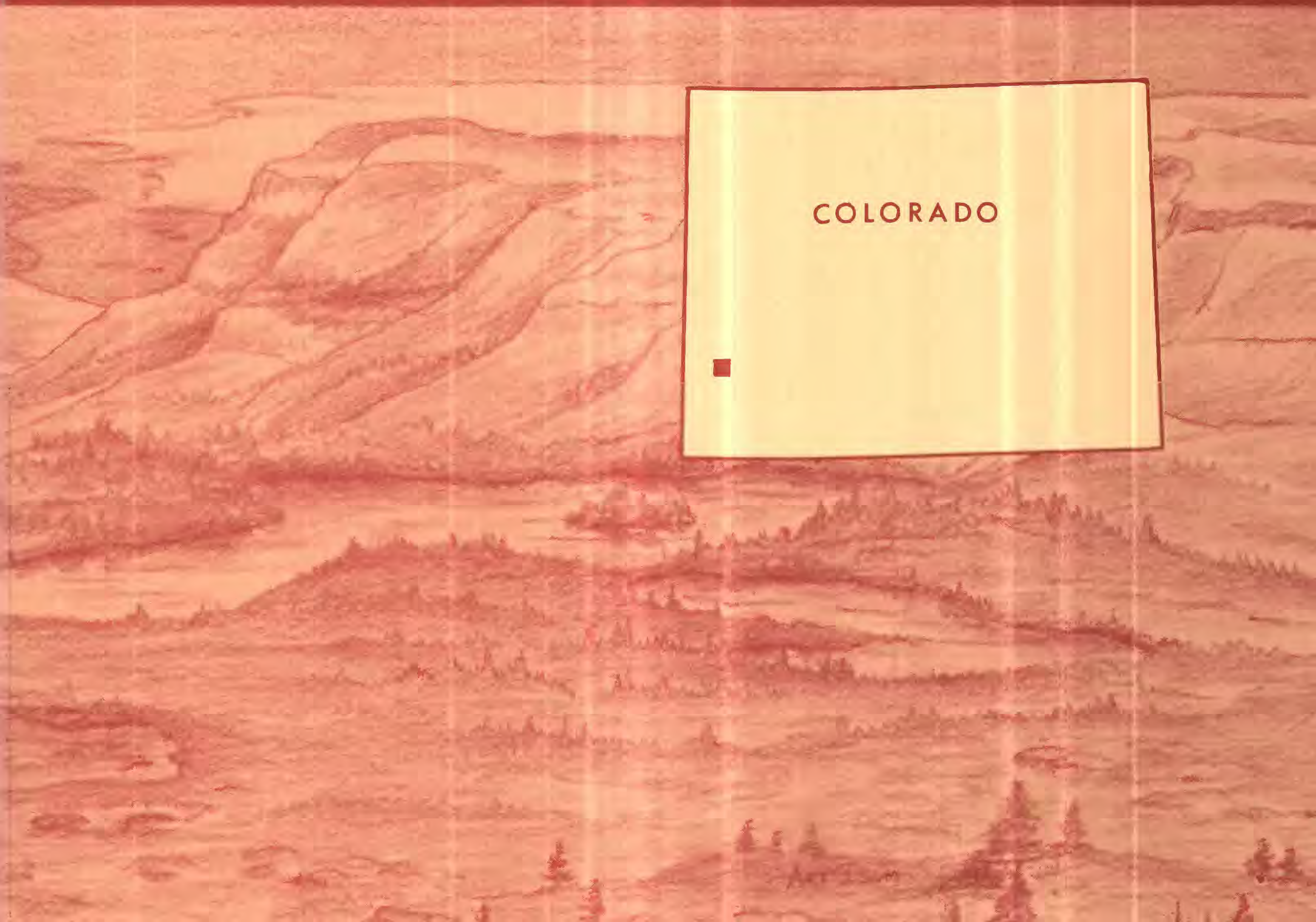
Mineral Resources of the Sewemup Mesa Wilderness Study Area, Mesa and Montrose Counties, Colorado

U.S. GEOLOGICAL SURVEY BULLETIN 1736–B



Chapter B

Mineral Resources of the Sewemup Mesa Wilderness Study Area, Mesa and Montrose Counties, Colorado

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U.S. GEOLOGICAL SURVEY BULLETIN 1736

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
GRAND JUNCTION REGION, COLORADO

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

U. S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

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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 Sewemup Mesa (CO-070-176/030-310A) Wilderness Study Area, Mesa and Montrose Counties, Colorado.

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Mineral Resources of the Sewemup Mesa Wilderness Study Area, Mesa and Montrose Counties, Colorado

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Abstract

In 1983 and 1986 the USGS (U.S. Geological Survey) and the USBM (U.S. Bureau of Mines) conducted studies to appraise the identified resources (known) and assess the mineral resource potential (undiscovered) of 18,835 acres of the Sewemup Mesa (CO-070-176/030-310A) Wilderness Study Area (hereafter referred to as "study area"). There are no mines, prospects, economic or marginally economic resources in the study area; however, there are inferred subeconomic resources of sand and gravel, and sandstone, and occurrences of evaporite minerals. Geological, geochemical, and geophysical studies indicate a moderate mineral resource potential for undiscovered uranium, vanadium, and copper in the Morrison Formation at the southeast edge of the study area. A moderate mineral resource potential exists for copper and silver in a zone of faulted sedimentary rocks along the northern, western, and southern sides of the study area. The entire wilderness study area has moderate energy resource potential for oil and gas and low resource potential for all metals, geothermal energy, anhydrite, gypsum, and potassium salts. There is no energy resource potential for coal resources.

SUMMARY

The Sewemup Mesa Wilderness Study Area is about 50 mi (miles) southwest of Grand Junction in Mesa and Montrose Counties, Colorado (fig. 1). The study area includes 18,835 acres and is bounded by the Dolores River on the east, Salt Creek on the north, Sinbad Valley on the west, and Roc Creek on the south. Colorado State Highway 141 and a gravel road along Salt Creek and into Sinbad Valley provide access along the base of Sewemup Mesa. Sewemup Mesa, the main topographic feature of the study area, slopes west and rises about 1,500 ft (feet) above the floor of Sinbad Valley. Tributaries of Salt Creek and the Dolores River drain the mesa, forming numerous shallow canyons. The southwestern part of the study area includes terrain of low to moderate relief in part of Sinbad Valley.

The study area abuts the Uncompahgre Plateau, a major landform and structural feature of western Colorado (fig. 2), and is underlain by flat-lying to monoclinally folded sedimentary formations of late Paleozoic and Mesozoic age (see Appendix for geologic time chart). These are, in ascending order, the Hermosa Formation, Cutler Formation, Moenkopi Formation, Chinle Formation, Wingate Sandstone, Kayenta Formation, Navajo Sandstone, Dewey Bridge Member of the Entrada Formation, upper Entrada Formation, undivided Entrada, Wanakah Formation, and Morrison Formation. Precambrian igneous and metamorphic rocks probably underlie the area at depths of 10,000 to 15,000 ft. Normal faults, shallow synclines, and salt anticlines are the dominant structural features in and near the southern and western parts of the study area. An isolated salt plug is indicated by a nearly circular pattern of collapse faults that cut through the Mesozoic rocks in the southern part of the study area.

