Mineral Resources of the Blue Eagle Wilderness Study Area, Nye County, Nevada

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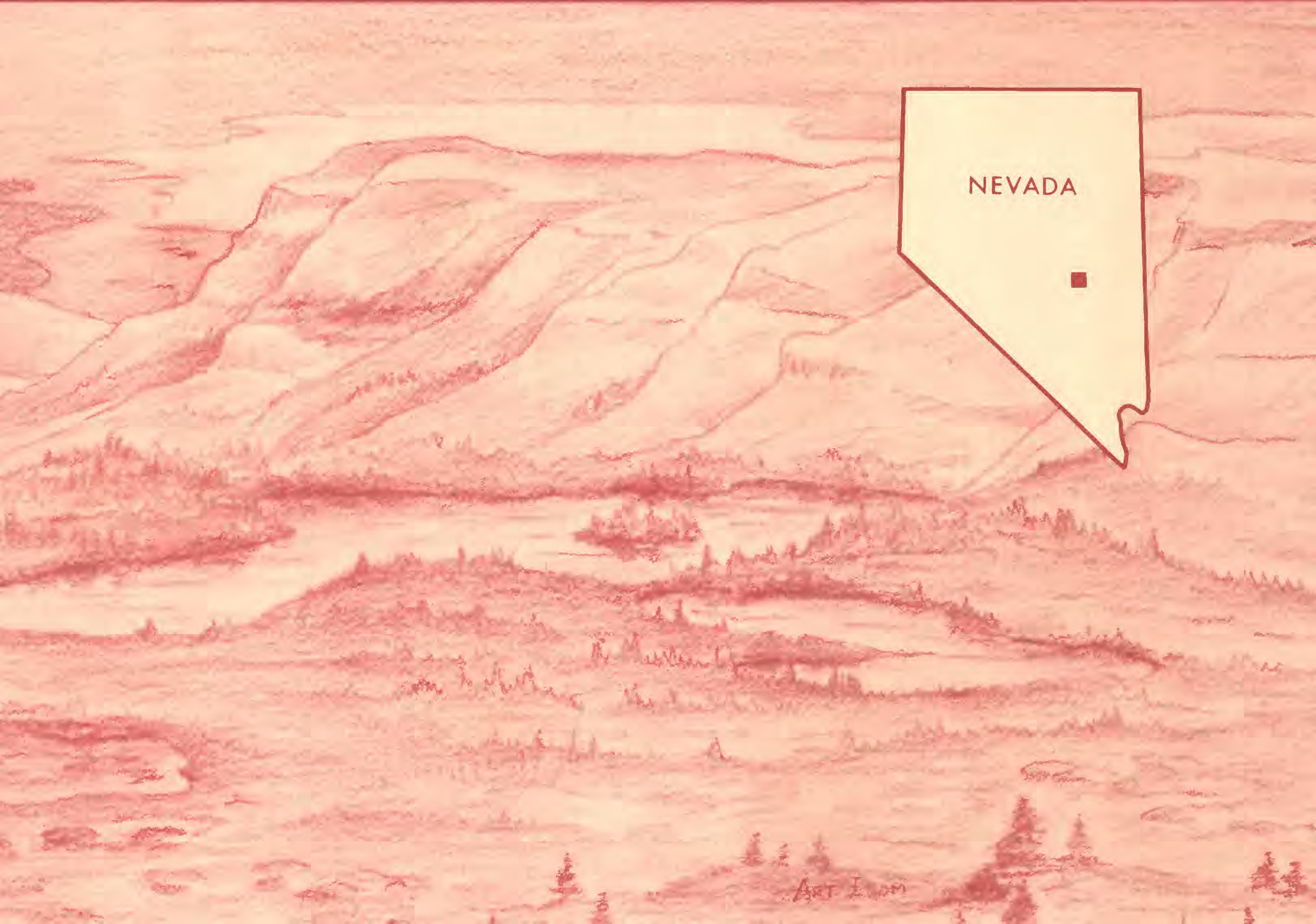

Chapter D

Mineral Resources of the Blue Eagle Wilderness Study Area, Nye County, Nevada

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U.S. GEOLOGICAL SURVEY BULLETIN 1731

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—CENTRAL NEVADA

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 Blue Eagle Wilderness Study Area (NV–060–158/199), Nye County, Nevada.

CONTENTS

PLATE

[Plate is in pocket]

FIGURES

FIGURES

Mineral Resources of the Blue Eagle Wilderness Study Area, Nye County, Nevada

By Karen Lund, J. Thomas Nash, L. S. Beard, *and* H. R. Blank, Jr.
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SUMMARY

Abstract

The Blue Eagle Wilderness Study Area (NV–060–158/199) lies in the Basin and Range province of east-central Nevada (fig. 1). A mineral survey of 51,350 acres of the wilderness study area in Nye County, Nev., was conducted by the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) during 1984 and 1985. New geologic mapping of the area was completed, geochemical sampling of the area was conducted, geophysical characteristics were evaluated, and unpatented claim blocks in the area were investigated.

The entire Blue Eagle Wilderness Study Area has high energy resource potential for petroleum, although appropriate traps have not been identified. Most of the area is covered by oil and gas leases.

Moderate mineral resource potential is recognized for three types of metal occurrence in five areas (fig. 2). The southwestern corner of the area has moderate potential for tungsten and polymetallic base-metal (bismuth, molybdenum, copper, lead, and zinc) deposits in hydrothermal (low- to medium-temperature) replacement deposits in low-grade metamorphic rocks and for gold and silver in quartz veins associated with the replacement mineralization. The north and central parts of the area have moderate potential for gold in disseminated deposits associated with jasperoid occurrences. Two areas on the southeastern and western sides of the wilderness study area have moderate potential for zinc and antimony deposits possibly associated with hydrothermal fluids that moved along highly brecciated fault zones.

The study area has low resource potential for all other metals, nonmetals, geothermal energy, and coal. The study area has no identified resources.

Character and Setting

The Blue Eagle Wilderness Study Area is in northeastern Nye County, Nev., in the northern Grant Range 4 mi (miles) southeast of Currant (fig. 1). Improved and unimproved roads provide access to the northern, northeastern, and western sides of the wilderness study area. Old unimproved roads along the eastern and southern boundaries of the wilderness study area are impassable.

The eastern side of the northern Grant Range is topographically gentle and generally heavily forested; the western side is cliffy and deeply dissected. The total relief is about 4,960 ft (feet) between Railroad Valley, west of the range, and the highest point in the range at Blue Eagle Mountain (9,561 ft).

The Grant Range is an east-tilted fault block. The faulting exposed a stratigraphic section, from west to east, of thick carbonate sedimentary rocks of the Paleozoic (see geologic time scale in Appendix) continental shelf that are overlain by Tertiary basin deposits and by a sequence of Tertiary volcanic and basin-fill deposits. The oldest exposed rocks, which are on the western side of the range, are metamorphosed lower Paleozoic rocks. In detail, the range is structurally complex; the area has been affected by both Mesozoic compressional and Tertiary extensional processes.

The wilderness study area is northeast of the Troy and Willow Creek mining districts (fig. 1). One group of unpatented lode claims is in the wilderness study

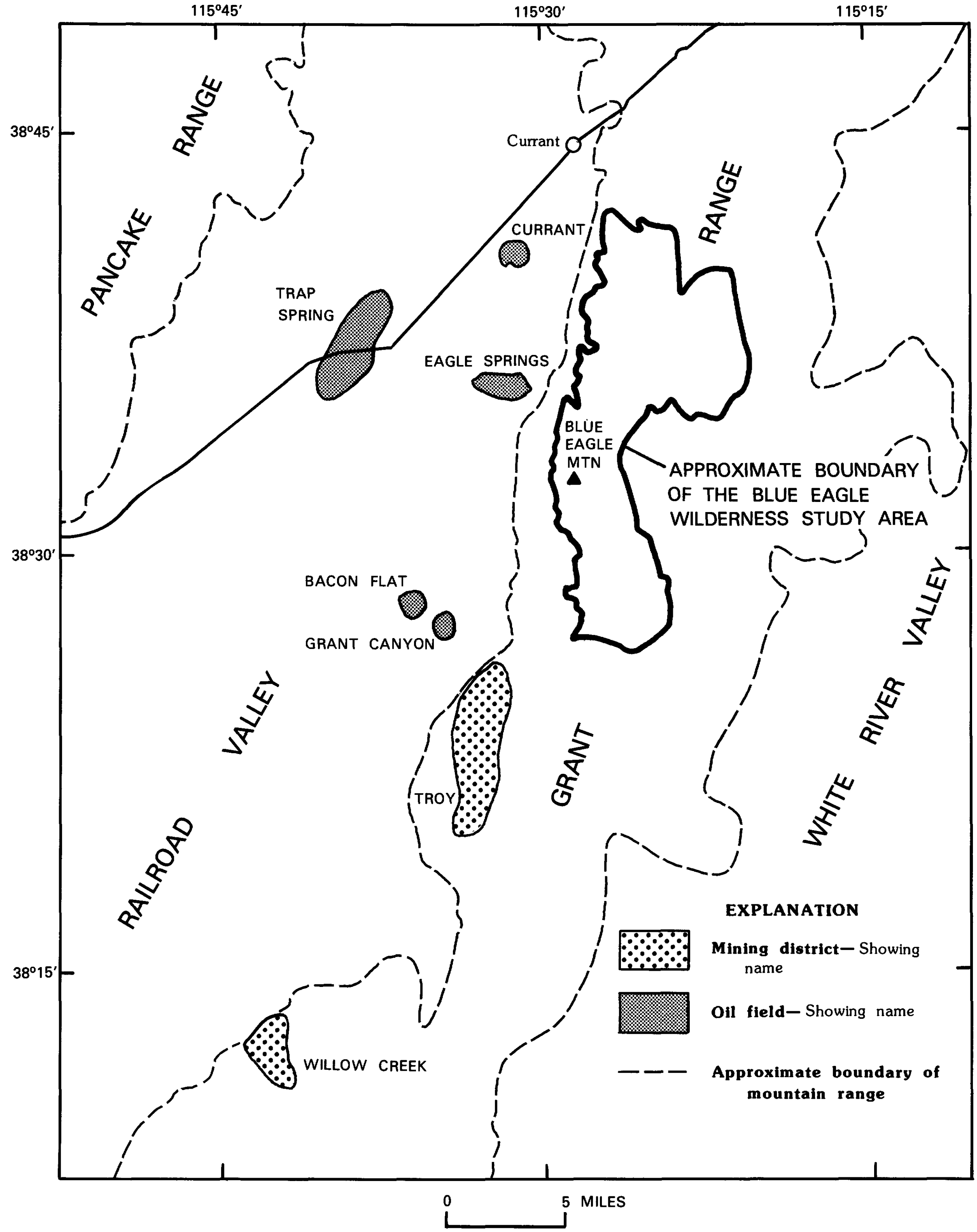

Figure 1. Index map showing the location of the Blue Eagle Wilderness Study Area, Nye County, Nevada, and nearby mining districts and oil fields.

