DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1576-A
PAMPHLET

MINERAL RESOURCE POTENTIAL OF THE SPECIAL MINING MANAGEMENT ZONE—CLEAR CREEK, LEMHI COUNTY, IDAHO

By

Karen Lund and Karl V. Evans, U.S. Geological Survey
and
Leon E. Esparza, U.S. Bureau of Mines

STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Special Mining Management Zone—Clear Creek in the Salmon National Forest, Lemhi County, Idaho. The area was included in the River of No Return Wilderness by Public Law (96-312, July 23, 1980). It was originally part of the West Panther Creek Roadless Area (W4-504), Salmon National Forest, Lemhi County, Idaho, which was classified as a proposed wilderness during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

A high potential for the occurrence of cobalt-copper-gold-silver deposits similar to those of the Blackbird mine near Cobalt, Idaho, exists in the Elkhorn and upper Garden Creek areas of the Special Mining Management Zone—Clear Creek, Lemhi County, Idaho. The combination of rocks correlative with the Yellowjacket Formation lithologies hosting stratabound cobalt-copper-gold-silver at the Blackbird mine, anomalously high cobalt-copper values in rocks and stream sediments, tourmaline breccia, and cobalt and copper oxides in outcrop in these drainages, supports this conclusion. All other areas underlain by Yellowjacket-equivalent rocks have moderate potential based on stratigraphy and scattered occurrences of the features mentioned above.

A low potential for porphyry-type copper-molybdenum deposits exists along Clear Creek and upper Squaw Gulch within the study area. This is suggested by extensive fracturing and alteration of the nonporphyritic granite, magnetite mineralization, and the close proximity of a known Tertiary pluton. Such geologic features are commonly associated with porphyry systems in Idaho and southwestern Montana.

INTRODUCTION

The Special Mining Management Zone—Clear Creek, Lemhi County, Idaho, covers 39,000 acres located in the Salmon River Mountains 24 mi west of Salmon, Idaho (fig. 1). It presently forms the northeast portion of the River of No Return Wilderness Area but was initially included as part of the West Panther Creek Roadless Area (RARE II). The study area is about 6 mi north of the Blackbird cobalt mine (fig. 2), the largest mine in the United States worked primarily for cobalt. The area has rugged topography with alpine ridges on the southwest side and deeply incised canyons of Panther Creek and the Salmon River on the east and north sides. Northeast-flowing Clear Creek and Garden Creek are the major drainages within the area. Maximum relief is 6,289 ft across a distance of 5.6 mi from Dome Mountain, 9,316 ft to the mouth of the Middle Fork of the Salmon River, 3,027 ft.

The area lies south of the main mass of the Bitterroot lobe of the Idaho batholith and east of the main mass of the Atlanta lobe of the Idaho batholith. Rocks of the Tertiary Bighorn Crags pluton are immediately southwest. The study area itself is underlain by Proterozoic metasedimentary rocks, most of which correlate with the Yellowjacket Formation, and form part of a northwest-trending zone of Yellowjacket that probably continues to include the rocks at the Blackbird mine.

