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Report No. 7

ANNUAL REPORT OF RESEARCH PROGRESS

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University of Alaska
College, Alaska 99701

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MINERAL INDUSTRY
RESEARCH LABORATORY1966 Annual Report
of
Research Progress

"The American mining industry at home and throughout the free world developed abundant sources of metals, minerals, and energy fuel for the industrial societies of the West. Recent economic and political difficulties remind us that this worldwide productive network is not a gift of nature but the work of man and of his drive and ingenuity, and that it needs to be sustained and furthered."

Quoted from "A Declaration of Policy, 1966"
American Mining Congress as adopted at Salt Lake
City, Utah, September 11, 1966

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FOREWORD

The mineral and human resources of a state and/or nation are to a large extent the basis of a strong and flourishing economy. In Alaska this is currently illustrated by the activities of the oil and gas industry and the resulting large sums of money that have gone into the State Treasury to help give a sound financial basis to Alaska.

The Mineral Industry Research Laboratory has concentrated its efforts on research that will help in the more complete utilization of Alaska's mineral resources for work in the state's mineral industry. This report describes in moderate detail the projects that have been undertaken. These are in the areas of mineral economics, exploration, mining, mineral beneficiation, beach and ocean mining, utilization of nonmetallics, use of coal resources, and the solving of numerous specific problems posed by mining people of the state.

Training of young men and women for the mineral industry is stimulated by their having the opportunity to work on projects as a part of their graduate program under the supervision of the staff of MIRL. Theses completed offer a considerable amount of information to the public. Recent completed theses are listed in this report.

The laboratory has been supported financially by the State of Alaska and various grants and work in kind from individuals and agencies. Private industry has helped in purchasing equipment and cooperative projects are underway with government agencies. Personnel and facilities of the College of Earth Sciences and Mineral Industry supplemented by other professional personnel are involved in teaching and research as set forth in enabling legislation for the Laboratory.

The Staff
MIRL

MINERAL INDUSTRY RESEARCH LABORATORY STAFF

- Earl H. Beistline, Dean, College of Earth Sciences and Mineral Industry and Professor of Mining Engineering
- Donald J. Cook, Head, Department of Mineral Engineering and Professor of Mineral Benefication
- *Ernest N. Wolff, Associate Professor of Geology (Sabbatical leave from Colorado State University)
- *Pemmasani D. Rao, Assistant Professor of Coal Technology
- Douglas W. Huber, Assistant Professor of Mineral Engineering
- Norman S. Smith, Assistant Professor of Mining Engineering
- *Lawrence E. Heiner, Senior Research Assistant
- Bruce I. Thomas, Mining Engineer, representing the Bureau of Mines, U. S. Department of Interior, in a Cooperative Agreement in the Study of Factors Affecting Lode Mining in the Fairbanks District, Central Alaska
- Stephen Stoney, Graduate Assistant, Mineral Engineering
- John Loperfideo, Undergraduate Assistant, Chemistry
- Paul S. Glavinovich, Graduate Assistant, Geology
- *Full time basis. All others on part time basis

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I GENERAL BACKGROUND

INTRODUCTION

The Mineral Research Laboratory was established as a part of the College of Earth Sciences and Mineral Industry by the 1963 State Legislature (Alaska Statutes Title 14, Chapter 40, Section 14:40.115). The overall objective of the Laboratory is to help expand and diversify the mineral industry of the State through applied and basic research in coordination with State and Federal mineral agencies. The program is implemented by using laboratory facilities and staff for research on mineral deposits in the State and other studies, upon request, on specific problems of Alaska's mineral industry.

The Laboratory, which became a reality on July 1, 1963, has an advisory committee composed of staff members of the College to evaluate proposed projects and to guide general policy within the limits of authorizing legislation. The direction and scope of individual studies are coordinated with government agencies and other institutes where possible overlap might occur. In these instances, the investigations are planned to extend knowledge rather than duplicate efforts.

The advisory committee recognizes the desirability of short term investigations to assist economic growth, but it also recognizes the need for longer range studies to ensure continuous development for future generations. The soundness of this concept is fully appreciated when one recognizes that the development of any resource is correlated in time with availability of data and advances in technology.

