Annual Report

July 1, 1975 to June 30, 1976

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New Mexico Bureau of Mines & Mineral Resources

A DIVISION OF

NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

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

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

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Publications: 505/835-5410
After hours: 505/835-5011

July 30, 1976

To: Board of Regents and President of
New Mexico Institute of Mining & Technology
Governor of New Mexico

I have the honor of transmitting to you the Annual Report of the New Mexico Bureau of Mines & Mineral Resources for the fiscal year July 1, 1975 to June 30, 1976, as required by Section 3, Chapter 115, of the Eighth New Mexico Legislature sessions laws, approved March 4, 1927.

During the fiscal year 20 new technical reports were published by the Bureau, 10 talks were presented at scientific meetings, and 32 papers by Bureau staff and consultants were published in scientific and mineral resources journals. Information concerning exploration, development, and conservation of New Mexico's mineral resources was provided in 7,540 letters, in 4,320 telephone calls, and in 4,195 visitor conferences in Bureau offices. Sales of publications, priced at about cost of printing, totaled $38,997. More than 8,500 publications were distributed to state officials, libraries, and scientific agencies.

Professional staff was at full authorized strength by June 30, 1976; an additional position, approved by the Regents and the Legislature, will be filled. The Board of Educational Finance and the New Mexico Legislature closely followed the Regents' recommendation for a 12-percent increase in the Bureau's budget for the 1976-1977 fiscal year, allowing salary adjustments to stay competitive with State agencies.

Increased involvement with energy resources, quality of environment, and economic development is the result of the Bureau's participation, required by state statutes and the Governor, in the Coal Surfacemining Commission, the Energy Resources Board, the Energy and Science Subcabinet, the Commerce and Industry Subcabinet, and the Water Quality Control Commission.

Respectfully submitted,

Frank E. Kottlowski

Frank E. Kottlowski
Director

AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER

New Mexico Bureau of Mines & Mineral Resources

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

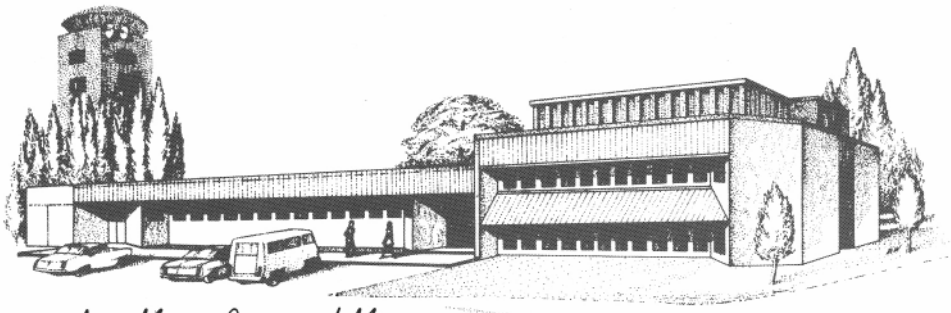
ANNUAL REPORT

for the Fiscal Year
July 1, 1975 to June 30, 1976

by

Frank E. Kottlowski
and Staff

1976



New Mexico Bureau of Mines and Mineral Resources

NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

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NEW MEXICO BUREAU OF MINES & MINERAL RESOURCES

FRANK E. KOTTLOWSKI, *Director*

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JOHN REICHE, *Instrument Manager*
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THOMAS E. ZIMMERMAN, *Chief Security Officer*

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ROBERT BROD
RICHARD CHAMBERLIN
HENRY L. FLEISCHHAUER
JOSEPH IOVENITTI
GLENN R. OSBURN
CHARLES SHEARER
TERRY SIEMERS

Plus about 30 undergraduate assistants

Our front cover displays a miniature of the 1973 1:500,000 shaded relief map published by the U.S. Geological survey. Copies of full-scale map are available from New Mexico Bureau of Mines & Mineral Resources. Color separations for the cover were prepared by USGS Rocky Mountain Mapping Center, Denver, Colorado.

Published by Authority of State of New Mexico, NMSA 1953 Sec. 63–1–3
Printed by University of New Mexico Printing Plant, October, 1976

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

Purpose and Functions

Introduction

By law, the New Mexico Bureau of Mines & Mineral Resources is the official State organization charged with investigating and reporting on the geology and mineral resources of New Mexico, including the energy resources. The Bureau is required to give technical and scientific assistance in the exploration, development, production, and conservation of New Mexico's mineral wealth. That is the basis of our program.

In 1975, the value of minerals extracted in New Mexico totalled more than $2.16 billion. Thus, New Mexico's mineral industry contributes mightily to the State's economy.

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

Geology and Resources

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

Is the scientific and technical information generated by the Bureau useful to the mineral exploration industry? Sales of Bureau publications totalled $38,997 this fiscal year; about 8,500 copies of the new publications were issued free to state officials, libraries, and scientific organizations. Nor do the sales figures of a particular publication necessarily reflect its ultimate worth to New Mexico; a single report or map may contain the clue that leads to the discovery of a huge orebody or a million-barrel oil pool.

Many New Mexicans, and most of the tourists visiting the state, are not concerned directly with technical geologic investigations but do have a true interest in our enchanting landscapes. They want to know how the canyons and mountains, arroyos and mesas, and 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 booklets also are designed to keep tourists in the state "that extra day"—so important to New Mexico's economy. Tens of thousands of copies have been distributed already, and the demand continues.

Metallurgy

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

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

Basic Services

Citizens of New Mexico (and elsewhere) including geologists, engineers, landowners, prospectors, legislators, students, industry personnel, and tourists asked for technical advice from Bureau staff. Our records show that 7,540 letters and 4,320 telephone inquiries were answered, and 4,195 office visitors counseled. Many adults and school children toured the Bureau's mineral museum. Many 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 65,000 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 various campus committees.

Laboratories

Analytical and X-ray

The Bureau's laboratories are equipped to perform extensive chemical, mineralogical, and petrological investigations. Chemical analyses, both qualitative and quantitative, are performed by classic wet-chemical and optical-spectrographic procedures, as well as by atomic absorption, X-ray, and electron-microprobe spectrometry. Capabilities include analyzing water, ores, concentrates, geological samples, and leach liquids for the common elements or parameters. A total of 3,135 analytic reports on 795 samples was prepared.

New Mexico Library of Subsurface Data

During the year 168 sets of drilling samples were added, bringing the total number of sets on hand to more than 9,400. Also acquired were electric and other types of mechanical logs from 958 wells, in addition to 1,159 well records from drilling operations.

In October 1975 a special collection of records was acquired from Neil Wills. It consists of sample descriptions from 658 wells, plotted strip logs from 2,783 wells, 3,282 mechanical logs, and 19,857 well records—evaluated by the Bureau at $30,663. Mr. Wills donated this collection to the Bureau upon his retirement from a 50-year career in New Mexico as a geologist and independent oil operator.

Geology and Resource Projects

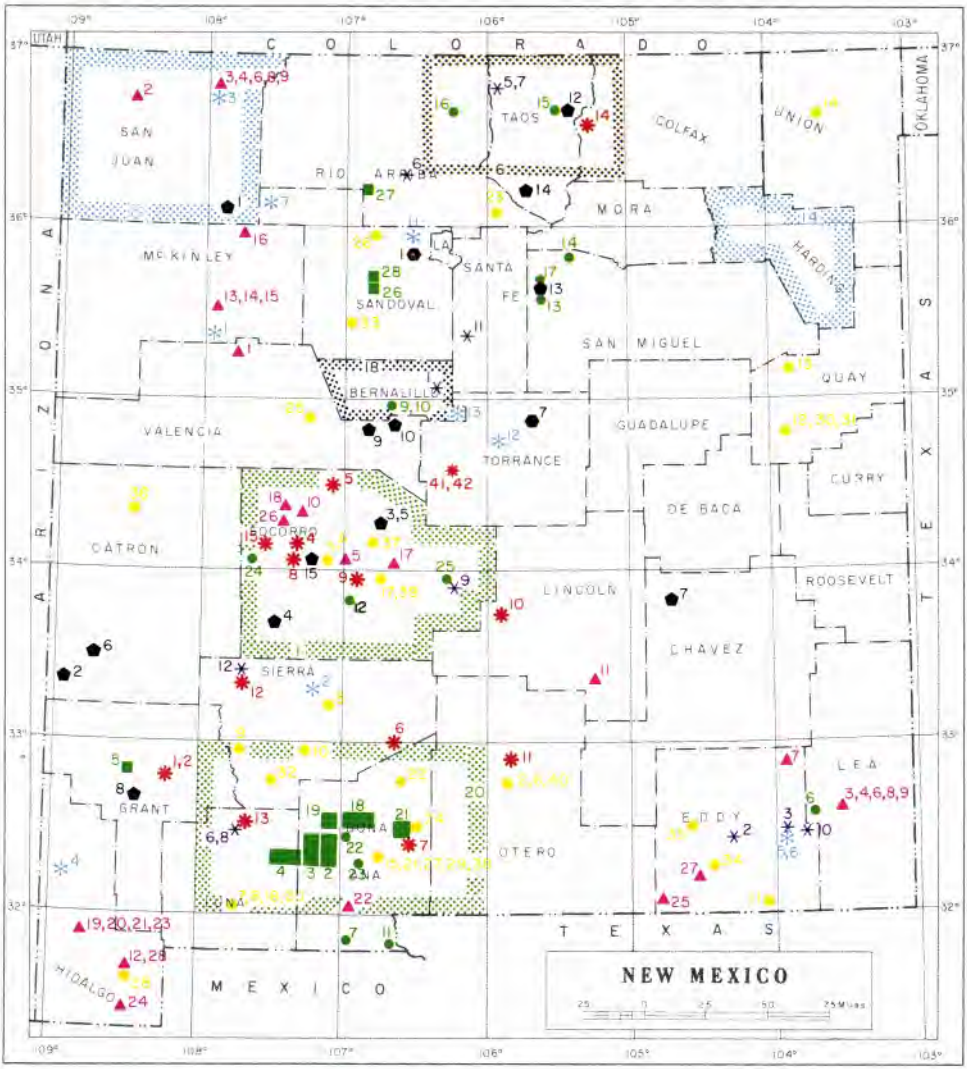
The object of the Bureau's program of investigations is to provide statewide evaluations of mineral resources, to study key areas in detail, and to recommend guidelines for exploration, development, metallurgical extraction, and conservation of New Mexico resources. Completed and ongoing projects, wholly or partly funded by the Bureau, follow. (*Index map is on p. 6.*)

Energy Resources

1. Arnold, Foster, Hill, Kottlowski, Page, Reiter, and Stone—New Mexico's energy resources '75 (Bulletin 107)
2. Austin, Tabet, and Whyte—Statewide coal sampling program (in cooperation with U.S. Geological Survey)
3. Bieberman—Catalog of samples available in New Mexico Library of Subsurface Data
4. Bieberman—Oil and gas fields and exploration map of New Mexico
5. Chapin, Stone, Reiter, and Chamberlin—Geology and geothermal potential of Socorro Peak area
6. Christiansen—History of oil and gas exploration and production in New Mexico
7. Foster—Geology of Loco Hills field, Eddy County
8. Foster—Petroleum developments, 1974 (1974-75 Annual Report and Open-file Report 58)
9. Foster—Estimate of oil and gas reserves in New Mexico (in Bulletin 107, and continuing)
10. Massingill—Cretaceous coals and Tertiary uranium in Riley area
11. Milner—Glorieta-San Andres facies in east-central New Mexico (Open-file Report 59)
12. Potter and Thompson—Paleocurrent directions in Cretaceous sandstones of southwestern New Mexico
13. Rautman—Uranium resources of New Mexico
14. Renault and Hayslip—Thermoluminescence of quartz as a guide to exploration for uranium in sandstone deposits
15. Schilling, F.—Annotated bibliography of Grants uranium region (Bulletin 105)
16. Shomaker and Whyte—Deep coal deposits of Mesaverde Group in San Juan Basin (in cooperation with U.S. Bureau of Mines; Circular 155, in preparation)
17. Tabet—Geology of Jornada del Muerto coal field, Socorro County
18. Tabet—Geology of the Datil coal field, Socorro and Catron Counties
19. Thompson—Petroleum potential of southwest New Mexico
20. Thompson—Tectonic and igneous effects on petroleum accumulation in southwestern New Mexico (in New Mexico Geological Society Special Publication 6)
21. Thompson—Petroleum sources and reservoirs in Hidalgo County outcrops and oil tests
22. Thompson and Bieberman—Oil and gas exploration wells in Doña Ana County, New Mexico (New Mexico Geological Society 26th Guidebook)
23. Thompson and Cernock—Organic geochemical analyses of well samples from KCM No. 1 Forest Federal oil test (Circular 152, in preparation)
24. Thompson, Greenwood, and Kottlowski—Petroleum potential of Pedregosa Basin
25. Wheeler—Goat Seep reef in Guadalupe Mountains
26. Whyte—Uranium occurrences in the Bear Mountains area
27. Yurewicz—Capitan Formation in Guadalupe Mountains
28. Zeller and Thompson—Structural geology of the Big Hatchet Peak quadrangle (Circular 146)

Mineral Resources and Geology

1. Chapin—Geology and mineral resources of Socorro County
2. Clemons—Geologic map of east half of Corralitos Ranch quadrangle (Geologic Map 36)
3. Clemons—Geologic map of west half of Corralitos Ranch quadrangle (Geologic Map 44, in preparation)
4. Clemons—Geology and mineral resources of southern Goodsight Mountains
5. Cunningham—Circle Mesa quadrangle
6. Hiss—Structure of Permian Ochoan Rustler Formation, southeast New Mexico and west Texas (Resource Map 7; in cooperation with U.S. Geological Survey)



INDEX MAP OF BUREAU FIELD PROJECTS.

7. Hoffer—Geology of Potrillo basalt field, south-central New Mexico (Circular 149, in press)
8. Hunt—Surficial geology of New Mexico (Geologic Maps 40, 41, 42, and 43, in preparation)
9. Kelley, V.—Geology of Albuquerque Basin (Memoir 33, in preparation)
10. Kelley, V. and Kudo—Volcanoes and related basalts of Albuquerque Basin, New Mexico (Circular 156, in preparation)
11. Lovejoy—Geology of Cristo Rey (Memoir 31, in preparation)
12. Renault—Geology of Chupadera Mountains
13. Robertson—Annotated bibliography and index to mapping of Precambrian geology of New Mexico (Bulletin 103, in preparation)
14. Robertson and Budding—Geology and ore deposits of Rociada-Elk Mountain area
15. Robertson and Callender—Precambrian rocks of northeast New Mexico (New Mexico Geological Society 27th Guidebook, in preparation)
16. Robertson and Condie—Precambrian rocks of northern New Mexico
17. Robertson, Mathewson, and Condie—Precambrian geology and ore deposits of the Upper Pecos area
18. Seager—Geologic map and sections of south half San Diego Mountain quadrangle (Geologic Map 35)
19. Seager and Clemons—Geology of Cedar Hills-Selden Hills area Doña Ana County (Circular 133)
20. Seager and Clemons—Geology of Las Cruces 1:250,000 quadrangle
21. Seager and Dulas—Geology and ore deposits of the Organ quadrangle
22. Seager and Kottlowski—Geology of Doña Ana Mountains (Circular 147, in press)
23. Seager, Kottlowski, and Hawley—Geology of Robledo Mountains
24. Weber—Geology of Plains of San Agustin
25. Weber—Geology of Mockingbird Gap site
26. Woodward—Geologic map of San Ysidro quadrangle (Geologic Map 37)
27. Woodward—Geologic map of Gallina quadrangle (Geologic Map 39, in preparation)
28. Woodward—Geology of Gilman quadrangle

Water Resources

1. Brandvold—Selenium analyses of ground water near Grants
2. Brandvold and Dauchy—Trace metal concentration in the Rio Grande within New Mexico
3. Brown—Hydrogeology of Aztec quadrangle
4. Fleischhauer—Hydrogeology of Animas Valley
5. Hiss—Thickness of Permian Guadalupian Capitan aquifer, southeast New Mexico and west Texas (Resource Map 5; in cooperation with U.S. Geological Survey)
6. Hiss—Structure of Permian Guadalupian Capital aquifer, southeast New Mexico and west Texas (Resource Map 6; in cooperation with U.S. Geological Survey)
7. Shomaker—Deep aquifers in the San Juan Basin (in cooperation with companies in area)
8. Stone—Geology and ground-water resources of San Juan County (in cooperation with U.S. Geological Survey)
9. Stone—Question-and-answer pamphlet on ground-water resources
10. Stone—New Mexico water resources information
11. Summers—Catalog of thermal waters in New Mexico (Hydrologic Report 4)
12. Titus—Ground-water resources and geology of Estancia Basin
13. Titus—Ground-water resources of Sandia and Manzano Mountains (in cooperation with U.S. Geological Survey)
14. Trauger—Ground-water resources of Harding County (in cooperation with U.S. Geological Survey)