area, and two groups of unpatented lode claims adjoin the wilderness study area (fig. 3). Unrecorded mineral-exploration activity in the form of several prospect pits was found in the southeastern part of the area. No mineral resources were identified within the study area.

Mineral Resource Potential

The southwestern corner of the wilderness study area has moderate mineral resource potential for tungsten in hydrothermal replacement deposits (fig. 2). This area of moderate potential is adjacent to the Galena claims (fig. 3), which have a history of prospecting and limited production. Polymetallic base-metal (copper, lead, zinc, molybdenum, and bismuth) anomalies in stream-sediment samples as well as in mineralized rock-chip samples helped to define an area of interest (see discussion below). Geologically and geochemically, the area is similar to the Troy mining district that lies 6 mi southwest (fig. 1).

A moderate mineral resource potential for gold and silver exists in different geologic settings in two parts of the wilderness study area. In the southwestern corner of the wilderness study area (fig. 2), there is a moderate potential for gold and silver in quartz veins that are in steep fault zones in low-grade metamorphosed lower Paleozoic dolomites. Geochemical anomalies defined by stream-sediment concentrate samples and mineralized rock samples are additional evidence of this potential. In the north and central parts of the wilderness study area, there is a moderate potential for gold in disseminated deposits (fig. 2). Many jasperoid breccias occur in this area along high- and low-angle normal faults that cut upper Paleozoic shale and limestone units. However, stream-sediment and rock-chip samples from this area did not contain anomalous concentrations of metals.

Anomalous concentrations of base metals were found in two different geologic environments in the Blue Eagle Wilderness Study Area. The southwestern corner of the wilderness study area has moderate mineral resource potential for an association of copper-lead-zinc-molybdenum-bismuth in hydrothermal replacement deposits (fig. 2) in metamorphic rocks. The area of geochemical anomalies in stream-sediment concentrates and mineralized rock samples includes the area of the Galena claims.

Two elongate areas along the southeastern and western sides of the wilderness study area have moderate mineral resource potential for zinc and antimony related to a possible fault-controlled hydrothermal system (fig. 2). The rock types are different in these two areas; the eastern area is underlain by upper Paleozoic shale and limestone, whereas the western area is underlain by lower Paleozoic dolomite. Both areas have been affected by both steeply and shallowly dipping normal faults, and mineralized rock has been observed along shallow fault zones. In spite of the different rock types, the geochemical signatures of the areas are similar.

The entire wilderness study area has been assigned a high energy resource potential for petroleum (Sandberg, 1983). Wells in oil fields in Railroad Valley on the western side of the wilderness study area (fig. 1) have been active since 1954 (Bortz and Murray, 1979), and commercial exploration and production are ongoing. Both Paleozoic and Tertiary source rocks (Poole and Claypool, 1984) are present in the wilderness study area. These source rocks are at optimum maturation for oil and gas generation (Sandberg, 1983). Many structures are present that would allow fluid migration and trapping in reservoirs; however, effective reservoir seals and traps may be absent in the wilderness study area.

INTRODUCTION

The Blue Eagle Wilderness Study Area (NV–060–158/199) covers 51,350 acres of northeastern Nye County, Nev., in the Battle Mountain and Ely districts of the U.S. Bureau of Land Management (BLM). The wilderness study area is in east-central Nevada 4 mi southeast of Currant, Nev. (fig. 1), and 55 mi southwest of Ely, Nev. Access to the northern and western sides of the wilderness study area is by several improved and unimproved roads (pl. 1). Because old unimproved roads along the eastern and southern sides of the study area have been washed out, access from these sides is difficult. The wilderness study area includes most of the rugged northern Grant Range, which is a fault-bound block that has been tilted to the east. The greatest relief is on the western side of the range where Railroad Valley is at an elevation of less than 4,800 ft only 3 mi west of Blue Eagle Mountain, which has an elevation of 9,561 ft (total relief about 4,960 ft). The western side of the range is cliffy and has been dissected by many deep canyons. The eastern side of the range is more gentle and, in general, is heavily forested with pinon pine and juniper trees.

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 USBM and the USGS. Identified resources are classified according to the system of the U.S. Bureau of Mines and U.S. Geological Survey (1980), which is shown in the Appendix of this report. Identified resources are studied by the USBM. Mineral

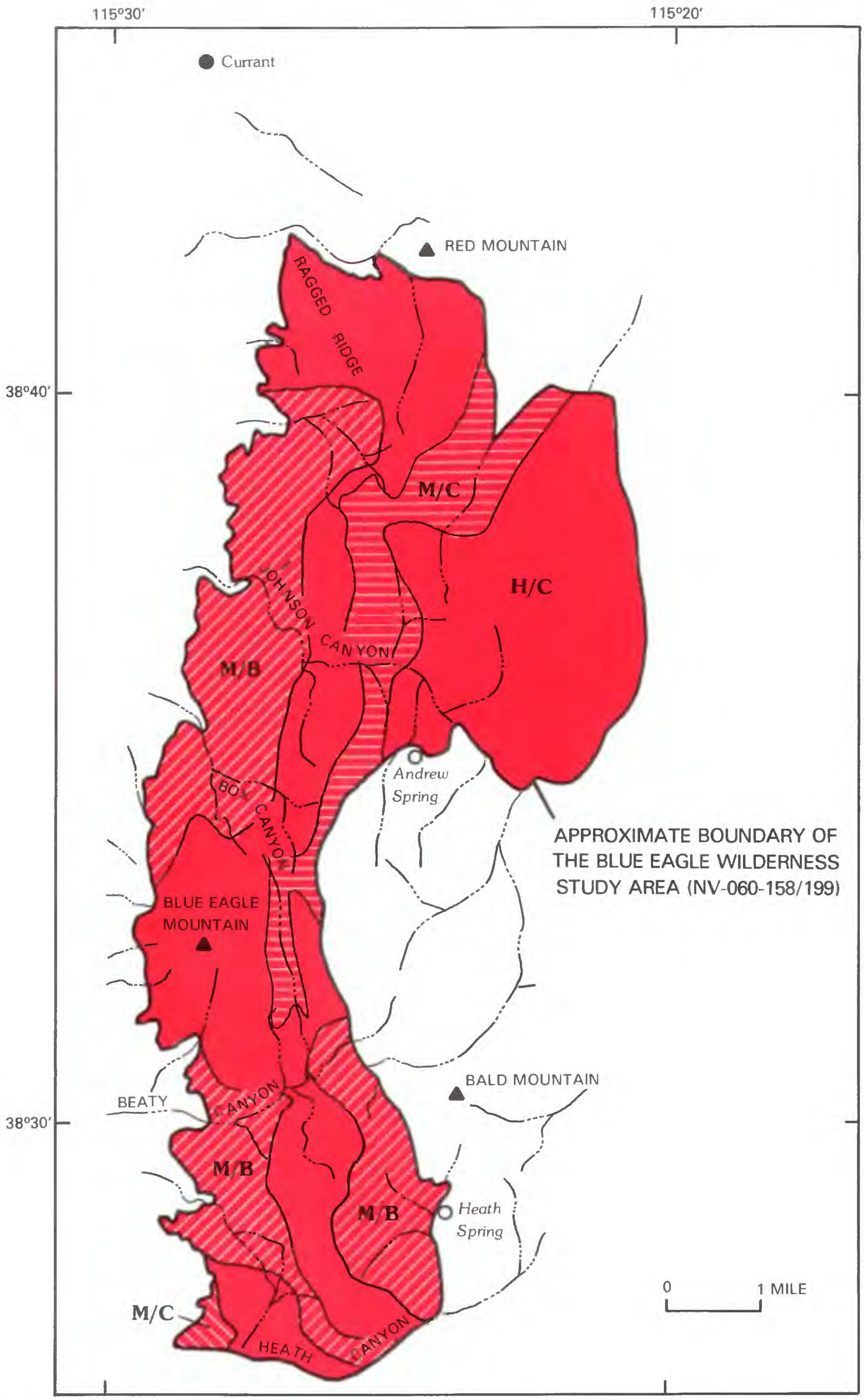

Figure 2 (above and facing page). Summary map showing mineral resource potential of the Blue Eagle Wilderness Study Area, Nye County, Nevada.

