EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

2.

a. PENSION SYSTEMS (Continued)

Pension Plan of 3/1/1950 (Cont'd.)

During the year the following age pensions were granted:

Name	Mine	Eff.Date	Gross Pension	Net Pension
John Pizziola	Maas	1/1/56	140.00	55.00
Mike Leone	Agnew	1/1/56	132.00	47.00
Amedio Spelgatti	Bunker-Hill	1/1/56	123.17	38.00
Thomas J. Ellis	Maas	1/1/56	140.00	55.00
Arthur I. Simula	Cliffs-Shaft	1/1/56	110.33	25.00
Jalmer Salo	Maas	2/1/56	138.50	54.00
Herbert Brewer	Cliffs-Shaft	2/1/56	140.00	55.00
Sam Kerkes	Canisteo	2/1/56	129.33	44.00
Joseph Misale	Bunker-Hill	3/1/56	132.67	48.00
John N. Johnson	Maas	3/1/56	140.00	55.00
Isaac Pentimaki	Bunker-Hill	3/1/56	140.00	55.00
John Nikula	Agnew	3/1/56	117.33	32.00
Edward Lampsa	Maas	4/1/56	119.00	34.00
Joseph A. Pepin	Lloyd	4/1/56	126.83	42.00
Sam Trevarton	Spies	4/1/56	140.00	55.00
Oscar Tislov	Maas	4/1/56	117.67	33.00
Bozo Perkovich	Agnew	4/1/56	132.50	48.00
Anthony Angelo	Agnew	4/1/56	128.33	43.00
Werner J. Salo	Agnew	4/1/56	131.00	46.00
Wilfred H. Fayle	Agnew	4/1/56	132.50	48.00
John A. Johnson	Agnew	5/1/56	123.67	39.00
Augustino Ricci	Agnew	5/1/56	121.50	37.00
John Steve	Cliffs-Shaft	5/1/56	170.66	86.00
Arthur Truscott	Maas	5/1/56	133.83	49.00
John A. Swanson	Cliffs-Shaft	5/1/56	140.00	55.00
Russell F. Pascoe	Maas	5/1/56	137.33	52.00
George Makinen	Cliffs-Shaft	5/1/56	100.00	36.00*
Alex Bertell	Bunker-Hill	6/1/56	140.00	55.00
James G. Pastore	Cambria-Jackson	6/1/56	140.00	55.00
Henning W. Blomquist	Maas	6/1/56	140.00	55.00
John J. Miller	Hawkins	6/1/56	132.83	48.00
Joseph Roy	Bunker-Hill	7/1/56	140.00	55.00
Martin G. Leckwold	Agnew	8/1/56	119.67	35.00
Amos C. Brown	Hawkins	8/1/56	133.17	48.00
Albert D. Dreon	Cambria-Jackson	8/1/56	134.67	50.00
John Gustafson	Maas	9/1/56	167.97	83.00
Martin Cimermancic	Sargent	9/1/56	120.83	36.00
Samuel R. Davey	Maas	9/1/56	140.00	55.00
Erland K. Maki	Maas	10/1/56	154.07	69.00
Arthur J. Hebert	Cliffs-Shaft	10/1/56	145.79	61.00
Edgar R. Staples	Maas	11/1/56	140.00	55.00
Arthur E. Matheson	Cliffs-Shaft	12/1/56	140.00	55.00
Massimo Spelgatti	Mather "B" Shaft	1/1/56	117.00	32.00
Richard J. Wills	Mather "B" Shaft	1/1/56	110.50	26.00

EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

2.

a. PENSION SYSTEMS (Continued)

Pension Plan of 3/1/1950 (Cont'd.)

Name	Mine	Eff.Date	Gross Pension	Net Pension
Joseph Giroux	Mather "B" Shaft	1/1/56	140.00	55.00
Gabriel Fosco	Negaunee	3/1/56	140.00	55.00
C. Adolph Okesson	Mather "A" Shaft	3/1/56	119.17	34.00
Thomas H. Hampton	Mather "A" Shaft	3/1/56	140.00	55.00
David Pynnonen	Mather "B" Shaft	3/1/56	140.00	55.00
Eino W. Hirvela	Mather "A" Shaft	5/1/56	145.20	60.00
Charles G. Tapola	Mather "B" Shaft	8/1/56	110.83	26.00
Erick Kuehn	Mather "A" Shaft	10/1/56	120.00	35.00
Andrew Columbo	Hill-Trumbull	7/1/56	140.00	55.00
Peter E. Oquist	Hill-Trumbull	7/1/56	110.50	26.00
Steve Rodich	Hill-Trumbull	8/1/56	134.67	50.00
Henry Waisanen	Holman-Cliffs	10/1/56	133.67	49.00
Frank W. Dionne	Hill-Trumbull	10/1/56	131.83	47.00

There were 57 age pensions granted during the year.

A standard Social Security deduction of $85.00 is provided by the pension contract on all age pensions effective on or after November 1, 1954. For that reason the amount of Social Security is not shown in the above list. George Makinen, Cliffs-Shaft, 5/1/56, was a disability pensioner who was converted to an age pension when he became sixty-five. Since his disability retirement predated the 10/1/1954 revisions his age pension was computed under the original plan which provided a minimum gross pension of $100 less his Social Security of $64.10.

Six disability pensions were approved for payment during the year.

Name	Mine	Eff.Date	Gross Pension	Net Pension
Philip E. Pepin	Cliffs-Shaft	1/1/56	93.60	94.00
William Bennett	Cambria-Jackson	7/1/56	75.00	75.00
Joseph Gagne, Sr.	Spies	8/1/56	119.06	119.00
Iver Larson	Lloyd	9/1/56	156.44	156.00
William A. Laitinen	Lloyd	12/1/56	115.30	115.00
Albert H. Kamowski	Mather "A" Shaft	10/1/56	75.00	75.00

EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

2.

a. PENSION SYSTEMS (Continued)

Pension Plan of 3/1/1950 (Cont'd.)

The following pensions, sixteen in number, were discontinued during the year for the reasons shown.

Name	Mine	Pension No.	
Oscar Pulkinen	Cambria-Jackson	CC-42	Died 10/11/56
John Juhola	Cliffs-Shaft	46	Died 6/14/56
Thomas G. Hill	Tilden	57	Died 10/15/56
George Makinen	Cliffs-Shaft	126D	Converted to age pension 5/1/56
Thomas C. Hodge	Maas	136	Died 12/29/56
Charles H. Collycott	Bunker-Hill	157	Died 11/21/56
Jacob Piirainen	Maas	184	Died 8/18/56
Mike Cvitkovich	Sargent	CC-187	Died 2/11/56
William H. Palmer	Cliffs-Shaft	200	Died 9/29/56
Louis Senical	Cambria-Jackson	239	Died 10/31/56
Sam Trevarton	Spies	263D	Converted to age pension 4/1/56
Philip E. Pepin	Cliffs-Shaft	265D	Died 3/8/56
James Hansen	Mather "A" Shaft	NM-25	Died 6/20/56
Otto Korhonen	Negaunee	26	Died 2/12/56
David Pynnonen	Mather "B" Shaft	38	Died 7/13/56
Albert Kamowski	Mather "A" Shaft	44D	Died 12/3/56
Luigi Basegio	Athens	AM-5	Died 5/9/56

At the close of 1956 there were 323 age pensioners and 11 disability pensioners under this plan in the Michigan and Minnesota Mining Departments.

An interesting development in the Pension Plan was encountered in the request of two pensioners for a reduction in the monthly amount of their pensions. Arthur Hoar, Ret. #CC-246, and Sam Beltrame, Ret. #CC-268, were eligible upon retirement for federal pensions because of military service in World War I. Income in excess of a certain figure can disqualify an applicant for this type of federal benefit, and both requested reductions to meet the income limitation. The requests were approved by the Pension Committee and reductions as outlined by the pensioners were granted.

EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

2.

a. PENSION SYSTEMS (Continued)

Pension Plan for Salaried Employees

The Pension Plan for Salaried Employees which became effective on January 1, 1951 was revised on November 1, 1954, to correspond with the hourly-rate Pension Plan. Details of the plan as now in effect may be found under the heading "Pension Plan of March 1, 1950."

This Department handles the initial processing of all pension applications under this Plan and submits them to the Pension Committee in Cleveland for final disposition.

During the year the following pensions were granted under the Plan.

Name	Former Occupation	Eff.Date	Gross	Deductions		Net
Walter Turino	Shift Boss Lloyd Mine	3/1/56	140.00	85.00 28.86	SS CR	26.00
Toivo Bergstrom	Janitor Research Lab.	8/1/56	140.00	85.00	SS	55.00
Arthur Olson	Chief Electrician	8/1/56	245.98	85.00 96.74	SS CR	64.00
Henry J. Mayrand	Superintendent of Water Power	10/1/56	219.82	85.00 88.08	SS CR	47.00

Code letters for deductions: SS-Social Security
CR-Contributory Retirement-Company proportion.

A list of pensioners whose pensions were discontinued during the year follows:

Toivo Bergstrom - S-34-D - Converted from disability to age pension on 8/1/56.

George McL. Waldie - Died 12/13/56.

At the end of the year there were 44 salaried pensioners from Michigan and Minnesota under this plan.

EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

2.

a. PENSION SYSTEM (Continued)

Retirement Payrolls

The original purpose of the Retirement Payrolls was to supplement Social Security benefits being paid to our retired employees. The payrolls were initiated on March 16, 1939 and were the major retirement plan of the Company through February 1950 when the Pension Plan of March 1, 1950 became effective. This latter Pension Plan has all but eliminated additions to the Retirement Payrolls, and any additions now are in the nature of special cases.

A retired employee's Social Security benefit was originally supplemented by $10.00 per month over The Retirement Payrolls. Beginning with July 1948 this amount was increased by $10.00 per month in all cases so that the usual allowance over the payroll was $20.00 per month. Our retired employees carry fifty per cent of the life insurance in force on their lives at the time of their retirement. Since March 1, 1950 this is done without cost to the employee.

There were no additions to the Mining Department Retirement Payroll during 1956. The following retirees, twelve in number, were dropped from the Mining Department Retirement Payroll during the year:

Name	Ret. No.	Amount	Reason
Charles Kirschner	268	$ 20.00	Died 1/9/56
Jacob Koski	191	20.00	Died 2/9/56
Albin Hamalainen	201	20.00	Died 2/28/56
John O. Jokela	203	20.00	Died 3/1/56
John O. Johnson	53	20.00	Died 3/24/56
Otto Franson	73	20.00	Died 3/25/56
Carl F. Swanson	143	20.00	Died 6/27/56
Lorenzo Marta	199	20.00	Died 7/20/56
George Young	84	20.00	Died 11/20/56
Antonio Filippi	128	20.00	Died 12/5/56
Thomas Hemming	125	20.00	Died 12/6/56
Fred L. Prudom	43	60.00	Died 12/30/56

Two Retirement Payrolls are prepared in this office to handle payments to Minnesota retired employees, one for the Canisteo Mine and the other for the Mesaba-Cliffs Mining Company - Mining Department.

There were no additions or deaths on the Canisteo Mine Retirement Payroll during the year.

There were no additions or deaths on the Retirement Payroll of The Mesaba-Cliffs Mining Company - Mining Department during 1956.

EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

2.

a. PENSION SYSTEM (Continued)

Retirement Payrolls (Cont'd.)

A resume of the 1956 Retirement Payrolls follows:

Number of Mining Department Retired Employees 12/31/1955	126
Number of Mining Department Retired Employees 12/31/1956	114
Total Expenditure to above employees for year 1956	31,181.44
Number of Canisteo Mine Retired Employees 12/31/1955	3
Number of Canisteo Mine Retired Employees 12/31/1956	3
Total Expenditure to above employees for year 1956	720.00
Number of Mesaba-Cliffs Mng. Co. Retired Employees 12/31/55	16
Number of Mesaba-Cliffs Mng. Co. Retired Employees 12/31/56	16
Total Expenditure to above employees for year 1956	3,840.00
Total Number of Retired Employees 12/31/1955	145
Total Number of Retired Employees 12/31/1956	133
Total Expenditure to retired employees for year 1956	35,741.44

EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

2.

a. PENSION SYSTEM (Continued)

The table below shows the pension payments for the Mining Department and Holmes Mine Department combined for the years 1908 through 1956. The Holmes Mine Department payroll became inactive with the death of its last pensioner on April 23, 1949.

Year	Old Age	Widows and Orphans	Total
1908 thru 1945	785,061.71	22,547.00	807,608.71
1946	5,648.60	-	5,648.60
1947	4,156.68	-	4,156.68
1948	3,840.68	-	3,840.68
1949	3,260.68	-	3,260.68
1950	2,400.68	-	2,400.68
1951	1,438.78	-	1,438.78
1952	1,076.00	-	1,076.00
1953	796.00	-	796.00
1954	936.00	-	936.00
1955	936.00	-	936.00
1956	936.00	-	936.00
	817,487.81	22,547.00	840,034.81

Includes payment of $2,500.00 made by the Cleveland Office in 1930.

Republic Mine Department

This payroll is inactive. During its active years - 1920 through June 1953 - a total of $149,689.04 was expended over the Republic Mine Department Pension Payroll.

Land Department

This payroll is inactive. During its active years - 1927 through June 1953 - a total of $6,836.88 was expended over the Land Department Pension Payroll.

Furnace Department

This payroll became inactive in 1948. During the years when it was active - 1910 through 1948 - a total of $66,155.22 was expended over the Furnace Department Pension Payroll.

EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

2.

b. INCAPACITATED EMPLOYEES (DONATION PAYROLL)

During the year payments were continued to certain men who did not have sufficient service to bring them within the provisions of the Pension Plan of 1/1/1909 but whose cases had merit and to other men who retired under Social Security but had so little employment under that system that their benefits were inadequate. These payments were made over the Donation Payroll. Some of these men were totally disabled through mine accidents while others became incapacitated from illness or disease and required assistance because of large families. There have been no additions to the payroll since 1952. It is the policy to avoid additions to this payroll and it is employed only in unusual circumstances.

On February 1, 1947 direct relief in the form of grocery, clothing, and fuel orders was discontinued as a regular practice, and allowances over the Donation Payroll were granted in their place. At the close of 1956 only one such recipient - Mrs. Johanna Forstrom - remained on the payroll.

The Holmes Mine Department Donation Payroll became inactive on June 30, 1953. During its active years - January 1932 through June 1953 - a total of $18,920.92 was expended over the Holmes Mine Department Donation Payroll.

After being granted, the Furnace Department donations were paid originally by the Furnace Department itself and later by the Cliffs-Dow Chemical Company. By direction from Cleveland on September 1, 1937 the donations were paid by this office over the Furnace Department Donation Payroll. The payroll became inactive in August 1950 with the death of its last payee, and it will remain inactive. During its active years - September 1937 through August 1950 - a total expenditure of $11,910.00 was made over the Furnace Department Donation Payroll.

The Mesaba-Cliffs Mining Company Donation Payroll remained inactive during the year. The last payment over this payroll was made in March 1948. From the date of origin, January 1, 1946, through March 1948 a total expenditure of $795.00 was made over the Mesaba-Cliffs Mining Company Donation Payroll.

There are four widows receiving Donation payments, all on the Mining Department Payroll. Two of these widows, Mrs. J. H. Tregoning and Mrs. Fiina Kampinen, were granted regular donations; one, Mrs. Johanna Forstrom appears on the payroll because of the conversion of direct aid orders to monetary allowances; and one, Mrs. Lyda M. G. Turgeon, is being paid over this payroll rather than under the Pension Plan of 3/1/1950.

The total expenditure over the Donation Payroll for 1956 was $4,108.80. The payroll carries thirteen names as the year closes.

EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

2.

c. SAFETY WORK

The Central Safety Committee meets regularly to review accidents and to classify them. The committee tries to interpret the cause of every accident and, as far as possible, establishes rules and regulations for the purpose of trying to prevent further accidents.

Central Safety Meetings were held on the following dates in 1956:

January 5
March 29
May 3
May 31
July 6
July 26
August 30
September 28
October 31
November 29
December 28

The roster of the Central Safety Committee as of December 31, 1956 was as follows:

Grover J. Holt
J. S. Westwater
S. W. Sundeen
Hugo H. Korpinen
Harry C. Swanson
T. A. Kauppila
Onnie Marjama
Gilbert A. Dawe
R. L. Tobie
Kenneth Olson
John M. Haivala
Dr. Bert E. Moore
H. W.Sundberg
J. D. Preston
E. D. Cory
R. G. Schaal
Grant Hollett
Gerald Anderson
H. W. Rembold
L. J. Erck
Max Madsen
R. M. DeGabriele
Ogden E. Johnson
Jack S. Bowen
Walter F. Gries
Walter E. Johnson
Arne Andelin
B. H. Peterson
Eric Beinlich
Emert W. Lindroos
A. J. Stromquist
Tom W. Hill
E. G. Bengry
Marvin Swanson
R. H. Lukkarinen

d. MEDICAL SERVICE

For years the Company has provided proper medical service for the care of all occupational accidents and injuries. The Company has contracted with Doctors A. W. Erickson of Ishpeming and R. L. Paine of Negaunee. The Doctors are on call in case of accidents and this program assures medical service in all cases of accidents and injuries associated with the work of our employees.

e. IRON RIVER HOSPITAL

The Superintendent of the Employees' Insurance and Compensation Department serves on the Board of Trustees of the Iron River General Hospital at Stambaugh. He attends the annual

2.

e. IRON RIVER HOSPITAL (Cont'd.)

meeting of the hospital trustees and participates in their deliberations. We have discontinued work at the Spies Mine and we are no longer participating directly in maintaining the employee medical plan in the Iron River district. Our Company retains its stock in the General Hospital of the Iron River District.

Dr. L. E. Irvine, who for several years gave medical attention to our employees in the Iron River district, no longer serves since we have no physical examination program in the area because the closing of the Spies Mine eliminated all the employees.

f. PHYSICAL EXAMINATION OF EMPLOYEES

Dr. Bert E. Moore serves in the capacity of Director of our Industrial Hygiene Department which is now housed at the clinic of Dr. R. G. Williams in the 8th Addition in Ishpeming. Dr. Moore became Director upon the retirement of Dr. George McL. Waldie. We are pleased to report that Dr. Moore carries on a good program and we often hear of his courtesy to our people.

The total of examinations made through December, 1956, is as follows:

	Cleveland-Cliffs	Inland Steel
January	269	31
February	258	30
March	313	7
April	293	33
May	263	40
June	264	33
July	6	2
August	238	28
September	277	18
October	333	13
November	236	2
December	254	
Total	3004	237

During 1956 no record was kept in this Department of the number of examinations at each individual property.

EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

2.

g. COMMUNITY HEALTH

During 1956 the health conditions in the area were near normal. We did have a number of cases of polio in the Northern Peninsula of Michigan but the prevalence of the disease did not assume the proportions of an epidemic. Morgan Heights Sanatorium, which is under the direction of Dr. James A. Acocks, continues its excellent service to the community and is considered one of the best County Tuberculosis Sanatoriums in the state. Moreover, we are fortunate to have Dr. Acocks remain at Morgan Heights since he has had opportunity to go elsewhere. He has done an outstanding job in the field of tuberculosis care.

Each city in Marquette County has a health officer and a full time school nurse. The County of Marquette also retains a full time nurse service and these services are made available to the township districts mostly through the schools.

The city health officers in Marquette County are:

W. A. Corcoran, M.D.	- Ishpeming
R. L. Paine, M.D.	- Negaunee
A. L. Swinton, M.D.	- Marquette

During the year there was more discussion regarding the possibility of the creation of a Marquette County Health Unit with a full time public health doctor in charge. This Department believes there is considerable advantage to our Company in establishing a full time health doctor in Marquette County. Marquette County is one of the two counties in the Northern Peninsula which does not have a fully established County Health Department.

The city of Marquette is known as the medical center of the Northern Peninsula because the Northern Michigan Children's Clinic continues to operate, and St. Luke's Hospital with its expanded capacity is taking care of more people, and particularly more afflicted children than it has in the past. There is being built also in Marquette, adjacent to St. Luke's Hospital, a new building which will become a doctor's clinic sometime in the summer of 1957.

The Superintendent of the Employees' Insurance and Compensation Department has now served 22 years as Chairman of the Board of Directors of Bay Cliff Health Camp in Marquette County. Bay Cliff Health Camp serves children from the fifteen counties of the Northern Peninsula of Michigan on a non-cost basis. These are afflicted or underprivileged children who are certified to the camp by local health departments or local doctors. Most of the children require special care

EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

2.

g. COMMUNITY HEALTH (Cont'd.)

because of their physical condition. The following types of cases are served: children with rheumatic hearts, convalescent poliomyelitis cases, diabetics, children with various cardiac conditions, children having speech and hearing defects, those having special personality problems resulting from illness and some who are undernourished.

h. RELIEF WORK

Direct relief is extended only in emergency cases. There are no regular recipients of direct relief. During the year we had two relief expenditures, one during the month of May in the amount of $47.07; and one during September in the amount of $46.70 - total for the year $93.77. This statement does not include cash assistance.

i. EMPLOYMENT

The Employees' Insurance and Compensation Department cooperates in every way possible with the Employment Office, which is under the supervision of Mr. H. W. Sundberg. Applications for employment which come to the Department are discussed with Mr. Sundberg and the best interest of the Company is kept in mind.

j. IMPROVEMENT WORK

The Company continues its improvement work by way of gardening and improvement of grounds and the Landscape Department is still in charge of Mr. Peter DeRoche. Mr. DeRoche succeeded Mr. Julian Payen in 1954. We receive many compliments from visitors and tourists upon the fine appearance of our mines and other Company properties.

k. COMMUNITY SERVICE WORK

Each year we call attention in our report to the American Legion Building in Negaunee, which is leased by our Company to the Legion. In recent years it has been the responsibility of the Legion to take proper care of the building and recently the Superintendent of the Employees' Insurance and Compensation Department recommended to Mr. Westwater, Manager of Michigan Mines, that the furniture and other equipment in the building which has been there for thirty years - and which no longer has any particular value - be turned over to the John H. Mitchell Post #66 - American Legion of Negaunee.

Many activities take place in the Negaunee Legion Clubhouse. The same is true of the American Legion Club building in Ishpeming, but this building is no longer owned by our Company.

EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

1. OUTDOOR ACTIVITIES

Every year shows added interest in the outdoor activities in the Ishpeming-Negaunee area. The ski tow and the Winter Sports Club is very popular and the ski tournaments which are held each year seem to attract as many people as in the past.

The National Ski Museum and Hall of Fame attracts a great many people to Ishpeming and will eventually become a very important attraction in the sports world. The 69th Annual Ski Tournament was held in Ishpeming under the supervision of the Ishpeming Ski Club in February.

m. THE MATHER INN

The Mather Inn seems to be the most popular hotel in the Northern Peninsula. Mr. Juel Casperson, who took over the management late in 1955 seems to have not only improved the services, but has increased the patronage. The Mather Inn is used more and more each year for various types of meetings of groups of people, particularly those from the Upper Peninsula.

n. VARIOUS DEPARTMENTS AND ACTIVITIES

The Superintendent of the Employees' Insurance and Compensation Department completed his service as President of the Michigan Tuberculosis Association in 1955 and presently is a member of the Executive Committee. He was recently appointed as the Michigan representative to the National Tuberculosis Association, with headquarters in New York City.

The Superintendent completed his term as President of the Michigan Society for Crippled Children and Adults, Inc. in 1956 and is now serving as a member of the Executive Committee and treasurer of the Society. In September of 1956 the Superintendent of the Department completed his service in the Grand Lodge Knights of Pythias of Michigan and is now a Past Grand Chancellor and a member of the Executive Committee.

The service of the Superintendent as Illustrious Potentate of Ahmed Temple, Ancient Order Nobles of the Mystic Shrine, was completed as of January 1, 1957. He is serving now as a member of the official board.

The Superintendent of the Employees' Insurance and Compensation Department continues to serve as a member of the advisory council staff to the State Department of Public Instruction on community planning and program. He also is a member of the survey of the National Probation and Parole Association, which is carrying on a project national in scope for a period of three

EMPLOYEES' INSURANCE AND COMPENSATION DEPARTMENT

ANNUAL REPORT YEAR 1956

2.

n. VARIOUS DEPARTMENTS AND ACTIVITIES (Cont'd.)

or four years in the field of penology and penal administration. This Association is made up of a number of men from the fields of business, medicine, education, lawyers, and management from the State of Michigan.

o. POLICE DEPARTMENT

Reference to the Police Department, under the direction of Chief of Police Emil Hoff, has been made previously in this report. Mr. Hoff contacts the regular officers of the Police Department with considerable regularity and checks on their reports.

p. APPRECIATION

I wish to express my appreciation for the splendid assistance, fine cooperation and the many courtesies extended to this Department by Mr. Grover J. Holt, General Manager; Mr. James S. Westwater, Manager of Michigan Mines; Mr. C. W. Allen, Vice President and former General Manager; Mr. Hugo H. Korpinen, District Superintendent of Underground Mines; Mr. Harry C. Swanson, District Superintendent of Open Pit Mines; and Mr. O. E. Johnson, Director of Industrial Relations. The excellent cooperation of the Safety Department and its Director, Mr. A. J. Stromquist, is appreciated. We shall continue to exert every effort to maintain cooperation and efficiency within this Department and we will cooperate in every possible manner with those departments associated with the Employees' Insurance and Compensation Department.

I wish also to point out and to express my appreciation for the splendid cooperation of the folks who make up the Employees' Insurance and Compensation Department, with its bureau of compensation, insurance, pensions and Industrial Hygiene. Special gratitude is hereby expressed for the services rendered by Mrs. Shirley Mattson, Secretary to the Superintendent and the Department, Mr. W. E. Johnson, Compensation Agent, Mr. L. C. Holmgren, Assistant, Compensation and Insurance Division, Mr. Emil Hoff, Chief of Police and Mr. Fred Olson, Stenographer, Compensation Bureau.

