STUDIES RELATED TO WILDERNESS

WILDLIFE REFUGES

BITTER LAKE *and* BOSQUE DEL APACHE NEW MEXICO

GEOLOGICAL SURVEY BULLETIN 1260-A,B

Summary Report on the Geology and Mineral Resources of the—

Salt Creek Area, Bitter Lake National Wildlife Refuge Chaves County, New Mexico

By GEORGE O. BACHMAN, U.S. GEOLOGICAL SURVEY

Bosque del Apache National Wildlife Refuge Socorro County, New Mexico

By GEORGE O. BACHMAN, U.S. GEOLOGICAL SURVEY, *and* RONALD B. STOTELMEYER, U.S. BUREAU of MINES

STUDIES RELATED TO WILDERNESS—WILDLIFE REFUGES

GEOLOGICAL SURVEY BULLETIN 1260-A, B

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1967

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 15 cents (paper cover)

STUDIES RELATED TO WILDERNESS

WILDLIFE REFUGES

The Wilderness Act (Public Law 88–577, Sept. 3, 1964) directs the Secretary of the Interior to review roadless areas of 5,000 contiguous acres or more, and every roadless island, within the national wildlife refuges and game ranges under his jurisdiction and to report on the suitability or nonsuitability of each such area or island for preservation as wilderness. As one aspect of the suitability studies, existing published and unpublished data on the geology and the occurrence of minerals subject to leasing under the mineral leasing laws are assembled in brief reports on each area. This bulletin is one such report and is one of a series by the U.S. Geological Survey and the U.S. Bureau of Mines on lands under the jurisdiction of the U.S. Department of the Interior.

Mineral Appraisal of the Salt Creek Area, Bitter Lake National Wildlife Refuge Chaves County, New Mexico

By GEORGE O. BACHMAN, U.S. GEOLOGICAL SURVEY

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MINERAL APPRAISAL OF THE SALT CREEK AREA, BITTER LAKE NATIONAL WILDLIFE REFUGE, CHAVES COUNTY NEW MEXICO

By GEORGE O. BACHMAN, U.S. Geological Survey

SUMMARY

The Salt Creek area, an area of 1,900 acres in the Bitter Lake National Wildlife Refuge in Chaves County, southeastern New Mexico, is being considered for inclusion in the National Wilderness Preservation System.

Sand and gravel near U.S. Highway 70 are the only mineral resources known to have been used from within the confines of the candidate area. Oil is produced south of the Salt Creek area from near the south end of the Bitter Lake Refuge at the Bitter Lake field and about 8 miles northeast of the Salt Creek area from the Linda San Andres field. Other minor oil production is obtained 4–6 miles northeast of the Salt Creek area.

The oil and gas potential of the Salt Creek candidate area is unproved, but data available at present indicate that the San Andres Limestone underlying the area could well have porosity, permeability, and structural relief that would allow production of oil from shallow depths. Oil has not been produced from formations older than Permian in this immediate area.

INTRODUCTION

The Bitter Lake National Wildlife Refuge, about 5 miles east of Roswell, Chaves County, N. Mex., is divided into two major units. The northern unit, or Salt Creek area, totaling 11,900 acres, is being considered for inclusion in the National Wilderness Preservation System. This report is concerned with the mineral resources of the Salt Creek area.

The Bitter Lake Refuge is in the Pecos River valley, an area of gently rolling hills. Much of the surface is covered by windblown sand and flood-plain silt. Vegetation consists of grasses, mesquite, saltcedar, creosotebush, and associated flora. U.S. Highway 70 passes along the southeastern edge of the Salt Creek area. Roads within the area are few and primitive.

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The U.S. Bureau of Mines has not had occasion to examine the candidate area, but the Bureau is informed of the findings and recommendations of the Geological Survey and concurs in them.

Acknowledgments.—T. F. Stipp, of the Roswell office of the Geological Survey, was of major assistance in supplying data upon which this report is based. W. C. Reffalt, Manager of the Bitter Lake National Wildlife Refuge, also was most helpful.

GEOLOGY

Rock outcrops in the Bitter Lake Refuge are sparse as most of the area is covered by Recent windblown sand and stream deposits. In the Salt Creek area, the exposed rock consists of dark-reddish-brown siltstone and fine sandstone in which are thin interbeds of gypsum. These rocks are assigned to the Artesia Group of Permian age. The stratigraphic section underlying the Salt Creek area is shown in table 1. Information in this table is derived in part from test wells drilled for oil in nearby areas.

Of the rocks underlying the Artesia Group, the San Andres Limestone is of economic interest because it is the host rock for oil produced from the Linda San Andres and Bitter Lake oil fields, a few miles north and south, respectively, of the Salt Creek area (fig. 1). Other production from the San Andres has been obtained from scattered individual wells near the Salt Creek area.

Deep tests have been drilled for oil east and west of the Salt Creek area, and data from these holes have been used to construct figure 2. This diagrammatic cross section, drawn on a generally east-west line across the area, shows that the sedimentary rocks dip to the east, and are approximately conformable with the Precambrian rock surface, which dips eastward at about 50–60 feet per mile (Foster and Stipp, 1961).

Sinkholes are conspicuous surface features of the Pecos Valley region. They are a principal feature of the Bottomless Lakes State Park east of Roswell, and many are present in the Bitter Lake Refuge. The sinkholes are believed to result from the solution of water-soluble rocks (for example, gypsum) beneath the ground surface. After the soluble beds are dissolved, a cavity is left, and at places where the roof of the cavity is weak, the roof collapses and forms a depression as much as hundreds of yards across and several hundred feet deep. Many of these sinkholes along the Pecos Valley are partly filled with water (Harrington, 1957). The depth below the surface to which sinkholes may disrupt rock strata is not known, but it is possible that during the formation of sinkholes circulation of ground water may be sufficiently deep to influence the circulation of petroleum. The Linda San

Andres oil field (fig. 4) is in a depression that could be interpreted as a sinkhole.

