

Orientation Study of Surface Geochemical Methods to Assist in the Exploration for Platinum Group Metals in the Whiterocks Mountain Alkalic Complex, Near Kelowna, British Columbia (82L/4)

By Colin E. Dunn¹, Gwendy E.M. Hall¹ and Graham Nixon²

KEYWORDS: Platinum, palladium, soils, multi-element selective leach, vegetation analysis.

INTRODUCTION

The surface geochemical response to bedrock containing elevated levels of the platinum group elements (PGE) is commonly so subtle that standard geochemical methods are insufficiently sensitive to assist the exploration geologist. At the Geological Survey of Canada, recent research on analytical methods by one of us (GEMH) has been directed toward the development of a selective leach of soils and sediments that will provide improved methodology for the detection of precious metals.

Along with soils, vegetation samples were collected for analysis. In effect, trees and shrubs perform a natural selective leach of elements contained within the substrate by absorbing through their root systems the elements that they require for healthy growth, while passively tolerating certain other elements and permitting their entry into cell structures. Thus, from a study of the chemical element content of common plant species it becomes possible to map zones of mineralization that are concealed by overburden.

To these ends an orientation study was undertaken to collect soil and vegetation from the vicinity of known PGE enrichment on the Dobbin property in south-central British Columbia, to further develop the use of surficial materials in the exploration for minerals. All data presented here should be considered 'preliminary', since method development is continuing. Data from the analysis of the plant tissues are pending. The study was undertaken in conjunction with a mapping program by the third author to evaluate the geological setting of the PGE mineralization.

WHITEROCKS MOUNTAIN AREA

Location, Climate and Vegetation Cover

The survey area is located 2 kilometres west-southwest of Whiterocks Mountain, in the south central part of NTS 82L/4 (Shorts Creek), at an elevation of approximately 1750 metres, within the West Okanagan Provincial Forest. Soils are poorly developed with a thin humic

layer overlying an oxidized B horizon. According to the classification of Valentine *et al.* (1978), the soils at this locality are generally humo-ferric podzols. The high-elevation forests that cover the plateaus of this region are dominated by subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*) and a few lodgepole pine (*Pinus contorta*). Common shrubs are rhododendron (*Rhododendron albiflorum*) and blueberry (*Vaccinium spp.*). Climate is severe with cool, short growing seasons and long, cold winters.

Local Geology

Within the small survey region the dominant rocks are biotite- and hornblende-bearing clinopyroxenites, melanocratic monzonites and microcline-porphyrific (<2.5 cm) to megacrystic (<15 cm) monzonites of the Jurassic(?) Whiterocks Mountain alkaline complex (Figure 1: lithologies 5, 4A, 4B, 3A, 3B). The geology of this part of the intrusion has been mapped in detail by Mehner (1982) and the results of new mapping elsewhere in the complex and surrounding region are presented by Nixon and Carbo (this volume). The host rocks of the intrusion are predominantly fine-grained, siliciclastic sediments with lesser carbonate and minor volcanic/volcaniclastic rocks which form part of the Devonian-Mississippian Harper Ranch Group (Figure 1: lithology 1). The PGE-enriched sulphide mineralization appears to be preferentially associated with the clinopyroxenites and with epidote albite carbonate veins that cut the ultramafic rocks. Previous workers (MINFILE 082LSW005) have related the Cu-Fe-PGE sulphides to an alkaline porphyry style of mineralization.

Mineralization and Exploration History

Mineral exploration in the Whiterocks Mountain area has been active intermittently since the beginning of the 20th century. Between 1968 and 1980, geological surveys and silt, soil and bedrock geochemical sampling conducted on the western flanks of Whiterocks Mountain successfully delineated the main copper anomalies, including the "central" Dobbin Cu-PGE anomaly

