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Examination and Analysis of Glass Beads from Finglesham, Kent

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Introduction

Beads from thirteen graves (34, 35, 57, 62B, 68, 83, 96, 120, 124, 138, 157, 174 and 197) from the Pagon Saxon cemetery site at Finglesham were examined. They included shell, amber and amethystine quartz [1] beads, but only the glass beads were examined in detail or analysed. The number of beads found in each grave varied considerably and a representative selection was made of the beads from those graves (57, 62B, 96 and 138) which contained a particularly large number. All the glass beads from the other graves were analysed.

Both the physical characteristics (colour, opacity, porosity) and the chemical composition of the beads were investigated. The colour of each monochrome bead was described in terms of a general colour category and a Munsell Number* both of which are given in appendix 1 below. The Munsell Number includes terms for the hue (H), the value (V) (the lightness or darkness), and the chroma (C) (the intensity of hue) of the bead. It should provide a reasonable indication of the colour of a bead, although many beads show considerable variation in colour. Where possible each field of a polychrome bead was described similarly, and these results are given in appendix 2. The opacity of

* Most of the Munsell Numbers were assigned by G. Grainger.

glass can range continuously from transparent to completely opaque. The opacity of each bead has therefore been described, together with the porosity, in some detail in appendices 1 and 2, but each bead has also been described as either transparent, translucent or opaque although each of these terms (particularly translucent) includes a wide range of actual opaciies.

The beads were analysed using energy dispensive X-ray fluorescence with an evacuated sample chamber. The elements analysed for were silicon, potassium, calcium, titanium, manganese, iron, cobalt, copper, zinc, lead, tin, and antimony. No attempt was made to analyse low atomic number elements such as sodium, magnesium or aluminium and therefore the bulk glass was not categorised. As the method used was required to be completely non-destructive no sample preparation for the purpose of analysis was possible so any results for light elements would have been unreliable had they been obtained [2]. The calcium results, which could have been affected by contamination and the potassium results, which were at a low but fairly constant level have also not been used. Since silicon is expected to be present at a relatively constant level in the beads it was used as an internal standard. The results were normalised by taking the ratio of the K_{α} peak height of each element (except for lead, when the L_{α} peak height was used) to that of the corresponding silicon K_{α} peak. Only cobalt, which was present at very low concentrations was not treated in this way. The normalised results and the presence or absence of cobalt for each analysed bead are listed in appendices 3 and 4.

Results and Discussion

1) Colour

Each of the elements analysed except titanium and zinc would be expected to have, potentially, a significant effect on the colour of glass beads. The appearance

of glass beads is affected by the presence of metal ions in solution and by opaque particles. Manganese, iron, cobalt, copper and antimony ions have a colouring effect (manganese and antimony can also act as decolourisers) while copper, cuprous oxide, tin oxide, lead-tin oxide and calcium and lead antimonates may be present as opaque particles. The colourants present in each colour bead are discussed below, but a more detailed general discussion of the relationship between colour and composition of glass is given in [3].

a) Green and Turquoise beads

Both copper and iron were used to produce green and turquoise colours in the glass, copper being present in the oxidised state as cupric, Cu^{2+} ions. Although iron was present, presumably as an impurity inroduced with the glass forming materials, in all the beads it probably only contributed significantly to the colour of four green or turquoise beads (grave 62B - number 21, 120-9, 174-10 and 174-19). These all contained low levels of lead and fairly low levels of copper although the copper may have contributed to the colour observed.

The colour of the remaining green and turquoise beads was due to the presence of copper. The colour produced by cupric ions in a silicate glass depends on the lead content of the glass. In a high lead glass a green colour is produced, whereas in a low lead glass a turquoise colour results, and a continuous range of colours are possible between the extremes. This effect is illustrated in figure 1, where the colour of the bead (in terms of its Munsell Number Hue) clearly becomes more blue with decreasing lead content.

The results, perhaps surprisingly, tend to fall into two groups, and a similar grouping is apparent in figure 2 in which the lead content of the

beads is plotted against their copper content. The ratio of lead to copper in the turquoise beads is, in general, relatively low annd relatively constant, perhaps suggesting that the lead was introduced with the copper rather than as a separate, deliberate, addition (see below for similar comments about zinc and tin). The lead to copper ratio for the green beads was, in contrast, much more variable and, usually, significally higher suggesting that lead was introduced independently of the copper. This may indicate that the green and turquoise beads were distinguished by the producers, rather than being the extremes of variation in a single bead colour, but the sample of beads analysed was too small for a definite conclusion to be reached.

b) Blue beads

Cobalt was the colourant used in all the blue beads. Cobalt is capable of producing an intense colour even when present at a fairly low concentration and it was therefore difficult to confirm its presence in some cases. However copper, which can also produce a blue colour, was not present at significant levels.

c) White beads

These beads consisted of a high density of opaque white particles in a coloured matrix glass which resulted in an opaque bead with a very pale yellow, green or turquoise colour. They contained high levels of tin (figure 3) but no antimony and the opaque particles were almost certainly tin oxide. The beads also contained some lead, although the amount varied. The colour of the matrix glass was probably due to iron, present accidentally, rather than copper which was only present at very low level.

d) Yellow beads

The yellow beads all contained relatively high levels of lead (figure 2) and fairly high levels of tin (figure 3) but no antimony. The colour is almost certainly due to a high density of opaque lead-tin oxide particles in the matrix glass. Lead-tin oxide is unstable on heating and decomposes irreversibly above 900°C to give white tin oxide which is present in the white beads. The white beads do not however appear to be overheated yellow beads as the latter consistently contain higher levels of lead than the white beads (figure 4).

e) Red and orange beads

Copper was the colourant in both the red and orange beads. It was almost certainly present in a reduced form as particles of either cuprous oxide (Cu_2O) or metallic copper [4]. The orange bead contained very high levels of copper as have similar beads from other sites [5, 6]. Tin was present in all the red beads, in most cases at about the same level that it was present in the copper coloured green and turquoise beads (figure 3). Tin would not be expected to have any effect as an opacifier on the appearance of the red beads which were in any case fully opacified by the copper or copper oxide particles. This would suggest that the tin in the red beads was introduced with the copper and was not a deliberate addition. Tin in the green and turquoise beads could be accidental also, but in this case tin does have an opacifying effect on the glass.

f) Other beads

Two other monochrome beads were analysed, a clear bead (96-52) which contained both mangenese and antimony, both of which contained a high level of iron which was almost certainly the colourant.

Several polychrome beads were analysed, but it was not usually possible to analyse individual fields. The analytical results (given in appendix 4) are therefore difficult to interpret.

