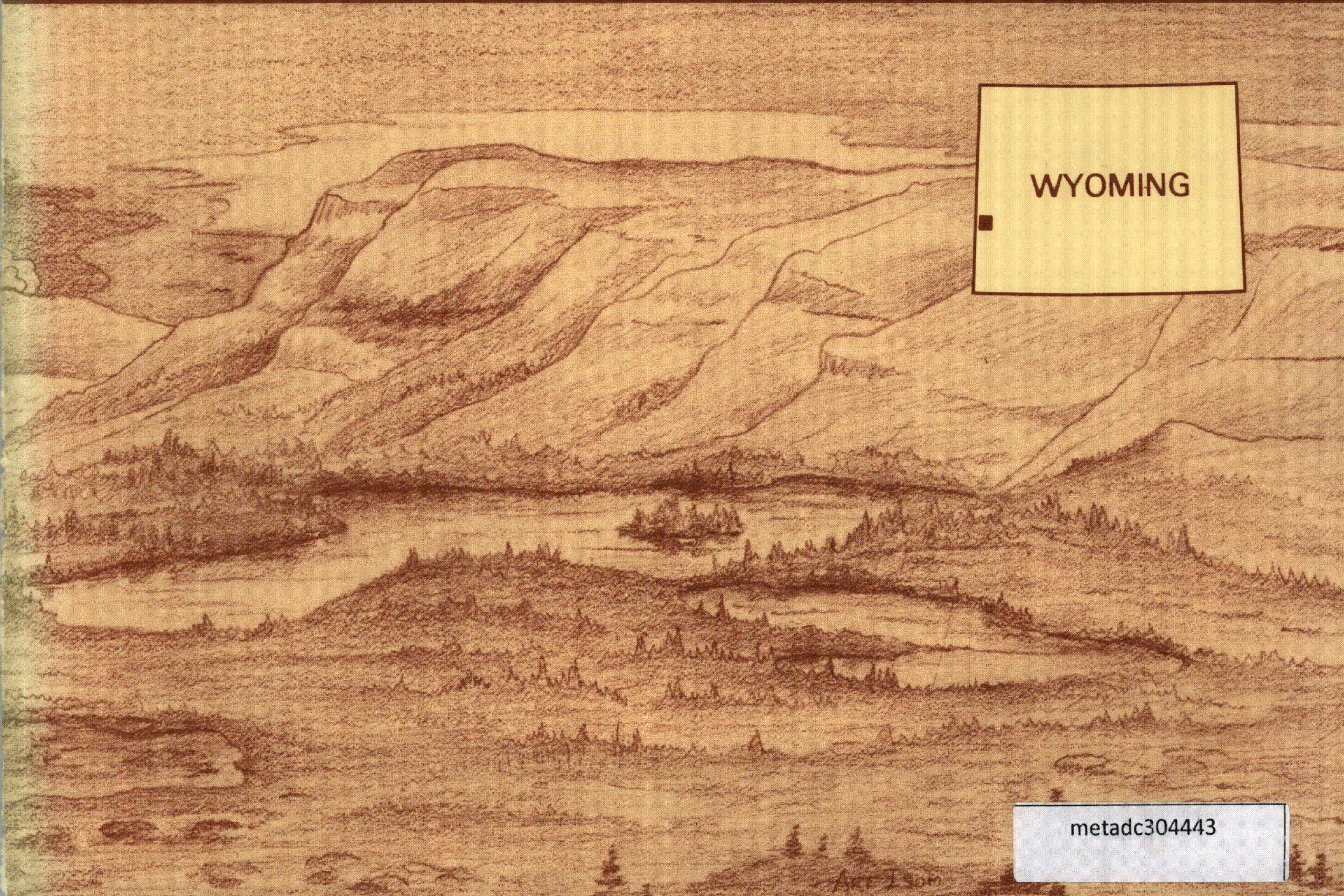
Mineral Resources of the Raymond Mountain Wilderness Study Area, Lincoln County, Wyoming

U.S. DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY
U.S. DEPARTMENT OF THE INTERIOR BUREAU OF MINES
U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT

U.S. GEOLOGICAL SURVEY BULLETIN 1757–I



Chapter I

Mineral Resources of the Raymond Mountain Wilderness Study Area, Lincoln County, Wyoming

By KAREN LUND
U.S. Geological Survey

JAMES P. EVANS
Utah State University

RANDALL H. HILL and VIKI BANKEY
U.S. Geological Survey

MICHAEL E. LANE
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1757

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—SOUTHERN WYOMING

DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

UNITED STATES GOVERNMENT PRINTING OFFICE: 1990

For sale by the
Books and Open-File Reports Section
U.S. Geological Survey
Federal Center
Box 25425
Denver, CO 80225

Library of Congress Cataloging-in-Publication Data

Mineral resources of the Raymond Mountain Wilderness Study Area, Lincoln County, Wyoming / by Karen Lund ... [et al.].
p. cm. — (U.S. Geological Survey bulletin ; 1757) (Mineral resources of wilderness study areas—southern Wyoming ; ch. I)
Includes bibliographical references.
Supt. of Docs. no.: I 19.3:1757I
1. Mines and mineral resources—Wyoming—Raymond Mountain Wilderness. 2. Raymond Mountain Wilderness (Wyo.) I. Lund, Karen. II. Series. III. Series: Mineral resources of wilderness study areas—southern Wyoming ; ch. I.
QE75.B9 no. 1757-I
[TN24.W]
557.3 s—dc20 90-2928
[553'.09787'82] CIP

STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94–579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of the Raymond Mountain (WY–040–221) Wilderness Study Area, Lincoln County, Wyoming.

CONTENTS

PLATE

[Plate is in pocket]

FIGURES

Mineral Resources of the Raymond Mountain Wilderness Study Area, Lincoln County, Wyoming

By Karen Lund
U.S. Geological Survey

James P. Evans
Utah State University

Randall H. Hill *and* Viki Bankey
U.S. Geological Survey

Michael E. Lane
U.S. Bureau of Mines

ABSTRACT

The 32,936-acre Raymond Mountain (WY-040-221) Wilderness Study Area lies in the Wyoming salient of the Idaho-Wyoming-Utah overthrust belt, in Lincoln County, extreme west-central Wyoming. The wilderness study area has no identified (known) mineral or energy resources. The wilderness study area has moderate energy resource potential for oil and gas. Less than 10 percent of the area has been leased for oil and gas exploration. The wilderness study area has low energy resource potential for coal, which may occur as thin layers in the Cokeville Formation. The wilderness study area has low mineral resource potential for phosphate. The Phosphoria Formation is only exposed in a fault block west of the study area and is exposed in the study area between Raymond and Rose Canyons. These otherwise deeply buried, unweathered beds contain low P_2O_6 values. The wilderness study area also has low mineral resource potential for vanadium in the Phosphoria Formation because of the depth of burial. The wilderness study area has low resource potential for other metals, including uranium, for high-purity limestone or dolostone, and for geothermal energy.

Manuscript approved for publication February 19, 1990.

SUMMARY

Character and Setting

The Raymond Mountain (WY-040-221) Wilderness Study Area encompasses most of the Sublette Range and extends southward to 3 mi (miles) north of Cokeville, in western Lincoln County, Wyo. (fig. 1). U.S. Highway 89 borders the northwestern side of the wilderness study area, Wyoming Highways 61 and 89 extend along the western side, and U.S. Highway 30N and Wyoming Highway 89 extend along the southwestern side. Old unimproved roads form most of the eastern border and provide access into much of the wilderness study area.

The eastern side of the Sublette Range is topographically gentle, open grassland. The western part is a high ridge that is steep on both sides and mostly forested. The total relief is about 3,000 ft (feet) from the top of Sublette Mountain at 9,313 ft to the Thomas Fork Valley at the northwest corner of the study area at about 6,300 ft.

The Sublette Range is bounded on the west by a normal fault that raised the range relative to the valleys to the west and exposed Paleozoic (see geologic time scale in Appendix) rocks on the west and Mesozoic rocks on the east. Rocks of the Sublette Range show a complex structural history; most deformation occurred during late Mesozoic to early Tertiary compressional events that formed the Idaho-Wyoming-Utah overthrust belt.

