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MINERAL RESOURCE POTENTIAL OF THE TEN LAKES WILDERNESS STUDY AREA, LINCOLN COUNTY, 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 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 Ten Lakes Wilderness Study Area, Kootenai National Forest, Lincoln County, Mont. The area was established as a congressionally designated Wilderness Study Area by Public Law 95-150, 1978, and later as a further planning area during the Second Roadless Area Review and Evaluation (RARE II, No. 1-683) by the U.S. Forest Service, January 1979.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

Geological, geochemical, and geophysical investigations and a survey of mines and prospects were conducted in the Ten Lakes Wilderness Study Area in order to evaluate the mineral resource potential. Four types of mineral occurrences of probable value were identified in the area: (1) copper-silver-barite-bearing veins in basaltic lava, (2) zinc-bearing veins associated with metadiorite sills, (3) copper-silver-lead-zinc-bearing veins in calcareous metasedimentary rocks, and (4) stratabound copper occurrences. Mineral exploration and mining occurred at seven properties in the study area and at two properties adjacent to the area.

The area is assigned a high resource potential for copper and silver that occur in veins in basalt; these veins were the focus of past mining activity. The area has a moderate to high resource potential for metals in the copper-silver-lead-zinc-bearing veins, but a low resource potential for metals in zinc-bearing veins and stratabound copper occurrences and for barite in veins. However, if the source of metals in some of the vein systems is shallowly buried plutons, additional mineral deposits may be present at depth. On the basis of available surface geologic data and reasonable extrapolations of the subsurface geologic framework from these data, there seems little likelihood for occurrences of oil and gas in the study area.

INTRODUCTION

Gold, copper, silver, and lead lured prospectors to the Ten Lakes area in the 1880's. Veins containing these metals were actively prospected through the early 1900's; several mining claims were filed and six were patented. Sporadic attempts to mine some of the larger occurrences resulted in failure largely because of low grades and poor access. Today, access is still a problem and grades remain a critical factor, both of which determine the mineral resource potential of the area. Interest in developing the mineral resources has not died, new and old claims are still prospected.

Area description

The Ten Lakes Wilderness Study Area contains 34,000 acres or 53 mi^2 in Lincoln County, Mont., in the Kootenai National Forest (fig. 1). The study area spans the southern end of the Galton Range, and its northern limit coincides with the boundary between the United States and Canada. In the north part of the study area, about 6,500 acres or 10.1 mi^2 are presently designated the Ten Lakes Scenic Area (see fig. 2).

Primary access to the study area is provided by U.S. Forest Service road 319 that connects with State Highway 93 about 8 mi south of Eureka, Mont., and extends up Grave Creek and the Wigwam River to Therriault Lakes. Many secondary timber-access roads and pack trails furnish access to the interior of the Ten Lakes Study Area.

Previous studies

The first detailed map and discussion of the geology of the Ten Lakes area was by Smith (1963).

