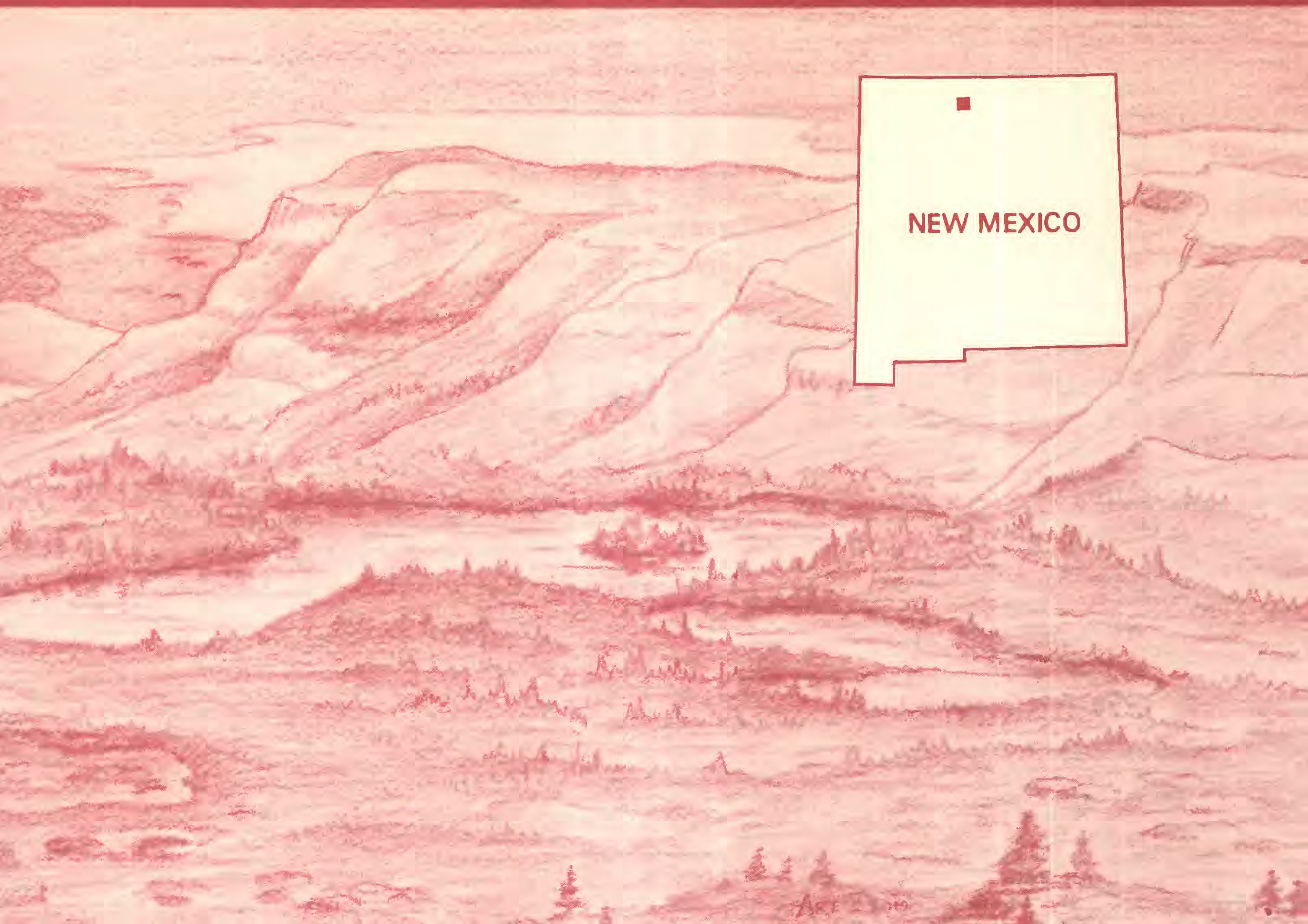
Mineral Resources of the Rio Chama Wilderness Study Area, Rio Arriba County, New Mexico

U.S. GEOLOGICAL SURVEY BULLETIN 1733–C



Chapter C

Mineral Resources of the Rio Chama Wilderness Study Area, Rio Arriba County, New Mexico

By JENNIE L. RIDGLEY and CARL L. LONG
U.S. Geological Survey

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U.S. GEOLOGICAL SURVEY BULLETIN 1733

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
NORTHERN NEW MEXICO

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

U. S. GEOLOGICAL SURVEY
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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94–579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of a part of the Rio Chama Wilderness Study Area (NM–010–059), Rio Arriba County, New Mexico.

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Mineral Resources of the Rio Chama Wilderness Study Area, Rio Arriba County, New Mexico

By Jennie L. Ridgley *and* Carl L. Long
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ABSTRACT

The Rio Chama Wilderness Study Area (NM–010–059), Rio Arriba County, N. Mex., has inferred subeconomic sand and gravel, limestone, and sandstone resources. The study area has moderate mineral resource potential for undiscovered limestone and gypsum resources in the subsurface; low mineral resource potential for undiscovered oil and gas, for undiscovered silver, manganese, tin, vanadium, zinc, uranium, and all other metals, and for clinoptilolite; and low resource potential for undiscovered geothermal energy.

SUMMARY

The Rio Chama Wilderness Study Area, Rio Arriba County, N. Mex., is in the western part of the Chama Basin (fig. 1) approximately 3.5 mi (miles) south of El Vado and El Vado Reservoir. The Jicarilla Apache Indian Reservation is just west of the northern part of the study area, and the Santa Fe National Forest is adjacent to the study area on the west and south. The Chama River Canyon Wilderness, managed by the U.S. Forest Service, is contiguous to the southern boundary of the study area. The Rio Chama cuts through the study area and forms part of its western boundary. Access to the study area is by an unmarked dirt road that joins New Mexico Highway 112 south of El Vado and by unmarked roads that intersect U.S. Highway 84 at Cebolla and New Mexico Highway 112 east of El Vado. In this area the Rio Chama cuts a steep canyon through the mesas, the relief being as much as 900 ft (feet). The river is accessible in only a few places.

The Rio Chama Wilderness Study Area is in the southeastern part of the Colorado Plateaus physiographic province. Sedimentary rocks in the study area are folded and faulted and are part of a complex fold belt that separates the Chama Basin from the San Juan Basin to the west. The structural features formed primarily during the Late Cretaceous and early Tertiary (see geologic time chart in appendix) (Landis and Dane, 1967). However, movement on some structures near the study area occurred earlier than that (Ridgley, 1987a). Faulting in the study area is generally limited to displacements of less than 200 ft along high-angle, normal faults.

