A Preliminary Report of

Geochemical Investigations in the Blackbird District

by

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General Introduction

This paper reviews an experimental geochemical prospecting survey in the Blackbird cobalt-copper mining district. The district is in east-central Idaho, about 20 miles west-southwest of Salmon. The area is one of deeply weathered nearly flat-topped upland surfaces cut by steep-walled valleys which are tributary to the canyon of Panther Creek. Most of the area has a relatively heavy vegetative cover, and outcrops are scarce except on the sides of the steeper valleys. Because of the importance of the surficial deposits and soils and the physiographic history of the region on the interpretation of the geochemical data, a separate chapter on this subject by Gerald M. Richmond follows the following brief description of the geology of the district.

Brief Outline of Geology

by J. S. Vhay

The rocks of the district consist mostly of interbedded quartz-biotite schist and fine-grained quartzite which are metamorphosed sedimentary rocks of the pre-Cambrian Yellowjacket formation (Belt Series). A part of the Cretaceous Idaho batholith and the associated porphyroblastic paragneisses cut across the northern part of the district. Acid porphyry dikes and strongly metamorphosed basic rocks cut the Yellowjacket rocks.

The important part of the district economically is the Blackbird structural block (see pl. 1), which is about two miles wide and extends south from the granite at least 7 1/2 miles, although the geochemical data suggest that the favorable part of the block pinches out going south, about at the West Fork of Blackbird Creek. This favorable structural block is separated from the rocks to the east and west by faults. The rocks within the block appear to have been more tightly squeezed than those outside it, with the development of relatively tight folds and thrust faults and of widespread schistosity. The rocks on either side of the Blackbird block are in more open folds and are in general less schistose. The northern part of the Blackbird block and of the country to the west contain garnet and chloritoid schists which are thrust southward over the quartz-biotite schist facies.

The Blackbird structural block is cut by a number of shear zones, many of which are mineralized. Those dipping moderately northeast and striking northwest and those dipping steeply and striking north and northeast appear to be the most important. The mineralized rock contains chalcopyrite, cobaltite, pyrite and pyrrhotite in a gangue of quartz, biotite, siderite, tourmaline and in places muscovite. The deposits were formed mostly by replacement of the shear zones and in many places consist of numerous plunging pods of high grade ore lying within much broader zones of low grade material. The formation of the cobaltite preceeded that of the chalcopyrite and in places one may be present without the other. In addition, the block is cut by north dipping thrust faults and a number of high angle faults which are not mineralized.

Weathering and oxidation are commonly deep. Where cobaltite and chalcopyrite or pyrite are both present the minerals are destroyed to a great depth, whereas if only one is present it may be found fairly near the surface, and, rarely, cobaltite can be found in outcrops. Even on steep slopes oxidation is fairly complete to a depth of more than 50 feet, and on the gentler upland surfaces it is presumably much deeper, perhaps exceeding one hundred feet, though no exploration has as yet been attempted there.

Although green copper minerals, like malachite, may be found in the oxidized zone if chalcopyrite is present in the primary ore, cobalt, even where present in the primary ore, is thoroughly leached in the zone of oxidation, at least as far as ordinary assay methods are concerned. This fact makes the geochemical prospecting methods described in this paper of special value in searching for cobalt deposits. Rarely two varieties of cobalt bloom are found in the district, generally where weathering has not destroyed all outcrops. Erythrite, the relatively insoluble hydrated cobalt arsenate has been found at a few places, and cobalt chalcanthite, hydrated cobalt sulfate, is found on outcrops as a pink efflorescense.

Hematite and goethite are abundant in the gossans. In addition, wherever cobaltite has been present in the unoxidized ore, its oxidation has formed a group of minerals of yellowish to greenish color, which though containing extremely little, if any, cobalt, are good indicators of the former presence of cobaltite; these minerals include the arsenates scorodite and pitticite (?), as well as jarosite, nontronite and probably others as yet unidentified. One or more of these minerals occurs in the oxidized zone either as solid masses or as a yellowish or greenish stain on porous sugary quartz.

The geochemical technique described in this paper has already proved its value, inasmuch as in October 1951 a company started exploring the Merle zones, where high cobalt anomalies were found, and by bulldozing have shown several strongly mineralized zones trending northwest and north to be present; the bulldozing has been followed by diamond drilling and underground exploration which is proving that the zones are continuous at depth.

