



GEOLOGICAL
SURVEY
OF
CANADA

DEPARTMENT OF MINES
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PAPER 63-23

EIGHT PAPERS ON REGIONAL
GEOCHEMISTRY IN CANADA

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R. H. C. Holman, A. Y. Smith

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A regional geochemical reconnaissance of stream
sediments in the northern mainland of Nova Scotia,
Canada (with 4 maps)

by R.H.C. Holman

Walton - Cheverie area, Nova Scotia

by R.W. Boyle

Southwestern Nova Scotia

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Southeastern New Brunswick

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A regional geochemical reconnaissance of bedrock
in the Red Lake - Lansdowne House area of Ontario,
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southern part of the Canadian Shield

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CANADA

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A REGIONAL GEOCHEMICAL RECONNAISSANCE OF
STREAM SEDIMENTS IN THE NORTHERN MAINLAND OF
NOVA SCOTIA, CANADA

by

R.H.C. Holman

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SUMMARY

A geochemical survey of copper, lead, and zinc in sediment carried by streams draining a 10,000 square mile region in the Nova Scotia mainland has shown that variations in these metal concentrations are not random, but follow broad regional patterns permitting the compilation of regional geochemical maps on a scale of 1:250,000. Mean concentrations of 80 ppm zinc and 18 ppm lead in the sediments agree with crustal abundances given by Vinogradov but the mean for copper of 7 ppm is very low and suggests copper impoverishment.

INTRODUCTION

During 1957 and 1958 a geochemical reconnaissance was made within the mainland of Nova Scotia, Canada, northeast of a line drawn between the towns of Halifax and Windsor. The region surveyed

has an area of about 10,000 square miles, and lies between longitudes 61 and 65 degrees and latitudes 44 and 46 degrees.

The purpose of the reconnaissance was to,

a) Study the regional variations in the amounts of copper, lead and zinc metals in sediments (silt and sand) carried by the streams flowing in the area.

b) Investigate the possibility that regional patterns revealed by this data might be sufficiently well-defined to permit the compilation of geochemical maps.

c) Publish geochemical maps which, together with the data acquired, would provide (i) basic information for more detailed mineral exploration work in any area, and (ii) outline favourable mineral exploration areas geochemically.

The survey was concerned solely with the application of geochemistry to regional exploration and no attempt was made to integrate it with other techniques.

GENERAL DESCRIPTION OF THE REGION

The descriptive information given under this heading has been taken from the 'Atlas of Canada', 1957, and other publications of the Department of Mines and Technical Surveys which should be consulted for more detailed information and authoritative accounts of particular subjects.

Topography - The chief topographic features of the region are, (a) a comparatively narrow belt of highland rising to elevations of 900 feet, (b) a broad belt of uplands with elevations usually below 600 feet and (c) minor lowlands below 200 feet.

Drainage - Most of the area is freely drained by a well-developed system of streams that flow, for the most part, all the year round. Rivers are nearly all small and rarely exceed 100 feet wide. Drainage in the uplands is often impeded and chains of lakes are common.

Waters - Stream waters in well-drained areas are usually clear and colourless except at flood time during the spring thaw. Waters are slightly acid with a pH of 6 near the stream sources but further downstream they are nearly neutral or very slightly alkaline.

As the sea is approached the alkalinity rises to about pH 8. In boggy areas of the uplands underlain by granites, waters are often distinctly brown in colour and acidities of pH of 4 or 5 are common.

Climate - The climate is humid continental. Mean daily temperatures vary from 20°F to 65°F throughout the year. The annual precipitation of between 38 to 55 inches is spread evenly through the year with a minimum of under 10 inches during the summer period June to August. Winter snow varies from 60 to 90 inches.

Vegetation - The area lies within the major vegetation region of North-eastern hardwood forest characterized by spruce, fir, birch, maple, beech and hemlock.

Industry - Population is generally sparse and is located mainly along the coasts. There is little industry that might give rise to contamination except possibly for coal-mining in the Springhill and New Glasgow districts, current road construction, quarrying, and old mine dumps.

Geology - The region is mostly underlain by Palaeozoic rocks with ages ranging from Ordovician (or earlier) to Carboniferous with the Triassic as a minor feature. The following list of major rock types, not necessarily in order of age, with brief descriptions is taken from G.S.C. map 910A (1949).

TRIASSIC

Conglomerate, sandstone, shale; basalt.

CARBONIFEROUS

Pennsylvanian

Sandstone, shale, conglomerate, coal; volcanics.

Mississippian

Windsor group

Limestone, gypsum-anhydrite, shale, sandstone; volcanics.

Horton group

Sandstone, shale, conglomerate

DEVONIAN

Mainly granite

SILURIAN

Conglomerate, sandstone, shale, limestone; volcanics.

ORDOVICIAN

Monzonite, granite, rhyolite.

Browns Mountain group

Sandstone, slate, argillite, quartzite; volcanics; schist.

Meguma group

Slate, argillite, minor quartzites

Quartzite and slate.

CARBONIFEROUS
(or earlier)

Cobequid rocks
chiefly granitic

Complex of sedimentary and volcanic rocks
cut by granitic intrusions

The relative importance of the different rock groups in terms of area are,

| | | |
|---|-----|---------------|
| Meguma slates and quartzites | 30% | of total area |
| Mississippian shales, sandstones, and limestones | 25% | " |
| Pennsylvanian sandstones and shales | 20% | " |
| Cobequid granitics and complex | 10% | " |
| Browns Mountain sandstone and shales | 10% | " |
| Triassic and Silurian conglomerates and sandstones | 5% | " |

Mineralisation - Within the slates and quartzites of the Meguma group many gold-quartz veins have been discovered; most of these occurrences have been mined. Common sulphides of iron, zinc, lead and copper with arsenic are often associated with the gold.

Barite, gypsum, salt, limestone and dolomite are mined from the Carboniferous rocks chiefly of the Windsor group. An important barite deposit lying at the contact between the Windsor and Horton groups near Walton is especially interesting since it is associated with economic amounts of base metal sulphides. Sulphides of lead and zinc are known to be disseminated and sporadically concentrated throughout the Windsor group. Copper sulphides, on the other hand, seem to be rare.

Many occurrences of manganese minerals have been reported along the Windsor-Horton contact.

The coal measures of the Pennsylvanian have been mined extensively.

Iron occurrences are known to be associated with the Cobequid sedimentary complex, and also, with the Silurian rocks.

Many other mineral occurrences of sub-economic grade have been reported from the region.

Weathering - Exposures of bedrock usually show relatively little weathering apart from a thin selvage of discolouration. Weathering

effects at the sub-outcrop surface may, therefore, be presumed quite restricted, except in limestone areas where karst topography is common.

Overburden - The region has been glaciated and is mostly covered with Wisconsin till and associated deposits. The glacial overburden has an average thickness of twenty feet but locally increases to 100 feet; it thickens in the valleys and thins on the hill tops. The till is largely derived from rocks immediately below, or near-by, and consequently varies in composition with rock type.

Soils belong to the podsol group and show the usual modifications according to the site.

TECHNIQUES

Sampling - Most of the region is accessible through a network of highways, secondary roads and rough tracks. All intersections of these routes with streams were visited and grab samples, weighing about three quarters of a pound, were taken of the silt-sand material in the stream beds. Care was exercised to collect neither material which had slumped directly from the banks, nor clean washed or sorted sand. To minimize the dangers of contamination samples were taken at points well upstream from the roads. Samples were collected in paper envelopes and protected during transport by polyethelene bags.

Some 4,400 sediment samples were taken in this manner during two summer field seasons.

Sample preparation - The samples were dried at a base camp in the paper envelopes by removing the polyethelene bags and exposing them to an atmosphere of warm dry air. The dried material was sieved through an 80 mesh nylon screen, and the fine fraction was sent to the laboratories at headquarters for analysis. The coarser fraction was retained for reference.

Chemical analysis - Tests for readily-soluble zinc, lead and copper were made on the-unsieved samples whilst wet using:

- (a) the simple colorimetric dithizone technique devised by Bloom (1955) sensitive to all three metals, and
- (b) a similar test specific for copper published by Holman (1956).

Early use of Bloom's test was made at the sample site with the titration techniques he describes. This procedure was abandoned subsequently in favour of testing all samples centrally at one field laboratory using a fixed volume of dithizone solution in the manner described for copper by Holman. A set of zinc standards was used for comparing the colours. The 'total heavy metal' (zinc, lead and copper) figures are for this reason expressed as zinc. This procedure is justified mainly because (i) zinc is likely to be present in concentrations greatly exceeding lead and copper, and (ii) the test is much more sensitive to zinc than the other two metals.

The dried and sieved fractions of the samples were tested by M. A. Gilbert in the geochemical laboratories of the Survey in Ottawa for 'total' copper, zinc and lead using the techniques described by Gilbert (1959).

RESULTS

General - A discussion of the results is given under each of the four headings, copper, lead, zinc and readily-soluble metals. In the discussion reference is made to four provisional geochemical maps compiled from the results of the reconnaissance published by the Geological Survey of Canada, Holman (1959).

Data collected during the survey has been filed on I.B.M. punch cards for statistical treatment, and an investigation of the effects of topography, stream characteristics and geology on the metal concentrations. This work is in progress and will be published shortly. It is proposed, therefore to give only brief comments on some tabulated results at this stage.

Copper in the sediments - Amounts of copper liberated from the sediment samples with a potassium bisulphate fusion varied from less than 2 ppm up to 250 ppm. Comparative tests using an HF/HCl digestion show the extraction of copper by KHSO₄ fusion can be assumed complete (greater than 90%) for the purposes of this report.

Some difficulty in calculating an average concentration for copper arises from the large number of samples with copper contents below the detection limit. If the average of the low values is taken to be 1 ppm the overall mean becomes approximately 7, and this is reduced only slightly to 6 ppm when an extreme mean low value of zero is assumed. This average concentration of well under 10 ppm Cu is much lower than the general abundance figures given by Vinogradov (1956) for the earth's crust in Table 1.

