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Analysis of Variance (ANOVA) of G-BASE Sub-Surface Soil Data from 11 Urban Centres in England and Wales

G-BASE

Internal Report IR/02/009

BRITISH GEOLOGICAL SURVEY

INTERNAL REPORT IR/02/009

Analysis of Variance (ANOVA) of G-BASE Sub-Surface Soil Data from 11 Urban Centres in England and Wales

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Key words

Analysis of variance, distribution, duplicates

Bibliographical reference

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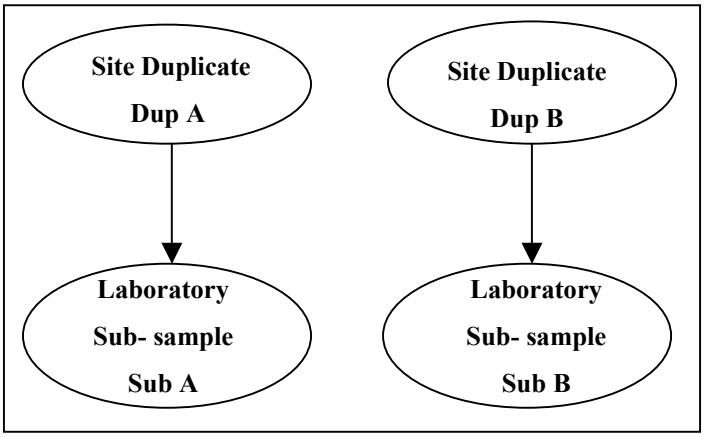
1 Introduction

The G-BASE (Geochemical Baseline Survey of the Environment) programme of the British Geological Survey has collected soil samples throughout a number of urban centres in England and Wales. Surface (0.05m – 0.15m) and sub-surface (0.40m – 0.50m) samples were collected according to a schematic grid pattern, with a density of four samples per square kilometre. At one sample site in each discrete batch of 100 samples, a site sample duplicate was collected. Each of the duplicate pair was subsequently sub-sampled at the sample preparation laboratory to produce a replicate set of four samples for each duplicate site. (Figure 1.)

Figure 1. Sample replicate methodology



All samples, including duplicates and replicates, were routinely analysed in the BGS laboratories by wavelength-dispersive X-ray fluorescence, for a total of 16 major and trace elements.

In order to quantify sampling and analytical precision, analysis of variance (ANOVA) was carried out on the replicate data. For sub-surface samples, a total of 50 replicate sets, collected from 11 different urban centres, were used in the ANOVA calculations. The procedures carried out for the sub-surface soils are detailed in this report. Replicate site data is unavailable at present in order to carry out a similar study on surface soils. Table 1 shows the distribution of replicate sites throughout the urban centres.

Table 1. Distribution of replicate sites.

Urban Centre	Laboratory Number	Number of Replicates Sites
Cardiff	5029 & 5030	8
Swansea	5031	4
Stoke	5009 & 5011	14
Telford	5032	6
York	5035	2
Hull	5033	4
Doncaster	5457	3
Mansfield	5658	2
Scunthorpe	5034	1
Lincoln	5659	2
Sheffield	5458 & 5459	4

2 Sample Collection

Samples included in this study were collected from a number of urban centres in South Wales, West, East, and Central England (Cardiff, Swansea, Stoke-on-Trent, Telford, York, Hull, Doncaster, Mansfield, Scunthorpe, Lincoln and Sheffield). Samples were collected on a regular grid, at a density of 4 samples per square kilometre. Within the urban centres, each 1km grid square (on 1:25k Ordnance Survey maps) was divided into 500m x 500m quadrangles. Sample sites were located as closely as possible to the centre of each quadrangle. At each sample site, a composite sample from three separate auger holes, along a diagonal line within a 2m x 2m square, was collected by drilling with a 1m hand auger. Common sites for collection included gardens, parks, road verges, allotments, open spaces, school playing fields and waste ground etc.

Within each batch of 100 samples, a set of field duplicate samples was collected within 2 m of the original samples using identical methodology.

3 Sample Preparation & Analysis

Samples were air dried prior to sieving to <150µm for sub-surface soils. All samples were then coned and quartered, and a 30g sub-sample ground in an agate planetary ball mill until 95% was <53 µm. The pulverised material was further sub-sampled to obtain portions for analysis.

Total major and trace element concentrations in soil samples were determined at the BGS by Wavelength Dispersive X-ray Fluorescence Spectrometry (WD-XRF) (Ingham & Vrebos 1994). XRF pellets were prepared by grinding 12g of milled sample and 3g of Elvacite 2013 binder (n-butyl methacrylate copolymer, Dupont & Co) in an agate planetary ball mill for 30 minutes. The ground mixture was then pressed under a 25 ton load into 40 mm diameter pellets.

Three sequential XRF spectrometers were used: a Philips model PW1480 and two Philips' model PW2400. The PW1480 spectrometer was fitted with a 216 position sample changer and a 3 kW/100 kV tungsten anode x-ray tube and was used to determine Cd, Sn and Sb.

Both PW2400 spectrometers had 102 position sample changers and were fitted with 3 kW/60 kV rhodium anode x-ray tubes and were used to determine MnO, Fe_2O_3, V, Cr, Co, and Ba as one suite and Ni, Cu, Zn, As, Mo, Pb, and U as another.

Lower limits of detection (LLD) and upper and lower reporting limits (URL and LLR) are shown in

Table 2. The quoted LLDs are theoretical values for the concentration equivalent to three standard deviations above the background count rate for the analyte in a silica matrix. High instrumental stability results in practical values for these materials approaching the theoretical.

Table 2. Lower limits of detection and upper and lower limits of reporting WD-XRF.

Analyte	LLD (µg/g)	LLR (%)	ULR (µg/g)	ULR (%)
MnO	-	0.010	-	10.0
Fe_2O_3	-	0.01	-	100.0
V	2	-	20000	-
Cr	3	-	250000	-
Co	2	-	10000	-
Ba	3	-	600000	-
Ni	1	-	4000	-
Cu	1	-	6500	-
Zn	1	-	10000	-
Mo	1	-	1000	-
Pb	1	-	10000	-
As	1	-	10000	-
U	1	-	650	-
Cd	1	-	500	-
Sn	1	-	10000	-
Sb	1	-	10000	-

4 Data Validation

As a preliminary check, the analyses of the field sample and laboratory split were plotted against each other to highlight any errors, such as mis-labelling, introduced during splitting of the sample. Correlation plots of the field duplicate pair (Duplicate A and Duplicate B) were also generated.

Figures 2a – 4p show the results of these plots for each of the 16 elements reported.

In order to be able to carry out ANOVA, the normality of the data distribution was firstly investigated.

A combination of percentile rank plots, box and whisker plots, and histograms (figures 5a – 5p) were used to determine the distribution of each element. In most cases (U and Cd being the only exceptions) the data are not normally distributed, but are skewed. Data were therefore log-transformed, and the subsequent plots show each element distribution to be much closer to that of a Gaussian distribution. (Plant et al., 1975). To reduce skewness, prior to transformation, the highest and lowest values in the dataset were removed.

5 ANOVA

A random nested model of ANOVA was selected, since all the analyses form part of a single randomised dataset (Snedecor & Cochran, 1989). The NESTED procedure from the MINITAB^{TM} statistical software package was used to perform the ANOVA.

Within-sample variance (represented by multiple components including inhomogeneities introduced during sample handling and preparation, and analytical errors), between-sample variance (representing within-site variation and any variation incorporated during collection of the sample) and between-site variance (the natural distribution of elements in profile soils) were calculated.

Because the frequency distribution of most elements is multi-modal and none fit the Gaussian model perfectly, there is an unquantifiable overstatement of the between-site variance - a problem that is inherent in using ANOVA on geochemical data.

Statistical F-tests have not been quoted because the data do not satisfy this and other assumptions required for formal analysis of variance.

Table 3 shows the percentage of variance attributable to each of the three components of variance described above. This gives a good indication as to the integrity of the sampling methodology. Complete ANOVA calculations for each element are contained in Appendix A.

Table 3. Percentage of variance in urban sub-surface soil samples attributable to between-site, between-sample and within-sample variance. All data log-transformed with the exception of U and Cd.

Element	Between Site (%)	Between Sample (%)	Within Sample (%)
MnO	96.03	3.92	0.05
Fe_2O_3	96.62	3.36	0.01
V	97.85	2.09	0.06
Cr	93.46	5.55	0.99
Co	94.00	5.62	0.38
Ba	97.39	2.56	0.05
Ni	95.96	3.83	0.21
Cu	98.87	1.08	0.06
Zn	92.64	7.34	0.02
Mo	93.59	3.23	3.17
Pb	96.51	3.43	0.06
As	97.87	1.82	0.31
U	76.92	10.99	12.09
Cd	65.44	3.95	30.61
Sn	95.77	2.42	1.81
Sb	87.68	3.05	9.27

6 Discussion

Figures 2a – 3p show the generally good correlation (>0.9) between site samples and laboratory sub-samples, indicating that no errors were introduced during the sub-sampling stage. Relatively poor correlation for U (fig. 2m; 3m) may be due to analytical imprecision, and that in Cd (fig. 2n; 3n) is due to the low concentration with respect to the lower limit of detection of the analytical method employed.

It is also likely that the integer reporting interval of data for Cd , obvious from fig. 5n, significantly affects the correlation.

Figures 4a- 4p also show extremely good correlation (>0.86) between the site duplicate samples, showing that the correct pairs of samples have been identified, and no numbering or mis-labelling errors have been introduced. The major discrepancy observed is in data for Sn (fig. 4o). One pair of field duplicates show significantly different results between the Dup A (607 ppm) and Dup B (250 ppm) samples. This is most likely due to site contamination, causing local inhomogeneity of the soil. Less significant outliers occur in Pb (fig.4k) and Sb (fig. 4p). The effect of these outliers on the ANOVA calculation is, however, almost negligible once data have undergone log-

transformation. Once again, relatively poor correlation for U(fig. 4m) and Cd (fig. 4n) is due to analytical imprecision in the case of U, and the low concentration with respect to the lower limit of detection in the case of Cd.

Figures 5a – 5p show that after log-transformation, the majority of elements in this study trend towards a Gaussian distribution.

Of the 16 elements analysed, results of the ANOVA show that data for MnO, Fe_2O_3, V, Cr, Co, Ba, Ni, Cu, Zn, Mo, Pb, As and Sb can be treated with a high degree of confidence. The ANOVA results for Sn show a higher component of between-sample variance in comparison to other elements, indicating that concentrations of Sn in sub-surface soils are less continuous.

In the instance of U, the high proportion of within-sample variance (12.09%) is indicative of an analytical problem with this element. The generally low concentrations of Cd in the samples collected occur near to or below the lower limit of detection of the analytical method employed. As a consequence of this, the relative error introduced becomes very significant in relation to the overall range of concentration of Cd. This is supported by the large component of within-sample variance (30.61%) shown in Table 2, which is mostly attributable to analytical noise.

7 Overall Conclusion

The results of the ANOVA indicate that the sampling methodology employed in the collection of sub-surface soils in urban environments is robust and of high integrity. With the exception of U and Cd, the data can be treated with a high degree of confidence. The generally low variance attributable to between-sample and within-sample components suggests that in the urban environment, the major variation in sub-surface soils is due to the natural distribution of the elements.

Figures 2a – 2h. Correlation plots for duplicate A versus sub-sample A. Elements MnO - Cu.