Industrial Minerals

1. Austin—Shale and clay resources in New Mexico
2. Austin—Ochoan and Guadalupian rocks (symposia scheduled in Carlsbad, May 1977; in cooperation with New Mexico Geological Society and Permian Basin Section of Society of Economic Paleontologists and Mineralogists)
3. Austin and Whyte—Potash deposits in New Mexico
4. Austin and Weber—Perlite deposits in New Mexico
5. Burlbaw—Refractory clays of Dakota Formation of eastern San Juan Basin
6. McAnulty—Fluorspar deposits in New Mexico
7. Naert and Wright—Geology of perlites from No Agua

8. Strickland and McAnulty—Fluorite deposits in Goat Ridge area, Luna County
9. Taggart—Mineralogy of Hansonburg mining district
10. Taggart and Renault—Analyses of evaporite minerals for Sandia Laboratory's exploratory tests at high-level radioactive waste disposal site
11. Taggart and Whyte—Mineralogy and geology of silica deposits at Oro Quay Peak
12. Weber—Zeolites of New Mexico

Metallic Ores and Mining Districts

1. Austin, Bieberman, Robertson, Shantz, Tabet, and Weber—Map of mines, mills, and operators (Resource Map 9, in preparation)
2. Chapin—Mining districts symposia (in cooperation with New Mexico Geological Society and others; publication planned for 1978)
3. Chapin, Clemons, Seager, Weber, and Kottlowski—Age dating of igneous rocks and metallic mineralization in central and southwestern New Mexico (Open-file Report 60 by Chapin, Siemers, and Osburn; and continuing)
4. Chapin, Wilkinson, Iovenitti, and Blakestad—Geology and mineral resources of the Magdalena area
5. Condie—Precambrian rocks of the Ladron Mountains, Socorro County (Geologic Map 38, in press)
6. Condie and Budding—Precambrian rocks of south-central New Mexico
7. Glover—Geology and ore deposits of northwestern Organ Mountains (Open-file Report 63)
8. Iovenitti—Origin of silification in Kelly mining district
9. Jahns and Willard—Manganese deposits of Luis Lopez district
10. Jahns and Willard—Gold deposits of White Oaks mining district
11. Mardirosian—Lead and zinc deposits of Cerrillos, High Rolls, Hansonburg, and Organ districts
12. MacMillan—Structure petrology, and ore deposits of southern part of Sierra Cuchillo
13. Proctor—Trace base metals in Cookes Peak stock
14. Robertson—Mining districts of northeast New Mexico (New Mexico Geological Society 27th Guidebook, in preparation)
15. Wilkinson—Cat Mountain mining district

Stratigraphy and Paleontology

1. Balk—Stratigraphic nomenclature for New Mexico
2. Benne—Lower Gobbler Formation in Sacramento Mountains, Otero County (Open-file Report 64)
3. Chapin—Cenozoic stratigraphy of Socorro-Magdalena area
4. Chapin and Siemers, T.—Chart of stratigraphic nomenclature of Socorro-Magdalena area
5. Dorr—Cenozoic vertebrates in south-central New Mexico
6. Dunning, Wilson, and Anderson—Channel deposits in Holder Formation of Sacramento Mountains
7. Flower—Ordovician correlation (Circular 148, in preparation)
8. Flower—Ordovician actinoceroids and endoceroids (Memoir 28)
9. Flower—Mollusca of the Devonian of New Mexico
10. Flower and LeMone—Faunal and petrologic studies of Bliss Sandstone, El Paso Group, and Montoya Group
11. Foster and Riese—Stratigraphy of the Castile Formation
12. Frye, Leonard, and Glass—Ogallala Formation of northeast New Mexico
13. Gage and Asquith—Mesa Rica Sandstone in Tucumcari area
14. Gilbert and Asquith—Sedimentology of braided alluvial interval of Dakota Sandstone in northeastern New Mexico (Circular 150)
15. Hawley—Quaternary geology of Las Cruces region
16. Hook and Gutjahr—Statistical analysis of planispiral coiling in cephalopods, gastropods, and fusulinids
17. Hook—Paleontology and correlation of the Cretaceous Mancos-Colorado Shale of southwestern New Mexico
18. Hook—Late Canadian cephalopod faunas from Scenic Drive and Filmore Formations
19. Hook—Guide to fossils of New Mexico
20. Hook and Flower—Cephalopod faunas of latest Canadian age from southwestern United States (Open-file Report 61; Memoir 32, in press)

21. King, Krause, and Dixon—Fusulinids of Hueco Formation in Las Cruces area
22. Kottlowski—Mississippian strata of San Andres Mountains (New Mexico Geological Society 26th Guidebook)
23. Kottlowski—Sedimentary fill of Rio Grande structural depression in New Mexico
24. Kottlowski, Seager, and LeMone—Marginal marine and continental facies of Lower Permian in central New Mexico
25. Kues—Fauna of Red Tanks Member of Madera Limestone in Lucero Mesa area (in New Mexico Geological Society Special Publication No. 6)
26. Kurtz and Anderson—Poleo Sandstone Member of Chinle Formation in Nacimiento Mountains
27. LeMone—Petrology of Permian carbonates of Doña Ana and Robledo Mountains
28. LeMone and Simpson—Wolfcamp megafauna and biostratigraphy of Franklin and Big Hatchet Mountains
29. LeMone, Simpson, and Klement—Paleoecology of transition beds of Abo and upper members of Hueco
30. Leonard and Frye—Paleontology of Ogallala Formation in New Mexico
31. Leonard, Frye, and Glass—Late Cenozoic mollusks and sediments, southeastern New Mexico (Circular 145)
32. Macurda—Mississippian crinoids in Lake Valley Formation
33. Owen and Siemers, C.—Dakota units in southeast San Juan Basin between Laguna and La Ventana
34. Pray, Neese, and Schwartz—Lithofacies of Yates-Tansill Formations in Walnut and Rattlesnake Canyons
35. Sarg—Carbonate-evaporite transition facies of Seven Rivers Formation
36. Schiebout—Vertebrate fossils from Baca Formation near Quemado
37. Siemers, T.—Pennsylvanian stratigraphy of Socorro County
38. Simpson—Abo-Hueco megafaunas from Doña Ana and Robledo Mountains
39. Stone, Tabet, and Hook—Cretaceous stratigraphy of Socorro County area
40. Van Wagoner and Wilson—Gobbler Formation facies in the Sacramento Mountains, Otero County
41. Zidek—Some fishes of the Wild Cow Formation (Pennsylvanian) Manzanita Mountains, New Mexico (Circular 135)
42. Zidek—Occurrence of *Platysomas* fish in Manzano Mountains

Remote Sensing

1. Morain, Budge, and Inglis—Vegetation types, landforms, and land use in New Mexico (Resource Map 8, in preparation)
2. Tabet and Inglis—Evaluation of mineral resources, geological structures, land use, and landforms in New Mexico from imagery transmitted from Landsat spacecraft (in cooperation with National Aeronautics and Space Administration and the Technology Application Center at University of New Mexico)
3. Tabet, Inglis, and Page—Regional land use survey based upon remote sensing and other data (in cooperation with Federation of Rocky Mountain States and the Technology Application Center at University of New Mexico)

Geophysical Surveys

1. Reiter—Subsurface temperature data in the Jemez Mountains (Circular 151, in press)
2. Reiter, Edwards and Shearer—Shallow (4000 ft or less) temperature logging in New Mexico and adjacent areas (in cooperation with National Science Foundation)
3. Reiter, Mansure, Edwards, and Shearer—Deep (more than 4000 ft) temperature logging and crustal radioactivity measurements in New Mexico and adjacent areas (in cooperation with National Science Foundation and New Mexico Energy Resources Board)
4. Sanford—Continuing survey of earthquakes in New Mexico
5. Sanford—Gravity survey in central New Mexico
6. U.S. Geological Survey—Aeromagnetic mapping of area from Socorro to north of Taos (matching funding with New Mexico Bureau of Mines & Mineral Resources)
7. U.S. Geological Survey—Aeromagnetic mapping of central New Mexico area (matching funding with New Mexico Bureau of Mines & Mineral Resources)

Metallurgy

1. Brierley—Biogenic extraction of copper and molybdenum at high temperature (in cooperation with U.S. Bureau of Mines)
2. Brierley—Biogenic extraction of uranium
3. Brierley—Thermophilic microorganisms in extraction of metals from ores (summary for *Developments in Industrial Microbiology*)
4. Roman—Development of scale-up procedures for dump and in situ leaching
5. Roman—Optimization of the open-pit mining sequence
6. Shantz—Cyanide leaching of chalcocite (Open-file Report 65)
7. Shantz—Cyanide electrowinning, current potential model
8. Shantz—Cyanide electrowinning, current efficiency model

Special Projects

1. Beaumont, Kottlowski, Shomaker, Siemers, C., and Stone—Guidebook to coal resources of western San Juan Basin and Madrid areas, New Mexico (Circular 154, in preparation)
2. Bikerman—Age dating of volcanic rocks in Glenwood area
3. Chapin—Origin and evolution of the Rio Grande rift
4. Chapin—Mechanics of transport and deposition of ash-flow tuffs
5. Chapin—Cenozoic tectonic and magmatic evolution of New Mexico
6. Chapin, Chamberlin, Clemons, Elston, Finnell, Ratté, and Seager—Geologic road logs for Socorro-Datil-Mogollon-Silver City-Hillsboro loop, New Mexico (circular in preparation)
7. Hunt—Physiographic map and description of New Mexico
8. James and Schilling, J.—Revision of Scenic Trips No. 10, Southwestern New Mexico
9. Kelley, V., Woodward, Kudo, and Callender—Guidebook to Albuquerque Basin of the Rio Grande rift, New Mexico (Circular 153)
10. Renault—Petrology and geochemistry of basalts in Isleta area
11. Schilling, J.—"Isochron/West," a periodic journal of isotopic geochronology (in cooperation with Nevada Bureau of Mines and Geology)
12. Schilling, J.—Revision of Scenic Trips No. 2, Taos, Red River, Eagle Nest (in preparation)
13. Sutherland—Revision of Scenic Trips No. 6, Trail guide to geology of the Upper Pecos (published)
14. Taggart—Harding pegmatite, outdoor museum and historic site
15. Taggart—Secondary copper-lead-zinc minerals at Kelly mining district
16. Taggart and Grigsby—Twinning mechanisms in quartz
17. Taggart and Rosenzweig—New copper-zinc clay mineral
18. U.S. Geological Survey—Topographic map (1:50,000 scale) of Bernalillo County (in cooperation with Four Corners Regional Commission, Bernalillo County, City of Albuquerque, and New Mexico Bureau of Mines & Mineral Resources)
19. Weber—Petrographic and chemical characteristics of 5 new meteorites from New Mexico
20. Wright and Burlbaw—Bibliography of New Mexico geology and mineral technology, 1971 through 1975 (Bulletin 106, in preparation)
21. Wright and Burlbaw—Bibliography of New Mexico geology and mineral technology, 1976 through 1980

Publications

The Bureau issued 26 new publications in the form of memoirs, bulletins, circulars, hydrologic reports, scenic trips to the geologic past, geologic maps, resource maps, journal of geochronology, pricelists, leaflets, and annual report. Another 4 publications were re-issued, while 8 were released as open-file reports. Nine publications announcement cards were prepared and released. Nine large-scale full-color geologic map sheets were prepared and released (3 sheets in 2 circulars, 1 sheet in a scenic trip, 1 sheet in the New Mexico Geological Society guidebook, and 4 sheets in 3 geologic maps).

The histogram on page 12 illustrates publication production for the past ten years (data from annual reports).

Editing and Publishing

A total of 719 pages were issued in new publications (scientific, 501; popular, 122; pricelists, 64; annual report, 32). A total of 638 pages were issued in reprinted publications (all scientific).

Funds allocated to printing totalled $46,792, or about 5 percent of the overall budget for operating the Bureau.

At the close of the fiscal year, 48 manuscripts were either in review or planning (about same as a year ago); another 28 were either being edited or were in press (up 25 percent).

Employee-years devoted to editing and publishing activities are estimated as follows: administrative, 0.3, editing, 0.9 internal plus 0.1 external; pasteup, markup, and copyreading, 1.4; clerical, 0.2; composing, 0.3; proofreading (student), 0.2; compiling New Mexico bibliography, 0.3. The hiring of another full-time employee six weeks before end of last fiscal year reestablished the staff of the editing section to an editor and two assistants.

About midyear, most of the in-house composing of camera-ready copy was reassigned to the administrative office in the Bureau. About 32 percent of new publication pages were prepared camera-ready within the Bureau; about 17 percent of new publication pages were printed at Tech.

Drafting and Illustrating

Full-time staff continued at 3 scientific illustrators; late in the fiscal year a part-time draftsman (student) was hired.

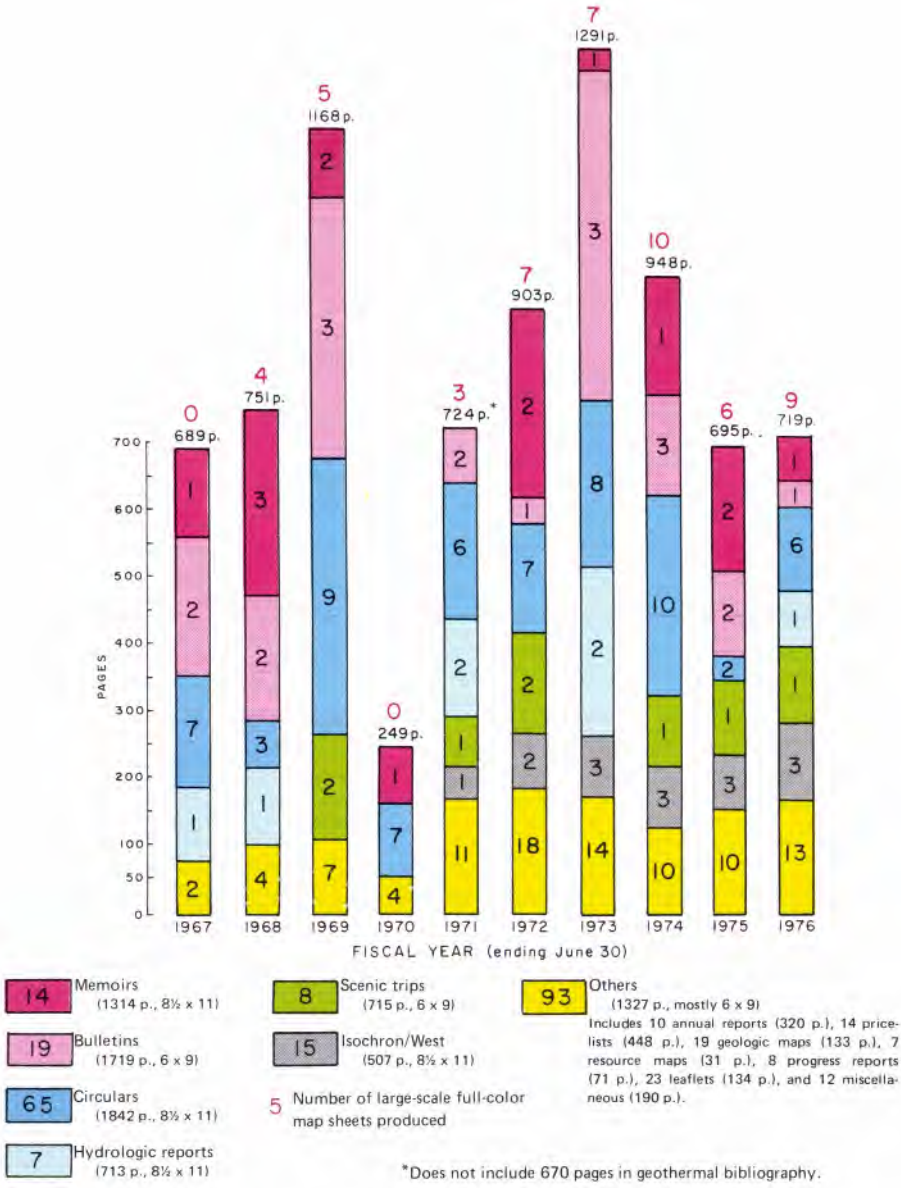
At midyear, preparing camera-ready legends on the Bureau's composing typewriter was assigned to a scientific illustrator.

