Annual Report

New Mexico Bureau of Mines
and Mineral Resources

July 1, 1965
to
June 30, 1966

A Division of New Mexico Tech
Socorro, New Mexico

November 1, 1966

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 for the New Mexico Bureau of Mines and Mineral Resources for the year ending June 30, 1966, as required by the session laws.

The Bureau has operated under a budget authorized by the State Legislature that has ranged from $15,000 in 1928 to $420,000 in 1966. This report contains an accounting of our stewardship of the funds for 1965-1966.

Of special significance in the Bureau operation during the past year have been the increased demands on Bureau personnel for teaching services in the College Division of the New Mexico Institute of Mining and Technology and increased activity in the Metallurgy, Hydrology, Geology, and Ceramic sections of the Bureau.

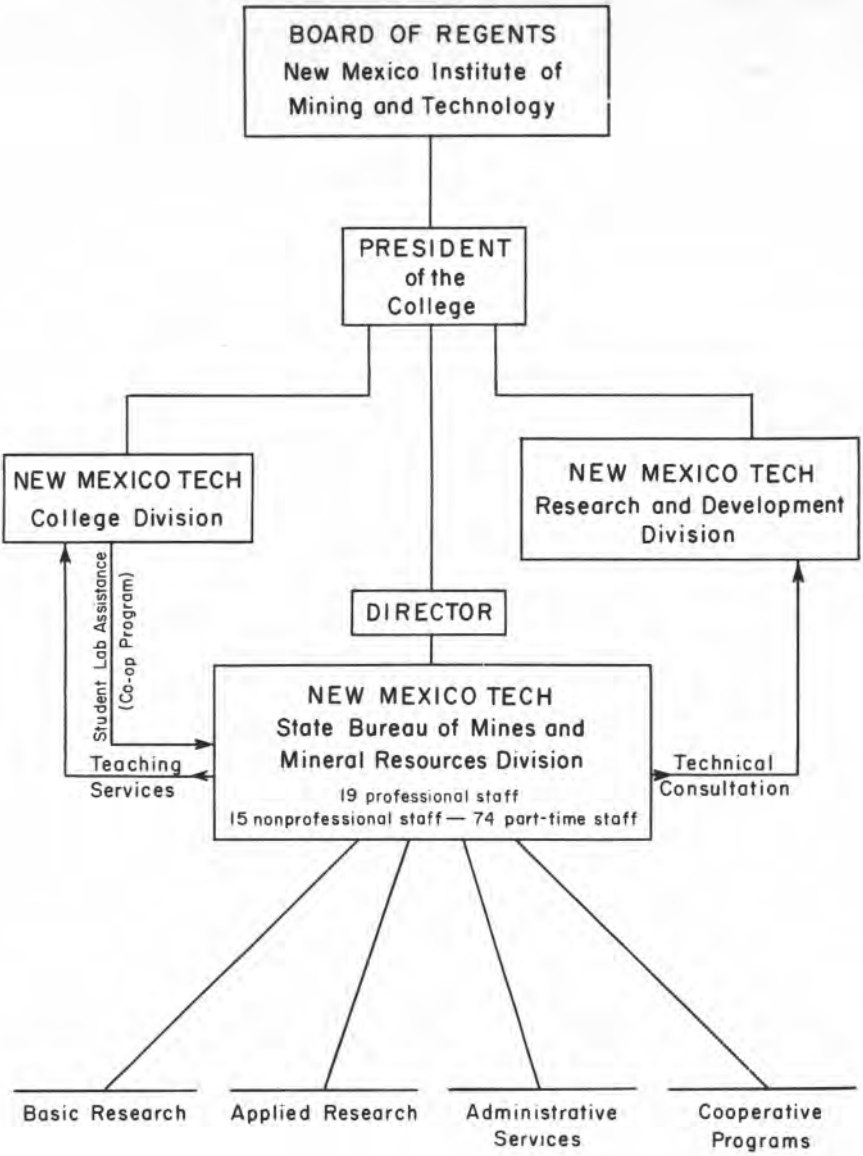
Various mineral industry projects and co-operative projects with other state, federal, and professional groups in which the Bureau has participated are given in this report.

The Bureau's activities are directed toward developing New Mexico's economy and increasing knowledge of the State's mineral resources.

Respectfully submitted,

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

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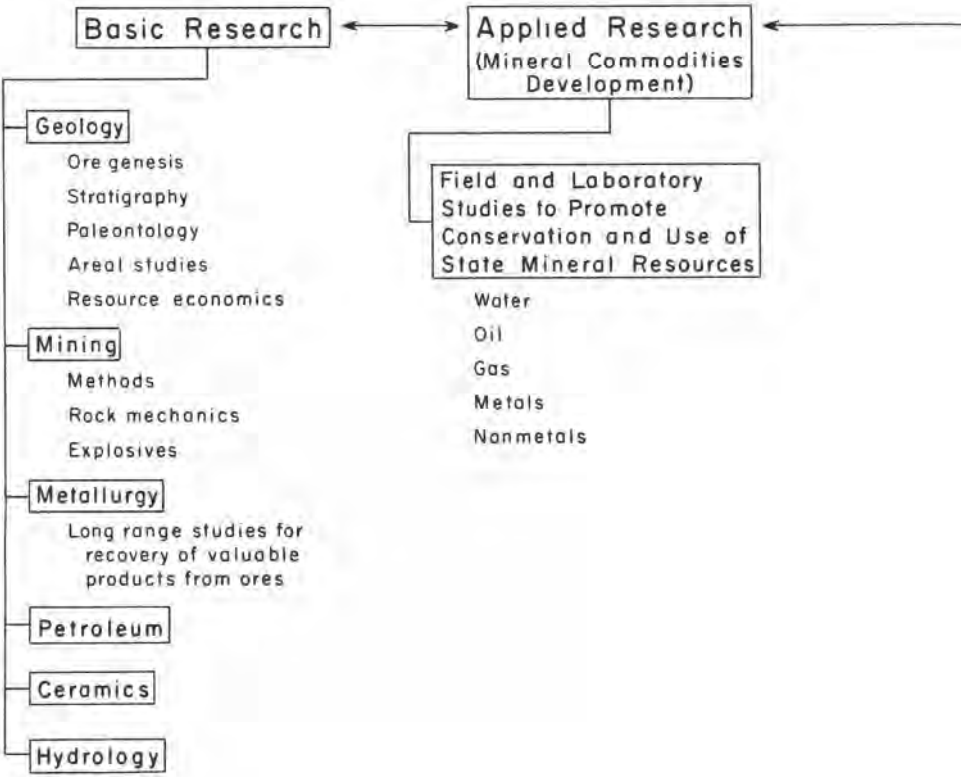

ORGANIZATION AND OPERATION OF THE STATE BUREAU OF MINES AND MINERAL RESOURCE

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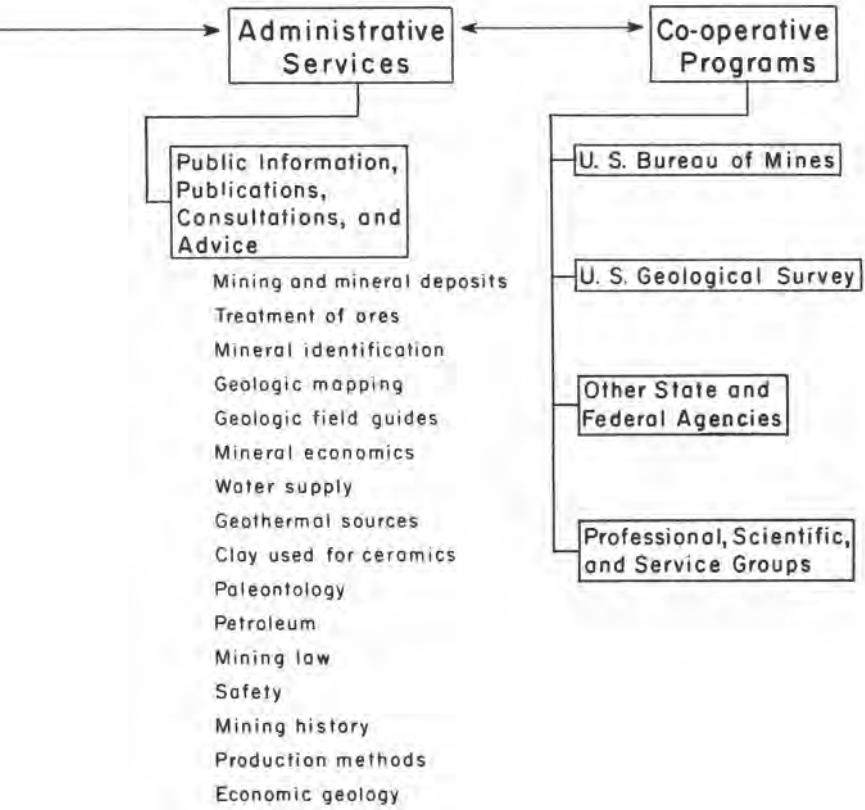

BUREAU OF MINES
DUTIES AND OBJECTIVES

The New Mexico Bureau of Mines and Mineral Resources is the only State organization charged with investigating, studying, and reporting on the geology of the entire State and conducting research on all types of mineral-bearing deposits for the purpose of increasing the State's mineral production and income. The Bureau was established March 14, 1927, by an act of the Eighth State Legislature as a division of the New Mexico School of Mines. In establishing the Bureau of Mines, the Legislature defined the objectives and duties of this State agency as follows:

(1) To collect, to compile, and to publish statistics relative to New Mexico geology, mining, metallurgy, and oil and natural gas and the refining thereof.

(2) To collect typical geological and mineral specimens and samples of products; to collect photographs, models, and drawings of appliances used in the mines, mills, smelters, oil wells, natural gas wells, and the refineries of oil and natural gas in New Mexico.

(3) To collect a library and bibliography of literature pertaining to the progress of geology, mining, milling, and smelting and the production of oil and natural gas and refining the same in New Mexico.

(4) To study the geological formations of the state with special reference to their economic mineral resources, both metallic and nonmetallic.

(5) To examine the topography and physical features of the state with reference to their practical bearing upon the occupation of the people.

(6) To study the mining, milling, and smelting operations and oil and natural gas production and the refining of the same carried on in the state with special reference to their improvement.

(7) To prepare and publish bulletins and reports with the necessary illustrations and maps, which shall embrace both a general and detailed description of the natural resources and geology, mines, mineral deposits, both metallic and nonmetallic, oil wells, natural gas wells, reduction plants, smelters, mills, oil refineries, and natural gas refineries.

(8) To make qualitative examinations of rocks and mineral samples and specimens.

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

(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.

(11) To communicate special information on New Mexico geology, mining, both metallic and nonmetallic, oil, and natural gas and to serve as a bureau of exchange and information on the mineral, oil, and natural gas resources of New Mexico.

(12) To co-operate with the University of New Mexico, with the State Mine Inspector, and with other departments of state government as may be mutually beneficial and to co-operate with the United States Geological Survey and with the United States Bureau of Mines in accordance with regulations of those institutions.

Offices of the Bureau of Mines are on the campus of the New Mexico Institute of Mining and Technology. The Bureau is organized as a branch of the Institute and does not maintain suboffices.

The staff included during the year 19 professional, 15 nonprofessional, and 74 part-time employees, including 12 graduate student employees, 26 co-op student employees, and 33 other student employees. There were also four geologists and engineers on special projects. (See Employee List, pages 34 and 35.)

1965 MINERAL PRODUCTION IN NEW MEXICO

Mineral production in New Mexico in 1965 was valued at 820 million dollars, an annual production figure that has nearly doubled in the last ten years and has increased more than tenfold in the last twenty-five.

As in recent years, the petroleum industry contributed nearly two-thirds of the total New Mexico production. Crude petroleum output, which passed the 100-million-barrels-a-year-mark for the first time in 1959, increased to 119 million barrels in 1965. In value, the 1965 production was 341.5 million dollars. Natural gas and the products derived from it in processing had a total value of 157.2 million dollars, which raised production by the petroleum industry to a total value of 498.7 million dollars.

As for many years, potash accounted for the major portion of the nonmetallic production. Seven companies in the Carlsbad area in Eddy County produced potash salts valued at 118 million dollars in 1965, the third year of record high. One of the seven, the Kermac Potash Company, first began production during the year. New Mexico provided a major percentage of the nation's potash.

The State's production of uranium concentrates was 9,182,949 pounds, purchased by the A.E.C. for $73,463,593. The decrease of approximately 2.5 million dollars in uranium production in 1965 compared to 1964 was a further result of the stretch-out procurement program initiated by the A.E.C. in 1962. Although production of uranium concentrates in New Mexico dropped from a maximum annual rate of about 125 million dollars in 1960 and 1961 to the present level of 73.5 million dollars, this State continued to

supply about 45 per cent of the nation's uranium. The total production of uranium concentrates in New Mexico now has a value in excess of 900 million dollars. By the end of 1967, this production should have passed 1 billion dollars in value, making this the third mineral product (along with potash and copper) that has reached such a high attainment during this decade.

