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# MINOR AND TRACE ELEMENT DISTRIBUTION IN THE HEAVY MINERALS OF THE RIVERS AND STREAMS OF THE BATHURST - JACQUET RIVER DISTRICT, NEW BRUNSWICK

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(Report and PS Map, 12-1967 and 13-1967)

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## Illustrations

ABSTRACT

This report describes the elemental distribution in heavy minerals collected from stream sediments in the Bathurst- Jacquet River district of New Brunswick.

In a general way the variations of the elemental content of the heavy minerals reflects underlying bedrock and it appears that heavy mineral sampling in detail would be a useful way to conduct a reconnaissance geochemical survey for mineral deposits in the area.

# MINOR AND TRACE ELEMENT DISTRIBUTION IN THE HEAVY MINERALS OF THE RIVERS AND STREAMS OF THE BATHURST -JACQUET RIVER DISTRICT, NEW BRUNSWICK

## INTRODUCTION

During the summer of 1965, six two-man field parties traversed the rivers and streams of the Bathurst- Jacquet River district, New Brunswick. The project was called Operation Bathurst. Water and stream sediment samples were tested in situ for their heavy metal content at intervals of about 1,500 feet. Stream sediment samples collected at each site were analyzed for Pb, Zn, Cu, As, Sb, Mo, Sn, W, Ag, Ni, Co, Cr, Ba, and Mn in field laboratories. For the results of this survey and a discussion of the geochemistry of the individual elements in the waters and stream sediments, the reader should consult Boyle et al. (1966).

In addition to stream sediment samples, heavy mineral concentrates were collected if convenient, mainly from the gravelly parts of each river, stream, and their major tributaries. This report deals with a study of the minor and trace element distribution in these heavy mineral concentrates.

## ACKNOWLEDGMENTS

W. M. Tupper was in charge of the field work. J. C. Paris and staff made the heavy liquid and magnetic separations. The spectrographic analyses were done by C. C. Durham, assisted by P. J. Lavergne and G. Mihailov. M. Shafiqullah compiled the chemical data on the heavy mineral concentrates, and R. W. Boyle supervised the project as a whole and prepared the report.

Individual field parties were headed by W. M. Tupper, G. Friedrich, M. Ziauddin, M. Shafiqullah, M. Carter and K. Bygrave. Able assistance on the field parties was performed by D. Picklyk, L. W. LeRoy, P. Martel, R. Bourassa, W. Taylor, W. Warren, R. Cormier, and E. T. Lever.

## SAMPLING AND ANALYTICAL PROCEDURE

The heavy mineral concentrates were panned from the gravels and sands of the rivers, streams, and their major tributaries at suitable locations. The ratio of concentration was about 30:1. The heavy mineral concentrates were bagged, dried, and shipped to the geochemical laboratories of the Geological Survey in Ottawa for chemical work.

The heavy minerals were separated from the field concentrate by methylene iodide of specific gravity 3.3. The heavy residue was dried and the magnetic and nonmagnetic fractions were separated with a Sepor Automagnet. The magnetic fraction consisted essentially of magnetite, pyrrhotite, and ilmenite, with some limonite and wad; the non-magnetic fraction was composed of numerous minerals depending on the site, principally zircon, garnet, olivine, rutile, amphibole, leucoxene, sphene, limonite, wad, chromite, sulphides, and locally probably barite, scheelite, and cassiterite. Both the magnetic and non-magnetic fractions were then ground to minus 150 mesh according to the procedure outlined by Lavergne (1965).

Both the magnetic and non-magnetic fractions from each sample were analyzed on a Jarrell-Ash 1.5 metre grating emission spectrograph for 26 elements. A 10 mg sample was mixed with 20 mg of graphite powder, packed into the cavity of a carbon anode cap, and then capped with 20 mg of a calcium carbonate-graphite buffer, mixed in the proportion of 1:4. The samples were then arced at 12 amps for 3 minutes and the spectra recorded on 35 mm Kodak SA-3 film.