MINERAL RESOURCES

Sand, gravel, and oil are the chief mineral commodities produced in the Pecos Valley near the Bitter Lake Refuge. Of these, only sand and gravel have been produced from the Salt Creek area. Oil is produced from the Bitter Lake field, near the south end of the Bitter Lake Refuge, and from other nearby areas.

TABLE 1.—*Rocks probably present in subsurface of Salt Creek area, Bitter Lake National Wildlife Refuge*

Formation	Approximate thickness (feet)	Description
Alluvium and windblown sand (Recent)	Less than 100	Sand, silt, and associated stream deposits.
Artesia Group (Permian)	600	Reddish-brown sandstone, silt, and shale with interbeds of gypsum.
San Andres Limestone (Permian)	1, 200	Medium-gray to medium-dark-gray limestone, dolomite, and some gypsum.
Yeso Formation (Permian)	2, 000	Reddish-brown to yellowish sandstone, silt, and shale with interbeds of gypsum.
Abo Formation (Permian)	1, 200	Reddish-brown sandstone, silt, and shale. Locally contains "granite wash."
Pennsylvanian rocks undivided	100	Reddish-brown to gray sandstone with some interbeds of shale and limestone.
Mississippian rocks undivided	100	Gray limestone; may be cherty.
Montoya Dolomite (Ordovician)	200	Gray cherty dolomite.
Precambrian		Granite "basement."

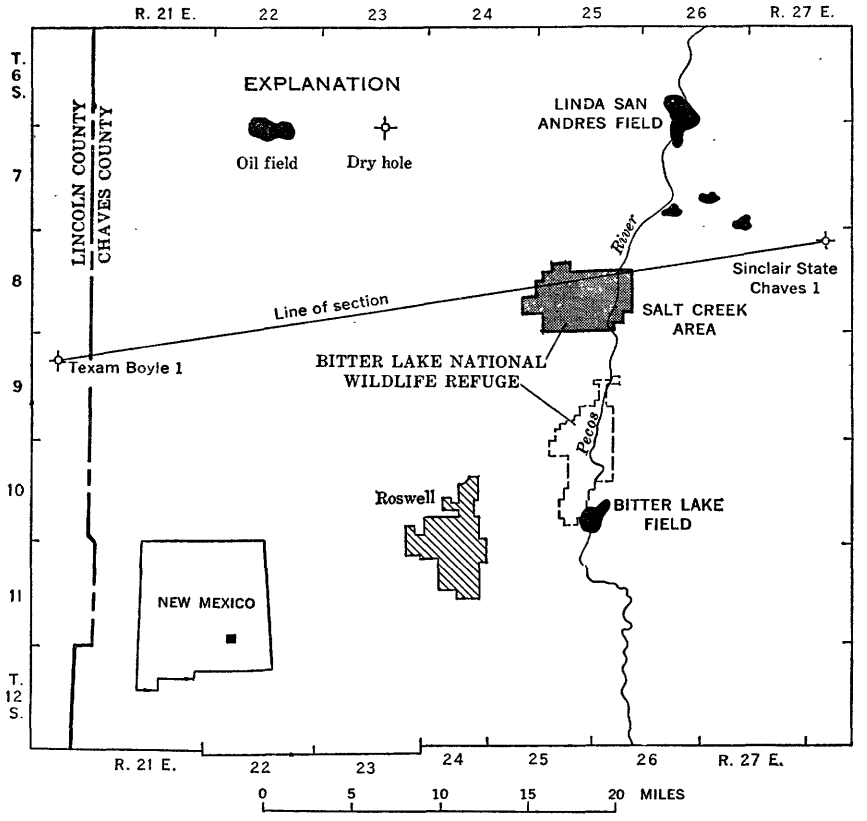

FIGURE 1.—Location of Salt Creek candidate area and line of section (fig. 2).

SAND AND GRAVEL

Some sand and gravel have been produced from the Salt Creek area, from the SE1/4SW1/4 sec. 34, T. 8 S., R. 25 E., adjacent to U.S. Highway 70 about 9 miles northeast of Roswell. The sand and gravel have come from an area of less than 80 acres. Sand and gravel also have been recovered from a small area, probably less than 10 acres, about 1 mile west of the large gravel pits (SE1/4SW1/4 sec. 33, T. 8 S., R. 25 E.). Neither the large nor small gravel pits are now in production.

OIL

Although the presence of oil in the Salt Creek area is not proved, its presence in that area is a geologic possibility. The Bitter Lake oil field (fig. 3) 9½ miles to the south, the Linda San Andres oil field (fig. 4) 8 miles northeast, and individual producing wells within 5 miles of the Salt Creek area (fig. 5) indicate that oil may be present

