Mineral Resources of the Dominguez Canyon Wilderness Study Area, Delta, Mesa, and Montrose Counties, Colorado

U.S. GEOLOGICAL SURVEY BULLETIN 1736–A

Chapter A

Mineral Resources of the Dominguez Canyon Wilderness Study Area, Delta, Mesa, and Montrose Counties, Colorado

By MARGO I. TOTH, CHARLES G. PATTERSON, and
DOLORES M. KULIK
U.S. Geological Survey

RUSSELL A. SCHREINER
U.S. Bureau of Mines

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

UNITED STATES GOVERNMENT PRINTING OFFICE: 1987

For sale by the
Books and Open-File Reports Section
U.S. Geological Survey
Federal Center
Box 25425
Denver, CO 80225

Library of Congress Cataloging in Publication Data

Mineral resources of the Dominguez Canyon Wilderness Study Area, Delta, Mesa, and Montrose counties, Colorado.

(Mineral resources of wilderness study areas—Grand Junction region, Colorado ; ch. A) (U.S. Geological Survey bulletin ; 1736)
Bibliography: p.
Supt. of Docs. no.: I 19.3:1736-A
1. Mines and mineral resources Colorado Dominguez Canyon Wilderness. 2. Dominguez Canyon Wilderness (Colo.) I. Toth, Margo I. II. Series. III. Series: U.S. Geological Survey bulletin ; 1736.
QE75.B9 no. 1736-A 557.3 s [553'.09788'1] 87-600391
[TN24.C6]

STUDIES RELATED TO WILDERNESS

Bur^eau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of a part of the Dominguez Canyon (CO-070-150/CO-030-363) Wilderness Study Area, Delta, Mesa, and Montrose Counties, Colorado.

CONTENTS

FIGURES

Mineral Resources of the Dominguez Canyon Wilderness Study Area, Delta, Mesa, and Montrose Counties, Colorado

By Margo I. Toth, Charles G. Patterson, *and*
Dolores M. Kulik
U.S. Geological Survey

Russell A. Schreiner
U.S. Bureau of Mines

ABSTRACT

The Dominguez Canyon Wilderness Study Area (CO–070–150/CO–030–363) covers about 75,800 acres in west-central Colorado in Delta, Mesa, and Montrose Counties. A joint mineral resource study of 73,568 acres of the area was completed in 1983 by the U.S. Geological Survey and in 1986 by the U.S. Bureau of Mines. The study area has low mineral resource potential for metals, including uranium, oil and gas, coal, and geothermal energy. No identified resources are present.

SUMMARY

The study area is about 20 mi (miles) southeast of Grand Junction and is accessed by Colorado Highway 141 and U.S. Highway 50. Within the study area, several gently dipping plateaus are dissected by Big Dominguez and Little Dominguez Creeks, which flow northeastward into the Gunnison River. Canyon bottoms in the wilderness study area expose Proterozoic (see geologic time chart in the Appendix) gneisses, schists, amphibolites, and granites. Overlying these crystalline rocks is a sequence of nearly flat-lying sandstones, siltstones, conglomerates, mudstones, and minor limestones, ranging in age from Triassic to Cretaceous.

Part of the Dominguez Canyon study area is in the Dominguez mining district; however, no production has been recorded for the district. No mineral resources were identified in the study area, but small occurrences of copper, amethyst, uranium, and shaly coal are present.

As a part of the resource appraisal, 68 streams were sampled; at each site a panned concentrate, a fine fraction of mud and silt, and a water sample (where water was present) were collected. Panned-concentrate samples were analyzed for 66 elements, and selected samples were also analyzed for gold. The fine-fraction samples were analyzed for 46 elements, including uranium. Water samples were analyzed for arsenic, selenium, molybdenum, and uranium. Crystalline rocks were sampled and analyzed for 66 elements.

Stream-sediment samples from the wilderness study area have low concentrations of elements generally associated with mineralized systems. Except for barium, no localized anomalies in any of the elements are present. The high concentration of barium is most likely related to barite cement in one of the sedimentary formations. Two streams showed anomalous concentrations of uranium in their waters. These waters were sampled adjacent to the Salt Wash Member of the Morrison Formation, which is the likely source of the uranium. Rock samples from the wilderness study area were also low in elements associated with mineralization.

The study area lies on a regional gravity high associated with Proterozoic crystalline rocks of the core of the Uncompahgre uplift. Southwest of the study area, a northwest-trending gradient marks the transition from crystalline rocks of the Uncompahgre uplift to sedimentary rocks. This gradient broadens in the southwest corner of the study area, and it is possible sedimentary rocks extend beneath this area; however, they would lie at depths of 15,000–20,000 ft (feet).

An east-trending magnetic anomaly occurs over the study area and is broken by a low north-south saddle in the eastern half of the study area. The saddle suggests a variation in the composition of the underlying Proterozoic crystalline rocks.

Geologic, geochemical, and geophysical data indicate that the Dominguez Canyon Wilderness Study Area has low potential for all metals. Anomalous barium concentrations are present in stream-sediment concentrate samples, but these are probably related to barite cement in the underlying Morrison Formation. The wilderness study area lacks host rocks and structures favorable for the occurrence of oil, gas, and coal. The resource potential for these commodities is therefore also low. The nearest known thermal waters are 40 mi east of the study area. The resource potential for geothermal energy in the study area is therefore also low.

The mineral resource potential for uranium is considered to be low because of several factors: location of the area outside of a known mineral belt, lack of mines or prospects, location within a zone of rocks unfavorable for uranium mineralization, and the lack of carbonaceous material within the Morrison Formation.

