Mineral Resources of the Gooding City of Rocks East and West Wilderness Study Areas, Gooding County, Idaho

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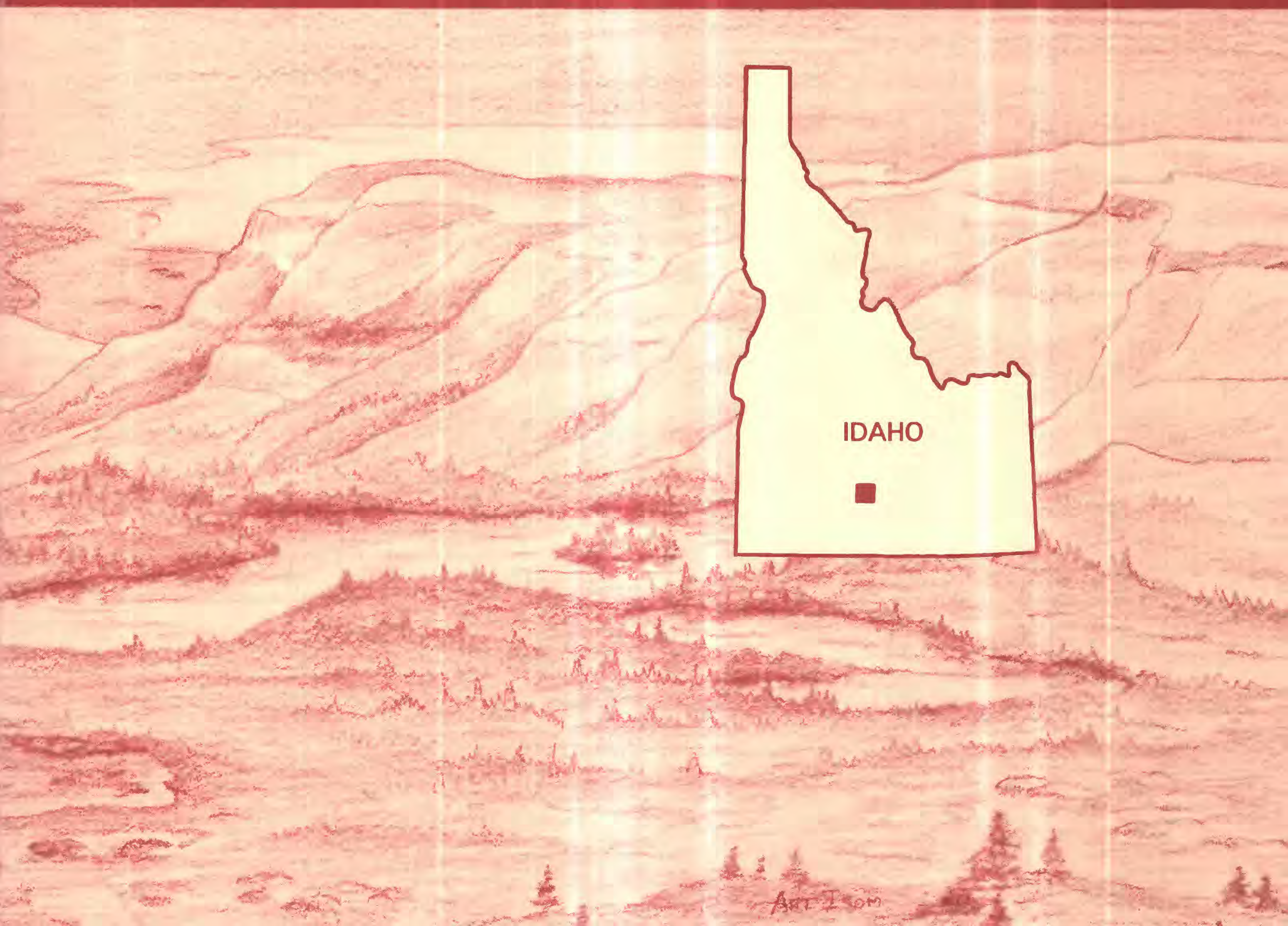

Chapter A

Mineral Resources of the Gooding City of Rocks East and West Wilderness Study Areas, Gooding County, Idaho

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MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
SOUTH-CENTRAL IDAHO

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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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 a part of the Gooding City of Rocks East and West (ID–54–8a and 8b) Wilderness Study Areas, Gooding County, Idaho.

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Mineral Resources of the Gooding City of Rocks East and West Wilderness Study Areas, Gooding County, Idaho

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SUMMARY

In 1984 and 1985, the U.S. Geological Survey and U.S. Bureau of Mines undertook a joint investigation to assess the potential for undiscovered mineral resources and to appraise the identified resources of 19,030 acres of the Gooding City of Rocks East (ID–54–8a) and Gooding City of Rocks West (ID–54–8b) Wilderness Study Areas (fig. 1). Both study areas have low resource potential for metals, oil, gas, and coal; the potential for geothermal energy is moderate. Much of the western part of the Gooding City of Rocks West study area and the southwest corner of the Gooding City of Rocks East study area has high potential for diatomite (fig. 2). To the west of study area ID–54–8b, the Clover Creek diatomite deposit contains an inferred marginal reserve of 35 million tons of diatomite.

The Gooding City of Rocks East and Gooding City of Rocks West Wilderness Study Areas are 15 mi (miles) north-northwest of Gooding, in Gooding County, Idaho. The study areas are bounded on the northern, eastern, and southern sides by four-wheel-drive roads; study area ID–54–8b is bounded on the western side by the East Fork of Clover Creek. Access is provided by those dirt roads that are passable except during heavy rains and spring thaw. The two wilderness areas contain six deeply incised canyons separated by basalt-covered plateaus. Each canyon is characterized by a central deep, narrow stream having very few tributaries. Steep gorges are developed within most of the canyons, and the resulting landscape is one of spectacular arches, pillars, and sculptured rock.

The Gooding City of Rocks East and West Wilderness Study Areas are on the northern edge of the Snake River Plain, south of the Idaho batholith. The Miocene Idavada Volcanics (see geologic time chart in appendix) is the oldest unit that crops out in the two areas. It consists of as much as 300 ft (feet) of dacite to rhyolite ash-flow tuff. The Idavada Volcanics is overlain either by diatomite and related sedimentary deposits or by vesicular basalt of the Banbury Basalt; the basalt is as thick as a few hundred feet in some places.

North of the study areas, high-angle faulting has resulted in as much as 9,000 ft of displacement since early Pliocene. Within the study areas steep normal dip-slip faults are common, but offsets average only 30–50 ft; no mineralized rock was observed along any of the faults.

Gravity measurements within the study areas show little variation. Lower gravity values to the north are associated with sedimentary rocks, and higher gravity values to the south are associated with basaltic rocks of the Snake River Plain. The various rock types in the study areas are not delineated by the gravity data; nor are any of the faults expressed. Offsets on the faults are therefore probably only minor.

