A Preliminary Mineral-Resource Potential of Valencia County, Northwestern New Mexico

by

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PREFACE

During the spring, 1985, the U.S. Bureau of Land Management (BLM) and the New Mexico Bureau of Mines and Mineral Resources (NMBMMR) entered a cooperative agreement to prepare a preliminary mineral-resource inventory and assessment of northwestern New Mexico, including Valencia, Cibola, McKinley, San Juan, and western Rio Arriba Counties. This is the second of six reports describing the geology and mineral-resource potential of northern New Mexico. The first report describes the methodology and classification of mineral-resource potential used in this report and includes a summary of the mineral-resource potential of Valencia County.

These reports are based upon time consuming analyses of all available data, published and unpublished, by a group of geologists and technical support staff. Without this team effort, this project would be impossible. In addition to the coauthors of the final report, many other people at the NMBMMR and BLM provided assistance, especially in reviewing the rough drafts.

This report is organized into a text, appendices, and supporting figures, maps (scale 1:100,000), and tables. Known mineral occurrences, mines, and deposits, including material pits, are briefly described in Appendix 1 and plotted on 1:100,000 scale maps. Mineral-resource potential of various commodities is discussed in the text and also shown on 1:100,000 scale maps.

ABSTRACT

A preliminary mineral-resource potential assessment of Valencia County involves analyses of available published and unpublished geologic, geochemical, geophysical, and economic data and a brief field reconnaissance. Mineral-resource potential is an assessment of the favorability that a commodity will occur in substantial concentrations in a given area that can be exploited under current or future economic conditions. A classification of high, moderate, low, very low, and unknown is used. A high mineral-resource potential exists in areas where geologic and economic data indicate an excellent probability that economic mineral deposits occur there. Moderate or low mineral-resource potential exists in areas where the data indicate a lesser probability that economic mineral deposits occur. A classification of very low potential is reserved for areas where sufficient information indicates that an area is unfavorable for economic deposits. A classification of unknown mineral-resource potential is assigned to areas where either necessary geologic, geochemical, geophysical, and economic data are inadequate to otherwise classify an area or where any other classification (high, moderate, low, or very low) would be misleading. Some areas have not been evaluated for specific commodities because of lack of useable data.

Travertine deposits along the Lucero uplift in western Valencia County are currently being mined for dimension stone and have a high resource potential. Products include 2-inch sheets and 8-inch slabs. Additional travertine deposits may occur along

the Hubbell bench where the resource potential is low. The potential for travertine as crushed stone is also high.

High potential also exists for sand and gravel deposits in Quaternary-Tertiary deposits. Resources in the Rio Puerco drainage system, central Rio Grande valley, and terraces in eastern Valencia County are extensive. Material for adobe also has a high-resource potential in these areas.

Crushed and dimension stone resources occur in Precambrian rocks and Paleozoic sandstones and limestones in the Manzano Mountains, where the resource potential is high. Limestone for cement occurs in the Pennsylvanian Madera Formation in the southern Manzano Mountains where the resource potential is high. Travertine from the Lucero uplift also could be used in cement.

Moderate potential exists for (1) Cu-Au-Ag ($\pm$ U, Pb) in Precambrian rocks in the Manzano Mountains, (2) gypsum in the Permian Yeso and San Andres Formations in the Lucero uplift, (3) scoria and cinders in the Cat Hills area in northern Valencia County, (4) silica sand in Precambrian quartzites in the Manzano Mountains, and (5) petroleum accumulations in Paleozoic and Mesozoic reservoirs in the Albuquerque Basin.

Additional geologic mapping and geochemical studies are suggested in areas with active claims, in the Lucero uplift and Manzano Mountains, and in areas with unknown resource potential. Aggregate resources should be mapped and sampled in greater detail prior to extraction. Isopach facies and structure contour maps of several formations in the Rio Grande valley in central Valencia County should be completed to delineate favorable areas for oil and gas accumulations.

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INTRODUCTION

Purpose and Scope

The Federal Land Policy and Management Act (FLPMA) of 1976 charges the U.S. Bureau of Land Management (BLM) with responsibility for preparing a mineral-resource inventory and assessment of mineral-resource potential for all of the public lands they manage. These studies are essential to land-use planning and management and they are required prior to BLM actions such as disposal, withdrawal, exchange, or conveyance of land and wilderness designations. In order to meet this statutory requirement, the BLM and the New Mexico Bureau of Mines and Mineral Resources (NMBMMR) entered a cooperative agreement to prepare a preliminary mineral-resource inventory and assessment for northwestern New Mexico, including Valencia, Cibola, McKinley, San Juan, and western Rio Arriba Counties (Fig. 1). The NMBMMR staff was already actively involved with compilations and geologic studies of various commodities on all lands within New Mexico, so the requirements of both agencies were satisfied. McLemore (1984) and McLemore et al. (1984) previously evaluated the mineral-resource potential of Torrance County and Sandoval and Bernalillo Counties and adjacent parts of McKinley, Cibola, and Santa Fe Counties (Fig. 1).

This preliminary mineral-resource inventory and assessment is based on analysis of available published and unpublished geologic, geochemical, geophysical, and economic data and brief field reconnaissance. Approximately nine man-months were spent compiling this report; less than a week was spent on field investigations. A more rigorous and complete analysis of all

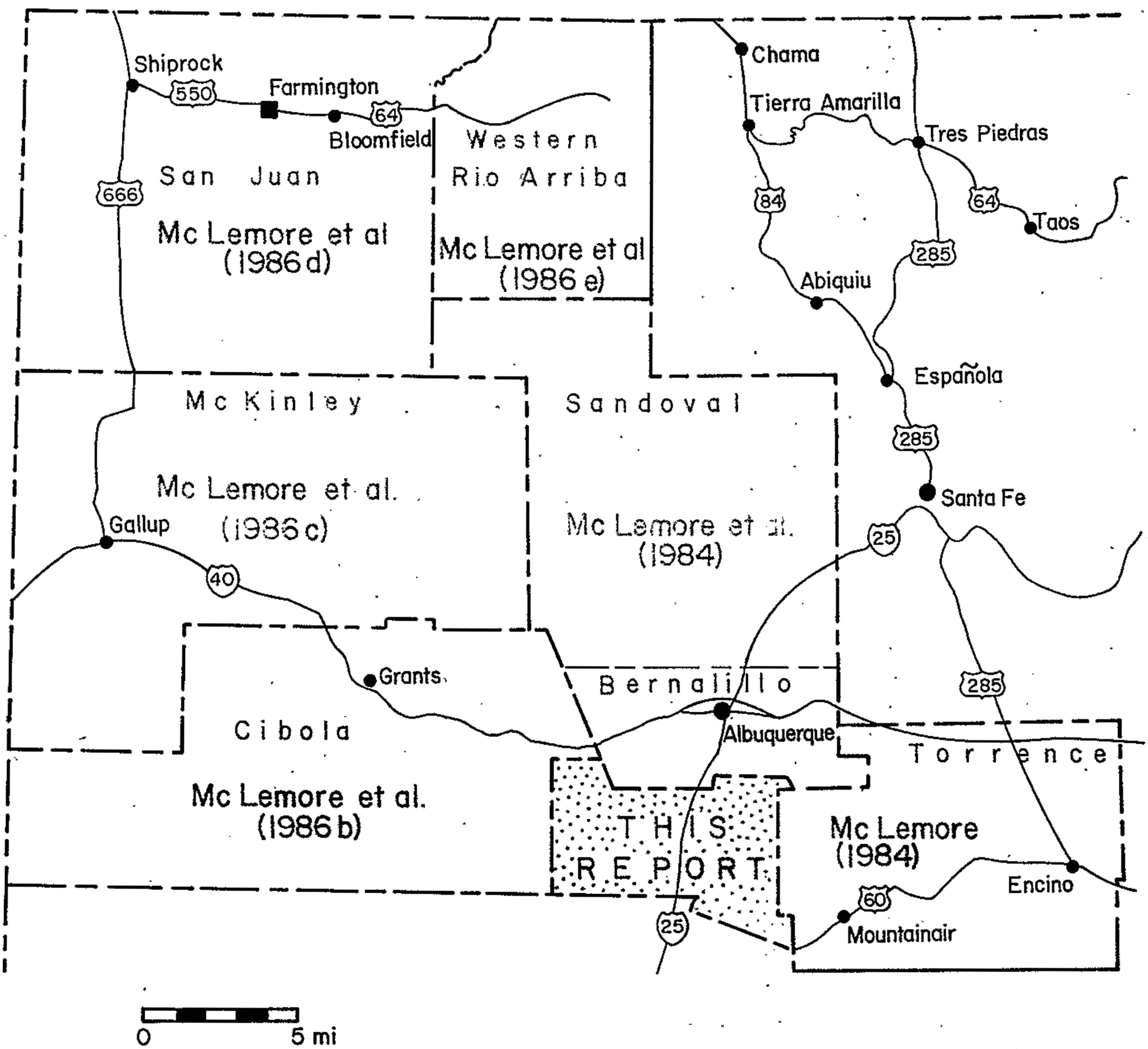


Figure 1 – Areas assessed by New Mexico Bureau of Mines and Mineral Resources.

available information and additiional field work could expand the preliminary conclusions of this report.

This report is organized into a text, appendices, and supporting figures, maps, and tables. Known mineral occurrences, prospects, deposits, and mines, including material pits, are briefly described in Appendix 1 and generally described by deposit type in the text. Petroleum tests are tabulated in Appendix 2. They are plotted on 1:100,000-scale maps; Figure 2 is an index to 1:100,000-scale topographic maps covering Valencia County. Mineral-resource potential of various commodities is discussed in the text and also shown on 1:100,000-scale maps.

Definitions

Mineral resources are the naturally occurring concentrations of materials (solid, gas, or liquid) in or on the earth's crust that can be extracted economically under current or future economic conditions. Reports describing mineral resources vary from simple inventories of known mineral deposits to detailed, geologic investigations.

A mineral occurrence is any locality where a useful mineral or material occurs. A mineral prospect is any occurrence that has been developed by underground or above ground techniques or by subsurface drilling. These two terms do not have any resource or economic implications. A mineral deposit is a sufficiently large concentration of a valuable or useful mineral or material that may be extracted under current or future economic conditions. A mine is any prospect which produced or is

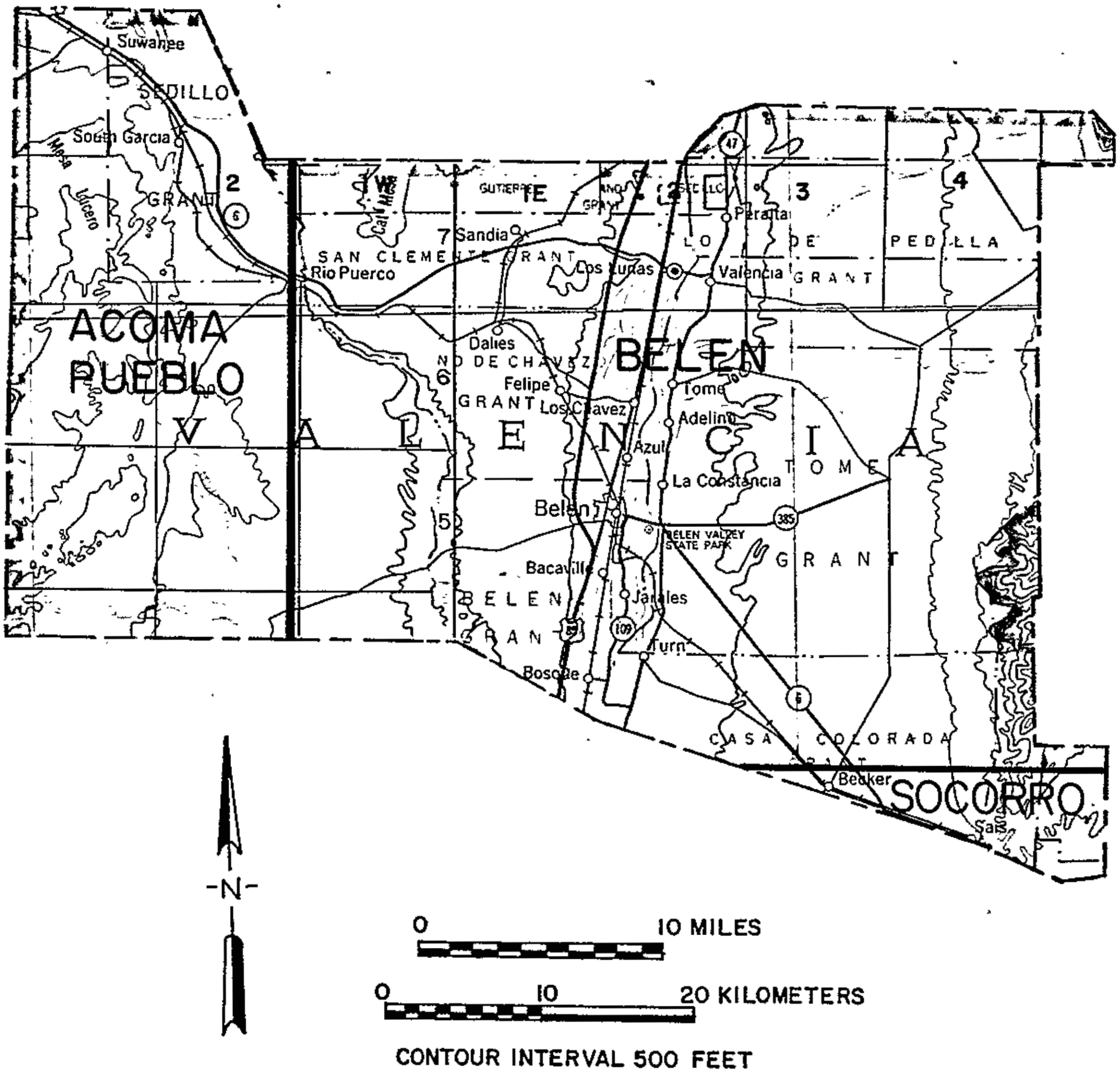


Figure 2 – 1:100,000 scale topographic maps covering Valencia County, New Mexico.

currently producing a useful mineral or material.

The mineral-resource potential of an area is the likelihood or probability that a mineral will occur in sufficient quantities so that it can be extracted economically under current or future conditions (Taylor and Steven, 1983). Mineral-resource potential is preferred in describing an area whereas mineral-resource favorability is used in describing a specific rock type or geologic environment (Goudarzi, 1984). The mineral-resource potential is not a measure of the quantities of the mineral resources, but is a measure of the potential of occurrence. Factors that could preclude development of the resources, such as the feasibility of extracting the minerals, land ownership, accessibility of the minerals, or cost of exploration, development, production, processing, or marketing, are not considered in assessing the resource potential; although these factors certainly affect the economics of extraction. Total evaluation of mineral-resource potential involves a complete understanding of the known and undiscovered mineral resources in a given area.

Classification of Mineral-Resource Potential

A simple subjective classification of mineral-resource potential is used for the purposes of this report. The potential is simply classified according to availability of geologic data and relative probability of occurrence as high, moderate, low, very low, or unknown (Fig. 3). More detailed descriptions of this classification scheme and evaluation process are by McLemore (1985) and McLemore et al. (1986a).

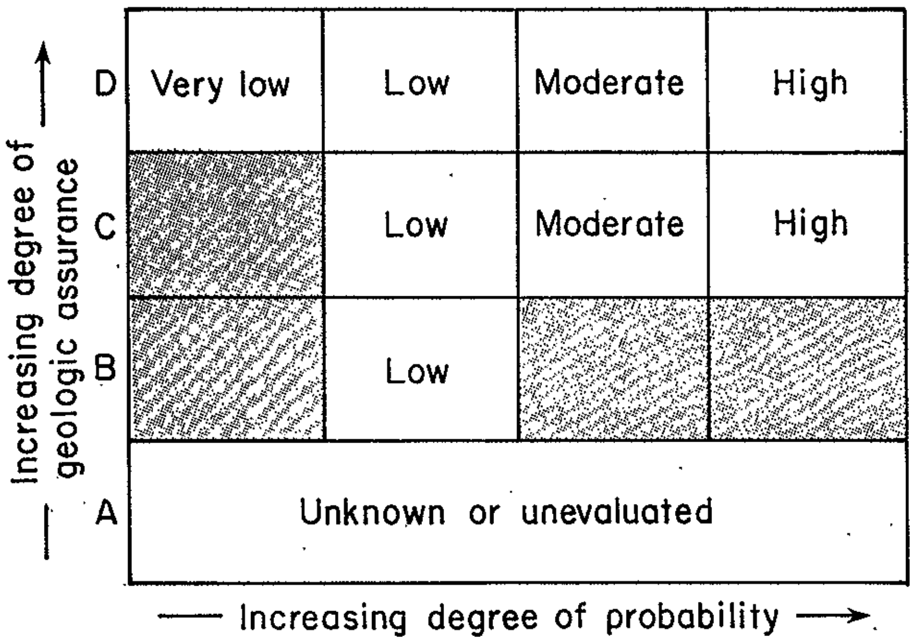


Figure 3-Classification of mineral-resource potential (modified from Taylor and others, 1984 and Goudarzi, 1984). A-D represent four levels of geologic assurance.

A high mineral-resource potential is assigned to areas where there are known mines or deposits or where the geologic, geochemical, or geophysical data indicate an excellent probability that mineral deposits occur. A moderate mineral-resource potential exists in areas where data suggest a reasonable possibility that undiscovered deposits occur in formations or geologic settings known to contain economic deposits in similar geologic settings elsewhere. A moderate to low mineral-resource potential exists in areas where data suggest a reasonable possibility that undiscovered mineralization occurs in an area, but the potential is not as good as moderate. Low mineral-resource potential exists in areas where available data imply the occurrence of mineralization, but indicate a low possibility for the occurrence of a deposit. A classification of very low mineral-resource potential is reserved for areas where sufficient information indicates that an area is unfavorable for economic deposits. Use of the very low classification requires a high level of geologic assurrance.

A classification of unknown mineral-resource potential is reserved for areas where necessary geologic, geochemical, and geophysical data are inadequate to otherwise classify an area. This assessment is assigned to areas where the degree of geologic assurance is low and any other classification (high, moderate, low, or very low) would be misleading. These areas should receive high priority for additional study.

The mineral-resource potential of some areas can not be assessed because of lack of useful data. Detailed geologic mapping at a scale of 1:24,000 may be required before the mineral-resource potential can be assessed. <u>The lack of data does not imply a very low mineral-resource potential</u>. The difference between an <u>unknown</u> resource potential and <u>unevaluated</u> area is that some data exists in an area of unknown resource potential which implies the possibility of the occurrence of resources.

In addition to evaulation of the mineral-resource potential, the potential for development is assessed. The potential for development is classified simply as high, moderate, or low and takes into account such factors as grade, tonnage, current market conditions, status, and similar economic factors. <u>High potential for development</u> indicates that the area is currently producing a commodity or economic conditions suggest that production of the deposit is economically feasible currently or in the near future. <u>Moderate potential for development</u> exists in areas where production of the deposit would occur if certain geologic or economic conditions became favorable. <u>Low potential for development</u> indicates only a slight possibility, if any, for production of the deposit. The potential for development classification is also a highly subjective judgment, but it does offer an evaluation of the economic feasibility of an area.

Previous Geologic Investigations

The geology of Valencia County is described as part of several regional geologic reports (Kottlowski, 1966; Titus, 1963; Hunter and Ingersoll, 1981; Machette, 1982; Kues et al., 1982), several reports concerning the geology of the Manzano Mountains (Reiche, 1949; Stark, 1956; Edwards, 1978, Titus, 1980; Cavin et al., 1982; Bauer, 1982, 1983; Myers, 1982; Grambling, 1982; Parchman, 1982), and reports of the Rio Grande valley and Lucero uplift (Duschatko, 1953; Kelley, 1977; Kelley and Kudo, 1978). Much of the county is covered by geologic maps of various scales (Figs. 4, 5, 6). Two state geologic maps (Dane and Bachman, 1965; New Mexico Geological Society and NMBMMR, 1983) and also one regional map (Dane and Bachman, 1957) include Valencia County.

Specific reports describing the mineral resources in Valencia County are few. The best source describing the mineral resources in New Mexico is a compilation prepared by the U.S. Geological Survey (1965) in cooperation with various state and federal government agencies. Various energy and mineral resources reports include Jones (1904), Talmage and Wootton (1937), Anderson (1957), Bieberman and Weber (1969), Foster and Grant (1974), Siemers and Austin (1979a,b), U.S. Geological Survey and NMBMMR (1981), Logsdon (1982a), Austin et al. (1982), Barker et al. (1984), and North and McLemore (1984, 1986). Additional commodity reports concerning New Mexico mineral resources include discussions of various commodities in Valencia County and are cited where appropriate. Production is from various file data, U.S. Geological Survey (1903-1931), U.S. Bureau of Mines (1932-

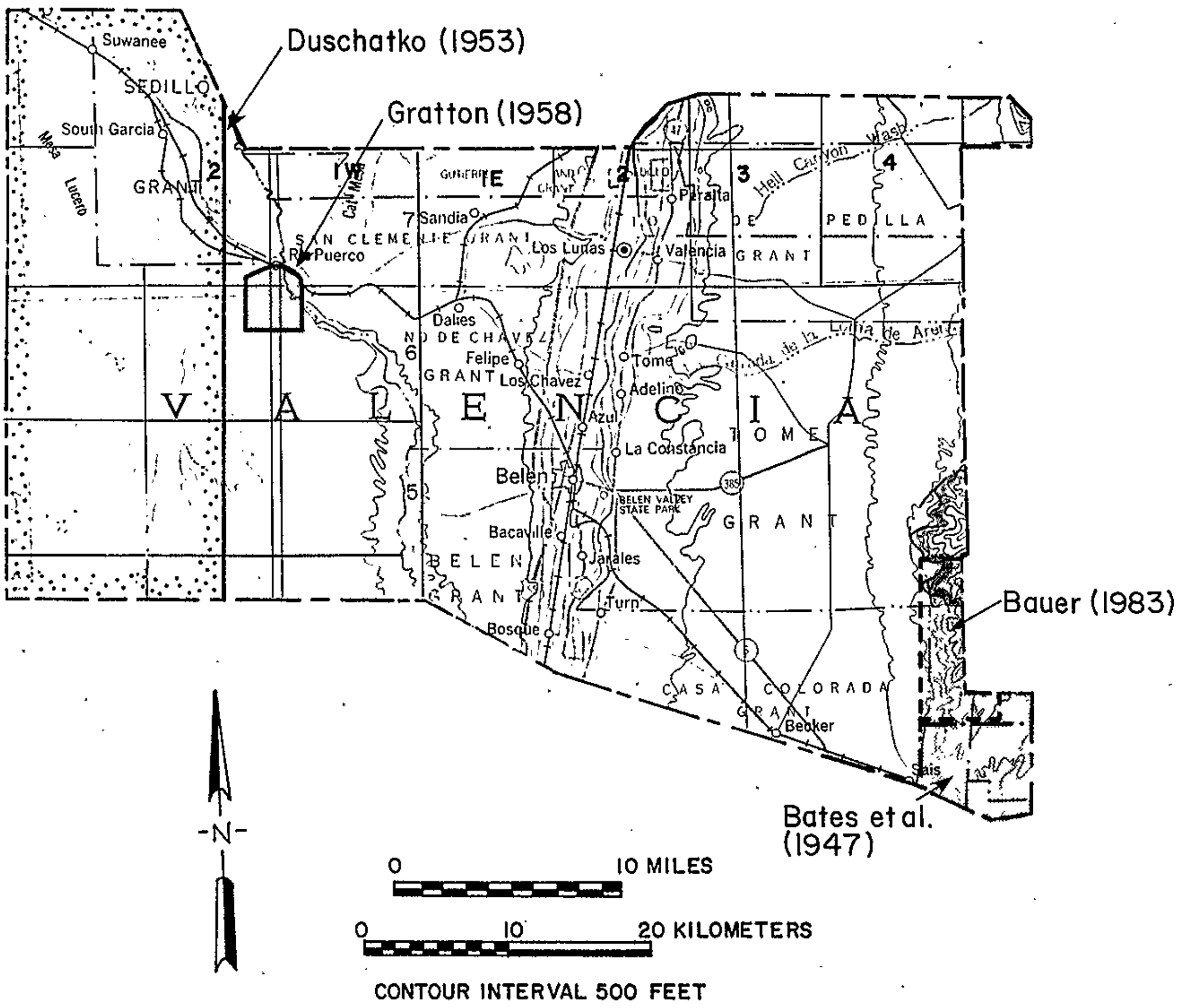


Figure 4 – Index of geologic mapping at scales larger than 1:24,000, Valencia County, New Mexico.

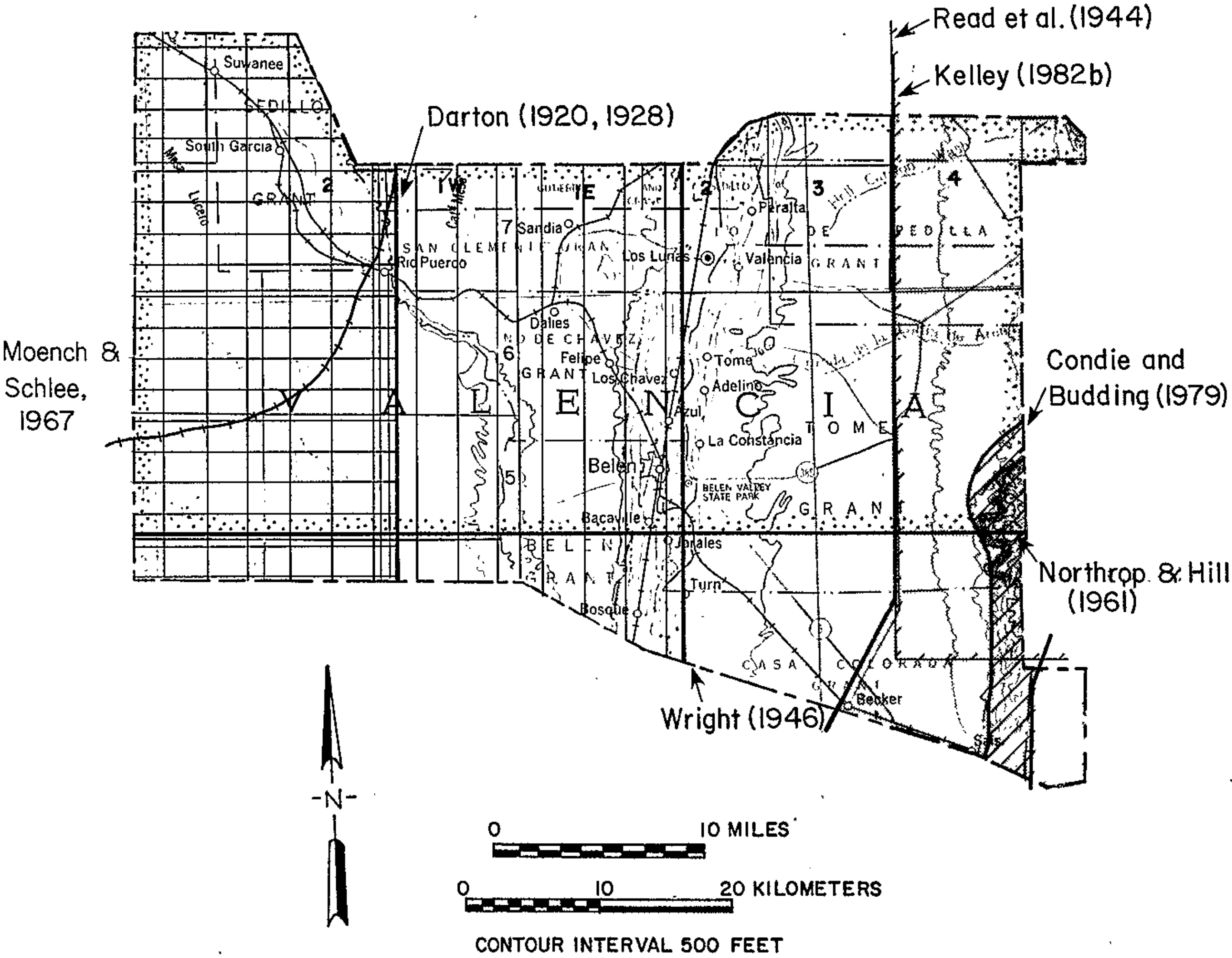


Figure 6 – Index of geologic mapping at scales 1:63,360 or smaller, Valencia County, New Mexico. Entire county covered by Kelley (1954, 1977), Dane and Bachman (1957, 1965), Herrick (1900), Machette (1978), and New Mexico Geological Society and NMBMMR (1983).

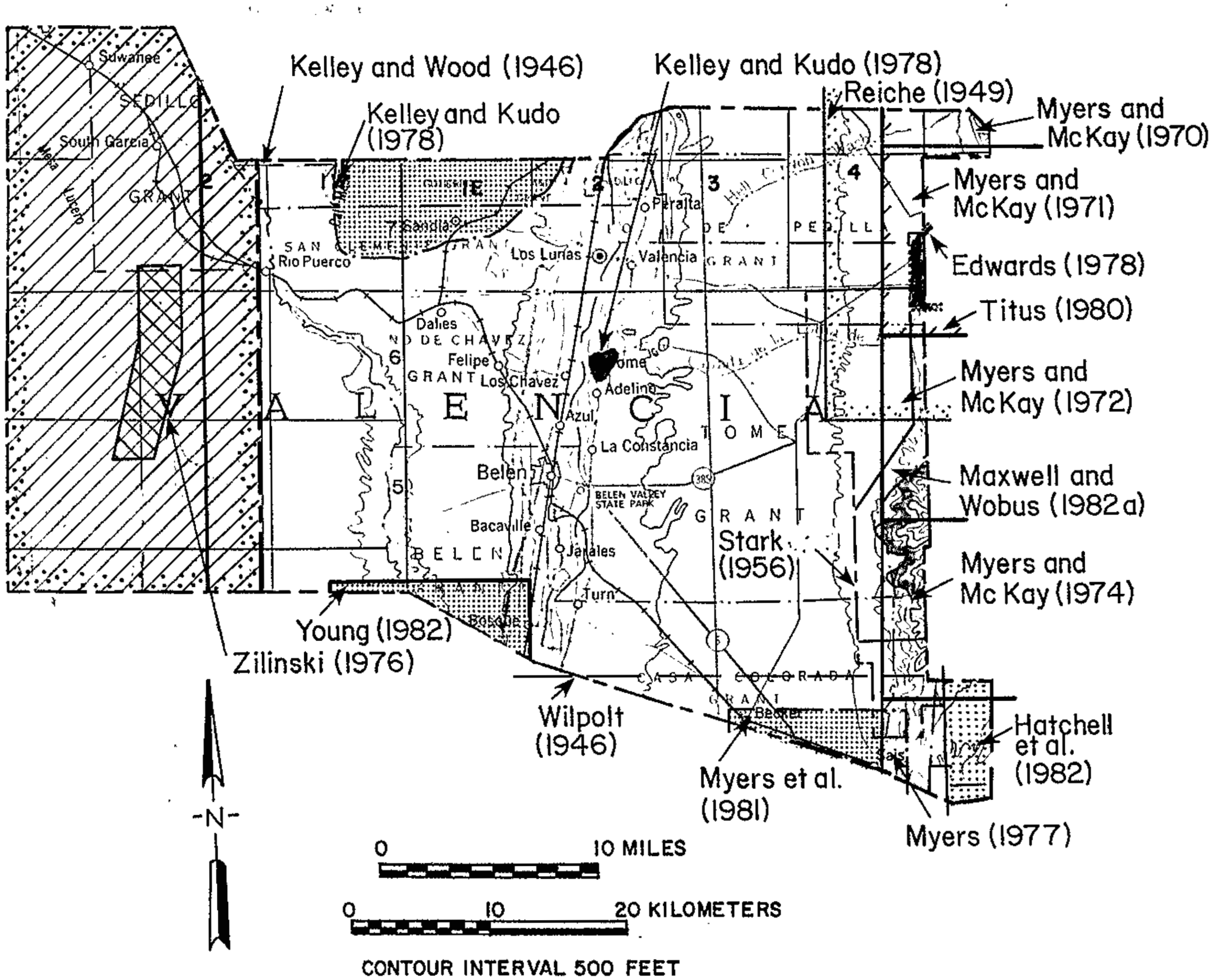


Figure 5 – Index of geologic mapping at scales 1:24,000 to 1:63,360, Valencia County, New Mexico. Entire county covered by Titus (1963).

1981), and New Mexico State Mines Inspector (1903-1983). A leaseable mineral-land classification map of Socorro $1^{o}x2^{o}$ quadrangle has been prepared by DeCicco et al. (1979). Several reports describe the mineral-resource potential of two different wilderness areas in the Manzano Mountains (Maxwell and Wobus, 1982b; Light, 1982; Maxwell et al., 1983; Maxwell and Light, 1984; and Krason et al., 1982). As part of the U.S. Department of Energy's NURE (National Uranium Resource Evaluation) program, much of Valencia County was examined as part of the Socorro $1^{o}x2^{o}$ topographic quadrangle (Geodata International, Inc., 1979; Planner, 1980; Pierson et al., 1982). Gravity and magnetic maps were published by Cordell et al. (1982), Cordell (1976, 1983), Keller and Cordell (1983), and U.S. Geological Survey (1975, 1976).

Acknowledgments

This project was completed under a cooperative agreement between the Bureau of Land Management (BLM) and the NMBMMR. The coordinators for the BLM include Henry Wilson, William Jonas, George Lasker, and Patricia Hester who provided some of the data needed to evaluate the mineral-resource potential. Warren Bennett, New Mexico State Highway Department, provided data on aggregate resources. Many people on the NMBMMR staff in addition to the coauthors assisted greatly in preparing this report. Lynn Brandvold and associates provided chemical analyses. Robert North and James Barker assisted the senior author in the field. Cindie Salisbury, Kris Klein, Lorie Baker, and Stella Smith, and

Cherie Pelletier drafted most of the figures and Lynne McNeil and Dolores Gomez typed the manuscript. Deb Shaw determined the acceptable boundary between Cibola and Valencia Counties. This manuscript benefited from critical reviews by George Austin, Robert North, Sam Thompson, Robert Bieberman, Gretchen Roybal, Peter Copeland, and Patricia Hester. Paul Garding of the Bureau of Indian Affairs accompanied the senior author to the Milagros gold mine. Zana Wolf and Mike Gobla assisted in obtaining many of the references. Finally, Brian Cristiansen, Kris Klein, Linda Frank, Karen Brown, Jose Manrique, Peter Copeland, Kent Anderson, and Lorie Baker assisted in copying, proofreading, and compiling the bibliography, the mineral occurrences, the geochemical anomaly maps, and the index to geologic mapping.

PHYSIOGRAPHY AND GEOLOGY

(by V. T. McLemore)

Valencia County lies in the Basin and Range physiographic province and is dominated by the Albuquerque Basin (Fig. 7). Complex faulting in Laramide and Tertiary times uplifted the Manzano Mountains on the east and the Lucero area on the west and downfaulted the Rio Grande graben. Two major rivers, the Rio Grande and Rio Puerco, drain the area.

Lithologic units in Valencia County range in age from Precambrian to Recent and many of the stratigraphic intervals contain mineral deposits (Table 1; Fig. 8). A brief synopsis of the stratigraphy and geologic history follows; for more detailed discussions of the geology of Valencia County, the reader is referred to references cited.

The oldest rocks exposed in Valencia County are Precambrian metamorphic and granitic rocks in the Manzano Mountains (Fig. 8). A small outcrop of Precambrian granite occurs along the Rio Puerco fault in western Valencia County (Titus, 1963). The oldest units are exposed in the northern Manzano Mountains and consists of a sequence of greenstone, talc, phyllite, argillite, and metavolcanic rocks comprising the Hell Canyon greenstone (Cavin et al., 1982; Parchman, 1982; Edwards, 1978). The Ojita granite intrudes this sequence and has been dated at 1,527 m.y. (White, 1975; Brookins, 1982). In the southern Manzano Mountains, a sequence of quartzites, schists, and phyllites form the Sais Quartzite and Blue Springs and White Ridge Formations and a younger sequence of metarhyolite, amphibolite, and schist form the Sevillita Formation (Bauer, 1982, 1983; Condie, 1981;

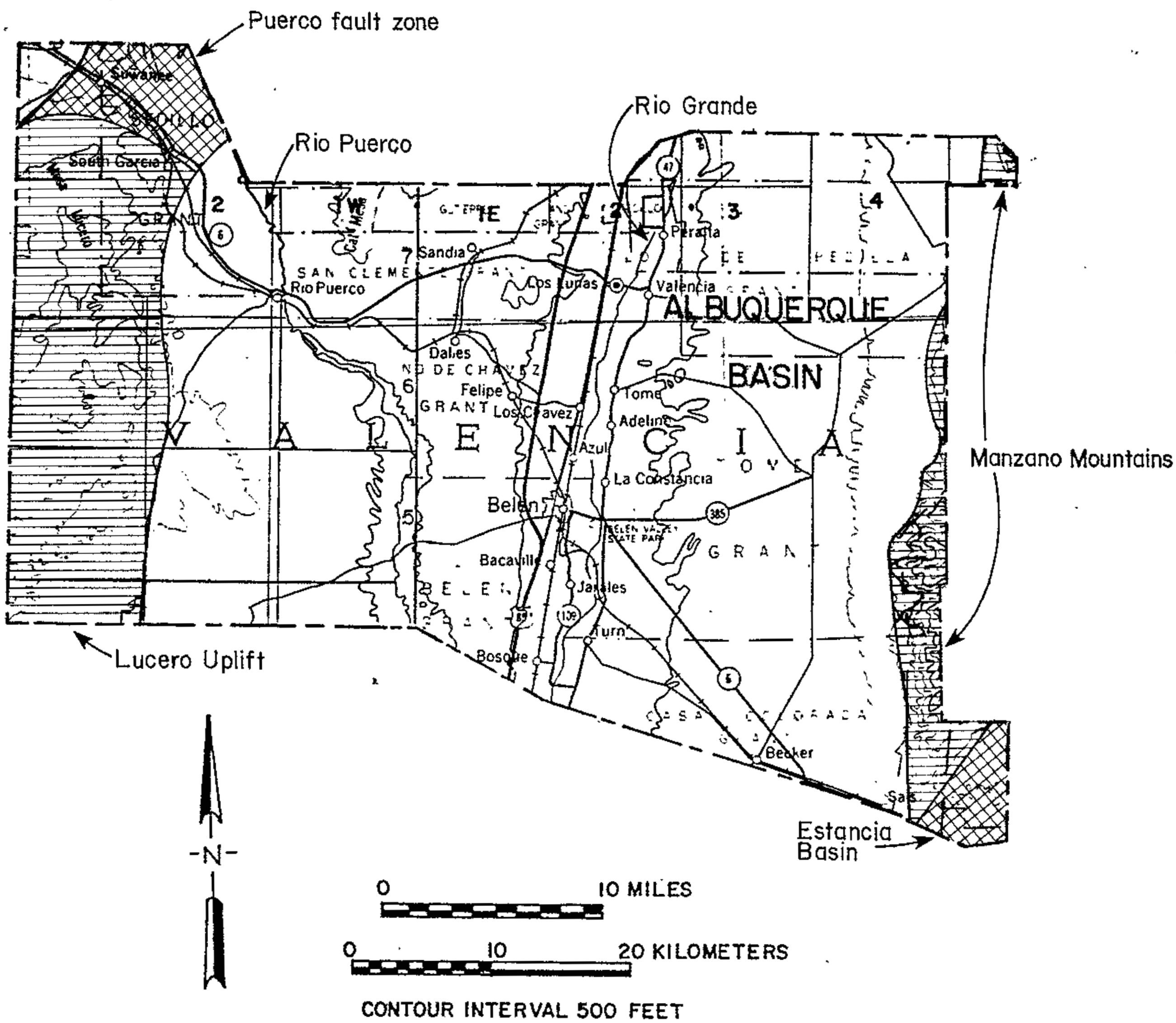


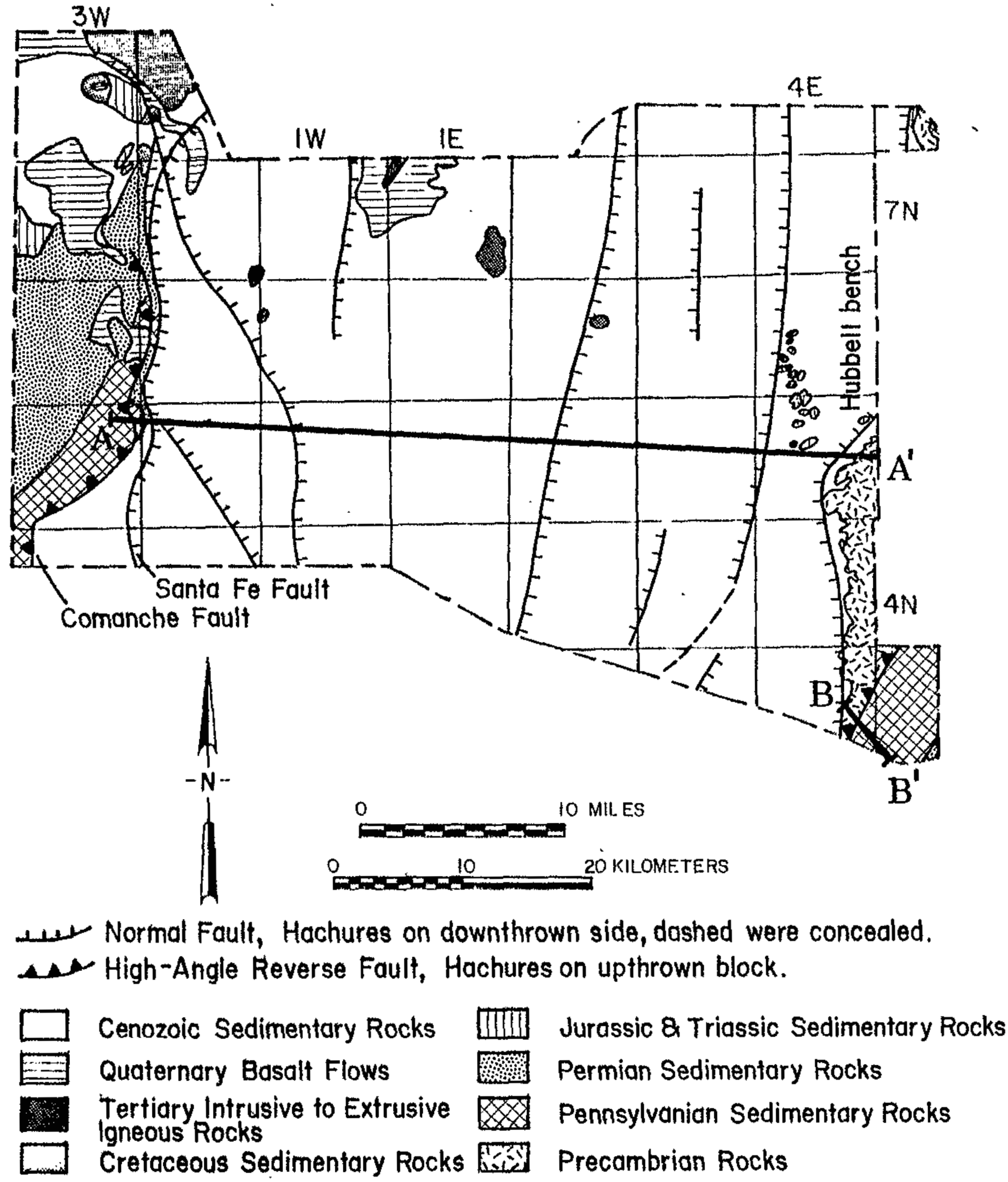
Figure 7 – Physiographic provinces in Valencia County, New Mexico. Boundaries of basins and uplifts taken from Kelley (1977), Zilinski (1976), Myers (1977), Myers and McKay (1970, 1971, 1972).

