OF99-9

Vertical Zonation of Elements in Glaciofluvial Sands and Gravels Overlying the Photo Lake Cu-Zn Massive Sulphide Type Deposit (Snow Lake Area): Preliminary Results of a Mobile Metal Ion Process Survey

By
M.A.F. Fedikow

OPEN FILE REPORT

Manitoba
Energy and Mines

David Newman
Minister

GEOREF

NTS GRID: 63K/16

Keywords:

Carbonates
Copper
Glaciofluvial environment
Gold
Ions
Massive sulphide deposits
Mobility
Mobilization
Rhyolites
Sand
Zoning

Suggested reference:

Fedikow, M.A.F.
1999: Vertical zonation of elements in glaciofluvial sands and gravels overlying the Photo Lake Cu-Zn massive sulphide type deposit (Snow Lake area): preliminary results of a mobile metal ion process survey; Manitoba Energy and Mines, Geological Services, Open File Report OF99-9, 17 p.

Manitoba
Energy and Mines
Geological Services

Open File Report OF99-9

Vertical Zonation of Elements in Glaciofluvial Sands and Gravels Overlying the Photo Lake Cu-Zn Massive Sulphide Type Deposit (Snow Lake Area): Preliminary Results of a Mobile Metal Ion Process Survey

by M.A.F. Fedikow
Winnipeg, 1999

Energy and Mines

Hon. David Newman
Minister

Oliver Boulette
Deputy Minister

Geological Services

C.A. Kaszycki
Director

This publication is available in large print, audiotape or braille on request.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

PURPOSE OF THE STUDY

This orientation study was undertaken to determine whether a mobile metal ion (MMI) process survey could provide information useful for base metal massive sulphide exploration, by assessing the geochemical response to the Photo Lake Cu-Zn deposit in a ca. 10-15 m thick sequence of fine- to coarse-grained variably oxidized sands and gravels that overlie the deposit. The vertical geochemical gradient from surface to mineralization subcrop should give an indication of geochemical "fractionation" or vertical zonation of the mobile ions diffusing from the deposit to surface, the depth at which these signatures can be expected, and whether a local or belt survey based on this technology would provide useful geochemical exploration criteria for base metal exploration. Moreover, the opportunity to inexpensively acquire the samples, avoiding relatively costly overburden drilling, was timely as the Photo Lake deposit is now exhausted and site rehabilitation will undoubtedly obliterate the overburden section.

The potential for anthropogenic particulate contamination by ongoing mining activity in this survey area was cause for concern. A fresh vertical sampling channel approximately 1 m wide and 1 m deep from surface to bedrock interface was hand-dug to try and avoid this contamination.

Finally, the opportunity to undertake this study in a surficial environment dominated by sand in a well-drained, non-saturated environment will permit a broader understanding of MMI capabilities and potential for application in glaciofluvial sediment-dominated terrain.

MOBILE METAL ION (MMI) PROCESS

The mobile metal ion process was developed in Western Australia by a consortium of exploration companies seeking tools to geochemically "see" through residual overburden. A weak partial extraction scheme is used on a 100 g sample of soil to liberate ions which have been mobilized to the surface, from buried or blind mineralization, where they become loosely bound to soil particles. Metal mobilization does not depend upon electrochemical cells. Separate dissolutions or extractants are used and provide an acidic leachate for a base metals package (Digest A for Cu, Pb, Zn and Cd) and an alkaline leachate for a precious metals package (Digest B for Au, Ag, Ni, Pd and Co). This leachate is then analyzed by ICP-MS for a multielement suite in the parts per billion concentration range. The method concentrates on commodity elements thereby reducing the need for the analysis of "pathfinder" elements.

The exact chemistry of the multicomponent dissolutions is unknown owing to proprietary considerations. The dissolution extracts loosely-bound metals from inorganic and organic materials in samples collected from a fixed depth of between 5-15 cm. Readsorption of ionic species on sample substrates and container surfaces subsequent to dissolution is accomplished by the use of multiple strong ligands that are capable of retaining metals in the leachate (Mann et al., 1998). Resultant anomalies are in the form of apical responses that are both high contrast and repeatable. Available literature citations indicate MMI anomalies are well-defined and usually overlie the mineralized zone, thereby defining the vertical surface projection of the mineralization. Numerous case histories have been undertaken in a variety of geological environments and document the effectiveness of this technique. A description of the method and its application is provided by Mann et al. (1998). A Manitoba example is provided from the Assean Lake area by Fedikow and Ziehlke (1998).

GEOLOGICAL SETTING OF THE STUDY AREA

The Photo Lake Cu-Zn-Au-Ag-Pb volcanogenic base metal massive sulphide deposit (533,623 tonnes grading 4.7 g/t Au, 4.5% Cu and 6% Zn; T. Heine, pers. comm., 1999) occurs in west-central Manitoba within the Snow Lake segment of the Proterozoic Flin Flon greenstone belt (Fig. 1). It was discovered in 1994 as a result of the diamond drill testing of an airborne-electromagnetic anomaly. The deposit is hosted by Photo Lake rhyodacite/rhyolite (Fig. 2) that forms part of the mature arc section of the Snow Lake arc assemblage (Bailes, 1997). The rhyodacite unit comprises a monotonous and relatively uniform sequence of felsic volcanic rocks and derived gneisses (Bailes, 1996). A period of volcanic quiescence in the sequence is interpreted from the presence of the Photo Lake deposit and a 90 m thick heterolithologic breccia that also occurs within the rhyodacite sequence (Bailes, 1997). Mineralization is present as three discreet lenses. Lens #1 is Cu-rich in the upper mine levels but becomes Zn-rich at depth; lens #2 is Zn-rich, and lens #3 is uneconomic and undeveloped. Sulphide mineralization in these lenses has an overall east-west strike; 40°-60° north dip and 40°-45° northeast plunge.

Synvolcanic hydrothermal alteration of the host rocks has been documented in the mine environment as well as in outcrop 700 m northwest of the deposit (Bailes, 1996; Heine and Prouse, 1998). The #1 lens is bounded on the north by a strongly altered zone containing chlorite with patchy and irregularly developed porphyroblasts of biotite, staurolite, magnetite and garnet. Less altered rhyolite is marked by patchy and moderate chloritization and sericitization. Garnet porphyroblasts (up to 3 cm) are present in the chlorite patches. The "footwall" style of alteration on the north side of the deposit is not consistent with local northfacing strata and suggests the deposit is isoclinally folded (Bailes et al., 1996, 1997). Northwest of the deposit, felsic rocks are altered and contain 15-30% garnet, 5-40% amphibole porphyroblasts and 2% disseminated pyrrhotite and lesser pyrite and chalcopyrite. Future rock geochemical and mineralogical studies at the deposit have been made possible by the collection of an archival suite of 104 underground rock chip samples as well as core samples collected from seven complete diamond drill holes (Heine and Prouse, 1998).

VEGETATION AND SURFICIAL DEPOSITS

A complete overburden section is present at the Photo Lake deposit and results from excavations undertaken to expose the buried portion of the orebody. Geochemical samples were collected from a channel (1 m wide by 1 m deep by 11 m long) that was dug into the south wall of the excavation pit. Digging of the sampling channel was considered to be important since wind-blown particulate contamination from ongoing mining activity and an ore stockpile 100 m south of the pit was possible.

