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RECONNAISSANCE ROCK GEOCHEMISTRY OF THE NICOLA AND KINGSVALE GROUPS BETWEEN MERRITT AND PRINCETON

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INTRODUCTION

The copper-rich, Upper Triassic Nicola Group between Merritt and Princeton was geologically mapped by Ministry staff during the summers of 1972 to 1975. Mapping was initiated by P. A. Christopher in the Fairweather Hills area near Aspen Grove (Christopher, 1973) and continued in the following years by the writer to the north and south to cover an area of approximately 650 square kilometres (Fig. 1). The results of this work have recently been summarized in Bulletin 69 of the British Columbia Ministry of Energy, Mines and Petroleum Resources (Preto, 1979).

In conjunction with the mapping program, it was decided to examine the geochemistry of the various rock units distinguished in the course of mapping to see whether a relation existed between the distribution of mineral deposits and the background metal content of these suites.

Within the study area, Nicola volcanic rocks comprise three roughly parallel, north-trending, fault-bounded belts. Most mineral occurrences are found in the Central Belt, which consists largely of subaerial and submarine pyroxene and plagioclase-rich andesitic and basaltic flows, breccia, conglomerate, and lahar deposits. Important volumes of diorite and subordinate syenite are comagmatic with this suite. The northern part of the Eastern Belt consists of a succession of submarine volcanic sediments but the southern part is dominated by extensive lahar deposits, some analcite-bearing basalt flows, and several high-level syenitic stocks. In contrast, the Western Belt consists of andesitic to rhyolitic flow and pyroclastic rocks that are interbedded in their upper part with abundant limestone, volcanic conglomerate, and sandstone.

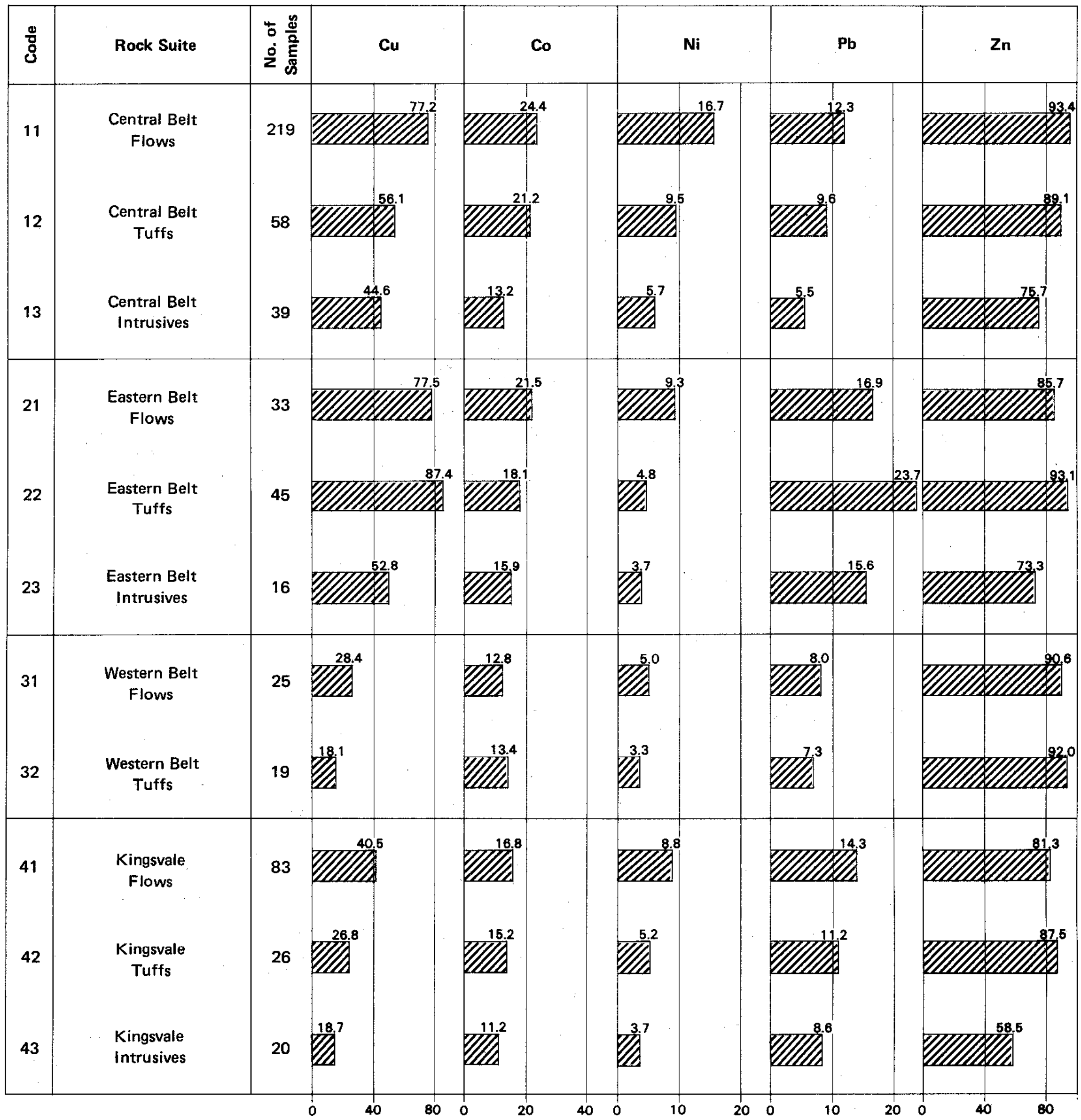
The Central and Eastern Belts include both alkaline and calc-alkaline rock suites, whereas the Western Belt is a markedly talc-alkaline assemblage.