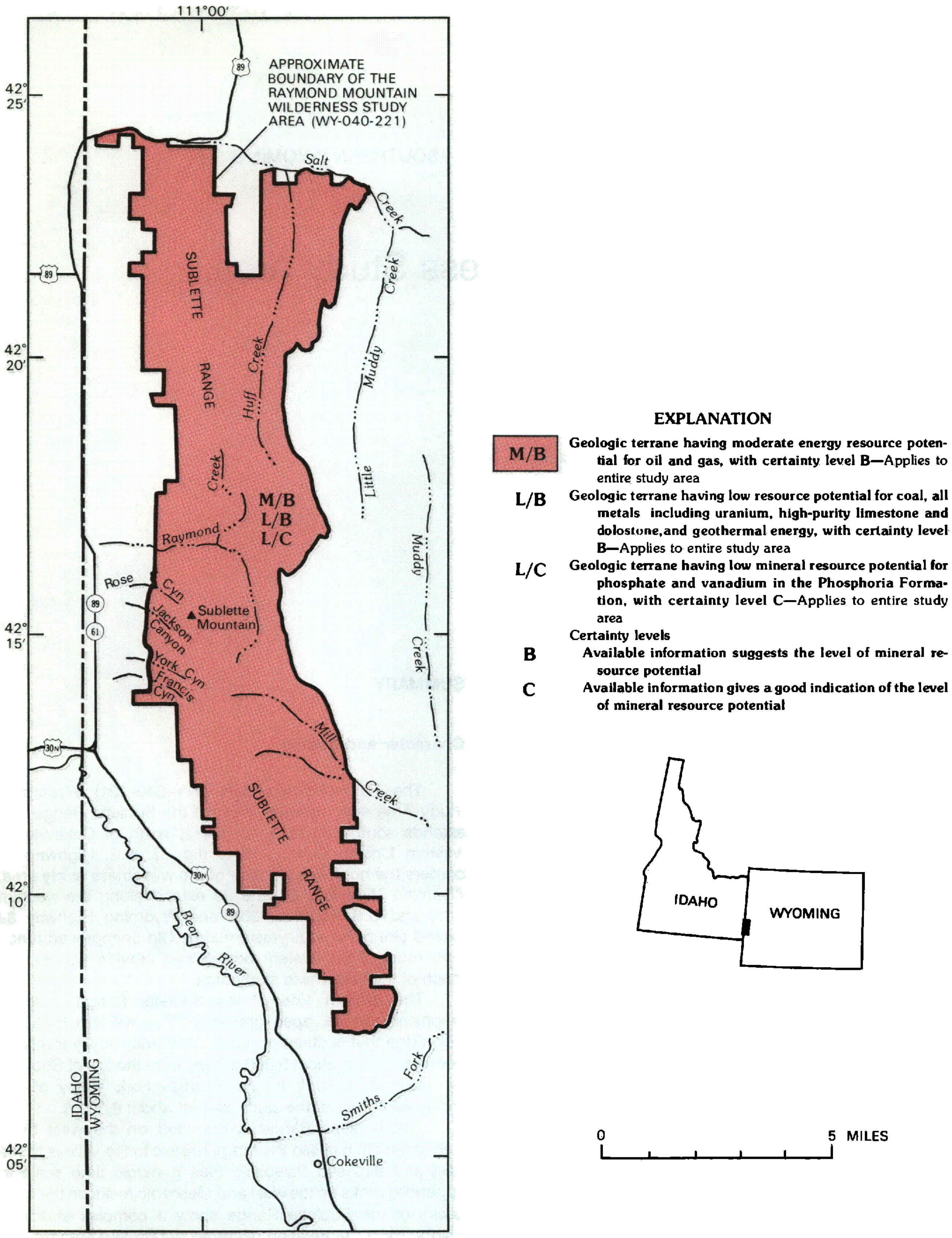


Figure 1. Summary map showing location and mineral resource potential of the Raymond Mountain Wilderness Study Area, Lincoln County, Wyoming.

Identified Resources

The wilderness study area is east of several groups of unpatented claims and prospects related to exploration for and limited production of phosphate (fig. 2). Several exploratory oil wells have been drilled in and near the wilderness study area (fig. 2).

There are no identified mineral or energy resources in the Raymond Mountain Wilderness Study Area.

Mineral Resource Potential

The entire wilderness study area has moderate energy resource potential for oil and gas. Commercial exploration for oil and gas is ongoing in the region. Both Paleozoic and Mesozoic rocks are source rocks, and these as well as reservoir rocks of several ages are present in the wilderness study area. Although favorable structures for migration and trapping also are present, the ideal juxtapositioning of suitable reservoir rocks over source rocks may be absent in the wilderness study area.

The wilderness study area has low energy resource potential for coal. The only units near the study area that contain coal are the Cokeville and Sage Junction Formations. Basal Cokeville Formation crops out in restricted areas along the eastern side of the study area.

The wilderness study area has low mineral resource potential for both phosphate and vanadium despite the occurrence of anomalous phosphate and vanadium in the Phosphoria Formation adjacent to the wilderness study area and despite the presence of mines, prospects, and claims for phosphate along the western boundary of the study area near Raymond Canyon. Because the Phosphoria Formation, which hosts these deposits, is nearly vertical and in a fault-bounded block, little of the Phosphoria Formation and its mineralized beds lie near the surface in the wilderness study area. Elsewhere in the study area, the Phosphoria Formation is at least 10,000 ft below the surface; therefore, it is unweathered and most likely contains low P_2O_5 values (Service and Popoff, 1964).

Because there are no known mines or prospects in the nearby region, because geochemical or geophysical indications for near-surface occurrences were not found during the study, and because geologic mapping showed no indications of these resources, the wilderness study area is considered to have low resource potential for other metals, including uranium, high-purity limestone or dolostone, and geothermal energy.

INTRODUCTION

At the request of the U.S. Bureau of Land Management (BLM), the 32,936-acre Raymond Mountain (WY–040–221) Wilderness Study Area in western Lincoln County, Wyo., was studied by the U.S. Bureau of Mines (USBM) and the U.S. Geological Survey (USGS). In this report, the studied area is called the "wilderness study area" or just the "study area." The wilderness study area is in west-central Wyoming, 3 mi north of Cokeville, Wyo., and 15 mi east of Montpelier, Idaho (fig. 1). U.S. Highway 89 borders the area on the northwest side, Wyoming Highways 89 and 61 extend along the western side, and U.S. Highway 30N and Wyoming Highway 89 extend along the southwestern side. Several unimproved roads in poor condition form most of the border on the eastern side, and others provide additional access into much of the wilderness study area.

The wilderness study area includes most of the Sublette Range, which is a normal-fault block. The main ridge of the Sublette Range is steep and forested, whereas low elevations on the eastern side of the range are more gentle and mostly grassland.

This report presents an evaluation of the mineral endowment (identified resources and mineral resource potential) of the wilderness study area and is the product of several separate studies by the USBM and the USGS. Identified resources are classified according to the system of the U.S. Bureau of Mines and U.S. Geological Survey (1980), which is shown in the Appendix of this report. Identified resources are studied by the USBM. Mineral resource potential is the likelihood of occurrence of undiscovered metals and nonmetals, of industrial rocks and minerals, and of undiscovered energy sources (coal, oil, gas, oil shale, and geothermal sources). It is classified according to the system of Goudarzi (1984) and is shown in the Appendix. Undiscovered resources are studied by the USGS.

Investigations by the U.S. Bureau of Mines

A search was conducted of county-courthouse and BLM records for information concerning mining-claim locations as well as oil and gas and phosphate leases. A literature search also was made for mining and mineral-related information concerning the area.

A field investigation was made by the USBM in 1982. During the field investigation, 22 rock-chip samples were taken from mine workings and prospects. Twenty samples were phosphate samples. Two samples were taken inside the wilderness study area at prospect pits in shale where minor copper staining was visible. Samples were analyzed for gold and silver by fire assay, for phosphate and vanadium by energy-dispersive X-ray fluorescence, and for 40 elements by semiquantitative spectrographic methods. All analyses were done by the USBM Research Center, Reno, Nev. Complete analyses are available for public inspection at the USBM Intermountain Field Operations Center, Denver Federal Center, Denver, CO 80225.

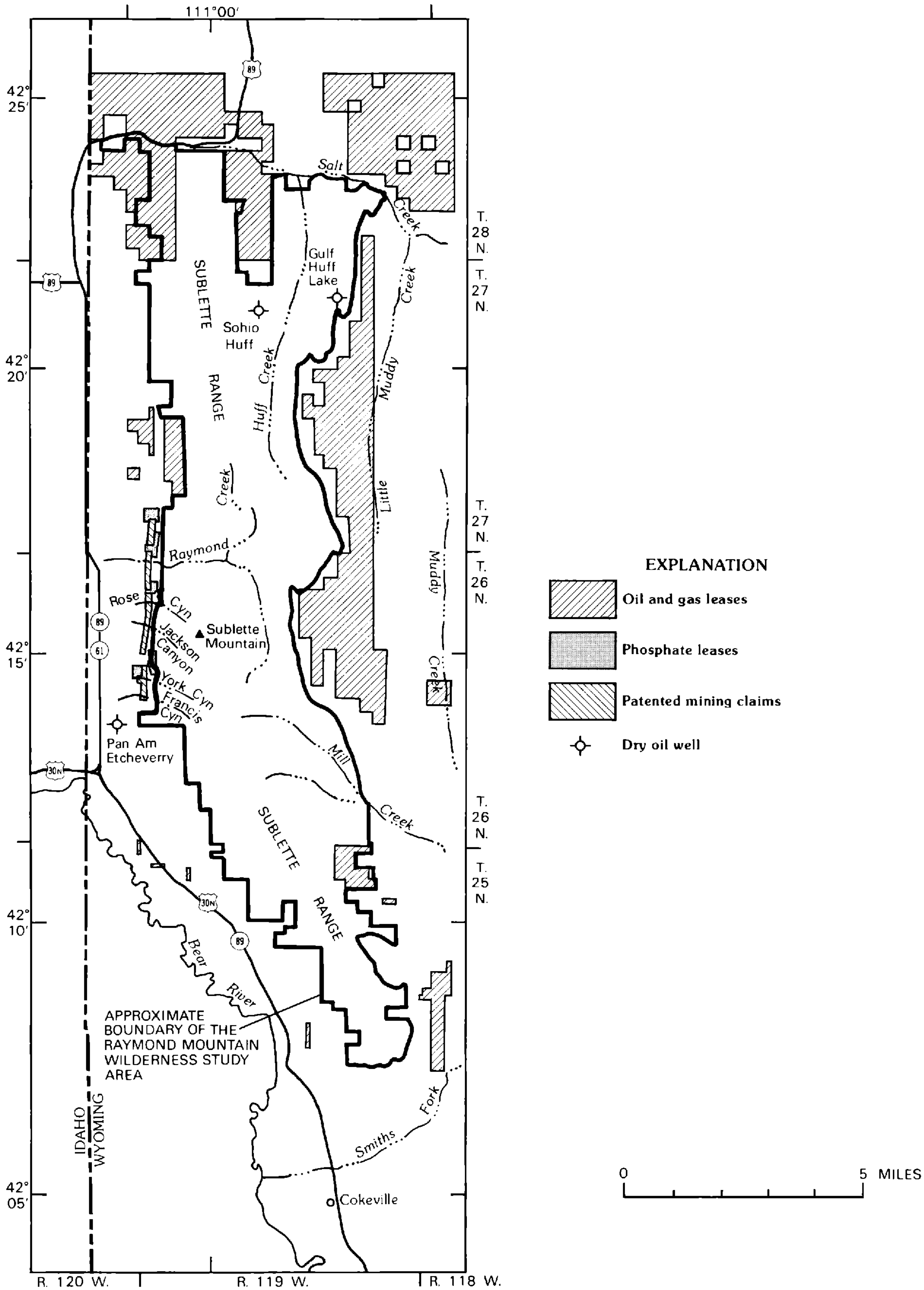


Figure 2. Map showing oil and gas leases, exploratory wells, phosphate leases, and patented mining claims in and near the Raymond Mountain Wilderness Study Area, Wyoming.