FACILITIES AND THE FUTURE

In the three years since its inception the Mineral Industry Research Laboratory has acquired equipment which the committee considers to be basic to the program. The apparatus obtained with funds from state, federal, and private sources during 1964 and 1965 are described in the appropriate annual reports. During the 1966 fiscal year, the following apparatus were purchased with

funds supplied by private industry:

Binocular microscope with photometer attachment for measurement of reflectivity of coal constituents.

Polishing machine with automatic arrangement for polishing six coal samples simultaneously.

As a part of instructional lab work in mining for the Mineral Technician Program, limited development was begun on an underground lode mining property owned by the University. This property may develop into a site for solving practical underground mining problems, as well as a laboratory for in situ rock studies, ventilation, surveying, and practices of cyclic mining operations.

Since research progress is often keyed to the availability of necessary apparatus and housing, adequate funding for facilities is of basic importance. The availability and retention of qualified personnel, and their ability to undertake fund-producing projects, (in addition to teaching and other responsibilities) is based on continuity and amount of core funds.

For example, required equipment which must be obtained for continued study of Alaskan coals includes:

- (1) Dilatometer for determining the expansion of coals on heating.
- (2) Plastometer for determining plasticity of coals on heating.
- (3) Apparatus for determining tar yield of coals on heating.
- (4) Apparatus for determining carbon and hydrogen content of organic materials.
- (5) Laboratory set-up for gassification study of coals.

It is anticipated that at least part of the above required items will be purchased with the 1967 Usibelli Coal Mine, Inc. grant.

In order to continue beneficiation studies, testing and research facilities must be established in a building suitable for joint use in the education program. Much of the equipment is on hand, but adequate housing is not now available. Although other specific pieces of apparatus are required for MIRL programs, space is critical and facilities are overcrowded. Also, the State Assayer uses laboratory equipment at operational cost through a cooperative arrangement with the Alaska Division of Mines and Minerals.

In the interest of efficiency, a need exists for at least one full-time laboratory technician who would relieve the scientific staff of routine investigative tasks associated with current research.

DUAL RESPONSIBILITY: RESEARCH AND EDUCATION

It is commonly agreed that the development of Alaska hinges on the development of the State's natural resources. A major prerequisite for this anticipated development is People. A nationwide shortage of trained people for the minerals industry exists and could deter Alaska's development. The staff members of MIRL have a responsibility for teaching technicians, undergraduates and graduate students for future careers in the mineral industry. The training and development of technically qualified people for Alaska's growing mineral industry is enhanced by association with faculty members engaged in research concurrently with teaching. Also, a mutual use of facilities enables students to become acquainted with modern instrumentation and research techniques without duplication of facilities, however, some facilities are crowded to the extent that laboratory space to accommodate more than 5 students at a time is not available.

The Mineral Technician Training Program for Native Alaskans was again sponsored by the Bureau of Indian Affairs of the U. S. Department of Interior. Graduates of last year's program were hired by Kennecott Copper Co. for work at Bornite, Alaska.

II RESEARCH ACTIVITIES

COAL RESEARCH

In Alaska coal is mainly produced from the Matanuska and Nenana coal fields and is used for generation of power and heat by commercial and military plants and to a smaller extent as domestic fuel. Although coal will remain competitive in many of its present applications (such as mine-mouth power plants) a decrease in use may occur through conversions of plants to natural gas. In view of the estimated Alaska coal reserves of 150 billion tons, coal can make an increasing contribution to the development of the State. Continuous research on coal utilization and marketing is certainly warranted.

Major areas of potential utilization are (1) production of coking quality coal by blending (2) production of pipe line quality gas for domestic and commercial use (3) production of gasoline and petrochemicals.

Production of coking quality blends seems to have good immediate prospects. For production of gasoline and pipeline quality gas it would be necessary to first undertake feasibility studies to evaluate future market potential and the economics of processing. Extensive work has been done by several workers under contracts with the Office of Coal Research but processes are not yet available for commercial application. It will require further testing before gasification of Alaskan coals can be seriously considered. Also, any estimation of coal demand must include the projected increase in population and industrial activity.