Fig. 2a

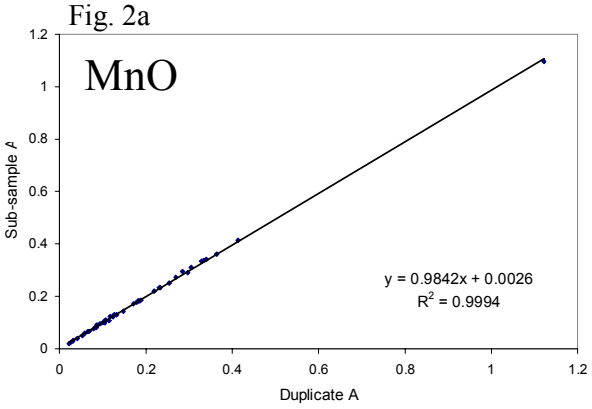


Fig. 2b

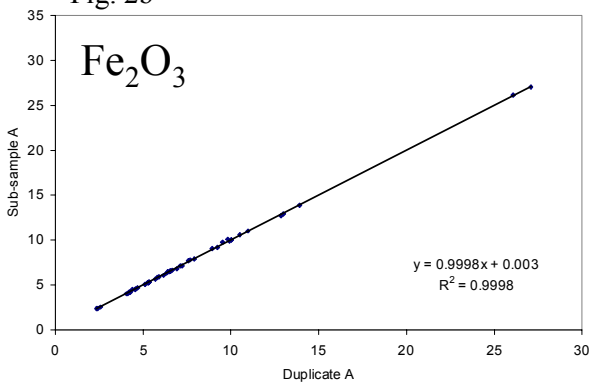


Fig. 2c

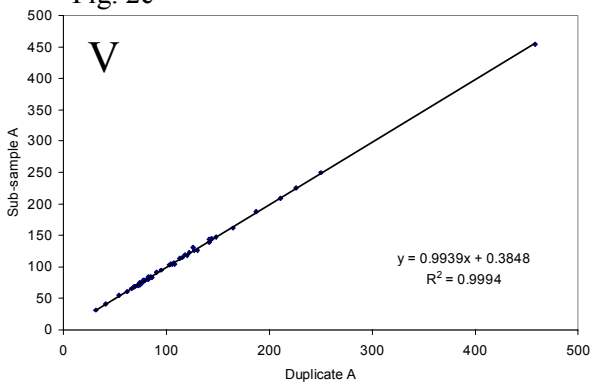


Fig. 2d

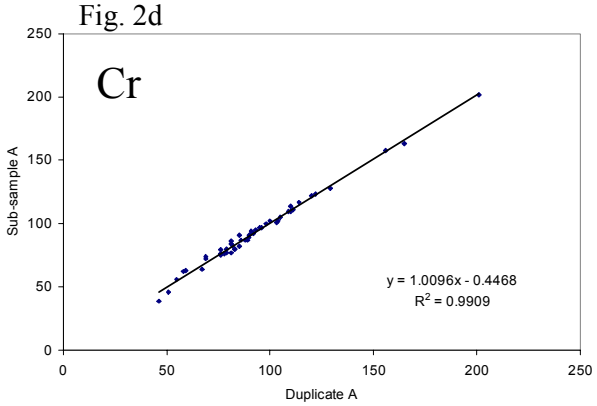


Fig. 2e

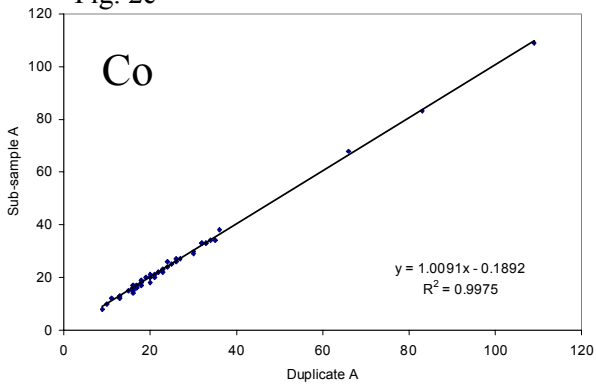


Fig. 2f

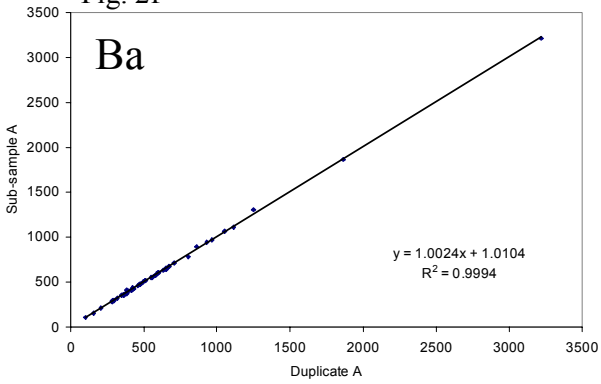


Fig. 2g

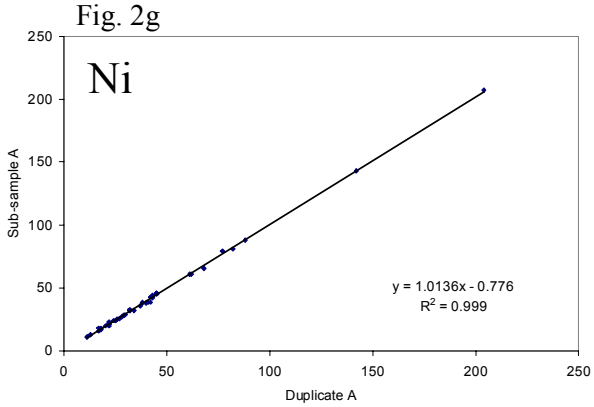
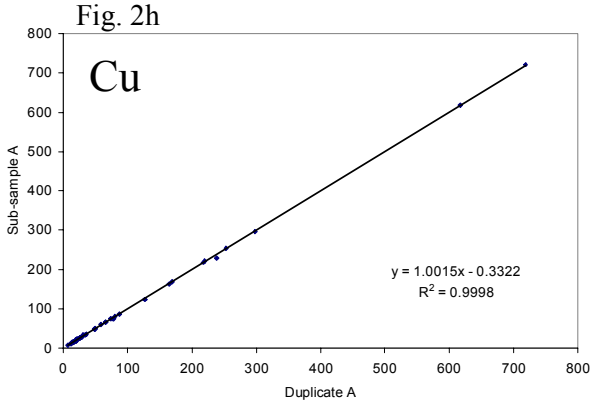


Fig. 2h



Figures 2i – 2p. Correlation plots for duplicate A versus sub-sample A. Elements Zn - Sb.

Fig. 2i

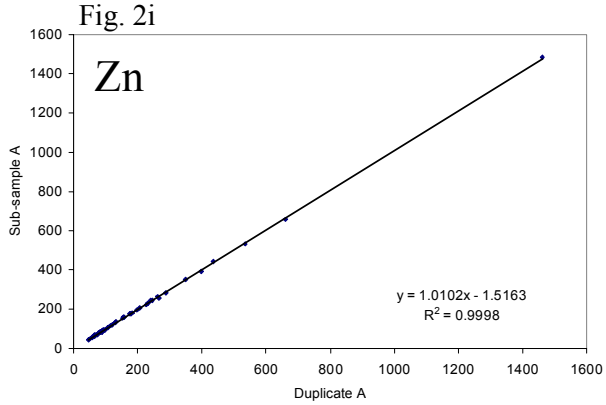


Fig. 2m

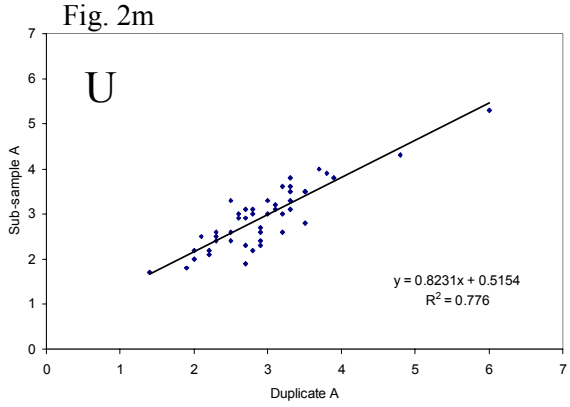


Fig. 2j

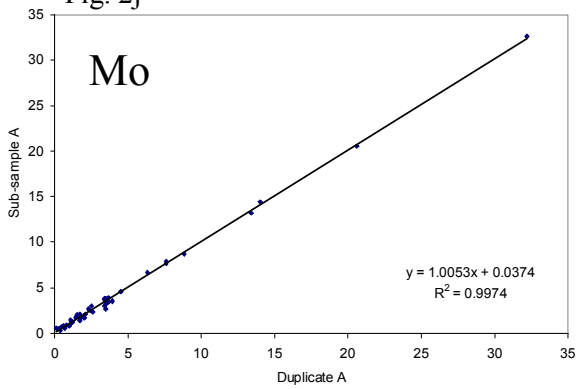


Fig. 2n

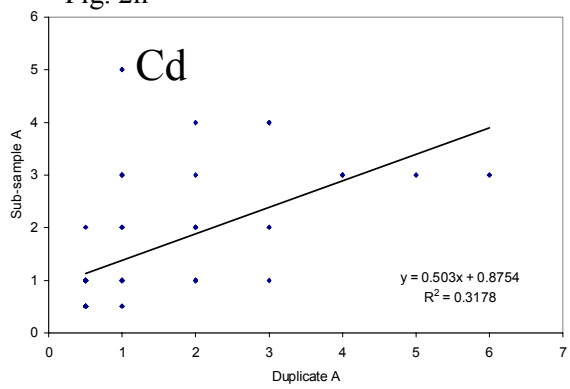


Fig. 2k

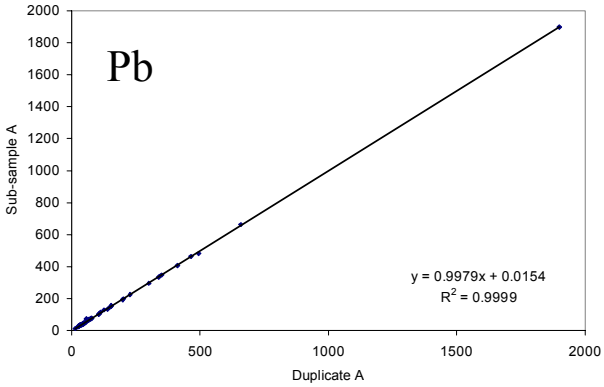


Fig. 2o

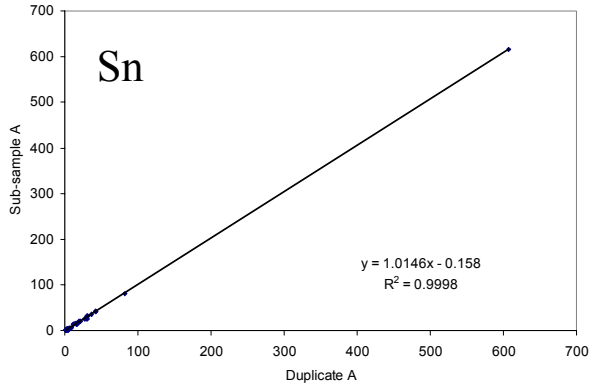


Fig. 2l

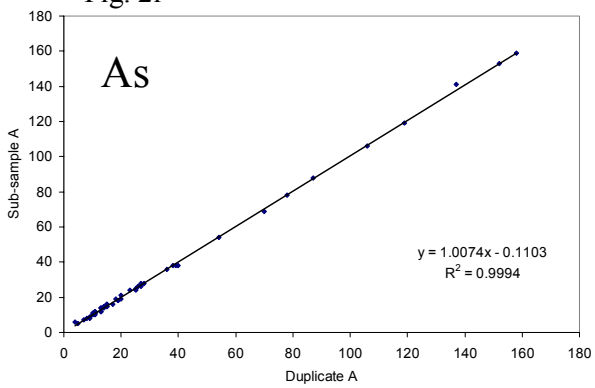
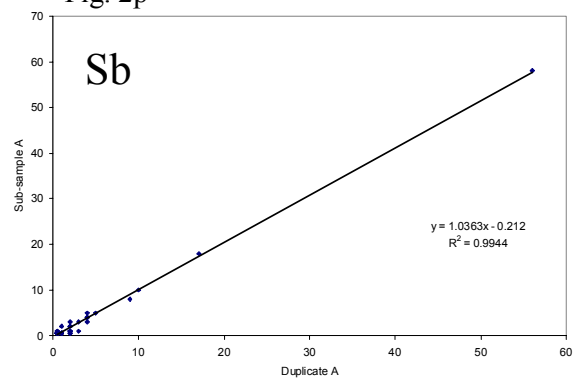


Fig. 2p



Figures 3a – 3h. Correlation plots for duplicate B versus sub-sample B. Elements MnO - Cu.