There are no mines or economic or marginally economic resources in the study area, but two mines are just outside the study area: the Rajah mine near Roc Creek, south of the study area, and the Copper Rivet mine about

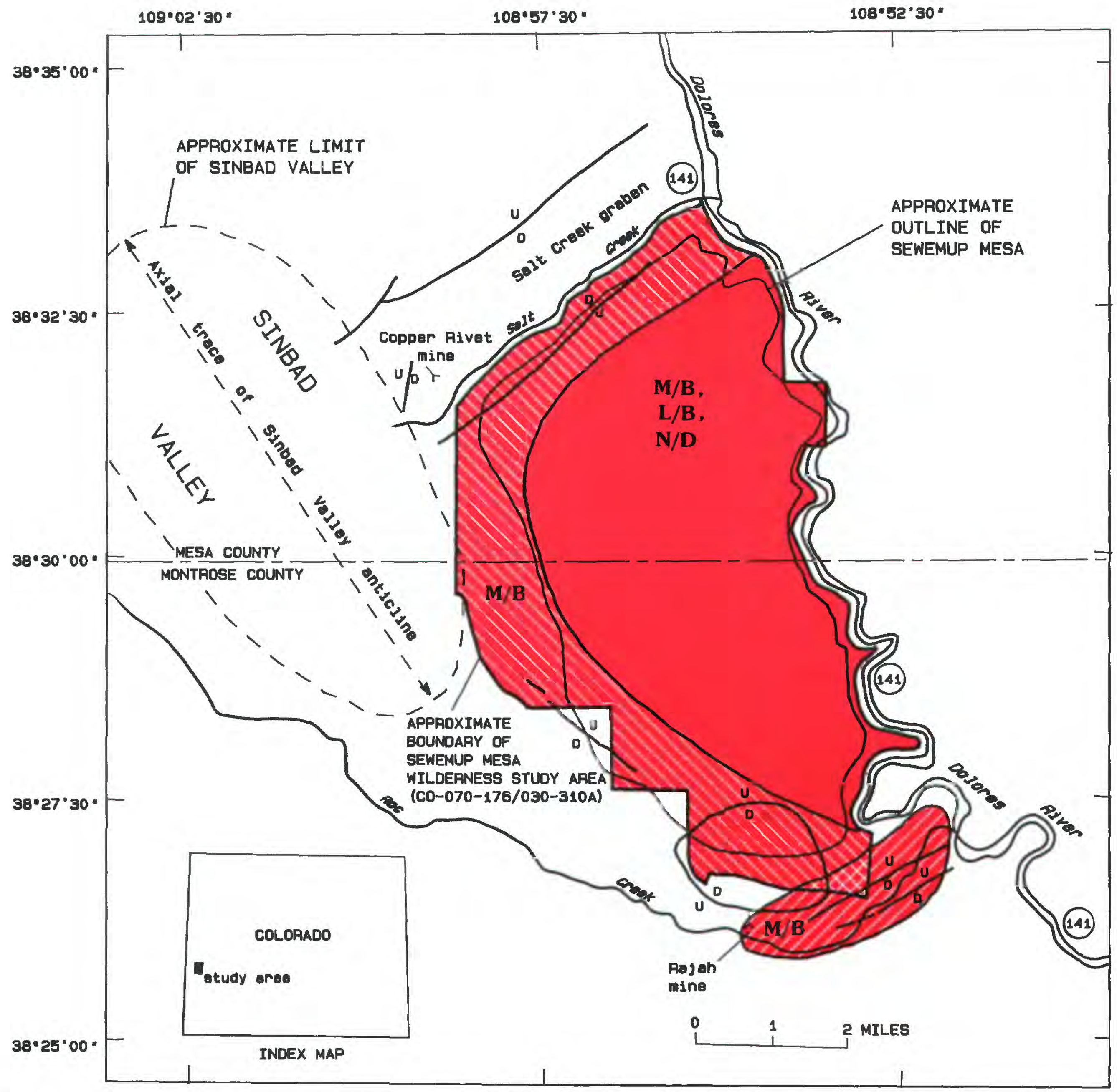

Figure 1 (above and facing page). Map showing location, identified resources, and mineral resource potential of the Sewemup Mesa Wilderness Study Area, Mesa and Montrose Counties, Colo.

0.25 mi northwest of the study area. The Rajah mine produced uranium, vanadium, and copper ore from the Salt Wash Member of the Morrison Formation. Copper and silver were mined from the Wingate Sandstone at the Copper Rivet mine. Numerous small prospect pits and trenches were found outside the study area, northwest of the Rajah mine. Nearly all of the study area is under lease for oil and gas (fig. 3); it contains one dry exploration drill hole.

Inferred subeconomic resources of sand and gravel, and sandstone, and occurrences of evaporite minerals exist in the study area. However, development of these materials is unlikely because readily available sources exist elsewhere in the region at locations closer to potential markets.

Geological and geochemical features of the study area suggest the possible presence of three types of undiscovered mineral resources: (1) uranium, vanadium, and copper in the Salt Wash Member of the Morrison Formation (Rajah mine type); (2) copper and silver in faulted sedimentary rocks (Copper Rivet mine type); and (3) the industrial minerals, gypsum, anhydrite, and potassium salts.

EXPLANATION

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

M/B Geologic terrane having moderate mineral resource potential for uranium, vanadium, and copper in the Morrison Formation, with certainty level B

M/B Geologic terrane having moderate mineral resource potential for copper and silver, with certainty B

L/B Geologic terrane having low mineral resource potential for all metals (except as noted above), gypsum, anhydrite, potassium salts, and geothermal energy, with certainty level B—Applies to entire study area

N/D Geologic terrane having no energy resource potential for coal, with certainty level D—Applies to entire study area

LEVELS OF CERTAINTY

B Data indicate geologic environment, and suggest level of resource potential

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

D Available information clearly defines the level of resource potential

U/D Fault—U, upthrown side; D, downthrown side. Dashed where approximately located

The potential for uranium, vanadium, and copper resources in the Morrison Formation is considered to be moderate, on the basis of the presence of fractured host rocks and occurrence of nearby small deposits. The potential for undiscovered copper and silver resources is moderate along the northern, western, and southern sides of the study area because of the presence of favorable, fractured host rocks, although the area lacks systematic geochemical anomalies. The mineral resource potential for all metals, gypsum, anhydrite, and potassium salts is low. The study area lacks geochemical anomalies indicative of metallic mineralization. Gypsum, anhydrite, and potassium salts were not observed in the study area, and where they occur nearby, they form thin, discontinuous beds.

Favorable host rocks for oil and gas may underlie the study area, and favorable structural traps are present. The study area therefore has moderate energy resource potential for oil and gas. There are no known geothermal sources and no warm springs were noted in the study area; the resource potential for geothermal energy is low. The study area lacks coal-bearing formations in the surface and subsurface; therefore there is no mineral resource potential for coal.

