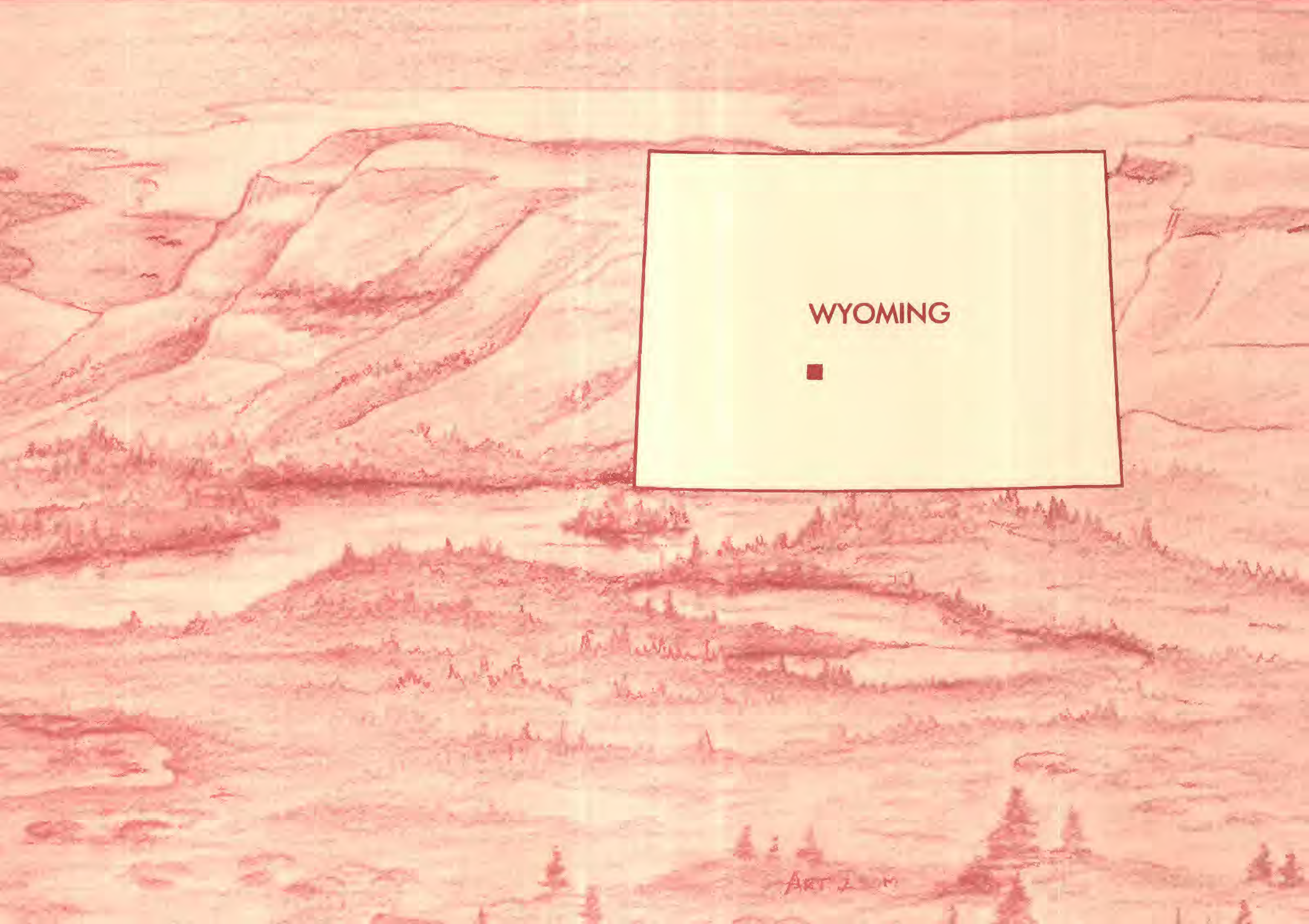
Mineral Resources of the Sweetwater Canyon Wilderness Study Area, Fremont County, Wyoming

U.S. GEOLOGICAL SURVEY BULLETIN 1757–D



Chapter D

Mineral Resources of the Sweetwater Canyon Wilderness Study Area, Fremont County, Wyoming

By WARREN C. DAY, RANDALL H. HILL, and
DOLORES M. KULIK
U.S. Geological Survey

DAVID C. SCOTT
U.S. Bureau of Mines

W. DAN HAUSEL
Geological Survey of Wyoming

U.S. GEOLOGICAL SURVEY BULLETIN 1757

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—SOUTHERN WYOMING

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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

UNITED STATES GOVERNMENT PRINTING OFFICE: 1988

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 Sweetwater Canyon Wilderness Study Area, Fremont County, Wyoming.

(Mineral resources of wilderness study areas—Southern Wyoming ; ch. D)
(U.S. Geological Survey bulletin ; 1757–D)
Bibliography: p.
Supt. of Docs. no.: I19.3:
1. Mines and mineral resources—Wyoming—Sweetwater Canyon Wilderness. 2. Sweetwater Canyon Wilderness (Wyo.) I. Day, Warren C. II. Series. III. Series: U.S. Geological Survey bulletin ; 1757–D.
QE75.B9 no. 1757–D 557.3 s [553'.09787'63] 88–600308
[TN24.W8]

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 Sweetwater Canyon Wilderness Study Area (WY–030–101), Fremont County, Wyoming.

CONTENTS

Abstract D1
Summary D1
Introduction D3
- Investigations by the U.S. Bureau of Mines D3
- Investigations by the U.S. Geological Survey D4

Appraisal of identified resources D5
- Mining history D5
- Commodities D6
  - Lode-gold deposits and prospects D7
  - Placer-gold deposits D9
  - Industrial minerals D9
- Recommendations for further study D10

Assessment of potential for undiscovered resources D10
- Geology D10
  - Regional geologic setting D10
  - Description of rock units D11
- Geochemistry D12
  - Analytical methods D12
  - Results of geochemical studies D13
- Geophysics D14
- Mineral and energy resources D15
  - Gold D15
    - Lode-gold deposits D15
    - Placer-gold deposits D18
  - Tin and tungsten D18
    - Placer-type deposits D18
    - Lode-type deposits D18
      - Lewiston mining district anomalous area D18
      - Eastern anomalous area D19
  - Uranium D20
  - Oil and gas D20
  - Geothermal energy D21

Suggestions for further study D21
References cited D21
Appendix D23

PLATE

[Plate is in pocket]

1. Map showing mineral resource potential, geology, and sample localities of the Sweetwater Canyon Wilderness Study Area

FIGURES

1.–6. Maps of the Sweetwater Canyon Wilderness Study Area showing:
1. Mineral resource potential D2
2. Location D4
3. Generalized geology of the South Pass greenstone belt D6

4. Faults and sample localities in the northwestern part of the study area **D8**
5. Generalized gravity and structure **D16**
6. Generalized aeromagnetics and structure **D17**

TABLES

1. Geochemical analyses of samples from the Lewiston mining district anomalous area **D13**
2. Geochemical analyses of samples from the eastern anomalous area **D14**

Mineral Resources of the Sweetwater Canyon Wilderness Study Area, Fremont County, Wyoming

By Warren C. Day, Randall H. Hill, *and*
Dolores M. Kulik
U.S. Geological Survey

David C. Scott
U.S. Bureau of Mines

W. Dan Hausel
Geological Survey of Wyoming

ABSTRACT

Field investigations to evaluate the mineral resource potential of the Sweetwater Canyon Wilderness Study Area (WY–030–101) (fig. 1) were conducted during the summer of 1986. Geologic mapping, geochemical sampling, geophysical surveys, and surveys of prospects indicated an area of identified resources of lode gold of moderate grade and low tonnage in faults and veins immediately west of the study area. The only identified resources within the study area are inferred subeconomic sand and gravel and granite dimension stone. The mineral resource potential (undiscovered) for several commodities was delineated in the study area. The western part of the wilderness study area has high mineral resource potential for gold in similar deposits. There is a high mineral resource potential for resources of placer gold along the Sweetwater River and Strawberry Creek. The study area also has a low mineral resource potential for low-grade placer tin and tungsten deposits in Quaternary gravels along the Sweetwater River and Strawberry Creek. The entire wilderness study area has low potential for tin and tungsten resources in Precambrian bedrock, and a low potential for uranium resources. There is no resource potential for oil, gas, or geothermal energy.

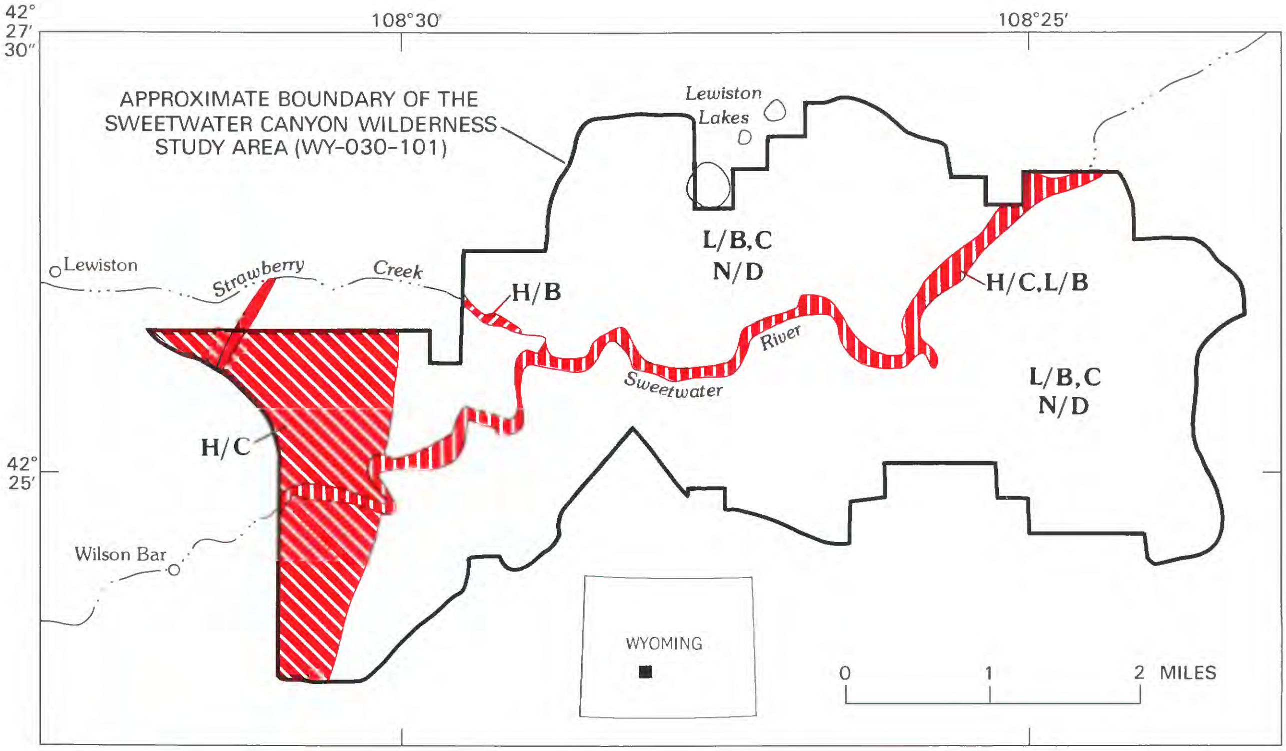
Publication approved by the Director, U.S. Geological Survey on May 2, 1988

SUMMARY

The Sweetwater Canyon Wilderness Study Area is about 40 mi (miles) south of Lander, Wyo., the nearest major town, and about 12 mi southeast of the historic mining camp of Atlantic City. The study area lies at the southeast end of the Wind River Range and is bisected by the Sweetwater River canyon.

Most of the study area is underlain by Precambrian rocks (see the geologic time chart in the Appendix of this report) thought to be 2,800 to 2,600 Ma (million years old). Along the western part of the study area greenstone (metamorphosed volcanic and sedimentary rocks) occurs, whereas the central part is underlain by Archean granite that makes up about 75 percent of the total study area. The eastern part is made up of Paleozoic sedimentary rocks that rest on the Precambrian crystalline basement. During the Laramide orogeny (about 70 Ma) the Precambrian and Paleozoic rocks of the Wind River Range and the study area were uplifted and tilted eastward. Subsequent erosion during Tertiary time created a broad peneplane that slopes gently to the southeast away from the range. The east-flowing Sweetwater River has eroded into the Precambrian crystalline rocks, forming a canyon of subtle beauty.

The South Pass-Atlantic City mining district is about 10 mi west of the study area and contains numerous gold deposits in the Miners Delight Formation. The Lewiston mining district includes the western part of the study area and was also a gold producer. About 75 percent of the study area



EXPLANATION

Identified lode-gold resource

H/C — Geologic terrane having high mineral resource potential for lode gold of Precambrian age, with certainty level C

H/B — Geologic terrane having high mineral resource potential for placer gold of Quaternary age, with certainty level B

H/C, L/B — Geologic terrane having high mineral resource potential for placer gold of Quaternary age, with certainty level C, and low mineral resource potential for placer tin and tungsten of Quaternary age, with certainty level B

L/B,C — Geologic terrane having low mineral resource potential for lode tin and tungsten (in Precambrian rocks), with certainty level B, and uranium, with certainty level C—Applies to entire study area

N/D — Geologic terrane having no resource potential for oil, gas, or geothermal energy, with certainty level D—Applies to entire study area

Certainty levels

B — Available information suggests the level of mineral resource potential

C — Available information gives a good indication of level of resource potential

D — Available information clearly defines the level of mineral resource potential

Figure 1. Map showing mineral resource potential of the Sweetwater Canyon Wilderness Study Area, Wyoming.

is underlain by Archean-age granite and is devoid of near-surface mineralized rock. A greenstone belt trends through the extreme northwestern part of the study area where short, narrow gold-bearing quartz veins occur in faults in graywacke of the Miners Delight Formation. Identified gold resources are present in these rocks outside of the study area. Topographic projection of, and analytical data for the exposed part of the veins, suggest that subsurface continuity of the veins is possible. Although these veins trend into the area, no resources were identified because of the short strike length exposed and lack of subsurface data. Small to moderate tonnage (less than 20,000 short tons) of vein material might be present, but subsurface sampling and sample analysis would be needed to determine if gold resources are present.