Copper is fourth in dollar value of mineral products in the State. Nationwide, New Mexico ranked fourth. The price of copper increased from 33.7 cents a pound to 36 cents a pound during 1965. The State's production of 98,740 short tons of copper was valued at 70.3 million dollars. In both tonage and value, the production reached an all-time high in 1965.

Sand and gravel production was valued at 11.5 million dollars in 1965, compared to 10.2 million in 1964. The principal use was in highway construction, although substantial amounts were employed in building projects.

The marked increase in coal production, which occurred in 1963 with the beginning of large-scale strip mining in the Four Corners area, rose substantially in each of the two following years. The total tonnage mined in 1965 was 3.3 million, valued at 10.7 million dollars. Further increases appear to be forthcoming during the next few years.

Zinc and lead, which normally are mined together in New Mexico, have had a history of wide fluctuation in quantity and value of production. Following a 35-year low during the two-year period 1958 and 1959, a remarkable revival occurred that raised the production value sixfold to close to 20 million dollars during the two-year period 1964 and 1965. The prices of lead

MINERAL PRODUCTION IN NEW MEXICO

	1965 #	
	QUANTITY	VALUE
*Barite (tons)	*	*
Carbon Dioxide (natural) (cu. ft.)	877,000,000	$ 65,000
*Cement (tons)	*	*
Clays (except fire clay) (tons)	79,000	155,000
Coal (Bituminous) (tons)	3,300,000	*
Copper (tons)	98,740	70,303,000
Fluorspar (tons)	—	—
Gem stones	***	45,000
Gold (troy ounces)	9,165	321,000
*Gypsum (tons)	*	*
Helium (cu. ft.)	83,000,000	2,905,000
*Iron ore (usable tons)	*	*
Lead (tons)	3,495	1,104,000
Lime (tons)	33,000	464,000
Manganese concentrate (tons)	5,610	145,000
Manganiferous ore (tons)	*	*
Mica (scrap) (tons)	7,800	105,000
*Molybdenum (tons)	*	*
Natural gas (cu. ft.)	960,100,000,000	112,330,000
Natural gas liquids:		
LP gases (gal.)	755,700,000	23,400,000
Natural gasolines & cycle products (gal.)	357,700,000	21,460,000
Perlite (tons)	320,795	3,206,000
Petroleum (crude) (42 gal. barrels)	118,990,000	341,501,000
Potassium salts (tons)	2,862,000	118,262,000
Pumice (tons)	239,000	710,000
Salt (tons)	64,000	597,000
Sand and gravel (tons)	10,009,000	11,548,000
Silver (troy ounces)	283,000	366,000
Stone (tons)	3,223,000	4,878,000
Sulfur (tons)	9,200	181,000
Tin concentrate (tons)	2	9,000
**Uranium concentrate (pounds)	9,182,949	73,463,593
Vanadium (tons)	*	10,000
Zinc (tons)	36,475	10,578,000
*Value of items not disclosed, cement, iron ore, molybdenum, gypsum, barite		19,262,000
TOTAL		$817,373,593

* Figures withheld to avoid disclosing individual company confidential data.

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

*** Not recorded.

Preliminary annual figures, U.S. Dept. of Interior, Bureau of Mines.

and zinc, which remained at 16 and 14.5 cents a pound, respectively, during most of the biennium, were a large factor in the high performance record achieved. Zinc, with a production value of 10.6 million dollars, ranked after uranium and copper as the most important metal produced in New Mexico.

The amount of stone produced in New Mexico in 1965 was 3.2 million tons. This had a value of 4.9 million dollars. Stone was used principally for highway projects, but New Mexico now is mining and processing substantial quantities of decorative building stone.

New Mexico continued to rank first in the nation in perlite production, accounting for 84 per cent of the nation's total. Valuation was 3.2 million dollars, a 25 per cent increase over 1964.

The production of helium in 1965 was essentially the same as that of the preceding year. The output of this gas, which began in 1953, dropped to a low value of 264,000 dollars in 1959 after five years of substantial production that averaged close to a million dollars a year. Production has increased each year since 1959 to reach a peak in 1964 of 85 million cubic feet valued at 3 million dollars.

As may be seen in the table, a number of mineral commodities other than those mentioned were produced. These together had a total value of 19 million dollars. The production figures for cement, which are withheld as confidential, accounted for a large part of this total. Molybdenum, another commodity whose quantity and value are confidential, is now a product of major importance to New Mexico. The Questa mine and mill of the Molybdenum Corporation of America were put into operation in January of 1966. It is expected that the value of production from this unit will exceed 10 million dollars during 1966, to account for about 10 per cent of the total output from the free world.

BUREAU ACTIVITIES

Administration

The New Mexico Bureau of Mines and Mineral Resources is charged with investigating, studying and reporting the technology of the State's mineral resources. It is responsible for conducting research on all types of ore deposits for the purpose of increasing the production and use of the State's minerals resources, with due regard to proper conservation. Immediate and future needs, industry trends, and the probable by-product aspects of mineral production are important factors guiding the Bureau's research.

Activities of the Bureau cover basic and applied investigations in eight major fields: *Ceramics, Geology, Hydrology, Metallurgy, Mining, Minerology, Paleontology, and Petroleum.*

Functions necessary to co-ordinate and implement work in these divisions include *administrative, publishing, stenographic, drafting and office services, equipment maintenance,* and *maintaining records,* such as oil well and mining records.

The *administration* of the Bureau activities is under the direction of Alvin J. Thompson, Bureau director. His duties include budgetary control, personnel and technical supervision, project planning and guidance, providing information and assistance on mineral problems by correspondence, phone and personal conference, purchasing of laboratory and office equipment, and maintaining records and inventory as required by the State fiscal agencies.

Publishing of the results of studies made by staff members is a major activity of the Bureau. After the manuscript is submitted, it must be edited, typed, and submitted for an estimate. Editing is under the supervision of Miss Teri Ray, publications journalist. Estimates on cost of publishing are obtained in advance and liaison with the printer is maintained to ensure economical production, a function which is performed by Mr. L. A. File, staff researcher, who also supervises the printing production schedule.

Maps and illustrations are vital to the publishing activities, and these are produced by draftsmen under the supervision of Mr. William Arnold, scientific illustrator.

Publications are in three formats: Circulars, which are 8½ x 11 inches in size; Bulletins, which are usually lengthier studies or reports of research results, in 6 x 9-inch sizes; and Memoirs, which are usually those reports that require large size, 9 x 12-inch illustrations.

Twenty-three publications, or almost two a month, were issued by the Bureau during the period covered by this report.

Storing, mailing, selling, and bookkeeping for publications are functions of the Bureau Publications Office, with Mrs. Lois Devlin in charge. Manuscript typing is also done in this office along with secretarial and stenographic work for Bureau personnel.

Equipment inventory and maintenance requires considerable attention, with nearly a thousand items of office and laboratory equipment to be accounted for as State property, plus the maintenance of trucks and passenger cars necessary for field work.

As a matter of economy, the Bureau pools its buying activities with the

College and the Research and Development divisions of New Mexico Tech and integrates its inventory with that of the College business office.

Information Service

To disseminate effectively the results of the Bureau's research, publications are sent on free or exchange basis to more than 500 libraries and organizations within and without the State. Announcements of the publications in abstract form are sent to a wide variety of prospective users.

Equally important in getting information to the public are phone calls and mail inquiries and personal visits of mining company officers and geologists, representatives of other state and federal agencies, professional organizations, officers, and university personnel. Qualified staff members meet with these people and discuss their problems.

In addition, services are rendered to New Mexico residents in identifying minerals, rocks, ores, and clays. Such services are performed free of charge. Samples are analyzed to determine what minerals or metals of potential value they contain. In some instances, this is sufficient. If it appears from the qualitative analysis that a quantitive determination of valuable components should be made, the person submitting the sample is advised so that a sample can be sent to a commercial assayer, if desired.

ACTIVITIES BY SECTIONS

While basic and applied research by the Bureau fall into distinct classifications, many staff members serve two or even more of the following sections. A study of a particular geology problem may be of importance to Mining, Ceramics, Hydrology, or Petroleum and, at times, important to more than one of these areas of New Mexico's economy. In the report of activities by sections, the nature of the work done by the individual as well as the contribution of the section to the Bureau's objectives can be seen. For abstracts of published studies by the various sections, see pages 36 to 43.

Practically every staff member and most of the sections of the Bureau were called upon during the past year to co-operate with professional organizations, civic groups, other state and federal agencies, other divisions of New Mexico Tech, and other colleges or universities.

The agencies the Bureau has worked with during the year are listed with the nature of the project described briefly under the heading *Co-operative Projects*, pages 27-31.

PETROLEUM

Although many Bureau studies and research problems are considered completed when they are published in a form that can be of use in improving the economy of the State (and they represent real contributions to scientific knowledge of mineral resources), there are many functions of the Bureau that are endless. These functions, nevertheless, require as much work annually as the more spectacular projects. Such a continuing function is that of keeping up-to-date petroleum exploration maps of 25 New Mexico counties and maintaining the samples from oil and gas well tests in the Bureau library.

Mr. Robert Bieberman, petroleum geologist, who has charge of the Petroleum section's activities, is responsible for maintaining the sample library and the petroleum maps.

Mr. Bieberman is engaged principally in activities relating to the oil and gas industry of New Mexico. Answering a large volume of inquiries by phone and mail and providing office visitors with information and assistance with petroleum problems account for a large portion of the time of Mr. Bieberman and his associates.

Mr. Bieberman has published Circular 72 (1966), *Petroleum Developments in New Mexico during 1960,* and Circular 88 (1966), *Index to Samples From Oil and Gas Well Tests in Library Tests at Socorro, July 1, 1966.* (See abstracts of Bureau publications, pages 37 and 39.)

As a contributor to the Bureau's co-operative projects, Mr. Bieberman also completed the New Mexico section of the directory, *Sample and Core Repositories of the United States, Alaska, and Canada,* for the Committee on Preservation of Samples and Cores of the American Association of Petroleum Geologists.

Mr. Roy Foster, associate petroleum geologist, has been occupied with research in petroleum geology and nonmetallics and has made significant contributions to the petroleum work of the Bureau. His petroleum projects initiated during the year have been the following:

1. Preliminary investigations of the shale oil potential in New Mexico
2. Oil and gas exploration in Colfax County
3. Post Queen stratigraphy of southeastern New Mexico
4. Analysis of the stratigraphy of the Sun well in the San Agustin Plains

Mr. Foster was in charge of arrangements for the acquisition of the Sun well by the Research Foundation of New Mexico Tech.

Dr. Frank Kottlowski, economic geologist and assistant director of the Bureau, contributed to the Bureau's activities in petroleum research. He is the author of an article, entitled "Sedimentary Basins in South-Central and Southwest New Mexico," printed in the Bulletin of the American Association of Petroleum Geologists, November 1965. He also edited articles for publication by the AAPG in co-operation with personnel from the United States Geological Survey, Nevada Bureau of Mines, U.S. Soil Conservation Service, University of New Mexico, and various petroleum companies.

GEOLOGY

Geology is a necessary background for development of mineral resources. Reconnaissance geologic maps, detailed geologic maps, stratigraphic studies, investigations of ore minerals—these and other types of geologic research aid in finding and extracting New Mexico's minerals. Most of the reports published during the year were geologic in nature. What may seem to be purely research today may turn out to be economically important in the future.

The vast majority of New Mexico's citizens are not directly concerned with technical geologic investigations but do have a vivid interest in the

spectacular beauty of the landscape. They seek explanations of "why is a hill here and a valley there." The Bureau has published eight popular guidebooks in a series titled, *Scenic Trips to the Geologic Past*, since 1955. These have been so much in demand by educators, students, hobbyists, book stores, chambers of commerce, and tourists that 1, 3, and 7 (see list below) were reprinted during the year and a reprint of 8 is in press.