Current Research Program A precise knowledge of the petrographic composition and rank of coal is necessary in evaluating the feasibility of utilizing coals for any of the three aforementioned purposes. Coals differ not only in the relative proportions of the various reactive and inert constituents, but also in degree of coalification of vitrinite. Reflectivities of vitrinites are widely used in defining the degree of coalification.

The first phase of the MIRC coal research program

is designed to determine the basic characteristics of coals occurring in various fields in Alaska. The work includes:

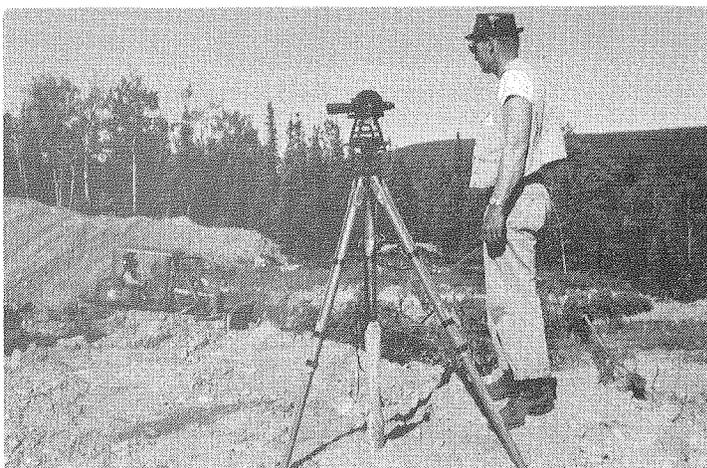
- (a) Collection of samples from various coal fields.
- (b) Proximate analysis and systematic classification of coals by rank.
- (c) Preparation of polished sections and determination of the petrographic composition by point counting technique in reflected light.

Work In Progress A total of eighty samples of coal were collected from the coal fields of Northern Alaska (Kukpowruk), Nenana, Jarvis Creek, Matanuska, Kenai and Bering River. All the samples were crushed to 20 mesh to produce a minimum of fines. Petrographic study, proximate analysis, and preparation of polished sections is completed for half of the samples. Further work on the first phase of the program is in progress.

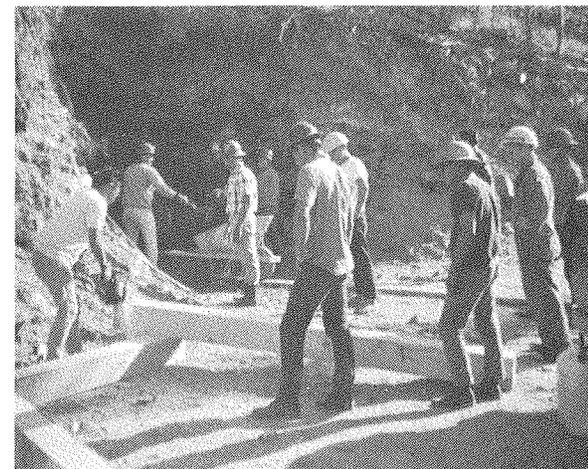
Future Program The second phase of the research program includes the investigation of potential uses of coal, based on the petrographic and analytical data gathered during the first phase of the program. Investigations to determine the blend proportions necessary for the production of metallurgical grade coke, and actual laboratory coking tests of the blends, can be undertaken with the funds from the Usibelli Coal Co. for purchase of equipment. Investigation of economics and development of techniques for gasification and liquifaction will require additional funds for equipment. The research program in this third phase will therefore be dependent on the availability of these additional funds.

BEACH AND OFF-SHORE DEPOSITS

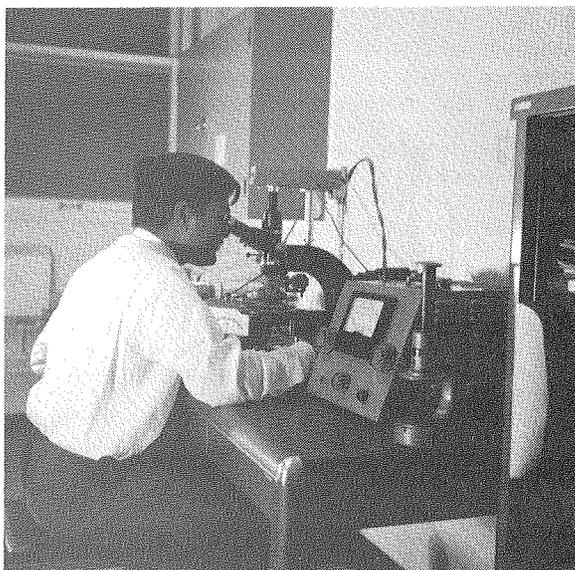
The economic occurrences of beach and off-shore mineral deposits along Alaska's coastline have been considered sporadically for many years. However, until



