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MINERAL RESOURCE POTENTIAL OF THE WEST PIONEER WILDERNESS STUDY AREA, BEAVERHEAD 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 West Pioneer Wilderness Study Area in the Beaverhead National Forest, Beaverhead County, Mont. The western Pioneer Mountains was established initially as a further planning area by Public Law 95-150, and the area was later included as a further planning roadless area (No. 1-1006) during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

Geologic, geochemical, and geophysical investigations and a survey of mines and prospects have been conducted to evaluate the mineral resource potential of the West Pioneer Wilderness Study Area, Beaverhead County, Mont. The area predominantly comprises Proterozoic quartzite, calc-alkaline intrusive rocks of late Cretaceous to early Tertiary age, and polydeformed metamorphic rocks. Most surface and mineral rights are federally owned.

Numerous precious- and base-metal-bearing quartz veins and porphyry-type molybdenum deposits occur in the study area and all of these occurrences have resource potential. Minor skarn occurrences were also found. All of the important mineral deposits appear to be related to the later phases of the batholithic rocks. The study area has moderate to high potential for the occurrence of molybdenum, gold, and silver, a low to moderate potential for copper, zinc, and lead, and low potential for tungsten and placer-gold resources. These conclusions are based on the results of geologic mapping, prospect evaluation, a geochemical survey of stream sediments, and an aeromagnetic survey.

INTRODUCTION

The West Pioneer Wilderness Study Area consists of 147,992 acres within Beaverhead County and is located in the western half of the Pioneer Mountains, Beaverhead National Forest, about 30 mi northwest of Dillon, Mont. (fig. 1). The study area contains a few small mines, and numerous organized mining districts are located around the immediate region. This report documents the geology, mineralization, and mineral resource potential of the study area based on geological, geochemical, and geophysical investigations by the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM).

Physiography

The western Pioneer Mountains constitute a northerly trending, 30-mile long and 13-mile wide mountain block between the north-flowing Wise River and south-flowing Grasshopper Creek on the east and the Big Hole valley on the west. The mountains rise abruptly from broad, flat valleys at about 7,000 ft to peak altitudes from 9,000 to over 9,400 ft. Many upland meadows and parks are located throughout the heavily forested range. Major drainages are Pattengail Creek, Lacy Creek, Wyman Creek, Warm Springs Creek, Steel Creek, Squaw Creek, Bryant Creek, and Alder Creek. The western Pioneer Mountains are a major watershed for the Big Hole River.

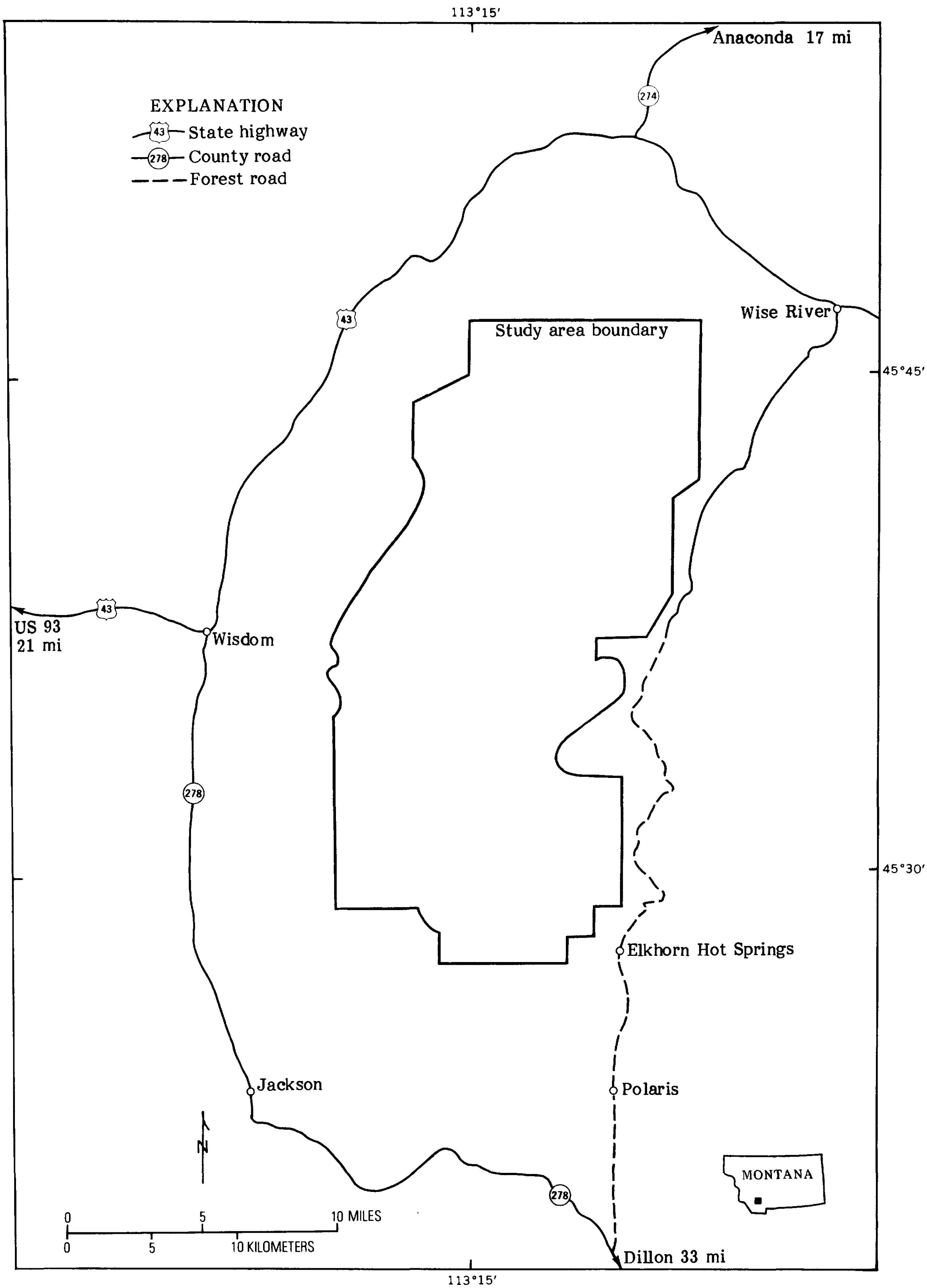

Figure 1.—Index map showing location of the West Pioneer Wilderness Study Area.

Previous Mineral Resource Investigations

Geach (1972) published the most comprehensive discussion of base-metal, precious-metal, and contact-metasomatic mineral deposits in the study area as part of a compilation of mineral resources in Beaverhead County, Mont. Walker (1963) described the known tungsten occurrences in the region, all located north and east of the study area. Sassman (1941) discussed the history of mining in the region. As part of uranium-resource investigations in southwestern Montana, the U.S. Department of Energy has sponsored a hydrogeochemical and stream-sediment reconnaissance (HSSR) survey that includes the study area (Broxton, 1979).

Geologic Setting

The western Pioneer Mountains are part of a broad mountain block that contains rocks of many ages. Early Proterozoic crystalline rocks are exposed in the northern part of the eastern Pioneer Mountains (Zen, and others, 1980) and are reported from diamond drilling (William Hand, Dillon, Mont., written commun., 1979) in the Argenta mining district at the south end of the eastern Pioneer Mountains. Quartzofeldspathic gneisses and metavolcanic rocks of Early Proterozoic(?) age are exposed in the northwestern part of the study area. Middle Proterozoic sedimentary rocks are exposed throughout the Pioneer Mountains and make up nearly 50 percent of all rock exposures in the study area. Paleozoic sedimentary rocks, extensively exposed in the eastern Pioneer Mountains, are only exposed in the western Pioneer Mountains beneath a thrust fault in a small area around Ross Gulch in the northeastern part of the study area and at Calvert Hill, as roof pendants in batholithic rocks on Foolhen Ridge, and unconformably on Proterozoic rocks near Jackson, Mont., outside the study area. Mesozoic sedimentary rocks are common along the eastern flank of the Pioneer Mountains, but are only exposed near Calvert Hill north of the study area in the western half of the range. Plutonic rocks of Late Mesozoic to Tertiary age intrude all of the older rocks and make up the Pioneer batholith. Batholithic rocks, ranging in composition from diorite to granite, are extensively exposed in the study area. Some Tertiary sedimentary and volcanic rocks crop out in the Pioneer Mountains, but none occurs within the study area. Quaternary glacial and alluvial deposits are found throughout the study area.

The structural setting of the study area is very complex. Low-angle thrust faults superpose Middle Proterozoic sedimentary rocks over other Middle Proterozoic sedimentary rocks and Early Proterzoic(?) metamorphic rocks, but east of the study area the same thrust sheets overlie Phanerozoic sedimentary rocks. In general, Phanerozoic rocks are not known to be associated with the thrust sheets in the western Pioneer Mountains. Exceptions are the Ross Gulch area where a wedge of Paleozoic sedimentary rocks occurs along a thrust fault between Middle Proterozoic units and in the north where the location of roof pendants of Phanerozoic rocks spatially indicates a relationship to thrust faults. The thrust faulting occurred before emplacement of the Pioneer batholith. Major north-northeast- and west-northwest-trending, high-angle faults cut the rocks in the study area and apparently were active during several periods. The high-angle faults appear to control drainage patterns, the distribution of rock-types, and the emplacement and chemistry of some igneous intrusions.

Mining Activity

Prospecting and mining activity have taken place intermittently in and adjacent to the study area since the late 1860's. Placer gold and lode gold and silver were the chief objectives in the early days, although copper was also of economic interest. Tungsten was apparently discovered in the eastern Pioneer Mountains in the late 1800's, but was not extensively prospected in the western Pioneer Mountains until the 1950's (Geach, 1972). Although production records are incomplete, some ores of all of these commodities have been shipped from mines in and adjacent to the study area. The history of prospecting for porphyry-type deposits is not known, but major exploration efforts for porphyry-type molybdenum deposits have been made since the late 1960's.

