Mineral Resources of the Ignacio Chavez Wilderness Study Area, McKinley and Sandoval Counties, New Mexico

U.S. GEOLOGICAL SURVEY BULLETIN 1733–D

Chapter D

Mineral Resources of the Ignacio Chavez Wilderness Study Area, McKinley and Sandoval Counties, New Mexico

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MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
NORTHERN NEW MEXICO

DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-597, 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 the Ignacio Chavez (NM-010-020) Wilderness Study Area, McKinley and Sandoval Counties, New Mexico.

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Mineral Resources of the Ignacio Chavez Wilderness Study Area, McKinley and Sandoval Counties, New Mexico

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ABSTRACT

In 1985 and 1986 the U.S. Bureau of Mines and the U.S. Geological Survey studied 33,609 acres of the Ignacio Chavez Wilderness Study Area in McKinley and Sandoval Counties, Utah. The study area has measured subeconomic resources of 19.2 million short tons and indicated subeconomic resources of 63 million short tons of high-volatile C bituminous coal and has inferred subeconomic resources of sand and gravel and sandstone. The entire wilderness study area has moderate mineral resource potential for undiscovered oil and gas, and low resource potential for all undiscovered metals, including uranium, and for geothermal energy.

SUMMARY

The Ignacio Chavez (NM-010-020) Wilderness Study Area is about 6 mi (miles) northwest of Guadalupe and about 50 mi northwest of Albuquerque in McKinley and Sandoval Counties, New Mexico (fig. 1). Access is provided by unimproved roads west of New Mexico Highway 44. In the study area, Upper Cretaceous sedimentary rocks have been locally intruded and are overlain by Tertiary basalt rocks. Sedimentary rocks exposed are, in ascending order, the Satan Tongue of the Mancos Shale, the Point Lookout Sandstone, and the Cleary Coal and Allison Members of the Menefee Formation.

Lenticular coal beds, as thick as 6 ft (feet), are in the Cleary Coal Member of the Menefee Formation in the northern part of the study area. A measured resource of 19.2 million short tons and an indicated resource of 63 million short tons of coal at depths of less than 500 ft were calculated in this area. The coal appears to range in rank from subbituminous to bituminous, and averages high-volatile C bituminous. Thickness of overburden and the thin lenticular character of the coal beds make development unlikely. Inferred subeconomic resources of sand and gravel, and of sandstone, are also present in the study area but have no current potential for development.

As of 1987, Federal oil and gas leases had been issued for most of the study area. Three dry holes have been drilled in the study area. As of January 1986, no mining claims were on file with the U.S. Bureau of Land Management, but in the late 1970's and early 1980's about 325 mining claims had been located for uranium in the area. In the 1970's, one site inside and three sites within 2 mi of the study area were drilled for uranium but no significant uranium concentrations were found. Depth to the Morrison Formation, which contains major uranium deposits in the Grants Uranium region, 20 mi to the south, is more than 1,650 ft near the eastern boundary of the study area and about 2,300 ft in the north-central part of the study area.

Geological, geochemical, and geophysical characteristics of the study area suggest possible models for the presence of uranium, oil, and gas. No minerals have been produced and no surface evidence exists for metallic mineral resources.

The study area has moderate energy resource potential for undiscovered oil and gas. Oil fields about 10 mi to the north and the Miguel Creek fields 3 mi to the west are in favorable reservoir and stratigraphic traps in nearshore marine sandstones (Cretaceous Gallup and Dakota

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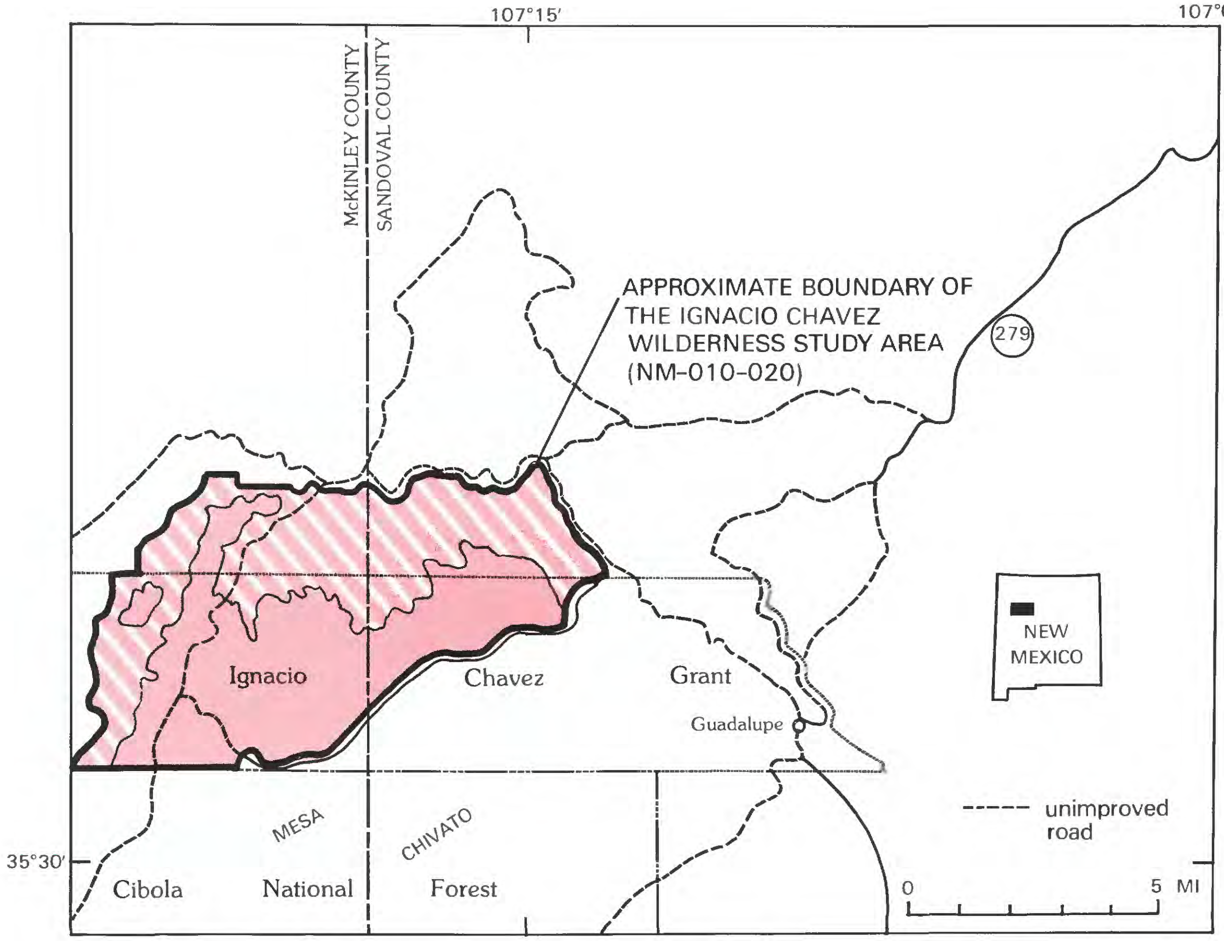