The overstory at the sampling site is characterized by mature stands of jack pine (Pinus banksiana) and black spruce (Picea mariana). Beneath these trees the soil profile (Fig. 3) is characterized by a 1 cm layer of forest litter underlain by 3-7 cm of brown, poorly decomposed humus that tops a 4-6 cm leached or elluviated zone. This white to grey layer tops rusty red-brown glaciofluvial sands that contain occasional cobbles and pebbles of granitic, metavolcanic and sedimentary lithologies. The contact area between the leached and upper sand layers is oxidized and marked by a rusty brown colour. Glaciofluvial sands persist for approximately 11 m to the bedrock interface. The sands are massive to bedded and locally cross-bedded, variably oxidized and marked by the presence of hematitic to limonitic pebbly gravel interbeds. Granitic pebbles in these beds are cemented by a white-grey to reddish-brown carbonate cement. Individual pebbles may be coated by this carbonate, which varies from fine-grained to scaly in appearance. Hematitic and limonitic carbonate-cemented pebbly gravels were observed at approximately 2.6 m below surface in the overburden section. The Photo Lake Cu-Zn mineralization subcrops at the sediment-bedrock interface, where near-solid to solid layers/veins of chalcopyrite, pyrite and pyrrhotite were observed.

SAMPLE COLLECTION

A total of 11 soil samples were collected at approximately 1 m intervals, from just below the leached horizon in the soil profile to the overburden-bedrock contact. Samples consisted of variably oxidized hematitic to limonitic sands and pebbly sands with rounded pebbly gravel interlayers. These gravels tended to be strongly hematitic, limonitic and were often cemented or individually coated with a white carbonate precipitate that locally was also hematitic to limonitic to black in colour (Appendix I). A hard nylon scoop was used to collect individual samples that consisted of 6-8 scoops of representative material over an approximate 1 m sample interval. Field duplicates were not collected for this survey.

SAMPLE PREPARATION AND ANALYSIS

Samples were placed in large ZIPLOC freezer bags and shipped to XRAL Laboratories (Don Mills, Ontario) where they were air-dried and then sieved to -80 mesh. Subsequently, this size fraction was analysed for MMI - Digest A (Cu, Pb, Zn, Cd) and for MMI - Digest B (Au, Ag, Ni, Pd, Co). The digest liquors from each of these 2 extractions were analysed by inductively coupled plasma-mass spectrometry (ICP-MS). Analytical data including one analytical duplicate are presented in Appendix II.

DATA TRANSFORMATION

Interpretation of MMI data is based on the calculation of response ratios that represent data normalized to a background concentration. Background is determined by first arbitrarily selecting the 25th percentile for a particular element. Analytical data below the first quartile is averaged and this arithmetic mean used as a divisor for the individual analyses. The resulting normalized data are referred to as "response ratios" representing peak to background ratios. This procedure is deemed appropriate so that 1) the effects of dissolution variation during extraction (time and/or temperature, sample weight, sample to sample inhomogeneity) can be minimized or avoided, 2) "stitching" of data batches can be undertaken, and 3) sample error introduced by samples representative of different soil horizons can be reduced.

This procedure is adopted for the Photo Lake study with the background or 25th percentile determined for each element (Table 1) and analyses normalized accordingly. It should be noted that only 11 samples were collected for this study and background concentrations determined from such a small sample population may not be appropriate. Additionally, the validity of determining background for any element that has a significant number of analyses below the lower limit of determination is questionable. It should be noted that 4 of 11 samples analysed for this study have Pb contents less than the determination limit of 20 parts per billion (ppb).

RESULTS

Analytical data from the 11 samples collected vertically through the overburden section overlying the Photo Lake deposit are presented in Table 1. Profiles based on non-transformed as well as response ratio data are given in figures 4 through 8.

A scatterplot matrix for non-transformed data is presented in figure 9 and illustrates strong linear relationships for the element pairs Zn-Cu, Zn-Co, Cu-Co, Ni-Cd, Ni-Pd, Au-Ag, Au-Pd and Ag-Pd. The linear associations between some of these element pairs is strongly influenced by one or two outliers.

Data for Cu, Zn and Pb exhibit wide ranges in concentration with the highest values occurring in a 1-5 m zone above the Photo Lake orebody. Lead responses tend to be more erratic than both Cu and Zn with one of the two highest values approximately 1 m above the orebody and the second 4 m from the overburden-bedrock interface. These two high values are separated by two low responses (10 and 45 ppb). Cadmium, normally correlated to Zn, shows a somewhat different distribution, although the anomaly of 53 ppb that occurs between 3.6-4.1 m is a low contrast response. The Cd anomaly occurs at a different level above the Photo Lake mineralization than the Cu, Zn and Pb responses. The highest Co responses occur between 2-5 m above the orebody and correspond to Cu, Zn and Pb responses. Cobalt responses are also low contrast.

The highest analytical values and response ratios for Au, Ag, Ni and Pd occur between 3.6-4.1 m and correspond to the highest Cd response. The Au (17.9 ppb), Ag (22 ppb) and Pd (0.7 ppb) anomalies are all single sample responses at approximately 8 m above the deposit, whereas high Ni values (29 and 27 ppb) form a two sample anomaly. Both the Ni and Pd anomalies are low contrast responses.

DISCUSSION

The MMI process has identified a vertical differentiation of ore and ore-related elements in variably oxidized sands and gravels overlying the Photo Lake Cu-Zn orebody on the basis of 1 m sample spacings. Vertical metal zonation has been previously documented in MMI information manuals and case history studies (Mann et al., 1998) whereby precious metal signatures to mineralized zones have been recognized closer to surface (15-20 cm) while base metal responses have been identified at deeper levels (40-50 cm). These observations have been based upon closely spaced (10 cm) samples. This survey however, utilized 0.5-1 m, (predominantly 1 m) sample spacings with individual sample analyses representing signatures derived from 6-8 aliquots of material collected over the 1 m interval. It is interesting that using this different scale of sampling, similar vertical metal zonation is observed, except that the relative positions of the maximum geochemical responses are occurring deeper in the overburden profile.

The development of two distinctive geochemical signatures characterized by unique element assemblages at two locations in the overburden profile suggests a variable and complex element migration scenario. Rates of element migration and residence sites are probably influenced by soil permeability and porosity, size (tonnage) of source and/or grade of deposit (and associated electro-dispersive mechanisms), diffusion, evapo-transpiration and perhaps capillary action. An important control to the identification of high MMI metal responses at specific levels in the overburden section is the presence of a metal-enriched, re-precipitated carbonate front represented by hematite-limonite-coloured, fine-grained and coarser flakes of carbonate that cement granitic pebbly gravels at 2.6 m below surface. It is at this location that anomalies for Cd, Au, Ag, Ni and Pd are observed. A second zone of elevated metals (Cu, Zn, Pb, Co) is documented approximately 9 m below surface (only 2-3 m above the Photo Lake deposit) and does not appear to be related to the presence of a carbonate-enriched sand or gravel. It is noteworthy that three of four elements determined by MMI Digest A, an acidic leachate, predominate in the anomaly at 9 m below surface in the more alkaline portion of the profile. These elements (Cu, Pb, Zn) may be present as a signature in the alkaline sediments and reflect limited mobility from the Photo Lake deposit and fixation approximately 3 m above mineralization. Four of five elements (Au, Ni, Pd and Ag) determined by the alkaline MMI Digest B occur in the zone of carbonate re-precipitation at 2.6 m. This would imply that these elements were capable of travelling from the deposit through the relatively alkaline environment below 2.6 m but were fixed to an unknown degree at the carbonate barrier. The potential for contributions of metals from the soil profile above 2.6 m is unknown.