EXPLANATION

[The wilderness study area has low resource potential for metals not shown below, nonmetals, and geothermal energy, with certainty level B]

H/C	Geologic terrane having high energy resource potential for oil and gas, at certainty level C
	Geologic terrane having high energy resource potential for oil and gas (certainty level C) and moderate mineral resource potential for commodities as indicated below
M/B	Zinc and antimony (certainty level B)
M/C	Gold (certainty level C)
M/C	Gold and silver; tungsten; bismuth, copper, molybdenum, lead, and zinc (certainty level C)

Levels of certainty

B—Available information suggests level of resource potential

C—Available information gives good indication of level of resource potential

resource potential is the likelihood of occurrence of undiscovered metals and 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. Undiscovered resources are studied by the USGS.

Investigations by the U.S. Bureau of Mines

U.S. Bureau of Mines personnel conducted a literature search for minerals information prior to field work. Oil and gas plat maps were examined for leases; BLM records were checked for current mining claims. During May and June 1984, two USBM geologists conducted a 7-day field examination. Foot traverses and a helicopter reconnaissance were made to search for prospects and mines in and near the wilderness study area. Sixty-one samples were taken from prospects, mines, and outcrops (Tuftin, 1985); 38 of these samples were from the wilderness study area. All samples were analyzed for gold and silver by inductively coupled plasma procedures. Eighteen samples were tested for 40 elements by semiquantitative optical emission spectrographic analysis. Four samples were analyzed for uranium by fluorometric methods. Selected samples were analyzed by atomic-absorption spectrophotometry for arsenic, antimony, and lead, and by X-ray fluorescence for tungsten and barium.

Investigations by the U.S. Geological Survey

In August 1984, USGS geochemists collected 106 samples of stream sediment and heavy-mineral concentrate at 100 sites in and near the wilderness study area. Rock samples were collected at 93 sites that had visible signs of alteration, veining, or possible sulfide minerals. Additional rock-chip samples of both altered and silicified rock and fresh rock were collected by USGS geologists at 65 sites in the course of geologic mapping. The sampling and analytical procedures (see the section on "Geochemistry") are described, and detailed analytical results are presented in a report by Tucker and others (1986).

New gravity measurements were made in the study area during the fall of 1985 by USGS geophysicists. Aeromagnetic studies include both a newly flown survey (U.S. Geological Survey, 1985) and older data (U.S. Geological Survey, 1976, 1979).

During the summer of 1984 and the summer and early fall of 1985, USGS geologists mapped the wilderness study area and additional areas not included in the study area but that lie between the study area and Railroad Valley to the west (Karen Lund and L. S. Beard, unpub. mapping). Mineral resource potential was classified according to the system of Goudarzi (1984; see Appendix, this report).

Acknowledgments.—The BLM personnel of the Ely district office provided much help; we are especially indebted to William Robison, geologist.

APPRAISAL OF IDENTIFIED RESOURCES

By S. E. Tuftin
U.S. Bureau of Mines

Mineral-Exploration History

No patented mining claims or organized mining districts are in the wilderness study area. However, three unpatented lode-claim groups have been located in and near the wilderness study area (fig. 3).

On the Galena claims, outside the southwestern corner of the wilderness study area, faults and quartz veins are exposed in 16 prospect pits, 1 shaft, and 3 adits. In June 1984, these claims were held and had been operated intermittently by Don Lani of Currant, Nev.

The GM claims, in the north-central part of the wilderness study area (fig. 3), contain outcrops of jasperoid (silicified limestone) associated with shale. In 1981, 12 holes were drilled into this jasperoid-shale sequence in a joint venture between Energy Reserves Group of Golden, Colo., and U.S. Minerals Exploration Co. of Arvada,

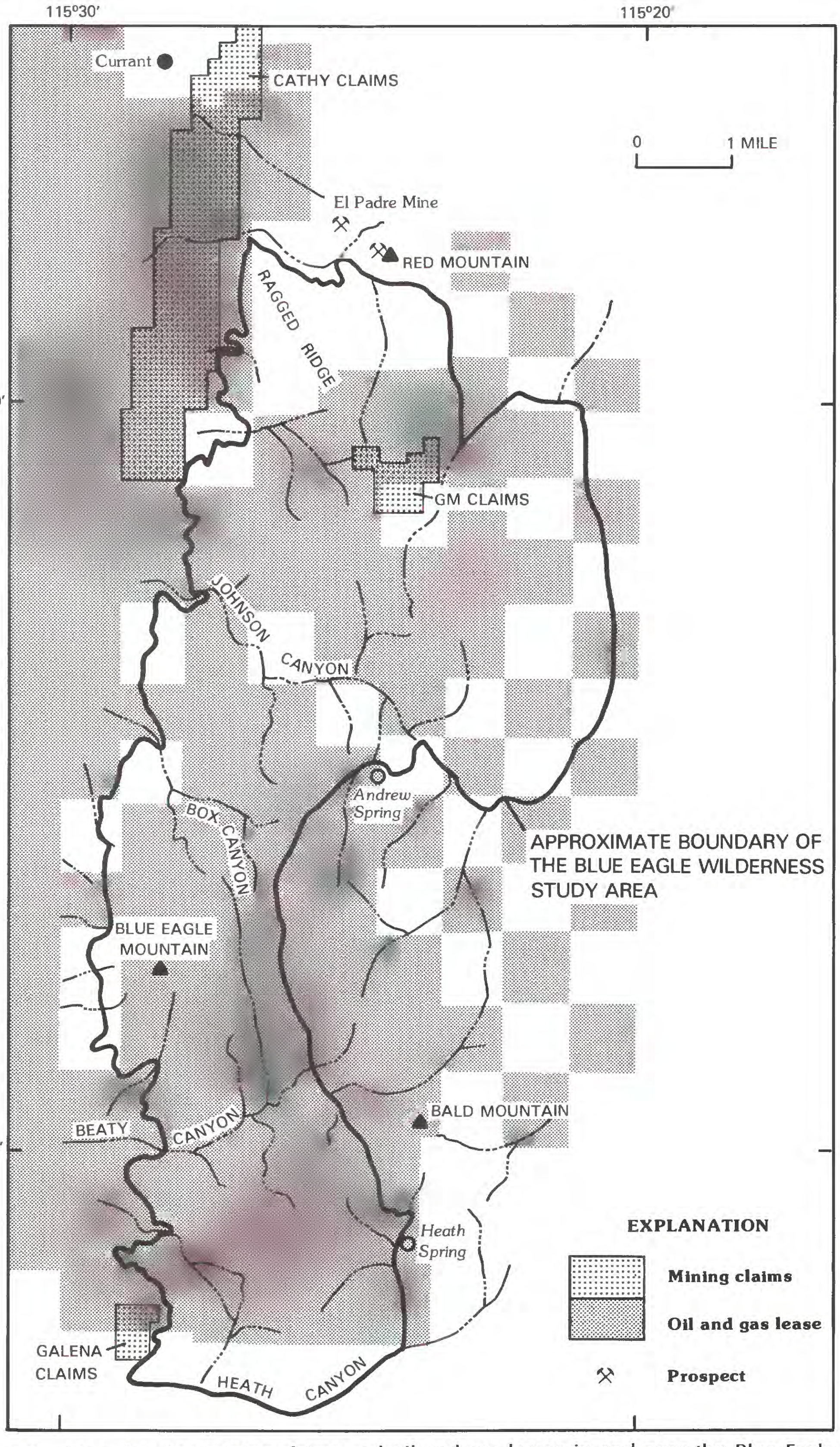

Figure 3. Map showing mining claims and oil and gas leases in and near the Blue Eagle Wilderness Study Area, Nye County, Nevada.

Colo. Apparently, these efforts revealed no significant gold anomalies, and the claims were allowed to lapse (Bob Hemming, U.S. Minerals Exploration Co., oral commun., 1985). The GM claims were restaked in 1984, and the same year a new block of claims was staked contiguous to and west of the old group by J. W. Mueller, Arvada, Colo. (fig. 3).

The Cathy claims are on alluvial gravels along the northwestern border of the wilderness study area (Tuftin, 1985). During the course of this study, no prospects or evidence of drilling were observed.

The El Padre mine, 0.5 mi north of the wilderness study area, has produced decorative stone (vitric tuff) used as facing stone for buildings and ornamental structures. The mine, which consists of bulldozer cuts and a small inclined shaft, has not been worked in recent years.

Exploration for uranium by private companies has occurred near the wilderness study area. One prospect includes a 30-ft-deep shaft in welded tuff on the west slope of Red Mountain (fig. 3), about 0.3 mi north of the wilderness study area boundary. In addition, bulldozer cuts in vitric tuff north of the El Padre mine were apparently made for uranium exploration. However, no mineral production was reported from any of these prospects, and no prospects are in the study area.

Appraisal of Mineral Sites Examined

Near the GM claims (fig. 3), jasperoid has been investigated as a possible host for disseminated gold deposits. Gold and silver were not detected in the jasperoid outcrops sampled by the USBM. Surface sampling and drilling by Energy Reserves Group and U.S. Minerals Exploration Co. showed no significant gold values (Bob Hemming, U.S. Minerals Exploration Co., oral commun., 1985).

Gold and silver are irregularly distributed in quartz veins and along faults exposed in prospects on the Galena claims adjacent to the southwestern corner of the wilderness study area. The quartz veins are typically 3–6 in. (inch) thick and are of undetermined length because of lack of surface exposures and faulting. Fifty-two samples were collected from these northeast-striking, steeply dipping veins and faults. Sixteen of the 52 samples contained more than 0.1 oz (troy ounce) gold per ton (Tuftin, 1985, table 1). The highest gold value (3.8 oz/ton) was from a chip sample that was collected across a 3-in.-wide quartz vein in an adit. Examination of surface exposures of quartz veins and faults was limited by cover. Tonnage and grade calculations are not possible without more extensive work that is beyond the scope of this study.

