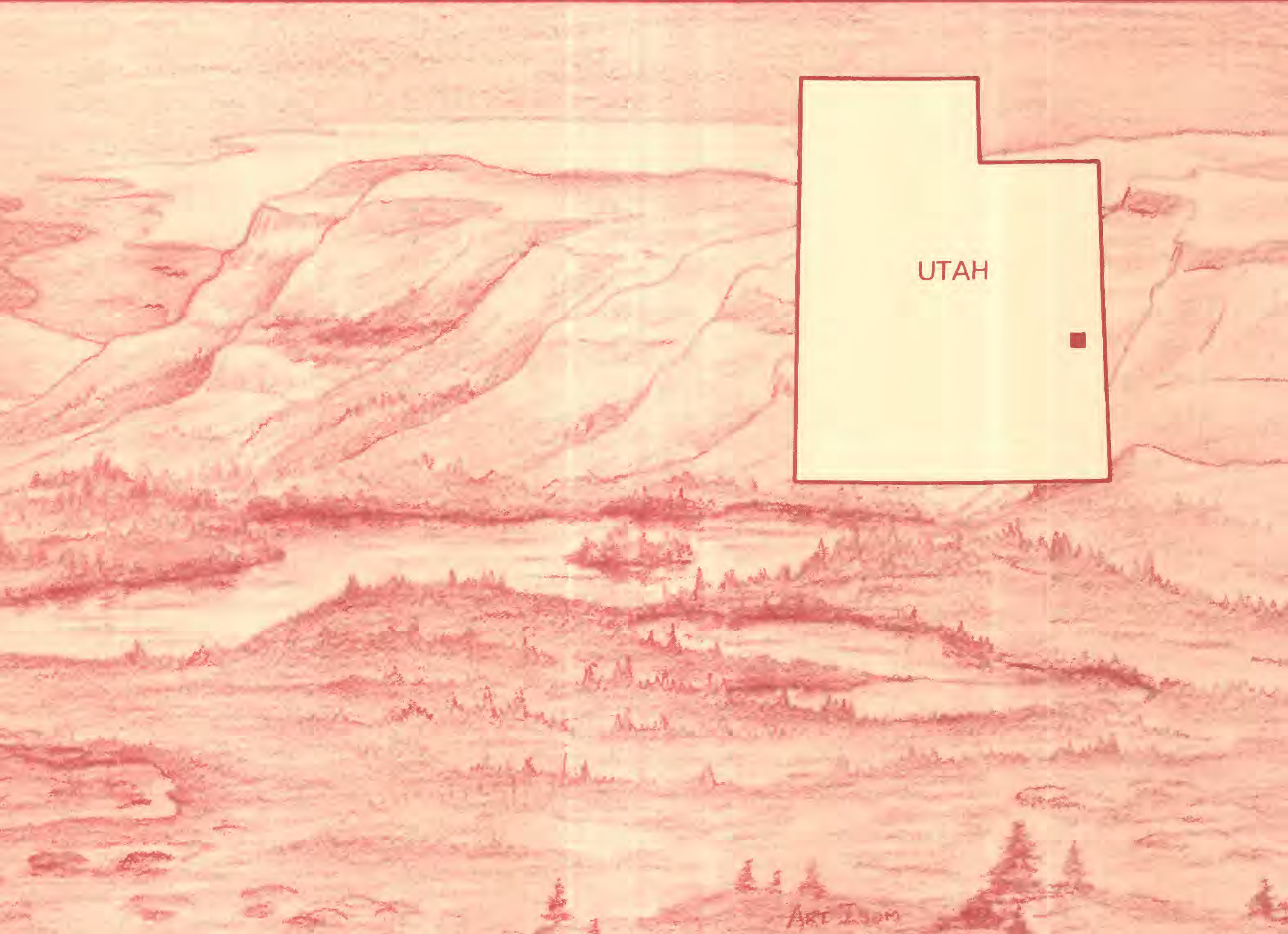
Mineral Resources of the Lost Spring Canyon Wilderness Study Area, Grand County, Utah

U.S. GEOLOGICAL SURVEY BULLETIN 1754–C



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Chapter C

Mineral Resources of the Lost Spring Canyon Wilderness Study Area, Grand County, Utah

By SANDRA J. SOULLIERE, GREG K. LEE, and
JAMES E. CASE
U.S. Geological Survey

DIANN D. GESE
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1754

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
UPPER COLORADO RIVER REGION, UTAH

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 the Lost Spring Canyon (UT–060–131B) Wilderness Study Area, Grand County, Utah.

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Mineral Resources of the Lost Spring Canyon Wilderness Study Area, Grand County, Utah

By Sandra J. Soulliere, Greg K. Lee, *and*
James E. Case
U.S. Geological Survey

Diann D. Gese
U.S. Bureau of Mines

ABSTRACT

The Lost Spring Canyon (UT–060–131B) Wilderness Study Area is about 15 miles north of Moab, Utah, and covers 3,880 acres adjacent to Arches National Park. Investigations by the U.S. Geological Survey and the U.S. Bureau of Mines conclude that the study area has no economic mineral resources, but has inferred subeconomic resources of sandstone and sand and gravel. There is moderate energy resource potential for undiscovered oil and gas, potash, and halite, and low resource potential for undiscovered geothermal resources and all metals, including uranium and manganese (fig. 1).

SUMMARY

The Lost Spring Canyon (UT–060–131B) Wilderness Study Area covers 3,880 acres adjacent to Arches National Park and is about 15 mi (miles) north of Moab, Utah (figs. 1, 2). The area is accessible by improved and unimproved roads south of Interstate 70 near Thompson or by foot from Arches National Park. In the study area, flat-lying to gently folded sedimentary rocks have been eroded by streams that formed Salt Wash and Lost Spring Canyon, which are major topographic features. Sandstones and shales of the Jurassic (see geologic time chart in Appendix) Entrada Sandstone and Morrison Formation exposed in the study area form rounded cliffs and hummocky topography. The sedimentary rocks dip only a few degrees, and the axis of a shallow syncline is in the valley known as Salt Wash. To the north of the study area, faults mark the boundary of the Yellow Cat graben. Two of these faults cross the northeastern boundary of the study area.

U.S. Geological Survey researchers collected and analyzed 12 stream-sediment samples, 9 heavy-mineral panned-concentrate samples, and 1 rock sample from the study area. No anomalous concentrations of any elements were detected. Gravity and aeromagnetic data were used to determine regional geologic structures of the area. Aerial gamma-ray data and Landsat Multispectral Scanner data were analyzed for characteristics indicative of mineral deposits.