Fig. 3a

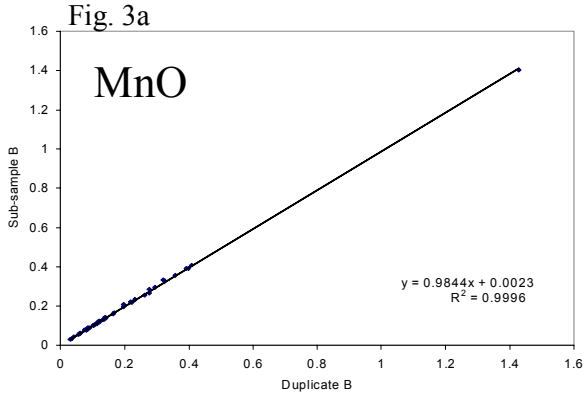


Fig. 3b

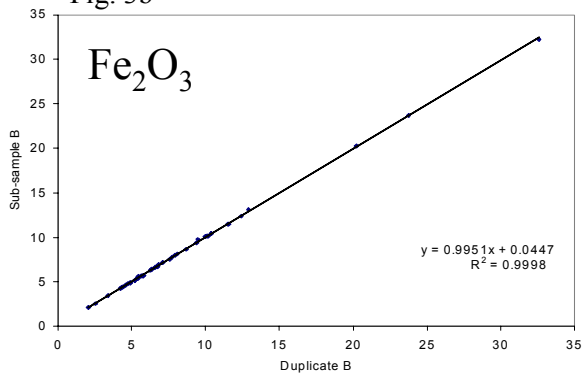


Fig. 3c

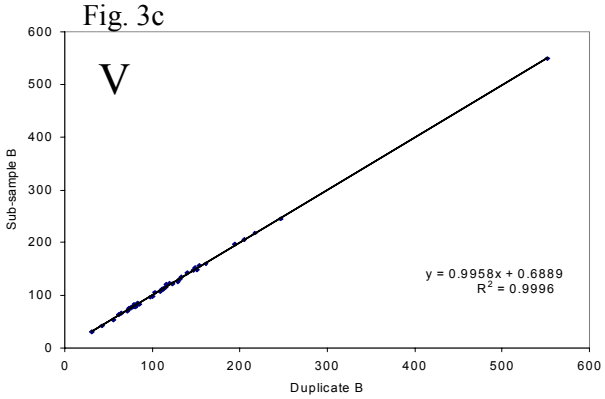


Fig. 3d

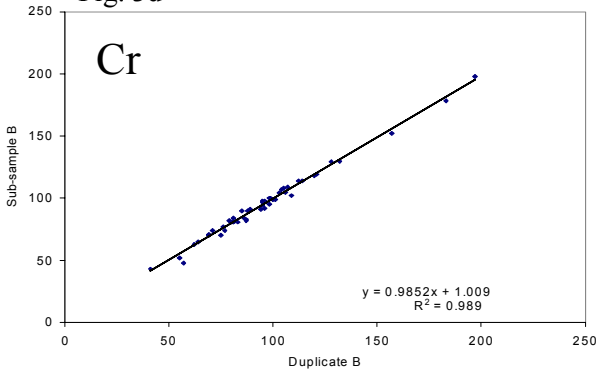


Fig. 3e

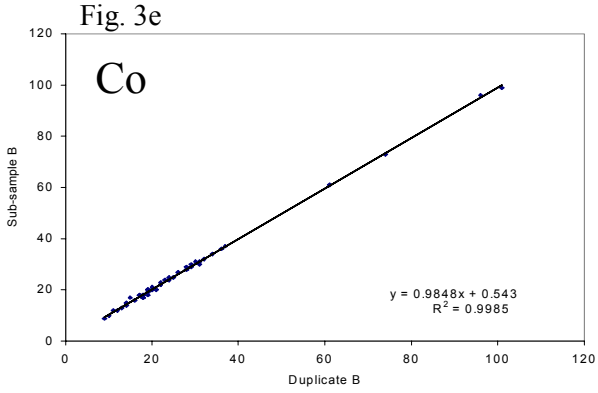


Fig. 3f

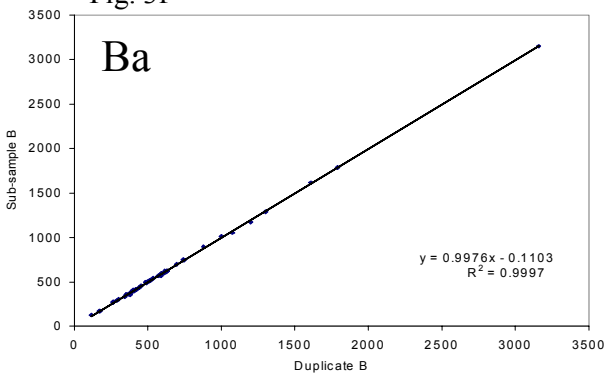


Fig. 3g

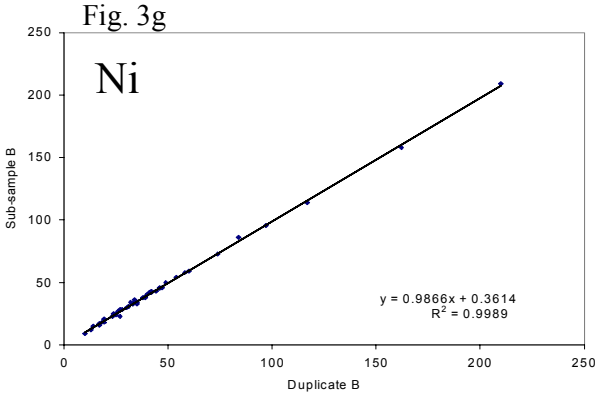
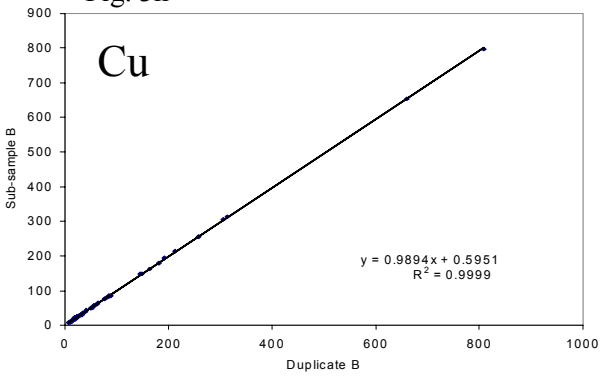


Fig. 3h



Figures 3i – 3p. Correlation plots for duplicate B versus sub-sample B. Elements Zn - Sb.

Fig. 3i

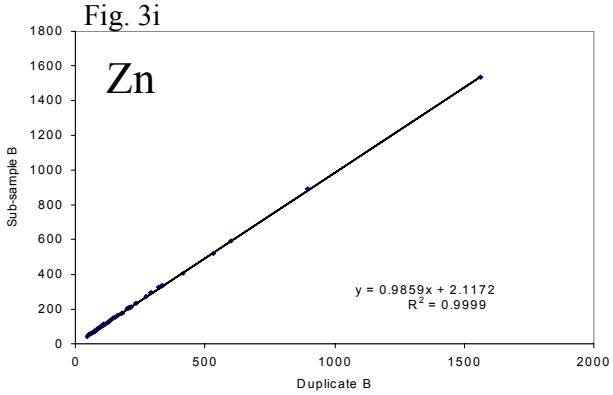


Fig. 3j

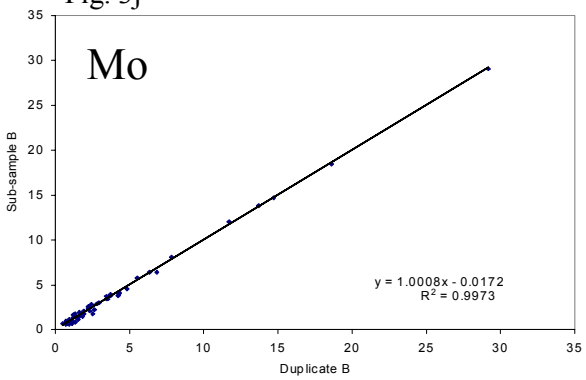


Fig. 3k

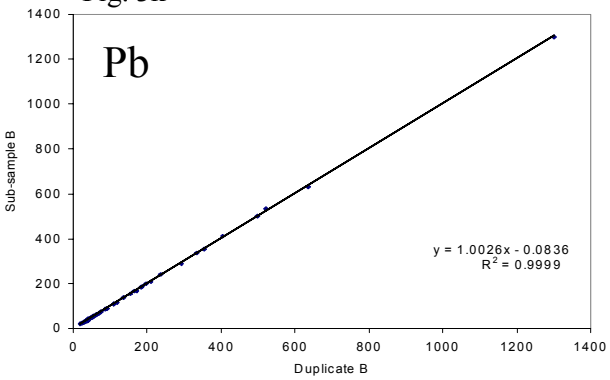


Fig. 3l

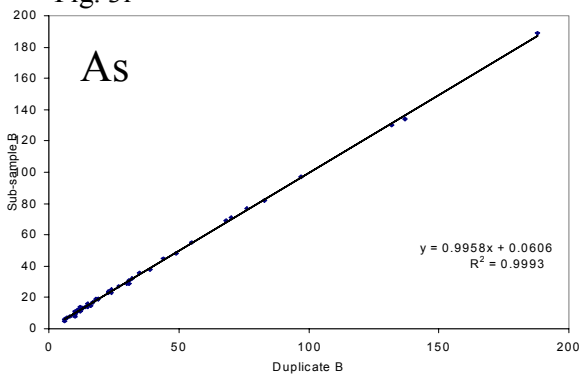


Fig. 3n

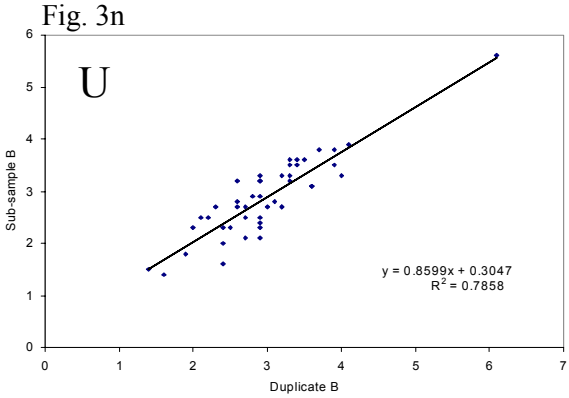


Fig. 3m

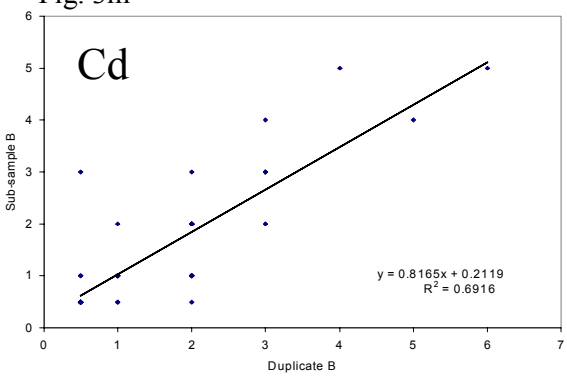


Fig. 3o

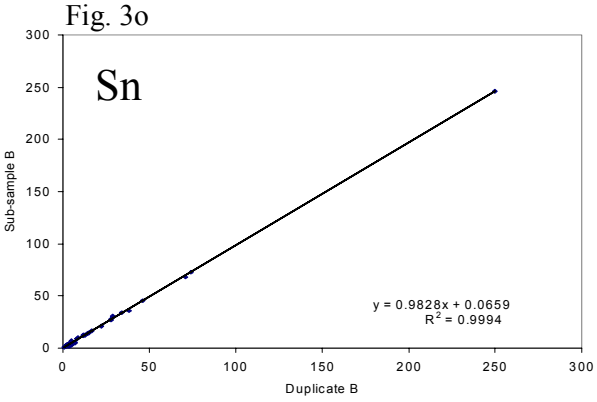
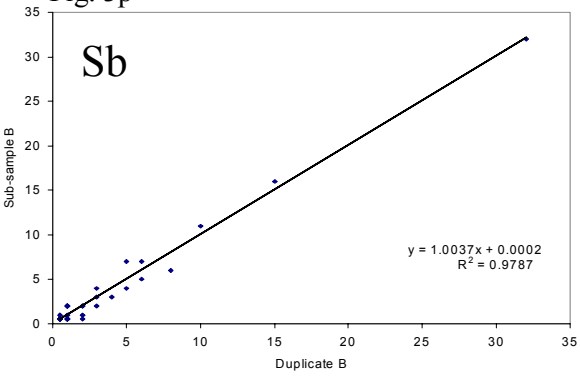


Fig. 3p



Figures 4a – 4h. Correlation plots for duplicate A versus duplicate B. Elements MnO - Cu.

