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MISCELLANEOUS FIELD STUDIES
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PAMPHLET

MINERAL RESOURCE POTENTIAL OF THE NORTHERN PART OF THE WASHAKIE WILDERNESS AND NEARBY ROADLESS AREAS, PARK COUNTY, WYOMING

By

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STUDIES RELATED TO WILDERNESS

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

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

The northern part of the Washakie Wilderness and nearby roadless areas (hereafter referred to as study area) have been evaluated for mineral resource potential by a multidisciplinary team of geoscientists from the U.S. Geological Survey and the U.S. Bureau of Mines. The mineral potential was classified for 21 areas: (1) the Kirwin mining district adjacent to the Francs Peak Roadless Area has an identified porphyry copper deposit and also has high mineral resource potential for Cu, Pb, Zn, Ag, and Au in vein deposits; (2) the Stinkingwater mining district within the Washakie Wilderness has an identified Cu-Mo porphyry-type deposit and also has high potential for base- and precious-metal resources in veins; (3) the Meadow Creek area and (4) the Silver Creek area have high potential for Cu-Mo resources in a porphyry-type deposit; (5) Lost Ranger Top ("Birthday Basin") and (6) Yellow Ridge (both within the Washakie Wilderness) have high potential for Cu-Mo resources in porphyry-type deposits; (7) Robinson Creek, within the Washakie Wilderness, has moderate potential for Cu and Mo resources in porphyry-type deposits and moderate potential for base- and precious-metal resources in veins; (8) Eagle Creek, within the Washakie Wilderness, has high potential for base- and precious-metal resources in veins and high potential for Cu-Mo resources in a porphyry-type deposit; (9) Clouds Home Peak, also within the Washakie Wilderness, has high potential for base- and precious-metal resources in veins, and high potential for Cu-Mo resources in a porphyry-type deposit; (10) Deer Creek, within the Washakie Wilderness, has moderate potential for base- and precious-metal resources in veins; and (11) the Gold Reef mining district, which is in the Francs Peak Roadless Area and has moderate potential for precious- and base-metal resources in veins. Ten other localities (Francs Fork, East Fork Pass, Reef Roadless Area, Sweetwater Creek, Ruth Creek, Rampart volcano, Ishawooa Creek, Anderson and Venus Creeks, Swede Creek, and Mount Burwell) have resource potential. Two of these areas (Francs Fork and East Fork Pass) have high resource potential for base and precious metals on the basis of geochemical and geophysical anomalies and a geological setting similar to some ore deposits in the region. Practically the entire study area, except in the vicinity of the igneous centers and the margins of intrusions, has low to moderate potential for resources of oil and gas in the sedimentary rocks below the volcaniclastic rocks. Oil seeps at Sweetwater Mineral Springs document the presence of oil beneath the volcaniclastic rocks. Regional stratigraphic and structural patterns also suggest that anticlines similar to those that produce oil and gas directly east of the study area are present under the study area; these anticlines probably are on a western platform extension of the petroleum-bearing Bighorn Basin, which lies to the east.

INTRODUCTION

This report summarizes the results of a mineral resource assessment conducted by the U.S. Geological Survey and the U.S. Bureau of Mines of the northern part of the Washakie Wilderness and several roadless areas adjacent to the Washakie and North Absaroka Wildernesses. The study area encompasses a total of 728,498 acres (1,138.3 mi^2) in northwestern Wyoming. The study area is in the nation's first national forest, the Shoshone National Forest and entirely within Park County, Wyo. (figs. 1 and 2). The U.S. Geological Survey used geological, geochemical, and geophysical techniques to (1) define the extent of mineralization associated with mines and prospects, (2) determine if previously unknown mineral resources exist in the area, and (3) describe the type and model for the mineralizing events. The investigation included a study of the resource potential for oil and gas, considered in the context of the geologic setting of several producing fields in the Bighorn Basin a few miles east of the study area (fig. 3). The U.S. Bureau of Mines made a detailed investigation of the mines and prospects in the study area (fig. 4) and helped integrate this information with that obtained by the U.S. Geological Survey.

The South Absaroka Wilderness was designated a wilderness area in 1932 by the U.S. Forest Service, and consisted of 483,678 acres (755.7 mi^2); it was included in the National Wilderness Preservation System under the Wilderness Act of 1964 (Public Law 88-577). In 1972, by Public Law 92-476, the South Absaroka Wilderness was renamed the Washakie Wilderness, and 208,000 acres (325.0 mi^2) were added, consisting mostly of the former Stratified Primitive Area which was adjacent to the southern part of the South Absaroka Wilderness. As a result of its first Roadless Area and Review Evaluation (RARE) in 1973, the U.S. Forest Service designated five roadless areas contiguous to the Washakie Wilderness and four roadless areas contiguous to the North Absaroka Wilderness as study areas to be further evaluated for their suitability for inclusion within the National Wilderness Preservation System. The roadless areas contiguous to the North Absaroka Wilderness are (see fig. 2): Reef (LB)--14,000 acres (21.9 mi^2); Trout Creek (LI)--27,000 acres (42.2 mi^2); Wapiti Valley North (LJ)--19,480 acres (30.4 mi^2); and Wapiti Valley East (LK)--480 acres (0.8 mi^2). The roadless areas contiguous to the Washakie Wilderness are: Sleeping Giant (LL)--5,160 acres (8.1 mi^2); Wapiti Valley South (LM)--40,000 acres (62.5 mi^2); South Fork (LN-1)--75,700 acres (118.3 mi^2); South Fork (LN)--7,300 acres (11.4 mi^2); and Francs Peak (LP)--55,700 acres (87.0 mi^2). The total study area in this report encompasses 728,498 acres (1,138.3 mi^2). Mineral resource surveys have been published for the North Absaroka Wilderness (Nelson and others, 1980) and for other areas included in the Washakie Wilderness (Stratified Primitive Area--Ketner and others, 1966; DuNoir Addition--Prostka and others, 1979).

The lands studied are east and southeast of Yellowstone National Park and west of the Bighorn Basin. The town of Cody, Wyo., is about 20 mi east of the northern part of the Washakie Wilderness, and Meeteetse, Wyo., is about 20 mi east of the southern part of the area. Cooke City, Mont., is about 5 mi north of the Reef Roadless Area. U.S. Highway 14-16-20 (one road) follows the North Fork Shoshone River from Cody, west to the East Entrance of Yellowstone National Park. Gravel roads extend considerable distances up the valleys of the South Fork Shoshone River, the Greybull River, and Wood River. Access to the Reef Roadless Area is provided by U.S. Highway 212 easterly from Cooke City, Mont., and then by a U.S. Forest Service road that follows the Clarks Fork Yellowstone River. Foot and horseback trails from the roads provide access to the interior of the wilderness and roadless areas.

The study area is in rugged mountainous terrain in the Absaroka Range. The total relief in the area is more than 7,000 ft and local relief is as much as 6,000 ft. Francs Peak, 13,153 ft is the highest mountain in the Absaroka Range and is in the southeastern part of the study area. Much of the area is underlain by relatively flat-lying stratified rocks. Deep dissection of the stratified sequence and subsequent glaciation of the peaks and valleys has created a topography of horns, cirques, and aretes, as well as high rolling plateaus, benches, and steep-walled canyons. For example, the canyon walls of the South Fork Shoshone River have a relief of as much as 5,000 ft.

The Washakie Wilderness and contiguous roadless areas are bounded on the north by the North Fork Shoshone River and on the south by the head of the Wood River drainage basin. The Greybull River and the South Fork Shoshone River both start in the wilderness and drain much of the area. High mountain and plateau areas border the study area to the north (North Absaroka Wilderness), west (Yellowstone National Park and Teton Wilderness), and south (Owl Creek Mountains and DuNoir Addition). The Washakie Wilderness, the roadless areas, DuNoir Addition, Teton Wilderness, and the southeastern part of Yellowstone National Park comprise a pristine roadless area of more than 2,000,000 acres (3,125 mi^2), which make it one of the largest areas of wilderness in the United States.

Results from this mineral resource evaluation are described in geochemical surveys (J. C. Antweiler, unpub. data, 1983; E. P. Welsch and others, unpub. data, 1983; F. S. Fisher, unpub. data, 1983; Fisher and Antweiler, 1980; Fisher and others, 1977; Antweiler and Campbell, 1982; Antweiler, 1979), geophysical surveys (C. L. Long, unpub. data, 1983), oil and gas surveys (Spencer and Dersch, 1981; J. D. Love, unpub. data, 1983), and an investigation of mines and prospects (Bieniewski and Smith, unpub. data, 1983).

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Field assistants who contributed substantially to the geologic and geochemical studies were Gregory Lee, R. C. and S. J. Antweiler (volunteer basis), Darby Fletcher, Steven Marshak, Steven Driese, and Gordon May. Chemical and spectrographic analyses in field and in permanent U.S. Geological Survey laboratories were performed by E. P. Welsch, W. L. Campbell, and R. T. Hopkins, Jr. U.S. Bureau of Mines assistance was provided by Thomas Light, G. Stucky, J. Davis,

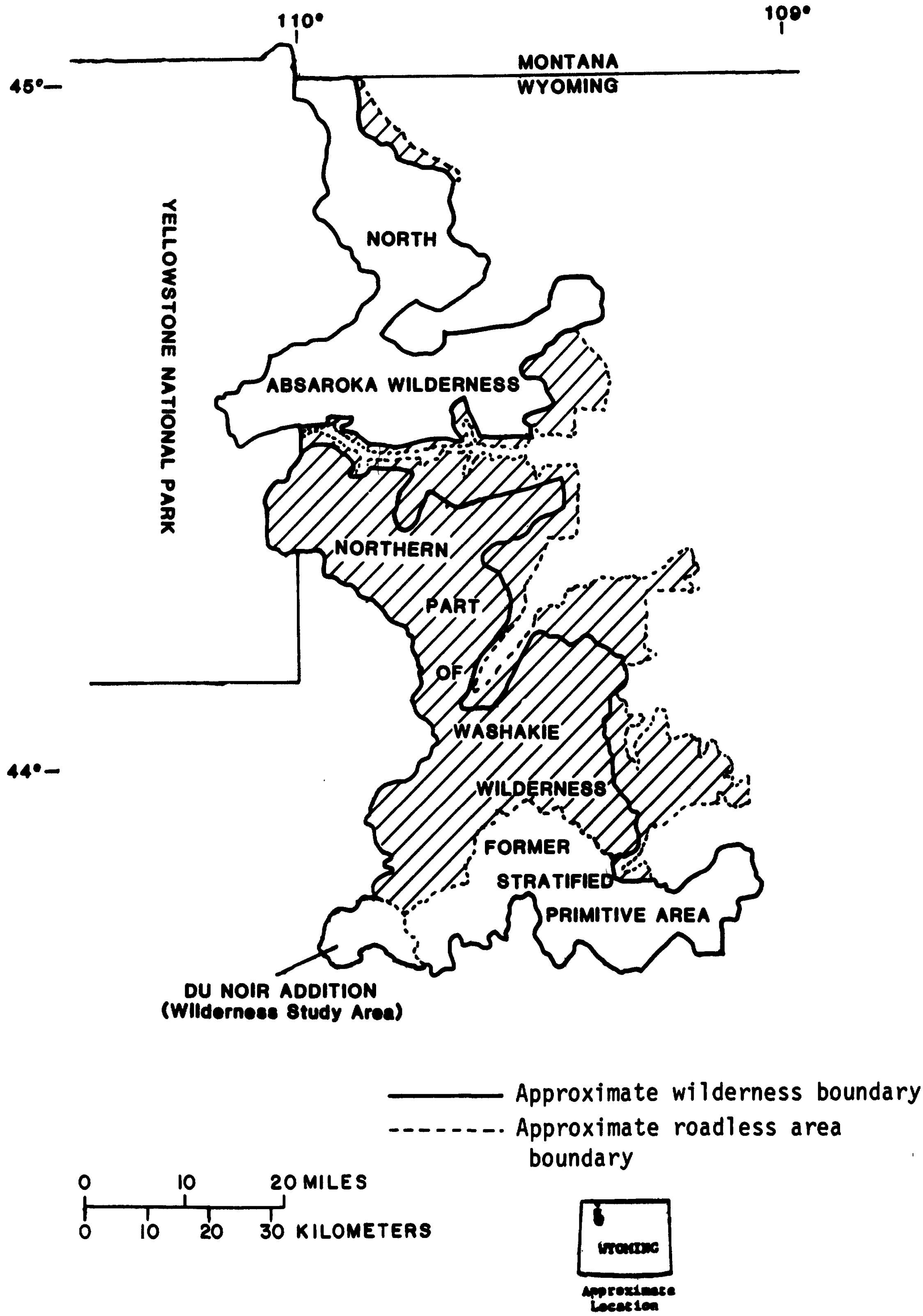

Figure 1.--Map showing location of northern part of the Washakie Wilderness and nearby roadless areas, Park County, Wyoming. Former Stratified Primitive Area constitutes remainder of Washakie Wilderness. Patterned areas apply to this study.