The unknown spectra of the samples were compared visually against a series of synthetic standards of known concentrations ranging from 0.5 to 10,000 ppm in a base matrix of iron oxide, in steps of 0.5, 1, 2, 5, 10, 20, 50, 100……10,000 ppm. The amounts present were visually estimated to the nearest half step.

The elements analyzed for and their lowest detection limits in parts per million were: Ag (0.5), Ti (2), Ba (5), Cu (5), Be (5), Co (7), Cr (10), Sr (10), Ni (10), Pb (20), Bi (20), Zr (20), B (30), Mo (30), Cd (50), V (50), Sh (70), Mn (100), W (100), Nb (100), Zn (100), Pt (30), Au (30), U (1,000), La (50), Ce (200).

## RESULTS OF THE INVESTIGATION WITH BRIEF NOTES ON THE DISTRIBUTION OF ELEMENTS DETERMINED

The Cu, Pb, Zn, Ag, Ba, Ni, Co, Cr, Sh, W, Mo, Nb, Bi, Cd, and Pt contents of 170 non-magnetic fractions, and the Cu, Pb, Zn, Ag, Ba, Ni, Co, Cr, Sn, W, Mo, Nb, and Bi contents of 166 magnetic fractions are presented in Maps 12-1967 and 13-1967 respectively. Be, Au, U, La, and Ce were not detected in any of the samples. Sb was not positively identified because of chromium interference. The analytical data on the content of B, Ti, V, Mn, Sr, and Zr in the heavy minerals have not been plotted for publication. Individuals wishing to consult these data may do so in the open files of the Geological Survey. Of these elements, Ti, V, Mn, Sr, and Zr were found in all of the samples. Boron was found in 58 non-magnetic fractions and in 12 magnetic fractions.

Most of the known mineral deposits and occurrences are plotted on the accompanying maps. A complete list and location of all known mineral deposits and occurrences in the Bathurst-Jacquet River district is given by Abbott (1965).

The dispersion of the elements in the heavy minerals of the map-area is discussed briefly below. The precise location of the various elements in the heavy minerals at each site is not known as detailed mineralogical and chemical work were not done on individual minerals separated from the concentrates. Some suggestions are included, however, as to where the bulk of each element is present. These suggestions are based on a knowledge of the chemistry of the primary and secondary minerals in the deposits and rocks of the area and on a preliminary investigation of some heavy concentrates.

Copper

The copper content of the magnetic and non-magnetic fractions of the heavy minerals ranges from 5 to greater than 10,000 ppm. The higher than normal amounts of copper in the heavy minerals from parts of Armstrong Brook flowing into Chaleur Bay, Belledune River, Hendry Brook, Quitard Creek, Millstream River and its tributaries, and Nigadoo River are probably associated with known sulphide deposits and occurrences. The higher copper content in the heavy minerals from parts of New Mills River, Benjamin River, two of the western tributaries of Fortymile Brook, and the upper reaches of Belledune River are not related to known copper occurrences. These merit further investigation.

Much of the copper in the heavy minerals is probably present in residuals of chalcopyrite and its oxidation products. There is probably also some copper in magnetite, pyrrhotite, and in particles of limonite and wad.

Lead

The lead content of the heavy minerals ranges from 20 to 7,000 ppm. Lead occurs in 169 non-magnetic and 112 magnetic samples. The high lead content of the heavy minerals in parts of South Nash Creek, Armstrong Brook flowing into Chaleur Bay, Belledune River, Hendry Brook, Elmtree River, Nigadoo River, and Millstream River are probably associated with known sulphide occurrences. The high lead content in the heavy minerals of Paynes Brook, Fortymile Brook, and in the tributaries of the Jacquet River flowing from the northwest (McNeill Brook, Hayes Gulch, Wildcat Brook, Falls Gulch Brook) merit further investigation.

Much of the lead in the heavy minerals is probably present in residuals of galena and its oxidation products, anglesite and cerussite. There may be some lead in feldspar residuals which could not be entirely separated from the heavy minerals. Small amounts of lead are also present in zircon and in particles of limonite and wad.