Allen D. Grieve

REPORT OF GEOLOGICAL DEPARTMENT FOR YEAR ENDING DECEMBER 31, 1956

CONTENTS

SUMMARY OF DEPARTMENTAL ACTIVITIES

The following is a brief summary of the outstanding 1956 activities of the Department in the Company's exploration program:

1. Cascade Direct Shipping Ore

We believe that the greatest single achievement for the year was the disclosure of a merchantable orebody of direct shipping ore in the Cascade District two miles east of the Village of Palmer. Our Disclosure Report dated June 30, 1956, indicated a reserve of 19,026,000 tons with an estimated natural analyses of 53.00% iron, 7.75 silica, .080 phos. and .033 sulfur. Our Ore Reserves Report No. 6 indicated a prospective reserve of 8,390,700 tons in addition to the 19,026,000 tons.

2. Albanel Mines, Ltd.

The outstanding feature of our Canadian Exploration was the formation of a joint company between the M. J. O'Brien Company of Ottawa and The Cleveland-Cliffs Iron Company. The claims of both companies in the Lake Albanel Region of Quebec were pooled, and the 1956 activities conducted by the joint company. Because of delays in the receipt of test results, it is not possible at this time to indicate the increase in reserves related to the 1956 activities. This testing has been done at the Quebec Department of Mines Laboratory in Quebec City.

3. Western U. S. Program

The year 1956 was a milestone in our continuing program for the development of significant reserves in the Western States. Three major areas were explored by field work and diamond drilling, namely;

a. Montana

Diamond drilling and field work was done on several claim groups in Judith Basin County, Montana. This was a joint effort with the Young-Montana Corporation. A total of 56 cars of ore was produced and shipped by the close of the shipping season.

b. California

Airborne magnetic reconnaissance ground investigation and diamond core drilling was conducted in San Bernardino County, California. Ownership problems complicated the first area investigated, however, significant anomaly areas are recommended for review and staking in 1957.

c. Idaho

Through the combined efforts of Young-Montana and Cliffs, an area near Mackay, Idaho was investigated and diamond drilling started. This is an iron and copper property - a possible joint venture with the Anaconda Company.

4. Marquette Range Low Grade Ores

The year 1956 featured our most extensive effort to date in terms of field work, core drilling and metallurgical testing of the Marquette Range low grade ore possibilities. Reserves for beneficiation by the magnetic oxide conversion process, with or without subsequent Amine flotation, were investigated.

Drilling was conducted at the Belleview, Cascade East-End, New Richmond, Tilden Fire Tower and Tilden West areas. Results were classified employing a new system, namely;

a. Class A

Material yielding 9% silica or less in the concentrate.

b. Class B

Material yielding from 9% to 15% silica in the concentrate.

c. Class C

Material yielding in excess of 15% silica in the concentrate.

5. Mine Subsidence

A system of triangulation of the source of rock noises by the microseismic technique was developed in cooperation with the U. S. Bureau of Mines and the Michigan College of Mining and Technology.

Extensive experiments were conducted employing the reflection seismic technique from surface to detect the position of a mine void. This was a joint project between Cliffs and Michigan College of Mining and Technology.

6. Research in Exploration Techniques

During the year 1956, progress was made in the field of research in exploration techniques.

a. Minnesota Open Pits

Mr. E. R. Randolph conducted preliminary investigations applying the EM and refraction seismic techniques to the open pit properties in Minnesota. These studies suggest direct indications of ore possibly by the application of these techniques. Additional work is planned for 1957.

b. Airborne Electromagnetic Induction

Our success in applying the ground EM has led us to consider airborne EM. Two differing systems were used in our Canadian Exploration during the year. Indications are that it will be employed more extensively in the future.

c. Diamond Drill Research

A program of research of diamond drilling was conducted at the Holman-Cliffs Mine in Minnesota using our new Joy 225 truck-mounted drill, with both air and mud as the cutting media and a variety of core barrels.

I. STAFF

A. Distribution

As in the past, Ishpeming continued to be the headquarters and base from which the Company's exploration activities operated, not only for Michigan, but for the other geographical areas. Minnesota exploration headquarters have been at the Hibbing Office, while Canada centered around our Canadian Cliffs office at Port Arthur, Ontario.

The Company's exploration activities increased in the year 1956 as compared with the year 1954 and 1955. The number of staff members in the Department was increased as is shown in Table I.

Mr. Burton H. Boyum continued as Chief Geologist, supervising the Company's exploration activities. While continuing emphasis on Michigan matters, considerable time was spent on program emphasis and on visits to the other areas in Minnesota, U. S. General and Canada.

Mr. Gerald J. Anderson continued as Michigan District Geologist co-ordinating Michigan drilling activities. During the last half of the year, Mr. Roy W. Hillmer was employed as Drilling Engineer. This will make a great difference in 1957 toward assisting Mr. Anderson in the supervision of the Drilling Division. The addition of Mr. Jack K. Nease as Assistant Diamond Drill Clerk, was also a valuable addition. Mr. Marvin Toivonen was added as Drill Foreman in anticipation of the retirement of Mr. Swante Merrila.

The Michigan Geologists may be considered in two groups, the men assigned to the operating properties and those on exploration projects. Four underground mine geologists and one open pit geologist constitute our staff at the operating mines. During the year 1956, Mr. Ted Engel took the place of Mr. Joseph L. Patrick, Mr. Paul R. Bluekamp replaced Mr. Bruno J. Haas, Mr. Lee Erickson replaced Mr. Gordon E. Frantti, and Mr. James W. Villar was added as the open pit geologist. When Mr. E. Richard Randolph was transferred to Minnesota, Mr. Donald R. Lukkari replaced him on the Michigan staff. Mr. Robert W. Riedel continued his work on the Cameo Project.

Mr. E. Richard Randolph moved to Minnesota in June to become the Minnesota Resident Geologist, a position which has been vacant since 1954 when Mr. Rolland L. Blake obtained a leave of absence for advance study.

Mr. Eric J. Rex, Project Supervisor, had started the year on U. S. General activities, but was transferred to our Canadian work in March. He continued on this the rest of the year. The U. S. General work was carried on by Mr. Boyum, assisted by Mr. E. Rufus Rantala on loan from the Engineering Department at the Hibbing office, and Dr. J. S. Sumner, Consultant.

Dr. Melville W. Bartley continued as Resident Manager for Canadian Cliffs, Ltd. with headquarters at Port Arthur, Ontario. He was assisted by Dr. James M. Neilson, Geological Consultant, together with Mr. Eric J. Rex, Project Supervisor, mentioned above. Mr. Walter R. Sutton was added to the staff in May, 1956.

TABLE I

GEOLOGICAL DEPARTMENT

Burton H. Boyum, Chief Geologist

MICHIGAN

Gerald J. Anderson, Michigan District Geologist

EXPLORATION DRILLING DIVISION

Gerald J. Anderson, Supervisor
Roy W. Hillmer, Drilling Engineer (A)
Swante Merrila, Foreman
Carl Ostlund, Foreman
Alvin Nelson, Foreman
Marvin Toivonen (B)
Eino O. Kujala, Diamond Drill Clerk
Jack Nease, Ass't. Diamond Drill Clerk (C)

TEMPORARY PERSONNEL

Neil H. Black, Geologist (L)
Jen-Ho Fang, Geologist
Robert E. Goodrich, Geologist
Thomas L. Longacre, Geologist
Robert H. Mount, Geologist
Keith C. Roberts, Geologist
Robert M. Steder, Geologist
Donald F. Anderson, Field Assistant
David H. Anderzon, Field Assistant
George M. DeRoche, Field Assistant
Roger R. Hall, Field Assistant
Dawson P. Hansen, Field Assistant
Robert W. Herman, Field Assistant
Roy A. Koskie, Field Assistant
Ted R. Larimer, Field Assistant
Douglas K. Pohlman, Field Assistant

GEOLOGISTS

Paul R. Bluekamp (D)
Ted Engel, Jr. (E)
Lee Erickson (F)
Gordon E. Frantti (G)
Bruno J. Haas (H)
Donald R. Lukkari (I)
James P. Meyers
E. Richard Randolph (J)
Robert W. Riedel
James W. Villar (K)

TECHNICIANS

Robert W. Ryan
Ronald C. Foisie

DRAFTSMEN

Gideon S. Johnson
John V. Larson
Donald R. Nankervis

SECRETARIAL

Mrs. Belle Bloch, Office Secretary
Miss Klara Marie Hult

MICROSCOPY

Tsu-Ming Han

MINNESOTA

E. Richard Randolph, Minnesota Geologist (J)
Maurice Comstock, Geological Helper

Donald Goodrich, Temporary Geologist
Douglas Trask, Field Assistant

U. S. GENERAL AND FOREIGN

Eric J. Rex, Project Supervisor

Dr. M. W. Bartley, Resident Manager, Canadian Cliffs Ltd.
Dr. James M. Neilson, Consultant, Canada
Walter R. Sutton

Dr. John S. Sumner, Consultant, U. S. General

TABLE I CONT'D

(A) Started July 30, 1956
(B) Became Acting Foreman, May, 1956
(C) Started February 7, 1956
(D) Started February 23, 1956
(E) Started January 16, 1956
(F) Started December 17, 1956
(G) Resigned September 14, 1956
(H) Resigned March 30, 1956
(I) Started April 18, 1956
(J) Transferred to Minnesota May 15, 1956
(K) Started June 18, 1956
(L) Worked at Ishpeming Office as Exploration Geologist on Orientation and Training Program. Began January 16, 1956. Left May 15, 1956

B. Man-Hour Summary

The following Table II is the hourly rate personnel carried on the General Storehouse payroll as members of the Exploration Drilling Department:

TABLE II

DISPOSITION OF HOURLY RATE PERSONNEL
GENERAL STOREHOUSE PAYROLL

Total Days Worked (5 Day Week)	-	229
Saturdays & Sundays	-	105
Holidays	-	6
Days lost due to strike, etc.	-	26
Total		366

Description	Total No. of Men	New Hire	Separations	Total Hours Worked	Statistical Men	Labor Cost
Runners	28	-	-	50,092-3/4	26.76	$ 125,978.01
Helpers	34	34	15	61,833	33.03	131,748.79
Total	62	34	15	111,925-3/4	59.79	$ 257,726.80

Table III shown below is a recapitulation of the various components of the Exploration staff:

TABLE III

MAN-HOUR SUMMARY

MICHIGAN

Geological (Account 426)	Men	Hours	Dollars
Permanent	19	28,965	$ 84,937.06 *
Temporary	16	8,464	20,133.03
Sub-Total	35	37,429	$105,070.09
Drilling Division (Account 435) (Does not include contract labor)			
Labor	62	111,925-3/4	$257,726.80
Supervisors and Clerks	7	12,560	30,530.87
Sub-Total	69	124,485-3/4	$288,257.67
Total	104	161,914.75	$393,327.76

TABLE III (CONT'D)

	Men	Hours	Dollars
Total for Michigan Brought Forward	104	161,914.75	$ 393,327.76
MINNESOTA (Account 326)			
Permanent	2	1,773)	$ 7,792.61 *
Temporary	2	1,040)	
Sub-Total	4	2,813	$ 7,792.61
Foremen (Assisting during strike)	5	600°	2,400.00°
Total	9	3,413	$ 10,192.61
U. S. GENERAL AND FOREIGN (Account 436)			
Western States Permanent	2	1,948°	9,100.00 *°
Temporary	2	2,065°	5,550.00 °
Sub-Total	4	4,013	14,650.00 °
Canada			
General	6	8,760°	30,082.18 *
Project 17	18	26,010°	43,112.08 *
Sub-Total	24	34,770	73,194.26
Total	28	38,783	$ 87,844.26
GRAND TOTAL	141	204,110.75	$491,364.63

* Includes pro-rated share of Burton H. Boyum's time.
° Estimated

The following tabulation, Table IV, shows the distribution of the professional members of the Geological Department by projects, during part or all of 1956:

TABLE IV

DISTRIBUTION OF PROFESSIONAL EXPLORATION STAFF
DURING PART OR ALL OF 1956

MICHIGAN

Operating Mines

Bunker Hill Group.....Ted Engel, Jr.
Cambria-Jackson.....Paul R. Bluekamp
Cliffs-Shaft.....James P. Meyers
Mather Mine "A" Shaft.....Gordon E. Frantti and Lee Erickson
Mather Mine "B" Shaft.....Paul R. Bluekamp
Humboldt.....James W. Villar
Ohio.....James W. Villar
Republic.....James W. Villar
Tilden.....James W. Villar

TABLE IV (CONT'D)

Exploration Projects

Belleview	Neil Black and Donald R. Lukkari
Cascade East End	Donald R. Lukkari
New Richmond	Donald R. Lukkari
Section 4, 47-27	James P. Meyers
Section 10, 47-27	James P. Meyers
Tilden Fire Tower	Donald R. Lukkari
Tilden West	Donald R. Lukkari
Humboldt	James W. Villar
Osier	Robert W. Riedel
Perkins	Robert W. Riedel
Trenary	Robert W. Riedel
Rock	Robert W. Riedel
East Central U. P. (Cameo Project)	Robert W. Riedel

II. GEOLOGICAL AND GEOPHYSICAL FIELD WORK

A. Michigan

1. Negaunee District - Donald R. Lukkari, Geologist

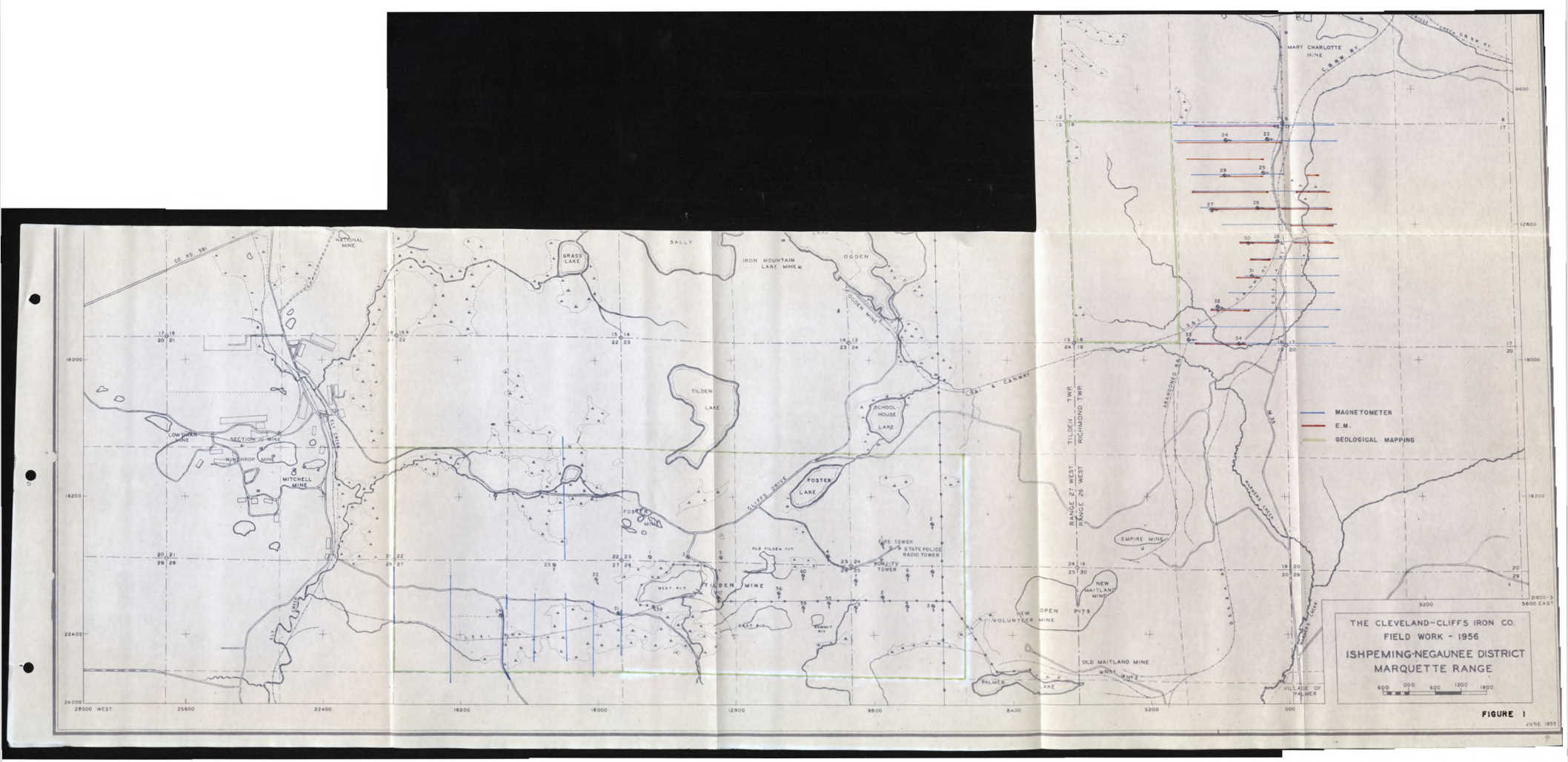
a. Belleview - Geological and geophysical mapping, drilling, and metallurgical testing of the drill core were conducted on the Belleview during 1956. Mr. Neil H. Black performed the geophysical work while on loan from Canadian Cliffs. The drill holes were spotted from his interpretations, combined with existing information. A total of 14,400 feet of EM traverse was run with 163 stations being occupied. A superdip survey covered 28,800 feet of line and occupied 292 stations.

One field crew consisting of Keith C. Roberts, geologist, and Roy A. Koski, field assistant, did geological mapping and surface sampling in the West 1/2 of Section 18. Approximately one month was spent building access roads, running four miles of sundial lines, sampling the iron-formation outcrops, and completing the maps and reports. Figure 1 shows the area that was mapped and indicates the lines on which geophysical work was conducted. A breakdown of the cost of the field work was as follows:

Geophysics	$ 2,543.19
Geology	$ 2,789.82
Engineering	$ 2,430.06

2. Eagle Mills District - R. W. Riedel, Geologist

During the early spring, a refraction seismic survey was undertaken on the Ore Improvement Plant site to determine the water table and bedrock characteristics underlying the general area. This area consisted of some 175 acres in Sections 2, 47-26, and 35, 48-26, between the Carp River and the L.S.&I. tracks. The area was traversed with 7 north-south lines and approximately 21 separate geophone spreads were utilized along these lines. Shots and subsequent depth determinations were made at each end and in the center of most of these spreads. In this manner the data yielded 49 points at which the elevation of the water table and ledge was determined. This information correlated with the known ledge elevations from the existing outcrops and the known water table elevations from the river, swamps, and shot-hole encounters yielded sufficient information for the purpose of the project.


MAGNETOMETER
E.M.
GEOLOGICAL MAPPING
THE CLEVELAND-CLIFFS IRON CO.
FIELD WORK - 1956
ISHPEMING-NEGAUNEE DISTRICT
MARQUETTE RANGE
600 000 600 1200 1800
FIGURE 1
JUNE 1955
MARY CHARLOTTE MINE
NATIONAL MINE
GRASS LAKE
SALLY
IRON MOUNTAIN LAKE MINE
OGDEN
TILDEN MINE
TILDEN LAKE
SCHOOL HOUSE LAKE
FOSTER LAKE
FOSTER MINE
CLIFFS DRIVE
LOWTHER MINE
SECTION 22 MINE
WINTHROP MINE
MITCHELL MINE
OLD TILDEN PIT
WEST PIT
EAST PIT
SUMMIT PIT
LAKE TOWER & STATE POLICE RADIO TOWER
WMBH-TV TOWER
EMPIRE MINE
NEW MAITLAND MINE
NEW VOLUNTEER OPEN PITS
OLD MAITLAND MINE
PALMER LAKE
VILLAGE OF PALMER
TILDEN TWP
RICHMOND TWP
RANGE 27 WEST
RANGE 26 WEST
ABANDONED R.R.
C.&W. R.Y.
D.S.S.&A. R.R.
WARREN CREEK
28000 WEST
25600
22400
19200
16000
12800
9600
8400
3200
000
5600 EAST

3. Cascade District - Donald R. Lukkari, Geologist

a. Cascade East End - Only a slight amount of field work was conducted in the Cascade East End. About 1½ days were spent laying out two shallow holes for the wagon-mounted drill to test for high grade ore at surface which was hit in Hole #40. A bulldozer was employed to dig test pits which were sampled and used to determine strike and dip. No ore was found.

b. New Richmond - A field crew consisting of Robert E. Goodrich, geologist, and George M. DeRoche, field assistant, conducted detailed geologic mapping and metallurgical sampling in the New Richmond Pit. The mapping was done with plane table and alidade at the scale of 1" = 50'. A total of 17 fifty pound channel samples was taken at regular intervals at the face of the benches. The metallurgical results of these samples will undoubtedly play an important part in the final analysis of the New Richmond Pit as a low grade metallurgical property. Approximately three weeks were consumed at a cost of $543.75.

4. Tilden Area - Donald R. Lukkari, Geologist

A total of three field parties worked in the Tilden Area during the summer of 1956. The parties and hours worked were as follows:

Party #1	Robert E. Goodrich, Geologist George M. DeRoche, Field Assistant	372 hours
Party #2	Keith C. Roberts, Geologist Roy A. Koski, Field Assistant	232 hours
Party #3	Robert M. Steder, Geologist Ted R. Larimer, Field Assistant	152 hours

An area covering 2½ square miles was geologically mapped and surface sampled. This area includes parts of Sections 22, 23, 24, 25, 26, and 27, as noted on Figure 1. In addition, the old Foster Mine pits were sampled in detail and 3½ miles of magnetometer survey were run. A breakdown of the cost of this work was as follows:

Geology	$ 2,982.88
Geophysics	$ 623.94
Engineering	$ 4,724.31

5. East Central Upper Peninsula (Cameo Project) - Robert W. Riedel, Party Chief

Exploration continued in this area throughout 1956 with both geophysical prospecting and diamond drilling based on this geophysical work. The geophysical tools used consisted of the vertical intensity magnetometer, the static gravimeter, the McPhar ground electromagnetic induction (EM) technique, and the reflection and refraction seismograph. The Cameo Project is divided into areas on the basis of each being a more or less separate region displaying anomalous aeromagnetics.

The geophysical field procedure in each area was generally the same, e.i. ground magnetics to pinpoint the magnetic anomaly and gain additional information of its size and shape; regional gravity to determine the regional gradient and general geologic setting and detailed gravity over selected magnetic traverses to yield the residual gravity anomaly associated with the magnetic anomaly; ground EM in an attempt to trace contacts or

conductive zones for drilling targets or horizon markers; possibly refraction seismic determinations of glacial overburden thickness as a factor in drill hole location plus bedrock information; and reflection seismic attempts to determine the depth to the Pre-Cambrian surface. This field work was accomplished by a permanent three-man crew, augmented by four two-man geophysical crews plus one additional two-man engineering crew during the summer field season, and a consultant geophysicist with helper for three field days in the fall field season.

Of the above techniques used or experimented with, two did not accomplish the tasks to which they were set - the McPhar ground EM unit and the High-Resolution reflection seismic equipment of Houston Technical Laboratory. The EM failed probably because of either the lack of good geologic electric conductors within its range or because the conductors were so deep that the resultant electromagnetic field contained too small a proportion of the secondary field from the conductor as compared to the primary field. The HR reflection seismograph failed in its attempt to obtain reflections from the Pre-Cambrian surface most probably because of excessive energy attenuation and dispersion, and multiple "reverberations" of reflected impulses within the intervening Paleozoic units until the signal was lost. These two techniques did not work in the areas tried (East Rock and South Sturgeon) because of the adverse geologic situations and through no fault or inherent weakness of the techniques - they are still valid valuable tools where physical conditions permit their utilization.

The physical characteristics of the Perkins, Rock, and Osier, areas were described in the 1955 Annual Report. Field work in other areas of the Cameo Project have disclosed the following physical characteristics as measured in the field.

a. Trenary, O.E. 1159 (E & A, CC-833)

Low (+200 to +1000 gammas) magnetic anomalies are seen to strike through the area in a general northwest-southeast direction and have no associated gravity expression, though a major gravity high lies to the south between Trenary and Osier.

b. Rapid River, O.E. 1162

One major moderate to high (+1,000 to +12,000 gammas) magnetic anomaly strikes east-west through this area with gravity anomalies of up to 2.95 mgals associated with the magnetic highs. This anomaly is continuous and regular, not interrupted or broken up; it therefore looks promising.

c. Gladstone-Cornell (O.E. 1160, E & A, CC-834)

This area contains several generally east-west anomalies which are not as continuous as the Rapid River one. The magnetic anomaly maximum is more intense being about +19,000 gammas and the gravity anomaly associated with it about 1.8 mgals as near as can be determined at present.

d. South Sturgeon-Indian Lake, O.E. 1164,(E & A, CC-832)

This is a large area and contains several anomalous areas which are somewhat different.

1. Elkhorn - This area is the center of two parallel anomalies with magnetic expression up to +10,000 gammas and associated gravity anomalies of up to 2.0 mgals.

2. Cooks - West and south of Elkhorn the major anomaly at Elkhorn and two associated anomalies reach another area of a maximum. Here the magnetic intensity is about +12,000 gammas with a gravity expression of as high as 4.2 mgals.

3. Sturgeon River - Near the intersection of the Sturgeon River and Federal Forest Highway 13, a magnetic high of about +12,000 gammas exists with a gravity high of some 1.5 mgals. This maximum lies between and along the general strike of the Elkhorn-Cooks anomaly and the Rapid River anomaly, it can be traced from the Cooks area westward to this maximum.

e. North Sturgeon, O.E. 1163

This anomaly differs from all the rest in the Cameo Project in having a strike of northeast-southwest, its magnetic expression is fairly high, about +13,000 gammas, but quite restricted in length and no gravity work has been done on it as yet.

f. Ford River-Escanaba, O.E. 1165

This area contains three parallel east-west anomalies of up to +11,000 gammas and 1.5-2.0 mgals and are believed to be outliers from the eastward extension of the Old Menominee Iron Range. Old diamond drilling in the Escanaba area, in two places on these anomalies, have cut and sampled hematitic cherty iron-formation.