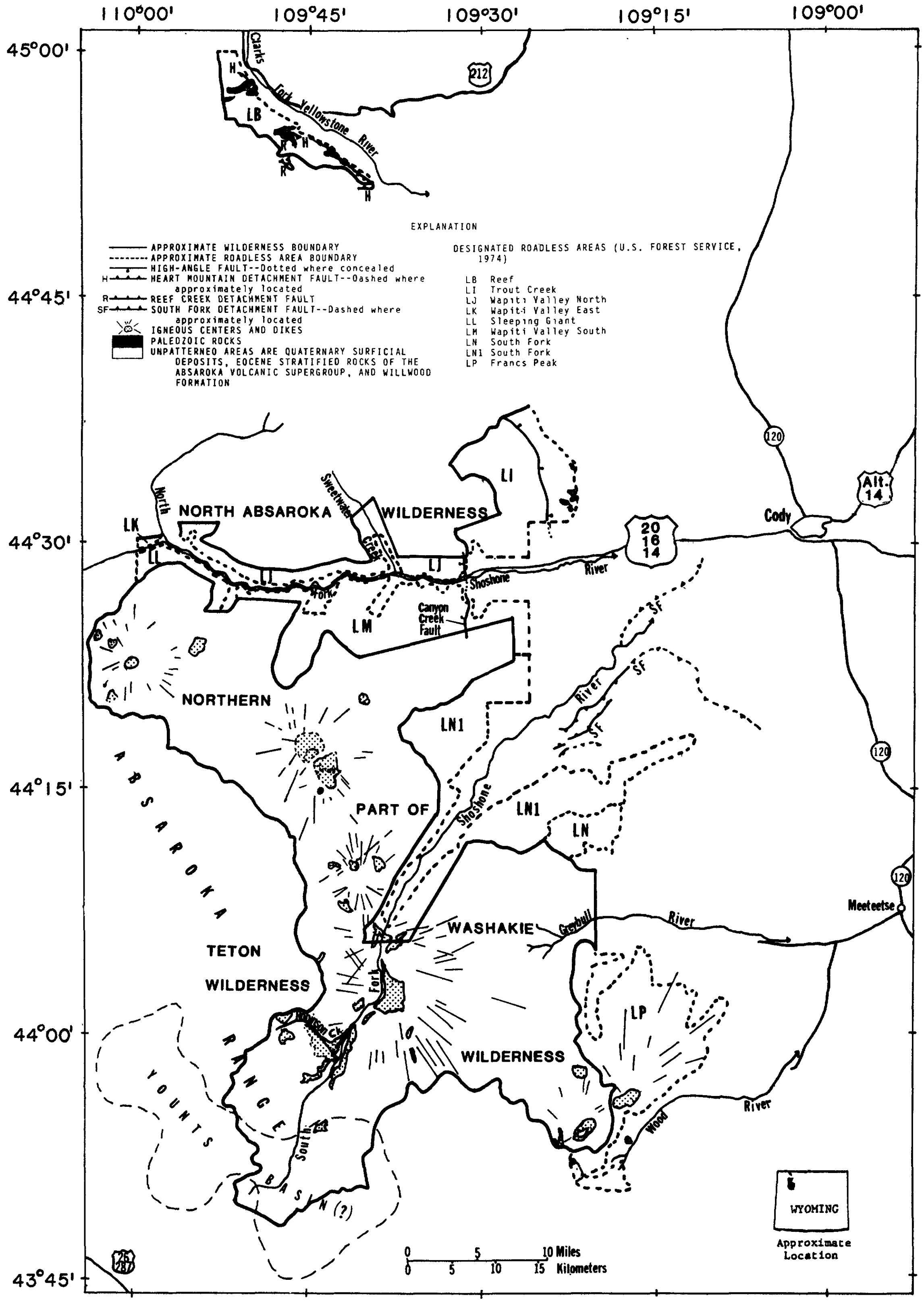

Figure 2.--Map showing location and generalized geology of northern part of Washakie Wilderness and nearby roadless areas, Park County, Wyoming.

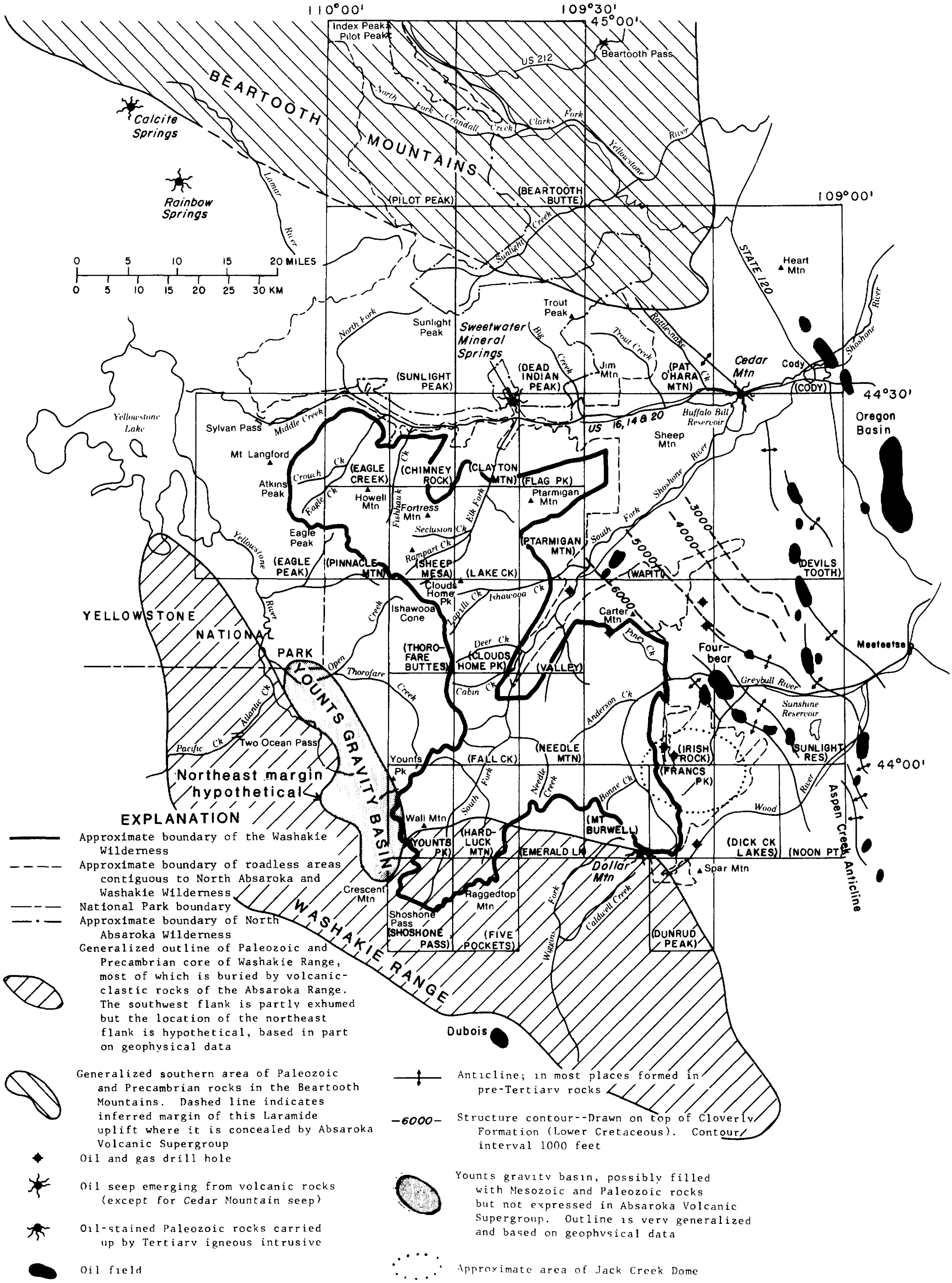

Figure 3.--Map showing oil fields near northern part of Washakie Wilderness and nearby roadless areas, Park County, Wyoming. Names of topographic quadrangles shown in parentheses.

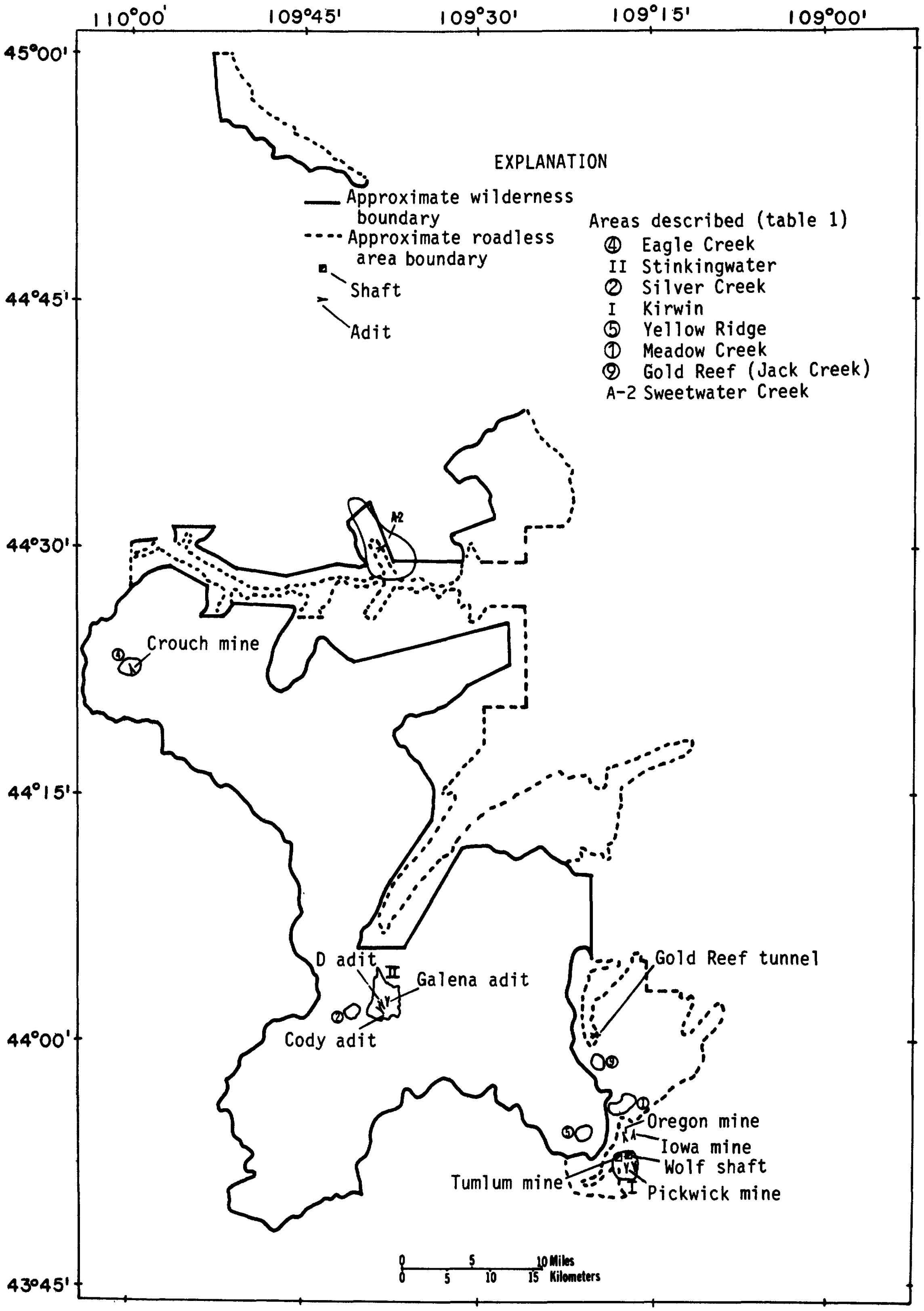

Figure 4.--Map showing mines and prospects in northern part of Washakie Wilderness and nearby roadless areas, Park County, Wyoming.