Silver

The silver content of 21 non-magnetic and 2 magnetic fractions ranged from 0.5 to 30 ppm. The element is associated principally with lead, especially in the Jacquet River and its tributaries, Elmtree River, Nigadoo River, and in Millstream River and its tributaries.

Most of the silver is probably in galena and its oxidation products. There may also be some silver in pyrite and the other sulphides and in particles of wad and limonite.

Zinc

The zinc content of 31 non-magnetic and 54 magnetic fractions ranged from 100 to greater than 10,000 ppm. The high zinc content of the heavy minerals in parts of Armstrong Brook flowing into Chaleur Bay, South Nash Creek, Belledune River, Hendry Brook, Elmtree River, Nigadoo River, and Millstream River are probably related to known sulphide occurrences. The higher than normal zinc content in the heavy minerals in parts of South Benjamin River and Blueberry Creek need further investigation.

In some heavy mineral samples much of the zinc appears to be present in magnetite. In others some zinc may be present in sphalerite residuals and in pyrite. Small amounts of zinc are probably also present in particles of limonite and wad.

Barium

The barium content of the heavy minerals ranges from 15 to greater than 10,000 ppm. The element is present in relatively high amounts in the heavy minerals of parts of the Millstream River and its tributaries, Belledune River, Hendry Brook, and the various tributaries of the Jacquet River. The barium content is highest in the non-magnetic fractions in which it is probably present in barite, a mineral that occurs in small amounts in the hypogene and supergene mineral suites of the deposits of the district. There is also much barium in particles of wad and limonite and in feldspar and mica residuals. In the magnetic fractions much of the barium is probably present in wad, limonite, and magnetite.

Strontium

The strontium content of the heavy minerals ranges from 10 to 3,000 ppm. The highest contents of strontium occur in the northwestern and southwestern parts of the district.

Much of the strontium is probably present in barite, in feldspar residuals, and in wad and limonite fragments.

Cadmium

The cadmium content of the heavy minerals ranges from 50 to 150 ppm. The element occurs only in 15 non-magnetic fractions and seems to be restricted principally to the southwestern part of the district, particularly in parts of the Upper South Jacquet River, tributaries of Tetagouche River near Upper and Middle Tetagouche Lakes, Middle River, Ninemile Brook, and Fortymile Brook. The location of cadmium in the heavy minerals is unknown.

Nickel

The nickel content of the heavy minerals ranges from 10 to 3,000 ppm. Higher than normal amounts of nickel are present in Little River, Middle River, Sixmile Brook, Tetagouche River, Nigadoo.River, Quitard Creek, and Elmtree River.

Most of the nickel in the magnetic fractions is probably present in pyrrhotite and magnetite. In the non-magnetic fractions the element is probably concentrated mainly in wad and limonite fragments and in pyrite and olivine.

Cobalt

The cobalt content of the heave minerals ranges from 7 to 200 ppm. The element follows nickel closely.

Chromium

The chromium content of the heave minerals ranges from 10 to greater than 10,000 ppm. Chromium follows nickel and cobalt to some extent, being much higher than normal in the Tetagouche Group rocks south of Millstream ]River There the element appears to reflect the presence of numerous basic sills.

The highest contents of chromium tend to occur in the magnetic fractions, in which the element is probably present mainly in magnetite. In the non-magnetic fractions chromium is probably mainly in chromite, garnet. in wad and limonite fragments, and in residuals of mica, pyroxenes, and amphiboles.

Titanium

The titanium content of the magnetic fractions is generally greater than 1 per cent. The non-magnetic fractions range from 700 to greater than 1 per cent Ti. Most of the titanium in the magnetic fractions is present in magnetite; in the nonmagnetic fractions the element is contained mainly in rutile, ilmenite, leucoxene, sphene, wad, limonite, and silicate residuals.

Vanadium

The vanadium content of the heavy minerals ranges from 50 to 3,000 ppm Both the magnetic and non-magnetic fractions tend to have about equal amounts of the element. There are, however, numerous exceptions to this generalization; in some samples the magnetic fractions are enriched in vanadium compared with the nonmagnetic fractions, in other samples the reverse is true.