Investigations by the U.S. Geological Survey

In 1988, USGS geochemists collected 30 samples of stream sediment and 16 samples of rock at sites in the wilderness study area. The sampling and analytical procedures are described in the section on "Geochemistry."

New gravity measurements were made in the study area during the spring of 1988 by USGS geophysicists as part of a more regional survey (Bankey and Kulik, 1989). Aeromagnetic data were taken from a 1981 survey of the Sublette Range (U.S. Geological Survey, 1981).

During the spring of 1988, reconnaissance geologic field work was done by USGS geologists. Geologic map data were compiled from published and unpublished sources (Oriel and Platt, 1980; Rubey and others, 1980; Evans, 1983; and J.P. Evans, unpub. mapping, 1984–88).

APPRAISAL OF IDENTIFIED RESOURCES

By Michael E. Lane U.S. Bureau of Mines

Mining History

No organized mining districts are in the Raymond Mountain Wilderness Study Area; however, mining activity has centered on phosphate occurrences in the Meade Peak Member of the Phosphoria Formation (Allsman and others, 1949; McKelvey, 1950) adjacent to the western boundary. No phosphate prospects or mines were found inside the study area, but several are within 0.25 mi of the western boundary (fig. 2).

Patented mining claims cover phosphate outcrops outside and parallel to the western boundary of the study area (fig. 2); there are no mining claims inside the study area. A few phosphate leases are also along the western boundary and extend into the wilderness study area near Layland Canyon (Lane, 1983).

Although earlier reports and maps cited many prospects, only a few were found during the USBM investigation; natural processes along with human-caused topographic changes have covered or destroyed many of the old workings. No workings were found in the wilderness study area.

Phosphate has not been produced recently in or near the Raymond Mountain Wilderness Study Area. However, the U.S. Phosphate Co. operated a mine in York Canyon less than 0.25 mi from the wilderness study area boundary (sec. 18, T. 26 N., R. 119 W.) from 1913 to 1917 (Osterwald and others, 1966), but no production records are known.

Previous Investigations

In 1942, the USBM conducted field investigations of vanadium occurrences in the phosphatic beds of the Meade Peak Member in an area adjacent to the present wilderness study area. Detailed mapping and sampling were done in York, Raymond, and Rose Canyons. Drifts were driven, and 26 trenches were excavated (Allsman and others, 1949).

Appraisal of Sites Examined

Phosphate and Vanadium

Phosphate and vanadium are the only significant commodities found in or near the wilderness study area. Osterwald and others (1966) reported that the Meade Peak Member of the Phosphoria Formation in the Rose Canyon area (secs. 6 and 7, T. 26 N., R. 119 W., called Coal Canyon by them) is 143 ft thick and averaged 10.6 percent P_2O_5 (phosphorus oxide). However, small parts of this phosphatic member, ranging in width from 1.9 to 6 ft, in Francis Canyon (sec. 19, T. 26 N., R. 119 W.) contained as much as 32 percent P_2O_5; in York Canyon (sec. 18, T. 26 N., R. 119 W.), the P_2O_5 content reached 35 percent; in Jackson Canyon (sec. 7, T. 26 N., R. 119 W.), P_2O_5 concentrations exceeded 35 percent; in Raymond Canyon (sec. 6, T. 26 N., R. 119 W.), P_2O_5 concentrations were more than 32 percent; in T. 27 N., R. 119 W., the Meade Peak Member has a P_2O_5 content of almost 39 percent, and an estimated 46,588,000 tons of phosphate rock is present (Osterwald and others, 1966). Sheldon and others (1953) stated that the average P_2O_5 content of samples taken across almost 30 ft of the upper phosphate zone in Raymond Canyon was 11.9 percent. McKelvey (1950) stated that, in the Phosphoria Formation, the total thickness of rocks containing more than 18 percent P_2O_5 is 30.7 ft. These analytical results and tonnages are from phosphate outcrops outside of the Raymond Mountain Wilderness Study Area.

Several inaccessible (caved) adits are about 0.25 mi west of the study area at the mouth of Raymond Canyon. These workings were to mine phosphate ore in the Meade Peak Member of the Phosphoria Formation. For the present study, the USBM took 20 samples to evaluate the grade of the phosphate, which is determined by the amount of P_2O_5. Dump samples contained between 1.8 percent and 20.9 percent P_2O_5 and between 0.05 percent and 0.52 percent V_2O_5 (vanadium oxide). Samples from two trenches, about 1,000 ft west of the wilderness study area boundary and about 3.5 mi north of Raymond Canyon, contained 1.3 to 32 percent P_2O_5 and 0.07 to 0.75 percent V_2O_5 (Lane, 1983).

The percentage of phosphate in a sample increases with weathering. Coffman and Service (1967) stated that a surface sample contains more P_2O_5 than a sample taken underground in the same bed. The P_2O_5 content in surface and underground samples may vary according to locale, but overall, underground values are generally less than surface values. Weathering reduces the content of carbonaceous material, resulting in higher P_2O_5 content (Service and Popoff, 1964). USBM samples were weathered surface samples, which suggests that subsurface phosphate in and near the study area could be of lower grade. The phosphate occurrences adjacent to the study area are low grade and are not likely to be developed in the near future. Current commercial phosphate deposits have grades of about 25 to 35 percent P_2O_5 (Stowasser, 1985).

A vanadium-bearing bed occurs in the Phosphoria Formation along the western side of the Raymond Mountain Wilderness Study Area (30 ft below the base of the Rex Chert Member of the Phosphoria Formation; Allsman and others, 1949). According to Allsman and others, the total thickness of the bed is 3.3 ft, the principal vanadium concentrations are in the upper 30 in. (inches) of the bed, and its average V_2O_5 content is 0.746 percent.

Oil and Gas

The study area is in the Idaho-Wyoming-Utah overthrust belt, which has possibilities for oil and gas occurrences. Two drill holes are inside the study area (fig. 2, pl. 1). In 1978, Gulf Oil Exploration and Production Co. drilled the 16,061-ft-deep Gulf Huff Lake well in SE¼SW¼ sec. 2, T. 27 N., R. 119 W. (James Haas, Gulf Oil Corp., oral commun., 1982). In 1982, Sohio drilled the Sohio Huff well in NE¼NE¼ sec. 9, T. 27 N., R. 119 W. that was 17,131 ft deep. A third exploratory well, the Pan Am Etcheverry, was drilled in the valley west of the Sublette Range (sec. 13, T. 26 N., R. 120 W.). The holes had no oil or gas shows.

Conclusions

The phosphate-bearing rocks in the Phosphoria Formation are directly adjacent to the wilderness study area near the western boundary. Although it is in an area of complex faulting and structural deformation, the phosphate may extend into the study area at depth near Raymond Canyon. The phosphate-bearing beds extend slightly into the study area near Francis Canyon. Phosphate resources inside the study area are probably small and are not likely to be developed. Vanadium is not widespread and is associated with the phosphate.

The Raymond Mountain Wilderness Study Area lies in the Idaho-Wyoming-Utah overthrust belt, which has been explored in several states for oil and gas. Oil and gas test holes have been drilled inside the wilderness study area (fig. 2, pl. 1) but with negative results.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Karen Lund, James P. Evans, Randall H. Hill, and Viki Bankey

Geology

The Raymond Mountain Wilderness Study Area is in the Idaho-Wyoming-Utah overthrust belt. During the Paleozoic, this region was on the continental shelf of North America; only the youngest rocks of this westward-thickening stratigraphic section are exposed in the wilderness study area. The majority of rocks that crop out in the wilderness study area were deposited during the Mesozoic and include predominantly nonmarine, mostly detrital rocks. During the Cenozoic, clastic sediments accumulated locally in small basins in response to tectonism. This part of Wyoming lies in the center of the Cretaceous-to-early Tertiary (Sevier) orogenic belt where much thrust faulting and folding occurred. The northern terminus of the Crawford thrust fault (pl. 1), which is one of the major faults in the center of the belt, is in the Raymond Mountain Wilderness Study Area. The present-day Sublette Range formed by Tertiary normal faulting.