Large volumes of inferred subeconomic resources of sandstone and sand and gravel are present within the study area, but no metallic mineral resources were identified. The common-variety sandstone is exposed over most of the study area, and sand and gravel were found along two drainages. The isolated location of the study area and the abundance of similar sandstone and sand and gravel deposits outside the area would make development of occurrences inside the study area unlikely. Uranium and manganese deposits occur within 2 mi of the study area but are not known to occur inside the study area boundaries.

The study area overlies the flank of the Salt Valley anticline, and Paleozoic source and reservoir rocks that are favorable for oil and gas underlie the study area. Oil shows were found in holes drilled 5 mi west of the study area. The potential for undiscovered oil and gas resources in the study area is therefore moderate.

The study area is within the boundaries of a major salt zone in the Paradox Member of the Hermosa Formation, and

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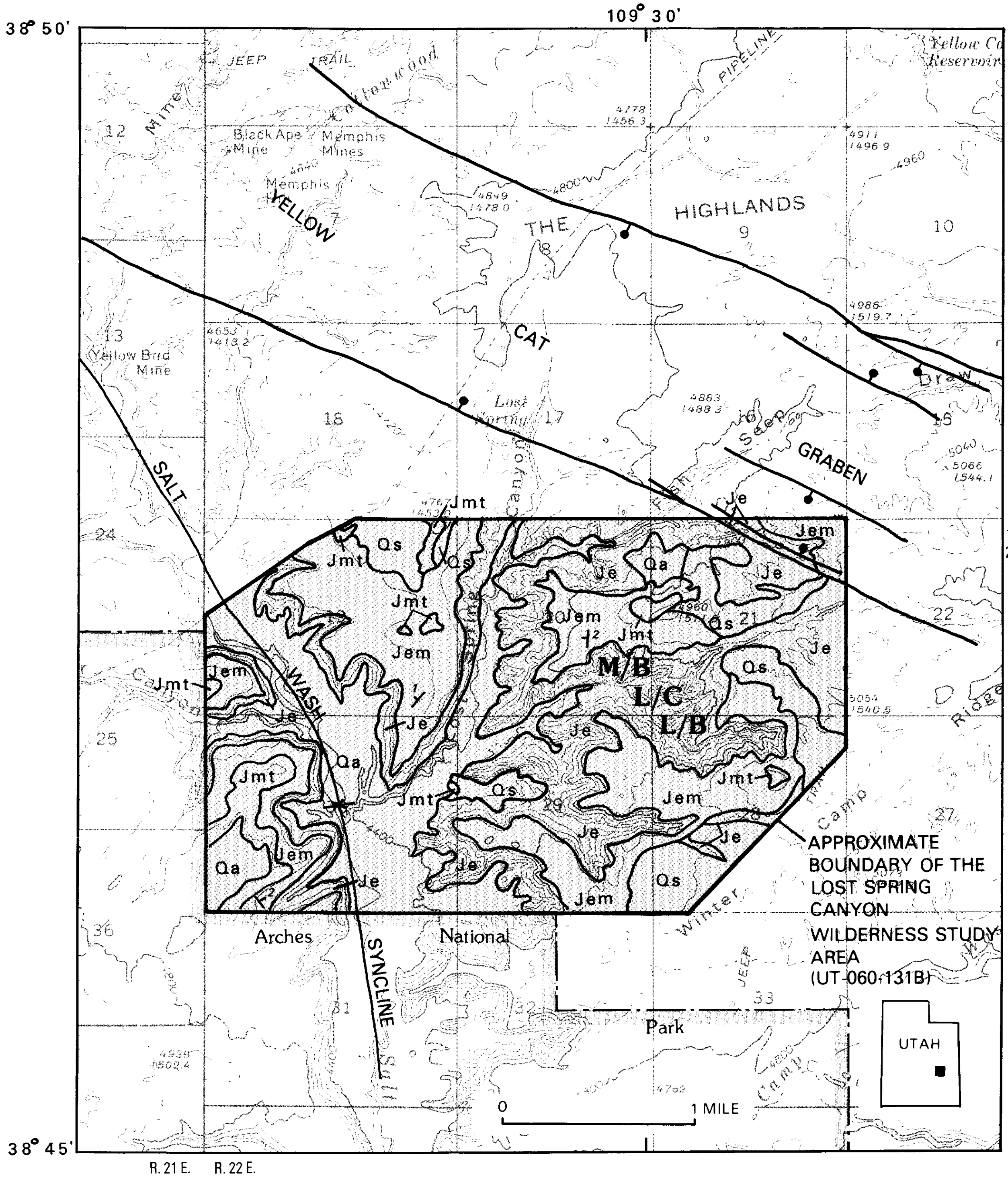

Figure 1 (above and facing page). Map showing mineral resource potential and geology of the Lost Spring Canyon Wilderness Study Area. Geology modified from Doelling (1985). Base from Arches National Park, Utah, 1974.

potash and halite may underlie the study area at a depth greater than 7,000 ft (feet). No test wells have been drilled for potash and halite in the study area. The mineral resource potential for undiscovered potash and halite is moderate in the study area.

Uranium has been mined from the Salt Wash Member of the Morrison Formation about 2 mi north of the study area. The Salt Wash Member has been eroded from the study area; therefore the resource potential for undiscovered uranium is low in the study area. The Tidwell Member of the

EXPLANATION

M/B	Geologic terrane having moderate energy resource potential for oil and gas, potash, and halite, with certainty level B—Applies to the entire study area
L/C	Geologic terrane having low mineral resource potential for all metals, including uranium, and geothermal energy, with certainty level C—Applies to entire study area
L/B	Geologic terrane having low mineral resource potential for manganese, with certainty level B—Applies to entire study area
Qa	Alluvium (Quaternary)
Qs	Eolian sand deposits (Quaternary)
Jmt	Tidwell Member of the Morrison Formation (Jurassic)
Jem	Moab Tongue of the Entrada Sandstone (Jurassic)
Je	Main body of the Entrada Sandstone (Jurassic)
——	Contact
(fault symbol)	Fault, bar and ball on downthrown side
(syncline symbol)	Syncline
(strike and dip symbol)	Strike and dip of beds
	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

Morrison Formation, which is known to contain manganese deposits in the region, is exposed in the study area where it ranges in thickness from 40 to 100 ft. No anomalous concentrations of manganese were found during the geochemical study; therefore the potential for undiscovered near-surface manganese resources is low. The geologic environment is not favorable for the presence of any other metallic minerals, and no anomalous concentrations of metals were found during the geochemical study. The resource potential for undiscovered metals and nonmetals, other than uranium and manganese, is low. No hot springs were noted, and the energy resource potential for undiscovered geothermal energy is low.

