

**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 till 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. The 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.

**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. Nickel was analyzed by direct-reading emission spectrometry. The technique summarized below has been described by Timperley, Horton and Lynch, (1973).

A 100 mg sediment sample was mixed with buffer composed of 1 part Na<sub>2</sub>CO<sub>3</sub> and 7 parts graphite and containing Pd and In as internal standards. The sample mixture was packed in 3/16" perforated anodes. These were burned in a D.C. arc enclosed in a chamber, through which there was a flow of oxygen-argon. The anodes are burned at 5 amperes for 10 sec, and 15 amperes for 50 sec. An 884 monochromator terminated measurement of the Ni 3415 line after volatilization of this metal was complete, but prior to development of excessive background. The monochromator converted the accumulated light energy of the Ni line to ppm Ni 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 46.5 ppm Ni a standard deviation of 4.4 ppm was obtained. This is equivalent to a coefficient of variation of 13%.

**Nickel in Rocks and Ores of the Survey Area** During the 1971 orientation survey (Allan, Cameron and Durham, 1973) lake sediment samples were collected from a number of areas within the Bear and Slave Provinces. A selective collection of the data for these lake sediments is given below as an aid to the interpretation of the levels on this map-sheet. Nickel was determined in the less than 250 mesh fraction after an HNO<sub>3</sub>-HCl attack. Nickel values given on this sheet are total contents and are likely to be higher than the values from the orientation survey.

Geological Province	Area	Number of Samples	Arithmetic Mean	Median	Geology*
Slave	Indin Lake	35	35	32	Sediments; volcanics, mainly basic; minor acidic volcanics.
	High Lake	31	32	29	Volcanics; sediments.
	Harding Lake	8	28	29	Granites; minor sediments.
	Musko Lake	11	46	50	Basic volcanics; sediments.
Hackett River		28	24	16	Acidic volcanics; siliceous sediments.
Bear	Babe Lake	15	23	18	Granodiorites.
	Terra Mine	28	34	34	Volcanics, mainly basic; sediments.
	Musko Intrusion	12	185	132	Ultramafics, minor gneisses.

\* Rocks listed in decreasing order of expected effect on lake sediments.

The lake sediments with the highest nickel content come from the area of the ultramafic, layered, Musko Intrusion. It is unlikely that such levels will occur in the Bear-Slave Operation area because there are no large bodies of ultramafic rock. The dimensions and the nickel content of this intrusion are such that high nickel contents were detected in lake sediments to the west of the direction of flow. However, copper levels were relatively low, because nickel sulphide mineralization of the Shield is often associated with copper sulphides, coincident anomalies for these two elements are more favorable exploration targets. In the Slave Province, there were fewer but sharp, nickel anomalies at Hackett River and High Lake. At High Lake, rock analyses for nickel showed the presence of nickel mineralization in both locations. It was suspected that the small, sharp nickel anomalies in lake sediments were to preferential leaching of nickel from sulphides in the metamorphosed rocks near the volcanic vents. At Hackett River, nickel was found to be relatively low in one sample (47 ppm Ni) in a sample containing 27% Zn and also low in the sediment from the lake adjacent to the deposit. This sediment sample contained 143 ppm Zn, 146 ppm Pb, 684 ppm Cu and 32 ppm Ni. Lake sediments overlying acidic volcanic areas are in nickel, show overlying lake sediments are generally high. For example, the sediments from lakes in the siliceous volcano-sedimentary area at Hackett River are low in nickel, whereas those from the basic volcanic and sedimentary area at Musko Lake (note not Musko Intrusion) are high. Although data on the level of nickel in the rocks from the orientation survey areas is not available, it is apparent from the above that nickel in lake sediments reflects major geological variations. Also, considering the relative levels of other elements in the lake sediments and rocks of these areas, it is likely that the nickel contents given in the table above for lake sediments are comparable with the mean nickel content of the rocks in each area.

In the Bear Province, nickel along with copper mineralization is found in showings in the high metamorphic belt in the northeast corner of Sheet 1. This is associated with a gabbroic unit and with a northward-trending fault. Nickel anomalies are also one of the constituents of the pegmatitic uranium and silver veins of the Bear Province. In the Slave Province, nickel mineralization is found in showings in the basic volcanics of the Yellowknife Supergroup. As noted above, it appears that nickel sulphides are present as the metamorphosed rocks around the massive sulphide deposits of this province. Nickel is one of the elements in the hierarchy of indicators for such deposits, as outlined in marginal notes for zinc, lead and copper.

**Nickel in the Surface Environment** Nickel is found in nature in the divalent form. When in solution it is moderately mobile and is probably transported in the form as  $(NiH_2O)_6^{2+}$ . It may travel considerable distances in this form, but is precipitated in neutral to alkaline environments as the hydroxide or is co-precipitated with iron hydroxides.