Forty-two placer claims within and adjacent to study area ID–54–8b cover the Clover Creek diatomite deposit. There has been minor production from four pits. Five exposures (or blocks) containing 416 million tons of diatomaceous material make up the Clover Creek deposit; four of the blocks are in the study areas, but are predominantly covered by basalt. The North Clover

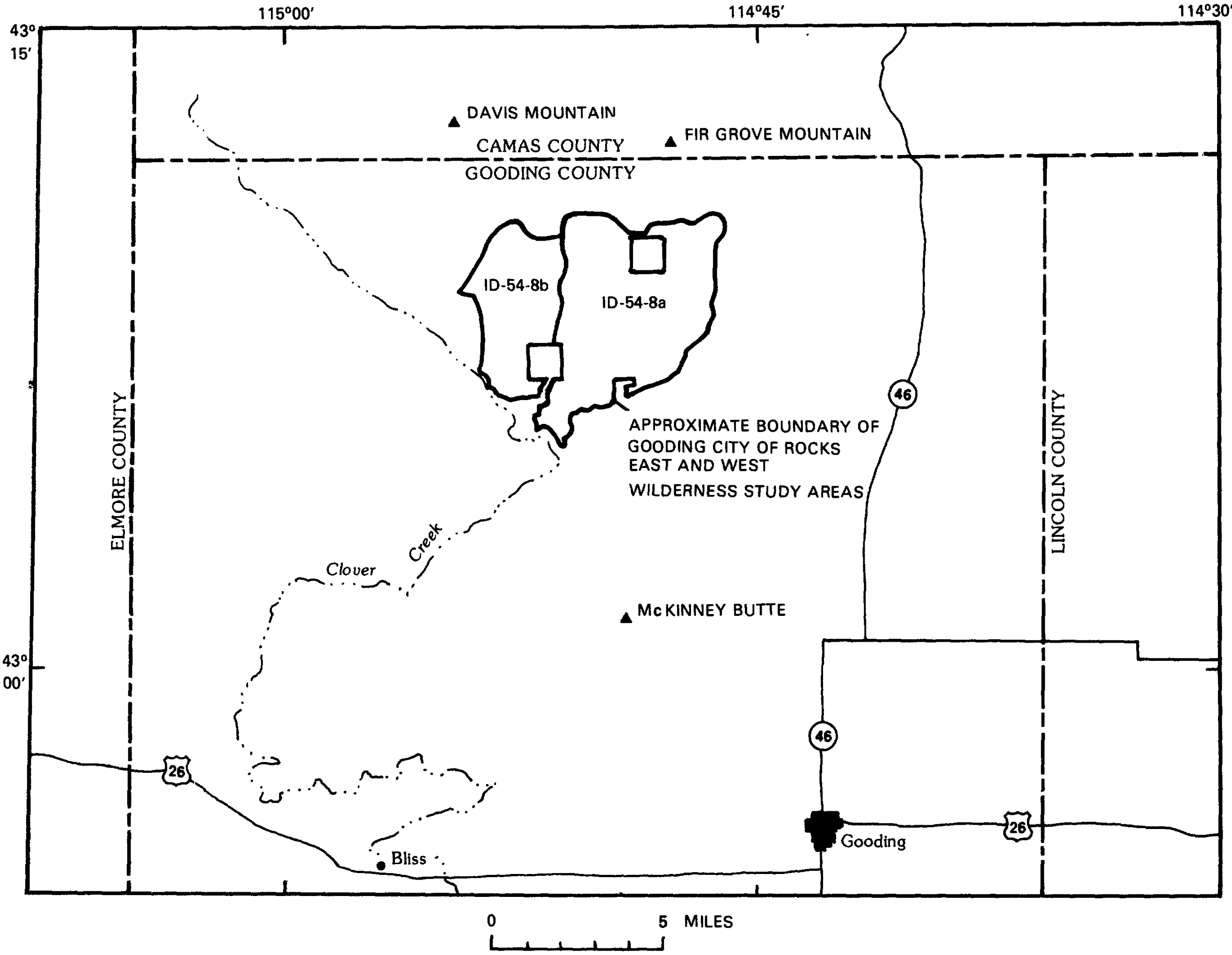


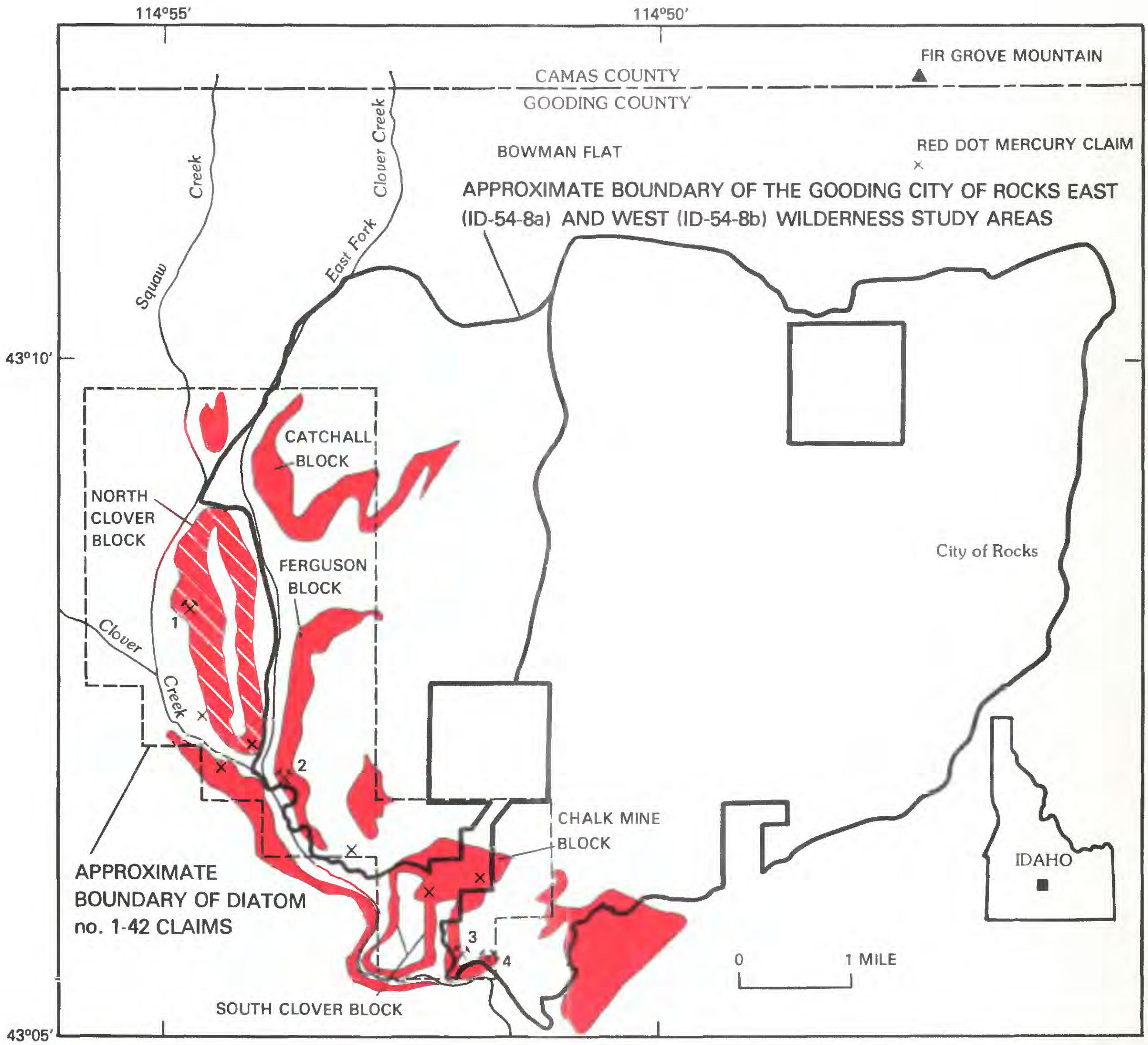
Figure 1. Index map showing the location of the Gooding City of Rocks East and West Wilderness Study Areas, Gooding County, Idaho.

