

SERVICES of the

NEW MEXICO

BUREAU OF MINES AND

MINERAL RESOURCES



Annual Report for the Year
July 1, 1967—June 30, 1968

THE NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES

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SAUL ESCALERA, *Metallurgist*
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MICHAEL L. HUYGEN, *Res. Assistant*

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FAJESH K. MISHRA, *Metallurgist*
RONALD W. RIESE, *Geologist*
EUGENE F. TOBY, *Geologist*

Plus more than 30 undergraduate student assistants

NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

Stirling A. Colgate, *President*

STATE BUREAU OF MINES AND MINERAL RESOURCES

Frank E. Kottlowski, *Acting Director*

THE REGENTS

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November 1, 1968

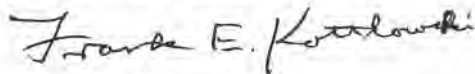
TO: President Stirling A. Colgate
Members of the Board of Regents
Members of the New Mexico Legislature

I have the honor of transmitting to you the annual report of the New Mexico Bureau of Mines and Mineral Resources for the year July 1, 1967, to June 30, 1968, as required by law.

On July 7, 1968, Alvin J. Thompson, Director of the Bureau for eleven years, reached the age of regulatory retirement. All the activities reported herein were carried out during his tenure.

The present Bureau staff of 17 professional members, with a total accumulative mineral resources research experience in New Mexico of 164 years, is gratified, as I am, to have carried out these programs under the direction of Alvin J. Thompson. It is my great pleasure to transmit this annual report to you.

Respectfully submitted,

A handwritten signature in dark ink, reading "Frank E. Kottlowski". The signature is written in a cursive, flowing style with a large initial 'F' and 'K'.

Frank E. Kottlowski
Acting Director

Bureau of Mines and Mineral Resources

Although established in 1927, the Bureau was only sporadically active until the late E. Carter Anderson became director in 1945. During his four-year term, Mr. Anderson began building an effective Bureau of Mines. His successor in 1949, Eugene Callaghan, continued this expansion, initiating many geological and mineral resources projects and increasing the professional staff to 17 earth scientists.

Alvin J. Thompson was appointed director in 1957. He diversified the activities of the Bureau, instituting a large metallurgical and chemical analysis section, as well as continuing a broad mineral resources and geologic program.

By 1957, the Bureau had published 41 bulletins and 42 circulars, reflecting the results of its first 29 years of scientific work. Mr. Thompson encouraged completion of pending and publication of additional mineral resources, geological, and metallurgical reports. During his term as director, 49 bulletins, 20 memoirs, 5 ground-water reports, 51 circulars, 5 scenic trips guidebooks, and 4 resources and land-status maps were issued. These Bureau reports serve as standard reference materials on New Mexico's mineral resources and are widely used by the mineral industry.

During his distinguished career of service to the mining and metallurgical industries, as chairman of New Mexico Tech's department of mining and metallurgy, and as director of the Bureau, Mr. Thompson personally wrote some 17 published reports, including three on silver, lead, and zinc deposits of New Mexico.

Mr. Thompson has served on the Board of Directors of the New Mexico Mining Association for twenty years and was a past president of that organization. He helped establish and is a past chairman of the Central New Mexico Section of AIME. For the last eight years, he has been chairman of the New Mexico Mining Safety Advisory Committee.

BUREAU PERSONNEL

Activities of the Bureau staff fall into four general areas: administration, geology and mineral resources, mining and economics, and metallurgy and chemistry. The administrative staff provides direction and services to the three applied-research sections. The general budget was divided among the three research sections with about 46 per cent to metallurgy and chemistry, 12 per cent to mining and economics, and 42 per cent to geology and mineral resources; these percentages include administrative funds allotted to each section.

Administration

Alvin J. Thompson, B.S., M.S., University of Arizona, Director. Budgetary control. Supervision of personnel. Supervision of technical work. Project planning and guidance. Purchasing. Maintaining records as required by state fiscal agencies. Adviser to the metallurgy section.

Frank E. Kottlowski, B.A., M.A., Ph.D., Indiana University. Assistant Director. Assisted the director. Mineral resources studies. Project supervision. Technical editing. Service work.

Becky Perry, Senior. Student assistant.

William Arnold. Scientific Illustrator.

Supervision of preparation of geologic maps. Drafting. Reproductions. Illustrative copy.

Robert Price. Draftsman.

Maps, Charts, Art work. Drafting.

Fred De Graff. Sophomore. Student assistant.

Lois M. Devlin. Office Manager.

Requisitions. Accounting. Directing distribution of publications.

Joyce M. Aguilar, Stenographer.

Staff correspondence. Manuscript typing. Sale and distribution of publications.

Cheryl A. LePlatt. Secretary.

Staff correspondence. Manuscript typing. Sale and distribution of publications.

Barbara Kehler. Sophomore. Student assistant.

Processing, mailing, and storage of publications.

Teri Ray. B.A., Mount St. Scholastica College. Editor.

Preparing manuscripts for publication. Editing. Proofreading. Scheduling printing.

Lucien A. File. B.A., Goddard College; M.A., University of Guanajuato (Mexico); M.P.J., University of Illinois. Staff Researcher, Administrative Aide

Equipment purchases. Inventory control. Liaison with government agencies. Maintenance of mining records. Historical records section. Information to the public on mining history, mining law, and economic data.

Juarine Wooldrige. Clerk-Typist.

Filing. Cataloging. Proofreading. Maintenance of mining records.

Geology and Mineral Resources

Robert A. Bieberman. A.B., M.A., Indiana University. Petroleum Geologist. Information and assistance to the public in areas of petroleum geology. Maintaining sample library records of test wells. Petroleum developments records.

Richard Chavez. Laboratory Assistant.

In charge of sample library. Map reproduction. Mimeographing. Maintenance of equipment. Publication storage and inventory.

Linda Lake. Secretary.

Secretarial duties and filing.

Rousseau Flower. B.A., M.A., Cornell University; Ph.D., University of Cincinnati. Senior Paleontologist

Description and identification of fossils in New Mexico with particular reference to their correlative value.

Michael L. Huygen. B.S., New Mexico Institute of Mining and Technology. Research Assistant.

Laboratory and photographic work. Field assistance. Clerical.

Roy W. Foster. B.Sc., Ohio State University. Associate Petroleum Geologist. Subsurface geology, with emphasis on petroleum. Operation of X-ray diffraction, emission spectrograph and DTA laboratory. Standard X-ray-diffraction patterns of minerals.

Mark Bloom. Freshman. Student assistant.

Laboratory assistant. X-ray diffraction work. Preparation and interpretation. Well-sample preparation.

Wayne Calderone. Sophomore. Student assistant.

Emission spectrograph.

Doris Mallard. Junior. Student assistant.

Well-sample preparation. X-ray diffraction.

Jacques Renault. B.S., Stanford University; M.S., New Mexico Institute of Mining and Technology; Ph.D., University of Toronto. Associate Geologist.

Petrographic research. Guest lecturer in College Division of NMIMT. Supervision of mineral museum. X-ray analysis.

Rena Mae Bonem. Junior. Student assistant.

Mineralogical museum cataloging and displays.

David Brown. Senior. Student assistant.

Mineral and rock preparation. X-ray analysis Basalt studies. X-ray fluorescence analysis.

Eugene F. Toby. B. S., New Mexico Institute of Mining and Technology. Candidate for M.S. Graduate Assistant.

Mineral and rock preparation. X-ray analysis. Basalt studies. Reference mineral data.

James Tyree. Senior. Student assistant.

Computer programming. Rock and mineral preparation for crystallographic calculation project. Basalt studies.

W. Kelly Summers. B.S., Wayne State University, M.A. Indiana University. Ground-Water Hydrologist.

Studies of hydrology of the Pecos River Basin. Studies of the ground-water and geothermal resources of New Mexico.

Robert H. Weber. B.S., Ohio State University; Ph.D., University of Arizona. Senior Geologist.

Mineral identification services. Geologic and industrial information. Research in volcanology, mineral deposits, Quaternary geology. Supervision of mineral museum display. Teaches special courses.

Ronald W. Riese. B.A., Western Washington State College. Candidate for M.S. Graduate Assistant.

Mineralogical museum displays and cataloging. Rock and mineral identification (with Dr. Weber and Dr. Renault).

Max E. Willard. B.S., South Dakota School of Mines; M.S., University of Idaho. Economic Geologist.

Research work in sedimentation, mineralization, and volcanic history. Lecturer in geochemistry, College Division, New Mexico Institute of Mining and Technology.

Barkley S. Wykoff. B.A., Cornell University. Candidate for M.S. Graduate Assistant.

Size analysis of Cretaceous sediments.

William E. Bertholf. B.S., M.S., Doctor of Law, University of Chicago. Vice-President of New Mexico Institute of Mining and Technology for Finance; Resource Economist for the Bureau; Member of the Board of Trustees and Corporate Secretary for New Mexico Tech Research Foundation.