GEOLOGY, GEOCHEMISTRY, AND GEOPHYSICS PERTAINING TO MINERAL RESOURCE POTENTIAL

Geology

The general geologic framework of the western Pioneer Mountains can be subdivided into polydeformed metamorphic rocks, Middle Proterozoic calcareous metasedimentary rocks, Middle Proterozoic sedimentary rocks, Paleozoic and Mesozoic sedimentary rocks, plutonic rocks of the Pioneer batholith, and surficial deposits. Because of complex structural relationships and the current incompleteness of geochronologic data, the relative ages of the polydeformed metamorphic rocks and the calcareous metasedimentary rocks with respect to Middle Proterozoic sedimentary rocks are unknown. Regardless of relative age, each rock group is distinct and forms a natural subdivision based on structural relations and lithology. This general geologic framework is pertinent for evaluating existing and potential mineral resources. In the West Pioneer Wilderness Study Area and vicinity, significant mineral resources occur in Middle Proterozoic, Paleozoic, and Mesozoic sedimentary rocks and in granitic intrusions of Late Cretaceous to early Tertiary age. A simplified geologic map of the study area is shown on figure 2.

Polydeformed metamorphic rocks in the northern portion of the western Pioneer Mountains form a terrane, interrupted only by plutons of the Pioneer batholith, that extends from Alder Peak westward to the Big Hole River and beyond (unit M, fig. 2). The metamorphic rocks are at amphibolite facies and include metahypabyssal igneous rock, granite gneiss, hornblende-biotite gneiss, and sillimanite-bearing metasedimentary rock. At least one and up to three foliations are present. Boudinaged pegmatites and detached isoclinal folds in hornblende-biotite gneiss and sillimanite-bearing metasedimentary rock are common. The amount of deformation within the terrane apparently increases westward, although in part this may be a function of rock type, as the more massive units occur in the east. In places, a contact-metamorphic overprint occurs and is indicated by epidote and secondary biotite in quartzofeldspathic

EXPLANATION

IIIc Late-felsic

IIIb Late-felsic porphyries

IIc Late-group plutons

IIb Main-group plutons

IIa Pre-main-group plutons

P Phanerozoic

Y Middle Proterozoic sedimentary rocks of the Missoula Group and/or the Helena Dolomite

M Metamorphic rocks

Contact

High-angle fault

Thrust fault

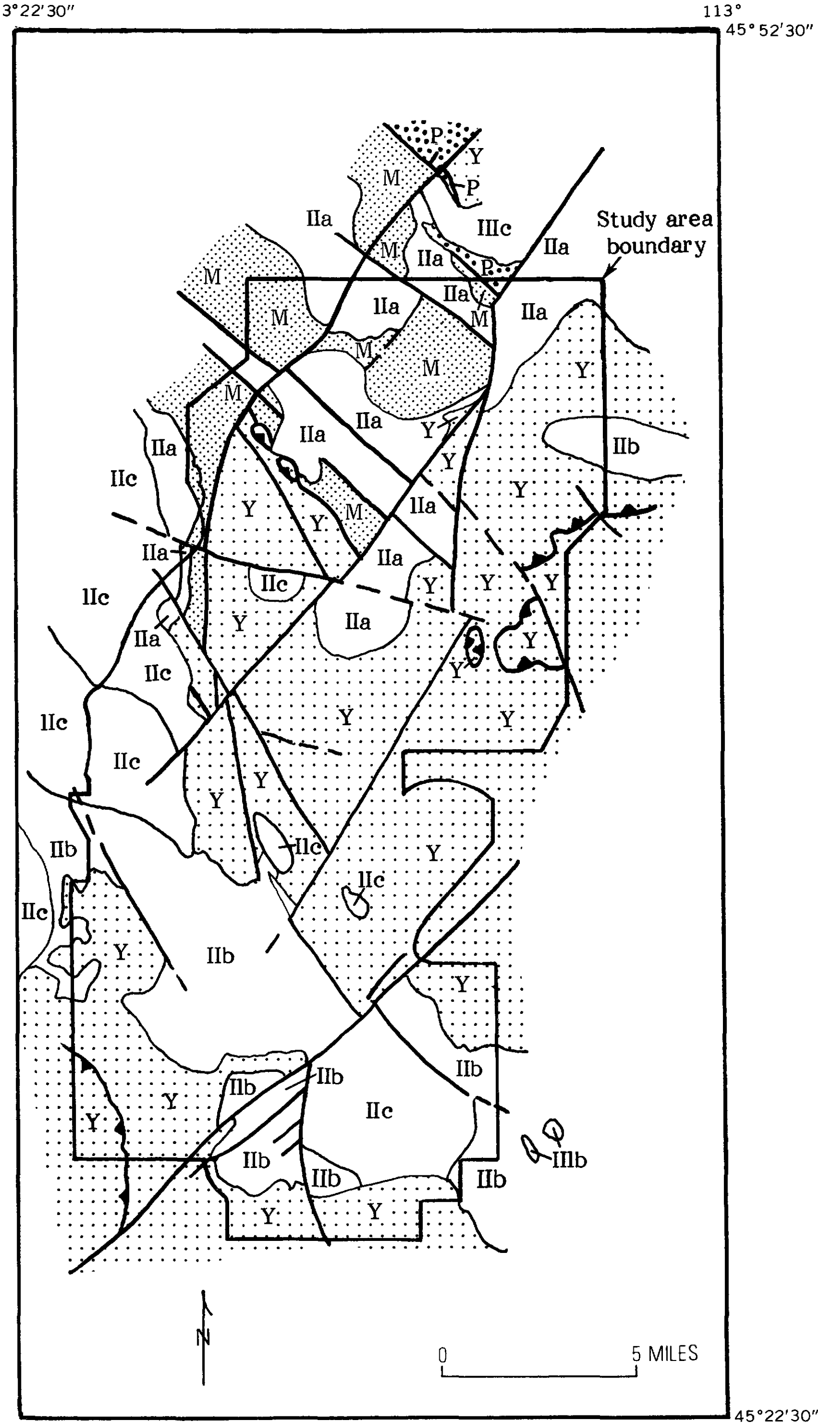

Figure 2.—Generalized geologic map of the West Pioneer Wilderness Study Area.

units or fibrolite after muscovite and white mica after garnet in aluminous units. The terrane is mainly bounded by plutons of the Pioneer batholith but in some areas high-angle faults juxtapose it against Middle Proterozoic or Phanerozoic sedimentary rocks. Although no Phanerozoic or thrusted Middle Proterozoic sedimentary units lie directly on metamorphic rocks, geometric considerations suggest that they once did. However, whether the metamorphic terrane itself is allochthonous is unknown. The terrane appears to represent a group of rocks that included granitic plutons, porphyritic volcanic plugs, volcanogenic sediments, conglomerates, clay-rich sandstones, and pelites. Unpublished data (Lawrence Snee and Thomas Stern, USGS, 1983) show that the crystallization age of the hypabyssal rocks is Early Proterozoic; the age of metamorphism is possibly Early Proterozoic, although a younger age of metamorphism, or several episodes of different ages occurring before emplacement of crosscutting plutons of Late Cretaceous age, is possible.

Calc-silicate rocks in the study area are structurally below thrust sheets of Middle Proterozoic sedimentary rocks. The metamorphosed carbonate-bearing sediments of Middle Proterozoic age are intercolated with metapelites and quartzite and crop out at three places surrounded by moraines within a belt extending north-northwest from east of Lake-of-the-Woods to east of Sand Lake (unit Y, fig. 2). The metacarbonates consist of dark green and white bands of calc-silicate minerals, and the metapelites contain cordierite. Common sedimentary structures include cross-bedding, ripple marks, load casts and dessication cracks. Thick sequences of fine-grained quartzite and argillaceous quartzite occur below and above the intercalated carbonate-clastic sequence. The sedimentary character of the sequence is indicative of deposition in a shallow marine environment in which there was intermittent deposition of prodeltaic sands (C. A. Wallace, USGS, oral commun., 1982). All of these rocks are complexly folded and are exposed only along high-angle faults and in windows through thrust sheets. Possible correlative calcareous metapelites are exposed near Stone Lake, and they also were encountered beneath a low-angle dipping fault gouge in diamond drill holes near Stone Creek (Utah International, unpub. data, 1979). These occurrences near Stone Creek indicate that Precambrian carbonate rocks may be extensive in the subsurface in the western Pioneer Mountains. The age of these rocks is unknown, but the composition and sedimentary features are similar to parts of the Middle Proterozoic Mount Shields Formation or Helena Dolomite.

Allochthonous (rocks of distant origin) Middle Proterozoic sedimentary rocks underlie about 50 percent of the map area and comprise quartzite, argillaceous quartzite, argillite, and conglomerate. (Y, fig. 2). The entire sequence is part of the Missoula Group and most of the units are probably Mount Shields Formation (C. A. Wallace, written commun., 1982), but some units along the southwestern edge of the study area are likely McNamara Formation. The base of the quartzite sequence is a thrust fault which, where exposed, places the sequence above sillimanite-bearing metasedimentary rocks or calc-silicates. At least one other thrust fault crosses through the sequence.

Three lithologically distinct units comprise the Proterozoic sedimentary rocks (Lawrence Snee and E-an Zen, unpub. data, 1983). The areally predominant unit occurs in the east-central part of the study area and is confined to the structurally lower thrust sheet. This first unit is poorly sorted quartzite and argillaceous quartzite with intercalated argillite. Sedimentary features, including cross-bedding, ripple marks, mud cracks, and load casts, are common. Where contact-metamorphosed, this unit is altered to spotted granofels with clots of muscovite and biotite. The thickness of the unit is unknown, but is probably greater than 0.9 mi.

A second unit of Middle Proterozoic sedimentary rocks occurs within the northeastern part of the study area and is confined to the structurally higher thrust sheet. This second unit consists of vitreous quartzite interbedded with steel-gray quartzite that grades downward into a lower section of quartz sandstone and quartzite. The total thickness of this second unit is approximately 1.25 mi.