block, just west of study area ID–54–8b, is only partly capped and could be mined by open-pit methods on the western flank of the exposure. The minable wedge contains an inferred marginal reserve (see resource/reserve classification chart in appendix) of 35 million tons of diatomite possibly suitable for filter aid, filler, insulation, and other applications. The resource is classified as marginal because products from it may be inferior to currently marketed diatomite products.

Several occurrences of platy welded tuff, possibly suitable as decorative stone, are in the study areas; however, abundant deposits to the east of the study areas could be more easily developed. Deposits of sand and gravel are too distant from markets, and there is little chance of development.

No mineralized rock was identified in the study areas. Abundant fragments of jasper were found in the eastern part of area ID–54–8b, but the source was not located. Chemical analyses of rock samples from a small prospect pit just to the north of study area ID–54–8a revealed no anomalous concentrations of any elements.

Figure 2 (facing page). Mineral resource potential map of the Gooding City of Rocks East and West Wilderness Study Areas, Gooding County, Idaho. Both study areas have low potential for metals, with certainty level B, and for oil, gas, and coal, with certainty level C. Both study areas also have moderate resource potential for geothermal energy, with certainty level B.



EXPLANATION

Area of identified diatomite resources

Geologic terrane having high mineral resource potential for diatomite, with certainty level C

⚒ **Diatomite mine**

1. **North pit mine**
2. **Middle pit mine**
3. **Chalk mine**
4. **Unnamed mine**

× **Prospect**

The Gooding City of Rocks East and West Wilderness Study Areas were determined to have low potential for metals on the basis of rocks exposed at the surface. However, 16 mi north of the study area granitic rocks of the Idaho batholith have been mineralized with gold, copper, lead, and zinc. Without exploratory drilling, the presence of mineralized rocks beneath the volcanic rocks of the study areas cannot be determined.

The resource potential for oil, gas, and coal in the study areas is low. The study areas do not contain rocks favorable for oil and gas accumulation or coal formation. Holes drilled in the region to depths of more than 11,000 ft did not penetrate sedimentary rocks.

Two geothermal resource areas are immediately adjacent to the Gooding City of Rocks East and West Wilderness Study Areas, and large areas favorable for the discovery and development of low-temperature geothermal resources have been indicated to the north and southwest of the study areas. However, no surface manifestations are present in the study areas. For these reasons, the potential for geothermal energy is moderate.

INTRODUCTION

The Gooding City of Rocks East (ID–54–8a) and Gooding City of Rocks West (ID–54–8b) Wilderness Study Areas, in Gooding County, Idaho, comprise 14,743 acres and 6,287 acres, respectively. At the request of the U.S. Bureau of Land Management, only 13,063 acres of the Gooding City of Rocks East Wilderness Study Area were studied. The two study areas are separated by a north-south four-wheel-drive road. The two areas are discussed together in this report and are referred to jointly as the "Gooding City of Rocks Wilderness Study Areas" or simply "the study areas." The study areas are about 15 mi north-northwest of Gooding and about 12 mi due south of the small town of Fairfield (fig. 1). They are bounded on the northern, eastern, and southern sides by four-wheel-drive roads; study area ID–54–8b is bounded on the western side by the East Fork of Clover Creek. Access to the study areas is provided by those dirt roads that are passable except during periods of rain or thaw. Elevations range from 5,615 ft in the northwestern part of study area ID–54–8b to 4,000 ft on Clover Creek.

Six deeply incised canyons separated by basalt-covered plateaus make up the study areas. Each canyon is characterized by a central deep, narrow channel having very few tributaries (pl. 1). Canyon streams drain southward into Clover Creek. Steep gorges have developed along most of the canyons, and the resulting landscape is one of spectacular arches, pillars, and sculptured rock. The canyon bottoms, as much as 400 ft below the plateaus, are generally densely covered with cottonwoods, which give way to sagebrush along canyon slopes and plateaus.

Investigations by the U.S. Bureau of Mines

During 1984 and 1985, the U.S. Bureau of Mines (USBM) undertook investigations to appraise the identified resources of the study areas (Moyle, 1985). Prior to field studies, published information was researched and Gooding County and U.S. Bureau of Land Management (BLM) mining and mineral lease records were examined. USBM, state, and other production records were searched and pertinent data were compiled. Claim owners were contacted for permission to examine properties and publish the results.

Frederic L. Kadey, Jr. (consultant, Industrial Minerals, Englewood, Colo.), an acknowledged expert in the evaluation of diatomite deposits, was consulted about the Clover Creek deposit and accompanied USBM personnel on a one-day visit to the field. Field studies involved searches for all mines, prospects, and claims indicated by library research to be in the study areas. Those found were mapped and sampled. Claims outside, but near, the study areas were also studied to determine whether mineralized zones might extend into the areas. Ground and air reconnaissance surveys were used to identify significant geologic structures and zones of alteration related to mineral deposits.

Lode samples were collected by USBM personnel at mines and prospects. Samples were also taken of country rock for chemical analysis, petrographic analysis, and density determination; sand and gravel was sampled to look for placer gold. Diatomite samples were examined microscopically by the USBM; suitable samples were submitted to the Manville Service Corporation for analyses.

