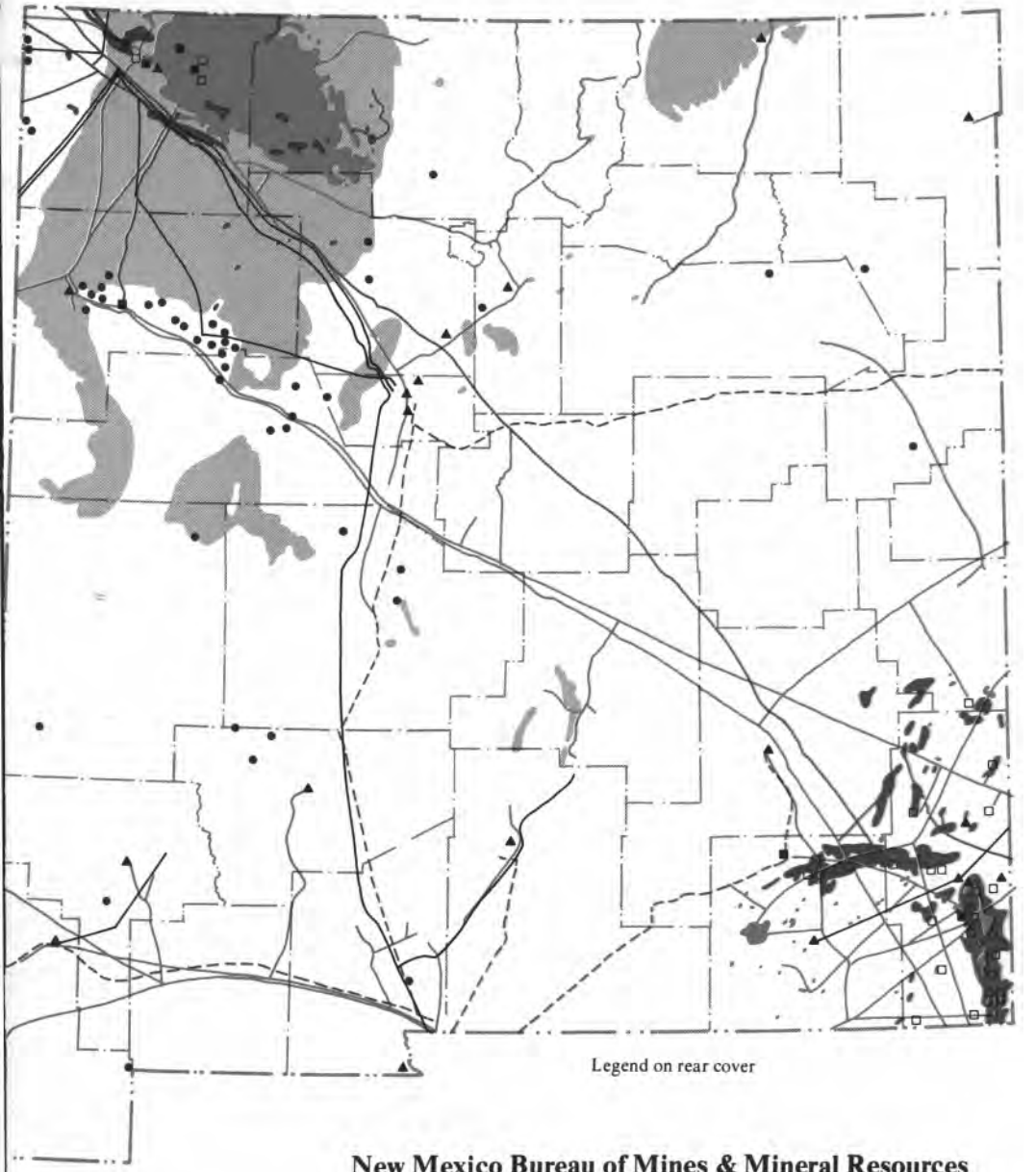
Annual Report

July 1, 1973, to June 30, 1974

FEATURED IN APPENDIX, pages 22-32

Energy reserves and resources
Mineral production 1973
Petroleum developments 1974
Symposium on base metals and fluorite



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New Mexico Bureau of Mines & Mineral Resources

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

New Mexico Bureau of Mines & Mineral Resources
Socorro, NM 87801

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

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December 12, 1974

To: The Governor of New Mexico, and
New Mexico Tech Board of Regents

I have the honor of transmitting to you the Annual Report of the New Mexico Bureau of Mines & Mineral Resources for the fiscal year July 1, 1973 to June 30, 1974, as required by Section 3, Chapter 115, of the Eighth State Legislature sessions laws, approved March 4, 1927.

During the fiscal year, 28 new technical reports were published, 15 talks were presented at scientific meetings, and 13 papers by Bureau staff and consultants were published in scientific journals. Information concerning exploration, development, and conservation of New Mexico's mineral resources was disseminated in 5,670 letters, in 4,210 telephone calls, and in 3,120 visitor conferences in Bureau offices. Sales of publications, priced at about cost of printing, totaled $27,453. More than 8,200 publications were distributed to state officials, libraries, and scientific agencies. In addition, about 45,000 brochures describing the geology and resources of the State's parks were given out in cooperation with the State Park and Recreation Commission.

Resignations and deaths during the last few months of the previous fiscal year and the first 2 months of the present fiscal year reduced the professional staff by 35 percent, but by the end of the year the Bureau was again at authorized strength. Upon the resignation of the Bureau's director, Don H. Baker, Jr., in July 1973, an acting director was appointed, while a 6-member committee headed by Dr. Robert H. Weber searched for a new director. On 4 February 1974 the Board of Regents appointed the present Director, who had been serving as acting director.

The Board of Educational Finance recommended an increase of 4.2 percent in the Bureau's appropriation for next fiscal year. Salaries for professional staff were about $1,200 below comparative college salaries, or about $4,000 less than comparative federal salaries. However, extra raises granted by the Board of Regents in October brought Bureau salaries even with college salaries.

Overall support by the Regents and President of Tech, by the Legislature, the taxpayers, and the mineral industry is appreciated--and makes sense because the technical service and research provided by the Bureau has helped develop the billion-dollar mineral industry of New Mexico.

Respectfully submitted,

Frank E. Kottlowski

Frank E. Kottlowski, Director

New Mexico Bureau of Mines & Mineral Resources

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

ANNUAL REPORT

for the Fiscal Year
July 1, 1973 to June 30, 1974

by

Frank E. Kottlowski
and Staff

SOCORRO
1975

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Introduction

Energy resources and other mineral resources are now everyday news. Where can New Mexico turn for reliable knowledge of these critical mineral resources?

By law, the New Mexico Bureau of Mines & Mineral Resources is the official State organization charged with investigating and reporting on the geology and mineral resources of New Mexico. The Bureau is required to give technical and scientific assistance in the exploration, development, production, and conservation of New Mexico's mineral wealth. That is the basis of our program. In 1973 the value of minerals extracted in New Mexico totaled more than 1.3 billion dollars—about 2000 times the Bureau's appropriation for that year.

New Mexico's mineral industry contributes mightily to the State's economy. In addition to the 1.3 billion dollar value of the raw products taken from the earth are the many jobs for mineral industry employees in Carlsbad, Artesia, Lovington, Hobbs, Roswell, Silver City, Hurley, Tyrone, Lordsburg, Central, Bayard, Grants, Gallup, Farmington, Fruitland, Questa, Raton, Cuba, and other cities. Furthermore the industry paid to the State and its subdivisions more than 125 million dollars in taxes, rentals, royalties, and bonuses. No other industry even approaches this kind of direct fiscal support. These tax monies comprise a major part of the current surplus in the general fund.

The need for answers to economic and technical problems throughout the mineral industry is considerable. Scientific evaluation has become increasingly important in assessing New Mexico's mineral potential. Geologic, mining, and metallurgical studies are needed to insure a stable mineral economy. New Mexicans must make sure that when presently producing deposits are used up, others, to be discovered, are ready to take their place.

Most of the talents and funds for finding and developing New Mexico's mineral resources must come from private industry. But the Bureau must continue to contribute actively to these programs by taking the lead in applied research that insures industry's prudent growth. Serving as a clearinghouse of the best possible scientific and technical information, the Bureau shares impartially its files of basic data with all companies, individuals, agencies, and institutions. A prime example is the New Mexico Library of Subsurface Data established in the Bureau. Oil well samples and records, secured by companies and individuals at a cost of several billion dollars, are freely available; their value increases with the passing of time.

The Bureau's financial statements follow on next page.

Financial Statements

BOARD OF EDUCATIONAL FINANCE—LEGISLATIVE

Funds Available			
Beginning balance		$ 11,758	
State appropriation		720,000	
Publications sales		27,453	$759,211
Expenditures			
Salaries			
Full-time staff	$352,825		
Part-time staff (mostly students)	90,858	443,683	
Project contracts		68,156	
Travel & automotive			
Per diem	11,380		
Fuel, repairs, insurance	5,535	16,915	
Scientific laboratories			
Maintenance	5,715		
Materials & supplies	13,914	19,629	
Office supplies		7,992	
Postage		4,046	
Printing		39,592	
Capital outlay		15,094	
Other expenses			
Telephone & telegraph	13,764		
Audit	1,500		
Subscriptions & dues	3,923		
Computer services	10,044		
Overhead & space charges	28,557		
Professional services	16,229		
Employee benefits	42,953	116,970	732,077
Encumbrances			16,470
Balance			$10,664

RESTRICTED FUNDS

Funds Available			
Beginning balance		7,958	
Receipts			
State & federal	26,236		
Other	31,677	57,913	65,871
Expenditures			
Salaries		23,470	
Employee benefits		1,876	
Surplus & travel		23,131	
Equipment		6,713	
Overhead		6,572	61,762
Balance			$4,109

NEW MEXICO COAL SURFACEMINING COMMISSION

Funds Available		
Beginning balance	9,273	
Fees collected	10,372	19,645
Expenditures		
Salaries	806	
Employee benefits	133	
Travel	2,031	
Supplies	1,031	
Other (including consulting services)	3,081	7,082
Balance		$12,563

Relation of Geology to Resources

Geological knowledge is indispensable in the exploration and development of mineral resources. Field investigations of mineral deposits, regional geologic reports, structure contour maps, detailed and reconnaissance geologic maps, and stratigraphic studies aid in finding, and, eventually, in extracting minerals. Many geologists, mining engineers, prospectors, and landowners visit the Bureau to confer on geologic data and interpretations.

