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MINERAL RESOURCE POTENTIAL OF THE MADISON ROADLESS AREA, GALLATIN AND MADISON COUNTIES, MONTANA

By

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STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provides that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and to be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Madison Roadless Area, Gallatin and Beaverhead National Forests, Gallatin and Madison Counties, Montana. The Roadless Area comprises the Madison RARE II area No. 1549, parts E, J, N, R, and S, which were classified as further planning areas during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979. Parts E, N, and S had been designated in 1977 for evaluation under the Montana Wilderness Study Act (Public Law 95-150). Part J was studied initially in 1968 as an extension of the proposed Spanish Peaks Primitive Area.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

A geological and mineral resource survey of the Madison Roadless Area in the Madison Range of southwestern Montana was made by the U.S. Geological Survey and the U.S. Bureau of Mines at various periods between 1970 and 1980. The area covers approximately 606 mi^2 (388,000 acres) in the Gallatin and Beaverhead National Forests. No minerals except for a possible small tonnage of asbestos have been produced from the area, and only a little prospecting has been done. One exploratory oil well, a dry hole, was drilled in 1949.

Mineral commodities of the area are phosphate rock, asbestos, and sillimanite; construction materials are present, but deposits are small or inaccessible and they are not further considered. Permian Shedhorn Sandstone, containing a large resource of phosphate rock, underlies much of the central and southern part of the area, but most of the beds of phosphorite and phosphatic shale are thin, or low grade, or both, and over most of the area are probably too deeply buried to be presently minable. Two occurrences, Indian Creek and Pulpit Rock, contain 9.0 million tons of phosphate rock with a grade in excess of 18 percent P_2O_5. Asbestos resources of the Karst prospect are estimated to be 83,000 tons of rock averaging 18 percent asbestos. The prospect is in Precambrian mafic metamorphic rocks and the asbestos mineral is anthophyllite. Other known occurrences of asbestos in the area are small. The Placer Creek deposit has an estimated 93,000 tons of sillimanite-bearing Precambrian gneiss that averages about 84 percent sillimanite and also contains 2 percent rutile. This deposit has a high potential for additional resources of sillimanite. Sillimanite occurs elsewhere in the roadless area, but the deposits appear to be small. Construction materials similar to those in the roadless area are available more easily nearby.

The area lacks the kinds of plutonic igneous rocks and the altered rocks that commonly accompany metalliferous mineral deposits in the Rocky Mountains, and the few apparently altered rocks that were sampled contained only ordinary amounts of any metal. However, an area near the south edge of the roadless area has a low potential for resources of copper and silver, and an area about 1 mi north of the northwest corner of the roadless area has a low potential for resources of silver and lead. Two areas that have a low potential for molybdenum, and one with a low potential for uranium, were outlined by geochemical sampling.

Coal occurs at several places in Cretaceous sedimentary rocks, but known seams are thin, discontinuous, and of low quality.

Some potential oil- and gas-bearing structures may exist west of the leading edge of the Hilgard fault system, but they can be sought and evaluated adequately only by geophysical methods, particularly seismic profiling. No hot springs or potential sources for geothermal energy are known.

INTRODUCTION

The Madison Roadless Area is in southwestern Montana immediately west and northwest of Yellowstone National Park (fig. 1). It extends about 50 mi north-northwestward along the crest of the Madison Range from Hebgen Lake to about 5 mi north of Ennis Lake and covers an area of approximately 606 mi^2 (388,000 acres). The west flank of the Madison Range is in the Beaverhead National Forest, the east flank in the Gallatin National Forest. The area is about equally divided between Madison and Gallatin Counties.

General access to the area is provided by U.S. Highway 287 along the Madison River and U.S. Highway 191 along the Gallatin River. Unimproved roads extend up most of the main drainages, and some penetrate short distances into the area, but access to most of the area is only by trail.