A recap of the geophysical activity on the Cameo Project for the two major tools appears as follows:

Area	Miles of Magnetometer Traverse	No. of Magnetometer Stations	Avg.Sta. Density per Mile	Miles of Gravity Traverse	No. of Gravity Stations	Avg. Sta. Density per Mile
Rock	13.0	396	30.5	4.0	175	43.8
Osier	4.75	187	39.4	1.75	56	32.0
Rapid River	25.75	755	29.3	14.50	503	34.7
South Sturgeon-Indian Lake	26.5	799	30.2	34.40	756	22.0
Trenary	24.50	285	11.6	37.75	375	9.9
Gladstone-Cornell	22.0	691	31.4	16.5	475	28.8
North Sturgeon	2.0	65	32.5	-	-	-
Stongton	5.0	50	10.0	18.0	163	9.1
Ford River-Escanaba	9.75	183	18.8	15.75	361	22.9
Totals	133.25	3411	25.6	142.65	2864	20.1

The thickness of the Paleozoic section in the Perkins-Rock-Osier area was approximately 400' to 500'. From present information and calculations based on current geophysical data, it is fairly evident that the section thickens to the south to some 500' to 700' in the Rapid River-Cornell-Escanaba area, and probably to as much as 1500' to 2000' to the east in the neighborhood of Cooks.

B. Minnesota

1. General

Mr. E. Richard Randolph was transferred to the Hibbing office as Minnesota Resident Geologist as of June 15th.

Temporary summer personnel included Mr. Donald Goodrich, geologist of Michigan State University, and Mr. Douglas Trask, compassman, of the University of Minnesota. These men were employed to conduct the field work on the Holding, Trask, and Barlow land offers. They left after thirteen weeks of service to return to school.

Mr. Maurice Comstock was engaged on October 8th as geologist's helper, working out of the Hibbing office.

Throughout the year, Mr. B. H. Boyum, Chief Geologist, visited the Minnesota offices and field locations in connection with the exploration program.

Use was made of five foremen during the strike period to cut lines for the geophysical work in the Barlow and Trask areas.

2. Mesabi Range

Field work was conducted on the Holding, Trask, and Barlow land offers, as well as lands adjoining these properties, figures 2 and 3. Pertinent data is included for the respective land offer wherever it adjoins the main area.

Two days were spent on the Holding Company property in Sec. 9, 55-25, cutting 3000 feet of line and running them with EM. No further drilling was recommended after this work. Its cost was approximately $45.00.

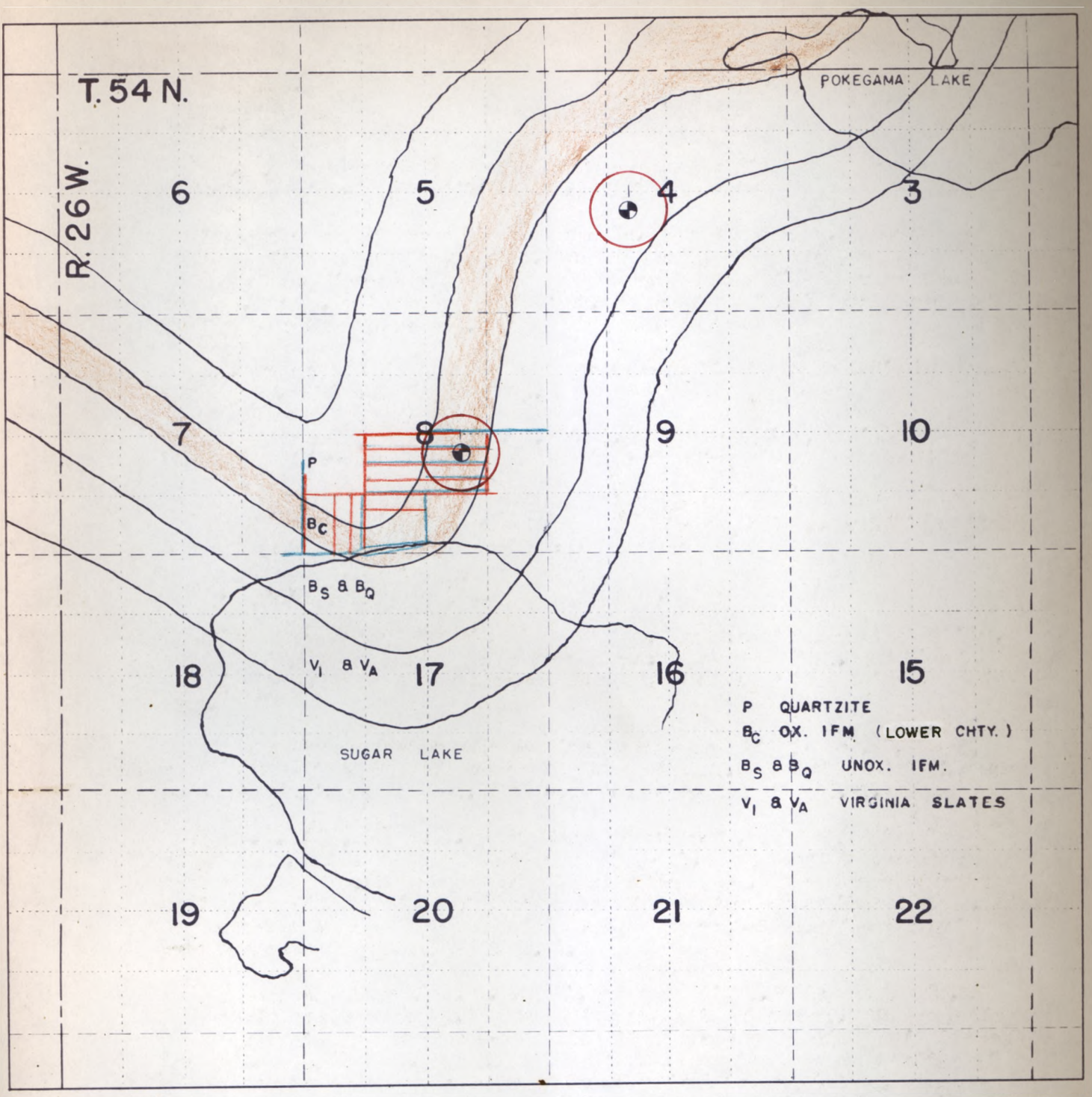
On L.O. 2918, the E. L. Trask Corporation lands, (and adjoining land offers 2934, 2928, 2935, and 2945 as well) - 21,200 feet of EM traverses were made, and 14,600 feet of magnetometer traverses. The EM proved very useful in spotting drill holes so as to drill minimum of useless footage. The magnetics were not conclusive in their interpretation. The cost of this work was approximately $1400.00.

The Barlow Exploration, L.O. 2932, consumed $1700.00 in running 29,040 feet of EM traverse and 22,900 feet of magnetometer traverse. The magnetics located and outlined over one-half mile of cretaceous material 300' wide and 15-35 ft. in thickness. The EM interpretation requires severe faulting of the entire formation, which opposes the classical interpretation, based on two drill holes, of a smooth bending of the iron-formation from a southerly strike to a northwesterly strike. Neither interpretation has been proven or disproven.

3. O.E. 1107 - Northeastern Itasca County

This area is one of many magnetic anomalies located in past years ago by dip needle, and recently more completely by a joint Federal-State aeromagnetic survey. Previous Cliffs' work has been in reconnaissance both magnetically and geologically.

During 1956, this information was brought up-to-date and groundwork was laid for expanding the program. Ownerships were established, and the survey control work was followed in the area selected for our initial drilling campaign. One line, 3/4 mile in length, was cut for magnetic prospecting to supplement lines cut by the County Engineers for survey control work. The total cost was $439.39.



BARLOW REALTY CO. EXPLORATION

L.O. 2932

0 1/4 1/2 3/4 MILES

EXPLORATION DRILL HOLE

E.M. TRAVERSE

MAGNETOMETER TRAVERSE

GEOLOGY BY D. A. WHITE 1953

M.E.C. 1956

FIGURE 2

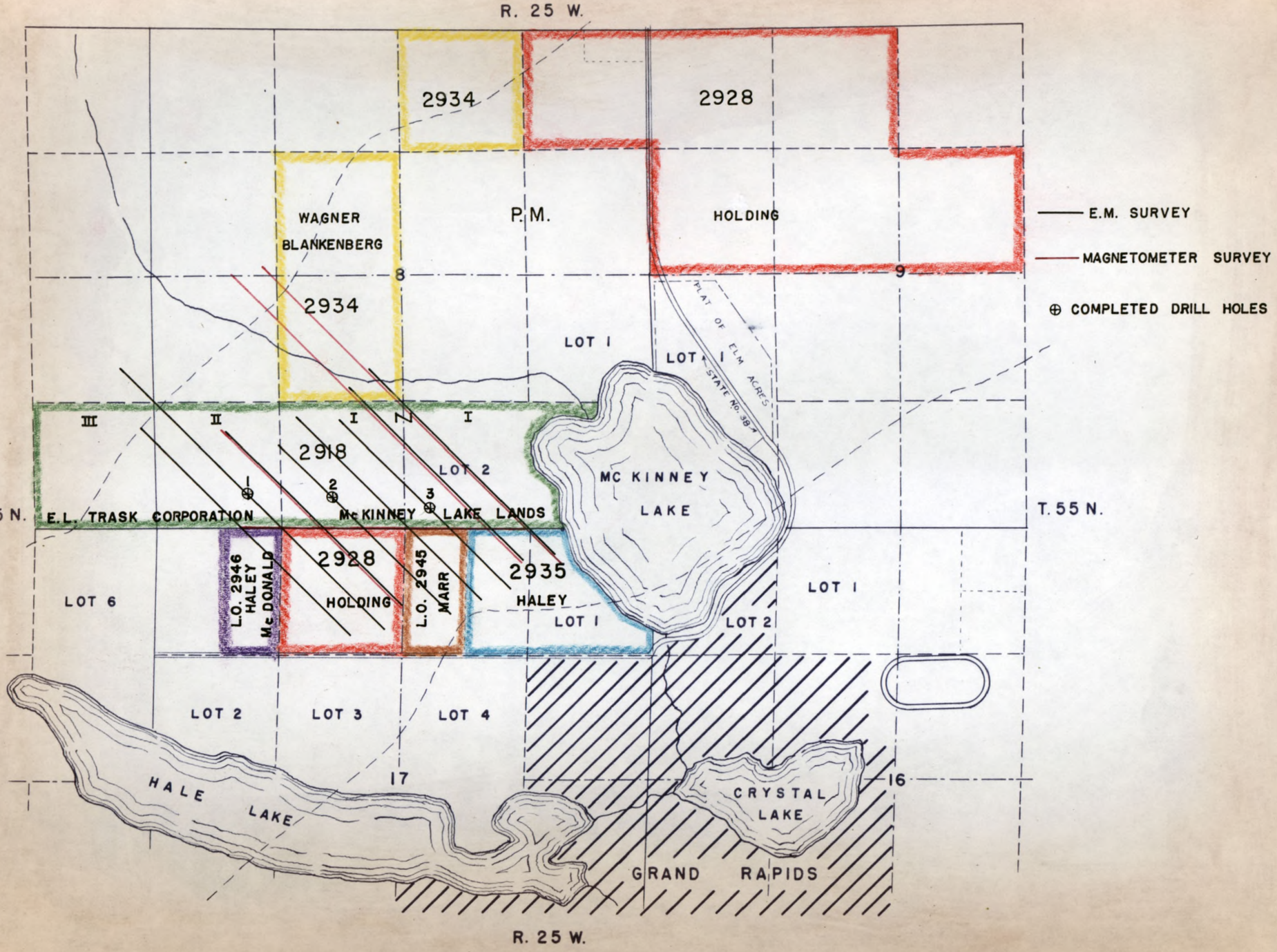

R. 25 W.
2934
2928
WAGNER
BLANKENBERG
P.M.
HOLDING
E.M. SURVEY
MAGNETOMETER SURVEY
COMPLETED DRILL HOLES
8
9
2934
LOT 1
LOT 1
PLAT OF ELM ACRES
STATE No. 387
III
II
I
I
I
2918
LOT 2
MC KINNEY
LAKE
T. 55 N.
E.L. TRASK CORPORATION
McKINNEY LAKE LANDS
T. 55 N.
L.O. 2946
HALEY
McDONALD
2928
HOLDING
L.O. 2945
MARR
2935
HALEY
LOT 6
LOT 1
LOT 2
LOT 1
LOT 2
LOT 3
LOT 4
17
16
HALE
LAKE
CRYSTAL
LAKE
GRAND RAPIDS
R. 25 W.

FIGURE 3

4. O.E. 1111 - East Central Minnesota

Two magnetometer survey lines, totaling 1½ miles, were run in the vicinity of L.O. 2954. Considerable land is available in this area if a favorable degree of enrichment can be found in the iron-formation. The cost of magnetics was $61.55 and the total cost of this work on L.O. 2954 was $207.00.

5. Vermilion Range

L.O. 2957, from Haley-Young, was investigated with 1-1/4 miles of magnetometer and geological traverses. The area was not found to be favorably endowed. Total cost of this reconnaissance was $96.62.

C. United States General

Section VI of this Annual Report covers the general subject of Land Offers and Outside Explorations.

This portion of the Annual Report covers the geological and geophysical field work which was done on U. S. General Land Offers during the year 1956. Some of these Land Offers were carried over from the year 1955 while others were originated during the year. Land Offers on which no field work was done are not included in this summary. At the beginning of the year, Mr. Rex was engaged in the investigation of the U. S. General Land Offers. It appeared that there would not be a significant U. S. General program for the balance of the year; hence, Mr. Rex transferred as Project Supervisor for the staking and subsequent summer exploration of the Albanel Project. In May, the U. S. General program had been re-activated and for the balance of the year, actual field work was conducted by a variety of persons including Gordon Frantti, Robert Riedel, and Burton Boyum. Mr. E. Rufus Rantala was transferred from the Minnesota Engineering Department to the Western exploration as Resident Supervisor. Also during the year, Dr. John S. Sumner was engaged as part-time consultant. In summary, it may be said that after a relatively slow start for the year, the net result was a greater amount of field investigation than had been pursued in previous years.

For those Land Offers on which drilling was conducted, additional details are contained in Part IV, C, of this report.

1. California

a. L.O. 3613, Bessemer Iron - The investigation of the Bessemer Iron Claims, L.O. 3613, was our initial effort in San Bernardino County, California. The work consisted of mapping, sampling, and ground superdip prospecting of this known mineral occurrence, and its possible extension. This work was terminated because of legal complications arising out of action of Kaiser Steel Corporation.

b. L.O. 3635, Southern Pacific Railway - An understanding was reached with the Mineral Department of the Southern Pacific Railway for the lands which they held adjacent to L.O. 3613 mentioned above. Field work was confined to superdip traversing. Reference is made in Part IV to the drilling conducted on these lands.

c. L.O. 3636, Nancy Group Claims - This group of claims was staked by The Cleveland-Cliffs Iron Company personnel following the airborne magnetic reconnaissance of this portion of San Bernardino County. Field work consisted of preliminary reconnaissance of the outcrop area, together with some random ground magnetic traverses. The project was abandoned following the unsuccessful drilling.

d. O.E. 1188, San Bernardino County Aeromagnetics - Portions of San Bernardino County were prospected by aeromagnetic means in both May and November. This work was done by the Fairchild Aero Survey Company of Los Angeles. The following table summarizes the cost and extent of this work:

May - 170 lineal miles	$ 2,011.00	$ 11.82 per line mile
November - 1337.5 lineal miles	$ 9,500.00	$ 7.11 per line mile

Additional anomalies were disclosed by this survey and it is recommended that these be followed in the year 1957.

2. Montana

a. L.O. 3581, Dewey Whittaker Claims, Judith Basin County - The field work on the Dewey Whittaker claims in the Willow Creek Area, Judith Basin County, near Stanford, Montana, was begun on May 1, 1956, and continued along with other work in the area until September 22nd. During this time the ground survey control was set up, and geophysical work was conducted in the way of ground superdip traversing. Twenty-one cross-sections, approximately 300' long with stations 20' apart, were made. The stripped area and the area of the trenches was mapped.

b. L.O. 3634, Norman Whittaker Claims, Judith Basin County - This Land Offer includes a variety of claims adjacent to, but not contiguous with, Land Offer 3581, Dewey Whittaker claims. Various claim groups are held by Mr. Norman Whittaker and his associates. Geologic reconnaissance and some geophysical traversing was done on a number of claims held by this group. In particular, emphasis was placed on the Iron King "N" Claim which is in the Running Wolf Creek area. Thirteen cross-sections were laid out, surveyed, and traversed with the superdip. This work was discontinued in the fall of the year.

c. L.O. 3603 and 3604, Eklund, Pahl and Albright respectively, Judith Basin County - These Land Offers include various claims in the Judith Basin County area in the vicinity of the two land offers described above. During the summer, Mr. Rufus Rantala and his field assistant, Mr. Ed. Hall, reconnoitered these claims, doing some mapping and sampling. Numerous short superdip traverses were made. It was concluded by Mr. Rantala that there was not a sufficient promise to these claims to warrant any more work.

d. L.O. 3638, Belt Park - This area was scouted by Mr. Rantala and later by Messrs. B. H. Boyum and W. A. Pakkala.

e. O.E. 1186 and 1187, Cascade County - Mr. Rantala prospected this general area and it is planned that additional work will be done there during the 1957 season.

3. Idaho

a. L.O. 3585, Ausich Iron, Mackay, Idaho - This is an area of former mining for copper. Some time was spent in the field reconciling the survey data with old mine records and maps. In addition, 15 cross-sections were established and traversed with the superdip. It is planned to continue this work during the 1957 season.

b. L.O. 3602 - A reconnaissance visit was made to this deposit by Messrs. Riedel and Rantala to determine the advisability of further geologic investigation. The deposit was not thoroughly examined. One sample was taken of the richest material. More extensive reconnaissance is planned for the year 1957.

c. O.E. 1190, McKim Creek, Idaho - These claims are south of Salmon and contain occurrences of high-grade hematite and magnetite. Examination by Mr. Riedel indicated that mineralizations were thin veins as fracture fillings. Since it did not constitute a mineable ore deposit, this Outside Exploration was abandoned.

4. Colorado

L.O. 3649, Blancha Trinchera Ranch, Costilla County - This is a magmatic segregation of magnetite and ilmenite. It was reconnoitered by Mr. Riedel. He conducted reconnaissance mapping and sampling, and examined the previous geophysical work which had been done for the owners. On the basis of the work done by him, this Land Offer has been declined.

5. Arkansas

L.O. 3629, Baxter County - Mr. Riedel visited this area and found minor occurrences of hematite and goethite within the weathered topsoil. His mapping and sampling indicated that the tonnage was limited and therefore the Land Offer was declined.

6. Utah

L.O. 3639, Marysvale - This deposit was visited by Dr. John S. Sumner. He conducted some mapping and sampling, and concluded that the mineralization was not sufficiently extensive to warrant additional investigation.

D. Canada - Canadian Cliffs, Ltd.

The Canadian Cliffs staff consists of the Resident Manager-Dr. M. W. Bartley, Chief Clerk-Mr. Les Dack, and Mr. W. R. Sutton, who are retained on an annual basis. Dr. Bartley and Mr. Dack are residents in Port Arthur, and Mr. Sutton, formerly Field Engineer for M. J. O'Brien, Ltd., was hired during the spring, and is a resident at Ottawa. Liaison with Cleveland-Cliffs is provided through Mr. Burton H. Boyum, Chief Geologist. Mr. Burton Boyum is concerned chiefly with matters pertaining to exploration emphasis and finances. Canadian Cliffs, Ltd., engaged Mr. E. J. Rex of Cleveland-Cliffs as Project Supervisor on the Albanel Project from March through December. Dr. J. M. Neilson, Geological Consultant, was engaged for summer exploration in Eastern Canada. Other personnel were engaged at various times on a temporary basis for specific projects.

1. Project 17, Albanel Area, Mistassini Territory of Quebec - Early in 1956, Cliffs and M. J. O'Brien, Ltd., agreed to make their Albanel holdings joint. M. J. O'Brien, Ltd., had flown the Albanel area with aeromagnetics searching for anomalies outside of the areas previously staked by both Canadian Cliffs and M. J. O'Brien, Ltd. Early in April, a party of 13 men, supervised by Mr. Rex, staked 250 claims in the Albanel area.

In the middle of June, the summer exploration was begun with the flying in of personnel, supplies, and drilling equipment. The technical men were made up of geologists and their assistants, geophysicists and their assistants, and plane survey crews. Preliminary geology and geophysics mapping was done on about 260 claims during the summer.

During the late summer and early fall, aeromagnetic lines were flown in areas extending northeast and southwest from the current Albanel area. Some experimental electromagnetic lines were flown over the Albanel area for the purpose of determining the value of airborne EM in the search for extensions of the iron-formation found in the Albanel area.

2. L.O. 3190-C, McChesney Claims, Nipissing District, Ontario - A group of claims near the west shore of Lake Temiscaming was investigated by Canadian Cliffs personnel. Aeromagnetic traverses and airborne EM traverses were made over the area testing for possible extensions of the iron rich materials in these claims. Plans have been made for the investigation of anomalies in the airborne magnetics and airborne EM work during 1957.

III. MICHIGAN DRILLING DIVISION - Gerald J. Anderson, Supervisor
Roy W. Hillmer, Drilling Engineer

A. General Highlights

The main objective during the year was to combat drilling costs. Detailed studies were made on the use of various types of bits. Several types of bits were submitted by the manufacturers in an attempt to find the right bit for the right job.

The new equipment items which were of major importance during the year were the Joy 225A, a truck mounted rotary drill; new sources for core barrels and casing; a heavy duty maintenance and supply truck; and more efficient means and methods of winter operations.

1. Joy 225A, Truck Mounted Rotary Drill

In May, the Joy 225A was delivered to the Diamond Drill Department. This is a self-contained mobile drill rig that is readily adaptable to air, mud, or water drilling and suitable for diamond or rotary tricone bits. The advantage of such a rig is in the case of setup and flexibility in moving.

This rig has already shown many variable uses. As an example, in September, this rig was sent to Minnesota to do experimental drilling in an attempt to solve the basic drilling problems--i.e. coring the wash ore type structures. This rig was used, not because it was the only type of rig that could be used, but because of its features that adapt it to experimental drilling work. These features are as follows: (a) mobility, (b) ease of setup, (c) hydraulic control, (d) adaptability to instrumentation, (e) sufficient weight and ruggedness for tricone drilling.

2. Core Barrels

The major portion of the department's core barrels are now being supplied by the Christensen Diamond Products Company. A considerable savings is made by purchasing the double rigid tubes from this company. Some difficulty was experienced with these barrels, there was considerable head failure. Christensen Diamond Products readily rectified this problem and to date it appears as though these barrels will be satisfactory. The unit savings represented by this use is $29.60 on the NX barrels, and $20.75 on the BX barrels.

3. Casing

The present system in the purchasing of 4 inch flush joint casing is to purchase the tubing separately and have the threads cut by the Bronson Machine Company. In the past, the E. J. Longyear Company has been supplying the completed casing. By purchasing the tubing and having it machined, the cost of this casing has been reduced by one half.

4. Heavy Duty Truck

In December, the E & A, CC-861 was approved for the purchase of a six ton International Truck. This truck will be equipped with a dump platform, double drum winch, and "A" frame. This unit will enable the department to handle any of its drill equipment. This will expedite setup time by having a unit immediately available to handle the placing and loading of the drill unit and pumps.

5. Winter Operations

During the winter of 1956-57, the department has been able to operate without the extensive use of boiler units on the water supply lines. Studies indicate that operating costs for a boiler pump station are about $1500 a month. This includes wages for the boiler tenders, coal, and depreciation of equipment. This winter the boiler system has been replaced by bottle gas heating torches. The present estimation of winter operational costs with bottle gas is $2000.

6. Experimental Drilling

As previously mentioned, the Joy 225A was used in Minnesota, Holman Cliffs Mine, Taconite, Minnesota. All types of the conventional Michigan diamond mud drilling practices were used as well as rotary tricone drilling with air as the circulating media. The results from the bottom discharge diamond mud bit are very encouraging and indicate that this method may be a possible substitute for structure drilling. Considerably more work will have to be done along the lines of a bottom discharge bit before definitely stating that this bit will solve the basic problems involved in drilling and coring wash ore type structures.

B. Specific Details

1. Diamond Cost

The following Table V represents an analysis of the diamond bit costs at the various locations and the respective hole sizes.

