PB94-134566

EXECUTIVE SUMMARY

Mineral Resource Appraisal of the Gallatin National Forest, Montana

U. S. DEPARTMENT OF THE INTERIOR

BUREAU OF MINES SPECIAL REPORT

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MINERAL RESOURCE APPRAISAL OF THE GALLATIN NATIONAL FOREST, MONTANA

By
Fredrick L. Johnson and others

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Western Field Operations Center
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PREFACE

A January 1987 Interagency Agreement between the U.S. Bureau of Mines, U.S. Geological Survey, and U.S. Forest Service describes the purpose, authority, and operation for a program of forest-wide studies. The program is intended to assist the U.S. Forest Service in incorporating mineral resource data in forest plans as specified by the National Forest Management Act (1976) and Title 36, Chapter 2, Part 219, Code of Federal Regulations and to augment the U.S. Bureau of Mines mineral information as required by the National Materials and Minerals Policy, Research and Development Act (1980). This report is based upon available published information, field investigations, and mining company data.

This special report contains data gathered and interpreted by personnel of the U.S. Bureau of Mines, Western Field Operations Center, Branch of Resource Evaluation, East 360 Third Avenue, Spokane, WA 99202. This report has been approved by the Branch of Mineral Land Assessment, Washington, D.C.

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UNITS OF MEASURE ABBREVIATIONS USED IN THIS REPORT

lb	avoirdupois pound
cu yds	cubic yards
˚C	degree Celsius
ft	foot
in.	inch
LCY	loose cubic yard
%	percent
ton	short ton
oz	troy ounce
$	U.S. dollar
MM	million

CONVERSION FACTORS FOR UNITS OF MEASURE USED IN THIS REPORT

1 cu yd =	0.7646 cu m
1 ft =	0.3048 m
1 in =	2.54 cm
1 m =	3.2808 ft
1 mg =	0.000002205 lb
1 ppb =	0.000029 oz/ton
1 ppm =	0.029167 oz/ton
1 ppm =	0.0001 %
1 ton =	2,000.0 lb

CHEMICAL ABBREVIATIONS USED IN THIS REPORT

Ag	Silver
As	Arsenic
Au	Gold
Ba	Barium
Bi	Bismuth
Cd	Cadmium
Co	Cobalt
Cr_2O_3	Chromium oxide
Cu	Copper
Fe	Iron
Ga	Gallium
Hg	Mercury
Mo	Molybdenum
Ni	Nickel
Pb	Lead
Pd	Palladium
Pt	Platinum
Rh	Rhenium
Sb	Antimony
Se	Selenium
Te	Tellurium
Tl	Thallium
Zn	Zinc

EXECUTIVE SUMMARY
MINERAL RESOURCE APPRAISAL OF THE GALLATIN NATIONAL FOREST, MONTANA

INTRODUCTION

This report describes the U.S. Bureau of Mines (USBM) investigation of mineral resources in the Gallatin National Forest. A second report, USBM Open-File Report MLA 5-93, contains extensive details of the work. The study was undertaken at the request of the U.S. Forest Service (USFS) and includes an examination of individual mines, prospects, claims, and mineralized zones, as well as an engineering study of identified mineral resources. Also included is an economic and socioeconomic study that illustrates the potential benefits to the region that are and could be derived from developing selected mineral deposits in the Gallatin National Forest.

A January 1987 Interagency Agreement between the USBM, U.S. Geological Survey (USGS), and USFS describes the purpose, authority, and operation for a program of forest-wide studies. Results of this investigation are intended to (1) help the USFS define areas in which to expect future mining and exploration activity, (2) help the USFS incorporate mineral resource data into forest plans as specified by the National Forest Management Act (1976) and Title 36, Chapter 2, Part 219, Code of Federal Regulations, and (3) augment the USBM resource data base as required by the National Materials and Minerals Policy, Research and Development Act (1980). Although the immediate goal of this and other USBM mineral surveys is to provide data for the President, Congress, Government agencies, and the public for land use decisions, the long term objective is to ensure that the Nation has an adequate and dependable supply of minerals at a reasonable cost.

Geographic and Geologic Setting

The Gallatin National Forest includes 1,735,412 acres of the mountainous southwest portion of Montana (fig. 1). An additional 415,826 acres of other ownership occurs within the forest boundary. Most of the forest is contained within the Beartooth and Crazy Mountains and the Absaroka, Gallatin, Madison, and Bridger Ranges. The crest of the Madison Range forms much of the western part of the Gallatin National Forest boundary and also the eastern boundary of the Beaverhead National Forest. The Gallatin National Forest also is bounded by the Lewis and Clark National Forest on the north, the Targhee and Shoshone National Forests on the south, and the Custer National Forest on the east. Yellowstone National Park forms much of the southern boundary.

Two large wilderness areas, the Lee Metcalf and Absaroka-Beartooth, are mostly in the forest. Together they cover 715,674 acres, or more than 41% of the Gallatin National Forest (fig. 2).

The forest has mineral deposits in rock units ranging from Precambrian (older than 570 million years) to Holocene (less than 10,000 years) age (fig. 3). The Absaroka Range and Beartooth Mountains consist of eroded, uplifted Precambrian crystalline blocks flanked by Paleozoic and Mesozoic sedimentary and metasedimentary rocks. Along the northeast edge of the Beartooth Mountains, Precambrian metamorphic rocks host the banded mafic Stillwater Complex, which contains copper, nickel, chromite, gold, platinum, palladium, and rhodium in layered, stratiform zones. Precambrian metasedimentary rocks contain an iron-formation-hosted gold deposit at Jardine, located northwest of Gardiner. Tertiary plutons occur along northwest-trending zones of crustal weakness and are partially covered by Eocene age andesite flows of the Absaroka Volcanic Supergroup (Chadwick, 1970). Metallic mineral deposits occur in stockworks, veins, skarns, and replacement bodies associated with the plutons. Several major faults transect the Absaroka-Beartooth Mountains and have possibly contributed in localizing volcanic intrusive centers and the distribution of mineralized areas. Along the Cooke City zone, a broad northwest-trending structural low, mineral deposits are, in general, associated with Tertiary intrusives and, in places, occur as replacements in Paleozoic rocks. At the Independence district, located at the head of the Boulder River, Late Cretaceous intrusive rocks host deposits of lead, silver, zinc, and gold in polymetallic veins. Tertiary intrusive rocks in the Emigrant district host stockwork deposits containing gold, silver, and copper.

The Gallatin Range consists of Tertiary volcanic flows and breccias which overlie both Precambrian and Paleozoic rocks (McMannis and Chadwick, 1964). Paleozoic sedimentary rocks predominate in the Madison Range although Precambrian metasedimentary rocks occupy the northern end, and Tertiary intrusives are present locally. The Permian age

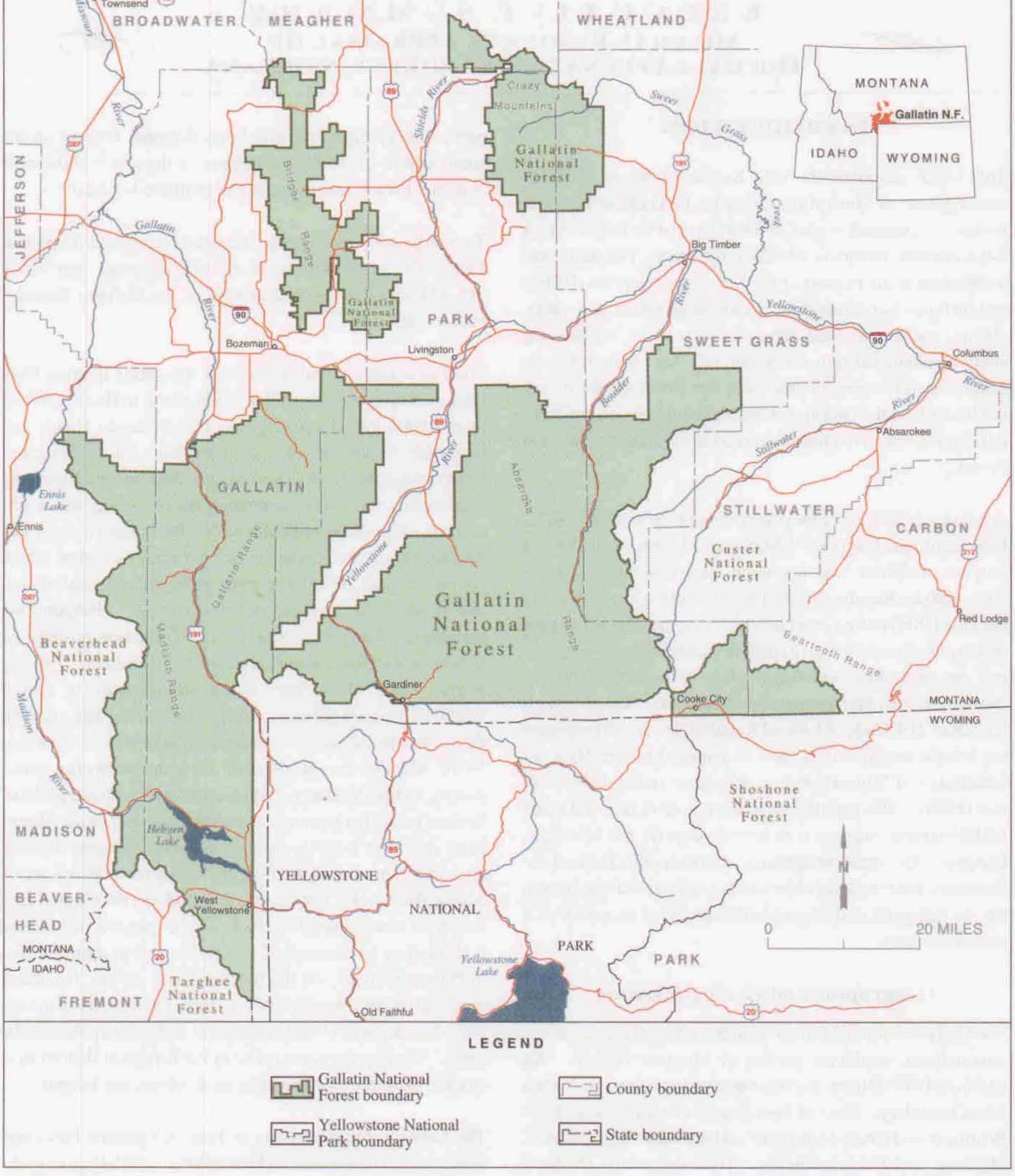

Figure 1. — Location of the Gallatin National Forest, MT.

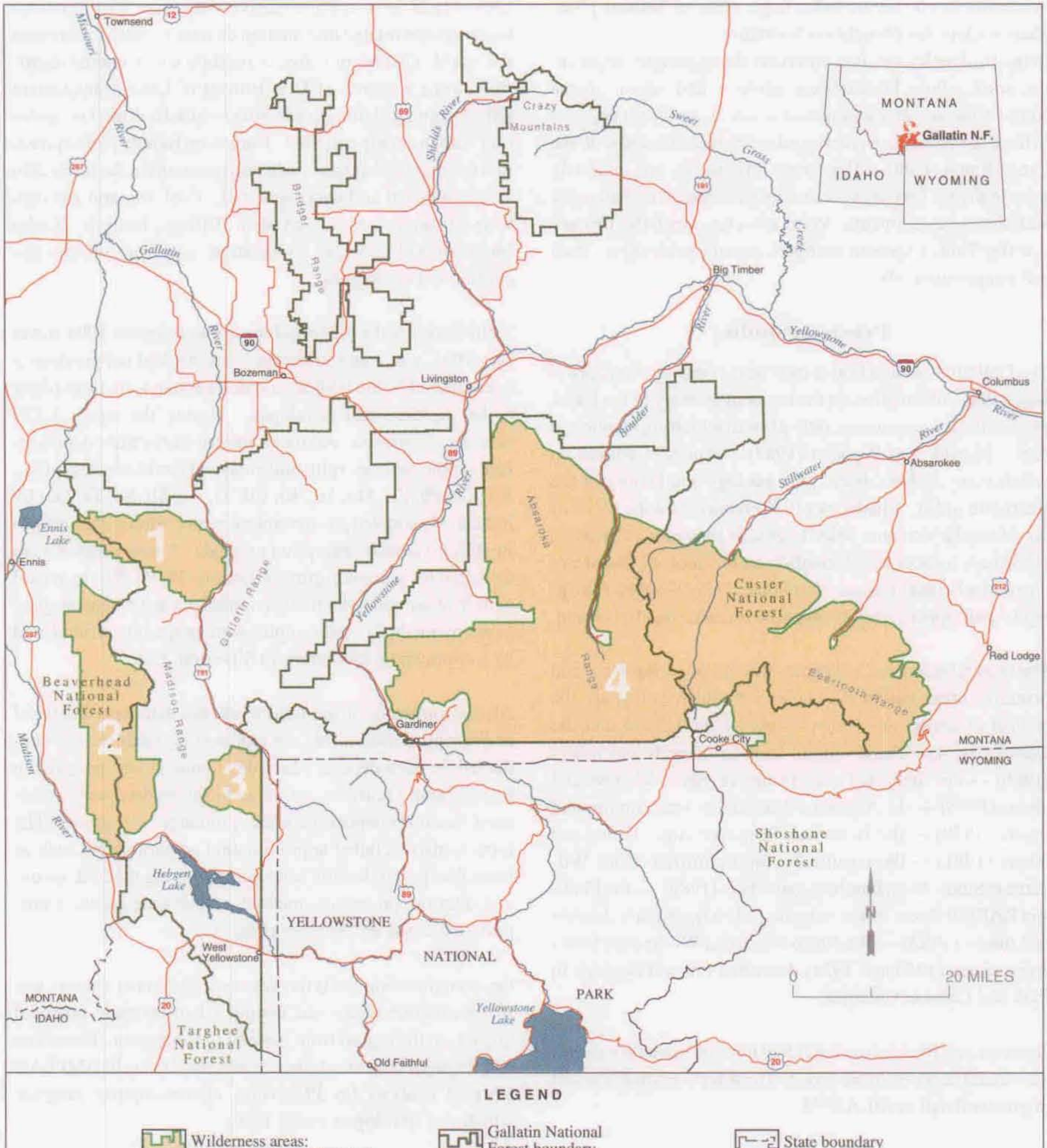

Figure 2. — Designated wilderness areas in the Gallatin National Forest, MT.