The entire area except for very small parts in the northwest and northeast corners is above 6,000 ft in altitude; the highest point is Hilgard Peak, 11,316 ft, and several other peaks exceed 11,000 ft in altitude. The western part of the Madison Range is rugged and characterized by jagged ridges and deep narrow canyons; the west flank rises steeply as much as 5,000 ft above the Madison Valley. The eastern part of the range has gentler slopes and more open valleys, and the highest peaks are about 10,000 ft in altitude. Evidence for alpine glaciation--cirques, rock-basin lakes, U-shaped valleys, and glacial deposits--is particularly well displayed in the southern part of the area but is seen throughout the area. Landslides and earthflows, some of enormous size, are abundant; the best known is the Madison River slide on the south edge of the area, which resulted from the Hebgen Lake earthquake of August 17, 1959, and dammed the Madison River canyon to produce the present Earthquake Lake.

Fieldwork in the Madison Roadless Area was done by the U.S. Geological Survey in 1980-1982, and by the U.S. Bureau of Mines in 1970 and 1978-1980. A geologic map of the area at a scale of 1:96,000 appears in Tysdal and Simons (in press) and geochemical maps in Simons and others (in press). Mineral resources of the Spanish Peaks Primitive Area were studied by Becraft and others (1966) and those of the Jack Creek area by Becraft and others (1970); these areas are entirely within the roadless area. Mineral resources of the Bear Trap Canyon Instant Study Area and vicinity were evaluated by Pinckney and others (1980); some of the area studied by them is within the roadless area.

GEOLOGY

The Madison Range of southwestern Montana extends north-northwestward from Hebgen Lake to the vicinity of Norris, a distance of about 55 mi. The Madison Range is geologically part of a Tertiary structural block that also includes the Gallatin Range to the east; the two ranges are separated geographically but not geologically by the Gallatin River. The Madison-Gallatin block consists of a basement of Precambrian metamorphic rocks of Archean W (Late Archean) age (2,500-3,000 m.y. old) overlain by a sequence of dominantly carbonate Paleozoic rocks, 3,000-4,000 ft thick, and a sequence of dominantly clastic Mesozoic sedimentary rocks, mainly Cretaceous, about 5,000-7,000 ft thick. Volcanic and volcaniclastic rocks of Late Cretaceous age, 1,500-2,500 ft thick, and conglomerate of early Tertiary age, 2,000 ft or more thick, occur in the central part of the range. Pliocene and Pleistocene silicic volcanic rocks blanket a few square miles in the southeastern part of the roadless area. Porphyritic dacitic igneous rocks of Late Cretaceous age intrude sedimentary rocks at Lone Mountain and Fan Mountain and along the Gallatin River at Snowslide Creek. Bedrock is concealed locally by Holocene glacial deposits, landslide deposits, talus, and alluvium.

Pre-Tertiary rocks of the Madison Range were folded and faulted along northern to northwestern trends during Laramide deformation resulting in northwest- to north-northwest-trending structures; among these, the Hilgard fault system trends north-northwest from Hebgen Lake for 30 mi, has a displacement of many thousands of feet, and in general forms the boundary between Precambrian rocks to the west and younger rocks to the east in the central and southern parts of the range. Rocks uplifted during Laramide deformation were subsequently eroded and in Eocene time may have been buried by volcanic rocks of the Absaroka volcanic field. A large part of the range was later blanketed by volcanic rocks of the Pliocene and Pleistocene Yellowstone Group. The Madison-Gallatin block was tilted gently southwestward during late Cenozoic uplift along a system of normal faults that define the west flank of the Madison Range. The present topography of the range resulted from erosion by water and ice.

GEOCHEMISTRY

Geochemical evaluation of the mineral potential of the Madison Roadless Area is based on chemical analyses of 898 stream-sediment samples, 280 rock samples, and 14 panned-concentrate samples of stream sediments collected by the U.S. Geological Survey (Simons and others, in press), 280 stream-sediment samples collected by Los Alamos Scientific Laboratory (Bolivar, 1980a, 1980b; Shannon, 1980), and more than 100 samples collected by the U.S. Bureau of Mines at some 35 localities (Lambeth and others, 1982).