A later sequence of Cretaceous volcanic rocks with minor associated sedimentary and intrusive rocks unconformably overlies the Nicola Group. It is correlative with the Kingsvale Group (Preto, 1979). The lavas range from basalt to rhyolite in composition and are almost exclusively subaerial. Apparently these rocks are devoid of mineral occurrences.

This report summarizes the distribution of copper, cobalt, nickel, lead, and zinc in flow, volcaniclastic, and intrusive rocks in each of the three tectonic/lithologic belts and, for comparison, in rocks of the Kingsvale suite. Sample collecting was done during the course of field work and, because background values were sought, only samples that carried no visible sulphides and were minimally altered were analysed. Samples not visibly mineralized but collected near areas of known mineralization were also excluded from the study. For these reasons, the metal distribution maps show large gaps in the vicinity of the Axe deposit and on Fairweather Hills. Other large gaps in coverage reflect extensive overburden, particularly in the Eastern Belt.

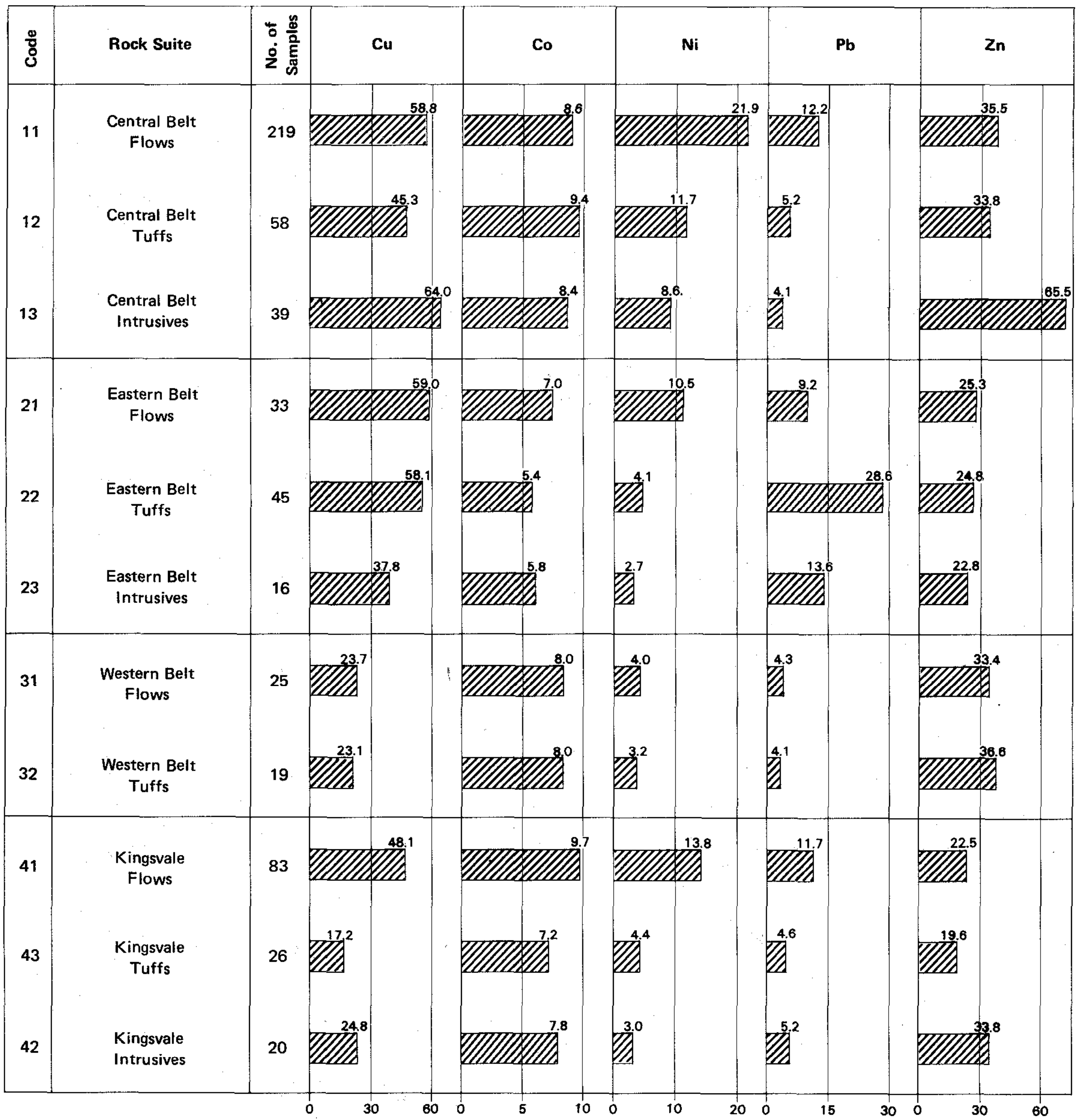
ACKNOWLEDGMENTS

This study is one of the results of a four-year mapping project to which several individuals contributed under the writer's direction. Valuable assistance in mapping and sample collecting was given in 1972 by P. A. Christopher, in 1973 by T. Kalnins, N. Thomsen, and J. Nebocat, in 1974 by S. Atkinson, J. Nebocat, and L. Robertson, and in 1975 by P. Tremblay-Clark, M. Mann, and D. Calder. D. V. Lefebure (1976) studied in detail a well-exposed area of Fairweather Hills and his work has been a very useful contribution. Sample preparation and analyses were carried out at the Analytical Laboratory of the British Columbia



NOTE: Numbers beside bars indicate mean in ppm.
The mean is a measure of the tendency of clustering of a distribution and an approximation to the background level of the metal studied.

FIGURE 2. MEAN



NOTE: Numbers beside bars indicate standard deviation in ppm.
Standard deviation is a measure of the spread of values about the mean in a given distribution.

