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Mineral Resource Studies of National Forest Roadless Areas in Idaho

Compiled by

Kathleen M. Johnson[1] and Ronald G. Worl[1]

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1 U.S. Geological Survey
Spokane, Washington

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MINERAL RESOURCE STUDIES OF NATIONAL FOREST ROADLESS AREAS IN IDAHO

INTRODUCTION

The U.S. Geological Survey (USGS), U.S. Bureau of Mines (USBM), and Idaho Geological Survey conducted cooperative mineral-resource studies on roadless public lands in Idaho that may be included in the National wilderness system. Appraisal of identified mineral resources (known) and assessment of mineral resource potential (undiscovered) is required for land-classification and land-use decision making purposes. This report describes potential for undiscovered mineral resources.

The roadless areas targeted for study during 1989, 1990, and 1991 were those shown in the 1989 version of the McClure-Andrus Idaho wilderness proposal that were not at that time under study by the USGS and USBM and that had not already been studied under provisions of the Wilderness Act (P. L. 88-557). For purposes of assessment and report preparation, the USGS has separated the proposed wilderness areas into five study groups, shown on figure 1.

This open-file report contains the results of quantitative assessment of potential for undiscovered mineral resources in each of the five study areas. This volume has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. The figures and tables presented here are not in their final form. After review, these same findings will be published as a USGS Bulletin, with large-format plates in addition to the page-size figures presented here. New geologic, geochemical, geophysical, and mineral-resource data gathered to support the assessments of mineral-resource potential will also be published in the Bulletin series.

The reports on assessment of potential for undiscovered resources contained in this document are designed for an audience of executive decision makers, economic analysts, and regional land-use planners. Scientists and land-use planners whose concerns are site specific should refer to the references cited and to the data reports as they become available.

METHOD OF ASSESSMENT

Assessment of potential for undiscovered mineral resources is a complex process that requires integration of regional and site-specific data that fall under the general headings of geology, geochemistry, geophysics, and mineral resources. It is paramount that the regional setting of the known mineral resources be understood before the assessment is attempted. Mineral deposits are seldom singular in occurrence; they generally occur within or along regional geologic, geochemical, or geophysical trends or structures.

During a resource assessment both conventional and unconventional mineral deposits must be considered. Conventional deposits are those that are known to occur in the area or region and for which mineral deposit models can be developed. Emphasis is placed on mineral deposit types that occur in the vicinity of the study area. Unconventional deposits are those not previously exploited in the work area. These may be deposit types that are known and studied elsewhere in the world, or they may be deposit types not known or exploited before anywhere.

In this study of roadless areas in Idaho, the USGS followed a proven method of assessment of potential for undiscovered resources that includes:

1. compilation of existing regional and site-specific geologic, geochemical, geophysical, and mineral-resource data;
2. development of regional models of deposit characteristics that relate to local geologic, geochemical, geophysical, and mineral-resource data;
3. delineation of tracts based on diagnostic characteristics of regional models. Tracts are geologic map units, combinations of map units, and other large geologic features (terranes) that form the broad ore controls of a deposit type. Detailed geochemical, geophysical, and mineral-resource data are used to refine delineation of tracts;
4. completion of site-specific field and laboratory studies where existing data are inadequate;
5. selection of appropriate models for use in the asessment of potential for undiscovered resources. These models are based on well-explored deposits and often include world-wide examples of the appropriate deposit type. If an appropriate model is not already available and enough information is available, a new model is developed;
6. estimation, using the 90, 50, and 10 percent levels of confidence, of the number of undiscovered deposits of the specified type that may be present within the tract. This estimate cannot be made for deposit types for which

no grade and tonnage data are available. Areas of historical mining or exploration activity with known or potential reserves are not included;

7. estimation of metal endowment for undiscovered resources through use of the USGS Mark3 simulator (Drew and others, 1986). Compiled grade and tonnage data in Cox and Singer (1986) and subsequent revisions are used in the Mark3 simulations; and

8. presentation of data in the form of maps, diagrams, tables, and texts that convey the mineral-resource potential of the study areas.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED MINERAL RESOURCES IN THE GROUP 1 STUDY AREA, INCLUDING LIME CREEK, TRINITIES, BLACK WARRIOR, TEN MILE, RED MOUNTAIN, AND HANSON LAKES

SUMMARY

Within the group 1 study area, there are tracts permissive for the occurrence of undiscovered deposits of five types: Tertiary low-fluorine porphyry molybdenum, Cretaceous low-fluorine porphyry molybdenum, Comstock-type epithermal veins, polymetallic quartz veins and lodes, and radioactive black sand placers.

One tract permissive for Tertiary low-fluorine porphyry molybdenum (fig. 3) has a 10 percent chance of containing at least one undiscovered deposit of a type that has a median size of 94 million tonnes of ore and a median grade of 0.085 percent molybdenum. Estimated mean metal endowment for this tract is 50,000 tonnes of contained molybdenum.

One tract permissive for Cretaceous low-fluorine porphyry molybdenum (fig. 4) has a 50 percent chance of containing at least one and a 10 percent chance of containing at least two undiscovered deposits of a type that has a median size of 94 million tonnes of ore and a median grade of 0.085 percent molybdenum. Estimated mean metal endowment for this tract is 200,000 tonnes of contained molybdenum.

One tract permissive for Comstock-type epithermal veins (fig. 5) has a 50 percent chance of containing at least one and a 10 percent chance of containing at least two undiscovered deposits of a type that has a median size of 770,000 tonnes of ore and a median grade of 7.5 grams/tonne gold and 110 grams/tonne silver. Estimated mean metal endowment for this tract is 25 tonnes of contained gold and 1,700 tonnes of contained silver.

One tract permissive for polymetallic quartz veins and lodes (fig. 6) has a 10 percent chance of containing at least one undiscovered deposit of a type that has a median size of 12,000 tonnes of ore and a median grade of 14 grams/tonne gold. Estimated mean metal endowment for this tract is 0.2 tonnes of contained gold.

Tracts permissive for radioactive black sand placers (fig. 7) were defined, but no estimate was made of the number of undiscovered deposits present. There is not adequate information on this deposit type to develop descriptive or grade/tonnage models.

INTRODUCTION

During 1989 and 1990, the USGS conducted geologic, geochemical, geophysical, and mineral resource studies in and around the proposed wilderness areas of group 1 (fig. 2). The purpose was to provide data adequate for assessment of the potential for undiscovered mineral resources within or near the proposed wilderness areas. The quantitative assessment of the group 1 area was performed in November 1990 with data available at that time.

The assessment of potential for undiscovered mineral resources was performed for an area that encompassed the proposed wilderness areas and all known roadless areas in their vicinity. Within the proposed wilderness areas, the assessment was based on site-specific data gathered for this study. In the intervening areas, the assessment is based on existing information and limited reconnaissance, and thus is preliminary. Additional site-specific studies are needed to complete the assessments in these intervening areas.

ASSESSMENT TEAM

The group 1 assessment team included:

John W. Cady	Branch of Geophysics, Denver
Theresa M. Cookro	Branch of Resource Analysis, Denver
Kathleen M. Johnson	Branch of Resource Analysis, Spokane
Harley D. King	Branch of Geochemistry, Denver
W. David Menzie	Branch of Resource Analysis, Reston
James A. Pitkin	Branch of Geophysics, Denver
Ronald G. Worl	Branch of Western Mineral Resources, Spokane

BACKGROUND DATA

Assessment of potential for undiscovered mineral deposits is a complex process based on the interrelationships of geologic, geochemical, geophysical, and mineral-resource data that are both local and regional in scope. A short summary of the data used for the group 1 study area follows, with emphasis on describing the mineral resources. Recent publications covering this area include Fisher and others (1983, in press), Fisher and Johnson (1987), McIntyre (1985), Mitchell and others (1991), Tschanz and Frischknecht (1986), Winkler and others (1989), and Worl and others (1991).

Geology

Rocks exposed in the group 1 area are mainly plutonic igneous rocks ranging in age from about 110 million to about 40 million years and surficial material deposited in the past 2 million years. Small areas of Tertiary volcanic and sedimentary rocks also occur in the area. The plutonic rocks belong to two groups. The older plutonic rocks (110–80 million years old) crop out in most of the study area, and are part of the Cretaceous Idaho batholith, which underlies much of central Idaho. The younger plutonic rocks (55–40 million years old) are related to the formation of the Tertiary Challis volcanic field which lies just to the east. The northern part of the group 1 study area is transected by the northeast-trending trans-Challis fault system, a major deep-seated regional structure. Large, high-angle northwest- and northeast-trending faults transect other parts of the study area.

Geochemistry

Geochemical data from the following eight studies were used in the assessment of the group 1 study area: (a) National Uranium Resource Evaluation (NURE) program, (b) Hailey CUSMAP (Cole Smith, unpub. data, 1989), (c) Challis CUSMAP (Kathleen M. Johnson, unpub. data, 1989), (d) Ten Mile wilderness study (Kiilsgaard, 1982, 1983), (e) Trinity Mountain-Steel Mountain area study (Bennett, 1980), (f) Sawtooth National Recreation Area study, (Tschanz and Frischknecht, 1986), (g) Sawtooth wilderness study (Kiilsgaard and others, 1970), and (h) samples collected for this study within or close to the proposed wilderness areas. These data sets were used to characterize the geochemical signature of the various mineral deposit types and mineral-bearing terranes present in the area.

Geophysics

Geophysical data sets used in the mineral-resource assessment included aeromagnetic, gravity, and aeroradiometric data compiled at 1:125,000 scale. These data were used in conjunction with geologic and mineral-resource data in defining the tracts permissive for the occurrence of undiscovered Tertiary low-fluorine porphyry molybdenum deposits, Cretaceous low-fluorine porphyry molybdenum deposits, and Comstock-type epithermal vein deposits. A geoelectrical survey conducted for this study was used to determine the character at depth of the major mineralized structures in the group 1 area.

Mineralizing Events

Three mineralizing events are recognized in the rocks of the group 1 study area: igneous-hydrothermal activity associated with emplacement of the Cretaceous Idaho batholith, igneous-hydrothermal-tectonic activity associated with the development of the Tertiary plutonic rocks, and mechanical concentration of metals through erosion during Pleistocene and recent times.

The oldest event, about 70–55 million years ago, was the concentration of metals by igneous-hydrothermal systems during the late phases of intrusion of the Idaho batholith. Three physical types of metal concentrations developed during this event—pegmatites, stockworks of veinlets, and massive quartz veins. Pegmatites hosted a characteristic suite of metals including niobium, thorium, tin, lithium, rare-earth elements, beryllium, and uranium. Pegmatites have not been a commercial source of metals in this area, but they did provide minerals and metals for the radioactive black sand placer deposits discussed below. Stockwork deposits formed during this event hosted molybdenum, tungsten, and some copper. Known deposits of this type in the region include Thompson Creek, a world-class molybdenum deposit currently in production, and the Tungsten Jim mine, a past tungsten producer. Quartz vein formation during this event seems to have been related to the intrusion of a late leucogranite phase of the Idaho batholith. Metals concentrated in the formation of these quartz veins were mainly gold and silver with local concentrations of lead, zinc, copper, and antimony. This deposit type includes the major gold deposits at Rocky Bar and Atlanta, in the Hailey gold belt, and in many other districts in central Idaho. Also included are the Hermada antimony deposits which have had minor past production.

The second event, Tertiary igneous-hydrothermal-tectonic activity, took place in an environment of crustal extension, mainly along deep-seated high-angle fault systems such as the trans-Challis fault system. Metal concentrations were mainly in stockworks of veins and veinlets and as disseminations in and next to intrusive igneous rocks. A variety of metals was introduced during this event including gold, silver, molybdenum, tungsten, beryllium, tin, antimony, bismuth, fluorine, lead, copper, and zinc. In addition, the solutions transporting these metals may have mobilized and reconcentrated some of the metals from the earlier event. Significant deposits in this area include the gold-silver-bismuth vein deposits of Boise Basin, which have been major past producers. Molybdenum stockwork deposits at Cumo and Little Falls Creek, just west of the study area, are proven deposits but are too low grade for current commercial exploitation. Tertiary pink granites throughout central Idaho contain disseminations and pods of beryllium, tin, tungsten, and molybdenum minerals. They have not been a source of metals, but in a few localities the minerals have been sought by collectors.

Certain minerals, including some heavy minerals, are resistant to chemical weathering and collect as a weathering residue in alluvium. During the past 2 million years, Pleistocene to recent times, radioactive black sands and gold have been concentrated in placer deposits throughout central Idaho. The source of the minerals and metals was igneous rocks and vein deposits formed in Cretaceous and Tertiary times. Radioactive black sand placers in Long Valley and Bear Valley are known major resources of thorium, rare-earth metals, niobium, and tantalum but have had little production. Gold placers such as those near Idaho City and Placerville were major sources of gold in the past.

MINERAL DEPOSIT TYPES

Several mineral deposit types are known or expected to occur within the group 1 study area. Many of these deposit types are genetically and physically associated and can be grouped for assessment purposes into the following models: Tertiary low-fluorine porphyry molybdenum deposits, Cretaceous low-fluorine molybdenum deposits, Comstock-type epithermal veins, polymetallic quartz veins and lodes, radioactive black sand placers, and gold placers.

Tertiary low-fluorine porphyry molybdenum deposits

These are vein stockworks and disseminations of molybdenite in or near hypabyssal rocks of Eocene age. They are generally localized along major high-angle fault systems. Tungsten veins and stockworks often accompany this type of deposit. Examples in central Idaho, including the Cumo and Little Falls deposits just west of the study area, have not been productive. Ore bodies range from small isolated pods of molybdenite to bodies containing as much as several hundred million tonnes of ore containing less than 0.1 percent MoS_2.

Cretaceous low-fluorine porphyry molybdenum deposits

Vein stockworks and disseminations of molybdenite within or associated with compositionally zoned Cretaceous stocks comprise this deposit type. Tungsten veins and stockworks often accompany this type of deposit. Examples in the region include the Thompson Creek deposit and the Little Boulder Creek prospect. The Thompson Creek deposit, in operation in 1990, is the only deposit of this type that has been exploited in Idaho. Ore bodies are large, elongate, tabular bodies containing more than 200 million tonnes of ore with grades as high as 0.18 percent MoS_2.

Comstock-type epithermal veins

Deposits consist of veins and stockworks of veins that occur along major fault zones such as those of the trans-Challis fault system. Most of the deposits are composed of many small veinlets of quartz and commonly have little surface expression. Examples of this deposit type occur in the Boise Basin just west of the group 1 area, including the ore bodies at the Gold Hill mine. These deposits were mined mainly for their gold and silver content, but locally the veins contain significant amounts of base metals and bismuth. Elsewhere in Idaho, veins of this type contain significant tungsten. Ore bodies in Boise Basin range from small pockets to bodies as much as 350 ft in length and several feet in width; most have a limited vertical depth. Ore grades across the larger bodies range from 6 to 34 grams per tonne gold with local pockets containing several ounces per tonne gold. Silver content ranges from trace amounts to several tens of grams per tonne in some zones.

Polymetallic quartz veins and lodes

Deposits are in veins of vuggy brecciated quartz within and next to massive composite quartz veins that commonly form prominent topographic features. Some of the massive quartz veins are exposed for distances exceeding 2 mi. This is a common deposit type in this region, occurring throughout the Idaho batholith. Examples within the map area include the Atlanta and Rocky Bar deposits. The ore zones constitute only a portion of the extensive quartz veins and lodes and are often separated by several tens to hundreds of feet of barren quartz. Most of the production was for gold and silver, although some veins contain significant amounts of lead, zinc, copper, and antimony. Individual ore bodies range from a few tonnes in isolated pods to pipe-like lenses as much as 450 ft long, 8 ft wide, and more than 1,000 ft deep. Ore grades vary considerably but across the larger ore bodies average 11–16 grams/tonne gold and 34–58 grams/tonne silver.

Radioactive black sand placers

Several alluvial deposits in central Idaho contain black sand minerals containing thorium dioxide, rare-earth oxides, niobium and tantalum pentoxides, and U_2O_8. The known deposits within the study area include the Big Meadow and Payette placer deposits. These deposits are generally large alluvial sand blankets, containing more than a million cubic yards of material.

Gold placers

There has been major gold production from placer deposits in the region, especially in the Placerville and Idaho City areas, just to the west of the study area. Placer deposits exploited prior to 1950 ranged from a few acres to several thousand acres in area and a few feet to more than 100 ft in thickness. Small placer operations continue along many of the major streams in the study area and small pockets of placer ore will continue to be found for many years.

MINERAL RESOURCE ASSESSMENT

Introduction

The probability that undiscovered deposits exist was assessed for Tertiary low-fluorine porphyry molybdenum, Cretaceous low-fluorine porphyry molybdenum, Comstock-type epithermal veins, and polymetallic quartz veins and lodes. Probabilistic estimates of the number of undiscovered deposits and total metal endowment could not be made for radioactive black sand placers, although tracts permissive for their occurrence were delineated, because not enough information is currently available for development of descriptive and grade/tonnage models. Tracts permissive for undiscovered placer gold deposits were not defined because the known areas of gravel have been thoroughly explored and there is little likelihood of the discovery of a new gold placer area. Deposit types that have only minor occurrences within the study area or are speculative were not included in the assessment process.

Tertiary low-fluorine porphyry molybdenum deposits

Deposit characteristics:

Approximately 80% of world-wide deposits are between 16 and 560 (median 94) million tonnes and contain 0.055–0.13 (median 0.085) percent molybdenum. This is model 21b in USGS Bulletin 1693 (Cox and Singer, 1986, p. 120).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *Tertiary low-fluorine porphyry molybdenum deposits* in group 1 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	0	1	
Contained molybdenum (tonnes)	0	0	100,000	50,000
Total ore (tonnes)	0	0	100,000,000	60,000,000

Discussion:

One tract, where small Tertiary rhyolite intrusions are known or suspected, is permissive for Tertiary low-fluorine porphyry molybdenum deposits (fig. 3). Aeroradiometric anomalies and anomalous molybdenum in panned concentrates and stream sediments support the delineation of this tract. Known deposits in Idaho include the Cumo and Little Falls deposits, both within the trans-Challis fault system in a continuation of this tract just west of the area. These deposits contain less than 0.1 percent MoS_2, which puts them on the low end of the grade curve for the model. The tract has probably been thoroughly explored for this deposit type, thus the estimate of only one undiscovered deposit, at 10 percent confidence level, in this tract.

Cretaceous low-fluorine porphyry molybdenum deposits

Deposit characteristics:

Approximately 80% of international deposits are between 16 and 560 (median 94) million tonnes and contain 0.055–0.13 (median 0.085) percent molybdenum. This is model 21b in USGS Bulletin 1693 (Cox and Singer, 1986, p. 120).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *Cretaceous low-fluorine porphyry molybdenum deposits* in group 1 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	1	2	
Contained molybdenum (tonnes)	0	50,000	500,000	200,000
Total ore (tonnes)	0	60,000,000	600,000,000	200,000,000

Discussion:

One tract containing known or suspected plutonic bodies of Cretaceous leucocratic granite is permissive for Cretaceous low-fluorine porphyry molybdenum deposits (fig. 4). Aeromagnetic data suggest the presence of several shallowly buried leucogranite plutons in the tract. Anomalous molybdenum in panned-concentrate and stream-sediment samples suggests molybdenum-bearing mineralization may have occurred in some of the suspected buried intrusive bodies. There are no known deposits of this type in the study area, and the amount of previous exploration activity is unknown. Based upon these factors, an estimate of at least one deposit at 50 percent confidence level and two deposits at 10 percent confidence level seems justified.

Comstock-type epithermal vein deposits

Deposit characteristics:

Most known deposits of this type occur in the western United States and are between 0.065 and 9.1 (median 0.77) million tonnes with 2.0–27 (median 7.5) grams/tonne gold and 10–1,300 (median 110) grams/tonne silver. This is model 25c in USGS Bulletin 1693 (Cox and Singer, 1986, p. 150).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *Comstock-type epithermal vein deposits* in group 1 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	1	2	
Contained metal (tonnes)				
Gold	0	4	58	25
Silver	0	57	3,000	1,700
Total ore (tonnes)	0	570,000	10,000,000	4,000,000

Discussion:

One tract, defined by the main strands of the trans-Challis fault system, is permissive for Comstock-type epithermal vein deposits (fig. 5). Known deposits of this type in the region include many of the important deposits in Boise Basin, just to the west of the study area in an extension of this tract. These individual deposits are aligned along fault zones in association with dikes and small bodies of Tertiary rhyolite. The tract has probably been thoroughly explored in the past, but the poor surface expression of this deposit type and the amount of surficial cover support an estimate of at least one deposit at 50 percent confidence level and two deposits at 10 percent confidence level. Additional ore of this type will also probably be found as extensions of known deposits.

Polymetallic quartz veins and lodes

Deposit characteristics:

Deposits of this type are typically 1.8–78 (median 12) thousand tonnes, and contain 2.7–78 (median 14) grams/tonne gold. Although silver is often present in these deposits, not enough information is available to include it in the grade and tonnage model. This is a new model developed for this study (James D. Bliss, written commun., 1991).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *polymetallic quartz veins and lodes* in group 1 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	0	1	
Contained gold (tonnes)	0	0	0.3	0.2
Total ore (tonnes)	0	0	20,000	10,000

Discussion:

One tract permissive for polymetallic quartz veins and lodes is defined by the outcrop of Cretaceous rocks (fig. 6). The prominent surface expressions of the known deposits of this type suggests that they have been thoroughly explored in the past. This combined with limited regional geochemical anomalies led to an estimate of one undiscovered deposit at 10 percent confidence level. Most new ore of this type will be found as extensions of known mineralized zones.

Radioactive black sand placers

Deposit characteristics:

Radioactive black sand placers known in Idaho are very large, containing more than 50 million tonnes of material in broad open valleys with slow moving streams. Large-scale dredging operations have been used to work these placers.

Discussion:

Tracts permissive for the occurrence of radioactive black sand placers were delineated in the northern part of group 1 area (fig. 7), but no estimate of the number of undiscovered deposits was made because there is no descriptive mineral deposit model.

Gold placer deposits

Deposit characteristics:

Placer deposits range from small pockets of gravel containing a few ounces of gold, which can be mined with a gold pan, to valley bottoms containing 50 million tons of gravel, which must be mined by hydraulic methods or with floating dredges.

Discussion:

All streams in the study area have been thoroughly explored, and we think there is no potential for discovery of any more major placer deposits near the level of the present stream valleys. However, there are still numerous small pods and pockets of gold-bearing gravel along streams throughout the region, and many of these are worked intermittently. In the past, some placer gold production came from high-level gravels, in places several hundred feet above current stream levels. There is not enough detail in the geologic mapping to accurately locate these high-level gravels; they are distributed irregularly throughout the study area, and some may contain significant gold.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED MINERAL RESOURCES IN THE GROUP 2 STUDY AREA, INCLUDING BORAH PEAK, PIONEER MOUNTAINS, AND WHITE CLOUDS

SUMMARY

Within the group 2 study area, there are tracts permissive for the occurrence of undiscovered deposits of several types: Comstock-type epithermal veins, polymetallic quartz veins and lodes, zinc-lead skarn, Cretaceous low-fluorine porphyry molybdenum, Tertiary low-fluorine porphyry molybdenum, and polymetallic veins.

There are two tracts permissive for Comstock-type epithermal veins (fig. 9). Tract 1 has a 10 percent chance of at least two undiscovered deposits; tract 2 has a 50 percent chance of at least one deposit and a 10 percent chance of at least two deposits. This deposit type has a median size of 770,000 tonnes of ore and a median grade of 7.5 grams/tonne gold and 110 grams/tonne silver. Estimated mean metal endowment is 25 tonnes contained gold and 1,000 tonnes contained silver in tract 1, and 25 tonnes contained gold and 1,700 tonnes contained silver in tract 2.

One tract permissive for polymetallic quartz veins and lodes (fig. 10) has a 10 percent chance of at least one undiscovered deposit of a type that has a median size of 12,000 tonnes of ore and a median grade of 14 grams/tonnes gold. Estimated mean metal endowment in this tract is 0.2 tonnes contained gold.

One tract permissive for zinc-lead skarn (fig. 11) has a 10 percent chance of at least one undiscovered deposit of a type that has a median size of 1.4 million tonnes of ore and a median grade of 5.9 percent zinc, 2.8 percent lead, 58 grams/tonne silver, and trace to 1.3 percent copper. Estimated mean metal endowment for this tract is 80,000 tonnes contained zinc, 40,000 tonnes contained lead, 70 tonnes contained silver, and 7,000 tonnes contained copper.

One tract permissive for Cretaceous low-fluorine porphyry molybdenum deposits (fig. 12) has a 10 percent chance of at least one undiscovered deposit of a type that has a median size of 94 million tonnes of ore and a median grade of 0.085 percent molybdenum. Estimated mean metal endowment for this tract is 50,000 tonnes of contained molybdenum.

One tract permissive for Tertiary low-fluorine porphyry molybdenum (fig. 13) has a 50 percent chance of at least one, and a 10 percent chance of at least two, undiscovered deposits of a type that has a median size of 94 million tonnes of ore and a median grade of 0.085 percent molybdenum. Estimated mean metal endowment for this tract is 100,000 tonnes contained molybdenum.

One tract permissive for polymetallic veins (fig. 14) has a 90 percent chance of having at least two, a 50 percent chance of at least four, and a 10 percent chance of at least seven undiscovered deposits of a type that has a median size of 7,600 tonnes of ore with a median grade of 820 grams/tonne silver, 9 percent lead, and 2.1 percent zinc. Estimated metal endowment for this tract is 400 tonnes contained silver, 30,000 tonnes contained lead, and 20,000 tonnes contained zinc.

INTRODUCTION

During 1989 and 1990, the USGS conducted geologic, geochemical, geophysical, and mineral-resource studies in and around the proposed wilderness areas of group 2 (fig. 8). The purpose was to provide data adequate for an assessment of the potential for undiscovered mineral resources within or near the proposed wilderness areas. A regional quantitative assessment of the group 2 area was performed in November 1990, with data available at that time.

The quantitative assessment of potential for undiscovered mineral resources was performed for an area that encompassed the proposed wilderness areas and all known roadless areas in their vicinity. The assessment was based on site-specific data gathered for this study in and near the proposed wilderness areas and on existing information and limited reconnaissance studies in intervening areas. Additional site-specific studies are needed to complete the assessment in the intervening areas.