TABLE 1 - CRUSTAL ABUNDANCES FOR COPPER,
LEAD AND ZINC, VINOGRADOV (1956)

| | Basic rocks | Neutral rocks | Acidic rocks | Sedimentary rocks |
|--------|-------------|---------------|--------------|-------------------|
| Copper | 140 | 30 | 57 | 70 |
| Lead | 8 | 15 | 20 | 20 |
| Zinc | 130 | 72 | 60 | 80 |

Analysis of the frequency distribution of the 4,400 results shows,
60 per cent to be in the 5 ppm Cu and less range
26 " " " " " " 6 to 10 ppm range
6 " " " " " " 11 to 15 " "
5 " " " " " " 16 to 20 " "
3 " " " " " " 21 and over "

These frequency distributions for copper are reflected by the regional patterns shown on G.S.C. map 27-1959, Holman (1959) for copper. There are extensive belts giving less than 5 ppm, more restricted zones with concentrations between 5 and 10 ppm, and a few small areas with concentrations above 10 ppm.

TABLE 2 - COPPER IN THE STREAM SEDIMENTS

| Rock | n | range ppm Cu | \bar{X} ppm Cu | Per cent frequency ranges, ppm Cu | | |
|-------------------------|-----|-----------------|---------------------|--------------------------------------|---------|---------|
| | | | | up to 5 | 6 to 10 | over 10 |
| Triassic | 159 | <u>2</u> to 30 | 5 | 55% | 30% | 15% |
| Pennsylvanian | 875 | <u>2</u> 60 | 6 | 55 | 35 | 10 |
| Windsor | 963 | <u>2</u> 125 | 6 | 70 | 20 | 10 |
| Horton | 779 | <u>2</u> 190 | 5 | 70 | 25 | 5 |
| Devonian granite | 99 | <u>2</u> 250 | 5 | 70 | 20 | 10 |
| Silurian | 84 | <u>2</u> 30 | 9 | 40 | 35 | 25 |
| Ordovician monzonite | 46 | <u>2</u> 90 | 7 | 50 | 35 | 15 |
| Browns Mountain | 165 | <u>2</u> 80 | 10 | 35 | 30 | 35 |
| Cobequid granite | 221 | <u>2</u> 50 | 9 | 35 | 40 | 25 |
| Cobequid complex | 109 | <u>2</u> 60 | 12 | 20 | 45 | 35 |
| Meguma slates | 343 | <u>2</u> 45 | 6 | 65 | 20 | 15 |
| Meguma quartzites | 459 | <u>2</u> 140 | 5 | 75 | 15 | 10 |

n = number of samples; \bar{X} = arithmetic mean, assuming 2 to be 1 ppm;

2 = less than 2.

Table 2 shows that the range of copper concentrations differs for each rock, but this parameter is likely to be influenced a good deal by the numbers of samples collected and is not stable enough to justify further comment.

Mean values for each rock (Table 2) vary slightly from 5 to 12 ppm Cu. Rocks of Triassic to Devonian age, and those of the Meguma group give similar means of 5 to 6 ppm, while the Silurian and other Ordovician groups range from 7 ppm for the Ordovician monzonite to 12 ppm for the Cobequid complex.

The frequency distributions for the different rocks (Table 2) are given for ranges of copper concentrations that correspond to the 'isograds' for 5 and 10 ppm Cu drawn on the copper map. These frequency distributions show sympathetic variations with the means and illustrate the control of the geology over the general trends of the copper isograds. It is interesting to note that discordances between the distribution patterns and the geology are present as well.

Sediment collected near the boundaries between one or more different rocks may have a mixed parentage. Some effects of this mixing on the copper concentrations can be seen in Table 3 which shows the mean copper contents of (1) samples collected within zones a quarter of a mile wide along the boundaries of each rock group and (2) other samples collected away from the boundaries.

TABLE 3 - COPPER IN STREAM SEDIMENTS, SHOWING CHANGES IN CONCENTRATIONS NEAR GEOLOGICAL BOUNDARIES

| Rock | At Boundary ^x | Away from Boundary |
|----------------------|--------------------------|--------------------|
| Triassic | 6 ppm Cu | 5 ppm Cu |
| Pennsylvanian | 9 | 6 |
| Windsor | 6 | 6 |
| Horton | 6 | 6 |
| Devonian granite | 4 | 6 |
| Silurian | 7 | 10 |
| Ordovician monzonite | 8 | 7 |
| Browns Mountain | 9 | 11 |
| Cobequid granite | 11 | 8 |
| Cobequid complex | 12 | 13 |
| Meguma slates | 4 | 7 |
| Meguma quartzites | 6 | 5 |
| All rocks | 7 | 6 |

x = a zone one quarter of a mile wide along the boundary.

Rocks giving the highest average copper content mostly show a drop in concentration in the boundary zone and those with the lowest averages an increase.

It is evident that means calculated from samples collected away from the boundaries will give more characteristic values for a particular rock group. The means might be improved further by rejecting samples taken from streams flowing across boundaries from adjacent rock groups.

The overall means of 7 and 6 ppm Cu for the two groups collected near to, and away from, the contacts are close, but the figure of 7 ppm Cu from the boundary zones suggests a possible weak enrichment of copper in some area. There appears to be no detectable enrichment of copper at the Windsor-Horton contact, but this topic could be explored further by considering data from this contact only.

Lead in the sediments - Concentrations of lead soluble in hot nitric acid varied from less than 3 to 650 ppm.

The average lead content of all the samples collected is 18 ppm, which agrees well with the range of 15 to 20 ppm for abundances given in Table 1 for the common rocks. The problem of values below the sensitivity limit of the analytical method mentioned in the case of copper does not arise with lead since very few values less than 3 ppm were obtained.

Analysis of the frequency distributions of the lead concentrations shows,

| | | | | |
|----|----------|--------------|--------------------|-------|
| 56 | per cent | to be in the | 10 ppm Pb and less | range |
| 25 | " | " | " | " |
| 7 | " | " | " | " |
| 5 | " | " | " | " |
| 2 | " | " | " | " |
| 5 | " | " | " | " |

These frequency distributions show over half the values to be below 10 ppm Pb and just over 80 per cent are less than 20 ppm. This distribution can be seen expressed on the G.S.C. map 26-1959 for lead. There are extensive tracts where concentrations do not rise above 10 ppm, more restricted zones with concentrations between 10 and 20 ppm, and a few relatively small areas giving values above 20 ppm.

The ranges of lead concentrations for each of the rock groups (Table 4) vary a good deal and on the whole are considerably greater than the ranges found for copper.

TABLE 4 - LEAD IN STREAM SEDIMENTS

| Rock | range ppm Pb | \bar{X} ppm Pb | Per cent frequency ranges in ppm Pb | | |
|----------------------|-----------------|---------------------|--|-------------|----------------|
| | | | up to 10 | 11 to 20 | 21 and over |
| Triassic | <u>3</u> to 90 | 7 | 81% | 13% | 6% |
| Pennsylvanian | <u>3</u> 190 | 12 | 65 | 22 | 13 |
| Windsor | <u>3</u> 450 | 13 | 65 | 26 | 9 |
| Horton | <u>3</u> 250 | 15 | 58 | 28 | 14 |
| Devonian granite | <u>3</u> 500 | 25 | 48 | 27 | 25 |
| Silurian | <u>3</u> 80 | 14 | 57 | 23 | 20 |
| Ordovician monzonite | <u>3</u> 45 | 15 | 57 | 26 | 17 |
| Browns Mountain | <u>3</u> 400 | 18 | 34 | 41 | 25 |
| Cobequid granite | <u>3</u> 650 | 60 | 20 | 21 | 59 |
| Cobequid complex | <u>3</u> 360 | 17 | 50 | 31 | 19 |
| Meguma slates | <u>3</u> 300 | 20 | 43 | 32 | 25 |
| Meguma quartzites | <u>3</u> 350 | 27 | 40 | 24 | 36 |

\bar{X} = average; 3 = less than 3 ppm Pb.

Samples of sediments taken from the three granitic masses give very different means of 60, 25, and 15 ppm, (Table 4) which suggest these bodies to have distinctly different lead contents. In the sedimentary rock groups there is a general drop in the lead concentrations with decreasing age. Figures for the Meguma groups indicate that more lead is associated with the quartzites than with the slates, whilst for copper the opposite seems to be true (Table 3).

The frequency distributions (Table 4) are given for ranges that correspond to the lead 'isograd' lines of 10 and 20 ppm drawn on the lead map. These frequency distributions indicate that areas of low and intermediate values are associated with most rock groups but the highest areas (over 20 ppm Pb) will be found most commonly within the Cobequid complex, the Meguma quartzites and to a lesser extent within the Devonian granite, Meguma slates, and Browns Mountain rocks.

A high area in the Pennsylvanian rocks near New Glasgow is interesting since the coal measures mined in this locality are reported to contain high amounts of the base metals.

TABLE 5 - LEAD IN STREAM SEDIMENTS, SHOWING CHANGES
IN CONCENTRATIONS NEAR GEOLOGICAL BOUNDARIES

| Rock | At Boundary ^x | Away from Boundary |
|----------------------|--------------------------|--------------------|
| Triassic | 10 ppm Pb | 7 ppm Pb |
| Pennsylvanian | 15 | 12 |
| Windsor | 15 | 12 |
| Horton | 16 | 15 |
| Devonian granite | 16 | 31 |
| Silurian | 13 | 15 |
| Ordovician monzonite | 17 | 15 |
| Browns Mountain | 13 | 27 |
| Cobequid granite | 60 | 60 |
| Cobequid complex | 15 | 18 |
| Meguma slates | 23 | 18 |
| Meguma quartzites | 29 | 26 |
| All rocks | 19 | 18 |

x - a zone one quarter of a mile wide along the boundary.

