Annual Report
July 1, 1982, to June 30, 1983
56th year

by Frank E. Kottlowski and staff

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES

Division of New Mexico Tech

Contributed papers

ANNUAL REPORT 1982–83 New Mexico Bureau of Mines & Mineral Resources 1984
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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May 23, 1984

TO: Toney Anaya, Governor of New Mexico
Board of Regents, New Mexico Institute of Mining & Technology
Laurence Lattman, President, New Mexico Institute of Mining and Technology
Paul Biderman, Secretary, New Mexico Energy & Minerals Department

We have the honor of transmitting to you a detailed Annual Report of the New Mexico Bureau of Mines and Mineral Resources for the fiscal year July 1, 1982 through June 30, 1983 as required by law (Section 3, Chapter 115, Eighth New Mexico Legislature, approved March 14, 1927).

In this, our 56th year of service and applied research, the Bureau provided information concerning exploration, development, and conservation of New Mexico's mineral resources, as well as doing broad investigations of the State's geology. Twenty new publications were issued, along with 17 open-file reports, and usual numbers of New Mexico Geology and Isochron/West. Our staff members served professional and scientific organizations and cooperated with other state agencies, including our liaison with the Energy and Minerals Department.

The Bureau's service to New Mexico is based on the expertise and dedication of our staff. With the demand for top-notch geologists and engineers and the higher salaries paid by industry and the federal government, hiring and retaining quality professionals continues to be significant problem.

Robert Kelley retired after 11 productive years as NMBM&MR Editor. John Hawley was made an Honorary Member by the New Mexico Geological Society. Seven staff members had more than 15 years of service: Lynn Brandvold 17, Jacques Renault 18, Lois Devlin 21, Richard Chavez 26, Frank Kottlowski 31, and Robert Weber and Robert Bieberman 33 years.

In cooperation with the New Mexico Geological Society, a handsome updated New Mexico Highway Geologic Map was published. The new two-story south addition to our wing was completed which houses the New Mexico Library of Subsurface Data, the AML Technical Information, Resources, and Service Center, and offices for petroleum, coal, and economic geologists.

New Mexico is rich in mineral resources, especially energy materials. Thus, the emphasis of our program will continue to be to aid and encourage the exploration, development, and prudent handling of these resources while striving, always, for technical and scientific excellence that accrues the greatest benefit to the State.

Respectfully submitted,

Frank E. Kottlowski
Director

George S. Austin
Deputy Director

New Mexico Bureau of Mines & Mineral Resources

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

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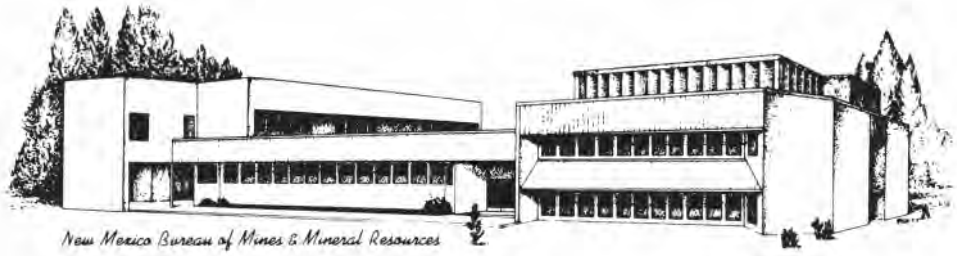

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Purpose and functions

The New Mexico Bureau of Mines and Mineral Resources is the official state agency responsible by law for original investigations in geology and mineral resources in the state. The Bureau investigates, evaluates, and disseminates information on geology, mineral resources, energy resources, and metallurgy. Our emphasis is on finding and harvesting the nonrenewable resources of the state for the benefit and well-being of the citizens of New Mexico with full consideration of environmental impacts.

For 56 yrs NMBMMR has served New Mexico in this legislative-assigned role. Most of our investigations have been reported on in numerous bulletins, memoirs, circulars, ground-water reports, hydrologic reports, geologic maps, scenic-trip guidebooks, resource maps, and open-file reports. In addition, hundreds of articles have been published by staff members and by research associates in journals of professional and scientific societies, and staff members have made many scientific and technical presentations to state, national, and international organizations. NMBMMR's program of geologic and mineral resources studies has contributed significantly to New Mexico's position as a leading producer of energy and mineral materials.

In 1982 the value of minerals extracted in New Mexico totaled $6.7 billion. Payments from the U.S. Bureau of Land Management and compensatory reimbursement in lieu of taxes totaled $121 million. State severance and other taxes collected on minerals extracted in New Mexico during 1982, plus bonus and royalties, were almost $1 billion. Thus, New Mexico's mineral industry is one of the major contributors to the state's economy.

The Bureau's operations extend into every corner of the state and cover most of the facets of geology and mineral resources. However, most of the talents and capital for finding and developing mineral resources in New Mexico come from private industry. The Bureau contributes actively to these programs by taking the lead in applied research that insures industry's prudent growth. We serve as a clearinghouse of the best possible scientific and technical information and impartially share our files of basic data with all companies, individuals, agencies, and institutions. An outstanding example is our New Mexico Library of Subsurface Data. Oil-well samples and records, secured by companies and individuals at a cost of billions of dollars, are freely accessible at the Bureau; the value of these files increases with the passing of time.

Geology and mineral resources

Geologic knowledge is indispensable in the exploration and development of mineral resources. Field investigations, regional geologic reports, structure–contour maps, detailed and reconnaissance geologic maps, and stratigraphic studies aid in finding and extracting mineral ores. Many geologists, mining engineers, prospectors, and landowners visit the Bureau to confer on geologic data and interpretations. Most of the Bureau's work is in technical services, but basic and applied geologic research is also significant.

The scientific and technical literature generated by the Bureau contributes greatly to mineral exploration. Sales of Bureau publications totaled $65,698 this fiscal year; approximately 8,600 copies of the new publications were issued free to state officials, libraries, and scientific organizations. Sales performance of a particular publication, however, does not necessarily reflect its ultimate worth to New Mexico; any 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, the arroyos and mesas, and the volcanoes 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 books also are designed to keep tourists in the state for an extra day that is so important to New Mexico's economy. Tens of thousands of copies have been distributed, and the demand continues. The Bureau also publishes other more technical guidebooks.

Most of our geologic work comprises "ground truth" investigations, as demonstrated by the more than 249,100 mi logged by Bureau field vehicles during the fiscal year.

Basic services

Citizens of New Mexico and elsewhere, including geologists, engineers, landowners, prospectors, legislators, students, industry personnel, and tourists, sought technical advice from Bureau staff this year. Our records show that 12,120 letters and 12,080 telephone inquiries were answered, and 9,470 office visitors were counseled. Many adults and school children toured the Bureau's mineral museum. More than 5,500 analytical reports were prepared on mineral, ore, metallurgical, and water samples. Staff mineralogists identified hundreds of hand specimens of rocks and minerals brought or mailed to the Bureau.

Direct services to petroleum exploration included making available records of many of the more than 80,000 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.

A number of 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 papers at scientific meetings, and served New Mexico Tech by teaching, directing graduate studies, and participating in the work of Institute groups.

ACKNOWLEDGMENTS—Editing was done by Deborah Shaw. George Austin, Judy Vaiza, and Jeanette Chavez compiled part of the report. Drafting was done by Michael Wooldridge and Linda Wells–McCowan. All staff members aided in providing data on projects and services; special appreciation is owed to authors of the technical articles.

Laboratories

Analytical

The analytical laboratory at the New Mexico Bureau of Mines and Mineral Resources is primarily a service facility for Bureau personnel. The laboratory is equipped to do geochemical analyses, bulk rock analyses, metallurgical analyses, water analyses, and fire assays. As a public service we will perform analyses on up to three samples per year, free of charge, for New Mexico citizens on samples from New Mexico. This year the laboratory ran 4,972 analyses on 1,377 samples.

The laboratory was also involved in several research projects in the areas of acid rain and trace-metal contaminants in Rio Grande sediments.

—Lynn A. Brandvold, Senior Chemist

Lynn A. Brandvold
Senior Chemist
11/10/65

Barbara R. Popp
Lab. Biotechnologist
7/17/78

Metallurgy

The metallurgy laboratory at the New Mexico Bureau of Mines and Mineral Resources offers technical assistance to those engaged in mining activities in New Mexico. The purpose is to develop or improve processes that can be applied to ores from New Mexico.

The laboratory is equipped with the standard equipment required for mineral-processing investigations, which includes crushing, grinding, sizing, flotation, gravity, and hydrometallurgy equipment. These facilities are open to use by the Bureau staff and the geotechnical departments at the New Mexico Institute of Mining and Technology.

—Michael Harris, Metallurgist

Ruben Archuleta
Metallurgical Technician
4/16/79

Annabelle Lopez
Staff Secretary
6/27/83

New Mexico Library of Subsurface Data

This year the staff aided 425 visitors and received 490 telephone calls and 438 letter inquiries. During the year 453 driller's logs and 435 petroleum-exploration maps were distributed, and 552 mechanical logs and 87 well-cuttings sets were loaned. In addition, 4,502 well records were copied.

Data added to the files during the year included 244 driller's logs (11,477 on file), 7,000 mechanical logs (over 60,000 on file) from 1,590 wells (26,789 on file), and 558 boxes of cuttings (37,742 on file) from 165 wells (11,171 on file). In addition, 2,398 new well records (over 80,000 on file) were added.

The library is an important source of information regarding exploration for petroleum, coal, uranium, and carbon dioxide. It is used by industry and graduate students as well as by Bureau geologists. Data items on file in the petroleum section include well cuttings, well records, driller's logs, sample descriptions and logs, mechanical logs, geologic maps, petroleum-exploration maps, production data, petroleum-geologic publications, and field and pool definitions and data.

In February, the Petroleum Records office moved into new quarters upon completion of an addition to the building housing the Bureau. The new facility provides much more efficient laboratory and file space and opens up growth space for the cuttings collection.

—Robert A. Bieberman, Senior Petroleum Geologist

Robert A. Bieberman
Senior Petrol. Geologist
6/1/50

Richard Chavez
Asst. Head, Petrol. Section
2/21/57

X-ray

The x-ray analytical laboratory, purchased in 1980–81, includes a modern x-ray fluorescence spectrometer, an x-ray diffractometer, and dedicated computer equipment. The lab is managed by the New Mexico Bureau of Mines and Mineral Resources and is used by many members of its professional staff and by graduate students supported by the Bureau. The geoscience department of New Mexico Tech also uses the equipment extensively. Researchers and students from the metallurgy and chemistry departments, the Petroleum Recovery Research Center, and from outside the Institute often take advantage of the facility.

The Rigaku 3064 x-ray fluorescence spectrometer has components that permit qualitative and quantitative analysis of rock powders for many elements of scientific and economic interest. The x-ray lab routinely performs accurate, precise, and rapid analyses of silicate rocks for 10 major oxides and a selected group of trace elements. A DEC PDP 11/23 computer is used to control the spectrometer and to collect, store, and process data. A great deal of effort has been directed toward developing the specialized software required to obtain high quality results automatically for the most requested elemental analyses. Purchased "Fundamental Parameters" software is also available for XRF data processing and is especially useful for specialized problems such as the analysis of ores.

The XRF spectrometer is a major tool in such current Bureau-sponsored research projects as the geochemical characterization of the Española Basin, Cenozoic volcanic rocks of the Datil–Mogollon volcanic field, and studies of coals, clays, carbonatites, Precambrian rocks, and uranium and tin ores. Upon request by state residents or organizations, analyses have been performed, free of charge, to help with specific technical questions and problems.

The Rigaku Geigerflex x-ray diffractometer is used to identify the crystalline phases present in a wide variety of geologic materials. The unit can be operated under the control of its own microprocessor or that of the PDP 11/23. With use of the computer and manufacturer-supplied "search-match" software, the diffraction pattern of a sample can be collected and stored, and its crystalline components can be identified after comparison with JCPDS reference patterns stored on disk. In addition to the new Rigaku diffractometer, older Philips diffraction equipment is available for use.

The Bureau routinely performs qualitative scans for the identification of mineral phases in samples submitted by staff members or the public. The x-ray diffraction equipment is used as a research tool by Bureau staff members. A turbine-drive sample spinner has been designed and built, which enables superb diffraction patterns to be obtained from less than 20 mg of sample. The new spinner also permits good patterns to be obtained from samples such as polished ore specimens that are normally too coarse grained for x-ray diffraction.

Because of the great increase in the use of the x-ray lab since the acquisition of the Rigaku instruments, the x-ray sample preparation facilities were modernized and expanded with the remodeling of laboratory space and the purchase of a programmable ashing furnace, efficient rock-grinding equipment, and suitable lab furniture.

—K. Babette Faris, X-ray Lab Manager

K. Babette Faris
X-ray Lab Manager
10/1/80

James Barker
Indus. Minerals Geologist
1/3/83

Core Library

The New Mexico Bureau of Mines and Mineral Resources core library occupies 3,750 ft^2 in two metal buildings west of the New Mexico Tech campus. The facility contains shelves with boxes of core, a processing area, and tables for examining material in a temperature-controlled room. Microscopes are available for use by visitors. Processing mostly involves the splitting of core, checking to see if the core is properly arranged, and labeling core boxes. The purpose for splitting the cores is to give better viewing, to reduce the weight of the core on the shelves, and to allow for sampling. The Bureau allows samples of cores to be taken, provided that at least one-half of the core remains. There are several different types of splitting machines in the core library. However, all sampling must be approved before samples are taken. In addition to the cores themselves, geophysical logs, driller's logs, and other materials are available.

The purpose of the core library is to have representative cores from many parts of New Mexico. This means that in some cases the Bureau must limit which cores can be accepted. When companies decide to empty their core sheds, they may give the Bureau many cores from a small district. In that case,the Bureau must determine what can be kept to give adequate representation and what must be returned or given away.

All core accepted must be adequately located by at least section, township, and range before it is made available for public viewing. Although the Bureau will restrict the use of core to the Bureau for a period of up to one year if requested, eventually all core must be made available for examination by the public.

More than 275 different cores in the library, from 15 companies or organizations, are now ready for examination and many others are being processed. Most of the cores that are available currently came from the Grants uranium mining district because of the recent slowdown in uranium mining activity, but there are a number of cores from other counties in the state. The age of units penetrated in these cores ranges from Holocene to Precambrian.

Companies or individuals wishing to give core to the Bureau are asked to call or write.

—George S. Austin, Deputy Director

Perlite evaluation

The Perlite evaluation laboratory of the New Mexico Bureau of Mines and Mineral Resouces is an applied research and public service facility. It is the sole perlite testing facility in New Mexico, although the state is the leading domestic perlite producer.

The laboratory consists of a Perlite Corporation Model LVP Laboratory Expanding Furnace (with preheater), which features a 4-inch × 45-inch vertical expansion chamber. Additional testing equipment includes a compaction resistance vessel and hydraulic press, a sink-float chamber, a compacted density unit, and various sieves (wet and dry), sampling devices, crushers, and other support equipment. The standard ore is Gorefco No Agua from bin #2 (−50 +100 mesh) and bin #3 (−30 +50 mesh).

The Perlite evaluation laboratory is capable of the following tests (Perlite Institute Standard) on request: sieve analysis of crude and expanded ore (PI 113 to 115–77), fractional density (PI 116–77), wet-screen analysis (PI 117–77), loose-weight density (PI 200–77), compacted density (PI 201–77), "floats" or "sinks" (PI 300–77), percent nonexpansibles (PI 301–80), and compaction resistance (PI 306–80). Many other tests can be performed by special arrangement.

A program to upgrade the accuracy and efficiency of the perlite facility is underway. This includes addition of many instruments, proper temperature control, automated feed devices to the furnace, and fabrication of specialized support equipment.

—James M. Barker, Industrial Minerals Geologist

Soils testing

The soils-testing laboratory is utilized by the NMBMMR staff for analyses of important soil parameters such as gradation, moisture content, and permeability. The laboratory is presently equipped to conduct a number of soil engineering tests such as specific gravity, Atterberg limits and indices, compaction tests, and shear strength.

These tests provide researchers with data required for environmental and geologic hazard assessments throughout the state. The basic services of the soils laboratory are available to all citizens of the state.

—Gary Johnpeer, Engineering Geologist

Service Activities

Mineral Museum

The New Mexico Bureau of Mines and Mineral Resources Mineral Museum has more than 10,000 catalogued display and study specimens. The display collection, with more than 2,000 minerals on display, may be viewed from 8:00 a.m. to 5:00 p.m., Monday through Friday. The study collection, which contains more than 6,000 specimens ar-

ranged by mineral groups, is available to the public for study during regular office hours.

During the last year, 25 groups, totaling more than 800 people, arranged for special museum tours. Both students and geologists took advantage of the study collection. Fourteen new specimens were purchased at a cost of $1,300.00. The museum received 16 donated specimens worth approximately $675.00.

The "Minerals for sale" case in the museum generated $254.50, which was used to purchase new specimens for the display collection.

—Robert M. North, Mineralogist

Robert M. North
Mineralogist
9/1/78

Gretchen H. Roybal
Coal Geologist
5/19/80

National Coal Resource Data System

NCRDS (National Coal Resource Data System) is the computerized storage and retrieval system developed by the U.S. Geological Survey's Branch of Coal Resources in Reston, Virginia, to help assess the nation's coal resources and coal quality. Information on New Mexico coals has been and continues to be entered into this system by the New Mexico Bureau of Mines and Mineral Resources through a cooperative grant. The data entered by NMBMMR is put into two computer files: USTRAT contains stratigraphic information on coal-bearing intervals and USALYT contains chemical analyses of individual coals. The information in USTRAT and USALYT is located by coal field, quadrangle, latitude and longitude, and township and range. Other files are in the NCRDS, such as a computer base of published resource estimates. ECOAL is the base for states east of the Mississippi River and WCOAL is for states west of the Mississippi River. The BMALYT data file has U.S. Bureau of Mines standard chemical analyses, located by state, county, coal bed name, or mine. Access to these files can be obtained by establishing an account with the U.S. Geological Survey's Coal Branch. Programs for using these files are PACER (Program to Analyze Coal Energy Resources) and GARNET (Graphic Analysis of Resources using Numerical Evaluation Techniques).

A computer data base on New Mexico coals has been established at the New Mexico Bureau of Mines and Mineral Resources. Point-source data on depth and thickness of coals have been entered for evaluation of coal resources in a coal field, formation, or township and range. Two sets of analytical data exist, one for the standard coal analyses and the other for trace-element analyses. These analyses can be statistically evaluated for a given coal field, formation, or township and range. These data bases are updated continually as more information is acquired.

Other computerized data files exist at NMBMMR on past and present coal production and mining in New Mexico. Coal production for New Mexico from the U.S. Bureau of Mines Mineral Yearbook from 1899 to 1977 is available. Information from the State Mine Inspector's reports from 1899 to 1932 on production by individual mines is on file. Also available from DOE reports is New Mexico coal production data from 1977 to the present. Additional information about the coal data present at NMBMMR can be obtained from Frank Campbell or Gretchen H. Roybal.

—Gretchen H. Roybal, Coal Geologist

Information, Resource, and Service Center

The Information, Resource, and Service Center is a repository for records pertaining to mines, prospects, mineral industries, and geology of New Mexico. The Center was initiated in 1983 under contract to New Mexico's Energy and Minerals Department with funds originating from the federal Office of Surface Mining. The Center has three basic functions: 1) acquisitions, 2) data management, and 3) information dissemination.

During the first year of operation, the Center acquired (through donations and purchases) records on approximately 10,000 mines and prospects, more than 500 geologic and mine maps, and several thousand technical reports and books.

In order to manage these records effectively, the Center is utilizing the Tech computer to index, store, and retrieve the information.

All material held by the Center is available for public inspection during regular business hours, and copies of maps, technical reports, etc., can be provided at cost. Referrals to Bureau staff members for additional technical data and services constitute another power source of information available to the Center.