Placer gold occurs in the gravels of the Sweetwater River in the study area. Bedrock gold concentrations and pay streaks of gold in gravels of the Sweetwater River could exist; however, because of the low gold concentrations of the gravel, no resources were identified.

Subeconomic quantities of sand and gravel and granite dimension stone exist within the study area. However, vast quantities of these commodities exist elsewhere in the region closer to viable markets.

A reconnaissance geochemical survey was conducted in the study area. Sample media included stream sediments, heavy-mineral panned concentrates, and grab samples from fresh and unaltered bedrock. Samples were taken from the Sweetwater River, Strawberry Creek, and all of the major tributaries within the study area. Anomalous concentrations of gold, tin, and tungsten were detected in the Quaternary gravels along the Sweetwater River and Strawberry Creek. In addition, based on the heavy-mineral fraction of the stream-sediment samples, two distinct areas were outlined within the study area. One area, the Lewiston district anomalous area, is in the greenstone rocks and is spatially associated with the lode-gold deposits of the Lewiston mining district. This area has elevated concentrations of gold, tin, and tungsten; the source for the anomalous concentrations seems to be the lode-gold system of the Lewiston mining district. The other area, the eastern anomalous area, is in Precambrian granitoid rocks. There is no clear bedrock source for the anomalous concentrations in this area.

Gravity and magnetic studies were undertaken to provide information on the regional subsurface distribution of the rock types and structures. A steep gravity gradient was identified that suggests that the contact between the Precambrian greenstone rocks and granitoids is steep and can be traced beneath the cover of Tertiary rocks. In addition, a magnetic gradient broadly parallels the contact between the Precambrian greenstone rocks and granitoids.

The studies of the Sweetwater Canyon Wilderness Study Area indicate a high mineral resource potential for undiscovered lode-gold resources in the greenstone rocks that underlie the western side of the study area; the historic Lewiston gold-mining district adjoins the northwestern border of the study area. Gold in the Lewiston district was mined from quartz-rich veins in fault zones and from associated placers adjacent to the western boundary of the study area. Similar structures have also been identified within the study area. A high mineral resource potential for undiscovered placer gold has been assigned to the alluvial gravels along the banks and streambed of the Sweetwater River and along Strawberry Creek. Visible gold was detected in many panned-concentrate samples from along the entire length of the river in the study area, although detected concentrations are uneconomic at gold prices of $400 per ounce.

Anomalous concentrations of tin and (or) tungsten occur in the alluvial gravels of the Sweetwater River and its tributaries. No placer-type tin and tungsten deposits or geochemical anomalies have previously been reported in the study area. However, tungsten has been reported associated with a lode-gold deposit in the adjacent Lewiston mining district. Cassiterite, a tin-bearing mineral, and scheelite, a tungsten-bearing mineral, were identified in the heavy-mineral fraction of several stream-sediment samples. A low resource potential is assigned for tin and tungsten in placer-type deposits in the Quaternary gravels along and in the channel of the Sweetwater River and Strawberry Creek. A low resource potential for undiscovered tin and tungsten in Precambrian lode-type deposits is assigned to the entire area.

The study area has no recognized energy resource potential for oil and gas, because most of it is underlain by Precambrian crystalline rocks. No subsurface oil or gas traps have been identified in the study area. There is no resource potential for geothermal energy. A low mineral resource potential for undiscovered uranium is assigned to the entire wilderness study area; no evidence of possible uranium deposits has been observed in the study area.

INTRODUCTION

Access to the study area is from State Highway 28 between Lander and Farson and from U.S. Highway 287 between Jeffrey City and Lander. The study area is most easily reached from State Highway 28, to Atlantic City, along graded gravel roads that lead to the abandoned townsite of Lewiston (fig. 2). The northern part of the study area can be reached by unimproved roads from Lewiston. The southern part of the study area is reached by crossing the Sweetwater River at the U.S. Bureau of Land Management bridge west of Lewiston, then by traveling on unimproved roads that form the southern boundary of the wilderness study area. Branches of the historic Oregon Trail, which followed the Sweetwater River through this part of Wyoming and which was utilized during the mid to late 1800's by Indians, explorers, miners, and emigrants, crosses both the northern and southern part of the study area.

The walls of the canyon rise from an elevation of 6,800 to 7,000 ft (feet) at the river level to 7,200 to 7,300 ft along the rims. Both north and south of the canyon rims the topography is gently rolling. The maximum elevation of 7,612 ft is in the southeastern part of the study area. Vegetation along the banks of the Sweetwater River and its tributaries consists primarily of willow bushes and aspen with minor juniper and conifer trees, which give way to sagebrush and range grasses away from the streambeds. The Sweetwater River, Strawberry Creek, and some of the springs in the area are perennial; however, the other tributaries to the Sweetwater River are intermittent and flow during spring snowmelt and following summer rainstorms.

Investigations by the U.S. Bureau of Mines

Investigations by the USBM (U.S. Bureau of Mines) included a review of pertinent literature on geology, mineral deposits, and mining activity in the Sweetwater Canyon Wilderness Study Area and vicinity prior to field examination. Patented and unpatented mining-claim information and oil and gas lease records were obtained from the U.S. Bureau of Land Management State Office in Cheyenne, Wyo.

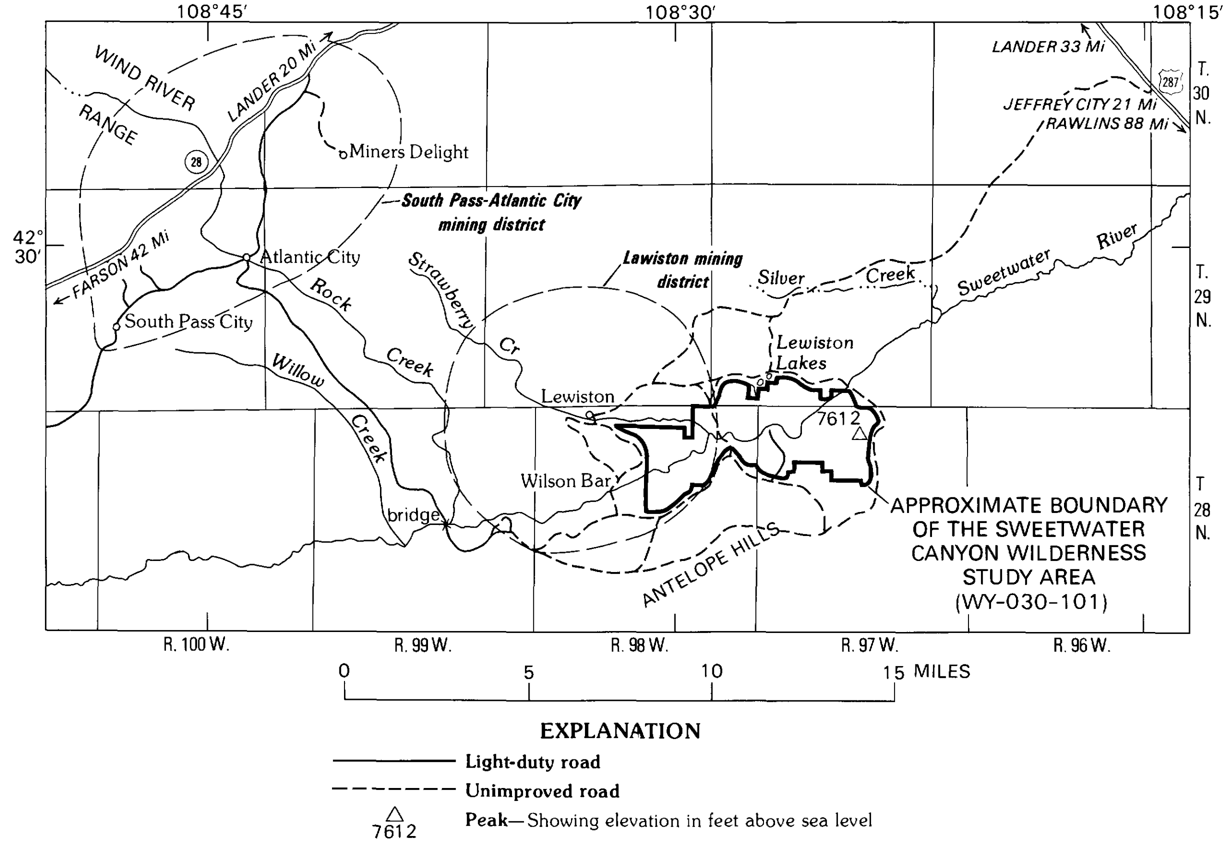


Figure 2. Index map of the Sweetwater Canyon Wilderness Study Area, Wyoming.

In 1986, USBM personnel spent 12 days carrying out a field examination of the study area. Accessible mine workings were surveyed by the compass-and-tape method and sampled. A total of 64 samples were taken, including 36 rock-chip samples, 18 selected rock samples, and 10 panned-concentrate samples. The chip and select samples were analyzed by the inductively coupled plasma-atomic emission spectrometry method for copper, lead, molybdenum, silver, tungsten, and zinc, and by fire assay-atomic absorption for gold. Fifteen samples were selected for analysis for tin. All of the USBM analytical work was performed by Chemex Labs, Inc.,[1] Sparks, Nev.

For each panned-concentrate sample, a measured volume of gravel was sluiced and then panned to recover the heavy minerals. Gold particles were separated from the concentrate under a microscope and weighed; the rest of the sample was then amalgamated and weighed. The amalgamated part was added to the hand-picked gold to determine total gold content. Analyses for gold in the panned-concentrate samples were performed by the USBM, Mineral Land Assessment Branch, Spokane, Wash. Data for all samples are discussed in Scott (1987), and complete data for all samples are available for public inspection at the U.S. Bureau of Mines, Intermountain Field Operations Center, Building 20, Denver Federal Center, Denver, CO 80225.

Investigations by the U.S. Geological Survey

Field work was performed during the summer of 1986 by W.C. Day, R.P. Dickerson, D.P. Busher, R.H. Hill, and M.A. Chaffee of the USGS (U.S. Geological Survey). W.D. Hausel of the Geological Survey of Wyoming made preliminary geologic maps of the Lewiston Lakes and Radium Springs quadrangles, which include the wilderness study area (Hausel, 1985a, 1986, 1987a). Hausel mapped during the summers of 1984, 1985, and 1986. Geophysical studies were undertaken by

[1]Use of company names or equipment does not imply endorsement by the USGS or the USBM.

D.M. Kulik in and adjacent to the study area during 1984, 1985, and 1987. The Geological Survey of Wyoming's contribution to this report consisted solely of providing preliminary geologic maps and information about the regional geology. The mineral appraisal of the wilderness study area was conducted by the USBM and the USGS.

Geologic investigations focused on resources likely to be present: principally lode gold, as well as copper, tin, and tungsten in quartz-rich veins in the greenstone rocks; placer gold in the alluvial gravels of the Sweetwater River; oil and gas; tin and tungsten in the Precambrian granitoid rocks; and uranium in Tertiary sedimentary rocks.

Geologic and geochemical studies consisted of geologic mapping, petrographic and petrologic analysis, rock and stream-sediment sampling, and scintillometer surveys. Various gold mines and prospect pits in the South Pass-Atlantic City mining district were visited and sampled in order to gain background data on the type and style of mineral deposits that may be present in the Sweetwater Canyon Wilderness Study Area. Additionally, the metavolcanic and metagabbroic rocks in the Atlantic City and Miners Delight areas were studied by petrographic and petrologic methods in order to compare and contrast the fundamental nature of volcanism and mafic plutonism with that in the study area.

This report presents an evaluation of the mineral endowment (identified resources and mineral resource potential) of the 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, 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.

Acknowledgments.—We thank R.P. Dickerson and D.P. Busher for their valuable assistance to Day and thank M.A. Chaffee for his assistance to Hill, in the field. R.A. Yeoman provided excellent trace-element geochemical analyses of bedrock samples, and E.A. duBray helped in our understanding of tin and tungsten mineralization in granite. Mary Allen of the Freeport-McMoRan Gold Co. provided helpful discussions on the regional geology as well as field trips through the South Pass-Atlantic City mining camp, and provided aerial photographs, preliminary geologic maps, and geochemical data for rocks in the Lewiston mining district.