INTRODUCTION

At the request of the U.S. Bureau of Land Management, 73,568 acres of the Dominguez Canyon Wilderness Study Area were studied by the U.S. Geological Survey (USGS) and U.S. Bureau of Mines (USBM). In this report, the studied area is called the "wilderness study area" or simply "study area." The Dominguez Canyon Wilderness Study Area (CO–070–150/CO–030–363) in Delta, Mesa, and Montrose Counties, Colorado, is about 20 mi southeast of Grand Junction between U.S. Highway 50 and Colorado Highway 141 (fig. 1). Access is by unpaved roads that lead off highways. The Gunnison River is along the northeastern boundary of the wilderness study area, and Escalante Creek is along the southeastern boundary. The small towns of Escalante and Dominguez are just east of the wilderness study area, and the larger community of Delta is 10 mi to the east along U.S. Highway 50.

The Dominguez Canyon Wilderness Study Area contains a series of gently northeast-dipping plateaus dissected by deep, narrow canyons of the Big Dominguez and Little Dominguez Creeks, which drain northeastward into the Gunnison River. Vertical relief in the canyons is as much as 3,100 ft. The tops of the plateaus have a dense cover of brush and scrub, except for natural grass meadows and areas that have been cleared. The walls of the canyons are cliffs with no vegetation and (or) sparsely vegetated, steep slopes. Elevations range from 4,700 ft near the Gunnison River on the northeast boundary to 8,176 ft on the top of the plateau.

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

Investigations by the U.S. Bureau of Mines

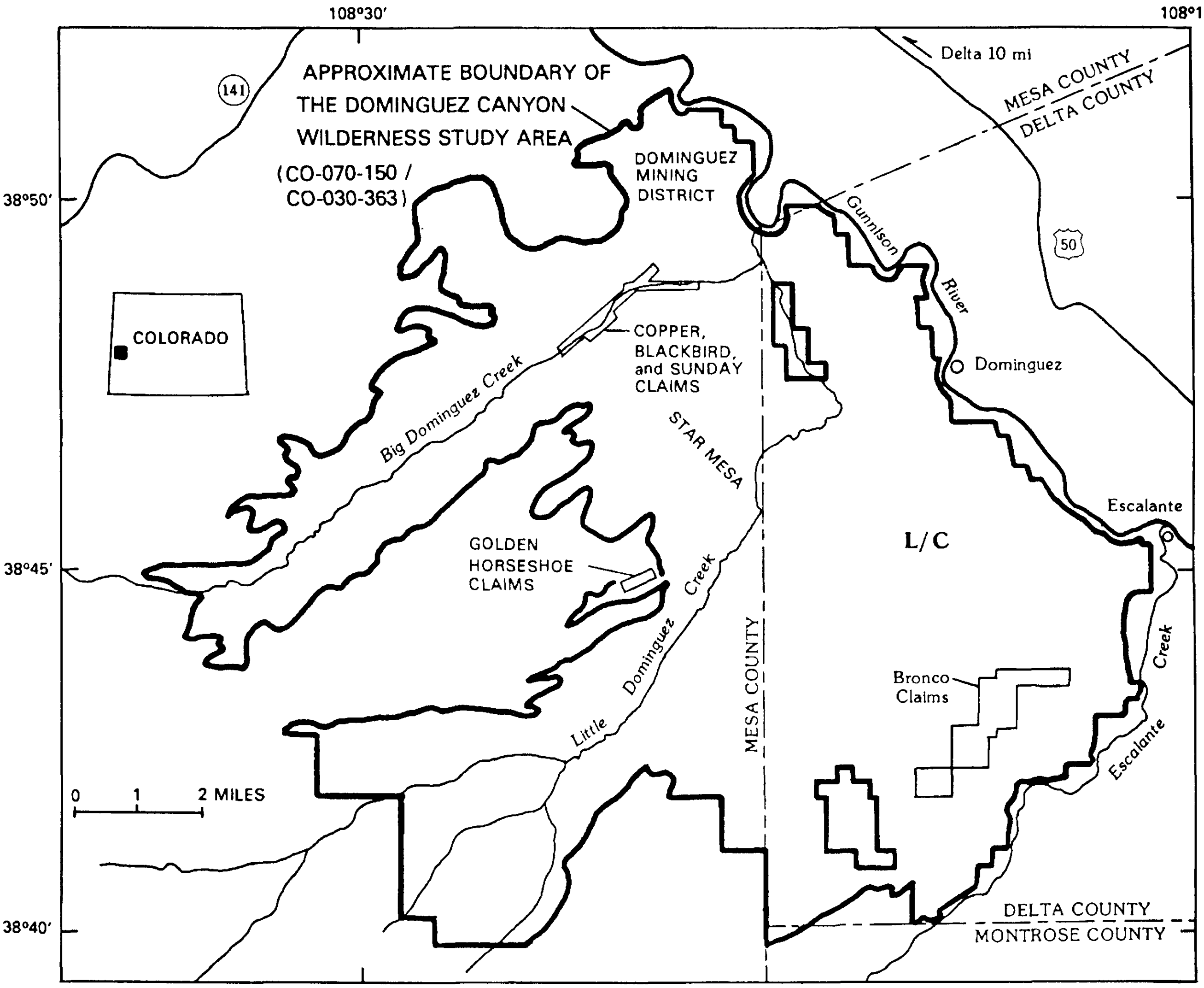
Published and unpublished literature relating to the study area was reviewed by the USBM to obtain pertinent information concerning mineral occurrences and mining activity. Land-status plats were acquired from the Bureau of Land Management State Office, Denver, Colorado. Twenty employee-days were spent mapping and sampling prospects and mineralized areas. Twenty-four samples were taken.

Analytical determinations were made by USBM, Reno Research Center, Reno, Nevada, and commercial laboratories. Twenty-three samples were analyzed by fire assay for gold and silver. Inductively coupled plasma-atomic emission spectroscopy was used to analyze for barium, copper, lead, molybdenum, vanadium, and zinc. Fluorine was determined by a wet chemical method and uranium by fluorimetry. X-ray diffraction was used to determine minerals present in a bentonitic mudstone. Proximate and ultimate analysisand a heat-value determination were made on a coal sample. At least one sample from each prospect was analyzed for 40 elements by semiquantitative-optical-emission spectroscopy to determine the presence of any unsuspected elements. Results are given in Schreiner (1986).