—David Menzie, Geologist–Manager

David Menzie
CRIB Geologist
12/16/80

Nanette Dynan
Receptionist
8/23/82

Ceramic testing

The New Mexico Bureau of Mines and Mineral Resources has facilities to determine many ceramic properties of clay minerals. Samples received are crushed, screened if necessary, recrushed to remove oversized material, and then splits are made. Some splits are subjected to a particle-size-distribution analysis to determine the amount of clay, silt, and coarser material present. Other splits undergo x-ray diffraction analyses to determine the mineralogy of both bulk-rock samples and $<2\mu$-m material. If necessary, further tests can be made to determine the reaction of the clay material to common ceramic processing. Samples weighing 20 lbs or more are mixed with water and extruded under pressure to form small bricketts. These bricketts can be fired in one of the Bureau's furnaces at several different temperatures to determine shrinkage, fired color, and other ceramic properties on relatively small amounts of material. Strength tests are handled under contract through the Mining Department of the New Mexico Institute of Mining and Technology, whose equipment permits a variety of testing such as determining modulus of rupture and compressive strength of dried and fired samples. New Mexico Bureau of Mines and Mineral Resources is able, therefore, to characterize the ceramic properties of clay samples. The results of these tests aid in the determination of the value of clay materials to the public, industry, and scientific communities.

—George S. Austin, Deputy Director

Geographic names

After correspondence and consultation with the NMBMMR and other state agencies, the United States Board on Geographic Names approved 60 name proposals in New Mexico from July 1982 to June 1983. The majority of these names were recommended by the U.S. Geological Survey while working on new topographic maps in the state. Thirty-two names were designated in Lincoln County, 10 in Taos County, six in Catron County, five in Hidalgo County, four in San Juan County, two in Rio Arriba County, and one in Colfax County.

—David Love, Environmental Geologist

Site identification for low-level radioactive-waste disposal in New Mexico

In accordance with provisions of the Site Identification Act, HENRCS/House Bill 397 (1981), five possible sites for a low-level radioactive-waste-disposal facility have been identified in New Mexico. These were based on national, regional, and state criteria for site selection. Major terrain, hydrogeologic features, and overall site descriptions were proposed and reported to the New Mexico Legislature on February 18, 1983 (Open-file Report 189). This is an identification of *possible* sites based on 1) review of published and unpublished information on hydrology, geology, and soils, and 2) brief visits to areas with site potential. Onsite characterization work and evaluation of socioeconomic and legal factors have not been done. This is a state-of-the-art effort that needs input and constructive criticism from public as well as professional sectors of society.

—John W. Hawley, Senior Environmental Geologist

Western States Seismic Policy Council

The purpose of the Western States Seismic Policy Council is to provide a forum for earthquake research, mitigation, preparedness, response, and seismic safety. These goals are achieved through interstate cooperation, identification of common policy issues, interdisciplinary exchange of knowledge, and influencing governmental policy. The membership of the WSSPC is open to all individuals interested in seismic policy. Meetings are held annually among the western states.

Having recognized that a seismic hazard does exist in New Mexico, the NMBMMR is an active participant in WSSPC activities. Through this organization, it is hoped that awareness of and preparation for a potentially damaging earthquake can be made.

—Gary Johnpeer, Engineering Geologist

Bibliography

The 1927 law that established the Bureau of Mines and Mineral Resources for the State of New Mexico included among the Bureau's responsibilities, "to collect a library and bibliography of literature pertaining to the progress of geology, mining, milling, smelting and the production of oil and natural gas and refining the same in New Mexico" and "to collect, to compile and to publish statistics relative to New Mexico, geology, mining, milling, metallurgy and oil and natural gas and the refining thereof." Appropriately, *Geologic literature of New Mexico* was published in 1930. Nine other bibliographies of New Mexico geology and mineral technology have been published by the Bureau since 1930, and eight of these remain in print. These bibliographies provide researchers with a way to search comprehensively the geologic literature of the state published since the middle of the 19th century. The bibliographic literature of the Bureau also includes topical and annotated bibliographies available as published bulletins or as reproducible open-file reports. Whereas the Bureau's first bibliography included nearly 1,200 citations for the 82-year period from 1847 to 1929, in the 10 years from 1971 to 1981 the number of bibliographic citations has doubled from approximately 400 to 800 for each calendar year. In an effort to make current geologic literature more readily known and to minimize the problems inherent in organizing an increasing number of citations, less formal bibliographic bulletins are now published annually. Editions for the calendar years 1981 and 1982 were released in 1982 and 1983, respectively, in cooperation with the American Geological Institute and GeoRef Information System. This year the Bureau began compiling, formatting, and storing bibliographic data in its own searchable computer files. This will make bibliographic information even more accessible and facilitate prompt publication of future annual editions.

—Jane Calvert Love, Assistant Editor

Water Quality Control Commission

The Water Quality Control Commission was created in 1967 by the State Legislature. There are no permanent full-time members of the Commission. The members consist of a representative from each of the following agencies: Environmental Improvement Division, the State Engineer, the State Department of Game and Fish, the Oil Conservation Division, the State Parks and Recreation Commission, the New Mexico Department of Agriculture, the State Natural Resource Conservation Commission, the New Mexico Bureau of Mines and Mineral Resources, and a representative of the public appointed by the governor. The Commission is the official state water-pollution agency for New Mexico and may take all necessary action required by the federal Water Pollution Control Act, the federal Clean Waters Restoration Act, and the state Water Quality Act. The Commission usually meets once a month and, since its creation, has developed a comprehensive and workable set of surface and ground-water regulations. New Mexico was one of the first states to develop regulations to protect ground water. These regulations have been used by other states as a model from which to write their own regulations.

—Lynn A. Brandvold, Senior Chemist

New Mexico Coal Surface Mining Commission

The NMCSMC adopts reasonable regulations concerning coal strip mining and the surface effects of underground coal mining, including regulations for the productive reclamation of affected areas. It also acts as an appeals board for any affected party to appeal decisions of the Director of the Mining and Minerals Division of the New Mexico Energy and Minerals Department. The M&MD Director is charged with carrying out the CSMC regulations.

By law (NM statute 1979, chapter 291), the Commission is composed of the following state officials or their designated alternate: State Engineer, Director of NMBMMR, State Land Commissioner, Director of Soil & Water Conservation Division, Director of Environmental Improvement Division, Dean of College of Agriculture, and Director of Department of Game and Fish. M&MD provides logistical support for NMCSMC. The current elected officers are: Frank E. Kottlowski, NMBMMR, chairman, and Robert Q. Rogers, Jr., State Engineer's Office, vice chairman.

Commission activities during FY 82–83 mainly related to consideration of surface mining in the Bisti area and changing of New Mexico's regulations to track with new regulations by the federal Office of Surface Mining.

—Frank E. Kottlowski, Director

3rd annual New Mexico Mineral Symposium

The New Mexico Bureau of Mines and Mineral Resources again hosted the New Mexico Mineral Symposium on No-

vember 13–14, 1982. Cosponsors of the meeting were the Albuquerque Gem and Mineral Club and the New Mexico Tech Mineralogical Society. The purpose of the New Mexico Mineral Symposium is to bring together amateurs and professionals interested in the hobby and science of mineralogy for their mutual benefit. The mineralogy of New Mexico is stressed.

Four mineral species previously not known to occur in New Mexico were described by participants giving papers. These new occurrences included fornacite from Silver Hill, Socorro County, and villiaumite, neptunite, and serandite from Point of Rocks Mesa, Colfax County. Other papers included discussions on chalcophanite from Hanover, Grant County; "Psilomelane" from Socorro County; zeolites from the Gila Cliff Dwellings area, Grant and Catron Counties; and a proposal for educational mineral displays for the New Mexico Museum of Natural History, Albuquerque.

Approximately 80 people registered for the two-day symposium, which included a field trip to the Orogrande mining district in Otero County.

—Robert M. North, Mineralogist

Aerial photography collection

The New Mexico Bureau of Mines and Mineral Resources serves as a repository for large-scale aerial photography taken in New Mexico. The collection consists of over 50,000 9″ × 9″ contact prints and over 2,000 oversized photo mosaics and indices covering approximately 70% of the state.

During the past three years, staff and student workers have organized the collection with respect to photo location, project, and vintage. Cataloging efforts are about 80% complete. The collection is available for inspection to all interested people and is used heavily by the staff and students. Any donations of vintage photos are accepted and catalogued.

The Bureau maintains a current National Cartographic Information Center (NCIC) microfilm index to New Mexico photography. Photo availability and ordering information can be obtained by specifying the latitude–longitude coordinates of the area of interest.

—JoAnne Cima Osburn, Coal Geologist

Computerization of Bureau's water data

A NMBMMR ground-water or hydrologic report may contain thousands of well records and chemical analyses. Searching through such information visually is tedious and time consuming. Therefore, computerized water-data files are being made for each county or area covered by major NMBMMR water-resource publications and two PASCAL programs have been written to facilitate searching such files. NORIAW (noria means water wheel in Spanish) permits searching well-record data by any combination of 19 parameters and NORIAC permits searching chemical-analysis data by any combination of 20 parameters. Desired search parameters are entered on a check-list form that is called up on the video-terminal screen. When a search is completed, output is in the form of a table that gives all information available for the wells meeting the specified search parameters.

—William J. Stone, Hydrogeologist

Staff

New employees joining the Bureau were James Barker, Industrial Minerals Geologist, 3 January 1983; Marc Chavez, Driller's Helper, 17 January 1983; Nanette Dynan, Receptionist, 23 August 1982; Johnny Gonzales, Driller's Helper, 19 July 1982; Gary Johnpeer, Engineering Geologist, 13 December 1982; Annabelle Lopez, Staff Secretary, 27 June 1983; Tom O'Donnell, Metallurgist (part time), 24 August 1982; Lorenzo Pino, Driller's Helper, 13 June 1983; Joseph Salazar, Driller's Helper, 30 August 1982; Betty Townsend, Staff Secretary, 6 January 1983; Manuel Vasquez, Laborer, 27 May 1983; Jack Waldron, Metallurgist, 11 August 1982; and Jiri Zidek, Editor/Geologist, 3 January 1983.

Resignations during the fiscal year were Corale Brierley, Chemical Microbiologist, 13 May 1983; John Christiansen, Driller's Helper, 6 June 1983; Amelia Dondero, Metallurgist (temporary), 15 July 1982; Johnny Gonzales, Driller's Helper, 30 April 1983; Jimmy Hale, Driller's Helper, 9 August 1982; Cindy Howell, Staff Secretary, 17 December 1982; Robert Kelley, Editor/Geologist, 31 August 1982; Helen Limvorratre, Receptionist, 4 August 1982; Mark Logsdon, Industrial Minerals Geologist, 31 July 1982; Joseph Salazar, Driller's Helper, 15 January 1983; Rob Sanford, Lab Assistant, 8 August 1982; Betty Townsend, Staff Secretary, 10 June 1983; Debra Vetterman, Drafter, 2 December 1982; and Jack Waldron, Metallurgist, 31 December 1982.

Lynn Brandvold was promoted to Senior Chemist.

TABLE OF ORGANIZATION

June 30, 1983

Administration & information
Kottlowski, Director, Sr. Geologist
Austin, Deputy Director, Geologist
Vaiza, Executive Secretary
Chavez, J., Administrative Secretary I
Lindsey, Staff Secretary
Baca, Technician II
Crespin, Mechanic

Business office & publication sales
Devlin, Director, Bus.–Pub. Office
Meeks, Department Secretary
McNeil, Staff Secretary
Dynan, Receptionist

Publishing group
Zidek, Editor & Geologist
Adkins-Heljeson, Associate Editor
Blodgett, Assistant Editor
Calvert Love, J., Assistant Editor
Shaw, Editorial Technician
Wooldridge, Chief Sci. Illustrator
Brannan, Drafter
Mueller, Drafter
Wood, Drafter

Environmental geology
Hawley, Senior Environmental Geologist
Love, D., Environmental Geologist
Johnpeer, Engineering Geologist

Geophysics
Reiter, Senior Geophysicist
Broadwell, Lab Technician

Hydrogeology & geothermal
Stone, Hydrogeologist
Reiter, Senior Geophysicist (P)
O'Brien, Hydrologist

Industrial minerals & coal
Weber, Senior Geologist
Barker, Industrial Minerals Geologist
Anderson, Coal Geologist
Campbell, Coal Geologist
Osburn, J., Coal Geologist
Roybal, Coal Geologist
Mauldin, Driller

Metallic ores
Chapin, Senior Geologist
Renault, Senior Petrologist
Robertson, Mining Geologist
Weber, Senior Geologist (P)
Eveleth, Mining Engineer
Chamberlin, Economic Geologist
Osborn, G., Volcanologist
McLemore, Uranium Geologist
Menzie, CRIB Geologist

Metallurgy & chemistry
Brandvold, Senior Chemist
Popp, Lab Biotechnologist
Archuleta, Metallurgical Technician
O'Donnell, Metallurgist

Mineralogy & x-ray
North, Mineralogist
Renault, Senior Petrologist (P)
Faris, x-ray Lab Manager

Oil and gas
Bieberman, Senior Petroleum Geologist
Thompson, Senior Petroleum Geologist
Broadhead, Petroleum Geologist
Chavez, R., Assistant Head Petroleum Section
Lopez, Staff Secretary

Paleontology
Wolberg, Paleontologist
Flower, Sr. Emeritus Paleontologist

(P) Secondary assignment

Frank E. Kottlowski
Director, Senior Geologist
7/2/51

Judy M. Vaiza
Executive Secretary
2/25/74

Lois M. Devlin
Director, Bus.–Pub. Office
1/24/62

Norma J. Meeks
Department Secretary
4/21/75

Lynne McNeil
Staff Secretary
6/23/80

Jeanette Chavez
Admin. Secretary I
6/14/78

Arleen Montoya Lindsey
Staff Secretary
5/22/78

Ruben A. Crespin
Mechanic
2/24/75

Albert Baca
Technician II
6/7/82

Geology and resource projects

The object of the Bureau's program of investigations is to provide statewide evaluations of mineral resources and geology, to study key areas in detail, and to recommend guidelines for exploration, development, metallurgical extraction, and conservation of New Mexico resources. Completed and continuing projects, wholly or party funded by the Bureau, are listed in this section. An index map of field projects is shown on pages 12 and 13. A list of part-time research associates working cooperatively on projects with the Bureau appears on pages 17 and 18. Bureau staff employed during the fiscal year are shown in photographs throughout this report.

Oil and gas

1. Austin—Core repository for New Mexico cores drilled for oil and gas, coal, metallic ores, and industrial minerals (continuing)
2. Bieberman—Oil and gas fields, exploration tests, and major pipelines map of New Mexico
3. Bieberman—Catalog of samples available in New Mexico Library of Subsurface Data (continuing update)
4. Bieberman—Scout-information file, mechanical-log file, lithologic-log file, driller's-log file, and county petroleum-exploration maps (continuing update)
5. Broadhead—Gas production and sedimentology of tight gas-producing sandstones of Abo Formation in east-central New Mexico
6. Broadhead—Oil and gas discovery wells in New Mexico in 1982
7. Broadhead—Guidebook of Abo red beds in central and south-central New Mexico
8. Broadhead—Subsurface geology and heavy oil occurrences in Santa Rosa Sandstone and Chinle Formation, northeast New Mexico
9. Broadhead—Petroleum exploration in Socorro County
10. Christiansen—History of oil and gas exploration and production in New Mexico
11. King—Petroleum potential of Otero Mesa region, south-central New Mexico
12. Lozinsky (Hawley)—Stratigraphy and sedimentology of Santa Fe Group in Albuquerque Basin, north-central New Mexico
13. Reiss (LeMone)—Thermal maturation study of Cretaceous petroleum source rocks (thesis available May 1984)
14. Thompson—Petroleum geology of southwestern New Mexico
15. Thompson—Subsurface geology of the Cockrell No. 1 Playas well, Hidalgo County
16. Thompson—Subsurface geology of the Humble No. 1 State BA well, Hidalgo County
17. Thompson—Oil and gas exploration wells in southwestern New Mexico
18. Thompson—Petroleum source rocks in southwestern New Mexico
19. Thompson—Structure-contour map on top of Precambrian basement, southwestern New Mexico
20. Thompson and Jacka—Cambrian-Mississippian stratigraphy, petrography and petroleum geology of the Mescal Canyon section, Hidalgo County
21. Thompson and Jacka—Guidebook to Middle Permian depositional and diagenetic features, Guadalupe Mountains, New Mexico and Texas

Sam Thompson, III
Senior Petrol. Geologist
10/14/74

Ronald Broadhead
Petroleum Geologist
9/21/81

Industrial minerals and coal

1. Anderson—Geology and coal resources of Atarque Lake quadrangle (Open-file Report 167)
2. Anderson—Geology and coal resources of Mesita de Yeso quadrangle (Open-file Report 171)
3. Anderson—Geology and coal resources of Upper Gallistina Canyon quadrangle (in cooperation with U.S. Geological Survey)
4. Anderson—Geologic map and coal resources of Fence Lake NW quadrangle (1:50,000)
5. Anderson—Geology and coal resources of the Vanderwagen quadrangle, McKinley County
6. Anderson, Campbell, and Roybal—Coal resources of the Salt Lake and Zuni coal fields
7. Anderson and Mapel—Geology and coal resources of Shoemaker Canyon SE quadrangle (in cooperation with U.S. Geological Survey; Open-file Report 172)
8. Arkell (Smith)—Geology and coal resources of Carrizozo area (thesis available July 1983)
9. Austin—Shale and clay resources of New Mexico

George S. Austin
Deputy Director
9/1/74

Robert H. Weber
Senior Geologist
5/15/50

10. Austin—Adobe clay as an insulating building material (AIME, October 1983)
11. Austin—Industrial minerals: 50 years of development (April 1983 symposium)
12. Beaumont, Campbell, Cohen, Roybal, Kuellmer, and Kottlowski—Strippable coals of New Mexico, quality assessment (in cooperation with New Mexico Energy Research and Development Institute)
13. Campbell and Anderson—Geologic and coal map of Fence Lake quadrangle (1:100,000)
14. Campbell, Arkell, and Blount—Annotated bibliography of coal geology (ongoing)
15. Campbell and Roybal—Geology and coal resources of Quemado quadrangle (1:50,000)
16. Campbell and Roybal—Coal resources of Fence Lake quadrangle (1:50,000; Open-file Report 207)
17. Campbell and Roybal—Coal resources of New Mexico
18. Filsinger (Clark)—Barite deposits of Palm Park, Caballo Mountains, Doña Ana County
19. Jensen (MacMillan)—Depositional environments of Mesaverde Group in Capitan coal field (unpublished report available)
20. Johnpeer—Geotechnical study of Heaton Canyon mine area near Gallup
21. Kottlowski, Campbell, Roybal, and Hatton—New Mexico coal seams (1983 Keystone Coal Industry Manual)
22. Nickelson—History of coal mining in New Mexico
23. Osburn, J. C.—Geology and coal resources of Pueblo Viejo Mesa quadrangle (Geologic Map 55)
24. Osburn, J. C.—Coal geology of Pasture Canyon quadrangle, Catron County (Open-file Report 182)
25. Osburn, J. C.—Coal resources of Socorro County (for NMGS guidebook)

26. Osburn, J. C.—Coal geology of Wildhorse Canyon quadrangle, Catron and Cibola Counties
27. Perry (Johnson)—Depositional environments of Sugarite coal zone, Raton coal field, Colfax County
28. Roybal—Computerization of point-source coal data for New Mexico (in cooperation with U.S. Geological Survey)
29. Roybal—Contour program for Tektronix—mapping coal quality versus thickness or other quality parameters (in cooperation with New Mexico Energy and Minerals Department)
30. Roybal—Geology and coal resources of Tejana Mesa quadrangle, Catron County (Open-file report 178)
31. Roybal and Campbell—Stratigraphic sequence and drilling data for Fence Lake area (Open-file Report 145)
32. Smith, T. J.—Barite deposits of New Mexico (revision of Circular 76)
33. Stricker, Mapel, and Anderson—Geology and coal resources of Shoemaker Canyon quadrangle (in cooperation with U.S. Geological Survey; to be published as USGS Miscellaneous Field Studies Map)
34. Wallin (MacMillan)—Stratigraphy and paleoenvironments of the Engle coal field