The activity of duplicating open-file reports and petroleum exploration maps declined somewhat. Drafting jobs for talks and publications outside the Bureau and for other divisions of Tech increased substantially (totalling 130 drawings per year) to an estimated 0.3 drafting man-years.

At the close of the fiscal year, drafting and illustrating on 16 Bureau publications was either underway or awaiting a start.

New Publications

Memoir 28—PART I—NEW AMERICAN WUTINOCERATIDAE WITH REVIEW OF ACTIN-



*Does not include 670 pages in geothermal bibliography.

PRODUCTION OF PUBLICATIONS BY THE NEW MEXICO BUREAU OF MINES & MINERAL RESOURCES 1966 TO 1976.

Numbers within columns designate total new issues for each category. Numbers within boxes designate total new publications for 10-year period. Grand total is 225 new publications with 8237 pages.

OCEROID OCCURRENCES IN EASTERN HEMISPHERE AND PART II–SOME WHITEROCK AND CHAZY ENDOCEROIDS, by R. H. Flower, 1976, 76 p., 16 plates, 3 figs. $9.00

Descriptions of some new Wutinoceratidae from North America.

Bulletin 107–NEW MEXICO'S ENERGY RESOURCES '75, by E. C. Arnold and others, 1976, 40 p., 9 tables, 18 figs. $1.00

Inventory of energy resources including oil and gas, coal, uranium, and geothermal in New Mexico. Displays information in useful tables, figures, and maps. $1.00

Circular 95–WATER LAW ATLAS–A WATER LAW PRIMER, by T. A. Garrity, Jr. and E. T. Nitzschke, Jr., 1975 (completely revised format), 24 p., 21 maps. $1.50

Series of maps showing water law doctrines applying to both surface and ground water of the fifty states. Includes general information maps of some factors affecting water use such as land ownership, rainfall, and elevation.

Circular 133–MIDDLE TO LATE TERTIARY GEOLOGY OF CEDAR HILLS–SELDEN HILLS AREA, NEW MEXICO, by W. R. Seager and R. E. Clemons, 1975, 23 p., 2 tables, 14 figs., 2 appendices, map and cross sections. $5.00

Emphasis on rock units and structures genetically related to Cedar Hills vent zone or critical to interpretation of the evolution of late Tertiary rifting.

Circular 135–SOME FISHES OF THE WILD COW FORMATION (PENNSYLVANIAN), MANZANITA MOUNTAINS, NEW MEXICO, by Jiri Zidek, 1975, 22 p., 2 plates, 4 figs. $3.00

First description of fish fauna in Pine Shadow Member shales. Includes specimens of genus *Acanthodes,* the first described from Pennsylvanian of North America to warrant assignment to this genus.

Circular 145–LATE CENOZOIC MOLLUSKS AND SEDIMENTS, SOUTHEASTERN NEW MEXICO, by A. B. Leonard, J. C. Frye, and H. D. Glass, 1975, 18 p., 2 tables, 2 figs., 1 appendix. $3.00

Reconnaissance of late Cenozoic geology and correlation of data with stratigraphic, paleontologic, and clay-mineral data from adjacent parts of New Mexico and Texas.

Circular 146–STRUCTURAL GEOLOGY OF BIG HATCHET PEAK QUADRANGLE, HIDALGO COUNTY, NEW MEXICO, by R. A. Zeller, Jr. (with commentary by Sam Thompson III), 1975, 23 p., 3 figs., 1 map. $4.00

Discusses the three general episodes of deformation. Supplement to Zeller's Memoir 16 (1965).

Circular 150–SEDIMENTOLOGY OF BRAIDED ALLUVIAL INTERVAL OF DAKOTA SANDSTONE, NORTHEASTERN NEW MEXICO, by J. L. Gilbert and G. B. Asquith, 1976, 16 p., 4 tables, 20 figs. $2.00

Paleocurrent analysis, grain size, and thickness of this interval indicates a dominant southeasterly transport direction. Source areas were San Luis and Apishapa uplifts.

Hydrologic Report 4–CATALOG OF THERMAL WATERS IN NEW MEXICO, by W. K. Summers, 1976, 80 p., 29 tables, 47 figs., 1 microfiche in pocket. $10.00

Presents data such as location, temperature, discharge rate, field pH, and specific conductance of water discharging at anomalous temperatures from 67 locations.

Scenic Trips to the Geologic Past No. 6 (completely revised, 3rd edition)–TRAIL GUIDE TO GEOLOGY OF THE UPPER PECOS, by P. K. Sutherland and A. Montgomery, 1975, 116 p., 26 figs., 50 photos, 15 color plates, 1 map. $3.50

Fifteen trail logs for hiking and horseback riding in the Pecos Wilderness of the southern Sangre de Cristo Mountains. This area encompasses one of the most beautiful recreational and wilderness regions in the Southwest. Includes a geology and trail map and a glossary.

Geologic Map 35–GEOLOGIC MAP OF SOUTH HALF SAN DIEGO MOUNTAIN QUADRANGLE, NEW MEXICO, by W. R. Seager, 1975, text, scale 1:24,000. $2.50

Geologic Map 36–GEOLOGY OF EAST HALF CORRALITOS RANCH QUADRANGLE, NEW MEXICO, by R. E. Clemons, 1976, text, 2 maps, scale 1:24,000. $4.00

Geologic Map 37–GEOLOGY OF SAN YSIDRO QUADRANGLE, NEW MEXICO, by L. A. Woodward and R. L. Ruetschilling, 1976, text, scale 1:24,000. $2.00

Resource Map 4–CHLORIDE-ION CONCENTRATION IN GROUND WATER IN PERMIAN GUADALUPIAN ROCKS, SOUTHEAST NEW MEXICO AND WEST TEXAS, by W. L. Hiss, 1975, text, scale 1 inch about 8 miles. $1.00

Map depicts varying water quality available from aquifers in study area.

Resource Map 5–THICKNESS OF THE PERMIAN GUADALUPIAN CAPITAN AQUIFER, SOUTHEAST NEW MEXICO AND WEST TEXAS, by W. L. Hiss, 1975, text, scale 1 inch about 8 miles. $1.00

Map depicts position and dimensions of the Capitan aquifer, an important source of ground water.

Resource Map 6–STRUCTURE OF THE PERMIAN GUADALUPIAN CAPITAN AQUIFER, SOUTHEAST NEW MEXICO AND WEST TEXAS, by W. L. Hiss, 1976, text, scale 1 inch about 8 miles. $1.00

Map depicts the structural position of the Capitan aquifer, an important source of ground water.

Resource Map 7–STRUCTURE OF THE PERMIAN OCHOAN RUSTLER FORMATION, SOUTHEAST NEW MEXICO AND WEST TEXAS, by W. L. Hiss, 1976, text, scale 1 inch about 8 miles. $1.00

Map depicts structure of the Rustler Formation, an ideal marker bed that can be readily distinguished in drill cutting samples and on geophysical logs.

Isochron/West–Nos. 13, 14, 15, edited by John H. Schilling, 21 p., 50 p., and 41 p. Available by subscription (4 issues for $8.00)

A serial journal of isotopic geochronology.

Pricelist 8 and 9–PUBLICATIONS AVAILABLE FROM NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES, October 1975 and March 1976. Free

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

Annual Report–NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES July 1, 1974 to June 30, 1975, by F. E. Kottlowski and staff, 1975, 32 p. Free

Summarizes Bureau activities and services. Also includes articles on petroleum developments, mineral production, and turquoise.

TECTONIC MAP OF THE RIO GRANDE REGION, NEW MEXICO, prepared by New Mexico Geological Society in cooperation with Bureau, 1975, scale 1:1,000,000. $2.50

Accompanies 26th guidebook, Las Cruces country.

Leaflet–SCENIC TRIPS TO THE GEOLOGIC PAST, 1975. Free

Briefly describes and locates the twelve scenic trips.

Leaflet–VALLEY OF SILVER–LAKE VALLEY DISTRICT, 1976. Free

Describes the Lake Valley district, famous for the Bridal Chamber, one of the richest silver pockets in the world.

Re-issued Publications

Memoir 25–STRIPPABLE LOW-SULFUR COAL RESOURCES OF THE SAN JUAN BASIN IN NEW MEXICO AND COLORADO, by J. W. Shomaker, E. C. Beaumont, and F. E. Kottlowski, 1971 (reprinted 1976), 189 p., 57 tables, 59 figs., 4 plates, 1 appendix. $9.50

Bulletin 8–THE ORE DEPOSITS OF SOCORRO COUNTY, NEW MEXICO, by S. G. Lasky, 1932 (reprinted 1976), 139 p., 21 figs., 4 plates. $5.00

Bulletin 10–THE GEOLOGY AND ORE DEPOSITS OF SIERRA COUNTY, NEW MEXICO, G. T. Harley, 1934 (reprinted 1975), 220 p., 19 figs., 11 plates. $5.50

Bulletin 104–LAWS GOVERNING MINERAL RIGHTS IN NEW MEXICO, by V. H. Verity and R. J. Young, 1973 (reprinted 1976), 70 p.

Open-file Reports

OF-58–PETROLEUM DEVELOPMENTS IN NEW MEXICO 1974, by R. W. Foster, 1975, 22 tables, 15 figs.

OF-59–SEDIMENTOLOGY OF A SANDSTONE-CARBONATE TRANSITION, LOWER SAN ANDRES FORMATION (MIDDLE PERMIAN), LINCOLN COUNTY, NEW MEXICO, by S. Milner, 1974, 156 p., 4 tables, 31 figs., 11 plates

OF-60–SUMMARY OF RADIOMETRIC AGES OF NEW MEXICO ROCKS, by C. E. Chapin, W. T. Siemers, and G. R. Osburn, 1975

OF-61–CEPHALOPOD FAUNAS OF LATEST CANADIAN AGE FROM SOUTHWESTERN UNITED STATES, by S. C. Hook, 1975, 241 p., 1 table, 5 figs., 21 plates

OF-62–GEOLOGIC AND GEOCHEMICAL INVESTIGATIONS OF GEOPHYSICAL ANOMALIES, SIERRA RICA, HIDALGO COUNTY, NEW MEXICO, by P. M. van der Spuy, 1970, 156 p., 3 tables, 32 figs., 6 plates, 3 appendices

OF-63–GEOLOGY AND ORE DEPOSITS OF THE NORTHWESTERN ORGAN MOUNTAINS, DOÑA ANA COUNTY, NEW MEXICO, by T. J. Glover, 1975, 93 p., 1 table, 12 figs., 8 plates, 1 appendix

OF-64–THE STRATIGRAPHY OF THE LOWER GOBBLER FORMATION, SACRAMENTO MOUNTAINS, NEW MEXICO, by R. E. Benne, 1975, 141 p., 1 table, 4 figs., 3 plates, 1 appendix

OF-65–CYANIDE LEACHING OF CHALCOCITE, by R. Shantz, 1976, 213 p., 45 tables, 12 figs., 3 appendices

Outside Papers Sponsored in Part by Bureau

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Austin, G. S., and Leininger, R. K., 1976, The effect of heat-treating sedimented mixed-layer illite-smectite as related to quantitative clay mineral determinations: Jour. Sed. Petrology, v. 46, p. 206-215

Austin, G. S., and Weber, R. H., 1976, Perlite operations in New Mexico (abs): Geol. Soc. America, Abstracts with Programs, v. 8, no. 5, p. 564-565

Austin, G. S., and Whyte, M. R., 1976, Potash deposits of southeastern New Mexico (abs.): Geol. Soc. America, Abstracts with Programs, v. 8, no. 5, p. 565

Bikerman, Michael, 1976, Initial Sr^{87}/Sr^{86} ratios and K-Ar dates of some volcanic rocks from Catron County, New Mexico (abs.): Geol. Soc. America, Abstracts with Programs, v. 8, no. 5, p. 569

Brierley, C. L., and Brierley, J. A., 1975, Reduction of molybdenum by a thermophilic bacterium (abs.): Abstracts of International Conf. on Heavy Metals in the Environment, p. C211-C213

Chapin, C. E., and Deal, E. G., 1976, The A-L Peak tuff, New Mexico: a composite ash-flow sheet: Geol. Soc. America, Abstracts with Programs, v. 8, no. 5, p. 575

Chapin, C. E., and Seager, W. R., 1975, Evolution of the Rio Grande rift in the Socorro and Las Cruces areas: New Mexico Geol. Soc., Guidebook 26th field conf., p. 297-321

Clemons, R. E., 1976, Origin of the Bell Top Formation ash-flow tuffs, south-central New Mexico (abs.): Geol. Soc. America, Abstracts with Programs, v. 8, no. 5, p. 577

Edwards, C. L., Reiter, M. A., and Shearer, C., 1975, Heat flow and crustal radioactivity in northeast New Mexico and southeast Colorado: Am. Geophys. Union, Trans., v. 56, no. 12, p. 1069

Epis, R. C., and Chapin, C. E., 1975, Geomorphic and tectonic implications of the post-Laramide, late Eocene erosion surface in the southern Rocky Mountains, *in* Curtis, B. F. (ed.), Cenozoic evolution of the Southern Rocky Mountains: Geol. Soc. America, Mem. 144, p. 45-74

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Hawley, J. W., 1975, Quaternary history of the Doña Ana County region, south-central New Mexico: New Mexico Geol. Soc., Guidebook 26th field conf., p. 139-150

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Hayslip, D. L., and Renault, J. R., 1976, Potential of quartz thermoluminescence in uranium exploration (abs.): Geol. Soc. America, Abstracts with Programs, v. 8, no. 5, p. 590

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Hook, S. C., and Flower, R. H., 1976, *Tajaroceras* and the origin of Troedssonellidae: Jour. Paleontology, v. 50, p. 203-300, 2 pls., 1 fig.