INTRODUCTION

In 1986 the U.S. Bureau of Mines (USBM) and the U.S. Geological Survey (USGS) studied 3,880 acres of the Lost Spring Canyon Wilderness Study Area (UT–060–131B). The study of this acreage was requested by the U.S. Bureau of Land Management (BLM). 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

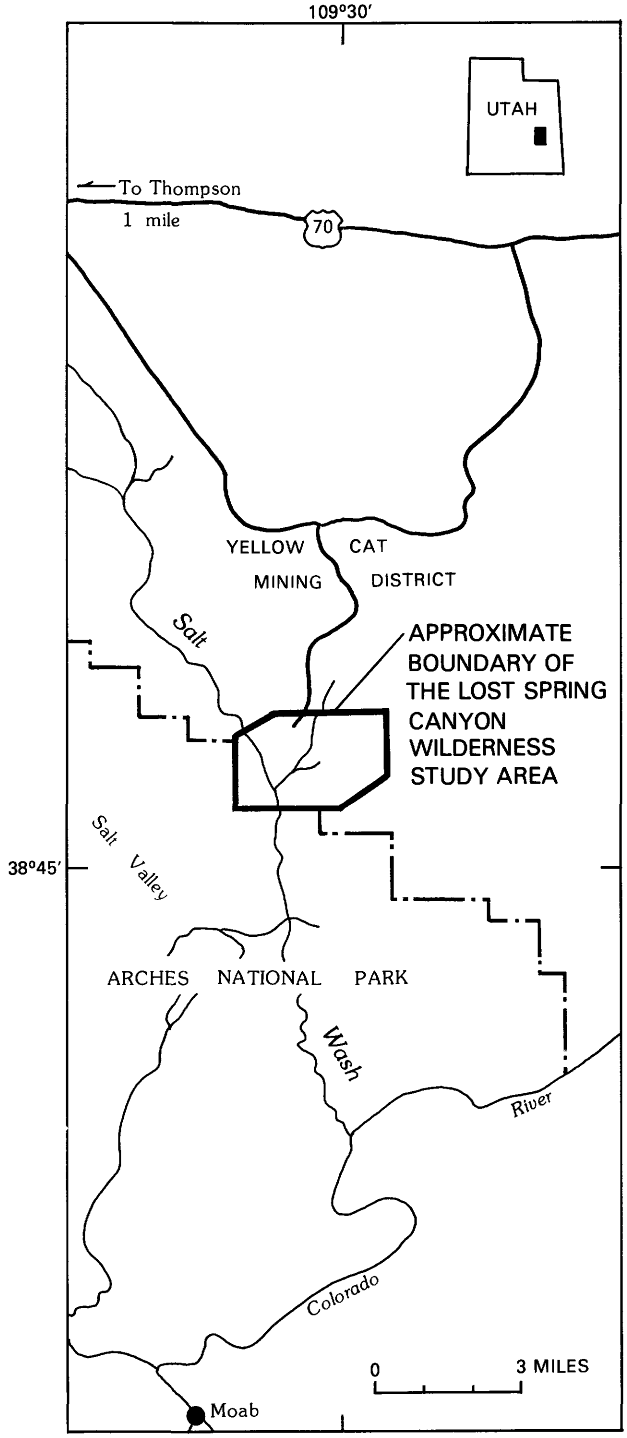

Figure 2. Index map of the Lost Spring Canyon Wilderness Study Area, Grand County, Utah.

separate studies by the USBM and the USGS. Identified resources are classified according to the system of the U.S. Bureau of Mines and U.S. Geological Survey (1980) which is shown in the Appendix. Identified resources are studied by the USBM. Mineral resource potential is the likelihood of occurrence of undiscovered concentrations of metals and nonmetals, industrial rocks and minerals, and of undiscovered energy resources (coal, oil, gas, oil shale, and geothermal sources). Mineral resource potential and the level of certainty of each mineral resource assessment are classified according to the system of Goudarzi (1984; see Appendix). The potential for undiscovered resources is studied by the USGS.

Investigations by the U.S. Bureau of Mines

Pertinent published and unpublished literature and files at the BLM State Office in Salt Lake City, Utah, were checked for patented and unpatented mining claim locations and for oil and gas, coal, geothermal, and potash leases and lease applications. Persons having knowledge of mineral occurrences and mining activities within and near the study area were contacted.

Two USBM geologists spent two days in the field and collected three rock chip samples and one grab sample. Two samples were fire assayed for gold and silver, one sample was analyzed by atomic absorption for manganese, and two samples were analyzed for 32 elements by inductively coupled plasma atomic emission spectroscopy (Gese, 1987). Two rock samples were analyzed by inductively coupled plasma atomic emission spectroscopy to determine their suitability for industrial use. All analyses were performed at Chemex Labs, Inc., Sparks, Nev.

Investigations by the U.S. Geological Survey

S.J. Soulliere and A.M. Leibold reviewed published and unpublished information about the region and field checked previous geologic mapping. G.K. Lee collected stream-sediment and rock samples for geochemical analysis. J.E. Case reviewed data from regional geophysical surveys. Keenan Lee analyzed satellite imagery data, and J.S. Duval examined regional aerial gamma-ray data. R.T. Hopkins, Jr., J.D. Sharkey, and D.L. Fey analyzed the samples.

APPRAISAL OF IDENTIFIED RESOURCES

By Diann D. Gese
U.S. Bureau of Mines

Mining History

The area is not within any mining districts. Uranium, vanadium, and radium were first mined in 1911 from the Salt Wash Member of the Morrison Formation in the Yellow Cat (Thompson) mining district about 2 mi north of the study area (fig. 3). The mining ceased around the mid-1960's. The uranium- and vanadium-bearing Salt Wash Member, present in the Yellow Cat district, has been eroded from the study area. Manganese has been mined in the region from various deposits in the Tidwell Member of the Morrison Formation. This member crops out within the study area; however, the nearest manganese occurrence is about 1 mi northeast of the study area (Gese, 1987).

About 12 mi southwest of the study area and 2 mi northwest of Moab, bedded potash and halite deposits have been mined since 1965 from Texasgulf Inc.'s Cane Creek mine. The deposits occur within the Middle Pennsylvanian Paradox Member of the Hermosa Formation (Hite and Gere, 1958). The potassium-bearing zone of the Hermosa Formation is estimated to be more than 7,000 ft below the surface of the study area (U.S. Department of Interior, 1986).

Oil and Gas

Oil and gas leases cover most of the study area (fig. 3). The study area is on the northern edge of the Paradox Basin, along the east limb of the Salt Valley-Cache Valley anticline, which is one of the northwest-trending salt anticlines that characterize this part of the Paradox Basin. Petroleum deposits in the northern part of the Paradox Basin occur in faulted salt anticlines where the oil has accumulated in favorable Mississippian limestones (Clem and Brown, 1984).

