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MINERAL RESOURCE POTENTIAL OF THE MIDDLE MOUNTAIN-TOBACCO ROOT ROADLESS AREA, MADISON COUNTY, MONTANA

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STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Middle Mountain-Tobacco Root Roadless Area (B1013), Deerlodge and Beaverhead National Forests, Madison County, Mont. The Middle Mountain-Tobacco Root Roadless Area was classified as a further planning area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

The Middle Mountain-Tobacco Root Roadless Area of southwestern Montana contains areas of low to high mineral resource potential (fig. 3). The areas of highest potential are in or adjacent to intrusive rocks of Late Cretaceous age.

Most of the roadless area is underlain by Archean metamorphic and igneous rocks that are locally overlain by Paleozoic and Mesozoic sedimentary rocks; all rocks have been intruded by the Late Cretaceous Tobacco Root batholith or its apophyses. Metamorphic rocks adjacent to the batholith, and metamorphic and sedimentary rocks intruded by apophyses of the batholith, commonly show some sulfide mineralization. Disseminated and stockwork copper and molybdenum sulfides are present at Granite Peak in that part of the batholith that extends into the roadless area. Sulfide-bearing breccia pipes on Middle Mountain appear to be related to this mineralized zone. The Granite Peak area exhibits high mineral resource potential for copper and molybdenum.

Apophyses of the Tobacco Root batholith are present in the Boulder Lakes area, partly within the roadless area. Many of these intrusive bodies bear minor disseminated or weakly developed stockwork sulfides and local fluorite and are associated with quartz veins that contain important amounts of gold. A weakly mineralized breccia pipe is also present in the Boulder Lakes area, as well as gold-bearing quartz veins that have been actively mined. Two properties in this area, the Snyder mine and the Curly Bill-Curly Bill No. 2 claims, have identified resources totalling about 90,000 tons. Gold resources at depth are indicated for the nearby Boulder Cobalt, Curly Bill No. 3, Midnight, and Old Cabin prospects. The Boulder Lakes area displays moderate to high mineral resource potential for precious metals, especially gold, and a low to moderate potential for base-metal sulfides.

The Strawn Mine, near the mouth of Beall Creek, is an active gold mine that is nearly surrounded by the roadless area. The main vein at this mine can be traced southward into the roadless area. The Nicholson (Ridgeway) mine, an active gold mine located along the Bismark fault zone, is not within the the roadless area but is essentially surrounded by it. The Strawn and Nicholson mines have identified gold resources of about 28,000 tons. The Nicholson mine, the now inactive Bismark mine at the north end of Middle Mountain, and the nearby Baugus Hughes, Moggolian, Lester Baker, Quartz City, and Sultana prospects explore major mineralized areas along the Bismark fault zone. Sulfide mineralization and associated gold-bearing quartz veins are more common along this fault zone than along any other structural feature in the northern Tobacco Root Mountains. These areas show high potential for precious metals. Areas along the Bismark fault zone adjacent to the Bismark mine also show moderate to high potential for base metals.

Many of the streams that provide water for irrigation of lands adjacent to the Tobacco Root Mountains have their headwaters in glacial cirques in or adjacent to the roadless area. The value of this resource is very high.

INTRODUCTION

The Middle Mountain-Tobacco Root Roadless Area encompasses 36,640 acres, mainly within the Deerlodge and Beaverhead National Forests, Madison County, Mont. (fig. 1). The area studied for this report includes the roadless area and parts of the national forest peripheral to it.

The Tobacco Root Mountains are a linear, north-trending range bounded on the east and west by broad intermontane valleys. The highest peaks of the range occur within the roadless area, reaching a maximum elevation of 10,604 ft on Mt. Jefferson. Topographic relief is nearly 5,000 ft along the western part of the range. The roadless area encompasses nearly all of the drainage basin of the South Boulder River, a north-flowing tributary of the Jefferson River. The headwaters of this drainage system are in a ring of north-facing cirques that mark the formidable southern boundary of the roadless area. Middle Mountain is the prominent peak on the ridge that trends northward into the center of the cirque complex.

GEOLOGY

Rocks exposed in the Tobacco Root Mountains range in age from Precambrian to Quaternary. A detailed geologic map is given by O'Neill (1983a). The core of the range is composed of two major rock types: layered Archean rocks in much of the northern, western, and southern parts of the range, and dioritic to granitic batholithic rocks of Late Cretaceous age in much of the east-central part of the range. Sedimentary rocks, mainly Paleozoic in age, are present along the northwest and north margins of the uplift and are remnants of the extensive sedimentary section that once covered the region. These sedimentary rocks, which almost everywhere dip away from the range core, appear to have been draped over the edge of a basement block that was initially uplifted in Late Cretaceous-early Tertiary time (Schmidt, 1975). Basin-fill sediments were shed from this and adjacent uplifts into the intermontane valleys and are now exposed along the west and north margins of the range. Block faulting that raised the range to its present height and position began in late Miocene time and continues today (Pardee, 1950). The range was intensely glaciated in the Pleistocene and contains many cirques, tarns, and ice-carved valleys. Quaternary deposits, largely glacial in origin, commonly blanket the floors of most mountain valleys.

Precambrian metamorphic rocks

Archean metamorphic rocks of the Tobacco Root Mountains consist mainly of amphibolite-grade quartzofeldspathic gneiss interlayered with varying proportions of calc-silicate rock and marble, quartzite, aluminous schist, anthophyllite- and garnet-rich schist and gneiss, magnetite gneiss, hornblende-plagioclase gneiss, and amphibolite (Vitaliano and others, 1979). The structurally lowest rocks are the most lithologically complex and show the greatest amount of megascopic deformation. All Archean rocks were subjected to strong regional metamorphism and penetrative deformation during a major tectonic event 2.7 b.y. ago (Mueller and Cordua, 1976; James and Hedge, 1980). These rocks also were affected by a pervasive thermal event about 1.6 b.y. ago (Giletti, 1966). All rocks have been intruded by Archean metabasite and ultramafic dikes and sills, by Proterozoic diabasic dikes (Wooden and others, 1978), and by granitic pegmatites of probable Precambrian age.

Phanerozoic sedimentary rocks

Sedimentary rocks exposed in the Tobacco Root Mountains are typical of the southwestern Montana succession (Sloss and Moritz, 1951; Tysdal, 1976) and are exposed along the northwest and north sides of the uplift. Quartz sandstone and minor pebble conglomerate are present at the base of the section and mark the encroachment of Middle Cambrian seas onto the craton (Perry, 1962). Above the sandstone lies a thick succession of interlayered carbonate and fine-grained clastic rocks indicative of a fluctuating shoreline in this area from Middle to Late Cambrian time. A major erosional unconformity marks the contact between the Upper Cambrian sandy shale and Devonian dolomite (Sloss and Moritz, 1951; Tysdal, 1976). A thick succession of Lower Mississippian rocks overlies the Devonian sequence; these Mississippian rocks consist of limestone interlayered with calcareous shale. They grade upward into massive, thick-bedded, cherty limestone. A minor unconformity separates the Mississippian rocks from fine-grained sandstone, black shale and red shale, oolitic phosphatic rock, bedded chert, and minor limestone of late Paleozoic age.

Quaternary sediments are present in the roadless area and are largely confined to the valley floors. These deposits include alluvial sands and gravels, glacial till and outwash, talus, rock glaciers, and minor landslide debris. Alluvial fans and pediment gravels are common along the western margin of the range.