Table 1 -- Stratigraphic units and associated commodities in Valencia County (from Kelley, 1977; Titus, 1963; Myers, 1982; Kues et al., 1982).

Age	Group, Formation, Member, or rock unit	Description	Potential economic commodities present
Quaternary	valley alluvium and assorted surficial deposits	stream gravels, floodplains and landslide deposits	sand and gravel, adobe, and placer gold
	eolian deposits	sand dunes and blankets	sand
	terrace and pediment deposits	gravels, caliche, and travertine	sand and gravel, and dimension stone
	basalt flows	basalt	crushed rock, and cinder
Tertiary	Santa Fe Formation or Group	fluvial sediments	sand and gravel, adobe, and zeolites
	Datil Formation	volcanic fanglomerate and tuff	---
	basalt, andesite, and rhyolite	flows, intrusives,and dikes	crushed stone, cinder, and scoria
Cretaceous	Mesaverde, Mancos, and Dakota Formations	sandstone, shale, and coal	coal
Jurassic	Morrison, Entrada, and Todilto Formations	sandstone, shale, limestone, and gypsum	limestone, gypsum, and uranium
Triassic	Chinle Formation	shale and sandstone	---
Permian	San Andres Formation Glorieta Sandstone Member	limestone quartz sandstone	limestone, gypsum, and silica sand
	Yeso Formation	limestone, shale, and gypsum	gypsum and copper
	Abo Formation	sandstone and shale	Cu, U, Ag, and dimension and crushed stone
Pennsylvanian	Madera Group Bursum Formation	sandstones, shales, and and limestones	copper
	Wild Cow Formation	sandstone and calcarenite	clay
	Los Moyos Limestone	limestone	high-calcium limestone, and clay
Mississippian	Kelly Limestone	shales, sandstones, limestones	---
Precambrian	Manzano Mountains	complex basement lithologies	Au, Ag, Cu, Pb, Zn, U, dimension stone, kyanite, mica, and silica sand

Figure 8 – Simplified geologic map of Valencia County, New Mexico.

Major faults are shown, but many faults that control basinal structure are hidden beneath Tertiary valley fill deposits and Quaternary alluvial and eolian deposits. Compiled from Dane and Bachman (1965), Myers (1977), Myers and McKay (1970, 1971, 1972), Myers et al. (1981), Kelley (1977), Kelley and Kudo (1978), and Zilinski (1976). Cross sections A–A' in Figure 22 and B–B' in Figure 23.



Condie and Budding, 1979; Stark, 1956; Reiche, 1949). These units are in turn intruded by the Monte Largo and Priest granitic plutons (Condie and Budding, 1979). The Priest pluton has been dated as 1,569 m.y. (Brookins et al., 1980; Brookins, 1982). Schists and metavolcanic rocks are about 1.7 to 1.5 b.y. old (Bowring and Condie, 1982; Condie, 1981; Bolton, 1976).

Lower and middle Paleozoic sedimentary rocks are absent in Valencia County (Fig. 8, Table 1). The oldest sedimentary unit exposed is the Mississippian Kelly Limestone which is exposed only as erosional remnants in the Sandia and Manzano Mountains (Armstrong and Mamet, 1977). The Pennsylvanian Sandia Formation (Kelley, 1977; Kottlowski, 1960, 1966) overlies the Kelley Limestone and consist of micaceous sandstone, siltstone, and conglomerate with a few beds of marine limestone. The Madera Group (Pennsylvanian), a predominantly marine sequence, overlies the Sandia Formation. In the Abo Pass area in southeastern Valencia County, the Madera Group consists of the Los Moyos Limestone, the Wild Cow Formation, and the Bursum Formation of Early Permian age (Myers, 1982). The Los Moyos Limestone consists of marine cherty limestone beds overlain by 3- to 9- ft of conglomerate, sandstone, and calcarenite. The Wild Cow Formation consists of alternating layers of arkose, sandstone, conglomerate, siltstone, shale, and calcarenite. The Bursum Formation (Early Permian) consists of shallow-marine to deltaic sandstone, shale, and calcarenite and represents the last phase of marine deposition during this period (Kottlowski, 1960; Siemers, 1983; Myers, 1982). The Madera Group has not been subdivided on the Lucero uplift and typically is referred to as the Madera Limestone (Titus, 1963; Kelley, 1977).

Permian rocks consist of the Abo, Yeso, and San Andres Formations (Fig. 8, Table 1). Fluvial sandstones and conglomerates with massive reddish-brown shale and siltstone overbank and lacustrine deposits comprise the Abo Formation. The Yeso Formation overlies the Abo Formation and consists predominantly of marine or shallow marine units. Three members of the Yeso Formation are recognized in Valencia County; a lower quartz sandstone, the Meseta Blanca Sandstone Member; a middle sequence of limestone, dolomite, sandstone, and gypsum, the Los Vallos or Torres Members; and an upper sequence of sandstone with minor carbonate and shales, the Joyita Sandstone Member (Hunter and Ingersoll, 1981; Needham and Bates, 1943). The Cañas Gypsum Member, consisting of gypsum and carbonate, was not deposited in Valencia County (Hunter and Ingersoll, 1981). The San Andres Formation overlies the Yeso Formation and consists of the basal shallow-marine Glorieta Sandstone Member and an upper sequence of marine limestones.

A few scattered outcrops of Triassic Chinle Formation occur in eastern Valencia County (Fig. 8; Reiche, 1949) and more extensive sections occur along the Lucero uplift (Kelley and Wood, 1946; Titus, 1963). The Chinle Formation consists of fluvial sandstones and massive siltstone and shale overbank and lacustrine deposits.

Rocks of Jurassic age occur only in northwestern Valencia County and consist of the Entrada Sandstone and Todilto and Morrison Formations. The Entrada Sandstone consists of 160 to

220 ft of eolian quartz sandstone. The Todilto Formation is composed of limestone and gypsum and the Morrison Formation consists of fluvial sandstones and shale and siltstone overbank deposits.

Cretaceous sedimentary rocks also occur, but only in northwestern Valencia County and consist of the marine Dakota, Mancos, and Mesaverde Formations. The Dakota Formation consists of sandstone and the Mancos and Mesaverde Formations consists of shale, coal, and thin sandstone beds.

Sedimentary rocks of early Tertiary age are not exposed in Valencia County; however, the Santa Fe Group (Tertiary-Quaternary) is present throughout much of central Valencia County (Titus, 1963; Kelley, 1977). The Santa Fe Group is a thick accumulation of sand, silt, clay, and conglomerate deposited in the Rio Grande graben. Various Quaternary alluvial deposits, including Recent floodplain deposits, overlie the Santa Fe Group.

Numerous basaltic flows and several intrusive bodies occur within the Albuquerque Basin and on Lucero uplift (Fig. 8; Kelley, 1977; Kudo, 1982; Kasten, 1977; Gambill, 1980). Small shield and cinder cone volcanoes are present. Many mesas are capped by basalt flows. The youngest is probably the Cat Hills, dated at 140,000 years (Kudo et al., 1977; Kudo, 1982). Dominant lithologies include andesites, olivine tholeiites, and alkali basalts.

MINING HISTORY

(by K. B. Brown)

Much of what was once Valencia County is now Cibola County. The latter was created in 1983 from the western three-fourths of former Valencia County. Mining districts within present Valencia County are Hell Canyon, Manzano, Scholle, and Rio Puerco (Romero Ranch; Fig. 9), each is partially in adjacent counties. Data for the Scholle district were included in a previous report of Torrance County (McLemore, 1984).

From the Rio Puerco district, 162 tons of ore yielding 24 ounces of silver and 9,300 pounds of copper were mined in 1929 and 1956 for a total value of $2,973 (U.S. Bureau of Mines, 1956; U.S. Geological Survey, 1929). From 1880 to 1976, the Hell Canyon district produced 3,349 ounces of silver, 2,724 ounces of gold, and 7,900 pounds of copper valued at over $349,000 (Woodward et al., 1978; Reiche, 1949). Ore production from 1915 to 1961 from the Scholle district amounted to over 1.1 million pounds of copper, 426 pounds of lead, 8,147 ounces of silver, and 9.96 ounces of gold worth over $252,000.

Aggregate from river sediments has been produced, but exact production figures are unavailable. A travertine quarry 30 miles west of Belen has been producing dimension stone since 1961. For several years the production data had been combined with crushed stone and exact figures are unavailable.

Present mining claims, leasing, and exploration activity

Only a few mining claims cover portions of Valencia County

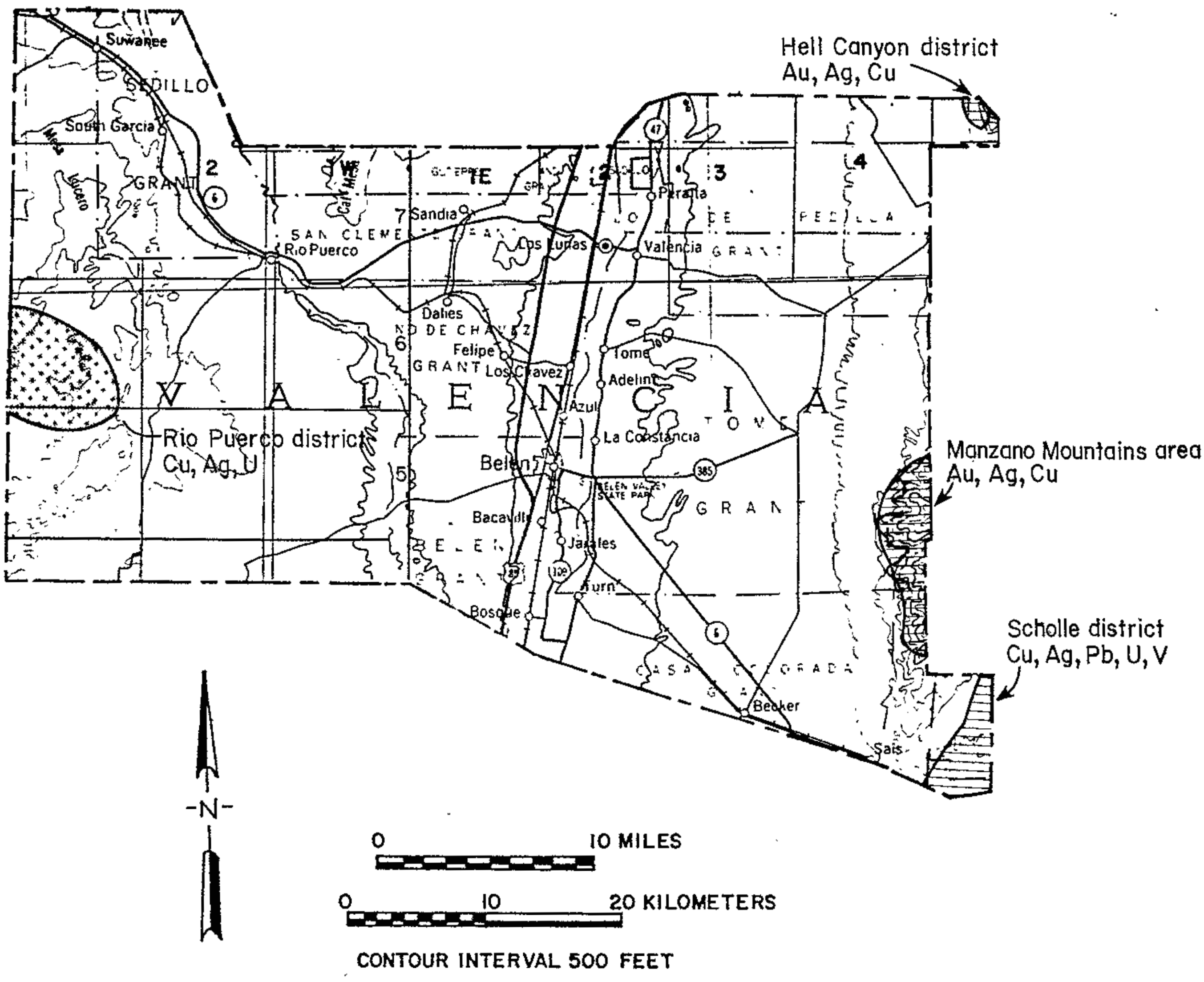
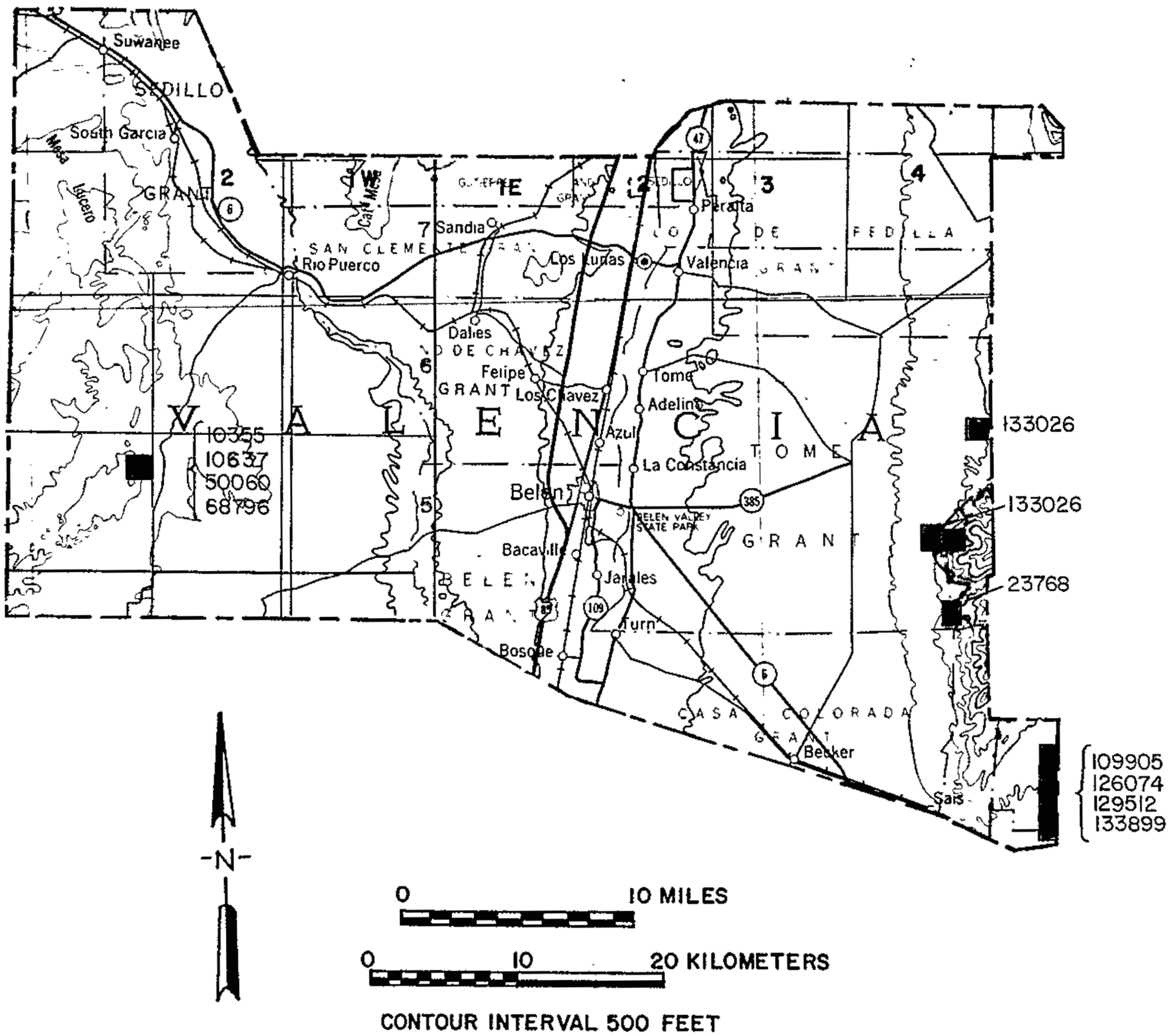


Figure 9 – Mining districts and areas in Valencia County, New Mexico.



Section with one or more active mining claims as of 7/22/85

133026 Lead file number

Figure 10 – Sections with active mining claims in Valencia County, New Mexico.

(Fig. 10). These claims occur in the Scholle mining district, the Manzano Mountains, and Lucero uplift. A few sand and gravel operations, one building and landscaping stone pit, one travertine quarry, and two adobe plants are presently active.

DESCRIPTION OF KNOWN DEPOSITS AND MINERAL-RESOURCE POTENTIAL

METALS

(by V. T. McLemore)

Deposit Types

Precious- and base-metal mineralization occurs in stratabound, sedimentary-copper deposits (red-bed copper) and gold-silver-copper veins in Precambrian rocks in the Manzano Mountains and Lucero area (Fig. 9; Maps 1, 2, 3); however, production has been small. Favorable geologic and geochemical environments and minor metal occurrences suggest potential mineral deposits may be concealed elsewhere in Valencia County, including gold-silver-copper veins in Precambrian rocks and Precambrian massive-sulfide deposits (Fig. 11, Maps 1, 2).

Hell Canyon mining district

General description--Copper, gold, and silver occur in Precambrian metavolcanic and metasedimentary rocks in the Hell Canyon mining district in northeastern Valencia County (Fig. 9, Map 2, Appendix 1). Minor occurrences of copper, occasionally with silver and gold, are widespread in Precambrian rocks in the area.

Mining and production--Copper, silver, and gold were first produced during the 1880's from the Milagros patented claims (Table 2; Reiche, 1949). Some production from the Belvidere patented claim occurred in 1955 and 1956. Significant production occurred in 1975 and 1976 when over $338,000 of gold and silver were produced from the Milagros mine (Table 2) by cyanide heap-leaching (Chisholm, 1975; Woodward et al., 1978). Environmental

Figure 11 - Mineral-resource potential for metals, barite, fluorite, and uranium in Valencia County, New Mexico.

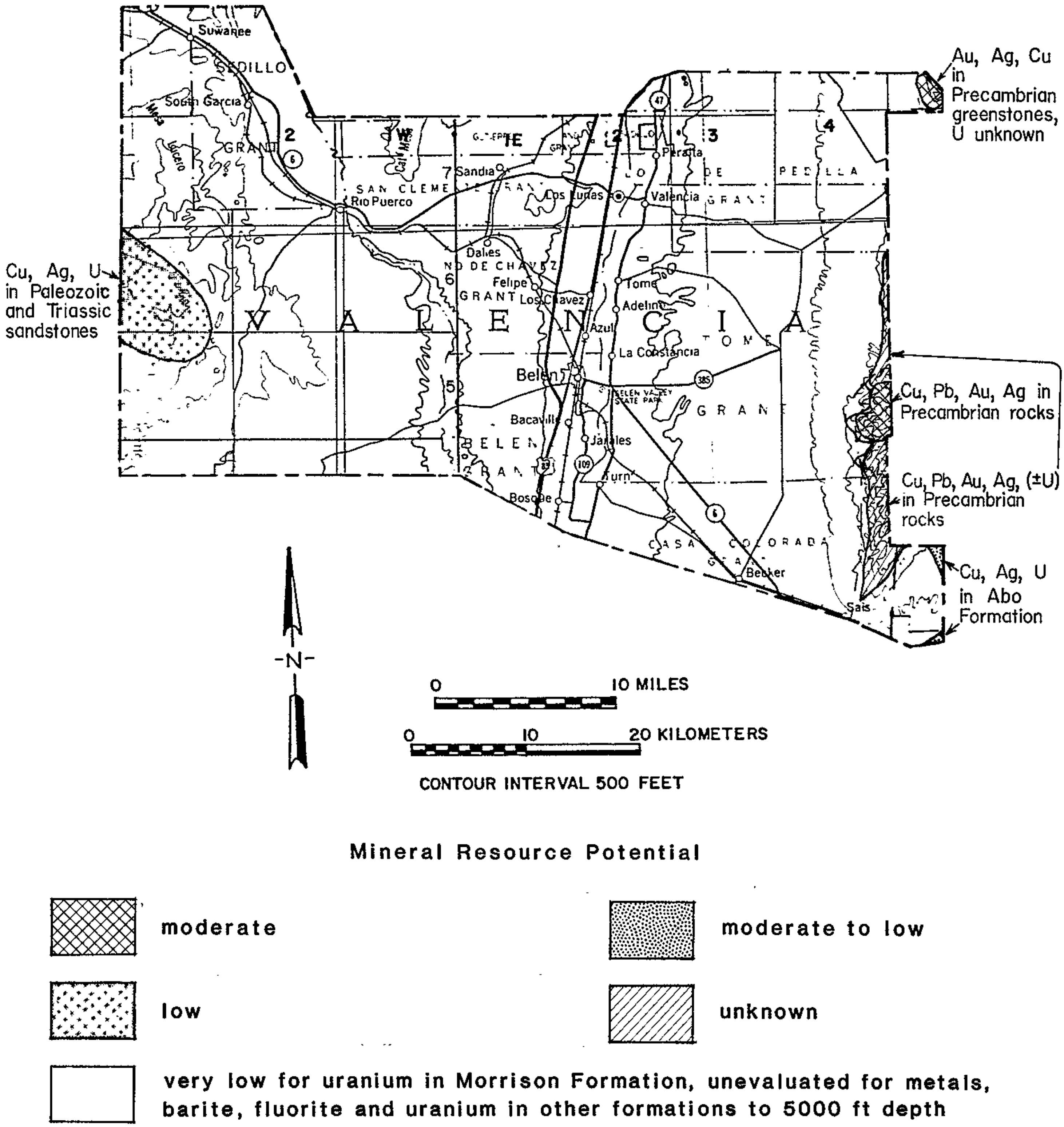


Table 2 -- Mine production from the Hell Canyon district, Valencia County (from U.S. Bureau of Mines Mineral Yearbooks; Woodward et al., 1978; and Reiche, 1949).

Year	Tons of ore	Au (oz)	Ag (oz)	Cu (lbs)	Total Value ($)
1880-1910	1,500 (e)	375 (e)	--	--	7,500 (e)
1955	50	--	12	5,900	2,242
1956	55	1	4	2,000	889
1975-1976	--	2,348	3,333	--	338,604
TOTAL	--	2,724	3,349	7,900	349,235

problems forced closure of the operation soon after. Total known production from the Hell Canyon district is 2,724 oz of gold, 3,349 oz of silver, and 7,900 lbs of copper (Table 2). Land adjacent to the patented claims is part of the Isleta Indian Reservation and exploration for additional deposits has been restricted.

Geology--Copper, gold, and silver occur in lenticular quartz veins and along fractures and shear zones in Precambrian quartzite, greenstone, and interlayered metasedimentary rocks (Woodward et al., 1978; Parchman, 1982). An orebody containing about 100,000 tons of ore averaging 0.23 oz/ton of gold and 0.63 oz/ton of silver was delineated in 1975 at the Milagros mine (Chisholm, 1975). Additional orebodies occur on the Belvidere claim and occurrences of copper, silver, and gold occur throughout the area (Edwards, 1978; Parchman, 1982). Detailed mineralogical studies of the Milagros ore deposit are not available, but native gold, malachite, azurite, and chrysocolla are present (McLemore, field notes, 9/28/83; Woodward et al., 1978; Parchman, 1982). Pyrite, iron oxides, and quartz are present. The area also was investigated for platinum from 1959 to 1961, but the presence of platinum could not be confirmed (Elston, 1967).

Archean greenstone terranes consist of predominantly metamorphosed, mafic volcanic sequences and contain many of the world's primary gold deposits (Anhaeusser et al., 1969). Similar rocks of Proterozoic age occur in the Hell Canyon district. These deposits may be syngenetic and possibly formed contemporaneously by hot brines with submarine volcanism.

Subsequent hydrothermal activity or metamorphism may have redistributed and reconcentrated gold from primary hot-springs deposits or gold-enriched volcanic rocks to form deposits in stratabound horizons, veins, shear zones, or saddle reefs. Host rocks in the Hell Canyon district are enriched in gold and silver and probably were leached to form the Milagros and Belvidere deposits (Woodward et al., 1978).

A few placer gold deposits have been reported from the western drainages of the Manzano Mountains; however, very little information concerning these small deposits is known (McLemore et al., 1984).

Resource development potential--The mineral-resource potential for gold, silver, and copper in Precambrian greenstones in the Hell Canyon mining district is moderate (Fig. 11; Map 2). Although mineralization is known to occur, economic orebodies have yet to be delineated. The Milagros deposit may be low grade or depleted. The potential for development is moderate; however, most of the favorable greenstones lie on the Isleta Indian Reservation. The mineral-resource potential for platinum is unknown, but presumed low because of unfavorable geologic environments. Geochemical sampling should be completed to assess the area for platinum. The mineral-resource potential for placer deposits is unknown.

Manzano Mountains area

Several prospects occur along faults and shear zones in the Precambrian metasedimentary rocks in the southern Manzano Mountains in Valencia and Torrance Counties (Fig. 9; Map 2;

Maxwell and Wobus, 1982a, b; Maxwell and Light, 1984), although there is no reported production. One sample from the Bartolo mining claims contained 0.37 oz/ton (12.6 ppm) Au, 4.0 oz/ton (136 ppm) Ag, 0.65% Cu, and 1.45% Pb (Maxwell and Light, 1984). Samples collected by the author and Robert North contained concentrations up to 29.8 oz/ton (1,022 ppm) Ag, 0.48 oz/ton (16 ppm) Au, 3.13% Cu, 3.68% Pb, and 0.014% Zn (Table 3, Fig. 12). Anomalously high values of Au, Ba, Cr, Pb, and Cu were found in stream-sediment samples collected by Maxwell and Wobus (1982b) from Comanche Canyon, Cañon del Trigo, and the southwestern part of the Manzano Wilderness (McLemore, 1984, fig. 9). Additional geochemical anomalies of Cr, Ni, Pb, and Co were found in the NURE HSSR samples from streams draining from the Manzano Mountains. These areas certainly warrant further study.

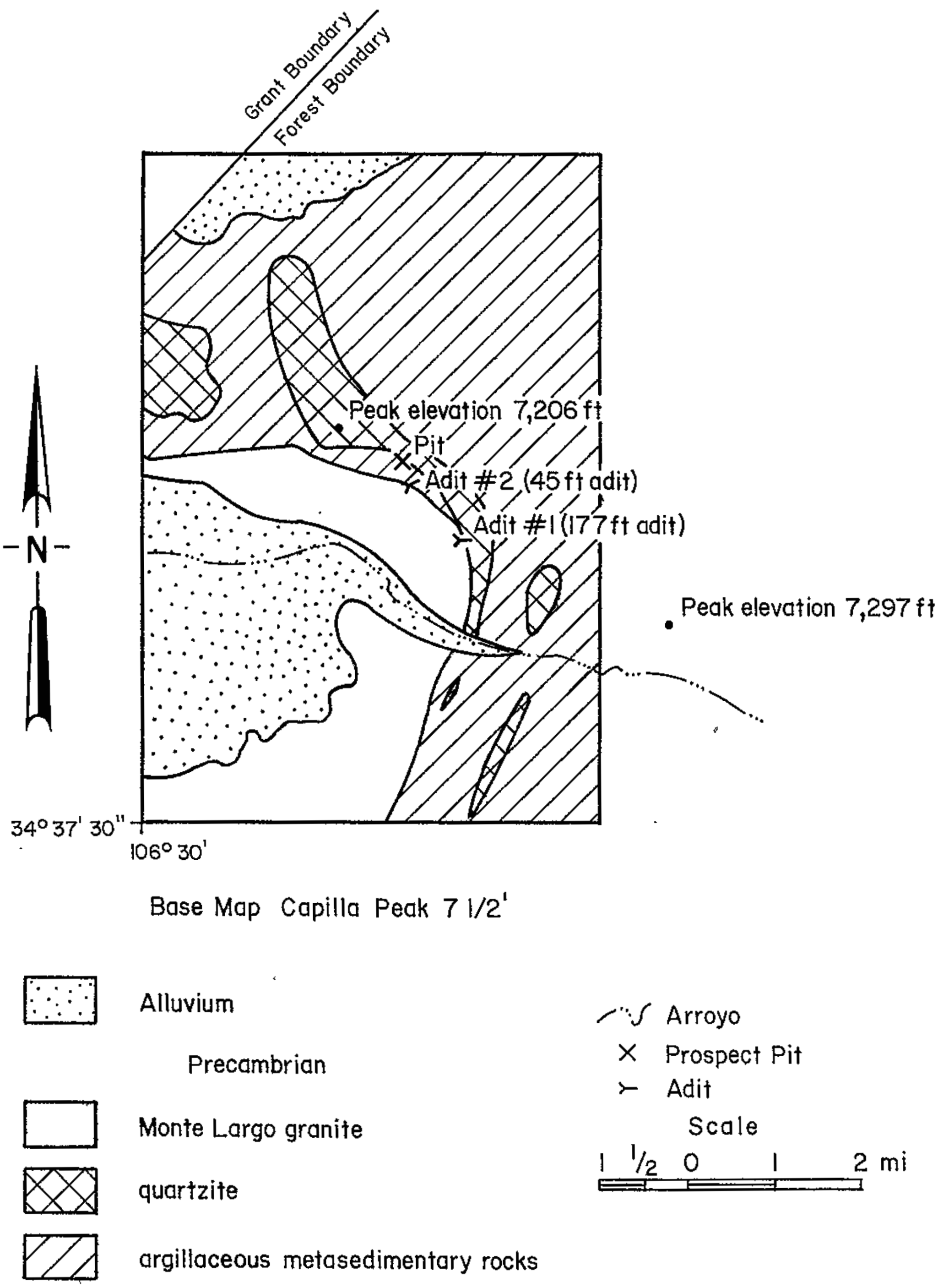
The deposits in the Manzano Mountains are probably Precambrian in age (Fulp and Woodward, 1981), but the exact age of the deposits is uncertain. Mineralized faults and shears are probably Precambrian and mineralization may be locally controlled by metamorphism. Although the extent and average grade of these deposits is not known, Light (1982) believes there is a good possibility for a small deposit containing several thousand to several hundred thousand tons of ore averaging 0.01 to 0.40 oz/ton of gold. Additional work is required to determine the extent, origin, size, and grade of these deposits.

Maxwell and Light (1984) and Maxwell et al. (1983) classified the mineral-resource potential for gold in the southern portion of the Manzano Wilderness as probable or moderate (Fig. 11; Map 2). The mineral-resource potential for

Table 3 -- Chemical analyses of samples from Bartolo Canyon (TG Claims), sec. 26, T5N R4E, Manzano Mountains, Valencia County. Sample location refers to Figure 12. Trace Au (oz/ton) is less than 0.02 oz/ton. Chemical analyses by Lynn Brandvold and associates, NMBMMR chemical laboratory.

Sample No.	Sample Location (Fig. 12)	Au (oz/ton)	Ag (oz/ton)	Cu (ppm)	Pb %	Zn %
3	adit #1	trace	0.00	60	0.028	0.009
4849	adit #1	0.00	0.86	300	--	--
4848	adit #1-dump	0.02	0.52	168	--	--
4850	adit #1	0.00	0.40	30	--	--
4855	adit #1	0.00	0.00	300	--	--
P	adit #2	trace	0.00	80	<0.01	0.004
P footwall	adit #2	trace	0.00	270	3.68	0.014
4851	adit #2-dump	trace	2.22	0.31%	--	--
4852	adit #2	trace	0.24	45	--	--
4853	adit #2	trace	0.14	152	--	--
A	pit	trace	0.36	100	0.015	0.002
4854	pit-dump	trace	0.00	20	--	--
4856	pit-dump	0.48	29.80	3.13%	--	--
4857	pit	0.14	0.10	74	--	--

Figure 12 – Location of prospects in Bartolo Canyon in approximately sec. 26 T5N R4E, Manzano Mountains, Valencia County, New Mexico. Geology from Maxwell and Wobus (1982a).



base metals in this area is also moderate. However, the mineral-resource potential for gold and other metals in the metamorphic rocks elsewhere in the Manzano Mountains is unknown (Maps 1, 2). The resource potential for gold placer deposits along arroyos draining the Manzano Mountains is unknown. The potential for development is low in the wilderness area and moderate to high elsewhere.

Scholle mining district

General description--Copper mineralization with associated silver, gold, lead, uranium, and vanadium occurs in stratabound, sedimentary deposits in the Abo Formation in the Scholle district at the junction of Torrance, Socorro, and Valencia Counties (Figs. 9, 13; Map 1; Appendix 1). Minor occurrences of copper and local uranium mineralization also are found in sandstones of the Wild Cow, Bursum, and lower Yeso Formations in the Scholle district and in the Abo Formation in the Manzano Mountains north of the Scholle district (McLemore, 1982, 1983, 1984; Hatchell et al., 1982).

Mining and production--As early as 1905, copper deposits were known in the Scholle district, but production of the deposits did not begin until 1915. Prospecting for uranium occurred during the 1950's after a local prospector discovered a thin seam that assayed 13% U_3O_8. From 1915 to 1961, total production from this district amounted to 15,037 tons of ore that contained 1,122,465 lbs of copper, 8,147 oz of silver, 426 lbs of lead, and 9.96 oz of gold that was worth more than $255,000 (Table 4). In addition, $700 worth of radium was mined in 1916

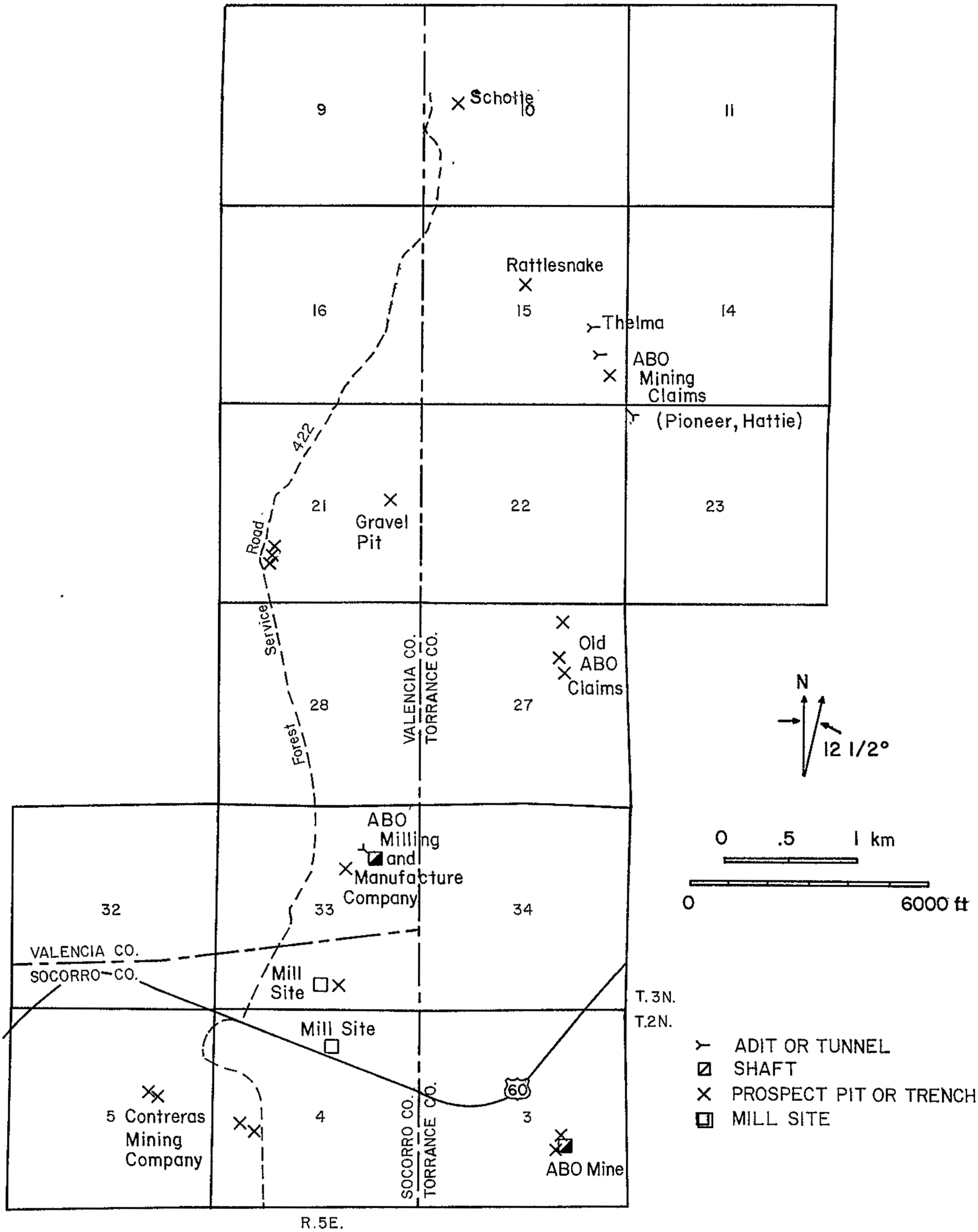


Figure 13 – Location of mines in the Scholle district, Torrance, Socorro, and Valencia counties, New Mexico.