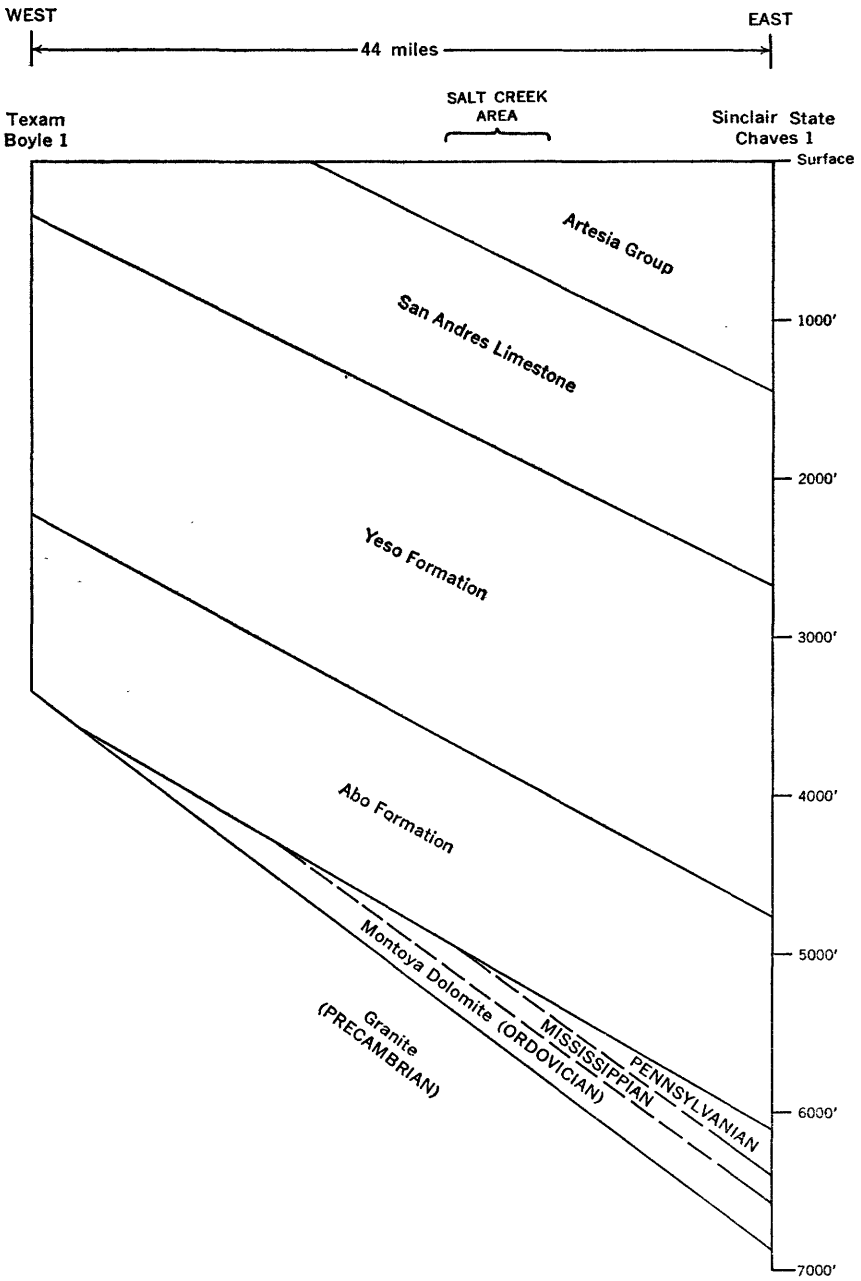

FIGURE 2.—Diagrammatic cross section showing rocks underlying the Salt Creek area.

in the immediate vicinity of the Salt Creek area. Production is from the San Andres Limestone, which underlies the Salt Creek area also. Structural relief is low in the nearby fields (figs. 3, 4), and similar relief could be present in the Salt Creek area without being evident at the surface.

The discovery well of the Bitter Lake oil field was completed in March 1960 (Harrison, 1960, p. 19). The pay zone of this field is the San Andres Limestone and consists of a 20-foot interval of finely crystalline granular dolomite with some gypsum. The porosity is mostly intercrystalline, and the trap is considered to be stratigraphic. By January 1966, about 18 wells in the Bitter Lake field had produced slightly more than 68,500 barrels of oil. All production is from depths of less than 1,000 feet. The northernmost producing well is about 9½ miles south of the Salt Creek area.

At the Linda San Andres oil field, about 8 miles northeast of the Salt Creek area (fig. 1), oil also is produced from the San Andres Limestone. Contour maps drawn on the productive horizon of both these fields indicate that structural relief is low in the producing areas. It would be difficult, if not impossible, to detect such low structural relief in the candidate area from available rock exposures.

Other wells have been drilled within 5 miles of the Salt Creek area. Some have produced oil (fig. 5), but most have been dry holes.

CONCLUSIONS

The present study indicates a geologic possibility that oil or gas is present in the San Andres Limestone beneath the Salt Creek area. Structural relief similar to that of producing oil fields near the Salt Creek area may be present, though it is not evident from available information. If porosity, permeability, and structural relief are present in the limestone, oil might be produced from shallow depths. Available evidence indicates that formations older than Permian have not produced oil in this area.