Geology of Surficial Deposits and Soils

by G. M. Richmond

The study of the relation of soil profiles to the surficial deposits on which they are formed and to erosional unconformities has led to the recognition that soils formed during each of the several interglacial intervals of the Pleistocene. The soil of any one age, of course, tends to differ markedly from place to place, depending on local differences in the environment under which it developed, such as climate, slope, drainage, and vegetation. However, under any given conditions of environment, there are broad differences in degree of development and extent of weathering between soils of different age that are coincident with their stratigraphic position. These broad differences, inherent in soils of different age, appear applicable to geochemical prospecting of surficial deposits, especially to the interpretation of anomalies obtained from these deposits and from the soils developed on them. This subject is only in an experimental stage, but the results so far attained seem to justify three general conclusions:

1. The interpretation of geochemical anomalies from surficial deposits depends to a large extent on a knowledge of the origin and source of the deposits.

2. The relative magnitude of geochemical anomalies obtained from soil profiles depends in part on the degree of development of the profile.

3. A knowledge of the relative stratigraphic position of a soil is helpful in interpreting geochemical anomalies because of its apparent coincidence with relative degree of development.

Physiographic setting

The area concerned includes about 8 square miles along Blackbird Creek and on the upland to the north. This upland is a rolling ancient erosion surface sloping northeast from 8,000 feet altitude along its southwest margin to 7,000 feet along its northwest margin, at an average gradient of about 500 feet per mile. Steeper knobs rise along the southwest margin.

The valleys of Blackbird Creek and its tributaries are steep-walled with slopes ranging from 15° to over 35°. The valleys are V-shaped with no indication of having been glaciated. However, glacial deposits are known to exist in many parts of the Salmon River Mountains.

Surficial deposits

Four kinds of surficial deposits were examined in the area: talus, creep mantle, frost stirred mantle, and block fields. Four ages of accumulation were recognized: pre-Wisconsin Pleistocene, early Wisconsin, late Wisconsin and Recent. The deposits may be described in two general groups: those formed on the relatively gentle upland slopes and those formed on the steep-sloped valley walls. In addition, in the valley bottoms are at least two sets of gravel terraces which were not examined during the reconnaissance.

Surficial deposits of the uplands

Tertiary deposits.—No deposits or soil profiles of positive Tertiary age were identified, nor was any evidence found by which the age of the erosion surface might be ascertained, except that it preceded the development of the oldest probable Pleistocene deposits in the area. In places certain layers in the bedrock have been completely disintegrated and oxidized to a depth of more than six feet. These weathered layers are overlain unconformably by a frost-riven creep mantle, probably of pre-Wisconsin Pleistocene age, that contains fresh rock fragments. The weathering of the bedrock may be older than the overlying mantle and therefore possibly of Tertiary age but could also have occurred beneath the mantle, beginning at any time and continuing up to the present.

Geochemical prospecting of these deposits would yield values reflecting conditions in the bedrock in the immediate vicinity.

Pre-Wisconsin frost-riven creep mantle.—Along the well-drained western rim of the upland, bedrock is overlain by an unsorted mixture of rock fragments, sand, micaceous silt and clay, commonly at least 8 to 10 feet thick. The clay content varies somewhat from one locality to another. Minor lenses and streaks of fine subangular gravel are present locally. The material is compact and has a platy parting structure essentially parallel to the land surface. The rock fragments range from unaltered to deeply disintegrated, with the preponderance of disintegrated fragments in the upper part of the deposit. Fresh material becomes more abundant downward and in places grades into large closely spaced fragments that have been only slightly disturbed from their original position in fractured bedrock. The deposit is interpreted as a frost-riven mantle that is essentially in place except for a small amount of creep in its upper part.

This mantle is dark red in color, ranging from 10 R, 3/6 through 2.5 YR 3/6 to 5 YR 4/8. The color together with the increasing abundance of weathered rock fragments and clay in the upper part of the deposit suggests that the full thickness of the deposit has been affected by soil profile development under climate conditions unlike those of the present.

Geochemical prospecting in this red creep mantle would yield values reflecting the relative conditions of bedrock immediately beneath, or only a short distance upslope.