Rocks exposed in the study area range in age from Jurassic to Quaternary. No Tertiary rocks are present. In the subsurface, rocks of Pennsylvanian age unconformably overlie Precambrian rocks and are in turn overlain by rocks of Permian and Triassic age. Jurassic rocks exposed in the study area are the Entrada Sandstone, Wanakah Formation, and Morrison Formation. Cretaceous rocks are represented by the Burro Canyon(?) Formation, Dakota Sandstone, and Mancos Shale.

About one-half of the study area is under lease for oil and gas, but no test holes have been drilled. In 1981 most of the study area was covered with mining claims; however, these have been abandoned. The wilderness study area has been prospected for uranium. Two uranium prospects are located near the wilderness boundary (fig. 1); neither has produced any uranium. The only identified resources in the study area are sand and gravel, limestone, and sandstone.

The Rio Chama Wilderness Study Area has moderate potential for limestone and gypsum in the subsurface (fig. 1). This assessment applies to the entire study area because any resources present would be in the subsurface. Extension of the geology from the nearby Gallina Mountain area indicates that Pennsylvanian limestone, which is quarried for road metal in the southern part of the Chama Basin, underlies the study area. On the basis of known relationships of the facies distribution of the gypsum and limestone in the Wanakah Formation, gypsum can be expected to have an irregular distribution in the subsurface in the study area.

The Rio Chama Wilderness Study Area has low mineral resource potential for undiscovered oil and gas resources, for undiscovered resources of silver, manganese, tin, vanadium, zinc, uranium, and all other metals, and for clinoptilolite; and low resource potential for undiscovered geothermal energy (fig. 1). Favorable oil and gas host and source rocks and structural and stratigraphic traps may exist in the Pennsylvanian rocks that underlie the study area. However, extensive faulting of the rocks and close proximity to a deep dissected canyon and basin margin could permit flushing of hydrocarbons. Clinoptilolite is found approximately 5 mi south of the study area. However, rocks containing this zeolite do not extend into the study area. No uranium deposits are known to be present in the study area. Geochemical and aeroradiometric surveys did not detect any anomalies that would indicate the presence of buried deposits of these commodities. Extensive faulting and proximity of the study area to a steep, dissected canyon could permit migration of ground water, which might oxidize and remove uranium or metal concentrations.

There are no known geothermal energy sources in the form of buried intrusions or warm springs in the study area. However, two warm springs are within 0.25 mi to the north of the study area (fig. 2). The springs emanate from a fault that cuts the west limb of the Rio Chama anticline. Warm water circulating through the fault discharges at the springs; the source of heat that warms the water is not known. There is low potential for geothermal resources throughout the study area.

EXPLANATION

M/C Geologic terrane having moderate resource potential for gypsum and limestone in the subsurface, with a certainty level of C—Applies to entire study area

L/B Geologic terrane having low resource potential for oil, gas, silver, manganese, tin, vanadium, zinc, uranium, and all other metals, and for geothermal energy, with a certainty level of B—Applies to entire study area

L/C Geologic terrane having low resource potential for clinoptilolite, with a certainty level of C—Applies to entire study area

—< Adit

× Prospect

Levels of certainty

B Data indicate geologic environment and suggest level of resource potential

C Data indicate geologic environment and resource potential, but do not establish activity of resource-forming processes

INTRODUCTION

The U.S. Geological Survey and the U.S. Bureau of Mines studied 5,232 acres of the Rio Chama Wilderness Study Area (NM–010–059). The study of this acreage was requested by the U.S. Bureau of Land Management. In this report the studied area is called the "wilderness study area" or simply the "study area."

This report presents an evaluation of the mineral endowment (identified resources and mineral resource potential) of the study area and is the product of several separate studies by the U.S. Bureau of Mines (USBM) and the U.S. Geological Survey (USGS). Identified resources are classified according to the system of the USBM and USGS (1980), which is shown in the appendix of this report. Identified resources are studied by the USBM. Mineral resource potential is the likelihood of occurrence of undiscovered metals and nonmetals, industrial rocks and minerals, and energy sources (coal, oil, gas, oil shale, and geothermal sources). It is classified according to the system of Goudarzi (1984), which is also shown in the appendix. Potential for undiscovered resources is studied by the USGS.

The Rio Chama Wilderness Study Area, Rio Arriba County, N. Mex., is along the northern part of the Rio Chama in the western part of the Chama Basin (fig. 1). The study area is bounded on the northwest by the Jicarilla Apache Indian Reservation and on the south and west by the Santa Fe National Forest. The Chama River Canyon Wilderness, managed by the U.S. Forest Service, is contiguous to the southern study area boundary. The study area is approximately 3.5 mi south of El Vado and El Vado Reservoir and may be reached by an unmarked dirt road that joins New Mexico Highway 112 south of El Vado and by unmarked roads that intersect U.S. Highway 84 at Cebolla and New Mexico Highway 112 east of El Vado. Access is by public and private roads that are passable only in dry weather. The study area is characterized by steep canyons and mesas and has as much as 900 ft relief. Canyon walls are rugged, and the river is accessible in only a few places. Elevation of the mesa tops is consistently about 7,500 ft. The Rio Chama flows through the study area and forms part of its western boundary.

Investigations by the U.S. Bureau of Mines

The Rio Chama Wilderness Study Area was examined by the U.S. Bureau of Mines personnel in 1985. Prior to field investigations, published and unpublished literature relating to the study area was reviewed for information concerning mineral deposits, occurrences, mineralized areas, and mining activity. Land status plats were acquired from the U.S. Bureau of Land Management State Office, Sante Fe, N. Mex. Six employee-days were spent in the field.