J. Goety, and R. Woodcock. Personnel of the U.S. Forest Service, especially "Butch" Ellis, "Slim" Wright, and Ralph Wheeler were most helpful and cooperative with many aspects of the study. We are grateful to: William G. Pierce, Harold J. Prostka, and W. H. Wilson for sharing their knowledge of the area through field conferences and stimulating discussions. The investigations were facilitated by the cooperation of the U.S. Bureau of Land Management, the Wyoming Geological Survey, Park County officials, and private individuals. The Phelps Dodge Corporation, AMAX Corporation, and William Bowes and Associates provided valuable information and data about specific mineral properties. Special thanks are extended to Carl Dunrud and Jack Richard for sharing their knowledge of the history of some of the mining properties.

GEOLOGY AND STRUCTURE

Geologic setting

A generalized geologic map is shown on figure 2, and topographic quadrangles with pertinent geographic names are shown on figure 3. Exposed rock in the entire study area consists largely of the Absaroka Volcanic Supergroup of Eocene age, an assemblage of volcanic and epiclastic rocks, dominantly calc-alkalic andesite but ranging in composition from alkalic basalt to rhyolite. These rocks are intruded by high-level plutons and accompanying dike swarms of similar compositions. The volcanic field is composed of coalescing stratovolcanoes made up of laharic breccias, lava flows, autoclastic flow breccias, avalanche debris, and tuffs. This chaotic assemblage of rocks, which formed part of a volcanic cone, is referred to as vent facies (Smedes and Prostka, 1972). Epiclastic volcanic rocks derived from the erosion of these volcanoes form alluvial aprons around, beneath, and, in places, over the volcanoes (alluvial facies of Smedes and Prostka, 1972). Subsequent erosion has cut deeply into the volcanic pile, cutting steep-sided canyons and exposing shallow plutons and associated radiating dike swarms. Some of the shallow plutons are interpreted as subvolcanic intrusions.

The Absaroka Volcanic Supergroup was deposited on a sequence of lower Tertiary, Mesozoic, and Paleozoic sedimentary rocks. Based upon lithologic and paleontologic studies in nearby areas, these sedimentary rocks are as old as Middle Cambrian. The sedimentary rocks are underlain by Precambrian crystalline rocks 2.6 b.y. old (Ruppel, 1972; Reed and Zartman, 1973). Paleozoic rocks are exposed at only a few localities. Roof pendants consisting of blocks of Paleozoic rocks were pushed up and are now exposed near the headwaters of Wood River in the Dunrud Peak 7.5-minute quadrangle (fig. 3) and along the South Fork Shoshone River in the Hardluck Mountain 7.5-minute quadrangle (fig. 3). Paleozoic rocks crop out in the northern and northeastern part of the area, and in a narrow belt southwest of Clarks Fork Yellowstone River. Small blocks of Paleozoic rocks also occur in a few other scattered exposures. Mesozoic rocks are exposed in a few small areas near the confluence of Ishawooa Creek and the South Fork Shoshone River but presumably occur widely in the subsurface beneath the volcanic pile. The lower Eocene Willwood Formation is exposed along the eastern edge of the study area and in the deep valleys of the North and South Forks Shoshone River and the Greybull River.

The Absaroka Volcanic Supergroup consists of three groups, from oldest to youngest, the Washburn Group, the Sunlight Group, and the Thorofare Creek Group. The Washburn Group is exposed mostly northwest of the study area but is exposed in two areas contiguous to the North Absaroka Wilderness (the Reef and Trout Creek Roadless Areas; LB and LI, fig. 2). There the group is associated with the Heart Mountain detachment fault. The Sunlight Group is exposed throughout the northern part of the study area. The Thorofare Creek Group is exposed over most of the study area.

The Sunlight Group is the most mafic of the supergroup. The Wapiti Formation is mostly a sequence of dark-colored pyroxene-andesite lava flows and volcaniclastic rocks interlayered with and overlain by potassium-rich andesite and basalt of its Jim Mountain Member and the Trout Peak Trachyandesite. A rhyodacite ash-flow sheet, the Pacific Creek Tuff Member, is locally present in the Trout Peak Trachyandesite. This tuff member occurs on Clayton Mountain and on the north side of Ptarmigan Mountain. A major vent area for the Sunlight Group is in the Sunlight mining region northwest of the Trout Creek Roadless Area (LI, fig. 2). No stratovolcanoes or vent areas for the Sunlight Group have been identified within the study area. The proportion of alluvial facies increases southward in the Wapiti Formation. Detrital rocks consisting of sandstone, siltstone, and conglomerate, which contain volcanic debris at the base of the volcanic pile south of the crest of Carter Mountain, are correlated with the Wapiti Formation.

The Langford Formation overlies the Trout Peak Trachyandesite everywhere except in the very southeastern part of the area where the Trout Peak has thinned to a feather edge and disappears. There the basal unit of the Thorofare Creek Group is the generally darker colored Aycross Formation. Volcanic rocks of the Thorofare Creek Group, which commonly range from andesite through dacite to rhyolite, are typically lighter colored and less mafic than those of the Sunlight Group. The Thorofare Creek Group in the study area is composed of the Wiggins Formation and associated intrusive rocks. Rhyolite-bearing breccia occurs in the southern part of the Francs Peak Roadless Area (LP, fig. 2). Extrusive rhyolite crops out on Yellow Ridge, and rhyolite plutons are exposed on Dunrud Peak and in the basin of Avalanche Creek west of Francs Peak.

In general, eruptive centers are identified by dike swarms radiating from the vicinity of single or clusters of plutons. Parts of two volcanoes have been recognized in the northwestern part of the Washakie Wilderness; the one near Eagle Pass is older than the Two Ocean Formation, and the Rampart volcano is younger than the Two Ocean. Other eruptive centers for rocks in the Thorofare Creek Group occur to the south in the drainage area of the South Fork Shoshone River and in the Greybull-Wood River area. Other

Thorofare Creek Group centers are in the Deer Creek Valley, the canyon of the South Fork Shoshone River between Cabin and Fall Creeks, the Stinkingwater area (junction of South Fork Shoshone River and Needle Creek), near the headwaters of Robinson Creek, the basin of Meadow Creek, and in the Yellow Ridge-Dunrud Peak area. The South Fork center is not well developed, but the Stinkingwater center is probably the largest center in the study area. Another possible eruptive center is in the upper part of the Anderson Creek drainage (Needle Mountain quadrangle). Although no pluton is exposed there, a constructional dome of vent-facies rocks about 3 mi in diameter overlies the alluvial facies of the Wiggins Formation, and a positive Bouguer anomaly roughly coincides with the center of the dome.

Intrusive rocks

Dikes were observed in most parts of the study area except on Carter Mountain and in the upper drainage basin of the South Fork Shoshone River. Most are of intermediate composition, but they range from mafic through intermediate to felsic. In any given region, the dikes are more variable in composition than the plutons. Many are part of a radial swarm related to a volcanic center or are concentrated near a pluton and are interpreted to be genetically related to that center. The borders of some plutons are ill defined and are gradational into dike swarms. Examples of plutons grading into dike swarms are in the center of the Rampart volcano and on the ridge between Eagle and Crouch Creeks on the border between the Eagle Peak and Eagle Creek quadrangles.

Most plutonic bodies in the study area intrude the Thorofare Creek Group and must be at least as young as that group. Most of them are intermediate in composition, grading from granodiorite and tonalite to monzodiorite and diorite of the Streckeisen classification (1976). The greatest diversity in composition is in the area between Francs Peak and Dunrud Peak where gabbro and intrusive rhyolite are also found.

Plutons of presumed Langford age are exposed in the northwestern part of the Washakie Wilderness. One of these is a tonalite stock about 1 mi^2 in area on Howell Mountain in the Eagle Creek quadrangle. No dike swarm is associated with this stock.

A sizeable stock (about 4 mi^2), several smaller stocks, and a dike complex in the Seclusion-Borron Creek area are assigned an age equivalent to the upper part of the Wiggins Formation and are interpreted as subvolcanic plutons within the Rampart volcano. A sill about 50 ft thick, related to the Rampart center, intrudes the contact between the Trout Peak Trachyandesite and the overlying Wiggins Formation and crops out southeast of the Rampart center along Ishawooa Creek. A small stock on Clouds Home Peak is a satellite of the Rampart center.

A hornblende-porphyry stock of andesitic composition, about 0.8 mi^2 in area, intrudes the Wapiti Formation in the Swede Creek Valley. Columnar joints, which are unusual in the area, are about 30 ft in length in the contact zones and have axes roughly perpendicular to the contact.

Plutons in the drainage area of the South Fork Shoshone River are generally intermediate to felsic in composition. Many of these are related to eruptive centers--Deer Creek, South Fork, Stinkingwater, and upper Robinson Creek. Other plutons are not associated with dike swarms and are not clearly subvolcanic plutons. One of the largest plutons in the study area is the body of biotite-hornblende granodiorite at the intersection of South Fork Shoshone River and Robinson Creek; it has no obviously related dike swarm.

Plutons of the Greybull-Wood River area include stocks of porphyritic rhyolite, 0.8-1.6 mi^2 in area, that are exposed in the basin of Avalanche Creek west of Francs Peak in Steer Creek basin (Mount Burwell quadrangle) and on Dunrud Peak. An isolated plug of rhyolite, about 0.04 mi^2 in area, is exposed on the southwest side of Piney Creek, in the Irish Rock 15-minute quadrangle. Several small bodies, which range from diorite to gabbro, are exposed in the Greybull-Wood River area. The largest of these, about 0.32 mi^2 in area, crops out at the head of the southern tributary of Francs Fork Creek.

Structure and geologic history

Precambrian crystalline rocks of the Wyoming Archean province (2.9 to 2.6 b.y. old) are exposed in several Laramide (Late Cretaceous-early Tertiary) uplifts outside the study area. These include the Buffalo Plateau to the northwest, which is along the northern border of Yellowstone National Park (Ruppel, 1972), the Beartooth uplift to the north, the Rattlesnake Mountain anticline to the northeast, and the Washakie Range in the Teton Wilderness to the south. Presumably these rocks underlie the Absaroka volcanic field at depth. The Archean rocks are intruded by nonmetamorphosed diabase dikes of Middle(?) Proterozoic age (Reed and Zartman, 1973). The Phanerozoic sequence of shelf and continental sedimentary strata is interrupted by several disconformities that indicate recurrent and mild uplift of the craton but no appreciable folding or tilting (Nelson and others, 1980).