Shedhorn Sandstone includes large areas of bedded phosphate rock in the Phosphoria Formation.

In the Bridger Range, Precambrian arkosic conglomerates in the north adjoin Precambrian gneisses and schists to the south. Base and precious metals occur in stratiform deposits in the late Precambrian rocks and in veins associated with the Cross Range Fault. The Crazy Mountains are underlain principally by Tertiary volcanic rocks bordered by Paleozoic and Mesozoic sediments. Veins associated with the Tertiary age Big Timber igneous complex contain gold, silver, lead, and copper minerals.

Previous Studies

The Gallatin National Forest includes several geologic provinces, thus, information on the regional geology of the forest comes from many sources, only a few of which are mentioned here. Mueller and Wooden (1982) compiled a volume in which many authors discuss the geology and history of the Beartooth uplift. Chadwick (1970) reported on the rocks of the Absaroka Volcanic field. Lageson (1989) and McMannis (1955) are sources of information on the geology and structure of the Bridger Range. Harrison (1972) described stratigraphy and copper occurrences of the Precambrian Belt Basin.

The mineral resources and geology of various wilderness and primitive areas within the Gallatin National Forest are the subject of several previous reports by the USBM and the USGS (fig. 4). These reports include: Becraft and others (1966) — the Spanish Peaks Primitive Area; Wedow and others (1975) — the Absaroka Wilderness Area; Simons and others (1979) — the Beartooth Primitive Area; Close and others (1981) — the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area; Lambeth and others (1982) — the Madison RARE II Area; Elliot and others (1983), and Stotelmeyer and others (1983) — the North Absaroka Wilderness Study Area. Reed (1950 and 1951) described mineral deposits in Park and Gallatin Counties.

Other reports focused on individual mining districts or metallic mineral deposits in the forest. These reports are discussed in greater detail in MLA 5-93.

Present Studies

Preliminary work included a review of applicable published literature, mining claim and lease records, mining and exploration data in the Anaconda Geological Document Collection housed at the University of Wyoming, and the USBM Mineral Industry Location System (MILS) data base and property files. MILS is a comprehensive data base that provides locations and related information on mineral sites throughout the world. Owners of active or recently active claims identified during a search of U.S. Bureau of Land Management (BLM) mining claim records were notified and their cooperation with the study solicited. Numerous mining and exploration companies that had conducted programs in the forest also were contacted and data requested. Coal, oil, and gas data were obtained from the BLM in Billings, from the Rocky Mountain Oil and Gas Association, and from oil and gas exploration companies.

Field work, conducted from June through August 1991 and in July 1992, was concentrated in areas that had not previously been studied by the USBM, and in areas that were most likely to be explored and developed. During the study, 1,326 samples were taken. All rock samples were crushed, pulverized, homogenized, split, and analyzed for 15 elements (Au, Ag, Cu, Pb, Zn, Mo, Hg, Bi, Cd, Tl, As, Sb, Se, Te, Ga) by inductively coupled plasma emission spectroscopy and graphite furnace atomic absorption methods. A few samples were analyzed for platinum-group elements (Pt, Pd, Rh) by nickel sulfide assay and inductively coupled plasma emission spectroscopy methods. All samples were prepared and analyzed by a commercial laboratory in Silverton, CO.

After completion of the field work, the data were analyzed and resources estimated. An engineering analysis was conducted for each deposit where development was believed to be potentially feasible. Mine and mill models were developed based on deposit geometry, tonnage, and grade. The models also included approximation of parameters such as mine life, preproduction scheduling, mining method, recovery, dilution, processing method, concentrate grades, transportation costs, and smelter charges.

Once engineering analysis was complete, an economic and socioeconomic study was conducted to estimate potential impacts to the region from mineral development. Economic and employment impacts were determined using the IMPLAN (IMpact analysis for PLANing) microcomputer program which was developed by the USFS.

ACKNOWLEDGMENTS

This study was made possible by the professional contributions of USBM Western Field Operations Center (WFOC) geologists Dave Boleneus, Eric Cather, Don Graham, Curt Hughes, and Dick Winters. Dave Benjamin, WFOC mining engineer, Michael Horn, WFOC geologist, Nicholas Wetzel,

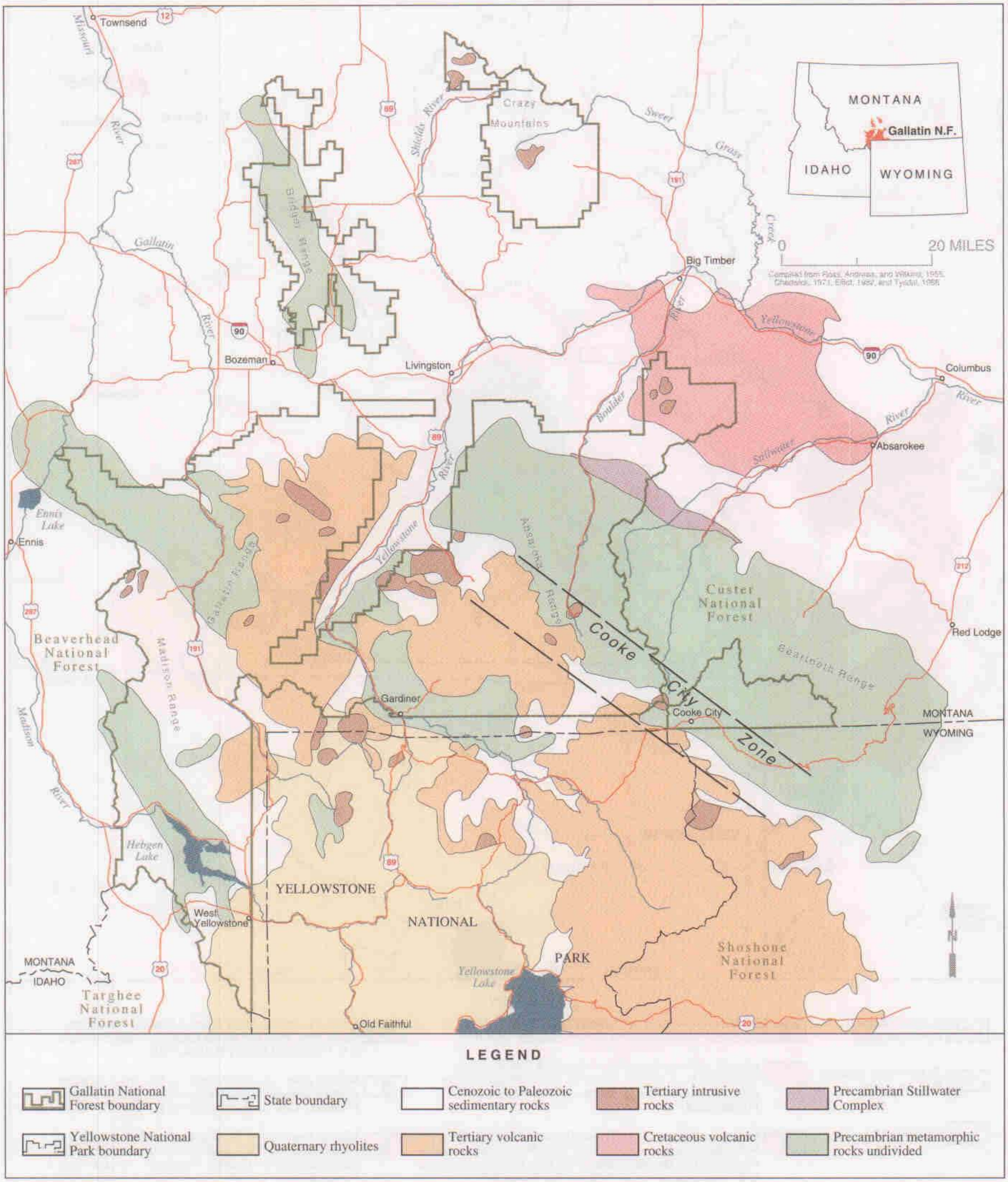

Figure 3. — Generalized geologic map of the Gallatin National Forest, MT.

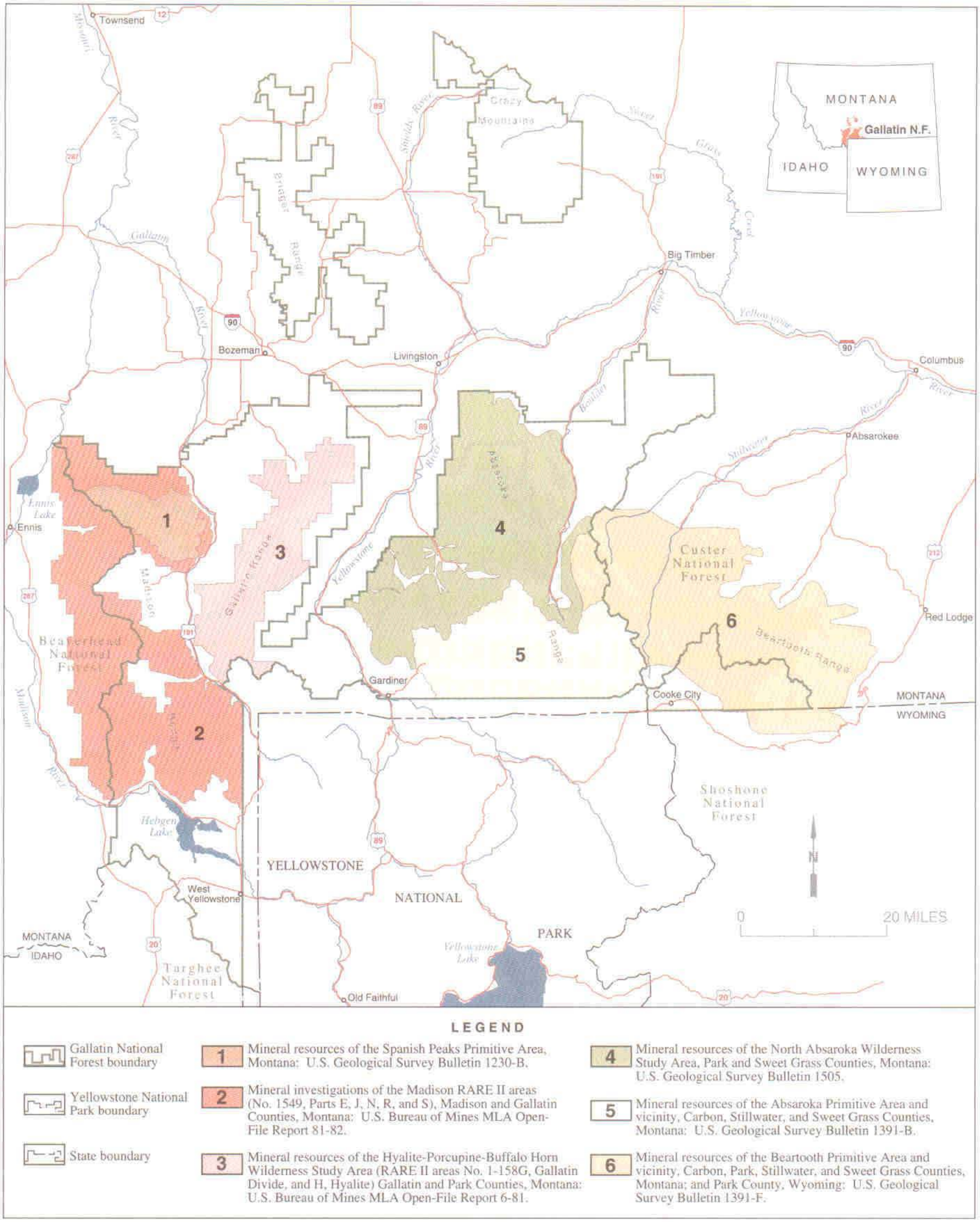

Figure 4. — Areas previously studied by the USBM and USGS in the Gallatin National Forest, MT.