A third unit of Middle Proterozoic sedimentary rock is also confined to the upper thrust sheet within the study area and occurs both in the eastern and the southwestern parts of the area. This third unit is pink, cross-bedded feldspathic quartzite with minor argillite. Cross-beds, slump structures, and mud chips are common. This unit may be in part correlative to the upper part of the second unit based on field relations in the northeastern part of the study area. Along the southwestern edge of the area, this third unit apparently grades upward into interbedded pink quartzite and sericite cemented, dark reddish gray to maroon feldspathic quartzite, similar to parts of the McNamara Formation (Lawrence Snee and E-an Zen, unpub. data, 1983).

Paleozoic rocks are exposed in only two areas within the study area. The Upper Mississippian(?) and Pennsylvanian Amsden Formation(?) occurs as a thrust slice between the Middle Proterozoic sedimentary units near the mouth of Ross Gulch (Calbeck, 1975). The rocks consist of silicified dolomite and limestone, silty limestone, siltstone, and marly siltstone. Metamorphosed carbonate rock and quartzite occur as roof pendants in granitic plutons along Foolhen Ridge near Ferguson Lake and near Foolhen Mountain. Contact metamorphic and metasomatic effects make stratigraphic assignment of the roof pendants difficult, but the Foolhen occurrences are similar to the Amsden Formation and Mississippian Mission Canyon Limestone.

No Mesozoic sedimentary rocks have been recognized in the study area, although Triassic and Cretaceous argillite, conglomerate, sandstone, skarn, and limy sandstone occur at Calvert Hill north of the study area boundary.

Plutonic rocks of Late Mesozoic to Early Tertiary age intrude all of the Proterozic units in the study area and the Paleozoic rocks on Foolhen Ridge. The intrusions form part of the complex Pioneer batholith that makes up the core of the Pioneer Mountains. Snee (1982) divided the batholithic rocks into seven separate groups of intrusions that are generalized here into three groups: the early-mafic (I), main-stage (II), and late-felsic (III)(fig. 2). The seven groups were defined by Snee (1982) on the basis of lithology, mineral evolution, major-element chemistry, and field relationships. Radiometric-age relationships throughout the Pioneer Mountains support the group definition but define a regional cooling history that occurred after emplacement of the batholith. A summary of the mineralogy of the major plutons in each group of plutons in the study area is shown in table 1.

Early mafic-group intrusions (group I) in the study area are restricted to fine-grained, locally porphyritic diorite inclusions in younger, more granitic intrusions near Copper Creek in the central part of the area and south of the Steel Creek campground at the Arnold mine along the western margin of the study area. These intrusions are too small to be shown on figure 2. The main-stage plutons (group II) may be divided into three subgroups based on mineralogy, appearance, chemical composition, and age: pre-main (IIa), main (IIb), and late (IIc). Group IIa intrusions make up most of the batholith in the northwestern portion of the study area. The main plutons are tonalites at Foolhen Mountain and Pattengail Creek and the granodiorite at Stine Creek (table 1). The normal variety is a fine-grained to porphyritic, fine-grained tonalite to granodiorite. A mafic variety is quartz diorite to tonalite with up to 55 percent hornblende. Compositional heterogeneity is characteristic of IIa plutons. Group IIb plutons crop out along the southwestern and southern portions of the study area. The main bodies are medium-grained granodiorites at Uphill and Shoestring Creeks (table 1). Group IIc plutons (table 1) crop out primarily along a northwesterly trend through the study area and consist of biotite granodiorite. The granodiorites at Odell Lake and Doolittle Creek locally have a contact intrusion breccia, the matrix of which is often pegmatitic. The late-felsic intrusions (group III) occur as dikes and small plugs of rhyodacite porphyry, smoky "quartz-eye" porphyritic granite, and granite pegmatite and as plutons of muscovite-biotite granite. The rhyodacite dikes (IIIa) occur at Baldy Lake cross-cutting the intrusion breccia and are unaltered, whereas the "quartz-eye" porphyries (IIIb) are present at several localities and are always altered to quartz and sericite. The muscovite-biotite granite (IIIc) occurs at Salefsky and at Bryant Creeks, northwest and north of the study area, respectively.

Unconsolidated morainal deposits mantle some of the higher ridges and valley sidewalls and glaciofluvial and stream-sediment deposits cover most of the valley floors. Few gravels that might have a potential for placer deposits are in the study area.

Mineral Deposits

There are a variety of metallic mineral deposit types found in and around the study area (fig. 3). Metals of economic interest include silver, gold, lead, zinc, copper, tungsten, and molybdenum. Historically, most of the production has come from fissure veins and carbonate-replacement deposits, but porphyry-type deposits have been found in recent years.

Open-space-filling quartz veins along faults, fractures, and joints are the most common type of deposit in and around the study area. The veins vary from a few inches to several feet wide, and the wallrock is commonly altered to quartz, sericite, chlorite, and occasionally potassium-feldspar. Primary ore minerals include tetrahedrite, native gold, galena, sphalerite, and chalcopyrite with associated pyrite, and commonly arsenopyrite and huebnerite. Secondary minerals include cerargyrite, native metals, cerrusite, hemimorphite, malachite, and chrysocolla. Important examples of this type of deposit in the vicinity of the study area are the Elkhorn and Park mines in the Elkhorn mining district, the Polaris mine in the Polaris mining district, and the Mauldin mine in the Argenta mining district. All of these mines are associated with the Pioneer batholith. The Elkhorn, Park, and Polaris mines are localized along a major, through-going fault system, while the Mauldin mine is localized in fractures related to a large anticline. Throughout the region, most of the production has come from secondary mineralization in the oxidized, upper portions of the veins. The results of geochemical sampling of selected vein-type deposits within the study area are shown in table 2.

There are two important types of carbonate-replacement deposits in the region: tungsten-bearing garnet-pyroxene-epidote skarns and precious- and base-metal-bearing mantos and chimneys. The productive skarns occur at contacts with granodioritic phases of the Pioneer batholith and primarily in the Upper Mississippian(?) and Pennsylvanian Amsden Formation(?). The skarn consists of andradite garnet, diopsidic pyroxene, epidote, quartz, and calcite. The main ore mineral is scheelite, but there may be associated molybdenite, chalcopyrite, sphalerite, and galena. Bismuthinite and beryl are found occasionally. Examples of this type of deposit are Calvert Hill north of the study area and Brown's Lake in the eastern Pioneer Mountains. Base- and precious-metal-replacement deposits occur in Paleozoic dolomitic carbonate rocks near contacts with the Pioneer batholith. The selective replacement of bedding away from feeder structures creates mantos and replacement along structures creates chimneys or veins of quartz and calcite with galena, sphalerite, chalcopyrite, tetrahedrite, and pyrite with occasional molybdenite. Significant production has come from the Hecla mining district, but there are also occurrences in the Baldy Mountain and Argenta mining districts.

The Pioneer Mountains contain a number of porphyry-molybdenum-type prospects and deposits. These large-tonnage deposits are associated with the group IIIb granitic phases of the Pioneer batholith (Berger and others, 1981) and occur as stockworks of quartz veinlets. Alteration minerals include quartz, potassium feldspar, sericite, chlorite, pyrite, and magnetite. Intrusion breccias, intrusive breccias, and pebble dikes occur at some prospects. The multiple intrusion of leucocratic granite or rhyolite porphyry dikes is an important attribute of this type of deposit. The most significant ore mineral is molybdenite, and there may be associated chalcopyrite and fluorite. Galena and sphalerite occur rarely. Vein occurrences of silver and base metals with huebnerite are common around these deposits. Cannivan Gulch is the major example of this deposit type in the Pioneer Mountains, but other examples include Black Lion Lake, Jacobson Meadows, and Price Creek.

Other deposit types that may occur in this geological terrane but were not recognized in the course of this study are porphyry copper-molybdenum.

Exploration Geochemistry

Trace elements useful in the evaluation of the mineral resource potential in the western Pioneer Mountains were identified through the sampling and

Table 1.--*A summary of the primary and alteration minerals of the major plutons in the study area*

	PLUTON	GROUP	PRIMARY MINERALOGY													ALTERATION MINERALOGY					
			Plagioclase (An_x)	Potassium Feldspar	Quartz	Biotite	Hornblende	Muscovite	Epidote	Magnetite	Sphene	Apatite	Zircon	Allanite	Pyroxene	Epidote	Chlorite	Sercite	Biotite	Potassium Feldspar	Quartz
OLDER	Diorite	I	50		●	●	●			●	●	●			●	★	★	★			
	Tonalite of Foolhen Mountain	I	70 35-	●	●	●	●		●	●	●	●	●	●	●	★	★		★		
	Tonalite of Pattengail Creek	IIa	70 20-	●	●	●	●		●	●	●	●	●	●	●	★	★		★		
	Pluton of Stine Creek	IIa	40 20-	●	●	●	●	▲	●	●	●	●	●	●		★	★	★			
	Granodiorite of Uphill Creek	IIb	50 20-	●	●	●	●		●	●	●	●	●	●			★				
	Granodiorite of Shoestring Creek	IIb	45 25-	●	●	●		▲	●	●	✳	●	●	●			★				
	Granodiorite of Odell Lake	IIc	30	●	●	●		▲		●	✳	●	●	●			★				
	Granodiorite of Francis Creek	IIc	30	●	●	●		▲		●	✳	●	●	●			★				
	Granodiorite of Stone Creek	IIc	35	●	●	●		▲		●		●	●	●			★				
	Granodiorite of Doolittle Creek	IIc	25	●	●	●		▲		●	✳	●	●	●			★				
	Rhyodacite porphyry	IIIa	20	●	●	●											★				
	Rhyolite porphyry	IIIb		●	●	●												★		★	★
	Granite of Salefsky Creek	IIIc	30 3-	●	●	●		●		■		●	●				★	★			
YOUNGER	Granite of Bryant Creek	IIIc	20	●	●	●		●		●		●	●				★	★			