King, W. E., and Hawley, J. W., 1975, Geology and ground-water resources of the Las Cruces area, New Mexico: New Mexico Geol. Soc., Guidebook 26th field conf., p. 195-204

Kottlowski, F. E., 1975, Stratigraphy of San Andres Mountains in south-central New Mexico: New Mexico Geol. Soc., Guidebook 26th field conf., p. 95-104

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———, 1976, Geology and mineralogy of some copper sulfide deposits near Mount Bohemia, Keweenaw County, Michigan (abs): Inst. Lake Superior Geology, Minneapolis, Minnesota, p. 51

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Stone, W. J., and Brown, D., 1975, Rainfall-runoff relationships for a small semiarid watershed, western flank San Andres Mountains, New Mexico: New Mexico Geol. Soc., Guidebook 26th field conf., p. 205-212
Tabet, D. E., 1976, Geology of the Jornada del Muerto coal field, eastern Socorro County, New Mexico (abs.): Geol. Soc. America, Abstracts with Programs, v. 8, no. 5, p. 638-639
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Articles in Bureau Publications

Foster, R. W., 1975, Petroleum developments for 1974, Appendix to Annual Report 1974-1975, p. 22-23
——— (coauthor), 1976, New Mexico's Energy Resources '75, Bull. 107
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Thompson, Sam, III, 1975, Commentary on structural geology of Big Hatchet Peak quadrangle, Hidalgo County, New Mexico, by R. A. Zeller, Jr., Circular 146
Weber, R. H., 1975, Turquoise in New Mexico, Appendix to Annual Report 1974-1975, p. 25-28

Other Activities

Participation in Scientific and Professional Conferences

American Association for Advancement of Science: Southwestern and Rocky Mountain Division Meeting, April-May
American Association of Petroleum Geologists: Annual Meeting, May; Southwest Section, March
American Association of State Geologists: Annual Meeting, June
American Chemical Society: Pacific Conference on Analytical Chemistry and Spectroscopy (Society for Applied Spectroscopy, cosponsor), October
American Institute of Mining, Metallurgical and Petroleum Engineers: Annual Meeting, February; Arizona Section, December; Central New Mexico Section, September
American Mining Congress: 1st Annual William T. Pecora Symposium on Remote Sensing, October
American Society for Microbiology: New Mexico Branch Meeting, October; Southwest Regional Tri-State, March
Archaeological Society of New Mexico: Annual Meeting, April-May
Arizona Geological Society: Porphyry Copper Symposium (cosponsored by University of Arizona), March
Association of Earth Science Editors: Annual Meeting, October
Colorado Geological Survey: Symposium on Geology of Rocky Mountain Coal (cosponsored by Colorado School of Mines), April
Colorado State University: 1st Regional Remote Sensing Workshop, March
Forum on the Geology of Industrial Minerals: Annual Meeting, April
Friends of Mineralogy: Regional Meeting, February
Friends of Pleistocene: October
Geological Society of America: Annual Meeting, October; Cordilleran Section, April; Penrose Conference 1) Geodynamics of Continental Interiors, December 2) Sulfides in Mafic Magmas,

September 3) Tectonics and Geophysics of the Intermountain West, September; Rocky Mountain Section, May
International Association of Sedimentologists: International Congress, July
International Conference on Heavy Metals in the Environment: (Sponsored by 8 organizations) October
Lake Superior Institute: Annual Meeting, May 1976
Mineral Museums Advisory Council: Bi-annual Meeting, February
Mineralogical Society of America: Annual Meeting, February
National Science Foundation: Geothermal Conference, May
New Mexico Geological Society: Twenty-sixth Field Conference, November
New Mexico Mining Association: International Mining Days and Annual Meeting, October
New Mexico Oil and Gas Association: Annual Meeting, October
New Mexico State University: Geothermal Conference, October
Pecos Conference: August
Rocky Mountain Federation of Mineral Societies: Regional Meeting, June
Rocky Mountain Ground-Water Conference: May
Solid Mineral Waste Stabilization Liaison Committee: 1975 Meeting, August
U.S. Federation of Mineral Societies: Annual Meeting, July; Annual Meeting, June
U.S. Geological Survey: Geothermal Logging Symposium (with ERDA), September; State Geological Survey Liaison Meeting, September; Uranium and Thorium Research and Resource Conference, December
Water Resources Research Institute: 21st Annual New Mexico Water Conference, April
West Texas Geological Society: Field trip to Wolfcampian Reference Section in Hueco Mountains, November

Participation in Committees and Commissions

GOVERNMENTAL

Austin—Energy Resources Board-Energy Institute for Fossil Fuels (Advisory and Peer Review Committee)
Brandvold—New Mexico Water Quality Control Commission (Bureau representative)
Foster—Bureau of Land Management (Socorro District Advisory Board); Governor's Committee on Technical Excellence (Subcommittee on Radioactive Waste)
Kottlowski—Energy Resources Board; Governor's Commerce and Industry Subcabinet; Governor's Council of Economic Advisors (Subcommittee of Energy Related Growth and Development); Governor's Energy and Science Subcabinet; New Mexico Coal Surfacemining Commission (Director/Secretary); New Mexico Mine Safety Advisory Board (Chairman); New Mexico Mining Association (Board of Directors)
Stone—State Water Conference (Advisory Committee)
Weber—New Mexico Mapping (Advisory Committee); New Mexico Natural Heritage Committee

PROFESSIONAL

Austin—New Mexico Geological Society (Publications Committee, chairman); New Mexico Institute of Mining and Technology Sedimentary Geology Research Group (Steering Committee, coordinator); Sigma Xi Club (treasurer)
Bieberman—American Association of Petroleum Geologists (House of Delegates; Committee on Preservation of Samples and Cores; Membership Committee); New Mexico Geological Society (Publications Committee)
Brierley—American Society for Microbiology, New Mexico Branch (Vice-President)
Burlbaw—Association of Earth Science Editors (Committee on Local Arrangements for 10th Annual Meeting), New Mexico Institute of Mining and Technology Sedimentary Geology Research Group (Steering Committee, recorder)
Chapin—Geological Society of America-Rocky Mountain Section (Symposium on ash-flow tuffs, cochairman; Datil-Mogollon field trip, coleader); New Mexico Geological Society (Publications Committee, chairman-member)
Flower—International Commission on the Cambrian-Ordovician Boundary (consulting member)
Hook—New Mexico Institute of Mining and Technology Sedimentary Geology Research Group (Steering Committee, member)
Kelley—Association of Earth Science Editors (Board of Directors; Committee on Local Arrangements for 10th Annual Meeting, chairman); New Mexico Geological Society (Publications Committee)
Kottlowski—American Association of Petroleum Geologists (Associate Editor; Publications Committee; Strategic Committee on Public Affairs); American Commission on Stratigraphic

Nomenclature (American Association of State Geologists, representative); Geological Society of America (Publications Committee)

Merillat–Association of Earth Science Editors (Committee on Local Arrangements for 10th Annual Meeting)

Renault–Geological Society of America-Rocky Mountain Section (Session on Igneous Petrology, cochairman)

Robertson–International Union of Geological Sciences–Commission on Stratigraphy (Precambrian Working Group), New Mexico Geological Society (Treasurer; Student Grants-in-Aid, chairman)

Stone–New Mexico Institute of Mining and Technology Sedimentary Geology Research Group (Steering Committee, coordinator)

Thompson–New Mexico Institute of Mining and Technology Sedimentary Geology Research Group (Steering Committee, member)

Weber–Archaeological Society of New Mexico (Board of Trustees, president)

NEW MEXICO TECH

Austin–Geological Engineering Administrative Committee; Financial Aids Committee

Brandvold–Equal Opportunity Self-Evaluation Committee

Kottlowski–Executive Committee; Property Committee

Renault–Academic Freedom and Tenure; Graduate Council; Library; Radiation Committee

Shantz–Computer Center Advisory Committee; Safety Committee

Stone–Council of Chairpersons

Weber–Financial Aids Committee

Off-Campus Talks

Austin, G., "Industrial minerals program at the Bureau" at Executive Committee of New Mexico Mining Association, Socorro, Fall

Brandvold, L., "Problems in the laboratory" at New Mexico Water Conference, Las Cruces, April

Brierley, C., "Reduction of molybdenum by a thermophilic acidophilic bacterium" at New Mexico branch of American Society for Microbiology, Los Alamos, October

———, "Women's heritage–mining" at Xi Theta Chapter, Beta Sigma Phi, Socorro, March

Chapin, C., "Cenozoic tectonic and magmatic evolution of New Mexico and Colorado" at Arizona Geological Society, Tucson, AZ, March

Kottlowski, F., "Projects of New Mexico Bureau of Mines and Mineral Resources" at Energy Resources Board, Santa Fe, June

———— , "Water requirements for New Mexico's mineral development" at Rocky Mountain Ground-water Conference, Denver, CO, May

Reiter, M., "Heat flow studies in New Mexico" at New Mexico State University Geothermal Conference, Las Cruces, October

———, "Geothermal studies in the southwest United States" at National Science Foundation, Boulder, CO, May

Taggart, J., "Mineralogy of Hansonburg mining district" at U.S. Federation of Mineral Societies, Austin, TX, June

Staff

New employees joining the Bureau were: Patricia Candelaria, Secretary, August 27, 1975; Thea Davidson, Technician, September 2, 1975; Charles Grigsby, Technician, October 20, 1975; Steve Hook, Paleontologist (Post Doctoral Fellow), April 1, 1976; Arthur Mansure, Geophysicist (Post Doctoral Fellow), September 15, 1975; Christopher Rautman, Economic Geologist, June 28, 1976; Robert Shantz, Metallurgist, July 1, 1975; Michael R. Whyte, Field Geologist, April 1, 1976.

Resignations during the fiscal year were: Leslie Mott, Secretary, August 13, 1975; John W. Hawley, Geologist, shared with the U.S. Soil Conservation Service on the Inter-Governmental Assignment Program, was reassigned August 31, 1975.

Promotions on July 1, 1975 were: Robert A. Bieberman to Senior Petroleum Geologist; Roy W. Foster to Senior Petroleum Geologist; David E. Tabet to Geologist; and Joseph E. Taggart, Jr. to Associate Mineralogist. Promotions on July 1, 1976 were: Judy Burlbaw to Assistant to Editor; Charles Chapin to Senior Geologist; Candace Merillat to Editorial Assistant; Judy Peralta to Secretary II; Joseph E. Taggart, Jr. to Mineralogist; and Shirley Whyte to Secretary I.

During the fiscal year Ronald Roman was on sabbatical leave with the National Institute for Metallurgy at the University of Natal in Durban, South Africa.

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

William E. Arnold
Scientific Illustrator 1/4/54

George S. Austin
Industrial Minerals Geologist
9/1/74

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

Lynn A. Brandvold
Chemist 11/10/65

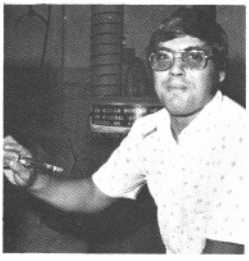
Corale Brierley
Chemical Microbiologist
9/1/71

Judy R. Burlbaw
Assistant to the Editor
9/4/73

Patricia E. Candelaria
Secretary 8/27/75

Charles E. Chapin
Geologist 6/1/70

Richard R. Chavez
Technician 2/21/57



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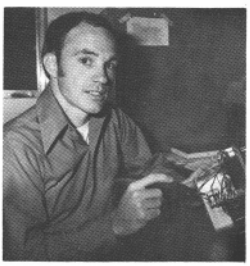

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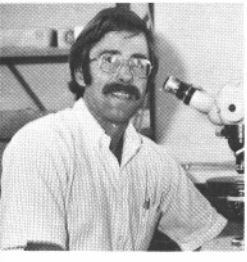

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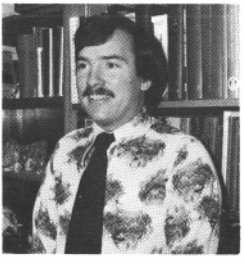

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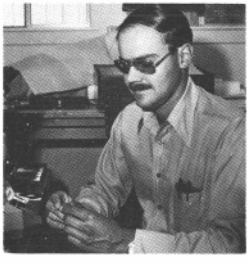

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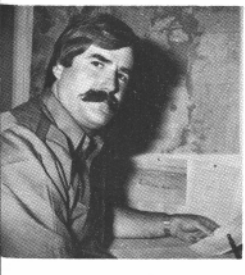

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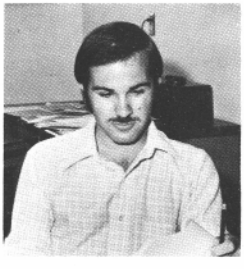

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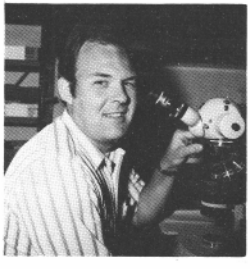

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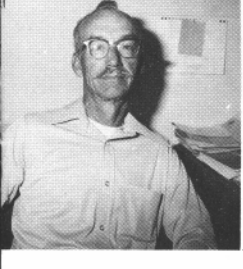

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Potash in New Mexico

by George S. Austin

INTRODUCTION

New Mexico contains the nation's largest concentration of potash reserves; in 1975, 5.1 million tons of concentrate were produced in the state, about 83 percent of the domestic production, or 34 percent of the domestic demand. Potash is the common term for compounds containing the element potassium. Natural potassium-bearing compounds of greatest importance are the soluble mineral salts, especially sylvite (KCl) and langbeinite ($K_2SO_4 \cdot 2MgSO_4$); these minerals are the dominant potash ore minerals in the United States. The principal use of soluble potash minerals is in manufactured fertilizers. Potassium is essential to plant metabolism—no alternative exists. In addition, potash cannot be recycled.

The potassium content of fertilizers is commonly reported as percent K_2O, even though no oxide is present. For example, the mineral sylvite (KCl) contains about 52 percent potassium by weight; however, in converting to the K_2O equivalent percent, sylvite is rated at 63.17 percent. In other words, every 1,000 lbs of pure sylvite contains about 630 lbs of K_2O, or about 524 lbs of elemental potassium. Langbeinite, the other principal ore mineral of potassium, is rated at 22.69 percent K_2O equivalent. Although containing less potassium, langbeinite is also low in the chloride ion for which some plants have low tolerance. In addition, both the magnesium and sulfate ions in langbeinite aid in conditioning highly leached soil.

Adams (1975), in a review of potash resources, stated that the world's recoverable potash in known deposits was approximately 135 billion short tons and that the United States' share was 4 percent. Adams also stated (p. 977), "The current reserves [in the Carlsbad mining district of New Mexico] of 90 million tons K_2O include sylvinite, argillaceous sylvinite . . . and mixed ores containing sylvite, langbeinite, and lesser amounts of other sulfate minerals." Sylvinite ores contain 20 percent or greater sylvite and, commonly, halite. If present as KCl, 90 million tons of K_2O would be equal to about 150 million tons of sylvite; sylvite accounts for about 94 percent of the potash produced in the state.

Ninety million tons of K_2O may be too low. Alto and Fulton (1965) stated that the crude sylvite reserve tonnages in 1965 were 1.3 billion tons having an average K_2O grade of 17 percent. The crude langbeinite ore tonnage reserves were about 0.2 billion tons with an average K_2O grade of approximately 9 percent. Although these estimates were made more than 10 years ago (mining continued during that time), new drilling has delineated additional ore. The total present reserves are probably somewhere between the 90 million tons of K_2O estimated by Adams (1975) and 240 million tons that can be calculated using the data from Alto and Fulton (1965).

Potash from U.S. mines, chiefly from the Carlsbad mining district, supplied all of the nation's needs for many years until 1962, when imports, primarily from Canada, increased dramatically. Since then domestic production has remained fairly constant while imports have continued to increase (fig. 1). Most of the

Canadian imports come from the province of Saskatchewan; in 1970 the Saskatchewan government began setting minimum prices and cutting back production. These actions resulted in market prices high enough to continue mining the lower grade Carlsbad ores. The double-digit inflation rate of the 1970's, however, wiped out much of the increased profits and, in terms of constant dollars, New Mexico's deposits are now about at the profit levels of the early 1960's. To compound the problems of costs and profits, the ores being mined today are lower grade and contain larger amounts of insoluble clay material. These clay minerals tend to require additional chemical treatment in the mills, thus increasing the cost of processing.

GEOLOGY

Thick sections of salt and other evaporite minerals are present in the Permian Basin of west Texas and southeastern New Mexico (fig. 2). These rocks were deposited in a shallow but subsiding basin during Ochoan time (Late Permian), about 250 to 225 million years ago. During the Ochoan, marine waters within the basin were replenished; dissolved solids in the water were being continually concentrated by evaporation. In time, this led to the deposition of potassium salts, some of the most soluble and nearly the last minerals to be deposited from evaporating seawater.

Carlsbad Mining District

The potash minerals were concentrated in a small area on the west side of the Permian Basin; today this small area is known as the Carlsbad mining district. It is astride the Capitan reef, a prominent geologic structure that separates the Delaware Basin from the Northwestern shelf in the western part of the Permian Basin. The Capitan reef is exposed at the surface in the mountains to the southwest of Carlsbad. In the vicinity of the potash mines this reef (shown in fig.

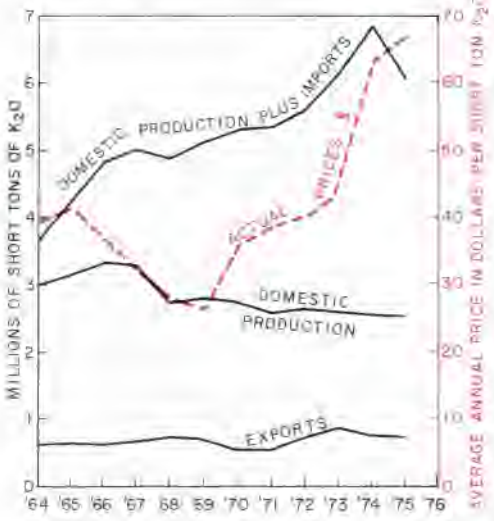

FIGURE 1—U.S. POTASH MARKET 1964 TO 1975.

FIGURE 2—REGIONAL INDEX MAP.

3 as the Capitan Limestone) is deeply buried below the Ochoan evaporites. Ochoan rocks include the Castile, Salado, and Rustler Formations, primarily a sequence of marine evaporites. The McNutt potash zone, the middle member of the Salado Formation, contains 11 potash ore zones (fig. 4). Of these eleven zones, the 1st, 3rd, 4th, 5th, 7th, 8th, and 10th have proved concentrations of potash, but by far the greatest tonnages have been produced in the 1st zone.