ASSESSMENT TEAM

The group 2 assessment team included:

John W. Cady	Branch of Geophysics, Denver
Theresa M. Cookro	Branch of Resource Analysis, Denver
Kathleen M. Johnson	Branch of Resource Analysis, Spokane
Harley D. King	Branch of Geochemistry, Denver
M. Dean Kleinkopf	Branch of Geophysics, Denver
W. David Menzie	Branch of Resource Analysis, Reston
James A. Pitkin	Branch of Geophysics, Denver
Gary R. Winkler	Branch of Central Mineral Resources, Denver
Ronald G. Worl	Branch of Western Mineral Resources, Spokane

BACKGROUND DATA

Assessment of potential for undiscovered mineral deposits is a complex process based on interrelationships of geologic, geochemical, geophysical, and mineral-resource data that are both local and regional in scope. A short summary of the data used for the group 2 study area follows, with emphasis on describing the mineral resources. Recent publications covering this area include Capstick and others (1987), Federspiel and others (1987), Fisher and others (1983, in press), Fisher and Johnson (1987), McIntyre (1985), Mitchell and others (1986), Winkler and others (1989), Worl and others (1989), and Worl and others (1991).

Geology

Diverse sedimentary, volcanic, intrusive, and metamorphic rocks ranging in age from about 2 billion to about 45 million years make up the broad highlands of the Pioneer, Boulder, and White Knob Mountains, and the White Cloud Peaks, all in the western part of the area. The highest peaks in the Pioneer Mountains are composed of heterogeneous metamorphic rocks as old as 2 billion years that form the core of a large structural dome. Flanking this core, and separated from it by outwardly dipping faults, are thick sequences of unmetamorphosed marine sedimentary rocks that were deposited in successive basins from about 500 to 260 million years ago. These sequences are structurally stacked in a series of fault-bounded sheets that extended entirely across the structural dome prior to its uplift. Some of the highest peaks in the Boulder and White Knob Mountains are made up of the flanking sequences.

In the western part of the area, the complex of intrusions known as the Idaho batholith was emplaced in the stacked sequences of sedimentary rocks between about 110 and 70 million years ago. The highest summits in the White Clouds are composed of these intrusions. Subsequently, rocks of the Pioneer core and flanks were intruded by smaller bodies of igneous rocks between about 66 and 42 million years ago, with the older age approximately dating initial uplift of the structural dome. During the latter part of this interval, an enormous outpouring of volcanic rocks formed what has become known as the Challis volcanic field. Compositionally varied flows, domes, plugs, dikes, and tuffs cover large parts of the area and extend as far south as the Snake River Plain and at least as far north as Salmon, Idaho. Most of the high ridges east of the White Cloud Peaks and the Pioneer Mountains are formed from rocks of the Challis Volcanic Group.

The lithologically varied and structurally complex ranges in the western part of the area are separated from the precipitous fault-bounded uplift of the Lost River Range, in the eastern part of the area, by the sediment-filled half-graben that includes the valleys of the Big Lost River and Thousand Springs. The Lost River Range is eroded principally from unmetamorphosed marine sedimentary rocks ranging in age from about 600 to 285 million years old. These rocks differ from age-equivalent rocks in the ranges to the west in three ways: (1) they contain a much higher proportion of limestone and more numerous fossils, (2) they are less severely deformed, and (3) they have not been intruded by large masses of igneous rock. The eastern flank and northern end of the range are concealed beneath rocks of the Challis Volcanic Group that are essentially the same as those in ranges to the west. The abrupt, youthful topography of the Lost River Range, which includes Borah Peak (at 12,662 ft the highest peak in Idaho), is related to uplift along the Lost River fault near the western base of the range. Movement along the fault has tilted Thousand Springs valley down to the east, ponding drainage against the base of the range, and has elevated the range as a massive crustal block, also tilted eastward. Net vertical displacement of at least 1.6 mi has occurred along the fault in the last 2 million years, and continues today, as manifested by as much as 9 ft of displacement during the Borah Peak earthquake of October 28, 1983.

Geochemistry

In the group 2 study area geochemical data from the following eight studies were used in the assessment: (a) National Uranium Resource Evaluation (NURE) program, (b) Hailey CUSMAP (Cole Smith, unpub. data, 1989), (c) Challis CUSMAP (Kathleen Johnson, unpub. data, 1989), (d) Sawtooth National Recreation Area study (Tschanz and Frischknecht, 1986), (e) Boulder-Pioneer Wilderness study (Simons and others, 1981), (f) Borah Peak BLM wilderness study (Wilson and others, 1990), (g) Burnt Creek BLM wilderness study (Skipp and others, 1988), and (h) samples collected for this study within or close to the proposed wilderness areas. These data sets were used to characterize the geochemical signature of the various mineral deposit types and mineral-bearing terranes present in the area.

Geophysics

Geophysical data used in the mineral resource assessment included aeromagnetic, gravity, and aeroradiometric data compiled at 1:125,000 scale. These data sets were used in conjunction with geologic and mineral-resource data in defining the tracts permissive for the occurrence of undiscovered Comstock-type epithermal vein deposits, Cretaceous low-fluorine porphyry molybdenum deposits, and Tertiary low-fluorine porphyry molybdenum deposits. A geoelectrical survey conducted for this study was used to determine the character at depth of the major fracture systems in the group 2 study area.

Mineralizing events

Four mineralizing events are recognized in the rocks of the group 2 study area; metal concentration during Paleozoic sedimentation, igneous-hydrothermal activity associated with emplacement of the Cretaceous Idaho batholith, igneous-hydrothermal-tectonic activity associated with the development of the Tertiary plutonic rocks, and mechanical concentration of metals through erosion during Pleistocene and recent times.

The earliest event was concentration of metals in sediments (black shales) deposited on the sea floor between about 450 and 250 million years ago. Metals concentrated by this process include silver, barium, copper, molybdenum, vanadium, lead, zinc, nickel. Known stratabound metal concentrations of importance in the group 2 area include zinc, lead, and silver deposits at the Hoodo and Livingston mines and barite deposits in the Muldoon area. Much of the black shale exposed in the western part of the group 2 area contains significant amounts of vanadium. Black shale sequences are enormous reservoirs of metals and may have been the source of much of the metal in the later hydrothermal deposits described below.

Between 70 and 55 million years ago, metals were concentrated by igneous-hydrothermal systems during the late phases of intrusion of the Idaho batholith. Three physical types of metal concentrations developed during this event: replacement deposits, stockworks of veinlets, and large veins. Replacement deposits are significant in the Hailey area, just to the southwest of the study area, where they have been mined for their silver, lead, and zinc content. These replacement deposits occur where the intrusive rocks intruded carbonate-bearing members of the Paleozoic black shale sequence. Stockwork deposits formed during this event concentrated molybdenum, tungsten, and some copper. Known deposits of this type in the region include Thompson Creek, a world-class molybdenum deposit, in operation in 1990, and the Tungsten Jim mine, a past tungsten producer. An example in the study area is at the Little Boulder Creek prospect in the White Clouds. Veins that formed in the intrusive rocks during this event are mainly quartz with gold or silver, or both, and minor concentrations of lead, zinc, copper, and antimony. These include gold deposits in the Hailey gold belt just south of the area, and silver deposits in the Vienna district. Veins that formed in the carbonaceous black shales close to the intrusive rocks contain significant amounts of silver, lead, and zinc. These include the majority of the deposits in the central and northwestern parts of the study area. The extremely rich silver and lead veins in the Wood River valley, just to the southwest of the study area, are of this type.

Tertiary igneous-hydrothermal-tectonic activity took place in an environment of crustal extension mainly along deep-seated high-angle fault systems. A variety of metals were introduced during this event including gold, silver, molybdenum, tungsten, beryllium, tin, antimony, bismuth, fluorine, lead, copper, and zinc. In addition, the solutions transporting these metals may have mobilized and reconcentrated metals from earlier events. Metal concentrations were of two types: replacement of sedimentary carbonate beds, and stockworks of veins and veinlets. The replacement deposits, including skarns, concentrated copper, lead, zinc, silver, and gold. The deposits in the White Knob Mountains near Mackay, just east of the study area, are of this type. The Empire mine was a major past producer of copper, and deposits in the Alta and Muldoon districts, both partially within the study area, produced silver, lead, and zinc. The Drummond Mine Limestone, which extends in a northerly direction through much of the central part of the study area, is almost entirely a replacement deposit. The metal content of replacement ores in the Drummond Mine Limestone varies considerably even within a small area. Replacement deposits close to the study area are currently (1991) being explored for their gold content. Stockworks of veins and veinlets occur throughout the area but are best developed next to intrusive igneous rocks or in extrusive igneous rocks. Deposits of this type have been mined for their silver, lead, and zinc contents in the Alta district, the Muldoon district, and the White Knob Mountains. The currently productive gold deposits in the Champagne Creek portion of the Lava Creek district, just south of the study area, are of this type.

Certain minerals, including some heavy minerals, are resistant to chemical weathering and collect as a weathering residue in alluvium. During the past 2 million years (Pleistocene to recent times) gold has been concentrated in placer deposits throughout central Idaho. The source of the metals was igneous rocks and vein deposits formed in Cretaceous and Tertiary times. Gold placers such as those near Idaho City and Placerville were a major source of gold in the past. Only minor occurrences of gold placers are known in the group 2 study area.

MINERAL DEPOSIT TYPES

Several mineral deposit types are known or expected to occur within the group 2 study area. Many deposits are genetically and physically associated and can be grouped for assessment purposes into the following types: Comstock-type epithermal veins, polymetallic quartz veins and lodes, zinc-lead skarn deposits, Cretaceous low-fluorine porphyry molybdenum deposits, Tertiary low-fluorine molybdenum deposits, polymetallic vein and replacement deposits, sedimentary (stratabound) zinc and lead deposits, and bedded barite deposits.

Comstock-type epithermal veins

These deposits consist of veins and stockworks of veins that occur along fault zones, mainly in rocks of the Challis Volcanic Group. Most of the deposits are composed of many small veinlets of quartz and commonly have little surface expression. Examples of this deposit type occur in the Lava Creek district just south of the group 2 area, including the ore bodies at the Champagne Creek mine. These deposits were mined mainly for their gold and silver content, but locally the veins contain significant amounts of base metals and bismuth. Distribution of ore in the veins is erratic. Ore bodies in the Lava Creek area range from small pockets to bodies as much as 350 ft long and several feet wide; most have limited vertical extent.

Polymetallic quartz veins and lodes

This deposit type is genetically related to and gradational with polymetallic vein and replacement deposits described below. Deposits are multi-staged quartz veins and lodes within shear zones and fault fissures that contain gold, silver, and variable amounts of base metals, antimony, and tungsten. Some of the massive quartz veins are exposed for distances exceeding 2 mi. This is a common deposit type in this region, occurring throughout the Idaho batholith. The ore zones constitute only a portion of the extensive massive quartz veins and lodes, and are often separated by several tens to hundreds of feet of barren quartz. Examples include the Atlanta and Rocky Bar gold districts, just west of the study area. Examples in the group 2 study area are in the Vienna district, where silver was the main commodity produced, although some veins contain significant amounts of lead, zinc, gold, copper, and antimony. Individual ore bodies range from a few tons in isolated pods to pipe-like lenses as much as 700 ft long, 15 ft wide, and more than 1,000 ft deep. Ore grades across the larger silver-rich ore bodies in the Vienna district averaged 600–1,000 grams/tonne silver, and some zones contained as much as 70,000 grams/tonne silver and significant gold.

Zinc-lead skarns

Deposits are within local concentrations of metal-bearing sulfide minerals, mainly galena and sphalerite within irregular to blanket-like bodies of calc-silicate minerals. The skarn and sulfide minerals formed as a replacement of carbonate rocks within the aureole of some intrusive rocks. The important known zinc-lead skarn deposits within and close to the group 2 study area are hosted by the Drummond Mine Limestone, a unit within the Copper Basin Formation that extends north and south through the area. The Eagle Bird mine, in the Muldoon district, and the Phi Kappa mine, in the Alta district, are both examples of this type that have had significant past production. Ore zones average about 4 ft in thickness, range from 200 to 4,000 ft in length, and contain 100-300 grams/tonne silver, 2.6–7.6 percent lead, and 2.5–3.5 percent zinc.

Cretaceous low-fluorine porphyry molybdenum deposits

Vein stockworks and disseminations of molybdenite within or associated with compositionally zoned Cretaceous stocks comprise this deposit type. Tungsten veins and stockworks often accompany this type of deposit. Examples in the region include the Thompson Creek deposit and the Little Boulder Creek prospect. The Thompson Creek mine, in operation in 1990, is the only deposit of this type that has been exploited in Idaho. Ore bodies are large, elongate, tabular bodies containing more than 200 million tons of ore with grades as high as 0.18 percent MoS_2.

Tertiary low-fluorine porphyry molybdenum deposits

Deposits consist of vein stockworks and disseminations of molybdenite in or near hypabyssal rocks of Eocene age which are generally localized along major high-angle fault systems. Tungsten veins and stockworks often accompany this type of deposit. An example in the group 2 study area is at the White Mountain prospect in the Alta district. Although the mineral molybdenite is obvious in surface expressions, and the deposit has been drilled, there has been no mining at this site.

Polymetallic vein and replacement deposits

This deposit type is genetically related to and gradational with polymetallic quartz veins and lodes described above. Deposits are characterized by the presence of quartz, siderite, and galena. Some of the veins are exposed for distances exceeding 2 mi. This type of deposit is common in the Wood River valley and was the source of significant past silver, lead, and zinc production. Individual ore bodies in the vein systems are as much as 200 ft long, 40 ft wide, and more than 300 ft deep. Replacement ores are blanket-like bodies as much as 1,200 ft long by 400 ft deep and 18 ft thick. Ore grades generally averaged 8–10 percent lead, 0–4 percent zinc, and 300-350 grams/tonne silver. Richer zones containing 60 percent lead, 20 percent zinc, and 2,500 grams/tonne silver were common.

Sedimentary (stratabound) zinc and lead deposits

These are blanket-like bodies containing high concentrations of zinc, lead, silver, and other metals within sedimentary strata. This type of deposit is common elsewhere in the world in rocks similar in age and lithology to rocks in the central Idaho black shale belt, which extends through the western part of the study area. Examples include the Hoodo and Livingston mines, in the northern part of the study area, and the Triumph mine, just south of the area. Although genetically different, the polymetallic vein and replacement deposits and the sedimentary (stratabound) zinc and lead deposits are physically and mineralogically very similar, and it is difficult to distinguish between them in the field. Because of their similarities to the more numerous polymetallic vein and replacement deposits, the importance and characteristics of the sedimentary deposits in this area are unknown.

Bedded barite deposits

Barite commonly occurs within sedimentary strata in sequences of rocks similar to those of the central Idaho black shale belt. The barite concentrations sometimes occur in the vicinity of sedimentary (stratabound) zinc and lead deposits. Bedded barite deposits are blanket-like bodies that are various shades of white, brown, or gray in color. White beds are readily apparent, but gray beds are indistinguishable from country rock. Barite deposits in the Wood River valley, just to the south of the area, are probably bedded within strata and thus are likely deposits of this type. In the Muldoon district, barite occurs mainly in veins that may or may not be reconstituted from bedded barite deposits. The important barite deposits in the world and the western United States are of the bedded type.

MINERAL RESOURCE ASSESSMENT

Introduction

The probability that undiscovered deposits exist in the study area was assessed for Comstock-type epithermal veins, polymetallic quartz vein and lode deposits, zinc-lead skarns, Cretaceous low-fluorine porphyry molybdenum deposits, Tertiary low-fluorine porphyry molybdenum deposits, and polymetallic veins. There is currently not enough world-wide information on sedimentary (stratabound) zinc and lead deposits and bedded barite deposits to develop descriptive mineral deposit models, and regional information is not adequate to define permissive tracts. Deposit types that have only minor occurrences within the study area or are speculative were not included in the assessment process. These deposits include tungsten skarns and gold skarns.

Comstock-type epithermal vein deposits

Deposit characteristics:

Most known deposits of this type occur in the western United States and are between 0.065 and 9.1 (median 0.77) million tonnes with 2.0–27 (median 7.5) grams/tonne gold and 10–1,300 (median 110) grams/tonne silver. This is model 25c in USGS Bulletin 1693 (Cox and Singer, 1986, p. 150).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *Comstock-type epithermal vein deposits* in group 2 tracts:

Tract 1:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	0	2	
Contained gold (tonnes)	0	0	32	25
Contained silver (tonnes)	0	0	1,400	1,000
Total ore (tonnes)	0	0	5,000,000	2,500,000

Tract 2:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	1	2	
Contained gold (tonnes)	0	4	58	25
Contained silver (tonnes)	0	57	3,000	1,700
Total ore (tonnes)	0	570,000	10,000,000	4,000,000

Discussion:

Two tracts, defined by the presence of Eocene volcanic rocks, are permissive for Comstock-type epithermal veins (fig. 9). Known deposits of this type in the region are within or associated with Eocene volcanic rocks. The important precious-metal deposits at Champagne Creek, just south of the study area, are of this type. These deposits are aligned along fault zones in association with dikes and small bodies of Tertiary rhyolite. Although these tracts have been explored, the poor surface expression of this deposit type and the amount of surficial cover suggest the possibility of undiscovered deposits in both tracts. The estimate of at least one undiscovered deposit in tract 2 at 50 percent confidence level is supported by the presence of geochemical anomalies and each tract has potential for at least two undiscovered deposits at 10 percent confidence level.

Polymetallic quartz veins and lodes

Deposit characteristics:

Deposits of this type typically contain 1.8–78 (median 12) thousand tonnes, and contain 2.7–78 (median 14) grams/tonne gold. Although silver is often present in these deposits, not enough information is available to include it in the grade and tonnage model. This is a new model developed for this study (James D. Bliss, written commun., 1991).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *polymetallic quartz veins and lodes* in group 2 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	0	1	
Contained gold (tonnes)	0	0	0.33	0.2
Total ore (tonnes)	0	0	20,000	10,000

Discussion:

One tract permissive for polymetallic quartz veins and lodes is defined by the outcrop of Cretaceous igneous rocks (fig. 10). The prominent surface expressions of these deposits suggests that they have been thoroughly explored in the past. This combined with a lack of regional geochemical anomalies led to an estimate of one undiscovered deposit at 10 percent confidence level. The silver deposits in the Vienna district occur within this tract and are silver-enriched variants of this deposit type. We believe that most new ore of this type will be found as extensions of known mineralized zones.

Zinc-lead skarn

Deposit characteristics:

Most deposits are 0.16–12.0 (median 1.4) million tons and contain 2.7–13 (median 58) percent zinc, and trace to 1.3 percent copper. A few deposits contain minor gold; the median for those few deposits is less than 0.46 grams/tonne. This is model 18c in USGS Bulletin 1693 (Cox and Singer, 1986, p. 90).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *zinc-lead skarn deposits* in group 2 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	0	1	
Contained metal (tonnes)				
Zinc	0	0	200,000	80,000
Lead	0	0	90,000	40,000
Silver	0	0	100	70
Copper	0	0	300	7,000
Total ore (tonnes)	0	0	3,000,000	1,000,000

Discussion:

One tract defined by the presence of the Drummond Mine Limestone member of the Copper Basin Formation is permissive for zinc-lead skarn deposits (fig. 11). The tract contains several known deposits (Phi Kappa, Eagle Bird, Solid Muldoon) and numerous prospects, thus the estimate of only one undiscovered deposit, at 10 percent confidence level, in this tract. We believe that most new ore of this type will be found as extensions of known mineralized zones.

Cretaceous low-fluorine porphyry molybdenum

Deposit characteristics:

Most deposits are between 16 and 560 (median 94) million tonnes, and contain 0.055–0.13 (median 0.085) percent molybdenum. This is model 21b in USGS Bulletin 1693 (Cox and Singer, 1986, p. 120).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *Cretaceous low-fluorine porphyry molybdenum deposits* in group 2 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	0	1	
Contained molybdenum (tonnes)	0	0	100,000	50,000
Total ore (tonnes)	0	0	100,000,000	60,000,000

Discussion:

One tract, defined by outcrop of Cretaceous granitic rocks, aeromagnetic lows, and anomalous molybdenum in panned-concentrate and stream-sediment samples, is permissive for Cretaceous low-fluorine porphyry molybdenum deposits (fig 12). One known deposit of this type, the Little Boulder Creek prospect, occurs within this tract. The tract has probably been thoroughly explored for this deposit type, thus the estimate of only one undiscovered deposit, at 10 percent confidence level, in this tract.

Tertiary low-fluorine porphyry molybdenum

Deposit characteristics:

Most deposits are between 16 and 560 (median 94) million tonnes, and contain 0.055–0.13 (median 0.085) percent molybdenum. This is model 21b in USGS Bulletin 1693 (Cox and Singer, 1986, p. 120).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *Tertiary low-fluorine porphyry molybdenum deposits* in group 2 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	1	2	
Contained molybdenum (tonnes)	0	30,000	300,000	100,000
Total ore (tonnes)	0	30,000,000	400,000,000	100,000,000

Discussion:

One tract, where Tertiary granite and rhyolite intrusions are known or suspected, is permissive for Tertiary low-fluorine porphyry molybdenum deposits (fig. 13). Aeroradiometric anomalies and anomalous molybdenum in panned concentrates and stream sediments support the delineation of this tract. Recognized examples include the White Mountain prospect and other prospects around the Summit Creek intrusive. These prospects are small and have produced only mineral specimens of molybdenite. Because other portions of the tract may not have been thoroughly explored, an estimate of one undiscovered deposit at the 50 percent confidence level and two undiscovered deposits at the 10 percent confidence level is justified.

Polymetallic vein deposits

Deposit characteristics:

Most known deposits are found in western North America and have 290–200,000 (median 7.0) tonnes of ore with 140–4,700 (median 820) grams/tonne silver, 2.4–33 (median 9) percent lead, 1.0–7.6 (median 2.1) percent zinc. Although gold may be present in these deposits, not enough information is available to include it in the grade and tonnage model. Model 22c from USGS Bulletin 1693 (Cox and Singer, 1986, p. 125) was used in this estimate.

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *polymetallic vein deposits* in group 2 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	2	4	7	
Contained metal (tonnes)				
Silver	20	100	700	400
Lead	2,000	10,000	90,000	30,000
Zinc	500	5,000	80,000	20,000
Total ore (tonnes)	20,000	200,000	1,000,000	500,000

Discussion:

One tract, defined by the presence of Paleozoic silty black shales, is permissive for polymetallic veins (fig. 14). Features important for this deposit type are the presence of faults and plutonic intrusive rocks. The presence of numerous plutonic intrusive rocks, thrust faults, steep faults, and geochemical anomalies, together with the generally mineralized nature of this terrane, supports an estimate of at least two undiscovered deposits at 90 percent confidence level, four undiscovered deposits at 50 percent confidence level, and seven undiscovered deposits at 10 percent confidence level. Another tract in the Borah Peak area, defined by the presence of the McGowan Creek Formation, is also considered permissive but subjective estimates were not made because data are inadequate.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED MINERAL RESOURCES IN THE GROUP 3 STUDY AREA, INCLUDING FRENCH CREEK, PATRICK BUTTE, PAYETTE CREST (NEEDLES), SOUTH FORK OF THE SALMON, AND SECESH

SUMMARY

Within the group 3 study area, there are tracts permissive for the occurrence of undiscovered deposits of seven types: polymetallic quartz veins and lodes, placer gold, tungsten skarn, stratabound volcanogenic deposits, low-sulfide gold veins, sediment-hosted (Blackbird-type) cobalt-copper deposits, and radioactive black sand placers.

One tract permissive for polymetallic quartz veins and lodes (fig. 16) has a 50 percent chance of having at least one, and a 10 percent chance of having at least two, undiscovered deposits of a type that has a median size of 12,000 tonnes and a median grade of 14 grams/tonne gold. Estimated mean metal endowment for this tract is 0.67 tonnes contained gold.

One tract permissive for placer gold (fig. 17) has a 50 percent chance of having at least two, and a 10 percent chance of at least four, undiscovered deposits that contain a minimum of 22,000 tonnes of ore and a median grade of 0.2 grams/tonne gold. Estimated mean metal endowment for this tract is 0.28 tonnes contained gold.

Tracts permissive for tungsten skarn (fig. 18), stratabound volcanogenic deposits (fig. 19), low-sulfide gold deposits (fig. 20), sediment-hosted (Blackbird-type) cobalt-copper deposits (fig. 21), and radioactive black sand placers (fig. 22) were defined, but estimates of the number of undiscovered deposits present were not made. There is not adequate information on these deposit types to develop descriptive or grade/tonnage models.

INTRODUCTION

During 1989 and 1990, the USGS conducted geologic, geochemical, geophysical, and mineral resource studies in and around the proposed wilderness areas of group 3 (fig. 15). The purpose was to provide data adequate for assessment of the potential for undiscovered mineral resources within or near the proposed wilderness areas. The quantitative assessment of the group 3 area was performed in February 1991, with all geologic, geochemical, geophysical, and mineral-resource data that were available at that time.

The assessment of potential for undiscovered mineral resources was made for an area that encompassed the proposed wilderness areas and all known roadless areas in their vicinity. Within the proposed wilderness areas, the assessment is based on site-specific data gathered for this study. In the intervening areas, the assessment is based on existing information and limited reconnaissance, and thus is preliminary. Additional site-specific studies are needed to complete the assessments in these intervening areas.

ASSESSMENT TEAM

The group 3 assessment team included:

Harlan N. Barton	Branch of Geochemistry, Denver
James D. Bliss	Branch of Resource Analysis, Tucson
John W. Cady	Branch of Geophysics, Denver
Theresa M. Cookro	Branch of Resource Analysis, Denver
Karl V. Evans	Branch of Central Mineral Resources, Denver
Kathleen M. Johnson	Branch of Resource Analysis, Spokane
Harley D. King	Branch of Geochemistry, Denver
Dolores M. Kulik	Branch of Geophysics, Denver
Karen I. Lund	Branch of Central Mineral Resources, Denver
James A. Pitkin	Branch of Geophysics, Denver
Ronald G. Worl	Branch of Western Mineral Resources, Spokane

BACKGROUND DATA

Assessment of potential for undiscovered mineral deposits is a complex process based on the interrelationships of geologic, geochemical, geophysical, and mineral-resource data that are both local and regional in scope. A short summary of the data used for the group 3 study area follows, with emphasis on describing the mineral resources. Recent publications covering this area include Lund, Alminas, and others (1989), Lund and Benham (1983), Lund and Esparza (1990), Lund, Evans, and Esparza (1983), Mitchell and Bennett (1979), and Mitchell and others (1981).