APPRAISAL OF IDENTIFIED RESOURCES

By D.C. Scott
U.S. Bureau of Mines

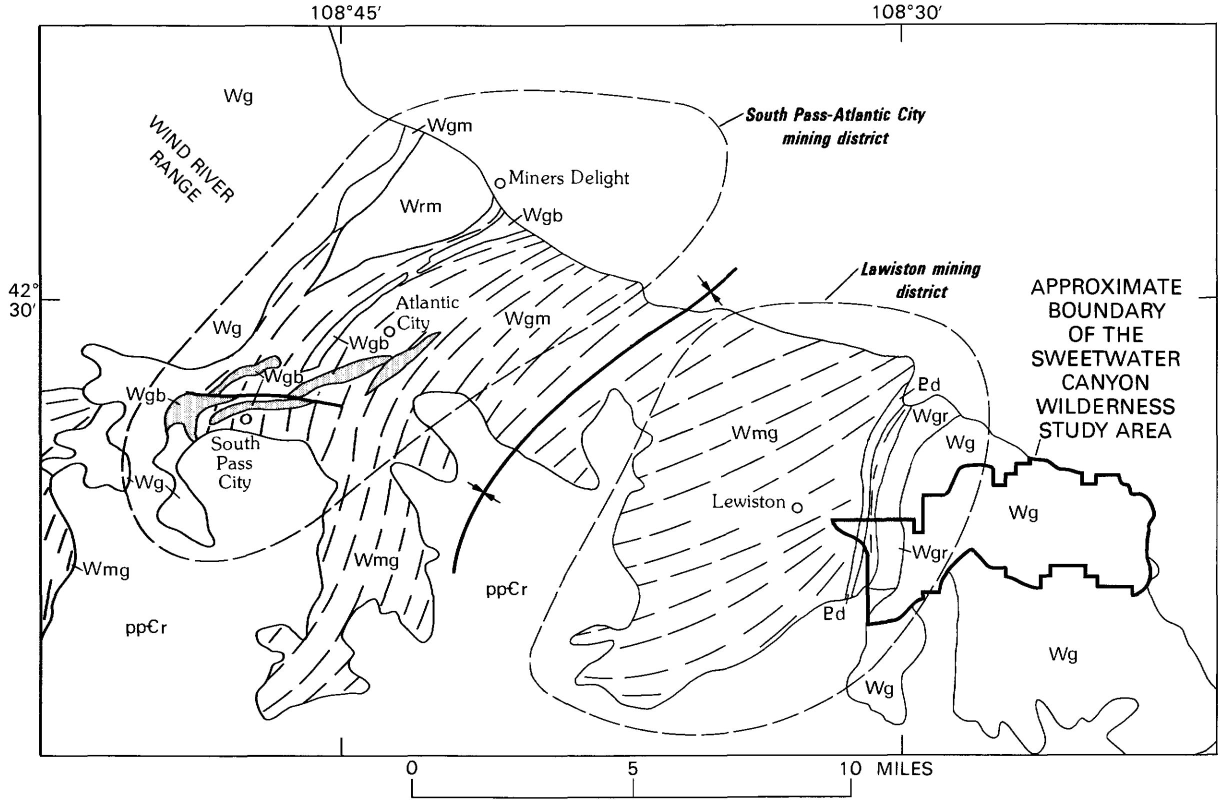
Mining History

In 1842, placer gold was discovered along the Sweetwater River and other streams adjacent to the wilderness study area. This discovery was apparently made along the old Emigrant Trail in the area now known as the Lewiston mining district (Hale, 1883). During the summer of 1867, the placer gold was traced up Willow Creek to what subsequently became the Carissa lode near South Pass City. This discovery led to a gold rush, and the South Pass-Atlantic City and Miners Delight mining districts were established. By 1869 as many as 2,000 people were reported living in the region, and in 1871, 12 stamp mills were operating; however, by 1872, South Pass City was nearly deserted, and by 1875, the districts were essentially abandoned (Hausel, 1980, p. 2).

The South Pass-Atlantic City mining district, about 10 mi west of the study area (fig. 3), lies along the northwestern flank of a greenstone belt and contains numerous gold deposits in faults that conform to the regional foliation of metagraywacke of the Archean Miners Delight Formation. Estimates of production of as much as 325,000 oz (ounces) of gold were made for the South Pass-Atlantic City district (Hausel, 1985b, p. 184).

The Lewiston mining district was established about 1879 and includes the western part of the study area (fig. 3). The district is along the southeastern margin of the greenstone belt and includes several faults similar to those in the South Pass-Atlantic City district. These faults also conform to the regional foliation of metagraywacke of the Miners Delight Formation (Hausel, 1986). No production records were kept; however, because of fewer mines and less development, production is estimated to be less than in the South Pass-Atlantic City district (Hausel, 1985b, p. 184–189).

Between 1933 and 1941, about 11,500 oz of gold were dredged from Rock Creek over a distance of about 7 mi downstream from Atlantic City (Hausel, 1980, p. 6). After 1941, the equipment used in the Rock Creek dredging operation reportedly was sold to another company that planned to dredge the Sweetwater River at Wilson Bar, ¾ mi west of the study area (Armstrong, 1948, p. 63). Exploration and prospecting for gold in the districts has taken place sporadically since 1941. In 1985 Freeport Exploration Co. conducted a geochemical study for gold throughout the Lewiston and South Pass-



EXPLANATION

pp€r	Post-Precambrian rocks, undivided
Pd	Proterozoic diabase dike
Wg	Archean granodiorite
Wgb	Archean gabbro
Wmg	Archean Miners Delight Formation—Metagraywacke, schist, and meta-andesite. Dashed lines indicate regional trend of bedding
Wrm	Archean Roundtop Mountain Greenstone Formation—Mafic metavolcanic rocks
Wgm	Archean Goldman Meadows Formation—Iron-formation, schist, and quartzite
Wgr	Archean Goldman Meadows Formation and Roundtop Mountain Greenstone Formation—Undivided
	Contact
	Axis of synclinorium
	Fault

Figure 3. Generalized geologic map of the South Pass greenstone belt, Fremont County, Wyoming. Modified from Hausel (1985).

Atlantic City mining districts. Since 1983, the Geological Survey of Wyoming has undertaken geologic mapping and conducted geochemical, petrologic, and wallrock-alteration studies in both the Lewiston and South Pass-Atlantic City mining districts.

Numerous prospect pits and shafts are present in the western part of the study area, and one patented claim, the Wilson Bar lode claim, extends into the extreme western part of the area (fig. 4). Approximately 20 percent of the study area is currently under oil and gas lease or lease application.

Commodities

Approximately 75 percent of the Sweetwater Canyon Wilderness Study Area is underlain by granite which is devoid of evidence of near-surface mineralization. The extreme western part of the Sweetwater Canyon Wilderness Study Area is part of an Archean greenstone belt containing metagraywacke of the Miners Delight Formation. Gold occurs in short, narrow quartz veins within faults conformable with regional foliation of the metagraywacke. Placer gold was found in the gravels in and adjacent to the Sweetwater River in the study area. Identified resources of industrial minerals (sand and gravel and granite dimension stone) were classified within the study area, but vast quantities of similar or better quality materials exist elsewhere in the region at locations closer to potential markets.

Lode-Gold Deposits and Prospects

Historic and geologic reports indicated that gold might be expected both within the metagraywacke in the greenstone belt in the extreme western part of the study area, and in the gravels of the Sweetwater River (see Scott (1987) for references). Most of the samples collected by the USBM from prospect pits in the western part of the study area contained gold (Scott, 1987). The gold occurs in quartz veins in faults which, for this report, are labeled A, B, C, and D (fig. 4). Gold occurrences do not appear to be associated with Archean granite, which underlies about 75 percent of the study area.

Fault A.—Fault A contains a quartz vein that strikes northeast into the extreme northwestern corner of the Sweetwater Canyon Wilderness Study Area (fig. 4). Eight samples were collected along fault A. Vein material along the fault was examined in three prospect pits outside the study area and on the dump of a prospect pit inside the study area. The 1.2- to 2.8-ft-thick vein is vuggy, highly fractured, and stained with limonite, hematite, and minor amounts of malachite.

Gold concentrations range from 0.010 to 0.100 oz/ton (ounce per short ton) and silver from less than 0.006 oz/ton to 0.419 oz/ton; copper, lead, molybdenum, tungsten, and zinc concentrations are above background levels but are not economically significant. Samples that have copper concentrations greater than 10,000 ppm (parts per million) also have correspondingly greater concentrations of tungsten (as much as 340 ppm) and tin (as much as 15 ppm). A sample taken from the dump of a prospect pit about 20 ft east of fault A contained the highest gold concentration of all samples collected. Although no vein material was exposed at this pit, gold in quartz collected from the dump of the pit assayed 0.114 oz/ton (Scott, 1987).

The vein is not exposed along the strike of the fault between each of the four prospect pits previously described, but the geological projection of and analytical data for the vein suggest possible subsurface continuity. Geophysical exploration, trenching, and drilling along the strike of the vein are needed to prove subsurface continuity of the vein. If the vein is continuous, the estimated length would be at least 3,600 ft, of which 1,300 ft are inside the study area. A moderate-tonnage (less than 20,000 short tons based on an estimated 1,300-ft strike length, 100-ft depth, and 2.0-ft thickness) of vein material could be present; subsurface sampling would be required to classify an identified gold resource.

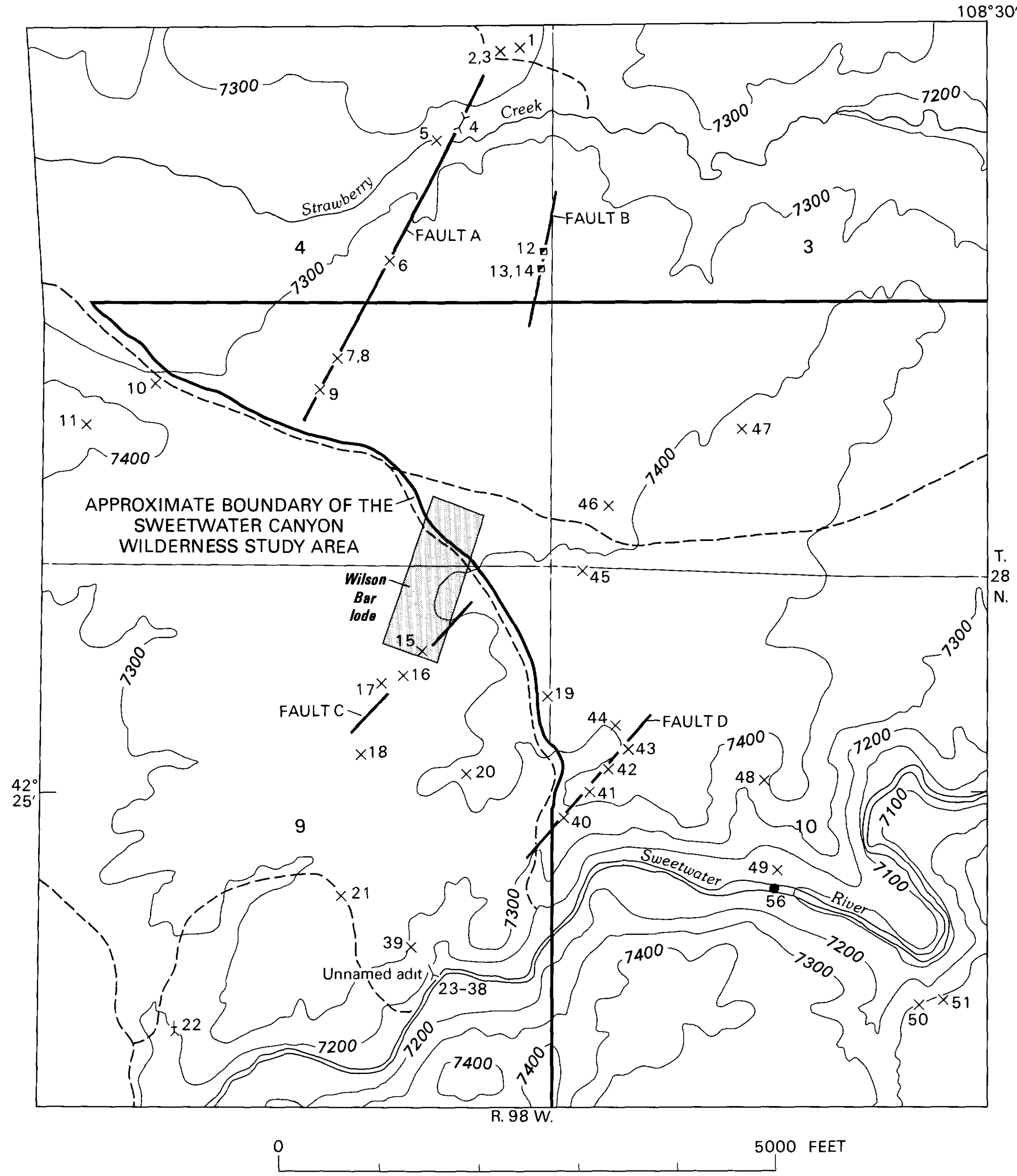
Fault B.—Fault B, approximately 1,300 ft east of fault A, contains a quartz vein that strikes northeast and extends into the northwestern part of the study area (fig. 4). The vein, exposed in two shallow shafts, is highly fractured, limonite stained, and about 3 to 4 in. (inches) thick. Malachite and azurite are visible along fractures in the quartz. The fault and vein conform to the regional foliation of the metagraywacke country rock. Gold in a grab sample from the dump of one shaft assayed less than 0.002 oz/ton. Two chip samples were taken across the vein and fault exposed in the other shaft, and gold concentrations were 0.058 and 0.018 oz/ton. Silver concentrations ranged from less than 0.006 oz/ton to 0.040 oz/ton in the three samples. Copper, lead, molybdenum, tungsten, and zinc concentrations were not economically significant (Scott, 1987). One sample of brecciated quartz with minor epidote and malachite had elevated concentrations of copper (7,380 ppm) and tin (28 ppm).

Although the vein trends toward and might be present in the study area, an identified resource could not be classified because of the limited width and strike length exposed and the uncertainty of subsurface vein continuity.

Fault C.—Fault C contains a quartz vein that strikes northeast toward the western part of the study area and crosses the Wilson Bar lode patented mining claim (fig. 4). The 2.0-in.-thick vein, exposed in two prospect pits, is brecciated and limonite stained; the fault conforms to the regional foliation of the metagraywacke country rock.