Fig. 4a

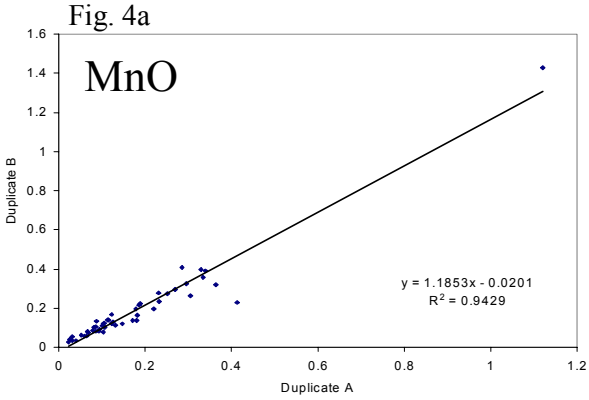


Fig. 4b

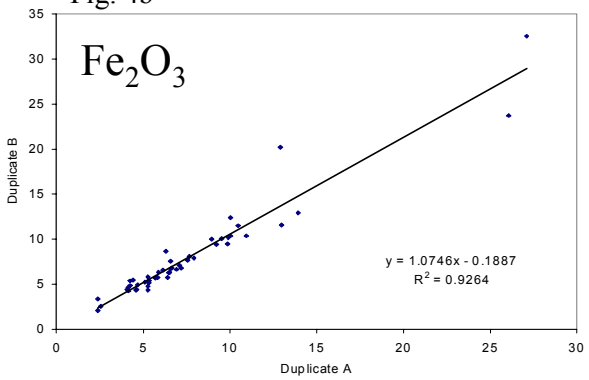


Fig. 4c

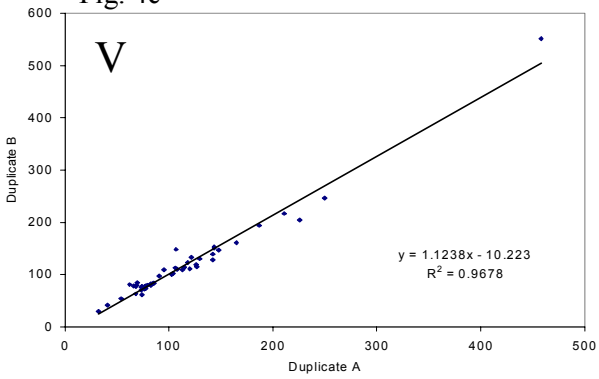


Fig. 4d

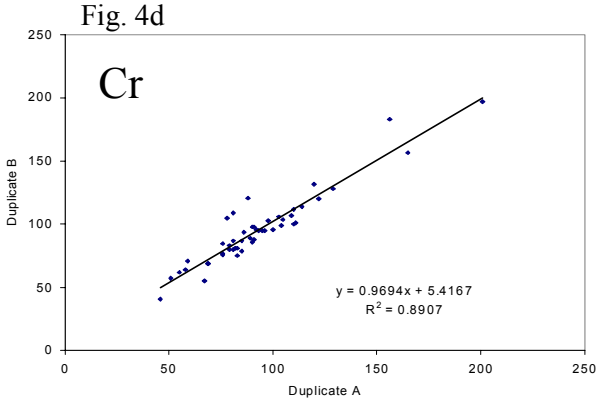


Fig. 4e

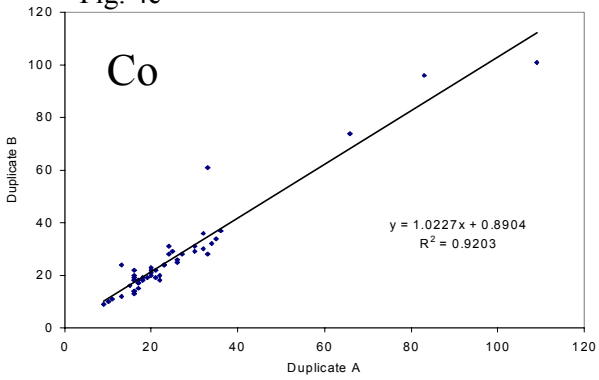


Fig. 4f

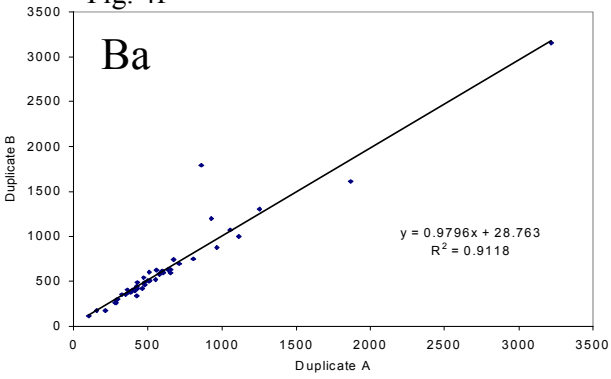


Fig. 4g

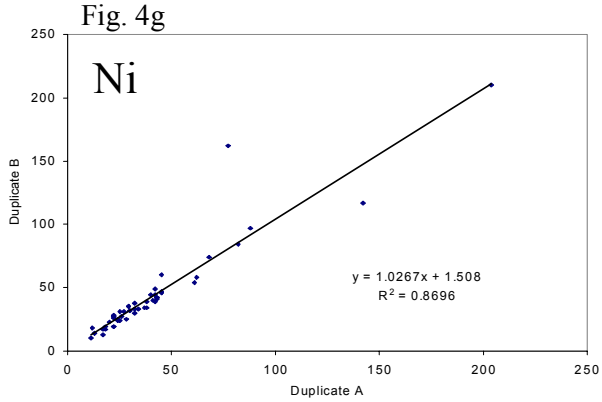
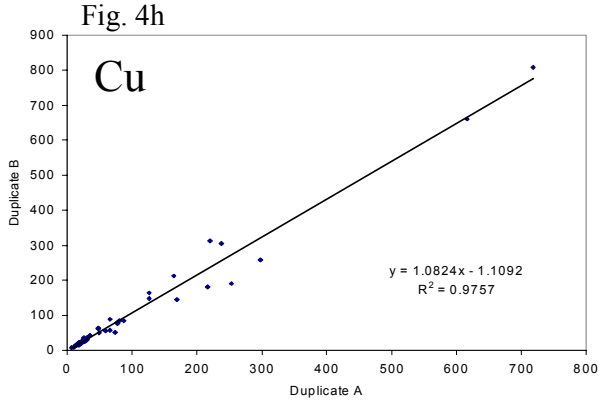


Fig. 4h



Figures 4i – 4p Correlation plots for duplicate A versus duplicate B. Elements Zn - Sb.

Fig. 4i

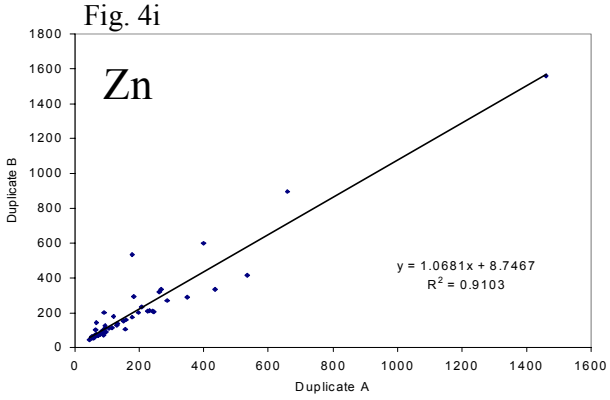


Fig. 4m

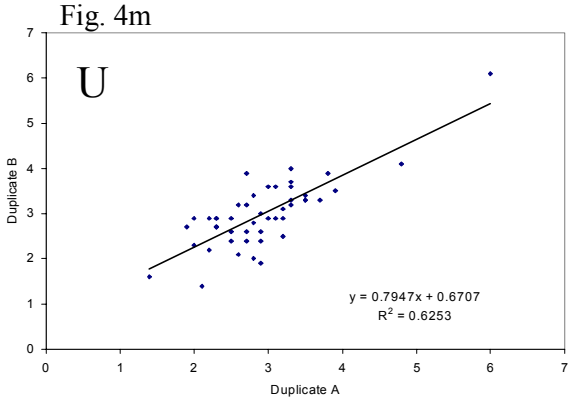


Fig. 4j

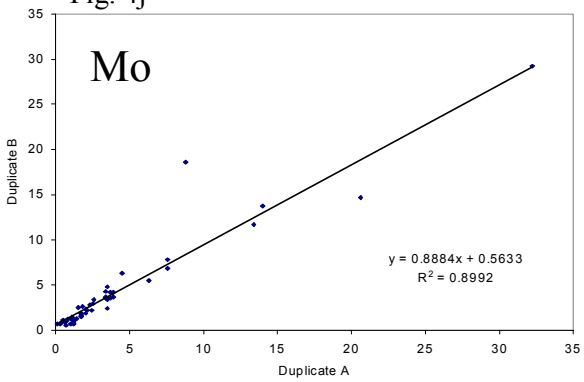


Fig. 4n

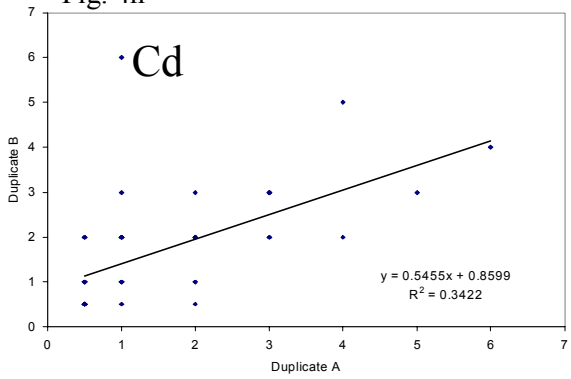


Fig. 4k

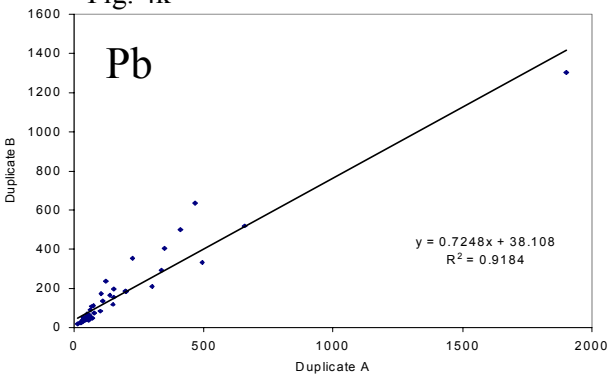


Fig. 4o

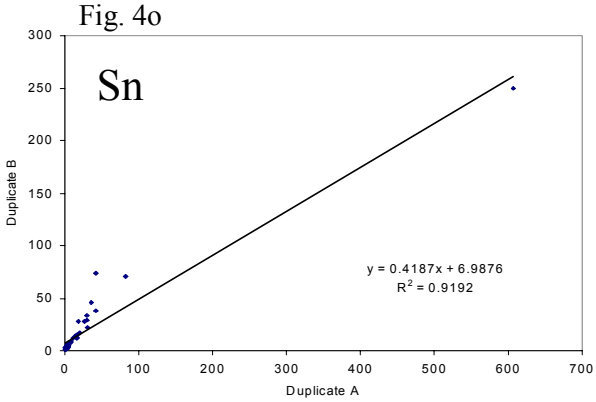


Fig. 4l

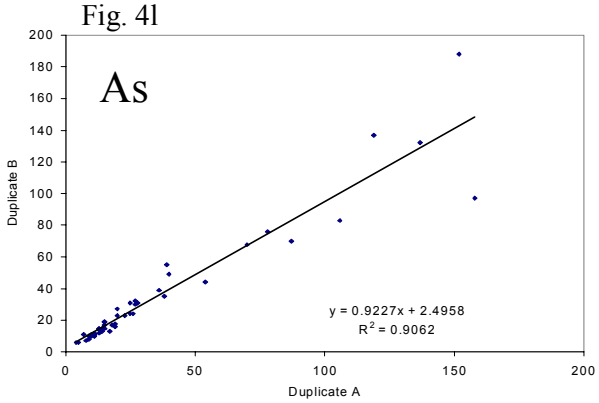
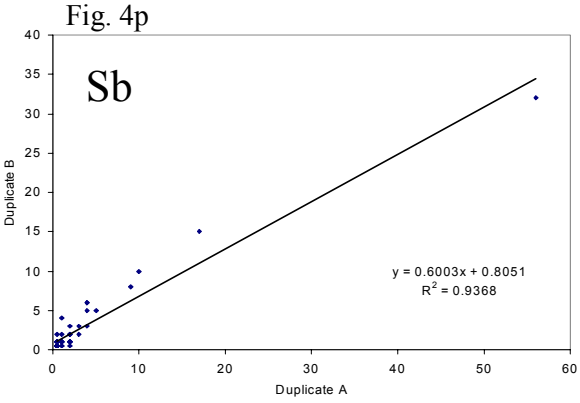


Fig. 4p



Figures 5a –5c. Combination plots of raw and log-transformed data. Elements Mno, Fe_2O_3 and V.