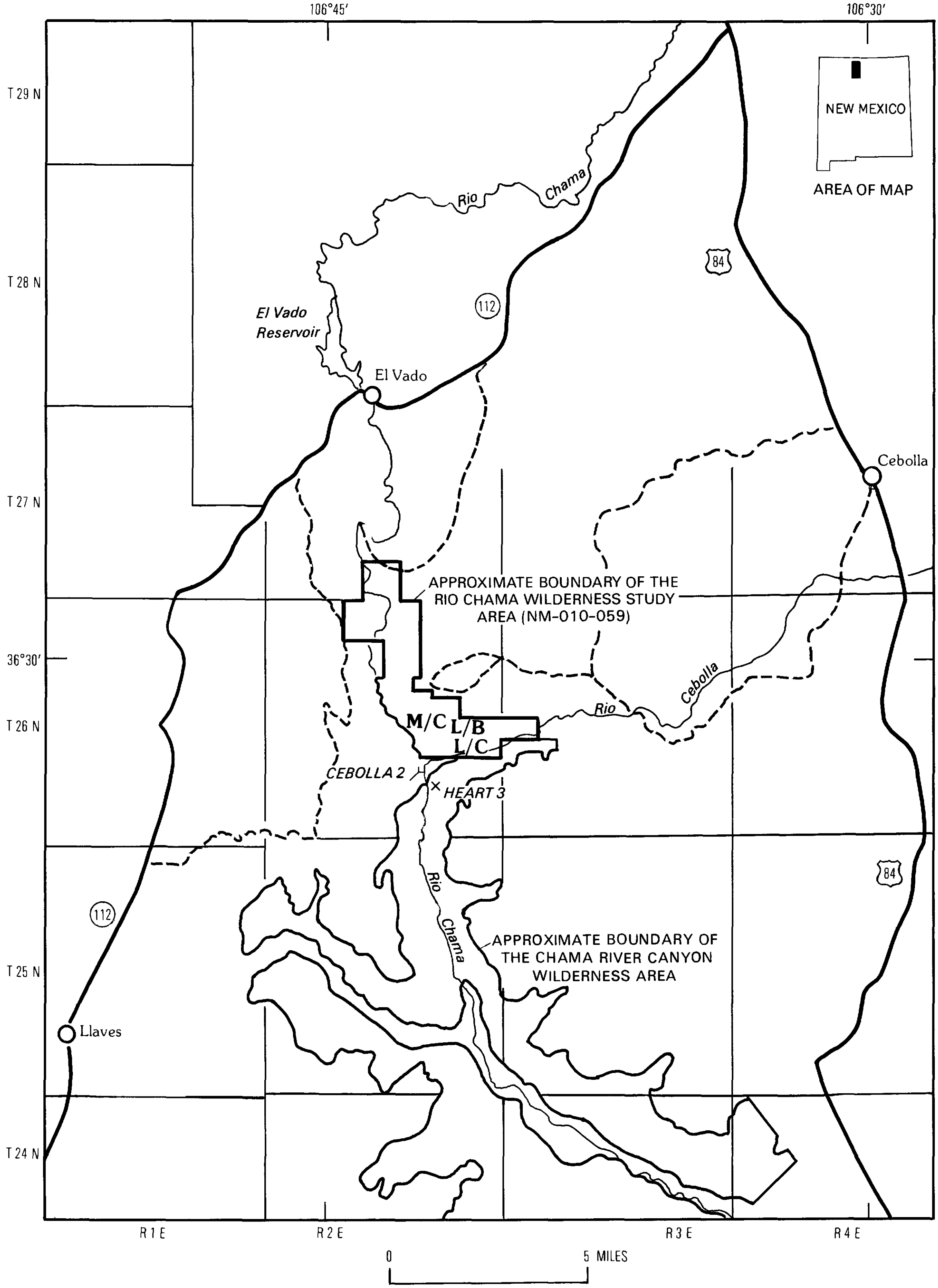

Figure 1. Summary map showing location of wilderness study areas along the Rio Chama, northern New Mexico; mineral resource potential; and principal mines and prospects in the Rio Chama Wilderness Study Area and vicinity, Rio Arriba County, N. Mex.

Field investigations by U.S. Bureau of Mines personnel included examination of mines and prospects within 1 mi of the study area and the collection of seven panned-concentrate samples along the Rio Chama in and near the study area. All samples were analyzed for gold and silver by fire assay, inductively coupled plasma, and atomic-emission spectroscopy, and for 50 elements by semiquantitative optical-emission spectroscopy by the USBM, Reno Research Center, Reno, Nev. All analytical data are in Schreiner (1986, table 1 and appendix A).

Investigations by the U.S. Geological Survey

An assessment of the mineral resource potential of the Rio Chama Wilderness Study Area was conducted during the summers of 1985 and 1986. As part of this assessment, a geologic map was prepared at a scale of 1:24,000 (Ridgley, in press); about 65 percent of this map includes new geologic mapping for this area of the Chama Basin, and the rest represents modification of existing geologic mapping (Landis and Dane, 1967; Ridgley, 1983). No new geochemical data were gathered for this study, but data from a report prepared for the U.S. Forest Service on the Chama River Canyon Wilderness and contiguous roadless areas (Ridgley, 1986) were used. Geophysical studies included an evaluation of existing aeroradiometric data by J.S. Duval and an evaluation of existing aeromagnetic and gravity data by C.L. Long.

Acknowledgments.—The USGS thanks the several ranchers in the area for providing location information and access to the study area.

APPRAISAL OF IDENTIFIED RESOURCES

By Russell A. Schreiner
U.S. Bureau of Mines

Mining History

Uranium occurrences were discovered during the late 1950's in the southern Chama Basin. The basin was prospected during the uranium boom starting in the late 1960's. Uranium exploration in and near the study area concentrated on the Cretaceous Burro Canyon Formation; several small roll-front deposits were discovered approximately 8–16 mi east of the study area (Saucier, 1974). In 1981 most of the study area was covered with mining claims (Light, 1982), which have since been abandoned.

Mineral Appraisal

The only mineral resources identified in the study area were common industrial materials. The following inferred subeconomic resources are present: sand and gravel along the river bed of the Rio Chama, limestone in the Jurassic-age Todilto Limestone exposed in a small area at the base of the canyon of the Rio Chama, and sandstone in the Jurassic- and Cretaceous-age formations exposed in the walls of the canyon of the Rio Chama. Because of the abundance of these materials in the region, the distance from markets and their lack of unique properties, it is unlikely they would be developed in the near future.

Seven panned-concentrate samples were taken along the Rio Chama in and near the study area. One sample contained silver, determined by fire assay (Schreiner, 1986, table 1). Semiquantitative optical-emission spectroscopic analysis of the other samples showed no element concentrations that could be considered anomalous for a panned-concentrate sample. No known mineral occurrences containing elements in the concentrates are present in the area. Detailed sampling would be required to determine the significance of the analytical value.

Two uranium prospects, Cebolla 2 and Heart 3, are within 1 mi of the southern boundary of the study area (fig. 2). Uranium occurs in small, local concentrations in amounts as much as 0.37 percent equivalent uranium (determined by radiometric assay), associated with fossil bone fragments in the Morrison Formation at the Cebolla 2 prospect and in limonite-stained limestone fragments along the contact between the Todilto and upper member of the Wanakah at the Heart 3 prospect (Hilpert, 1969; Light, 1982). A stream-sediment sample taken just outside the southeastern boundary of the study area at the mouth of Berry Canyon contained a minor concentration of uranium (5 ppm) (Ridgley and Light, 1983).

