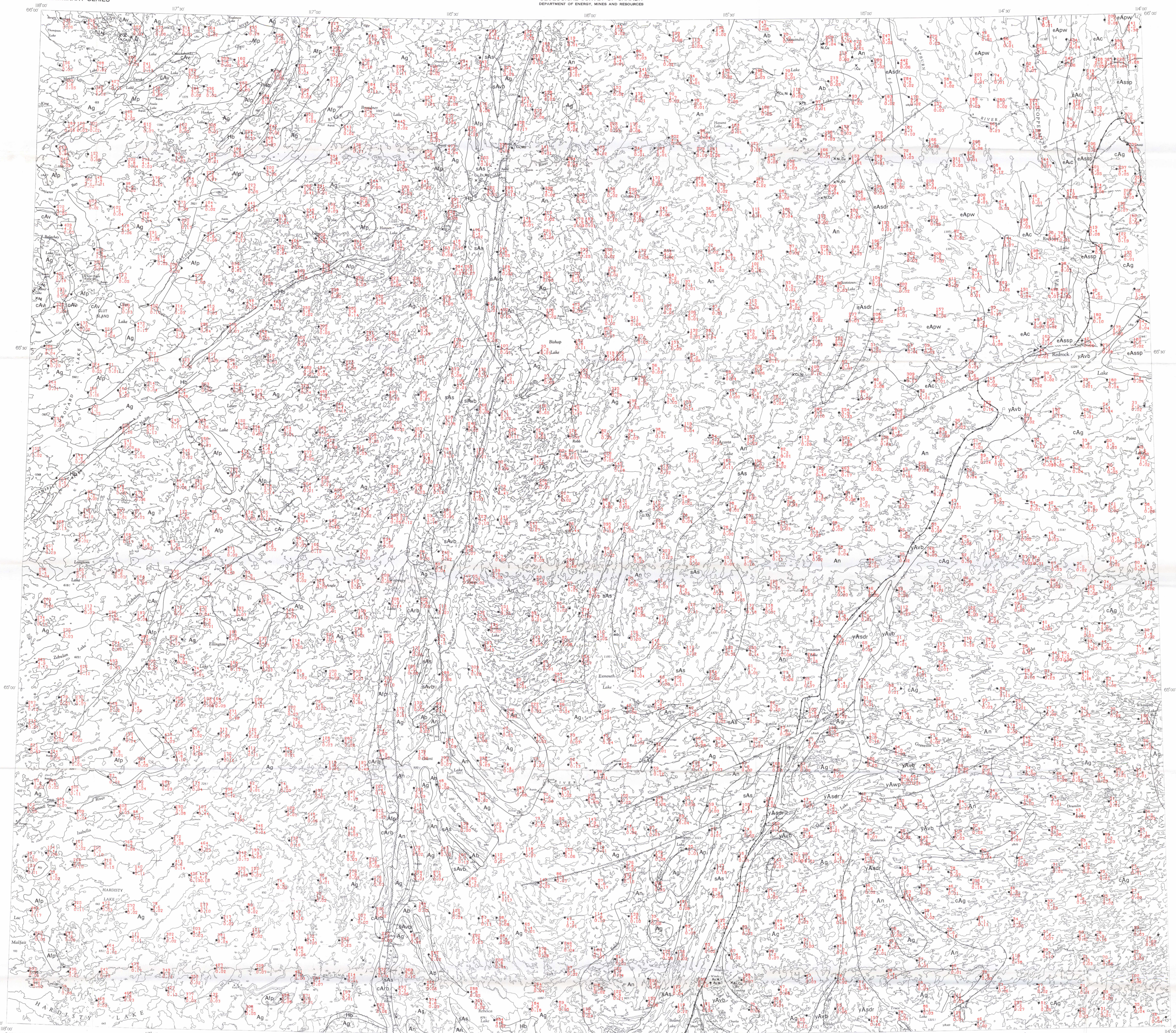
PRELIMINARY SERIES

GEOLOGICAL SURVEY OF CANADA
DEPARTMENT OF ENERGY, MINES AND RESOURCES



LEGEND

PROTEROZOIC

HADRYNIAN

Hb	Gabbro sheets, sills

APHEBIAN

Afp	Felsite porphyry
Ag	Granodiorite, diorite, quartz diorite
An	Migmatite, granitic gneiss