We would like to acknowledge the help of Larry Dee, district geologist at the Shoshone BLM office. Frederick L. Kadey, Jr., visited the diatomite deposit at Clover Creek and instructed USBM personnel in identification and evaluation of diatomite. Edward and Leroy Strout accompanied Phillip Moyle to the diatomite deposit and also provided important production data. Identified resources are classified according to the guidelines set up by the U.S. Bureau of Mines and the U.S. Geological Survey (1980).

Investigations by the U.S. Geological Survey

The U.S. Geological Survey (USGS) undertook investigations in the summer of 1984 to assess the potential for undiscovered mineral resources of the wilderness study areas. The work consisted of geologic mapping at a 1:62,500 scale, combined with stream-sediment and rock sampling and subsequent analyses of the samples. Black-and-white and color aerial photographs were used to supplement the geologic mapping and to locate faults.

Helicopter transport was used to sample the more inaccessible streams and to look for altered and (or) mineralized outcrops. Representative volcanic rock samples were collected and cut into thin sections for more detailed petrologic study.

This report is based upon earlier mapping of the wilderness study areas by Malde and others (1963), descriptive work on the volcanic rocks by Smith (1966), and unpublished data prepared for the BLM in 1983. Mineral resource appraisal was classified according to the system of Goudarzi (1984; see appendix).

APPRAISAL OF IDENTIFIED RESOURCES

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Mining and Mineral Exploration History

No mining districts are known in or near the study areas. Forty-two 160-acre placer claims, Diatom No. 1–42, covering about 6,700 acres, are located in and along the west side of the study areas (fig. 2). These are the only active claims in or near the study areas.

The claims for diatomite were staked by many individuals. Thomas Conaway and family settled the north end of Ferguson Flat in 1910 and, with George Chaffin and others, located the Bank Bar Nos. 1–3, the first recorded placer claims, on diatomite in sec. 34, T. 3 S., R. 13 E. Numerous subsequent placer claims include the Crown Point Placer Group in 1918 by Rockhills, Chaffin, and others; the Zeolite Group in 1926 by Chaffin and others; the Snowdrift Group in the mid-1930's by Becker, Chaffin, and others; and many real estate exchanges made by various parties through the 1970's.

The Strout family has been involved in the ownership of the claims since the 1930's. The placers were consolidated into one property by Edward Strout in 1974. He reported (oral commun., 1984) that the first production of diatomite from the property occurred about 1930. It was shipped to Gooding by horse-drawn wagon and then in two rail cars to a sugar factory in Utah, possibly for use as a filter aid. In the mid-1930's, 50–150 tons/year were sold to the Sterling Lumber Co. of Twin Falls for use as insulation. An attempt in the 1940's to use the diatomite as an additive to hot asphalt for roof application did not succeed. During the 1950's and 1960's, claimants sold modest amounts of crude diatomite in southern Idaho for use as an athletic-field marker. According to Mr. Strout, the diatomite was displaced from the 100-tons/year market by byproduct calcined gypsum. Diatomite was produced from four open pits along the southwestern boundary of the study areas, most from a site identified as the Chalk mine on the Davis Mountain 15-minute topographic quadrangle (pl. 1). Mr. Strout also noted that the Johns–Manville Corp. examined the deposit about 1960; however, no data are available. Assessment work is currently being done on the claims.

R. K. Johnson located the R.K. and M. lode claim and the Queen Marine and Blue Flower placer claims 5 mi west of Flat Top Butte in July 1932. The claims were probably situated near, but outside, the eastern boundary road of study area ID–54–8a. Ted Neeley located and explored the Red Dot claim (fig. 2) for mercury in sec. 3, T. 3 S., R. 14 E. about 1968 (Larry Dee, written commun., 1984).

Diatomite

Classification and Market

Diatomite is a light-colored, siliceous sedimentary rock that consists of the microscopic remains of diatoms—one-celled aquatic plants related to algae. Deposits are formed by the induration (compaction) of diatomaceous oozes. The rock is commonly soft, friable, and lightweight. "Diatomite" or "diatomaceous earth" are terms generally reserved for deposits of actual or potential commercial value. Useful characteristics, primarily due to the character of diatom skeletons, are a large surface area, high absorptive capacity, and relative chemical stability (Bates and Jackson, 1980; Kadey, 1983).

Most of the known diatomite deposits in the world, like the Clover Creek deposit, are of freshwater origin; however, the largest deposits are marine. Other deposit classes include modern lake, marsh, bog, or brackish origins. Freshwater deposits occur in many localities in the Western United States; however, the largest producer is the marine deposit at Lompoc, Calif. The assemblage of diatom forms (species or genera) is used to determine the deposit origin and is unique to each deposit or geographic area (Kadey, 1983). The type, variety, and condition of the diatom skeletons determine the suitability of a deposit for particular applications.

Uses for diatomite are extremely varied. Most processed diatomite is used as a filter aid for the separation of suspended solids from fluids. Of 1983 domestic production, 66 percent was sold as a filter aid and 21 percent was sold as a filler or extender, the second largest use (Meisinger, 1984).

Manville Service Corp. at Lompoc, Calif., produces 12 different diatomite filter-aid products, each designed to meet a specific filtration requirement. In addition, 11 natural, 6 calcined, and 17 flux-calcined diatomite filler products are sold. Other applications, requiring minimal processing, include use as insulation, absorbents, silica additives to cement, abrasives (polishing compounds), catalysts, lightweight aggregates for soil conditioners, and as chemical carriers. Although there are a great number of product types and a variety of applications, Kadey (1983) notes that the probability of economic success for a potential deposit is seriously reduced if it cannot be processed into one or more filter-aid products.

Published literature and unpublished USBM statistical files show a significant price distinction between marine- and nonmarine-derived (mostly freshwater) diatomite products. The most recent year of published prices, by end use (Meisinger, 1984), shows average values in 1983 of $200/ton for filter aids, $177/ton for fillers, $119/ton for insulation, and an average $116/ton for other uses. These prices reflect a composite of marine and nonmarine types. It is estimated (Moyle, 1985) that current (1985) values for nonmarine-derived products average about $170/ton for filter aids, more than $95/ton for fillers, $150/ton for insulation, and $100/ton for other uses (prices are FOB plant site, material that is loaded and ready for delivery).

Clover Creek Deposit

Geology

Thick deposits of diatomaceous sediments deposited in an ancient freshwater lake are along the western and southwestern boundaries of the study areas, east of Clover Creek. Other facies (sedimentary units) associated or interbedded with these sediments are lenses and beds of sand, silt, clay, ash, and chert, and at least one lenticular-shaped sand and pebble-gravel river-channel deposit. Plate 1 shows the distribution of the diatomaceous deposits (Tbd), and figure 2 identifies the five main exposures, or blocks, of observed and inferred diatomaceous material that make up the Clover Creek deposit (shown in red). In total areal extent, these blocks cover 4.4 mi^2 (square miles), of which about 2 mi^2 is partly covered by 15- to 20-ft-thick cappings of Banbury Basalt. The diatomaceous deposit is more than 440 ft thick in the Ferguson block. The configuration of the Catchall and Ferguson blocks—thin near their eastern edges—and the presence of beach sands and near-shore sediments in the Chalk mine block suggest that the eastern exposure of the deposit may have formed part of the original lake shoreline.