The movement of metals to surface as a result of oxidation of the Photo Lake deposit is probably enhanced by a number of processes including electro-dispersive mechanisms and gaseous transport. The rate of mobilization is impeded to a certain degree by the presence of a more alkaline environment below 2.6 m. The presence of a carbonate front, such as the one observed at 2.6 m in this study, should not prevent the formation of MMI signatures at near-surface locations, as indicated in numerous studies in variable geological and climatic exploration environments (Mann and Birrell, 1999). The highest contrast geochemical signatures in these studies however, are often observed in carbonate-rich layers. This observation has been elucidated by studies in semi-arid environments. Pedogenic carbonate-metal associations in soil profiles have been documented by Lintern et al. (1997) in a soil and vegetation geochemical study undertaken in the Kalgoorlie area of Western Australia. In this study a significant correlation was observed between Au and Ca. The Ca is present as secondary, low-Mg calcite (pedogenic carbonate) that occurs as friable aggregates (<2 mm in diameter) and coatings on ferruginous fragments and as individual grains in the <63 micron size fraction of the soil. Lintern and Butt (1993) point to the importance of sampling pedogenic carbonate during gold exploration in semi-arid conditions. The presence of "carbonate-dumping fronts" in overburden profiles in the Snow Lake area should be assessed as preferred sampling sites for geochemical exploration.

Concerns of anthropogenic particulate contamination blanketing the vertical sediment profile samples for this survey, thereby invalidating the results, appear to be unfounded. The consistent vertical MMI metal zonation would suggest that characteristic patterns of element migration have been documented and contamination has been avoided by digging a fresh sampling channel through the section.

CONCLUSIONS

The limited MMI survey through a vertical section of glaciolacustrine sediment overlying the Photo Lake deposit indicates the following:

1. The Photo Lake Cu-Zn deposit has a recognizable MMI signature in vertical section from near surface to the overburden-bedrock interface at approximately 11 m below surface. A characteristic element assemblage is documented from two different levels in the sampling profile. A Au-Ag-Ni-Pd-Cd signature occurs approximately 2.6 m below surface and a Cu-Zn-Pd-Co response is developed over a broader front at depths below surface of 7-11m. The development of the former anomaly is related to the presence of a carbonate and metal dumping front at 2.6 m whereas the latter element signature may reflect decreased element mobility from source due to the relatively alkaline environment that exists below 2.6 m.

2. The scale of element zonation and the development of maximum geochemical response sites is significantly different in 1 m bulk samples compared to the results for surveys based on 10 cm closely-spaced sample profiles documented in the scientific literature. Sampling is required in the upper 50 cm of the Photo Lake profile to confirm this observation.

3. An MMI orientation survey centered on the Photo Lake deposit and based on the collection of soil samples at 10 cm sample spacings from surface to 1 m should be undertaken. This sampling should be initiated at the site of this orientation survey and then extrapolated to a grid sampling project over the deposit and into adjacent areas of "high prospectivity".

ACKNOWLEDGMENTS

Hudson Bay Exploration and Development Co. Ltd. are thanked for permission to undertake this study. G. H. Gale, Manitoba Energy and Mines, first observed the opportunity to sample surficial deposits from a vertical section above the Photo Lake deposit and is acknowledged for his suggestion to undertake this survey. Christine Kaszycki and Ric Syme are thanked for their constructive criticism of this report. Kelly Proutt typed this manuscript. Bonnie Lenton produced the figures.

REFERENCES

Bailes, A.H.

1996: Setting of Cu-Zn-Au mineralization at Photo Lake (part of 63K/16); **in** Manitoba Energy and Mines, Geological Services, Report of Activities, 1996, p. 66-74.

1997: Geochemistry of Paleoproterozoic volcanic rocks in the Photo Lake area, Flin Flon Belt (part of NTS 63K/16); **in** Manitoba Energy and Mines, Geological Services, Report of Activities, 1997, p. 61-72.

Bailes, A.H., Simms, D., Galley, A.G., and Young, J.

1996: Geology of the Photo Lake area, Snow Lake, Manitoba (part of NTS 63K/16SE); Manitoba Energy and Mines, Preliminary Map 1996F-1, 1:10 000.

1997: Geological setting of the Photo Lake volcanic-hosted massive sulphide deposit, Snow Lake, Manitoba (part of 63K/16SE); Manitoba Energy and Mines, Open File OF97-5, annotated 1:5 000 colour map.

Fedikow, M.A.F. and Ziehlke, D.V.

1998: Enzyme leach and mobile metal ion b-horizon soil geochemical signatures of buried geophysical conductors, Assean Lake area, northeast Manitoba; Manitoba Energy and Mines, Geological Services, Open File Report OF98-3, 36 p.

Heine, T.H. and Prouse, D.

1998: Photo Lake Mine archive project (NTS 63K/16 SE); **in** Manitoba Energy and Mines, Geological Services, Report of Activities, 1998, p. 23-24.

Lintern, M.J. and Butt, C.R.M.

1993: Pedogenic carbonate—an important sampling medium for gold exploration in semi-arid areas; Exploration Research News, Number 7, CSIRO Division of Exploration Geoscience, p. 7-11.

Lintern, M.J., Butt, C.R.M., and Scott, K.M.

1997: Gold in vegetation and soil—three case studies from the goldfields of southern West Australia; Journal of Geochemical Exploration, v. 58, p. 1-14.

Mann, A.W. and Birrell, R.D.
1999: Mobile ions in weathering environments (an alternative view of geochemistry towards the new millenium); Geochemistry Research Centre Workshop Notes with CD-ROM; International Geochemical Exploration Symposium, Vancouver, 1999.

Mann, A.W., Birrell, R.D., Mann, A.T., Humphreys, D.B., and Perdrix, J.L.
1998: Application of the MMI technique to routine geochemical exploration; Journal of Geochemical Exploration, v. 61, p. 87-103.

TABLE 1

Descriptive statistics for 11 soil samples collected and analysed using the MMI process at the Photo Lake Cu-Zn massive sulphide type deposit

ELEMENT	RANGE	BACKGROUND 25TH PERCENTILE*	MEDIAN	75TH PERCENTILE
Cu	202-1980	716	1090	1635
Zn	33-1410	198	242	778
Cd	5-53	17	22	28
Pb	10-164	10	45	76
Au	0.31-17.9	1.9	2.4	2.8
Co	2-17	2.5	6	9
Ni	6-29	10.5	15	19
Pd	0.125-0.69	0.28	0.33	0.36
Ag	2.8-22.0	4.0	5.8	7.3

*The 25th percentile was selected as "background" for the calculation of response ratios.