Over many parts of the upland the red mantle appears to be lacking and an olive-gray (5Y, 4/2) compact frost riven creep mantle of rock fragments, sand, micaceous silt and clay overlies bedrock. Except for color this olive-gray mantle resembles in all respects the red mantle. The ground water table over much of the upland is near the surface and drainage is generally poor. It is entirely possible that the olive-gray mantle is the poorly drained equivalent of the red mantle and that its color is the result of reduction under high water-table conditions. It is also possible that the red mantle at one time overlay the whole surface but has been locally stripped.

Geochemical prospecting of olive-gray mantle would probably yield relatively low values on the whole, but areas in which relative "highs" are obtained might indicate that conditions in the bedrock beneath are comparable to those indicated by relative "highs" in the red mantle.

A pre-Wisconsin Pleistocene age for these deposits is based on two kinds of evidence: (a) The character of the material and its relation to bedrock suggest that it was formed by frost riving, frost stirring, and creep under glacial climatic conditions. (b) The color, degree of weathering, and clay development of the soil profile formed on the deposit is similar to other datable pre-Wisconsin Pleistocene soil profiles in the Rocky Mountain region and is very unlike any known datable Wisconsin or younger soil profiles.

Early Wisconsin frost-stirred mantle.--Overlying the red mantle and the olive-gray mantle over much of the upland is a deposit of rock fragments, sand and micaceous silt, with minor amounts of clay, that is 3 to 5 feet thick. Deeply weathered fragments are not as abundant as in the older red mantle. The color of the deposit is brown to olive (10 YR, 5/3 - 5Y, 5/4). The material is loose, friable, and unsorted; it commonly lacks structure, though in a few places streaks and thin lenses of poorly sorted debris and an imbricate arrangement of slabby fragments indicate that a minor amount of downslope movement has taken place. The contact with the underlying older red or olive-gray mantles is commonly sharp and even, but is locally gradational with small clots of the older mantle occurring in the brown above the contact. In a few places the contact is sharp and involuted through a depth of about a foot, suggesting a common movement of the material above and below the contact under saturated conditions.

The brown mantle is considered to be derived from the red or olive-gray mantles by frost stirring under saturated conditions in a glacial climate. The material thus reworked became loose and friable, and lost its red color through reduction beneath the ground water table. The underlying older mantle may have been frozen during this interval, or more probably, because of its compact nature, perched the water table.

A relatively thin soil profile 12 to 24 inches thick is developed on the brown mantle. It consists of a humus horizon 4 to 6 inches thick underlain by an oxidized horizon having a dark brown color (7.5 YR 4/4 to 10 YR, 4/4) that is 8 to 18 inches thick.

Geochemical prospecting at the surface of the brown mantle would yield values reflecting the relative conditions in bedrock immediately beneath or only a short distance upslope. According to geochemical data these values are in general considerably lower than those obtained in the red mantle. Comparison of values in these two materials should be avoided because the brown mantle, derived by frost stirring of the red, has undoubtedly lost some of its cobalt content in the process. Because of this, relative "highs" encountered in the brown mantle would normally be lower than "highs" in the red. Similarly low or background values in the brown mantle would be lower than "lows" in the red. Relative "highs" in the brown mantle should not be overlooked in prospecting nor considered to be less important than relative "highs" in the red mantle.

The age of the brown mantle is believed to be early Wisconsin largely because of the relative degree of maturity of the soil profile developed on it. The profile is much less well developed than that of the older red soil and is considerably better developed than younger soil profiles in this area. In these respects it is similar - both in relative degree of development and in relative stratigraphic position to a mid-Wisconsin (Tazewell-Cary interval) soil profile that has been positively dated in other areas in the Rocky Mountains.

Surficial deposits of the steep-sloped valley walls

Early Wisconsin talus.—Stable soil-covered and vegetation-covered talus derived from cliffs and ledges along the valley walls. The material consists of blocky or slabby angular rock fragments with relatively few fines. There is little apparent sorting with depth in the deposit but a definite tendency for the material to be coarser near the toe and finer near the head of the deposit. Sufficient ~~soil~~ mantle has accumulated in the upper part of these deposits to support a forest, brush, or grassy cover.

Geochemical prospecting of these deposits would yield values reflecting relative conditions in surface or near-surface bedrock at the head of the deposits.

Early Wisconsin frost-riven creep mantle.--Stable, soil-covered and vegetation-covered angular rock fragments, sand, and micaceous silt with some clay. The material is locally sorted into crude textural gradations or bedding that trend down slope from their bedrock source and may locally be folded. The more permeable zones have been stained with iron oxide deposited from ground water passing through them.