At the El Padre mine north of the study area, vitric tuff was mined for decorative building stone and was prospected for uranium. Much of the stone is plain pale gray or yellow; some of it has colored bands and swirls of reds, purples, and yellows. The colors and aesthetics of the vitric tuff vary greatly; therefore, tonnage and grade estimates are difficult to apply to this material. Although outcrops of vitric tuff extend into the northern part of the wilderness study area, the aesthetic qualities cannot be determined from weathered outcrops. Analyses of USBM samples indicate that the vitric tuff has as much as 3.3 ppm (parts per million) uranium. A dump sample from a 30-ft-deep shaft in welded tuff on Red Mountain (north of the wilderness study area) assayed 23 ppm uranium.

Petroleum Production History

The Blue Eagle Wilderness Study Area borders oil fields in Railroad Valley to the west (fig. 1). The Eagle Springs oil field is the closest to the wilderness study area (2 mi west). This field was discovered in 1954 by Shell Oil Co. and has been explored extensively. Since discovery of the Eagle Springs oil field, four other fields have been located in Railroad Valley (Poole and Claypool, 1984): the Trap Spring oil field (about 8 mi west of the wilderness study area), the Grant Canyon and Bacon Flat fields (about 4 and 5 mi southwest of the wilderness study area, respectively), and the Currant field (about 3 mi west of the wilderness study area). The oil fields are separated from the Grant Range (and the wilderness study area) by a series of normal faults that have an apparent stratigraphic displacement of 10,000 to 15,000 ft (Bortz and Murray, 1979). The Eagle Springs field produced 3.74 million barrels of oil through April 1985; total recoverable reserves for the field are estimated at 4.5 to 5.0 million barrels (Norman Melvin, BLM, Reno, Nev., oral commun., 1985). Both Paleozoic and Tertiary rocks have been suggested as source rocks. Most of the wilderness study area and the surrounding area are covered by oil and gas leases (fig. 3).

Recommendations

Gold and silver occur in thin, short, discontinuous quartz veins and in fault zones near the southwestern part of the wilderness study area. The gold and silver distribution in the veins is irregular. The small size of the gold- and silver-bearing veins and the erratic distribution of these metals precludes mining at a profit at 1984 prices. More detailed mapping and surface and subsurface sampling are needed to determine the extent and grade of gold and silver occurrences in the wilderness study area near the Galena claims.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Karen Lund, J. Thomas Nash, L. S. Beard, and H. R. Blank, Jr.
U.S. Geological Survey

Geology

The Blue Eagle Wilderness Study Area is in the middle of the Great Basin of east-central Nevada. During the Paleozoic, this part of Nevada was on the continental shelf of North America and was the site of deposition of about 20,000 ft of predominantly carbonate rocks. This part of Nevada lies east of the regions most affected by deformation that occurred during the Devonian to Mississippian (Antler) and Permian to Triassic (Sonoma) orogenies and west of the main zone of thrust-fault ramping that occurred during Mesozoic orogenic activity. Lower Tertiary sedimentary deposits in and near the wilderness study area may have formed in basins that were caused by upper crustal disturbances during the late Mesozoic thrust faulting. The present-day Basin-and-Range configuration of the region formed during later Tertiary crustal extension that was concomitant with volcanism and local sediment deposition. The regional extension is expressed by both low- and high-angle normal faults, the youngest of which brought about relative uplift and tilting of the mountain ranges.

Stratigraphy

The stratigraphic succession in the wilderness study area is divisible into two general sequences that were deposited in different tectonic environments. Rocks of Upper Cambrian through Pennsylvanian (and possible Permian) ages make up the Paleozoic continental-shelf strata. These strata are predominantly carbonate rocks. Upper Cambrian rocks in the wilderness study area are low- to medium-grade metamorphosed silty carbonate rocks. The Early to Middle Ordovician Epochs are represented by the Pogonip Group, which occurs both as low-grade metamorphosed silty carbonate rocks in the southern part of the area and as brittlely deformed rock in the northern part, and by quartzose sands of the Eureka Quartzite. The Upper Ordovician Ely Springs Dolomite, Silurian Laketown Dolomite, Upper Silurian to Lower Devonian Sevy Dolomite, and Middle and Lower Devonian Simonson Dolomite compose a thick section of carbonate rocks that are shown combined on plate 1. This Ordovician to Devonian dolomitic section is overlain by the thick, cliff-forming Upper and Middle Devonian Guilmette Formation that is composed of limestone interlayered with less prevalent dolomite and minor shaley limestone beds. The Upper Devonian Pilot Shale, which is a major gold-producing unit in the region, is absent in the wilderness study area because of nondeposition (Poole and others, 1977). The Lower Mississippian Joana Limestone and Upper Mississippian Chainman Shale are shown combined on plate 1. Many occurrences of jasperoid (Lovering, 1972) are in the Joana Limestone where it is in fault contact with Chainman Shale. The Pennsylvanian Ely Limestone is gradational with the Chainman Shale. An unnamed minor silty limestone of Permian(?) age may be present above the Ely Limestone in places (F. G. Poole and F. J. Kleinhampl, oral commun., 1985).

Eocene nonmarine rocks of the Sheep Pass Formation unconformably overlie Paleozoic strata. The environment of deposition is interpreted to have been lacustrine (Fouch, 1979).

Younger rocks unconformably overlie Middle Devonian to Eocene rocks. Oligocene and younger volcanic rocks are interlayered with and overlain by Miocene to Pliocene basin-fill sedimentary rocks. The volcanic rocks are rhyolitic ignimbrite (ash-flow) and tuffaceous rocks that have been subdivided into several different formations (Cook, 1960; Scott, 1965). The distribution of the volcanic units is uneven; some have local sources, whereas other volcanic units occur regionally and have more distant sources (Cook, 1960; Moores and others, 1968). Miocene to Pliocene sedimentary rocks of the Horse Camp Formation are composed of sandstone, conglomerate, and freshwater limestone. These detrital rocks are mostly volcanic derived but also contain clasts of Paleozoic carbonate rocks indicating that the Horse Camp Formation formed during extensional tectonism (Moores and others, 1968).

Quaternary alluvium and colluvium occur as bouldery to sandy debris in stream-channel, valley-fill, pediment-covering, alluvial-fan, and windblown deposits.

Metamorphism

Upper Cambrian to Middle Ordovician rocks have been metamorphosed to both low and medium grades. The metamorphic fabric is defined by aligned mineral flakes or by transposed bedding. Fabrics in these rocks indicate that metamorphism occurred by dynamic, regional processes rather than by static contact metamorphism. In the Troy mining district (fig. 1), intrusion of the Troy Canyon pluton postdates the metamorphism of country rocks (Hill, 1916). Metamorphosed rocks are separated from overlying unmetamorphosed rocks by a low-angle fault.

Structure

Metamorphosed Upper Cambrian and Lower and Middle Ordovician rocks were subjected to Mesozoic ductile deformation. The Mesozoic structures consist predominantly of east-directed minor folds. Six miles south of the wilderness study area, the regional metamorphic fabric in these rocks was deformed into a large, east-vergent, overturned anticline before being intruded by the late Mesozoic (70-million-year-old) Troy Canyon granite pluton (J. E. Fryxell, written commun., 1985). Dismembered fragments of Mesozoic compressional structures are also present as minor features in nonmetamorphosed younger rocks of the wilderness study area.

Cenozoic low-angle and associated minor high-angle extensional faults attenuate the stratigraphic section in the wilderness study area and cut and rotate units from Cambrian to Holocene in age. Major detachment faults occur at the base of Tertiary and Mississippian strata and at the base of the Middle and Upper Devonian Guilmette Formation as well as within the Guilmette Formation and the upper part of the Pogonip Group. Metamorphosed Upper Cambrian to Middle Ordovician rocks, which previously underwent Mesozoic ductile deformation, are juxtaposed against the overlying younger, nonmetamorphosed Devonian and Mississippian rocks along a shallow west-dipping detachment fault on the western side of the wilderness study area. Rocks of the upper plate are intensely brecciated, whereas those of the lower plate are not. Jasperoid breccias are common along low-angle faults in the Mississippian rocks. The effects of hydrothermal alteration are found along the low-angle faults at the base of the Middle and Upper Devonian Guilmette Formation. Quartz veins are common in steep faults in the Upper Cambrian metamorphic rocks.

Steep normal faults with down-to-the-west movement are concentrated along the western side of the wilderness study area. Although only minor movement has occurred along them, these faults are probably related to the range-front fault that dropped Railroad Valley relative to the Grant Range. This fault may flatten at depth (be shovel shaped) (Effimoff and Pinezich, 1981) and may join a low-angle detachment-fault system beneath the cover in Railroad Valley (see the section on "Geophysics"). These steep normal faults may form the migration paths for petroleum out of source rocks in the range into traps in Railroad Valley (Poole and Claypool, 1984). The down-to-the-west faults separate petroleum-bearing strata in Railroad Valley from like rocks on the eastern side of the wilderness study area.

Geochemistry

The geochemical evaluation of the wilderness study area was based on analytical results for stream-sediment and heavy-mineral-concentrate samples (described below) from 100 sites and for rock samples from 158 sites in the Blue Eagle Wilderness Study Area (Tucker and others, 1986).

The composition of stream-sediment samples reflects the chemical composition of rocks exposed in the drainage basin upstream from the sample site. For this study, two fractions were analyzed from each sample collected from active stream alluvium: the minus-60-mesh (less than 0.25 mm or millimeter) fraction and the nonmagnetic heavy-mineral fraction. The minus-60-mesh fraction, termed "stream sediment" for simplicity, is utilized to provide an indirect sample of rocks exposed upstream; this medium has none of the advantages or disadvantages of fractionating minerals from the source rock. The nonmagnetic heavy-mineral concentrate fraction is employed because it contains certain minerals that generally can be interpreted to be related to mineralization or alteration processes. Results of these analyses are used to identify areas with unusual geochemical composition, an important step in identifying areas with mineral resource potential.