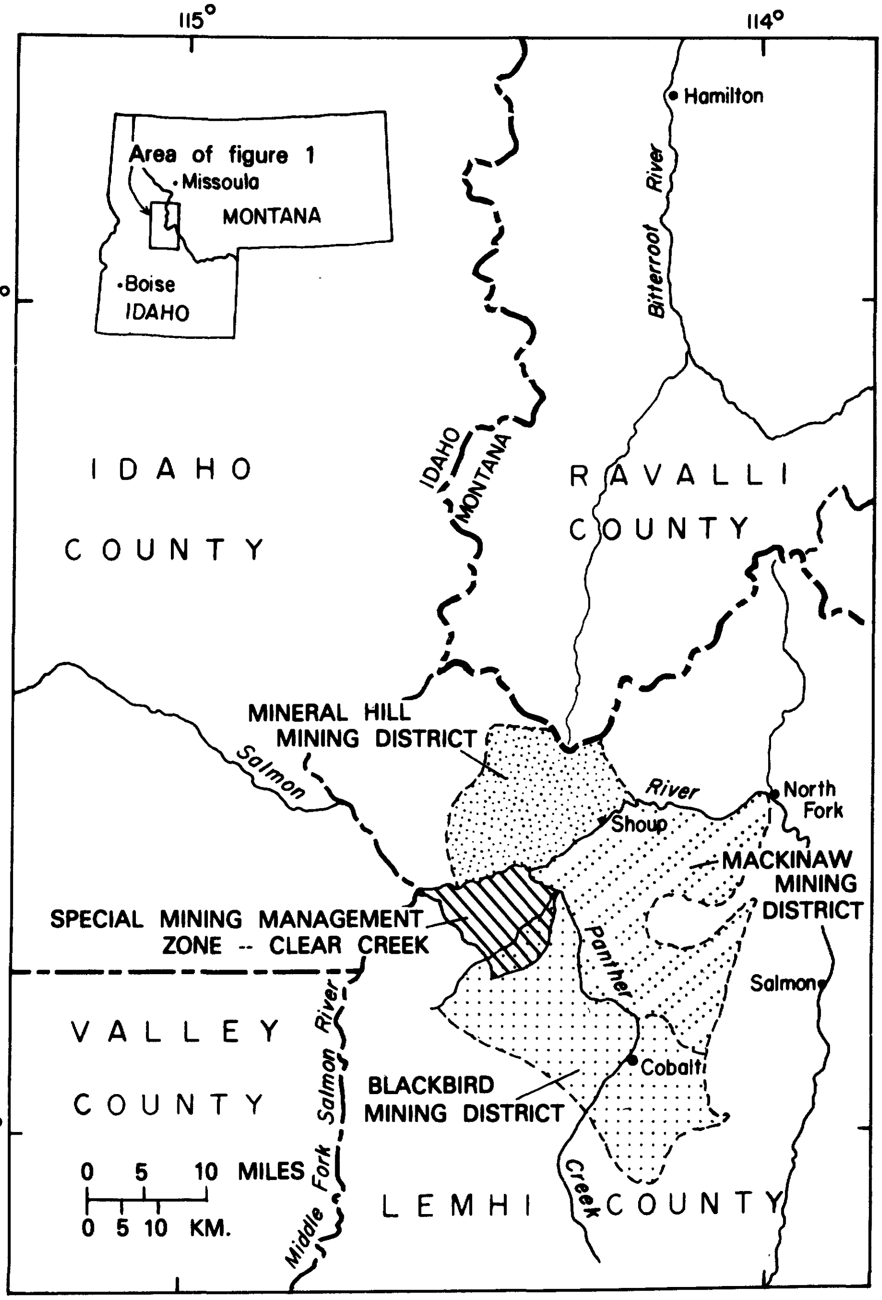
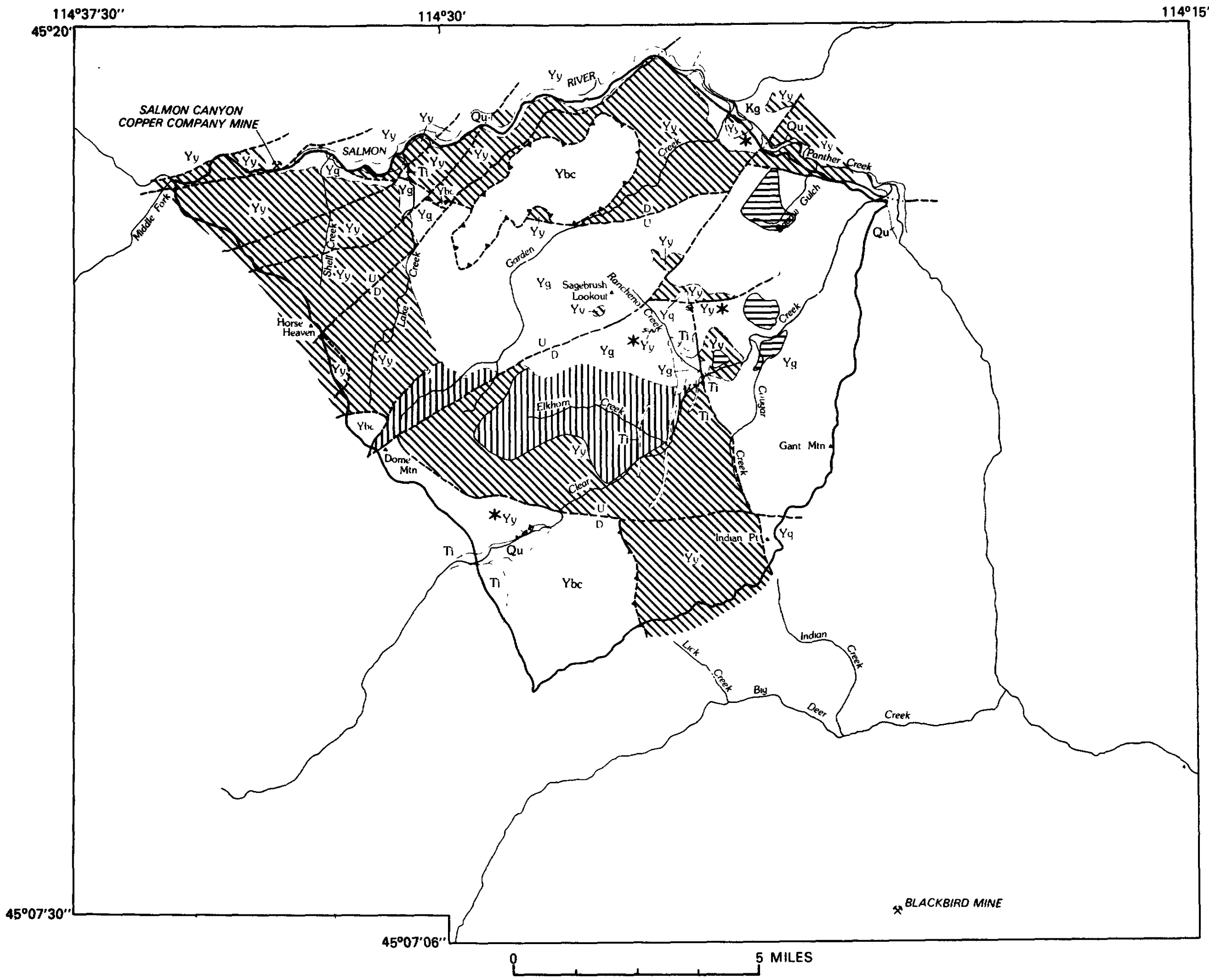


Figure 1.--Index map showing location of the Special Mining Management Zone--Clear Creek, Lemhi County, Idaho.