Most of the structural features in the region date from the Laramide orogeny or younger. The orogeny began in the Late Cretaceous and extended to the late Paleocene and locally into Eocene time (Nelson and others, 1980). Precambrian and Paleozoic rocks of the Washakie Range were deformed by a series of northwest-trending folds and faults (both normal and reverse) and were deeply eroded prior to the deposition of the coarse- to fine-grained clastic sedimentary rocks of the lower Eocene Indian Meadows Formation and subsequent Thorofare Creek Group (Prostka and others, 1979; Ketner and others, 1966). The northwest-trending Buffalo Plateau-Beartooth Mountain block is bounded on the southwest by the Gardner fault, a high-angle reverse fault that cuts gently folded youngest Cretaceous sedimentary rocks (Ruppel, 1972). Major uplift of the Beartooth block began in Paleocene (Fort Union Formation) time and culminated in early Eocene time according to Foose and others (1961). Also at this time, the Bighorn Basin to the east subsided and formed the northwest-trending Rattlesnake Mountain anticline, which is bordered on the southwest by a high-angle normal fault (Pierce and Nelson, 1968). Tightly folded beds as young as Paleocene (Fort Union) in the Bighorn Basin are unconformably overlain by the Willwood Formation (Nelson and others, 1980). The average structural relief between the Bighorn Basin and the Beartooth block is about 15,000 ft (Foose and others, 1961).

During the waning stages of the Laramide orogeny, in middle and late Eocene time, tremendous volumes of volcanics poured out over Willwood and older rocks. Coincident with the early stages of the eruptions, several low-angle detachment faults developed--the South Fork, Reef Creek, and Heart Mountain. The youngest and largest of these is the Heart Mountain, whose characteristics have been summarized by Pierce (1973) and Nelson and others (1980). The Heart Mountain detachment fault carried Paleozoic and Eocene rocks southeastward. The fault mass, both the frontal part, which moved across the land surface, and the posterior part, which moved on bedding plane surfaces, broke up into discrete blocks as it moved. The breakaway fault scarp (west of the Pilot Peak area) and many of the detached fault masses were engulfed almost immediately by the Wapiti Formation, Trout Peak Trachyandesite of the Sunlight Group, and possibly the youngest rocks of the older Washburn Group. Deformation along northwest axes continued after movement along the Heart Mountain fault. Cross sections drawn by Pierce and Nelson (1968) suggest that continued rise of the Rattlesnake Mountain anticline lifted the now-eroded Heart Mountain fault plane about 2,500 ft. Structure contours (D. W. Rankin, unpub. data, 1983) on the upper surface of the Trout Peak Trachyandesite identify a northwest-trending block at least 43 mi long from the East Entrance of Yellowstone National Park to the Greybull River that dips about 2° southwest. The time of tilting is certainly later than deposition of the Trout Peak and probably preceded deposition of the Wiggins Formation of the Thorofare Creek Group.

A dome-like tectonic feature, here called the Jack Creek dome, occurs in the cirque at the head of Jack Creek and deforms the Wapiti, Trout Peak, and upper and lower parts of the Wiggins Formations. It measures about 8.1 x 10 mi and has a structural relief of about 1,650 ft. It has no magnetic expression.

Following the early Eocene, a high-angle north-trending fault down-dropped the Jim Mountain Member of the Wapiti about 1,095 ft near Canyon Creek in the northeastern part of the Flag Peak quadrangle. This fault, which has a profound geomorphic expression, is here called the Canyon Creek fault (west side is down).

GEOCHEMISTRY

Geochemical studies to assess the mineral resource potential of the Washakie Wilderness and roadless areas contiguous to it and the North Absaroka Wilderness consisted of reconnaissance sampling and detailed sampling of several mineralized areas to delineate the extent of mineralization in such areas. Reconnaissance geochemical sampling involved the collection of panned concentrates and fine-grained stream sediments from all first- and second-order streams. Snowfield-silt samples were collected in snow-covered drainages. In some areas, water and vegetation samples were also collected. Rock and soil samples were collected in traverses along all the major summits and ridges and from altered and mineralized areas. Nearly 6,000 geochemical samples were collected. More than half of these were collected to evaluate mineralized areas. Stream-sediment, soil, and snowfield-silt samples were sieved through 80-mesh stainless-steel sieves. Panned concentrates were prepared from stream-sediment samples by panning to a heavy-mineral concentrate, from which magnetite was removed prior to analysis. Rocks were crushed, ground, and pulverized. Samples of vegetation were ashed by slowly increasing oven temperature to 400°C, and only the ash was analyzed. Water samples were split into two portions for analysis, one of which was filtered and acidified, and the other was untreated. All the samples except the water samples were analyzed for 31 elements by a semiquantitative emission-spectrographic method (Grimes and Marranzino, 1968) by R. T. Hopkins, Jr., and chemical analyses for Au, Cu, Pb, and Zn were made by W. L. Campbell in 1975 and by E. P. Welsch in 1975, 1976, and 1977 using methods described by Ward and others (1969). Chemical analyses of the water samples were made by W. H. Ficklin for Cu, Pb, Zn, Mo, U, Cl^-, F^-, $SO_4^=$, and conductivity was determined using methods described by Miller and others (1982). To enable computer retrieval and handling, the data were entered into the U.S. Geological Survey Rock Analysis Storage System (RASS), and a magnetic tape of these data has been prepared (S. K. McDanal and others, unpub. data, 1983).

Separate analytical data sets were prepared for each sample type (stream sediment, panned concentrate of stream sediment, snowfield silt, soil, water, ash of vegetation, and rock). The rock samples were subdivided into felsic, intermediate, mafic, and ultramafic groups, and into other classifications such as mineralized, altered, unaltered, geographic area, and formation.

Histograms of elements usually detected in the analyses were examined in each of the data sets to determine background values and the threshold for anomalously high values. Such elements for most sampling media are Ti, Mn, Ba, Co, Cr, Cu, La, Ni, Pb, Sr, V, Y, and Zr. The histograms are especially useful to determine whether or not two or more populations of element concentrations exist. The most common mixed populations are for Ba, Cu, Pb, and Sr. Because of the limitations of the analytical methods used, Ag, As, Bi, Cd, Mo, Sb, Sn, W, Zn, and Au were considered to have anomalous concentrations in all samples in which they were detected except in water samples and in the ash of vegetation. All the analytical data were useful in identifying geochemical anomalies, but panned concentrates, particularly those in which Au was determined, were the most useful reconnaissance samples, and rock and soil samples were the most useful in evaluating mineralized areas.

Examination of geochemical anomalies associated with known mineralized areas provided an excellent basis for evaluating other geochemical anomalies. For example, eight elements (Au, Ag, Cu, Pb, Zn, Mo, As, and Hg) are geochemically anomalous in rock samples from the Stinkingwater mineralized area (Fisher, 1981), and other mineralized areas invariably have one or more of these elements in anomalous amounts in one or more types of samples. The geochemical anomalies also tend to be geographically clustered.

The geochemical sampling program, in conjunction with geologic mapping, field observations of alteration patterns, and geophysical studies, proved to be of great value in characterizing known mineralized areas, and it was even more valuable in identifying previously unrecognized mineralized areas. The more important geochemical anomalies are discussed in the section on resource potential.

GEOPHYSICS

Geophysical investigations conducted as part of the mineral resource evaluation consisted of an aeromagnetic survey (U.S. Geological Survey, 1973), and a Bouguer gravity survey (Long, 1982).

The observed magnetic field in the study area largely reflects topography and surface deposits of the Absaroka Volcanic Supergroup. A few of the anomalies may be related to areas of mineralization where the mineralizing fluids have demagnetized the rocks. At the southeastern edge of the study area, a magnetic low correlates with a roof pendant of Paleozoic rock and the silicic rock of the Dollar Mountain rhyolite pluton. Near the northeastern corner of the study area, a north-south elongate low, with steep relief at its west edge, reflects the high-angle, north-south-trending Canyon Creek fault.

In general, the magnetic data show an increase in the amplitude and number of anomalies from south to north. A thicker section of the more mafic Sunlight Group of the Absaroka Volcanic Supergroup at the northern side of the study area may explain these anomalies.

Gravity data exhibit some northwesterly trends that parallel structural features formed during the Laramide breakup of the foreland and probably reflect many of these deeply buried structures. A northwest-trending gravity plateau correlates well with the known mineralized zones and is indicative of the intrusive bodies of greater density within the less dense volcanic rocks. Most of the mineralized zones lie along gravity ridges or at the transition between high- and low-gravity features; these gravity features probably indicate a basement fracture zone and conduit for the related intrusion. Most of the areas having high potential for mineral resources are at or near intersecting gravity trends.

A northwest-trending gravity low at the southeast side of the study area is indicative of a graben-like feature, possibly a deep sedimentary basin. This could be the postulated Younts Basin (Long, 1982), which is south and west of the area. Several gravity highs with a northwest trend coincide with the trend of known oil fields to the east and south (see section on oil and gas) and probably reflect basement highs.

MINES, PROSPECTS, AND MINERALIZED AREAS

During the study of the mineral resource potential of the study area, the U.S. Bureau of Mines collected 600 samples consisting of chip samples of rock in place, grab samples of dumps of mine and prospect pits, and panned concentrates of stream sand and gravel. All samples were analyzed for 42 elements by semiquantitative spectrographic methods and for gold and silver by fire assay.

Records of mining activities in Park County were checked at the County courthouse at Cody, Wyo. The U.S. Bureau of Land Management records were also checked for location of patented mining claims and mineral leases in the areas. Production records of the U.S. Bureau of Mines were examined. Attempts were made to contact all known claimants and owners of patented mining properties for permission to examine their prospects and mines and to obtain pertinent scientific or historical information. The U.S. Forest Service, the Wyoming Geological Survey, mining companies, and others who might have knowledge of mineral activity also were contacted.

Mining activity

Mining activity in and near the Washakie Wilderness began in the early 1890's with the staking of mining claims in two localities, which later became the Wood River and South Fork mining districts. These districts are today better known, respectively, as the Kirwin and Stinkingwater mining districts. Early interests were for gold, silver, and copper in both districts and, in addition, lead in the Kirwin district (Hill, 1912). Mining activity subsided about 1920 and did not revive until the early 1960's when major mining companies discovered large, low-grade copper-molybdenum deposits in both districts. Additional drilling was done in the summer of 1975 at the deposit in the Stinkingwater district.

During the summer of 1976, drilling by a major company was started in the Meadow Creek area in search of mineral deposits like those discovered in the 1960's in the Kirwin and Stinkingwater districts.

Two other localities where mining has been attempted are along Eagle Creek and along Jack Creek. The Eagle Creek locality has had some activity for placer and lode gold dating back to 1911 (Galey, 1971). At the headwaters of Jack Creek, mining claims for gold were staked as early as 1894. The locality later became known as the Gold Reef district.

Evidence of prospecting, in the form of a small adit and many pits, was observed at small sulfur deposits clustered along Sweetwater Creek near one of the roadless areas contiguous to the North Absaroka Wilderness. The time of that prospecting is unknown, but an oil seep that was known as early as 1911 is located at these deposits; Hewett (1914b) mentioned that "it was reported that during the summer of 1911 sufficient oil was collected to supply the lamps at a temporary camp."

The exact time when drilling began for oil and gas in the vicinity of the study area is not known but was probably in the 1920's. No oil and gas exploration holes are known to have been drilled in the study area but several have been drilled nearby. The first oil field discovered, the Fourbear in 1928 (Reaves, 1975), was still producing as of 1976. This oil field is about 5 mi east of the Washakie Wilderness (fig. 3). Since the discovery of the Fourbear oil field, and until 1975, 20 oil or gas fields have been discovered within 15 mi of the study area. The latest discovery was the Doctor Ditch oil field in 1974.