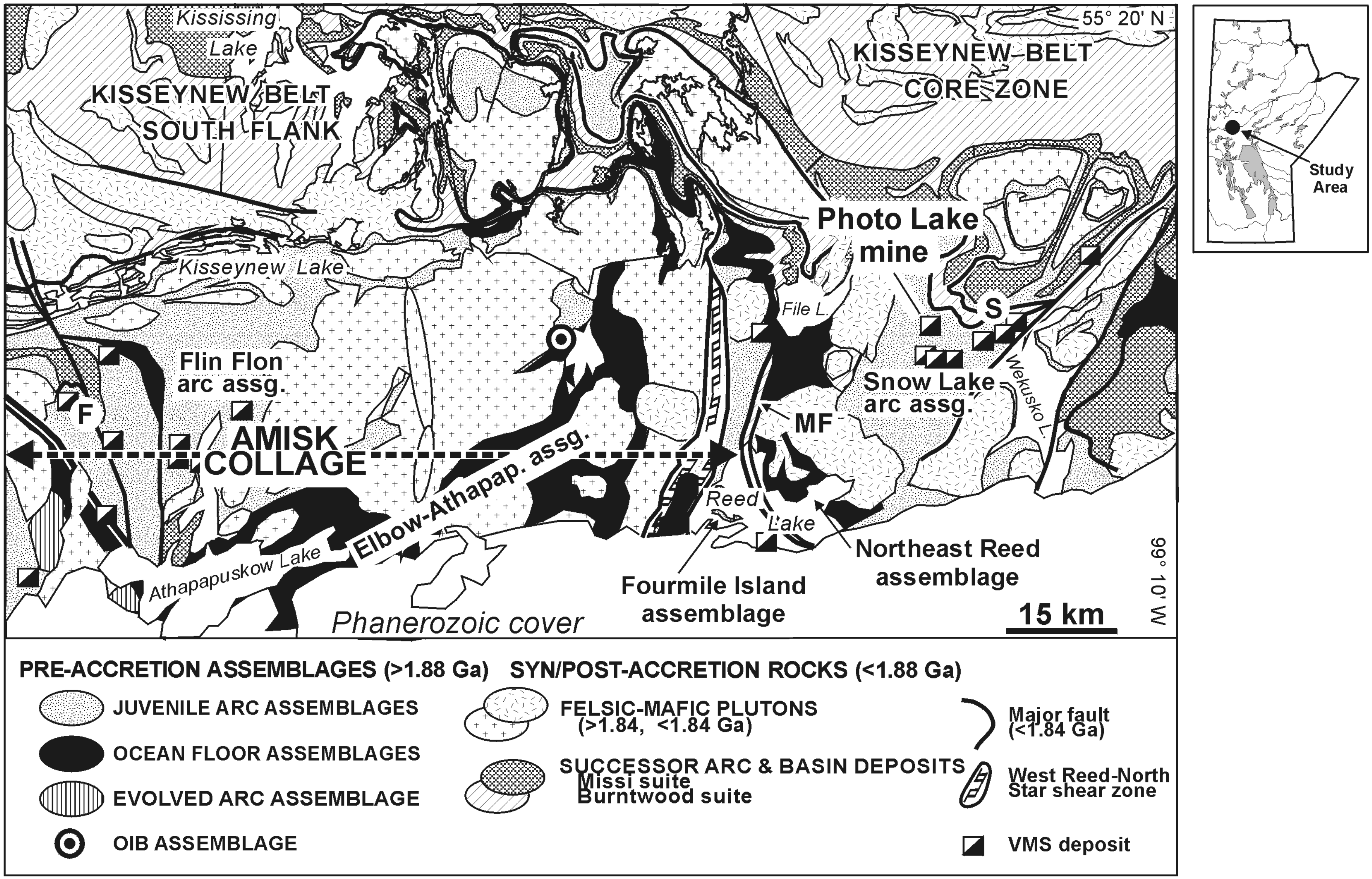

Figure 1: *Location of the mobile metal ion process survey and the regional geological setting of the Photo Lake Cu-Zn massive sulphide type deposit, Snow Lake, Manitoba.*

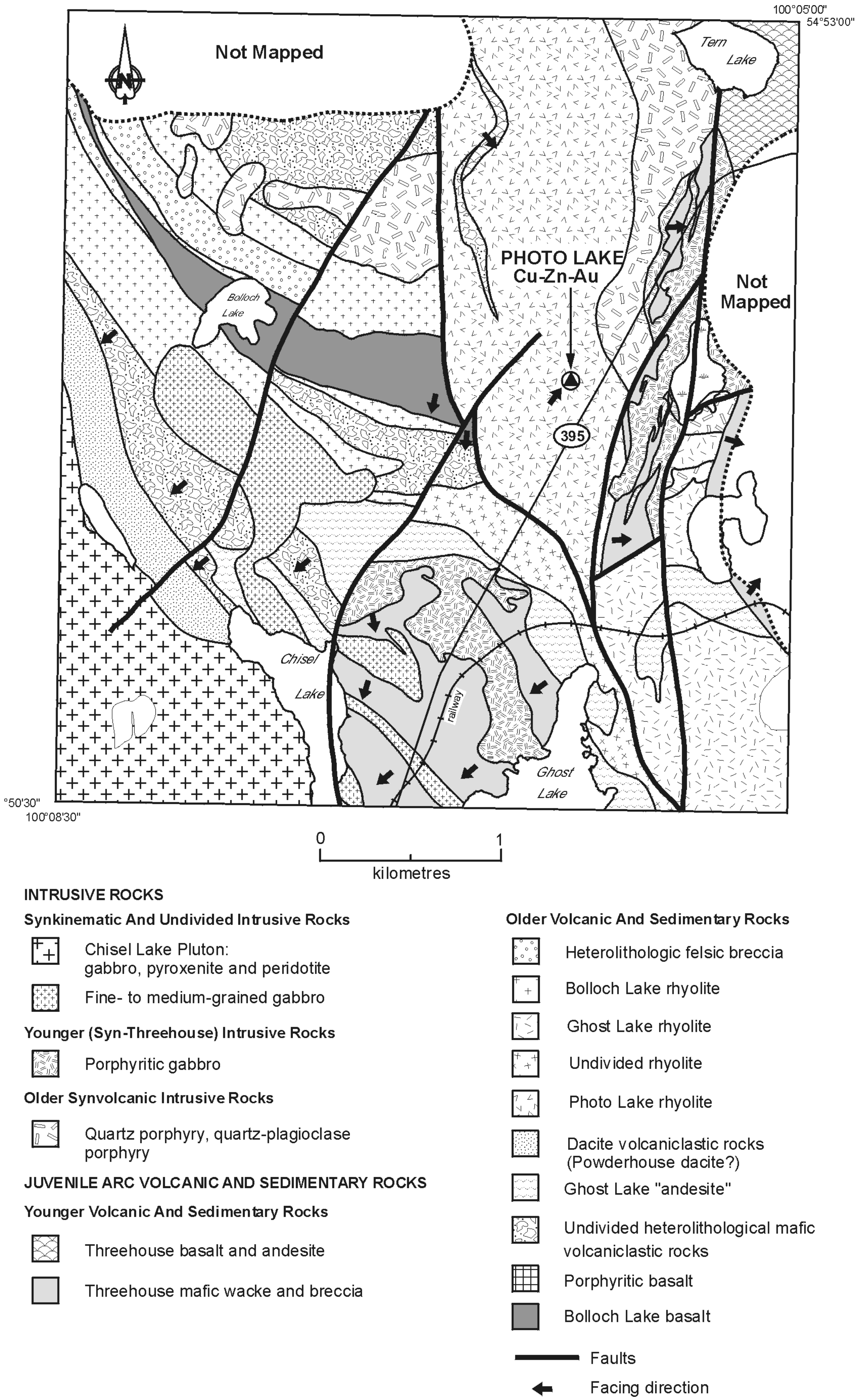

Figure 2:

Local geological setting of the Photo Lake Cu-Zn massive sulphide type deposit.

