ANNUAL REPORT
of
RESEARCH PROGRESS
1965

Mineral Industry Research Laboratory
University of Alaska
College, Alaska 99735

"Technical research is obviously the critical element in a program of conserving and strengthening both our mineral resources and our minerals industries. To assure us of adequate quantities of minerals in the future, and to enable our minerals industries to compete in world markets, we must find more effective means of discovering and extracting mineral deposits, learn to refine materials of lower quality, and find both new uses for minerals which are relatively abundant, and substitutes for those which are scarce or difficult to procure."

John F. Kennedy

Quoted from "Message From the President of the United States Relative to Our Conservation Program", March 1, 1962.

MINERAL INDUSTRY RESEARCH LABORATORY

Annual Report of Research Progress 1965

The University of Alaska

College, Alaska

FOREWORD

Continuous research is the key to problem solutions and also to new developments in winning minerals from any environment, be it the land, the air, or the sea. Strong research programs yield both present and future benefits and are part of any vigorous, dynamic development.

In Alaska, new mineral deposits must be searched for; marginal and submarginal deposits must be reviewed in terms of sophisticated methods of mining, benefication and extraction; and greater utilization must be developed for Alaska's industrial minerals, fuels, and off-shore mineral deposits. Continuous research, directed toward solving problems of present mineral production and uses, yields a technology which will solve future problems, and is essential if a vigorous mineral industry is to continue to play its basic role in Alaska's growing economy.

Since mineral resources are of limited value without human resources, the Mineral Industry Research Laboratory is also dedicated to the development of Alaska's young men and women for careers in the mineral industry.

The Staff
MIRL

MINERAL INDUSTRY RESEARCH LABORATORY STAFF

(All on Part Time Basis)

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 Beneficiation.

Charles A. Beasley, Assistant Professor of Mineral Economics. (Presently at University of Minnesota)

Douglas W. Huber, Assistant Professor of Mineral Economics.

Lawrence E. Heiner, Instructor, Mineral Beneficiation.

Bruce I. Thomas, Mining Engineer, Representing the Bureau of Mines, U. S. Department of Interior in the Cooperative Agreement in Geochemical Investigations.

Fred Hankinson, Graduate Assistant, Mineral Engineering. (Presently at Stanford University)

James E. Wallis, Graduate Assistant (presently at Queen's University).

TABLE OF CONTENTS

I.
GENERAL BACKGROUND

INTRODUCTION

The Mineral Industry Research Laboratory, established July 1, 1963 by the 1963 Alaska Legislature (Alaska Statutes, Title 14, Chapter 40, Section 14:40.115), has for its objective the expansion and diversification of the mineral economy of the state through a program of applied research.

An advisory committee, composed of staff members, evaluates research projects and guides general policy. The direction and scope of individual studies are coordinated with government agencies and other institutes in areas of possible overlap. 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 is also cognizant of the need for longer range studies to ensure continuous development for future generations. This latter concept is essential, as the economic development of any resource is correlated in time with availability of data and advances in technology.

During the current year, research has been undertaken in the fields of: mineral beneficiation with emphasis on coal and beach sands, use of industrial minerals, geochemical and geophysical prospecting techniques, and mineral economics studies. These projects are covered in more detail in Part II of this report.

Cooperative programs took place with private industry, the United States Bureau of Mines and the Institute of Business, Economics and Government of the University of Alaska.

FACILITIES

The progress of any research program is dependent upon the personnel available and the ability to secure the necessary funding to conduct the studies. On the other hand, to interest qualified personnel, modern instrumentation and equipment must be available, and their ability to raise funds from outside sources is contingent upon this facility aspect as well as knowledge in their respective fields.

During the past two years, the Mineral Industry Research Laboratory has been fortunate in acquiring the necessary basic equipment through combinations of state, Federal and private industry funding. The 1964 annual report contained an itemized list of some of the more sophisticated pieces of equipment available for the conduct of research in varying fields of interest. Subsequent to the publication of that report the following facilities have been added:

1. Recording Comparator Microphotometer: an auxiliary unit to the emission spectrograph which will allow more rapid and a recorded interpretation of analytical results.