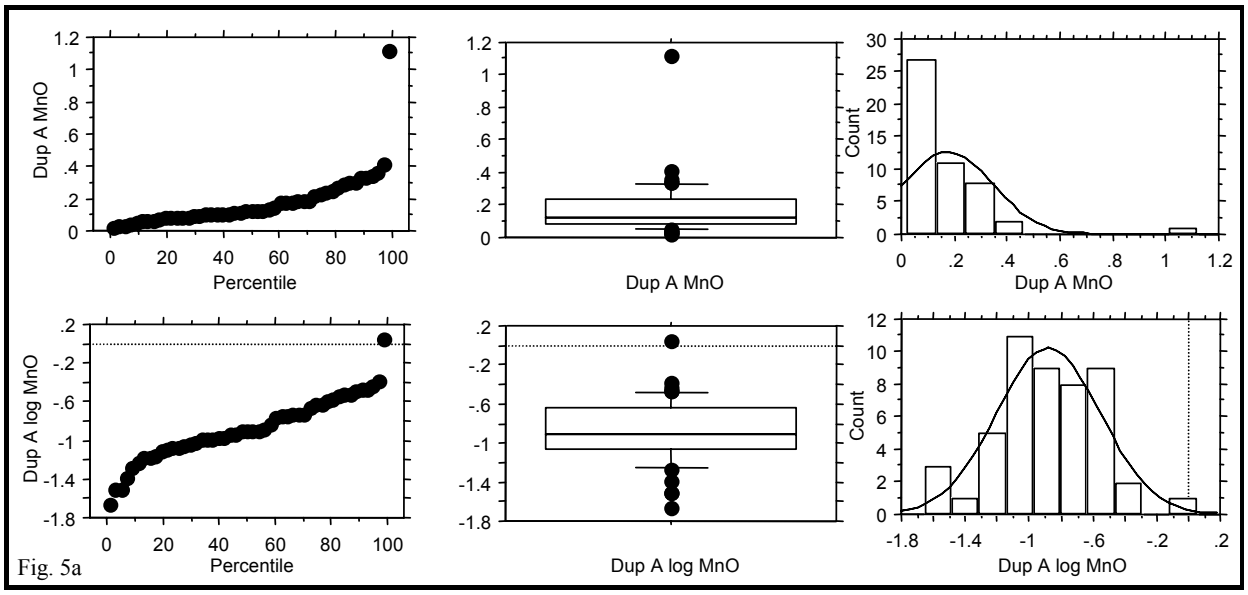


Fig. 5a

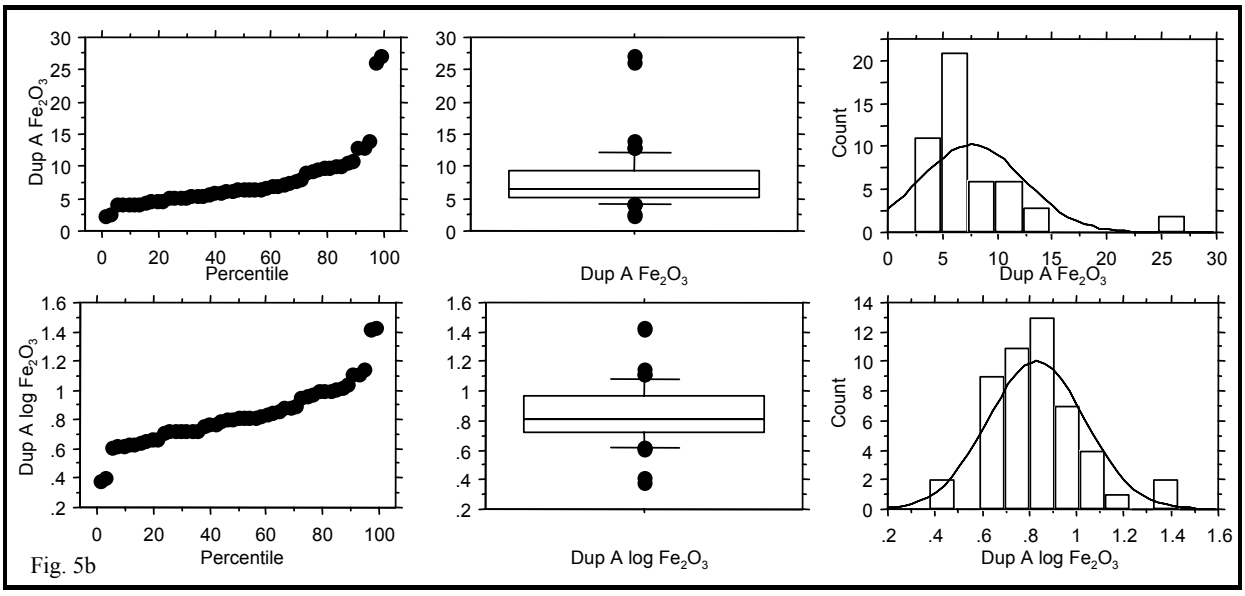


Fig. 5b

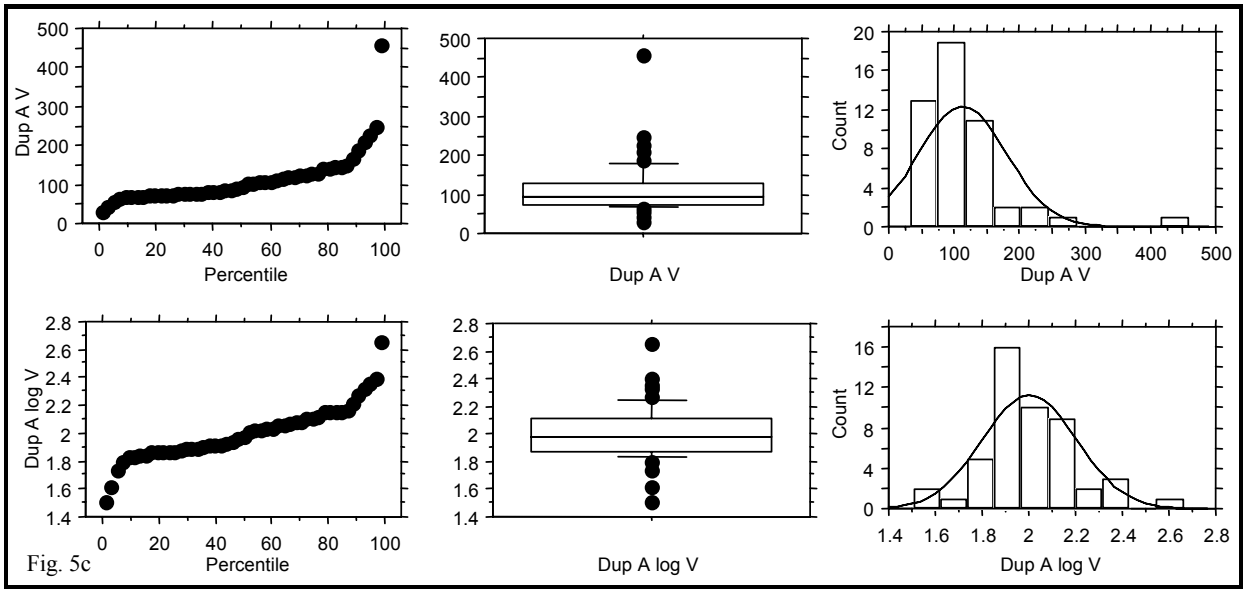


Fig. 5c

Figures 5d –5f. Combination plots of raw and log-transformed data. Elements Cr, Co and Ba.