EXPLANATION OF MINERAL RESOURCE POTENTIAL

Area underlain by subeconomic coal resources: less than 500 ft overburden, includes measured and indicated resources

M/B **Geologic terrane having moderate energy resource potential for oil and gas with certainty level B**—Applies to entire study area

L/B **Geologic terrane having low mineral resource potential for uranium, with certainty level B**—Applies to entire study area

L/C **Geologic terrane having low mineral resource potential for all metals other than uranium, and for geothermal energy, with certainty level C**—Applies to entire study area

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**

Figure 1. Map showing location, identified resources, and mineral resource potential of the Ignacio Chavez Wilderness Study Area.

Sandstones) and in the Jurassic Entrada Sandstone; these three formations are present beneath the study area. Oil shows were found in nearby drill holes; however, one test well drilled through the Dakota Sandstone and two others drilled to a depth of 400 ft in the study area were dry. The energy resource potential is not high because the possible reservoir rocks are intruded by volcanic plugs that may have raised the paleotemperature above the limit for the preservation of oil and gas.

The study area has a low mineral resource potential for undiscovered uranium in the Morrison Formation, which is a favorable host for uranium elsewhere. Geologic mapping and drill-hole data indicate that the Morrison Formation is present beneath the study area, but the presence of uranium in the formation is not known with certainty. Mineral resource potential for all undiscovered metals other than uranium is low in the study area. No surface evidence was found to indicate metallic-mineral resources. No geothermal sources are known within the study area, nor were warm springs or other geothermal sources noted during this investigation. The energy resource potential for undiscovered geothermal energy is therefore low.

INTRODUCTION

In 1985 and 1986 the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) studied 33,609 acres of the Ignacio Chavez Wilderness Study Area (NM–010–020). The study of this acreage was requested by the U.S. Bureau of Land Management (BLM). 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 was the product of several separate studies by the USBM and the USGS. Identified resources were classified according to the system of the U.S. Bureau of Mines and the U.S. Geological Survey (1980), which is shown in the appendix. Identified resources were 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). It was classified according to the system of Goudarzi (1984) shown in the Appendix. The potential for undiscovered resources was studied by the USGS.

The study area is about 6 mi northwest of Guadalupe and about 50 mi northwest of Albuquerque in McKinley and Sandoval Counties, New Mexico (fig. 1). It is on the southeastern edge of the San Juan basin in the Colorado Plateaus physiographic province. Access is provided by unimproved roads west of New Mexico Highway 44. The topography of the study area is characterized by a steep escarpment at the northern end of Mesa Chivato. Elevations range from 6,400 ft at the base of the escarpment to more than 8,000 ft at the mesa top. Tertiary basalt flows overlie the exposed Upper Cretaceous sedimentary rocks and form the top of Mesa Chivato. Basalt dikes and plugs, also of Tertiary age, intrude the sedimentary rocks.

Acknowledgments.—D.M. McKown, R.B. Vaughn, F.E. Lichte, and P.H. Briggs analyzed the stream-sediment and rock samples. We thank Pat Hester and George Lasker of the U.S. Bureau of Land Management in Albuquerque for supplying information on the study area from their files. Western Energy Company of Butte, Mont., provided drill-hole data and coal analyses from their evaluation of the Chico Wash tract that adjoins part of the northern boundary of the Ignacio Chavez Wilderness Study Area. The New Mexico Bureau of Mines and Mineral Resources, Socorro, N. Mex., supplied additional drill-hole, analytical, and other pertinent data from their files.

Investigation by the U.S. Bureau of Mines

In August 1985 and June 1986, the Bureau of Mines conducted a mineral investigation of the study area. Published and unpublished literature relating to the study area was reviewed to obtain information pertaining to mineral occurrences and mining activity. Field work included mapping and sampling of coal beds at nine sites. Proximate and ultimate analyses, and calorific value determinations were made for all samples by Hazen Research Inc., Golden, Colo., and Core Laboratories Inc., Denver, Colo. In addition, a determination of the random vitrinite reflectance was made on one coal sample by Neely Bostick, USGS, Denver, Colo. A modification of the coal resource classification system of the U.S. Geological Survey (fig. 2; Wood and others, 1983) was used because the coal is in thin, lenticular, multiple beds in the study area. Measured coal resources were calculated from outcrop data of individual beds (all beds 1.2 ft or more in thickness) projected to extend ¼ mi from the outcrop; no indicated resources (¼–¾ mi) were projected for individual beds. Calculations of coal resources from drill-hole data were made using the total coal thickness (including all beds 1.2 ft or more in thickness); measured resources were projected to extend to a ¼-mi radius from the drill site, and indicated resources were projected to extend to a ¼– to ¾ mi radius from the drill site. An acre-foot of coal was assumed to weigh 1,800 short tons. Area determinations were made by planimeter on maps at a scale of 1:50,000. Schreiner (1988) contains location, depth to coal, thickness of beds, total coal thickness, year completed, and reference for 27 drill holes near the study area.

Investigation by the U.S. Geological Survey

In 1985 and 1986, the USGS conducted an investigation to assess the potential for undiscovered mineral resources of the study area. This investigation included a search for published and unpublished information about the area, a review of previous geological mapping, the collection of stream-sediment and rock samples for geochemical analysis, a