WFOC geologist, and Richard Marshall, USFS mineral economist, Northern Region, conducted the engineering, economic, and socioeconomic analyses.

Gratitude also is extended to the many and diverse groups that have cooperated with this study by contributing their time and resources. Company and individual contributions are credited fully in MLA 5-93.

MINING HISTORY AND EXPLORATION ACTIVITY

Although gold, silver, copper, lead, zinc, arsenic, tungsten, coal, and small amounts of chromite and asbestos have been mined in the Gallatin National Forest, exploration and mining activity have generally concentrated on precious metals. The first significant production was from gold-bearing placers in Emigrant Creek during the mid-1860's. Major production from lode deposits began in the New World district during the 1870's, and in the Jardine-Crevice district about the turn of the century. Most of the base metal (copper, lead, and zinc) production to date has come from the Irma/Republic, Homestake, and McLaren mines in the New World district. By product arsenic trioxide and tungsten were recovered at the Jardine Gold mine in the Jardine-Crevice district.

Most recent exploration programs conducted by major mining companies have been for copper, molybdenum, platinum, palladium, rhodium, cobalt, nickel, and chromium in addition to gold and silver. During the last 30 years, exploration programs for copper-molybdenum deposits were conducted in both the Emigrant and New World mining districts. Numerous exploration programs for platinum-group elements (and to a lesser extent for copper, nickel, and chromium), have been conducted in the Stillwater Complex, including the segment that extends into the Gallatin National Forest. A plan of operation has been submitted for the East Boulder Project where platinum, palladium, rhodium, gold, copper, and nickel would be recovered. A plan of operation also has been submitted for the New World Project in the New World mining district; gold, silver, and copper would be recovered there. Exploration programs are being conducted for both gold placer deposits and gold-copper lode deposits in the Emigrant mining district (fig. 5).

The only large operating mine in the forest, the Mineral Hill mine, is located in the Jardine-Crevice district. The mine began producing gold in 1989 and has a projected mine life of another 6 years. The value of recorded historical mineral production from the Gallatin National Forest, using metal prices averaged over the last 5 years (1987-91), totals more than $186,000,000.

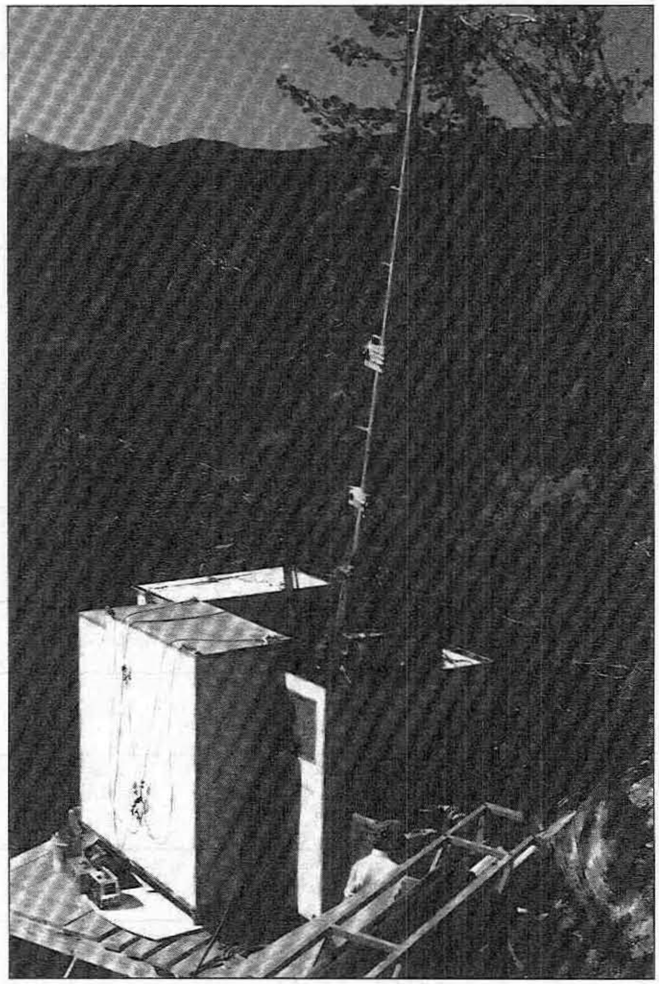

Figure 5. — Core drilling at the DUV deposit in the Emigrant mining district.

During the preliminary part of this study, BLM mining claim records were reviewed to determine where claim staking activity had occurred. Figure 6 shows those areas containing active (as of the end of 1990) and recently active mining claims.

IDENTIFIED MINERAL ENDOWMENT

Nearly 700 mines, prospects, and mineral occurrences in and near the Gallatin National Forest were located during this study. Significant identified resources (table 1) occur at 22 sites (fig. 7) and are divided into 3 categories. The first includes published resources, usually delineated by mining companies that have drilled the deposit. The second category includes resources that were calculated by the USBM. Calculations were based on samples and measurements taken by

Table 1. - Significant identified resources in the Gallatin National Forest, MT

Deposit name (Mining district)	Type	Tons (Classification)	Grade	Source (References)
Mineral Hill mine (Jardine-Crevice)	Stratabound Vein	800,000 (Demonstrated)	0.268 oz Au/ton	Published resources (Homestake Mining Company, 1992)
New World Project (New World)	Skarn Breccia pipe Replacement	12 million (Demonstrated)	0.222 oz Au/ton .87 oz Ag/ton .75% Cu	Published resources (Crown Butte Resources, Ltd., 1992a)
East Boulder Project (Stillwater)	Magmatic segregation	32.7 million (Demonstrated)	0.14 oz Pt/ton .48 oz Pd/ton .003 oz Rh/ton .016 oz Au/ton .07% Cu .12% Ni	Company data (Stillwater PGM Resources,1992; Thompson,1987)
Iron Mountain-Camp (Stillwater)	Magmatic segregation	13.9 million (Demonstrated)	0.42% Ni .23% Cu .04% Co	Company data (Kuxhausen,1973)
Gish mine (Stillwater)	Magmatic segregation	940,000 (Demonstrated)	15% Cr_2O_3	Published resources (Wetzel,1986)
Picket Pin zone (Stillwater)	Magmatic segregation	12 million (Identified)	0.01 oz Pt/ton .01 oz Pd/ton .13% Cu .07% Ni	Published resources (Turner,1980; Boudreau and McCallum,1986)
Big Group (Iron Mountain) (Stillwater)	Stratabound	200 million (Identified)	15% to 40% Fe	Published resources (Walker,1960; Hubbard and Roby, 1961)
Stillwater Anorthosite (Stillwater)	Magmatic segregation	8.3 billion (Identified)	29.7% Al_2O_3 48.8% SiO_2	Published resources (Miller,1967)
Basic Metals (Emigrant)	Breccia pipe	1.7 million (Identified)	0.41% Cu .39% Zn .18% Pb .81 oz Ag/ton	Published resources (Green, 1976)
J-M Reef (Stillwater)	Magmatic segregation	166.4 million (Identified)	0.13 oz Pt/ton .44 oz Pd/ton	Calculated from company data (represents J-M Reef to sea level minus East Boulder Project resource)
DUV (Emigrant)	Stockwork	38 million (Identified)	0.044 oz Au/ton .24 oz Ag/ton .44% Cu	Calculated from USBM sample analyses and geological measurements
St. Julian (Emigrant)	Breccia pipe	42 million (Identified)	0.009 oz Au/ton .04 oz Ag/ton	Calculated from USBM sample analyses and geological measurements
Half Moon (Big Timber Creek)	Vein	116,000 (Identified)	0.0285 oz Au/ton 6.25 oz Ag/ton 3.76% Pb .09% Cu	Calculated from USBM sample analyses and geological measurements
Pass Creek-Sheridan (Pass Creek)	Vein	40,000 (Identified)	3.2% Zn 3.2% Pb 0.2 oz Ag/ton	Calculated from USBM and company sample analyses and geological measurements
Emigrant Peak (Emigrant)	Breccia pipe	100 million (Identified)	0.006 oz Au/ton .04 oz Ag/ton .3% Cu	Calculated from USBM sample analyses and interpretation of deposit models
Barbara Ann-St. Croix (Emigrant)	Vein	673,500 (Identified)	0.06 oz Au/ton 3.43 oz Ag/ton .59% Cu	Calculated from USBM sample analyses (Stolelmeyer and others, 1983)
Lori Kay (Boulder)	Skarn	11 million (Identified)	0.87% Cu .05% Mo 45.9% Fe .001 oz Au/ton .29 oz Ag/ton	Calculated from USBM sample analyses (Stotelmeyer and others, 1983)
Red Fox (Boulder)	Vein	21,000 (Identified)	0.1 oz Au/ton	Calculated from USBM sample analyses (Stotelmeyer and others, 1983)
Magnetic group (Emigrant)	Stratabound	175,000 (Identified)	27.5% Fe	Calculated from USBM sample analyses (Stotelmeyer and others, 1983)
Emigrant Creek (Emigrant)	Placer	Large (Identified)	Not determined	Based on geological interpretation and past production
Irma-Republic (New World)	Replacement	200,000 (Identified)	15 oz Ag/ton 3% to 4% Pb 5% Zn	Based on sample analyses and geologic inference
Nicon group (Stillwater)	Magmatic segregation	300 million (Identified)	0.12% Ni .12% Cu	Based on sample analyses and interpretation of deposit models (Stotelmeyer and others, 1983)

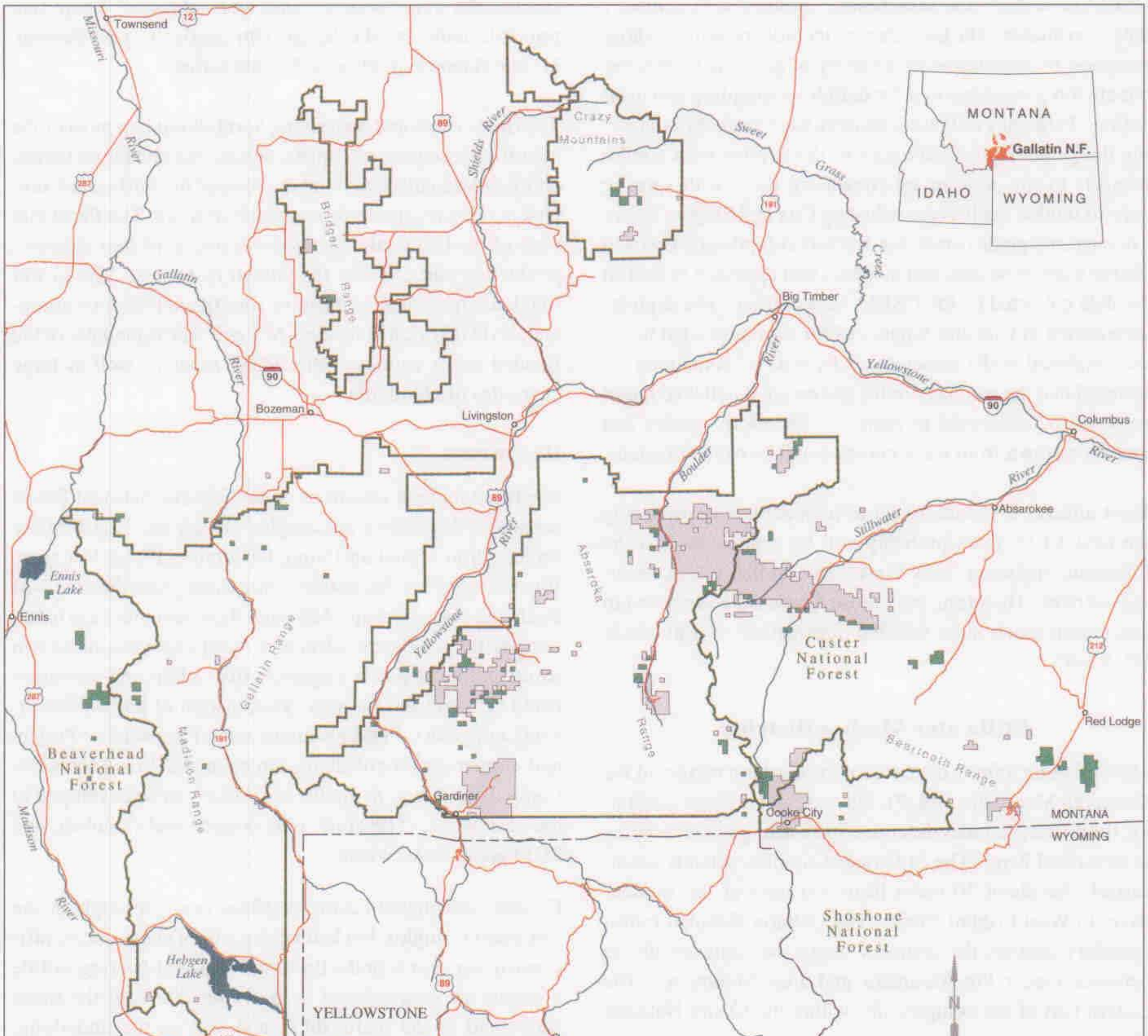

Figure 6. — Areas containing active and recently active mining claims in and near the Gallatin National Forest, MT.