EXPLANATION

Qu	UNCONSOLIDATED SEDIMENTS (QUATERNARY)--Includes alluvial, colluvial, and morainal deposits
Ti	INTRUSIVE ROCKS (TERTIARY)--Related to the Eocene Bighorn Crags pluton; medium-grained granite, porphyritic rhyolite, and porphyritic dacite
Kg	TWO-MICA GRANITE (CRETACEOUS)--Medium-grained, slightly foliated; related to the main phase of the Idaho batholith
Ybc	METAQUARTZITE (PROTEROZOIC Y)--White; correlated with Big Creek Formation
Yg	GRANITE (PROTEROZOIC Y)--Porphyritic or nonporphyritic, gray or pink, strongly foliated
Yy	METAGRAYWACKE AND SCHIST (PROTEROZOIC Y)--Weakly to strongly metamorphosed, biotitic; correlated with Yellowjacket Formation

CONTACT--Dashed where approximately located or inferred; dotted where concealed

NORMAL FAULT--Dashed where approximately located; dotted where concealed; queried where uncertain; U, upthrown side, D, downthrown side

THRUST FAULT--Dashed where approximately located; sawteeth on upper plate

APPROXIMATE BOUNDARY OF MANAGEMENT ZONE

AREAS WITH HIGH COBALT-COPPER POTENTIAL

* AREAS WITH MODERATE COBALT-COPPER POTENTIAL--(Areas too small to show with pattern are starred)

AREAS WITH LOW COPPER-MOLYBDENUM POTENTIAL

Figure 2.--Map showing mineral resource potential and generalized geology of the Special Mining Management Zone—Clear Creek, Lemhi County, Idaho.

PREVIOUS INVESTIGATIONS

Previous geologic work in the study area includes several reconnaissance mineral resource evaluations based primarily on geochemical sampling of rocks, soils, and stream sediments by Cater and others (1975), Knowles (1975), and Bennett (1977). Other geochemical data are available in Broxton and Beyth (1980) and U.S. Department of Energy (1980). Additionally, Maley (1974) mapped a portion of the area as part of a structural geologic study.

Several studies of adjacent areas are also pertinent to this investigation. In particular, unpublished company reports on the Blackbird mine by Shenon, Full, Bauer, and Snyder (1955), Shenon, Full, Snyder, and Bauer (1955), Cole (1956), and Markland (1974) were utilized by us, as were the studies by Umpleby (1913), Anderson (1947), Vhay (1948), and Canney and others (1953). The geology and ore deposits of the Blackbird mining district were also described by Purdue (1975). The conclusions of most of these studies are summarized by Bennett (1977). Most recently Hughes (1983) has concluded that the cobalt-copper mineralization at the Blackbird mine is syngenetic and is associated with mafic intrusive and volcanic rocks.

Further background geologic studies of nearby areas include those of Cater and others (1973) in the Idaho Primitive Area, which is contiguous to the study area, and Roberts (1953), in the region between the Blackbird mine and the present study area. The stratigraphy and sedimentology of the metasedimentary Yellowjacket Formation has been studied by Lopez (1981) and Sobel (1981) but remains incompletely known. Finally, the Proterozoic granites and augen gneisses that extend into the area have been studied by Davidson (1928), Maley (1974), Armstrong (1975), and Evans and Zartman (1981).

GEOLOGY

The study area is underlain by two Proterozoic Y, dominantly clastic metasedimentary formations which are intruded by felsic plutons of Proterozoic Y, Cretaceous, and Tertiary ages (fig. 2). Locally these rocks are covered by alluvium and morainal deposits. The metasedimentary and granitic rocks are cut by thrust faults and numerous steeply-dipping normal faults. Observed cobalt-copper mineralization is confined to the lower metasedimentary formation.

Yellowjacket Formation

Fine- to medium-grained, light- to medium-gray biotite-feldspar-quartz metagraywacke (Yy) underlies most of the area. Although the rocks are completely recrystallized, many mesoscopic sedimentary features such as fine laminations, possible graded bedding, and crossbedding are preserved in the southern and eastern parts of the area where the metamorphic grade is lowest. Bedding is commonly 2-6 in. thick; sections with apparent graded beds have an additional 0.4-1 in. of meta-argillite at the top of each cycle.

Garnet-muscovite-biotite schist (Yy) in the northwestern part of the area represents similar lithologies at higher metamorphic grade and degree of deformation, although the most schistose units probably also reflect an originally higher argillite component than is common in most of the metagraywacke. Color ranges from light to medium gray, depending on the biotite and garnet content. Compositional layering (locally still bedding ?) is 0.4-6 in. thick, with thinner layers more common than in the metagraywacke.

Continuity of stratigraphic units from the southeastern to northwestern portions of the study area is suggested by structural trends and lithologic similarities, including the presence of tourmaline breccias, possible metachert beds, and possible metamorphosed mafic tuffaceous layers. Reconnaissance south of the area suggests that this resemblance continues to the low-grade metamorphic rocks of the Yellowjacket Formation at the Blackbird mine. Therefore, the metagraywacke and schist of the study area are correlated with the Yellowjacket Formation of east-central Idaho (Ruppel, 1975), which has been interpreted as a deep-water, marine turbidite sequence (Lopez, 1981; Sobel, 1981; Hughes, 1983). Such differences as do exist between the Management Zone and most other areas of exposure of the formation (Lopez, 1981) reflect differences in degree of metamorphism superimposed on original facies differences.