Anomalous amounts of 21 elements were detected in samples collected during the geochemical study, but many elements (beryllium, bismuth, thorium, tin, tungsten, zinc) were found in only very small amounts, and others (barium, boron, chromium, cobalt, copper, lanthanum, lead, manganese, nickel, niobium, silver, vanadium, yttrium) were mostly in low concentrations and in widely scattered samples. No geochemical anomaly considered to be significant was found for any element, but very low level anomalies were recognized for molybdenum in two areas and for uranium in one region.

GEOPHYSICS

Aeromagnetic and gravity surveys of the Madison Roadless Area were made to obtain geophysical information on subsurface lithology and structure that would assist in the evaluation of mineral resource potential. Interpretation of the geophysical data is in progress, but the results are not available at present.

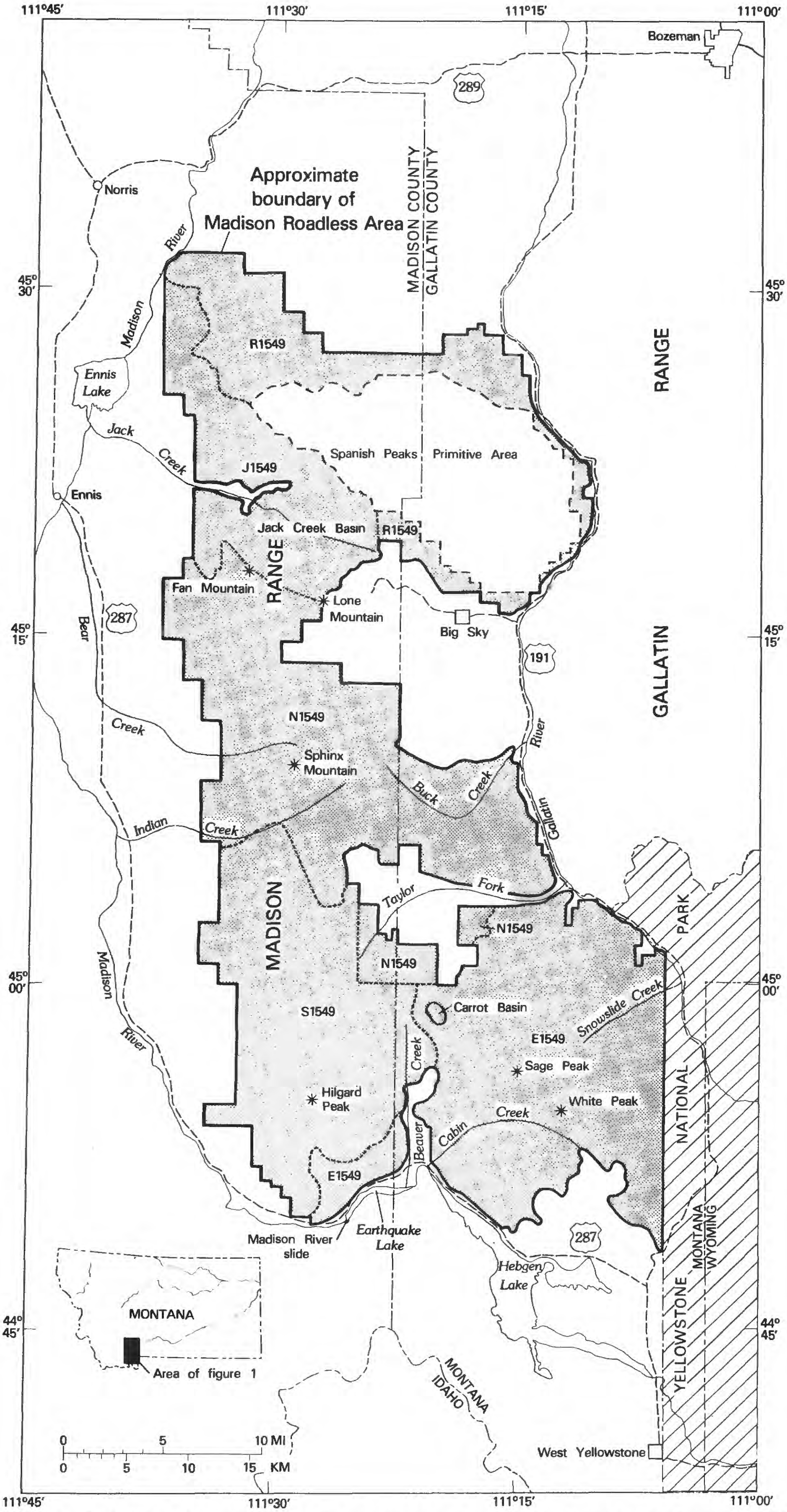
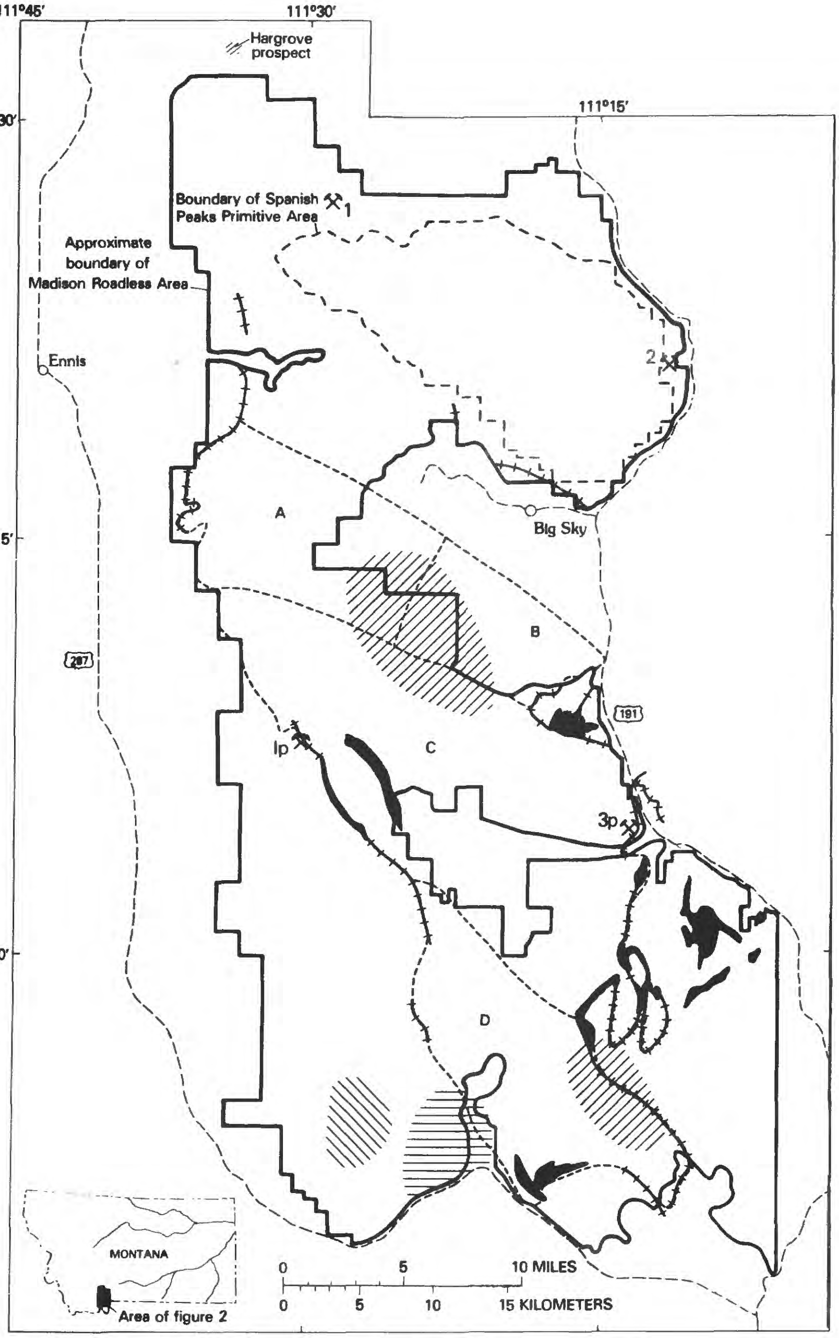