Geology

Within the group 3 area there is a major boundary between island arc-derived rocks on the west, and metamorphosed older continent-derived rocks on the east. All these rocks were deformed and metamorphosed during collision of the island arc with the North American continent between 120 and 90 million years ago. Plutonic rocks of the Idaho batholith were emplaced across the area between about 95 and 75 million years ago. The earliest of these plutons, between 95 and 85 million years old, are strongly deformed tonalites and granodiorites, which are foliated and lineated parallel to the suture zone. The younger plutons are biotite and muscovite-biotite granites and are generally undeformed except where they are cut by younger fault zones. Between 50 and 45 million years ago, young plutons intruded the older rocks in the eastern part of the area. Dikes and volcanic rocks were associated with the emplacement of the plutons. The volcanic rocks overlie rocks older than the Idaho batholith in a small part of the eastern border of the study area. A small patch of mafic volcanic rocks of the Columbia River Basalt Group, between 21 and 11 million years old, occurs in the far western part of the study area. Alluvial deposits, which range in age from 20 million years old to recent, fill valleys throughout the area. Glacial material was deposited in the last 2 million years.

Geochemistry

Geochemical data from the following three studies were used in the group 3 assessment: (a) National Uranium Resource Evaluation (NURE) for the Elk City 1° x 2° quadrangle, (b) Challis CUSMAP (Kathleen M. Johnson, unpub. data, 1989), and (c) samples collected for this study from within or close to the proposed wilderness areas. These data were used to characterize the geochemical signature of the various mineral deposit types and mineral-bearing terranes in the area. A program utilizing mechanical panning was used for evaluating gold resources near the Secesh study area.

Geophysics

Geophysical data sets used in the mineral resource assessment included aeromagnetic, gravity, and aeroradiometric data compiled at 1:125,000 scale. These data were used in conjunction with geologic and mineral-resource data in defining the various terranes and the tracts permissive for the occurrence of undiscovered radioactive black sand placers and polymetallic quartz veins and lodes. A geoelectrical survey conducted for this study was used to determine the character at depth of the major structures in and near the group 3 area.

Mineralizing Events

Five possible mineralizing events are recognized in the rocks of the group 3 study area: metal concentration during Middle Proterozoic sedimentation, Permian to Triassic volcanic activity, igneous-hydrothermal activity associated with emplacement of the Cretaceous Idaho batholith, igneous-hydrothermal-tectonic activity associated with development of Tertiary plutonic rocks, and mechanical concentration of metals through erosion during Pleistocene and recent times.

The oldest recognized event was concentration of metals in sediments deposited on the sea floor 1.6 billion years ago. Copper and cobalt were concentrated where mafic volcanic material was extruded on to the sea floor. Stratabound copper-cobalt concentrations of importance occur within a restricted sedimentary sequence at the Blackbird mine near Salmon, Idaho. The stratabound metals in the 1.6 billion-year-old rocks were remobilized into vein-like deposits at a later time.

Rocks in the western part of the area formed in an island arc environment about 200 to 300 million years ago. Metal-rich volcanic sedimentary rocks commonly form on the sea floor in this type of environment, and in some areas massive beds of sulfide minerals were deposited directly onto the sea floor by exhalative processes. No examples of this deposit type are known in the area. Later metamorphism by heat and pressure, probably during the igneous-hydrothermal event described below, converted this sequence of rocks into greenstones. During late stages of metamorphism, quartz veins and veinlets can form in regional fractures; these quartz veins often carry significant amounts of precious metals. Only small prospects of this type are known in the area.

About 75 to 70 million years ago, metals were concentrated by igneous-hydrothermal systems operational during the late phases of intrusion of the Idaho batholith. Two physical types of metal concentrations developed during this event, replacement deposits and veins. Replacement deposits formed where intrusive rocks of the Idaho batholith engulfed carbonate sedimentary rocks. The most important metal concentrated by this process was tungsten; an example in the area is at the Springfield mine. Veins that formed during this event are mainly quartz with variable concentrations of gold, silver, lead, zinc, copper, antimony, and tungsten. Most deposits in this area are of this type and include those of the Warren, Yellow Pine, and Edwardsburg districts. Many of these veins formed in fissures and shear zones near the roof of muscovite-biotite plutons.

Tertiary igneous-hydrothermal-tectonic activity starting about 50 million years ago took place in an environment of crustal extension mainly along deep-seated high-angle fault systems. Regionally, a variety of metals were introduced during this event including gold, silver, molybdenum, tungsten, beryllium, tin, antimony, bismuth, fluorine, mercury, lead, copper, and zinc. Deposits of this type generally occur within or next to Tertiary intrusive rocks or within Tertiary extrusive rocks. The only deposits of this type recognized in the area are mercury deposits such as at the Pretty Maid mine. This event may have remobilized some of the previous deposits because Tertiary dikes intruded into and along older shear zones and fractures that hosted gold-bearing quartz veins formed during the earlier event.

Certain minerals, including some heavy minerals, are resistant to chemical weathering and collect as a weathering residue in alluvium. During the past 2 million years, Pleistocene to recent times, gold and radioactive black sands have been concentrated in placer deposits throughout central Idaho. The source of the metals was the igneous rocks and vein deposits formed in Cretaceous and Tertiary times. Gold placers such as those near Warren and Florence were a major source of gold in the past. Radioactive black sand placers in Long Valley and Bear Valley, to the south of the study area, are known major resources of thorium, rare-earth metals, niobium, and tantalum but have had little production.

MINERAL DEPOSIT TYPES

Several mineral deposit types are known or expected to occur within the group 3 study area. Many of these are genetically and physically associated and can be grouped into the following models for assessment purposes: polymetallic quartz veins and lodes, gold placers, Cretaceous tungsten skarn deposits, sediment-hosted (Blackbird-type) cobalt-copper deposits, and radioactive black sand placers.

Polymetallic quartz veins and lodes

Deposits are in quartz veins and stockworks of quartz veinlets (lodes) within fracture systems that commonly trend northwest or north-northeast. They are within or close to intrusive rocks of the Idaho batholith and many seem to be genetically related to a muscovite-biotite granite phase. Individual ore zones constitute only a portion of the extensive quartz veins and lodes and are often separated by several tens to hundreds of feet of barren quartz. Most past production was for gold and silver, although some deposits produced significant amounts of tungsten, antimony, lead, zinc, and copper. Individual ore bodies range from a few tonnes in isolated pods to bodies containing several thousand tonnes of ore. Although not all metals are together in each deposit, rough estimates of ore grade indicate ranges of 1–24 grams/tonne gold, 17–85 grams/tonne silver, 2–5 percent tungsten oxide, 0.1–1.12 percent lead, trace to 0.46 percent zinc, and as much as 200 lbs/ton antimony. Most of the known deposits within the study area are of this type: examples include deposits at Yellow Pine, Dixie, Warren, and Edwardsburg.

Gold placers

There has been major gold production from placer deposits in the region, especially in the Warren and Florence areas. Placer deposits exploited prior to 1950 ranged from a few to several thousand acres in area and a few to more than 100 ft in thickness. Small placer operations continue along many of the major streams in the study area, and small pockets of placer ore will continue to be found for many years.

Cretaceous tungsten skarn deposits

Tungsten skarn deposits occur where rocks of the Idaho batholith have intruded calcareous Paleozoic and possibly Proterozoic metamorphic rocks. The deposits consist mainly of skarn minerals with pods and disseminations of tungsten minerals, mainly scheelite. An example of this deposit type is at the Springfield mine, where tungsten is enriched in the metamorphic rocks that form a small roof pendant near the top of the batholith. The mine produced about 60 tons of tungsten oxide from 40,000 tons of ore.

Sediment-hosted (Blackbird-type) cobalt-copper deposits

Sediment-hosted (Blackbird-type) cobalt-copper deposits in Idaho are best known at the Blackbird mine near Salmon, Idaho. Ore at Blackbird occurs near the transition from the middle to upper units of the Yellowjacket Formation of Middle Proterozoic (Late Precambrian) age. The Yellowjacket Formation near the mine ranges from interbedded siltite-argillite to fine-grained quartzite. The cobalt and copper occur in the stratum that is extremely rich in biotite. Some geologists have interpreted the biotite-rich rocks as mafic tuff or mafic airfall volcanic rock. In the Big Creek-Yellow Pine area, small amounts of biotite are present in rocks equivalent to the middle unit of the Yellowjacket Formation.

Radioactive black sand placers

Several alluvial deposits in central Idaho contain black sand minerals containing thorium dioxide, rare-earth oxides, niobium and tantalum pentoxides, and U_2O_8. The closest known deposits are in Long Valley and Bear Valley, to the south of the study area. Potential deposits are generally large alluvial sand blankets, containing more than a million cubic yards of material.

MINERAL RESOURCE ASSESSMENT

Introduction

The probability that undiscovered deposits exist in the study area was assessed for polymetallic quartz veins and lodes and placer gold. Estimates of the number of undiscovered deposits and metal endowment were not made for tungsten skarn, stratabound volcanogenic deposits, low-sulfide gold veins, sediment-hosted (Blackbird-type) cobalt-copper, and black sand placers although tracts permissive for their occurrence were delineated, because not enough information is currently available for development of descriptive and grade/tonnage models. Deposit types that have only minor occurrences within the study area or are speculative were not included in the assessment process.

Polymetallic quartz veins and lodes

Deposit characteristics:

Most deposits in the model are between 1.8 and 78 (median 12) thousand tonnes, and contain from 2.7–78 (median 14) grams/tonne gold. Although silver is often present in these deposits, not enough information is available to include it in the grade and tonnage model. The model used for this evaluation is a new model prepared for this study (James D. Bliss, written commun., 1991).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *polymetallic quartz veins and lodes* in group 3 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	1	2	
Contained gold (tonnes)	0	0.1	1.4	0.67
Total ore (tonnes)	0	9,200	110,000	33,000

Discussion:

One tract permissive for polymetallic quartz veins and lodes is defined by the outcrop of Cretaceous intrusive rocks, including roof pendants, and the presence of fissure faults with evidence of hydrothermal alteration (fig. 16). Several geochemical anomalies combined with the presence of muscovite-biotite granite within this tract supports an estimate of one undiscovered deposit at 50 percent confidence level and two deposits at 10 percent confidence level.

Placer gold

Deposit characteristics:

Placer deposits range from small pockets of gravel to valley bottoms with 50 million tonnes of gravel; the median size is 1.1 million tonnes. They contain 0.084–0.48 (median 0.2) grams/tonne gold. This is model 39a in USGS Bulletin 1693 (Cox and Singer, 1986, p. 261).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for the *placer gold* in group 3 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	2	4	
Contained gold (tonnes)	0	0.12	0.71	0.28
Total ore (tonnes)	0	140,000	1,400,000	410,000

Discussion:

Known placers in this area are believed to have been derived from gold-bearing quartz veins and lodes found in fissures and in wide shear zones. Although large areas have been placered in the past, the large extent of gravels residing on and near potential gold-bearing mineralized zones support an estimate of two undiscovered deposits at 50 percent confidence level and four undiscovered deposits at 10 percent confidence level (fig. 17).

Tungsten skarn

Deposit description:

There are known tungsten skarn deposits in the area. These deposits are hosted by carbonate metamorphic rocks that are inclusions within rocks of the Idaho batholith, and are generally of a limited size.

Discussion:

Tungsten skarn deposits form at the contacts of felsic igneous rocks and carbonate sedimentary and metamorphic rocks. One tract defined by the outcrop of the carbonate metamorphic rocks is permissive for tungsten skarn deposits (fig. 18). Estimates of the number of undiscovered deposits and contained metal endowment were not made because the local known deposits do not fit any existing model for tungsten skarn.

Stratabound volcanogenic deposits

Deposit characteristics

Deposits of this type form in volcanic island arc terranes where hot springs associated with marine volcanism deposit copper- and zinc-bearing massive sulfide beds on the sea floor. The deposits are 0.12–18 (median 1.5) million tons of ore containing 0.45–3.5 (median 1.3) percent copper and trace to 8.7 (median 2.0) percent zinc. This is essentially model 28a in USGS Bulletin 1693 (Cox and Singer, 1986, p. 189).

Discussion:

The western part of the group 3 area is underlain by metamorphosed volcanic and volcaniclastic rocks deposited in an island arc environment. Examples of this deposit type may exist in the same sequence of rocks to the west of the study area, but there is not adequate data on these deposits to confirm. One tract, defined by the outcrop of metamorphic island arc derived metavolcanic and metavolcaniclastic rocks, is considered permissive for stratabound volcanogenic deposits (fig. 19). Estimates of the number of undiscovered deposits and contained metal endowment were not made.

Low-sulfide gold deposits

Deposit characteristics:

Deposits of this type form during the late stages of regional metamorphism associated with continental margin accretion. They are most common in metamorphosed volcanic and volcaniclastic rocks. They are 1–910 (median 30) thousand tonnes of ore containing 6–43 (median 16) grams/tonne gold and trace to 2.5 grams/tonne silver. This is model 36a in USGS Bulletin 1693 (Cox and Singer, 1986, p. 239).

Discussion:

The western part of the area is underlain by volcanic and volcaniclastic rocks that were regionally metamorphosed during continental accretion. Small prospects in deposits of this type are known just to the west of the study area in this sequence of rocks. One tract, defined by the outcrop of regionally metamorphosed volcanic and volcaniclastic rocks, is permissive for low-sulfide gold veins (fig. 20). Estimates of the number of undiscovered deposits and contained metal endowment were not made.

Sediment-hosted (Blackbird-type) cobalt-copper deposits

Description:

There is a single known deposit of this type, at the Blackbird mine near Salmon, Idaho; it is included as model 24d in USGS Bulletin 1693 (Cox and Singer, 1986, p. 142). Because there are no other known deposits, grade and tonnage figures are not available.

Discussion:

The Blackbird ore body is hosted in a distinct section of the Yellowjacket Formation. Similar rocks in the eastern part of the study area are thought to be the same sequence. One tract defined by the outcrop of the Yellowjacket Formation is permissive for sediment-hosted (Blackbird-type) cobalt-copper deposits (fig. 21). Estimates of the number of undiscovered deposits and contained metal were not made.

Radioactive black sand placers

Deposit characteristics:

Radioactive black sand placers known in Idaho are very large, containing more than 50 million tonnes of material in broad open valleys with slow moving streams. Large-scale dredging operations have been used to work these placers.

Discussion:

Tracts permissive for the occurrence of radioactive black sand placers were delineated in group 3 area (fig. 22), but no estimate of the number of undiscovered deposits was made because there is not sufficient information to develop a descriptive mineral deposit model.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED MINERAL RESOURCES IN THE GROUP 4 STUDY AREA, INCLUDING CLEARWATER, COOK MOUNTAIN-EAST WEITAS, KELLY-CAYUSE, AND MALLARD-LARKINS

SUMMARY

Within the group 4 study area, there are tracts permissive for the occurrence of undiscovered deposits of several types: polymetallic quartz veins and lodes, polymetallic veins, Comstock-type epithermal veins, placer gold, and metamorphic kyanite.

One tract permissive for polymetallic quartz veins and lodes (fig. 24) has a 10 percent chance of having at least one undiscovered deposit of a type that has a median size of 12,000 tonnes of ore and a median grade of 14 grams/tonne gold. Estimated mean metal endowment for this tract is 0.22 tonnes contained gold.

Tracts permissive for polymetallic vein deposits (fig. 25) have a 50 percent chance of having at least two, and a 10 percent chance of at least five, undiscovered deposits of a type that has a median size of 7,600 tonnes of ore and a median grade of 0.13 grams/tonne gold, 820 grams/tonne silver, 9 percent lead, and 2.1 percent zinc. Estimated mean metal endowment for these tracts is 0.67 tonnes contained gold, 230 tonnes contained silver, 19,000 tonnes contained lead, and 13,000 tonnes contained zinc.

One tract permissive for Comstock-type epithermal veins (fig. 26) has a 50 percent chance of having at least one, and a 10 percent chance of having at least two, undiscovered deposits of a type that has a median size of 770,000 tons of ore and a median grade of 7.5 grams/tonne gold, and 110 grams/tonne silver. Estimated mean metal endowment for this tract is 25 tonnes contained gold and 1,700 tonnes contained silver.

Tracts permissive for placer gold (fig. 27) have a 50 percent chance of having at least one, and a 10 percent chance of at least two, undiscovered deposits that contain a minimum of 22,000 tonnes of ore at a median grade of 0.2 grams/tonne gold. Estimated mean metal endowment for these tracts is 0.24 tonnes contained gold.

A tract permissive for metamorphic kyanite deposits was defined (fig. 28), but an estimate of the number of undiscovered deposits present was not made. There is not adequate information on this deposit type to develop descriptive or grade/tonnage models.

INTRODUCTION

During 1989 and 1990, the USGS conducted geologic, geochemical, geophysical, and mineral-resource studies in and around the proposed wilderness areas of group 4 (fig. 23). The purpose was to provide data adequate for assessment of potential for undiscovered mineral resources within or near the proposed wilderness areas. The quantitative assessment of the group 4 area was performed in April 1991, with all geologic, geochemical, geophysical, and mineral-resource data that were available at that time.

The quantitative assessment of potential for undiscovered mineral resources was performed for an area that encompassed the proposed wilderness areas and all known roadless areas in their vicinity. Within the proposed wilderness areas, the assessment was based on site-specific data gathered for this study. In the intervening areas, the assessment was based on existing information and limited reconnaissance. Additional site-specific studies are needed to complete the assessments in these intervening areas.

ASSESSMENT TEAM

The group 4 assessment team included:

Harlan N. Barton	Branch of Geochemistry, Denver
James D. Bliss	Branch of Resource Analysis, Tucson
Stephen E. Box	Branch of Western Mineral Resources, Spokane
Theresa M. Cookro	Branch of Resource Analysis, Denver
Thomas P. Frost	Branch of Western Mineral Resources, Spokane
Bruce R. Johnson	Branch of Western Mineral Resources, Spokane
Kathleen M. Johnson	Branch of Resource Analysis, Spokane
Reed S. Lewis	Idaho Geological Survey, Moscow
Dolores M. Kulik	Branch of Geophysics, Denver
James A. Pitkin	Branch of Geophysics, Denver
Ronald G. Worl	Branch of Western Mineral Resources, Spokane

BACKGROUND DATA

Assessment of potential for undiscovered mineral deposits is a complex process based on the interrelationships between geologic, geochemical, geophysical, and mineral-resource data that are both local and regional in scope. A short summary of the data used for the group 4 study area follows, with emphasis on describing the mineral resources. Recent publications covering this area include Griggs (1973), Harrison and others (1986), Hustedde and others (1981a, 1981b, 1981c), and Mitchell and others (1981).

Geology

The group 4 study area is principally underlain by Precambrian metasedimentary rocks that have been intruded in the south by the Cretaceous Idaho batholith. Both have in turn been intruded by Tertiary plutons and dike swarms.

The metasedimentary rocks (as old as 1.4 billion years) in the northern part of the study area are characterized by argillite, dolomitic siltite, quartzite, and carbonate-rich sedimentary breccias. Metamorphic grade increases from lower (greenschist facies) to higher (amphibolite facies) southward towards the Idaho batholith.

Anorthosite of uncertain age and origin is exposed in the western part of the study area. Numerous amphibolite sills and dikes of uncertain age are also present throughout the area.

The oldest intrusive rocks of the Cretaceous Idaho batholith were emplaced about 110 million years ago and the younger phases as recently as 70 million years ago. Eocene intrusive activity (50-40 million years ago) was dominated by shallow-level plutons, small stocks, and dikes. Eocene volcanic rocks are preserved in a down-dropped block in the eastern part of the study area. Numerous rhyolitic to andesitic dikes intrude the Eocene plutons and surrounding rocks.

Prominent structures in the study area include west-northwest-trending normal faults, thrust faults, and a series of northeast-trending faults along which Eocene intrusive activity was concentrated.

Geochemistry

In the group 4 study area, geochemical data from the following two studies were used in the assessment: (a) the National Uranium Resource Evaluation (NURE) for the Hamilton and Wallace 1° x 2° quadrangles and (b) samples collected for this study from within or close to the proposed wilderness areas. These data were used to characterize the geochemical signatures of the various mineral deposit types and mineral-bearing terranes in the area.

Geophysics

Gravity, aeromagnetic, and aeroradiometric data compiled at a scale of 1:125,000 were used in the mineral-resource assessment. Gravity, magnetic, and radio-element anomalies define the location and extent of Tertiary granitic intrusions and are clues to the location of additional similar buried or unmapped bodies and associated mineral deposits. These data were used in conjunction with geologic and geochemical data to define the tracts permissive for Comstock-type epithermal veins.

Mineralizing events

Four mineralizing events are recognized in rocks of the group 4 study area: (1) metamorphism or metasomatism of Precambrian sedimentary rocks, (2) igneous-hydrothermal-tectonic activity associated with the emplacement of Late Cretaceous to Paleocene plutonic rocks of the Idaho batholith, (3) igneous-hydrothermal-tectonic activity associated with the emplacement of Tertiary plutons and volcanic rocks, and (4) mechanical concentration of metallic and industrial minerals, dominantly through erosion and alluvial processes, occurring at two distinct times, in early mid-Tertiary time and in Pleistocene to recent time. A fifth event that might be present is hydrothermal activity associated with the formation of Coeur d'Alene-type silver-lead-zinc veins in Precambrian sedimentary rocks.

The first recorded mineralizing event in the area was metamorphism or metasomatism which produced kyanite-bearing gneisses and schists from aluminous Precambrian sedimentary rocks, and garnetiferous schists and gneisses from calcareous sedimentary rocks. The age of the metamorphism which produced kyanite- and garnet-bearing gneisses is uncertain, but is at least as old as the Cretaceous plutonic rocks of the Idaho batholith, and possibly much older.

Thermal and hydrothermal activity associated with the waning stages of the emplacement and cooling of the Idaho batholith about 70–55 million years ago produced most of the recognized deposits in the study area. Distinct types of metal concentrations associated with this event include: polymetallic veins and stockworks, pegmatites, replacement deposits, and quartz-carbonate veins. Elements concentrated in the diverse suite of polymetallic veins include gold, silver, copper, lead, and arsenic. A few small, underground mines and prospects have been worked for gold, silver, lead, and copper; numerous occurrences of gold, copper, and lead are scattered through the study area. Pegmatites are present throughout the study area; a few have been reported to contain anomalous concentrations of the metals beryllium and niobium, and the industrial mineral muscovite (mica). Pegmatites may have provided sources for the anomalous concentrations of minerals and metals in heavy-mineral placers. A small area of carbonate replacement occurrences in the eastern part of the study area has been prospected for copper and iron. Quartz-carbonate veins hosted in the Wallace Formation contain elevated amounts of fluorine, thorium, and light rare-earth elements. One deposit has been mined for fluorine.

Tertiary igneous-hydrothermal activity 50–40 million years ago resulted in the emplacement of shallow plutonic rocks of granitic and quartz monzodioritic affinities. Unlike similar rocks to the south, these plutons do not appear to have economic concentrations of tin, uranium, and thorium.

At least two cycles of placer gold concentration are preserved in the study area. The earliest recognized cycle is represented by relicts of alluvial gravels preserved on topographic highs in the Moose Creek drainages as well as small scattered patches of gravel near Cayuse Junction. The second cycle is represented by the currently active stream channels which have been the source of small scale-gold production since the late 1800s. Other placer deposits have been mined for monazite, garnet, and kyanite.

Specific examples of hydrothermal activity of the Coeur d'Alene type have not been recognized in the group 4 study area. However, the proximity to the Coeur d'Alene mining district and the presence of host rocks similar to those of the Coeur d'Alene district raises the possibility of Coeur d'Alene-type mineralization having occurred in this area. The age of this event is unknown, but if it was pre-Cretaceous the preservation of pre-existing silver-lead-zinc veins is unlikely. Remobilization of metals during metamorphism may account for some of the metals which were deposited during subsequent mineralizing events.

MINERAL DEPOSIT TYPES

Several types of mineral deposits are known or expected to occur within the group 4 study area. Many of these deposits are physically and genetically similar and can be grouped for assessment purposes. Models based on the following deposit types were used for the assessment of resource potential: polymetallic quartz veins and lodes, copper-gold and lead-silver (polymetallic) veins, Comstock-type epithermal veins, gold placers, metamorphic kyanite deposits, barite veins, fluorite-rare earth-thorium veins, iron replacement deposits, pegmatites, monazite-gold placers, and heavy-mineral placers.

Polymetallic quartz veins and lodes

Polymetallic vein deposits occur in the meta-sedimentary rocks around the northern end of the Idaho batholith and, to a lesser extent, within the batholith. Three common types occur in this area: polymetallic quartz veins and lodes, copper-dominant gold veins, and lead-silver veins. All gradations between types can be found. The polymetallic quartz veins and lodes are described here; the other two types are described in the section titled *Copper-gold and lead-silver (polymetallic) veins*. The polymetallic quartz veins and lodes appear to be related to the last stages of intrusion of the Idaho batholith; they rarely occur more than 1,500 ft from late-stage intrusive rocks. The host rock is generally amphibolite-grade gneiss or schist, which is probably Belt Supergroup equivalent, or granitic batholith. The deposits are small to medium-sized, irregular veins, lenses, and pods which tend to follow local northeast-striking structures. The largest ore body in the vicinity of the study area was the Wild Rose mine, whose maximum dimensions were 30 ft by 200 ft by 500 ft. The production was gold and, to a lesser extent, silver. Some of these veins also contain significant amounts of lead, zinc, copper, and antimony.

Copper-gold and lead-silver (polymetallic) veins

Copper-dominant gold veins and lead-silver veins have been combined for assessment purposes. Both occur as irregular, elongate veins, lenses, and pods which tend to follow local fissures and shear zones which lie in, or are parallel to, major northwest-striking faults. These mixed base- and precious-metal veins are hosted in argillite, dolomitic argillite, quartzite, gneiss, and schist, and less commonly in quartz diorite, diorite, or meta-diabase. They do not appear to occur in high-grade metamorphic rocks. Deposit size ranges from a few tons in irregular pods to deposits with hundreds of feet of vertical and horizontal extent and average widths of tens of feet. The Iron Mountain mine, a lead-silver deposit, has a vertical extent of over 2,200 ft and an average width of 3–5 ft. Major products from these veins are gold, copper, silver, and lead; minor products are zinc and bismuth.