In addition to these stratigraphic and structural trends, a spatially coincident, northwest-trending belt of mineralization is defined by cobalt-copper prospects at Iron Creek (22 mi southeast of Blackbird), Blackpine mine, Blackbird mine, Indian Creek, Elkhorn and upper Garden Creeks, and the Salmon Canyon Copper Company mine (at the northwest edge of the study area). The apparent continuity of structure, stratigraphy, and mineralization suggests that the horizons bearing ore at the Blackbird mine extend into the study area.

Big Creek Formation

Fine- to coarse-grained, moderately feldspathic, white or tan metaquartzite (Ybc) of the Proterozoic Y Big Creek Formation underlies small areas in the southwestern and north-central parts of the Management Zone. These rocks generally have massive beds in which there are sparse crossbeds and finely laminated biotitic layers. Metamorphic grade is at least biotite-grade but is difficult to determine because of the dominantly quartzo-feldspathic composition. Poor exposure also precludes realistic evaluation of thickness and internal structure.

Biotite Granite

Biotite granite (Yg) occurs as distinctive porphyritic and nonporphyritic phases; field relationships indicate the two are comagmatic. The porphyritic variety is a medium- to coarse-grained, weakly to strongly foliated plutonic rock. Phenocrysts are gray or pink potassium feldspars as much as 4 in. in length and commonly rimmed with plagioclase. The nonporphyritic variety is medium to coarse grained and strongly foliated. These granites are part of an intrusive suite which has been dated at 1,370 m.y. (Evans and Zartman, 1981). Contacts with the host Yellowjacket rocks are both intrusive and faulted; a fault places the metaquartzite (Ybc) on the granite. Gossans developed in biotite granite in Squaw Gulch and lower Clear Creek are an alteration product which may be related to an unseen younger intrusion, such as part of the Bighorn Crags pluton. Both the gossans and postulated younger granite may also be controlled by regional fault patterns.

Two-mica Granite

Tan, medium-grained, nonfoliated to weakly foliated two-mica granite (Kg) is possibly an outlier of the main phase of the Idaho batholith, which is exposed in Owl Creek about 3 mi north of the study area. The two-mica granite intrudes metagraywacke and schist near the mouth of Panther Creek and is partly truncated by steep faults.

Bighorn Crags Pluton and Related Rocks

Scattered dikes and small stocks of pink, medium-grained biotite granite, porphyritic rhyolite, and porphyritic dacite (Ti) occur within the study area. These rocks are related to the Tertiary Bighorn Crags pluton which crops out on Clear Creek at the southwestern edge of the study area.

Unconsolidated Sediments

Quaternary alluvial and colluvial deposits (Qu) are found in the Salmon River and Panther Creek canyons. Valley-glacier moraine and outwash are found in Clear Creek.

STRUCTURE

Yellowjacket Formation

The metagraywacke and schist of the Yellowjacket Formation have been affected by multiple phases of deformation. In the northwestern part of the study area, where metamorphic grade is higher, isoclinal intrafolial folds indicate ductile deformation and transposition of original layering. In roadcuts along the Salmon River, contiguous to the northern border of the study area, several fold sets can easily be recognized; however, time constraints prevented a detailed structural analysis.

In the lower grade rocks of the central and southern parts of the Management Zone, the structure is less obviously complex. A well-developed foliation (S_1) parallel to bedding can be interpreted to imply an early isoclinal-folding event; however, independent data to confirm this, such as rapid reversals of stratigraphic facing, have not been observed.

Within the schist, and less frequently in the metagraywacke, a generally shallow-dipping, secondary foliation (S_2) cuts bedding and S_1. The S_2 foliation is approximately axial-planar to open flexures in the steeply dipping beds near Clear Creek and to the rare tight folds in bedding and S_1. Furthermore, shallow-dipping faults are subparallel to S_2 foliation. Most of these faults have demonstrably minor movement, but one along Clear Creek apparently floors an east-closing recumbent fold that is at least tens of feet in amplitude. This introduces the possibility of major thrusting (probably east-directed) or fold-nappe development in the study area. Gentle arching of lineations associated with the S_2 foliation may reflect differential strain during thrust (or nappe) development.

Although the cobalt-copper deposit at Blackbird mine is thought to be stratabound (Hughes, 1983), deformation of the Yellowjacket host rocks at the mine may be responsible for concentration of the cobalt-copper minerals in folds and shear zones (Vhay, 1948; Lopez, 1981). In light of this, the structures observed and inferred in the Yellowjacket Formation of the study area are potentially equivalent to mineralized structures at the Blackbird deposit.

Big Creek Formation

Poor exposure and limited areas of outcrop prevented an evaluation of folding within the Big Creek rocks. The metaquartzite (Ybc) occurs as allochthonous plates which have been placed over the Yellowjacket Formation and Proterozoic granite along a thrust or low-angle normal fault, as evidenced by brecciation and greatly disparate foliation (bedding) attitudes across the contact. The map pattern also demonstrates this conclusion. Subsequent steep faults, which account for all other Big Creek-Yellowjacket contacts in the Management Zone, have probably modified the dip of the basal dislocation surface.