Studies and reports on socioeconomic jurisprudence having substantial influence on the search for, development of, and use of mineral resources.

Richard D. Clark. B.S., New Mexico Institute of Mining and Technology. Candidate for M.S. Graduate Assistant.

Research and writing on regional mineral socioeconomics.

George B. Griswold. B.S., New Mexico Institute of Mining and Technology; M.S., Ph.D., University of Arizona. Mining Engineer.

During the first part of the reporting period, Dr. Griswold participated in a joint copper-leaching project with Kennecott Corporation, the U.S. Bureau of Mines, and the New Mexico Bureau of Mines and Mineral Resources. Later, he transferred to the College Division as an associate professor.

Leo Misaqi. B.S., University of Teheran; Dr. Eng. Sc., Montanistische Hochschule (Austria). Assistant Professor Mining Engineering, Mining Engineer.

Taught electrical engineering and surveying in the College Division, NMIMT. Geochemical surveying of promising areas in New Mexico.

Metallurgy and Analytical Chemistry

Roshan B. Bhappu. Met. Eng., M.S., D.Sc., Colorado School of Mines. Senior Metallurgist.

In charge of metallurgy laboratory. Basic and applied research in recovery of valuable metals and minerals from New Mexico and other ores. Taught in College Division.

Tom Barela. Senior. Student assistant.

Barium strontium project.

Kayreen Barela. Senior. Student assistant.

Strontium barium project.

Gary Bild. Sophomore. Student assistant.

Laboratory testing and instrument repairs.

Tom Dailey. Senior. Student assistant.

Metallurgical testing.

- Raul A. Deju. B.S., New Mexico Institute of Mining and Technology. Candidate for Ph.D. Graduate Assistant
Surface chemistry of minerals.
- Saul Escalera. Mining Engineering, Oruro Technical University; M.S., New Mexico Institute of Mining and Technology. Candidate for Ph.D. Graduate Assistant.
Surface chemistry in flotation.
- Walter W. Fisher. B.S., University of Utah; M.S., New Mexico Institute of Mining and Technology. Candidate for Ph.D. Dissolution of sulfide minerals.
- Lorna M. Goebel. B.S., University of Texas. Candidate for M.S. Graduate Assistant.
Rhenium analysis and geochemistry. Museum displays and cataloging.
- Joe Padilla. Junior. Student assistant.
Laboratory testing and repairs.
- Gail Stockton. Senior. Student assistant.
Rhenium extraction.
- Bruce Stockton. Senior. Student assistant.
Rhenium extraction.
- Charles Silva. Sophomore. Student assistant.
Flotation testing.
- Lynn A. Brandyold B.S., M.S., North Dakota State University. Ass't, Chemist
Supervises analytical laboratory. Special analytical assays.
Assists in developing new methods of analysis
- Carolyn Roybal. Sophomore. Student assistant.
Analytical laboratory.
- Richard Barbaras. Sophomore. Student assistant.
Analytical laboratory.
- Elizabeth Ewing. Sophomore. Student assistant.
Analytical laboratory.
- Helena Mozden. Sophomore. Co-op. student.
Analytical laboratory.
- Melinda Patton. Junior. Co-op student.
Analytical laboratory.
- Frank Delnick. Freshman. Co-op. student.
Analytical laboratory.
- Rita Calderon. Junior. Student assistant.
- Jean Edenburn. Freshman. Co-op. student.
- James A. Brierley. B.S., Colorado State University; M.S., Ph.D., Montana State University. Assistant Professor of Biology.
Biological aspects of dump leaching.
- Elise Brower. B.S., M.S., New Mexico Institute of Mining and Technology. Ass't, Chemist

Applied research. Shell project. Preparation of activated carbon products.

Paul H. Johnson. B.S., M.S., University of Washington; Ph.D., University of Utah. Metallurgist.

Basic and applied extractive metallurgy research. Taught in College Division.

Rajesh Kumar Mishra. B.S., Bihar Institute of Technology Sindri Bihar, India . Candidate for M.S. Graduate Assistant.

Metallurgical testing. Compiling test results.

Richard Johnson. Sophomore. Student assistant.

Metallurgical testing. Compiling test results.

Dexter H. Reynolds. A.B., University of Missouri; M.S., University of Arizona; Ph.D., University of Illinois. Research Chemist.

Supervision of analytical laboratory and personnel. Taught in College Division. Developing analytical procedures for Bureau use. Chemical and Hydrometallurgical research.

Jackie H. Smith, Laboratory Assistant.

Metallurgical testing on samples submitted to the Bureau.

Maintenance, repairs, and building of testing equipment.

Looking after supplies and instruments.

BUREAU ACTIVITIES

When the New Mexico Bureau of Mines and Mineral Resources was established forty years ago, its objectives and duties were set forth by the Legislature in twelve paragraphs, summarized as follows:

- (1) Collect, compile, and publish statistics....
- (2) Collect typical geological and mineral specimens.....
- (3) Collect a library and bibliography of literature pertaining to the progress of geology, mining, milling, and smelting....
- (4) To study geological formations of the state with special reference to the economy of mineral resources....
- (5) To examine the topography and physical features of the state with reference to their practical bearing upon the application of the people.....
- (6) To study mining, milling, smelting operations...with special reference to their improvement....
- (7) To prepare and publish bulletins and reports with the necessary illustrations and maps which shall embrace both general and detailed descriptions of natural resources, geology and mines, mineral deposits, etc....
- (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 information on New Mexico geology, mining, etc....and to serve as a bureau of exchange and information in mineral, oil, and natural-gas resources....
- (12) To co-operate with the University of New Mexico, State Mine Inspector, and other departments of (the state and federal government)....as may be mutually beneficial....

The Bureau engages in basic and applied research within the framework of the law which created it. Factors guiding its investigations include:

- (1) increased exploration and production of minerals.
- (2) trends in the mineral industry, and
- (3) future mineral resource needs of New Mexico.

Bureau work concerns three general areas: (1) geology and mineral resources, (2) mining and economics, and (3) metallurgy and chemistry. Trends in industry and changing mineral needs have altered the Bureau's services somewhat. "Assisting in the education of miners and prospectors" is now mainly college teaching of future mining engineers, geologists, and metallurgists and lectures to mining and petroleum oriented professional groups.

Although a number of persons visiting the Bureau for help in the field still represent individual prospectors and miners, by far the largest service demand comes from company exploration representatives.

The staff answered approximately 2603 inquiries by mail and 2101 personal inquiries during the period covered by this report. This averages about 10 letters a day and 8 phone calls and visitors in each of 254 working days.

ADMINISTRATION

Besides project planning and guidance, the director of the Bureau is responsible for supervising technical work, budgetary management of funds, and supervising personnel. The director also provided information to the public by phone and letter and personal conferences. He acted in an advisory capacity to the metallurgy section in projects involving extractive metallurgy.

Special activities during the report period included a directorship on the Board of Directors of the New Mexico Mining Association and chairmanship of the New Mexico Mining Safety Advisory Council, Association of State Geologists, and the Executive Committee of the New Mexico Institute of Mining and Technology.

The assistant director of the Bureau, in addition to his duties as economic geologist, served as adviser for geologic projects, supervised technical editing of publications, and assisted in public relations, answering mail and personal inquiries.

The administrative section of the Bureau is also responsible for publishing maps and reports of research projects and studies. This involves processing the manuscripts written by the authors, preparing them for publication, and supervising actual printing production. After publication, the books are distributed to libraries and universities and sold to the public.

Production during the period consisted of three Bulletins, Nos. 81, 87, and 89; three Memoirs, Nos. 18, 19, and 20; five Scenic Trips revisions, Nos. 2, 3, 4, 5, and 6; four Circulars, Nos. 61 (reprinted), 91, 92, and 95; two Ground-Water Reports, Nos. 8 and 9; a Publications Price List; an Annual Report; one Reprint, No. 22; and a Scenic Trip Brochure.

The distribution of publications involves storing, packaging, and mailing and answering inquiries, as well as accounting for cash sales. These functions are performed by the Publication Office of the Bureau.

A large amount of art work and technical drafting was necessary to illustrate the books, pamphlets, and maps published by the Bureau and papers and lectures for other divisions during the period. A scientific illustrator and expert draftsmen are employed for this purpose.

The drafting section completed illustrations for eight bulletins, circulars, and memoirs, produced three geological maps, one ghost town map, and twelve miscellaneous drawings for the College Division.

State Land Owned by NMIMT is accounted for by Mr. Bieberman of the Bureau staff who has the responsibility of keeping records and informing New Mexico Tech's administration about oil and gas lease activities.

Mineral Identification

The Bureau offers services, without fee, to New Mexico residents for the identification of minerals, rocks, and ores. Bureau mineralogists study samples submitted and determine what minerals and metals of potential value they may contain. In some instances, this identification work suffices. If it appears from the qualitative analysis of the sample that a quantitative determination should be made, the Bureau so advises the owner, who can then send his sample to a commercial assayer if he desires.

