

8th ANNUAL MEETING

Institute on Lake Superior Geology

MAY 10, 11, 12, 1962



Sponsored by

Department of Geology & Geological Engineering

in Cooperation with

The Institute of Extension Service

Michigan College of Mining & Technology

BOARD OF DIRECTORS

Dr. E. N. Cameron, Madison, Wisconsin
Dr. W. L. C. Greer, Port Arthur, Ontario
Dr. Henry, Lepp, Duluth, Minnesota
Dr. G. M. Schwartz, Minneapolis, Minnesota
Dr. A. K. Snelgrove, Houghton, Michigan

STEERING COMMITTEE

Dr. M. W. Bartley, Port Arthur, Ontario
Dr. W. L. Daoust, State Geologist, Lansing, Michigan
Dr. C. E. Dutton, U.S. Geological Survey, Madison, Wisconsin
Dr. J. P. Dobell, Michigan Tech., Houghton, Michigan
Mr. Robert Edwards, Inland Steel Company, Iron River, Michigan
Dr. D. H. Hase, University of Iowa, Iowa City, Iowa
Dr. R. L. Heller, Duluth Branch, University of Minnesota,
Duluth, Minnesota
Dr. H. L. James, University of Minnesota, Minneapolis, Minnesota
Dr. E. G. Pye, Ontario Department of Mines, Port Arthur, Ontario
Dr. P. Tyghsen, Wisconsin State College, Superior, Wisconsin
Dr. J. Zinn, Michigan State University, East Lansing, Michigan
Dr. J. H. Zumberge, University of Michigan, Ann Arbor, Michigan

EIGHTH ANNUAL MEETING
OF
THE INSTITUTE ON LAKE SUPERIOR GEOLOGY

May 10, 11, and 12, 1962

Co-Chairmen: A. K. Snelgrove and J. P. Dobell

PROGRAM

Civil-Geology Auditorium

THURSDAY, MAY 10

8:30	Registration	Memorial Union Building
9:30	Address of Welcome	President J. R. Van Pelt
	Business Session	Henry Lepp

Chairman - J. P. Dobell

10:30	Current Geological Research in the Palmer Area of the Marquette District, Michigan	Justin Zinn
11:00	Geological Survey, Pikes Peak Area, Baraga County, Michigan	Kiril Spiroff
11:30	Petrology of a Precambrian Pluton near Pembine, Wisconsin	J. Allan Cain

12 - 1:30 Lunch

Chairman - L. O. Bacon

1:30	Geophysical Evidence for the Presence of Keweenaw Volcanics in the Area of Upper Michigan between Marquette and Sault Ste. Marie	R. W. Patenaude
2:00	Application of the High Speed Digital Computer to Gravity and Magnetic Analyses	R. L. Coons* and Peter Wolfe

THURSDAY, MAY 10

- | | | |
|----------|--|---|
| 2:30 | Magnetic Investigations in Iowa -
A Preliminary Report | D. H. Hase |
| 3 - 3:15 | Coffee Break | |
| 3:15 | Extension of the Normal
Distribution to Filtering of Two-
Dimensional (Surface) Gravity
and Magnetic Data | W. W. Johnson*
and
S. A. Finnegan |
| 3:45 | The Optimum Dip Needle Reading
Method | W. J. Hinze |
| 4:15 | Geophysical Investigation of a
Diabase Dike near L'Anse,
Michigan | R. J. Reuss |

FRIDAY, MAY 11

Chairman - M. W. Bartley

- | | | |
|-----------|---|-------------------------------------|
| 9:30 | A Regional Vertical Intensity Map
of the Southern Peninsula of
Michigan | W. J. Hinze |
| 10:00 | Diagenetic Replacement in Ore of
the Empire Mine of Northern
Michigan, and Its Effect on
Metallurgical Concentration | Tsu-Ming Han |
| 10:30 | Footwall Mineralization of the
Osceola Amygdaloid in the
Michigan Copper District | R. Weege*
and
A. Schillinger |
| 11:00 | Induced Polarization Logging in
the Search for Native Copper in
the Osceola Footwall Zones | L. O. Bacon |
| 11:30 | Preliminary Investigation of Late
Wisconsin Drift North of Lake
Superior | T. W. Page*
and
D. R. Lindsay |
| 12 - 1:30 | Lunch | |