Most of the results for polychrome beads are similar to those for monochrome beads of the same colour, however a few comments can be made about two particular polychrome beads. The only example of a black bead found was 62B-23, which consisted of turquoise spots in a black bead. The black glass has a very high iron content and a fairly high level of copper. The colour was essentially due to the effect of these elements. The apparent opacity of the bead was probably due to the intensity of colouration. Similar results have been obtained on analysing black beads from other Saxon sites [5, 6]. Bead 83-2, a thick bead which consisted of yellow spots and trails in a light blue glass, was also unusual. The blue glass contained low levels of copper, fairly low level of iron, and no cobalt was detectable. The colour was probably due to the combined effects of copper and iron and was not very intense. No tin was detected on analysing the yellow spots, but significant amounts of antimony and some lead (which was not detectable in the blue glass) were present which suggest that the colourant was lead antimonate, which is rarely found as a colourant in glass later than the Roman period [7].

2) Opacity

The red, orange, yellow and white beads were opacified by the particles giving the colour and could not have been produced in a transparent form (except by using a different colourant). Of the remaining beads, the green, turquoise and blue beads were, in some cases, partially opacified.

The opacifiers which might have been used at this period were tin and antimony, although the latter is not often found in post-Roman glass [7]. Tin opacifies glass by forming opaque particles of white tin oxide or yellow lead-tin oxide. Antimony, in an oxidised state, forms lead or calcium antimonate particles which are respectively yellow and white. Only one (blue) bead analysed in this work was definitely antimony opacified (138-59), although a green bead (138-39) which contained both white and yellow particles contained antimony, but tin was also detectable.

As has been found at other Saxon sites of a similar date tin was the major opacifer used. This suggest that Roman glass was only rarely reused in making the beads. The antimony detected in a few beads (68-6, 68-7, 96-52, 138-39, 83-2 and 174-10) may be due to the occasional reuse of Roman glass, the beads themselves may hae been residual Roman objects or they may have been made in areas such as the mediterranean where Roman glass-making traditions survived. Antimony has been found occasionally in beads from other Saxon sites, usually in polychromes [5, 6].

3) Zinc

Significant amounts of zinc were prresent in a large proprotion of the beads (figure 5), particularly those coloured by copper. it was probably introduced with the copper colourant in a similr way to the tin in red beads discussed above. The presence of tin and zinc in beads in which they would have little or not effect on the appearance of the bead suggest that the major source of copper was metallic copper alloys containing tin and/or zinc, although it is not possible ot comment on how the metal would have been treated before addition to the glass.

4) Titanium

The amount of titanium present in the beads varied considerably. It was presumably introduced as an impurity in the sand used as a source of silica, and it has been suggested that the amount of titanium present is indicative of the source of sand [8]. Although the concentration of titanium cannot be used to identify the source of silica used in a particular bead, widely varying levels in different beads do suggest that a variety of sources of silica were used to produce them.

Figure 6 illustrates the variation in titanium content of beads from the five graves which each contained at least twelve monochrone beads. There graves clearly fall into two categories, those (62B, 138) in which all the beads contain similar low levels of titanium and those (57, 68, 96) in which the titanium content varies over a wide range and has a relatively high mean. This suggests that several sources of silica were used to produce the glass for the beads from graves 57, 68 and 96, whereas the beads from graves 62B and 138 were more likely to have been produced at a single site, which differed from that producing most of the beads from graves 57, 68 and 96.

No pattern connecting the titanium content and colour of the beads was found, except for the cobalt blue beads which were all low in titanium. It is possible (though by no means certain) that these beads, which require a colourant, cobalt, which may not have been as generally available as the colourants in the other beads, were made at one manufacturing centre. The results suggest that the red, orange, green, turquoise, yellow and white beads came from several sources, and that the sources varied from grave to grave.

5) Decolourants

Iron is invariably present in glass of the Saxon period as an impurity and it can affect the colour of the glass. Under appropriate conditions, manganese or antimony can act as a decolouriser of glass coloured by iron. However, although manganese was detectable in most of the beads analysed and several of them contained antimony as well or instead, there was no evidence that either element was used consistently as a decolourant in any of the colours of bead analysed. The levels of manganese detected in different beads of the same colour varied considerably. This result might be expected as iron probably had almost no effect on the colour of most of the beads (with some exceptions discussed above). The white beads were the only group in which iron may have had a significant effect as the colour of the matrix glass, which was almost certainly due to iron, gave a pale colour to what would otherwise have been a pure white bead. Nevertheless there was no evidence that any attempt was made to decolourise the white beads.

References

[1] M Hutchinson, personnal communcation.

[2] G A Cox and A M Pollard, "X-ray fluorescence analysis of ancient glass: The importance of sample preparation", Archaeometry 19, 1, (1977)

[3] J Bayley, "Notes on the composition of coloured glasses" in The Archaeology of Canterbury, Vol III: Excavation in the Cathedral Precincts, 1, by S Campbell,

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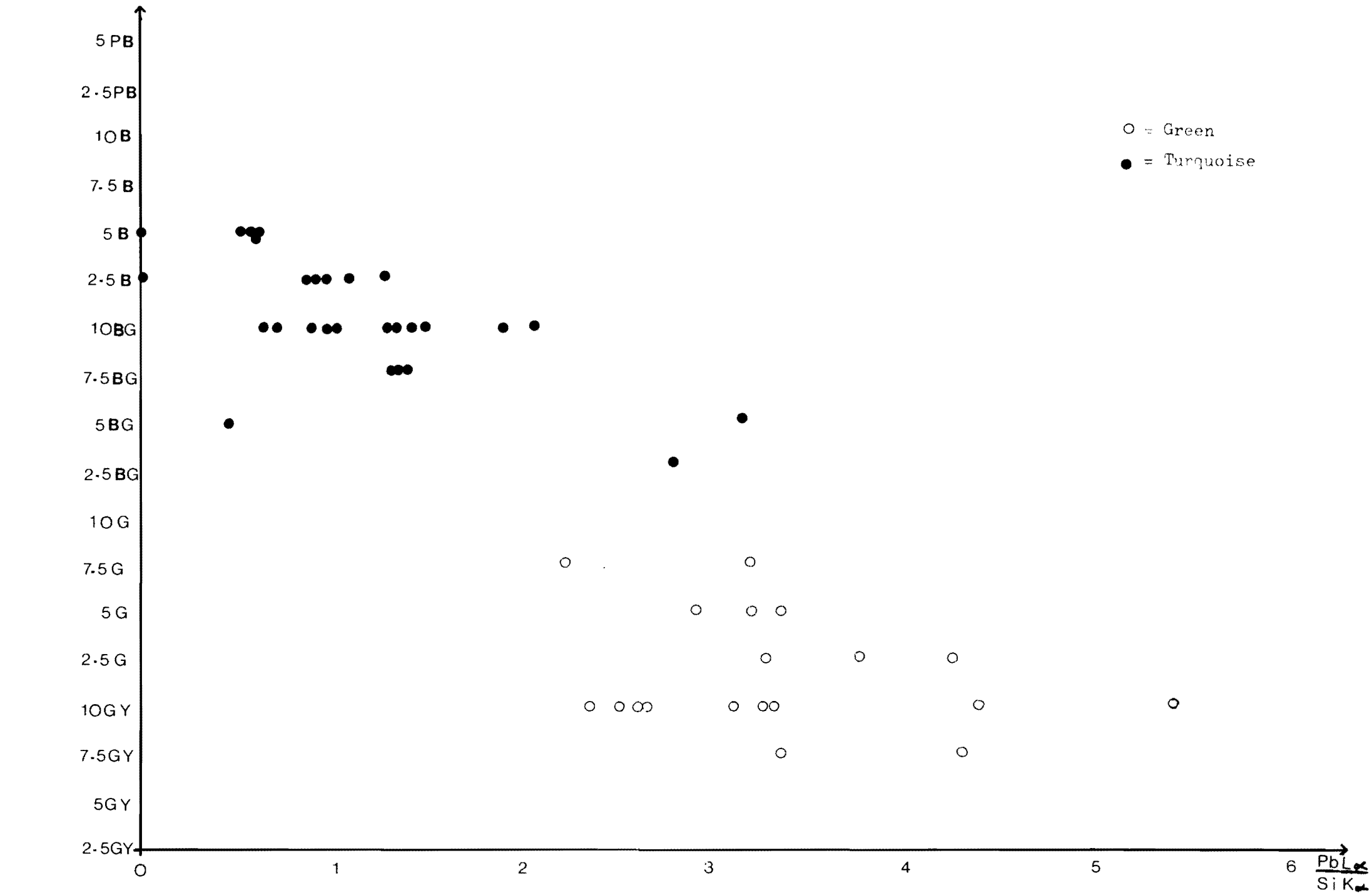
[5] J Bayley, "Qualitative analyses of some of the beads" in V I Evison, Dover Saxon Cemetery, forthcoming.