No satisfactory qualitative determination can be applied to detect the presence or absence of gold, silver, or the platinum-group metals in an ore sample. For gold, an ore containing 1 part of gold in 30,000 parts of ore is considered a fairly rich one. The presence or absence of such a small portion of metal in any ore is difficult to verify without an actual assay. Similar considerations apply to silver and platinum metals. However, it is often possible to reach some conclusions as to the likelihood of a sample containing any of the precious metals by observing its general character.

MUSEUM

The Bureau maintains a museum of geological and mineralogical specimens for general use, consisting of more than 10,000 specimens from all over the world. Recent exhibit gifts by Standard Oil Company have allowed us to set up a display of petroleum geology and refining. The museum is in the Bureau wing of the Research building, is open to the public, and is maintained by Dr. Robert Weber and Dr. Jacques Renault with student help. A travelling display of these minerals was shown at the state meeting of Gem Clubs at Deming in May 1968. The exhibit designed by Lorna Goebel, a graduate student, won third prize in the competition. Ronald Riese, another graduate student, supervises the permanent displays.

REFERENCE MATERIALS

Besides available personnel for advice on geology, mining, and mineral-resource problems, the Bureau maintains a large amount of reference material that is available to the public. Samples of oil-well cuttings are kept in a special library. Open files contain reports of investigations on many areas of the state that have not been published by the Bureau. These include microfilms of mining patent records, early reports of the State Inspector of Mines, and exploration data from the Atomic Energy Commission for each county of the state. Card records are maintained concerning many past and present mining companies and mines. A file of place names, of use to cartographers and historians is also available.

BUREAU PROJECTS

One half to one third of the Bureau's work consists of service to the various parts of New Mexico's mineral exploration and development industry. Scientific investigations by the Bureau's professional staff members range from fundamental studies of rocks or of metallurgical and chemical properties of ores through direct applied projects that aid in finding new mineral deposits to contract work for individual development and producing companies.

The projects are divided into three groups according to their major emphases: (1) geology and mineral resources, (2) metallurgy and chemistry, and (3) mining and economics. Bureau funds are divided among these three groups in the approximate ratio 42:46:12, respectively. The majority of published reports made available to the general public concerns geology and mineral resources. Many of the results of research projects in metallurgy, chemistry, mining, and economics apply only to a specific ore or mine studied; therefore, these reports are submitted only to the company or individual involved. A careful examination of the projects, listed in following pages, gives an idea of the scope and direction of the expanded program in metallurgy and chemistry.

Geology and Mineral Resources

1. Fuel resources of New Mexico, revision and updating of maps and data. Target date 1968. (Bieberman)
2. Petroleum exploration maps, continuing project of keeping up-to-date information on petroleum exploration in 25 New Mexico counties as new wells are drilled. (Bieberman)
3. Petroleum developments in New Mexico during 1961, started in June 1967, completed June 1968. (Bieberman)
4. Petroleum developments in New Mexico during 1962, compilation of well data, started May 1968; target date for publication, fall 1968. (Bieberman)
5. Petroleum data, a continuing project of cataloging and filing new additions to the Bureau's sample library, including electric and special types of logs. The latter were gifts to the Bureau by the Phillips Petroleum Company and include logs from 130 wells drilled in many parts of New Mexico. (Bieberman)
6. Establishing spectrographic laboratory for Bureau use. (Foster)
7. Clay resources and structural clay products, continuing. Use of clay for commercial purposes. (Foster)
8. Diatomite deposits in New Mexico, a regional study of deposits in the state. (Foster)
9. Subsurface oil exploration in Valencia County. (Foster)
10. Radon control in underground environments. A study and proposals submitted to the Atomic Energy Commission. (Foster)
11. Lightweight Aggregates. A continuing project in the evaluation of samples. (Foster)
12. Soil Tests. Pyrometric Cone Equivalent tests of selective soils for Sandia Corporation. (Foster)
13. Standard Mineral Data studies. Continuing project using X-ray diffraction and differential, thermal analysis on minerals in the Bureau collection. (Foster)
14. Mineralogical Museum. (Continuing Project) Cataloging and display. Preparation of reference X-ray data for minerals (Renault).
15. Systematization of Crystallographic Calculations by means of a digital computer. (1968) Emphasis has been on the determination of the lattice parameters of all crystal systems from the data of Debye-Scherrer films (Renault)
16. Geology and geochemistry of New Mexico basalts. A continuing study of mineralogical and chemical variations in New Mexico basalts, especially of Quaternary age. Emphasis has been on determination of mineralogical and chemical parameters in the same sample by means of X-ray diffraction and fluorescence. Target date for completion is 1970. (Renault)

17. Routine determination of the molybdenum and rare earths by X-ray fluorescence. This study is sponsored by the Molybdenum Corporation of America by way of the Tech Research Foundation. Its aim is to develop a rapid means of analysis for mine and mill control. New project, expected to be completed in 1968. (Renault)
18. Crystal perfection studies. This is a study of dislocations in common minerals such as quartz in an effort to distinguish between various modes of crystallization such as precipitation from a melt and precipitation from an aqueous solution. Studies have been concerned with precision measurements of specific gravity and with X-ray diffraction line broadening. Target date, 1970. (Renault)
19. Geomorphology of three pluvial basins. This project includes mapping of lake-stage shorelines, sedimentation, soil morphology, archaeology and paleontology of White Lake and C bar N basins. Lake Agustin Basin is in abeyance until adequate topographic maps become available. (Weber)
20. Zeolites of New Mexico. Continuing project. Distribution, mode of occurrence, genesis, and possible economic significance of zeolites throughout the state. Field examination and laboratory studies of this significant group of minerals, some of which have recently become of appreciable economic significance. This work is being done on an-as-time-permits basis, with much of the information to date derived as a by-product of volcanic studies of the Datil-Mogollon field. (Weber)
21. Datil-Mogollon volcanic field. Continuing project. Mapping of volcanic regions in Socorro and Catron counties to determine distribution, sequence of events, radiometric dating, structure, genesis, and relationship to intrusive rocks and associated ore mineralization of volcanic rocks and derived sediments. (Weber)
22. Sedimentary history and the correlation of the Cretaceous sediments along the west side of the San Juan Basin, using petrologic techniques. (Willard)
23. Volcanic history of the Chupadera Mountains. (Willard)
24. Manganese Mineralization of the Luis Lopez and its geochemistry. (Willard)
25. Geothermal Resources in New Mexico. A continuing study project. (Summers)
26. Pecos ground-water study. Interpretation of the geology and hydrogeology of ground-water in the Pecos River Basin. (Summers)
27. Bibliography of Geothermal Phenomena. A compilation of source material references to provide an annotated bibliography. (Summers)
28. The role of the hydrologic cycle in the formation of White Sands,

- Tularosa Basin, Dona Ana and Sierra counties, New Mexico. New project. (Summers)
29. Philmont ranch studies. Geochemical anomalies in the Philmont Ranch Region of New Mexico. Completed, Circular 92. (Misaqi)
 30. Geochemical and biogeochemical studies in the Eagle Nest quadrangle, New Mexico. Submitted for publication. (Misaqi)
 31. Illustrations of fossils of the Early Paleozoic of New Mexico. (Flower)
 32. Future petroleum provinces in west-central and southwest New Mexico and southern Arizona (Kottlowski)
 33. Late Paleozoic sediments derived from Pedernal uplift. To be published by North Texas Geological Society. (Kottlowski)
 34. Geology of the Las Cruces quadrangle. Work completed and manuscript in preparation. (Kottlowski)
 35. Sedimentational influence of the Pedernal uplift (Kottlowski)
 36. Revision of Scenic Trips Number 4. Trip follows N. Mex. 53 from Grants around southern tip of the Zuni Mountains, across Continental Divide to El Morro National Monument and the Zuni Pueblo. One of nine trips to the geologic past. (Foster)
 37. Revision of Scenic Trip No. 1, Santa Fe area. In press (Kottlowski).
 38. Study of Ordovician and Silurian cephalopods of Europe, September 1, 1967-September 1, 1969, an NSF grant. (Flower)
 39. Silurian outcrops of south-central and southwest New Mexico. (Frank Kottlowski with Lloyd C. Pray) Published.
 40. Pennsylvanian and Early Permian of Joyita Hills, Wendell J. Stewart and Frank E. Kottlowski. Completion date, December 1968.
 41. Early Ordovician highlands of Precambrian rocks and their associated facies, Franklin Mountains. (Kottlowski, with Dave V. LeMone and Roy Foster)
 42. San Andres Limestone west of the Sacramentos. (Kottlowski)
 43. Late Paleozoic Strata in El Paso border region. (Kottlowski)
 44. Revision of Scenic Trips No. 3. (Kottlowski) published. Roswell—Capitan—Ruidoso, Bottomless Lakes State Park area.
 45. Endoceratida of the El Paso group ms. of part I completed, with about 40 plates. (Flower)
 46. El Paso and related Tarphyceratida ms. and plates. Completed (Flower)
 47. Fauna of the Florida Formation of the El Paso Group. (R. H. Flower and Dave LeMone)
 48. Faunas and stratigraphy of the Montoya group. (Flower)
 49. A Cotter fauna in the El Paso group. (Flower)
 50. Revision of the type section of the El Paso group. (Flower, and Dave LeMone)

Metallurgy and Analytical Chemistry

Following projects were studied on a co-operative basis by all the staff members of the Metallurgy section, including Reynolds, Johnson, Brandvold, Brower, Smith, Brierley, and Bhappu, with exceptions as noted. Most of these projects required numerous chemical analyses; the analytical laboratory made 11,128 chemical determinations on 4850 samples during the fiscal year.