2. Versa Tester: an electrically operated press, capable of 60,000 lbs. pressure, utilized for rock mechanics studies, concrete testing and pelletizing of analytical samples.

3. Geophysical Prospecting Units:
   Electromagnetic: portable electromagnetic induction unit for detection of sub-surface conductors. Principal conductors applicable are metallic sulfides.

   Self Potential: detects electric current generated by sub-surface ore zones by the phenomenon of spontaneous polarization exhibited under proper structural and chemical conditions.

   Resistivity: Indicates conducting properties of sub-surface materials by enabling the calculation of the apparent resistivity of the ground.

4. Experimental Air Flow Equipment: for the study and testing of controlled air flow in round and rectangular ducts. Apparatus can be arranged to simulate air flow problems in mines, beneficiation plants and industrial applications.

Future facilities of the laboratory will be augmented by a $25,-000 grant from the Usibelli Coal Company. These funds, to be received over a three year period, are for the purpose of equipping a coal research laboratory in memory of the late Emil Usibelli. Equipment purchased by these funds will allow research in utilization of Alaska's coal reserves as explained on page 6 of this report.

EDUCATIONAL RESPONSIBILITY

Academic Program: The growth of our state is dependent not only upon the development and utilization of our natural resources, but also upon a corresponding development of our human resources. To this end, personnel in the Mineral Industry Research Laboratory have a responsibility for the education and training of the undergraduate and graduate students who will be tomorrow's leaders in this industry.

Rapid technological advances within the past two decades requires knowledge in highly specialized fields and familiarization with instrumentation used in these areas. This becomes increasingly important as manpower is being replaced by mechanical means in the development and utilization of lower grade ore deposits. Student participation and association with the activities of this facility are therefore important to their educational growth as well as that of the faculty members.

Technician Program: A heretofore untapped human resource is available in the many thousands of native Alaskans who, because of educational deficiencies, are not prepared for professional careers. However, many of these people have the inherent capability of making a significant contribution to the development of this industry. With a minimum training period, these people can take their place as technicians in many facetsof the mineral industry. This training, augmented by their knowledge of the country and ability to live in isolated areas under extreme climatic conditions, will make them useful to private industry, and they can also serve as a potential prospecting force for the State.

With these thoughts in mind, the Department of Mineral Engineering has initiated a technical training program financed with a $36,-750 instructional appropriation from the Employment Assistant Division

of the Bureau of Indian Affairs. The initial program has an enrollment of fifteen students selected from applications received from the Seward Peninsula and Kobuk areas. These students have thirty five hours of instruction per week over the regular academic year on such subjects as: map reading, drafting, measurements, geography, geology, mineralogy, prospecting and exploration techniques, drilling, blasting methods, milling, and written and oral communications.

The Kennicott Copper Corporation will give preference at their Bornite operation to all students completing this initial program. In fact, the majority of the students currently enrolled have been employed by Kennicott and were recommended for the program by company officials. It is hoped that the program will expand to include participation by other mining companies and the oil industry.

II.
RESEARCH ACTIVITIES

BEACH AND OFF-SHORE DEPOSITS

The recent focus of national and international attention to the potential of mineral resources from the sea has resulted in extensive research programs, both government and privately sponsored, aimed towards methods of evaluating, mining, and processing these reserves. The investigations of these mineral resources are generally approached through four specific routes: 1. deep water deposits of manganese nodules, 2. shallower water beds of phosphorite and glauconite, 3. near shore and on shore deposits containing concentrations of heavy minerals, and 4. extraction of elements or compounds from sea water.

Introduction: Probably the greatest obstacle confronting investigators of marine resources is the large investment required to fit out ships for studies of the deep water deposits. Therefore, if investigations are to be pursued within modest means, the logical starting place would be the present and past marine beaches for evaluation of their potential as well as indications of what might be found immediately off-shore.

