

Seventh
SIXTH ANNUAL MEETING
INSTITUTE ON LAKE SUPERIOR GEOLOGY

APRIL 27th - 29th, 1961

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LAKEHEAD BRANCH - CANADIAN INSTITUTE OF MINING & METALLURGY

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PORT ARTHUR & FORT WILLIAM, ONTARIO

SIXTH ANNUAL MEETING OF THE
INSTITUTE OF LAKE SUPERIOR GEOLOGY
April 27, 28 and 29, 1961

PROGRAM

Provincial Room, Prince Arthur Hotel

Thursday, April 27

SESSION I

Chairman - E. G. Pye

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8.30 A.M.	Registration and Social Hour	
9.30	Address of Welcome - W.L.C. Greer	
	Business Session - Henry Lepp	
10.30	Glimpses of the XXI International Geological Congress - A. K. Snelgrove	15
11.00	Geochemical Anomalies in Forest Floor Material - A Progress Report - D.H. Yardley	18
11.20	The Petrology of the Geco Mine - R.C.E. Bray	5
11.40	An Investigation of Some Gold-Quartz Veins - R. V. Oja	12

Institute Luncheon 12.30 P.M.

SESSION II

Co-Chairmen - Henry Lepp, A. K. Snelgrove

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2.30	Recent Contributions to the Late and Recent Geological History of Lake Superior - John H. Zumberge	
3.00	Velocity and Isotropy Studies of Precambrian Lamellar Formations (to be presented by G. Secor) - D. W. Merritt	10
3.30	Coffee and biscuits (no charge)	
4.00	Granitic Rocks of the Pembine Area, Northeast Wisconsin - J. Allen Cain	6
4.30	Tectonic Analysis of Some Precambrian Rocks, Horn Area, Bighorn Mountains, Wyoming - John C. Palmquist	13
5.00	Lithology of the Seine Series in the Vicinity of Crilly, Ontario - W. L. Young	19

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9.30	Geology of the Nakina Iron Property, Ontario - W. T. Swensen	17
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Co-Chairmen - Trevor Page, R. V. Oja

- 2.00 P.M.	Remanent Magnetism and the Origin of Hard Hematites in Precambrian Banded Iron Formation - W. A. Gross and D. W. Strangway	7
- 2.30	The Use of the Dip Needle with Special Reference to Magnetic Taconite Exploration - William J. Hinze	8
- 2.00	Manganese in the Menominee Iron Range, Michigan (to be presented by Paul Zimmer) - Paul Zimmer and G. Kustra	20
3.30	Coffee and biscuits (no charge)	
- 4.00	Replacement Texture in Negaunee Iron Formation - E. L. Beutner	4
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GEOLOGY OF THE EAST LAKE ST. JOSEPH IRON PROPERTY

A. T. Avison and J. F. White

Magnetite iron formation occurs in a belt of metamorphosed Keewatin-type sediments at the east end of Lake St. Joseph in North-central Ontario. Two major horizons and numerous smaller lenses of iron formation are interbedded with a series of quartz-biotite schists and talc, chlorite and garnetiferous schists near the north contact of an igneous mass of granite and gabbro. The two major horizons vary between 320 and 1180 feet wide at surface and are believed to be made up of closely interfingered lenses rather than widespread regular beds.

THE INTERPOLATION PARABOLA APPLIED TO SECOND DERIVATIVE INTERPRETATION

Lloyal O. Bacon

Numerical second derivative formulation is derived for one dimensional (profile) and two dimensional (surface) data. Comparison with other methods of second derivative calculation is presented for several mineral exploration areas.

THE BRUCE LAKE IRON FORMATION, RED LAKE MINING DIVISION, ONTARIO

M. W. Bartley

The history of exploration for treatable iron formation at Bruce Lake, Red Lake Mining Division, Ontario is described along with a brief review of the general stratigraphy and structure. The Keewatin-type iron formation has been delineated by geological and geophysical mapping, and diamond drilling has outlined two substantial iron ore deposits from which a desirable pelletized product can be derived.

REPLACEMENT TEXTURE IN NEGAUNEE IRON FORMATION

E. L. Beutner

Studies and observations which were made during the past fifteen years in the course of field mapping, exploration drilling and mining in a portion of the Marquette Range south of Negaunee, Michigan, point up some interesting relations between characteristics of the iron formation, geological structure and the localization of soft iron ore deposits.