FIGURE 3. STANDARD DEVIATION

Code	Rock Suite	No. of Samples	Cu	Co	Ni	Pb	Zn
11	Central Belt Flows	219	164	40	70	26	137
12	Central Belt Tuffs	58	128	34	41	19	160
13	Central Belt Intrusives	39	187	28	21	16	242
21	Eastern Belt Flows	33	190	33	33	35	129
22	Eastern Belt Tuffs	45	181	29	14	91	146
23	Eastern Belt Intrusives	16	129	25	11	64	113
31	Western Belt Flows	25	61	26	14	16	140
32	Western Belt Tuffs	19	93	29	16	16	180
41	Kingsvale Flows	83	143	32	31	43	117
42	Kingsvale Tuffs	26	60	26	16	17	129
43	Kingsvale Intrusives	20	104	29	12	24	152
			0 100 200	0 20 40	0 40 80	0 50 100	0 100 200

NOTE: Numbers beside bars show threshold values in ppm.
Numbers of samples are shown beside the mnemonic.
The 95th percentile of the cumulative frequency distribution is arbitrarily taken as the level above which values are considered anomalous.

FIGURE 4. 95TH PERCENTILE THRESHOLD

Ministry of Energy, Mines and Petroleum Resources. Analyses were performed by background-corrected atomic absorption of totally digested samples.

Computer treatment of the data for statistical and graphic purposes was done with the Provincial Government's computing facilities with the assistance of W. J. McMillan.

ROCK GEOCHEMISTRY

A total of 583 samples were analysed for copper, lead, zinc, cobalt, and nickel. Given a study area of approximately 650 square kilometres, this yields a sample density of 0.9 per square kilometre. A quick glance at the geological and metal distribution maps, however, will reveal that the sample distribution is uneven because rock exposures are not ubiquitous and because the nature of the survey required that samples be relatively fresh and not visibly mineralized. For these reasons, the data are of limited reliability and significance, especially in the northern part of the study area (Fig. 1).

Summaries of the basic statistical parameters – mean, standard deviation, 95th percentile threshold, skewness, and kurtosis – are presented for each map unit and for each element analysed on Figures 2 to 6. In addition, histograms for each element in the four divisions are given on Figure 7. Within each histogram the contributions made by flows, tuffs, and intrusives are tabulated.

Figures 8 to 12 are metal distribution maps for the five analysed elements. Because sample distribution was uneven, it was decided to hand contour the maps. The results should be studied in conjunction with the enclosed geological map (Fig. 1). In the pocket, there is a microfiche file of complete analytical results for all the samples.

COPPER

Copper is the most widespread and economically important metal in the Nicola Group. Its most important mode of occurrence is in porphyry deposits of the alkaline suite, like those associated with the Copper Mountain intrusions and the Iron Mask batholith (Barr, *et al.,* 1976). These deposits formed in a subvolcanic environment and occur within, or very close to, volcanic centres. In the study area, many rocks of the Central and Eastern Belts are alkaline (Preto, 1979) and several were extruded from nearby high-level alkalic stocks. In the Eastern Belt, along the north shore of Missezula Lake, for example, analcite-bearing trachybasalt porphyry flows, tuff, and lahar deposits are closely related to a small syenite-monzonite stock. Significantly, the intrusion and the proximal extrusive assemblage are both marked by high copper values; several individual readings ran two to three times higher than the mean and a few exceeded the 95th percentile threshold values for copper in the Eastern Belt.