JoAnne Cima Osburn
Coal Geologist
9/16/79

Orin J. Anderson
Coal Geologist
7/25/79

Frank Campbell
Coal Geologist
4/1/79

Wess Mauldin
Driller
6/11/79

Water and geothermal resources

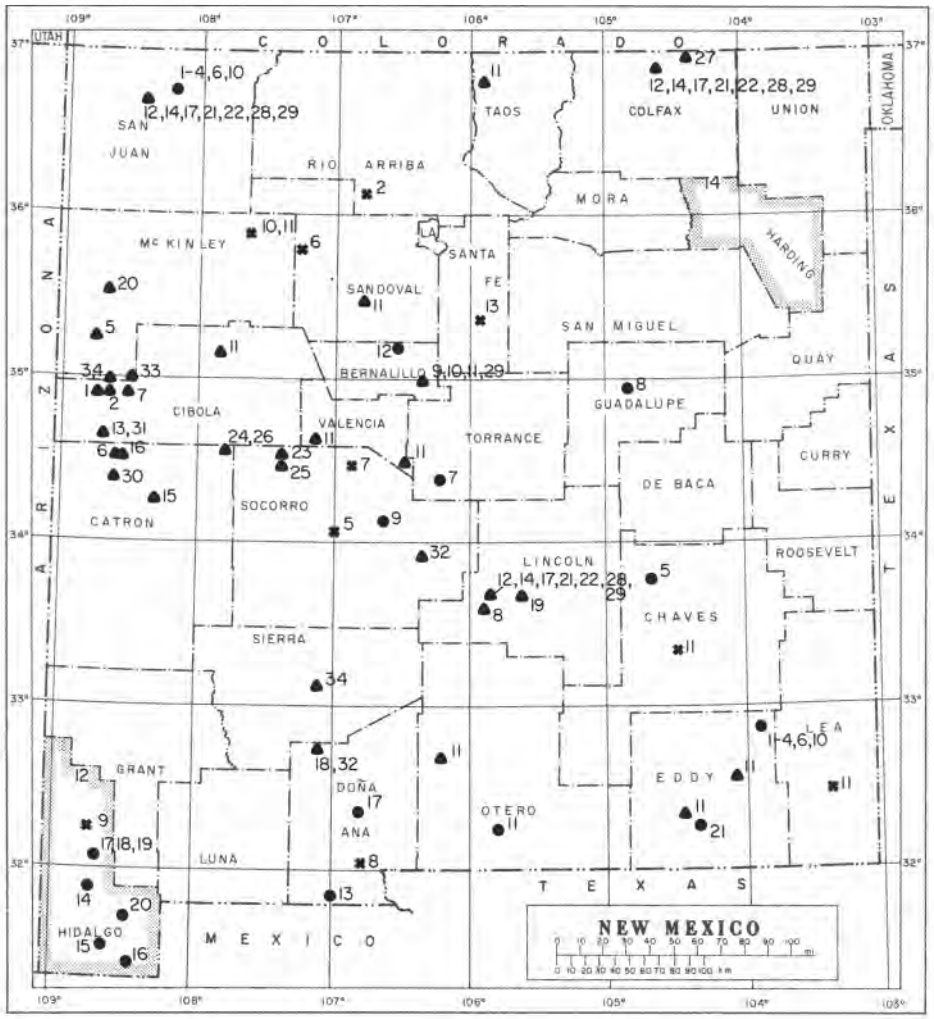
1. Allison, Stone, and Hughes—Recharge in karst and dune elements of semiarid landscape as indicated by natural isotopes and chloride (in cooperation with CSIRO Division of Soils, Adelaide, South Australia)
2. Anderholm and Stone—Hydrogeology and water resources of Cuba 15-min quadrangle (Hydrogeologic Sheet 3, in preparation)
3. Brandvold—Water Quality Control Commission projects (continuing update)
4. Brandvold—Water analyses file (continuing update)
5. Chapin—Socorro Peak KGRA geology
6. Craigg and Stone—Hydrogeology and water resources of the Arroyo Chico–Torreon Wash area (Hydrogeologic Sheet 4)
7. Heath (Hawley)—Flood and recharge relationships of the lower Rio Puerco, Socorro County (report available)
8. Khaleel and Hawley—Numerical simulation of lower Rio Grande Basin, Doña Ana County (in cooperation with New Mexico Tech Geoscience Department and Water Resources Research Institute)
9. O'Brien and Stone—A two-dimensional hydrological model of the Animas Valley, Hidalgo County (in cooperation with U.S. Geological Survey; Open-file Report 133)
10. Stone, Lyford, Frenzel, Mizell, and Padgett—Hydrogeology and water resources of San Juan Basin, New Mexico (in cooperation with U.S. Geological Survey and New Mexico State Engineer; Hydrologic Report 6)
11. Stone—Computerization of NMBMMR well-record data (continuing update)
12. Stone and O'Brien—Hydrogeology and water resources of Hidalgo County
13. Summers—Hydrology of Galisteo River drainage basin in Santa Fe County
14. Roybal and Pinkston—Ground-water resources and geologic map of Harding County (in cooperation with U.S. Geological Survey)

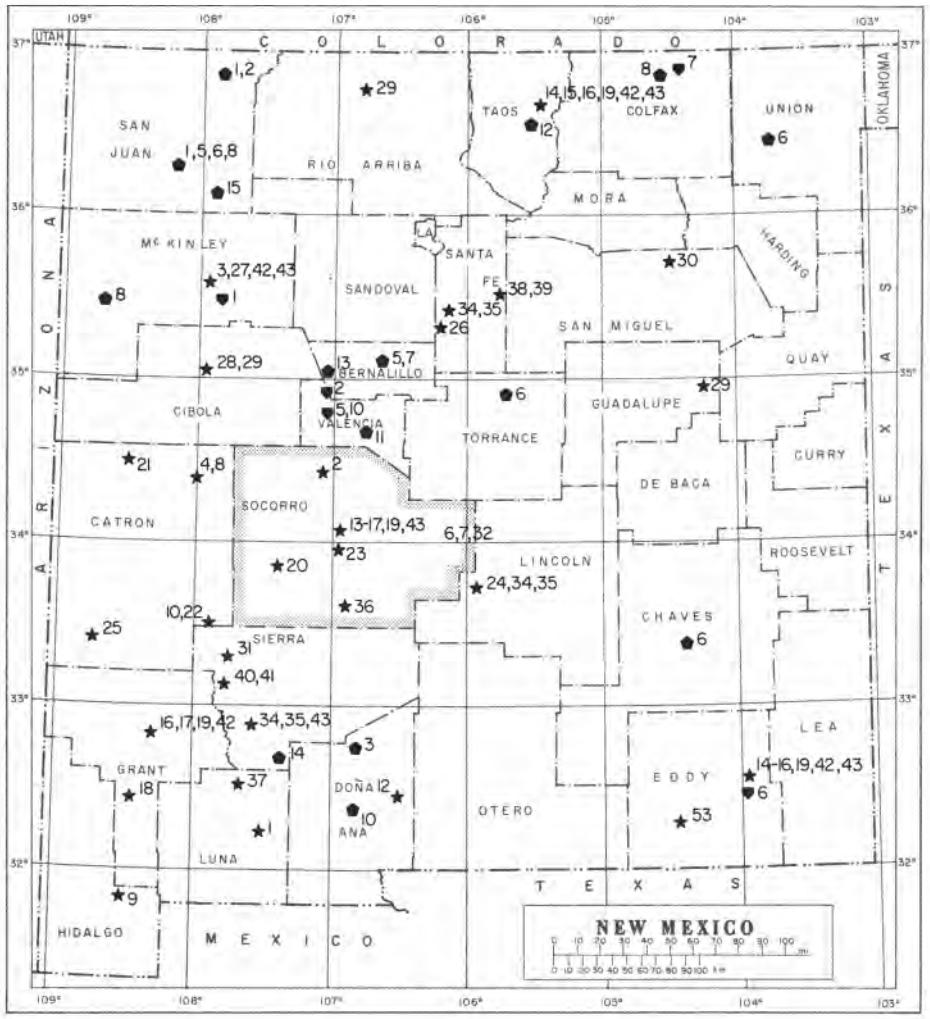
William J. Stone
Hydrogeologist
9/1/74

Keith O'Brien
Hydrologist
1/5/81

Metallic ores and mining districts

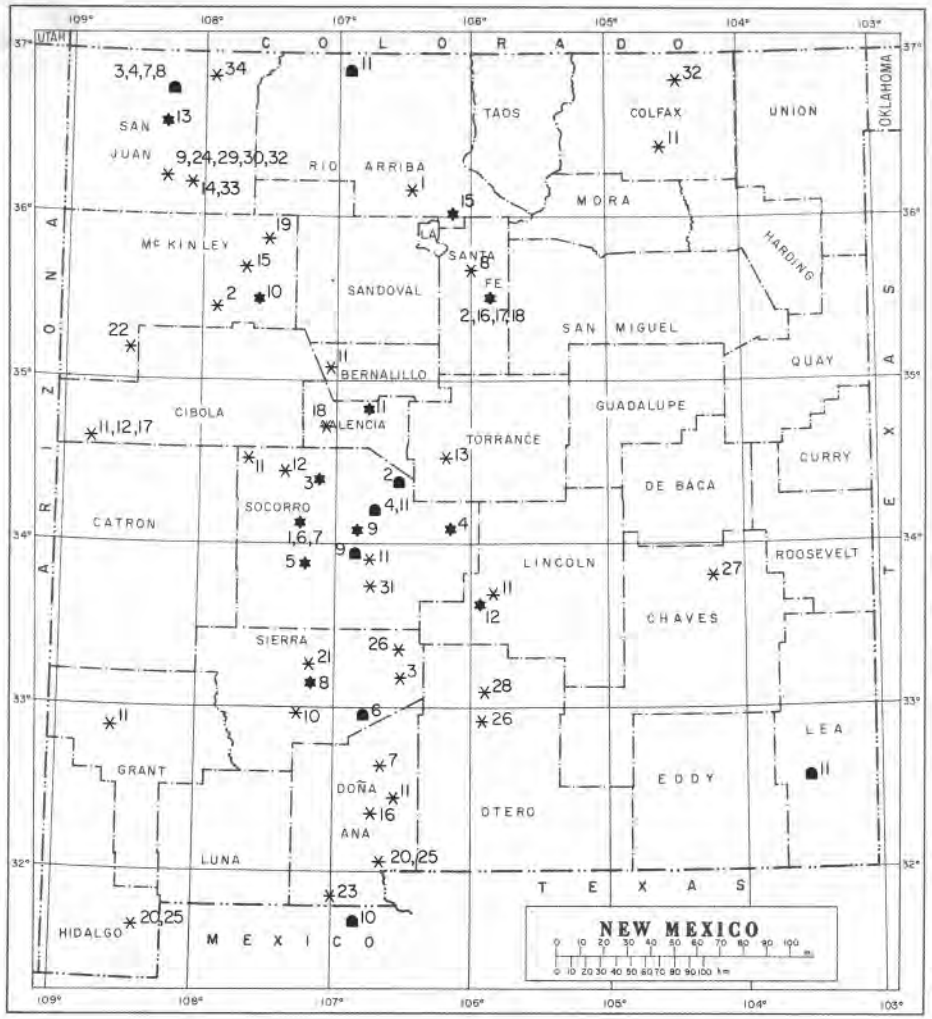
1. Brown, G. (Clemons)—Mineralization of Mahoney mines and Gym Park area, Florida Mountains (thesis available)
2. Chamberlin—Resource analysis of Sierra Ladron Wilderness study area (Open-file report 179)
3. Chamberlin—Monitor uranium exploration in New Mexico (continuing update)
4. Chamberlin—Geologic map and uranium occurrences in Datil Mountains–Pie Town area
5. Chamberlin—Distribution of uranium-bearing, lateritic-weathering profile of Paleocene(?) age in central and southern New Mexico
6. Chapin—Geology and mineral resources of the southeast Colorado Plateau margin
7. Chapin and Osburn, G. R.—Geology and mineral resources of Socorro–Magdalena–Datil area
8. Chapin and Osburn, G. R.—Data bank of radiometric dates in New Mexico (continuing update)
9. Edwards (Annis)—Mineralization of Sylvanite–Bager area, Little Hatchet Mountains
10. Eggleston, T. (Norman)—Genesis of Taylor Creek tin deposits
11. Eveleth—New Mexico's mining railroads (continuing update)
12. Eveleth—Stephenson–Bennett mine, Organ mining district, Doña Ana County (published in *New Mexico Geology*)
13. Eveleth—Billing smelter, its role in the territorial mining industry of New Mexico
14. Eveleth and Bieberman—Mineral and mineral-fuel production in New Mexico, 1980–82 (published in *New Mexico Geology*)
15. Eveleth and Bieberman—Mineral and mineral-fuel production activities in New Mexico during 1982 (in this report)
16. Eveleth and Menzie—Computerization of mineral resources information for MRDS (Mineral Resource Data System, formerly CRIB; in cooperation with U.S. Geological Survey)
17. Eveleth and North—Mines, prospects, and mineral potential of Socorro Peak mining district, Socorro County
18. Eveleth and North—Mines, prospects, and mineral potential of Gold Hill mining district, Grant County
19. Eveleth and Pettit—Laws and regulations for mineral rights in New Mexico
20. Ferguson (Osburn, G. R.)—Geology of east Red Canyon–Rosedale mine area, east-central San Mateo Mountains, Socorro County
21. Guilinger (Chamberlin)—Uranium potential of Tejana Mesa–Hubbell Draw area, Catron County (Open-file report 176)
22. Harvey (Goodell)—Volcanic geology and cassiterite mineralization in a part of the Taylor Creek tin district, Sierra and Catron Counties
23. Jahns—Manganese deposits of Luis Lopez district, Lincoln County

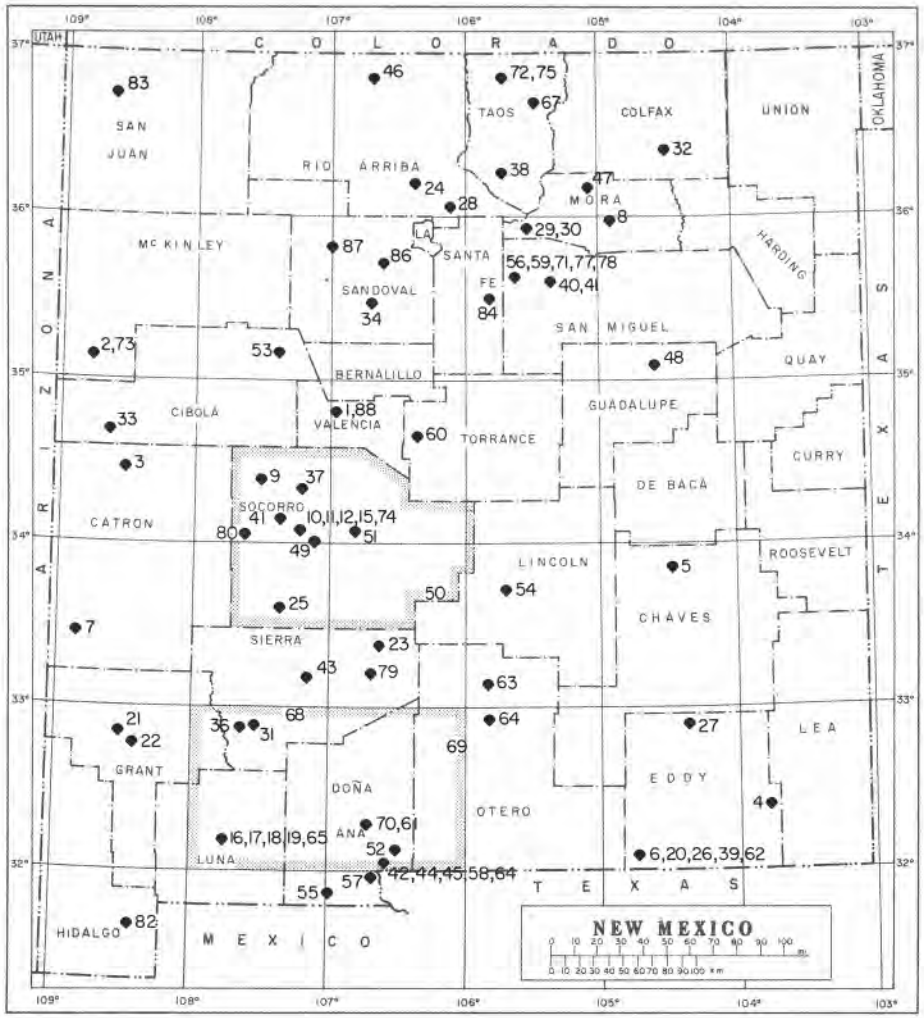




▲ Industrial minerals and coal ● Oil and gas
■ Water resources and geothermal

⬟ Environmental geology ★ Metallic ores and mining districts
♥ Metallurgy and chemistry





✱ Mineralogy, petrology, and geochemistry ■ Geophysics

✱ Paleontology

● Geology – geologic mapping, stratigraphy, and special projects

24. Jahns and Vonder Linden—Gold deposits of White Oaks mining district, Lincoln County
25. Kent, G. (Robertson)—Mineralization in the Mogollon mining district
26. Lee, C. G.—Hornfels petrogenesis at the San Pedro mine
27. McLemore—Radioactive occurrences in New Mexico
28. McLemore—Radioactive occurrences in veins and igneous and metamorphic rocks of New Mexico [NMBMMR Open-file Report 155 and U.S. Department of Energy Open-file Report GJBX-100(82)]
29. McLemore—Analysis of U.S. Department of Energy's HSSR (Hydrogeochemical Stream Sediment Reconnaissance) data
30. McLemore and Menzie—Uranium in the Sabinoso district, San Miguel County (Published in *New Mexico Geology*)
31. McMillan and Jahns—Structure, petrology, and ore deposits of Chise quadrangle in southern Sierra Cuchillo, Sierra County (thesis available)
32. North—History and geology of precious-metal occurrences in Socorro County
33. North—Geology of the Two Ladies prospect, Eddy County
34. North, Eveleth, and McLemore—Precious-metal mining and occurrences in New Mexico (continuing update)
35. North, Eveleth, and McLemore—Gold and silver occurrences in New Mexico (Mineral Resources Map)
36. Proctor—Tularosa quadrangle NURE anomaly maps (1:250,000)
37. Proctor—Trace base metals in Cooke's Peak stock
38. Robertson—Wall-rock alteration associated with massive sulfide deposits in Pecos greenstone belt
39. Robertson—Precambrian rocks and mineral deposits of Doctor Creek area, Santa Fe County
40. Sanders (Giordano, Seager)—Black Colt mine in Kingston mining district
41. Shepard (Clark)—Ore deposits of the Hermosa district
42. Ward and Eveleth—The mineral industry in New Mexico (1982; *in* Minerals Yearbook, v. II, pp. 345–356, U.S. Bureau of Mines)
43. Weber—Prehistoric and early historic mining in New Mexico

Metallurgy and chemistry

1. Brandvold—Transport mechanisms in sediment-rich streams (in cooperation with Office of Water Research and Technology; report available)
2. Brandvold—Speciation of uranium in organic-rich high-uranium stream sediment from NURE project
3. Brandvold—Water analyses (continuing)
4. Brandvold—Rock and ore analyses (continuing)
5. Brandvold—Comparison of wet-chemical methods for silicate analysis with XRF analysis
6. Brandvold—Methods for thorium analysis in rocks
7. Brandvold, L., Brandvold, D., and Popp—Acid rain in New Mexico (continuing)
8. Brierley, C., and Brierley, J.—Trace elements in oil shale (in cooperation with U.S. Department of Energy and University of Colorado)
9. Dehn (Love)—Lead 210 and Cesium 137 dating of sediments from Rio Puerco, Socorro County (thesis available)
10. Novo-Gradac (Love)—Trace-metal and radionuclide distributions in recent sediments of the Rio Puerco, Rio San Jose, and Paguate Reservoir in the Grants mineral belt (thesis available)