Environmental Considerations

The surface relief in the Carlsbad district is not great, averaging a few hundred feet. The surface is characterized by dune fields as well as collapse features typical of karst or sinkhole topography. The soils have developed under mixed shrubs and grasses common to the semiarid continental climate prevailing in the southern High Plains province. Most of the soils have developed caliches and gypsum and have been worked by the wind. The Carlsbad mining district lacks cities and towns; besides the structures relating to the mining of the potash ores, only oil well sites and a few ranches are present. The land is capable of supporting only a few cattle per section.

Identification and Evaluation of Potash Land

The Conservation Division of the U.S. Geological Survey receives all drill-hole information for the federal and state land in the Carlsbad mining district. The U.S. Geological Survey has defined the Carlsbad enclave (fig. 5) as the land within the district containing mineable quantities of potash. Mineable quantities is defined as a bed at least 4 ft thick containing at least 10 percent K_2O as sylvite or at least 4 percent K_2O as langbeinite. All drill-hole information is confidential and can be released only by the companies involved. The information, however, is used to prepare an open-file map showing the boundaries of the enclave, mined out areas, and barren zones. This map is updated annually as a result of new drilling and mining.

Although each of the 11 ore zones is fairly continuous within the enclave, mineable concentrations of potash-bearing minerals are restricted to certain smaller areas. Jones and Madsen (1968) have shown the variability of the 5th ore zone in the district and apparently the other ore zones have equal variability in mineable concentrations. Barren zones within the enclave have resulted from either nondeposition or removal of potash minerals within the Permian sea, later mobilization of the valuable minerals, or both. Thus, drilling programs are used

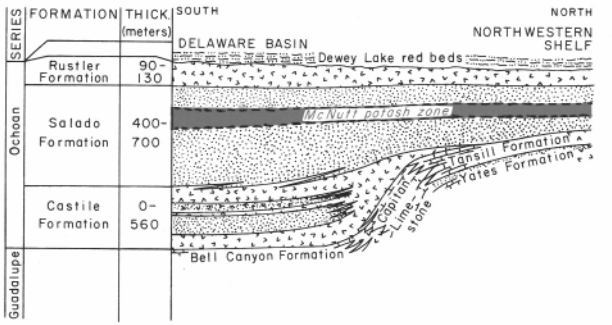

FIGURE 3—SCHEMATIC SOUTH-NORTH CROSS SECTION ACROSS CARLSBAD MINING DISTRICT.

extensively by companies looking for potash. Both chemical analysis of the cores and geophysical logging of the drill holes serve to identify the areas of concentration of the valuable potash minerals.

Mining and Milling

All the mines in the Carlsbad district are underground mines with vertical shafts. The depth of the shafts ranges from 650 to 1,750 ft. To the west of the district the soluble potash minerals have been removed by solution; on the east side of the district the beds dip about 1°E., are deeply buried, and are of lower

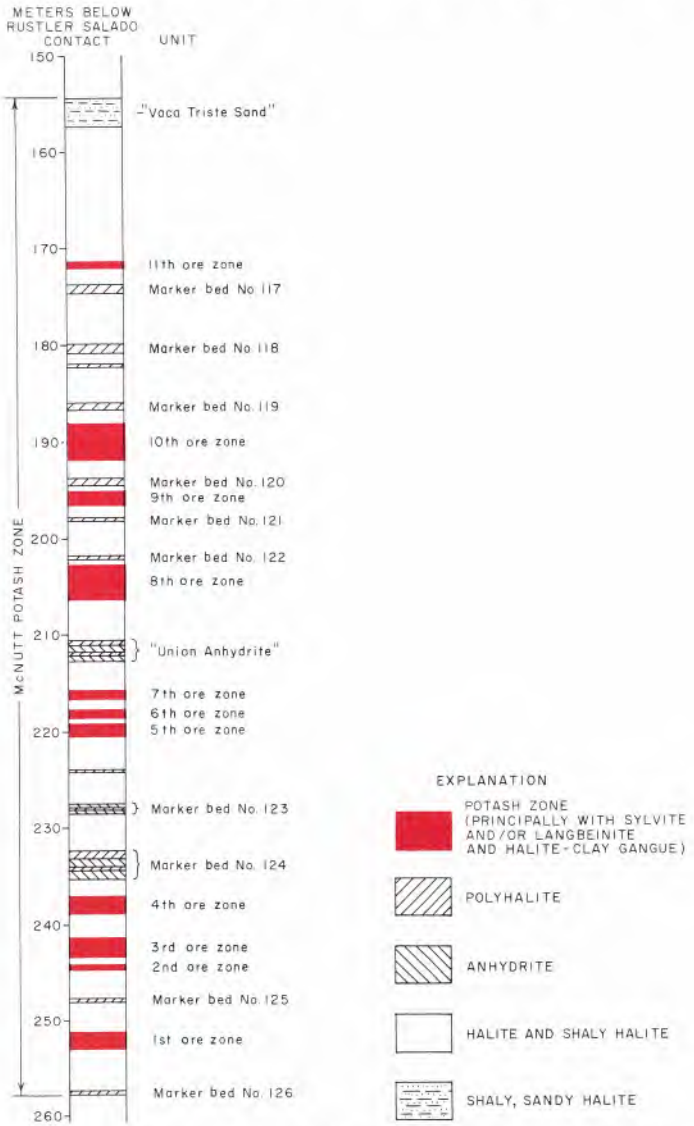

FIGURE 4—COLUMNAR SECTION THROUGH McNUTT POTASH ZONE. (AFTER JONES, BOWLES, and BELL, 1960).

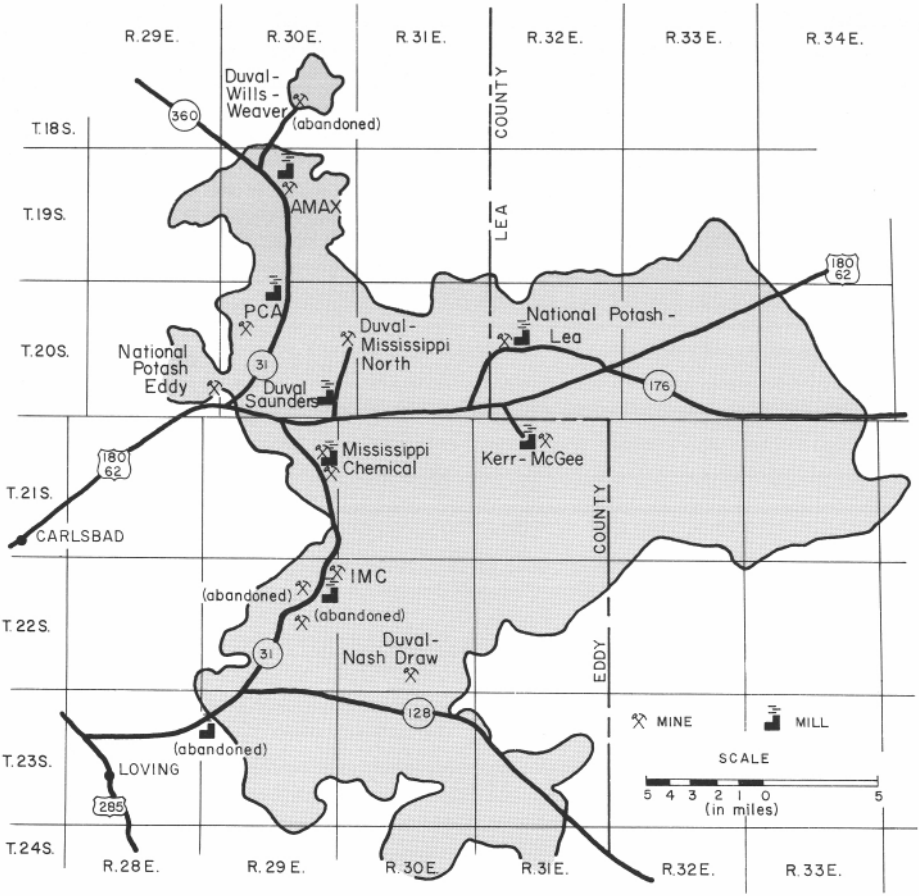

FIGURE 5—CARLSBAD ENCLAVE INCLUDING MINES AND MILLS (Boundaries of enclave defined by U.S. Geological Survey, May 1975).

grade. Shafts are either drilled with large diameter drilling machines or drilled and blasted with conventional shaft sinking equipment. Ground water is scarce, therefore not a problem in sinking shafts.

The ore zones are nearly flat lying; the potash ore is mined with only slightly modified conventional coal mining equipment. The workings are commonly from 5 to 6½ ft high; the room-and-pillar method of mining is used. As much as 70 percent of the ore is taken during the first stage of mining. The second stage consists of robbing the pillars during the withdrawal from a section of the mine; overlying rock units are allowed to settle slowly. Thus, as much as 90 to 92 percent of the ore may be removed. With few exceptions only one ore zone is worked in a given mine. Even in these multilevel mines, however, upper ore zones are seldom worked if lower ore zones have been mined. Subsidence fractures have been observed in the land surface above workings that have collapsed at depths of 1,000 ft or more.

The seven active mines (fig. 5) are owned and operated by seven companies: Amax Chemical Corporation, Duval Corporation, International Minerals and Chemicals (IMC), Kerr-McGee Chemical Corporation, Mississippi Chemical

Corporation, National Potash Company, and Potash Company of America (PCA). Two newcomers, Noranda Exploration Company and Day Mines, Inc. hold leases within the enclave but, as of June 1976, have not developed their properties.

Other Uses for Potash Lands Near Carlsbad

Two additional uses for potash-bearing lands in southeast New Mexico must be considered: the production of petroleum and natural gas and the disposal of atomic waste. Although major oil or gas fields are not known within the Carlsbad enclave, some wells have been completed. The U.S. Geological Survey limits the drilling for oil on potash lands because such wells limit the amount of potash that can be taken out of the ground. Potash cannot be extracted within a 150-ft radius of a well. In addition, to diminish any possibility of well disruption by subsidence, only about 60 percent of the ore is removed within a radius equal to the depth to the mined zone. In other words, if an ore zone lies 1,000 ft below the surface, the mining company loses about 90 percent of ore in a cylinder with a radius of 150 ft. Also lost is about 30 percent of the ore in a cylinder with a radius of 1,000 ft, minus the volume of the first cylinder. The amount of potash ore thus eliminated is considerable.

The site proposed for atomic waste disposal in southeastern New Mexico is a different matter. If developed, the federal government will locate the site outside of the present enclave, away from known oil fields, away from centers of population, and in a geologically stable area. However, once the site is chosen, further potash development of the area will be exceedingly difficult. The facility also will be of such a size and complexity as to limit, or at least affect, mining even outside of immediate area.

To assess the effect of the oil and gas industry and of the proposed atomic waste disposal site on the potash industry, the economics of potash must be considered. At present the individual interests of these separate groups are not in conflict. However, the potash-rich zones are known to extend, if at sub-ore levels, beyond the boundaries of the enclave. Also outside the enclave are areas of mineable ore (using the U.S. Geological Survey definition of ore). These latter concentrations are low grade and most deeply buried (as much as 2,000 to 3,000 ft). At present they cannot be mined economically. However, if the price of potash continues to rise and reserves of the higher grade ores in the enclave dwindle, these marginal ores may indeed become economically important. The boundaries of the enclave will then be moved drastically and consist of numerous isolated pockets surrounded by barren areas. Such changes would surely result in conflicts between the potash industry and other groups.

OTHER OCCURRENCES

Halite has been reported in a well drilled in Lincoln County from 10 to 15 miles northwest of Carrizozo. The salt was encountered in the Yeso Formation (Lower Permian) nearly 2,000 ft thick in the area. Although the well log indicates that limestone, sandstone, shale, and anhydrite are present in the interval, potash-bearing salts were not mentioned.

The Paradox Member of the Hermosa Formation (Pennsylvanian) is known in the subsurface in extreme northwest New Mexico. No information on the mineralogy of the salts, nor their quality of thickness is available, but potash salts are produced from this interval in southeastern Utah.

SUMMARY AND CONCLUSIONS

The demand for fertilizers and potassium will increase in accordance with projected increases in world food needs. The United States has about 4 percent of the world's known potash resources. However, the New Mexico deposits near Carlsbad occur at mineable depths in an area of sparse population, and in a concentration that can be mined profitably even though lower in grade than the Canadian deposits. Other concentrations of potash salts in the United States occur in Arizona, California, Utah, Michigan, and North Dakota, but none match the New Mexico deposits in volume and grade. The potash industry of southeastern New Mexico is assured of continued production for the foreseeable future.

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How Reliable Are Chemical Analyses?

by Lynn A. Brandvold

The importance of reliable chemical analyses is well understood, yet the meaning of the reported results is too often misunderstood. Accuracy is frequently confused with precision and sensitivity. This confusion persists along with the increasing tendency to devote more and more time to drawing conclusions from the analyses, and less and less time to the analyses themselves. Many users of chemical data tend to assume that reported values for chemical analyses are without inherent error. This assumption is incorrect; chemical values are never absolute. They should always be examined carefully. Each has a degree of uncertainty, depending upon the sample, the method of analysis, and the analyst.

The sample must be considered first; the chemical analysis will only be as good as the sampling involved. In some cases an excellent analysis is useless because of careless sampling. This precept is true for both water and solid samples, although the sampling problems differ. Changes occur in water samples because of oxidation, precipitation, dissolution, volatilization, complexation, and absorption. Soluble constituents may be converted to organically bound material, or cell lysis may result in release of cellular materials into solution. Changes can occur in solid samples because of oxidation, grinding, splitting, sieving, loss or gain of carbon dioxide and water, and differences between the compositions of fine and coarse particles. Complete preservation of samples is a practical impossibility. Problems in sampling must be resolved before an analysis is begun.

Once a representative sample is obtained then the best method of analysis can be selected, based on the degree of accuracy required, the sensitivity desired, the interferences that may be encountered, amount of time available, established validity of a method, and the appropriate equipment.

The concepts of accuracy, precision, and sensitivity must be understood. Precision refers to the variability among repeated measurements. Accuracy refers to the difference between a measured value and the true value. The distinction between precision and accuracy may be likened to the result of shooting a series of arrows at a target. Precision refers to how close together the several arrows hit. Accuracy, on the other hand, refers to the proximity of the arrows to the bullseye. High precision does not insure high accuracy. However, to consider the accuracy of a series of determinations is meaningless unless precision is also considered. Determining the precision that can be expected from a certain method is simple, whereas determining the accuracy is an altogether different matter because the results are matters of opinion, the true result not being known.

Sensitivity refers to the degree of response received for a certain amount of an element. A method can be highly sensitive yet have a low degree of accuracy. Consider sensitivity and accuracy when determining copper by the emission spectrograph. Copper can be determined to 1 ppm or less, but the results have an accuracy of ±50 percent.

A comparison of accuracy and precision for different general analytical methods is difficult to make. Both accuracy and precision can depend on the specific element involved, the specific method, and on the concentration of that element. Also precision and accuracy determined under the best of conditions may not apply to routine determinations. The values shown in the accompanying table are general. The range can be extended upward or downward, for instance, although with decreasing accuracy.

Gravimetric methods are generally the most accurate because the only

USEFUL RANGE, ACCURACY, AND PRECISION FOR COMMON METHODS OF ANALYSIS

Method	Useful Range (sensitivity, %)	Accuracy (± relative %)	Precision (parts/1000)
Gravimetric	1 to 100	0.1 to 0.5	1
Volumetric	0.05 to 50	0.3 to 3	3
Colorimetric	0.001 to 30	0.5 to 10	5
Atomic absorption (flame)	0.005 to 30	1 to 10	20
Atomic absorption (carbon rod)	10^{-5} to 10^{-2}	10 to 30	50
X-ray fluorescence	0.01 to 50	3 to 10	20
Emission spectrograph (photographic plate)	10^{-4} to 10^{-1}	50 to 200	100

measurements are those made on a balance having a precision of about 1 part per 1000. This type of analysis is lengthy and valid only when the element being measured is present in amounts greater than 1 percent. Gravimetric methods, still in wide use, are unsurpassed for accuracy when major constituents are being determined.

Volumetric methods (also called titrimetric) have an accuracy of 0.3 to 3 percent depending on the element and the method. This type of analysis is subject to titration error intrinsic in the method, depending upon the nature of the titration indicator and the equilibrium constant of the underlying reaction. Volumetric analyses are also subject to the same methodic errors of analyses. These methods are faster than gravimetric methods, taking advantage of a specific property of the element being determined, thus eliminating many of the separations necessary in the gravimetric methods. Volumetric methods are useful for determining major and minor constituents, and in some cases can be stretched to trace constituents. Although in the case of trace constituents the samples may have to be concentrated and the accuracy can fall to ±20 percent.