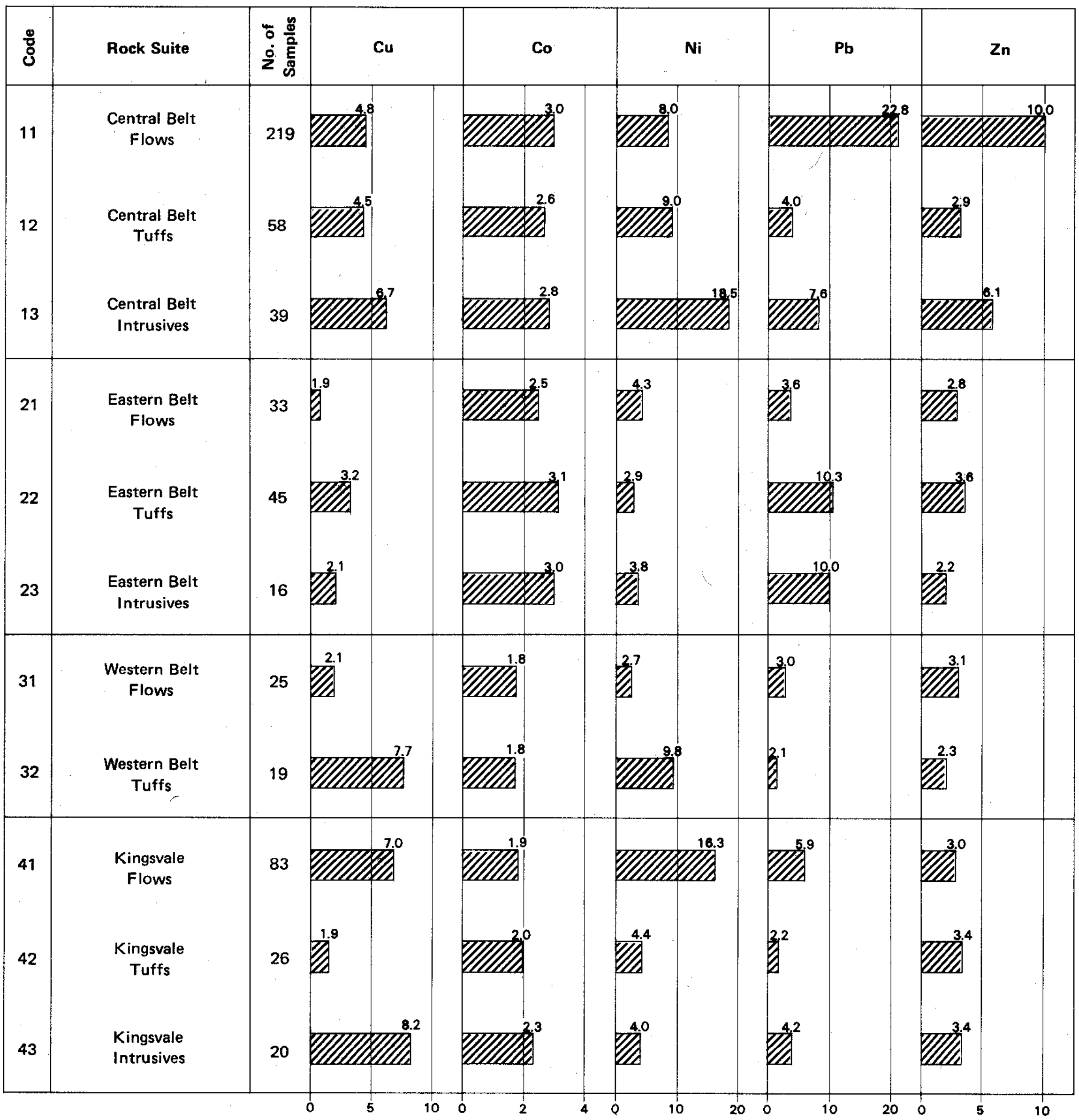
A similar situation occurs in the vicinity of Missezula Mountain in the Central Belt. There, the geology is dominated by thick accumulations of green, massive to coarsely brecciated augite-plagioclase basalt flows with a few intercalated tuff horizons. The coarse flow breccias and the abundance and thickness of flow accumulations again indicate proximity to the volcanic source, and again copper values are high with several that are three to four times higher than the mean value for Central Belt flows. Other less pronounced highs occur in similar rocks in the Central Belt north of Missezula Mountain.

In general the copper distribution, mean, and threshold values for the Central and Eastern Belts are similar. This is in broad agreement with the similarities in the geology of these two assemblages.