Mines and mineralized areas

Records of mineral production, which date back to about 1906, contain no reported mineral production from the Washakie Wilderness or the other roadless areas. The only known references to mineral production are those made by Hewett (1914a, 1914b) and Wilson (1956). Hewett (1914b, p. 181), in his discussion of ore deposits at Kirwin, stated that "The only shipment known to have been made from the district was a carload taken from the upper or No. 2 Bryan tunnel and is reported to have yielded a net return of $65 a ton after all transportation and smelting charges had been deducted." Wilson (1956), in a report on the Crouch gold prospect at the Eagle Creek locality, stated that "Two gold shipments were made from the prospect to the Denver Mint sometime during the 1930's. This accounted for a production value of approximately $1,000."

Although only slight mineral production from the study area has been recorded, considerable prospecting has been done since 1960. Table 1 summarizes the results of U.S. Bureau of Mines investigations for the areas studied for this report.

The Crouch mine is on the west side of Eagle Creek meadow in the Eagle Creek mineralized area. Lode and placer claims had been located as early as 1911 by Earl Crouch. Crouch did considerable prospecting and development work, including digging several pits, a shaft, an adit, and erection of a small mill. In 1976, Timberline Minerals located a group of mining claims in the Eagle Creek meadows area including that part which was the Crouch prospect area.

During the field examination, the caved adit, known locally as the Crouch mine, was found at the west side of the Eagle Creek meadows at the valley floor. About 250 ft higher, along the hillside west of the caved adit, are the scant remains of a small mill. Near the mill site are several prospect pits and a caved shaft. In addition, several prospect pits were observed at the saddle between Eagle Creek and Crouch Creek.

According to a mine map made by Earl Crouch, the adit was driven 722 ft to intersect the "Golden Eagle" vein exposed on the surface. An analysis of a weighted composite of samples of veins in the adit taken by Galey (1971) shows: 0.004 percent Mo, 0.14 oz Ag per ton, 0.13 percent Pb, and 0.03 percent Zn. Wilson (1956) mentioned that five mineralized veins (or veinlets) were intersected by the adit; four of these varied from 0.25 to 1 in. in width and the fifth was about 11 in. wide and was exposed in the face. He stated that pyrite, sphalerite, and chalcopyrite are the metallic minerals, with quartz as the chief gangue mineral.

Copper and lead were detected in most of the samples taken at the Crouch prospect area, and molybdenum and silver were detected in a few samples. One of the three grab samples taken from the three "fingers" of the mine dump at the caved adit was enriched in copper. A specimen from the dump assayed 0.23 oz Au and 4.5 oz Ag per ton, 2,900 ppm Cu, and 3,400 ppm Pb. A panned concentrate from Crouch Creek west of the saddle assayed 90 ppm Mo and traces of Au and Ag.

Stinkingwater mining district

The Stinkingwater mining district is at the confluence of Needle Creek and the South Fork Shoshone River entirely within the Washakie Wilderness (fig. 4).

Mining claims were first staked in the district in 1895. Early prospectors concentrated on veins containing gold and silver that radiated from a highly altered intrusive complex. No mineral production has been reported from the district.

The layered volcanic rocks in the area have been intruded by a large multiple intrusion composed of the Eocene Needle Mountain Granodiorite succeeded by the Eocene Crater Mountain Dacite. Two types of mineralization are present. One is disseminated copper and molybdenum in a zone associated with the intrusive complex. The other is lead, copper, zinc, and minor silver in narrow, steeply dipping veins cutting the layered volcanic rocks (Wilson, 1971); these veins are clustered mostly around and within the zone of disseminated copper and molybdenum.

The district was relatively idle until 1960 when AMAX Corporation, Inc., known then as American Metals Climax Corp., became interested in the disseminated copper and molybdenum, leased the mining property in the district, and located additional claims. After some geochemical and geophysical exploration in 1962 and 1963, AMAX dropped their lease. Bear Creek Mining Company leased the claims in 1964 and during 1964 and 1965 diamond-drilled eight holes, the deepest 838 ft. In 1968, Phelps Dodge Corporation leased the property and drilled seven holes in 1968-1969 and six more in 1975. The drilling by Bear Creek and Phelps Dodge has established a multimillion ton, low-grade copper-molybdenum deposit.

During field work in 1975 and 1976, prospect pits and adits were examined and sampled. The largest of these workings were the Cody and D adits (fig. 4) along the east side of the South Fork Shoshone River near the bottom of the northwest slope of Crater Mountain. The Cody adit was about 600 ft long and the D adit about 115 ft long. Samples from the Cody and D adits assayed as high as 10,000 ppm Cu and 720 ppm Mo; other values ranged from zero to 0.3 oz Ag per ton and zero to a trace Au. Both adits are in the low-grade copper-molybdenum deposit outlined by the diamond drilling. A sample taken from the contact zone of Crater Mountain Dacite and Needle Mountain Granodiorite along the west side of Needle Mountain assayed a trace of Au, 260 ppm Cu, and 20 ppm Mo.

Analyses of samples taken at prospect pits and adits along the west side of the South Fork Shoshone River showed few or no metal concentrations.

Table 1.--Summary descriptions of mines and prospects within and near the Washakie Wilderness and nearby roadless areas

Map No. (fig. 4)	Name	Workings	Resource data
4	Eagle Creek, Crouch mine.	One adit, about 720 ft; numerous shallow pits and scrapings.	Veins containing Au, Ag, Cu, Mo, Pb, Zn. Production: few oz Au. Specimen from dump assayed 0.23 oz Au and 4.5 oz Ag per ton, 2,900 ppm Cu, 3,400 ppm Pb. Mo and Zn detected in other samples.
11	Stinkingwater mining district.	Three adits, numerous shallow pits, scrapings, and cuts. Major mining companies have drilled 21 diamond-drill holes.	Multimillion-ton low-grade Cu-Mo porphyry deposit.
2	Silver Creek----	Two diamond-drill holes as of 1976.	Outcrop and float samples at several sites are stained with malachite. One sample assayed 10,000 ppm Cu, and 10-20 ppm Mo. Geologic setting similar to other porphyry-Cu deposits in area.
1	Kirwin mining district.	Several adits, shafts, cuts, and pits. Orebody outlined by drilling by major company.	Orebody estimated to contain 70,000,000 tons averaging 0.75 percent Cu. Mo, Au, Ag, Pb, and Zn also detected in samples.
5	Yellow Ridge----	None. Claims have been staked since 1976.	Geologic setting similar to that for porphyry-Cu deposits in area. Anomalous Cu, Ag, Mo, and Pb in several samples.
1	Meadow Creek----	Several small prospects. Two diamond-drill holes by major company in 1976.	Drill holes reportedly encountered low-grade Cu at several depths, in both holes. Assays of samples from area as much as 0.10 oz Au per ton.
9	Gold reef (Jack Creek).	Two adits, one 1,600 ft, the other 190 ft.	Samples from dump and inside the adits lacked significant metal concentrations. One sample contained 420 ppm Bi.
A-2	Sweetwater Creek.	One adit, and several small prospect pits in fumarolic sulfur deposits.	Assays of samples showed no metal concentrations.

Silver Creek

Silver Creek is a small tributary of the South Fork Shoshone River. It is completely within the Washakie Wilderness and is 1-4 mi west of the Stinkingwater mining district. Near the mouth of the creek, a mineralized zone containing pyrite, malachite, chalcopyrite, and small amounts of molybdenite occurs in an intrusive complex of dacite-rhyodacite porphyry and dacite porphyry.

At the time of field examination, no mining claims or prospect workings were known at Silver Creek. Specimens taken contained as much as 10,000 ppm Cu and 10-20 ppm Mo.

Kirwin mining district

The Kirwin (Wood River) mining district is near the headwaters of the Wood River. A southern part of the Francs Peak Roadless Area is either in or adjacent to the district.

The district was organized in the early 1890's. Shafts were sunk on quartz veins, and adits were driven to intersect the veins at depth. Hewett (1914b, p. 121) reported that between 12,000 and 15,000 linear ft of tunnels (adits) and shafts were opened by about 1911. No production has been recorded, but Hewett (1914b, p. 131) reported a shipment from the No. 2 Bryan tunnel (adit) that yielded a net return of $65.00 per ton.

Two types of mineralization in the Kirwin district have been described by Wilson (1964a, p. 9). One consists of pyrite, chalcopyrite, molybdenite, and quartz in veins occurring in a highly altered and partly silicified zone on Bald Mountain. The other type consists of galena, sphalerite, tetrahedrite, minor pyrite, and chalcopyrite in veins with a carbonate-mineral gangue; these veins commonly contain silver.

AMAX Corporation, Inc., acquired considerable mining property in the district in the early 1960's and commenced an exploratory diamond-drilling program that culminated in the discovery of a disseminated copper deposit with minor molybdenum. The deposit is in andesite and quartz monzonite underlying Spar Mountain just southwest of Bald Mountain. Known as the Kirwin deposit, it reportedly contains 70 million tons averaging 0.75 percent Cu (World Mining, 1977, p. 111). The deposit is about 0.5 mi east of the southeastern part of the Francs Peak Roadless Area.

Most of the old adits and shafts in the district were caved at the time of the field examination. Where the workings were caved, grab samples were collected from the dumps and chip samples were taken of veins exposed in the vicinity. Panned-concentrate samples were also taken of stream sand and gravel in Wood River. Many of the samples were enriched in Au, Ag, Cu, Pb, Zn, and Mo.

Yellow Ridge

Yellow Ridge is about 3.5 mi west of the Kirwin mining district and is within the Washakie Wilderness. Highly altered intrusive rocks containing copper minerals are exposed on Yellow Ridge, but no mining claims were known there at the time of the field work in 1976. Samples taken from the altered zone on the northeast side of the ridge were strongly enriched in Cu and slightly enriched in Pb and Zn; Mo did not exceed 60 ppm. No Au or Ag was reported in the assays except for one sample that assayed 0.01 oz Au per ton.

Meadow Creek

Meadow Creek, a small tributary of Wood River, is about 1.5 mi north of the northern end of the Kirwin mining district. Most of Meadow Creek, including Meadow Creek basin, is within the Francs Peak Roadless Area. The basin is adjacent to the southeastern boundary of the Washakie Wilderness.

In the Meadow Creek basin, according to Wilson (1964b), a multiple pluton of younger and older granodiorite invaded a vent structure initially occupied by intrusive andesite. The rocks exposed in the basin show varying degrees of alteration and sulfide mineralization, principally copper. In 1974, 126 mining claims were staked that covered Meadow Creek basin and most of Meadow Creek to its confluence with Wood River. Exxon Corporation leased the claims, and in the next 2 years drilled two diamond-drill holes. Shortly after, they gave up their lease. According to William Bowes of William Bowes and Associates (oral commun., 1979), low-grade copper was encountered in the holes.

Samples taken in Meadow Creek basin during field work contained anomalously high concentrations of Cu and some contained as much as 0.10 oz Au per ton. Other elements, such as Pb, Zn, Ag, and Mo, were reported as either absent or only slightly above background values for rocks in that area.

Other localities

The headwaters of Francs Fork Greybull River is in the center of the Francs Peak Roadless Area. A few panned concentrates taken of stream sand and gravel from Francs Fork contained a trace of gold, but most did not have detectable gold. However, all samples contained a small quantity of Ag (0.1 or 0.2 oz per ton) and some were enriched in Mo, Pb, Co, Cr, and Ni. Most of these values do not represent mineralized rocks but rather are the result of concentration by sedimentary processes.