Geochemical analyses of rocks provide a variety of information that is useful in identifying rock types, the character of altered rocks, and elements lost or gained during alteration or mineralization processes. Analyses of rock are utilized to identify zones containing metals of possible significance as well as associated elements that might serve as guides to undiscovered deposits. Much of our rock geochemical study was aimed at identifying silver and gold, as well as commonly associated or pathfinder elements such as arsenic, antimony, bismuth, cadmium, and zinc. Rock samples collected by the USGS were taken to highlight geochemical characteristics rather than to obtain an assay of a vein or wall rock.

All samples were analyzed for 31 elements using a six-step semiquantitative emission spectrographic method (Meyers and others, 1961). In addition, for elements with high limits of determination by the spectrographic method, rock and stream-sediment samples were analyzed by a chemical method (Crock and others, 1983) for arsenic, bismuth, cadmium, antimony, and zinc; selected rock samples were analyzed by atomic-absorption spectrometry for gold and thallium. The analytical results are presented in Tucker and others (1986).

The framework for interpretation of these data is USGS geochemical studies in the nearby Tonopah 1°×2° quadrangle that include analyses of more than 1,200 samples of stream sediments, an equal number of concentrates, and more than 2,000 samples of mineralized rocks from mines and prospects (Nash and Siems, in press). Thus, we interpret the geochemistry of the wilderness study area by comparison with the geochemical signatures of known deposits and mining areas in the region, using similar geochemical data. In this interpretation, geochemical anomalies are considered to be especially important if several elements are enriched at a site and if several adjacent sites are characterized by the same geochemical suite. In addition, sites characterized by multiple-element associations, which are consistent with geochemical theory or are recognized in known ore deposits in the region, are considered most diagnostic and reliable for mineral resource assessment. Also, our experience with stream-sediment and concentrate data from the Tonopah quadrangle shows that anomalies in concentrates tend to be more directly relatable to areas of significant alteration or mineral deposition than are those in the stream sediments.

Low-magnitude geochemically anomalous sites are scattered across the wilderness study area, but most of the anomalies do not suggest the presence of significant mineral deposits. Three types of geochemical anomalies (gold and silver, zinc and antimony, and polymetallic base metal) are present in four areas; only the area of the polymetallic base-metal anomaly seems to indicate significant mineral deposition.

Polymetallic Base-Metal Anomaly

An area in the southwestern corner of the wilderness study area, which adjoins the Galena claims (fig. 3), contains a cluster of sites with anomalously high values of base metals. These high to very high values are for bismuth (50–700 ppm), lead (500–15,000 ppm), and tungsten (100–7,000 ppm) in concentrates and arsenic (>10 ppm) and antimony (>5 ppm) in stream sediments. Three concentrate samples were anomalous in silver (2–70 ppm). Although copper and molybdenum are not enriched at these sites, this polymetallic suite otherwise resembles that found in concentrate and stream-sediment samples near known tungsten skarn deposits to the west in the Tonopah quadrangle (Nash and Siems, in press). This suite of elements plus zinc, copper, and gold (as much as 19 ppm) were present in high concentrations in our mineralized rock samples from prospect pits in the Galena claims. Such a polymetallic suite, and particularly the presence of bismuth and tungsten, is characteristic of vein or skarn deposits near the margins of plutons (Nash and others, 1985). Although we do not have geochemical data from the Troy mining district 6 mi to the south, the data from the Galena claims suggest a similar geologic environment to that described by Hill (1916) for the Troy mining district.

Jasperoid Alteration

Only a few weak single-element anomalies were found in scattered stream-sediment samples from drainages that cut the area of jasperoid alteration in the north-central part of the wilderness study area. Five weak anomalies in zinc, arsenic, antimony, and silver were found at four sites. Thirty rock samples taken by the USGS from outcropping jasperoid contained a few scattered single-element anomalies in arsenic, molybdenum, and mercury; gold, ranging from 0.05 to 0.25 ppm, was detected in three samples (Tucker and others, 1986). Similar scattered, weak anomalies in gold and these other metals were found in about 100 samples collected by J. W. Mueller (owner of GM claims, written commun., 1985) during geochemical exploration of the GM claims. These geochemical results, along with the obvious silicification, indicate that there has been hydrothermal activity, but available geochemical evidence suggests that it was not the type that results in gold resources. In other parts of Nevada, favorable geochemical indications of gold deposits underlying jasperoid are multielement associations of arsenic, mercury, and antimony in jasperoid that contain values consistently greater than 100 ppm, 1 ppm, and 20 ppm, respectively (Tooker, 1985); values of these magnitudes were not found in the wilderness study area. However, gold may or may not be detected in outcropping jasperoid above disseminated gold deposits (Radtke and others, 1980; Tooker, 1985).

Zinc-Antimony Anomalies

Two elongate areas in the southeastern and western parts of the wilderness study area (fig. 2) are characterized by many adjacent sites of zinc and antimony anomalies in stream sediments (with values greater than 70 and 3 ppm, respectively). The area in the southeastern corner of the wilderness study area has a few sites of anomalous arsenic (>15 ppm) in stream sediments and lead and zinc (>150 ppm each) in concentrates. The other area, along the western range front, has 19 sites with stream sediment containing anomalous antimony; three of the sites contain anomalous zinc. The source of these anomalous values is not well understood geologically, but the two areas are underlain by complexly normal-faulted carbonate rocks. The anomalies probably reflect hydrothermal-fluid leakage along low-angle north-trending faults (pl. 1); altered fault zones have been recognized in the field.

Some scattered sites in the northwestern part of the wilderness study area also have weak, single-element anomalies of arsenic, antimony, or zinc in stream sediment. In the absence of geologic evidence for mineralization, these weak anomalies are not sufficient evidence to postulate the existence of significant mineral deposits.

Geophysics

Data

The Blue Eagle Wilderness Study Area was included in a high-level (11,500-ft) aeromagnetic survey of the northwestern part of the Lund 1°×2° quadrangle (U.S. Geological Survey, 1976) and was partly covered in the south by a draped (constant elevation above the surface) aeromagnetic survey of the Quinn Canyon Range (U.S. Geological Survey, 1979). In addition, the Blue Eagle Wilderness Study Area and adjacent areas were the target of a survey flown in January 1985 designed to provide uniformly low-level, closely spaced total-intensity magnetic data (U.S. Geological Survey, 1985).

Gravity data for the study area were obtained from files of the U.S. Defense Mapping Agency (available through the National Center for Geophysical and Polar Terrestrial Data, Boulder, CO 80303). Twenty new gravity stations were established in the wilderness study area and vicinity in November 1985 and April 1986 with the assistance of J. H. Hassemer of the USGS. Together, the aeromagnetic and gravity data contribute to understanding the regional geologic framework upon which the mineral resource potential assessment of the study area is founded.

Magnetics

The aeromagnetic data from the three data sets were merged to produce a total-intensity residual field map of the wilderness study area and vicinity at a drape altitude of 1,000 ft above terrain (fig. 4). This map reveals two prominent long-wavelength positive anomalies and a complex of intense positive-negative dipolar anomalies approximately along the axis of a north-trending broad anomaly that occupies the western half of the map area, including large parts of both Railroad Valley and the Grant Range. The character of the dipole anomaly complex, which is in the northwestern corner of the map area and is centered in Railroad Valley, suggests a steep vertical shape of the source or sources. Because this complex is in the vicinity of outcrops of Tertiary volcanic rocks (Kleinhampl and Ziony, 1985), we infer a buried volcanic edifice or plugs in the shallow subsurface of the valley. The two positive anomalies, farther south along the anomaly ridge, suggest homogeneous bottomless source bodies whose upper surfaces are more or less domoform. These anomalies are discussed further below. On the eastern flank of the broad ridge is a relatively narrow belt of short-wavelength anomalies associated with Tertiary extrusive volcanic rocks of the Grant Range (pl. 1). A strong, partly delineated positive anomaly is in the northeastern corner of the map area. This feature is associated with a Tertiary volcanic center east of the axis of the White Pine Range (Kleinhampl and Ziony, 1985). Like the dipole anomaly complex, it is remote from the study area and does not affect the present investigation.

The focus of this study was mainly on the geological significance of the broad linear feature and especially on its two prominent highs, both of which require sources that project into the Blue Eagle Wilderness Study Area. The ridge and two highs occur almost entirely over very weakly magnetic rocks: unconsolidated sediments on the west and Paleozoic sedimentary strata of the Grant Range on the east (pl. 1). However, the southern flank of the southern, more intense, high coincides with outcrops of the Troy Canyon pluton (see the section on "Structure"). Because the gradients indicate that the top of the source is locally at or near the ground surface, we infer that the anomaly reflects the largely buried pluton. The source of the northern high, which appears to be of similar areal extent but more deeply buried, is also likely to be a granitic pluton. More tenuous is the interpretation of the broad anomaly ridge itself. This feature may be the expression of a much more extensive granitic body underlying but connected with the interpreted higher level plutons. The aeromagnetic signature of cupolas would be expected to be more intense than that of a subjacent parent body because of their relative proximity to the detector and also because the upper, peripheral phases of a large intrusive mass may have a higher content of magnetic minerals. An alternative interpretation of the anomaly ridge, and of the northerly positive anomaly as well, is that they are due to structural highs on a magnetic Precambrian crystalline basement. This interpretation requires the Paleozoic rocks of the Grant Range to have been tectonically thinned on one or more low-angle structures, a condition indicated in the Grant Range by the geologic mapping (pl. 1). Without more data, neither explanation is more favored.

Whatever the nature of the causative bodies, they extend at depth across the physiographic boundary between Railroad Valley and the Grant Range. No offsets of any of the source bodies at the margin of the range are evident from the aeromagnetic data; the concealed magnetic basement appears to be independent of Cenozoic basin-and-range structure. This lack of correlation strengthens the geologic interpretation that the range-front faults flatten to the west and terminate on a detachment fault at the surface of the magnetic basement (see the section on "Structure"; pl. 1). The sources of the two positive anomalies may be displaced by range-front faults, but the offsets were not detected by the magnetic survey because of the combination of fault geometry and shape of the upper surfaces of the magnetized bodies.