Code	Rock Suite	No. of Samples	Cu	Co	Ni	Pb	Zn
11	Central Belt Flows	219	1.2	−0.5	2.3	4.0	1.8
12	Central Belt Tuffs	58	1.1	0	2.5	0.9	0.3
13	Central Belt Intrusives	39	2.1	0.7	3.7	2.1	1.7
21	Eastern Belt Flows	33	0.5	0	1.5	1.1	0.3
22	Eastern Belt Tuffs	45	0.8	0.8	1.2	2.8	1.0
23	Eastern Belt Intrusives	16	0.5	−0.6	1.4	2.7	−0.1
31	Western Belt Flows	25	0.7	0.3	1.1	0.7	−0.5
32	Western Belt Tuffs	19	2.2	0.4	2.7	0.5	0.2
41	Kingsvale Flows	83	2.0	0.1	3.4	1.8	−0.1
42	Kingsvale Tuffs	26	0.4	0	1.6	−0.5	0.7
43	Kingsvale Intrusives	20	2.3	0.8	1.6	1.4	1.2
			−1 0 1 2	−1 0 1 2	−2 0 2 4	−2 0 2 4	−1 0 2

NOTE: Numbers beside bars show the skewness.
Numbers of samples are shown beside the mnemonic.
Skewness is a measure of symmetry about the central value of a distribution. Positive skewness indicates a relative abundance of low values in a distribution. Negative skewness indicates the opposite.

FIGURE 5. SKEWNESS



NOTE: Numbers beside bars indicate the kurtosis.
Numbers of samples are shown beside the mnemonic.
Kurtosis is a measure of the peakedness of the distribution, that is, the proportion of values clustered around the mean. A kurtosis of zero indicates a log normal distribution. Positive kurtosis indicates a more peaked distribution and a negative kurtosis a less peaked distribution from log normal.