Scenic Trips to the Geologic Past for sale by the Bureau are as follows:

1	Sante Fe, New Mexico; Brewster Baldwin and Frank E. Kottlowski	1955	.25
2	Taos-Red River-Eagle Nest, New Mexico, Circle Drive; John H. Schilling	1956	.25
3	Roswell-Capitan-Ruidoso-Bottomless Lakes Park, New Mexico; John Eliot Allen and Frank E. Kottlowski	1958	.25
4	Southern Zuni Mountains, New Mexico, Roy W. Foster	1958	.25
5	Silver City-Santa Rita-Hurley, New Mexico; John H. Schilling	1959	.25
6	Trail Guide to the Upper Pecos; Arthur Montgomery and Patrick K. Sutherland	1960	1.00
7	High Plains Northeastern New Mexico (Raton-Capulin Mountain-Clayton); William R. Muehlberger, Brewster Baldwin, and Roy W. Foster	1962	.50
8	Mosaic of New Mexico's Scenery, Rocks, and History; edited by Paige W. Christiansen and Frank E. Kottlowski.	1964	1.00

In the field of technical geology, a wide range of studies was made. Ten studies were completed and published, some of which also have a bearing on ceramics and petroleum. (See abstract of publications by the Bureau on pages 36 to 43.)

Seven Bureau staff members contributed the major part of the geologic studies during the current year: Mr. Robert Bieberman, petroleum geologist; Mr. Roy Foster, associate petroleum geologist; Dr. Frank Kottlowski, economic geologist and assistant director of the Bureau; Dr. Jacques Renault, associate geologist; Dr. Edward Bingler, associate geologist; Dr. Robert Weber, economic geologist; and Mr. Kelly Summers, groundwater geologist.

Mr. Robert Bieberman, in co-operation with the Committee on Preservation of Samples and Cores of the American Association of Petroleum Geologists, furnished a revision of the New Mexico section of the directory compiled by the committee entitled *Sample and Core Repositories of the United States, Alaska, and Canada.* His main duties are the administration of the petroleum division (see page 12.)

Mr. Foster's work in petroleum geology is reported under the petroleum section. His geologic projects included a study of sources for lightweight shale in New Mexico, a preliminary investigation of the shale oil in the State, extensive study of and assistance in the field of gas and oil investigations in Catron County, studies on post Queen stratigraphy of southeastern New Mexico and analysis of stratigraphy of the Sun Well. He did research also in the Precambrian of New Mexico, diatomites, and considerable analysis work for thermal studies. He assisted in the accumulation of data on strip mining in the State for a report made by the Bureau to the Depart-

ment of the Interior in connection with their studies implemented by the Appalachian bill passed by Congress in 1965.

Dr. Kottlowski gives advice by conference and correspondence on mineral resources, professional service to technical personnel, and talks to professional scientific societies. He also undertook basic geologic studies of several areas in the state, with emphasis on mineral resources. His projects in this field include a study of Quaternary geology of the southwest; a study of sedimentary basins in south-central and southwestern New Mexico; and a study of fluorite-barite mineralization in New Mexico.

Projects on which Dr. Kottlowski is continuing research and which were started during the year are the geology of the Las Cruces quadrangle, the Pennsylvanian and early Permian rocks of the Joyita Hills, and the dating of igneous rocks of Parajito Peak.

Dr. Kottlowski was active in the New Mexico Geological Society, working on road logs and articles for the Society's Guidebook. He also furnished the American Institute of Mining, Metallurgical, and Petroleum Engineers (A.I.M.E.) with a report of mineral exploration in New Mexico and geological road logs for the International Association for Quaternary Research (I.N.Q.U.A.) International VII Congress field trip.

Dr. Jacques Renault, associate geologist, is engaged principally in petrologic research and teaches a graduate course in igneous petrology in the College Division of New Mexico Tech. He initiated three projects in mining (see mining section) and one on the geology and geochemistry of New Mexico basalts. Dr. Renault was coauthor of two papers, "Statistical Analysis of Some Characteristics of British Columbia Molybdenite Occurrences," published in *Economic Geology* and "Silicate–Molybdenite Paragenesis in Granite Rocks," which was published in the annual meeting reports of the Geological Society of America. (See abstracts of individual papers, pages 45 and 46.)

Dr. Edward Bingler, associate geologist, has a variety of duties that include teaching a graduate course in metamorphic petrology in the College Division; the routine examination of rocks and minerals submitted by New Mexico residents; and areal geology studies and detailed studies of mineral districts with respect to commodity minerals. He also has charge of the maintenance of the mineral collection and museum in the Research and Development Building for the use of students and the public.

Dr. Bingler has four geology studies under way; the titaniferous sandstones deposits of the San Juan Basin; the geology and mineral resources of the Hopewell–Bromide mining districts; the geology and mineral resources of Rio Arriba County; and the geology of the Woods Tunnel site in Socorro County.

Dr. Robert Weber, economic geologist, identifies, interprets and evaluates minerals, rocks, and ores. He consults with users of the Bureau's services on matters pertaining to geology, mineralogy, and exploration and development. His basic research is in the fields of mineralogy and geology, and he has the collateral duties of assisting in editing maps and reports as they are prepared for Bureau publication.

Dr. Weber has worked on six projects during the year, with publications

and talks summarizing three of them. Published were studies for the New Mexico Geological Society guidebook pertaining to southwestern New Mexico; "Clovis Points and Associated Implements of the Bingham Site, Central New Mexico," given before the Rocky Mountain Division of the American Association for the Advancement of Science; and "Mockingbird Gap Site: A Clovis Site with Possible Transitional Folsom Characteristics," presented at the thirty-first annual meeting of the Society for American Archeology at Reno, Nevada. (See abstracts of individual papers.) Dr. Weber is doing research on the geology of the northeastern segment of the Datil–Mogollon volcanic field, Quaternary geology of the northern Jornada del Muerto, and Pleistocene shoreline and lake chronology of the Plains of San Agustin.

Mr. Kelly Summers, ground-water geologist, was principally concerned with so-called "heat mining" or the location of thermal springs and thermal waters and their possible commercial uses. His work is reported under the hydrology section.

Mr. Max Willard, economic geologist, taught a graduate course in volcanic geology at the College Division of New Mexico Tech and served as thesis advisor on a study of beryllium mineralization at Apache Hot Springs.

In the geological section, Mr. Willard initiated laboratory and field investigations of the petrographic zoning and correlation of the Cretaceous rocks along the west side of the San Juan Basin; a study of the distribution of trace impurities in the Tower mine, Luis Lopez manganese district, Socorro County; a study of the areal geology of the Chupadera Mountains area in Socorro County; and research in the geologic control of uranium mineralization in the Bonanza mine, Socorro county.

Two of Mr. Willard's projects were accomplished in co-operation with industry. He furnished advisory service to the Mountain Copper Company of California during the deep-diamond-drilling test of the Tower manganese vein and assisted Sandia Corporation engineers in locating clay raw material for experimental thermal gradient tests by supplying X-ray analyses of materials.

METALLURGY

Research in metallurgy was begun by the Bureau in 1957. During 1965 and 1966, the work in this section increased in volume as laboratory space and staff personnel became available.

The metallurgical section conducts studies in various aspects of extra-active metallurgy and provides technical assistance to those who request it. A great many prospectors and small-mine operators and most of the major mining companies have availed themselves of this service.

Dr. Roshan Bhappu, senior metallurgist and research professor, and Dr. Dexter Reynolds, research chemist, initiated or completed numerous projects and work assignments. They are engaged principally in

(1) Basic and applied research in extracting metals and minerals from from ores;
(2) service work in the form of assistance or consultation with indi-

Potash and copper continue to be important contributors to mining income in New Mexico. Above, refined copper is poured from the fire refinery into a large ladle which pours it into molds. Nearly 200 tons of fire-refined copper are cast each day at Kennecott Copper Company's Chino plant. Below is a potash mine of the United States Borax and Chemical Company in Eddy County. This company has recently added new equipment and has established a method for recovering valuable materials from support pillars in worked-out areas by entering the pillar boundary near the top and mining the pillar internally.

viduals and mining companies in solving operating problems and in metallurgical evaluation of ore samples submitted;

(3) long-range studies involving surface chemistry of silicate minerals, sorption processes in hydrometallurgy, and studies of in-place and dump leaching ores; and

(4) supervising the training of several co-operative students at various levels, providing in the laboratory, a practical application of the students' college training. Dr. Bhappu gives special lectures in chemistry and metallurgy to classes in the College Division and supervises graduate theses work. He supervises the undergraduate work of National Science Foundation students.

Additional studies are planned in the use of bacteria and carbonate leaching of molybdenum sulfide, the first part of which was completed in 1966. Some of the work done for industry this year includes evaluation of Shell chemicals in mining and water treatment, with special emphasis on the use of fuel oils for flotation of molybdenum sulfide; determination of the nature and treatment of Ducktownite ore, a complex copper-iron-bearing ore occurring in the Chino mine, as well as a study of the treatment of middlings fraction from current and future milling operations at Chino for the Kennecott Company; and studies for the Molybdenum Corporation of America on the removal of impurities from molybdenum sulfide concentrates and the recovery of barium sulfate minerals from the Mountain Pass deposit. Also initiated or completed and of interest to the mining industry at large were the following projects:

Evaluation of potassium permanganate in mining and metallurgical applications
Recovery of beryllium from Winston mine ore
Studies of tungsten-iron complexes
Recovery of valuable by-products from Socorro County manganese ores
Sulfonate flotation of olivine group minerals
Use of chelating compounds as selective flotation reagents for copper and zinc minerals
A geochemical model of ground water in contact with a solid media

Reports on other projects completed by the Metallurgical Section during the year have been published (see abstracts of Bulletins published by the Bureau), while some are pending:

1. Design of an Apparatus for Determining Zero Point of Charge, R. Deju and R. Bhappu, Circular 79.
2. Surface Properties of Silicate Minerals, R. Deju and R. Bhappu.
3. A Chemical Interpretation Of Surface Phenomena In Silicate Minerals, R. Deju and R. Bhappu.
4. Winning Metallic Values from Leach Solutions by Sorption Processes, D. H. Reynolds, W. Long, and R. Bhappu.

5. A Correlation Between Surface Phenomena and Flotation of Silicates, R. Deju and R. Bhappu.
6. A Status Report On Sorption Studies: What Has Been Done and What Must Be Done, R. Deju and R. Bhappu.

Dr. Reynolds has also done considerable work on developing and using chemical and instrumental methods of analysis of water and rock samples, taught a graduate course in electrochemistry in the College Division and supervised graduate study. Some of his projects during the year concerned analysis of thermal waters; he is compiling a laboratory procedure manual in this field.

CERAMICS

The Governor's Advisory Committee on Mineral Development on December 8, 1964, recommended a clay resources survey to delineate potentially valuable clay deposits in New Mexico.

Clay uses are numerous and among other applications include the manufacture of tableware, bricks, electrical insulators, and soil and sewer pipes.

Mr. William Hawks, ceramic engineer, is in charge of the Bureau's studies in ceramics and directs the work in the clay testing laboratory that was set up last year and is maintained by the Bureau. Clay and shale samples are submitted by individuals and by industry and are collected by Bureau personnel in the field. Mr. Hawks also teaches a course in ceramic engineering in the College Division of New Mexico Tech.

Current projects under his supervision are a study of the feasibility of building additional ceramic plants in New Mexico and possible utilization of New Mexico clays.

Mr. Roy Foster, associate petroleum geologist, contributed to the work of the ceramics section during the year with a study on shales and clays as a potential source for common and refractory bricks and a study of sources for lightweight shale aggregate in New Mexico.

MINERALOGY

Identification of minerals, rocks, ores, and clays is offered New Mexico residents free of charge. Dr. Edward Bingler, associate geologist; Dr. Robert Weber, economic geologist; Dr. Dexter Reynolds, research chemist; and Dr. Jacques Renault, associate geologist, are the four persons who are mainly called upon for this type of service. To aid in identification, the mineralogy laboratory facilities include X-ray diffraction apparatus, petrographic microscopes, X-ray fluorescence unit, radiometric apparatus, spectrophotometers and an emission spectograph.

Besides identification of minerals for individuals and industrial concerns, the results of mineralogical studies may initiate research and development in other fields, such as extractive metallurgy. Past work which has shown the presence of appreciable amounts of titanium, rare earths, and selenium in certain sandstone formations has resulted in studies to recover these elements.

Dr. Renault initiated four mineralogy projects this year: statistical analysis

Newest of recent major developments in New Mexico's mining economy is the Questa molybdenum open-pit mine of Molybdenum Corporation of America (above) which went into operation this year and Arizona Public Service Company's Four Corners Power Plant near Fruitland (below). Coal-fired boilers of the 575-megawatt plant, seen from the reservoir created to provide cooling water, require 2.5 million tons of fuel annually. The coal is mined from nearby Utah Construction and Mining Company's Navajo strip mine, eighth largest in the nation. Plans have been announced to add 1500 megawatts to the Four Corners Power Plant's capability by 1970.

of rock textures, crystal perfection studies, lead mineralogy of Questa molybdenum concentrates, and the Ducktownite project, a determination of the nature and treatment of Ducktownite ore, a complex copper-iron-bearing ore from Kennecott Company's Chino mine.

