GEOLOGICAL SURVEY CIRCULAR 607

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Washington 1968

United States Department of the Interior
WALTER J. HICKEL, *Secretary*

Geological Survey
William T. Pecora, *Director*

First printing 1968

Second printing 1969

*Free on application to the U.S. Geological Survey, Washington, D.C. 20242*

# CONTENTS



# ILLUSTRATIONS



# TABLES

# PLATINUM AND ASSOCIATED ELEMENTS AT THE NEW RAMBLER MINE AND VICINITY, ALBANY AND CARBON COUNTIES, WYOMING

By P. K. THEOBALD, Jr., and C. E. THOMPSON


## ABSTRACT

Platinum-group metals in the Medicine Bow Mountains were first identified by W. C. Knight in 1901. In the Medicine Bow Mountains, these metals are commonly associated with copper, silver, or gold in shear zones that cut a series of mafic igneous and metamorphic rocks. At the New Rambler mine, where the initial discovery was made, about 50,000 tons of mine and mill waste contain an average of 0.3 percent copper, 7 ppm (parts per million) silver, 1 ppm platinum plus palladium, and 0.7 ppm gold. This material is believed to be from a low-grade envelope around the high-grade pod of complex ore that was mined selectively in the old workings.

Soil samples in the vicinity of the New Rambler mine exhibit a wide range of content of several elements associated with the ore. Most of the variation can be attributed to contamination from the mine workings. Even though soil samples identify a low-level copper anomaly that persists to the limit of the area sampled, soils do not offer a promising medium for tracing mineralization owing to the blanket of transported overburden.

Stream sediments, if preconcentrated for analysis, do reveal anomalies not only in the contaminated stream below the New Rambler mine, but in adjacent drainage and on Dave Creek. Examination of a spectrum of elements in heavy-mineral concentrates from stream sediment may contribute to knowledge of the nature of the mineralization and of the basic geology of the environment.

The sampling of bedrock exposures is not particularly fruitful because outcrops are sparse and the exposed rocks are the least altered and mineralized. Bedrock sampling does, however, provide information on the large size and provincial nature of the platinum-rich area. We feel that a properly integrated program of geological, geophysical, and geochemical exploration in the Medicine Bow Mountains and probably in the Sierra Madre to the west has a reasonable probability of successfully locating a complex ore body.


## INTRODUCTION

The New Rambler mine is in the Centennial mining district, near the crest of the Medicine Bow Mountains in Albany County, Wyo. The mine is shown on the topographic map of the Keystone quadrangle (U.S. Geol. Survey 7.5-minute series, 1961) where, on editions with the green overprint, the extent of the treeless scar surrounding the mine and millsites may be seen. On this map the abbreviated name "Rambler mine" is used though we prefer to use the name New Rambler in order to distinguish this mine from the Doane-Rambler mine in the Encampment mining district of the next range to the west. The name of the townsite, Holmes, that served the mine is perpetuated in the title of the Holmes Campground, southeast of the mine.

The crestal area of the Medicine Bow Mountains at this latitude has a subdued, wooded topography with rounded ridge crests rising to 9,500–10,000 feet in altitude. The mine is at an altitude of 9,700 feet. Bedrock geology is largely obscured by a thick cover of forest litter that generally rests on an additional cover of Tertiary or Quaternary gravels. Emmons (1903) visited the area while active prospecting was at a peak and noted that the prospectors had to dig through "6 to 16 feet of wash" in order to sample bedrock.

Knight (1901) first called attention to the platinum at the New Rambler mine and noted previous knowledge of platinum in placer mines in the area and of the association of platinum with "blue copper ore"—covellite. Wells and Penfield (1902) isolated and identified sperrylite in the covellite. Read (1905) verified the identification of sperrylite and isolated native platinum and gold at the same time. He further noted that the ratio of palladium to platinum in the raw ore is 5:1 and that the severe KCN-$HNO_3$-caustic soda leach utilized to isolate the platinum minerals put all the palladium into solution. Finch (1925) appears to have discouraged further interest in the district by his statement that dikes had not been valuable platinum producers elsewhere in the world.

We were attracted to the area by the need to test in the field an analytical procedure for the determination of platinum-group metals in geologic materials. The presence of sperrylite ($PtAs_2$) at the New Rambler mine lent this area to indirect evaluation through established analytical procedures for the determination of arsenic. The subsequent development of the platinum method (Thompson, 1967) and the near ubiquitous presence of platinum and palladium in our samples from the New Rambler mine and vicinity led us to examine several methods of geochemical exploration for the elements and environment found and prompted this summary of our findings.

## GEOLOGY AND MINERAL DEPOSITS

The geology of the area is well outlined as a result of work by graduate students under Prof. R. S. Houston at the University of Wyoming. In particular, an unpublished map made available to us by M. E. McCallum provides an excellent summary of the geology of the east-central part of the Medicine Bow Mountains. A highly generalized form of this map is the basis for figure 1. Two reports of the Geological Survey of Wyoming (McCallum, 1968; McCallum and Orback, 1968) provide more detailed geologic descriptions of the Centennial Ridge mining district, northeast of the New Rambler mine, and of the immediate environment of the New Rambler mine. These reports should be consulted for more complete descriptions of the mines as well as of the geology.

Mineralized rock is concentrated along zones of intense cataclastic deformation that culminated in the formation of shear zones composed largely of phyllonite and mylonite. Platinum metals are most abundant in these zones where the host rocks are mafic to ultramafic metaigneous varieties. McCallum recognized an older and a younger group of Precambrian mafic rocks. The older group, comprising three of his large map units,