The vein was sampled in each pit, and assays for gold yielded 0.072 and 0.090 oz/ton. Silver concentrations were 0.011 oz/ton and 0.122 oz/ton; copper, lead, molybdenum, tungsten, and zinc concentrations were not economically significant (Scott, 1987). Although the vein is not exposed between the pits, the geologic projection of and the similar analytical data for the vein in each pit suggest that subsurface continuity of the vein is possible.

Two prospect pits were sampled that are not along strike of the fault but were apparently dug in an attempt to further expose fault C. Although no vein was observed in either pit, quartz-bearing material was found on the dump of each pit and sampled. The gold concentrations of the samples were 0.030 and 0.044 oz/ton. Silver concentrations were 0.011 oz/ton and 0.017 oz/ton;



EXPLANATION

(shaded box)	**Patented mining claim**
———	**Fault with vein**—Approximately located
●56	**Locality of panned concentrate sample**—Showing sample number
– – – – –	**Unimproved road**
	Surface openings—Showing sample number(s)
×1	**Prospect pit**
≻≺4	**Trench**
▪12	**Shaft**
≻23-38	**Adit**
≻22	**Inaccessible adit**

copper, lead, molybdenum, tungsten, and zinc concentrations were similar to the concentrations in samples from the vein in fault C (Scott, 1987).

Fault D.—Fault D, in the western part of the study area (fig. 4), contains a 2.0-in.-thick quartz vein that strikes northeast. The strike and dip of the vein could be measured in only one of the four prospect pits along the trend of the fault. Pieces of highly fractured, limonite-stained, vuggy quartz, containing epidote and malachite along fractures, are present in the dumps of each of the four prospect pits.

Gold concentrations ranged from less than 0.002 oz/ton to 0.020 oz/ton. Silver concentrations ranged from less than 0.006 oz/ton to 0.315 oz/ton. One sample contained greater than 10,000 ppm copper. Other copper, lead, molybdenum, tungsten, and zinc concentrations were not economically significant (Scott, 1987).

Because the quartz vein was found in place in only one of the prospect pits, no identified resource could be classified. However, based on geologic projection, subsurface vein continuity between the pits is possible. If the vein is continuous, a moderate-tonnage (less than 20,000 short tons, based on an estimated 1,200-ft strike length, 100-ft depth, and 20-in. thickness) of vein material could be present; subsurface sampling would be necessary to classify any identified gold resources.

Unnamed adit.—A 468-ft-long adit, subsequently identified as the Lone Pine adit, was driven into the north wall of the Sweetwater River canyon approximately 1,100 ft west of the western boundary of the study area (fig. 4). The adit is perpendicular to the foliation of the graywacke country rock and intersects 11 faults. All the faults contain limonite- and malachite-stained gouge and brecciated lenses of calcite and quartz.

Gold concentrations in samples from the adit were consistently low, ranging from 0.002 to 0.008 oz/ton, except for one sample that contained 0.012 oz/ton. Copper, lead, molybdenum, tungsten, and zinc concentrations were not economically significant (Scott, 1987). Two narrow quartz-arsenopyrite veins are exposed along the Sweetwater River 100 yards east of the Lone Pine adit outside the western boundary of the study area. One sample of the veins contained no detectable gold and 0.61 oz/ton silver (Hausel, 1983).

Placer-Gold Deposits

The gravels in the Sweetwater River near the study area contain placer gold (Hausel, 1980, p. 15). The placers occur in the gravel flats in and adjacent to the channel of the present-day river. Extensive dredging in the gravel of the Sweetwater River was done at Wilson Bar, about ¾ mi outside the western boundary of the study area. Although many placer claims have been staked along the Sweetwater River in the study area, no evidence of past placer mining was found.

Panned-concentrate samples were taken in and near the study area to check for placer gold. Geochemical data for the samples are given in Scott (1987). Of the eight samples taken along the Sweetwater River, five contained visible fine gold particles. Two samples collected along Strawberry Creek (draining into the study area) contained no visible gold particles; however, analytical results showed all 10 samples contained gold (Scott, 1987).

The value of the gold content was determined at a price of \$393.00/oz (as of Dec. 15, 1986). Samples 55 and 61 yielded the highest gold values. Sample 55 was collected from Wilson Bar outside the study area and yielded \$0.42/yd^3 (cubic yard). Sample 61, the only sample collected at bedrock inside the study area, yielded \$0.26/yd^3. The rest of the samples were collected from gravel bars at a depth of about 3.0 ft.

To aid in identifying the source of the gold placers, individual gold particles in the sample from Wilson Bar were examined under a binocular microscope. Gold particles either were rounded, indicating considerable transport, or consisted of wire, indicating very little transport. Probably the gold occurrence has two separate sources. The rounded gold might have come from the Atlantic City area and was transported down Rock Creek or other drainages into the Sweetwater River. The wire gold might be from the nearby gold-bearing quartz veins in the Lewiston mining district or it may have grown in place.

Data suggest that gold concentrations are higher at bedrock in the Sweetwater River gravels and that the origin of the placer gold is outside the study area. Greater concentrations of gold could exist not only at bedrock, but as pay-streaks within individual gravel bars. Because all samples but one were taken at a 3.0-ft depth without exposing bedrock, a minimum of 3.0 ft of gravel probably exists along the Sweetwater River throughout the study area. The low gold concentrations from gravel in the study area preclude calculation of resources.

Industrial Minerals

Inferred subeconomic resources (see resource/reserve classification chart in the Appendix) of sand and gravel are common in the valley floor of the Sweetwater River. Access to these deposits is limited in the easternmost part of the study area, which is the most remote part (Lander is about 45 mi north). Therefore,

Figure 4. Map of the northwestern part of the Sweetwater Canyon Wilderness Study Area , Wyoming, showing faults A, B, C, and D, and U.S. Bureau of Mines sample localities 1–51 and 56. Data for U.S. Bureau of Mines samples reported in Scott (1987).

these deposits are not easily accessible, and they are far from potential markets. Ample resources of sand and gravel are available elsewhere in the region at locations closer to markets.

Inferred subeconomic resources of granite dimension stone occur throughout approximately 75 percent of the study area. However, weathering along the surface and joints in the granite limits the suitability for dimension stone; the granite would be suitable for concrete aggregate. However, vast quantities of equal or higher quality are available throughout the region at locations closer to markets, which minimizes the likelihood of development of the granite resources from the study area.

Recommendations for Further Study

Geophysical exploration, trenching across the veins, and drilling along the strike of faults A, B, C, and D are needed to verify subsurface continuity of the quartz veins and to test the gold concentrations in them.

To adequately assess the placer gold in the study area, an extensive sampling and mapping program is needed.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Warren C. Day, Randall H. Hill, and Dolores M. Kulik
U.S. Geological Survey

Geology

Regional Geologic Setting

The Sweetwater Canyon Wilderness Study Area lies within the southern part of the Archean Wyoming province, which is exposed along the southern flanks of the Wind River Mountains (fig. 3). The Wyoming province forms the Precambrian basement that underlies a large area extending from the Black Hills of South Dakota west to the Albion Range of Idaho and Utah, and from the Little Rocky Mountains of Montana south to the Wyoming-Colorado and Wyoming-Utah State borders (Hausel, 1986; Houston, 1986).

The study area is within the easternmost extent of the South Pass greenstone belt, which consists of Archean supracrustal rocks (sedimentary and volcanic rocks). This greenstone belt, along with the whole Wind River Range to the north, forms a Precambrian basement complex that is about 135 mi long and 40 mi wide, which was uplifted during the Laramide orogeny. On the eastern side of the range Paleozoic and Mesozoic sedimentary rocks dip gently to the east into the Wind River basin, but on the north and northwestern flanks of the range the Phanerozoic sedimentary rocks are folded and faulted against the Precambrian basement rocks. Along the southern and southwestern flanks of the range, the Precambrian basement has been thrust westward over the Phanerozoic sedimentary rocks along major east-dipping thrust faults (Lynn and others, 1983).

Bayley and others (1973) proposed that in a general sense the rocks in the Archean South Pass greenstone belt lie in a major northeast-trending synclinorium that wraps around the southern tip of the Wind River Range (fig. 3). In their structural model, rocks in the study area lie on the southeastern limb, and those in the South Pass-Atlantic City area lie on the northwestern limb of the major regional synclinorium. Therefore, gold-bearing rock units present in the South Pass-Atlantic City area may crop out in and adjacent to the study area. And in fact, the now-abandoned Lewiston mining district adjacent to the study area is in the Miners Delight Formation, which hosts the major gold camps in the South Pass-Atlantic City area (Bayley and others, 1973).

Significant amounts of gold have been won from both lode and placer deposits in the South Pass greenstone belt. Hausel (1980) estimated that as much as 325,000 oz of gold have been recovered, principally from mines in the vicinity of the South Pass-Atlantic City area and the Lewiston mining district.

The South Pass greenstone belt consists of metamorphosed volcanic and sedimentary supracrustal rocks that were intruded by granite. In the South Pass-Atlantic City area, Bayley (1968) and Bayley and others (1973) recognized two suites of supracrustal rocks of distinctly different origin. The oldest suite is composed of two units. The basal unit (unnamed) is made up of basalt[2], gabbro, tremolite-talc-chlorite schist, and serpentinite that is overlain by quartzite, oxide-facies iron-formation, and schist of the Archean Goldman Meadows Formation. Bayley and others (1973) suggested that this suite represents a sequence deposited on "a stable marine shelf environment of considerable duration" formed on the edge of a continental margin.

The youngest suite of Archean supracrustal rocks comprises pillowed basalt and gabbro of the Roundtop Mountain Greenstone and ultramafic and mafic amphibolite, gabbro, graywacke, andalusite schist, felsic tuff, and andesite of the Miners Delight Formation. Bow (1986) suggested that the ultramafic amphibolite in the Miners

[2]For brevity, the prefix "meta-", commonly used to describe metamorphosed rocks, is not used here because all of the Precambrian rocks have undergone at least greenschist-facies metamorphism.

Delight Formation, which is now tremolite-actinolite and talc-tremolite schist, represents recrystallized komatiite lavas. Bayley and others (1973) proposed that the younger supracrustal suite "composed mainly of submarine volcanic rocks and graywacke turbidites indicates deep-water deposition in a tectonically active unstable basin," implying that the basin formed at the edge of actively rifting continental margin as later suggested by Bow (1986).

Granite of two distinct episodes of intrusion is present on both the northern and western edges of the greenstone belt. The first episode produced the Louis Lake batholith, which was emplaced about 2,630±20 Ma (Stuckless and others, 1985). This massive batholith is composed predominantly of medium-grained hornblende-biotite granodiorite along its southern margin near the contact with the South Pass greenstone belt.

The second episode of granite intrusion, which is represented by the Bears Ear pluton, occurred about 2,575±50 Ma (Stuckless and others, 1985). As noted by Pearson and others (1971) and Stuckless and others (1985), the Bears Ear pluton is more evolved (enriched in SiO_2 and large-ion lithophile elements) and has coarser grained porphyritic granite than does the Louis Lake batholith.

Description of Rock Units

Rocks within the study area are stratigraphically similar to those in the South Pass-Atlantic City area. Two distinct Archean supracrustal rock suites are in the study area. The oldest suite comprises several units that occur in a thin ½- to 1-mi-wide north-trending belt on the western side of the study area (Hausel, 1987a). The lowermost unit in this suite is a dark-green to black interlayered mafic to ultramafic rock that is made up of plagioclase-actinolite, talc-chlorite, actinolite-tremolite, and minor andalusite-bearing pelitic schist. This unit is structurally overlain by rocks of the Goldman Meadows Formation, which comprises a thin, discontinuous belt of fuchsite-bearing quartzite and interlayered andalusite-mica schist and medium-grained, dark-green to black, strongly foliated amphibolitic schist (recrystallized gabbro?) that has minor interlayers of biotite and andalusite-mica schist.

Above the rocks of the Goldman Meadows Formation is a fine-grained, well-foliated hornblende-biotite schist of basaltic composition that has minor interlayers of amphibolite, as well as andalusite and chlorite schist. The pillow basalts and gabbros of the Roundtop Mountain Greenstone in the South Pass-Atlantic City area were not observed here. Possibly the hornblende-biotite schist and amphibolite that overlie the Goldman Meadows Formation may be stratigraphically equivalent to the Roundtop Mountain Greenstone.

The youngest suite of supracrustal rocks are the sedimentary rocks of the Miners Delight Formation, which structurally overlie the hornblende-biotite schist (Roundtop Mountain Greenstone?). The basal unit, which is light-brown to gray, fine- to medium-grained immature quartzite, is in fault contact with the underlying schists of the Goldman Meadows Formation. The immature quartzite grades upward into light-brown, fine-grained graywacke typical of the Miners Delight Formation. The graywacke is immature and is interbedded with minor felsic tuff and felsic volcaniclastic sedimentary rocks that are thought to be distal to felsic volcanic centers observed farther to the west in the Miners Delight area. The ubiquitous andesitic flows and pyroclastic rocks observed in the Miners Delight Formation elsewhere were not observed in the study area.

The Archean sedimentary and volcanic rocks were intruded by a metaluminous calc-alkalic granodioritic batholith (map unit Wg, pl. 1). This batholith is the major rock exposed in the study area. Although the age of the batholith has not been determined, it is thought to be approximately equivalent in age to the Louis Lake batholith, which is about 2,630 Ma (Stuckless and others, 1985).

The batholith is composite, made up chiefly of pinkish-white to salmon biotite granodiorite and trondhjemitic (quartz-rich tonalite) pegmatite. The granodiorite has a medium-grained hypidiomorphic texture and contains autoliths of dark-gray hornblende-biotite tonalite.