CAMERON BAY GROUP

cAv	Intermediate porphyritic flow, tuff, agglomerate
cArb	Red arkose, conglomerate, shale
Ab	Gabbro, diorite

SNARE GROUP

sAvb	Basalt, tuff, minor chert
sAs	Quartzite, dolomite, siltstone, shale

EPWORTH GROUP

eApw	RECLUSE FORMATION: argillite, shale, greywacke
eAc	ROCKNEST FORMATION: dolomite
eAssp	ODJICK FORMATION: sandstone, shale, argillite, andesite
eAsdr	Metamorphosed Epworth Group

ARCHEAN

Ag	Quartz diorite, quartz monzonite, granodiorite, granite. In part porphyritic
An	Granite gneiss, migmatite, mixed gneisses involving Yellowknife rocks
cAg	Complex of plutonic granitic rocks that may be, in part, older than Yellowknife Supergroup

YELLOWKNIFE SUPERGROUP

yAwp	Greywacke, shale
yAsdr	Cordierite-andalusite bearing knotted schist and other metamorphic equivalents of yAwp
yAvb	Intermediate to basic lava, tuff, agglomerate, and undifferentiated acidic volcanic rocks

Boundary between Bear and Slave geological provinces ....

Fault, observed or assumed ....

Mineral prospect showing principal element(s) .... Cu ×

Lake sample site and metal concentration (sediment sieved to minus 250 mesh) 308 3.5 0.05

Lake sample site and metal concentration (sediment sieved to minus 100 mesh) 63 1.5 0.01

302 Mn ppm
1.4 Fe percent
0.02 Optical density

MINERALS

Asbestos	asb	Molybdenum	Mo
Bismuth	Bi	Nickel	Ni
Cobalt	Co	Silver	Ag
Copper	Cu	Thorium	Th
Gold	Au	Uranium	U
Lead	Pb	Zinc	Zn

Geology after unpublished map compiled by J. C. McGlynn, 1971

Field work by R. J. Allan, E. M. Cameron, C. C. Durham, R. Benson, R. Colley, B. Cumming, G. Lund, D. Mann, C. Pride, G. Thomas and B. Woronuk

Analyses by J. J. Lynch, Alice I. MacLaurin, A. P. Lemieux, R. T. Crook, R. Horton, W. H. Nelson, W. Alexander and A. Martineau

Marginal notes by R. J. Allan and E. M. Cameron

Geochemical contours and metal concentration numbers drawn by computer drum plotter

Geological cartography by the Geological Survey of Canada

Any revisions or additional geological information known to the user would be welcomed by the Geological Survey of Canada

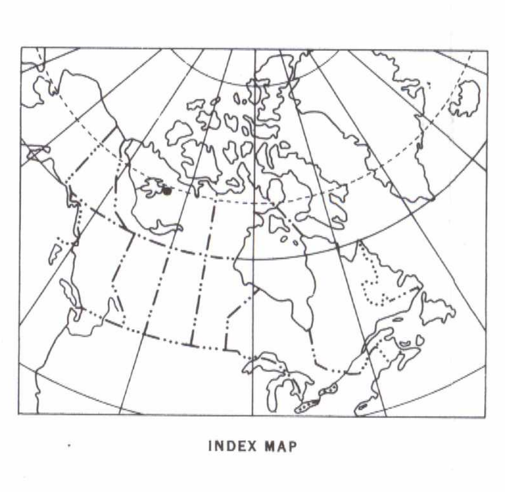
Base-map assembled by the Geological Survey of Canada from maps published at the same scale by the Army Survey Establishment R. C. E. in 1961, 1962