[6] J Bayley and P T Wilthew, "Qualitative and semi-quantitative analysis of glass beads", Proc. 1984 Archaeometerey symposium, Washington DC, forthcoming.

[7] L Bick and J Bayley, "Glass and other vitreous materials", World Archaeology, 11, 1,(1979)

[8] M Spitzer-Aronsom, "Titanium, possible indicator for Medieval archaeology owing to exactness of a new method for the study of the old stained glasses", Achaeophysiko 10, 286, (1979).

Figure 1: The effect of lead on copper coloured green and turquoise beads



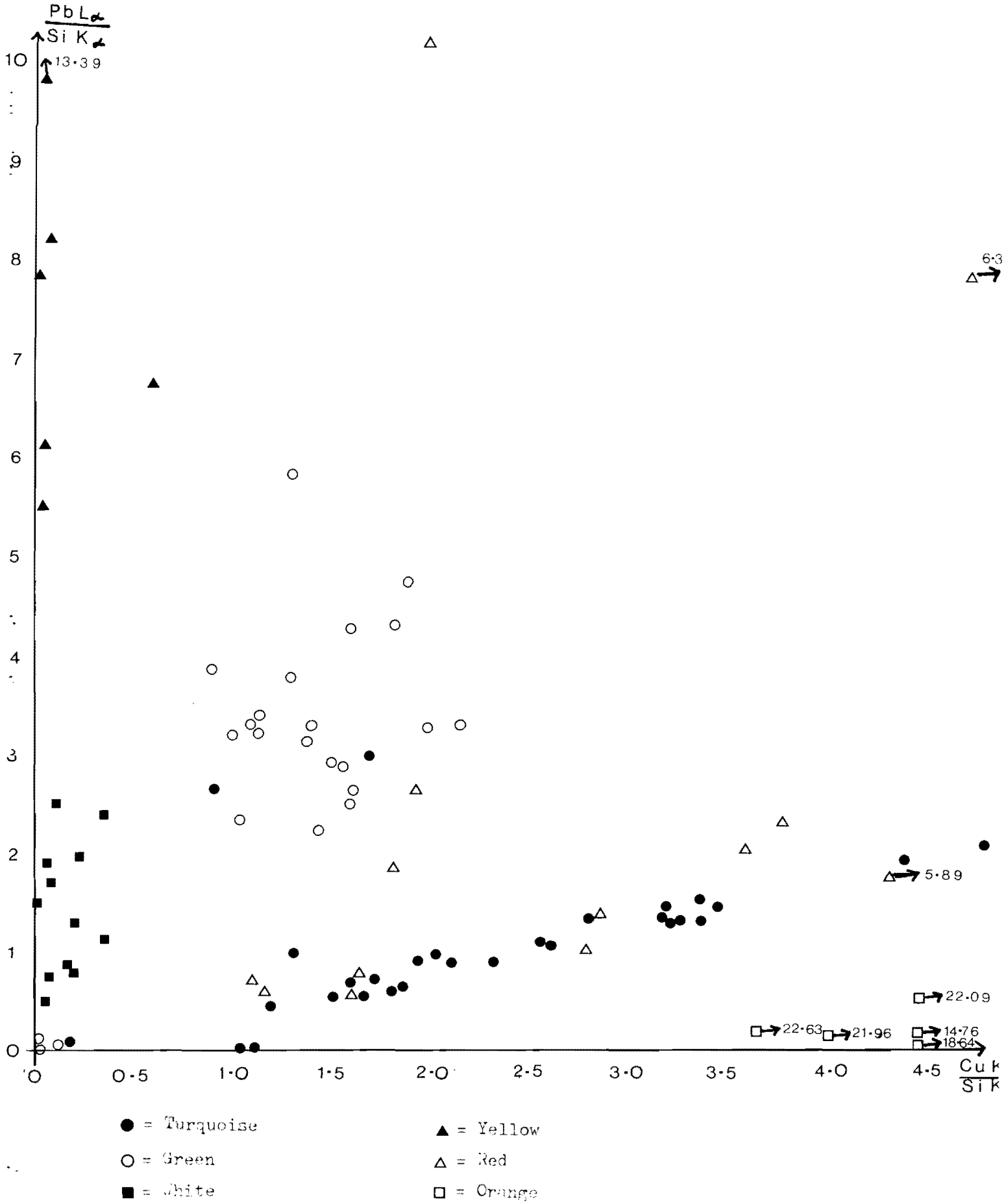


Figure 2: The relationship between the lead and copper contents of the beads

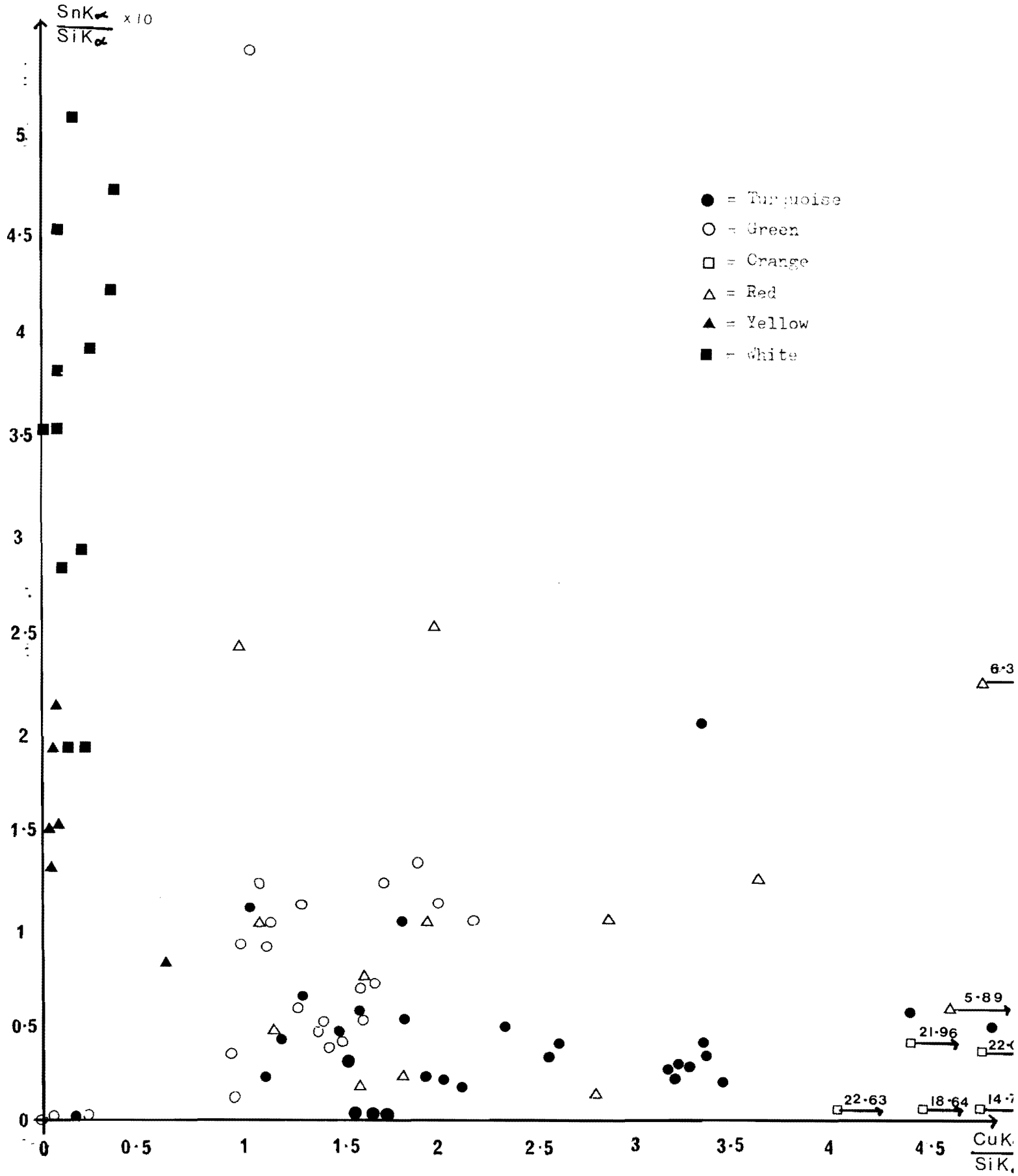


Figure 3 : The relationship between the tin and copper contents of the beads

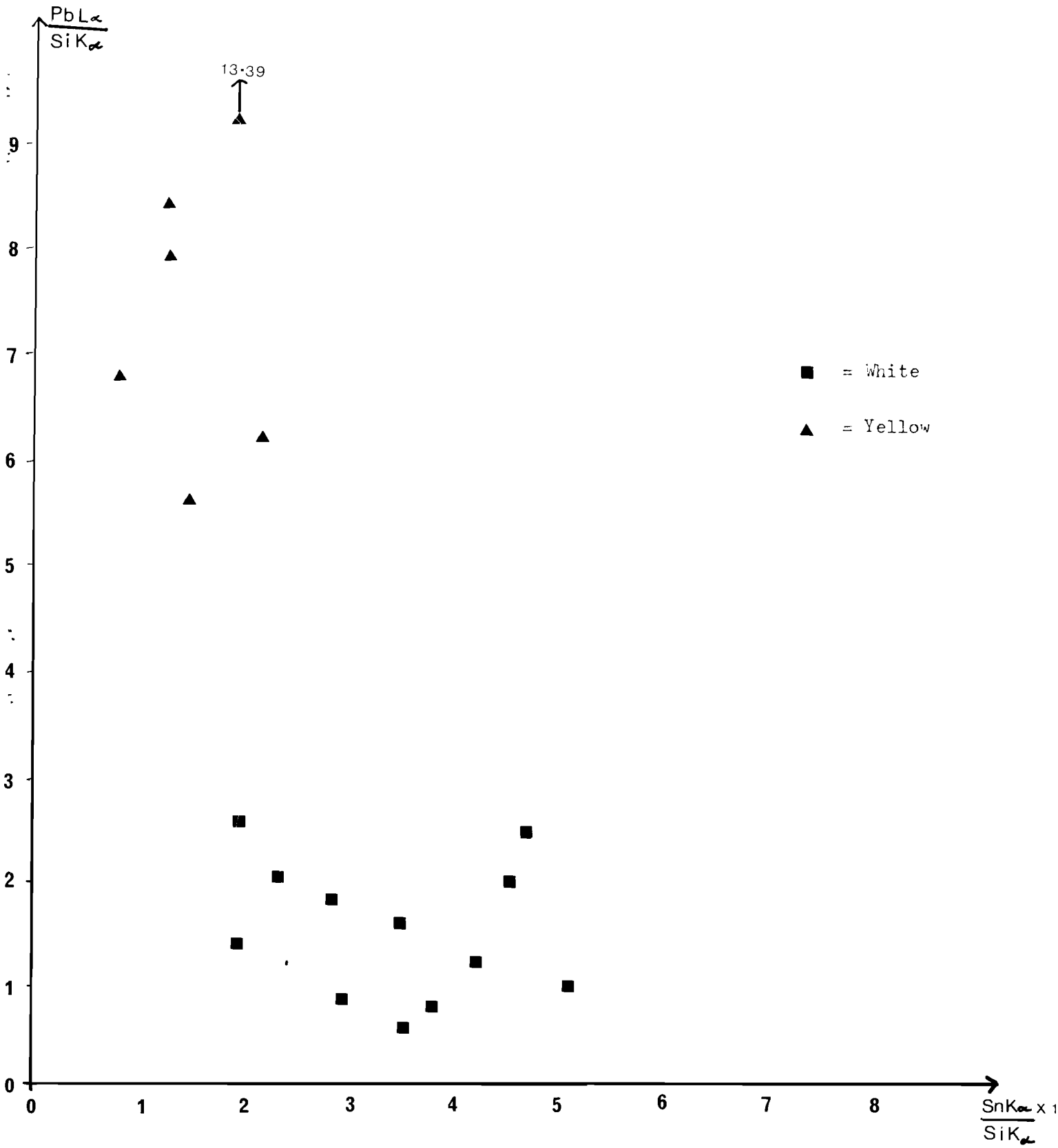


Figure 4: The relationship between the lead and tin contents of the white and yellow beads