Upper Cretaceous igneous rocks

The main igneous body in the Tobacco Root Mountains is the Tobacco Root batholith of Late Cretaceous age, dated at 72-77 m.y. (Vitaliano and others, 1976). The batholith is elongate northwest-southeast, and its intrusion appears to have been controlled in large part by pre-existing, northwest-trending, high-angle faults (Reid, 1957). The pluton is zoned from tonalite and minor hornblende diorite along its margins to a small, elliptical core of granite (Smith, 1970). Diorite and tonalite are present in that part of the batholith exposed in the roadless area. Apophyses of the batholith are common in the southern and western parts of the roadless area. Small plugs, ranging in composition from granodiorite to latite porphyry, intrude Archean rocks of the Boulder Lakes area. Granodioritic to quartz monzonitic sills and mostly concordant plugs intrude the sedimentary rocks exposed along the western margin of the range (Reyner, 1947; Johns, 1961).

Structure

The rocks of the roadless area are deformed to various degrees. Archean rocks, the most strongly deformed, were folded, faulted and strongly attenuated during metamorphism. Foliation is axial planar (Reid, 1957), but is parallel to, and controlled

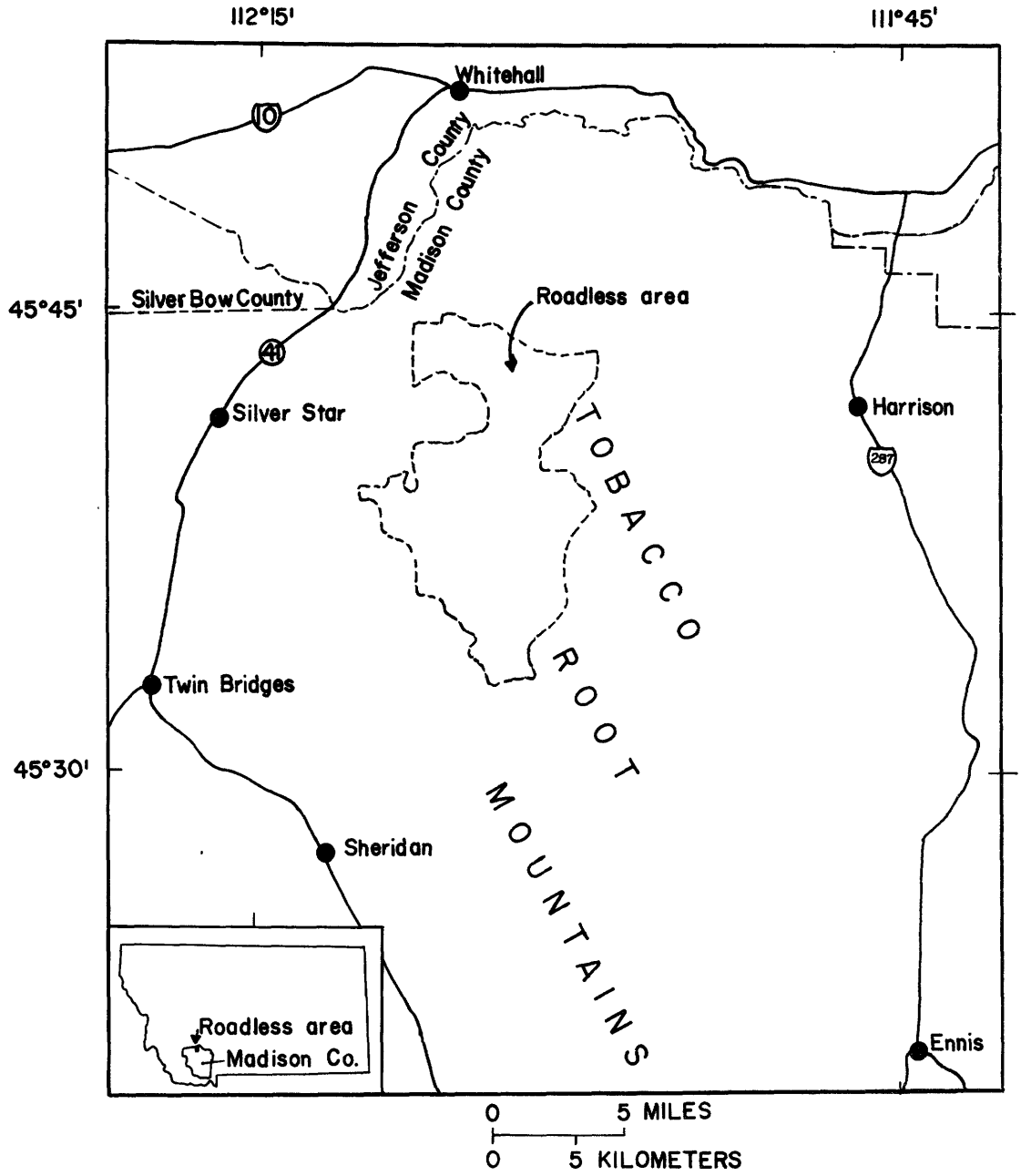

Figure 1.--Index map showing location of the Middle Mountain-Tobacco Root Roadless Area (B1013), Madison County, Mont.

by, original bedding (Burger, 1967). Megascopic isoclinal folds characterize the structurally lower, multilithologic metamorphic assemblage, whereas a single, broad antiformal fold megascopically deforms the structurally higher quartzofeldspathic gneiss.

The Paleozoic sedimentary rocks have been faulted and folded during several periods of tectonism. Thrust faults of small apparent horizontal displacement that place older upon younger rocks and that are associated with folds overturned to the east are present along the western part of the range. Many of these faults are subparallel to bedding and tend to be localized within shale horizons that separate the carbonate rocks. These shales have been tectonically thinned, internally deformed, and sheared. The sedimentary rocks, thrust faults, and related structures dip steeply to the west at the range front, but east of the front, within the range, they are more gently inclined. The monoclinal aspect of this structure appears to be due to draping over the west edge of the Laramide-age Tobacco Root uplift. To the south, in the Tidal Wave mining district, the sedimentary rocks are folded into broad, open folds and are displaced by minor thrust faults (Johns, 1961).

Two major northwest-trending, high-angle faults cross the roadless area, dividing it into three basement blocks. These faults formed in Precambrian time (Reid, 1957) and show recurrent movement (Schmidt, 1975). Major deformation along these faults occurred in Archean time. Although these faults cut the sedimentary rocks on the north and west sides of the range, the major deformation of the sedimentary succession involved the folding of the sedimentary rocks above these faults (Schmidt, 1976, 1979).

The steep front of the Tobacco Roots along the west side of the range and the associated widespread alluvial-fan development, small fault scarps, slumping, and pronounced alinement of springs are taken as evidence for recent uplift of the Tobacco Root Mountains (Tansley and others, 1933; Alden, 1953). High-angle, north- to northeast-trending faults that cut thrust faults and sedimentary rocks in the Tidal Wave mining district may be related to this youngest period of faulting.

GEOCHEMISTRY

Geochemical analyses of stream-sediment samples collected in and near the roadless area define several target areas in which anomalously high concentrations of base and precious metals were detected (O'Neill, 1983b).

A major copper and molybdenum anomaly is centered on Granite Peak (fig. 2), partly within the roadless area. Stream-sediment samples collected from this area contain a significant concentration of copper (1,000 ppm) and molybdenum (100 ppm). The anomaly is elliptical in plan, is more than 1 mi across, and is surrounded by a lead-zinc-arsenic-silver halo. The halo is defined by anomalously high concentrations of lead, zinc, and arsenic that were detected in samples collected east of Granite Peak, in samples collected from the headwaters of Wisconsin Creek, Noble Fork, and from streams west of Middle Mountain, and in samples collected from the Middle Mountain breccia pipe and the Bismark Mine, north of Granite Peak.