MINING

New Mexico hoists more metallic and nonmetallic ore from underground than any other state in the Union. The Bureau's rock physics research, its studies in better ways to extract minerals from refractory ore, and its research in geochemical prospecting continue to be major efforts directed toward aiding the mining industry.

The entire bureau staff served as consultants to numerous prospectors and exploration personnel of mining and petroleum companies on problems pertaining to economic mineral deposits during 1965 and 1966.

Mr. George Griswold, mining engineer, whose primary research for the Bureau during the past year has been in rock mechanics, taught engineering drawing, directed study in mining, rock mechanics, and mechanics of materials courses in the College Division.

Mr. Griswold did considerable work on the following projects:

Project Mohole. A NFS-sponsored program to drill a deep hole into the floor of the Pacific Ocean to gain knowledge of the earth's mantle. Mr. Griswold is assisting the prime contractor in developing a technique to measure rock stress in this hole, a project which is estimated to last another year.

Explosive Hydrofracing. A joint Bureau and Research and Development project to devise a means of preparing mineral-bearing zones for *in situ* mining. Current research in the Bureau is aimed at devising a method for emplacement of explosives along a preferred hydrofrace plane. This project has as its basic aim that of making it economically feasible to extract low-grade ores at depth by leaching or in-place retorting or, for oil and gas, profoundly increasing formation permeability.

Lead Wires. A Sandia Corporation-sponsored project for the study of the effects of lightning strokes near electric impulse detonators. This work is being done during the summer of 1965-1966 at Langmuir Laboratory. The project may continue if significant results are obtained.

Open-Pit Slope Stability. A project that is the outgrowth of a graduate student's thesis. Slope stability is analyzed with the aid of mine models. A sensitive tilt meter is being developed as part of this project so as to be able to predict early movements that forewarn of an impending slide.

Raise Boring Device. A rotary type of raise boring machine is being developed. The machine promises to be a safe, yet efficient, means of driving a raise, which by present conventional methods is one of the more expensive and dangerous underground mining operations. Preliminary designs for the machine have been drawn, but it will probably be at least a year before significant results can be expected.

Underground Nuclear Explosions Project. A Sandia Corporation-spon-

Making a connection during the drilling of the 12,284-foot San Agustin Plains Unit oil test.

sored project for the theoretical investigation of certain phases of the blast effects from underground nuclear explosions. The ultimate aim is to be able to increase the fracturing and brecciation of rock from the explosion. This study is a joint effort on the part of the Bureau and Research and Development divisions of the Institute.

Geothermal Study Within Woods Tunnel in Socorro Peak. The Research and Development Division of New Mexico Tech has been investigating the geothermal gradients within Socorro Peak for several years. The Bureau assisted in this project by drilling a pattern of holes from within Woods Tunnel (which extends some 1200 feet into the mountain). These holes will be instrumented with thermistors to obtain information concerning heat flow within the mountain. Dr. Edward Bingler of the Bureau assisted on this project by making a detailed geological map of the area.

Index of Literature on Mining Engineering for the Period 1950 to 1966. A complex index of current mining literature is not now available in any library or State or Federal agency. A card sort index of abstracts taken from the engineering index is being prepared by the Bureau. When complete, this index should be of aid to mining companies and research personnel in keeping abreast of new techniques and developments in mining.

Mr. Griswold presented two papers to professional organizations during the year: "The Need for Mining Engineers in the Growing Minerals Industry," presented to the Carlsbad section of the A.I.M.E. in October 1965, and "Project Mohole," presented to the central New Mexico section of the A.I.M.E. in Grants, New Mexico, February 1965. Abstracts of these talks are contained elsewhere in this report.

Dr. Fazlollah Missaghi, mining engineer, is presently engaged in geochemical prospecting studies of promising areas of New Mexico. He also teaches classes in surveying, principles of mining, mine plant design, and other courses in mining engineering in the College Division. Dr. Missaghi started a program of geochmical prospecting in September 1962 and is continuing his work in this area.

Specifically, Dr. Missaghi has been working on three projects: a *geochemical survey of stream sediments in Philmont country; biogeochemistry and geochemical survey* of the *Red River quadrangle, New Mexico;* and a *geochemical survey of the Magdalena mining district, New Mexico, the mercury content of stream sediments.*

Circular 85 by Dr. Missaghi is titled *A geochemical survey of the Magdalena mining district, New Mexico.* Circular 85 is in press.

Mining Records

Mr. Lucien File, staff researcher, coauthored a listing of county, township, and range locations of New Mexico mining districts with Dr. Stuart A. Northrop of the University of New Mexico. The purpose of the study is to clarify mining district locations and to offer a measure of standardization as a guide line for future designation of mining districts. The information was compiled in co-operation with the Bureau of Land Management and the State Inspector of Mines and contains a complete history of mining in New Mexico from 1535 to 1966, as well as a table of dates of establishments of New Mexico counties.

Also published by Mr. File during the year was a compilation of a mining directory (see abstracts) listing most of the known mines of the State, along with some historic mining company names.

Mr. File initiated a program for the exchange of information by microfilm and other methods among the Bureau of Land Management, the State Archives Division, and the State Bureau of Mines. The information, not heretofore available, will provide a source of research information on the history and economic aspects of individual mines, particularly of those no longer in production.

A large part of Mr. File's time is given to answering inquiries about mines, mine locations, mining districts, ghost mining towns, and mining history and searching out background information for staff members and others.

Strip Mining Study

The Federal Appalachian Regional Development Act provides for a study of recommendations for reclaiming and rehabilitating strip and surface mines throughout the nation. At the request of the Appalachian Regional Commission, the New Mexico Bureau of Mines assisted in preparing a pre-

Engineers and scientists needed by the mineral industry receive their education at New Mexico Tech and part of their training is provided by practical work with scientists in the State Bureau of Mines who, in conducting research in metallurgy and mining, utilize student help. Above are students in a class held in a mine near Socorro. Below is the Research and Development Building which houses the Bureau of Mines and its laboratories on New Mexico Tech campus.

liminary report of the extent of strip mining in the State. It also co-ordinated a meeting of all State department heads concerned and a working committee from the Department of the Interior and several other national agencies. The meeting was held in Mabry Hall, State Capitol Building, July 27, 1966, with preparatory work completed in the year covered by this report.

HYDROLOGY

The Bureau as a State agency charged with the responsibility of investigating underground resources maintained its interest in the ground-water resources field. For several years, the activity of the agency in this area was in the location and evaluation of water wells and in studying ground-water problems. These activities have continued.

Recently, however, emphasis shifted to the study of geothermal resources. The economic implications of heat and hot water sources are enormous, with possibilities of use for generating electricity, for furnishing heat for homes, as a source of preheated water for steam energy production, and for crop growing, especially in greenhouses.

Mr. Kelly Summers, ground-water geologist, is engaged in the study of thermal waters and the prospects of developing geothermal power in New Mexico.

Mr. Summers is preparing a bibliography of geothermal phenomena and since September 1965 has been working under a matching fund grant from the U.S. Department of the Interior, Office of Water Resources Research, on a project entitled, "Appraisal of Some of the Factors Adding To or Detracting From the Socio-Economic Use of New Mexico's Thermal Waters."

The Bureau, in the period covered by this report, published two reports of Mr. Summers' studies: Circular 80, *A Preliminary Report of New Mexico's Geothermal Resources*, and Circular 83, *Chemical Characteristics of New Mexico's Thermal Waters—A Critique.*" (See abstracts of published papers.)

Mr. Summers presented papers to the New Mexico Academy of Science on October 8, 1965, and the New Mexico Geological Society in Roswell on May 6, 1965 (See abstracts of papers delivered by Bureau personnel).

All sections of the Bureau assist in this search for geothermal resources. The analytical facilities of the metallurgical section have proved especially helpful, with analyses and reports from Dr. Dexter Reynolds and others.

PALEONTOLOGY

Knowledge of the fossil content of rocks serves to fix the age and to permit intelligent correlation of units whose continuity is interrupted by erosion or cover with other formations. Certain formations are more favorable as locations for petroleum and natural gas accumulations; others are more favorable for locations of uranium; and still others for various other metals and nonmetals.

Exploration for mineral resources, almost all of which are hidden, must

take into account the thickness and succession of rock units between the unit sought and the surface, as well as the structural discontinuities that affect the situation.

Work in the Bureau continued on the unending task of adding to the knowledge of fossils and their use for correlation and dating of strata of New Mexico. Material from the Bureau's collection of fossils has contributed to many major studies.

Dr. Rousseau Flower, stratigraphic geologist in charge of this section, is primarily concerned with the fossils of New Mexico, concentrating largely on those of the older formations. However, his services have been in demand from all over the world in consultation for identification and description of cephalopods.

Collecting involves not only obtaining of specimens but also establishing faunal zones; ascertaining their characteristics lithically and faunally, tracing them over the State and beyond into other regions. Considerable time is required to extract the fossils, prepare them for study, and photograph them to illustrate published results of studies.

Various projects that have emerged as part of the paleontology section's general study are as follows:

(1) Faunas and faunal zonation of the Bliss Sandstone.

(2) Faunas and faunal zonation of the El Paso Group.

(3) Faunas and faunal zonation of the Montoya Group

(4) Identification, study and, where needed, description of various submitted materials, mainly Paleozoic cephalopods from throughout the world.

(5) Cephalopods of the Garden City and Pogonip group

(6) Furthering the progress of systematic paleontology of the Paleozoic Nautiloidea

(7) Early Paleozoic of New Mexico

(8) Silurian Cephalopods of the James Bay Lowland, with a revision of the family Narthecocoeratidae, which was completed and submitted to the Geological Survey of Canada for publication

(9) Structure and evaluation of Ordovician corals (results of this project were prepared and presented by request before the Paleontological Society of America as part of a symposium on fossil corals.

(10) Silurian cephalopods from Monon, Indiana (undertaken at the request of the Indiana Department of Geology and Natural Resources)

CO-OPERATIVE ACTIVITIES

A large part of the work done by Bureau staff members during the year has been giving co-operative assistance to industry, state, and federal government agencies, both of the United States and Canada, and to professional organizations and other institutions of higher learning. The following is a report of these activities:

ACADEMY OF SCIENCE OF NEW MEXICO

Editing services and maintenance of mailing facilities for the Academy of Science Bulletin (File).

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

Assistance and editing of publications and articles in co-operation with the United States Geological Survey, Nevada Bureau of Mines, United States Soil Conservation Service, University of New Mexico, and various petroleum companies (Kottlowski).

Co-operated with the committee on the preservation of samples and core revisions of the New Mexico section of the committee directory of repositories of the United States and Canada (Bieberman).

Stratigraphic studies on stratigraphic correlations (Kottlowski).

AMERICAN ASSOCIATION OF STATE GEOLOGISTS

Dr. Kottlowski represented New Mexico in place of Mr. Thompson, as State Geologist at the annual meeting at Bloomington, Indiana.

AMERICAN COMMISSION ON STRATIGRAPHIC NOMENCLATURE

Dr. Kottlowski served as vice-chairman of this Commission.

AMERICAN INSTITUTE OF MINING, METALLURGICAL, AND PETROLEUM ENGINEERS (A.I.M.E.)

Report on mineral exploration in New Mexico (Kottlowski).

Speaker on mining ghost towns of New Mexico for the annual meeting of the organization (File).

Annual review of engineering and mining for Mining Engineering Magazine (Bhappu).

Service as chairman of Central New Mexico Section of AIME 1965 (Bhappu).

AMERICAN INSTITUTE OF PROFESSIONAL GEOLOGISTS

Screening applications of professional geologists and services as vice-chairman of the Institute's New Mexico Section (Kottlowski).

ARCHIVES DIVISION, STATE OF NEW MEXICO

Assistance in planning project to microfilm county records (File).

BRIGHAM YOUNG UNIVERSITY

Study of cephalopods from the Pogonip of the Ibex area of Utah. Extensive collecting was done plus field work in co-operation with the National Science Foundation grants to Brigham Young University (Flower).

CALIFORNIA INSTITUTE OF TECHNOLOGY

Study of absolute ages of Precambrian in New Mexico (Foster).

COLORADO SCHOOL OF MINES

Studies on flotation of silicate minerals (Bhappu).

DEPARTMENT OF DEVELOPMENT OF NEW MEXICO

Prepared slide lecture on "Ghost Towns of New Mexico" for sending to Canada, England, Europe, Africa, and Asian countries. (File).

Video-taped shows for KNME educational TV, Channel 5, Albuquerque, and KOAT television, Channel 7, Albuquerque (File).

Article on Lost Padre mine for New Mexico Magazine (Kottlowski).

EASTERN NEW MEXICO UNIVERSITY

Consulting associate service in Pleistocene geology or the Paleo-Indian Institute (Weber).

FEDERAL BAR ASSOCIATION

Committee service on mines, minerals, and natural resources (Bertholf).