Although much of the Bureau's work is in technical services, both pure and applied geologic research are also important. Prior to 1960, Schilling's study of low-grade molybdenum deposits near Questa was in the realm of pure research; today, a mill is extracting this ore. Prior to 1962, studies of late Paleozoic reefs in the San Andres, Sacramento, and Guadalupe Mountains were mostly stratigraphic research; today, similar Abo reefs in southeastern New Mexico are yielding oil and gas. Today investigation of asphaltic sandstones may be pure research, but, sooner than we realize, these sandstones could be important in meeting part of the nation's petroleum needs. Outcrop and subsurface stratigraphic studies of the 24 counties not now producing oil and gas may be considered pure geologic research today, but, tomorrow, could lead to the discovery of petroleum in these areas.

Geologic investigations that may help exploration for metals and industrial rocks ranged from tabulation of county-by-county mineral production to detailed work on such areas as the gold deposits at White Oaks. Evaluation of ground-water supplies is aided by hydrogeologic reports setting forth basic geologic and engineering data for counties or other areas. Areal geologic mapping, fundamental to all geologic and mineral resources investigations, has been completed for many quadrangle areas.

Many of the Bureau's technical publications are designed to aid in the search for fuels and minerals. These publications range from reconnaissance maps in the *Geologic Map* series to detailed studies contained in the *Bulletins*, *Memoirs*, and *Circulars*. Is the scientific and technical information generated by the Bureau useful to the mineral exploration industry? Sales of Bureau publications totaled more than $27,400 this fiscal year; about 8,500 copies of the new publications were issued free to state officials, libraries, and scientific organizations. Nor do the sales figures of a particular publication necessarily reflect its ultimate worth to New Mexico; a single report or map may contain the clue that leads to the discovery of a huge orebody or a million-barrel oil pool.

Many New Mexicans, and most of the tourists visiting the state, are not concerned directly with technical geologic investigations but do have a lively interest in our enchanting landscapes. They want to know how the canyons and mountains, arroyos and mesas, and volcanos and desert playas were formed. The popular guides *Scenic Trips to the Geologic Past* explain the geology of local areas, and point out scenic and geologic wonders. These booklets also are designed to keep tourists in the state "that extra day"—so important to New Mexico's economy. Tens of thousands of copies have been distributed already, and the demand continues.

Basic Services

Citizens of New Mexico (and elsewhere) including scientists, landowners, prospectors, legislators, students, industry personnel, and tourists required

considerable assistance from the Bureau. Our records show that 5,617 letters and 4,210 telephone inquiries were answered, and 3,210 office visitors counseled.

More than 15,000 adults and school children toured the Bureau's mineral museum. Bureau laboratories prepared 3,374 analytic reports on 1,830 samples (mineral, ore, water, and metallurgical). Staff mineralogists also made cursory identifications of hundreds of hand specimens brought or mailed to the Bureau.

Direct services to petroleum endeavors included making available records of many of the more than 64,000 test wells drilled in New Mexico, including cuttings from selected wells and a variety of borehole logs such as electric, radioactive, and sonic. Up-to-date petroleum exploration maps for most counties are maintained and available.

The business office sold 16,369 publications and maps for a total sale figure of $27,453. In addition, about $24,000 of New Mexico Geological Society guidebooks were sold; the Bureau handles these special publications as a public service. The business office also furnished secretarial and stenographic services, assisted in the selection of vendors for specialized materials, and prepared 850 requisitions and purchase orders.

The Mineralmobile was on display in various parts of the state for 17 days, as well as being exhibited at the State Fair.

The Director of the New Mexico Bureau of Mines & Mineral Resources is *ex officio* Director-Secretary of the New Mexico Coal Surfacemining Commission, and therefore serves as official liaison between coal mining company officials, the Commission, and the public. Four surfacemining permits were issued: York Canyon Mine of Kaiser Steel Co., Mesa Resources Development Mine, McKinley Mine of Pittsburg & Midway Coal Co., and the San Juan Mine of Western Coal Co.

Several cooperative projects were continued with state and federal agencies. Staff members served on various government committees and commissions, served as officers of professional organizations, presented 15 papers at scientific meetings, and served New Mexico Tech by teaching, directing thesis studies, and participating in the work of various committees.

Resource Investigations

(see index map on page 9)

The emphasis in the Bureau's program of resource investigations is to provide statewide evaluations of resources and reserves of mineral occurrences, to study key areas in detail, and to recommend guides for exploration, development, production, and conservation of our resources. Projects in this program follow (*names of Bureau staff are italicized*).

Energy Resources

1. *Foster*–Petroleum potential of radioactive waste disposal site (cooperative with U.S. Atomic Energy Commission) (open-file report 48)
2. *Bieberman*–Oil and gas fields and exploration map of New Mexico (kept current)
3. Shomaker–Deep coal deposits in the San Juan basin (cooperative with U.S. Bureau of Mines) (open-file report 34)
4. *Foster*–Stratigraphy and petroleum resources of the Delaware Mountain Group
5. *Bieberman*–Computerization of petroleum sample library data (kept current)
6. Shomaker–Coal resources of the Ute Indian Reservation (in cooperation with Bureau of Indian Affairs) (Circular 134)
7. *Foster*–Subsurface geology of east-central New Mexico (New Mexico Geological Society Special Paper No. 4)

8. *Kottlowski*, Shomaker, and Beaumont—Sulfur in San Juan basin coals
9. *Foster*—Carbon dioxide in northeastern New Mexico (New Mexico Geological Society 23rd Guidebook)
10. Milner—Glorieta-San Andres facies in east-central New Mexico
11. Chapman, Wood, and Griswold, Inc.—Geologic map of Grants uranium region (Geologic Map 31)
12. Pitt—Hydrocarbon potential of pre-Pennsylvanian rocks in Roosevelt County (Circular 130)
13. Symposium on energy crisis (in cooperation with New Mexico Geological Society, the Univ. of New Mexico, and six other professional groups) (Circular 140)

Metallic Ores

1. *Weber*, Clemons, *Chapin*, Seager, *Willard*, and *Kottlowski*—Age dating of igneous rocks and metallic mineralization in south-central and southwestern New Mexico
2. *Brandvold*—Mercury content of natural waters in New Mexico
3. *Walker*—Trace elements distribution as an indicator of mineralization
4. Doraibabu and Proctor—Trace base metals in stocks (Circular 132)
5. Lufkin—Tin in rhyolite flow-domes in Black Range

Industrial Rocks and Minerals

1. Frye and Leonard—Caliche in the Ogallala Formation southeastern New Mexico (Circular 144, in press)
2. *Hawks*—Clay deposits of New Mexico
3. *Renault*—Spinel composition of Rio Grande basalts
4. Sarg—Carbonate-evaporite transition facies of the Seven Rivers Formation
5. Frye—Surficial deposits of northeast New Mexico
6. McAnulty—Fluorspar deposits of New Mexico
7. Glass, Frye, and Leonard—Clay minerals in east-central New Mexico (Circular 139)

Water Resources

1. Shomaker—Deep aquifers in the San Juan basin (cooperative with New Mexico Water Resources Research Institute and companies in San Juan basin area)
2. Trauger—Ground-water resources of Harding County (cooperative with U.S. Geological Survey and State Engineer)
3. Summers—Water supply in the Zuni Indian Reservation (open-file report 33)
4. Titus—Ground-water resources and geology of the Estancia Basin (Bulletin 103, in press)
5. Blodgett and Titus—Ground-water of the Plains of San Agustin (open-file report 51)
6. Titus—Ground-water resources of the Sandia and Manzano Mountains area (cooperative with U.S. Geological Survey and State Engineer)
7. Sorensen, Stotelmeyer, and *Baker*—Mineral resources and water requirements for New Mexico industries (Circular 138)
8. Summers—Geology and regional hydrology of Pecos River basin (open-file report 37)
9. Summers & *Brandvold*—Geothermal waters of New Mexico (manuscript being re-worked for publication)

Environmental—geologic hazards mapping

1. *Vonder Linden*—Environmental geology of Socorro area
2. *Vonder Linden*, Inglis, Feldman, *Willard*, *Weber*, *Chapin*, and *Kottlowski*—Geologic application of remote sensing to New Mexico as part of the ERTS (Earth Resources Technology Satellite) program

Mapping Projects

(see index map on page 9)

Areal Geology

1. *Weber*—Geology of northeastern Plains of San Agustin
2. *Renault*—Geology of the Chupadera Mountains
3. Clemons—Geology and mineral resources of the NE Corralitos Ranch quadrangle (Geologic Map 36, in press)
4. Cunningham—Circle Mesa quadrangle
5. Woodward—San Miguel Mountain quadrangle (Geologic Map 34, in press)

6. *Weber*—Geology of the Mockingbird Gap site
7. *Chapin*—Origin and evolution of the Rio Grande rift
8. Seager and *Kottlowski*—Geology and mineral resources of the Las Cruces quadrangle area
9. Lovejoy—Geology and mineral resources of Cristo Rey (Memoir 31, in press)
10. Kelley and Northrop—Geology of the Sandia Mountains (Memoir 29, in press)
11. Seager and Clemons—Geology of the Sierra Alta quadrangle (Bulletin 102, in press)
12. Hoffer—Geology of East Potrillo Mountains area
13. Woodward—Geology of Nacimiento Peak quadrangle (Geologic Map 32)
14. Clemons—Geology of the Souse Springs quadrangle (Bulletin 100)
15. Woodward—Geology of the Holy Ghost quadrangle (Geologic Map 33, in press)
16. Hoffer—Geology of the West Potrillo Mountains
17. Seager—Geology and mineral resources of the Bishop Cap area (Geologic Map 29)
18. Woodward—Geology of Ranchero del Chaparral quadrangle (Geologic Map 27)
19. Cunningham—Geology and mineral resources of the Silver City quadrangle (Geologic Map 30, in press)
20. Seager and Hawley—Geology of the Rincon quadrangle (Bulletin 101)
21. Woodward—Geology of the La Ventana quadrangle (Geologic Map 28)
22. Bruning—Popotosa Formation, north-central Socorro County (open-file report 38)
23. Woodward—Geology of San Ysidro quadrangle (Geologic Map 37, in press)
24. Seager and Clemons—Geology of Cedar Hills-Selden Hills area (Circular 133, in press; also open-file report 52)
25. *Hunt*—Physiographic map of New Mexico (in progress)
26. Deal—Northern San Mateo Mountains
27. Jordan—Permian of southern New Mexico
28. Yurewicz—Rancheria and Las Cruces Formations