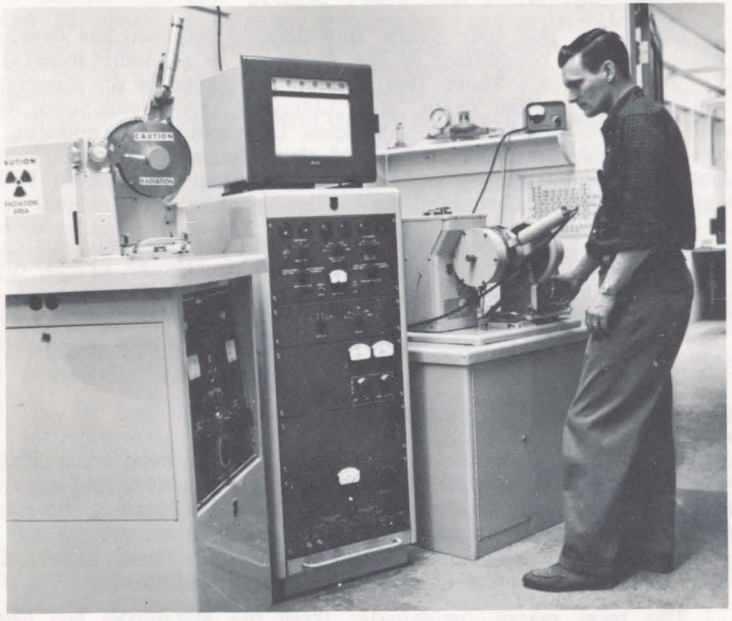
It is commonly accepted that the constituents of beach deposits originated in suitable host rock outcrops which have become eroded with passage of time so that the more durable minerals were liberated and carried by stream action to the sea shores. As the result of wave action and long shore currents this material (containing possible accumulations of gold, silver, platinum, magnetite, ilmenite, rutile, zircon, monazite, cassiterite, chromite, scheelite, columbite-tantalite and rare earth minerals) became concentrated in low, elongated ridges parallel to the shore line and somewhat perpendicular to the carrying stream. In contrast, a stream deposit, concentrated by the river system, is oriented perpendicular to the shore line and the richest deposits should occur near river mouths in response to both stream and wave action. These concentrations can occur at the present shore line, offshore and at some distance inland if subsequent shore line elevation has occurred.

Deposits of this type, if in economic concentrations, offer an attractive mineable source of minerals as nature has furnished the necessary liberation actions of crushing and grinding with a degree of sizing and concentrations. This provides industry with a head start in a relatively simple mining operation.

National Significance: Recovery of heavy-mineral content from beach sand deposits began in 1922 along the East Florida coast where significant concentrations of titanium minerals were exploited. However, competition with foreign sources curbed the expansion of this industry until World War II, when most of this foreign supply was cut off and the United States had to rely on its domestic production. The end of World War II again revived most of the foreign supply source, but meanwhile the location of new deposits, improved mining methods and more efficient beneficiation has allowed domestic producers to compete with foreign imports.

The primary United States production of ilmenite, rutile and associated minerals from beach sand deposits are centralized along the East Florida Coast, the inland Trail Ridge Florida area and in

MICROPHOTOMETER-COMPARATOR USED FOR ANALYSIS OF SPECTROGRAPHIC FILMS



NORELCO X-RAY DIFFRACTOMETER AND VACUUM SPECTROMETER FOR RAPID COMPOUND AND ELEMENTAL ANALYSIS

the vicinity of Lake Hurst, New Jersey. Other concentrations are known to exist along the Gulf Coast, the California and Oregon shore lines and in areas of the Alaskan coastline.

To alleviate our dependency upon foreign sources for certain strategic minerals, the long term solution indicates the necessity of obtaining as much knowledge as possible pertaining to the resources available from and near our coastlines.

Alaskan Potential: The United States Bureau of Mines has conducted reconnaissance surveys of beach sand deposits as noted in Reports of Investigations 5986 and 6214 on the Eastern Gulf and Bristol Bay areas respectively. The former report states:

> "Black sands are known to occur in unconsolidated marine deposits at many localities, along the 6,640 miles of Alaska's coastline. The easily accessible beaches have long been prospected for gold and in some localities, as at Nome on the Seward Peninsula, have been enormously productive. Prospecting for other minerals in these deposits has been either cursory or entirely neglected. If no indication of gold in paying quantities were found on preliminary examination, the beach deposit received little or no further attention. Some less accessible areas, such as those along the eastern coast of the Gulf of Alaska, have been recognized as containing potentially commercial black sand deposits. Some gold has been recovered from these deposits, notably in the vicinity of Cape Yakataga and Lituya Bay. However, few attempts have been made to evaluate the accessory heavy-mineral content."

