UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Mineral Resource Potential of the Greenhorn Mountain Wilderness Study Area, Huerfano and Pueblo Counties, Colorado

By

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Open-File Report 83-473
1983

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Greenhorn Mountain Wilderness Study Area, San Isabel National Forest, Huerfano and Pueblo Counties, Colo. The Greenhorn Mountain Wilderness Study Area was so established by the Colorado Wilderness Act, Public Law 96-560, December 22, 1980.

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SUMMARY STATEMENT

Mineral resource studies by the U.S. Bureau of Mines and U.S. Geological Survey indicate that one area within the Greenhorn Mountain Wilderness Study Area has low to moderate mineral resource potential. Chemical analyses of stream-sediment samples suggest that the Precambrian igneous and metamorphic rocks underlying the drainage basin of South Apache Creek have very high concentrations of tungsten. Although mineralized rock was not located, similar Precambrian rocks elsewhere in Colorado have tungsten in skarn-type deposits. The potential for tungsten in this basin is deemed low to moderate on the basis of geologic environment and the tungsten geochemical anomaly. The Greenhorn Mountain Wilderness Study Area has no known potential for oil and gas, coal, geothermal resources, or other energy-related commodities.

INTRODUCTION

The Greenhorn Mountain Wilderness Study Area (WSA) in south-central Colorado covers about 22,300 acres in Huerfano and Pueblo Counties (fig. 1). It lies 20 mi southwest of Pueblo and 130 mi almost due south of Denver. Cities within 10 mi include Rye to the northeast, San Isabel to the north, and Gardner to the southwest.

The Greenhorn Mountain WSA lies across the southernmost end of the Wet Mountains and is characterized by a steep eastern flank with V-shaped canyons and a gently sloping western side typified by flat-bottomed arroyos. Elevations range from 12,347 ft at Greenhorn Mountain to 7,600 ft at the southern end of the WSA. Badito Cone, a round symmetrical peak (8,942 ft) rises prominently just south of the WSA boundary. Access to the periphery of the study area is provided by dirt roads, one of which leads nearly to the top of Greenhorn Mountain. Foot trails provide access to the interior of the WSA and traverse across the Wet Mountains.

A mineral survey of the Greenhorn Mountain WSA was done by the U.S. Geological Survey (USGS) during the summer of 1982 and by the U.S. Bureau of Mines (USBM) during September and October 1981 and June 1982. The USBM studied mines, prospects, and mineralized areas (Baskin, 1983), and the USGS performed geological and geochemical investigations. This report summarizes the findings of the mineral survey and assesses the mineral resource potential of the WSA. A geologic map of the southern Wet Mountains by Boyer (1962) was field checked and modified for the geologic base map used in this report (fig. 2). Information on oil and gas potential was obtained from reports by Creely and Saterdal (1956) and Landes (1970).