TRENCHING AND MAPPING OF BEDROCK GEOLOGY BY BUREAU OF MINES PERSONNEL (U.S. DEPARTMENT OF THE INTERIOR) ON A COOPERATIVE PROJECT WITH MRL FOR GEOCHEMICAL-GEOPHYSICAL INVESTIGATIONS.



MINERAL TECHNICIAN STUDENTS OBSERVING AND LEARNING TO INSTALL A PORTAL SET OF TIMBERS AT THE UNIVERSITY'S BLUBIRD MINE.



RESEARCH MICROSCOPE WITH ATTACHMENT FOR ACCURATELY DETERMINING REFLECTIVITY OF COAL CONSTITUENTS.



AN ALASKAN GOLD PLACER MINER OBTAINING ASSISTANCE IN CLEANING UP HIS GOLD CONCENTRATE THROUGH USE OF LABORATORY FACILITIES.

recently actual investigations have been confined to the on-shore deposits.

A large scale federal program to search for heavy metals is to be initiated in 1967, and is in part concerned with probing the continental shelf off the west coast and Alaska for extensions of deposits known to exist on-shore. This off-shore exploration program is under direction of the United States Geological Survey. The University of Washington has contracted to investigate the continental shelf off the Seward Peninsula in the Bering and Chukchi Seas. In addition, under a separate contract, the University of Alaska through the Institute of Marine Sciences will investigate possible off-shore extensions of beach deposits in the Yakutat-Yakataga areas.

The Mineral Industry Research Laboratory is involved in the latter investigation to the extent that a staff member will be part of the investigation team and information obtained from samples processed through the Laboratory will be used to predict the most likely off-shore areas for investigation.

Due to the high capital costs of off-shore investigation, MIRL has been concerned with investigations of beach deposits from samples submitted by individuals. Usually the precious metal and mineralogical content of samples is determined. This is a logical first step in delineating areas for future off-shore investigations, and should be continued in a cooperative program with other agencies such as The Bureau of Mines and Geological Survey of the U. S. Department of the Interior.

FACTORS AFFECTING LODE MINING IN THE FAIRBANKS DISTRICT

The Cleary Summit-Pedro Dome and Ester Dome lode mining areas form a gold lode mining complex that comprises the core of the Fairbanks lode mining district. Production from the lodes has been sporadic during the past 25 years. Small-scale mining, using antiquated hand methods and equipment, continues. Outdated mining and milling costs form an inadequate base for evaluation. Sound estimates based on the optimum use of modern equipment and current technology may form an economic base for reviving and sustaining a lode mining industry in the district.

Despite the pegged price of gold at \$35.00 per fine ounce, a gradual inflationary spiral, self-imposed outmoded methods, and use of antiquated equipment some profits are won from select deposits. The profit cycle is usually of short duration and consequently there is little or no incentive to explore for and develop reserves. Under present circumstances, high grade pay shoots are extracted without regard to a preconceived cost cutoff, therefore mill heads are not balanced so that profits can be prorated for a self-sustaining development program. Analysis of factors affecting costs along with suggested methods and techniques for up-grading the output potential are the only practical guidelines for establishing minimum values and tonnages in the district.

This project is a cooperative effort of the United States Bureau of Mines and MIRL, each institution contributing approximately one-half of the report. The contract requires a completion of the MIRL portion by March 31, 1967 at which time the report will be turned over to the Bureau of Mines for appropriate action which includes possible publication.