Colorimetric methods are based upon the principle that the concentration of a colored substance in solution is proportional to the amount of light energy (of a restricted wavelength) absorbed by that substance. The method is quick, but full advantage of savings of time can be realized only when a large number of samples are run. For some elements there are no colorimetric methods; for others the methods are not sufficiently sensitive. Even if a color reagent is available, a satisfactory method for isolating the constituent from interfering elements may not be available.

Emission spectrography can be applied to the analysis of almost any element. Other advantages are sensitivity, speed, versatility (many elements can be determined simultaneously), and small sample size. These advantages are offset by the much lower accuracy. The composition of a sample has a great effect on the accuracy of the emission spectrograph; whereas in gravimetric, titrimetric, or colorimetric methods the isolation or semi-isolation of a constituent eliminates this problem. The emission spectrograph is most useful for low concentrations.

X-ray fluorescence is not as sensitive or as versatile as emission spectrography. The useful range extends only to 0.01 percent; only the elements with atomic numbers greater than 11 can be determined. However, the accuracy is much better. This method is based on the characteristic fluorescence spectrum emitted by an element when irradiated by a beam of X-rays. Each element is individually determined; errors due to obtaining results by difference and by group separations are avoided. The method is fast, highly specific, and nondestructive.

Precision depends on the number of counts, which in turn depend on the concentration of the unknown element. No preliminary separations are necessary but the homogeneity of the sample is critical.

Atomic absorption spectrometry (AAS) has, since its introduction 18 years ago, become a popular major analytical method. The method is highly specific, requires little or no analytical separations, allows the determination of many elements on a single sample, is very sensitive, rapid, and each element is determined separately. It is not as accurate as gravimetric or volumetric methods. When first introduced AAS was claimed to be free of interferences. But subsequent work has shown AAS to be no different than other methods in this respect. Because analytical separations are not usually done, the composition of the sample can have a great effect on the accuracy. Reagents used in the solution of the sample can also affect the accuracy.

Probably the most critical determinant in analyses is the analyst, who must determine the following: 1) a representative sample has been obtained; 2) the needed accuracy and sensitivity will be achieved; 3) any possible interferences have been identified and corrected for; 4) all procedures in the assay have been faithfully followed; and 5) final calculations have been made without error. The human error in an analysis is a greater unknown than the instrumental error—and much harder to find.

In summary, then, how does one evaluate the reliability of chemical results? The sampling procedures, the analyst or laboratory, and the analytical method must be known. If doubt persists, the best way to establish the most probable answer (the true answer is never known!) is to use another method differing as much as possible in basic principle. For example, if the first assay was by atomic absorption, then the second should be by a gravimetric method. If the results agree, doubt has been removed. If the results do not agree, the precision and accuracy of each method should be compared. If doubt still persists, the sample should be assayed by a third method. Because these processes are costly, the difference that can be tolerated should be described beforehand. For example, if the only answer sought is whether or not an element is present in amounts greater than 1 percent, answers of 2.5 percent and 3.3 percent are acceptable even though the percent difference (27.6 percent) is high.

TERRESTRIAL HEAT FLOW NEAR DATIL, NEW MEXICO

by

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INTRODUCTION

Terrestrial heat flow data are significant in both evaluating regional and local geothermal potential and understanding geologic processes operating in the crust and upper mantle. Regions with heat flow values of about 2.0 HFU and greater typically have considerable Cenozoic tectonic and volcanic activity, with above normal temperatures in the crust and upper mantle. (HFU = heat flow unit; 1 HFU = 1 μcal/cm^2-sec; normal heat flow for stable continental interiors is about 1.0 to 1.4 HFU.) Such regions have geothermal potential. Local areas with heat flow values of 5.0 HFU to 10.0 HFU and greater have significant geothermal potential. Numerous heat flow studies in the western United States have indicated that much of the country west of the Rocky Mountain front has higher-than-normal heat flow, and consequently has regional geothermal potential. The heat flow data at Datil, New Mexico are important because they relate to the geothermal potential of the area. Our data define subsurface temperatures to 4800 ft and aid in the extrapolation to deeper subsurface temperatures within the area. The information also helps determine thermal conditions in the crust and upper mantle in the area.

Terrestrial heat flow was determined at a site approximately ten miles south of Datil, New Mexico, in the Plains of San Agustin (SWSW sec. 29, T. 3 S., R. 9 W.). The well was drilled by Sun Oil Co. and was completed on June 23, 1966. Temperatures were logged in mid-August 1966 to a depth of 4580 ft; four years later in August, 1970 to a depth of 2650 ft; and in December, 1975 to a depth of 4800 ft. Table 1 presents temperatures read from the logs. These subsurface temperature data permit estimates of the geothermal gradient (the increase of temperature with depth) at this location. By measuring the thermal conductivity of the rocks penetrated by the drill test, the heat flow from the earth's interior can be estimated (the product of the geothermal gradient and the rock thermal conductivity).

Fig. 1 is a generalized columnar section of the well. The Tertiary unit consists of ash-flow and ash-fall tuffs, poorly to densely welded, varying from a rhyolitic to a latitic composition. The area of the Plains of San Agustin is surrounded by the immense Datil-Mogollon volcanic field; considerable Tertiary volcanic activity has occurred in proximity to the drill test (Willard, 1957; Willard and Givens, 1958). The Plains of San Agustin, the major structural and topographic feature of the area, is a graben in which the principal development is younger than the mapped volcanic rocks (Stearns, 1962). Interpretation of geologic provinces, according to Eardley (1962), places the site near the boundary between the Colorado Plateau and the Basin and Range province.

EXPERIMENTAL PROCEDURE

A continuous temperature log was obtained in 1966 using the equipment described by Simmons (1965). Absolute accuracy was about 0.5°C, but the relative accuracy or precision was about .01°C.

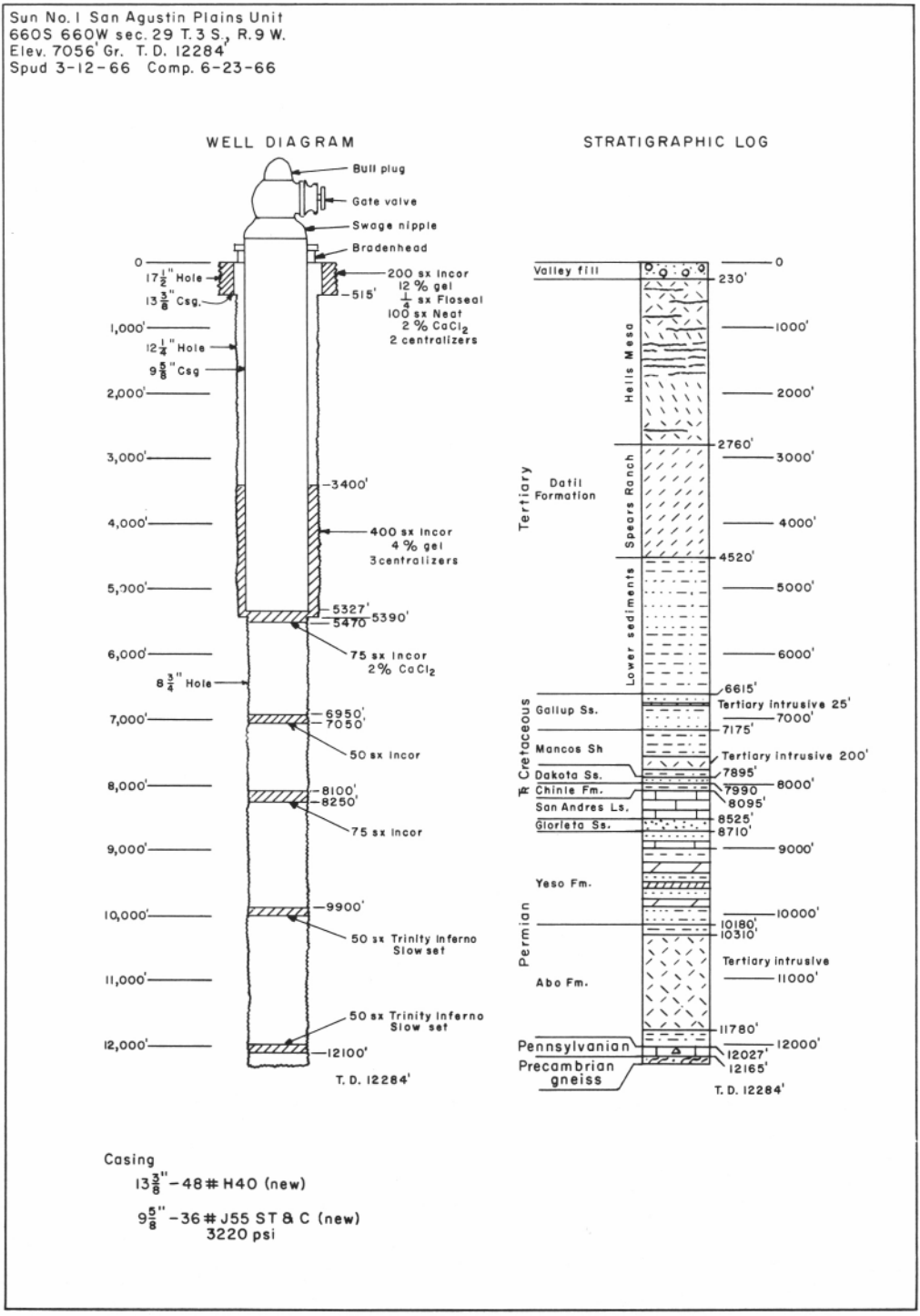

FIGURE 1—COLUMNAR SECTION FOR SUN NO. 1 SAN AGUSTIN PLAINS TEST (BY ROY W. FOSTER).

TABLE 1—SUBSURFACE TEMPERATURE DATA FOR THREE LOGS OF THE SUN NO. 1 SAN AGUSTIN PLAINS TEST (in °C)

Depth (ft)	Log 1	Log 2	Log 3	Depth (ft)	Log 1	Log 2	Log 3
250	23.72	17.969		2050	48.24	45.266	
300	23.94	18.826		2100	48.17	45.500	45.65
350	25.625	19.521		2150	48.75	45.918	
400	27.855	20.518	20.25	2200	49.03	46.219	46.18
450	28.98	21.345		2250	49.25	46.438	
500	30.19	22.464	22.24	2300	50.22	46.713	47.01
550	30.965	23.492		2350	51.08	47.952	
600	31.67	24.320	24.23	2400	51.84	49.010	49.17
650	32.02	25.563		2450	52.62	49.989	
700	32.30	25.946	25.79	2500	53.41	50.938	51.17
750	33.00	27.046		2550	54.13	51.793	
800	33.59	27.877	27.68	2600	54.88	52.648	53.03
850	33.76	28.600		2650	55.69	53.416	
900	34.09	29.173	29.02	2700	56.39	--	54.66
950	34.73	29.894		2800	57.82	--	56.34
1000	35.265	30.289	30.10	2900	58.92	--	57.83
1050	35.70	30.758		3000	60.45	--	59.47
1100	37.15	32.471	32.04	3100	61.96	--	61.06
1150	37.40	33.055		3200	63.39	--	62.63
1200	38.23	33.372	33.27	3300	64.76	--	64.24
1250	39.15	33.565		3400	66.00	--	65.78
1300	39.93	34.106	34.23	3500	67.47	--	67.28
1350	40.53	35.056		3600	68.78	--	68.91
1400	40.97	36.453	36.28	3700	70.07	--	70.43
1450	41.75	37.434		3800	71.46	--	71.97
1500	42.36	38.192	38.23	3900	72.77	--	73.39
1550	42.78	38.893		4000	74.04	--	74.94
1600	43.41	39.560	39.66	4100	75.44	--	76.49
1650	44.18	40.287		4200	76.78	--	78.03
1700	44.87	41.071	41.19	4300	78.09	--	79.46
1750	45.47	41.896		4400	79.67	--	81.08
1800	46.09	42.651	42.65	4500	81.24	--	82.78
1850	46.60	43.382		4600	--	--	84.42
1900	47.14	43.972	43.92	4700	--	--	85.83
1950	47.48	44.405		4800	--	--	87.80
2000	47.85	44.787	44.85				

TABLE 2—HEAT FLOW DATA FOR LOG 2 FOR SAN AGUSTIN PLAINS TEST

Depth interval (ft)	Thermal gradient (°C/km)	Total thermal conductivity samples	Estimated porosities (%)	Uncorrected thermal conductivities (mcal/cm-°C-sec)
250- 850	59.75 ± 0.26	5	29	4.82 ± 0.97
1400-1900	48.94 ± 0.19	5	29	4.51 ± 0.41
2400-2600	57.86 ± 0.37	3	29	3.97 ± 0.22

Depth interval (ft)	Porosity corrected thermal conductivities mcal/cm-°C-sec)	Uncorrected heat flow (μcal/cm^2-sec)	Porosity corrected heat flow (HFU)	Final heat flow (HFU)
250- 850	3.39 ± 0.48	2.88 ± 0.59	2.03 ± 0.30	2.03 ± 0.30
1400-1900	3.25 ± 0.21	2.21 ± 0.21	1.59 ± 0.11	1.59 ± 0.11
2400-2650	2.97 ± 0.12	2.30 ± 0.14	1.72 ± 0.08	1.72 ± 0.08

Average for all 3 depth intervals = 1.75

Temperatures were measured at discrete points for the later logs. The gradients used to estimate heat flow were obtained from the second log in which temperatures were measured at 50-ft intervals with a platinum resistance device. The resistance of platinum as a function of temperature is well known. A lead-compensated Mueller bridge with precision resistances was used to measure the resistance of the platinum coil. The entire measuring system was periodically calibrated at the ice point of distilled water and over several years the ice point was reproducible within ±0.05°C. We believe the absolute accuracy of each temperature measurement to be ±0.05°C. The relative accuracy of two points 50 ft apart in the drill test is probably an order of magnitude better, i.e., ±0.005°C. The third log was performed with a thermistor sonde in conjunction with a lead-compensated Mueller bridge.

Thermal conductivities were measured on well cuttings with the technique described by Sass and others (1971). Our thermal conductivity instrument is described by Reiter and Hartman (1971). To estimate the thermal conductivity of the rock from the conductivity of the cuttings, the porosity of the in situ rock was estimated by comparing the density of dried and vacuum-flooded cores taken from outcrops believed to approximate the rocks penetrated by the test. These estimates are approximations because weathering and stratigraphic variations appreciably affect porosity.

DATA

The values for the temperature logs are presented in table 1. The plots for these data are presented in fig. 2. The columnar section for the well is presented in fig. 1. Log 1 is included to provide an example of the effect of time on temperature relaxation after boreholes have been drilled. Log 2 was used in our estimate of the heat flow.

The pronounced thermal anomalies at depths of 1050 ft, 1350 ft, and 2300 ft are probably due to small water flows in the annulus between the casing and the rock. Such effects were eliminated on the estimated heat flow by ignoring those zones in the log that showed erratic behavior. Those zones demonstrating constant thermal gradients are most likely representative of the true thermal gradient.

Log 2 contains three zones of constant thermal gradients; an upper zone from 250 to 850 ft, a middle zone from 1400 to 1900 ft and a bottom zone from 2400 to 2650 ft. Table 2 presents data on the thermal gradient, thermal conductivity, and heat flow. The best estimate of the terrestrial heat flow at this site is 1.7 HFU (1 HFU = 1 μcal/cm^2-sec), a value intermediate between heat flows typically measured in the stable interior of the continent (1.1 to 1.2 HFU) and heat flows generally measured in the Basin and Range province (~2.0 HFU). Our value is obtained by averaging the calculated heat flows for the three zones having constant gradients.

ACKNOWLEDGMENTS

We thank Sun Oil Company for preserving the upper part of the Sun No. 1, San Agustin Plains Test, for the present heat flow measurement. Roy Foster, of the New Mexico Bureau of Mines & Mineral Resources, provided a generalized stratigraphic log of the drill test. Partial financial support was provided by the Air Force Office of Scientific Research contract AF49(638)-1694 as part of the Vela Uniform program, the National Science Foundation Grant GI-32482, the New Mexico Energy Research and Development Program, Proposal #5. A significant contribution of equipment was provided by the Sandia Corporation.