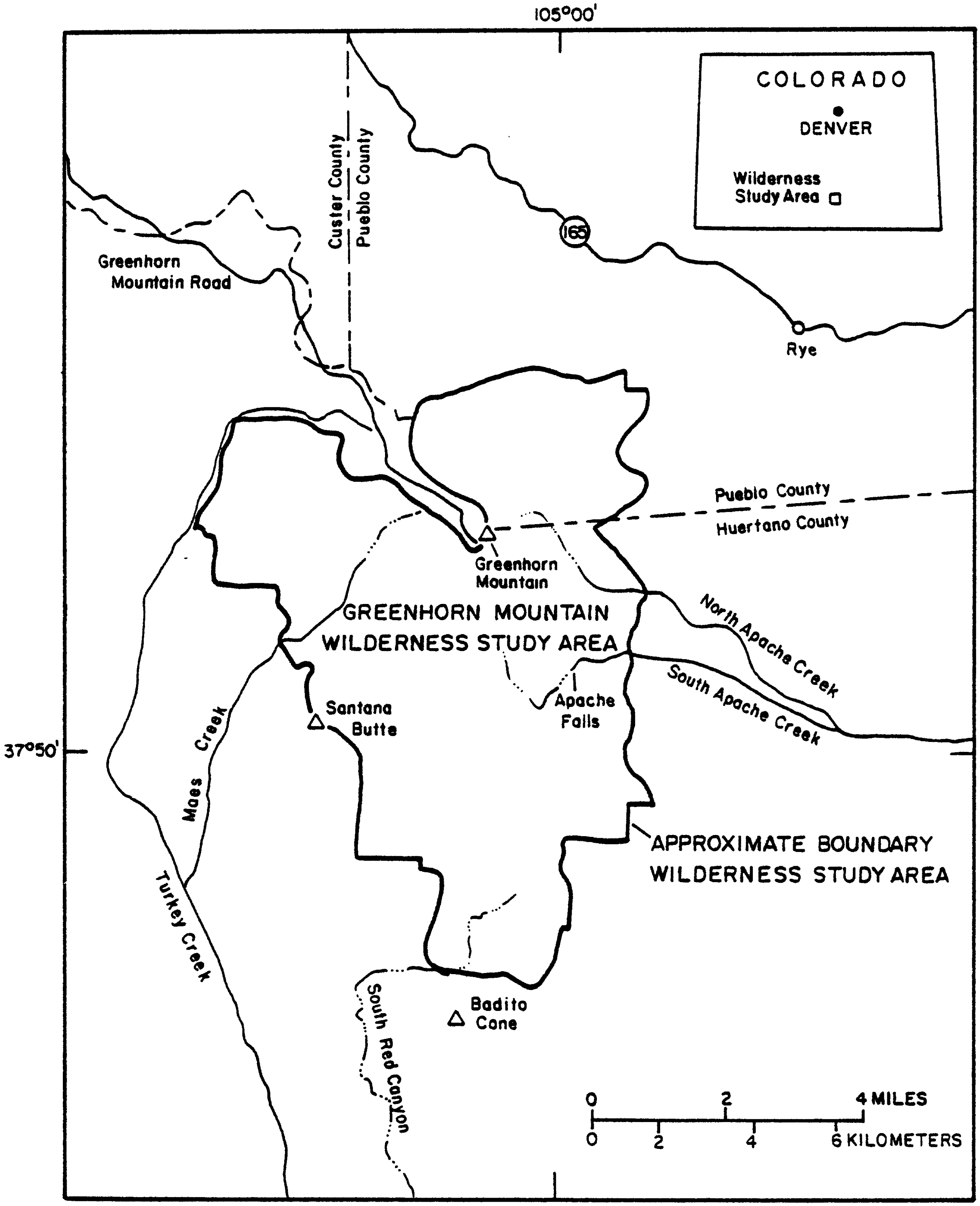

Figure 1.--Index map showing location of the Greenhorn Mountain Wilderness Study Area, Huerfano and Pueblo Counties, Colo.