Key: ● = mineral present as primary phase; ▲ = Late-stage phase, ragged; ■ = magnetite and ilmenite; ✳ = altered to leucoxene; ★ = alteration mineral

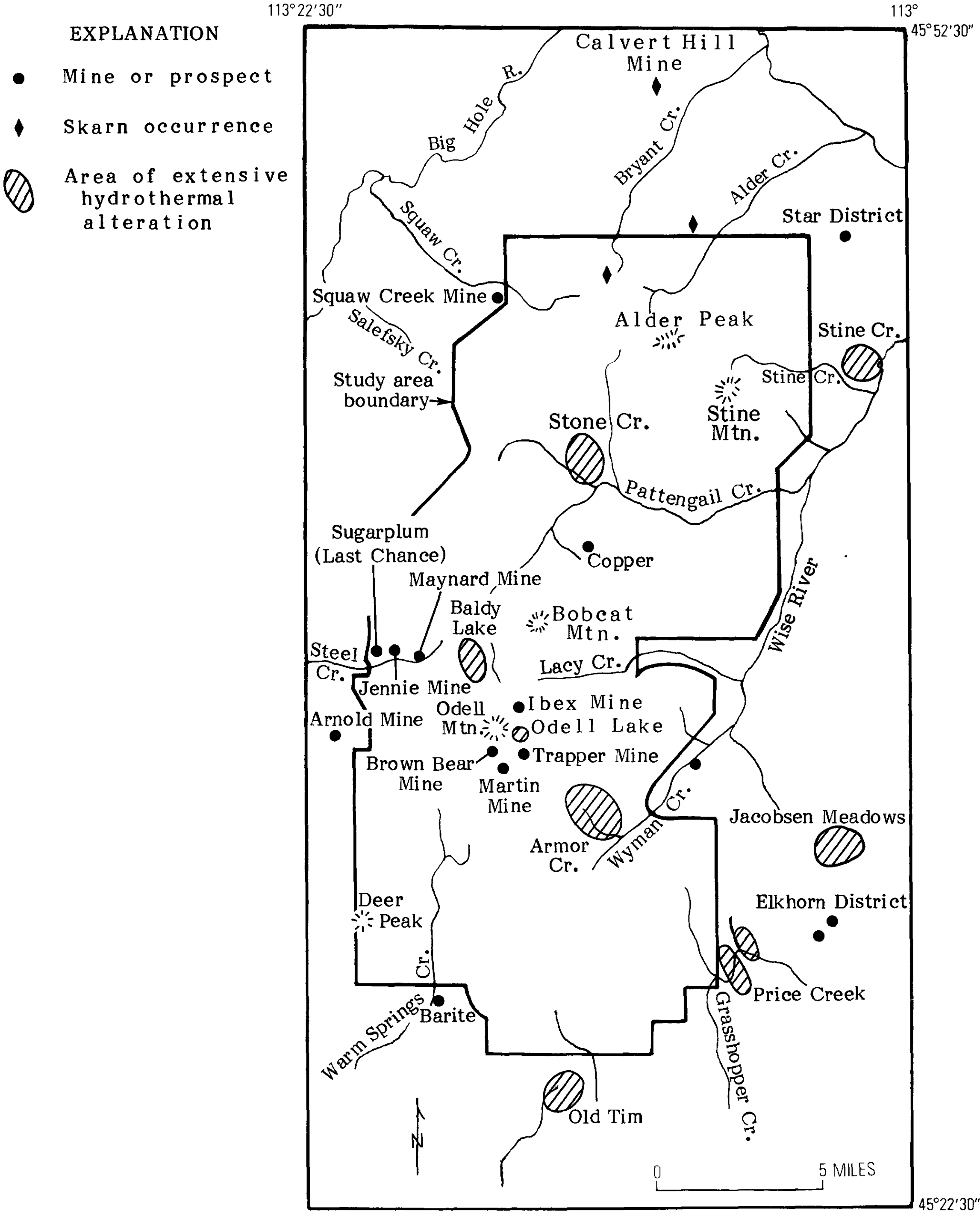

Figure 3.--Locations of known mineralized areas.

Table 2. —*Selected analyses of ore and altered rock samples from mine sand prospects in and near the study area All values as ppm, <-less than value shown; >-greater than value shown*

Locality		Ag	As	Cu	Mo	Pb	Zn
Coeur d'Alene mine		1500	200	500	7	5000	560
Sugarplum mine		<0.5	<10	150	<5	<10	15
Franklin mine		0.7	<10	20	5	10	20
Jennie mine		50	20	100	<5	150	600
Maynard mine		15	40	1000	<5	150	>2000
-do-		10	<10	100	7	100	>2000
Star mine	Sec. 36 T. 1 N. R. 12 W.	1	<10	100	<5	20	70
-do-	-do-	7	80	1000	<5	100	80
-do-	-do-	<0.5	<10	20	<5	10	15
Barite vein	Sec. 26 T. 4 S. R. 14 W.	<0.5	<10	20	<5	10	5
-do-	-do-	<0.5	<10	5	<5	10	5
Baldy Lake Breccia	Sec. 1 T. 3 S. R. 14 W.	20	20	1500	200	100	75
-do-	-do-	3	10	5000	500	20	100
-do-	-do-	7	40	300	100	<10	5
-do-	-do-	15	10	1500	300	30	40
-do-	-do-	30	10	3000	500	30	20
-do-	-do-	1	10	150	<5	150	10
-do-	-do-	<0.5	10	7	<5	10	<5

chemical analysis of ores and altered rocks from known mines and prospects in and around the study area (table 2). The general distribution of these mineral-deposit related elements was determined through the sampling and analysis of the minus 200-mesh (<75 μm) fraction of stream sediments at an approximate sample density of one sample per line-mile of selected streams. This fraction of the sediments was chosen on the basis of a pilot study by Breit (1980) that compared several sample media and determined that molybdenum and tungsten, in addition to the other ore-forming elements, were more consistently detected analytically in the minus 200-mesh (<75 μm) fraction than in other sieve fractions. The pilot study also indicated that mineral deposits must be either large or contain high concentrations of ore metals to assure recognition in the regional stream-sediment survey.

The generalized distribution of higher concentrations of molybdenum, copper, lead, zinc, and silver are shown in figure 4. There is a prominent northwest-trending zone across the study area, extending from Doolittle and McVey Creeks on the western edge of the study area to Crystal Park on the eastern edge. This zone intersects a more north-trending zone which extends from Stewart Meadows on the south to Stone Creek on the north. Another northwest-trending belt of these elements extends from Alder Peak southwest to the Wise River near Stine Creek. Two other areas showing a high metal concentration are at the south end of the study area at Old Tim Creek and in the southwestern corner of the area along the west side of Warm Springs Creek.

Geophysics

Magnetic and gravity anomaly data in the study area are chiefly useful for delineating subsurface occurrences of sedimentary rocks, plutonic rocks, and alluvial fill. These geophysical data, considered in the context of known mineral occurrences, point to one area having potential for fuel resources and several areas that have potential for non-fuel resources occurrences.

Of possible interest for hydrocarbon accumulation, the area labeled "anomaly quiet zone" (fig. 5) is unusual in the following way: The absence of magnetic anomalies and the general absence of gravity anomalies, except for lows associated with alluvial fill, indicate that the quiet zone is the only region of the study area devoid of plutonic rocks in the subsurface. Where plutonic rocks are absent, there is a possibility that thermally unmetamorphosed Paleozoic sedimentary rocks may occur beneath thrust plates as in the eastern Pioneer Mountains.

Much of the study area outside of the quiet zone exhibits ten anomaly patterns characteristic of those related to major mineral occurrences, which have potential for resources (fig. 5). Two general conclusions can be drawn from the data; (1) major mineral occurrences of some regions are spatially associated with the middle-to-upper flanks of magnetic highs (e.g., Squaw Creek-Foolhen Mountain, Stone Creek-Lost Horse Creek, Baldy Lake-Odell Mountain, Steel Creek, and Price Creek), and (2) major mineral occurrences of other regions are spatially associated with magnetic lows (e.g., Alder Peak-Stine Mountain, Armor Creek, Warm Springs Creek, Seymour Mountain, and Old Tim).

At least two gravity anomalies may also be significant as a guide for mineral concentrations. The first anomaly, a gravity low within the triangular area outlined by the Armor Creek, Price Creek, and Old Tim regions, is associated with granodiorite of Shoestring Creek, also marked by a magnetic low. The gravity low is an extension of a broad low passing through a breccia pipe in the Armor Creek region (marked by a magnetic low) and the Jacobson Meadows and Elkhorn veins east of the Price Creek region (also marked by a magnetic low). The second anomaly, a local gravity high west of the Stone Creek-Lost Horse Creek region, is associated with sedimentary and plutonic rocks marked, respectively, by a magnetic low and high. Either type of combination of anomalies has significance farther south in the study area: In the Steel Creek region, a gravity high is paired with a magnetic high, both associated with plutonic rocks; in the Warm Springs Creek region, the same gravity high is paired with a magnetic low, both associated with sedimentary rocks.

MINES AND PROSPECTS

The West Pioneer Wilderness Study Area includes part of the Wisdom mining district. Other important nearby districts are the Elkhorn, Bannack, Hecla, and Argenta (Sahinen, 1935, p. 20-30). Mining in the Wisdom district began in 1869 when prospectors discovered placer gold in Steel Creek (Sassman, 1941, p. 288).

Since 1869, numerous claims have been located throughout the Wisdom District (fig. 6). In the study area, they include the Last Chance (Sugarplum), Shelley, Franklin No. 1, Maynard (Shady Rest), Trapper, Coeur d'Alene, Martin, Black Bear, Silver Bear, and Pocahanas lode claims. Other claims outside the district, but within the study area, include the Bear Paw (Ibex) and the Indian Girl. In 1950, five 20-acre placer claims were staked along the study area's eastern boundary. The Odell molybdenum claim block was located by Crypus (now Amoco Minerals) in 1971 and it was later joint ventured with Moly Corp. Inc. The Cob molybdenum claim block, obtained by Utah International in 1978, was originally staked as the Stone Horse group by Bear Creek Mining Inc.