¹Geological Survey of Canada

²British Columbia Ministry of Energy and Mines

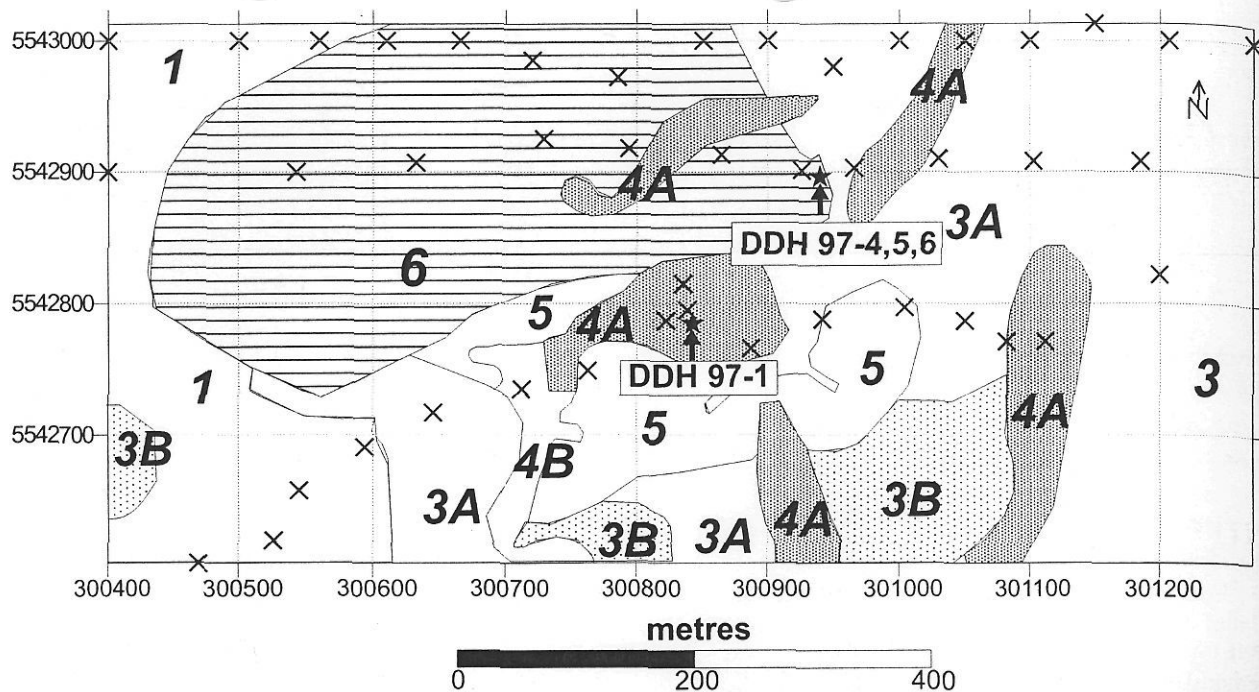


Figure 1. Geology of the Dobbin property showing selected recent drill holes and soil sample sites. Geological units modified after Osatenko (1979) and Mehner (1982): 6, porphyritic (megacrystic) monzonite (Kspar > 2 cm); 5, porphyritic monzonite (Kspar < 2 cm); 4A, hornblende pyroxenite; 4B, biotite pyroxenite; 3A, B, mafic monzonite and hornblende gabbro/diorite; 1, metasedimentary and metavolcanic rocks (Harper Ranch Group).

(MINFILE 082LSW005) which is the prime target of this study. Recent work by joint venture partners Verdstone Gold Corporation and Molycor Gold Corporation has established a northerly-trending zone (250 x 600 m) of Cu-enriched soils underlain by bedrock containing disseminated Cu-Fe sulphides (pyrite-chalcopyrite-bornite), which carry anomalous concentrations of PGE. Chip samples of outcrops in this zone have yielded maximum concentrations of 0.73 % Cu, 0.20 g/t Pt and 0.35 g/t Pd over widths of about 1 metre (Kikauka, 1997). Drilling that took place in 1997 encountered mineralization in diamond drill hole (DDH) 97-1, a few metres from mineralized outcrop, from 0-3 metres grading 0.21% Cu, 0.41 g/t Pt and 0.21 g/t Pd. Approximately 150 m to the northeast DDH 97-4, 5, and 6 were drilled within a few metres of each other. Hole #4 yielded grades of 0.08% Cu, 0.05 g/t Pt and 0.05 g/t Pd from depths of 3-6 m, with higher grades at greater depth. Further details of the exploration history may be found in Nixon and Carbo (this volume) and the B.C. Ministry of Energy and Mines assessment reports.