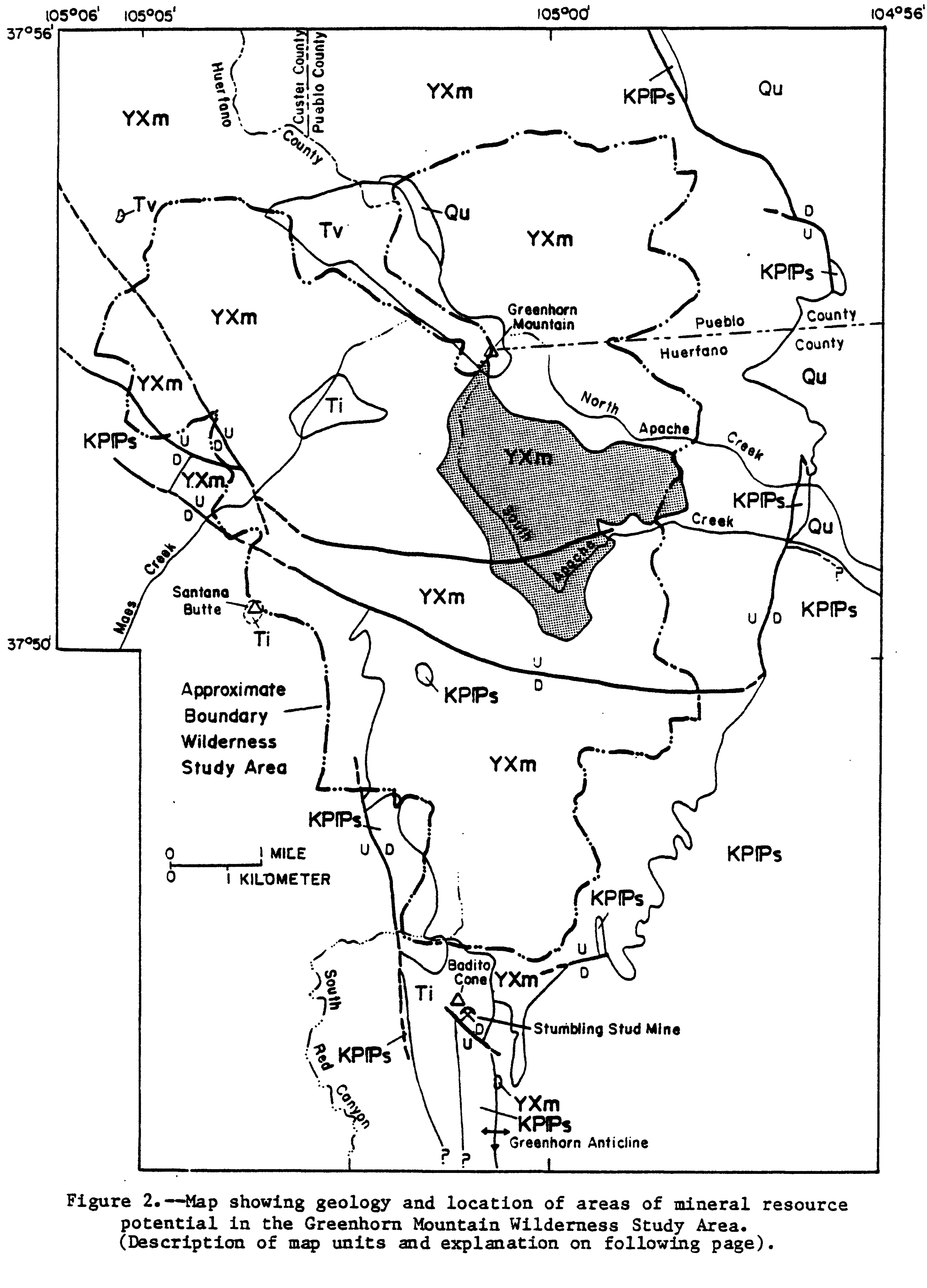

Figure 2.--Map showing geology and location of areas of mineral resource potential in the Greenhorn Mountain Wilderness Study Area. (Description of map units and explanation on following page).

DESCRIPTION OF MAP UNITS

Qu	UNDIFFERENTIATED ALLUVIUM AND TALUS (QUATERNARY)
Tv	VOLCANIC ROCKS (TERTIARY)
Ti	INTRUSIVE ALKALIC IGNEOUS ROCKS (TERTIARY)
KPIPs	SEDIMENTARY ROCK (CRETACEOUS TO PERMIAN-PENNSYLVANIAN)
YXm	METAMORPHIC AND INTRUSIVE IGNEOUS ROCK (PROTEROZOIC (X) AND PROTEROZOIC (Y))
?	CONTACT--Dashed where approximately located or inferred. Queried where extension is uncertain
	FAULT--U, upthrown side; D, downthrown side. Dashed where approximately located
	ANTICLINE--Showing trace of axial plane and direction of plunge of axis
	MINE
	AREA DRAINED BY STREAMS WITH ANOMALOUS TUNGSTEN IN SEDIMENT SAMPLES
	APPROXIMATE BOUNDARY OF GREENHORN MOUNTAIN WILDERNESS STUDY AREA