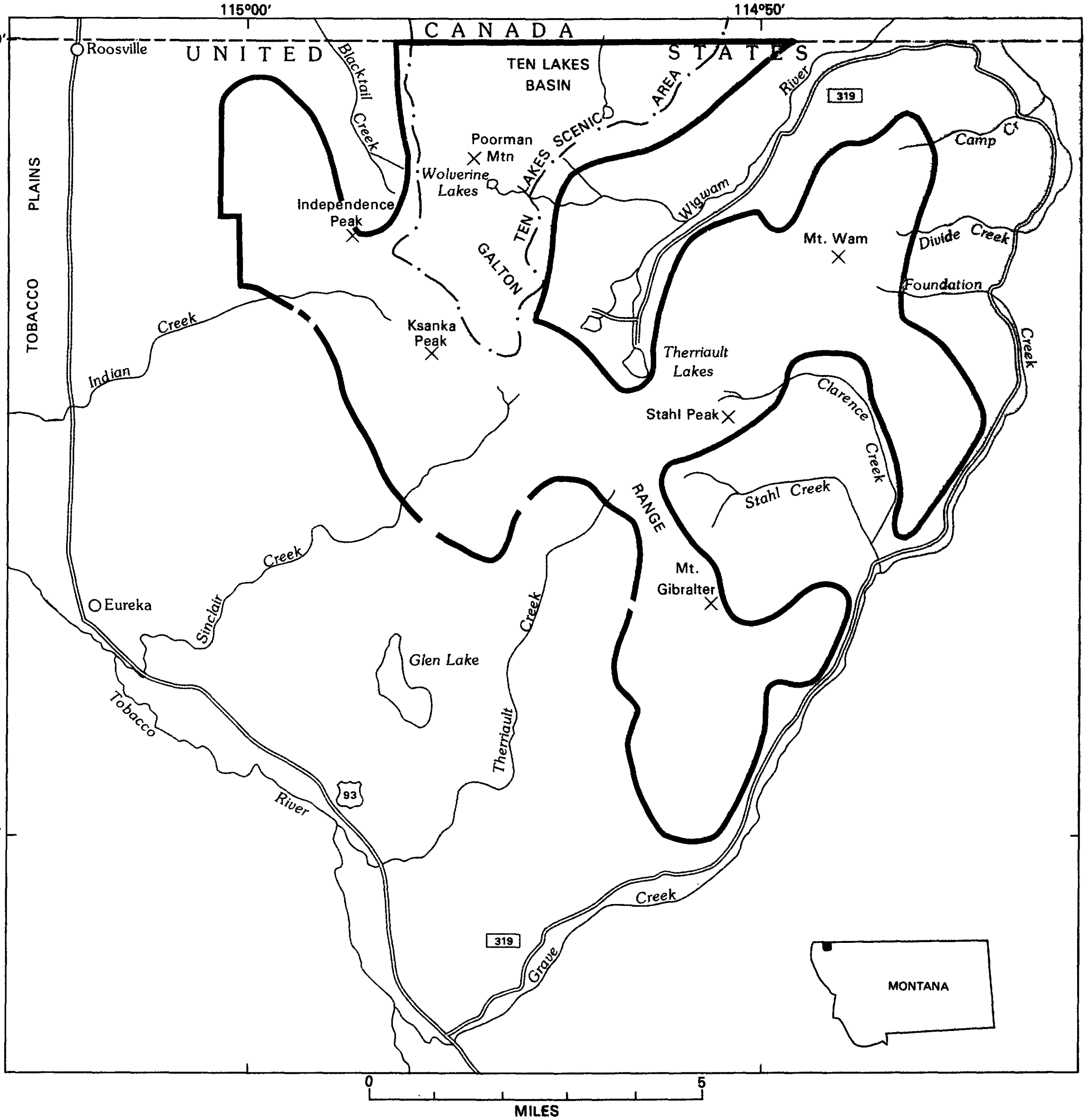

Figure 1.—Index map showing location of the Ten Lakes Wilderness Study Area (1-683), Lincoln County, Montana.

This work was later compiled and expanded upon by Johns (1970), who also inventoried and reported on the mineral resources of the area. An examination of patented and unpatented mining claims in the Ten Lakes Scenic Area was conducted by the U.S. Forest Service in 1966 (J. C. Stentz, U.S. Forest Service, unpub. report, 1967). The present study utilized geologic reports on the Independence Lode by C. M. Fassett (Anaconda Mining Company, unpub. report, 1904) and by Reno Sales (Strasberger Engineering Company, unpub. report, 1907). In addition, the Twin Peaks mine and prospect (now called the Red Bird, Midnight, and Copper Kettle lodes) were examined by Newman (1944) and H. Johns and R. Keffer (British Columbia Copper Company, unpub. report, 1912).