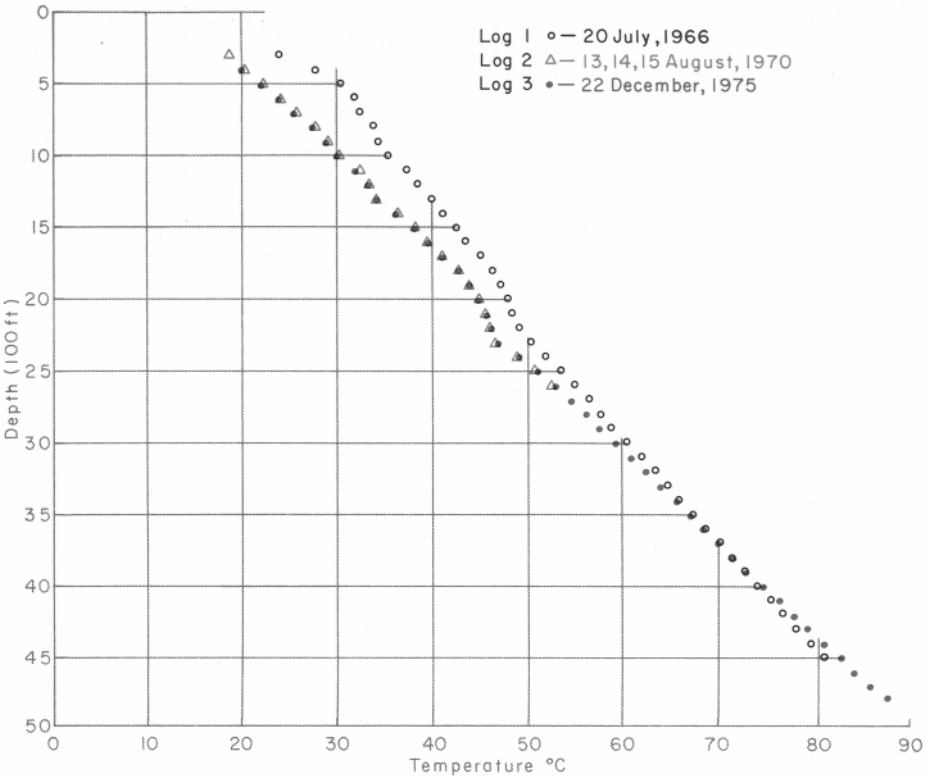

FIGURE 2—PLOTS OF SUBSURFACE TEMPERATURES MEASURED IN THE SUN NO. 1 SAN AGUSTIN PLAINS TEST.

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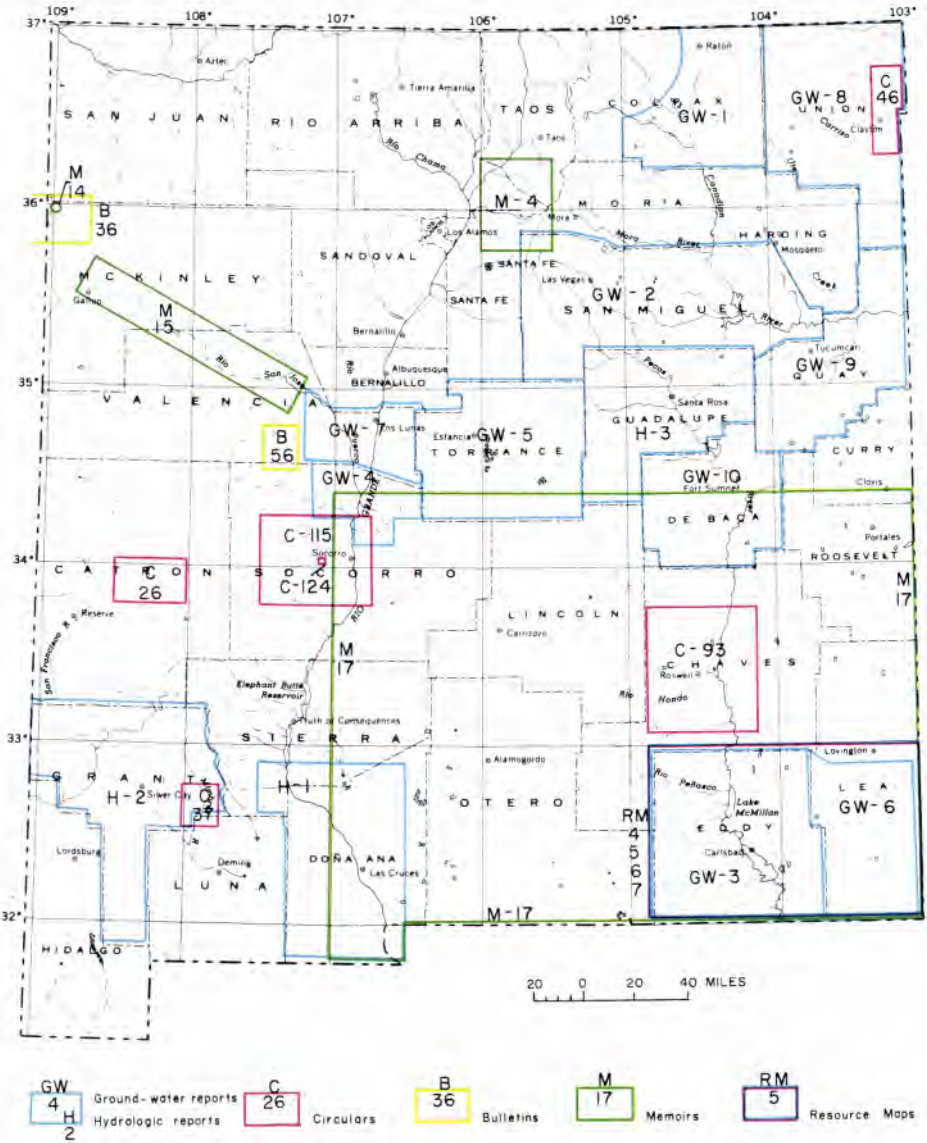

FIGURE 1—INDEX OF AREAS COVERED BY BUREAU PUBLICATIONS HAVING INFORMATION ON GROUND WATER.

INDEX TO BUREAU WATER-RESOURCE DATA

by William J. Stone

INTRODUCTION

Water is essential for human existence in any setting, but in the arid Southwest water is particularly precious. Natives and early settlers of the region relied on the major rivers and springs for their water supply. As the population grew, various manmade devices were used to store river water during high-flow periods for later use during low-flow periods, to permit conveyance of needed surface water to dry areas, and to decrease the hazard of devastating floods. In areas too distant from streams for reasonable conveyance, ground-water resources had to be tapped.

From 1960 to 1970 the population of the West increased 24.1 percent, or more than twice that of the rest of the United States (Lerner, 1971). With this growth, the Southwest is rapidly approaching total utilization of its available surface waters (Garstka, 1972). Although engineering capabilities now make possible the transfer of surface water on a colossal scale (for example, the proposed transfer of water from the Fraser River in British Columbia, Canada, to the western and southwestern parts of the United States described by Smith, 1972), such projects are far from implementation. Improved practices in the use of surface water, as described by the National Academy of Sciences (1974), together with extensive phreatophyte control may be a more economical interim solution. Because perennial streams are rare in the Southwest, the immediate new water needs of most areas in the region must be met by further developing ground-water supplies. Therefore, careful study of the availability and quality of ground water in the Southwest is necessary for locating needed new supplies and promoting the wise use and protection of this vital resource.

Numerous state and federal agencies have contributed importantly to the present understanding of the water resources of the Southwest. A bibliography of ground-water studies in New Mexico alone (Borton, 1972) lists 274 water-resource reports published by these agencies. The New Mexico Bureau of Mines & Mineral Resources has provided a significant share of this essential information on the ground-water resources of New Mexico (see map). The purpose of this article is to list and summarize this information so that it may be more readily located and used.

MAJOR WATER-RESOURCE PUBLICATIONS BY BUREAU

The major sources of water-resource information published by the Bureau are the Ground-water Report series and the Hydrologic Report series. The Ground-water Reports were the first Bureau publications devoted solely to the dissemination of water-resource information. Ten reports were published from 1948 to 1971. Thereafter, the format was enlarged and the series redesignated the Hydrologic Report series. These two series have been used to present results of water-resource studies of fairly large areas (county or larger).

The types of information contained in each of these publications are summarized in the accompanying table. Emphasis is on ground-water resources but climatic data, results of chemical analyses of waters, well and spring records, geologic maps, and measured sections or well logs are also provided. Some contain water-table maps, geologic-structure or tectonic maps, and other special information.

(*denotes that area is not shown on fig. 1 but is outlined on index maps in Bur
Report; HR, Hydrologic Report; M, Mem

Publication	Year	Location	General availability of water	Ground-water resources	Surface-water resources	Climate	Water chemistry
GW-1	1948	Eastern Colfax Co.		X		X	X
GW-2	1951	San Miguel Co.		X		X	X
GW-3	1952	Eddy Co.		X		X	X
GW-4	1955	Northeastern Socorro Co.		X	X	X	X
GW-5	1957	Torrance Co.		X		X	X
GW-6	1961	Southern Lea Co.		X		X	X
GW-7	1963	Eastern Valencia Co.		X	X	X	X
GW-8	1967	Union Co.		X		X	X
GW-9	1966	Quay Co.		X		X	X
GW-10	1970	De Baca Co.		X	X	X	X
HR-1	1971	Central and western Doña Ana Co.		X		X	X
HR-2	1972	Grant Co.		X	X	X	X
HR-3	1973	Guadalupe Co.		X	X	X	X
HR-4*	1976	Selected areas of state		X			X
B-1*	1915	Entire state	X				
B-3*	1919	Puertecito district	X				
B-9*	1933	Entire state					
B-11*	1935	Organ Mountains	X				
B-18*	1942	Entire state					
B-26*	1947	Gran Quivira quad.	X				
B-31*	1953	Thoreau quad.	X				
B-36	1954	Ft. Defiance-Tohatchi quads.		X	X	X	X
B-42*	1956	Costilla and Latir Peak quads.	X				
B-53*	1957	Questa quad.	X				
B-54*	1958	Cienaga quad.	X				
B-56	1958	Mesa del Oro quad.		X	X	X	X
B-57*	1958	Peloncillo Mountains	X				
B-58*	1957	Dog Springs quad.	X				
B-62*	1959	Lordsburg quad.	X				
B-63*	1960	Union Co.	X				
B-75*	1961	Southeastern Chama Basin	X				
B-87*	1965	Entire state					
M-4	1958	Sangre de Cristo Mountains					
M-15	1963	Grants uranium region					
M-17	1966	Southeastern New Mexico					
C-26	1954	San Agustin Plains		X			X
C-36*	1956	Eastern Valencia Co.	X				
C-37	1955	Dwyer quad.		X			X
C-46	1957	Clayton		X			X
C-56*	1959	Entire state					
C-68*	1963	Western San Juan Co.	X				
C-75*	1964	Little Black Peak quad.	X				
C-80*	1965	Entire state					X
C-83*	1965	Entire state					X
C-93	1968	Northern Roswell Basin		X	X		X
C-95*	1968	Entire country					
C-98*	1968	Entire state					
C-115	1971	Socorro-Magdalena		X			X
C-123*	1973	Nogal-Bonito mining districts	X				
C-124	1972	Magdalena Mountains		X			X
C-128*	1972	Entire state					
C-136*	1973	Entire state					
C-138*	1973	Entire state					
RM-1*	1972	Entire state					
RM-4	1976	Southeastern New Mexico					
RM-5	1976	Southeastern New Mexico					
RM-6	1976	Southeastern New Mexico					
RM-7	1976	Southeastern New Mexico					
OF-14*	1946	Telegraph mining district	X				
OF-28*	1970	East-central New Mexico	X				
OF-33*	1972	Pueblo of Zuni		X	X	X	X
OF-37*	1972	Pecos River Basin		X	X	X	
OF-48*	1973	Southeastern New Mexico					
OF-51*	1973	San Agustin Plains		X		X	X
OF-55*	1973	White Sands area		X	X	X	X

celists; following abbreviations used: B, Bulletin; C, Circular; GW, Ground-Water
, Open-file Report; RM, Resource Map)

ll or pring entory	Water table map	Measured sections or logs	Cross section	Geologic map	Structure or tectonic map	Other information and remarks	
X		X		X	X		GW-1
X				X			GW-2
X	X	X	X	X	X	Water movement	GW-3
X	X		X	X			GW-4
X	X	X		X		Hydrographs	GW-5
X	X	X	X	X	X	Contamination by brine	GW-6
X	X	X	X	X		Water-table fluctuation	GW-7
X		X				Water-table fluctuation	GW-8
X	X	X	X	X		Water utilization, water-level decline	GW-9
X	X	X	X	X		Water sales, conductivity map	GW-10
X	X	X	X	X			HR-1
X	X	X		X		Glossary of terms	HR-2
X	X	X	X	X	X		HR-3
X	X	X	X	X			HR-4*
							B-1*
							B-3*
						Water in selected oil fields	B-9*
							B-11*
						Water in selected oil fields	B-18*
							B-26*
							B-31*
X		X	X	X	X		B-36
							B-42*
							B-53*
							B-54*
X			X	X		Some yields	B-56
							B-57*
							B-58*
							B-62*
							B-63*
							B-75*
						Summary of state's water resources	B-87*
						Geology and channel characteristics	M-4
						Ground water at selected mines	M-15
						Oil field brine chemistry	M-17
X		X					C-26
							C-36*
X	X	X					C-37
X		X		X	X		C-46
						Hydrologic studies for 1959	C-56*
							C-68*
							C-75*
X				X		Geothermal resources, economics	C-80*
X						Geothermal resources	C-83*
		X	X			Core analyses	C-93
						Water law atlas and primer	C-95*
						Geothermal resources summary	C-98*
X		X					C-115
							C-123*
X	X			X			C-124
						Hydrologic studies for 1972	C-128*
						Hydrologic studies for 1973	C-136*
						Industrial water requirements	C-138*
						Geothermal resources	RM-1*
						Chloride ion concentration	RM-4
						Thickness of Capitan aquifer	RM-5
						Structure of Capitan aquifer	RM-6
						Structure of Rustler Formation	RM-7
							OF-14*
							OF-28*
X	X	X	X	X	X		OF-33*
	X		X	X	X		OF-37*
						Waste-injection and waste-disposal wells	OF-48*
X	X						OF-51*
	X		X	X			OF-55*

A new series of publications—Hydrogeologic Maps—is being planned. Emphasis will be on graphic presentation of investigations of small areas. Each report will consist of a color map and sections supplemented by text, tables, figures, and photographs—all printed on a 38-inch x 25-inch sheet folded and stuffed into an 8½-inch x 11-inch pocket, similar to the Bureau's Geologic Map series.

OTHER SOURCES OF BUREAU WATER INFORMATION

Other Bureau publications containing, but not restricted to, water-resource information include Bulletins, Memoirs, Circulars, and Resource Maps. Though usually concerned with the geologic or economic aspects of counties or mining districts, Bulletins often contain a general summary statement on water resources as well. Bulletins 36 and 56 contain fairly complete discussions of the availability of ground water in the subject areas. Bulletins 9, 18, and 38 give data on specific hydrologic topics; Bulletin 87 gives a summary of the water resources of the state.

Memoirs are also usually devoted to other topics, but Memoirs 4, 15, and 17 deal with hydrologic problems or include some mention of ground-water characteristics of the study area.

Detailed water-resource studies of areas smaller than those usually covered by the Ground-water or Hydrologic Reports have been published in Circulars 26, 37, 46, 93, 115, and 124. Circulars 36, 68, 75, and 123 include general summaries of water availability in the area studied. Circulars 80, 83, and 98 are concerned with various aspects of the hot springs and geothermal resources of New Mexico. Circular 95 outlines water law; Circular 138 presents projected water requirements of various mineral industries in the state. Bureau Circulars 56, 128, and 136 contain compilations of hydrologic research conducted in the state by various organizations in 1959, 1972, and 1973 respectively.

Resource Maps 1, 4, 5, 6, and 7 are devoted to water-resource topics or problems.

The Bureau's unpublished Open-file Report series includes four detailed reports on water resources (33, 37, 51, 55). General statements of the water-resource situation of study areas appear in Open-file Reports 14 and 28; selected water-injection and waste-disposal wells are discussed briefly in Open-file Report 48.