FRIDAY, MAY 11

Chairman - J. M. Neilson

1:30	Precipitation Chromatography in Geochemical Exploration	J. D. Spain
2:00	The Water Problems of the Mining Industry of the Upper Peninsula, Michigan	J. H. Butler
2:30	Iron Ores of Bihar and Orissa, India	A. K. Snelgrove
3:00	Mineral Exploration in the East Clare District of Ireland	R. W. Schultz
3:30	Magnetite Analysis of Magnetic Susceptibility	P. D. Shandley
4:00	An Investigation of the Remanent Magnetization of the Covington Dike	C. G. Bufo

* Indicates speaker.

AUTHORS

		<u>Page No.</u>
L. O. Bacon	Department of Physics, Michigan Tech., Houghton, Michigan	1
C. G. Bufe	University of Michigan, Ann Arbor, Michigan	2
J. H. Butler	Geography Department, Michigan Tech., Houghton, Michigan	4
J. A. Cain	Department of Geology, Western Reserve University, Cleveland, Ohio	5
R. L. Coons	Madison, Wisconsin	6
S. A. Finnegan	Michigan Tech., Houghton, Michigan	11
Tsu-Ming Han	The Cleveland-Cliffs Iron Company, Ishpeming, Michigan	7
D. H. Hase	Department of Geology, University of Iowa, Iowa City, Iowa	8
W. J. Hinze	Department of Geology, Michigan State University, East Lansing, Michigan	9 - 10
W. W. Johnson	Michigan Tech., Houghton, Michigan	11
D. R. Lindsay	Lakehead College of Arts, Science and Technology, Port Arthur, Ontario	12
T. W. Page	Lakehead College of Arts, Science and Technology, Port Arthur, Ontario	12
R. W. Patenaude	University of Wisconsin, Madison, Wisconsin	14
R. J. Reuss	Michigan Tech., Houghton, Michigan	15
A. Schillinger	Geology Department, Calumet & Hecla Incorporated, Calumet, Michigan	22
R. W. Schultz	Michigan Tech., Houghton, Michigan	16
P. D. Shandley	Department of Physics, Michigan Tech., Houghton, Michigan	18
A. K. Snelgrove	Department of Geology and Geological Engineering, Michigan Tech., Houghton, Michigan	19
J. D. Spain	Department of Chemistry and Chemical Engineering, Michigan Tech., Houghton, Michigan	20
K. Spiroff	Department of Geology and Geological Engineering, Michigan Tech., Houghton, Michigan	21
R. Weege	Geology Department, Calumet & Hecla Incorporated, Calumet, Michigan	22
Peter Wolfe	Madison, Wisconsin	6
Justin Zinn	Department of Geology, Michigan State University East Lansing, Michigan	23

INDUCED POLARIZATION LOGGING IN THE SEARCH
FOR NATIVE COPPER IN THE OSCEOLA FOOTWALL ZONES

L. O. Bacon

A program in cooperation with Calumet and Hecla, Inc., has been carried out to adopt the induced polarization method to underground logging of exploratory holes. The paper discusses equipment, logging techniques, interpretational methods and results.

AN INVESTIGATION OF THE REMANENT MAGNETIZATION
OF THE COVINGTON DIKE

C. G. Bufe

The investigation of the remanent magnetization of the Covington dike near Watton, Michigan, was begun in September of 1960, and in the course of the investigation oriented cores were taken from the dike and country rock on both sides, thin sections and magnetic samples were prepared from the cores, a spinner magnetometer was built and used to determine the direction of remanent magnetization of the cores, several of the cores were partly demagnetized to check their magnetic stability, and the vertical magnetic anomaly recorded over the dike analyzed.