Within the last four years considerable interest has developed in Alaska on the possibility of the existence of economic mineral deposits along Alaska's shore line. This is evidenced by the prospecting permits issued by the State, particularly in the Norton Sound Area. Other off-shore areas located adjacent to major gold producing regions should be potential sources of that element. However, investigations should not be limited only to this facet, but should include appraisal of all mineral constituents.

With a long range viewpoint in mind, the Mineral Industry Research Laboratory is gathering information concerning origin, distribution, evaluation, mineability and processing methods for total constituents of deposits of this type. Only in this manner is it possible to assess the total reserves available for present and future consideration.

COAL

Introduction: Coal reserves in Alaska have been conservatively estimated in excess of 150 billion tons, yet the active coal mining industry is small if compared with other coal producing states. The greater proportion of this coal is ranked as lignite and sub-bituminous, but lower volatile bituminous and anthracite coals are found in several localities that have undergone more intensive metamorphism.

The total output, principally from the Matanuska and Nenana fields of the railbelt area, is consumed by commercial and military plants for the generation of power and heat, with a minor usage as

domestic fuel. These two fields, located close to the major population centers of Anchorage and Fairbanks respectively, can expect a decline in production with the increasing discovery and utilization of oil and gas in the Cook Inlet area.

If coal is to play a part in the economic development of Alaska, other uses for this important resource must be investigated. Studies should be conducted on the proper blending techniques for producing higher grade coals and possible coking coals from large low-grade deposits. Exploitation of these deposits and others located close to the coast will allow competitive export shipment, and, in light of recent iron ore discoveries in the Western portion of the state, will also stimulate development of a domestic metallurgical industry.

Development of this industry is impeded by the fact that mine operators are working on a yearly competitive price contract; consequently, their efforts are expended primarily toward producing lower price coal from reserves available. This situation is not conducive to long- range investigations concerning alternate potential usage of these reserves. Intensive sampling of these coal reserves, correlated with comprehensive investigations to predict alternate uses, is needed if this industry is to progress beyond its present limited development.

Research Procedure: Prior to the last two decades coal, within each rank classification, had been treated as a uniform, homogeneous substance capable of being characterized by means of proximate analysis, ultimate analysis and plastic property analysis of a representative sample. As a result of this concept very little success was obtained in predicting carbonization characteristics of individual coals or blends, and actual tests had to be performed to determine their behavior under different conditions.

During the past several years coal petrography has been accepted in areas of mining, preparation, and utilization as a useful analytical tool for prediction and control purposes. This is based on the knowledge that coal is a heterogeneous as opposed to a homegeneous substance and is composed of macerals which, in any particular rank, have somewhat similar chemical but distinct physical properties.

The petrographic approach is directed toward knowledge of the nature of the coal entities through such properties as hardness, texture, transmission and reflectance of light. By using the polished surface of a coal briquette, the petrographic components of a representative sample of coal can be determined, and the percent reflectance from the reactive component vitrinite will show a regular increase in proportion to the degree of coalification or rank. As it is recognized that variations in the ratio of reactive to inert components will produce changes in the carbonization characteristics, petrographic analyses are practically employed to predict a coal's utilization properties.

It is frequently found that not only is a coal seam unsuitable for carbonization, but separate banded constituents are unacceptable for other purposes. Yet this seam may contain large quantities of coking constituents that could be reblended in suitable proportions to obto obtain a coking mixture. These low-grade coals can be upgraded by appropriate methods of washing and blending with suitable high-rank coals, but a full understanding of their chemical composition, petrographic composition and rank is needed before they can be utilized to their fullest potential.