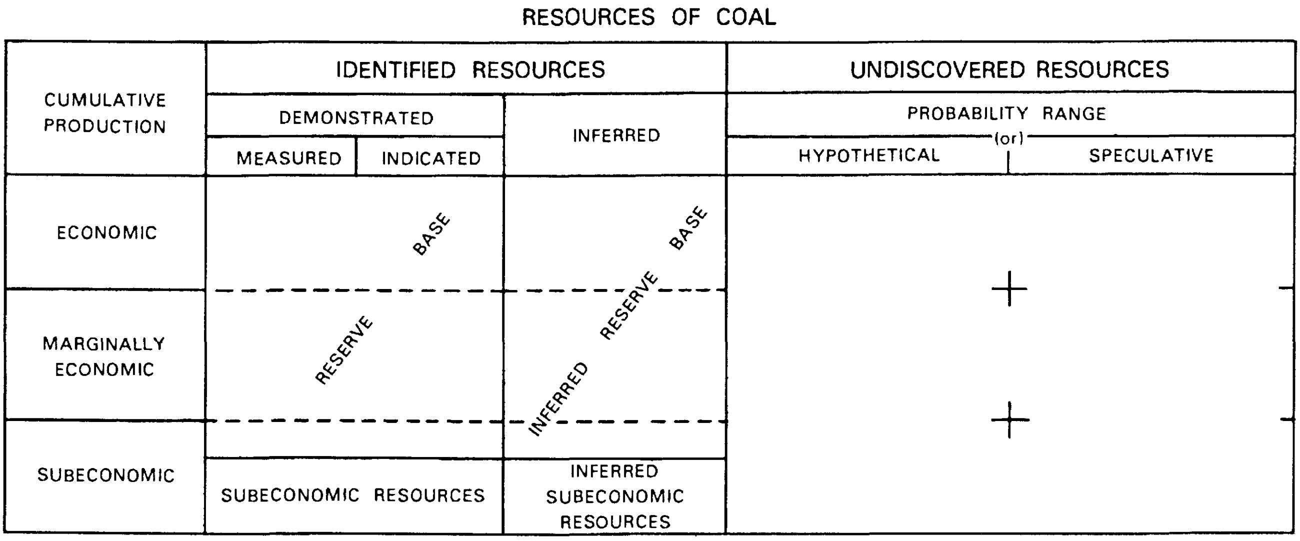


Figure 2. Format and classification of coal resources by reserve and inferred reserve bases and subeconomic and inferred subeconomic resources categories.

reconnaissance geophysical survey, and a search for mineralized and altered areas.

APPRAISAL OF IDENTIFIED RESOURCES

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

Previous Investigations

The geology and coal resources of the Torreon Wash area, which includes the wilderness study area, were described by Campbell (1987) and by Tabet and Frost (1979a,b). A geologic map at 1:24,000 scale is included in their publication (1979b). After a field check, a modified version of this map at a scale of 1:50,000 was used. Preliminary assessments of mineral resources in the study area were written by D.B. Roberts and others (unpub. data) and by McLemore and others (1984). Coal resources in the Cerro Parido 7 ½-minute quadrangle, which includes a part of the study area, were assessed by the U.S. Geological Survey (1985).

Exploration, Development, and Mining History

Coal

The northern end of the study area, about 9,000 acres, is part of a tract of land designated by the BLM as La Ventana Known Recoverable Coal Resource Area (KCRA) and is part of the San Mateo coal field as described by Roybal (1984). Coal occurs in the Cleary Coal Member of the Menefee Formation in the KRCRA. Coal has been produced from three sites, and evaluated at another, near the study area.

The Tachias property, 3 mi northeast of the study area (N½ sec. 34, T. 17 N., R. 4 W.) produced 282.5 short tons of coal from 1933 to 1939 (U.S. Bureau of Land Management records, Farmington, N. Mex., and unpublished notes from H.B. Nickelson, 1979, History of coal mines in New Mexico, New Mexico Bureau of Mines and Mineral Resources, Socorro, N. Mex.). Coal was mined in two adits from a 4-ft-thick bed.

The Arroyo #1 mine, 10 mi northeast of the study area (N½ sec. 16, T. 17 N., R. 2 W.), produced 57,214 short tons of coal from 1979 to 1982 (Roybal, 1984). Coal was strip-mined from two beds with a total thickness of 6–8 ft.

The Lee Ranch mine, 10 mi west of the study area (secs. 21, 23, 25, 27, 29, 31, 32, 35, T. 16 N., R. 8 W., and sec. 19, T. 15 N., R. 7 W.), was producing about 2 million short tons of coal annually, as of August 1987. Coal is strip-mined from multiple beds containing a minimum total thickness of 8 ft and averaging 16 ft. The average "as received" shipments of coal to power plants for generation of steam contain 16 percent moisture, 16 percent ash, 0.8 percent sulfur, and 9,350 Btu/lb (British thermal unit per pound) (Robert Gray, Santa Fe Pacific Minerals, Albuquerque, N. Mex., oral commun., 1987).

An exploration license was granted to Western Energy Company on the Chico Wash tract (T. 16 N., R. 5 W.) that adjoins part of the northern boundary of the study area. In 1983, the company drilled 29 holes to evaluate the coal and found it to be uneconomic.

Uranium

As of 1987, no mining claims were on file with the BLM, but in the late 1970's and early 1980's about 325 mining claims had been located in the area for uranium (D.B. Roberts and others, unpub. data).

One site in the western part of the study area in sec. 6, T. 15 N., R. 5 W. was drilled for uranium in 1975 by Pioneer Nuclear, Inc. Three sites within 2 mi of the eastern boundary of the study area were drilled for uranium by Pioneer Nuclear, Inc. in 1975 (sec. 34, T. 16 N., R. 4 W.) and by Homestake Mining, Inc. in 1971 (sec. 36, T. 16 N., R. 4 W.) and in 1972 (sec. 6, T. 15 N., R. 3 W.). A geologic log from the 1972 Homestake hole shows the top of the Jurassic Morrison Formation to be more than 1,650 ft deep (Steve Craigg, U.S. Geological Survey, Albuquerque, N. Mex., oral commun., 1988). In the north-central part of the study area the Morrison Formation is more than 2,300 ft deep (unpublished data from Petroleum Information card files, Petroleum Information Corporation, Denver, Colo.). The Morrison Formation hosts major uranium deposits in the Grants uranium region, about 20 mi to the south. Apparently no uranium concentrations were penetrated in these drill holes in the study area, and activity was suspended in the early 1980's due to low uranium prices.

Oil and Gas

As of 1987, Federal oil and gas leases had been issued for most of the study area (Schreiner, 1988). Three sites have been drilled in the study area and 37 sites within 2 ½ mi of the boundary since 1923. All holes have been dry except for those drilled in or near the Miguel Creek oil fields, on the north flank of Miguel Creek dome, about 3 mi west of the study area. Hydrocarbons have been produced from the Hospah sand of Cretaceous Gallup Sandstone. The North Miguel Creek Gallup oil field (sec. 16, T. 16 N., R. 6 W.) and the Miguel Creek oil field (secs. 20, 21, 28, 29, T. 16 N., R. 6 W.) last produced in 1985 and have had a cumulative production of 8,995 and 46,919 barrels of oil, respectively (Ronald Broadhead, New Mexico Bureau of Mines and Mineral Resources, Socorro, N. Mex., written commun., 1988). In addition, a show of oil was present in a coal drill hole (no. 8; Schreiner, 1988) at 320 ft in the Menefee Formation, within a mile of the study area.