Present studies

Geological, geochemical, and geophysical studies were conducted by the U.S. Geological Survey during the 1981 and 1982 field seasons. The U.S. Bureau of Mines conducted a study of all mines, prospects, and mining claims in and adjacent to the study area in 1980. Results of these investigations are published as part of a map series on the Ten Lakes Wilderness Study Area and are as follows: (1) geologic map (Whipple, 1984), (2) geochemical map (Leinz and Whipple, in press), (3) geophysical map (Bankey and others, in press), and (4) mines and prospects map (Hamilton and Avery, 1983, fig. 1).

Acknowledgments

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GEOLOGY

Slightly metamorphosed Proterozoic sedimentary and igneous rocks of the Belt Supergroup underlie all of the Ten Lakes study area and consist of varicolored argillite, siltite, arenite, limestone, dolomite, basalt, and diorite. The oldest exposed rocks are assigned to the upper part of the Grinnell Formation which is overlain successively by the Empire, Helena (mapped unit includes middle part of Wallace Formation), Snowslip, Shepard, and Mount Shields Formations, the Bonner Quartzite, and the McNamara Formation. Approximately 9,800 ft of stratigraphic section is represented. Just outside and northeast of the study area boundary, the Libby Formation overlies the McNamara and is in turn unconformably overlain by Middle Cambrian rocks. For the most part, Belt strata were deposited in shallow, nearshore marine environments and conjugate fluvial environments.

Igneous rocks of the study area include the Purcell Lava, which is predominantly basalt and intertongues with the Snowslip Formation or, in some places, separates the Snowslip and Shepard Formations. The Purcell consists of several thin (less than 7 ft thick) flows, most of which were extruded in a subaerial environment. A Precambrian(?) metadiorite sill has intruded the Empire Formation and, in places, separates the Empire Formation from the Helena Formation.

All rocks in the study area rest on two thrust plates. The Ten Lakes thrust fault is the major structural element that separates the plates. The lower or easternmost thrust plate is characterized by numerous asymmetric folds with steep west-dipping axial planes that indicate original thrust transport to the east. This plate is bounded on the northeast by a major down-to-the-west normal fault, which probably flattens with depth, and on which both the lower and upper thrust plates of the Ten Lakes fault have slid back to the west. The original direction of movement of the upper thrust plate, with respect to the lower plate, was also from west to east; the amount of eastward movement is unknown. A large normal fault borders the study area on the west and forms the eastern edge of the Rocky Mountain trench. This frontal fault is downfaulted to the west and separates the Tobacco Plains from the Galton Range; it is estimated to have 9,000-9,800 ft of vertical displacement.

GEOCHEMISTRY

Stream-sediment samples were collected from all the major drainages in or adjacent to the study area, and rock samples were collected at all mines and prospects to help evaluate the mineral resource potential of the Ten Lakes Wilderness Study Area. In addition, samples of all veins encountered during geologic mapping of rocks suspected to contain stratabound mineralization, and of representative rock types were gathered, and all samples were analyzed for 31 elements using a semiquantitative emission spectrographic technique (Grimes and Marranzino, 1968). Selected samples were also analyzed for gold, tellurium, zinc, molybdenum, cadmium, bismuth, antimony, arsenic, fluorine, and mercury, using a variety of standard chemical methods.

Results of the stream-sediment sampling and analyses indicate anomalous concentrations of heavy metals in several drainage basins; most of these drainage basins have known mines, prospects, or mineralized zones. For example, anomalous concentrations of copper (50-100 ppm) in sediments from Indian Creek reflect the mineral deposit mined at the Independence mine near the headwaters of Indian Creek. Two areas of anomalous metal concentrations that are not associated with known mineral deposits have been identified in upper Sinclair Creek and in Ten Lakes basin near Rainbow Lake (Leinz and Whipple, in press). Elevated metal concentrations of copper, lead, and zinc in the oxide fraction of sediments from Sinclair Creek are interpreted to reflect veins whose exact location is uncertain, but that are probably on the north side and near the headwaters of the drainage basin. Anomalous concentrations of the same metals in sediment samples from Rainbow Lake probably reflect the proximity of the sample site to a metadiorite sill that is known to contain high concentrations of heavy metals.