Geochemical techniques used in this study were not sensitive enough to outline areas of anomalous gold concentrations. The presence, of many mines having significant gold production adjacent to the roadless area indicates a broad area of high gold values. The distribution of these mines is approximately coincident with the location of stream-sediment samples that contained 1 ppm or more of silver. Silver in amounts greater than 0.5 ppm was also detected in most samples collected from the Granite Peak area.

MINING DISTRICTS AND MINERALIZED AREAS

Several small, overlapping mining districts are adjacent to or partly within the roadless area (fig. 2). Many of the mines were operated in the early 1900's (Tansley and others, 1933). An estimated 200 claims have been located in the roadless area since the 1870's, and 157 were current in October 1982. These claims include six patented claims, comprising about 91 acres, that are partly or totally within the roadless area and a group of 120 claims covering the head of Beall Creek and the area directly to the east. A list of mines and prospects in or adjacent to the roadless area is given in table 1, and their locations are shown in figure 2.

South Boulder mining district

The South Boulder mining district is in the South Boulder River drainage basin. The Mammoth and Bismark faults have been the main controls in localizing ore minerals in this district. The Mammoth and adjacent mines were the largest producers in this district; they are 0.5 mi outside the roadless area, along the Mammoth fault. At the Mammoth mine, gold was produced from vein-filled fractures associated with the Mammoth fault zone (Tansley and others, 1933). The mine is now inactive, but a cyanide-leaching plant has been constructed to process tailings. Two patented mining claims directly west of the Mammoth mine, the Mountain Boy and Bonanza patents, explore north-trending gold- and copper-bearing veins that are adjacent to the roadless area.

Along the Bismark fault, several properties have yielded base and precious metals from fissure veins and disseminated ore. The Bismark mine explores gold-bearing quartz veins localized along the fault where it juxtaposes batholithic and Archean rocks. Copper ore at this mine is disseminated in granitic rocks; however, the Quartz City and Sultana prospects dug along the fault zone about 0.5 mi northwest and north of the mine expose sulfide-bearing quartz veins and silicified rock that contain rare galena and molybdenite. The Nicholson (Ridgeway) and Moggolian mines, and the adjacent Baugus Hughes and Lester Baker properties, about 2 mi southeast of the Bismark mine and on the Bismark fault (fig. 2), expose east-trending quartz veins containing gold and silver. The Nicholson mine produced more than 360 oz of gold from 1900 to 1975; in 1980 about 60 oz of gold was recovered from the lode by the present operators. Gold occurs in auriferous pyrite or as fine gold in oxidized parts of the vein.

Tidal Wave and Sheridan mining districts

Winchell (1914), Tansley and others (1933), and Johns (1961) described many of the mines in the Tidal

Wave mining district, which includes the area south of Dry Boulder Creek and is partly within the roadless area (fig. 2). The Sheridan mining district includes all mines along Wisconsin, Indian, and Mill Creeks and abuts the Tidal Wave district to the west. Headwaters of these creeks are adjacent to or within the roadless area. About 60 unpatented lode claims and part or all of six patented mining claims are within the roadless area in these two districts. Mines and prospects in the Tidal Wave-Sheridan area have been opened along quartz-rich fissure veins following pre-existing fractures in Archean rocks, or along replacement and contact metasomatic zones in Paleozoic carbonate rocks adjacent to granodiorite or quartz monzonite sills. The quartz veins and sills are presumed to be related to the Tobacco Root batholith. Most deposits yielded gold, silver, and lead, and minor zinc and copper (Johns, 1961). Almost all gold and silver was recovered from narrow fissure veins. The richest parts of the veins are near the surface, where meteoric waters have oxidized and removed gold-bearing sulfide minerals, leaving behind gold-enriched, limonite-filled fractures. Principal deposits of lead and silver are in irregular metasomatic-replacement zones in Cambrian carbonate rocks. Tactite zones adjacent to sills have yielded mainly gold and copper (Johns, 1961). The Tidal Wave and Sheridan mining districts are now largely inactive; however, those mines closed at the beginning of World War II probably have recoverable gold reserves at depth.

No recorded production has come from any mines of the Tidal Wave-Sheridan districts in the roadless area, except from the Old Cabin extension (the Snyder mine), which yielded in a single shipment in 1934, 10 oz of gold, 75 oz of silver, and 362 lbs of copper. Extensive but caved workings at the Curly Bill No. 3 prospect suggest that some ore was recovered from this property. The Snyder mine and the Curly Bill-Curly Bill No. 2 prospect have estimated gold-bearing resources of about 90,000 tons.

Granite Peak, in the southern part of the roadless area, and included within the Sheridan mining district, is the site of a block of 51 claims that is mostly within the roadless area. Granite Peak (fig. 2) is underlain by the northwest-trending lobe of the Tobacco Root batholith that extends into the roadless area. This lobe of the batholith is bounded on the northeast by the northwest-trending Bismark fault zone. The rocks of the batholith in the Granite Peak area are porphyritic hornblende diorite and tonalite (Smith, 1970) that, on the north face of Granite Peak, have been intruded by north-trending dikes, 20 to 30 ft thick, of fine-grained quartz monzonite. Intensely altered and fractured rocks occupy an elliptical area around these dikes. The batholithic rocks adjacent to the dikes contain moderately to strongly chloritized amphiboles, and frayed, light-brown tablets of biotite. The rocks are cut by thin quartz veins and quartz monzonite dikes, which are locally abundant, and by thin stockwork fractures filled with sulfides. The rocks contain disseminated copper and molybdenum minerals and display pronounced fracturing and limonite staining. Sulfides are also common along east-trending faults and fractures south of Granite Peak, outside the major alteration zone.

On Middle Mountain, about 1 mi north of the mineralized area of Granite Peak (fig. 2), two mineralized breccia pipes have intruded Archean quartz-feldspar-biotite gneiss and amphibolite. These pipes are exposed on the north side of Middle Mountain but are partly covered by talus; they probably are connected with one another at depth. They occupy an elliptical area nearly 0.5 mi long and 0.2 mi wide. Breccia in the pipes consists of angular fragments of Archean gneiss. The breccia is stained yellow-orange and contains abundant veinlets of pyrite. Rock samples from the pipe contain significant amounts of silver, arsenic, molybdenum, and zinc. The pipes are probably related to the hydrothermal mineralization at Granite Peak, and may be the surface expression of an important subsurface extension of the mineralized zone.

Renova mining district

The Renova mining district includes the northwestern and northern slopes of the Tobacco Root Mountains north of Dry Boulder Creek (fig. 2). Production from the district has come mainly from gold mines 5 mi or more north of the roadless area. Two properties in this district are adjacent to the roadless area.

An isolated, narrow gold vein is being mined in the lower part of Beall Creek, in the Strawn Mine (fig. 2). This vein is in a contact metasomatic zone in the Cambrian Meagher Limestone adjacent to a thin, altered mafic dike (Tansley and others, 1933). The main workings are almost completely surrounded by the roadless area. At least 1,600 oz of gold has been mined from the oxidized parts of silicified limestone at the Strawn mine. A narrow mineralized zone is present south of the Strawn mine at the Ohio Lode property; more than 1,500 oz of gold and 2,700 oz of silver were recovered from this mine.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The assessment of mineral resource potential is based on the following criteria: (1) structural and stratigraphic environments favorable for the occurrence of ore minerals; (2) visible mineralized rock or patterns of altered rock associated with ore minerals; (3) the presence of anomalously high concentrations of base or precious metals or of pathfinder elements in stream sediments; and (4) the historic presence of prospecting or mining activity. A high resource potential requires that all of the above criteria are met. A moderate resource potential indicates that some of the above criteria are met but that further exploration is required. A low resource potential indicates that none of the above criteria are met.