A boundary effect similar to that shown by copper is given by average lead concentrations listed in Table 5. Lead-rich rocks generally show a dilution and lead-poor rocks an enrichment. The overall means for lead in the samples collected near, and away from the boundaries differ only slightly (Table 5) but again suggest a weak enrichment of the metal in the boundary zone noted for copper.

Average figures show that there is generally three times as much lead as there is copper in the sediments as sampled (Table 6). The different rocks give lead/copper ratios varying from 7.5 in the Cobequid granite to 1.5 for several other rocks. The Ordovician monzonite shows a much lower lead/copper ratio than the other two granites. The magnitude of the lead/copper ratios is influenced mainly by lead since this metal displays the greatest change in means.

TABLE 6 - RATIOS OF LEAD TO COPPER
IN THE STREAM SEDIMENTS

| Rock type | Lead to copper ratio ^x |
|----------------------|-----------------------------------|
| Triassic | 1.5 |
| Pennsylvanian | 2.0 |
| Windsor | 2.0 |
| Horton | 2.5 |
| Devonian granite | 5.0 |
| Silurian | 1.5 |
| Ordovician monzonite | 2.1 |
| Browns Mountain | 2.5 |
| Cobequid granite | 7.5 |
| Cobequid complex | 1.5 |
| Meguma slates | 2.6 |
| Meguma quartzites | 5.2 |
| All rocks | 3.0 |

x - calculated from samples collected away from boundaries.

Zinc in the sediments - The zinc content of the sediment samples released by fusion with potassium bisulphate varied from less than 5 ppm up to 900 ppm.

Analysis of the frequency distribution of the result within this range shows,

| | |
|----------------|--------------------------------------|
| 46 per cent | to be in the 60 ppm Zn or less range |
| 38 " " " " " " | 60 to 120 ppm " |
| 16 " " " " " " | greater than 120 ppm " |

The average zinc content of the 4,400 samples analysed is 80 ppm. This figure is free from errors due to concentrations below the sensitivity limit of the method since there were few samples of this sort. The overall average agrees well with that of 80 ppm given by Vinogradov (Table 1) for sedimentary rocks.

The frequency distributions of the zinc concentrations show that almost half of the values are under 60 ppm, just over a third are within the 60 to 120 ppm range, and less than a fifth are greater than 120 ppm. This distribution is expressed areally by the 'isograds' for 60 and 120 ppm shown on the G.S.C. map 25-1959 for zinc and delineate broad belts of less than 60 ppm zinc, less extensive zones with intermediate values of between 60 and 120 ppm, and in these zones there are a few restricted areas of over 120 ppm.

TABLE 7 - ZINC IN THE STREAM SEDIMENTS

| Rock | range ppm Zn | \bar{X} ppm Zn | Per cent frequency ranges in ppm Zn | | |
|----------------------|-----------------|---------------------|--|--------|-------------|
| | | | up to 60 | 60-120 | over 120 |
| Triassic | 15 to 180 | 50 | 69% | 21% | 10% |
| Pennsylvanian | <u>5</u> 500 | 70 | 51 | 40 | 9 |
| Windsor | <u>5</u> 500 | 60 | 56 | 38 | 6 |
| Horton | <u>5</u> 750 | 80 | 41 | 50 | 9 |
| Devonian granite | <u>5</u> 300 | 45 | 80 | 14 | 6 |
| Silurian | <u>5</u> 750 | 110 | 15 | 67 | 18 |
| Ordovician monzonite | <u>5</u> 700 | 120 | 26 | 46 | 28 |
| Browns Mountain | <u>5</u> 950 | 250 | 7 | 35 | 52 |
| Cobequid granite | <u>5</u> 550 | 140 | 10 | 43 | 37 |
| Cobequid complex | <u>5</u> 600 | 90 | 38 | 38 | 24 |
| Meguma slates | <u>5</u> 450 | 70 | 44 | 47 | 9 |
| Meguma quartzites | <u>5</u> 800 | 75 | 63 | 27 | 10 |
| All rocks | <u>5</u> 950 | 80 | 46 | 38 | 16 |

\bar{X} = arithmetic mean.

Ranges of zinc concentrations for the individual rock groups vary markedly giving higher maximum values than copper and lead in most cases (Table 7).

The arithmetic means for zinc (Table 7) vary from a minimum of 45 ppm in the Devonian granite up to a maximum of 250 ppm for the Browns Mountain group. The low figure of 45 ppm Zn for the Devonian granite contrasts sharply with the means of 120 and 140 ppm for the two other granites. Most of the sedimentary groups have mean zinc contents below, or close to, the general average of 80 ppm, except for the Silurian and Browns Mountain groups in which the zinc content rises well above the average.

The frequency distributions given in Table 7 correspond with the 'isograds' given on the zinc map and show the areas of highest concentrations to be associated mainly with the Browns Mountain group, the Cobequid granite and complex, and the Ordovician monzonite.

TABLE 8 - ZINC IN STREAM SEDIMENT SAMPLES SHOWING CHANGES IN CONCENTRATIONS NEAR GEOLOGICAL BOUNDARIES

| Rock | At Boundary | Away from Boundary |
|----------------------|-------------|--------------------|
| Triassic | 60 ppm Zn | 50 ppm Zn |
| Pennsylvanian | 90 | 65 |
| Windsor | 70 | 60 |
| Horton | 75 | 80 |
| Devonian granite | 60 | 40 |
| Silurian | 110 | 110 |
| Ordovician monzonite | 90 | 130 |
| Browns Mountain | 150 | 260 |
| Cobequid granite | 120 | 140 |
| Cobequid complex | 100 | 90 |
| Meguma slates | 70 | 80 |
| Meguma quartzites | 80 | 75 |
| All rocks | 80 | 80 |

The average zinc contents of samples collected within a quarter of a mile of the rock boundaries show the same effects of dilution and enrichment noted for copper and lead (Table 8). The overall averages for zinc in the two groups of samples are the same suggesting that there is no general enrichment of zinc along the boundary zones considered. No further comment on possible enrichment along contacts is possible without a more detailed breakdown of the data.

TABLE 9 - RATIOS OF ZINC TO LEAD AND COPPER

| Rock type | Zinc to lead ^x ratios | Zinc to copper ^x ratios |
|---------------|-------------------------------------|---------------------------------------|
| Triassic | 7 | 10 |
| Pennsylvanian | 5 | 11 |
| Windsor | 5 | 10 |

Table 9 (cont'd)

| Rock type | Zinc to lead ^x ratios | Zinc to copper ^x ratios |
|-----------------------|-------------------------------------|---------------------------------------|
| Horton | 5 | 13 |
| Devonian granite | 3 | 7 |
| Silurian | 7 | 11 |
| Ordovician monzonite | 9 | 19 |
| Browns Mountain group | 10 | 24 |
| Cobequid granite | 2 | 17 |
| Cobequid complex | 5 | 7 |
| Meguma slates | 4 | 11 |
| Meguma quartzites | 3 | 15 |
| All rocks | 4 | 13 |

x = calculated on means obtained from samples collected away from the contacts.

The zinc to lead ratios for the different rocks (Table 9) vary from 2 up to 10. Ratios of 2 and 3 from the two large Cobequid and Devonian granites are below the general average (Table 9) and contrast sharply with that of 9 given by the smaller Ordovician monzonite. Most sedimentary rocks give zinc/lead ratios close to the average, or slightly greater, except for the Triassic, Silurian, and Browns Mountain groups in which the ratios rise to between 7 and 10.

The ratios of zinc to copper for each rock are all much higher than might be expected from the general abundance figures of zinc 80 ppm and copper about 70 ppm. These high zinc/copper ratios support the impression given by the overall average values for copper that most of the rocks in the region are markedly low in copper.

The mean overall figures for copper, lead and zinc in all samples indicate that the relative abundances of the metals in the sediments are,

Copper 1
Lead 3
Zinc 12

These relative abundances are quite different from those given by Vinogradov for the earth's crust of,

Copper 3
Lead 1
Zinc 4

and also suggest an impoverishment with respect to copper - since both zinc and lead show normal abundances.

Readily soluble metal in the sediments - Tests on the wet samples for weakly-bonded copper using a cold citrate extraction at pH2 were negative, and it may be concluded that concentrations of readily-soluble copper are below 1 ppm.

Metal reacting in the cold extraction test for the heavy metals is assumed to be mainly zinc for the purposes of this discussion because,

1. Weakly bonded copper concentrations are less than 1 ppm in all samples.
2. Concentrations of zinc are usually greater than those of lead.
3. The response of the test for zinc is more than four times as strong as it is for lead.

Amounts of soluble zinc in the wet and unsieved sediments gave a general average of 3 ppm, and an overall range of less than 75 ppm.

Ranges of soluble zinc for the different rock groups (Table 10) varied from less than 1 up to 15 ppm in the Devonian granite and 75 ppm in the Pennsylvanian Group. Mean figures for the different rocks varied only slightly, from 1 ppm in the Devonian granite to 6 ppm in the Browns Mountain rocks.

Transitional effects at the boundaries are again evident, (Table 10). The highest mean of 7 ppm for samples taken near the boundary of the Browns Mountain group is interesting since (i) this group gave the highest amounts of total zinc, and (ii) the total zinc shows a considerable drop near the boundary (Table 8).