Workings

Four production pits, several trenches or bulldozer cuts, and many small prospect pits are on the Clover Creek deposit (fig. 2). Surface maps of three of the production pits, the so-called Chalk mine, the Middle pit, and North pit, along with maps of large bulldozer cuts on the south end of the North Clover block, are given in Moyle (1985).

Sampling

Greg Fernette (unpub. data, 1983) took 32 samples from the Clover Creek deposit in 1983 (J. Rishel and L. Dee, unpub. data, 1984), and the USBM took 83 samples in 1984 (Moyle, 1985). Results of the microscopic examination, preliminary characterization tests, and chemical analyses for the 115 diatomite samples are listed in Moyle (1985). Samples considered to have good properties contain 5 percent or less contaminants, have loss on ignition of 3–5 percent, and would be soft and white after ignition.

Microscopic examination (J. Rishel and L. Dee, unpub. data, 1984; Manville Service Corp., 1984) revealed all samples to be freshwater diatomite. The diatoms range from whole to very fragmented; most are partly fragmented. Samples generally contained from 5 to 15 percent, and as much as 40 percent, quartz, clay, or other unidentified contaminants. Preliminary characterization tests show crude samples ranging from soft to semihard and light to dark beige, whereas ignited samples were soft and generally orange. Ignition loss ranged from 3.4 to 10.5 percent but was generally less than 5 percent.

Manville Service Corp. concluded that a number of samples were poor in quality due to high contamination, high crystalline content (quartz, clay, and other contaminants), or poor diatom structure (fragmented). Eight samples exhibited good properties, and nine other samples were slightly poorer in quality but could be given consideration for further testing. Most of the samples exhibiting favorable properties came from well-exposed diatomite in pits or trenches. Near-surface samples contained higher amounts of carbonates, clays (primarily montmorillonite), and organic matter.

The highest quality samples determined by preliminary tests were further tested by Manville Service Corp. (1985) for determination of natural and flux-calcined properties and were also analyzed chemically. Tests included milling and classification, loose weight, wet density, screening, blue-light reflectance, pH, resistivity, and flow rate. The results of detailed testing and the specifications, especially for filter-aid applications, are given in Moyle (1985). Manville Service Corp. (1985) summarized the tests as follows:

> It is concluded, based on these four samples, that filter aid products could be made from similar materials but their quality would be inferior to diatomite products that are in the market place today, based on the stated deficiencies. In addition, because of their poor color (not white), they could not be used in most major filler applications.

One sample of diatomite was taken from the Clover Creek deposit by Treco Industries, Inc. (1974). The sample was classed as "very high quality" diatomite suitable for application to filtration products and animal feed.

Table 1. Cumulative tonnage of probable diatomaceous sediments within and adjacent to the Gooding City of Rocks East and West Wilderness Study Areas, Gooding County, Idaho

Claim block	Average thickness (ft)	Tonnage within study areas (million tons)	Tonnage outside study areas (million tons)	Total (million tons)
Catchall-----------	195	34	None	34
Chalk mine---------	160	61	8	69
Ferguson-----------	365	137	3	140
North Clover-------	310	None	147	147
South Clover-------	120	None	26	26
Total-------------------------------		232	184	416

Resources

From cross sections based on topographic and geologic maps (Malde and others, 1963; J. Rishel and L. Dee, unpub. data, 1984), the volume of probable diatomaceous sediments contained in each block was calculated by the mean-area method. To determine a tonnage factor, three samples of diatomite were analyzed for apparent density; they averaged 50 lb/ft^3 (pounds per cubic feet). The area studied is estimated to contain a total of 416 million tons of diatomaceous sediments, 232 million tons within and 184 million tons outside the study areas. Table 1 lists the average thickness and estimated tonnage in each block within and outside the study areas.

The North Clover block contains approximately 147 million tons of diatomaceous sediments, is only partially covered with basalt, and is entirely outside the study areas. A large, wedge-shaped exposure of diatomaceous sediments along the west side of the North Clover block could be mined by surface methods along stepped benches without undermining the basalt cap, and with a minimum exposure to the study areas. The model would require a 30° pit slope dipping to the west from the basalt cap due to the instability of diatomaceous sediments. The wedge contains about 50 million tons of Banbury sediments between the overlying Banbury Basalt and the underlying Idavada Volcanics. Based on a suite of samples and a mapped stratigraphic section at the south end of the North Clover block, 70 percent of the wedge is considered diatomaceous. Therefore, the wedge contains an inferred resource of 35 million tons of diatomite possibly suitable for certain filter, filler, insulation, and other applications. Treco Industries, Inc. (1974), estimated that the Clover Creek diatomite deposit contained approximately 1.5 billion tons. This figure is considered excessive but may have included possible diatomite in Banbury sediments west of the study area.

Appraisal of Resources

Diatomite

A variety of diatomite products might be produced at a profit from the Clover Creek deposit, if the diatomite were suitable for filtration and filler applications, and if current markets were not dominated by currently producing companies. Small amounts of diatomite could be mined from other exposures along Clover Creek and at historical production areas such as the Chalk mine (table 1).

Although the subject diatomite is only marginally suitable for these applications, a hypothetical major mining and processing operation was designed to produce a wide variety of products, including filter aids and fillers. Such an operation would account for one-half of the United States output of 300,000 tons/year of nonmarine diatomite products. Production would be at a rate of 500 tons/day for 300 days/year. A 2:1 crude- (in place) to-product weight ratio was assumed, due primarily to milling losses (Kadey, 1983). At this production rate, about one-third of the deposit would be mined in 40 years.

Data are lacking that would enable an estimate of capital and operating costs of a major diatomite-processing plant. Costs for a hypothetical plant adjacent to the study areas were determined here by analogy or proportion. Eagle Picher Industries, Inc., is planning as of 1985 to build a $13-million processing plant in east-central Oregon to replace some or all of their Nevada operations (Moyle, 1985). The plant is designed to employ 30–35 workers and to operate for 40 years. Cost data for that plant, and from Benton (1983), were used to supplement costs determined by the USBM Cost Estimating System (STRAAM Engineers, Inc., 1977).

A processing plant would best be located at Bliss or Gooding, Idaho, where there are rail facilities and an interstate highway. Overall costs of the hypothetical operation were estimated as shown in table 2.

Typical rail freight costs for transporting materials like diatomite 150–600 mi are about $9.50–$38/ton.