GEOLOGIC SETTING

The core of the Greenhorn Mountain WSA consists of complexly related Proterozoic X granite gneiss, hornblende gneiss, amphibolite, biotite and biotite-hornblende schist, migmatite, and minor amounts of calc-silicate gneiss and Proterozoic Y San Isabel Granite. Unconformably overlying the basement rock are Permian-Pennsylvanian to Cretaceous interlayered conglomerate, sandstone, siltstone, shale, and limestone as much as 4,150 ft thick. Tertiary alkalic hypabyssal rocks intrude the Precambrian sedimentary rocks at Badito Cone, in Maes Creek, and at Santana Butte. The intrusive rocks are white to light gray and contain 5-10 percent phenocrysts of plagioclase, oxyhornblende, and acmite in an aphanitic groundmass. The ages of the stocks are unknown but may be Miocene, based on correlation with similar appearing rocks in the adjacent Huerfano Park (Briggs and Goddard, 1956). Crystal-vitric rhyolite tuff of both lacustrine and fluvial origins and of Oligocene(?) or Miocene(?) age is preserved in the southwestern and northeastern faces of Greenhorn Mountain. Overlying the rhyolite tuff are erosional remnants of several dark-green to black andesitic lava flows as much as 100 ft in composite thickness, and of Oligocene(?) or Miocene(?) age. The flows contain 5-20 percent phenocrysts of plagioclase, augite, and oxyhornblende in an aphanitic groundmass.

The southern Wet Mountains form a southeast-plunging anticline defined by tilted sedimentary rocks that flank the range and wrap around its southern end. The mountains are bounded by high-angle, northwest-trending normal faults on both the east and west sides of the range. Also trending northwest, minor faults, dikes, and joint sets parallel the elongation of the range, but strike east-west in places. Faults are commonly expressed as brecciated zones that contain hematite, chlorite, and epidote, and abundant slickensides. Several periods of faulting are recognized, and most faults have Laramide (late Campanian Cretaceous to late Eocene) or younger movement; the youngest faults are commonly marked by breaks in the topographic slopes. An extensive, nearly flat erosion surface was formed in late Eocene time before mid-Tertiary uplift of the range, and remnants of it are present along the crest of the mountains near Greenhorn Mountain and beneath the volcanic rocks forming this peak.

GEOCHEMICAL SURVEY

A geochemical survey of the WSA by the USGS included sampling stream sediments and rocks for chemical analysis. Thirty-one samples of stream sediments were taken; the drainage basin areas of the streams varied between 2 and 3 mi^2. The samples were collected as close to the WSA boundary as was feasible, but as most of the sedimentary rocks on the east side of the range crop out east of the WSA boundary, these were not included in the sampling. Large-volume composite samples were collected at each stream site and were separated into three fractions before analysis. Different concentrating techniques were used to produce a fine fraction (consisting mostly of clays), nonmagnetic fraction (consisting of nonmagnetic minerals greater than clay size), and a magnetic fraction (consisting of magnetic minerals greater than clay size). These concentrating techniques were used to enable better recognition of anomalous samples. Composite rock samples were also taken of fresh representative bedrock outcrops and also wherever alteration or evidence of mineralization was present.

All samples were analyzed for 30 elements by six-step semiquantitative emission spectrography (Grimes and Marranzino, 1968). The data for each element were composited into histograms for the various fractions of the stream sediments and for the rock samples. Chemically anomalous samples were defined as the higher population wherever a well-defined separation was present in the data. Analyses of these anomalous samples were usually 2 or 3 spectrographic intervals higher than the rest of the analyses.

The stream-sediment samples from the Greenhorn Mountain WSA generally lack anomalous concentrations of elements associated with metallic deposits. Isolated anomalies are present for some elements but could not be traced to a geologic source. Barium and lanthanum are slightly anomalous in many stream samples; one sample from South Red Canyon contains 10,000 ppm barium in the nonmagnetic fraction of the sediment sample. Anomalous thorium (200 ppm) is present in the nonmagnetic fraction of a sample from Turkey Creek; tin was detected in the nonmagnetic fraction of four widely spaced samples, ranging in concentration from 20 to 50 ppm. A slightly anomalous tungsten content (100-150 ppm) is present in the sediments from streams draining Precambrian igneous and metamorphic rocks in the southernmost part of the WSA.