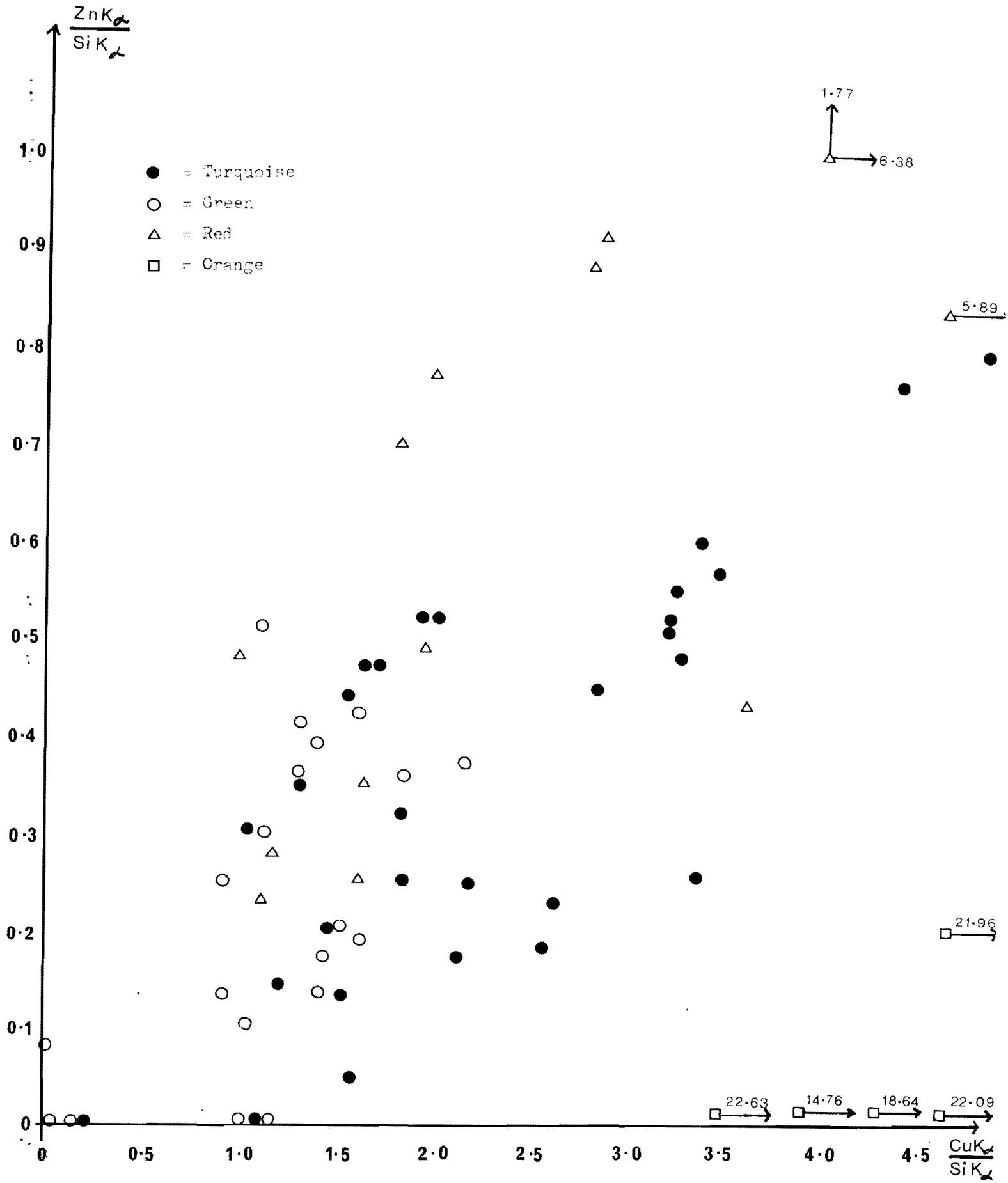
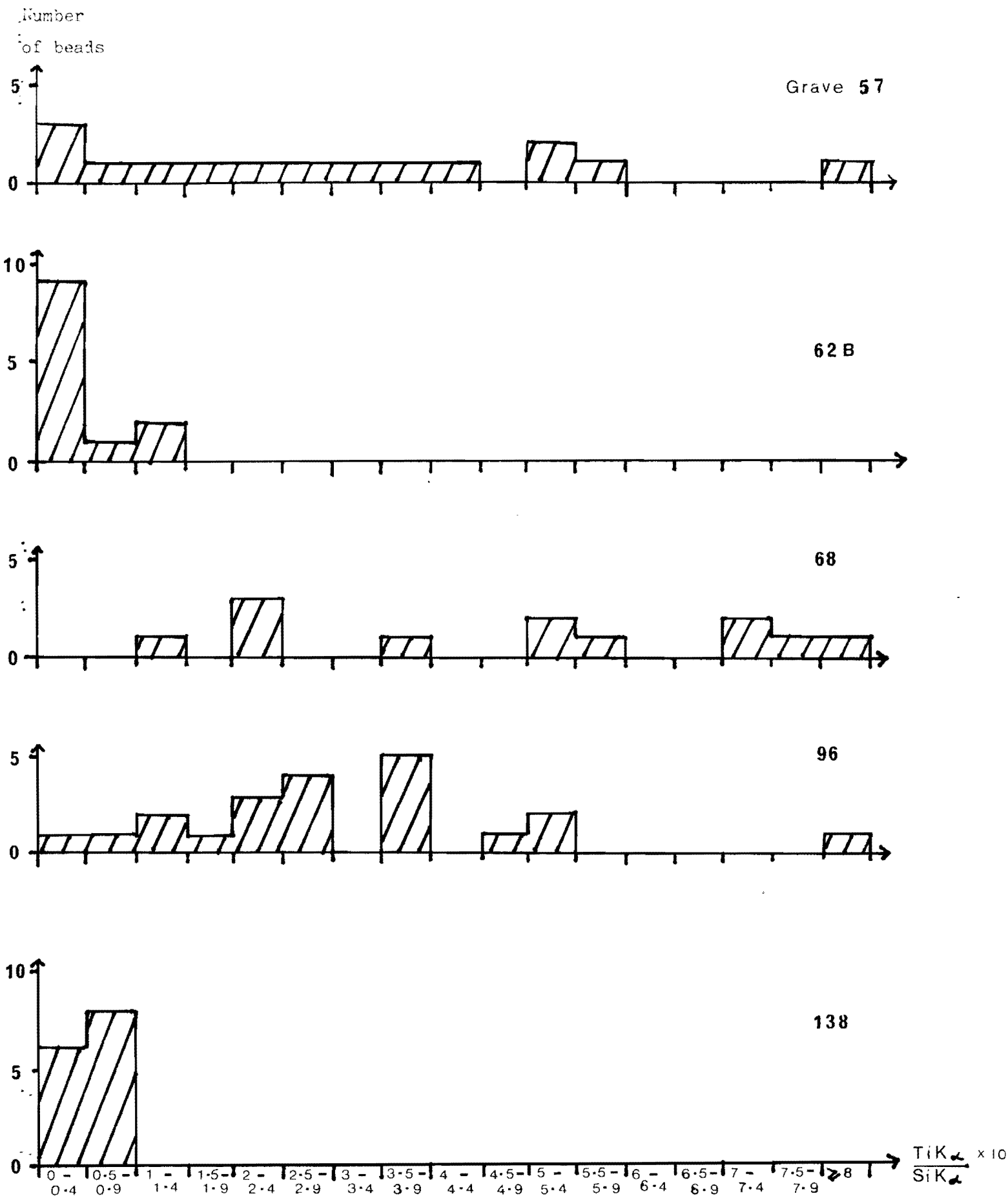