Stratigraphy

A minimum thickness of about 10,000 ft of upper Paleozoic to Mesozoic sedimentary rocks crop out in the Raymond Mountain Wilderness Study Area (Rubey and others, 1980) (pl. 1). During the late Paleozoic, the previously stable continental shelf became fragmented into local sedimentary depocenters by a series of uplifts and basins (Stearns and others, 1975); chert, shale, limestone, and phosphatic rocks of the Lower Permian Phosphoria Formation and sandstone, quartzite, and limestone of the Lower Permian and Middle and Upper Pennsylvanian Wells Formation were deposited in this environment. Subsequent stable, shallow marine environments (Stearns and others, 1975) resulted in deposition of sandstone, shale, and limestone of the Lower Triassic Dinwoody Formation, Woodside Shale, and Thaynes Limestone. A period of relative emergence followed during deposition of the Upper Triassic Ankareh Formation limestone, shale, and quartzite, and Triassic(?) and Jurassic(?) Nugget Sandstone (and quartzite) in a shallow nonmarine environment.

This continental sedimentation was succeeded by marine conditions and the deposition of sandstone, shale, and limestone of the Middle Jurassic Twin Creek Limestone and Preuss Redbeds and the Upper and

Middle Jurassic Stump Formation (Furer, 1970). Nonmarine sedimentation prevailed during deposition of most of the Lower Cretaceous sedimentary rocks (Wiltschko and Dorr, 1983). The Lower Cretaceous Gannett Group is composed of sandstone, shale, some limestone, and several conglomerate units (Eyer, 1969). The other Lower Cretaceous units, the Smiths Formation, Thomas Fork Formation, Cokeville Formation, Quealy Formation, and Sage Junction Formation, contain variably colored sandstone and shale (Rubey, 1973). The Cokeville Formation also includes minor bentonite, porcellanite, and coal; the Sage Junction Formation includes minor porcellanite and coal (Rubey and others, 1980).

Paleocene or Eocene conglomerate of Sublette Range (informally named by Rubey and others, 1980), the Eocene Wasatch Formation, and Eocene and Pliocene(?) Fowkes Formation are accumulations of mudstone, sandstone, and conglomerate. The Wasatch Formation and Fowkes Formation crop out on the west side of the wilderness study area in the down-dropped block on the west side of the Cokeville normal fault. The conglomerate of Sublette Range (unit Tsr, pl. 1) crops out along the main ridge south of Raymond Mountain and on the southeast side of the wilderness study area. These units represent local syntectonic sedimentation resulting from structural disruption during thrust faulting and predate motion on the Cokeville normal-fault system (Evans and Spang, 1984). The relationship among the three units has not been established (Rubey and others, 1980).

Quaternary alluvium and colluvium are bouldery to sandy debris in stream-channel, valley-fill, pediment-covering, and alluvial-fan deposits.

Structure

Paleozoic and Mesozoic rocks were subjected to Late Cretaceous east-directed compressional deformation. This deformation is expressed by thrust faulting and by folding on both major and minor scales. The general structure of rocks in the Raymond Mountain Wilderness Study Area is that of a thrust-cored anticline (Sublette anticline, Evans and Spang, 1984; Coogan and Yonkee, 1985) flanked on the east by a syncline. The Sublette anticline was breached during Tertiary normal faulting.

The east-dipping limb of the Sublette anticline underlies the northern two-thirds of the wilderness study area and consists of moderately to steeply east dipping upright beds and locally west dipping overturned beds of the Middle Jurassic Twin Creek Limestone through the Middle and Upper Pennsylvanian and Lower Permian Wells Formation. Both limbs of the fold are exposed in complexly folded and faulted Twin Creek Limestone in an area about 3 mi northeast of Cokeville, west of the study-area boundary. East of the Sublette anticline, the flanking syncline is doubly plunging and involves only Cretaceous rocks.

The major fault in the study area is the Crawford thrust fault; it crops out in the southern part of the wilderness study area (pl. 1). The Crawford thrust fault is a large regional structure traced throughout the southern and central Idaho-Wyoming-Utah overthrust belt; it has a maximum slip of 30 km in southern Idaho (Dixon, 1982). Movement on the fault decreases to the north; there are about 11 km of slip and more than 5,000 m of stratigraphic separation across the fault at the south end of the wilderness study area (Evans and Craddock, 1985), whereas no slip or separation have been seen further north, east of the central part of the study area (Evans and Spang, 1984). Where it crops out in the southern part of the wilderness study area, the Crawford thrust fault ramps upsection to the north from Pennsylvanian and Permian rocks to Upper Jurassic rocks; northeast-trending folds in Twin Creek Limestone formed in response to this lateral fault ramping (Conrad, 1977).

Because it is not exposed, the structural geometry at the termination of the Crawford thrust fault is controversial. Evans and Spang (1984) suggested that the Crawford thrust fault (1) loses displacement and drops to a lower structural level to the north, and (2) ends in the core of an anticline in Cretaceous rocks that was penetrated by the Gulf and Sohio drill holes (fig. 2, pl. 1). They concluded that displacement lost along the Crawford thrust fault was compensated for by creation of structures in the hanging wall of the fault, such as (1) tightening of the Sublette anticline, (2) development of a small thrust fault within the Sublette anticline, and (3) development of small folds and pervasive solution cleavage in the Twin Creek Limestone. Alternatively, Coogan and Yonkee (1985) suggested that the Crawford thrust does not drop to a lower structural level but, instead, is a relatively shallow thrust fault that underlies the Sublette anticline. According to this interpretation, deeper folds (including that penetrated by the Gulf Huff Lake and Sohio Huff drill holes, pl. 1) formed in the hanging wall of and in response to the next deeper thrust fault in the overthrust stack (Porcupine Creek thrust fault). However, a shallow-level thrust fault was not seen in the Pan Am Etcheverry drill hole, as would be required by the model proposed by Coogan and Yonkee (1985).

The Sublette Range was formed in post-Eocene time as the upthrown block on the eastern side of the north-trending Cokeville normal-fault system (pl. 1). Based on data from the Pan Am Etcheverry drill hole (J.D. Morse, AMOCO, written commun., 1982; J.S. Dixon, Champlin Petroleum Co., written commun., 1982), this normal-fault system may connect with and reactivate a ramp on the Crawford thrust fault at depth in the valley west of the Sublette Range (Evans and Spang, 1984) in a manner common to other thrust-fault ramps in the region (Royse and others, 1975).

Geochemistry

Methods of Study

Thirty-seven stream-sediment samples were collected from active stream alluvium. The sediments are considered to represent a composite of the chemistry of the rock and soil exposed in the drainage basin upstream from the sample site. Chemical analyses of these stream-sediment samples provide data useful in identifying those basins which contain unusually high concentrations of elements that may be related to mineral occurrences.

In addition, 16 fresh and unaltered rock samples were collected to represent the rocks exposed in the vicinity of the sample sites. The actual areal extent of influence of the geochemical information is not known; the sampling program was designed only to provide some general information on the geochemical nature of the rocks present.

The dry stream-sediment samples were sieved through 60-mesh stainless-steel sieves. The minus-60-mesh material was retained for analysis and pulverized with ceramic plates to at least minus-100-mesh prior to analysis.

Rock and stream sediments were analyzed for 35 elements using a semiquantitative, direct-current arc emission spectrographic method (Grimes and Marranzino, 1968). In addition, the sample media were analyzed for arsenic, antimony, and zinc by atomic-absorption spectroscopy and for uranium and thorium by delayed neutron counting (R.H. Hill, U.S. Geological Survey, unpub. data).

Geochemical Results and Discussion

Threshold values, which are defined as the upper limit of normal background values, were determined for each element by inspection of frequency-distribution histograms for both sample media. A geochemical concentration higher than the threshold value is considered anomalous and worthy of scrutiny as a possible indicator of mineralized rock. The primary criterion for delineating an area as anomalous is the presence of multielement geochemical anomalies clustered in a restricted geographic region. A proviso defined by the scale of sampling for this compilation is that moderate-size deposits could be indicated by only one sample site or perhaps completely missed. Surface studies such as this may not reflect mineralized rock at depth.

An above-threshold silver value of 1 ppm (part per million) was detected at the mouth of Raymond Canyon in a stream-sediment sample. Two other stream-sediment samples, one from the extreme northeast part of the study area and the other from the east-central part, showed detectable (but less than 0.5 ppm) silver. In addition, a rock sample of pebble conglomerate from the Lower Cretaceous Gannett Group contained 0.5 ppm silver. These values are not considered to be related to any process of mineralization, and the source is likely to be arkosic sandstone and pebble conglomerate.