Table 4 - Mine production from Scholle district, Torrance, Socorro, and Valencia Counties (U.S. Geological Survey, 1915-1931; U.S. Bureau of Mines, 1932-1961). [1] In 1938, 47 tons yielding 4,700 lbs Cu, 405 oz Ag, and 14.2 oz Au were shipped from Scholle in Torrance County. However, this shipment is not included here because the Ag and Au contents are too high for the average red-bed sandstone deposit. It is probable that the shipment originated elsewhere than the Scholle district.

Year	No. mines	Ore tons	Cu (lbs)	Cu ($)	Pb (lbs)	Pb ($)	Ag (oz)	Ag ($)	Au (oz)	Au ($)	Total $
1915	5	188	25,143	4,400			124	63			4,463
1916	13	3,172	331,475	81,543			2,600	1,711			83,254
1917	14	2,169	200,626	54,771	326	28	1,312	1,081	1.45	30	55,910
1918	7	637	78,757	19,453			361	361			19,814
1919	2	75	5,468	1,017			25	28			1,045
1920-1921	no production										
1922	1	16	1,740	235			13	13			248
1923	2	59	6,476	952			15	12			964
1924-1927	no production										
1928	7	1,943	187,083	23,940			1,952	1,142	8.22	171	25,253
1929	4	2,001	160,500	28,248			1,413	753			29,001
1930	2	120	9,000	1,170			57	22			1,192
1931-1932	no production										
1933	1	56	2,000	128			17	6	0.29	6	140
1934-1935	no production										
1936	1	25	1,500	138			5	4			142
1937	1	48	2,000	242			5	4			246
1938	see footnote 1										
1939-1942	no production										
1943	2	220	19,000	2,470			135	96			2,566
1944-1952	no production										
1953	1	192	6,400	1,837	100	13	13	12			1,862
1954	2	1,086	11,100	3,274			2	2			3,276
1955	no production										
1956	2	146	4,600	1,955			17	15			1,970
1957	2	2,876	69,500	20,919			81	73			20,992
1958-1960	no production										
1961	1	8	100	60							60
1962-1983	no production										
TOTAL		15,037	1,122,468	246,752	426	41	8,147	5,398	9.96	207	252,398

(U.S. Bureau of Mines files). Most of this production was from Torrance County (McLemore, 1984). The district has not yielded any ore since 1961, although numerous active claims are located in the area (Fig. 10; U.S. Bureau of Land Management files).

Geology--All of the known deposits occur at or near the surface and were mined by both surface and underground methods. The largest mines in the district are the Copper Girl and Abo. The depths to the deposits are relatively shallow (several tens of feet deep) and most of the ore produced was hand sorted before shipping. The Abo mine probably reached a depth of about 100 ft. Several leach plants attempted unsuccessfully to recover the metals during the 1950's and 1960's.

Mineralization is restricted to the lower member of the Abo Formation, the upper member of the Wild Cow Formation, the Bursum Formation, and the Meseta Blanca Sandstone Member of the Yeso Formation. Several horizons of copper and uranium mineralization are associated with bleaching of typically red arkoses and pink to gray sandstones. Copper and uranium minerals in the Abo, Wild Cow, and Bursum Formations occur (1) as disseminations within bleached arkoses, limestone-pebble conglomerates, and siltstones, (2) along bedding planes and fractures at or near sandstone-shale, sandstone-siltstone, and sandstone-limestone contacts, and (3) as replacements of wood and other organic materials. Copper oxides, chalcopyrite, and chalcocite are the dominant copper minerals, whereas tyuyamunite, and metatyuyamunite, carnotite, and uraninite are the dominant uranium minerals (Gibson, 1952; Collins and Nye, 1957). Selected samples contain as much as 14.37% Cu, 0.017% U_3O_8, 3.18 oz/ton (108 ppm) Ag, 0.05% Pb, and 0.05% Zn

(McLemore, 1984). In addition, samples collected by Pierson et al. (1982) contain as much as 230 ppm Th, 920 ppm Co, and 1,300 ppm V. LaPoint (1979) includes analyses of 60 samples from Scholle that contained as much as 27% Cu, 100 ppm Ag, 200 ppm Pb, 123 ppm Zn, and 500 ppm V.

The larger deposits are associated with channel sandstones in the Abo Formation; only small occurrences are found in the Wild Cow and Bursum Formations. However, Abo deposits are low grade and discontinuous along outcrop. Several small, but scattered orebodies have been located in the subsurface near the Abo mining claims by drilling in meandering channel sandstones. However, none of these orebodies were economic during the 1950's (Collins and Nye, 1957).

These stratabound ore deposits are typical of many "red-bed" copper deposits in New Mexico and elsewhere in the world (LaPoint, 1976, 1979). Erosion of pre-existing mineral deposits or of rocks high in copper, uranium, vanadium, silver, and gold from local Precambrian terranes in the Pedernal Hills and Manzano Mountains could have provided a source for the Scholle ore deposits (LaPoint, 1976, 1979; Fischer and Stewart, 1961). Some copper mineralization may have been emplaced as detritus in the sediments; however, most of the mineralization is a result of deposition from groundwater. Copper was released from the clay and mafic minerals in the sediments and from the Precambrian terrane and was transported in permeable channel sands. Deposition occurred near organic material, at the contact of H_2S-rich waters, near clay minerals, or when the solubility of copper and associated metals decreased due to an increase in pH (LaPoint, 1979).

Resource and development potential--The mineral-resource potential for copper, silver, and uranium deposits in the basal Abo Formation in the Scholle district is low to moderate (Fig. 11, Map 1). Although mineralization is known to occur in the area, these deposits are too small, discontinuous, low in grade, and widely scattered to be considered economic at the present time. Anomalously high uranium concentrations do occur in water samples in the immediate vicinity of the mineralized areas, but only weak anomalies occur down dip from these areas (Pierson et al., 1982). Only a few anomalously high uranium concentrations occur in stream-sediment samples in the area. Anomalously high tin, niobium, tungsten, silver, lithium, bismuth, and cobalt are found in stream-sediment samples from the Scholle area (McLemore, 1984) where mining claims have been located. Should the market for uranium and copper improve, this area may warrant additional exploration; however, under current economic conditions, the potential for development is low.

The mineral-resource potential in the Wild Cow and Bursum Formations in the Scholle district is very low because economic orebodies have yet to be proven (Map 1). The mineral-resource potential for copper in any of these units below depths of about 200 ft is very low due to current or expected future economic conditions. The mineral-resource potential of the Scholle ore with regard to fluxing ore is low because of the high feldspar and relatively low silica content.

Rio Puerco mining district

Very little information is known about the Rio Puerco (Romero Ranch) mining district in western Valencia County (Fig. 9). U.S. Geological Survey (1929) and U.S. Bureau of Mines (1956) report production of 9,300 lbs of copper and 24 oz of silver from the area (Table 5). It is assumed that the deposits are stratabound copper deposits similar to the Scholle district. One occurrence of copper is found in the vicinity (Appendix 1; Map 3).

The resource potential for sedementary-copper deposits in the Rio Puerco mining district is low because no deposits have been delineated. Field investigations of the area could upgrade this classification. The potential for development is low because of remoteness of the area and poor market conditions for copper.

Table 5 -- Mine production from the Rio Puerco district, Cibola and Valencia Counties (from U.S. Bureau of Mines Mineral Yearbooks).

Year	Tons of ore	Ag (oz)	Cu (lbs)	Total Value ($)
1929	43	13	4,000	711
1956	119	11	5,300	2,262
TOTAL	162	24	9,300	2,973

Industrial Materials

Introduction (by J. M. Barker)

Industrial materials are very difficult to classify. They have traditionally been called "non-metallics" or "industrial minerals and rocks". Both terms are inadequate because some industrial materials classifications include solids, liquids (brine), and gases (carbon dioxide, nitrogen, etc.) along with minerals, rocks, manufactured products (lime), and some metals (boron, lithium, silicon) in a strict chemical sense. The end use of the material is typically the defining factor in classification so that coal, lignite, bitumen, asphalt, uranium/thorium and other materials are, in certain instances, considered "industrial materials", the term used in this report. Details of classification problems of industrial materials are in Wright and Burnett (1962); Fisher (1969); Bates (1969); Kline (1970); Dunn (1973); and Blair (1981).

More than twenty-two major end uses for industrial materials have been identified (Lefond, 1983) along with about 100 major and several hundred minor industrial materials unevenly distributed throughout the major categories. A very simplified classification matrix is presented in Table 6 to highlight this diversity along with some resources and possible resources for Valencia County. This matrix does not cover all the possible industrial material types. Building or dimension stone, for example, has at least 56 types of stone used in this capacity. Many of these types of stone occur within Valencia County but only those with a favorable combination of quality, quantity, marketability, and transportability can be distributed and sold.

Table 6a – Classification of industrial materials that occur in Valencia County by geology and industrial end use. See Tables 6b and 6c for lists of industrial materials and end uses. X = present; P = produced; a = Northrop (1959); b = U.S. Geological Survey (1965); c = U.S. Bureau of Mines Mineral Yearbooks; d = Austin (1982).

Geology			Sedimentary Rocks			Metamorphic Rocks	Igneous Rocks			
							Plutonic Rocks (subsurface)		Volcanic Rocks (surface)	
Rock, Mineral, Material	Composition	End use	Clastic	Chemical	Organic		Deep	Shallow	Flow	Pyro.
Aggregate	sand, gravel		P							
Alunite	$K Al_3(SO_4)_2(OH)_6$	3,14								
Amblygonite	$(Li,Na)Al(PO_4)(F,OH)$	3								
Andalusite	$Al_2 SiO_5$	2,21								
Asbestos Minerals	various silicates	15,16,22								
Barite	$BaSO_4$	2,3,15,19,22								
Bauxite Minerals	various	2,3,15,21,22								
Beryl	$Be_3Al_2Si_6O_{18}$	2,3								
Borate Minerals	various	2,3,11,14,16,19								
Bromine	Br	3								
Brucite	$Mg(OH)_2$	14,21								
Carbon Materials	C or C-compounds	2,15,16,19,21,22								
Celestite	$SrCO_3$	3								
Chalcocite	CuS_2	14								
Chalcopyrite	$CuFeS_2$	14								
Chromite	$FeCr_2O_4$	2,3,17,19,21								
Clay Minerals	layer silicates	1,2,5,15,16,17, 19,21,22	X							
Cordierite	$Mg_2Al_4Si_5O_{18}$	2								
Corundum	Al_2O_3	1								
Cuprite	Cu_2O	14								
Diaspore	$AlO(OH)$	2,21								
Diatomite	$SiO_2 \cdot nH_2O$	15,21,22								
Dolomite	$Ca,Mg(CO_3)_2$	2,4,9,11,14,15, 16,19,21,22								
Dumortierite	$(Al,Fe)_7BSi_3O_{18}$	2								
Epsomite	$MgSO_4 \cdot 7H_2O$	14								
Feldspar Group	silicate	1,2,8,11,15,16,19								
Fluorspar	CaF_2	2,3,16,19								
Galena	PbS	22								
Garnet	silicate	1								
Gases	various	13,14,16								
Gems	various	1,2								
Glauconite	silicate	14,15								
Graphite	C	2,21								
Gypsum/Anhydrite	$CaSO_4 \cdot nH_2O$	2,3,8,10,13,14, 15,19,22		X[b]						
Halite	NaCl	2,3,8,22		X[a]						
Humate	humic acid	14								
Ilmenite	$FeOTiO_2$	22,16								
Iron Oxide Minerals	$Fe_xO_y \cdot nH_2O$	1,2,16,20,22								
Iodine Materials	I	3								
Kyanite	Al_2SiO_5	2,21				X	X	X		
Limestone	$CaCO_3$	2,3,4,9,11,13-16,19,21,22		X[d]						
Lithium Materials	various	2,3								
Magnesite	$MgCO_3$	2,3,11,14,21								
Manganese	various	8								
Mica Minerals	various	13,15,16,22				X				
Molybdenite	MoS_2	14								
Nepheline Syenite	rock	2,11,15,19								
Nitrate Materials	various	2,3,14								
Olivine	$(Mg,Fe)_2SiO_4$	2,14,17								
Periclase	MgO	2,14								
Perlite	volc. glass	5,11,15,21,22						X		
Phosphate Materials	$Ca_5(PO_4)_3(OH,F,Cl)$	3,14								
Potash Minerals	KCl, etc.	2,3,14,16,19,22								
Psilomelane	$(Ba,H_2O)_2Mn_5O_{10}$	14								
Pyrite	FeS_2	3,19,20								
Pyrolusite	MnO_2	3,14								
Pyrophyllite	$Al_4(Si_8O_{20})(OH)_4$	2,15								
Pyrrhotite	Fe_xS	3								
Rare Earths & Thorium	various	3,19					X[a]			
Siderite	$FeCO_3$	20,22								
Silica Materials	SiO_2	1-4,9,11,13, 15-17,19,21,22	X							
Sillimanite	Al_2SiO_5	2,21								
Sodium Minerals	various	2,3,11,19,21,22		X[a,b]						
Sphalerite	$(Zn,Fe)S$	14								
Spodumene	$LiAlSi_2O_6$	2,3								
Staurolite	$(Fe,Mg,Zn)_2Al_9Si_4O_{23}(OH)$	17								
Stone	various	1,2,4-9,12,14, 15,19,20	P[c]				P[c]	P[c]	P[c]	
Strontianite	$SrCO_3$	13								
Sulfur	S	3,14								
Talc	$Mg_6(Si_8O_{20})(OH)_4$	2,15								
Titanium Minerals	TiO_2	2,3,15,16								
Tourmaline	complex silicate	2								
Trona	Na_2CO_3	3								
Vermiculite	complex silicate	5,11,15,21								
Wollastonite	$Ca(SiO_3)$	2,15								
Witherite	$BaCO_3$	3								
Zeolite	complex silicates	15								
Zirconium Minerals	various	2,3,16,17,21								

Table 6b
List of industrial materials to accompany Table 6a

Alunite
Amblygonite
Andalusite
Asbestos
  chrysotile   crocidolite
  actinolite   amosite
  anthophyllite   tremolite
Barite
Bauxite (Gibbsite, Boehmite)
Beryl
Borate
  borax
  colemanite
  kernite
  probertite
  tincalconite
  ulexite
Bromine
Brucite
Carbon
  amorphous
  graphite
  coal (anthracite)
  lignite
  peat
  gilsonite, elaterite, wurtzilite
  bitumen, albertite, grahamite, impsonite
  asphalt
Celestite
Cerussite
Chalcocite

Magnesite
Mica Minerals
  muscovite (sericite)
  phlogopite
  biotite
  lepidolite
Molybdenite
Nepheline Syenite
Nitrate Materials
  guano
  niter, nitre (KNO_3)
Olivine
Periclase
Perlite
Phosphate Materials
  apatite
  allophane (colloid)
Potash Minerals
  sylvite   carnallite
  langbeinite   polyhalite
  kieserite
  potassium sulphate
  potassium carbonate
    (pearl ash)

Psilomelane
Pyrite
Pyrolusite
Pyrophyllite
Pyrrhotite

Strontianite
Sulfur
Talc
Titanium Minerals
  rutile, anatase, brookite
  titania, titanite (sphene)
Tourmaline
Trona
Vermiculite
Wollastonite
Witherite
Zeolite
Zirconium (Hafnium) Minerals

Chalcopyrite
Chromite
Clay Minerals
  kaolin, dickite, metahalloysite, halloysite, endellite
  illite
  smectite, montmorillonite, bentonite, hectorite
  attapulgite/seprolite/meerschaum
Cordierite
Corundum
  emery
Cuprite
Diaspore
Diatomite
Dolomite (see limestone)
Dumortierite

Epsomite
Feldspar
  potassium (orthoclase, microcline)
  sodium (albite)
  calcium (anorthite)
  perthite
Fluorspar
  cryolite
Galena
Garnet
Gases
  nitrogen   sulfur dioxide
  helium   hydrogen sulfide
  carbon dioxide   noble

Rare Earths & Accessory Minerals
  bastnoesite   thorium
  monozite   yttrium
  xenotime
Siderite
Silica
  opaline
  flint
  chert
  agate
  rottenstone
  tripoli
  ground
  novaculite
  colloidal
  quartzite
  pebbles (beach, river)
  sandstone
  gannister
  crystal
Sillimanite
Sodium
  sodium sulfate (salt cake)
  sodium carbonate (soda ash, trona)
  sodium nitrate (caliche)
  NaI
  NaBr
  sodium bicarbonate

Gems (semi-precious & precious)
Glauconite
Graphite
  amorphous
  flake
Gypsum/Anhydrite
  calcined
  selenite
Halite
Humate
Ilmenite
Iron Oxide
  rouge   goethite
  crocus   lipidocrocite/epidocrocite
  ochre   limonite

  sienna   hematite
  umber   magnetite
  micaceous
Iodine Materials
Kyanite
Limestone
  calcite   vaughanite (lithographics)
  aragonite   shell
  chalk (whiting)   coquina
  dolomitic   caliche
  argillaceous
Lithium Minerals
  brine   amblygonite
  spodumene

Sphalerite
Spadumene
Staurolite
Stone
  limestone   granite
  dolomite   syenite
  dolomitic
    limestone   anorthosite
  marble   aplite
  calcareous marl   andesite
  shell   dacite (porphyry)
  coquina   rhyolite
  coral   trachyte
  travertine   felsite
  onyx   gabbro
  sandstone   basalt
  graywacke   diabase
  chert   traprock
  shale   norite
  argillite   diorite
  quartzite   peridotite
  gneiss   tuff
  schist   pumice, pumicite
  slate   perlite

  amphibolite   volcanic glass
  talc   volcanic rock
  serpentine   volcanic cinders
  greenstone   volcanic breccia
  arkosic
    quartzite   scoria

Table 6c - List of end use categories for industrial minerals as numbered on Table 6a

END USE	NUMBER ON TABLE 6a
Abrasive	1
Ceramics/Art	2
Chemical	3
Crushed Stone	4
Lightweight Aggregate	5
Sand and Gravel	6
Slag	7
Cement	8
Dimension & Cut Stone	9
Gypsum and Anhydrite	10
Insulation	11
Roofing	12
Electronics & Optical	13
Fertilizer	14
Filler, Filter, Absorbent	15
Flux	16
Foundry Sand	17
Precious/Semi-Precious Gem	18
Glass	19
Mineral Pigment	20
Refractory	21
Well Drilling	22

Source: Lefond (1983)

Industrial materials are highly differentiated products compared to undifferentiated ones such as copper, gold, and mercury, among many. Undifferentiated products are the same from each producer and have ready-made, highly-visible markets with set prices and standard, generally simple specifications. In contrast, industrial materials are highly diverse with no central market, no set price and complex specifications. This relationship is often seen in the extreme when each customer for an industrial material sets unique specifications that must be met, basically on a custom basis, over the long term by the producer. Frequently, continually varying specifications are contractual grounds for abrogation of formal sales agreements. Producers catering to different markets may have dozens of "products" based on one material because of each consumer's preference for slight differences in grain size, shape, purity, and other specifications.

The relationships described above lead to the dominance of price, product specifications, customer location, transportation, and production costs over geology. Many industrial materials are potentially present in Valencia County (Table 6a) but only in the broadest sense are they a resource because no markets exist or the details of specifications cannot be met.

Barite and Fluorite (by J. M. Barker)

Although fluorite from the Zuni Mountains, Cibola County, was once milled in Los Lunas, barite and fluorite are not common in Valencia County. Barite is reported in Holocene sediments along the Rio Grande (Northrop, 1959, p. 134) while fluorite is unknown. The Rio Grande rift transects the eastern three-quarters of Valencia County. Limestone (San Andres, Madera, etc.) is abundant. This combination of tectonism and favorable host rocks has produced abundant barite and trace fluorite along the rift both north and south of Valencia County (McLemore and Barker, 1985). High barium anomalies occur in NURE samples from the southern part of the Albuquerque Basin (Chamberlin and Copeland, in preparation) and may be a result of barite emplacement along buried fault zones. The implication is that barite and fluorite(?) may occur in substantial deposits at depth along the Rio Grande rift in Valencia County. Mineral resource potential is low based on the relatively minor production elsewhere in deposits similar to those expected in Valencia County.

Clay Materials (by G. S. Austin)

General description--New Mexico has an abundance of clay materials. Adobe was the most common building material for many years, and has recently undergone a resurgence as a common building material in the construction of both passive and active solar homes. In addition, clay material now produced is used commercially in the state in the production of brick and pottery clay. A minor amount of fire clay is used in low to moderate duty refractory products, in the manufacture of cement, and in the production of copper.

The principal use of clay material in Valencia County is as adobe bricks. Adobe consists of a mixture of clay-rich materials, straw, and water, which becomes hard and durable when sun dried. The material used for adobe is of variable composition, much of which is calcareous. The chief requirement is that sufficient clay-size materials are present to form a workable mixture when wet and a cohesive block when dry (Smith, 1982a, b).

Geology--Several units exposed in Valencia County contain clay material--the Pennsylvanian Sandia Formation, the Jurassic Morrison Formation, the Cretaceous Mancos Shale, and Mesaverde Formation, plus Quaternary and Tertiary piedmont terrace deposits (Santa Fe Group) and alluvial materials (Fig. 8). The Sandia Formation is exposed only at the tops of mountainous areas within the county, particularly in the southeast. The Morrison Formation, as well as the Mesaverde and Mancos, are found principally in the northwestern part of the county and are in rugged areas. The Tertiary and Quaternary materials are found in valleys and are the principal source of adobe clays.

Two adobe operations reported in Smith (1982a, b) are in the county (Fig. 14). The Rio Abajo Adobe Works is in Belen and produces 150,000 adobe bricks per year. The Otero Brothers adobe operation is in Los Lunas and produces approximately 40,000 adobe bricks per year. No mineralogy of the clay material used is available. The principal adobe clays in Valencia County are the middle and late Tertiary deposits and Quaternary units found associated with the Rio Grande.

Other clay materials in units older than the middle Tertiary are chiefly composed of, in order of decreasing abundance: smectite, illite, and kaolinite. These units have been exploited in the past as sources of burned brick clay; there is no recent use of these units for this material. Specialty clays, such as halloysite, illite, sepiolite, chlorite, and kaolinite as pure, or nearly pure substances, are not known to occur in Valencia County (Patterson and Holmes, 1965).

Resource and development potential--The resource potential for adobe clays is virtually unlimited in Valencia County. There is some material suitable and available for brick clays, etc. The nearest brick plant is in Albuquerque, but it uses material equally as good as the material in Valencia County, but much closer. In summary, the potential for adobe clays is high, the potential for clays for other uses are very low. The development potential for adobe clays is high near populated areas and low elsewhere.

Crushed Stone (by M. R. Bowie)

General description--The stone industry can be divided into two main segments, crushed (broken or powdered) stone, and dimension stone. Crushed stone is obtained from a variety of rock types either by mechanical crushers or sledge hammers. Of the domestic crushed stone produced in 1985, about 72% was obtained from limestone and dolomite, 14% from granite, 9% from traprock, 2% from sandstone and quartzite, and the remaining 3% from shell, marl, volcanic cinder and scoria, basalt, slate, marble, and other rocks (U.S. Bureau of Mines, 1986).

The desirable properties and industrial specifications of crushed stone vary with its end use. In general, the stone should possess strength and durability, and should be easy to excavate and process. Ideally, the stone should crush to strong, equidimensional granules, with minimal dust and powder. Stone

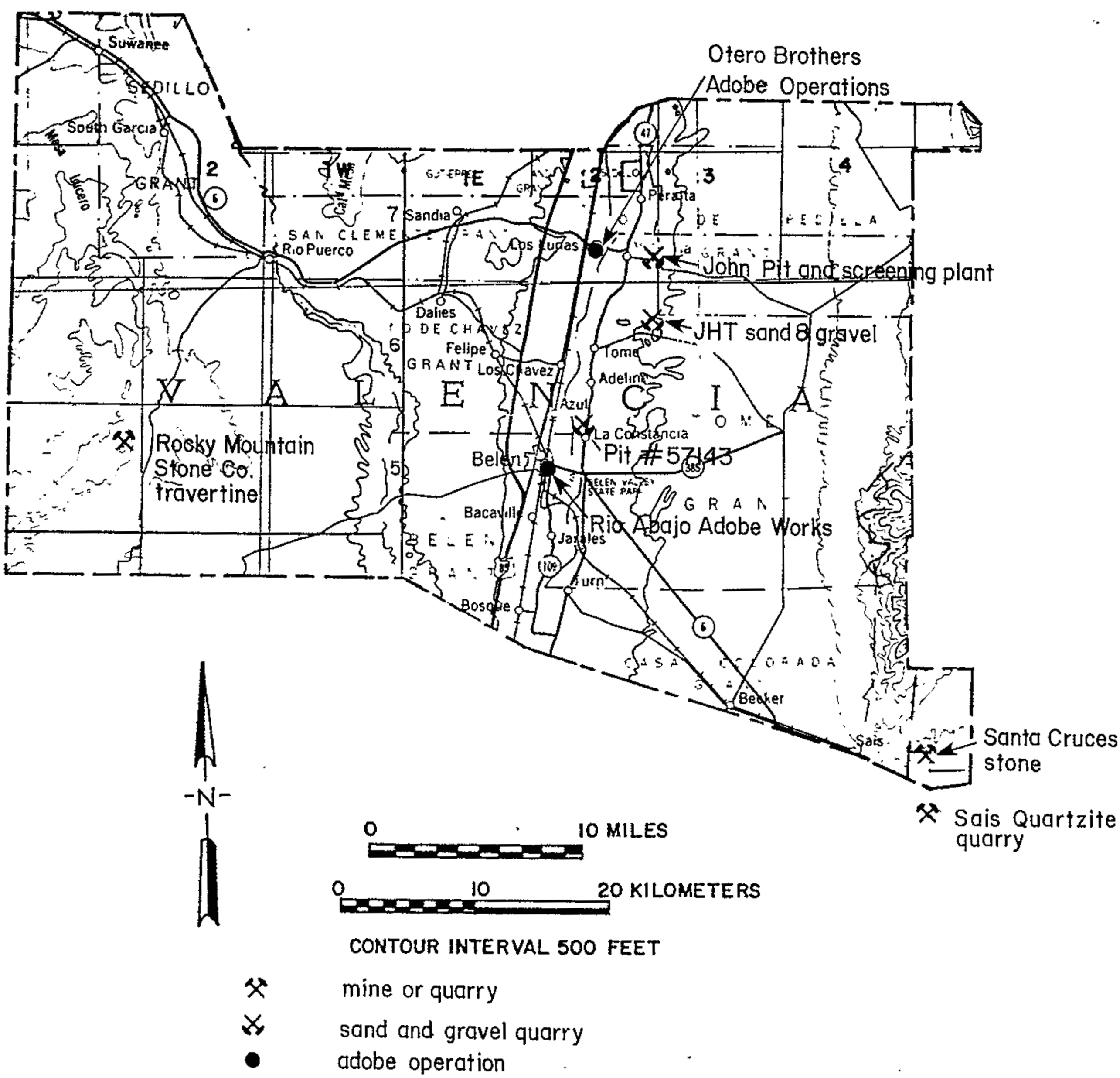


Figure 14 – Active industrial materials operations in Valencia County, New Mexico.

used for landscaping and decorative purposes is selected primarily on the basis of aesthetic appeal, but also for strength and durability.

In 1985, $4.2 billion worth of crushed stone was produced from 3,800 quarries in the United States. The leading producing states were Texas, Florida, Pennsylvania, Georgia, and Virginia, which together accounted for approximately 33% of the national output (U.S. Bureau of Mines, 1986). Crushed stone is widely used as a substitute for sand and gravel. Nearly 65% of the national production was used as construction aggregate, mostly for highway and road construction and maintenance, but also for railroad ballast and riprap. Approximately 12% was used for cement and lime manufacturing, 2% for agricultural purposes, 1% for metallurgical processes, and the remaining 20% for other uses, including landscaping and home decoration (U.S. Bureau of Mines, 1986).

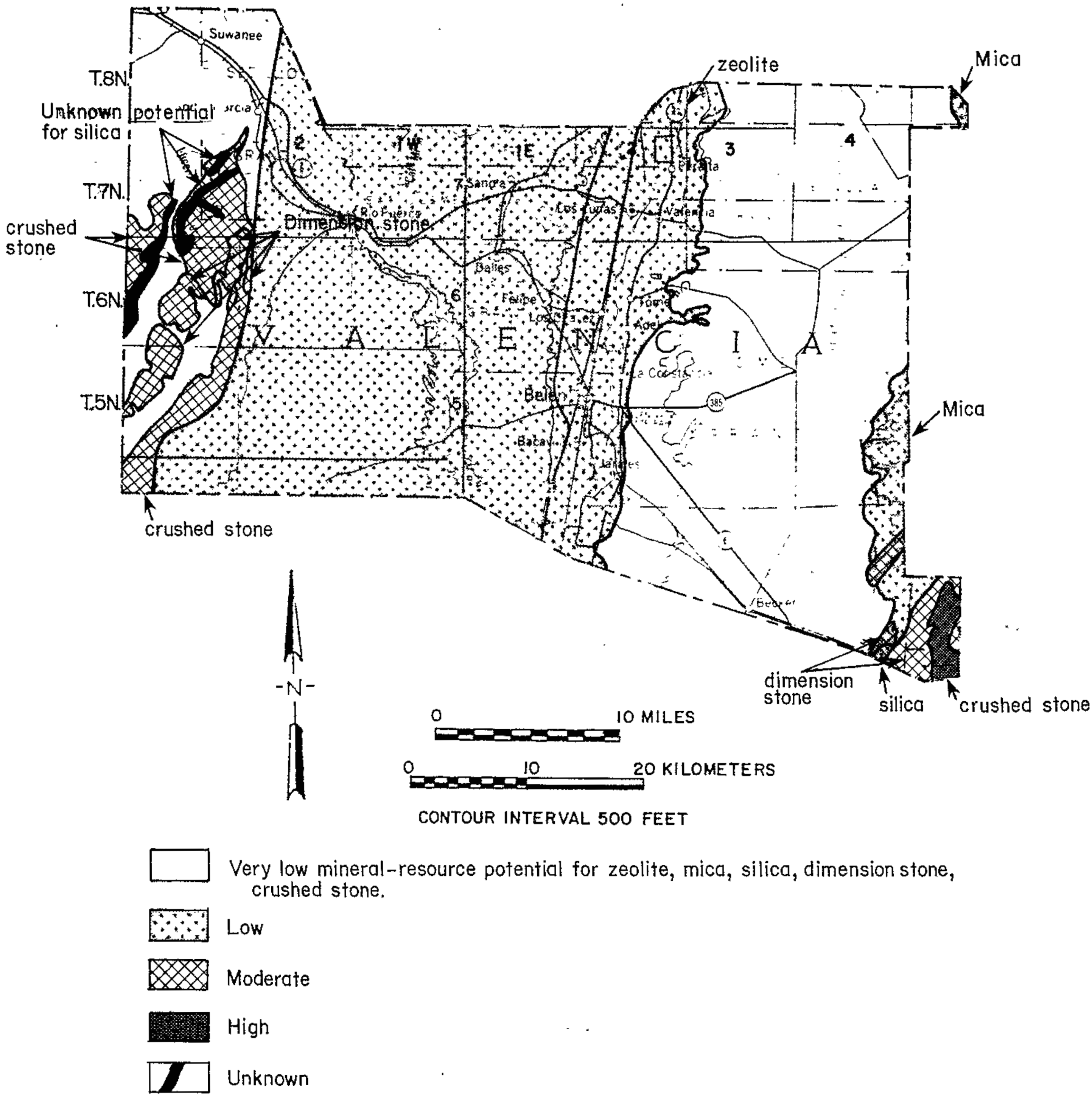
As of 1979, there were about 75 crushed-stone producers in New Mexico with a total average annual output of about 2.5 million tons. In 1985, 5 million tons of crushed stone were quarried in the state, mostly from limestone and basalt, but also from sandstone, quartzite, granite, and related rocks (U.S. Bureau of Mines, 1986). The stone was used primarily for highway construction and as railroad ballast. Stone quarries are usually small roadside or railside pits that operate only long enough to supply immediate local demand.

<u>Geology and resource potential</u>--Crushed stone was excavated from the Sais Quartzite quarry in northern Socorro County, one mile south of the Valencia County line. It is adjacent to the

Atchison, Topeka, and Santa Fe Railway line from Belen to Clovis (Fig. 14; Budding and Hartman, 1963). The quarry is now only intermittently active. It was operated by the Sharp and Fellows Construction Company for the A.T. & S.F. Railroad. The rock was crushed at the quarry for use as railroad ballast. Some finer material was used to surface station platforms. In 1950, about 1,000 cu yd per day of rock was excavated from the quarry (Stark, 1956).

The three rock units in the Sais Quartzite quarry are of Precambrian age. They are, from older to younger, the Sais Quartzite, and the Blue Springs and the White Ridge Formations. The Sais Quartzite is at least 2,000 ft thick in the Manzano Mountains. This unit represents the metamorphosed equivalent of medium- to coarse-grained, mature, quartz sandstones and pelites, probably deposited in either a shallow-water deltaic, continental shelf, or floodplain environment (Budding and Hartman, 1963; Edwards, 1978; Bauer, 1983). In the quarry, the Sais Quartzite is white to light gray and is locally iron-oxide stained. It consists dominantly of brecciated, vitreous, moderately well-sorted metaquartzite. The metaquartzite typically consists of 99% strained, lobate, recrystallized quartz grains less than 1 mm in diameter (Stark and Dapples, 1946; Stark, 1956; Bauer, 1983). Rare micaceous zones are mixed with the quartz. Highly sheared and brecciated zones, where the metaquartzite crumbles easily, have been targeted for quarrying. The resource potential for crushed stone around the Sais Quartzite quarry as well as the rest of the Sais Quartzite in the Manzano Mountains of Valencia,

Figure 15 – Resource potential for crushed and dimension stone, mica, silica, and zeolite in Valencia County, New Mexico.



Socorro, and Torrance counties is considered high (Fig. 15). The potential for its development is moderate.

In eastern Valencia County, crushed and dimension stone is actively being produced from the lower part of the Permian Abo Formation at the Santa Cruces stone quarry in the eastern half of sec. 21, T. 3 N., R. 5 E., (Fig. 14; U.S. Bureau of Land Management files, 1985). As of August, 1985, four tons of stone were marketed for building and landscaping use. The lower part of the Abo Formation consists of reddish-brown shale, reddish-brown to reddish-orange siltstone, fine-grained sandstone, red, crossbedded, arkosic sandstone, and conglomerate (Myers, 1977). The Abo is about 900 ft thick in the Scholle quadrangle in nearby Torrance County. The resource potential for crushed stone in the lower part of the Abo Formation in the eastern part of Valencia County is considered high, and its development potential is moderate (Fig. 15).

Myers (1977) locates a "gravel" pit in the southeast corner of Valencia County in NW1/2 32, T. 3 N., R. 5 E. (Map 4). The pit is currently inactive, although stone was quarried from the central part of the La Casa Member (Pennsylvanian) of the Wild Cow Formation. The rock consists of two 25-30 ft thick beds of gray calcarenite, the uppermost of which is cherty, separated by greenish- to yellowish-gray, fine-grained sandstone, siltstone, and claystone, and thin beds of impure calcarenite (Myers, 1977). There are several currently inactive stone pits in the La Casa Member of the Wild Cow Formation and in the overlying Bursum and Abo Formations in northern Socorro County near the southeastern border of Valencia County. Subsequently, the resource potential for crushed stone in these units in southeastern Valencia County is considered high. The potential for further development is moderate (Fig. 15).

In western Valencia County, crushed stone is produced as a by-product of travertine quarrying at Rocky Mountain Stone Company's travertine pit (Fig. 14). The pit is in secs. 12 and 13, T. 5 N., R. 3 W. (Fig. 14; Barker, this volume). The broken travertine is marketed for decorative and landscaping applications. The numerous travertine occurrences in western Valencia County, as discussed by Barker (this volume), have high resource potential but low to high development potentials for travertine. The travertines generally contain high amounts of calcium but many deposits are remote from major markets. The resource and development potentials for crushed stone derived from travertine excavation are high and low to moderate, respectively (Fig. 15).

A moderate resource potential for crushed stone exists in the Pennsylvanian Madera and Sandia Formations and in the Permian Abo, Yeso, and San Andres Formations in western Valencia County (Figs. 8, 15; Kelley and Wood, 1946; Jicha, 1958; Kelley, 1977). The development potential is considered low to moderate because of the remoteness from markets.

To summarize, the resource potential for crushed stone in Valencia County is considered moderate to high in areas where Precambrian, Pennsylvanian, or Permian bedrock is exposed. The generally unconsolidated Cenozoic valley fill has a very low resource potential for crushed stone.

Dimension Stone (by M. R. Bowie)

General description--Dimension stone is any natural, consolidated rock that is quarried and shaped to specified dimensions for structural or decorative purposes. Dimension stone can include rough stone, blocks, panels, and polished material (Allison, 1984). The terms building stone and decorative stone are used synonymously with dimension stone. The term flagstone refers to any natural, fissile stone that readily splits into thin slabs 7-10 cm thick (Allison, 1984). Flagstone is often used as a decorative stone. Crushed or powdered stone used as aggregate or reconstituted to form artificial stone is not considered dimension stone.

Dimension stone is produced from a variety of igneous, sedimentary, and metamorphic rocks. Of the total domestic production of dimension stone (1.30 millions tons) in 1985, 52% was quarried from granite, 21% from limestone, 12% from sandstone, 4% from slate, 3% from marble, and 8% from other sources, including diabase, quartzite, and travertine (U.S. Bureau of Mines, 1986). The leading producing states were North Carolina, Georgia and Indiana, which accounted for about 40% of the national output (U.S. Bureau of Mines, 1986).

Dimension stone is an attractive construction material because of its widespread occurrence, strength, durability, and pleasing appearance. The aesthetic appeal and popularity of natural stone is largely determined by its color, grain size, and texture, as well as by architectural and designer fashion trends (Allison, 1984). The aesthetic appeal generally controls the price and marketability of the stone. Of the total domestic production in 1985, 42% of the stone was used for building construction and 27% for monuments. The remainder was principally used for flagging, curbing, paving, roofing slate, laboratory furniture, and refractory brick (Power, 1983; U.S. Bureau of Mines, 1986).

In New Mexico, dimension stone quarrying has historically been a small industry. Small quantities of nearby stone have been used by local markets. The widespread use of adobe, concrete, brick, steel, and glass in modern construction has limited the use of stone to times when it is the most economical material available or when its decorative appeal makes it desirable for a particular project.

In 1983, 26,000 tons of dimension stone were produced in New Mexico (Eveleth et al., 1984), mostly from two quarries. New Mexico dimension stone deposits and quarries have been briefly described by Talmage and Wootton (1937) and Lindvall (1965). Lindvall (1965) claimed that every county in New Mexico contains potentially marketable stone; but most occurrences have not been evaluated.

Geology and resource potential--In western Valencia County, dimension stone is quarried from travertines (Barker, this volume). It is also quarried from the Chinle and Abo Formations (Triassic and Permian, respectively) in the Mesa del Oro area as well as from the Abo Formation along the southeastern edge of the county (Fig. 14). Jicha (1958) notes that many of the old dwellings in the Mesa del Oro area are constructed of flagstone cemented with adobe. The flagstone was quarried from platy, thin-bedded sandstones that break into slabs 2-5 inches thick. The sandstones are exposed at scattered localities in the Chinle and Abo Formations.