Base metals

The Granite Peak area (fig. 3) is interpreted to represent a major hydrothermal porphyry system by virtue of: (1) the high values of copper and molybdenum in both stream sediment and rocks; (2) the abundance of quartz veins and disseminated sulfides over an area more than 1 mi in diameter; (3) the anomalous lead-zinc-silver-gold metal zonation around the Granite Peak copper-molybdenum anomaly; and (4) the presence of a nearby mineralized breccia pipe. The immediate area around Granite Peak is assigned a high potential for copper and molybdenum resources.

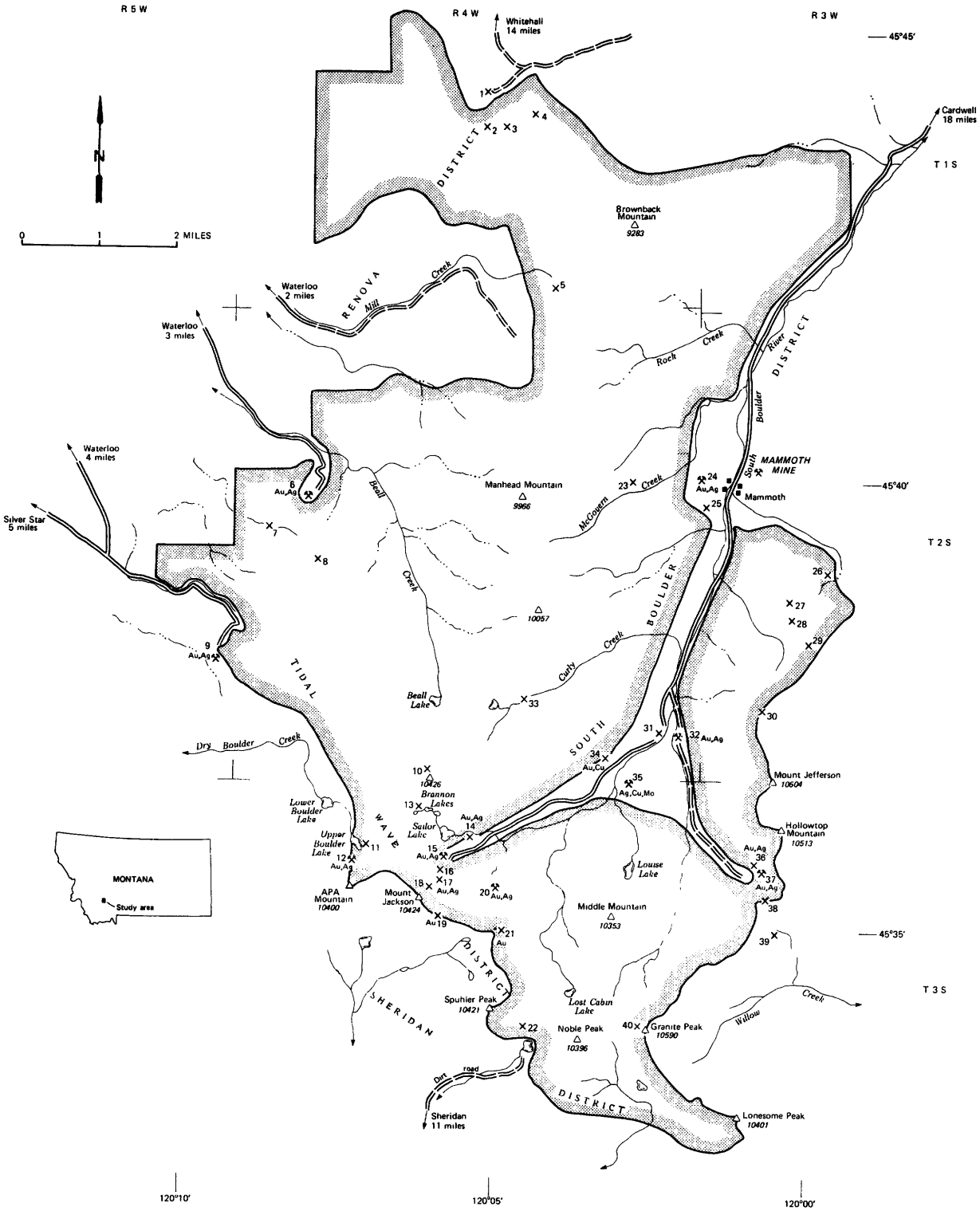

Figure 2.--Map showing the location of the Middle Mountain-Tobacco Root Roadless Area relative to mines and prospects, mining districts, and main geographic features mentioned in text.

EXPLANATION

ROADLESS AREA BOUNDARY

⚒ MINE WITH PAST PRODUCTION (RECORDED OR APPARENT)--
Number is keyed to list below.
Some mines show commodities:
Au, gold; Ag, silver; Cu, copper;
Mo, molybdenum

× PROSPECT--Number is keyed to list below

Mines and prospects

1. Bisch's (Perry) mine
2. Poor Boy prospect
3. Poor Boy prospect
4. Poor Boy prospect
5. Unknown prospect
6. Strawn mine
7. Unknown prospect
8. Kathleen (?) prospect
9. Ohio Lode mine
10. Unknown prospect
11. Boulder Cobalt prospect
12. Boulder Cobalt mine
13. Craig prospect
14. Old Cabin prospect
15. Snyder (Old Cabin extension?) mine
16. Lakeview prospect
17. Midnight prospect
18. Castlerock prospect
19. Gen Jackson mine
20. Curly Bill No. 3 prospect
21. Curly Bill-Curly Bill No. 2 prospect
22. Unknown prospects
23. Highland Mary prospect
24. Mountain Boy prospect
25. Bonanza mine
26. Western Pacific prospect
27. Unknown prospect
28. Unknown prospect
29. Carrol prospect
30. Unknown prospect
31. White Chief prospect
32. Sultana prospect
33. Squirrel prospect
34. Quartz City prospect
35. Bismark mine
36. Lester Baker prospect,
Billie prospect,
Moggolian mine
37. Ridge Way mine, Baugus-
Hughes prospect
38. Inha prospect (?)
39. Iron King prospect (?)
40. Granite Peak prospect

Figure 2.--Continued.

The inactive Bismark Mine is directly north of Middle Mountain (fig. 2) and has produced significant amounts of both base and precious metals; some stream-sediment samples from this area showed anomalously high base-metal values. The mine and the adjacent Quartz City and Sultana prospects explore veins that are localized along faults and shear zones that are associated with the northwest-trending Bismark fault zone and are peripheral to the Granite Peak copper-molybdenum anomaly. The area adjacent to the fault zone near and southeast of the Bismark mine is considered to have high potential for resources of both base and precious metals.

Lead, zinc, and silver ore commonly is found around the margins of porphyry copper and molybdenum deposits throughout the North American cordillera. The base-metal halo around Granite Peak is in keeping with this observed mineral zonation and is considered to be indicative of a moderate base-metal mineral resource potential in this area (fig. 3).

Small bodies of quartz monzonite, granodiorite, and related rocks intrude the Archean metamorphic rocks in the roadless area; most of these bodies contain small veinlets or disseminations of sulfide minerals. One small body of porphyritic latite exposed west of the Boulder Lakes (fig. 2) contains disseminated fluorite along with sulfide minerals. A small, weakly mineralized pipe of breccia similar to that on Middle Mountain is present at the roadless area boundary directly east of the Boulder Lakes. Biotite-rich gneiss adjacent to the pipe is bleached; chloritization of biotite in brecciated igneous rocks in the pipe is common. All small stocks in this area are associated with minor intrusive breccias along their margins. Prospects and mines in this area have been dug along gold-bearing vein systems concentrated at the margins of these stocks.