51. Basic studies on properties of silicate minerals and their influence on flotation leaching and ground-water technology. This is a continuing project and a Ph.D. thesis being conducted by Raul A. Deju and partly sponsored by the Bureau. It concerns the surface properties of silicate minerals with varying oxygen-silicate ratios as they influence the flotation behavior of silicates, control the leaching characteristics of the silicates, determine selective absorption of detergents on the silicate surfaces, and influence the quality of water as it percolates through beds of different minerals. The target date for completion is June 1969.
52. Removal of copper from molybdenite concentrates. Project started September 1966, completed in May 1968; concerns the removal of copper impurities from molybdenite concentrates by leaching under pressure at elevated temperatures. The copper, as well as iron and zinc, was effectively removed from molybdenite concentrates, thereby producing a premium-grade product. This Bureau project was sponsored by Pima Mining Company, Tucson, Arizona.
53. Leaching of low-grade uranium ores from New Mexico. A continuing long-range project of basic and applied research for obtaining pertinent information on dump leaching, heap leaching, and underground leaching of low-grade uranium ores.
54. Improved analytical and extraction procedures for rhenium. This continuing project has a completion target date of June 1969; sponsored by the Bureau. It will serve as a master of science thesis for Lorna Goebel and concerns the development of improved analytical procedures for determining rhenium in molybdenite samples. Efforts are being made to develop more effective procedures for extracting rhenium from molybdenite concentrates using data collected in the analytical research.
55. Handbook on analytical procedures for (a) water and (b) rock. This continuing project is expected to be completed in June 1969 and is conducted exclusively by Reynolds and Brandvold. The project was initiated to fill a gap in the technical literature concerning appropriate, detailed analysis for water and rocks and minerals.
56. Potassium permanganate in flotation of sulfide minerals. Starting date was February 1966; completed in June 1968. This was a study of the effectiveness of potassium permanganate as a depressant for copper and

iron sulfides in the selective flotation of molybdenite. The effectiveness was evaluated against the performance of the other oxidants used in practice. Efforts were made to determine optimum conditions for using permanganate in different flotation systems and to understand the mechanism of depression of gangue sulfides by oxidizing agents. This was a Foundation project, sponsored by Carcus Chemical Company.

57. Preparation of activated products from asphaltenes and carbon black. Starting date was July 1966; completed February 1968. Basic research was conducted to obtain activated products from Shell asphaltenes and carbon blacks. Such products would be capable of absorbing cation and anions from leach solutions. Several activation techniques were employed to determine the optimum procedure for obtaining suitable activated products. This was a Foundation project, sponsored by Shell Chemical Company. (Brower)
58. Studies on activated charcoal. This is a new project with a target date of June 1970. A basic studies project, it attempts to develop activated charcoal capable of absorbing metal ions by introducing suitable functional groups to the charcoal surface. (Brower)
59. Determination of optimum hydrocarbon oil for molybdenite flotation. The project was started in September 1966 and completed in February 1968. A large number of Shell hydrocarbon products and fuel oils was evaluated for determining the optimum recovery of molybdenite from Questa ores. Efforts were made to determine the specific active groups in the hydrocarbons and to understand the mechanism of molybdenite flotation. On the basis of this research, it is now possible to obtain maximum recovery of molybdenite from different ores by using appropriate hydrocarbon oils.
(Foundation project sponsored by Shell Chemical Company)
60. Recovery of copper from Moroccan copper ore. A new project started in November 1967 and completed in April 1968, this Tech Research Foundation project concerned the recovery of copper and silver from a copper ore from Morocco. This experience would be useful for treating similar copper ores in New Mexico.
61. Nickel analysis for an extraction from lateritic ores. A new project instituted by the Bureau and expected to be completed about December 1968. This Tech Research Foundation project involves chemical analyses of nickel and cobalt containing lateritic ores from Guatemala and development of new extraction techniques for recovering nickel values from such ores. This project provided an opportunity to test some of the newly developed hydrometallurgical techniques conceived by the Bureau staff. (met staff)
62. Kinetics of the dissolution of copper sulfides, basic studies. This continuing project has a target date of June 1969 for completion. It is a Ph.D. dissertation for Walter Fisher, sponsored by the Bureau, in which

efforts are made to determine the dissolution rates of sulfide minerals under different conditions.

63. Leaching of oxide-copper ores. A new project on heap-leaching studies and development of new column-leaching techniques. The project was initiated as a technical service for a leading copper mining company interested in opening a mine in New Mexico. Initial acid consumption tests followed by heap and vat leaching studies in the laboratories as well as in the field were conducted. Laboratory tests were performed to evaluate a newly developed column-leaching technique that was found more effective than the heap-leaching process. Additional studies will be continued to obtain pertinent data on the method of leaching. (met staff)
64. Analysis of manganese minerals by atomic absorption and X-ray fluorescence (Reynolds)
65. Chemical mining-theoretical and practical aspects, by Paul H. Johnson and Roshan B. Bhappu, Bureau reprint series September 1967.
66. Recovery of barium and strontium from bastnaesite ores. A continuing project with completion expected in December 1968. The project was to determine the optimum method for recovering strontium as a carbonate and barium as a sulfate from ores (Mountain Pass, California) containing an intimate mixture of barium and strontium sulfates and carbonates. This Bureau project was sponsored by the Molybdenum Corporation of America.
67. Programming computer routines for processing atomic absorption and X-ray fluorescence analysis of rocks and minerals (Reynolds)
68. Feasibility of miniaturizing a direct-reading optical spectrograph for quantitative analysis of rocks and minerals (Reynolds)
69. Copper dump leaching project. A continuing long-range project studying (a) the physical aspects of dump leaching (b) chemical aspects of dump leaching (c) biological aspects of dump leaching. This is a comprehensive basic and applied research study involving the determination of the physical makeup of copper dumps, the zones of leach solution penetrations, the amount of water and soluble copper compounds present at various depths, the dissolution rates of various copper minerals, mineralogical alteration of valuable and gangue minerals, the effect of acid and ferrous-ferric ions on the dissolution of various copper minerals, the extent of bacteria activity with depth, etc. This is a co-operative project among the Bureau, U.S. Bureau of Mines, and Kennecott Copper Corporation.
70. Bacteria leaching of sulfide minerals. This continuing project, long-range in nature, was conducted by Brierley in two phases:
 - (A.) Determination of optimum conditions for dissolution of copper, iron, zinc, and molybdenum sulfides with select strains of bacteria.

(B) Determination of the extent of bacteria activity with depth in typical copper dumps. A new project in this connection started during the period is the study of ways of increasing the effectiveness of bacteria leaching through the use of specific nutrients.

71. "Chemical Mining" studies; investigation of new techniques and new, cheap reagents for use in underground environments.(Met. Section)
72. Physical and Chemical aspects of chemical mining. This new long-range project is a study of physical and chemical parameters concerned with selective dissolution of metals and minerals with suitable solvents in an underground environment, followed by recovery of leach solutions, extraction of metals from acid solutions, and regeneration of leach liquors for reuse. (Met staff)
73. Techniques for copper and iron sulfide depression through the use of ammonium sulfide and sodium sulphhydrate. Project started February 1967, completed April 1968, involved selective flotation of molybdenite from copper concentrates by depressing the copper and iron sulfides through the use of sulfide ions. The current practices are quite complicated and involve the use of strong corrosives and poisonous chemicals. It was shown that ammonium sulfide and sodium sulphhydrate, both of which are noncorrosive and nontoxic, are effective depressants for gangue sulfides. This Bureau project was sponsored by Pima Mining Company, Tucson, Arizona. (Met staff)
74. MISCELLANEOUS PROJECTS by the metallurgy staff included 25 smaller studies, some lasting as little as a few hours and some lasting several days. These were undertaken for prospectors, mining companies, and individuals in the state. Most included analytical work as well as metallurgical testing. The metallurgical tests were performed by Jackie Smith.