TABLE V

PER FOOT COST OF DIAMOND BITS USED IN 1956
SURFACE

Name	PROJECT Sec.	T&R	Hole	AX Ft.	AX Amt.	AX Per Ft.	BX Ft.	BX Amt.	BX Per Ft.	NX Ft.	NX Amt.	NX Per Ft.	Total Footage	Total Bit Cost
Osier	18	43-21	2	-	$ -	-	170	$ 661.00	3.89	-	$ -	-	170	$ 661.00
			2a	40	126.00	3.15	1382	2609.00	1.89	-	-	-	1422	2735.00
			3	738	1224.00	1.66	1028	1654.00	1.61	711	412.00	.58	2477	3290.00
Perkins	24	42-22	1	-	-	-	336	1084.81	3.23	-	-	-	336	1084.81
Trenary	9	44-22	1	-	-	-	527	1938.20	3.68	648	706.00	1.09	1175	2644.20
Rock	4	42-23	1	-	-	-	760	1574.60	2.07	689	541.25	.79	1559	2115.85
			2	-	-	-	458	434.00	.95	740	593.00	.80	1198	1027.00
Rock	35	43-23	1	-	-	-	-	-	-	74	162.39	2.19	74	162.39
			2	-	-	-	476	919.00	1.93	765	847.00	1.11	1241	1766.00
Rock	36	43-23	1	-	-	-	-	-	-	176	363.33	2.06	176	363.33
Cascade	26	47-26	1	-	-	-	389	1257.14	3.23	95	334.75	3.52	484	1591.89
Cascade	27	47-26	38	-	-	-	1263	5938.93	4.70	-	-	-	1263	5938.93
			39	-	-	-	841	6263.10	7.45	739	7468.21	10.11	1560	13731.31
			40	383	1098.05	2.87	611	4748.05	7.77	117	218.04	1.86	1111	6064.14
			41	-	-	-	78	88.96	1.14	950	5927.48	6.24	1028	6016.44
			42	-	-	-	1375	5017.00	3.70	-	-	-	1375	5017.00
			43	-	-	-	136	451.38	3.32	-	-	-	136	451.38
			44	-	-	-	66	192.30	2.91	-	-	-	66	192.30
			47	190	268.57	1.41	352	1793.96	5.10	-	-	-	542*	2063.57
			48	-	-	-	-	-	-	1626	10830.35	6.66	1626	10830.55
Richmond	27	47-26	45	-	-	-	-	-	-	727	4929.73	6.78	727	4929.73
			46	-	-	-	-	-	-	724	4025.94	5.56	724	4025.94
			49	-	-	-	-	-	-	720	3876.96	5.38	720	3876.96
			50	-	-	-	-	-	-	675	3576.80	5.30	675	3576.80
			51	-	-	-	-	-	-	744	4669.60	6.68	744	4669.60
			52	-	-	-	-	-	-	744	4470.33	6.01	744	4470.33
			53	-	-	-	-	-	-	755	3848.07	5.10	755	3848.07
			54	-	-	-	-	-	-	1400	8320.00	5.94	1400	8320.00
			55	-	-	-	-	-	-	628	4335.00	6.90	628	4335.00
			56	-	-	-	-	-	-	702	5274.37	7.51	702	5274.37
			57	-	-	-	207	964.49	4.66	403	3584.61	8.89	610	4549.10
Mather "B"	1	47-27	167	-	-	-	-	-	-	1002	4822.18	4.82	1002	4822.18
Mather "A"	2	47-27	68	-	-	-	828	1589.62	1.92	-	-	-	828	1589.62
			69	-	-	-	1299	4160.70	3.21	-	-	-	1299	4160.70
	4	47-27	52	-	-	-	-	-	-	2892	13498.25	4.68	2892	13498.25
			53	-	-	-	-	-	-	1402	4380.15	3.12	1402	4380.15
	10**	47-27	29	-	-	-	-	-	-	4943	20023.81	4.05	4943	20023.81

* Total footage and total bit cost not shown on first 930 ft. of Hole - NX drilling on contract/ft.
** 89 ft. BX drilled in 1956 - cost not as yet available, NX footage includes that lost due to wedging.

TABLE V (CONT'D)

PER FOOT COST OF DIAMOND BITS USED IN 1956
SURFACE

Name	PROJECT Sec.	T&R	Hole	AX Ft.	AX Amt.	AX Per Ft.	BX Ft.	BX Amt.	BX Per Ft.	NX Ft.	NX Amt.	NX Per Ft.	Total Footage	Total Bit Cost
Tilden W.	22	47-27	1	-	$ -	-	-	$ -	-	-	$ -	-	-	$ -
Tilden F.T.	23	47-27	4	-	-	-	1086	7731.40	7.12	14	209.70	14.98	1100	7941.10
	25	47-27	3				696	5325.32	7.65	50	112.00	22.40	744	5437.32
			4				579	2786.52	4.81	28	372.58	13.31	614	3159.10
			5				648	6483.83	10.01	28	369.61	13.20	675	6853.44
			6				565	4726.01	8.34	14	479.10	34.22	579	5205.11
			7				511	2964.14	5.80	29	461.00	15.89	539	3425.14
Tilden F.T.	26	47-27	55				478	5658.32	11.84	10	429.96	43.00	700	6088.28
			56				883	6517.91	7.38	40	338.89	8.47	931	6856.80
			57				642	1839.65	2.87	10	202.20	20.22	692	2041.85
			58				365	6559.44	17.97	36	1027.19	28.53	403	7586.63
			59				694	9378.19	13.51	20	631.06	31.55	714	10009.25
			60				167	2386.38	14.20	17	206.61	12.15	194	3092.99
McColeman	17	44-35	1				204	54.00	.26	-	-	-	204	54.00
Humboldt	2	47-27	8	-	-	-	-	-	-	-	-	-	-	-
	TOTAL			1351	$ 2716.62	$ 2.01	20100	$ 104,774.06	$ 5.21	26113	$ 127,572.65	$ 4.88	47903	$ 235,848.71

2. Diamond Inventory - Hand Setting

The following Table VI shows the distribution of carbon during the year 1956.

TABLE VI

DIAMOND INVENTORY (Hand Setting), December 31, 1956

CARBON (Hand Set)

		Kts.	Amount
On Hand 1/1/56		791.66	$ 49,367.40
Ballas Transferred		40.89 at $60/kt.	2,453.40
	TOTAL	832.55	$ 46,914.00
Used		.28 at $10/kt.	2.80
Sold		293.98 at $60/kt.	17,638.80
Scrap		44.16 at $10/kt.	441.60
Transferred		16.34 at $10/kt.	163.40
On Hand 12/31/56		477.79 at $60/kt.	$ 28,667.40

3. Diamond Inventory - Mechanical Setting

The following tabulation in Table VII shows the over-all distribution of all types of diamonds used and on hand during 1956.

TABLE VII

DIAMOND INVENTORY (Mechanical Setting), December 31, 1956

	SCRAP CARBON		SCRAP BORTZ		LONGYEAR		"R" GRADE		"G" GRADE		TOTAL	
	Kts.	Amount	Kts.	Amount	Kts.	Amount	Kts.	Amount	Kts.	Amount	Kts.	Amount
On Hand 1/1/56	250.93	$ 3,774.77	4505.15	$ 8,052.01	175.90	$ 1,934.90	26,063.44	$ 162,697.07	919.53	$ 6,476.49	31,914.95	$ 182,935.24
Purchased 1956	16.34	163.40	5187.99	9,043.55			24,399.39	235,461.11	6.88	75.68	29,610.60	244,743.74
TOTAL	267.27	$ 3,938.17	9693.14	$ 17,095.56	175.90	$ 1,934.90	50,462.83	$ 398,158.18	926.41	$ 6,552.17	61,525.55	$ 427,678.98
Used 1956 (loss)	1.74	34.80	1868.19	3,078.31	-	-	19,987.81	196,909.80	166.62	1,664.87	22,024.36	201,687.78
Scrap Credit	-	-	-	-	-	-	-	9,043.55	-	-	-	9,043.55
On Hand 12/31/56	265.53	$ 3,903.37	7824.95	$ 14,017.25	175.90	$ 1,934.90	30,475.02	$ 192,204.83	759.79	$ 4,887.30	39,501.19	$ 216,947.65

DISTRIBUTION OF INVENTORY IN CARATS

	SCRAP CARBON	SCRAP BORTZ	LONGYEAR	"R" NEW	"R" USED	TOTAL "R"	TOTAL "G"	TOTAL INVENTORY
Loose (Mfr's Possession)	249.19	5,907.52	-	20.00	6,665.14	6,685.14	-	12,841.85
Loose (C.C.I.Co. Possession)	16.34	-	-	-	2.85	2.85	-	19.19
Salvage Reports Pending	-	337.24	-	-	5,988.73	5,988.73	51.88	6,377.85
Bits in Stock or Issued	-	1,580.19	175.90	-	17,798.30	17,798.30	707.91	20,262.30
TOTAL	265.53	7,824.95	175.90	20.00	30,455.02	30,475.02	759.79	39,501.19

4. Contract Drilling

Table VIII summarizes the footages drilled and the costs per foot of the drilling conducted by contractors during the year.

TABLE VIII

1956 CONTRACT DIAMOND DRILLING

Section	Township & Range	Hole	Contract Company	Ax Footage	Bx Footage	Nx Footage	Total Footage	Over-all Cost Per Ft.	Total Drilling Cost
18	43-21	2	Odgers	170	-	-	170	$ 20.81	$ 3,538.80
		2a	"	40	1382	-	1422	13.95	19,833.50
		3	"	738	1028	711	2477	10.20	25,244.35
9	44-22	1	"	-	527	648	1175	10.85	12,749.94
4	42-23	2	"	-	458	740	1198	5.53	6,619.50
35	43-23	2	"	-	476	765	1241	9.27	11,508.05
27	47-26	42	"	-	1355	-	1375	13.16	18,092.75
27	47-26	51	"	-	-	744	744	16.55	12,314.05
		54	"	-	-	1400	1400	15.49	21,687.20
		55	"	-	-	628	628	21.58	13,550.00
TOTALS		10		948	5226	5636	11830	$ 11.19	$ 132,388.79

TABLE VIII (CONT'D)

1956 CONTRACT DIAMOND DRILLING

Section	Township & Range	Hole	Contract Company	Ax Footage	Bx Footage	Nx Footage	Total Footage	Over-all Cost Per Ft.	Total Drilling Cost
18	47-26	23	Sprague & Henwood	-	644	-	644	$ 6.49	$ 4,180.80
		24	" " "	-	717	-	717	6.60	4,729.15
		25	" " "	-	587	-	587	6.50	3,814.65
		26	" " "	-	775	-	775	6.62	5,127.25
		27	" " "	-	772	-	772	6.92	5,341.80
		28	" " "	-	610	-	610	6.77	4,128.50
		29	" " "	-	781	-	781	6.59	5,200.95
		30	" " "	-	799	-	799	6.65	5,312.05
		31	" " "	-	617	-	617	7.38	4,557.67
		32	" " "	-	771	-	771	6.93	5,342.63
		33	" " "	-	830	-	830	6.65	5,522.50
		34	" " "	-	750	-	750	6.59	4,942.50
26	47-26	2	" " "	-	366	-	366	6.23	2,279.70
27	47-26	47	" " "	190	352	906	1471	15.57	22,903.12
23	47-27	4	" " "	-	1086	14	1100	13.01	14,308.78
25	47-27	3	" " "	-	696	50	744	17.29	12,866.28
		4	" " "	-	579	28	614	16.77	10,296.13
		5	" " "	-	648	28	675	26.60	17,956.48
		6	" " "	-	565	14	579	25.49	14,756.47
		7	" " "	-	511	29	539	21.57	11,626.47
26	47-27	55	" " "	-	478	10	700	21.76	15,235.80
		56	" " "	-	883	40	931	19.82	18,494.79
		57	" " "	-	642	10	692	12.83	8,876.07
		58	" " "	-	365	36	403	33.68	13,573.89
		59	" " "	-	694	20	714	29.56	21,104.45
		60	" " "	-	167	17	194	7.36	1,428.00
TOTALS		26		190	16685	1202	18100	$13.47	$ 243,867.43

5. Plant Account

Table IX shows the comparative status with reference to depreciation of the Department owned equipment.

TABLE IX

	Schedule "A"	Schedule "B"	Schedule "C"	Total
December 31, 1955	$23,132.26	$208,577.23	$191,566.08	$423,257.57
December 31, 1956	23,132.26	280,873.91	206,657.45	510,663.62
Net Change	$ 00.00	$ 72,296.68	$ 15,091.37	$ 87,388.05

Income from "Per-Shift Charges"	
Total year 1955	$ 59,243.16
Total year 1956	66,557.78
Expenses from "Per-Shift Charges"	
Repairs and Maintenance	$ 16,055.82
Depreciation	
Equipment	23,110.43
Rods	27,391.53
Net loss for year 1956	00.00
Total equipment book value, 1956	$ 510,663.62
Depreciation Reserve Fund, 1956	236,503.48
Depreciation Rods and Equipment from above	66,557.78
Net	$ 207,602.36

IV. SURFACE EXPLORATION

The projects discussed in this section of the Annual Report are those involving drilling in addition to geological and geophysical field work. The details of the geological and geophysical field work have been covered in Section II of this report.

A. Michigan

1. The following Table X is a summary of the surface drilling including the cost analysis. Each of the areas are discussed separately.

TABLE X

SUMMARY OF SURFACE DRILLING - COST ANALYSIS

LOCATION	HOLES	RIGS	OVER-BURDEN	DIAMOND DRILLING	TOTAL	1ST CLASS ORE FOOTAGE	%	MET. ORE FOOTAGE	%	TOTAL COST "A"	COST/FT "A"	TOTAL COST "B"	COST/FT "B"
a. Marquette Range													
1'. New Richmond Metallurgical	45,46,49,50,51, 52-57	C.C.I. & Odgers	213	7,540	7,753	—	—	7,039	90.79	136,039.28	17.55	145,022.99	18.71
Direct Shipping	54	Odgers	0	680	680	—	—	—	—	9,913.60	14.58	10,677.17	15.70
Sub Total			213	8,220	8,433	—	—	7,039	83.46	145,952.88	17.31	155,700.16	18.46
2'. Belleview	23-34	Sprague & Henwood	284	8,449	8,733	—	—	6,957	79.66	58,200.45	6.66	80,407.79	9.21
3'. Tilden Area	1(Sec.22),4(Sec.23), 3-7(Sec.25),55-60(Sec.26), 24(Sec.27)	C.C.I. & Sprague & Henwood	387	7,608	7,995	64	0.80	6,961	87.06	175,939.34	22.01	198,570.69	24.84
4'. Mather "A" Surface	68-69	C.C.I.	141	2,107	2,248	—	—	—	—	19,820.09	8.82	24,456.31	10.88
5'. Mather "B" Surface	167	C.C.I.	24	979	1,003	—	—	—	—	15,289.65	15.28	16,328.65	16.28
6'. Section 4, Deep	52-53	C.C.I.	131	4,163	4,294	8	0.19	—	—	93,464.06	21.77	94,361.50	21.98
7'. Section 10, Deep	29	C.C.I.	0	4,095	4,095	—	—	—	—	93,166.23	22.75	94,434.47	23.06
8'. Humboldt	8	C.C.I.	56	—	—	—	—	—	—	—	—	—	—
9'. Cascade East End Exploration Metallurgical	1,2,40,41,42,39	C.C.I., Odgers, Sprague & Henwood	334	2,750	3,084	—	—	1,985	64.36	68,122.29	22.09	80,180.57	23.16
Direct Development	38,39,40,41,42, 43,44	C.C.I., Odgers, Sprague & Henwood	0	2,511	2,511	457	18.20	—	—	67,659.47	26.95	67,896.19	27.04
Metallurgical	47,48,33,39-42,1	C.C.I., Odgers	53	1,534	1,587	—	—	1,534	96.66	31,533.69	19.87	34,866.39	21.97
Direct	42,47,48,38	Sprague & Henwood	0	2,746	2,746	137	4.99	—	—	76,884.68*	28.00	82,517.19*	30.05
Sub Total Cascade			387	9,541	9,928	594	5.98	4,197	42.27	244,200.13	24.60	265,460.34	26.74
Sub Total Marquette Range	55 Holes		1,623	45,162	46,785	666	1.42	25,154	53.76	829,100.05	17.72	911,474.75	19.48

*Costs from 33, 39-42 and Hole 1 transferred to Exploration for purpose of this cost sheet as these charges represent late charges and therefore embrace zero footage.

TABLE X (CONT'D)

SUMMARY OF SURFACE DRILLING - COST ANALYSIS

LOCATION	HOLES	RIGS	OVERBURDEN AND PALEOZOIC	DIAMOND DRILLING	TOTAL	1ST CLASS ORE FOOTAGE	%	MET. ORE FOOTAGE	%	TOTAL COST "A"	COST/FT "A"	TOTAL COST "B"	COST/FT "B"
b. Cameo Project													
1'. Osier - Section 18	2,2-A, 3	Odgers	640	3,969	3,969	—	—	444	11.19	57,346.03	14.45	65,259.17	16.44
2'. Perkins - Section 24	1	C.C.I.	0	336	336	—	—	—	—	3,999.29	11.88	4,137.29	12.31
3'. Trenary - Section 9	1	Odgers	567	1,175	1,175	—	—	—	—	12,968.17	11.04	13,114.01	11.16
4'. Rock - Section 4	1,2	Odgers,C.C.I.	1278	2,578	2,757	—	—	263	9.54	16,301.70	5.91	19,372.82	7.03
Section 35, 43-23	1,2	Odgers,C.C.I.	378	1,315	1,797	—	—	132	7.35)	47,512.04		50,812.30	20.97
Section 36, 43-23	1	C.C.I.	557	186	626	—	—	—	—)				
Sub Total Cameo	10 Holes		3,417	9,559	10,660			839		138,127.23		152,695.59	
GRAND TOTAL ALL DRILLING	65 Holes			54,721	57,445	666		25,903		967,227.28		1,064,170.34	

Cost "A" is direct drilling charges

Cost "B" includes both direct and indirect charges

3. Summary of Results

a. Marquette Range

1'. Belleview - Donald R. Lukkari, Geologist

Twelve holes were drilled in the Belleview to test the metallurgical characteristics of the material. Drilling began February 3, 1956, and was completed by July 28, 1956. A total of 8,733 feet was drilled at a cost of $80,407.79.

The results of the metallurgical testing ranged from fair in the north part to poor in the south portion of the section. No further work is anticipated at the present time because of other areas that look more attractive at this time.

2'. Cascade East End - Donald R. Lukkari, Geologist

Drilling continued in the Cascade East End for both high grade and metallurgical ore. A total of 4,671 feet of metallurgical drilling and 5,257 feet of direct shipping drilling was accomplished. The metallurgical results in the area have been spotty.

Holes #40, #41, and #39, all cored significant amounts of high grade ore. Hole #39 cut a total of 231 feet of first class ore. The deep drilling has revealed an orebody between the Isabella Dike and the Palmer Fault which contains an estimated 19,000,000 tons. A report was drawn up and Disclosure of an Economic Orebody was made in July. Exploration is continuing to the west in the north structure and in the structure south of the Isabella Dike.

3'. New Richmond Pit - Donald R. Lukkari, Geologist

In the spring of 1956 the lease was acquired on the SW¼ of Section 27, 47-26. A grid of twelve holes was laid out to test the metallurgical possibilities of the area. By the end of 1956, eleven of the holes had been drilled for a total of 8,433 feet. Thus far, the test results have been questionable. The results of the surface samples in the pit were fair to excellent. At the end of the year Hole #54 was being carried to footwall to check for ore at depth. It had reached a depth of 1400' but no ore had been drilled.

4'. Tilden Area - Donald R. Lukkari, Geologist

A program of drilling in the Tilden Area was started in June of 1956. The object was to test the area for low grade metallurgical ore in more detail than the drilling done in conjunction with Bethlehem Steel Corporation several years ago. After several holes, the so-called Fire Tower Area was blocked out and tested in detail at 600 foot intervals. The test results received so far have shown fair results by the MOC process.

A total of 7,995 feet was drilled during the year. Some high grade ore was found near the footwall. A total of 64 feet of first class ore was cut in three holes. One seam of approximately 15 feet thickness appears to be continuous over a distance of 1,200 feet. It was hit in Holes #4 and #5, Section 25, and appeared as a zone of no recovery in Hole #2 several years ago.

With the completion of drilling in the Fire Tower Area, the program was reduced to one rig testing the two sections to the west.

5'. Section 10, 47-27, Deep Exploration - J. P. Meyers, Geologist

Diamond drilling for deep soft ore in Section 10, 47-27, which was commenced in 1955, was continued throughout 1956. Drilling in this area has been confined to one hole, D.D.H. #29. This hole was located on the basis of the geology predicted in the Deep Soft Ore Study. Any future holes will also be located on the basis of the Deep Soft Ore Study and with consideration of the knowledge gained in the first hole.

D.D.H. #29 is located on the old Lake Mine surface on the north shore of Lake Angeline in the NW¼ of the SE¼ of Section 10, 47-27. The hole, which was drilled to a depth of 855' by the end of 1955, was continued to a depth of 4950' by the end of 1956. In 1956, this hole has been drilled through intrusive and unoxidized iron-formation. This hole will be continued until the footwall Siamo slates are encountered. Throughout the year, operations at this hole have been hampered by a series of accidents. These accidents consisted of the loss of strings of drill rods down the hole twice during the year and the collapse of some BX casing which was put in the hole to prevent the possible disturbance of any of the 5 Hall-Row wedges in the hole. Total down time while rods were being recovered, etc. amounted to 110 days.

6'. Section 4, 47-27, Deep Exploration - J. P. Meyers, Geologist

In February 1956, thought was given to further drilling in Section 4, 47-27, to confirm the knowledge previously gained and to try to expand and further outline the predicted orebody. Drilling was commenced on the first hole in March and on the second hole in August. Both holes were planned and located on the basis of the geology interpreted from previous drill hole information and that predicted in the Deep Soft Ore Study. The first hole, D.D.H. #52, was located approximately 150' due north of D.D.H. #44, and was to be drilled in an effort to confirm the cross-section interpreted with information from D.D.H.'s #43 and #44. The second hole was located midway between D.D.H.'s #37 and #44, in which ore was cored, in an effort to prove or disprove a continuous ore structure between these holes. Any future holes drilled in this area will depend upon the results obtained by the first two holes.

D.D.H. #52 is located approximately 150' due north of D.D.H. #44 in Section 4, 47-27. This hole was commenced in March and completed in October. Total depth of hole was 2892' and only 8' of mineable ore was cored. Using the geological information gained by this drilling, a new interpretation of the geology of this cross-section was made. The new interpretation indicates a considerable reduced ore structure on this section. The idea of wedging #52 to the south in an effort to confirm the remaining section was broached but any such action was suspended pending the results of drilling in D.D.H. #53.

D.D.H. #53 is located approximately midway between D.D.H.'s #37 and #44 in Section 4, 47-27. This hole was commenced in August and drilled to a depth of 1402' by the end of 1956. Drilling to date has been done in the Goodrich formation which overlies the Negaunee Iron-Formation. If D.D.H. #53 does not encounter ore, the Section 4 project will probably be dropped since it will then be nearly impossible to prove up sufficient ore reserves to warrant deepening "C" Shaft, Cliffs Shaft Mine. If it should encounter ore, consideration will be given to the idea of wedging D.D.H. #52 and perhaps to drilling several more holes so as to prove up sufficient ore reserves to warrant sinking "C" Shaft and commencing a deep soft ore mining program.

7'. Cliffs-Shaft Mine - J. P. Meyers, Geologist

Reflection Seismic Work

Some reflection seismic work was conducted upon Cliffs-Shaft Mine surface in September. The work was an experiment to determine the possibility of using reflection seismics to locate caving areas and plot the expansion of caving voids. This geophysical method was first tried at Cliffs-Shaft before further work was done at the Mather Mines. Cliffs-Shaft was used primarily because the exact location of the underground voids is known. The depth of overburden and overlying strata above the voids is also known and the character or type of overlying strata is known.

The results of the experiment at Cliffs-Shaft were inconclusive and the information gained was of no use because the thickness of overburden and overlying strata was not sufficient to allow the reflections to be recorded by the equipment. The high shock transmitting velocity of the overlying strata allowed the reflection to follow so closely behind the initial or primary shock that the record produced by the equipment became unintelligible.

8'. Mather Mine "A" Shaft - Lee Erickson, Geologist

Subsidence

The U. S. Bureau of Mines and The Cleveland-Cliffs Iron Company continued with the cooperative subsidence study during the year. D.D.H. #65 was re-entered and attempts made to deepen the hole. Two additional holes were drilled, D.D.H. #68 and D.D.H. #69, for the purpose of setting up a triangulation network.

D.D.H. #65 was re-entered early in February for the following reasons:

(1) To attempt to locate the position of the void above the old 5th and 6th Level workings by extending the hole.

(2) To follow progressively the advancement of the void towards surface.

(3) To correlate all information so obtained with the general subsidence studies.

During the re-entry period, difficulties were encountered which caused abandonment of all attempts to deepen the hole. Observations of significant value were:

(1) There appears to be ground fracturing and movement at a depth of 1,000 feet.

(2) After setting a cement plug below 800', the hole stopped taking air and water.

The hole was again cemented off at 767' and a microseismic recorder and other associated equipment were set up at the hole. A geophone was set in the hole and located at various depths until July 3rd. On July 30th, a newly designed geophone was set at the

bottom of the hole, 767' below the collar, and remained there the rest of the year. The microseismic activity recorded at Hole #65 during the year indicated very little disturbance in the area under test. Enough activity was noted, however, to warrant continued study in this area.

D.D.H. #68 was completed in May with the final effective bottom being at a depth of 861'. The collar of this hole is 100' West and 400' North of D.D.H. #65, and it was drilled at an inclination of -65° due South. The hole bottom is over the principal mined out area above the 5th Level.

In September, a geophone was installed at D.D.H. #68. It was set at hole bottom, 861' from the collar. During the remainder of the year, microseismic disturbances were present in the area but the disturbances were infrequent and of very low magnitude.

D.D.H. #69 was the third subsidence hole to be drilled in the Mather "A" area. It was collared 250' North and 400' East of D.D.H. #65, and drilled at an inclination of -65° due South. The hole bottom is over the principal mined out area above the 6th Level. The drilling was completed in September with a depth of 1,326' being attained. On October 31st, a geophone was lowered to a depth of 1,215'. It was readily discovered that the hole was not supporting a head of water and that air was flowing into the hole. Consequently, on November 7th, a drill crew plugged and cemented off the hole at 1,150'. The seal is not entirely satisfactory but it does support a small column of water allowing the geophone to function properly. Except for a group of noises recorded coincidently in Hole #65 and Hole #69 on December 26th, microseismic activity in the area was of very low magnitude.

Holes #65, #68, and #69 are critically located and a triangulation network can be set up which might enable the performance of tests to establish the source of rock disturbances in the Mather Mine "A" Shaft area above the 5th and 6th Level mining areas. For the present, however, the plan to triangulate on the noise sources will have to be postponed until energy of greater magnitude is received by all geophones and a high percentage of the same disturbances recorded coincidently.

The subsidence studies undertaken during 1956 indicate that ground fracturing above the old 5th and 6th Level workings has reached an elevation between 1,200' and 1,000' from surface. However, the rate of subsidence, as indicated by microseismic activity, does not seem to be rapid. Future information on the rate of subsidence can be noted by determining when additional ground fracturing will cause the lowering of the water columns that are now present in D.D.H. #65, #68, and #69. Air entering or exhausting from the holes will give further indication that fracturing of the ground above the old workings has reached the effective bottoms of the subsidence holes.

During the month of September, Mr. L. Bacon, Geophysics Department, Michigan College of Mining and Technology, spent considerable time at the Mather Mine "A" Shaft conducting a reflection seismograph survey. The results of the survey have not as yet been submitted. The purpose of the survey was to attempt to locate the void over the old mining areas above the 5th and 6th Levels by reflection principles.