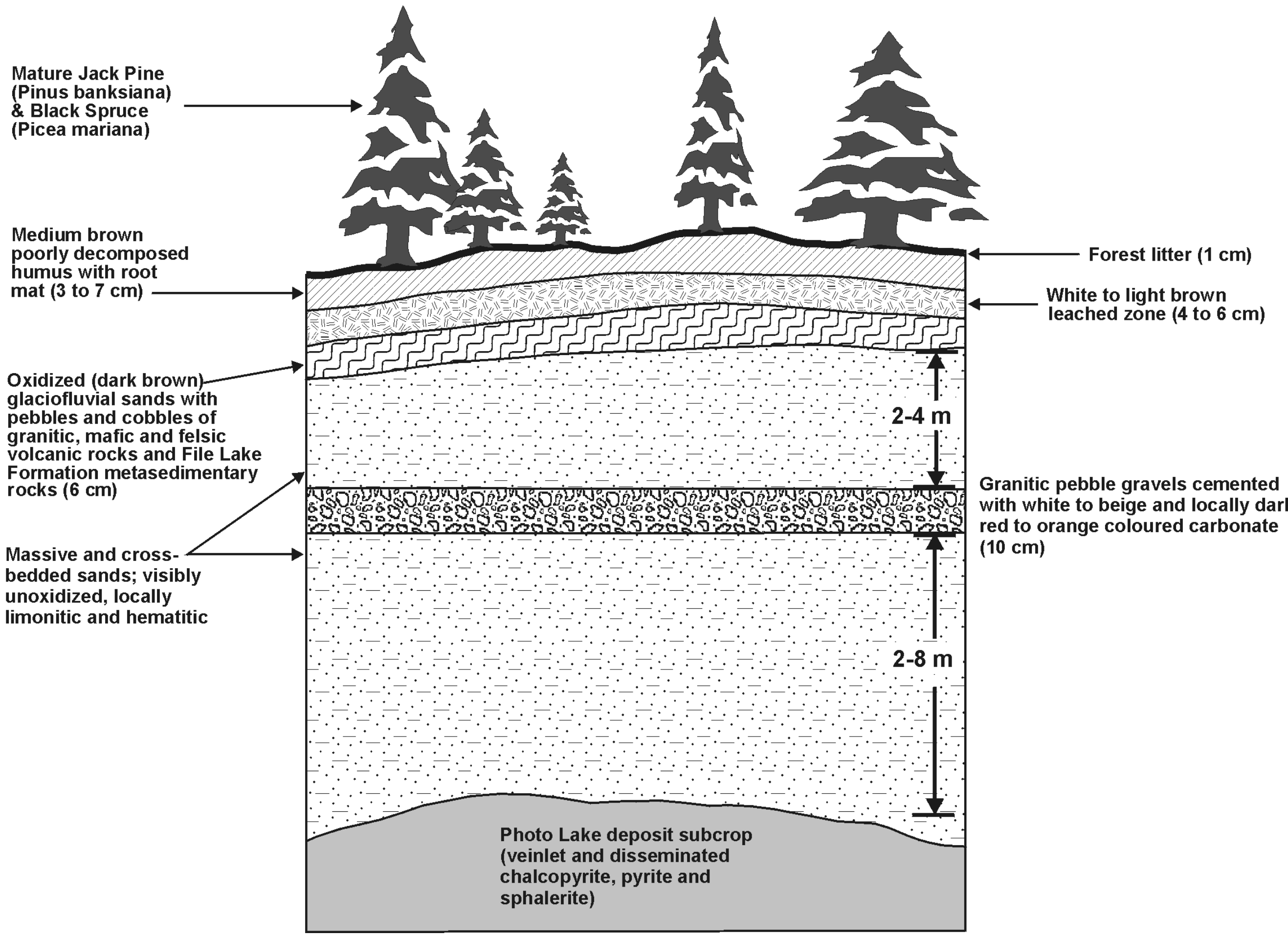

Figure 3: *Schematic diagram of the soil profile overlying the Photo Lake Cu-Zn massive sulphide type deposit.*

Photo Lake Cu-Zn Deposit MMI Profile-Response Ratios

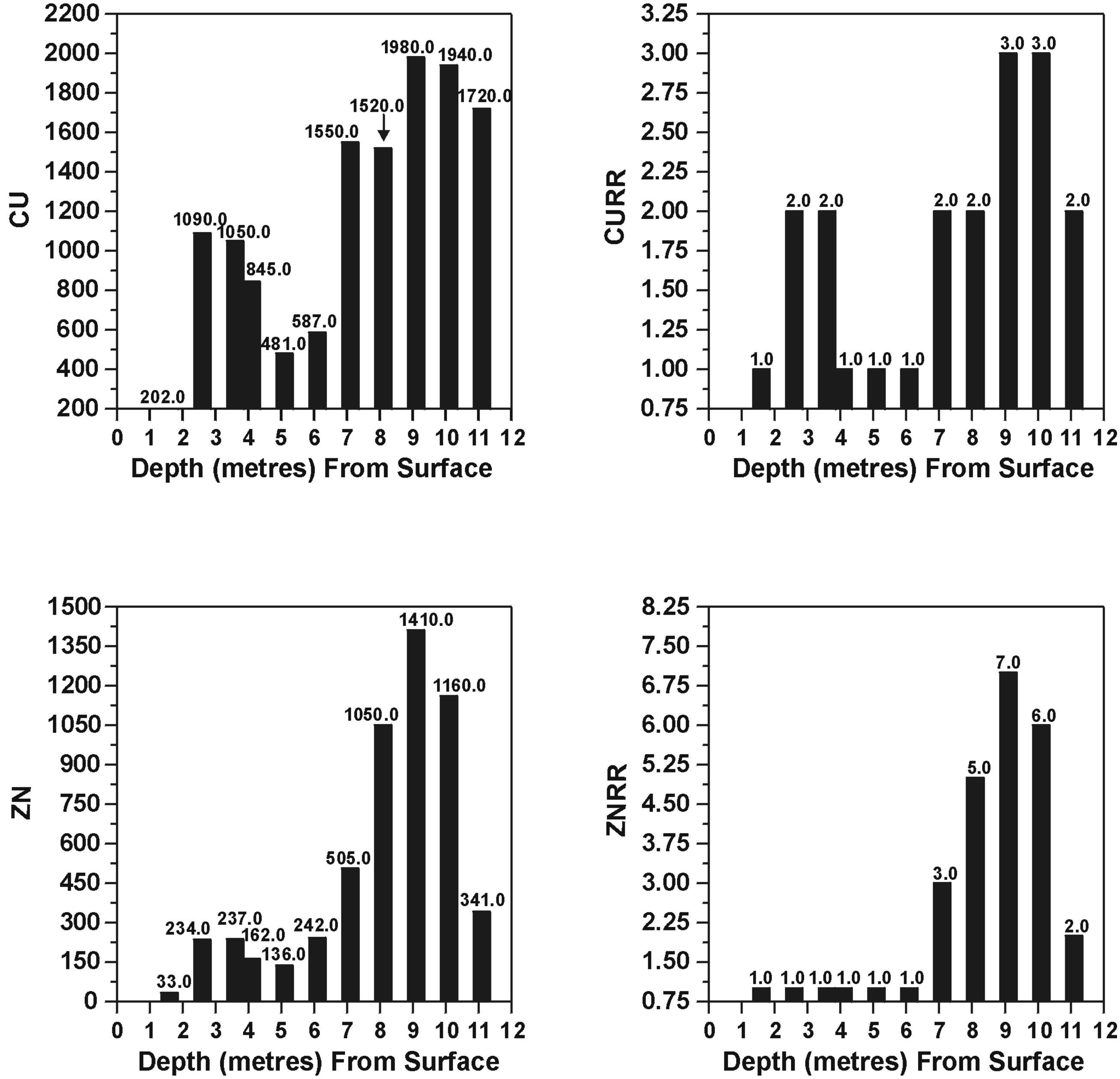

Figure 4: *Non-transformed and response ratio Cu and Zn MMI profiles, Photo Lake Cu-Zn deposit. Actual analytical values and corresponding response ratios are given at the top of each bar on the profile. Element profiles based on response ratio data are denoted by the suffix "RR".*