USBM personnel, and sometimes combined with company data, if available. The last category includes resources whose presence are manifested by a variety of geologic signatures, but are too poorly exposed for definitive sampling and measuring. Estimates of these resources were made by comparing the geologic characteristics of the deposit with similar deposits in the area, or by comparing them with specific deposit models such as described by Cox and Singer (1986). Tonnage and grade curves for deposits compiled by Cox and Singer were reviewed, and numbers that appeared to best fit the data collected by the USBM were chosen. The deposits inventoried in Cox and Singer (1986) were restricted to "... well explored, well characterized deposits ..." containing "... material that the company or the government believed might someday be economic to mine..." Therefore, grades and tonnages drawn from these curves could be overestimated.

Most mineral exploration and development activity during the next 10-15 years probably will be concentrated in the Emigrant, Stillwater, New World, and Jardine-Crevice mining districts. Therefore, only those districts are discussed in this report; much more detailed information is available in MLA 5-93.

Stillwater Mining District

The Stillwater mining district is at the northern margin of the Beartooth Mountains (fig. 7). Because of geologic continuity, the district includes the entire Stillwater igneous complex as described here. The Stillwater Complex extends southeasterly for about 30 miles from just west of the Boulder River to West Fishtail Creek. The Gallatin National Forest boundary crosses the complex along the drainage divide between Picket Pin Mountain and Iron Mountain. The eastern part of the complex lies within the Custer National Forest.

Geology

The Stillwater Complex is a layered mafic to ultramafic intrusion that was emplaced 2.7 billion years ago. Stillwater magmas intruded horizontally into folded sedimentary rocks that were altered mainly to hornfels. Fractionation and crystal segregation within the cooling magma chamber resulted in persistent cyclic mineralogic and textural layering. The exposed thickness of the tabular complex is about 18,000 ft.

Over the years of study by various investigators, the Stillwater Complex has been partitioned in several ways; Zientek and others (1985) designed a systematic scheme to correlate stratigraphy into "series, zone, and subzone." Their five principle units are the Basal, Ultramafic, Lower Banded, Middle Banded, and Upper Banded series.

The Basal series and underlying hornfels contain most of the identified resources of copper, nickel, and cobalt; metamorphosed sedimentary rocks at the base of the Stillwater Complex contain resources of magnetite iron ore. The Peridotite zone of the Ultramafic series is the source of past chromite production and contains the known resources. The Lower Banded series contains the most significant platinum-group-metals (PGM)-rich body the J-M Reef. The remainder of the Banded series contains other PGM zones as well as large quantities of aluminum.

Resources

Identified mineral resources in the Gallatin National Forest portion of the Stillwater Complex include the East Boulder Project, Iron Mountain-Camp, Gish mine, Picket Pin zone, Big Group (Iron Mountain), Stillwater Anorthosite, J-M Reef, and Nicon Group. Although these resources are based on specific geologic evidence, in most cases the stratiform nature of the deposits suggests that additional resources could be estimated through extrapolation of known dimensions and grades. PGM resources at the East Boulder Project and copper-nickel-cobalt resources at the Iron Mountain-Camp deposit (fig. 8) are the most likely to be developed in the near future. Therefore, only copper, nickel, cobalt, and PGM are addressed here.

Copper- and nickel-bearing sulfides occur throughout the Stillwater Complex, but known deposits of economic significance occur in or near the Basal series. Metal-bearing sulfide minerals are concentrated in the lower 200 ft of the Basal series and in the mafic dikes and sills in the underlying hornfels. Copper and nickel grades decline with increasing distance both above and below the contact of Basal norite with hornfels. The sulfides consist primarily of pyrrhotite, with exsolved nickel-bearing pentlandite, and chalcopyrite, which contains nearly all of the copper. Cobalt occurs in pyrrhotite, pentlandite, chalcopyrite, and gersdorffite (nickel-bearing sulfarsenide) in a cobalt-nickel ratio of about 1:10.

The mineralized zone at the Iron Mountain-Camp deposit occurs in olivine cumulates of the Ultramafic series, about 1,000 ft above the Basal norite. The mineralized zone may be at the margin of a thrust sheet that placed basement hornfels over the olivine cumulates. Resources are 13.9 million tons grading 0.23% copper, 0.42% nickel, and 0.04 % cobalt.

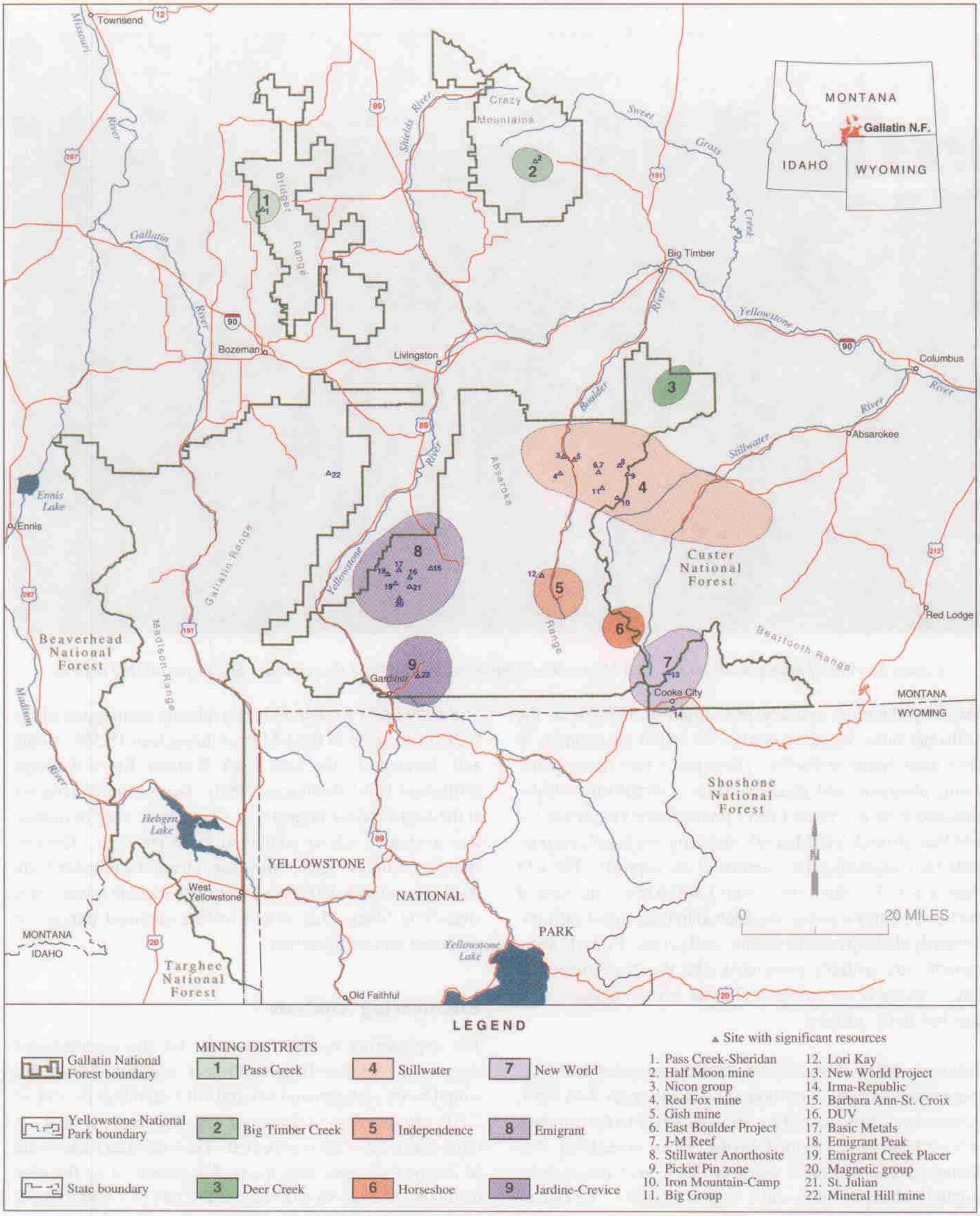

Figure 7. — Mining districts and sites containing significant mineral resources in the Gallatin National Forest, MT.

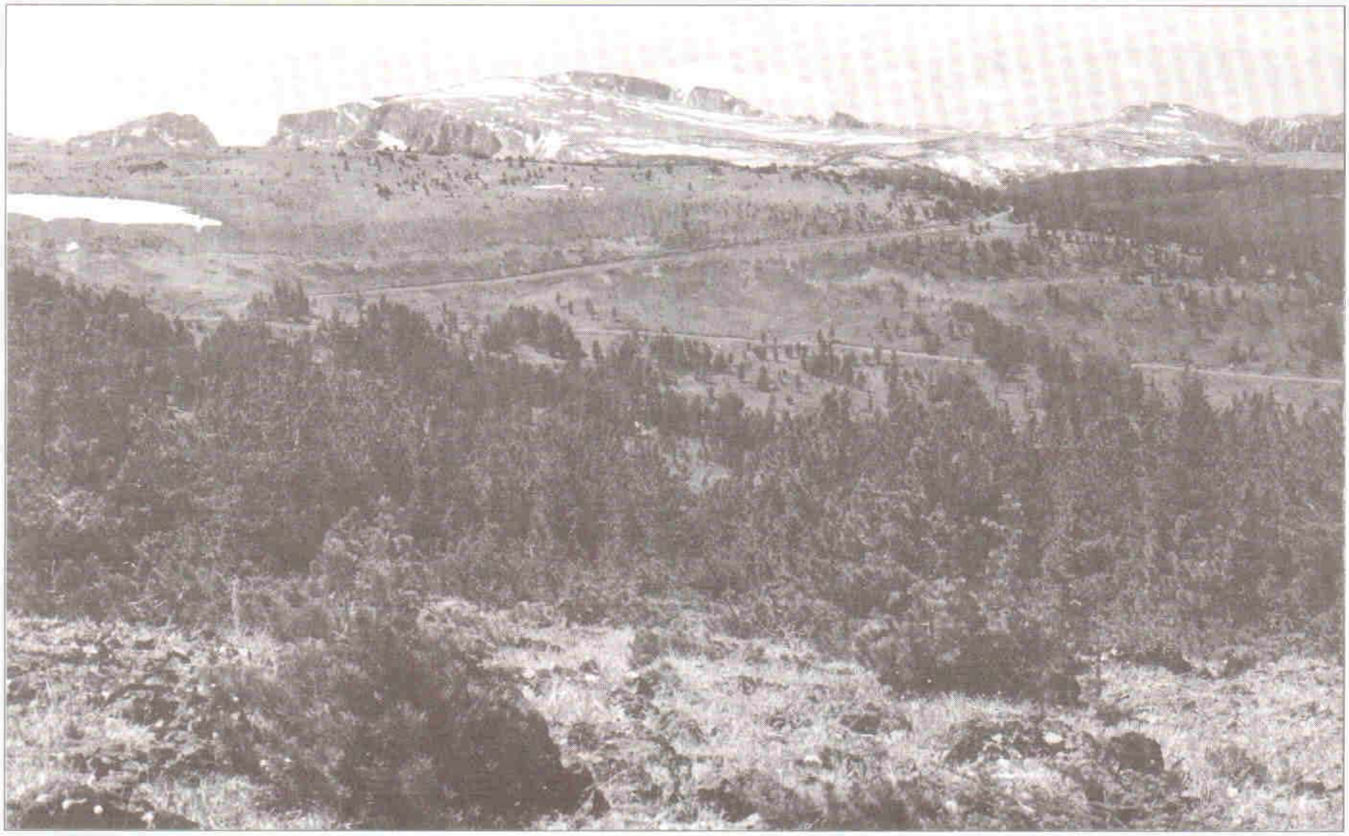

Figure 8. - View looking south at the Iron Mountain-Camp deposit area (middle ground), Stillwater mining district

The only domestic primary production of PGM is at the Stillwater mine, located near the east end of the complex in the Custer National Forest. The mine is recovering palladium, platinum, and rhodium from a stratiform sulfide-enriched zone within the Lower Banded series known as the J-M Reef (from Johns-Manville, the company largely responsible for recognizing the potential of the deposit). The J-M Reef, a 4- to 7-ft-thick zone about 1,400 ft above the base of the Lower Banded series, is enriched in base-metal sulfides, primarily chalcopyrite, pyrrhotite, and pyrite. PGM-bearing minerals are spatially associated with the base-metal sulfides, normally occurring as discrete grains enclosed in or attached to the sulfides.