Analytical data and prospect maps are available for public inspection at the USBM, Intermountain Field Operations Center, Denver Federal Center, Denver, CO 80225.

Investigations by the U.S. Geological Survey

A mineral resource assessment of the Dominguez Canyon Wilderness Study Area by the USGS in June and July of 1983 consisted of geologic mapping at a scale of 1:24,000, combined with stream-sediment, rock, and



EXPLANATION

L/C **Geologic terrane with low mineral resource potential for all metals, oil and gas, coal, geothermal energy, and uranium, with certainty level C**

Figure 1. Map showing mineral resource potential, mines, prospects, and mining claims, and location of the Dominguez Canyon Wilderness Study Area, Colorado.

water sampling, and subsequent analysis of the samples. Further detailed mapping and study of the Salt Wash Member of the Morrison Formation was undertaken to determine its resource potential for uranium. Color aerial photographs were used to supplement the geologic mapping and determine regional structures. The results of this study are given in detail in Toth and others (1983). Parts of this report present a summarized version of that study.

Acknowledgments.—The geologic mapping, geochemical sampling, interpretation, and manuscript preparation were facilitated by many people in the USGS. L.L. Davis, R.J. Stoneman, S.J. Soulliere, A.M. Leibold, and M.A. Arnold assisted in geologic mapping. L.R. Layman, D.B. Hatfield, L.L. Coles, and K.K. Wise assisted in the stream-sediment and water sampling.

Further invaluable support was provided by L.L. Jackson and J.L. Seeley of the USGS. D.B. Hatfield and J.L. Seeley developed the analytical method for the uranium determination in acetic acid extracts, with D.B. Hatfield performing the analyses. C.G. Patterson assisted in the uranium evaluation. Thanks go to the

personnel in the U.S. Bureau of Land Management office in Grand Junction for their assistance and cooperation.

APPRAISAL OF IDENTIFIED RESOURCES

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

Mining History

Part of the Dominguez Canyon study area is in the Dominguez mining district (fig. 1). The area was probably first prospected about the same time period as the Unaweep mining district approximately 6 mi to the northwest, where copper-bearing veins were noted in the 1870's. The Unaweep district had recorded production of 4,650 lbs (pounds) of copper in 1899 and was reported also to have been worked for amethyst (Schwochow, 1978). The Dominguez district also contains copper-bearing veins on similar structural trends (approximately N. 70° W.) and appears to be an extension of the Unaweep district. The Copper, Blackbird, and Sunday claims are located on copper and amethyst occurrences in Big Dominguez Creek (fig. 1). No production has been recorded for the Dominguez mining district.

The Morrison Formation, which contains major uranium deposits in the Uravan Mineral Belt approximately 20 mi to the southwest, was explored extensively in the study area during the 1950's. Drilling operations were reported in the late 1970's, but no significant discoveries were made (Toth and others, 1983). Four minor uranium occurrences in the Morrison Formation and one in the Dakota Sandstone were identified in the study area. The Bronco and Golden Horseshoe claims are located on or near two of these occurrences (fig. 1).

Identified Resources

No mineral resources were identified, but small occurrences of copper, amethyst, uranium, and shaly coal exist in the Dominguez Canyon study area.

Copper prospects are located in the Precambrian rocks on the Copper, Blackbird, and Sunday claims in Big Dominguez Creek (fig. 1). The two principal mineral occurrences in the area are present on these claims. One occurrence consists of veinlets, as wide as ½ in. (inch), containing chalcopyrite, malachite, azurite, hematite, quartz, calcite, and barite within a granite dike. The second, a vein 0.8 ft wide, contains chalcopyrite, malachite, hematite, calcite, barite, fluorite, and quartz, including the variety amethyst, within a pegmatite dike. The amethyst is of poor clarity and therefore not of gemstone quality, but it could be sold as specimens. Copper values in chip samples were as high as 3.0 percent, but gold, lead, molybdenum, silver, and zinc values were near or below detection limits of the analytical methods. Resources were not identified due to the small size of the occurrences and low metal values.

Small, localized uranium concentrations, as much as 900 ppm (parts per million), are associated with fossil bone fragments and calcareous siltstone and mudstone in the Morrison Formation, and a carbonaceous shale in the Dakota Sandstone. Five areas emitted radioactivity, and the scintillometer measured 50–300 cps (counts per second) above a background of 25 cps. Previous prospecting in these areas consists of shallow bulldozer cuts and pits. No resources were identified because of the small size of the occurrences and low metal values.

A 7-ft-thick bed of shaly coal is exposed inside the study area near the top of Star Mesa in the Dakota Sandstone (fig. 1). A channel sample of the bed, on an "as received basis," contained 11.59 percent moisture, 46.15 percent ash, 19.55 percent volatile matter, 22.71 percent fixed carbon, 0.22 percent sulfur, and had a heat value of 4,383 Btu/lb (British thermal units/pound). Calculation of heat value to determine the apparent rank (ASTM designation D–388–82, American Society for Testing and Materials, 1982) of the sample was made on a moist mineral-matter-free basis. The calculated value was 8,906 Btu/lb, and the apparent rank of the coal is subbituminous C. The high ash content, more than 33 percent, would exclude it as a resource according to the coal resource classification system of the USGS (Wood and others, 1983).