The Gold Reef, or Jack Creek mining region is within the Francs Peak Roadless Area. Two open adits are in the region. One, known as the Gold Reef tunnel, is about 1,600 ft long and the other is 190 ft long. Bismuth ranged from 250 to 420 ppm in samples taken inside the adits, but no other metal values of interest were reported in the assays.

Panned concentrates of stream sand and gravel from the North Fork of Anderson Creek, Anderson Creek, and Eleanor Creek in the South Absaroka Wilderness assayed a few parts per million Mo.

Small sulfur deposits of fumarolic origin exist along Sweetwater Creek in the Wapiti Valley East Roadless Area (LK, fig. 2) contiguous to the North Absaroka Wilderness. Some of these deposits may extend into the study area and others may be concealed. Analyses of samples from the adit and

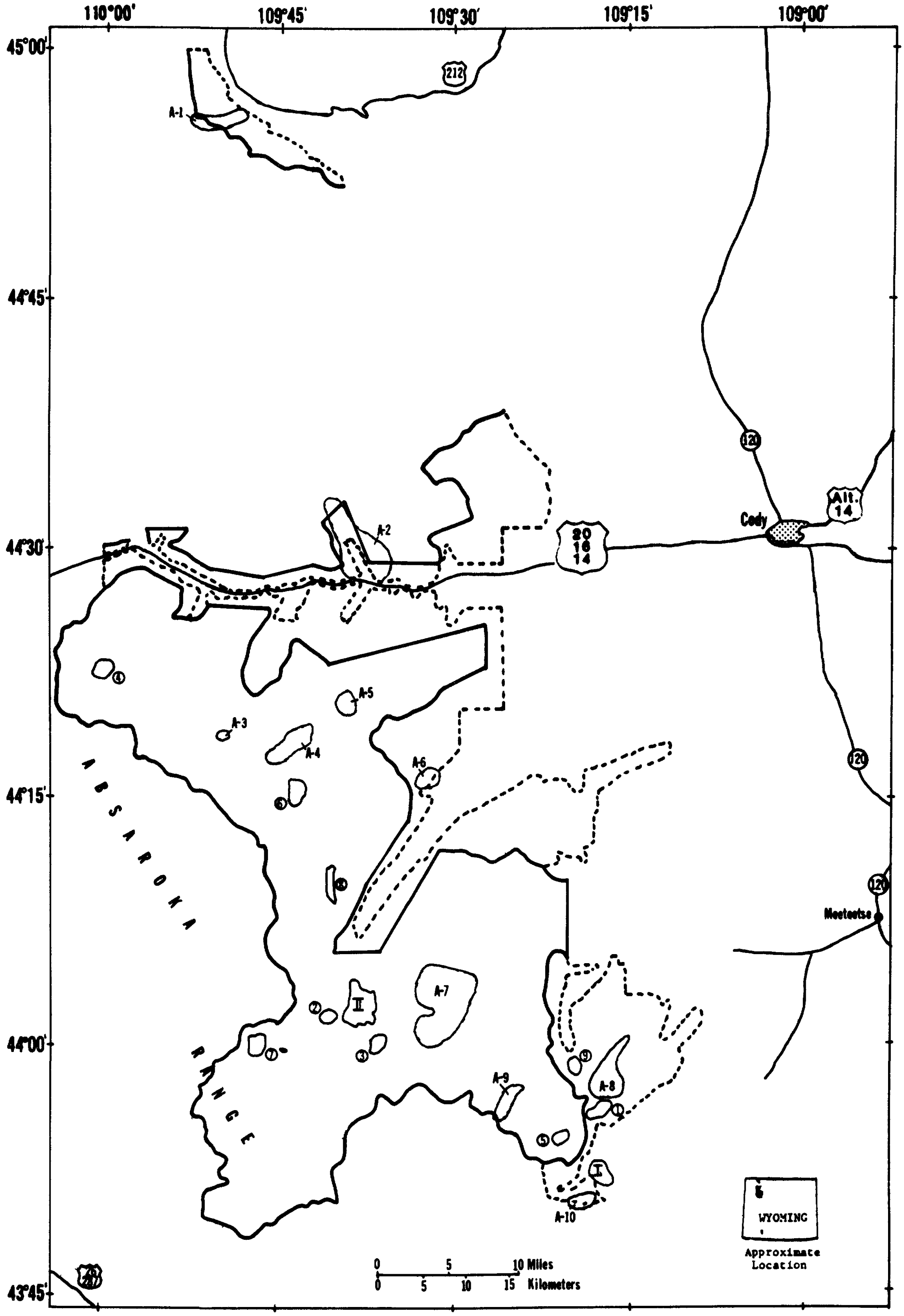

Figure 5.--Map showing areas of mineral resource potential in and near the northern part of the Washakie Wilderness and nearby roadless areas, Park, County, Wyoming (see following page for explanation).

EXPLANATION OF MINERAL RESOURCE POTENTIAL

AREAS HAVING IDENTIFIED RESOURCES AND HIGH RESOURCE POTENTIAL FOR BASE AND PRECIOUS METALS

I Kirwin mining district
II Stinkingwater mining district

AREAS HAVING HIGH MINERAL RESOURCE POTENTIAL--On the basis of geologic, geochemical, and geophysical data, and results of known mineral exploration activity

(1) Meadow Creek
(2) Silver Creek
(3) Lost Ranger Top
(4) Eagle Creek
(5) Yellow Ridge
(6) Clouds Home Peak

AREAS HAVING MODERATE RESOURCE POTENTIAL--On the basis of geologic, geochemical, and geophysical data and results of known mineral exploration activity

(7) Robinson Creek
(8) Deer Creek
(9) Gold reef (Jack Creek)

AREAS HAVING HIGH RESOURCE POTENTIAL--On the basis of strong geochemical anomalies and supporting geologic or geophysical data or evidence of mineral exploration activity

A-8 Francs Fork
A-10 Near East Fork Pass

AREAS HAVING MODERATE RESOURCE POTENTIAL--On the basis of generally weak geochemical anomalies but accompanied by supporting geologic or geophysical data or evidence of mineral exploration activity

A-1 Reef Roadless Area
A-2 Sweetwater Creek
A-3 Ruth Creek
A-4 Rampart volcano
A-6 North of Ishawooa Creek
A-7 Anderson and Venus Creeks

AREAS HAVING LOW RESOURCE POTENTIAL--On the basis of weak geochemical anomalies and minor evidence from geologic, geochemical, or geophysical data

A-5 Swede Creek
A-9 North of Mount Burwell

—— APPROXIMATE WILDERNESS BOUNDARY

------- APPROXIMATE ROADLESS AREA BOUNDARY prospect pits indicate nothing of metallic mineral significance.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Principal mineralized areas

The areas of mineral resource potential defined in the Washakie Wilderness and nearby roadless areas contiguous to it and the North Absaroka Wilderness are classified as having high, moderate, or low potential for mineral resources. Several mineralized areas were known prior to the mineral resource investigations: Eagle Creek, Stinkingwater, Gold Reef, Meadow Creek, and Kirwin. Our studies have contributed new information on those areas. In addition, several previously unknown mineralized areas having resource potential were identified as a result of the studies: Yellow Ridge and Silver Creek (Fisher and others, 1977); Clouds Home Peak, Robinson Creek, and Lost Ranger Top (Birthday Basin) (Fisher and Antweiler, 1980); and Deer Creek. Characteristics of the more important mineralized areas are summarized in table 2; based on our studies, the areas are listed in the order of their significance. Table 2 shows characteristic geological features, kind and extent of alteration, geochemical characteristics, geophysical anomalies, the extent of mining-related activity, and, in the last column, our assignment of a high, moderate, or low mineral resource potential for each area.

Mineralized areas and other areas having clustered geochemical anomalies are shown on figure 4. Kirwin mining district (I, fig. 5), outside but near the boundaries of the Washakie Wilderness has an identified porphyry-Cu deposit, with other base and precious metals present and has high potential for resources of base and precious metals in veins. Stinkingwater mining district (II, fig. 5) also has an identified resource for Cu and Mo in a porphyry-type deposit and has high potential for resources of other base and precious metals in veins. Meadow Creek (1, fig. 5) and Silver Creek (2, fig. 5) have high potential for resources of Cu and Mo in porphyry-type deposits. Lost Ranger Top (Birthday Basin) (3, fig. 5) has high potential for resources of Cu and Mo in porphyry-type deposits. Eagle Creek (4, fig. 5) has high potential for base- and precious-metal resources in veins, and high potential for Cu and Mo resources in a porphyry-type deposit. Yellow Ridge (5, fig. 5) and Clouds Home Peak (6, fig. 5) have high potential for resources of Cu and Mo in porphyry-type deposits; high potential also exists for resources of base and precious metals in veins at Clouds Home Peak. A moderate potential exists for resources of base and precious metals in veins at Robinson Creek (7, fig. 5) and Deer Creek (8, fig. 5); Robinson Creek also has moderate potential for resources of Cu and Mo in deposits of the porphyry-Cu type. A moderate potential for resources of base and precious metals in veins exists in the Gold Reef (Jack Creek) mining district (9, fig. 5), which is outside the Washakie Wilderness, but in the Francs Peak Roadless Area.

Areas delineated by geochemical anomalies

Geochemical anomalies, in addition to those associated with the mineralized areas summarized in table 2, were identified in several areas in the wilderness, as well as in or near several of the roadless areas. Areas containing these anomalies are classified as having a low or moderate mineral-resource potential, except areas A-8 and A-10, which have a high resource potential. These geochemically anomalous areas are shown on figure 5 and are summarized in the following paragraphs.

In the Reef Roadless Area, contiguous to the northern boundary of the North Absaroka Wilderness, weak geochemical anomalies (A-1, fig. 5) for Cu, Au, Pb, and Mo were detected in analyses of rock, soil, and panned-concentrate samples; follow-up sampling failed to identify Au. The weak base-metal anomalies are near the summit of the ridge at the southern boundary of the roadless area. No other indication of mineralization was observed, but the area has a moderate resource potential for Cu, Pb, And Mo in vein-type deposits.

An adit and several prospect pits occur in the Sweetwater Creek sulfur deposits (Bieniewski and Smith, unpub. data, 1983), which are in and adjacent to the Wapiti Valley East Roadless Area. The sulfur deposits are of fumarolic origin (Hewett, 1913, 1914a), are small, and the Sweetwater Creek area has low potential for sulfur resources. An area (A-2, fig. 5) of geochemical anomalies of Cu, Pb, and Zn is in and near the sulfur deposits and upstream from Sweetwater Mineral Springs on Sweetwater Creek above the road end. The strongest anomaly (Zn, 820 ppm) was in a stream-sediment sample below the sulfur deposits. These weak anomalies reflect slight enrichment of base metals and indicate an area of moderate resource potential for Cu, Pb, and Zn in vein-type deposits. The metal enrichment may be related to emplacement of the small intrusive body northeast of the sulfur deposits (Nelson and others, 1980), but rock samples from the intrusion did not contain anomalous amounts of the base metals.

The Ruth Creek area (A-3, fig. 5) is an area of moderate mineral resource potential for Mo in porphyry-type deposits, on the basis of analyses (5-30 ppm Mo) of samples taken along Ruth Creek, a tributary of Fishhawk Creek. The headwaters of Ruth Creek are on an igneous intrusion, but no geochemical anomalies for elements other than Mo were detected in the area.

Sediment samples from streams that drain the Rampart volcano (area A-4) contain geochemically anomalous values for Au and base metals. The maximum values for Au (0.9 ppm in panned concentrates), Cu (150 ppm), Pb (70 ppm), and Zn (300 ppm from panned concentrate) in the sediment samples are the strongest evidence of mineralization. The Cu, Pb, and Zn contents of rock samples from the slightly iron-stained intrusion and the stratified rocks penetrated by the intrusive body were well within the normal range of background values. No mineral deposits were identified, but the geologic setting and geochemical data appear favorable, so the area is classified as having a moderate mineral resource potential for Au, Cu, Pb, and Zn in vein-type deposits.