Rock samples include both mineralized and barren samples. As expected, the geochemistry of mineralized samples shows high concentrations of heavy metals; and samples of many mineralized veins show anomalously large amounts of volatile elements such as arsenic, mercury, and antimony. For example, a vein in Purcell Lava sampled at the Red Bird, Midnight, and Copper Kettle lodes (fig. 2, no. 1) contains 1,000 ppm arsenic and 0.32 ppm mercury. Lead-zinc veins in the Helena Formation on south Gibralter Ridge contain as much as 700 ppm arsenic, 6.7 ppm mercury, and 1,000 ppm antimony. These high concentrations of volatile elements suggest that vein-forming fluids had a magmatic source.

GEOPHYSICS

The gravity, aeromagnetic, and reconnaissance electrical surveys show weak evidence for mineralized rocks at several places in the Ten Lakes study area (Bankey and others, in press). In particular, the magnetic and electrical data identify several areas of interest along the western side of the study area.

The regional gravity survey consists of 134 stations in and around the study area and suggests several structural features that may have a bearing on mineral resource potential. The dominant feature of the Bouguer gravity map is a broad, low-amplitude positive anomaly that corresponds to extensive outcrops of high-density rocks in the Helena Formation. A gravity high also covers the central part of the study area and correlates with a broad magnetic low.

The aeromagnetic survey was conducted along flight lines spaced about 0.6 mi apart, and the aeromagnetic map shows possibilities for small buried intrusions in the vicinity of several known mineral occurrences (Bankey and others, in press). The most prominent magnetic feature is a northwest-trending series of 50-100 gamma anomalies centered along the ridge extending northwest of Independence Peak. Although basalt of the Purcell Lava is exposed just east of the ridge, the anomalies are centered over exposures of relatively nonmagnetic Belt metasedimentary rocks and correlate poorly with the basalts. These anomalies suggest small, shallowly buried granitic intrusions. South of the Independence Peak anomalies, on the western side of the study area, north-south, low-amplitude positive magnetic anomalies, similar to the Independence Peak anomalies, show little direct correlation with outcrops of Purcell Lava and may reflect small intrusions at shallow depth.

Electrical surveys within and adjacent to the study area consisted of 41 audiomagnetotelluric (AMT) soundings and two E-field-ratio telluric transverses. The AMT soundings were made using a frequency range of 4.5 Hz to 27 kHz; in the study area, the soundings provided information on variations of earth resistivity from the surface to a maximum depth of about 15,000 ft.

The AMT data show that, in general, resistivities within the study area are very high, and are indicative of tight sedimentary or igneous rocks. Even at shallow depth, resistivities generally are greater than 1,000 ohm meters. AMT methods average the properties of a large volume of rock so results do not relate to the presence or absence of small vein deposits. The AMT data do suggest, however, that no zones of extensively altered or mineralized rock are present within the parts of the study area tested by the soundings, with the possible exception of near the southwest edge of the study area.

Along the southwest border of the study area, the AMT data show a discontinuous northwest-trending zone of low resistivities of 100-200 ohm meters. The resistivities in this zone are lower than resistivities of the metasedimentary rocks within the study area, and also lower than resistivities of alluvial fill near Glen Lake (see fig. 2) southwest of the study area. These lower resistivities suggest an increased porosity that is interpreted to be a feature of the Rocky Mountain trench fault zone. The low-resistivity fault zone is interrupted by a region of intermediate resistivity just northeast of Glen Lake; this intermediate-resistivity region appears to correlate with a magnetic high, and may indicate a small intrusion at shallow depth, probably less than 300 ft deep.

A seismic survey was not a part of this investigation, but at least two seismic reflection crews were active in 1982 along Grave Creek on the southern margin of the Ten Lakes area. The recognition of stratiform seismic reflections at depth, obtained by Vibroseis surveys in northwestern Montana, west of Glacier Park, and rumors of hydrocarbon seepages in this region have led to numerous applications for oil and gas leases in the region.