9'. Mather Mine "B" Shaft - Paul R. Bluekamp, Geologist

Subsidence

A considerable amount of time was spent on subsidence studies in an attempt to trace the progress of the cave at Mather Mine "B" Shaft.

The cave advanced about 600' in height during the year and encroached upon Holes S-300 and S-170 rendering them useless for geophone installation. Subsidence Hole S-233 was drilled from the Cambria-Jackson 6th Level to extend out over the cave area. However, due to extremely hard drilling, the cave advanced above the hole before it was completed. Subsidence Hole S-167 was drilled from surface on the north side of the cave area to a depth of 1002'. This hole will be used to set off charges, the energy travel time of which will be recorded by the geophone and counters in D.D.H. #153 on the south side of the cave. An increase in this time will indicate that the cave has passed the line between the charge and the geophone. No significant microseisms have been detected by the geophone in D.D.H. #153.

Pumping

The pumping of the North Jackson Mine underground workings continued throughout 1956. The average rate of pumping was 400 g.p.m. The purpose of this pumping is to de-water the overburden and workings over the future mining areas. The pumping rate has dropped 9,000,000 gallons per month during the year.

A total of 9 churn drill holes were drilled in the Partridge Creek area, these included one 6 inch observation well, one 8 inch observation well, and seven 10 inch pumping wells. Three of the 10 inch wells were found to produce over 200 g.p.m. and pumps were installed in them. These three pumps have been running since April at an average rate of 600 g.p.m. A fourth 10 inch well will have a pump installed in the near future. The purpose of these pumps is to intercept underground water which is draining toward the area overlying the present mining area. The 8 inch observation well shows a drop of 4' 3" in the water table over the present mining area since the pumps were installed.

10'. Humboldt Mine - James W. Villar, Geologist

In conjunction with exploring the possibility of an extended iron-formation north and northeast of the present pit limits, a diamond drilling program was initiated during the latter part of the year. D.D.H. #8, Sec. 2, was set up at co-ordinates S. 4809.09 and 8394.90 W. to be drilled on a course of S. 38° 46' E. at an inclination of -45°. By the end of the year of 1956, 56' of clear sand and 7' of quartzite boulders and broken ledge had been penetrated.

The framework for a detailed magnetic survey of the Weber Lease, inclusive of the East Hill area, was commenced. Additional sampling from the faces of old pits within the area further substantiated the area as warranting considerable exploration.

Field mapping consisted of compiling standard 1" = 50' scale bench maps. The previous 1625' and 1585' bench maps were supplemented with additional information as blasting and stripping provided new exposures. Preliminary plan maps of the 1560' and 1545' benches were also compiled as a result of the sinking-cut in the southern portion of the pit and the extensive stripping at the present northern pit limits. The mineralogical and structural complexities have certainly been exemplified as a result of these initial maps.

In conjunction with the fore-mentioned mapping, diamond drill records, geophysical reconnaissance data, previous outcrop maps and some rather desultory interpretations, two composite geologic maps were prepared. These generalized maps consist of a 1" = 50' plan of the area restricted to the immediate vicinity of the presently proposed pit limits and a 1" = 200' map inclusive of the entire East Hill location.

A ledge contour map was compiled employing the depths of overburden determined by a seismic refraction survey, diamond drill hole records and present exposures in both the pit and adjacent hanging wall. Although closer control would be desirable, ten foot contour intervals were plotted with a relative degree of certainty. The data has been of considerable value with respect to pit planning and development.

In light of the information compiled during the year, as well as reviewing previously reckoned data, a detailed re-estimate of the concentratable iron-formation was undertaken. A total of thirty-three sections were prepared and areas of overburden, hanging wall rock, pit waste, footwall rock and oxidized iron-formation were perimetered for 35' - 40' benches to an elevation of 1210'. The data compiled afforded numerous opportunities to analyze various figures relevant to stripping ratios and costs at individual depths. The series of graphs evolving from this study have proven to be of considerable assistance in devising plans relative to pit development.

In an attempt to gain a better insight on the geologic relationships of the hard ore iron deposits, a detailed examination of all the drill core from the Humboldt area was initiated. Thin sections and polished surfaces are being prepared for zones of complexity in order to relate mineralogical variations to field occurrences. Although core samples from several drill holes have been studied, a more thorough investigation is certainly in order, prior to formulating a hypothesis or endorsing any previous conceptions.

11'. Republic Mine - James W. Villar, Geologist

Standard 1" = 50' scale bench maps were compiled for the recently exposed areas on the 1600' bench. Structural and mineralogical variations were recorded in order to facilitate planning with respect to mining at lower benches and lateral extensions.

Outcrop mapping was restricted to delineating the southeast portion of the footwall contact. The major purpose was to obtain some criteria for planning future road sites.

A sequence of generalized plan maps and cross-sections were prepared. For the most part, these are analogous with previous interpretations with only minor modifications.

In conjunction with the over-all investigation of the geologic relationships of hard iron ore deposits, a megoscopic and microscopic study of the drill core from Republic was also initiated.

12'. Ohio Mine (Portland Lease) - James W. Villar, Geologist

The pro's and con's of maintaining the Portland Lease were reviewed and the data presented to the Ore Committee during September. Geologic and engineering maps and cross-sections were assembled in conjunction with previous drilling records. It was the decision of the committee, on the basis of metallurgical tests, previous engineering experiences, and known as well as interpreted geological data, that the property be considered unfavorable and the lease be dropped.

b. Cameo Project

At the beginning of 1956, two Company-owned rigs and one Odgers Drilling Company rig were in operation. By February, the program had dropped to two rigs, by July, one rig, and by September, the drilling was completed for the year.

Table XI shows the recap of the drilling in terms of the Paleozoic cover of limestone and sandstone and also the Pre-Cambrian material including the iron-formation.

TABLE XI
RECAP OF DRILLING

	Hole No.	Sec.	Overburden & Paleozoic Cover	Pre-Cambrian Non-Iron-Formation	Iron-Formation	Total	% in Iron-Formation	Grand Total
OSIER (43-21)								
	2	18	0	70	0	70	0.0	70'
	2-A	18	0	978	444	1,422	32.0	1,422
	3	18	640	1,824	13	1,837	0.1	2,477
PERKINS (42-22)								
	1	24	0	336	0	336	0.0	336
TRENARY (44-22)								
	1	9	567	608	0	608	0.0	1,175
ROCK (42-23)								
	1	4	554	897	108	1,005	10.7	1,559
	2	4	724	319	155	474	32.7	1,198
ROCK (43-23)								
	1	35	512	44	0	44	0.0	556
	2	35	775	334	132	466	28.4	1,241
	1	36	557	69	0	69	0.0	626
Total			4,329'	5,479'	852'	6,331'	13.5%	10,660'

1'. Summary

The 500 feet, plus or minus, of Paleozoic cover over the Pre-Cambrian rocks of the Cameo Area necessitate the choice of area to drill, the location of the drill, and the extension of the resulting geologic information by geophysical means entirely. The recap of drilling shows that of the 10,660' of drilling in ten different holes, only 13.5% was in iron-formation. This compares with a figure of 41% for the previous year. The reason for this decrease of iron-formation drilled is that we have proven that medium to high magnetics are caused by magnetic iron-formation; the low magnetic anomalies were hoped to represent low-magnetic and low-density soft hematitic iron-formation. This could have been the situation, however, they could also be produced by other things, i.e., thinly disseminated magnetite, weakly magnetic basic intrusives, other low-susceptibility minerals like pyrrhotite or ilmenite, or even topographic highs on the Pre-Cambrian surface. This was the type of anomaly explored to a large extent during 1956 (Perkins, West Rock, and Trenary), and we found most of the above possibilities except the soft hematite of the soft-ore variety in this Perkins-Rock-Osier Area. Locally, however, adjacent to intrusives, the blue-steel type of hematite is encountered, as in Section 31, 43-22. In regard to this feature of metamorphism within the Cameo Project, it is interesting to note that while the metamorphic order is fairly high around Perkins, the drilling in Escanaba disclosed iron-formation more like the soft ore type; hence going southward appears to be going down the metamorphic scale and so increasing the chances for soft hematite deposits.

2'. Perkins

Diamond core drilling continued into 1956 in the Perkins Area only in Section 24, 42-22, where D.D.H. #1 was completed. This hole was exploring a very low intensity magnetic anomaly which was thought to have been the northward faulted extension of the main Perkins anomaly to the south in Section 26; the anomaly producing material was a pyrrhotitic mica schist. This hole essentially terminated the exploration on the Perkins anomaly and subsequently all remaining unexpired mineral leases were given up.

3'. Osier

During 1956 the remaining 70' of D.D.H. #2 was drilled. No. 2-A was wedged off and crossed the eastward extension of the iron-formation encountered in D.D.H. #1, and D.D.H. #3 was drilled to test the westward extension of the iron-formation encountered in D.D.H. #1. Hole #2-A, located some 1400' east of Hole #1, cut a total of 444' of iron-formation in a distance of 670' with only one major bed being completely free of dikes and argillaceous seams, this bed has a stratigraphic thickness of about 80'. Hole #3, located some 490' west of #1 encountered only 13' of iron-formation. Thus, the surprisingly thick section of iron-formation cut by D.D.H. #1 is a structural feature in which a fairly thin lean iron-formation was thickened through repetition by folding and faulting. Although the material in D.D.H. #1 responded favorably to beneficiation, the drilling results correlated with the geophysical evidence indicated a relatively small tonnage present and no potential for the surrounding area, hence the exploration of this Osier area was terminated and any unexpired mineral leases and options were given up.

4'. Rock

West of the town of Rock is an area containing magnetic anomalies whose configuration in plan indicate a high degree of structural complexity in the Pre-Cambrian rocks. The anomalies are quite definitely extensions of drilled iron-formation, but they are all very low (300 to 400 gammas at the most, with no associated gravity anomaly) and were interpreted as possibly being a more hematitic facies of the iron-formation and were thus a fair geologic target to explore by diamond drilling. Holes #1 and #2, Section 4, 42-23, were drilled with the following results. Magnetite-rich rocks were encountered within a series of quartzites, schists, pegmatites and granitized rocks; some specularite was found, but no soft red hematite was present; the crude analysis of the magnetite rocks was low, too low to even attempt beneficiation tests. These rocks are interpreted as being either a very lean iron-formation which was regionally metamorphosed or by the intruded pegmatites, disseminations of replacement magnetite in the schists and quartzites, or most probably 90% of the first plus 10% of the second possibility. In any regard, the similarity of all the rest of the geophysical anomalies throughout this area west of Rock correlated with this drilling information in Section 4, led us to discontinue exploration in this area also.

East of Rock, however, and west of the one hole drilled in Section 31, 43-23, the magnetic and gravity anomalies indicate definite iron-formation and a local pitching anticline-syncline structure which looked geologically promising. Three holes were drilled in an attempt to sample these rocks, one conventional angle diamond drill hole and two vertical holes drilled with the new Joy 225 utilizing compressed air as a circulating medium. The angle hole, D.D.H. #2, Section 35, 43-23, cut the iron-formation which was a magnetic hematitic jasper iron-formation, but the stratigraphic thickness was only about 50 feet.

The two vertical holes, D.D.H. #1, Section 35, 43-23, and D.D.H. #1, Section 36, 43-23, and D.D.H. #1, Section 36, 43-23, both were planned to merely enter the Pre-Cambrian and attempt to hit this formation. The latitude of error in positioning the formation from the geophysics plus the deviation off the vertical with the drill resulted in missing the target in both holes, a 50' target at an average depth of 530 feet.

The Joy 225 was utilized in an attempt to drill a rapid vertical hole through the Paleozoic section, sample the Pre-Cambrian rock and thus gain positive information prior to more lengthy angle diamond drilling and in fact, reduce the amount of angle drilling necessary. The air-compressor on the unit delivered air at 50 p.s.i. and with the excessive water in the Paleozoic rocks of the area, this system of air circulation could not be used below the depth where the air failed to lift the head of water above it in the deepening hole. In this application, without going to installing a compressor which would deliver air at a higher pressure, the holes were drilled with the air and tricone rotary bits as far as possible and then finished with mud as a drilling medium to the Pre-Cambrian ledge.

With the encouraging results of the drilling in Section 31, 43-22, and Section 35, 43-23, correlated with the known geophysics, we have not given up the options and mineral leases currently held in the area east of Rock and west of the Osier Area; although the drilling program has been terminated therein.

5'. Trenary

There are a series of low magnetic anomalies which have no associated gravity anomalies in and about Section 9, 44-22. Our experience with similar anomalies in west Rock and north Perkins led us to feel that similar negative results could be expected at Trenary. However, no positive information on these Pre-Cambrian rocks could be obtained without drilling and one hole was justifiable to explore the area. This hole cut a series of schists, granite gneisses, pegmatites, and a magnetite-bearing feldspathic-chloritic rock. The magnetite content was very low and erratic and the drilling was discontinued. This magnetite-bearing rock could either be a metamorphosed and "granitized" argillaceous iron-formation, an igneous rock containing replacement magnetite, or again some combination of the two.

B. Minnesota

1. The following Table XII is a summary of the drilling including the cost analysis. Each of the areas are discussed separately.

TABLE XII

SUMMARY OF DRILLING - COST ANALYSIS

LOCATION		CONTRACTOR	HOLES NO.	T.FOOTAGE	FT/SHIFT OBN.	FT/SHIFT I-FM	ORE QTE.	ORE FEET	ORE %	A COST/FT OBN.	A COST/FT I-FM	COST DRILLING	SUPPLIES	TOTAL A	COST/FT.A	GEOL-ENG.	CHEM. MET.	SOC.SEC. TAX	TOTAL B	COST/FT. B
Trask	L.O. 2918	Schultze	3	1356	541	815	5	105	7.7	7.72	5.43	16.60	16.60	22,325.21	189.97	22,515.18	16.60	3,617.88	2,333.03	50.74	$28,516.83	21.03
																$23,663.43*	17.45*					21.88*
Holding	L.O. 2928	Schultze	5	1419	515	881	23	40	2.8	28.61	9.08	17.14	17.14	24,425.12	113.08	24,538.20	17.14	1,374.79	4,427.93	51.01	29,880.14	20.87
																25,113.20*	17.70*					21.43*
Barlow	L.O. 2932	Walker	2	766	355	411	-	-	-	39.44	4.28	6.24	25.12	12,454.30	84.02	12,538.32	16.37	2,988.63	1,713.31	39.71	17,279.97	22.56
Pillsbury	L.O. 2921	Schultze	1	204	153	49	2	12	5.9	15.3	5.44	14.50	14.50	2,958.00	-	2,958.00	14.50	89.35	292.28	2.61	3,342.24	16.38
																3,053.00*	14.97*					16.85*
Sub Total				3745										62,162.63		62,549.70	16.70				79,019.18	21.10
Ex.&Invest.Rotary Drilling		C.C.I.	12	714	30	684	-	349	48.9	-	6.67	28.02	28.02	20,006.21	-	20,006.21**	28.42	1,276.26	440.80	42.35	21,794.04	30.95
								***184	40.5													
Sub Total				4459										82,168.84		82,555.91	18.51				100,812.98	22.61
OPERATING MINES																						
Canisteo Mine		Schultze	3 C-874 to C-876	574	194	380	-	122	21.25	21.75	9.05	14.50	14.50	-	-	8,323.00	14.50				-	-
																8,626.00*	15.03*					
Hill-Trumbull Mine Walker Lease		Walker	5 W-148 to W-152	257	113	139	5	25	9.7	5.15	9.42	14.19	18.56			4,275.95	16.64				-	-
Sub Total				831										12,598.95		12,598.95	15.16				12,598.95	15.16
GRAND TOTAL ALL DRILLING				9035										156,930.42		157,704.56	17.45				192,431.11	21.29

* These figures include an approximation of $5.00 per shift

Rig rental charge and $0.50 per foot diamond charge which was not accounted for in the billing.

** Does not include large credit balance due this project.

*** Diamond drilling only.

IV-1956

B. Minnesota

2. Operating Mines

a. Canisteo - Three structure drill holes totaling 574' were completed at the Canisteo Mine during 1956. Purpose of the drilling was to test for ore concentrations in the plant area. Fifteen to twenty feet of retreat ore was found. Drilling was done by Henry Schultze Drilling Company at a cost of $8,323.00 or $14.50 per foot.

b. Hill-Trumbull - Several holes were required by the Great Northern Iron Ore Properties engineers in the Walker to prove reserves adjacent to the footwall contact. Ore was found in approximately the expected amounts. By the year's end, five holes totaling 257 feet of structure drilling had been completed at a cost of $4,275.95, or $16.64 per foot. Drilling was done by the Atkins-Walker Drilling Company.

3. Mesabi Range Exploration

a. Holding Company Sec. 9, 55-25 - E&A CC-664, 809, 860.

Drilling continued on this property from 1955 and five holes totaling 1419' were structural drilled. One hundred fifty million tons of crude ore were proven, some of it lean intermediate ore, but nearly all satisfactory as an MOC product. Drilling was stopped on May 21, 1956 and the mining lease was taken up. The surface lands have been purchased to avoid further encroachment by the housing area bordering this property to the south. This drilling was done by Henry Schultze for $29,880.14 or $20.87 per foot.

b. E. L. Trask Corp. McKinney Lake Lands - Sec. 8, 55-25 - E&A CC-665.

Drilling commenced May 25, 1956 with Hole #1, and three holes were completed by the end of the year. The total cost was $28,516.83 or $21.03 per foot. Hole #1 was in an area of deep (250') overburden, and extreme difficulty was had in getting casing to ledge. Holes #2 and #3 encountered hard drilling near the bottoms and 106'of these holes were diamond drilled. A total of 105' of retreat ore was drilled. Hole #4 was being set up as the year ended.

c. Barlow Realty Co. Lands, Sec's 4 & 8, 54-26 - E&A CC-839.

Hole #1, Sec. 4, was begun on September 19th by the Atkins-Walker Drilling Company of Duluth. This forty (NE-SW Sec. 4, 55-25) was adjacent to an area previously drilled by Pickands-Mather, and our aim was to test this ground for any value as land adjacent to an open pit. It did not contain appreciable ore values.

Hole #1, Sec. 8, was drilled on the NW-SE, a portion of the southern block of four Barlow forties. The iron-formation proved to be relatively richer than most in the western Mesabi Range, but it did not make grade as retreat ore. Its appearance was more nearly like Marquette Range Hem. Goet. Cherty iron-formation than previously known specimens from the Mesabi. The total cost was $17,279.97 or $22.56 per foot.

d. Wagner-Pillsbury - Sec. 19, 54-22 - E&A CC-838.

One hole, 204' in depth, was drilled to determine the amount of ore on this property which lies along the footwall contact north of Oliver's Morrison Mine near the Canisteo pit. Twelve feet of ore was recovered out of a total of 47' of iron-formation which was the maximum thickness. This offer was declined. Drilling was done by Schultze for $2,958.00 or $14.50 per foot.

C. U. S. General

The year 1956 has been a significant one in the history of the Company's exploration program. During this year a substantial amount of field work, and particularly core drilling, has been initiated in the Western States. The details of the geologic and geophysical field work have been covered in Part II of this report. Three significant areas were investigated during the year, namely, Montana, California, and Idaho, as enumerated below:

1. Montana - Judith Basin County - Our exploration activities in Judith Basin County, Montana, were conducted in association with the Young-Montana Corporation. This company is the Western exploration and mining subsidiary of the Haley-Young Corporation of Hibbing, Minnesota.

a. L.O. 3651, Dewey Whittaker Claims - A total of six diamond drill holes was completed amounting to a total of 556½'. The ore vein averaged slightly over 17½' in normal intersected thickness. This diamond drilling was conducted under the supervision of Mr. E. Rufus Rantala, Technical Representative for The Cleveland-Cliffs Iron Company, and was done under contract by Orin C. Thatcher of Stanford, Montana. An exploration cost summary is shown below:

Hole 1	68'	$ 361.55	$ 5.42	Cost Per Foot
2	90'	467.70	5.19	" " "
3	65'	332.65	5.12	" " "
4	102'	516.20	5.06	" " "
5	80'	448.00	5.60	" " "
6	151.5'	814.85	5.37	" " "
6	556.5'	$2,940.95	$ 5.28	" " "

Mining was commenced in 1956 on these claims by the Young-Montana Corporation with an agreement designating The Cleveland-Cliffs Iron Company as the sales representatives. A total of 56 cars of ore was produced and shipped. This was known as the Arrow grade ore.

b. L.O. 3634, Norman Whittaker Lands - Three diamond drill holes were completed on the Iron King "N" Claim. The total footage was 358' of drilling. Seventeen feet of ore alternating with limestone seams was intersected in Hole #1. The other two holes were barren except for small insignificant ore seams. The other lands of Norman Whittaker were not considered promising enough to warrant drilling during the 1956 campaign.

A cost summary is shown below:

Hole 1	90'	$ 504.00	$ 5.60	Cost Per Foot
2	132'	739.20	5.60	" " "
3	136'	761.60	5.60	" " "
	358'	$2,004.80	$ 5.60	" " "

2. San Bernardino County, California

a. L.O. 3613, Bessemer Claim Group - One diamond drill hole was begun in May. This was located on the so-called California Claim, one of the patented claims in the Bessemer group. The hole was completed at a depth of 298½'. Several runs of iron-bearing material were cut and the concentrating characteristics of this material determined. Drilling was stopped because of legal action taken by the Kaiser Steel Corporation.

This drilling was done by the Sprague and Henwood Corporation operating out of the Grand Junction, Colorado, Field Office. A cost summary of the drilling is shown below:

Hole 1	298.5'	$ 3,487.85	$ 11.68 Cost Per Foot

Because of the legal action referred to above, we withdrew from this exploration project. We did not abandon our effort in San Bernardino County, but rather took advantage of an airborne magnetic survey which we had made and decided to drill two other areas, as follows:

b. L.O. 3635, Southern Pacific Lands - A letter of intent was exchanged with the Southern Pacific Railway for permission to explore on their lands which were adjacent to the Bessemer group above. One hole in Section 33, T. 6 N., R. 4 E., was drilled and bottomed at a depth of 315' without encountering any iron-bearing material. Upon the completion of this hole, the area was abandoned. This also was drilled by the Sprague and Henwood Company. A cost summary of the drilling is shown below:

Hole 1	315'	$ 2,723.50	$ 8.65 Cost Per Foot

c. L.O. 3636, Cliffs' Claims - As a result of the airborne magnetics, two anomaly areas were indicated. Dr. John Sumner staked the easterly of these two anomalies. Although the field work did not reveal any iron rich material, it was still deemed worthy of one hole. This hole was drilled in Section 31, T. 5 N., R. 5 E., to a total depth of 339½' without encountering iron mineralization. This was also drilled by the Sprague and Henwood Corporation. The completion of this hole concluded our drilling activities in the San Bernardino County. Cost summary is shown below:

Hole 1	339'	$ 2,820.05	$ 8.32 Cost Per Foot

3. Idaho - L.O. 3585, Mackay, Idaho - This exploration project was also a joint effort with the Young-Montana Corporation. As noted in Part II of this report, the mineralization was both copper and iron. The plan of drilling was to intersect the copper mineralization which lies above the iron as well as the iron zone, and determine the concentrating characteristics of both. Hole #1, Section 1, T. 6 N., R. 23 E., was started on Pacific Claim. The hole reached a depth of 53' and was discontinued on October 26 because of adverse weather. It is contemplated that this will be resumed in the spring of 1957.

Hole 1	53'	$ 452.50	$ 8.52 Cost Per Foot

D. Canada

The principal exploration project undertaken in Canada during 1956 was that of the Albanel area, Project 17, in the Mistassini Territory.

Early in 1956, Canadian Cliffs' claims and claims owned by M. J. O'Brien were consolidated and a joint company formed which was later named Albanel Minerals, Ltd. Plans were made for an extensive exploration program for 1956. Mr. Rex was designated as Project Supervisor for the area. Early in April, Mr. Rex and a party of 13 stakers moved into the Albanel area to stake a series of claims over anomalies found by a 1955 aeromagnetic survey undertaken by M. J. O'Brien, Ltd. During the spring staking a total of 250 claims of 40 acres each were staked. By mid-June, summer exploration was underway and four drills were moved into the area. In addition to the four drills and their runners, 18 technical men conducted geological mapping, geophysical traversing, and plane surveying. A more detailed coverage of the geology and geophysics is found in Part II, D.

A total of 34 holes were drilled in various claim groups for a total of 8,392'. All servicing was done by water based aircraft. All analytical and metallurgical testing was performed by the Quebec Department of Mines Laboratory in Quebec City. Direct drilling costs of the exploration for 1956 are tabulated below:

Drill #1	10 Holes	3059'	$ 18,497.01	$ 6.05 Cost Per Foot
Drill #2	11 Holes	3050'	17,862.08	5.86 Cost Per Foot
Drill #3	7 Holes	1333'	10,109.84	7.58 Cost Per Foot
Drill #4	6 Holes	951'	10,377.50	10.94 Cost Per Foot

Over-all average is $ 7.18 per foot.

V. UNDERGROUND DRILLING

A. Michigan

1. Summary of Drilling

The following tabulation, Table XIII, is a summary of underground drilling.

TABLE XIII

UNDERGROUND DRILLING

LOCATION	HOLES	RIGS	FOOTAGE DRILLED	1ST CLASS ORE FOOTAGE	%	TOTAL COST "A"	COST/FT "A"	TOTAL COST "B"	COST/FT "B"
Bunker Hill	58-70	C.C.I. & Mine	4,038	1,204	29.82	$42,663.95	$10.56	$43,234.45	$10.71
Cambria-Jackson	234,235,236,237,238	Mine	880	358	40.76	Costs carried by Mather Mine "B" Shaft			
Maas (Including Pioneer & Arctic)	88-100	C.C.I. & Mine	3,721	952	25.59	34,571.10	9.29	35,259.25	9.48
Mather Mine "A" Shaft	210,314,315,318,319, 323,324,332,333,334, 335,342,343,344,352, 357,358	C.C.I. Odgers (210)	5,902	1,663	28.18	50,230.47	8.511	56,226.09	9.526
Mather Mine "B" Shaft	140,141,142,143,144, 145,146,147,148,149*, 313,316,317,320,321, 322,325,326,327,328, 329,330,331,336,337, 338,339,340,341,345, 346,347,348,349,350, 351,353,354,355,356, 361,362,363,364,365, 366,367,368,369,370	Mine	9,897	3,790	38.29	68,694.42	6.37	75,964.38	7.05

* Percussion Test Holes

2. Recap by Organization

The following tabulation, Table XIV, is the recap by organization.