Evidence here seems to indicate that much of the iron formation had undergone oxidation before ore forming processes were active and possibly before completion of diastrophism. Secondary oxidation, leaching, replacement and sometimes actual removal of both iron and silica occurred in some zones which had been strongly fractured through folding or faulting and along the contacts between the iron formation and intrusive rocks. Where waters circulated through such disturbed areas they left their mark in a distinctive spotty or "leopard" texture which is superimposed on the normal straight bedded iron formation.

The avenues of circulation may be traced from the present surface through steeply dipping fault zones to the lower thin bedded part of the iron formation where the soft ore bodies are localized. The fact that the hanging wall iron formation of many of the ore deposits exhibits the porous "leopard" texture suggests that the same solutions which were responsible for leaching and replacement in the iron formation may also have brought about nearly complete removal of silica and enrichment of iron in selected structural situations to form the high grade ores.

THE PETROLOGY OF THE GECO MINE

R.C.E. Bray, M.K. Abel, V.T. Onodera

More detailed petrographic studies of the rocks associated with the Geco copper-zinc ore deposit at Manitouwadge, Ontario, than was previously possible have established the sedimentary origin of the grey gneiss. The variations in the quartz-muscovite schist and in the hornfels are described. The intrusive quartz diorites and pegmatites are also described. The metamorphic minerals connected with the ore zone are discussed.

PRECAMBRIAN GRANITIC COMPLEX OF NORTHEASTERN WISCONSIN

J. Allan Cain

From an area of some 350 square miles mapped within the Wisconsin Precambrian complex, a rock-unit was selected for more detailed structural and modal analysis. This unit -- the Newingham Granite -- lies immediately adjacent to the town of Pembine, is some 40 square miles in area, and has intrusive contacts with greenstone, biotite gneiss and hornblende gneiss.

Modal data from 70 specimens for quartz, color index, feldspar ratio (potash feldspar/plagioclase), and total feldspar, as well as specific gravity, were analyzed. Non-orthogonal polynomial analysis was used -- via I.B.M. 650 -- to compute linear and quadratic trend-surfaces and deviations for each variable.

A comparison of these results with those obtained by Whitten from his similar study of the "older granite" of Donegal (Ireland) indicates the potential petrogenetic significance of trend-surface analysis.

REMANENT MAGNETISM AND THE ORIGIN OF HARD HEMATITES
IN PRECAMBRIAN BANDED IRON FORMATION

W. H. Gross and D. W. Strangway

Because hematite is a mineral with a high degree of magnetic stability it was considered possible that a study of the remanent magnetism of hematite ore bodies in iron formation might add to a knowledge of their origin. To test this possibility, a number of oriented specimens were collected from two hard hematite ore bodies that occur in an iron formation near Fort Gouraud, Mauritania.

One of these ore bodies is an elongated lens of hard hematite which occurs in a steep plunging "S" shaped fold. The lens is roughly concordant with the trend of the bedding of the surrounding iron formation and it is known to extend to a depth of at least 750 feet below the present surface without any detectable change in physical or chemical properties. It was found that the principal directions of remanent magnetization must have been formed in the hematite when the beds were essentially flat. This is interpreted to mean that the bulk of the hematite in the ore is either syngenetic and was formed as an iron rich horizon during sedimentation or it was formed by leaching of the flat-lying iron formation. The steep inclination of the magnetization in the beds when they have been "unfolded" to the flat position suggests that the ore was formed in the Precambrian when the earth's magnetic pole was located in Northwestern Africa.

A second rather minor magnetic direction on one of the limbs is thought to indicate the formation of secondary hematite that was formed either by reworking of the primary hematite or by introduction of hematite into the ore zone at the time of folding. If the ore is essentially syngenetic, prospecting for additional ore bodies of this type at Fort Gouraud should be governed by a knowledge of the primary features in the original basin of deposition.

A second ore body is composed primarily of soft hematite that has a hard hematite capping. The soft ore is relatively shallow in depth and is discordant with the bedding in the underlying iron formation. The magnetic directions in the hard hematite capping were largely random but have some preference towards the present magnetic north. These results suggest that this type of hard hematite was formed by leaching in relatively modern times.

It is concluded that the hematite ores at Fort Gouraud have had a complex and multiple origin.

THE USE OF THE DIP NEEDLE
WITH SPECIAL REFERENCE TO MAGNETIC TACONITE EXPLORATION

William J. Minze

The dip needle, one of the oldest of geophysical exploration instruments, is still being used as an exploration tool particularly in the search for magnetic taconite ores. However, the highly distorted magnetic fields associated with these ores often produce misleading dip needle anomalies due to the interaction of intensity and inclination effects. Case histories and a laboratory investigation employing controlled magnetic fields illustrate the profound effect that both of these magnetic variables have on dip needle readings. Results of a laboratory investigation indicate that large negative normal settings may be used to subordinate the effect of inclination over high intensity ranges thus forcing the dip needle to give a clearer picture of the magnetic character and distribution of the rock formations. The period of oscillation of the swinging dip needle, which decreases as the vertical magnetic intensity increases and as the inclination decreases, can also be used as an aid to the successful geological interpretation of dip needle anomalies.