Comstock-type epithermal veins

Comstock-type deposits consist of veins and stockworks of veins which occur along major fault zones such as the trans-Challis fault system of central Idaho. Most of these deposits are composed of many small veinlets of quartz which commonly have little surface expression. In central Idaho (Boise Basin area), Comstock-type deposits were mined mainly for their gold and silver content, but the veins contain significant amounts of base metals and bismuth. Veins of this type may also contain significant tungsten. There are no known Comstock-type epithermal veins within the study area; however, there is a belt of Eocene syenitic plutons and rhyolite porphyry dikes and extrusive rocks which may have potential for Comstock-type veins. In addition to the Eocene igneous activity, the area includes northeast-trending structures and a northeast-trending gravity gradient which may represent the buried edge of the Idaho batholith. This part of the study area also includes the highest concentration of geochemically anomalous samples. In other parts of western North America, similar plutonic lithologies and geochemical anomalies are associated with major vein and disseminated gold deposits as well as distal base-metal deposits and skarns.

Gold placers

Placer deposits in this area have formed primarily in recent alluvial environments, but have also been preserved in Tertiary high-level terrace gravels. Local deposits range in size from a few acres to several hundred acres and from a few feet to several tens of feet thick. Some placer gold deposits in recent alluvium were apparently derived from Tertiary gravels. Other sources may include ilmenite-bearing quartz veins. There has been major gold production from placer deposits in the vicinity of the study area, particularly in the Pierce City district, southwest of the study area, and in the Ninemile Creek district, to the northeast. Although many of the streams in the study area have been worked for gold, production has been minor. Small placer operations (primarily suction dredge) continue along several streams, particularly in the Moose Creek area.

Metamorphic kyanite

Layers of amphibolite-grade micaceous schist, containing up to 47 percent kyanite, occur in areas of amphibolite metamorphic facies schist and gneiss. These layers are closely associated with meta-anorthosite and garnet amphibolite, and appear to be confined to contact zones between meta-anorthosite and micaceous schist. The deposits are long and narrow, as much as 15,000 ft along strike, 1,600 ft wide, and 140 ft thick. There has been no production from these deposits. The major product of these deposits would be kyanite and other alumino-silicate minerals; garnet might be produced as a minor product.

Barite veins

Barite-bearing veins, stockworks, and breccia fillings are associated with major northwest-striking faults in Proterozoic argillaceous sedimentary rocks. Barite veins tend to be spatially associated with lead-silver veins and with fluorite-rare earth-thorium veins. Barite occurs in a gangue of quartz, calcite, and ankerite with local pyrite and galena. The deposits tend to be small, with maximum dimensions of tens of feet. The major product is barite; minor products include silver, copper, and lead.

Fluorite-rare earth-thorium veins

These deposits are broadly horizontal, lenticular to pod-shaped hydrothermal veins and breccia fillings with sharp contacts in regionally metamorphosed calc-silicate and argillaceous rocks within the thermal and hydrothermal aureoles of granitic batholiths. Fluorite, rare-earth minerals, and thorium minerals are most abundant in irregular zones in the core of the lens or pod. The deposit at the Snowbird mine is as much as 100 ft thick and 300 ft wide. The major product is fluorine; minor products include rare-earth elements and thorium.

Iron replacement deposits

The study area contains one small area of anastomosing, broadly layer-parallel, irregular veins of magnetite and minor chalcopyrite, with or without arsenopyrite, in sharp contact with marble. The deposits are associated with granodiorite plutons or quartz syenite dikes, or both. The host rock is the Proterozoic or Paleozoic Blacklead Limestone; mineralization may be Cretaceous or Tertiary. No pyroxene or garnet skarn minerals have been found in the known examples. The exposed deposits are as much as several feet thick and are exposed for a lateral extent of about 250 ft. There has been no production from replacement deposits in the region.

Pegmatites

Small pegmatitic fracture and open-space fillings occur in various host rocks in or near Cretaceous and Tertiary plutonic rocks. Pegmatites may be important for rare metals such as beryllium or niobium, or for large, pure crystals of more common materials such as mica. Rare-metal pegmatites in the study area are generally coarse- to very coarse-grained and are composed of quartz, feldspar, mica, and beryl with occasional large muscovite books. Beryl crystals are widely scattered with the largest being 0.25 in. wide and less than 1 in. long. Small veins and pods up to 8 ft wide have been reported. Minor production of beryllium has been reported from these deposits. Potential products include niobium and other rare metals. Mica pegmatite veins are generally not zoned and are composed of very large crystals of quartz, feldspar, and muscovite. At some localities there are abundant large muscovite books up to 6 in. across and 0.5 in. thick. The deposits are small (up to 5 ft thick by 26 ft wide), but there has been minor production of industrial mica.

Monazite-gold placers

Heavy-mineral placer deposits are found in recent fluvial environments and Tertiary high-level terrace gravels. In the study area, monazite-gold placers occur only near intrusive rocks that represent the last stages of emplacement of the Cretaceous Idaho batholith. The heavy minerals are primarily monazite, gold, ilmenite, rutile, zircon, and garnet. Concentrates contain as much as 3 percent thorium oxide. Gold and thorium oxide have been produced from the Musselshell area, in the southeast corner of the study area. Minor products include zirconium, garnet, and titanium.

Heavy-mineral placers

In addition to the monazite-gold placer deposits, there are heavy-mineral placers which have been mined for garnet and kyanite. These placer deposits are only found near and downstream from source terranes which consist of garnet- or kyanite-rich metamorphic rocks. The heavy minerals are primarily garnet, kyanite, andalusite, and gold. Garnet and kyanite have been produced from deposits in the northwest quarter of the study area. Gold is a minor product.

Other deposit types

There are two other mineral deposit types that have had major production within 50 mi of the study area: Coeur d'Alene-type silver-lead-zinc veins and Spar Lake-type sediment-hosted copper-silver deposits. An assessment of potential for undiscovered deposits of these two types concluded, in both cases, that the appropriate host rocks do not exist within the study area. Rocks which may have been appropriate hosts for the formation of these deposit types have been metamorphosed to amphibolite grade in the study area. If deposits of these types were formed previously in the study area, there is no indication that they have been preserved.

MINERAL RESOURCE ASSESSMENT

Introduction

The probability that undiscovered deposits exist in the study area was assessed for polymetallic quartz veins and lodes, polymetallic veins, Comstock-type epithermal veins, and gold placers. A probabilistic estimate of the number of undiscovered deposits and of metal endowment was not made for metamorphic kyanite deposits, although tracts permissive for their occurrence were delineated, because not enough information is currently available for development of descriptive and grade/tonnage models. Deposit types that have only minor occurrences within the study area or are speculative were not included in the assessment process. There is currently not enough data on these deposit types to develop descriptive mineral deposit models, define permissive tracts, or make subjective estimates of the numbers of undiscovered deposits. These deposits include barite veins, fluorite-rare earth-thorium veins, iron-replacement deposits, and heavy-mineral placers.

Polymetallic quartz veins and lodes

Deposit characteristics:

Deposits of this type are typically 1.8–78 (median 12) thousand tonnes, and contain 2.7–78 (median 14) grams/tonne gold. Although silver is often present in these deposits, not enough information is available to include it in the grade and tonnage model. This is a new model developed for this study (James D. Bliss, written commun., 1991).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *polymetallic quartz veins and lodes* in group 4 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	0	1	
Contained gold (tonnes)	0	0	0.35	0.22
Total ore (tonnes)	0	0	21,000	10,000

Discussion:

One tract permissive for polymetallic quartz veins and lodes is defined by the outcrop of rocks older than 60 million years within proximity of the late muscovite-biotite granite phase of the Idaho batholith (fig. 24). This tract has probably been thoroughly explored for this deposit type in the past. This combined with a lack of geochemical anomalies led to an estimate of one undiscovered deposit at 10 percent confidence level. Most new ore of this type will probably be found as extensions of known mineralized zones.

Polymetallic vein deposits

Deposit characteristics:

Most known deposits occur in western North America and have 290–200,000 (median 7,600) tonnes of ore with 140–4,700 (median 820) grams/tonne silver, 2.4–33 (median 9) percent lead, 1.0–7.6 (median 2.1) percent zinc, and a probable median of 0.13 grams/tonne gold (statistics are inadequate for the range in gold). Model 22c in USGS Bulletin 1693 (Cox and Singer, 1986, p. 125) was used in this estimate. [1]

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *polymetallic veins deposits* in group 4 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	2	5	
Contained metal (tonnes)				
Gold	0	0.01	1.1	0.67
Silver	0	22	410	230
Lead	0	3,000	49,000	19,000
Zinc	0	800	36,000	13,000
Total ore (tonnes)	0	34,000	790,000	260,000

1 Vein deposits associated with formation of the Idaho batholith are regionally characterized by two descriptive and grade/tonnage models: polymetallic quartz veins and lodes (described above) and polymetallic veins (described in this section). All gradations between the two models can be found. The local vein types, copper-gold veins and lead-silver veins, represent intermediate types between the two models but are closer to the polymetallic vein model. The grade/tonnage model for polymetallic veins is based on deposits hosted in black shale terranes, which are higher in silver, lead, and zinc and lower in gold than the local vein types. Therefore, the contained metal values given here may be high for silver, lead, and zinc, and low for gold.

Discussion:

One tract permissive for polymetallic vein deposits is defined by the outcrop of Precambrian sedimentary rocks; high-grade metasedimentary rocks were excluded (fig. 27). Poor exposures, known mineralized structures, limited exploration activity, and geochemical anomalies in the tract led to an estimate of at least two undiscovered deposits at 50 percent confidence level and at least five undiscovered deposits at 10 percent confidence level.

Comstock-type epithermal vein deposits

Deposit characteristics:

Most known deposits occur in the western United States and are between 0.065 and 9.1 (median 0.77) million tonnes with 2.0–27 (median 7.5) grams/tonne gold and 10–1,300 (median 110) grams/tonne silver. This is model 25c in USGS Bulletin 1693 (Cox and Singer, 1986, p. 150).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *Comstock-type epithermal veins* in group 4 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	1	2	
Contained metal (tonnes)				
Gold	0	4.2	58	25
Silver	0	56	3,100	1,700
Total ore (tonnes)	0	590,000	9,100,000	4,200,000

Discussion:

One tract permissive for Comstock-type epithermal veins was defined by a series of northeast-trending faults, a parallel gravity gradient, and the outcrop pattern of Eocene syenitic plutons, rhyolite dikes, and volcanic rocks (fig. 26). The tract contains the highest concentration of stream-sediment samples in the area that are anomalous in precious metals, and alteration zones were noted along some of the northeast-trending faults. Based upon these factors, an estimate of at least one deposit at 50 percent confidence level and two deposits at 10 percent confidence level seems justified.

Placer gold

Deposit characteristics:

Most world-wide placer deposits are 0.022–50 (median 1.1) million tonnes gravel containing 0.084–0.48 (median 0.2) grams/tonne gold. This is model 39a in USGS Bulletin 1693 (Cox and Singer, 1986, p. 261).

Estimates:

Estimated minimum number of undiscovered deposits and calculated contained metal for *placer gold* in group 4 tracts:

Confidence levels	90%	50%	10%	Mean
Estimated number	0	1	2	
Contained gold (tonnes)	0	0.02	0.24	0.09
Total ore (tonnes)	0	6,800	480,000	150,000

Discussion:

Known placers in this area are believed to have been derived from gold-bearing quartz veins and lodes, or from high-level gravels that were probably deposited in Tertiary time. The extent of unplacered gravels in areas of geochemical anomalies and known deposits supports an estimate of at least one undiscovered deposit at 50 percent confidence level, and at least two undiscovered deposits at 10 percent confidence level. Not included in this estimate are extensions of known gold placer areas.

Metamorphic kyanite

Deposit characteristics:

The deposits consist of metamorphic rocks that contain as much as 47 percent kyanite. Kyanite-bearing zones are as much as 15,000 ft long and 1,600 ft wide. Several deposits are known in the region, but none have been productive.

Discussion:

One tract, defined by the outcrop of high-grade metamorphic rocks, is permissive for metamorphic kyanite deposits (fig. 28). Estimates of the number of unknown deposits and contained mineral endowment were not made because there is not sufficient data to develop descriptive and grade/tonnage models.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED MINERAL RESOURCES IN THE GROUP 5 STUDY AREA, INCLUDING PALISADES

SUMMARY

Within the group 5 study area, phosphate-rich beds of the Meade Peak Member of the Permian Phosphoria Formation occur in the Caribou Range between Bear Creek and Fall Creek (fig. 30). Although the grade and thickness of the phosphate beds in this area are less than those currently mined in the phosphate district of southeastern Idaho, the Bureau of Land Management has classified about 9,800 acres in the Caribou Range as known phosphate leasing area. Sheldon (1963, p. 154 and pl. 12) has estimated that for this area there are 68.1 million tons of high-grade, 228.7 million tons of medium-grade, and 603.4 million tons of low-grade rocks above entry level. In addition, there are 88.1 million tons of high-grade, 215.9 million tons of medium-grade, and 540.6 million tons of low-grade rock less than 5,000 ft below entry level.

INTRODUCTION

During 1989 and 1990, the USGS conducted geologic, geochemical, geophysical, and mineral-resource studies in and around the proposed wilderness areas of group 5 (fig. 29). The purpose was to provide data adequate for assessment of the potential for undiscovered mineral resources within or near the proposed wilderness areas. The quantitative assessment of the group 5 area was performed in March 1991, with data available at that time.

The assessment of potential for undiscovered mineral resources was performed for an area that encompassed the proposed wilderness areas and all known roadless areas in their vicinity. Within the proposed wilderness areas, the assessment is based on site-specific data gathered for this study. In the intervening areas, the assessment is based on existing information and limited reconnaissance. Additional site-specific studies are needed to complete the assessments in these intervening areas.

ASSESSMENT TEAM

George Desborough	Branch of Central Mineral Resources, Denver
Harley King	Branch of Geochemistry, Denver

BACKGROUND DATA

Assessment of potential for undiscovered mineral deposits is a complex process based on the interrelationships of geologic, geochemical, geophysical, and mineral-resource data that are both local and regional in scope. A short summary of the data available for the group 5 study area follows.

Geology

Rocks exposed in the area are sedimentary and range in age from Cambrian to Cretaceous. These strata include sandstone, shale, siltstone, limestone, dolostone, and phosphorite; all have been thrust from west to east.

Geochemistry

Geochemical data comprised panned-concentrate and stream-sediment samples collected for this study within or close to the proposed wilderness areas. These data were used to characterize the geochemical signature of the various rock types in the area. No anomalous metal concentrations were found.

MINERAL RESOURCES

Bedded phosphorite is the major known mineral resource in the study area, and it occurs at the surface chiefly in the Caribou Range. This phosphorite occurs in beds of the Meade Peak Member of the Phosphoria Formation of Permian age. Thickness and grade values for three localities in the study area are given in table 1.

Table 1.—Thickness and phosphate content of the Meade Peak Member of the Phosphoria Formation at three localities in the Caribou Range, Bonneville County, Idaho. [Data from Bureau of Land Management, 1990]

Location	Thickness (feet)	P_2O_5 (percent)
Fall Creek (bulldozer trench, Lot No. 1338)		
	1.0	waste
	3.4	26.7
	17.0	waste
	1.6	24.4
	9.2	waste
	10.9	18.4
	10.3	waste
Indian Creek (bulldozer trench, CF-26)		
	1.0	waste
	5.9	29.2
	3.0	waste
	2.0	16.7
	15.9	waste
	6.9	14.1
	4.2	29.0
	1.3	waste
	1.1	30.1
	1.1	waste
	0.3	26.7
	3.6	waste
Bear Creek (bulldozer trench, Lot No. 1353)		
	12.7	32.9
	1.9	waste
	3.5	13.6
	12.2	waste
	5.5	13.0
	1.9	27.5
	4.8	waste
	5.1	20.3
	3.3	25.2
	0.8	waste
	4.5	30.0
	1.3	waste
	0.4	31.7
	2.0	waste

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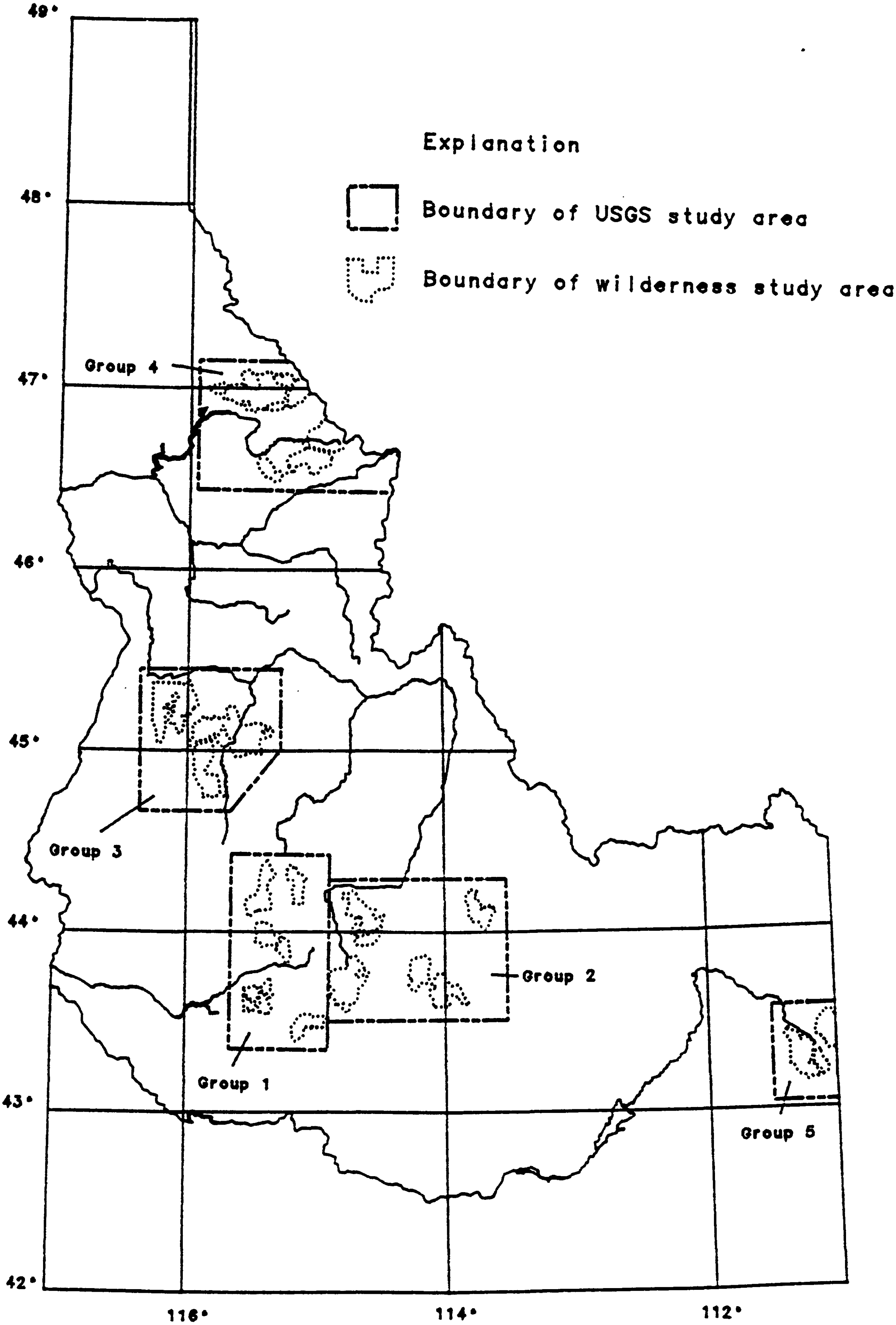

Figure 1. Map showing boundaries of proposed wilderness areas and USGS study areas.

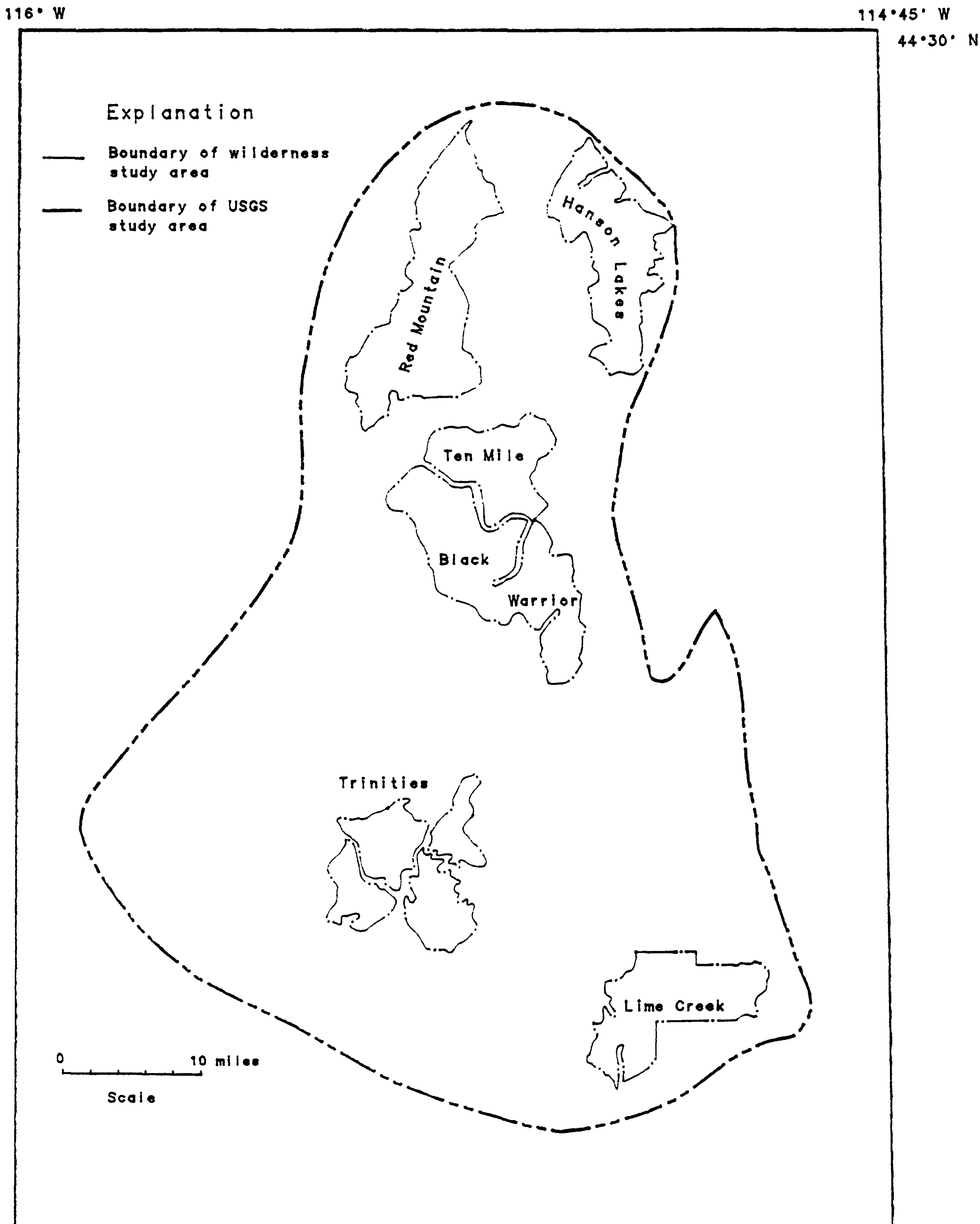

Figure 2. Map showing boundaries of proposed wilderness areas and USGS group 1 study area.

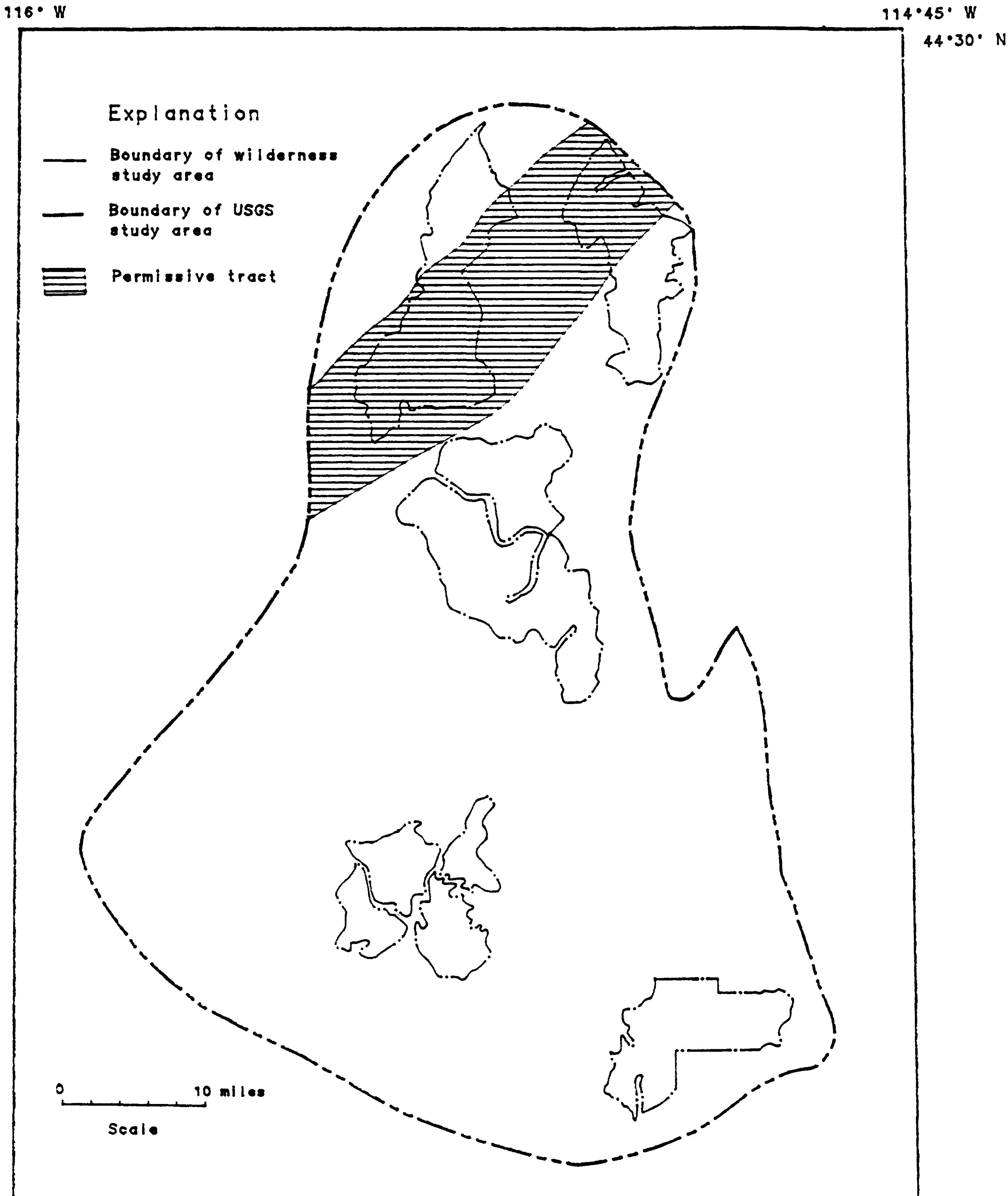

Figure 3. Map showing tract permissive for undiscovered Tertiary low-fluorine molybdenum deposits in group 1 study area.