Resource Appraisal

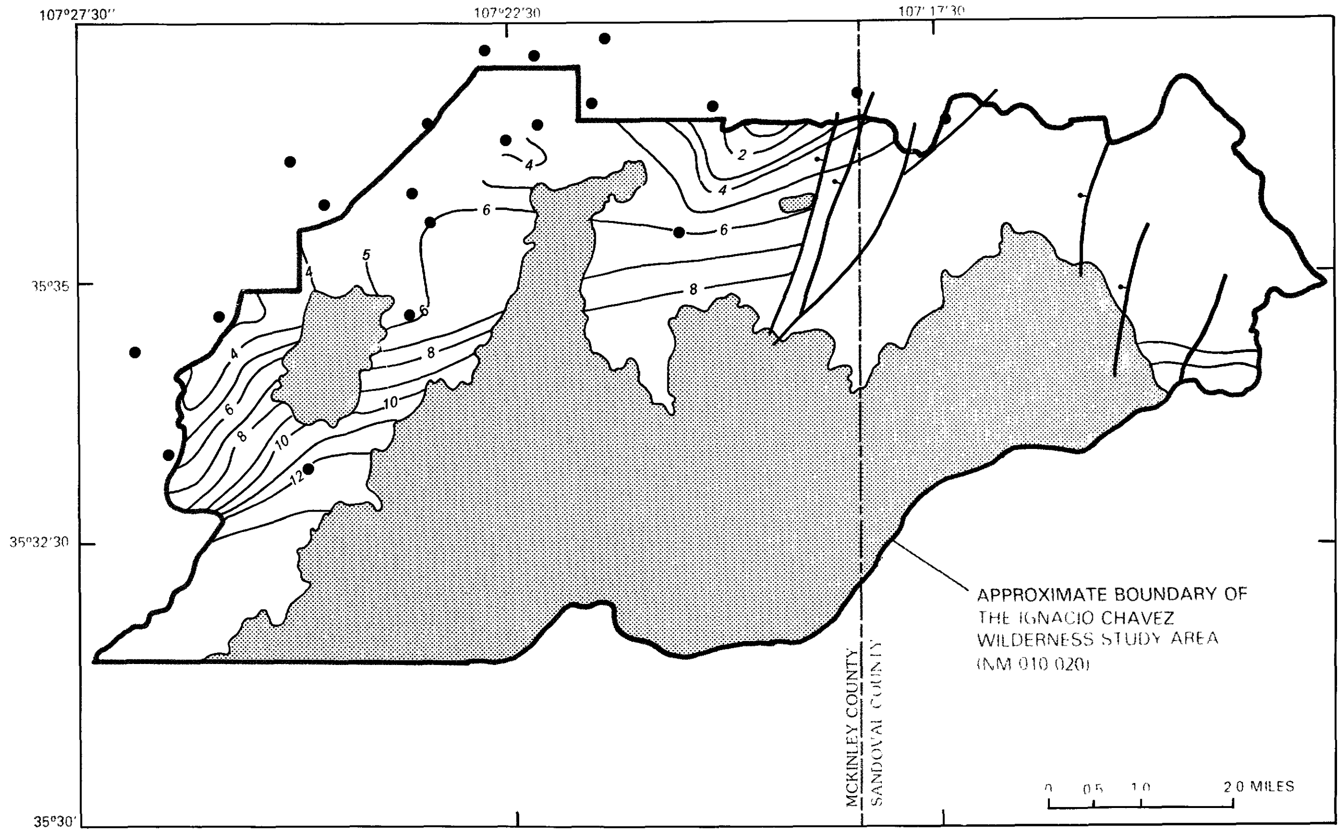
Coal

Coal occurs in the Cleary Coal Member of the Menefee Formation in the study area. Coal crops out in the northern part of the study area (fig. 3) on the steep slopes of Mesa Chivato around Mesa La Azabache (secs. 22 and 23, T. 16 N., R. 5 W.) and from Cerro Parido to the eastern boundary of the study area (secs. 19, 20, 27, 28, 29, 30, 34, T. 16 N., R. 4 W.). The coal occurs as thin stringers and beds as thick as 6.3 ft (average thickness 2.5 ft), including thin partings (no greater than 0.9 ft thick) of carbonaceous shale. Individual beds are lenticular and split and change in thickness over short distances. The beds can be grouped into coal zones (sections of thin lenticular multiple beds) that can be correlated for at least a few miles. Although coal zones appear to occur throughout the Cleary Coal Member, the most laterally extensive, usually containing the thickest beds, is found at the base of the member, just above the Point Lookout Sandstone. Drill-hole data indicate that the thickness of the individual beds and the total coal thickness in the Cleary Coal Member increase in the southern parts of the study area.

Analytical Data

Nine outcrop channel samples of the thicker parts of the coal beds average 13.00 percent moisture, 22.59 percent ash, 31.18 percent volatile matter, 33.13 percent fixed carbon, 0.42 percent sulfur, and 7,489 Btu/lb on an "as received" basis (table 1). An apparent rather than a standard rank determination was made to classify the coal because outcrop samples are not permitted for such use according to ASTM designation D–388–82 (American Society for Testing and Materials, 1982). Calculations of calorific values to determine the apparent rank of the samples were made on a moist (moisture questionable), mineral-matter-free (MMF) basis. Calculated calorific values range from 8,845 to 10,371 Btu/lb and average 9,358 Btu/lb. The apparent rank of the coal in the study area is subbituminous.

In addition to the proximate and ultimate analyses and calorific determinations, a determination of the random vitrinite reflectance was made on coal sample 9 (table 1). Oxidation can directly affect calorific value and agglomeration characteristics used in the ASTM ranking of coals, but it usually does not affect the vitrinite reflectance, which is comparable in accuracy to the preceding parameters for use in ranking coals. The



EXPLANATION

—*10*— **Isopach showing total thickness of coal beds in feet; isopach interval, 1 ft**

● **Drill hole**

Areas where overburden is greater than 500 ft

Fault, bar and ball on downthrown side

Figure 3. Map showing thickness of coal beds and localities of coal drill holes in the Ignacio Chavez Wilderness Study Area.

random reflectance measurement (oil immersion) of 0.48 percent for the sample ranks this coal as subbituminous A, bordering on high-volatile C bituminous (0.50 percent) according to the oil reflectance limits of ASTM coal rank classes by McCartney and Teichmuller (1972).