The Boulder Lakes area may be underlain by a major hydrothermal system, perhaps an extension of the system that mineralized the Granite Peak area. The presence of such a system is suggested by the probable hydrothermal, gold-bearing fissure veins in the Tidal Wave mining district (Johns, 1961), the presence of numerous sulfide-bearing stocks containing locally abundant fluorite and sparce tourmaline, by the recorded production of copper ore from the Snyder mine area, and by the weakly mineralized breccia pipe nearby. A moderate potential for base-metal resources is present east of the Boulder Lakes, within the roadless area.

Precious metals

Mines having recorded gold and silver production are outside the roadless area (Tansley and others, 1933; Johns, 1961), but some, such as those in the Boulder Lakes area (fig. 2), are adjacent to it. Samples from veins in the Boulder Lakes area show as much as 35 ppm gold in Bear Gulch and 700 ppm silver east of the Boulder Lakes, in the roadless area (O'Neill, 1983b). The anomalously high concentrations in vein material and the production history of the district indicate a potential for gold resources in this and adjacent areas. Gold is probably the only primary ore that can be readily exploited by small-scale underground mining methods. The Tidal Wave-Sheridan mining district in the area around Boulder Lakes shows high potential for gold and silver.

Gold is the only ore recovered from the presently active Nicholson mine, located along the northwest-trending Bismark fault zone and directly north of Granite Peak (fig. 2). Gold reserves at the Nicholson mine appear to be restricted to the mineralized parts of the Bismark fault zone; additional ore, if present, would most probably be found along the northwestward or southeastward trace of the fault zone. The area around the Nicholson mine, including the Moggolian mine, and the Lester Baker and Baugus Hughes prospects, has high resource potential for gold.

The Strawn Mine (fig. 3) was opened along a vein that bears free gold in a thin contact metasomatic zone in the Cambrian Meagher Limestone. This vein can be followed southward into the roadless area. The vein has been claimed by the operators of the Strawn mine for a distance of nearly 3,000 ft south of the main workings. Mineralization at the Ohio Lode mine is similar to that at the Strawn mine to the north in that ore is localized along bedding adjacent to an igneous sill.

Mineralization along the Mammoth fault appears to be mainly restricted to areas southeast of the Mammoth mine, and outside the roadless area; however, some gold reserves are present directly northwest of the mine and may extend a short distance into the roadless area.

Platinum group metals and cobalt, nickel, and chromium

Samples from small pods and lenses of ultramafic rock, possible hosts for cobalt, copper, nickel, chromium, and platinum deposits, were found to contain no significant amounts of these metals (Bruce Lipin, written commun., 1980).

Nonmetallic resources

Talc.—Talc prospects in the Tobacco Root Mountains, as reported by Berg (1979), are outside the roadless area, along Carmichael Creek and directly east of Wisconsin Creek (fig. 3). Talc has not been reported as present in the roadless area and was not seen during field mapping. Calc-silicate rock and marble, the host rocks for talc deposits in the nearby Ruby Mountains (Berg, 1979), were seen in only one minor zone south of Manhead Mountain (fig. 2) and did not contain talc. No potential for talc resources exists within the roadless area.

Construction materials.—A large resource of lime exists in the dolomite and limestone that rim the northwest and north margins of the Tobacco Root Mountains. These rocks are most abundant in the northern part of the roadless area but are not readily accessible. Carbonate rocks are abundant elsewhere in this part of Montana and many easily accessible deposits are much closer to established markets than are those in the roadless area.

Resources of gravel are limited and are confined to small areas of glacial outwash in the roadless area and vicinity, but abundant and readily accessible gravel is present along the Jefferson River and adjacent to major highways.

Oil, gas, and coal.—Deposits of oil, natural gas, and coal are not known, and are not likely to be present in, the roadless area.

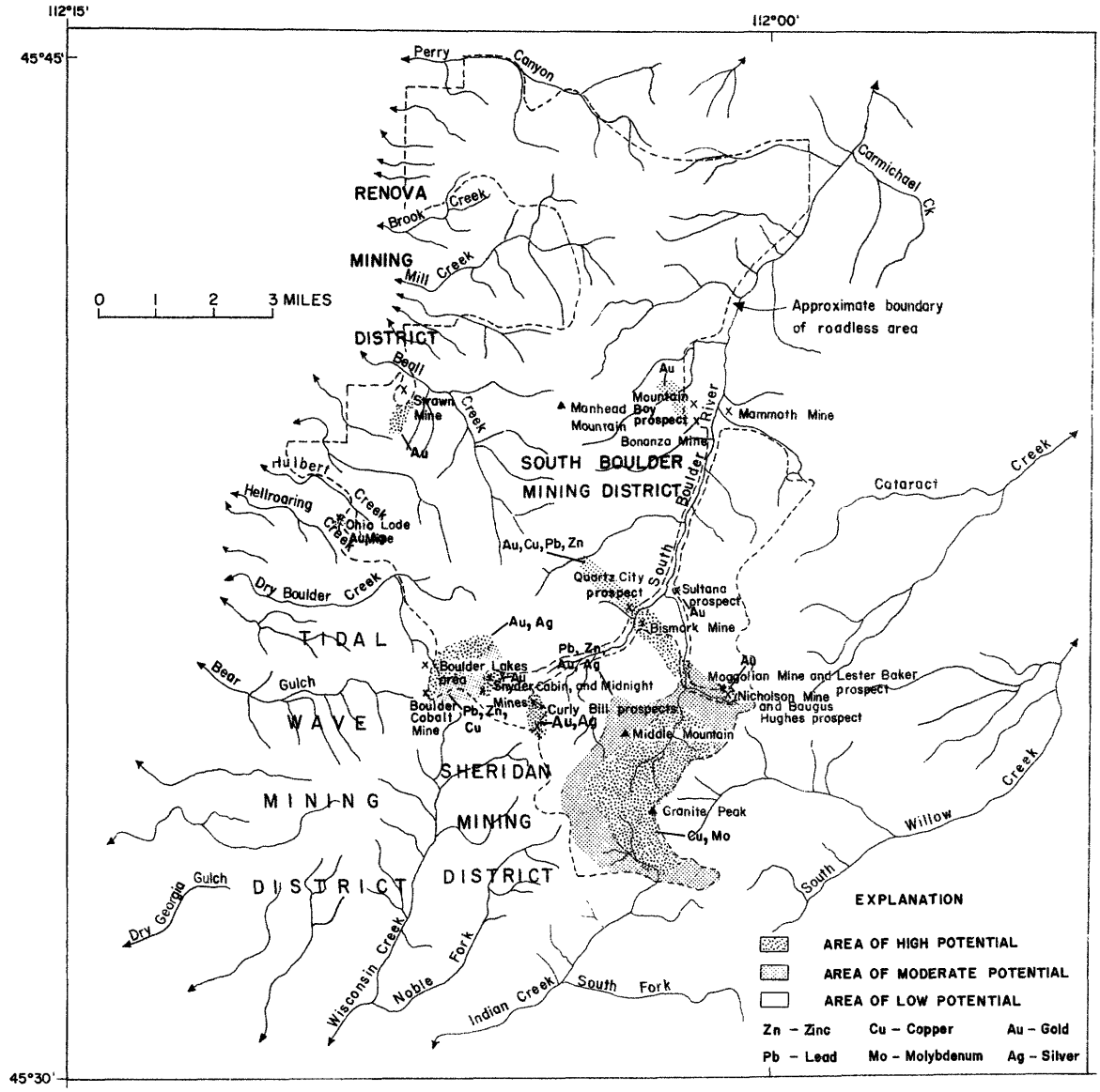

Figure 3.--Map of the Middle Mountain-Tobacco Root Roadless Area showing areas of high, moderate, and low resource potential.