TABLE 10 - READILY-SOLUBLE METAL (ZINC AND COPPER LEAD) IN THE SEDIMENTS EXPRESSED AS ZINC

| Rock | Range ppm (Zn) | \bar{X} All samples ppm (Zn) | At boundary ppm (Zn) | Away from boundary ppm (Zn) |
|------------------|-------------------|--------------------------------------|----------------------------|-----------------------------------|
| Triassic | <u>1</u> to 10 | 2 | 2 | 2 |
| Pennsylvanian | <u>1</u> 75 | 3 | 3 | 3 |
| Windsor | <u>1</u> 47 | 3 | 4 | 3 |
| Horton | <u>1</u> 30 | 3 | 3 | 4 |
| Devonian granite | <u>1</u> 15 | 1 | 3 | 1 |
| Silurian | <u>1</u> 14 | 4 | 4 | 4 |

Table 10 (cont'd)

| Rock | Range ppm (Zn) | \bar{X} All samples ppm (Zn) | At boundary ppm (Zn) | Away from boundary ppm (Zn) |
|-------------------------|-------------------|--------------------------------------|----------------------------|-----------------------------------|
| Ordovician monzonite | <u>1</u> to 25 | 5 | 3 | 5 |
| Browns Mountain | <u>1</u> 60 | 6 | 7 | 5 |
| Cobequid granite | <u>1</u> 30 | 5 | 4 | 5 |
| Cobequid complex | <u>1</u> 19 | 3 | 2 | 4 |
| Meguma slates | <u>1</u> 60 | 4 | 3 | 5 |
| Meguma quartzites | <u>1</u> 60 | 4 | 4 | 3 |
| All rocks | <u>1</u> 75 | 3 | 3 | 3 |

1 = less than 1 ppm.

TABLE 11 - RATIOS OF TOTAL ZINC TO
READILY-SOLUBLE ZINC IN THE SEDIMENTS

| Rock | $\frac{\text{Total zinc}}{\text{Soluble zinc}}$ |
|----------------------|---|
| Triassic | 25 |
| Pennsylvanian | 22 |
| Windsor | 20 |
| Horton | 20 |
| Devonian granite | 40 |
| Silurian | 30 |
| Ordovician monzonite | 30 |
| Browns Mountain | 50 |
| Cobequid granite | 30 |
| Cobequid complex | 20 |
| Meguma slates | 20 |
| Meguma quartzites | 25 |
| All rocks | 30 |

A comparison of the total zinc and soluble zinc (Table 11) shows a general correlation, with the ratio of total metal to weakly-bonded metal averaging about 30. For the individual rock groups the ratio varied between 20 and 30 except for the Devonian granite and Browns Mountain group which gave 40 and 50 respectively.

CONCLUSIONS

Some general inferences from the results obtained are possible.

Variations in the trace concentrations of copper, lead and zinc in the minus 80 mesh fractions of the stream sediments occur, and can be detected using simple and rapid analytical techniques.

The concentration variations are not random, and when plotted on a map of scale one inch to four miles show an orderly grouping of high, intermediate and low values within well defined zones.

Maps can be compiled from this data showing the regional geochemical patterns for the three metals, and these provide basic information for more detailed mineral exploration work, Holman (1959).

The trends of the geochemical patterns can often be related to the bedrock geology, but there are, also, interesting discordances that may be due to several different factors.

The relationship between the geochemistry of the sediments and the geology is also shown by the average contents and frequency distributions of the three metals for the different rocks underlying the region.

Bearing in mind that metal concentrations in stream sediment samples may not necessarily be characteristic of those in bedrock, the following comments are made.

Average concentrations of 80 ppm zinc and 18 ppm lead in the sediments agree closely with the general crustal abundances of 80 ppm Zn and 20 ppm Pb in sedimentary rocks given by Vinogradov (1956).

The average concentration for copper of less than 10 ppm is low compared to crustal abundances of 30 to 70 ppm Cu given by Vinogradov and suggests copper impoverishment.

Considered generally, no marked enrichment of the metals is detectable near boundaries* between different rocks, but important ore loci, such as the Windsor-Horton contact, require further investigation.

Transitional effects along rock boundaries due to the differing metal content of each rock can be detected. This is important

*Within a zone 1/4 mile wide.

since it illustrates the technique is responding to quite small changes in average concentrations in parent material from which the sediment was derived. It is likely, therefore, that all targets giving relatively weak chemical expressions in the sediments will be detected, providing they are of sufficient size.

Interpretation of the results in terms of delimiting favourable areas for mineral exploration is not possible at this stage, and more detailed work is required.

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WALTON - CHEVERIE AREA, NOVA SCOTIA

by

R.W. Boyle

The Walton - Cheverie area is underlain mainly by rocks of Carboniferous (Mississippian) age that are divisible into two groups - the Horton group and Windsor group. Triassic conglomerates and sandstones outcrop locally along the coasts of Minas Basin.

In the type sections in the Windsor - Walton area the Horton Group is divisible into two formations - the lower Horton Bluff and the upper Cheverie. The Horton Bluff is composed essentially of fluvial and fluvio-lacustrine sediments, comprising sandstones, quartzites, ironstones, ferruginous limestones, pyritiferous carbonaceous shales, and siltstones, all of which may contain plant remains, fish scales, ostracods, and other fossils. The sediments have gentle easterly dips in some places, but in others, especially along the shore of Minas Basin, they are severely contorted and extensively faulted.

The Cheverie rocks are also of fluvial and fluvio-lacustrine origin and lie with apparent conformity on those of the Horton Bluff. They include arkosic and feldspathic conglomerates, grits, sandstones, siltstones, mudstones, and shales, some of which contain plant remains, ostracods, and other fossils. In most places the Cheverie rocks have low easterly dips, and all are severely faulted.

The Windsor rocks are of marine origin and appear to lie conformably on those of the Cheverie Formation. The lower Windsor Formations include the Macumber composed of fissile arenaceous limestone and limy shales and the Pembroke consisting principally of limestone conglomerate, limestone, and minor limy shale. Upward the Windsor group grades through red sandstones, red shales, gypsum and anhydrite, to fossiliferous limestones, dolomites, and shales.

The area has been glaciated and glacial till covers most of the area. Rock outcrops occur only in the stream bottoms and along the coast.

The climate of the area is temperate and the rainfall is moderate.

Five types of deposits occur in the area: 1) a massive barite deposit with an associated lead-zinc-silver-copper orebody; 2) barite deposits with no known associated sulphide bodies; 3) manganese (psilomelane, pyrolusite) deposits; 4) limonite-hematite deposits; and 5) gypsum-anhydrite deposits. The massive barite deposit has been mined since 1941 and the sulphide orebody was brought into production in 1961. Gypsum and anhydrite have been quarried for over a hundred years in the area. The manganese deposits were mined

before the turn of the present century. The iron deposits are small, and there has been no production from them.

The barite-sulphide, barite, manganese, and iron deposits occur in fault and fracture zones, particularly where these structures intersect the limestones of the Macumber and Pembroke Formations. All are within a short distance of what is locally known as the Windsor - Horton contact. The gypsum-anhydrite deposits occur in beds, lenses, and shallow basins.

Geochemically the barite-sulphide deposit represents a marked enrichment of Ba, Sr, Fe, Pb, Zn, Cd, Cu, Ag, As, Sb, and Mn and a minor enrichment of Co and Ni. These elements are contained in primary barite, manganiferous siderite, pyrite, marcasite, hematite, galena, sphalerite, tennantite, proustite, and gersdorffite. Secondary minerals, due to oxidation, include psilomelane, pyrolusite, azurite, malachite, and a nickeliferous cobalt sulphate tetrahydrate.

Following the initial discovery that some of the stream sediments in the Walton - Cheverie area were high in lead, zinc, copper, and silver, more detailed surveys were carried out using the following indicator elements - barium, strontium, lead, zinc, copper, silver, arsenic, antimony, and manganese. The results of these surveys are briefly described below.

LITHOGEOCHEMICAL METHODS

In most parts of the Walton - Cheverie area the Horton - Windsor rocks are poorly exposed, and detailed sampling of rocks on a grid system is generally not possible. However, local areas may be amenable to such surveys.

During the 1956 and 1957 field seasons rock samples were collected from all available outcrops and analyzed for Ba, Pb, Zn, Cu, Ag, As, Sb, and S. Several zones were found that were anomalously high in Ba, Pb, Zn, Cu, and Ag, and at the time it was thought that certain beds or series of beds contained higher than average amounts of these elements as a result of original sedimentation processes. Upon re-examination of the anomalous zones in 1960, in conjunction with structural studies, it was found that they could be correlated with east-west fault and breccia zones. Several of these are now receiving detailed attention by private companies.

The writer's experience with lithogeochemical methods in the Walton - Cheverie area is that the work must be done in great detail, preferably in conjunction with large scale geological mapping and structural studies.

PEDOGEOCHEMICAL METHODS

In 1957 and again in 1960 several traverses were run over known barite occurrences in the Walton - Cheverie area, and soil samples from the A, B, and C horizons were collected. These were analyzed for Ba, Pb, Zn, Cu, As, Sb, and Ag. All of the

results have not yet been plotted, but preliminary indications are that the soils reflect the presence of the deposits if they are not over 5 feet in depth. At the time of writing it would appear that samples from the C horizon give the best high contrast anomalies and that Ba, Pb, and Ag are the most useful indicator elements.

HYDROGEOCHEMICAL SURVEYS

A reconnaissance survey of stream and spring waters in the Windsor - Walton area was carried out in 1956, and more detailed surveys were made in 1957 and 1960. The results of the work carried out in 1956 showed that the water issuing from fractures in the large barite quarry at Walton was enriched in both zinc and copper. Later drilling revealed the presence of the sulphide orebody beneath the barite deposit, and it is now known that the anomaly was related to this orebody.

The experience with water analyses suggests that copper and zinc are the only effective indicator elements in the area. The work has to be done in detail, and every spring or water seep should be examined carefully, especially if they have associated limonitic or manganiferous precipitates. It has been found that these precipitates often carry high contents of barium, strontium, zinc, lead, silver, and arsenic. Such springs may indicate favourable areas in which to prospect.

STREAM SEDIMENT METHODS

Stream sediments in all streams and draws of the area were analyzed for Cu, Pb, Zn, As, Sb, Ba, Sr, and Mn. All known deposits were indicated in the stream sediments and several other anomalous areas were outlined. These are now receiving detailed attention by private companies. The best indicator elements were Ba, Sr, Pb, Zn, As, and Ag.