FIGURE 6. KURTOSIS

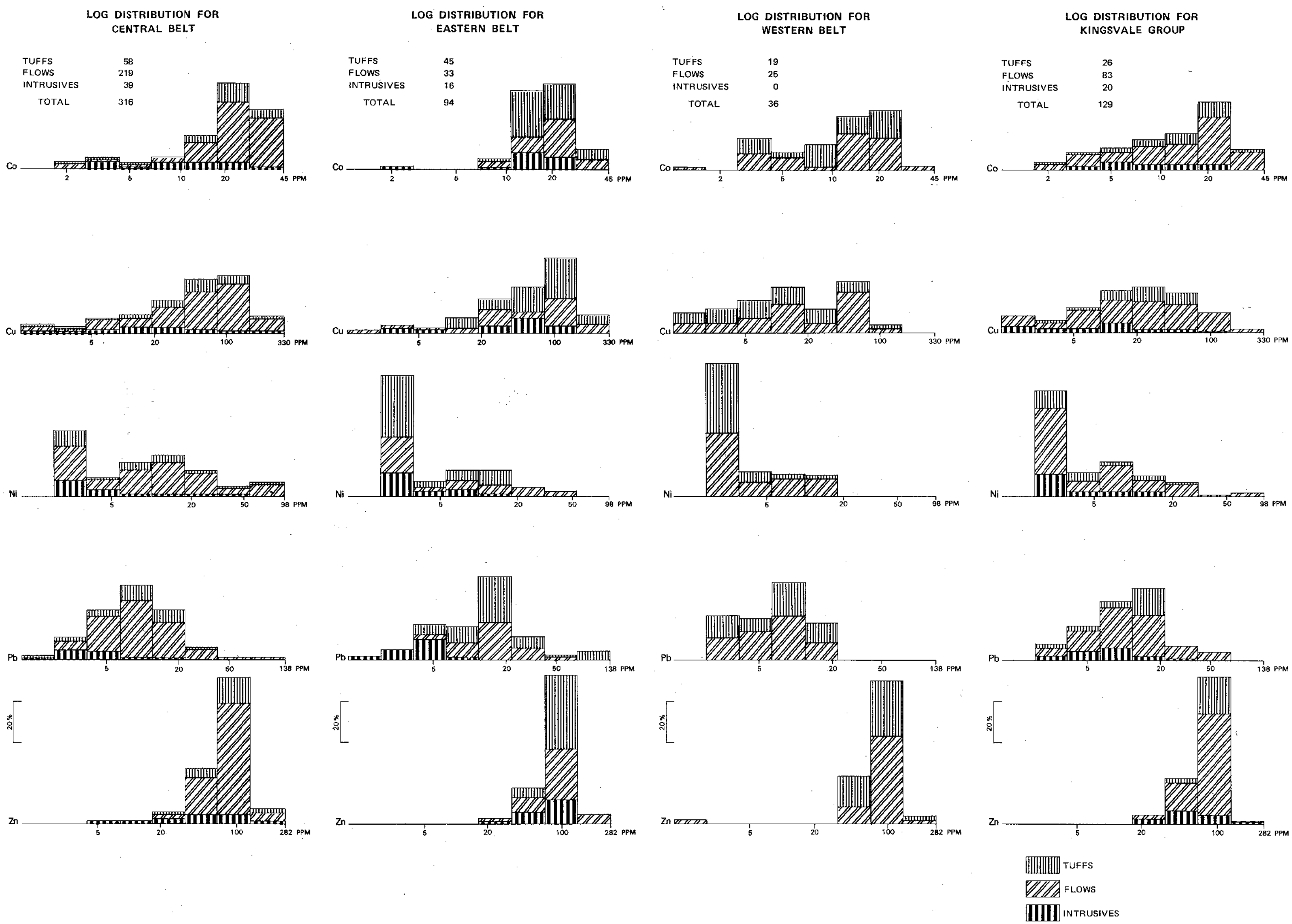


FIGURE 7. SUMMARY HISTOGRAMS OF METAL DISTRIBUTION

Western Belt rocks are found in only two corners of the map-area (Fig. 1) and therefore were tested by a very limited number of samples. The mean and threshold values for this assemblage are clearly lower than those of the Central and Eastern Belt assemblages and the few contour lines that could be drawn suggest a more northeasterly trend than the distinct northerly trend of the Central and Eastern Belts.

Rocks of the Cretaceous Kingsvale assemblage are divided into two suites: a northern one which underlies much of map-area 1 southwest of Lundbom Lake, and a southern one which straddles the ridge between Summers Creek and Allison Creek south of Laird Lake in map-area 2 (Fig. 1). Because the rocks are more basic, copper values from the northern suite tend to be higher than those from the southern suite. As a group, Kingsvale rocks have somewhat higher copper values than Western Belt rocks, but values are distinctly lower than those of either Eastern or Central Belt rocks.

COBALT AND NICKEL

As can be expected, given the similarity in the geochemistry of these two elements, the distributions of cobalt and nickel correlate closely and, in general, are very similar to that of copper; that is, cobalt and nickel highs and trends correspond very closely to those of copper, although the absolute values are considerably lower. The only exception to these general comments is the Missezula Lake volcanic centre in the Eastern Belt. Although copper values there are high, neither cobalt nor nickel are anomalous.