The results of the investigation indicate the following:

1. The directions of magnetization of the samples are fairly consistent, with mean declination of 134° , inclination of -86 degrees, with a four degree radius of confidence at the 95 percent level. This corresponds to a north magnetic pole position of 53° N., 95° W.
2. The intensity of magnetization varies greatly between adjacent samples, even between samples from the same core. The intensity is less than the average near the south contact of the dike and near the center. The average intensity of magnetization is 4.35×10^{-3} c. g. s. emu/cc.
3. 60-cycle a. c. partial demagnetization at a peak field of 500 oersteds slightly increases the intensity of magnetization of samples from near the contact, but reduces the intensity of the interior samples to about one half of their initial value. The higher percentages of chlorite and deuteritic hornblende near the contact indicate late stage oxidation reactions which may have produced a magnetic constituent of high coercive force. The percentage of magnetite is the same near the contact as near the center of the dike.
4. As the demagnetizing field strength is increased, the directions of magnetization of the cores converge. After demagnetization at a peak 60-cycle field of 500 oersteds, the mean inclination of the samples is -82° and the mean

declination is 55° , with a four degree radius at the 95 percent confidence level. The results of demagnetization are based upon the data from four samples.

5. The difficulties encountered in the interpretation of the anomaly over the Covington dike indicate that care must be taken in interpreting vertical field anomalies over bodies with reversed remanent magnetization by use of formulas such as Cook's (1950) which are based on the assumption that there are no anomalous polarization effects present.

THE WATER PROBLEMS OF THE MINING INDUSTRY
OF THE UPPER PENINSULA OF MICHIGAN

J. H. Butler

The irreversible trend toward extraction of lower-grade metallic mineral deposits, as localized, high-grade deposits become depleted through increasing consumption, involves large-scale, highly mechanized mining and mineral processing operations. Such operations normally have very high energy and water requirements. Year by year, the availability of water for mineral industries becomes of greater significance as growing population and intensification of economic activity throughout the nation bring about competition for existing water resources. Despite the very favorable hydrologic environment of Michigan's Upper Peninsula, water "problems" appear to be developing with respect to the mining and processing of low-grade iron ore deposits on the Marquette Iron Range. The situation at one plant is examined and water availability for future regional development of the Marquette Iron Range is considered. Implications are drawn for the future of low-grade mineral exploitation in the sub-humid areas of the country.

PETROLOGY OF A PRECAMBRIAN PLUTON

NEAR PEMBINE, WISCONSIN

J. A. Cain

Nine rock units have been mapped within some 350 square miles of the Precambrian granitic and metamorphic complex of northeastern Wisconsin. The relative age-relationships among these units are suggested, primarily from a study of xenoliths, as follows:

Youngest:	Diabase dikes
	Amberg Granite
	Newingham Granodiorite
	Hoskin Lake Granite
	Metagabbro sills
	Twelve Foot Fall Quartz Diorite
	Marinette Quartz Diorite
	Biotite gneiss

Oldest:	Quinneseec Formation
---------	----------------------

Structural, modal, and specific gravity data are presented for the Newingham Granodiorite to illustrate their behavior within this terrane. The results of structural analysis are somewhat inconclusive but suggest a roughly concentric foliation pattern for the 40 square mile pluton. Data derived from 53 specimens of Newingham Granodiorite are used to illustrate the geographic variability (by means of trend surface analysis) of quartz percentage, feldspar percentage, feldspar ratio (potash feldspar/plagioclase) color index, and specific gravity within the mass. Correlation coefficients are given for each of the 10 pairs of variates to indicate degrees of association. From this quantitative analysis, feldspar ratio is seen to be the one variate which does not conform to "expected" patterns of behavior.

APPLICATIONS OF THE HIGH SPEED DIGITAL COMPUTER
TO GRAVITY AND MAGNETIC ANALYSIS

R. L. Coons and Peter Wolfe

Ninety percent of the time spent in geophysical interpretation is taken up by manipulating numbers leaving only about ten percent of the time for geologic interpretation of the results. Until the advent of the high speed digital computer certain analysis techniques were too costly or time consuming to perform by hand. The proper applications of computer techniques to data reduction and analysis allow the geophysicist to reverse the above procedure spending ten percent of his time on arithmetic and ninety percent of his time on interpretation.

Programs developed to date in magnetic and gravity analysis clearly demonstrate some of the advantages in using the computer. Magnetic readings can be electronically recorded on paper tape, fed into a computer, corrected for drift and diurnal variations, and plots of total intensity, second derivatives, and downward continuation, made by the computer. This eliminates all errors that are normally introduced in recopying and manipulating the data by hand. The resulting maps of the analysis can be plotted and in certain cases even contoured by the computer.