Coal deposits along the railbelt area and others close to the coast will be examined by petrographic techniques to determine their chemical properties, carbonization characteristics, oxidation effects

and combustion behavior. When supplemented by conventional physical and chemical tests, it will be possible to evaluate the quality of coals that constitute unmined reserves and predict the products obtainable by appropriate blending.

Only after these studies have been made to predict compatible blending combinations will it be possible for maximum utilization of these low-grade deposits for thermo-powered generation, low temperature carbonization and production of liquid fuels.

Progress and Future Plans: An investigation has been conducted for a graduate thesis to determine the petrographic entities of certain Alaskan coals as a prediction of their blending characteristics to improve quality and predict possible coking potentials. The results of this work are published as Report No. 3 of the Mineral Industry Research Laboratory.

This study was preliminary in nature as the facilities were not available for the petrographic studies or some of the necessary correlated physical testing. Acquisition of the proper petrographic equipment and related testing facilities is now possible through a $25,000 grant by the Usibelli Coal Company for the establishment of a coal research laboratory.

Negotiations have been completed for a full-time research man with considerable formal education and industrial experience in the fields of coal geology, coal petrology and coal utilization. In addition, a technical assistance proposal has been submitted to the Economic Development Administration so that these investigations may be expanded to the proper magnitude necessary for a comprehensive study.

EXPANDING SHALES

Field reconnaissance and preliminary laboratory tests on four shales from the Elliott Highway indicate that each of them bloats. The proximity of these shales to the city of Fairbanks establishes a need for further testing to evaluate their potential as sources of lightweight aggregate. For this reason the laboratory has undertaken a program to determine the expansion properties, drying and crushing characteristics, mineralogical and chemical composition, pelletizing properties and firing characteristics of each of the deposits. Concrete test specimens utilizing "bloated" shales will be prepared and tested for structural and thermal conductivity properties.

This study and that by Mr. Alvin N. Loskamp in 1964 will complete the preliminary testwork of several shale deposits near Anchorage and Fairbanks. The next step in this program should be the determination of the expansion properties under commercial firing conditions. The purchase of a laboratory rotary kiln is anticipated to obtain this objective.

It is believed that the results of this and future studies could form the basis for establishing a substantial lightweight aggregate industry in the state. Lightweight aggregate is at present used in more than half of the concrete blocks produced in the United States. The desirable properties gained by its usage are: lightness, high strength-to-weight ratio, low thermal conductivity, and good acoustical properties. It may be used in masonry units and structural concrete with or entirely replacing normal weight concrete.

This study will be published in thesis form in May 1966 and a combined report, encompassing all work to that date by MIRL on expanding shales, is anticipated for publication.

MINERAL BENEFICIATION

Small scale mill testing facilities are available to prospectors and mine operators within the frame work of the Mineral Industry Research Laboratory. These include: crushing, grinding and screening studies; jigging, tabling, spiral, and heavy media concentration methods; low-intensity magnetic, high-intensity magnetic, and electro-static concentration methods; and amalgamation and flotation facilities.

These facilities, normally used for instructional purposes, have been made available to individuals, companies and government agencies. Students and faculty members are currently working on the following materials to recommend processing procedures:

1.* A high-purity silica is being studied with attritional scrubbing procedures to eliminate the aluminum, calcium, magnesium, and iron content. This quartzite could be a possible source material for many uses in the abrasive, glass, chemical, metallurgical and refractory industries.
2. Crushing, grinding, gravity concentration and chemical concentration studies are being conducted on two antimony ores to give recommended flowsheets for up-grading to market specifications.
3.* Material from a low-grade manganese deposit is being investigated to determine the processing procedures and feasibility of up-grading to commercial production.
4. Studies are being conducted on a lead-silver ore to recommend a flowsheet in the production of a shipping grade concentrate.
5. Crushing, grinding and magnetic concentration studies are continuing on a low-grade iron ore for the elimination of titanium and up-grading of the iron content.

These studies have a dual purpose in that they serve as a training program for future engineers as well as offering a service to individuals that is not available elsewhere within the state. A recent graduate assistantship grant of $3,000 by the Pan American Petroleum Corporation for beneficiation studies on Alaskan ores is a helpful aid in the continuance of this program.