Several products other than filter aids could be produced at a substantially lower processing cost (both capital and operating), estimated to be about $10–$20/ton, but the delicate drying and classifying operations would still be energy intensive (Benton, 1983). Because the current market for diatomite products is filled by the existing deposits, and major increases in demand are not expected in the near future, the 35-million-ton North Clover block is classified as an inferred marginal reserve. A significant technological improvement in upgrading diatomite, or a substantial increase in demand, could change the classification to that of reserve. Also, further exploration or drilling might lead to discovery of higher grade parts of the deposit better suited for filtration applications.

Table 2. Estimated costs of operation of a hypothetical diatomite-processing plant

Item	Production cost ($/ton)
Exploration and haulage roads-------	1.12
Mine capital (including power)------	.48
Plant capital-----------------------	2.17
Mine operation----------------------	8.58
Truck 17 mi to plant at Bliss, Idaho	9.48
Direct processing-------------------	51.48
Packaging and shipment preparation--	25.74
Total-------------------------	99.05

Rock Products

Small deposits of platy rock of the Idavada Volcanics are at the surface and on talus slopes within and to the east of the study areas, especially in wilderness study area ID–54–8a. The stone is a reddish-brown, dacitic welded tuff generally 1.5–3 in. thick and as much as 1.5–2.0 ft in diameter. Weathered surfaces are commonly covered with lichen of various colors. The deposits are derived from exfoliation along subparallel cooling fractures and flow bands of the volcanic rocks. Two samples analyzed for apparent density averaged 145 lb/ft^3. Individual deposits are small and scattered, and are estimated to contain from less than 100 tons to about 500 tons. The stone is similar to platy rhyolite mined from other areas of southern Idaho and sold in Boise as decorative stone. A market survey by the USBM indicates retail prices in the range of $85–$125/ton depending on building activity. The deposits are possibly suitable for decorative veneer, but because abundant deposits of rhyolitic decorative stone occur on accessible lands to the east of the study areas, the deposits are classified as occurrences.

Voluminous deposits of sand and gravel are present in the study areas. Most of the deposits are found in the Quaternary alluvium at lower elevations or in the Banbury sediments. Because of the high bulk and low unit value of sand and gravel, and the high transportation costs involved in shipping, there is little chance for development of these deposits, other than for minor local uses.

Metallic Mineral Deposits

No mining claims other than for diatomite have been located, and no metallic mineral deposits are known to occur within the study areas. Of 21 reconnaissance panned samples taken from sand and gravel deposited by streams that enter or drain the study area, 5 contained gold in amounts equivalent to 0.5–5 cents per cubic yard (at $300/oz (ounce) gold). All gold-bearing alluvium came from streams in the western half of the study areas.

Three samples of opalized volcanic breccia and a grab sample of dump material were taken from a trench on the Red Dot mercury claim. No mercury, precious metals, or base metals were detected in the rock samples; however, the dump sample, processed as a placer sample, contained 0.184 mg (milligrams) of gold, equivalent to about 0.002 oz/ton. The opalized rock contained tube-shaped cavities thought to be reed molds, possibly related to an ancient hot spring. Eight chip samples from rock outcrops and sediments typical of the Banbury Basalt and Idavada Volcanics showed no significant mineral content.

Energy Resources

There was no geothermal lease activity in or near the study area as of 1984, and no surface manifestations of geothermal energy are known to occur within the study areas.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Margo I. Toth, Rebecca J. Stoneman, and Dolores M. Kulik
U.S. Geological Survey

Geology

Geologic Setting

The Gooding City of Rocks East and West Wilderness Study Areas are on the northern edge of the Snake River Plain, 15 mi south of the Idaho batholith. The areas are in a southeast-dipping horst bounded by the Camas Prairie graben on the north (Walton, 1962) and the Snake River Plain downwarp on the south (Smith, 1966). Isolated outcrops of tuffs and flows of the Eocene 40- to 50-m.y. Challis Volcanics are overlain by andesitic to dacitic welded tuffs of the Miocene Idavada Volcanics. These are in turn overlain by more extensive outcrops of various basaltic units. Within the study areas outcrops of the Idavada (Malde and others, 1963) are overlain by basalt and lesser amounts of diatomite of the Banbury Basalt.

Description of Rock Units and Structure

In the study areas the Idavada Volcanics (pl. 1, unit Ti) consists of as much as 300 ft of welded dacite to rhyolite tuff, probably belonging to the City of Rocks Tuff (Smith, 1966). The member is lithologically homogeneous and is characterized by the presence of plagioclase and orthopyroxene phenocrysts and the absence of quartz, biotite, and hornblende phenocrysts. In the central and southern parts of the study areas the Idavada crops out in spectacular rounded columns bounded by joints filled with reddish-orange sand. The columns average 5–10 ft wide and are as much as 100 ft high. Horizontal joints are laterally continuous and are spaced at 0.5–5 ft intervals. Columnar jointing is also well developed in the rocks along the eastern edge of the study areas.

Foliation in the rocks is well defined, generally striking east-west or slightly northwest and dipping gently southward; in some of the more deformed areas the rocks dip as steeply as 90°. Both small- and large-scale folding are common in the rocks, and some overturned folds are also present.

The lowermost unit of the Idavada Volcanics (20–25 ft thick) consists of a black basal vitrophyre (glassy rock), which is extremely hard and contains 25–30 percent phenocrysts of well-formed plagioclase (0.2 in. long), well-formed orthopyroxene, and minor opaque minerals. Presence of several black vitrophyre layers at substantially different elevations in the study areas suggests that several different flow or cooling units may also be present.

Most of the Idavada Volcanics consists of a slightly to strongly welded, most commonly devitrified, medium-purple or gray tuff. The rock contains from 25 to 50 percent (average 30 percent) phenocrysts of aligned white plagioclase crystals (0.2 in. long), lesser amounts of orthopyroxene (less than 0.1 in. across), and less than 2 percent granular magnetite. Pumice fragments, variable in abundance, range to as much as 0.3 in. thick and are everywhere devitrified. In several areas, especially in the northern parts of the study areas, the tuff is layered alternately with purple and light-brown laminae that are probably sheared pumice fragments. Flow foliation in all the tuff units is strongly defined by aligned plagioclase grains and weathered-out pieces of flattened pumice lapilli.

Small amounts of pale-green and yellow jasper are commonly present as scattered fragments throughout study area ID–54–8b, commonly associated with the basal vitrophyre. A large outcrop of jasper is also present just north of study area ID–54–8a near Willow Spring. No mineralized rock was observed associated with the jasper in the study areas.