Mining Districts

1. *Vonder Linden* and Jaworski—Chupadera copper mine area
2. *Willard* and Jahns—Geology and ore deposits of the Luis Lopez Mining District
3. Jahns and *Willard*—White Oaks gold area
4. *Chapin* and others—Geology and mineral resources of the Magdalena-Tres Montosas area (open-file reports 39 through 47)
5. *Chapin*—Mineral resources of Socorro County
6. Armstrong and Silberman—Carbonate petrology and mineralization controls in the central Peloncillo Mountains
7. Symposium on base metal and fluorspar districts of New Mexico (in cooperation with New Mexico Geological Society)

Geophysical Investigations

1. U.S. Geological Survey cooperative project of aeromagnetic mapping of area from Silver City to Socorro
2. U.S. Geological Survey cooperative project of aeromagnetic mapping of area from Socorro to north of Santa Fe
3. Sanford and Toppozada—Seismicity of radioactive waste disposal site in southeastern New Mexico (Circular 143)

Stratigraphic Paleontology

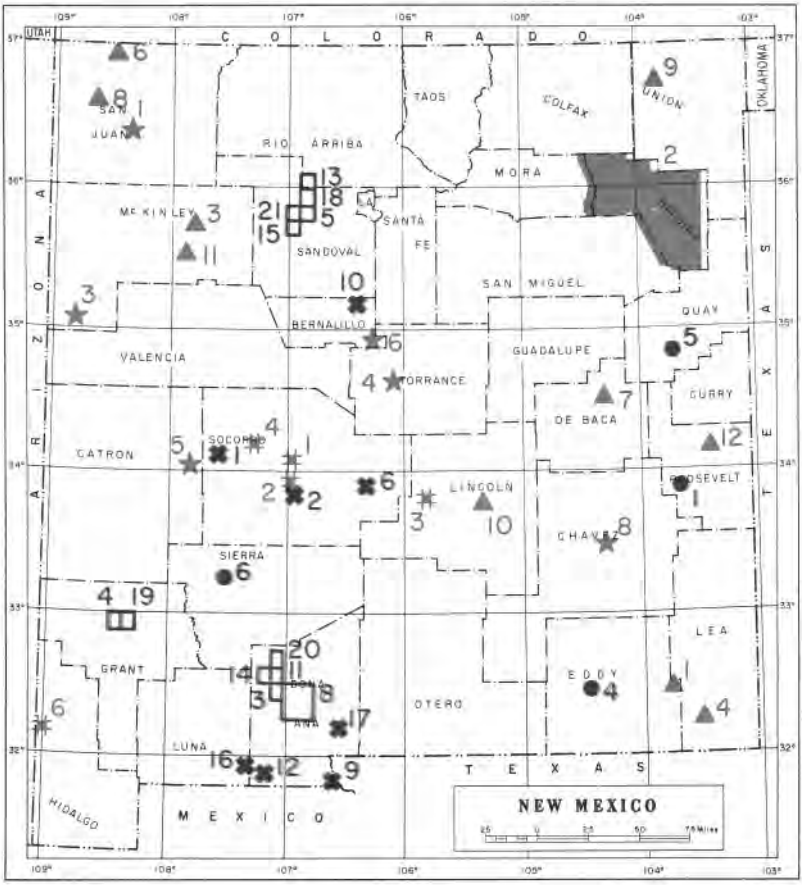
1. *Flower*—Ordovician actinoceroids and endoceroids (Memoir 28, in press)
2. LeMone—Pennsylvanian System of Chloride Flat, Grant County (Circular 131)
3. Zidek—Pennsylvanian fishes (Circular 135, in press)
4. Leonard, Frye, and Glass—Late Cenozoic mollusks and sediments, southeastern New Mexico
5. LeMone—Florida Formation
6. Leonard and Frye—Pliocene and Pleistocene deposits and molluscan faunas, east-central New Mexico (Memoir 30, in press)

Special Projects

1. *Roman*—Open-pit mining sequence (Progress Report 8)
2. Faith—Trace elements in Questa area (open-file report 50)

(continued on page 10)

Bureau Field Projects



Energy Resources

Industrial Rocks and Minerals

Water Resources

Mining Districts

Geologic-Mineral Resources Maps

3. Lifshitz-Roffman–Weathering of basalts (open-file report 36)
4. Publication of *Isochron/West*, a periodic bulletin of isotopic geochronology (in cooperation with Nevada Bureau of Mines and Geology)
5. *Brandvold*–Atomic absorption methods (Circular 142, in press)
6. *Weber*–Petrography and chemistry of two new meteorite finds in Plains of San Agustin

Metallurgy

The primary functions of the Metallurgy section are: 1) provide assistance to any individual or group seeking help in developing a technical process for a mineral deposit in the state, 2) improve processes for testing ores and procedures for operating mineral-processing plants, and 3) assist in the technical education of individuals interested in the mineral industry in this state.

The price increases of gold, silver, and zinc stimulated a marked increase of interest in these metals. Heap leaching of gold and the new activitated charcoal process for recovering gold from cyanide solutions were considered; cyanide leach tests were conducted on gold from the Mogollon and White Oaks districts. A high-grade zinc oxide ore from the Deming area was tested, and several alternative procedures for recovering the zinc were suggested. Copper and fluorspar ores were tested for beneficiation processes; possible buyers for the concentrates and specifications for concentrates were suggested.

Formal courses were taught, guest lectures given, and graduate theses directed for the College Division; papers were presented at technical meetings, and; current research results published.

Current metallurgical projects:

Brierley–1) Extraction of copper from sulfide ores using a thermophilic microorganism, 2) theoretical studies on high-temperature biological leaching, and 3) biological methods for removing heavy metals from aqueous sytems.

Plouf–1) Environmental equlibrium study with water and substrata samples from the Red River upstream and downstream from Questa, 2) a feasible chloridization system for removing aluminum from clay, 3) a small-scale pilot plant for the solvent extraction of metal ions from leached ores, 4) small-scale characterization of leachability of copper oxide ores.

Roman–1) Development of an algorithm for scheduling the mining of ore and waste from an open-pit mine, 2) prediction of production rate in leaching block-caved ore remaining in stopes, 3) design of heap-leaching operation.

Analytical and X-Ray Laboratory

These laboratories are equipped to perform extensive chemical, mineralogical, and petrologic investigations. Chemical analyses, both qualitative and quantitative, are performed by classic wet-chemical and optical-spectrographic procedures, as well as by atomic absorption, X-ray, and electron-microprobe spectrometry.

The laboratories serve the public and all divisions of New Mexico Tech. Capabilities include analyzing water, ores, concentrates, geological samples, and leach liquids for the common elements or parameters.

During the year analytic assays were made of mineral samples, ore samples, water samples, metallurgical solutions, heads, concentrates, and tails on a total of 380 samples (analyzing for 1,375 elements). A data system has been established to reproduce the many water analyses run in our laboratory during the past 10 years; the file contains 350 entries and is about 60 percent complete.

The X-ray laboratory was upgraded by improving the cooling system and

installing a more powerful pump and a fail-safe switching system. Analyses were performed on a large variety of rock materials. Machine time for X-ray diffraction totaled 850 hours; for X-ray fluorescence, 2,420 hours. The electron-microprobe facility was used mainly for microanalysis of spinel inclusions in olivine phenocrysts of basalts; more than 1,000 analyses were obtained.

The thin-section laboratory produced more than 1,000 thin sections for various Bureau projects; facilities were also used extensively by the Geoscience Department. The Henry Birdseye Petrographic Laboratory was upgraded by acquiring a heating stage for studying fluid inclusions, and by acquiring a new Vickers research model reflecting microscope. Over 2,000 thin sections have been cataloged for the Henry Birdseye Laboratory, including rocks from all areas of New Mexico.

New Mexico Library of Subsurface Data

During the year 226 sets of drilling samples were added, bringing the total number of sets on hand to more than 9,000. Also acquired were electric and other types of mechanical logs from 1,236 wells, in addition to 1,225 well records from drilling operations during the fiscal year.

A collection of 138,179 scout cards from wells drilled since 1948 in southeastern New Mexico and west Texas was donated by Mr. Howard P. Holmes of Hobbs.

In cooperation with the American Association of Petroleum Geologists Research Committee and the U.S. Geological Survey, the Bureau provided information on New Mexico for a computer project involving extensive compilation of data and preparation of a wall map of North America showing the distribution of all oil and gas fields and related tectonic elements.

R. A. Bieberman submitted 39 items for each of the 137 oil and gas pools in northwestern New Mexico with maps showing location of each pool.

Publications

The Bureau issued 28 new publications in the form of bulletins, circulars, memoir, progress report, journal of geochronology, geologic maps, scenic trip, symposium proceedings, annual report, and price list. In addition, 10 publications were re-issued, while 15 other reports were placed in open-file. Publications announcement cards were prepared and mailed monthly, as has been done for the past 4 or 5 years.

EDITING AND PRINTING

A total of 1000 pages of new publications were edited and printed (scientific, 830; popular, 106; annual report, 32; publications catalog, 32). A total of 513 pages of publications were reprinted (scientific, 226; popular, 255; publications catalog, 32). A total of 10 large scale full-color geologic map sheets were published (7 sheets in 5 Geologic Maps, and 3 sheets in 2 Bulletins). Funds allocated to printing totalled $37,000, or about 5 percent of the total budget for operating the Bureau.

At the close of the fiscal year, 46 manuscripts were either in status of review or planning (an increase of 14 from previous year), while another 18 were in various stages of editing and printing.

Estimated man-years devoted to publishing activities during the fiscal year were: editing, 0.80; composing, pasteup, copyreading, and proofreading, 2.25. Approximately 29 percent of copy was made camera-ready in the Bureau; about 13 percent of printing production was run at Tech. Most of the printing (about 87 percent) was handled at the University of New Mexico Printing Plant in Albuquerque, a procedure in effect for many years.

CARTOGRAPHY

The drafting section prepares the color separations for the geologic maps, drafts illustrations for publications and open-file reports, and prepares slides shown at technical talks. Preparation of slide material includes many illustrations for institute staff outside of the bureau. The section also handles the open-file maps. Reproduction of these maps, particularly the aeromagnetic maps, has increased about 50%. Eleven projects were awaiting cartography at the close of the year.

NEW PUBLICATIONS

Bulletin 100—GEOLOGY OF SOUSE SPRINGS QUADRANGLE, NEW MEXICO, 1973, by R. E. Clemons and W. R. Seager, 31 p., 6 figures, 7 appendices, 1 map. $2.50.

Establishes correlations of rock units of southern Caballo Mountains, Rincon Hills, and San Diego Mountain areas with rock units in the Sierra de las Uvas. Provides information for mineral exploration, ground-water and land use studies, and general economic development.

Bulletin 101—GEOLOGY OF RINCON QUADRANGLE, NEW MEXICO, 1973, by W. R. Seager and J. W. Hawley, 42 p., 7 figures, 5 tables, 2 maps. $3.50.