Studies indicate that temperature, orientation, and leveling variations normally encountered in field operation of the dip needle result in negligible errors and a study of dip needle reading methods indicates that the optimum reading method varies with the requirements and conditions of the survey, but that the reading method based on the arithmetic mean of the second, twice the third, and the fourth reversals of the oscillating dip needle is most universally acceptable.

THE DISTRIBUTION OF MANGANESE IN SEDIMENTARY IRON FORMATIONS
AND ASSOCIATED ROCKS

Henry Lepp

The average Mn:Fe ratio of Precambrian iron formations is 0.034 which is essentially the same as that of the average crystalline rock (0.028) from which these formations were derived. Post Precambrian iron formations, on the other hand, have an average Mn:Fe ratio of 0.007, indicating a pronounced geochemical separation of iron and manganese as compared to the crustal average. The difference in Mn:Fe ratios of the two age groups of iron sediments may be due to differences in depositional environments (oxidizing environment favors the separation of Mn and Fe, carbonate field does not) or to differences in the nature of their source rocks.

In Precambrian iron formations, the oxide horizons have considerably lower Mn:Fe ratios than the carbonate-silicate horizons. There appears to be a correlation between Mn:Fe ratio and CO₂ content.

The distribution of Mn:Fe ratios for analyses from the Guyana range is bimodal. The non-manganiferous sections of this iron formation show lower than normal Mn:Fe ratios whereas the reverse is true for the manganiferous horizons. The average value of the Mn:Fe ratio of an iron formation may provide an indication of whether or not sedimentary manganese deposits can be expected in the same sedimentary sequence.

VELOCITY ANISOTROPY STUDIES OF PRECAMBRIAN LAMELLAR FORMATIONS

Donald W. Merritt

A preliminary field investigation was made of seismic wave velocity anisotropy in lamellar formations. Results of the shallow seismic refraction surveys in seven different localities on Precambrian metasedimentary and metaigneous rocks comprising eight different lithologies including schist, granite gneiss, banded iron formation, slate and peridotite altered to serpentinite show that velocity anisotropy is measurable in the field and may be useful in delineating structural orientation in buried formations. Seismic wave velocities in steeply dipping formations characterized by bedding, jointing, cleavage or fractures were found to be faster in the direction parallel to the fractures than perpendicular to them. The ratios between the seismic wave velocities parallel to and perpendicular to these features approached values of two to one.

SOME PETROGRAPHIC AND CHEMICAL FEATURES OF
THE GUNFLINT IRON RANGE, PORT ARTHUR AREA

W. W. Moorehouse

The results of about 100 spectrochemical analyses of iron formation and associated argillites from the Gunflint and Mesabi ranges are summarized and compared with similar analyses of ancient and recent marine and non-marine sediments of various types. The results of these analyses are consistent with a marine or brackish-water environment of deposition of these iron formations.

The significance of various characteristic textures of the several facies of the Gunflint is reviewed. The granules and other features of the taconites, as well as their field characteristics are indicative of active or turbulent conditions of deposition. The variations often encountered in the mineralogy of the taconites point to the mixing of the products of local regimes of varying Eh and pH. The influence of diagenesis and metamorphism in modifying the mineralogy and texture is discussed. It is concluded that they have not seriously disturbed the significant environmental criteria.

The petrographic features of the other main facies of the Gunflint are considered. It is concluded that these result from variations in depth, turbulence and organic content in the environment of sedimentation.

Textural and compositional features bearing on the role of volcanic contributions to the accumulation of the sediments of the Gunflint conclude the discussion.

AN INVESTIGATION OF SOME GOLD-QUARTZ VEINS

R. V. Oja

This investigation was conducted on 30 of 70 ore- and non-ore-bearing quartz veins in one section of one of the gold mines of the Porcupine Camp, Ontario. Although all 70 veins had been exposed and developed by underground headings, not all contained gold in quantities sufficient to make ore. Since both ore- and non-ore-bearing quartz veins were identical in appearance in diamond drill intersections and in the underground exposures, the perplexing decision, "Should the vein be developed further?" nearly always had to be faced.