Gravity

A complete Bouguer gravity anomaly map (fig. 5) of the study area and vicinity was compiled by reducing all available gravity data at a density of 2.67 grams per cubic centimeter with standard procedures (Cordell and others, 1982, for example) and with the use of terrain corrections computed from a digital topographic image to a radius of 100 mi from each station. No terrain corrections were made manually. Where local relief is great, the complete Bouguer anomaly values have uncertainties that may exceed the contour interval.

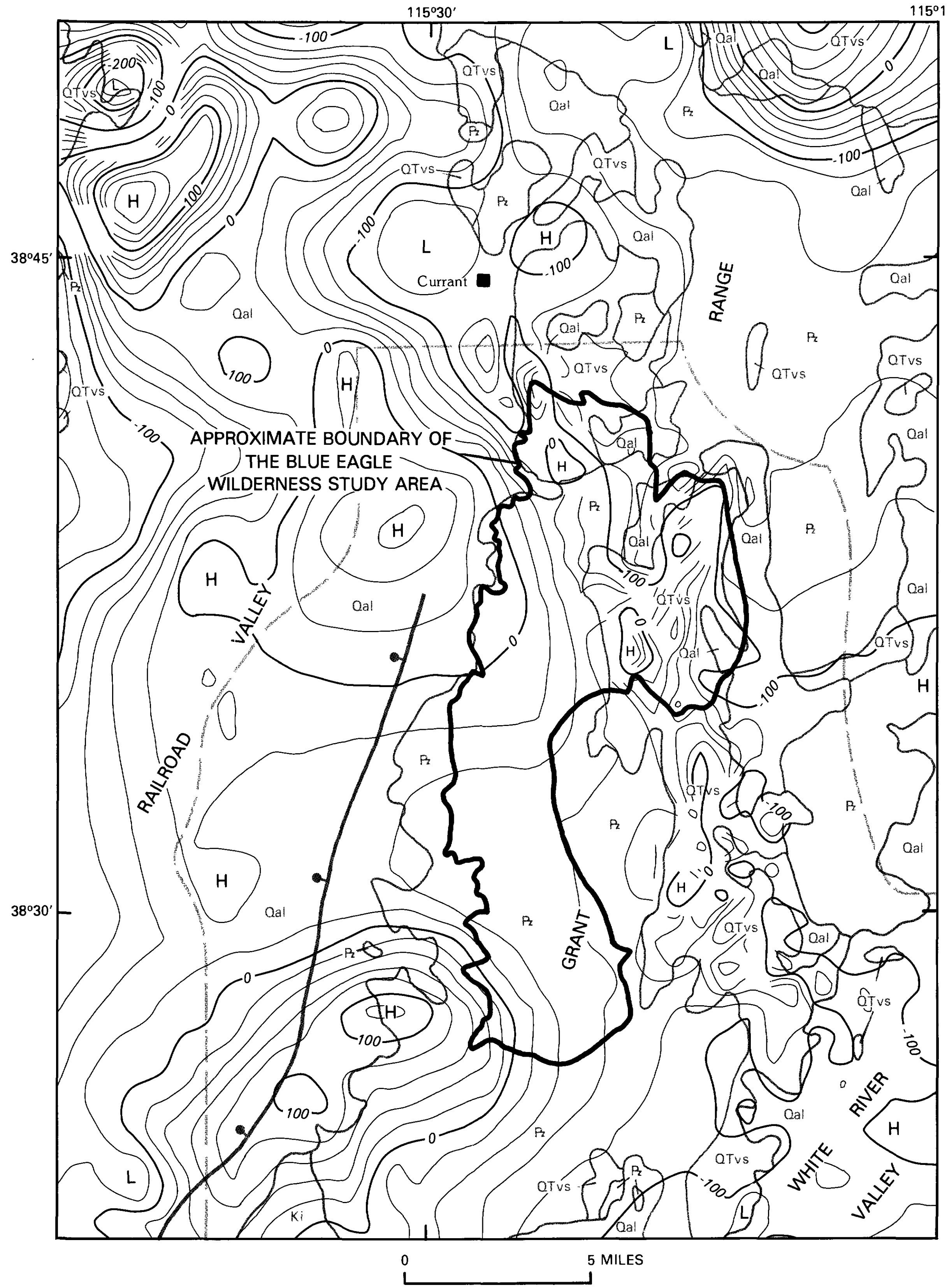

Figure 4 (above and facing page). Residual total-intensity aeromagnetic anomaly map of the Blue Eagle Wilderness Study Area and vicinity, Nye County, Nevada. Average height of survey, 1,000 ft above terrain; International Geomagnetic Reference Field removed; arbitrary datum.

EXPLANATION

— -200 —	**Anomaly contour**— Contour interval 20 and 100 nanoteslas
	Boundary of aeromagnetic survey of January 1985
H	**Anomaly high**
L	**Anomaly low**
Qal	**Quaternary alluvium**
QTvs	**Quaternary and Tertiary volcanic and sedimentary rocks**
Ki	**Cretaceous granite of Troy Canyon pluton**
Pz	**Paleozoic rocks**
	Range-front fault— Delineated by gravity gradient (fig. 5) and alignment of springs. Bar and ball on downthrown side
	Geologic contact Generalized from Kleinhampl and Ziony (1985)

The predominant feature of the gravity anomaly map is the contrast in anomaly values between Railroad Valley and the Grant Range. The large negative anomaly in the valley, which reaches a level 40 to 44 mGal (milligals) below that of the adjacent part of the range, is centered 10 to 12 mi southwest of Currant and about 3 mi west of the producing Eagle Springs oil field (compare figs. 1 and 5). The maximum depth of fill here is probably about 6,000 ft, depending on details of form and density contrast. The steep gradient on the eastern side of this low indicates the presence of a high-angle range-front fault as far as 2 mi west of the fault mapped by Kleinhampl and Ziony (1985). As noted above, this fault may flatten westward at depth. The fault is well delineated both by the gravity gradient (fig. 5) and by alignment of springs at the toe of the alluvial apron on the western side of the Grant Range (pl. 1). North of Currant, the gradient becomes diffuse, and it is difficult to locate any range-front fault on the basis of the gravity data, suggesting that in this vicinity frontal structures are gently inclined even at the surface. A weak gravity salient of about −4 mGal with respect to the range anomaly (near the southwestern corner of the wilderness study area) coincides with the southern of the two aeromagnetic highs discussed above. The source of the southern magnetic anomaly is therefore likely to be somewhat less dense than the average density of the Paleozoic carbonates, in agreement with its interpretation as the signature of the Troy Canyon pluton. The sources of the northern aeromagnetic high and of the broad linear aeromagnetic anomaly, on the other hand, have no apparent gravity expression, probably because the density contrast is weak, and they are more deeply buried.

A gravity low of about 6 mGal in the east-central part of the range (fig. 5) generally coincides with a topographic depression containing Quaternary alluvium and Tertiary sedimentary and volcanic rocks. Deeper lows shown on the eastern edge of the map area are associated with alluvial deposits of the White River Valley. The steep gradient in the extreme northeastern corner of the map area coincides with the magnetic high in that area and leads to a large gravity low associated with a volcanic complex on the eastern flank of the White Pine Range north of the wilderness study area. None of these features is of direct concern to the Blue Eagle Wilderness Study Area.

Mineral and Energy Resources

Replacement and Vein Deposits

Metamorphosed magnesian carbonate rocks commonly contain metal deposits that formed by hydrothermal replacement of the original rock; these deposits are called skarns or metasomatic replacement deposits. Most skarn deposits form near the contact between carbonate rocks and plutons of quartz monzonite to granodiorite composition where contact metamorphism forms calc-silicate minerals in carbonate rocks; alteration and mineralization result from circulation of hydrothermal fluids. Gold deposits are the most valuable deposits of the skarn type. Both tungsten and polymetallic base-metal sulfide skarns are formed by the same processes. Tungsten skarns may contain molybdenum, copper, zinc, or bismuth. Polymetallic base-metal skarns are characterized by anomalous contents of tungsten, copper, lead, zinc, molybdenum, bismuth, and silver. Lead-zinc skarn deposits may form in environments a few miles from a pluton under conditions where fluids traveled along fractures and cooled before deposition of the more soluble elements (Einaudi and others, 1981). Although this hydrothermal-replacement or skarn model seems to be the best model for mineralization in the southwestern part of the wilderness study area, not all aspects of the geology fit the model.