Analyses of samples from the area of an andesitic intrusion (A-5, fig. 5) on Swede Creek, northeast of the Rampart volcano, are at the upper range of background values in their content of Cu, Pb, and Mo. No samples had exceptionally high values, so the mineral resource potential of the area of this intrusion is deemed to be low for Cu, Pb, and Mo in vein-type deposits.

Some samples of the Willwood Formation in the Ishawooa Creek area (A-6, fig. 5) contain anomalously high concentrations of Mo--as much as 200 ppm. The Willwood underlies the volcanic field and is exposed in the southeastern part of the Ptarmigan Mountain quadrangle north of Ishawooa Creek. On the basis of the sample data and observations of secondary Mo minerals, which occur sparingly in small discontinuous lenses, the area has a moderate resource potential for Mo in sedimentary-type deposits. Neither the analyses of samples from outcrops with Mo minerals nor traverses using scintillometers to check radioactivity indicated suspected U concentrations.

An area of somewhat scattered geochemical anomalies for Au, Ag, Cu, and Mo is in the Irish Rock and Needle Mountain quadrangles along the drainages of Anderson and Venus Creeks (A-7, fig. 5). These anomalies occur where Rankin (unpub. data, 1982) noted the possibility of a volcanic center; although no pluton is exposed, a negative aeromagnetic anomaly roughly coincides with the center of the observed dome. Several aerial and foot traverses failed to reveal further evidence of mineralization, but the area is considered to have a moderate resource potential for base and precious metals in vein-type deposits.

Geochemical anomalies for base and precious metals are abundant in the drainage basin of Francs Fork (A-8, fig. 5). This area is adjacent to and north of the Meadow Creek basin, an area of high resource potential for Cu and Mo. Many dikes and veins related to the emplacement of plutons in this vicinity account for the geochemical anomalies. A high resource potential exists for base and precious metals in veins in the drainage basin of Francs Fork.

Rock samples from the ridge north of Mount Burwell (Mount Burwell quadrangle) indicate an area (A-9, fig. 5) of several weak Mo anomalies. These anomalies are based on samples containing 5 to 30 ppm Mo, and may represent atypical rocks of the Wiggins Formation, or they may be related to emplaced dikes. Because no specific geologic evidence indicates mineralization, the area is assigned a low mineral resource potential for disseminated Mo.

Geochemical data show that an area at the head of Wood River east of East Fork Pass (A-10, fig. 5) has anomalous concentrations of Cu, Mo, Pb, and Zn. This area overlaps the southernmost boundary of the Francs Peak Roadless Area. This area, which is about 2 mi southwest of Kirwin and is a part of the mineralized region surrounding Kirwin, has a high resource potential for base and precious metals in vein-type deposits.

The conceptual models of mineralization in the study areas are (1) precious- and base-metal veins and (2) porphyry-Cu-Mo systems in intrusive centers that have developed near volcanic vents--mostly stratovolcanoes. Propylitically altered rocks are typically widespread and extend into the country rocks to variable distances. Argillically altered rocks are generally minor; phyllic alteration is developed at Kirwin, Stinkingwater, Silver Creek, and Eagle Creek but less so elsewhere; potassically altered rocks are somewhat restricted except at Kirwin.

In terms of resource potential, chalcopyrite is the most abundant mineral in the study area; other minerals include pyrite, galena, molybdenite, sphalerite, and native gold. Geochemically anomalous elements associated with the porphyry deposits include Cu, Mo, and one or more of the following: Au, Ag, Pb, Zn, Bi, As, and Hg. Veins of precious and base metals radiate away from the centers and commonly have geochemical anomalies dominated by Cu, Mo, Au, Ag, Pb, and Zn.

Oil and gas

A large part of the Washakie Wilderness, North Absaroka Wilderness, and contiguous roadless areas is underlain by prevolcanic rocks in a large sedimentary basin. This part of the basin is a westward extension of the Bighorn Basin between the crystalline and metamorphic cores of two major Laramide mountain ranges--the Beartooth Mountains on the north and the Washakie Range on the south (fig. 3). Within the basin are Paleozoic, Mesozoic, and lowest Tertiary sedimentary strata. The mountains and the area between them, including much of the area of this study, are overlapped by gently dipping to flat volcaniclastic rocks of the Absaroka Range. These rocks are an erosional remnant of a vast sheet of volcaniclastic strata that formerly extended eastward across the Bighorn Basin (McKenna and Love, 1972) and southeastward across the Wind River Basin (Love, 1970).

Two major types of evidence that Mesozoic and older sedimentary rocks extend northwestward across the study area into Yellowstone National Park are the trends of anticlines and synclines in the western part of the Bighorn Basin and the distribution of oil seeps. The oil in the seeps is presumed to have been derived from Mesozoic strata and migrated upward through the volcaniclastic cover at Calcite Springs, Rainbow Springs, and Sweetwater Mineral Springs (fig. 3; Love and Good, 1970).

Twenty-one of the oil fields on anticlines involving Mesozoic strata in the Bighorn Basin are within 15 mi of the east margin of the Washakie Wilderness and nearby roadless areas. Several anticlines project into the lands studied for this report. These relations suggest that exploration for oil and gas may be successful within the study area.

Seven dry holes have been drilled within 2 mi of the study area. Data from these dry holes and nearby oil fields indicate the thickness of sedimentary rocks that probably underlie the volcanic rocks in the study area (table 3).

Table 2.--Classification of the mineral resource potential of 11 areas in the Washakie Wilderness and nearby roadless areas

[Sources of information: U.S. Geological Survey and U.S. Bureau of Mines field investigations 1975-1977; Fisher, 1967, 1971, 1972, Galey, 1971. Intrusive rocks are listed oldest to youngest within each area]

No. on fig. 5	Mineralized area	Extrusive rocks	Intrusive rocks: Description	Intrusive rocks: Approx. outcrop area (mi^2)	Fracture systems	Area of mineralized and altered rock (mi^2)	Alteration in rocks: [1]Propylitic (calcite, epidote, chlorite, pyrite) [2]Argillic (clay minerals) [3]Phyllic (secondary quartz, sericite, pyrite) [4]Potassic (secondary biotite, K-feldspar)	Oxidized zone from weathering of sulfide minerals
I	Kirwin mining district	Vent facies, flows and breccias of the Wiggins Formation (Thorofare Creek Group); a late explosion breccia in volcanic rock.	Granodiorite, andesite, quartz monzonite, quartz latite.	0.2	NW- and NE-trending fracture systems; N and E-W normal faults.	0.8-1	[1]Widespread in both intrusive and extrusive rocks. [2]Present, but not abundant. [3]Well developed in central part of area. [4]Common within central zone.	Well developed, common iron staining and some malachite.
II	Stinkingwater mining district	Vent facies, flows and breccias of Wiggins Formation.	Complex series of stocks, dikes, and sills; granodiorite, diorite, quartz monzonite, dacite, and rhyodacite porphyry.	4.2	NE- and NW-fracture systems; some randomly oriented normal faults; central zone of extensive shattering; well-developed radial dike pattern.	1	[1]Widespread in both intrusive and extrusive rocks. [2]Local, restricted patterns. [3]Well developed in central shattered zone and adjacent to faults and fracture systems. [4]Local areas within central shattered zone.	Well developed, much iron-oxide staining; drilling indicates zone is as much as 100 m thick; malachite, azurite, ferrimolybdenite, limonite, jarosite.
1	Meadow Creek	---do------------	Granodiorite, porphyritic dacite, andesite-dacite dikes.	1.5	N- and W-trending faults, N. 75° W.- and N. 5° E. shear zones.	.2	[1]Widespread in both intrusive and extrusive rocks. [2]None or very minor. [3]Scattered zones in central part of plutonic complex, especially along fractures and shears. [4]Some secondary biotite in local patches; veins of actinolite, pyrite, K-feldspar, chalcopyrite, and quartz.	Common in central parts of plutonic complex, some malachite.
2	Silver Creek	---do-----------	Porphyritic hornblende dacite, porphyritic quartz-biotite rhyodacite.	.8	N. 50° W.-N. 80° W. fractures and N. 10° E.-N. 35° E. fractures.	.2	[1]Widespread in both intrusive and extrusive rocks. [2]None or very minor. [3]Well developed within central part of pluton. [4]Small (300-1,000 ft^2) irregular zones characterized by quartz-K-feldspar and magnetite.	Local patches, commonly with malachite.
3	Lost Ranger Top (Birthday Basin)	---do------------	Granodiorite, andesite and dacite-andesite dikes.	.3	N. 10° W.-N. 45° W. faults and fractures.	<.2	[1]Well developed adjacent to faults and fracture systems and in central pluton. [2]None or very minor. [3]Mostly in scattered localized patches, commonly adjacent to fractures. [4]Two restricted areas adjacent to fracture and vein systems; veins contain actinolite, tremolite, K-feldspar, magnetite, quartz, and chalcopyrite.	Common, mostly contains limonite but some malachite and azurite.

1981; Fisher and others, 1977; Fisher and Antweiler, 1980; Wilson, 1963, 1964a, 1964b, 1971, 1975;

Chalcocite supergene-enriched zone	Ore minerals in central zone	Ore and gangue minerals in peripheral veins	Aeromagnetic features	Bouguer gravity features	Mining-related activity	Resource potential classification
Blanket deposit of sooty chalcocite after pyrite and chalcopyrite.	Chalcopyrite, chalcocite, and molybdenite; disseminated, coating fractures, and in small quartz veinlets.	Galena, sphalerite, chalcopyrite, tetrahedrite, gold, pyrite, quartz, carbonate, barite, hematite.	SE flank magnetic high; overall magnetic expression of altered zone probably obscured by influence of topography.	E flank of a N-S trend with some implications of an intersecting NW trend in the gravity data, possible basement structure.	Orebody outlined by major company. Several adits, shafts, cuts, and pits in district.	High potential for base- and precious-metal resources in veins. Identified Cu-Mo porphyry-type orebody estimated to contain 70,000,000 tons of rock averaging 0.75 percent Cu. Other base and precious metals present
Well developed; drilling indicates zone as much as 650 ft thick; sooty chalcocite after chalcopyrite and pyrite.	Chalcopyrite, bornite, and molybdenite; disseminated, coating fractures, and in quartz-pyrite veinlets and molybdenite-quartz veinlets.	Chalcopyrite, galena, sphalerite, tetrahedrite, gold, arsenopyrite, pyrite, quartz, calcite, dolomite, siderite.	S flank low-amplitude magnetic high, also topographic high; therefore, any magnetic expression of altered zone is probably obscured by influence of topography.	SE flank of intersection of major NE trend in gravity data and the NW-trending gravity plateau formed by intrusive centers; possibly near center of intrusive.	Major mining companies have drilled 21 diamond-drill holes. Two adits, numerous ditches, prospect pits, and scrapings.	High potential for base- and precious-metal resources in veins. Identified Cu-Mo porphyry-type deposits. Estimate (1982) many millions of tons of protore.
None known----	Chalcopyrite-----	Chalcopyrite, galena, sphalerite, pyrite, quartz, carbonate minerals.	Centered on magnetic high, also topographic high; therefore, any magnetic expression of alteration probably obscured by influence of topography.	E flank of a N-S gravity trend, possible N-S trend in basement structure.	Two diamond-drill holes by major company. Four adits, several small pits, and scrapings.	High potential for resources of Cu and Mo in a porphyry-type deposit.
---do---------	Chalcopyrite, bornite, and molybdenite; mostly disseminated but some in quartz-chalcopyrite veinlets.	Pyrite.	S flank low-amplitude magnetic high, also topographic high; therefore, any magnetic expression of altered zone is probably obscured by influence of topography.	SW flank of intersection of major NE trend in gravity data and the NW-trending gravity plateau; possibly the outer contact zone of intrusive body.	Two diamond-drill holes as of 1976.	Do.
---do---------	Chalcopyrite in disseminations, coating fractures, and in quartz-pyrite veinlets; some quartz-chalcopyrite stockworks.	Pyrite, quartz, calcite.	Low-amplitude area, local low magnetic anomaly; possible demagnetized zone of altered area or possible topographic effect.	SE flank of the NW-trending gravity plateau formed by intrusive centers; probably at the outer contact zone of intrusive body.	None---------------	Do.