Describes, in detail, Silurian to Holocene stratigraphy including development of Pleistocene geomorphic surfaces. The major structural features are fault systems associated with uplifts situated between the Rio Grande and Gramma grabens. Also discusses mineral deposits and ground water. Companion to Bulletins 97 and 100.

Bulletin 104—LAWS AND REGULATIONS GOVERNING MINERAL RIGHTS IN NEW MEXICO, 1973, by Victor H. Verity and Robert J. Young. $1.50.

Circular 130—HYDROCARBON POTENTIAL OF PRE-PENNSYLVANIAN ROCKS IN ROOSEVELT COUNTY, NEW MEXICO, 1973, by W. D. Pitt, 7 p., 3 tables, 3 maps. $2.00.

Briefly describes geologic structures, Precambrian terranes, stratigraphy of sedimentary units, and possible areas of hydrocarbon accumulation.

Circular 131—PENNSYLVANIAN SYSTEM OF CHLORIDE FLAT, GRANT COUNTY, NEW MEXICO, 1974, by D. V. LeMone, W. E. King, and J. E. Cunningham, 18 p., 4 figures, 9 tables, 11 photomicrographs. $1.00.

Analysis of the Oswaldo carbonate sequence indicates a shallow water, normal marine, low to moderate energy, open shelf environment. Occurrences of phylloid algae suggest a regional examination should be made to determine if biohermal bank structures are present and forming possible stratigraphic reservoirs for petroleum.

Circular 132—TRACE BASE METALS, PETROGRAPHY, AND ALTERATIONS, TRES HERMANAS STOCK, LUNA COUNTY, NEW MEXICO, 1973, by P. Doraibabu and Paul Dean Proctor, 29 p., 25 figures, and 11 tables. $2.00.

Spatial relationships exist between geochemical anamolies of zinc, lead, and copper with respect to surrounding sedimentary rocks and alluvium, known mineralized areas, petrographic textures, and alteration. Potential mineralized zones for exploring for zinc and lead are suggested.

Circular 134—COAL RESOURCES OF SOUTHERN UTE AND UTE MOUNTAIN, UTE INDIAN RESERVATIONS, COLORADO AND NEW MEXICO, 1973, by John W. Shomaker and Richard D. Holt, 22 p., 17 figures (maps in pocket), 9 tables, and appendix. $3.50.

Description and evaluation of coal resources in this area.

Circular 136—GEOSCIENCE PROJECTS FOR NEW MEXICO, 1973, by Jean Meyer Olsen and Roy W. Foster, 56 p. $2.00.

An annotated listing of current projects in geology and geophysics plus related engineering and hydrology projects. Includes current status of topographic mapping.

Circular 138–MINERAL RESOURCES AND WATER REQUIREMENTS FOR NEW MEXICO INDUSTRIES, 1973, by Earl F. Sorensen, Ronald B. Stotelmeyer, and Don H. Baker, Jr., 26 p., 1 figure, 9 tables. $1.00.

Summary of mineral production along with estimates of water supplies required by 1980, 2000, and 2020.

Circular 139–CLAY MINERALS IN EAST-CENTRAL NEW MEXICO, 1973, by H. D. Glass, John C. Frye, and A. Byron Leonard, 14 p., 8 figures, and appendix. $0.75.

Representative samples were analyzed for clay mineral composition and evaluated for identifiable sediment sources.

Circular 140–ENERGY CRISIS SYMPOSIUM, ALBUQUERQUE, NEW MEXICO, 1973, compiled by W. L. Hiss and J. W. Shomaker, 107 p. $2.50.

Organized by 7 professional societies to evaluate the effects of the energy crisis upon New Mexico. Includes the state's energy potential, options in sources and uses, and impact on development.

Circular 141–PETROGRAPHY AND PETROGENESIS OF TERTIARY CAMPTONITES AND DIORITES, SACRAMENTO MOUNTAINS, NEW MEXICO, 1974, by George B. Asquith, 6 p., 6 figures, 4 tables. $1.00.

Dominant igneous rocks are Tertiary dikes and sills of diorite and minor camptonite intruding Paleozoic sediments. Though comagmatic these rocks differ in texture and composition as a result of flow differentiation.

Circular 143–SEISMICITY OF PROPOSED RADIOACTIVE WASTE DISPOSAL SITE IN SOUTHEASTERN NEW MEXICO, 1974, by Allan R. Sanford and Tousson R. Toppozada, 15 p., 8 figures, 4 tables, 2 appendices. $1.50.

An area encompassed within a 300-km radius from the proposed site was studied for seismic risk during the planned lifetime of the facility. Seismicity was based on instrumental, reports of felt shocks, and geological evidence.

Memoir 27–PENNSYLVANIAN BRACHIOPODS AND BIOSTRATIGRAPHY IN SOUTHERN SANGRE DE CRISTO MOUNTAINS, NEW MEXICO, 1973, by Patrick K. Sutherland and Francis H. Harlow, 173 p., 18 plates, 51 figures, 30 photographs. $10.00.

Correlates local stratigraphy with Midcontinent. Proposes 3 new genera. Describes 29 new species and subspecies. Includes 21 measured sections. Companion piece to Memoir 11 issued in 1963. Descriptive statistics and specimen measurements on microfiche in appendix.

Progress Report 8–A NEW APPROACH TO THE OPEN-PIT MINING SEQUENCE PROBLEM, 1973, by Ronald J. Roman and Allan L. Gutjahr, 6 p., 3 figures. $0.50.

Uses "set dynamic programming" in a 2-dimensional example to solve the mining sequence and pit outline. Suggests how to apply this technique to a 3-dimensional real ore deposit.

Scenic Trip 9 (*completely revised*)–ALBUQUERQUE–ITS MOUNTAINS, VALLEY, WATER, AND VOLCANOES, 1974, by V. C. Kelley, 106 p., 14 figures, 3 tables, 10 maps, 40 photographs, $2.50.

Provides insight to geology of the Albuquerque area and how it affects present day use of the land. Explains problems posed by storm runoff, ground water, and river floods. Five motor trips tour the area plus a side trip into Tijeras Canyon and a ride up spectacular Sandia Peak Tramway.

Isochron/West–Nos. 7, 8, and 9, edited by John H. Schilling, 25 p., 43 p., and 32 p. Available by subscription (5 issues for $3.00) or $1.00 each. (Price increase with No. 11.)

A serial journal of isotopic geochronology.

Geologic Map 27–GEOLOGIC MAP AND SECTIONS OF RANCHO DEL CHAPARRAL QUADRANGLE, NEW MEXICO, 1973, by Lee A. Woodward, William H. Kaufman and Richard K. Reed. $1.50.

Text on map.

Geologic Map 28–GEOLOGIC MAP AND SECTIONS OF LA VENTANA QUADRANGLE, NEW MEXICO, 1973, by Lee A. Woodward and Otto Schumacher. $1.50.

Text on map.

Geologic Map 29–GEOLOGIC MAP AND SECTIONS OF BISHOP CAP-ORGAN MOUNTAINS AREA, NEW MEXICO, 1973, by William R. Seager. $1.50.

Text on map.

Geologic Map 31–GEOLOGIC MAP OF GRANTS URANIUM REGION, 1974, by Chapman, Wood and Griswold, Inc., 3 sheets. $5.00.

Shows major uranium mines and area of indicated substantial uranium mineralization in Morrison Formation: text also printed on map.

Geologic Map 32–GEOLOGIC MAP AND SECTIONS OF NACIMIENTO PEAK QUADRANGLE, NEW MEXICO, 1974, by L. A. Woodward, D. McLelland, and W. H Kaufman. $1.50.

Text on map.

Price List 5–PUBLICATIONS AVAILABLE FROM NEW MEXICO STATE BUREAU OF MINES AND MINERAL RESOURCES, December 1973. Free.

Comprehensive listing of geologic and mineral reports and maps, with subject and author index and colored index map.

Brochure–BASE METAL AND FLUORSPAR DISTRICTS OF NEW MEXICO

(Abstracts of papers presented at symposium in Socorro, May 1974 cosponsored by Bureau and the New Mexico Geological Society.)

Annual Report–NEW MEXICO BUREAU OF MINES & MINERAL RESOURCES JULY 1, 1972 TO JUNE 30, 1973, by F. E. Kottlowski and staff, 32 p. Free.

RE-ISSUED PUBLICATIONS

Bulletin 8–ORE DEPOSITS OF SOCORRO COUNTY, NEW MEXICO (1932). $4.00.
Isochron/West–Nos. 3, 4, and 5 (available by subscription only).
Resource Map 2–NEW MEXICO ENERGY RESOURCES (1969). $1.00.
State Park Brochures–ELEPHANT BUTTE LAKE and CONCHAS LAKE. Free.
Price List 5 (1973). Free.
Scenic Trip 8–MOSAIC OF NEW MEXICO'S SCENERY, ROCKS, AND HISTORY (1967). $2.50.
Scenic Trip 11–CUMBRES AND TOLTEC SCENIC RAILROAD (1972). $2.50.

OPEN-FILE REPORTS

Open-file Report 33–HYDROGEOLOGY AND WATER SUPPLY OF THE PUEBLO OF ZUNI, MCKINLEY, AND VALENCIA COUNTIES, NEW MEXICO, 1972, by W. K. Summers, 118 p., 11 tables, 24 figures, 7 appendices, 3 plates.

Open-file Report 34–COAL RESERVES OF HOGBACK MOUNTAIN TONGUE OF MENEFEE FORMATION, SAN JUAN BASIN, NEW MEXICO, 1974, by John W. Shomaker, 6 p., 1 table, 3 figures.

Open-file Report 35–SAN ANTONIO BARITE MILL FLOW SHEET, 1974, by Thomas M. Plouf, 6 p.

Open-file Report 36–NATURAL AND EXPERIMENTAL WEATHERING OF BASALTS, 1971, by Haia Lifshitz-Roffman, 123 p., 20 tables, 16 figures, New Mexico Tech Ph.D. dissertation.

Open-file Report 37–GEOLOGY AND REGIONAL HYDROLOGY OF THE PECOS RIVER BASIN, NEW MEXICO, 1972, by W. K. Summers, 208 p., 20 tables, 60 figures, 27 plates.

Open-file Report 38–ORIGIN OF POPOTOSA FORMATION, NORTH-CENTRAL SOCORRO COUNTY, NEW MEXICO, 1973, by James E. Bruning, 132 p., 7 tables, 29 figures, 5 plates, New Mexico Tech Ph.D. dissertation.

Open-file Report 39–MAP OF CAT MOUNTAIN-TRES MONTOSAS AREA (preliminary), 1974, by William W. Wilkinson.