Production records were not kept prior to 1902. The only mine with recorded production is the Martin; Geach (1972, p. 144) reported 1904 production was 70 tons of ore which yielded 17 oz of gold, 26,036 oz of silver, and 3,101 lbs of lead.

Mining-claim records indicate 300 lode and five placer-mining claims within the study area. All of these claims were located between the years of 1869 and 1979; 290 are currently active. Of these, 255 are associated with the molybdenum claim blocks. Table 3 contains descriptions of all properties. There are no patented claims or mineral leases in the study area.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The assessment of the mineral resource potential of the study area is based on the multidisciplinary studies by the USGS and the study of known mines and prospects by the USBM.

In this report, mineral resource potential refers to the extent to which characteristics suggestive of the presence of concealed mineral deposits fit various mineral-deposit models that are based on our

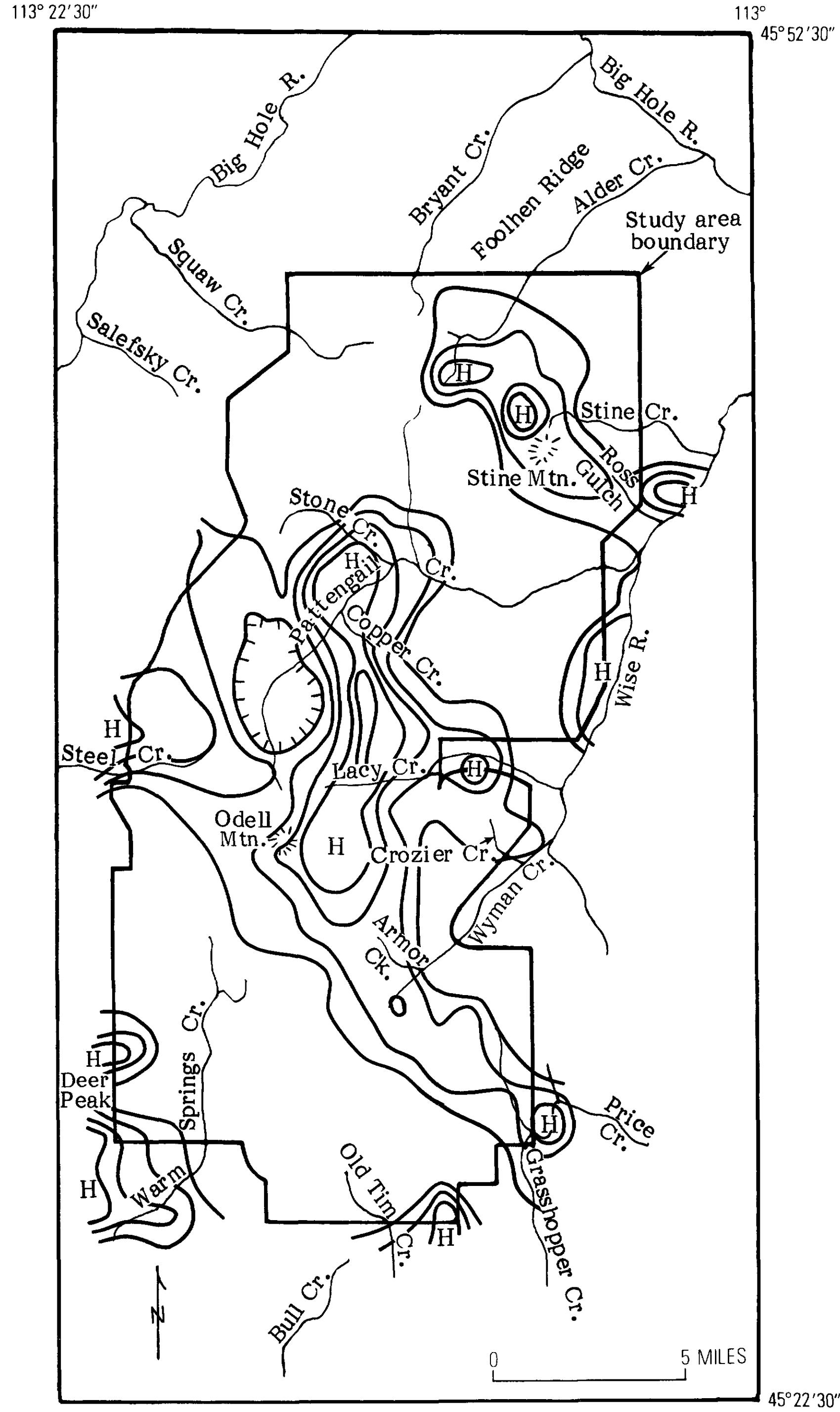

Figure 4.—Map showing combined distribution of Cu, Pb, Zn, Mo, and Ag in -200—mesh stream sediments. Contours, derived from multivariant R-mode factor analysis of data (B.R. Berger, unpub. data, 1980), show the areas with highest covariation for these elements. "H" designates the highest points on the contour map.

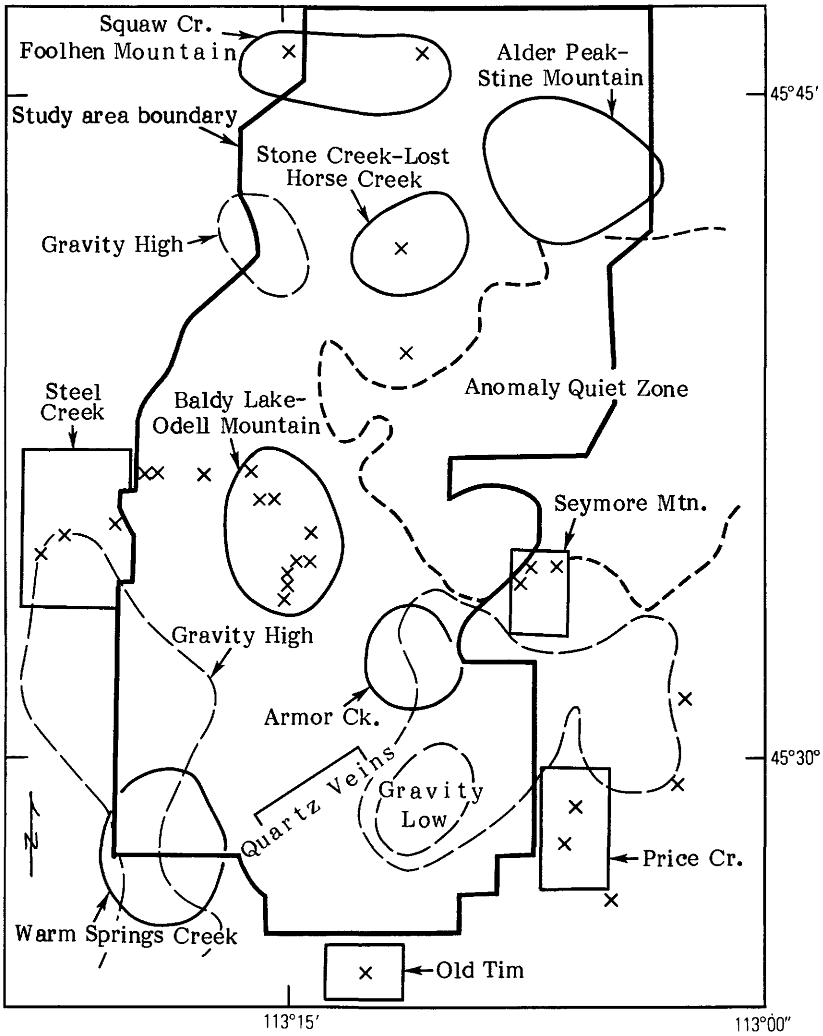

Figure 5.—Locations of 10 mineralized regions, the anomaly quite zone, and selected gravity anomalies. Magnetic anomalies are not shown. Specific mineral occurrences are shown by X's.