*Samples obtained through the cooperation of the United States Bureau of Mines.

GEOCHEMICAL INVESTIGATIONS

Technological improvements and increased demand for metals have brought about re-examination of countless properties better known to previous generations than they are today. In short, "mine finding" has been relatively unsuccessful for several decades, due principally to the past discovery of most outcroppings and near surface deposits. Applied research in geochemistry is therefore needed to help the discovery of sub-surface ore deposits.

Field Research: A closely controlled area of Cleary Hill has been studied with three main objectives in mind: a study of the trace element distribution, verification of the University of Alaska heavy metals method, and cause of anomalies detected.

Approximately 2200 samples were analyzed for copper, lead, silver, molybdenum and zinc content. The association between each element was determined statistically with the aid of the University owned IBM computer. Zinc followed the trend of all other elements analyzed, indicating its potential as a pathfinder for these elements in the Cleary area.

Several comments pertaining to difficulties experienced with the U of A heavy metals technique led to a field and laboratory study of the method. Extensive testing proved that the method is sensitive to low concentrations of the heavy metals and could be used to detect or trace quartz veins associated with slight mineralization.

Difficulties reported to the laboratory were:

1. yellowing of dithizone
2. poor reproducibility of results
3. contamination
4. differences in background level

In each case it was found that the errors were a result of the individual and not the method. If the procedures, outlined in the bulletin by Mr. Leo Mark Anthony, regarding testing of reagents and gasoline for purity and cleaning of test tubes are followed, there should be no difficulty in maintaining a closely controlled geochemical survey.

Several anomalies were established during the course of the preceding investigations which were confirmed with geophysical surveys. A study to determine the cause of the anomalies was initiated with the United States Bureau of Mines. The Bureau trenched each anomaly, sampled the uncovered veins and mapped the bedrock geology of the area. The Mineral Industry Research Laboratory performed assays for gold, silver and trace elements. Data analysis and compilation of the report are now in progress.

Laboratory Research: A comprehensive survey of the literature together with recent departmental studies and those conducted by Leo Mark Anthony in 1957-58, show that of all geochemical indicators, zinc appears to be the most universally applicable for hydrothermal mineral deposits. Zinc is commonly associated with areas of high mineralization and is very mobile. In acidic soils as much as 50% of the zinc present may be in the mobile state. Also, by comparison to other indicators, zinc is more uniformly distributed, its average concentration being around 60 ppm. Its concentration is slightly higher in basic soils where it is precipitated as the carbonate The dispersion patterns of zinc around areas of mineralization are normally distinct and not spread over too wide an area, which facilitates the process of more exactly locating a body of mineralization. Thus, the possibility of developing a geochemical prospecting method sensitive to zinc concentration in soils was investigated.

The quickest and easiest means of simultaneously effecting a qualitative and semiquantitative analysis is by developing a color with the zinc present in a soil sample and visually comparing this developed color to a standard. From the many possibilities, 8-hydroxyquinoline was chosen as the complexing reagent, not only on the basis of its chemical and physical properties, but also for economic reasons. This reagent, in conjunction with a simple ion exchange process, has yielded what preliminary studies show to be a method sensitive to 50 ppm zinc. This figure was set to give blank analyses for areas representing background, therefore enabling quick detection of anomalous values. Such a procedure is of much more value to a prospector than methods attempting

strict quantitative analyses of all samples, including those which are not significant. The procedure is easily and quickly executed, and has a greater tolerance for errors commonly introduced into this type of analysis, without a corresponding loss of sensitivity. Such a method should prove very beneficial for the average prospector who does not have access to laboratory equipment, let alone the benefit of technical training in the execution of analytical procedures.

A spectrogeochemical method for analysis of trace elements had been delayed waiting the arrival of a newly purchased densitometer. The new instrument was recently installed, enabling continuance of the project. This study should decrease analytical time required to analyze soil samples for trace elements. A survey of the literature indicates that it is possible to do 49 elemental determinations for 5 elements per man hour at a cost per element much lower than chemical procedures, in addition to providing a permanent record of all other detectable elements present.