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Jennie L. Ridgley and Carl L. Long
U.S. Geological Survey

Geology

Geologic Setting

The Rio Chama Wilderness Study Area is along the western margin of the Chama Basin in the southeastern part of the Colorado Plateaus physiographic province. Rocks in the study area are folded and faulted and form part of the Archuleta anticlinorium, a complex series of folded and faulted anticlines, synclines, and domes that separate the Chama Basin from the San Juan Basin to the west. The structural features formed mainly during the Laramide orogeny, of Late Cretaceous and early Tertiary age. However, movement occurred on some structures near the study area earlier than that; these movements influenced distribution and thickness of the sediments being deposited in the study area (Landis and Dane, 1967; Ridgley, 1987a, 1987b). Results of drilling in areas to the north, west, and south and examination of exposures of older rocks to the south and east indicate a complex structural history for the study area. Rocks of several ages are beveled or absent over some of the structural features; Laramide or later structures may not accurately reflect older structural features, which could contain large fault displacements or amplitudes of folds (Landis and Dane, 1967) that could affect the location of structural or stratigraphic traps for hydrocarbon accumulation.

Faulting in the study area is generally limited to displacements of less than 200 ft, although faults having displacements in excess of 200 ft are present. Traces of the faults commonly are short; however, a few can be mapped for several miles. Most of the faults are high-angle, normal faults. In the northern part of the study area, faults are so closely spaced that it is difficult to show all the faults on the map; thus, only the major faults are shown.

Rocks exposed in the study area range in age from Jurassic to Quaternary. No Tertiary rocks are present. In the subsurface, rocks of Pennsylvanian age unconformably overlie Precambrian rocks and are overlain by rocks of Permian and Triassic age.

Description of Rock Units

Individual rock units mapped in the study area are grouped into several map units in this report (fig. 2). A detailed geologic map may be found in Ridgley (in press).

Middle Jurassic Entrada Sandstone and Wanakah Formation and Upper Jurassic Morrison Formation, undivided (unit Ju*).*—The Entrada Sandstone is composed of orange, tan, or white, medium-grained sandstone that crops out in only a few places in the southern part of the study area as a result of a structure that brings older units to the surface. The Entrada is not completely exposed; a partial thickness of 140 ft is present.

In the study area the Wanakah Formation consists of the basal Todilto Limestone Member and an overlying unnamed upper member. The Todilto consists of limestone and, locally, gypsum that overlies the limestone in discontinuous lenses. The distribution of limestone and limestone-gypsum facies reflects changes in precipitation from calcium carbonate to calcium sulfate (Ridgley, 1984) at the time the Todilto was being deposited. Interbedded sandstone and mudstone and minor diamictite and limestone characterize the upper member. Sandstone is dominant in the lower two-thirds of the upper member and mudstone in the upper third. Limestone is locally present near the top of the upper member. The diamictite, which is present at the base of the upper member, represents debris flows originating from uplifted areas along the Archuleta anticlinorium just to the west of the study area (Ridgley, 1987a). Exposures of the Wanakah are poor. The estimated thickness is about 100 ft.

The Morrison Formation is composed of two members. The lower member consists of interbedded light-reddish-brown fluvial sandstone and reddish-brown mudstone. Sandstone, which is locally characterized by multiple stacking of channels, is dominant. This member crops out only in the southern part of the study area. The overlying Brushy Basin Member is composed of green, tan, and maroon mudstone and some buff-colored sandstone. The upper sandstone units are commonly conglomeratic. The total Morrison Formation is about 575 ft thick.

Lower Cretaceous Burro Canyon(?) Formation and Upper Cretaceous Dakota Sandstone, undivided (unit Kdb*).*—Sandstone and conglomeratic sandstone are characteristic of the Burro Canyon(?) Formation. A mudstone interval separates two thick sandstone sequences at a few localities; elsewhere the Burro Canyon(?) is composed only of sandstone. The Burro Canyon name is queried because detailed stratigraphic studies that would tie these sandstone sequences to those of the Burro Canyon at its type locality in western Colorado have not been completed. The Burro Canyon(?) Formation is as much as 140 ft thick.

Rocks of the Dakota Sandstone are sandstone, shale, and locally conglomeratic sandstone. The sandstone and shale are commonly carbonaceous. The Dakota Sandstone forms the cap rock of the mesas and steep canyon walls over most of the study area. The upper part of the Dakota is absent over parts of the study area. Total thickness is as much as 200 ft in the study area.

Upper Cretaceous Mancos Shale (unit Kmu*).*—The Mancos Shale consists of five units in the study area; the entire Mancos is not present. The Hartland Shale Beds, at the base, consist of gray, fossiliferous shale, bentonite beds, and minor amounts of sandstone. The fossils are equivalent in age to the Hartland Shale Member of the Greenhorn Limestone of eastern Colorado and Kansas (Sageman, 1985). Overlying the Hartland Shale Beds are the Bridge Creek Limestone Beds, which are composed primarily of limestone at the base and interbedded