Rocks from the Idavada Volcanics in the Mount Bennett Hills have not yet been dated, but similar rocks elsewhere have yielded dates from 8.4 to 12.2 m.y. (Armstrong and others, 1975). In the study areas the Idavada Volcanics is overlain either by diatomite and related sediments (pl. 1, unit Tbd) or vesicular basalt of the Banbury Basalt (pl. 1, unit Tb). The basalt is as much as a few hundred feet thick and generally crops out on the high plateaus. Vesicles average less than 0.1 in. across and are commonly filled with zeolites. The basalt is medium to dark gray and contains 10–15 percent phenocrysts of euhedral plagioclase 0.1–0.2 in. long and anhedral olivine less than 0.1 in. across. Armstrong and others (1975) give a range in ages from 3 to 10 m.y. for the Banbury Basalt.

Diatomite of the Banbury Basalt occurs as white chalky beds commonly covered by vegetation. The outcrop pattern of diatomite is irregular, and the diatomite locally pinches in and out. Malde and Powers (1962) report that freshwater mollusks and mammal fossils from the area of Clover Creek indicate mid-Pliocene ages for the diatomite units (now classified as Miocene).

Work by Bonini and Lanvin (1957), Malde (1959), and Malde and others (1963) indicates that the northern edge of the Snake River Plain is an east-west-trending zone of intense high-angle faulting along which as much as 9,000 ft of displacement has occurred since the early Pliocene. Most of the evidence of large-scale faulting is north of the study areas (Smith, 1966). Steep, normal dip-slip faults that trend dominantly to the east-northeast crosscut the rocks in the study areas. Offsets average 30–50 ft and a few of the faults predate the basalt. No mineralized rock was observed along any of the faults.

Geochemistry

Methods

A geochemical survey of the study areas included the sampling of stream sediments and rocks for chemical analysis. Twenty-five samples of stream sediments were taken; the areas of the drainage basins sampled vary between 1 and 2 mi^2. Streams were also sampled at the study area boundaries to determine whether any anomalous concentrations of elements were being imported from outside the study areas. At each stream site, panned-concentrate samples were collected at several different places in the active stream bed where heavy minerals would be concentrated. The sediment was sieved at the site through a stainless-steel screen to less than 10 mesh (0.066 in.). Where water was available, the samples were panned to a concentrate of 0.2–0.4 oz; in dry stream beds 15 lb of sediment were collected for later panning. Panned-concentrate samples were additionally screened in the laboratory to 35 mesh (0.0165 in.); the fraction greater than 35 mesh was discarded. The fraction less than 35 mesh was further processed through bromoform separation and a magnetic separation. The nonmagnetic heavy-mineral fraction was ground in a mortar and pestle to less than 100 mesh (0.0059 in.) for analysis.

Rock samples were collected at representative outcrops and at any location where altered or mineralized rock was noted. About 0.5 lb of thumb-sized, monolithologic, unweathered rock chips were collected from the outcrop by sampling along distances of 10–15 ft. Where foliation was evident, the sample was collected perpendicular to its trend. Rock samples were pulverized to less than 100 mesh in the laboratory before analysis.

All rock and stream-sediment samples were analyzed for 31 elements by six-step, direct-current arc, optical-emission semiquantitative spectrography (Grimes and Marranzino, 1968). The results for each element are reported as midpoints of geometric brackets within each order of magnitude (for example, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1). The precision of the results is approximately one standard deviation per bracket. Panned-concentrate samples were analyzed by G. W. Day, and the rock samples were analyzed by P. H. Briggs.

Results

Panned-concentrate samples from the study areas showed detectable concentrations of B, Ba, Be, Co, Cr, Cu, La, Ni, Pb, Sc, Sn, Sr, V, Y, and Zr. Of these elements, only barium, tin, yttrium, and zirconium were present in amounts substantially above the detection limit for each element, and none of these elements was present in anomalous concentrations. All samples contained barium (range 200–700 ppm (parts per million)), yttrium (range 50–500 ppm), and zirconium (greater than 2,000 ppm); two samples contained 20 ppm tin, and one sample contained 70 ppm tin. The high concentrations of yttrium and zirconium are probably related to the large amount of the heavy mineral zircon in the panned concentrates—zirconium is also an abundant accessory mineral in the Idavada Volcanics. The source of the tin anomalies is unknown.

Rock samples from the study areas showed no anomalous concentrations of any of the detected elements. In particular, two samples from the Red Dot mercury claim, just north of study area ID–54–8a (fig. 2), had the same concentrations of elements as rocks had within the study areas (pl. 1, samples GMT010 and GMT011). As Moyle indicated in the appraisal section, rock samples from the Red Dot mercury claim did not contain mercury or anomalous values of any metals; one sample contained 0.184 mg of gold, equivalent to about 0.002 oz/ton.

Geophysics

Geophysical data provide information on the subsurface distribution of rock masses and the structural framework of the rocks. Existing magnetic data (U.S. Geological Survey, 1978; Zietz and others, 1978) reflect a regional scale and so were not used in the evaluation. Gravity data were obtained from files maintained by the Defense Mapping Agency of the U.S. Department of Defense. No data were obtained from additional gravity stations.

Bouguer gravity anomaly values were computed according to the 1967 gravity formula (International Association of Geodesy, 1967) and a reduction density of 2.67 g/cm^3 (grams per cubic centimeter). Terrain corrections were made by computer for a distance of 100 mi from the station, using the method of Plouff (1977).