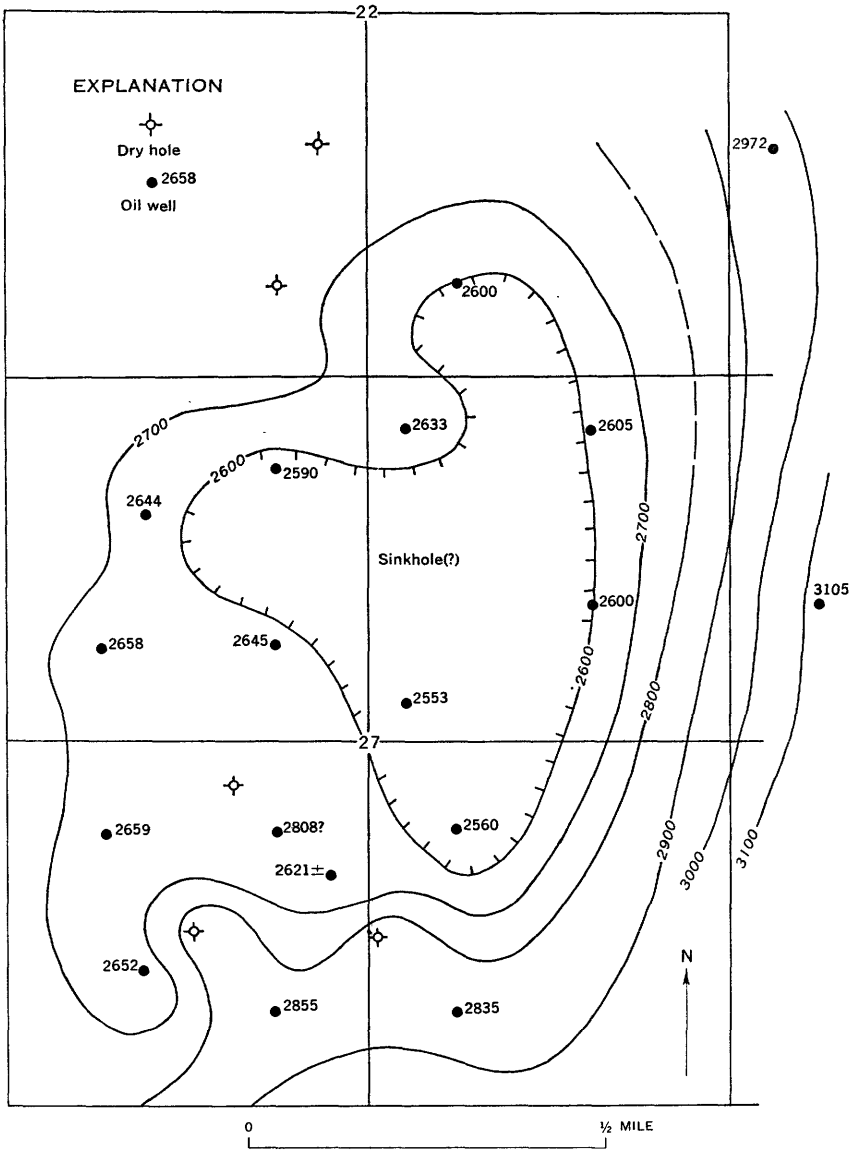

FIGURE 3.—Structure-contour map drawn at top of San Andres Limestone (elevations, in feet), Bitter Lake oil field (S½ secs. 22 and 27, T. 10 S., R. 25 E.), showing low structural relief on producing formation. Datum is mean sea level. Structure contours by T. F. Stipp, 1966.

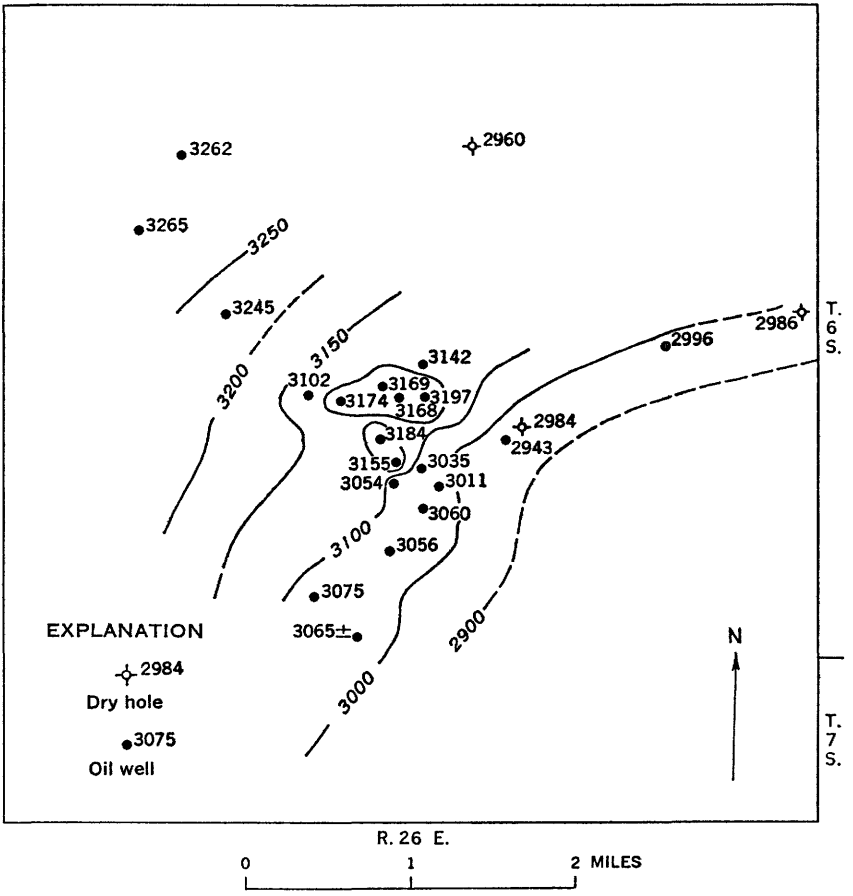

FIGURE 4.—Structure-contour map drawn at top of San Andres Limestone (elevations, in feet), Linda San Andres oil field (T. 6 S., R. 26 E.), showing structural relief on producing formation. Datum is mean sea level. Structure contours by T. F. Stipp, 1966.