Open-file Report 40–GEOLOGY OF THE COUNCIL ROCK DISTRICT, SOCORRO COUNTY, 1974, by Richard M. Chamberlin, 134 p., 5 tables, 19 figures, 1 plate, New Mexico Tech M.S. thesis.

Open-file Report 41–GEOLOGY OF THE SILVER HILL AREA, SOCORRO COUNTY, NEW MEXICO, 1973, by Donald B. Simon, 101 p., 2 tables, 18 figures, 1 plate, New Mexico Tech M.S. thesis.

Open-file Report 42–GEOLOGY OF THE SOUTHERN BEAR MOUNTAINS, SOCORRO COUNTY, NEW MEXICO, 1972, by David M. Brown, 110 p., 3 tables, 16 figures, 1 plate, New Mexico Tech M.S. thesis.

Open-file Report 43–MAP OF KELLY DISTRICT (preliminary), 1974, by Robert B. Blakestad.

Open-file Report 44–MAP OF CENTRAL MAGDALENA MOUNTAINS, 1974, by Dieter A. Krewedl.

Open-file Report 45–COMPOSITE MAP OF MAGDALENA-TRES MONTOSAS AREA (preliminary), 1974, by C. E. Chapin, R. B. Blakestad, D. M. Brown, R. M. Chamberlin, D. A. Krewedl, and D. B. Simon.

Open-file Report 46–COMPOSITE STRATIGRAPHIC COLUMN, MAGDALENA AREA, 1974, by C. E. Chapin.

Open-file Report 47–GENERALIZED MAP SHOWING STRUCTURE AND STOCKS IN MAGDALENA AREA, 1974, by C. E. Chapin.

OUTSIDE PAPERS SPONSORED IN PART BY BUREAU

(names of Bureau staff members are italicized)

Brierley, C. L., 1974, Leaching: use of a high-temperature microbe: Solution Mining Symposium, Proceedings of Symposium, 103rd AIME Annual Meeting, Dallas, Texas, p. 461.

———, 1973, Molybdenite leaching: use of a high-temperature microbe: Proceedings of the Climax First International Conference on the Chemistry and Uses of Molybdenum, University of Reading, England, ed. P. C. H. Mitchell, p. 126.

Brierley, C. L., Brierley, J. A., and Murr, L. E., 1973, Using the SEM in mining research: Research/Development, v. 24, n. 8, p. 24-28.

Bruning, J. E. and *Chapin, C. E.*, 1974, The Popotosa Formation—a Miocene record of Basin and Range deformation, Socorro County, New Mexico (abs.); Geol. Soc. America, Abstracts with Programs, v. 6, n. 5, p. 430-431.

Chapin, C. E., 1974, Three-fold tectonic subdivision of the Cenozoic in the Cordilleran foreland of Colorado, New Mexico, and Arizona (abs.): Geol. Soc. America, Abstracts with Programs, v. 6, n. 5, p. 433.

Chapin, C. E., Blakestead, R. B., and Loring, A. K., 1974, New Mexico in the Cenozoic tectono-magmatic framework (abs.): New Mexico Geol. Soc., Program from Annual Meeting, May, 1974, p. 8.

Chapin, C. E., Blakestad, R. B., Bruning, J. E., Brown, D. M., Chamberlin, R. M., Drewedl, D. A., Siemers, W. T., Simon, D. B., and Wilkinson, W. H., 1974, Exploration framework of the Magdalena area, Socorro County, New Mexico (abs.): New Mexico Geol Soc., Program from Annual Meeting, May, 1974, p. 9.

Coleman, D. D., 1974, Illinois State Geological Survey radiocarbon dates V: Radiocarbon, v. 16, n. 1, p. 105-117 (New Mexico dates p. 113-114, collected by J. C. Frye and A. B. Leonard).

Greenwood, E. and *Kottlowski, F. E.*, 1974, Geology of the Pedregosa basin in southwesternmost New Mexico (abs.): Southwest Section Am. Assoc. Petroleum Geologists, Program, El Paso, Texas.

Kelley, Vincent C. and *Kelley, Robert W.*, 1972, Road log of Tucumcari, Canadian Escarpment and Santa Rosa country, p. 46-55, illus.; Road log of Santa Rosa, Clines Corners, Encino, Duran, and Vaughn country, p. 56-64, illus.: New Mexico Geol. Soc. Guidebook of East-central New Mexico, 23rd Field Conf.

Kottlowski, F. E., 1973, Use, quality, and reserves of coal in San Juan basin, New Mexico (abs.): Geol. Soc. America, Abstracts with Programs, v. 5, n. 7, p. 697.

Kottlowski, F. E., LeMone, D. V., and *Foster, R. W.*, 1973, Remnant mountains in Early Ordovician seas of the El Paso region, Texas and New Mexico: Geology, v. 1, n. 11, p. 137-140.

Renault, J. R., 1974, Review: Granites and their enclaves by J. Didier: Am. Assoc. Petroleum Geologists, Bull., v. 58, n. 3, 555-556.

Roman, R. J., 1974, Solution mining: Mining Engineering, v. 26, n. 2, p. 43-44.

———, 1974, The role of time value of money in determining an open-pit mining sequence and pit limits: 12th International Symposium on Applications of Computers and Mathematics in the Mineral Industry, Dept. of Mining, Colorado School of Mines, Thys B. Johnson and Donald W. Gentry (eds.), v. 1, p. C72-C85.

———, 1974, Simulation of an in situ leaching operation as an aid to the feasibility study: 12th International Symposium on Application of Computers and Mathematics in the Mineral Industry, Dept. of Mining, Colorado School of Mines, Thys B. Johnson and Donald W. Gentry (eds.), v. 1, p. E22-E33.

Roman, R. J., and Olsen, C., 1974, Theoretical scale-up of heap leaching: Solution Mining, AIME, February.

Smith, D. B., 1974, Origin of tepees in Upper Permian shelf carbonate rocks of Guadalupe Mountains, New Mexico: Am. Assoc. Petroleum Geologists, Bull., v. 58, n. 1, p. 63-70.

Walker, C. W., 1972, Nature and origin of caprock overlying Gulf coast salt domes: Fourth Symposium on Salt, Northern Ohio Geological Society, Inc., Cleveland, Ohio, p. 169-195.

Weber, R. H., 1973, Geology of Mockingbird Gap site in central New Mexico (abs.): Geol. Soc. America, Abstracts with Programs, v. 5, n. 7, p. 857-858.

Yochelson, E. L., *Flower, R. H.*, and Webers, G. F., 1973, The bearing of the new Late Cambrian monoplacophoran genus *Knightoconus* upon the origin of the Cephalopoda: Lethaia, v. 6, p. 275-310.

Other Professional Activities

OUT OF STATE TRIPS BY BUREAU STAFF

Bieberman, R.: AAPG, San Antonio, TX, April.

Brandvold, L.: American Chemical Society, Southwest Section, El Paso, TX, December.

Brierley, C.: AIME, Dallas, TX, February; Conference on Heavy Metals in the Aquatic Environment, Nashville, TN, December; Hazen Research, Colorado Research Institute and AMAX Laboratories, Denver, CO, May; International Conference on Molybdenum Chemistry and Biochemistry, Stevenage and Reading, England, September; Mineral Waste Stabilization Liaison Committee, Hot Springs, AK, April; Teach short course at University of Utah, Salt Lake City, UT, March-April.

Chapin, C.: International Conference on the New Basement Tectonics, Salt Lake City, UT, June; Rocky Mountain Section GSA, Flagstaff, AZ, April; Symposium on Global Tectonics at Permian Basin Graduate Center, Midland, TX, April.

Flower, R.: International Congress of Systematic Zoology, Boulder, CO, August; U.S. National Museum, two weeks of study and discussion, June.

Foster, R.: AEC meeting, Denver, CO, October; Forum on Geology of Industrial Minerals, Columbus, OH, April; International Symposium on Underground Waste Management, New Orleans, LA, September; Interstate Oil Compact Commission, Tar Sands Committee, New Orleans, LA, December; Rocky Mountain Section on Energy Resources, Casper, WY and U.S. Bureau of Mines, Laramie, WY, June; Southwest Section AAPG, El Paso, TX, January.

Kelley, R.: Association of Earth Science Editors, Ottawa, Canada, October; Rocky Mountain Section GSA, Flagstaff, AZ, April; Southwest Section AAPG, El Paso, TX, January.

Kottlowski, F.: AAPG Executive Committee, Casper, WY, June; AASG, Bend, OR, June; AAPG, San Antonio, TX, April; GSA, Dallas, TX, November, Southwest Section AAPG, El Paso, TX, January.

Plouf, T.: Fourth Joint Chemical Engineering Conference, Vancouver, Canada, September.

Renault, J.: GSA, Dallas, TX, November; Rocky Mountain Section GSA, Flagstaff, AZ, April.

Roman, R.: AIME, Dallas, TX, February; American Mining Congress, Denver, CO, September; 12th International Symposium on Application of Computer Methods in the Mineral Industry, Golden, CO, April.

Russell, J.: AAPG, San Antonio, TX, April; GSA South Central Section, Stillwater, OK, March.

Weber, R.: Conference on Lubbock Lake Site, Lubbock, TX, March; GSA, Dallas, TX, November; Pecos Conference, Tucson, AZ, August.

OFF-CAMPUS TALKS BY BUREAU STAFF

Brierley, C.: "Molybdenite leaching and the effect of soluble molybdenum on the organisms" at Molybdenum Project Group, University of Colorado, Boulder, CO, May.

"Use of microorganisms in mining: high-temperature biogenic metals extraction" at Primary Metals Division of Anaconda, Tucson, AZ, March.

"Transport and biological effects of molybdenum in the environment" at Conference on Heavy Metals in the Aquatic Environment, Nashville, TN, December.

"Biological methods for stabilization and recovery of heavy metals in mine wastes, industrial effluents and geothermal brines" at Mineral Waste Stabilization Liaison Committee, Hot Springs, AK, April

Series of 12 lectures on bioextractive leaching, Metallurgical Engineering 573; "High temperature biological extraction of metals" at Graduate seminar; "Biological leaching", Undergraduate Seminar, Dept. of Mining, Metallurgical and Fuels Engineering, University of Utah, Salt Lake City, UT, March-April.

Flower, R.: "Evolution of the older cephalopods" at International Congress of Systematic Zoology, Boulder, CO, August.

Kottlowski, F.: "The mineral crisis" to the Santa Fe-Los Alamos chapter of New Mexico Society of Professional Engineers, Santa Fe, NM, April.