Nine wells have been drilled within 5 mi of the study area. Oil shows were reported in two of the holes drilled 5 mi west of the study area along the axis of the Salt Valley-Cache Valley anticline.

Appraisal of Sites Examined

Three rock chip samples and one grab sample were taken within and near the study area. Two samples are

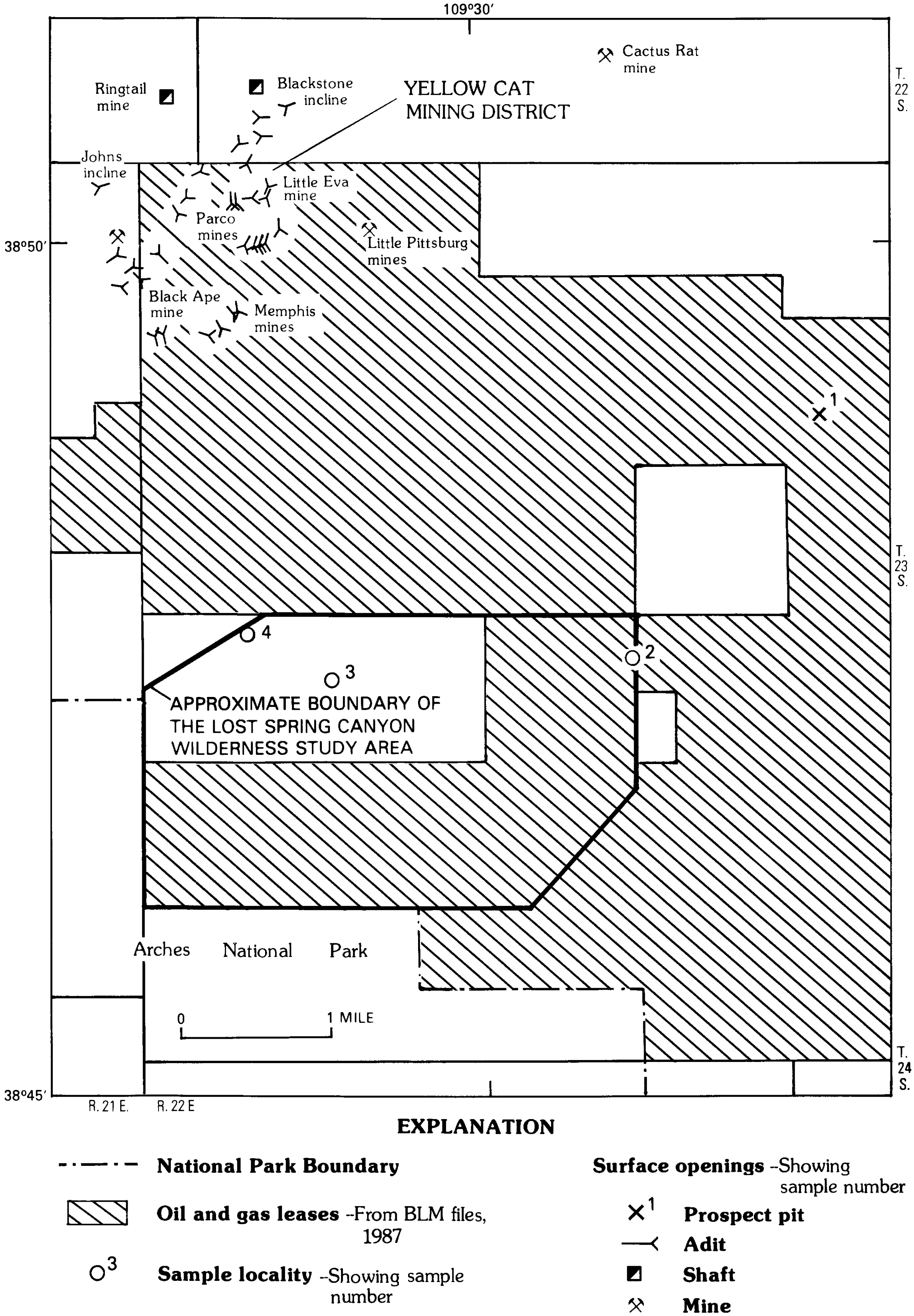

Figure 3. Map showing oil and gas leases in the Lost Spring Canyon Wilderness Study Area, Grand County, Utah.

from the Entrada Sandstone and two are from the Tidwell Member of the Morrison Formation, a known manganese host in the area. Manganese oxide occurs in a 6- to 8-in.-thick, 300-ft-long bed in medium-grained sandstone of the Tidwell Member about 1 mi northeast of the study area in the SW¼ sec. 11, T. 23 S., R. 22 E. (Gese, 1987). One grab sample taken from the stockpile at this location contained 2.2 percent manganese. Baker and others (1952) examined the prospect and concluded that it is unlikely that there is more than a few hundred tons of ore. Tidwell Member outcrops in the study area were examined for any manganese deposits; none was found. One sample taken from the Tidwell Member within the study area where the sandstone was partly altered, fractured, and coated with hematite and manganese oxides contained only 0.1 percent manganese. Currently the United States imports all its manganese ore. Domestic manganese deposits containing 5–34 percent manganese are not considered economic to develop.

Two samples of the Entrada Sandstone within the study area were evaluated for possible industrial uses. The sandstone was fine grained and highly friable, and the two samples contained 94 percent and 97 percent silica, 1.67 percent and 1.51 percent aluminum oxide (Al_2O_3), and 0.51 percent and 0.24 percent iron-oxide (Fe_2O_3). By the American Society for Testing and Materials (ASTM) standards, the sandstone would be suitable for use only as foundry sand (Davis and Tepordei, 1985; Coope and Harben, 1977). Sand and gravel occurs within the study area in both the Lost Spring Canyon and Salt Wash drainages. Inferred subeconomic sandstone and sand and gravel resources are present, but the isolated location of the study area and the abundance of similar common-variety sandstone and sand and gravel deposits outside the area would make development of deposits inside the study area unlikely.

Conclusions

Inferred subeconomic resources of sandstone and sand and gravel are present, but no metallic mineral resources were identified within the study area. Entrada Sandstone, which is suitable as foundry sand, is exposed over most of the study area but has no other unique or desirable qualities. The isolation of the study area and abundance of similar sandstone and sand and gravel deposits outside the study area would make development of the sandstone inside the study area unlikely. The Tidwell Member of the Morrison Formation hosts manganese deposits outside the study area but contained no significant manganese concentrations in outcrop within the study area.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Sandra J. Soulliere, Greg K. Lee, and James E. Case
U.S. Geological Survey

Geology

The geology of the Lost Spring Canyon Wilderness Study Area was mapped by Doelling (1985) during his study of the geology of Arches National Park. The geologic map (fig. 1) and the following description of rock units were modified from his report. The study area is in the Paradox Basin of the Colorado Plateaus physiographic province, an area characterized by northwest-trending salt anticlines. During Pennsylvanian time a thick sequence of marine sediments, mainly evaporites, filled the Paradox depositional basin in southeast Utah and southwest Colorado (Hite and Buckner, 1981). As the salt flowed into a diapiric fold, the overlying strata in the region were folded, fractured, faulted, and tilted. Erosion by wind and water formed rounded cliffs and narrow canyons in the study area.