Copies of the topographical maps covering this map-area may be obtained from the Canada Map Office, 615 Booth Street, Ottawa, Ontario K1A 0E9

Mean magnetic declination 1972, 36°31' East, decreasing 8.7' annually. Readings vary from 34°52' in the SE corner to 38°42' in the NW corner of the map area

Elevations in feet above mean sea-level

Published, 1973
Copies of this map may be obtained from the Geological Survey of Canada, Ottawa



INDEX MAP

MAP 12-1972
SHEET 1

MANGANESE, IRON AND ORGANIC MATTER CONTENT OF LAKE SEDIMENTS
BEAR-SLAVE OPERATION
DISTRICT OF MACKENZIE

Scale 1:250,000

Miles 4 0 4 8 12 Miles

Kilometres 6 0 6 12 18 Kilometres

MARGINAL NOTES

Lake Sediment Geochemistry The use of lake sediments as an aid to mineral exploration and geological mapping within the Canadian Shield is based on two principal concepts of their origin. The first is that the detrital portion of a fine-grained lake sediment is a good composite sample of the rocks in the vicinity of the lake. In perhaps a majority of cases, the material forming the sediment has passed through an intermediate stage as a component of locally derived tills or other glacial sediments before being transported to the lake. The second concept is that the fine-grained particles of the sediment are an excellent medium for the sorption of metal ions released during the weathering of nearby sulphide ore deposits or similar mineralization. Most of the known sulphide deposits in the Bear-Slave survey area show moderate to high degrees of oxidation.

At the wide, reconnaissance, sampling interval used, it is unlikely that many samples will be taken from lakes within the limits of the secondary dispersion halo of a single ore deposit. However, country containing such deposits may be defined by the trace element dispersion from the much more extensive non-economic mineralization that is often associated with economic deposits. Similar trace metal patterns may also be derived from mineralization that is not associated with ore deposits or from rock units of unusual chemical composition.

Lake Sediment Sampling The lake sediment samples were collected by post-hole auger from a helicopter. They were taken near the edge of the lake in water 3 to 8 feet deep. They comprise approximately the top 8 inches of sediment, less the surface layer. Of the variety of sediment types that may occur in lakes, the type of sample sought was of clay to silt grade and low in organic material.

Environmental Effects of Manganese, and Iron Oxides and Organic Matter Manganese and iron oxides and hydroxides are present in surficial sediments as amorphous coatings on mineral particles. Often in drainage sediments these coatings are closely associated with humic and fulvic acids, decay products of organic material. These organic acids and the iron and manganese oxides are often intimately mixed and form complex organo-metallic coatings on minerals, particularly those in the finer particle size ranges. However, they may also coat coarser particles.

Organic material, iron and manganese oxides and organo-metallic complexes of all three, have a strong affinity to sorb certain trace elements. The trace elements are either physically bound into sites during the aging of iron and manganese hydroxides and oxides, or are sorbed at specific sites in these materials. Likewise, for the organic acids or organo-metallic complexes, trace elements can be physically occluded or be actively sorbed on exchange sites, but can also be chelated by certain of the organic compounds, particularly those with ring structures such as porphyrins. The elements most affected by sorption in or on these compounds are those which are transported in solution. Of the elements that have been determined during this survey copper, uranium, zinc and molybdenum are examples of metals that are most likely to have been affected by these processes.

Because these organo-metallic coatings sorb trace elements preferentially from solution, the elements affected may accumulate at sites of high iron or manganese oxide or organic content. This effect could cause enhancement of heavy metals in a certain area and thereby produce a spurious anomaly. The data provided on this map allow the user to check anomalous sites for certain trace elements against the content of iron, manganese and "active" organic content.