Photo Lake Cu-Zn Deposit MMI Profile-Response Ratios

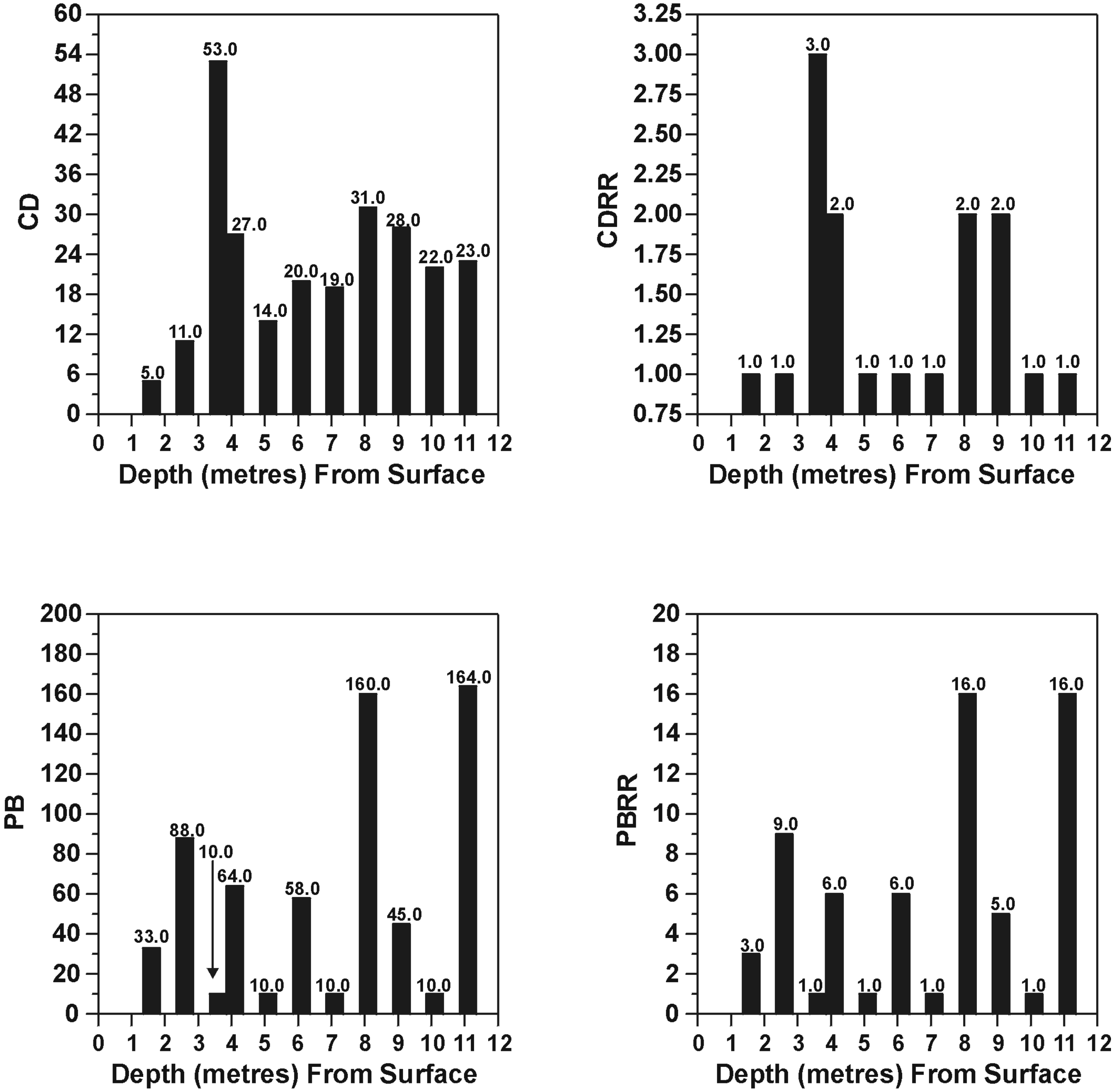

Figure 5: *Non-transformed and response ratio Cd and Pb MMI profiles, Photo Lake Cu-Zn deposit. Actual analytical values and corresponding response ratios are given at the top of each bar on the profile. Element profiles based on response ratio data are denoted by the suffix "RR".*