The experience with stream sediments in the Walton area suggests that the method is applicable for defining areas where mineralization may occur. Like other geochemical methods it cannot differentiate between zones containing disseminated barite and sulphide minerals and those containing deposits of economic grade. The work must be done in detail, the most insignificant draw or dry stream bed may give the clue the prospector is looking for.

PANNING

The long-neglected gold pan can be used with effect in prospecting for barite deposits in some of the streams and soils in the Walton area. If proper care is taken, fine particles of barite can be tailed from soils over known barite occurrences as well as in the streams and draws in their near vicinity. No galena was found in the pannings. However, this mineral does not weather too readily, and it and its oxidation products, anglesite and cerussite, are often found in soils and stream sediments in areas where lead deposits occur.

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SOUTHWESTERN NOVA SCOTIA

by

R.W. Boyle

During the summer of 1956 a regional geochemical survey was carried out over that part of Nova Scotia lying southwest of a line from Walton to Lunenburg. The heavy metal (Pb, Zn, Cu) content of stream, river, and lake waters and sediments was determined by dithizone methods.

The geology of the area is complex. The oldest rocks are of Palaeozoic age and include the Meguma group (gold-bearing series) which have been granitized and locally intruded by granites, probably of Devonian age; a series of shales and argillites of Ordovician age (Kentville Formation); and Devonian slates, quartzites, limestones, and ferruginous beds, principally in the Nictaux Falls - Torbrook area of Annapolis and Kings counties. In the northeast part of the area (Windsor-Walton district) the rocks are mainly of Carboniferous (Mississippian) age and consist of shales, argillites, sandstones, limestones, gypsum, and anhydrite. The youngest rocks are Triassic red sandstones, shales, conglomerates and amygdaloidal basaltic lavas. These outcrop along the northwest coast and underlie the Annapolis Valley.

The entire area has been glaciated by an ice-sheet whose general movement was from north to south. Glacial deposits cover most of the bedrock and exposures are found only along the coasts or along stream and river courses.

The climate of the area is temperate and the rainfall is moderate.

The results of the investigation indicated that most of the rivers and streams draining the area carry relatively little heavy metal in both the water and sediment. This suggested that extensive zones of base metal mineralization are absent in the area, but in some parts local anomalies may be related to gold-quartz deposits as yet undiscovered. A few traverses were run over known gold veins to see if they responded to pedogeochemical methods. The results were positive where the cover was light.

The survey directed attention to the Windsor - Walton district where relatively high values in copper, lead and zinc were found in streams draining an area underlain by a particularly favourable contact along which barite deposits had been known for many years. The sediments in streams near this contact also reported high values in silver. Recently a lead-zinc-silver-copper orebody associated with a massive barite pipe has been discovered along this contact. (See also paper on the Walton - Cheverie area.)

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SOUTHEASTERN NEW BRUNSWICK

by

A. Y. Smith

INTRODUCTION

The reconnaissance geochemical survey of southeastern New Brunswick was begun in 1959, and completed in 1961. Sampling was confined to active stream sediment material, which was dried, sieved to -80 mesh, and fused with potassium bisulphate prior to analysis for copper, lead and zinc. Analyses were carried out in the mobile geochemical laboratory of the Geological Survey of Canada (Smith and Washington, in press) using dithizone (diphenylthiocarbazone) methods (Gilbert, 1959). Samples were taken at the intersection of all streams and roads, with a frequency of approximately one sample per two square miles.

GENERAL GEOLOGY

The geology of southeastern New Brunswick has been summarized by Gussow (1953). The oldest rocks in the area are the metamorphosed volcanic and sedimentary rocks of the Caledonia complex, of probable Precambrian age. These are intruded by granite, granodiorite and gabbro masses of Devonian age. Overlying the pre-Carboniferous basement with great unconformity are the Carboniferous terrestrial sediments of the Moncton basin. These sediments include red arkosic sandstones, siltstones, and shales, with minor amounts of black shales, marine limestones and evaporites. Mississippian Formations have undergone some deformation with faulting and folding, but Pennsylvanian Formations are flat lying and undeformed. The entire area has undergone Pleistocene glaciation, but in a relatively mild form. Locally, valleys and depressions contain glacial drift to a depth of over 300 feet, but thicknesses of drift over 6 feet are uncommon.

The climate of southeastern New Brunswick is temperate, but somewhat modified by proximity to the sea. Mean temperature in July is 65°F, in January 15°F. Mean annual total precipitation is approximately 40 inches.

RESULTS OF THE SURVEY

As might be expected from such an area of diverse bedrock type, a single background value for each metal has little meaning. Background values of 2 parts per million copper, 7 ppm lead and 50 ppm zinc were assigned. These values were kept low so that useful information would not be lost. Several areas were found with background values for one or all three metals above the average. On the Kingston Peninsula, north of the city of St. John, lead background

increased to at least 12 ppm. Similarly, in areas underlain by lower Mississippian black shales and limestones of the Horton and Windsor groups, an increase in all three metals was noticed. In addition increases in background values were observed in certain areas underlain by pre-Carboniferous rocks. These areas of increased background are considered significant as "metallized" areas.

Within the metallized areas, several rather substantial anomalies were found. Some of these could be directly related to known deposits of base metal sulphides, others occurred in areas where such deposits are unknown. Of particular interest was the response of a band of Mississippian limestone which contains small deposits of manganese oxides. An analysis of a sample of manganite from one of these deposits gave 6,700 ppm zinc and 500 ppm lead. Stream sediment samples from the vicinity of this limestone band contained increased amounts of both zinc and lead, and may indicate other, as yet unknown, deposits of manganese minerals, and perhaps lead and zinc mineralization.

In general, stream sediment surveys appear to be a satisfactory and inexpensive method of reconnaissance geochemistry of large areas. It is felt that with the frequency of sampling possible in this area, large base metal deposits exposed to weathering would not be missed. Further the method seems capable of outlining large target areas where detailed work would be warranted. The samples, once collected, are available for a variety of analyses as the need arises. It is planned to run these samples for a number of elements in the near future.

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A REGIONAL GEOCHEMICAL RECONNAISSANCE OF BEDROCK IN
THE RED LAKE - LANSDOWNE HOUSE AREA OF
ONTARIO, CANADA

by

R.H.C. Holman

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SUMMARY

A geochemical reconnaissance has been made of bedrock for a large segment of the Canadian Shield. Preliminary results for zinc and copper are described and compared with published abundances.

INTRODUCTION

A geochemical reconnaissance based on bedrock sampling was made of a 43,000 square mile area of the Canadian Shield in Ontario, Canada, between longitude 86 and 94 degrees and latitudes 51 and 53 degrees.

The work initially scheduled over a three year period for this region comprised (1) bedrock mapping on a scale of 4 miles to 1 inch, (2) airborne magnetometry with special ground studies in geophysical interpretation, and (3) Pleistocene geology mapping. Pilot studies in these techniques were made during the first field season of 1959 in one of the eight '1 degree' rectangles forming the region.

| | | | |
|--|------------------------|------------------------|--------|
| 94° | | Lat. 55° | 86° |
| <u>Area 1</u> ===== | <u>Area 3</u> ===== | Area 5 | Area 7 |
| Area 2 Pilot studies (No geochemistry) | <u>Area 4</u> ===== | <u>Area 6</u> ===== | Area 8 |
| Lat. 51° | | | |

===== - Areas discussed in this report.

Diagram- Showing the four areas of the Red Lake - Lansdowne House district discussed in the report.

Geochemical work was considered only after these pilot studies had started and consequently a proper geochemical orientation survey was not possible. Furthermore, in the interests of reducing costs, geochemical sampling on the reconnaissance scale was necessarily restricted to the collection of material by traversing geological parties without seriously impeding their progress.

Within these limitations, decisions were made on the geochemical techniques to be employed. Stream sediments were rejected as a medium because of the weak erosive power of the streams on bedrock in this region of low relief, and stream transported debris was known to be either organic muck or sediment derived from reworked glacial deposits. It was also decided that the use of waters and swamp material would raise many problems of sampling and analysis, and the interpretation of the results might be difficult.

In view of these objections the use of bedrock sampling was adopted. Some advantages of this approach were apparent. Results obtained on rocks would be free of interpretative difficulties inherent in all studies based on surficial materials. An appraisal of bedrock sampling as an applied geochemical technique in the terrain of the Canadian Shield was urgently required. A bedrock study would provide a sound basis for further applied geochemical studies on waters, stream sediments, glacial drift, muskeg material or vegetation.

Chemical analysis has been restricted mainly to zinc and copper since these metals are of general interest and can be determined rapidly. This data and a petrological classification for each sample has been filed on data processing cards for mechanical sorting and the electronic computation of appropriate statistical parameters. Rigorous examination of the results in this way will allow efficient selection of samples for more extensive chemical analysis and general study.

Magnetic susceptibility and specific gravity measurements are being made on the samples. Mean values of these physical properties will be computed for each rock type and used to interpret

further gravity work, and study possible correlations between the geochemical and geophysical properties, pers. comm. A.S. McLaren, 1962.

Approximately 10,000 samples were collected during the field seasons of 1960 and 1961, but at present the data from only half this number, i.e. from areas 1, 3, 4, and 6 are in a form that allows some comment. Accordingly, the description of results that follows applies only to the areas mentioned. A report of the data from the whole area will be published when the statistical examination of the results is completed.

DESCRIPTION OF THE AREA

The region is principally a peneplain with a general elevation of less than 1,000 feet. There is a gentle drop in height of about 200 feet northwards across the entire area and a similar gentle gradient towards the east.

Drainage is generally sluggish through sub-parallel river systems that flow northwards to Hudson Bay and eastwards into James Bay. Glacial lakes are common and large areas of impeded drainage have resulted in extensive muskeg.