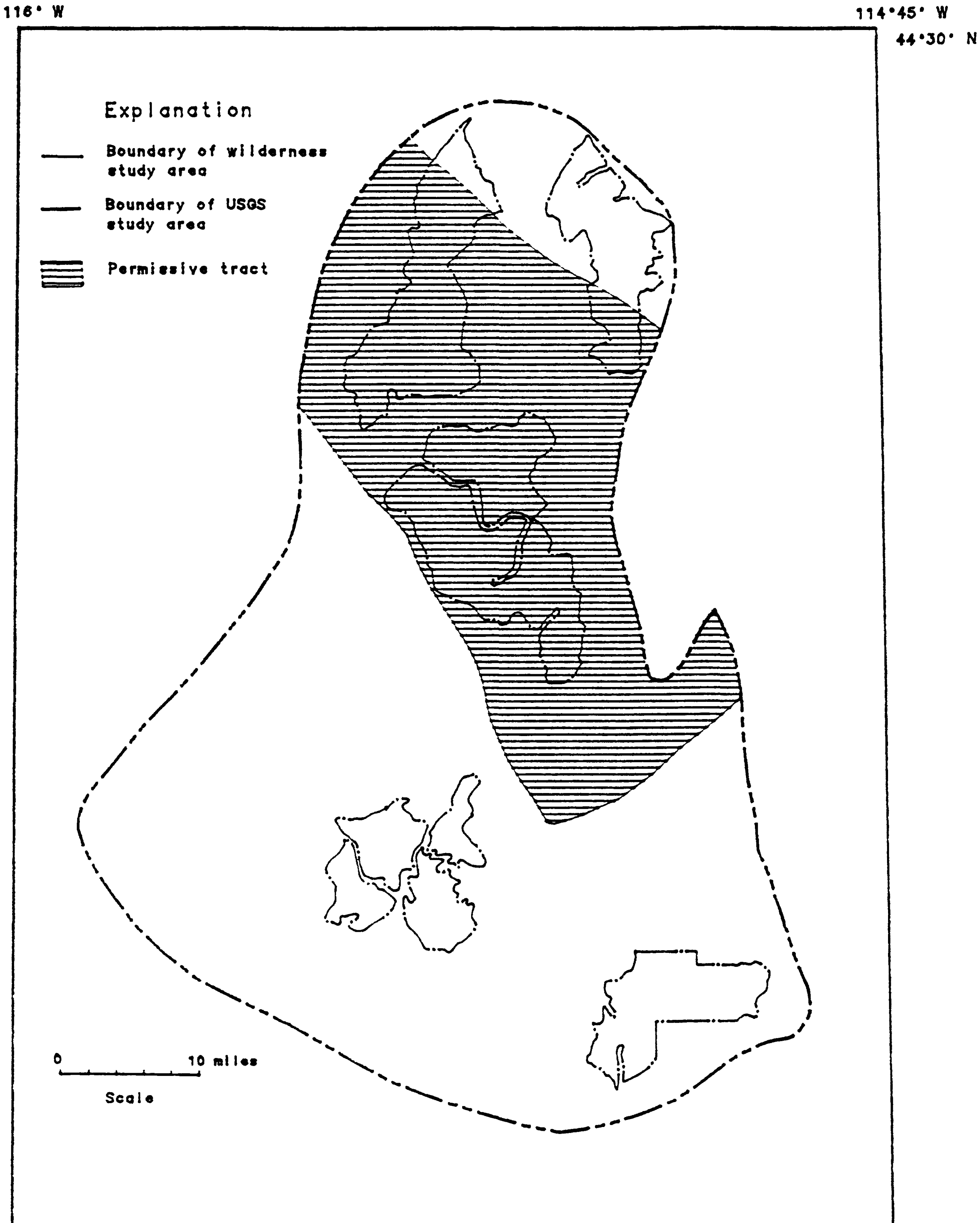

Figure 4. Map showing tract permissive for undiscovered Cretaceous low-fluorine molybdenum deposits in group 1 study area.

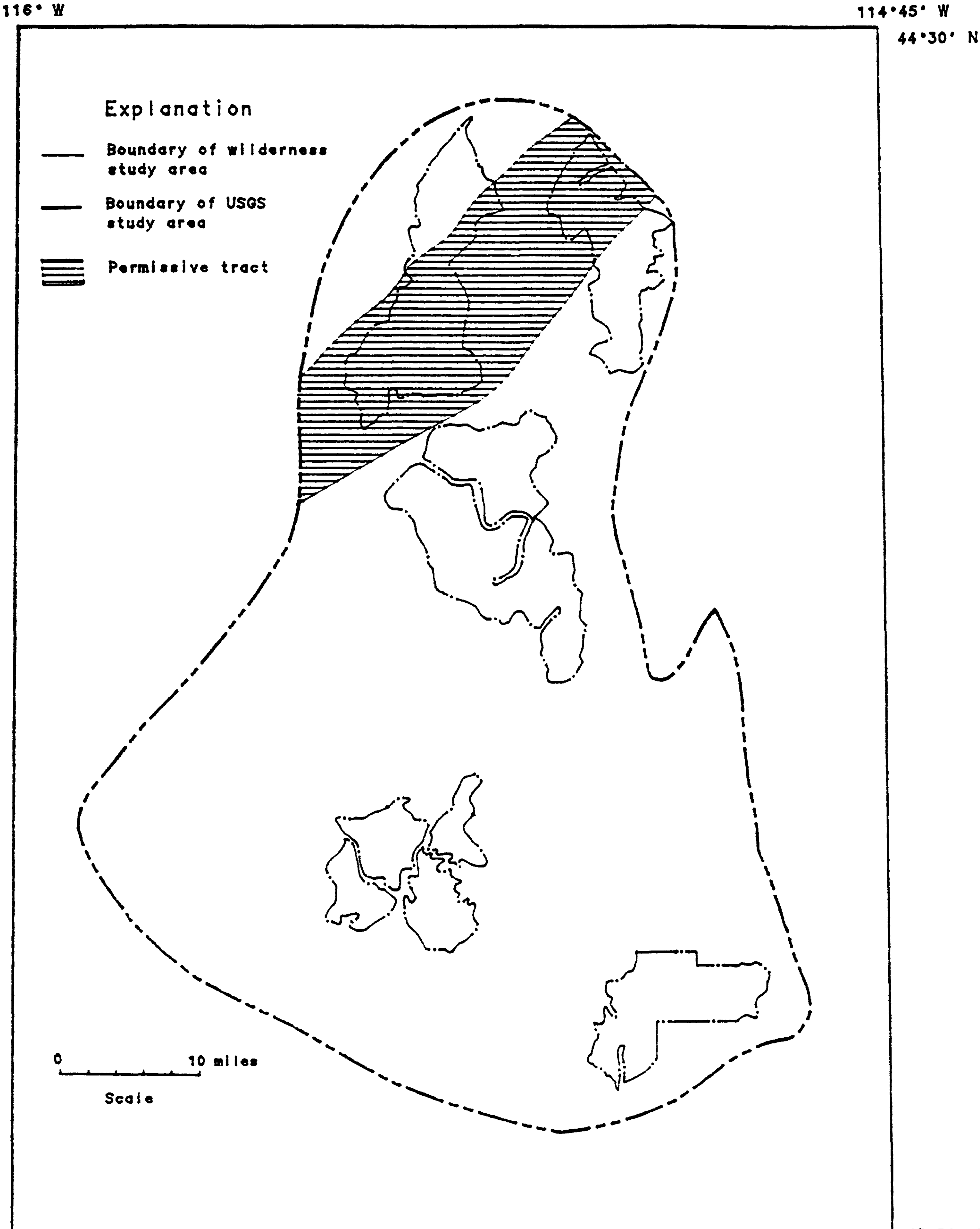

Figure 5. Map showing tract permissive for undiscovered Comstock-type epithermal vein deposits in group 1 study area.

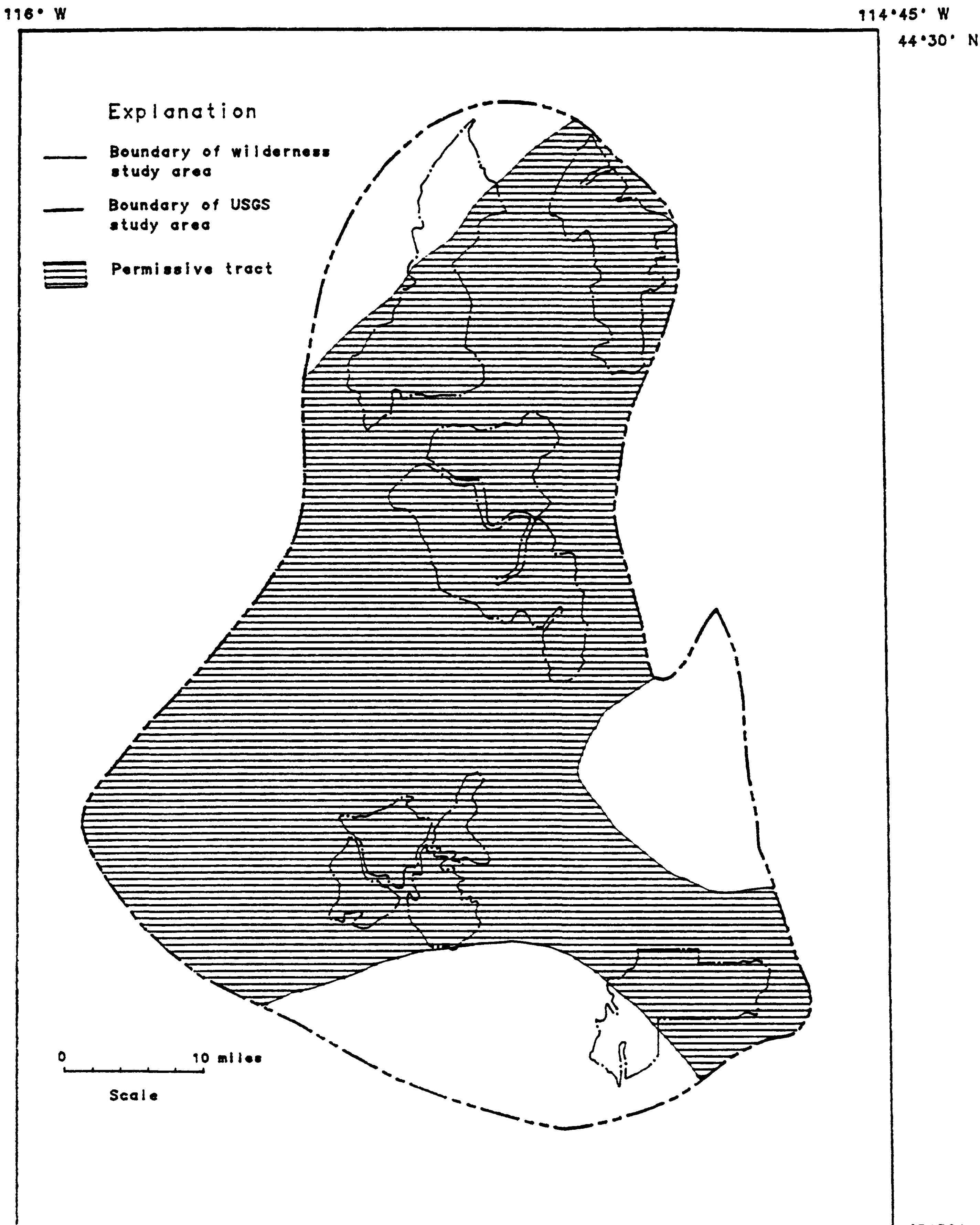

Figure 6. Map showing tract permissive for undiscovered polymetallic quartz vein and lode deposits in group 1 study area.

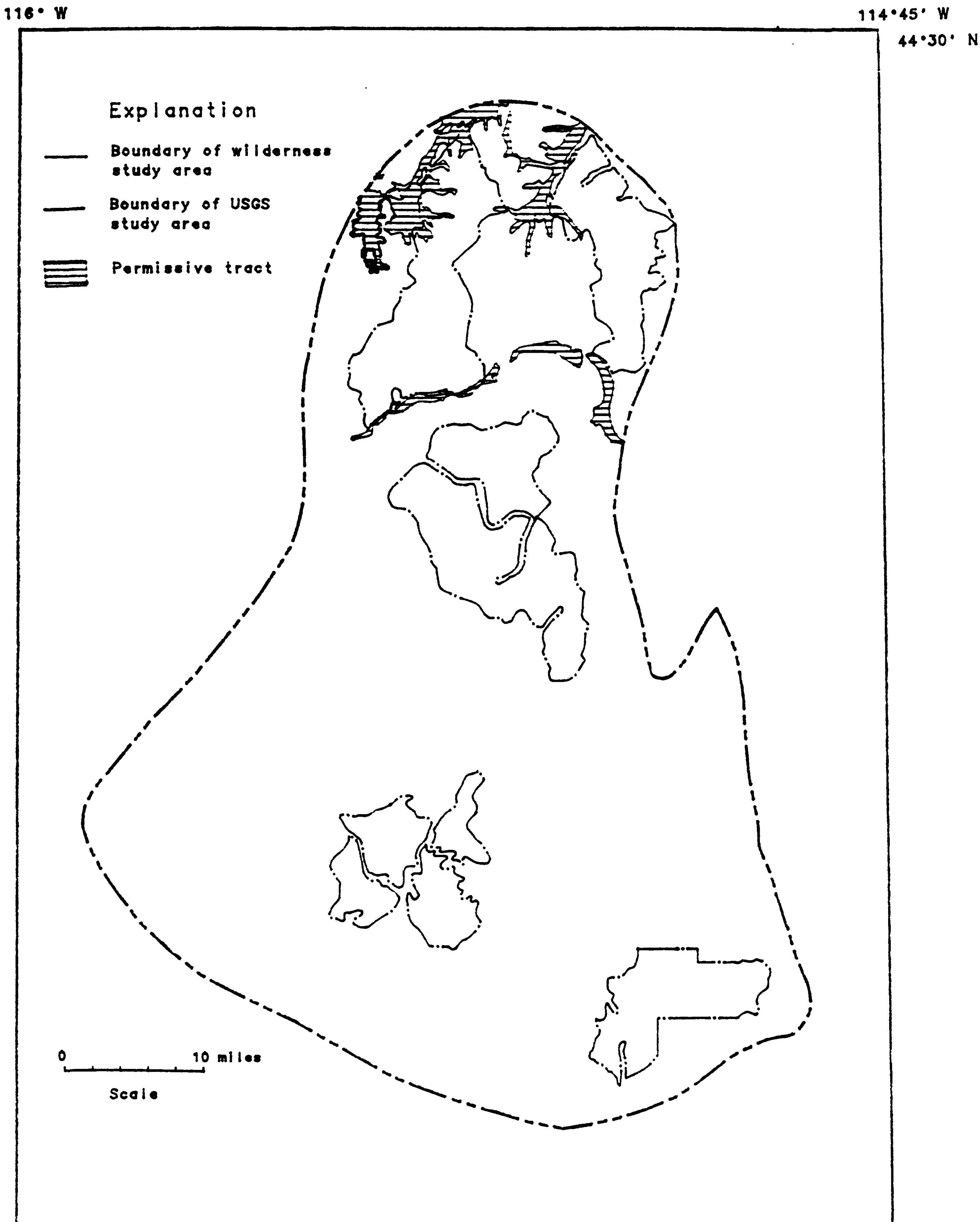

Figure 7. Map showing tracts permissive for undiscovered radioactive black sand placer deposits in group 1 study area.

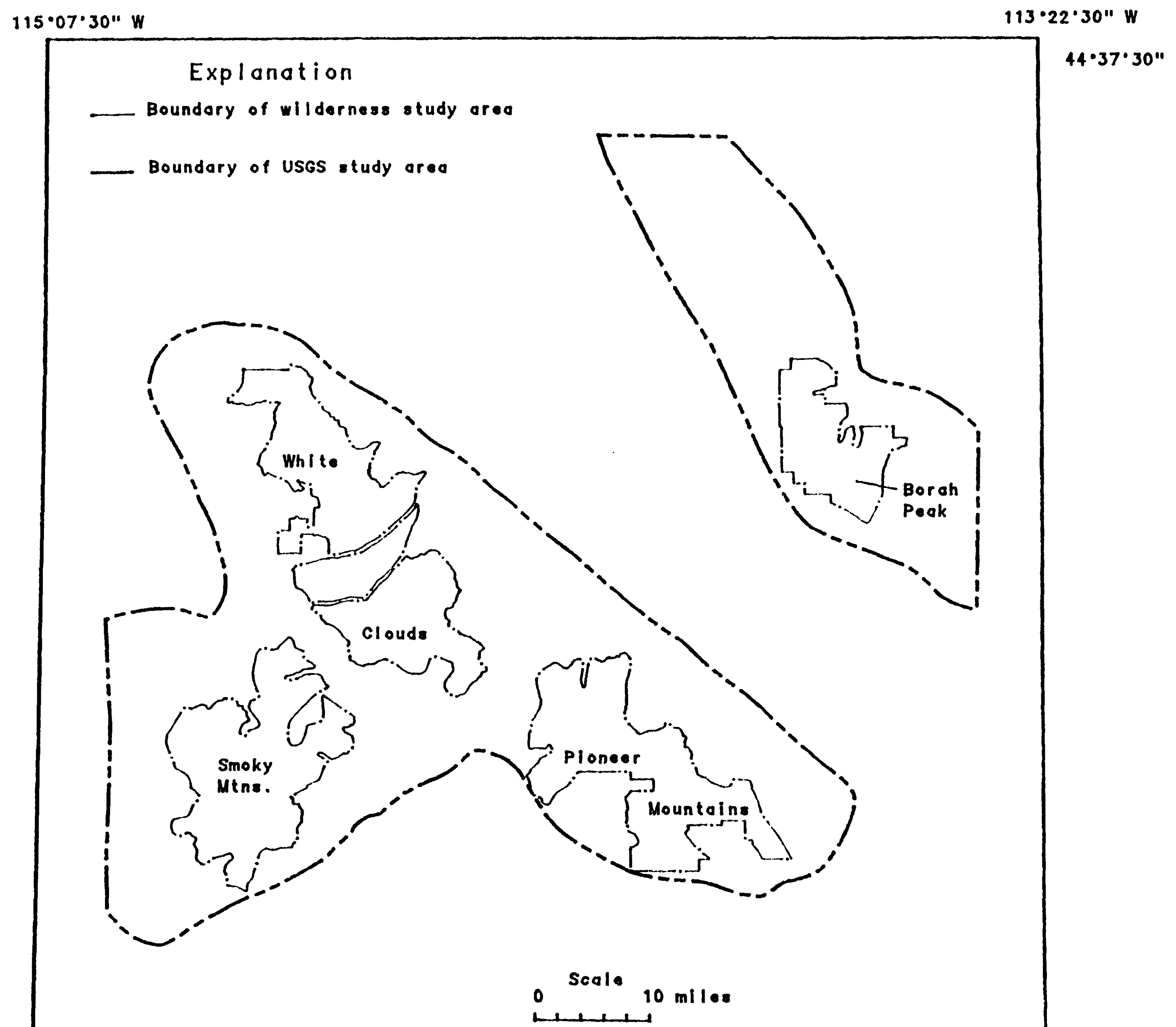

Figure 8. Map showing boundaries of proposed wilderness areas and USGS group 2 study area.

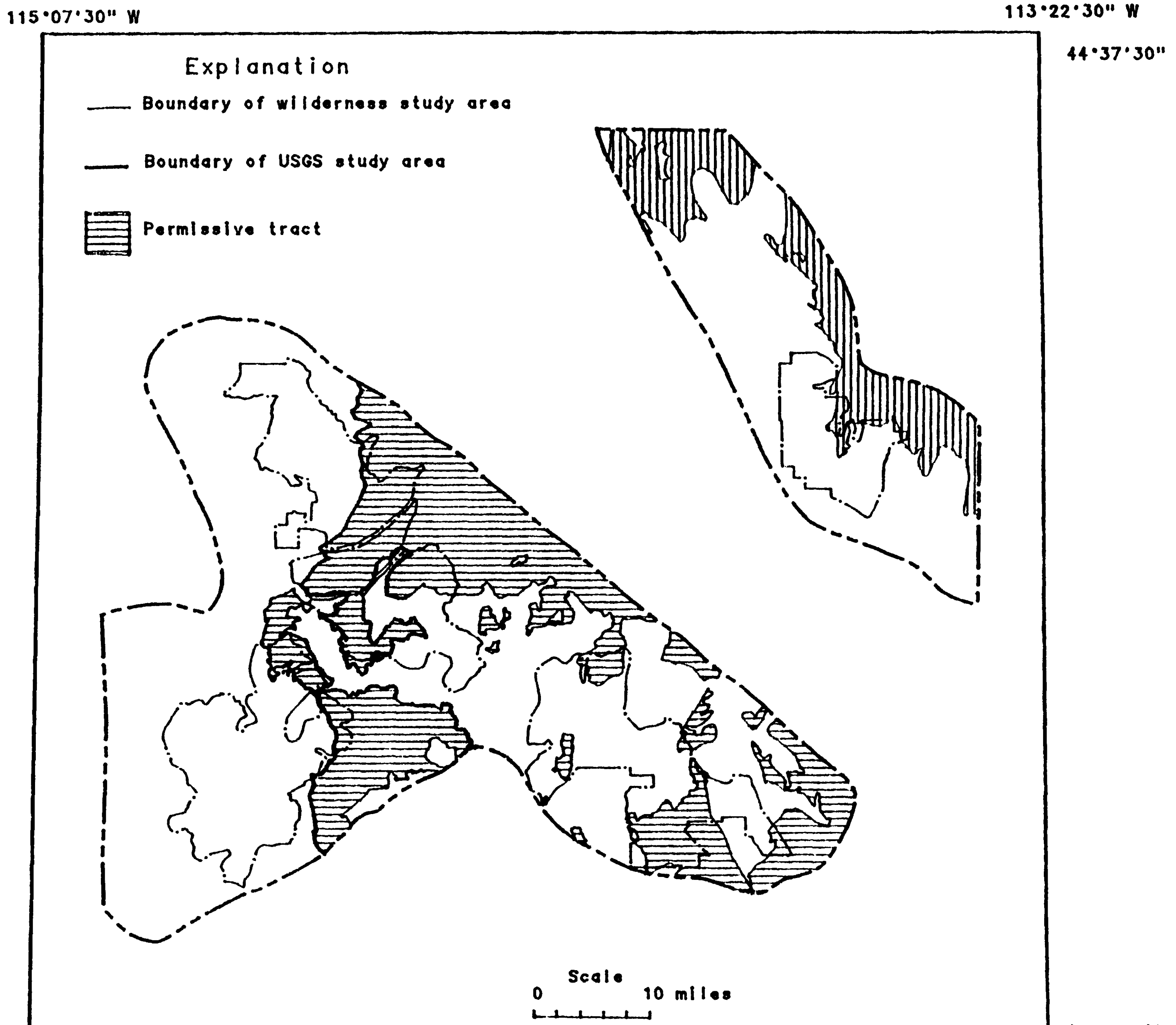

Figure 9. Map showing tracts permissive for undiscovered Comstock-type epithermal vein deposits in group 2 study area. Horizontal rule denotes tract 2; vertical rule denotes tract 1.

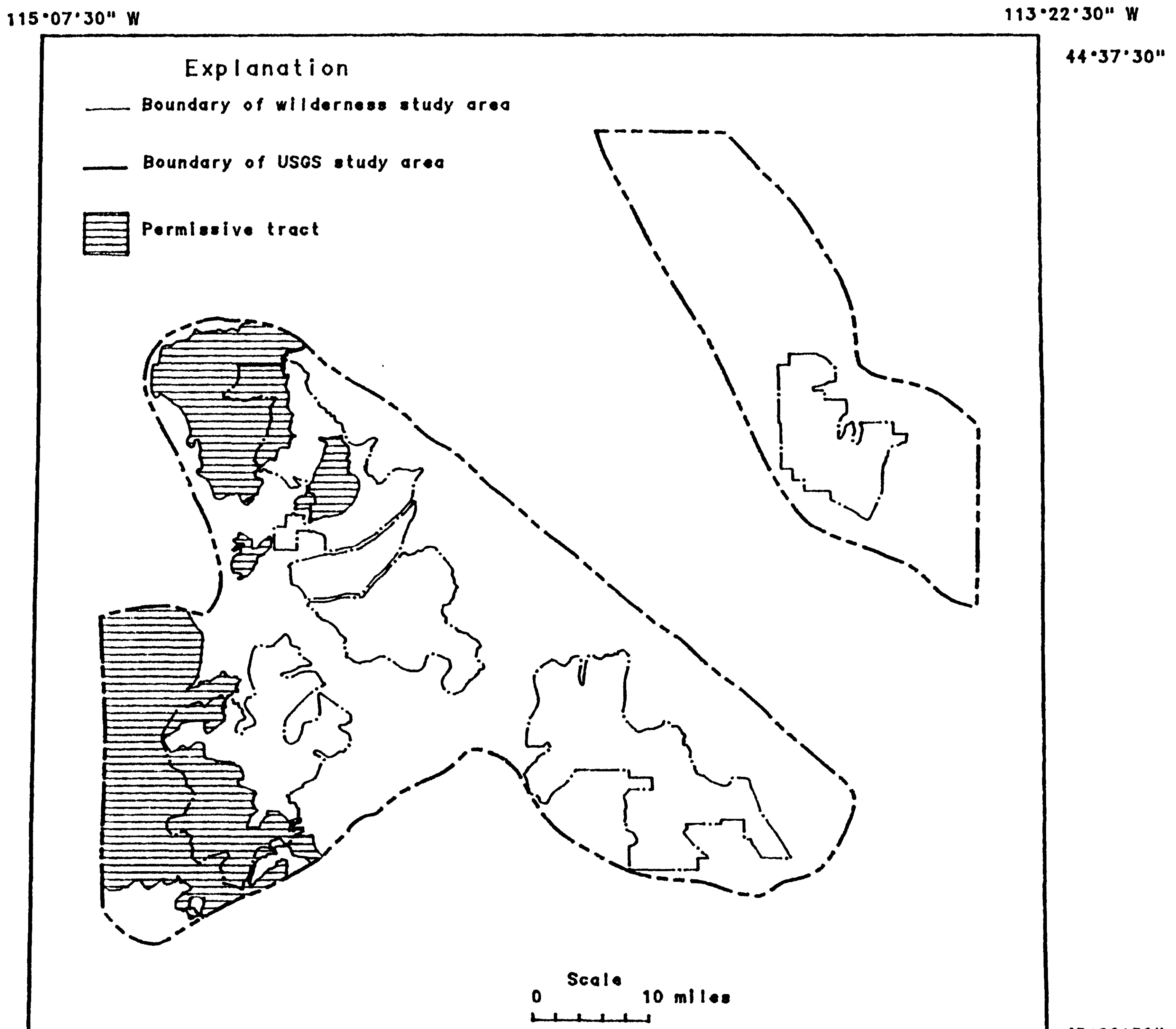

Figure 10. Map showing tracts permissive for undiscovered polymetallic quartz vein and lode deposits in group 2 study area.