The Archean rocks were intruded by two sets of Proterozoic mafic dikes. Condie and others (1969) dated similar rocks to the north at about 2,060 Ma. A major north-trending coarse-grained quartz dioritic to gabbroic dike was intruded during the first phase of dike emplacement. This phase was followed by intrusion of a conjugate set of northeast- and northwest-trending medium-grained diabase dikes. Both sets of dikes were subsequently offset along high-angle faults and shear zones, which have modest horizontal displacements ranging from 300 to 1,000 ft.

Paleozoic sedimentary rocks form an east-dipping blanket that covers the Precambrian basement rocks on the eastern side of the study area (pl. 1). The lowermost of the Paleozoic cover rocks is Cambrian in age and is made up of sandstone and conglomerate of the Flathead Sandstone (Middle Cambrian), shale of the Gros Ventre Formation (Middle and Upper Cambrian), and limestone of the Gallatin Formation (Upper Cambrian). The Cambrian sequence is overlain by the Middle and Upper Ordovician Bighorn Dolomite.

The Mississippian Madison Limestone was deposited disconformably on top of the Cambrian and Ordovician sedimentary rocks; Silurian and Devonian sedimentary rocks were stripped away by erosion during the Mississippian. Resting conformably on the Madison Limestone are the limestone, shale, and quartzite of the Amsden Formation (Upper Mississippian and Lower and Middle Pennsylvanian) and sandstone of the Tensleep Sandstone (Middle and Upper Pennsylvanian).

During the Laramide orogeny the Precambrian basement and Paleozoic cover rocks of the entire Wind River Range, including the study area, were uplifted and thrust westward over Paleozoic and Mesozoic sedimentary rocks (Lynn and others, 1983). During this deformation the originally flat lying Paleozoic cover rocks exposed on the eastern side of the study area were tilted into their present east-dipping attitude.

Extensive erosion during the middle Tertiary stripped the Precambrian basement of its Paleozoic cover rocks and formed a vast east-dipping, gently rolling peneplane. Siltstone and conglomerate of the South Pass Formation were deposited on this vast erosional surface during the late Miocene to middle Pliocene (Denson and Pipiringos, 1974).

The present drainage system, represented by the Sweetwater River and its tributaries, was superimposed during the Quaternary on the Tertiary erosional surface. Continuous stream erosion cut into the Precambrian basement rocks, forming the rugged and majestic canyons that now contain the Sweetwater River and its tributaries.

Geochemistry

Analytical Methods

In the summer of 1986, a reconnaissance geochemical survey was conducted in the Sweetwater Canyon Wilderness Study Area to assist in the mineral resource assessment of the area. Stream sediments were selected as the primary sample medium as they represent a composite of rock and soil exposed in the drainage basins upstream from the sample sites. Chemical analyses of these stream sediments provide data useful in identifying those basins which contain unusually high concentrations of elements that may be related to mineral occurrences. Twenty-four minus-80-mesh stream-sediment samples were collected from active stream alluvium.

In addition, 24 heavy-mineral panned-concentrate samples derived from stream sediments were collected. Studies have shown that heavy-mineral concentrates derived from stream sediment are a useful sample medium in arid-semiarid environments or in areas of rugged topography, where mechanical erosion predominates over chemical erosion (Overstreet and Marsh, 1981; Bugrov and Shalaby, 1975).

Eighteen fresh and unaltered grab samples of the bedrock were collected within 45 ft of the sediment-sample sites to gain some general information on the geochemical nature of the rock units present. In addition, one composite mine-dump rock sample was collected to provide some general geochemical information on the mineralized rocks around the area.

The dry stream-sediment samples were sieved through 80-mesh (0.17-millimeter) stainless-steel sieves. The minus-80-mesh material was retained for analysis and pulverized with ceramic plates to at least minus-100 mesh size prior to analysis.

To produce the heavy-mineral concentrate, bulk stream sediment from active alluvium was first sieved through a 10-mesh (2.0-mm) screen. Approximately 25–30 pounds of the minus-10-mesh sediment were panned to remove most of the quartz, feldspar, organic materials, and clay-sized material. These samples were then air dried, passed through a 30-mesh sieve, and split into two samples. One split was retained for gold analysis by atomic-absorption spectrometry. The other split was then separated into light and heavy fractions using bromoform (heavy liquid of specific gravity 2.86). The light fraction was discarded. The material of specific gravity greater than 2.86 was further separated into three fractions (highly magnetic, weakly magnetic, and nonmagnetic) using a modified Frantz isodynamic separator. The nonmagnetic fraction was hand ground and retained for emission spectrographic analysis. The above procedure produces a sample that represents a concentration of a mineral assemblage that may include ore-forming and ore-related minerals. This selective concentration of ore-related minerals permits determination of some elements that are not easily detected in bulk stream-sediment samples.

Rock samples were crushed and then pulverized to at least minus-100 mesh size with ceramic plates prior to analysis.

Rock, stream-sediment, and nonmagnetic parts of the prepared heavy-mineral concentrate were analyzed for 31 elements using a six-step semiquantitative emission spectrographic method (Grimes and Marranzino, 1968). Due to the limited amount of sample material, the nonmagnetic heavy-mineral concentrates were only analyzed spectrographically. The rock and minus-80-mesh stream-sediment samples were also analyzed for arsenic, bismuth, cadmium, antimony, and zinc by atomic-absorption spectrometry (O'Leary and Meier, 1984). The rock samples were also analyzed for gold and tin by atomic-absorption spectrometry (O'Leary and Meier, 1984) and tungsten by a visible spectrophotometric method (O'Leary and Meier, 1984). In addition, the untreated heavy-mineral panned-concentrate samples were analyzed for gold by atomic-absorption

Table 1. Geochemical analyses of samples from the Lewiston mining district anomalous area in the western part of the Sweetwater Canyon Wilderness Study Area, Wyoming

[N, concentration of element is below lower limit of determination (shown in parentheses); L, concentration of element is below lower limit of determination (shown in parentheses) but detectable; ppm, parts per million. Samples collected by W.C. Day and R.H. Hill. Analyses by R.H. Hill, D.M. Hopkins, R.T. Hopkins, J.W. Sharkey, and R.A. Yeoman, U.S. Geological Survey]

Field No.	Sample type	Element (ppm)					
		Au	As	Sn	W	Ba	Bi
		Stream-sediment samples					
SW005---	Panned concentrate†----------	L(0.009)	N(500)	2,000	200	700	N(20)
SW008---	--do--------------------------	N(0.010)	N(500)	30	300	70	N(20)
SW009---	--do--------------------------	L(0.017)	N(500)	500	700	200	N(20)
SW010*--	--do--------------------------	0.281	N(500)	150	150	N(50)	N(20)
SW011---	--do--------------------------	N(0.025)	N(500)	2,000	700	N(50)	N(20)
		Rock samples					
SW004---	Granodiorite-----------------	N(0.05)	20	N(2)	1.0	150	N(1.0)
SW007---	Quartz vein------------------	0.35	N(5)	N(2)	12.5	300	N(1.0)
SW008---	Graywacke--------------------	N(0.05)	10	N(2)	1.0	500	N(1.0)
SW009---	--do--------------------------	N(0.05)	15	N(2)	1.0	300	N(1.0)
SW010---	--do--------------------------	N(0.05)	10	N(2)	1.0	300	N(1.0)
WY86-10B	Amphibolite------------------	N(0.1)	N(10)	1.0	.5	84	N(10)
WY86-29A	Andalusite-chlorite schist---	N(0.1)	N(10)	N(1.0)	3.0	490	N(10)
WY86-29B	Actinolite schist------------	N(0.1)	N(10)	N(1.0)	1.5	210	N(10)
WY86-29C	Talc-tremolite schist--------	N(0.1)	N(10)	N(1.0)	1.0	93	N(10)
WY86-29D	Actinolite-plagioclase schist	N(0.1)	N(10)	N(1.0)	.7	98	N(10)
WY86-31-	Biotite schist---------------	N(0.1)	N(10)	1.0	1.0	220	N(10)

*Sample taken from the Sweetwater River.
†Panned concentrates not processed in bromoform and Frantz magnetic separator.

spectrometry (O'Leary and Meier, 1984). Analytical and sample data were prepared by R.H. Hill (unpub data, 1988).

Results of Geochemical Studies

Threshold concentrations, defined as the upper limit of normal background values, were determined for each element by inspection of frequency-distribution histograms. The mine-dump composite rock sample was not included in the data set. A geochemical concentration higher than the threshold concentration is considered anomalous and may indicate possible mineralization.

Two distinct geochemically anomalous areas were identified within the Sweetwater Canyon Wilderness Study Area. The primary criterion for delineating an area as anomalous was the presence of multielement anomalies clustered within a restricted geographic region. Delineation of these two areas was subjective, and any future geochemical studies should include resampling of the localities having anomalous values.

Lewiston district anomalous area.—Anomalous values of tin and tungsten, traces of gold, and weakly anomalous barium in heavy-mineral concentrates delineate this anomalous area. The most likely origin of these anomalies is the Lewiston gold deposits and associated rock units (table 1). Both the magnitude of the anomalies and the number of elements found in anomalous concentrations in the heavy-mineral concentrates and stream sediments are increased owing to previous mining activity. This activity made mineralized rock available for transport as sediment and also introduced contaminants into stream alluvium.

Eastern anomalous area.—This area is delineated by scattered anomalous values of tin, tungsten, and bismuth, and traces of gold in the heavy-mineral concentrates (table 2). One rock sample (SW014, table 2) does have an elevated arsenic concentration. These values are not associated with any previous mining activity or contamination nor are the drainages influenced by the greenstone belt rocks to the west; the drainages are confined primarily to the Precambrian granitoid rocks. Concentrations in rock samples in this area are well within normal background values for the rock types. Possible sources for the anomalous values in the heavy-mineral concentrates include (1) low-grade tin-tungsten mineralized zones associated with the granitoid and pegmatite within the area, (2) unidentified

Table 2. Geochemical analyses of samples from the eastern anomalous area, Sweetwater Canyon Wilderness Study Area, Wyoming

[N/A, not analyzed; N, concentration of element is below lower limit of determination (shown in parentheses); L, concentration of element is below lower limit of determination (shown in parentheses) but detectable; G, greater than; ppm, parts per million. Samples collected by W.C. Day and R.H. Hill. Analyses by R.H. Hill, D.M. Hopkins, R.T. Hopkins, J.W. Sharkey, and R.A. Yeoman, U.S. Geological Survey]

Field No.	Sample type	Element (ppm)					
		Au	As	Sn	W	Ba	Bi
	Stream-sediment samples						
SW012*--	Panned concentrate†----------	0.022	N(500)	100	L(100)	N(50)	N(20)
SW013---	--do-------------------------	N(0.012)	N(500)	500	2,000	N(50)	N(20)
SW014---	--do-------------------------	N(0.021)	N(500)	300	500	N(50)	N(20)
SW015---	--do-------------------------	0.45	N(500)	G(2,000)	L(100)	N(50)	N(20)
SW016---	--do-------------------------	N(0.004)	N(500)	200	N(100)	L(50)	N(20)
SW017---	--do-------------------------	N(0.012)	N(500)	500	N(100)	L(50)	N(20)
SW018*--	--do-------------------------	0.093	N(500)	200	150	N(50)	N(20)
SW019---	--do-------------------------	L(0.014)	N(500)	N(20)	N(100)	L(50)	N(20)
SW020---	--do-------------------------	N(0.035)	N(500)	150	N(100)	N(50)	N(20)
SW021---	--do-------------------------	N(0.015)	N(500)	N(20)	N(100)	50	500
SW022---	--do-------------------------	L(0.016)	N(500)	N(20)	500	50	N(20)
SW023---	--do-------------------------	L(0.007)	N(500)	L(20)	L(100)	70	N(20)
SW024---	--do-------------------------	N(0.011)	N(500)	150	200	200	100
SW026---	--do-------------------------	N(0.017)	N(500)	20	150	100	500
SW027*--	--do-------------------------	0.059	N(500)	700	100	50	N(20)
	Rock samples						
SW013---	Granitic gneiss--------------	N(0.05)	5	2	0.5	70	N(1.0)
SW014---	--do-------------------------	N(0.05)	65	N(2)	0.5	300	N(1.0)
SW015---	Tonalite---------------------	N(0.05)	N(5)	N(2)	1.0	500	N(1.0)
SW016---	--do-------------------------	N(0.05)	N(5)	N(2)	1.0	300	N(1.0)
SW017---	--do-------------------------	N(0.05)	N(5)	N(2)	0.5	500	N(1.0)
SW019---	Granodiorite-----------------	N(0.05)	N(5)	N(2)	1.0	300	N(1.0)
SW020---	Tonalite---------------------	N(0.05)	N(5)	N(2)	0.5	700	N(1.0)
SW021---	--do-------------------------	N(0.05)	N(5)	N(2)	1.0	150	N(1.0)
SW022---	Granodiorite-----------------	N(0.05)	N(5)	N(2)	1.0	300	N(1.0)
SW025---	Sandstone; Flathead Sandstone	N(0.05)	N(5)	N(2)	2.0	30	N(1.0)
SW026---	Granodiorite-----------------	N(0.05)	N(5)	N(2)	1.0	300	N(1.0)
WY86-8--	Granite----------------------	N(0.1)	N(10)	N/A	N/A	610	N(10)
WY86-9--	--do-------------------------	N(0.1)	N(10)	2.0	N(0.5)	220	N(10)
WY86-38-	Granodiorite-----------------	N(0.1)	N(10)	1.0	0.7	430	N(10)
WY86-42-	Tonalite pegmatite-----------	N(0.1)	N(10)	N(1.0)	1.0	110	N(10)

*Sample taken from the Sweetwater River.
†Panned concentrates not processed in bromoform and Frantz magnetic separator.

mineralized shear zones within the granitoid, and (3) accessory minerals from the middle Pliocene to upper Miocene South Pass Formation.