The possible seismic reflection horizons within the Belt Supergroup of northwestern Montana are: (1) the upper and lower contacts of the Bonner Quartzite, (2) calcareous layers within the Shepard Formation, (3) the underlying Purcell Lava, and (4) calcareous siltite and dolomite strata of the Helena Formation. Seismic reflections may also have been obtained from foliated (stratiform) older Precambrian crystalline rocks and associated mylonite zones inferred to lie beneath the Belt Supergroup.

MINING DISTRICTS AND MINERALIZED AREAS

Mining history

Mining in Lincoln County dates back to the 1860's when prospectors worked placer-gold deposits west of the study area. By the 1890's, several mines in the county were producing gold-silver-lead ore.

The earliest claim staking in the study area was in 1892 when prospectors found surface outcrops of copper-bearing veins and located the Independence and Blue Bird lodes. By the turn of the century, most of the copper showings in the north-central part of the study area had been claimed and explored. In 1907 Anaconda Copper Mining Company sampled and evaluated the Independence lode; British Columbia Copper Company evaluated the Twin Peaks mine (Red Bird, Midnight, and Copper Kettle lodes) in 1912. Interest by major mining companies had waned by 1920, probably because of the failure to locate significant mineral reserves.

Most copper-lead-zinc veins on Gibralter Ridge, including those on the Titchbourne and Stoken claim and the prospect on Gibralter Ridge, were probably prospected in the 1930's. Bulldozer work on the Blackjack claim was done in the late 1950's after logging roads gave access to the area.

Mining-related activity during the past 20 years has consisted mainly of claim staking and exploration work. This activity included core drilling on the Pluto claim and a short-lived attempt to access the Independence claim group with a road and tramway up Indian Creek (Hamilton and Avery, 1983, p. 13).

Prospecting is the only activity in the study area at this time.

County mining records indicate that 117 claims were located within or adjacent to the study area from the 1890's to 1981. Many of these claims were relocations; six were patented. U.S. Bureau of Land Management files list eight claims as being current.

Geology of deposits

Two types of mineral occurrences in the study area have been the focus of past development: copper-bearing veins in the Purcell Lava, and copper-lead-zinc-bearing veins primarily in the Helena Formation. Silver is a minor constituent in both types of veins.

Most of the veins are in the Purcell Lava in the northwest part of the study area. Typical gangue minerals in the veins include quartz, siderite, calcite, limonite, pyrite, and barite. Copper is the most abundant commodity; chalcopyrite is the principal copper mineral, and chalcocite, covellite, cuprite, tenorite, malachite, azurite, and chrysocolla are less abundant. Lead and zinc occur as galena and sphalerite, respectively, in one vein.

Mineral occurrences in veins in the Purcell Lava appear to be a result of several modes of mineralization. Johns (1970, p. 77) reported that the mineral occurrence on the Independence property may be, in part, a replacement deposit because of indefinite vein boundaries. Stentz (1967, p. 7-8) considered the possibility that the cupriferous veins of the Red Bird, Midnight, and Copper Kettle lodes were a result of a magmatic segregation in the lava flows. Geological observations and geochemical data from the present studies suggest that most mineral deposits in the Purcell Lava are related to hydrothermal activity.

Base metal veins exposed in prospects near Gibralter Ridge generally strike east and dip south and are within limestone and dolomite of the Helena Formation and in calcareous siltite of the upper part of the Grinnell Formation. The veins consist of chalcopyrite, galena, and malachite in a gangue of quartz, siderite, and limonite. Lead-isotope determinations on galena from these veins suggest that the lead is Precambrian and probably remobilized from stratiform occurrences lower in the stratigraphic section, possibly from the Prichard Formation (B. R. Doe and R. E. Zartman, written commun., 1981). Intrusive activity beneath the stratiform occurrence probably caused remobilization and was the upward driving force.