Environmental geology

1. Beaumont—Badlands in the San Juan Basin
2. Gillam (Hawley, Love)—Age and climatic effects on soil development in lower Animas River valley, San Juan County
3. Hawley—Low-level radioactive-waste-disposal site selection (in cooperation with Environmental Improvement Division)
4. Hawley—Quaternary stratigraphy and geomorphology of lower Rhodes Canyon area, White Sands Missile Range (in cooperation with Human Systems Research, Inc.)
5. Hawley, Lambert, and Wells—Environmental geology of Albuquerque (in cooperation with New Mexico Geological Society)
6. Hawley and Love—Quaternary geology of New Mexico (in cooperation with U.S. Geological Survey)
7. Hawley, Love, Broadhead, and others—Road logs of Albuquerque area (in New Mexico Geological Society guidebook)
8. Hawley, Love, and Hobbs—Alluvial valley floors in coal-surface-mine areas (in cooperation with New Mexico Bureau of Surface Mining)
9. Hawley, Love, Weber, O'Brien, Eveleth, Kottlowski, and others—Review and critique of Environmental Impact Statements and mining and reclamation plans (e.g., Con Paso mine of Consolidation Coal Co.; EIS of Waste Isolation Pilot Plant)
10. Hawley, Stone, and Kottlowski—Geologic evaluation of Basin and Range Province in New Mexico relative to disposal of high-level radioactive waste
11. Love and Hawley—Lower Hidden Mountain dam site, Late Quaternary stratigraphy, sedimentation, and geomorphology (in cooperation with Human Systems Research, Inc.)
12. Love, Hawley, Johnpeer, and Kottlowski—Geologic hazards designations: landslides, earthquakes, volcanic eruptions, flood-prone areas, rock falls, and subsidence (part of National Hazards Information System; in cooperation with State Highway Department, Office of Civil Emergency Preparedness, and Governor's Office)
13. Love, Hawley, and Popp—Radionuclide and heavy-metal distribution in recent sediments of major streams in Grants mineral belt (with New Mexico Tech Chemistry Department and U.S. Office of Surface Mining)
14. Sandor (Hawley)—Soils at prehistoric agricultural terracing sites in southwestern New Mexico (thesis available)
15. Wells, Love, and Gardner—Chaco Canyon County Guidebook

John W. Hawley
Environmental Geologist
5/22/77

David W. Love
Environmental Geologist
7/1/80

Gary Johnpeer
Engineering Geologist
12/13/82

Jacques R. Renault
Senior Petrologist
9/1/64

Mineralogy, petrology, and geochemistry

1. Bobrow (Osburn)—Geochemistry and petrology of Miocene silicic lavas in Socorro–Magdalena area, Socorro County (thesis available)
2. Bowring—Ages and isotopic geochemistry of Precambrian rocks in northern and central New Mexico
3. Chamberlin—Geology and geochemistry of Jeter uranium deposit
4. Chamberlin—Geochemical anomalies in stream sediments of Socorro quadrangle (1:250,000)—an analysis of NURE data
5. Chapin—Hydrothermal alteration of ash-flow tuffs
6. Kedzie (Chapin)—$^{40}Ar/^{39}Ar$ study of ash-flow tuffs in the Socorro area
7. Lindley (Chapin)—Geochemistry of potassium metasomatism of volcanic rocks of the Socorro area
8. McLemore—Carbonatites in New Mexico
9. North—Guide to New Mexico Bureau of Mines and Mineral Resources Mineral Museum (published)
10. Renault—Thermoluminescence studies of quartz (continuing)
11. Renault—Petrology of Cerro de Los Lunas volcano
12. Renault—Geochemistry of New Mexico basalts (continuing)

13. Renault—Rapid determination of coal chemistry by x-ray fluorescence spectroscopy (continuing)
14. Renault—X-ray diffraction profile analysis of silica (continuing)
15. Renault—Geochemistry of Española Basin drill cuttings
16. Robertson—Petrography and geochemistry of Precambrian volcanic and subvolcanic rocks from Pecos greenstone belt
17. Robertson (Bowring)—Geochronology of volcanism and plutonism in Pecos greenstone belt
18. Robertson—Fingerprinting Precambrian felsic metavolcanic rocks in northern New Mexico—a geochemical study

Geophysics

1. Brown, L.—Paleomagnetic study of the Española Basin
2. Chapin—COCORP seismic reflection profiles
3. Clarkson (Reiter)—Characteristics of thermal anomaly under the San Juan volcanic field
4. Eggleston, R. (Reiter)—Deep-temperature-data study in the Colorado Plateau and eastern Basin and Range Province
5. McIntosh (Chapin)—Paleomagnetic study of Socorro potassium anomaly and ash-flow tuff stratigraphy
6. Minier and Reiter—Geothermal transition across eastern Rio Grande rift, southern New Mexico
7. Reiter and Clarkson—Terrestrial heat flow in the Colorado Plateau (published October 1983)
8. Reiter, Clarkson, and Mansure—Geothermal studies in the San Juan Basin: 1) terrestrial heat-flow measurements; 2) paleotemperatures, coalification, and petroleum genesis; and 3) steady-state model of thermal source of heat flow
9. Reiter, Eggleston, R., and others—Deep heat-flow data along Rio Grande rift
10. Reiter and Tovar, R.—Heat-flow analysis in northern Chihuahua, Mexico (published)
11. Sanford—Statewide seismic monitoring (done mainly by New Mexico Tech Geoscience Department in cooperation with U.S. Geological Survey)

Marshall A. Reiter
Senior Geophysicist
4/1/75

Brenda R. Broadwell
Lab Technician
4/3/78

Paleontology

1. Berman—Early Permian vertebrates of north-central New Mexico
2. Brown, T. (Flessa)—*Crassostrea* reefs, Crevasse Canyon Formation, Borrego Pass area
3. DeKeyser—Conodonts in Lake Valley Formation of San Andres Mountains
4. Flower—Ordovician correlations (in preparation)
5. Flower—Faunas of the New Mexico Devonian
6. Flower—Studies of Endoceratida and Tarphyceratida
7. Flower and LeMone—Faunal and petrographic studies of Bliss Sandstone, El Paso Group and Montoya Group
8. Galusha—Catalog of American Museum of Natural History, records of collections from north-central New Mexico
9. Hartman—Cretaceous–Tertiary freshwater mollusks in San Juan Basin
10. Hook and Cobban—Stratigraphy and paleontology of Cretaceous rocks of Cooke's Range
11. Hook and Cobban—Stratigraphy and paleontology of Upper Cretaceous of a) Silver City area, b) Fence Lake area, c) southern San Andres Mountains, d) Carthage, e) Carrizozo–Capitan area, f) Rio Puerco area, g) Riley–Puertecito area, h) Springer area, and i) Trans-Pecos Texas
12. Hook, Cobban, and Molenaar—Stratigraphy, paleontology, sedimentology, and regional relationships of Upper Cretaceous Tres Hermanos Sandstone
13. Hunt—Plant fossils and lithostratigraphy of Abo Formation in Socorro area and plant biostratigraphy of Abo red beds in New Mexico (New Mexico Geological Society guidebook)
14. Hunt (Wolberg)—Stratigraphy, sedimentology, taphonomy, magnetostratigraphy of Fossil Forest area (thesis pending)
15. Jameossanaie (Cross)—Palynology and environments of deposition of Lower Menefee Formation, South Hospah area, McKinley County (in cooperation with Chaco Energy Co.; thesis available)
16. King—Fusulinids of the Hueco Formation in the Las Cruces area
17. Kelley, K. (Cross)—Palynology of Upper Cretaceous rocks in Fence Lake area (in cooperation with U.S. Geological Survey)
18. Kukalova–Peck—Late Paleozoic fossil insects of Carrizo Arroyo region
19. Leipzig (Wolberg)—Stratigraphy and depositional environments of Fruitland Formation and Kirtland Shale in Star Lake area (report available)
20. LeMone and Simpson—Wolfcampian megafauna and biostratigraphy of Franklin and Big Hatchet Mountains
21. Lozinsky, Hunt, and Wolberg—Vertebrate fossils from McRae Formation at Elephant Butte, Sierra County
22. Molenaar, Hook, and Cobban—Stratigraphy, paleontology, and regional correlations of the upper Cenomanian through lower Coniacian (Upper Cretaceous) strata of western New Mexico
23. Pickens (LeMone)—Early Cretaceous rudish–biostrome sequence, East Potrillo Mountains, Doña Ana County
24. Robison, Hunt, and Wolberg—Paleobotany and stratigraphy of Late Cretaceous leaf locality in lower Kirtland Shale (publication available)
25. Simpson—Permian brachiopods of southwest New Mexico and far west Texas
26. Sorauf—Devonian corals from south-central New Mexico
27. Taylor—Freshwater mollusks of New Mexico
28. Ward (Meyers)—Diagenesis of phylloid algal mounds in Laborcita Formation in Sacramento Mountains
29. Wolberg—Reptiles and elasmobranchs in the Fruitland and Kirtland Formations
30. Wolberg and Hunt—Paleontologic inventory of De-na-zin area (report available)
31. Wolberg, Hunt, and Lucas—Eocene titanothere from Baca Formation near Carthage (published)
32. Wolberg, Payne, and Hunt—Paleontology, stratigraphy, and magnetostratigraphy compared with Ir levels in San Juan and Raton Basins (published)
33. Wolberg, Rigby, Hunt, Robison, and Hartman—Paleontology and stratigraphy of a Late Cretaceous fossil stump field in the San Juan Basin near Split Lip Flats
34. Wolberg, Rigby, and Schiebout—A Torrejonian faunule from Nacimiento Formation in Bohannan Canyon

Donald Wolberg
Paleontologist
12/15/78

Rousseau H. Flower
Sr. Emerit. Paleontologist
9/1/51

Geology, geologic mapping, stratigraphy, and special projects

1. Amin (Love)—Modeling of sediment transport in Rio Puerco, Socorro County (report available)
2. Anderson—Redefinition of Zuni Sandstone (Open-file Report 174)
3. Anderson and Chamberlin—Structure and volcanism in the Techado Hills area, Cibola and Catron Counties

4. Bachman—Ochoan evaporites, Delaware Basin (published)
5. Balk—Stratigraphic nomenclature of New Mexico
6. Biggers (Barrick, Jacka)—Tansell–Capitan transition zone in Dark Canyon, Guadalupe Mountains
7. Bikerman—Age-dating volcanic rocks in Mogollon area
8. Boyd (Campbell)—Geology of Turkey Mountains, Mora County
9. Brouillard (Chapin)—Geology of north half of Indian Mesa quadrangle, Gallinas Mountains, Socorro County
10. Cather (Chapin)—Petrology and volcano-sedimentary evolution of the Oligocene Spears Formation
11. Chapin—Origin and evolution of the Rio Grande rift
12. Chapin—Editor and compiler of New Mexico Geological Society Guidebook of Socorro area
13. Chapin—Hydrothermal alteration of ash-flow tuffs
14. Chapin and Cather—Eocene tectonics and sedimentation in southern Cordillera
15. Chapin and Osburn, G. R.—Cenozoic stratigraphy of the Socorro–Magdalena–Datil area
16. Clemons—Geology of Capitol Dome quadrangle (Geologic Map 56)
17. Clemons—Geology of west half of Gym Peak quadrangle (Geologic Map 58)
18. Clemons—Geology of east half of South Peak quadrangle, Florida Mountains (Geologic Map 59)
19. Clemons and Russell—Geology of the Florida Mountains
20. Crawford (Pray)—Depositional history and diagenesis of Goat Seep Dolomite, Guadalupe Mountains, New Mexico and Texas (thesis available)
21. Cunningham—Circle Mesa quadrangle
22. Cunningham—Revision of geologic map of Silver City 7½-min quadrangle
23. Day—Depositional history of Devonian rocks in south-central New Mexico
24. Eberth—Sedimentology of Lower Permian red beds of north-central New Mexico
25. Farkes—Geology of southeastern San Mateo Mountains, Sierra and Socorro Counties
26. Franseen (Pray)—Sedimentology of the Grayburg (Gateway) bank of the Guadalupe Mountains escarpment
27. Frye and Leonard—Pleistocene history of the Pecos River system in New Mexico
28. Golombek—Geologic mapping in Española Basin
29. Grambling—Geologic mapping in Truchas–Rio Mora area
30. Grambling—Precambrian geology of Gascon area
31. Gutierrez (Seager)—Volcanic stratigraphy of area between Hillsboro and Kingston, Sierra County
32. Hattin—Limestone marker beds in the Greenhorn Formation
33. Hawley, Anderson, and Love—Investigations of Fence Lake and Bidahochi Formations in western New Mexico
34. Hawley, Tedford, Galusha, Barghoorn, and Love—Upper Cenozoic biostratigraphy of northern Albuquerque Basin (in cooperation with American Museum of Natural History)
35. Heljeson and Holts—Bibliography of New Mexico geology and mineral technology, 1976 through 1980 (Bulletin 109)
36. Ilchik (Clemons)—Geology of eastern edge of Emery cauldron (thesis pending)
37. Johansen (Chapin)—Petrology of Mesaverde Group in Rio Salado valley
38. Kepes (Callender, Robertson)—Geology and structure of Precambrian rocks in the Picuris–Cerro Azul–Tusas area
39. Kirkby (Pray)—Study of rocks beneath Cutoff Formation in southern Guadalupe Mountains
40. Klich (Robertson)—Precambrian geology of Elk Mountain–Spring Mountain area, San Miguel County (thesis available)
41. Klich and Robertson—Proterozoic pillow basalt and pillow breccias from Pecos greenstone belt, Sangre de Cristo Mountains, north-central New Mexico
42. Kondelin (LeMone)—Stratigraphy and microfacies analysis of Ordovician system, northern Franklin Mountains, Doña Ana County (thesis available)
43. Lozinsky (Hawley)—Geology of Elephant Butte area (thesis available; published)
44. Madden (LeMone)—Stratigraphy and microfacies analysis of Mississippian system, northern Franklin Mountains, Doña Ana County (thesis available)
45. McEvers (LeMone)—Silurian rocks in northern Franklin Mountains, Doña Ana County
46. Muehlberger—Scenic Trip No. 13 to Española–Chama–Cumbres Pass–Monero–Tres Piedras region
47. Nielsen—Ocate volcanic field, north-central New Mexico
48. North—Postcard geologic map of New Mexico (published)
49. Osburn, G. R.—Geology of northern San Mateo Mountains
50. Osburn, G. R.—Compilation of Socorro County geology (scale 1:100,000)
51. Osburn, G. R.—Geology of northern Jornada del Muerto volcanic area
52. Ottensman—Sedimentation of the Bliss Formation (thesis available)
53. Owen and Siemers, C.—Dakota units in southeast San Juan Basin between Laguna and La Ventana
54. Pertl (Campbell)—Geology of the Carrizo Mountains
55. Powell (LeMone)—Structure and stratigraphy of Early Cretaceous rocks in southernmost East Potrillo Mountains, Doña Ana County (thesis available)
56. Renshaw (Woodward, Callender, Robertson)—Precambrian geology of Wild Horse Canyon area, Southern Sangre de Cristo Mountains
57. Riley (LeMone)—Fort Hancock and Camp Rice Formations in southern Doña Ana County
58. Roark (LeMone)—Microfacies of Pennsylvanian system, north Franklin Mountains, Doña Ana County
59. Robertson (Bowring)—Geochronology of volcanism and plutonism in Pecos greenstone belt
60. Robertson, Bowring, Callender, and Grambling—Precambrian geology of New Mexico (text, 1:1,000,000-scale maps, and chronostratigraphic chart)
61. Roepke (LeMone)—Microfacies analysis of Pennsylvanian strata in Robledo Mountains
62. Rosenblum (Pray)—Environmental and diagenetic interpretation of the Tepees and associated pisolite of the Capital backreef carbonates in the Guadalupe Mountains
63. Rundell (Johnson)—Depositional relationships between carbonate bioherms and clastic sediments of the Laborcita Formation, Sacramento Mountains (thesis available)
64. Sandidge (LeMone)—Isopach maps of Paleozoic and Mesozoic rocks in El Paso region
65. Savanyo Lemley (Clemons, Mack)—Lobo Formation and lithologically similar units in Luna and southwestern Doña Ana Counties (thesis pending)
66. Schilling—*Isochron/West*, a periodic journal of isotopic geochronology
67. Schilling, Taggart, and Pendleton—Revision of Scenic Trip No. 2, Taos–Red River–Eagle Nest region
68. Seager, Clemons, Hawley, and Kelley, R. E.—Geology of northwest part of Las Cruces 1° × 2° quadrangle (scale 1:125,000; Geologic Map 53)
69. Seager, Hawley, Kottlowski, Kelley, S. A.—Geology of east halves of Las Cruces and El Paso 1° × 2° quadrangles (scale 1:125,000; Geologic Map 57, in progress)
70. Seager, Kottlowski, Hawley, and King—Geology of Robledo Mountains
71. Smith (Robertson)—Precambrian geology of the Jawbone Mountain area, Rio Arriba County
72. Stoll (Dungan)—Intermediate to silicic volcanic rocks of Taos Plateau
73. Stricker and Anderson—Ramah Member of the Gallup Sandstone
74. Sumner, Bowring, and Kent (Chapin)—Compilation of Precambrian geology in Socorro area for New Mexico Geological Society guidebook

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75. Thompson, R. A. (Dungan)—Studies of early rift-age volcanic rocks, Taos Plateau
76. Thompson and Slaczka—A revision of the fluxoturbidite concept based on type examples in the Polish Carpathian flysch (published)
77. Wakefield (Robertson)—Precambrian geology of Glorieta Baldy–Ruiz Canyon area, Santa Fe County
78. Ward (Grambling)—Geochronology of Ortega Quartzites in Truchas Range and Rio Mora areas
79. Weber, L. (Johnson, Kottlowski)—Facies analysis of Pennsylvanian carbonate rocks in Rhodes Canyon area, San Andres Mountains
80. Weber, R.—Geology of Plains of San Agustin
81. Weber, R.—Petrographic and chemical characteristics of 10 new meteorites from New Mexico
82. Weise (LeMone)—Carbonate petrology of U-Bar Limestone in Big Hatchet Mountains
83. West (Flessa)—Paleoenvironment of Dakota–Mancos transition beds in western San Juan Basin
84. Wilson and Bieberman—The civil war in New Mexico: tall tales and true (New Mexico Geological Society guidebook, October 1983)
85. Wolberg and Kottlowski—Correlation of stratigraphic units in southwest New Mexico and westernmost Texas (COSUNA project)
86. Woodward—Geology of the Nacimiento Mountains
87. Wright (Anderson)—Facies of Mancos and lower Mesaverde Group near La Ventana
88. Young (Hawley)—Late Cenozoic geology of the lower Rio Puerco, Valencia and Socorro Counties (thesis available)

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Funds for printing totaled $149,385 approximately 7.4% of the Bureau's overall budget, of which $37,412 went toward keeping selected older publications in print in order to meet the demand for information pertinent to mineral-exploration activities in the state.

Most of the printing continued to be handled by the University of New Mexico Printing Plant. Only the trimonthly journal *Isochron/West*, *Guidebook for field trip to the Abo red beds (Permian), central and south-central New Mexico*, and *Open-file List 2* were printed by the New Mexico Tech Print Plant.

Twenty new publications, eight reissued publications, 17 open-file reports, and six announcement cards were released. The number of pages printed totaled 800 in new publications and 1,140 in reissued publications. This is about 150 pages fewer than were printed in 1981–82, a decrease due to a) rising printing costs, b) unusually expensive typesetting and photomechanical processing needed for some of the 1982–83 publications (namely Hydrologic Report 6, Bulletin 35, and Bulletin 72), and c) production difficulties with *Bibliography of New Mexico geology and mineral technology 1976–1980* (about 200 pages). This bibliography was paid for largely from the 1981–82 budget, but, because it could not be released during the 1982–83 fiscal year, it is not included in this report.

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New publications

Memoir 40—CONODONTS FROM EL PASO GROUP (LOWER ORDOVICIAN) OF WESTERNMOST TEXAS AND SOUTHERN NEW MEXICO, by J. E. Repetski, 1982, 121 pp., 1 table, 8 figs., 28 pls., $13.00

Conodonts are microscopic toothlike elements of unknown biological affinity. They are common to abundant in Paleozoic and early Mesozoic marine deposits and are widely used for relative-age determinations and correlations of those deposits. Conodonts of Early Ordovician age are as yet poorly known, and Repetski's study thus represents an important biostratigraphic contribution. Seventeen new species are described, correlation by means of conodonts is discussed, and the El Paso faunal sequence is compared with faunas from Lower Ordovician conodont-bearing successions elsewhere in the United States and abroad.