SCOPE OF SAMPLING PROGRAM

The principal intent of this orientation program was to collect approximately 50 soil samples. A total of 43 samples were collected from the vicinity of known PGE mineralization, and an additional 7 samples from 'background' sites over parts of the Whiterocks Complex considered remote (several kilometers) from known mineralization. The 43 samples were from the Dobbin claims,

currently held by Verdstone Gold Corporation of Whiterock, B.C.

At each sample site a small pit was dug with a shovel, and a stainless steel trowel was used to collect sufficient B horizon soil (depth of about 20 cm) to fill a standard 'kraft' soil bag. At selected sites, 50-70 g of outer bark from Engelmann spruce was collected with a hardened-steel paint scraper and placed into a second kraft bag. In addition, at a few sites samples of twigs were snipped from subalpine fir, rhododendron and blueberry, following the collection protocols developed and described in Dunn (1999 and in press).

SAMPLE PREPARATION AND ANALYSIS

Soils

Soil samples were oven-dried at 60°C, and then screened through a -80 mesh stainless steel Tyler sieve (mesh aperture of 177µm). A bulk sample of soil from a site close to subcropping mineralization was also dried, sieved, and used as a guide to analytical precision and accuracy by interspersing several portions at random through the sequence of samples. Several soil samples were split to obtain an estimate of sample precision, and the laboratory staff at the GSC inserted additional analytical quality control samples of known composition to monitor the accuracy.

Details of the selective leach that is being developed at the GSC are confidential at the present time. In general,

samples are digested in an acidic leach of sufficient strength to selectively target elements associated with both hydrous Mn and Fe oxide phases, and adsorbed, exchangeable and carbonate-bound fractions. The pH of each solution is carefully controlled. Elements structurally incorporated in crystal lattices are not released. The methodology is being developed specifically to extract and stabilize the precious metals Au, Pt and Pd in the leachate for measurement at low detection limits. For this orientation phase of the work, 1 g of soil was accurately weighed, the elements extracted, and the solution analysed for 57 elements by inductively coupled plasma mass spectrometry (ICP-MS).

Vegetation

Samples were dried in an oven for 12 hours at 90°C. Foliage was then removed from twigs, and the twigs and bark were reduced to ash by controlled ignition at 470°C for approximately 12 hours. After the insertion of appropriate quality control samples, they were submitted to Activation Laboratories Ltd (Ancaster, Ontario) for digestion in aqua regia followed by analysis by ICP-MS to provide data for 60 elements. The data are pending, and will be compared with the soil selective leach data to assess which method is the more suitable and informative for PGE exploration in this environment. By comparison with previous studies of PGEs in vegetation tissues from the vicinities of PGE mineralization in British Columbia, a modest response might be expected (Dunn, 1992).

PRELIMINARY RESULTS

Table 1 shows summary statistics for the 43 soil samples from three transects that extended from background sites, across subcropping PGE mineralization, and back into background. The last column to the right shows average values from seven background sites several kilometres from the survey area. In general, the median values from the survey area are similar to the mean values from the seven background sites, indicating that samples from many of the survey sites were from unmineralized ground. Exceptions are higher Cu, Cs, Br and I from survey area suggesting that these elements were associated with the mineralizing event and might be of value as pathfinder elements. At background sites, levels of Ca, Mg, Rb, Sr, Mn and the rare earth elements (REE) are higher, presumably reflecting the typically more elevated levels of these elements in the more felsic lithologies that predominate within the region.

The three 700–800 metre long transects (43 sites) were designed to sample at intervals of approximately 50 metres across zones known to contain Pt and Pd. A sketch of soil sample sites (Figure 1) shows the geology and the locations of drill holes that have intersected significant mineralization.

Elements that show the greatest anomaly to background contrast near known zones of mineralization are Pt, Bi, Ag, Cu, Mo. Dots proportional in size to concen-

trations of Pt, Bi and Ag (Figure 2) and Cu, Mo and Pb (Figure 3) are superimposed on data that have been contoured, using a natural neighbour plotting method ('Surfer' software), at percentile intervals of 50, 70, 80 and 90. Comparison of the dot patterns with the sample sites that are shown on Figure 1 permits the relationship of element concentrations to underlying lithology to be observed.