The vanadium content of the heavy minerals tends to be low in the northwestern and southeastern parts of the district, a feature that reflects the presence of low vanadium bearing rocks in these areas - viz. southeastern part - granite and Pennsylvanian sediments; northwestern part - rhyolites, granitic rocks, and low grade metasediments. Fractions high in titanium tend to be enriched in vanadium. This suggests that most of the vanadium is associated with titanium in magnetite in the magnetic fractions, and that the element is present mainly in rutile, ilmenite, and sphene in the non-magnetic fractions.

Boron

The boron content of the heavy minerals ranges from 30 to 150 ppm. The element occurs most frequently in the non-magnetic fractions in which it is probably present mainly in tourmaline.

Zirconium

The zirconium content of the heavy minerals ranges from 20 to 3,000 ppm. The element is concentrated in the non-magnetic fractions in which it is probably present mainly in zircon. The highest amount of zirconium is generally present in the heavy minerals of the rivers and streams draining the granitic terrains and metasedimentary areas.

Manganese

The manganese content of the heavy minerals ranges from 500 to greater than 10,000 ppm. In some magnetic fractions the manganese content is greater than in the non-magnetic fraction; in others the reverse is true. In the magnetic fraction much of the manganese is evidently present in magnetite. Some also occurs in fragments of wad and limonite. Most of the manganese in the non-magnetic fraction is probably present in wad, limonite, garnet, olivine, epidote, and residuals of other silicates.

The manganese content of the heavy minerals is relatively high in the area south of Millstream River, particularly in Little River, Middle River, Roughwater Brook, Nepisiguit River, and South Tetagouche River. In the northwestern part of the district the streams draining into Jacquet River tend to have relatively high contents of manganese in their heavy mineral suite.

Tin

Tin was found in 35 non-magnetic and 29 magnetic fractions, the range in content being 70 to 5,000 ppm. The location of the tin in the samples is not known. It may be present as cassiterite in some samples; in others it may occur in mica residuals, in rutile and sphene, or in sulphides.

Higher than normal amounts of tin occur in the heavy minerals of the streams and rivers draining the Bathurst, Nicholas Dénys, and Antinouri Lake granitic bodies, a feature which suggests that these rocks are slightly stanniferous. Some higher than normal tin contents also occur in the heavy minerals of the streams and rivers draining the area underlain by the Pennsylvanian Bathurst Formation. This may indicate the presence of small amounts of detrital cassiterite in these sedimentary rocks.

Tungsten

Tungsten was found in six non-magnetic and five magnetic fractions. The content in these fractions ranged from 100 to 10,000 ppm. The location of the element in the heavy mineral samples is unknown. Probably it is present as scheelite, a mineral that occurs in some of the skarn-type copper and magnetite deposits associated with the Nicholas Dénys granitic body.

Higher than normal contents of tungsten occur in some of the heavy mineral concentrates taken from streams and rivers draining the Bathurst, Nicholas Dénys, and Antinouri Lake granitic bodies and their associated metasediments (hornfels and skarn).

Molybdenum

Molybdenum was found in seven non-magnetic and four magnetic fractions, the range in content being 30 to 100 ppm. Molybdenite has been observed in the heavy mineral concentrates and probably all of the element is present in this mineral in both the magnetic and non-magnetic fractions.

Most of the heavy minerals containing detectable molybdenum came from streams and rivers draining the granitic bodies and their associated metasediments (hornfels and skarn). The element is generally associated with higher than normal contents of tin or tungsten in the samples.

Niobium

Niobium was found in one magnetic sample from Hendry Brook (150 ppm) and one non-magnetic sample from Roughwater Brook (200 ppm).

Bismuth

Bismuth was found in four samples, one from Roughwater Brook and three from Millstream River basin. The range of the bismuth content in the heavy mineral fractions is 20 to 100 ppm.