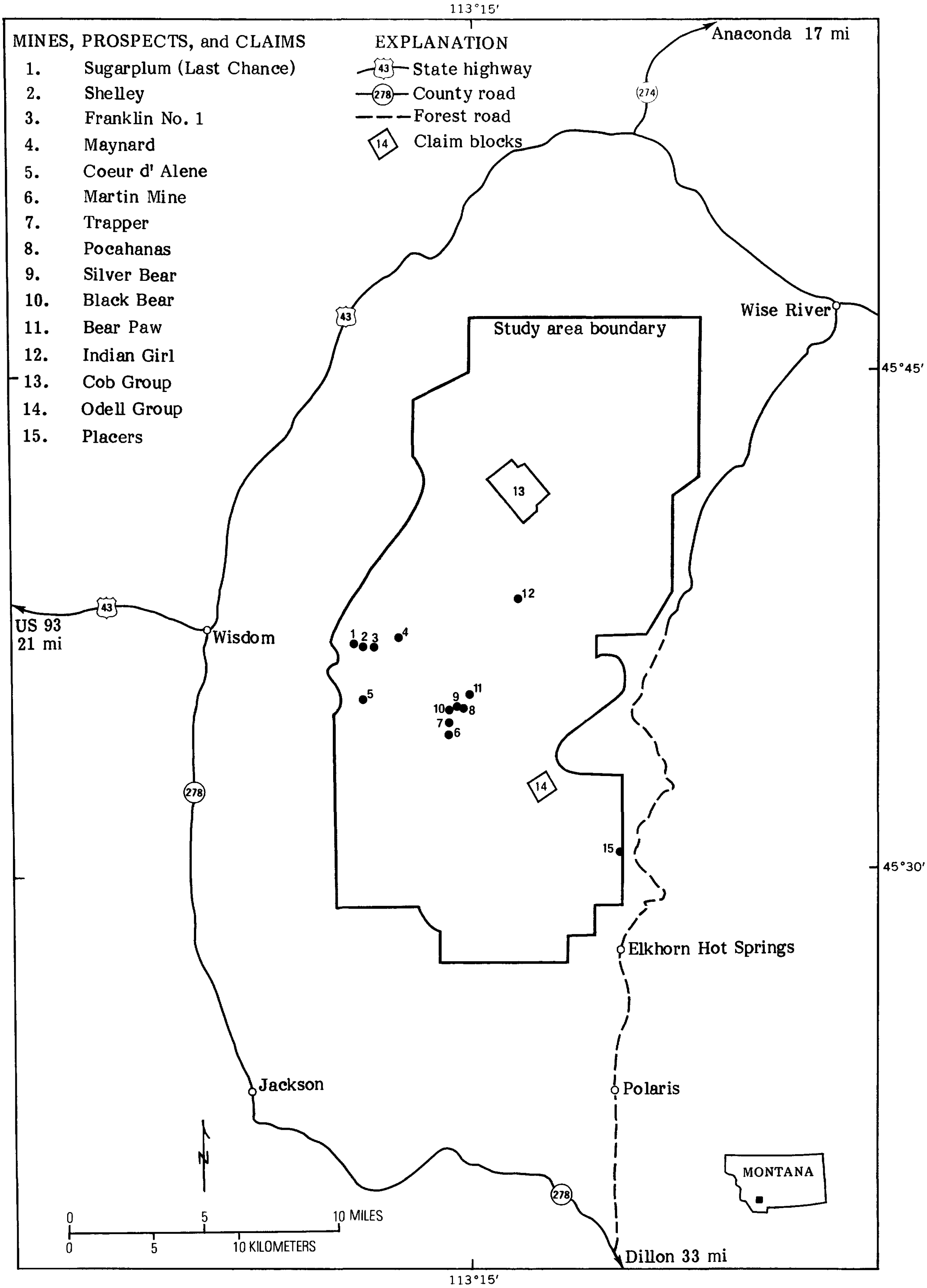

Figure 6.—Locations of mines, prospects, and claims.

Table 3. --*Mines and prospects*

Figure 6	Name	Summary	Workings	Sample data
1	Last Chance (Sugarplum)	A 6 in. shear zone in granodiorite.	A 50 ft adit, and a 20 x 15 ft pit 10 ft deep.	Three 1-foot chip samples; one contained 0.19 oz gold per ton.
2	Shelley	Limonite-stained shear zone 1 ft wide in quartz monzonite.	Six prospect pits and trenches.	Three 2 ft samples; one contained 0.02 ounces gold per ton.
3	Franklin	All workings cut into quartz monzonite. One 6 in. shear zone is exposed in the open adit. It strikes N. 70° E. and dips 70° NW. All workings appear to be following this shear zone.	A 5 ft adit, one caved adit probably less than 50 ft in length and a 10 ft caved shaft.	Five samples: one 1-foot chip sample across the shear zone contained 1.2 oz gold per ton and 1.0 oz silver per ton. One select dump sample contained 0.39 oz gold per ton and 0.5 oz silver per ton. The remaining three samples were barren.
4	Maynard Mine (Shady Rest)	All workings are in quartz monzonite following a 6 in. shear zone trending N. 60° E. and dipping 50° to 65° NW. Minerals in zone include pyrite and some limonite-stained sericite.	Two caved adits. The lower probably extended 200 ft and the upper about 50 ft. Two prospect pits, remains of four arrastras and mill buildings present.	Five samples: one sample from the arrastra contained 0.03 oz gold per ton and 0.3 oz silver per ton. One sample from mineralized rock in an ore bin contained 0.94 oz gold per ton and 1.5 oz silver ton. One selected dump sample contained 0.35 oz gold per ton One chip sample across a 6 in shear zone contained 0.12 oz gold per ton and 0.3 gold per ton and 0.3 oz silver per ton. Chip sample across a 2 1/2-inch shear zone contained 0.47 oz gold per ton and 0.6 oz silver per ton.
5	Coeur d'Alene	Cut into quartzite. Dump material indicates 6 in. or less shear zone.	Three caved adits and three dozer scrapes. The longer adit probably did not extend beyong 150 ft. Total workings are less than 220 ft.	Five samples of stockpiles and selected dump material; four of these contained silver ranging from 1.7 to 62.9 oz per ton and one assayed 0.10 oz gold per ton.
6	Martin Mine	All workings are in quartz monzonite. Dump material indicates a 6 in. or less shear zone containing pyrite, chalcopyrite, and sphalerite.	Still existing are a caved adit, probably 1,000 ft long, a caved shaft 50 ft deep, and four dozer trenches. Several buildings remain standing.	Three samples of stockpiles and material: gold ranged from 0.32 to 2.96 oz per ton; siler from 2.5 to 16.2 oz per ton; copper from 0.11 to 0.54 percent; zinc from 0.005 to 0.82 percent; and molybdenum from nil to 0.15 percent.
7	Trapper	Located on glaciofluvial material.	Two 20 ft caved adits.	One sample: economically insignificant assays.
8	Pocahanas	A 6 in. shear zone in quartzite, as indicated by dump material.	A caved adit about 30 ft long.	One sample: economically insignificant assays.
9	Silver Bear	2 in. vein shear zone with limonite staining.	A 15 ft adit and a 20 ft caved adit.	Three samples: economically insignificant assays.
10	Black Bear	Cut into quartzite. Dump material indicates 6 in. or less vein containing galena sphalerite.	One caved adit 30 ft long and one caved shaft 20 ft deep.	Two select dump samples: 12.1 and 16.7 oz silver per ton; 0.11 percent and 450 ppm molybdenum; 490 and 290 ppm copper; 1.0 and 0.35 percent lead; and 460 and 200 ppm zinc.
11	Bear Paw	Cut into quartz monzonite and quartzite, no vein outcrop was seen. Dump material contained pyrite, chalcopyrite, and galena.	Four adits, three covered by snowpack, one caved. One inaccessible adit was 140 ft long (Geach, 1972, p. 149).	Four select dump samples ranging 0.2 to 6.3 oz silver per ton. One sample contained 0.02 percent copper, 0.14 percent lead, and 0.06 percent zinc, lead, and 0.06 percent zinc.
12	Indian Girl	A 6 in. shear zone in quartz monzonite.	A prospect pit.	One chip sample across shear zone: 0.9 oz silver per ton.
13	Cob claim group	One hundred sixty-nine claims located for molybdenum. Grey quartzite and quartz monzonite and diorite are found here. Some NE-SW fracturing was also seen.	None.	Twelve samples were taken. No economic minerals were found; however, geochemical sampling by Bear Creek Mining Co. found anomalous zones containing as much as 490 ppm molybdenum.
14	Odell claim group	One hundred fourteen claims were located for molybdenum. They are in brecciated granodiorite and quartzite containing disseminated molybdenum.	Moly Corp Inc. has drilled six holes ranging from 715 to 1,831 ft deep. Several dozer trenches exist.	Twenty-one samples were taken on the claims by Bureau personnel. Molybdenum assays range from less than 60 to 320 ppm. One sample contains 2.3 oz silver per ton. One zone of alluvial material contains anomalous molybdenum values from 140 to 320 ppm.
15	Shamrock West Point, Irene, Goldenwall of the Moon, Golden Eagle	Placer claims on glaciofluvial material.	None.	Twenty-nine samples; no gold or other significant heavy minerals detected.

professional experience, geological theory and reasoning, and field and laboratory observations. The mineral resource potential of mines and prospects was effected by detailed geologic mapping of vein exposures and bulk-sampling vein material for assaying. The degree of geological resource potential was determined by comparing all of the observations made and data accumulated to descriptive ore-deposit models. The models used are based on three categories of mineral occurrence: (1) the types of mineral deposits actually known to occur in the study area; (2) the types of deposits that occur in the region around the study area; and, (3) the types of deposits that may occur in the geological environments recognized in the study area based on geological inference but were not recognized in or around the study area. Table 4 lists the types of deposits in categories (1) and (2) and the essential criteria that define each model.

Resource Potential Within The Study Area

Areas identified as having mineral-resource potential are shown in figure 7. Selection of these areas is based on an assemblage of geological data that strongly indicate the presence of concealed mineral resources on an assemblage of data that support the interpreation that concealed mineral resources may be present. The areas are discussed below according to the principal commodity of interest.

Silver and gold—Precious metals occur principally in small, open-space-filling quartz veins. These veins are most commonly along faults, fractures, and joints, and the vein widths vary from a few inches to several feet. The silver most commonly occurs in the unoxidized ores in galena or tetrahedrite. The gold is free, although it may occur as inclusions in pyrite or other sulfides. The deposits are thought to have formed during the emplacement of the Pioneer batholith of Late Cretaceous to early Paleocene age. Although a genetic relationship has not been proven, there is a spatial and temporal association between the fissure vein deposits and porphyry-type deposits.

Because of the importance of structural control to the formation of fissure veins, the areas with the high potential for concentrations of precious metals within the study area occur primarily along northwest- and northeast-trending fault zones. Snee (1982) demonstrated that these major fault zones had a key role in the emplacement of many of the plutons of the Pioneer batholith, and we conclude from this information that these trends were likely conduits for metalliferous hydrothermal fluids. Ancillary structures that locally contain vein deposits are joints in the plutonic rocks. The joints, for the most part, have a north-northeast to northeast trend.

Past production from mines within and adjacent to the study area indicates that silver is much more abundant than gold in the veins (Geach, 1972). The silver/gold ratio varies widely from mine to mine, from as low as 2:1 to well over 100:1. The published production data are too scant to provide a reasonable estimate of expectable ore grades.