TABLE XIV

ORGANIZATION	NO. OF RIGS	FOOTAGE	PER CENT
a. C.C.I. Co.			
1. Department	3	7,898	32.1
2. Mine	7	16,479	67.1
b. Contract	1	200	.8
Total	11	24,577	100.0%

Cost "A" is direct drilling charges
Cost "B" includes both direct and indirect charges

3. Summary by Properties - Marquette Range Underground

a. Bunker Hill Mine - Ted Engel, Jr., Geologist

Athens - Geological mapping of mining development and the drilling of two short test holes was the extent of exploration in the Athens property during the year.

Routine mapping of the development from the 2100 cross-cut on 12th Level indicates that the Athens dike is sharply folded or more probably faulted to the north between the 1200-W and 1365-W coordinates.

Mapping in this area has also indicated a 20 to 30 foot zone of ferruginous argillite and argillaceous iron-formation occurring along the south side of the Athens dike in the north orebody, thus reducing the amount of mineable ore expected from this area.

Bunker Hill - A continuous diamond drilling program significantly increased the ore reserves during 1956. This exploration was concentrated in the following three areas:

1. Ore intersected by the north end of the 10th Level conveyor drift.

2. Initial exploration of the Boundary Orebody.

3. The westward extension of the south and upper 10th Level orebodies.

Two holes were drilled for power cables from 10th to 12th, and 12th to 14th Levels.

10th Level - Three drill holes outlined the small section of ore cut by the north end of the 10th Level conveyor drift. This ore structure appears to be quite limited in extent by occurring in a V-shaped trough formed by the intersection of a north dipping dike and the south dipping footwall; and being bounded on the east by a NE-SW fault on about the 2100-W coordinate.

Two holes were drilled along the 2400-W coordinate in search of an ore structure which may be formed by the intersection of the north limb of the engine house anticline and the Negaunee fault. As a result of this and subsequent drilling, a very significant ore structure was outlined. This structure occurs in a down faulted zone of the north footwall with the Negaunee fault as the major controlling feature on the north and an east-west north dipping dike on the south. This structure is referred to as the Boundary Orebody as it is cut diagonally by the Bunker Hill-Pioneer and Arctic property line.

Five holes, three along the 3000-W section and two along the 3200-W section, explored the upper 10th Level and the south orebodies, as they extend to the west.

The sill-like intrusive, which underlies the upper 10th Level orebody, is folded with the axis of the fold plunging to the northwest at about 32°. This fold appears to control the ore lying above the sill as a marked reduction in thickness occurs at the flanks.

The south orebody continues west to the 3200-W coordinate. This structure occurs between the Athens dike and the Bunker Hill fault. Information gained from diamond drilling indicates that this fault has changed in strike from NW-SE to an E-W direction at about the 2300-W coordinate, and appears to be paralleling the Athens dike about 80' south of it. This change in strike of the Bunker Hill fault favors a continued ore structure to the west.

b. Cambria-Jackson Mine - Paul Bluekamp, Geologist

Exploration - Five diamond drill holes were drilled downward from the Cambria-Jackson 8th Level to outline the orebody extending from this level to the Mather Mine "B" Shaft 5th Level. This drilling proved a substantial tonnage of ore of which about one-third is standard ore and the remainder is sulfurous. The 40' of ore immediately underlying the Cambria 8th Level will be mined by the Cambria by using an inclined drift and conveyor. This adds about 200,000 tons to the Cambria-Jackson reserves. The total ore reserves as of December 31, 1956 were 608,866 tons.

c. Cliffs-Shaft Mine - James P. Meyers, Geologist

No drilling for hard ore was conducted at the Cliffs Shaft Mine in 1956.

The mine Geologist, throughout the year, was employed on the following items: (A) routine mapping duties, (B) general geological activities, (C) mine duties, (D) engineering work, (E) completing geological cross section maps for all areas of the mine, (F) planning and executing exploration pertinent to the Deep Soft Ore Program, (G) various reserve studies, (H) various reports to the lessor, (I) special mine studies enumerated in the following section.

Mining Areas - Some time was spent reviewing past, present, and possible future mining areas with the mine captain. This review included both underground inspection of stopes and study of maps on surface. The purpose of this review was and is to determine those areas which are mined out or will be mined out in the near future so as to time the moving of mining contracts and prepare the new places well in advance of moving time. It also served as a basis for a mining plan so that outlying areas will be mined out first, etc. and so that any by-pass drifts necessary to maintain the required production level might be planned, laid out, and commenced.

Production Reports - A meeting was held on March 22, 1956, at the mine office with Mr. Onnie Marjama, Superintendent; the writer; Mr. Harvey Hakala, O.I.M. Co.; and Mr. John Lake, O.I.M. Co. At this meeting, reports of mine production to the O.I.M. Co. were discussed and many small points concerning methods of calculation were cleared up. Also, Mr. Hakala supplied copies of several new forms they would like to have us use pending approval by the Cleveland Office.

Contract Location - Some time was spent with the mine captain checking over present contract working areas with respect to reserve life in the area. A study was then made to find new mining places for contracts which are currently depleted or will be depleted in the near future.

Reserves - A short meeting was held on June 19 in the mine office to discuss the possibilities of treating some Cliffs-Shaft second class ores in the new sink-float plant at Eagle Mills. A program of sampling areas with some potential reserves was instituted and carried out. These samples will be tested at the Metallurgical Laboratory. Upon the receipt of the results of these tests, an estimate of reserves of this material will be made in the areas in which a sink-float treatment may provide a suitable product.

Considerable time was spent on a detailed cost study which covers the estimated remaining life of the mine. The study should be of considerable value in determining the size and scope of future operation of the mine.

d. Maas Mine - Ted Engel, Jr., Geologist

A full-time diamond drilling program explored the south limb of the Maas orebody in the Pioneer and Arctic and outlined an ore section left along the Pioneer and Arctic property line above 6th Level. One hole was drilled to test the ground conditions near the crusher site on the Bunker Hill 6th Level elevation.

A total of 3721' were drilled during the year, 1426' of which were in the Maas property and 2295' in the Pioneer and Arctic. This includes footage drilled into the Pioneer and Arctic from the Bunker Hill 10th Level.

Results of this exploration are as follows:

1'. The ore occurring south of dike #82 throughout the Maas orebody on 7th Level discontinues between the 2700-W and 3000-W coordinates. This appears to be the result of the lack of ore enrichment and is suggested on the 2700-W coordinate by a reduction of ore height and iron-formation zones within the ore section.

2'. A significant amount of mineable ore occurs along the Pioneer and Arctic property line above 6th Level and between the 1500-W and 1800-W coordinates.

3'. A large portion of the Boundary orebody explored from the Bunker Hill 10th Level is within the Pioneer and Arctic property. This structure is described under the Bunker Hill section of this report.

e. Mather Mine

1'. "A" Shaft - Lee Erickson, Geologist

The 1956 diamond drilling program for the Mather Mine "A" Shaft totaled 5902 feet with a drilling cost-per-foot of $9.53. Drilling from the various levels was as follows:

Level	Footage	Per Cent of Total
6th	264	4.5
7th	401	6.8
8th	830	14.0
9th	4407	74.7

The 1956 estimate indicates a net loss in reserves of 587,641 tons as compared to a gain in 1955 of 3,282,952 tons.

	Tons
Estimated Net Reserves as of December 31, 1955	10,077,875
Production December 31, 1955 to December 31, 1956	1,252,192
Net Reserves as of Dec. 31, 1956 by subtraction	8,825,683
Estimated Net Reserves as of December 31, 1956	8,238,042
Net Loss in Reserves	587,641

Reserves on the 8th Level and above were decreased and reserves between the 8th and 9th Levels were increased. The increase in reserves was not sufficient to offset the decrease. A decrease in anticipated reserves of some of the ore areas due to contamination by intrusives, abandonment of small isolated areas for economic reasons, and a decrease in the size of some ore areas due to more accurate delineation by development drifts and raises all contributed to the decline in reserves on the 8th Level and above.

Production for the year was 1,252,192 tons. Of the year's production, 49.20% came from the 8th Level, 48.15% from the 7th Level, 2.13% from the 5th Level, and .52% from the 9th Level.

6th Level - One hole, U.H. #352, was drilled from the 6th Level on the 9,962 W. section. The hole was drilled to test for ore northeast of the present mining operations over the #9 B Cross-cut on the 7th Level. No enrichment was disclosed.

7th Level - In October, U.H. #210, located along the 13,400 W. section, was re-entered after having previously been bottomed at 1,239'. The purpose of this hole is to test for ore above the footwall at the 12th Level elevation. Drilling was still in progress at the end of the year and no enrichment encountered.

8th Level - Four diamond drill holes were completed on the 8th Level during the year. Holes #315, #318, and #319 were drilled from a top-timber cutout above the 8300 Cross-cut to outline the orebody above the level in advance of development for mining. U.H. #358 was drilled from the footwall drift on the 10,075 W. section to outline ore east of the present mining operations in the #9 Cross-cut.

9th Level - During the year, eleven diamond drill holes were drilled from the 9th Level. Eight of these holes were drilled to outline the orebody above the 9th Level. A summary of the drilling is as follows:

U.H. #314, located on the 10,850 W. section, and drilled from the 9700 Cross-cut stub, indicated a reduction in ore thickness south above the 9th Level. After passing through a probable fault zone, 235' of greenstone was encountered. The hole was stopped in the greenstone.

U.H. #323, on the 10,600 W. section, and drilled from the 9800 Cross-cut stub, indicated that the bedding flattens to the south above the 9th Level.

U.H. #324, drilled from the same location, was drilled to investigate the ore section south above the 9th Level, and to locate the greenstone intrusive along the 10,600 W. coordinate. The hole was stopped in the intrusive.

U.H. #335, on the 11,590 W. section, was drilled from the -1275 sub level to outline the orebody north and east of the Mather Fault between the 8th and 9th Levels.

U.H. #342, on the 11,500 W. section, was drilled from the -1250 sub level to delineate the orebody south of the Mather Fault, and to locate the footwall north of the fault. The hole indicated little enrichment south of the fault.

U.H. #343, on the 11,500 W. section, was drilled from the -1275 sub level to test for ore south of the Mather Fault above the 9th Level. No enrichment was indicated.

U.H. #344, on the 11,100 W. section, was drilled from the 9600 Cross-cut to outline the orebody above the 9th Level.

U.H. #357, on the 11,100 W. section, was drilled from the 9600 Cross-cut. The log indicated ore to the Mather Fault, iron-formation between the Mather and the East-West Faults, and a large intrusive south of the East-West Fault.

The other three holes drilled from the 9th Level, #332, #333, and #334, were drilled from a location south of the major East-West trending fault and along the 11,100 W. section.

U.H. #332, drilled from a Top-timber cutout in the 9600 Cross-cut, indicated spotty ore runs in a zone adjacent to the large East-West fault and located the fault position at the 10th Level elevation. U.H. #333, drilled from the 9600 Cross-cut, outlined the enrichment south of the Negaunee Shaft Fault and located the footwall and fault position below the 9th Level. U.H. #334, drilled from the 9600 Cross-cut, indicated at least 800' of displacement along the East-West Fault. The hole was drilled due south at an inclination parallel to the dip of the fault. A total of 155' of ore was disclosed above the -2100 elevation; between the 11th and 12th Level elevations. This ore was correlated with ore disclosed in Surface D.D.H. #44.

2'. "B" Shaft - Paul Bluekamp, Geologist

Exploration

A total of 10,777' of diamond and percussion drilling was done during 1956 as compared to 6,034' in 1955. The major portion of the drilling was carried out from 8th and 10th Levels, the remainder being distributed among 5th, 7th, and 9th Levels. The objectives of the drilling program were:

1. Detailing 5th and 8th Level ore.
2. Outlining 9th and 10th Level ore.
3. Exploring for 10th Level ore west of the Cambria-Jackson Fault.

5th Level - Six diamond drill holes were drilled from the 5th Level, two of these were drilled to explore the continuation of the 5th Level ore up the footwall and the remaining four were drilled to detail the ore above 5th Level.

Seven percussion holes were drilled from 5th Level to detail an ore block prior to developing the block.

7th Level - Three holes were drilled from this level to detail a small ore pocket below the level.

8th Level - Eighteen diamond drill holes were completed on 8th Level; one was drilled for ventilation purposes, three were drilled to explore for ore south of the Negaunee Fault at and below the 8th Level. Fourteen holes were drilled to outline and detail orebodies prior to mining development.

9th Level - Four holes were drilled from the 9th Level; three holes were drilled to detail the ore east of the Cambria Fault prior to planning the mining development, and one hole was drilled to explore for ore west of the Cambria Fault.

10th Level - Nine diamond drill holes were drilled from the 10th Level; one was drilled to outline the ore east of the Cambria Fault and eight were drilled to explore for ore west of the fault.

Three percussion holes were also drilled to aid in planning the course of the main level drift.

The emphasis on the diamond drilling program in 1957 will be on detailing 8th Level ore and exploring for ore on 9th and 10th Levels west of the Cambria Fault.

The total feet drilled was 10,777. The total ore cut was 4,148'. Drilling costs were $7.05 per foot.

Ore Reserves

The net ore reserves reported to the Tax Commission on December 31, 1956 were 12,662,092 tons, a decrease of 2,495,763 tons from the previous year. This reduction was due to mining and also to new information on the ore above 5th Level which diminished the sulfurous ore 1,000,000 tons and the standard about 125,000 tons.

VI. LAND OFFERS AND OUTSIDE EXPLORATIONS

A. Land Offers

During 1956 the Geological Department continued to process various land offers submitted to the Company. A total of 94 land offers was submitted by various owners and agents in 1956. They may be allotted to five geographical groups as follows:

Area	No.	Percent of Total
1. Michigan	15	16.0
2. Minnesota	8	8.5
3. Canada	30	31.9
4. U. S. General	31	33.0
5. South & Central America	10*	10.6
Total	94	100.0

*Includes 2 land offers in Mexico.

It is interesting to note that U. S. General became the largest group in 1956. During the period of 1952 through 1955, Canada was the leader. Michigan, Minnesota, and Canada showed a decline in Land Offers submitted from their respective 1955 figures. U. S. General, and South and Central America showed increases. Total offers increased from 85 in 1955, to 94 in 1956, although a number of offers were carried forward from past years.

During the year 1956, a total of $8,379.12 was spent by Canadian Cliffs, Ltd., for the investigation of Land Offers, diamond drilling, metallurgical testing, and analyses of samples from them. Cleveland-Cliffs spent $8,304.88 on Minnesota Land Offers, $5,696.69 on those in Michigan, and $51,350.83 on those classified under U. S. General. (The last group covers the entire United States except Michigan and Minnesota.) Figure 4 shows the five-year trend of Land Offers.

B. Outside Explorations

We use the term "Outside Explorations" for mineral areas and deposits which are not actually offered to Cliffs, but are studied as: 1. deposits or areas for later acquisition on the basis of their potential; or, 2. as a source of valuable information. The distribution of Outside Explorations, new in 1956, is as follows:

Area	No.	Percent of Total
1. Michigan	3	10.0
2. Minnesota	2	6.7
3. Canada	8	26.6
4. U. S. General	15	50.0
5. South & Central America	2	6.7
Total	30	100.0

The number of new Outside Explorations considered in 1956, thirty, was a significant rise from that of nine in 1955. The all time high in the past five years was forty-six in 1951. In 1956, as in 1955, U. S. General was the locus of the greatest single number of Outside Explorations. In Minnesota $1,416.65, Michigan $59,867.31, U. S. General $14,280.36, and Canada $1,272.23 was spent on the Outside Explorations.

Figure 5 shows the distribution of Outside Explorations for the past five years. Figures 6 and 7 show the locations of 1956 Land Offers and Outside Explorations in the United States and Canada respectively.

Figure 4

GRAPH SHOWING RATE OF MINERAL LAND OFFERS 1952–1956 incl.

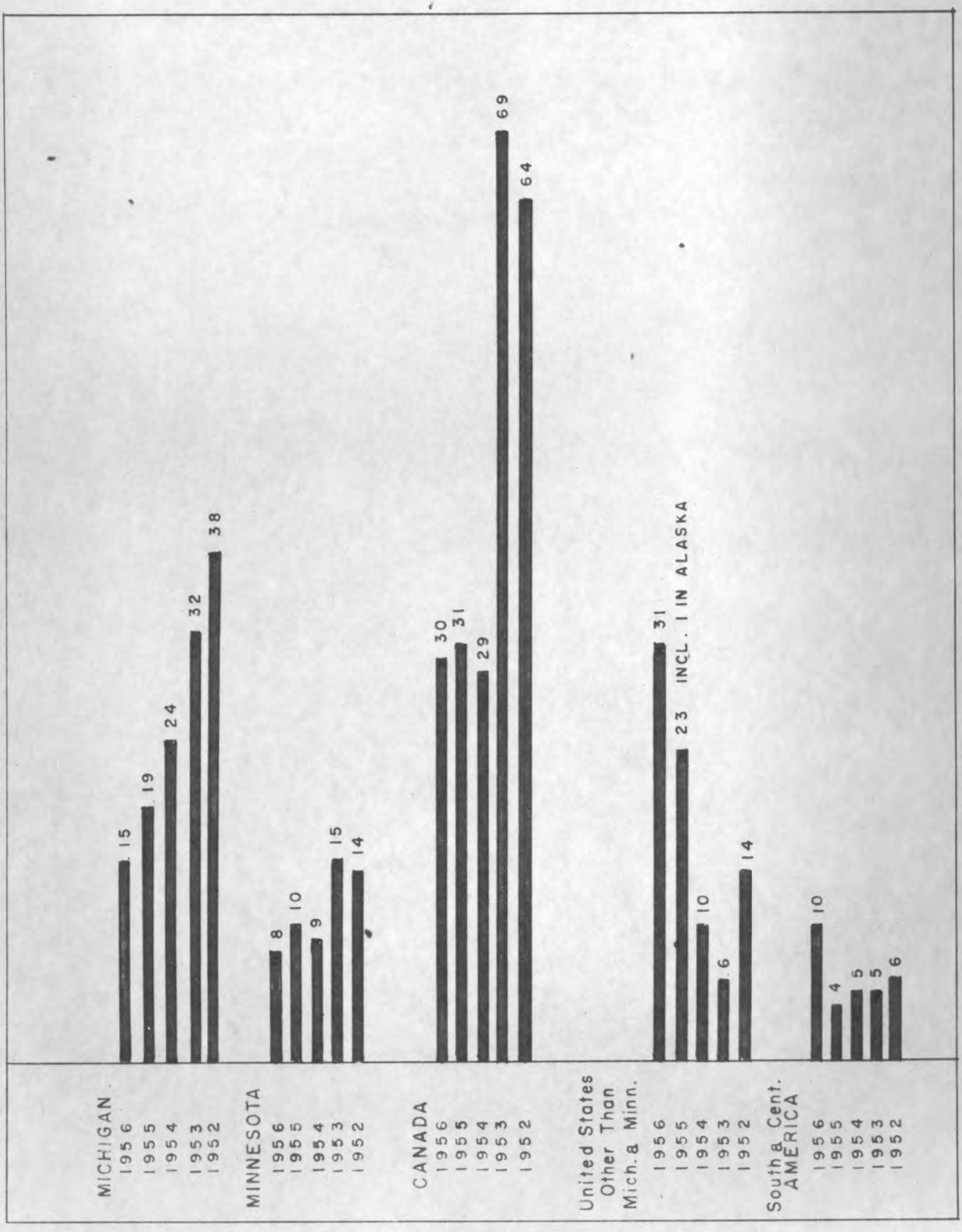
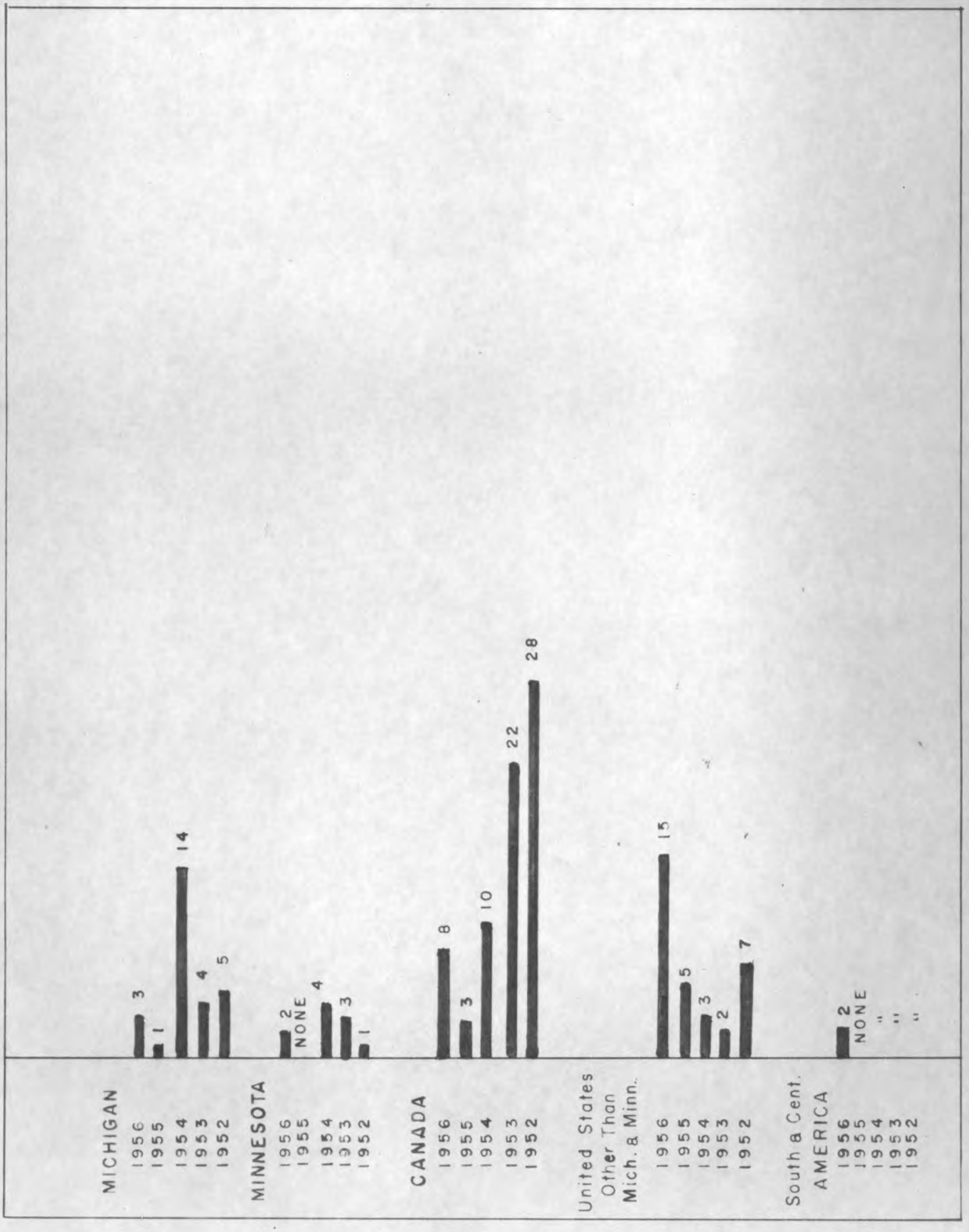
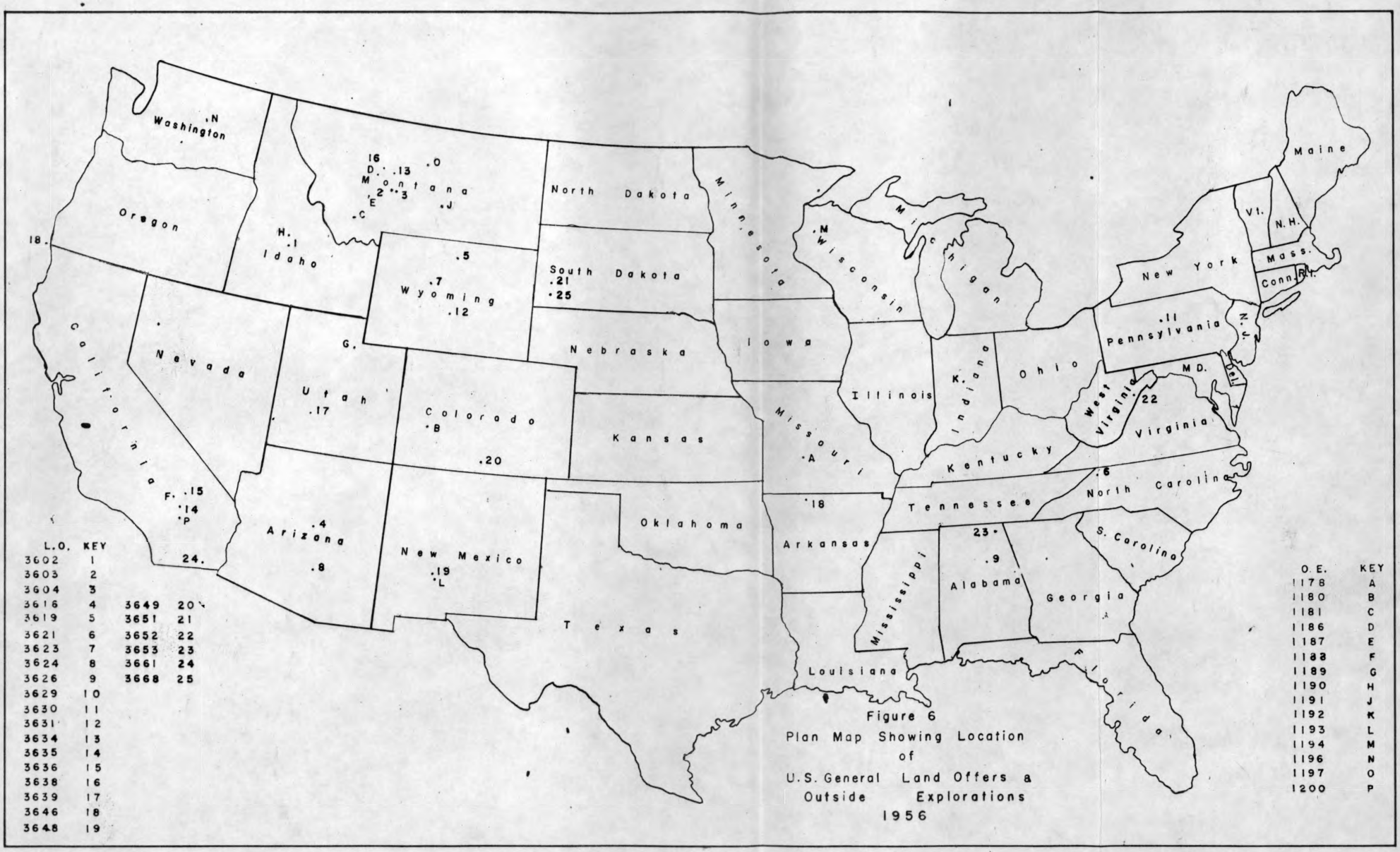


Figure 5

GRAPH SHOWING RATE OF OUTSIDE EXPLORATIONS 1952–1956 incl.