APPLICATION OF STATISTICS AND COMPUTER TECHNIQUES TO ORE DEPOSITS, SOUTHEASTERN ALASKA

A three phase program has been initiated to study regional geologic data as applied to ore deposits in southeastern Alaska. The basic study technique is regression analysis, a computer oriented approach, which removes personal bias in data interpretation. This technique may enable the definition of regional trends of mineralogy or structure not made evident by plotting ordinary geologic data. Deviations from this trend may then indicate areas worthy of prospecting.

The program is being approached in three phases:

- I. Data Gathering - All available literature pertinent to the subject is being perused in an effort to tabulate data for the study. This portion of the study will determine the amount and type of information available and will indicate to some extent the degree of success to be expected in Phase III.

II. Program Development - This portion of the project will adopt one of several existing regression analysis programs to the University of Alaska computer facilities.

III. Statistical Analysis - The first step in Phase III will be the sorting and grouping of the data gathered in Phase I. This may allow the information to be placed in categories so that it can be of value to an exploration company. It may be possible to evaluate relative potential of vein systems when only dip and strike are known, but other parametric and non-parametric data may also prove valuable.

The final step in the program will be computer analysis of the data by regression and trend surface methods, and the preparation of a report. To date Phase I is about two-thirds complete and an existing regression analysis program has been successfully run on the computer.

STUDY OF DISTRIBUTION OF COPPER MINERALIZATION IN PART OF THE DENALI COPPER BELT, ALASKA RANGE

During the summer of 1966 a graduate student in Geology, partially supported by MIRL funds, sampled and mapped an area in the Alaska Range. The results of this investigation will appear as a thesis entitled "Trace Element Copper Distribution and Areal Geology in a Portion of the Clearwater Mountains, Alaska."

The area of investigation is located in the southern portion of the Clearwater Mountains, Central Alaska Range, Alaska. The area is bounded by latitudes 63°08'N on the north and 63°03'N on the south and by longitudes 147°30'W on the west and 147°09'W on the east.

Throughout this area there are numerous small occurrences of copper mineralization in association with altered volcanic rocks. A similarity in lithology, mineralization and perhaps, age of rocks exists between the copper deposits in this area and the Kennecott deposit in the McCarthy area.

Field work in the area, commenced on 14 June 1966 and completed on 3 August 1966, consisted of mapping and sampling along controlled traverse lines on a scale of four inches equals one mile. In addition to areal coverage, several known copper occurrences were investigated.

Research currently in progress or soon to be initiated includes:

1. Semiquantitative spectrochemical analysis of rock samples taken at one thousand foot intervals along controlled traverses. The samples are being analyzed for trace element copper content.
2. Semiquantitative spectrochemical analysis of rock samples taken at close intervals around the Greathouse copper prospect.
3. Petrographic examination of selected rock specimens from the areal and local sampling patterns.
4. Polished section studies of selected mineralized specimens from several of the copper occurrences.
5. Compilation of an areal map showing lithology, structure, and copper distribution.

Results of this investigation should be of considerable interest to exploration companies anticipating programs in this and immediately adjacent areas.

STATE TECHNICAL SERVICES ACT OF 1965

The United States Department of Commerce, Office of State Technical Services, authorized a \$25,000 planning grant to the Alaska State Department of Economic Development on March 25, 1966. This planning grant was made for the preparation of the five-year plan and initial annual technical services program required under the State Technical Services Act for the State of Alaska.

The University of Alaska was awarded the working

contract for the preparation of the five-year plan and the initial annual technical services program. The grant involves the participation of the Institute of Social, Economic and Government Research, the Arctic Environment Engineering Laboratory, the Mineral Industry Research Laboratory, and the Division of Statewide Services, all of the University of Alaska. These organizations have facilities and capabilities uniquely suited to the preparation of the required plan and program.

The five-year plan will include an outline of the technological and economic conditions of Alaska, and it will specify the activities and programs needed by Alaska's business and industry for overcoming major regional and industrial problems.

GEOCHEMICAL--GEOPHYSICAL INVESTIGATIONS

A final report on a cooperative project in which the Bureau of Mines, U. S. Department of the Interior, provided work in kind for a series of geochemical-geophysical investigations conducted in the vicinity of Cleary Hill, Alaska, is being prepared. The report describes trace element distribution, methods of chemical analysis, and the application of several inexpensive geophysical instruments to the search for ore in this area. Maps showing distribution of trace amounts of copper, lead, molybdenum, zinc, and silver, as well as maps showing the bedrock geology of a portion of the study are presented. A new cold acid extractable method for zinc is discussed.