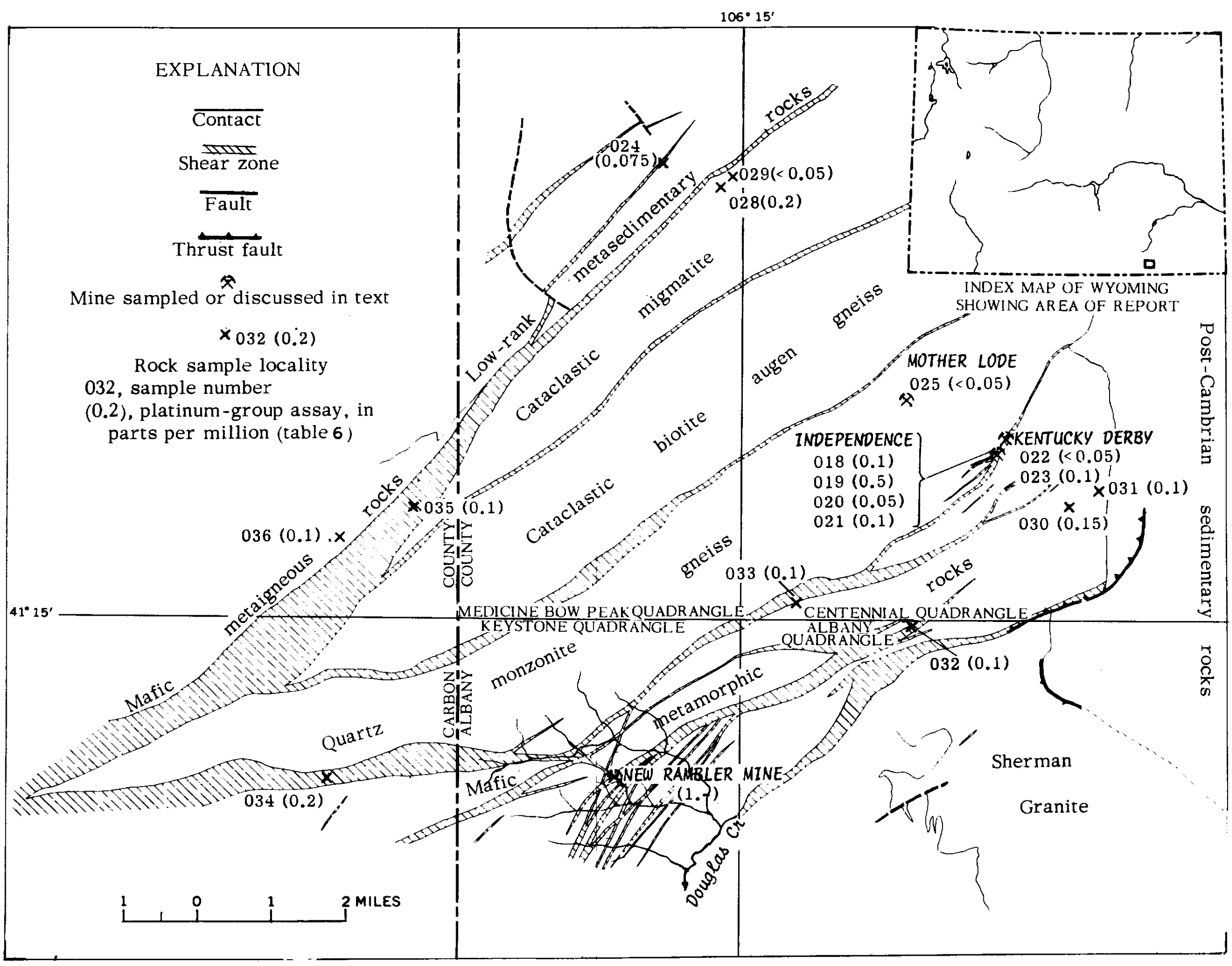


FIGURE 1.—Simplified geologic map of Precambrian rocks in the east-central part of the Medicine Bow Mountains. (Modified from M. E. McCallum, unpub. map, 1964.)

includes a "lime-silicate" assemblage, "gabbroic material," and a variety of unassigned hornblende- or pyroxene-rich metamorphic rocks. This group is confined to the area south and east of the conspicuous shear zone extending in figure 1 from the Kentucky Derby and Independence mines south and west through sample localities 033 and 034. The younger group is more widespread and generally less metamorphosed. McCallum identified these rocks as metadiorite, metagabbro, metapyroxenite, metabasalt, and metaandesite. They form an extensive, generally chloritized, mass along the west edge of the mapped area (fig. 1), occur as dikes and sills throughout the older group, form extensive sills in other rocks along the east and north boundaries of the mapped area, and commonly are included within what may be a younger group of shear zones.

The extensive cover of Tertiary and Quaternary gravels, not shown in figure 1, was subdivided into three general units by McCallum: (1) glacial deposits of Pinedale(?) and Bull Lake(?) age, (2) Pliocene(?) and Pleistocene quartzite boulder gravel, and (3) Miocene(?) and Pliocene(?) cobble-to-boulder gravel, composed chiefly of mafic rocks. The first of these surficial units is largely confined to the northern third of the mapped area, where it obscures most of the bedrock geology. The second mantles much of the upland south of the glacial deposits. The third appears to be confined to a few square miles in the extreme northwest corner of the Sherman Granite shown in figure 1. Placer deposits may have accumulated in the preglacial gravels.

The most productive mine of the district was the New Rambler, which is located at a complex intersection of shear zones in the older group of mafic rocks (fig. 1). At this intersection, younger mafic rocks appear to be somewhat more abundant and in larger masses than usual. The mine workings are inaccessible, but an excellent description of the generally podlike masses of high-grade carbonate- and sulfide-copper ores is given by Read (1905). On the basis of disconnected statements reported between 1901 and 1918, we surmise that the pod of ore was zoned downward from the oxidized zone through covellite to chalcopyrite and then to tetrahedrite. Taft (1918) listed recorded production at 7,000 tons of ore which contained 17 percent copper. He gave as a "typical assay": 5 percent copper and 0.02 oz (ounce) gold, 1 oz silver, 0.4 oz palladium, and 0.6 oz platinum per ton. The ratio of palladium to platinum indicated by this assay is 2:3 and thus differs markedly from the ratio of 5:1 estimated by Read (1905) and from the ratios we have found in the mine waste. Finch (1925) listed assays of seven samples from the district; five samples contained no detectable platinum metals, but when included with the other two, yield an average of 0.04 oz platinum and 0.05 oz palladium per ton.

The present areal distribution of mine waste and workings is given in figure 2. Water issuing from a shaft at the toe of the mine dump has coated the stream channel with malachite for 500 feet downstream.