Figure 1.--Index map of Madison Roadless Area and vicinity. Heavy solid line, approximate boundary of roadless area; heavy dashed line, boundary of Spanish Peaks Primitive Area; dotted lines, boundaries of the five further planning areas (No. 1549, parts E, J, N, R, and S) that together make up the roadless area.



EXPLANATION

OUTCROP OF PERMIAN SHEDHORN SANDSTONE

OUTLINE OF AREA USED FOR ESTIMATE OF PHOSPHATE ROCK RESOURCES--After Swanson (1970, p. 737, fig. 188). A, Cedar Creek-Jack Creek; B, West Fork Gallatin River; C, Indian Creek-Taylor Fork; D, Beaver Creek-Cabin Creek

AREA OF LOW POTENTIAL FOR COPPER AND SILVER

AREA OF LOW POTENTIAL FOR LEAD AND SILVER

AREA OF LOW POTENTIAL FOR MOLYBDENUM

AREA OF LOW POTENTIAL FOR URANIUM

LOCALITY THAT HAS MINERAL RESOURCES--1, Placer Creek (sillimanite); 2, Karst (asbestos); 1p, Indian Creek (phosphate rock); 3p, Pulpit Rock (phosphate rock)

Figure 2.—Map of the Madison Roadless Area showing outcrop of Permian Shedhorn Sandstone, localities that have mineral resources, and areas that have potential for mineral resources.

MINING DISTRICTS AND MINERALIZED AREAS

Mining activity

No minerals have been produced from the Madison Roadless Area, and no active mining claims exist. Several small mining districts and mineral deposits adjoin or are near the area; these include the Boaz mine in the Lower Hot Springs district near the northwest corner of the area, which has produced about 62,000 tons of gold-silver-lead ore, and the Karst mine just east of the area, which has produced a few thousand tons of asbestos ore. A few hundred ounces of gold are reported to have been produced from placer deposits on West Fork Gallatin River and Taylor Fork near the east edge of the area, and small amounts of coal are reported to have been mined on the Taylor Fork and West Fork Gallatin River. A little prospecting has been done for corundum and sillimanite around the north end of the area. Copper and silver have been sought at a few places along the Spanish Peaks fault and near the south end of the area, and a dozen or so prospects were found during this study. Phosphate resources in Permian rocks in the area were studied by the U.S. Geological Survey in 1928 (Condit and others, 1928, p. 147-191) and again in 1947-1948 (Swanson, 1970, p. 733-739). The Gallatin and Yellowstone Valleys were prospected for oil and gas in the 1920's, but the only exploratory drilling in the roadless area was a dry hole in Carrot Basin in the southern part of the area (Tutten, 1960). This well was 2,140 ft deep and found minor oil stains but no commercial oil or gas.

Lease applications for oil and gas exploration have been made for about 105 sq mi of the area, mainly in the drainage basins of West Fork Gallatin River, Jack Creek, Taylor Fork, Indian Creek, and Beaver Creek. Terrace gravels and talus along the Gallatin River near the Madison area have been utilized extensively for road building.

Mineral commodities

Mineral commodities in the Madison Roadless Area are phosphate rock, sillimanite, asbestos, and construction materials. Traces of copper, silver, molybdenum, gold, lead, and zinc were found at several prospects. No oil, gas, or geothermal resources are known. No other mineral deposits are known to exist, nor are there any active mining claims. Locations of deposits of phosphate rock, asbestos, sillimanite, and of areas that have mineral potential are shown on figure 2. Occurrences of construction materials are not shown because they are small or inaccessible, and similar materials are more easily available nearby.