Approximately four tons of building and landscaping stone have been shipped from the currently active Santa Cruces stone quarry in SE1/4 21, T. 3 N., R. 5 E., along the eastern edge of Valencia County (Fig. 14; U. S. Bureau of Land Management files, 1985). The stone is produced from the lower part of the Abo Formation, which consists of reddish-brown shale, reddish-brown to reddish-orange siltstone, fine-grained sandstone, and red, crossbedded, arkosic sandstone and conglomerate (Myers, 1977).

In Valencia County, the resource potential of dimension stone is considered high in the areas of Tertiary and Quaternary travertine deposition (Fig. 15). Extension of travertine deposits currently quarried in the western half of the county are potentially commercial (Barker, this volume). The potential for their further development is moderate to high.

A moderate to high resource potential for dimension stone exists where the Wild Cow and Abo Formations are exposed in the southeasternmost corner of the county and where the Abo and Chinle Formations crop out in the western half of the county (Fig. 15). Flagstone and dimension stone have been and are currently being quarried in these areas. Extensions of these deposits may be suitable for dimension stone. The potential for further development of these deposits or extensions of them is moderate.

The Precambrian Sais Quartzite and Blue Springs and White

Ridge Formations exposed in the southern Manzano Mountains in the eastern half of the county locally have been quarried and crushed for use as railroad ballast. These units have a moderate resource potential for dimension stone (Fig. 15). The potential for their development for use as dimension stone is moderate.

Gypsum (by V. T. McLemore)

General description--Gypsum is used primarily in the manufacture of wallboard and portland cement, although other uses are in plaster and as a soil conditioner. Gypsum, like many industrial materials, is a low unit-value commodity. Presently, crushed gypsum at the mine-site in New Mexico is worth $0.10 to $2.00/ton, but transportation costs add $1.00/mile per truck carrying up to 30 tons. Therefore, gypsum plants tend to be close to the mines as well as the markets. In New Mexico, most of the gypsum is mined from the Todilto Formation near Albuquerque and used in wallboard and portland cement (Weber, 1965a; Logsdon, 1982b; McLemore et al., 1984).

Geology--Gypsum occurs in the Todilto Formation near Suwanee in northwestern Valencia County. One quarry was mined for agricultural purposes in the 1950's (Weber and Kottlowski, 1959). The gypsum occurs in beds 90 to 110 ft thick, however, they thin in all directions and are faulted in places. A thin veneer of soft gypsite covers most of the gypsum, which may be suitable for agricultural purposes. A selected sample contained 93% gypsum (Weber and Kottlowski, 1959).

Extensive beds of gypsum occur in Permian rocks in the Lucero uplift in western Valencia County (Fig. 7), although there has been no reported production. Gypsum occurs in numerous intervals in the Yeso and San Andres Formations, including the Glorieta Sandstone Member (Fig. 8; Weber and Kottlowski, 1959); however, detailed geochemical studies are required to determine the quality. Darton (1920, p. 164) describes a section containing 80-ft and 100-ft thick gypsum beds on the east side of Mesa Lucero. The San Andres Formation in the Carrizo Arroyo area contains thick beds of gypsum (Kelley and Wood, 1946, sec. 6); one bed is 70 ft thick. The Yeso Formation also contains gypsum near Los Vallos (T. 4 N., R. 4 W.; Jicha, 1958) and in Sierra Lucero area (Jicha, 1958).

Resource and development potential--The resource potential for gypsum near Suwanee and on the Lucero uplift is moderate (Map 6). The extent and quality of the gypsum in these areas are poorly known. Some of the gypsum has been complexly faulted and tilted (Weber and Kottlowski, 1959; Duschatko, 1953). The potential for development in the Suwanee area is moderate to high as it occurs near the railroad. The potential for development of gypsum in the southern Lucero uplift area is low because of the poor access to and remoteness of the area (Weber and Kottlowski, 1959). Only dirt roads occur in this area and transportation costs would be high compared to those of existing operations. Most of the gypsum in New Mexico is produced from the Todilto Formation near Albuquerque and is sufficient to supply the needs of the region.

Kyanite (by V. T. McLemore)

Although kyanite has not been produced from Valencia County, it has been reported in the Manzano Mountains (Map 5; Jicha, 1951). Kyanite is used as a refractory material in the manufacture of furnace linings, crucibles, mortars, and other glassmaking ceramic products (U.S. Bureu of Mines, 1986).

Kyanite occurs as stringers and veins in the Precambrian White Ridge quartzite and Sevilleta Rhyolite (Stark, 1956). The stringers are thin (several inches) and discontinuous, but consist of relatively pure kyanite. The zones vary in thickness from 15 ft wide and up to a mile long.

The mineral-resource potential for kyanite in southern Manzano Mountains is low (Map 5). Kyanite may occur elsewhere in the Precambrian terrain in the Manzano Mountains. Large pure deposits of kyanite probably are not found in Valencia County. The potential for development of kyanite in the Manzano Mountains is low because of the small deposit size.

Lightweight aggregate (by J. S. Hingtgen)

General description--Lightweight aggregates are generally used as ingredients in construction materials. They may be divided into three geological categories: volcanic, shale, and vermiculite. Volcanic products are pumice, pumicite, scoria, volcanic cinders, and perlite. Expansible shale is a particular type of sedimentary rock. Vermiculite is a family of minerals generally found as alteration products in igneous rocks. Perlite, expansible shale, and vermiculite each contain bound water and are heated during processing to produce expansion. The other lightweight aggregates are simply milled and sized to the specified grades. The volcanic products can be further divided by mechanism of formation. Explosive eruptions form pumice, pumicite, scoria, and volcanic cinders. These deposits are aggregates of ejected particles, which can range in size from fine dust to boulders. During perlite formation, the lava is fluid enough to flow from the volcanic vent and a continuous lava body is extruded.

"Pumice is a light-colored, cellular, almost frothy rock made up of glass-walled bubble casts. It may occur as coherent, massive blocks composed of highly vesicular glassy lava in either a flow or vent filling, or it may be more or less fragmented by violent eruption. Pumicite, the diminutive of pumice, has the same origin, chemical composition, and glassy structure, differing only in particle size. Particles less than 0.16-inch in diameter are designated pumicite" (Peterson and Mason, 1983, p. 1079). An alternate definition of pumicite is that it consists "largely of angular and curved particles (shards) of the shattered vesicle walls of pumice" (Weber, 1965b, p. 341). Although cinders and scoria also form from explosive eruptions, the composition is mafic, like basalt, rather than felsic, like rhyolite. Cinders and scoria tend to be black or red, whereas pumice and pumicite are typically white or off-white. Pumice and pumicite are generally lower in density than cinder and scoria. Uses of pumice and pumicite nationally in 1984 were 92% for concrete aggregate, as a pozzolanic additive, and building blocks (U.S. Bureau of Mines, 1985, p. 120) with the balance used in plaster aggregate, as loose fill insulation, and as an abrasive. Cinders and scoria are deposited as coarser particles and are more coarsely cellular. they are used as aggregate for road construction, in concrete blocks (Peterson and Mason, 1983), in landscaping, roofing, and erosion control, and for railroad ballast. In New Mexico during 1980, 28% of scoria produced went into landscaping and, along with block production, these two uses accounted for 70% of sales (Osburn, 1982, p. 58).

Perlite is a glassy, extrusive volcanic rock of rhyolitic composition that has a pearly luster and concentric, spherical fractures often forming "onionskin" texture. Its post-emplacement hydration results in a water content of between 2 and 5%. When heated from 1,200° to 1,700°F, steam is produced and the rock fragments expand 10 to 20 times or more, much like popcorn expands. Commercially, "perlite" is applied to rocks that do have the classic "onionskin" texture, but will still "pop" when flash heated. Domestic use in 1984 was 69% for building construction products and 17% for filter aids (U.S. Bureau of Mines, 1985, p. 112). The balance is comprised of horticultural, cryogenic, and foundry insulating applications.

Expansible shale, when heated from 1,800° to 2,200°F, bloats to yield a lightweight aggregate. "Chemically combined water in the clay minerals" is the constituent of most importance (Foster, 1966, p. 21). Montmorillonite-illite clay species have been found "more favorable for expansion than kaolinite" (Fisher and Garner, 1965, in Foster, 1966, p. 22). Use in cement block in former years is being surpassed by use as aggregate in construction materials. Expanded shale has the advantage of absorbing less water than other lightweight aggregates. A disadvantage is its higher firing temperature, thus making processing costs higher (Foster, 1966, p. 4).

Vermiculite is a group of closely related, hydrated, ferromagnesian clay minerals, whose structure is like that of talc; they feel slippery like talc when wet. Temperatures around 500^{o} F are optimum for vermiculite expansion and the final density ranges from 5-50 lb/ft^3. Expansion also is known as exfoliation and may be produced by soaking in certain chemicals (Strand and Stewart, 1983, p. 1375). National use of exfoliated vermiculite in 1984 was 28% for insulation, 25% for agriculture, 24% for plaster and cement premixes, and 21% for lightweight concrete aggregates (U.S. Bureau of Mines, 1985, p. 172). Unexfoliated material is used in producing fire-retardant gypsum wallboard (Strand and Stewart, 1983, p. 1380).

<u>Geology and Resource Potential</u>--Pumice and pumicite are types of volcanic ash produced in "explosive volcanism when expansion of magmatic gases in hot, plastic, fragmental ejecta causes rapid vesiculation... Deposits may be massive or stratified, depending upon the mechanics of eruption, the influence of deposition in subaerial and subaqueous environments, and modifications resulting from reworking by water and wind (Chestermain, 1956; Bates, 1960, pp. 38-50). The deposits include ash-fall and ash-flow tuff, tuff breccia, and reworked volcanic sediment. Because of its tendency to devitrify with time and the ease of alteration by several geologic processes, commercial-grade pumice is restricted to deposits of Tertiary and Quaternary age" (Weber, 1965b, p. 342). Many small pumice occurrences in Cibola County indicate the possibility of occurrence in Valencia County. However, no deposits within the

county have been found. There is an outcrop of tuffaceous sandstone in projected southwest sect. 1, T. 5 N., R. 4 E., approximately 0.1 mile long (Myers and McKay, 1972). Described as fine-grained with pebbles of vesicular basalt and devitrified tuff enclosing relict pumice, this formation may have potential for some applications where pumice is needed. However, its impurities would limit use for other purposes. Lack of felsic extrusive rocks in Valencia County imply a very low mineral resource potential (Fig. 16).

Scoria and cinders are often considered synonymous; the term "cinders" is more common in industrial usage. Technically, scoria is an in-place deposit, a "crust on the surface of andesitic or basaltic lave", whereas cinder is a mass of "pyroclastic fragments" (Gary et al., 1972, pp. 636, 126). In practice the physical properties of either rock are similar, so both cinder cones as well as basaltic flows have the potential for suitable deposits. In either case, formation occurs because of expanding gases during eruption. The surface of a lava flow vesiculates because atmospheric pressure is lower than the partial pressure of the gases dissolved in the lava. Cinders ejected from a volcanic neck vesiculate during their flight through the air. The "cinder cone" is thus the typical form ejected material assumes and depending on wind strength, lava vent shape, and lava viscosity, may be elongated in the downwind direction (Osburn, 1982, p. 57). Within Valencia County there are two cinder cones; SE1/4 1, T. 7 N., R. 1 W. and NW1/4 6, T. 7 N., R. 1 E. (Map 5; Titus, 1963, plate 1). No record of production from either has been reported. Eleven miles west of the Cibola County line an outcrop is described as "scoria, bombs, etc., forming cone of volcano" (Jicha, 1958, plate 1). Two cones just north in Bernalillo County, in T. 8 N., R. 1 E., are being mined (Osburn, 1980, p. 78). These two cones and several deposits in Cibola County preclude ruling out that all deposits in Valencia County have been discovered. The mineral-resource potential is rated moderate for the areas of basalt outcrop, and very low for the majority of the county (Fig. 16).

"Perlite occurs as mushroom-shaped and bulbous masses in volcanic domes and as short tongues in and near the vents of siliceous volcanoes; it also occurs as intrusive necks, dikes, and sills and in the basal zones of welded ash-flow tuffs. Glassy rocks, including obsidian and pitchstone, commonly are part of an eruptive sequence that includes pyroclastic and lithoidal phases. Individual bodies of perlite range from a few feet to several hundred feet thick and extend over areas of up to several square miles. Perlite domes are particularly favorable for commercial development because of their large size and shallow overburden, which permits low-cost mining by open-pit methods. Most perlites are rhyolitic, but compositions extending into the dacitic range have been reported... Perlites are largely restricted to Oligocene or younger volcanic assemblages because they tend to devitrify with age into microsrystalline aggregates of quartz and feldspar" (Weber and Austin, 1982, p. 97).

No perlite occurrences are reported for the county (Weber, 1965c; Osburn, 1980, 1982). Rhyolitic to dacitic extrusives do

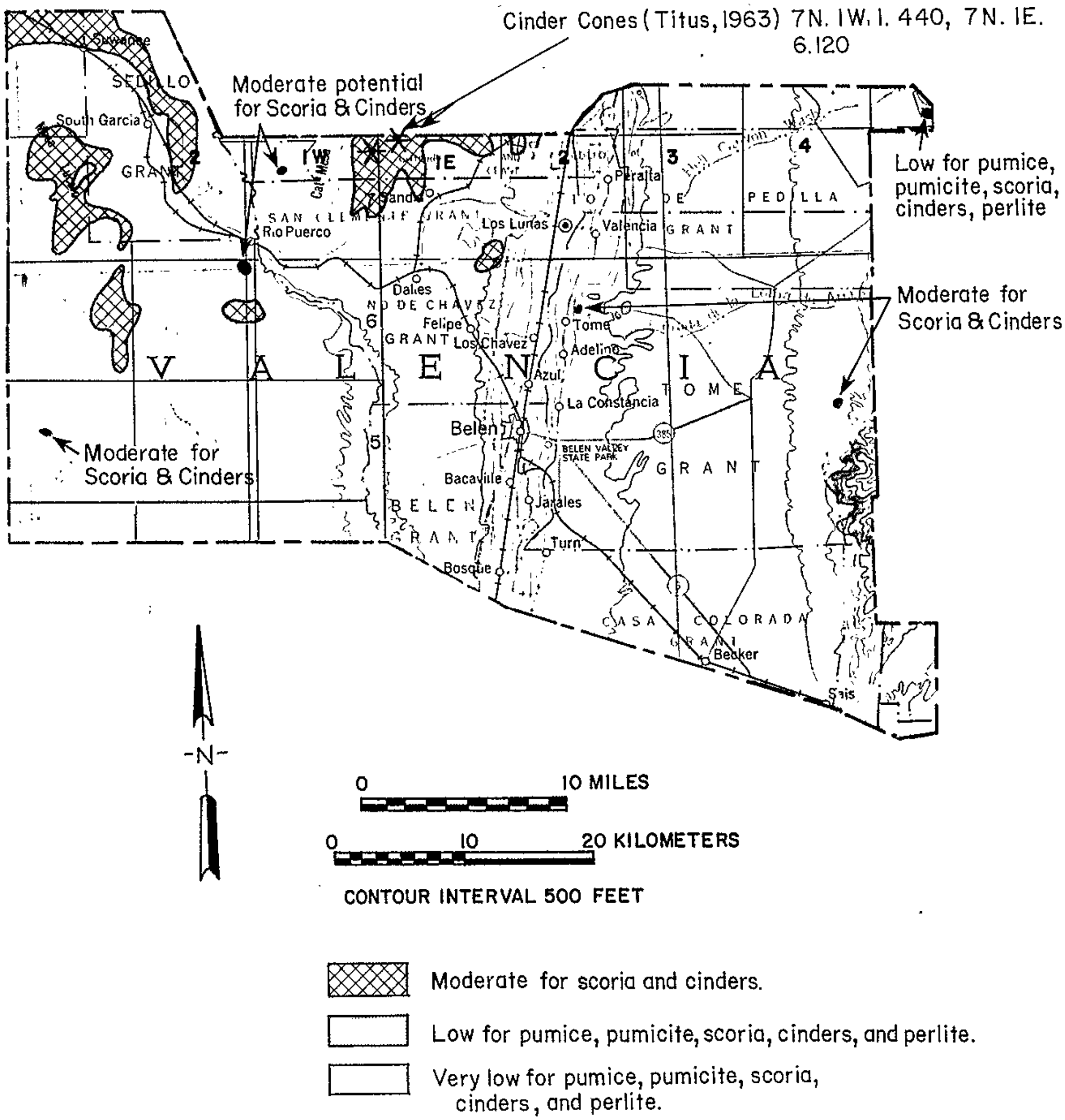


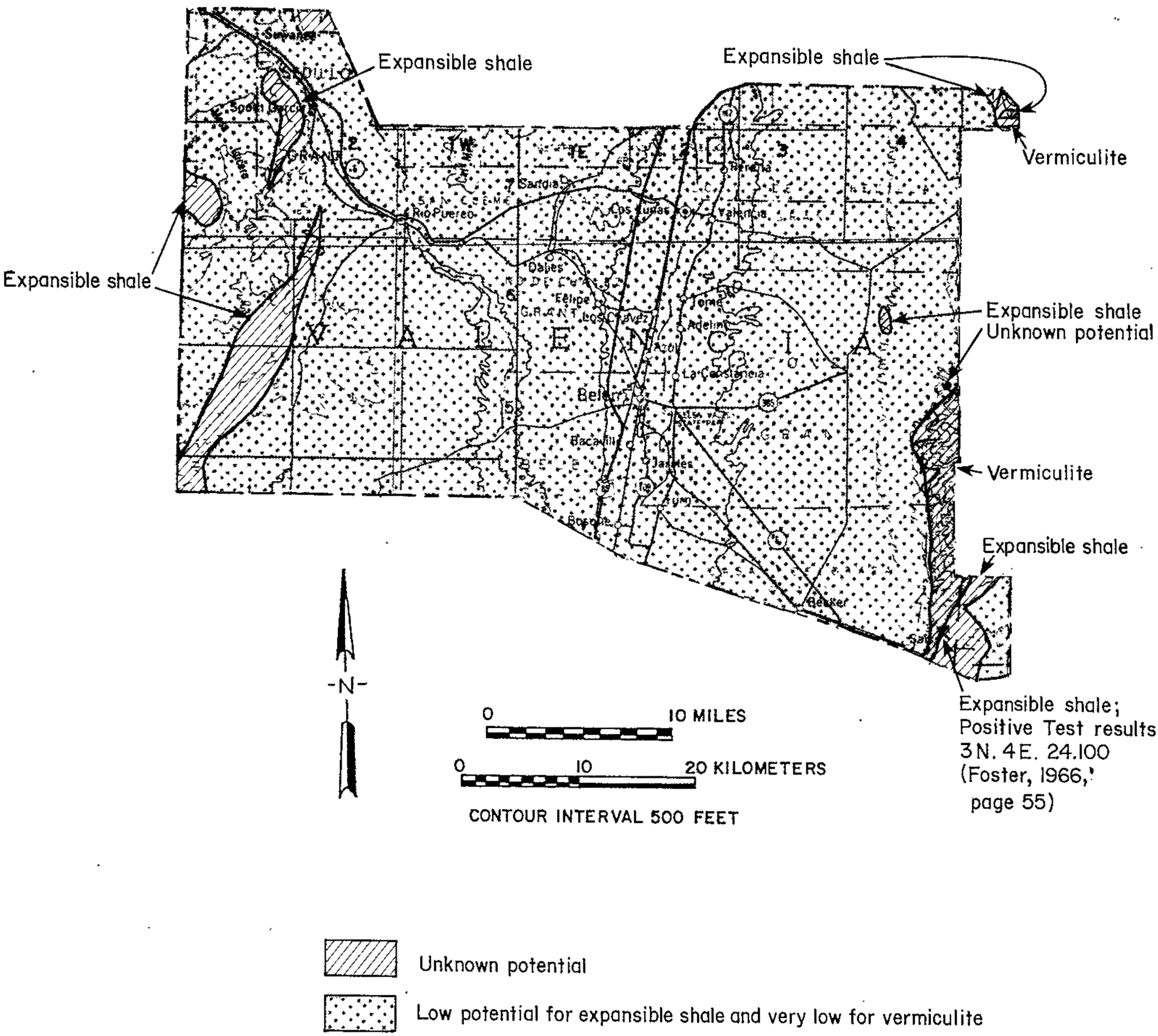
Figure 16 – Resource potential for pumice, pumicite, scoria, cinders, and perlite in Valencia County, New Mexico.

not occur in Valencia County; however, deposits are being mined near Grants and Socorro. The mineral-resource potential is very low for the county (Fig. 16).

Localities of expansible shale are difficult to predict even knowing what age rocks are likely to contain them. One occurrence is reported for Valencia County but no record of production exists. The NMBMMR identified shales suitable for expansion near Abo Pass on U.S. Highway 60. The samples from NW1/4 24, T. 3 N., R. 4 E. (Fig. 17), "indicated good expansion over a continuous thickness of 56 feet" in an interval comprised of shale, thin sandstone beds, and several ironstone concretions (Foster, 1966, p. 55). Foster (1966, p. 68) recommended that the most likely units to contain suitable shales are Cretaceous and Triassic in age. Pennsylvanian shale from the locality in T. 3 N, R. 4 E, was the best of all units samples of any age.

Outcrops of the Pennsylvanian, Madera, and Sandia Formations trend north-northeast in bands flanking the eastern side of the Manzano Mountains. However, it cannot be assumed that there is equal expansibility along the strike of the formation. At a sampling site on U.S. Highway 60, not more than four miles from the samples that proved adequate, the shale was unsuitable. Potential units include the Triassic Chinle, Cretaceous Mancos and Dakota, and Pennsylvanian Madera and Sandia Formations, west of the Comanche thrush fault, in western Valencia County. East of the Qjuelos Fault, on the eatern side of the Rio Grande, there is also a small (0.1 mi long) outcrop of Triassic fine sandstone and shale which lies in the eastern side of projected sect. 12, T. 5 N., R. 4 E. (Myers and McKay, 1972). Its expansibility is

Figure 17 – Resource potential for expansible shale and vermiculite in Valencia County, New Mexico.



unknown (Fig. 17).

The resource potential is unknown in the "boot heels" of southeastern and northeastern corners of the county, as well as in a zone in the Tome Grant and in the bedrock outcrops in the western side of the county. It is low elsewhere (Fig. 17). To evaluate the extent of the expansible zone in the Pennsylvanian and determine the suitablity of the Triassic and Cretaceous, a thorough sampling and expansion testing program would be required.

Vermiculite results from alteration of biotite, usually itself derived from amphibole derived from pyroxene. The large commercial ores are found in complexes of ultramafic and alkalic intrusions. The emplacement may occur in sedimentary or metasedimentary rocks and is followed by hydrothermal or meteoric conversion of biotite. The host rock is most often pyroxenite, with the vermiculite occurring near serpentinized zones (Strand and Stewart, 1983, p. 1376). Vermiculite also has been found disseminted with apatite, but commercial vermiculite must be 60-80% and not disseminate. Although vermiculite has not been found in Valencia County, the Precambrian units of the Manzano Mountains may contain hosts suitable for formation. However, the dominance of other than ultramafic or pyroxenite-like lithologies makes this unlikely. The majority of the county, west of the Manzano Mountains, has a very low mineral resource potential. The potential in the Manzano Mountains is unknown (Fig. 17). Better definition of the resource potential could be found by specifically looking for vermiculite mineralization. It is not a common mineral, and so existing geologic maps, even at large scale, do not mention its occurrence. The schist mapped by Myers (1977) and Myers and McKay (1972, 1974) should be examined with the focus on vermiculite.

Development potential--Pumice and pumicite development potential is moderate in most flat-lying areas of the county, because of the numerous secondary roads and jeep trails offering access. Due to high use as construction material, deposits discovered near the urban zone along the Rio Grande would have high potential for development. In the Manzano Mountains, high transportation expenses would make low-cost resources such as these unprofitable and the potential is thus low. Scoria and cinders, used for much the same purpose, are also low-cost minerals and the same three zones of development potential apply to them.

Perlite development potential is affected by competition from two nearby opertaing mines, at Grants and Socorro. The higher unit price of perlite would permit longer transportation distances and the rail and highway connections of the operating mines to Valencia County would allow perlite to be imported to the county at low cost.

The shale samples taken from north of Abo Pass test positive for expansion and indicate a potential for expansible shale units here. Because of the existing rail and highway routes to the population centers, and thus construction markets, there is moderate development potential. The cost of mining in the foothills where relief is fairly high would make development contingent upon a rise in the current price. This is turn would be affected by the price of other aggregates, many of which are now cheaper. Nearer the Rio Grande, and especially on the rail lines, the development potential is also moderate. There the mining costs would be cheaper, but expansibility-oriented exploration for shale would have to prove the existence of good ores.

Vermiculite potential depends greatly on the need for a low-density aggregate. Its market price is higher by weight than any of the other aggregates described herein, and so lower cost substitutes will normally be used if low-density is not critical. The fire-retardant and horticultural uses appear to be growing markets (strand and Stewart, 1983, p. 1380), but sales are limited by proximity to urban centers. Because of nearness to Albuquerque, occurrences in the northeastern "bootheel" of the county are positioned more favorably for development than those in the southeast. Balanced against this potential the expense of mining in the Manzano Mountains must be considered.

Limestone (by J. M. Barker)

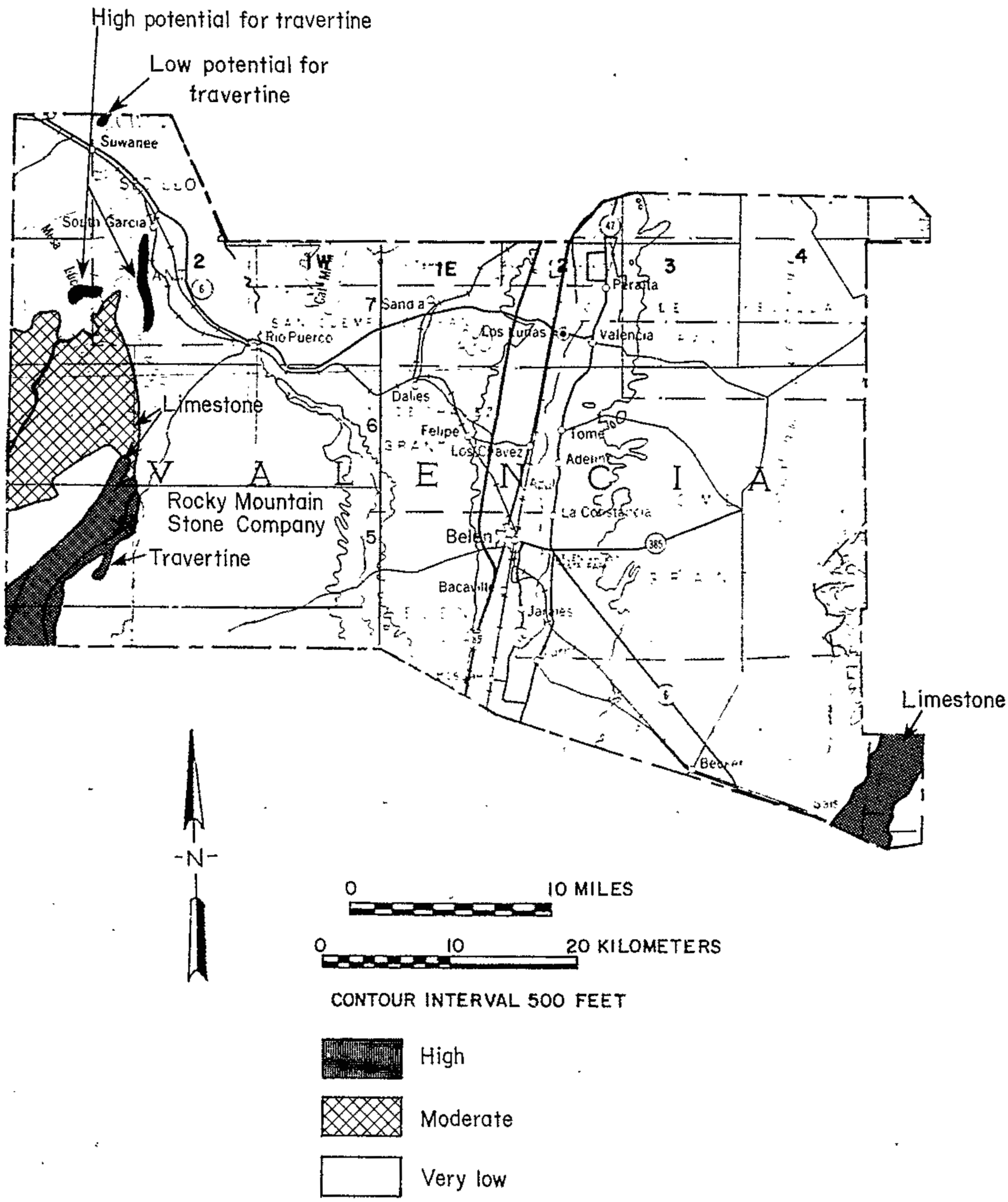
General description--Limestone includes any rock composed of more than 50% calcium carbonate. Limestone is a term relatively free of genetic connotations which causes some classification problems. For example, the Mesa Aparejo travertine (spring deposit), discussed under a separate heading elsewhere in this report, is a limestone as is a marine deposit such as the San Andres. The following discussion deals primarily with bedded limestones of the Madera Group (Pennsylvanian) and the Yeso and San Andres (Permian) Formations called simply limestone hereafter. Travertine is mentioned as necessary to place it in context.

Few, if any, industrial mineral commodities have as many end uses as limestone which comprises over 75% of all stone quarried domestically and 15% of the sedimentary crust of the earth. The literature on limestone is voluminous with Carr and Rooney (1983) listing nearly 400 references while noting that this was but a fraction of the total. Carr and Rooney (1983, p. 846, table 7) group limestone end uses into 30 main groups out of literally hundreds of specific end uses. The basic bifurcation is between chemical-property end uses and physical-property end uses. Chemical uses are predominantly as raw material for lime (Boynton and Gutschick, 1983) and cement (Ames and Cutcliffe, 1983), or stack-gas cleanup. Physical uses include building stone or aggregate. All of these basic uses are either possible or actual uses made of limestone in New Mexico.

Limestone use is generally heavily tied to the relationship of the stone's specifications to the end use contemplated (Power, 1985). Details of limestone specifications are far too complex to summarize herein. A complex set of standards is in place exemplified by numerous ASTM (American Society for Testing and Materials) and AASHTO (American Association of State Highway and Transportation Officials) standards. Limestone for chemical use tyically exceeds 95% $CaCO_3$ with a 97% $CaCo_3$ minimum not unusual. Cement rock must be at least 65% $CacO_3$. Physical uses allow a wilder range in composition.

Two main limestone outcrop belts occur in Valencia County: A western belt along Sierra Lucero and a southeastern belt in the

Figure 18 - Resource potential for limestone and travertine in Valencia County, New Mexico.



southernmost Manzano Mountains (Fig. 18). Regional geology including both areas is in Kottlowski (1962), Titus (1963), Kelley (1977), and Hunt (1978). The Sierra Lucero was mapped by Kelley and Wood (1946), Duschatko (1953), and Jicha (1958). The southern Manzano Mountains were mapped by Myers and McKay (1972, 1974) and Myers (1977).

Limestone is not presently being produced in Valencia County. The production records in the past are unclear, but show significant quantities of "crushed ballast" and "stone" some of whch may have been limestone. Also, "caliche" is often a type of limestone which has been produced sporadically within the county. The New Mexico State Highway Department records from the early 1950's forward do not show any crushed limestone use but such use earlier is possible. Travertine, a form of limestone, is currently quarried for dimension stone in Valencia County.

Limestone is typically quarried but can support underground mining depending on a complex interaction among economic factors. These factors have limited underground limestone mining primarily to the eastern United States. The current producers of limestone in New Mexico utilize open pit operations primarily supplying cement, stack-age cleanup, or crushed stone end uses.

Siera Lucero and Vicinity--Three units contain significant bedded limestone in western Valencia County (Fig. 18). These are Madera Group (Pennsylvanian) and the Yeso and San Andres Formations (Permian). All three contain limestone but the Madera is purest followed by the San Andres. The least pure limestone is in the Yeso and is generally silty or sandy (Jicha, 1958, pp. 10-15) so Kottlowski (1962, p. 26, fig. 2) did not include it as a limestone resource.

The Madera limestone is thick and pure. Three widespread samples from the Ladron Mountains to the south averaged 98.34% $CaCO_3$ (Table 7) and appear similar to those in Valencia County (Kottlowski, 1962, p. 26). The Madera limestone is about 1540 ft thick in three members (Kottlowski, 1960, pp. 29-31). The lowermost member is the Gray Mesa which is cherty, ledge-forming, and about 800-890 ft thick. Above is the Atrasado Member which is more arkosic and is 555 ft thick with shaly sections increasing northward. The uppermost member is the Red Tanks which is primarily clastic and is about 200-300 ft thick with some thin-bedded limestone (Kottlowski, 1960). The Gray Mesa Member is most likely to be used as a limestone resource but even this unit is almost 50% limy shale at Mesa Aparejo. Local outcrops of Gray Mesa will be of commercial quality, perhaps also some of the Atrasado will be, but none of the Red Tanks are likely to be commercial. The Madera is utilized as cement-plant feed in Bernalillo County east of Albuquerque and has been proposed as a cement-plant feed in southeastern Valencia County. Use in lime manufacture of stack gas cleanup is less likely unless limestone with exceptional purity, which can support transport, can be located.

The Yeso Formation contains a few massive limestone beds with a maximum thickness of 16.5 ft. The Los Vallos Member of the Yeso is 1211.5 ft thick in far western Valencia County (Jicha, 1958, pp. 11-13). Limestone comprises 8.6% (104.5 ft) of the section. The Mesita Blanca Sandstone Member (93.5 ft thick)

Table 7 - Carbonate analyses, Valencia County and vicinity. 1 = Barker (1983); 2 = Kottlowski (1962); 3 = Jicha (1958); AA = atomic absorption; XRF = x-ray fluorescence; ppm = parts per million (10^{-6}%), — signifies that this parameter was not analyzed.

Parameter \ Deposit	Mesa Aparejo[1]	Lucero Mesa[2]	Mesa del Oro[2,3]	Riley Travertine[1]	Riley Travertine[2]	Madera[2] Ladron Mtns	Madera[1] Ladron Mtns	Madera[2] (Tijeras)	Madera[2] (Scholle)	Madera[2] (Scholle)
HCl insoluble	0.91%	—	—	4.85%	—	—	—	—	—	—
HCl soluble	99.09%	—	—	95.15%	—	—	—	—	—	—
$CaCO_3$	98.39%	85.07	96.48%	94.38%	99.00%	96.80%	98.34%	95.40	93.14	92.50
CaO	—	47.66%	54.61%	—	—	—	—	53.44	52.18	—
CaO(CO_2 free)	—	—	95.9%	—	—	—	—	—	—	—
Calcium	39.4%	—	—	38.26%	—	—	—	—	—	—
CO_2	—	37.66%	42.68%	—	43.8%	43.10%	39.38%	41.64	41.38	41.20
$MgCO_3$	—	1.38%	0.29%	—	0.46%	0.92%	—	0.80	1.44	1.30
MgO	—	0.66%	0.14%	—	—	—	—	0.36	0.69	—
Magnesium	0.27%	—	—	0.26%	—	—	0.36%	—	—	—
Strontium (AA)	471 ppm	—	—	—	—	—	1052 ppm	—	—	—
Strontium (XRF)	617 ppm	—	—	856 ppm	—	—	952 ppm	—	—	—
Manganese	37 ppm	—	—	207 ppm	—	—	285 ppm	—	—	—
SiO_2	—	10.11%	tr	—	0.11%	1.50%	—	4.06	4.57	4.78
Al_2O_3	—	0.91%	0.23%	—	0.04%	0.20%	—	0.63	0.59	0.49
Fe_2O_3	—	0.61%	0.31%	—	0.04%	0.12%	—	0.21	0.52	0.39
P_2O_5	—	0.025%	—	—	0.007%	0.12%	—	0.016	0.024	0.049
Sulfur	—	0.160%	—	—	0.056%	0.010%	—	0.012	0.015	0.015
K_2O	—	—	0.33%	—	—	—	—	—	—	—
Na_2O	—	—	1.30%	—	—	—	—	—	—	—
H_2O	—	—	0.66%	—	—	—	—	—	—	—

underlies the Los Vallos yielding a total Yeso thickness of 1305 ft (Jicha, 1958, pp. 11-13).

The San Andres is divided into three members. The upper limestone member (100-125 ft thick) is the most significant resource consisting of about 85% limestone. The lower evaporite member contains, near the top, a prominent 50-ft layer of massive blocky limestone which is 22.4% limestone and mostly silty (Jicha, 1958, p. 15). The basal Glorieta Sandstone Member is not a limestone resource and is occassionally broken out as a separate formation.

The uncertainties concerning bedded limestone purity and the availability of high-calcium travertine locally are factors limiting the bedded-limestone potential in the area. Perhaps some high-calcium limestone is present but additional testing is needed to resolve the uncertainties. Also, the specific end use contemplated would dictate limestone specifications which could make more, or less, rock useable.

Southern Manzano Mountains--The Madera Limestone crops out extensively in the Manzano Mountains (Fig. 18; Myers, 1977; Myers and McKay, 1972, 1974). This unit is upper Pennsylvanian (mainly Virgilian) in age and contains a lower limestone member and an upper arkosic member which together total about 1100 ft thick in the Abo Pass area (Kottlowski, 1960, p. 48).

The main end use for these rocks appears to be in cement. The Tijeras plant of Ideal Basic is operating now on the northern side of the Manzanito Mountains in Bernalillo County east of Albuquerque. Serious efforts were expended in 1955 and again in 1966, by units of Kaiser Industries, to place a cement plant at

Scholle (Anonymous, 1966; Kaiser Ind., unpubl. reports, 1957, 1966). Scholle, near Abo Pass, is a small siding on the AT&SF Railroad on U.S. 60 about 27 miles southeast of Belen. It is about 1 mile south of Valencia County. The proposed site lies east of the confluence of Abo Canyon and Canada Montosa in sec. 6, T. 2 N., R. 5 E., and sec. 1 and 12, T. 2 N., R.4 E.

No limestone is currently mined in the southern Manzano Mountains. The proposed plant at Scholle had reserves of 54 million tons, averaged 82 ft thick, and the burnt limestone consisted of 24.07% SiO_2, 6.00% R_2O_3, 67.32% CaO, and 2.15% MgO (total 99.54%). Total alkalinity as Na_2O is 0.55 and loss on ignition was 35.02%.

The lower member of the Madera is mainly cherty limestone with some nodular shale beds and scattered lenses of white sandstone (Kottlowski, 1960, p. 48). The lower limestone member is about 670 ft thick at Abo Pass (Kottlowski, 1960, p. 48).

The upper member of the Madera consists of cherty limestone, gray shale, and sandstone. Reddish interbeds of siltstone and arkose occur near the top (Kottlowski, 1960, p. 48). The upper arkosic member is about 430 ft thick in the Abo Pass area (Kottlowski, 1960, p. 48). Two Virgilian-age chip-channel samples from near the top of this unit were in the low 90% $CaCO_3$ range (Table 7) as reported by Kottlowski (1962, table 2, sample no. 22 and 23). Data for the limestone at Tijeras Canyon is included for comparison. Selective quarrying would be necessary to produce a high-calcium limestone (Kottlowski, 1962, p. 39).

The likely uses for limestone from western and southeastern

Valencia County are for cement-plant feed, in lime manufacture, as crushed stone, or in stack--gas cleanup.

Cement resource potential is high in southeastern Valencia County (Fig, 18; Map 4, 5) based on the history of the Scholle deposit and the current cement production in similar units east of Albuquerque. Potential for development is low because the Tijeras plant can meet all regional cement requirements well into the future. Much of the Madera is in the Manzano and Sandia wildnernesses north of Valencia County. This makes the southern Manzano Mountain reserves more important if additional cement capacity is needed.

Cement resource potential is high in western Valencia County (Fig. 18, Map 6) based on the quality and quantity of Madera limestone there. The travertine resource is also large in this regard. Potential for development is low owing to relative remoteness and the competition inherent in the Tijeras plant of Ideal Basic Cement.