GEOLOGICAL SOCIETY OF AMERICA

Organization of technical sessions, coal geology division, for a national meeting in San Francisco in November 1966 (Kottlowski).

INDUSTRIAL PLANNING, STATE OF NEW MEXICO

Feasibility study on the manufacturing of high-tension ceramic insulators in New Mexico (Hawks).

Extensive work for the State Planning Office in the over-all State Planning Program on resource economics, mineral element (Bertholf).

INDIANA DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES

Description of Silurian cephalopods of Indiana (Flower).

INQUA (INTERNATIONAL ASSOCIATION FOR QUATERNARY RESEARCH)

Field discussion of Carrizozo Malpais and San Augustin Plains given by Robert Weber in connection with the field conference, September 1965.

Geologic roadlogs for field conference (Kottlowski).

MAPPING ADVISORY COMMITTEE OF NEW MEXICO

Preparation of section maps and aerial photographs for the eleventh annual report and committee service (Weber).

MINING INDUSTRY

Project Mohole, work with the contractor, Brown and Root, Inc. (Griswold).

Premature detonation of explosives, Sandia Corporation (Griswold).

Open slope stability, Kennecott Copper Corporation (Griswold).

Annual review of engineering and mining for *Mining Engineering Journal*, February 1966 (Bhappu).

Studies on application of fuel oils to flotation with Shell Chemical Company (Bhappu).

Improvement of mill operation and metallurgy with staffs of Molybdenum Corporation of America at Questa, N.M., and Kennecott Copper Corporation at Hurley, N.M. (Bhappu and Reynolds).

Underground nuclear explosions, Sandia Corporation and Research and Development Division, New Mexico Tech (Griswold).

Fabricated a high-temperature ceramic reflector for an oven design by Research and Development (Hawks).

Study of Pennsylvanian and Early Permian rocks of Joyita Hills; report with geologists of Texaco, Inc. (Kottlowski).

A study on the dating of igneous rocks of Parajito Peak, with geologists from Mobil Oil Company (Kottlowski).

Studies on Mississippian of northern New Mexico, with geologists of Shell Oil Company (Kottlowski).

Pyrite–Ducktownite research for Chino Mines Division of Kennecott Copper Company (Bhappu and Reynolds).

Assembling data on early mining history, districts, and individual mines of New Mexico (File).

Advisory service to Mountain Copper Company, California, during deep-diamond-drilling test of Tower manganese vein (Willard).

Assisted Sandia Corporation engineers in locating clay raw material for experimental thermal gradient tests; supplied X-ray analysis of material (Willard).

MUSEUM OF NEW MEXICO

Identification of minerals and mineral pigments, data, and samples of lithic materials showing archeological usage (Weber).

NATIONAL ACADEMY OF SCIENCE—NATIONAL RESEARCH COUNCIL

Co-ordinated the formation of a group willing to investigate immediately new fossil discoveries unearthed by construction contractors and the pit and quarry operators, with the Division of Earth Sciences of the Academy (File).

NATIONAL SCIENCE FOUNDATION

Project Mohole (Griswold).

Undergraduate research participation program (Bhappu).

NEW MEXICO GEOLOGICAL SOCIETY

Provided speakers and assisted in preparation and editing of annual field conference guidebooks, and geological road logs of southwestern New Mexico (Kottlowski, Weber).

Prepared a paper at request of the Society on the Early Paleozoic of New Mexico (Flower).

NEW MEXICO MINING ASSOCIATION

Co-operated in the production of the 1966 edition of "Magic M," the story of mining, milling and smelting in New Mexico (File).

Mr. Thompson served on the Board of Directors and special committees.

NEW MEXICO TECH

Study of explosive hydrofracing for Research and Development Division (Griswold).

Assistance in preparing research contracts (Bertholf).

Study of underground loading of ore broken by nuclear explosions (Bhappu & Reynolds).

Underground nuclear explosions study (Griswold).

Acquisition of Sun well for Research Foundation (Foster).

Geothermal research (Griswold).

Study of tunnel site for Research and Development Division (Foster).

Co-operative effort with Research and Development Division to develop universal analyzer (Reynolds).

Legal assistance with Research Foundation (Bertholf).

Co-operative study initiated to study ground-water phenomena related to leaching inplace or dumps (Jacobs, Bhappu, Deju, Fisher).

Series of stratigraphic studies of Socorro Mountain for College Division (Foster).

PALEONTOLOGICAL SOCIETY OF AMERICA

Paper was prepared and given by request for the coral symposium of the Society, the abstract being published in the Geological Society of America program, November 1965 (Flower).

Paper prepared for publication in the *Handbook of Paleontological Techniques* under the auspices of the Society (Flower).

QUEBEC BUREAU OF MINES—GEOLOGICAL SURVEY OF CANADA

Study on Silurian cephalopods of James Bay Lowland (Flower).

Identification of cephalopods from Cat Head of Manitoba and Timiskaming area of Ontario (Flower).

SIGMA DELTA CHI, PROFESSIONAL JOURNALISM FRATERNITY

Furnished speaker on Mining Ghost Towns in New Mexico (File).

STATE MINE INSPECTOR

Mr. Thompson served as chairman of the Governor's Mine Safety Advisory Board.

Co-operation with the State Mine Inspector in preparing list of locations of mining districts in New Mexico (File).

UNITED NATIONS

Consultant services and work in connection with the organizing and programming of the United States Seminar on ore concentration in water-short areas in New York, February 14-25, 1966 (Bhappu).

Presentation of papers at the United Nations Seminar, New York, February 14-25, 1966 (Bhappu).

U.S. ARMY ATMOSPHERIC SCIENCES LABORATORY, WSMR

Study was initiated of the geology and geochemistry of New Mexico basalts by Dr. Jacques Renault of the Bureau in co-operation with Dr. Charles Chapin of New Mexico Tech College Division, Mr. Ted Barber, and the U.S. Atmospheric Sciences Laboratory personnel.

U.S. BUREAU OF LAND MANAGEMENT

Instituted a co-operative microfilm and information exchange agreement for recording mining records for research purposes (File).

Co-operated in listing the location of mining districts in New Mexico (File).

Mr. Thompson served on the State Advisory board representing mineral interests.

U.S. BUREAU OF MINES, DEPARTMENT OF THE INTERIOR

Samples furnished for pozzuolana tests (Foster).

Co-operative exchanges of information and identification of mineral rocks and ores (Weber).

Preparation of a preliminary study on the extent of strip mining in New Mexico in connection with the Appalachian Reclamation Law. Mr. Thompson acted as State Coordinator (Thompson, Foster, File, Kottlowski).

Survey of copper leaching practices in the southwestern United States for a future United States Bureau of Mines report (Bhappu).

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION

Quaternary geology of the southwest, assisting the United States Geological Survey and the Soil Conservation Service (Kottlowski).

U.S. DEPARTMENT OF STATE

Counsel work on socioeconomic and jurisprudence of exploration and development expenses (Bertholf).

U.S. GEOLOGICAL SURVEY

Services in checking New Mexico geological map published in December 1965 (Kottlowski, Weber, Willard and Foster).

Identification of Ordovician cephalopods in material from Alaska, western United States, and Kentucky (Flower).

UNIVERSITY OF NEW MEXICO

Publication of a directory of mining districts by county, township, and range with Dr. Stuart A. Northrop, coauthor (File).

WEATHER CONTROL AND CLOUD MODIFICATION COMMISSION

Drafting of rules, regulations, and forms for operating the commission (Bertholf).

Organizing research in support of weather modification regulation under the New Mexico Act of 1965 (Bertholf).

Service as chairman of the New Mexico Weather Control and Cloud Modification Commission (Bertholf).

WESTERN GOVERNOR'S MINING ADVISORY COUNCIL

Established by legislature action in 1961. Mr. Thompson served on this committee.

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	*1965–1966*	
Beginning balance July 1	26,912	
State appropriation	400,000	
Receipts from sales of bulletins, etc.	10,243	
Add prior year adjustments	—0—	
TOTAL revenue		$437,155
Disbursements and Commitments		
Personal services:		
Regular salaries	213,296	
Part-time salaries	77,414	
		$290,710
Travel and automotive:		
Travel and per diem	4,951	
Gas, repairs, and insurance	3,175	
		$ 8,126
Repairs and maintenance	1,191	
		$ 1,191
Supplies and materials:		
Postage and resale supplies	2,874	
Office supplies	4,249	
Laboratory and scientific supplies	9,514	
		$ 16,637
Printing and reproduction	26,263	
		$ 26,263
Other operating expenses:		
Telephone and telegraph	3,954	
Professional services	6,374	
Retirement	13,424	
Social Security	6,305	
Overhead	14,600	
Freight, expenses, insurance, audit repairs, subscriptions, etc.	11,951	
		$ 56,608
Capital outlay		$ 21,558
TOTAL expenditures		$421,093
Year-end balance		$ 16,062

FINANCIAL STATEMENT

BASIC GEOLOGY

Receipts	*1965–1966*	
Beginning balance July 1	—0—	
State appropriation	$ 10,000	
TOTAL revenue		$ 10,000
Disbursements and Commitments		
Salaries	$ 8,251	
Travel	308	
Retirement	235	
Social Security	206	
Overhead	1,000	
TOTAL expenditure		$ 10,000
Year-end balance		—0—

GROUND-WATER SURVEYS

Receipts	*1965–1966*	
Beginning balance July 1	—0—	
State appropriation	$ 10,000	
TOTAL revenue		$ 10,000
Disbursements and Commitments		
Salaries	8,000	
Printing and publication	1,000	
Overhead	1,000	
TOTAL expenditures		$ 10,000
Year-end balance		—0—

FINANCIAL STATEMENT

STATE RESOURCES DEVELOPMENT PLAN

Receipts	*1965–1966*	
Beginning balance July 1	2070	
State appropriation and Federal contribution	4,823	
TOTAL revenue		$ 6,893
Disbursements and commitments		
Salaries	$ 6,801	
Travel	27	
Retirement	—0—	
Social Security	65	
Overhead	—0—	
		$ 6,893
Year-end balance		—0—

STAFF MEMBERS

Name	Title
Arnold, William E.	Scientific Illustrator
Bertholf, William E. II	Resource Economist
Bhappu, Roshan B.	Senior Metallurgist and Research Professor
Bieberman, Robert A.	Associate Petroleum Geologist
Bingler, Edward C.	Associate Geologist
Brandvold, Lynn	Chemist
Chavez, Richard	Laboratory Assistant
Devlin, Lois	Secretary
Edgar, Myrtie M.	Secretary
File, Lucien A.	Bureau Staff Researcher
Flower, Rousseau H.	Stratigraphic Geologist
Foster, Roy W.	Associate Petroleum Geologist
*Grandjean, Mary Ann	Secretary
Griswold, George B.	Mining Engineer and Associate Professor of Mining
Hawks, William L.	Ceramic Engineer
*Houston, Betty	Secretary
Jewell, Doris	Secretary
Kottlowski, Frank E.	Economic Geologist
Missaghi, Fazlollah	Mining Engineer
Nicholson, Wilma	Secretary
Price, Robert L.	Draftsman
Ray, Teri	Publications Journalist
Renault, Jacques	Associate Geologist
Reynolds, Dexter H.	Research Chemist
*Reynolds, Susan T.	Secretary
Smith, Jackie H.	Laboratory Assistant and Technician
Summers, W. Kelly	Ground-Water Hydrologist
Thompson, Alvin J.	Director
Wagner, Mildred	Secretary
*Waxler, Helen W.	Secretary
Weber, Robert H.	Economic Geologist
*White, Lola M.	Cartographer
Whitmore, Sharyn	Secretary
Willard, Max E.	Economic Geologist

*Not employed at end of year.

GEOLOGISTS AND ENGINEERS ON SPECIAL PROJECTS

Bushman, Francis X.	Hydraulic Engineer
Muehlberger, William R.	Geologist
Schilling, John H.	Geologist
Sutherland, Patrick K.	Geologist

GRADUATE STUDENT EMPLYOEES

Escalera, Saul J.
Fisher, Walter W.
Haupt, David
Hillard, Patrick
Lee, Jai Young
Mallon, Kenneth
Paik, Young Hyun
Rowles, James A.
Schwab, David A.
Uy, D. C.
Wainwright, Kent
Wilson, John R.