The deposits are 3 to 20 feet thick and lie unconformably on frost riven bedrock. The upper 3 to 5 feet of the deposits has been mixed or stirred by frost heave so as to destroy the crude bedding of the creep mantle.

Geochemical prospecting of individual layers in the crudely bedded creep mantle would require exposures at least 3 feet deep. Such prospecting would probably reflect in detail the relative conditions in specific and probably recognizable layers in the bedrock upslope. It is estimated that this material has probably moved less than 100 feet.

Early Wisconsin frost-stirred mantle.--Stable, soil-covered and vegetation covered mantle 3 to 5 feet thick composed of angular rock fragments, sand, micaceous silt and some clay. The material shows no sorting or textural gradation. It formed essentially in place on either the frost-riven creep mantle or on frost riven rock.

Geochemical prospecting at the surface of these deposits would yield values reflecting conditions in the rock immediately beneath--if the deposit is developed on frost riven rock. If the deposit is developed on frost riven creep mantle, geochemical prospecting of the surface material would reveal composite values for the creep mantle beneath, which is estimated to be derived from bedrock less than 100 feet upslope.

These three types of deposits are end members of a three-way gradational series, but can be readily distinguished in most places. Their importance to geochemical prospecting is that the talus is derived from surface or very near surface bedrock exposures upslope; the creep mantle is derived from buried bedrock exposures upslope; and the frost stirred deposits are nearly in place.

An early Wisconsin age is postulated for these deposits because of the relative degree of development of the soil profile formed on them as compared to demonstrably younger and older soil profiles in the area. This profile is similar in its relative degree of development to known mid-Wisconsin soil profiles (formed during the Tazewell-Cary interval) elsewhere in the Rocky Mountain region. The soil profile changes character (but not in relative degree of development) with altitude. In the vicinity of the Panther Creek Inn (5,200 feet altitude) it consists of a thin (6" to 8") humus horizon, a 12" to 18" intermediate horizon leached of lime, and a lower 3 to 4 foot horizon of lime accumulation in which lime coats the lower side of the rock fragments and mottles the matrix. This profile becomes progressively less calcareous with increasing altitude and in the vicinity of the Blackbird mill consists of 4" to 6" of humus overlying an oxidized horizon 6" to 18" thick in which the particles are thinly coated with iron oxide (color-10 YR 4/3 to 10 YR 4/4). At this altitude (6,700 feet) no horizon of lime accumulation is present in the profile.

Glassy volcanic ash occurs as local pockets 10 to 18 inches thick near the top of the early Wisconsin deposits beneath or within the zone of soil development. The presence of this ash might locally mask the true values of the deposits in surface geochemical prospecting. However, the ash is readily identified and not particularly thick.

Late Wisconsin talus.--Stable, lichen covered talus with little other vegetation. Weak soil development on wind blown silt or other fine material partly filling the interstices of blocky to slabby fragments that compose the deposit. No apparent sorting of the debris in section, but a tendency for the material to be coarsest near the toe of the deposit.

Late Wisconsin block fields.--These deposits look at first glance like talus. They are composed of coarse blocky or slabby rock fragments at the surface but the material tends to become finer with depth to fine gravel size material at the base of the deposit. Locally the interstices near the surface are filled with wind blown silt. These deposits contrast with talus slopes in surface form in that they may be inclined at angles well below the angle of repose of the material in them, and in that they have characteristically lobate fronts, in many places bordered by low ridges termed ramparts. In addition there is no evidence for cliffs or near surface rock exposures at their head. They are believed to have developed in older soil-covered mantle or on frost riven bedrock by frost-stirring and washing out of the fines. Essentially they have formed in place with a minimum of down slope movement, though there are many deposits intermediate in origin between talus and block fields.

Geochemical prospecting of these block field deposits would yield values that reflect the conditions immediately beneath in the parent mantle or bedrock rather than upslope as in talus. Care should be taken in sampling to avoid wind blown slits that locally fill the interstices in the upper part of the deposit.

The age of these talus accumulations and block fields is believed to be late Wisconsin for two reasons. (1) The deposits are formed on, and transect the soil profile formed on deposits believed to be of early Wisconsin age. (2) The soil development on interstitial fines beneath the surface of these deposits is weaker in its degree of development than either of the two older soil profiles in this region. In this respect it is similar to soils that have formed continuously since the end of Wisconsin time elsewhere in the Rocky Mountains.