## ANALYTICAL PROCEDURES

Analytical procedures for the metals other than the platinum group are those currently in use in geochemical exploration. Gold and silver were estimated by atomic absorption, tellurium, by the catalytic method of Lakin and Thompson (1963); and the remainder of the metals, by colorimetric field methods, as described by Ward and others (1963), or by standard semiquantitative spectrographic methods. The method used for determination of platinum plus palladium has been described by Thompson (1967) and is based on separation of platinum-group metals by precipitation with tellurium and estimation of their concentration by the catalytic effect of these metals in the reduction of molybdophosphoric acid to molybdenum blue. The precision of the method may be estimated from the comparison of analyses of five samples from the New Rambler mine waste shown in table 1. Differences between the results for individual samples may be due largely to sampling error because separate splits of the original sample were used. The generally higher results by Joseph Haffty's method reflect a more complete extraction of the platinum metals by much more thorough digestion. The analyses of platinum and palladium given in this report are considered to represent a minimum content of these metals.

Analyses for gold, like those for the platinum metals, often give erratic results owing to sampling errors. A measure of this variation is provided in table 2 in which gold analyses are given for two splits of each of the samples.

## SAMPLING AND ANALYSIS OF MINE WASTE, NEW RAMBLER MINE

The locations of samples reported in tables 1 and 2 are shown in figure 2. The boundaries of the

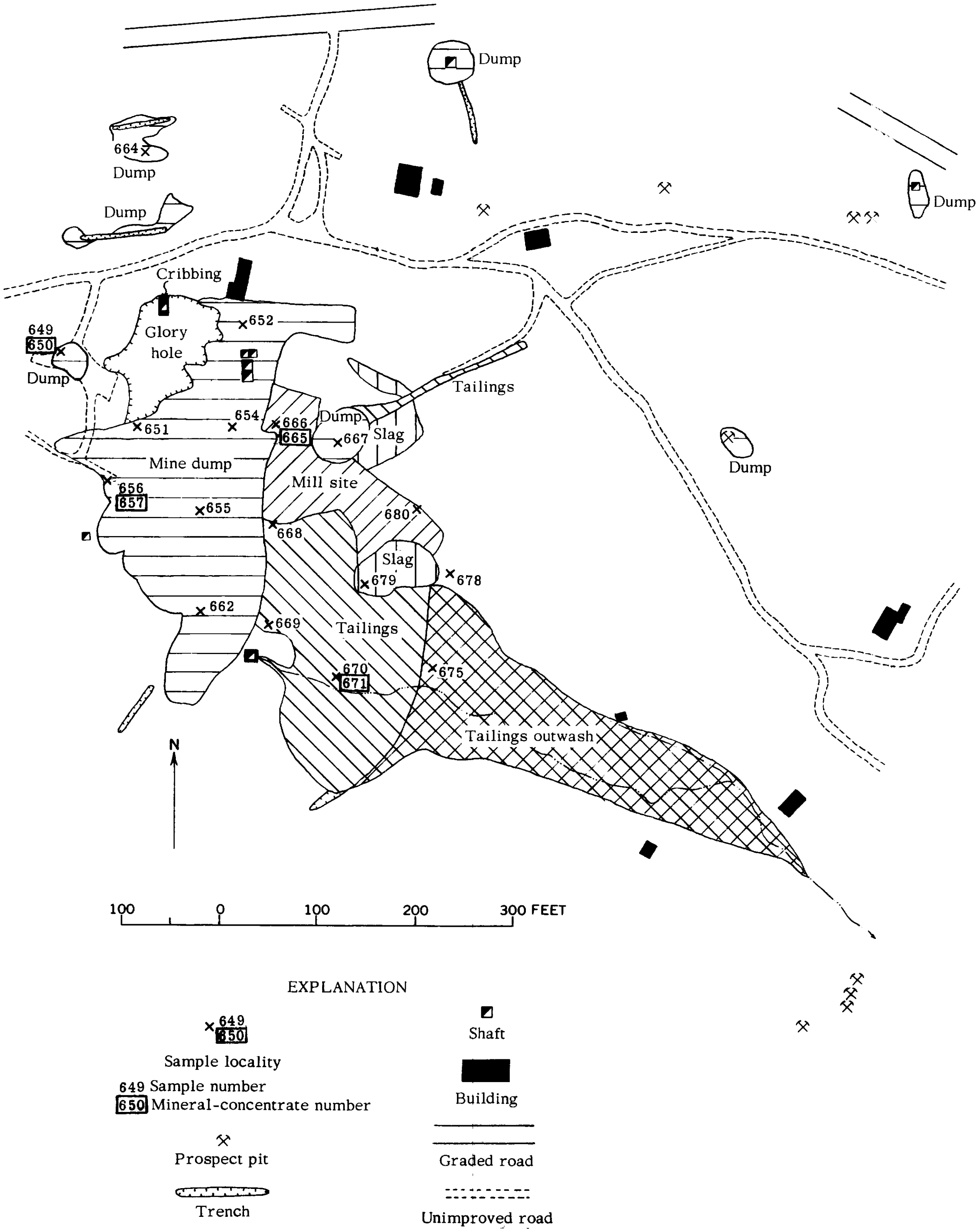


FIGURE 2.—Map of mine waste in the vicinity of the New Rambler mine.