Stream-sediment samples from six adjacent streams draining into South Apache Creek contain anomalous amounts of barium, lanthanum, yttrium, and tungsten. Three of the streams also have highly anomalous tungsten (100, 300, and 500 ppm) in the nonmagnetic fraction, and the two drainages to the north of South Apache Creek also contain anomalous tungsten (100 and 150 ppm) in this fraction. Reconnaissance geologic studies did not locate a geologic source for this tungsten, and chemical analyses of samples from the granite gneiss in this area did not indicate chemical anomalies, except for a barium content slightly higher than normal for this rock type.

Rock samples from the Greenhorn Mountain WSA are also low in metals associated with mineralized systems; and most of the geochemical anomalies that were found are restricted to isolated samples. Barium, chromium, and nickel have anomalous values in a few igneous and metamorphic rock samples from widely separated localities, and tin was detected in a biotite-hornblende-plagioclase gneiss (30 ppm). Boron is present in anomalous concentrations (200 ppm) in a tourmaline-rich pegmatite.

The Tertiary alkalic stocks around Badito Cone (outside of WSA) and in Maes Creek contain anomalous amounts of niobium (70 and 150 ppm). Along the northeast margin of the stock at Badito Cone, metals occur in an inlier of sedimentary rock along a narrow fault zone in the Dakota Sandstone, just below the contact with the Graneros Shale. The sandstone contains detectable amounts of molybdenum (30 and 50 ppm) and arsenic (300 ppm); it has a high zirconium content (1,000 ppm). Because of its proximity and composition, the highly differentiated alkalic stock is regarded as the source for the metals which were deposited in the sandstone. No anomalous concentrations of any elements were detected in the streams draining the mineralized area.

SCINTILLOMETER SURVEY

A reconnaissance scintillometer survey of the WSA was made by recording measurements at randomly distributed locations and along obvious shear zones. By taking a large number of measurements, we were able to establish the background radiation level (2,000-4,000 counts per second (cps)) and therefore define anomalous radiation levels.

Most of the measurements were within the range of the expected background, but one sample from a fault zone in granite gneiss on the west side of the WSA has 7,500 cps; the source of radiation is unknown. The mineralized Dakota Sandstone at the Stumbling Stud Mine south of the WSA has anomalous radiation of 5,000 cps (Baskin, 1983), and background readings are 80 cps for unaltered rock. These high radiation levels are most likely due to anomalous concentrations of uranium and thorium in the sandstone.

MINES, PROSPECTS, AND MINERALIZED AREAS

Fifty samples from known mines, prospects, and mineralized zones were collected by the USBM for analysis (Baskin, 1983). Samples at the workings consisted of chip samples taken across visible or suspected zones of altered or mineralized rock, and grab and select samples of dump material. Most samples were analyzed for gold and silver by fire-assay, U_3O_8 by radiometric analysis, specific elements in selected samples by atomic absorption, and 40 elements by semiquantitative spectrographic analysis. Results of all analyses are available for public inspection at the USBM, Intermountain Field Operations Center, Denver Federal Center, Denver, Colo. 80225.

Mining history and production

Prospecting in and around the WSA probably began in the late 1860's but there are no records of production before 1900. Most of the workings in and near the WSA are small prospect pits, probably dug for gold or silver. There is no evidence of production from any prospects examined in the WSA.

Several oil and gas leases and lease applications were on record in the WSA and vicinity in September 1982. Only about 100 acres of the WSA were covered by oil and gas lease application and no test drilling has taken place on those properties.

Mining districts and mineralized areas

No mining districts are in or near the Greenhorn Mountain WSA but several small prospects are inside the WSA boundary.