Lime--Most of the limestone in southeastern Valencia County contains less than 95% $CaCO_3$ and is therefore of low lime resource potential. Potential for development is low because more favorable resources exist elsewhere in the state, including western Valencia County.

The Madera in western Valencia County is of lime quality, as is much of the travertine, so resource potential is high. However, the area is remote so development potential is low.

Stack-gas cleanup--Limestone resources become progressively less abundant to the northwest in New Mexico as demand for stack-gas cleanup in coal-fired power plants increases. The high calcium carbonate content of the Madera Group and travertine in western Valencia County is a likely source for limestone for stack-gas cleanup. Resource potential in western Valencia County is high as is potential for development because suitable limestone occurs within transport distance of the Prewitt generating plant. The material in southestern Valencia County is of very low resource potential owing to low calcium carbonate content. Development potential is low.

Crushed limestone--Resource potential for crushed limestone is moderate in southeastern Valencia County. Development potential is low because no projects needing crushed stone nearby appear likely in the future. The railroad prefers crushed quartzite over crushed limestone.

The limestone in western Valencia County has high resource potential based on tonnage and grade but has low development potential owing to remoteness. Some crushed travertine is produced as a byproduct at the Mesa Aparejo travertine quarry. It is apparently sold as decorative stone.

Mica (by M. R. Bowie)

Mica is a group name for a variety of complex hydrous aluminosilicates. Most micas contain one or more of the elements iron, magnesium, potassium, calcium, lithium, and fluorine. The most common micas are biotite, lepiodite, phlogopite, muscovite, and sericite. The dark, iron-magnesium variety, biotite, is of little or no economic importance. Lepiodite has a characteristic pinkish color and has been mined as a source of lithium (Bates, 1960). Phlogopite is magnesium-bearing and has a characteristic lustrous, bronze-yellow color. Muscovite contains potassium and is generally colorless or pale brown, yellow, red, or green. Sericite is a white, fine-grained, potassium-bearing mica. Although micas are common minerals, only muscovite and sericite are currently mined in the United States.

There are no known mica deposits in Valencia County. The county as a whole has a very low mineral-resource potential for mica (Fig. 15), and consequently, a low potential for mica development. The most favorable area for significant mica concentrations is in the Precambrian core of the southern Manzano Mountains along the eastern edge of the county. Here, a metaclastic sequence contains micaceous (biotite, sericite), granitic stocks, quartzites, and schists (Stark and Dapples, 1946; Myers and McKay, 1972, 1974; Myers, 1977). The mineral-resource potential and the development potential for mica in the metaclastic sequence is low.

Saline Minerals (by K. B. Brown)

Saline minerals occur only rarely within Valencia County. Several occurrences are associated with spring discharge. Other occurrences are in bedded deposits. Gypsum, limestone, and dolomite (usually in bedded deposits) are discussed elsewhere in this report.

Soda-niter ($NaNO_3$) with fine selenite crystals (variety of gypsum) occurs in a travertine cone-crater in fibrous crusts up to one inch thick. This cone is about three miles south of Correo (Northrop, 1959, p. 477). Herrick (1900; Northrop, 1959) describes halite incrustations adjacent to springs at the foot of

Mesa Negra, near Suwanee on the South Garcia SE quadrangle (sec. 6, T. 6 N., R. 2 W.; sec. 36, T. 7 N., R. 3 W.).

Permian San Andres and Yeso Formations crop out in the extreme western portion of the county. Halite is reported to occur in beds in these formations and there is low to moderate potential of occurrence within Valencia County (Alto et al., 1965); however, development potential is low.

Sand and gravel (by D. Murray)

General description--Sand and gravel are inert fragmental materials used extensively during the production of portland cement concrete and asphaltic mixtures by the building and highway construction industries. Sand and gravel must meet many rigid standards and specifications for use in the construction industries. The American Society for Testing and Materials (ASTM), governmental agencies, and commercial users all have specifications governing acceptable rock types, degree of weathering and soundness, size and grading, particle shapes, hardness, strength, coatings, and organic impurities. Each job will require a specific aggregate (Goldman and Reining, 1983; Davis and Tepordi, 1985). Sand and gravel aggregates in Valencia County have been used mainly in building, highway, and railroad roadbed construction.

The New Mexico State Highway Department (NMSHD) uses several tests to determine the quality of aggregate materials located throughout the state. The Highway Department uses tests on gradation, Atterberg Limits, Los Angeles wear, magnesium soundness, and "R" values. The following test descriptions were provided by Warren Bennett, chief geotechnical engineer, New Mexico State Highway Department (Bennett, unpublished report, 1985). The tests are performed following procedures listed in American Association of State Highway and Transportation Officials (AASHTO; 1982).

A. Gradation separates the sample by grain sizes and is run on all samples whether borrow or surfacing. Three inches down to No. 4 (1/4 inch) screen is designated as gravel. The No. 4 screen to the No. 10 (1/10 inch) screen is coarse sand, the No. 10 screen to the No. 40 (1/40 inch) screen is medium sand, and the No. 40 screen to the No. 200 (1/200 inch) screen is fine sand. Material passing the No. 200 screen is silt and clay.

B. Atterberg Limits (L.L., P.L. & P.I.) measures the plasticity or "stickiness" of the fine part of a sample and is run on that portion of the sample finer than the No. 40 screen (fine sand, silt and clay). The test determines (1) the point at which the moisture content causes the sample to act as a liquid rather than plastic mass (the L.L. or Liquid Limit), (2) the lower moisture content at which it begins to lose its plasticity and act as a solid mass (the P.L. or Plastic Limit), and (3) the P.I. or Plasticity Index, which is the difference between the L.L. & P.L. as a percentage and thus the range of moisture contents through which the soil is plastic. A relatively pure sand or silt will show little plasticity and may be termed S.N.P. (Sandy, Non-

Plastic). Extremely plastic clays may absorb far more than their own weight in water and have Liquid Limits and Plastic Indexes of well over 100. Specifications generally require a Liquid Limit of 25 or less for base course material and a non-plastic material for bituminous pavement.

C. The Los Angeles Wear (L.A.W.) measures the resistance of coarse surfacing-aggregate to abrasive action by tumbling measured portions in a steel cylinder with a number of steel balls. The result is given as the percent of material lost and specifications range from 50 or less for base course to 40 or less for Open Graded Friction Course (O.G.F.C.).

D. The Magnesium Soundness Test (Soundness) measures the resistance of coarse surfacing-aggregate to freeze-thaw damage. It consists of soaking samples in a saturated magnesium sulfate solution and drying them repeatedly. Specifications for the percent lost range from 18 or less for base course to 8 or less for O.G.F.C.

E. The "R" value test measures the resistance of a sample of compacted, saturated soil to having a large cylinder pushed into it while it is held firmly, and thus the resistance to deformation under highway traffic when wet. The theoretical range is from 0 (water) to 100 (solid rock) but soils will range from 5 (clay) to about 82-83 (crushed stone). Specifications require a "R" value to be as high as possible. A low "R" value will require more material for a given project than a high "R" value.

Geology--Sand and gravel deposits are found throughout Valencia County. In western Valencia County, Late Tertiary to Quaternary fine-grained playa deposits (upper Popatosa Formation), younger fluvial deposits (Sierra Ladrones Formation), and Quaternary terrace deposits are found in the Rio Puerco drainage system and Llano de Albuquerque (Fig. 8; Love and Young, 1983; Hawley et al., 1982b; Hunt, 1978; NMSHD, 1977). In central Valencia County, Holocene valley fill and floodplain deposits are found in the Rio Grande valley (Hawley et al., 1982a; Hunt, 1978; NMSHD, 1977). East of the Rio Grande valley to the county line are four late Pleistocene fluvial terraces (Hawley et al., 1982a; Hunt, 1978; NMSHD, 1977). The two highest terraces are erosional (strath) terraces with several generations of eolian veneer, and the two lower terraces are constructional surfaces associated with very thick fluvial channel and floodplain deposits, primarily sand and gravel with some interbedded silt and clay (Titus, 1963). The thickness of sediments ranges from over 328 ft in the Rio Puerco drainage to a maximum of 118 ft in the Rio Grande valley to about 128 ft in the eastern terrace fills (Love and Young, 1983; Hawley et al., 1982a).

Mining and past production--Sand and gravel pit locations in Valencia County are shown on Maps 4, 5, and 6 and described in Appendix 1. Table 8 lists active sand and gravel operations. Table 9 lists NMSHD pit and borrow locations and test data. Transportation costs are the largest factor in the final price of

Table 8 – Active Sand and Gravel Operations in Valencia County (11/85).

Pit Name	Operator	Land Owner	Location
Pit #57143	Belen Sand and Gravel 509 N. 5th Street Belen, NM 87002	Valley Improvements Belen, NM 87002	5N.2E.4.400 (Projected) Take State Highway north to La Constancia. Turn right 1/2 mile north of La Constancia on La Entrada Road. Pit is approximately 2 blocks east of intersection.
J. H. T. Sand and Gravel	J. H. T. Construction 606 Baca Belen, NM 87002	Juan Orona Property Belen, NM 87002	6N.2E.12.311 Take State Highway 47 north 11 miles to El Cerro Road. Turn east on El Cerro and go 4.5 miles to pit location. Pit is on east side of road.
John Pit and Screening Plant	Nitty Gritty Dirt Sand and Gravel Rt. 6, Box 709 Los Lunas, NM 87031	Juan Orona Property Belen, NM 87002	7N.2E.25

Table 9 - New Mexico State Highway Department pit and borrow locations in Valencia County. All are inactive pits except #57143.
(1) Qal = Quaternary alluvium; Qb = Quaternary basalt; QTsf = Quaternary-Tertiary Santa Fe Formation; Qt = Quaternary terrace deposit; Qip = Quaternary intermediate pediment deposits.
(2) No data available, see Pit 57 133.
(3) Fill pit, no data available.
* Projected township, range, section

Pit Number	1:100,000 scale Quadrangle	Location	Rock Type	Formation(1)	Estimated Quantity (cu. yds.)	Los Angeles Wear	Soundness Loss	Plasticity Index
56-10-S	Belen	7N.3E.31.300	sand and gravel	Qt	(2)	25.2	(2)	(2)
5704	Belen	8N.3E.26.230	sand and gravel	QTsf	200,000	24.4	0.5	N.P.
57104	Belen	4N.2E.6.300*	sand and gravel	Qip	100,000	(3)	(3)	(3)
57133	Belen	7N.3E.31.330	sand and gravel	Qt	150,000	25.6	1.5	N.P.
57136	Belen	7N.1E.36.400	basalt and dacite	Qb	150,000	31.2	1.5	N.P.
57138	Socorro	3N.5E.32.122	sand and gravel	Qal	25,000	27.6	—	N.P.
57143	Belen	5N.2E.3.400*	sand and gravel	QTsf	100,000	27.2	—	N.P.
6401	Belen	5N.1E.11.400*	sand and gravel	QTsf	250,000	29.4	—	N.P.
6468	Belen	8N.3E.33.140	sand and gravel	Qal	100,000	20.0	1.2	N.P.
65-28-F	Belen	7N.2E.31*	dacite(?)	Qb(?)	(3)	(3)	(3)	(3)
6529	Belen	7N.1E.25.400*	dacite	Qb	500,000	21.2	7.4	N.P.
66-1-F	Belen	5N.1W.11*	sand and gravel	QTsf	250,000	(3)	(3)	(3)
6822	Belen	6N.3E.7.200	sand and gravel	Qt	250,000	21.2	3.6	N.P.
7208	Belen	7N.3E.31.100	sand and gravel	Qt	100,000	24.0	2.8	N.P.
7301	Belen	7N.3E.30.430	sand and gravel	QTsf	175,000	23.9	1.9	N.P.

sand and gravel. This has resulted in most sand and gravel pits and borrows being located near highways and urban areas in central Valencia County. Production figures published by the U.S. Bureau of Mines for the years 1957-1975 show an approximate total production of 10,656,000 tons of sand and gravel valued at approximately $11,094,060. These figures include production data for sites currently located in Cibola County. Production figures for sand and gravel have been withheld since 1975 by the U.S. Bureau of Mines (Table 10).

Resource and development potential--Resource and development potential for sand and gravel in Valencia County is high. Resources in the Rio Puerco drainage system, the central Rio Grande valley, and the eastern terraces are extensive. The majority of sand and gravel locations have been in the central Rio Grande valley Holocene valley-fill and floodplain deposits and the eastern Pleistocene fluvial terrace deposits. Very few pits have been located in the thick Tertiary-Quaternary deposits in the Rio Puerco drainage system, mainly due to the increased transportation costs. Development potential also is extremely high due to increasing demands by the growing communities of Belen and Los Lunas. As metropolitan Albuquerque in Bernalillo County expands and covers available resources in Bernalillo County, the large deposits of Valencia County will be in greater demand. Transportation costs will be kept relatively low due to the proximity of Valencia County to Albuquerque and to the large network of federal, state, and county roads connecting Valencia County with Albuquerque.

Table 10 - Sand and gravel production from Valencia and Cibola Counties, New Mexico. Figures since 1975 have been withheld (W) by the USBM. From U.S. Bureau of Mines (1957-1975).

Year		Tons produced	Value $
1957		567,000	674,000
1958		971,000	1,088,000
1959		408,000	597,000
1960		86,000	91,000
1961		313,000	542,000
1962		197,000	274,000
1963		314,000	537,000
1964		220,000	221,000
1965		211,000	215,000
1966		1,969,000	1,431,000
1967		1,236,000	1,247,000
1968		366,000	450,000
1969		283,000	183,000
1970		2,751,000	2,842,000
1971		97,000	86,000
1972		W	W
1973		421,000	W
1974		87,000	169,000
1975		159,000	447,000
	TOTAL	10,656,000	11,094,000

Silica sand (by M. R. Bowie)

General description--The term silica refers to any compound composed almost entirely of silicon dioxide. Natural silica polymorphs include quartz, tridymite, cristobalite, coesite, and stishovite. Quartz is by far the most common silica polymorph. Silica sand generally refers to sand composed almost entirely as quartz grains. The terms industrial sand and special sand are synonymous with silica sand.

Siliceous raw materials are occassionally marketed directly as finished products, that is, shipped without extraction of natural contaminants. When desired, the silica content of impure siliceous materials can be increased by beneficiation, via screening, washing with water, leaching with acid, flotation, or magnetic and gravity separation.

Silica sands are used principally in glass manufacture, ferrous and nonferrous foundry operations, certain chemical and metallurgical processes, and in many manufactured products as fillers or extenders (Tepordei, 1980). Some sands are informally named for their special uses, such as glass, foundry, abrasive, filter, and hydraulic-fracture sands.

Most industrial sands are required to meet rigid specifications with respect to purity, silica (SiO_2) content, and grain size and shape. Murphy and Henderson (1983) discuss general specifications which industrial sands must meet for certain commercial applications. On a general textural basis, the siliceous material should be light-colored, have at least 95% of its grains between U.S. Standard Sieves of 20 mesh and 140 mesh, and have a fairly uniform size frequency distribution. Further, the material should have a low percentage of alumina, magnesia, and calcium oxides, and should be relatively free of iron oxide, cobalt, copper, chromium, and nickel compounds (Tepordei, 1980; Murphy and Henderson, 1983).

Silica deposits have formed in all geologic eras since the Precambrian. Commercial silica deposits have three modes of origin: primary, secondary, and replacement (Kuck, 1980). Deposits of primary origin, such as massive quartz pegmatites and quartz dikes, generally form by silica precipitation from hydrothermal solutions. Secondary deposits, including sand, sandstone, and quartzite, form after erosion, redeposition, and sediment compaction. As an example of the replacement mode of origin, metaquartzites have been totally recrystallized by metamorphism and does not exhibit relict sedimentary textures. Their sedimentary origin is inferred from field relationships.

Geology and resource potential--Several sandstones in northwest and central New Mexico are potential sources of silica sand. These include the Zuni Sandstone and the Entrada, Todilto, Summerville, Bluff, and Morrison beds, as well as the Chuska, Dakota, Sarten, and Glorieta Sandstones (Carter, 1965). Phelps Dodge analyzed selected areas of several of these units but found them to be unsuitable sources of high-grade ($\geq$ 90% S_1O_2) silica flux, due primarily to excessive natural contamination and the inaccessibility of the units (Tipton, 1979). In addition, the extent of potential silica resources have not been delineated. The potential for silica sand is considered unknown in all of these units except certain areas of the Glorieta Sandstone.

The Glorieta Sandstone represents beach-upper-shore, middle shoreface, lagoonal, and tidal channel deposits deposited along north-northeast to south-southwest-trending coastlines (Milner, 1978). In central New Mexico, the Glorieta is a light-colored, clean, mature, fine-grained, moderately- to very well-sorted, calcite-cemented quartz arenite that is medium- to thick-bedded (Milner, 1978). Distinguishing characteristics include internal cross-stratification, ripples, moderate friability, and a high resistance to erosion (Bates et al., 1947).

The Glorieta crops out in west-central Valencia County

(Kelley and Wood, 1946; Kelley, 1977) and is similar to material once quarried at the New Mexico silica mine in the San Pedro Mountains, Santa Fe County (S. Milner, unpublished report, 1976, 1978; Kelley (1977) estimates that the Glorieta was up to 200 ft thick in this area. Due to a lack of analytical data, the Glorieta is considered to have an unknown resource-potential for silica here (Fig. 15).

The Sais Quartzite is a potential source of silica. It crops out primarily in the Precambrian core of the southern Manzano Mountains in southeastern Valencia County, northern Socorro County, and western Torrance County (Myers and McKay, 1972; 1974; Myers, 1977). The thickness of the Sais in Valencia County is unknown, but further east, in Torrance County; Edwards (1978) estimated the Sais to be a minimum of 630 ft thick.

Bauer (1983) speculates that the Sais Quartzite represents metamorphosed sandstones and pelites, probably deposited in either shallow-water deltaic, continental shelf, or floodplain environments. The formation contains 3-5 ft thick beds of bluish-gray, medium- to coarse-grained orthoquartzite interbedded with thin beds of sericitic orthoquartzite (Stark and Dapples, 1946). The unit is locally conglomeratic. The quartzite texture is generally masked by indurated silica and the effects of local metamorphosism.

Several qualitative mineralogic analyses of the Sais Quartzite have been published. Bauer (1983) observed that typical Sais Quartzite is 99% strained, lobate quartz grains 0.2-0.4 mm long, with traces of muscovite, biotite, chlorite, and opaque oxides. Stark (1956) also examined thin-sections of Sais Quartzite from north of Comanche Canyon in western Torrance County. He found that quartz forms 99% of the thin-sections. The remainder consists of intergranular sericite, magnetite, and apatite. Staatz and Norton (1942) analyzed the mineralogy of Sais Quartzite beds at varying distances from the Montosa fault. A major reverse fault that has put the Precambrian core in contact with Pennsylvanian sedimentary units. His results are tabulated in Table 11.

Table 11 -- Mineralogy of Sais Quartzite beds away from the Montosa fault. tr = trace; -- = not found (after Staatz and Norton, 1942, p. 30).

	Horizontal distance (in ft) from the Montosa fault						
	0	5	38	103	160	265	452
Quartz	96%	88%	99%	93%	60%	90%	98%
Sericite	4	12	1	7	39	10	2
Magnetite	tr	tr	tr	tr	1	tr	--
Zircon	tr	tr	tr	tr	--	--	--
Epidote	tr	tr	--	--	tr	--	--
Apatite	--	--	--	--	--	tr	tr

The Sais Quartzite has been quarried for use as railroad ballast (Bowie, this volume). The Sais quarry is in northern Socorro County, about 1 mile south of Valencia County (Fig. 14).

The mineral-resource potential of the Sais Quartzite as a commercial source of silica is considered moderate (Fig. 15). Should a suitable source of silica be identified in the Sais

Quartzite in Valencia County, its potential for development would probably be considered moderate, due to its proximity to Albuquerque, some 30 miles away. The resource potential for silica in rocks other than the Glorieta and Sais Quartzite in Valencia County is considered very low (Fig. 15).

Travertine (by J. M. Barker)

General description--Travertine is composed primarily of calcium carbonate with various impurities imparting a variety of colors. Commercial travertine is a hard, dense, finely crystalline, compact, massive to concretionary limestone. It typically has fibrous or concentric structure and splintery fracture (Gary et al., 1974). Travertine is a term with a broad meaning which is here restricted to deposits formed by precipitation of calcium carbonate in a spring system. The spring system may be warm or cold and nearsurface (cave) or surface. Other terms for travertine include tufa (spongy), Mexican onyx, and calcareous sinter, among many. Impurities can color bands in a layered travertine which forms a valuable decorative stone often called onyx marble (Sanders and Friedman, 1967), although true onyx is banded silica (i.e. agate). Commercial travertine must be hard, banded, and able to take a polish.

Precipitation of calcium carbonate (calcite) in and around springs occurs when the waters become very supersaturated (about 10 to 20 times). Supersaturation occurs mainly upon CO_2 loss by: degassing (pressure decrease), floral photosynthesis, mainly by algae, mosses, hepatica (Julia, 1983; Fisher, 1979), or bacterial metabolism (Chafetz and Folk, 1984); evaporation may contribute to supersaturation. Travertine is often associated with low-temperature hydrothermal activity and consequently with spring waters of moderate temperature (Schmalz, 1972).

The known travertine resources in Valencia County are concentrated in its western third. These can be segregated into three main areas (Fig. 18): Mesa Lucero (Laguna Indian Reservation), Sierra Lucero, and Mesa Aparejo (Gray Mesa). More speculative resources of travertine are perhaps associated with the Hubbell bench in eastern Valencia County.

Lucero-uplift--The Lucero uplift is one of the major structures comprising the southeastern margin of the San Juan Basin. The uplift is represented in Valencia County mainly by the Sierra Lucero (to the south) and Lucero Mesa (to the north). North of Lucero Mesa, the uplift includes Suwannee Peak described below.

The main portions of the Lucero uplift in Valencia County contain abundant travertine deposits of Plio-Pleistocene age (Wright, 1946, p. 450). Some travertine is now forming particularly west of Mesa Aparejo (Fisher, 1979; Kelley, 1977, p. 23). Some springs were active during late Santa Fe deposition because this unit contains travertine pebbles (Wright, 1946, p. 453).

The travertine deposits are widespread in a narrow, sporadic band three miles wide along the Lucero uplift from near South Garcia to beyond the Socorro County line (Kelley and Wood, 1946; Kottlowski, 1962, p. 26, figs. 2, 4; Titus, 1963; Kelley, 1977; Hunt, 1978; Siemers, 1982). The travertine reaches 178 ft in thickness (Kutnewsky, 1965). The source of the carbonate in the travertine appears to be at least 2100 ft deep (Wright, 1946) and is probably the San Andres limestone and other nearby carbonates (Kottlowski, 1962).

Numerous occurrences of travertine are mapped on the west slope of Lucero Mesa (Kelley and Wood, 1946; Jicha, 1958; Titus, 1963). Some are active and most are relatively small.

Ultramarble, Inc. (formerly All American Marble Co.) mined travertine on the Laguna Indian Reservation in the 1960's. The main quarry was on leased Indian land in unsurveyed sec. 7, T. 7 N., R. 2 W. with additional reserves in sec. 6, 18, 19, 30, and 31 (Map 6). This quarry, known as the Ultra quarry (a/k/a Omission quarry) is not in operation at the present time. The production data in Table 12 are for this operation. Many buildings in Albuquerque contain Ultra travertine. The quarry utilized wire-saw techniques to produce 10-20 ton blocks trucked to Albuquerque for slabbing and polishing (Kutnewsky, 1965, p. 38). Products included interior sheets (1-inch thick), exterior sheets (2-inches thick), and 8-inch slabs for shipping (slabbed on site after delivery). The deeper travertine is much harder and more translucent than the near-surface rock (Kutnewsky, 1965, p. 38).

Table 12 -- Production of dimension stone (travertine) from the Ultra quarry. Much of the production from the quarry is unidentifiable, as all stone production (crushed aggregate and dimension stone) was reported as a lump sum. 1. U.S. Bureau of Mines (1961-1966); 2. New Mexico State Mines Inspector (1967-1982); W = withheld. *The Ultra quarry closed and the Lucero quarry opened during this period.

1961	80 t[1]	$11,029[1]
1962	W[1]	
1963	145[2]	8,420[2]
1964	805[2]	52,325[2]
1965	10,000[2]	40,000[2]
1966	1,184[1]	42,351[1]
1967-82	W*	W*

Mesa Aparejo (Gray Mesa)--The deposits of travertine here are mapped by Kelley and Wood (1946) and are much larger than those of the Lucero uplift (Kelley, 1977, p. 24). They formed along the Comanche fault and are mostly dormant except for very localized small springs (Kelley, 1977; H. S. Chafetz, verbal commun., 1985). Kelley (1977) estimated a resource of 200 million tons. Only a small portion of this resource has been exploited.

During the 1960's, Ultramarble Inc. (Albuquerque) quarried the travertine at the eastern base of Mesa Aparejo (Elston, 1967, p. 56-57). This was a drill and saw operation. The blocks produced were slabbed and polished for use in the capitol building in Santa Fe (Kelley, 1977).

Rocky Mountain Stone Company currently operates the Lucero travertine quarry in secs. 12 and 13, T. 5 N., R. 3 W. (Fig. 14). The blocks, produced using a cable saw, are slabbed in a mill just west of Belen and the finished product is widely marketed through a sales office in Albuquerque. Capacity is 4800 tons/year (Barker et al., 1984, p. 30) which, compared to the 200 million tons of reserves, will not deplete the deposit for many years.

Interest in travertine as dimension stone is high at the present time. Marble USA, Inc. has acquired mineral rights to the southwest of the Lucero quarry operated by Rocky Mountain Stone Company. The Marble USA property includes all or part of secs. 13, 23-24, 26-28, 33-35, T. 5 N., R. 3 W. A foreign investor has apparently backed the acquisition of travertine rights to part of the Mesa de Oro deposits, a few miles west of Valencia County.

The resource potential for travertine as dimension stone is high (Fig. 18). The deposits in Valencia County are among the largest in the state and are currently mined. Unexploited travertine is abundant along the Lucero uplift. The potential for development also is high. New companies have formed recently to exploit travertine. The NMBMMR has received numerous requests for information on this commodity during 1984-85. The use of the travertine as a high-calcium limestone is a distinct possibility. The content of $CaCO_3$ exceeds 95% for much of the travertine resource (Table 7). Competition from marine limestone and travertine deposits just outside Valencia County to the south (Riley travertine; Barker, 1983) and west (Mesa del Oro; Jicha,

1958) could be expected.

Carrizo Arroyo-Bobo Butte--Travertine deposits occur in the vicinity of Carrizo Arroyo and Bobo Butte (Kelley et al., 1976, p. 14). The deposits in Carrizo Arroyo are very small. Those at Bobo Butte are areally larger but consist of "travertine-cemented pediment gravels" (Zilinski and Callender, 1976) which may not be a true travertine as used herein.

The small size of the Carrizo Arroyo deposits and the occurrence of travertine cement in pediment gravel at Bobo Butte is unfavorable. The resource and development potential at these localities is very low.

Suwannee-Peak--Suwannee Peak is just northeast of Suwannee Siding (AT&SFRR) along New Mexico Highway 6 in the northwesternmost corner of Valencia County. It is Hill 5995 (Correo VABM) on the South Garcia 15-min topographic quadrangle with Suwannee Spring at its base. It is on the Laguna Indian Reservation in NW 1/4 2, T. 8 N., R. 3 W. (unsurveyed). Suwannee Peak consists of Entrada Sandstone at its base overlain in ascending order by the Morrison shale, Dakota Sandstone, and Mancos Shale. The peak is capped by a knob of travertine (Kelley et al., 1976, p. 15). The small size and location suggest low resource and development potential.

Hubbell Bench--The Hubbell bench and its southward extension, the Joyita bench are prominent features west of the Manzano Mountains in eastern Valencia County. The western edge of the Hubbell-Joyita bench is bounded by the Hubbell Springs-West Joyita fault system (Kelley, 1977, fig. 19).

The northernmost portion of the Hubbell bench has relatively large travertine occurrences (Grant, 1982; Reiche, 1949) which are about 5 miles north of Valencia County. Similar geology occurs in Valencia County so low travertine potential exists along the faults mentioned above.

Travertine resource and development potential--The resource potential for travertine as dimension stone is high (Fig. 18). The deposits in Valencia County are among the largest in the state and are currently mined. Unexploited travertine is abundant along the Lucero uplift.

The potential for development also is high. New companies have formed recently to exploit travertine. The NMBMMR has received numerous requests for information on this commodity during 1984-85.

The use of the travertine as a high-calcium limestone is a distinct possibility. The $CaCO_3$ content exceeds 95% for much of the travertine resource (Table 7). Competition from marine limestone and travertine deposits just outside Valencia County to the south (Riley travertine; Barker, 1983) and west (Mesa del Oro; Jicha, 1958) can be expected.

Zeolites (by M. R. Bowie)

General description--Zeolites are hydrated aluminosilicates of the alkali and alkaline earth elements, similar in composition to feldspars. They are among the most common authigenic silicates in sedimentary rocks and include over 35 naturally occurring minerals.

Zeolites are commercially exploited largely for their high cation exchange capacity. In addition, their porous framework enables them to act as molecular sieves whereby molecular mixtures are separated according to the size and shape of the molecular compounds (Sheppard, 1983). Mumpton (1973, 1983) discusses numerous industrial applications of natural zeolite, including uses for dimension and decorative stone, pozzolanic material, lightweight aggregate, paper filler, gas adsorption, industrial waste water treatment, air separation, animal nutrition, and agricultural products.

Prior to the late 1950's, most zeolite occurrences were reported from and most museum specimens were collected from fracture and vesicle fillings in igneous rocks. However, these occurrences have little or no commercial potential. In recent years, zeolites have been recognized as common and potentially commercial rock-forming constituents of diversity of sedimentary and low-grade metamorphic rocks (Hay, 1966).

Table 13 lists the most abundant zeolites in sedimentary rocks. Zeolites are commonly alteration products of the diagenetic reaction of precursor aluminosilicate materials (usually silicic volcanic glass, clay minerals, or feldspathoids) with pore solutions. Hay (1966) demonstrated that the formation of authigenic zeolites and associated silicates is greatly influenced by: 1) composition, grain size, permeability, and age of the host rocks, 2) composition of the pore water, and 3) depth of burial of the host rocks.

Zeolites occur in sedimentary rocks of diverse lithology, age, and depositional environment; several classifications of zeolite deposits have been proposed (Hay, 1966, 1977, 1978;

Sheppard, 1971, 1973, 1975; Munson and Sheppard, 1974). Zeolites commonly form in the following geologic settings: 1) closed-hydrologic (saline, alkaline lake), 2) open-hydrologic, 3) hydrothermal, 4) burial metamorphic, 5) saline, alkaline soils, and 6) deep-sea.

Table 13 -- Zeolites most commonly reported from sedimentary rocks.

Zeolite	Formula
Analcime	$NaAlSi_2O_6 \cdot H_2O$
Chabazite	$(Ca,Na_2)Al_2Si_4O_{12} \cdot 6\ H_2O$
Clinoptilolite	$(Na_2,K_2,Ca)_3Al_6Si_{30}O_{72} \cdot 24\ H_2O$
Erionite	$(Na_2,K_2,Ca)_{4.5}Al_9Si_{27}O_{72} \cdot 27\ H_2O$
Ferrierite	$(K,Na)_2(Mg,Ca)_2Al_6Si_{30}O_{72} \cdot 18\ H_2O$
Heulandite	$(Ca,Na_2)_4Al_8Si_{28}O_{72} \cdot 24\ H_2O$
Laumontite	$Ca_4Al_8Si_{16}O_{48} \cdot 16\ H_2O$
Mordenite	$(Na_2,K_2,Ca)Al_2Si_{10}O_{24} \cdot 7\ H_2O$
Phillipsite	$(K_2,Na_2,Ca)_2Al_4Si_{12}O_{32} \cdot 12\ H_2O$

Geology and resource potential--There are numerous zeolite occurrences in New Mexico. Three potentially commercial deposits are located near Buckhorn, in Grant County (Olander, 1979; Eyde, 1982; Sheppard and Mumpton, 1984; Bowie, 1985; Bowie et al., 1986), at Cuchillo Negro, in Sierra County (Maxwell and Heyl, 1976; Bowie et al., 1986), and in Foster Canyon, Doña Ana County (Seager and Clemons, 1975; Clemons, 1976; Bowie et al., 1986). Turner-Peterson (1985) delineates a clinoptilolite and an analcime/potassium feldspar facies within the Brushy Basin Member

(Olson, 1983) of the Morrison Formation in the San Juan Basin.

In western Valencia County, minor analcime occurs in the sericitically altered Able Hill diabase intrusive in the Lucero uplift (Gambill, 1980). The analcime has a very low mineral-resource potential (Fig. 15) and a low potential for development.

The only area of Valencia County that does not have a very low mineral-resource potential for zeolite is that occupied by the Santa Fe Group. Here, the mineral-resource potential for commercially exploitable zeolite is considered low (Fig. 15).

The Santa Fe Group is a 12,000 ft sequence of late Tertiary unconsolidated basin-fill deposits occupying the Albuquerque-Belen Basin and adjacent areas (Kelley, 1977). This basin-fill consists of peripheral alluvial-fan deposits, central playa deposits, and axial river gravels. The playa covered at least 15-40 sq miles in early and middle Santa Fe time, but was buried in late Santa Fe time by at least 700 ft of alluvial gravel (Wright, 1946). The playa deposits are best exposed in the Gabaldon badlands, mostly in T. 6 N., R. 2 W. According to Wright (1946), they consist of up to 4100 ft of dominantly tan, buff, and brown sand, and brown and red gypsiferous silt and clay.

Volcanic rocks are interbedded with the basin-fill. The volcanics are dominantly basaltic but local patches of rhyolitic tuff are present. The rhyolitic tuff is suspected of being altered to zeolite. Wright (1946) briefly describes rhyolitic tuff from three localities in the lower Rio Puerco area. These tuffs are exposed in secs. 7 and 14, T. 9 N., R. 1 W., and sec.

26, T. 7 N., R. 1 E., are 15-75 ft thick, and lie within the middle(?) and upper members of the Santa Fe. The tuffs are assigned a low mineral-resource potential for zeolite and their potential for development is very low. Large reserves of high-purity natural zeolite are currently exploited or are slated to begin production in the near future elsewhere in the western United States.

Energy Resources

Petroleum (by R. F. Broadhead)

Production and occurrences--Petroleum (crude oil and natural hydrocarbon gas) has never been produced from Valencia County. Twenty-six petroleum exploration wells drilled in Valencia County have reported oil or gas shows (Figs. 19, 20; Maps 7, 8; Appendix 2), but no commercial accumulations are indicated. Several surface seeps of crude oil have been reported in the Albuquerque Basin (Black, 1982). Nearest production is 50 miles northwest in the San Juan Basin of Sandoval County. Numerous noncommercial occurrences of petroleum have been reported from Valencia County, however.

Forty-nine petroleum exploration wells have been drilled in Valencia County (Figs. 19, 20; Appendix 2). Only 20 of those wells have reached Mesozoic, Paleozoic, or Precambrian rocks; the other 29 wells reached total depth in Cenozoic sediments. Drilling has been in the Albuquerque Basin and the Lucero uplift (Fig. 7). The Manzano Mountains and the Valencia County part of the Estancia Basin have not been drilled.

The eastern side of the Lucero uplift forms the western boundary of the Albuquerque Basin in Valencia County. Thirteen petroleum exploration wells have been drilled in the Valencia County part of the Lucero uplift (Figs. 19, 20; Appendix 2). All but one of those wells drilled to the Precambrian. Seven of the wells encountered oil and gas shows in the Magdalena Group (Pennsylvanian) and an eighth well had a reported oil show in Permian sedimentary rocks. Several wells reportedly encountered

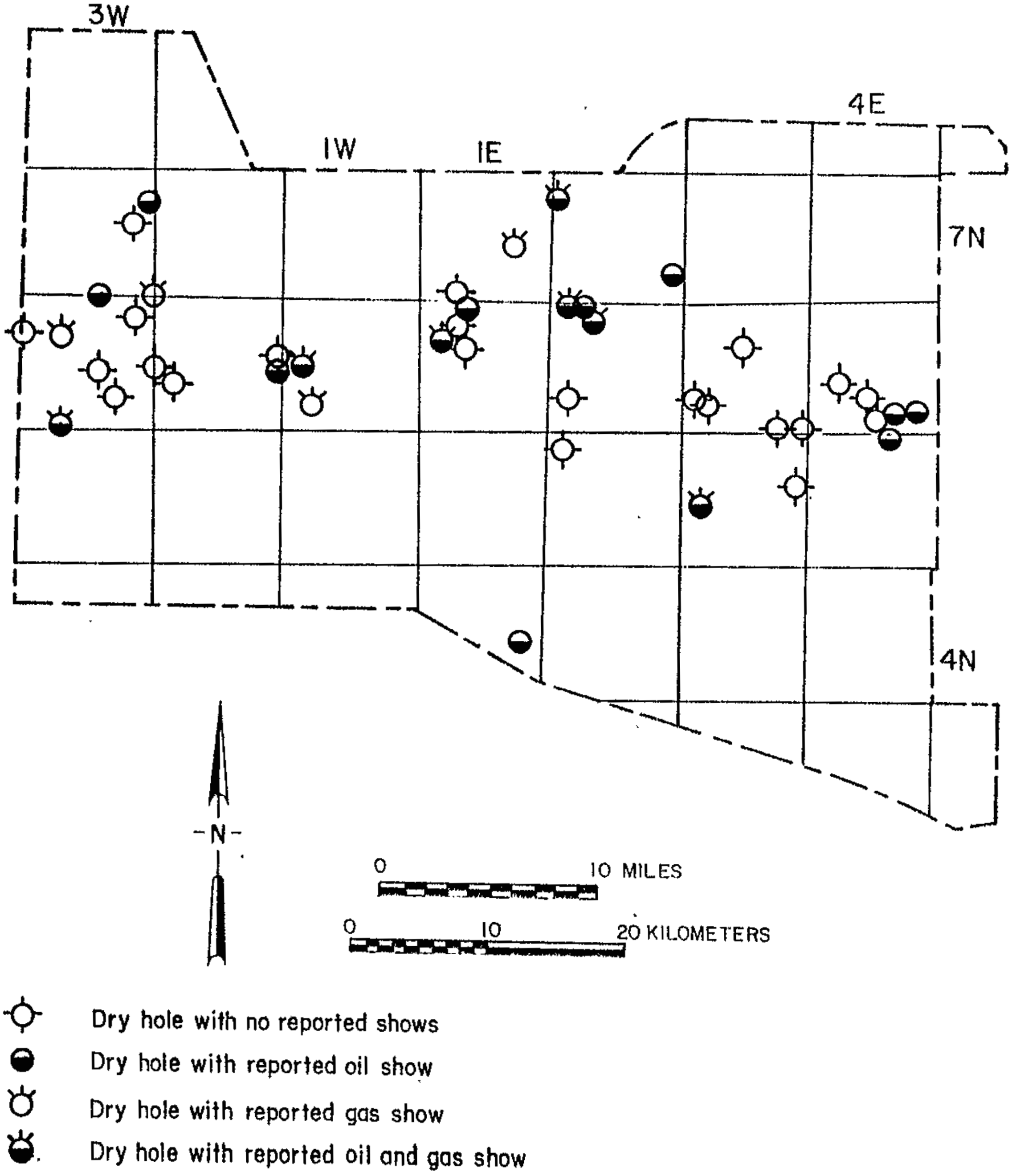
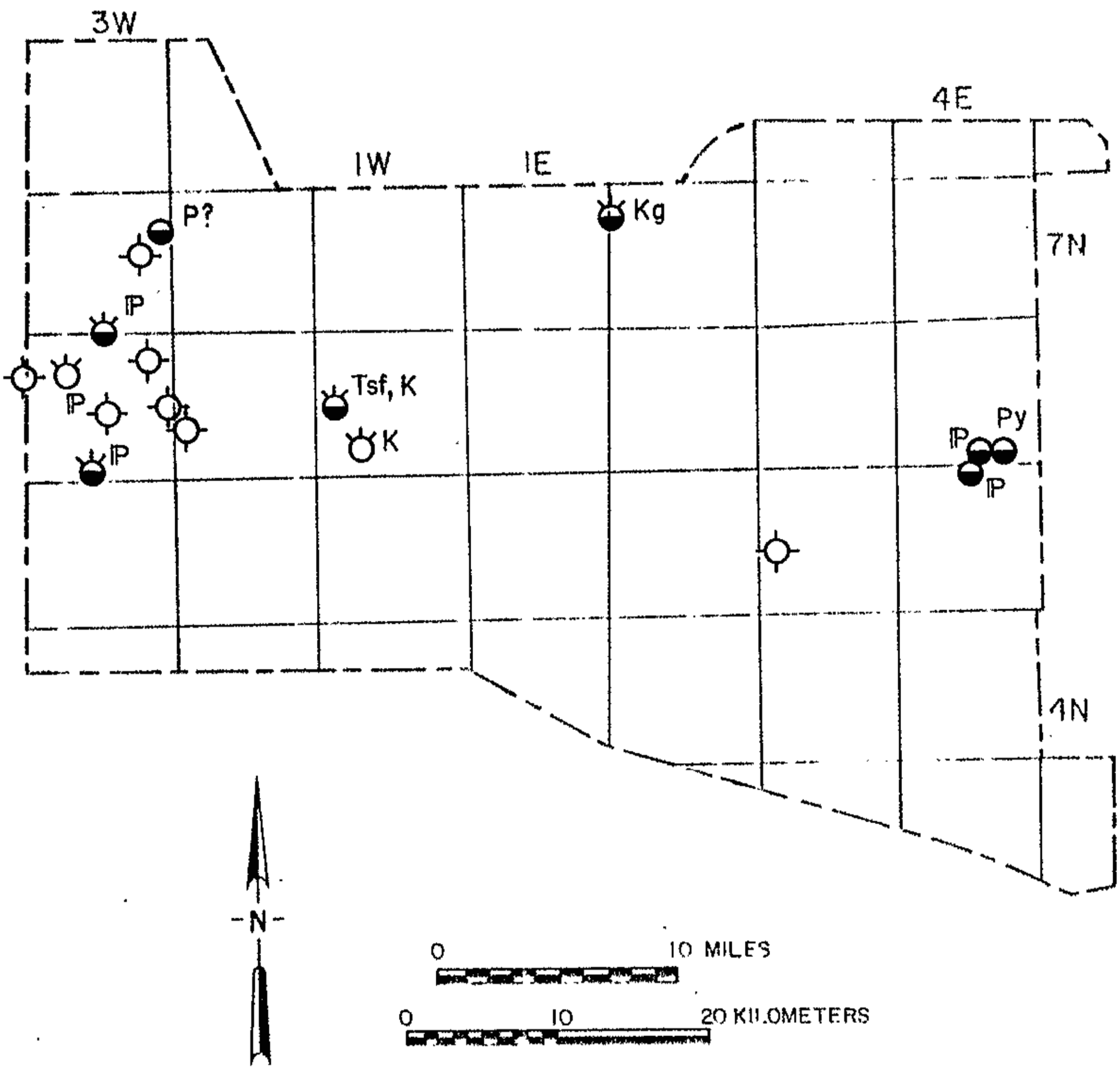


Figure 19 – Petroleum exploration wells drilled in Valencia County, New Mexico. See Appendix 2 for well data.