The study area is on the northwestern edge of the Paradox Basin. Pennsylvanian and Permian rocks of the basin consist of interbedded sandstone, siltstone, shale, conglomerate, and evaporite. Rocks of this age are not exposed in the study area, but drill-hole data and geologic mapping indicate that they are present in the subsurface. The Paradox Member of the Middle and Upper Pennsylvanian Hermosa Formation in particular is important to this study because it may have reservoir characteristics for oil and gas. It has also been mined locally for potash and halite.

Sedimentary rocks exposed in the study area are Jurassic in age and consist of the Slick Rock Member and the Moab Tongue of the Entrada Sandstone and the Tidwell Member of the Morrison Formation. The Entrada Sandstone represents deposition in tidal-flat, beach, and sand-dune environments. The Tidwell Member of the Morrison Formation was deposited in a variety of environments, including lacustrine, evaporative, mudflat, and minor eolian and fluvial environments (Peterson, 1988).

The Jurassic Entrada Sandstone consists of three members; in ascending order they are the Dewey Bridge Member, the Slick Rock Member, and the Moab Tongue. The Dewey Bridge Member is not exposed at the surface but is present beneath the study area where it consists of dark-reddish-brown silty sandstone. The Slick Rock Member, or main body of the Entrada Sandstone, is about 200–500 ft thick and consists of orange-red, sometimes banded, fine-grained, massive sandstone. The Slick Rock Member forms smooth rounded cliffs. Resistant, cliff-forming beds of yellow-gray sandstone make up the Moab Tongue. This member is variable in thickness (60–120 ft) and is unconformable with the overlying Tidwell Member of the Morrison Formation. The Tidwell Member is about 40–100 ft thick and consists of red and greenish-gray silty shale interbedded with thin yellow sandstone and gray limestone beds. Some of these beds locally contain red and yellow chert nodules or concretions.

Geochemistry

Sample Media

Analyses of stream-sediment samples represent the chemistry of the rock material eroded from the drainage basin upstream from each sample site. In addition, the fine (silt) fraction of the sediment provides nuclei for the adsorption of dissolved metals contained in the stream water. Such information is useful in identifying basins that contain concentrations of elements that may be related to mineral deposits.

Analyses of heavy-mineral-concentrate samples provide information about the chemistry of certain minerals in rock eroded from the drainage basin upstream from each sample site. The selective concentration of minerals, many of which may be ore related, permits determination of some elements that are not easily detected in stream-sediment samples.

Analyses of altered or mineralized rocks, where present, may provide useful geochemical information about the major- and trace-element assemblages associated with a mineralizing system.

Geochemical Sampling Methods

Stream-sediment samples were collected from most active stream drainages in the study area. At each sample site a composite of fine material from several localities within the stream was taken and later air dried for sieving and analysis.

Panned concentrates of stream sediments were collected from drainages that were large enough to deposit gravel-size and coarser sediment. These samples were generally taken near the stream-sediment-sample localities but were derived from coarser material that represents a relatively high energy depositional environment in the stream. A heavy-mineral concentrate was obtained by panning, after which the concentrate samples were submitted to the laboratory for drying and analysis. A rock sample of an apparent manganese nodule was taken from float.

Sample Preparation and Analysis

The rock sample was crushed, ground, split, and analyzed. Stream-sediment samples were dried and sieved through an 80-mesh (177 micrometer) screen, and the fraction finer than 80-mesh was analyzed. Panned-concentrate samples were dried, and a small split of each sample was separated for spectrographic analysis. The entire remainder of each concentrate was weighed and chemically analyzed for gold content.

Six-step semiquantitative emission spectrographic analyses were made of all samples using the method of Grimes and Marranzino (1968). Each spectrographic analysis included determinations of 35 elements. Atomic absorption spectrographic analysis for gold was performed on every panned-concentrate sample using the method described by Thompson and others (1968). Inductively coupled plasma atomic emission spectrometric determinations of antimony, arsenic, bismuth, cadmium, and zinc were made on the rock samples using the method described by Crock and others (1987). All rock and stream-sediment samples were analyzed for uranium using a modification of the method described by Centanni and others (1956).

Summary of Results

Inspection of the statistical distributions of the analytical data and consideration of average crustal abundances of the elements in comparable lithologic terranes (Rose and others, 1979) suggest that the study area is generally lacking in mineral enrichment. No anomalous concentrations of any elements were found. Minor indications of chromium enrichment occurred in panned-concentrate samples from Lost Spring Canyon and Fish Seep Draw (1,000 and 1,500 ppm, respectively). The source of the chromium is unknown.

Geophysics

Only regional gravity and aeromagnetic surveys have been made in the vicinity of the Lost Spring Canyon Wilderness Study Area. These surveys were summarized by Case and Joesting (1972) and Hildenbrand and Kucks

(1983). The area was crossed by only two aeromagnetic traverses. Nearby gravity stations provide regional control (Joesting and Case, 1962; Case and Joesting, 1972), but no gravity stations were established within the study area. It is possible that oil companies or other groups have conducted surveys of which we are unaware.

Regional Gravity Setting

The Salt Valley anticline produces a northwest-trending residual gravity low of about 28–32 mGals (milligals) with respect to relative gravity highs on the flanks of the main anomaly (fig. 4). The thickened, low-density salt that composes the core of the anticline produces the negative gravity anomaly. The gravity anomaly trends northwest, consistent with the strike of the salt anticline. For the gravity modeling, a mean density of the evaporite sequence was assumed to be about 2.2 g/cm³ (grams per cubic centimeter) and that of the adjacent sedimentary sequence to be about 2.55 g/cm³, which resulted in a density contrast of -0.35 g/cm³ (Joesting and Case, 1962). Daniels and others (1980) provided additional density information about the evaporite sequence. According to drill-hole data (Hite and Lohman, 1973) and gravity models (Joesting and Case, 1962), the structural relief of the top of the salt northwest of the study area is as much as 7,000–8,000 ft. The study area is on the northeast flank of the gravity low and near the edge of the low. Such a setting indicates that the study area is near the edge of a deep-seated salt thickening. Indeed, relatively little salt may remain directly beneath the study area; most of the original salt has probably flowed southwest into the core of the anticline.