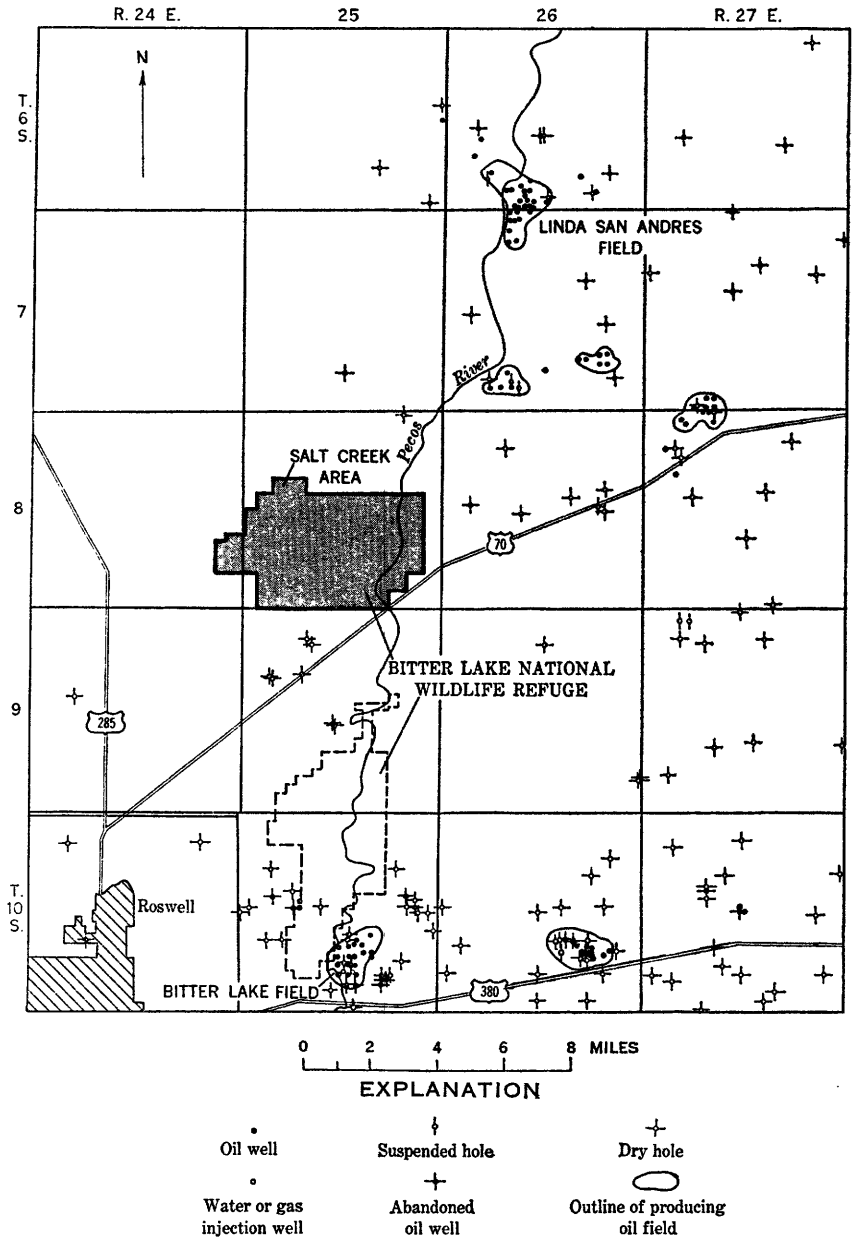

FIGURE 5.—Location of wells drilled for oil and gas in vicinity of Bitter Lake National Wildlife Refuge.

REFERENCES CITED

Foster, R. W., and Stipp, T. F., 1961, Preliminary geologic and relief map of the Precambrian rocks of New Mexico: New Mexico Bur. Mines and Mineral Resources Circ. 57.

Harrington, E. R., 1957, Sinkholes, bottomless lakes, and the Pecos River [N. Mex.]: Sci. Monthly, p. 302–308.

Harrison, C. R., 1960, The Bitter Lake field, p. 19, *in* The oil and gas fields of southeastern New Mexico, a symposium, 1960 Supp.: Roswell, N. Mex., Roswell Geol. Soc.

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Mineral Appraisal of the Bosque del Apache National Wildlife Refuge Socorro County, New Mexico

By GEORGE O. BACHMAN, U.S. GEOLOGICAL SURVEY *and* RONALD B. STOTELMEYER, U.S. BUREAU OF MINES

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MINERAL APPRAISAL OF THE BOSQUE DEL APACHE NATIONAL WILDLIFE REFUGE, SOCORRO COUNTY NEW MEXICO

By GEORGE O. BACHMAN, U.S. Geological Survey, and RONALD B. STOTELMEYER, U.S. Bureau of Mines

SUMMARY

The Bosque del Apache National Wildlife Refuge, Socorro County, N. Mex., encompasses three candidate wilderness areas—the Chupadera, Indian Well, and Little San Pascual units.

Most of the refuge is covered by sand, gravel, and associated alluvial deposits of Tertiary and Recent age. Older rocks of Precambrian, Mississippian, and Pennsylvanian ages are exposed in the western part (Chupadera unit) of the refuge, and rocks of Pennsylvanian, Permian, and early Teritary age are in the eastern part (Little San Pascual unit).

Occurrences of copper, manganese, lead, fluorite, and barite are present in the older rocks of the Chupadera and Little San Pascual units. These occurrences have all been prospected in the past, but there is no record of production. There are no indications of significant mineral resources at these prospects. Sand and gravel are widespread in the refuge but are too far from present markets to be regarded as of economic value. As presently understood, the geologic environment does not offer encouragement for the development of oil or gas resources.

INTRODUCTION

LOCATION, GEOGRAPHY, AND ACCESS

The Bosque del Apache Wildlife Refuge is in central New Mexico (fig. 1). Its northern limit is about 12 miles south of the town of Socorro, and it extends southward along the Rio Grande Valley for about 12 miles.

Three units in the Bosque del Apache Wildlife Refuge have been proposed as candidate areas for wilderness status. These units, and the total acreage of each, are as follows:

Candidate area unit	*Acreage*
Chupadera	5,583.6
Indian Well	15,427.9
Little San Pascual	22,477.85