Steep Faults

Northeast-southwest and east-west trending, steep faults control the exposure of the allochthonous metaquartzite (Ybc) and the Proterozoic granite (Yg). In the northwestern part of the area, the increase in metamorphic grade may have been accentuated by uplift along the steep faults, although an original increase in metamorphic gradient in that direction is also likely. Hughes (1983) suggested some of these faults may have been syndepositional with the Yellowjacket Formation and controlled sedimentation, volcanism, and ore deposition within the Yellowjacket basin. If correct, the movement on some faults was recurrent, as the youngest age of faulting is indicated by offset Cretaceous and Tertiary intrusive rocks.

GEOCHEMISTRY

By
Byron R. Berger, U.S. Geological Survey

Trace elements useful for the assessment of the mineral resource potential in the study area were identified through the sampling and chemical analysis of minus-80-mesh stream sediments within and around the study area. Seventy-nine samples originally collected by Cater and others (1975) and Knowles (1975) were reanalyzed and included with eighty-nine samples collected during the present study. Threshold values correspond to natural breaks in the distribution of values and generally were well above background levels.

Several suites of elements were noted for the study area; these suites correspond to major lithologic units or restricted mineralized zones within the major units. An association of cobalt, copper, and boron occurs in the Garden, Elkhorn, Cougar, and Indian Creek drainages; both Elkhorn and Indian Creek have known cobalt-copper mineralization. Arsenic is a common pathfinder element for cobalt systems, but few values exceeded the lower detection limit of 200 ppm for the analytical method used. However, a low relief arsenic anomaly trending northwest across the study area from Blackbird mine to the Salmon Canyon Copper Company mine is reported by Broxton and Beyth (1980) using the x-ray fluorescence method at a detection limit of 5 ppm. Nickel values above the detection limit (5 ppm) range from 10 to 30 ppm and appear to correlate with areas in which amphibolite or possible mafic tuffs crop out. An association of lead and tin occurs in the vicinity of Lick Creek and the lower reaches of Clear Creek, most likely reflecting the distribution of the Proterozoic granite.

Direct comparison of stream-sediment data from the study area and from the area of the Blackbird mine is difficult because available published data only cover areas peripheral to the mine. However, Bennett (1977) had several samples from streams that drain the north side of the ridge containing the Blackbird deposit; this area should be free of surface mine workings. Therefore, his reported cobalt values of 200-300 ppm probably reflect reasonable values for streams that drain the deposit but that have not been contaminated by mining activity. Comparable values (150-300 ppm) of cobalt in sediment from upper Garden Creek in the study area strongly suggest the presence of similar mineralization in that area.

GEOPHYSICS

A compilation of aeromagnetic studies (Zietz and others, 1978; and references cited therein) covers the study area and provides some useful information. On a regional scale there are two systems of intersecting troughs defined by contoured total magnetic intensity values; one set trends northwest-southeast, and the other is approximately perpendicular to it. The study area and the Blackbird mine lie in a single northwest-trending trough that is intersected near lower Clear Creek by a trough of the other set. These pronounced lows are in sharp contrast to the extreme high values over the Eocene Bighorn Crags pluton to the west, Napoleon Ridge area to the east, Painted Rocks pluton to the north, and other known Eocene granitic rocks in central Idaho. The low values forming these troughs in the aeromagnetic pattern do not seem to reflect any particular rock type but may instead follow major structures in this region. It is perhaps significant that the trends of the troughs parallel major faults in the study area and intersect approximately at the location of the gossans in lower Clear Creek.

MINING DISTRICTS AND MINERALIZATION

By
Leon E. Esparza, Michael S. Miller,
Paul A. Pierce, U.S. Bureau of Mines

There are no mines or mining activity within the study area, but as of 1982 there were at least 40 mining claims located mostly by Noranda Exploration, Inc. A few claims had been located prior to 1960 by other groups or individuals.

Because of the similarity of the geology of the study area with adjacent mining districts (fig. 1), a summary of the production record of the Mineral Hill, Mackinaw (Leesburg), and Blackbird mining districts is given in table 1. Nearly all production from the Blackbird district is from the vicinity of the Blackbird mine. Gold, silver, copper, and lead were mined mainly from the late 1800's and prior to the 1940's; cobalt was mined from the Blackbird district mainly in the early 1900's and in the 1950's. Mining in the Mackinaw and Mineral Hill mining districts is currently more active than in the recent past due to relatively high gold and silver prices. However, low copper and cobalt prices have tended to discourage mining for these metals, especially in the Blackbird district.

Mills and facilities for processing the cobalt and copper ores mined near the study area exist at the Blackbird mine. Other mills, for copper, gold, silver, and lead, exist in the Mackinaw and Mineral Hill mining districts.

Table 1.—Lode production from mining districts near Special Mining Management Zone—Clear Creek, Lemhi County, Idaho

U.S. Bureau of Mines unpublished production records and reports of the Idaho State Mineralogist (unpub. data, 1952-59). N indicates none reported

Mining district	Gold (troy oz x 1000)	Silver (troy oz x 1000)	Copper (lb x 1000)	Lead (lb x 1000)	Cobalt (lb x 1000)
Blackbird--	35	80	64,000	1	14,000[1]
Mackinaw---	2	6	74	114	N
Mineral Hill.	23	15	13	99	N

[1]Prior to 1940's, production of Blackbird district was 21.5 tons of cobalt from 618 tons of ore (Reed and Herdlick, 1947, p. 4).