Like those of copper, the mean values of cobalt and nickel are mostly similar for the Central and Eastern Belts. Mean values for both these elements are higher, but not as much as for copper, than corresponding values for the Western Belt.

Like copper, mean cobalt and nickel values for the Kingsvale assemblage are higher than corresponding values for Western Belt rocks, markedly lower than their counterparts for Central Belt rocks and only slightly lower than those for Eastern Belt rocks.

The southern Kingsvale suite is marked by a strong east-west trend of cobalt, and, to a lesser extent, nickel values. This is in sharp contrast to the pronounced north-south trends in the Central and Eastern Belt assemblages. Values in the northern Kingsvale assemblage, like those of the Western Belt, trend in a more northeasterly direction.

LEAD

The distribution map (Fig. 11) and Figure 2 indicate that lead values are higher in the Central and Eastern Nicola Belts and in the Kingsvale assemblage than they are in Nicola rocks of the Western Belt. Although high concentrations mark the Missezula Mountain and Missezula Lake volcanic centres, trends in the rest of the Central and Eastern Belts are more diffuse than those of copper, nickel, and cobalt.

Trends in the southern Kingsvale suite are again east-west and well defined, and clearly delineate the distribution of these rocks. Values are generally higher than those of most nearby Nicola rocks. Although this suite of Kingsvale rocks consists of andesite, dacite, and rhyolite, it contains, in all its facies, nearly twice the lead in Western Belt rocks of similar intermediate to acid composition and appreciably more lead than the predominantly basaltic rocks of the Central Belt.