Platinum

A trace of platinum was noted in a non-magnetic heavy mineral fraction from Bass River. Bass River also has a higher than normal tin content in its heavy minerals, suggesting that both detrital cassiterite and platinum may have been slightly concentrated in the Pennsylvanian sediments.

## SUMMARY AND CONCLUSIONS

This summary of the elemental constitution of the heavy minerals in the streams and rivers of the Bathurst- Jacquet River district shows the following:

1. Cu, Pb, Zn, Ag, and Ba show a general correlation and have similar dispersion characteristics in the heavy mineral concentrates. These elements are particularly high in the non-magnetic fractions. The Petit Rocher - Beresford - Nicholas Dénys and the Belledune River - Pointe Verte - Culligan - Mitchell settlement areas have higher than normal contents of Cu, Pb, Zn, and Ag, a feature that probably reflects the presence of known sulphide bodies and occurrences in these areas. The Zn and many of the Cu contents of the magnetic fractions in the Nigadoo River and Millstream River drainage basins are generally much higher than those in the nonmagnetic fractions, a feature which indicates that these elements are largely concentrated in magnetite, a mineral that occurs in some abundance in the skarn-type deposits associated with the Nicholas Dénys granitic body. The non-magnetic fractions from the tributaries of Jacquet River (McNeill Brook, Hayes Gulch, Wildcat Brook, and Falls Gulch Brook) and South Jacquet River are anomalous in Zn, Pb, and Ag, and their

magnetic fractions are high in Cu in places. The non-magnetic samples from New Mills River and parts of Benjamin River are anomalous in Cu, and some of the magnetic fractions tend to be high in zinc and lead. South of Millstream River, in the areas underlain by Tetagouche Group rocks, the Bathurst granite, and the Pennsylvanian Bathurst Formation, the contents of Cu, Pb, and Zn in the heavy minerals tend to be lower than in those in the area north of Millstream River.

2. Higher than normal Ni, Co, and Cr contents in the heavy minerals appear to be associated with basic rocks and the high grade metasediments of the Tetagouche, Elmtree, and Chaleur Bay Groups. The Ni and Co contents of the heavy minerals in the streams and rivers north of Millstream River, particularly in the Petit Rocher - Beresford - Nicholas Dénys and Belledune River - Pointe Verte areas, are much higher than those in rivers and streams south of Millstream River. This feature seems to reflect the presence of pyrrhotite and other nickel-bearing minerals in the high grade metasediments (skarn and hornfels) associated with the Nicholas Dénys and Antinouri Lake granitic bodies as well as the presence of basic intrusive rocks west of Pointe Verte and elsewhere. The high chromium content of the heavy minerals south of Millstream River, in the area south and southeast of Nicholas Dénys, is probably related to the abundance of basic sills in this area.

3. High contents of Sn, W, Mo, Bi, and Nb in the heavy minerals are generally found in. the streams and rivers draining granitic bodies and their associated high grade metasediments (skarn and hornfels).

4. Sn, probably as cassiterite, and a trace of platinum occur in the heavy minerals of streams and rivers draining the Pennsylvanian Bathurst Formation. This suggests that there is a weak residual concentration of cassiterite and platinum in parts of these Carboniferous sediments.

5. In a general way the variations in the elemental content of the heavy minerals reflects the type of underlying bedrock drained by the streams and rivers. There is also a reflection of many of the known sulphide deposits in the heavy. minerals taken from the streams and rivers draining the areas containing the deposits. Similarly, the heavy minerals tend, in most cases, to substantiate and support the numerous geochemical anomalies found in the district as described in a previous paper (Boyle et al. 1966).

6. The effects of glaciation on the distribution of the heavy minerals in the district do not seem to be marked, and the dispersion patterns of the heavy minerals with respect to rock types and known deposits are apparently not disturbed significantly.

7. There are numerous interesting streams and rivers whose heavy minerals contain higher than normal contents of several of the elements investigated. These merit further work.

8. Heavy mineral sampling in detail would seem to be a useful way of reconnaissance geochemical prospecting for deposits in the Bathurst area of New Brunswick.

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