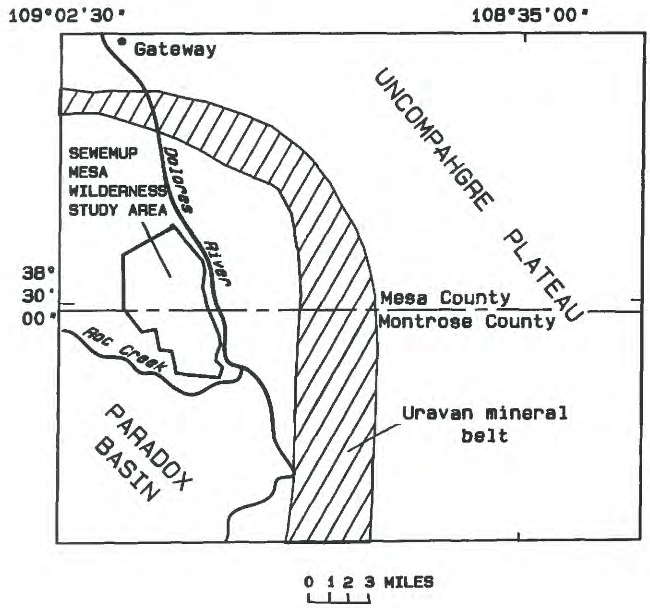

Figure 2. Index map showing location of the Sewemup Mesa Wilderness Study Area, Mesa and Montrose Counties, Colo.

INTRODUCTION

At the request of the BLM (U.S. Bureau of Land Management), the USGS and the USBM studied 18,835 acres of the 19,140-acre Sewemup Mesa Wilderness Study Area (CO-070-176/030-310A). Throughout this report "study area" and "wilderness study area" refer only to the smaller area. This report, the product of several separate studies by the USBM and the USGS, presents an evaluation of the mineral endowment (identified resources and mineral resource potential) of the study area. Identified resources were studied by the USBM and are classified according to the system of the USBM and USGS (1980), which is shown in the appendix. Mineral resource potential, studied by the USGS, is the likelihood of occurrence of undiscovered concentrations of metals and nonmetals, of unappraised industrial rocks and minerals, and of undiscovered energy sources (coal, oil, gas, oil shale, and geothermal sources). Mineral resource potential and the level of certainty of each resource assessment were classified according to the system of Goudarzi (1984; see appendix).

The Sewemup Mesa Wilderness Study Area includes 18,835 acres of high mesa terrain in Mesa and Montrose Counties, Colorado (fig. 1). Located about 10 mi south of the community of Gateway and about 50 mi southwest of

Grand Junction, Sewemup Mesa is bounded by the Dolores River on the east, Salt Creek on the northwest, Sinbad Valley on the west, and Roc Creek on the south. The mesa rises about 1,500 ft from the floor of Sinbad Valley and is dissected by numerous shallow canyon systems. The southwestern part of the study area includes terrain of low to moderate relief in part of the collapsed salt anticline region of Sinbad Valley. Total relief in the study area is approximately 2,800 ft; elevation ranges from about 4,600 ft in the canyon of the Dolores River to 7,400 ft on the west ridge of the mesa. Colorado State Highway 141 and a gravel road along Salt Creek into Sinbad Valley provide access along the base of the mesa. The top of the mesa can be reached only by aircraft or by foot.

Investigation by the U.S. Bureau of Mines

In May and August 1986, the USBM conducted a mineral investigation of the Sewemup Mesa Wilderness Study Area. The field investigation of the study area was preceded by a survey of relevant literature about the geology and mineral resources of the region. Information about surface and mineral ownership, oil and gas leases, claims, and prospecting activity was researched from records of the BLM state office in Lakewood, Colo.

Field investigation included the examination and sampling of mineralized areas in and near the study area, scintillometer readings to detect anomalous radioactivity at sample sites and along foot and vehicle traverses, and the collection of minus-80-mesh stream-sediment samples to determine the extent of mineralized areas. One hundred and three rock samples and 17 stream-sediment samples were collected in and near the study area (Martin, 1987). All rock and stream-sediment samples underwent semiquantitative inductively coupled plasma analysis for 30 elements at the USBM labs in Reno, Nev. Samples from the Rajah and Copper Rivet mines were analyzed for gold by neutron activation analysis. Results of the analyses are in Martin (1987).

Investigation by the U.S. Geological Survey

Prior to field work, the USGS researched published and unpublished information about the study area and reviewed existing geophysical data. Field work in 1983 consisted of a check of previous geologic mapping, the collection of stream-sediment samples for geochemical analyses, and a search for mineralized and altered areas in the study area.

Previous geologic studies providing background for this report include geologic maps of three quadrangles covering the Sewemup Mesa study area published at a scale of 1:24,000 by the USGS (Shoemaker, 1955, 1956; McKay, 1955). Earlier mineral resource potential studies include Soulliere and others (1983) and a report by Mountain States Mineral Enterprises and Wallaby Enterprises (unpub. data, 1982) for the BLM.

APPRAISAL OF IDENTIFIED RESOURCES

By Clay M. Martin
U.S. Bureau of Mines

Mining and Leasing Activity

There are no mines in or recorded mineral production from the Sewemup Mesa Wilderness Study Area. The study area is along the western margin of the Uravan mineral belt (fig. 2), an elongated, arcuate area in Mesa, Montrose, and San Miguel Counties that contains more abundant large, closely spaced, high-grade carnotite deposits than the surrounding region (Fischer and Hilpert, 1952). Carnotite ore has been mined for uranium, vanadium, and radium in the Uravan district since the end of the nineteenth century. Nearly all carnotite production from the region was from the Salt Wash Member of the Morrison Formation.

During the late 19th and early 20th centuries, the Sinbad Valley area was prospected and mined for copper and silver. No mines or prospects are in the study area. However, two mines are just outside the study area (fig. 1). At the Copper Rivet mine, about 0.25 mi north of the study area, copper-silver sulfide and carbonate ore was mined from a fault zone in the Wingate Sandstone. Extensive prospecting and some mining occurred at the Rajah mine near Roc Creek, south of the study area. Blocks of patented lode claims cover the Rajah mine area. Numerous prospect trenches and pits and two adits are west and southwest of the study area. Hundreds of unpatented lode claims for uranium were in and near the study area. Most of the study area is under lease for oil and gas and one dry exploration hole has been drilled inside the study area (fig. 3).

