NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES

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Annual Report

July 1, 1966
to
June 30, 1967

A Division of New Mexico Tech • Socorro, New Mexico

November 1, 1967

To: President Stirling A. Colgate
Members of the Board of Regents
Members of the New Mexico Legislature

I have the honor of transmitting to you the annual report of the State Bureau of Mines and Mineral Resources for the year July 1, 1966 to June 30, 1967 as required by the session laws.

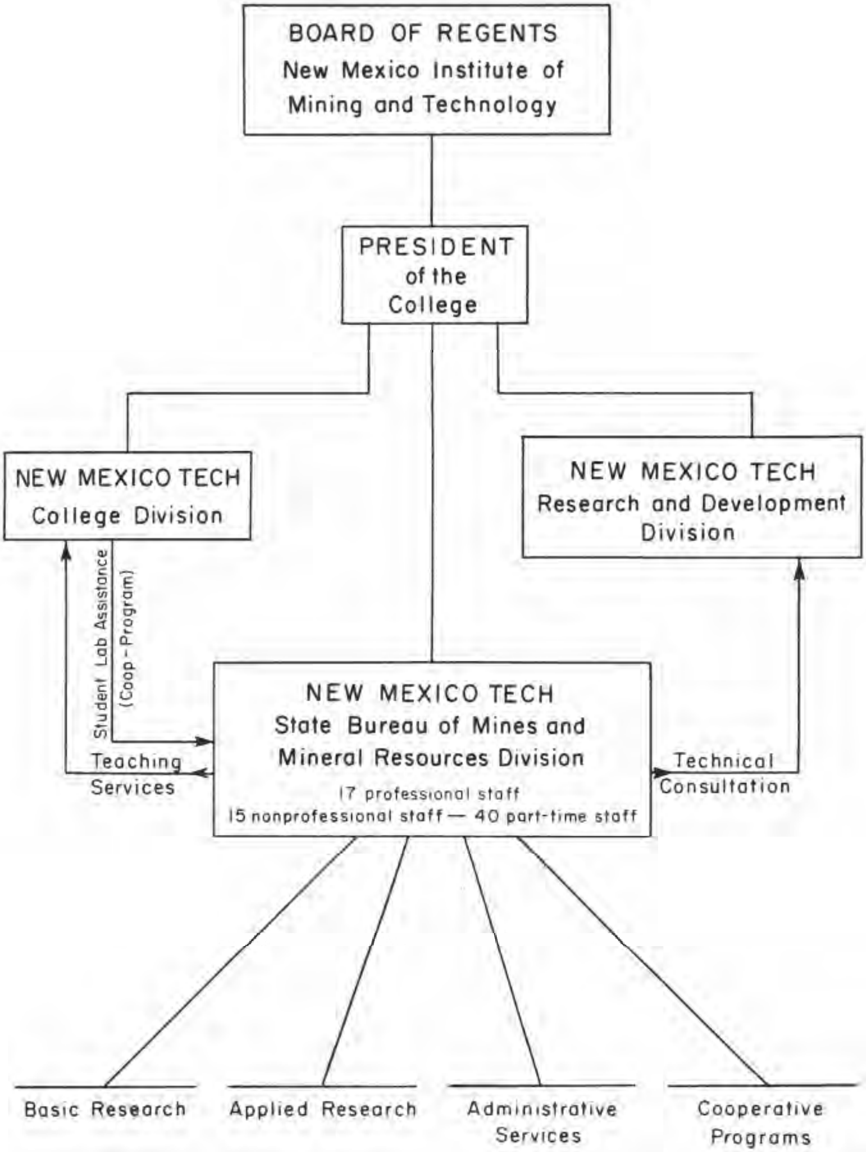
A proposed program of action by the Bureau of Mines is presented at the end of this report. This program if adopted would aid in the development of the mineral industry in New Mexico and thereby improve the state's economy.

Respectfully submitted,

Alvin J. Thompson

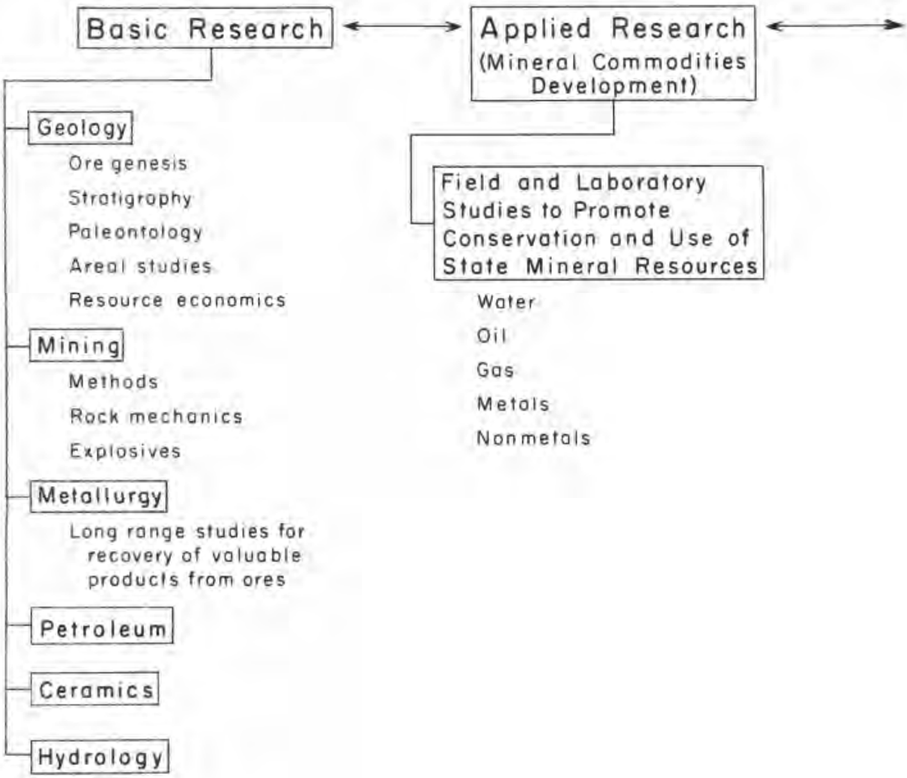
Alvin J. Thompson, Director
State Bureau of Mines and
Mineral Resources

ORGANIZATION AND OPERATION OF THE STATE BUREAU OF MINES AND MINERAL RESOURCES



ORGANIZATION AND OPERATION OF THE STATE BUREAU OF MINES AND MINERAL RESOURCES

(Continued)



ORGANIZATION AND OPERATION
OF THE
STATE BUREAU OF MINES AND MINERAL RESOURCES

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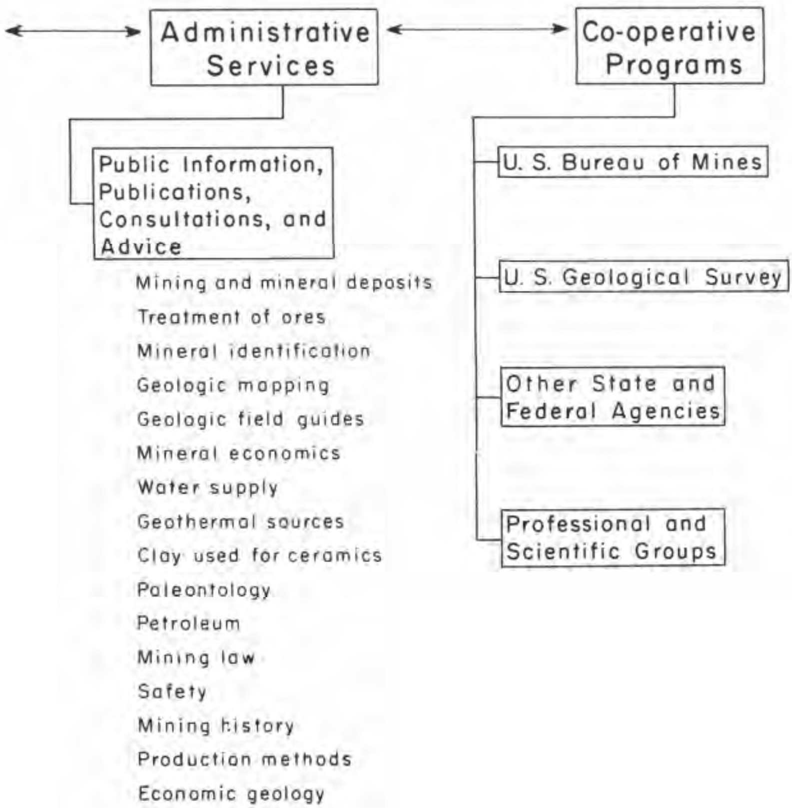


OBJECTIVES AND DUTIES

In 1927 the Eighth State Legislature established the Bureau of Mines as a division (department) of the School of Mines, which was changed by later statute to the New Mexico Institute of Mining and Technology. The objectives and duties of the Bureau were set forth in twelve paragraphs, which are summarized in the following headings. Under these headings some of the Bureau activities, fulfilling these directives during the period covered by this report, are set forth briefly:

(1) *"Collect compile and publish statistics"*—
a. Statistics on mines and mining companies are kept and directories of mines and mining districts were published.
b. The contents of the petroleum sample library were indexed and the index published, as a perpetual activity.

(2) *"Collect typical geological and mineral specimens"*
a. Samples of well cuttings are stored for public use in the Bureau petroleum section.
b. A museum of geological specimens is maintained for student and public use in the R & D building by the Bureau.

(3) *"Collect a library and bibliography of literature pertaining to the progress of geology, mining, milling and smelting . . ."*
a. Indexes to mining records are maintained.
b. Mining history and bibliography is being researched.
c. A file of geographic place names for cartographic purposes is maintained.
d. Microfilms of Bureau of Land Management mining records are maintained and kept up to date through cooperation with BLM.
e. A project in cooperation with the Archives Division of State Government provides for a copy of all mining data in county courthouses, when furnished to the Archives, to be made in microfilm for Bureau filing and use of the public.
f. Bulletin 90 published during this report period, written by Teri Ray, is a complete Bibliography of New Mexico Geology and Mineral Technology.
g. The Atomic Energy Commission has furnished the Bureau with microfilms of records of uranium deposits in the state to be used by industry, scientific workers and students. Copies of these are furnished on request.

(4) *"To study geological formations of the state with special reference to the economy of mineral resources . . ."*
a. Memoir 17, Geology of Pennsylvanian, Wolfcampian Rocks in Southeastern New Mexico, published.
b. Memoir 18, Geomorphic Surfaces and Surficial Deposits in Southern New Mexico, published.
c. Circular 85, Geochemical Survey of Magdalena District, Mercury Content of Streams, published.
d. Groundwater 8 Bulletin, A Study of Groundwater in Union County, published.
e. Groundwater 9 Bulletin, Study of Groundwater in Quay County, published.

(5) *"To examine the topography and physical features of the state with reference to their practical bearing upon the occupation of the people."*
a. Topographic mapping assistance has been given the USGS.
b. Memoir 18 by Ruhe, listed under (4) is carrying out this objective as well fulfilling item four above.
c. Bulletin 81, A Summary of the Mineral Resources of Bernalillo, Sandoval and Santa Fe Counties, and the several other area surveys listed in department activities and in abstracts of publications in this report fulfill this directive and directive (4) above.
d. Many of the studies and research projects that are on-going, studying the paleontology, mineralogy and geology of selected areas of the state are in fulfillment of this directive.

(6) *"To study mining, milling, smelting operations . . . with special reference to their improvement."*
a. Practically all of the work of the Metallurgy section reported herein is directed toward finding better methods of refining ore or obtaining values from mining, milling and smelting operations.
b. The following publications, and others, specifically fulfill this directive:
Circular 86, Study of Precipitation of Copper on Iron from Acid Solutions. Circular 89, Chemical Interpretation of Surface Phenomena in Silicate Minerals. Circular 90, Correlation between surface phenomena and flotation silicates.

(7) *"To prepare and publish bulletins and reports with the necessary illustrations and maps which shall embrace both general and detailed descriptions of natural resources, geology and mines, mineral deposits, etc . . . "*
a. Practically all publications by the Bureau are carrying out this directive. See Publications Abstracts (this report).

(8) "To make qualitative examinations of rocks and mineral samples and specimens."
Dr. Edward C. Bingler assisted by graduate students, had this phase of the Bureau work assigned as one of his major undertakings. X-ray and spectographic analysis are run, if necessary, in the various sections concerned. Dr. Bingler resigned to teach geology at South Dakota School of Mines in August 1967; the work is now under the direction of Dr. Robert H. Weber.

(9) *"To assist in the education of miners and prospectors through lectures and publications."*

The old time prospector and miner is rare today. However, the services assigned the Bureau under section 9 have been continuing in the form of assistance to mining companies, professional engineering organizations such as AIME, Exploration Geologists, Consulting Geologists and Mining Engineers. These are served by Bureau personnel. All staff members are available for this purpose and fulfill this directive by letters, consultations, speeches to societies and teaching in classes. See section on Cooperative Activities.

(10) "*To consider such other kindred scientific and economic problems and questions as in the judgment of the Board of Regents shall be deemed of value to the people of the state.*"
The Board of Regents by approval of this annual report, and by directing the Bureau to carry out such activities as they "deem of value", have control over any projects not specifically directed by the legislature in items 1 through 9 and 11 and 12.

(11) "To communicate special information on New Mexico. Geology, Mining, etc. . . and to serve as a bureau of exchange and information in the mineral, oil and natural gas resources."
Work under this directive is exemplified by such activities as described for the petroleum section, microfilming and copying AEC uranium location records and having them available for the industry; studies of dual nuclear explosives to increase rock fragmentation and the effects of thunderstorms on detonation of explosives. This information is transmitted to interested companies such as Sandia Corporation for specific application. The bureau furnishes speakers whenever requested to communicate information on geology mining etc. to interested groups.

(12) "*To cooperate with University of New Mexico, State Mine Inspectors and with other departments (of State and Federal Government) . . . as may be mutually beneficial.*"
Many studies have been undertaken and reports published in cooperation with State and Federal government agencies. In the area of cooperation with various organizations, the Bureau has furnished speakers, editing service and research service. These instances of cooperation during the year 1966-67 are listed in the section of this report on Cooperative Activities.

BUREAU ACTIVITIES

ADMINISTRATION

Basic and applied investigations by the Bureau are within the framework of the duties laid down by the law creating it. Behind the projects undertaken is the guiding policy that increasing the production and use of the State's mineral resources is of greatest importance. Immediate and future needs, industry trends, and the probable by-products of mineral production are important factors guiding the Bureau's research.

The work of the Bureau is in seven major fields: *Ceramics, Geology, Hydrology, Metallurgy, Mining, Paleontology, and Resource Economy*. The activities of these sections of the Bureau are described under the respective headings below.