Calculated calorific values (MMF) of nonoxidized samples from holes drilled in 1987 by the New Mexico Bureau of Mines and Mineral Resources at locations from along the boundary of the study area to several miles north would place the coal in the volatile C bituminous rank (Campbell, 1987).

Considering all the preceding data, including the oxidation effects on the USBM samples, the coal in the study area would range in rank from subbituminous to bituminous, averaging high-volatile C bituminous.

Resources

The USBM calculated measured resources of 19.2 million short tons and indicated resources of 63 million short tons of bituminous coal at depths of 500 ft or less in the study area (table 2). Additional tonnages of coal resources exist outside the areas of measured and indicated resources at depths of less than 500 ft and underneath Mesa Chivato at depths greater than 500 ft in the study area. Coal resources could not be calculated in these areas due to insufficient data-point spacing or an absence of data. Tabet and Frost (1979a) used slightly different criteria to calculate an indicated resource of about 16 million short tons of coal at depths of less than 250 ft in the study area.

Mineral Economics

The coal in the study area is less than 5 ft thick and is too thin to be mined by underground methods. In the San Juan basin, criteria for economically surface-minable coal (strippable reserve base coal) as of 1987 are as follows: coal beds (including one bed at least 2.3 ft thick) must be covered by at least 20 ft of overburden, and the maximum amount of overburden cannot exceed a 15 to 1 stripping ratio (15 ft of overburden plus interburden for every foot of coal). These criteria are being used by the BLM to evaluate tracts of land for lease sale and are

Table 1. Proximate, ultimate, and calorific value analyses for channel coal samples from the Ignacio Chavez Wilderness Study Area, McKinley and Sandoval Counties, New Mexico

[Btu/lb, British thermal unit per pound; MMF Btu/lb, British thermal unit per pound on a mineral-matter-free basis; MAF Btu/lb, British thermal unit per pound on a moisture-ash-free basis; nc, not calculated. All samples reported nonagglomerating]

Sample			Proximate analyses (percent)				Ultimate analyses (percent)					Calorific value		
No.	Length (ft)	Reporting basis	Moisture	Ash	Volatile matter	Fixed carbon	Carbon	Hydrogen	Nitrogen	Sulfur	Oxygen	Btu/lb	MMF Btu/lb	MAF Btu/lb
1	3.3:	As received	13.81	29.92	27.92	28.35	37.72	2.41	0.81	0.36	14.97	5,930	8,845	nc
		Dry........	.00	34.71	32.40	32.89	43.76	2.80	.94	.42	17.37	6,879	11,012	10,537
2	3.5:	As received	15.20	11.18	34.05	39.57	50.84	3.01	1.03	.48	18.26	7,989	9,114	nc
		Dry........	.00	13.18	40.15	46.67	59.95	3.55	1.22	.57	21.53	9,421	10,992	10,852
3	2.4:	As received	13.14	16.05	35.80	35.01	47.60	3.24	.96	.61	18.4	7,678	9,331	nc
		Dry........	.00	18.74	41.22	40.31	54.80	3.73	1.11	.70	21.19	8,839	11,051	10,842
4	2.5:	As received	18.33	6.54	34.95	40.18	52.41	3.14	1.03	.43	18.12	8,555	9,222	nc
		Dry........	.00	8.01	42.79	49.20	64.17	3.84	1.26	.52	22.20	10,476	11,475	11,388
5	1.7:	As received	10.18	53.29	20.01	16.52	23.54	1.79	.55	.22	10.43	3,685	8,910	nc
		Dry........	.00	59.33	22.28	18.39	26.21	2.00	.62	.24	11.60	4,102	11,428	10,086
6	3.7:	As received	10.93	29.02	28.82	31.23	41.68	3.07	.81	.39	14.10	6,787	9,975	nc
		Dry........	.00	32.58	32.35	35.07	46.80	3.44	.91	.44	15.83	7,620	11,766	11,302
7	2.3:	As received	8.91	9.93	38.10	43.06	56.77	3.63	1.13	.52	19.11	9,233	10,371	nc
		Dry........	.00	10.90	41.83	47.27	62.32	3.99	1.24	.57	20.98	10,136	11,497	11,376
8	6.3:	As received	9.95	36.90	27.12	26.03	35.61	2.48	.74	.22	14.10	5,758	9,696	nc
		Dry........	.00	40.98	30.12	28.90	39.54	2.76	.82	.25	15.58	6,394	11,478	10,835
9	5.0:	As received	17.51	10.45	33.84	38.20	48.79	2.80	1.02	.42	19.01	7,751	8,762	nc
		Dry........	.00	12.67	41.02	46.31	59.15	3.40	1.24	.51	23.03	9,396	10,924	10,760

Table 2. Calculated bituminous coal resources in reliability, thickness of coal, and overburden categories in the Ignacio Chavez Wilderness Study Area, McKinley and Sandoval Counties, New Mexico

Geological assurance category	Coal thickness category (ft)			
	1.2-2.3	2.3-3.5	3.5-7.0	7.0-14.0
0-500 feet overburden				
Measured (short tons)--	253,000	3,070,000	12,354,000	3,571,000
Indicated (short tons)--	476,000	2,477,000	32,516,000	27,490,000

based on coal industry mining methods and practices in the San Juan basin (Ralph Wilcox, BLM District Office, Albuquerque, N. Mex., oral commun., 1987). Most of the coal in the study area is covered by overburden exceeding the 15 to 1 stripping ratio. Some of the outcropping coal beds, at an average thickness of 2.5 ft, achieve the 15 to 1 stripping ratio (overburden less than 40 ft thick) in narrow belts as wide as about 200 ft around the edges of Mesa Chivato. The coal could be mined for limited local use, as in domestic heating.

Western Energy Company evaluated the adjoining area north of the study area, where the overburden is much less than in the study area, but still believed that the coal was not economic due to the thin lenticular character of the beds and high ash content (Thomas Loberg, Western Energy Company, Butte, Mont., oral commun., 1986).

Common Industrial Materials

Inferred subeconomic resources of sand and gravel, and of sandstone, are present in the study area. Because of the abundance of these materials in the region, the distance from markets, and their lack of unique properties, they have no current potential for development.