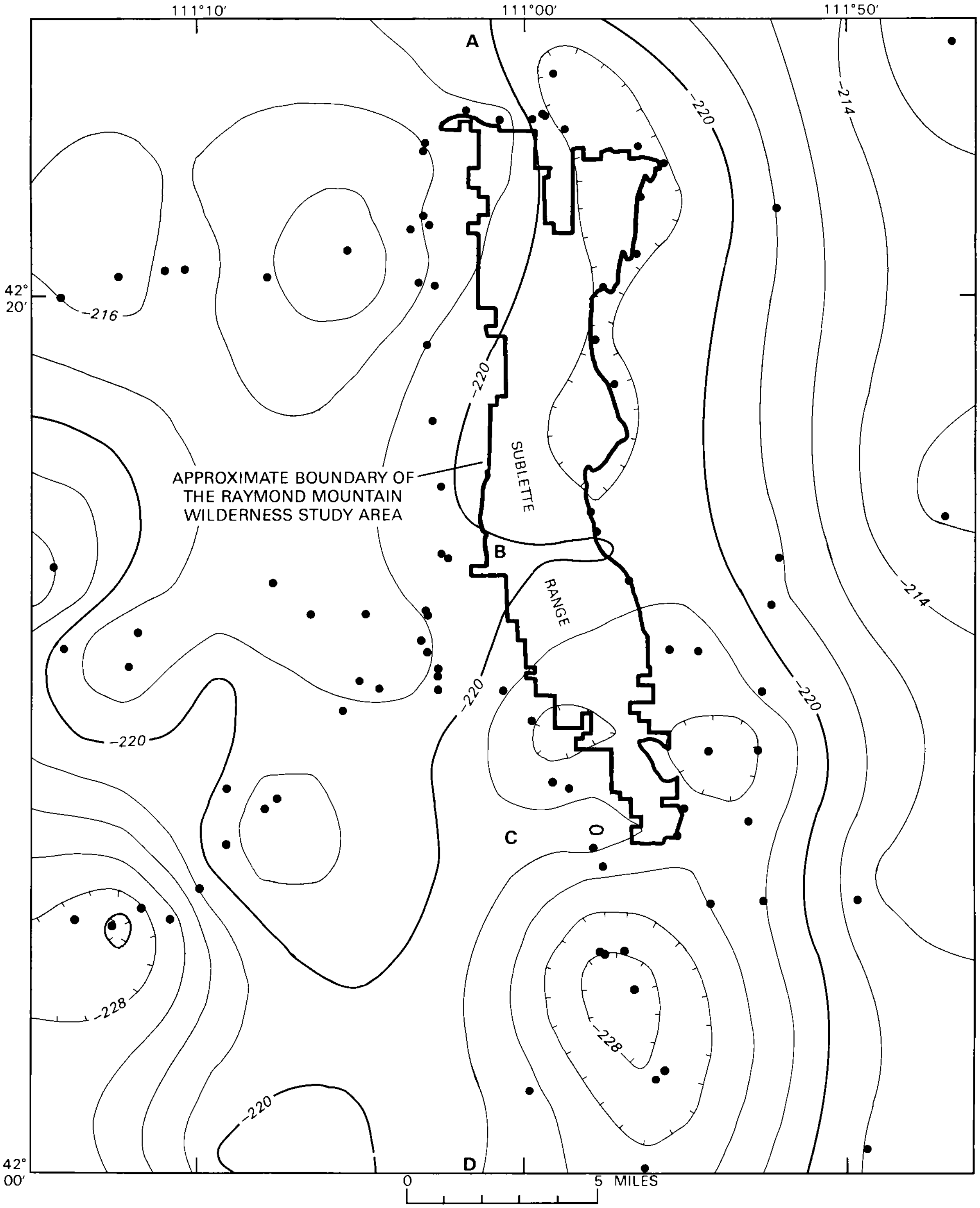
Geophysics

Gravity Data

Gravity stations are commonly too sparsely scattered to locate or define small mineral deposits. On a regional scale, however, gravity can be a useful mapping tool for indicating structural breaks and folds and for delineating shallowly buried pediments.

Gravity data (fig. 3) used in this report are a subset of a larger regional map of southwestern Wyoming (Bankey and Kulik, 1989). Few gravity stations were located in the Raymond Mountain Wilderness Study Area. The texture of the regional gravity field shows the north-south linearity expected from the presence of thrust faults and folds that trend north-south across the area (pl. 1). Rocks of the Sublette Range are associated with a gravity low that reflects relatively low density rocks lying between Thomas Fork Valley west of the wilderness study area and Smith's Fork valley to the east. Gravity values are consistently high in and west of Thomas Fork Valley, suggesting that Thomas Fork Valley is shallow and probably underlain by the dense Jurassic limestone that crops out further to the west. This structure was confirmed by the approximately 1,100 ft of Tertiary sedimentary rocks found in drilling the Pan Am Etchevery drill hole. Bear River valley, south of Cokeville and south of the study area, is a deeper valley, as shown by the associated gravity low over the alluvium.

Four small, east-west-trending gravity highs interrupt the major gravity low of the Sublette Range (labeled A–D on fig. 3). Only feature C, near The Narrows between Thomas Fork Valley and Bear River valley, reflects an apparent structural high. Features A, B, and D may show small faults crosscutting the major thrust faults; feature B is where two thrust faults apparently end (pl. 1). Conversely, the east-west-trending valleys at the northern and southern study-area boundaries have no associated east-west gravity features and appear to be valleys having topographical rather than structural control.



EXPLANATION

—-220— Gravity contours—Showing gravity field. Contour interval 2 milligals. Hachures show closed areas of lower gravity values

● Gravity station location

Figure 3. Complete Bouguer gravity anomaly map of the Raymond Mountain Wilderness Study Area and vicinity, Wyoming. A density value of 2.67 grams per cubic centimeter was used in reducing data to the Bouguer anomaly. Data from gravity stations outside the map area were used to provide additional control for contours near the edge of the map area.

Magnetic Data

Aeromagnetic data (fig. 4) for the Raymond Mountain Wilderness Study Area were taken from a survey (U.S. Geological Survey, 1981) flown using a fixed-wing aircraft at a nominal ground clearance of 1,000 ft; the east-west flight traverses were spaced 0.5 mi apart. Aeromagnetic instruments in the aircraft can detect point sources on the ground as much as 45° to each side of the flight path. At 0.5-mi spacing, 62 percent of magnetic sources at the surface should be detected. One-hundred percent coverage by the instruments is theoretically achieved at 1,640 ft below the ground surface for magnetic sources, although magnetic-signal strength diminishes with depth.

The aeromagnetic field over the Raymond Mountain Wilderness Study Area is notable for the high-frequency anomalies associated with sedimentary rocks in topographic relief. Normally, sedimentary rocks are relatively nonmagnetic, but in this area, the Jurassic Preuss Redbeds contain enough detrital magnetite to cause appreciable anomalies where they crop out and smaller anomalies where they are shallowly buried (Fishman and others, 1989). This property aids in mapping rocks of the Preuss Redbeds; however, lack of association of Preuss Redbeds with mineral or oil and gas occurrences limits magnetic mapping to stratigraphy and structure.

Mineral and Energy Resources

Oil and Gas Resources

Models for oil and gas occurrences in the western Wyoming part of the Idaho-Wyoming-Utah overthrust belt include traditional anticline models as well as fault models that consider the structural setting of source and reservoir rocks. Source units in the region include Paleozoic rocks of the Lower Permian Phosphoria Formation and Mesozoic rocks of the Lower Triassic Thaynes Limestone, Middle Jurassic Twin Creek Limestone, Lower Cretaceous Cokeville, Quealy, and Sage Junction Formations, and the Eocene Wasatch Formation (Dixon, 1982). Reservoir units in this area include Upper Ordovician Bighorn Dolostone, Mississippian Madison Limestone, Lower Triassic Thaynes Limestone, and Triassic(?) and Jurassic(?) Nugget Sandstone (Picard, 1975; Brock and Nicolaysen, 1975; Dixon, 1982). Thrust-fault juxtaposition of appropriate reservoir rocks over mature source rocks is one of the prime exploration targets of this part of the overthrust belt (Dixon, 1982).

Because both regional-scale and smaller scale thrust faults and anticlinal structures exist in the study area, exploration has been ongoing. Three petroleum exploration wells were drilled in and near the wilderness study area (fig. 3, pl. 1). These wells have provided good structural and stratigraphic controls at depth but have not resulted in petroleum production.

Both appropriate source rocks and reservoir rocks exist in the Raymond Mountain Wilderness Study Area (pl. 1). Recent geologic interpretation (Evans, 1983; pl. 1) has combined surface geologic mapping with information from the available drill-hole data. Cross sections drawn by Evans and Spang (1984) indicate that suitable source and reservoir rocks exist in the study area and that favorable structures for migration and trapping of petroleum also are present. However, these cross sections also show that the ideal juxtapositioning of source rocks over reservoir rocks by means of thrust faulting may not have occurred in the wilderness study area. Additionally, information about the prevalence of cleavage in the Twin Creek Limestone (Evans and Spang, 1984), which contains both potential source and reservoir rocks, may indicate that rocks in the wilderness study area have been deeply buried as a result of thrust faulting and may have achieved relatively high geothermal temperatures, possibly resulting in over-maturation of source rocks. Although the wilderness study area was previously rated as having a high energy resource potential for petroleum in a regional study (Spencer, 1983), data available for this study suggest a moderate level of oil and gas resource potential with certainty level B.