Regional Aeromagnetic Setting

The study area is located just south of a broad east-trending aeromagnetic high of about 150 gammas which centers near Yellow Cat dome (fig. 5). It has been demonstrated from drill-hole data that most aeromagnetic anomalies in the Paradox Basin originate from sources within the Precambrian basement; the Phanerozoic sedimentary sequence is effectively nonmagnetic (see summary by Case and Joesting, 1972). The source of the high is probably magnetic quartz monzonite or metadiorite, similar to anomaly sources over exposed Precambrian rocks of the Uncompahgre uplift (Case, 1966) where susceptibility contrasts are about 0.003 (cgs system: centimeters, grams, seconds). From drill-hole data and depth estimates from magnetic data, the Precambrian basement surface beneath the study area may lie at depths of 11,000 ft or more below sea level (fig. 6).

Remote-Sensing Data

Landsat Multispectral Scanner (MSS) imagery data were acquired and processed to map variations in limonite. The images were used to target hydrothermal alteration associated with mineralization and limonite anomalies associated with either uranium deposition or hydrocarbon seepage.

Landsat MSS images also were used as the basis of a lineament analysis that covered a large area of western Colorado and eastern Utah. Linear features mapped on the images were interpreted to derive longer linear trends of parallel linear features called lineaments. Lineaments were interpreted, along with geophysical surveys and deep drill-hole data, for possible basement structures. The methods used are described more fully in Lee (1988).

The Lost Spring Canyon Wilderness Study Area does not correlate directly with any lineament derived from the regional lineament analysis. The area is between two lineaments, and there is no suggestion of basement faulting under this area.

Variations in limonite were sought that might be related to either uranium deposition or hydrocarbon leakage. No limonite anomalies were found in the area. These results are described more fully in Lee (1988).

Aerial Gamma-Ray Data

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). These data (K, eU, eTh) provide us with a partial geochemical representation of the near-surface materials. For a typical aerial survey each measurement reflects average concentrations for a surface area on the order of 70,000 square yards to an average depth of about 1 ft. Examination of this map indicates that the study area has overall moderate radioactivity with concentrations of 0.8–1.2 percent K, 1.5–5.0 ppm eU, and 2–6 ppm eTh. There are no thorium or potassium anomalies in or near the study area. There is a relatively strong uranium anomaly along the northern border and immediately north of the study area (J.S. Duval, written commun., 1987).

Mineral and Energy Resources

Metallic Minerals

Uranium

Although uranium has been mined from the Salt Wash Member of the Morrison Formation about 2 mi north of the study area, the Salt Wash Member has been

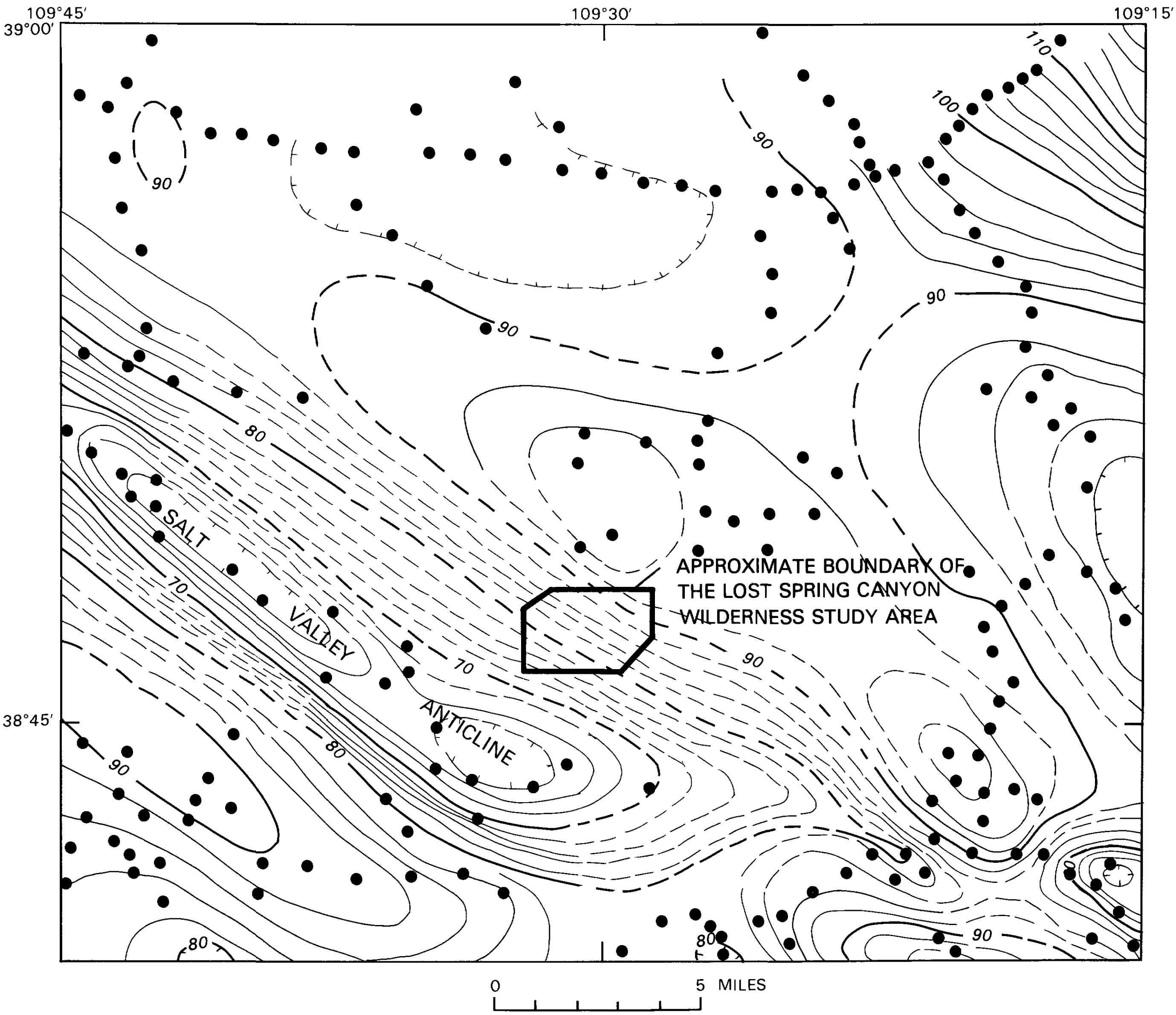

Figure 4. Bouguer anomaly map of the Lost Spring Canyon Wilderness Study Area and vicinity. Contour interval 2 mGals; contours dashed where values are uncertain; hachures indicate relative lows. Dots indicate locations of gravity stations. The anomalies were calculated using a reduction density of 2.5 g/cm³. Three hundred milligals were added to the Bouguer anomalies so that all values would be positive. From Case and Joesting (1972).

eroded from the study area and no outcrops are present. The mineral potential for undiscovered uranium resources is low in the study area, with a certainty level of C.