Memoir 41—MID-CRETACEOUS (TURONIAN) AMMONITE FAUNA FROM FENCE LAKE AREA OF WEST-CENTRAL NEW MEXICO, by W. A. Cobban and S. C. Hook, 1983, 50 pp., 1 table, 14 figs., 14 pls., $7.50

Ammonites are extinct mollusks important for stratigraphic zonation of Cretaceous marine deposits. The Turonian ammonite fauna of Fence Lake area consists of nine genera and 10 species, of which two genera and two species are new. Three species previously not known from North America are present in the Fence Lake fauna.

Circular 177—GEOLOGY AND GEOTHERMAL WATERS OF LIGHTNING DOCK REGION, ANIMAS VALLEY AND PYRAMID MOUNTAINS, HIDALGO COUNTY, NEW MEXICO, by W. E. Elston, E. G. Deal, and M. J. Logsdon, 1983, 44 pp., 7 tables, 26 figs., geologic map at 1:48,000 scale, $10.00

Described are aspects of regional geology that bear on the interpretation of the Lightning Dock geothermal anomaly, chemistry of thermal and cold waters, and the environment, phases, geometry, and hydrodynamics of the geothermal system. A summary is provided of the geothermal system known as well as inferred.

Circular 186—VERTEBRATE PALEONTOLOGY, STRATIGRAPHY, AND BIOSTRATIGRAPHY OF EOCENE GALISTEO FORMATION, NORTH-CENTRAL NEW MEXICO, by S. G. Lucas, 1982, 34 pp., 2 tables, 17 figs., $6.00

The vertebrate fossils recovered from the Galisteo Formation are described, placed into precise stratigraphic context within the formation, and used in conjunction with rock stratigraphy for correlating major outcrops of the formation with each other. The age of the Galisteo Formation is determined and an attempt is made at its correlation with the San Jose and Baca Formations.

Hydrologic Report 6—HYDROGEOLOGY AND WATER RESOURCES OF SAN JUAN BASIN, NEW MEXICO, by W. J. Stone, F. P. Lyford, P. F. Frenzel, N. H. Mizell, and E. T. Padgett, 1983, 70 pp., 14 tables, 103 figs., 1 map, scale 1:500,000, cross sections, $20.00

The report presents the results of a cooperative five-year study undertaken by the New Mexico Bureau of Mines and Mineral Resources, the U.S. Geological Survey, and the New Mexico State Engineer. The San Juan Basin contains vast resources of uranium and coal, and availability of water is crucial to development of these resources. Due to the aridity of the region, the supply of surface water is limited and fully appropriated; therefore, new water supplies for energy development and growing municipalities must be derived from negotiated surface water or ground water. The study concludes that deep aquifers, excess uranium-mine effluent, and Tertiary sandstone aquifers in areas adjacent to the coal belt are potential sources of ground water in the region. Future water needs of growing municipalities may be met in some areas by tapping deeper aquifers and in others by obtaining uranium-mine effluent; however, water treatment may be required in both cases.

Hydrogeologic Sheet 4—HYDROGEOLOGY OF ARROYO CHICO–TORREON WASH AREA, McKINLEY AND SANDOVAL COUNTIES, NEW MEXICO, by S. D. Craigg and W. J. Stone, 1983, 1 sheet, scale 1:62,500, text, 6 tables, 14 figs., $3.50

The area is located in the southwest part of the San Juan Basin and contains sizable reserves of coal. Because the climate is semi-arid and local streams are ephemeral or intermittent, ground water is the main source of water; however, yields of wells and springs are generally low. It is concluded that future supplies of water for domestic, livestock, and energy-resource development should be available from the Cretaceous sandstone aquifers, but the potential of the Westwater Canyon Member of the Morrison Formation (Jurassic) should also be tested.

Geologic Map 54—GEOLOGY OF ANTHONY QUADRANGLE, DOÑA ANA COUNTY, NEW MEXICO, by S. Kelley and J. P. Matheny, 1983, 1 sheet, scale 1:24,000, text, 1 table, 3 figs., $4.00

Illustrated and described are the rock units, structure, and mineral deposits. The dominant feature of the quadrangle is a tilted block of Paleozoic carbonates and shales that forms the northernmost extension of the Franklin Mountains, just north of the New Mexico–Texas state line.

Resource Map 12—SATELLITE PHOTOMAP OF NEW MEXICO, compiled by U.S. Stabilization and Conservation Service, 1983, scale 1:1,000,000, $3.00

This is a revised, black and white enlargement of the color print published in 1980.

Resource Map 14—ACTIVE MINES AND PROCESSING PLANTS IN NEW MEXICO, by M. J. Logsdon, 1982 (revision of RM–9), $9.70

Plate A is a color map (scale 1:3,500,000) of the state's energy and mineral resources. Plate B is a blueline, continuously updated location map (scale 1:1,000,000) of active mines and processing plants, cross-referenced with eight directories of specific commodities.

Scenic Trip 9—ALBUQUERQUE, ITS MOUNTAINS, VALLEY, WATER, AND VOLCANOES (3rd edition), by V. C. Kelley, 1982, 106 pp., 3 tables, 14 figs., 41 photos, 10 maps, $4.50

Guidebooks of the scenic-trip series are intended primarily for the interested public and, in addition to geology, include accounts of scenery and history. However, a professional geologist unfamiliar with the details of regional geology of New Mexico will find a wealth of information in these publications. The tour guide to Albuquerque and vicinity covers the geologic features and processes with emphasis on how they influence the urban development of the area. The road logs cover Sandia Mountains through Tijeras Canyon, west side of Sandia Mountains, Tijeras Arroyo and airport surface, lowlands and conservancy works, and Albuquerque volcanoes.

GUIDEBOOK FOR FIELD TRIP TO THE ABO RED BEDS (PERMIAN), CENTRAL AND SOUTH-CENTRAL NEW MEXICO, compiled by R. F. Broadhead, 1983, 73 pp., 36 figs., $10.00

Issued jointly with the Roswell Geological Society, this guidebook contains road logs and articles on the Abo Formation, the principal gas-producing unit in the state. Aspects covered include correlation of the Abo outcrops with the subsurface gas-producing Abo red beds of east-central New Mexico, paleocurrent analysis of the Abo Formation in the Cerros de Amado area, lithology and depositional environments of the Abo in north-central Sacramento Mountains, and an account of the Pecos Slope Abo gas field in Chaves County.

BIBLIOGRAPHY AND INDEX OF NEW MEXICO GEOLOGY—REFERENCES ADDED TO GEOREF DATABASE DURING 1982, edited by G. N. Rassam, 1983, 116 pp., $6.50

Produced in cooperation with the GeoRef Information System of the American Geological Institute, this bibliography contains approximately 1,000 references. In addition to citations by senior author with cross references, the work includes indices by subject, county, and rock unit. Both published and unpublished materials are included.

NEW MEXICO GEOLOGY, Vol. 4, No. 3 (August 1982), edited by M. D. Adkins–Heljeson, 16 pp.

Petrography and age of plutonic rocks of Florida Mountains; Structural history of Pajarito fault zone in the Española Basin; New Late Cretaceous leaf locality from lower Kirtland Shale member, Bisti area, San Juan Basin; new publications, open-file reports, abstracts, mineral notes, announcements.

NEW MEXICO GEOLOGY, Vol. 4, No. 4 (November 1982), edited by M. D. Adkins–Heljeson, 16 pp.

Earthquake sequence of 1938–1939 in Mogollon Mountains; Fence Lake Formation (Tertiary), west-central New Mexico; Active mines and processing plants in New Mexico (Resource Map 14); Santa Fe River and Hyde Memorial Park; new publications, open-file reports, abstracts, announcements, index to volume 4.

NEW MEXICO GEOLOGY, Vol. 5, No. 1 (February 1983), edited by M. D. Adkins–Heljeson, 20 pp.

Taylor Creek tin district—stratigraphy, structure, and timing of mineralization; Geology and coal resources of Alamo Band Navajo Reservation, Socorro County; Stephenson–Bennett mine; Bluewater Lake State Park; Mineral and mineral-fuel production in New Mexico, 1980–82; Gallery of geology; new publications, open-file reports, reviews, abstracts, announcements.

NEW MEXICO GEOLOGY, Vol. 5, No. 2 (May 1983), edited by M. D. Adkins–Heljeson, 20 pp.

Sedimentology and paleontology of Lower Permian fluvial redbeds of north-central New Mexico; Florida Mountains section of southwest New Mexico overthrust belt—a reevaluation; Oil and gas discovery wells drilled in New Mexico in 1982; Geology and uranium potential of Sabinoso district, San Miguel County; Gallery of geology; new publications, open-file reports, announcements.

ISOCHRON/WEST, No. 34 (August 1982), edited by Bridgett Boulton, 20 pp.

Issued jointly with the Nevada Bureau of Mines and Geology, contains five articles on isotopic geochronology.

ISOCHRON/WEST, No. 35 (December 1982), edited by Bridgett Boulton, 18 pp.

Issued jointly with the Nevada Bureau of Mines and Geology, contains four articles on isotopic geochronology.

ISOCHRON/WEST, No. 36 (April 1983), edited by Bridgett Boulton, 20 pp.

Issued jointly with the Nevada Bureau of Mines and Geology, contains five articles on isotopic geochronology.

Pricelist 17—PUBLICATIONS AVAILABLE FROM NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES, April 1983, 34 pp., free

Comprehensive listing of geologic and mineral reports and maps, indexed by subject and author.

Open-file list 2—OPEN-FILE REPORTS AVAILABLE FROM NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES, January 1983, 15 pp., free

Comprehensive listing of open-file reports and geographic index maps, indexed by subject and author.

Announcement cards 30–35—Announcements of new publications and open-file reports, November 1982–June 1983.

Reissued publications

Memoir 33—GEOLOGY OF ALBUQUERQUE BASIN, NEW MEXICO, by V. C. Kelley, 1977, 60 pp., 9 tables, 24 figs., geologic map, scale 1:190,000, $9.50

Bulletin 8—THE ORE DEPOSITS OF SOCORRO COUNTY, NEW MEXICO, by S. G. Lasky, 1932, 139 pp., 21 figs., 4 pls., $9.50

Bulletin 35—GEOLOGY OF THE SACRAMENTO MOUNTAINS ESCARPMENT, OTERO COUNTY, NEW MEXICO, by L. C. Pray, 1961, 144 pp., 34 figs., 3 pls., 11 stratigraphic sections, $12.00

Bulletin 71—MINERAL RESOURCES OF TAOS COUNTY, NEW MEXICO, by J. H. Schilling, 1960, 124 pp., 3 tables, 43 figs., 2 pls., $4.50

Bulletin 72—MINERAL DEPOSITS OF LUNA COUNTY, NEW MEXICO, by G. B. Griswold, 1961, 157 pp., 14 tables, 24 figs., 10 pls., $12.00

Bulletin 87—MINERAL AND WATER RESOURCES OF NEW MEXICO, by U.S. Geological Survey, 1965, 437 pp., 56 tables, 89 figs., $7.50

Circular 123—MINERAL DEPOSITS OF NOGAL AND BONITO MINING DISTRICTS, NEW MEXICO, by T. B. Thompson, 1973, 29 pp., 15 figs., $6.00

Scenic Trip 1—SANTA FE (2nd edition), by B. Baldwin and F. E. Kottlowski, 1968, 51 pp., $5.50

Open-file reports

OF-133—A TWO-DIMENSIONAL HYDROLOGIC MODEL OF THE ANIMAS VALLEY, HIDALGO COUNTY, NEW MEXICO, by K. M. O'Brien and W. J. Stone, February 1983, 51 pp., 1 table, 16 figs., $10.20

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Payne, M. A., Wolberg, D. L., and Hunt, A., "Magnetostratigraphy, Raton and San Juan Basins, New Mexico—implications for synchroneity of Cretaceous–Tertiary boundary," to Geological Society of America, New Orleans, Louisiana, October.

———, "Magnetostratigraphy, Raton Basin, New Mexico—implications for magnetostratigraphy of the San Juan Basin and synchroneity of Cretaceous–Tertiary boundary events," to Geological Society of America, Rocky Mountain and Cordilleran Sections regional meeting, Salt Lake City, Utah, May.

Popp, C. J., Brandvold, D. K., Ohline, R. W., and Brandvold, L. A., "Distribution and nature of acid precipitation in central and northern New Mexico," to New Mexico Academy of Science annual meeting, Socorro, New Mexico, October.

Reiter, M. A., "Aspects of alternative energy sources and a practical example of the use of solar energy," to Rotary Club, Socorro, New Mexico, December.

Reiter, M. A., and Eggleston, R., "Estimates of terrestrial heat flow along the Rio Grande rift in New Mexico from bottom-hole temperature data in deep petroleum tests," to Geological Society of America, Rocky Mountain and Cordilleran Sections regional meeting, Salt Lake City, Utah, May.

Renault, J. R., "XRF analysis of undiluted rock powders," to Society of Applied Spectroscopy, Chicago Section, Chicago, Illinois, May.

Rigby, J. K., Jr., and Wolberg, D. L., "Late Cretaceous mammals from the fossil forest area, San Juan Basin, New Mexico," to Geological Society of America, Rocky Mountain and Cordilleran Sections regional meeting, Salt Lake City, Utah, May.

Roybal, G. H., "Geology of Salt Lake coal field and evaluation of coal resources in the Salt Lake field," to NMIMT Mining Engineering class, Socorro, New Mexico, December.

Sandor, J. A., Gersper, P. L., and Hawley, J. W., "Soil changes persisting at some prehistoric terracing sites in New Mexico," to Soil Science Society of America, Anaheim, California, November.

Stone, W. J., "Dakota aquifer system in New Mexico," to First C. J. Theis Conference on Geohydrology: The Dakota Aquifer, Lincoln, Nebraska, October.

———, "Water resources, research, and rovings down under," to Socorro Rotary Club, Socorro, New Mexico, December.

Stone, W. J., Allison, G. B., and Hughes, M. W., "Environmental changes in a calcrete surface (South Australia) from isotopes and Cl in the unsaturated zone," to Fifth International Conference on Geochronology, Cosmochronology, and Isotope Geology, Nikko, Japan, July.

Thompson, S., III, "Petroleum exploration in the Pedregosa Basin, southwestern New Mexico," to West Texas Geological Society, Midland, Texas, August.

Waldron, J., "History of gold and silver mining in New Mexico," to American Institute of Mining and Metallurgical Engineers, Southeast New Mexico Section, Carlsbad, New Mexico, September.

Wallin, E. T., "Stratigraphy and paleoenvironments of Upper Cretaceous marine to fluvial facies transition, Sierra County, New Mexico," to New Mexico Geological Society, Socorro, New Mexico, April.

Weber, R. H., "Prehistoric exploitation of mineral resources in New Mexico," to Historical Society of New Mexico, Albuquerque, New Mexico, May.

———, "Early man in the southwest," to American Institute of Mining and Metallurgical Engineers, Southeast New Mexico Section, Carlsbad, New Mexico, January.

———, "Archaeology of the Socorro area," to Socorro Garden Club, Socorro, New Mexico, September.

———, "Quaternary geology of the plains of San Agustin," to New Mexico Academy of Science, Socorro, New Mexico, October.

———, "Lithic materials," to New Mexico Archaeological Society and Museum of New Mexico field school, Gallup, New Mexico, July.

———, "Lithic typology," to New Mexico Archaeological Society and Museum of New Mexico field school, Gallup, New Mexico, July.

Young, J., and Love, D. W., "Late Tertiary and Quaternary evolution of the lower Rio Puerco, New Mexico," to American Geomorphological field group, Pinedale, Wyoming, September.

Other activities

Participation in scientific and professional conferences

Abo Field Trip and Conference, April
American Association of Petroleum Geologists: annual meeting, April
American Association of Petroleum Geologists: Petroleum Exploration School, October
American Chemical Society: national meeting, October
American Geomorphology Field Group Conference, September
American Institute of Mining Engineers–Society of Mining Engineers: annual meetings, April and September
American Institute of Professional Geologists: annual meeting, September
Association of American State Geologists: annual meeting, June
Association of American State Geologists: Central Region Cluster meeting with USGS, October
Association of Earth Science Editors: annual meeting, October
Association of Engineering Geologists: annual meeting, April
Chapman Conference on Point Defects in Minerals, September
Clay Mineral Society: annual meeting, August
Denver x-ray Conference, August
Fifth International Conference on Isotope Geology, July
Foam III "From Rift to Rift," January
Forum on the Geology of Industrial Minerals: annual meeting, May
Friends of the Pleistocene Geological Conference: annual field trip, September
Geological Society of America: annual meeting, October
Geological Society of America, Cordilleran and Rocky Mountain Sections: annual meeting, May
Geological Society of America, Penrose Conference on Laramide Structure of the Rocky Mountains, August
Geological Society of America, Penrose Conference on Tectonic Geomorphology, April
Mogollon Archaeological Conference, October
National Academy of Sciences, Committee on Highwalls and Approximate Original Contour: meetings and field trips, November and December
National Academy of Sciences, Uranium on Federal and Indian Lands: workshop, December
New Mexico Archaeological Council: annual meeting, April
New Mexico Geological Society: annual meeting, April
New Mexico Geological Society: 33rd Field Conference, November
New Mexico Historical Society: annual meeting, May
New Mexico Mapping Advisory Committee: annual meeting, October
New Mexico Oil and Gas Association: annual meeting, October
New Mexico Mining Association: annual meeting, November
New Mexico Natural History Museum: Advisory Board meetings
New Mexico State Fair: display, September
New Mexico Water Resources Research Institute, State Water Conference, April
Revolution in the Earth's Science: Carlton College symposium, April
Rocky Mountain Association of Geologists, Field Trip to Southwestern New Mexico and Southeastern Arizona, October
Roswell Geological Society: meetings
Sigma Xi: annual meeting, October
Society for Applied Spectroscopy: national meeting, October
Society of Vertebrate Paleontologists: annual meeting, October
Soil Conservation Society of America, New Mexico Chapter: meeting on mined land reclamation, October
Symposium on Dakota Aquifer, October
Western States Seismic Policy Council: fifth annual meeting, June

Participation in committees and commissions

Austin—Sigma Xi, NMIMT chapter secretary; AIME–SME Continuing Education Committee; AIME–SME Technical Papers Subcommittee; IndMd, Div. of AIME–SME, Technical Committee chairman, Publication Committee chairman, Executive Committee; NMIMT Geoscience Executive Committee; NMIMT Institute Benefits Committee chairman; NMIMT Space Utilization and Campus Planning Committee chairman; NMIMT Financial Aids committee; NMIMT graduate student committees; NMIMT tenure committees; Clay Mineral Society, Executive Committee; Private Industrial Council of Alamo School Board.

Bieberman—AAPG House of Delegates; AAPG Committee on Preservation of Samples and Cores; AAPG Membership Committee; EMD Subcommittee on Natural Resources at the Waste Isolation Pilot Plant Site; New Mexico Geological Society 1983 Spring Meeting, registration chairman; NMIMT Tenure Committees.

Brandvold—New Mexico Water Conference Advisory Board; New Mexico Water Quality Control Commission, director's representative; New Mexico Water Well Drillers Association, technical support group; Sigma XI, NMIMT Membership Committee; NMIMT Financial Aids Committee; NMIMT Safety Committee, secretary; NMIMT Affirmative Action Committee; Society for Applied Spectroscopy, Rio Grande Chapter, secretary.

Brierley—Society for Industrial Microbiology, Program Committee, chairman; International Symposium on Environmental Biogeochemistry, co-chairman; NMIMT Women's Science and Engineering Conference, co-chairman; Society for Environmental Toxicology and Chemistry, Journal Editorial Board.

Chapin—Consortium for Rio Grande Rift Studies, Executive Committee, chairman; New Mexico Geological Society, Nominating Committee chairman, Field Conference general co-chairman, Editor of the 34th Field Conference guidebook.