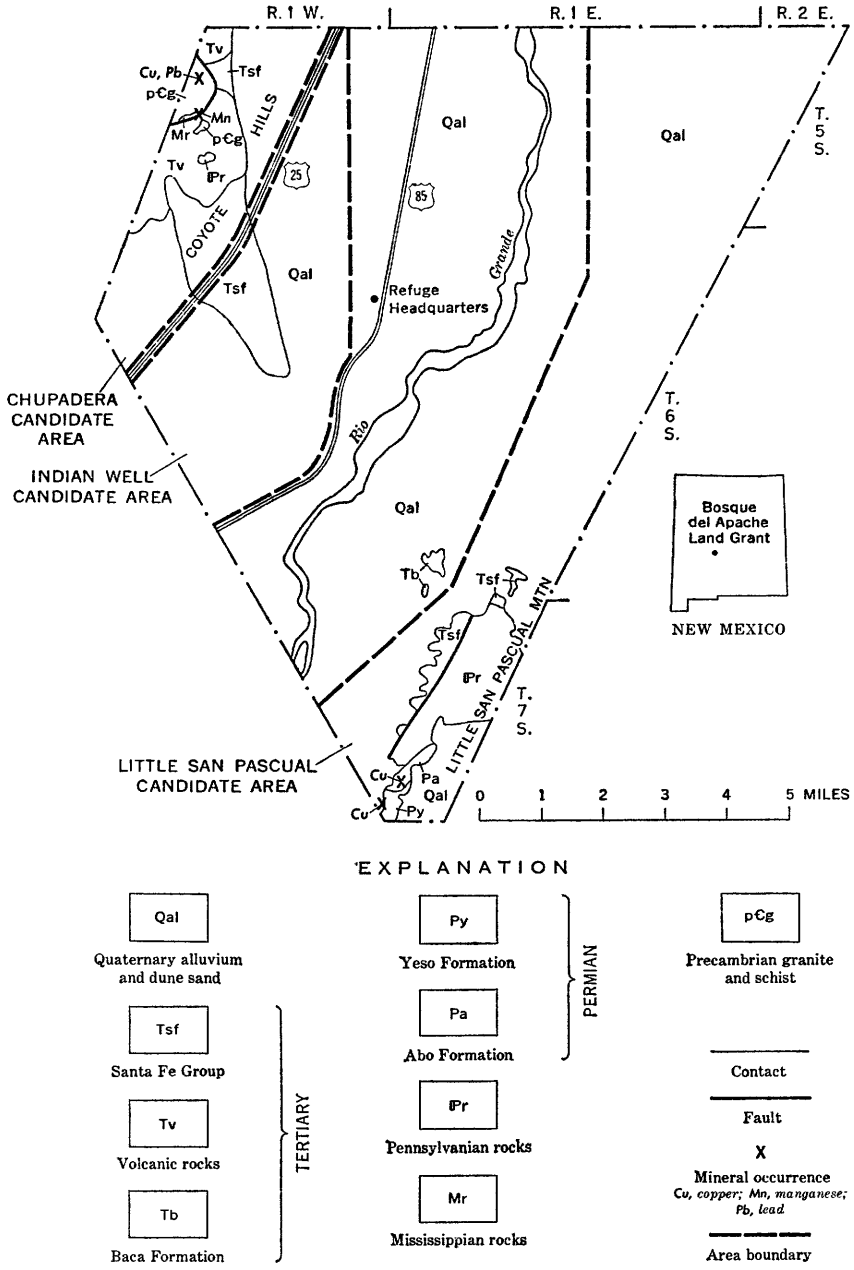

FIGURE 1.—Geologic map of Bosque del Apache National Wildlife Refuge. Generalized from maps by Geddes (1963) and Kottlowski (1960).

The Chupadera and Indian Well units are in the western part of the refuge, and the Little San Pascual unit is along the east edge.

The Bosque del Apache Refuge extends across part of the Rio Grande Valley and includes terraces on both the east and west sides of the valley. The Rio Grande Valley trends southwesterly through the central part of the refuge. Within the refuge, the flood plain of the Rio Grande ranges from about 2 to 3 miles in width; it is relatively flat, and ranges in altitude from about 4,490 feet above sea level at the south end of the refuge to about 4,520 feet at the north end.

Terraces rise from the flood plain toward bordering hills and form relatively gentle slopes along most of the east side of the refuge. They are steeper in the southeastern part, where they form fans on Little San Pascual Mountain. The terraces along the west side of the refuge have a steeper gradient and are dissected by numerous arroyos.

Bedrock is exposed in the southeastern part of the refuge in the Little San Pascual Mountain (fig. 1). The highest peak in the mountain is about 5,500 feet above sea level. Bedrock also is exposed along the west edge of the refuge in the Coyote Hills, where the highest elevation is about 6,700 feet.

Vegetation in the flood-plain area consists of scattered softwood trees (cottonwood, salt cedar, and others) and many varieties of marsh grass. Vegetation is sparse on the adjacent terraces and hills, and consists mainly of creosotebush, mesquite, scattered grasses, cacti, and other arid-land plants.

Modern paved highways provide access to the Bosque del Apache Refuge. U.S. Highway 85 passes along the west side of the Rio Grande and gives access to Refuge Headquarters. U.S. Interstate Highway 25 passes through the western part of the refuge. Access to remote areas of the refuge is difficult and can best be attained on foot.

INVESTIGATIONS AND ACKNOWLEDGMENTS

Two separate areas within the refuge have been discussed in previous geologic reports. Darton (1928, fig. 79*B*) referred to Little San Pascual Mountain in one of his diagrammatic cross sections. Geddes (1963) prepared a geologic map and discussed the general geology and geologic structure of Little San Pascual Mountain. Kottlowski (1960, p. 60–61) discussed the geology of Little San Pascual Mountain and, briefly, the Coyote Hills (1960, p. 58–60).

During the present investigation, existing geologic maps were checked, as was all available information on mineral prospects or occurrences within the area. The geologic map in this report (fig. 1) is generalized from the maps by Geddes (1963, p. 198) and Kottlowski (1960, p. 59). F. E. Kottlowski and R. H. Weber, of the New Mexico Bureau

of Mines and Mineral Resources, provided valuable information on the location of mineral prospects in the refuge, and personnel of the Bureau of Sport Fisheries and Wildlife provided information on geography and access. All known occurrences of minerals and mineral prospects were reviewed by the authors during the course of the investigation, which was made in the autumn of 1966.