GEOLOGY OF THE BLACKBIRD DEPOSIT

A useful method for evaluating the mineral resource potential of an area is to compare its geologic features to known ore deposits or generalized models assembled from study of such deposits. Unfortunately, known cobalt systems are relatively rare. Proximity of the Blackbird mine to the study area, however, suggests that consideration of the geology at the mine may be of use in interpreting the potential of the Management Zone. This section provides a brief summary of the cobalt-copper deposit at Blackbird mine and the various theories for its origin; comparison with the study area will be considered in the "Assessment of Mineral Resource Potential" section of this report.

Cobaltite and chalcopyrite are the main ore minerals found in the host Yellowjacket Formation at the Blackbird mine; minor ore minerals include gold, silver, and electrum (Anderson, 1947). Iron sulfides are common as pyrite and pyrrhotite. The ore is present as tabular and podiform bodies that persist down the structural plunge. Within these bodies mineralization occurs as disseminations, veinlets, and small layers. In addition, at least some of the tourmaline breccias contain cobaltite grains visible in hand sample. Much of the ore is obviously remobilized and apparently is concentrated along localized zones of increased schistosity (shear zones of Vhay, 1948).

Despite a number of investigations of the Blackbird deposit, there is no general consensus regarding the genesis of the ores. Most early workers proposed a replacement origin related to hydrothermal emanations from deep-seated Tertiary plutons (Anderson, 1947) or from Proterozoic granites exposed north of the mine (Cole, 1956; Bennett, 1977). A mafic igneous source is another possibility, based on Umpleby's (1913) observation of copper-cobalt-nickel minerals in a gabbroic dike. A considerably different explanation by Noranda Exploration, Inc. (Hughes, 1983) suggests that the cobalt-copper minerals were deposited syndepositionally on the seafloor with the Yellowjacket sediments. According to this model, features associated with the tectonic setting and mineralizing process include mafic volcanic tuffs and feeder(?) dikes, exhalative cherts, tourmaline breccias, and syndepositional faulting.

EFFECTS OF THERMAL HISTORY ON MINERALIZATION

By
Lawrence W. Snee, U.S. Geological Survey

Preliminary evaluation of the thermal history of the study area has been done using $^{40}Ar/^{39}Ar$ age-spectrum dating of selected samples, particularly as it relates to remobilization and concentration of the deposit at the Blackbird mine. A date that results from this technique represents the time at which an appropriate mineral cooled to its characteristic Ar-retention temperature—the temperature at which the particular mineral becomes a closed system to diffusion of argon. Thus, the method is ideal for thermal history studies.

In the study area and vicinity, two thermal sources have been revealed by $^{40}Ar/^{39}Ar$ age-spectrum dates on eight mineral separates from four samples. One thermal source, the Bighorn Crags pluton, is exposed at the southwest edge of the study area; the other source, located northeast of Shoup, is concealed. The exposed Bighorn Crags pluton was dated using biotite and potassium feldspar from one sample. The minimum age of this pluton is 48.5 m.y., and the dates support the geologic inference that the pluton is epizonal. Furthermore, the data show that the pluton was not reheated above 100°C after 47 m.y. ago. The concealed thermal source is inferred from $^{40}Ar/^{39}Ar$ age-spectrum data obtained from the other three samples. The analyzed mineral separates are muscovite, biotite, and potassium feldspar from a two-mica granite of the Idaho batholith located along the northeastern edge of the study area, muscovite and biotite from Proterozoic granite near Shoup, and hornblende from a Proterozoic mafic dike east of Shoup. This concealed source northeast of Shoup may coincide with a broad magnetic high that extends northwestward from Napoleon Ridge. The thermal activity is Eocene in age and it produced an aureole whose 150°C isotherm crossed the northeastern part of the study area; thermal effects from this aureole decrease southward. A large area was affected by this single thermal source as indicated by a gradient of approximately 300°C over a distance of 10 mi.

Geologic evidence suggests that concentration of the metallic minerals at the Blackbird mine was due to remobilization of early stratabound cobaltiferous units in the Yellowjacket Formation. Igneous activity in the Proterozoic, Cambrian, Ordovician, Cretaceous, and Eocene is known from geologic mapping, but the extent of thermal effects associated with most of these igneous events is unclear. The $^{40}Ar/^{39}Ar$ age-spectrum dates presented above, however, indicate that Eocene igneous activity produced strong thermal effects in the region. In the areas represented by the analyzed samples, the Eocene thermal event overprinted any earlier thermal effects. Because of this complexity and the lack of appropriate samples, the age of the thermal event(s) that concentrated the ore at the Blackbird mine is uncertain. Additional $^{40}Ar/^{39}Ar$ age-spectrum dating of appropriate samples from the vicinity of the mine has the potential to reveal when that area was thermally affected. Furthermore, additional thermal studies on a regional scale can facilitate the identification of potential zones of ore concentration elsewhere.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Introduction

The geologic setting of the study area is compatible with several types of ore deposits. Comparison of the geologic, geochemical, and geophysical data from the study area with similar data from known ore deposits of each type forms the basis for our mineral resource evaluation. The types suggested by the geologic setting are: (1) cobalt-copper, as at Blackbird mine; (2) porphyry-type copper-molybdenum, similar to prospects in southwestern Montana and east-central Idaho; (3) stratabound copper-silver as found in the Belt Supergroup, especially at the Troy (formerly Spar Lake) and Blacktail Mountain deposits; (4) stratabound lead-zinc as best known from Sullivan, British Columbia; and (5) epithermal precious-metal deposits associated with shallow Tertiary plutons (Bennett, 1980).