TABLE 1.—*Comparison of content of platinum plus palladium, in parts per million, of five samples of mine waste from the New Rambler mine, as determined by three analytical procedures*

| Sample No. | Platinum plus palladium | | | |
|---|---|---|---|---|
| | 1 | 1 (repeat) | 2 | 3 |
| AAE 655 | 0.4 | 1<br>1.2 | 0.5 | 0.82 |
| 656 | 1.7 | ---- | 5.3 | 10.1 |
| 666 | 1.0 | >2<br>3 | 1.7 | 3.9 |
| 667 | 6.0 | .9<br>.4 | .3 | .82 |
| 668 | 2.5 | ---- | 3.7 | 4.0 |
| Average | 2.3 | ---- | 2.1 | 4.0 |

1. Catalytic method of C. E. Thompson.
2. Electrolysis and X-ray fluorescence method of J. S. Wahlberg.
3. Fire-assay and emission-spectrographic method of Joseph Haffty.

waste materials from which these samples were taken were generally well defined. The coarse mine waste forms prominent ridges radiating from the working shafts; smaller mounds of debris are present around outlying shafts, trenches, and prospect pits. Several ages of material are evident from the main workings; older, oxidized waste is generally to the west and is partially covered by less altered material to the east and south. Samples taken in the millsite area are mostly debris that filtered through the floor of the now-missing building. The slag-strewn areas around the millsite indicate that a minor amount of smelting was done, but the quantity of slag is insignificant in comparison with that of the coarse mine waste and mill tailings. The mill tailings, south of the millsite and confined on the east by a cribbed dam, consist of white, uniform, very fine grained stratified sand. The dam is breached at several places and a long cone of sand extends downstream from the mill tailings. Below the area of figure 2, the stream draining the mine area is confined to a narrow canyon, and deposits of mill tailings are insignificant. On the flood plain of Bear Creek, at the mouth of this canyon, a broad fan of outwash from the tailings has accumulated. The total amount of mine and mill waste is estimated to be about 50,000 tons.

Analytical data for the samples of mine waste are presented in table 2. Grab samples of about 300 g (grams) were taken at each locality. Metals that were found to be of potential commercial interest were copper, silver, platinum, palladium, and gold. The variety of materials represented seemed to influence only slightly the overall variation for these elements. The relative proportions of the two principal platinum group metals were determined for the five samples used as analytical control in table 1 and are given in table 3. The average ratio of palladium to platinum was 5:1 by the fire-assay and emission-spectrographic (Haffty) method and 8:1 by the electrolysis and X-ray fluorescence (Wahlberg) method. Comparison of these results with statements concerning shipments and assays when the mine was active leads to the conclusions that: (1) copper was selectively mined and effectively concentrated, (2) a sizable halo of low-grade material, now represented by the mine waste, bordered the high-grade material, and (3) the milling process was ineffective for separation of gold and the platinum group. The overall averages for these elements indicate that the mine and mill waste constitutes a potential resource in itself. Furthermore, if this waste material consists largely of rock removed to gain access to the ore body, it is possible that an additional sizable volume of similar material still remains in the mine workings.

Tellurium, particularly, and arsenic are sufficiently abundant in the tailings so that they may provide useful information as indicator elements for geochemical exploration. Molybdenum is slightly more abundant than normal. Neither zinc nor lead appears to be significantly enriched; the single lead-rich sample from the millsite probably reflects contamination from litharge.

Additional data on the mine waste are provided by spectrographic analyses. Of the 27 elements sought, five were consistently below the limits of sensitivity: arsenic <200, antimony <100, tungsten <50, indium <100, cadmium <20. An additional five elements were found in only one or two samples: tin <10, except 700 ppm (parts per million) in sample 652 and 300 ppm in sample 666; bismuth <10, except 10 ppm in sample 680; beryllium <1, except 1 ppm in sample 678 and 3 ppm in sample 737; niobium <10, except 10 ppm in samples 678 and 737; and lanthanum <20, except 70 ppm in sample 737. Evidently, samples 678 and 737 are relatively rich in felsic components. Five elements also reported in table 2 were determined spectrographically, and the results verify those determined chemically. Analyses for two of these elements, copper and silver, are shown in figure 3 and have sufficient spread to enable comparison between chemical and spectrographic precision. Average values obtained from the spectographic analyses, 5,000 ppm copper and 10 ppm silver, are similar to those given in table 2.

TABLE 2.—*Analyses of mine waste from the New Rambler mine*

[Analyses by C. E. Thompson, reported in parts per million. Platinum plus palladium, determined by method 1 of table 1]

| Sample No. | Copper | Silver | Platinum plus palladium | Gold: 2-g sample | Gold: 10-g sample | Arsenic | Tellurium | Molybdenum | Lead | Zinc |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Coarse mine tailings in main mine area | | | | | | |
| AAE 651 | 2,000 | 7.8 | 3.5 | <0.1 | 1.3 | 40 | 8 | 15 | <25 | 25 |
| 652 | 1,200 | 55 | 3 | .9 | 3.0 | 10 | 25 | 15 | 50 | <25 |
| 654 | >6,000 | 1.5 | .1 | .3 | .4 | 60 | 1 | <5 | 25 | 50 |
| 655 | 2,000 | 1.0 | .4 | <.1 | .2 | 30 | 2.5 | <5 | <25 | 25 |
| 656 | 1,000 | 14 | 1.7 | .9 | 2.5 | 30 | 2 | 10 | <25 | 25 |
| 662 | 3,000 | 2.0 | .5 | .8 | .5 | 40 | 20 | <5 | <25 | 25 |
| 667 | 1,200 | 1.8 | 6 | .7 | .2 | 30 | 2.5 | 5 | 25 | 50 |
| | | | | Coarse mine tailings in outlying piles and mines | | | | | | |
| 664 | 80 | 1.0 | 0.2 | 0.2 | 0.04 | 10 | 0.25 | <5 | 25 | 25 |
| 649 | >6,000 | 2.8 | .4 | .9 | 1.0 | 30 | 2.5 | <5 | <25 | 50 |
| | | | | Millsite debris | | | | | | |
| 666 | 2,000 | 7.2 | 1.0 | 2.6 | 0.3 | 120 | 13 | 5 | 750 | 25 |
| 680 | 2,000 | 4.2 | 1.6 | .1 | .5 | 160 | 15 | <5 | 25 | 25 |
| | | | | Mill tailings | | | | | | |
| 668 | 2,000 | 4.5 | 2.5 | 0.3 | 0.9 | 80 | 13 | 10 | <25 | 25 |
| 669 | 2,000 | 2.2 | .3 | 1.6 | .2 | 30 | 4 | 5 | 25 | 25 |
| 670 | 1,000 | 2.8 | 1.0 | .6 | .3 | 60 | 7 | 5 | <25 | 25 |
| | | | | Outwash from mill tailings | | | | | | |
| 675 | 2,000 | 1.8 | 0.8 | 0.8 | 0.3 | 40 | 7 | <5 | <25 | 50 |
| 678 | 1,000 | .5 | .4 | .5 | .02 | 10 | .1 | <5 | <25 | 25 |
| | | | | Slag | | | | | | |
| 679 | >6,000 | 3.8 | 0.7 | 1.5 | 0.08 | <10 | 1.3 | 5 | <25 | 75 |
| Average | 3,000 | 7 | 1.1 | .8 | .7 | ---- | ---- | ---- | ---- | ---- |
| | | | | Outwash from mill tailings on Bear Creek flood plain | | | | | | |
| 737 | 600 | 0.8 | 0.6 | 0.3 | 0.06 | 20 | 0.5 | <5 | <25 | 50 |
| 738 | 2,000 | 4.8 | 2.0 | .1 | 1.0 | 80 | 7 | 5 | <25 | 50 |