ROCK WOOL

An investigation into Alaskan insulation markets and feasibility for regional manufacture was conducted jointly by the Mineral Industry Research Laboratory and the Institute of Business, Economic and Government Research, University of Alaska.

In order to determine the potential for marketing Alaskan produced insulation products, an insulation market analysis was conducted. Insulation product forms and material types most desired by the market were determined by evaluating the building construction programs recently completed and in process in the state. Construction firms, designers, and insulation distributors were interviewed, and national insulation manufacturers were surveyed by mail.

The structure of the insulation market, including distribution channels to and within Alaska, were studied. Economics of transportation and local versus stateside manufacture, although difficult to qualify, were considered. A survey of manufacturing processes of the most popular products was necessary. In order to study feasibility of regional manufacture, a survey of raw material sites close to the Anchorage and Fairbanks markets was made.

The entire study conclusions indicate that certain kinds of insulation products can be profitably produced and sold in Alaska. Polystyrene foam insulation production will continue to expand. A small-scale rock wool plant, using slag from a smelter, may be feasible. Utilization of Alaskan raw materials in the production of lightweight aggregate should begin in the near future.

The investigation revealed that the regional market is insufficient at the present time to justify, economically, a large scale, integrated insulation-producing plant. Such a plant would have to produce multiple products and would be unable to compete in the national market.

The results of the rock wool studies were published as MIRL Report No. 4, "Market for Insulation in Alaska and Feasibility of Regional Manufacture", July 1965.

BASIC RESEARCH

The continued depletion of high grade ore and the increased demand for raw materials can be met only by working lower grade ore reserves. The fact that low grade deposits may be profitably treated is

largely attributed to gradual improvements in technology. Basic research provides the foundation for development of new technology through the application of physics, chemistry and the related sciences.

Two investigations of this type are currently in progress. Each is an outgrowth of student course work under the supervision of the Mineral Industry Research Laboratory. A project study of the paramagnetic susceptibility of aluminum and magnesium minerals is nearing completion. The mathematical relationship of the susceptibility to chemical content is being evaluated through the use of statistics and computer techniques. The second study is designed to correlate bloating of shales to their mineralogical and chemical composition. This information should advance knowledge pertaining to the mechanism of bloating.

III.
FINANCES AND CONTRIBUTIONS

The 1965 State Legislature provided $50,000 for continued support of the program. In addition, $25,000 will be realized from the Usibelli Coal Mine, Inc., payable over a three year period, for the establishment of a Coal Research Laboratory.

In accordance with the current cooperative agreement between the Bureau of Mines and the University of Alaska, the Bureau participated in the research program to an estimated amount of $7,500 in the use of equipment, engineering services and other work-in-kind.

Pan American Petroleum Corporation has granted a $3,000 graduate assistantship for beneficiation studies of Alaskan minerals as well as contributing seismic equipment for educational and research activities.

Shell Oil Company has contributed $2,500 of which $1,500 was utilized in the purchase of spectrographic equipment.

Effort is continuing to secure additional funding through the Economic Development Administration, the Bureau of Indian Affairs, other government agencies and private industry. Sources of financial support for applied research, however, are limited and recognized to be primarily the obligation of private industry or those agencies interested in area development. Consequently, the State of Alaska has the principal responsibility for financing a long range program dedicated to the development of its natural resources.

The Alaska Division of Mines and Minerals has assisted MIRL projects in various ways. Conversely, a cooperative arrangement permits the use of certain laboratory equipment at operational cost by a State Assayer for mineral identification and assaying.

Assistance from others has ranged from financial, statistical and informative data, to property access. Although space does not permit a complete listing of all contributors, the MIRL staff wishes to acknowledge the many assists received.

IV.
FUTURE PROGRAMS

The development of Alaska's mineral potential is contingent upon obtaining a vast amount of knowledge that is not presently available. Therefore, the total program must strike a balance between projects of a relatively short-term nature and those projects designed to give information of value for the future. It is convenient to catagorize the future program into areas of subject matter in which research contributions are vitally needed.