CO-OP STUDENT EMPLOYEES

Bessey, Lee
Brown, David
Corderman, LeeAnna
Culver, Lewis
Deju, Raul
Fischer, Cathy
Henry, James E.
Hogg, Melvin
Huygen, Machaele
Kastner, Frederick E.
Kelley, Eugene D.
Lilley John
Mallard, Doris
Miller, Guy
Mozden, Helena
Page, Nancy J.
Patton, Melinda
Pitts, Roland
Rapparlie, Gail
Roybal, Ila
Schmidt, Verlean
Sharp, Linda N.
Shortridge, Earl W.
Sitzer, Scott
Tyree, James W.
Williams, Kathryn

OTHER STUDENT EMPLOYEES

Alexander, Lloyd
Aragon, Celedon
Betts, Weldon
Biebelle, Mary
Bonnet, John
Bouwkamp, William
Buck, Dennis
Calderon, Rita
Campbell, Frank
Chaney, Kathryn
Dailey, W. Thomas
Danna, Kathleen
Dougherty, Bernard
Gilpin, Gordon
Hall, William K.
Hill, Kayreen
Howe, William
Kelher, Robert
Kowalski, Michael A.
Krein, Frederick
Maucione, Carl
Misquez, Joseph
Molina, Ramon
Montonati, Franklin J.
Morris, Gary
Nielsen, Charles
Roybal, Carolyn
Rumph, C. Lee
Silc, Frank R.
Soderblom, Laurence A.
White, Brent
Wood, Jean
Wyrick, Royce

OTHER PART-TIME EMPLOYEES

Brower, Elsie
Chamberlin, Robert
Chreist, Fred Jr.
Chemist
Miner
Market Analyst

ABSTRACTS OF PUBLICATIONS

By

New Mexico Bureau of Mines and Mineral Resources

July 1, 1965—June 30, 1966

Quaternary Geology of the Southwest: Reprinted from QUATERNARY OF THE UNITED STATES, a review volume for the VII Congress of the International Association for Quaternary Research, Princeton University Press, pages 287-298, 3 maps, by Frank E. Kottlowski, Maurice E. Cooley, and Robert V. Ruhe; 10¢.

Brief up-to-date description of the Quaternary geology of New Mexico from the Pecos Valley westward, Arizona, southeastern California, southeastern Utah, and southwestern Colorado. Physiographic sections included are the Pecos Valley section of the 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. Within or bordering the region are exhibited the interrelations between mountain glaciation, alluviation and erosion on the High Plains and along major streams that raise in the mountains and then traverse semiarid grabens, and deposition in closed intermontane basins.

Southwestern Arid Lands: Guidebook for Field Conference H, International Association for Quaternary Research, VII Congress; 109 pages, 31 figures including 13 maps, 5½ x 8 inches; $2.25.

This pocket-size guidebook of the Southwest was prepared by many individuals and organizations for the VIIth Congress of INQUA; road logs describe the geology, plants, animals, climate, ground water, soils, and archaeology, emphasizing tthe Southwest's Quaternary aspects. The route begins and ends in Denver, passing through Montrose, Black Canyon of the Gunnison, Silverton, Mesa Verde, Cortez, Monument Valley, Chinle, Canyon de Chelly, Hopi villages, Cameron, Grand Canyon, Flagstaff, Sunset Crater, Wupatki, Oak Creek Canyon, Montezuma Well, Phoenix, Casa Grande, Tucson, Lehner Site, Wilcox, Safford, Lordsburg, Deming, Las Cruces, White Sands, Carrizozo malpais, Socorro, San Agustin Plains, Zuni Salt Lake, Zuni, El Morro, Grants, Acoma, Albuquerque, Santa Fe, Bandelier, Taos, Eagle Nest, and Raton Pass.

Stratigraphy of the Big Hatchet Mountains Area, New Mexico: MEMOIR 16 by Robert A. Zeller, Jr., 128 pages, 18 figures, 6 plates, 3 tables; $3.00.

Detailed descriptions are of stratigraphic units, 18 measured sections, and two oil tests in and near the Big Hatchet Mountains of southeasternmost Hidalgo County. Units investigated include Precambrian rocks; the Paleozoic Bliss, El Paso, Montoya, Percha, Escabrosa, Paradise, Horquilla, Earp, Colina, Epitaph, Scherrer, and Concha formations; and the Early Cretaceous Hell-to-finish, U-Bar, and Mojada formations. Lithology, thickness, and location of faunal collections are shown on columnar sections.

Petroleum Developments in New Mexico During 1960: CIRCULAR 72 by Robert A. Bieberman and Mary Ann Grandjean, 67 pages, 1 figure, 4 tables; 50¢.

During 1960, the value of crude oil, natural gas, and natural gas liquids made up almost 68 per cent of the minerals produced in New Mexico. Crude oil and distillate totaled more than 107 million barrels, and production of natural gas was about 822 billion cubic feet. Crude oil reserves are estimated at more than 1083 million barrels, ith natural gas reserves about 15 trillion cubic feet. A total of 1798 wells are drilled with 1396 finding oil and/or gas. Total footage drilled exceeded 9 million feet. Subsurface completion data are listed for all the oil and gas tests drilled.

Directory of Mines in New Mexico: CIRCULAR 77 by Lucien A. File, 188 pages, 1 plate; $2.00, hardbound $3.00.

Names of mines or prospects, and a few petroleum-producing structures, are tabulated on 97 pages. The principal mineral produced is listed for some mines; most are located by mining district and county, with a reference for obtaining information about the mine or prospect being given in most instances. The last 99 pages are devoted to an almost complete historic listing of mining companies by name and address.

An Instrumental Study of New Mexico Earthquakes: CIRCULAR 78 by Allan R. Sanford, 12 pages, 3 figures, and 4 tables; 25¢.

Data from seismic stations in and near New Mexico were used to establish locations and magnitudes of earthquakes that occurred in the state from January 1962 through June 1964; these are plotted on a map. The shocks indicate a seismicity of New Mexico about 1/50 as great as southern California, with the strongest shock being rated at 3.5. The majority of the earthquakes are confined to the western half of the state.

Design of an Apparatus for Determining Isoelectric Point of Charge: CIRCULAR 79 by Raul A. Deju and Roshan B. Bhappu, 7 pages, 4 figures; 25¢.

The theory of electrophoresis is briefly outlined, and an apparatus that may be used for electrophoretic studies like the ones described is explained. Results using this apparatus agree with those obtained by other investigators. Also explained is how to solve some of the complications that occur in the measurement of zero charge and zeta potential. It is believed at this point that the apparatus described in this paper allows rapid measurements of zeta potential, zero point of charge, electrophoretic mobility, and zeta coefficient.

A Preliminary Report on New Mexico's Geothermal Energy Resources: CIRCULAR 80 by W. K. Summers, 41 pages, 1 figure, 1 plate (in pocket), 3 tables; 75¢.

This circular summarizes available information on geothermal energy and geothermal power for New Mexico, including the sources of heat, pertinent world-wide background information, locations and characteristics of warm

and hot waters in New Mexico; tables list the temperatures and chemical analyses of springs and wells from the literature..

Hydrometallurgical Recovery of Molybdenum From the Questa Mine: CIRCULAR 81 by Roshan B. Bhappu, Dexter H. Reynolds, Ronald J. Roman, and David A. Schwab, 24 pages, 12 figures, 4 tables; 50¢.

The dissolution of molybdenite was studied using various oxidizing agents. Molybdenum from the primary oxide-molybdenum minerals may be extracted either by leaching with acid solutions or decomposing with carbonate solution. The recovery of molybdenum from solutions as a marketable iron-molybdenum product appears to be feasible.

Surface Properties of Silicate Minerals: CIRCULAR 82 by Raul A. Deju and Roshan B. Bhappu, 6 pages, 4 figures, 2 tables; 25¢.

Given are a list of physical and optical properties of 9 silicates and 3 species, and experimental results of tests on 8 minerals. The degree of reaction with acidified water depends on the oxygen-silicon ratio of the silicate structure, seems to be related to the total surface area of the solid, and seems to be influenced by the amount of iron present on the solid.

Chemical Characteristics of New Mexico's Thermal Waters, a Critique: CIRCULAR 83 by W. K. Summers, 27 pages, 9 figures, 5 tables; $1.00.

This companion circular to No. 80 summarizes data available on waters 90 degrees F or warmer. Most of the springs and wells are located along faults and near igneous rocks of Cenozoic age. Characteristics of the Truth or Consequences, Valle Grande, Socorro, and Lordsburg thermal waters are noted, and those of other areas are listed in tables. A concluding comment is that much remains to be learned about thermal waters.

County, Township, and Range Locations of New Mexico Mining Districts, by Lucien File and Stuart A. Northrop, CIRCULAR 84.

Prepared in co-operation with William H. Hayes, State Inspector of Mines and the U.S. Bureau of Land Management, 66 pages, price $1.00, New Mexico Bureau of Mines and Mineral Resources, Campus Station, Socorro, includes tables giving New Mexico counties in the order of establishment, nonmetals other than gold produced by counties and reported to the State Inspector of Mines, 1952-1964, and two figures showing counties created by Territorial Legislation in 1852 and present New Mexico counties.

This Circular recommends a measure of standardization or stabilization and is offered as a guide line for future designation of mining districts. Locations of mining districts including subdistricts, camps, synomyms, and selected prospect regions are given by county, township, and range, cross-indexed for quick reference. The appendix gives historical highlights in the development of New Mexico's mineral resources from 1534 to 1966 by dates. A list of available maps pertaining to New Mexico mining districts and a selected list of references are included. Fully indexed.

Study of Precipitation of Copper on Iron Acid Solutions: CIRCULAR 86 by David W. Mitchell, 5 pages, 2 figures; 25¢.

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; 50¢.

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.

A Chemical Interpretation of Surface Phenomena in Silicate Minerals: CIRCULAR 89, Paul A. Deju and Roshan B. Bhappu.

In this report, the oxygen-silicon ratio for a representative series of silicate minerals is correlated to the degree of absorption of 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 biography on electrokinetic properties of silicates has been included at the end of the paper.

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 E. Whitmore, 11 pages; 25¢.

This index, in which 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.

Molybdenum Resources of New Mexico: BULLETIN 76 by John H. Schilling, 76 pages, 7 figures, 2 plates, and 1 table; $2.00.

Seventy-four occurrences of molybdenum minerals, widely distributed in New Mexico, are described. Details of economics, properties, uses, mining, concentration, processing, marketing, present production and consumption, and future outlook and resources are given, along with mineralogy of the molybdenum minerals, geologic classification of deposits, and geographic distribution. General guides for molybdenum exploration include geologic structures, intrusive bodies of granite to monzonite composition, alteration of country rock, and association with copper, tungsten, or uranium. The two largest producers are the Santa Rita porphyry-copper mine in Grant County and the Questa molybdenum-quartz vein and porphyry-molybdenum deposit in Taos County.

Precambrian Geology of La Madera Quadrangle, Rio Arriba County, New Mexico: BULLETIN 80 by Edward C. Bingler, 132 pages, 22 figures, 2 plates (including colored geologic map, scale 1:24,000), 2 tables; $3.00.

Detailed descriptions and a geologic map of the structurally and petrographically complex sequence of Precambrian quartzite, schist, granitic gneiss, and phyllite, as well as intrusive granitic pegmatites are given in this report. Emphasis is on the mineralogical and structural results of three episodes of metamorphism. These relationships are well shown along the canyon of Rio Vallecitos that trends southeastward across the quadrangle, as well as in the Ortega Mountains to the southwest and Mesa de la Jarita to the northeast.

Geology of Jarilla Mountains, Otero County, New Mexico: BULLETIN 82 by Paul G. Schmidt and Campbell Craddock (1964), 55 pages, 13 figures, 2 plates (Geologic map of the Jarilla Mounttains and tabulation of igneous and metamorphic thinsection data); $1.50.

The Jarilla Mountains are a small range of hills in southern New Mexico. The oldest exposed rocks are of Desmoinesian (Pennsylvanian) age; they consist of cherty gray limestone with minor sandstone and shale and are correlated with the Bug Scuffle Member of the Gobbler Formation. This unit is incompletely exposed but is 822 feet thick. Rocks of early to middle Wolfcampian (Permian) and probably latest Pennsylvanian age crop out in the northern and eastern parts of the range. This section is also incompletely exposed but consists of 1200 feet of interbedded thin limestone, siltstone, shale, and conglomerate correlated with the Laborcita Formation. The Laborcita Formation and possibly the Bug Scuffle Member and the Huerco Formation were deposited in the Orogrande basin, a local subsiding element on the marine shelf of late Pennsylvanian and early Permian time.

Igneous stocks, dikes, and sills of probable Tertiary age were intruded into the Paleozoic rocks. Three main stages of injection are recognized; a massive syenodiorite, followed by monzonite-adamellite of somewhat variable composition, then by adamellite with large orthoclase phenocrysts. The monzonite-adamellite has in places undergone several hydrothermal alterations.

Metasomatism and thermal metamorphism, locally intense, accompanied the intrusions. Beds of shaly siltstone were recrystallized to a scapolite-diopside-garnet rock; the limestones were mainly changed to marble. Adjacent to igneous contacts, however, the limestones were locally converted to andradite-specularite skarms. Gold, silver, copper, lead, and iron mineralization was spottily developed in some of the skarns.