Figure 20 – Petroleum exploration wells in Valencia County, New Mexico, drilled to Mesozoic, Paleozoic, or Precambrian rocks. Stratigraphic units in which shows were encountered are indicated adjacent to the well symbols. See Appendix 2 for well data.



(open circle)	Dry hole with no reported shows
(half-filled circle)	Dry hole with reported oil show
(circle with rays)	Dry hole with reported gas show
(half-filled circle with rays)	Dry hole with reported oil and gas show

Tsf	Santa Fe Group (Tertiary)
K	Cretaceous
Kg	Gallup Sandstone (Cretaceous)
P	Permian
Py	Yeso Formation (Permian)
ℙ	Pennsylvanian

oil shows in porous dolostones in the upper part of the Permian section (Reese, 1975). The Lucero uplift wells were apparently drilled on the hypothesis that oil was trapped in west-dipping Pennsylvanian strata by the Comanche and Santa Fe faults. Three wells (Brana Corp. No. 1-X Penteco Trinity, Brana Corp. No. 2 Penteco Trinity,and Brana Corp. No. 3 Trinity; Appendix 2) were drilled to the Precambrian on the narrow fault block bounded on the west by the Comanche reverse fault and on the east by the Santa Fe normal fault; none of those three wells had reported shows of oil or gas.

Thirty-five petroleum exploration wells have been drilled in the Valencia County part of the Albuquerque Basin (Fig. 19; Appendix 2). Only seven of those wells drilled deep enough to completely drill through the Tertiary section and therefore test the Mesozoic and Paleozoic sections. The other 28 wells reached total depth in Tertiary sediments, which are thicker than 21,000 ft in some parts of the Albuquerque Basin (Black, 1982). Of the 28 wells that reached total depth in the Tertiary section, 18 had reported oil or gas shows; all of those 18 wells were completed prior to 1954. Only four wells had documented shows of oil or gas in hydrocarbon logs, sample descriptions, cores, or drill-stem tests. The reported shows in the other 14 wells were not documented and may not be reliable.

Seven wells drilled in the Albuquerque Basin reached total depth in rocks of pre-Tertiary age. Three of the wells drilled to Pennsylvanian or Permian sedimentary rocks on the Hubbell bench in T. 5 N., R. 4 E., and T. 6 N., R. 4 E. The Hubbell bench is a shallow fault block that forms the eastern part of the

Albuquerque Basin and separates the deeper part of the basin on the west from the Manzano Mountains on the east (Kelley, 1982b fig. 22). Two of the wells had reported oil shows in Pennsylvanian rocks and one well had a reported oil show in rocks that are probably the Yeso Formation (Permian). Another well, the Grober No. 1 Fuqua, drilled in sec. 19, T. 5 N., R. 3 E. and located west of the Hubbell bench, reached a total depth of 4,065 ft in sediments that Foster (1978) believed are the Baca Formation (Tertiary) but that Reiche (1949) and the author believe are the Dockum Group (Triassic). In the Fuqua well, several oil and gas shows were reported from the Tertiary section but none were reported from strata believed to be of Triassic or Cretaceous age.

The Shell Oil Co. No. 1 Isleta Central, located in sec. 7, T. 7 N., R. 2 E., was drilled to a total depth of 16,346 ft in Precambrian rocks. After the Gallup Sandstone (Cretaceous) was artificially fractured between depths of 13,210 ft and 13,246 ft, it flowed gas at a rate of 9 MCFGPD (thousand ft^3 gas per day). The Humble Oil and Refining Co. No. 1 Santa Fe Pacific, located in sec. 18, T. 6 N., R. 1 W., drilled to a total depth of 12,691 ft in Cretaceous strata. Oil and gas were recovered by drill-stem tests in the Cretaceous section. The Shell Oil Co., No. 2 Santa Fe Pacific, located in sec. 29, T. 6 N., R. 1 W., drilled to a total depth of 14,305 ft in the Chinle Formation (Triassic). Gas shows were reported from the Cretaceous section (Black, 1982), but depth intervals of gassy zones have not been released.

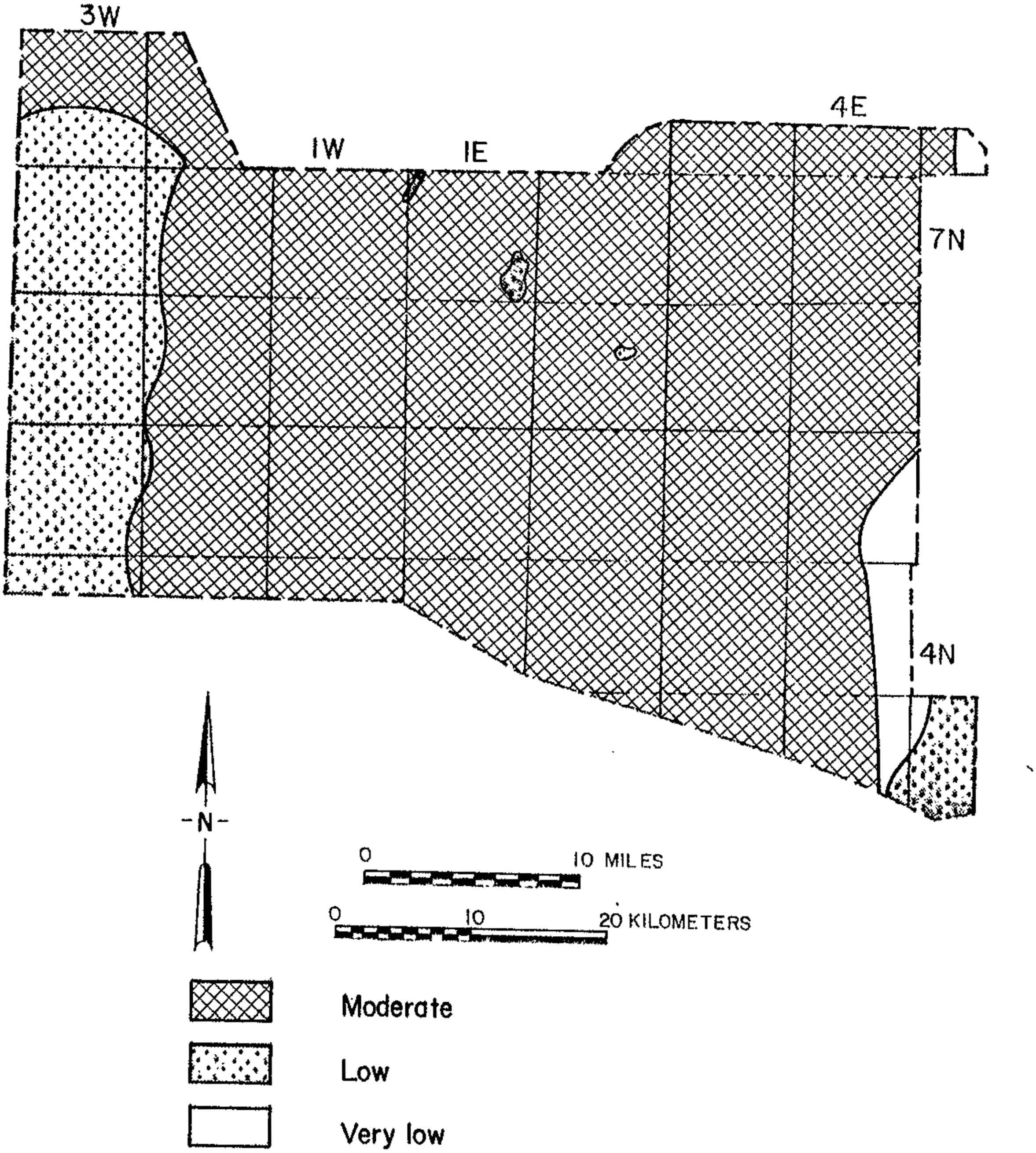
<u>Petroleum resource potential</u>--Valencia County is classified

as a frontier exploration area because there is no petroleum production from Valencia County or from any of the geologic basins or uplifts present in Valencia County. Four key factors need to be analyzed in order to evaluate the petroleum potential of a frontier area: source rocks, reservoir rocks, traps, and preservation of petroleum that has been generated and trapped. These four factors are analyzed below for each of the five tectonic subdivisions present in Valencia County (Fig. 7): Albuquerque Basin, Lucero uplift, Puerco fault belt, Manzano Mountains, and Estancia Basin. The potential for petroleum occurrence is then evaluated based on the analyses of the four factors (Fig. 21, Maps 9, 10, 11).

The potential for petroleum occurrence in an area is classified as "high" if geologic analyses indicate that source rocks, reservoirs, and traps are present in that area. Geologic analyses must also indicate that petroleum which has been generated has been preserved. Furthermore, a classification of high in a basin or on an uplift is only warranted if there is petroleum production elsewhere in that basin or on that uplift or if known but undeveloped petroleum accumulations have been proven to exist (by drilling) in that basin or on that uplift.

The potential for petroleum occurrence in an area is classified as "moderate" if geologic analyses indicate that source rocks, reservoirs, and traps are present in that area. Geologic analyses must also indicate that petroleum which has been generated has been preserved. A moderate classification differs from a high classification because a basin or uplift may be assigned a moderate classification even though there is no

Figure 21 - Potential for petroleum occurrence in Valencia County, New Mexico.



petroleum production in that basin or on that uplift. Also, part of a producing basin may be assigned a moderate potential for petroleum occurrence if either source rocks, reservoirs, or traps are questionably present or if there is doubt that petroleum has been preserved.

The potential for petroleum occurrence in an area is classified as "low" if geologic analyses indicate that source rocks, reservoirs, and traps are only questionably present in an area, but that stratigraphic units in that area are known to contain source rocks and reservoirs elsewhere. An area also may have a low classification if source rocks, reservoirs, and traps are probably present but if geologic analyses indicate that petroleum has almost certainly not been preserved.

The potential for petroleum occurrence in an area is classified as "very low" if geologic analyses indicate that source rocks, and more importantly, reservoirs, are probably not present in that area. A classification of very low is almost always reserved for areas of outcropping Precambrian metamorphic or igneous rocks that have not been thrust over a Phanerozoic section that might have petroleum potential. A classification of very low is also assigned for areas where extensive intrusive volcanism has occurred, such as in a volcanic caldera.

Albuquerque Basin--The general structure of the Albuquerque basin is an elongate, north-trending graben bounded on the east and west sides by north-trending normal faults (Kelley, 1977; Black, 1982; Kelley, 1982a). Although the rift-bounding normal faults dip steeply where exposed, they may be listric with depth (Cape et al., 1983). The interior of the basin is formed by north-trending fault blocks that are shallow at the basin margins and buried more deeply along the center axial part of the basin (Figs. 8, 22). In addition, there may be uplifted horst blocks in the deeper parts of the basin (Black and Hiss, 1974; Black, 1982; Baars, 1982). The Cretaceous section has been eroded from the eastern part of the basin and portions of the western margin of the basin. A partial Cretaceous section is preserved on shallow fault blocks in the western part of the basin (Figs. 8, 22). The thickest Cretaceous section is preserved in the deeper, central parts of the Albuquerque Basin. At least part of the Paleozoic section has been preserved throughout the entire basin.

Analyses presently available indicate that the best source rocks in the Albuquerque Basin are probably the dark-grey marine shales of the Mancos Formation (Cretaceous). Marine Mancos shales are believed to be the source of much of the oil and natural gas that is produced from the San Juan Basin (Ross, 1980). Petrographic and gas-chromatograph analyses indicate that lipid-rich, oil-prone source rocks are present in the marine Cretaceous shales of the Albuquerque Basin (Black, 1982). It appears that the Cretaceous section in the Humble No. 1 Santa Fe Pacific (Sec. 18, T. 6 N., R. 1 W.) is overmature and therefore gas prone and not oil prone; levels of organic maturity range from 12 to 14 (Black, 1982) and are in the metamorphic hydrocarbon facies according to the chart of Staplin (1982). These high levels of organic maturity probably indicate that any liquid hydrocarbons in the Humble well were thermally destroyed; this hypothesis is supported by the presence of anthraxalite in

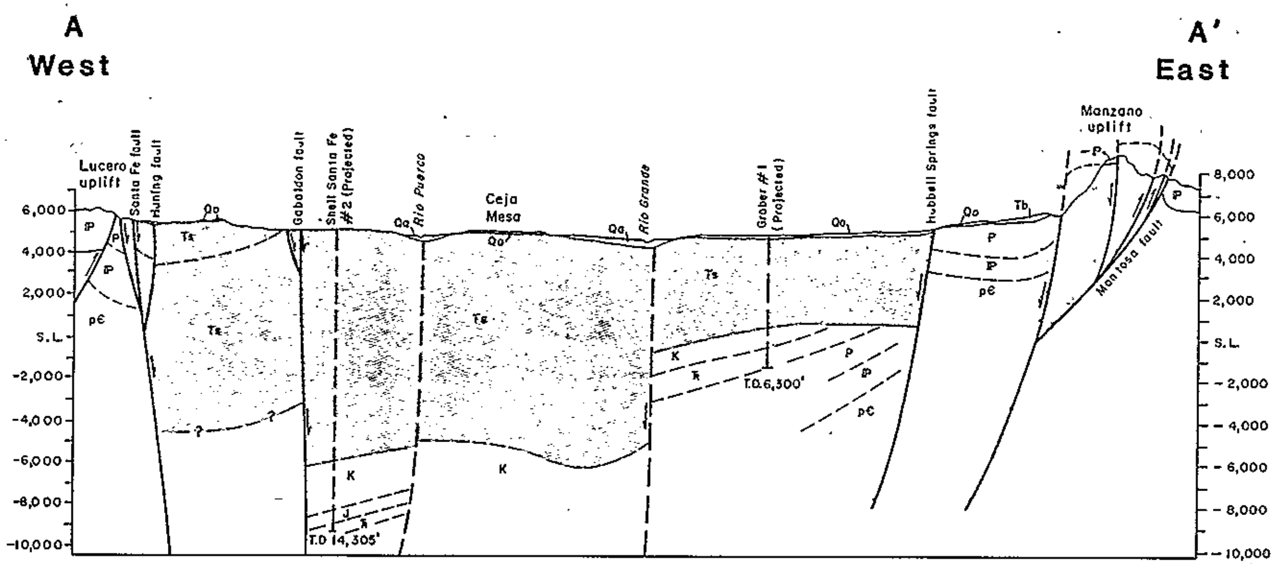


Figure 22 – West to east cross section through Albuquerque Basin in Valencia County, New Mexico. See Figure 8 for location. From Kelley (1977).

the Cretaceous section. The Shell No. 2 Santa Fe Pacific (sec. 29, T. 6 N., R. 1 W.) was drilled approximately 2 miles south of the Humble well and encountered high bottom-hole temperatures as well as levels of organic maturity greater than 18 at total depth in Triassic sedimentary rocks. It is probable that any liquid hydrocarbons in the Cretaceous of the Shell No. 2 Santa Fe Pacific also have been altered to hydrocarbon gases or even to non-fuel carbon-dioxide gas. To the north in the Shell No. 1 Isleta Central (sec. 7, T. 7 N., R. 2 E.), the Cretaceous section may have had optimum levels of thermal maturity for oil generation (Black, 1982), but this is not well documented. In summary, it appears that marine Cretaceous shales in the Valencia County part of the Albuquerque Basin are oil-prone source rocks that have reached levels of thermal maturity for thermal gas generation but in places may have levels of thermal maturity that are optimum for oil generation. Additionally, the coal-rich, nonmarine Menefee Formation (Cretaceous) could be a source rock for gas, and possibly oil. The Menefee is thought to be the source of much of the gas (Rice, 1983) and possibly some of the oil (Ross, 1980) produced from Cretaceous rocks in the San Juan Basin.

Other possible source rocks in the Valencia County part of the Albuquerque Basin are the Todilto Formation (Jurassic), the Madera Formation (Pennsylvanian), and shales of the Santa Fe Group and other Tertiary units. Black, fetid lacustrine limestones of the Todilto Formation are probably present in the northern part of Valencia County. The Todilto is the source of oil produced from the Entrada Sandstone (Jurassic) in the San

Juan Basin (Vincelette and Chittum, 1981). The thermal maturity of the Todilto in Valencia County is unknown but the Todilto is mature in Sandoval County in the northern part of the Albuquerque Basin (Leutloff and Curry, 1982). The Todilto can be expected to be more mature than the shallower Cretaceous section. Organic-rich shales of the Madera Formation (Pennsylvanian) are other possible petroleum source rocks, but they appear to be overmature in at least some parts of the Albuquerque Basin (Black, 1982; Leutloff and Curry, 1982). Madera shales may have generated petroleum in the past when they were less deeply buried than at present. Source quality of Tertiary shales is undocumented.

The main reservoir objectives in the Albuquerque Basin are the Dakota and Gallup Sandstones (Cretaceous). The Dakota is a prolific producer of gas and oil in the San Juan Basin and the Gallup is a prolific producer of oil in the San Juan Basin. Other Upper Cretaceous sandstones, such as the Point Lookout Sandstone, are secondary objectives. In parts of the Albuquerque Basin, the Cretaceous sandstones have been tightly cemented with calcite and are poor reservoirs. Elsewhere, however, the sands have little cement and reservoir quality is good with porosities ranging from 16 to 24% (Black, 1982). Interbedded shales make ideal seals for the sand reservoirs.

Another major reservoir target is the Entrada Sandstone (Jurassic) which is present in the northern part of Valencia County. It pinches out south of the Shell No. 2 Santa Fe Pacific (Black, 1982). The Entrada is mostly a clean, porous, permeable eolian sand that is a major oil reservoir in the southeast part of the San Juan Basin. The reservoir properties of the Entrada in the Albuquerque Basin are undocumented.

Pennsylvanian and Permian sedimentary rocks are also possible reservoirs but have not been documented in the Albuquerque Basin. Carbonate rocks of the San Andres Formation (Permian) are locally very permeable in New Mexico. The good permeability may be caused by large karstic solution cavities and channels initially formed during the Late Permian or Early Triassic when the San Andres was subaerially exposed. Several wells drilled in Catron County, which is located southwest of Valencia County, have lost circulation in the San Andres. The Glorieta Sandstone Member (Permian) is also a possible reservoir because it is a permeable and porous unit elsewhere in New Mexico. Wells drilled in Catron County have lost circulation in the Glorieta, also. Limestones and sandstones of the Madera and Sandia Formations (Pennsylvanian) are possible reservoirs, but their reservoir properties remain undocumented in the Albuquerque Basin. On the Lucero uplift, limestones in the lower Madera have porosities of 2% or less and sandstones in the Sandia have porosities ranging from 10 to 20% (Reese, 1975). Similar porosities might be expected on shallow fault blocks near the edges of the Albuquerque Basin but porosities are expected to be less in the deeper, central parts of the basin where the Pennsylvanian section is buried more deeply and compaction has been greater. In the Manzano Mountains, the Sandia is composed mostly of siltstone, sandstone, and conglomerate with minor thin beds and lenses of carbonaceous shale and marine limestone (Myers, 1982). In the northern Ladron Mountains the Sandia is dominated by sandstone and shale (Kottlowski, 1960). The Madera of the Manzano Mountains is characterized by interbedded sandstone, shale, and marine limestone (Myers, 1982); Wengerd (1959) noted the presence of bioherms in the limestone beds. On Lucero uplift and in the Ladron Mountains, the Madera is composed of interbedded shale and marine limestone with some sandstone (Kelley and Wood, 1946). Pre-basin Tertiary sands and basin-filling Tertiary sands are secondary reservoir objectives and numerous oil and gas shows have been reported from them. It is not known, however, if enough shale is present in the Tertiary section to adequately seal the reservoir sands.

Possible traps in the Albuquerque Basin are both stratigraphic and structural. Traps in Cretaceous sands may be at least partially stratigraphic; many of the oil pools in Cretaceous sands in the San Juan Basin are trapped stratigraphically. However, structure probably plays an important or even dominant role in trap formation in the Albuquerque Basin because the structures that form the basin are so large. Both the Laramide and rift stages of deformation produced major structures that could form traps. Laramide deformation produced compressive structures (anticlines and reverse faults) that could form traps for oil and gas. Similar structures have formed major oil and gas pools in other areas, such as the Permian Basin of west Texas and the Bighorn Basin of Wyoming (Harding and Lowell, 1979). Oil and gas would be preserved in Laramide structures only if those structures were not severely deformed by the post-Laramide rift stage of deformation.

The rift-stage of deformation produced many fault blocks in the Albuquerque Basin. Those fault blocks could be traps for petroleum accumulations. Similar fault blocks have trapped major oil and gas accumulations in the North Sea, in the Gulf of Suez, and in the Sirte Basin of Libya (Harding, 1984). Although Quaternary eolian and alluvial sediments have obscured surface evidence for many basin-forming faults, several faults have still been mapped, including shallow fault blocks along the east and west flanks of the basin (Kelley, 1977, 1982b). One such block forms the Hubbell bench of eastern Valencia County. These fault blocks may be tilted and form ideal traps. Some of the faults may be listric with depth (Cape et al., 1983) and rollover anticlines that occur on the downthrown sides of the listric faults could form traps (Woodward, 1985) similar to traps found in the Tertiary of the U.S. Gulf Coast. Upper Paleozoic reservoirs are major targets in the shallow fault blocks along the basin flanks where Cenozoic erosion has removed most or all of the Cretaceous section. Because the Paleozoic strata have not been buried as deeply in these shallow fault blocks as in the deeper central parts of the basin, Paleozoic source rocks in the shallow fault blocks may not be thermally overmature (as in the basin center) and therefore may be good oil source rocks. As noted previously, wells drilled on the Hubbell bench have encountered oil shows in Pennsylvanian strata.

In the deeper, central parts of the basin, Paleozoic source units appear to be overmature for oil generation. Oil generated from the Paleozoic during shallower stages of burial and trapped in Paleozoic reservoirs may have been converted to gas. However, oil generated from the Paleozoic during shallower stages of burial may have migrated upward and may be preserved in Mesozoic or Cenozoic reservoirs. Oil generated from Cretaceous sources may be preserved in Cretaceous reservoirs in large parts of the basin where thermal decomposition of oil to gas has not occurred. Elsewhere, the geothermal gradient may have been high enough so that only gas is preserved in the Cretaceous section. As noted previously, several deep tests in the Albuquerque Basin have encountered gas shows in the Cretaceous section. A few oil shows also have been reported. Horst blocks may be present in the deeper parts of the basin (Black and Hiss, 1974) which would place the Cretaceous section at varying levels of thermal maturity.

The potential for petroleum occurrence in most of the Albuquerque Basin is rated moderate (Fig. 21; Map 10). Source rocks appear to be present in the basin and the complex structure of the basin has resulted in source rocks with a wide range of thermal maturities. Cretaceous, Jurassic, Permian, and Pennsylvanian reservoirs are present throughout the basin, although Cretaceous reservoirs have been eroded from shallow fault blocks near the basin margins. Structures appropriate for trap formation are numerous and it appears that gas is likely to have been preserved throughout the entire basin. Some parts of the basin are amenable to oil preservation. Numerous oil and gas shows encountered by petroleum test wells indicate that accumulations of oil and gas may be present in Pennsylvanian, Cretaceous, and possibly Tertiary reservoirs.

The potential for petroleum occurrence is rated low near intrusive volcanic centers (Fig. 21). The volcanic rocks are Tertiary in age and their intrusion into sediments of the upper part of the Santa Fe Group indicates that volcanism occurred during late stages of rift formation or after rift formation. Heat from the intrusive body may have destroyed any petroleum that had previously accumulated in reservoirs near the intrusion. It is possible that petroleum migrated into reservoirs near the intrusion after the intrusive rock body had cooled sufficiently that it would not cause thermal decomposition of petroleum. It is also possible, but unlikely, that fractures and vesicles in the intrusive rock bodies could serve as reservoirs for petroleum that has migrated after the intrusion cooled; that has happened in the Dineh-bi-Keyah oil field of northeast Arizona (Danie, 1978).

Lucero Uplift--The Lucero uplift in Valencia County is formed by a west-dipping fault block of upper Paleozoic strata that is bounded on the east by the Santa Fe fault. The Santa Fe fault separates the Lucero uplift from the Albuquerque Basin. The Lucero uplift is bounded on the west by the Acoma Basin. There is no major structural discontinuity between the Lucero uplift and the Acoma Basin. The Lucero uplift merges northward with the Puerco fault belt (Fig. 7).

Possible source rocks in the Lucero uplift are dark-grey shales of the Madera Formation (Pennsylvanian). Oil may also have migrated updip into the Lucero uplift from Madera shales in the Acoma Basin to the west. Source-rock geochemistry of Madera shales in the Lucero uplift and Acoma Basin is undocumented.

Possible reservoirs on the Lucero uplift are limestones and sandstones of the Madera and Sandia Formations (Pennsylvanian). On the Lucero uplift, limestones in the lower part of the Madera have porosities of 2% or less and sandstones in the Sandia have porosities ranging from 10 to 20% (Reese, 1975). The Mesozoic section has been removed by erosion. Possible Permian reservoirs, the San Andres Formation, including the Glorieta Sandstone Member, and sandstones of the Yeso Formation, crop out over a large part of the Lucero uplift and have probably been flushed by fresh water.

The most likely traps on the Lucero uplift are fault traps formed by truncation of west-dipping Pennsylvanian strata by the Comanche and Santa Fe faults. This hypothesis has been tested by the Reese and Jones wells, and by the Brana Corporation wells (Figs. 19, 20; Appendix 2) and has been found false. Those wells either encountered no petroleum at all or only shows of oil and gas. It is probable that the sands and gravels of the Santa Fe Group in the Albuquerque Basin do not provide an adequate updip seal for Pennsylvanian reservoirs and that the oil shows represent either petroleum that is currently migrating updip and into the the valley fill of the Albuquerque Basin or that the oil shows are the remnants of an oil pool that was destroyed by structural movement during rift formation. Also, the travertine deposits that occur along the Comanche fault zone (Kelley and Wood, 1946; Kelley, 1977) may have been formed by carbon-dioxide charged water that has migrated upward along the Comanche fault;

if that is true, then it is unlikely that the Comanche fault could act as a seal for hydrocarbon traps.

The Lucero uplift is assigned a low potential for petroleum occurrence (Fig. 21; Map 11) for three reasons. First, several exploration wells drilled on the uplift have not found petroleum accumulations other than small shows of oil and gas. Second, reservoirs are limited to Pennsylvanian units. Third, there is no obvious seal that would prevent leakage of oil updip and to the east into Tertiary sands and gravels of the Albuquerque Basin. There is still a small possibility that undiscovered petroleum accumulations are present, however, because of the occurrence of favorable reservoir facies. It is possible that local stratigraphic barriers have trapped small petroleum accumulations in the Lucero uplift. Also, several small north-trending faults and anticlines are present on the uplift (Kelley and Wood, 1946). These structures may provide enough closure to trap small accumulations of oil and gas.

Puerco Fault Belt--The Puerco fault belt (Kelley, 1977) is a complexly faulted structural zone north of the Lucero uplift (Fig. 7). Cretaceous and Tertiary sediments crop out over most of the Puerco fault belt in Valencia County (Fig. 8). The Santa Fe fault separates the Puerco fault belt from the Albuquerque Basin.

The Puerco fault belt has not been drilled in Valencia County, but is assigned a moderate potential for petroleum occurrence (Fig. 21). Possible source rocks are the marine Mancos Shale (Cretaceous), fetid limestones of the Todilto Formation (Jurassic), and dark-grey marine shales of the Madera

Formation (Pennsylvanian). The Mancos and Todilto are documented source rocks in the San Juan Basin (Ross, 1980; Vincelette and Chittum, 1981). Because maximum burial depths are probably similar to maximum burial depths where the Mancos and Todilto are oil sources in the southeast part of San Juan Basin, they may have similar thermal maturity and therefore act as oil sources. Also, oil may have migrated updip into the fault zone from source areas in the Acoma Basin.

Possible reservoirs present in the Puerco fault belt are the Dakota Sandstone (Cretaceous), the Entrada Sandstone (Jurassic), and sandstones and limestones of the Madera and Sandia Formations (Pennsylvanian). The reservoir qualities of those units are undocumented in the Puerco fault belt, but the Dakota and Entrada produce oil and gas in the San Juan Basin.

The complex structure of the Puerco fault belt indicates that only fault-controlled traps are likely to be present. Faulting has probably destroyed any early, stratigraphic petroleum accumulations. A moderate, and not a high, potential for petroleum occurrence is assigned to the fault belt because of the relatively thin, exposed Cretaceous section and because the complex structure is a deterrent to the preservation of pre-Tertiary oil accumulations (Map 9). Also, nearest production is in the San Juan Basin, 50 miles to the north-northwest.

<u>Manzano Mountains</u>--The Manzano Mountains are composed mostly of Precambrian granite, gabbro, metavolcanics, metasediments, and amphibolite (Figs. 7, 8; Myers and McKay, 1970, 1971, 1972; Myers, 1977; Myers et al., 1981). In places, the Precambrian is

capped by erosional remnants of the Sandia and Madera Formations (Pennsylvanian). The Manzano Mountains are separated from the Albuquerque Basin by the Manzano normal fault. They are separated from the Estancia Basin by the Montosa fault, which is a high-angle reverse fault in Valencia County.

The Manzano Mountains are assigned a very low potential for petroleum occurrence (Fig. 21; Map 9, 10) for two reasons. First, the Precambrian rocks that form most of the mountains are unlikely source and reservoir units for petroleum as are the thin erosional remnants of Pennsylvanian strata that cap parts of the range. Second, there is no evidence that the Montosa reverse fault has caused significant thrusting of the Precambrian over upper Paleozoic reservoir units of the Estancia Basin. Surface maps (Myers, 1977; Myers et al., 1981) indicate that overthrusting is negligible (Fig. 23). Therefore, Paleozoic reservoirs do not exist beneath a Precambrian thrust plate. A part of the Manzano Mountains in Valencia County was previously determined to have a negligible potential for petroleum occurrence (Maxwell et al., 1983).

Estancia Basin--The southwesternmost part of the Estancia Basin extends into southeast Valencia County (Fig. 7). A maximum of approximately 1400 ft of Pennsylvanian and Lower Permian sedimentary rocks are present in the Valencia County part of the Estancia Basin. Those units have a uniform, gentle southeast dip of approximately three degrees except where they are steeply upturned and locally overturned in a zone less than 1 mile wide that is adjacent to the Montosa fault (Myers, 1977). Possible petroleum reservoirs are limestones and sandstones of the Sandia

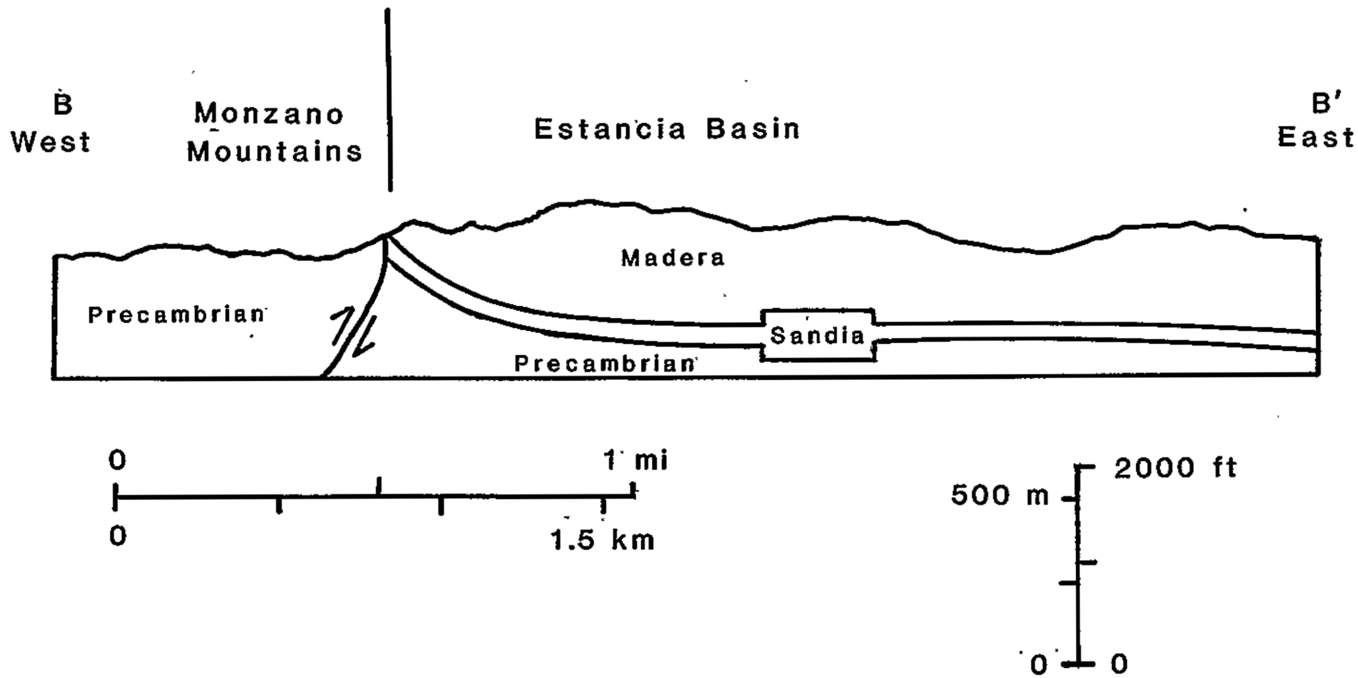


Figure 23 – West to east cross section from Manzano Mountains to Estancia Basin in southeast Valencia County, New Mexico. Simplified from Myers (1977). See Figure 8 for location.

and Madera Formations (Pennsylvanian). Possible, but undocumented, source rocks are dark-grey Madera shales downdip and to the east in Torrance County, where the center of the Estancia Basin is located. No petroleum exploration wells have been drilled in the Valencia County part of the Estancia Basin but wells drilled in the Socorro and Torrance County parts of the basin have reported shows of oil and gas.

The Estancia Basin in Valencia County is assigned a low potential for petroleum occurrence (Map 9). Although favorable reservoirs may be present in the area and favorable source rocks may occur in the basin, no obvious trapping mechanisms are present. Almost the entire Paleozoic section is exposed along the Montosa fault and therefore is probably flushed with fresh water.

<u>Potential for Development</u>--Petroleum is a marketable commodity that will be in great demand well into the twenty-first century. The major uses of petroleum are: (1) a major energy source, and (2) feedstock for the petrochemical industry. Because of the great demand for petroleum, any accumulations of commercial size discovered in the future in Valencia County will almost certainly be developed and produced. Oil pools are readily developed because oil can be conveniently shipped by trucks from the wellsite to the refinery. The transportation of natural gas from the wellsite to the gas processing plant is almost always through an underground pipeline and therefore gas pools are generally not developed as easily as oil pools. The proximity of Valencia County to the major metropolitan area of Albuquerque and the presence of segments of several large gas

pipelines in the county (U.S. Geological Survey and NMBMMR, 1981) ensures that any gas pools that will be discovered will also be developed and produced.

Uranium (by V. T. McLemore)

Although there has not been any production of uranium from Valencia County, a few occurrences are found in the Scholle and Rio Puerco districts (Fig. 9; Appendix 1), where uranium occurs in small discontinuous stratabound, sedimentary-copper deposits (previously discussed). Uranium concentrations rarely exceed 0.08% U_3O_8 (McLemore, 1983, 1984). The mineral-resource potential for uranium as a byproduct of copper mining is low to moderate in the Scholle district and low in the Rio Puerco district (Fig. 11; Maps 1, 3).

Uranium anomalies in the NURE stream-sediment samples are found in the Manzano Mountains (McLemore, 1984; McLemore et al., 1986a) and in the Lucero area (McLemore et al., 1984; 1986a). The anomalies in the Manzano Mountains suggest that uranium may occur in Precambrian greenstones with precious metals or in the overlying Bosque metasediments or adjacent Precambrian granitic rocks. One of the more likely traps for uranium in Proterozoic rocks would be at the transition from marine rocks, possibly containing algal bioherms, to nonmarine rocks without any organic material (Nash et al., 1981). Grauch (1978) briefly describes a deposit where uraninite is associated with massive sulphide mineralization near the contact between leucocratic and melanocratic metamorphic rocks. This area warrants additional study for uranium potential as the uranium-resource potential is unknown (Fig. 11; Maps 1, 2).

The uranium anomalies in the Lucero uplift are probably derived from the Grants uranium district. It is believed that these anomalies may represent a broad redox boundary produced by thermal waters associated with the Rio Grande rift (McLemore et al., 1984). Small secondary uranium deposits may have formed at depth in this area; however, there is not enough information available to determine the uranium-resource potential of this area. More work is required.