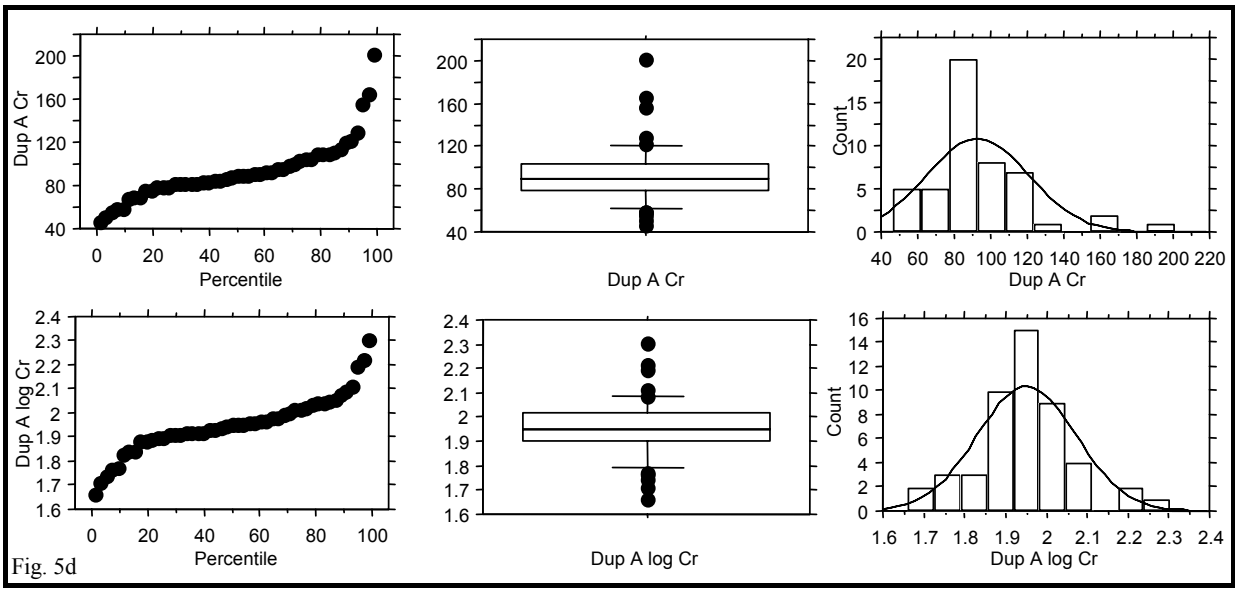


Fig. 5d

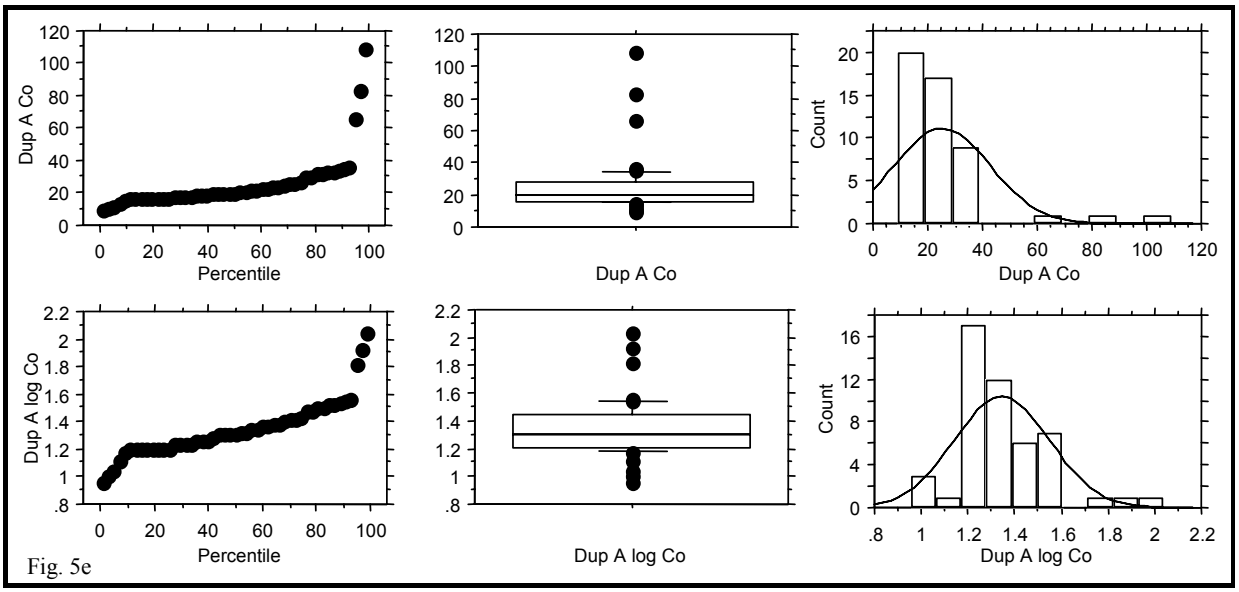


Fig. 5e

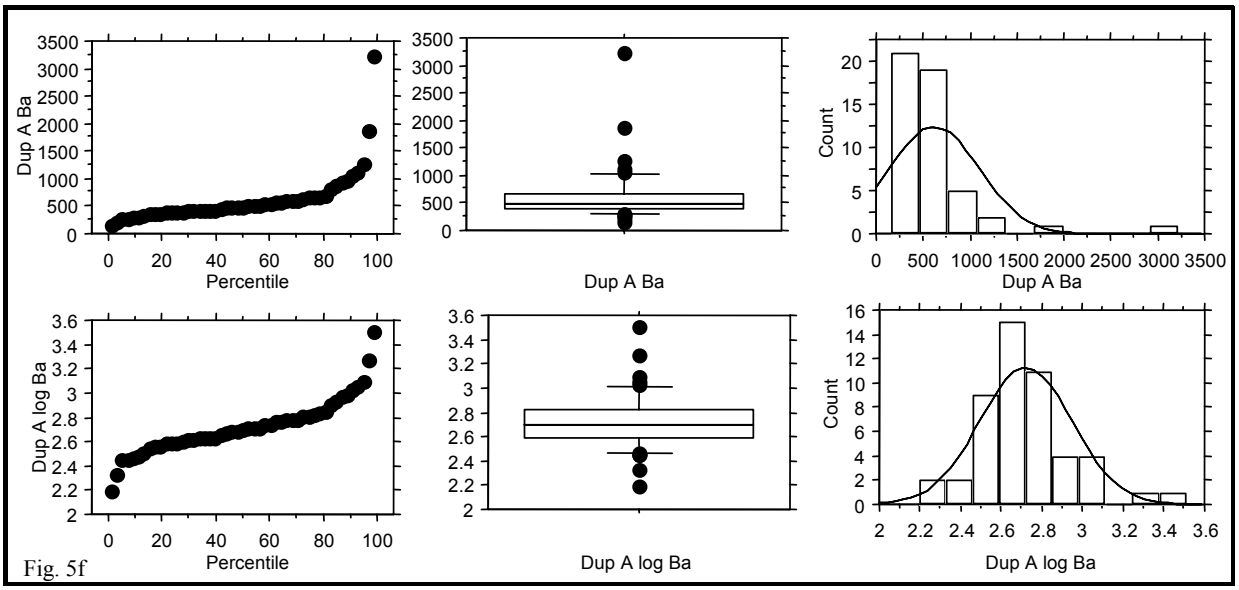


Fig. 5f

Figures 5g –5i. Combination plots of raw and log-transformed data. Elements Ni, Cu and Zn.

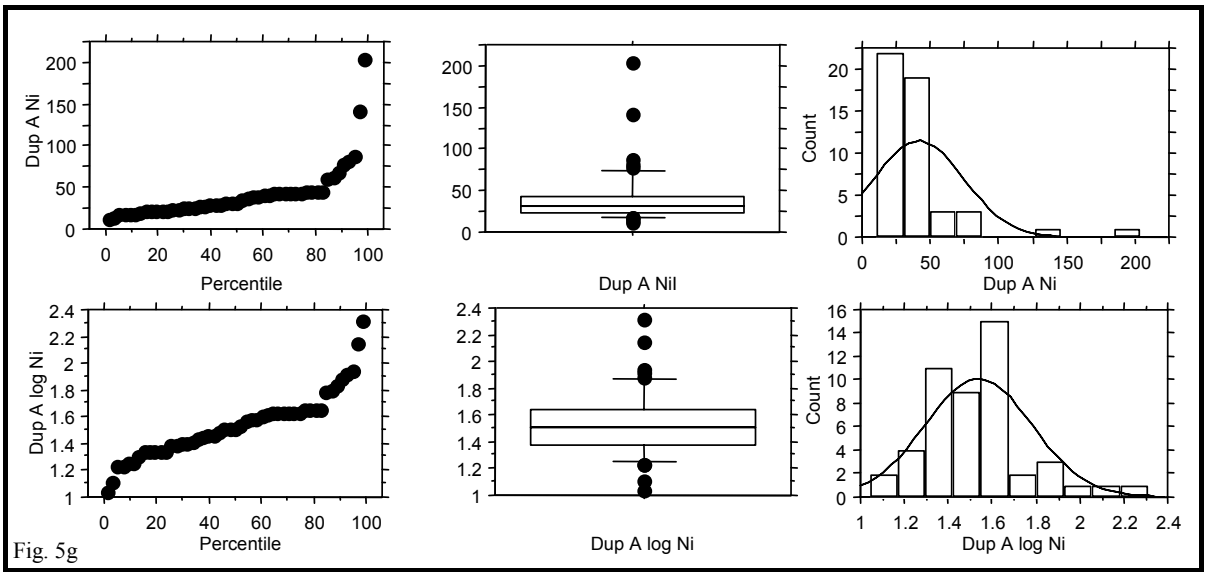


Fig. 5g

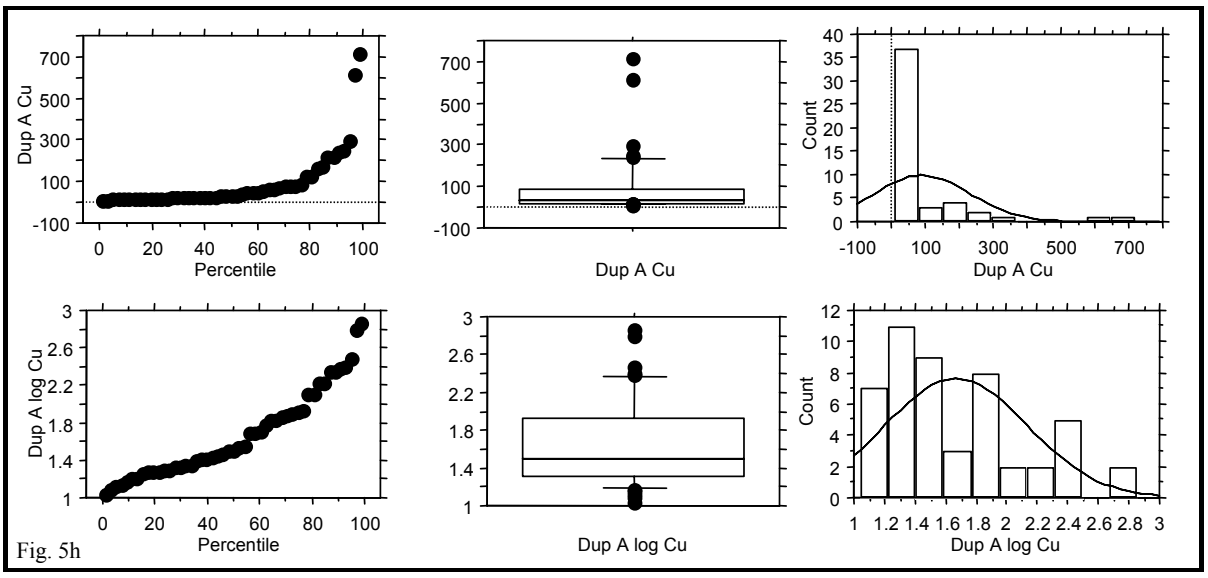


Fig. 5h

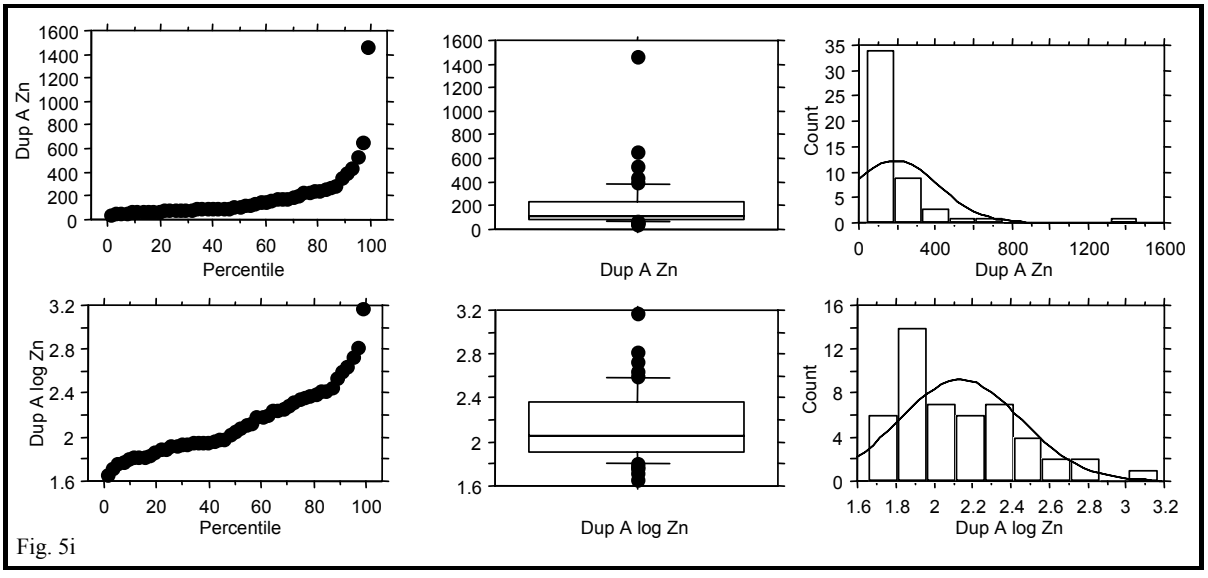


Fig. 5i

Figures 5j –5l. Combination plots of raw and log-transformed data. Elements Pb, Mo and As.