Rajah Mine

The deposits at the Rajah mine, just south of the study area, were mined and extensively prospected during several different periods. At the mine, uranium, vanadium, and copper are associated with fault zones in the Morrison Formation. Workings at the Rajah mine include 26 adits, many of which are collapsed, and many surface pits and trenches

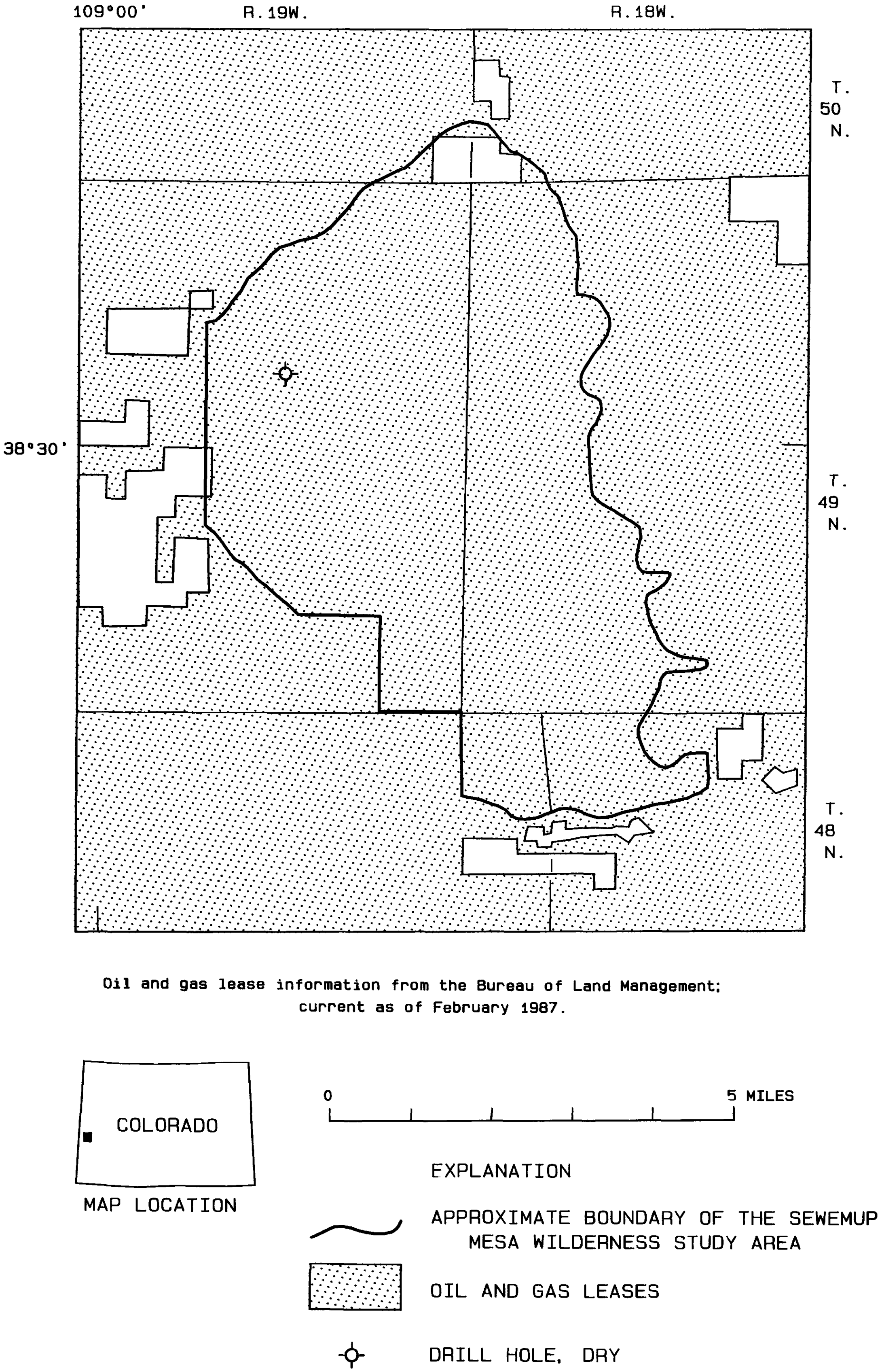

Figure 3. Map showing oil and gas leases for the Sewemup Mesa Wilderness Study Area, Mesa and Montrose Counties, Colo.

(Martin, 1987). Surface investigation of the mine area indicated no anomalous radiation or mineralized rock in any formations more than a few feet outside fault zones. Uranium mineralization seems to have been confined to faults and adjacent beds where sandstone has been replaced and impregnated by uranium, vanadium, and copper minerals. Copper concentrations from samples in the Rajah mine area range from less than 0.003 percent to over 1 percent; silver concentrations ranged from the lower detection limit of 0.2 ppm to 90 ppm (parts per million). Gold content of the samples ranged from nil to 174 ppb (parts per billion). Only 9 of 57 rock samples taken in this area showed more than 0.1 percent U_3O_8 (Martin, 1987). Several faults that bear uranium in the vicinity of the Rajah mine extend into the southeastern part of the study area but are unmineralized at the surface. Rock samples and surface scintillometer surveys along the fault zones in the study area showed no anomalous radiation.

Copper Rivet Mine

The Copper Rivet mine is the only mine in the Salt Creek graben area having recorded production. Mine workings follow a vein in the northern boundary fault of the Salt Creek graben, about 0.25 mi north of the study area. Between 1908 and about 1942, the mine sporadically produced copper-silver sulfide and carbonate ore from a fault zone in the Wingate Sandstone. The workings consist of three adits that are described in detail by Martin (1987). Nineteen samples were taken from the Copper Rivet mine area. Copper concentrations ranged from less than 0.008 percent to over 1 percent; silver concentrations ranged from the lower detection limit of 0.2 parts per million (ppm) to more than 200 ppm (the upper detection limit). Gold content of the samples was generally insignificant, with most sample concentrations ranging from 0 to 2 ppb. One select dump sample from the middle adit assayed 45 ppb gold. Assay results from the lower parts of the adits may not accurately indicate concentrations in the upper inaccessible parts of the fault zone or in the unmined fault beyond the adit face.

Prospects

Fault zones hosting copper minerals occur near the head of Salt Creek, to the northwest of the Rajah mine area, and southwest of the study area. The area has been prospected intermittently since the end of the 19th century, but no known production has occurred. Workings consist of two adits and numerous prospect trenches and pits. Malachite and azurite are commonly found as impregnations and replacements in sandstone and in gouge in faults associated with the Sinbad Valley anticline. No significant concentrations of uranium or vanadium are found in this vicinity. This is probably due to the general absence of the Morrison Formation in the area. Eighteen samples were taken from prospect pits in the area. The samples contained 0.002 percent to over 1 percent copper, 0.2 ppm to 54 ppm silver, and 0 to 4 ppb gold (Martin, 1987).

Identified Mineral Resources

There are no economic or marginally economic resources in the study area. However, there are large inferred subeconomic resources of sandstone present in the study area in a wide range of textures, colors, cementations, and bedding thicknesses. Many of the sandstone units would be suitable for use as dimension stone, flagstone, or concrete aggregate. However, vast quantities of sandstone of equal or higher quality are available throughout the region at locations closer to markets, which minimizes the economic significance of sandstone from the study area.

The Hermosa Formation, which contains large amounts of evaporitic gypsum, anhydrite, and potash elsewhere, crops out over about 1.5 sq mi (square miles) of the western part of the study area, and the study area is underlain by a thick sequence of Hermosa Formation rock. Resources of these evaporitic minerals may underlie the study area, but none were identified during this study.