The *administration* of these activities is under the direction of *Alvin J. Thompson, Bureau Director*. He is responsible for budgetary control, supervision of personnel, supervision of technical work, and project planning and guidance. He provides information and assistance on mineral problems by phone and correspondence and personal conference. A part of his duties are the supervision of purchases of equipment for laboratory office and field work, and the maintaining of the records as required by State fiscal agencies. The director acts in an advisory capacity to the metallurgy section in projects involving extractive metallurgy.

Special activities of the director during the year include a directorship on the Board of Directors of the New Mexico Mining Association; Chairman of the New Mexico Mining Safety Advisory Board, a position conferred by statute; Member of the Western Governor's Mining Advisory Council; Member of the American Association of State Geologists representing New Mexico; and Member of the Executive Committee of New Mexico Institute of Mining and Technology.

Assistant Director of the Bureau is *Dr. Frank E. Kottlowski, Economic Geologist*. He advises on geologic projects and technical publications editing. He assists with public relations, answering mail, phone, and personal inquiries.

Mrs. Myrtie M. Edgar is *Secretary to the Director.*

Publications reporting the results of research involve editing, printing and distribution of the bulletins, circulars and memoirs. *Miss Teri Ray, Publications Journalist* is in charge of editing, proofreading and printing production. . *Mrs. Lois Devlin* has charge of the Publications Office which distributes the publications and accounts for the collections involved. Maps and illustrations for the publications are the responsibility of *Mr. William E. Arnold, Scientific Illustrator and Robert L. Price, Draftsman*.

While most of the results of Bureau research are published and are sent to more than 500 libraries and organizations in New Mexico and throughout the world, many of the results are in the form of data which go in "open file". These facts are scientific information, mining laws information, mining history, safety, equipment design and modification.

Staff Research is the function of *Lucien A. File, Staff Researcher*, who assists staff members in researching background material. He maintains records of mines and mining companies, history of mining, names and locations of mines and mineral surveys, plats and charts. A file of place names for cartographic use is maintained. As *administrative aide* he assists the Director and Assistant Director as required, and is responsible for the inventory and maintenance of Bureau property including laboratory and office equipment. He also has collateral duties of liaison with other government agencies.

1966—1967 PROJECTS

Projects in the various sections of the Bureau, started or completed during the year, are given in the following list. One asterisk indicates a completed project, two asterisks indicate the project completed and a publication made of the results of the research. L indicates an ongoing or uncompleted project:

** work completed and published
* completed study
L continuing project

CERAMICS

William Hawks, Ceramics Engineer, was in charge of the studies of clay and shale, the ceramics laboratory and the location of possible sites for obtaining ceramic materials in New Mexico, for such products as tableware, bricks, electrical insulators, soil and sewer pipes, etc. Mr. Hawks resigned in September 1966, to accept a job with industry and has not been replaced. Some work has been done on ceramics by Mr. Roy Foster, Associate Petroleum Geologist.

* Melting Points of Selected Soils. (Foster)
* Organization of Data on Structural Clay Products. (Foster)
L Kaolin Deposits of the Black Range. (Foster)

GEOLOGY

Dr. Frank E. Kottlowski, Assistant Director, besides his duties as assistant director, his main technical work is stratigraphic studies of Paleozoic rocks in New Mexico, technical editing and aiding publication of the Bureau's Publications; service work of advising technical visitors, correspondence, and cooperating with technical societies and professional people throughout the state.

Dr. Robert H. Weber, Senior Geologist, identification, interpretation, and evaluation of minerals, rocks, and ores. Technical consultation with government, private and educational agencies concerning geology, mineral deposits, exploration and development.

Dr. Edward C. Bingler, Associate Geologist, service work, identification of minerals, rocks, ores and clays; studies of regional geology and commodity studies.

Mr. Roy W. Foster, Petroleum Geologist, research in the geology of non-metallic rocks and minerals, including petroleum.

Mr. Max Willard, Economic Geologist, concerned with studies of mineralization and geological structure of various areas of the state in reference to their economic possibilities.

Dr. Jacques R. Renault, Associate Geologist, is engaged principally in petrologic and mineralogic research.

Dr. Fazlollah Missaghi, Mining Engineer, conducts geochemical surveying in promising areas of New Mexico. He taught approximately 75% of this time.

** Bulletin 88—Source of Lightweight Shale Aggregate in New Mexico (Foster)

** Early Ordovician Highlands of Precambrian Rocks and Their Associated Carbonate-rock-facies. (LeMone, University of Texas in El Paso, Kottlowski and Foster)

**Geological Interpretation of Stratigraphic Relationships at Archeological Sites for Paleo-Indian Institute, Eastern New Mexico University. (Weber)

** New Mexico Mapping Advisory Committee. Committee service and preparation of section on maps and aerial photographs in Annual Report. (Weber)

**Bulletin 90—Bibliography of New Mexico Geology and Mineral Technology. (Ray)

* Geology of the Woods Tunnel Site in Socorro County. (Bingler) (open file report)

** Bulletin 10—reprint—Geology and Ore Deposits of Sierra County.

* Geology and Mineral Resources of Rio Arriba County. (Bingler) (in press)

** Memoir 18—Geomorphic Surfaces and Surficial Deposits in Southern New Mexico. Ruhe (Dept. of Agr.)

** Memoir 17—Geology of Pennsylvanian and Wolfcampian Rocks in Southeast New Mexico. (Meyer)

** Revision of Scenic Trip 4—Southern Zuni Mountains, New Mexico (Foster)

** Scenic Trip 6—reprint—Trail Guide to the Upper Pecos. (Montgomery and Sutherland)

** Scenic Trip 7—reprint—High Plains, Northeastern New Mexico. (Muehlberger, Baldwin, and Foster)

* Scenic Trip 8—reprint—Mosaic of New Mexico's Scenery, Rocks, and History. Revised by Kottlowski

L Absolute Ages of Precambrian Rocks in Central New Mexico. (Foster)

L Diatomite Resources of New Mexico. (Foster)

L Silurian of Southern New Mexico. (Kottlowski and Pray)

L Geochemical Studies of the Manganese Mineralization in the Luis Lopez District (Willard)

L Geochemical Studies of Luis Lopez Mining Mineralization (Willard)

L Geology of Datil-Mogollon Volcanic Field. (Weber)

L Geology and Geochemistry of New Mexico Basalts (Renault)

L Geology and Archeology of Mockingbird Gap Site (Weber)

** New Mexico part of AAPG Geologic Highway Map of Southern Rockies (Kottlowski)

L Las Cruces Quadrangle (Kottlowski)

L Late Paleozoic of Joyita Hills with Wendell Stewart (Kottlowki)

L Pleistocene Geology and Chronology of Plains of San Agustin (Weber)

L Post-Queen Stratigraphy of Southeast New Mexico (Foster)

L Quaternary Geology of northern Jornada Del Muerto. (Weber)

L Sedimentary Influence of Pedernal Uplift (Kottlowski)

L Revision of Scenic Trip 1—Santa Fe. Area. (Kottlowski)

L Revision of Scenic Trip 3—Roswell, Carrizozo, Ruidoso Area (Kottlowski)

L Sedimentology of Cretaceous in Western San Juan Basin (Willard)

L Special Analyses for individuals, industry and institutions (Willard)

L Stratigraphy of Dakota Group, Northwestern New Mexico (Foster)

L Volcanic Geology and Structure of the Chupadera Mountains (Willard)

Geology and Mineral Resources of the Hopewell-Bromide Mining Districts. (Bingler) (inactive project)

Titaniferous Sandstone Deposits of the San Juan Basin (Bingler) (inactive project)

** Circular 85—Geochemical Survey of Magdalena District. Mercury Content of Streams. (Missaghi)

* Geochemical Anomalies in the Philmont Quadrangle, New Mexico. (Missaghi)

* Geochemical and Biogeochemical Surveying in the Eagle Nest Quadrangle, New Mexico. (Missaghi)

* Lead Mineralogy of Questa Molybdenite Concentrates. (Renault)

* Organization of Spectrographic X-ray and Differential Thermal Analysis. (Foster)

* Statistical Analysis of Rock Structures. (Renault)

** Bulletin 81—Summary of Mineral Resources in Bernalillo, Sandoval and Santa Fe Counties. (Elston)

L Crystal Perfection Studies. (Renault)

L Potash Deposits of Southeastern New Mexico. (Foster)

L Museum—Collection of Mineral Specimens. (Jacques Renault and Ron Riese)

L Qualitative Analysis of Rock Samples and Specimens. (Bingler and Weber)

METALLURGY

Dr. Roshan B. Bhappu, Senior Metallurgist, is in over-all charge of the work in the metallurgical laboratory of the Bureau; concerned with the processes of extracting valuable components from New Mexico ores, helping the industry through consultation, and training of future engineers.

Dr. Dexter H. Reynolds, Research Chemist, has charge of research in the analytical laboratory and related activities.

Dr. Paul H. Johnson, Metallurgist, engages principally in research in the field of extractive metallurgy; does basic and applied research for various individuals, and industrial concerns.

Dr. James A. Brierley, Microbiologist, is in charge of research pertaining to bacterial leaching of ores.

Mr. Jackie Smith, Laboratory-Assistant.

Mrs. Lynn Brandvold, Chemist.

Mrs. Elise Brower, Chemist.

Besides the regular staff members, the metallurgical section employs 27 students on a part-time basis through cooperative, work-study and research-assistantship programs. These students range from freshmen to doctoral candidates and work actively on basic and applied research projects.

L Modification of Techniques for Copper and Iron Sulfide Depression Through the Use of Ammonium Sulfide.

* Bacterial and Carbonate Leaching of Oxide-Molybdenum Ores.

* Detailed Analysis of Thermal and Saline Waters.

** Circular 86—Study of Precipitation of Copper on Iron from Acid Solution. (Mitchell)

** Circular 89—Chemical Interpretation of Surface Phenomena in Silicate Minerals. (Raul Deju and Roshan Bhappu)

** Circular 90—Correlation Between Surface Phenomena and Flotation Silicates. (Raul Deju and Roshan Bhappu)

* Leaching of Lead from Molybdenite Concentrates.

* Pyrite Leaching of Beryllium Ore.

* Recovery of Barium and Strontium Values from Bastnaesite Ores.

** Selective Separation of Molybdenum, Tungsten, and Rhenium by Sorption Processes. (Jai Y Lee, D. H. Reynolds, and R. B. Bhappu) (reprint series)

* Solution Chemistry of Iron, Related to the Leaching of Copper. Applied as part of the Metallurgy Laboratory Copper Leaching Project.

* Solution to Technical Problems submitted through Volunteers for International Technical Assistance Inc.

* Studies on Recovery of Molybdenum from Mixed Sulfide-Oxide Ores from Questa Deposit.

* Thermodynamic Feasibility of In-situ Smelting of Metals and Recovery of Values by In-Place Formation and Distillation of Volatile Metal and other Chlorides.

** Winning Metallic Values from Leach Solutions by Sorption Processes. (Bhappu, Reynolds, and W. V. Long (reprint series 21)

L Bacterial and Carbonate Leaching of Oxide Molybdenum Ores.

L Basic Studies on the Effect of Bacteria on Copper Dump Leaching.

L Basic Studies on Dissolution of Pyrite and Copper Sulfides.

L Chemical Mining Studies.

L Chemistry of Dump Leaching.

L Complete Analysis of Manganese Minerals.

L Desalination of Brackish Waters Using Established Metallurgical Techniques.

L Determination of Optimum Hydrocarbon Oil from Molybdenite Flotation.

L Evaluation of Potassium Permanganate in Mining and Metallurgical Applications.

L Handbook on Analytical Procedures.

L Improved Analytical Procedure for Rhenium Analysis in Presence of Excess Molybdenum.

L The Influence of Bacteria in the Leaching of Chino Dump Ores.

L In Place Leaching of Copper and Uranium Ores.

L Laboratory Handbook, for technical guidance of students and other Bureau personnel.

L Basic Studies on Properties of Silicate Minerals and Their Influence on Flotation, Leaching and Groundwater Technologies.

L Methods of Water Analysis, methods developed for the complete analysis of thermal waters.

L Methods of Rock Analysis, a collection of tested methods for complete analysis of rocks and minerals.

L Recovery of Copper from Pyritic Concentrates.

L Recovery of Rhenium from Molybdenite Concentrate.

L Removal of Copper from Pima Molybdenite Concentrates and Depression of Gangue Sulfides in Molybdenite Flotation Sulfide with Ammonium Sulfide.

** Waste Problems Relative to Mining and Milling Molybdenum. (R. Bhappu of the Bureau, John Fair and John Wright of the N. M. Dept. of Public Health, and Staff of the Molybdenum Corporation of America.)

MINERAL RESOURCES ECONOMY

Dr. William E. Bertholf, Resource Economist, has cognizance of the legal aspects of Bureau work and contracts, with a large part of his time given to corporate counsel work for New Mexico Tech and Mineral Resources Economy cooperative matters. Following are the main areas of activity:

New Mexico Tech and New Mexico Tech Research Foundation

Corporate Secretarial work.
Service on Executive Committee and Trustee duties.
Services as Vice President for Finance.
Completion of legal work on $100,000 bond issue.
Reports for Board of Educational Finance.
Reorganization of the financial accounts for computer use. Corporate counsel services.
Chairman of New Mexico Weather Control Committee.
Preparation of the valuation presentation for NMIMT corporate matters.
Organization of sub-division and sale of faculty housing on Campus Hill, East.

State Planning Office

Continuation of work on mineral element of state resources plan for State Planning Office.
Supervision of the work leading to publication of "Metalliferous Occurrences in New Mexico", by Viet Howard for the Planning Office.
Consulting services to the Governor's Committee on Reorganization of State Government.

Federal Bar Association

National Deputy Chairman of the Committee on Mines, Minerals and Natural Resources.

Rocky Mountain Mineral Law Institute

Editing services for the Rocky Mountain Mineral Law Foundation's work on "American Law of Mining" . . . Title XXV, The Marketing of Minerals.

New Mexico Legislature

Completion of the preliminary work on geothermal energy in New Mexico and assistance in drafting geothermal act of 1966.
Assistance in drafting and passage of the Mineral Socioeconomics Act.

MINING

Dr. George B. Griswold, Mining Engineer, during the period covered by this report worked for the Bureau and the college, with most of his efforts directed toward college affairs. His work is in the field of mining technology.

Preliminary work has been done on a Mexican-American mining conference to be held on New Mexico Tech campus.