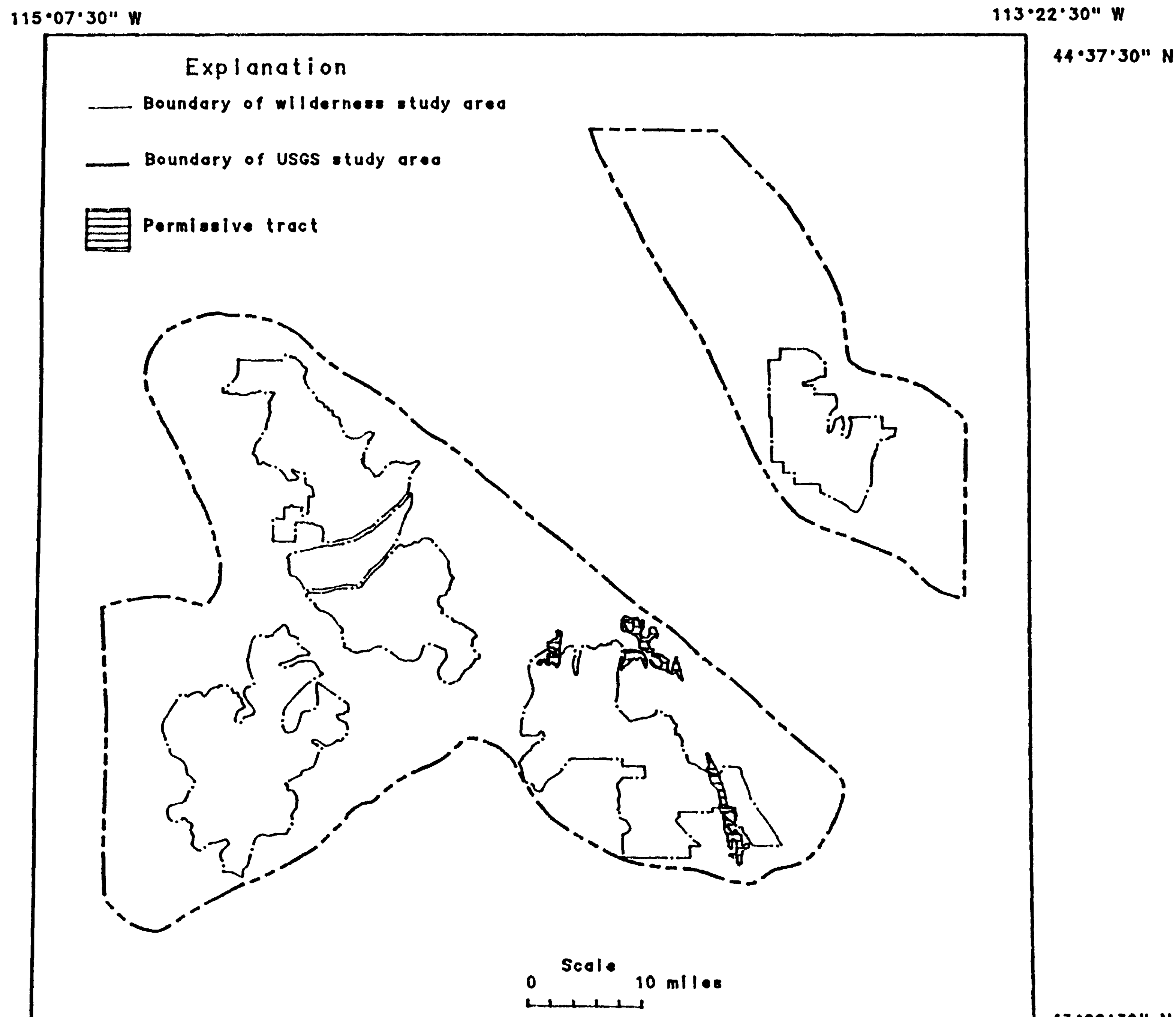

Figure 11. Map showing tracts permissive for undiscovered zinc-lead skarn deposits in group 2 study area.

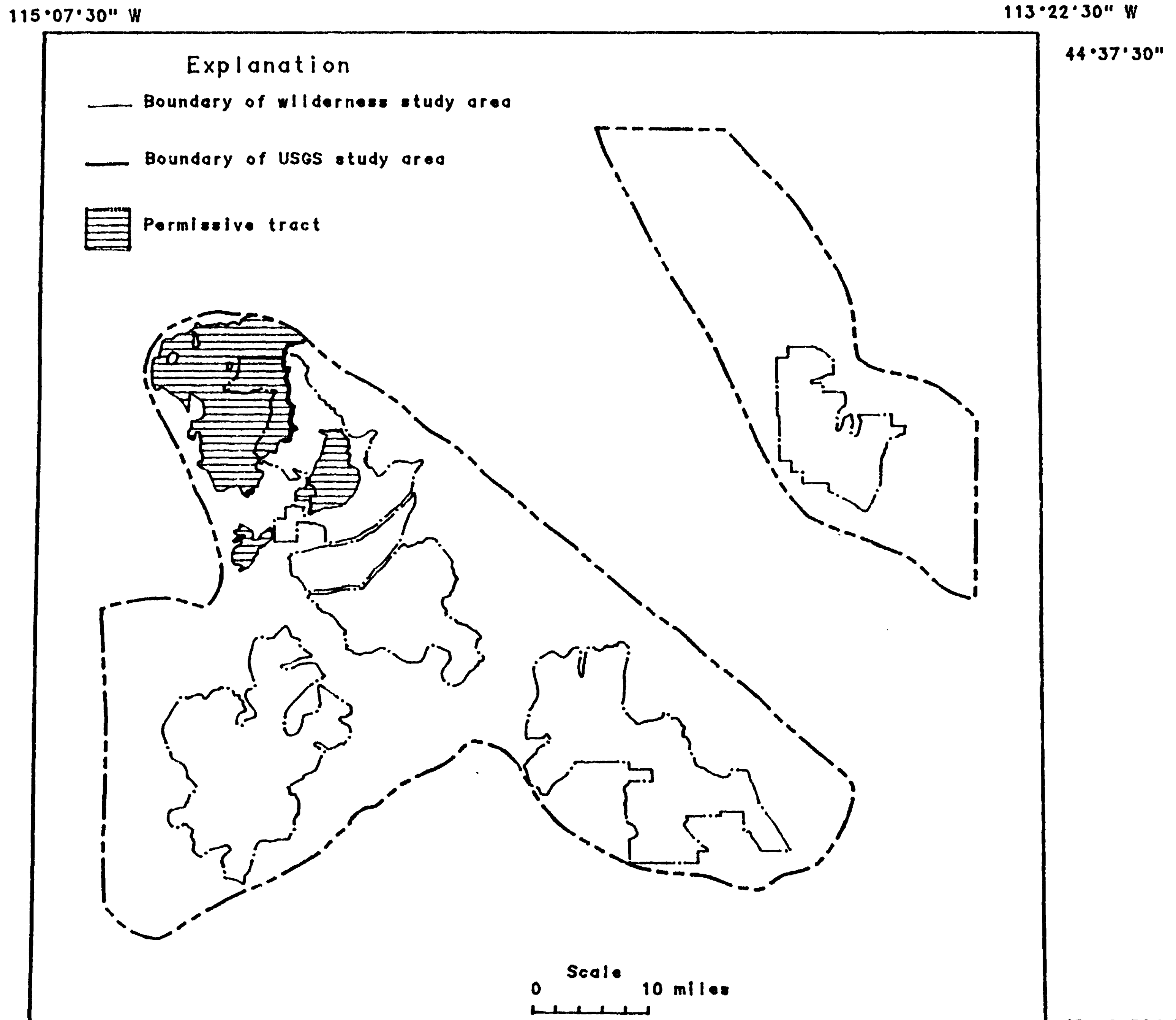

Figure 12. Map showing tracts permissive for undiscovered Cretaceous low-fluorine molybdenum deposits in group 2 study area.

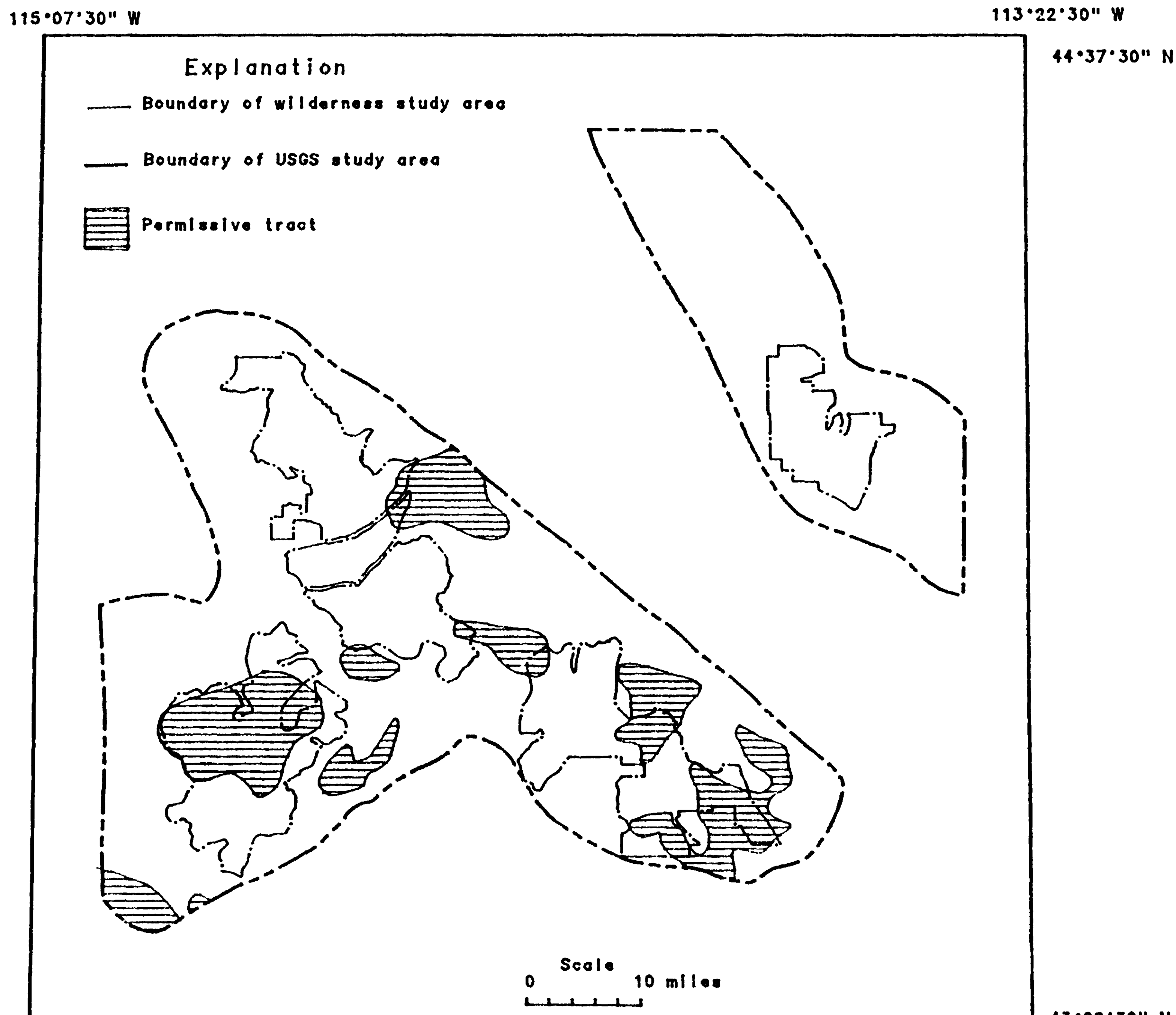

Figure 13. Map showing tracts permissive for Tertiary low-fluorine porphyry molybdenum deposits in group 2 study area.

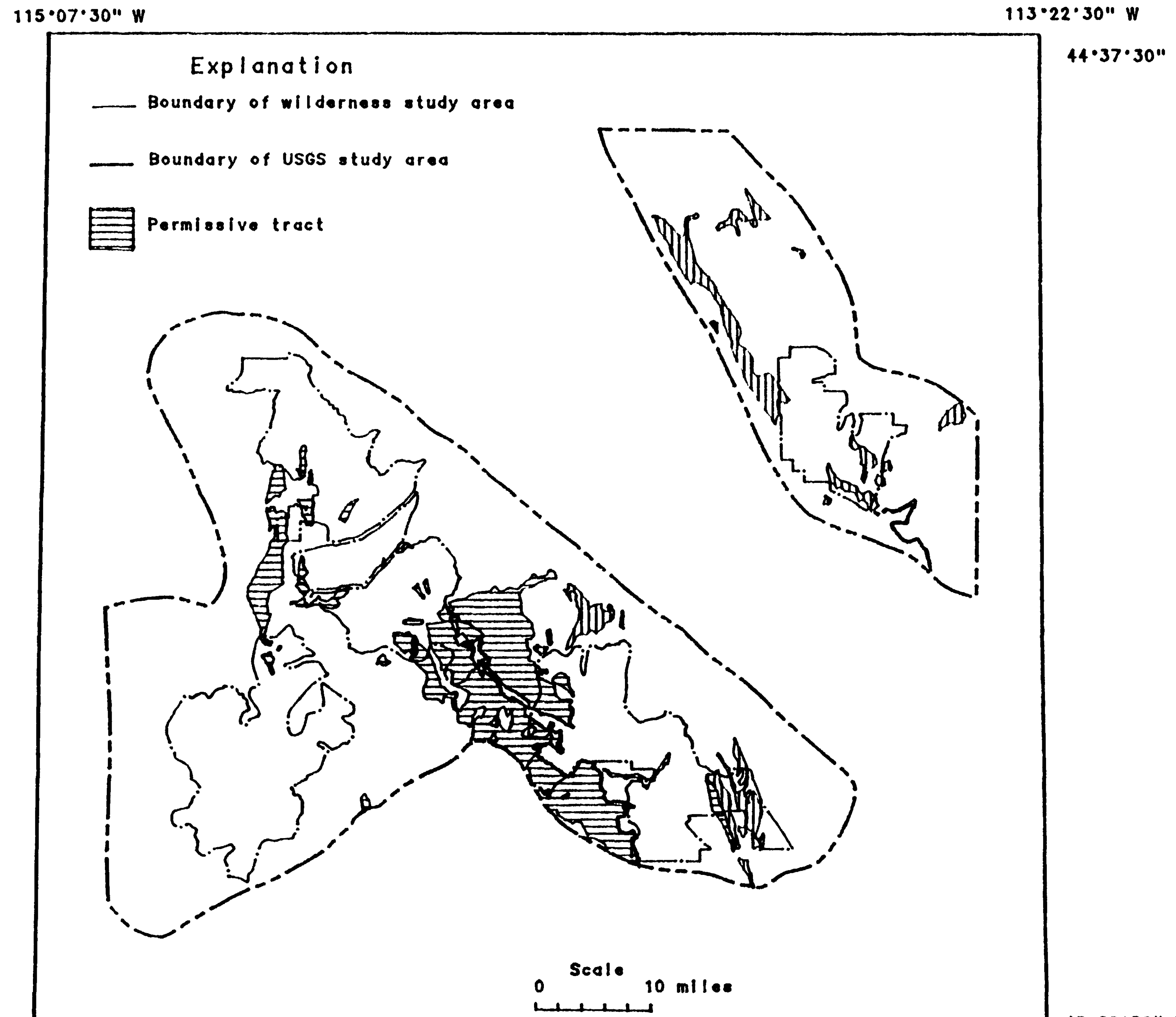

Figure 14. Map showing tracts permissive for undiscovered polymetallic vein deposits in group 2 study area. Horizontal rule denotes tracts for which estimate was made.

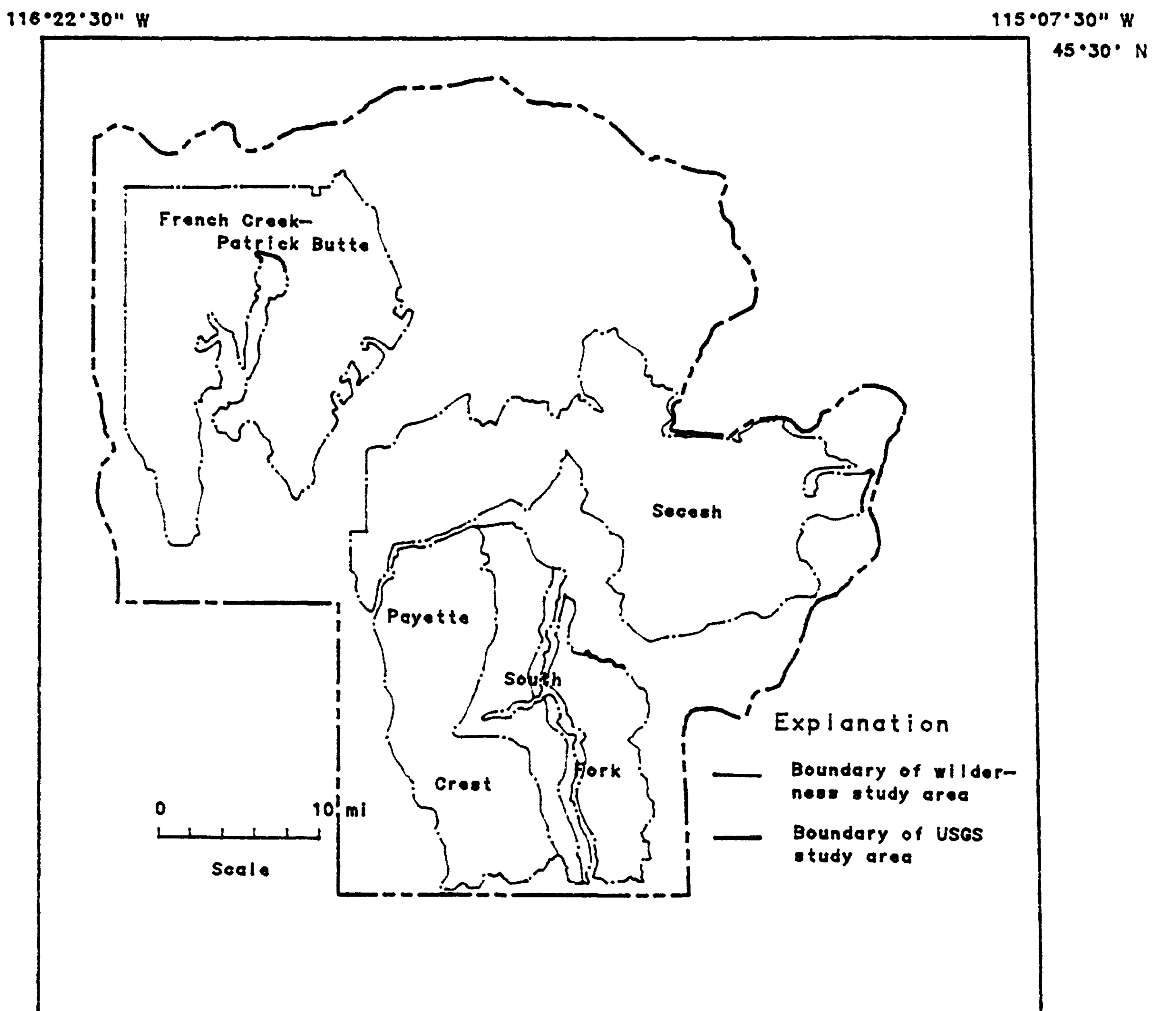

Figure 15. Map showing boundaries of proposed wilderness areas and USGS group 3 study area.

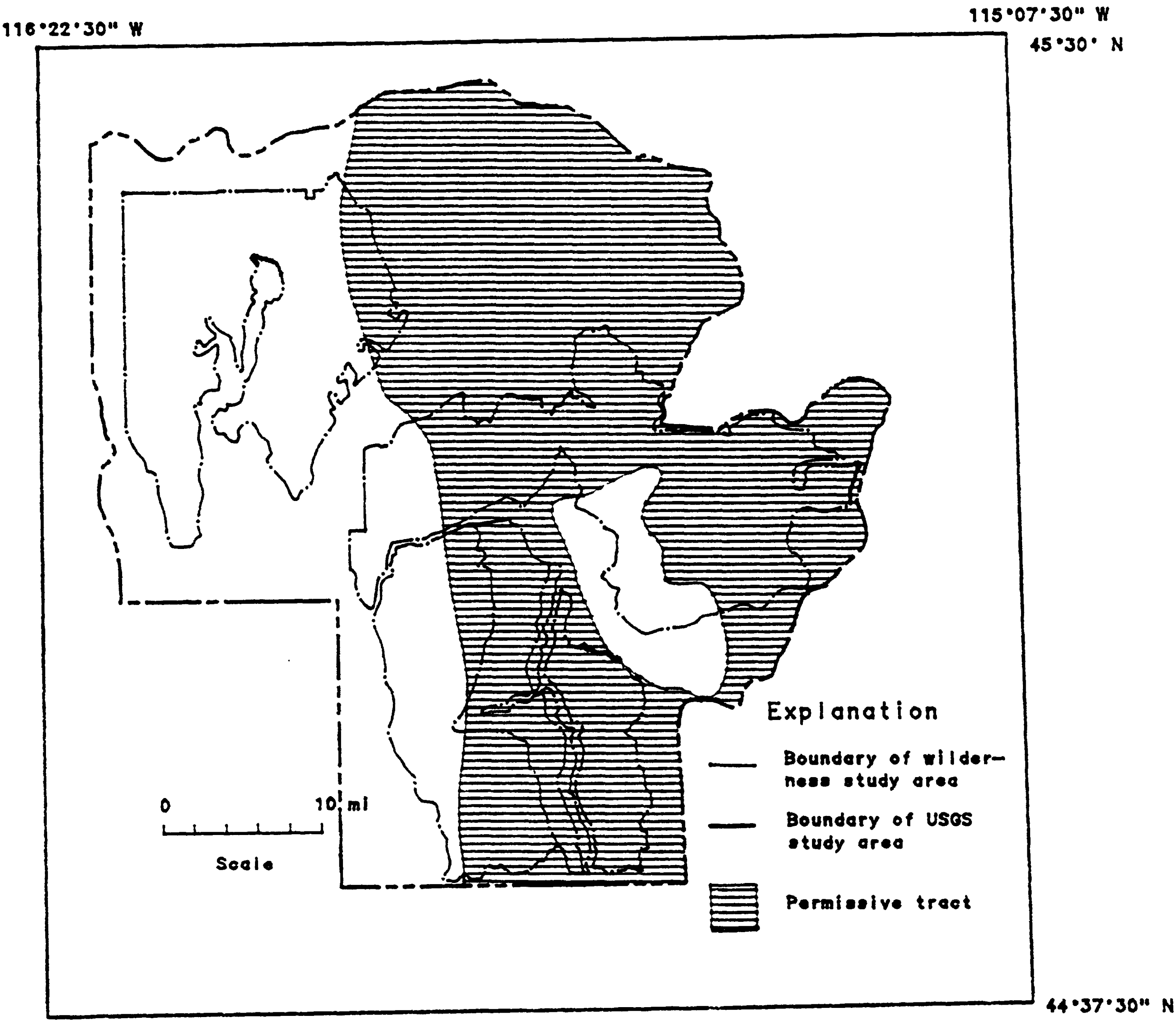

Figure 16. Map showing tract permissive for undiscovered polymetallic quartz vein and lode deposits in group 3 study area.