Mineral occurrences

Four types of mineral occurrences have been identified in the study area: (1) Copper and silver minerals, locally associated with barite, occur in well-developed vein systems and shear zones in the Purcell Lava; this is the most extensive and most explored of the types of mineral occurrences. (2) Veins that contain copper, lead, zinc, and silver minerals are present near the south end of the study area on the nose of Gibralter Ridge, and are in the Helena Formation; some of these veins were prospected as recently as 1982. (3) Small isolated occurrences of zinc minerals associated with a thin metadiorite sill also have been prospected. (4) Stratabound copper minerals occur in some calcareous arenite beds in the McNamara Formation and in talus derived from the Grinnell and Shepard Formations

Most of the exploration and development activity at the mines and prospects in the study area was on copper-bearing, quartz-barite-siderite veins in the Purcell Lava. The veins occur in shear or breccia zones that trend west-northwest and range in thickness from 6 in. to 12 ft. In addition, the copper mineral chalcopyrite commonly occurs as vesicle fillings in the lava near mineralized shear zones. Although copper is the principal metal in the veins, silver, gold, cobalt, and lead occur in sparse amounts.

Barite is an important gangue mineral in most of the copper-bearing veins in the Purcell Lava. The amount of barite varies, but has been reported to be as much as 60.6 percent BaO (Johns, 1970, p. 152) in a vein exposed just off the Burma road and northwest of the study area. Many of the veins exposed in propsects on Green Mountain (fig. 2, nos. 2, 3) also contain large amounts of barite, but were developed only for copper.

Veins hosted by dolomite beds in the lower part of the Helena Formation have been explored at several prospects on Gibralter Ridge near the south end of the study area. The quartz-calcite veins contain lead, zinc, silver, and copper minerals, and range in thickness from 0.4 to 16 in. In addition to well-defined veins at the prospects, small veinlets and fracture fillings were observed at several outcrops, and samples from them contained as much as 1,000 ppm lead, 1,900 ppm zinc, 700 ppm copper, and 1.5 ppm silver.