Small inferred subeconomic resources of sand and gravel are in the canyons forming the boundaries of the study area. These resources would be suitable for construction aggregate; however, none of these deposits are easily accessible, and they are far from potential markets. Ample resources of sand and gravel exist closer to current markets elsewhere in the region.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Sandra J. Soulliere, Charles G. Patterson, Anne M. Leibold, and Dolores M. Kulik
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Geology

Geologic Setting

The Sewemup Mesa Wilderness Study Area is on the northeastern margin of the Paradox Basin in the Canyon Lands section of the Colorado Plateaus physiographic province (Fenneman, 1931). The regional structure of the Colorado Plateaus province consists of uplifted blocks bounded by locally faulted monoclines, domical uplifts, and large salt anticlines. Sewemup Mesa is between the uplifted block of the Uncompahgre Plateau and a breached salt anticline of Sinbad Valley. The Uncompahgre Plateau is a large uplift consisting of partially exposed Precambrian igneous and metamorphic rocks overlain by flat-lying to monoclinally folded sedimentary rocks of late Paleozoic and Mesozoic age. The salt anticline at Sinbad Valley has an intrusive core of salt and gypsum derived from the Paradox Member of the Hermosa Formation. Dissolution and erosion of the salt core resulted in the collapse of the crest of the anticline and the formation of the valley.

Precambrian igneous and metamorphic rocks probably underlie the study area at depths of 10,000 to 15,000 ft (Baars and Stevenson, 1981). Flat-lying to monoclinally folded Paleozoic and Mesozoic sedimentary rocks are exposed in the study area. The oldest rocks, of Pennsylvanian age, crop out in Sinbad Valley and near Roc Creek. Rocks of Permian, Triassic, and Jurassic age are exposed on the flanks, walls, and plateau of Sewemup Mesa and in the Roc Creek drainage. Normal faults, shallow synclines, and salt anticlines are the dominant structural features along the southern and western part of the boundary of the study area. Salt Creek meanders across a fault graben in the northern part of the study area. This 3.5-mi-long downdropped block trends perpendicular to the axis of the Sinbad Valley anticline (Shoemaker, 1955). The faults that bound the graben have downward displacement near Sinbad Valley and die out to the northeast near the Dolores River. In the southern part of the study area, just north of Roc Creek, the presence of an isolated salt plug is indicated only by the nearly circular pattern of collapse faults that cut through the overlying Mesozoic rocks (fig. 1).

Description of Rock Units

Geologic quadrangle maps at a scale of 1:24,000 by McKay (1955) and Shoemaker (1955, 1956) include the Sewemup Mesa Wilderness Study Area. The following description of rock units is modified from Soulliere and others (1983), which includes a complete geologic map of the Sewemup Mesa Wilderness Study Area.

The Hermosa Formation of Middle and Late Pennsylvanian age is divided into lower, or Paradox, and upper members. The Paradox Member consists of gypsum, dark-gray shale, micaceous sandstone, arkose, and gray marine limestone in surface exposures, but is mainly salt at depth. Highly contorted beds of the Paradox Member crop out on the floor of Sinbad Valley and in the Roc Creek drainage. The upper, unnamed member is gray arkose and marine limestone. A steeply dipping and contorted belt of the upper member is exposed near the center of Sinbad Valley.

The Lower Permian Cutler Formation conformably overlies the Hermosa Formation and consists of maroon and purple arkosic conglomerate and sandstone with some red-brown sandy mudstone. About 1,000 ft of the formation is exposed along Roc Creek. Ripple marks, cut and fill structures, and irregular bedding indicate a fluvial environment of deposition. The Moenkopi Formation of Early and Middle(?) Triassic age unconformably overlies the Cutler Formation. The formation is divided into three members, and has a total thickness of 300 ft along the Dolores River and 1,000 ft in Sinbad Valley. The lower member consists of evenly bedded, brick-red, micaceous mudstone, sandy siltstone, and a massive white gypsum bed, as much as 6 ft thick, near the base of the member. The middle member consists of purplish and red-brown conglomerate and arkosic sandstone that is interbedded with silty shale. The thin- to medium-bedded sandstone is cross laminated and has channeling, current lineation, and ripple marks. The upper member consists of uniformly bedded red-brown and chocolate-brown shale and scattered thin beds of gypsiferous sandstone.

The Chinle Formation of Late Triassic age unconformably overlies the Moenkopi. It forms steep, stepped slopes and consists of discontinuous lenses of sandstone and limestone-pebble and mudstone-pebble conglomerate interbedded with bright-red and red-brown mudstone and siltstone. As much as 700 ft of the Chinle Formation is present in the study area. The Upper Triassic Wingate Sandstone conformably overlies the Chinle Formation. Orange-red, massive, fine-grained, well-sorted sandstone, as much as 350 ft thick, forms the steep cliffs of Sewemup Mesa. Massive crossbeds, vertical joints, and desert varnish are common features of the Wingate. The Upper Triassic(?) Kayenta Formation conformably overlies the Wingate Sandstone. As much as 300 ft thick in places, the formation consists of discontinuous lenses of purplish-red sandstone interbedded with shale and conglomerate, forming a series of benches and ledges. Irregular to flaggy bedding and trough crossbedding are characteristics of the Kayenta Formation. The Navajo Sandstone of Triassic(?) and Jurassic age lies conformably on the Kayenta and is a massive, fine-grained, clean sandstone of eolian origin that locally contains large-scale tangential crossbeds. The Navajo Sandstone weathers to rounded cliffs and is as much as 100 ft thick; it thins to the east. A 6-ft-thick bed of limestone is locally present in the Navajo on Sewemup Mesa (Shoemaker, 1956).

The Middle Jurassic Entrada Sandstone is less than 100 ft thick in most places. The Dewey Bridge Member at the base of the Entrada is unconformable with the Navajo Sandstone. It consists of red to buff, nonresistant, horizontally bedded siltstone, mudstone, and sandstone. In places it contains small (as much as 1 in. (inch) across) pebbles of white and gray chert, pebbles and cobbles of gray, red, and yellow quartzite, and scattered barite nodules. The Dewey Bridge grades upward into the Slick Rock and Moab Members of the Entrada. The salmon-colored, fine-grained sandstone of the upper members of the Entrada forms smooth, rounded cliffs in the study area. Large-scale sweeping crossbeds indicate the eolian origin of this sandstone. The Wanakah Formation of Middle Jurassic age lies conformably on the Entrada Sandstone. About 130 ft thick at the top of Sewemup Mesa, the Wanakah Formation consists of sandy and silty shales interbedded with fine-grained sandstone and siltstone. Beds are predominantly red but may be green, brown, light yellow, or white. Outcrops of the Summerville Formation exhibit even, thin, horizontal bedding.

Only the lower part of the Upper Jurassic Morrison Formation is exposed in the study area; the lower part consists of the Tidwell and the Salt Wash Members. Peterson (1980) recognized the Tidwell Member as consisting of light-gray, laminated to thin-bedded, fine-grained sandstone with interbedded greenish-gray and reddish-brown shale and mudstone. The Tidwell was not differentiated from the Salt Wash Member in the study area. The Salt Wash Member consists of lenses of gray to buff, fine-grained, fluvial sandstone and conglomerate as much as 40 ft thick interbedded with reddish shale and mudstone and gray limestone. Approximately 80 ft of the Salt Wash and Tidwell Members are exposed at the highest elevation on Sewemup Mesa.

Geochemistry

Sample Collection and Analytical Methods

Stream-sediment and heavy-mineral-concentrate samples were collected from 20 sites in the study area (Soulliere and others, 1983). Most of the sampled sites were at the mouths of ephemeral streams that flow from the top of Sewemup Mesa to either the Dolores River on the east or Salt Creek on the northwest. The streams have drainage basins from 1 to 3 sq mi in area and cover approximately 90 percent of the wilderness study area.