Mining and Economics

75. Jurisprudence of water-resources concepts. (Bertholf) Continuing project.
76. Use of thermal waters. Appraisal of some of the factors adding to or detracting from the socioeconomic use of New Mexico thermal waters. (Bertholf and Summers). Project started September 1965, completion report made August 1967. Undertaken with financing under Title 1, PL.88-379, it had three phases:to locate and inventory the physical and chemical properties of New Mexico thermal waters; to ascertain and appraise present and potential use value of the hottest thermal waters for geothermal power; and to determine the probable relationship of the jurisprudential doctrine of waste on such use. The first two phases have been completed. Third phase has been substantially completed through state legislation. (Bertholf)

77. Water Law Atlas: The New Mexico chapter of the Federal Bar Association in co-operation with the State Bureau of Mines and Mineral Resources published this as Circular 95. It has received international notice, and the American Bar Association has requested permission to reprint the text in a forthcoming issue of the American Bar Journal. (Bertholf)
78. Marine science project. Started as a study of physical, chemical, meteorological, and biological conditions at Elephant Butte Dam and water above the lake. It is now being expanded to include Cochiti Dam backwater and sites down to and including the Gulf of Mexico (for an interdisciplinary field of study). (Bertholf)
79. Government reorganizational interim report of the Governor's Committee on reorganization of state government; completed in December, 1967. A continuing project. (Bertholf)
80. Coal-search, exploration, and reserve calculation of coal deposits. Submitted for publication. (Misaqi)
81. Mexican-American mining conference, Preliminary work on this project was completed three years ago, and it has been indefinitely delayed for lack of funds. The project would bring Mexican and United States mining interests together to discuss mutual problems on New Mexico Tech Campus. (File)
82. Mining history. Revision of the Ghost Town Map for the 1968 edition. (File)
83. Information, maintaining mining information on cards and microfilm. Continuing project. (File)

Co-operative Projects

The Bureau is required by law to co-operate with the University of New Mexico, the State Mine Inspector, and other departments of the state and federal governments. "as may be mutually beneficial."

Following is a listing, by agency, of the activities of the Bureau in co-operation with other organizations:

Adams State College, Alamosa, Colorado

Inventory of historical ceramic types in Middle Rio Grande Valley (Weber)

Albuquerque Archeological Society

Geological consultation in research projects. (Weber)

American Association for the Advancement of Science

Chairman of the symposium on border stratigraphy in El Paso late April. (Kottlowski)

American Association of Petroleum Geologists

Service on the Highway Geological Map Committee (Foster). Reviewed papers submitted for bulletin (Foster).

Associate Editor, District Representative for Central New Mexico, Standard Stratigraphic Computer Coding Committee, Stratigraphic Correlations Committee, (Kottlowski).

District Representative, June 1968-1970 (Bieberman).

American Chemical Society

Chairman-elect of the central New Mexico section of the American Chemical Society (Reynolds).

American Commission on Stratigraphic Nomenclature

Vice-Chairman and Secretary (Kottlowski).

American Institute of Mining Engineers.

Chairman, Council of Section Delegates (Bhappu).

Chairman, Waste Disposal Committee (Bhappu).

Program Chairman, Solution Mining Committee (Bhappu).

Vice-Chairman, Hydrometallurgy Committee (Bhappu).

Student paper awards committee (member)(Bhappu).

American Institute of Professional Geologists (New Mexico Section)

Service as president. (Kottlowski)

Atomic Energy Commission.

Proposal for control of radon in the underground environment. (Foster)

Brigham Young University

Continued study of the Ordovician cephalopods of the Ibex region of Utah, supported in part by a NSF grant to that institution. The cephalopods are being described here. (Flower)

Carcus Chemical Company

Evaluation of potassium permanganate in flotation of sulfide minerals. (Met. section)

Federal Bar Association

Prepared the 1968 Annual Meeting of the Committee on the topic of "160 acre limitation on water use in Federal Land Law", served as National Deputy Chairman, Committee on Mines, Minerals, and Natural Resources.(Bertholf)

Review of various public lands laws.

Review of commission matters.

Conversion of property data to uniform digitized law descriptions (with W. K. Summers).

Digitization of the geography-geology for New Mexico. (Bertholf and graduate students)

Application of the doctrine of waste and the duty of the sovereign to manage resources efficiently and effectively (Bertholf).

National Deputy Chairman (Bertholf). Term completed November 1967

New Mexico Chapter in co-operation with State Bureau of Mines published Water Law Atlas. (Bertholf)

Geological society of America.

Cochairman coal geology division. Technical sessions at November 1967 meeting. Cochairman, preparation for symposium on coal resources of the Americas to be held at GSA 1968 meeting in Mexico City. (Kottlowski)

Geological Survey of Canada

Cephalopod identification and description, with attendance age indication. A large work on cephalopods of the Silurian of the James Bay lowland is finished, and to be published this fall. Another, on the cephalopods of the Cat Head formation L. Winnipeg was completed last November. Similar work on the Ordovician Cephalopods of Lake Timiskaming is in progress. (Flower)

Geological Survey of Indiana

Identification and description of Silurian cephalopods of northern Indiana. (Flower)

Governor's Office

Member of Governor Cargo's Committee on Economic Development (Kottlowski). also (See State Legislature).

Assisted with the interim report of the Governor's Committee on reorganization of state government. Completed December 1967.(Bertholf)

Idea Conference

On mineral resources and development held at New Mexico Tech, May 2 and 3, 1968. Sponsored by the Bureau and New Mexico Tech Research Foundation. (Foster, Kottlowski, File, Willard)

Jemez Valley High School

Worked with high school science class in the collection and interpretation of water chemistry data for hot springs. (Summers)

Kennecott Copper Corporation

See "U.S. Bureau of Mines".

Museum of New Mexico

Identification of minerals in archaeological materials and determination of probable sources. (Weber)

Molybdenum Corporation of America

Recovery of barium and strontium from bastnaesite ore.

Determination of molybdenum and rare earths by X-ray fluorescence sponsored by Molycorp. (Renault)

By Products recovery from Questa tailings.(Met. section)

Narodni Museum v Praze

At the request of this institution, cooperative work was initiated on the revision of the Paleozoic cephalopods of the Bohemian basin. An extensive conference and discussion on this matter was interrupted by the Russian invasion of Czechoslovakia on August 21; it will be resumed unless workers in that country do not dare enter into extensive correspondence with a capitalist.

New Mexico Institute of Mining and Technology

Guest lectures in the chemistry department (geochemistry), geology department, (sedimentology) hydrology department (local volcanic history). (Willard)

Lectures in Geology, Chemistry and member Library Committee. (Renault)

Graduate council, publicity committee. (Kottlowski)

Lecture on use of the microscope in mineral dressing problems (Weber).

Proposal for study of radon control in the underground environment (AEC) (Foster).

Service on four committees: Ombudsman Committee, Insurance, Bureau Director, and Geology Luncheon Club (Foster).

Lecture on oil shale and Bituminous deposits (Foster).

Geological Information for geophysical studies in the San Agustin Plains (Foster).

Review of various proposals and papers (Foster).

New Mexico Tech Research Foundation-Shell Project on hydrocarbon oils as flotation reagents and preparation of activated products from asphaltines and carbon blacks. (Bhappu)

Moroccan copper ore project (Bhappu).

Nickel analysis and extraction from lateritic ores from Guatemala. (Bhappu)

Fall Semester 1967-68 taught two semester hours (Bhappu).

Spring semester 1968 taught Chemical Metallurgy 2, laboratory, one semester hour. (Bhappu)

Supervising three Ph. D. theses and one M.S. thesis. (Bhappu)

Chairman, Off-campus Coop Education Committee; graduate council.(Bhappu)

Miscellaneous art work and drawings for 13 individuals. (Arnold)

Co-chairman of May Idea Conference on Mineral Resources. (Kottlowski)

Teaching of electrical engineering and surveying courses. (Misaqi)

Teaching graduate mining, geology, and ground-water hydrology courses. Service on doctoral committee; proctoring one master's thesis; ex officio on the doctoral committee of D. F. McLeroy Lehigh University; New Mexico Tech Research Foundation, trustee, Corporate Secretary, and on the executive committee; Vice-President for Finance (Berthoff).

Exhibit for State NMEA Convention. Assist public relations department (File)

New Mexico Academy of Science

Editing and publishing the Academy of Science Bulletin, two issues annually (File);

Public Relations Committee Chairman (File).

New Mexico Mining Association

Preparation of a handbook for high school counselors on science-oriented jobs in New Mexico in co-operation with the Academy of Science (File).

New Mexico Geological Society

Registration Chairman, Fall Field Trip October, 1967 (Bieberman).

Society-Treasurer, starting May 1968 (Bieberman).

Cochairman of Caravan Committee (Summers).

Fall Field Conference (Summers).

Cochairman of Spring Meeting and San Andres Symposium (Summers).

New Mexico Mapping Advisory Committee.

Preparation of annual reports for recommendations for topographic mapping. (Weber)

New Mexico Water Resources Institute

Evaluation project started on the role of the hydrologic cycle in the development of the White Sands and the determination of the origin of the gypsum there.(Summers)

New Mexico Waterwells Contractors Association

Director of Waterwell Conference with NMIMT. (Summers)

Paleo-Indian Institute, Eastern New Mexico University

Co-operative project on geology and archaeology of Mockingbird Gap Site (Weber).