Small volumes of sand and gravel occur in the wilderness study area but are not considered an identified resource.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Margo I. Toth, Charles G. Patterson, and Dolores M. Kulik
U.S. Geological Survey

Geology

Geologic Setting

The Dominguez Canyon Wilderness Study Area is on the northeast flank of the Uncompahgre Plateau, a major landform and structural feature of western

Colorado. The plateau is approximately 100 mi long by 25 mi wide, and trends northwest-southeast from Grand Junction and Colorado National Monument to near Ridgway and the San Juan Mountains. Structurally, it is a large arch with a steeper southwest limb and a gentler northeast limb, bordered by the Paradox Basin to the southwest, Douglas Arch and Piceance Creek Basin to the north and northeast, and the Gunnison Uplift and San Juan Volcanic Field to the southeast and south. The plateau contains Proterozoic igneous and metamorphic rocks overlain by nearly flat lying to monoclinally folded sedimentary rocks of Paleozoic and Mesozoic age. West-northwest- and northwest-trending, high-angle faults are found mostly along the western margin of but also within the Uncompahgre Plateau.

Description of Rock Units

A detailed geologic map and description of rock units is given in Toth and others (1983). The following is a summary of that work.

Proterozoic crystalline rocks crop out in the study area only in the deeper canyon bottoms and consist of biotite schist, gneiss, hornblende-biotite granite, and amphibolite. Diabase dikes crosscut the Proterozoic granite in Big Dominguez Creek; the age of the diabase is unknown, but Schwochow (1978) indicated that many of the diabase dikes in the Unaweep and Dominguez districts may be Cambrian, based upon correlation with other similar diabase dikes in the Dominguez district. Ogden Tweto (oral commun., 1983), however, indicated that the diabase dikes in Big Dominguez Creek are probably Proterozoic in age, based upon their physical similarities to other Proterozoic diabase dikes in the area.

Pegmatite dikes crosscut the diabase in a dense array in Big Dominguez Creek and range in thickness from a few inches to 20 ft, averaging 2 ft in thickness. Almost all of the pegmatites strike northwest. Sparse copper mineralization occurs along the contacts between some of the pegmatite and diabase dikes in Big Dominguez Creek. The age of the pegmatites is unknown, but they clearly postdate the diabase and predate the overlying Triassic sedimentary rocks.

The Triassic Chinle Formation directly overlies the crystalline rocks and ranges from 30 to 160 ft thick, thinning to the northeast. The formation consists of brick-red, interlayered siltstones, shales, and fine-grained sandstones.

The Triassic Wingate Sandstone lies unconformably on the Chinle Formation and forms steep, slabby cliffs ranging from 80 to 100 ft high. In some places it forms arches and in almost all exposures it has vertical joints. Overlying the Wingate Sandstone, the Jurassic Entrada Sandstone is salmon pink and very fine grained; the total thickness ranges from 70 to 120 ft.

The Jurassic Wanakah Formation unconformably overlies the Entrada Sandstone and consists of thin and evenly bedded sandy shale and mudstone with nodular limestone and chert layers. The formation commonly forms a talus-covered slope and ranges in thickness from 20 to 45 ft thick.

The Jurassic Morrison Formation overlies the Wanakah and is divided into three members in the wilderness study area. The lower or Tidwell Member consists of about 40–50 ft of flat-bedded, fine-grained sandstone, mudstone, and a few nodular limestones. The middle or Salt Wash Member consists of fine- to medium-grained sandstone; mudstone with scattered, thin limestone beds: and white, medium- to fine-grained eolian sandstone at the base. The lower half of the Salt Wash Member has a distinct gray-green color. The member ranges from 285 to 425 ft thick, thickening to the west, and generally forms ledges; it is the uranium-bearing unit of the Morrison Formation. The overlying upper or Brushy Basin Member contains red, green, and buff variegated bentonitic shales and mudstones with interbedded red, fine-grained sandstones and conglomerate. The Brushy Basin Member ranges from 285 to approximately 400 ft thick and generally forms gentle slopes.

The Cretaceous Burro Canyon Formation overlies the Morrison Formation and consists of fine-grained, well-indurated sandstones that are locally crossbedded, and crossbedded conglomerate with interbedded green and purplish shale. Conformably overlying the Burro Canyon Formation, the Cretaceous Dakota Sandstone consists of sandstone and conglomerate with interbedded carbonaceous shale and impure coal. The Dakota Sandstone and the Burro Canyon Formation together are at least 140 ft thick in the study area.

Structure

The major structural features in the wilderness study area are two northwest-trending, high-angle, normal faults that may have a small component of left-lateral, strike-slip movement. A major northwest-trending fault, the north side down dropped, is just to the east of the study area. The sedimentary rocks in the study area strike northwest and are nearly flat-lying with a maximum dip of 8° to the northeast. Where foliation in the Proterozoic rock is evident, the rocks show variable strikes and dips.

Geochemistry

Methods

The geochemical survey included sampling stream sediments, water, and rocks for chemical analysis.

Detailed methods of analysis are in Toth and others (1983), and sample localities are also given in that report.

Sixty-eight streams in the study area were sampled, and two types of stream sediments were collected at each sampling locality. Panned-concentrate samples were collected to analyze for the heavier metallic elements such as copper, lead, and zinc, and fine fractions of mud and clay were collected to analyze for metals such as molybdenum and uranium, which typically adhere to clays. When water was present, it was also collected for analysis. Conductivity, temperature, and acidity of the water were also measured at each site.

Rock samples were collected at two types of localities within the wilderness study area. The first were any localities containing mineralized or altered rock, or areas with characteristics indicative of related mineralized rock. The second were localities with outcrops of Proterozoic crystalline rocks. These were sampled at random intervals to establish background values of the various elements and to look for any trends or values that indicate presence of mineralized rock.

Panned-concentrate samples were analyzed semiquantitatively for 66 elements by optical-emission spectrography (Myers and others, 1961). Panned concentrates were additionally analyzed for gold by atomic-absorption spectroscopy (Thompson and others, 1968). Ten grams of sample are normally used in this procedure, with a resultant limit of determination of 0.1 ppm gold. When only smaller amounts of sample were available, the limit of determination was increased proportionately.