Element concentrations are lower than those that typically occur in analyses of soils by an aqua regia leach, because the method employed for this study is selective in its attack on the soil particles. The leach extracts only that portion of an element that is readily released (details above). Figure 2 shows that the highest Pt concentration, although only 2.5 ppb, occurs close to DDH97-1 (center of the map, and see Figure 1). The contoured plot of Pt indicates that the zone with values greater than the 80th percentile occurs to the north and northwest from this site that includes an area that has not been drill tested. Distribution patterns of Bi and Ag also show relatively high concentrations close to DDH97-1, with modest enrichment northeastward from DDH97-4, 5 and 6. Figure 3 shows that most of the highest concentrations of Cu, Mo and Pb occur in the northeast part of the survey area, east of DDH 97-4, 5 and 6. Lead values are highest close to the drill hole locations. Elements commonly associated with PGE enrichment in ultramafic rocks include Ni, Co, Cr, and Mg, but none of these exhibit relative enrichment in the leachates of soils from these sites. Therefore, for this style of mineralization, they are of limited use as pathfinders for PGE by this analytical method. A brief review of the distribution patterns of the other elements indicates that, with the exception of Cs, none are of obvious value as pathfinders for the PGEs. Cesium, however, exhibits a similar distribution pattern to the other elements shown in Figures 2 and 3, and especially to those of Cu, Mo and Ag. As stated above, the analytical methodology, especially data for Pd, needs refining before conclusions are drawn as to its value in delineating enrichments of PGE in the substrate. Preliminary indications are encouraging.

CONCLUSIONS

The analytical methodology currently under development, especially the analysis for Pd, needs refining before conclusions are drawn as to its value in delineating enrichments of PGE in the substrate. Preliminary indications from the Dobbin property in south-central British Columbia are encouraging. Compared to background sites, there is a general slight enrichment of Br and I in soil samples from the Dobbin property. Subtle enrichments of Bi, Ag, Mo, Cu, Pb and Cs appear to be associated with known Cu-PGE mineralization, thereby providing a multi-element signature that may assist in delineating mineralized zones concealed by overburden.