Table 1.--Mines and prospects in or adjacent to the Middle Mountain-Tobacco Root Roadless Area, Madison County, Montana

[Underlined properties have identified mineral resources or moderate or high potential for resources. Asterisk (*) indicates the property is outside the roadless area]

No. on map	Property name (commodity)	Summary	Workings and production	Sample and resource data
1	Bisch's (Perry) mine * (lead)	A fracture zone in limestone, trending northeast and dipping steeply eastward, is exposed in workings for about 1,000 ft along strike. The mineralized zone is less than 1 ft thick and could not be followed along strike. Sporadic galena and secondary lead minerals were seen in rocks on dumps.	Four caved shafts about 10 ft deep, several prospect pits and trenches.	Fifteen samples: five contained from 0.57 to 3.27 percent lead. The mineralized zone could not be traced between workings; therefore, the resource potential could not be determined.
2	Poor Boy prospect	A 10-ft-thick jasperoid zone in limestone trends northeast.	A pit 3 x 4 ft and 2 ft deep	One sample: no significant amounts of metal.
3	Poor Boy prospect	Limestone containing calcite veinlets and jasperoid occurs in a poorly exposed fracture zone about 5 ft thick.	A pit 8 x 8 ft and 4 ft deep	One sample: no significant amounts of metal.
4	Poor Boy prospect	Fractured limestone containing abundant jasperoid occurs in a 1-ft-thick shear zone.	A shaft 8 x 10 ft and 10 ft deep.	Two samples: no significant amounts of metal.
5	Unknown prospect	A poorly exposed quartz vein in gneiss contains chalcopyrite and secondary copper minerals. The vein is less than 1 ft thick.	A caved shaft 10 x 10 ft and 6 ft deep.	One select sample of vein quartz from the dump contained 2.4 percent copper. The vein is too poorly exposed to determine the mineral potential.
6	Strawn mine * (gold, silver)	A silicified replacement zone averaging 2.2 ft thick trends northeast and dips about 35° NW. The zone is adjacent to a sill-like intrusive that contains gold in the upper three levels of the mine. Copper and silver occur in a less silicified zone in the lower two levels. The upper zone is exposed in workings for about 500 ft.	Five adit levels totalling about 2,000 ft of workings; a partially reconstructed ore-processing mill and an operating sawmill are on the properties. About 1,700 oz of gold has been produced since 1921. Small tonnages of ore are currently being shipped.	Twenty-seven chip samples: eighteen contained from 0.01 to 0.560 oz gold per ton, and a high-grade 3.0-ft chip sample contained 1.460 oz gold per ton, eight contained 0.5-2.7 oz silver per ton one 1.5-ft chip sample contained 11.5 oz silver per ton. There are an estimated 23,000 tons of marginal indicated and inferred resources averaging 0.15 oz gold per ton at the upper three levels. Low gold content at the end of one level, and a fault at the end of another, suggest low potential for additional resources along strike. Sporadically high silver content in adit 4 indicates moderate potential for this metal.
7	Unknown prospect (antimony gold, silver)	A silicified, 2.4-ft-thick fracture zone in limestone, trending northeast and dipping northwest, contains irregular masses of stibnite.	A 60-ft adit	Three chip samples: one contained 3.10 percent antimony, 0.096 oz gold and 0.5 oz silver per ton. The small, irregular concentrations of minerals show the property to have low potential for resources.

8	Kathleen prospect (?) (gold, silver)	Poorly exposed vein quartz and silicified limestone. The vein is less than 0.5 ft thick.	A trench 30 x 4 ft and 3 ft deep	One select sample of vein quartz and silicified limestone contained 0.086 oz gold and 1.7 oz silver per ton. The narrow vein and low gold and silver content suggest a low mineral potential.
9	Ohio Lode mine * (gold, silver)	Northeast-trending fissure veins as much as 15 ft, but generally less than 1 ft, thick and a skarn zone occur in limestone near a sill-like intrusive.	Three caved adits, an 80-ft-diameter open pit, and several prospect pits. Underground workings total several thousand feet. More than 1,500 oz of gold and 2,700 oz of silver have been produced since 1937.	Sixteen samples: ten of the highest grade samples contained between 0.038 and 0.414 oz gold per ton. One grab sample from a dump assayed 5.8 oz silver per ton. The caved condition of the workings precluded an estimate of tonnage and grade, but high assay values of surface samples, extent of workings, and records of production suggest a high potential for gold and silver resources.
10	Unknown prospect	Poorly exposed, 5-ft-thick altered zone is in amphibolite.	A pit 15 x 10 ft and 3 ft deep	One sample contained 0.282 oz gold per ton. The altered zone is too poorly exposed to determine resource potential.
11	Boulder Cobalt prospect (gold)	Quartz and calcite veins averaging 0.9 ft thick occur with pyrite in a northwest-trending shear zone near a gneiss-amphibolite contact. The mineralized zone is not continuous along strike.	A 67-ft adit and a trench 20 x 7 ft and 6 ft deep.	Six samples: one contained 0.272 oz gold and 0.3 oz silver per ton across a 3.1-ft vein thickness. The property has low potential for gold resources.
12	Boulder Colbalt mine (gold, minor copper, and silver)	North- to northwest-trending veins, shears, and altered areas in a steeply dipping zone at least 0.25 mi long contained disseminated to locally abundant pyrite and sporadic secondary minerals. Siderite is locally abundant gangue. Quartz veins in the zone average 1.4 ft thick.	Five adits, one consisting of about 1,000 ft of workings, the others less than 100 ft and caved; one flooded inclined shaft; several pits.	Twenty-seven samples: eight contained from 0.124 to 1.074 oz gold per ton, a 0.2 ft chip sample contained 2.140 oz gold per ton, three samples contained from 0.12 to 0.36 percent copper, two samples assayed 1.2 and 0.6 oz silver per ton. The property has high potential for gold resources.
13	Craig prospect (gold, silver copper, lead, zinc)	West-trending, steeply dipping fracture zone contains discontinuous quartz vein with sphalerite, galena, and chalcopyrite. The vein is less than 0.5 ft thick and could not be traced along strike.	A 195-ft adit and two pits	Four samples: one chip sample contained 0.038 oz gold and 1.8 oz silver per ton, 1.71 percent zinc, 1.30 percent lead, and 0.18 percent copper; one select sample contained 0.068 oz gold and 5.8 oz silver per ton, 2.21 percent zinc, 0.49 percent lead, and 0.40 percent copper. There is low potential for metallic resources.