The fine fraction of the stream-sediment samples was sieved through a minus-100 mesh (0.0059 in.) screen and analyzed for 45 elements using inductively coupled plasma atomic emission spectroscopy (ICP) (Taggart and others, 1981). Uranium in the fine fraction of the stream sediments was determined by fluorimetry and had a determination limit of 0.2 ppm.

Rock samples were crushed, pulverized, and analyzed by semiquantitative emission spectrography for 66 elements, similar to the method used for panned concentrates as discussed above.

The water samples were analyzed for arsenic, selenium, molybdenum, and uranium. Arsenic and selenium were determined using procedures of Crock and Lichte (1982). Samples were analyzed for molybdenum by ICP methods, and uranium in the waters was determined by fluorescence methods (Thatcher and Janzer, 1977).

The analyses were done by N.M. Conklin and D.B. Hatfield under project leader J.L. Seeley. Albert Yang of the USGS did the uranium analysis of the waters.

Results

The panned-concentrate samples from the Dominguez Canyon Wilderness Study Area were analyzed for 66 elements but only showed detectable amounts of boron, barium, cobalt, chromium, copper, nickel, niobium, lead, scandium, strontium, vanadium, yttrium, and zirconium, mainly in low concentrations near the detection limits. The analytical data for each of these elements were composited into histograms to look for anomalous concentrations. Except for barium and possibly zirconium, none of the elements was present in anomalous concentration. The elements were in general characterized by a very wide range of low concentrations, possibly reflecting the high variability in the lithologies of the source rocks.

The concentration of barium in the panned concentrates ranged from 1,500 ppm to >100,000 ppm, with a median value of 20,000 ppm. Two samples along the east and northeast sides of the wilderness study area contained 100,000 ppm barium and were collected where the streams cut through outcrop of Wingate Sandstone and Morrison Formation. A third sample from the northeast side of the wilderness study area contained >100,000 ppm barium and was collected where the stream cut through outcrop of Wingate Sandstone. Barite was identified in the panned concentrates by visual examination and by X-ray diffraction.

Because the streams drained an area with a variety of rock types, it is not possible to identify the source of the barium. However, because the samples were collected above outcrops of the Chinle Formation, the source of the barium must also be above the Chinle. Barite could be contained in barite cement, barite nodules, or barite veinlets. Fred Peterson (oral commun., 1983) stated that the Salt Wash Member of the Morrison locally contains a barite cement, so this member may be a source of the barium.

Two samples from the wilderness study area contained 20,000 ppm zirconium in the panned concentrates. The source for the high zirconium is probably zircon in the Proterozoic crystalline rocks.

Panned-concentrate samples from drainages with substantial amounts of Proterozoic outcrop were also analyzed for gold. No gold was detected in any of the samples (detection limit 0.1 ppm).

The fine fraction of the stream sediments had no anomalous concentrations of any elements. Very few of the samples contained concentrations of elements above the detection limits. Uranium values ranged from <0.2 to 0.5 ppm, with almost three-fourths of all values being <0.2 ppm.

Water samples from the Dominguez Canyon Wilderness Study Area showed no anomalous concentrations of the analyzed elements, except for two samples, which contained 48 and 34 ppb (parts per billion) uranium/conductivity X 1000, respectively. These waters were sampled adjacent to the Salt Wash Member of the Morrison Formation, which was a likely source for the uranium.

The rock samples from the wilderness study area are low in elements associated with mineralization. Of the elements looked for in the rocks, only barium, beryllium, cobalt, chromium, copper, lanthanum, lead, scandium, strontium, vanadium, yttrium, and zirconium were present, and most of these were in low concentrations near the detection limit for each element.

Geophysics

Gravity and Aeromagnetic Data

Gravity and aeromagnetic studies were undertaken as part of the mineral resource evaluation of the Dominguez Canyon Wilderness Study Area. These studies provide information on the subsurface distribution of rock masses and the structural framework.

The gravity data were obtained in and adjacent to the study area in 1986 and 1987 and were supplemented by data maintained in the files of the Defense Mapping Agency of the U.S. Department of Defense. Stations measured in this study were established using the Worden gravimeter W–177[1]. The data were tied to the International Gravity Standardization Net 1971 (U.S. Defense Mapping Agency, Aerospace Center, 1974) at base station ACIC 4023–1 at Delta, Colo. Station elevations were obtained from benchmarks, spot elevations, and estimates from topographic maps at a scale of 1:24,000 and are accurate to ±20 ft. The error in the Bouguer anomaly is less than 1.2 mGal (milligals) for errors in elevation control. Bouguer anomaly values were computed using the 1967 gravity formula (International Association of Geodesy, 1967) and a reduction density of 2.67 g/cm^3 (grams/cubic centimeter). Mathematical formulas are given in Cordell and others (1982). Terrain corrections were made by computer for a distance of 100 mi from the station using the method of Plouff (1977). The data are shown on figure 2 as a complete Bouguer anomaly map with a contour interval of 5 mGal.