All stream-sediment and panned-concentrate samples were collected from drainage basins underlain by sedimentary rocks. Four stream-sediment and panned-concentrate samples were taken from terrain underlain by the Hermosa Formation (Pennsylvanian) and from streams whose basins also include outcrops of Permian and Triassic sedimentary rocks. All other samples were collected in terrain of Mesozoic sedimentary rocks that include either the Chinle Formation or the Moenkopi Formation.

Stream-sediment samples were collected and analyzed to determine the presence of easily soluble metals. At each sample site, about 25 oz (ounces) of stream sediment were collected from four or more points in the active stream channel, usually along point bars or sections of lower gradient. In the laboratory, the sediment was coarsely ground with a mortar and pestle to release clay-cemented aggregate and then sieved to minus-100-mesh (0.0059 in.). Five grams of sample were analyzed by Scintrex[1] pulsed laser fluorimetry for uranium following the techniques of Rose and Keith (1976). Two hundred milligrams of sample were then analyzed by inductively coupled plasma atomic emission spectroscopy (ICP) for 45 elements using the methods of Taggart and others (1981).

The heavy-mineral-concentrate samples were obtained by collecting sediment from four or more points within the active stream bed. Approximately 15 lb (pounds) of sediment was screened through a 10-mesh (0.039 in.) stainless steel screen at the sample site. The sediment was then panned until approximately half of the remaining sediment in the pan was quartz and feldspar; this constituted a panned-concentrate sample for analysis. Ten milligrams of the panned-concentrate sample were analyzed semiquantitatively for 66 elements by optical emission spectrographic methods (Myers and others, 1961).

Results of Survey

Interpretations of the geochemical analyses included the determination and evaluation of anomalous values from histograms and single element plots. Histograms revealed significant anomalous values for 14 of the 22 elements detected in the panned-concentrate samples. Single-element plots from data for the panned-concentrate samples revealed three single elements (zirconium, barium, molybdenum) and a suite of elements (iron, manganese, chromium, cobalt, nickel, scandium, vanadium, yttrium, lanthanum, copper, lead) that displayed coherent patterns pertinent to the mineral resource assessment. High zirconium concentrations (1,000-1,500 ppm) found in samples from the southeast side of Sewemup Mesa are assumed to be the result of detrital zircon in the Triassic and Jurassic sedimentary rocks. Four samples having anomalous barium concentrations (10,000-15,000 ppm) are from the northern half of the study area but are not clustered around any apparent geologic or geographic feature. Authigenic barite has been noted in the Chinle and Moenkopi Formations (Cadigan, 1971; Stewart and others, 1972) and is a possible source for the high barium values. Further studies would be necessary to confidently explain the source of the barium and apparent randomness in anomaly locations. Only one sample contained molybdenum (5 ppm); the source of the molybdenum is unknown. Uranium was not detected in any of the panned-concentrate samples. The association of anomalous concentrations of iron, manganese, chromium, cobalt, nickel, scandium, vanadium, yttrium, lanthanum, copper, and lead is probably from detrital magnetite in four

[1]Any use of trade names is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

samples taken from the western side of the study area. Although the source of this magnetite is unknown, all four sites are underlain by the Hermosa Formation.

Histograms and single element plots showed significant geochemical anomalies in the minus-100-mesh fraction of four stream-sediment samples. Locations of anomalous values for molybdenum and for iron-suite elements correspond well with the locations of molybdenum and iron-suite element anomalies identified in the panned-concentrate samples. Barium was present in anomalous concentrations only in these four samples; zirconium was not detected. Uranium was not detected in any of the samples either by emission spectroscopy, ICP, or fluorimetry.

Geophysics

Gravity and Aeromagnetic Data

Gravity and magnetic studies were done as part of the mineral resource evaluation of the Sewemup Mesa Wilderness Study Area. These studies provide information on the subsurface distribution of rock masses and the structural framework of the area.

The gravity data were obtained from files of the U.S. Defense Mapping Agency (1974) of the U.S. Department of Defense. Bouguer anomaly values were computed using the gravity formula from the International Association of Geodesy (1967) (Cordell and others, 1982) and a reduction density of 2.67 g/cm^3 (grams per cubic centimeter). Terrain corrections were made by computer for a distance of 167 km (kilometers) from the station using the method of Plouff (1977). The data are shown on figure 4 as a complete Bouguer anomaly map with a contour interval of 5 mGal (milligals).

Magnetic data shown in figure 5 are reproduced from part of the Moab quadrangle residual intensity magnetic contour map with the 1975 reference field removed (U.S. Department of Energy, 1983). Flight elevation was 400 ft, flight-line spacing was approximately 3 mi, and flight lines were flown in an east-west direction.

The gravity data in the region surrounding the study area mostly reflect the distribution of salt in the sedimentary section. A major gravity low (A) occurs over the Paradox Valley anticline and low gravity anomalies of smaller amplitude occur over the Pine Ridge anticline (B and B') and the Sinbad Valley anticline (C) adjacent to the western part of the study area. A gravity low (D) at the southeastern part of the study area suggests that a salt dome is present in the shallow subsurface there. A more detailed Bouguer anomaly map (Joestling and Byerly, 1958) shows the anomaly extending over the exposed Roc Creek plug. Other gravity lows (E, F) north and east of the study area suggest that salt is also present beneath these areas. No data are available within the study area to determine if similar buried salt structures might be present there. The gradient in the northeasternmost corner of the map is associated with Precambrian rocks in the Uncompahgre uplift.

The magnetic data mostly reflect the distribution of the Precambrian rocks beneath the essentially nonmagnetic sedimentary cover rocks. The magnetic highs at the northeastern corner of the map are part of a more extensive northwesterly trend (U.S. Department of Energy, 1983) associated with the Precambrian rocks of the Uncompahgre uplift. The high magnetic anomaly (A) which trends northwest through the southern and central part of the map may indicate that the basement rocks are offset along faults parallel to those of the Uncompahgre uplift. However, Joesting and Byerly (1958) suggest that this and other similar anomalies of small amplitude and low gradient between the Uncompahgre front and Big Gypsum Valley are related to small contrasts in the magnetization of basement rocks, to basement relief, or to very deep seated sources.

Remote Sensing Data

A remote sensing study of the Sewemup Mesa Wilderness Study Area was done by Keenan Lee (unpub. data, 1987) and was based on Landsat 2 multispectral-scanner imagery. These data were processed and analyzed for lineaments and for areas of limonitic anomalies that might relate to hydrothermal alteration, migrating hydrocarbons, or uranium. From the lineament analysis, no major basement faults were detected. No limonite anomalies of interest are apparent in the imagery, but the narrow outcrop widths compared with the image resolution suggest that any such anomalies would go undetected.

Mineral and Energy Resources

The potential for mineral resources in the Sewemup Mesa Wilderness Study Area was assessed by comparing geochemical, geophysical, and geological characteristics of the study area with those of nearby mineralized areas and with those of mineral deposit models. These characteristics suggest three kinds of mineral resources may be present in the study area: (1) uranium, vanadium, and copper in the Salt Wash Member of the Morrison Formation (Rajah mine type); (2) copper and silver in Copper Rivet mine type deposits; and (3) industrial minerals (gypsum, anhydrite, and potassium salts).