Analytical data for the remaining 12 elements are summarized in the histograms in figure 4. The six ferride elements of the upper tier of histograms are enriched, as expected from both the mafic environment and the copper-platinum association in the ore deposit. In this group, only the concentration of nickel approaches economic significance. Concentration of the six elements of the lower tier of histograms is near normal. The range for zirconium is exceptional and the lower limit is abnormally low. Zirconium appears to have a negative correlation with the ore metals, but the correlation is not statistically significant in these samples.

In order to compare analyses of heavy-mineral concentrates and bulk samples, concentrates were prepared by panning four samples of about 10 pounds each from localities in the mine waste. The concentrates represent about a thousandth part of the original sample. In table 4, analyses of these concentrates are compared with analyses of the

TABLE 3.—*Platinum and palladium contents, in parts per million, in five samples of mine waste from the New Rambler mine*

| Sample No. | Method 2 (Wahlberg): Palladium | Method 2 (Wahlberg): Platinum | Method 2 (Wahlberg): Ratio | Method 3 (Haffty): Palladium | Method 3 (Haffty): Platinum | Method 3 (Haffty): Ratio |
|---|---|---|---|---|---|---|
| AAE 655 | 0.4 | 0.1 | 4 | 0.58 | 0.24 | 2.4 |
| 656 | 5 | .3 | 17 | 9.2 | .91 | 10 |
| 666 | 1.5 | .2 | 7.5 | 3.2 | .67 | 4.8 |
| 667 | .3 | <.03 | >10 | .68 | .14 | 4.9 |
| 668 | 3 | .7 | 4.3 | 2.7 | 1.3 | 2.1 |
| Average | 1.8 | 0.26 | 8 | 3.3 | 0.65 | 4.8 |

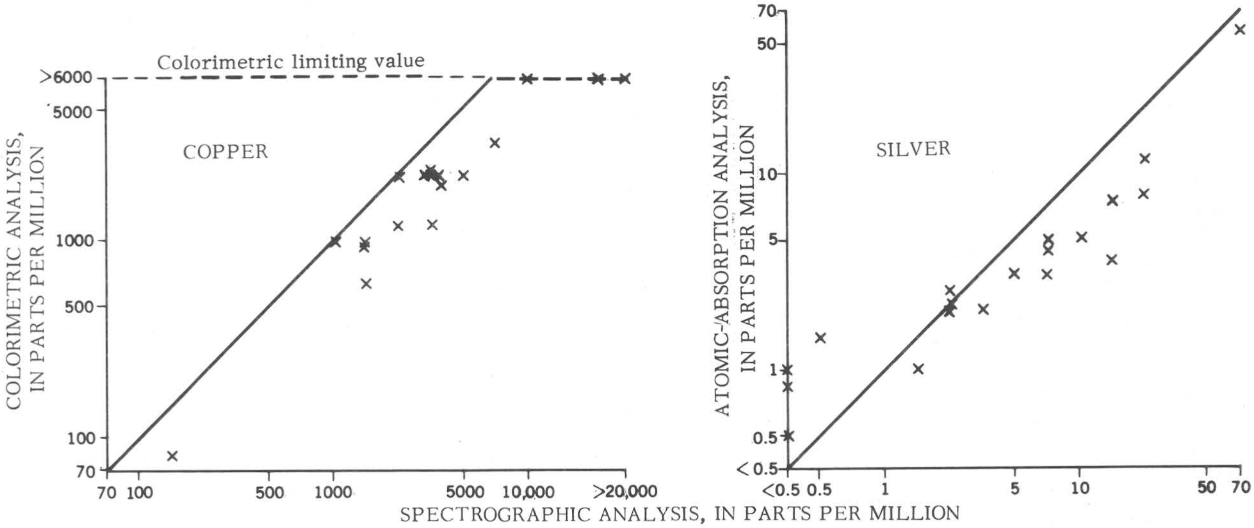


FIGURE 3.—Comparison of spectrographic analyses for copper and silver with analyses by colorimetric and atomic-absorption methods.

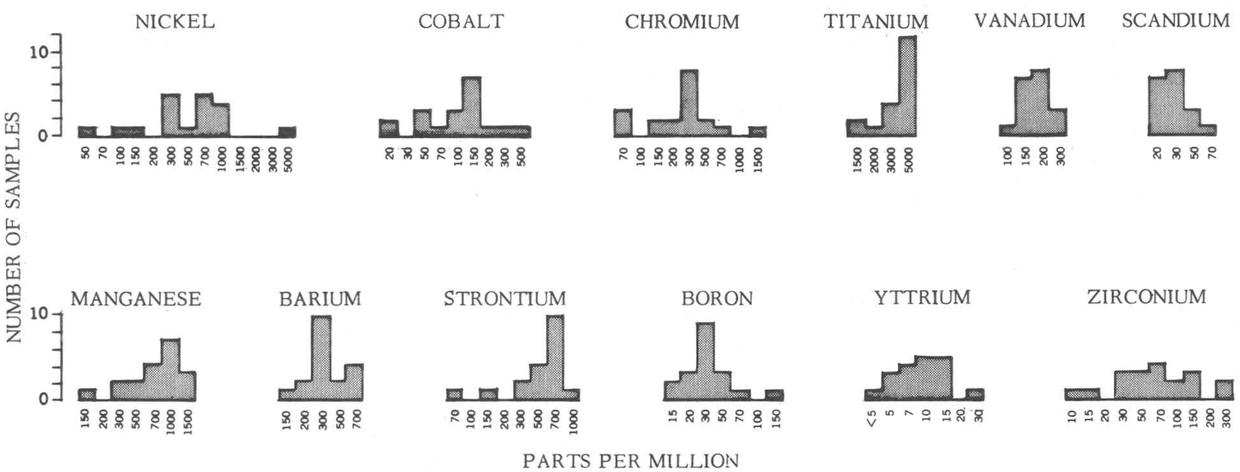


FIGURE 4.—Histograms of spectrographic determinations for selected elements in mine waste at the New Rambler mine. Analyses by D. J. Grimes.