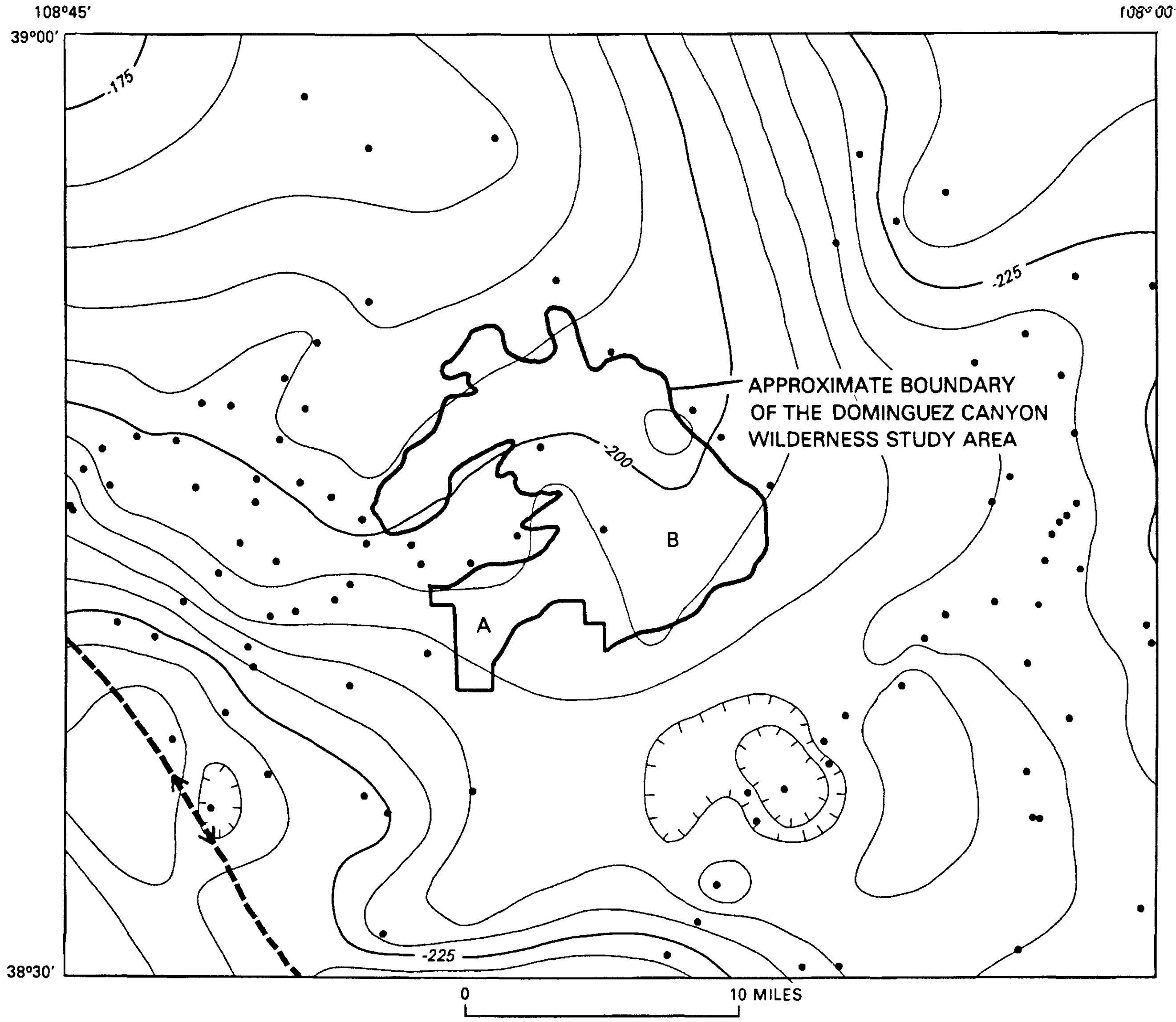
A regional gravity high is associated with Proterozoic crystalline rocks of the core of the Uncompahgre uplift. Case (1966) attributed the large regional anomaly of over 50 mGal to a combination of structural relief of 16,000 to 19,000 ft on the Proterozoic rocks, the northeastward wedgeout of Paleozoic sedimentary rocks, and density variations of the Proterozoic rocks. A northwest-trending gradient in the southwest corner of the map area marks the transition from crystalline rocks in the uplift to sedimentary rocks of the Paradox Basin southwest of the map area. Data from two wells approximately 50 mi northwest of the study area, the Mobil-American Petrofina Elba Flats Unit No. 1–30 and the Mobil No. 1 McCormick Federal "C", along with seismic data, were used to estimate the dip of the fault plane beneath the uplift at about 30° to the northeast, overhanging the sedimentary rocks in the Paradox Basin (Frahme and Vaughn, 1983). The northwest-trending gravity gradient between the crystalline rocks of the uplift and the sedimentary rocks of the basin is located between the wells. Well control data and preliminary gravity models suggest that underlying sedimentary rocks of the Paradox Basin do not extend northeast of the area bounded by the gradient. The gradient broadens across the southwest corner of the study area, and it is possible that sedimentary rocks with lower relative density extend beneath this area (A on fig. 2); if so, they would lie at depths of at least 15,000–20,000 ft if the fault bounding the uplift is projected at 30°. A northeast trend, apparent in the gravity data at the southeast margin of the study area, extends at least 25 mi to the northeast and about the same distance to the southwest near where the axis of the uplift shows a change in direction of plunge (fig. 2). The gravity trend and the warp in the uplift are probably associated with a warp or ramp in the underlying crystalline basement rocks. Gravity measurements were obtained on widely spaced traverses, and no small features are apparent in the data.

A relatively high east-trending magnetic anomaly (U.S. Department of Energy, 1983) occurs over the study area and extends approximately 10 mi to the east and 40 mi to the west. The anomaly is broken by a low saddle less than 30 gammas in amplitude which trends north-south through the eastern half of the study area. A nosing of the contours of the regional gravity high occurs in the same area (B on fig. 2). The magnetic saddle and gravity nose suggest a variation in composition of the Precambrian rocks as discussed by Case (1966) in the northwestern Uncompahgre Plateau.

Remote Sensing

A remote sensing study of the Dominguez Canyon Wilderness Study Area was based on Landsat 2 Multispectral Scanner imagery and is given in detail in Lee (1987). These data were processed and analyzed for lineaments and for limonite anomalies that might relate

[1]Use of brand names in this report is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.



EXPLANATION

• **Gravity station location**

Axis of Uncompahgre Uplift -- Arrows show direction of plunge

Figure 2. Complete Bouguer gravity anomaly map of the Dominguez Canyon Wilderness Study Area. Letters are referred to in text. Contour interval 5 mGal; hachures indicate gravity low.

to mineralization, hydrothermal alteration, migrating hydrocarbons, or uranium.