The manganese value given is the acid soluble content of the sample. This content is more likely to represent the free manganese content than the total content. It is then a better measure of the manganese fraction which may cause enhancement of trace element anomalies. The iron content given is total. This is likely to be considerably higher than the free iron content for most samples. The organic matter given is a measure of the "active" organic content. This fraction is the easily oxidizable portion, which is a measure of the free radicles which in turn are mainly responsible for sorption of trace elements.

Despite the above, we believe that these three materials have not greatly altered regional trace element patterns. The contents of both iron and manganese are low. The iron contents correlate well with other elements, such as Mg, Cr, V, Ni, and Ti, found in ferromagnesian and heavy minerals. This implies that most of the iron is present in minerals in the lake sediments and not as free oxide coatings. It is probable that some sample sites within the survey area will contain anomalous amounts of one or more trace elements and also enhanced contents of manganese and/or iron. Such sites should be treated with caution. However, it would be unwise to dismiss all such values as spurious, since all of the anomalous metals, including iron and manganese, may be associated with primary mineralization. For these reasons, the trace element maps produced have not been "corrected" for the effects of iron and manganese. There may also be misleading correlations between trace elements and organic matter. For instance, the western part of the survey area, underlain by uranium-rich Great Bear Batholith, is also the most densely forested part of the survey area. There may then possibly be a certain amount of correlation between uranium and organic matter in lake sediments that is due to this. At sites that contain anomalous contents of one or more trace elements and also a large quantity of organic matter in the minus 250 mesh fraction, it cannot be assumed that the result is spurious. Although organic matter may enhance the trace element content at a site, there must still be a source for the metal. By the same reasoning all carbonaceous shales are not enriched in heavy metals.

When interpreting anomalous values that are also associated with high amounts of organic matter, iron or manganese, much more caution should be placed on single-site anomalies than on multiple-site anomalies. Ultimately, the most satisfactory way of checking suspicious values is to resample the area in question.

Sample Preparation and Analysis. The sediment samples were dried, then sieved to minus 250 mesh to give a powder suitable for analysis. A few coarse samples were sieved to minus 100 mesh, then ball-milled. Iron was determined by direct reading emission spectrometry. The technique summarised below for iron has been described by Timperley, Horton and Lynch 1973. Manganese was determined by atomic absorption spectrophotometry following a hot acid leach of the sediment, as described below. To provide a measurement of "active" content of lake sediment sample the optical density on the solution from the hot acid leach of the sediment was determined. This method of organic content determination, summarized below was developed by Lynch, Jonasson and Garrett (in press).

The method for iron is as follows: A 100 mg sediment sample was mixed with buffer composed of 1 part Na_2CO_3 and 7 parts graphite and containing Pd and In as internal standards. The sample mixture was packed in 3/16" preformed anodes. These were burned in a D. C. arc enclosed in a chamber, through which there was a flow of oxygen-argon. The arc burnt at 5 amps for 10 sec. and 15 amps for 50 sec. An 8K minicomputer terminated measurement of the Fe 4405 line after volatilization of this metal was complete, but prior to development of excessive background. The minicomputer converted the accumulated light energy of the Fe line to ppm Fe in real time using calibration curves derived from standards. Background corrections were made and Pd 3421 served as an internal standard. A control standard was run after every tenth sample. For 254 replicate analyses of a lake sediment sample containing 3.1% Fe a standard deviation of 0.2% was obtained. This is equivalent to a coefficient of variation of 9%.

The method for manganese is as follows: For the Mn determination, 400 mg of the sample was digested on a water bath at 90°C for 1.5 hours with 6 ml of 4N HNO_3 plus two drops of concentrated HCl. The sample was diluted to 20 ml with metal-free water, well shaken, and allowed to settle. This sample solution was aspirated through a 10 cm single slot burner of a Perkin-Elmer 303 atomic absorption spectrophotometer using an air-acetylene flame. Measurements were made at 4030Å with a slit width equivalent to 20Å. The detection limit of the method is 10 ppm Mn but all samples analyzed contain greater than this amount.