The Jarilla Mountains consist structurally of a dome formed by the forceful injection of the magmas. The sedimentary rocks dip uniformly away from the igneous core and are cut by many small radial faults. Numerous xenoliths, sills, and dikes occur in the southern part of the range, which is interpreted as a roof area of the intrusives.

Mining of the copper, gold, lead, and silver lode ores and placer gold was begun about 1900, and iron mining activity about 1913. Except for brief periods of placer operations, mining activity ceased about 1930. There are no known ground-water reservoirs of potable water near the Jarilla Mountains. Water is piped 36 miles from the Sacramento Mountains.

Geology of the Walnut Wells Quadrangle, Hidalgo County, New Mexico: BULLETIN 84 by Robert A. Zeller and Allen M. Alper, 105 pages; 13 figures, 15 tables, 2 plates including colored geologic map, 1:48,000; $2.50.

The quadrangle includes most of the central part of the Animas Mountains in southwestern New Mexico. Outcrops are mostly of Tertiary igneous rocks and their associated sediments. Several areas of Pennsylvanian, Permian, and Early Cretaceous strata occur; these were deformed during four periods ranging in age from pre-Early Cretaceous to late Tertiary. The Winkler anticline is the most notable structure in the region. Mineral deposits include those of manganese, silver, lead, and fluorspar.

Stratigraphy and Petroleum Possibilities of Catron County, New Mexico: BULLETIN 85 by Roy W. Foster (1964), 55 pages, 11 figures, table listing oil test drilled in Catron County and 2 plates, including physiographic map of Catron County; 50¢.

Most of Catorn County is underlain by volcanic and sediments of Tertiary and Quaternary age. Outcrops of pre-Tertiary rocks are restricted to a strip, four townships wide, across the northern part of the county and to a few isolated exposures in the volcanic rocks. Data on pre-Mesozoic rocks are almost entirely restricted to a few deep oil tests drilled in the northern part of the county. These tests reveal that the lower Permain Abo Formation directly overlies the Precambrian in most of the area. Permian rocks consist of carbonates, evaporites, sandstones, and shale. They probably attain a maximum thickness of 3000 feet in the southeastern part of the country. Projection of control points from adjacent parts of New Mexico and Arizona suggests that approximately 2000 feet of Paleozoic rocks older than Permian underlie the volcanics of the southern half of Catron County.

Mesozoic rocks (Triassic and Cretaceous) have a maximum thickness of slightly more than 3000 feet in the northern part of the county, but Triassic strata thin rapidly to the south and are absent in southern Catron County.

Cretaceous rocks beneath the southern two thirds of the county may attain a thickness of from 2000 to 3000 feet, but thinner sections are to be expected.

The most favorable stratigraphic intervals for petroleum exploration are Cretaceous sandstones, Permian carbonates and sandstones, and, where present, Pennsylvanian carbonates. Exploration is difficult in much of the area because favorable structures are concealed by volcanic rocks, and thicknesses of volcanic intervals are unknown. Areas where minimal sections of Tertiary rocks are present are pointed out.

Geology and Ore Deposits of the Sacramento (High Rolls) Mining District, Otero County, New Mexico: BULLETIN 86 by S. E. Jerome, Douglas D. Campbell, Jack S. Wright, and Howard E. Vitz, 29 pages, 18 plates (including 8 multicolored geologic maps); $2.00.

The Permian Abo red beds, near High Rolls in the Sacramento Mountains, contain scattered deposits of copper and lead. The 5 to 11 per cent lead and 2 to 7 per cent copper ores occur in arkosic lenses. Detailed surface and underground geologic mapping, numerous assays, and testing with acetic acid and potassium idoide suggest that the ores are "semisyngenetic" in origin. Extent of the ores and their relations to arkosic beds of the Abo Formation are shown on 8 geologic maps and 11 assay maps, including those of the Warnock Mine, and East Warnock, Red Hill, Sacramento Gulch, Courtney, Black Bear, Arcente Canyon, Warnock Extension, and Ady areas.

Mineral and Water Resources of New Mexico: BULLETIN 87 compiled by U.S. Geological Survey in co-operation with New Mexico Bureau of Mines and other state and federal agencies for the U.S. Senate's Committee on Interior and Insular Affairs, 437 pages, 89 figures, 56 tables; $1.00.

Brief descriptions of all known nonmetallic and metallic ore resources, mineral fuels (oil, gas, coal, and others), and water resources in New Mexico are given, emphasizing use, manner of occurrence, distribution, and future outlook. An objective appraisal of the State's resources is presented, based on the information now available.

Sources for Lightweight Shale Aggregate in New Mexico: BULLETIN 88 by Roy W. Foster, 82 pages, 22 figures, 4 tables; $2.50.

This report is the result of studies on the shales of New Mexico for their possible use as a lightweight aggregate in concrete. Of 42 shales sampled and tested, four are considered suitable for this purpose and six others may be suitable but require additional testing.

Limited testing of Devonian shales in central New Mexico indicates that the carbonate content of these rocks is too high for proper expansion. In most sections examined, Pennsylvanian shales are intimately interbedded with other rock types and low-cost surface mining methods cannot be used. In addition, most of the Pennsylvanian shales tested have very short expansion ranges and would be difficult to fire in a rotary kiln. However, two possibly useful deposits were discovered in rocks of this age, one near Abo Pass, the other in the Mud Springs Mountains.

The Cretaceous System contains numerous thick shales that crop out in many parts of the state. Large deposits with good expansion properties occur in the Pierre Shale of northeastern New Mexico. Other thick intervals of shale present in the northeast melt at relatively low temperatures and either have short expansion ranges or are too refractory. Possible sources in the Mancos Shale of northwestern and central New Mexico include the Mount Powell and Carthage areas. Additional Cretaceous shales that look promising occur in the Fruitland Formation at the Navajo Coal Mine, and in the Menefee Formation near Chaco Canyon National Monument, and in the Lewis Shale near Dulce. Considerable sampling would have to be done to evaluate fully the potential of the Cretaceous section. Tertiary shales possibly suitable for expanded aggregate are restricted for the most part to the San Juan and Raton basins. Limited sampling in the Raton area failed to reveal any suitable deposits.

Samples were tested by flash firing.

Each locality sampled is described in the report, and bulk specific gravity, weight in pounds per cubic foot, absorption per cent, and internal structure are discussed for the more favorable deposits.

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.

GEOLOGY

Facets of the Late Paleozoic in Southwestern New Mexico: Frank E. Kottlowski (1965), New Mexico Geological Society Guidebook of Southwest New Mexico II, p. 141-147, October 1965.

Recent studies of the Late Paleozoic in southwest New Mexico have found several new Paleozoic outcrops near the southeast San Mateo Mountains, suggested that the Lobo Formation is a complex of different units (Abo on Cooks Peak, probable Cretaceous or earliest Tertiary in Florida Mountains and Early Cretaceous in Victorio Mountains), and delineated the extent of the Early Cretaceous Burro uplift. Deep oil tests drilled during and since 1962 have encountered thick late Paleozoic sections near the Big Hatchet Mountains but erosionally thinned Paleozoic sequences near the West Potrillo Mountains. Locally, thick masses of volcanic rocks have been drilled because they yielded geophysical highs.

Sedimentary Basins of South-Central and Southwestern New Mexico: Frank E. Kottlowski, Reprinted from ROCKY MOUNTAIN SEDIMENTARY

BASINS, Bulletin of the American Association of Petroleum Geologists, p. 2120-2139, 11 figures, 1 table, November 1965.

Major sedimentary basins in this, the eastern part of the Basin and Range province, are the Orogrande and Pedregosa basins of Mississippian, Pennsylvanian, and Wolfcampian ages, 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 Cenzoic 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 red beds. The Orogrande basin began as a poorly defined autogeosyncline 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 inter-tongued red beds and marine limestones.

Middle Oligocene fluorite–barite mineralization in New Mexico: Frank E. Kottlowski, (1965) Presented to the Geological Society of America, Nov. 1965.

Most of central and southwestern New Mexico's fluorite-barite deposits are fissure veins and replaced fault breccias that occur mainly in Precambrian rocks and Paleozoic limestones. In Lordsburg and Steeple Rock mining districts, the fissure veins are in andesite and granodiorite believed to be of late Cretaceous or early Tertiary age. Silver Cliff prospect in southern Organ Mountains is in Soledad Rhyolite, an early Tertiary welded tuff that overlies Orejon Andesite. Both have been intruded by Organ Mountains quartz monzonite.

Fluorite-barite veins on San Diego Mountain, 23 miles northwest of Las

Cruces, are in Precambrian granite gneiss and schist. The basal conglomerate of Thurman Formation truncates the veins; clasts include schist, granite, fluorspar-barite ore, and andesite. The andesite cobbles are from Palm Park Formation which underlies Thurman conglomerates in neighboring areas.

Rhyolite tuff in basal Thurman yielded K-Ar date of 33.6 m.y. (Burke, et al., 1963). Uvas basaltic-andesite above Thurman was dated at 31 m.y. (Geochron Laboratories, per letter from Robert V. Ruhe, September, 1963). The basal Spears Member of Datil Formation, a latite-andesite in stratigraphic position similar to Orejon Andesite and Palm Park Formation, yielded K-Ar date of 37 m.y. from Joyita Hills in central New Mexico. Fluorite-barite mineralization thus occurred between 37 m.y. and 33.6 m.y. in middle Oligocene time and probably was a late hydrothermal stage related to monzonitic stocks and widespread monzonitic-dioritic dikes. Apparently related copper-gold, zinc, and lead-silver ores may be of same age.

A Regional Look at the Precambrian of New Mexico: Roy W. Foster (1965), Presented before the New Mexico Geological Society, May 6, 1966.

Based on outcrops and data from 325 oil tests, the Precambrian is divided into three major rock types. These include granite and related rocks such as gneiss, metamorphic rocks, and intrusive and extrusive rhyolites. Gabbro, diorite, and unmetamorphosed sediments, although present, are rare.

Granite underlies most of northeastern New Mexico, the southern Sangre de Cristo Mountains, the southeastern part of the San Juan Basin, south-central and southwestern New Mexico, and a large area in Eddy and Lea counties. Metamorphic rocks are prominent in the eastern San Juan Basin and from the Estancia Basin east into the Las Vegas and western Tucumcari basins. Rhyolites are found in the San Juan Basin and adjacent uplifts and in the subsurface of southern Otero County and east-central New Mexico.

Absolute age dates indicate a range from 1200 to 1400 m.y. (million years), for most of the Precambrian. Rocks of Grenville Age, 1000 to 1150 m.y., have not been found, although they are known to occur in the Franklin Mountains of west Texas and in southeastern Arizona.

The total structural relief on the Precambrian surface exceeds 28,000 feet. The greatest local displacement that has been found is the Rio Grande trough where there are 20,000 feet of relief between outcrops in the Lucero uplift and a well drilled seven miles to the east. Precambrian rocks are at a depth in excess of 6000 feet below sea level in the San Juan Basin and more than 15,000 feet below sea level in the Delaware basin.

Silicate Molybdenite Paragenesis in Granitic Rocks: P. A. Peach and J. R. Renault, Presented at the Geological Society of America, Inc., Kansas City, Missouri, November 4-6, 1965.

Microscopic investigation of molybenite associated with silicates in igneous rocks of granitic composition from 11 deposits in the United States, Canada, and Greenland reveals a consistent mineral paragenesis which relates molybdenite deposition to the pegmatitic state of igneous differentiation. A five-stage sequence consisting of (1) replacement of primary plagioclase by

alkali feldspar, (2) hydrous deuteric alteration of alkali feldspar, (3) redeposition of alkali feldspar, (4) deposition of molybdenite, and (5) deposition of quartz occurs in deposits characterized by intense fracturing prior to mineralization. Where stockwork structures have developed, the feldspar, molybdenite, and quartz following stage two are very fine-grained. In the aplitic rocks examined, stages one and two are sometimes absent, and in the pegmatic rocks, stage one is sometimes absent.

Deuteric alteration of alkalic feldspar followed by its redeposition suggests that feldspar was rendered unstable by high water pressure but that its stability was re-established by loss of water. The fine grain size of feldspar, molybdenite, and quartz is accounted for by postulating high supersaturation of feldspar, molybdenite, and quartz in residual magmatic fluids that had rapidly lost water pressure.

Statistical Analysis of Some Characteristics of British Columbia Molybdenite Occurrences: P. A. Peach and J. R. Renault, Presented at the Geological Society of America, Inc., Kansas City, Missouri, November 4-6, 1965.