FAIRBANKS NORTH STAR BOROUGH COMPREHENSIVE PLANNING PROGRAM

To facilitate future planning, the Borough commissioned the Institute of Social, Economic and Government Research, University of Alaska, to write a comprehensive report bringing together much information now scattered through the literature. The section on Geology and Natural Resources was written by a member of Mineral Industry Research Laboratory during the summer of 1966. This work has resumes of geography, climate, physiography, geology, water resources, soils and mining, including an estimate of future activity.

SERVICE TO INDIVIDUALS

The facilities and personnel of the Laboratory are available to individuals and other organizations as a service function. Unfortunately, personnel time is limited due to instructional commitments of the staff as well as their research assignments.

Over the past three years several short term investigations have been conducted at the request of individuals, and equipment has been used by small scale mine operators in processes such as amalgamation, screening, and cleaning of gold for sale at premium prices.

University facilities are currently being utilized by personnel of The Division of Mines and Minerals. Beside office space this includes laboratory equipment such as crushing, grinding, screening, fire assaying, spectrographic, x-ray, and magnetic.

The dual use of these facilities for instructional, research and service functions is in keeping with the philosophy of aiding the development of the mineral industry within the available financial and physical framework of the laboratory.

BASIC RESEARCH

Industry can advance no more rapidly than basic research. It is the responsibility of every educational institution, research institution, government laboratory to sustain progress in the basic scientific phases of their respective fields of endeavor. The only alternative to basic research is a slow-down of technical advances of the applied nature.

In keeping abreast of its responsibilities in basic research, MIRL has completed the study of the bloating mechanism of shales. A synopsis follows:

THE BLOATING MECHANISM OF ELLIOTT HIGHWAY SHALES

The Mineral Industry Research Laboratory has concluded its investigations of expanding shales. The results of these studies are available as Theses at the University of Alaska Library. A compilation of the

information potentially most valuable to industry has been extracted from these theses and published as MIRL Report No. 6.

The thesis covering the Elliott highway shale deposit explores the mechanism of bloating, specifically, the relationship existing between mineralogical and elemental content to bloating. This type of study provides basic data necessary for determining economical additives which will cause "non-bloating" shales to expand.

Each shale was treated with dilute hydrochloric acid to remove calcite which is often a source of bloating gas. The samples were washed, dried, pelletized and fired in the furnace. With the exception of shale from 34.5 mile on the Elliott Highway, each sample bloated in the furnace. The Fe_2O_3 was dissolved, as indicated by color change and a reduction in Fe^{+++} content of the 34.5 mile shale. Treatment with hot 6 Normal hydrochloric acid prevented bloating in each case. Analysis of the residues with x-ray diffraction showed that the mineral chlorite had been removed by the acid treatment.

A series of tests were designed to see what effects additions of calcite, hematite, and chlorite would have upon the bloating characteristics of the acid treated shales. The 44.7 mile shale required additions of both calcite and hematite to obtain a good bloat. The shale from 34.5 mile bloated satisfactorily with additions of all three constituents, but not with any combination of two of them; this was true for the 59 mile shale also. Combinations of chlorite and calcite, and chlorite, hematite and calcite, the latter giving the better product, caused vesiculation in 56 mile shale.

Analysis of shale particles at elevated temperatures showed the presence of illite and chlorite at temperatures higher than that theoretically required for their destruction. The phenomenon is thought to be due to differential heating caused by the flash firing used. This fact, plus the factors previously discussed lead to the conclusion that the source of bloating gas in at least three of the shales (44.7, 56, and 59 mile) is obtained through loss of hydroxyl from the mineral chlorite upon heating. Calcite and hematite may be the source of gas for the shale from 34.5 mile.

III FINANCES AND CONTRIBUTIONS

The 1966 Legislature provided \$30,000 for the support of MIRL.

The Usibelli Coal Mine Inc. made the second payment on a grant of \$25,000 to be paid over a three year period for the establishment of a Coal Research Laboratory.