Pleistocene geology of Northern Jornada del Muerto. A field study supported by laboratory investigations of late Pleistocene history of northern Jornada (Weber).

Pima Mining Company

Removal of copper from molybdenite concentrates. (Met. section)

Rocky Mountain Mineral Law Foundation

Editing services (Bertholf).

Sandia Corporation

Pyrometric cone equivalent tests on selected soils (Foster).

Teaching engineering geology course for Tech Research Foundation. (Foster, Kottlowski, Weber)

Geologic consultation on the Nevada Test Site (Kottlowski, with Weber and Foster).

Shell Chemical Company

Preparation of activated products from asphaltene and carbon black.

State Department of Development

Revision of Ghost Town maps (Arnold , File).

Public meetings and conferences work (Bertholf).

State Engineer's Office

Various water-quality matters, including Steve Reynolds' participation in the FBA National Water Quality Seminar.(Bertholf)

State Department of Finance and Administration

Several working meetings to reorganize the state computer center and to select the senior staff for same (Bertholf).

State Land Office

Public Hearings to develop rules and regulations for development of lands under the geothermal act of 1966 (Bertholf).

State Legislature and Governor's Office

Consulting staff of the Governor's Committee on Reorganization of State government. (Bertholf)

State Planning Commission

Information on Mining, various studies (File).

State Planning Office

Continuing participation in the state-resources development plan (Bertholf).

State Science Fair

Assistance in judging (Bhappu, Johnson, Brandvold, Renault, Weber, Summers). Academy of Science arrangements (File) and registration supervision (Reynolds).

United Nations

Organization of a seminar on hydrometallurgy (Bhappu).

University Council on Water Resources

Delegate to the council, representing New Mexico Institute of Mining and Technology. (Bertholf)

University of New Mexico

Preparation of reference sets and descriptive definition of lithic types for use of students in the department of anthropology (Weber).

University of Texas at El Paso

Review of proposal (Foster). Paper on Precambrian in Franklin Mountains (Foster).

U.S. Forest Service

Assisted in training project for engineers on wells and geology of wells (Summers).

Identification and interpretation and evaluation of minerals, rocks, and ores (Weber).

U.S. Geological Survey

Interpretation of infrared imagery of the Animas Valley Hot Spot, Hidalgo County, New Mexico (Summers).

Co-operative work with geologists on geologic problems in New Mexico (Weber).

Cephalopod identification, with resulting indications of age. Significant collections in process of study are from several horizons in the Seward Peninsula of Alaska (two finished) extensive material from Utah, Nevada, New Mexico, and a large collection from the Ordovician of Kentucky, with numerous minor collections. (Flower)

U.S. Geological Survey and U.S. Bureau of Mines

Consultation services. (Bertholf)

U.S. Department of Health, Education, and Welfare

Public Health Service. Studies in fluoride content of water.

U.S. Bureau of Health, Education, and Welfare (Public Health)

Co-operation on testing methods for water qualities and analysis (Reynolds).

U.S. Department of the Interior.

Supervision of work of transferring of mine records from microfilm to cards (File)

U.S. Bureau of Land Management

Continuation of mining records project. Work on mining law compilation (File).

U.S. Bureau of Mines

Identification and interpretation and valuation of minerals, rocks, and ores. (Weber).

U.S. Bureau of Mines and Kennecott Copper Corporation

Copper leaching project (Met. section)

U.S. National Museum

Identification, study and description of cephalopods as requested. (Flower)

U.S. Regional Solicitor's Office

Requests answered for information on mineral jurisprudence. (Bertholf)

Volunteers for International Technical Assistance Inc. (VITA)

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

Water Conference

Advisory committee. (Bertholf)

Water Resources Institute

New Mexico Water Resources Institute, New Mexico State University, Univ. of N.M., and NMIMT Research and Development Division. Study of water resources of the Pecos River Valley. (Summers).

Weather-Control Commission

Chairman. (Bertholf)

BUREAU PUBLICATIONS

(Abstracts)

During the period July 1, 1967, to June 30, 1968, the following publications were printed and are being distributed by the Bureau:

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

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

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

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

GENERAL OCCURRENCE AND QUALITY OF GROUND WATER IN UNION COUNTY, NEW MEXICO: Ground-Water Report 8 by James R. Cooper and Leon V. Davis, 168 pages, 6 tables, 3 figures, 1 plate; \$3.00.

Included are a generalized section on the water-bearing formations, driller's logs of 92 water and test wells, extensive tables giving records of wells and springs, chemical analyses of water, a map showing location of wells and springs as well as the altitude of the ground-water surface.

The main aquifers are the undifferentiated Dakota Sandstone and Purgatoire Formation of Cretaceous age and the Tertiary Ogallala Formation. Aquifers yield adequate supplies of water for stock and domestic use but in general irrigation supplies are available only in the east part of the county.

GEOLOGY OF THE CHAMA QUADRANGLE, NEW MEXICO: Bulletin 89 by William R. Muehlberger, 114 pages, 1 table, 17 figures, 2 plates (including color geologic map); \$3.00.

The Chama quadrangle, in the central part of the Chama Basin along the northeast margin of the San Juan Basin, contains outcrops of Precambrian rocks; Pennsylvania, Triassic Chinle, Jurassic Entrada, Todilto, and Morrison, Cretaceous Dakota, Mancos, Mesaverde, and Lewis strata; the Blanco Basin, El Rito, and Conejos Quartz Latite, and Cenozoic gravels, moraines, and alluvium.

Northwest-trending folds and faults dominate, cut by the west-trending Brazos fault zone. Willow Creek and Horse Lake anticlines, about 10 miles long, and 2 to 4 miles wide, are asymmetrical with crests 1000 feet above adjoining troughs. Structural relief between the Chama syncline and the Laramide monoclinial upwarp of the Tusas Mountains is about 5000 feet.

ANNUAL REPORT, NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES, JULY 1, 1966 TO JUNE 30, 1967: by Alvin J. Thompson, 44 pages, 4 charts, 2 tables; no charge.

Mineral production in New Mexico has increased (1966) to \$844 million. The State's agency charged with investigating mineral resources published 27 reports during the fiscal year, as well as providing numerous nonpublication services. Listed are projects in progress, cooperative projects and publications with other agencies, and abstracts of publications and technical talks. A continuing program to aid development of New Mexico's mineral industries is proposed.

BIOSTRATIGRAPHY AND CARBONATE FACIES OF THE MISSISSIPPIAN ARROYO PENASCO FORMATION, NORTH-CENTRAL NEW MEXICO: Memoir 20 by Augustus K. Armstrong, 80 pages, 45 figures, 12 plates, 4 tables; \$3.50.

The Late Osage to Meramec Arroyo Penasco Formation, 10-130 feet thick, crops out in mountains of north-central New Mexico, and rests on peneplained Precambrian rocks. Basal clastic beds, dolomite, dedolomite, various limestones bearing rich microfaunas, and collapse breccia resulting from solution of gypsum are features of the complex formation.

U.S. ATOMIC ENERGY COMMISSION "PRELIMINARY RECONNAISSANCE REPORTS" ON URANIUM OCCURRENCES IN NEW MEXICO: 575 unbound sheets; \$50.00 (separate sheets 10 cents per sheet)

Briefly describes localities examined for reported anomalous radioactivity by U.S. Government geologists and engineers during the period of 1950-1958. Many of these localities were developed into producing mines; others were not.

The reports include data on location, ownership of the property at the time of investigation, type of examination, pertinent surface geologic and radiometric features, radioactivity of samples collected, and reference to other published information on the area.

NEW MEXICO'S MINERAL RESOURCES: by W. Wilson Cliff, 14 pages; no charge (limited copies available)

This series of articles first published in the Albuquerque Journal outlines the present (October 1967) condition of New Mexico's mineral industry, its problems of future growth, taxes, and in-state production, as well as ideas to aid exploration and increased processing and production.

SILVER CITY-SANTA RITA-HURLEY, NEW MEXICO: Scenic Trips to the Geologic Past No. 5 by John H. Schilling, 37 pages, 19 figures, 16 photographs, and color cover by Wayne B. Bera; 50 cents.

These up-to-date road logs and descriptions of the geology, scenery, history, and mining activities in the famous southwest New Mexico region are aimed at the layman. They cover Silver City, Tyrone, Boston Hill, Chloride Flat, Pinos Altos, Santa Rita, Copper Flat, Hanover, Fierro, the Chino open-pit mine, Georgetown, and Hurley, as well as highlights of the mining, milling, and smelting operations.

ROSWELL-CAPITAN-RUIDOSO-BOTTOMLESS LAKES STATE PARK, NEW MEXICO: Scenic Trips to the Geologic Past No. 3 by John Eliot Allen and Frank E. Kottlowski, 51 pages, 23 figures, and 19 photographs (4 in color) by Wayne B. Bera; 50 cents.