bulk sample from the same locality. Of the four elements determined, only the gold approaches a hundredfold enrichment. Platinum plus palladium is enriched only by a factor of 10 or less, indicating that our efforts to concentrate these metals gravimetrically were no more successful than many other attempts have been in the Centennial district. We suspect, as did Read (1905) in his experiment, that we may have concentrated only the platinum and that the palladium was lost in the waste. It is difficult to establish whether arsenic and tellurium were concentrated at all.

## SAMPLING AND ANALYSIS OF SOILS

Soil samples, 52 in number, were collected during mapping of the mine waste at the New Rambler mine in order to assess soils as a medium for geochemical exploration. As has been noted, a nearly continuous, thick mantle of debris obscures bedrock on the upland surface. Blocks of white quartzite throughout the surficial debris were transported from sources miles to the north and northwest. Virtually all outcrops of bedrock

TABLE 4.—*Comparison of analytical data for bulk samples and heavy-mineral concentrates from the New Rambler mine*

[Analyses of bulk samples and all platinum determinations by C. E. Thompson. Heavy-mineral concentrates, analyzed by R. L. Turner and Eric Welsch for arsenic and tellurium and by R. L. Turner and J. B. McHugh for gold. All analyses reported in parts per million]

| Sample No. | | Platinum plus palladium | | Gold | | Arsenic | | Tellurium | | Weight of concentrate (grams) | Material sampled |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bulk | Heavy mineral | Bulk | Heavy mineral | Bulk | Heavy mineral | Bulk | Heavy mineral | Bulk | Heavy mineral | | |
| AAE 649 | AAE 650 | 0.4 | 3 | 1.0 | 67 | 30 | 60 | 2.5 | 25 | 3 | Mine tailings. |
| 656 | 657 | 1.7 | 2 | 2.5 | 160 | 30 | 40 | 2.0 | 12 | 2 | Do. |
| 666 | 665 | 1.0 | 19 | .3 | 38 | 120 | 80 | 13 | 10 | 19 | Millsite debris. |
| 670 | 671 | 1.0 | 4 | .3 | 12 | 60 | (1) | 7 | 2 | 4 | Mill tailings. |

[1] Insufficient sample.

are in artificial exposures. Soils offer the only reasonably continuous sampling media.

The soils are poorly developed and consist generally of a surface coating of forest litter and a thin humic layer, resting on the oxidized surface of the poorly sorted surficial mantle. Samples were collected from the oxidized zone beneath the humus at depths of from 2 to 8 inches. These were passed through 10- and 80-mesh sieves and the coarsest fraction was discarded. Two size fractions, −10 +80 mesh and −80 mesh, were ground and analyzed for copper, silver, platinum plus palladium, gold, arsenic, tellurium, molybdenum, and zinc. The results are summarized in figure 5. There was little difference in the distributions of analyses for the two sieve fractions; therefore, only that of the finer fraction is discussed.

The ranges obtained for the eight determinations, except for copper, are slight. As expected from analyses of the mine waste, neither molybdenum nor zinc exhibits more than background concentrations. Significant anomalously high values are evident for all the other elements determined despite the small range. For copper the overall distribution and range are unusual. Figure 6 shows the distribution of copper, as related spatially to the mine and mine waste, and the localities of anomalous values for the other elements. The major part of the anomaly can be explained by contamination from the former mining operations. Only the relatively low-level (less than 100 ppm) copper anomaly still incompletely defined to the east and west of the area sampled would seem likely to reflect a high copper content