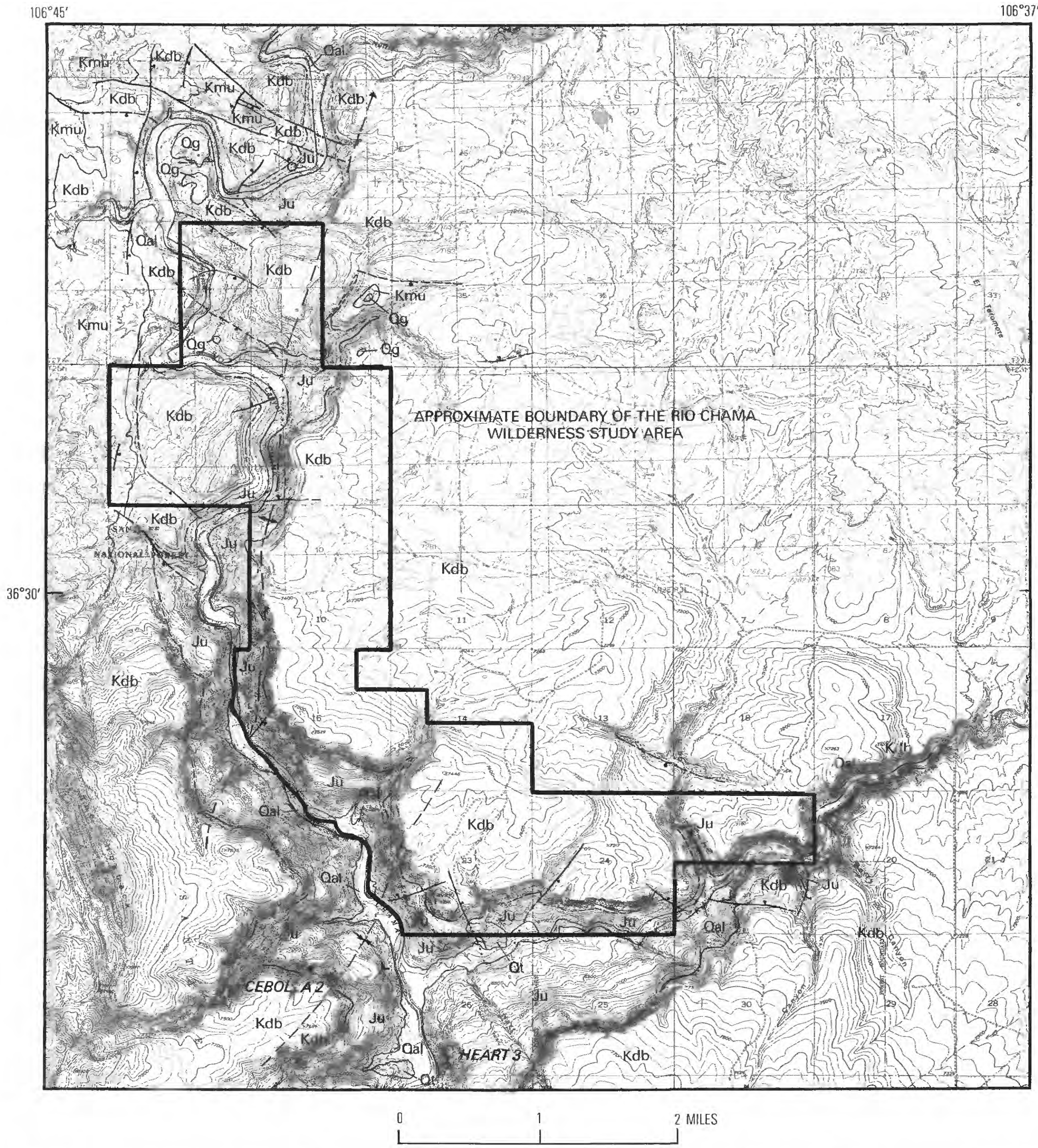

Figure 2. Geologic map of the Rio Chama Wilderness Study Area, Rio Arriba County, N. Mex. Geology mapped 1985–86 by J.L. Ridgley; prospect and adit from Schreiner (1986). Base from U.S. Geological Survey 1:24,000, Navajo Peak, 1953; El Vado, 1983.

limestone and shale in the upper part. These beds are commonly used as a regional datum for correlation. The lower shale member overlies the Bridge Creek Limestone Beds and is composed mainly of shale and siltstone. Overlying the lower shale member are the Juana Lopez Member and middle shale member. Both members are composed primarily of shale. The Mancos is about 625 ft thick in the study area.

Quaternary surficial deposits (units Qal, Qg, *and* Qt*).*—Quaternary deposits include unconsolidated

CORRELATION OF MAP UNITS

Qal	Qg	Qt	Holocene / Pleistocene(?)	QUATERNARY
Unconformity				
		Kmu	Upper Cretaceous	CRETACEOUS
		Kdb	Lower Cretaceous	
Unconformity				
		Ju	Upper and Middle Jurassic	JURASSIC

LIST OF MAP UNITS

Qal **Alluvium (Holocene)**

Qg **Gravels (Holocene and Pleistocene?)**

Qt **Talus (Holocene or Pleistocene?)**

Kmu **Mancos Shale (Upper Cretaceous)**

Kdb **Dakota Sandstone (Upper Cretaceous) and Burro Canyon(?) Formation (Lower Cretaceous), undivided**

Ju **Morrison Formation (Upper Jurassic), Wanakah Formation and Entrada Sandstone (Middle Jurassic), undivided**

Contact—Dashed where approximately located

Fault—Dashed where approximately located, dotted where concealed; bar and ball on downthrown side

Uranium adit

× **Uranium prospect**

Warm spring

Anticline—Showing trace of axial plane and plunge; approximately located

Syncline—Showing trace of axial plane and plunge; approximately located

alluvium of streams that are of Holocene age, gravels of Holocene and Pleistocene(?) age, and talus of Holocene or Pleistocene(?) age.

Geochemistry

The U.S. Geological Survey did not conduct a geochemical survey of the study area; some samples were taken within the study area during geochemical sampling in 1980–1981 of the adjacent Chama River Canyon Wilderness and Roadless Areas. As part of this earlier survey, stream-sediment and panned-concentrate samples were collected from two first-order drainages inside the Rio Chama Wilderness Study Area. Sample sites were in the drainage adjacent to the east side of Navajo Peak and the drainage from Lobo Canyon (Ridgley, 1986, samples 221 and 223). Samples were also collected from drainages just to the south of the study area and within the Chama River Canyon Wilderness. First-order drainages just to the west of the Rio Chama Wilderness Study Area and within a proposed U.S. Forest Service roadless area were also sampled (Ridgley, 1986, samples 215–217, 220). All samples were collected upstream from the stream mouth to avoid contamination during flood stage of the Rio Cebolla and the Rio Chama. In addition to the stream-sediment samples, three rock samples were collected from the Morrison and Burro Canyon(?) Formations near Aragon Spring, just west of the northern part of the study area (Ridgley, 1986, samples 128–130).

The rock, stream-sediment, and panned-concentrate samples were analyzed by U.S. Geological Survey laboratories by the six-step semiquantitative spectrographic analysis technique (Matooka and Grimes, 1976). Additional details on analytical methods and the chemical analyses are found in Ridgley (1986). The panned-concentrate sample from Lobo Canyon (sample 223), within the study area, contained anomalous concentrations of copper (70 ppm); the drainage next to Navajo Peak yielded no anomalous values. In the drainages adjacent to the study area, anomalous concentrations of beryllium (5 ppm), manganese (1,500 ppm), and cobalt (200 ppm) were detected in stream-sediments from Long Canyon; a weakly anomalous concentration of uranium (5 ppm) was detected in stream sediments from Berry Canyon; and an anomalous concentration of manganese (1,000 ppm) was detected in a sandstone sample from the upper part of the Morrison Formation near Aragon Spring. None of the anomalies that were detected is considered to be indicative of mineral resources.

Geophysics

Aeroradiometric Study

Aerial gamma-ray spectroscopy is a technique that provides estimates of the near-surface (0–20 in. depth) concentrations of percent potassium (K), parts per million equivalent uranium (eU), and parts per million equivalent thorium (eTh). Aerial gamma-ray spectroscopic data for New Mexico have been compiled and processed to produce a series of 1:1,000,000 maps (Duval, 1983). The Rio Chama Wilderness Study Area has overall low radioactivity, the concentrations of radioactive elements being 0.9–1.1 percent K, 1.7–2.6 ppm eU, and 6.5–8 ppm eTh. No anomalies were detected within or near the study area (J.S. Duval, written commun., 1986).

Aeromagnetic and Gravity Study

Gravity and aeromagnetic data were obtained from existing files as part of the mineral resource evaluation of the Rio Chama Wilderness Study Area. These data provide information on general surface and subsurface distribution of rock masses and structural features.