Alluvium transported by streams and available for easy collection is principally an organic-rich ooze or suspension. Sandy silts are common only in those streams draining glacial features such as eskers and moraines.

The climate is sub-arctic, giving short cool summers with no more than three months with mean temperatures above 50 degrees F. Winter snowfall usually exceeds 30 inches.

The area is thickly forested where drainage is adequate; elsewhere there is extensive muskeg.

The most common rocks in this segment of the Precambrian Shield are granodiorites that exhibit varying degrees of foliation. The granodiorites are interrupted by discontinuous belts and irregularly shaped bodies of massive granite. These granites are usually pink but in the southeast corner of the region white varieties are common. Porphyritic granitic rocks are extensively developed in the western half of the area. Infolded masses of mixed volcanic rocks (basalts, andesites, rhyolites, and tuffs) with minor associated sedimentary rocks extend throughout the region often as long, narrow, and curving belts. Basic rocks are comparatively uncommon. An idea of the relative importance of each rock type is given by the estimates made for the areas 1, 3, 4, and 6 shown in Table 1.

Continental glaciation is likely to have scoured the bedrock in this region thoroughly, and destroyed near-surface zones of oxidation and old residual soils. Complex reworking of ground moraine during the ice retreat caused the extensive deposition of sands, silts and varved clays. Eskers and moraines traverse the region for great distances. Exposure of the bedrock varies from a maximum of about 50 per cent in the northwest corner to as little as 1 per cent in the east (pers. comm. V.K. Prest, 1962).

On well-drained sites poorly-developed podzol or grey wooded soils are found.

The region is practically uninhabited and there are no roads.

TABLE 1 - SHOWING THE ESTIMATED AREAS OCCUPIED BY MAJOR ROCK TYPES IN THE WESTERN HALF OF THE RED LAKE - LANSDOWNE HOUSE REGION, ONTARIO

| Rock | Percentage of total area |
|---|--------------------------|
| Weakly-foliated granite or granodiorite | 32 |
| Foliated granodiorite | 16 |
| Massive granite | 12 |
| Porphyritic granites | 11 |
| Gneiss and migmatite | 8 |
| Undivided granitic rocks | 5 |
| Volcanic rocks | 11 |
| Sedimentary rocks | 5 |

TECHNIQUES

Sampling - Specimens weighing between two and three pounds were collected from exposed bedrock at intervals of about one mile, along traverses made during geological mapping. Composite sampling was not attempted and the general policy was to take a single sample of the most representative rock. In areas of visible heterogeneous rocks, such as gneisses and migmatites, whatever material was available for sampling at the outcrop was collected. Descriptions of all samples were recorded.

Samples were collected from the field parties every ten days by aircraft on service flights. In this way, an average of about 100 samples a day were obtained and shipped to headquarters. The overall sampling density averaged approximately one specimen every three to four square miles, but in areas of very sparse outcrop, especially in the east, the coverage was not as good.

Sample preparation - Each sample was split, a chip retained, and the rest reduced to about 1/4 inch size with a jaw crusher. It was then ground to about 60 mesh size by passing through a Braun Pulveriser

(rotating disc type) fitted with ceramic plates. The resulting powder was mixed by rolling on paper sheets, and a 15 to 20 gram sample taken for fine grinding to about 200 mesh size by mechanical agitation in small ceramic ball mills on a paint shaking machine. This procedure introduces negligible contamination and has a productivity of up to 100 samples daily for a crew of two men. Contamination from sample to sample was guarded against by recording the sample sequence through all stages of the preparation.

Chemical analysis - The samples were tested for copper and zinc by fusion with potassium bisulphate using the dithizone methods described by Gilbert (1959)^x. All analytical work was supervised by M.A. Gilbert in the G.S.C. laboratories, Ottawa.

RESULTS

Adequate assessment of the results of the bedrock geochemical survey is not possible until the projected statistical work requiring electronic computation is completed. Meanwhile, analysis of the data has not proceeded beyond the calculation of sample mean values for zinc and copper concentrations in the different rocks within the areas 1, 3, 4, and 6. These means for copper and zinc will be described, compared with some published abundance figures for the two metals, and briefly discussed.

Copper in the rocks - Amounts of copper liberated from the rock samples by fusion with potassium bisulphate vary from less than 5 ppm upwards, but seldom exceed 500 ppm unless visible sulphides are present. Concentrations greater than 100 ppm are rare except from basic and volcanic rocks. Many concentrations are in the low ranges giving an approximate frequency distribution of,

| | |
|--------------------|---------------|
| 65 per cent under | 20 ppm copper |
| 15 " " between | 20 and 40 ppm |
| 10 " " " 40 " 60 " | |
| 5 " " " 60 " 80 " | |
| 4 " " " 80 " 100 " | |
| and 1 " " " over | 100 " |

A simple average of 35 ppm copper can be quoted for the 5,000 samples, but its significance is limited by the arbitrary influence of the varying numbers of samples collected from each rock and area. A more meaningful average may be calculated by considering the mean copper content of each rock and weighing these means with the

^xComparative tests using an HF/HCl digestion on finely-ground rock samples show the extraction of Cu and Zn by KHSO₄ fusion can be regarded as complete (greater than 90%) for the purposes of this report.

importance of the rock on an areal basis as quoted in Table 1. The weighted mean copper content for the four areas arrived at in this way falls between 15 and 20 ppm.

Calculations using the data for copper raise the question of assigning a probable average magnitude to concentrations below the detection limit of 5 ppm. For the purpose of this account 2 ppm has been adopted and has been used in all calculations unless otherwise stated.

The overall weighted mean of 15 and 20 ppm copper is low compared to most of the abundances quoted by Vinogradov (1956) and reproduced in part in Table 2.

TABLE 2 - ABUNDANCE OF COPPER IN PPM FOR
DIFFERENT ROCKS - VINOGRADOV (1956)

| Basic rocks | Neutral rocks | Acidic rocks | Sedimentary rocks ^{xx} | Author |
|------------------|-----------------|-----------------|---------------------------------|-------------------|
| 40 | 30 | - | - | Coats (1951) |
| 160 | - | - | - | Hotz (1953) |
| 150 | 38 | 16 | - | Sandell (1943) |
| 75 | - | - | - | Butler (1954) |
| 68 | 32 | 4 | 50 | Sugawara (1951) |
| 110 | 40 | 34 | 48 | Malyuga (1947) |
| - | - | - | 18 | Shaw (1954) |
| - | - | - | 34 | Ronov (1955) |
| - | - | - | 50 | Leutwein (1951) |
| - | - | - | 34 | Ronov (1955) |
| 140 ^x | 35 ^x | 30 ^x | 57 ^x | Vinogradov (1956) |

^{xx}Clay and shale

^xProbable means estimated by Vinogradov

When the copper concentrations for each of the different rocks are considered (Table 3) it will be noticed that the overall ranges of values extend from less than 5 ppm upwards to maximums of between 135 and 900 ppm. These ranges are of limited significance and a more useful measure of spread will be given by the frequency distributions and standard deviations when these have been computed.

The overall mean copper content of each rock for the four areas varies from 6 ppm in the massive granite to 60 ppm in the volcanic rocks, but the massive granite - foliated granodiorite sequence shows only a weak increase of copper from 6 to 11 ppm, rising to 17 ppm in the gneisses.

The copper content of 6 ppm for the massive granite is lower than all figures quoted for acidic rocks in Table 2 except for that 4 ppm given by Sugawara.

TABLE 3 - AVERAGE COPPER CONTENT (PPM)
OF THE MAJOR ROCKS IN PART OF
RED LAKE - LANSDOWNE HOUSE REGION, ONTARIO

(Chemical analyses by M.A. Gilbert)

| Rock | Overall range Cu ppm | | Overall mean Cu ppm | Mean in Cu ppm xxAreas | | | |
|-----------------------------------|-------------------------|--------|------------------------|------------------------------|----|----|----|
| | 1 | 3 | | 4 | 6 | | |
| Massive granite | ^x 5 | to 135 | 6 | 6 | 7 | 6 | - |
| Weakly-foliated granitic rocks | <u>5</u> | 450 | 9 | 9 | 10 | - | 8 |
| Porphyritic granitic rocks | <u>5</u> | 200 | 9 | 8 | 11 | 8 | 11 |
| Foliated granodiorites | <u>5</u> | 500 | 11 | 11 | 8 | 10 | 11 |
| Gneisses | <u>5</u> | 190 | 17 | - | 14 | - | 23 |
| Sedimentary rocks | <u>5</u> | 900 | 37 | 49 | 35 | 27 | 33 |
| Volcanic rocks | <u>5</u> | 700 | 60 | 70 | 58 | 56 | 61 |
| Gabbroic rocks | <u>5</u> | 350 | 49 | 36 | 36 | 58 | 68 |
| Weighted means (approx.) | | | 15 to 20 | 14 | 15 | 15 | 22 |

^x5 = less than 5

^{xx}6,000 square mile rectangles

The overall mean of 37 ppm copper for the sedimentary rocks is much lower than the mean of 57 ppm suggested by Vinogradov and lies near the lower end of the range of figures given by the several authors for sedimentary rocks.

The overall mean of 60 ppm copper for the volcanic rocks lies between 35 and 140 ppm for neutral and basic rocks respectively given by Vinogradov, and is, therefore, what might be expected from a mixture of acid and other volcanic rocks.

The gabbroic rocks have an overall mean copper content of 49 ppm. This is much lower than the suggested abundance of 140 ppm given by Vinogradov and is in better agreement with the range of 40 to 75 ppm indicated by Coats, Sugawara, and Butler.

The distribution of copper in the rocks of each of the four areas 1, 3, 4 and 6 is similar to that described above for the area as a whole.

The four granite granodiorite sequences each show small changes of copper concentrations within the narrow range of 6 to 11 ppm. The two groups of gneisses from areas 3 and 6 have means of 14 and 23 ppm respectively, markedly different from each other, but roughly twice the mean copper contents of 8 and 11 ppm given by the granodiorites from their respective areas.