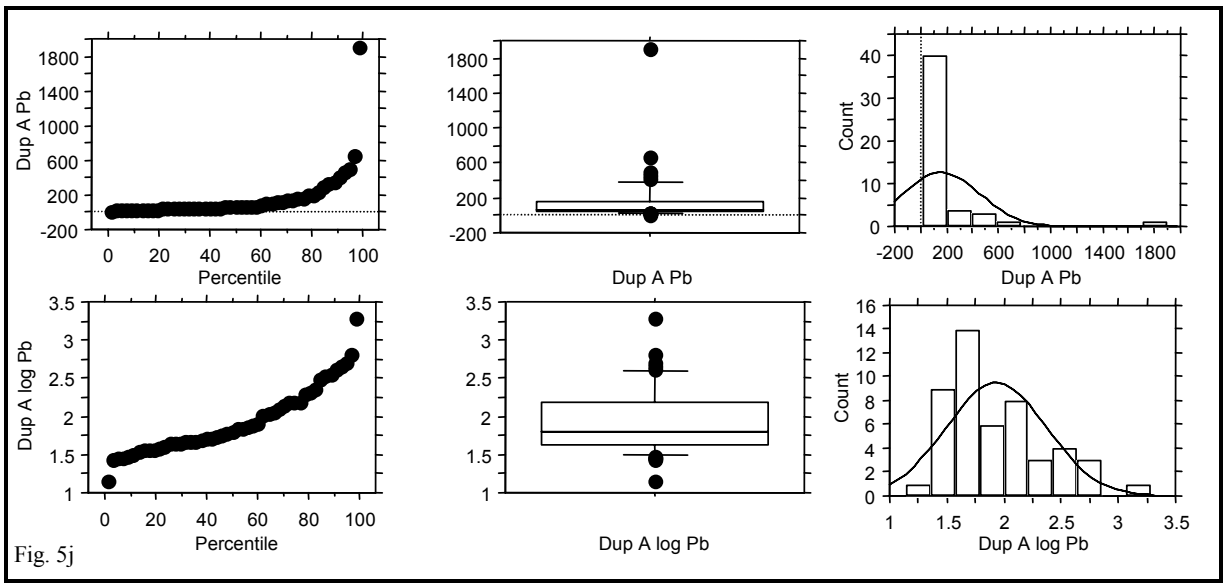


Fig. 5j

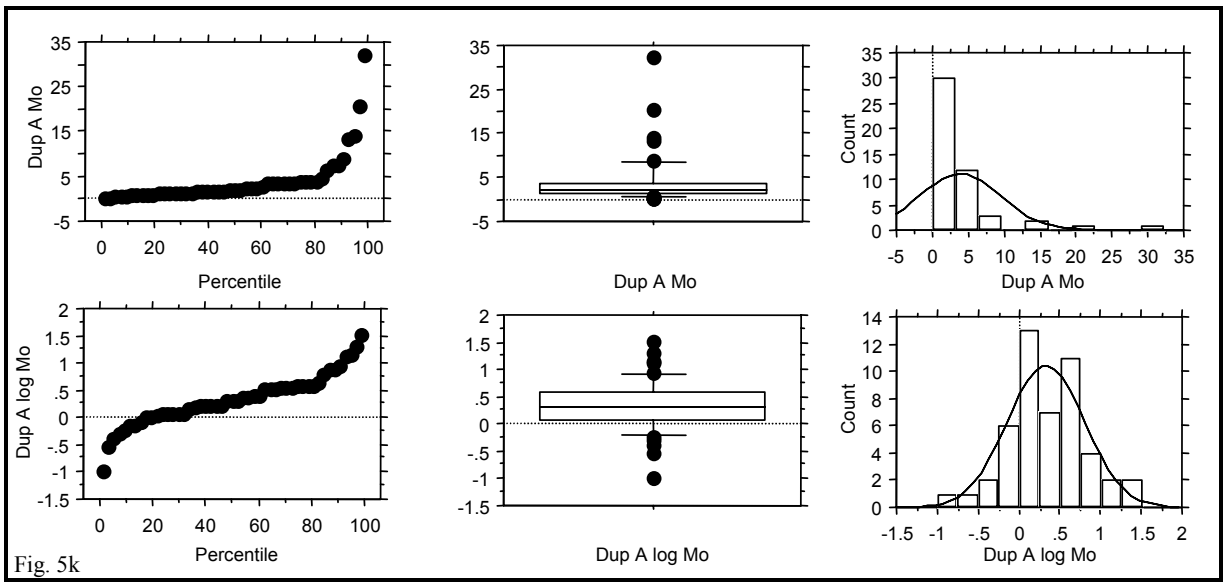


Fig. 5k

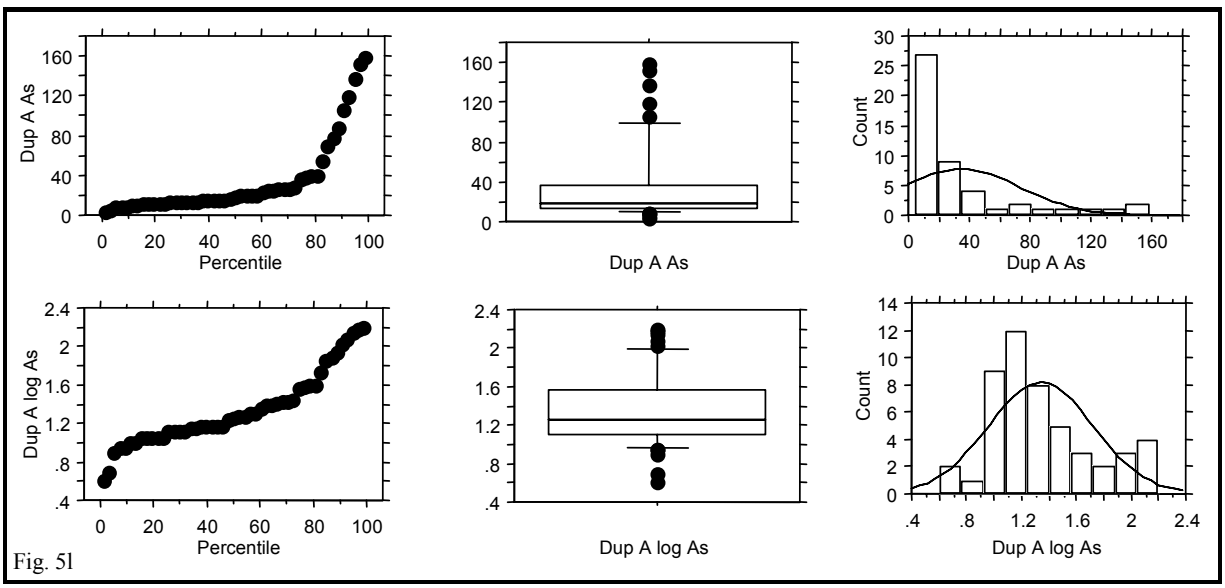


Fig. 5l

Figures 5m –5o. Combination plots of raw and log-transformed data. Elements U, Cd and Sn.

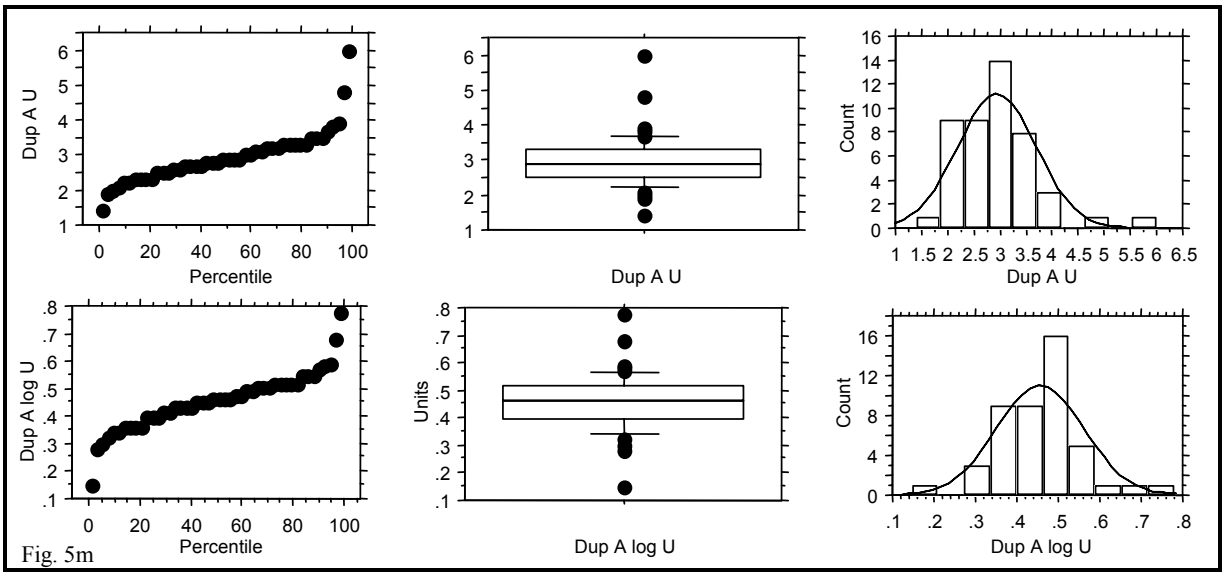


Fig. 5m

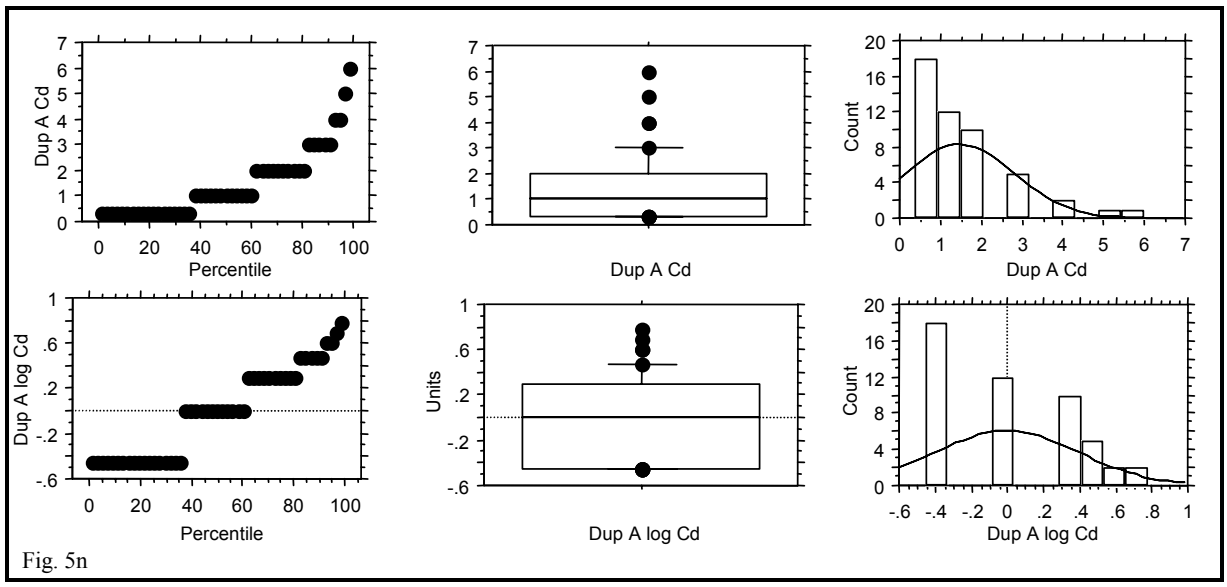


Fig. 5n

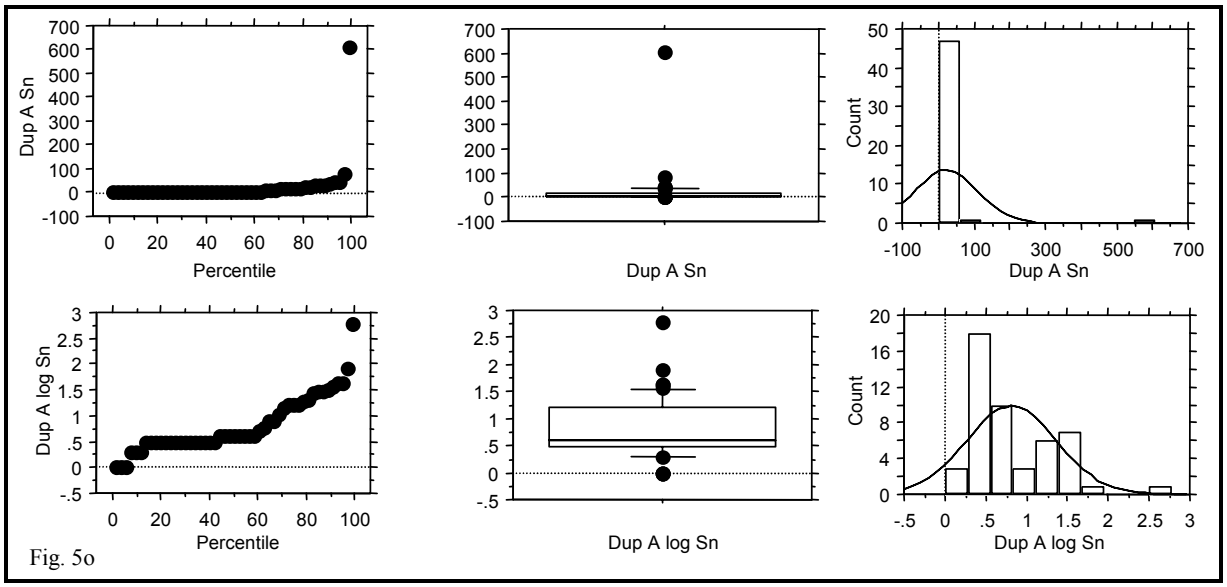


Fig. 5o

Figure 5p. Combination plots of raw and log-transformed data. Element Sb.