The southwestern corner of the wilderness study area and the nearby Galena claims are in the lower plate directly below the detachment fault that separates regional metamorphosed silty carbonate rocks from unmetamorphosed rocks; the metamorphic rocks are cut by many steep normal faults. Although geophysical information indicates the presence of buried plutonic rocks in this area (see above), the metamorphism is a regional type that occurred before intrusion of the plutons and is not the contact type. Thin, discontinuous quartz veins in fractures contain sulfide minerals. The area is characterized by anomalously high values for tungsten, molybdenum, bismuth, lead, zinc, copper, arsenic, silver, and gold in the

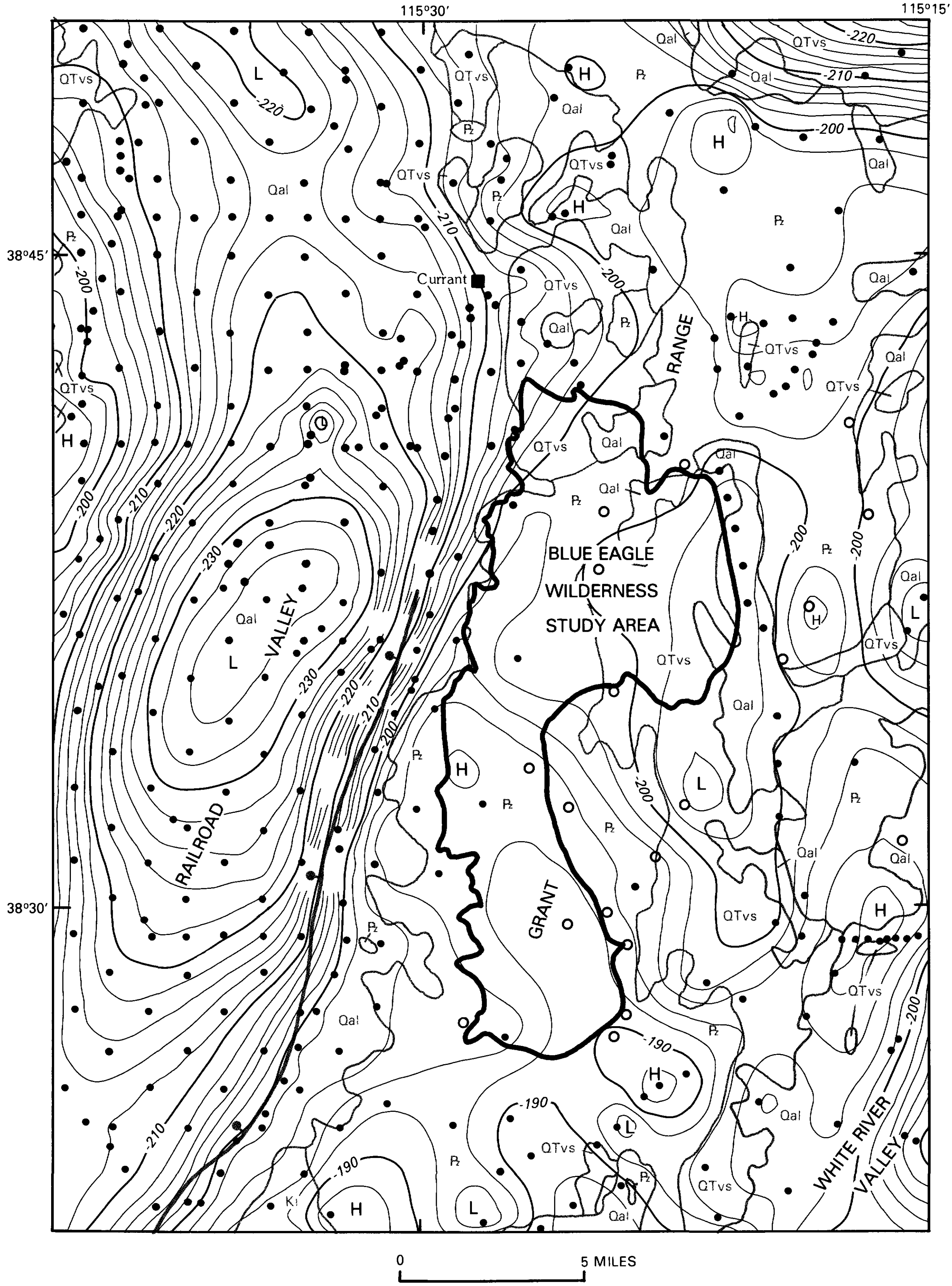

Figure 5 (above and facing page). Complete Bouguer gravity anomaly map of the Blue Eagle Wilderness Study Area and vicinity, Nye County, Nevada. Terrain corrected from digital topography to 100 mi.

EXPLANATION

-210-	**Complete Bouguer gravity anomaly contour**— Contour interval 2 milligals
H	**Anomaly high**
L	**Anomaly low**
•	**Gravity station**— U.S. Defense Mapping Agency
o	**Gravity station**— This study
Qal	**Quaternary alluvium**
QTvs	**Quaternary and Tertiary volcanic and sedimentary rocks**
Kı	**Cretaceous granite of Troy Canyon pluton**
Pz	**Paleozoic rocks**
	Range-front fault— Delineated by gravity gradient and alignment of springs. Bar and ball on downthrown side.
	Geologic contact— Generalized from Kleinhampl and Ziony (1985)

various sample media (see the section on "Geochemistry"). The southwestern corner of the wilderness study area has several features in common with metal-mineralized skarns: (1) the suite of anomalous elements is similar to that of known skarns, (2) the sulfide mineralogy is similar to that in skarn deposits, (3) the country rock is metamorphosed shaley carbonate rocks, and (4) an intermediate-composition pluton is nearby as in known deposits and may extend beneath the study area.

Similar deposits were exploited from 1867 to 1872 in the Troy mining district 6 mi south, and from 1911 to at least 1921 in the Willow Creek district 20 mi south (Lincoln, 1923; fig. 1). Only minor contact metamorphic effects are reported from around the granitic intrusion in these districts. In the Troy and Willow Creek districts, silver, gold, and copper were mined from quartz veins and mineralized fractures that cut both the Troy Canyon granite pluton and the regionally metamorphosed and deformed Cambrian carbonate rocks. The veins are not related to the minor contact-metamorphic effects found in some places near the granite, and generally the veins have clay gouge along them. The quartz vein material formed as open-space filling and shows multiple shearing episodes. Some deposits formed as replacements along bedding where movement of fluids may have been restricted by shale-rich layers (Hill, 1916).

Several important indications of skarn-type mineral deposits are absent from the wilderness study area and the deposits in nearby districts. The contact-metamorphic mineral assemblage that would be expected in skarn deposits related to the granite pluton is uncommon or absent. Although a buried pluton is indicated from geophysical data, the nearest exposure of granite is in the Troy district about 6 mi south of the wilderness study area, so there is no direct link between ore-forming fluids and intrusive rock; deposits in the Troy district were not linked with the adjacent granite (Hill, 1916). The absolute timing of veins and structures that contain veins is unknown, so more study is necessary to understand the structural setting of the veins and to determine if the host structures are old enough to have been the conduits for fluids circulating during emplacement and cooling of a 70-million-year-old pluton.

Because of the several positive indications of mineralization and in spite of unanswered questions about the origin of the mineralizing fluids and the host structures, this southwestern part of the wilderness study area has moderate mineral resource potential for tungsten in hydrothermal replacement deposits, for polymetallic base metals (Mo-Bi-Cu-Pb-Zn) in both replacement deposits and in quartz veins, and for gold and silver in quartz veins (fig. 2). Some important questions remain about the timing of structural events and mineralization relative to emplacement of the granite pluton, about the geometry of structures that contain mineralized rock, and about the unexposed extent of the Troy Canyon granite pluton. Without this information, the genesis of deposits in the nearby mining districts cannot be completely understood. The geochemical, geological, and historic-mining information give a good but not conclusive indication of the certainty of mineral resource potential (certainty level C, pl. 1).

Disseminated Gold Deposits

Disseminated gold deposits (Carlin-type) of the Great Basin are fine-grained, metal-bearing, siliceous replacements of Upper Devonian to Mississippian silty carbonate rocks, commonly associated with jasperoid occurrences. The deposits are thought to have formed by migration of low-temperature hydrothermal fluids along normal-fault conduits at shallow crustal levels. The hydrothermal fluids were meteoric water probably driven by shallow Tertiary igneous processes. The deposits are geochemically characterized by anomalously high values of the assemblage arsenic, mercury, antimony, and thallium (Radtke and others, 1980).

Jasperoid bodies occur in the wilderness study area along a north-northeast trend in the north-central part of the area that is underlain by complexly faulted Joana Limestone and Chainman Shale and is structurally overlain by Oligocene volcanic rocks (pl. 1). The jasperoids are localized in low- and moderate-angle normal-fault zones in the Joana Limestone or Chainman Shale; these faults have rotated and transported the volcanic rocks above the low-angle faults in the Joana-Chainman interval. The jasperoids are evidence that fluids circulated through the fault systems probably during and after volcanic activity. Two main kinds of jasperoid were recognized in the wilderness study area, as in the Ely mining district of White Pine County (Lovering, 1972). One type is massive, bright-colored, porcelain-like jasperoid in the northern part of the wilderness study area near the GM claims (fig. 3). This type is silicified Joana Limestone in which silicified fossils can be identified; many of these jasperoids have been brecciated and recemented by later jasperoid. Samples of the massive jasperoids of the GM claims have shown only weak geochemical anomalies. The other type is dark, vuggy, iron-oxide-stained jasperoid and recemented jasperoid breccia that crops out in the north-central part of the area (from north of Johnson Canyon to east of Blue Eagle Mountain, fig. 2) where the Chainman Shale was almost completely removed by low-angle normal faulting (pl. 1). These dark, vuggy jasperoids are anomalously high in arsenic, antimony, and zinc.

In the region near the wilderness study area, several disseminated gold and silver deposits have been discovered and recently mined; these are additional deposit models for comparison with the Carlin-type model. The Alligator Ridge gold mine, White Pine County, is about 100 mi north of the wilderness study area and fits the general characteristics of the Carlin-type model. The mine is in the Upper Devonian Pilot Shale (Klessig, 1984). The Taylor mine, on the western side of the Schell Creek Range in White Pine County, about 50 mi northeast of the wilderness study area, is a group of disseminated silver deposits in the Guilmette Formation, Pilot Shale, and Joana Limestone. Both deposits are associated with jasperoid occurrences; the source of the gold and silver is not known but may be the carbonaceous shales.