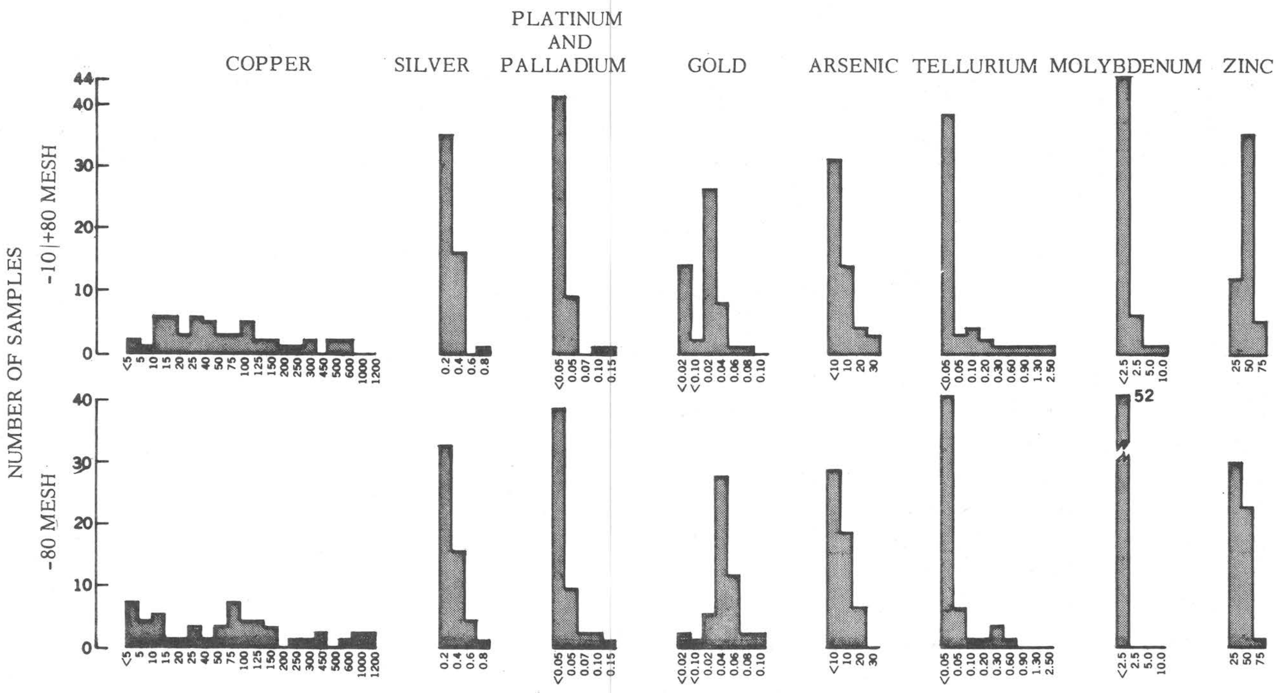


FIGURE 5.—Histograms of analyses of metal content of soils in the vicinity of the New Rambler mine. Analyses by Allan Meier, C. E. Thompson, Eric Welsch, R. L. Turner, J. B. McHugh, and James Watteson.

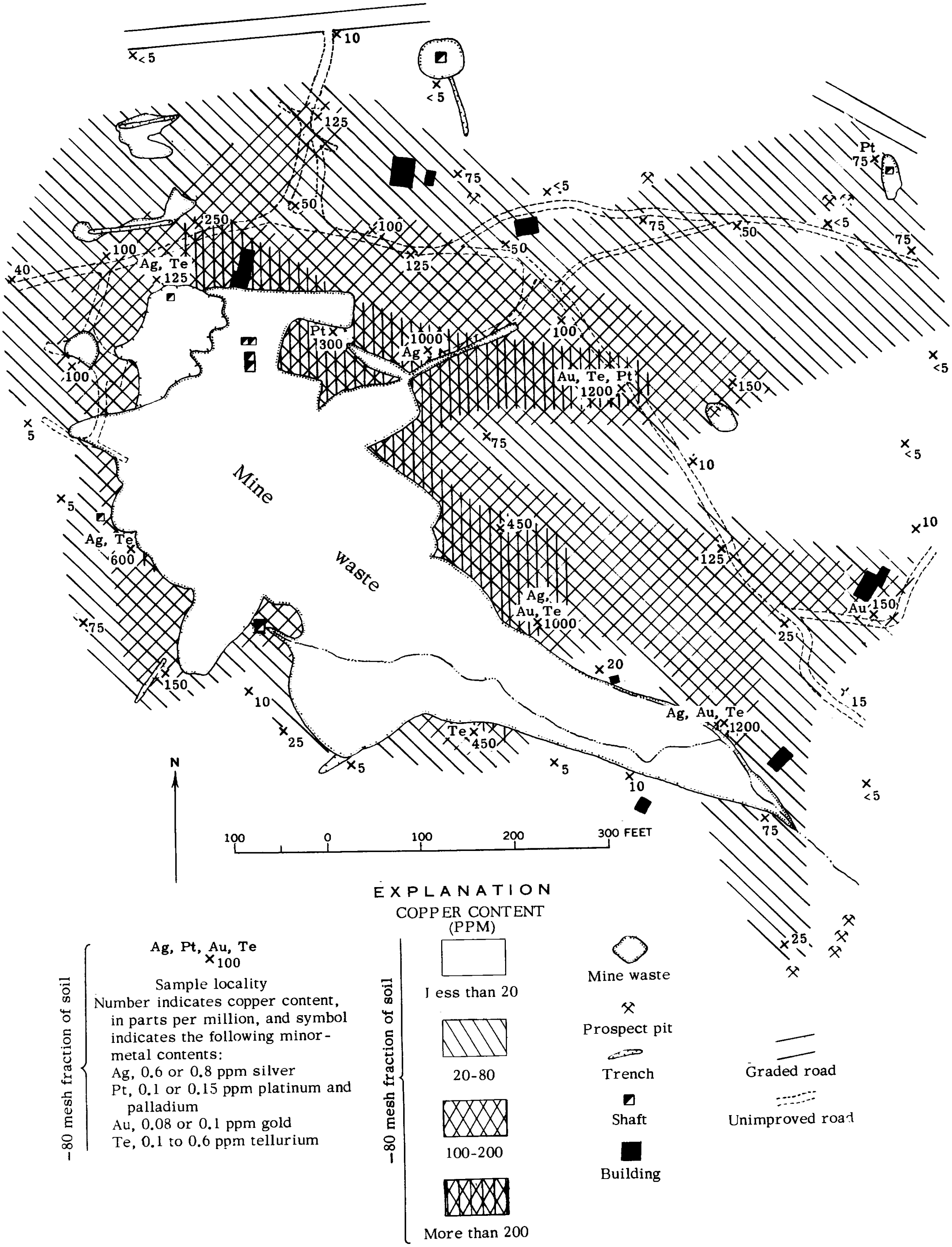


FIGURE 6.—Distribution of soil samples and unusual metal concentrations in soils, New Rambler mine.

in bedrock. However, designation of this level of copper content as anomalous presumes a low regional background of less than 20 ppm copper, a value compatible with the supposed source for the surficial debris in quartzitic terrane but incompatible with the mafic nature of the underlying rocks. Therefore, areas of shallow cover might well appear anomalous, as would areas of deeper cover overlying bedrock rich in copper sulfides.

We conclude that soils are of limited usefulness for exploration in this environment.

## SAMPLING AND ANALYSIS OF STREAM SEDIMENT

Stream sediment commonly provides an excellent reconnaissance geochemical medium. To evaluate this medium in the New Rambler mine area, 10 samples were collected in the area around the New Rambler mine and an additional two samples on Dave Creek were obtained from J. C. Antweiler (fig. 7). Most streams of the area have a low gradient and have been extensively dammed by beaver. The coarsest available material was collected; at some localities this was sandy muck. Samples 692 and 734, in the drainage below the New Rambler mine, consisted mainly of debris washed from the mill tailings and clearly are contaminated; sample 822 was from a terrace.

At each sample site about 20 pounds of material was panned to produce a heavy-mineral concentrate, because both the gold and platinum should be enriched in this heavy fraction of the sediment.