Stillwater PGM Resources (SPGMR) estimated PGM resources totaling 464.6 million tons for the entire J-M Reef; these extend from west of the Boulder River to the drainage of West Fishtail Creek, and from the surface to sea level. The Gallatin National Forest segment of the reef has a strike length of about 11 miles and averages 5 ft thick. Resources in the segment total 199.1 million tons averaging 0.13 oz platinum and 0.44 oz palladium per ton (Stillwater PGM Resources, written commun., 1992).

Stillwater PGM Resources is considering mining part of the Gallatin segment of the J-M Reef through an 18,550-ft-long adit located in the East Fork Boulder River drainage (Stillwater PGM Resources, 1990). Demonstrated reserves at the East Boulder Project (fig. 9) are more than 18 million tons averaging 0.8 oz combined PGM per ton. Demonstrated resources (32.7 million tons) from the proposed adit level (elevation 6,350 ft) to the surface include lower grade zones and blocks that would be left unmined during the proposed mining operation.

Engineering Analysis

The engineering model developed for the demonstrated reserves at the East Boulder Project assumes that mining would be by underground cut-and-fill methods at the rate of 2,808 tons per day, 2 shifts per day, 260 days per year. A mine life of 28 years is expected. The mine-run rock would be crushed, ground, and the metals recovered by flotation methods. Milling would occur at the rate of 2,000 tons per day, 3 shifts per day, 365 days per year. Concentrate from the mill, located at the mine, would be transported by truck to the smelter at Columbus, MT, for final processing.

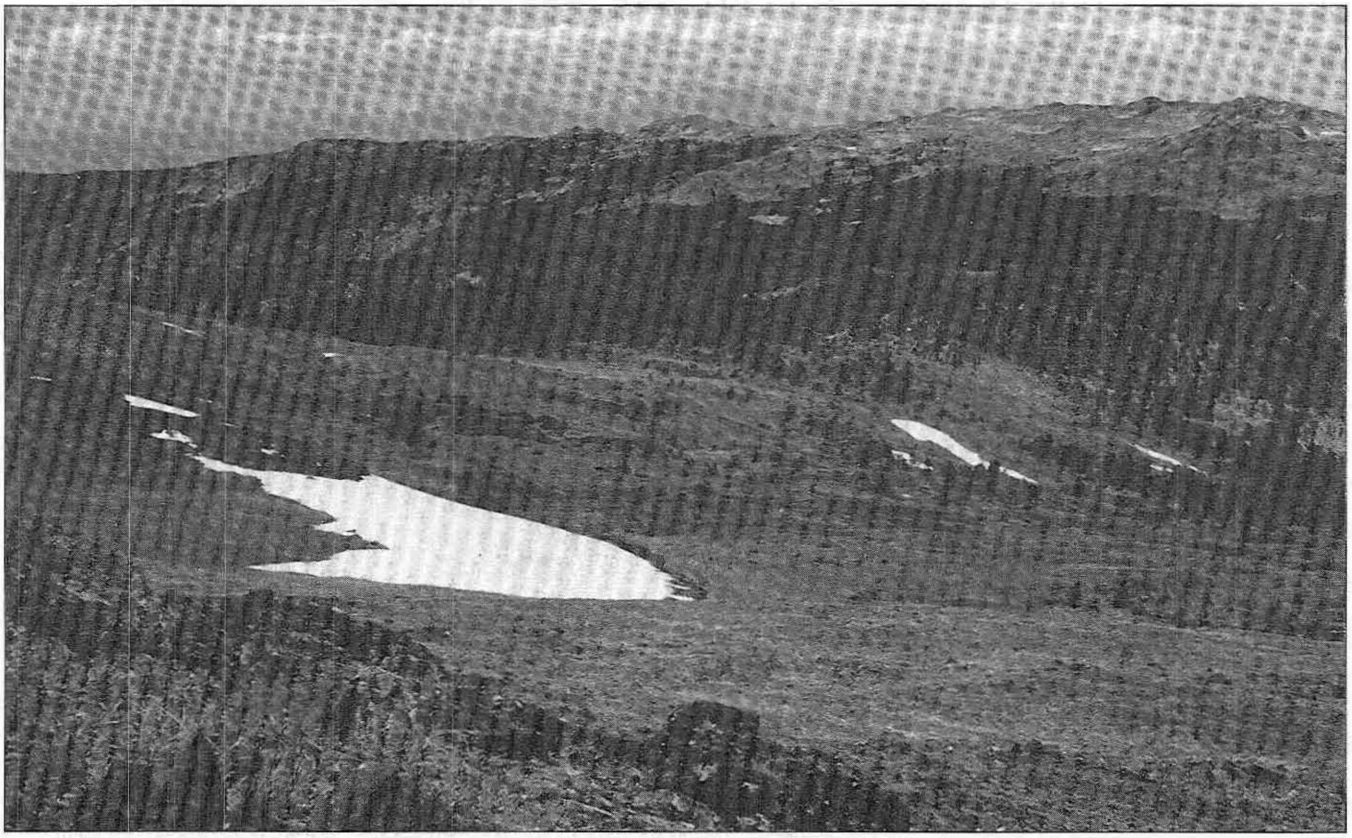

Figure 9. - View looking northwest at the East Boulder Project site (middle ground), Stillwater mining district

The engineering model developed for the Iron Mountain-Camp deposit assumes mining by open-pit methods. The mining rate would be 5,676 tons ore and 19,298 tons waste per day, 3 shifts per day, 260 days per year for 9 years. Mine-run rock would be crushed, ground, and the metals recovered by flotation-ammoniacal leach methods. Milling would occur at a 4,100 ton per day rate, 3 shifts per day, 360 days per year.

Both the East Boulder and the Iron Mountain-Camp deposits meet the criteria (see economic and socioeconomic analysis section) established to yield a 15% discounted cash flow rate of return (DCFROR) and are included in the economic and socioeconomic study.

New World Mining District

The New World mining district, located about 3 miles north of Cooke City, lies at the headwaters of an unusual radiating drainage pattern largely resulting from Pleistocene-age glaciation (fig. 10). Three main streams eventually flow into the Yellowstone River through widely divergent channels. Fisher Creek flows southeast into the Clark Fork of the Yellowstone River; the Stillwater River flows north from the flanks of the Daisy Pass divide; and Soda Butte Creek flows westward through Cooke City. A small portion of the New World district, the head of the Stillwater River drainage, lies in the Custer National Forest.

Geology

The district lies in the Cooke City zone, a major structural zone cutting across the interior of the Beartooth uplift (fig. 3). It trends northwest from near Sunlight Basin in Wyoming, to the Mill Creek area of Montana, a distance of about 60 miles (Eyrich, 1969). The New World mining district is about midway along this zone.

Resources

By December 1991, 12 million tons of ore containing about 2.7 million oz gold, 10 million oz silver, and 180 million lb copper had been blocked out in 5 deposits at the New World Project (Crown Butte Resources, Ltd., 1992a). Drilling is still in progress to delineate the full extent of one of the five deposits.

The Custer/Gallatin National Forest boundary appears to cross the Como, Fisher Mountain, and McLaren deposits.

Figure 10. - View looking northwest at Fisher Mountain (10,237 ft.), New World mining district

No attempt was made to divide the resources at these deposits between the two forests. All resources at the New World Project, as reported at the end of 1991, are included in the Gallatin National Forest mineral endowment.

Replacement-type resources at the Irma/Republic are inferred in the Meagher Limestone along the same vertical structures that were mined in the Pilgrim Limestone. The Meagher Limestone, about 250 ft below the Pilgrim Limestone, has been recognized for many years as a favorable host for replacement and contact metamorphic ore deposits. Resources are estimated to be more than 200,000 tons with a grade at least equal to the grade of ore mined from the Pilgrim Limestone: 15 oz silver per ton, 3 to 4% lead, and 5% zinc.

Engineering Analysis

Crown Butte Mines, Inc. plans to mine the Fisher Mountain, Miller Creek, and Homestake deposits by underground cut-and-fill and modified room-and-pillar methods (fig. 11). The Como and McLaren deposits, originally slated to be mined by open-pit methods, have been deleted from the permit application. The future of the open-pit reserves will be subject to metal prices and metallurgical innovation (Crown Butte Mines, Inc., written commun., 1992). To minimize the visual impact of mining, underground haulageways are planned to transport all ore to a point on the eastern side of Henderson Mountain near the plant site and tailings pond along Fisher Creek. It is anticipated that production will begin in 1995 at a rate of 1,800 tons per day. The operation is expected to yield in excess of 125,000 oz of gold annually, plus silver and copper. Crown Butte plans to recover those metals by gravity and froth-flotation methods; cyanide will not be used. Gold and silver will be smelted on site with the resulting dore being shipped to Salt Lake City for final refinement. The copper concentrates will be shipped to Trail, British Columbia. Mine life is expected to be approximately 15 years.

The USBM developed an engineering model to assess the economic and socioeconomic impacts of the New World Project. The model assumes mining by both open-pit and underground room-and-pillar methods at an average rate of 1,800 tons ore per day, 2 shifts per day, 365 days per year. Mine-run rock would be crushed, ground, and the metals recovered by flotation methods. The mill would operate 3 shifts per day, 365 days per year.

Figure 11. - View looking south at Henderson Mountain (10,338 ft.), New World mining district

The engineering model developed for the identified resources at the Irma/Republic assumes mining by underground shrinkage-stope methods. Mining would occur 2 shifts per day, 365 days per year, at a 100 ton per day rate. Mine-run rock would be crushed, ground, and the metals recovered by flotation methods. The mill would operate 3 shifts per day, 260 days per year; a mine life of 8 years is projected.

Both the Irma/Republic and New World deposits meet the criteria required to yield a 15% DCFROR and are included in the economic and socioeconomic study.

Emigrant Mining District

The Emigrant mining district, located 26 miles south of Livingston, encompasses the Emigrant Creek drainage and parts of the Mill Creek and Sixmile Creek drainages. Some consider the Mill Creek and Sixmile areas to be separate mining districts, but for the purpose of this report they are included with the Emigrant.

Geology

The geology in the Emigrant mining district is dominated by the Emigrant stock, a large, 49 million year old, multiphase, hypabyssal body, consisting primarily of rhyodacite that intruded and domed older volcanic flows and flow breccias (Pfau, 1981). According to Moore (1982), five distinct periods of quartz monzonite porphyry intrusion followed the emplacement of the stock. The numerous intrusive events produced several types of mineral deposits including vein, disseminated, stockwork, and breccia pipe.

Resources

Gold-copper-silver resources at the DUV deposit (fig. 12) occur in a limonite-stained, hydrothermally altered, locally silicified and brecciated zone in rhyodacite porphyry. Sulfide minerals include pyrite and chalcopyrite that occur as disseminations and fracture fillings. Minor to trace amounts of bornite, galena, magnetite, molybdenite, and sphalerite were detected by scanning electron microscopy, and all but sphalerite occur as inclusions in pyrite. Inferred resources are estimated to be 38 million tons grading 0.044 oz gold per ton, 0.24 oz silver per ton, and 0.44% copper. Resource grades at the DUV, as well as at the Emigrant Peak breccia pipe deposit, were adjusted to compensate for surface metal depletion.