The "active" organic content of a sediment refers to the oxidizable content of organic matter and thereby the fraction of the organic content most likely to be involved with sorption processes with trace metals. A portion of the acid leach solution described above was allowed to stand in a test tube for two days. The optical density of the solution was then determined at 500 mμ on a Bausch and Lomb Spectronic 20. An optical density value of 1.0 is equal to an organic content of approximately 35% and a value of 0.01 to an organic content of approximately 2%.

Manganese and Iron in Rocks and Ores of the Survey Area During the 1971 orientation survey (Allan, Cameron and Durham, 1972) rock samples were collected from a number of areas within the Bear and Slave Provinces. A selection of data for these rocks and sediments from the same area is given below as an aid to the interpretation of the iron and manganese data given on this sheet. The lake sediments, sieved to minus 250 mesh, and rock samples were fused with lithium tetraborate, containing cobalt oxide and strontium tetraborate as stabilizers and internal standards. The resulting powder was sparked on a tape machine and total iron and manganese determined by the ARL 29000 direct reading spectrometer. The iron values on this sheet for sediments collected in 1972 are also total contents. However, the 1972 manganese values, as noted above, were determined after a hot nitric acid leach. This does not give total manganese content and the manganese values are probably less than the total manganese content.

As expected, iron increases in content from acid to basic volcanic rocks at both Indin Lake and High Lake. For the sedimentary and granitic rocks at Indin Lake, the iron content is intermediate. The iron content of the volcanics and sediments at Hackett River indicates their acidic character. The rocks at Terra Mine are apparently rather basic in composition. The lake sediment average iron content for the different areas is usually less than that of most of the rock units. The lake sediment samples came from the top few inches of the bottom sediment; iron may, in fact, be removed from these surface layers by diagenesis. There may be additional factors involved.

	Number of Samples	Arithmetic Mean Fe_2O_3%	Fe%	MnO ppm	Mn ppm
SLAVE PROVINCE					
High Lake:					
basic volcanics	22	9.41	6.49	1180	909
intermediate volcanics	54	7.08	4.89	960	739
acid volcanics	16	3.29	2.27	310	239
lake sediments	31	4.06	2.80	630	485
Hackett River:					
volcanics and sedimentary	37	4.66	3.22	2110	1625
lake sediments	28	2.67	1.84	420	323
Indin Lake:					
basic volcanics	55	13.92	9.60	2540	1956
intermediate volcanics	21	6.62	4.57	840	647
acid volcanics	31	1.48	1.02	250	193
sedimentary rocks	81	6.81	4.70	760	585
granites	5	7.29	5.38	1120	862
lake sediments	35	4.03	2.78	680	523
BEAR PROVINCE					
Bode Lake:					
porphyries	57	6.13	4.23	970	747
lake sediments	12	2.78	1.92	590	454
Terra Mine:					
volcanic, sedimentary and intrusive rocks	65	9.56	6.60	2150	1656
lake sediments	39	4.60	3.17	880	678
Archean rock average*	-	4.80	3.31	800	616
Proterozoic rock average*	-	5.00	3.45	900	700

* From Eade and Fahrig (1971)