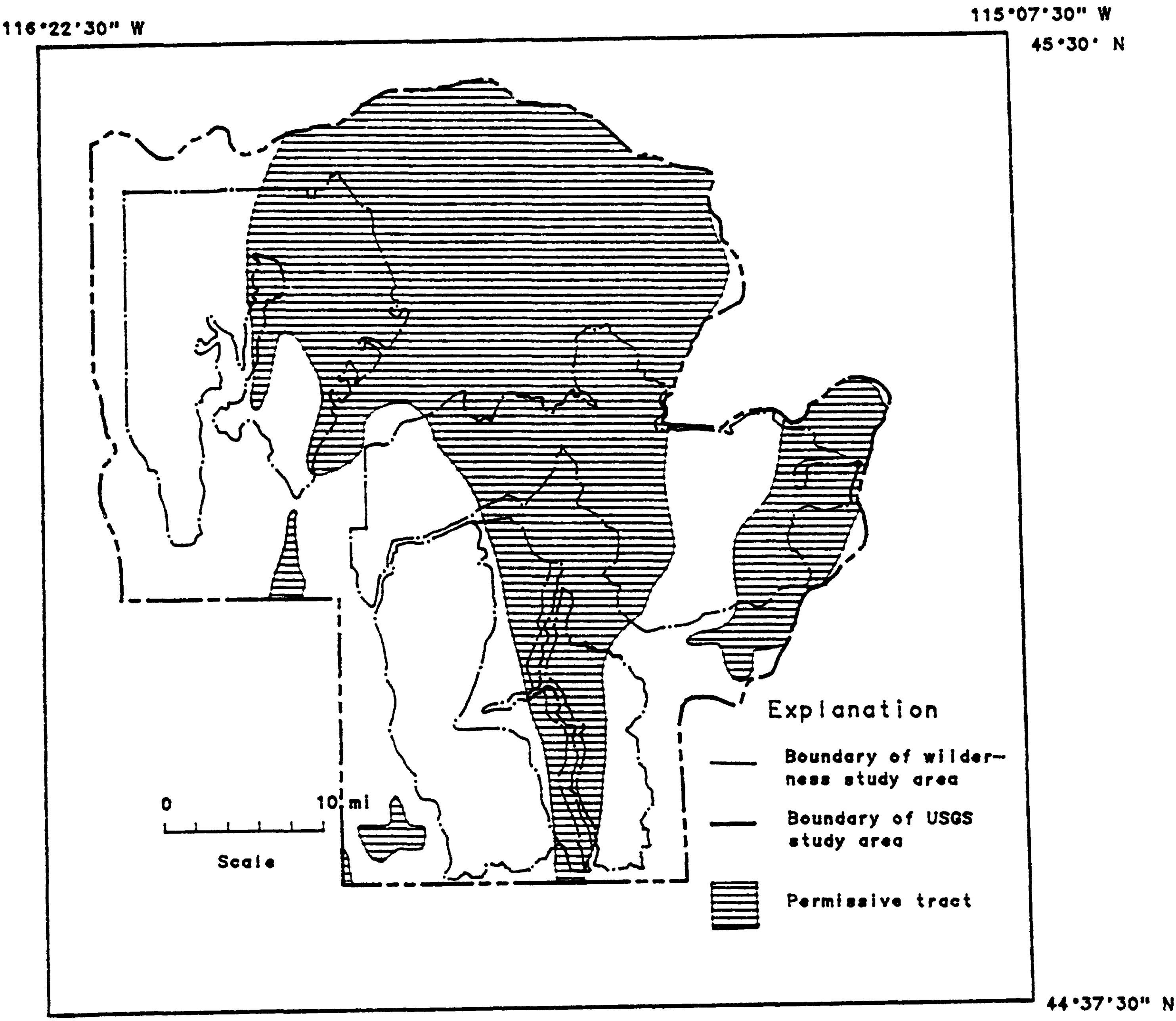

Figure 17. Map showing tracts permissive for undiscovered placer gold deposits in group 3 study area.

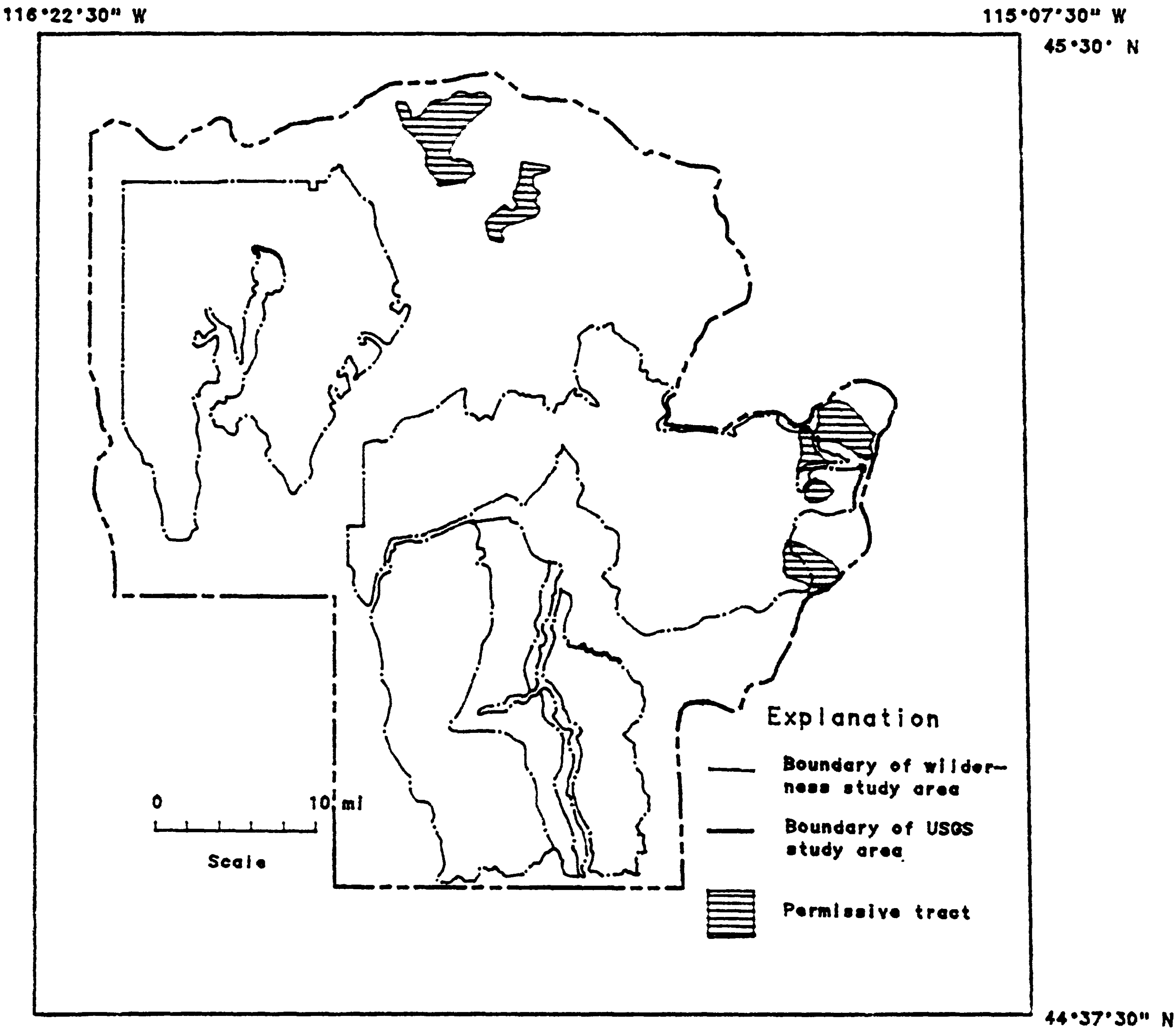

Figure 18. Map showing tracts permissive for undiscovered tungsten skarn deposits in group 3 study area.

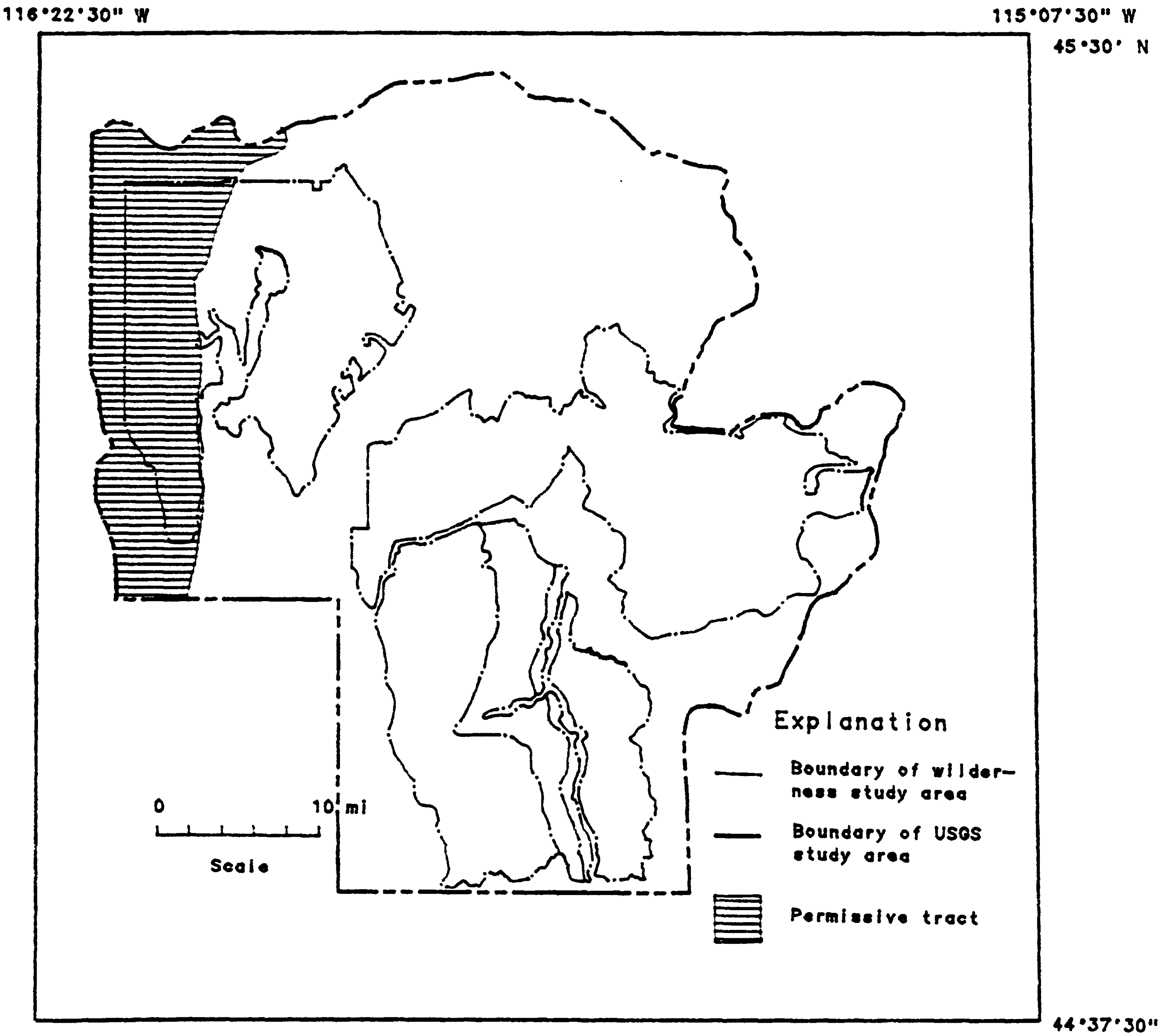

Figure 19. Map showing tracts permissive for undiscovered stratabound volcanic deposits in group 3 study area.

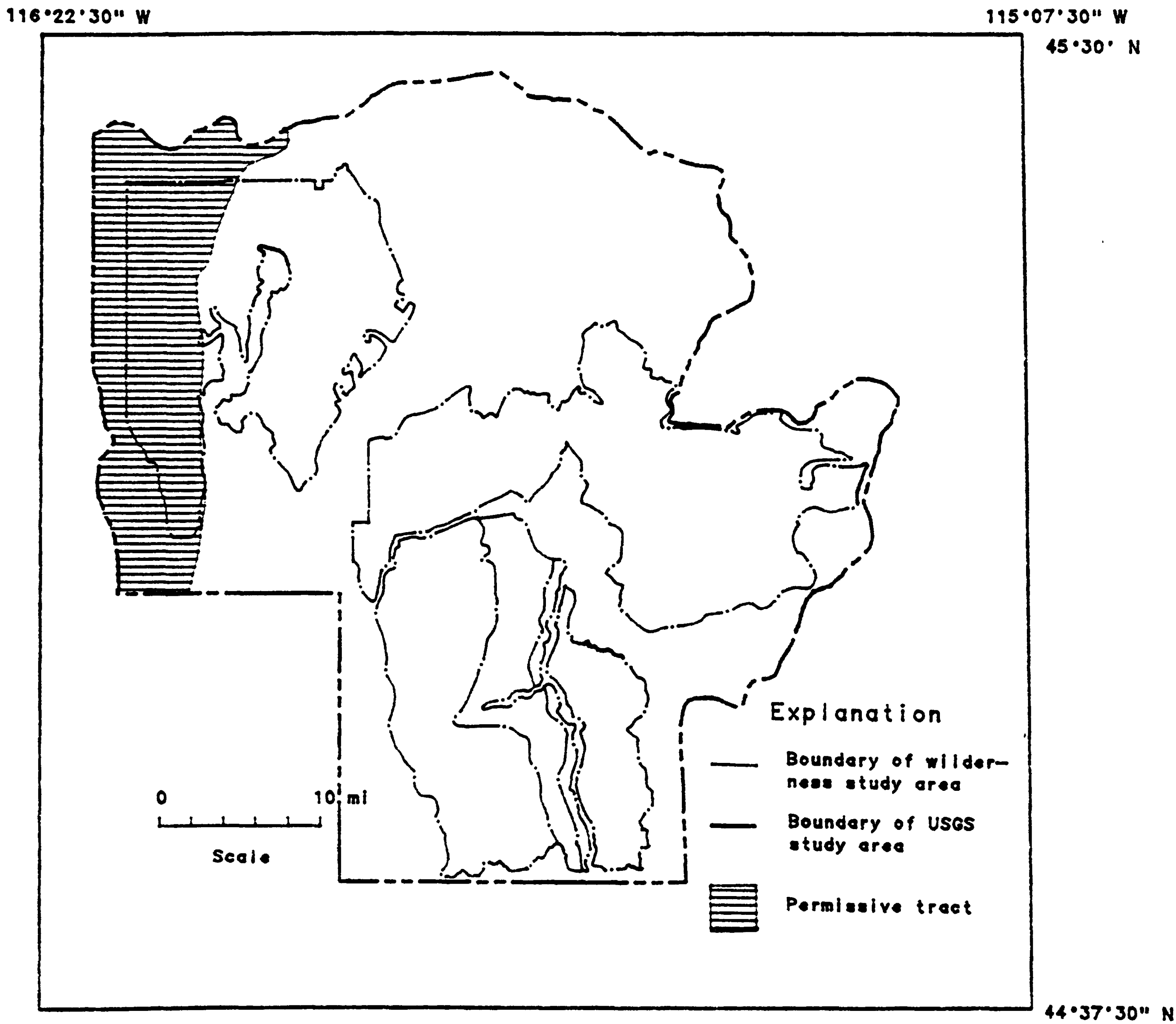

Figure 20. Map showing tract permissive for undiscovered low-sulfide gold deposits in group 3 study area.

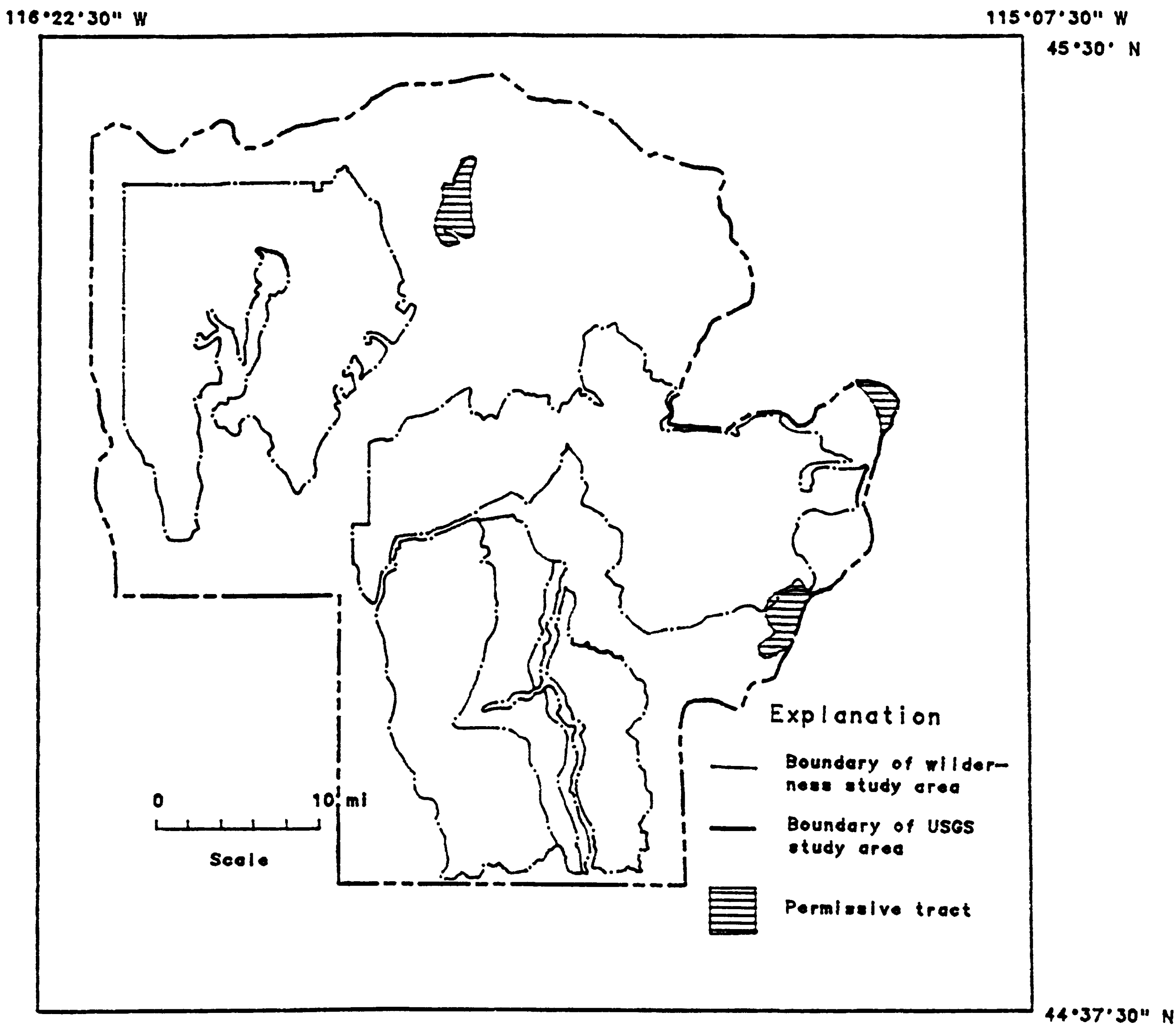

Figure 21. Map showing tracts permissive for undiscovered sediment-hosted (Blackbird-type) cobalt-copper deposits in group 3 study area.

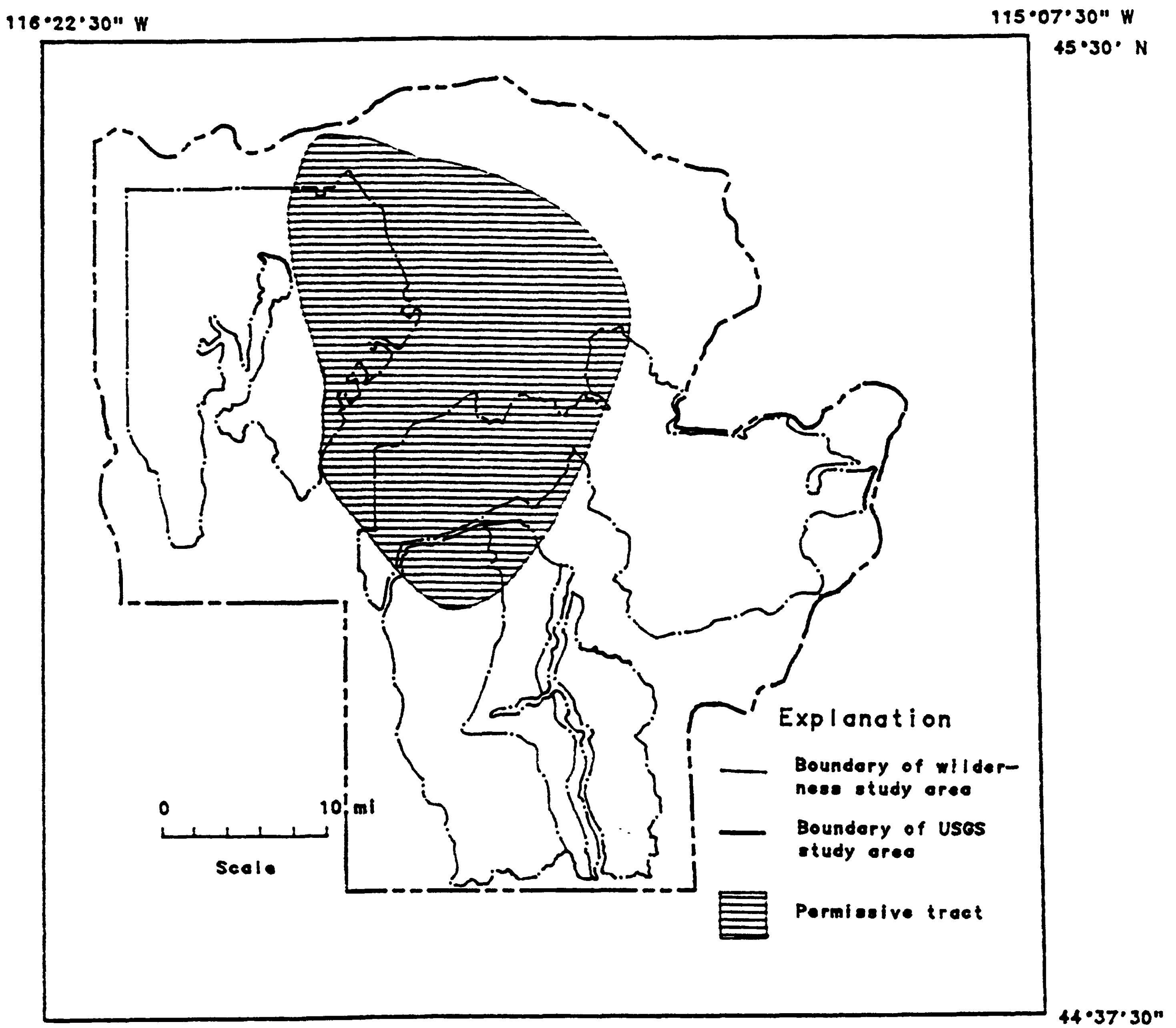

Figure 22. Map showing tract permissive for undiscovered radioactive black sand placer deposits in group 3 study area.

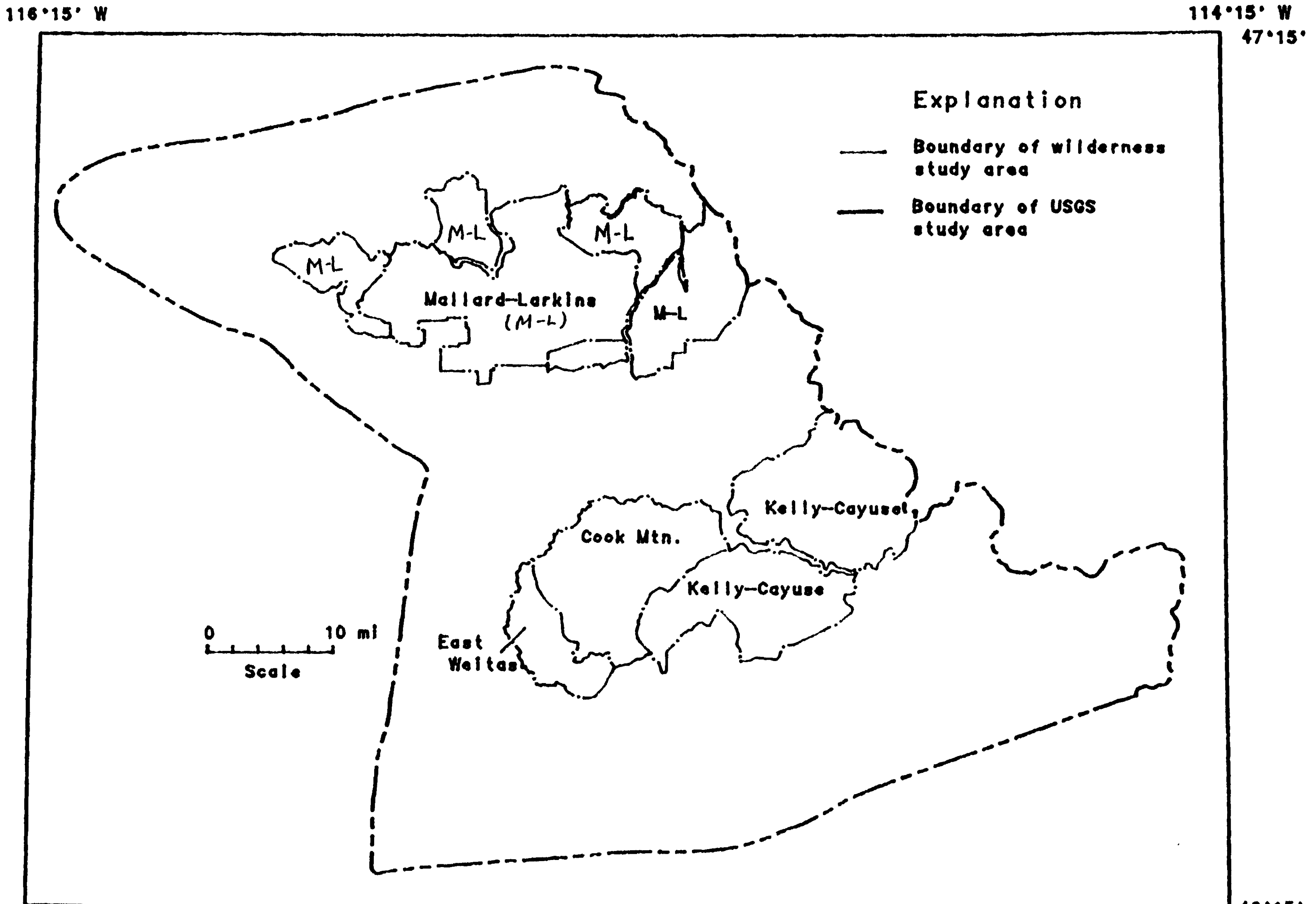

Figure 23. Map showing boundaries of proposed wilderness areas and USGS group 4 study area.