Hawley—American Institute of Professional Geologists, Ad Hoc Committee on Hazardous Waste; Geological Society of America; Soil Science Society of America, Interdisciplinary Committee; New Mexico Geological Society Guidebook Committee, road logs co-chairman; New Mexico Water Resources Research Institute, Advisory Committee; Sigma Xi, NMIMT, Nominating Committee and Hazardous Waste Committee.

Eveleth—NMIMT Mineral Museum Advisory Group; Metallurgist Search Committee, chairman.

Kottlowski—American Association of Petroleum Geologists, Publications Committee, Associate Editor; Energy Minerals Division, Publication Councilor; American Commission on Stratigraphic Nomenclature, CODES Committee; Association of American State Geologists, AAPG liaison; Geological Society of America, Executive committee and Councilor and Chairman of Budget Committee; Geological Society of America, Coal Geology Division councilor; Cady Award Committee; New Mexico Coal Surface Mining Commission; New Mexico Energy Research and Development Review Board; New Mexico Mines Safety Advisory Board, chairman; New Mexico Mining Association, Board of Directors and Information and Education Committee; Potential Gas Committee; Regional Coordinator for COSUNA (Correlations of Stratigraphic Units of North America); National Research Council, CODES chairman; COHOAC; New Mexico State Land Office, mining representative on Advisory Council; San Juan River Regional Coal Team.

Love—Geoscience–Bureau Seminar Program; American Geomorphological Field Group trips to Chaco Canyon, co-editor of guidebook and co-organizer; New Mexico Hazardous Waste Management Society, Program Committee.

North—New Mexico Minerals Symposium Organization Committee, Mineral Museum Committee.

Reiter—NMIMT Presidential Search Committee; NMIMT tenure committees.

Renault—NMIMT Computer Advisory Committee; NMIMT Performing Arts Series; NMIMT Honorary Degrees Committee; San Miguel School, school board member.

Robertson—New Mexico Geological Society, Publications Committee chairman, Advertising Committee chairman, and Development Committee chairman; International Science and Engineering Fair, Tours Committee chairman; Sigma Xi, Executive Committee vice president; NMIMT Institute Senate Budget Committee; NMIMT Graduate Council.

Thompson—NMIMT tenure committees; AAPG Matson Award Judge.

Weber—New Mexico Natural History Museum Policy/Advisory Committee; NMIMT Mineral Museum Committee; Archaeological Society of New Mexico Board of Trustees, Certification Council vice president; NMIMT tenure committees; NMIMT search committees.

Wolberg—New Mexico Coal Surface Mining Commission, alternate; NMIMT Mineral Museum Committee; State Paleontology Mitigation Program Committee; New Mexico Natural History Museum, Exhibits Committee; graduate student committees; Society of Vertebrate Paleontology, Government Liaison Committee; co-founder of New Mexico Paleontological Society; Society of Vertebrate Paleontology, representative to Association of North American Paleontological Societies.

Mineral exploration in New Mexico, 1983

by George Austin, *Deputy Director*, and staff,
New Mexico Bureau of Mines and Mineral Resources,
Socorro, New Mexico

Mineral exploration in New Mexico was very restricted in 1983 because of the slow recovery from the economic recession and generally low prices for base metals and industrial minerals. Optimism for exploration still exists, however, especially for gold, silver, and coal. By the end of 1983, several mines that had closed earlier in 1983 and in 1982 were reopened, although some were opened only on a reduced basis. The largest such mines were Molycorp's mine near Questa (1) and the Chino mine near Hurley (2). (All numbers in parentheses refer to locations in Fig. 1.)

Metals

Santa Fe Mining continued to explore for metals and to develop their existing mines. They also continued to drill in the old Pecos mine area (3) of the southern Sangre de Cristo Mountains from the surface in an effort to determine more closely the extent of massive sulfide mineralization. Weststar signed contracts with Federal Resources to supply base- and precious-metal flux from the Lordsburg area (4) in southwest New Mexico. Phelps Dodge Corporation signed similar contracts with Capitan Resources to obtain flux from the Great Republic mine (5) at the northeast end of the Black Range in south-central New Mexico. Mining and development continued at Goldfield Corporation's St. Cloud (6) and U.S. Treasury (7) mines near Winston in Sierra County in the Black Range. Goldfield also brought a new mill on line in 1983 in the same area with a capacity of 460 short tons per day.

Industrial minerals

The only exploration that took place in the potash district of southeast New Mexico in 1983 was the drilling of one hole by Duval Corporation (8) in order to satisfy lease requirements. First Mississippi (FRM Minerals, Inc.) explored an alunite deposit (9) with associated precious metals, which is located six mi north of Chloride in the Black Range, and Tenneco continued to explore for fluorite near Truth or Consequences (10). Zeotech took samples of its zeolite deposit near Buckhorn (11) in the southwest part of the state.

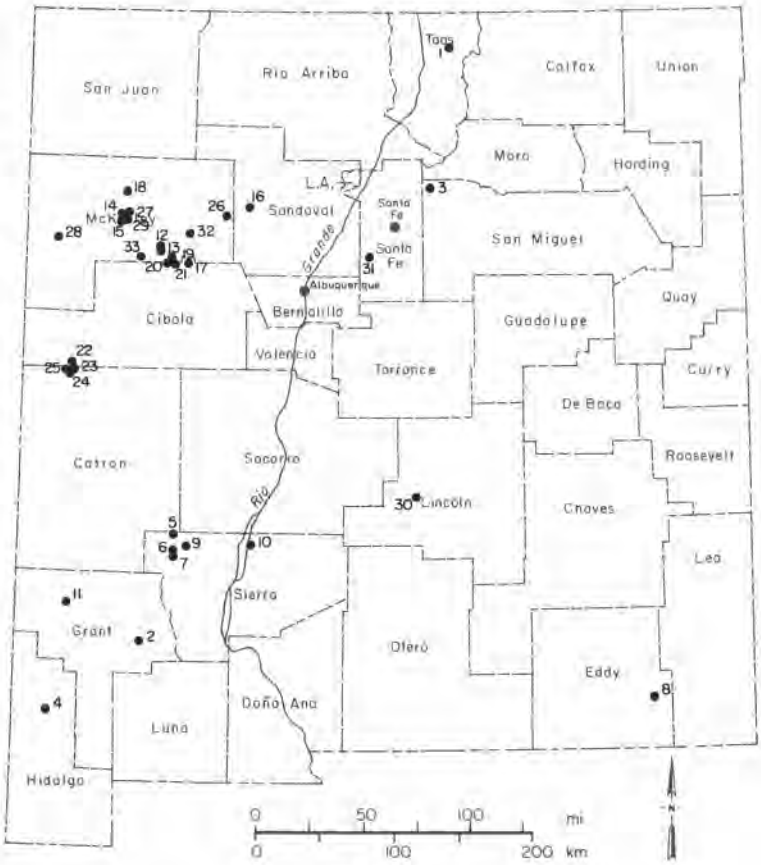

FIGURE 1.

Mineral fuels

Although uranium production in the U.S. has decreased in recent years, some exploration occurred in 1983, chiefly in the southern San Juan Basin. United Nuclear Corporation (12) and Quivira Mining Company, the new mining and production subsidiary of Kerr-McGee Corporation, had a few exploration rigs drilling both in the Ambrosia Lake area (13) and near Church Rock (14) in 1983. Mobil continued development near Crownpoint (15), while Teton drilled near Torreon (16). In addition, Gulf Mineral Resources worked on their Mount Taylor property (17), Phillips Uranium Corporation drilled at their Nose Rock property (18), and Ranchers Exploration and Development Corporation explored near the Hope mine (19). Midas International, Inc., made a discovery of minable uranium at La Jara Mesa (20) approximately five mi north of Milan. Wind River Mining Company, a new subsidiary of Homestake Mining Company, and Rich Mining Company were negotiating lease agreements. Wind River Mining Company will handle production, due to begin in 1985, if market conditions are favorable. Pathfinder Mines also drilled in the La Jara Mesa area (21), but the results have not been released.

Coal exploration centered primarily in the Salt Lake coal field in west-central New Mexico. Salt River Project (22) and Santa Fe Mining (23) both conducted drilling programs there. Dorado Energy (24) and Western Energy (25) were reported to be active in the same area. Western Energy also participated in coal exploration in southeast San Juan Basin in the Chico Wash–Torreon area (26).

Other activity in the San Juan Basin included Crown Coal in the Crownpoint area (27) and the USGS drilling for the BLM near Twin Buttes (28) and Crownpoint (29), where several blocks were drilled under an exploration contract. Other exploratory drilling for coal was conducted by Sunbelt Mining Company near Carrizozo (30) on land held by Newmont Exploration and by Global Exploration near Cerrillos (31).

Santa Fe Mining Company developed the Lee Ranch coal mine (32) during 1983. Coal from this operation will be sold to the Plains Electric Cooperative's Escalante generating station (33) near Prewitt, New Mexico, and to a new generating station near Springerville, Arizona. The first coal shipments are scheduled for October 1984, when the 15-mile Lee Ranch railroad spur should be completed.

Mineral and mineral-fuel production activities in New Mexico during 1982

by Robert W. Eveleth, *Mining Engineer,* and Robert A. Bieberman, *Senior Petroleum Geologist,*
New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico

The overall value of mineral and mineral-fuel production in New Mexico declined 10% to just over $6.7 billion during 1982, the first such decline since 1970–71. Continuing worldwide recession has lessened demand for mineral commodities across the board. With the single exception of coal, all major commodities produced in state show both production and dollar value decreases (Table 1). The largest decreases were posted by the oil and gas industry. While oil and gas production have decreased steadily for several years, higher energy prices, a result of high demand and inflation, had more than offset the difference in prior years. But decreasing production coupled with energy conservation programs and industrial consumers turning to alternate fuel sources (such as coal, etc.) resulted in the decrease for the first time in more than a decade.

The natural gas industry was particularly affected by lessened demand. A similar decrease in demand was registered by the uranium and non-fuel minerals sector. Compared to 1981, uranium production dropped 37% and was down a full 50% (revised data) from the all-time-high production in 1980. This low production was anticipated because approximately three-fourths of the mines active during 1980 have closed.

Production of copper fell dramatically, which affected production of byproduct gold and silver. Potash declined in value 22% to $205 million, but still exceeded the value of copper for the first time. Again, as in 1981, coal was the only major commodity to register an increase during the year.

Despite declining totals, New Mexico continued to lead the nation in the production of uranium, perlite, and potash, advanced to second place in the production of pumice, and remained in third place (behind Arizona and Utah) in copper production (Table 2).

TABLE 1—MINERAL AND MINERAL-FUEL PRODUCTION IN NEW MEXICO. Short tons unless noted. **NA,** not available; **XX,** not applicable; **W,** withheld to avoid disclosing individual company data; **P,** preliminary, subject to revision; **R,** revised; **—,** no production. Data sources: U.S. Bureau of Mines, 1983c; U.S. Dept. of Energy, 1983b,c,d; Oil Conservation Division, New Mexico Department of Energy and Minerals, unpublished data; Oil and Gas Accounting Division, New Mexico Department of Taxation and Revenue, unpublished data; Resource and Development Division, New Mexico Department of Energy and Minerals, unpublished data. *1 bbl = 42 gal.

	1981		1982	
	Quantity	Value (thousand dollars)	Quantity	Value (thousand dollars)
Clays, excluding fire clay (thousand tons)	64	119	60	112
Coal (thousand tons)	18,794	342,035	20,134[R]	386,363[R]
Copper (tons)	169,881	289,204	W	W
Gem stones	NA	200	NA	200
Gold (troy oz)	65,749	30,221	W	W
Gypsum (thousand tons)	166	2,256	198	887
Manganiferous ore, 5%–35% Mn (tons)	12,741	W	—	—
Natural gas (million ft^3)	1,118,589	2,415,033	990,055	2,485,038
Natural gas liquids (thousand bbls*)	53,867	958,837	49,954	849,218
Peat (tons)	NA	NA	NA	NA
Perlite (thousand tons)	489	14,983	408	13,355
Petroleum, crude (thousand bbls*)	72,155	2,474,196	71,024	2,249,344
Potash (thousand tons)	1,765	261,200	1,650	204,600
Pumice, including cinder (thousand tons)	93	919	97	809
Sand and gravel (thousand tons)	7,300[P]	18,000[P]	5,616	17,670
Silver (thousand troy oz)	1,632	17,170	805	6,397
Stone, crushed (thousand tons)	4,162	12,485	2,800[P]	13,700[P]
Stone, dimenson (thousand tons)	26	173	18[P]	138[P]
Uranium, recoverable U_3O_8 (thousand lbs)	12,420	356,454	7,812[R]	299,746[R]
Combined value of barite, CO_2, cement, fire clay, lead, lime, mica, molybdenum, salt, sulfur, vanadium, zinc, and values indicated by **W**	XX	47,747	XX	173,945
Total	XX	7,241,232	XX	6,701,522

Mineral fuels

Oil and gas

New Mexico oil production for 1982 decreased by 1.6% (1.1 million bbls) from 1981 (Table 3). The southeast part of New Mexico produced 0.95% or 0.62 million bbls less oil than in 1981, while the northwest part of the state produced 7.4% or 0.51 million bbls less oil than in 1981. Natural gas production in New Mexico decreased by 11.5% or 129 million ft^3. A decline of 6.4% or 36 million ft^3 in natural gas production was posted in the southeast, and production decreased by 93 million ft^3 or 16.6% in the northwest. New Mexico ranked seventh in the nation in crude oil production and fourth in natural gas production.

In 1982 exploratory drilling increased, but the rates of success in New Mexico decreased from 1981 levels (Table 4). The 351 wildcats that were drilled in 1982 had a success rate of 38.5% compared with 294 wildcats and a success rate of 53.4% in 1981. Greater wildcat activity was reported in southeast New Mexico than in the northwest areas of the state.

There was an increase in the number of new field wildcats drilled, the best indicator of the level of exploration activity,

TABLE 2—NEW MEXICO PRODUCTION AND NATIONAL RANKING BY COMMODITY. Asterisk denotes percent of total quantity produced; all others are percent of total value produced. **W,** withheld to avoid disclosing individual company data. Sources: U.S. Bureau of Mines, personal communication 1984; U.S. Department of Energy, 1983c.

	1981			1982		
Mineral commodity	Rank of New Mexico	Number of States producing	Percent of total	Rank of New Mexico	Number of states producing	Percent of total
Uranium	1	9	32	1	9	28
Perlite	1	7	83	1	6	83
Potash	1	3	83	1	3	85
Natural carbon dioxide	2	4	W			
Pumice	3	8	19	2	8	23
Copper	3	14	10	3	13	W
Natural gas	4	31	5.6*	4	32	5.4*
Natural gas liquids	4	17	7.3*	4	18	6.4*
Molybdenum	4	5	W	5	6	W
Gold	5	14	5	7	12	4
Crude petroleum	7	31	2.3*	7	31	2.3*
Silver	8	20	4	8	16	2

TABLE 3—OIL AND GAS PRODUCTION, 1982. Source: Oil Conservation Division, New Mexico Department of Energy and Minerals, personal communication 1983.

County and area	Crude Oil (bbls) Production	Crude Oil (bbls) Gain (+) or decline (−) from 1981	Natural Gas (thousand ft³) Production	Natural Gas (thousand ft³) Gain (+) or decline (−) from 1981
Chaves	2,636,203	+ 148,406	40,325,264	+ 21,554,109
Eddy	10,568,993	−1,793,805	197,928,674	− 23,345,737
Guadalupe	47	+ 47	—	—
Lea	50,153,717	+1,207,335	280,054,448	− 35,106,289
Roosevelt	1,250,762	− 181,087	5,134,689	+ 931,507
Southeast totals	64,609,722	− 619,104	523,443,075	− 35,966,410
McKinley	826,543	− 20,225	74,906	+ 792
Rio Arriba	2,473,061	− 5,761	159,706,318	− 16,869,227
Sandoval	420,103	− 117,103	3,462,021	+ 576,229
San Juan	2,695,050	− 367,837	303,368,569	− 76,275,152
Northwest totals	6,414,757	− 511,434	466,611,814	− 92,567,288
State totals	71,024,479	−1,130,538	990,054,889	−128,533,698

TABLE 4—DRILLING STATISTICS 1981 AND 1982. Source: American Petroleum Institute, 1982, 1983.

	1981	1982
Wildcats drilled	294	351
Southeast	193	257
Northwest	101	94
Oil	72	61
Southeast	42	41
Northwest	30	20
Gas	85	74
Southeast	58	66
Northwest	27	8
Success rate (%)	53.4	38.5
Southeast	51.8	41.6
Northwest	56.4	29.8
New field wildcats drilled	195	246
Southeast	142	186
Northwest	53	60
Oil	32	24
Southeast	22	19
Northwest	10	5
Gas	41	48
Southeast	34	47
Northwest	7	1
Success rate (%)	37.4	29.3
Southeast	39.4	35.5
Northwest	32.1	10.0
Development wells drilled	2,077	1,882
Southeast	1,005	1,231
Northwest	1,072	651
Oil	752	663
Southeast	575	502
Northwest	177	161
Gas	1,161	1,032
Southeast	310	578
Northwest	851	454
Success rate (%)	92.1	90.1
Southeast	88.1	87.7
Northwest	95.9	94.5

but the percentage of discoveries decreased. In 1982, 246 new field wildcats were drilled with a success rate of 29.3% compared to 195 wildcats drilled in 1981 with 37.4% discoveries.

As a result of the depressed gas market, a renewed search for oil production was begun in northwest New Mexico. The Gallup Sandstone is the primary oil exploration target. In southeast New Mexico, exploration for gas in the Morrow play in southern Eddy and Lea Counties continued at a high rate. Eight oil discoveries were made in Bone Spring carbonates of Lea County and 11 oil and five gas discoveries were made in Bone Spring stratigraphic sands in southeast Eddy County (Collier and others, 1983). Potentially commercial quantities of hydrocarbon gas from wells drilled in DeBaca and Guadalupe Counties were reported (Broadhead, 1983).

The total number of development wells drilled in 1982 was 1,882 with 663 producing oil and 1,032 producing natural gas. The overall success rate was 90.1%. The 1,231 development wells drilled in the southeast area represent a 22.5% increase from 1981, and the 651 development wells drilled in the northwest area represent a decrease of 39.3%. Development well success rates were 87.7% in the southeast and 94.5% in the northwest.

Development drilling in southeast New Mexico continued at a fast pace. Much of the activity can be attributed to drilling in Chaves County, where more than 300 wells were completed in the growing Pecos Slope Abo gas field (Collier and others, 1983). Infill drilling in the natural gas producing area of northwest New Mexico has slowed, and a considerable amount of the drilling has been done to protect leases and to satisfy operating agreements and demands (Western Oil Reporter, 1983, p. 39, 41).

Development of the Bravo Dome carbon dioxide unit continued with the drilling of three wells in Harding County and one in Union County. The completed wells are shut in pending the completion of the pipeline to west Texas.

The addition to proved oil reserves in New Mexico from new field discoveries was about 1 million bbls, which is one-half the 1981 contribution (Table 5). Extensions of old reservoirs and discovery of new ones in old fields added an additional 18 million bbls to proved oil reserves, an increase of 20% from the total proved oil reserves in 1981.

Contributions to proved natural gas reserves from new field discoveries decreased 42.4% from the 1981 level to 68 billion ft³. Extension of existing reservoirs and discovery of new ones in old fields added 503 billion ft³, a decrease of 44.6% from 1981.

TABLE 5—CONTRIBUTIONS TO PROVED RESERVES FROM DISCOVERIES IN 1981 AND 1982. Source: U.S. Department of Energy, 1983a.

	1981	1982
Added new field proved oil reserves (million 42-gal bbls)	2	1
Added old field extensions and new reservoirs proved oil reserves (million 42-gal bbls)	15	18
Added new field proved natural gas reserves (billion ft³)	118	68
Added old field extensions and new reservoirs proved natural gas reserves (billion ft³)	908	503
Total proved oil reserves (million 42-gal bbls)	555	563
Total proved natural gas reserves (billion ft³)	13,870	12,418

Once again, production of crude oil and natural gas exceeded discoveries in 1982. However, the net effect of production and corrections, adjustments, and revisions of previously reported reserve figures was an approximate 1.4% increase in New Mexico's proved crude oil reserve to approximately 563 million bbls and a decrease of 10.5% in natural gas reserves to approximately 12.42 trillion ft^3.