These revised scenic trip road logs and their descriptions of the geology, history, and scenery cover the present main routes from Roswell westward through Hondo, Billy

the Kid's Lincoln, Capitan, and Carrizozo to the Valley of Fires State Park; then south along the flanks of towering Sierra Blanca through Nogal and Alto to Ruidoso; and the eastward route past Ruidoso Downs returning to Roswell. An eastern side trip is to Bottomless Lakes State Parks.

GEOCHEMICAL ANOMALIES IN THE PHILMONT RANCH REGION, NEW MEXICO: Circular 92 by F. Leo Misaqi, 12 pages, 6 figures, 1 plate, 1 table; 50 cents.

Stream sediment samples were tested for arsenic, lead, zinc, molybdenum, and copper. Anomalous metal contents were noted near Baldy Mountain, along North Fork of Cimarroncito Creek, Sawmill Canyon, Clarks Fork, Bear Creek, Agua Fria Creek, Apache Creek, Bonito Creek, and Moras Creek. More detailed geologic study of these areas may lead to discovery of new ore deposits.

TAOS-RED RIVER-EAGLE NEST, NEW MEXICO CIRCLE DRIVE: Scenic Trips to the Geologic Past No. 2 by John H. Schilling, 26 pages, 21 figures, 9 photographs (2 in color); 50 cents.

These revised scenic trip road logs and their descriptions of the geology, history, mines, and scenery cover the famous Taos region, Rio Grande gorge, Hondo Valley, Questa moly mine, spectacular Red River Valley, Moreno Valley, Elizabethtown ghost town, Eagle Nest reservoir, and Palo Flechado Pass. With the Santa Fe region, this is the tourist mecca of New Mexico.

WATER LAW ATLAS: Circular 95 by Thomas A. Garrity, Jr., and Elmer T. Nitzschke, Jr., 46 pages, 21 maps; 50 cents.

This series of 21 maps of the United States shows how the individual states solve particular problems of water law, giving with each map a discussion of the problems and the solutions. Facts affecting water use - land ownership, rainfall, elevation, population, irrigation, value of farm products, water-well drilling, and weather modification - are also shown.

SILURIAN OUTCROPS OF SOUTH-CENTRAL AND SOUTHWESTERN NEW MEXICO: Reprint 22 by Frank E. Kottowski and Lloyd C. Pray, p. 209-230, Tulsa Geological Society Digest, v. 35, Symposium "Silurian-Devonian Rocks of Oklahoma and Environs," 6 figures, 1 table; 10 cents.

Outcrops of Silurian Fusselman Dolomite, as well as data from the scattered oil tests, are described for the region from the Sacramento Mountains westward to Silver City area. A redescription of the type section in the Franklin Mountains subdivides the Fusselman into three mappable members, the Chamberino, Flag Hill, and Crazy Cat Members.

GEOLOGIC MAP OF THE TIERRA AMARILLA QUADRANGLE, RIO ARriba COUNTY, NEW MEXICO (WITH DESCRIPTION): Geologic Map 19 by Edwin R. Landis and Carle H. Dane in envelope, 15 pages of text and separate 7-color geologic map; \$1.00.

Rocks mapped are Morrison Formation, Burro Canyon and Dakota Sandstone, Mancos Shale with its Graneros, Greenhorn, Juana Lopez, Cooper Arroyo, El Vado, and other members, Mesaverde Group with its Point Lookout and Menefee formations, Lewis Shale, and various Quaternary units. Most of the quadrangle is in the Chama syncline; domal or anticlinal structures are Horse Lake, Willow Creek, and Rio Chama anticlines, and Puente, North El Vado, South El Vado, and Lagunas domes.

PART I - FIRST GREAT EXPANSION OF THE ACTINOCEROIDS; PART II - SOME ADDITIONAL WHITEROCK CEPHALOPODS: Memoir 19 by Rousseau H. Flower, 120 pages, 30 plates, 6 figures; \$3.50.

Part I describes cephalopods from the family Wutinoceratidae, collected in Nevada, Utah, and Newfoundland. Part II illustrates and describes 15 genera and 27 species from the Whiterock stage, mainly of specimens from Nevada and Utah.

GRAVITY SURVEY IN CENTRAL SOCORRO COUNTY, NEW MEXICO: Circular 91 by Allan R. Sanford, 14 pages, 9 figures, 1 table; 50 cents.

Detailed gravity survey covering parts of Rio Grande depression and adjacent areas, presented by regional and residual Bouguer anomaly maps and cross sections showing the Rio Grande Valley to be a series of linked structural depressions asymmetrical in cross section and other similar significant structural depressions that exist in the region.

ABSTRACTS - SYMPOSIUM ON THE SAN ANDRES LIMESTONE: Program of New Mexico Geological Society and Hobbs Geological Society Symposium, May 9-11, 1968, 21 pages; 50 cents.

Abstracts of 12 papers cover the San Andres Limestone and equivalents from Arizona eastward to Texas, including some details of Cato and Chaveroo oil fields and Roswell ground-water basin. Complete symposium papers to be available in volume now being compiled and printed.

Papers and Talks given by Bureau Staff

Dr. Frank Kottowski

With Dave V. LeMone and Roy W. Foster "Early Ordovician Highlands of Precambrian Rocks and Their Associated Facies, Franklin Mountains" at Geological Society of American Meeting, New Orleans, Nov. 22, 1967, Published in GSA Abstracts for 1968.

"Late Paleozoic sediments derived from Pedernal Uplift" at Amer. Assoc. Petroleum Geologists meeting, Wichita Falls, Feb. 9, 1968, Published in AAPG Bulletin for January 1968 (abstract).

"Sedimentational Influence of the Pedernal Uplift," at Soc. Econ. Mineralogists and Paleontologists meeting in Oklahoma City, April 25. Won the best paper award for the meeting, Published in AAPG Bulletin for March 1968 (Abstract).

"Late Paleozoic Strata in the El Paso Border Region" at Southwest AAAS meeting in El Paso, April 30, 1968. Published in program of AAAS meeting (abstract).

"San Andres Limestone west of the Sacramentos" at New Mexico Geological Society meeting in Hobbs, May 10, 1968. Published in program of NMGS meeting (abstract).

Also four TV programs on Geology and Bureau of Mines projects.

Silurian outcrops of south-central and southwest New Mexico, with Lloyd C. Pray, printed in Tulsa Geological Society Digest, v. 35, 1967, (Nov.)

Dr. Roshan B. Bhappu

"Chemical Mining - Theoretical and Practical Aspects" by Paul H. Johnson and Roshan B. Bhappu, Bureau Preprint Series - Sept. 1967. Paper presented at Fall Meeting of AIME, Las Vegas, Nevada, September 1967.

"A Mathematical and Experimental Model of the Electrical Properties of Silicate Minerals," by Raul A. Deju and Roshan B. Bhappu; paper presented at the Interamerican Conference on Materials Technology, San Antonio, Texas, May 20-24, 1968. This paper published in Symposium Volume "Materials Technology - An Interamerican Approach", ASME, New York, May 1968, page 97.

"Challenge of the Century", a technical talk presented at the Fall Meeting of the Colorado Plateau section AIME, Grand Junction, Colorado, Dec. 4, 1967.

"Mining's Dynamic Age", a technical talk presented at the Spring Meeting of Southwest N.M. Section AIME, Silver City, N.M.; March 14, 1968.

"Future Mining in New Mexico", a technical talk presented at the May meeting of the Central N.M. Section, AIME, Grants, New Mexico, May 18, 1968.

Mr. W. Kelly Summers

Northern Rio Grande Resource Conservation and Development Project.-August 23, 1967 - Geothermal energy in Northern New Mexico - Taos, New Mexico.

Water Well Conference-January 13, 1968-"Outline of hydrologic principles"-Socorro, New Mexico.

U.S. Forest Service Training Center-April 16, 1968-"What project engineer's should know about wells"-Continental Divide, New Mexico.

Geological Society of America, Cordilleran Section, April 13, 1968-The hydrologic significance of the Animas Valley Hot Spot, Hidalgo County, New Mexico, Tucson, Arizona.

New Mexico Geol. Soc., May 11, 1968, Hydrodynamic aspects of ground water chemistry--Hobbs, N.M.

Holloman AFB Chapter Soc. Mil. Eng. -Nov. 1967 - Ground Water dynamics--Alamogordo New Mexico Chapter American Chap. of Survey of mapping--Jan. 18, 1968--Proper control data with reference to survey monuments in the state and what can be done about it.

Public Works April 1968, "Avoiding Problems in New Wells."

New Mexico Magazine, April 1968, "Scientists in Hot Water."

Dr. Robert H. Weber

"The Mockingbird Gap Clovis Site." Paper presented at Symposium on Great Plains Prehistory, Eastern New Mexico University, Portales, July 15, 1967.

"History of Fort Craig", Talk, with exhibits, presented at meeting of Service Tech Boy Scout Troop, Socorro, February 8, 1968.