Terms for Assessment of Mineral Resource Potential

Areas given low potential for a certain deposit type have either anomalously high values for the element or suite of elements under consideration, or they have characteristics associated with a known deposit (or generalized model) of the appropriate type—but not both. These areas may be considered as marginally favorable.

Those areas with a moderate potential have anomalously high elemental values. In these areas, many of the important characteristics of a known deposit (or deposit model) are found while some other important characteristics may be missing. There will be no evidence of mining activity for this element or suite of elements although there may have been exploration interests. These areas are considered to be favorable.

Areas rated as having high potential have anomalously high values for the element or element suite and most of the characteristics to fit a known deposit (or deposit model). There will be spatial association with past or present mining districts that produced this element from a deposit which would fit the model under consideration. These areas are highly favorable.

Cobalt-Copper

The areas in the Management Zone underlain by the Yellowjacket Formation have high or moderate potential for cobalt-copper mineralization (fig. 2), based on the following: (1) rock units similar to those hosting the stratabound deposit at the Blackbird mine occur along strike to the northwest in the study area; (2) apparently stratabound cobalt mineralization similar in form to the Blackbird deposit is found along Elkhorn Creek; (3) geochemical anomalies similar to those around Blackbird are found at Elkhorn and upper Garden Creeks; and (4) the study area occurs in a northwest-trending belt of cobalt-copper mineralization that extends at least 37 mi from Iron Creek, through the Blackpine mine, Blackbird mine, and study area, to the Salmon Canyon Copper Company mine on the north side of the Salmon River.

The geochemical anomalies at Elkhorn and upper Garden Creeks, combined with lithology similar to the Blackbird deposit and cobalt mineralization at Elkhorn Creek, give these two areas a high potential for cobalt-copper deposits. The spatial coincidence of the rock units trending northwestward from the Blackbird mine to the study area and the belt of known cobalt occurrences indicate that the remaining areas of the Management Zone underlain by Yellowjacket rocks have a moderate potential for cobalt-copper deposits.

Copper-Molybdenum

A low potential for porphyry-type copper-molybdenum mineralization is assigned to an area along Clear Creek below Rancherio Creek and in upper Squaw Gulch, where bright reddish-orange gossans are developed in the Proterozoic foliated, nonporphyritic granite. Extensive stockwork fracturing, quartz and limonite veining, alteration (possibly potassic), disseminated magnetite mineralization, and the bleaching of originally dark-gray metasedimentary rocks to white "quartzites" are all features attributable to a porphyry-type hydrothermal system and suggest the presence of a buried Tertiary(?) pluton, even though geochemical anomalies were not found. A small exposure of what appears to be epizonal, Tertiary pink granite in a fault block at the mouth of Rancherio Creek provides added credence to this interpretation. The intersection of major regional structural trends inferred from aeromagnetic data and mapping may indicate some structural control. Molybdenum mineralization similar to that inferred here probably is present a few miles east of Panther Creek near the headwaters of Beaver Creek (Bennett, 1977) and at the Napoleon Ridge prospect yet further east near North Fork, Idaho (Bennett, 1980).

Copper-Silver, Lead-Zinc, and Precious Metals

The Yellowjacket Formation is probably equivalent to at least part of the Belt Supergroup (Ruppel, 1975), a very thick sedimentary sequence with many occurrences of stratabound copper-silver mineralization (Harrison, 1974). However, the study area has no identified potential for this mineral system because (1) appropriate geochemical anomalies are absent; (2) the red-bed/green-bed lithologies typical of the mineralized Belt rocks are missing; and (3) the Yellowjacket Formation most likely correlates with the Prichard Formation, one of the few Belt units which is devoid of copper-silver occurrences. Similarly, no identified potential is given for stratabound lead-zinc (a system hosted by Prichard-equivalent rocks at Sullivan, British Columbia) because of the total lack of a lead-zinc chemical signature associated with the Yellowjacket Formation. Finally, epithermal precious-metal deposits in Idaho are commonly associated with felsic Tertiary plutons (Bennett, 1980), such as the Bighorn Crags pluton which is located at the southwestern boundary of the study area. However, no potential is assigned to areas within the confines of the Management Zone because of the lack of both geochemical anomalies and geologic features such as alteration zones, fractures, veins, or mineralized host rocks.

REFERENCES CITED

Anderson, A. L., 1947, Cobalt mineralization in the Blackbird District, Lemhi County, Idaho: Economic Geology, v. 42, p. 22-46.

Armstrong, R. L., 1975, Precambrian (1,500 m.y. old) rocks of central Idaho—the Salmon River Arch and its role in Cordilleran sedimentation and tectonics: American Journal of Science, v. 275-A, p. 437-467.

Bennett, E. H., 1977, Reconnaissance geology and geochemistry of the Blackbird Mountain—Panther Creek region, Lemhi County, Idaho: Idaho Bureau of Mines and Geology Pamphlet 167, 108 p.

______1980, Granitic rocks of Tertiary age in the Idaho batholith and their relation to mineralization: Economic Geology, v. 75, p. 278-288.