OUTSIDE CONTRACTUAL PROJECTS

Consultants

Shomaker, J. W., Albuquerque: Deep coal in San Juan Basin.
Beaumont, E. C., Albuquerque: Coal resources of New Mexico.

Professors

Clemons, R. E., New Mexico State University: Geologic map and report on the Cedar Hills-Selden Hills area; geologic report on the SE ¼ of the Corralitos Ranch 15-minute quadrangle.
Hunt, C., New Mexico State University: Surficial geological map of New Mexico.
Jahns, R. H., Stanford University: White Oaks gold district.
King, W. E., New Mexico State University: Fusulinid faunas in the Doña Ana Mountains.
LeMone, D. V., University of Texas, El Paso: Permian Hueco Group in the Doña Ana Mountains.
McAnulty, W. N., University of Texas, El Paso: New Mexico fluorspar studies in the Silver City area and Zuni district.
Owen, D. E., Bowling Green State University: Stratigraphy of the Dakota Sandstone in the area between El Vado and the southern part of the Nacimiento Mountains near Warm Springs.
Pfefferkorn, H. W., University of Pennsylvania: Plant megafossils in the Pennsylvanian in New Mexico.
Seager, W. R., New Mexico State University: Geologic maps of the Las Cruces area.
Siemers, C. T., University of New Mexico: Comparative petrology of outcrop and deep-core sandstone samples of the Cliff House and Pictured Cliffs Sandstones.
Sutherland, P. K., University of Oklahoma: Revision of Scenic Trips to the Geologic Past No. 6, Trail Guide to the Upper Pecos.
Woodward, L. A., University of New Mexico: Geologic map of the San Ysidro quadrangle and a part of the Gallina quadrangle.

Students

Benne, R. E., University of Oklahoma: Lower Gobbler Formation in the Sacramento Mountains.
Sarg, J. F., University of Wisconsin: Seven Rivers transition units.
Simpson, R., New Mexico State University: Invertebrate megafauna of the Hueco Formation of the Doña Ana Mountains.
Wheeler, C. W., University of Wisconsin: Study of the Goat Seep Reef in southeastern New Mexico.
Yurewicz, D. A., University of Wisconsin: Massive facies of the Permian Capital Formation of southeastern New Mexico.

Bureau Personnel

STAFF CHANGES

New employees joining the Bureau were: Neila M. Pearson, Draftswoman, in August 1973; Judy Russell Burlbaw, Editorial Assistant, in September 1973; Judy Peralta, Secretary in February 1974. Frank B. Kottlowski was appointed director by the Board of Regents, February 4, 1974.

Resignations during the fiscal year were: Don H. Baker, Jr., Bureau director, in July 1973; Karl Vonder Linden, Environmental Geologist, in September 1973; Charles W. Walker, Mineralogist, in September 1973; Russell J. Wood, Draftsman, in March 1974; Juarine W. Wooldridge in May 1974. Max E. Willard, Economic Geologist, passed away in July 1973.

STAFF PORTRAITS

Frank E. Kottlowski
Director,
Senior Geologist
July 2, 1951

Diane Allmendinger
Clerk-Typist
August 10, 1972

William E. Arnold
Scientific Illustrator
January 4, 1954

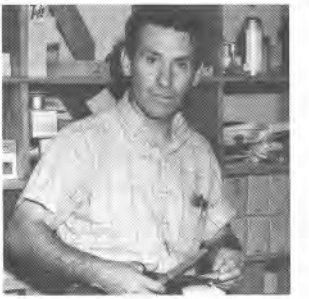
Robert A. Bieberman
Petroleum Geologist
June 1, 1950

Lynn A. Brandvold
Chemist
November 10, 1965

Corale Brierley
Chemical Microbiologist
September 1, 1971

Judy Burlbaw
Editorial Assistant
September 4, 1973

Charles E. Chapin
Geologist
June 1, 1970



Richard R. Chavez
Technician
February 21, 1957

Jill Collis
Secretary
June 28, 1971

Lois M. Devlin
Office Manager
January 24, 1962

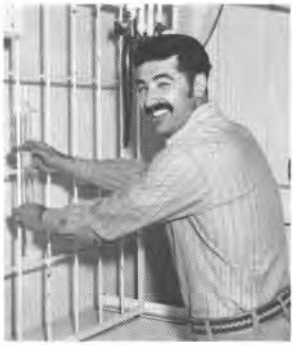
Jo Drake
Administrative Assistant, Director's Secretary
September 10, 1968

Rousseau H. Flower
Senior Paleontologist
September 1, 1951

Roy W. Foster
Petroleum Geologist
November 19, 1953

Robert W. Kelley
Editor, Geologist
May 15, 1971

Neila M. Pearson
Draftswoman
August 15, 1973



Thomas M. Plouf
Research Extractive Metallurgist
August 14, 1972

Jacques R. Renault
Geologist
September 1, 1964

Ronald J. Roman
Chief Research Metallurgist
May 5, 1969

Jackie H. Smith
Laboratory Assistant
December 16, 1963

Robert H. Weber
Senior Geologist
May 15, 1950

Shirley Whyte
Clerk-Typist
April 26, 1972

Juarine W. Wooldridge
Editorial Clerk
July 22, 1968

Michael W. Wooldridge
Scientific Illustrator
January 25, 1971

Appendix

follows

ENERGY RESERVES AND RESOURCES OF NEW MEXICO

by R. A. Bieberman, R. H. Weber, W. K. Summers
J. W. Shomaker, and F. E. Kottlowski, February 1975

In the order of their long-term importance to the state's citizens, New Mexico's energy reserves and resources are ranked as follows: uranium, coal, oil, gas, hydropower, geothermal, and solar.

Though large uranium reserves have been blocked out, they may be only 20 to 30 percent of the undiscovered resources. Large reserves of coal are identified, but further intensive exploration is not expected to increase the reserves more than 50 percent. Much of our coal is below strippable depth, therefore classified as a "resource" rather than as a reserve. Reserves of oil and gas are relatively low, but will be increased considerably by intensified exploration, though these efforts will be costly. The ultimate amount of petroleum that may be found could be as much as 12 times the present reserves. Geothermal power resources, though potentially large, are minor in comparison with other sources; major problems of finding and producing geothermal power relate to the infancy of production technology and the intense heat encountered.

ENERGY RESERVES AND RESOURCES OF NEW MEXICO

Energy type	Identified reserves (*proved*)	Undiscovered resources (*potential*)
Uranium	136,960 tons U_3O_8 (\$8/lb ore)	327,600 tons U_3O_8 (\$10/lb ore)
Strippable coal	5.97 billion tons	Little additional
Deeper coal	121.8 billion tons	Little additional
Oil	643 million barrels	12.6 billion barrels (speculative)
Gas	12.5 trillion cu ft	33 trillion cu ft (speculative)
Hydropower	Insignificant	Insignificant
Geothermal	Undetermined	10,000 megawatts
Solar		Unlimited

Uranium

Through 1973, New Mexico had produced 46,259,210 tons of 0.22 percent ore yielding 101,749 tons of U_3O_8. According to the U.S. Atomic Energy Commission the reserves of ore-grade uranium (at \$8.00 per lb of U_3O_8 concentrate) as of January 1, 1974 were 49,397,638 tons (average grade of 0.277 percent, containing 136,958 tons of U_3O_8 in 78 deposits). Estimates of how much more uranium will be found in New Mexico are speculative, despite present geologic knowledge of the deposits. If we consider extremely low-grade deposits such as the bituminous shales and some of the granites, a large amount of uranium could occur in these deposits, but is uneconomic to mine at present.

The AEC estimate of potential reserves (January 1, 1974) in the Colorado Plateau region is 250,000 tons of U_3O_8 at \$8.00 per lb and 360,000 tons at \$10.00 per lb. As New Mexico has 91 percent of the identified reserves in the Colorado Plateau region, the state's share of these potential reserves is 227,500 tons of \$8.00 ore and 327,600 tons of \$10.00 ore. Thus, *at \$8.00 per lb*, New Mexico's uranium reserves and resources, identified and undiscovered, total at least 364,500 tons, or, more than 3 times the entire production from 1948 to 1973.

The reserves considered by the A.E.C. are mainly in the Morrison Formation (Jurassic), with small amounts in the Todilto Limestone (Jurassic) and the Dakota Sandstone (Cretaceous). Peripheral to the Church Rock-Ambrosia Lake-Laguna-Mount Taylor mining districts, and scattered in other sandstones of Permian through Eocene age, are submarginal deposits of uranium containing 0.1 to 0.01 percent U_3O_8. If these low-grade deposits were to be mined—at future higher prices—they could double the state's reserves.

The cost of generating electric power from nuclear-powered reactors appears to range from 20 to 30¢ per million Btu's. An electrical megawatt (1 million watts) hour is equivalent to 10.32 million Btu's per hour, and thus would cost $2.06 to $3.10 per megawatt hour as compared with the present residential average of $1.59 (Speer *in* Shomaker, Beaumont, and Kottlowski, 1971).

At present productive rates of 77.6 Btu's per gram of U-235, New Mexico's reserves and undiscovered resources of 364,500 tons ($8/lb ore) could produce (455 grams per lb x 2,000 lbs per ton x 750/833 x 364,500) about 280 x 10^9 x 77.6 or about 22 x 10^{12} mega (million) Btu's in a breeder reactor. If present light-water reactors are used, the energy available (about 1½ percent of available U) would be 0.32 x 10^{12} mega Btu's.

Coal

New Mexico's major coal reserves and resources are in the San Juan basin in the northwest, and in the Raton area in the northeast. Smaller deposits occur in the Cerrillos, Una del Gato, Tijeras, Rio Puerco, Datil Mountain, Jornado del Muerto, Carthage, Sierra Blanca, and Engle areas. Most of the coal in the Raton field and the Carthage field and several other small fields is coking coal—too valuable to be used in the generation of power at a time when coking coal brings a price about four times that of steam coal.

Reserves of coking coal, therefore, should be excluded in calculating coal reserves and resources for producing electricity, synthetic gas, or synthetic oil. Coking coal reserves, as calculated by Pillmore (1969) chiefly from the Casa Grande area of the Raton field, are at least 715 million tons of coal averaging more than 13,000 Btu's per lb or a total of (13,000 x 2,000 x 715,000,000) 18.6 x 10^9 mega Btu's or 0.0186 x 10^{12} mega Btu's. Read and others (1950) estimated coking coal reserves (including measured, indicated, and inferred) for the entire Raton region as follows: 2,461 million tons to depths of 1,000 ft, 1,846.2 million tons between 1,000 and 2,000 ft, and 402.1 million tons between 2,000 and 3,000 ft—a total of 4.709 billion tons of coking coal averaging more than 13,000 Btu's per lb, giving an equivalent of 0.1222 x 10^{12} mega Btu's.

