The pattern runs right through the thickness of the bead so it is true millefiori and not applied decoration on a base colour.

P24: The bead was made by rolling up a 2 x 4 slab of fused millefiori slices with a plain red stripe on one end. The red glass contained less iron and more lead than most reds analysed.

P25: The centre band (red/yellow) was made by arranging 4 thin yellow rods equally spaced round a thicker red and chestnut brown streaky rod, twisting the whole and then marvering it. The end bands (red/"white") were probably made by laying two rods, one of each colour, side by side and twisting them to produce the spiral. The "white" glass is translucent but has bubbles and opaque angular inclusions and streaks of transparent blueish-grey.

P26: Five composite rods were applied onto a core of glass. The rods do not all joint at the same place on the circumference of the bead which shows they were individually applied to a core rather than fused into a slab and then rolled up. The individual rods were made in the same way as described above (P25). The colour combinations are a) red and yellow, b) black with 4 yellow rods, c) red + ? 4 yellow rods, d) black with 4 rods, alternately yellow and red, and e) red with 3 rods, 2 yellow, and one colourless. The core is red with yellow and black streaks, perhaps made from the less perfectly formed parts of the composite rods.

The antimony may be decolourising the colourless glass while the tin opacifies the yellow (but see P27, below).

P27: A further bead made by winding composite spiral rods round a core. The two end rods were a red/brown and colourless spiral. The two centre rods were of slightly different patterns of red and yellow thin rods on a colourless core;

the first seemed to be one red and three yellows, the second red, yellow, red and two yellows. It is curious that antimony was not detected in this bead as the range of colours is the same as in P26 which otherwise looks very similar.

3/1: The lead levels both in this bead and in 3/2 are rather higher than expected.

3/26: Millefiori bead made by rolling up a slab made of slices of composite rods. The red on the ends is not solid but is rods of colourless glass cased in red laid alongside the white on blue and yellow on green millefiori "slices".

3/30: Made in a similar way to 3/26 though the pattern of one of the millefiori slices is different. The red glass casing the colourless has worn off at one end.

The polychrome beads appear to be made in several different traditions. There are wound beads comparable to the monochrome ones which were then decorated with trails and/or spots of other colours; there are beads produced by rolling up slabs of glass formed by fusing together strips of monochrome glass or slices of millefiori rods and there are twisted composite rods laid side by side round a core. Most of the beads were marvered, producing a variety of shapes within each manufacturing tradition.

The most striking difference between the monochrome and polychrome beads is the detection of significant amounts of antimony in some of the latter. This suggests a different source for these objects. This is more likely to be an area of sub-Roman, Frankish or Mediterranean rather than Germanic influence but insufficient analyses are available to allow any firm conclusions to be drawn.

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APPENDIX I: DESCRIPTION OF BEADS AND CORRELATION OF REPORT AND EXCAVATION NUMBERS

Report No	Excavation No		Description
M1	62/4j	(222)	Rust red short 4-sided cylinder
M2	62/4d	(222)	Yellow pentagonal cylinder
M3	1/4b	(19)	Orange barrel
M4	157/1b	(604)	Yellow translucent disc
M5	83/1	(290)	Very light green translucent disc
M6	6/10f	(45)	Light green translucent disc
M7	133/2c	(530b)	Light green pentagonal cylinder
M8	75/1b	(272)	Green short cylinder
M9	129/5a	(514)	Dark green biconical
M10	129/5e	(514)	Light olive/dark blue translucent disc
M11	32/4h	(346)	Blue-green short cylinder
M12	38/4c	(257b)	Blue-green hexagonal flat
M13	55/1d	(175)	Dark blue-green cylinder
M14	Un/5	(4)	Light green-blue barrel
M15	1/4i	(19)	Green-blue with rust red streaks disc
M16	132/2b	(527)	Green-blue barrel
M17	129/5b	(514)	Dark green-blue biconical
M18	30/4e	(369)	Blue disc
M19	30/4g	(369)	Dark blue translucent disc
M20	62/4f	(222)	Blue-white disc
M21	62/4b	(222)	White pentagonal cylinder
M22	30/4f	(369)	Black disc
M23	20/5i	(131)	Colourless annular
M24	59/3p	(203)	Curved fragment of bright green-blue glass 1.5 mm thick containing sand fragments
P1	59/3m	(203)	Disc white, dark blue translucent stripes
P2	59/30	(203)	Barrel rust red, yellow stripes
P3	133/2b	(530b)	Disc black, white zig-zag trails
P4	30/4n	(369)	Disc rust red, yellow zig-zag trails
P5	133/1a	(530a)	Annular dark blue translucent, white zig-zag trails
P6	1/4h	(19)	Biconical light green, yellow zig-zag trails
P7	1/4d	(19)	Cylinder rust red, white combed trails
P8	76/1a	(277)	Short cylinder dark grey, yellow and combed white trails
P9	30/4o	(369)	Disc yellow, rust red crossing trails
P10	55/1g	(175)	Barrel white, blue translucent crossing trails