Aeromagnetic Data

The aeromagnetic data are from a compilation of magnetic data for the state of New Mexico by Cordell (1984) and are shown in figure 3. The magnetic survey of the Rio Chama area was flown at 1,000 ft above ground level, and the flight lines were oriented north-south at a spacing of approximately 1 mi apart. Magnetic values vary from an average of about –70 nT (nanoteslas) over the study area to 60 nT just northeast of the area. The only notable anomaly in the area is the symmetrical magnetic high northeast of the study area. This anomaly probably indicates a structural high in the basement rock or an intrabasement susceptibility contrast between the nonmagnetic, flat-lying Cretaceous, Jurassic, and older Mesozoic and Paleozoic sedimentary rocks and the more magnetic crystalline basement rocks.

Gravity Data

Gravity data were obtained from a file collected by the U.S. Department of Defense (National Oceanic and Atmospheric Administration National Geophysical Data Center). The 1967 gravity formula (International Association of Geodesy, 1967) and a reduction density of 2.67 g/cm^3 (grams per cubic centimeter) were used to compute the Bouguer gravity anomaly values. Using the method of Plouff (1977), we corrected for terrain by computer for a distance of 100 mi from each station. The results are shown in figure 4. Although the study area includes only one gravity station, there were enough stations in the surrounding area to get a general regional signature of the gravity. The Bouguer values decrease to the northwest from –252 mGal (milligals) at the southeast corner of the study area to –260 mGal at the northwest corner, indicating a thickening of the sedimentary section toward the San Juan Basin.

Mineral and Energy Resources

Oil and Gas

The Dakota Sandstone and Burro Canyon(?) Formation, which yield oil in the eastern part of the San Juan Basin, are at the surface over most of the study area and thus would not contain oil or gas resources. Pennsylvanian strata, which have yielded oil and gas in the western part of the San Juan Basin, have not been sufficiently drilled to determine the potential for the existence of favorable facies and structural and stratigraphic traps at depth. Several structural traps (parts of anticlines) occur in the study area (Ridgley, in press); however, these structural features are cut by numerous faults that could serve as conduits for migration of oil and fresh water.

Fitter (1958) reported that at the Skelly Oil Company No. 1 Crittenden drill hole, spudded in 1948, shows of oil were found in the Pennsylvanian rocks at two horizons. The well was drilled 14 mi south of the study area in sec. 36, T. 24 N., R. 1 E. Lithologic data from the drill hole indicated that the Pennsylvanian strata consisted of gray, fine- to medium-grained crystalline limestone, gray and maroon shale, and arkosic sandstone (Fitter, 1958).

Lookingbill (1955) reported a thick sequence (1,864 ft) of limestone and black shale of possible Pennsylvanian age in a dry oil-test well, Hall No. 1 Silver, which was drilled 3 mi west of the study area, on Gallina Mountain. At this locality the presence of fresh water at three horizons suggested that if hydrocarbons had been present they would have been flushed away. This thick sequence of Pennsylvanian rocks does not appear to be present at South El Vado dome, about 4 mi north of the study area (Foster and Stipp, 1961), where the Precambrian was encountered at 1,815 ft in the Helmerich and Payne No. 1 El Vado. This oil-test hole was spudded in the Dakota Sandstone. The limestone and black shale of the Pennsylvanian rocks are possible reservoirs or source rocks. The thickness of the Pennsylvanian rocks in the study area is not known.

According to Ryder (1983), in an analysis of oil and gas potential of some wilderness lands in northern New Mexico, Pennsylvanian reservoir rocks in the Chama Basin are very susceptible to flushing by fresh water. This is likely due to the deep dissection of the region, exposing potential reservoirs at the surface, and the proximity of the strata to uplifted margins of the basin. For these reasons he assigned a low potential for hydrocarbon resources in the area he evaluated. The Rio Chama Wilderness Study Area is north of the area Ryder evaluated. Although favorable structural traps occur in the study area (Landis and Dane, 1967; Ridgley, 1983), the lack of any oil or gas production and dry holes drilled on structural features directly to the north, where greater overburden exists, support the premise that there may have been flushing of the rocks. For these reasons, the resource potential for oil and gas is rated as low, with a certainty level of B (fig. 1), throughout the study area.

Industrial Minerals

Clinoptilolite

The zeolite mineral clinoptilolite has been found as aggregates visible to the unaided eye in mudstone and as solid beds of altered tuff in approximately 20–30 percent