Geophysics

Gravity and magnetic studies were undertaken to provide information on subsurface distribution of rock masses and the structural framework of the Sweetwater Canyon Wilderness Study Area. The gravity and magnetic data are of a reconnaissance nature and are adequate only to define regional structural features.

The gravity data from in and near the study area were collected in 1984, 1985, and 1987, and were supplemented by data maintained in the files of the Defense Mapping Agency of the U.S. Department of Defense. Gravity measurements by Kulik were made with a Worden gravimeter W–177. The data were tied to the International Gravity Standardization Net 1971 (U.S. Defense Mapping Agency, Aerospace Center, 1974) at base station ACIC 0585–1 at Atlantic City, Wyo., and ACIC 0588–1 at Rock Springs, Wyo. Station elevations were obtained from benchmarks, spot elevations, and estimates from topographic maps at 1:24,000 and 1:62,500 scales, and are accurate to ±20 to 40 ft. The error in the Bouguer anomaly due to elevation inaccuracy is less than 2.5 mGal (milligals). Bouguer anomaly values were computed using the 1967 gravity formula (International Association of Geodesy, 1971) and a reduction density of 2.67 grams per cubic centimeter. Mathematical formulas are in Cordell and others (1982). Terrain corrections were made by computer for a radial distance of 100 mi from the station using the method of Plouff (1977). The data are shown in figure 5 as a complete Bouguer anomaly map with a contour interval of 5 mGal.

Magnetic data are from Geodata International (1980). Flight lines were flown east-west at 2- to 5-mi intervals and 400-ft barometric elevation. The data are shown in figure 6 as a residual intensity magnetic contour map with a contour interval of 20 nT (nanoteslas).

The north-trending gravity gradient (fig. 5) in the wilderness study area is caused by the contrast of lower density granite to the east of the gradient with higher density metamorphic rocks to the west. The steep gradient suggests that the contact between the granite and metamorphic rocks dips steeply. The southward extension of the gravity high (A on fig. 5) suggests that the contact between the granite and the metamorphic rocks continues beneath the Tertiary rocks. A less well defined gravity high (B on fig. 5) in the eastern part of the map area is caused by the relatively high density Paleozoic rocks that overlie the granite on the east. The east-west-trending gravity gradient in the southern part of the map area is associated with the Continental fault, which brings Precambrian rocks into contact with low-density sedimentary rocks in the subsurface.

A magnetic gradient (fig. 6) broadly parallels the contact between granitic and metamorphic rocks, with higher values occurring over the granitic terrain and lower values over the belt of metamorphic rocks. The high magnetic anomaly in the northwestern corner of the map area is caused by iron deposits of the Atlantic City district. Moderately low values form a bend in the contours in the northeastern corner of the map area, which is caused by the nonmagnetic sedimentary rocks on the eastern flank of the Wind River Range.

Mineral and Energy Resources

Gold

Two types of gold deposits occur in and adjacent to the wilderness study area. Lode-gold deposits are in the greenstone-belt rocks of the Lewiston mining district and in similar rocks along the western part of the study area. Placer-gold deposits, which occur in the alluvial gravels of the Sweetwater River, have been exploited immediately upstream from the study area at Wilson Bar, and similar deposits were delineated by Scott (1987) in the alluvial gravels along the Sweetwater River throughout the study area.

Lode-Gold Deposits

Mining in the Lewiston mining district, which is currently inactive, focused on the quartz-rich veins in the graywacke of the Miners Delight Formation. These veins occur within discontinuous anastomosing fault zones that generally parallel the original bedding in the graywacke. Based on the scanty mine records for the district, the ore grade along strike of a vein system was erratic, with the high-grade ore within local pockets (Scott, 1987). Where exposed, the veins are oxidized and rusty owing to supergene alteration (weathering) of pyrite and other sulfide minerals. Postmineralization movement along the fault zones fractured and deformed the quartz in the veins. The late-stage fracturing of the quartz veins enhanced the supergene alteration that tended to enrich the tenor of the gold deposits (Bayley, 1968).

Currently there are two basic models for the origin of sediment-hosted lode-gold deposits like those in the Lewiston mining district. In the syngenetic model as reviewed by Boyle (1987) gold was introduced into the host sedimentary rock at the time of formation of the host sediment. Hutchinson and Burlington (1984) described such a model in which the mineralized horizons in the host strata were originally deposited as exhalative chemical sediments derived from discharged auriferous hydrothermal fluids on the sea floor. Iron-formation and carbonate-rich sedimentary rocks are commonly the host rock for this type of deposit. Later metamorphism and tectonism may have remobilized the gold from these sediments to form concordant ore bodies (stratabound within certain favorable horizons) and (or) discordant bodies (as within shear zones, like those of the Lewiston mining district).

In contrast, in the epigenetic model, gold was introduced after the host sedimentary rock had formed. Mineralization was from auriferous hydrothermal fluids that emanated from devolatilizing greenstone rocks and concentrated gold in fractures, faults, and shear zones during metamorphism and tectonism (Boyle, 1987; Phillips and others, 1987). For the epigentic model neither a special source rock, like that required for the syngenetic models, nor an unreasonable quantity of greenstone rocks are necessary; the most critical parameters are suitable structurally controlled channels for the metamorphic-hydrothermal fluids and a chemically favorable host rock.

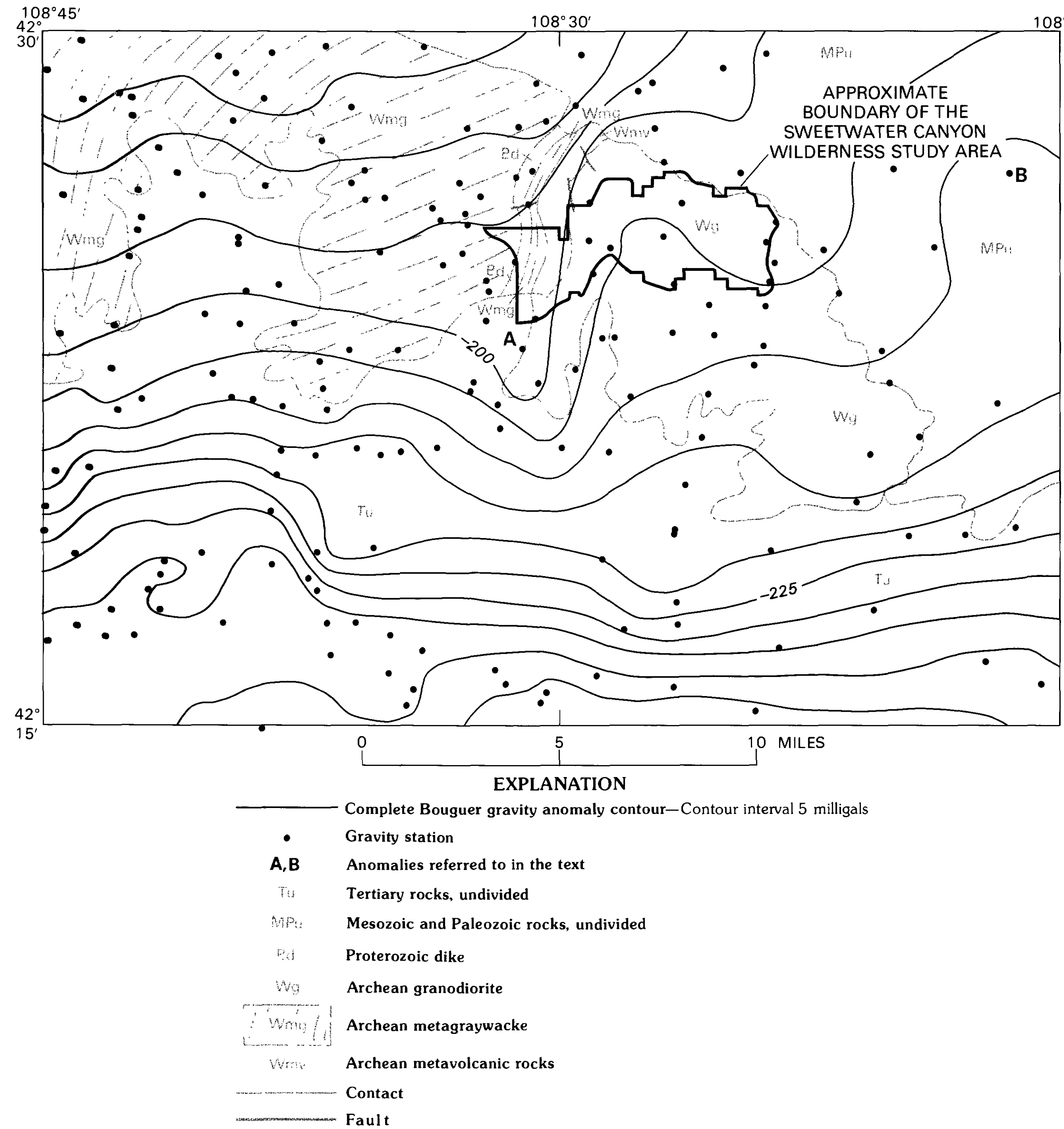
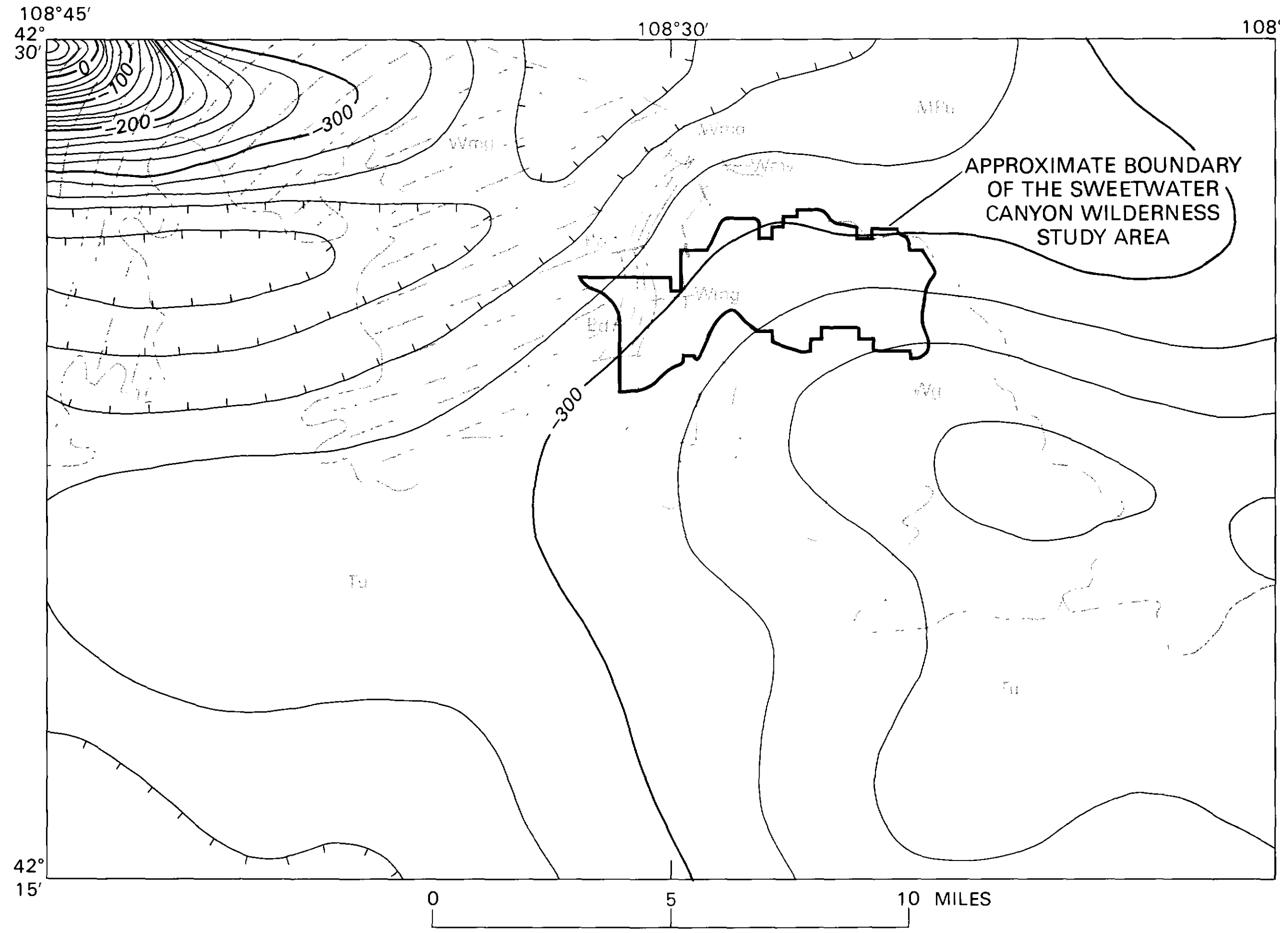


Figure 5. Complete Bouguer anomaly and generalized geologic map of the Sweetwater Canyon Wilderness Study Area, Wyoming, and adjacent areas.

Bow (1986) preferred an epigenetic model for the origin of the gold deposits of the South Pass-Atlantic City and the Lewiston districts. The deposits of the Lewiston district adjacent to the study area contain supporting evidence for an epigenetic origin. They are along discontinuous ductile shear zones that subparallel the original bedding of the host graywacke. No sedimentary horizon within the graywacke seemed to be preferred for mineralization as is required by the syngenetic models, nor are there any gold-rich chemical sedimentary rocks (for example, iron-formation, carbonate-rich sedimentary rocks) that indicate extensive exhalative hydrothermal activity at the time of sediment deposition in the Lewiston district.