TABLE 1
SELECTIVE LEACH OF SOILS - STATISTICS

	D.L.	Mean	Std. Dev.	Minimum	Percentiles					Maximum	Mean Bkgrd-7 sites
					25	50	70	80	90		
Pd ppb*	2	2.07	1.57	1	1	1	2.96	3.52	4.56	7	1.00
Pt ppb	0.1	0.715	0.394	0.2	0.52	0.61	0.80	0.92	1.25	2.5	0.57
Au ppb	0.1	0.641	0.304	0.3	0.42	0.59	0.75	0.934	1.06	1.7	0.52
Ag ppb	2	179	121	46	98	139	200	263	305	553	122
As ppb	40	421	200	204	286	375	465	543	627	1331	337
Be ppb	2	201	64	68	171	185	208	242	302	407	164
Bi ppb	4	153	149	47	86	116	145	182	273	914	247
Br ppb	1600	2589	1618	800	800	2235	3161	3972	4780	7551	1320
Cd ppb	8	129	122	39	63	91	125	155	257	603	73
Ce ppb	4	6271	2970	1493	3938	5511	8675	10042	10465	13218	9750
Cs ppb	4	584	744	28	164	234	567	808	1798	3277	167
Dy ppb	2	454	272	91	248	378	539	670	787	1403	666
Er ppb	2	231	157	40	107	183	292	362	417	852	323
Eu ppb	2	141	87	35	75	112	169	210	253	413	231
Gd ppb	2	609	400	123	308	458	741	949	1108	2001	990
Ho ppb	2	82	54	14	43	66	103	126	145	282	117
I ppb	600	3480	1488	300	2650	3493	4119	4528	5304	7945	2036
In ppb	4	9	2	6	8	9	10	10	10	15	9
La ppb	4	3111	2196	779	1666	2326	3310	3991	7126	10413	4161
Li ppb	2	293	353	96	143	176	240	296	670	2134	278
Lu ppb	2	24	19	3	10	18	30	36	45	109	30
Mo ppb	20	128	191	10	36	74	110	159	255	1157	116
Nd ppb	2	2821	1939	573	1403	2122	3293	4139	5683	9420	4503
Pb ppb	4	3500	1113	1389	2799	3362	3859	4185	4798	7610	3185
Pr ppb	2	719	486	151	365	530	827	1074	1487	2424	1068
Rb ppb	20	2232	1034	701	1414	1878	2763	3190	2232	4595	3134
Re ppb	2	1	0	1	1	1	1	1	1	1	1
Sb ppb	4	17	7	4	12	17	20	21	26	33	13
Se ppb	400	220	105	200	200	200	200	200	200	864	228
Sm ppb	2	559	357	111	301	441	666	837	1012	1751	966
Tb ppb	2	91	55	17	50	70	112	142	163	275	142
Th ppb	2	83	55	1	49	70	107	122	145	269	120
Ti ppb	2	18	11	5	12	17	20	24	28	74	13
Tm ppb	2	29	20	4	13	23	38	43	54	108	36
U ppb	2	248	104	91	179	214	272	323	391	621	259
Y ppb	4	2142	1763	324	917	1560	2696	3350	3974	10321	2810
Yb ppb	2	173	124	25	80	146	218	249	321	696	223
Al ppm	4	7141	2401	2623	5650	6896	8342	9237	9929	14889	5976
B ppm	0.1	0.6	0.3	0.4	0.5	0.6	0.7	0.9	1	1.5	0.4
Ba ppm	0.2	47	29	17	29	40	52	60	87	157	69
Ca ppm	4	1858	2115	86	364	958	2031	3381	5362	8874	3022
Co ppm	0.02	3	4.7	0.2	0.9	2	2.8	3.9	5.5	31	2.7
Cr ppm	0.02	1.9	0.6	1	1.4	1.8	2.2	2.4	2.8	3.4	2
Cu ppm	0.04	43	116	3	5	12	25	40	69	707	6
Fe ppm	1	4086	1140	2329	3154	3925	4664	4987	5953	6642	3470
K ppm	2	165	76	71	102	150	195	235	266	372	173
Mg ppm	1	221	438	17	55	92	173	257	478	2825	271
Mn ppm	1.0	199	147	12	77	160	273	294	427	657	207
Na ppm	1	22	6	11	19	22	24	25	29	43	20
Ni ppm	0.04	1.1	1.2	0.2	0.5	0.9	1.1	1.4	2.1	7.8	0.8
P ppm	10	510	476	110	217	343	551	710	1122	2382	1198
Sc ppm	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.05	0.10
Si ppm	4	1459	796	328	922	1338	1732	2002	2429	3933	1411
Sr ppm	0.02	9	10	1	2	5	10	15	22	43	24
Ti ppm	0.4	34	14	20	26	31	37	40	47	107	39
V ppm	0.04	11	5	5	8	10	13	14	18	26	9
Zn ppm	0.1	8.2	5.4	1.8	4.1	7	10	11	18	24	5

*Data for Pd are preliminary and subject to modification. DL= detection limit: for computational purposes values below DL were taken at half DL. Data for Pd and Pt are shown first, followed by elements with concentrations in ppb then elements in ppm.