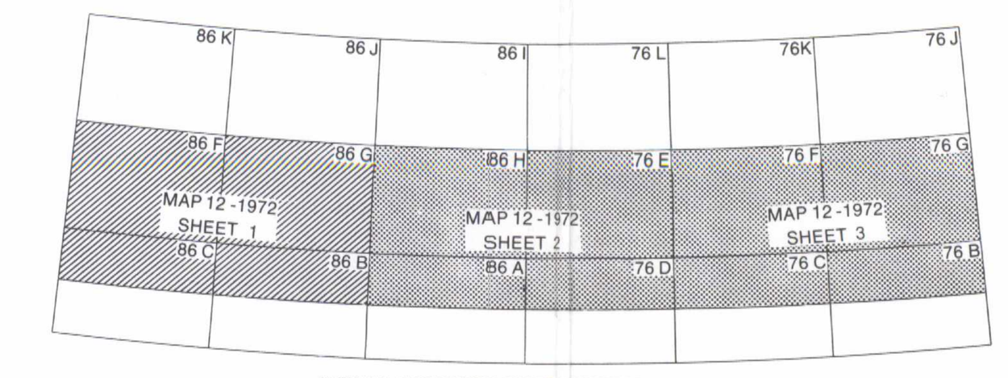
As for iron, manganese increases in acid to basic rocks at both Indin and High Lakes and as Fe_2O_3, the mean lake sediment MnO values for these two areas are very similar. Eade and Fahrig (1971), have shown that manganese is slightly enriched in Proterozoic rocks relative to Archean Rocks. This effect may be part of the reason for the higher Mn content of the rocks and lake sediments at Terra Mine, although the higher Mn may also be in part related to the silver and uranium ores of the area. At Hackett River, the high Mn content of the volcanic and sedimentary rocks that are of generally acidic composition is almost certainly related to the mineralization present in this area (Allan, Cameron and Durham, 1972). Manganese is apparently enriched in rocks associated with massive sulphide ore in this greenstone area and is perhaps of exhalative origin. Manganese anomalies in lake sediments in this area may then be related to mineralization. In acidic volcanic areas, such as Hackett River, the anomalies for manganese in lake sediments will be superimposed on a background that is less than that of lakes in areas of basic volcanic rocks. This association of elevated Mn levels with mineralization may occur elsewhere, so that consideration should be given to the geological history of an area before discarding coincident trace metal and manganese anomalies on the basis that the metals are spuriously high due to sorption by manganese oxides.

Manganese, Iron and Organic Content in Lake Sediments, This Sheet Manganese concentrations are highest (200-500 ppm Mn) in the Great Bear Batholith. The higher manganese values extend in the north across the Wopmay Fault into the area of migmatized eugeosynclinal rocks. Generally, east of the fault and in the area of the Slave Province on this sheet, levels of manganese are less than 150 ppm. The regional manganese distribution follows that for zinc. However, it is of interest that in the northeast part of Sheet 1, in the area of miogeosynclinal sediments, manganese is also higher. This is possibly related to the occurrence of manganese-rich carbonate rocks. Zinc is not high in this area. This tends to confirm that there is a source for both zinc and manganese in the Bear Batholith and that the generally higher level of zinc there is not an environmental effect.

Concentrations of iron are highest in Sheet 1 in the area underlain by the Great Bear Batholith. Concentrations in the northern part of the Batholith are often greater than 2.5% Fe. In that part of the Slave Province surveyed, iron concentrations are usually less than 2%. On Sheet 1 there is a relatively strong correlation between iron and manganese and the elements vanadium, titanium, nickel, chromium and cobalt. These elements are usually associated with either ferromagnesian or heavy minerals. This signifies that much of the iron and manganese is probably present in the lake sediments as a constituent of mineral particles and not as free oxides. As such, they should not influence the pattern of elements susceptible to sorption.

The area where the regional content of organic matter in lake sediments is highest is, as would be expected, below the treeline. Although the actual treeline runs north to south on the west margin of Sheet 2, the "effective" treeline is on Sheet 1. By effective, we mean that line above which boreal forest gives way to open tundra with isolated patches of trees. This line runs north to south on Sheet 1 along longitude 116°W. Organic content in lake sediments is generally higher to the west of this line and lower to the east.

* Geological Survey Paper 72-50, contains a detailed description of the experimental basis for lake sediment sampling in the Shield; the geology and metallogeny of the region; the organization, methods, and costs of the sampling operation; the methods of sample analysis and the references for the articles quoted above.



MAP 12-1972
SHEET 1
MANGANESE, IRON AND ORGANIC MATTER
BEAR-SLAVE OPERATION
DISTRICT OF MACKENZIE