** County Township and Range Locations of Mining Districts. (L.A. File and S. A. Northop)

* Effects of Thunderstorms on Detonation of Explosives for Sandia Corporation. (Griswold)

* San Pedro Silica Mines. (Foster)

** Stress Measurements in the Mohole. (Griswold)

* Use of Dual Nuclear Underground Explosives to Increase Rock Fragmentation. (Griswold)

L Consultation, Sandia Corp. Underground Mining at Nevada Test Site. (Griswold, Foster, Kottlowski, and Weber)

L Explosive Hydrofacing as Applied to Uniform Copper Leaching. (Griswold)

L Microfilm of BLM mining records and mining history files. (File)

L Mines and Mining companies, card indexes and microfilm. (File)

L Dual Nuclear Underground Explosive Studies. (Griswold)

* AEC microfilm of Uranium reports.

L Microfilming of county mining records. (File)

HYDROLOGY

W. Kelly Summers, Ground water Geologist, specializing in Geothermal Energy. Consulted by interested groups and individuals; answers requests for information about groundwater in New Mexico. Assigned to Groundwater Division of the college during latter part of year.

** The Hydrologic Significance of the Animas Valley Hot Spot, Hidalgo County New Mexico (Summers) Paper given before New Mexico Academy of Science, Portales Meeting, October 15, 1966. (abstract published in proceedings)

** Speculations on the Occurrence of Oil in South New Mexico and West Texas. (Summers) Presented before New Mexico Geological Society at Socorro, April 27, 1967.

* Indexed Cross Section of Literature on Geothermal Phenomena (Summers)

* Groundwater 8—Groundwater of Union County. (USGS)

* Groundwater 9—Groundwater Quay County. (USGS)

* Bulletin 87—Mineral and Water Resources of New Mexico. (USGS)

* Thermal Waters of New Mexico (open file) Parts I and II completed (Summers, Reynolds and Brandvold)

L Evaluation of Geology and Hydrology of the Pecos River Basin (with New Mexico Tech., UNM, New Mexico State University and New Mexico Institute of Water Resources Research) (Summers)

L Hydrodynamic Aspects of Groundwater Chemistry. (Summers)

L Background Information to Interpret Differences in Temperature of Springs in Some Areas of Significance for In-place Mining, Ground Water Leaching, etc. (Summers)

PALEONTOLOGY

Dr. Rousseau H. Flower, Senior Paleontologist, is concerned with the preparation, photography, description and identification of fossils in New Mexico, particularly Cephalopods, collecting, measuring sections and determining the positions of fossils in the sections, and establishing zonation and coloration.

L A Fossiliferous Lower Ordovician Section from Eastern United States. (L.F. Hintze, L. F. Brathuaite, D. L. Clark, R. L. Ethington, R. H. Flower) International Geological Congress in Prague in 1968.

* Additional Whiterock Cephalopods. (Flower)

* The First Great Expansion of the Actinoceratida. (Flower)

L Description of El Paso Miscellaneous Fossils. (Flower)

L El Paso and Related Tarphyceratida. (Flower)

L El Paso Endoceratids, Part I, 40 plates. (Flower)

L Illustrations of Early Paleozoic Guide Fossils. (Flower)

PETROLEUM

Mr. Robert A. Bieberman, Petroleum Geologist, in charge of the Petroleum section. Engaged principally in activities relating to the oil and gas industry of New Mexico; maintaining records of test wells; sample library; maps of oil resources and other publications. Answers inquiries by phone and mail and provides information and assistance to visitors who come to the office.

* Cataloging and filing electric and other type logs and data from Phillips Petroleum Company from 205 wells drilled in New Mexico. (Bieberman)

** Circular 88—Index to Samples from Oil and Gas Wells. (Bieberman)

** Oil and Gas Exploration in Colfax County. (Foster)

* Circular 87—Preliminary Investigation of Oil Shale Potential in New Mexico (Foster)

L Cataloging and filing additions to sample library of cuttings. (Bieberman)

L Maintaining well records and well log files as new wells are drilled.(Bieberman)

L Petroleum Developments in 1961. (Bieberman)

L Petroleum Developments during 1962. (Bieberman)

L Petroleum Exploration Maps of 25 New Mexico Counties kept up to date as wells are drilled. (Bieberman)

L Revision of article in Scenic Trip 8 on Frontier Forts of New Mexico. (Bieberman)

L Subsurface Stratigraphy of Valencia County. (Foster)

COOPERATIVE ACTIVITIES

The Bureau of Mines is directed by law to co-operate with the departments of State and Federal governments as may be "mutually beneficial."

Following is an alphabetical listing of the agencies and organizations with which the Bureau has cooperated in the period covered by this report showing the nature of the cooperation and the names of the staff members involved:

Albuquerque Geological Society

Paper on lightweight aggregates presented before the society May 16, 1967 (Foster).

American Association of Petroleum Geologists

** Basement Map of North America (AAPG USGS, Peter Flawn Chairman)—(Foster) (Published)

Furnished help on geologic highway map of the southern Rocky Mountains. (Kottlowski)

Associate Editor of A A P G Bulletin (Kottlowski)

District representative for central New Mexico (Kottlowski)
Stratigraphic Correlations Committee (Kottlowski)
Standard Stratigraphic Coding for Computers Committee (Kottlowski)

American Commission On Stratigraphic Nomenclature

Vice Chairman and Secretary. (Kottlowski)

American Institute of Mining, Metallurgical and Petroleum Engineers

Hydrology of the Pecos River Basin (Summers) Carlsbad meeting, 1967
Production of Acid-Ferric Sulphate for Chemical Mining at Central N M AIME meeting, (Johnson)
Paleozoic and Mesozoic Rocks of Southwest New Mexico. Silver City meeting in May, 1967. (Kottlowski)

Served as senior representative, Southwest Region Council of Section Delegates of AIME for 1966-67. (Bhappu)
First Vice Chairman for the Council of Section Delegates of AIME for 1967-68. (Bhappu)

Winning Metallic Values from Leach Solution by Sorption Processes—Bhappu—Annual meeting AIME (1966) New York
Transactions of the Society of Mining Engineers AIME—Dec. 1966—V 235 p. 355—360.

Chairman of the Chemical Processing Committee MBD—AIME 1967-68 (Bhappu)

AIME—"Sources and Properties of Lightweight Shale Aggregate in New Mexico," presented before National Meeting Los Angeles, February 23, 1967 by Foster.

American Institute of Professional Geologists

New Mexico Section. Service on executive committee and president elect for 1968 (Kottlowski)

Brigham Young University (Geology Department)

Collecting of cephalopods and description of the Pogonip Group of western Nevada. (Flower)

California Institute of Technology

Absolute Ages of Precambrian Rocks in Central N. M. (Foster)

Carus Chemical Corp.

Evaluation of potassium permanganate in mining and metallurgical applications (Bhappu)

Civic Clubs

Speaker was provided for various Rotary, Lions, and Civic groups on mining history. (File)
Speech—"Hydrology of the Roswell Basin"—(Summers) Roswell Lions Club

Eastern New Mexico University

Geological interpretation of Stratigraphic Relationships at Archeological Sites for Paleo-Indian Institute (Weber)

El Paso Geological Society
Paper—"Geology and Petroleum Possibilities of West-Central New Mexico" (Foster)
"Geology of South-Central New Mexico" in May (Kottlowski)

Federal Bar Association

National Committee on Mines, Minerals and Natural Resources.
Reviewing the work of the Public Land Law Review Commission (Bertholf)
Geothermal energy and a national energy policy (Bertholf)
The concept of a national department of land resources (Bertholf)
A water law atlas for the United States (Bertholf)
A national water law conference (probably) next spring (Bertholf)
National Council delegate for the New Mexico Chapter (Bertholf)

Geological Society of America

Co-chairman coal geology division technical sessions at Nov., 1967 meeting (Kottlowski)
Co-chairman for symposium on Coal Resources of the Americas to be held at GSA 1968 meeting in Mexico City (Kottlowski)
Tertiary Geologic History of the Tusas Mountains—paper by Bingler, GSA—Golden, Colo. May, 1967.
Joyita Hills, a Key to Wolfcampian Orogeny—Paper by Kottlowski, San Francisco, Nov. 1966.

Highlands University

Talks to research seminar and to Sigma Xi chapter (Kottlowski)

Kennecott Corporation

A study of the nature and treatment of Ducktownite ore, from Chino Kennecott Company mine. (Renault)

Kennecott Corporation (and U.S. Bureau of Mines)

The influence of bacteria on the leaching of Chino dump ores. (Johnson)
Chemistry of dump leaching at Chino (Johnson)
Flotation and autoclave leaching of a Chino middling product (Johnson)

Molybdenum Corporation

Recovery of rhenium from molybdenite concentrate

Waste problems relative to mining and milling molybdenum (Bhappu, John Fair, John Wright et al.)

Studies on recovery of molybdenum from mixed sulfide-oxide ores from Questa deposit. (Bhappu)

Molybdenum Corporation of America

Recovery of barium and strontium values from bastnaesite ores. (Bhappu)

Molybdenum Corporation of California

Leaching of lead from molybdenite concentrates (Johnson-Reynolds)

Bacterial and Carbonate leaching of oxide molybdenum ores.(Bhappu)

New Mexico Academy of Science

Paper—"Hydrologic Significance of Animas Valley Hot Spot, Hidalgo County."—Portales meeting—Oct. 14, 1966 (Summers)

Editing the Academy of Science Bulletin for the Academy (File)

New Mexico Geological Society

Honorary Member for service to geology in New Mexico . . . Kottlowski
Paper: Thermal Waters, A Statistical Summary —May 5, 1967 at Roswell (Summers)
Summers symposium chairman for Spring 1968 meeting.
Registration Chairman, fall meeting, 1967 (Bieberman)

U. S. Department of Interior, Office of Water Resources Research

At Socorro, April 28, 1967—Summers. Speculation on the Occurrences of Oil in South New Mexico and West Texas.

New Mexico State University

(New Mexico Institute of Water Resources Research)—Executive Committee Member Water Resources Research Board, (Bertholf)

New Mexico Institute of Water Resources Research—Planning Committee member for New Mexico annual water resources conference—program chairman for water quality (Bertholf)

New Mexico State University and U. S. Department of the Interior

Appraisal of Some of the Factors Adding to or Detracting From the Socio-economic Use of New Mexico's Thermal Waters. (Summers)

New Mexico Tech.

Bureau staff members taught or supervised theses work for the College Division of New Mexico Tech during the year:
Dr. Ed Bingler, Dr. William Bertholf II, Mr. Max Willard, Dr. Fazlollah Missaghi, Dr. George Griswold, Dr. Dexter Reynolds, Dr. Paul Johnson, and Dr. Jacques Renault.

New Mexico Institute of Water Resources Research

Cooperation with New Mexico Tech, UNM, New Mexico State in research to evaluate the geology and hydrology of the Pecos River Basin (Summers)

Research and Development

Consulting on Woods Tunnel site project, Socorro County (Bingler)

Research Foundation

Thermodynamic feasibility of in situ smelting of metals and recovery of values by in-place formation and distillation of volatile metal and other chlorides (Reynolds).
Reviewing and revising syllabus used for teaching groundwater hydrology 551 and 552—Bertholf

New Mexico Weather Control Commission (New Mexico Tech)

Valuation presentation for various New Mexico Institute of Mining and Technology cooperative matters, locally and in various areas of the State—(Bertholf)
Organized sub division and sales of faculty houses on campus hill east (Bertholf)
Channel 5 TV program, Kottlowski and Bhappu on services of the Bureau
Channel 7 TV program, Kottlowski and Jackson on Bureau services to laymen, scenic trips, etc.

Research and Development (Tech) and Department of Interior

Speculation on the Occurrence of Oil in Southeast New Mexico and West Texas. (Summers)

College Division and Biology Department

Bacteria Leaching (Bhappu)

Research and Development and Tech

In situ mining and leaching (Bhappu). Cooperative with Dr. James Brierley on the influence of bacteria in leaching Chino dump ores. (Johnson)

Off Campus Coop Committee

To explore possibility of incorporating an off campus coop program at the Institute.
Service on Graduate Council, Library Committee, Coop Committee and Revision and updating of records of state land owned by NMIMT cooperation with Mr. Howard Manning of NMIMT. (Bieberman)

Research Foundation

(a) Corporate Secretarial work.

(b) Executive Committee work.

(c) Trustee duties: all in support of the mission of SOM/NMIMT (Bertholf)

Finance SOM/NMIMT

(a) Reorganized the system of financial accounts and activated NCR 390/ equipment.

(b) Completed a $100,000 bond issue.

(c) BEF finance officer meetings and reports.

Northern Rio Grande Resource Conservation and Development Project

Steering Committee. (Summers)

Pima Mining Company

Removal of copper from Pima Molybdenite concentrates and depression of gangue sulfides in molybdenite flotation with ammonium sulfide. (Johnson)
Recovery of rhenium from molybdenite concentrate. (for Molycorp. and Pima)

Rocky Mountain Mineral Law Foundation

Editing service and work on "American Law of Mining" . . . Title XXV The Marketing of Minerals. (Bertholf)

Sandia Corporation

RFQ 47—0025 Feasibility of increasing leachability of underground mineral deposits by means of multiple nuclear explosions. (Renault)
Bureau Staff Members acted as consultants on various problems in the fields of mining and geology. (Griswold, Foster, Weber, Kottlowski, and Thompson)
Staff members set up and taught a course in Engineering Geology and visited the Nevada test site operations, in cooperation with Sandia Corp. (Bingler, Griswold, Weber, Kottlowski, and Foster)

X—ray Clay Analysis. (Willard)

* Melting Points of Selected Soils. (Foster)

Southwest Federation of Geological Societies

Geology and Petroleum Possibilities of West-Central New Mexico. At Hobbs, N.M., Feb. 2, 1967. (Foster)

Shell Chemical Company

Determination of optimum hydrocarbon oil from molybdenite flotation.

Socorro, City of

Bureau personnel planned and carried out a school for policemen, at the request of the Socorro Police and in cooperation with the State Police Department. College guards and city policemen attended the sessions.

State of New Mexico

Governor

Committee on Economic Development member. (Kottlowski)
Consultant to the Governor's committee on reorganization of state government. (Bertholf)

New Mexico Legislature

Completed preliminary work on geothermal energy in New Mexico, and assisted in drafting Geothermal Act of 1966. (Bertholf)
Assisted in drafting and passing a mineral socioeconomics act. (Bertholf)

Museum of New Mexico

Mineralogical, chemical, spectrographic determination of archeological material. (Weber)

Department of Public Health

Waste problems relative to mining and milling of molybdenum, cooperation with Department of Public Health.

State Planning Office

Work on mineral element of state resources development plan: supervision of the publication "Metalliferous Occurrence in New Mexico" by E. V. Howard. (Bertholf)

Texas Bureau of Economic Geologists
Aid in preliminary studies of Tucumcari area for Geologic Atlas project. (Kottlowski)

Tulsa Geological Society

Paper on Silurian of Southern New Mexico. (Kottlowski with Lloyd Pray)

United Nations

Hydrometallurgy Seminar for Developing Nations.(Bhappu)

United States Air Force

Office of Scientific Research F44620—67—0113, artificial stimulation of earthquakes. (Renault)

United States Atomic Energy Commission

Microfilm—A file of uranium exploration data from the AEC is maintained and copies made for the convenience of the public. (Thompson)

United States Bureau of Mines

X—ray clay analysis for individuals and agencies. (Willard)
Sandia—X-ray clay analysis. (Willard)
Chemistry of dump leaching at Chino. (Johnson)
Hydrofracturing technique in dump leaching R&D.