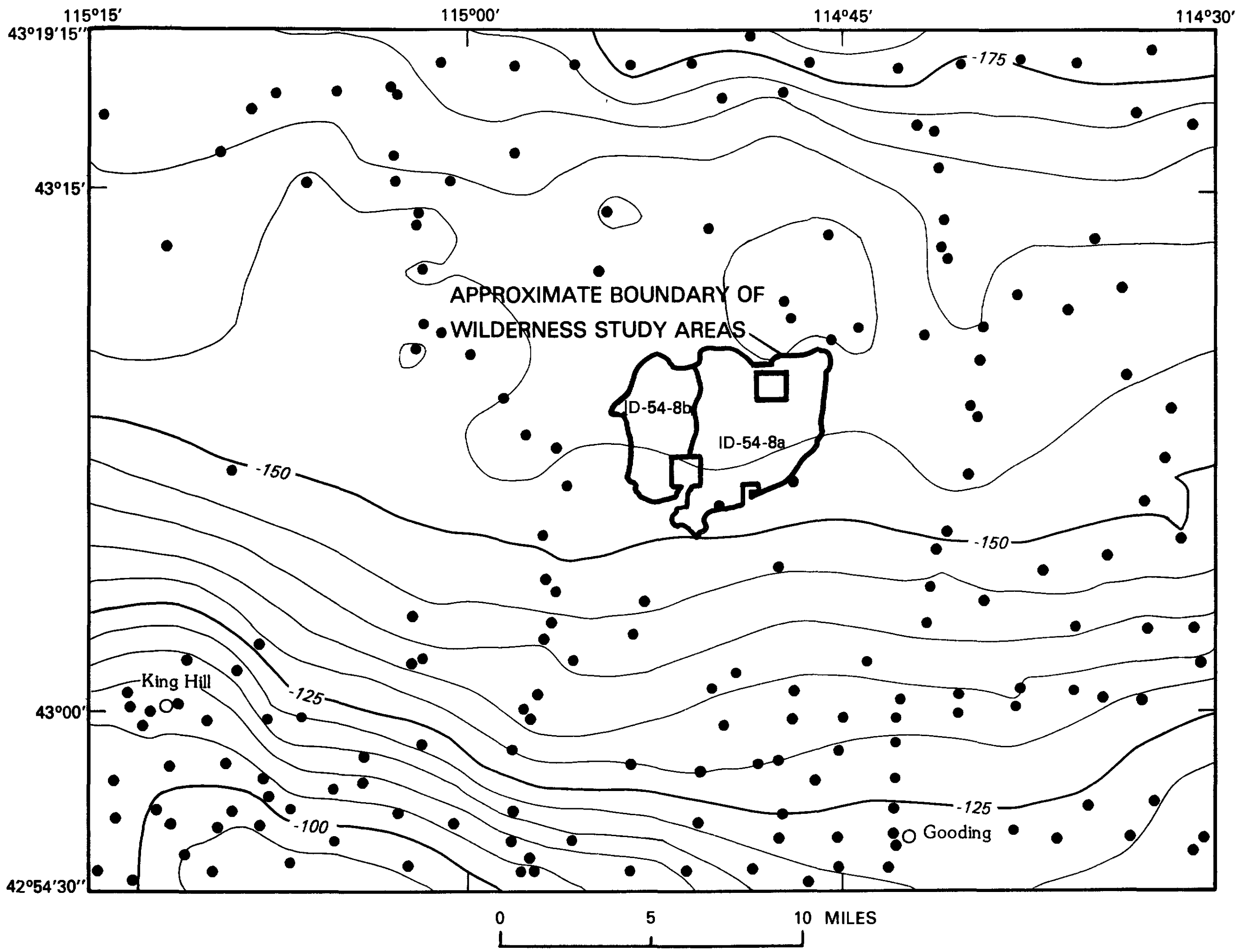

Figure 3. Complete Bouguer gravity map for area around the Gooding City of Rocks East and West Wilderness Study Areas, Gooding County, Idaho. Contour interval 5 milligals. Dots show locations of gravity stations.

The study areas lie within a regional gravity plateau (fig. 3). Lower gravity measurements to the north are associated with sedimentary rocks in the Camas Prairie graben. South of the study areas a gravity gradient is associated with basalt terrane adjacent to the Snake River Plain that causes increasingly higher measurements to the south. Volcanic rocks that have an intermediate composition are present over most of the study areas, and basalt is present along the northern border (pl. 1). The various geologic units are not expressed in the gravity data at this contour interval and density of measurements. The faults mapped in the area are not expressed in the gravity data and probably do not have major offset. Diatomite present in the study area has no expression because the regional gravity data were sparse and included no stations within the study area boundaries.

Mineral and Energy Resource Potential

Metals

No areas of mineralized rock were identified within the study areas. Abundant scattered fragments of jasper were found in the eastern part of study area ID–54–8b, particularly in association with a basal vitrophyre, but the source was not located. Chemical analysis of samples from a small prospect pit north of study area ID–54–8a revealed no anomalous concentrations of any elements. One sample collected from the pit by the USBM (Moyle, 1985) showed some gold equivalent to 0.002 oz/ton. Tube-shaped cavities (unmineralized) in the breccia may be reed molds, possibly related to an ancient hot spring (Moyle, 1985).

On the basis of geochemical analyses and field mapping, the Gooding City of Rocks East and West Wilderness Study Areas are considered to have low mineral resource potential for metals, with certainty level B. However, 16 mi north of the study areas, granitic rocks of the Idaho batholith contain some gold, copper, lead, and zinc. Taubeneck (1971) suggests that the Idaho batholith is present beneath the volcanic rocks of the study areas. Without exploratory drilling, the presence of mineralized rocks beneath the volcanics of the study areas is uncertain.

Diatomite

Moyle (1985) indicates that the only identified diatomite resource is in the Clover Creek claim west of area ID–54–8b. Because outcrops of diatomaceous rock are abundant in study area ID–54–8b, the resource potential is high for diatomite, with certainty level C. Because outcrops of diatomite are exposed in the southwest corner of area ID–54–8a, this part of the study area also has high resource potential for diatomite, with certainty level C.

Oil, Gas, and Coal

The Gooding City of Rocks East and West Wilderness Study Areas lack host rocks or structures favorable for oil and gas accumulation or coal formation. The study areas are on the northern edge of the Snake River Plain province, south of the Idaho batholith. Few test holes have been drilled in this region of the Snake River Plain province, but those that have been drilled did not penetrate sedimentary rocks above depths as great as 11,125 ft (Breckenridge, 1982). The potential for oil, gas, and coal is therefore low, with certainty level C. Rocks of the Idaho batholith may be present beneath the volcanic rocks of the study areas (Taubeneck, 1971). For these reasons, the potential for oil, gas, and coal in the underlying rocks is also rated low.

Geothermal Energy

Two geothermal resource areas are present immediately adjacent to the Gooding City of Rocks East and West Wilderness Study Areas (Mitchell, 1976; Mitchell and others, 1980): Mount Bennett Hills on the west and Camas Prairie on the north. The geothermal areas are possibly related to faulting along the northern edge of the Snake River Plain (Mabey, 1983). Sammel (1979) has also indicated large areas favorable for the discovery and development of low-temperature geothermal resources north and southwest of the study areas. Several hot springs and wells and a warm-water lake are also 4–6 mi southwest of the study area. Surface temperatures range from a low of 81 °F in Hot Sulfur Lake to 109 °F–149 °F in the hot springs. Mabey (1983) identified three geothermal reservoirs, one at Wardrop (207 °F), Barron's hot springs (217 °F) in Camas Prairie to the north, and Magic Reservoir (217 °F) to the east.

Springs are abundant along both the north- and south-facing slopes of the Mount Bennett Hills, immediately north of the study areas, and an intermittent stream named Hot Creek drains into the study area from the north. The presence of hot springs surrounding the study areas also indicates an environment favorable for geothermal resources; however, no surface manifestations are presently known in the study areas. For these reasons, the potential for geothermal energy in the Gooding City of Rocks East and West Wilderness Study Areas is rated moderate, with certainty level B.

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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

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

LEVEL OF CERTAINTY →

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

Abstracted with minor modifications from:

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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 by the U. S. Geological Survey, 1986

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.