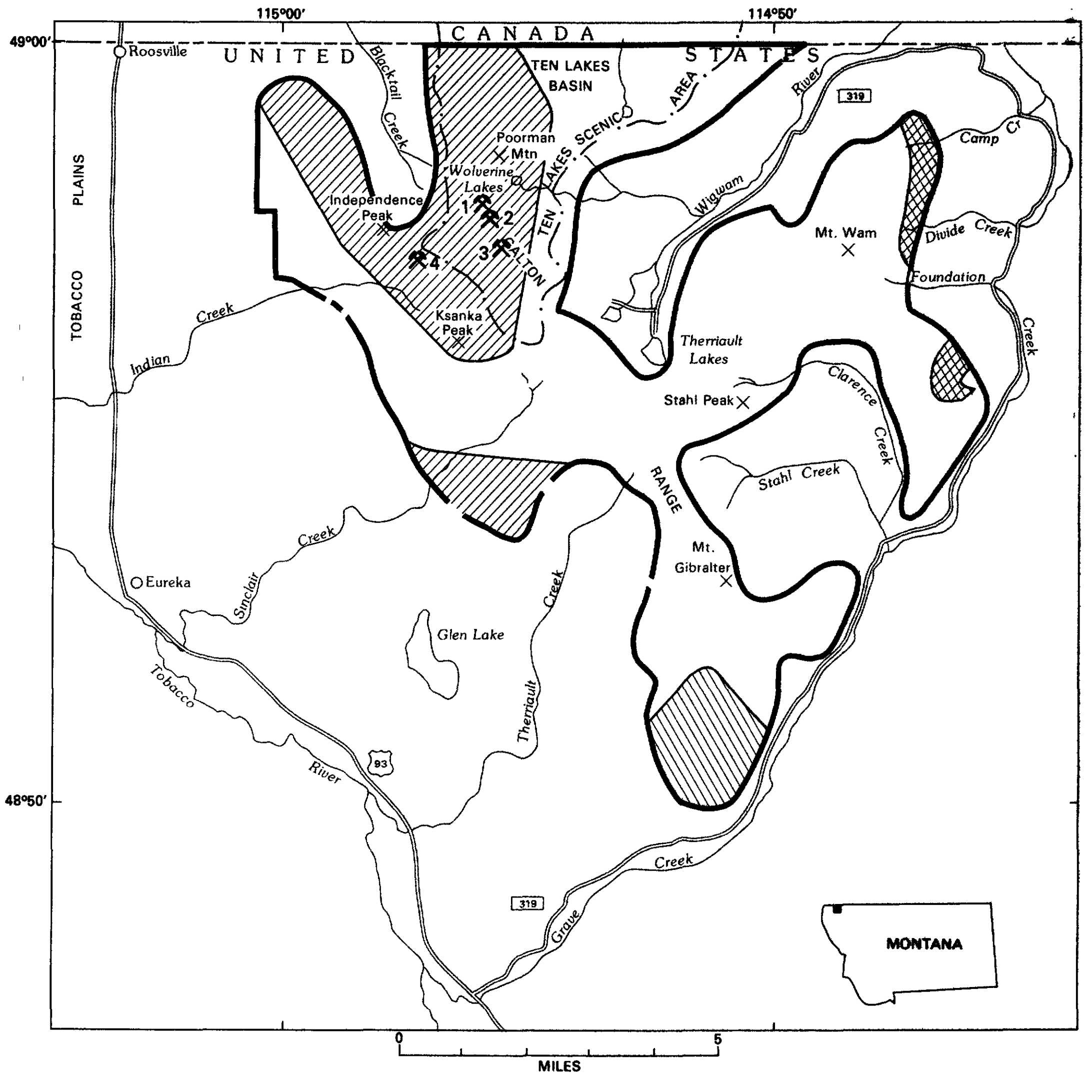
Metal-bearing veins associated with metadiorite sills are common in rocks of the Belt Supergroup in the Whitefish Range and elsewhere in Montana; however, only small isolated veins are present in metadiorite in the Ten Lakes study area. A vein associated with metadiorite is exposed at one prospect on the south end of Gibralter Ridge; a sample from the vein contained 400 ppm zinc. Samples of other veins in metadiorite did not contain appreciable quantities of metals. Samples of metadiorite typically contain 150-200 ppm zinc.

Stratabound copper minerals are disseminated in some calcareous arenite beds of the lower McNamara Formation and in blocks of siltite in talus from the Shepard and Grinnell Formations. Mineralized strata in the McNamara are less than 4 in. thick and contain about 2,000 ppm copper and 0.5-3 ppm silver. Samples of malachite-stained talus from the Shepard and Grinnell Formations contain 1,000 ppm copper.

The mineral deposits that have sufficient tonnage and grade to constitute mineral resources in the study area are all in veins in the Purcell Lava (table 1). These deposits are on the Independence property (fig. 2, no. 4); the Red Bird, Midnight, and Copper Kettle lodes (fig. 2, no. 1); and the trend of mineralized rock through the Green Mountain claim and the Swansea Rosa and Bluebird lodes (fig. 2, nos. 2, 3).

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The determination of the mineral resource potential of the Ten Lakes Wilderness Study Area is based largely on geological, geochemical, geophysical, and mine and prospect data that were gathered during 1980-82.



HIGH MINERAL RESOURCE POTENTIAL FOR COPPER IN VEINS

MODERATE TO HIGH MINERAL RESOURCE POTENTIAL FOR LEAD AND ZINC IN VEINS

LOW MINERAL RESOURCE POTENTIAL FOR STRATABOUND COPPER

⚒ MINE OR PROSPECT—Numbered mines or prospects are discussed in text or table 1.

Figure 2.—Map showing locations of mines, prospects, and areas of mineral resource potential in Ten Lakes Wilderness Study Area.