Identification of minerals, rocks and ores, and consultation on geology and mineral deposits. (Weber)
The influence of bacteria in the leaching of Chino dump ores. (Johnson)
Trigg and Chino dump leaching. (Johnson)

U.S. Department of Agriculture

Geomorphic surfaces and surficial reports in Southern New Mexico (Ruhe, Memoir 18)

U.S. Department of the Interior

Prepared a survey and report on the acreage disturbed by strip and surface mining activities in New Mexico. A conference on this was held in Santa Fe July 7, 1966. (Thompson, File and Foster)

Speculation on the Occurrence of oil in Southeast New Mexico and western Texa

U.S. Forest Service

Identification of minerals, rocks and ores and consultation on geology and mineral deposits. (Weber)

U.S. Geological Survey

Basement and mineral map of North America. (American Association of Petroleum Geologists, Foster)
Assistance in Topographic mapping.

U.S. National Museum

Cephalopod identification, study and description of Cephalopods from the Tyrone area of Kentucky. (Flower)

Soil Conservation Service

Cooperated in geologic studies of Rincon Hills; participated in symposium on urban land use planning at New Mexico State University. (Kottlowski)

University of Texas at El Paso

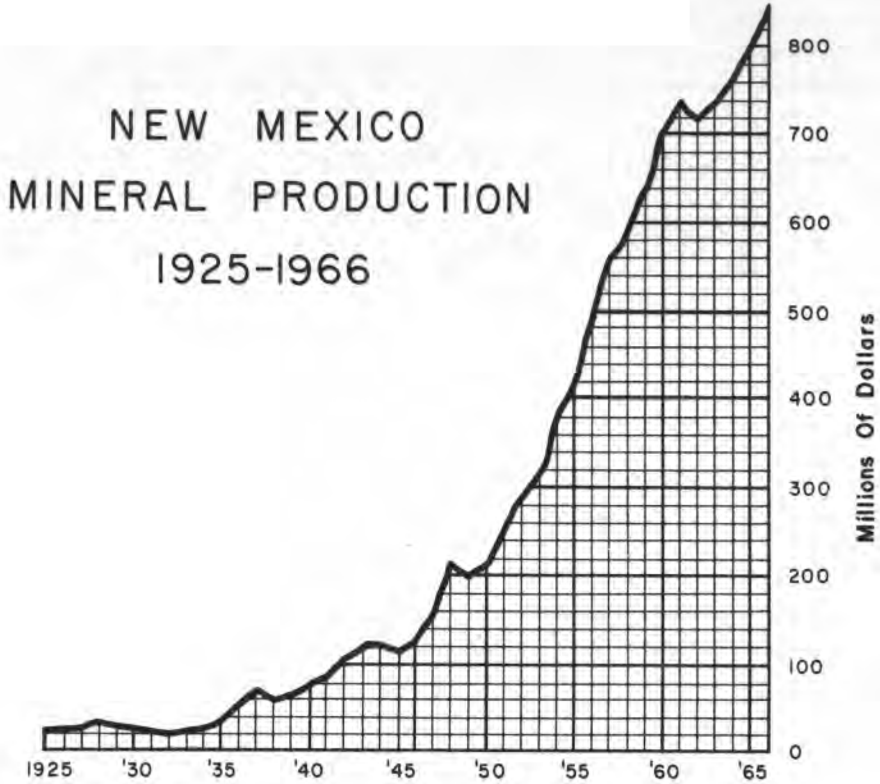
Early Ordovician Highlands of Precambrian rocks and their associated carbonate rock facies. (With LeMone, University of Texas at El Paso, Kottlowski and Foster)

Volunteers For International Technical Assistance, Inc.

Solution of various technical problems submitted through VITA. (Bhappu)

Water Well Drillers Association

How to interpret a chemical analysis of water. (Summers)
Planning service for a joint conference with geologists and water well drillers, hydrologists, engineers and irrigators for January 1968. (Summers)



MINERAL PRODUCTION IN 1966 IN NEW MEXICO

Mineral production in New Mexico in 1966 was valued at 844 million dollars, up 24 million dollars from the previous year.

Of the total value of mineral production in 1966 the mineral fuels, crude petroleum, natural gas and liquids therefrom, and coal contributed 63 per cent.

Significant new developments in the fuels field was (l) the discovery of high flowing gas at a depth in excess of 16,000 feet in the Delaware basin, Lea County and (2) the beginning of a power plant expansion program in the Farmington area which by 1970 will bring its power production capacity to over 2 million kilowatts, and require 8.5 million tons of coal per year. The total coal production in New Mexico by 1970, anticipated to be around 10 million tons, would be more than three times the current level, which is itself a near all time record.

As for many years, potash accounted for the major portion of nonmetallic production. Seven companies in the Carlsbad Area in Eddy and Lea Counties produced potash salts valued at 109 million dollars in 1966, as compared with a production valued at 118 million dollars in 1965. The calculated average grade of crude potassium salts mined in New Mexico, which dropped to 17.55 percent K_2O compared with 18.12 in 1965, contributed to the decline in production value. New Mexico continued to maintain its dominant position in the potash market with 89 percent of the U.S. total being produced in this state. Of the other non-metallics perlite output increased substantially, with the value of New Mexico's production climbing from 2.9 million in 1965 to 3.4 million in 1966. As in the case of potash, New Mexico continued to maintain its dominant position in this commodity, accounting for about 75 percent of the nation's total output.

In the field of metallic mining, copper for the first time in ten years replaced uranium as the commodity with highest production value. Uranium, which reached a production value of 125 million dollars in 1960 has declined steadily since that year. The value of copper production has doubled during the same period, rising from 41 million dollars in 1957 to 79 million dollars in 1966.

In both copper and uranium mining, new developments that occurred in 1966 would appear to increase greatly the prospect for expanding production for both of these commodities. Phelps Dodge Corporation announced plans to develop a large open-pit copper mine at its idle underground mine at Tyrone. Output of copper is to be about 55,000 tons per year when full capacity is reached in three or four years. In the case of uranium, estimates of the cost of producing nuclear power have been so steadily reduced in recent years that by 1966 it became apparent that its competitive position with other fuels would become so favorable that a drastic increase in production would be needed to meet U.S. and world needs in the next few years. With this forecast it can be expected that New Mexico, which has contributed nearly half of all the United States uranium to date, will soon see a pronounced rise in production.

ABSTRACTS OF PUBLICATIONS

By

New Mexico Bureau of Mines and Mineral Resources

July 1966 to June 30, 1967

GEOMORPHIC SURFACES AND SURFICIAL DEPOSITS IN SOUTHERN NEW MEXICO: Memoir 18 by Robert V. Ruhe, 66 pages, 31 figures, 15 tables, 2 colored geologic maps; $4.50.

Geomorphic surfaces ranging from post late Kansas-Illinoian to historic time, and the related surficial deposits are described for an area near Los Cruces that stretches westward from the Organ Mountains, crosses the Rio Grande fault-controlled trench, to the edge of the Robledo Mountains horst. Geomorphic surfaces are grouped as alluvial fans, piedmonts, aprons, and valley-border surfaces. This complete study of landscapes and soils of a desertic area is unique, and is applicable to other arid and semiarid regions of the world.

SUMMARY OF THE MINERAL RESOURCES OF BERNALILLO, SANDOVAL, AND SANTA FE COUNTIES, NEW MEXICO (exclusive of Oil and Gas): Bulletin 81 by Wolfang E. Elston, 81 pages, 2 plates, 13 figures; $2.00.

The Cerrillos, Old Placer, New Placer, Nacimiento, and Cochiti metal-mining districts, all presently inactive are described, as are producing deposits of sand and gravel, shale, pumice, scoria, and gypsum. Reserves of bituminous coal and anthracite, silica sand, bentonite, fluorspar, barite, "marble", sulfur, perlite, and ocher are available. Turquoise, lead, zinc, silver, copper, and gold produced totaled more than $14 million; annual production of nonmetals ranges from $9 to $13 million.

GEOLOGY OF PENNSYLVANIAN AND WOLFCAMPIAN ROCKS IN SOUTHEAST NEW MEXICO: Richard F. Meyer, 123 pages, 76 figures, 15 tables, 4 plates; $3.00, Memoir 17.

This comprehensive report covers more than a quarter of New Mexico and includes the rich oil-and-gas-producing region of the southeast where the Pennsylvanian and Wolfcampian strata have yielded more than 150 million barrels of oil and more than 110 billion cubic feet of natural gas through 1965. For each subdivision of the Pennsylvanian and for the Wolfcampian the strata are described in detail and subcrop, supercrop, isopach, lithofacies, sandstone isolith, shale isolith, shale color, nonclastic isolith, structure contour, and oil and gas field index maps are given. Two detailed north-south and two east-west cross sections show correlations and the habitat of petroleum accumulation.

COUNTY, TOWNSHIP, AND RANGE LOCATIONS OF NEW MEXICO'S MINING DISTRICTS: Circular 84 by Lucien File and Stuart A. Northrop, 66 pages, 2 tables, 2 figures; $1.00

The mining districts are listed by county, giving location, ores mined, subdistricts, camps, and synonyms. Also listed are the year-by-year highlights of mining developments from 1535 to the present.

MINERAL PRODUCTION IN NEW MEXICO

Mineral	1966	
	Quantity	Value (thousands)
* Barite (short tons)	*	*
Carbon dioxide (natural) (thous. cu. ft.)	795,885	$ 58
* Clays (thousand short tons)	*	*
Coal (bituminous) (do)	2,755	9,110
Copper (recoverable content of ores, etc.) (short tons)	108,614	78,571
Gem stones	000	45
Gold (recoverable content of ores, etc.) (troy ounces)	9,295	325
Gypsum (thousand short tons)	146	545
Helium (thousand cu. ft.)	95,900	3,357
Lead (recoverable content of ores, etc.) (short tons)	1,596	482
Lime (thousand short tons)	34	472
* Manganese ore and concentrate (35 percent or more Mn) (short tons, gross weight)	*	*
Manganiferous ore (5 to 35 percent Mn) (do)	47,590	324
* Mica (scrap) (short tons)	*	*
Natural gas (marketed) (million cu. ft.)	985,400	117,263
Natural gas liquids:		
Lp gases (thousands gals.)	816,202	31,832
Natural gasoline and cycle products (do)	338,732	19,736
Perlite (short tons)	343,334	3,423
Petroleum (crude) (thousand 42-gal. barrels)	124,154	352,101
Potassium salts (thousand short tons, K_2O equivalent) 2 2 2	2,953	108,653
Pumice (thousand short tons)	245	787
Salt (do)	66	716
Sand and gravel (do)	15,503	13,029
Silver (recoverable content of ores, etc.) (thousand troy ounces)	243	314
Stone (thousand short tons)	2,652	4,056
** Uranium concentrates (pounds)	8,786,000	70,285
* Vandium (short tons)	*	53
Zinc (recoverable content of ores, etc.) (do)	29,296	8,496
Value of items not disclosed, cement, iron ore, molybdenum, tin, gypsum, barite and items indicated by * symbol	000	20,328
Total		844,361

* Figures withheld to avoid disclsoing individual company confidential data.

** Atomic Energy Commission figures. Except for uranium, all production figures are from U. S. Bureau of Mines and Minerals Yearbook.

BIBLIOGRAPHY OF NEW MEXICO GEOLOGY AND MINERAL TECHNOLOGY: 1961-1065 Bulletin 90 by Teri Ray, 124 pages: $2.00

Listed alphabetically are 1077 reports by 825 authors. These are indexed under basins, canyons, caves, companies, counties, formations, fossils, geologic divisions, general geology, lakes, maps, minerals, mines, mining, oil and gas, plains-plateaus, projects, quadrangles, rivers, rocks, towns-areas, valleys, volcanics, and water. Publications from about 130 technical journals and agencies were used in this comprehensive bibliography.

ANNUAL REPORT, NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES, JULY 1, 1965 TO JUNE 30, 1966: by Alvin J. Thompson, 52 pages, 7 figures, 4 charts, 9 tables; no charge

Mineral production in New Mexico has increased (1965) to $817 million. The State's agency charged with investigating mineral resources published 23 reports during the fiscal year on a budget of $420,000, as well as providing numerous nonpublication services. Listed are the projects in progress, cooperative projects and publications with other agencies, and abstracts of publications and technical talks. Of special significance have been the increased demands for teaching services in the College Division of New Mexico Tech, and increasing activity in geology, matallurgy, hydrology, and ceramics.

A CHEMICAL INTERPRETATION OF SURFACE PHENOMENA IN SILICATE MINERALS: Circular 89 by Raul A. Deju and Roshan B. B. Bhappu, 13 pages, 3 figures, 1 table; 50¢

The O:Si ratio for 8 silicate minerals is correlated with the degree of surface adsorption of the minerals immersed in water. Adsorption and zero point of charge increases with increasing O:Si ratio.

GROUND-WATER RESOURCES AND GEOLOGY OF QUAY COUNTY, NEW MEXICO: Ground-water Report 9 by Charles F. Berkstresser and Walter A. Mourant, 115 pages, 6 tables, 6 figures, 5 plates; $3.00

Included is a brief description of the geology of Quay County, extensive tables giving records of wells and springs, chemical analyses of the water, and maps showing locations of wells and springs, altitude of the ground-water surface, and the geology.

Ground water used for irrigation is obtained mostly from the Tertiary Ogallala Formation; water levels continue to decline. Tucumcari's water supply is from the Entrada Sandstone and alluvium. Most of the aquifers in the county yield adequate supplies of water for domestic and stock uses.

MERCURY OF CONTENT OF STREAM SEDIMENTS - A GEOCHEMICAL SURVEY OF THE MAGDALENA MINING DISTRICT, NEW MEXICO: Circular 85 by Fazlollah Missaghi, 26 pages, 2 tables, 20 figures, 1 plate: $1.00.

Geochemical surveys of lead, zinc, molybdenum and copper in stream sediments were compared with mercury samples and showed that 76 per cent of the mercury anomalies correspond to anomalies of the other metals. In bedrock surveys, only 22 percent of the mercury anomalies coincide with the other anomalies.

A CORRELATION BETWEEN SURFACE PHENOMENA AND FLOTATION IN SILICATES: Circular 90 by Raul A. Deju and Roshan B. Bhappu, 22 pages, 4 table, 15 figures; 50 cents.