Manganese

The Tidwell Member of the Morrison Formation, known for manganese deposits in the region, is exposed in the study area where it ranges in thickness from 40 to 100 ft. Geochemical analysis of 12 stream-sediment samples and one rock sample did not reveal any anomalous concentrations of manganese. Therefore the mineral resource potential for undiscovered near-surface manganese is low in the study area, with a certainty level of B.

Other Metals

The geologic environment of the study area is not favorable for the formation of any other metallic minerals. In addition, geochemical evidence does not indicate abnormally high concentrations of metals at the surface in the study area. No minerals have been

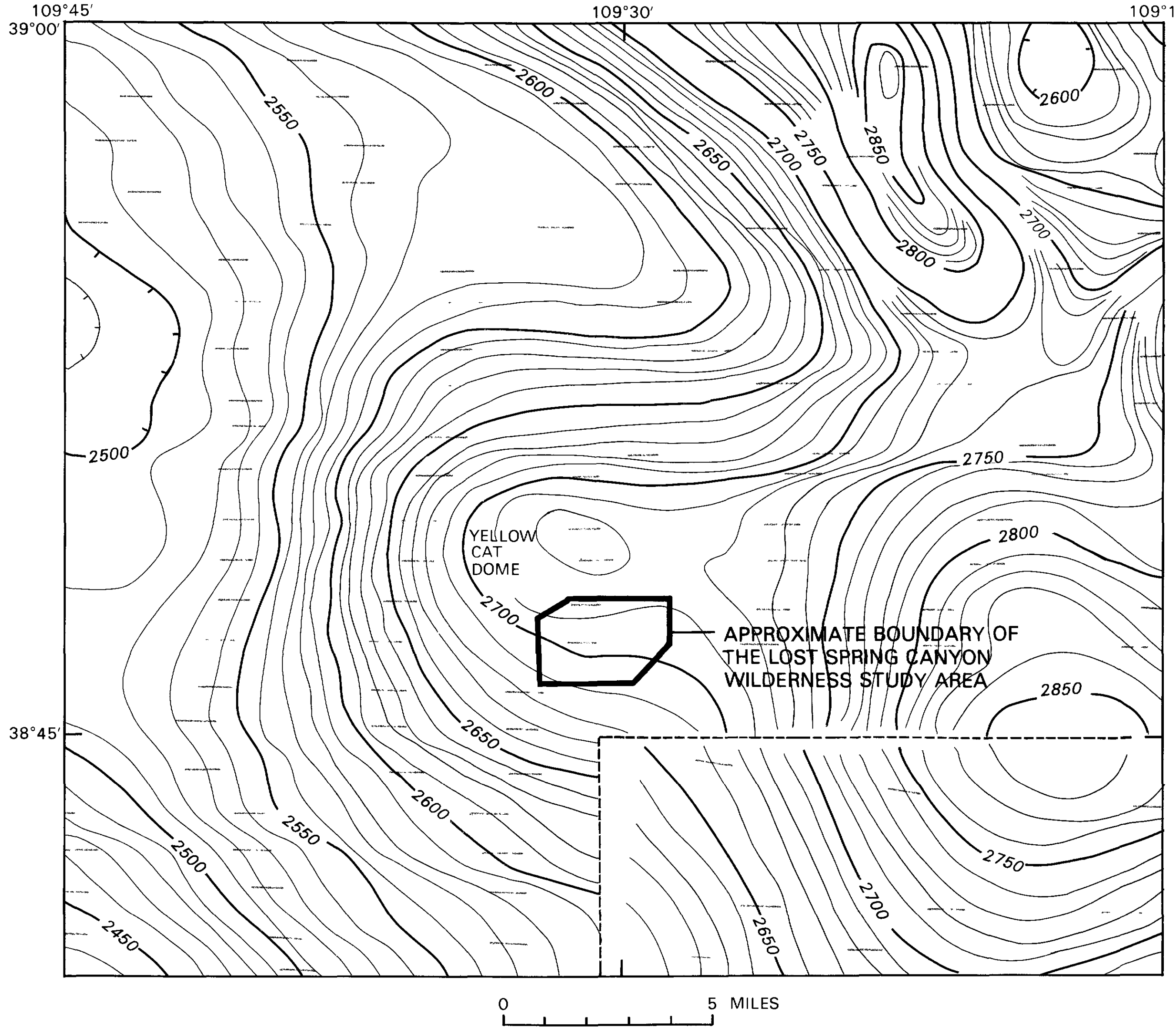

Figure 5. Aeromagnetic anomaly map of the Lost Spring Canyon Wilderness Study Area and vicinity. Contour intervals 10 and 50 gammas. The anomalies are total intensity values with respect to an arbitrary datum. Short dashed lines indicate boundary of surveys having different data. Hachures indicate relative magnetic low. No regional field has been removed. Flight paths are indicated by long dashes oriented about east-west. The survey was flown at an elevation of 8,500 ft, except the southeast part which was flown at an elevation of 12,500 ft. From Case and Joesting (1972).

produced, and no surface evidence was found to indicate the presence of metallic mineral resources. Therefore, the study area is assigned a low resource potential for all undiscovered metals, including uranium, with a certainty level of C.

Potash and Halite

Potash and halite deposits in the Paradox Basin occur in the Middle Pennsylvanian Paradox Member of the Hermosa Formation. Potash and halite from the Paradox Member, if present, would underlie the study area at a depth greater than 7,000 ft. Hite (1961, 1976, 1977) delineated the limits of major potash zones in the Paradox Member, and the study area is within one of these zones. Drill-hole information concerning potash in the area is meager, and most has come from oil and gas wells. No test wells have been drilled for potash and halite in the study area. The potential for undiscovered potash and halite resources is moderate in the study area, with a certainty level of B.