Conclusions

The USBM calculated measured subeconomic resources of 19.2 million short tons and indicated subeconomic resources of 63 million short tons of high-volatile C bituminous coal at depths of 500 ft or less in the study area; however, thick overburden and the thin lenticular character of the beds make development unlikely. Inferred subeconomic resources of sand and gravel and sandstone have no current potential for development.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Sandra J. Soulliere and Carl L. Long
U.S. Geological Survey

Geology

The following description of geologic setting and rock units of the Ignacio Chavez Wilderness Study Area was modified from Tabet and Frost (1979a,b). Upper Cretaceous marine and continental sedimentary rocks exposed in the study area are, in ascending order, the Satan Tongue of the Mancos Shale (Kms), the Point Lookout Sandstone (Kpl), and the Cleary Coal (Kmfc) and Allison (Kmfa) Members of the Menefee Formation. These strata have a northeasterly strike and dip about 5 degrees to the northwest. They have been intruded locally, or are overlain, by Tertiary basaltic rocks (Tb, Ti) related to the Mount Taylor volcanic field to the southwest (pl. 1). These rocks are cut by northeast-trending normal faults that generally have only a few tens of feet of displacement; maximum displacement is 150 ft. Basaltic dikes in the area also reflect to some extent the same northeast-trending fracture pattern.

Jurassic and Cretaceous sedimentary rocks are present beneath the study area and are important to this assessment because of their potential as host rocks for uranium and oil and gas. The Jurassic Morrison Formation underlies the north-central part of the study area at a depth of about 2,300 ft (Schreiner, 1988) and is a favorable host for uranium elsewhere. Upper Cretaceous nearshore marine sandstones, in particular the Dakota and Gallup Sandstones, and the Jurassic Entrada Sandstone are favorable reservoir rocks for oil and gas.

Description of Rock Units

During Cretaceous time, transgressive and regressive sequences of sediments were deposited in intertonguing offshore-marine, nearshore-marine, and continental environments. This is evidenced by the intertonguing relationship of the outcropping sedimentary rocks of the Mancos Shale, Point Lookout Sandstone, and Menefee Formation. The Satan Tongue of the Mancos Shale consists of medium-gray, silty, laminated marine shale. It is conformable with the overlying regressive marine Point Lookout Sandstone. The transitional contact between these two units is characterized by a series of sandstone and shale interbeds. The sandstone beds gradually thicken upward until only a massive cliff-forming sandstone exists. In outcrops, the Point Lookout Sandstone is very pale orange to light gray to white, fine grained and even bedded to crossbedded. The Menefee Formation is conformable with the Point Lookout Sandstone and consists of interbedded shale, siltstone, sandstone, and coal. Two members of the Menefee are exposed in and underlie the entire study area—the basal coal-bearing Cleary Coal Member and the sandy Allison Member. The contact between the members is gradational and not easily distinguished. Tabet and Frost (1979a) placed the contact at the base of a thick, cliff-forming channel sandstone sequence that overlies the uppermost major coal horizon of the Cleary. The Cleary Coal Member is a fine-grained paludal (marsh) deposit consisting of gray to dark-brown carbonaceous shale that contains abundant organic debris, lenticular sandstone, and coal beds. It is about 200–300 ft thick. The Allison Member consists of fine- to medium-grained, crossbedded sandstone and tan to light-gray shale and is about 400–550 ft thick. Rocks of the Allison Member have very little organic debris, but thin coal beds and some brown humic shales occur locally, generally comprising less than 5 percent of the Allison.

Tertiary basalt flows, about 100 ft thick, cap Mesa Chivato in the southern part of the study area. Rubble from this basalt forms talus along the slopes of the mesa and obscures the contact with the underlying sedimentary rocks. Several dikes and plugs of basalt are exposed at the northern end of Mesa Chivato. Sedimentary rocks surrounding these intrusions show little or no alteration.

Geochemistry

Analytical Methods

Stream-sediment samples were collected at 30 sites in the study area (pl. 1). All samples were taken from intermittent streams that drain the study area. At each site, the sample was sieved to minus 100 mesh (0.15 mm) to obtain the silt and clay fraction, the most effective adsorbent of elements that might indicate mineral deposits. The fine-grained samples were then analyzed by inductively coupled plasma atomic-emission spectroscopy (ICP) for 44 elements following the methods of Crock and others (1987), and by delayed neutron activation for uranium and thorium following the techniques of McKown and Millard (1987).

Nine samples of basalt flows and plugs were also taken (pl. 1). Samples were crushed and pulverized to minus 100 mesh (0.15 mm) and analyzed for 31 elements by semiquantitative emission spectrography following the methods of Grimes and Marranzino (1968).

Results of Study

For each data set (stream-sediment and rocks), concentration of a given element was considered to be anomalous if it was greater than 2–3 times the mean concentration in the set. By this definition, no sample contained anomalous amounts of any element. Analytical results for these samples are available for public inspection at the U.S. Geological Survey, MS 905, Building 25, Denver Federal Center, Denver, CO 80225.

Geophysics

Gravity and aeromagnetic data were obtained from existing data files as part of the mineral resource evaluation of the study area. These data provide information on 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 on figure 4. The magnetic survey was flown at 1,000 ft above ground level and the flight lines were oriented north-south at a spacing of about 1 mi.