Shedhorn Sandstone of Permian age contains beds of phosphorite and phosphatic shale at many places along its outcrop (fig. 2). Phosphate rock ranges in thickness from less than 1 in. to more than 6 ft, but most of it is less than 3 ft thick. Phosphate deposits of the Madison Range were studied by Swanson (1970, p. 733-739; pl. 28C), who calculated resources based on the total area of the Retort Phosphatic Shale Member of the Phosphoria Formation (a tongue of the Shedhorn Sandstone in the area of this report) inferred to underlie the range and on average thicknesses and grades based on measurements made at various places along the outcrop. Areas used by Swanson for resource calculation are shown in figure 2, and his estimates of resources for each area are given in table 1; most of the West Fork Gallatin River area, and large parts of the Cedar Creek-Jack Creek and Indian Creek-Taylor Fork areas are not in the roadless area. Most of the phosphate rock in the Cedar Creek-Jack Creek area, and much of it in the Indian Creek-Taylor Fork area, is probably too deeply buried ever to be minable, and that of the Beaver Creek-Cabin Creek area is less than 4 ft thick; nevertheless, the roadless area has a substantial resource of phosphate rock.

The Placer Creek sillimanite deposit (fig. 2, no. 1) is a northeast-trending lens of sillimanite-rich gneiss in garnet-hornblende gneiss. The lens, 20 ft thick and at least 150 ft long, is estimated to contain about 21,000 tons of indicated resource and 70,000 tons of inferred resource having 84 percent sillimanite and 2 percent rutile.

The Karst asbestos prospect (fig. 2, no. 2) explores veins and replacement bodies of asbestiform anthophyllite in a pod of mafic rocks 90 ft thick. The asbestos occurs where the pod is cut by a steeply dipping, north-northwest-striking 24-ft-wide shear zone. The maximum vein thickness is 4 ft. Estimated asbestos resources are 37,000 tons indicated and 46,000 tons inferred with an average grade of 18 percent asbestos.

An area near the south edge of the roadless area is considered to have low potential for resources of copper and silver. Several prospects in the area explore quartz-pyrite-chalcopyrite veins in Precambrian gneiss. Most of the veins are only a few tens of feet long and less than 2 ft wide, and most samples of vein material contain less than 1 percent copper and less than 0.5 oz silver per ton. All known deposits in the area are small, but the number of prospects in the area and the occurrence of traces of silver in a few sediment samples from streams draining the area suggest that it has a low potential for copper and silver resources.

The Hargrove prospect, a small area about 1 mi north of the northwest corner of the roadless area, has a low potential for silver and lead resources (fig. 2). The prospect consists of an adit, two shafts, and several pits and trenches on pods and veins of quartz enclosed in Tertiary(?) dacitic porphyry and quartz diorite dikes. The quartz contains traces of galena, sphalerite, chalcopyrite, and pyrite. One sample of a dump contained 2.4 oz of silver per ton, and another sample of an altered dike contained 0.9 percent of lead, 0.3 percent of zinc, and a trace of silver. The other 27 samples collected contained only traces of silver, lead, zinc, or copper.

Samples in which molybdenum was detected are mostly of Precambrian rocks or of stream sediments derived from Precambrian rocks. However, two areas in which Precambrian rocks are not exposed yielded numerous stream-sediment samples containing traces to as much as 10 ppm molybdenum. One is a large area comprising parts of the headwater basins of Indian, Bear, and Buck Creeks and West Fork Gallatin River; the only rocks in the area known to contain as much as 5 ppm molybdenum are tuff of the Cretaceous Livingston Group and black shale of the Jurassic Morrison Formation which is exposed in a few places. The second area is around Sage and White Peaks, particularly in upper Cabin Creek; no source rock was recognized, but the Morrison Formation occurs in this area also. Both areas are considered to have a low resource potential for molybdenum.