Broxton, D. E., and Beyth, M., 1980, Uranium hydrogeochemical and stream sediment reconnaissance data release for the Elk City NTMS Quadrangle, Idaho/Montana, including concentrations of 45 additional elements: U.S. Department of Energy Open-File Report GJBX176 (80), 212 p.

Canney, F. C., Hawkes, H. E., Richmond, G. M., and Vhay, J. S., 1953, A preliminary report of geochemical investigations in the Blackbird district: U.S. Geological Survey Open-file report, 20 p.

Cater, F. W., Pinckney, D. M., Hamilton, W. B., Parker, R. L., Weldin, R. D., Close, T. J., Zilka, N. T., Leonard, B. F., and Davis, W. E., 1973, Mineral resources of the Idaho Primitive Area and vicinity, Idaho: U.S. Geological Survey Bulletin 1304, 431 p.

Cater, F. W., Pinckney, D. M., and Stotelmeyer, R. B., 1975, Mineral resources of the Clear Creek—Upper Big Creek study area, contiguous to the Idaho Primitive Area, Lemhi County, Idaho: U.S. Geological Survey Bulletin 1391-C, 41 p.

Cole, W. C., 1956, Geology of the Blackbird mine: Unpublished report, Calera Mining Company; available from Noranda Mining, Inc., Salmon, Idaho 83467.

Davidson, D. M., 1928, Geology and petrology of the Mineral Hill mining district, Lemhi County, Idaho: Minneapolis, Minnesota University Ph. D. thesis, 65 p.

Evans, K. V., and Zartman, R. E., 1981, U-Th-Pb zircon geochronology of Proterozoic Y granitic intrusions in the Salmon area, east-central Idaho: Geological Society of America Abstracts with Programs, v. 13, no. 4, p. 195.

Harrison, J. E., 1974, Copper mineralization in miogeosynclinal clastics of the Belt Supergroup, northwestern United States, in Bartholome, P., ed., Gisements stratiformes et provinces cupriferes: Liege, Societe Geologique de Belgique, p. 353-366.

Hughes, G. B., 1983, The basinal setting of the Blackbird District cobalt deposits, Lemhi County, Idaho: Denver Regional Exploration Geologists Society Symposium, p. 21-28.

Knowles, Charles, 1975, Reconnaissance geochemistry of the Bighorn Crags: Idaho Bureau of Mines and Geology Information Circular 26, 24 p.

Lopez, D. A., 1981, Stratigraphy of the Yellowjacket Formation of east-central Idaho: U.S. Geological Survey Open-File Report 81-1088, 209 p.

Maley, T. S., 1974, Structure and petrology of the lower Panther Creek area, Lemhi County, Idaho: Moscow, Idaho University Ph. D. thesis, 130 p.

Markland, G. D., 1974, Geologic map of the Blackbird Mine area: Calera and Idaho Mining Company report; available from Noranda Mining, Inc., Salmon, Idaho 83467.

Purdue, G. L., 1975, Geology and ore deposits of the Blackbird District, Lemhi County, Idaho: Albuquerque, New Mexico University M.S. thesis, 49 p.

Reed, G. C., and Herdlick, J. A., 1947, Blackbird cobalt deposits, Lemhi County, Idaho: U.S. Bureau of Mines Report of Investigations 4012, 37 p.

Roberts, W. A., 1953, Metamorphic differentiates in the Blackbird mining district, Lemhi County, Idaho: Economic Geology, v. 48, p. 447-456.

Ruppel, E. T., 1975, Precambrian Y sedimentary rocks in east-central Idaho: U.S. Geological Survey Professional Paper 889-A, 23 p.

Shenon, P. J., Full, R. P., Bauer, H. L., and Snyder, D. M., 1955, Geologic study of the Blackbird-Big Deer Creek area, Blackbird Mining District, Lemhi County, Idaho: Unpublished report for North Field Mines, Inc.; available from Noranda Mining, Inc., Salmon, Idaho 83467.

Shenon, P. J., Full, R. P., Snyder, D. M., and Bauer, H. L., 1955, Geologic study of the Blackbird-Big Deer Creek area, Blackbird Mining District, Lemhi County, Idaho: Unpublished report for Idaho Metallurgical Industries, Inc.; available from Noranda Mining, Inc., Salmon, Idaho 83467.

Sobel, L. S., 1981, A stratigraphic model for Precambrian-Y turbidites of central Idaho: Geological Society of America Abstracts with Programs, v. 13, no. 7, p. 557.

Umpleby, J. B., 1913, Geology and ore deposits of Lemhi County, Idaho: U.S. Geological Survey Bulletin 528, 182 p.

U.S Department of Energy, 1980, Aerial gamma ray and magnetic survey, Idaho project, Elk City quadrangle of Idaho/Montana, final report: U.S. Department of Energy, Grand Junction, Colorado, v. 11 (prepared by Bendix, Contract DE-AC13-76-GJ01664, subcontract 79-323-S).

Vhay, J. S., 1948, Cobalt-copper deposits in the Blackbird District, Lemhi County, Idaho: U.S. Geological Survey Strategic Mineral Investigations Preliminary Report 3-219, 26 p.

Zietz, Isidore, Gilbert, F. P., and Kirby, J. R., 1978, Aeromagnetic map of Idaho—Color coded intensities: U.S. Geological Survey Geophysical Investigations Map GP-920.