The Maes Creek prospects on the western boundary consist of a few small pits and one 20-ft adit, and the Apache Falls prospect on the eastern boundary consists of one small pit. Scant mineralization is present in the gneisses and granitic gneisses at these workings; assay results from samples taken at these workings show only minor amounts of copper (Baskin, 1983). The Greenhorn Mountain prospects on the northern boundary consist of two small pits in gray andesite; a trench on the Red Canyon claims on the southern boundary is in alluvium. Samples taken from these locales contain no significant amounts of silver, gold, or uranium.

Two mineralized areas lie approximately 1 mi outside the boundary of the WSA. To the northwest of the WSA, the Little Joe claims are staked along a fault zone in quartz-biotite gneiss and biotite schist. Specular hematite occurs in sheared and fractured quartz lenses, blebs, and veinlets that are approximately parallel to the foliation in the gneiss. Two of three samples taken at this location assayed 0.2 oz silver per ton; gold was not detected. Although the fault extends about 1,000 ft inside the WSA, no evidence of mineralization was found along this fault inside the study area.

To the south of the WSA, the Stumbling Stud Mine consists of a group of pits and trenches along a contact between inliers of Cretaceous Dakota Sandstone in a Tertiary alkalic stock. Fluorite and uranium occur as disseminations and veinlets in the sandstone and in lesser amounts in the stock, and appear to be confined primarily to the area around the contact between the intrusive and the sandstone. None of the mineralized area extends into the WSA. Samples from the workings contained as much as 0.12 percent U_3O_8, 0.07 percent V_2O_5, 5.98 percent fluorine, and 1.4 percent zirconium (Baskin, 1983). Production of 510 tons of uranium-bearing rock was reported, but no uranium was extracted because it is chemically bound to a refractory mineral (Nelson-Moore and others, 1978).

The alkalic stock at Badito Cone extends to the southern boundary of the WSA where it is in contact with Precambrian granitic gneisses. The intrusive-sandstone contact does not extend into the WSA and no mineral occurrences of the type described above were observed in the WSA. Two similar stocks crop out in the area of Maes Creek and Santana Butte; the stock in Maes Creek intrudes Precambrian gneiss and the stock at Santana Butte intrudes Cretaceous sediments. No evidence of mineralization was observed at either locality.

Creely and Saterdal (1956) report favorable structural and stratigraphic conditions for oil and gas reserves immediately south of the WSA within the Greenhorn anticline. Most of the drill holes reported by them had shows of oil and (or) gas but none of the holes had any production as of 1956. Although part of the Greenhorn Anticline extends into the WSA, closed structures, which act to trap oil and gas, are absent. Furthermore, extensive erosion has removed the vast bulk of the sedimentary rocks that Creely and Saterdal (1956) report as favorable for oil and gas reserves. No potential for oil and gas is inferred inside the WSA.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Geological, geochemical, and scintillometer surveys, combined with the examination of mines, prospects, and claims, revealed few indications of near-surface mineral resources within the Greenhorn Mountain WSA; thus, there is little likelihood for occurrence of mineral resources in most of the WSA. Our studies indicate that one area in the WSA has a low to moderate mineral resource potential (fig. 2).

Most of the geochemical anomalies in the stream-sediment and rock samples are isolated in their occurrence, are low in value, and have no known geologic source. One cluster of barium, lanthanum, yttrium, and tungsten anomalies is present in the streams draining into South Apache Creek. Although tungsten occurrence is indicated for this area, our mapping did not locate evidence of mineralization in the Precambrian rocks in these drainages. Comparison with other tungsten-bearing Precambrian rocks elsewhere in Colorado (Tweto, 1960; Heinrich, 1981) suggests that large inclusions of calc-silicate gneiss or amphibolite in the Precambrian granite gneiss are a likely source for the tungsten. Detailed mapping would be necessary to establish the location of the mineralized rock in the area of the stream anomalies. The mineral potential for tungsten assigned to this area is therefore low to moderate.

There is no known geological evidence for nonmetallic resources, oil and gas, coal, geothermal resources, or other energy-related commodities within the WSA.

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