Field trip with above group to Ft. Craig, with description of fort and history and account of Civil War engagements, Saturday, February 10, 1968.

"History of Firearms Development". Talk, with exhibits, presented at meeting of Socorro Lions Club, Socorro, February 22, 1968.

"Mockingbird Gap Paleo-Indian Site". Illustrated talk presented at meeting of Albuquerque Archaeological Society, Albuquerque, April 4, 1968.

"Mockingbird Gap Paleo-Indian Site: Excavations in 1967". Paper presented at 33rd Annual Meeting of the Society for American Archaeology, Santa Fe, 10 May 1968.

"History of the Civil War in New Mexico". Talk, with exhibits, presented in class in New Mexico history, Socorro Public Schools, 15 May 1968.

"Mockingbird Gap Paleo-Indian Site: Excavations in 1967" (Abs.), Program, 33rd Annual Meeting Society for American Archaeology, May 1968.

Appendix B, Maps and Aerial Photographs, 13th Ann. Rpt. of New Mexico Mapping Advisory Comm., Jan. 1968.

Dr. Paul Johnson

"Chemical Mining - Theoretical and Practical Aspects" by Paul H. Johnson and Roshan B. Bhappu. Paper delivered at Fall AIME Meeting, Las Vegas, Nevada, September, 1967.

Mr. Lucien A. File

October 16, 1967 - Women's Club of Belen, "New Mexico Ghost Towns".

November 15, 1967 - Lions Club, Socorro, New Mexico, "Mexico, Contrast in Culture"

February 8, 1968 - WAIMME, Grants, New Mexico, "Ghost Towns of New Mexico"

June 1, 1968 - State Organization of Gem and Rock Clubs - "Ghost Towns"

Dr. William Bertholf

"Some Socioeconomic Jurisprudence for the Hydrosphere", Federal Bar Association, National Water Quality Seminar, UNM Kiva, April 6, 1968. This paper will appear in the 1967-68 transactions of the New Mexico chapter of the Federal Bar Association when published.

Interim Report of the Governor's Committee on Reorganization of State Government, 15 November 1967, Santa Fe, N.M. (A co-editor and compiler).

Annual report of the Weather Control Commission to the Regents, June 1968

Mr. Robert A. Bieberman

"Cartridge Collecting" - Socorro Rotary Club - Summer 1967

FINANCIAL STATEMENT

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

GENERAL

Receipts	1967-68	
Beginning balance July 1	\$ 12,994	
State appropriation	473,000	
Receipts from sales of bulletins, etc.	15,362	
Add prior year adjustments	3,703	
TOTAL revenue		\$ 505,059
Disbursements and Commitments		
Personal services:		
Regular salaries	\$ 242,334	
Part-time salaries, mainly students	90,761	
		\$ 333,095
Travel and automotive:		
Travel and per diem	7,107	
Gas, repairs, and insurance	869	
		7,976
Repairs and maintenance	1,189	
		1,189
Supplies and materials:		
Postage and resale supplies	4,727	
Office supplies	5,543	
Laboratory and scientific supplies	10,137	
		20,407
Printing and reproduction	24,233	
		24,233
Other operating expenses:		
Building use charge by New Mexico Tech	7,000	
Telephone and telegraph	8,822	
Professional services	6,067	
Retirement	14,136	
Social Security	7,672	
Overhead-to New Mexico Tech	14,600	
Computer Service	5,000	
Freight, expenses, insurance, audit repairs, subscriptions, etc.	3,775	

	67,072
Capital outlay	18,864
TOTAL expenditures	\$ 472,836
Year-end balance	32,223

BASIC GEOLOGY

Receipts	1967-68	
Beginning balance July		
State appropriation	\$10,000	
TOTAL revenue		\$ 10,000
Disbursements and Commitments		
Salaries	8000.00	
Travel	226.00	
Retirement	520.00	
Social Security	254.00	
Overhead	1000.00	
		10,000
Year-end balance	--0--	

GROUND-WATER SURVEYS

Receipts	1967-68	
Beginning balance July 1	--0--	
State appropriation	\$10,000	
		\$ 10,000
Disbursements and Commitments		
Salaries	8000	
Printing and publication	1000	
Overhead	1000	
		10,000
Year-end balance		--0--

THE MINERAL INDUSTRY OF NEW MEXICO, 1967*

Mineral production during 1967 in New Mexico was valued at \$874.1 million, an increase of \$17.8 million over the 1966 figure, according to the Bureau of Mines, United States Department of the Interior. The state continued to be the principal source of perlite, potassium salts (potash), and uranium in the nation.

Coal production increased 26 per cent, reflecting the continuing expansion of the Navajo mine near the Four Corners power plant. Also, the first full year of production was recorded at the York Canyon mine in the northeast corner of the state.

Marketed natural gas increased 7 per cent, mainly because of increased output from the Eddy county fields. Several significant deep-gas discoveries were made in the Delaware basin. The first attempt at commercial use of nuclear explosions was Project Gasbuggy's experiment to increase permeability of a gas-bearing sandstone by nuclear fracturing; initial tests indicated success, but final evaluation was not expected before mid-1968. Output of natural-gas liquids increased as new plants were constructed and older plants modernized.

Petroleum accounted for 42 per cent of the value of mineral production and increased slightly over that of 1966. Drilling, however, declined sharply. The Cato and Chaveroo fields were sites for much development drilling. Exploration resulted in 28 oil discoveries, some of which appeared to be significant.

A decline of more than \$21 million in the value of copper production was recorded, principally because of a labor strike in the copper industry that began on July 15 and continued through the year. Stripping of overburden was begun at the Tyrone open-pit copper mine of Phelps Dodge Corporation. Output of copper, at an initial rate of 55,000 tons a year is to begin in 1969 at the \$100-million mine-mill project.

Molybdenum production increased 18 per cent. The first full year of operations was recorded at the mine of Molybdenum Corporation of America near Questa. Nearly 10 million pounds of molybdenum were produced at the mine. Uranium production gained 20 per cent as activities of the industry increased to meet expanding commitments to the nuclear electric-power market.

United State Borax & Chemical Corporation closed its Carlsbad potash operations, and International Minerals & Chemical Corporation reduced its output of potash by about 50 per cent. These production curtailments resulted mainly from sharply lowered prices.

*Area Report, Mineral Industry Surveys, U.S. Department of the Interior, Bureau of Mines, September 1968; by Ronald B. Stotelmeyer and William C. Henkes.

Table 1.—Mineral production in New Mexico

Mineral	1966		1967	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Carbon dioxide (natural)—thousand cubic feet	795,885	\$58	771,516	\$57
Clays—thousand short tons	W	W	46	74
Coal (Bituminous)—do	2,755	9,110	3,463	12,641
Copper (recoverable content of ores, etc.)—short tons	108,614	78,571	75,008	57,345
Gem Stones—	NA	45	NA	60
Gold (recoverable content of ores, etc.)—troy ounces	9,295	325	5,188	182
Gypsum—thousand short tons	146	545	155	588
Helium—thousand cubic feet	95,900	3,357	71,200	2,492
Lead (recoverable content of ores, etc.)—short tons	1,596	482	1,827	512
Lime—thousand short tons	34	472	17	243
Manganiferous ore (5 to 35 % Mn) short tons, gross	47,590	324	49,323	348
Natural gas (marketed)—millioncubic feet	998,076	124,760	1,067,510	138,776
Natural gas liquids:				
Lp gases—thousand gallons	816,202	31,832	909,168	40,003
Natural gasoline and cycle products—do	338,732	19,736	338,114	20,730
Perlite—short tons	343,334	3,423	346,586	3,424
Petroleum (crude)—thousand 42-gallon barrels	124,154	352,101	126,144	368,340
Potassium salts—thousand short tons, K ₂ O equivalent	2,953	108,653	2,883	91,098
Pumice—thousand short tons	245	787	220	639
Salt—do	66	716	82	1,036
Sand and gravel—do	15,503	13,029	14,672	14,336
Silver (recoverable content of ores, 000's) troy ounces	243	314	157	244
Stone—thousand short tons	2,652	4,056	1,391	2,403
Uranium (recoverable content U ₃ O ₈) thousand pounds	9,340	74,721	11,202	89,615
Vanadium—short tons	W	53	W	W
Zinc (recoverable content of ores, etc.)—do	29,296	8,496	21,380	5,919
Value of items that cannot be disclosed: Cement, fluorspar (1967), iron ore, manganese concentrates (35 percent or more Mn), mica (scrap), molybdenum, tin (1966), and values indicated by symbol W	XX	20,328	XX	23,001
Total	XX (r)	856,294	XX	874,106
Total 1957-59 constant dollars	XX (r)	822,513	XX	832,858

(r) Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data; included with "Value of items that cannot be disclosed." XX Not applicable.

(a) Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

(b) Method of reporting changed from short tons of ore and f.o.b. mine value (AEC Circular 5, Revised, price schedule) to recoverable pounds of uranium oxide and f.o.b. mill value.