L.O.	KEY
3602	1
3603	2
3604	3
3616	4
3619	5
3621	6
3623	7
3624	8
3626	9
3629	10
3630	11
3631	12
3634	13
3635	14
3636	15
3638	16
3639	17
3646	18
3648	19
3649	20
3651	21
3652	22
3653	23
3661	24
3668	25

O.E.	KEY
1178	A
1180	B
1181	C
1186	D
1187	E
1188	F
1189	G
1190	H
1191	J
1192	K
1193	L
1194	M
1196	N
1197	O
1200	P

Figure 6
Plan Map Showing Location
of
U.S. General Land Offers &
Outside Explorations
1956

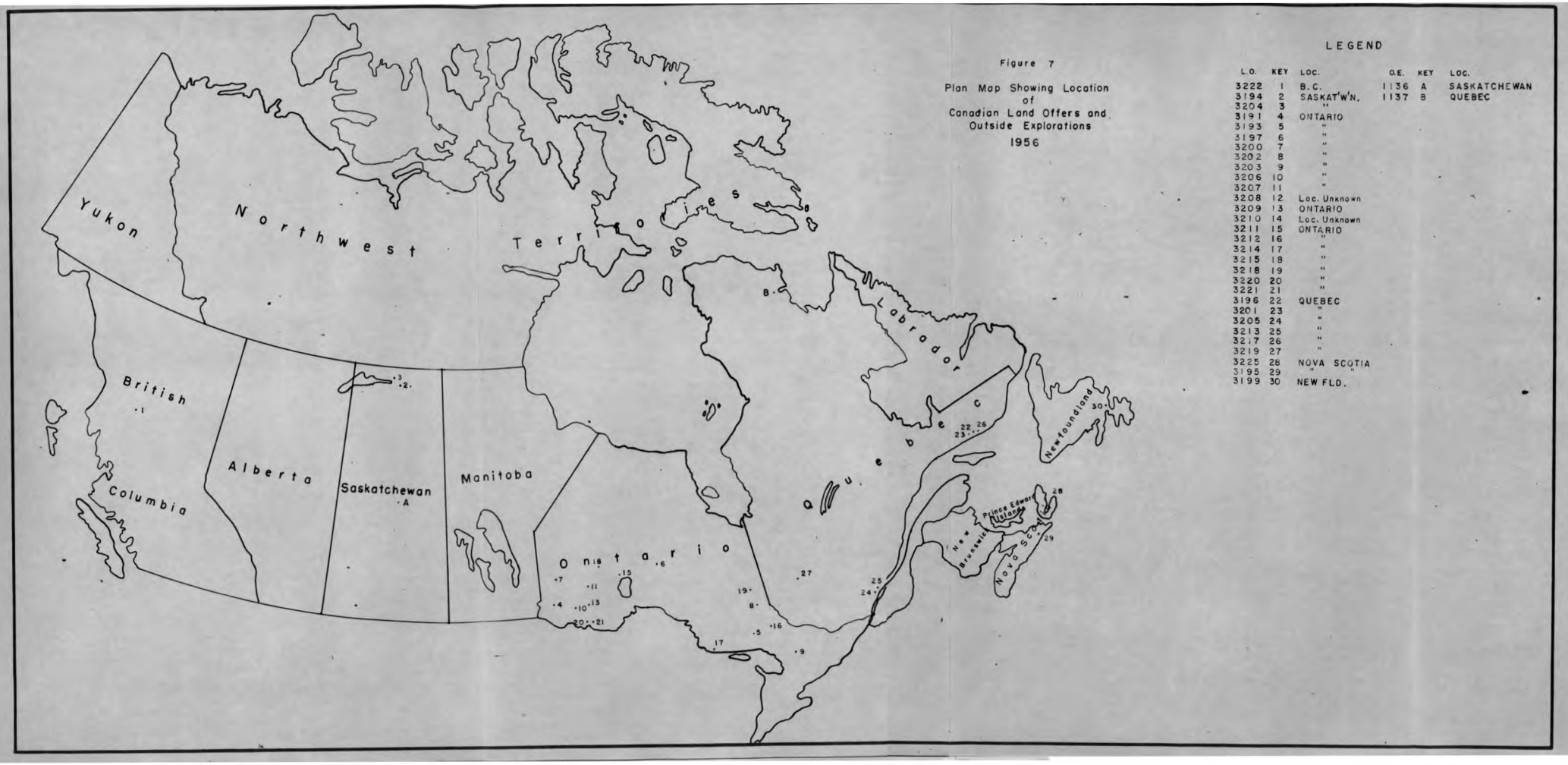


Figure 7

Plan Map Showing Location of Canadian Land Offers and Outside Explorations 1956

LEGEND

L.O.	KEY	LOC.	O.E.	KEY	LOC.
3222	1	B.C.	1136	A	SASKATCHEWAN
3194	2	SASKAT'W'N.	1137	B	QUEBEC
3204	3	"			
3191	4	ONTARIO			
3193	5	"			
3197	6	"			
3200	7	"			
3202	8	"			
3203	9	"			
3206	10	"			
3207	11	"			
3208	12	Loc. Unknown			
3209	13	ONTARIO			
3210	14	Loc. Unknown			
3211	15	ONTARIO			
3212	16	"			
3214	17	"			
3215	18	"			
3218	19	"			
3220	20	"			
3221	21	"			
3196	22	QUEBEC			
3201	23	"			
3205	24	"			
3213	25	"			
3217	26	"			
3219	27	"			
3225	28	NOVA SCOTIA			
3195	29	" "			
3199	30	NEW FLD.			

VII. MICROSCOPY - Tsu-Ming Han, Geologist

During the year 1956, the writer has completed the following work for the Geological Department in the Microscopy Section of the Research Laboratory:

A. Michigan

1. Cascade and Tilden Projects

An intensive microscopic examination was conducted on drill core samples and core specimens from the Cascade and Tilden Districts. The objectives were to determine the concentratability of iron minerals, and to ascertain the lithological facies of the iron-formation in these districts.

The iron-formation in the Tilden District differs from that in the Cascade District in many respects. The former is chiefly composed of martitic jaspilite, martitic chert, clastics, goethitic chert, and cherty magnetite-carbonate, while the latter is composed of martitic chert, goethitic chert, hematitic chert, and some clastics.

The martite in the iron-formation appears to be the only iron mineral that could be favorably concentrated by the laboratory standard MOC process. The concentratability of the martite is further determined by the martite grain size; and the presence and abundance of hematite and goethite.

Metallurgically, the iron-formation in these districts may be classified as follows:

a. Most desirable material (0-5% silica in concentrate): Coarse-grained martite in clean chert (Plate 1).

b. Desirable material (5-15% silica in concentrate): Medium-grained martite in clean chert (Plate 2), coarse-grained martite in clastics (Plate 3), and coarse-grained martite in chert containing some hematite fines.

c. Undesirable material (10-15% silica in concentrate): Fine-grained martite in clean chert (Plate 4), coarse-grained martite in chert containing noticeable amount of hematite fines (Plate 5), intensely oxidized coarse-grained martite in chert (Plate 6), and goethite with appreciable amount of martite in chert.

d. Most undesirable material (15% silica and up in concentrate): Coarse-grained martite in chert containing considerable hematite fines (Plate 7), goethite in chert (Plate 8), and earthy hematite in chert and in clastics (Plate 9).

2. Microscopic Examination of Materials from Exploration Projects and Operating Mines

Drill cores, samples, and hand specimens have intermittently been received from geologists for microscopic examinations. The material was from various operating mines including Mather Mine "A" and "B" Shafts, Cliffs-Shaft, Humboldt Mine, Republic Mine, and from various exploration projects including Cascade, Belleview, Tilden, Rock, Osier, Perkins, and Minnesota (L.O. 2954). This work was generally done coincidental to the drilling program.

B. U. S. General

1. Colorado

A number of magnetic specimens from O.E. 1180, Powderhorn, Gunnison County, were examined. The materials cannot be an acceptable iron ore at present due to the finely intergrowth of ilmenite and magnetite (Plate 10), but they might be valuable for titanium ore (more than 14% perovskite is present in the specimens).

Three samples listed under L.O. 3649, Costilla County, were received from Mr. Robert W. Riedel for microscopic examination. It was concluded that the samples are an ilmenite-magnetite-bearing gabbroic rock (Plate 11). Most of the ilmenite in the samples can be mechanically separated from the magnetite. Unfortunately, the samples seem too low grade for both iron and titanium ore at the present.

2. California

A series of crushed samples from DDH #21, Section 28, under L.O. 3613, Bessemer Iron Claims, was examined microscopically. The samples are essentially made up of magnetite, carbonate, silicates, and quartz. The magnetite could be concentrated magnetically by a -48 mesh grind.

3. Montana

A specimen collected from Snowbird Shaft Dump and listed under L.O. 3634 was studied. A suitable magnetic concentrate may be obtained by magnetic separation by grinding to -48 mesh.

A mineralogic examination was conducted on a copper-bearing iron ore sample from Willow Creek, Stanford, L.O. 3581. The study was to determine the age relationships between the minerals of iron and copper occurring in the sample. The result revealed that the material is a malachite-goethite bearing magnetite ore (Plate 12) and was probably collected from a zone of oxidation of a copper and iron sulfide-bearing magnetite orebody.

A sample listed under O.E. 1186, Belt County, is a gluconitic sandstone which does not show any economic value at the present.

A specimen from Cascade County, listed under O.E. 1187, is a carbonate-magnetite rock and it could be either a direct shipping ore having a low iron content, or a concentratable ore by grinding the material to -200 mesh and treated by magnetic separation.

4. New Mexico

A copper-bearing iron ore sample from Fierro, listed under O.E. 1193 (Plate 13) was examined in detail. The sample appears to be favorable for metallurgical treatment. A desirable iron ore concentrate and an acceptable copper concentrate may be produced by grinding the sample to -150 mesh and concentrating by magnetic separation and froth flotation.

5. Idaho

A sample from L.O. 3603, Big Iron, was studied and concluded that the material is not a desirable material for beneficiation even when -400 mesh grinding is employed.

6. Wyoming

Two specimens from L.O. 3612, the Pattison Iron Company lands in the Seminoe Mountains, were received for examination. The size of the iron mineral particles are extraordinarily fine-grained (Plate 14), and it seems impossible that they could be economically treated by any of the current mineral dressing techniques.

7. New York

A graphite sample listed under L.O. 3614, Whitehall, is a sericite-quartz schist. The graphite occupies approximately 6% of the rock and could be liberated by grinding to -65 mesh and concentrated by flotation.

8. Wisconsin

A laboratory examination was conducted on O.E. 1173, some Wisconsin thorium-bearing materials. The preliminary examination shows that an acceptable thorium ore may be produced by gravity concentration from most of the materials examined.

C. Canada

A number of beach sand samples from L.O. 2585, Mingan and Natashquan, Quebec, were investigated. The purpose was to discover the relationship between the titanium and iron minerals occurring in the samples (Plates 15 to 17), and to find out whether the two constituents are mechanically and economically separable. The result revealed that the sample from Natashquan is a better beneficiable material and could produce a concentrate having a higher iron, lower titanium, and lower silica content then those from Mingan.

Samples listed under L.O. 3190-C, McChesney Claims, were submitted to the Microscopy Section for microscopic examination. The objective was to explain the discrepancy in iron analyses of these samples which were tested at The Cleveland-Cliffs Chemical Laboratory and the Quebec Department of Mines Laboratory. At the latter, total iron content is measured while at the former, soluble iron content is measured.

D. Nicaragua and Cuba

A sample from Monte Carmelo, Nicaragua, listed under L.O. 3628, was submitted for genetic study. The material in this sample was probably formed by pyrometasomatic replacement and subsequently oxidized.

Three manganese samples listed under O.E. 1195, Cuba, were received for mineralogical investigation. The study reveals that the manganese minerals are chiefly wad, manganite, and a subordinate amount of pyrolusite. The gangue minerals are chiefly quartz and carbonate.

In short, during the year 1956, the Land Offers and Outside Explorations examined were twelve iron deposits, one graphite deposit, one manganese deposit, and one thorium deposit.

The iron deposits examined may be genetically classified into the following:

(1) Magmatic segregation type, which includes L.O.'s 3649 and O.E. 1180 (Plates 10, 11).

(2) Contact metamorphic and replacement type, which includes L.O.'s 3613, 3638, 3634, 3581, and O.E.'s 1187 and 1183 (Plates 12, 13).

(3) Sedimentary and detrital type, which includes L.O.'s 3612, 3603, and O.E. 1186 (Plates 14-17).

Generally speaking, the specimens and samples of the contact metamorphic and replacement type are more suitable for iron ore beneficiation, and some could be direct shipping ores.

E. Special Research

Mr. G. J. Anderson and the writer have prepared a paper entitled, "The Relationship of Diagenesis, Metamorphism, and Secondary Oxidation to the Concentrating Characteristics of the Negaunee Iron-Formation of the Marquette Range" which was presented by Mr. Anderson at the Lake Superior Mining Geology Meeting at Houghton on May 11, 1956.

The purpose of the paper is to illustrate the various types of iron-formation produced by the geological processes and their concentrating characteristics.

ILLUSTRATIONS

Plate 1
Cascade
D.D.H. #38,
Sec. 27, 47-26
Depth 110'-160'

Coarse-grained martite in chert. 125 x.
Martite, white; magnetite, greyish white; gangue, dark grey; and pits, black.
Martite Size: approximately 150 mesh.
Polished Section No. 1332. Photomicrograph No. 558.

Plate 2
Cascade
D.D.H. #41
Sec. 27, 47-26
Depth 77'-80'.

Medium-grained martite in chert. 125 x.
Martite, white; gangue, grey; and bakelite, dark grey.
Martite Size: -325 +400 mesh.
Martite-chert Size: 100 mesh.
Polished Section No. 762. Photomicrograph No. 571.

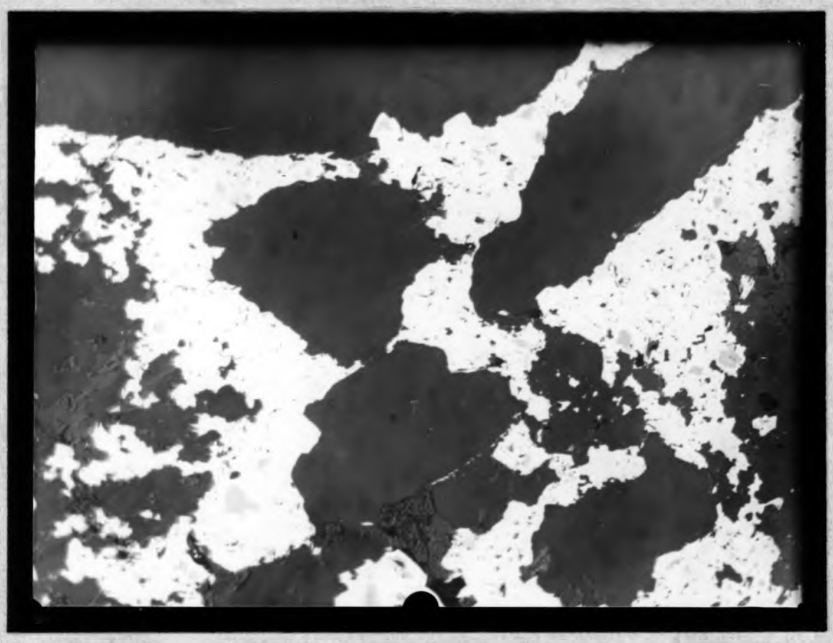


Plate 3
Tilden
D.D.H. #55,
Sec. 26, 47-27
Depth 550'

Martite in clastics. 125 x.
Martite, white; magnetite, greyish white; quartz, grey.
Common Martite Size: approximately -150 mesh +200 mesh.
Polished Section No. 912. Photomicrograph No. 828.

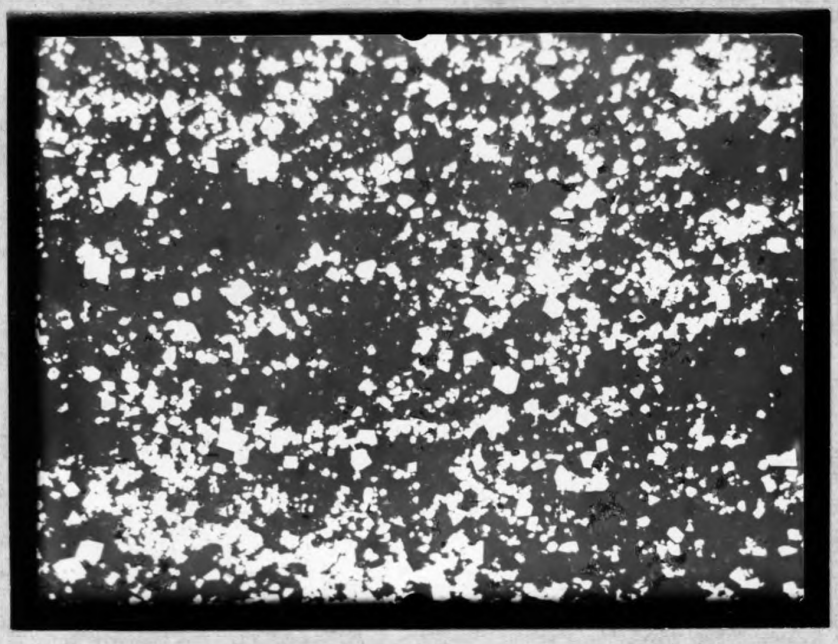


Plate 4
Tilden
D.D.H. #56,
Sec. 26, 47-27
Depth 43'

Fine-grained martite in chert. 125 x.
Martite, white; chert, grey; and pits, black.
Martite Size: -400 mesh.
Polished Section No. 916. Photomicrograph No. 832.

Plate 5
Tilden
D.D.H. #55,
Sec. 26, 47-27
Depth 690'

Coarse-grained martite in fine iron oxide-bearing chert. 125 x.
Martite and hematite, white; quartz and chert, grey; and pits, black.
Martite Size: 150 mesh
Polished Section No. 915. Photomicrograph No. 831

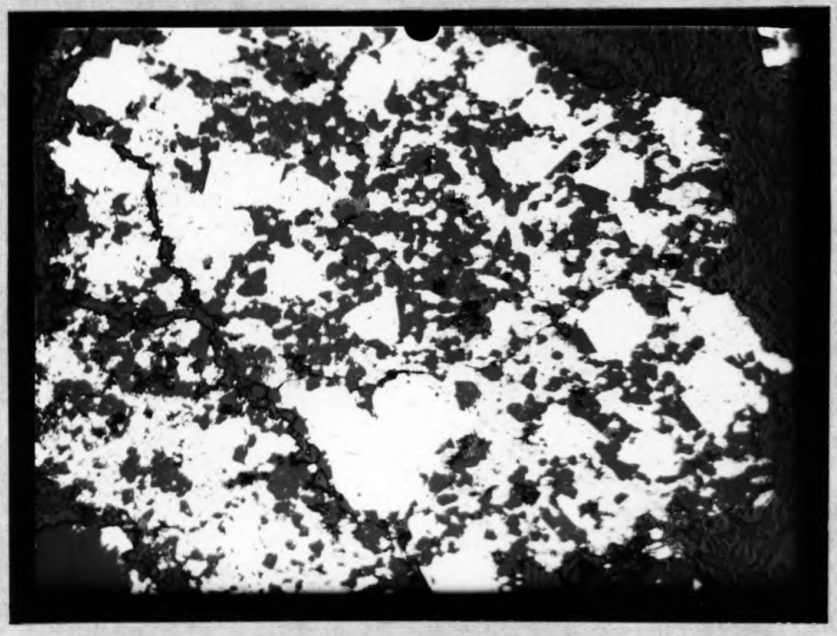


Plate 6
Cascade
D.D.H. #38,
Sec. 27, 47-26
Depth 303'-355'

Intensely oxidized coarse-grained martite in chert. 125 x.
Martite and hematite, white; chert, grey; and bakelite, grey.
Martite Size: 200 mesh; and hematite size: -20 micron.
Martite-hematite-chert size: -20 mesh + 28 mesh.
Polished Section No. 1335. Photomicrograph No. 560.

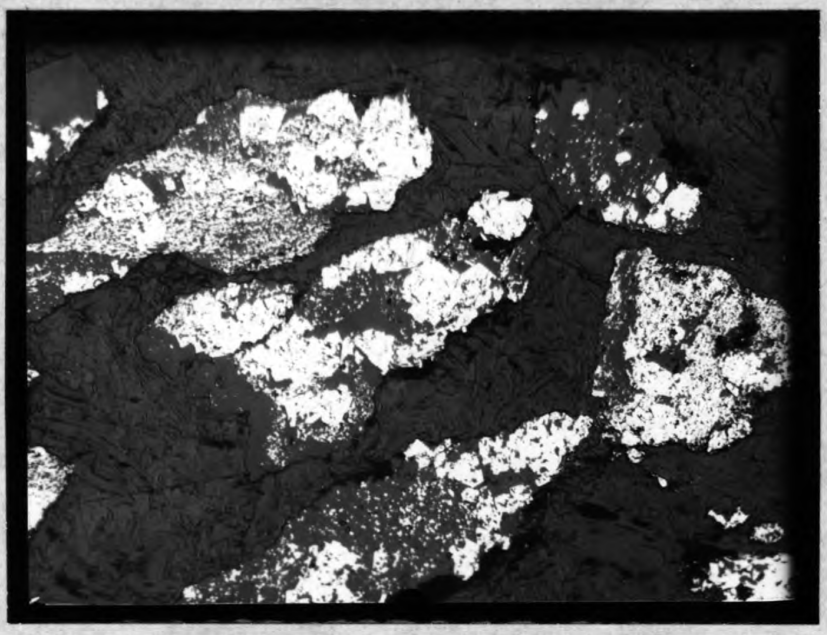


Plate 7
Tilden
D.D.H. #21,
Sec. 27, 47-27
Depth 5'-35'

Martite in hematite-bearing chert. 125 x.
Martite and hematite, white; chert, grey; and bakelite, dark grey.
Martite Size: -200 to 400 mesh.
Hematite Size: a few microns to less than a micron.
Martite-hematite-chert size: 100 mesh.
Polished Section No. 871. Photomicrograph No. 578.

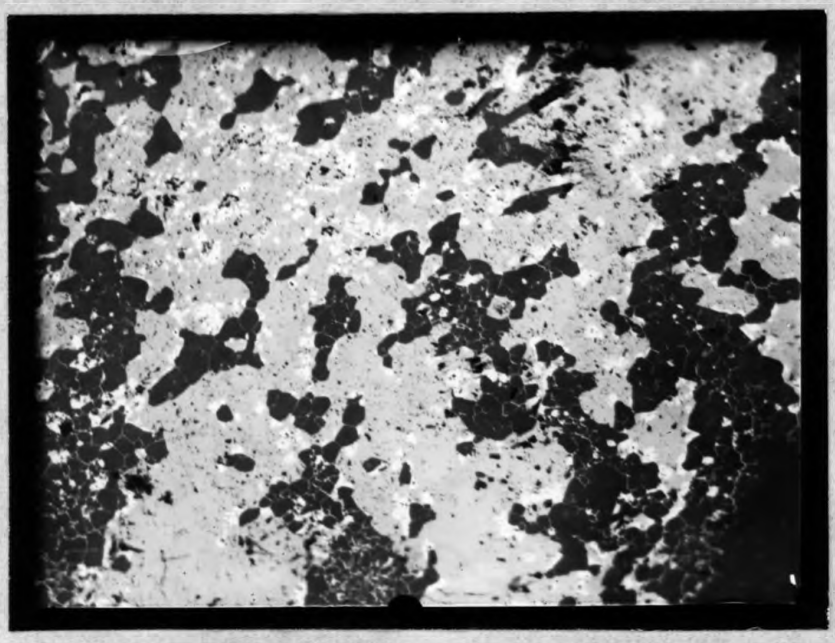


Plate 8
Tilden
D.D.H. #1,
Sec. 22, 47-27
Depth 212'

Goethite in chert. 125 x.
Hematite, white; goethite, greyish white; chert, dark grey.
Goethite Size: irregular.
Polished Section No. 884. Photomicrograph No. 813.