Figure 5: The relationship between zinc and copper content of the copper coloured beads

Figure 6: Titanium content of beads from five graves



Appendix 1 - Colour and Opacity of the Monochrome beads analysed.

Grave	No	Munsell Number Hue (H)	Value (V)	Chrome (C)	Description
34	4a	10BG	3	4	Dark turquoise, translucent bead. Partially opacified by a high bubble density.
	4b	10BG	3	4	"
	4c	7.5BG	3	4	"
	4d	10BG	3	4	"
	4e	7.5BG	3	4	"
57	18	2.5GY	5	4	Translucent green with red streaks. Partially opacified by yellow particles.
	54	5PB	4	8	Translucent blue.
	60	10GY	8	1	Opaque white. Pale green(?) glass opacified by a high density white particles.
	66	5G	5	6	Translucent green, partially opacified by yellow and white particles.
	68	10GY	5-6	8	"
	69	10GY	6	10	"
	70	2.5BG	4	6	Translucent turquoise with red streaks, partially opacified by white and yellow particle.
	73	7.5SG	4	8	Translucent green, partially opacified with white and yellow particles.

Grave	No	Hue (H)	Value (V)	Chrome (C)	Description
57	79	5PB	3-4	6-10	Translucent blue.
	80	7.5R	3	6	Opaque red. Opacity and colour due to copper or cuprous oxide particles
	82	5BG	5	4	Translucent turquoise, partially opacified by white particles and bubbles.
	85	7.5R	4	2-4	Opaque red. Opacity and colour due to copper or cuprous oxide particles.
	86	5GY	8.5	2	Opaque white. Pale green(?) glass opacified by a high density of white particles.
	88	SR	4	8	Opaque red. Opacity and colour due to copper or cuprous oxide particles.
	91	10GY	6	6	Translucent green, partially opacified by white particles.
62B	15	10Y	8-8.5	1	Opaque white. Pale glass opacified by a high density of white particles.
	16	5PB	3	4	Translucent blue.
	21	5GR	9	4	Translucent green with yellow and white particles.
	25	5YR	6	10	Opaque orange. Colour and opacity due to copper or cuprous oxide particles.

Grave	No	Hue (H)	Value (V)	Chrome (C)	Description
62B	29	2.5B	3	4	Translucent turquoise, partially bubble opacified.
	30	5Y	8	10	Opaque yellow, opacity and colour due to yellow particles.
	31	10GY	5	6	Translucent green, partially opacified with yellow and some white particles.
	32	2.5B	5	8	Translucent turquoise with some bubbles relatively transparant.
	33	7.5Y	8.5	10	Opaque yellow. Opacity due to yellow particles.
	34	2.5G	8	2	Opaque white opacified with white particles.
	39	5YR	6	12	Very degraded translucent brown.
	42	10R	4	6	Opaque red. Colour and opacity due to copper or cuprous oxide particles.
68	1	5YR	6	8	Opaque orange. Colour and opacity due to copper or cuprous oxide particles.
	2	5Y	8	12	Opaque yellow. Colour and opacity due to yellow particles.
	4	5G	6	6	Translucent green with some white particles.
	5	5Y	8.5	12	Opaque yellow. Colour and opacity due to yellow particles.

Grave	No	Hue (H)	Value (V)	Chrome (C)	Description
68	6	2.5G	3	2-4	Dark turquoise, partially opacified by a high density of bubbles.
	7	10BG	3	4	
	8	7.5G	7	6	Translucent green with opaque white and some yellow particles.
	10	10G	9	1	Opaque white. Pale green(?) glass opacified by a high density of white particles.
	12	10G	9	1	"
	14	10BG	4	6	Dark turquoise, partially opacified by a high density of bubbles.
	16	2.5B	4	6	"
	20	5RR	5	8	Opaque red. Colour and opacity due to copper or cuprous oxide particles.
96	15	5YR	6	10	Opaque orange. Colour and opacity due to copper or cuprous oxide particles.
	16	5YR	6	10	
	17	5B	3	4	Translucent turquoise, partially opacified by bubbles.
	18	7.5R	4	6	Opaque red. Colour and opacity due to copper or cuprous oxide particles.
96	21	2.5G	4	6	Translucent green partially opacified by yellow and white particles.

Grave	No	Hue (H)	Value (V)	Chrome (C)	Description
96	23	10GY	5	4	Translucent green, partially opacified by by white particles.
	24	5G	9	1	Opaque white. Pale green(?) glass opacified by white particles.
	25	7.5GY	7	2	"
	29	2.5B	3	2-4	Translucent turquoise, partially bubble opacified.
	30	5GY	7	2	Opaque white. Pale green(?) glass opacified by white particles and bubbles.
	36	10R	4	6	Opaque red. Colour and opacity due to copper or cuprous oxide particles.
	39	2.5B	3	4	Translucent turquoise, partially bubble opacified.
	40	10GY	5	8	Translucent green, partially opacified by white and yellow particles.
	41	5BG	5	6	Translucent turquoise, partially opacified by white particles.
	43	2.5Y	7	10	Opaque yellow. Colour and opacity due to yellow particles.
	44	2.5G	5	8	Translucent green, partially opacified by white and yellow particles.
	46	5Y	8	12	Opaque yellow. Colour and opacity due to yellow particles.