Factors in explaining flotability of silicate minerals include: value of sorption index and its functional relation to sulfonate concentration, mineral electrokinetic properties, stablity and formation of metal-collector complexes, number and kind of ions exchanged at the solid-liquid interface, and preferential attachment properties of the collector.

INDEX TO SAMPLES FROM OIL AND GAS WELL TESTS IN LIBRARY AT SOCORRO, NEW MEXICO, July 1, 1961 TO JULY 1, 1966: Circular 88 by Robert A. Bieberman and Sharyn Whitmore, 11 pages; 25¢

This index, in which the wells are listed by section, township, and range, is a reference catalog for those persons interested in subsurface data of New Mexico. Wells represented are selected ones from the producing fields and all available wildcat tests. These cuttings are available for study by qualified individuals and organizations. This index supplements previous indexes and lists about 1500 tests including a few from Utah, Colorado, and Arizona.

SOURCES FOR LIGHTWEIGHT SHALE AGGREGATE IN NEW MEXICO: Bulletin 88 by Roy W. Foster, 86 pages, 22 figures, 4 tables; $2.50

Of the 42 shales sampled and tested for possible use as a lightweight aggregate in concrete, four are suitable, and six others may be suitable for this purpose. These are of Devonian, Pennsylvanian, Triassic, Cretaceous, and Tertiary age. Useful deposits are near Abo Pass, Mud Springs Mountains, the Raton-Las Vegas area, near Mount Powell, Carthage, the Navajo Coal Mine, Chaco National Monument, and Dulce. Bulk specific gravity, weight in pounds per cubic foot, absorption per cent, and internal structure are given for the more favorable shales.

NEW MEXICO'S MAGIC M: by New Mexico Mining Association and New Mexico Bureau of Mines and Mineral Resources, 22 pages, 24 figures, 1 table; free

The magic of New Mexico's rich mineral wealth, whether it be potash, uranium, copper, coal, and sand produced in large quantities, or gold, silver, and gem stones in relatively small amounts, is given, as the practical and romantic aspects of one of the State's main industries are presented in nontechnical language. This pamphlet presents views of mining from the first ore found by a geologist to the ultimate product produced from huge complex mills.

STUDY OF PRECIPITATION OF COPPER ON IRON ACID SOLUTIONS: Circular 86 by David W. Mitchell. 5 pages 2 figures, 25c

This study is a beginning to elucidate the principles of cementation of copper on iron and to search for the optimum chemical and hydrodynamic conditions for such precipitation of copper.

PRELIMINARY INVESTIGATION OF THE OIL SHALE POTENTIAL IN NEW MEXICO: Circular 87 by R. W. Foster, P.B. Luce, L.G. Culver, and B.B. Maras, 22 pages, 4 plates, 4 tables; 50c

More than 4800 qualitive and quantitive tests were conducted on New Mexico shales to determine the presence of commercial deposits of oil shale. To date, this testing has not revealed any extensive deposits of this type. Testing was restricted to gray and black shales that occur in quantity only in rocks of Devonian, Pennsylvanian, Cretaceous, and Tertiary ages. Low-yield deposits of oil shale were found in Pennsylvanian shales, particularly near Abo Pass; in the Cretaceous Mancos Shale at Carthage and in the northwestern part of the San Juan Basin; in the Cretaceous Graneros Shale near Springer; and in the Tertiary Raton Formation near Raton. Additional testing of these intervals and of the gray to black shales exposed in southwestern New Mexico is needed to complete an oil shale evaluation of the state.

ABSTRACTS OF PAPERS AND TALKS

Presented and Published

By

State Bureau of Mines Staff Members

The following studies have been presented by Bureau staff members before public groups, and/or published in publications other than those printed by the State Bureau.

TERTIARY GEOLOGIC HISTORY OF THE SOUTHERN TUSAS MOUNTAINS, RIO ARRIBA COUNTY, NORTH-CENTRAL NEW MEXICO: by Edward C. Bingler. A talk before the Rocky Mountain Section of the Geological Society of America, Golden, Colorado, May 1967.

During most of Tertiary time the Abiquiu-El Rito-Tres Piedras area in north-central New Mexico was part of an extensive intermontane basin receiving clastic fluviatile sediment derived from both local and distant sources.

The oldest Tertiary sediments in the Tusas Mountains represent an alluvial fan complex developed along the southwestern margin of the Tusas uplift. Course conglomerate of metamorphic rock fragments set in a matrix of arkosic sand and reworked Paleozoic and Mesozoic sediment grade westward into coarse arkosic sandstone. This fan complex represents a period of tectonic quiescence interspersed between Laramide orogeny and active subsidence of the basin area.

Initial subsidence of the basin in early Oligocene time was marked by a thick accumulation of gravels derived from the Precambrian core of the Tusas uplift. Sediments consisting of grantic debris derived from a distant source and metasedimentary fragments from a local source formed around the southwestern flank of the uplift. During the Oligocene, volcanic conglomerate and sandstone began to spread southward across and around the Tusas uplift. Volcanic activity along the axis of the uplift contributed to this large volume of sediment that had, by late Miocene time completely covered the Tusas uplift. Arkosic silt and sand carried westward by streams flowing out of the Sangre de Cristo Mountains intertongued with the coarse volcanic detritus. By late Pliocene the basin was completely filled. Subsequent normal faulting resulted in renewed expression of the Tusas uplift and the formation of the Rio Grande structural depression.

A MODIFIED ELECTROPHORESIS APPARATUS by R. A. Deju and R. B. Bhappu. Appeared in SME Transactions, September 1966, and AIME Transactions, 1966, v. 235.

The theory of electrophoresis is briefly outlined and an apparatus which may be used for electrophoretic studies is explained. The results obtained using this apparatus are in agreement with those obtained by other investigators. How to solve some of the complications which occur in the measurement of zero charge and zeta potential is explained. It is believed that the apparatus described in this paper will allow rapid measurements of zeta potential, zero point of charge, electrophoretic mobility and zeta coefficient.

OIL AND GAS EXPLORATION IN COLFAX COUNTY by Roy W. Foster Presented at the New Mexico Geological Society, Seventeenth field conference, Taos, Raton, Spanish Peaks Country 1966.

Carbon dioxide was first discovered in the California No. 1 Floersheim-Statewell, located on Jaritas dome. The approximate yield was 5000,000 cuic feet of noncombustible gas a day from 1,510 to 1,560 feet in the Glorieta Sandstone. The gas contained 67.2 percent carbon dioxide, 28.7 percent nitrogen, 4.1 percent oxygen, and 0.46 percent helium. Other reports give a helium content as low as 0.2 percent. Carbon dioxide also was discovered in the York No. 1 Tex-Mex and Neill No. 3

Sauble tests in T.26 N., R.23 E. The York well yielded an estimated 250,000 cubic feet a day and the Neill well, 133,000. In both wells the gas was recovered from the Glorieta Sandstone. Gas from the York well was reported to contain 99.85 percent carbon dioxide.

Crude Oil and natural gas shows have been reported from numerous tests in Colfax County. Often it is difficult to substantiate these "shows" and to separate the real from the imagined. Most of the reported shows are listed in Table 1 without any thought to authenticity. Oil stains were observed in the Dakota Sandstone during examination of the cuttings of the Conoco No. 1 Maxwell, Condron No. 1 Moore, Conoco No. 4 Rocky Mountain, and Gourley No. 1 Vermejo Park. Data from tests and core analyses verify the presence of oil in the Dakota Sandstone in the Howard No. 1 Moore, Conoco No. 1 Springer, and Conoco Nos. 1, 2, 3, 5, and 6 Rocky Mountain. The two areas were wells have encountered oil in the Dakota Sandstone are shown by heavy lines in Figure 2.

Additional testing at least through the Dakota Sandstone is warranted in the Raton basin and on the west flank of the Sierra Grande arch. Cretaceous shale reservoirs similar to the El Vado, Chromo, and Florence fields represent possible, although less attractive, targets for drilling in the Raton basin area. Pre-Cretaceous strata, with the exception of the limited Pennsylvanian section, do not appear favorable for petroleum but might be tested for helium and carbon dioxide.

QUATERNARY GEOLOGY OF THE SOUTHWEST by Frank E. Kottlowski, Maurice E. Cooley, and Robert V. Ruhe. Taken from The Quaternary of the United States, a review volume for the VII Congress of the International Aasociation for Quaternary Research, published by the Princeton University Press, 1965, p. 287-298. Bureau Reprint Series No. 18.

The region considered in this report consists of westernmost Texas, New Mexico from the Pecos Valley westward, Arizona, southeastern California, southeastern Utah, and southwestern Colorado. Physiographic sections encompassed are the Pecos Valley section of Great Plains; the Sacramento, Mexican Highland, Sonoran Desert, and Salton Trough sections of the Basin and Range province; and most of the Colorado Plateau province. Geomorphic features are the mesas, high plateaus, deep canyons, and rugged escarpments of the Colorado Plateau province on the north and the isolated mountain ranges separated by desert basins of the Basin and Range Province on the south.

The Southwest is a key junction of the Quaternary deposits and geomorphic surfaces of the Great Plains from the east, the semiarid Basin and Range on the west and to the northwest, the Colorado Plateau on the north, and the glaciated Rocky Mountains and their intermontane basins on the northeast. Within or bordering the region are exhibited the interrelations between Quaternary mountain glaciation, alluviation and erosion on the High Plains and along major streams that rise in the mountains and then traverse semiarid grabens of the Basin and Range country, lacustrine and alluvial deposition in closed intermontane basins, and deltaic and marine sedimentation at the mouth of the Colorado River.

Except on the high mountains and high plateaus, semiaridity is the present chief characteristic of this region. The Quaternary geologic history is a record of such aridity alternating with cool wet periods and complicated by diastrophism and volcanism. Structural control of geomorphic processes is more evident for the early Quaternary, whereas climatic change was, and still is, the dominant factor during the late Quaternary.

SURFACE PROPERTIES OF SILICATE MINERALS by R. A. Deju and R. B. Bhappu. Appeared in SME Transactions, September 1966, and AIME Transactions, 1966, v. 235.

The basic structural unit of all silicate minerals is a tetrahedron with a silcon atom at the center and four oxygen atoms at the corners. The oxygen-silicon distance is about 1.6 Angstrom and the oxygen-oxygen distance about 2.6 Angstrom. The different types of oxygen-silicon frameworks in the various silicates are based entirely on the combinations of the tetrahedral oxygen-silicon groups through sharing of oxygen atoms.

In recent years, infrared spectroscopy has permitted estimation of the ratio of the ionic character of the oxygen-silicon bond

As the oxygen-silicon ratio increases from quartz to the olivines, a greater percentage of oxygen bounding power is available for bonding to cations other than silicon. Hence, with an increasing oxygen-silicon ratio, there is increasing oxygen-to-metal bonding. Upon the fracturing of a silicate mineral crystal, the oxygen-metal bond, which is almost entirely ionic in character, should break more easily than the stronger oxygen-silicon bond, resulting in a greater number of unsatisfied negative forces on the surface. If, then, the mineral is immersed in a liquid containing hydrogen ions, these negative forces should tend to be neutralized by hydrogen ions from solution, resulting in a change of the pH of the solution. An increase in the degree of adsorption of hydrogen ions is to be expected as the oxygen-silicon ratio in the crystal structure increases.

This study attempted to correlate the oxygen-silicon ratio for various representative silicate minerals to the adsorption of hydrogen ions. Experiments to determine the effect of surface area on this adsorption and to investigate the effect of surface ions were also conducted. It is believed that such studies of the surface properties of silicate minerals will supply pertinent information about their behavior in froth flotation systems.

SPECULATIONS ON THE OCCURRENCE OF OIL IN SOUTHEAST NEW MEXICO AND WEST TEXAS by W. K. Summers. Read before the New Mexico Geological Society at Socorro, New Mexico, April 28, 1967. (This project was supported in part by funds provided by the U.S. Department of the Interior, under Water Resources Act of 1964. (Pecos Ruin Project.)

Consideration of the hydraulic characteristics of the rocks, fluid potential relations, water chemistry, and geologic history of southeast New Mexico and west Texas suggests that the occurrence of oil there is hydrodynamically controlled. Application of the principles of fluid dynamics to the region should, (1) lead to new prospects, (2) increase normal production, and (3) improve water-flooding techniques.

PHYSICAL AND CHEMICAL VARIATIONS IN THE DISCHARGE OF A FLOWING WELL by W. K. Summers and L. A. Brandvold in Ground-Water v. 5-No. 1, January 1967

Observations of temperature, pH, specific condition, and discharge, and concentrations of calcium, magnesium, potassium, lithium, and sodium in the discharge of a flowing well reveal that geochemistry of aquifers should be based on sample wells which have been allowed to discharge for an extended period.

Geohydrologists who sample water from flowing wells and springs raise two fundamental questions: How representative are the samples? Does the chemical or physical character of the discharging water vary with time? A well in New Mexico offered a unique opportunity to gain insight into the variation of some physical and chemical properties of the discharging water, discussed in this paper.

SOME ASPECTS OF ROCK MECHANICS ARE APPLIED TO PROJECT MOHOLE by George Griswold. (unpublished PhD Dissertation) University of Arizona 1967.

Project Mohole was an ambitious deep-drilling program aimed at penetration into the mantle beneath the Pacific Ocean northeast of Hawaii. Among the scientific and engineering problems involved in planning the deepest hole ever to be drilled were the need for a means to measure the horizontal IN SITU rock stress and to define the alteration effects due to the introduction of drilling fluid. These are related problems in that inelastic behavior of the rock, thermal strains, and mineralogic changes caused by the creation of a hole in an undisturbed medium would affect the state of stress.

A new method of stress measurement was developed for utilization in deep, fluid-filled holes. The technique depends on the shift in the stress envelope surrounding an originally circular hole when slots are cut into the wall. Such slotting simulates the transformation of a circle into an ellipse, which results in a corresponding diametral deformation. By measuring this deformation, the IN SITU lateral rock stress may be calculated. The actual tool required to accomplish the slotting and deformation measuring operations was never built because of the premature termination of Project Mohole. Laboratory experiments, however, verified the feasibility of the new method.

Hydrothermal alteration may be induced into both the core and the walls of the hole. Tests proved, however, that water alone does not produce appreciable effects in basalt and mantlelike rocks subjected to 20 days of exposure in an environment of 200°C and 20,000 psi. These conditions approximate those expected at a total depth of 35,000 feet. The favorable results do not preclude the inducement of alteration if reactive agents were added to the drilling fluid.

The over-all rock mechanics of the Mohole should be consistent with deep continental drilling. Careful attention to detail would be required because the objective of the hole is not to gain simple access, as with most drilling, but instead to collect reliable scientific data concerning the nature of the upper mantle.

INTRODUCTION TO ROCK MECHANICS by George Griswold in Engineering Geology in Southern California, Association of Engineering Geologists, pp. 345-363, Ocober 1966.