Report No	Excavation No		Description
P11	42/11	(411)	Disc light blue, blue translucent crossing trails
P12	18/2e	(88)	Short cylinder blue-white, green-blue translucent crossing trails
P13	59/3n	(203)	Barrel rust red, yellow crossing trails and circumference trail
P14	1/4e	(19)	Disc rust red, white crossing trails and circumference trail
P15	13/3c	(110)	Disc light blue, blue translucent crossing trails and rust red dots
P16	35/5i	(338)	Barrel dark green, yellow crossing trails and dots
P17	129/5f	(514)	Barrel black, white crossing trails and rust red dots
P18	157/1e	(604)	Disc blue, rust red marvered dots
P19	30/4k	(369)	Biconical purple translucent, rust red and white band
P20	30/41	(369)	Biconical dark green translucent, rust red and white band
P21	59/3j	(203)	Oval green, dark blue translucent end
P22	60/3i	(206b)	Oval green, yellow end
P23	38/4e	(257b)	Barrel dark blue translucent, rust red dots in white rings
P24	132/2f	(527)	Cylinder, green translucent and yellow spirals, dark blue translucent and white flowers, rust red band
P25	42/1m	(411)	Short cylinder reticella, blue-white, rust red and yellow twists
P26	92/3c	(354a)	Short cylinder reticella, rust red with rust red, yellow and green twists
P27	93/1	(357)	Short cylinder reticella, rust red, yellow and very light green translucent twists
3/1	.1/4e	(19)	Disc rust red, white crossing trails
3/2	1/4e	(19)	Disc rust red, white crossing trails (double)
3/3	1/4e	(19)	Disc rust red, white crossing trails and circumference trail
3/4	1/	(19)	Disc white, blue translucent crossing trails
3/5	1/4e	(19)	Barrel rust red, yellow crossing trails and dots
3/6	30/4n	(369)	Disc rust red, yellow zig-zag trail
3/7	30/4n	(369)	Barrel rust red, yellow crossing trails
3/8	30/4n	(369)	Barrel rust red, yellow crossing trails and circumference trail

Report No	Excavation No		Description
3/9	32/4b	(346)	Globular yellow
3/10	32/4i	(346)	Disc rust red, yellow crossing trails
3/11	32/4j	(346)	Short cylinder white, blue translucent crossing trails
3/12	32/4j	(346)	Disc white, blue translucent crossing trails (cf. Koch 34.1 or 34.5)
3/13	35/	(338)	Small short cylinder blue-green
3/14	42/1j	(411)	Barrel rust red, striped with yellow trails
3/15	42/1i	(411)	Disc rust red, white crossing trails
3/16	42/1k	(411)	Barrel blue-white, crossing trails missing
3/17	42/1k	(411)	Barrel white, rust red crossing trails and [illegible]
3/18	42/1j	(411)	Short cylinder rust red, yellow crossing tra[illegible] and dots
3/19	42/1k	(411)	Annular blue-white, crossing trails missing
3/20	46/3b		Globular yellow
3/21	48/4a		Amber: wedge-shaped
[illegible]	48/4e		Globular colourless drawn
[illegible]	48/[illegible]		Globular colourless drawn (quadruple[illegible]
	48/		Globular colourless drawn beaded
[illegible]	48/		Globular colourless gilt drawn (double[illegible]
3/26	53/1c		Millefiori
3/27	59/3d	(203)	Barrel rust red, white crossing trails and [illegible]
3/28	60/ n	(206)	Disc white, blue translucent crossing trails
3/29	92/3c	(354a)	Reticella
3/30	132/2e	(527)	Millefiori
3/31	59/3d	(203)	Rust red barrel, white crossing trails and [illegible]
3/32	59/3b	(203)	Rust red cylinder with combed yellow trails
3/33	59/3c	(203)	Rust red cylinder with combed yellow trails [illegible]