Table 1.--Mines and prospects in or adjacent to the Middle Mountain-Tobacco Root Roadless Area, Madison County, Montana--Continued

No. on map	Property name (commodity)	Summary	Workings and production	Sample and resource data
14	Old Cabin prospect (gold, silver)	A 1- to 2-in.-thick quartz vein concordant with gneiss country rock strikes N. 38° E. and dips 60° NW. Pyrite locally abundant. Gneiss is bleached within 1 ft of vein.	A caved, 100-ft inclined shaft, one 20-ft adit, two 3-ft-deep trenches, and three 2-ft-deep pits.	Of four samples, three contained 0.005 to 0.0346 oz gold and from 0.2 to 2.2 oz silver per ton. Although the veins are narrow, the relatively high gold and silver assays suggest a moderate potential for mineral resources.
15	Snyder mine (Old Cabin extension?) (gold, silver, copper)	A west-trending, south-dipping fissure vein and shear zone averaging 3.3 ft thick cuts altered gneiss in a zone about 760 ft long. The vein contains sporadic pyrite and secondary copper minerals.	Five adits, one 390 ft long, one 55 ft long, one about 1,000 ft long and caved, two less than 100 ft long and caved. Production in 1934 was 326 lbs of copper, 10 oz of gold, and 75 oz of silver.	Eleven samples: six chip samples ranged from 0.010 to 0.280 oz gold per ton, one grab sample from a 100-lb stockpile contained 0.641 oz gold and 6.0 oz silver per ton, and 0.46 percent copper. There are 80,000 tons of indicated and inferred subeconomic resources averaging 0.08 oz gold per ton; silver and copper would be by-products. Exposures in the lower levels are insufficient to determine resource potential.
16	Lakeview prospect	A west-trending, south-dipping quartz vein as thick as 0.3 ft contains sporadic pyrite.	A trench 6 x 10 ft and 4 ft deep	One sample: contained no significant amounts of metal.
17	Midnight prospect (patent) (gold, silver)	Two quartz veins trend northeast in gneiss. One is as thick as 0.5 ft and is intermittently exposed for about 1,000 ft along strike. The other vein ranges from 0.7 to 1.5 ft thick and is exposed for about 60 ft along strike. Both veins contain sporadic sulfides.	Four adits, 30-100 ft long, and three prospect pits.	Nine samples: seven from the 1,000-ft vein ranged from trace to 0.126 oz gold per ton, and six contained from 0.2 to 1.4 oz silver per ton. A sample from a 100-lb stockpile near the shorter vein contained 4.1 oz gold and 2.8 oz silver per ton. The veins are not well enough exposed to determine if they constitute gold resources, but assays indicate there is moderate potential.
18	Castle Rock prospect (patent) (gold, silver)	A 0.8-ft-thick quartz vein containing pyrite and galena is exposed for about 5 ft. A 1-ft-thick zone of altered gneiss surrounds the vein.	One prospect pit	Two samples: one from the vein contained 0.278 oz gold and 4.0 oz silver per ton. The vein is insufficiently exposed to determine resource potential.
19	Gen Jackson mine (patent) (gold, silver)	Northeast- to southeast-striking quartz veins dip steeply south and contain sporadic pyrite and galena. Veins are as much as 0.9 ft thick.	A 125-ft adit and six pits less than 4 ft deep.	Thirteen samples: four chip samples contained from 0.028 to 0.090 oz gold per ton; five select samples contained from 0.024 to 0.334 oz per ton and as much as 0.8 oz silver per ton. Scarsity of exposure precluded an estimation of resource potential.
20	Curly Bill No. 3 prospect (gold, silver, copper)	A northeast-trending, steeply dipping quartz vein as much as 1 ft thick contains locally abundant pyrite and sporadic chalcopyrite and secondary copper minerals.	A caved adit about 500 ft long, two caved adits less than 50 ft long, a 20-ft shaft, and two 3-ft-deep pits.	Five samples: two contained 0.280 and 0.178 oz gold per ton, three contained 0.6, 2.4, and 4.4 oz silver per ton, respectively; the five samples ranged from 0.02 to 1.65 percent copper. The property has a moderate potential for resources

21	Curly Bill-Curly Bill No. 2 (patent) (gold)	A quartz vein is exposed intermittently for about 580 ft along a northwest trend. The vein averages about 0.8 ft thick and contains abundant limonite and sporadic pyrite.	Five caved adits less than 50 ft long.	Four samples had a weighted average of 0.3 oz gold per ton and ranged from 0.026 to 0.450 oz gold per ton. There are 10,000 tons of inferred, subeconomic gold-bearing resources. The narrowness of the vein makes the property subeconomic.
22	Unknown prospect (silver, lead, gold)	A poorly exposed shear zone in altered gneiss strikes N. 46° E. and is nearly vertical. The zone contains limonite-stained, brecciated quartz as much as 3 ft thick and sporadic pyrite and anglesite.	A pit 4 x 2 ft and 1 ft deep	One sample contained 0.56 percent lead, 0.011 oz gold, and 0.08 oz silver per ton. The shear zone is too poorly exposed for its potential to be determined.
23	Highland Mary prospect (patent)	A quartz vein as thick as 4 ft is along the contact between gneiss and dike rock. The vein strikes northeasterly and dips about 50° NW.	Two adits, one 50 ft and one about 300 ft long; one 12-ft trench and one 5-ft trench.	Nine samples contained no significant amounts of metal.
24	Mountain Boy mine * (patent) (gold, silver)	A north-trending quartz vein averaging 1.8 ft thick is exposed for about 220 ft in an adit. The vein is moderately limonite stained, contains sporadic pyrite, and is faulted and pinches out at its north end.	A 400-ft adit	Fifteen samples: six contained from 0.028 to 0.158 oz gold per ton, seven samples contained from 0.5 to 4.0 oz silver per ton. There is an occurrence of at least 6,200 tons that averages 0.06 oz gold and 1.17 oz silver per ton.
25	Bonanza mine * (patent)	Shear zones containing a few quartz-vein segments as much as 0.5 ft thick are near contact between gneiss and pegmatite. The quartz is moderately limonite stained and contains sporadic pyrite.	A 300-ft adit	Eight samples were essentially barren.
26	Western Pacific prospect	Several sheared and altered zones containing quartz-vein segments as thick as 0.7 ft occur in granodiorite. They strike between northeast and southeast and have moderate dips.	Five adits, one 205 ft long, three 100-200 ft long, and one caved; nine 20-70 ft long trenches.	Nineteen samples: three contained from 0.18 to 0.054 oz gold per ton, and one contained 0.5 oz silver per ton. There is low potential for mineral resources.
27	Unknown prospect (gold)	Probable northeast-trending quartz-vein segments are in gneiss. Segments are not exposed, but dumps contain compact limonite-stained vein quartz as much 1.3 ft thick.	Four sloughed trenches as long as 50 ft; seven pits as deep as 4 ft.	Six samples: one select sample contained 0.268 oz gold per ton. The property has low potential for mineral resources.
28	Unknown prospect (gold, silver)	A poorly exposed quartz vein as thick as 0.7 ft contains limonite and sporadic malachite.	Three sloughed pits less than 2 ft deep.	Four samples: one contained 0.1 oz gold and 1.5 oz silver per ton, and another 0.018 oz gold per ton. The vein is too poorly exposed for its potential to be determined.

Table 1.--Mines and prospects in or adjacent to the Middle Mountain-Tobacco Root Roadless Area, Madison County, Montana--Continued