Recent active deposits:--The only active surficial slope deposits in the area are small talus accumulations showing no soil or vegetation development. Geochemical prospecting of these deposits would yield values reflecting conditions in surface or near-surface bedrock at the head of these accumulations.

Conclusions applicable to geochemical prospecting

The following general conclusions appear to be applicable to geochemical prospecting in the Cobalt district. It is realized that they have not yet been fully tested and that a thorough comparison of geochemical data with stratigraphic data is essential to their proof.

1. Knowledge of the source of a surficial deposit is essential to interpreting the bedrock source of anomalous high values found in the deposit.

2. Values obtained from the pre-Wisconsin red and olive-gray creep mantles should not be compared with values obtained from the other deposits or soils.

3. Values obtained from any of the Wisconsin or post-Wisconsin deposits and soils can probably be compared except as the deposits are derived from pre-Wisconsin deposits and soils. For example, values obtained from the early Wisconsin creep mantle developed on the pre-Wisconsin red creep mantle should probably not be compared with values obtained from the early Wisconsin creep mantle developed on rock. It is possible, assuming uniform values in the parent materials, that the values obtained from the mid-Wisconsin soil may be slightly lower than those obtained from younger deposits and soils because of increased leaching of cobalt from the older and more strongly developed soil. Such differences, however, are probably small and possibly within the limits of error of the test methods.

Geochemical Investigations

by F. C. Canney and H. E. Hawkes

Ore bodies resemble ordinary rocks in that both are subject to destruction once they are brought into the zone of weathering by erosional processes. It is to be expected then that residual soils forming over a mineralized area should contain greater percentages of the ore metals than would be found in soils forming over the non-mineralized country rock. Previous investigations by the Geological Survey over known ore deposits have indicated that this seems to be generally true. In fact, except for one or two trivial examples, no area has been found yet that failed to show a chemical anomaly in residual soil derived from a known ore deposit. The areas over mineralized zones where the soils or rocks contain abnormal concentrations of the ore metals are known as chemical halos or "anomalies". The degree of concentration of an ore metal in the soil is dependent upon many factors such as the grade of the ore deposit, the chemical nature of the element in question, the chemistry of the soil zones involved, the composition and pH of the soil, etc. Geochemical prospecting is the search for concealed ore deposits by attempting to locate these chemical "anomalies" in the surficial materials. This involves the systematic sampling and chemical analysis of such materials as soils, alluvium, water or vegetation.

The Blackbird district was selected as the best location to test the feasibility of a geochemical prospecting method for cobalt for several reasons. First, it is the only active mining district in the United States where cobalt is one of the major ore metals. Second, prospecting in the area is hampered by a scarcity of outcrops due to a thick blanket of essentially residual soil. Therefore, should a geochemical prospecting method for cobalt be proved feasible, a new method of prospecting would be available to the property owners to aid them in the development of the district and possibly help increase the reserves of this strategic metal. Third, a large part of the area is essentially undisturbed although desultory mining operations have been conducted in the area for about the past 50 years. It was not believed that these past mining operations as well as exploration work during World War II had contaminated the soil except perhaps in small areas along Meadow Creek.

The writers are indebted to all the property owners on whose ground work was done, for permitting and facilitating the investigation. In particular, grateful acknowledgment is made to the staff of the Calera Mining Company who furnished maps of the area, space for a field laboratory, and otherwise aided the writers in many ways.

Sampling

Sample spacing

The decision on the proper spacing of sample stations for reconnaissance-type traverses was made after conducting preliminary orientation studies on the saddle northwest of the main Calera ore zone and around the Sunshine mine. These studies indicated that a spacing of 100 feet between sample points would be adequate for all reconnaissance work, and this was the spacing adopted. The results of subsequent work verified that this spacing was adequate to detect any significant anomalies, because many of the major anomalies found had widths of 500 to 1,000 feet. In fact, a sample spacing of as much as 200 feet would have been adequate in many areas.