Although the Morrison and Todilto Formations crop out in northwestern Valencia County, the resource potential for uranium is very low. No occurrences have been reported in these formations in Valencia County. Both the Morrison and Todilto pinchout in this area and uranium mineralization is unlikely to occur near the pinchout.

Geothermal Resources (by V. T. McLemore and K. Klein)

Introduction--In New Mexico, geothermal energy is used for space heating and as hot water (Hatton and Peters, 1982) and several areas are being investigated for potential use for generating electricity. Geothermal resources refer to the natural concentrations of heat generated within the interior of the earth that can be extracted economically (Muffler, 1981). The major thermal areas of the world are associated with volcanism and calderas, typically of late Tertiary to Quaternary age (Godwin et al., 1971) and the source for geothermal energy in these areas is probably magmatic. Other geothermal systems are associated with active tectonic sedimentary basins where geothermal energy probably results from waters heated by a moderate geothermal gradient, and ascended from great depth along major faults without any apparent magmatic activity. Both types occur in Valencia County (Callender, 1981).

The fluid in most geothermal reservoirs is water that is held in liquid form, but above the boiling temperature, by the confining pressures. Reservoirs with hot water (between 68 and 300°F) are common, but are not used to generate electricity. Some geothermal systems contain dry steam without any water (Godwin et al., 1971). Hydrothermal reservoirs are classified as high-temperature (>300°F or 150°C), intermediate-temperature (194°-300°F or 90°-150°C), and low-temperature (68°-194°F or 20°-90°C). However, these convective hydrothermal systems have a restricted distribution where they can be economically tapped (depths less than 15,000 ft) and are of limited potential.

The Geothermal Steam Act of 1970 established criteria for the USGS to utilize in designating areas that are prospectively valuable for geothermal resources; these areas are termed KGRA (Known Geothermal Resource Areas; Godwin et al., 1971). The New Mexico State Land Office also designates favorable areas for potential geothermal reservoris; these areas are termed KGRF (Known Geothermal Resource Fields; Hatton and Peters, 1982; Hatton, 1977, 1980, 1981a, b).

<u>Geology</u>--Although no KGRA's have been delineated by the USGS in Valencia County, one KGRF (#4) has been identified by the New Mexico State Land Office in western Valencia County (Fig. 24, Map 13) on the basis of high heat flow (Reiter et al., 1975, 1978,

1979), late Tertiary to Quaternary volcanism (Callender et al., 1983), and presence of geothermal wells and springs (Table 14; Summers, 1965a). The average heat flow along the Rio Grande rift is about 2.56 $\pm$ 0.63 HFU (heat flow units; Reiter et al., 1975, 1978, 1979; Edwards et al., 1978). Numerous volcanoes and lava-capped mesas occur along the Lucero uplift (Kasten, 1977; Kelley and Kudo, 1978; Gambill, 1980; Callender et al., 1983); some of these volcanoes are only 190,000 yrs old (Kudo, 1982; Kudo et al., 1977; Bachman and Mehnert, 1978). Geothermal wells in the area range in temperature up to 375°F (191°C; Table 14) and geothermal springs range up to 86°F (30°C; Table 14; McLemore et al., 1986b).

Geophysical studies elsewhere within the Rio Grande rift indicate that geothermal waters occur near buried magma bodies or along major faults in the subsurface (Callender, 1981). Several studies suggest a shallow magma body lies beneath the Lucero uplift (Ander and Huestis, 1978; Ander, 1980). The mean reservoir temperature is about 80°F (Mariner et al., 1983). Geochemical studies of the groundwater and presence of extensive travertine deposits also support the presence of a geothermal reservoir in the Lucero area (Trainer and Lyford, 1979; Titus, 1963; Goff et al., 1983); however, complex faulting hampers development of potential reservoirs.

The geothermal resource potential has not been examined in detail in eastern Valencia County near the Manzano Mountains. Travertine deposits and a few volcanic and intrusive rocks occur in the area, suggesting that a major fault system underneath the alluvium is present (Grant, 1982). However, additional data is

Figure 24 - Geothermal areas and resource potential in Valencia County, New Mexico.

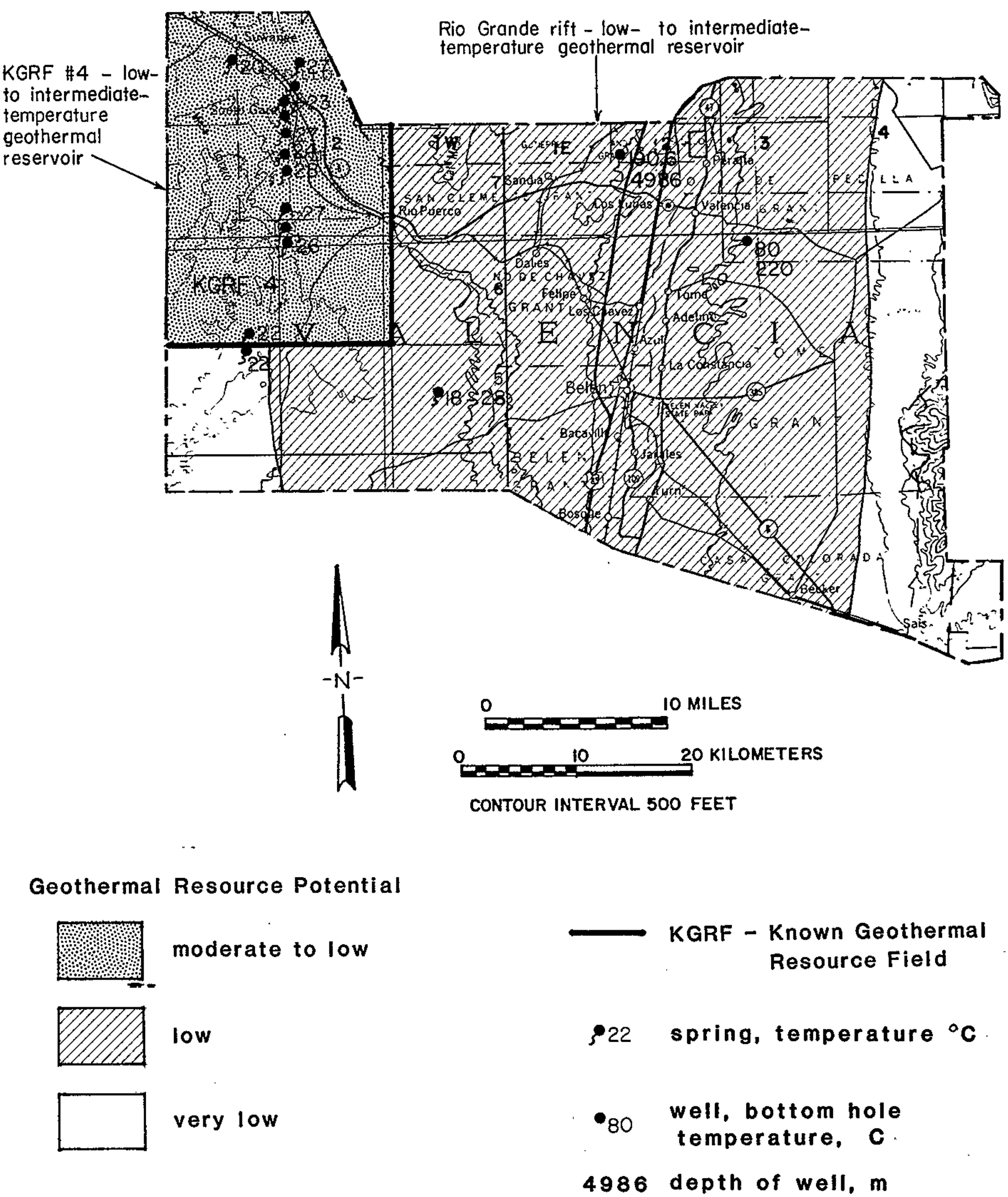


Table 14 — Geothermal wells and springs in Valencia County.

Name	Location	Temp. °C	Temp. °F	Depth of well (m)	Comments	References
Valencia County						
Spring	5N.1W.16	18-28	64-82			Summers (1965b); Stearns et al. (1937)
Spring	5N.3W.2.100	22	72			Bliss (1983); Berry et al. (1980); Swanberg (1980)
Unnamed Well	6N.3E.5.234	80	176	220		Bliss (1983); Summers (1976)
Spring	6N.2W.6.340	26	78			Summers (1965b); Wright (1946); Swanberg (1980)
Spring (salt)	6N.2W.6.430	26	79			Bliss (1983); Berry et al. (1980)
Spring	6N.3W.35.340	22	71			Summers (1965b); Wright (1946); Titus (1963)
Shell No. 1	7N.2E.7	190.6	375	4,986	bottom hole temp.	Grant (1982)
Spring	7N.2W.6.400	27	80			Summers (1965b); Titus (1963)
Laguna Pueblo Spring	7N.2W.6.444 & .210	27	68			Swanberg (1980); Bliss (1983); Berry et al. (1980); Titus (1963); Summers (1965b)
Spring (salt)	7N.2W.7.124	24	76			Berry et al. (1980); Summers (1965b); Wright (1946); Titus (1963); Bliss (1983); Swanberg (1980)
Spring	7N.2W.7.320	>18	>65			Summers (1965b); Titus (1963)
Spring	7N.2W.7.340	≥18	≥65			Summers (1965b); Wright (1946)
Laguna Pueblo Seeps	7N.2W.18.140, .132 & .313	28	82			Bliss (1983); Berry et al. (1980); Titus (1963); Summers (1965b); Swanberg (1980)
Unnamed Spring	7N.2W.30	24	75			Summers (1965b); Wright (1946); Titus (1963)
Unnamed Spring	7N.2W.30	28	82			Summers (1965b); Wright (1946); Titus (1963)
Unnamed Spring	7N.2W.30	22	72			Summers (1965b); Wright (1946); Titus (1963)
Spring (salt)	7N.2W.30 N1/2	30	86			Summers (1965b); Bliss (1983); Berry et al. (1980); Swanberg (1980); Titus (1963); Wright (1946)
Spring	7N.2W.31.140	27	80			Swanberg (1980); Summers (1965b); Wright (1946); Bliss (1983); Berry et al. (1980)
Quelities Mineral Spring	8N.2W.17	27	80			Summers (1965b); Stearns et al. (1937)
El Ojo Escondido	8N.2W.19.421	23	73			Summers (1965b); Swanberg (1980); Bliss (1983); Berry et al. (1980); Titus (1963); Wright (1946)
Spring	8N.2W.30.340	23	73			Summers (1965b); Wright (1946); Swanberg (1980)
Spring	8N.2W.30.340	22	72			Summers (1965b); Hood and Kister (1962)
Unnamed Spring	8N.2W.31.100	23	73			Bliss (1983); Berry et al. (1980)
Unnamed Spring	8N.3W.15.431	20	68			Bliss (1983); Berry et al. (1980); Summers (1965b); Swanberg (1980)

needed.

Resource and development potential--The geothermal resource potential in the Lucero uplift is moderate to low for low- to intermediate-temperature geothermal reservoirs (Fig. 24; Map 13). The geothermal resource potential elsewhere in the Rio Grande rift is low for low- to intermediate-temperature geothermal reservoirs (Fig. 24; Map 12). Elsewhere in Valencia County the geothermal-resource potential is very low because of lack of magmatic activity, low-temperature springs, and depth to major fault systems. The potential for development would be moderate near Los Lunas and Belen, but low elsewhere in Valencia County.

Coal (by V. T. McLemore)

General description--The southern portion of the Rio Puerco coal field extends into northwestern Valencia County; however, production has been restricted to the north in Sandoval and Bernalillo Counties (McLemore et al., 1984, pp. 214-217). The mining occurred in the 1920's through the 1940's, but only minor production was reported.

Geology--The Rio Puerco coal field occurs in the Dilco and Gibson Members of the Crevasse Canyon Formation (Cretaceous). Several coal beds of economic thickness occur in the Gibson Member; however, the Rio Puerco fault zone breaks the coal beds into narrow, lenticular, steeply-dipping fault blocks.

The average thickness is 2.5 ft and the average as-received heating value for coal in this area is 10,278 Btu/lb, indicating a rank of subbituminous A to high volatile C bituminous. The ash content is low (8.0%) and sulfur content is relatively high

(McLemore et al., 1984, p. 215).

Resource and development potential--The coal resource potential of the Rio Puerco field is low because of thin coal beds, high-angle faulting, and insufficient data on coal quality. Drilling in this area would help to evaluate the resource potential. Development potential of the Rio Puerco coal field is low because of faulting of the beds and lack of transportation (McLemore et al., 1984, pp. 216-217).

SUMMARY

As is true with all preliminary investigations, additional studies are necessary to adequately assess the mineral-resource potential in Valencia County. These assessments must be re-evaluated as economic conditions, geologic interpretations, and models change.

The mineral-resource potentials for various commodities in Valencia County are summarized in Table 15 and Figures 11, 15, 16, 17, 18, 19, 21, and 24. The most important commodity in Valencia County is travertine used for dimension stone in the Lucero uplift. High potential also exists for sand and gravel, limestone, adobe material, and crushed and dimension stone. Moderate potential exists for Cu-Au-Ag (±U, Pb) in Precambrian rocks, gypsum, scoria and cinders, silica sand, zeolites, and petroleum. Additional work is necessary to calculate reserves and resources in these areas.

Table 15 - Summary of mineral-resource potential in Valencia County. See Figures 11, 15, 16, 17, 18, 19, 21, and 24 for specific locations.

Commodity or type of deposit	Formation	Geographic location	Mineral-resource potential
Cu-Au-Ag (± U, Pb)	Precambrian greenstones or metasedimentary rocks	Hell Canyon district Manzano Mountains	moderate unknown
Placer Au	Quaternary or Tertiary gravels	Manzano Mountains, Albuquerque Basin	unknown
Stratabound sedimentary Cu-U deposits (± Ag)	Permian and Pennsylvanian sedimentary rocks	Scholle district	moderate to low
	Permian and Triassic sedimentary rocks	Rio Puerco district	low
Barite and fluorite	—	Valencia County	low
Adobe	Quaternary deposits	Valencia County	high
Crushed and dimension stone	Precambrian rocks Permian Abo Formation, Pennsylvanian Wild Cow and Bursum Formations	Various localities in in Manzano Mountains and Lucero uplift	high to moderate
Gypsum	Permian Yeso and San Andres Formations	Lucero uplift	moderate
Kyanite	Precambrian White Ridge quartzite and Sevilleta Formation	Manzano Mountains	low
Lightweight aggregate	Tertiary scoria and cinders	Cat Hills Manzano Mountains	moderate moderate
	Paleozoic and Cretaceous shales (expansible)	Lucero uplift and Manzano Mountains	unknown
Limestone and travertine	Paleozoic limestones and Quaternary travertines	Lucero uplift and southern Manzano Mountains	high
Mica	Precambrian rocks	Manzano Mountains	low
Sand and gravel	Quaternary and Tertiary deposits	Valencia County	high
Silica sand	Permian Glorieta Sandstone Member	Lucero uplift	unknown
	Precambrian Sais Quartzite	Manzano Mountains	moderate
Zeolites	Tertiary-Quaternary Santa Fe Group	Albuquerque Basin	low
Petroleum	Paleozoic and Mesozoic sedimentary rocks	Albuquerque Basin, Rio Puerco Fault zone	moderate
Geothermal	—	Lucero uplift	moderate to low
Coal	Cretaceous rocks	Rio Puerco field	low

RECOMMENDATIONS

1) Detailed geologic mapping and geochemical studies in Precambrian terranes in the Manzano Mountains are needed to determine the mineral-resource potential for base- and precious-metals and uranium.
2) Isopach facies and structure-contour maps of several formations in the Rio Grande valley in central Valencia County should be completed in order to delineate favorable areas for oil and gas accumulations.
3) Aggregate resources should be mapped and sampled in greater detail prior to extraction of such materials.
4) Any areas with active claims should be examined (Fig. 10).
5) Geologic mapping and geochemical studies are required on the Luerco uplift to evaluate the resource potential.
6) Area near the Manzano Mountains should be examined for geothermal resource potential.
7) Drilling is required in the Rio Puerco coal field in northwestern Valencia County to aid in evaluating the coal resource potential.
8) The rating of unknown for vermiculite and expansible shale does not imply that the potential is low. Rather, the appropriate rock types are present but need to be examined in more detail specifically for these resources.

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APPENDIX 1

MINERAL AND OTHER COMMODITY OCCURRENCES, DEPOSITS, AND MINES IN VALENCIA COUNTY

Introduction

The following compilation of mineral and other commodity occurrences (excluding oil, gas, and CO_2 tests) is the most comprehensive tabulation of mineral occurrences in the area. It is probable that additional occurrences will be discovered in the future. For the purposes of this report, any locality where mineralization or potential economic materials are found is considered an occurrence, including sand and gravel (materials) pits. Each occurrence is plotted on Maps 1-6. Mineral occurrences are arranged by township and range.

Each description is a brief account of the location, commodities present, production, and geology of the occurrence that was compiled from the literature, unpublished sources, and field reconnaissance.

Explanation of descriptions

The descriptions of mineral occurrences in this section are brief summaries of published and unpublished information. However, not all of the available information could be included; information for some occurrences is considered confidential by a company or the information is very extensive. Very little information could be obtained for some occurrences. Each description consists of 12 entries or less (depending on available information), and the entries are listed by number as described below.

1: Occurrence number refers to the location or approximate location of each mineral occurrence, prospect, deposit, or mine. The numbering system used is based upon the township, range, and section land-grid system (Fig. 1-1) and is used by the New Mexico State Engineer for numbering water wells and springs. By this system, each occurrence has a unique location number consisting of four parts separated by periods (e.g., 3N.5E.15.441). The first part refers to the township, the second part to the range, and the third part to the section. The fourth part places the occurrence within the nearest quarter-quarter-quarter section block as indicated in Figure 1-1. An occurrence designated 3N.5E.15.441 is located in the NW1/4 SE1/4 SE1/4 of section 15, T. 3 N., R. 5 E. Some occurrences are located only to the nearest section, quarter-section, or quarter-quarter section because the occurrence can not be located more accurately or the occurrence extends over the entire given area. Some occurrences are listed by township and range and located in the center of the township. In unsurveyed areas the locations are approximated by projecting section lines.

2: Name of the occurrence, prospect, deposit, or mine as found in the literature. Aliases are given in parentheses.

3: Location of the occurrence by the section, township, and range and by latitude and longitude.

4: Names of the 7 1/2-minute or 15-minute topographical quadrangle maps; the 30-minute by 60-minute topographical quadrangle map is in parentheses.

5: Mining district or geographical area.

6: Commodities present at the locality.

7: The extent of development or prospecting.

8: Production statistics for various commodities.

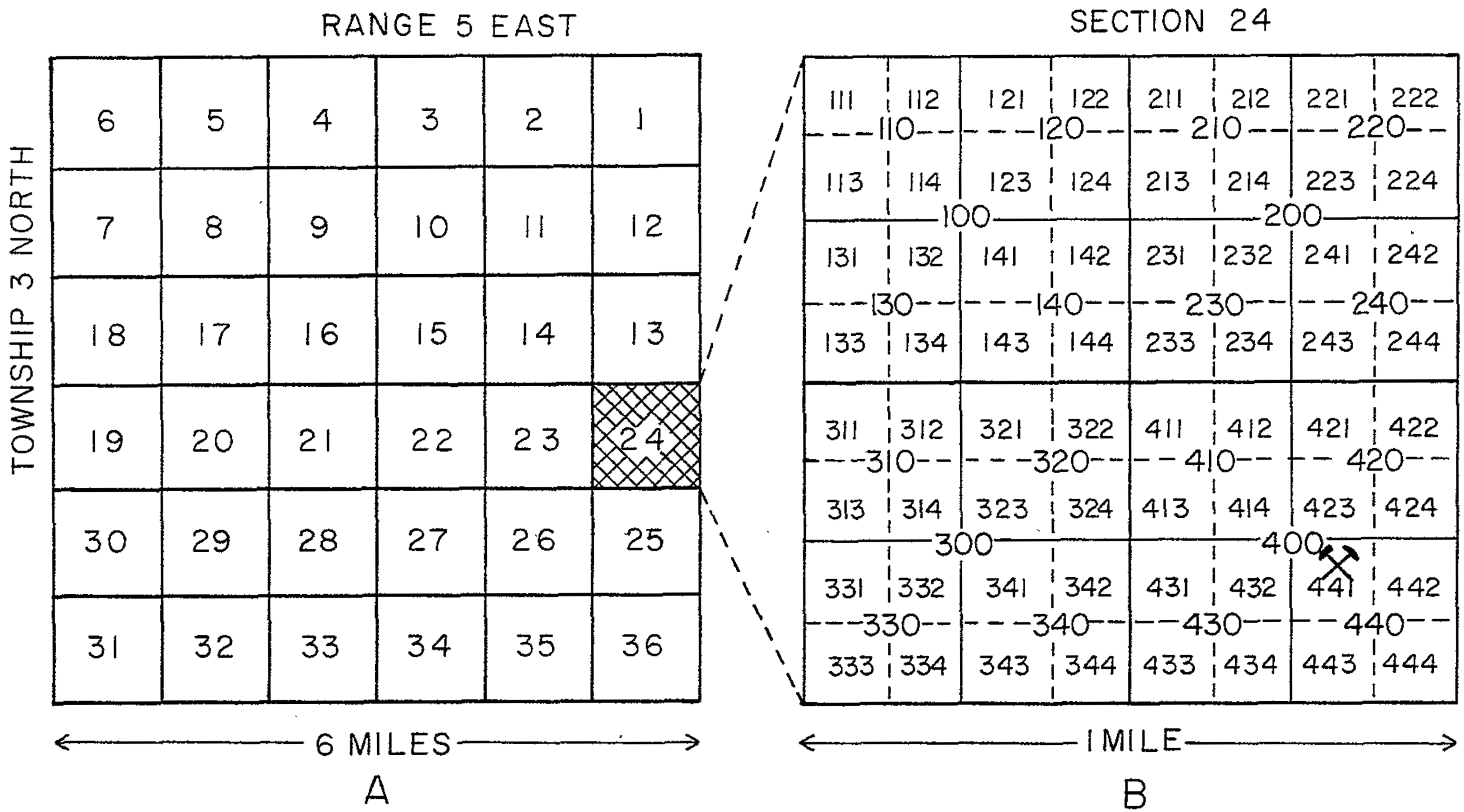
9: The formation name and geologic age of the host rock.

10: Brief description of the geology, host rock, and character of the deposit; including chemical analyses and other pertinent information.

11: Comments or additional information.

12: References or sources of information are listed in an abbreviated form and arranged in chronological order. Published reports are listed with last name of author(s) and year of publication in parentheses; the complete citation may be found in the reference section. Unpublished sources are abbreviated as follows: FN (field notes); NMBMMR files (New Mexico Bureau of Mines and Mineral Resources unpublished files); USAEC files (U.S. Atomic Energy Commission files); PRR (Preliminary Reconnaissance Reports of the Atomic Energy Commission); USBM files (U.S. Bureau of Mines files); USBLM (U.S. Bureau of Land Management files); CRIB (Computerized Resource Information Bank, U.S. Geological Survey); MILS (Mineral Industry Location Survey, U.S. Bureau of Mines); NMSHD (New Mexico State Highway Department, 1975); PC (personal communication); and WC (written communication). Copies of most of these reports are available for inspection at the New Mexico Bureau of Mines and Mineral Resources.

FIGURE 1-1 - Numbering system used in this report.
A - Subdivision of a township into sections.
B - Subdivision of a section into quarter-quarter-quarter section blocks. Mine symbol indicates location of an occurrence numbered 3N.5E.24.441.



VALENCIA COUNTY
METALS

1: 3N.5E.21.340
2: Santa Fe Claims (Unknown-Scholle)
3: SW1/4 21 T3N R5E 34°28'00"N 106°26'00"W
4: Scholle 7-1/2 Elevation 5,800 ft (Socorro)
5: Scholle district-Manzano Mountains
6: Cu, U, V, Ag
7: numerous open cuts, trenches
8: no production
9: Permian Abo Formation
10: radioactive minerals associated with copper oxides in red and gray arkose and siltstone
12: FN 6/26/81; McLemore (1983); Myers (1977); USBLM files (1984)

1: 3N.5E.21.421
2: Santa Crucis Claims (Unknown-Gravel Pit)
3: CE1/2 21 T3N R5E 34°28'00"N 106°26'00"W
4: Scholle 7-1/2 Elevation 5,860 ft (Socorro)
5: Scholle district-Manzano Mountains
6: Cu, U, V, Ag, stone
7: several shallow open cuts, trenches
8: no metals production; shipped 4 tons of landscaping stone
9: Permian Abo Formation
10: radioactive minerals associated with copper oxides and organic debris in arkose and siltstone
11: labeled as Gravel Pit on topographic map
12: FN 6/26/81; McLemore (1983); Myers (1977); USBLM files (1984)

1: 3N.5E.28
2: Santa Crucis Claims
3: C28 T3N R5E
4: Scholle 7-1/2 (Socorro)
5: Scholle district-Manzano Mountains
6: Cu
7: no development
8: no production
9: Permian Bursum Formation
10: sandstone copper occurrence
12: DeCicco, et al. (1979)

1: 3N.5E.31.422
2: Santa Crucis Claims
3: SE1/4 31 T3N R5E
4: Scholle 7-1/2 Elevation 5,750 ft (Socorro)
5: Scholle district-Manzano Mountains
6: Cu, Ag
7: several shallow open cuts
8: no production
9: Pennsylvanian Wild Cow Formation
10: copper sandstone deposits in arkosic conglomerate, very small occurrences 1/4 in thick and 3-4 in long; 24 ppm gallium reported (USBLM files, 1984)
12: FN 11/7/82; Myers (1977); USBLM files (1984)

1: 3N.5E.33.230
2: Abo Milling and Manufacture Co. (Blue Star)
3: NE1/4 33 T3N R5E 34°26'45"N 106°24'00"W
4: Scholle 7-1/2 Elevation 5,860 ft (Socorro)
5: Scholle district-Manzano Mountains
6: Cu, U, V, Ag
7: adit, 20-ft shaft, pits, trenches
8: production unknown
9: Permian Abo Formation
10: radioactive minerals associated with copper oxides in red and bleached gray arkose and limey conglomerates
11: private property owned by Clarence Pohl
12: FN 6/24/81; McLemore (1983); Myers (1977); Phillips (1960)

1: 4N.4E.11.130
2: Cordova
3: E C 11 T4N R4E (unsurveyed)
4: Torreon 15 (Belen)
5: Manzano Mountains
6: Au, Ag
7: 42-ft trench; 44-ft trench; shaft (flooded)
8: no production
11: mine map (Light, 1982)
12: Maxwell et al. (1983); Light (1982); USBLM files (1978)

1: 4N.4E.12.300
2: Unknown
3: SW1/4 12 T4N R4E (unsurveyed)
4: Torreon 15 (Belen)
5: Manzano Mountains
6: Au, Ag
7: 210-ft adit
8: no production
11: mine map (Light, 1982)
12: Maxwell et al. (1983); Light (1982); Maxwell and Wobus (1982b)

1: 5N.4E.24.100
2: Cañon de Salas
3: NW1/4 24 T5N R4E (unsurveyed) 34°39'00"N 106°28'45"W
4: Capilla Peak 7-1/2 Elevation 6,250 ft Torreon 15 (Belen)
5: Manzano Mountain
6: Au, Cu, Pb
7: 10-ft adit
8: no production
9: Precambrian argillaceous metasedimentary rocks
10: minor pyrite, chalcopyrite, and galena in quartz vein
11: mine map (Light, 1982)
12: Maxwell et al. (1983); Light (1982); Maxwell and Wobus (1982b)

1: 5N.4E.26.200
2: Bartolo Canyon (TG claims)
3: S1/2 23 and N1/2 26 T5N R4E (unsurveyed)
4: Capilla Peak 7-1/2, Torreon 15 (Belen)
5: Manzano Mountains
6: Au, Cu, Pb
7: 18-ft adit; 177-ft adit; 45-ft adit; 7 prospect pits
8: no production
9: Precambrian quartzites and schists
10: mineralized shears in Precambrian rocks, samples assayed trace Au, up to 0.36% oz/ton Ag, 270 ppm Cu, 3.68% Pb, and 0.014% Zn (NMBMMR chem lab)
11: mine map (Light, 1982)
12: FN 1/26/84; Maxwell and Light (1984); Maxwell et al. (1983); Light (1982); Maxwell and Wobus (1982b); Myers and McKay (1972)

1: 6N.3W.28
2: Unknown
3: C 28 T6N R3W
4: Mesa Aparejo 15 (Acoma Pueblo)
6: Cu, Ag
9: Permian(?)
10: stratabound sedimentary copper deposits
12: North and McLemore (1984); DeCicco et al. (1979); U.S. Bureau of Mines Mineral Yearbooks (1929, 1956)

1: 8N.5E.20.441
2: Unknown
3: SE1/4 20 T8N R5E
4: Mt. Washington 7-1/2 (Belen)
5: Hell Canyon district
6: Au, Ag, Cu
7: pit
8: no production
9: Precambrian greenstone and Pennsylvanian Madera Group
10: mineralized fault zone at contact
12: Parchman (1982)

1: 8N.5E.28.123
2: Lady Betsy
3: 28 T8N R5E
4: Mt. Washington 7-1/2 (Belen)
5: Hell Canyon district
6: Cu, Au, Ag
7: prospect pits
8: no production
9: Precambrian quartzite
11: patent #385881, mineral survey #1507
12: McLemore et al. (1984); Parchman (1982); NMBMMR files (1914)

1: 8N.5E.29.242
2: Milagros (including Star shaft)
3: NE1/4 29 T8N R5E 34°53'37"N 106°25'48"W
4: Mt. Washington 7-1/2 Elevation 6,300 ft (Belen)
5: Hell Canyon district
6: Au, Ag, Cu
7: 2 adits and shaft--open pit in 1970's, prospect pits
8: 2,724 oz Au, 3,349 oz Ag, 7,900 lbs Cu 1880-1976 (estimated production)
9: Precambrian greenstone
10: mineralized quartz vein and shears in greenstone, assays as high as 1.32 oz/ton Au and 1.23 oz/ton Ag reported by Parchman (1981)
11: patented claims; mine map of original underground workings by Woodward et al. (1978)
12: FN 9/28/83; Parchman (1982); Woodward et al. (1979); Woodward et al. (1978); Chisholm (1975); Myers and McKay (1970); CRIB (1982)

1: 8N.5E.29.421
2: Belvidere (Cerro del Oro)
3: SE1/4 29 T8N R5E
4: Mt. Washington 7-1/2 (Belen)
5: Hell Canyon district
6: Au, Ag, Cu
8: In 1955, 5,900 lbs Cu and 12 oz Ag produced
9: Precambrian greenstone
10: mineralized quartz vein and shears in greenstone
11: Elston (1967) mentions that this claim was prospected for platinum, however, no platinum has been found
12: Parchman (1982); Woodward et al. (1979); Woodward et al. (1978); Fulp et al. (1982); NMBMMR files (1979)

1: 8N.5E.33
2: Unknown
3: S1/2 33 T8N R5E
4: Bosque Peak 7-1/2 Elevation 6,320 ft (Belen)
5: Manzano Mountains
6: Au, Cu, Ag
7: prospect pit
8: no production
9: Precambrian greenstone
10: small occurrences of copper and gold in mafic volcanic rocks; sample collected several hundred feet south (Torrance County) assayed 0.027 oz/ton Ag, 80 ppm Cu, and <0.001 oz/ton Au
12: Edwards (1978)

VALENCIA COUNTY
INDUSTRIAL MINERALS AND MATERIALS PITS

1: 3N.3E.1
2: Belen Kyanite
3: 1 T3N R3E, 35 T4N R3N (unsurveyed) 34°31'05"N 106°28'45"W
4: Torreon 15 (Belen)
5: Manzano Mountains
6: kyanite
7: no workings
8: no production
9: Precambrian White Ridge quartzite
10: small, steeply dipping zones of pure kyanite up to 15 ft wide and about 1 mi long
12: Stark (1956); Jicha (1951)

1: 3N.5E.21.420
2: Santa Cruces
3: E1/2 21 T3N R5E
4: Scholle 7-1/2 (Socorro)
6: stone
7: developed pit--active
8: 4 tons of building and landscaping stone shipped
9: Permian Abo Formation
12: MILS (1981); USBLM files (1985)

1: 3N.5E.32.122
2: Pit #57138
3: NE1/4, NE1/4, NW1/4, 32 T3N R5E 35°20'57"N 106°27'34"W
4: Scholle 7-1/2 (Socorro)
6: sand and gravel
7: pit
9: Quaternary alluvium
10: 25,000 cu yds
12: MILS (1981); Hunt (1978)

1: 3N.5E.32.311
2: Unnamed Pit
3: NW1/4, NW1/4, SW1/4, 32 T3N R5E 34°28'16"N 106°25'9"W
4: Scholle 7-1/2 (Socorro)
6: sand and gravel
7: pit
9: Pennsylvanian Wild Cow Formation
12: MILS (1981); Hunt (1978)

1: 4N.1E.11.200
2: Pit #55104
3: NE1/4 11 T4N R1E
4: Veguita 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary Santa Fe Formation
10: 12 ft thick, fair quality, 200,000 cu yds
12: NMSHD (1977, p. 53-1); Hunt (1978)

1: 4N.2E.9
2: Unnamed Pit
3: 9 T4N R2E 34°35'13"N 106°44'9"W
4: Turn 7-1/2 (Belen)
6: sand and gravel
12: MILS (1981)

1: 4N.2E.33.300
2: Pit #55103
3: SW1/4 33 T4N R2E
4: Veguita 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary alluvium
10: 8 ft thick, good quality, 200,000 cu yds
12: NMSHD (1977, p. 53-1); Hunt (1978)

1: 4N.3E.6.300
2: Pit #57104 (57-104-F)
3: SW1/4 6 T4N R3E
4: Turn 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary intermediate pediment deposits
10: 6-ft thick, good quality, 100,000 cu yds
12: NMSHD (1977, p. 53-1); Hunt (1978)

1: 5N.1E.11.400
2: Pit #6401
3: SE1/4 11 T5N R1E
4: Belen 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary Santa Fe Formation
10: sand and gravel, 20 ft thick, good quality, 250,000 cu yds
12: NMSHD (1977, p 53-2); Hunt (1978)

1: 5N.1E.14.400
2: Pit #5455
3: SE1/4 14 T5N R1E
4: (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary Santa Fe Formation
10: sand and gravel, 76 ft thick, fair quality, 500,000 cu yds
12: NMSHD (1977, p. 53-1); Hunt (1978)

1: 5N.1E.36.310
2: Unnamed Pit
3: NW1/4, SW1/4 36 T5N R1E 34°36'48"N 106°47'44"W
4: Veguita 7-1/2 (Belen)
6: sand and gravel
12: MILS (1981)

1: 5N.2E.3.140
2: Unnamed Pit
3: SE1/4 NW1/4 3 T5N R2E 34°40'48"N 106°44'4"W
4: Tome 7-1/2 (Belen)
6: sand and gravel
12: MILS (1981); Hunt (1978)

1: 5N.2E.3.400
2: Pit #57143 (Belen Pit)
3: SE1/4 4 T5N R2E
4: Tome 7-1/2 (Belen)
6: sand and gravel
7: developed pit - active
8: production unknown
9: Quaternary Santa Fe Formation
10: 12+ ft thick, good quality, 100,000 cu yds
12: NMSHD (1977, p. 53-2); Hunt (1978)

1: 5N.2E.9
2: Unnamed Pit
3: E1/2 9 T5N R2E 34°40'29"N 106°43'59"W
4: Tome 7-1/2 (Belen)
6: sand and gravel
12: MILS (1981); Hunt (1978)

1: 5N.3W.12.331
2: Rocky Mountain Stone Co. #1-5 (Lucero)
3: 12, 13 T5N R3W
4: Mesa Aparejo 15 (Acoma Pueblo)
6: travertine
7: 6 open pits (quarries)
8: active; 4,800 tpy; produced intermittently since 1950's
9: Quaternary travertine deposits
11: estimate of reserves 700,000,000 cu yds
12: Barker et al. (1984); USBLM files (1984); Zilinski (1976)

1: 5N.4E.4.300
2: Pit #0919
3: SW1/4 4 T5N R4E
4: Tome NE 7-1/2 (Belen)
6: limestone
7: prospect pit
8: production unknown
9: Quaternary alluvium
10: 10 ft thick, good quality, 200,000 cu yds
12: NMSHD (1977, p. 53-5)

1: 5N.4E.22.400
2: Pit #0920
3: SE1/4 22 T5N R4E
4: Tome NE 7-1/2 (Belen)
6: stone
7: prospect pit
8: production unknown
9: Precambrian quartzite
10: 75 ft thick, good quality, 500,000 cu yds
12: NMSHD (1977, p. 53-5)

1: 5N.4E.34.400
2: Pit #0921
3: SE1/4 34 T5N R4E
4: Tome SE 7-1/2 (Belen)
6: sand and gravel
7: pit
8: production unknown
9: Quaternary alluvial fan deposits
10: gravel, 25 ft thick, good quality, 175,000 cu yds
12: NMSHD (1977, p. 53-4)

1: 5N.1W.11
2: Materials Pit 66-1-F
3: S1/2 N1/2 11 T5N R1W 34°40'33"N 106°48'29"W
4: Belen NW 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: quaternary Santa Fe Formation
10: 250,000 cu yds
12: MILS (1981)

1: 5N.3W.13
2: Marble USA
3: 13 T5N R3W
4: Mesa Aparejo (Acoma Pueblo)
6: travertine
8: no production
9: Quaternary travertine deposits
12: NMSHD files (1985)

1: 5N.3W.23
2: Marble USA
3: 23 T5N R3W
4: Mesa Aparejo (Acoma Pueblo)
6: travertine
8: no production
9: Quaternary travertine deposits
12: NMSHD files (1985)

1: 5N.3W.24
2: Marble USA
3: 24 T5N R3W
4: Mesa Aparejo (Acoma Pueblo)
6: travertine
8: no production
9: Quaternary travertine deposits
12: NMSHD files (1985)

1: 5N.3W.26
2: Marble USA
3: 26 T5N R3W
4: Mesa Aparejo (Acoma Pueblo)
6: travertine
8: no production
9: Quaternary travertine deposits
12: NMSHD files (1985)

1: 5N.3W.27
2: Marble USA
3: 27 T5N R3W
4: Mesa Aparejo (Acoma Pueblo)
6: travertine
8: no production
9: Quaternary travertine deposits
12: NMSHD files (1985)

1: 5N.3W.28
2: Marble USA
3: 28 T5N R3W
4: Mesa Aparejo (Acoma Pueblo)
6: travertine
8: no production
9: Quaternary travertine deposits
12: NMSHD files (1985)

1: 5N.3W.33
2: Marble USA
3: 33 T5N R3W
4: Mesa Aparejo (Acoma Pueblo)
6: travertine
8: no production
9: Quaternary travertine deposits
12: NMSHD files (1985)

1: 5N.3W.34
2: Marble USA
3: 34 T5N R3W
4: Mesa Aparejo (Acoma Pueblo)
6: travertine
8: no production
9: Quaternary travertine deposits
12: NMSHD files (1985)

1: 5N.3W.35
2: Marble USA
3: 35 T5N R3W
4: Mesa Aparejo (Acoma Pueblo)
6: travertine
8: no production
9: Quaternary travertine deposits
12: NMSHD files (1985)

1: 6N.1E.36.300
2: Pit #5456
3: SW1/4 36 T6N R1E
4: Belen 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary Santa Fe Formation
10: 10 ft thick, good quality, 150,000 cu yds
12: NMSHD (1977, p. 53-1); Hunt (1978)

1: 6N.2E.1.442
2: Unnamed Pit
3: NE1/4 SE1/4 SE1/4 1 T6N R2E 34°46'16"N 106°40'32"W
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary terrace deposits
10: good quality
12: BLM files (1985)

1: 6N.3E.6
2: Materials Pit 68-22-S
3: S1/2 6 T6N R3E 34°51'23"N 106°40'17"W
4: Los Lunas 7-1/2 (Belen)
6: limestone
10: limestone
12: MILS (1981); Hunt (1978)