Because of some positive geologic, geochemical, and regional indications of mineralization and the applicability of the disseminated replacement gold deposit model, the north-central part of the wilderness study area has moderate resource potential for gold in Carlin-type deposits (fig. 2). A possibly significant contraindication is the absence of the Upper Devonian Pilot Shale due to nondeposition in the wilderness study area; this unit contains Carlin-type gold deposits regionally. The few favorable geochemical indications of mineralization were found along previously unprospected jasperoid zones near the attenuation fault between Mississippian and Devonian strata at the head of Box Canyon (pl. 1); these jasperoids may only persist to shallow depths (as was suggested for some in the Ely district by Lovering, 1972) and may be relatively small, isolated features. Because the size and extent of the hydrothermal systems associated with the outcropping jasperoid occurrences are unknown, but the positive indications of mineralization are present, the available information provides good but not conclusive certainty of the level of mineral resource potential (certainty level C, pl. 1).

Fault-Controlled Hydrothermal Deposits

Minor amounts of distal fluid from a hydrothermal system, such as that which caused replacement mineralization in Cambrian carbonate rocks in the southwestern corner of the wilderness study area, may have been the cause of zinc and antimony anomalies in samples from the southeastern and western sides of the wilderness study area. The areas with geochemical anomalies are underlain by magnesium carbonate rocks of several ages. The rocks have been cut by several groups of steep and shallow normal faults and are strongly brecciated. Evidence of hydrothermal alteration and minor concentration of metals occurs along shallow normal faults that are subparallel to bedding at the base of the Devonian Guilmette Formation in the southeastern part of the area. The rocks are compositionally favorable for chemical reaction with hydrothermal fluids and structurally favorable for the movement of such fluids; however, the source of the fluids is problematic. The normal faults that produced the excellent fluid-migration routes in the southeastern and western areas are probably Oligocene or younger (Moores and others, 1968; Fryxell, 1984), whereas fluids that caused mineralization in the southwestern corner of the area are most plausibly related to the earlier (Late Cretaceous) Troy Canyon granite pluton that crops out 6 mi south. The other possible fluids may be the same fluids (possibly related to the volcanic episode) that caused formation of jasperoid and some geochemical anomalies in Mississippian rocks along the north-central parts of the wilderness study area during or after the normal faulting (Oligocene or younger time).

Because of the positive geologic and geochemical indications of mineralization, these areas on the southeastern and western sides of the wilderness study area have a moderate mineral resource potential for zinc and antimony in deposits related to minor hydrothermal fluid circulation in fault zones. Because the source and age of the hydrothermal solutions is not well understood and the areas of interest are large with somewhat diffuse geochemical anomalies, the available information only suggests the certainty level of mineral resource potential (certainty level B, pl. 1).

Oil and Gas Resources

Models for petroleum occurrences in central Nevada are based on five oil fields that have been located in Railroad Valley west of the wilderness study area (fig. 1).

Source rocks in these fields are the Sheep Pass Formation for the Currant and Eagle Springs fields, and the Chainman Shale for the Trap Spring, Grant Canyon, and Bacon Flat fields; two periods of oil generation occurred. Three types of oil traps are present in Railroad Valley. These are Paleogene sedimentary and volcanic rocks in the Eagle Springs, Trap Spring, and Currant fields; Paleozoic dolomite and sandstone in the Bacon Flat and Grant Canyon fields; and fractured Eureka Quartzite in the Soda Springs no. 1 well, 1 mi south of the Eagle Springs field. Oil is thought to have migrated into the valley during the Quaternary by means of shovel-shaped normal faults that bound the Grant Range and by buried alluvial fans that cover the faults; these young faults were conduits for both newly generated oil and oil from older traps (Poole and Claypool, 1984).

The wilderness study area has been previously rated as having high energy resource potential for petroleum based on thermal maturation of source beds and the occurrence of producing oil fields in the adjacent Railroad Valley wells (Sandberg, 1983). Both Sheep Pass Formation and Chainman Shale source beds crop out in the wilderness study area. The Chainman Shale contains oil in outcrop in the north-central part of the wilderness study area (Poole and Claypool, 1984) and is at optimum thermal maturity for oil and gas generation throughout the wilderness study area (Sandberg, 1983). Many structural conduits for migration of petroleum are present as well as structures that would be suitable reservoirs; the geometry of structural features allows oil of either age to migrate into traps in rocks of any age as is demonstrated in the Railroad Valley fields. The range-bounding normal faults are the youngest and most extensive faults; these cut earlier low-angle and associated steeper normal-fault systems and form the main conduits for migration of fluids into traps both in Railroad Valley and possibly in other structural settings in the Grant Range. The likelihood, from geophysical information, that these range-front faults become shallow with depth westward beneath Railroad Valley and separate thermally mature Paleozoic source rocks from metamorphosed older(?) sediments indicates the possibility of the same favorable conditions for oil occurring in the wilderness study area.

Several aspects of the geology that are important to the resource potential for petroleum in the wilderness study area are not well known. The complexity of normal faulting makes it difficult to project the position of structures at depth beneath younger cover, and the migration capacity of particular faults and fault systems has not been established. The shape, depth of shallowing, orientation, and relative timing of the range-bounding faults are only partly modeled from seismic studies (Effimoff and Pinezich, 1981) and the present geologic mapping and geophysical interpretation. The information available gives a good indication of the level of petroleum resource potential (certainty level C, pl. 1). However, there are unanswered questions about petroleum migration and traps; the wilderness study area may be a better source area for oil and gas than a reservoir area.

Other Energy Resources

There are no known coal-bearing beds in the vicinity of the wilderness study area. The area has a low potential for the occurrence of coal resources (certainty level B, pl. 1).

Some history of uranium prospecting north of the wilderness study area was found during this mineral survey (see the section on "Mineral-Exploration History"). However, the units of interest are younger than those in the Blue Eagle Wilderness Study Area and have been eroded or were never deposited in the wilderness study area. The study area has a low potential for the occurrence of uranium deposits (certainty level B, pl. 1).

No thermal springs are known in the wilderness study area. The only known warm springs in the vicinity occur along range-bounding faults in Railroad Valley (pl. 1) and possibly along similar faults in the White River Valley. The wilderness study area has a low potential for geothermal energy resources (certainty level B, pl. 1).

Other Metal and Nonmetal Mineral Resources

For other metals not described above, no indication from geochemical study showed that anomalously high values of multiple-element associations or enrichments at several adjacent sites were present, no appropriate deposit models fit the geologic setting, and no history of production for the metals was found in the region. However, in general, the geologic information does not completely determine the level of resource potential. Therefore, other metals have a low mineral resource potential in the wilderness study area (certainty level B, pl. 1).

Magnesite deposits are known outside of the wilderness study area about 5 mi northeast of the area of figure 1. These deposits occur in a white volcanic tuff unit (Faust and Callahan, 1948) that does not crop out in the wilderness study area (Moores and others, 1968) due to nondeposition or erosion. The resource potential for magnesite deposits in the wilderness study area is low (certainty level B, pl. 1).

There has been no history of production of high-purity limestone or dolomite in the Blue Eagle Wilderness Study Area or vicinity. Although no chemical data are available, other information suggests that the limestone and dolomite abundantly available in the wilderness study area contain too much clay and silt to be of high purity. Therefore, the resource potential for undiscovered high-purity limestone or dolomite in the wilderness study area is low (certainty level B, pl. 1).

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APPENDIX

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

Definitions of Mineral Resource Potential

LOW mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is unlikely. This broad category embraces areas with dispersed but insignificantly mineralized rock as well as areas with few or no indications of having been mineralized.

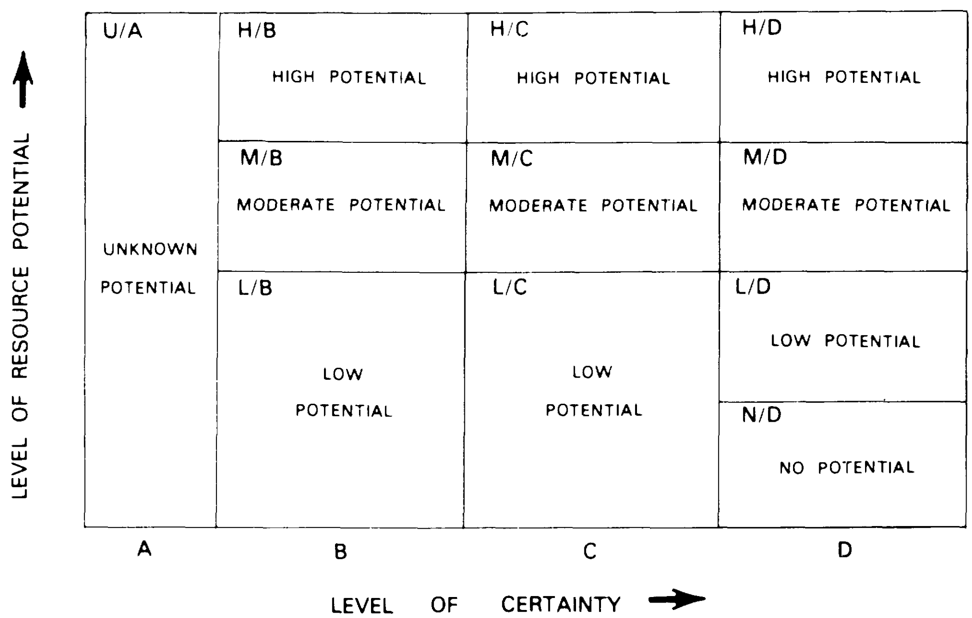
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

HIGH mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data support mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.

UNKNOWN mineral resource potential is assigned to areas where information is inadequate to assign low, moderate, or high levels of resource potential.

NO mineral resource potential is a category reserved for a specific type of resource in a well-defined area.

Levels of Certainty



A. Available information is not adequate for determination of the level of mineral resource potential.
B. Available information suggests the level of mineral resource potential.
C. Available information gives a good indication of the level of mineral resource potential.
D Available information clearly defines the level of mineral resource potential.

Abstracted with minor modifications from:

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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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