Stream-sediment samples containing more than a few parts per million of uranium come almost entirely from drainages underlain wholly or mainly by Precambrian metamorphic rocks; all streams that drain dominantly Precambrian rocks, except for some in the northwesternmost part of the area, yield sediment samples high in uranium. These data indicate that the background uranium content of Precambrian rocks is high relative to that of other rocks in the area. Samples containing exceptionally high uranium contents—100 ppm or more—are concentrated in the southwest corner of the roadless area around and south of Hilgard Peak (fig. 1). This area is entirely underlain by Precambrian rocks and has 20 of the 25 samples from the roadless area that contain 100 ppm or more uranium. It is likely that these samples too reflect a relatively high background uranium content in the source rocks; that is, the uranium is dispersed in the Precambrian rocks rather than being concentrated into deposits, but because of the large number of uranium-rich samples, the area is considered to have a low resource potential for uranium.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Mineral commodities of the Madison Roadless Area comprise phosphate rock, sillimanite, and asbestos. Except possibly for a small amount of asbestos, no mineral production is known from the area.

Resources of phosphate rock in the Permian Shedhorn Sandstone are substantial, but large parts of the beds of phosphate rock are thin and (or) low grade, and much of the resource is probably too deeply buried ever to be minable. The Indian Creek locality (fig. 2, no. 1p) has 4.7 million tons of phosphate rock containing more than 18 percent of P_2O_5, and the Pulpit Rock locality (fig. 2, no. 3p) has 4.3 million tons of similar grade.

Sillimanite resources are mostly in the Placer Creek deposit (fig. 2, no. 1), which is estimated to contain about 93,000 tons of material averaging 84 percent sillimanite and 2 percent rutile. The deposit has a high potential for additional resources.

Asbestos resources are mainly in the Karst deposit (fig. 2, no. 2) and are estimated at about 83,000 tons containing 18 percent asbestos. Other known occurrences are small.

The roadless area lacks the kinds of plutonic igneous rocks and the altered rocks that commonly are associated with metalliferous mineral deposits in the Rocky Mountains, and the overall potential of the area for these resources is low. However, five areas are considered to have low potential. An area near the south edge of the roadless area has several small copper-silver prospects, and traces of silver occur in sediment samples from streams in the area; it is considered to have a low potential for copper and silver resources. A small area about 1 mi north of the northwest corner of the roadless area contains the Hargrove prospect and has a low potential for silver and lead resources. Low-level geochemical anomalies for molybdenum were outlined in two places by geochemical sampling, and a low-level anomaly for uranium was recognized in the southwest part of the area (fig. 2). The resource potential of these areas is low. No other geochemical anomalies of consequence were found.

Known beds of coal are thin, discontinuous, and of low quality, and the potential for minable coal resources is low.

The only oil exploration well drilled in the area, at Carrot Basin in 1949, was a dry hole. Potential oil- and gas-bearing structures in the area east of the leading edge of the Hilgard fault system are small, deeply eroded, and intruded locally by igneous rocks. The best structural setting for entrapment of hydrocarbons lies west of the leading edge and can be sought and evaluated adequately only by geophysical investigations, particularly seismic profiling.

No hot springs or potential sources for geothermal energy are known in the roadless area. The nearest hot spring is Bozeman Hot Springs, about 7 mi west of Bozeman and 14 mi north of the roadless area; this spring is reported by Waring (1965, p. 32) to have a temperature of 137° F and a flow of 250 gallons per minute. The area around Bozeman Hot Springs is considered by Sammel (1979, p. 112-113) to be favorable for the discovery and development of local sources of low-temperature geothermal water.

REFERENCES CITED

Becraft, G. E., Calkins, J. A., Pattee, E. C., Weldin, R. D., and Roche, J. M., 1966, Mineral resources of the Spanish Peaks primitive area, Montana: U.S. Geological Survey Bulletin 1230-B, 45 p.