No. on map	Property name (commodity)	Summary	Workings and production	Sample and resource data
29	Carrol prospect	Probable north-trending vein segments in gneiss are exposed in pits on ridgetop. Vein fragments as much as 1 ft thick are on dumps; sporadic chrysocolla.	Several small pits less than 3 ft deep.	Five samples contained no significant amounts of metal.
30	Unknown prospect	Two 1-ft-thick quartz veins probably trend northeast in gneiss. The vein contains sporadic chrysocolla.	Two pits less than 3 ft deep	Three samples: one contained 0.062 oz gold per ton, and two contained no significant amounts of metal. The structure is not exposed well enough for its potential to be determined.
31	White Chief prospect * (patent) (gold, silver copper, lead, tungsten)	West- to northwest-trending segments of vein quartz less than 0.5 ft thick, and associated pegmatite, occur in gneiss. The quartz contains locally abundant pyrite and minor chalcopyrite, bornite, and galena.	Two adits, one 180 ft long, one about 450 ft long and caved; a 10 x 35 ft trench and five pits as deep as 4 ft.	Fifteen samples: one select sample contained 0.16 oz gold and 2.5 oz silver per ton, 0.33 percent copper, 2.93 percent lead, and 0.15 percent tungsten trioxide (WO_3). Five samples contained from 0.8 to 2.5 oz silver per ton. There is low potential for mineral resources because the mineralization was spotty and the vein is narrow.
32	Sultana prospect * (gold, silver)	Locally vuggy, limonite-stained quartz veins trend east and dip steeply in altered granitic rock. The longest vein is as much as 0.5 ft thick and can be traced discontinuously about 280 ft along strike.	Three partially caved adits as long as 55 ft, and an 11-ft tunnel.	Fourteen samples: one select sample contained 1.22 oz gold and 21.7 oz silver per ton. Nine other samples contained from 0.022 to 0.918 oz gold per ton and five had 0.2 to 7.3 oz silver per ton. There is high potential for resources in high-grade shoots.
33	Squirrel prospect (Julia No. 1)	Altered and silicified gneiss contains quartz veins as thick as 0.2 ft in a shear zone associated with the Bismark fault. Zone appears north-trending, but is poorly exposed.	A 20- to 30-ft caved shaft	Three samples contained no significant amounts of metal.
34	Quartz City prospect * (gold, copper, molybdenum)	Several quartz-vein segments as much as 1.5 ft thick are in granitic rock and gneiss near the Bismark fault. The veins contain sporadic but locally abundant chalcopyrite and sporadic galena and molybdenite. The mineralized zone may be continuous with that of the Bismark mine 0.25 mi to the southeast.	Four adits, one 170 ft long, one 125 ft long, and two 20 ft long; eight trenches as long as 40 ft, and several shallow pits.	Thirty-six samples: nine contained from 0.01 to 0.27 oz gold per ton; 16 contained from 0.05 to 0.5 percent copper, five contained from 0.5 to 2.56 percent copper. Although the veins are narrow and discontinuous, commonly high assays show there is high potential for gold and copper resources.

35	Bismark mine * (copper, molybdenum, silver, lead?)	Mineralized zones occur in quartz-vein segments and disseminated in altered granitic rock near the Bismark fault. The vein segments are as thick as 1.5 ft, but do not persist along strike. Pyrite, chalcopyrite, molybdenite, and secondary copper minerals occur in the veins and disseminated in the granitic rock.	Four adits; levels 2 and 4 total about 800 ft, level 1 is about 1,000 ft long but caved at the portal, and level 3 is less than 50 ft long and caved. Recorded production: about 58,000 lb of copper, 7,000 lb of lead, 1,200 oz of silver, and minor gold.	Twelve samples: three contained 0.6, 4.1, and 4.1 oz silver per ton; eight contained from 0.06 to 1.91 percent copper; molybdenum content was erratic and averaged less than 0.05 percent. Although lead production has been reported, insignificant amounts were detected in the samples. Caved condition of workings precluded an estimate of resource tonnage and grade. Based on extent of mine workings, production records, and reconnaissance sampling, there is high potential for copper and molybdenum resources, both in veins and disseminated in the granitic rocks.
36	Lester Baker prospect (gold, silver)	Several northeast- to northwest-trending quartz veins as thick as 1.1 ft occur in altered granitic rock. The veins are limonite stained and contain pyrite and sporadic galena. Moggolian mine adjoins on the south.	Two adits less than 40 ft long, and four open cuts less than 10 ft wide.	Eleven samples: nine contained from 0.016 to 0.752 oz gold per ton; a 1.1-ft chip sample contained 11.5 oz silver per ton; a 2.5-ft chip sample contained 1.3 oz silver per ton. There is moderate potential for resources.
36	Billie prospect (gold, silver)	Several east-trending vein segments and silicified zones as much as 1.5 ft thick cut altered quartz monzonite. The Moggolian mine is about 1,000 ft to the east.	An adit with 340 ft of workings	Thirteen samples: two contained 0.282 and 0.278 oz gold per ton, respectively; three contained 2.1, 1.3, and 1.1 oz silver per ton, respectively. A low potential exists for gold resources because the mineralization was spotty.
36	Moggolian mine (patent) (silver)	Two west-trending shear zones dip steeply and contain quartz veins as much as 2.6 ft thick. Pyrite is locally abundant in the vein and wall rock; galena is sporadic.	A 580-ft adit	Sixteen samples: nine samples contained significant concentration of silver ranging from 0.9 to 2.4 oz per ton. Lead and zinc are localized in minor amounts. The vein system is on strike with the operating Ridgeway gold mine 700 ft east. There is moderate potential for resources.
37	Ridgeway mine * (gold, silver)	A west-trending, steeply dipping fissure vein is exposed for 200 ft along strike and in places downdip for about 103 ft the vein averages 0.8 ft thick and contains sporadic pyrite, chalcopyrite, and galena.	Four adits; one caved adit not located; the others total 780 ft. Recorded production: Records show more than 360 oz of gold produced prior to 1975, and lessors report 60 oz produced in 1980. Mine was operated in 1981.	Twenty-three samples: Twenty had detectable gold assaying from 0.012 to 1.854 oz per ton; thirteen contained silver ranging from 0.8 to 4.2 oz per ton. Pockets are reported to contain as much as 11 oz of gold per ton. There are an estimated 4,600 tons of indicated and inferred marginal reserves averaging 0.70 oz gold per ton.

Table 1.--Mines and prospects in or adjacent to the Middle Mountain-Tobacco Root Roadless Area, Madison County, Montana--Continued

No. on map	Property name (commodity)	Summary	Workings and production	Sample and resource data
37	Baugus-Hughes No. 1 prospect* (gold)	A quartz vein striking N. 75° E. and dipping 72° NW. contains abundant pyrite and limonite. The vein is about 0.6 ft thick and traceable for about 35 ft along strike. The Ridgeway vein is about 700 ft to the northwest.	A 35-ft adit	Three samples contained 0.300, 0.254, and 0.200 oz gold per ton and minor silver. The structure is not sufficiently exposed to determine tonnage and grade, but assays indicate there is high potential for gold resources.
38	Inha prospect(?) (patent) (silver, lead, zinc)	A quartz vein striking N. 80° W. and dipping 55° NE. contains galena, pyrite, sphalerite, azurite, malachite, and calcite. The vein is about 0.2 ft thick and not traceable along strike.	A 5-ft adit	One chip sample contained 11.6 oz silver per ton, 0.77 percent lead, and 0.92 percent zinc; a small, high-grade occurrence with low potential for resources.
39	Iron King (?) prospect * (patent)	A quartz vein striking about N. 32° E. and dipping 48° NW. contains locally abundant pyrite and limonite. The vein pinches and swells to a maximum of 5.5 ft along 110 ft of exposure.	Two 100-ft adits, one caved and one flooded.	Three samples contained no significant amounts of metal.
40	Granite Peak prospect	A lobe of the Tobacco Root batholith contains sporadically disseminated chalcopyrite and molybdenite associated with stockwork quartz veins and aplite dikes.	An access road to seven drill sites.	None. Drill-hole data were not available.

Geothermal resources.—Potential for geothermal energy is restricted to areas of above-average geothermal gradient. The only known hot springs in the Tobacco Root Mountains are at Renova and Potosi; both are outside the roadless area. Hot springs have not been reported as present within the roadless area.

Water resources.—Irrigation water for lands bordering the Tobacco Root Mountains is an important resource presently being widely utilized, especially on the west and north sides of the range. Many of the streams that provide water for irrigation purposes have their headwaters in cirques in or adjacent to the roadless area. The value of this water is obviously very great.

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