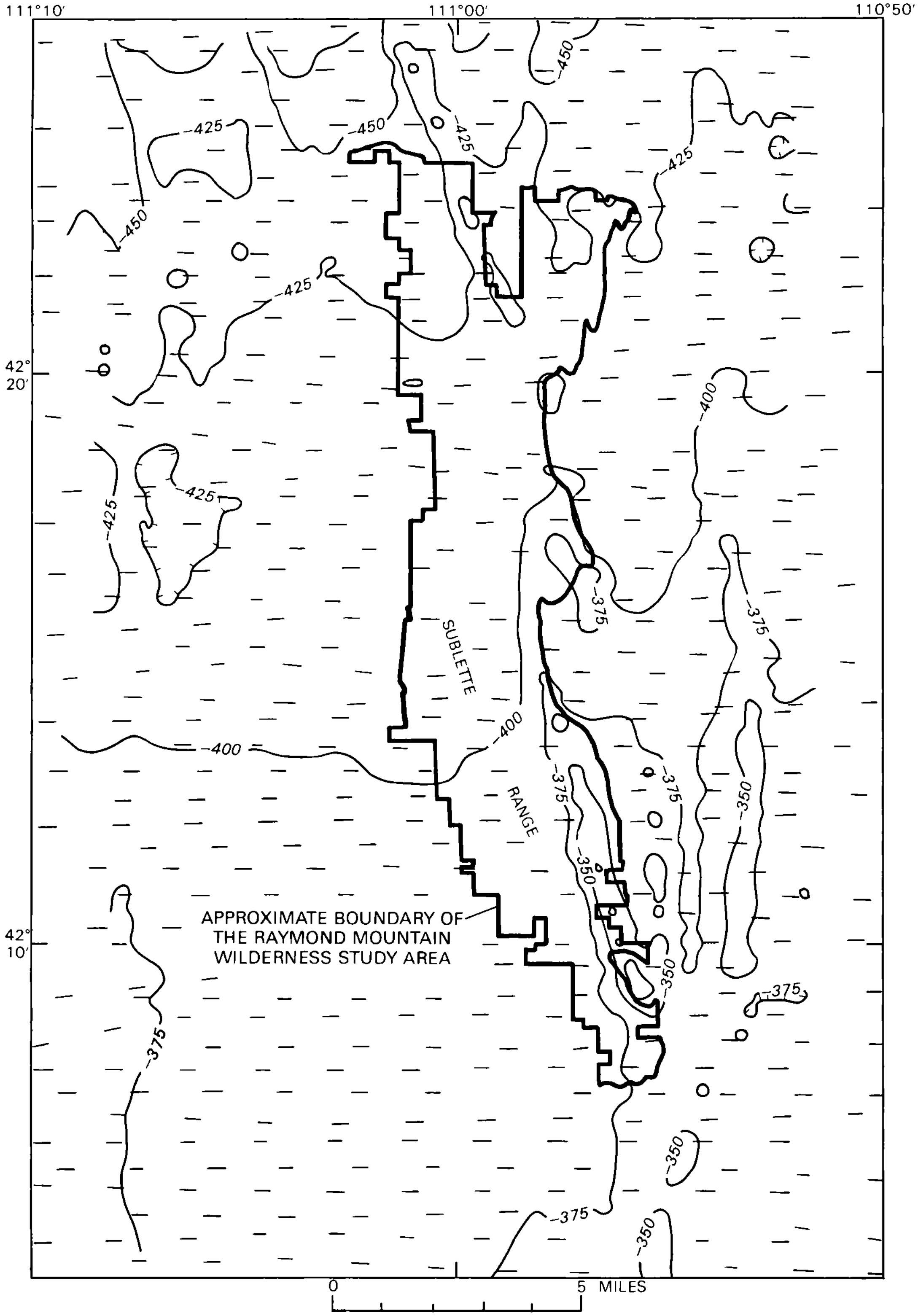
Other Energy Resources

Coal-bearing beds occur within both the Lower Cretaceous Cokeville and Sage Junction Formations. The Sage Junction Formation crops out east of the wilderness study area, and the Cokeville Formation crops out only in restricted areas along the eastern side of the wilderness study area (unit Kck, pl. 1). Neither formation occurs at depth within the study-area boundaries (cross sections in Rubey and others, 1980; Evans and Spang, 1984; Coogan and Yonkee, 1985). The study area has a low resource potential for coal with certainty level B.

Uranium deposits and geothermal springs do not occur in rocks in the wilderness study area or in the vicinity. The study area has a low potential for these other energy resources, with certainty level B.

Phosphate and Vanadium Resources

Phosphate-bearing layers are in the Meade Peak and Retort Members of the Lower Permian Phosphoria Formation, and vanadium-bearing layers are below the Rex Chert Member of the Phosphoria Formation throughout the region (Gale and Richards, 1910; McKelvey and others, 1953; Gulbrandsen, 1960). Claims, prospects, and abandoned mining operations for



EXPLANATION

—*-400*— **Aeromagnetic contours**—Showing magnetic field. Contour interval 25 nanoteslas. Hachures show closed areas of lower magnetic values

— — — **Flight path**—Showing location and spacing of data

Figure 4. Residual total-intensity aeromagnetic anomaly map of the Raymond Mountain Wilderness Study Area and vicinity, Wyoming. Average height of survey, 1,000 ft above terrain; International Geomagnetic Reference Field removed; arbitrary datum.

phosphate are adjacent to the western edge of the Raymond Mountain Wilderness Study Area (fig. 2).

Strata of the Phosphoria Formation, which host these deposits, are nearly vertical to steeply overturned on the east limb of the overturned Sublette anticline. These strata are in a fault-bounded block that is cut off at depth and to the east by the Sublette anticline thrust fault and is cut off to the west by the Cokeville normal-fault system (Evans and Spang, 1984). Thus, mineralized beds of the Phosphoria Formation cannot be present in large volume near the surface in the wilderness study area; small areas underlain by exposed or near-surface Phosphoria Formation occur within the study-area boundary near York and Francis Canyons (pl. 1). Elsewhere in the study area, the Phosphoria Formation is at least 10,000 ft below the surface (from cross sections in Evans and Spang, 1984). At such depths, it is relatively inaccessible for mining either phosphate or vanadium and would be unweathered (therefore containing lower P_2O_5 values).

The wilderness study area has low mineral resource potential for phosphate and vanadium despite the occurrence of both anomalous phosphate and vanadium concentrations adjacent to the wilderness study area. The available structural information gives a good indication of the low phosphate and vanadium resource potential, with certainty level C.

Other Metal Resources

The geochemical survey did not indicate the presence of anomalously high values for metals not considered above, no appropriate deposit models fit the geologic setting, and no history of production for other metals was found in the region. Therefore, other metals have a low mineral resource potential in the wilderness study area, with certainty level B.

High-Purity Limestone and Dolostone Resources

There is no history of production of high-purity limestone or dolostone in the Raymond Mountain Wilderness Study Area or its vicinity. Although no chemical data are available, the limestone and dolostone that occur in the wilderness study area are impure and may contain too much clay and silt for use in the chemical industry. Therefore, the mineral resource potential for high-purity limestone or dolostone in the wilderness study area is low, with certainty level B.

REFERENCES CITED

Allsman, P.T., Majors, F.H., Mahoney, S.R., and Young, W.A., 1949, Investigations of Sublette Ridge vanadium deposit, Lincoln County, Wyoming: U.S. Bureau of Mines Report of Investigations RI–4476, 8 p.

Bankey, Viki, and Kulik, D.M., 1989, Gravity survey data and Bouguer gravity anomaly map of southwestern Wyoming, northeastern Utah, and northwestern Colorado: U.S. Geological Survey Open-File Report 89–175A–B, 31 p., 1 computer diskette.

Brock, W.G., and Nicolaysen, Jerry, 1975, Geology of the Brady unit, Sweetwater County, Wyoming, *in* Deep drilling frontiers of the central Rocky Mountains: Rocky Mountain Association of Geologists, 1975 Symposium, p. 225–237.

Coffman, J.S., and Service, A.L., 1967, An evaluation of the western phosphate industry and its resources, pt. 4, Wyoming and Utah: U.S. Bureau of Mines Report of Investigations RI–6934, 158 p.

Conrad, J.F., 1977, Surface expression of concentric folds and apparent detachment zone near Cokeville, Wyoming, *in* Wyoming Geological Association, 29th Annual Field Conference, guidebook, p. 385–390.

Coogan, J.C., and Yonkee, W.A., 1985, Salt detachments in the Jurassic Preuss redbeds within the Meade and Crawford thrust systems, Idaho and Wyoming, *in* Kerns, G.J., and Kerns, R.L., eds., Orogenic patterns and stratigraphy of north-central Utah and southeastern Idaho: Utah Geological Association Publication 14, p. 75–82.

Dixon, J.S., 1982, Regional structural synthesis, Wyoming salient of western overthrust belt: American Association of Petroleum Geologists Bulletin, v. 66, p. 1560–1580.

Evans, J.P., 1983, Structural geology of the northern termination of the Crawford thrust, western Wyoming: College Station, Tex., Texas A&M University Master's thesis, 144 p.

Evans, J.P., and Craddock, J.P., 1985, Deformation history and displacement transfer between the Crawford and Meade thrust systems, Idaho-Wyoming overthrust belt, *in* Kerns, G.J., and Kerns, R.L., eds., Orogenic patterns and stratigraphy of north-central Utah and southeastern Idaho: Utah Geological Association Publication 14, p. 83–96.

Evans, J.P., and Spang, J.H., 1984, The northern termination of the Crawford thrust, western Wyoming: Contributions to Geology, v. 23, no. 1, p. 15–31.

Eyer, J.E., 1969, Gannett Group of western Wyoming and southeastern Idaho: American Association of Petroleum Geologists Bulletin, v. 53, p. 1368–1390.

Fishman, N.S., Reynolds, R.L., Hudson, M.R., and Nuccio, V.F., 1989, Source of anomalous magnetization in area of hydrocarbon potential; petrological evidence from Jurassic Preuss sandstone, Wyoming-Idaho thrust belt: American Association of Petroleum Geologists Bulletin, v. 73, p. 182–194.

Furer, L.C., 1970, Petrology and stratigraphy of Upper Jurassic-Lower Cretaceous rocks of western Wyoming and southeastern Idaho: American Association of Petroleum Geologists Bulletin, v. 54, p. 2282–2302.

Gale, H.S., and Richards, R.W., 1910, Preliminary report on the phosphate deposits in southeastern Idaho and adjacent parts of Wyoming and Utah, *in* Contributions to economic geology, 1909, pt. I—Metals and nonmetals except fuels: U.S. Geological Survey Bulletin 430–H, p. 457–535.

Goudarzi, G.H., 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84–787, 9 p.

Grimes, D.J., and Marranzino, A.P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 6 p.

Gulbrandsen, R.A., 1960, Petrology of the Meade Peak phosphatic shale member of the Phosphoria Formation at Coal Canyon, Wyoming, *in* Contributions to general geology: U.S. Geological Survey Bulletin 111–C, p. 71–146.