ZINC

Mean values for zinc are very similar for all four rock suites. General trends and locations of high concentrations, however, vary.

The Missezula Mountain suite in the Central Belt is marked by high concentrations of the other four metals but only a weak zinc high. However, several high zinc values occur in the area between Missezula Mountain and Missezula Lake, whereas the other four metals occur in only modest concentrations.

The volcanic centre north of Missezula Lake, which is the site of high copper and lead concentrations, is the site of several weakly defined zinc lows.

Trends in the Central and Eastern Belts are diffuse but northerly. In the Western Belt they are northeasterly. The southern Kingsvale suite has fairly well-defined east-west trends of values.

PARTITIONING OF ELEMENTS IN ROCK FACIES

Figure 7 was designed to graphically illustrate the partitioning of metals between flows, tuffs, and intrusive rocks for each of the four main rock suites. Although the total proportions in each class interval on these diagrams are strongly influenced by the number of samples analysed for each of the three rock types, within a given rock type the relative proportions in the various class intervals do indicate where the values for a given element tend to be concentrated.

In the Central Belt, copper, nickel, cobalt, and lead tend to be more concentrated in flows and tuffs than in intrusive rocks. Zinc, on the other hand, is fairly evenly distributed in all three facies. In the Eastern Belt lead tends to be more concentrated in tuffs and flows, but cobalt, copper, nickel, and zinc have fairly similar distributions in all three rock types. The Western Belt is not represented by any samples of intrusive rocks, and all five metals are partitioned in similar fashion in flows and tuffs.

In Kingsvale rocks, nickel seems to be more concentrated in flows and tuffs than in intrusive rocks, but the other four elements are more or less evenly distributed in all three rock facies.

COMPARISON OF ROCK GEOCHEMISTRY WITH STREAM SEDIMENT DATA

The summary of an extensive stream sediment geochemical survey for copper, molybdenum, and zinc over a large area of south-central British Columbia was recently published by Wallis, *et al*. (1978). In their report the authors discussed moving-average maps for the three metals investigated as well as metal trends and geological implications. The area discussed in this report is much smaller but is in the centre of that studied by Wallis, *et al* In general, the rock geochemistry is in accord with the stream sediment geochemistry and the two studies complement each other. Wallis, *et al.*, found a striking correlation (p. 14) between the stream sediment geochemistry of copper and molybdenum and the north-south lithotectonic 'belts' within the Nicola Group (Preto, 1975, 1976, 1977). The rock geochemistry of copper, cobalt, nickel, and lead described in this report also correlates strongly with the 'belts.' The stream sediment and rock geochemical trends for zinc, on the other hand, are not as obviously related to geology in the Nicola Group.

CONCLUSIONS

This study has provided data on the background distribution of copper, cobalt, nickel, lead, and zinc in a recently mapped area of Late Triassic Nicola and Cretaceous Kingsvale volcanic rocks. The scope of the study has been limited by the uneven distribution of rock exposures and by sampling limitations.

When this project was conceived it was hoped that it might corroborate the geological map and help outline areas favourable and unfavourable for mineral exploration. It was also hoped that within a given sequence of rocks, such as, for instance, the Central or Eastern Belts, the rock geochemical data would help to pinpoint rock units which might hold a higher promise for mineral deposits.

Most of these goals have been achieved. The metal distributions generally confirm and strengthen the subdivision of rock units that has resulted from geological mapping. The data support the interpretation based on mineral occurrences that copper is concentrated in the Central and Eastern Belts, particularly in rock assemblages that either represent or are very close to former volcanic centres.

The study, however, has not in itself provided new or unique concepts about the distribution of metals in the area, nor has it materially contributed in defining target areas for mineral exploration not already defined by geological mapping. In this respect therefore, the author can only concur with Tempelman-Kluit and Currie in concluding that 'geochemical studies such as this are a luxury, considering the expense of time and effort involved' (1978, p. 65).

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