Gravity readings are drift corrected by hand along with the surveyers notes. These operations could be performed by the computer but this gives the interpreter a chance to examine the reliability of the data. The computer then calculates the Bouguer Anomalies using several density assumptions, plots profiles, checks for errors, performs least square surface analysis, and plots the residual maps. Several types of residual analysis are thus quickly obtained leaving more time for geologic interpretation of the results.

DIAGENETIC REPLACEMENT IN ORE
OF THE EMPIRE MINE OF NORTHERN MICHIGAN
AND ITS EFFECT ON METALLURGICAL CONCENTRATION

Tsu-Ming Han

This paper describes the texture, mineralogical, and chemical criteria of diagenetic enrichment of the low grade iron-formation at the new Empire Mine near Palmer, Michigan, and the influence of the diagenetic changes upon metallurgical response of the crude ore to beneficiation.

At the Empire Mine, in Section 19, 47-26, the iron-formation is involved in a secondary fold of the Marquette synclorium. The strike changes from N-S at the north side of the section to E-W in the southern part of the section. Dips also change from W to NW to N as the formation swings around the fold. In general the dips average about 30° . On the basis of mineral ratio, and mineral assemblage, the iron-formation may be classified into five lithological types: (a) interbedded complex (which includes magnetite-bearing greywacke, magnetite-hematitic chert with clastics, and the other four lithological types), (b) magnetite-carbonate-chert, (c) magnetite-silicate-chert-carbonate, (d) magnetite-chert-carbonate, and (e) magnetite-bearing chert-carbonate.

Laboratory data revealed that the iron content among the above-mentioned nonclastic rocks is fairly uniform averaging 32% in type (e) to 36% in type (c). The magnetite content varies considerably averaging 20% in type (e) to more than 42% in type (b). The iron unit recovery averages 44% in type (e) to 88% in type (b). Such variations are, in a large part, attributed to the differential diagenetic enrichment of magnetite in the different lithological types.

The following criteria, involving the formation of the mineral magnetite, support the contention that diagenesis has played an important role in the geologic history of the Empire ore: (a) more or less the same mineral assemblage but different mineral ratios; (b) more than one generation of magnetite; (c) cut-off and replacement of carbonate-chert by magnetite lamina; (d) evenly distributed magnetite; and (e) lack of correlation of metallurgical concentration results between samples from the same lithologic horizons.

MAGNETIC INVESTIGATIONS IN IOWA

D. H. Hase

In 1961, vertical intensity magnetic measurements were made in several areas for the Iowa Geological Survey as the initial phase of a project to map the entire state magnetically. Ground and airborne magnetometer surveys of the state are currently in progress. The magnetic anomalies are attributed to changes in the lithology and/or configuration of the Precambrian crystalline basement rocks. The Vincennes anomaly is probably due to a body of feldspathized gneiss or diorite which is a few square miles in extent, has a maximum relief of a few hundred feet, and is about 2900 feet below the surface. The Manson anomaly is attributed to somewhat feldspathized, magnetite-rich, biotite and augen gneiss. Relief owing to erosion and perhaps partly to faulting in the vicinity of the main anomaly may be of the order of 1000 to 1500 feet along a northeast-trending buried ridge. Large gravity and magnetic anomalies in the Adair area are apparently related to rather shallow, basic igneous rocks. Departures from the smoothed profiles define the Thurman-Redfield and other basement structural zones. A magnetic high without a corresponding gravity high near Greenfield is attributed to ferruginous schists in the basement rocks.

OPTIMUM DIP NEEDLE READING METHOD

Wm. J. Hinze

A good deal of the confusion surrounding the use and interpretation of dip needle observation originates from the method by which the instrument is read. The selection of the optimum reading method is dependent on four criteria: accuracy, reliability, simplicity, and rapidity. These are all important; however, their relative importance varies depending on the requirement and conditions of the survey. Various reading methods are evaluated with respect to these criteria with the aid of a laboratory investigation employing controlled magnetic fields. The optimum reading method varies with the survey, but 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.