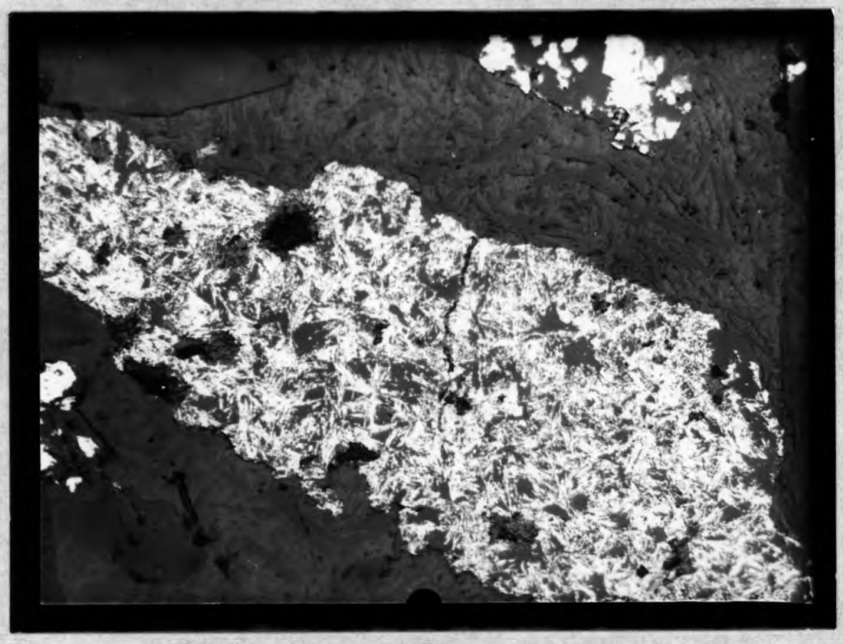


Plate 9
Cascade
D.D.H. #38,
Sec. 27, 47-26
Depth 13'-77'

Earthy hematite in chert. 125 x.
Hematite, white; chert, grey; and pits, black.
Hematite Size: -20 microns.
Hematite-chert size: -28 +35 mesh.
Polished Section No. 1331. Photomicrograph No. 557.

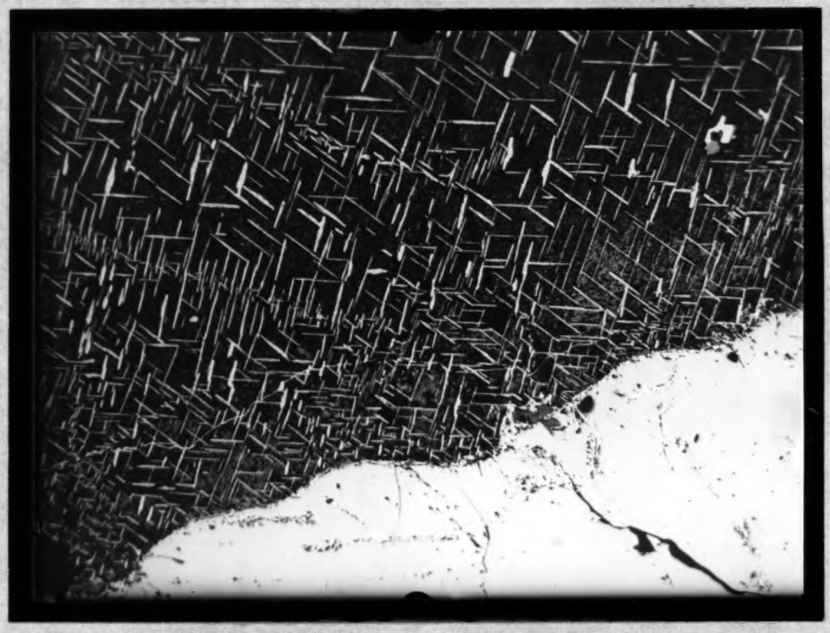


Plate 10
O.E. 1180
Gunnison County,
Colorado

Titaniferous magnetite, the lattice growth of ilmenite in magnetite. 125 x.
Platy ilmenite and massive perovskite, white; magnetite, etched black; and gangue, dark grey.
Polished Section No. 1438. Photomicrograph No. 807.

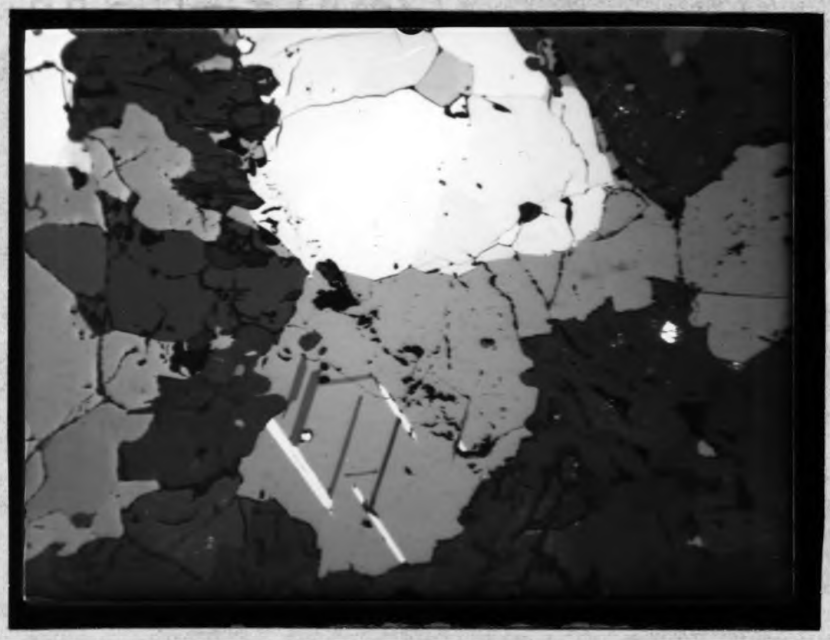


Plate 11
L.O. 3649
Costilla Co.,
Colorado

Ilmenite-magnetite-bearing gabbroic rock under polarized light. 100 x.
Magnetite, light grey; ilmenite, white; two sets of parallel ilmenite plates in magnetite, white and grey; gangue, dark grey; and pits, black.
Polished Section No. 1474. Photomicrograph No. 856.

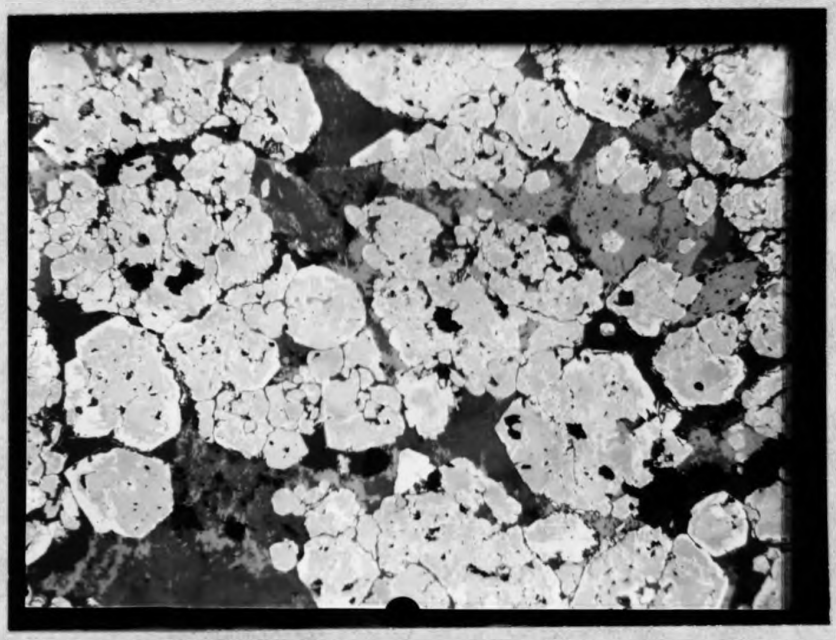


Plate 12
L.O. 3581
Stanford,
Montana

Partially oxidized magnetite. 125 x.
Martite, white; magnetite, greyish white; goethite, light grey; malachite, grey; gangue, dark grey; and pits, black.
Polished Section No. 1469. Photomicrograph No. 885.

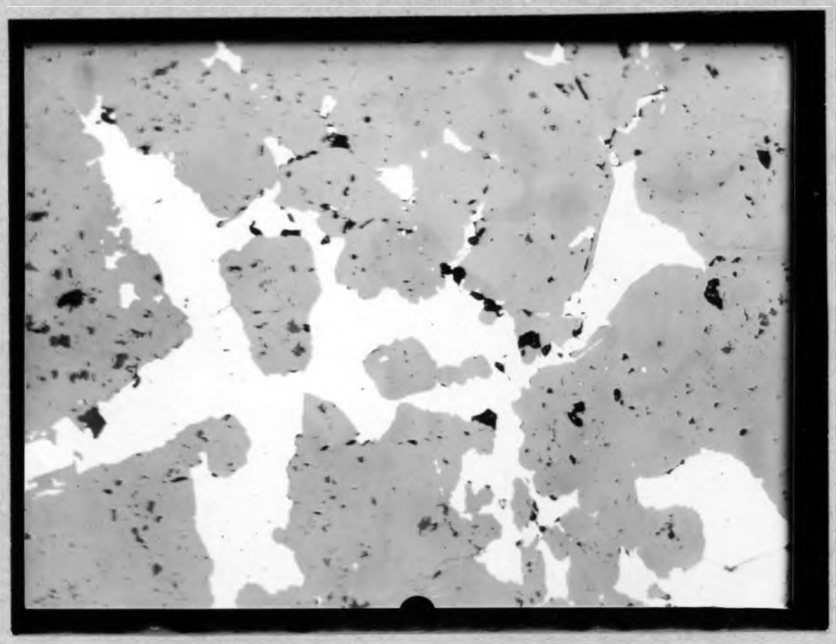


Plate 13
O.E. 1193
Fierro, New Mexico

Sulfide bearing-magnetite. 125 x.
Magnetite, grey; pyrrhotite, white; and pits, black.
Polished Section No. 1487. Photomicrograph No. 868.

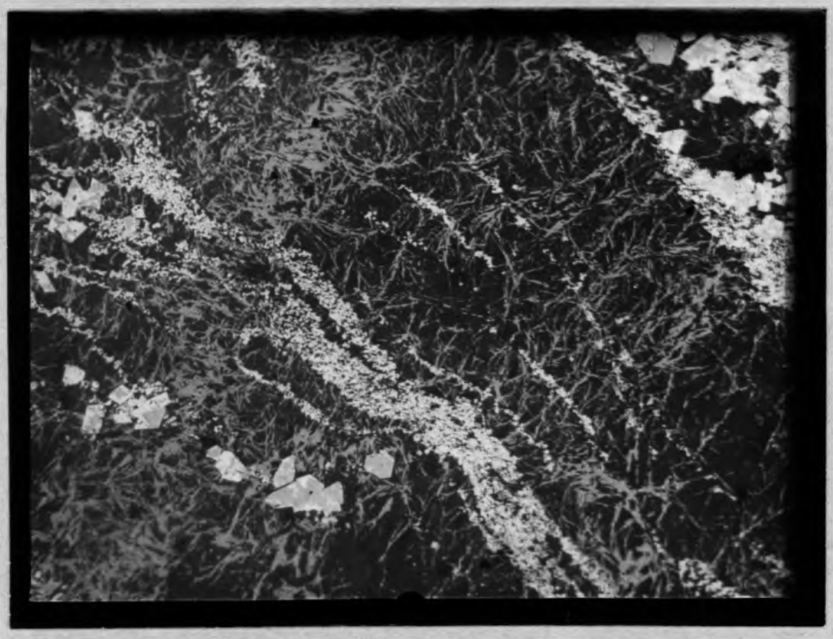


Plate 14
L.O. 3612
Seminoe Mountains,
Wyoming

Goethitic jaspilite. 125 x.
Martite, white; magnetite, light grey; and goethite, grey; and gangue, dark grey.
Euhedral crystal size: 400 mesh.
Polished Section No. 1361. Photomicrograph No. 565.

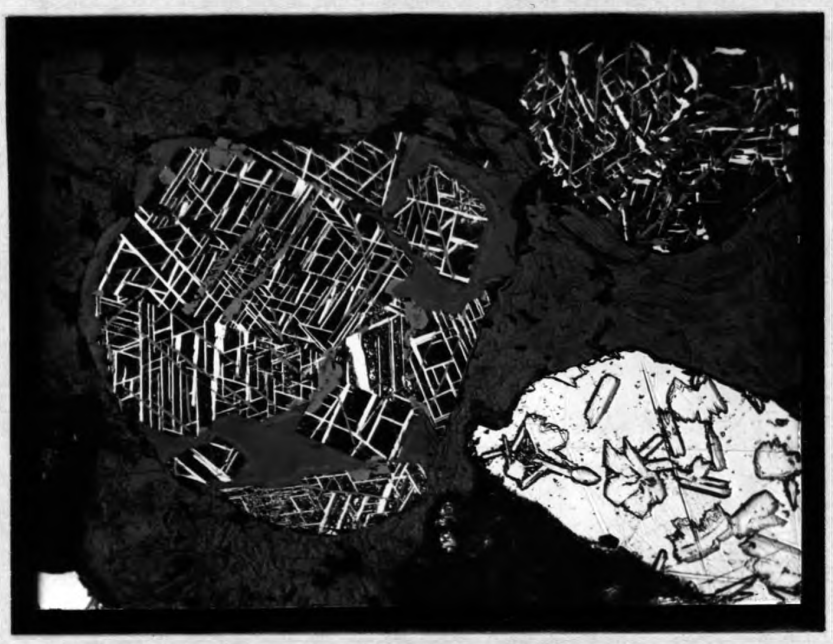


Plate 15
L.O. 2585
Mingan, Quebec

Sample No. MXC-437 - Mingan, Quebec
+65 mesh magnetic concentrate etched by concentrate HCL. 125 x.
Ilmenite, white; magnetite, etched black; and gangue and bakelite, grey.
Polished Section No. 1383. Photomicrograph No. 794.

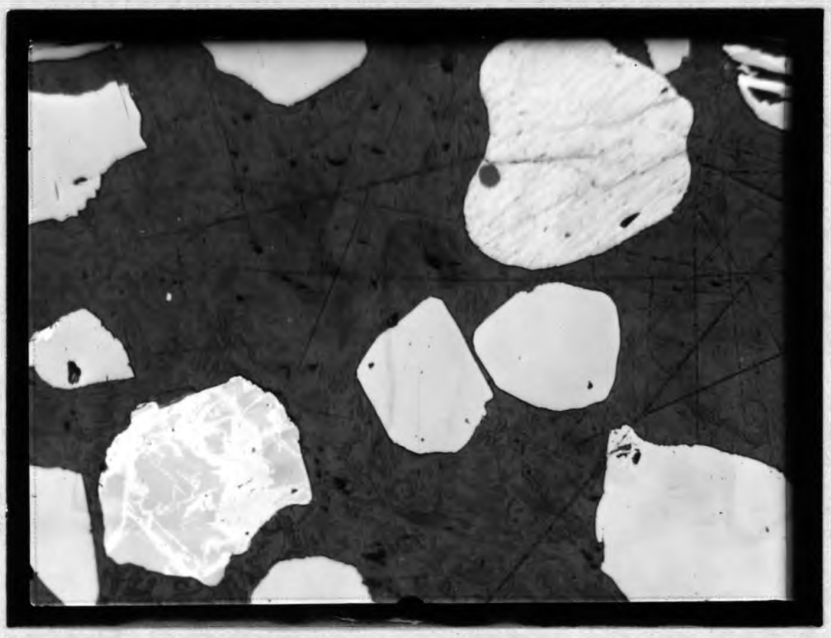


Plate 16
L.O. 2585
Natashquan, Quebec

Sample No. MXC-444.
-65 mesh magnetic concentrate. Composed of magnetite, martite-magnetite, and ilmenite-hematite. 125 x.
Magnetite and ilmenite, greyish white; hematite, white; and bakelite, dark grey.
Polished Section No. 1392. Photomicrograph No. 797.

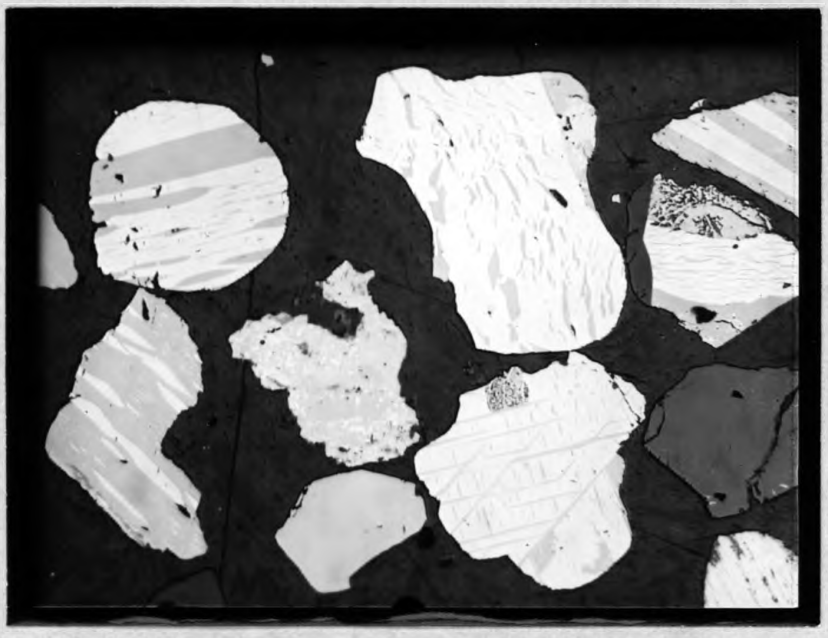


Plate 17
L.O. 2585
Mingan, Quebec

Sample No. MXC-437.
-65 mesh ilmenite-hematite concentrate.
Ilmenite, light grey; hematite, white; gangue, dark grey; and bakelite, black.
Polished Section No. 1385. Photomicrograph No. 794.

VIII. OTHER DEPARTMENTAL HIGHLIGHTS

A. Research in Exploration

During the year 1956 the Department intensified its program of research in exploration techniques and equipment. Experimentation was done in the fields of geophysics and in drilling. The principal items of investigation may be summarized as follows:

1. Experimental Ore Geophysics - This program was conducted in Minnesota in the operating open pit properties. The goal was to investigate the application of refraction seismic and electromagnetic induction techniques. The Holman-Cliffs Mine was selected for this experimental work conducted by Mr. E. R. Randolph.

Twenty-eight seismic shots were made on thirteen traverses. Results indicated a good grouping of velocities in ledge from 1000 to 7000 feet per second. The correlation with rock and ore types is plausible. The method shows definite promise of aiding pit-bottom mapping.

Sixty-one EM stations were occupied from a single transmitter setup located near the sumps in the pit bottom. Cross-overs were weak, but occurred over the contacts between taconite and intermediate ore. Better electromagnetic coupling with the formations may produce more concrete results.

2. Experimental Rotary Drilling - It has been our goal for several years to experiment with new equipment in the field of rotary drilling. The purchase of the Joy 225 truck mounted drill made possible this testing. This drill is equipped not only with hydraulic swivel head but also a compressor and a pump for air, water or mud drilling. The plan was to drill in portions of our Minnesota mines that had been structure drilled and in areas that would be processed through the mill in the relatively near future.

Twelve rotary drill holes totaling 714 feet were drilled, of which 454 feet was with diamond core bits and 260 feet with rotary tricone bits. Of the tricone drilling, 77 feet was for casing overburden prior to diamond drilling, and 44 feet was drilled searching for solid ground on a new bench. Average core recovery over the 454 feet was approximately 70%. However, since the ground became successively more difficult to drill at each new location, the ±70% recovery in the friable wash ore structure in Hole #445 was a significant advance in technique.

The machine used was a truck mounted, hydraulic power assisted Joy 225. It was instrumented to observe data on bit pressure, bit R.P.M., pump pressure, and fluid volumes, and penetration rates. Air, water and mud circulating mediums were used.

This experimental work demonstrates the variations of the portability and flexibility of this drill. It also demonstrated that the two man crew can be used in contrast to three on the structure drilling. Additional work is recommended for 1957 in the field of bit and core barrel design.

3. Airborne Electromagnetic Induction - Our success in pioneering the application of electromagnetic induction (EM) on the ground has led us to speculate on the application of airborne EM. Two systems have been in use in Canada for the past two years and programs were set up comparing the application of each system.

The older system used by Photographic Surveys Corporation, Ltd. (PSC) through its subsidiary, Aeromagnetic Surveys, Ltd., employs the Finnish system. In this system, the airborne magnetics and airborne EM can be measured simultaneously. Two frequencies, 400 and 2300 cycles per second, are employed. Comparison is made of the ratio of the anomalies determined by the two frequencies. In its application in the area of O.E. 1140-C, also known as Block 1, known occurrences of iron-formation were covered. Base metal deposits of the sulphide type would also be detected.

The second system was utilized at our Albanel Project 17 in our joint venture with the M. J. O'Brien Company. Here again iron-formation and base metal mineralizations were prospected. This survey was done by Aero Physics, at that time a combination of Aero Service, Spartan Air Services, and McPhar Geophysics, Ltd. A single frequency of 140 cycles per second characterizes this system developed by McPhar. The airborne EM is flown singly and not in connection with the aeromagnetics. Before the survey was started, technical representatives of Aero Physics doubted that we would obtain anomalies over the iron-formation. The flying showed a number of anomalies, almost to the point where their technicians could not interpret their results.

In December, Mr. R. W. Riedel visited Toronto and the offices of both companies. His analysis of the two systems is presented in our Geophysical Report #7. We believe that additional research in this technique is warranted.

4. Survey Control - The subject of survey control is more properly in the province of mining engineering. However, our large scale exploration projects emphasize surveying problems. In August, Mr. Boyum conferred with Mr. G. R. Johnson of Radar Exploration Company, Toronto, concerning their electronic Shoran type surveying gear. This system is still under development but reads directly in coordinates in surveys up to the range of 50 miles. Later in October, he conferred with Mr. Robert Moran of the Moran Instrument Company on their Shoran electronic surveying gear. An area such as our Albanel Project might utilize one of these techniques.

B. Departmental Reports

During the year 1956 the following reports were prepared and issued by the Department under the following headings:

1. General Exploration Reports

Memo No. 7 - Geology of the Millie Pit and Related Area, L.O. 3607 by Robert M. Steder and Ted R. Larimer
Memo No. 8 - Geology of the Vulcan Area, L.O. 3643 by Robert M. Steder and Ted R. Larimer
Memo No. 9 - Geological Field Exploration of the W½ of the Belleview Property by Keith C. Roberts and Roy A. Koski
Memo No. 10 - Menominee Range (3 Areas), Dickinson County, Michigan by Robert M. Steder
Memo No. 11 - Tilden Mine, Section 2-27, 47-27 by Robert E. Goodrich, Keith C. Roberts and Robert M. Steder
Memo No. 12 - Mining and Tax Laws - Western United States by R. E. Magnuson, Jr.
Memo No. 13 - United States General Exploration by Burton H. Boyum
Memo No. 14 - Northern Wisconsin Iron by Burton H. Boyum
Memo No. 15 - Land Offer Investigation, A Bankrupt Policy by Burton H. Boyum
Memo No. 16 - Operations Research by R. E. Magnuson, Jr.
Memo No. 18 - 1957 Exploration Program by Burton H. Boyum
Memo No. 24 - Report of Airborne Magnetic Data on the Estancia and Albuquerque Basins, New Mexico by J. S. Sumner
Memo No. 25 - Report of Aeromagnetic Data on the Williston and Powder River Basins by J. S. Sumner

2. Geology and Mineralogy

Report No. 12, Memo No. 365 - Preliminary Examination of Wisconsin Thorium Bearing Rocks by Tsu Ming Han
Report No. 13, Memo No. 368 - Microscopic Examination of Core Specimens and Composite Samples from D.D.H. #1, Section 26, Cascade, Michigan by Tsu Ming Han
Report No. 14, Memo No. 378 - Microscopic Sampling, Drill Hole #41, Section 27, Cascade Area by Tsu Ming Han
Report No. 15, Memo No. 379 - Metallurgical Characteristics of Drill Core Samples from D.D.H. #21, Section 27, Tilden by Tsu Ming Han
Report No. 16, Memo No. 390 - A Laboratory Investigation of St. Lawrence River Sand Deposits by Tsu Ming Han
Report No. 17, Lake Ainslie, Nova Scotia, Barite-Fluorite Deposit by Eric J. Rex

3. Geophysics

Memo No. 4 - Mesabi Range Ore Geophysics by E. R. Randolph
Memo No. 5 - Cornell-Gladstone Area by Thomas L. Longacre
Memo No. 6 - South Sturgeon-Indian Lake District by Roger Hall
Memo No. 7 - Airborne Electromagnetic Induction Prospecting by Robert W. Riedel

4. Diamond Drilling

Memo No. 4 - Experimental Drilling, Holman-Cliffs Mine, Taconite, Minnesota by Roy W. Hillmer
Memo No. 5 - Experimental Drilling, Holman-Cliffs Mine, Taconite, Minnesota by E. R. Randolph
Memo No. 6 - Experimental Drilling, Holman-Cliffs Mine, Taconite, Minnesota by E. R. Randolph
Memo No. 7 - Experimental Drilling, Holman-Cliffs Mine, Taconite, Minnesota by Roy W. Hillmer
Memo No. 8 - Experimental Drilling, Holman-Cliffs Mine, Taconite, Minnesota by Roy W. Hillmer
Memo No. 9 - Experimental Drilling, Holman-Cliffs Mine, Taconite, Minnesota by Roy W. Hillmer
Memo No. 10 - Joy Experimental Drilling by E. R. Randolph
Memo No. 11 - Minnesota Experimental Drilling by Roy W. Hillmer and E. R. Randolph

5. Ore Reserves

Memo No. 3 - Abstract of Estimates by J. P. Meyers
Memo No. 4 - Mather Mine "B" Shaft and Cambria-Jackson Mine Ore Reserves by P. R. Bluekamp

6. Subsidence

Memo No. 2 - Review of Microseismic Study at Mather Mine "B" Shaft by G. H. Ulrickson
Memo No. 3 - A Review of Drilling and Subsidence Activities at D.D.H. #65 - Mather Mine "A" Shaft by G. E. Frantti
Memo No. 4 - A Review of the Partridge Creek Pumping Project by P. R. Bluekamp