Grave	No	Hue (H)	Value (V)	Chrome (C)	Description
96	47	5B	3	4	Translucent turquoise, partially bubble opacified.
	50	7.5GY	5	6	Translucent green, partially opacified by white and yellow particles.
	51	10R	4	6	Opaque red. Colour and opacity due to copper or cuprous oxide particles.
	52	2.5G	9	2	Clear.
120	7	5B	4	6	Translucent turquoise, partially opacified by white and bubbles.
	9	5GY	7	8	Transparent green.
124	9	7.5R	4	8	Opaque red. Colour and opacity due to copper or cuprows oxide particles.
124	10	10GY	5	8	Translucent green, partially opacified by bubbles and yellow particles.
	14	5BG	9	1	Opaque white. pale green (?) glass opacified by white particles.
	15	2.5G	5	8	Translucent green, partially opacified by yellow and white particles.
138	19	5G	4	6	Translucent green, partially opacified by white particles.

Grave	No	Hue (H)	Value (V)	Chrome (C)	Description
138	22	5R	4	8	Opaque red. Colour and opacity due to copper or cuprous oxide particles.
	30	10GY	4	4	Translucent green, partially opacified by white and yellow particles.
	34	10R	4	6	Opaque red. Colour and opacity due to copper or cuprous oxide particles.
	36	10BG	4	4	Translucent turquoise with red streaks, partially opacified by yellow and white particles.
	39	10GY	4	4	"
	41	7.5PB	4	12	Translucent blue.
	42	10BG	3	4	Translucent turquoise, partially bubble opacified.
	45	2.5GY	8	2	Opaque white. Pale green(?) glass opacified by white particles
	49	2.5GY	8	2	"
	51	10BG	3	4	Translucent turuoise, partially bubble opacified.
	59	5PB	3	4	Translucent blue, partially opacified by white particles.
	61	7.5PB	3	8	Translucent blue.
	62	7.5R	4	2	Opaque red, opacity and colour due to copper or cuprous oxide particles.

Grave	No	Hue (H)	Value (V)	Chrome (C)	Description
138	68	5B	3	6	Translucent turquoise, partially opacified by bubbles.
157	10	5YR	6	10-12	Opaque orange. Colour and opacity due to copper or cuprous oxide particles.
174	8	7.5R	4	6	Opaque red. Colour and opacity due to copper or cuprous oxide particles.
	10	5BG	9	2	Transparent pale turquoise, with some bubbles.
	18	10B	6	4	Translucent blue, partially opacified with white particles.
	19	10Y	8	4	Transparent green, with some bubbles.
197	1	10BG	2.5	2	Translucent dark turquoise, partially opacified by a high density of bubbles.
	3	10BG	2.5	2	"
	4	10BG	2.5	2	"
	7	7.5BG	3	4	"

Appendix 2 - Physical characteristics of the polychrome beads analysed

Grave	Find No.	Colour	Munsell No. H	V	C	Comments
35	1	White	-	-	-	Opaque white spiral in a translucent
		Green	5G	3	2	green glass (with some red streaks)
57	28	Red	7.5R	3	4	Opaque yellow spots marvered into
		Yellow	5Y	8	10	red matrix glass
	44	Pale turquoise	10B	6	4	Translucent turquoise trail and
		Turquoise	5B	5	4	opaque red spots in an opaque pale
		Red	7.5R	4	8	turquoise matrix. White particles in turquoise and pale turquoise. Pale turquoise quite bubbly.
	52	Red	7.5R	3	4	Opaque yellow spots in opaque red
		Yellow	5Y	8	12	matrix
	55	Pale turquoise	7.5Y	8.5	2	As 57-44 , except no white particles
		Red	7.5R	4	8	in remaining turquoise glass
		Turquoise	10B	6-7	6-8	
62B	23	Black	-	-	-	Opaque black bead with a translucent
		Turquoise	7.5BG	6	4	turquoise trail
	27	Turquoise	10BG	4	2	Opaque white spiral trail in a
		White	2.5GY	8	2	translucent turquoise matrix
	40	Turquoise	5BG	3	4	As 62B-27
		White	7.5GY	8	2	
83	2	Light blue	5PB	7-8	4	Opaque yellow spots in an opaque
		Yellow	2.5Y	8	12	light blue matrix. Opacity of blue due to bubbles and the thickness of the bead.
157	8	Orange	5YR	7	2	Opaque orange with red streaks
		Red	7.5R	5	10	

Appendix 3 - XRF peak heights normalised to silicon (SiK_{α} =1), monochrome beads.

Grave	Find	Colour	TiK_{α}	MnK_{α}	FeK_{α}	Co	CuK_{α}	ZnK_{α}	PbL_{α}	SnK_{α}	SbK_{α}
34	4a	Turquoise	0.03	0.02	0.31	-	3.27	0.48	1.32	0.02	-
	4b	Turquoise	0.02	0.02	0.37	-	3.45	0.57	1.45	0.02	-
	4c	Turquoise	0.02	?	0.40	-	3.20	0.51	1.41	0.02	-
	4d	Turquoise	0.01	0.03	0.40	-	3.20	0.52	1.37	0.02	-
	4e	Turquoise	0.03	0.02	0.64	-	3.24	0.55	1.36	0.03	-
57	18	Green	0.03	?	0.48	-	0.91	3.89	0.03	-	
	54	Blue	0.07	0.26	0.63		0.13	0.05	0.02	-	?
	60	White	0.03	0.03	0.48	-	0.08	0.06	1.74	0.28	-
	66	Green	0.54	tr	0.71	-	1.52	0.20	2.92	0.04	-
	68	Green	0.29	?	0.50	-	1.41	0.14	3.28	0.05	-
	69	Green	0.58	?	0.50	-	1.39	0.39	3.14	0.04	-
	70	Turquoise	0.33	?	0.55	-	1.49	0.20	2.79	0.04	-
	73	Green	0.21	?	0.44	-	1.44	0.17	2.24	0.04	-
	79	Blue	0.09	0.19	0.72		0.22	0.05	0.40	-	-
	80	Red	0.35	0.01	3.63	-	1.60	0.25	0.59	0.02	-
	82	Turquoise	0.14	?	0.71	-	1.20	0.14	0.46	0.04	-
	85	Red	1.18	0.08	3.80	-	1.10	0.23	0.71	0.10	-
	86	White	0.17	?	0.32	-	0.11	0.08	2.51	0.19	-
	88	Red	0.43	tr	2.76	-	2.9	0.88	0.99	0.01	-
	91	Green	0.53	?	0.81	-	1.62	0.42	2.51	0.05	-
62B	15	White	x	01.16	0.62	x	0.16	0.11	0.92	0.51	x
	16	Blue	0.03	0.15	0.74	?	0.25	x	x	0.50	x
	21	Green	0.08	0.61	0.90	x	x	0.08	0.07	x	x
	25	Orange	0.07	0.14	0.81	x	22.63	x	0.20	x	x
	29	Turquoise	0.02	0.02	0.26	x	3.36	0.26	1.29	0.07	x
	30	Yellow	0.02	0.05	0.29	x	0.05	x	6.17	0.22	x
	31	Green	0.05	0.21	0.35	x	1.65	0.19	2.66	0.07	0.04