Photo Lake Cu-Zn Deposit MMI Profile-Response Ratios

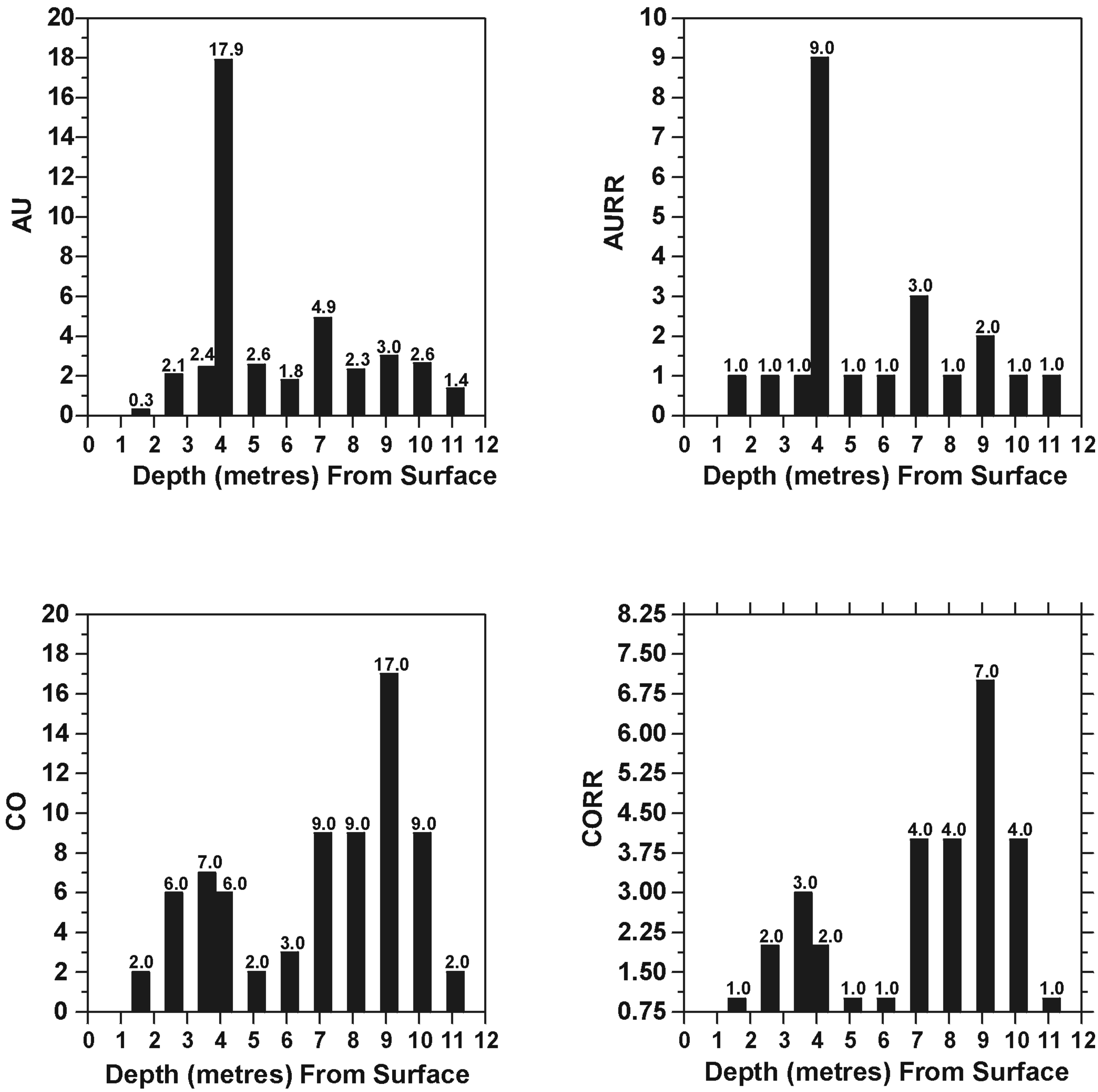

Figure 6: *Non-transformed and response ratio Au and Co MMI profiles, Photo Lake Cu-Zn deposit. Actual analytical values and corresponding response ratios are given at the top of each bar on the profile. Element profiles based on response ratio data are denoted by the suffix "RR".*

Photo Lake Cu-Zn Deposit MMI Profile-Response Ratios

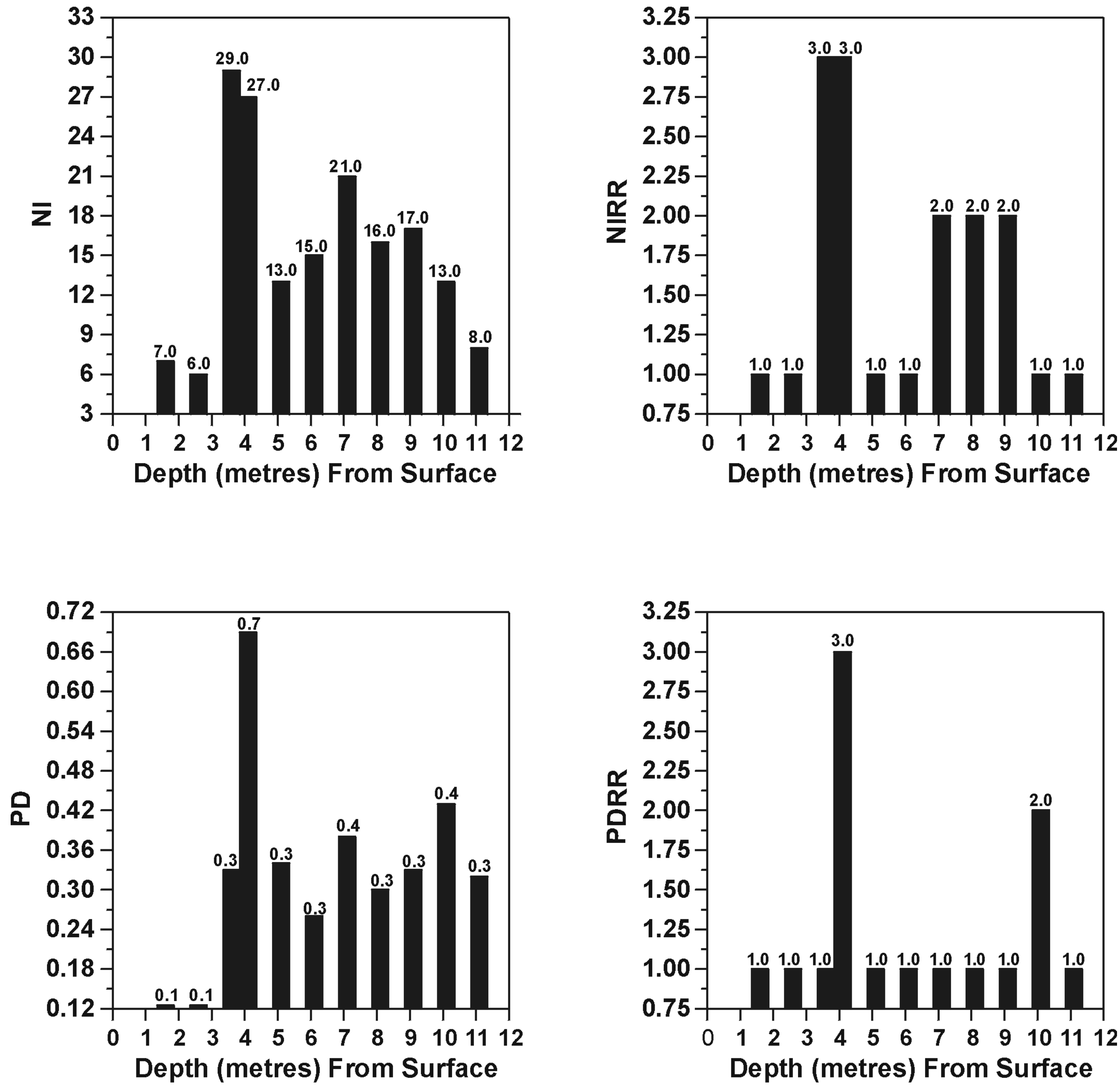

Figure 7: *Non-transformed and response ratio Ni and Pd MMI profiles, Photo Lake Cu-Zn deposit. Actual analytical values and corresponding response ratios are given at the top of each bar on the profile. Element profiles based on response ratio data are denoted by the suffix "RR".*