A REGIONAL MAGNETIC MAP
OF THE SOUTHERN PENINSULA OF MICHIGAN

Wm. J. Hinze

A regional vertical magnetic intensity map is presented of the Southern Peninsula of Michigan. It is based on a peninsula-wide ground magnetic survey with observations made on a six mile interval plus detailed observations in local areas. This map which primarily reflects lithological and structural variations in the Precambrian basement rocks and their depth beneath the surface shows a strong relationship to the trend of sedimentary structures of the Michigan basin and Precambrian trends of Wisconsin and the Northern Peninsula extrapolated into the basin. The magnetic map and the regional gravity map also show a marked resemblance in many areas. In particular the Michigan Gravity High correlates with a major positive magnetic anomaly.

EXTENSION OF THE NORMAL DISTRIBUTION TO FILTERING
OF TWO DIMENSIONAL (SURFACE) GRAVITY AND MAGNETIC DATA

W. W. Johnson and S. A. Finnegan

The normal distribution curve has been successfully used in filtering one dimensional (profile) data. This method has been extended to two dimensional measurements of potential fields, both as a smoothing function and as a high-pass filter. The method involves the use of weights determined by different processes operating on a normal curve of revolution.

Results of this method are shown applied to remove regional trends from gravity anomalies yielded by a buried spherical body and a buried infinite vertical sheet.

PRELIMINARY INVESTIGATIONS OF LATE WISCONSIN DRIFT

NORTH OF LAKE SUPERIOR

T. W. Page and D. R. Lindsay

Problems of late Wisconsin chronology have been studied for the past 60 years in the Lake Superior region of Minnesota and adjacent States. Work of a similar nature has been carried out on the Canadian side of the Lake but has been local and disconnected.

Investigations of a regional nature and correlation of new findings with presently known data will help to complete the Canadian picture and possibly aid in solving some of the admitted problems remaining on the American side.

As an offshoot of work presently in progress and supported by the Geological Survey of Canada, some new data and correlations are presented. The Rainey lobe of Patrician ice is believed to have developed at least two morainal systems within the area discussed after retreat from the Vermillion moraine in Minnesota. They are believed to be post Two Creeks in age. Retreat to and beyond the Hartman-Kaiashk moraine allowed development of Lake Johnson in the Steeprock area and a similar lake in the Wabigoon basin. Outlets to both lakes were blocked by ice to the west during their early history.

The Nipigon and Dog Lake moraines are both considered younger than the Hartman-Kaiashk moraine and may represent the positions of an ice front during the life of Lake Duluth.

While definite conclusions cannot be drawn at present, it appears that a large area in northeastern Minnesota was free of ice from Two Creeks time on and was closely followed by disappearance of the ice from adjoining areas in Ontario. A study of plant geography lends further credence to this hypothesis.

After retreat of the ice from the Nipigon moraine a later front developed some 30 miles east of Lake Nipigon and trended in a southeasterly direction to the White River area. The presence of extensive outwash plains and varved clays east of Lake Nipigon suggest a greatly expanded forerunner of this lake and possible connection with Lake Ojibway.

Final retreat of the ice over the continental divide impounded the early stages of Lake Ojibway which at this time drained through the Pic

river system to the Lake Superior basin.

No definite eastern outlet for Lake Agassiz II has yet been determined. This and more complete detail of events throughout the area await continuing investigation.

GEOPHYSICAL EVIDENCE
FOR THE PRESENCE OF KEWEENAWAN VOLCANICS
IN THE AREA OF UPPER MICHIGAN
BETWEEN MARQUETTE AND SAULT STÉ. MARIE

R. W. Patenaude

During five days in August, 1961, 1100 data miles were flown with an Elsec proton precession magnetometer in the area of Paleozoic sediments between Marquette and Sault Ste. Marie. The magnetic data suggests that the area between Grand Island and Sault Ste. Marie is underlain by Keweenawan type volcanics. The magnetic pattern is believed to reflect the influence of thermo-remanent magnetization in the volcanics.

GEOPHYSICAL INVESTIGATION
OF A DIABASE DIKE NEAR L'ANSE, MICHIGAN

R. J. Reuss

The purpose of the investigation was to determine the relative age of the reversely magnetized, fresh diabase dikes that occur in the area near L'Anse, Michigan.