Becraft, G. E., Kiilsgaard, T. H., and Van Noy, R. M., 1970, Mineral resources of the Jack Creek Basin, Madison County, Montana: U.S. Geological Survey Bulletin 1319-B, 24 p.

Bolivar, S. L., 1980a, Uranium hydrogeochemical and stream sediment reconnaissance of the Bozeman NTMS quadrangle, Montana, including concentrations of forty-two additional elements: Los Alamos Scientific Laboratory Informal Report LA-7504-MS, Supplement, 169 p.

______1980b, Uranium hydrogeochemical and stream sediment reconnaissance data listing release for the Three Forks Basin, Spanish Peaks, and Boulder River area in the Bozeman NTMS quadrangle, Montana, including concentrations of forty-six additional elements: Los Alamos Scientific Laboratory Informal Report LA-8486-MS, 131 p.

Condit, D. D., Finch, E. H., and Pardee, J. T., 1928, Phosphate rock in the Three Forks-Yellowstone Park region, Montana: U.S. Geological Survey Bulletin 795-G, p. 147-209.

Lambeth, R. H., Schmauch, S. W., Mayerle, R. T., and Hamilton, M. M., 1982, Mineral investigations of the Madison RARE II areas (No. 1549, parts E, J, N, R, and S) Beaverhead and Gallatin National Forests, Madison and Gallatin Counties, Montana: U.S. Bureau of Mines Open-File Report MLA 81-82, 31 p.

Pinckney, D. M., Hanna, W. F., Kaufmann, H. E., and Larson, C. E., 1980, Resource potential of the Bear Trap Canyon Instant Study Area, Madison County, Montana: U.S. Geological Survey Open-File Report 80-835, 32 p.

Sammel, E. H., 1979, Occurrence of low-temperature geothermal waters in the United States, in

Muffler, L. J. P., ed., Assessment of geothermal resources of the United States—1978: U.S. Geological Survey Circular 790, p. 86-131.

Shannon, S. S., Jr., 1980, Uranium hydrogeochemical and stream sediment reconnaissance data release for the Ashton NTMS quadrangle, Idaho/Montana/Wyoming, including concentrations of forty-two additional elements: Los Alamos Scientific Laboratory Informal Report LA-8009-MS, 168 p.

Simons, F. S., Van Loenen, R. E., and Tysdal, R. G., in press, Geochemical map of the Madison Roadless Area, Gallatin and Madison Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-1605-C.

Swanson, R. W., 1970, Mineral resources in Permian rocks of southwest Montana: U.S. Geological Survey Professional Paper 313-E, p. 661-777.

Tutten, W. D., 1960, Carrot Basin anticline, Gallatin County, Montana, in West Yellowstone—Earthquake area: Billings Geological Society Guidebook, 11th Annual Field Conference, p. 261-264.

Tysdal, R. G., and Simons, F. S., in press, Geologic map of the Madison Roadless Area, Gallatin and Madison Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-1605-B.

Waring, G. A., 1965, Thermal springs of the United States and other countries of the world—A summary, revised by R. R. Blankenship and Ray Bentall: U.S. Geological Survey Professional Paper 492, 383 p.

Table 1.--Estimates of resources of phosphate rock in the Madison Range, Montana (after Swanson, 1970, p. 737, table 7)

[Amounts in millions of short tons; grades in percent of P_2O_5. Letters in parentheses refer to resource blocks shown on fig. 2; leaders (---), not determined]

Resource block	Rock containing >24 percent P_2O_5	Grade	Rock containing >18 percent P_2O_5	Grade
Cedar Creek-Jack Creek (A)-----	350	25.9	550	24.6
West Fork Gallatin River (B)---	250	24.8	400	19.3
Indian Creek-Taylor Fork (C)---	500	26.0	1,500	19.1
Beaver Creek-Cabin Creek (D)---	---	---	150	19.7