GEOLOGY

The Bosque del Apache Refuge is mainly underlain by alluvial deposits, consisting of poorly consolidated gravel, sand, and clay eroded from the adjacent hills and deposited in the Rio Grande Valley. Older rocks that range in age from Precambrian to Pliocene are exposed along the west side and in the southeastern part of the refuge.

PRECAMBRIAN ROCKS

Rocks of Precambrian age are exposed in a very small area on the west edge of the refuge (Chupadera unit); they consist of gray to pink coarsely crystalline granite and gneiss that intrude gray muscovite-hornblende schist. Formal names have not been applied to these rocks.

MISSISSIPPIAN ROCKS

Beds of limestone of Mississippian age, about 30 feet or more thick, rest on Precambrian rocks in the Coyote Hills. About 5 feet of arkose is present at the base of the Mississippian rocks at their contact with the underlying Precambrian. The limestone is medium gray and massive, and forms a prominent ledge.

PENNSYLVANIAN ROCKS

Rocks of Pennsylvanian age are well exposed in the central part of Little San Pascual Mountain; they consist of arkosic sandstone, shale, and limestone varying from tan to gray. Along the west margin of Little San Pascual Mountain some Pennsylvanian rocks are silicified. Although rocks of Pennsylvanian age in New Mexico have been divided into many formations and informal rock units (Kottlowski, 1960), they are undifferentiated in the present report.

PERMIAN ROCKS

Rocks of Permian age are well exposed in many parts of New Mexico. Some of these compose a part of the so-called "red beds" that are well known in the Southwest. Of the many Permian formations in New Mexico, only two—the Abo and Yeso Formations (Lee, 1909, p. 12;

Needham and Bates, 1943, p. 1654–1661)—are present in the report area.

ABO FORMATION

The Abo Formation consists of reddish-brown conglomerate and arkosic sandstone with interbeds of siltstone; some beds of shale are present. In many places the Abo is mottled gray.

The Abo is exposed in Little San Pascual Mountain in the southeastern part of the Bosque del Apache Refuge. There it consists chiefly of dark-reddish-brown fine- to medium-grained arkosic sandstone; some shaly interbeds are present. Geddes (1963, p. 200) states that the Abo Formation is 753 feet thick in the Little San Pascual area.

YESO FORMATION

The Yeso Formation consists of yellow to salmon-pink sandstone, siltstone, shale, and dolomitic limestone and some beds of gypsum. The sandstone is well sorted and contains a high percentage of quartz grains, in contrast to the poorly sorted and feldspathic sandstone of the underlying Abo Formation.

The Yeso Formation is exposed in the southern part of Little San Pascual Mountain; many of the soft beds are poorly exposed. Only one bed of gypsum was observed; it is about 6 feet thick, and probably contains impurities of clay. Geddes (1963, p. 200) estimates that the Yeso is about 900 feet thick in Little San Pascual Mountain.

TERTIARY ROCKS

Rocks of Tertiary age exposed in the Bosque del Apache Refuge are, in ascending order, the Baca Formation, undifferentiated volcanic rocks, and the Santa Fe Group. The undifferentiated volcanic rocks may be equivalent, in part, to the Datil Formation of southwestern New Mexico.

BACA FORMATION

The Baca Formation (Wilpolt and others, 1946) consists typically of reddish-brown sandstone and siltstone, with some interbedded conglomerate and shale. It is well exposed on two small mesas northwest of Little San Pascual Mountain; as neither its base nor its top is exposed, its thickness is not known.

VOLCANIC ROCKS

Volcanic rocks, including andesite and related flows as well as volcanic tuff, are particularly well exposed in the Coyote Hills in the northwestern part of the refuge. Andesite underlies the Santa Fe Group in Little San Pascual Mountain.

SANTA FE GROUP

The Santa Fe Group is composed chiefly of alluvium that fills parts of the Rio Grande Valley, and consists of conglomerate, sandstone, and some interbeds of clay. The rocks are tan to yellowish gray and contain some limy cement. In the western part of the refuge, beds of the group locally dip as much as 65° toward the east; in Little San Pascual Mountain they dip gently toward the west.

RECENT DEPOSITS

Recent deposits include terrace gravel, sand dunes, and the alluvial flood-plain sediments of the Rio Grande. Sand dunes are a prominent part of the terrace along the western part of Little San Pascual Mountain. The flood plain of the Rio Grande consists of sand, silt, and clay, and is marshy in places.

ECONOMIC APPRAISAL

Data were compiled regarding mineral-right ownership and regulations governing location and leasing of mineral occurrences in the Bosque del Apache Wildlife Refuge. All available information on known mineral deposits was reviewed.

The Bosque del Apache National Wildlife Refuge was established on November 22, 1939. The refuge consists of the entire area formerly embraced by the Bosque del Apache Land Grant, established on November 28, 1845. The mineral right accompanied the transfer of title to the U.S. Government. The refuge has been closed to mineral exploitation since its establishment; prospecting is prohibited.

There is evidence of prospecting, probably carried on before 1939, at a "red-bed copper" prospect and at a fault-gouge copper prospect, both in the southern part of Little San Pascual Mountain (fig. 1). In the Chupadera candidate area prospect, holes have been excavated in an area containing manganese and along a fault zone containing copper minerals. Before their establishment as a wildlife refuge, the candidate areas were privately owned, and no official recording of claims was required.

METALLIC MINERAL DEPOSITS

COPPER—LITTLE SAN PASCUAL CANDIDATE AREA

The location of two copper prospects is shown in figure 1. At the "red-bed copper" deposit in the Abo Formation, workings consist of three shallow pits and a shaft, excavated along the N. 60° E. strike of beds. The pits and shaft are about 10 feet apart. Each pit is less than 10 feet square and 3–7 feet deep. The shaft is 4 feet square and about 20 feet deep. The volume of dump material approximately equals the

volume of material excavated, which indicates that little or no ore was shipped from the site.