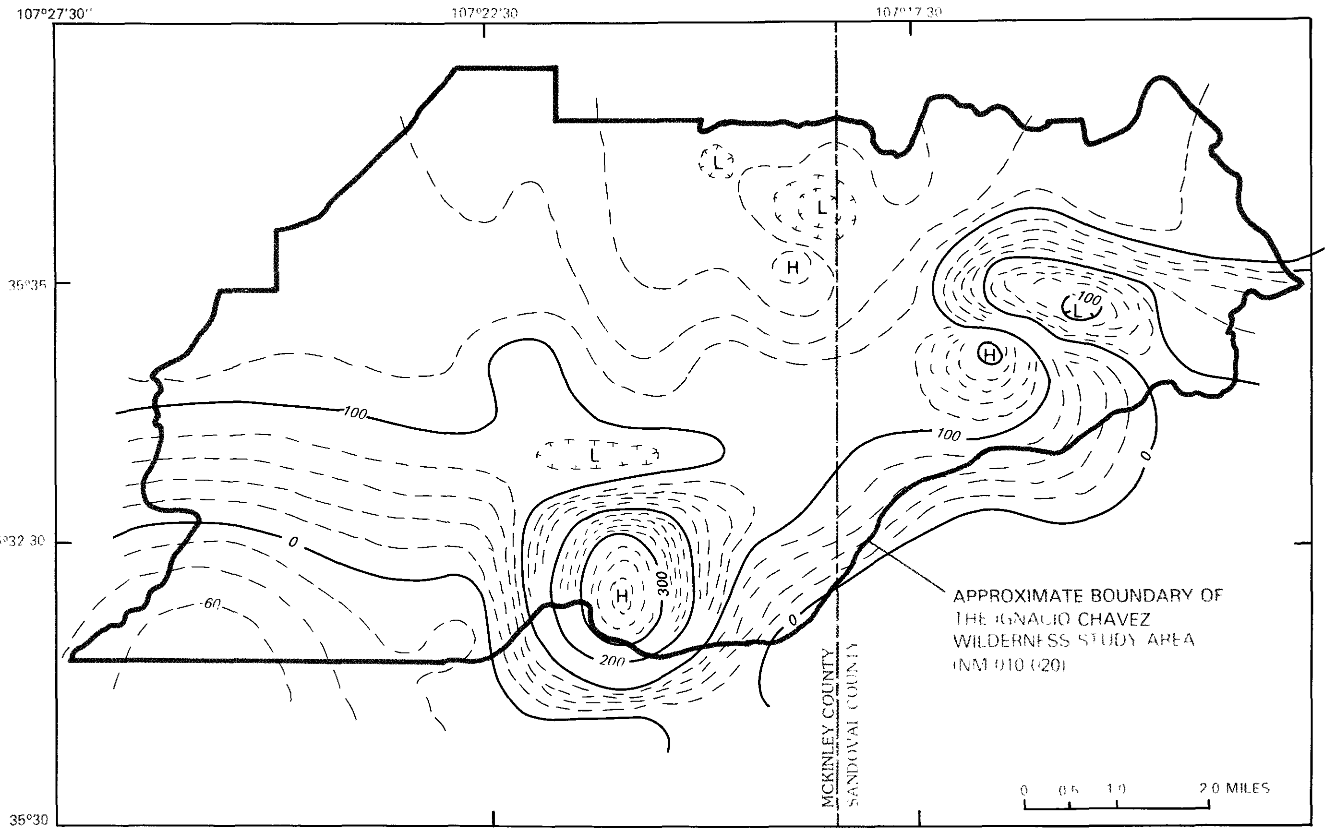


Figure 4. Map showing lines of magnetic intensity in the Ignacio Chavez Wilderness Study Area. Contour interval 20 gammas. Hachures indicate direction of decreasing magnetic intensity; H, magnetic high; L, magnetic low.

The major magnetic highs in the study area are associated with the Tertiary intrusive basalts (Ti). The 360-gamma magnetic high in the south central part of the area could indicate more magnetic material near a vent area and (or) a thicker section of normally magnetized basalt. A magnetic low (<-100 gammas) near the northeast corner of the study area and two other magnetic lows to the northwest, all centered on outcrops of Tertiary intrusives, possibly indicate a reversed magnetic field for this unit.

Gravity Data

Gravity data were obtained from a file collected by the U.S. Department of Defense (NOAA National Geophysical Data Center). Bouguer gravity values were computed using the 1967 gravity formula (International Association of Geodesy, 1967) and a reduction density of 2.67 g/cm^3 (grams per cubic centimeter). Terrain corrections were made by computer for a distance of 100 mi from each station using the method of Plouff (1977). The data are shown on figure 5.

The Bouguer values vary from -220 mgal (milligals) at the east side of the study area to -228 mgal on the west side. This gentle gradient may indicate the thickening of the sedimentary section northwestward toward the San Juan basin.

Radiometric Data

From 1975 to 1983, the U.S. Department of Energy contracted for aerial gamma-ray surveys that covered almost all of the United States. Aerial gamma-ray spectroscopy is a technique that provides estimates of near-surface (0–50 cm depth) concentrations of potassium (K; in percent), equivalent uranium (eU; in ppm (parts per million)), and equivalent thorium (eTh; in ppm). These data provide a partial geochemical representation of the near-surface materials (J.S. Duval, written commun., 1986).

Data from the survey (J.S. Duval, written commun., 1986) indicate that the study area has overall moderate radioactivity with concentrations of 1.6–2.1 percent K, 2.2–3.1 ppm eU, and 8.4–10 ppm eTh. There are no anomalies within or near the study area.

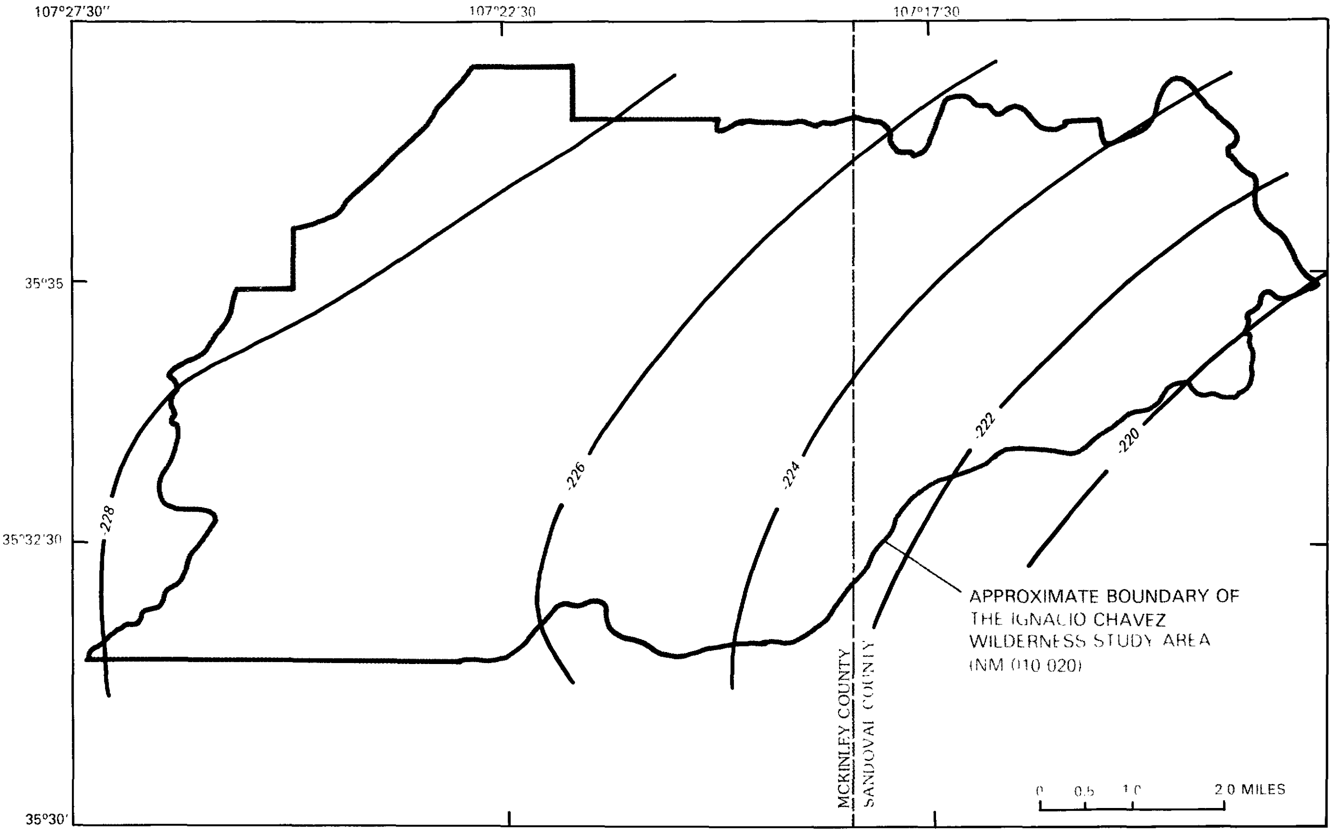


Figure 5. Map showing Bouguer gravity of the Ignacio Chavez Wilderness Study Area. Contour interval 2 milligals.