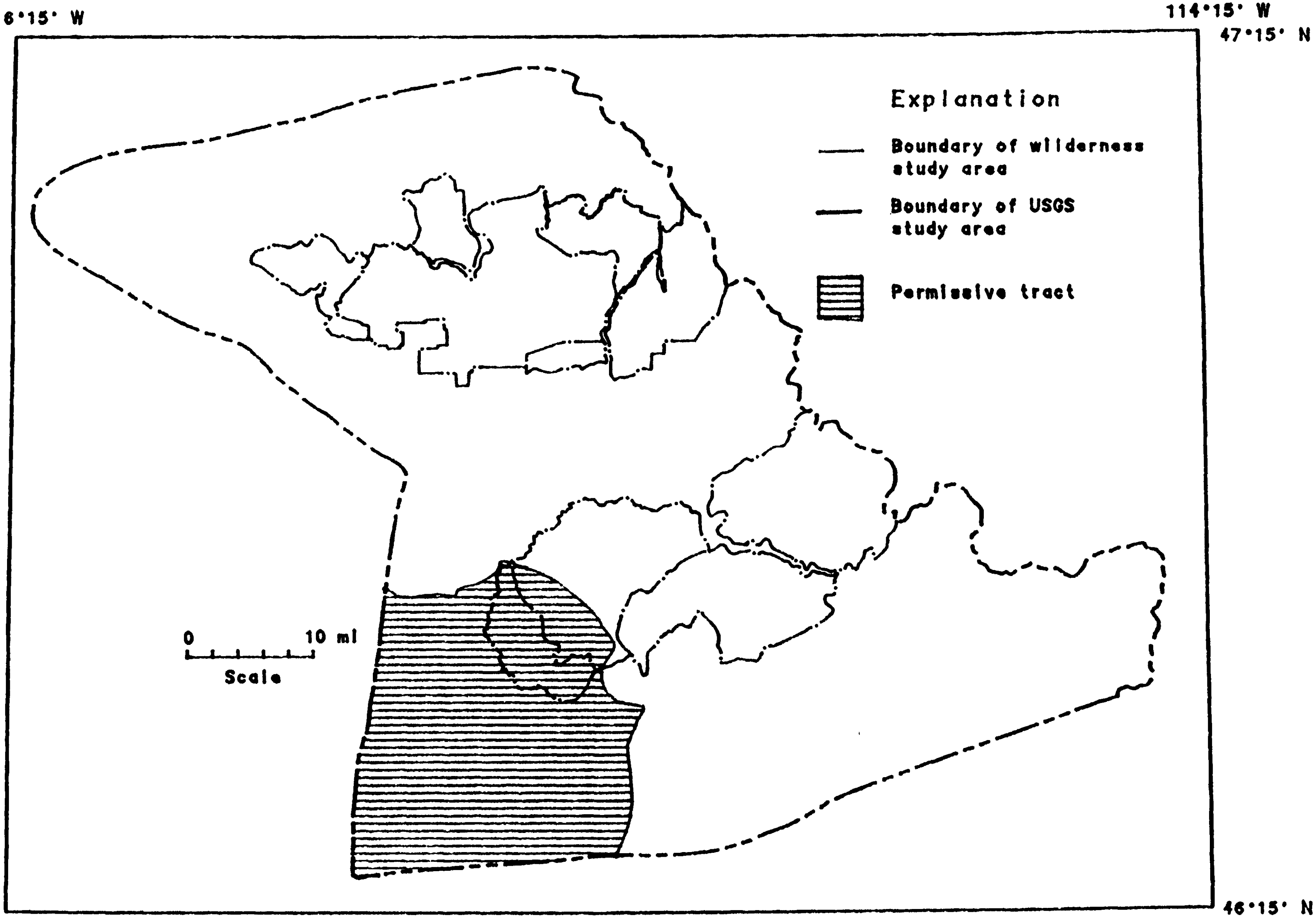

Figure 24. Map showing tract permissive for undiscovered polymetallic quartz vein and lode deposits in group 4 study area.

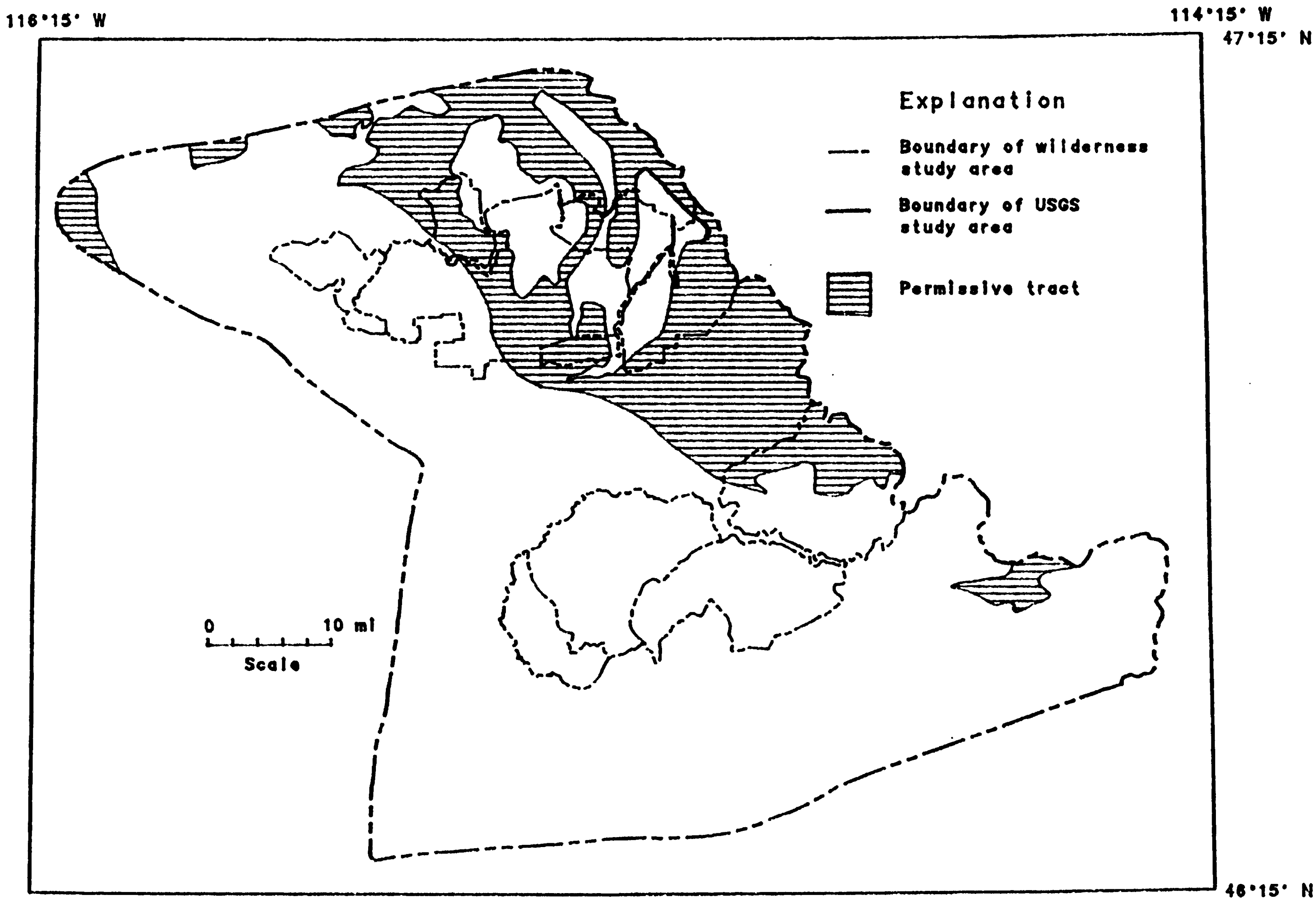

Figure 25. Map showing tracts permissive for undiscovered polymetallic vein deposits in group 4 study area.

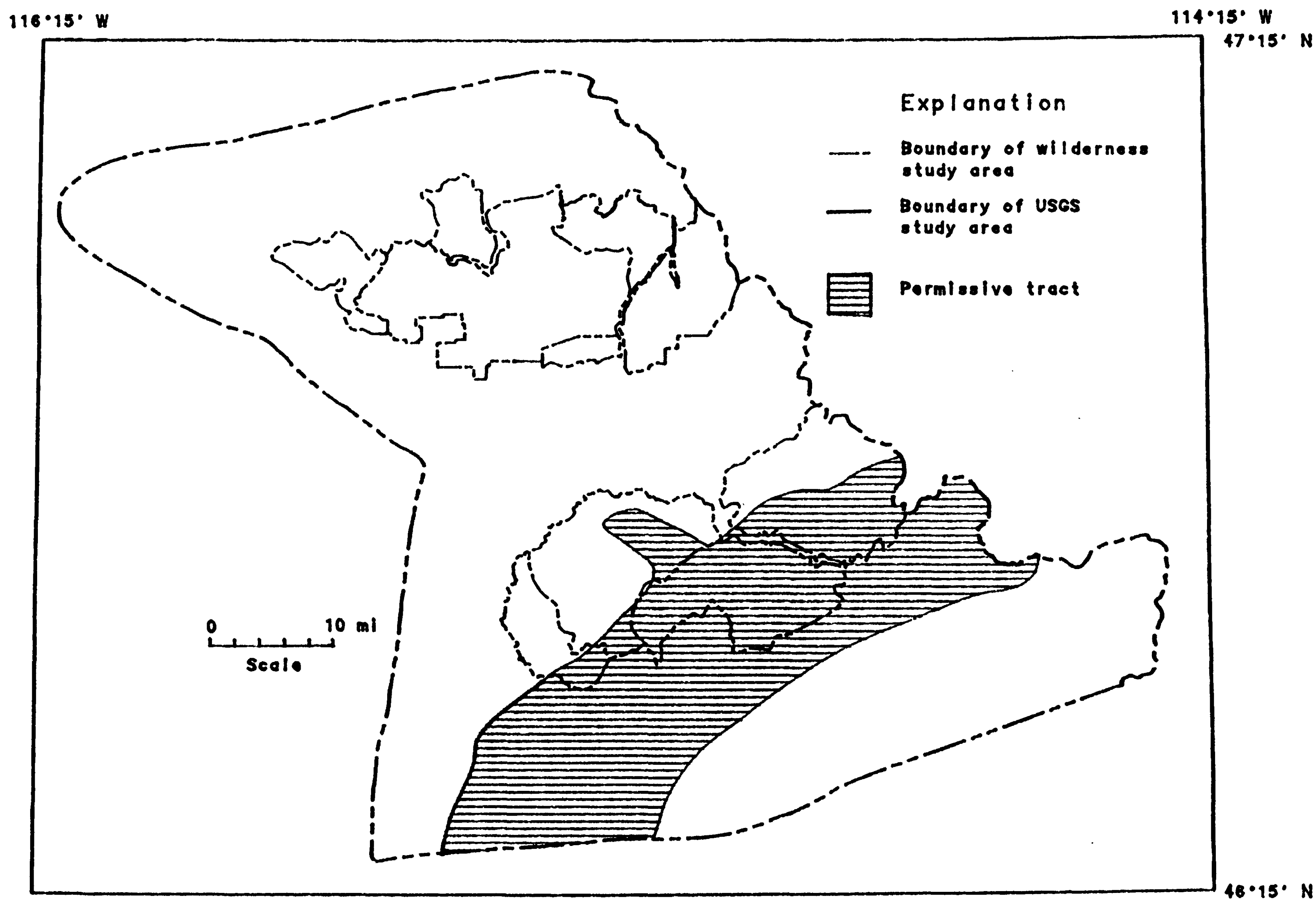

Figure 26. Map showing tract permissive for undiscovered Comstock-type epithermal vein deposits in group 4 study area.

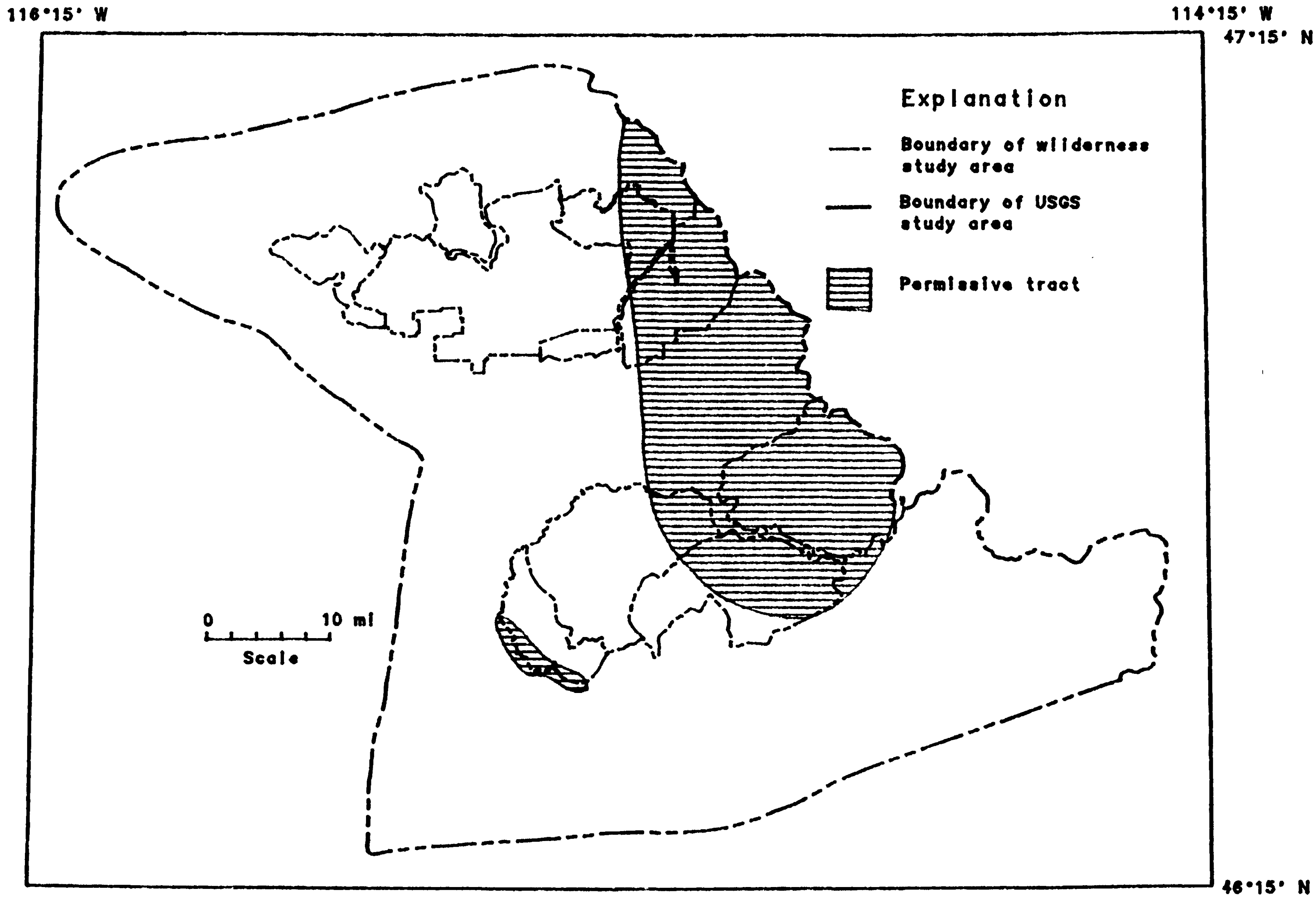

Figure 27. Map showing tracts permissive for undiscovered placer gold deposits in group 4 study area.

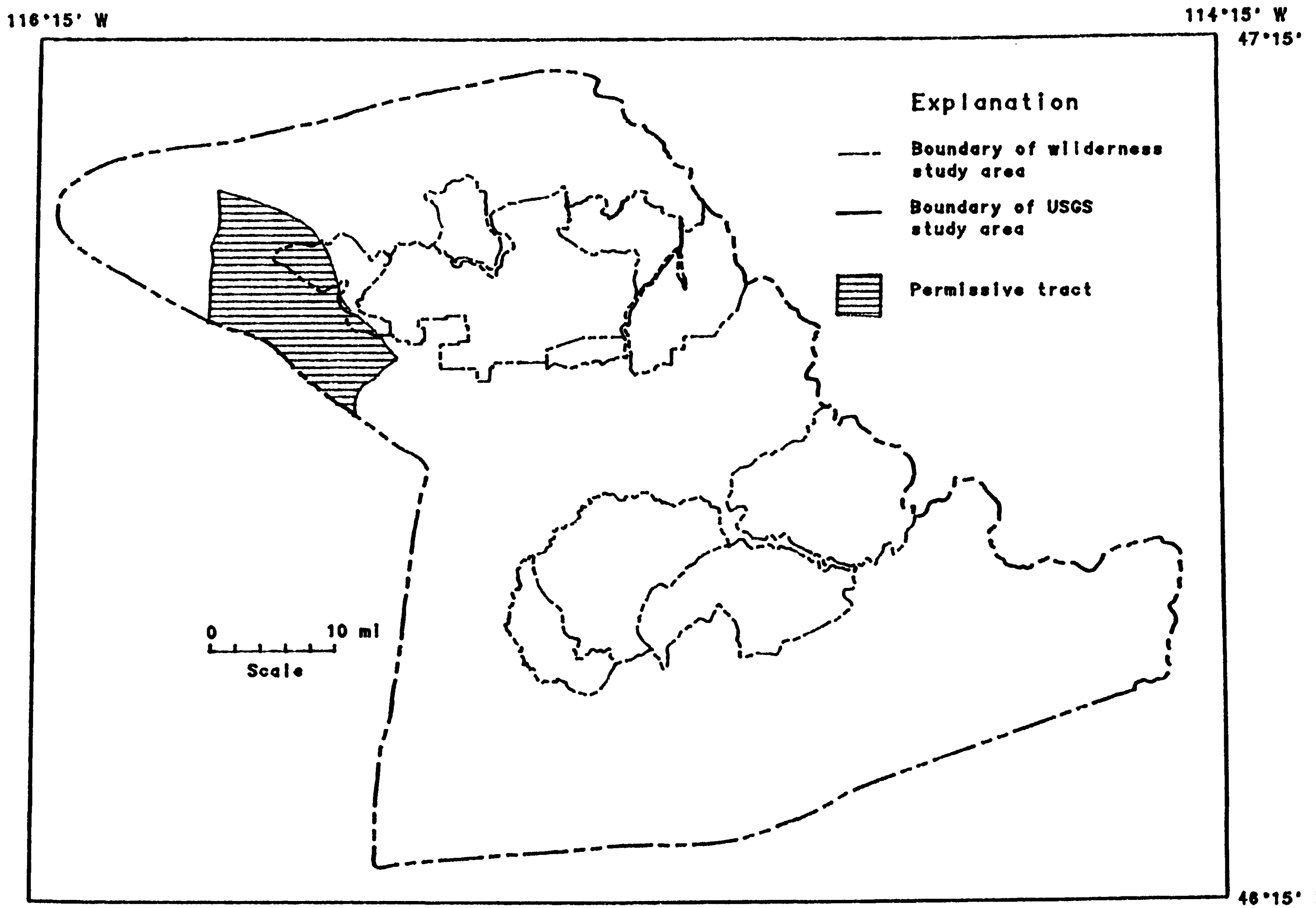

Figure 28. Map showing tract permissive for undiscovered metamorphic kyanite deposits in group 4 study area.

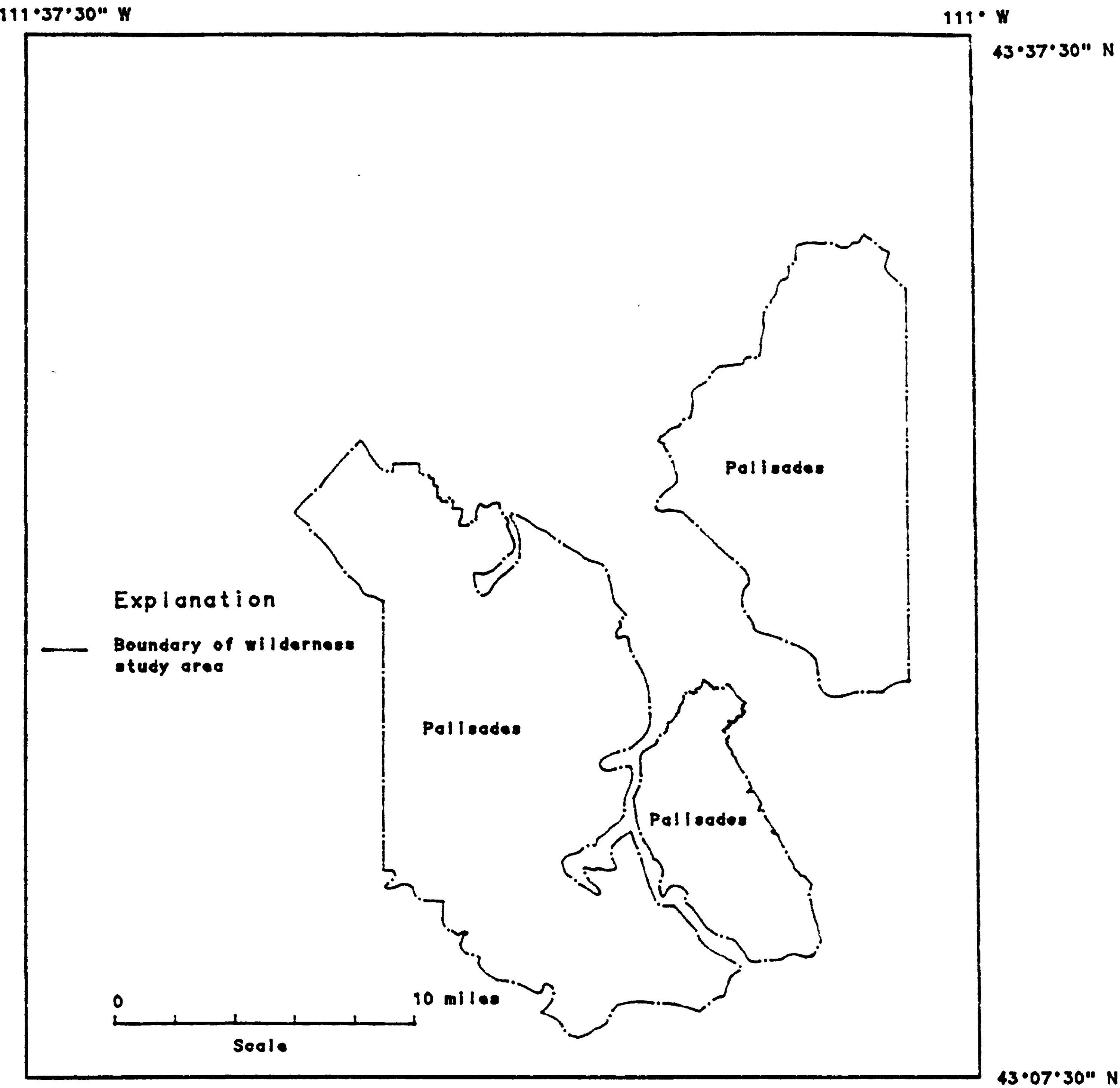

Figure 29. Map showing boundaries of proposed wilderness areas in USGS group 5 study area.

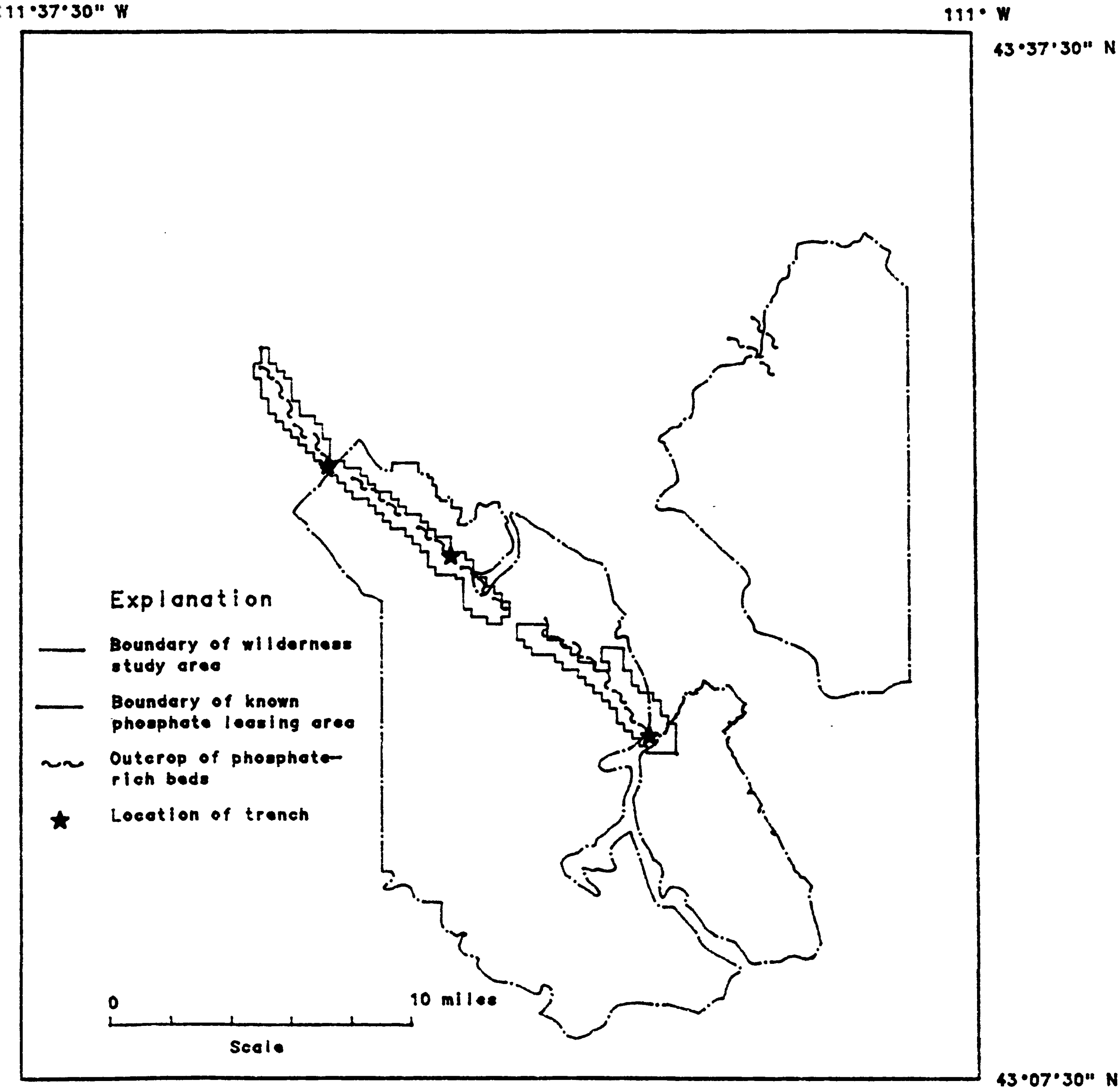

Figure 30. Map showing phosphate areas in group 5 study area. Boundary of known phosphate leasing area from Bureau of Land Management (written commun., 1990).