1: 6N.3E.6.111
2: JHT Sand and Gravel (Tome Pit)
3: NW1/4 NW1/4 NW1/4 6 T6N R3E 34°46'53"N 106°40'24"W
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: up to 300,000 cu yds removed (12/17/85)
9: Quaternary terrace deposits
10: good quality
12: New mines registration (1982); NMSMI files (1985)

1: 6N.3E.6.111
2: Saiz Sand and Gravel
3: NW1/4 NW1/4 NW1/4 6 T6N R3E 34°46'53"N 106°40'24"W
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
7: developed pit - active
8: approximately 200,000 cu yds removed
9: Quaternary terrace deposits
10: good quality
12: NMSMI files (1985); BLM files (1985); New mines listing (1986)

1: 6N.3E.7.200
2: Pit #6822
3: NE1/4 7 T6N R3E
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary terrace deposits
10: 10 ft thick, excellent quality, 250,000 cu yds
12: NMSHD (1977, p. 53-3); Hunt (1978)

1: 6N.4E.13.200
2: Pit #0707
3: NE1/4 13 T6N R4E
4: Tome NE 7-1/2 (Belen)
6: sand and gravel
7: prospect pit
8: production unknown
9: Quaternary alluvial fan deposits
10: 50 ft thick, good quality, 565,000 cu yds
12: NMSHD (1977, p. 54-3)

1: 6N.2W.12.230
2: Pit #0918
3: NE1/4 12 T6N R2W
4: Rio Puerco 7-1/2 (Belen)
6: sand and gravel
7: prospect pit
8: production unknown
9: Quaternary deposits
10: 2-10 ft thick, good quality, 175,000 cu yds
12: NMSHD (1977, p. 53-4)

1: 7N.1E.25.400
2: Pit #6529
3: SE1/4 25 T7N R1E
4: Dalies 7-1/2 (Belen)
6: stone
7: developed pit
8: production unknown
9: Quaternary basalt
10: 12 ft thick, good quality, 500,000 cu yds
12: NMSHD (1977, p. 53-2); Hunt (1978)

1: 7N.1E.36.400
2: Pit #57136
3: SE1/4 36 T7N R1E
4: Dalies 7-1/2 (Belen)
6: stone
7: developed pit
8: production unknown
9: Quaternary basalt
10: 70+ ft thick, good quality, 150,000 cu yds
12: NMSHD (1977, p. 53-2); Hunt (1978)

1: 7N.2E.19.200
2: Materials Pit 65-29-S
3: NE1/4 19 T7N R2E 34°48'7"N 106°46'59"W
4: Dalies 7-1/2 (Belen)
6: stone
12: MILS (1981); Hunt (1978)

1: 7N.2E.25
2: John Pit and screening plant (Nino's pit, screening pit)
3: 25 T7N R2E 34°48'31"N 106°40'29"W
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
7: active pit since 1978
9: Quaternary deposits
12: MILS (1981); New Mexico State Mine Inspector's files (1978); Hunt (1978)

1: 7N.2E.25.100
2: Corona Pit and Crusher
3: NW1/4 25 T7N R2E 34°48'27"N 106°41'21"W
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
12: MILS (1981); New Mines Listings (1973)

1: 7N.2E.31
2: Materials Pit 65-28-F
3: C, W1/2 31 T7N R2E 34°47'54"N 106°46'48"W
4: Dalies 7-1/2 (Belen)
6: sand and gravel
12: MILS (1981)

1: 7N.3E.29
2: El Cerro Plant
3: 29 T7N R3E 34°48'19"N 106°38'52"W
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
12: MILS (1981); Hunt (1978); New Mines Listings (1975)

1: 7N.3E.30.430
2: Pit #7301 (73-01-S)
3: SW1/4 30 T7N R3E 34°48'2"N 106°39'57"W
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary Santa Fe Formation
10: 14 ft thick, good quality, 175,000 cu yds
12: MILS (1981); Hunt (1978)

1: 7N.3E.31.100
2: Pit #7208 (72-08-S)
3: NW1/4 31 T7N R3E 34°47'41"N 106°40'11"W
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary terrace deposits
10: 15 ft thick, excellent quality, 100,000 cu yds
12: MILS (1981); Hunt (1978); NMSHD (1977, p. 53-3)

1: 7N.3E.31.111
2: Nick's Sand and Gravel
3: NW1/4 NW1/4 NW1/4 31 T7n R3E 34°47'45"N 106°40'24"W
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
7: developed pit-active
8: approximately 200,000 cu yds removed
9: Quaternary terrace deposits
10: good quality
12: NMSMI files (1985); BLM files (1985); New Mines Listings (1986)

1: 7N.3E.31.113
2: Nitty Gritty Sand and Gravel
3: SW1/4 NW1/4 NW1/4 31 T7N R3E 34°47'40"N 106°40'24"W
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary terrace deposits
10: good quality, 10-25 ft thick
12: NMSMI (1985); BLM files (1985)

1: 7N.3E.31.300
2: Materials Pit 56-10-S
3: SW1/4 31 T7N R3E 34°47'17"N 106°40'11"W
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary terrace deposits
12: MILS (1981); Hunt (1978)

1: 7N.3E.31.330
2: Pit #57133 (57-133-S)
3: SW1/4 SW1/4 31 T7N R3E 34°47'5"N 106°40'18"W
4: Los Lunas 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary terrace deposits
10: 10 ft thick, good quality, 150,000 cu yds
12: MILS (1981); Hunt (1978); NMSHD (1977, p. 53-2)

1: 7N.4E.4.200
2: Pit #0917
3: NE1/4 4 T7N R4E
4: (Belen)
6: sand and gravel
7: prospect pit
8: production unknown
9: Quaternary alluvium
10: 5 ft thick, poor quality, 15,000+ cu yds
12: NMSHD (1977, p. 53-3)

1: 8N.3E.26.230
2: Pit #5704
3: NE1/4 26 T8N R3E
4: Hubbell Spring 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary Santa Fe Formation
10: 10 ft thick, good quality, 200,000 cu yds
12: NMSHD (1977, p. 53-1)

1: 8N.3E.33.140
2: Pit #6468
3: NW1/4 33 T8N R3E
4: Isleta 7-1/2 (Belen)
6: sand and gravel
7: developed pit
8: production unknown
9: Quaternary alluvium
10: 12 ft thick, good quality, 100,000 cu yds
12: NMSHD (1977, p. 53-2)

1: 8N.3W.24
2: White Eagle Gypsum Co. Quarry
3: 24 T8N R3W
4: South Garcia 7-1/2 (Acoma Pueblo)
6: gypsum
7: developed pit
8: production reproted 1954 but unknown amount
9: Jurassic Todilto Formation-Quaternary gypsite
10: gypsite (thin weathered gypsum) and gypsum 90 to 110 ft thick
11: 1952 operated for agricultural purposes by Suwanee Gypsum Products Corp., then in 1954 by White Eagle Gypsum Co., Inc.
12: Weber and Kottlowski (1959, p. 29)

APPENDIX 2.

TABLE 1. Petroleum exploration wells drilled in Valencia County, New Mexico; D&A, dry and abandoned; TA, temporarily abandoned; DST, drill-stem test; perf, perforated; owdd, old well drilled deeper. See Maps 7 and 8 in this appendix.

Operator, well number, and lease	Location (section-township-range, county)	Completion date (month/year)	Status	Total depth (ft)	Rock unit at surface	Rock unit at total depth	Comments
Belen Oil Drilling Co. No. 1 Seipple	NE NE NE 23-4N-1E, Valencia	7/27	D&A	3,545	Cenozoic	Cenozoic	Oil show at 2,375 ft (Cenozoic).
Ringle Development Co. No. 1 Ringle	6-5N-2E, Valencia	11/35	D&A	750	Cenozoic	Cenozoic	
Ringle Development Co. No. 1 Fuqua	2130 ft FSL, 1500 ft FWL 13-5N-3E, Valencia	3/35	D&A	100	Cenozoic	Cenozoic	
G. A. Grober No. 1 Fuqua	NE NE 19-5N-3E, Valencia	10/40	D&A	5,065	Cenozoic	Dockum (Triassic)	Oil and gas show at 720 ft (Cenozoic); gas show at 1,045 ft (Cenozoic); oil show at 1,559 ft (Cenozoic); oil show at 1,777 ft (Cenozoic); oil show at 2,250 ft (Cenozoic); oil and gas show at 3,856 ft (Cenozoic); gas shows from 3,975-3,978 ft (Cenozoic).
C. R. Robinson No. 1 Baca	660 ft FNL, 1980 ft FWL 3-5N-4E, Valencia	1/84	TA	2,360	Cenozoic	Pennsylvanian	Perf 1,830-1,850 ft (Pennsylvanian), swabbed 200 gallons oil-cut water; acidized 1,830-1,850 ft, swabbed 2,500 gallons oil-cut water.
Bailes & Von Glahan No. 1 Dalies	660 ft FSL, 1980 ft FEL 5-6N-1E, Valencia	9/49	D&A	6,096	Cenozoic	Cenozoic	Reported numerous oil and gas shows.
Western Natural Resources No. 2 Fee	SW NE 5-6N-1E, Valencia	11/37	D&A	6,113	Cenozoic	Cenozoic	Reported numerous oil and gas shows; oil-saturated core from 5985-5997 ft
California-New Mexico Co. No. 1 DeChaves	660 ft FNL, 660 ft FWL 8-6N-1E, Valencia	8/26	D&A	2,900	Cenozoic	Cenozoic	Oil show from 1,030-1,045 ft; oil show from 1,219-1,250 ft; oil and gas show from 1,355-1,370 ft
Western Natural Resources No. 1 Fee	NW NE 8-6N-1E, Valencia	8/32	D&A	1,725	Cenozoic	Cenozoic	
Harlan et al. No. 1 Harlan	300 ft FNL, 2500 ft FEL, 5-6N-2E, Valencia	8/30	D&A	4,223	Cenozoic	Cenozoic	Oil show in core at 2,847 ft
Valencia Petroleum No. 1 Harlan	2475 ft FNL, 1760 ft FEL 5-6N-2E, Valencia		D&A	2,093	Cenozoic	Cenozoic	Oil and gas shows at 1,641 ft and 1,980 ft
Harlan et al. No. 2 Harlan	300 ft FNL, 2640 ft FWL 5-6N-2E, Valencia	11/30	D&A	4,021	Cenozoic	Cenozoic	

TABLE 1 (cont'd)

Operator, well number, and lease	Location (section-township-range, county)	Completion date (month/year)	Status	Total depth (ft)	Rock unit at surface	Rock unit at total depth	Comments
Harlan et al. No. 3 Harlan	324 ft FNL, 2640 ft FWL 5-6N-2E, Valencia	4/31	D&A	6,474	Cenozoic	Cenozoic	Reported several gas shows.
Harlan et al. No. 4 Harlan	330 ft FNL, 1870 ft FEL 5-6N-2E, Valencia	6/31	D&A	3,820	Cenozoic	Cenozoic	Slight gas shows at 3,220 ft and 3,318 ft.
Harlan et al. No. 5 Harlan	880 ft FSL, 1760 ft FEL 5-6N-2E, Valencia	8/31	D&A	4,007	Cenozoic	Cenozoic	Numerous slight oil and gas shows.
Gilmore and Sheldon No. 1 Tome Grant	NE 30-6N-2E, Valencia	12/26	D&A	1,180	Cenozoic	Cenozoic	
Homer C. Mills No. 2 Tome Grant	SE SE 9-6N-3E, Valencia	11/32	D&A	446	Cenozoic	Cenozoic	
Homer C. Mills No. 1 Tome Grant	1980 ft FSL, 660 ft FWL 29-6N-3E, Valencia	8/33	D&A	507	Cenozoic	Cenozoic	
Gilmore and Sheldon No. 1 Tome	NE NE 30-6N-3E, Valencia	4/28	D&A	1,100	Cenozoic	Cenozoic	
Ringle Development Co. No. 1 Tome Grant	SE SE 35-6N-3E, Valencia		D&A	948	Cenozoic	Cenozoic	
Ringle Development Co. No. 1 Patented Lands	SE SE 36-6N-3E, Valencia	7/35	D&A	1,115	Cenozoic	Cenozoic	
S. M. Castleberry No. 1 Tome	1650 ft FSL, 990 ft FWL 20-6N-4E, Valencia	5/48	D&A	500	Cenozoic	Cenozoic	
Cecil S. Ringle No. 1 Ringle	990 ft FNL, 990 ft FEL 34-6N-4E, Valencia	6/47	D&A	823	Cenozoic	Pennsylvanian?	Oil shows at 820 ft and 823 ft (Pennsylvanian?)
Cecil S. Ringle No. 1 Tome	990 ft FNL, 1650 ft FWL 34-6N-4E, Valencia	7/46	D&A	641	Cenozoic	Pennsylvanian	
Cecil S. Ringle No. 3 Tome	330 ft FNL, 1980 ft FWL 34-6N-4E, Valencia	4/47	D&A	597	Cenozoic	Pennsylvanian	
Cecil S. Ringle No. 2 Tome	990 ft FNL, 1650 ft FEL 35-6N-4E, Valencia	3/47	D&A	890	Cenozoic	Pennsylvanian	Oil show at 559 ft (Yeso Formation).

TABLE 1 (cont'd)

Operator, well number, and lease	Location (section-township-range, county)	Completion date (month/year)	Status	Total depth (ft)	Rock unit at surface	Rock unit at total depth	Comments
Humble Oil & Refining Co. No. 1 Santa Fe Pacific	660 ft FSL, 660 ft FEL 18-6N-1W, Valencia	11/53	D&A	12,691	Cenozoic	Cretaceous	DST from 4060-4090 ft (Cenozoic) received 75 ft gas-cut mud + 60 ft gas-cut mud with oil show; DST from 10613-10665 ft (Cretaceous) received 1080 ft water + 340 ft slight gas-cut muddy salt water; DST from 10740-10846 ft (Cretaceous) received 45 ft mud + 150 ft slight gas-cut mud + 120 ft heavy gas-cut mud with slight oil show.
Shell Oil Co. No. 2 Santa Fe Pacific	1650 ft FSL, 660 ft FWL 29-6N-1W, Valencia	9/74	D&A	14,305	Cenozoic	Dockum (Triassic)	Reported gas shows, depths unknown.
Hub Oil Co. No. 1 Thomas	1470 ft FNL, 400 ft FEL 13-6N-2W, Valencia	12/26	D&A	3,400	Cenozoic		
Rio Puerco Oil Co. No. 1 Santa Fe	1470 ft FNL, 400 ft FWL 13-6N-2W, Valencia	9/30	D&A	3,425	Cenozoic		Oil show at 2,900 ft.
Brana Corp. No. 1-X Penteco Trinity	2490 ft FNL, 2330 ft FEL 19-6N-2W, Valencia	12/84	D&A	3,000	Basalt (Tertiary)	Precambrian	
Brana Corp. No. 2 Penteco Trinity	1670 ft FNL, 1960 ft FEL 19-6N-2W, Valencia			2,840	Basalt (Tertiary)	Precambrian	Perf and acidized 532-538 ft, swabbed water. Perf and acidized 705-714 ft, swabbed water. No reported shows.
Brana Corp. No. 3 Trinity	1595 ft FNL, 2130 ft FEL 19-6N-2W, Valencia			1,005	Basalt (Tertiary)		Perf and acidized 474-478 ft; no reported shows.
Reese and Jones No. 1 NZ	660 ft FSL, 660 ft FWL 1-6N-3W, Valencia	4/80	D&A	3,215	Abo (Permian)	Precambrian	
Refiners Petroleum No. 1 White Ridge	2310 ft FSL, 330 ft FWL 7-6N-3W, Valencia	10/71	D&A	4,298		Precambrian	DST from 3974-4131 ft (Pennsylvanian), received 300 ft mud + 360 ft water-cut mud + 2320 ft salt water; DST 4200-4272 ft (Pennsylvanian), received 20 ft mud.
Reese and Jones No. 1 Tecolote	1650 ft FSL, 1980 ft FEL 8-6N-3W, Valencia	5/74	D&A	3,512		Precambrian	DST 2468-2528 ft (Pennsylvanian), received 20 ft mud; DST 2540-2614 ft (Pennsylvanian), received 15 ft mud + 2217 ft gas-cut muddy water; DST 3310-3350 ft (Pennsylvanian), received 2191 ft heavy gas-cut mud and water.

TABLE 1 (cont'd)

Operator, well number, and lease	Location (section-township-range, county)	Completion date (month/year)	Status	Total depth (ft)	Rock unit at surface	Rock unit at total depth	Comments
Reese and Jones No. 1 Lawton	660 ft FSL, 660 ft FEL 13-6N-3W, Valencia	4/75	D&A	2,410	Basalt (Quaternary)	Precambrian	
Reese and Jones No. 3 NZ	660 ft FNL, 2313 ft FWL 22-6N-3W, Valencia	4/80	D&A	2,725	Abo (Permian)	Precambrian	DST 2095-2125 ft (Pennsylvanian), received 110 ft mud.
Refiners Petroleum No. 1 Romero	2010 ft FSL, 330 ft FEL 32-6N-3W, Valencia	5/71	D&A	3,028		Precambrian	DST 2440-2550 ft (Pennsylvanian), received 91 ft slight oil- and gas-cut mud + 124 ft water oil- and gas-cut mud + 1230 ft slight oil- and gas-cut salt water; DST 2620-2747 ft (Pennsylvanian), received 315 ft mud + 1115 ft slight gas- and oil-cut mud + 690 ft gas-cut water.
C. M. Joiner No. 1 San Clemente	1650 ft FNL, 2310 ft FWL 23-7N-1E, Valencia	8/39	D&A	5,606	Cenozoic	Cenozoic	Slight show of gas in core from 4292-4295 ft.
P. D. Lynch-McCormick No. 1 Dalies (OWDD)	SE SE 32-7N-1E, Valencia	8/53	D&A	8,495	Cenozoic	Cenozoic	DST, depth unreported, slight oil and gas show.
Shell Oil Co. No. 1 Isleta Central	810 ft FNL, 640 ft FWL 7-7N-2E, Valencia	7/75	D&A	16,346	Cenozoic	Precambrian	Perf and frac 13,210-13,246 ft (Gallup), flowed 9 MCFGPD; Perf 12,420-12,610 ft (Menefee), no flow, swabbed load water; Perf 2,600-2,650 ft (Santa Fe), swabbed 10 bbls water per hour; Perf 1310-1390 ft (Santa Fe), bailed 124 bbls water in 6 hours.
A. W. Stone No. 1	SE NW NW 25-7N-2E, Valencia	6/26	D&A	1,405	Cenozoic	Cenozoic	
Stone et al. No. 2	SE NW NW 25-7N-2E, Valencia	11/28	D&A	1,976	Cenozoic	Cenozoic	Oil show at 902 ft.
Stone et al. No. 1 Horland	NE NE SW 32-7N-2E, Valencia	11/27	D&A	2,144	Cenozoic	Cenozoic	Oil show from 1982-1986 ft.
Hoosier Oil No. 1 Valley	SE NW SE 12-7N-3W, Valencia		D&A	520	San Andres		Oil show at 500 ft (Yeso?).
Richard King, Jr. No. 1 Wilson Heirs Unit	2310 ft FSL, 330 ft FEL 14-7N-3W, Valencia	10/58	D&A	3,993	Basalt (Quaternary)	Precambrian	

TABLE 1 (cont'd)

Operator, well number, and lease	Location (section-township-range, county)	Completion date (month/year)	Status	Total depth (ft)	Rock unit at surface	Rock unit at total depth	Comments
Reese and Jones No. 1 Carrizo	990 ft FSL, 2050 ft FWL 34-7N-3W, Valencia	7/74	D&A	3,588	Yeso (Permian)	Precambrian	DST 2468-2575 ft (Pennsylvanian), received 60 ft oil- and gas-cut mud; DST 3315-3395 ft (Pennsylvanian), received 2400 ft water; DST 3465-3530 ft ft (Pennsylvanian), received 65 ft mud; Perf 2702-2712 ft (Pennsylvanian), swabbed water with trace of oil; Perf 2515-2531 ft (Pennsylvanian), swabbed water with trace of oil; Perf 2482-2500 ft (Pennsylvanian), swabbed water with trace of oil; Perf 2426-2438 ft (Pennsylvanian), swabbed water with trace of oil and gas.
Reese and Jones No. 1 Lucero	660 ft FSL, 660 ft FEL 36-7N-3W, Valencia	6/74	D&A	2,962	Abo (Permian)	Precambrian	DST 1670-1843 ft (Pennsylvanian), received 3 ft slightly gas-cut mud; DST 2480-2513 ft (Pennsylvanian), received 2000 ft mud.

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MAP 1

MAP 1 - Mineral occurrences and resource potential for metals and uranium in the Socorro 30- by 60-minute topographic quadrangle, Valencia County, New Mexico.

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MAP 2

BELEN, NEW MEXICO

30x60 MINUTE SERIES (TOPOGRAPHIC)

BELEN, NEW MEXICO
N3430—W10600/30x60
1979

MAP 2 - Mineral occurrences and resource potential for metals and uranium in the Belen 30- by 60-minute topographic quadrangle, Valencia County, New Mexico.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ACOMA PUEBLO QUADRANGLE
NEW MEXICO
1:100 000-SCALE SERIES (PLANIMETRIC)

Produced by the Geological Survey
in cooperation with the Soil Conservation Service

Compiled from USGS 1:24 000 and 1:62 500-scale topographic maps dated 1954–1964. See index for dates of individual maps
Partially revised from aerial photographs taken 1974–1975 and other source data. Revised information not field checked
Map edited 1978

Projection and 10 000-meter grid, zone 13, Universal Transverse Mercator
50 000-foot grid ticks based on New Mexico coordinate system, west and central zones. 1927 North American datum

There may be private inholdings within the boundaries of the National or State reservations shown on this map

MAP INDEX

UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF MAP

SCALE 1:100 000

KILOMETERS

MILES

FEET

ELEVATIONS SHOWN IN METERS

Moderate
Low

QUADRANGLE LOCATION

LEGEND

ROAD CLASSIFICATION

Primary highway, hard surface
Secondary highway, hard surface
Light-duty road, hard or improved surface
Street or other road
Trail
Interstate route U.S. route State route

MAP 3 - Mineral occurrences, prospects, mines, and resource potential for metals, uranium, barite, and fluorite in the Acoma Pueblo 30- by 60-minute topographic quadrangle, Valencia and Cibola Counties, New Mexico.

This map complies with national map accuracy standards
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225 OR RESTON, VIRGINIA 22092

ACOMA PUEBLO, NEW MEXICO
NW/4 SOCORRO (NI 13-4) 1:250 000-SCALE MAP
N3430-W10700/30x60
1978

OF-229

MAP 4

SOCORRO, NEW MEXICO

MAP 4 – Industrial materials, occurrences, mines, and resource potential in the Socorro 30- by 60-minute topographic quadrangle, Valencia County, New Mexico.

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MAP 5

BELEN, NEW MEXICO

30x60 MINUTE SERIES (TOPOGRAPHIC)

MAP 5 – *Industrial materials, occurrences, mines, and resource potential in the Belen 30- by 60-minute topographic quadrangle Valencia County, New Mexico.*

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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MAP 6

ACOMA PUEBLO QUADRANGLE
NEW MEXICO
1:100 000-SCALE SERIES (PLANIMETRIC)

Produced by the Geological Survey
in cooperation with the Soil Conservation Service

Compiled from USGS 1:24 000 and 1:62 500-scale topographic maps dated 1954–1964. See index for dates of individual maps
Partially revised from aerial photographs taken 1974–1975 and other source data. Revised information not field checked
Map edited 1978

Projection and 10 000-meter grid, zone 13,
Universal Transverse Mercator
50 000-foot grid ticks based on New Mexico coordinate system, west and central zones. 1927 North American datum

There may be private inholdings within the boundaries of the National or State reservations shown on this map

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1 Arrosa Ranch–1961
2 Los Pilares–1961
3 Crow Point–1961
4 Acoma Pueblo–1961
5 South Butte–1960
6 Dough Mountain–1960 (Photorevised–1971)
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8 South Garcia–1954 (Photorevised–1971)
9 North Pasture–1961
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17 Cebollita Peak–1964
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19 Broom Mountain–1964
20 Cerro Del Oro–1964
21 Chicken Mountain–1964
22 Mesa Aparejo–1956
23 Bonnie Canyon–1964
24 Wild Horse Canyon–1964
25 Wiley Mesa–1964
26 Pueblo Viejo Mesa–1964
27 Field Ranch–1964
28 Puerto De Los Cavadores–1964

MAP 6 – Industrial materials, occurrences, mines, and resource potential in the Acoma Pueblo 30- by 60-minute topographic quadrangle, Valencia and Cibola counties, New Mexico.

LEGEND

- Perennial stream, lake
- Intermittent stream, lake
- Village or locality
- Landmark structure
- Public park or recreation area
- Forest or game land area
- Other public area or Military or Indian reservation

ROAD CLASSIFICATION

- Primary highway, hard surface
- Secondary highway, hard surface
- Light-duty road, hard or improved surface
- Street or other road
- Trail
- Interstate route
- U.S. route
- State route

ACOMA PUEBLO, NEW MEXICO
NW/4 SOCORRO (NI 13-4) 1:250 000-SCALE MAP
N3430–W10700/30x60
1978

OF-229

MAP 7

LEGEND

- Dry hole with no reported shows
- Dry hole with reported gas show
- Dry hole with reported oil show
- Dry hole with reported oil and gas show

16,346, p€ (K_g) — Total depth of well, feet; Rock unit at total depth; Rock unit(s) with reported oil or gas shows

T_{sf}	Santa Fe Group (Tertiary)
K	Cretaceous
K_g	Gallup Sandstone (Cretaceous)
P_y	Yeso Formation (Permian)
IP	Pennsylvanian
p€	Precambrian

MAP 7 - Petroleum tests in the Belen 30- by 60-minute topographic quadrangle, Valencia County, New Mexico.

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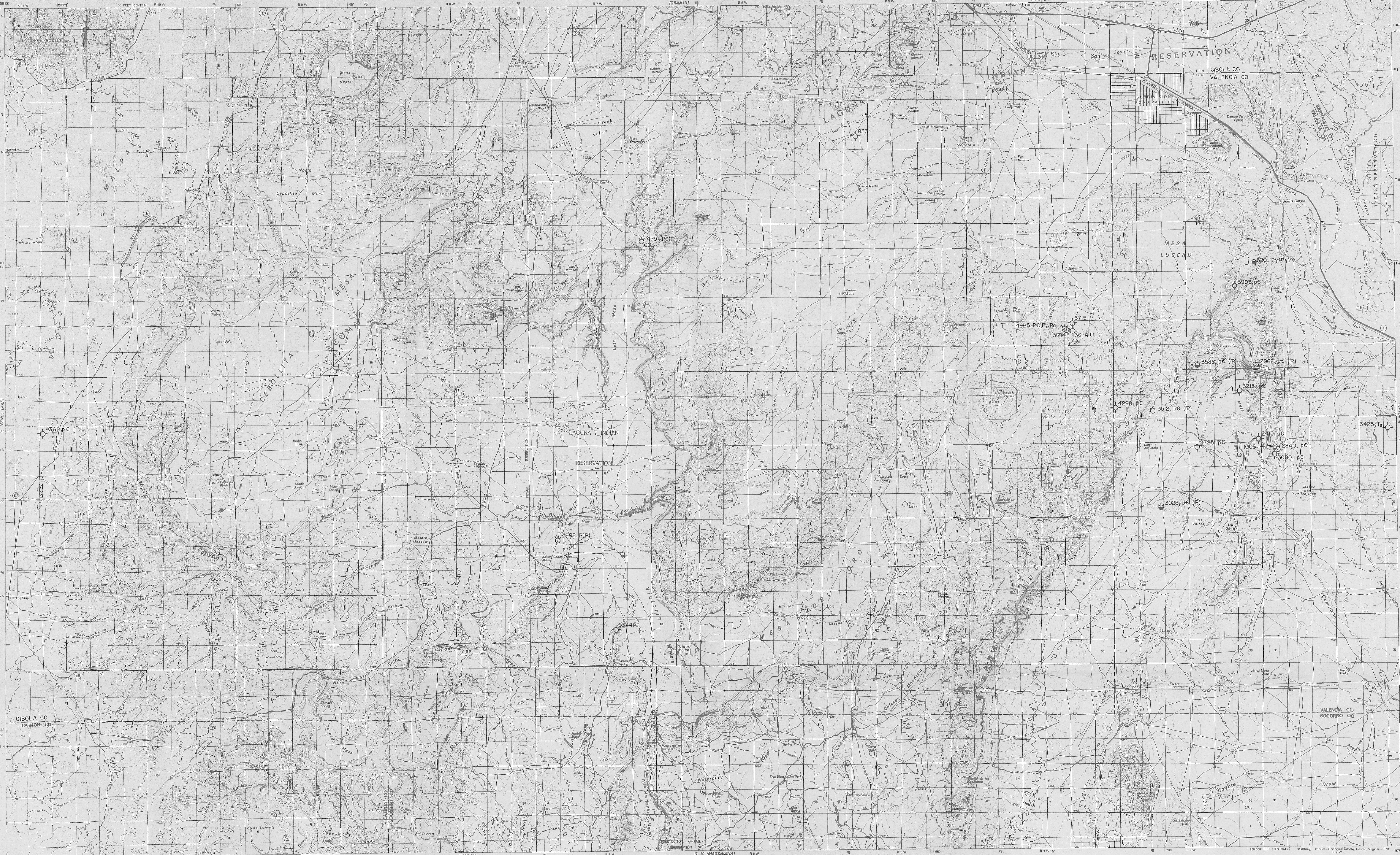
MAP 8

ACOMA PUEBLO QUADRANGLE
NEW MEXICO
1:100 000-SCALE SERIES (PLANIMETRIC)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



Produced by the Geological Survey
in cooperation with the Soil Conservation Service

Compiled from USGS 1:24 000 and 1:62 500-scale topographic maps dated 1954–1964. See index for dates of individual maps
Partially revised from aerial photographs taken 1974–1975 and other source data. Revised information not field checked
Map edited 1978

Projection and 10 000-meter grid, zone 13,
Universal Transverse Mercator
50 000-foot grid ticks based on New Mexico coordinate system, west and central zones. 1927 North American datum

There may be private inholdings within the boundaries of the National or State reservations shown on this map

MAP INDEX

SCALE 1:100 000

KILOMETERS

MILES

FEET

ELEVATIONS SHOWN IN METERS

MAP 8 - Petroleum tests in the Acoma Pueblo 30- by 60-minute topographic quadrangle, Valencia and Cibola counties, New Mexico.

LEGEND

- Dry hole with no reported shows
- Dry hole with reported gas show
- Dry hole with reported oil show
- Dry hole with reported oil and gas show

16,346, pC (Kg)

Total depth of well, feet — Rock unit at total depth — Rock unit(s) with reported oil or gas shows

NEW MEXICO

QUADRANGLE LOCATION

T_{sf}	Santa Fe Group (Tertiary)
P_{sa}	San Andres Formation (Permian)
P_y	Yeso Formation (Permian)
IP	Pennsylvanian
p€	Precambrian

LEGEND

Perennial stream, lake

Intermittent stream, lake

Village or locality

Landmark structure

Public park or recreation area

Forest or game land area

Other public area or Military or Indian reservation

ROAD CLASSIFICATION

Primary highway, hard surface

Secondary highway, hard surface

Light-duty road, hard or improved surface

Street or other road

Trail

Interstate route — U.S. route — State route

ACOMA PUEBLO, NEW MEXICO
NW/4 SOCORRO (NI 13-4) 1:250 000-SCALE MAP
N3430–W10700/30x60
1978

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MAP 9

MAP 9 - Petroleum-resource potential in the Socorro 30- by 60-minute topographic quadrangle, Valencia County, New Mexico.

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MAP 10

BELEN, NEW MEXICO

MAP 10 - Petroleum-resource potential in the Belen 30- by 60-minute topographic quadrangle, Valencia County, New Mexico.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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MAP 11

NEW MEXICO
1:100 000-SCALE SERIES (PLANIMETRIC)

Produced by the Geological Survey
in cooperation with the Soil Conservation Service

Compiled from USGS 1:24 000 and 1:62 500-scale topographic maps dated 1954–1964. See index for dates of individual maps
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Map edited 1978

Projection and 10 000-meter grid, zone 13.
Universal Transverse Mercator
10 000-foot grid ticks based on New Mexico coordinate system, west and central zones. 1927 North American datum

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1 Arrosa Ranch–1961
2 Los Pilares–1961
3 Crow Point–1961
4 Acoma Pueblo–1961
5 South Butte–1960
6 Dough Mountain–1960 (Photorevised–1971)
7 South Garcia–1956
8 South Garcia–1954 (Photorevised–1971)
9 North Pasture–1961
10 Laguna Honda–1961
11 Blue Mesa–1961
12 East Mesa–1961
13 Marmon Ranch–1961
14 Cerro Verde–1960
15 South Garcia SE–1954
16 Sand Canyon–1964
17 Cebolita Peak–1964
18 Mecate Meadow–1964
19 Broom Mountain–1964
20 Cerro Del Oro–1964
21 Chicken Mountain–1964
22 Mesa Aparejo–1956
23 Bonnie Canyon–1964
24 Wild Horse Canyon–1964
25 Wiley Mesa–1964
26 Pueblo Viejo Mesa–1964
27 Field Ranch–1964
28 Puerto De Los Cavadores–1964

UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF MAP

SCALE 1:100 000

KILOMETERS

MILES

FEET

ELEVATIONS SHOWN IN METERS

Moderate
Low
Very low

NEW MEXICO

QUADRANGLE LOCATION

LEGEND

Perennial stream, lake
Intermittent stream, lake
Village or locality
Landmark structure
Public park or recreation area
Forest or game land area
Other public area or Military or Indian reservation

ROAD CLASSIFICATION

Primary highway, hard surface
Secondary highway, hard surface
Light-duty road, hard or improved surface
Street or other road
Trail
Interstate route U.S. route State route

MAP 11 - Petroleum-resource potential in the Acoma Pueblo 30- by 60-minute topographic quadrangle, Valencia and Cibola counties, New Mexico.

ACOMA PUEBLO, NEW MEXICO
NW/4 SOCORRO (NI 13-4) 1:250 000-SCALE MAP
N3430–W10700/30x60
1978

Interior—Geological Survey, Reston, Virginia—1979

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MAP 12

BELEN, NEW MEXICO

MAP 12 - Geothermal springs and wells and geothermal-resource potential in the Belen 30- by 60-minute topographic quadrangle, Valencia County, New Mexico.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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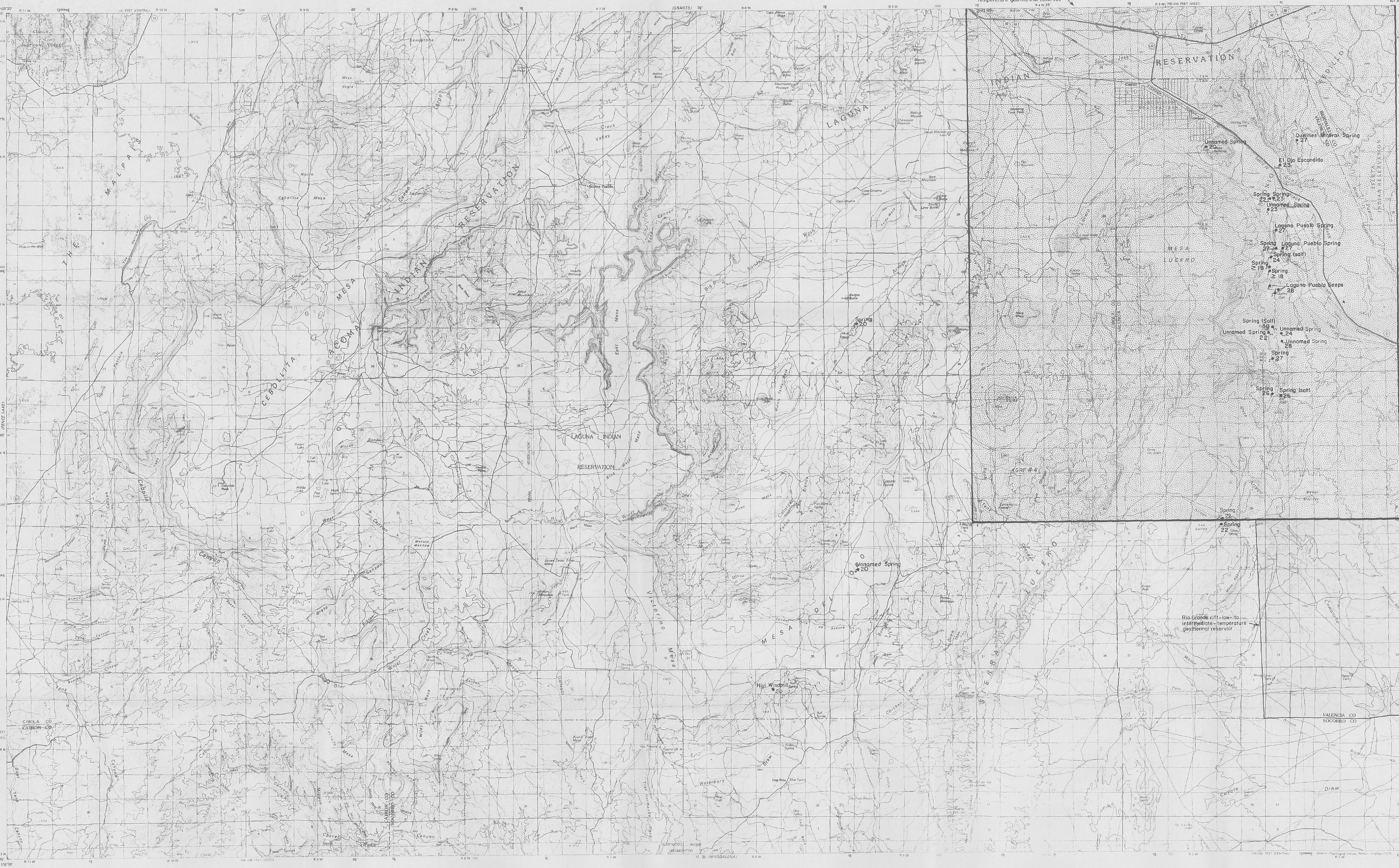
MAP 13
ACOMA PUEBLO QUADRANGLE
NEW MEXICO
1:100 000-SCALE SERIES (PLANIMETRIC)



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Map edited 1978

Projection and 10 000 meter grid, zone 13,
Universal Transverse Mercator
50 000-foot grid ticks based on New Mexico coordinate system, west and central zones 1927 North American datum

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15 South Garcia SE-1954
16 *Sand Canyon-1964*
17 Cebollita Peak-1964
18 Mecate Meadow-1964
19 Broom Mountain-1964
20 Cerro Del Oro-1964
21 Chicken Mountain-1964
22 Mesa Aparejo-1956
23 *Bonnie Canyon-1964*
24 Wild Horse Canyon-1964
25 Wiley Mesa-1964
26 Pueblo Viejo Mesa-1964
27 Field Ranch-1964
28 Puerto De Los Cavadores-1964

UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF MAP

SCALE 1:100 000

KILOMETERS

MILES

FEET

ELEVATIONS SHOWN IN METERS

Moderate - Low

Low

NEW MEXICO

QUADRANGLE LOCATION

LEGEND

Perennial stream, lake
Intermittent stream, lake
Village or locality
Landmark structure
Public park or recreation area
Forest or game land area
Other public area or
Military or Indian reservation

ROAD CLASSIFICATION

Primary highway, hard surface
Secondary highway, hard surface
Light-duty road, hard or improved surface
Street or other road
Trail
Interstate route *U.S. route* *State route*

MAP 13 - Geothermal springs and wells, KGRF's, and geothermal-resource potential in the Acoma Pueblo 30- by 60-minute topographic quadrangle, Valencia and Cibola counties, New Mexico.

ACOMA PUEBLO, NEW MEXICO
NW/4 SOCORRO (NI 13-4) 1:250 000-SCALE MAP
N3430-W10700/30x60
1978