The mineralized zone extends about 70 feet along the strike, and is about 4 feet wide. The ore minerals occur along the bedding, which dips 65° E. The copper minerals are mainly azurite and malachite; no copper sulfide minerals were seen. The deposit is similar to other "red-bed copper" deposits described by Lindgren and others (1910, p. 76–79). Because of the small size and steep dip of the mineralized zone and the small quantities of copper minerals in it, the deposit is unlikely to be of commercial value.

The fault-gouge copper prospect (fig. 1) occurs in the Yeso Formation and consists of a small adit extending about 5 feet into the hillside; height of the adit is about 4 feet. These small workings are along a fault that contains several inches of gouge. Minor copper-mineral stains occur in the dump material, but no copper minerals were seen in place. A small pit across the arroyo from the adit probably represents an attempt by the prospector to locate the continuation of the fault; the fault zone appears to be small in extent. The economic potential of the deposit is considered to be negligible.

COPPER AND LEAD—CHUPADERA CANDIDATE AREA

A prospect in the Coyote Hills (fig. 1) consists of a shaft 20 feet deep and a pit about 20 feet long, 3–8 feet wide, and 7 feet deep. The pit is 36 feet southwest of the shaft. The copper minerals azurite and malachite occur on the dump, as does limonite. Chemical analyses of a sample of the dump material are 0.01 ounce gold per ton, 1.2 ounces silver per ton, 1.1 percent copper, 2.4 percent lead, and 2.9 percent zinc.

The pits are in Precambrian schist along a fracture zone adjacent to a major fault. The absence of well-defined mineralized outcrops of geologic structural features indicates that there is little economic potential in the area and probably no exploitable mineralization at depth.

MANGANESE—CHUPADERA CANDIDATE AREA

A manganese mineral, presumably pyrolusite, occurs as a thin coating on the surfaces of joints and small fractures in the Mississippian limestone, near the contact of the limestone and the Precambrian rocks (fig. 1). The coatings range in thickness from a stain to about one-half inch. The mineralized zone averages about 6 feet thick and covers an observable area several hundred feet wide and about one-fourth mile long, but the overall manganese content in material as it would have to be mined is small. A small adit has been driven about

6 feet into the manganese-stained area. At present manganese prices, the deposit would not be economically minable.

NONMETALLIC MINERAL DEPOSITS

SAND AND GRAVEL

Sand and gravel deposits occur throughout much of the Bosque del Apache Refuge. Similar deposits are abundant and more easily accessible elsewhere in the Rio Grande Valley, however, so those of the refuge are presently of minor economic importance.

LIMESTONE, GYPSUM, BARITE, AND FLUORSPAR—LITTLE SAN PASCUAL CANDIDATE AREA

Although limestone occurs in Little San Pascual Mountain, access to this remote area would entail considerable expense. Major occurrences outside the refuge assure adequate supplies for any demand foreseeable at present. Gypsum occurs in the Yeso Formation, but the beds, as exposed, are too thin and impure to be profitably mined. Minor amounts of barite and fluorspar occur in a siliceous zone, but they have no economic value.

PUMICE—CHUPADERA CANDIDATE AREA

A volcanic tuff in the Chupadera area contains some pumice. The deposit has little value, owing to its great amount of impurities.

MINERAL FUELS

OIL AND GAS

Three test wells, between 2,000 and 3,000 feet deep, were drilled on the Bosque del Apache Land Grant during 1927–29, before the establishment of the wildlife refuge. The wells are in the area excluded from consideration as wilderness. One well was dry, one had a show of oil, and one had a show of gas; the shows probably occurred in the valley alluvium. All the wells were abandoned. Surface exposures of bedrock suggest that complex faulted structure underlies the refuge. This complex structure and the proximity to volcanic rocks indicate that the probability of finding oil or gas in the candidate areas is very small.

COAL

Coal occurs near the extreme northeast corner of the refuge but outside the areas proposed for wilderness. Coal-bearing formations do not crop out in the refuge.

MINERAL POTENTIAL

Available data indicate little potential for commercially important occurrences of minerals in the candidate areas. The manganese deposits would become economically minable only after a considerable increase in the price of manganese. At the Chupadera copper-lead prospect, a commercial operation is not feasible in view of the observed limited mineralized outcrops. The geologic environment indicates that the chances for finding oil or gas or other usable mineral resources in the candidate areas are very small.

REFERENCES CITED

Darton, N. H., 1928, "Red Beds" and associated formations in New Mexico, with an outline of the geology of the State: U.S. Geol. Survey Bull. 794, 356 p. [1929].

Geddes, R. W., 1963, Geology of Little San Pasqual Mountain, *in* New Mexico Geol. Soc. Guidebook 14th Field Conf., Socorro region, New Mexico: p. 197–203.

Kottlowski, F. E., 1960, Summary of Pennsylvanian sections in southwestern New Mexico and southeastern Arizona: New Mexico Bur. Mines and Mineral Resources Bull. 66, 187 p.

Lee, W. T., and Girty, G. H., 1909, The Manzano group of the Rio Grande valley, New Mexico: U.S. Geol. Survey Bull. 389, 141 p.

Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., 1910, The ore deposits of New Mexico: U.S. Geol. Survey Prof. Paper 68, 361 p.

Needham, C. E., and Bates, R. L., 1943, Permian type sections in central New Mexico: Geol. Soc. American Bull., v. 54, no. 11, p. 1653–1667.

Wilpolt, R. H., MacAlpin, A. J., Bates, R. L., and Vorbe, Georges, 1946, Geologic map and stratigraphic sections of Paleozoic rocks of Joyita Hills, Los Pinos Mountains, and northern Chupadera Mesa, Valencia, Torrance, and Socorro Counties, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 61.

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