Rock mechanics can be defined as the application of engineering design principles to rock materials for the purpose of forming table slopes and openings in rocks and to develop methods efficiently to apply external forces to penetrate or fragment the rock. Hence, there are two basic subdivisions of the field, ground stabilization and breakage. These subdivisions are not independent of one another because both are related to the physical properties of the rock and the geologic environment enclosing the rock. Also, most engineering projects in rock simultaneously involve excavation of openings followed by support of the openings thus formed.

Rock mechanics is an old science. The necessity for ground support must have been realized by the earliest cave dwellers. Difficulties encountered in the earliest quarrying operations certainly must have put the minds of the workers to pondering ways of breaking rock more easily. In spite of this early beginning, it has been only within the last decade that rock mechanics matured into a separate discipline. Essentially every mining school is conducting research in one aspect or another of rock mechanics; the Federal Bureau of Mines appropriated some three million dollars for basic research in this field during 1965; the Bureau of Reclamation has a vigorous program; and even such unlikely agencies as NASA and the Department of Defense are supporting research programs. It is gratifying to realize that the mining and construction industries are not only applying existing theory but also doing applied research to develop new concepts. The title of Rock Mechanics Engineer is coming into vogue on organization charts of the major companies. Two scientific journals are now devoted exclusively to rock mechanics, and articles on special aspects of the science are appearing with increasing frequency in trade and professional society journals related to mining, construction, geology, and geophysics. An estimate of the author's personal library on the subject totals more than 5,000 pages; a complete list would probably be ten times this amount. There are four regularly scheduled symposia on rock mechanics (two in the United States, one in Canada, and one in Europe), plus special meetings.

All this activity does not mean that rock mechanics is a well-defined engineering practice. Indeed, there is only one "textbook" on rock mechanics (Isaacson, 1962). This apparent disparity is due to the lack of proved laws and rules concerning the behavior of rock en masse. The rock mechanics engineer cannot predict the behavior of rock materials with the precision that an engineer in the sister field of soil mechanics is able to achieve with granulated materials. The intensity of the present research activity, however, promises to close the gap in the near future.

In view of the rapidly growing state of the field of rock mechanics, a rather complete listing is included in the bibliography of the important symposia, transactions, journals, and so on through which new developments will be made public. Within five years, essentially all the discussion that follows will probably be hopelessly out of date. This is to be expected of any field under intense study.

A COMPARISON OF LONG TERM AND SHORT TERM PUMPING TESTS by W. K. Summers. Appeared in Ground-Water v. 5-No. 3, July 1967.

Comparison of the analysis of 3- and 4-day pumping tests with the analysis of water-level changes due to 18 years of pumping suggests that experience in an area can be a critical factor in determining the transmissivity and storativity of an aquifer.

MANGANESE DIOXIDE-SULFURIC ACID OXIDATION OF MOLYBDENITE by Ronald J. Roman, Roshan B. Bhappu, and Dexter H. Reynolds appeared in Transactions of the Metallurgical Society of AIME v. 233, p. 2051, December 1965

The reaction between manganese dioxide and molybdenite in a water-sulfuric acid medium was studied at atmospheric pressure and from 25° to 103°C. Both solids are dissolved to give, as final products in solution.

$$Mo(VI),\ S(VI),\ \text{and}\ Mn(II)$$

Stoichiometric relationships are most simply represented by the equation

$$MoS_2 + 9MnO_2 + 15H^+ \longrightarrow HMoO_4 + 2HSO_4 + 9Mn^{++} + 6\ H_2O$$

The rate of this reaction was found to be dependent on temperature, manganese sulfate concentration, acid concentration, and, in a complex way, the surface areas of both manganese dioxide and molybdenite. Both the total amount of manganese dioxide and molybdenite and the ratio of manganese dioxide to molybdenite played a part in determining the over-all rate of the reaction. The effect of acid concentration on the rate was also dependent on the ratio of manganese dioxide to molybdenite.

FLOTATION OF SOME SILICATES by Geoffrey Purcell and Roshan B. Bhappu. Presented at the Annual Meeting of AIME, New York, February 27, March 3, 1966.

The flotation response to amine collectors of quartz and the feldspars microcline and albite, of the pyroxenes augite and spodumene, and of olivine can be explained by a physical adsorption mode. Flotation decreases in the order given above, and the different behavior of the three groups is attributed to structural variations of the silicates. With sulfonate collectors both chemical action and physical adsorption play their part in producing hydrophobic surfaces, and flotation increases in the order given.

SEDIMENTARY BASINS OF SOUTH-CENTRAL AND SOUTHWESTERN NEW MEXICO by Frank E. Kottlowski. In the bulletin of the American Association of Petroleum Geologists, Vol. 49, No. 11, November, 1965, Reprint Series No. 19.

Major sedimentary basins in the eastern part of the Basin-and-Range province are the Orogrande and Pedregosa basins of Mississippian, Pennsylvanian, and Wolfcampian age, the San Mateo and Lucero basins of Pennsylvanian age, the Carrizozo and Quemado-Cuchillo evaporite basins of Leonardian age, the Early Cretaceous basin near the Hatchet Mountains, and the continental basins containing much volcanic debris of late Cretaceous age in central Sierra County and near Steeple Rock. Numerous Cenozoic intermontane grabens occur in the region, including the southern part of a long north-south string of interconnected grabens now followed by the Rio Grande and called the Rio Grande structural depression. Sediments filling the Cenozoic basins are mainly of Miocene, Pliocene, and Pleistocene ages.

Pre-Devonian strata, the Cambrian-Ordovician Bliss Sandstone, the Ordovician El Paso Limestone and Montoya Dolomite, and the Silurian Fusselman Dolomite, thin northward and westward mostly because of periodic erosion but the thinning is partly depositional. The Devonian shaly beds are relatively uniform in thickness, although marking the first large-scale influx of clay and silt. As with all older Paleozoic sediments, they appear to have been deposited in shallow epicontinental seas.

The Pedregosa basin was autogeosynclinal, receiving thick deposits of Middle Mississippian crinoidal limestones, Late Mississippian arenaceous calcarenites, Pennsylvanian limestones, and Wolfcampian interbeds of limestone, black shale, and redbeds. The Orogrande basin began as a poorly defined auto geosyncline in which siliceous Middle Mississippian limestones were deposited, then became zeugogeosynclinal during late Pennsylvanian time as detritus was swept westward from the Pedernal landmass, and during Wolfcampian time was filled by limestone and shale that grade northward into redbeds. The San Mateo and Lucero basins were small autogeosynclines that connected the Pennsylvanian seas northward with the San Juan and Paradox basins.

Source beds and possible petroleum reservoir rocks occur in the Paleozoic and Mesozoic sequences. The reservoir beds include porous sandstone, bioclastic calcarenite, dolomite, reef masses, porous lenses beneath truncating unconformities or amid intertongued redbeds and marine limestones.

ROAD LOG, SOUTHERN LADRON MOUNTAINS FROM MAGDALENA TO INTERSTATE 25 VIA SNAKE RANCH FLATS, RIO SALADO, AND SOUTHERN LADRON MOUNTAINS by Roy Foster, George Evans, Phillip Luce and Robert Weber.

This road log was for use by the New Mexico Geological Society's 21st Annual Meeting April 28-29, 1967.

It delineates geological formations along a route beginning in Magdalena at the junction of highway 60 and the Riley Road, along the Rio Salado and ending at San Acacia interchange overlooking the dunes of the Rio Salado.

ROAD LOG, SOCORRO WESTWARD TO MAGDALENA BY US 60 by Robert H. Weber and Max E. Willard. Road log for the New Mexico Geological Society's 21st annual meeting April 28-29, 1967.

The log delineates the geological formation along a route leaving Socorro, extending southwestward on US 60 across the first local terrace level above the Rio Grande Valley Floor, passes the Great Lakes Corporation Perlite Deposit, passing Luis Lopez District and onward to Magdalena.

WASTE PROBLEMS RELATIVE TO MINING AND MILLING OF MOLYBDENUM by Roshan Bhappu. Presented at the 22nd Annual Industrial Waste Conference at Purdue University, May 1967.

The state of New Mexico solved the difficult problem of an industrial waste discharge into a well known trout stream and recreational area. Though the technological problems were great, the most difficult problem was one of human relations and resolving the difference between two competing interest groups.

Much of the technological portion of this report concerns itself with the chemistry and toxicology of cyanide, as sodium cyanide is one of the reagents used in the industrial ore milling process. One very important fact established by this investigation is that sodium cyanide is not harmful to aquatic life if its use is carefully controlled. The report introduces us to the northern New Mexico wilderness and describes how a mining company has opened up the second largest molybdenum mine in the world. The report further describes how a "fish kill" aroused the ire of sportsmen all over the nation, and how the New Mexico Department of Public Health, aided by other state agencies and with the cooperation of the Molybdenum Corporation of America, "grabbed the bull by the horns" so to speak, and solved this problem satisfactorily.

The report describes the mining and milling process, with a table of the nature and amounts of reagents used. The monitoring program of the New Mexico Department of Public Health is outlined, and the report concludes by acknowledging the splendid cooperation among all parties concerned to solve this unusual and difficult problem.

WINNING METALLIC VALUES FROM LEACH SOLUTIONS BY SORPTION PROCESSES by D. H. Reynolds, W. V. Long, and R. B. Bhappu. (Transactions of the Society of Mining Engineers, AIME, December 1966, v. 235, pp. 355-360. Bureau reprint series 21.)

Equilibrium distribution coefficients were determined for some monovalent and polyvalent ions for several absorbing and exchanging media as functions of pH and initial ion concentration. Among ions studied were NH4 (I), K(I), Ni(II), Ce(III), Th(IV), and Mo(VI). Absorbents used were: ion exchange resins; a tertiary amine and a quaternary amine in an inert solvent; and some activated carbons. The ions studied were in aqueous HC1, HNO3, H2SO4, or HC1OO4 solutions.

The classical mass action expression proved of little value in describing the variations observed. The data indicate that the determining factors in absorption and ion exchange may be the ionic species in the aqueous solution, which in turn depend upon pH, dilution, and perhaps other conditions.

A CHEMICAL INTERPRETATION OF SURFACE PHENOMENA IN SILICATE MINERALS, by Raul A. Deju and Roshan B. Bhappu. Published as Circular 89, Bureau of Mines and Mineral Resources and in transactions of the Society of Mining Engineers AIME, December 1966, v. 235, pp 329-332.

In this report, the oxygen-silicon ratio for a representative series of silicate minerals is correlated to the degree of adsorption on the surface of the mineral when it is immersed in water. Experiments are conducted to prove that there is a corresponding increase in adsorption with increasing oxygen-silicon ratio. The behavior of the minerals in an electric field is investigated using zero point of charge as a parameter. Equipment for these zero point of charge experiments consists of a moving boundary cell, a mass transport cell, two cataphoresis cells, and a streaming potential cell. Finally, a theoretical model is developed to explain the increase in zero point of charge with increasing oxygen-silicon ratio. A comprehensive bibliography on electrokinetic properties of silicates is included at the end of the paper.

SELECTIVE SEPARATION OF MOLYBDENUM, TUNGSTEN, AND RHENIUM BY SORPTION PROCESSES by Jai Y. Kee, Dexter H. Reynolds, and Roshan B. Bhappu. Presented at the 1966 operating Metallurgy Conference (AIME) Philadelphia, December 5-8, 1966. Preprint by the Bureau.

The current investigation concerns the separation of molybdenum, tungsten, and rhenium in single and mixed systems using ion-exchange resins and activated carbons as sorption media. Use of certain weak base resins, like Dowex 3, permits the selective separation of molybdenum from tungsten and rhenium by simple pH adjustment. All three may be loaded on the resin in the pH range 2 to 3. Molybdenum may be selectively eluted above pH 6 and below pH9. The separation between tungsten and rhenium may then be obtained by selective elution using perchloric acid. The strong base resins do not permit efficient selective separation of the three metals.

The activated carbons investigated behave more or less like the weak base resins and are found to be somewhat more effective for selective separation of the three components under the same conditions.

THE LOST PADRE MINE, by Frank E. Kottlowski in NEW MEXICO MAGAZINE, October 1966, v. 44, No. 10, p. 22-23, 34, 36.

The legend of Padre La Rue states he led his parishioners into southern New Mexico in the early 1800's, found a gold mine two days travel north of El Paso, hid the gold when Spanish soldiers came, and died with its secret. Doc Noss claimed the mine was in Hembrillo Canyon, San Andres Mountains. There is no sign of gold in Hembrillo Canyon. A more likely region is the northern part of the Organ Mountains, where gold was mined between 1880 to 1910 and during the 1930's.

THE JOYITA UPLIFT, a Key to Wolfcampian Orogeny by Frank E. Kottlowski and Wendell J. Stewart (Texaco). Talk presented at Geological Society of America meeting, San Francisco, November 16, 1966. Published in GSA Abstracts for 1966 (in press).

Present-day Joyita Hills, Los Cañoncitos, is Cenozoic horst east of Rio Grande graben in central New Mexico. Previous reports postulated a nearby uplift during lateDesmoinesian, Missourian, and Virgilian times coextensive with Peñoncitos. Early Wolfcampian Bursum arkosic limestone-conglomerates, derived from Pennsylvanian limestones and Precambrian granite gneiss of southern Caconcitos region, unconformably truncate southward, in order Missourian, Desmoinesian, Atokan, and Precambrian rocks. In southern cañoncitos, Bursum strata abut against remnant hills of Precambrian gneiss. These hills were buried by basal Abo red beds which, adjacent to the hills, gradationally overlie Bursum purplish-green shales and limestones.

Recently (1963) Missourian fusulinids were identified from upper Pennsylvanian limestones in Cañoncitos. Early Wolfcampian Bursum arkosic limestone-conglomerates, derived from Pennsylvanian limestones and Precambrian granite gneiss of southern Cañoncitos region, unconformably truncate southward, in order Missourian, Desmoinesian, Atokan, and Precambrian rocks. In southern Cañoncitos, Bursum strata abut against remnant hills of Precambrian gneiss. These hills were burried by basal Abo red beds which, adjacent to the hills, graduationally overlie Bursum purplish-green shales and limestones.

Cañoncitos area, lying east of Lucero basin and southwest of Estancia trough, was a sill of shallow marine lagoons and shoals (and small islands?) during Atokan and Desmoinesian times, as attested by black Atokan shales and Desmoinesian limestone-conglomerates. Thinness of remnant upper Pennsylvanian strata is believed due *mainly* to erosion during early Wolfcampian time, not owing to erosion during Desmoinesian, Missourian, or early Virgilian times.

PRE-TERTIARY ROCKS OF SOUTHERN NEW MEXICO, by Frank E. Kottlowski. Talk presented at Highlands University Research Seminar, February 1967.