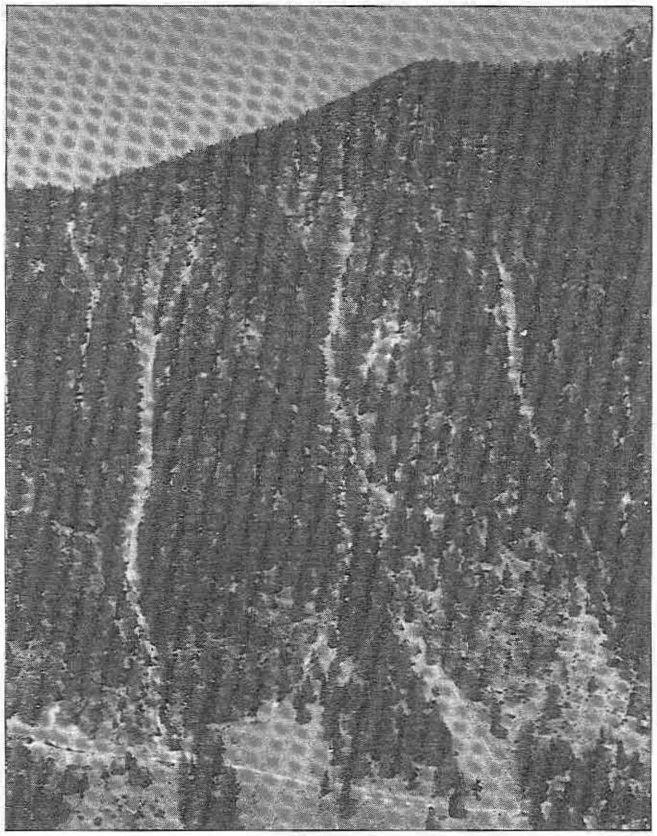

Figure 12. - View looking north at the DUV deposit area, Emigrant mining district.

Analyses of 430 samples taken from the St. Julian breccia pipe (fig. 13) indicate that gold concentrations are highest in quartz monzonite suites where silicification is accompanied by, or grades into, advanced argillic alteration. Gold-silver resources, estimated from 97 samples taken from the area, total 42 million tons grading 0.009 oz gold per ton and 0.04 oz silver per ton.

The analyses of 90 samples taken from the Emigrant Peak breccia pipe (fig. 14) show the presence of a large gold anomaly. Gold analyses are highest along the south and east sides of the pipe where porphyritic rhyolite and rhyodacite are heavily limonite- and hematite-stained, strongly hydrothermally altered, brecciated, and locally silicified. Based on the sample analyses and geologic interpretation of the deposit, gold-copper resources in the outer shell of the pipe could conceivably exceed 100 million tons and grade 0.006 oz gold per ton, 0.04 oz silver per ton, and 0.3% copper.

In the Basic Metals breccia pipe, 15 holes drilled during 1970 delineated a copper-lead-zinc-silver resource. According to Green (1976), the resource totals approximately 1.7 million tons grading 0.41% copper, 0.39% zinc, 0.18% lead, and 0.81 oz silver per ton.

Engineering Analysis

An engineering model was developed for three lode deposits, the DUV, Basic Metals, and Emigrant Peak, and for one placer deposit, the Emigrant Creek. The model assumes the lode deposits would be mined by open-pit methods and the ore would be processed at one centrally located mill, where ore would be crushed, ground, and the metals recovered by flotation methods. The mill would operate 3 shifts per day, 365 days per year, and be capable of processing 10,000 tons per day.

The DUV deposit would be mined first and have a mine life of 10 years. The mining rate would be 10,000 tons ore and 32,000 tons waste per day, 3 shifts per day, 365 days per year.

After depletion of the DUV deposit, the Emigrant Peak and Basic Metals deposits would be mined simultaneously. Mine production would be 10,000 tons ore and 1,335 tons waste per day, 3 shifts per day, 365 days per year. A mine life of 10 years is expected for the two deposits.

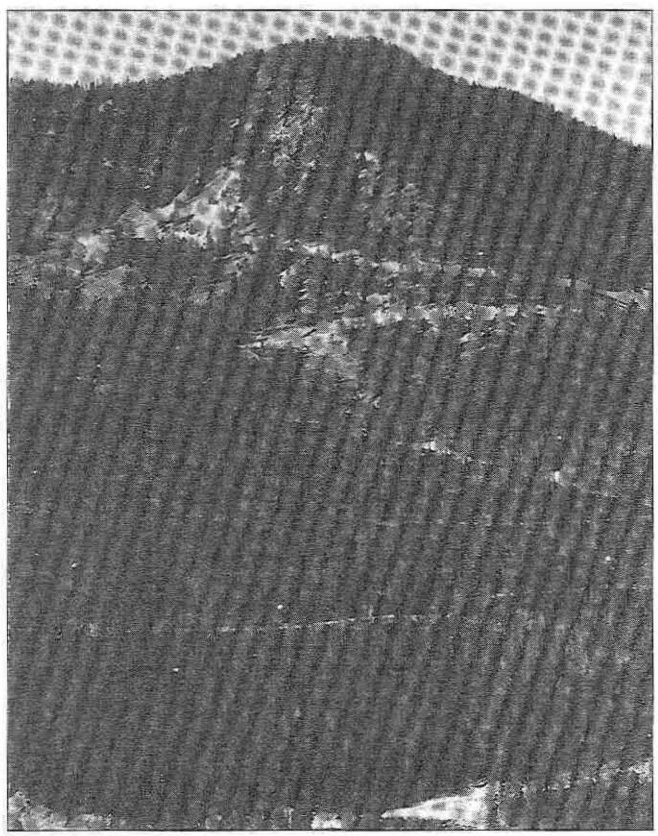

Figure 13. - View looking south at the St. Julian deposit area, Emigrant mining district.

No attempt was made to sample the gold-bearing placer deposits in the district during this study. They were surficially sampled by the USBM during the North Absaroka study and found to contain significant amounts of gold (Stotelmeyer and others, 1983). Although gold is known to be present and has a history of being mined, its concentration and distribution remain unknown. To determine parameters for potentially economic placer operations, two scenarios were developed, and engineering studies were conducted for each.

In the first scenario, gold is assumed to be (1) concentrated on bedrock in a zone averaging 30 ft wide and 4 ft thick, (2) covered by 80 ft of overburden on the average, and (3) amenable to open-pit mining methods with pit wall slopes of 60°. In this scenario, only the placer in the 30-ft-wide, 4-ft-thick zone would be put through a washing and sizing plant, and finally through a sluice box. Results of the engineering study indicate that a net recoverable metal value of $91 per loose cubic yard (LCY) would be required to yield a real rate of return of 15%. At a gold price of $405 per oz and a recovery rate of 90%, the "pay gravel" would have to contain 0.25 oz gold per LCY.

In the second scenario, gold is assumed to be distributed through all of the gravel, rather than being concentrated on bedrock only. If that were the case, all of the material mined would have to go through the washing and sizing plant and sluice box. Results of the engineering study for this scenario indicate that a net recoverable metal value of $3.40 per LCY would be required to yield a rate of return of 15%. Again, at a gold price of $405 per oz and a recovery rate of 90%, the gravel would have to contain 0.0092 oz gold per LCY.

The engineering model developed for each scenario assumes mining by surface methods and milling by gravity methods. Mining and processing would take place 10 hours per day, 150 days per year, at a rate of 5,000 LCY per day. A mine life of 10 years is projected.

The three lode deposits and the modeled placer deposit meet the criteria established to yield a 15% DCFROR and are included in the economic and socioeconomic study.

Jardine-Crevice Mining District

The Jardine-Crevice mining district lies immediately north of Yellowstone National Park and to the east and northeast of Gardiner, MT. It is bounded on the north and east by the Absaroka Wilderness.

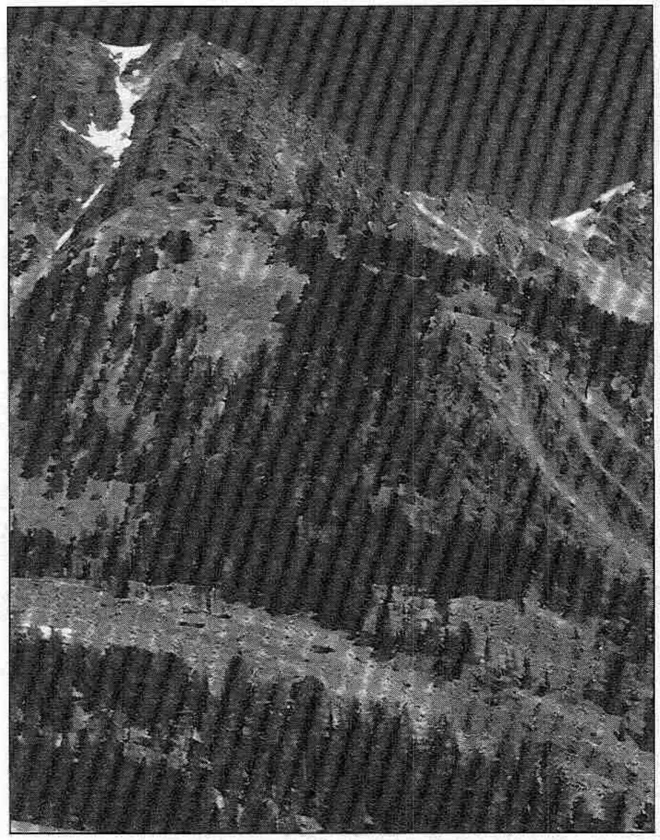

Figure 14. - View looking west at Emigrant Peak (10,921 ft.) and the Emigrant Peak breccia pipe deposit, Emigrant mining district.

Geology

The Jardine-Crevice district occurs within the southwest edge of the Beartooth-Absaroka uplift in an Archean assemblage of greenschist to lower amphibolite grade schists and gneisses. The assemblage is dominated by quartz-biotite schist, but contains subordinate biotite schist and iron formation.

Resources

Over 1 million tons of proven and probable reserves were originally blocked out at the Mineral Hill mine by the joint venture partners. At the end of 1991, reserves were 800,000 tons averaging 0.268 oz gold per ton (Homestake Mining Company, 1992). Exploration continues at possible targets in and near the mine. In 1990, a drilling program in the Crevice area showed results that were "...promising but not definitive..." (McCulloch, 1990).

Engineering Analysis

Although the Mineral Hill mine is currently operating (fig. 15), an engineering model was developed to assess the

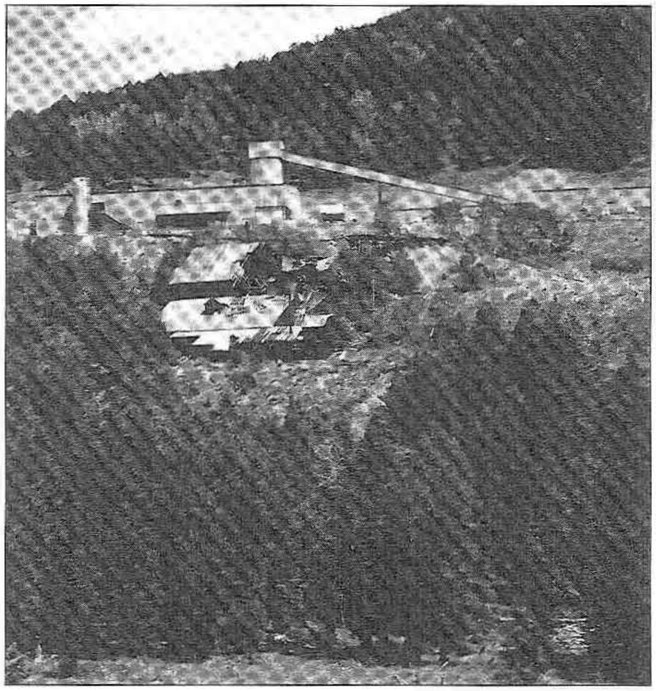

Figure 15. - View looking northeast at the Mineral Hill mill (top) and the historic Revenue Stamp mill (bottom), Jardine-Crevice mining district

economic and socioeconomic impacts. The model assumes mining by underground cut-and-fill methods at a rate of 632 tons per day, 2 shifts per day, 260 days per year. Mine-run rock would be crushed, ground, and the metals recovered by vat cyanide-leach methods. The milling rate would be 450 tons per day, 3 shifts per day, 360 days per year.