NB P4 is same bead as 3/6

P14 is same bead as 3/3

P26 is same bead as 3/29

Appendix II: XRF peak heights normalised to Silicon for monochrome beads

Report No.	Ti	Mn	Fe	Co	Cu	Zn	Pb	Sn	Sb	Colour
M1	?	.39	2.28		.66		.46	?		Red (O)
M2	?	.38	1.00				12.21	.22		Yellow (O)
M3	.20	.61	1.59		29.20	.43	.48			Orange (O)
M4		?	.70							Yellow (T)
M5	.04	.21	.38		.06					"Colourless" (T)
M6	.17		.96		1.90		.87	.12		Green (T)
M7	.12	.79	2.18		6.88	.82	1.42	1.02		Blue/green (O)
M8	.11	?	.53		1.52	.45	5.82	.09		Green (O)
M9	.06	.08	.58		2.77	.44	1.66	.06		Blue/green (T)
M11	.15		.74		1.43	.43	3.29	.15		Blue/green (T)
M12	?	.07	.34		.83		9.08	.06		Green (O)
M13	.04	?	.4[illegible]		2.53	.85	.85	.05		Blue/green (T)
M14	?	.14	.76		3.03	.61	2.55	.38		Blue/green (O)
M15	.10	.30	1.24		1.92	.29	2.52	.18		Blue/green (O)
M16	.03	.03	.26		.79	.21	.17	.09		Blue/green (T)
M17	.03	.03	.22		1.43	.32	.62	.03		Blue/green (T)
M18	?	.06	.41	?	.11		.33	.14		Blue (T)
M19	?	?	.22	✓	.09		.15			Blue (T)
M20	.12	.56	.87		.13	.12	.46	.86		White (O)
M21	.05	.38	.89		.03		.54	.29		White (O)
M22	?	.07	1.53		.13		.18			Black (T)
M23	?	.68	.50							"colourless"(T)
M24	.03	?	.46		1.73		.22	.04	.14	Blue/green (O)
								(As = .2)		
3/9	?	.75	1.54				15.83	.24		Yellow (O)
3/13	?		1.99		4.25		6.82	.40		Blue/green (T)

Appendix II contd

Report No.	Ti	Mn	Fe	Co	Cu	Zn	Pb	Sn	Sb	Colour
3/20	.19	.47	1.36				15.88	.31		Yellow (O)
3/23	.04	.57	.75							"Colourless" (T)
3/24	.06	.74	.84							"Colourless" (T)

Key to Appendices II and III

O = opaque

T = translucent

? = uncertain

\- = no figure available

Appendix III: XRF peak heights normalised to silicon for polychrome beads

Report No	Ti	Mn	Fe	Co	Cu	Zn	Pb	Sn	Sb	Notes and Colours
P1	.04	.25	.72		.07		.11		.09	Mainly white (0)
	.03	.12	1.25	✓	0.15		.21	.07	.07	White (0) + Blue (
P2	.19	.45	2.66		.51	.22	8.55	.17		Red (0) + Yellow (
P3	.05	.48	1.87		.09		.19	.23	?	Mainly black (0)
	.10	.82	4.82		.22		.25	.28	?	Black (0) + White(
P4	.10	.47	3.53		.85	.22	4.56	.16		Red (0) + Yellow(0
P5	.08	.51	.84	✓	.20		.21		.09	Blue (T) + some White (0)
	.04	.22	.42		.10		.12		.05	White (0) + some Blue (T)
P6	.17	.41	1.35		4.53	.40	9.72	.71		Green (0) + yellow (0)
P7	.11	.54	2.68		.72	.15	2.13	.28		Red (0) + White(0)
P8	.18		8.09		.21	.20	5.08	.27		Black (0) + Yellow (0)
	.12		2.59		?	?	5.02	.33		Black (0) + Yellow (0) + White (0)
	.13		.94		?	?	7.10	.41		Mainly Yellow (0) + White (0)
P9	?	.68	2.59		.54	.32	3.86	.11		Yellow (0) + red(0
	?	.68	–		?	?	8.01	.62		Mainly yellow (0)
P10	.19	.31	1.31	?	.23		.54	.66		White (0) + Blue(T
P11	.04	.23	.89		.07		.48	.28		White (0) + Blue(T
		.46	–				.96	.94		White only
P12	.11	.15	.69		3.19	1.04	2.23	.52		White (0) + Turquoise (0)
P13	.18	.42	2.45		.65	.16	6.06	.11		Red (0) + Yellow(0
P14	.13	.29	2.15		.60		1.11	.37		Red(0) + White(0)
P15	.10	.58	1.04		.20	.14	.22	?	?	"Colourless" (T) + Blue (T)
	.13	.46	1.36		.41		.58		?	"Colourless(T) + Blue (T) + Red (0)
P16	.10	.32	1.02		.36	?	3.78	.12		"Colourless"/Turq. (T) + some Yellow(
	.10	.32	1.02		.36	?	3.78	.12		"Colourless"/Turq. (T) + some yellow(