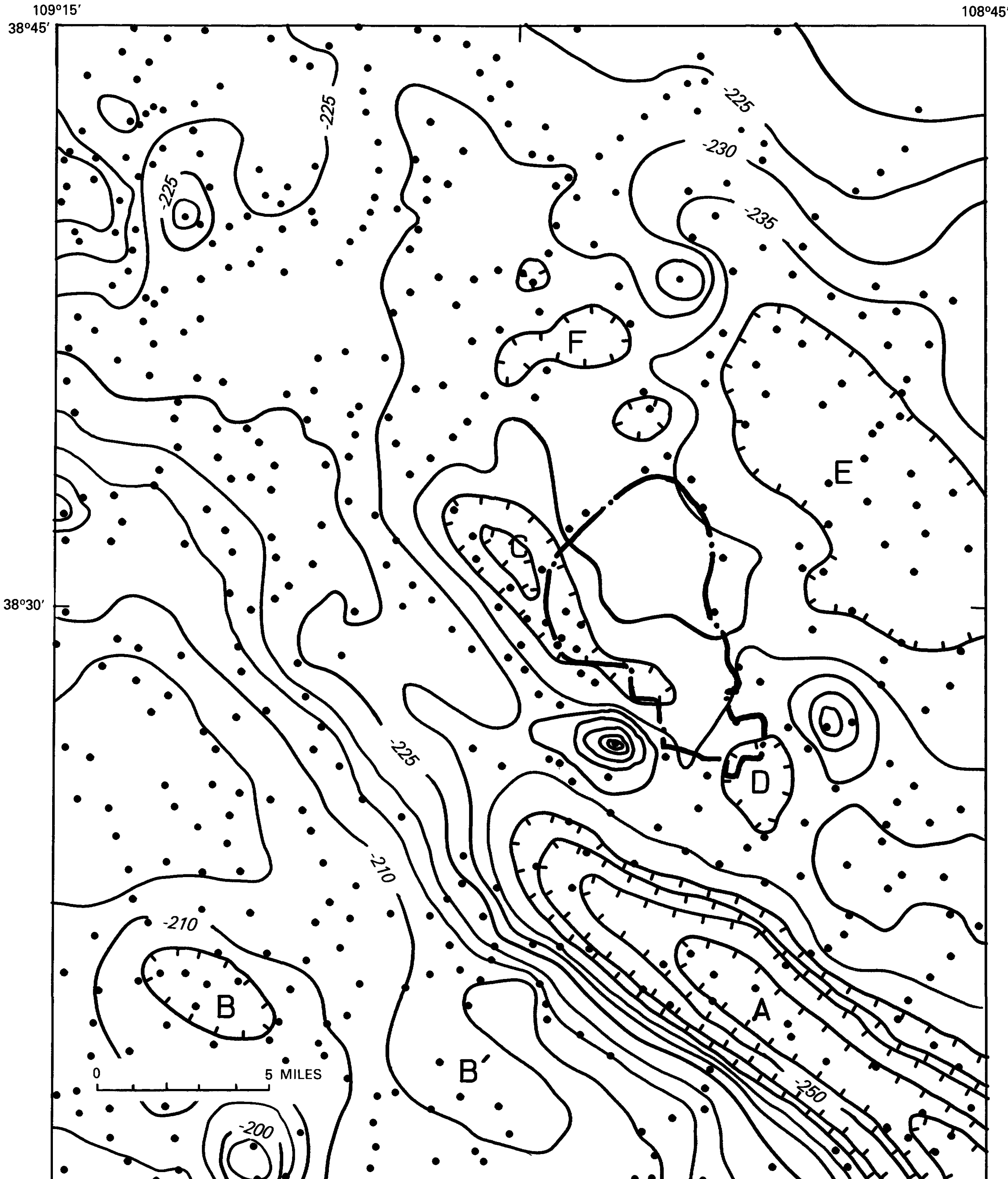

Figure 4 (above and facing page). Complete Bouguer gravity anomaly map of the Sewemup Mesa Wilderness Study Area, Mesa and Montrose Counties, Colo. Gravity lows A-F are referred to in the text.

EXPLANATION

Approximate boundary of the Sewemup Mesa Wilderness Study Area

Contour—Contour interval 5 mGal (milligals). Hachures point towards area of lower gravity

Gravity station

Uranium, Vanadium, and Copper

The mineral resource potential is moderate for uranium, vanadium, and copper in the Salt Wash Member of the Morrison Formation, with a certainty level of B. More than 12 percent of the uranium mined in the United States as of 1978 was supplied from the Colorado Plateau (Chenoweth, 1978). The deposits are principally found in the Salt Wash Member of the Morrison Formation. At the Rajah mine, just south of the study area, uranium, vanadium, and copper minerals are disseminated in sandstone of the Salt Wash Member along an east-west-trending portion of the fault zone bounding the salt collapse structure in the southern part of the wilderness study area. Similar conditions exist in the southern part of the study area, where minor exposures of the Morrison Formation are cut by faults. However, scintillometer surveys and geochemical analyses of stream-sediment samples did not reveal near-surface uranium, vanadium, or copper in this area. The Sewemup Mesa Wilderness Study Area is adjacent to the extensive Uravan mineral belt (fig. 2). The Uravan mineral belt is composed of a number of uranium-vanadium mining districts that form a nearly arcuate pattern that is perpendicular to the paleocurrent directions of the Salt Wash. However, the mineral belt exhibits a rather abrupt cut-off in uranium and vanadium occurrence towards the study area.

Copper and Silver

The mineral resource potential is moderate for copper and silver in the study area, with a certainty level of B. The model locality for copper-silver occurrence is the Copper Rivet mine, which is about 0.25 mi northwest of the study area. Much of the mine description is derived from information in reports by Fischer (1936) and Schwochow (1978) and from a visit to the mine by C.G. Patterson. At the Copper Rivet mine, copper and silver minerals are localized along a northeast-trending fault associated with the Salt Creek graben. The deposit consists of copper sulfides and carbonates with calcite and barite gangue in fault-shattered Wingate Sandstone. The mineralization was apparently produced by hydrothermal fluids migrating up a fault related to the collapse of the Sinbad Valley salt anticline.

A combination of structure and host rock similar to that at the Copper Rivet mine exists along the southeastern wall of Salt Creek Canyon and along the western and southern parts of the boundary of the study area. In small prospect pits just south of the study area, uranium, vanadium, and copper minerals are found in faulted Chinle Formation, Wingate Sandstone, and Kayenta and Summerville Formations (Shoemaker, 1956). However, geochemical data showed low values for copper, silver, uranium, and vanadium in samples from areas where Copper Rivet mine type mineralization would be expected to occur. Anomalous concentrations of barium were found in many stream-sediment samples. Because barite is a common gangue mineral in deposits of this type, the presence of barium would be considered favorable. However, the source of the barium anomalies in the stream-sediment samples was not found during our investigations, and no traces of mineralized rock were noted when the areas were examined.