ENERGY ENDOWMENT

The following section describes the geology and the likelihood of developing oil, gas, coal, and geothermal resources in and near the Gallatin National Forest. The section is based entirely on the compilation and interpretation of published and company data; no field investigation was conducted.

Oil and Gas

Evaluation of available data suggests that certain areas in the Gallatin National Forest could contain significant quantities of petroleum in organic-rich black shale and oil shale. Although at a modest level, exploration continues in the region (fig. 16).

Geology

Marine and non-marine sedimentary rocks are about 19,600 ft thick in the Bridger Range and approach 30,000 ft in the center of the Crazy Mountains Basin. Sedimentary rocks in the Madison and Paradise Valleys are at least 15,000 and 7,500 ft thick, respectively. Important petroleum source rocks in these sections include the Cody-Frontier, Mowry-Thermopolis-Skull Creek, Phosphoria, and Three Forks Formations (Rocky Mountain Association of Geologists, 1972; Perry and others, 1983a and b; Long and Hansen, 1991; Peterson, 1985; Tissot and Welte, 1984; Cressman and Swanson, 1964; Hagen and Surdam, 1984; Beutner and Warner, 1984; Hunt, 1979; Fanshawe, 1985).

The Thrust Belt, one of the most important geologic features in the area, is a zone of thrust faulting and folding that extends from the North Slope oil fields in Alaska, south through the Rocky Mountains of Canada and the United States into Mexico. The belt is 150 miles wide where it passes through Montana. It is important not only because it contains oil-bearing source rocks, but because it provides abundant structural traps. The leading edge (east side) is especially important because petroleum traps there are more likely to be preserved. In the Gallatin National Forest, the belt comprises the north half of the Bridger Range and extends to the Crazy Mountains.

Resources

The most important geologic conditions needed to produce economic accumulations of oil and gas are (1) a source rock of adequate organic richness and sufficient thermal maturity to generate petroleum, (2) rock units permeable enough to allow migration of the petroleum, (3) a structure capable of trapping the petroleum in a reservoir rock, and (4) geologic conditions that are conducive to the preservation of the trapped petroleum (Hunt, 1979; Tissot and Welte, 1984). Four areas in and adjacent to the forest appear to meet the criteria and are described below (fig. 17).

Area 1 includes the Bridger Range and the west part of the Crazy Mountains Basin and is believed to have moderate to high potential for significant amounts of oil and gas. Oil and gas may originate from either one or all of the Cody-Frontier, Mowry-Thermopolis-Skull Creek, and Three Forks Formations mapped in the area. Wells drilled along the Battle Ridge Monocline by Scat Drilling Company, Sohio Petroleum Company, and Flank Oil Company encountered significant amounts of oil and/or gas (Hadley, 1972). Because the monocline is structurally favorable for trapping oil and gas, the entire area along the monocline is rated high. Mixed wet and dry gas likely predominate in the east part of the range (east of Bridger Creek and Cache Creek drainages) and the Crazy Mountains Basin.

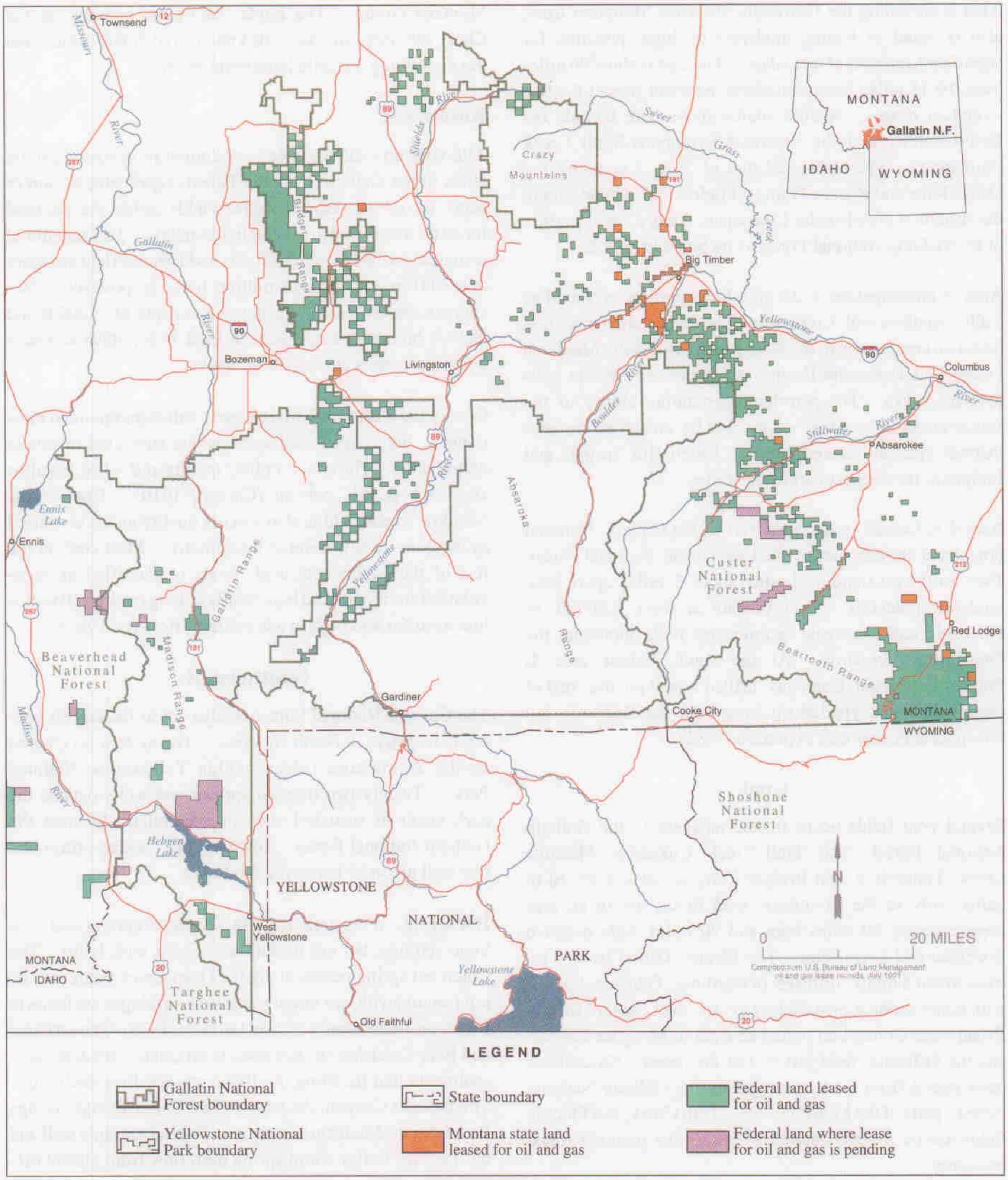

Figure 16. — Oil and gas leasing activity in and near the Gallatin National Forest, MT.

Area 2, including the Beartooth-Absaroka Mountain front, also is rated as having moderate to high potential for significant amounts of oil and gas. The area is about 80 miles long, 10-15 miles wide, and skirts the north side of the two mountain ranges. Mature source rocks here include the Cody-Frontier and the Mowry-Thermopolis-Skull Creek Formations. The high-rated part of area 2 contains the Dean Dome and Roscoe Dome oil fields and extends along the structural Nye-Bowler Lineament. Only a small portion of the Gallatin National Forest is included in area 2.

Area 3 encompasses a 25-mile-long portion of Paradise Valley southwest of Livingston. The area is rated moderate based on similarities to the Deer Lodge, Big Hole, Medicine Lodge, and Townsend Basins, which contain Eocene sedimentary rocks. The petroleum-generating ability of the source strata in Paradise Valley may be enhanced by geothermal systems located between Chico Hot Springs and Emigrant, the deepest part of the valley.

Area 4 is located in the west part of the Gallatin National Forest and the east part of the Beaverhead National Forest. Two northwest-trending basins about 5 miles apart have moderate potential. They contain at least 6,000 ft of Paleozoic and Mesozoic sedimentary rock including the Phosphoria Formation. At the south end of area 4, Phillips Petroleum Company drilled a well on the crest of an anticline that yielded oil from both the Kootenai and Phosphoria Formations (Tonnsen, 1982).

Coal

Several coal fields occur in and adjacent to the Gallatin National Forest. The Trail Creek, Cokedale, Meadow Creek, Timberline, and Bridger Canyon fields, referred to collectively as the Livingston coal fields, are in an area approximately 20 miles long and 20 miles wide between Bozeman and Livingston. The Electric (Horr) field is located about 5 miles northwest of Gardiner. Other coal fields, with minor production used locally, are the Lombard field in Broadwater County, an unnamed field in Meagher County, and the Stillwater field just east of the forest. No coal has been mined from lands managed by the Gallatin National Forest; parts of the Meadow Creek, Trail Creek, and Electric fields are on private inholdings within the nominal forest boundary.

Geology

Coal in or near the Gallatin National Forest occurs in the Upper Cretaceous Eagle Sandstone, a formation of the Montana Group. The Eagle Sandstone consists of the Coaly Member, in which all known coal zones occur, and the underlying Virgelle Sandstone Member.

Resources

Although no coal resources are known to occur on public lands in the Gallatin National Forest, significant resources occur on private land (Electric Field) inside the nominal forest boundary and in several fields nearby. Estimated coal resources in the Livingston fields and Electric field are more than 300 million and 40 million tons, respectively. Resources are estimated to a maximum depth of 3,000 ft and include bituminous coal beds at least 14 in. thick and sub-bituminous beds at least 30 in. thick.

Coal in the Electric field is mostly sub-bituminous to bituminous, but is semi-anthracitic where subjected to severe deformation. The coal is coking quality and is low in sulfur and high in ash content (Calvert, 1910). Coal in the Meadow Creek field is also coking quality and is classified as medium- to low-volatile bituminous. Most coal in the rest of the Livingston coal fields is classified as high-volatile bituminous and is generally coking quality. It is also low in sulfur and high in ash content (Roberts, 1966).

Geothermal

The Gallatin National Forest is adjacent to the largest geothermal system in North America. The system is centered on the Yellowstone caldera within Yellowstone National Park. Twenty-two thermal springs and wells outside the park occur at scattered sites in and relatively near the Gallatin National Forest. However, just seven springs and one well are in or bordering the forest.

Hot springs in the area occur in several structural and geologic settings, but are usually associated with faults. The Chico hot spring occurs along the Deep Creek Fault near its intersection with two minor northwest-striking cross faults in Paleozoic beds (Chadwick and Leonard, 1979). The La Duke and Bear Creek hot springs issue from Quaternary-Cenozoic sediments that lie along the Bismarck-Gardiner fault zone. The Bridger Canyon, Andersons, and Carter Bridge springs flow from the Madison Limestone. The Bakers Hole well and the Targhee Sulfur warm spring both flow from glacial till.