Gulf Energy Processing Co. of Houston announced plans to build a $490,000 natural gas processing plant near Fruitland, New Mexico. Giant Industries, Inc. announced that it plans to shift refining emphasis from its Kirtland, New Mexico, plant to its newly acquired Ciniza refinery near Gallup. The Kirtland plant will continue as an integral part of the overall operation. Southern Union Refining Company is spending $13.3 million on a hydrodesulfurization unit at the Famariss refinery south of Lovington, New Mexico. The unit will enable the refinery to process sour (sulfur-bearing) crude oil.

Construction is underway on two carbon dioxide pipelines that will cross New Mexico. Cortez Pipeline Co., a partnership of Shell Oil, Mobil Oil, and Continental Resources will transport carbon dioxide gas from southwest Colorado to Gaines and Yoakum Counties in west Texas. The Sheep Mountain Pipeline System, a joint venture of Arco, Exxon, and Amerada Hess, will transport carbon dioxide from southeast Colorado and northeast New Mexico to a point near Seminole in Gaines County, Texas.

Coal

New Mexico's coal production increased 7% to a new all-time high of more than 20 million tons in 1982 and is the only major mineral commodity with improved production and sales. Nearly 90% of New Mexico's coal was produced in the northwest portion of the state where large-scale strip mines are operated by Pittsburg and Midway, Utah International, and San Juan Coal Companies. The remainder came from smaller mines in the four corners area as well as from Kaiser Steel Corporation mines near Raton (Table 6). Most New Mexico coal is consumed in coal-fired power plants, but coal from Kaiser's is used almost exclusively in the production of steel.

Production from the York Canyon underground mine dropped 10%, which reflects poor demand from the iron and steel industry. Most of this decrease was due to the closing of the Lone Star steel plant in Fort Worth, Texas, which had consumed about one-third of Kaiser's underground production.

Kaiser's steel mill at Fontana, California, experienced hard times along with the rest of the U.S. steel industry and, although shipments of coal from the York Canyon strip mine to the plant continued via unit train, Kaiser was considering closing the Fontana plant. Negotiations for the sale of Kaiser's properties to a California investment group were carried on throughout 1981 and early 1982, but they were terminated by mid March; the company apparently decided to stay in the steel business. Market situations worsened steadily, however, and all underground mining came to a halt in December. Additional coal sales were lost when Magma Copper Company and the Salt River Power Plant in Arizona closed temporarily.

New Mexico legislators voted to assist the ailing underground coal industry and reduced the severance tax by 2 cents per ton. The rate had been set at 57 cents per ton in both surface- and underground-mined coal.

The Lee Ranch mine of Santa Fe Coal Corp. and the Gateway mine of Sunbelt Mining Co. (a subsidiary of Public Service Company of New Mexico) had permits and were active during 1982 although neither were in production (Gretchen Roybal, personal communication 1983). Santa Fe Industries signed a contract (for their plant at Springerville, Arizona) in May with the Tucson Electric Company for the delivery of 15 million tons of Lee Ranch coal beginning in 1984. Additional coal markets were being sought in New Mexico, Arizona, California, and Texas. Strippable reserves at Lee Ranch are known to be approximately 244 million tons.

Mining operations at the Gateway mine were halted in August by a temporary judicial restraining order because of the mine's proximity to the proposed Bisti Badlands Wilderness area. Five other mines had permits during the year, but were not active: Alamito Coal's Gallo Wash, Chaco Energy's South Hospah, Ideal Basic's La Ventana, Carbon Coal's Carbon No. 2, and San Juan Coal's La Plata. Mining operations at Amcoal Inc.'s mine were completed and reclamation was started (Gretchen Roybal, personal communication 1983).

Carbon Coal Company obtained state approval early in December for their Carbon No. 2 mine which is located approximately 3.5 mi south of Gallup. Reserves of 3.5 million tons of coal are to be mined from the deposit during the next 6–10 yrs.

Of major interest to the future of New Mexico's coal industry is the construction of the proposed Star Lake Railroad. Eight mines still in the planning stage would be dependent on this line for transportation. Approval of the railroad by the Interstate Commerce Commission was granted in February, but more legal hurdles with the DNA–Peoples Legal Services, representing the Navajo Indians, remain before construction can begin.

Santa Fe Railway will put up the initial investment for the railroad when and if a final agreement is reached; negotiations are currently underway with other area mine owners and operators to arrange the remaining financing. Construction costs have nearly doubled from the $1 million per mile initially projected in 1976.

TABLE 6—NEW MEXICO INDIVIDUAL COAL-MINE PRODUCTION. **U**, underground; **NA**, not available; —, no production. Sources: U.S. Department of Energy, 1983b; New Mexico Energy and Minerals Department, personal communication 1982; Keystone Coal Industry Manual, 1983.

Mine	Owner	Production (short tons) 1981	1982
Potato Canyon (U)	Kaiser Steel Corp.	27,878	18,887
York Canyon (U)	Kaiser Steel Corp.	763,000	689,010
West York Canyon	Kaiser Steel Corp.	510,000	599,015
McKinley	Pittsburg & Midway Coal Co.	4,936,900	5,251,417
Navajo	Utah International	6,845,000	7,144,802
San Juan	San Juan Coal Co.	4,119,000	4,906,034
Burnham	Consolidation Coal Co.	48,000	89,459
De Na Zin	Sunbelt Mining Co.	211,145	229,585
Mentmore	Carbon Coal Co.	1,024,000	1,164,879
Arroyo No. 1	Arroyo Mining Co.	NA	37,000
Upper York Prospect	Kaiser Steel Corp.	—	3,446
	Total	18,793,666	20,133,534

Metallic commodities

Copper

At the beginning of the year copper prices were already low, at about $.80 per lb, but they eroded to severely depressed levels by October (the commodities exchange price, COMEX, actually dipped to 54.2 cents/lb on June 18) and closed out the year at $.76/lb. Most of New Mexico's copper industry had had enough by mid-year.

Sharon Steel, which operates both an underground and a surface mine at Fierro in Grant County and doubtless has the highest unit costs, was the first mine to close. A series

of layoffs began in June 1981, but in January the work force was pared to just 90 employees who performed only necessary maintenance or stripped overburden in the pit because the price of copper was only $.81/lb. This lasted until May 20 when complete shutdown was announced. Sharon Steel had been producing approximately 85,000 st per year of copper concentrates (Engineering and Mining Journal, 1982a, p. 60).

Phelps Dodge suffered a similar, although not so rapid, fate. A 20% reduction in output was announced early in the year for all divisions including the Tyrone mine and concentrator. All operations were shut down on April 17 except for the company's newest smelter in Hidalgo County, which remained in operation to smelt leach-dump precipitates and toll ore, mostly from the few remaining operating mines in Arizona (Phelps Dodge Corporation, 1982, p. 4).

Perhaps the greatest surprise came in March when Kennecott closed the Chino operation beginning with shutdown of the concentrator on March 28 (the ore train from Santa Rita made its final run the previous day) followed by shutdown of the smelter in early May; stripping operations in the pit ceased June 1 and New Mexico's oldest and largest copper operation ground to a halt for the first time since the great depression.

Oddly enough, Quintana Minerals, the state's newest operation, had the short-lived and unique distinction of being New Mexico's only copper producer during June. Quintana had bravely entered the failing copper market when they began shakedown operations in January, and they went into full production in mid March. But even the newest of the copper mines, with a short, favorable haulage and low cost, state-of-the-art autogenous milling, could not compete with copper prices at $.70/lb (in terms of real, uninflated dollars the lowest price in 50 yrs or more), and they were forced to close June 30. The recession in the copper industry resulted in the worst unemployment ever, even exceeding unemployment during the depression when the average was 25%. According to one report, the unemployment rate reached as high as 38% in Grant County (Pay Dirt, 1982b, p. 18).

Grant County copper miners and others in the southwest have weathered many severe economic storms before and remained in operation, so why was this time any worse than the others? The answer is complex and involves the obvious factors such as poor demand, low prices (brought about in large part by a glut of foreign copper), high wages, and so on. But the deciding factors in this instance are poor demand and/or low prices for byproducts of copper mining, which include gold, silver, and molybdenum. Total credits for these products can amount to $.20–.90 per pound of copper produced (*see* Engineering and Mining Journal, 1982b, p. 59) and, although the copper itself may be produced at a loss, byproduct revenues can make the overall operation profitable. Molybdenum, silver, and even gold prices have remained low throughout much of 1982, so low that total revenues have fallen below production costs, and this has caused complete shutdown of mining operations.

Planning for that ultimate day when the situation improves, Chino's new concentrator was put through shakedown tests during the summer and plans were underway to gear up for the eventual smelter modernization project at Hurley. Final approval for the project came in late September, and Kennecott formally announced that it would immediately proceed with the $100 million program. An INCO (International Nickel Co. of Canada) flash furnace will replace the existing reverbs. The INCO process requires the injection of oxygen gas, and an oxygen plant will be built at Hurley. A contractor for the project had not been designated by the end of the year, but Stearn–Roger was undertaking engineering studies and was considered to be a likely contractor candidate.

The new concentrator, placed back in limited production along with the mine in September, was running so smoothly late in the year that it was producing approximately 400 tons/day more concentrate than the existing furnaces could handle. It was necessary to store the excess concentrates in a temporary, and rapidly growing, stockpile. Some shipments were made to the McGill smelter in Nevada. Construction on the Hurley smelter project was slated to begin in December with startup projected for early 1985.

Elsewhere in the world of copper mining, Exxon had reached an agreement with Boliden Minerals, Inc., whereby the latter company will acquire the Pinos Altos property. The three-year exploration contract will allow Boliden sufficient time to explore and develop the property and eventually acquire 100% ownership. Exxon will retain a production royalty. For the immediate future Boliden intends to do surface drilling and bulk sampling. A contractor was selected in December to start construction of the "test mine." The orebody will be opened by a decline using trackless diesel equipment; subsequent drifting out of the decline will open the orebody on several levels. The bulk samples thus obtained will be subjected to metallurgical testing. Development of the mine is expected to require about two years. This is much the same plan of operations as projected by Exxon; if all is favorable, Boliden probably will construct a mill on the property with about 2,000 tpd capacity. The Pinos Altos orebody is said to contain known reserves of 7 million metric tons graded at 2% Cu and 3% Zn, along with undisclosed values in gold and silver. Boliden tentatively projects production at 8,000 metric tons of Cu annually for 15 yrs.

The year 1982 marks the first time total copper production and dollar value data were withheld. The two major producers, Chino Mines and Phelps Dodge, produced over 100 million and 23 million pounds, respectively (Standard Oil Company, 1982, p. 27; D. Kinneberg, personal communication 1984; Phelps Dodge Corporation, 1982, p. 8), and they accounted for well over 70% of the total production. Other copper production was reported by Summit Minerals at East Camp (Steeplerock), by the San Pedro mine near Golden, and by the St. Cloud mine near Winston.

Very little copper exploration is ongoing elsewhere, although Exxon was investigating some 300 claims in the Flying A Ranch area, Burro Mountain district.

Gold/silver

Predictably, production of both gold and silver declined during 1982; gold production dropped 21% from 65,749 troy oz produced in 1981 to just over 54,000 troy oz produced in 1982 (U.S. Bureau of Mines, 1983a, table 1, p. 2) while silver production dropped 51% to 804,594 troy oz (U.S. Bureau of Mines, 1983b, table 7, p. 5). Phelps Dodge Tyrone mine, the number 11 silver producer in 1982 (Engineering and Mining Journal, 1982c, p. 15), Sharon Steel's Continental mine (one of the top 45 U.S. silver mines, although not listed), and occasionally Chino mine are significant producers of these metals, but because of the copper situation production was minimal. In fact, if it were not for Gold Fields' Ortiz mine at Cerrillos, which produced more than 50,000 troy oz of gold during their 1982 fiscal year (Amcon Group, Inc., 1982, p. 14), and the Goldfield Corporation (no relation to above firm), which produced more than 400,000 troy oz of silver at their St. Cloud mine (Engineering and Mining Journal, 1983a, p. 112; Skillings Mining Review, 1983, p. 5), production of these metals would have been much lower. During fiscal 1982 Gold Fields mined and processed about 830,000 tons of ore; gold produced was valued at $19

million (Amcon Group, Inc., 1982, p. 14). Overall performance was superb: as of the end of fiscal 1982, the facility had paid back its entire capital cost, a most admirable accomplishment (Gold Fields Consolidated, Ltd., 1982, p. 8). The mine generally produced its 3,000 tpd capacity and occasionally did better than this. Gold Fields utilizes the cyanide heap-leaching process pioneered by the U.S. Bureau of Mines beginning in about 1950. Metallurgical research conducted by Gold Fields has improved overall precious metal recovery to about 90%. Innovations include the use of a gantry (crane) arrangement that selectively stacks the ore for optimum cyanide percolation and aeration of the heap. Leached gold is recovered by activated carbon and precipitated electrolytically as gold metal. Gold Fields is unusual in that electrolytically refined gold foil is produced at the plant instead of shipping the raw gold-plated steel wool to a refinery as is the general practice elsewhere. Gold Fields has 36,000 acres of the Ortiz mine grant under long-term lease and has an ongoing exploration program on the nonactive portions of that lease.

Goldfield Corporation's St. Cloud mine in the Black Range mining district began producing on a limited basis in January and was in full production by March. Initial mining was planned from 67,791 ton blocks of ground averaging 18.08 oz silver, 2.15% copper, and 0.03 oz gold (Doremus & Company, 1981, p. 2; 1982, p. 2, 3). The company also owns and operates a 250 tpd mill at their San Pedro mine northeast of Albuquerque (more than 200 mi from the mine) where the St. Cloud ore is hauled for treatment. This long haul trims profits considerably; therefore, Goldfield has decided to erect a mill with approximately 400 tpd capacity in the Winston–Chloride area. The $3 million facility was scheduled to come on stream by summer 1983; production at the mine will be increased to match the capacity of the new mill; the company also is considering purchasing custom ore from surrounding districts. Savings of about $1 million in haulage costs alone are expected to be realized by the new facility (including the reduced distance from the new mill to the El Paso smelter).

In addition to the two properties mentioned above, gold and silver were produced during 1982 at Quintana's Copper Flat project, Goldfield's San Pedro mine, Summit Mineral's properties at Steeplerock, and several small properties. Goldfield's success at St. Cloud has spurred activity in other area mines including the Great Republic at the north end of that district and at several mines in the Hermosa district to the south. Elsewhere, Conoco conducted exploration for gold in the extreme southern portion of the Ortiz mine grant, particularly in the Gypsy Queen–Candelaria mine areas. The project was terminated, however, with the phaseout of Conoco's minerals department subsequent to that firm's takeover by DuPont in August 1981.

Molybdenum

Like copper, it was a dismal year for molybdenum production nationwide, but for New Mexico, molybdenum production was nearly nonexistent. Only one company (down from three the previous year), Kerr–McGee in Grants, produced molybdenum in New Mexico during 1982, and this production was the result of byproduct recovery from uranium mining. A quick look at the market explains the dismal situation.

While official producer prices held steady at $8.50/lb throughout most of the year, spot prices hovered in the $4.00/lb range (or less than half the official price). Some major sales netted prices well below $4.00 (Engineering and Mining Journal, 1982c, p. 19; 1983b, p. 13). The immediate future holds little promise for improvement because of very large stocks held in world inventory, estimated to amount to a full year's supply by some economists. Despite hefty production cutbacks by major U.S. producers, little change was noted in the spot market. Compounding the problem for both short- and long-term sales are several new deposits scheduled to come into production during the next two or three years.

Of greatest interest to New Mexico is Union Oil/Molycorp's underground mine at Questa that is currently being developed. Molycorp is developing a 124-million-ton orebody containing 0.29% MoS_2 (Engineering and Mining Journal, 1983b, p. 17) that was scheduled to go into limited production in July 1983 and to reach full production (approximately 18,000 tpd/20+ million lb/yr MoS_2 concentrate) a year later.

Molycorp closed its mill in August 1981 and has produced no concentrate since then. The new mill was essentially completed during 1982. The mine will be developed by the block-caving method used extensively in similar Colorado mines. The Questa deposit is opened by two 1300-ft shafts (service and ventilation) while the haulageway is a $-10°$ decline 6,600 ft in length through which ore will be transported by conveyor to the surface. Rail-mounted equipment is used underground. About 150 million tons of tailings are expected to be produced by the mine during its more than 20-year life, and the construction of a new tailings impoundment area in the nearby Guadalupe Mountains is being contemplated.

Quintana Mineral's concentrator produces (when operating) about 200 st/d of copper concentrates containing, among other things, 4,000 lb MoS_2 (52–53% Mo; Engineering and Mining Journal, 1982c, p. 104). Thus, Quintana should have produced 200,000–300,000 lb MoS_2 during the three months of operations terminating at mid year. No production, however, was reported.

Understandably, molybdenum exploration was at or near zero level although Superior Oil's mineral division continued to evaluate (at a reduced level) their molybdenum prospect in the White Mountains–Bonito area, Lincoln County (Superior Oil Co., personal communication 1982).

Lead/zinc

Production of lead remained small during 1982 as it has since the closing of the Groundhog mine at Vanadium. Lead prices, in terms of constant (or real) dollars, dropped to predepression levels. The lead that was produced was recovered only as a byproduct from the mining of silver, gold, and more rarely, copper ores. Ironically the state's largest producer, Goldfield Corporation, received no payment for lead contained in their concentrate because it is shipped as copper-gold-silver ore. Other lead production was reported by Sierra Corporation at Georgetown, Summit Minerals Co. at Steeplerock, and Resources America from the Great Republic mine.

No zinc was produced in New Mexico during 1982.

Uranium

The uranium industry in New Mexico and elsewhere in the U.S. continued its precipitous decline from its peak year in 1980; production was down 37% in 1981 and declined another 50% in 1982. World overproduction is responsible for the five-year supply of yellowcake currently held in inventory (Engineering and Mining Journal, 1983b, p. 84), which exerts a continuous downward pressure on uranium spot market prices. Spot prices have remained so low for so long now (below $23/lb is the average for the year) that all but two New Mexico uranium producers ceased production. The uranium market is in total chaos; some 80% of the sellers are utility companies attempting to dump costly inventories at nearly any price, while 80% of the

buyers are the mining companies fulfilling yellowcake contracts with spot market uranium at prices lower than their production costs (Paydirt, 1982a, p. 1).

Despite the low spot prices, the average price of uranium sold during 1982 as determined by the Energy Information Administration of the Department of Energy was $38.37/lb. The price is determined on the basis of older contract purchases combined with the more recent (and lower) spot prices.

Eight companies (25 mines) were operating at the beginning of 1982; the total shrank to two companies and seven mines by the end of the year. The following were among the mines to cease operations: United Nuclear at Churchrock, Homestake's section 25, Western Nuclear at Thoreau, Gulf Minerals at Mt. Taylor, and Anaconda at the Jackpile. The last train of ore left the Jackpile in early February, and the Bluewater mill ceased operations at the end of March. Of the two companies still active, both were operating on reduced production schedules: Homestake employees worked a 4-day 32-hour week; Kerr–McGee's mine production was reduced by 30% and the mill workers were reduced to a 10 on/4 off schedule.

The only significant exploratory drilling was done at La Jara Mesa in the Ambrosia Lake district by a consortium of companies including Midas, Homestake, and Pathfinder Mines, Inc. (V. McLemore, personal communication 1983).

Other metals

The New Mexico Bureau of Mines and Mineral Resources staff is frequently asked by the general public for information regarding deposits and production of platinum group metal (PGM) deposits in the southwest. No platinum or PGM deposits are currently known to exist anywhere in the southwest United States in concentrations sufficient to justify mining, although many claims are made to the contrary either out of scientific ignorance or with fraudulent intent. A very small amount of PGM is recovered from southwest ores, however, along with other "exotics" such as selenium and tellurium.