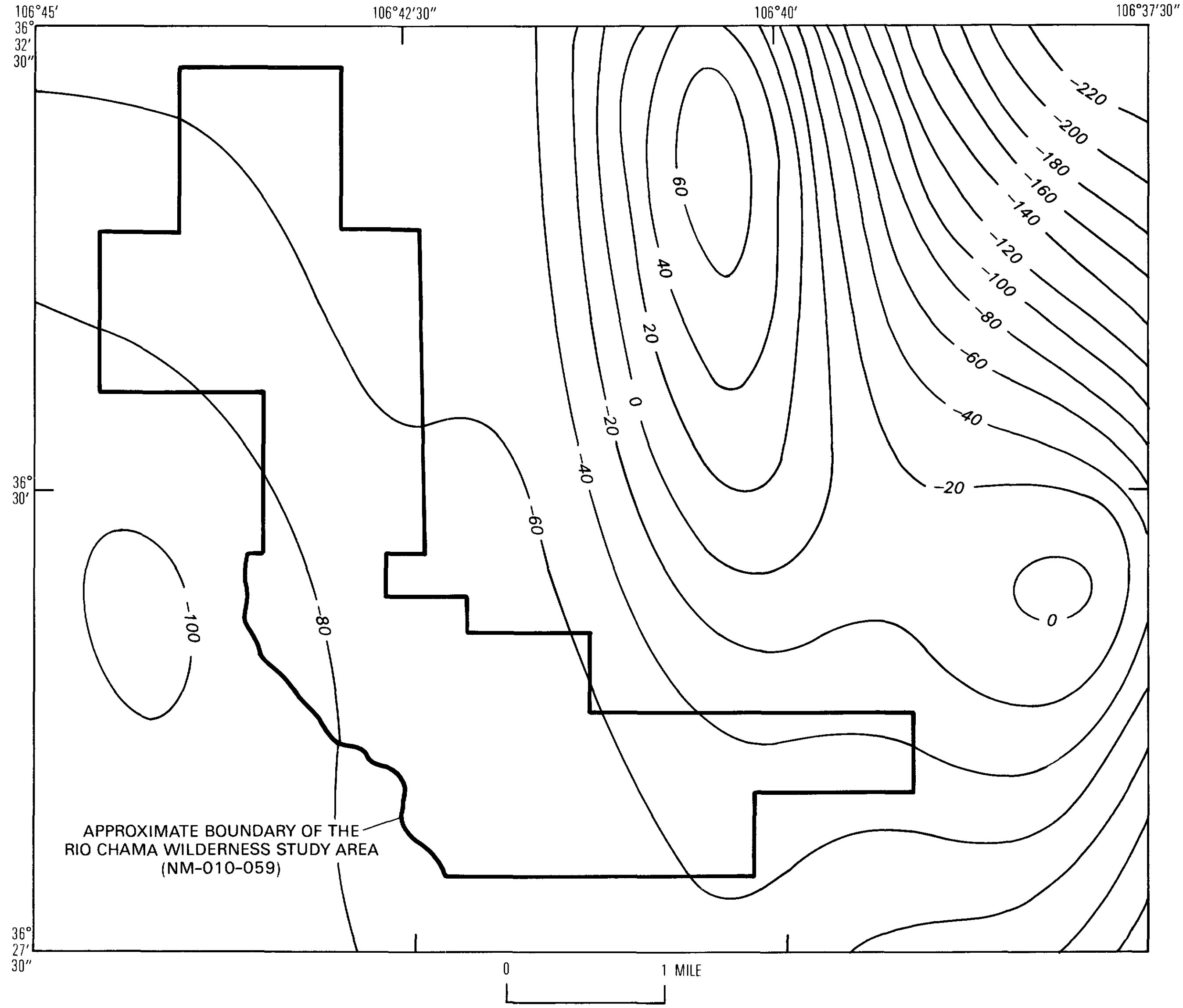

Figure 3. Map showing lines of magnetic intensity in the Rio Chama Wilderness Study Area, Rio Arriba County, N. Mex. Contour interval 20 nanoteslas.

of the Brushy Basin Member of the Morrison Formation in the Chama River Canyon Wilderness, south of the study area (Christine Turner-Peterson, oral commun., 1985). The clinoptilolite-bearing facies of the Brushy Basin, which is characterized by distinctive orange outcrops, is not present in the study area. The clinoptilolite-bearing facies changes laterally into the analcime-bearing facies of the Brushy Basin Member approximately 5 mi south of the study area. Thus, the resource potential for clinoptilolite is low, with a certainty level of C (fig. 1), throughout the study area.

Gypsum

Gypsum, as much as 105 ft thick (Ridgley, 1983), occurs in the upper part of the Todilto Limestone Member of the Wanakah Formation in the Chama River Canyon Wilderness south of the study area. Although the Todilto occurs in the study area, no gypsum is exposed. Gypsum does crop out adjacent to the southern boundary of the study area. Results of detailed surface and subsurface reconnaissance of the Todilto by Ridgley (unpub. data, 1984) show that the gypsum has an irregular distribution in the Chama Basin and eastern part of the San Juan Basin and in the study area. The distribution of the gypsum facies is controlled by underlying topographic relief on the top of the Entrada sand dunes, which exerted control on lateral and vertical salinity gradients in the marine waters from which the Todilto was precipitated (Ridgley, 1984). The lower half of the gypsum facies is commonly interbedded with limestone; the upper half of the gypsum facies is nearly pure gypsum in most places.

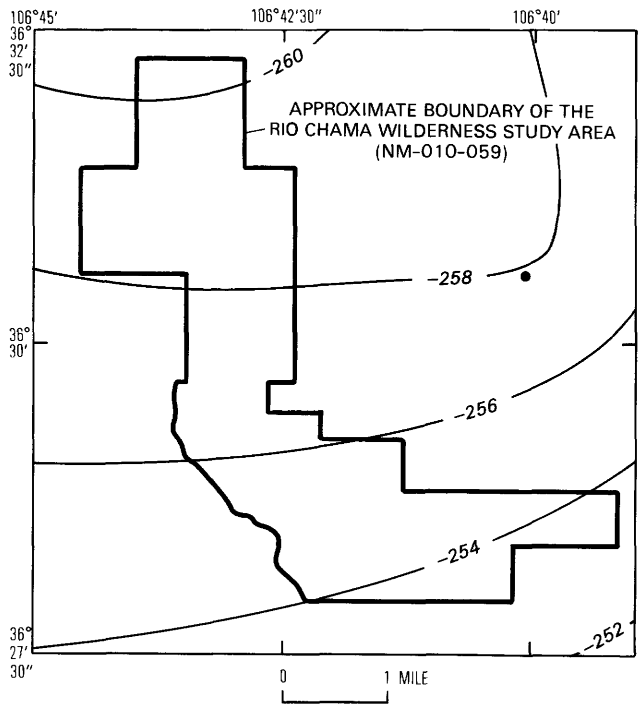

Figure 4. Map showing Bouguer gravity of the Rio Chama Wilderness Study Area , Rio Arriba County, N. Mex. Contour interval 2 milligals; dot, gravity station.

The gypsum in the Todilto Limestone Member has been mined for years at White Mesa, San Ysidro, N. Mex., and has been extracted locally at Cerro Blanco, near Gallina. Both areas are more than 10 mi south of the study area. The potential for gypsum resources in the subsurface of the study area is moderate, with a certainty level of C (fig. 1).

Limestone

Pennsylvanian limestone is projected to be present only in the subsurface. The nearest Pennsylvanian outcrops are along the southern margin of the Chama Basin. In this area the limestone is hard and dense and can be broken into fragments suitable for road metal. The U.S. Forest Service has several quarries from which they mine the limestone for road metal used on National Forest roads. Drilling at Gallina Mountain, approximately 3 mi to the west of the study area, indicated an 1,815-ft Pennsylvanian section of limestone and shale. Thus, Pennsylvanian limestone underlies the study area; and the mineral resource potential for undiscovered limestone resources in the subsurface is moderate, with a certainty level of C (fig. 1), throughout the study area.

Metals

The limited geochemical sampling by the USGS in 1980–81 did not indicate the presence of any metallic resources in the study area. One of the panned-concentrate samples collected by the USBM had anomalous amounts of silver; the rest of the samples had only slightly elevated values of manganese, tin, vanadium, and zinc (Schreiner, 1986). The samples were not collected from first-order drainages, but were taken from gravel bars along the Rio Chama, which is greater than a first- or second-order stream; thus, the material could have come from anywhere upstream. None of these elements was detected in anomalous concentrations in samples collected by the USGS in 1980–81 from first-order drainages in the same area. The mineral resource potential for silver, manganese, tin, vanadium, zinc, and all other metals is considered to be low, with a certainty level of B (fig. 1).

Uranium

There are small uranium prospects near the study area boundary (figs. 1, 2; Schreiner, 1986; Light, 1982). At these prospects the uranium is locally confined to sandstone and (or) bone fragments. Throughout the Colorado Plateaus all members of the Morrison Formation, the Todilto Limestone Member of the Wanakah Formation, the Burro Canyon(?) Formation, and the Dakota Sandstone may host uranium occurrences or deposits. No radioactivity was detected through the aeroradiometric survey, nor were any prospects found in the study area. During the 1940's and early 1950's the Colorado Plateaus were extensively prospected for uranium under a program supported by the U.S. Atomic Energy Commission, and no uranium occurrences were noted in the study area. The Anaconda Company also extensively explored and drilled for uranium in the 1970's in the areas to the north, east, and south of the study area. The only uranium-mineralized rock encountered was in Martinez Canyon near Ghost Ranch, about 10 mi southeast of the study area (Saucier, 1974).