Appendix III contd

Report No	Ti	Mn	Fe	Co	Cu	Zn	Pb	Sn	Sb	Notes and Colours
P17	?	.79	5.03		.47	?	.77	.24		Mainly Black (T)
	.07	.56	2.99		.65	.13	1.20	.15		Black (T) + White (O) + Red (O)
P18		.27	1.01	?	.34	.16	.52		.14	Mainly Blue (T)
	.11	.39	1.78		.67	.16	2.03		.18	Blue (T) + Red (O)
P19		.94	–		?	?				"colourless"/pink (T)
	.04	.74	.56		.21	.14	.64	.13		"Colourless"/Pink (T) + White (O) + Red (O)
P20	.21	.81	1.48		2.02	.39	.83			Turquoise (T)
	.05	.53	.66		1.26	.26	.88	.17		Turquoise (T) + Red (O) + White (O
P21	.09	?	.66		1.24	.28	4.36	.17		Mainly Green (O) + Blue (T)
	.05	.08	.59		.68	.14	2.12	.10		Mainly Blue (T) + Green (O)
P22	.28		6.7		1.07	.62	3.07	.12		Green (O)
	?	.65	1.07		.65	.76	5.85	.19		Yellow (O) + some Green (O)
P23	.06	.19	.68		.49	.12	.99	.14		Blue (T) + White (T) + Red (O)
P24	?	.58	1.39		1.67	.84	2.05	.19		Red (O)
	.08	.36	.67		1.65	.14	1.16	.15		Mainly Blue (T) + White (O)
	.07	.50	.69		1.00	.16	.169	.12		Mainly Green (T) + Yellow (O)
P25		.48	2.66		1.55	.27	2.38	.55		Red (O) + "White" (T)
	.24	.98	3.66		2.63	.49	5.85	.26		Mainly Red (O) + Yellow (O)
P26	.08	.37	6.12		1.98	.24	2.43	.08	.04	Mainly Red (O) + Yellow (O)
	.10	25	2.83		2.13	.37	3.64	.07	.03	Red (O) + Yellow (O) + Black (O)
P27	.19	2.29	4.43		1.33	.46	2.27			Mainly Red/Brown (O) + "colourless" (T)
	.14	1.54	2.75		.97	.33	3.56	.11		Red(O) + Yellow (O) + "colourless" (T)

Appendix III contd

Report No	Ti	Mn	Fe	Co	Cu	Zn	Pb	Sn	Sb	Notes and Colours
M10	?	.11	1.41		.14					Yellow (T)
	.09	.24	.86	✓	.30		.34	.07		Yellow (T) + Blue (T)
3/1	.11	.76	4.67		1.30	.34	2.14	.35		Red (O) + White (O)
3/2	.07	.20	2.15		.63	.33	2.69	.35		Red (O) + White (O)
3/4	.08	.49	1.66	?	.20		1.67	1.26		White (O) + Blue (T
3/5	.12	.16	2.18		1.04	.39	7.17	.24		Red (O) + Yellow(O)
3/7	.13	.54	2.61		.76	.15	4.86	.16		Red (O) + Yellow(O)
3/26	.12	.85	1.22		1.26	.42	1.56	.16		Mainly colourless (T) + Red (O)
	.13	1.00	1.20		1.81	.20	2.41	.19		Mainly Green (T) + Yellow (O)
3/28	.10	.14	1.04	?	.27		.80	.61		White (O) + Blue (T
3/30	.09	.38	.90		.93	.44	1.74	.13		Red (O) + White (O) + Blue (T)
	.10	.58	1.03		1.25	.49	2.93	.19		Yellow (O) + Green (T) + Red (O)
3/32	.06	.43	1.81		.69	.08	4.01	.07		Red (O) + Yellow (