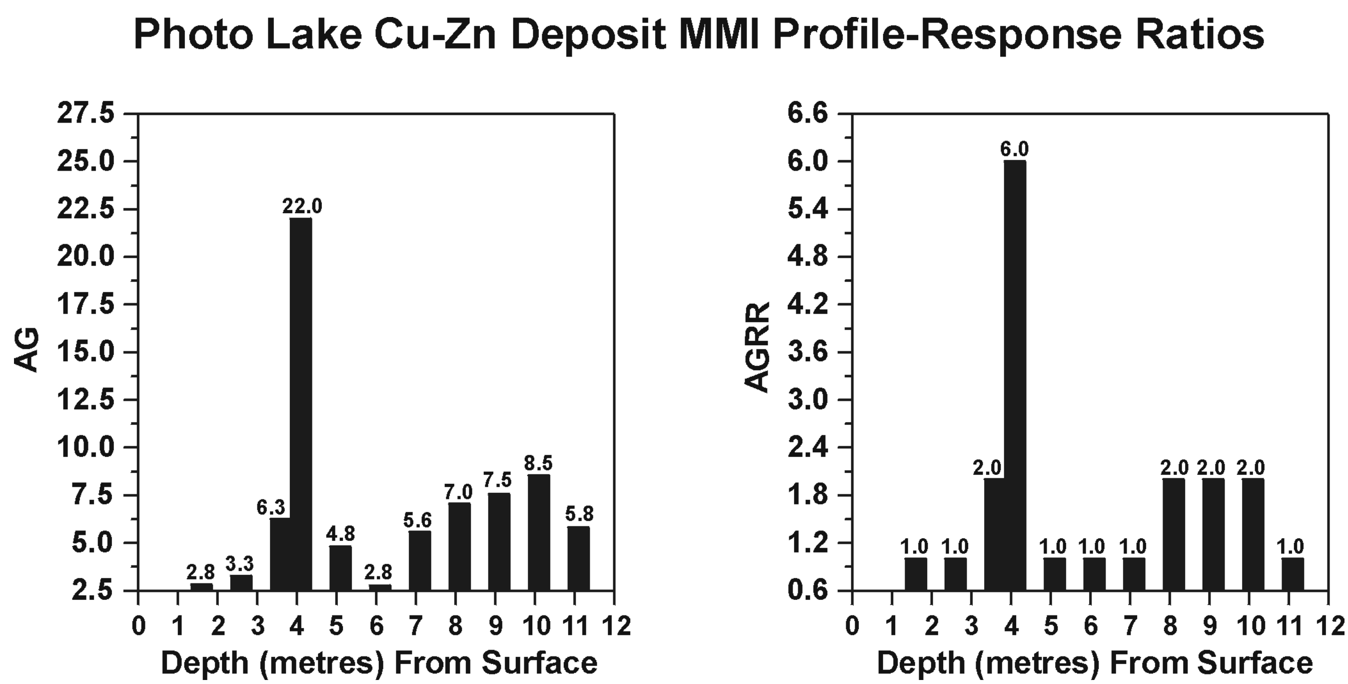

Figure 8: *Non-transformed and response ratio Ag MMI profiles, Photo Lake Cu-Zn deposit. Actual analytical values and corresponding response ratios are given at the top of each bar on the profile. Element profiles based on response ratio data are denoted by the suffix "RR".*

Photo Lake Cu-Zn Deposit MMI Survey

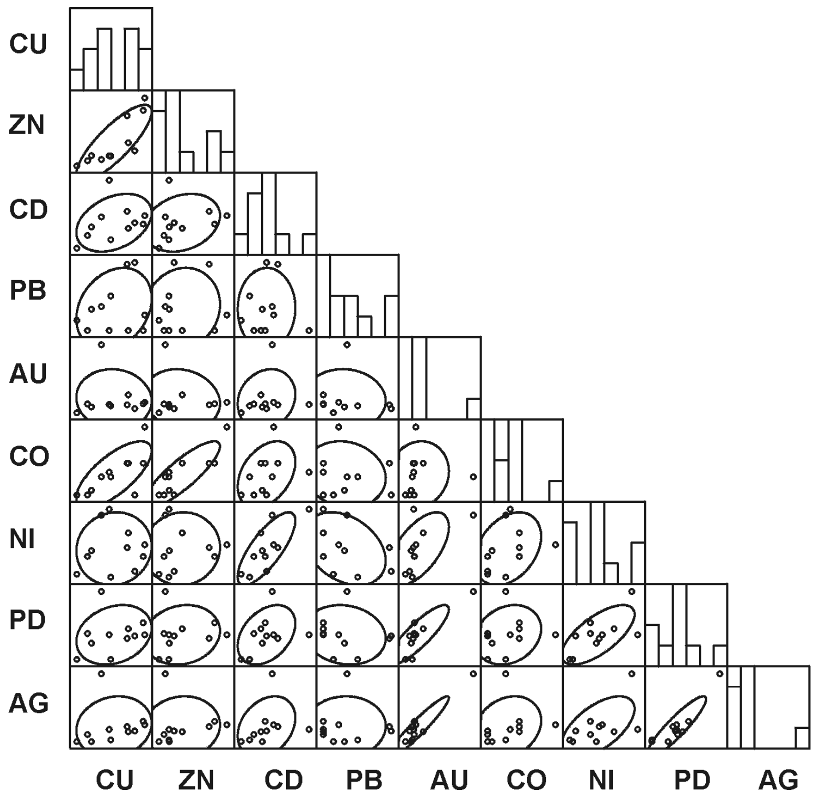

Figure 9: *A scatterplot matrix for non-transformed mobile metal ion process analyses, Photo Lake Cu-Zn deposit.*

APPENDIX 1
SOIL SAMPLE DESCRIPTIONS

Sample

0728: (0.6-1.6 m)	beige to strongly hematitic sand
0729: (1.6-2.6 m)	light to medium grey, moderately indiviated pebbly sand; granitic pebbles tend to be hematitic and limonitic
0730: (2.6-3.6 m)	coarse, pebbly, hematitic-limonitic sand; 6 to 8 cm beds of strongly oxidized pebbles partially coated with calcite flakes/precipitate; the calcite tends to cement pebbles together; locally this cement is hematitic; **initial observation of carbonate re-precipitation**
0731: (3.6-4.1 m)	hematitic-limonitic sand with an increase in the number of coarser, rusty weathered pebbles and an overall reduction in grain size of the sand
0732: (4.1-5.1 m)	hematitic-limonitic sand interlayered with coarser, pebbly, relatively unoxidized sand
0733: (5.1-6.1 m)	weakly to visibly unoxidized sand; oxidation (hematitic) haloes formed around occasional granitic pebble
0734: (6.1-7.1 m)	"blotchy" hematitic sand with hematite-coated granitic pebbles and cobbles
0735: (7.1-8.1 m)	dark grey, indurated, pebbly sand; relatively unoxidized
0736: (8.1-9.1 m)	dark grey sand with strongly oxidized (hematitic) pods/patches/zones
0737: (9.1-10.1 m)	dark grey, moderately indurated dark grey to hematitic sand; locally bright orange in colour; near the base of this sample interval some bright orange sand is interlayered or interfingers with white to grey unoxidized sand
0738: (10.1-11.1 m)	whitish grey to dark grey sand with variably oxidized multicompositional pebbles and cobbles; this sample was essentially collected from the bedrock surface

APPENDIX II
MOBILE METAL ION PROCESS ANALYSES

Sample	Depth From Surface (m)	Cu	Zn	Cd	Pb	Au	Co	Ni	Pd	Ag
		MMI-A	MMI-A	MMI-A	MMI-A	MMI-B	MMI-B	MMI-B	MMI-B	MMI-B
Detection Limit		(5 ppb)	(5 ppb)	(10 ppb)	(20 ppb)	(0.25 ppb)	(1 ppb)	(5 ppb)	(0.25 ppb)	(0.25 ppb)
728	0.6-1.6	202	33	<10	33	0.31	2	7	<0.25	2.8
729	1.6-2.6	1090	234	11	88	2.09	6	6	<0.25	3.27
730	2.6-3.6	1050	237	53	<20	2.44	7	29	0.33	6.25
731	3.6-4.1	845	162	27	64	17.9	6	27	0.69	22
732	4.1-5.1	481	136	14	<20	2.57	2	13	0.34	4.8
733	5.1-6.1	587	242	20	58	1.8	3	15	0.26	2.77
734	6.1-7.1	1550	505	19	<20	4.92	9	21	0.38	5.58
735	7.1-8.1	1520	1050	31	160	2.32	9	16	0.3	7.04
736	8.1-9.1	1980	1410	28	45	3.01	17	17	0.33	7.55
737	9.1-10.1	1940	1160	22	<20	2.64	9	13	0.43	8.54
738	10.1-11.1	1720	341	23	164	1.37	2	8	0.32	5.8
Duplicate 728		182	35	23	22	0.37	3	9	<0.25	2.61
(analytical)										
Background		716	198	17	10	1.95	2.5	10.5	0.28	4.04
(n=11)										