Pre-Tertiary strata in south-central and southwestern New Mexico consist of 8,000 to 11,000 feet of Paleozoic rocks and 7,000 to 22,000 feet of Cretaceous rocks. In the southern regions, the Paleozoic includes Cambrian-Ordovician Bliss Sandstone, Ordovician El Paso Limestone and Montoya Dolomite, Silurian Fusselman Dolomite, argillaceous Devonian strata, crinoidal Mississippian limestones, a thin to thick Pennsylvanian sequence, and thick, largely marine Permian beds with basal units marked by a southward transition from red beds into limestones. Pre-Pennsylvanian units thin northward chiefly owing to various erosion episodes but are thick in southern New Mexico. More than 3,000 feet of Pennsylvanian strata were deposited west of the Pedernal uplift in north-south-trending basins such as the Orogrande and Pedregosa basins. Reefoid masses locally characterize the Ordovician, Mississippian, Pennsylvanian, and Permian limestones.

Early Mesozoic was a time of uplift and erosion, accelerated during earliest Cretaceous when all Paleozoic rocks were stripped from the Burro uplift in western Grant County, and all of the upper Permian beds removed throughout large areas of southwest New Mexico.

Early Cretaceous strata are 7,000 to 17,000 feet thick in southwest New Mexico and consist of red beds, shoreline sandstones, nearshore conglomerates, fossiliferous limestones, and volcanic detritus. The shoreline of this early Cretaceous sea probably followed an irregular east-west line drawn near Lordsburg, Deming, and Las Cruces. To the northeast, Late Cretaceous sediments, the Dakota Sandstone, Mancos Shale, and Mesaverde Formation rest on middle Permian beds or on a thin, northward-tapering edge of Early Cretaceous strata. The dark Mancos shales of south-central New Mexico grade southward into the shaly Eagle Ford standstones near El Paso. Erosion during Tertiary time locally removed Cretaceous strata and cut down to lower Permian beds.

USE OF GEOLOGY IN URBAN LAND PLANNING, by Frank E. Kottlowski, Talk presented at Annual Meeting of Soil Conservation Society of America, April 27, 1967 at Las Cruces.

Understanding the geology is necessary in three land-use considerations: (1) natural resources, (2) urban engineering, and (3) geologic hazards. Water is a city's major resource: determination of underground water supplies, drilling of wells, and preventing encroachment of unusable water, such as saline water, is the problem of ground-water geologists.

Construction materials are natural resources necessary for urban growth Concrete aggregate such as sand, gravel, and crushed stone; building stone; brick and tile clays; and even such rare deposits as high-calcium limestone to make lime should be available. These are low cost materials; haulage charges make distant deposits too expensive. They must be used where they are found; later their sites can be covered by buildings.

Urban engineers must know relationships between geologic materials and transportation routes, drainage, flood control facilities, sewerage and sewage disposal systems, sites for schools and other public facilities, sites for recreational purposes, and foundations for large buildings and other structures.

Geologic hazards that need to be evaluated for urban land use include earthquakes, landslides, instable high cuts, ground-water pollution, floods, and debris flows.

To prevent wastage of natural resources, to help solve urban engeering problems, to forestall geologic hazards, detailed geologic maps and soils maps are essential. These should be on a scale of at least 2000 feet to one inch. Detailed geologic maps should be made of at least the larger cities in the region, Albuquerque, El Paso, Las Cruces, Santa Fe, Roswell, and for future use, Silver City, Deming, Truth or Consequences, Alamogordo, Socorro, Artesia, Carlsbad, Hobbs, Portales, Clovis, Tucumcari, Raton, Las Vegas, Taos, Santa Rosa, Los Alamos, Grants, Gallup, Farmington, and others. Geologic maps have been made by New Mexico Bureau of Mines and Mineral Resources of the Santa Fe and Las Cruces areas, but even these cities, as well as the others listed, should be mapped geologically in more detail to aid urban land-use planning.

QUATERNARY LANDSCAPES IN NEW MEXICO, by Frank E. Kottlowski, Sigma Xi lecture given at Highlands University, February 1967.

Pre-Wisconsin Quaternary time was marked by uplift, volcanism, erosion, and graben-filling deposition, as well as glaciation in the northern mountains. Climatic changes during Wisconsin and Recent resulted in trenching and relatively minor alluviation. Four complex surfaces and associated sediments were formed during late Quaternary along the Pecos River at the west edge of the High Plains, locally in closed intermontane basins, and along the Rio Grande and its tributaries from the southern Rockies southward to the Big Big Bend country.

Thick paleosols were developed during middle Pleistocene on fossiliferous sediments deposited in late Kansan and Illinoian time. The highest Quaternary surface was cut on these mid-Pleistocene materials, and in turn was trenched by the Rio Grande during late Quaternary (earliest Wisconsin?). The third highest terrace, such as Tortugas, probably developed during the time of Bull Lake Glaciation and the Tahoka Pluvial (early Wisconsin) when high-level lakes (20,000-27,000 B.P.) occupied intermontane basins.

The next youngest terrace, like Picacho, probably formed during late Wisconsin time, correlative with Pinedale Glaciation. The youngest alluvial terrace complex, probably correlative with Temple Lack and Gannett Peak glaciations, was developed mainly after 2600 B.C.

PALEOZOIC AND MESOZOIC ROCKS OF SOUTHWEST NEW MEXICO, by Frank E. Kottlowski. Talk presented at AIME meeting in Silver City, May 1967.

Paleozoic rocks in southwest New Mexico consist of the Cambrian-Ordovician Bliss Sandstone, the Ordovician El Paso Limestone and Montoya Dolomite, the Silurian Fusselman Dolomite, the Devonian Percha Shale, the Mississippian Escabrosa Limestone and Paradise Formation, Pennsylvanian formations such as the Horquilla Limestone in the Big Hatchet Mountains and the Oswaldo and Syrena Formations near Silver City, and Permian units, the Bursum, Abo, and Hueco to the east, and the Earp, Colina, Scherrer, and Concha to the southwest. Relatively complete sections total 8,000 to 11,000 feet in thickness. Reef, bank, and/or biohermal limestone masses occur in Ordovician, Silurian, Mississippian, Pennsylvanian, and Permian units.

The Lower Cretaceous beds include terrestrial red beds, shoreline sandstones and conglomerates, shallow marine fossiliferous reefoidal limestones, and intercalated volcanic materials: total thicknesses range from 7,000 to 17,000 (or 22,000) feet. They pinch out northward, locally underlying Upper Cretaceous strata as in the Cooks Range. Upper Cretaceous rocks are several thousand feet thick here maximum sections remain and consist of the Beartooth Quartzite overlain by the Colorado Shale. Near Steeple Rock, latest Cretaceous strata are mainly of conglomeratic volcanic sediments, and may be as much as a mile thick.

GEOLOGY OF SOUTH-CENTRAL NEW MEXICO, By Frank E. Kottlowski Talk presented to El Paso Geological Society, May 1967 at El Paso.

The basin-and-range country of southwest New Mexico, wherein isolated fault-block ranges are scattered like islands amid a sea of sandy, semiarid plains, adjoins the Sacramento province in south- central New Mexico, a region of long, narrow mountain ranges (like the San Andres and Sacramento Mountains) separated by long, wide basins (such as the Tularosa Basin and Jornada del Muerto). In the central part of the region, the Rio Grande structural depression of northern and central New Mexico appears to die out southward against the post-Oligocene syncline of the west flank of the faulted Sierra de las Uvas dome.

A relatively complete section of Paleozoic rocks crops out in the Franklin Mountains near the New Mexico-Texas boundary, including units of Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian in age, as much as 11,000 feet in thickness. Northward the pre-Pennsylvanian formations thin, mainly due to various periods of erosion. In the Fra Cristobal and northern San Andres Mountains, Pennsylvanian strata rest uncomformably on Precambrian rocks, the pre-Pennsylvanian beds having been removed by erosion.

A thin, northward thickening wedge of Triassic red beds occurs in the northern part of south-central New Mexico, but Jurassic strata are absent. Only to the south near El Paso and to the southwest in Cooks Range and the East Potrillo Mountains do Lower Cretaceous beds occur; they are mainly marine sandstone, dark shale, and fossiliferous limestone. Upper Cretaceous units are several thousand feet thick, consisting of the Dakota Sandstone, Mancos Shale, and Mesaverde Formation. Southward the Mancos dark shales grade into the Eagle Ford sandy beds. Near Elephant Butte, the thick McRae Formation, of late Cretaceous and early Tertiary age, includes thick interbeds of volcanic detritus.

THE HYDROLOGIC SIGNIFICANCE OF THE ANIMAS VALLEY HOT SPOT, HIDALGO COUNTY, NEW MEXICO presented to the New Mexico Academy of Science, October, 1966 by W. K. Summers, Ground Water Geologist.

Water temperatures of as much as 216°F have been observed in wells located in the SE 1/4, SW 1/4, NE 1/4, sec. 7, T.25 S., R. 19 W., Lower Animas Valley, Hidalgo County, New Mexico. The high temperatures apparently result from a continuous injection of natural steam from a deep seated source into the strongly stratified clay, sand, and gravel aquifer. The injection occurs in a five acre area one quarter mile south of the wells.

Ground water moves through the valley from south to north. In 1948 irrigation began in the valley and a center of pumpage has developed about five miles southwest of the steam injection point.

The evidence suggests that the dispersion-diffusion pattern which developed in the aquifer about the injection point prior to its development as a source of irrigation water is being shifted toward the center of pumpage. As a consequence the value of at least part of the water resource for irrigation is slowly diminishing.

GEOLOGY AND PETROLEUM POSSIBILITIES OF WEST-CENTRAL NEW MEXICO by Roy W. Foster. Presented to the Southwest Federation of Geological Societies Annual Meeting at Hobbs, New Mexico, February 2, 1967 and the El Paso Geological Society, March 20, 1967.

Post-Precambrian rocks are limited to strata of Mississippian age and younger. Older Paleozoic rocks were probably deposited in west-central New Mexico and then removed during various erosional cycles prior to Mississippian deposition. Then remnants of Mississippian limestones occur in the Ladron, Lemitar, and Magdalena mountains. Pennsylvanian sediments record a complex history of deposition and erosion as they thin to the west from almost 3,000 feet in the Ladron Mountains to zero over the buried ancestral Zuni Mountains. Permian evaporites, carbonates, and sandstones thicken southward from less than 1,000 feet in the Zuni Mountains to more than 2,600 feet in parts of Catron County. Triassic and Jurassic sediments then in this direction and are absent in southern Catron and adjacent parts of Socorro counties. Sandstones and shales of Cretaceous age are exposed over large areas. Early Tertiary sediments and volcanics, rhyolitic to basaltic in composition, underlie considerable areas in Catron and Socorro counties, and extensive Quaternary basalt flows cover large areas in central Valencia County.

The best possibility for petroleum accumulation appears to be in uncomformity traps in the Pennsylvanian cast of the late Paleozoic ancestral Zuni uplift. Cretaceous sandstones and Permian carbonates and sandstones are secondary possibilities in this and other parts of west-central New Mexico. The possibility of helium accumulation in the upper part of the Permian is an additional incentive for exploration in this area.

PYRITE LEACHING OF A BERYLLIUM ORE IN A VERTICAL, AIR-AGITATED AUTOCLAVE by Paul H. Johnson Presented at the 96th ANNUAL MEETING OF THE AIME in Los Angeles, Feb. 22, 1967.

Laboratory experiments were conducted on the pyrite pressure leaching of a low-grade, calcareous, Spor Mountain, Utah beryllium ore. A laboratory model, titanium, air-agitated autoclave of 15 liter capacity was used. This autoclave operated on the principle of liquid fluidization air agitation and was capable of agitating a charge of course solids in an aqueous media at relatively high pressures and temperatures. In a series of experiments, an aqueous pulp consisting of minus 14 mesh beryllium ore and pyrite flotation concentrates was leached at temperatures between 185 and 200°C, air pressures in the range of 400 to 500 psig and air flow rates between 0.05 and 1.0 cfm/sq. in. of autoclave cross-sectional area. Sulphuric acid injection was required to initiate the pyrite oxidation reaction. Much of the heat and acid requirements of the leach were provided by aqueous pyrite oxidation. Ninety-nine per cent of the BeO contained in the ore was leached in 30 minutes. The pregnant leach liquors were high in BeO content and extremely low in iron and alumina contaminants, and the liquid-solids separation step was enhanced by the coarse size of the feed. Pyrite consumption would amount to approximately 500 pounds per ton of ore on a complete pyrite leach basis.

SOURCES AND PROPERTIES OF LIGHTWEIGHT SHALE AGGREGATES IN NEW MEXICO by Roy W. Foster. Appeared in Mining Engineering December 1966, p. 52, and presented to the national meeting of AIME, Los Angeles, February 23, 1967, and to the Albuquerque Geological Society, May 16, 1967.

Shales of possible use as sources for lightweight aggregate occur in rocks of the Devonian, Pennsylvanian, Triassic, Cretaceous, and Tertiary age in New Mexico. Large reserves of expansible Shales occur among rocks of the Cretaceous age.

Analyses of 312 shale samples showed that 199 contained some carbonate. 67% of the carbonate-bearing shale samples and 49% of the noncarbonate shale samples expanded. However, 50% of the carbonate shale samples melted when test-fired at 2100°F for 15 minutes, compared with only 3% of the noncarbonate shales. A higher percentage of shales with montmorillonite, illite, and chlorite expanded than those having kaolinite as the principal clay mineral. Some shaly sandstones may have excellent expansion properties and those interbedded with shales should be tested.

Selected shales were preheated at various temperatures between 400° and 1800°F and flash-fired from 1800° to 2200°F. Little change in expansion was noted until samples were preheated at 1200°F and higher. High-expansion shales from Abo Pass showed very little expansion when preheated at high temperatures. Bloating of only slightly expansible shales from Bishop Cap was improved when preheated above 1200°F. In both instances, chemically combined water appears to be responsible for the change in expansion properties.

GEOLOGY OF THE CHUPADERA MOUNTAINS IN NEW MEXICO, by Max Willard. Presented to the New Mexico Geological Society April 28, 1967, at Socorro.

The Chupadera Mountains 10 miles southeast of Socorro are a southern extension of the Polvadera, Lemitar, Socorro Mountains structural highland. They are bordered on the east by the Rio Grande Valley and on the west by the southern projection of the Snake Ranch Flats.

Structurally these mountains are an elevated and complexly faulted block of Tertiary Volcanics.

The volcanic rocks on the Chupadera, although not traceable into the Datil formation, are tentatively correlated with that formation. The oldest unit, known only from drilling, is a latitic tuff. Above this is series of rhyolite flows and pyroclastics. Typical welded tuff, crystal tuff, vitric tuff, tuff breccia, and coarse volcanic breccia are represented. Intravolcanic sandstone occurs at places. Interbedded in this pile of rhyolitic rocks is one relatively thin basaltic-andesite flow.