Although no uranium anomalies were detected in the study area, the Morrison, Wanakah, and Burro Canyon(?) Formations and the Dakota Sandstone contain sandstone or limestone of a composition similar to that which is associated with favorable uranium host rocks in these formations elsewhere on the Colorado Plateaus. The mineral resource potential for uranium is considered to be low, with a certainty level of B (fig. 1), on the basis of the lack of anomalies in the study area and the proximity of the study area to a deep, dissected canyon that could permit the migration of oxidizing ground water that could remove any concentration of uranium from the rocks.

Geothermal Energy

No warm springs or evidence for buried intrusions was found in the study area. However, two warm springs were recently identified by personnel from the U.S.

Forest Service and the BLM (Bruce Sims, oral commun., 1987; Tom Mottl, oral commun., 1987) about 0.25 mi north of the study area at Ward ranch (fig. 2). One spring, shown on the El Vado 7 ½-minute quadrangle, is on the west side of the river; the other spring is on the east side of the river. Both springs are associated with a fault near the crest of the Rio Chama anticline that cuts the west limb. Warm water, about 90–100 °F, emanates from the springs; no chemical analyses are available. The source of the heated water is not known. The mineral resource potential for geothermal energy is low, with a certainty level of B based on the lack of evidence for geothermal activity in the study area and the presence of warm springs near the study area.

Recommendations for Future Work

The resource potential for oil and gas in the vicinity of the study area could be assessed more accurately if more detail were known about the underlying Pennsylvanian rock units.

Detailed sampling and appropriate chemical analysis of individual tuff beds in the Brushy Basin Member of the Morrison Formation would be necessary to see if rock units contain anomalous amounts of elements of potential economic interest.

Drilling would help delineate the thickness, purity, and extent of the gypsum resources.

Analysis of the regional gravity and magnetic data did not reveal reasons to suggest that mineral resources occur in the study area. However, detailed geophysical surveys might provide information on subsurface stratigraphy that would aid in the definition of structural traps or offer prospective exploration targets.

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APPENDIX

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

Definitions of Mineral Resource Potential

LOW mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is unlikely. This broad category embraces areas with dispersed but insignificantly mineralized rock as well as areas with few or no indications of having been mineralized.

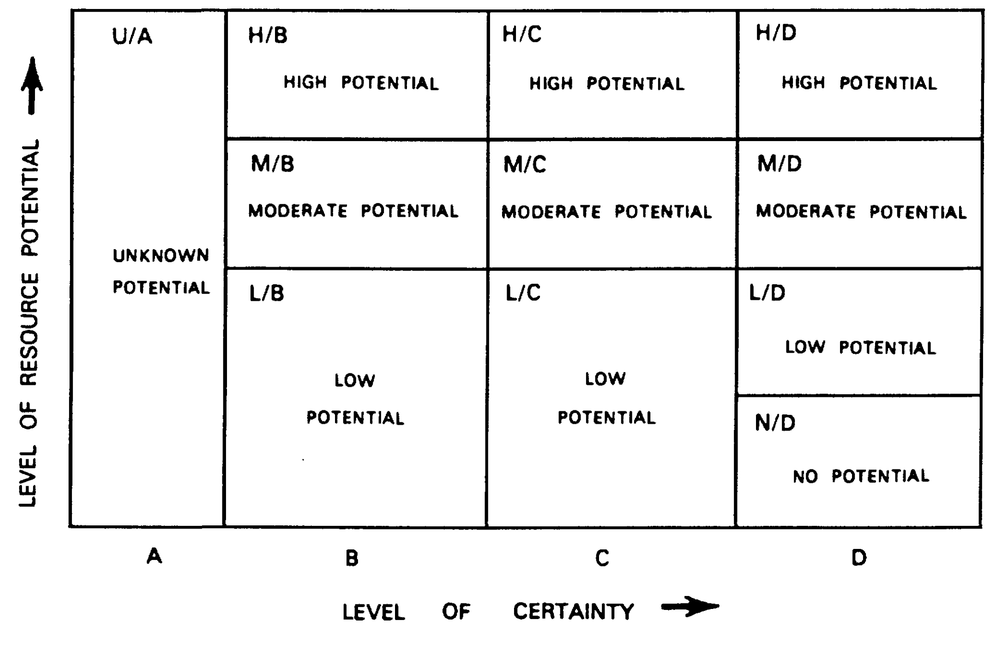
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

HIGH mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data support mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.

UNKNOWN mineral resource potential is assigned to areas where information is inadequate to assign low, moderate, or high levels of resource potential.

NO mineral resource potential is a category reserved for a specific type of resource in a well-defined area.

Levels of Certainty



A. Available information is not adequate for determination of the level of mineral resource potential.
B. Available information suggests the level of mineral resource potential.
C. Available information gives a good indication of the level of mineral resource potential.
D. Available information clearly defines the level of mineral resource potential.

Abstracted with minor modifications from:

Taylor, R. B., and Steven, T. A., 1983, Definition of mineral resource potential: Economic Geology, v. 78, no. 6, p. 1268–1270.

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RESOURCE / RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range (or)	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUB-ECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		

Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from U. S. Bureau of Mines and U. S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U. S. Geological Survey Circular 831, p. 5.

GEOLOGIC TIME CHART

Terms and boundary ages used in this report

EON	ERA	PERIOD		EPOCH	BOUNDARY AGE IN MILLION YEARS
Phanerozoic	Cenozoic	Quaternary		Holocene	0.010
				Pleistocene	1.7
		Tertiary	Neogene Subperiod	Pliocene	5
				Miocene	24
			Paleogene Subperiod	Oligocene	38
				Eocene	55
				Paleocene	66
	Mesozoic	Cretaceous		Late	96
				Early	138
		Jurassic		Late Middle Early	205
		Triassic		Late Middle Early	~ 240
	Paleozoic	Permian		Late Early	290
		Carboniferous Periods	Pennsylvanian	Late Middle Early	~ 330
			Mississippian	Late Early	360
		Devonian		Late Middle Early	410
		Silurian		Late Middle Early	435
		Ordovician		Late Middle Early	500
		Cambrian		Late Middle Early	~ 570[1]
Proterozoic	Late Proterozoic				900
	Middle Proterozoic				1600
	Early Proterozoic				2500
Archean	Late Archean				3000
	Middle Archean				3400
	Early Archean	3800?			
pre-Archean[2]					4550

[1] Rocks older than 570 m.y. also called Precambrian, a time term without specific rank.

[2] Informal time term without specific rank.

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