From the lineament analysis, a major basement fault is interpreted to the east of the wilderness study area, with probable down-to-the-northeast displacement. 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 probably would go undetected.

Mineral and Energy Resources

Metals Other Than Uranium

Geologic, geochemical, and geophysical data indicate that the Dominguez Canyon Wilderness Study Area has low potential for all metals, with certainty level C. Anomalous barium concentrations are present in panned-concentrate samples and are probably related to barite cement in the underlying Morrison Formation; barite does not constitute a resource. Although mineralized rock is present at two locations in Big Dominguez Creek in Proterozoic crystalline rock, the extent of mineralization is extremely local.

Oil, Gas, and Coal

The Dominguez Canyon Wilderness Study Area lacks host rocks and structures favorable for the occurrence of oil, gas, and coal resources. The total sedimentary rock section is exposed, eliminating sealed structural or stratigraphic traps. Although the gravity data indicate that sedimentary rocks could underlie the crystalline rocks at the southwestern part of the study area, the sedimentary rocks would be at a depth of 15,000–20,000 ft. No oil and gas leases are present in the wilderness study area (Schreiner, 1986). Spencer (1983) rated the study area as having zero to low hydrocarbon potential. Coal beds in the Dakota Sandstone are thin, discontinuous, and have a high ash content. The resource potential for oil, gas, and coal is therefore low, with certainty level C.

Uranium

Isopach data for the Salt Wash Member of the Morrison Formation in the Dominguez Canyon Wilderness Study Area reveal a trend shown first by Craig and others (1955) and by Mullens and Freeman (1957). Total thickness and limestone thickness outline a trough or synclinal feature oriented approximately transverse to ancient flow directions in the Salt Wash Member. This may be due to deflection and ponding of Salt Wash paleodrainages by a remnant of the ancestral Uncompahgre highland. Fred Peterson (oral commun., 1983) thought that the downstream edge of the cross-trending trough is the most favorable location for generation of uranium-trapping humate substances generated in anoxic, swampy lakes, now represented by gray mudstones. A dolomite, rather than calcite, cement that is highly persistent in the Salt Wash Member throughout the Dominguez Canyon Wilderness Study Area at approximately 75 ft below the top of the uppermost rim sandstone coincides with a level of very sparse carbonaceous material. Intersections of carbonaceous material with areas of high concentrations of dolomite cement are considered favorable indicators of mineralization (Northrop, 1982). Slight uranium mineralization was observed in and near the carbonaceous material. Two factors, however, argue against larger deposits. First, erosion by the Gunnison River may have removed the most favorable rocks; and second, the extreme scarcity of carbonaceous debris and favorable gray mudstones in the upper or lower rims of the Salt Wash diminished opportunities for uranium-bearing solutions to precipitate the uranium.

Anomalous uranium concentrations were detected in water samples collected for this study and by the National Uranium Resource Evaluation investigation (Campbell and others, 1980). Field mapping revealed these to be associated with a northwest-trending fault system. Because the Salt Wash is known to contain widespread but extremely low-grade amounts of uranium, it is likely that the anomaly is due to leaching and secondary concentration of uranium along the fault, and does not necessarily indicate the presence of a resource.

The mineral resource potential for uranium in the Dominguez Canyon Wilderness Study Area is considered low, with certainty level C. In summary, this is because of extremely sparse carbonaceous material, lack of favorable gray mudstones, location outside of a known mineral belt, lack of uranium mines or prospects, and location in a zone of unfavorable facies for these types of deposits.

Geothermal Energy

The nearest known thermal waters are about 40 mi to the east, between Hotchkiss and Paonia (Pearl, 1980). No warm springs were observed in the wilderness study area, and no known geothermal sources are present. The entire study area therefore has low resource potential for geothermal energy, with certainty level C.

REFERENCES CITED

American Society for Testing and Materials, 1982, Standard classification of coals by rank (ASTM Designation D–388–82): 1982 Annual book of ASTM Standards, pt. 26, p. 242–246.

Campbell, J.A., Franczyk, K.J., Lupe, R.D., and Peterson, Fred, 1980, National uranium resource evaluation, Moab quadrangle, Colorado and Utah: U.S. Department of Energy Report PGJ/F–056(82), 68 p. text, 855 p. microfiche.

Case, J.E., 1966, Geophysical anomalies over Precambrian rocks, northwestern Uncompahgre Plateau, Utah and Colorado: Amerian Association of Petroleum Geologists Bulletin, v. 50, no. 7, p. 1423–1443.

Cordell, Lindreth, Keller, G.R., and Hildenbrand, T.G., 1982, Bouguer gravity map of the Rio Grande Rift, Colorado, New Mexico, and Texas: U.S. Geological Survey Geophysical Investigations Map GP–949, scale 1:1,000,000.

Craig, L.C., Holmes, C.N., Cadigan, R.A., Freeman, V.L., Mullens, T.E., and Weir, G.W., 1955, Stratigraphy of the Morrison and related formations, Colorado Plateau Region, a preliminary report: U.S. Geological Survey Bulletin 1009–E, p. 125–168.

Crock, J.G., and Lichte, F.E., 1982, An improved method for the determination of trace levels of arsenic and antimony in geological materials by automated hydride generation-atomic absorption spectroscopy: Analytica Chimica Acta, v. 144, p. 223–233.

Frahme, C.W., and Vaughn, E.B., 1983, Paleozoic geology and seismic stratigraphy of the northern Uncompahgre front, Grand County, Utah, *in* Lowell, J.D., and Gries, R., eds., Rocky Mountain foreland basin and uplifts: Rocky Mountain Association of Geologists, p. 201–218.

Goudarzi, G.H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84–787, 42 p.