COAL An expanding research program is needed in this area if our coal reserves are to be utilized beyond their present limited development. The Mineral Industry Research Laboratory is continuing work on this aspect with the employment of a coal specialist who will devote full-time to petrographic investigations of Alaskan coals as outlined previously in this report.

MINERAL BENEFICIATION A policy of continuing aid to individuals and small mine operators will be maintained through the testing facilities available at the University. These are relatively short-term projects designed as a service function that is not available elsewhere in the state.

STATISTICS AS APPLIED TO EXPLORATION The advent of new techniques of statistical analysis of ore occurrences and probability distributions have provided a relatively new tool to aid the search for ore. Modern electronic computers, capable of rapid analysis of large volumes of data, make this type of study feasible. To enable statistical analysis of ore occurrences in Alaska, it would be necessary to store mineralogical and geological data pertaining to known ore occurrences on magnetic tape in such a form as to be readily available for use with statistical computer programs. A complete statistical study of Alaska would require many years for completion. It is therefore more feasibly approached on an area basis which would ultimately provide total coverage for Alaska.

Statistical investigations of this nature need to be initiated immediately to provide basic information necessary to attract industry to the state. As it now stands, there is little information available which (1) indicates the probability of discovering an ore body in a particular region of Alaska or (2) the probability laws governing the disposition of ore.

BEACH AND OFF-SHORE MINERAL DEPOSITS In addition to the study underway as described in part II of this report, an expanded project would be timely. Alaskan coastal mineral development may be assisted through studies on (1) coastal geologic history, (2) hydrographic influences on mineral deposition, (3) development of reliable sampling devices, and (4) economic mining procedures.

The first study which should be made is a trend surface analysis of available data for the evaluation of coastal locations for mineral deposits. The data used would be mainly geologic information of selected coastal areas which is available in publications of the Alaska Division of Mines and Minerals, U. S. Bureau of Mines, and the U. S. Geological Survey. The basic mathematical technique of trend surface analysis is linear regression, a method for finding linear relationships among variables. The variables in this case would be geologic data as mentioned. The use of this tool could be later expanded into interior areas for eventual complete state coverage.

As MIRL facilities and staff are able to handle the projects, expansion into the other aspects of coastal minerals development mentioned presents an area worthy of much future attention.

MINING ECONOMICS Traditionally, the economics of mining are rarely published. Mining firms develop their own economic objectives based upon experience, and establish required exploration target grades on the basis of cost estimates in a possible deposit locale. Obviously, as availability of economic facts increases in the possible deposit area, the reliability of final cost estimates increases, yielding a definite benefit to the mining firm.

Alaska's undeveloped status forces mineral exploration firms to invest valuable effort in searching out, individually, transportation costs, labor, services availability and costs, and answers to other mining economics questions. Alaska, as a state, would benefit in the long run from a continuous policy of publishing such economic data on an area basis keyed to now known and future discovered mineral provinces.

FROST INFLUENCES ON ROCK MECHANICS, DRILLING, AND BLASTING In spite of current mining and earth moving projects conducted in areas of deep seasonal frost and permafrost, relatively little published data is available to assist present and prospective mine operators. In the Alaskan north, overburden becomes a resilient mass which yields low blasting efficiencies when typical procedures are used. The design of underground openings in frozen rock should be studied as well as the mechanism of rock yielding (or strain) (1) as stressed frozen rock thaws, and (2) in cases where it remains frozen. Such studies should include the influence of frost upon the design of support methods such as bolting, yieldable arches, and conventional timbering. These investigations, begun now, could influence the future safety and economics of northern Alaskan mining.

CONTINUATION OF JOINT INVESTIGATIONS Plans are underway to continue joint research investigations with the Bureau of Mines under the cooperative agreement presently in existence. Possible areas of mutual interest are in the fields of mineral economics, coal utilization and rock mechanics.

V.
PUBLICATIONS

PUBLISHED REPORTS

Reports available from MIRL, College of Earth Sciences and Mineral Industry, University of Alaska, College, Alaska. 99735.

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

THE MARKET POTENTIAL FOR ALASKAN CLAY PRODUCTS, MIRL Report No. 2, Jan. 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

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.

Reports available at the University of Alaska Library:

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

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