The Bureau of Mines of The U. S. Department of the Interior contracted with MIRL for sections of a study entitled "Factors Affecting Underground Lode Mining In The Fairbanks District, Central Alaska" for a sum of \$7,908.13.

Institute of Social, Economic, and Government Research, for a portion of a study for the Fairbanks North Star Borough - - \$3,600.

Pan American Petroleum Company grant for assistantships to the Mineral Engineering Department which directly aid MIRL - - \$3,000.

McNally-Pittsburg Mfg. Corp, Pittsburg, Kansas, an eight inch classifying cyclone with a set of vortex finders and apex nozzles.

Assistance from many individuals ranges from financial; statistical and informative data, to property access. Space does not permit a complete listing of all contributions, but the MIRL staff wishes to acknowledge and extend appreciation for the help received.

IV FUTURE PROGRAMS

Elements of continuity and stability are essential to the long range success of the Laboratory in its objective of diversifying and expanding the mineral economy of Alaska. Projects requiring years of work will eventually pay off. Equally important is the solution of current problems of major concern to the mining industry. By utilization of the College faculty and graduate students and working in cooperation and coordination with private industry and other government and University units, a stimulating program can be continued and expanded.

Specifically, long range programs of particular importance to Alaska include:

- Coal utilization
- Mineral beneficiation
- Mineral exploration - including geochemical and geophysical techniques
- Beach and off-shore mineral deposits
- Mining and mineral economics
- Mining techniques

Short time investigations on current problems submitted by the industry will continue to be a function of the Laboratory. These occur in a wide range of subject field and require anywhere from several hours to several months of time.

Use of facilities by qualified persons in the mining industry continues to be encouraged.

Activities of the Laboratory will be expanded, commensurate with space and equipment availability and operating funds. A continuous effort is made to supplement state financing with contract, grant research funds that will allow diversification and expansion of program and thereby be of even greater value to the people of Alaska.

V PUBLICATIONS

Published Reports available from MIRL, College of Earth Sciences and Mineral Industry, University of Alaska, College, Alaska. 99701.

*ANNUAL REPORT OF RESEARCH PROGRESS 1964, MIRL Report No. 1.

*THE MARKET POTENTIAL FOR ALASKAN CLAY PRODUCTS, MIRL Report No. 2, January 1965.

PETROGRAPHIC EVALUATION OF COKING POTENTIAL OF SELECTED ALASKAN COALS AND BLENDS, MIRL Report No. 3, July, 1965.

MARKET FOR INSULATION IN ALASKA AND FEASIBILITY OF REGIONAL MANUFACTURE, MIRL Report No. 4, July, 1965.

ANNUAL REPORT OF RESEARCH PROGRESS 1965, MIRL Report No. 5.

LIGHTWEIGHT AGGREGATE INVESTIGATIONS, MIRL Report No. 6, December 1966.

ANNUAL REPORT OF RESEARCH PROGRESS 1966, MIRL Report No. 7.

*ALASKAN CEMENT MARKETS AND OPPORTUNITIES FOR REGIONAL PRODUCTION, published as research Monograph No. 4 by the Institute of Business, Economics and Government Research of the University of Alaska in cooperation with MIRL, February, 1965.

FAIRBANKS NORTH STAR BOROUGH COMPREHENSIVE PLANNING STUDY, to be published by the Institute of Social, Economic and Government Research of the University of Alaska. The section on geology and natural resources was written by a MIRL staff member.

*Out of print - available at the University of Alaska Library or possibly on loan from the College of Earth Sciences and Mineral Industry.

Theses available at the University of Alaska Library:

THE FEASIBILITY OF UTILIZATION OF CERTAIN ALASKA
BLOATING SHALES FOR LIGHTWEIGHT AGGREGATE, M. S.
Thesis, Loskamp, Alvin N., University of Alaska,
May, 1964.

COAL PETROGRAPHY AS RELATED TO THE PREPARATION AND
PRODUCTION OF COKE FROM SELECTED ALASKA COALS,
M. S. Thesis, Hankinson, Fred C., University of
Alaska, May, 1965.

EXPANSION PROPERTIES OF SELECTED ELLIOTT HIGHWAY
SHALES, M. S. Thesis, Heiner, Lawrence E.,
University of Alaska, May, 1966.