The dike investigated trended from an area of late Huronian slates into an area overlain by red sandstones of Cambrian or late Precambrian age.

A magnetometer survey was run across the dike at several places in an attempt to determine whether or not the dike penetrated the sandstone, or was overlain by it.

The results of the survey seem to indicate that the dike is overlain by the sandstone, and is therefore of an earlier geological age.

GEOCHEMICAL AND GEOPHYSICAL PROSPECTING

FOR COPPER, LEAD, AND ZINC

IN THE EAST CLARE AREA OF IRELAND

Richard W. Schultz

The rocks in this area are predominantly lower Carboniferous limestones and shales, underlain by Upper Devonian shales and sandstones. The major structural feature is a large, shallow, south westerly trending syncline. The nearest exposure of post-Carboniferous intrusive rocks lies over one hundred miles from this area.

On the north limb of the syncline, in an area containing numerous minor folds, are several small base metal sulphide deposits which had been mined in the last century. A small, but geologically significant chalcopyrite replacement deposit has been discovered recently by means of the induced polarization method. The two basic types of sulphide deposits found in the area are: (1) fracture-filling calcite-sulphide lodes with minor wallrock replacement in competent limestone, and (2) replacement deposits in shaly limestone controlled by upfolded impermeable barrier rocks.

High pH of stream and ground water throughout the area inhibits the solubility of heavy metals and renders them practically immobile. For that reason, as well as poor drainage conditions in general, stream water and sediment sampling was found to be ineffective. Also, blind deposits could not be expected to have secondary chemical dispersion haloes associated with them. However, glacial erosion has caused strong and clearly discernible physical dispersion of metals from suboutcropping deposits and, therefore, a method of reconnaissance soil sampling was adopted to search specifically for glacial dispersion patterns. Experimental work showed that all of the known deposits could have been found by geochemical float tracing, and several new anomalies have been discovered.

The variable-frequency induced polarization method was used in reconnaissance and detailed geophysical prospecting. It was found to be effective in detecting even relatively small amounts of disseminated sulphides and, therefore, to be more sensitive than other electrical methods. Its main disadvantage is poor resolution and geometric definition of anomalies, making it difficult to spot drill holes.

The vertical-coil electromagnetic technique was found to be unsatisfactory for most reconnaissance work as it does not respond well to dis-

erminated sulphide mineralization. However, it has been effective in discerning flat-lying black shale beds containing primary pyrite which give rise to strong induced polarization anomalies. Self-potential measurements provided an additional means of recognizing the troublesome pyritic shale.

MAGNETITE ANALYSIS BY MAGNETIC SUSCEPTIBILITY

P. D. Shandley

A transistorized magnetic susceptibility meter which utilizes the balanced transformer principle is described. The instrument has been used to determine the percent magnetite in ores. The results of this method of analysis are comparable to the results obtained by magnetic separation and chemical analysis.

IRON ORES OF
BIHAR AND ORISSA, INDIA

A. K. Snelgrove

While visiting the University of Sind, Hyderabad, West Pakistan, in 1961-62, as Fulbright Lecturer in Geology, the speaker made a brief tour of the Tata iron and steel empire of Northeast India.

The Iron Ore Series, containing an estimated 8 billion tons of good grade workable ore in Bihar and Orissa produced 6,670,000 in 1960.

Rocks of the Iron Ore Series range from shales and quartzites to coarse-grained clastics and are associated with pyroclastics, only slightly metamorphosed. The well layered major deposits occur chiefly along ridges. Generally soft, friable and powdered varieties together form the major part of a deposit, and hard, compact varieties are found mostly in the top portions. Depths are about 300 feet.

Properties of varieties generally available in one deposit are hard 33%, soft 16%, lateritic 9%, biscuity or flaky friable 33%, blude dust 10%.

Principal minerals are hematite, magnetite, martite, and occasionally also limonite and goethite, together with some hydrous iron silicates such as greenlite and chamosite.

Quality, origin structure, alterations, and development planning, treatment, and economics will also be discussed.

The author is indebted to Tata Iron and Steel Corporation for much information and many courtesies.