In some of the epigenetic models (for example, Phillips and others, 1987) the source for the auriferous



EXPLANATION

Residual intensity magnetic anomaly contour—Contour interval 20 nanoteslas. Hachures show closed areas of lower magnetic intensity

Tu — Tertiary rocks, undivided

MPu — Mesozoic and Paleozoic rocks, undivided

Pd — Proterozoic dike

Wg — Archean granodiorite

Wmg — Archean metagraywacke

Wmv — Archean metavolcanic rocks

Contact

Fault

Figure 6. Residual intensity magnetic anomaly and generalized geologic map of the Sweetwater Canyon Wilderness Study Area, Wyoming, and adjacent areas.

hydrothermal fluids is the associated metamorphosed greenstone rocks (that is, mafic volcanic rocks). Mafic and ultramafic rocks structurally underlie the gold deposits of both the South Pass-Altantic City and Lewiston mining districts. These rocks were metamorphosed and subsequently intruded by granite (pl. 1). It is reasonable to suggest that the deposits of the Lewiston district formed as a result of metamorphic devolatilization of the greenstones and that hydrothermal fluids rose into and were channeled along fractures and shear zones within the overlying graywacke of the Miners Delight Formation. Although the relationship of the granitoid body to mineralization in the study area is unclear, it may have been a source either for thermal energy or auriferous hydrothermal fluids at the time of metamorphism.

In summary, lode-gold deposits occur in the Miners Delight Formation in the Lewiston mining district. This formation extends into the western part of the study area. The mineral resource potential for lode-gold resources is judged as high in the greenstone rocks along the western margin of the study area, although the size of such deposits is likely small. This judgment has a certainty level of C.

Placer-Gold Deposits

Gold also occurs in the wilderness study area in placer deposits in the alluvial gravels along the Sweetwater River. Placer mining has taken place at Wilson Bar, which is about ¾ mi upstream from the boundary of the study area (pl. 1). Gold was visible in five of eight panned-concentrate samples collected by Scott (1987) from in and near the study area. Two samples collected along Strawberry Creek, which drains into the northwestern part of the study area, contained no visible gold. However, analyses of all 10 samples showed anomalous gold concentrations (Scott, 1987). Analyses of some panned-concentrate samples collected from the Sweetwater River by R.H. Hill (tables 1 and 2) indicated the presence of gold within the alluvial gravels, albeit in low concentrations.

Two sources for the placer gold were proposed by Scott (1987). The rounded gold particles may have originated upstream and outside the study area, from the lode-gold deposits of the South Pass-Atlantic City mining district. The wire gold may have come from gold-bearing veins in the nearby Lewiston mining district and within the study area, or it may have grown in place by replacement of organic material.

Preliminary calculations by Scott (1987) for the grade and tonnage of the placer-gold deposits suggest that the grade is subeconomic under present conditions. However, undiscovered pay-streaks of gold may exist within the alluvial gravels. Accordingly, a high potential for low-grade and low-tonnage placer-gold resources is assigned to the alluvial gravels in the drainage of the present-day Sweetwater River and Strawberry Creek. The certainty level for this deposit type is rated at C for the Sweetwater River and B for Strawberry Creek.

Tin and Tungsten

Geologic and geochemical studies have shown that tin and tungsten may occur in either placer- or lode-type deposits within the wilderness study area. The placer-type tin and tungsten deposits may occur within the Quaternary gravels and in the channel of the Sweetwater River and Strawberry Creek. Lode-type tin and tungsten deposits may occur in the Precambrian bedrock in two areas: (1) in the western anomalous area associated with the lode-gold deposits of the Lewiston mining district, and (2) in the eastern anomalous area associated with granitoids.

Placer-type Deposits

Analyses of panned-concentrate samples from the Quaternary alluvial gravels along the banks and in the channel of the Sweetwater River and Strawberry Creek showed anomalous concentrations of tin and tungsten. Heavy-mineral fractions of the stream-sediment samples from the Sweetwater River (SW010, SW012, SW018, and SW027; tables 1 and 2) have anomalous concentrations of tin (as much as 700 ppm) and tungsten (as much as 150 ppm), as well as gold and barium. The heavy-mineral fraction of one sample (SW011, table 1) from Strawberry Creek has 2,000 ppm tungsten and 700 ppm tin. Cassiterite and scheelite were identified by X-ray diffraction in the heavy-mineral concentrations, and their presence may account for the elevated concentrations of tin and tungsten in the samples.

No placer-type tin and tungsten deposits have been reported within or near the study area from the Quaternary gravels of the Sweetwater River or Strawberry Creek. However, based on the geochemical data from the heavy-mineral fractions of the stream-sediment samples, a low mineral resource potential for placer-type tin and tungsten in the Quaternary gravels along and within the channel of the Sweetwater River and Strawberry Creek is assigned. This judgment has a certainty level of B.

Lode-type Deposits

Lewiston Mining District Anomalous Area

The western (Lewiston mining district) anomalous area is defined by anomalous concentrations of tin, tungsten, barium, and (or) gold in heavy-mineral concentrates and by arsenic in rock samples (table 1). This area is in and near the Lewiston mining district and lies within the Precambrian greenstone rocks where tin and tungsten occur in minor concentrations and are assumed to be associated with the lode-gold deposits. Samples collected from dumps of mines and prospect pits have anomalous concentrations of tungsten (as much as 340 ppm; mean, 44 ppm; Scott, 1987) and tin (as much as 42 ppm; mean, 8 ppm). Heavy-mineral fractions of the stream-sediment samples from this area also have anomalous concentrations of tin (as much as 2,000 ppm) and tungsten (as much as 700 ppm), as well as gold and barium (table 1). Cassiterite and scheelite were identified by X-ray diffraction in the heavy-mineral concentrates, and Scott (1987) identified visible gold in panned-concentrate samples from the gravels of the Sweetwater River. These data support the interpretation that the source of the tin and tungsten is the lode-gold vein system associated with the Lewiston mining district. And in the Lewiston mining district, Wilson (1951) mapped a scheelite-bearing shear zone on the first level of the Burr mine, a lode-gold deposit.

No economic quantities of tin or tungsten from the Lewiston mining district were recorded, although Wilson (1951) reported that the scheelite-bearing shear zone in the Burr mine averaged 4.2 weight percent tungsten; gold and silver were the only minerals exploited. And, although tungsten and tin were detected in anomalous concentrations in dump samples from the Lewiston mining district, Scott (1987) found that there were no economic accumulations in the lode-gold system. Therefore, a low mineral resource potential for vein-type tin and tungsten hosted in Precambrian rocks is assigned to the western part of the study area, with certainty level of B.

Eastern Anomalous Area

The eastern anomalous area is defined by anomalous concentrations of tin, tungsten, and bismuth, and traces of gold in heavy-mineral concentrates (table 2). Stream-sediment samples were taken from two types of streams. Samples were taken from the active alluvial gravels of the Sweetwater River, one type of stream, which drains the Lewiston mining district. The other type of stream drains only areas of Precambrian granitoid and Tertiary sedimentary rocks (pl. 1). The most obvious source for the anomalous concentrations in the alluvial gravels of the Sweetwater River (samples SW012, SW018, and SW027; table 2, pl. 1) is the lode-gold vein systems upstream in the Lewiston mining district. However, samples from the other type of stream were not obviously influenced by the rocks or mining activity (like that of the Lewiston mining district) because the streams from which the anomalous stream-sediment samples were taken only drain across bedrock of the Precambrian granitoid bodies and mafic dikes and Tertiary sedimentary rocks. The ultimate source for these elevated tin and tungsten concentrations in samples from the second type of tributary is enigmatic. Possible sources include: (1) unrecognized hydrothermal tin-tungsten deposits associated with the granitoids, (2) association with unidentified vein-hosted gold deposits in the granitoids, and (3) accessory minerals derived from Tertiary sedimentary rocks.

Hydrothermal tin-tungsten deposits associated with granitoids.—Undiscovered hydrothermal tin-tungsten deposits may possibly be associated with the granitoid batholith in the eastern part of the study area. Cox and Bagby (1986) and Reed (1986a) presented descriptive models for tin and tungsten vein deposits associated with granitoids. Vein deposits of tin and tungsten have several features in common. They both generally occur within late to postorogenic composite stocks of monzodiorite to granite composition that intrude sedimentary rocks. The veins are commonly less than 5 ft wide and occur in swarms over an area of ½ to 2 square miles. Distinctive altered ground is commonly zoned from a periphery of propylite, through sericite and pyrite, to a core of quartz and tourmaline, near the veins.

Minerals in the veins are generally quartz and cassiterite (for tin deposits) or wolframite and minor scheelite (for tungsten deposits). Geochemical pathfinder elements include tin, tungsten, molybdenum, bismuth, arsenic, copper, lead, zinc, beryllium, and fluorine.

Reed (1986b) described a model for tin greisen deposits, which occur as disseminated cassiterite and cassiterite-bearing veinlets, stockworks, lenses, and pipes in greisenized granite. The host granite is generally biotite and (or) muscovite leucogranite and characteristically has topaz, fluorite, tourmaline, and (or) beryl as accessory phases. Mineralization was postmagmatic. The granite is generally late orogenic to postorogenic and is highly evolved, containing SiO_2 greater than 73 percent, and K_2O greater than 4 percent. It is generally enriched in tin, rubidium, fluorine, lithium, beryllium, tungsten, molybdenum, niobium, and other lithophile elements and impoverished in calcium, barium, strontium, lanthanum, and the transition metals.

The granitoid bodies exposed in the eastern part of the study area lack mineralogical and geochemical characteristics common to granitoids related to tin and tungsten vein and tin greisen mineralization. Analyses of only three rock samples (SW013, WY86–9, and WY86–38) had detectable concentrations of tin and (or) tungsten (table 2). The most promising sample (WY86–9) from the most evolved rock had high SiO_2 (74.9 percent) and rubidium (197 ppm), is relatively impoverished in calcium (0.88 percent CaO), but has concentrations of strontium (304 ppm), barium (220 ppm), and lanthanum (9 ppm) typical of calc-alkalic granite. This sample has the relatively highest tin content (2 ppm, table 2), but this amount is typical of unmineralized granite (Tischendorf, 1977), and the tungsten (less than 0.5 ppm) and molybdenum (less than 7 ppm) contents are very low. None of the characteristic accessory minerals (topaz, fluorite, tourmaline, and (or) beryl) typically associated with tin-tungsten mineralized granitoid were observed. In addition, the widespread alteration halos associated with tin-tungsten mineralization were not observed.

Therefore, if the anomalous tin and tungsten concentrations observed in the heavy-mineral fraction of the stream-sediment samples were derived from mineral deposits within the granitoids in the study area, then the source was not observed or sampled.

Vein-hosted gold deposits in the granitoids.—A second possible source for the anomalous tin and tungsten concentrations in the stream sediments from the eastern part of the study area is unidentified mineralized veins, similar to those of the South Pass-Atlantic City and Lewiston mining districts, in shear zones within the granitoids. In a review of the nature and timing of mineralization within the South Pass-Atlantic City mining district, Bayley (1968) noted that gold occurred in veins in the Precambrian sedimentary rocks, gabbro, and small pretectonic tonalite plugs. The mineralized vein systems were thought by Bayley to have been emplaced before intrusion of the late orogenic to postorogenic Louis Lake batholith, which we think correlates with the granitoid pluton within the study area. Bayley (1968) noted that no shear-zone gold deposits of economic value have been recognized within the Louis Lake batholith. Therefore, if the timing of emplacement of the granitoid pluton in the study area correlates with that of the Louis Lake batholith, then no significant shear-zone gold with associated tin and tungsten deposits would be expected to be within the pluton in the study area.

Accessory minerals derived from Tertiary sedimentary rocks.—A third possible source for the anomalous tin and tungsten contents in the heavy-mineral concentrates from the eastern part of the study area is accessory minerals derived from the erosion of the Tertiary sediments. The Tertiary gravels and associated unconsolidated clastic sediments were derived from weathering and erosion of the underlying Precambrian and lower Phanerozoic rocks. Accessory cassiterite and scheelite may have been originally derived from the lode-gold veins in the Archean Miners Delight Formation. These minerals may have been remobilized and reconcentrated during weathering of the Tertiary sediments and deposited within the Quaternary alluvial gravels and sediments.

In summary, the ultimate source for the anomalous tin and tungsten concentrations found in stream-sediment samples in the eastern anomalous zone remains unclear. However, a low mineral resource potential for lode-type tin and tungsten deposits is assigned to the Precambrian granitoid rocks of the eastern anomalous area, with a certainty level of B.

Uranium

Uranium deposits occur in the vicinity of the wilderness study area. As reviewed by Patterson and others (1987), the uranium occurs in roll-front deposits in Paleocene and Eocene alluvial sediments, in tabular deposits in sandstone, in schroekingerite deposits (in which the uranium minerals appear as crusts or caliche at or near the surface), and in Tertiary coal beds. In addition to these deposits, other geologically feasible models for the study area include unconformity-related uranium deposits possibly in the basal Cambrian sedimentary rocks and granite-hosted deposits in the Precambrian granitoid rocks.

Surface scintillometer surveys were conducted over the rock types and structures most likely to contain uranium in the wilderness study area to determine the possibility for undiscovered uranium deposits. Careful investigation was made for possible roll-front uranium deposits in the Tertiary sedimentary rocks, for unconformity-related deposits in the Middle Cambrian Flathead Sandstone, and for granite-hosted deposits.