This research, therefore, sought to establish a means of distinguishing between ore- and non-ore-bearing quartz veins by petrographic, decrepitation and spectrographic techniques. Although it was discovered that ore-bearing quartz contains more liquid inclusions and decrepitates 11% to 31% more than the non-ore-bearing quartz, so much overlap exists in the results of these observations so that no single specimen can be categorized with assurance. Similarly, no conclusive differences were revealed by spectrographic investigation.

After reconsidering the methods of quartz vein formation and gold introduction, it is concluded that, apart from the gold, there need be no major differences in the chemical or physical properties of the ore- and non-ore-bearing quartz veins considered in this investigation.

TECTONIC ANALYSIS OF SOME PRECAMBRIAN ROCKS,
HORN AREA, BIGHORN MOUNTAINS, WYOMING

John C. Palmquist

A Laramide block-like uplift of the Precambrian basement resulted in the formation of a faulted mountain mass, covering approximately 27 square miles, extending southward from the central Bighorn unit. The core of this uplift contains complexly folded, foliated high-grade metamorphic rocks.

Precambrian rock types include pegmatite, amphibolite, calc-silicate rock, feldspathic rock, biotite schist, marble, banded ironstones, quartzite, varieties of garnetiferous rock and amphibole rocks in addition to the predominant gneiss. Schistosity, mineralogical and lithological layering are conformable throughout the complex with cross-cutting pegmatites being the only exception. These rocks are believed to have originated from regional metamorphism and later alkali metasomatism of supracrustal rocks. Alkali metasomatism, apparently a post-tectonic event and perhaps a late stage of the regional metamorphism, culminated in pegmatitization. The staurolite-quartz subfacies of the almandine-amphibolite facies is indicated.

The internal structure of the metamorphic rocks is dominated by a complex anticline plunging to the north-northwest. Foliation, lineation, relation of minor folds and distribution of mapped units all point to the existence of this fold, but the precise geometry of the fold is elucidated only after a study involving methods of statistical analysis and tectonic profile construction. This study reveals a closed, slightly overturned cylindrical anticline with planar limbs. Measured lineation corresponds to the axial line as determined from statistical analysis of foliation data, and is, therefore, b-lineation.

Sedimentary-cover structures are believed to result from passive draping over active basement blocks. The blocks are bounded by the Horn and Tensleep faults. The attitude of the Horn fault parallels foliation whereas the Tensleep fault appears to be a rejuvenated Precambrian fault. These relations demonstrate that the structural grain of the basement may influence later deformation.

SUBLACUSTRINE TOPOGRAPHY OF EASTERN LAKE SUPERIOR

Jack Parker

Interpretation of recent echo-soundings taken by the U.S. Lake Survey indicates that the Lake Superior basin has been excavated by ice out of relatively soft rocks, and that moraines on the south shore hold the water at its present level. Long, narrow valleys, as much as 700 feet below sea level, extend as much as 50 miles in a north-south direction.

Differential erosion of hard and soft rocks, and of shear zones, permits mapping of the general limits of lavas, sandstones, and glacial drift, the direction of ice movement, and the major faults.

GLIMPSES OF THE XXI INTERNATIONAL GEOLOGICAL CONGRESS

A. K. Snelgrove

A travelogue of the Copenhagen Congress in August, 1960, by one of Michigan Tech's official professional delegates.

In addition to attending the meetings, the speaker visited the Western Norwegian Fjord country, and participated in geological excursions in the Oslo area and in the mining centers of Southern Norway.

TYPES OF IRON FORMATION IN WESTERN ONTARIO AND THEIR
ORIGINAL ENVIRONMENT

G. G. Suffel

A detailed study of published literature mentioning or describing sedimentary iron formation in Western Ontario has confirmed that there are four types sufficiently different in character and lithologic and structural environment that they can be readily distinguished. The Patricia and Port Arthur Mining Divisions provide a north-south section across the Superior province in Canada. It is suggested that the iron formations were deposited in environments compatible with those supposed to occur during a sequence of geosynclinal sedimentation with the development of island arcs.

It seems conceivable that the Marshall Lake series and related rocks of Couthiching type represent ancient shelf deposits, the oldest rocks in the Province. The Keewatin type is almost certainly lagoonal marine, the iron probably originating from volcanic emanations. The Windigoan or Timiskaming type is closely associated with products of mechanical erosion of eugeosynclinal rocks. The origin of the iron may have varied with time and place. The Animikie formations are miogeosynclinal, belonging to a new and uncompleted cycle.

Although this area is supposed to represent one of the original continental nuclei, considerable evidence suggests that still older land masses existed, as yet unrecognized.