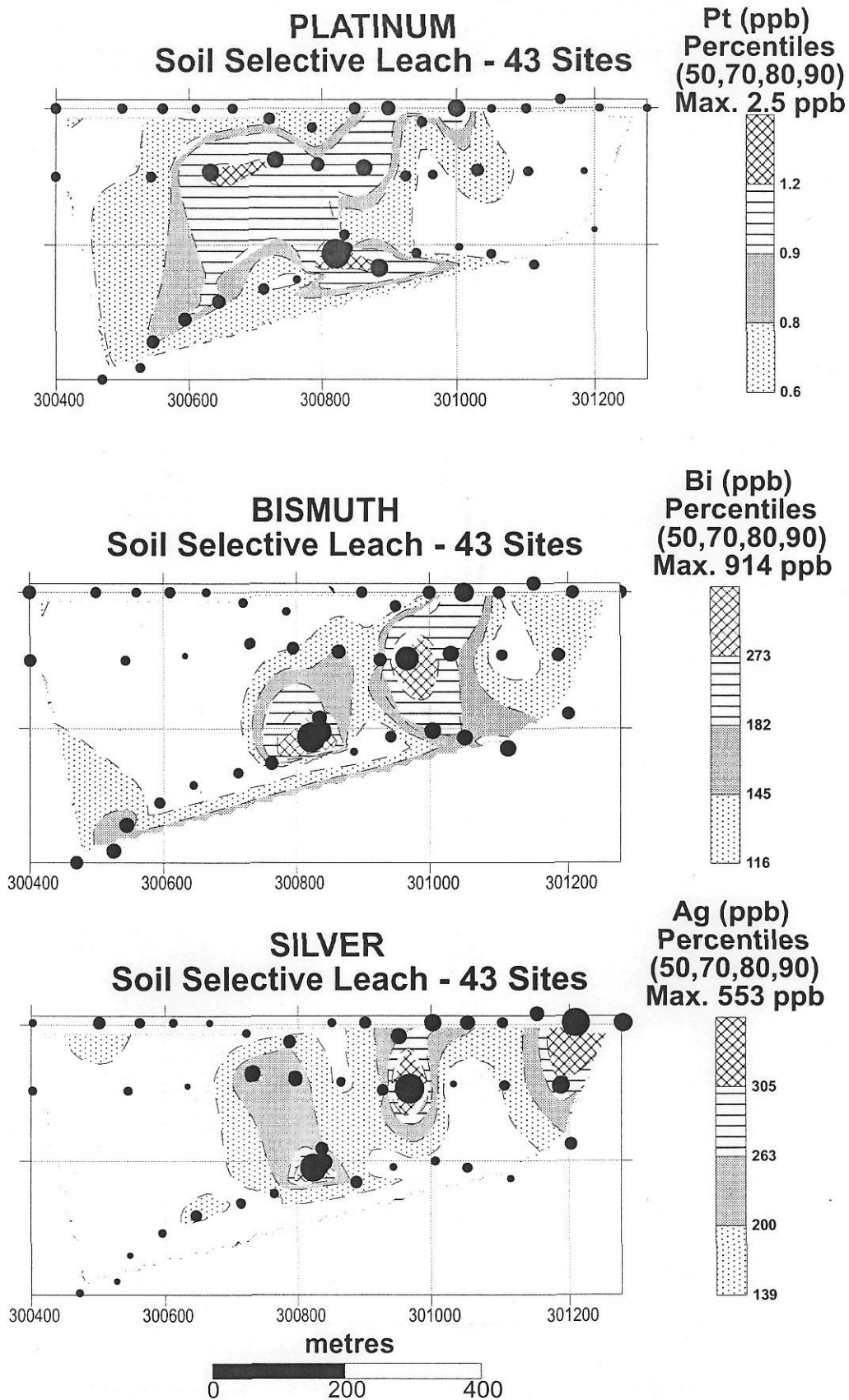


Figure 2. Platinum, bismuth and silver values derived from a selective leach of soils. Values contoured as percentiles and overlain with dots proportional to concentrations.