The most favorable areas or the areas that have potential for the occurrence of silver/gold fissure-vein deposits are outlined on figure 7. The following criteria were used to define each area:

Silver-gold area	Criteria used to define areas
Ag/Au-1	(1) A prominent northeast-trending fault zone from the Warm Springs Creek area to Wyman Creek; (2) A prominent north-trending fault zone from Old Tim Creek north to Cox Creek; (3) The presence of sulfide-bearing quartz veins along the faults; (4) The occurrence of a prominent association of silver, antimony, zinc, lead, and barium in stream sediments in the area; and (5) The occurrence of major centers of hydrothermal alteration at Armor Creek and Old Tim Creek. <u>Comment</u>: Unspecified bodies of mineralized-vein material may exist, but no discoveries have been made nor was there much evidence of exploration activity, and the likelihood for further exploration is low.
Ag/Au-2	(1) A prominent northwest-trending fault zone from Price Creek on the south to Doolittle Creek on the north; (2) The occurrence of major centers of hydrothermal alteration at Price Creek, Armor Creek, Odell Mountain, and Baldy Lake; (3) The occurrence of productive precious-metal-bearing fissure veins at Odell Mountain, and the presence of sulfide-bearing quartz veins at Price Creek and Baldy Lake; and,

Table 4. —*Descriptive models for mineral deposits that may occur within and adjacent to the boundaries of the study area*

A. Molybdenum stockwork deposit
   1. Favorable geologic framework
      a. Pre-intrusive, through-going fault system
      b. Calc-alkaline plutonic suite
      c. Mineral deposits
         i. Complex sulfide veins with accessory molybdenum, tungsten, and/or tin
         ii. Tungsten skarn
         iii. Iron-tin skarn
         iv. Carbonate-hosted gold-silver deposits
   2. Favorable intrusive system
      a. Biotite granite (possibly miarolytic cavities with fluorite)
      b. Alaskite-felsite
      c. "Quartz-eye" rhyolite porphyry dikes
      d. Biotite granodiorite (sphene contains tin with possible molybdenum)
      e. Intrusive breccias, altered intrusion breccias
   3. Favorable alteration or metallization
      a. Stockwork quartz veining
      b. Magnetite-chlorite-quartz veins
      c. Quartz-sericite alteration
      d. Potassium feldspar alteration
      e. Molybdenite-quartz veins
      f. Huebnerite-quartz veins (with possible fluorite, and silver sulfosalts)

B. Silver-gold fissure-vein deposit
   1. Favorable geologic framework
      a. Major fault or fracture system
      b. Calc-alkaline igneous activity
      c. Known fissure-vein deposits in area
   2. Favorable intrusive system
      a. Biotite quartz monzonite, granodiorite, or granite
      b. Andesite, dacite, or rhyolite dikes
      c. Lamprophyre dikes
   3. Favorable alteration or metallization
      a. Sulfide-quartz veins
      b. Silica-clay alteration
      c. Quartz-sericite alteration
      d. Barite or sulfosalt minerals
      e. Nearby porphyry-type mineralization

C. Tungsten skarn
   1. Favorable geologic framework
      a. Thin- to medium-bedded limestone or dolomite
      b. Calc-alkaline plutonic rocks (contact zones)
   2. Favorable intrusive system
      a. Quartz monzonite and/or granodiorite plutons
      b. Alaskite (rare)
      c. Large plutons or batholiths
   3. Favorable alteration or metallization
      a. Exoskarn
         i. High aluminum and iron composition; low sulfur
         ii. Garnet, pyroxene, wollastonite, plagioclase
      b. Localized endoskarn (pyroxene and plagioclase)
      c. Scheelite with some chalcopyrite and molybdenite

D. Strata-bound Cu-Ag (sedimentary)
   1. Favorable geologic framework
      a. Green strata in Precambrian red-bed sequences
      b. White to buff or pale green quartzites
      c. Deltaic, channel, or bar facies
   2. Favorable alteration or metallization
      a. Lens shaped bodies of disseminated sulfides
      b. Bornite, chalcocite, chalcopyrite, tetrahedrite
      c. Sulfides concentrated in sedimentary structures

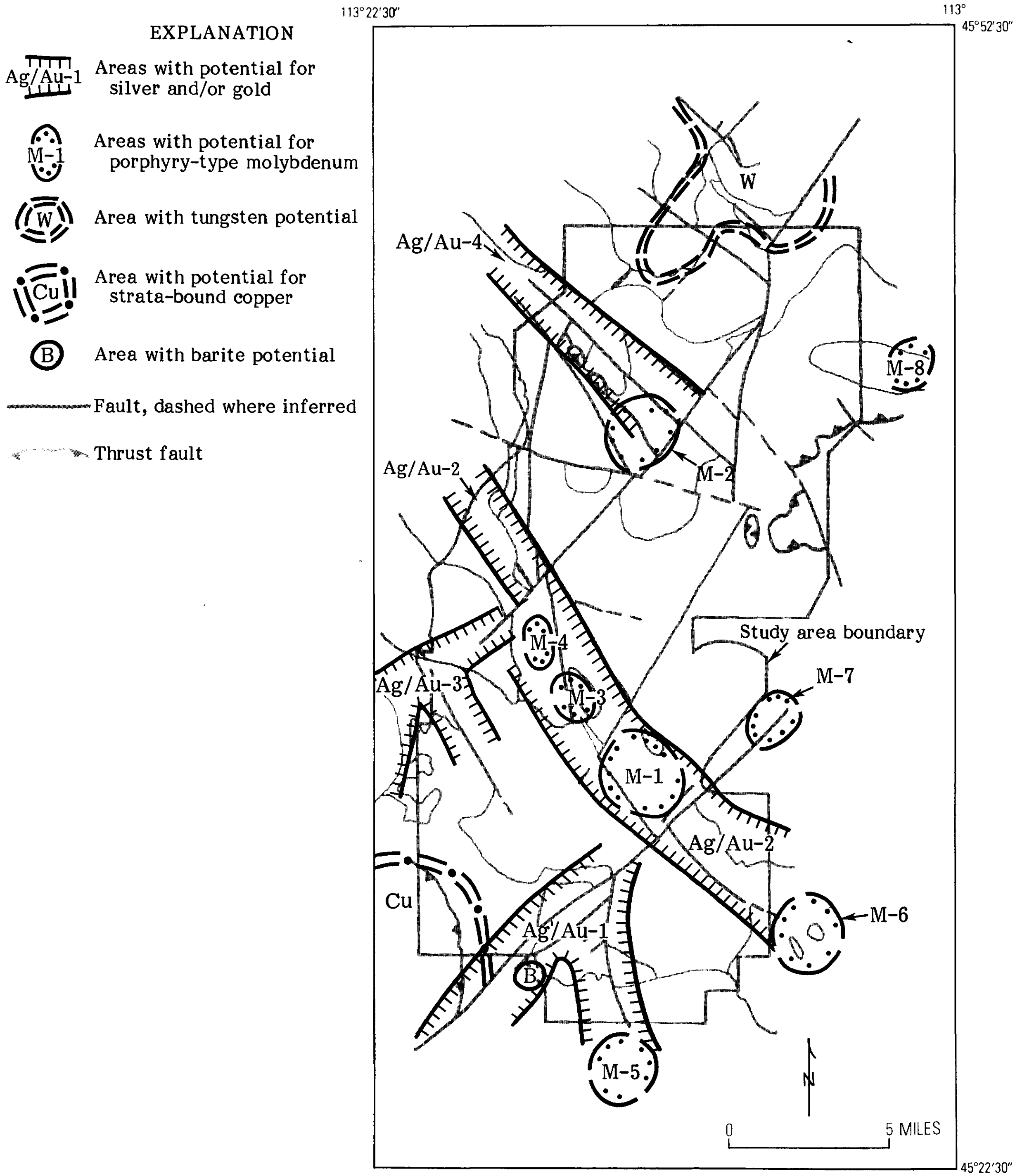

Figure 7.—Areas with mineral resource potential.

(4) The occurrence of a prominent association of silver, lead, zinc, copper, and barium in stream sediments in the area.

Comment: A high potential for the presence of vein deposits exists. The presence of known, productive deposits suggests that the possibility of new resources is good, and there is a likelihood of low to moderate levels of exploration activity.

Ag/Au-3

(1) Northwest- and northeast-trending faults;

(2) The occurrence of productive precious-metal-bearing fissure veins along Steel and Wisconsin Creeks; and,

(3) The occurrence of a prominent association of silver, lead, zinc, and copper in stream sediments in the area.

Comment: A high potential for the presence of vein deposits is likely to exist and there is evidence of moderate levels of exploration activity. The likelihood for continued exploration activity is low to moderate.

Ag/Au-4

(1) A northwest-trending fault zone;

(2) The occurrence of sulfide-bearing quartz veins along the trend;

(3) The occurrence of a major center of hydrothermal alteration at Stone Creek; and,

(4) The occurrence of higher values for copper, lead, and zinc in stream sediments than are found in many other parts of the study area.

Comment: Unspecified bodies of mineral-bearing vein material exist, but no discoveries have been made nor was there much evidence of more than low levels of exploration activity. The likelihood for further exploration activity is low.

Molybdenum—The most important molybdenum deposits are porphyry-type stockworks of quartz veins. These deposits are generally large, and occur along major structural trends. The intersections of major fault trends appear to be particularly favorable sites for the occurrence of deposits. Based upon the detailed study of alteration minerals and geochronological studies on the alteration (Lawrence Snee, USGS, unpub. data, 1982), the molybdenum stockwork deposits are related to the intrusion of granite porphyry and rhyolite porphyry dikes and small plugs during the later stages of the emplacement of the Pioneer batholith. The molybdenum occurs in the form of molybdenite in the quartz veinlets. Chalcopyrite is found as a minor coproduct in the veins.

The stockwork fracturing is commonly spatially associated with intrusive breccias and/or intrusion breccias. These breccias often contain mineralized clasts and fragments of rhyolite porphyry. Both the intrusion and intrusive breccias may contain pegmatitic quartz and potassium feldspar. Quartz veins peripheral to the molybdenum-enriched veining normally contain magnetite, chlorite, and pyrite.