WATER-RESOURCE BIBLIOGRAPHIES

Publications on the water resources of New Mexico prepared by other organizations have been listed in several bibliographies. For a selected bibliography on various aspects of the water resources of the state, see Hale and others (1965, Appendix F). For a compilation of references on ground-water studies in New Mexico, see Borton (1972). Bureau Bulletins 43, 52, 74, 99, and 106 (in preparation) are bibliographies of New Mexico geology and collectively include references on ground-water studies through 1975.

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HARDING PEGMATITE—OUTDOOR MUSEUM AND HISTORICAL SITE

by Joseph E. Taggart, Jr.

For many years the Harding pegmatite mining claims near Dixon, New Mexico have been known to geologists as a most unusual occurrence of minerals. Although commercial mining was suspended some time ago, reserves are still present and much of the body is still intact. Lately many persons have felt that this unique site should be preserved for the enjoyment and edification of all who are interested in geology and collecting minerals. Through the joint efforts of Arthur Montgomery (professor emeritus of geology and owner of the property) and the Geology Department of the University of New Mexico, and with the assistance of the New Mexico Bureau of Mines and Mineral Resources, the area has now been leased at no charge to the State of New Mexico through UNM for an outdoor museum and historic site.

The Harding pegmatite is located midway between Santa Fe and Taos, about 6 miles east of the village of Dixon. Discovered about 1910, the property was worked during the early 20's for lepidolite, used in the manufacture of heat-resistant glass. Presumably the mine was named in honor of President Harding who held office 1921-1923. During World War II the War Production Board encouraged active mining of the strategic minerals found here, including tantalum-rich microlite, columbite-tantalite, beryl, and spodumene.

Mining and beneficiation methods at the Harding mine were rather primitive. Most materials were mined and sorted by hand.

Nevertheless the Harding mine was a record producer. The mine is unique as the only substantial producer of microlite in the entire world. From 1950 through 1955, 752 tons of beryl were produced, amounting to more than 20 percent of the total United States production, ranking New Mexico ahead of all other beryl-producing states.

The main pegmatite body consists of a flat dike dipping gently to the southwest. Exposures and drilling show the mass to be 70 ft thick, several

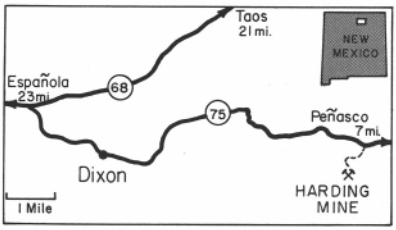

FIGURE 1—LOCATION OF DIXON, NEW MEXICO.

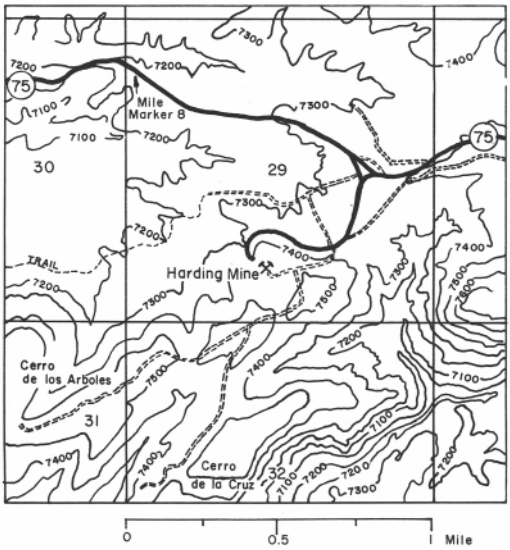

FIGURE 2—LOCATION OF HARDING MINE.

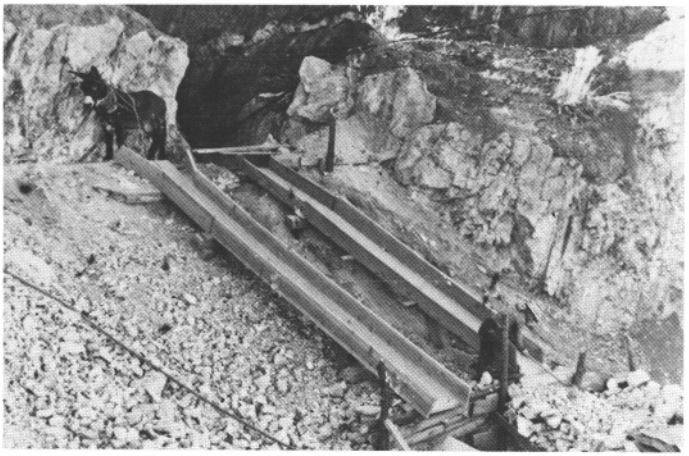

FIGURE 3—BERYL WAS HAULED FROM TUNNEL BY MULE, THEN DUMPED DOWN WOODEN CHUTES, COBBED, SORTED, AND STACKED ON A PLATFORM.

FIGURE 4—ENTRANCE TO MICROLITE WORKINGS. NOTE CRYSTALS OF SPODUMENE ABOVE OPENING.

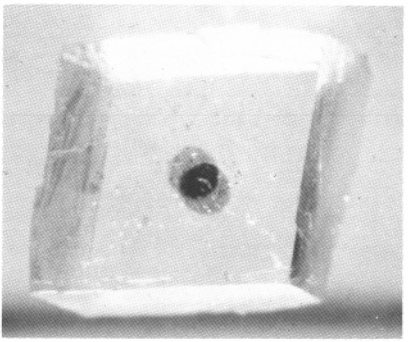

FIGURE 5—CLEAVAGE FRAGMENT OF CALCITE SHOWING DOUBLE REFRACTION.

hundred feet across north-south, and more than a thousand feet east-west. The pegmatite lies within a zone of probable thrust faulting in steeply dipping amphibolite and micaceous schists of Precambrian age. Emplacement occurred at 1335 ± 35 million years ago, most probably at great depth. The dike is well zoned, with each zonal layer having remarkably consistent sequential position. Given layers, however, may show considerable variation in thickness.

The mine faces and dumps are excellent collecting spots. Large lathlike crystals of dull white spodumene (to 4 ft long), masses of rose muscovite and gray-lilac lepidolite, milky quartz, pink to white microcline feldspar, platy white albite feldspar, and crude tabular crystals and rough masses of white beryl (difficult to distinguish from the quartz and feldspar) can be collected easily. The rarer minerals of the pegmatite suite will interest advanced collectors. The following list was compiled with the help of Richard H. Jahns and Rodney C. Ewing.

Allanite	Chalcopyrite	Monazite
Almandine	Chrysocolla	Pyrite
Azurite	Eucryptite	Pyrolusite
Bertrandite	Fluorite	Rutile
Beyerite	Gahnite	Spessartine
Bismite	Lithiophilite	Spodumene
Bismuth	Loellingite	Tantalite-Columbite
Bismuthinite	Magnetite	Tenorite
Bismutite	Malachite	Thorite
Bismutotantalite	Manganapatite	Topaz
Chalcocite	Microlite-Pyrochlore	Zircon

Adjacent to the Harding mine is the Iceland Spar claim (formerly called the Iceberg claim), which produced the world's second and third largest-known crystals of Iceland spar (optical grade calcite). One crystal measured 7 ft x 8 ft x 11 ft, the other 8 ft x 9 ft x 10 ft. The small abandoned pit and waste piles are located 300 ft southwest of the Harding mine. Cleavage fragments of suboptical calcite can be found on the dump.

Bulk collecting as well as collecting for any commercial purpose whatsoever is expressly prohibited. The caretaker of the property resides in the vicinity. Permission to visit the mine must be obtained from either the Geology Department of the University of New Mexico (Albuquerque, New Mexico 87106) or Arthur Montgomery (P.O. Box 11, Dixon, New Mexico 87527). A nominal charge to assist with maintenance and service may become necessary. Future plans include a self-guided walking tour of this unique locality, complete with a pamphlet describing the various features of the area.

The benefits of this conservation project are twofold. It provides New Mexico citizens, both youth and adult, with educational information regarding one of our most significant natural resources—minerals—as well as adding another attraction to interest tourists.

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MINERAL PRODUCTION IN NEW MEXICO[1]

Prepared by U.S. Bureau of Mines, December 16, 1975

Mineral	1974 Quantity	1974 Value (thousands $)	1975 preliminary Quantity	1975 preliminary Value (thousands $)
Clays[2] ..... thousand short tons	55	317	41	53
Coal (bituminous) ..... do	9,392	W	9,000	W
Copper (recoverable content of ores, etc.) short tons	196,585	303,920	140,535	179,885
Gem stones	NA	200	NA	200
Gold (recoverable content of ores, etc.) troy ounces	15,427	2,464	13,185	2,139
Gypsum ..... thousand short tons	157	532	W	W
Iron ore (usable) thousand long tons, gross weight	6	135	--	--
Lead (recoverable content of ores, etc.) short tons	2,364	1,064	2,085	901
Lime ..... thousand short tons	58	1,679	67	1,841
Manganiferous ore (5 to 35 percent Mn) short tons	47,348	W	W	W
Mica, scrap ..... thousand short tons	12	60	W	W
Natural gas ..... million cubic feet	1,244,779	390,861	1,203,302	452,442
Natural gas liquids:				
Natural gasoline and cycle products thousand 42-gallon barrels	9,713	53,545	9,048	63,080
LP gases ..... do	30,271	120,781	29,672	169,480
Peat ..... thousand short tons	4	111	--	--
Perlite ..... do	480	6,306	419	6,228
Petroleum (crude)—thousand 24-gallon barrels	98,695	712,578	94,553	770,607
Potassium salts (K_2O eq) thousand short tons	2,102	128,588	2,099	181,151
Pumice ..... do	471	1,466	404	1,374
Salt ..... thousand short tons	167	W	146	W
Sand and gravel ..... do	7,413	10,605	6,895	10,342
Silver (recoverable content of ores, etc.) thousand troy ounces	1,195	5,628	746	3,304
Stone ..... thousand short tons	3,531[3]	8,359	2,373[3]	6,002
Uranium (recoverable content U_3O_8) thousand pounds	9,971	104,693	9,900	215,800
Zinc (recoverable content of ores, etc.) short tons	13,784	9,897	11,515	9,005
Value of items that cannot be disclosed: Carbon dioxide, cement, fire clay, fluorspar, molybdenum, stone (dimension), tin, vanadium and values indicated by symbol W	XX	77,755	XX	85,991
Total	XX	1,941,544	XX	2,159,825

NA Not available

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

XX Not applicable

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

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

[3]Excludes dimension stone quantity

About the map on the back cover

Our state also contains a wealth of industrial or nonmetallic mineral resources—those naturally occurring substances other than the metallic ores, mineral fuels, and gemstones. The map depicts the general location of the major active deposits and developments.

In addition to sand and gravel (too numerous to depict) and clay and stone, New Mexico is the leading domestic producer of potash and perlite, as well as a producer of several important but uncommon minerals as pumice, fluorite, and mica.

Industrial minerals now account for about 10 percent of the dollar value of all mineral resources produced in New Mexico. This percentage is expected to increase as the state's economy expands.

The Bureau's Financial Statements

BOARD OF EDUCATIONAL FINANCE–LEGISLATIVE

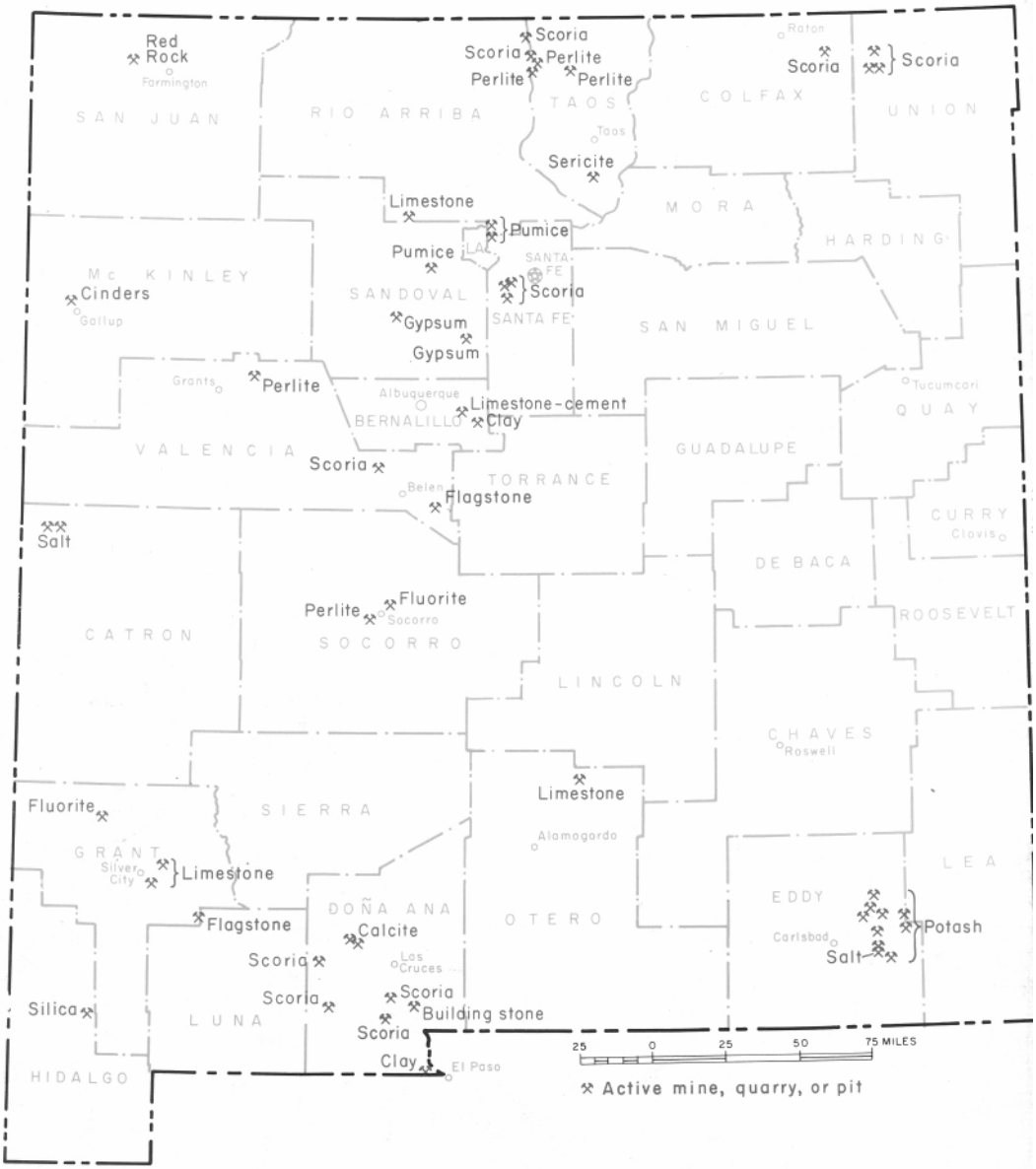
Funds available			
Beginning balance		$ 11,298	
Budgeted surplus		4,400	
Tuition waiver income		5,734	
State appropriation		885,000	
Publication sales		38,997	$945,429
Expenditures			
Salaries:			
Full-time staff	$498,790		
Part-time (mostly students)	85,253	584,043	
Employee benefits		68,545	
Project contracts		64,092	
Travel & automotive		34,525	
Scientific laboratories:			
Maintenance	3,705		
Materials & supplies	19,894	23,599	
Office supplies		13,394	
Postage		6,538	
Printing		46,792	
Equipment		30,477	
General expenses:			
Telephone	17,665		
Subscriptions & dues	2,847		
Computer service	3,176		
Overhead & audit (to Tech)	24,500		
Tuition for staff	5,651		
Heat, water, electricity	15,136	68,975	940,980
Balance			$ 4,449

GRANTS AND CONTRACTS

Funds available		
Beginning balance	37,922	
State grants	37,244	
Federal and company grants	100,983	176,149
Expenditures		
Encumbered '74-'75, paid '75-'76	31,502	
Salaries	64,077	
Benefits	3,844	
Travel	15,982	
Equipment, supplies, printing, computer	21,859	
Overhead	14,873	152,137
Balance		$ 24,012

NEW MEXICO COAL SURFACEMINING COMMISSION

Funds available		
Beginning balance	9,107	
Fees collected	13,531	22,631
Expenditures		
Salaries and fees	12,571	
Travel	2,112	
Supplies and reports	1,535	16,218
Balance		$ 6,413

New Mexico's Industrial Minerals, 1976
excluding sand and gravel

see also pages 6, 7, 23, 47 and 48