Lane, M.E., 1983, Mineral investigation of the Raymond Mountains Wilderness Study Area, Lincoln County, Wyoming: U.S. Bureau of Mines open-file report MLA 97–83, 12 p.

McKelvey, V.E., 1950, Geological studies of the western phosphate field: American Institute of Mining and Metallurgical Engineers Transactions, v. 184, p. 270–279.

McKelvey, V.E., Smith, L.E., Hoppin, R.A., and Armstrong, F.C., 1953, Stratigraphic sections of the Phosphoria Formation in Wyoming, 1947–1948: U.S. Geological Survey Circular 210, 35 p.

Oriel, S.S., and Platt, L.B., 1980 [1981], Geologic map of the Preston $1° \times 2°$ quadrangle, southeastern Idaho and western Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I–1127, scale 1:250,000.

Osterwald, F.W., Osterwald, D.B., Long, J.S., Jr., and Wilson, W.H., 1966, Mineral resources of Wyoming: Geological Survey of Wyoming Bulletin 50, 259 p.

Picard, M.D., 1975, Facies, petrography and petroleum potential of Nugget Sandstone (Jurassic), southwestern Wyoming and northeastern Utah, *in* Deep drilling frontiers of the central Rocky Mountains: Rocky Mountain Association of Geologists, 1975 Symposium, p. 109–127.

Royse, F., Jr., Warner, M.A., and Reese, D.L., 1975, Thrust belt structural geometry and related stratigraphic problems, Wyoming-Idaho-northern Utah, *in* Deep drilling frontiers of the central Rocky Mountains: Rocky Mountain Association of Geologists, 1975 Symposium, p. 41–54.

Rubey, W.W., 1973, New Cretaceous formations in the western Wyoming thrust belt: U.S. Geological Survey Bulletin 1372–I, 32 p.

Rubey, W.W., Oriel, S.S., and Tracey, J.I., Jr., 1980, Geologic map and structure sections of the Cokeville 30-minute quadrangle, Lincoln and Sublette Counties, Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I–1129, scale 1:62,500.

Service, A.L., and Popoff, C.C., 1964, An evaluation of the western phosphate industry and its resources, pt. 1, Introductory review: U.S. Bureau of Mines Report of Investigations RI–6485, 86 p.

Sheldon, R.P., Waring, M.S., and Smart, R.A., 1953, Stratigraphic sections of the Phosphoria Formation in Wyoming, 1949–1950: U.S. Geological Survey Circular 307, 45 p.

Spencer, C.W., 1983, Petroleum potential of wilderness lands in Wyoming, *in* Miller, B.M., ed., Petroleum potential of wilderness lands in the western United States: U.S. Geological Survey Circular 902–A–P, p. M1–M10.

Stearns, D.W., Sacrison, W.R., and Hanson, R.C., 1975, Structural history of southwestern Wyoming as evidenced from outcrop and seismic, *in* Deep drilling frontiers of the central Rocky Mountains: Rocky Mountain Association of Geologists, 1975 Symposium, p. 9–20.

Stowasser, W.F., 1985, Phosphate rock, *in* Mineral facts and problems: U.S. Bureau of Mines Bulletin 675, p. 579–594.

U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, 5 p.

U.S. Geological Survey, 1981, Aeromagnetic map of the Sublette Range area, Idaho and Wyoming: U.S. Geological Survey Open-File Report 81–1163, scale 1:62,500.

Wiltschko, D.V., and Dorr, J.A., Jr., 1983, Timing of deformation in overthrust belt and foreland of Idaho, Wyoming, and Utah: American Association of Petroleum Geologists Bulletin, v. 67, p. 1304–1322.

APPENDIX

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

Definitions of Mineral Resource Potential

LOW mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is unlikely. This broad category embraces areas with dispersed but insignificantly mineralized rock as well as areas with few or no indications of having been mineralized.

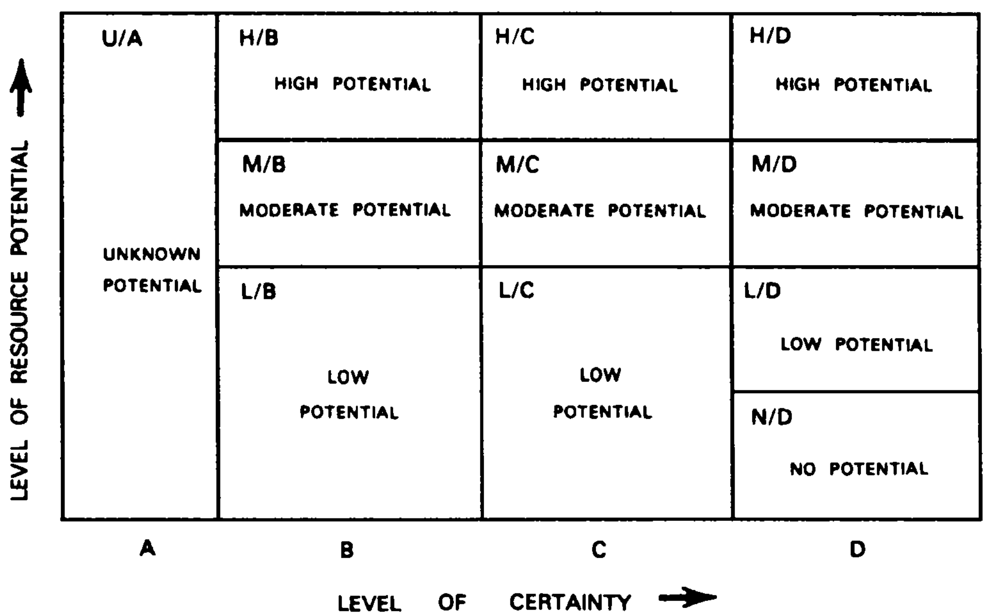
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

HIGH mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data support mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.

UNKNOWN mineral resource potential is assigned to areas where information is inadequate to assign low, moderate, or high levels of resource potential.

NO mineral resource potential is a category reserved for a specific type of resource in a well-defined area.

Levels of Certainty



A. Available information is not adequate for determination of the level of mineral resource potential.
B. Available information suggests the level of mineral resource potential.
C. Available information gives a good indication of the level of mineral resource potential.
D. Available information clearly defines the level of mineral resource potential.

Abstracted with minor modifications from:

Taylor, R. B., and Steven, T. A., 1983, Definition of mineral resource potential: Economic Geology, v. 78, no. 6, p. 1268–1270.

Taylor, R. B., Stoneman, R. J., and Marsh, S. P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: U.S. Geological Survey Bulletin 1638, p. 40–42.

Goudarzi, G. H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84–0787, p. 7, 8.

RESOURCE/RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range (or)	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUB-ECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		

Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from McKelvey, 1972, Mineral resource estimates and public policy: American Scientist, v.60, p.32-40, and U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, p.5.

GEOLOGIC TIME CHART

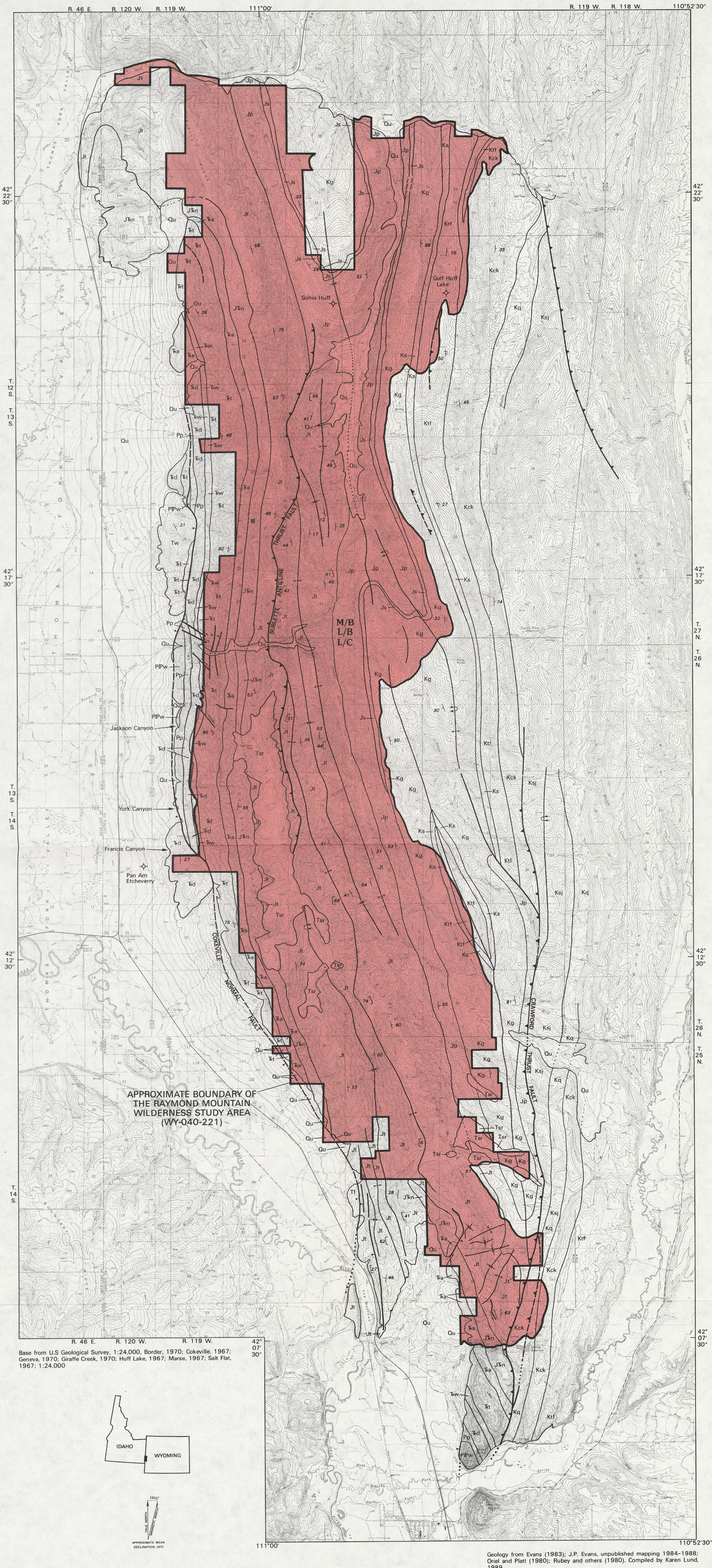
Terms and boundary ages used in this report