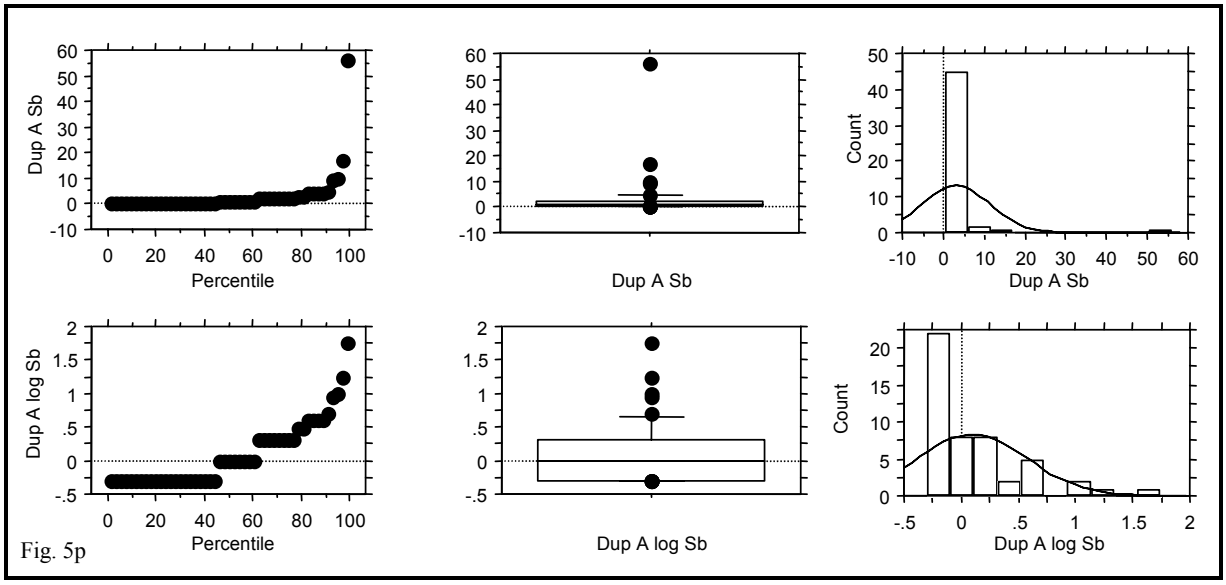


Fig. 5p

Appendix A. Full ANOVA calculations for all elements.

Nested ANOVA: Log MnO

Analysis of Variance for Log MnO

Source	DF	SS	MS	F	P
SITE	49	21.2909	0.4345	49.623	0.000
Sub	50	0.4378	0.0088	156.515	0.000
Error	100	0.0056	0.0001		
Total	199	21.7343			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.106	96.03	0.326
Sub	0.004	3.92	0.066
Error	0.000	0.05	0.007
Total	0.111		0.333

Expected Mean Squares

1	SITE	1.00(3) + 2.00(2) + 4.00(1)
2	Sub	1.00(3) + 2.00(2)
3	Error	1.00(3)

Nested ANOVA: Log Fe2O3

Analysis of Variance for Log Fe2O

Source	DF	SS	MS	F	P
SITE	49	9.0948	0.1856	58.308	0.000
Sub	50	0.1592	0.0032	461.023	0.000
Error	100	0.0007	0.0000		
Total	199	9.2546			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.046	96.62	0.214
Sub	0.002	3.36	0.040
Error	0.000	0.01	0.003
Total	0.047		0.217

Expected Mean Squares

1	SITE	1.00(3) + 2.00(2) + 4.00(1)
2	Sub	1.00(3) + 2.00(2)
3	Error	1.00(3)

Nested ANOVA: Log V

Analysis of Variance for Log V

Source	DF	SS	MS	F	P
SITE	49	7.8835	0.1609	93.364	0.000
Sub	50	0.0862	0.0017	73.189	0.000
Error	100	0.0024	0.0000		
Total	199	7.9720			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.040	97.85	0.199
Sub	0.001	2.09	0.029
Error	0.000	0.06	0.005
Total	0.041		0.202

Expected Mean Squares

1	SITE	1.00(3) + 2.00(2) + 4.00(1)
2	Sub	1.00(3) + 2.00(2)
3	Error	1.00(3)

Nested ANOVA: Log Cr

Analysis of Variance for Log Cr

Source	DF	SS	MS	F	P
SITE	49	2.8494	0.0582	31.915	0.000
Sub	50	0.0911	0.0018	12.224	0.000
Error	100	0.0149	0.0001		
Total	199	2.9554			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.014	93.46	0.119
Sub	0.001	5.55	0.029
Error	0.000	0.99	0.012
Total	0.015		0.123

Expected Mean Squares

1	SITE	1.00(3) + 2.00(2) + 4.00(1)
2	Sub	1.00(3) + 2.00(2)
3	Error	1.00(3)

Nested ANOVA: Log Co

Analysis of Variance for Log Co

Source	DF	SS	MS	F	P
SITE	49	8.5166	0.1738	33.353	0.000
Sub	50	0.2606	0.0052	30.753	0.000
Error	100	0.0169	0.0002		
Total	199	8.7941			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.042	94.00	0.205
Sub	0.003	5.62	0.050
Error	0.000	0.38	0.013
Total	0.045		0.212

Expected Mean Squares

1 SITE	1.00(3) +	2.00(2) + 4.00(1)
2 Sub	1.00(3) +	2.00(2)
3 Error	1.00(3)	

Nested ANOVA: Log Ba

Analysis of Variance for Log Ba

Source	DF	SS	MS	F	P
SITE	49	12.2034	0.2490	76.354	0.000
Sub	50	0.1631	0.0033	99.175	0.000
Error	100	0.0033	0.0000		
Total	199	12.3698			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.061	97.39	0.248
Sub	0.002	2.56	0.040
Error	0.000	0.05	0.006
Total	0.063		0.251

Expected Mean Squares

1 SITE	1.00(3) +	2.00(2) + 4.00(1)
2 Sub	1.00(3) +	2.00(2)
3 Error	1.00(3)	

Nested ANOVA: Log Ni

Analysis of Variance for Log Ni

Source	DF	SS	MS	F	P
SITE	49	12.7402	0.2600	49.813	0.000
Sub	50	0.2610	0.0052	37.436	0.000
Error	100	0.0139	0.0001		
Total	199	13.0151			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.064	95.96	0.252
Sub	0.003	3.83	0.050
Error	0.000	0.21	0.012
Total	0.066		0.258

Expected Mean Squares

1	SITE	1.00(3) + 2.00(2) + 4.00(1)
2	Sub	1.00(3) + 2.00(2)
3	Error	1.00(3)

Nested ANOVA: Log Cu

Analysis of Variance for Log Cu

Source	DF	SS	MS	F	P
SITE	49	44.4307	0.9067	179.990	0.000
Sub	50	0.2519	0.0050	37.259	0.000
Error	100	0.0135	0.0001		
Total	199	44.6961			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.225	98.87	0.475
Sub	0.002	1.08	0.050
Error	0.000	0.06	0.012
Total	0.228		0.478

Expected Mean Squares

1	SITE	1.00(3) + 2.00(2) + 4.00(1)
2	Sub	1.00(3) + 2.00(2)
3	Error	1.00(3)

Nested ANOVA: Log Zn

Analysis of Variance for Log Zn

Source	DF	SS	MS	F	P
SITE	49	19.8471	0.4050	26.200	0.000
Sub	50	0.7730	0.0155	630.809	0.000
Error	100	0.0025	0.0000		
Total	199	20.6225			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.097	92.64	0.312
Sub	0.008	7.34	0.088
Error	0.000	0.02	0.005
Total	0.105		0.324

Expected Mean Squares

1	SITE	1.00(3) + 2.00(2) + 4.00(1)
2	Sub	1.00(3) + 2.00(2)
3	Error	1.00(3)

Nested ANOVA: Log Mo

Analysis of Variance for Log Mo

Source	DF	SS	MS	F	P
SITE	49	34.5592	0.7053	39.832	0.000
Sub	50	0.8853	0.0177	3.039	0.000
Error	100	0.5826	0.0058		
Total	199	36.0271			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.172	93.59	0.415
Sub	0.006	3.23	0.077
Error	0.006	3.17	0.076
Total	0.184		0.429

Expected Mean Squares

1	SITE	1.00(3) + 2.00(2) + 4.00(1)
2	Sub	1.00(3) + 2.00(2)
3	Error	1.00(3)

Nested ANOVA: Log Pb

Analysis of Variance for Log Pb

Source	DF	SS	MS	F	P
SITE	49	35.8690	0.7320	56.856	0.000
Sub	50	0.6438	0.0129	117.102	0.000
Error	100	0.0110	0.0001		
Total	199	36.5238			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.180	96.51	0.424
Sub	0.006	3.43	0.080
Error	0.000	0.06	0.010
Total	0.186		0.432

Expected Mean Squares

1 SITE	1.00(3) +	2.00(2) + 4.00(1)
2 Sub	1.00(3) +	2.00(2)
3 Error	1.00(3)	

Nested ANOVA: Log As

Analysis of Variance for Log As

Source	DF	SS	MS	F	P
SITE	49	27.2267	0.5556	100.055	0.000
Sub	50	0.2777	0.0056	12.913	0.000
Error	100	0.0430	0.0004		
Total	199	27.5474			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.138	97.87	0.371
Sub	0.003	1.82	0.051
Error	0.000	0.31	0.021
Total	0.141		0.375

Expected Mean Squares

1 SITE	1.00(3) +	2.00(2) + 4.00(1)
2 Sub	1.00(3) +	2.00(2)
3 Error	1.00(3)	

Nested ANOVA: U

Analysis of Variance for U

Source	DF	SS	MS	F	P
SITE	46	87.3523	1.8990	10.031	0.000
Sub	47	8.8975	0.1893	2.818	0.000
Error	94	6.3150	0.0672		
Total	187	102.5648			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.427	76.92	0.654
Sub	0.061	10.99	0.247
Error	0.067	12.09	0.259
Total	0.556		0.745

Expected Mean Squares

1	SITE	1.00(3) + 2.00(2) + 4.00(1)
2	Sub	1.00(3) + 2.00(2)
3	Error	1.00(3)

Nested ANOVA: CD

Analysis of Variance for CD

Source	DF	SS	MS	F	P
SITE	49	209.6862	4.2793	7.798	0.000
Sub	50	27.4375	0.5488	1.258	0.166
Error	100	43.6250	0.4363		
Total	199	280.7487			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.933	65.44	0.966
Sub	0.056	3.95	0.237
Error	0.436	30.61	0.660
Total	1.425		1.194

Expected Mean Squares

1	SITE	1.00(3) + 2.00(2) + 4.00(1)
2	Sub	1.00(3) + 2.00(2)
3	Error	1.00(3)

Nested ANOVA: Log Sn

Analysis of Variance for Log Sn

Source	DF	SS	MS	F	P
SITE	49	54.2300	1.1067	58.680	0.000
Sub	50	0.9430	0.0189	3.670	0.000
Error	100	0.5139	0.0051		
Total	199	55.6869			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.272	95.77	0.522
Sub	0.007	2.42	0.083
Error	0.005	1.81	0.072
Total	0.284		0.533

Expected Mean Squares

1	SITE	1.00(3) + 2.00(2) + 4.00(1)
2	Sub	1.00(3) + 2.00(2)
3	Error	1.00(3)

Nested ANOVA: Log Sb

Analysis of Variance for Log Sb

Source	DF	SS	MS	F	P
SITE	49	40.7747	0.8321	23.807	0.000
Sub	50	1.7477	0.0350	1.659	0.016
Error	100	2.1075	0.0211		
Total	199	44.6299			

Variance Components

Source	Var Comp.	% of Total	StDev
SITE	0.199	87.68	0.446
Sub	0.007	3.05	0.083
Error	0.021	9.27	0.145
Total	0.227		0.477

Expected Mean Squares

1	SITE	1.00(3) + 2.00(2) + 4.00(1)
2	Sub	1.00(3) + 2.00(2)
3	Error	1.00(3)

9 References

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