International Association of Geodesy, 1967, Geodetic Reference System, 1967: International Association of Geodesy Special Publication No. 3, 116 p.

Lee, Keenan, 1987, Remote sensing study in support of mineral resource appraisal of the Dominguez Canyon Wilderness Study Area, Montrose, Mesa, and Delta Counties, Colorado: U.S. Geological Survey Open-File Report 87–421.

Mullens, T.G., and Freeman, V.L., 1957, Lithofacies of the Salt Wash Member of the Morrison Formation, Colorado Plateau: Geological Society of America Bulletin, v. 68, no. 4, p. 505–526.

Myers, A.T., Havens, R.A., and Dunton, P.J., 1961, A spectrochemical method for the semiquantitative analysis of rocks, minerals, and ores: U.S. Geological Survey Bulletin 1084–I, p. 207–229.

Northrop, H.R., 1982, Origin of the tabular-type vanadium-uranium deposits in the Henry structural basin, Utah: Golden, Colorado School of Mines, Ph.D. thesis, 340 p.

Pearl, R.H., 1980, Geothermal resources of Colorado: Colorado Geological Survey Map Series 14, scale 1:500,000.

Plouff, Donald, 1977, Preliminary documentation for a FORTRAN program to compute gravity terrain corrections based on topography digitized on a geographic grid: U.S. Geological Survey Open-File Report 77–535.

Schwochow, S.D., 1978, Mineral resources survey of Mesa County—a model study: Colorado Geological Survey, Department of Natural Resources, series 2, 110 p.

Spencer, C.W., 1983, Petroleum potential of wilderness lands in Colorado, *in* Miller, B.M., ed., Petroleum potential of wilderness lands in the Western United States: U.S. Geological Survey Circular 902–A–P, p. E1–E8.

Schreiner, R.A., 1986, Mineral investigation of a part of the Dominguez Canyon Wilderness Study Area (CO-070–150), Delta, Mesa, and Montrose Counties, Colorado: U.S. Bureau of Mines Open File Report MLA 65–86, 13 p.

Taggart, J.E., Lichte, F.E., and Wahlberg, J.S., 1981, Methods of analysis of samples using X-ray fluorescence and induction coupled plasma spectroscopy: U.S. Geological Survey Professional Paper 1250, p. 683–687.

Thatcher, L.L., and Janzer, V.J., 1977, Methods for determination of radioactive substances in water and fluvial sediments, U.S. Geological Survey Techniques of water resources investigations TWI 05—A5, 95 p.

Thompson, C.E., Nakagawa, H.M., and Van Sickle, G.H., 1968, Rapid analysis for gold in geological materials: U.S. Geological Survey Professional Paper 600–B, p. 130–132.

Toth, M.I., Davis, L.L., Patterson, C.G., and Seeley, J.L., 1983, Geology and mineral resource potential of the Dominguez Canyon Wilderness Study Area, Delta, Mesa, and Montrose Counties, Colorado: U.S. Geological Survey Open-File Report 83–797, 44 p.

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, 5 p.

U.S. Defense Mapping Agency, Aerospace Center, 1974, World Relative Gravity Reference Network, North America, Part 2: Defense Mapping Agency Aerospace Center Reference Publication 25, with supplement updating Gravity Standardization Net, 1971, 1,635 p.

U.S. Department of Energy, 1983, Moab Quadrangle: Residual Intensity Magnetic Anomaly Contour Map, GJM 406, pl. 4.

Wood, G.H., Kehn, T.M., Carter, M.D., and Culbertson, W.C., 1983, Coal resource classification system of the U.S. Geological Survey: U.S. Geological Survey Circular 891, 65 p.

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.

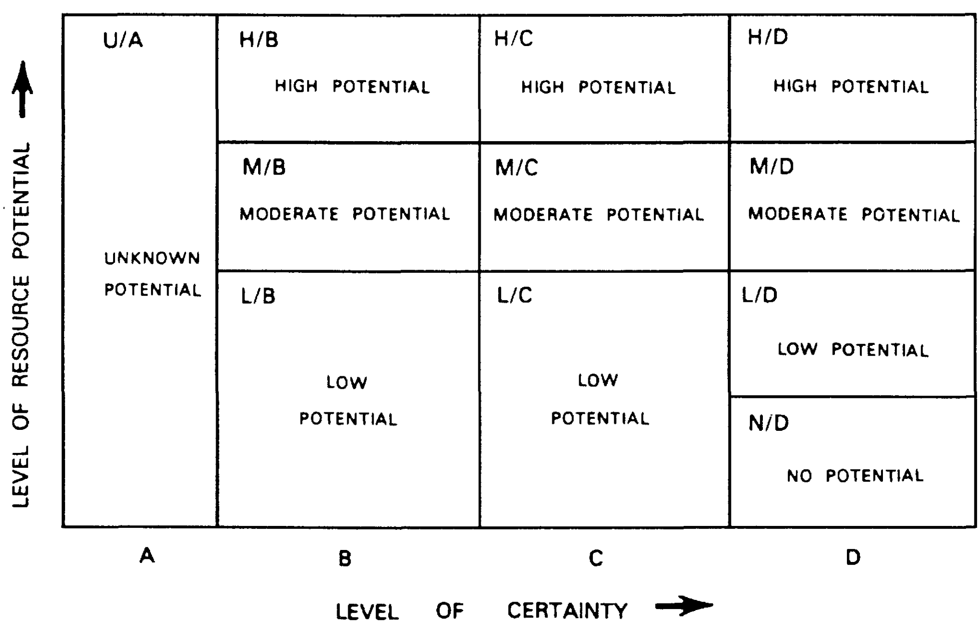
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application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

Goudarzi, G. H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84–0787, p. 7, 8.

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.

☆ U.S. GOVERNMENT PRINTING OFFICE:1987-573-047/66017

U.S. DEPARTMENT OF THE INTERIOR

March 3, 1849