Table 2.--Classification of the mineral resource potential of 11 areas in the Washakie Wilderness and nearby roadless areas--Continued

[Sources of information: U.S. Geological Survey and U.S. Bureau of Mines field investigations 1975-1977; Fisher, 1967, 1971, 1972, Galey, 1971. Intrusive rocks are listed oldest to youngest within each area]

No. on fig. 5	Mineralized area	Extrusive rocks	Intrusive rocks: Description	Intrusive rocks: Approx. outcrop area (mi^2)	Fracture systems	Area of mineralized and altered rock (mi^2)	Alteration in rocks: [1]Propylitic (calcite, epidote, chlorite, pyrite) [2]Argillic (clay minerals) [3]Phyllic (secondary quartz, sericite, pyrite) [4]Potassic (secondary biotite, K-feldspar)	Oxidized zone from weathering of sulfide minerals
4	Eagle Creek	Flows and breccias of the Trout Peak Trachyandesite (Sunlight Group) and Langford Formation (Thorofare Creek Group).	Latite porphyry, quartz porphyry, andesite dikes.	.3	NW- and NE-trending zones of fracturing, some NW-trending faults.	<.2	[1]Widespread in both intrusive and extrusive rocks. [2]None or very minor. [3]Well developed in scattered patches in central zone of mineralized and altered rocks. [4]None or very minor.	In central zone, some malachite.
5	Yellow Ridge	Vent facies flows and breccias of Wiggins Formation.	Granodiorite and diorite, biotite-andesite porphyry, hornblende andesite.	.8	N-NE-trending fractures, local zones of shattered rock.	<.1	[1]Widespread in both intrusive and extrusive rocks. [2]None or very minor. [3]Local areas in central parts of intrusive complex. [4]Local patches with quartz and K-feldspar veinlets.	Local patches some malachite.
6	Clouds Home Peak	Vent facies flows and breccias of the Wiggins Formation (Thorofare Creek Group).	Granodiorite, quartz monzonite, porphyritic dacite, and rhyodacite andesite dikes.	1-1.5	N. 20° E.-N. 30° E. shears, N. 30° W. shears.	.4-.8	[1]Widespread within intrusive rocks. [2]None or very minor. [3]Locally adjacent to veins, dikes, and shear zones. [4]None.	In central zone, some malachite, azurite.
7	Robinson Creek	---do------------	Rhyodacite-dacite, andesite dikes.	.8	N. 20° W.-N. 60° W. features.	.2	[1]Widespread within plutonic rocks. [2]Restricted patches, mostly near fractured zones. [3]Within central parts of plutonic zone. [4]None or very minor.	Common in central parts of pluton, some malachite.
8	Deer Creek	---do------------	Granodiorite, porphyritic dacite, andesite dikes.	.4	Local fractures with no preferred orientation.	<.1	[1]Local patches, mostly within central intrusive rock. [2]None or very minor. [3]Very restricted adjacent to fractures. [4]None or very minor.	Local small several ft^2 patches.
9	Gold Reef (Jack Creek)	---do------------	None exposed-------	0	N. 40° W.-N. 60° W. fractures.	<.1	[1]Poorly developed adjacent to veins and fracture systems. [2]None or very minor. [3]None. [4]None.	Only developed adjacent to veins.

1981; Fisher and others, 1977; Fisher and Antweiler, 1980; Wilson, 1963, 1964a, 1964b, 1971, 1975;

Chalcocite supergene-enriched zone	Ore minerals in central zone	Ore and gangue minerals in peripheral veins	Aeromagnetic features	Bouguer gravity features	Mining-related activity	Resource potential classification
---do---------	Chalcopyrite and molybdenite; disseminated, and in quartz-pyrite stockwork veinlets.	Chalcopyrite, galena, sphalerite, quartz, carbonate minerals trace gold, pyrite.	Magnetic saddle indicating possible demagnetized zone of altered area.	NE flank of gravity high, probably at outer contact zone of main intrusive body.	One adit, about 720 ft. Numerous shallow pits, ditches, and scrapings. Minor gold production.	High potential for resources of base and precious metals in veins and for resources of Cu and Mo in a porphyry-type deposit.
---do---------	Chalcopyrite, bornite, and molybdenite.	Pyrite.	S flank of low-amplitude high, no significant magnetic expression; probably obscured by high influence of topography.	N-S trend with some implications of an intersecting NW trend in the gravity data, probably basement structure.	None---------------	High potential for resources of Cu and Mo in a porphyry-type deposit.
---do---------	Chalcopyrite; disseminated and in quartz-pyrite stockwork veinlets.	Chalcopyrite, pyrite, quartz, carbonate minerals, rhodochrosite.	SW flank magnetic high, also topographic high; therefore, magnetic expression of alteration probably obscured by influence of topography.	Center of gravity high possibly coincidental with the center of intrusive; high is at end of a NW-trending gravity plateau formed by intrusive centers.	None---------------	High potential for base and precious metals in veins and for resources of Cu and Mo in a porphyry type deposit
---do---------	Chalcopyrite in disseminated grains, as fracture coatings, and in small quartz-pyrite veinlets.	Pyrite.	No significant magnetic anomaly.	Major N-E trend in gravity data, possibly a basement fracture zone and conduit for the intrusive.	None---------------	Moderate potential for Cu and Mo resources in porphyry-type deposits and for resources of base and precious metals in veins.
---do---------	None--------------	Pyrite.	SE flank low-amplitude magnetic high; no distinct magnetic expression of altered zone, probably obscured by topography.	NW flank of gravity ridge, probably at outer contact zone; area also occurs within the NW-trending gravity plateau formed by intrusive centers.	None---------------	Moderate potential for resources of base and precious metals in veins.
---do---------	None--------------	Sparse chalcopyrite and galena, quartz, pyrite, calcite.	E flank low-amplitude low probably only a topographic effect.	E flank of a N-S trend in gravity data, possible N-S trending basement structure.	Two adits and several small prospect pits.	Moderate potential for resources of precious and base metals in veins.

Table 3.--Estimated thicknesses of sedimentary rocks that may underlie parts of the northern part of the Washakie Wilderness and nearby roadless areas on the basis of data from oil fields and dry holes in the Bighorn Basin

Cody Shale (Upper Cretaceous), 2,500 ft.
Frontier Formation (Upper Cretaceous), 500-700 ft.
Mowry and Thermopolis Shales (Lower Cretaceous), 800-900 ft.
Cloverly and Morrison Formations (Lower Cretaceous and Upper Jurassic), 400-600 ft.
Sundance and Gypsum Spring Formations (Upper and Middle Jurassic), 300-500 ft.
Triassic rocks, 800-1,450 ft.
Phosphoria Formation and equivalent rocks (Permian), 100-200 ft.
Pennsylvanian rocks, 400-600 ft.
Madison Limestone (Mississippian), 500-800 ft.
Darby Formation (Devonian), 100-250 ft.
Bighorn Dolomite (Ordovician), 300-450 ft.
Cambrian rocks, 900-1,100 ft.

Detailed geophysical studies and drilling in the study area are required to determine the configuration of structures and possible stratigraphic traps involving pre-Tertiary strata and to estimate the volume of source rocks that could contribute hydrocarbons to these traps. A gravity survey of the adjacent Teton Wilderness, directly to the west, defined a negative gravity anomaly, which may represent a deep sedimentary basin, the Younts Basin(?), on the east side of the Washakie Range (fig. 3; Kulik, 1981, p. 18). If later work confirms that this possible basin is as deep as 20,000 ft, it would indicate that much of the present study area is on a Laramide structural shelf probably complicated by a series of en echelon northwest-trending anticlines and synclines, similar to those exposed east of the volcaniclastic cover.

In assessing the potential for oil and gas in possible structural and stratigraphic traps, some factors that were considered are summarized here: (1) Laramide folding east of the study area formed most of the anticlines where oil is produced in the Bighorn Basin, (2) Patterns of folding and faulting may trend north-northwest or northwest and be asymmetric as in the folds and faults east of the study area; however, some Laramide structures may have been disrupted by the major Eocene eruptive centers in the study area, (3) Volcaniclastic rocks and intravolcanic and postvolcanic structural events, such as development of the South Fork, Reef Creek, and Heart Mountain low-angle detachment faults, obscure underlying structures, as do large contorted lithified slide masses of volcaniclastic rocks, (4) In an oil drilling test in the northern part of the Fourbear oil field (fig. 3), 4 mi east of the study area, 1,065 ft of igneous rock similar to Absaroka volcaniclastic rocks was cored, but the well was completed for an initial production of 350 bbl oil per day. Moreover, an oil test in the Kirwin area drilled through the Wiggins Formation and an igneous sill; the sill did not appreciably affect adjoining Jurassic and Triassic strata. These two tests demonstrate that oil can survive near a younger major igneous intrusion, (5) The oil in the Sweetwater Mineral Springs oil seeps (Hewett, 1913) has emerged through the volcaniclastic rocks of the Wapiti Formation, including igneous flows and breccias; analysis of the oil (Love and Good, 1970) suggests that it is low-sulfur Cretaceous oil, (6) High magnetic anomalies in the study area correlate in a general way with some of the known intrusive igneous bodies; these igneous bodies may represent tectonic forces that may have disrupted older Laramide structures. Unfortunately, for comparative purposes, no magnetic anomalies are known to parallel the exposed anticlines east of the study area, and (7) None of the areas of oil fields east of the study area are eroded below Cretaceous rocks; if this is also true of structures beneath the study area, possible hydrocarbon traps may not have been breached by erosion, and adequate reservoir and source rocks are likely below the volcanic rocks in the study area.

This assessment and supporting data indicate that low to moderate potential exists for oil and gas resources in the study area. Most potential reservoir rocks could be tested by drilling to depths of 15,000 ft or less if the hole is favorably located structurally. For further evaluation, seismic reflection surveys might define Laramide folds below the volcaniclastic rocks, determine the now-buried western margin of the Bighorn Basin, locate the northeast flank of the Washakie Range, and confirm or refute the existence and configuration of the Younts Basin(?).

Uranium

The data suggest that there is no evidence of a potential for uranium resources in the study area. This assessment is based on the many field traverses with scintillometers that failed to reveal any radioactivity anomalies and on analyses of about 10 percent of the samples that showed U contents ranging from less than 1 ppm to about 15 ppm. The few samples having the higher values were of thin lenses of carbonaceous shale in the stratified volcanic rocks. Moreover, no uranium anomalies were detected in the area during the National Uranium Resource Evaluation (NURE) (J. G. Hill, written commun., 1979).

Rock products

Sand and gravel deposits are present along all the major streams within the study area, but higher quality and more accessible deposits are present outside the study area. Deposits of sand and gravel in the study area tend to be poorly sorted, contain a high proportion of soft volcanic fragments, and are generally unsuitable for concrete aggregate or road metal. Building stone could probably be quarried from some of the rock formations, such as the Trout Peak Trachyandesite, but most of the volcanic rock is not well suited for building stone; better material is available outside the study area.

Geothermal resources

No evidence of a potential for geothermal resources was observed in the study area.

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