Location of sample stations

Three general schemes of locating sample stations were used in this investigation:

Arbitrary coordinate system.--Traverses were on N. 60° E. lines, and sample stations were located at fixed horizontal intervals, generally 100 feet, without regard to topography. N. 60° E. traverses were chosen because the more important mineralized shear zones generally have a northwesterly to north strike. All sample stations were surveyed with a metallic tape and Brunton compass. Abbreviated coordinates of each station on this type of a traverse were marked generally on a nearby tree or rock. Thus a station located 1,000 feet southeast and 3,700 feet northeast of the zero point of the coordinate system would be marked 10 S. 37 E. The horizontal interval of 100 feet between stations on sloping ground was maintained by estimating the angle of slope and then roughly calculating the correct distance to measure along the slope. With very few exceptions, excellent horizontal closures were obtained. Wherever possible sample locations were tied into points that had been accurately surveyed by the Calera Mining Company. The main disadvantage of this type of traverse is that different portions of a traverse are subject to slightly different interpretations due to varying topography along the line of traverse.

Ridge crest traverses.--The majority of the long reconnaissance traverses in the southern portion of the district (pl. 2C) were of this type. This type of traverse has three distinct advantages. First, soils on ridge tops are more nearly in place than are soils on the sides of steep-walled valleys. The metal content of ridge crest soil samples therefore will reflect more nearly the conditions in the bedrock directly underlying the sample station. Second, in thickly wooded areas, such as are common in the Blackbird district, the ridge crests tend to be somewhat freer of thick underbrush and debris, thus making for easier and faster sampling. Third, the plotting of sample stations is facilitated; this is particularly important in areas where accurately located control stations are scarce or entirely lacking. The reconnaissance traverses shown in plate 2C were facilitated by the presence of fire roads along the ridge crests.

Detailed grid systems of various types.--Grid patterns and spacing of sample points varied from problem to problem. This type of detail was generally adopted when there was visible evidence of mineralization at some point such as an old caved adit, trench with gossan exposed, or an exposed shear zone, and it was desired to determine the strike and strength of any possible mineralized zone. The general scheme adopted was to place the caved adit or pit in the approximate center of a square or system of concentric squares of sample points. The detailed grid around Chelan no. 43 discovery pit (pls. 2A and 4C) is a good illustration of this type.

Collection of samples

All soil samples, if at all possible, should be collected from the same soil horizon for the sake of uniformity. Preliminary experiments were conducted to determine what horizon would give the best picture. The results of these experiments indicated that the composition of a small sample taken at a depth of 6 to 9 inches was actually representative of a much larger volume of surrounding soil. In the Blackbird district, as pointed out in the section by G. M. Richmond, the upper parts of the soil profile have been thoroughly churned up and mixed by Pleistocene frost action, and this is undoubtedly the reason why a small sample will in effect be a composite sample. All samples therefore were taken at a standard depth of 6 to 9 inches, in the top of the dark-brown oxidized horizon immediately below the humus horizon. Nonresidual soils were rarely encountered although in a few scattered localities the material sampled looked suspiciously like wind-blown silt or stream sediment. Very local and easily recognized deposits of volcanic ash were also encountered.

Field procedure

The majority of samples were collected by two-man teams. On reconnaissance traverses, the lead man would keep the compass line, dig the sample hole at the proper distance with a folding Army-type foxhole shovel, and mark the station location on a convenient tree or rock with weatherproof crayon. The end man would take the sample and record any necessary notes. All samples were stored in 2-ounce cardboard cylinders which proved satisfactory except for the very occasional wet sample that caused the container to become unglued. To prevent duplication of sample numbers, a consecutive series of sample numbers was printed on a strip of gummed tape. When a sample was taken, the proper number was torn off from the coil of tape and pasted on the sample container; the tape also served to fasten the cover to the rest of the container, thus preventing spilling of samples in the storage knapsack.

In a full day of continuous work by two men, the number of samples spaced 100 feet apart which could be collected ranged from approximately 50 in very rugged and heavily timbered terrain to as many as 150 where the traverse lay along roads or open ridge crests.

Sample preparation

The samples as collected were generally too damp for immediate sieving. Therefore all samples were brought back to the base camp unsieved and allowed to dry. The samples were usually dry enough to sieve within a day or two without removing them from the containers.

All samples were sieved through an 80-mesh stainless steel sieve and the minus 80-mesh fraction saved for analysis.