Mineral and Energy Resources

The mineral resource potential of the Ignacio Chavez Wilderness Study Area was assessed by comparing geological, geochemical, and geophysical characteristics of the study area with those of nearby mineralized areas and with resource deposit models. The geologic features of the study area suggest two possible models for the presence of mineral resources: (1) oil and gas in the Gallup, Dakota, and Entrada Sandstones; and (2) uranium in the Morrison Formation.

Oil and Gas

The study area has a moderate energy resource potential for oil and gas, with a certainty level of B. Ryder (1983) rated the potential for oil and gas as medium in the study area (roughly equivalent to the moderate potential rating of Goudarzi, 1984). This rating was based on the presence of Jurassic and Upper Cretaceous oil fields about 10 mi to the north, Cretaceous Miguel Creek oil fields 3 mi to the west, the oil shows in nearby drill holes, and favorable reservoir and stratigraphic traps in Upper Cretaceous nearshore marine sandstones (Dakota and Gallup Sandstones) and the Jurassic Entrada Sandstone. These formations are present beneath the study area. Oil shows were found in nearby drill holes; however, one test well drilled through the Dakota and two others 400 ft deep in the study area were dry. The resource potential rating is only moderate because the rocks are intruded by volcanic plugs that may have raised the paleotemperature above the limit for preservation of oil and gas.

Uranium

The mineral resource potential is low for uranium in the study area, with a certainty level of B. Uranium minerals in the Grants Uranium region, about 20 mi to the south, are associated with organic material in the fluvial sandstone of the Upper Jurassic Morrison Formation. Ore in the Grants region is typically confined to the upper part of the Westwater Canyon Member and to a sandstone unit called the Jackpile Sandstone Member of the Morrison Formation (Santos, 1963; Owen and others, 1984). Mineralization is localized at oxidation-reduction boundaries. Criteria favorable for uranium mineralization in the Morrison Formation include thick beds of sandstone, abundant organic material, high sandstone to mudstone ratio, and the presence of greenish-gray mudstone thought to be a source of organic material (Turner-Peterson, 1986).

Geologic mapping (Turner-Peterson and Fishman, 1986) and sparse drill-hole data by Pioneer Nuclear, Inc. and Homestake Mining, Inc. (Schreiner, 1988) indicate that the Morrison Formation is present beneath the study area. The top of the Morrison is more than 1,650 ft deep at the eastern boundary and more than 2,300 ft at the northern boundary. Apparently no uranium was found in these drill holes. No information was found regarding the sandstone to mudstone ratio or the presence or absence of organic material in the Morrison Formation beneath the study area. More information on subsurface stratigraphy is needed in order to raise the level of certainty. For these reasons, the potential for uranium is low in the study area.

The aerial gamma-ray data indicated that the area has moderate radioactivity. These data only provide information on near-surface materials. No radioactivity anomalies were found, and the geochemistry data revealed no anomalous concentrations of uranium.

Other Commodities

Mineral resource potential for all metals other than uranium is low in the study area, with a certainty level of C. No minerals have been produced and no surface evidence was found to indicate metallic-mineral resources. The geochemical sampling revealed no anomalous concentrations of any element indicative of mineralization.

The energy resource potential for geothermal energy is low in the study area, with a certainty level of C. No geothermal sources are known within the study area, nor were warm springs or other geothermal sources noted during this investigation.

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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.

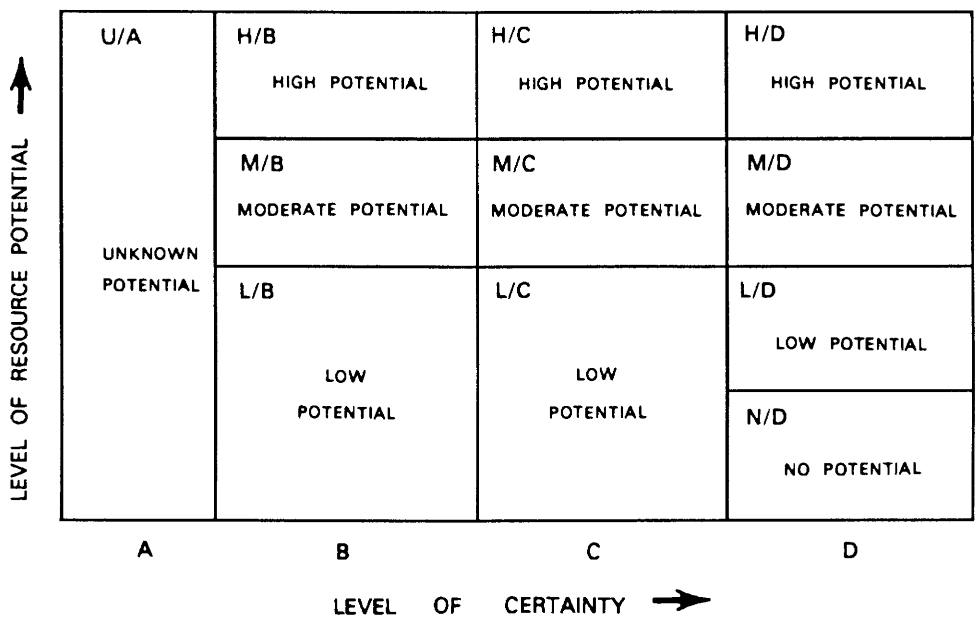
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application 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.

Taylor, R. B., Stoneman, R. J., and Marsh, S. P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: U.S. Geological Survey Bulletin 1638, p. 40–42.

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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 McKelvey, 1972, Mineral resource estimates and public policy: American Scientist, v.60, p.32-40, and U.S. Bureau of Minas 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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