The means for the four groups of sedimentary rocks vary from 27 to 49 ppm copper, and are all much higher than the granite - granodiorite rocks from each of the areas. The gabbroic rocks from the two northerly areas 1 and 3 both give means of 36 ppm Cu, much lower than the means of 58 and 68 ppm from the gabbros of the two southern areas. The volcanic rocks also show a considerable range of mean values from 56 to 70 ppm Cu but these cannot be correlated simply with the values given by any other rocks.

The weighted mean copper concentrations for areas 1, 3 and 4 are 14, 15 and 15 ppm respectively, an interesting agreement, and quite different from the higher mean of 22 ppm of area 6. This apparent increase in copper for area 6 is probably due to the comparatively high copper content of the gneisses in that area.

Zinc in the rocks - Concentrations of zinc liberated from the samples after fusion with potassium bisulphate range from 5 to 800 ppm, but are mostly below 100 ppm as shown by the following frequency distribution of,

| | |
|-------------------|-----------------------|
| 26 per cent under | 20 ppm zinc |
| 51 " " | between 20 and 40 ppm |
| 17 " " | " 40 " 60 " |
| 6 " " | " over 60 " |

The mean zinc concentration of all samples collected in the four areas 1, 3, 4 and 6 is 36 ppm but when this is weighed for each rock as discussed earlier under copper the mean falls slightly to 31 ppm. This figure is much lower than the general range of 60 to 80 ppm Zn suggested by Vinogradov in Table 4 and approaches more closely the abundances given by Wedepohl and Heide.

TABLE 4 - ABUNDANCE OF ZINC (PPM)
IN DIFFERENT ROCKS - VINOGRADOV (1956)

| Basic rocks | Neutral rocks | Acidic rocks | Sedimentary rocks ^{xx} | Author |
|------------------|-----------------|-----------------|---------------------------------|-------------------|
| 120 | 40 | 34 | 40 | Wedepohl (1953) |
| 110 | 87 | 49 | 110 | Sugawara (1951) |
| - | - | 56 | - | Tauson (1955) |
| 130 | 41 | 63 | - | Sandell (1943) |
| - | - | - | 71 | Leutwein (1951) |
| - | - | - | 21 | Heide (1955) |
| 130 ^x | 72 ^x | 60 ^x | 80 ^x | Vinogradov (1956) |

^{xx}Clay and shale

^xProbable means estimated by Vinogradov

The overall ranges of zinc concentrations for the different rocks throughout the four areas vary from less than 5 ppm up to maximums of 80 ppm in the gneisses and 800 ppm in the volcanic rocks (Table 5) but they are generally narrower than corresponding ranges for copper.

Overall mean zinc contents of the different rocks throughout the four areas vary from a minimum of 27 ppm in the massive granites to a maximum of 35 in the volcanic rocks. This is a much more restricted variation than that of 6 to 60 ppm given by copper. The overall mean for massive granite of 27 ppm Zn is lower than the quoted abundances for acidic rocks but is close to the value of 34 ppm given by Wedepohl for acidic rocks. The mean of 33 ppm Zn for the sedimentary rocks lies within the range given by the several authors (Table 4) but is much lower than the probable mean of 80 ppm suggested by Vinogradov. The volcanic rocks show a mean of 35 ppm Zn, much lower than that expected from the abundances given by Vinogradov. The gabbroic rocks, also, appear to be unusually low in zinc.

The variations of zinc concentrations in the different rocks within each of the four areas are also limited (Table 5), and indicate a remarkable constancy in the distribution of the metal over a large area. Zinc contents of the granite-granodiorite-gneiss clan vary between 24 and 32 ppm only, while the greatest deviation, up to 45 ppm, is shown by the volcanic rocks of area 4.

TABLE 5 - AVERAGE ZINC CONTENT (PPM)
OF THE MAJOR ROCKS IN PART OF THE
RED LAKE - LANSDOWNE HOUSE REGION, ONTARIO

(Chemical analyses by M.A. Gilbert)

| Rock | Overall range Zn ppm | Overall mean Zn ppm | Mean in Zn ppm Areas ^{xx} | | | |
|-----------------------------------|------------------------------|---------------------------|--|----|----|----|
| | | | 1 | 3 | 4 | 6 |
| Massive granite | ^x <u>5</u> to 170 | 27 | 24 | 26 | 28 | - |
| Weakly-foliated granitic rocks | <u>5</u> 130 | 29 | 28 | 31 | - | 22 |
| Porphyritic granitic rocks | <u>5</u> 165 | 32 | 30 | 31 | 32 | 32 |
| Foliated granodiorites | <u>5</u> 125 | 27 | 26 | - | 25 | 27 |
| Gneisses | <u>5</u> 80 | 30 | - | 31 | - | 28 |
| Sedimentary rocks | <u>5</u> 185 | 33 | 35 | 27 | 31 | 39 |
| Volcanic rocks | <u>5</u> 800 | 35 | 28 | 32 | 45 | 29 |
| Gabbroic rocks | <u>5</u> 175 | 32 | 32 | - | 35 | 33 |
| Weighted means (approx.) | | 31 | - | - | - | - |

^x5 = less than 5

^{xx}6, 000 square mile rectangles

Copper:Zinc ratios - The ratios of copper to zinc computed from the overall means for each rock throughout the whole area vary from a minimum of 0.3 in the granitic rocks to a maximum of 1.7 in the volcanic rocks (Table 6). There is a slight rise in the ratios within the granitic sequence from 0.3 in the massive granite to 0.6 in the gneisses, an increase to 1.0 in the sediments, and a further increase to 1.5 in the volcanic and gabbroic rocks.

This general increase in copper:zinc ratios through the acid to basic series conforms with the trend shown by the abundance figures quoted by Vinogradov but the magnitudes differ slightly. Acidic rocks from the area give lower ratios and the basic rocks higher ratios.

The change in copper:zinc ratios outlined above is apparent in each of the four areas. Ratios for the granitic rocks are fairly uniform, except for the gneisses in area 6 where an increase in

the Cu:Zn ratio to 0.8 reflects the relatively high copper content of these gneisses (see Table 3). Ratios for the sediments in each area oscillate around 1.0 but those of the volcanic and gabbroic rocks are all above 1.0 and reach a maximum of 2.5.

TABLE 6 - COPPER:ZINC RATIOS FOR THE MAJOR ROCKS IN PART OF THE RED LAKE - LANSDOWNE HOUSE REGION, ONTARIO

| Rock | Copper:Zinc ratios Area | | | | Overall |
|----------------------------|----------------------------|-----|-----|-----|---------|
| | 1 | 3 | 4 | 6 | |
| Massive granite | 0.3 | 0.3 | 0.2 | - | 0.3 |
| Weakly-foliated rocks | 0.3 | 0.3 | - | 0.3 | 0.3 |
| Porphyritic granitic rocks | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Foliated granodiorites | 0.4 | - | 0.4 | 0.4 | 0.4 |
| Gneisses | - | 0.5 | - | 0.8 | 0.6 |
| Sedimentary rocks | 0.7 | 1.3 | 0.9 | 0.8 | 1.0 |
| Volcanic rocks | 2.5 | 1.7 | 1.3 | 2.0 | 1.7 |
| Gabbroic rocks | 1.1 | - | 1.7 | 2.0 | 1.4 |
| Acidic rocks 0.5) | | | | | |
| Basic rocks 1.1) x | | | | | |
| Sediments 0.7) | | | | | |

*From abundances given by Vinogradov.

CONCLUSIONS

Some general inferences arising from the data presented are,

1. Concentrations of copper and zinc in rocks of a 25,000 square mile segment of the Canadian Shield are low compared to many published abundance figures for the two metals.
2. Zinc concentrations do not show an expected increase with basicity but usually remain close to 30 ppm in all rocks for each of the four areas.

3. Copper concentrations, on the other hand, show a general increase from 10 ppm to 50 ppm through the acid to basic rock sequence.

4. Ratios of copper to zinc when compared with published abundances, are relatively low in the acidic rocks (0.3), slightly above normal in the sedimentary rocks (1.0), and much higher than average in the basic rocks (1.0 to 2.0).

Further comment on the results of this geochemical work must await completion of a statistical appraisal of the data.

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YELLOWKNIFE GOLD BELT, NORTHWEST TERRITORIES

by

R. W. Boyle

The gold deposits of the Yellowknife Gold Belt occur in two settings - in shear zones that cut a Precambrian series of greenstones, and in fractures, small faults, saddle reefs, and other structures in a series of Precambrian sediments that include greywackes, phyllite, slate, argillite, quartzite, and conglomerate. Both the volcanic and sedimentary rocks show evidence of granitization and are intruded in places by granites and granodiorites.

The Yellowknife district was severely glaciated during Pleistocene time, and erratics, roches moutonnees, outwash sand and gravel plains, eskers, glacial lacustrine clays, and other glacial features are present in many areas. In the vicinity of most of the deposits, the country, except for stream valleys, draws, etc., is nearly continuous rock outcrop.

The district is in the region of permanently frozen ground, but the permafrost is patchy in its distribution, being present mainly beneath drift covered areas and absent below those that outcrop.

The region has a sub-arctic climate.

The deposits in the greenstones are veins and irregular lenses of quartz with associated carbonates, pyrite, arsenopyrite, galena, sphalerite, stibnite, and a variety of sulphosalts. The deposits in the sediments are quartz veins with associated tourmaline, pyrite, arsenopyrite, galena, and sphalerite.

Geochemically the deposits in the greenstones represent concentrations of silica, carbon dioxide, sulphur, arsenic, antimony, gold, silver, lead, zinc, copper, and iron. Those in the sediments are concentrations of silica, sulphur, boron, iron, lead, zinc, gold, and silver.