Analysis of samples

Cobalt and copper being the two major ore metals in the district, all soil samples were analyzed for these two metals, using the rapid colorimetric field tests developed by the U. S. Geological Survey. The copper analyses followed the procedures described by Stevens and Lakin (1949). During the first half of the field work the samples were analyzed for cobalt according to the methods described by Almond and Bloom (1951); the new test described by Almond (1953) was used for the remaining samples.

The majority of samples were sent to the Denver laboratory of the U. S. Geological Survey for analysis. The only samples analyzed by the writers in the field laboratory were those where immediate results were desired for various reasons. These samples were later reanalyzed in the Denver laboratory.

All analyses in the Denver laboratory were performed by the following group of chemists: Mr. Harold Bloom, Mr. Harry E. Crowe, Mr. Albert P. Marranzino, and Mr. J. Howard McCarthy.

Interpretation

Background

The normal or average concentration of an ore metal in soil must be determined before a decision can be made as to what constitutes abnormal concentrations. This can generally be accomplished by determining the metal concentration in residual soils from unmineralized areas where the general geologic setting is similar to that in the mineralized areas. The determination of a true background metal value is sometimes complicated though by the presence of a primary dispersion of ore metals occurring throughout a large mass of rock surrounding the ore deposits. This may make it necessary to go many thousands of feet away from known mineralized zones before true background values can be obtained. This was true in the Blackbird district where a large area was found to have an abnormal concentration of cobalt in the soil, thus indicating the probable presence of a primary cobalt halo. The approximate outline of this halo is indicated in plate 1. Within the halo area the average concentration of cobalt in the soil is 100 ppm, and the median value is 70 ppm. Outside this areathe average and median values are both approximately 20 ppm. Thus for interpreting what constitutes abnormal concentrations of cobalt in the soil, two separate values had to be used. Within the halo area background cobalt values were considered to be 40 to 50 ppm, whereas outside of the area this value dropped to about 10 to 20 ppm.

The copper values show that there is also a copper halo in approximately the same location as the cobalt halo, although the copper picture is not as well defined. In addition, an area shown in the west-central section of plate 1 has high copper values in the soil but only background cobalt. This indicates that the cobalt and copper patterns do not always coincide.

Traverses across a known zone

The best known mineralized zone in the district at the present time is the Chicago-Brown Bear zone, which lies along the east side of Meadow Creek for more than 3,000 feet. Three traverses, AA^1, BB^1, and CC^1 in plate 2B were run across this zone to assess the magnitude and extent of the anomaly in the soil over a mineralized zone of commercial grade. Abnormal concentrations of cobalt and copper were found in all three traverses although the sharpest cobalt anomaly was along traverse B. The anomalies were not as sharp as had been anticipated but they were definite enough that the existence of a mineralized area would have been suspected even though no advance information on its location had been available. The anomaly found along traverse BB^1 is extremely interesting in that its peak occurs on the hillside a considerable distance above the projected surface expression of the Chicago-Brown Bear zone. Huff who made a preliminary geochemical study in this district in 1950 also made the same observation and noted that this hillside would be a good place for further prospecting.

Reconnaissance traverses

The major reconnaissance traverses undertaken were along the ridge crests between Blackbird Creek and the West Fort of Blackbird Creek (pl. 2C), and the long northeasterly traverse from a starting point near the Sunshine shaft (pls. 1, 2A, and 2B). The ridge crest traverses detected a zone of abnormal cobalt and copper values in the soil that trends in a southeasterly direction from the central part of the district as far as the West Fork of Blackbird Creek.

Detailed studies

The majority of the detailed studies are shown in plates 3 and 4. In connection with these detailed studies it was found that the cobalt content of composite samples of fine material from the dumps of old gold prospects and of more recent "discovery" pits gave an excellent qualitative idea of the probability of associated cobalt mineralization. In the detailed studies where enough samples have been taken, making a rough isograd map of the values gives some indication of the shape and trend of the deposit. On some of the detailed studies, although scattered anomalous values were found, an insufficient number of samples were taken to give a picture of the probable shape and trend of possible deposits, and many more samples would have to be taken before a decision could be reached.

The two most successful detailed studies from the point of view of finding apparently strongly mineralized zones are the Sunshine (pl. 3) and Merle details (pl. 2B). In both of these studies, areas were found where the cobalt concentration in the soil was much higher than in any location over the Chicago zone. Whether this indicates higher grade deposits or whether conditions were such that less leaching of the cobalt from the soil profile took place cannot be determined at the present time.