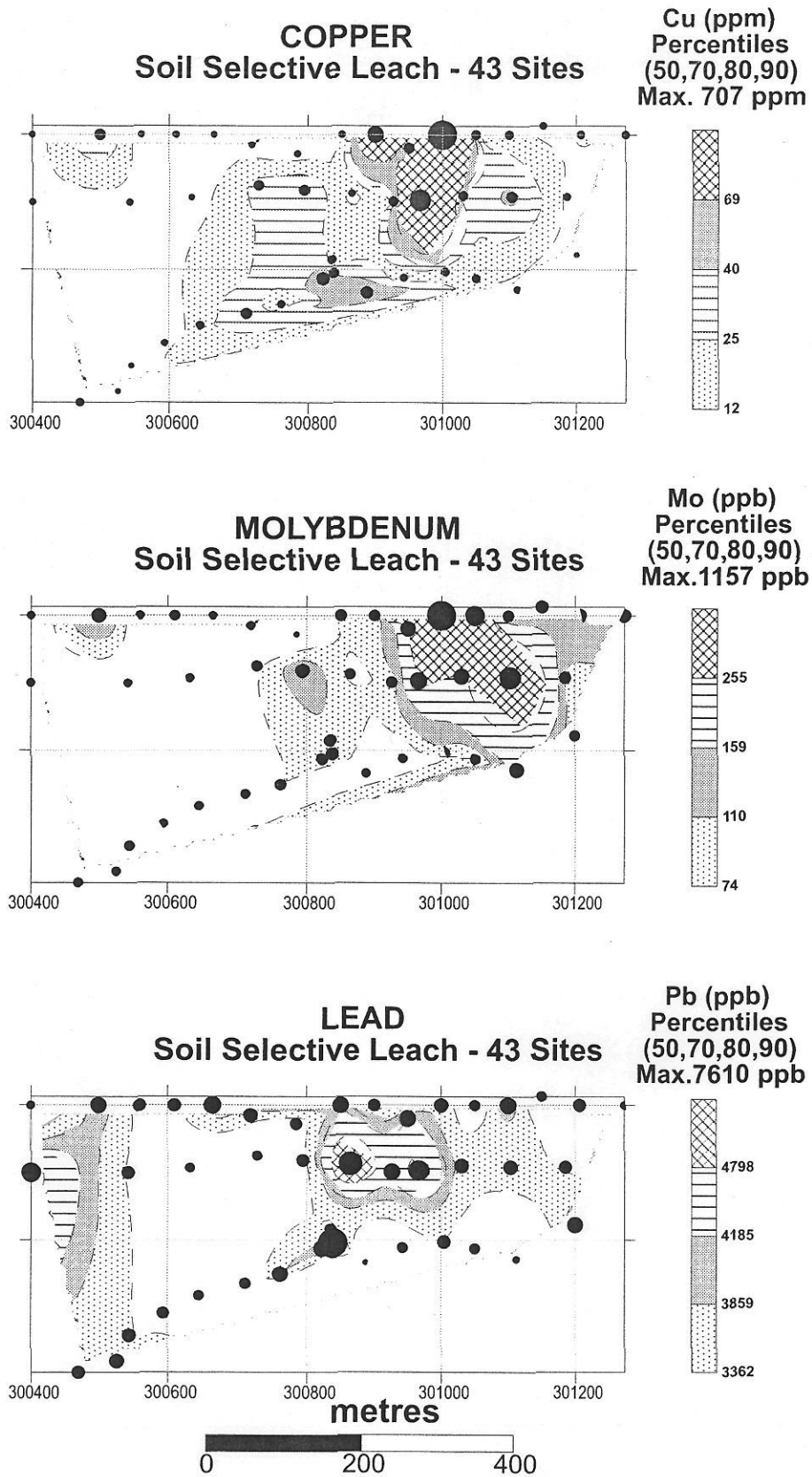


Figure 3. Copper, molybdenum and lead values derived from a selective leach of soils. Values contoured as percentiles and overlain with dots proportional to concentrations.

REFERENCES

- Dunn, C.E., (1992). Biogeochemical exploration for deposits of the noble metals. Chapter 3 in: Noble Metals and Biological Systems (Ed. R.R. Brooks), *CRC Press*, Boca Raton, FL, pages 47-89.
- Dunn, C.E., (1999). Biogeochemical exploration methods in the Canadian Shield and Cordillera. 19th International Geochemical Exploration Symposium, Vancouver, *Association of Exploration Geochemists*, Short Course Notes.
- Dunn, C.E. (in press). Biogeochemical exploration methods in the Canadian Shield and Cordillera. *Geochemistry: Exploration, Environment, Analysis*.
- Kikauka, A. (1997): Geological, geochemical and diamond drilling report on the Dobbin Claim Group, Whiterocks Mountain, Kelowna, B.C; *British Columbia Ministry of Energy and Mines*, Assessment Report 25290.
- Makepeace, D. K. (2000): Summary review of the Dobbin Property, Tadpole Lake Area, Vernon and Nicola Mining Divisions, British Columbia, Canada; Internal Report for Verdstone/Molycor Gold Corporations, Surrey, British Columbia, 48 pages.
- Mehner, D. T. (1982): Geology of the Whiterocks Mountain Alkalic Complex, South-central British Columbia; unpublished M.Sc. thesis, *University of Manitoba*, 89 pages.
- Valentine, K.V., Sprout, P.N., Baker, T.E. and Lavkulich, L.M., (1978): The soil landscapes of British Columbia, *B.C. Ministry of Environment*, Resource Analysis Branch, 197 pages.