Grave	Find No	Colour	TiK$_\alpha$	MnK$_\alpha$	FeK$_\alpha$	Co	CuK$_\alpha$	ZnK$_\alpha$	PbL$_\alpha$	SnK$_\alpha$	SbK$_\alpha$
	32	Turquoise	0.03	x	0.38	x	1.04	0.31	x	0.12	x
	33	Yellow	0.04	0.05	0.37	x	0.05	x	5.53	0.15	x
	34	White	0.04	0.06	0.71	x	x	x	1.55	0.35	x
	39	Brown	0.13	0.17	3.93	x	0.03	x	x	x	x
	42	Red	0.12	0.16	4.86	-	0.98	0.48	3.75	0.24	-
68	1	Orange	0.74	0.13	1.33	-	22.09	?	0.53	0.03	-
	2	Yellow	0.10	0.05	1.26	-	0.06	-	8.18	0.15	?
	4	Green	0.22	0.04	1.38	-	1.00	-	3.22	0.09	-
	5	Yellow	0.53	0.04	0.89	-	0.03	-	7.85	0.13	?
	6	Turquoise	0.76	0.10	1.54	-	2.02	0.51	0.98	0.02	0.02
	7	Turquoise	0.23	0.11	0.96	-	1.94	0.51	0.09	0.02	0.02
	8	Green	0.73	0.01	0.89	-	1.13	-	3.23	0.09	-
	10	White	0.23	0.02	0.37	-	0.07	-	0.75	0.38	-
	12	White	0.12	0.03	0.57	-	0.07	0.02	1.93	0.45	-
	14	Turquoise	0.59	0.06	0.93	-	2.61	0.23	1.04	0.04	-
	16	Turquoise	0.51	0.08	0.75	-	2.12	0.17	0.89	0.02	-
	20	Red	0.35	0.10	5.46	-	5.89	0.83	1.76	0.05	-
96	15	Orange	0.08	0.50	1.97	-	14.76	-	0.13	-	-
	16	Orange	0.38	0.03	1.42	-	18.64	tr	0.06	-	-
	17	Turquoise	0.54	?	1.23	-	1.82	0.25	0.58	0.05	-
	18	Red	0.11	0.02	3.84	-	1.94	0.49	2.66	0.10	-
	21	Green	0.25	?	1.51	-	2.00	0.64	3.29	0.11	-
	23	Green	0.12	tr	1.87	-	1.90	0.50	4.76	0.13	-
	24	White	0.39	tr	0.88	-	0.19	0.16	0.80	0.29	-
	25	White	0.51	0.07	1.03	-	0.23	0.16	1.99	0.23	-
	29	Turquoise	0.35	?	0.54	-	2.56	0.18	1.10	0.03	-
	30	White	0.21	0.07	1.03	-	0.20	0.15	1.33	0.19	-
	36	Red	0.21	0.16	1.92	-	1.16	0.28	0.58	0.04	-

Grave	Find No	Colour	TiK$_\alpha$	MnK$_\alpha$	FeK$_\alpha$	Co	CuK$_\alpha$	ZnK$_\alpha$	PbL$_\alpha$	SnK$_\alpha$	SbK$_\alpha$
	59	Blue	0.04	0.04	0.74		0.32	0.09	0.84	–	
	61	Blue	0.04	0.18	0.74		0.25	0.10	tr	?	?
	62	Red	0.03	0.07	6.32	–	1.98	0.77	10.2	0.25	–
	68	Turquoise	0.04	tr	0.75	–	1.66	0.47	0.56	tr	–
157	10	Orange	0.04	0.04	0.94	–	21.96	0.20	0.15	0.03	–
174	8	Red	0.02	0.05	1.70	–	1.82	0.70	1.85	0.02	–
	10	Turquoise	0.02	0.10	0.54	–	0.17	0.01	0.02	–	0.07
	18	Blue	0.03	0.08	0.96	?	0.21	0.29	0.42	0.38	–
	19	Green	0.03	0.81	0.71	–	0.15	–	–	–	–
197	1	Turquoise	0.01	0.04	0.46	–	3.36	0.60	1.52	0.03	–
	3	Turquoise	0.01	0.02	0.77	–	4.84	0.79	2.09	0.04	–
	4	Turquoise	0.01	0.05	0.64	–	4.39	0.76	1.94	0.05	–
	7	Turquoise	0.05	0.04	0.65	–	2.83	0.45	1.34	0.20	–

Appendix 4 - Analytical Results for Polychrome Beads

Grave	Find No	Area Analysed	TiK_{α}	MnK_{α}	FeK_{α}	Co	CuK_{α}	ZnK_{α}	PbL_{α}	SnK_{α}	SbK_{α}
35	1	Green	tr	-	1.50	-	6.62	tr	4.70	0.08	-
		White stripe (+ green)	tr	?	1.37	-	4.56	tr	4.60	0.15	-
57	28	Red (+ yellow)	?	0.46	6.73	-	2.89	0.88	3.81	0.33	-
		Yellow (+ red)	tr	0.48	6.30	-	1.99	0.91	5.04	0.36	-
	44	White (opaque)	0.22	1.00	3.70	-	0.68	0.57	3.65	1.66	-
		White + Turquoise (translucent)	0.15	0.71	2.67	-	0.52	0.24	2.57	1.08	-
		White + Red	0.17	0.77	2.86	-	0.63	0.26	2.03	1.05	-
	52	Red (+ yellow)	tr	0.33	5.29	-	2.07	0.59	1.50	0.24	-
		Yellow (+ red)	tr	0.49	6.01	-	1.90	0.86	4.81	0.34	-
	55	White	0.18	1.57	3.45	-	0.45	0.30	4.92	1.56	-
		White + Turquoise	0.17	1.45	2.99	-	0.43	0.26	4.15	1.35	-
		White + Red	0.27	2.15	4.73	-	1.21	0.83	5.68	1.74	-
62B	23	Black	0.01	1.20	6.50	-	0.04	x	x	x	x
		Black + Turquoise	0.02	0.68	4.68	-	2.27	x	0.32	x	0.20
	27	Turquoise + White	0.12	0.44	1.05	-	1.53	0.40	1.93	0.32	-
	40	Turquoise + White	3.21	0.30	0.24	-	2.17	0.80	3.99	0.30	-
83	2	Light Blue	-	1.08	3.91	-	0.26	0.19	?	-	0.68
		Light Blue + Yellow	tr	1.17	1.08	-	0.25	0.19	1.12	-	0.89
157	8	Orange + Red	0.03	0.047	0.61	-	23.78	0.25	0.17	0.033	-