A preliminary interpretation of the results in the Sunshine detail points to the presence of two mineralized pods which on the basis of geology are believed to plunge to the north. A small amount of rich cobaltite ore was seen on the dump of the Sunshine shaft. Another interesting feature in this detail is the very sharp break between the area containing abnormal concentrations of cobalt and copper and the area to the west where only normal (?) background concentrations prevail.

In the Merle area, located in the east central part of the area on the ridge lying between the two forks of Little Deer Creek, the presence of wide, strongly-mineralized, northwesterly trending zones is indicated. The only previous indications of mineralization here had been the presence of small amounts of cobaltite in the outcrop above a discovery pit and evidence of shearing in a nearby roadcut.

The detailed grid northwest of the main Chicago-Brown Bear zone (pl. 2B) was an attempt to prove a northwesterly extension of the main ore zone. Although certain areas covered by the grid system were found to contain abnormal concentrations of cobalt and copper, the over-all picture is somewhat clouded, and it is not possible to make any positive interpretation at this time. It is believed that some landslide material here has complicated the picture. However, trenching by the Calera Mining Company in the extreme northwestern section of the area covered by the grid system on the basis of the geochemical values did uncover evidence of strong mineralization in several locations. This evidence included a 5- to 6-foot wide vertical zone of gossan material which must have contained at one time a considerable proportion of heavy sulfides, another zone which contained a large pod of rich cobaltite ore, and a third zone where considerable quantities of native copper and cuprite were present.

At the Alice K prospect (pl. 4A) the fan of geochemical samples was laid out to cover the possible extension of the mineralized rock as observed in an outcrop. The background cobalt values obtained suggest that the mineralized zone dies out going northwest, but there is a possibility that the trend of the zone is more northerly than is indicated in the outcrop, in which case the sampling missed it.

The detailed studies at the Deuce, Dewey, Harding and Northeast zone prospects, all located along the north fork of Little Deer Creek (pl. 2B) were attempts to determine the size and continuity of possible bedrock deposits. The Northeast zone (pl. 4B) gives a very weak indication of a zone trending about N 40° E, if cobalt values of 50 ppm and 60 ppm can be taken as significant, which is rather doubtful. The cobalt values shown on plate 4D, the Harding prospect, and on plate 4E, the Deuce prospect, are not enough above background to be significant. The copper values, however, suggest a faint northwest trend for the Harding, and a west-northwest trend for the Deuce, although the Deuce prospect is believed to lie on the northerly extension of a north-south zone of shearing. Plate 4F, the Dewey prospect, with only one cobalt value of 120 ppm significantly above background, shows either that only a small pod of mineralized rock occurs there, or that many more samples need to be taken.

The results shown on plate 4C at the Chelan 43 prospect are difficult to interpret, because although there are a number of samples containing 100 ppm cobalt and three showing 150 ppm, they are somewhat scattered and interspersed with lower values. There is a suggestion of a northeast trending zone, but this is not confirmed on the larger grid around the area (shown on pl. 2A) which has a faint suggestion of north and northwest trending zones. To the southeast at the Dusty prospect (pl. 4G) the geochemical picture shows fairly well a broad zone of weak anomalies trending between northwest and north-northwest, and straddling the upper prospect hole at which some cobalt minerals can be found. Of further interest for geochemical prospecting would be the ground between this area of anomalies and that around the Chelan 43 prospect.

Conclusions

1. In the Blackbird district, there appears to be a reliable correlation between the cobalt content of soil and known cobalt mineralization. Cobalt anomalies over known ore ranged from 100 to 300 ppm with only very occasional samples exceeding 300 ppm.

2. The cobalt content of small soil samples taken at 6 to 9 inches depth and at 100-foot intervals will give an indication of any important mineralized zone occurring along the line of traverse.

3. The presence of a large primary cobalt halo is indicated by a large area enclosing almost all the known cobaltite occurrences where the background value for the cobalt content of the soil is approximately 40 to 50 ppm. Outside of this area, the background value drops to about 10 to 20 ppm.

4. In parts of the district, the variation in the copper content of the soil parallels the cobalt content; elsewhere the cobalt and copper patterns appear to be independent.

5. The cobalt content of composite samples of the fine material from the dumps of old prospects in the district appears to be a fairly reliable qualitative measure of the likelihood of associated cobalt mineralization.

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