The total coal probably available in the smaller fields in New Mexico, Tijeras, Sierra Blanca, Una del Gato, Cerrillos, Carthage, and Jornado del Muerto fields, is about 1,754 million tons of bituminous and anthracite coal, averaging about 12,500 Btu's per lb, or a total of 0.0438 x 10^{12} Btu's. This total is subdivided into 841 million tons to 1,000 ft depth, 594 million tons between 1,000 and 2,000 ft, and 319 million tons between 2,000 and 3,000 ft.

Most of New Mexico's steam coal occurs in the San Juan basin. These coal beds range from subbituminous to bituminous in rank and probably have an overall average of about 11,000 Btu's per lb. Read and others (1950) estimated reserves for this large region at 54 billion tons subdivided into 22 billion tons above 1,000 ft depth, 15 billion tons between 1,000 and 2,000 ft, and 17 billion tons between 2,000 and 3,000 ft.

Fassett and Hinds (1971) and Shomaker, Beaumont, and Kottlowski (1971)

have revised the Read and others (1950) estimates upward to 120 billion tons, indicating that even more coal will be found between the surface and depths of 3,000 ft. At depths below 3,000 ft, the coal resources are probably as large as those above 3,000 ft; estimates of their occurrence are based on widely scattered data.

Strippable coal in the San Juan basin, calculated to depths of 250 ft and including only coals of minable thickness, total at least 5.97 billion tons; this estimate will be revised upward by further exploration, particularly in the southern part of the basin.

Using the estimate of 120 billion tons to a depth of 3,000 ft, and a heating value of 22 mega Btu's per ton, obtains a total heating value of 2.64×10^{12} mega Btu's available in the San Juan basin.

The Datil Mountains coal area has not been explored; it is in a rugged region remote from transportation. Read and others (1950) estimated that 1.3 billion tons of subbituminous coal may be available in that area; thorough geologic exploration would be needed to verify this figure. Much of this coal probably could not be obtained by stripmining methods.

In summary, the main coal that can be used to produce energy during the next few decades is the strippable coal in the San Juan basin totaling at least 5.97 billion tons, or an equivalent 0.13×10^{12} mega Btu's. The coal between depths of 250 and 3,000 ft, coking coal, and coal in remote areas could yield an additional 121.8 billion tons, or an equivalent of 2.7×10^{12} mega Btu's.

Oil

Estimated drilled reserves of crude oil in New Mexico at the end of 1973 were 643 million barrels, only 6.68 years supply at present producing rates. Estimates of undiscovered oil in southeast New Mexico by the National Petroleum Council (1971) (in which the New Mexico Bureau of Mines & Mineral Resources participated) total 10.1 billion barrels. In northwest New Mexico, estimating undiscovered oil is difficult because of the sparcity of deep oil tests. The Council's studies indicate that about 1.85 billion barrels of oil may be available in the northwest. The presently unproductive parts of the state may contain additional reserves; estimating them would be highly speculative. These estimates of undiscovered oil may be too optimistic by a factor of 4 or more; they may be nearer to 2 or 3 billion barrels, rather than 12 billion barrels.

Identified reserves (643 million barrels) plus undiscovered resources (11.95 billion barrels) total 12.6 billion barrels, or an equivalent heating value (crude oil averages 5⅔ mega Btu's per barrel) of 71×10^{6} mega Btu's.

Natural Gas

Proved reserves of natural gas in New Mexico at the end of 1973 were 12.5 trillion cubic feet, only 10.45 years supply at present producing rates. Estimates of undiscovered gas by the Potential Gas Committee (1969) indicate 15 trillion cubic feet available in the "potential" and "possible" categories, and an additional 13 trillion cubic feet available in the "speculative" category, for a total of 28 trillion cubic feet. Beginning with 1971 this Committee changed its reporting areas, therefore figures are no longer available for New Mexico. However, an analysis of the Committee's data, and other factors, indicates that 33 trillion cubic feet is a reasonable estimate of undiscovered potential gas in New Mexico for 1973. The total of the various "reserves" is 45.5 trillion cubic feet, or

an equivalent heating value (at 1.035 mega Btu's per MCF) of 47.1 x 10^9 mega Btu's. The present unproductive parts of the state could yield additional reserves, but estimating them is too speculative. As with the undiscovered oil, these estimates of undiscovered gas may be too large; they may be nearer 10 or 15 trillion cubic feet rather than 33 trillion cubic feet.

Hydropower

Most of the better dam sites for hydropower have been used, thus not much additional power can be gained in New Mexico from running water. Also some of the impoundments are filling with silt, diminishing their power-producing capacity.

Geothermal

At present the geothermal resources in New Mexico can only be construed. The Rio Grande rift has many features that are similar to the Imperial Valley of southern California where the U.S. Bureau of Reclamation is developing a geothermal project. Their estimates indicate that 10,500 megawatts of electric power will be available in California with present technology. With present technology, the Rio Grande rift could probably produce 1,000 to 2,000 megawatts; with foreseeable technology, production could reach 5,000 to 10,000 megawatts. Most of the development will be on federal-controlled land. Other areas, especially those in the Gila River basin, have potential but the magnitude of the resource cannot be estimated by analogy. Exploration by Union Oil Co. in the Jemez Mountains could lead to development of a power plant in that area within the next few years.

Solar

New Mexico is situated in one of the major high-intensity sunshine belts of the United States. When the technology is developed to the stage where solar power becomes commercially feasible, New Mexico would be in a favorable position for its utilization. The source of this type of energy is practically unlimited. Production depends almost entirely upon the availability of sunshine and technological developments of gathering solar energy and converting to other useable forms. However, space heating and cooling appear to be the main practical usage of solar energy.

Asphaltic Sandstones and Oil Shales

There are numerous occurrences of asphaltic sandstone and limestone in New Mexico (Foster, 1965). The only known large deposit occurs in the Santa Rosa Sandstone near the city of Santa Rosa. This deposit contains an estimated 100 million tons of sandstone having an asphalt content of at least 4 percent. Most of this deposit will be covered by the waters of Los Esteros Lake.

Potential shale oil occurs in many parts of New Mexico; however, the oil shale deposits are relatively thin as compared with those in the Green River Formation of Colorado and Utah. The commercial significance of New Mexico oil shales, therefore, is doubtful.

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MINERAL PRODUCTION IN NEW MEXICO[1]

Prepared by U.S. Bureau of Mines, October 18, 1974

Mineral	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
Clays[2] ..... thousand short tons	65	$108	88	$619
Coal (bituminous) ..... do	8,248	29,794	9,069	31,862
Copper (recoverable content of ores, etc.) short tons	168,034	172,067	204,742	243,643
Gem stones	NA	68	NA	70
Gold (recoverable content of ores, etc.) troy ounces	14,897	873	13,864	1,356
Gypsum ..... thousand short tons	W	W	255	1,220
Iron ore (usable) thousand long tons, gross weight	W	W	5	114
Lead (recoverable content of ores, etc.) short tons	3,582	1,077	2,556	833
Lime ..... thousand short tons	28	W	44	793
Manganiferous ore (5 to 35 percent Mn) short tons	27,837	W	32,084	W
Mica, scrap ..... thousand short tons	14	W	10	82
Natural gas ..... million cubic feet	1,216,061	225,420	1,218,749	287,889
Natural gas liquids:				
Natural gasoline and cycle products thousand 42-gallon barrels	10,338	29,970	9,848	32,449
LP gases ..... do	27,859	45,689	29,652	74,427
Peat ..... thousand short tons	2	46	3	50
Perlite ..... do	478	5,698	478	5,024
Petroleum (crude)—thousand 42-gallon barrels	110,525	376,778	100,986	414,041
Potassium salts ..... thousand short tons	2,296	91,115	2,168	91,996
Pumice ..... do	311	809	339	1,001
Sand and gravel ..... do	7,600	8,553	10,641	15,753
Silver (recoverable content of ores, etc.) thousand troy ounces	1,017	1,713	1,111	2,843
Stone ..... thousand short tons	2,768	5,499	2,830	5,894
Tin ..... long tons	—	—	8	25
Uranium (recoverable content U_3O_8) thousand pounds	10,808	68,091	9,140	59,410
Zinc (recoverable content of ores, etc.) short tons	12,735	4,521	12,327	5,094
Value of items that cannot be disclosed: Carbon dioxide, cement, fire clay, fluorspar (1972), molybdenum, salt, vanadium and values indicated by symbol W	XX	29,403	XX	29,606
Total	XX	1,097,292	XX	1,305,644
Total 1967 constant dollars	XX	905,376	XX	958,604[3]

[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers)

[2]Excludes fire clay: included with "Value of items that cannot be disclosed"

[3]Preliminary

NA–Not available

W–Withheld to avoid disclosing individual company confidential data; included with "Value of items that cannot be disclosed"

XX–Not applicable

PETROLEUM DEVELOPMENTS FOR 1973

by Roy W. Foster

Production and Reserves

In 1973 (calendar year) New Mexico ranked 6th in the production of crude oil in the United States, and 4th in the production of natural gas. The leading states in terms of both production and reserves are given below.

LEADING STATES IN PRODUCTION AND RESERVES
OF OIL AND GAS, 1973
(rank based on percent of total for U.S.;
sources: American Petroleum Institute & American Gas Association)

CRUDE OIL				NATURAL GAS			
Production		Proved reserves		Production		Proved reserves	
Texas	40%	Texas	33%	Louisiana	37%	Texas	34%
Louisiana	23	Alaska	29	Texas	36	Louisiana	28
California	11	Louisiana	13	Oklahoma	8	Alaska	13
Oklahoma	6	California	10	New Mexico	5	Oklahoma	6
Wyoming	4	Oklahoma	4			New Mexico	5
New Mexico	3	Wyoming	3				
		New Mexico	2				

Production of crude oil and condensate continued to decline from the high of 122 million barrels produced in 1970 to slightly less than 101 million barrels in 1973. Between 1972 and 1973 production declined 9 percent. Most of the decrease occurred in Lea County, but all producing counties had lower production figures for 1973. The American Petroleum Institute estimate of recoverable reserves of crude oil showed an increase of approximately 60 million barrels over 1972. Less than one percent of this increase was attributable to new discoveries, the rest being accounted for by revisions of estimates of recoverable oil from previously discovered reservoirs.