THE USE OF PRECIPITATION CHROMATOGRAPHY

IN GEOCHEMICAL PROSPECTING

J. D. Spain

The use of agar gel columns containing ammonium sulfide precipitant for mineral identifications and trace element determination will be described. (Spain, J. D., Anal. Chem. 32; 1622-1624 (1960), Spain, J. D., Ludeman, F. L., and Snelgrove, A. K., Econ. Geology, in press).

Sensitivity studies showed cobalt, zinc, lead, bismuth, antimony, and tin, to be determined in solutions containing 20 ppm or less. Iron, cadmium, copper, and arsenic were determined in solutions containing less than 300 ppm. All analyses involved the standard ammonium sulfide column with the metal ions applied in 6 M HCl solution. In preliminary studies to determine accuracy of qualitative identification, 80 synthetic unknowns composed of three component mixtures of the previously mentioned ions were analysed. Iron, lead, cadmium and cobalt were identified correctly in all unknowns. Only arsenic, antimony, and tin gave any extensive difficulty, these having been determined with less than 80% accuracy.

Sixty one mineral samples were analysed by this method and the results were compared with those obtained from the emission spectrograph. It was found that the major metallic constituents of minerals can be determined with a high degree of accuracy. However, in most cases the minor constituents were missed. It was concluded that in special cases the method would be a useful field tool.

The more recently developed technique of filter paper precipitation chromatography will be described and its advantages over the agar gel technique will be discussed. These advantages include stability of the precipitation media, speed of chromatogram development, quantitative as well as qualitative results in a permanent form, and inexpensive, portable apparatus.

GEOLOGICAL SURVEY, PIKES PEAK AREA,

BARAGA COUNTY, MICHIGAN

Kiril Spiroff

Unusually high geiger counter readings were detected in outcrops on the west side of Huron Bay, ten miles east of L'Anse, in Baraga County, Michigan. The area was investigated by trenching and diamond drilling.

Surface mapping and information from three diamond drill holes yields the following geological column (from top to bottom): sandstone, "iron formation", quartzite, conglomerate, and granite.

The study fills a gap in our knowledge of the Precambrian area of Michigan's Upper Peninsula. It did not reveal any deposits of economic significance.

FOOTWALL MINERALIZATION IN THE OSCEOLA AMYGDALOIDMICHIGAN NATIVE COPPER DISTRICT

R. J. Weege and A. W. Schillinger

Conventional underground mapping methods and diamond drilling are being applied in a study to determine the nature of the copper ore occurrences near the footwall of the Osceola amygdaloid. A description is given of the physical character of the amygdaloid and the types and location of native copper mineralization and associated alteration. Work to date suggests that the footwall ore is formed independently from the hanging-wall ore and that localization at the footwall is caused by impermeable barriers. The barrier concept as advanced by earlier writers to explain the concentration of solutions in the ore body as a whole is carried one step further and is found to be equally as applicable for the localization of smaller ore shoots within the Osceola ore body.

CURRENT GEOLOGICAL RESEARCH IN THE PALMER AREA,MARQUETTE DISTRICT, MICHIGAN

J. Zinn

The Palmer area is structurally a distinct syncline containing Animikean rocks and is separated from the main Marquette synclinorium by the prominent Volunteer Fault. Exposures of the Negaunee iron formation in this area show variations not characteristic of this formation as seen elsewhere. The lower horizons at the Negaunee contain various proportions of clastic debris and some lenses of conglomerate material. Also, this formation rests on Ajibic quartzite locally without the normally intervening Siamo slate. Currently, these sedimentational problems are being investigated by Robert Henny. The investigation to date appears to show that the Negaunee was a near shore deposit in this area, that the chert layers in the formation rapidly solidified into durable beds and that the iron precipitated in trivalent condition. Iron formation was deposited continuously with the clastics even in the conglomerate horizons. The implications of such deposition encourage speculation as to rate of deposition and other sedimentary problems concerned with Lake Superior type formations.

Several other problems in the Palmer area deserve attention. Some of these are the extent and nature of the Volunteer Fault, the Eastern limits of the Palmer syncline and the pyroclastics in the iron formation. It is understood that research on some of these problems is being done at the University of Wisconsin.