Pedogeochemical methods are not effective on a large scale because of the large amount of outcrop present. These methods could, however, be used to check valleys and draws overlying shear zones, faults, and areas suspected of containing quartz veins in the greenstones and sediments. From limited work the best indicator elements appear to be arsenic and antimony in the greenstones and lead and zinc in the sedimentary rocks.

Hydrochemical methods are, likewise, probably not effective because of the permafrost and also because there are few soluble elements in the ores. Some sphalerite and chalcopyrite are present in places but usually in quantities too small to produce any

local anomaly. The maximum content of zinc detected in underground water flowing in the shear zones was 0.1 ppm Zn.

A considerable amount of work was done on the chemistry of rocks in both the greenstone belt and sedimentary area. From this it is fairly certain that both types of rocks exhibit no unusual concentrations of the various ore elements, and it is doubtful if rock analyses would indicate the presence of gold deposits unless material from the shear zones or immediate wall-rocks of the sedimentary deposits were analyzed.

Certain regional features may, however, indicate the presence of gold deposits in the rocks. These are as follows:

1. All of the economic gold orebodies in the greenstone belt occur in the lower grade metamorphic facies, specifically in the epidote-amphibolite and greenschist facies. These facies are enriched in water and carbon-dioxide and probably also in sulphur, compared with the amphibolite facies and adjacent granites and granodiorites.
2. Most of the economic gold-quartz veins in the sedimentary area occur either in the relatively unmetamorphosed greywackes, slates, phyllites, and argillites or just within a zone where these exhibit a transition to knotted quartz-mica schists. The latter transition zone exhibits a few knots and appears to be particularly favourable for the concentration of gold-quartz veins. This is probably due to a temperature effect.

On a more local scale the gold-quartz deposits in the greenstones are indicated by the following features:

1. The shear zones containing the gold-quartz lenses are enriched in carbon-dioxide, water, and sulphur compared with the country rocks. In the vicinity of the gold-quartz lenses the sulphur content increases as do also the arsenic and antimony contents. This effect is generally quite local, and is seldom observed over 20 feet laterally from the gold-quartz lenses.
2. Adjacent to the quartz lenses there is a marked decrease in silica and increase in carbon-dioxide in the alteration zones. This chemical halo can be traced outward from the veins as far as 100 feet in places.

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KENO HILL - GALENA HILL AREA, YUKON

by

R.W. Boyle

The Keno Hill - Galena Hill area is in central Yukon, 35 miles northeast of Mayo and about 220 miles due north of Whitehorse. The area is particularly noted for its lead-zinc-silver deposits which have been prolific producers since their original discovery in 1913. In addition the area has gold-scheelite placers which have produced considerable quantities of gold and some scheelite.

The consolidated rocks underlying the area consist of sericitic, chloritic, and graphitic schists, phyllites, thick and thin-bedded quartzites, and a few limestone beds and lenses. These are interbedded with numerous greenstone sills and lenses. The sediments are probably of Palaeozoic age and are intruded in places by granitic bodies thought to be of Mesozoic age.

The area has been severely glaciated on the lower levels of the mountainous terrain. At the higher levels the soils are mainly residual. Permafrost underlies the whole area but is rather patchy in its distribution.

The climate of the region is sub-arctic and is rigorous with long cold winters and short warm summers. The average annual precipitation is about 12 inches.

Five types of deposits occur in the area:

1. Gold-quartz deposits containing essentially quartz, pyrite, arsenopyrite, jamesonite, and various other sulphosalts.
2. Lead-zinc-silver deposits consisting essentially of galena, sphalerite, chalcopyrite, pyrite, freibergite, and other sulphosalts in a gangue of siderite and minor quartz.
3. Tin impregnation deposits containing mainly cassiterite, chalcopyrite, tourmaline and quartz.
4. Small skarn and stockwork deposits containing scheelite and wolframite.
5. Gold-scheelite placer deposits containing native gold, scheelite, cassiterite, wolframite, and small amounts of native bismuth.

A hydrogeochemical survey was conducted over some 500 square miles of the area centred on Galena Hill, and pedogeochemical surveys were carried out over the principal vein deposits in the Galena Hill - Keno Hill and Dublin Gulch areas.

Zinc was used as the indicator element in the hydrogeochemical surveys. The results of the survey indicated that the heavy metal anomalies in the stream systems are restricted to a belt centred on the areas underlain by a favourable quartzite formation in which most of the important lead-zinc-silver deposits occur. The survey extended the known mineralized belt to the east and west. Numerous iron springs that report relatively high values in zinc, copper, and manganese were found in the mineralized belt and these are thought to be good indicators of mineralization.

The presence of permafrost in the area did not seriously affect the application of hydrogeochemical methods because there are sufficient windows in the permafrost to allow ingress and egress of oxidizing waters. Some lodes, however, are sealed by permafrost and do not contribute heavy metals to springs and streams. Where this is the case the water leaching surface accumulations of float may still pick up sufficient metal to give a clue to the presence of mineralization.

The results of the research on pedogeochemical methods over the lead-zinc-silver deposits show that zinc is widely dispersed by groundwater, and is therefore not suitable as an indicator element for methods using soil analyses. Copper, likewise, due to its erratic dispersion and its general scarcity in the deposits, is not a suitable indicator in the soils. Lead, silver, and antimony on the other hand have a limited dispersion and are enriched in soils near the lode deposits making them excellent indicators.

The results of analyses of partly residual soil along traverses across known mineralized vein faults indicate that the lead, silver, and antimony contents of the soil rise several times above background and give a strongly contrasting anomaly over the deposits in some cases and slightly down hill in others. Analyses of near surface glacial materials, muck, and peat along traverses across known vein faults were generally ineffective for locating vein faults or deposits. Samples of the glacial material taken close to bedrock, however, give good anomalies with strong contrast over some vein faults and deposits.

Arsenic is a particularly good indicator in soils for detecting quartz-pyrite-arsenopyrite-gold deposits in the area. Over the deposits marked arsenic anomalies with a high contrast were found on Keno Hill and in the Dublin Gulch area.

Tin and boron were used as the indicator elements on traverses across the tin impregnation deposits. Both elements give marked anomalies in the vicinity of the deposits.

Panning is particularly useful in determining the location of gold and scheelite placers. The method has been used for over sixty years in the Yukon and does not require further comment. A variation of the panning technique, namely spectrographic analyses of the heavy residues, was tried in the Dublin Gulch area. The spectrographic results in combination with ultraviolet examinations indicate that tin, tungsten, gold, and bismuth can be detected in the streams many miles from the productive gold-scheelite placers.

The presence of bismuth in the heavy residues is indicative of cassiterite and wolframite deposits in the stream basins.

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HYDROGEOCHEMICAL PROSPECTING FOR URANIUM IN THE SOUTHERN PART OF THE CANADIAN SHIELD

by

J.A. Chamberlain

INTRODUCTION

This study was undertaken for the purpose of obtaining information regarding concentrations of uranium in natural waters with a view to testing the practicality of the hydrogeochemical method as a prospecting technique in the search for uranium or associated metals. The results are fully described by Chamberlain (1962, in press).

The test area comprises some two thousand square miles, centred on Bancroft, Ontario. It was selected for study because it contains many known uranium occurrences and because much of it has been mapped geologically (Satterly, 1957). From August to November, 1961, over 1,100 samples were collected from surface and underground waters and analyzed for uranium in a field laboratory. A colorimetric method (Smith and Chandler, 1958) was found to be well suited to field conditions although its lower limit of sensitivity of one part per billion (ppb) was found to be insufficient to establish background levels in all cases.

GENERAL GEOLOGY OF AREA

The rocks of the area fall into two main groups: (1) the older Grenville type metasediments, including marble, paragneiss and amphibolite, intruded by (2) a complex series of mafic, sialic and alkalic igneous rocks. All consolidated rocks of the area are of Precambrian age.

The uranium deposits are generally located near the margins of dome-like granitic or syenitic intrusions. The most productive deposits are pegmatitic bodies of both intrusive and replacement origin. Other types of deposits include metasomatic replacements in limy rocks and uraniferous calcite-fluorite veins of hydrothermal origin (Hewitt, 1957).

CLIMATE AND RAINFALL

The climate is typical of southeastern Ontario. Over a 37 year period, the annual daily mean temperature averages 39°F. Precipitation for the same period averages 32.3 inches annually, expressed as rainfall.

RESULTS OF SURVEY

The plot of the hydrogeochemical data on a scale of 1 inch to 2 miles outlines in a general way the many known occurrences and deposits that together form the belt of uranium mineralization in the investigated area. Changes in background levels seem related to changes in character of bedrock, with syenitic rocks showing a spatial relationship to waters of high uranium content.

Strong influences of chemical environment on the primary dispersion of uranium in water are indicated by the fact that natural waters contain less uranium with increasing availability of decaying organic material. Creeks are estimated to contain 1.2 ppb while the uranium content of lakes and swamps shows reductions of 18 and 50 per cent, respectively. Accordingly, under non-anomalous conditions in most parts of the Canadian Shield, groundwaters and creeks fed by watershed basins would be expected to contain more uranium than lakes or lake-fed creeks. Lowest quantities of uranium would be anticipated in swamp waters, where reducing conditions predominate.

The influence of chemical environment is also demonstrated locally in areas where waters are associated directly with uranium deposits. Here, waters are generally found to contain anomalously high uranium values for only a few tens or a few hundreds of feet before decreasing to background levels. Results again indicate that uranium is extracted from solution by decaying organic material.

It seems probable that uranium orebodies will escape direct detection by routine hydrogeochemical studies in the Canadian Shield because of the restricted nature of their dispersion patterns. The greatest potential economic use of the method appears to be in establishing regional anomalies of low magnitude outlining broad areas for which additional exploratory work may be warranted. On the basis of the present study, such anomalies could have significance with values as low as twice regional background, or 2 ppb. Values of three or four times regional background (3 to 5 ppb in the investigated area) would be of definite interest.

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