Dry and casinghead gas production increased slightly over 1972 to a record 1.2 trillion cubic feet. Production increases were recorded in Lea, Eddy, and McKinley Counties, with declines in Chaves, Roosevelt, Rio Arriba, Sandoval, and San Juan Counties. As in 1972 the greatest increase was in Eddy County where production gained 43 billion cubic feet over the previous high registered in 1972. The American Gas Association estimate of reserves of natural gas increased some 152 billion cubic feet despite the record production level. As in the case of crude oil most of the increase was the result of revisions of estimates of previously discovered reserves. However, six percent of the new reserves were credited to 1973 discoveries.

OIL AND GAS PRODUCTION, 1973

(Annual Report of New Mexico Oil and Gas Engineering Committee)

County and area	CRUDE OIL (barrels) Production	Gain (+) or decline (–) from 1972	NATURAL GAS (thousands cu ft) Production	Gain (+) or decline (–) from 1972
Chaves	1,921,113	–383,158	10,308,112	–2,551,911
Eddy	18,040,298	–1,154,047	211,255,626	+43,138,687
Lea	71,834,891	–6,292,178	420,152,926	+809,880
Roosevelt	1,619,834	–674,693	7,704,278	–3,410,984
Southeast area	93,416,136 (93%)	–8,504,076	649,420,942 (54%)	+37,985,672
McKinley	1,673,451	–179,106	2,355,302	+785,551
Rio Arriba	1,615,735	–279,278	178,646,703	–6,378,399
Sandoval	200,408	–37,930	1,039,199	–280,211
San Juan	4,079,956	–539,148	368,077,284	–30,342,841
Northwest area	7,569,550 (7%)	–1,035,462	550,118,488 (46%)	–36,215,900
State totals	100,985,686	–9,539,538	1,197,769,658	+1,769,772

OIL AND GAS RESERVES, 1973

(Annual Reports of American Gas Association and American Petroleum Institute)

Area	CRUDE OIL (barrels) Reserves	Gain (+) or decline (–) from 1972	NATURAL GAS (thousands cu ft) Reserves	Gain (+) or decline (–) from 1972
Southeast area	619,134,000 (96%)	+60,787,000	4,502,977,000 (36%)	+328,204,000
Northwest area	23,860,000 (4%)	–386,000	7,985,386,000 (64%)	–175,488,000
State totals	642,944,000	+60,401,000	12,488,363,000	+152,716,000

Drilling Summary

The number of wells drilled in New Mexico from 1972 to 1973 decreased slightly from 1,030 to 981. Drilling was approximately evenly divided between the southeast and northwest producing areas. Wildcat or exploratory wells increased from 215 to 226. New oil reserves were found in 9 of these wells; 56 were completed as gas discoveries. Exploratory success averaged 29 percent, or one discovery well for every 3.5 wells drilled—considerably above the national average. Eddy County led in the number of exploratory wells drilled with 87; 46 percent were successful, with 2 oil wells and 38 gas wells completed. Independent operators drilled 81 percent of the exploratory wells with 182 completions versus 44 for major or integrated oil companies.

Development or extension drilling of known oil and gas fields numbered 755 wells of which 212 were completed as oil wells and 445 as gas wells. Eighty-seven percent of the development wells drilled were successfully completed. The northwest area led in the number of development wells drilled during the year. The majority of development wells were drilled by integrated oil companies with 452 completions compared with 303 wells for independent operators.

Twenty-nine tests were drilled in the nonproducing counties: Colfax 9, Harding 4, Guadalupe 3, Curry 2, De Baca 2, Luna 2, Union 2, Doña Ana 1, Mora 1, San Miguel 1, Sierra 1, and Socorro 1. The Mora County well had a reported potential of 490 thousand cubic feet of gas per day. A number of the wells drilled in the northeastern part of the state were drilled to evaluate reserves of carbon dioxide. The Harding County wells and one of the Colfax tests apparently were successful in finding CO_2 but potential yields were not reported. The remaining wells drilled in the nonproducing counties failed to discover commercial amounts of oil or gas.

Forty-two service wells were drilled for a total footage of 156,461 ft. This figure includes wells for water disposal, water injection, gas storage, and gas injection.

DRILLING STATISTICS, 1973

	WILDCATS			DEVELOPMENT			TOTALS		
County and area	No. of wells	Total footage	Average depth (ft)	No. of wells	Total footage	Average depth (ft)	No. of wells	Total footage	Average depth (ft)
Chaves	29	130,367	4,495	16	47,203	2,950	45	177,570	3,946
Eddy	87	695,594	7,995	106	939,132	8,860	193	1,634,726	8,470
Lea	22	220,922	10,042	193	1,262,997	6,544	215	1,483,919	6,902
Roosevelt	8	66,853	8,357	11	60,856	5,532	19	127,709	6,772
Southeast area	146	1,113,736	7,628	326	2,310,188	7,086	472	3,423,924	7,254
McKinley	25	72,330	2,893	11	19,149	1,740	36	91,479	2,541
Rio Arriba	3	10,418	3,473	169	871,596	5,157	172	882,014	5,128
Sandoval	10	26,137	2,614	14	42,057	3,004	24	68,194	2,841
San Juan	13	26,112	2,009	235	921,688	3,922	248	947,800	3,822
Northwest area	51	134,997	2,647	429	1,854,490	4,323	480	1,989,487	4,145
All other counties	29	118,483	4,086	–	–	–	29	118,483	4,086
State totals	226	1,367,216	6,050	755	4,164,678	5,516	981	5,531,894	5,639

SYMPOSIUM ON BASE METALS AND FLUORSPAR

by Charles E. Chapin

Base metal districts of New Mexico and fluorspar highlighted a 3-day symposium held May 22-25 on campus, and cosponsored by the Bureau and the New Mexico Geological Society. Twenty-six papers with 46 authors were presented to more than 300 attendees from throughout the United States. Dr. Spencer Titley, University of Arizona, gave the keynote address *The nature and significance of pyrometasomatic alteration of some Cordilleran ore deposits.* The outstanding response to the symposium was due to the boom in mineral exploration being experienced by New Mexico. Realization is spreading that New Mexico is a relatively unexplored state with enormous mineral potential and a variety of significant geologic and mineral research problems. Sixty-five percent of the papers represented initial publication of research projects instituted since 1970 (12 papers represented projects supported by the Bureau).

The conference committee was chaired by Charles Chapin. W. N. McAnulty, University of Texas at El Paso, organized the fluorspar part of the program. The symposium concluded with a day long field trip to the Magdalena area lead by Chapin. The 180 participants traveled to the crest of the Magdalena range at North Baldy in a caravan of 48 four-wheel-drive vehicles. Two other stops were made to examine the newly recognized Permian section at the northern end of the Magdalena range and the Cat Mountain mining district.

On the day before the symposium, the Bureau released open-file geologic maps covering about 300 square miles of the Magdalena area (prepared by C. E. Chapin, R. B. Blakestad, J. E. Bruning, D. M. Brown, R. M. Chamberlin, D. A. Krewedl, W. T. Siemers, D. B. Simon, and W. H. Wilkinson). A composite stratigraphic column and a generalized structure map of the Magdalena area were included. In addition, open-file geologic and geochemical maps of the Central Peloncillo Mountains in Hidalgo County, prepared by R. B. Carter, M. L. Silberman, and A. K. Armstrong of the U.S. Geological Survey (in a cooperative project with the Bureau) were available for review.

(Color photos on following page are through courtesy of W. L. Hiss.)

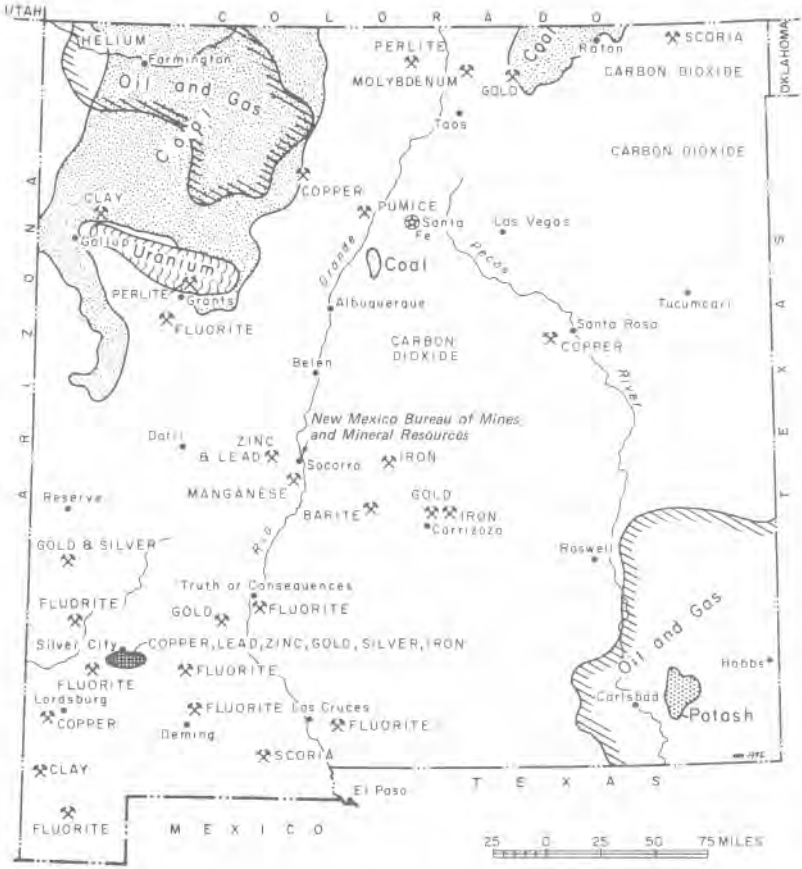
Field trip leader Charles Chapin points out geology from atop North Baldy (about 10,000 ft) in the Magdalena Mountains. In the distant background, to the north, is Ladron Peak and the Colorado Plateau.

Rugged mountain terrain at the south end of the Kelly mining district. The high point on right skyline is South Baldy (about 11,000 ft) that overlooks Tech's well-known Langmuir Laboratory for research in atmospheric physics (beyond skyline to south).

Lunch stop at high point of jeep road on east slope of North Baldy. View is east. Distance to Socorro Peak at left is about 12 miles. Valley of Rio Grande is another 5 or 6 miles.

SOME OF NEW MEXICO'S MINERAL RESOURCES

New Mexico ranks among the leading states in value of minerals produced – over $1 billion annually



LEGEND

- Oil field
- Gas field
- Oil pipeline (6 to 16 inch)
- Petroleum products pipeline (6 to 12 inch)
- Gas pipeline (2 to 34 inch)
- Coal field
- Gas processing plant
- Oil refinery
- Generating station
- Major electric lines
- Uranium production

COVER: "New Mexico Energy Resources"
Small-scale version of Resource Map 2 by
New Mexico Bureau of Mines & Mineral Resources