However, most nickel is probably transported mechanically, either in primary silicates or in silicates formed during weathering. The primary ferromagnesian minerals of igneous rocks that contain nickel may be converted during weathering to complex nickel-bearing layer silicates. Factor analyses of the data for 34 major and trace elements from Sheet 1 showed that a high proportion of the total variance for nickel, cobalt, chromium, vanadium, iron and manganese is contained in the most significant common factor. This factor contains approximately one-half of the total variance of the data set. Preliminary X-ray diffraction and microprobe examination of samples with heavy loadings, showed that this factor is correlated with ferromagnesian minerals in the samples. Further work may, however, show that it is more complex than being a simple "ferromagnesian mineral" factor. Nevertheless, as a working hypothesis it may be expected that most, but not all, of the variation of nickel across the map-sheet is due to changes in the ferromagnesian mineral content of the sediments. This, in turn, is related to the content of such minerals in the rocks and tills of each lake-drainage basin.

Predominantly mechanical transport of nickel has been demonstrated in two nickel-rich areas underlain by peridotite. Nickel was found to be concentrated in the coarse plus 250 mesh fractions of lake sediments that overlie an ultramafic intrusion containing only minor nickel sulphides (Allan and Cameron, 1973). Nickel was not detected in lake waters in this area. The reverse was true for sediments from an area of nickel sulphide-bearing ultramafic sills. Here nickel was readily detected in lake waters and was concentrated in the fine (minus 250 mesh) fraction of the sediments. In the latter case, the high nickel levels were accompanied by high values for copper.

Considering the above, it may be possible to detect, in lake sediments, nearby weathering nickel sulphides by considering the anomalous nickel areas in relation to (1) the levels of the other elements present in ferromagnesian minerals; and (2) the levels of other elements, e.g., Cu that could accompany the nickel in sulphides.

Nickel that is transported mechanically will be subject in the lake environment to variations due to particle sorting. For such reasons an attempt was made to collect samples from similar bottom environments and of similar size grade as outlined above under Lake Sediment Sampling. Analyzing a constant size fraction of the sediment also helps to reduce variations of this type.

**Nickel in Lake Sediments, This Sheet** Samples from Sheet 3 show a higher mean nickel content and a greater variance than samples from either Sheet 1 or Sheet 2:

	Sheet 1	Sheet 2	Sheet 3
Number of samples	1541	1554	1549
Arithmetic mean, ppm Ni	24	21	28
Geometric mean, ppm Ni	20	18	23
Standard deviation, ppm Ni	16	13	22

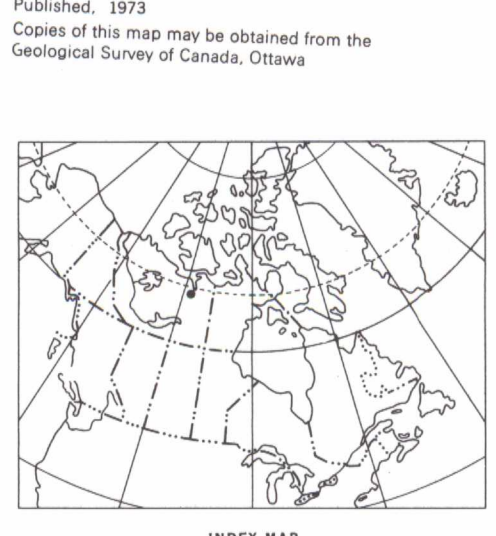
As was the case for copper, the greater abundance of nickel on Sheet 3 can be related to the presence of nickel anomalies in the granitoid belts of this sheet. The most extensive anomalies are found along the western margin of the granitoid belt in which the Hackett River massive sulphide deposit lies. Here the anomalies coincide with anomalies for copper, zinc and potassium and are most probably indicative of sulphide mineralization associated with acidic volcanic rocks. Along this margin there are substantial areas enclosed by the 50 ppm Ni contour with values to 200 ppm Ni. The Hackett River deposit itself is not defined on this map by a prominent nickel anomaly. Eastwards from the margin of the granitoid belt, nickel values decline.

Elsewhere on this map-sheet there are nickel anomalies along the margin of granitoid belts, most of which coincide with anomalies for copper and zinc. Prominent anomalies are found along the southern and western margins of the large volcanic belt south of Regan Lake. This group of anomalies contain nickel values to 215 ppm. The Regan Lake volcanic belt itself has rather low nickel contents.

The granitic areas in the northwestern and western parts of this sheet have low nickel contents in their lake sediments, generally less than 20 ppm. Some slightly anomalous areas of 40 ppm or more may be related to more basic rock compositions in the underlying "granitic" rocks. There is a strong nickel anomaly in the granitic area within the southeast corner of this sheet. This area has been discussed in the marginal notes for a number of other elements, since it is anomalous for a variety of different elements.

\* Geological Survey Paper 73-56, 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.

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MAP 14-1972  
SHEET 3  
**NICKEL CONTENT OF LAKE SEDIMENTS  
BEAR-SLAVE OPERATION  
DISTRICT OF MACKENZIE**  
Scale 1:250,000  
Miles 4 0 4 8 12  
Kilometres 6 0 6 12 18