No anomalous scintillometer readings were obtained for any of the rock types. In fact, some of the lowest readings (200–300 counts per second) were from the Tertiary sedimentary rocks. A careful traverse was made at the erosional unconformity between the Precambrian granite and the Middle Cambrian Flathead Sandstone. No anomalous readings were observed; the average was 200 counts per second. The highest recorded measurements were of the Precambrian granite, but they were well within nominal background values for granite (250–300 counts per second). In addition, no anomalous concentrations of uranium were observed in the stream-sediment samples. Therefore, there was no evidence for uranium deposits at the ground surface within the study area. The mineral resource potential for uranium for the entire study area is rated low, with a certainty level of C.

Oil and Gas

Approximately 95 percent of the wilderness study area is underlain by Precambrian metamorphic and igneous crystalline rocks. One permissive source and (or) reservoir rock for oil and gas in the area are the Phanerozoic sedimentary rocks that occur only along the eastern margin of the study area (pl. 1). These rocks are exposed at the surface and dip uniformly northeast, away from the Precambrian crystalline rocks. Under these circumstances oil and gas traps would not be expected in the strata.

Another permissive source and (or) reservoir for oil and gas are Phanerozoic sedimentary rocks that may underlie the Precambrian rocks of the study area along the Wind River thrust-fault system. Lynn and others (1983) reduced the COCORP seismic reflection data by depth migration in order to delineate the structural features associated with the Wind River and associated thrust faults. The seismic reflection data indicate that Precambrian rocks, including those of the study area, have been thrust westward over oil- and gas-bearing Phanerozoic sedimentary rocks along the Wind River and the associated Continental thrust faults. A preliminary depth estimate to the rocks underlying the Wind River fault can be made by projecting the location of the study area to the COCORP transect. The transect is about 10 mi north of the study area. The projected location of the study area would be at a point between stations 200 and 275 on line 1A (Lynn and others, 1983, fig. 2). Using their interpretive figure of the seismic data (Lynn and others, 1983, fig. 8), this location corresponds to a depth of the Wind River fault (and the possible underlying Phanerozoic sedimentary rocks) of between 13 and 20 mi. This depth is thought here to exceed a reasonable depth of recovery of oil and gas.

Therefore, in view of the data outlined above, the area probably has no oil and gas resource potential, with a certainty level of D.

Geothermal Energy

There is no evidence of recent geothermal activity throughout the entire wilderness study area. Except for the easternmost part of the study area, which is underlain by Paleozoic sedimentary rocks, the area is underlain by Precambrian rocks of more than 2,000 Ma. Throughout the entire study area there are no Tertiary volcanic rocks, no signs of recent hydrothermal alteration of bedrock, and no active hot springs common to recent geothermal activity. Therefore, there is no resource potential for geothermal energy in the study area, with a certainty level of D.

SUGGESTIONS FOR FURTHER STUDY

The source for the tin and tungsten anomalies in the stream-sediment samples is not entirely clear. Further study might ascertain if indeed the Precambrian granitoid or Tertiary sedimentary rocks are a critical source. In addition, very detailed geochemical sampling of bedrock and stream sediments might delineate the amount of placer accumulation in the gravels of the Sweetwater River and help pinpoint their source.

REFERENCES CITED

Armstrong, F.C., 1948, Preliminary report on the geology of the Atlantic City-South Pass mining district: U.S. Geological Survey Open-File Report, 65 p.

Bayley, R.W., 1968, Ore deposits of the Atlantic City district, Fremont County, Wyoming, *in* Ore deposits of the United States 1933–1967 (Graton-Sales volume): New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, p. 589–604.

Bayley, R.W., Proctor, P.D., and Condie, K.C., 1973, Geology of the South Pass area, Fremont County, Wyoming: U.S. Geological Survey Professional Paper 793, 39 p.

Bow, C.S., 1986, Structural and lithologic controls on Archean, greywacke-hosted gold mineralization within the Sweetwater district, Wyoming, U.S.A., *in* Duncan, K.J., Boyle, R.W., and Haynes, S.J., Turbidite-hosted gold deposits: Geological Association of Canada Special Paper 32, p. 107–118.

Boyle, R.W., 1987, Gold—History and genesis of deposits: New York, Van Nostrand Reinhold Company Inc., 676 p.

Bugrov, V.A., and Shalaby, I.M., 1975, Geochemical prospecting in the eastern desert of Egypt, *in* Elliott, I.L., and Fletcher, W.K., eds., Geochemical exploration, 1974: New York, Elsevier, p. 523–530.

Condie, K.C., Leech, A.P., and Baadsgaard, H., 1969, Potassium-argon ages of Precambrian mafic dikes from Wyoming: Geological Society of America Bulletin, v. 80, no. 5, p. 899–906.

Cordell, Lindreth, Keller, G.R., and Hildenbrand, T.G., 1982, Complete Bouguer gravity anomaly map of the Rio Grande rift, Colorado, New Mexico, and Texas: U.S. Geological Survey Geophysical Investigations Map GP–949, scale 1:1,000,000.

Cox, D.P., and Bagby, W.C., 1986, Descriptive model of W veins, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 64.

Denson, N.M., and Pipiringos, G.N., 1974, Geologic map and sections showing areal distribution of Tertiary rocks near the southeastern terminus of the Wind River Range, Fremont and Sweetwater Counties, Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I–835, scale 1:48,000.

Geodata International, 1980, Aerial radiometric and magnetic survey, Lander National Topographic Map, Wyoming, Rocky Mountains, 1979: U.S. Department of Energy Report GJBX–62–80, 2 maps, scale 1:50,000.

Goudarzi, G.H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84–787, 42 p.

Graff, P.J., and Hausel, W.D., 1986, Gold from Wyoming greenstone belts—Production and prognostications, *in* Roberts, Sheila, ed., Metallic and nonmetallic deposits of Wyoming and adjacent areas [1983 Conference Proceedings]: Wyoming Geological Survey Public Information Circular 25, p. 13–21.

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.

Hale, William, 1883, Report of the Governor of Wyoming, *in* Report of the Secretary of the Interior to the House of Representatives: U.S. 48th Congress, 1st Session, Executive Document 1, part 5, v. II, p. 591.

Hausel, W.D., 1980, Gold districts of Wyoming: Wyoming Geological Survey Report of Investigations 23, 71 p.

——— 1983, Field report on the Lone Pine mine, Lewiston district, South Pass greenstone belt, Wyoming: Wyoming Geological Survey Mineral Report MR–83–2, 5 p.

——— 1985a, Geologic map of the Lewiston Lakes quadrangle, Fremont County, Wyoming: Wyoming Geological Survey unpub. map, scale 1:24,000, available from Geological Survey of Wyoming, P.O. Box 3008, University of Wyoming, Laramie, Wyo. 82071.

——— 1985b, Geology and gold mineralization of the South Pass granite-greenstone terrain, western Wyoming (with a discussion on supracrustal rocks of the Wyoming province of eastern Idaho, northern Utah, 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. 183–192.

——— 1986, Preliminary geologic map of the Lewiston gold district, Radium Springs quadrangle, Fremont County, Wyoming: Wyoming Geological Survey Open-File Report 86–25, scale 1:24,000.

——— 1987a, Geologic map of the Sweetwater rock area [Wyoming]: Wyoming Geological Survey Mineral Report 87–1, scale 1:24,000.

——— 1987b, Preliminary report on gold mineralization, petrology, and geochemistry of the South Pass granite-greenstone belt, Wind River Mountains, Wyoming, *in* Miller, W.R., ed., The Thrust Belt revisited: Wyoming Geological Association, 38th Field Conference, Guidebook, p. 287–304, map scale 1:100,000.

Houston, R.S., 1986, Wyoming Precambrian province—Example of the evolution of mineral deposits through time?, *in* Roberts, Sheila, ed., Metallic and nonmetallic deposits of Wyoming and adjacent areas [1983 Conference Proceedings]: Wyoming Geological Survey Public Information Circular 25, p. 1–12.

Hutchinson, R.W., and Burlington, J.L., 1984, Some broad characteristics of greenstone belt gold lodes, *in* Foster, R.P., ed., Gold '82—The geology, geochemistry, and genesis of gold deposits: Rotterdam, A.A. Balkema, p. 339–371.

International Association of Geodesy, 1971, Geodetic Reference System, 1967: International Association of Geodesy Special Publication 3, 116 p.

Lynn, H.B., Quam, Spencer, and Thompson, G.A., 1983, Depth migration and interpretation of the COCORP Wind River, Wyoming, seismic reflection data: Geology, v. 11, p. 462–469.

O'Leary, R.M., and Meier, A.L., 1984 [1986], Analytical methods used in geochemical exploration: U.S. Geological Survey Circular 948, 48 p.

Overstreet, W.C., and Marsh, S.P., 1981, Some concepts and techniques in geochemical exploration, *in* Skinner, B.J., ed., Economic Geology—Seventy-Fifth Anniversary Volume, 1905–1980: Economic Geology Publishing Company, p. 775–805.

Patterson, C.G., Kulik, D.M., Loen, J.S., Koesterer, M.E., and Scott, D.C., 1987, Mineral resources of the Honeycomb Buttes Wilderness Study Area, Fremont and Sweetwater Counties, Wyoming: U.S. Geological Survey Bulletin 1757–B, 19 p.

Pearson, R.C., Kilsgaard, T.H., Patten, L.L., and Mattick, R.E., 1971, Mineral resources of the Popo Agie Primitive Area, Fremont and Sublette Counties, Wyoming: U.S. Geological Survey Bulletin 1353–B, 55 p.

Phillips, G.N., Groves, D.I., and Brown, I.J., 1987, Source requirements for the Golden Mile, Kalgoorlie—Significance to the metamorphic replacement model for Archean gold deposits: Canadian Journal of Earth Sciences, v. 24, p. 1643–1651.

Plouff, Donald, 1977, Preliminary documentation for a FORTRAN program to compute gravity terrain corrections based on topography digitized on a geographic grid: U.S. Geological Survey Open-File Report 77–535, 45 p.

Reed, B.L., 1986a, Descriptive model of Sn veins, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 67–69.

——— 1986b, Descriptive model of Sn greisen deposits, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 70.

Scott, D.C., 1987, Mineral resources of the Sweetwater Canyon Wilderness Study Area (WY–030–101), Fremont County, Wyoming: U.S. Bureau of Mines Open File Report MLA 19–87, 24 p.

Spencer, C.W., 1983, Petroleum potential of wilderness lands in Wyoming, *with a section on* The Wyoming part of the Wyoming-Utah-Idaho overthrust belt province, *in* Miller, B.M., ed., Petroleum potential of wilderness lands in the western United States: U.S. Geological Survey Circular 902M, p. M1–M10.

Stuckless, J.S., Hedge, C.E., Worl, R.G., Simmons, K.R., Nkomo, I.T., and Wenner, D.B., 1985, Isotopic studies of the late Archean plutonic rocks of the Wind River Range, Wyoming: Geological Society of America Bulletin, v. 96, p. 850–860.

Tischendorf, G., 1977, Geochemical and petrographic characteristics of silicic magmatic rocks associated with rare element mineralization, *in* Stemprok, M., Burnol, L., and Tischendorf, G., eds., Metallization associated with acid magmatism, volume 2: Prague Geological Survey, p. 41–96.

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. Defense Mapping Agency, Aerospace Center, 1974, World Relative Gravity Reference Network, North America, Part 2: U.S. Defense Mapping Agency Aerospace Center Reference Publication 25, with supplement updating Gravity Standardization Net, 1971, 1,635 p.

Wilson, W.H., 1951, A scheelite deposit near Lewiston, Fremont County, Wyoming: Geological Survey of Wyoming Mineral Report MR–51–5, 3 p.

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.

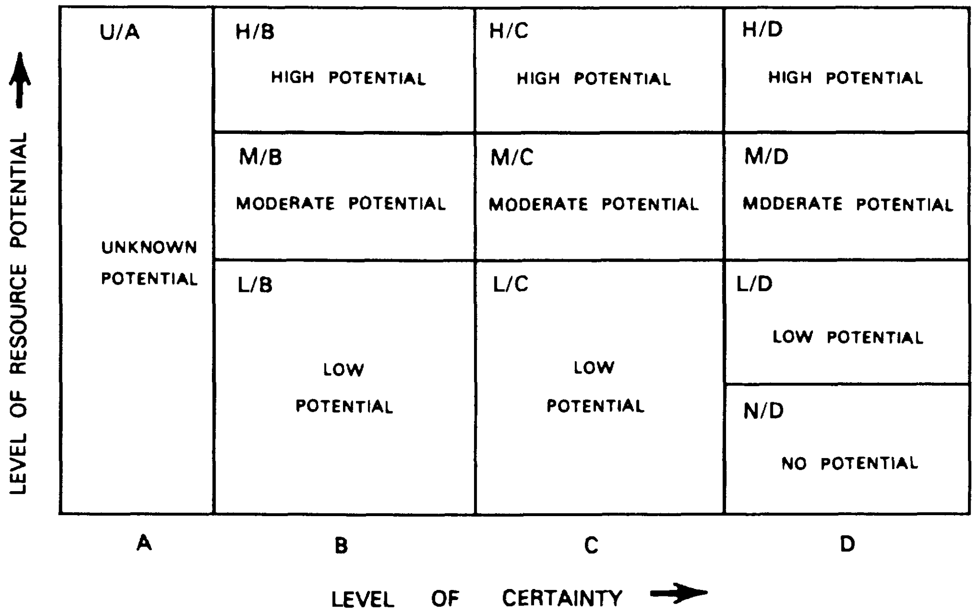
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application 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: 1988—573-047/86,002 REGION NO. 8