EON	ERA	PERIOD		EPOCH	BOUNDARY AGE IN MILLION YEARS
Phanerozoic	Cenozoic	Quaternary		Holocene	0.010
				Pleistocene	1.7
		Tertiary	Neogene Subperiod	Pliocene	5
				Miocene	24
			Paleogene Subperiod	Oligocene	38
				Eocene	55
				Paleocene	66
	Mesozoic	Cretaceous		Late	96
				Early	138
		Jurassic		Late Middle Early	205
		Triassic		Late Middle Early	~ 240
	Paleozoic	Permian		Late Early	290
		Carboniferous Periods	Pennsylvanian	Late Middle Early	~ 330
			Mississippian	Late Early	360
		Devonian		Late Middle Early	410
		Silurian		Late Middle Early	435
		Ordovician		Late Middle Early	500
		Cambrian		Late Middle Early	~ 570[1]
Proterozoic	Late Proterozoic				900
	Middle Proterozoic				1600
	Early Proterozoic				2500
Archean	Late Archean				3000
	Middle Archean				3400
	Early Archean				3800?
pre-Archean[2]					4550

[1] Rocks older than 570 m.y. also called Precambrian, a time term without specific rank.

[2] Informal time term without specific rank.

☆U.S. GOVERNMENT PRINTING OFFICE: 1990-773-047/06060



Base from U.S Geological Survey, 1:24,000, Border, 1970; Cokeville, 1967; Geneva, 1970; Giraffe Creek, 1970; Huff Lake, 1967; Marse, 1967; Salt Flat, 1967; 1:24,000

Geology from Evans (1983); J.P. Evans, unpublished mapping 1984–1988; Oriel and Platt (1980); Rubey and others (1980). Compiled by Karen Lund, 1989

SCALE 1:50 000

1 ½ 0 1 2 3 MILES

1 .5 0 1 2 3 KILOMETERS

CONTOUR INTERVAL 20 AND 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

EXPLANATION OF MINERAL RESOURCE POTENTIAL

M/B **Geologic terrane having moderate energy resource potential for oil and gas, with certainty level B**—Applies to entire study area

L/B **Geologic terrane having low resource potential for coal, all metals including uranium, high-purity limestone and dolostone, and geothermal energy, with certainty level B**—Applies to entire study area

L/C **Geologic terrane having low mineral resource potential for phosphate and vanadium in the Phosphoria Formation, with certainty level C**—Applies to entire study area

CORRELATION OF MAP UNITS

Qu		QUATERNARY
Unconformity		
Tf	Pliocene(?) and Eocene	TERTIARY
Tw	Eocene	TERTIARY
Tsr (Stratigraphic relationship to Wasatch Formation is unknown)	Eocene or Paleocene	TERTIARY
Unconformity		
Ksj, Kq, Kck, Ktf, Ks, Kg	Lower Cretaceous	CRETACEOUS
Js	Upper and Middle Jurassic	JURASSIC
Jp, Jt	Middle Jurassic	JURASSIC
JꞦn		JURASSIC(?) AND TRIASSIC(?)
Ꞧa	Upper Triassic	TRIASSIC
Ꞧt, Ꞧw, Ꞧd	Lower Triassic	TRIASSIC
Unconformity		
Pp	Lower Permian	PERMIAN
PIPw	Upper and Middle Pennsylvanian	PENNSYLVANIAN

DESCRIPTION OF MAP UNITS

Qu **Alluvium and colluvium (Quaternary)**—Unconsolidated bouldery to sandy debris

Tf **Fowkes Formation (Pliocene? and Eocene)**—Light-colored, tuffaceous conglomerate, sandstone, and siltstone. Shown only outside the southern boundary of the wilderness study area

Tw **Wasatch Formation (Eocene)**—Variegated red to gray mudstone; brown to gray sandstone; and conglomeratic lenses. Occurs in down-dropped block on west side of Cokeville normal fault, west side of Sublette Range

Tsr **Conglomerate of Sublette Range (Eocene or Paleocene)**—Basal coarse-grained sandstone and upper boulder-to-cobble conglomerate in gravel-sand matrix. Exposed in south and central parts of Sublette Range. Stratigraphic relationship to Wasatch Formation not established

Ksj **Sage Junction Formation (Lower Cretaceous)**—Gray and tan siltstone and sandstone; minor quartzite, limestone, conglomerate, porcellanite, and coal beds

Kq **Quealy Formation (Lower Cretaceous)**—Red and variegated mudstone and tan sandstone

Kck **Cokeville Formation (Lower Cretaceous)**—Gray to tan sandstone; some siltstone, claystone, limestone, bentonite, porcellanite, and coal

Ktf **Thomas Fork Formation (Lower Cretaceous)**—Red, purple, brown, and green mudstone; some sandstone

Ks **Smiths Formation (Lower Cretaceous)**—Ferruginous black and tan to brown sandstone

Kg **Gannett Group (Lower Cretaceous)**—Red sandy mudstone, sandstone, and chert-pebble conglomerate. Thin limestone and shale beds in upper part; more conglomerate in lower part

Js **Stump Formation (Upper and Middle Jurassic)**—Glauconitic siltstone, sandstone, and limestone

Jp **Preuss Redbeds (Middle Jurassic)**—Purple, maroon, and reddish-gray argillaceous limestone and calcareous siltstone

Jt **Twin Creek Limestone (Middle Jurassic)**—Greenish-gray argillaceous limestone and calcareous siltstone

JꞦn **Nugget Sandstone (Jurassic? and Triassic?)**—Buff to pink, crossbedded, well-sorted sandstone and quartzite

Ꞧa **Ankareh Formation (Upper Triassic)**—Red and maroon shale and pale-purple limestone; minor white to red fine-grained quartzite

Ꞧt **Thaynes Limestone (Lower Triassic)**—Gray limestone and brown-weathering gray, calcareous siltstone; dark-gray shale and limestone abundant in lower part

Ꞧw **Woodside Shale (Lower Triassic)**—Red siltstone and shale; minor sandstone and gray limestone

Ꞧd **Dinwoody Formation (Lower Triassic)**—Gray limestone and olive to greenish-brown siltstone

Pp **Phosphoria Formation (Lower Permian)**—Upper part dark- to light-gray chert and shale; lower part brown-weathering phosphatic shale and limestone

PIPw **Wells Formation (Lower Permian and Upper and Middle Pennsylvanian)**—Interbedded gray limestone and pale-yellow calcareous sandstone; minor gray dolostone

Contact—Dashed where approximately located, dotted where concealed

High-angle fault—Dashed where approximately located; dotted where concealed; bar and ball on downthrown side; arrows show direction of movement

Thrust fault—Dashed where approximately located; dotted where concealed; sawteeth on upper plate

16 **Strike and dip of bedding**

21 **Strike and dip of cleavage**

43 **Strike and dip of overturned bedding**

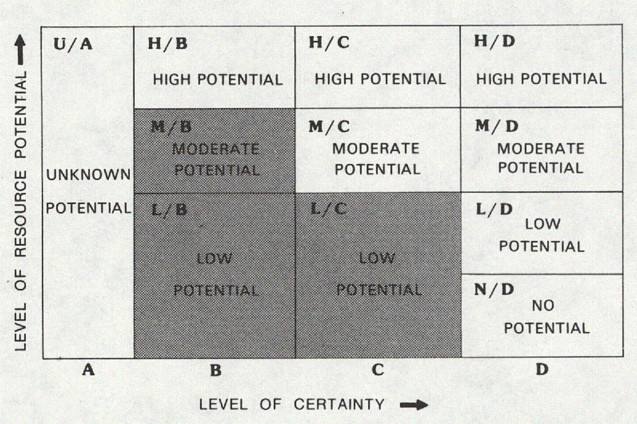
Upright anticline

Overturned anticline

Upright syncline

Overturned syncline

Exploratory oil well



LEVELS OF RESOURCE POTENTIAL

H High mineral resource potential

M Moderate mineral resource potential

L Low mineral resource potential

U Unknown mineral resource potential

N No known mineral resource potential

LEVELS OF CERTAINTY

A Available data not adequate

B Data indicate geologic environment and suggest level of resource potential

C Data indicate geologic environment, give good indication of level of resource potential, but do not establish activity of resource-forming processes

D Data clearly define geologic environment and level of resource potential and indicate activity of resource-forming processes in all or part of the area

Diagram showing relationships between levels of mineral resource potential and levels of certainty. Shading shows levels that apply to this study area

MINERAL RESOURCE POTENTIAL AND GEOLOGIC MAP OF THE RAYMOND MOUNTAIN WILDERNESS STUDY AREA, LINCOLN COUNTY, WYOMING

U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849

Lund and others—MINERAL RESOURCES, RAYMOND MOUNTAIN WILDERNESS STUDY AREA, WYOMING—U.S. Geological Survey Bulletin 1757–I