Resources and Development Feasibility

Geothermal reservoirs in the region are water-dominated systems. Although dry-steam reservoirs are more easily

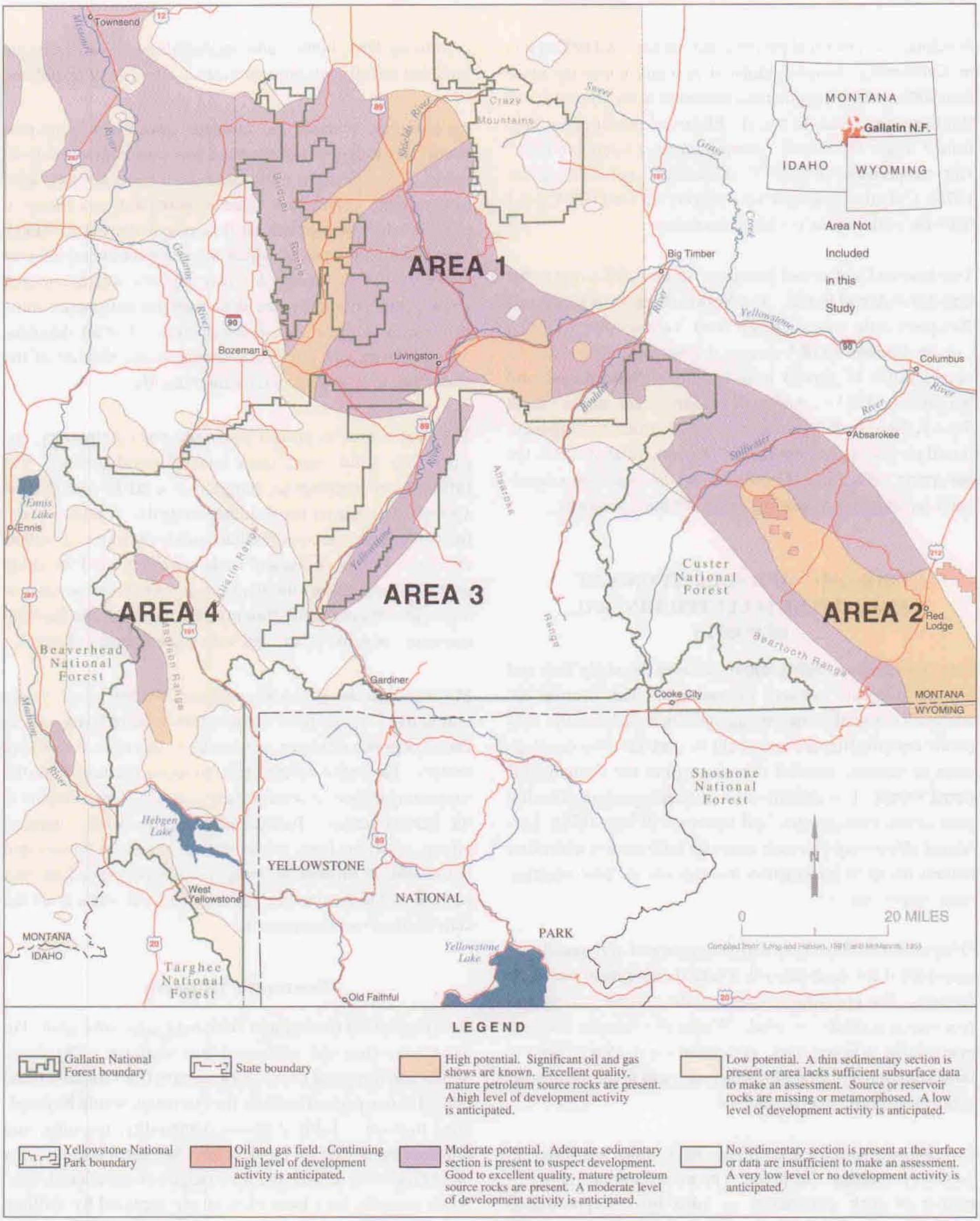

Figure 17. — Areas in and near the Gallatin National Forest that may contain significant amounts of oil and gas.

developed for electrical power generation (as at The Geysers in California), water-dominated systems comprise more than 90% of known geothermal resources in the United States (McLarty and Reed, in press). Electrical power generation from a water dominated system requires a minimum reservoir temperature of 150° C (Chadwick and Kaczmarek, 1975). Only the Ennis and Norris springs exceed 100° C, and both are well outside the forest boundary.

Two Known Geothermal Resource Areas (KGRA) are in the Gallatin National Forest. The Yellowstone KGRA covers a 20-square-mile area south of West Yellowstone, MT; the Corwin Springs KGRA covers a 32-square-mile area (18 square miles of forest) near Gardiner (Sonderegger and Bergantino, 1981). Although resources are unquantified, these KGRA's offer promise for geothermal development. Based on reservoir temperatures of geothermal systems, the hot spring at La Duke (Corwin) could be once again developed for spas, space heating, or aquiculture purposes.

ECONOMIC AND SOCIOECONOMIC ANALYSIS OF SELECTED MINERAL DEPOSITS

Previous sections of this report describe the study area and provide minerals resource information. This section describes a regional economic analysis that assesses the economic benefits that are and could be derived from development of selected mineral deposits within the Gallatin National Forest. It is anticipated that data regarding potential production, employment, and income will help USFS personnel effectively correlate minerals information with other natural resource information to carry out its land management responsibilities.

Once resources have been defined, mine and mill models are constructed for each deposit where development could be feasible. For operating properties, the current mining and processing systems are used. Where site specific data are unavailable or proprietary, systems in use at other producing mines of comparable commodity, size, and grade are used to estimate engineering parameters.

Development of mine and mill models is based upon deposit geometry, tonnage, and grade. The model includes approximation of such parameters as mine life, preproduction scheduling, mining method, recovery, dilution, processing method, concentrate grades, transportation costs, and smelter charges. Estimated or actual costs for environmental and permitting fees, bonds, and applicable state sales tax are included and all costs are calculated in current (1992) dollars.

An economic analysis that simulates development and production at the deposit is performed on each completed deposit model. To standardize output, the economic analysis is used to determine commodity price requirements necessary to generate a 15% discounted cash flow rate of return (DCFROR). These commodity prices, which are within the average 5-year (1987-91) levels (except for two deposits which required slightly higher prices), are then used for estimating mine revenues and state and Federal taxes. For all deposits, constant costs and prices are assumed over the life of the operation, to a 25-year maximum mine life.

The final step is to project economic and employment impacts that could result from mineral development. The IMPLAN microcomputer program is used to perform the appropriate regional input-output analysis. A region is defined to include the counties that contain the mines as well as the major supply points and trade centers around the study area. IMPLAN allows the analyst to remove or introduce new mines into the regional economy and determine the regional economic benefits associated with these industry changes.

Mining generates regional economic benefits directly and indirectly. Direct effects occur within those industry sectors that experience a change in demand, in this case, the mining sectors. The indirect effects refer to economic impacts on the supporting industries within the region that provide inputs to the mining sectors. Indirect effects also include induced effects resulting from households of mine employees and households of supporting industry employees spending their income within the region. The total regional impacts are the sum of these two components.

Economic Impacts

Nine deposits in the Gallatin National Forest are included in the engineering and socioeconomic analysis. The Basic Metals and Emigrant Peak resources have been combined and treated as one deposit because they probably would be developed together. Table 2 shows commodity, resource, and other pertinent data for the deposits. Resource estimates for these properties represent a wide range of confidence levels. Some deposits have been extensively explored by drilling, consequently, estimates are made with a high level of certainty. Others have been surficially sampled, and in two cases, not sampled at all by the USBM. Resources at these

Table 2. - Mineral deposits included in economic and socioeconomic analysis

Name	Commodity	Size 000 ton	In-place value, $MM 1/
East Boulder project	Pt, Pd	18,252	3,432
Emigrant Peak & Basic Metals	Au, Ag, Cu	101,700	977
Irma-Republic	Ag, Pb, Zn	200	35
DUV	Au, Cu, Ag	38,000	1,106
Iron Mountain-Camp	Ni, Cu, Co	13,900	696
Mineral Hill mine	Au	2/ 1,200	156
New World Project	Au, Ag, Cu	9,800	1,129
Emigrant Creek placers	Au	8,915 LCY	30
Name	**Activity**	**Operation type**	**Surface disturbance, acres**
East Boulder Project	Permitting	Underground	300
Emigrant Peak & Basic Metals	Prospect/explored	Surface	250
Irma-Republic	Prospect	Underground	50
DUV	Exploration	Surface	350
Iron Mountain-Camp	Explored	Surface	350
Mineral Hill mine	Operating	Underground	100
New World project	Permitting	Surface/underground	300
Emigrant Creek Placers	Exploration	Surface	500

1/ In-place value, gross value of resource in place based on the following average 5 year (1987-91) prices: gold, $405 per oz; silver, $5.57 per oz; platinum, $484 per oz; palladium, $120 per oz; rhodium, $2,343 per oz; copper, $1.13 per lb; lead, $0.385 per lb; zinc, $0.621 per lb; nickel, $4.46 per lb; and cobalt, $9.28 per lb.

2/ Pre-production resource.

deposits have a much lower level of confidence. Those deposits having a high level of confidence are the Mineral Hill mine (operating), East Boulder Project, Basic Metals, Iron Mountain-Camp, and New World Project. The DUV deposit has a moderate level of confidence, and the Emigrant Peak, Irma-Republic, and Emigrant Creek deposits each have a relatively low level of confidence.

If all nine properties undergo development in 1 year and are operated for the projected deposit life within the same 25-year period, the cumulative impacts from development and operation of these properties can be estimated (table 3). The total output value from the mining industry during the development phase of these properties is $493 million. Total output from other local industries during the 1-year development period is estimated to be $111 million. The value of output from the mining industry during operations is estimated at $2.86 billion and the total from other local industries during the same period is valued at $1.38 billion.

There would be an estimated 980 jobs at mine sites during development of these projects and 1,761 jobs in other local industries during the same period. Operating periods for the projects range from 8 to 25 years. To arrive at cumulative employment effects, annual jobs were multiplied by the operating years for each project, resulting in the number of person years of employment. During the operating period, 26,140 person years of employment would be required at the mines, and 21,850 person years of employment would result in the supporting local industries.

The earnings resulting from mine and non-mine jobs within the region are estimated from IMPLAN and from estimates of average mine wages and salaries. Jobs at mine sites during the construction period result in $92 million in earnings and jobs in other local industries during the construction period provide $30 million. Earnings from mine jobs during the operation phase of these projects are $1.15 billion. Earnings from non-mine jobs in the region during the operation phase of these projects are $363 million.

Table 3. - Cumulative impacts of development at selected mineral deposits, Gallatin National Forest, MT

	Direct impacts construction	Indirect impacts construction	Direct impacts operation	Indirect impacts operation
Total output, $MM	493.03	110.51	2,863.17	1,376.62
Employment, job years	980	1,761	26,140	21,850
Earnings, $MM	92.12	29.92	1,151.13	363.05

MINING AND EXPLORATION ACTIVITY FORECAST FOR THE GALLATIN NATIONAL FOREST FOR THE NEXT 10-15 YEARS

Exploration for and development of mineral deposits in the Gallatin National Forest have been ongoing since the 1860's, and will probably continue indefinitely. Several mineral deposits in the forest are currently in various stages of development.

The Mineral Hill mine, located in the Jardine-Crevice mining district, began producing gold in September 1989. Cut-and-fill underground mining methods and rubber-tired equipment are being used to mine about 600 tons of ore per day. The ore is processed in a 450 ton per day vat-leach mill using Merrill-Crowe methods to recover the gold. Reserves at the end of 1991 total 800,000 tons containing 214,000 oz gold (Homestake Mining Company, 1992). If current drilling programs do not develop more ore, reserves will be depleted in 1997, and mine site reclamation would begin (Dave Brown, Homestake Mining Co., personal commun., 1992). Optimism that reserves will be increased and the mine life extended is high, however. If there are no unforeseen problems with the issuance of the necessary permits at the New World Project, mill construction and mine development could begin in late 1993, with mill startup occurring in 1995 or 1996. The projected mine life, based on current geologic reserves, is estimated to be about 15 years (Crown Butte Resources, Ltd., 1992b). Mine life could be extended significantly with discovery of additional reserves, or an increase in metal prices. At the end of 1991, geologic reserves were more than 12 million tons containing about 2.7 million oz gold (Crown Butte Resources, Ltd., 1992a). The proposed flotation mill would process 1,800 tons per day and be located in Fisher Creek. It would not be visible from Yellowstone National Park.

Drilling to delineate resources at the DUV and St. Julian deposits, located in the Emigrant mining district, was scheduled to continue during the 1992 field season. Identified lode gold-silver-copper resources in the district would probably be mined by open-pit methods and processed through a flotation mill if economics were favorable at the time. Drilling on gold-bearing placer deposits also was scheduled to continue during 1992. A high level of exploration activity is expected to continue in the district for at least the next several years. If a decision is made to develop the resources in the future, mine life would probably be at least 10-15 years.

Exploration and development activity in the portion of the Stillwater Complex that extends into the Gallatin National Forest is expected to continue well into the future. Enormous resources for platinum, palladium, rhodium, chromium, cobalt, copper, and nickel occur there, and each has been determined by the President to be strategic and critical to the well being of the United States. A plan of operation for the East Boulder Project, located near the west end of the complex, was submitted to the USFS for approval in 1990. Reserves, stated in the plan as 18 million tons, would be mined by underground cut-and-fill methods. Ore would be concentrated in a flotation mill located near the mine site. At the proposed, full-production rate of 730,000 tons per year, a 28-year mine life is expected.

Although at a low level now, exploration activity in the Independence district is expected to increase and include drilling within the next five years. The district has a history of gold production, and USBM studies show the presence of significant gold mineralization.

Sample analyses and geology at the Irma/Republic mine suggest that a drilling exploration program is warranted; however, the current claim owner has no exploration plans.

Results of this study indicate that as precious metal and base metal prices increase, new exploration activity will be concentrated in the Emigrant, Stillwater, Independence, New World, and to a lesser extent, the Pass Creek and Jardine-Crevice mining districts. Oil and gas exploration activity in the Gallatin National Forest will probably continue at a very low level until there is a substantial increase in the price of oil. New exploration (geophysical and well drilling) would most likely occur in the Bridger Range and in a smaller area of the southern Madison Range.

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