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GEOLOGY OF THE NAKINA IRON PROPERTY, ONTARIO

W. T. Swensen

The Anaconda Company, through its wholly owned subsidiary The Anaconda Company (Canada) Ltd., has investigated, optioned and partially developed a large tonnage of iron ore amenable to magnetic concentration. The reserves are located in north central Ontario and occur within a twenty-two mile belt of layered and intricately folded metamorphic rocks, close to the north contact of an igneous complex of granite and pegmatite. There are two main ore deposits. Briarcliffe is a steep to vertically dipping body 100 to 500 feet wide and over a mile long. The Two Mile deposit is flat dipping and confined to an open, asymmetrical syncline; it is approximately a mile wide and 250 to 400 feet thick. On its flat easterly plunge, it is saucer-like in shape and is amenable to open-pitting for an east-west distance of several thousand feet. Its further extension has been indicated for at least three miles by magnetometer work in conjunction with diamond drill tests.

GEOCHEMICAL ANOMALIES IN FOREST FLOOR MATERIALS
A PROGRESS REPORT

D. H. Yardley

Geochemical investigations of forest duff (humus layer) near Ely, Minnesota demonstrate that Cu-Ni mineralization in underlying gabbro is reflected by the Cu-Ni content of the forest duff.

The anomalous pattern is more erratic than the pattern in the underlying till but does identify a target zone. Sampling of forest duff is faster than soil sampling but further simplification of both analytical and sampling methods appears necessary before recommending the method for general application.

LITHOLOGY OF THE SEINE SERIES NEAR CRILLY, ONTARIO

W. L. Young

The lithology of the Seine Series is discussed and the three principal facies are suggested.

Petrologic and geochemical analyses of the matrix of the Seine "Conglomerate" compare favourably with the nearby Keewatin lavas, suggesting a volcanic matrix for the Seine "Conglomerate".

Lack of sedimentary features within the matrix suggests a non-sedimentary origin. It is postulated that the matrix was a volcanic flow or glowing-avalanche-tuff which picked up and incorporated boulders while it was being laid down, and must, therefore, be thought of as a volcanic rather than a sediment.

If the Seine is to be used as a marker-formation, then it is important to recognize that the lithology may change from a "boulder conglomerate" to a "sericite-chlorite schist" in a short distance.

Near Crilly the Series dips under the Keewatin volcanics. At Mine Center the Series is intruded by the Bad Vermilion granite. It was concluded that the Seine Series is of Keewatin age.

MANGANESE MINERALIZATION IN THE CANNON IRON MINES,
IRON RIVER-CRYSTAL FALLS DISTRICT, MICHIGAN

P. W. Zimmer and C. R. Kustra

Manganese occurs in only one mine in this area in quantities large enough and with grade high enough to make a manganiferous iron ore product. This paper describes the mineralogy of this manganiferous ore body. The primary manganese mineral is hausmannite accompanied by such minerals as manganite, pyrolusite, rhodochrosite, braunite, and rhodonite, as well as small amounts of hydrohausmannite and manganese-rich sussexite.

Other minerals occurring with the manganese mineralization besides the hematite, limonite, and goethite are calcite, siderite, gypsum, quartz, pyrite, chalcopyrite, native copper, chrome, montmorillonite, and other clay minerals such as kaolinite and alunite.

Although many of the above minerals strongly suggest hydrothermal waters, no final conclusions are drawn at this time as it is felt much more work must be done before such conclusions can be made.

PROPOSED CORING IN LAKE SUPERIOR

James H. Zumberge

Shallow bottom cores and fathometer records obtained from Lake Superior in 1953 provide the basis for selecting sites for a coring program in 1961. Cores will be obtained from several locations in the western, central and eastern parts of the basin through the use of a rotary drilling rig mounted on a ship equipped to drill in water 1300 feet deep.

Fathometer records from a previous cruise reveal areas where more than 60 feet of lacustrine sediment occurs above denser material. Glacial till gives the same fathometer signal as Precambrian bedrock.

A core retrieved from a depth of 612 feet, 13 miles east of Grand Marais off the Minnesota shore, contained 105 laminated couplets of alternating light and dark silty clay layers with an average combined thickness of 8.5 mm. The lighter layer contains more carbonate than the darker layer, but is almost devoid of pollen. Highest pollen concentration occurs in the darker layers. Other material found includes frosted sand grains, magnetic spherules, and diatoms.

Laboratory analysis of the cores in which all of these elements are investigated should provide the basis for the geological history of the lake since its origin.