Industrial Minerals

The mineral resource potential is low for gypsum, anhydrite, and potassium salts in the study area, with a certainty level of B. Gypsum, anhydrite, and potassium salts are present in Sinbad Valley just outside the study area in the Paradox Member of the Hermosa Formation. This formation is exposed in the eastern part of the study area; however, no gypsum, anhydrite, or potash beds were observed there. Most of the study area is in a facies transition zone where gypsum, anhydrite, and potassium salt are interbedded with coarse clastic material. If gypsum, anhydrite, and potassium salt beds extend into the study area, they would probably be discontinuous and interbedded with conglomerate and arkose. An isolated salt plug is in the southern part of the study area, just north of Roc Creek. It is indicated by a nearly circular pattern of collapse faults that cut through the overlying Mesozoic rocks. There is no surface evidence of potassium salts in the study area, but it is possible that potassium salts could be found at depth. Wells drilled in the Sinbad Valley anticline average 42 percent mixed sodium and potassium salt (Shoemaker and others, 1958). More information is needed regarding the subsurface geology of this area in order to raise the level of certainty for the presence of these minerals within the study area.

Other Metals

A favorable geologic environment for the presence of metallic mineral resources is lacking in the study area. In addition, geochemical data do not indicate abnormally high concentrations of metals for this environment. Therefore, the study area is assigned a low mineral resource potential

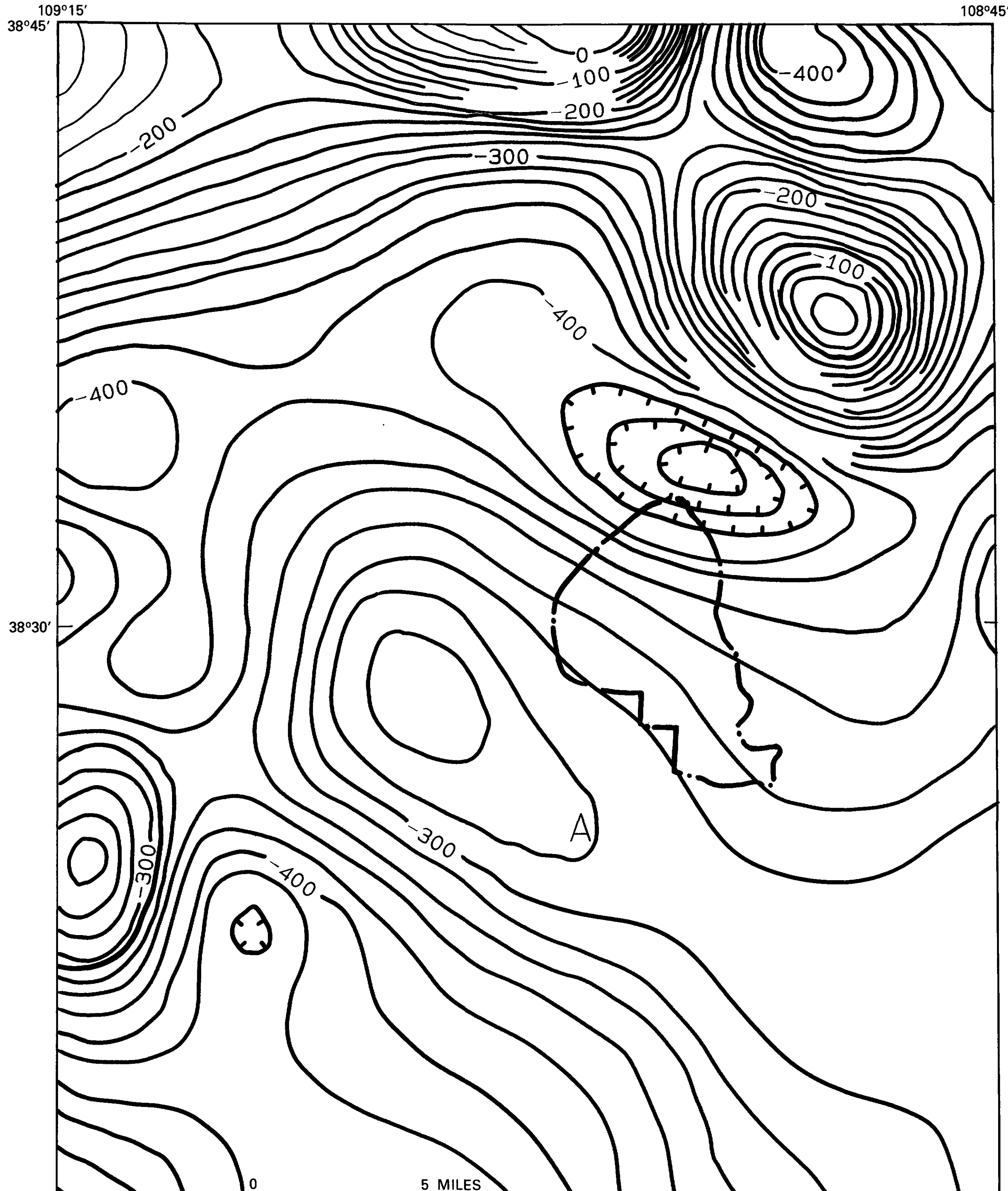

Figure 5 (above and facing page). Residual intensity magnetic anomaly map of the Sewemup Mesa Wilderness Study Area, Mesa and Montrose Counties, Colo. Anomaly A may indicate offset of basement rocks along faults parallel to Uncompahgre uplift.

EXPLANATION

—·— Approximate boundary of the Sewemup Mesa Wilderness Study Area

——— Contour—Contour interval 20 nT (nanoTeslas). Hachures point towards area of low magnetism

for all metals other than uranium, vanadium, silver, and copper; certainty level is B.

Energy Resources

The energy resource potential for oil and gas is moderate in the study area, with a certainty level of B on the basis of favorable structural and stratigraphic conditions in the subsurface. The study area is on the east flank of the Sinbad Valley anticline. Favorable host rocks of Pennsylvanian age may underlie the study area. Spencer (1983) assigned a low resource potential for oil and gas in the study area on the basis of sparse well control. The one well drilled in the study area was dry.

The study area has low energy resource potential for geothermal resources, with a certainty level of B. There are no known geothermal sources in the study area. No warm springs or other geothermal sources were noted during this investigation.

The study area lacks coal-bearing formations in the surface and subsurface; therefore there is no potential for coal, with certainty level D.

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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

LEVEL OF RESOURCE POTENTIAL →

<table>
<tr><td rowspan="4">U/A
UNKNOWN POTENTIAL</td><td>H/B
HIGH POTENTIAL</td><td>H/C
HIGH POTENTIAL</td><td>H/D
HIGH POTENTIAL</td></tr>
<tr><td>M/B
MODERATE POTENTIAL</td><td>M/C
MODERATE POTENTIAL</td><td>M/D
MODERATE POTENTIAL</td></tr>
<tr><td rowspan="2">L/B
LOW POTENTIAL</td><td rowspan="2">L/C
LOW POTENTIAL</td><td>L/D
LOW POTENTIAL</td></tr>
<tr><td>N/D
NO POTENTIAL</td></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td></tr>
</table>

LEVEL 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 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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