Table 1.--Identified mineral resources, Ten Lakes Wilderness Study Area

[Pct, percent]

Map No.	Property	Type	Tonnage[1]	Products	Grade[1]
1	Twin Peaks mine--Red Bird/ Midnight, and Copper Kettle/ patented claims) and Eureka.				
	Northwest part of vein---	--do--	150,000	Copper---- Silver----	0.36 pct .42 oz/ton
	Southeast part of vein---	--do--	290,000	Copper---- Silver----	.91 pct .23 oz/ton
4	Independence (patented claim).				
	High grade part of vein--	--do--	18,000	--do-----	2.9 pct
	Low grade part of vein---	--do--	1,300,000	--do------	.5 pct

[1]Metric conversion: tons x 0.9072 = tonnes; ounces (troy) per ton x 34.285 = grams per tonne.

The Ten Lakes area has a high resource potential for copper and silver in veins in the Purcell Lava. Aeromagnetic anomalies in the vicinity of Independence Peak suggest small shallowly buried granitic intrusions (Bankey and others, 1983), which could have been the source of the ore-forming fluids that formed the metalliferous veins. Stream-sediment samples from most of the streams that drain the Independence Peak area have anomalously high copper contents (Leinz and Whipple, 1983). A smaller area south of Independence Peak and east of Sinclair Creek has a similar geological, geochemical, and geophysical setting and also is considered to have a high mineral resource potential for copper (fig. 2).

Although most of the copper- and silver-bearing veins in the Purcell Lava also contain barite, the resource potential of the study area for barite is low. No production of barite from any of the vein systems is known (R. G. Berg, oral commun., 1983). If any of the copper- and silver-bearing veins were to be mined, barite possibly could be recovered as a byproduct.

An area in the vicinity of Gibralter Ridge near the southern boundary of the Ten Lakes study area has a moderate to high resource potential for copper, silver, lead, and zinc in veins, mainly in the Helena Formation (fig. 2). The dolomite host rocks in the Helena Formation and in calcareous siltite of the Empire Formation are locally silicified and pyritic, suggesting some hydrothermal alteration. No geophysical anomalies are centered over Gibralter Ridge, but small magnetic highs on the east and west sides of the ridge are interpreted to be small buried plutons (Bankey and others, 1983).

A low resource potential is assigned to the Ten Lakes area for zinc-bearing veins associated with metadiorite sills. The sills in the area are relatively thin, laterally discontinuous, and relatively devoid of metal-bearing veins.

Although copper-mineralized rocks in the McNamara Formation occur over a seemingly widespread area, the Ten Lakes study area has a low resource potential for stratabound copper (fig. 2). The thin interval of mineralized strata and relatively low copper content preclude any higher classification. The isolated occurrences of stratabound copper minerals observed in talus from the Shepard and Grinnell Formations are not considered significant.

Little is known about the oil and gas resource potential of the Ten Lakes Wilderness Study Area. No hydrocarbon seepages have been located in or near the Ten Lakes area, although rumors of seepages west of Glacier National Park have led to numerous applications for oil and gas leases in the region. Reports of oil-saturated limestone along Trail Creek and Thoma Creek east of the Ten Lakes area were examined and sampled; however, no samples contained significant hydrocarbons, no hydrocarbon seepages were observed, and the rock in question contained no visible porosity.

Neither the rocks in the Belt Supergroup nor the inferred underlying crystalline rocks would have oil or gas unless these rocks rest in fault contact above hydrocarbon source beds and the hydrocarbons would be trapped by structural closures in the subsurface. This may be the circumstance farther east, near the western margin of Glacier National Park, but this structural configuration is considered to be highly unlikely beneath the Ten Lakes study area. Narrow belts of Phanerozoic sedimentary rocks that could be source beds of hydrocarbons were examined both east and west of the study area, but they do not extend into the area and are erosional remnants on the downthrown sides of large normal faults. Therefore, these rocks cannot be projected to extend beneath the Ten Lakes area, and there is little likelihood for the presence of oil and gas in the study area.

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