Significant amounts of manganese have been mined from the Luis Lopez district in the northern part of the Chupaderas. The manganese occurs largely in fault zones in a crystal tuff, and is widely disseminated in small primary openings. Several deposits have been developed but only the Nancy and Black Canyon are still in operation.

The manganese of the district is of hypogene origin and it has been suggested that the ore bearing solutions originated in a subjacent source and were introduced into the volcanic rocks sometime after eruption. However, the physical geology at the deposits suggest the possibilities that the deposits are an effect of the extrusion and that the ore solutions were derived chiefly from the volcanic rock itself.

DETERMINATION OF THE AREA OF GRAIN CONTACT IN THIN SECTION by Jacques R. Renault before the Geological Society of America, 1966 Annual meeting Nov. 14-16, 1966, San Francisco.

The grain contact area of a rock is a neglected textural parameter which may be very useful. It is directly proportional to the total surface energy of the grains in a rock, so it can be used to assess textural modifications occurring in the solid state. A formula is derived for observations in thin section and relates the frequency of contacts intersected by straight line traverses of total length, T, to the specific contact area of a textural model composed of uniform hexagons. The model can be modified to increase contact area by using hexagons whose alternate sides are convex and concave arcs with a curvature of 4 pi K radians, where K is the ratio of the number of times the traverse cuts off embayments to the number, G, of grains it intersects. The specific contact "length" is then

$$L = \frac{G\sqrt{3}}{T} \quad \frac{2\pi K}{\sin 2\pi K}$$

in which L carries the dimensions of reciprocal length. The fraction of the total contact area contributed by embayments is

$$F = \frac{2\pi K}{\sin 2\pi K} - 1.$$

F approaches zero as the degree of curvature of contacts becomes less, so it is a measure of the degree of polygonalization in a texture. If the model of embayed hexagons is not used, L varies with K according to

$$\frac{G\ (1+K)\sqrt{3}}{T}$$

which is a straight line intersecting

$$L = \frac{G\sqrt{3}}{T} \quad \frac{2\pi K}{\sin 2\pi K} \quad \text{at } K=0.14$$

This implies that where K is greater than 0.14, surface energy can be minimized by development of fractures which eliminate embayments.

FINANCIAL STATEMENT

The Business Manager of the New Mexico Institute of Mining and Technology, who supervises the finances of the Bureau, has submitted the following statements.

STATE BUREAU OF MINES
GENERAL

Receipts	1966-1967	
Beginning balance July 1	19,482	
State appropriation	455,000	
Receipts from sales of bulletins, etc.	11,722	
Add prior year adjustments	--0--	
TOTAL revenue		$486,204
Disbursements and Commitments		
Personal services:		
Regular salaries	237,422	
Part-time salaries	86,836	
		$324,258
Travel and automotive:		
Travel and per diem	8,887	
Gas, repairs, and insurance	1,943	
		$ 10,830
Repairs and maintenance	1,634	
		$ 1,634
Supplies and materials:		
Postage and resale supplies	3,708	
Office supplies	5,103	
Laboratory and scientific supplies	10,164	
		$ 18,975
Printing and reproduction	30,444	
		$ 30,444
Other operating expenses:		
Telephone and telegraph	7,833	
Professional services	9,122	
Retirement	13,625	
Social Security	7,947	
Overhead	14,600	
Freight, expenses, insurance, audit repairs, subscriptions, etc.	11,130	
		$ 64,257
Capital outlay		$ 22,812
TOTAL expenditures		$473,210
Year-end balance		$ 12,994

FINANCIAL STATEMENT
BASIC GEOLOGY

Receipts	1966-1967	
Beginning balance July 1	--0--	
State appropriation	$ 10,000	
TOTAL revenue		$ 10,000
Disbursements and Commitments		
Salaries	$ 8,000	
Travel	226	
Retirement	520	
Social Security	254	
Overhead	1,000	
		$ 10,000
Year-end balance		--0--

GROUND-WATER SURVEYS

Receipts	1966-1967	
Beginning balance July 1	--0--	
State appropriation	$ 10,000	
		$ 10,000
Disbursements and Commitments		
Salaries	8,000	
Printing and publication	1,000	
Overhead	1,000	
		$ 10,000
Year-end balance		--0--

A SUGGESTED PROGRAM TO AID DEVELOPMENT OF THE MINERAL INDUSTRIES IN NEW MEXICO

A. J. Thompson

Mineral resources are a major factor contributing to the economic growth of New Mexico. The state's mineral production in 1966 had a value of 844 million dollars. Of this amount mineral producers paid directly into the state and county treasuries in excess of 70 million dollars. Indirect revenues would add significantly to this total. These funds now provide a large share of the revenue derived for the support of the state's school and governmental activities.

Good business practice would dictate that a significant portion of the revenue received as a result of mineral production in New Mexico be reinvested to help insure a continuing or accelerating high level of income from this source. Any proposed program or plan for economic growth of New Mexico should give due consideration as to what might be a proper level of state support for research and development activities in the mineral resources field so that the maximum benefit to the State and its people would be realized.

Present Status of State-Supported Mineral Industry Field Activities With Recommendations.

The State Bureau of Mines and Mineral Resources is by statutes responsible for such studies and programs in the mineral industry field as will serve best to develop the state's mineral potential, as this in turn will best serve the interest of its people. However, the Bureau of Mines also is charged with a wide variety of service work which, under the appropriations normally provided, greatly limits other efforts that should be exerted to extend and improve the development and utilization of the state's mineral wealth.

The State Bureau of Mines with what funds are available has supported both long range and short term research in mining and metallurgy. Because of the large expenditures that are required the state might not be justified in extensive exploration work. Nevertheless, the state can do things that would encourage others actively and extensively to explore for mineral deposits. The Bureau has endeavored to create interest in mineral development in New Mexico by the publication of geologic reports of potentially mineralized areas and of bulletins covering the known mineral resources of the counties which appear to offer the best prospects for future mineral development. Because of limited funds the coverage to date is far from complete. It is suggested that adequate funds should be provided to accomplish the following activities over the next five year period.

The Bureau has published bulletins on the mineral resources of seven counties. A survey should be undertaken and reports issued on the remaining twenty-five.

Reports have been prepared on a number of mineral commodities but a great deal more such reports should be forthcoming. Of special interest, as seen in the light of present knowledge, are studies on uranium, silver, gold, rare earths, mica, strippable-coal, and building materials (including clays, silica, and sand and gravel).

Geology and groundwater reports have been completed for ten counties. There is an ever increasing need for such reports that cover the whole state. The new studies should be expanded to include information on the geologic underground structure as it relates both to reservoirs and reserves of liquid fuels as well as water. Reports on the petroleum possibilities of each county would be of aid to petroleum exploration.

There have been tremendous advances in the art and science of geophysical prospecting in recent years. Important finds being made with the aid of geophysical methods attest to the increasing effectiveness of the methods. It is proposed that the State support geophysical surveys of the areas in the State that appear to offer the most promise of having subsurface mineral emplacements. The program should comprise airborne electromagnetic, magnetic, and radiometric surveys. In some cases geochemical ground surveys should be made to supplement the records. It is suggested that the initial work be in areas where the bulk of the land is owned by the State, since the greatest financial gain to the State would be forthcoming from new discoveries made on these lands.

These studies of the water and mineral resources of the counties and of commodities available in the State as a whole, together with the geophysical surveys, would help to satisfy existing demand for mineral information. By providing an account of the quality and extent of known and estimated mineral occurrences in the various areas of New Mexico, and by providing scientific and geologic guides to potentially new deposits, these studies would be a great stimulant to further mineral development in this state.

It is anticipated that to complete this program of field studies in the course of a five year period would require an expenditure in the order of $500,000 per year. This is an amount equal to only about 0.06 percent of the value of state's annual mineral production. It seems reasonable to believe that appropriations so provided would yield returns far out of proportion to the amount invested.

A relatively short period is proposed for studies to reveal the nature and extent of the state's mineral wealth because much is to be gained by having such information available soon. Because markets are often a determining factor in the exploitation of some commodities, mineral developments in one area often preclude or delay developments in adjoining areas. This is a consideration that can apply on a a statewide basis. New Mexico is the past has lost markets which it might have had, both within and without the state, because other areas have been ahead of it in the development of supplies to meet commodity demands as they occur.

Present Status of Laboratory Research:

In the past as potentially fruitful areas of research have been uncovered, either as a result of the Bureau's own field studies or as a result of field studies by others, appropriate laboratory investigations have been initiated. The extent and breadth of the research covered, however, has been limited by the staff and funds available. Some of the major areas in which the State Bureau of Mines now is supporting long range and short term studies are as follows:

(1) the use of conventional benefication processes for the recovery of various metallic and nonmetallic minerals found in the state;
(2) the application of new chemical and metallurgical techniques to mineral recovery processes now in use or under consideration;
(3) the possibility of economic recovery of rarer metals or minor mineral constituents from undeveloped deposits known to contain them, or from dumps and tailings that have resulted from past mining operations;
(4) methods and technology that might be applicable to the extraction of metals by chemical-mining of ores in place, including a study of the application of nuclear energy to prepare the ore for in-place leaching; and
(5) an overall evaluation of the state's potential for ceramic industry development.

Proposal for Expanded Research in the Mineral Industry Field:

A major area of research in which work has not been done to date is in the field of fuels. New Mexico ranks among the top states in the nation in fuel resources and should be actively engaged in research relating to their utilization. Various phases of fuel research in which the Bureau should undertake studies are:

(1) carbonization and decomposition of coal, including a study of the kinds and quantities of products that are formed when New Mexico coals are heated by various means;
(2) the utilization of low grade fuels in the mineral processing of New Mexico ores; or in the manufacture of such products as cement, paper pulp or glass;
(3) in-place production of gas from coal;
(4) the upgrading of low grade coals;
(5) the upgrading of low grade uranium ores;
(6) the low temperature carbonization of sub-bituminous coals in a fluidized bed, to produce useful yields of tars along with a powdered char which could be used in large-scale furnaces and power plants;
(7) the synthesis of organic compounds from natural gas;
(8) the formation of water soluble humic acids by the oxidation of coals and chars;
(9) the recovery of by-products such as helium and carbon dioxide from natural gas;
(10) the utilization of coals in road construction.

A list of other specific projects which would be deserving of state-supported research are presented below. Some of these are ones which might be in part supported by private capital after enough developmental work had been done to indicate some commercial possibilities:

Non-Metallic

(1) production of high purity silica for glass manufacture;
(2) production of high purity feldspar for glass manufacture;
(3) the expanding or bloating characteristics of New Mexico clays and shales, for use in building industry;
(4) field and laboratory studies in the utilization of natural building block material in New Mexico;
(5) methods of improving road aggregate material;
(6) recovery of mica and associated rare minerals from pegmatites and granites of northern New Mexico;
(7) utilization of the state's enormous reserve of gypsum; and
(8) the occurrence and utilization of roof rock, shingling granules, and landscape rock in New Mexico.

Metallic

(1) basic study on the genesis of ore deposits;
(2) the recovery of zinc oxides from complex ores;
(3) by-product recovery of tungsten from base metal ores;
(4) upgrading of taconite and other low-grade iron ores;

(5) beneficiation of low-grade manganese ores;
(6) the recovery of titanium and columbium from sandstone deposits in northern New Mexico;
(7) the recovery of copper from low-grade copper silicate ores; and
(8) the upgrading of submarginal uranium ores to bring them into a commercial range.

Promising Fields of Process Research

(1) the use of ultrasonic or electrical vibration for jigging or dispersion;
(2) the use of bacteria in the concentration of ores;
(3) application of flotation to problems in other industries;
(4) electrodialysis as applied to metal recovery;
(5) the use of dutch cyclone as a means of concentrating fine ores; and
(6) the application of vacuum magnetic levitation to metal refining.

The successful conclusion of an investigation in any of these lines of laboratory research could make a significant contribution to the state's economy. Other areas of investigation not noted here no doubt will be forthcoming as more becomes known of the state's mineral potential, and as technology advances and the needs of the market changes.

Areas of Joint Field and Laboratory Research:

In the field of ore-reserve development the Bureau has contemplated a research program directed towards improving exploration techniques. Although actual field-drilling and exploration work probably could not be justified, some expenditure of state funds on drilling and geophysics research for the purpose of lowering exploration costs would appear to be a worthwhile and proper state-supported activity. The Institute as a whole is eminently qualified to undertake such a study with its staff composed of a wide variety of specialists in physics, geophysics, mathematics, and mineral technology. The theoretical and practical aspects of the problem could be jointly and effectively pursued. The effort would be directed toward the phases of drilling and other exploration techniques that have the greatest bearing on New Mexico's special problems and terrain.

In the field of mining, theoretical studies have been made at the Institute on the application of hydrofracting and in-place leaching techniques to the treatment of deeply buried mineral deposits. These studies offer promise of greatly reducing the overall-costs of extracting metals from certain types of ores. The principles and techniques developed should have application also to treatment of worked-out mines, waste dumps, and tailing piles. From the standpoint of mineral conservation alone this line of investigation should be continued, and on an expanding scale.

Product Development Activities:

In addition to a need for increased activities to promote the development and conservation of the state's natural resources as outlined above, there is a need for studies to expand the utilization of the mineral commodities that already are being mined, and find applications for others that could be produced if markets were available. This area of research should be a significant part of any forward looking plan for economic growth in New Mexico. Any properly organized and implemented product-development program could be expected to make a significant contribution to the state's economy.

Appropriations:

In the first part of this report it was proposed that a five-year program be initiated to make a survey of the commodity resources of New Mexico and complete county reports on mineral and water resources. An annual appropriation of $500,000 per year was suggested.

The other phases of state-financed activities in support of mineral development in New Mexico should be on a continued basis, as part of the normal work now being performed by the New Mexico Bureau of Mines and Mineral Resources. The purely informational and service activities would require an expenditure of around $300,000 annually. It is believed that the augmentation of Bureau appropriations to a level in the order of one million dollars per year to incorporate activities in all the phases mentioned in this report is more than justified. For the five years during which the surveys were being conducted the total appropriations for the Bureau would be around one and one-half million dollars annually.

To aid in the proper expenditure of such funds it is recommended that a committee composed of representatives of the mineral industries and the state government be appointed by the governor. This committee would review and approve all programs proposed by the Bureau and consider any other programs or areas of activity that may be suggested to them. Such a committee should serve the purpose of insuring maximum economy and effectiveness in carrying out this state-supported work.

In conclusion it should be pointed out that the state has a special interest in its mineral resources. One-sixth of the mineral lands in New Mexico are owned by the state. By virtue of this ownership the state receives around 30 million dollars each year in revenue in the form of bonuses, royalties and rentals from those who lease the state-owned lands. A few percent increase in revenue from this source alone would more than justify the expenditures proposed in this report.