One hundred-nine British Columbia molybdenite occurrences are arranged by deposit types characterized by (1) quartz veins and lenses, (2) fractures and shears, (3) disseminations, (4) contact metasomatism, and (5) brecciation. The dependence of these deposit types on rock type is tested by means of chi-square enumeration statistics, and it is determined that deposit type is a function of rock type. It is concluded that molybdenite deposition is principally controlled by an igneous process and/or a property of igneous rocks.

HYDROLOGY

The Sodium Ion Concentration in New Mexico's Thermal Waters: W. K. Summers. Abstract of paper presented before the New Mexico Academy of Science, Las Vegas, October 8, 1965.

A survey of the chemical analyses of New Mexico's thermal waters shows that the sodium ion concentration ranges from as little as 12 to as much as 3550 ppm in discharging ground water both from springs and wells having temperatures of 90°F or higher. The average concentration is about 500 ppm.

Although no correlation between absolute sodium concentration and temperatures can be made, expressing the sodium ion concentration as a per cent of the sodium, potassium, calcium, and magnesium shows that sodium ion constitutes 60 per cent or more of these ions in the thermal waters, whereas it is generally less than 60 per cent in "cold" waters.

Distribution and Occurrence of New Mexico's Thermal Waters—A Statistical Summary: W. K. Summers. Abstract of paper presented at the New Mexico Geological Society Meeting, May 6, 1965.

Of 67 areas in New Mexico reported to discharge ground water at temperatures of 90° F or higher, 46 have been checked and substantiated in the field, 10 do not exist at the locations reported or have temperatures of less than 90° F, and 11 remain to be checked.

The data for the 46 areas that have been field-checked show that (1) thermal waters occur in the western half of the state, primarily in the Rio Grande and Gila–San Francisco drainage basins; (2) only 16 areas have been discovered by wells, whereas 30 areas were marked by springs; (3) the water issues from rocks ranging from Precambrian to Cenozoic age, with the Cenozoic rocks predominating; (4) the water is associated with igneous and sedimentary rocks in about equal proportions; (5) the water occurs primarily in areas of extensive vulcanism and secondarily in fault zones; (6) the water discharges from springs near streams but mostly at points well above the river levels; (7) the discharge may be from fractures directly, from beneath a talus cover, from alluvium, or from some combinations (one spring discharged from a tufa mound); (8) the median pH is 7.5, the median maximum temperature is about 105° F, the median discharge of springs is 30.5 gpm, and the median concentration of sodium is 146 ppm, of magnesium is 4.55 ppm, of potassium is 4.6 ppm, and of lithium is 0.28 ppm.

Most of the thermal waters have been used for some purpose, but only 18 are now used.

METALLURGY

Winning Metallic Values from Leach Solutions by Sorption Processes: D. H. Reynolds, W. V. Long, and R. B. Bhappu. Abstract of paper presented at the Annual Meeting of the A.I.M.E., New York, February 1966, and submitted for publication to A.I.M.E., March 1966.

Equalibrium 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 NH_4(I), K(I), Ni(III), Ce(III), Th(IV), and Mo(VI). Absorbants used were ion-exchange resins; a tertiary and a quaternary amine in an inert solvent; and some activated carbons. The ions studied were in aqueous HCl, HNO_3, H_2SO_4, or $HClO_4$ 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.

Manganese Dioxide–Sulphuric Acid Oxidation of Molybdenite: R. J. Roman, R. B. Bhappu, and D. H. Reynolds. Abstract of paper published in Transactions of the Metallurgical Society of A.I.M.E., Vol. 233, December 1965.

The reaction between manganese dioxide and molybdenite in a water–sulphuric 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), and Mn(II). Stoichiometric relationships are most simply represented by the equation,

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

The rate of this reaction was found to be dependent on temperature, manganese sulfate concentration, acid condition, 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.

Molybdenum Recovery from Sulfide and Oxide Ores: R. B. Bhappu, D. H. Reynolds, and R. J. Roman, Published in Journal of Metals, A.I.M.E. v. 17, p. 1199-1205, November 1965.

Optimum conditions were determined for leaching of sulfide and oxide molybdenum minerals and ores with selective solvents as well as bacteria. The recovery of molybdenum from leach solutions as a marketable iron-molybdenum product was investigated and found to be feasible.

Differential Disintegration: R. B. Bhappu, Presented at the United Nations Seminar on Ore Concentrations in Water-Short Areas, New York, February 1966.

Differential disintegration involves dry grinding, classification, and dust collection. This method can be effectively used for separating various minerals such as clays, micas, cement rock, barite, iron ores, uranium ores, asbestos, spodumene, fluorite, coal, and several others. This paper discusses theoretical and practical aspects of this versatile method of concentration.

Concentration Methods Using Limited Water and Saline Water: R. B. Bhappu, Presented at the United Nations Seminar on Ore Concentrations in Water-Short Areas, New York, February 1966.

Theoretical and practical aspects of wet concentration methods using limited water and saline water are discussed. Special emphasis is placed on heavy media (sink-float) separation, diamond pans, rotating cones, and pinched sluices.

Flotation of Some Silicates: G. Purcell and R. Bhappu, Presented at the Annual Meeting of A.I.M.E., New York, February 1966.

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

A Chemical Theory of Adsorption in Silicate Minerals: R. Deju and R. Bhappu. Abstract of paper accepted for publication in S.M.E., A.I.M.E., Transactions.

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.

MINING

"Need For Mining Engineers in a Growing Industry"— by George Griswold, presented at Carlsbad Section, A.I.M.E., October 1965.

Mining engineering is a promising and rewarding field for a young man to choose as a career. The romance of mining is stronger today than in the Forty-Niner gold rush era. We now mine gold in South Africa, copper in Chile, nickel in Canada, silver in Mexico, iron in Australia, and, yes, potash in Carlsbad. This variety and rugged environment are trademarks of a career that requires a mining engineer to be expert both in engineering and being able to lead other men. There are relatively few colleges or universities that teach mining engineering; New Mexico Tech is one of these schools. At Tech, the student is given a balance of courses: science, to understand the why of things; engineering, to know how; and humanities, to gain the necessary grasp of how men fit into their society.

Project Mohole, by George Griswold. Address at the Central New Mexico Section of A.I.M.E., at Grants, New Mexico, February 1966.

Project Mohole is a part of the United States' research contribution to the Upper Mantle Study—an outgrowth of the International Geophysical Year. Based on the analysis of earthquake waves and geophysical surveys, it is known that Mohorovicic discontinuity is shallower under the oceanic basins than under the continents. Thus Project Mohole, which will hopefully drill through the crust across the M discontinuity into the mantle, will go to sea. The site selected is northeast of the island of Maui in the Hawaiian Islands. At the site, the M discontinuity lies 32,000 feet below sea level and 18,000 feet below the ocean bottom.

The proposed drilling platform is immense. The rectangular hull is supported by six columns resting on two submarinelike buoyancy vessels. The platform measures 280 feet long, 235 feet wide, and 100 feet high. The drilling mechanism is to be the largest ever built, capable of rotating some 25,000 feet of drill pipe. The primary drill will be a turbocorer, but two back-up systems will be available. Major engineering problems are platform stabilization and location, riser pipe system from the platform to the ocean floor, drill string fatigue, mud circulation, hole stability, and the need for continuous coring.

PALEONTOLOGY

Structure and Evolution of Ordovician Colonial Corals: Rousseau H. Flower, presented to the Geological Society of America, 1965 Annual Meeting.

Wall and septal structures suggest an evolutionary pattern for Ordovician colonial corals, beginning with the simple fibrous wall of *Lichenaria*, but modified in some species which may be set apart as *Lamottia*. The thecae developed in the unrelated stocks of *Eofletcheria*, the Halysitda, and *Manipora* suggest that the structure was ancient and possibly shared by early cerioid forms in general. From the fibrous wall develop two types. The first is the trabecular wall of the syringoporids, within two lines of specialization are apparent—forms with solid trabecular skeletons and forms with porous walls. The second type is within *Foerstephyllum*, which shows the development of epithecae, forming the "axial plates." Again there is a split: one line leads to typical rugosan forms with long septa—the rearrangement of fibers and colony reduction apparent here may lead to the first solitary corals; another line shows a reduction of septa to spines, appearance of spores, and the group of *Foerstephyllum vacuum* leads to the Favositidae. If so, no division into Tabulata and Rugosa is possible. Poikiloplasm, beginning as a thin lining, develops into spheres, developed in some Halysitidae again as the colurnella of *Billingsarea*, and is found in some *Cyathophylloides*.

In Handbook of Paleontological Techniques: by Rousseau Flower, Kummel and Raup, Editors, W. H. Freeman and Co., 1965. *General procedures and techniques applicable to major fossil groups, Cephalopods,* as illustrated by Early Paleozoic forms (pp. 53-56).

This is a summary of general procedures in collecting and preparation of fossil cephalopods, the sort of material which is most useful, the parts most critical to taxonomy, methods of preparation involving extraction, cutting, and etching.

New Mexico Geological Society—1965 field trip guide—Early Paleozoic of New Mexico: by Rousseau Flower, pp. 112-131, 5 figs.

Geological history of New Mexico is traced in terms of periods of deposition alternating with periods of uplift and erosion. The Bliss Sandstone of former authors consists of discrete periods of deposition ranging from early Franconian through early Gasconadian; individual units are somewhat local in distribution. The El Paso Group is largely but not completely continuous, with some breaks at the Demingian–Jeffersonian contact, and are complicated by subsequent erosion that removed sediments to progressively lower levels west and south from El Paso. History of the Montoya Group involves discrete periods of deposition separated by intervals of elevation and erosion; four main depositional periods are recognized. Dolomitization obscures a possibly similarly complex history for the Silurian Fusselman Dolomite. Devonian history involves periods of deposition ranging from beds essentially athwart the Middle–Upper Devonian boundary to very late Devonian; six formations are currently recognized.

Review—Time and Stratigraphy: Rousseau Flower, in Science, 1965.

Clovis Points and Associated Implements of the Bingham Site, Central New Mexico: Robert H. Weber and George A. Agogino. An illustrated study presented to the Southwestern and Rocky Mountain Division of American Association for the Advancement of Science, 42nd Annual Meeting, and the New Mexico Academy of Science, Annual Spring Meeting, Las Cruces, New Mexico, May 1-4, 1966.

The Bingham site (JM9-1) approximately 35 acres in extent, has been the most productive of several Clovis (Llano) complex sites located during surveys by Weber in the Jornada del Muerto, an intermontane basin with features similar to parts of the southern High Plains. A total of 38 fluted projectile points, largely basal fragments, has been recovered from the surface. Two thirds of these are finished products. Associated implements include end scrapers, side scrapers, flake knives, utilized flakes, and gravers, accompanied by chipping waste.

Points are relatively small and varied in form, though conforming to the basic Clovis pattern. Some show marked similarities in both size and form to Folsom points from nearby sites but differ in the character and quality of workmanship. The principal stages and techniques of manufacture are illustrated by the series of both finished and unfinished specimens.

Full utilization of the lithic resources of the area is indicated by the diversity of materials, which were obtained from Pleistocene gravels at the site and from other sources within 35 miles thereof.

Although erosion by deflation and slope wash has been severe, correlation of the artifacts with both local and regional physical stratigraphy appears unwarranted. Proposed trenching may clarify these relationships.

Mining Ghost Towns: Lucien File, 50-minute illustrated slide lecture on ghost towns and lost mines of New Mexico. Delivered at state A.I.M.E. meeting at Socorro, 1965; taped as video show for and shown on KNME Channel 5, educational television; taped as viedo for and shown on KOAT television Channel 7; tape and slide version is touring Canada, Europe, England, Africa, United States, and Asia under the auspices of Indiana Recording Club (Indianapolis, Indiana) and "World-Wide Tape Talks" of England (1965-1966): delivered before Sigma Delta Chi, New Mexico chapter, Professional Journalism Fraternity at Albuquerque, 1965; various Rotary and Lions clubs (1965-66).

A thirty-minute to one-hour lecture tour of New Mexico ghost towns in a cross section from the northeastern to the southwestern areas of the State. Illustrated with 35 mm color and black and white slides; delineates causes of ghost towns, their effect on the economy of New Mexico, and their future as tourist attractions and places of retirement. Includes pictures from private collections taken when towns were in their prime.

History of Science, by William E. Bertholf II, presented as an address to

the American Association of University Women, Socorro chapter, 1965. Outlines the progress of the approaches to scientific solutions from Bacon to modern computer techniques.

The Mineral Element, by William Bertholf II, published in Summary Reports on New Mexico's Resources, Phase 1, State Resources Development Plan, State Planning Office, (1965).

The study reviews and evaluates the available mineral literature and library material with the intention of analyzing its meaning in terms of present or potential value to New Mexico. It is intended that this work be mindful of the development of urban values and, in addition, that it show that the federal government is becoming increasingly a risk underwriter in mineral development.