There has been no recorded production from molybdenum stockwork deposits within or adjacent to the study area, although there has been some premining development work done at the Cannivan Gulch porphyry-type molybdenum deposit in the eastern Pioneer Mountains. Nevertheless, the expectable tonnage and grade are $\geq$100 million tons at $\geq$ 0.05 percent molybdenum. This estimate is based on the observed sizes of the altered areas within the study-area boundary and rock-chip sampling of all of the known occurrences in the Pioneer Mountains (Pearson and others, 1982; Pearson and Berger, 1980; Hammitt and Schmidt, 1982; Berger and others, 1979).

The areas most favorable or the areas of high potential for the occurrence of molybdenum stockwork deposits are outlined on figure 7. The following criteria were used to define each area:

Molybdenum area	Criteria used to define areas
M-1	(1) The occurrence of sulfide-bearing stockwork quartz veinlets; (2) Evidence for multiple episodes of intrusive brecciation and associated mineralization; (3) The occurrence of molybdenite in quartz veinlets in drill core (Eberhard Schmidt, Amoco Minerals,

unpub. data, 1982);

(4) The occurrence of altered "quartz-eye" rhyolite porphyry dikes; and,

(5) The association of molybdenum and copper in stream sediments from the area.

Comment: There is currently a high level of exploration activity in the area and the results of this activity indicate the presence of a porphyry-type molybdenum system (Eberhard Schmidt, Amoco Minerals, personal commun., 1982). Unspecified tonnages of mineralized rock exist and the potential for additional resources is high. The likelihood of continued exploration is moderate to high.

M-2

(1) The occurrence of sulfide-bearing stockwork quartz veinlets;

(2) The occurrence of molybdenite in quartz veinlets in drill core (Richard Heine, Utah International, unpub. data, 1982);

(3) The occurrence of altered "quartz-eye" rhyolite porphyry dikes; and,

(4) The association of molybdenum, copper, and zinc in stream sediments from the area.

Comment: There is currently a high level of exploration activity in this area. Unspecified tonnages of mineralized rock are surmised to exist. The likelihood of continued exploration activity is moderate to high.

M-3

(1) The occurrence of sulfide-bearing intrusive breccia with quartz-sericite alteration;

(2) The occurrence of wulfenite in oxidized quartz veins in vicinity of breccia; and,

(3) The association of molybdenum, copper, and zinc in stream sediments from the area.

Comment: Unspecified bodies of mineralized rock exist based on the alteration observed. No minerals-exploration activity was evident at the time of this field examination. The likelihood of exploration activity is high.

M-4

(1) The occurrence of sulfide-bearing intrusive breccia with quartz-sericite alteration;

(2) The occurrence of sulfide-bearing quartz veins along fractures within a wide area around the breccia; and

(3) The association of molybdenum, copper, and zinc in stream sediments from the area.

Comment: Unspecified tonnages of mineralized rock exist based on the alteration observed. No minerals-exploration activity was evident at the time of this field examination. The likelihood of exploration activity is high.

Tungsten—Tungsten occurs primarily as scheelite in contact-metasomatic skarn deposits. These deposits occur at the contact zone of Paleozoic carbonate rocks with hornblende-bearing plutons of the Pioneer batholith. The productive deposits are commonly hundreds of thousands to several million tons in size with grades exceeding 0.2 percent WO_3.

Most tungsten production in the region has come from skarns developed in the Upper Mississippian(?) and Pennsylvanian Amsden Formation(?), although some skarn is found in all of the Paleozoic carbonate rocks where these rocks are in contact with the batholith. The alteration is mostly garnet, pyroxene, and epidote, with accessory quartz, calcite, plagioclase, and hornblende. Beryl is occasionally found in the skarn. In addition to scheelite, ore minerals include molybdenite and chalcopyrite with occasional bornite, sphalerite, and bismuthinite. There has been production from the Calvert tungsten mine north of the study area.

The area most favorable or of high potential for the occurrence of tungsten-bearing skarn deposits is outlined on figure 7 and on the accompanying map. The skarn occurrences are on Foolhen Mountain and along Foolhen Ridge. The following criteria were used to define the area:

Tungsten area	Criteria used to define area
W	(1) The occurrence of epidote skarn in Paleozoic carbonate roof pendants;
	(2) The presence of a granodiorite pluton; and,
	(3) The reported occurrence by Geach (1972) of scheelite in skarn on Foolhen Ridge.
	Comment: No ore minerals were recognized within the study area, although there is evidence of old prospecting activities. There is likelihood of low to moderate levels of exploration activity.

Strata-bound copper—A significant copper-geochemical anomaly occurs in the area adjoining Deer Peak in the southwestern corner of the study area (Area Cu, fig. 7). This anomaly does not appear to be associated with any quartz veining nor are there any exposures of igneous rocks known at this time in this area. Additionally, the aeromagnetic data do not unequivocally indicate the presence of a buried intrusion. One possible source for the copper anomaly is strata-bound mineralization in the Middle Proterozoic sedimentary rocks. Most known strata-bound copper occurrences in this section of Middle Proterozoic rocks elsewhere in western Montana are subeconomic, and it is most likely that any western Pioneer Mountain occurrences in similar host rock environments will also be subeconomic. However, the possibility of older, more favorable Middle Proterozoic host rocks at depth cannot be ruled out based on the geologic relationships inferred from elsewhere in the study area. Therefore, there is a likelihood of low levels of exploration in the southwestern part of the study area and adjacent lands.

Resource Potential Adjacent to the Study Area

There are several areas that have high to moderate mineral resource potential adjacent to the study area boundaries. These are the Bryant Creek, Steel Creek, Old Tim Creek, Price Creek, Seymore Mountain, Stine Creek, and Warm Springs Creek areas.

Small pendants of Paleozoic carbonate rocks with some skarn occur in a group IIa pluton on Foolhen Ridge near the north edge of the study area. The skarn consists of epidote with some garnet. There is evidence of exploration activity for tungsten mineralization in these skarns, although there is no historical production known. It is likely that these occurrences will continue to be objects of interest as low-priority exploration targets.

In the Steel Creek area, along the west side of the study area, vein-gold and placer deposits are known. There is also potential for a molybdenum porphyry system. Quartz veins occur along high-angle fracture systems. Placer accumulations of gold are found along Steel Creek; the number of quartz-vein occurrences in the area is suggestive by analogy of the possible presence of an unexposed porphyry-type mineral deposit. The likelihood of exploration activity on the vein deposits is high, whereas the likelihood on the placer- and porphyry-type occurrences is moderate to low.

Breccia pipes with quartz-sericite alteration, in association with group IIIb dikes, occur between Old Tim and Bull Creeks near the southern boundary of the study area (Area M-5, fig. 7). The breccias, alteration, and presence of rhyolite dikes are all suggestive of the presence of a porphyry-type molybdenum deposit of unknown grade and tonnage. There is evidence of a high level of exploration activity and a likelihood of continuing moderate to high levels of activity.

At Price Creek, Pearson and Berger (1980) noted the presence of at least two zones of alteration and metallization associated with group IIIb dikes (Area M-6, fig. 7). This mineralization was interpreted to be a porphyry-type molybdenum prospect. Subsequent exploration activity has been high and has confirmed the presence of molybdenite in quartz veins in association with sericite and potassium feldspar (G. McKelvey, Cominco American, written commun., 1982). The likelihood of continued exploration activity is high.

Stockwork quartz veins in Proterozoic quartzites were noted in float on the northern slope of Seymore Mountain, in outcrop in the valley of Wyman Creek, and in float along Crozier Creek on the south side of Table Mountain(Area M-7, fig. 7). These veins are similar to those found within the study area where porphyry-type molybdenum systems have been identified (e.g., Stone Creek). It is surmised that a porphyry-type deposit occurs in this area, and the likelihood of exploration activity is moderate to high.

Within the pluton of Stine Creek, an area of quartz-sercite alteration is localized on Hill 6825 (Area M-8, fig. 7). An aplitic dike (possibly of group IIIb) is present, and disseminated molybdenite was noted in altered granodiorite near the dike. Although bedrock exposures are few, the alteration, presence of molybdenite, and apparent size of altered area are interpreted to be associated with a porphyry-type deposit. The likelihood of exploration activity is moderate to high.

A barite vein has been prospected near the confluence of Old Tim and Warm Springs Creeks (Area B, fig. 7). The vein, as exposed, is several feet wide and strikes north towards the study area boundary. Samples for geochemical analysis showed no metals other than barium to be present. There is evidence that exploration activity has been moderate to high, low to moderate levels of continued activity may be expected.

Low Mineral Resource Potential
Within the Study Area.

Porphyry-type copper/molybdenum and precious- and base-metal-carbonate-replacement deposits are permissive within the geological framework of the study area but were not recognized in the course of this study.

Porphyry-type copper-molybdenum deposits are in association with granodioritic plutons in the Pioneer batholith southeast of the study area at Grasshopper Creek (Bannack) and Argenta. Considerable petrologic and thermal data gathered by Snee (1982) indicate that the granodioritic rocks in the study area were emplaced at depths that make it unlikely that any porphyry-type copper-molybdenum systems are present in the study area; however, the possibility cannot be totally ruled out.

In the eastern Pioneer Mountains, Paleozoic carbonate rocks are overthrust by Middle Proterozoic clastic sedimentary rocks. Numerous mineral deposits have been formed as replacements and veins in the carbonate rocks located near contacts with the Pioneer batholith. Examples are the Quartz Hill, Hecla, and Baldy Mountain mining districts. The thrust sheets dip to the west and the Paleozoic carbonate rocks may occur in the subsurface in the western Pioneer Mountains. Paleozoic rocks are present at Ross Gulch beneath Middle Proterozoic quartzites in the northeastern part of the study area and occur as roof pendants in group IIa plutonic rocks in the northern part of the area. No mineralization was noted in the Ross Gulch outcrops, and no further evidence was found of the presence of similar geologic occurrences of the carbonate rocks in the study area either in the mapping program or in unpublished, proprietary drilling data from minerals-exploration activity in the study area. However, the possibility of replacement-type deposits beneath Middle Proterozoic sedimentary rocks cannot be totally ruled out.

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