Copper metal arriving at a refinery is further purified by the electrolytic process and each copper anode yields a very small amount of noncopper material called anode slime in refinery language. Gold and silver are the only two components in this slime that are paid for by the refinery; the remainder is sent on to another stage in the refining process for further recovery. Indeed, it it were not for the fact that these remaining metals were concentrated several thousand fold in the copper-refining process, they would not be worth recovering at all. Any metals recovered beyond this point are not credited back to any individual mine, thus New Mexico, like other states, is not credited with any production of PGM, selenium, or tellurium no matter how small or large the amount recovered.

Arizona Department of Mineral Resources conducted an interesting study of this problem recently and arrived at the following figures based on refinery production from the Inspiration Consolidated Copper Company:

66 tons Cu ore	=	1 ton Cu concentrate
3 tons Cu concentrate (198 tons ore)	=	1 ton Cu anode
900 tons anode (178,200 tons ore)	=	1 ton slimes
2 tons slimes (356,400 tons ore)	=	1 oz PGM

Original copper ore then is assayed mathematically at 0.0000028 troy oz PGM per ton (Phillips, 1980). While figures for specific ores in New Mexico are not currently available, they are doubtless similar. So much for "platinum deposits" of the southwest!

Nonmetallics

Potash

Production and value of potash, New Mexico's leading nonmetallic mineral commodity, continued its steady decline from its peak years of production in 1979–1980. Total production was down 7% to 1.65 million short tons while value decreased 22% to $204.6 million (both figures were revised from preliminary data). Potash producers are facing many of the same problems as the rest of the mining industry: worldwide recession, high interest rates, and surplus capacity worldwide. The market situation forced cutbacks and layoffs in the domestic industry. At the same time, according to some analysts, foreign producers aggressively entered the American market and dumped their product at less than cost while they increased capacity at older facilities and developed new deposits. This situation was especially true with Israel, Jordan (both with facilities on the Dead Sea), the Soviet Union, and several oriental countries. The future may well bring a further glut and corresponding downward pressure on K_2O prices. Because of this economic situation, Carlsbad experienced some very difficult times.

National Potash Company (NPC) was the first casualty in the industry and announced in late January it would cease operations on February 3. NPC suffered shrinking markets and high production costs, as well as the other problems mentioned above, and after 26 yrs in the business it was no longer able to compete. Some 275 employees were affected by the closure. Efforts were made to find a buyer/operator for the mine and facilities, but no firm agreement had been made by the end of the year.

This left New Mexico with six potash firms operating and all were forced to curtail production via extended vacations and/or temporary layoffs in an effort to work off excess inventories. Potash Corporation of America (PCA) announced in March a three-week shutdown beginning June 7. In rapid succession similar announcements came from International Minerals and Chemical Corp. (IMCC), Mississippi Chemical Corp. (MCC), Amax, Duval, and Kerr–McGee. MCC received momentary economic relief with an unusual sale of 60,000 tons to India, but it made little difference in the overall picture.

Duval also was forced to reduce its work force even before the planned shutdown. Again, at year's end Duval and PCA scheduled additional shutdowns during the Christmas holiday; in addition, PCA reduced their workforce by 80.

Rising costs and increased foreign competition offered the domestic industry but two choices: cut costs or fail. Because of this at least two companies have announced plans for improvements to mine and/or plant facilities. Mississippi Chemical has decided to invest some $17 million in a new compaction plant to increase production of granular potash, which seems to be gaining preference over the standard product. Construction was to begin in January 1983 and should be essentially complete by the following summer. International Minerals is planning to expand their existing compaction plant and in addition has decided to sink a new production shaft southeast of the current mine area. The new shaft may require as much as a $10 million investment by IMCC, but it will significantly enhance overall efficiency by reducing haulage distance and time and it will improve ventilation.

Potash producers face being classified as "gassy" since Mine Safety Health Administration (MSHA) inspectors detected small amounts of methane in Kerr–McGee's and Mississippi Chemical's mines two years ago. To comply with the stringent regulations that come with the gassy classification, potash producers could be forced to spend millions of dollars. Quick legislative footwork on the part of Senator

Harrison Schmitt prevented a similar ruling on the other four potash mines.

Barite

Although no barite was produced in New Mexico during 1982, Barite of America did process some lead-silver-gold ore at their refitted barite mill near Deming. Unfortunately, ore sufficient to run the mill effectively could not be located and it ceased operations during September. Western General Resources' (aka Minopco) barite-lead-fluorspar mill at Hansonburg proved to be a total failure and the project was abandoned.

Mica

Mineral Industrial Commodities of America (MICA) has been attempting to build a new mill to process mica from the Tojo mine in Taos County. Two years ago, the Taos County Commission approved an industrial revenue bond to assist MICA during construction but later withdrew that offer. Recently MICA approached the Rio Arriba County Commission with a similar proposal which was approved. The new plant is to be located near Velarde. Substantial reduction in unit costs are anticipated because the plant will be much closer to the mine (thus lower haulage costs) and capacity will be substantially increased.

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Mineral and mineral-fuel production in New Mexico, 1983

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TABLE—Short tons unless noted. **NA,** not available; **XX** not applicable; **W,** withheld to avoid disclosing individual company data; **P,** preliminary, subject to revision; **R,** revised; **E,** estimated. Data sources: U.S. Bureau of Mines; U.S. Department of Energy; Oil Conservation Division, New Mexico Department of Energy and Minerals; Oil and Gas Accounting Division and Property Tax Division, New Mexico Department of Taxation and Revenue. *1 bbl = 42 gal.

	1982		1983	
	Quantity	Value (thousand dollars)	Quantity	Value (thousand dollars)
Clays, excluding fire clay (thousand tons)	60	112	52	98
Coal (thousand tons)	20,134[R]	386,363[R]	20,436	375,618(1)
Copper (thousand tons)	W	W	W	W
Gem stones	NA	200	NA	200
Gold (troy oz)	W	W	W	W
Gypsum (thousand tons)	198	887	229	1,091
Natural gas (million ft^3)	990,055	2,485,038	885,662	2,426,714
Natural gas liquids (thousand bbls*)	49,954	849,218	48,086	817,462[E]
Peat (tons)	NA	NA	NA	NA
Perlite (thousand tons)	408	13,355	400	13,245
Petroleum, crude (thousand bbls*)	71,024	2,249,344	75,169	2,203,952
Potash (thousand tons)	1,650	204,600	1,251	157,300
Pumice, including cinder (thousand tons)	97	809	144	1,041
Sand and gravel (thousand tons)	5,616	17,670	6,800	18,400
Silver (thousand troy oz)	805	6,397	1,513	17,400
Stone, crushed (thousand tons)	2,800[P]	13,700[P]	3,000	12,000
Stone, dimension (thousand tons)	18[P]	138[P]	26	172
Uranium, recoverable U_3O_8 (thousand lbs)	7,812[R]	299,746[R]	5,316(2)	200,994(3)
Combined value of Co_2, cement, fire, clay, copper, gold, helium (grade A), lead, lime, scrap mica, sulfur, molybdenum, salt, vanadium, zinc, and industrial sand and gravel (1982)	XX	173,945	XX	286,054
Total		6,701,522[R]		6,531,741

(1) Average value of $18.38/ton for 19.5 million tons sold, from Kay Hatton, New Mexico Energy and Minerals Department.
(2) William O. Hatchell's, New Mexico Energy and Minerals Department, estimation of 5,315,899 lbs.
(3) Department of Energy's estimated average of $37.81/lb.

The Upper Cretaceous guide fossil, *Mytiloides mytiloides* (Mantell), in New Mexico

by William A. Cobban, *Paleontologist*, U.S. Geological Survey, Denver, Colorado.

This is the seventh article in a series that describes and illustrates important and easily identified fossil mollusks that are found in Cretaceous rocks in New Mexico. The other six articles are by Hook and Cobban (1977, 1979, 1980, 1981, 1982) and by Cobban and Hook (1983b).

Mytiloides mytiloides (Mantell) is the marine bivalve of Turonian age that has usually been misidentified as *Inoceramus labiatus* (Schlotheim) in much of the literature on Upper Cretaceous rocks. *Inoceramus labiatus*, which should be referred to *Mytiloides*, is an uncommon species, whereas *M. mytiloides* is abundant throughout much of the western interior of the United States.

Mytiloides mytiloides is an elongate, nearly equivalved, moderately biconvex, thin-shelled species ornamented by fairly evenly spaced rugae and raised growth lines, both on the rugae as well as in the interspaces (Fig. 1). Beaks are located on the anterior side and project a little above the moderately long, straight hingeline. The axis of the shell is curved and strongly inclined to the hingeline. The species was described by Mantell (1822, p. 215, pl. 28, fig. 2), who assigned it to *Inoceramus*. Mantell's type specimen came from the Middle Chalk of England. The original illustration is a rather poor sketch, but a photograph of Mantell's specimen can be seen in a monograph on English inoceramids by Woods (1911, fig. 37).

Several lower Turonian species resemble *M. mytiloides* in their elongated form and general appearance. *Mytiloides labiatus* (Schlotheim) differs chiefly because it has a more inflated umbo and more irregular ornament. The holotype of *M. labiatus* seems to be lost, but several examples comparable to the type have been described and illustrated by Seitz (1934, p. 448, pl. 38, figs. 1–3; text figs. 9, 11.) *Mytiloides submytiloides* (Seitz, 1934, p. 444, pl. 37, figs. 1–3; text fig. 8) differs from *M. mytiloides* because it has weaker ornament and lacks distinct growth lines between rugae. *Mytiloides goppelnensis* (Sornay, 1982, p. 139, pl. 7, figs. 1, 3–5) has more circular early growth ornament. *Mytiloides duplicostatus* (Anderson, 1958, p. 100, pl. 17, figs. 3, 4) usually has two strong growth lines on each of the rugae as well as one or two between rugae, whereas several growth lines are present on and between rugae on *M. mytiloides*.

FIGURE 1—*Mytiloides mytiloides* (Mantell), natural size, from Atarque Sandstone Member of Tres Hermanos Formation. Hypotype USNM 374620, from USGS Mesozoic locality D11020 in Mescal Canyon east of Truth or Consequences, Sierra County, New Mexico.

Mytiloides mytiloides is distributed widely in New Mexico (Fig. 2). The species occurs abundantly in the ammonite zone of *Mammites nodosoides* of latest early Turonian age and ranges up into the lower part of the overlying zone of *Collignoniceras woollgari* of earliest middle Turonian age. For the Turonian ammonite sequence in New Mexico, the reader is referred to the chart of Cobban and Hook (1983a, table 1; reproduced in Hook, 1983, fig. 1).

In northeast New Mexico, *M. mytiloides* is found in the upper half of the Bridge Creek Member of the Greenhorn Limestone (e.g., Wood and others, 1953). Darton (1928, p. 41) noted that in the Greenhorn "many layers contain large numbers of the highly characteristic fossil *Inoceramus labiatus*." A little farther west, in north-central New Mexico, *M. mytiloides* (recorded as *Inoceramus labiatus*) occurs in the Greenhorn Limestone Member of the Mancos Shale (Lee, 1917, pp. 203, 214; Rankin, 1944, pp. 20, 24; Dane, 1960, p. 69; Landis and Dane, 1967, p. 5; Muehlberger, 1967, p. 26). The species has been found in the Greenhorn Limestone Member of the Mancos Shale at many localities around the San Juan Basin (e.g., Pike, 1947, table 1; Lamb, 1968, pp. 830, 835; Peterson and Kirk, 1977, p. 175). Rankin (1944, p. 9) noted that "Wherever the Greenhorn has been studied in northern New Mexico, the characteristic fossil, *Inoceramus labiatus* Schlotheim, has been found."

Limestone beds of Greenhorn age become thinner and fewer south and southeast of the San Juan Basin. In west-central and south-central New Mexico, a calcareous unit with a few thin beds of limestone in the Mancos Shale is

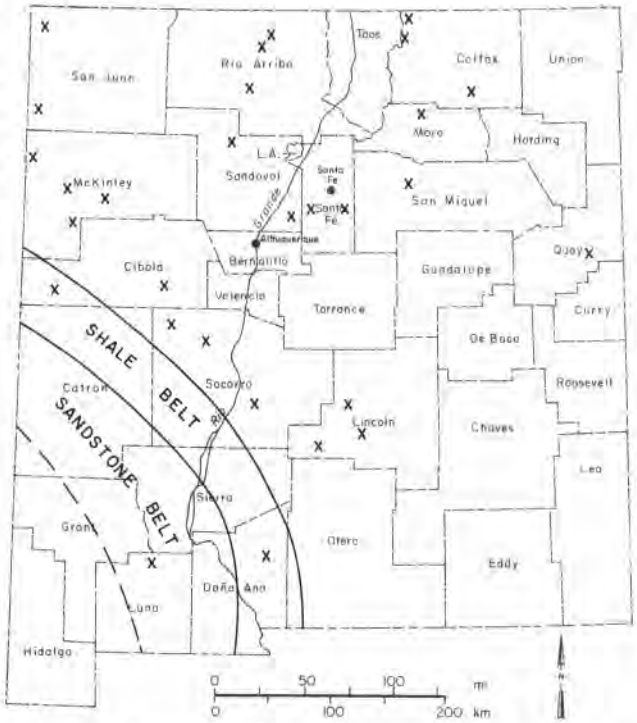

FIGURE 2—Map of New Mexico showing localities (X) where *Mytiloides mytiloides* has been collected and approximate position of shale and sandstone belts of *Mytiloides* age. Dashed line is approximate position of shoreline during this time. Northeast of the shale belt, rocks of *M. mytiloides* age are calcareous shale and limestone.

the age equivalent of only the Bridge Creek Member of the Greenhorn Limestone. Fragments of *Mytiloides mytiloides* are found in some beds (e.g., Rankin, 1944, p. 11; Dane and Bachman, 1957, p. 97; Hook, 1983, pp. 167, 171) in this calcareous unit, referred to as the Bridge Creek Limestone Beds of the Rio Salado Tongue of the Mancos Shale (Hook and others, 1983). These beds of limestone disappear westward, and, near the Arizona boundary, *M. mytiloides* occurs infrequently in limestone concretions in the upper part of the Rio Salado Tongue (Cobban and Hook, 1983a, pp. 5, 6).

The Mancos shale, containing fossiliferous limestone concretions, forms an arcuate belt (Fig. 2) that extends from the center of the west boundary of New Mexico southeastward to El Paso, Texas, where Böse (1910, pp. 29, 32, 34) recorded a unit of "Pizarras y areniscas con Inoceramus labiatus, Schloth" just across the Rio Grande near Ciudad Juarez, Mexico. West of this belt of shale, *M. mytiloides* occurs in a belt of near-shore sandstone near Truth or Consequences and Deming, New Mexico (Fig. 2). Very good examples of the species are present in the Atarque Sandstone Member of the Tres Hermanos Formation in Mescal Canyon near Truth or Consequences (Fig. 1).

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Financial statement

New Mexico Bureau of Mines and Mineral Resources
July 1, 1982, to June 30, 1983

Funds available			
Beginning balance July 1, 1982		$ 10,163	
State appropriation		1,966,370	
Publication receipts		50,204	
Reimbursements		15,698	$2,042,435
Expenditures			
Salaries:			
Scientists and engineers	$757,441		
Support staff	186,408		
Part-time staff (students)	124,916	$1,068,765	
Employee benefits		201,116	
Project contracts		168,212	
Travel and vehicles		92,323	
Scientific laboratories			
Maintenance	$ 19,557		
Materials & supplies	43,437	$ 62,994	
Office supplies		15,489	
Postage & freight		7,531	
Printing		149,385	
Equipment		83,555	
General expenses:			
Telephone	$ 26,444		
Subscriptions & dues	4,119		
Computer service	10,950		
Overhead to Tech	140,000	181,513	$2,030,883
Balance June 30, 1983			$ 11,552
Grants and contracts	$567,285		

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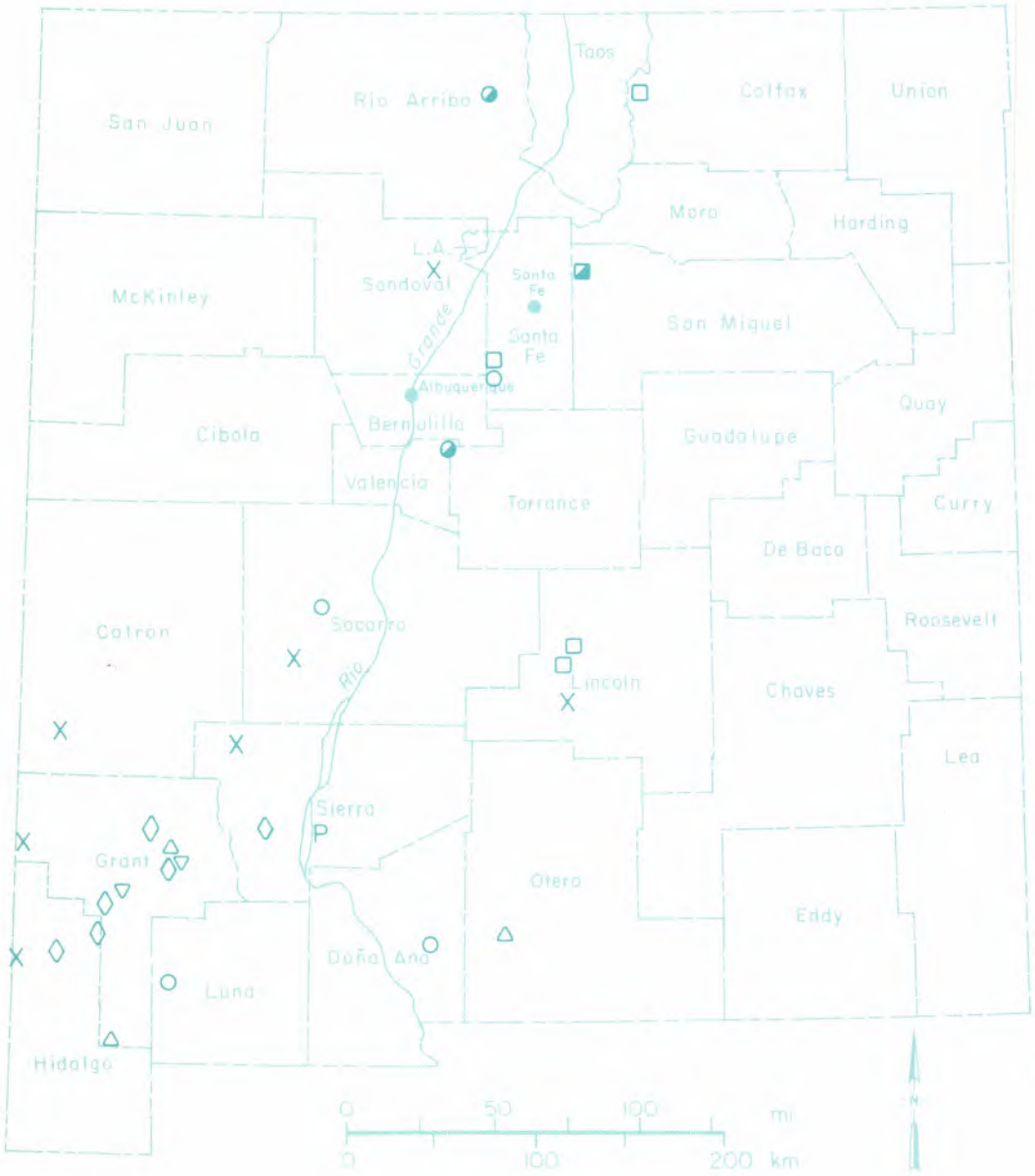
Mining districts in New Mexico that have produced more than 1,000 ounces of gold



P Placer deposit (Pliocene to Recent)

X Epithermal deposits in volcanic rocks (Oligocene to Pliocene)

□ Vein and breccia deposits dominantly in intrusive igneous rocks (Oligocene)

○ Replacement deposits in limestone (Oligocene)

△ Replacement deposits in limestone (Paleocene to Eocene)

▽ Porphyry copper deposits (Paleocene)

◊ Vein deposits (Late Cretaceous to Paleocene)

◪ Massive sulfide deposit (Precambrian)

◕ Vein deposits (Precambrian)