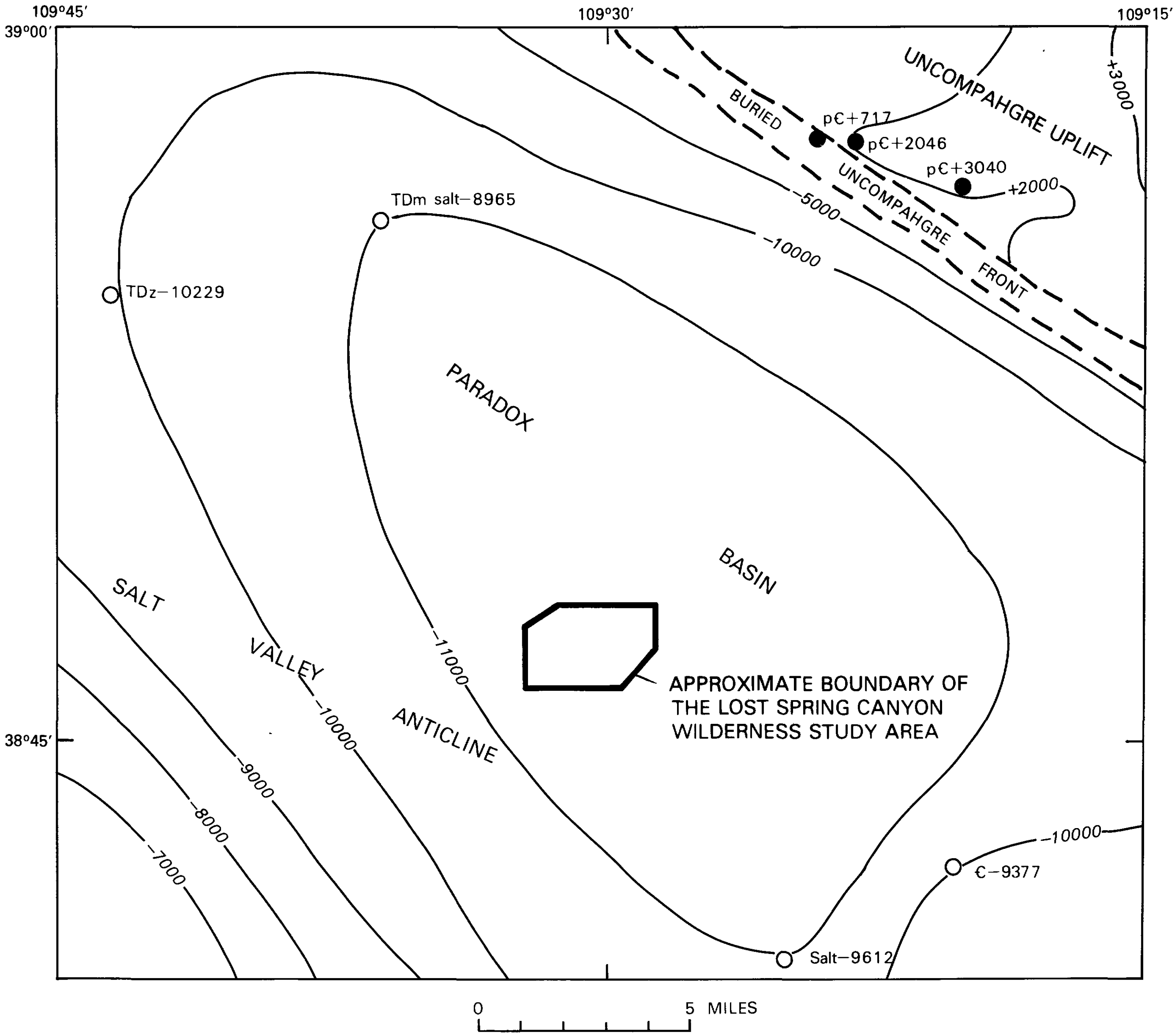

Figure 6. Map showing generalized structure of the Precambrian surface in the Lost Spring Canyon Wilderness Study Area and vicinity. Contour intervals 1,000 and 5,000 ft. Drill holes indicated by circles (solid circles indicate oil shows); elevations and ages of the oldest units penetrated are shown where known. From Case and Joesting (1972).

Oil and Gas

The Lost Spring Canyon Wilderness Study Area is underlain by rock units that produce oil and gas elsewhere in the Paradox Basin. Reservoir rocks include Mississippian carbonates and clastics in the Pennsylvanian Paradox Member of the Hermosa Formation. Source rocks are the black, organic-rich shales also found in the Paradox Member. The study area overlies the flank of the Salt Valley salt anticline, a favorable trap for oil and gas. Test wells drilled near the study area reported oil shows. Molenaar and Sandberg (1983) rated the potential for undiscovered oil and gas in the study area as medium (roughly equivalent to the moderate resource potential rating of Goudarzi, 1984). The presence of favorable source and reservoir beds with no production from wells and the possibility of production from these beds along the flank of the Salt Valley salt anticline indicate a moderate potential rating for undiscovered oil and gas resources in the study area, with a certainty level of B.

Geothermal Resources

No hot springs or other geothermal sources were noted during this investigation. The energy resource potential is low for undiscovered geothermal energy in the study area, with a certainty level of C.

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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.

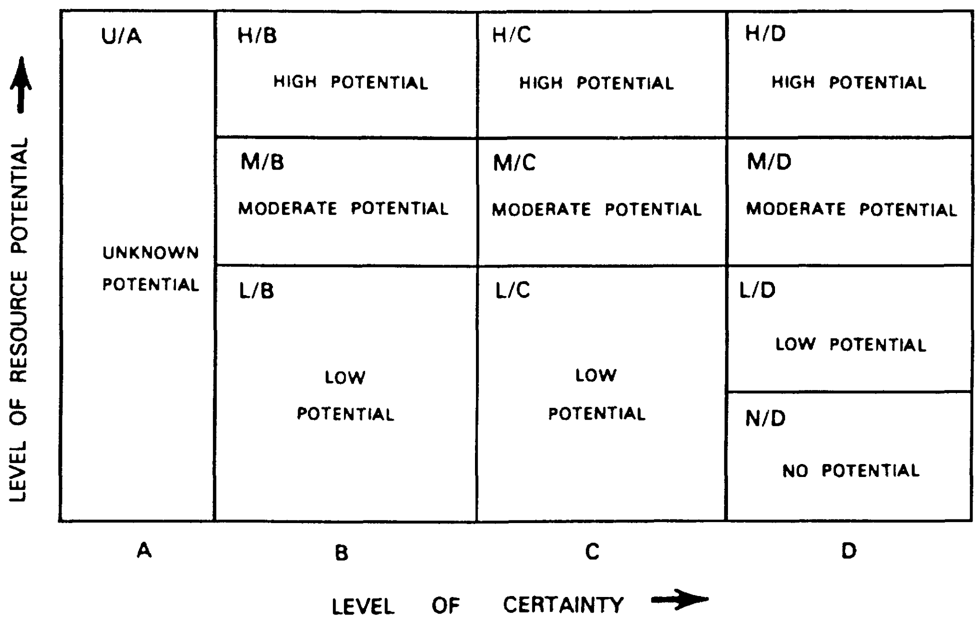
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application 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 McKalvey, 1972, Mineral resource estimates and public policy: American Scientist, v.60, p.32-40, and U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resourca/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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