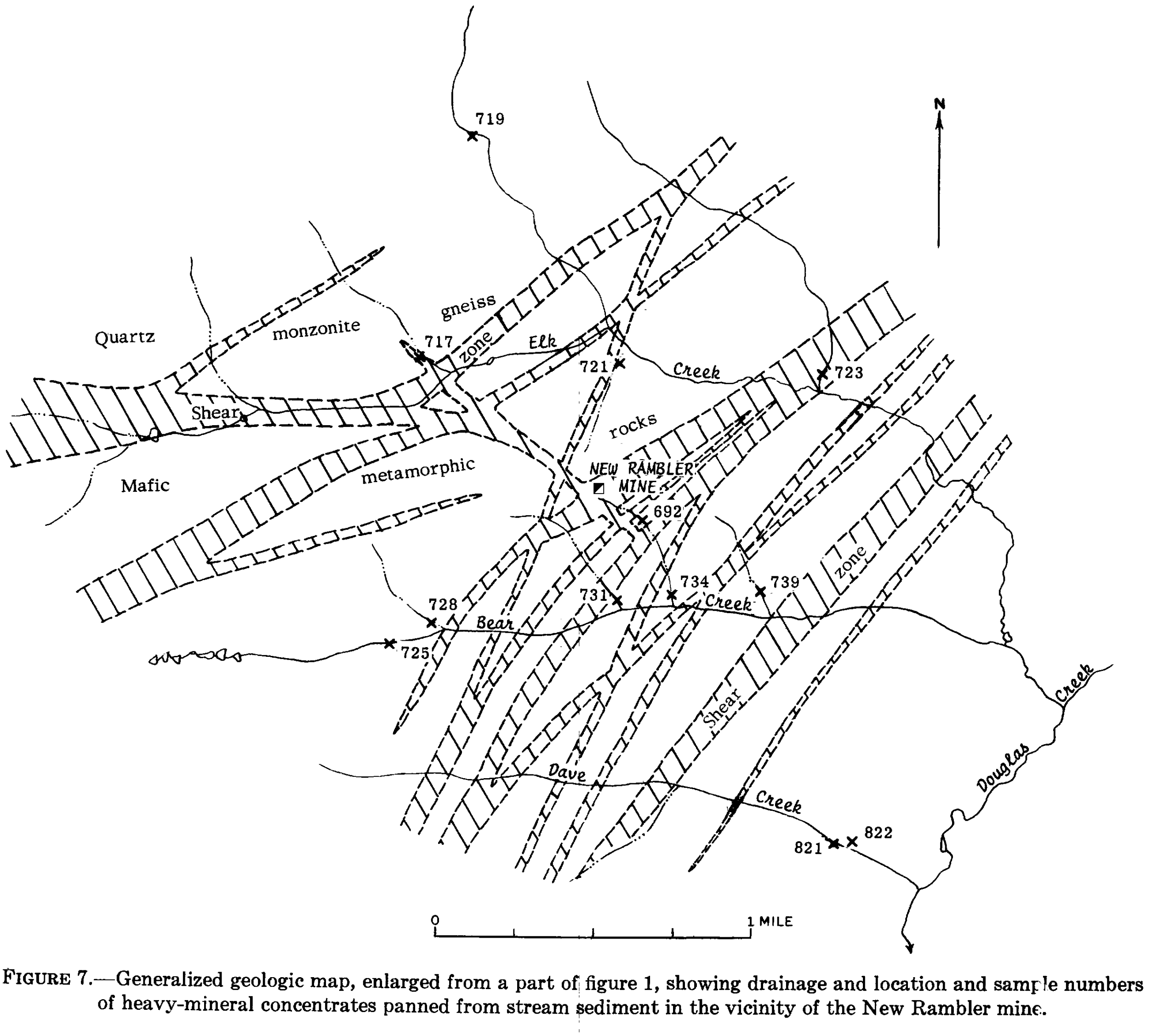


FIGURE 7.—Generalized geologic map, enlarged from a part of figure 1, showing drainage and location and sample numbers of heavy-mineral concentrates panned from stream sediment in the vicinity of the New Rambler mine.

The concentrates weighed from 0.9 to 31 g and averaged 6 g; the concentration ratio was about 1,000 to 1. At six localities a −10 +80 mesh and a −80 mesh screened fraction of the raw sediment were also collected. Chemical analyses for arsenic, gold, platinum plus palladium, and tellurium were made on all samples; spectrographic analyses were obtained on only the heavy-mineral concentrates.

Table 5 compares mineral contents in bulk samples and concentrates from tailings and from both contaminated and uncontaminated stream sediments. From the comparison it is clear that: (1) enrichment is considerable in the heavy-mineral concentrates from all sources even though it is not of the same order of magnitude as the concentration ratio, and (2) for the uncontaminated stream sediments, this enrichment raises the content of gold and platinum-palladium to an easily determined level. The heavy-mineral concentrates are reduced from a large volume of stream sediment; therefore, any discrete particles of gold and platinum-group metals which may be present are more effectively sampled. It is not surprising, therefore, that an anomalous value for platinum in heavy-mineral concentrate 731, from the drainage adjacent to the New Rambler mine on the west, is not evident in the analyses of the raw sediment. We conclude that heavy-mineral concentrates provide a useful medium for reconnaissance exploration of this environment, whereas the raw stream sediment is not likely to do so.

Analyses of the heavy-mineral concentrates of all samples of uncontaminated stream sediments are summarized in the histograms in figure 8. In addition to the elements shown, bismuth and antimony were sought spectrographically but were consistently below their limits of sensitivity, 10 and 100 ppm respectively. Silver was detected at the limit of sensitivity, 0.5 ppm, in sample 692 only. All samples contain 1 percent or more of titanium. In figure 8, the elements are grouped according to the geochemical associations evident in this suite of samples. The five elements in the upper row are enriched in the tailings of the New Rambler mine and in the two sediment samples from a contaminated stream. As noted above, the drainage just west of the mine is also enriched in platinum plus palladium. The Dave Creek drainage is enriched in platinum-palladium and is further enriched in gold—the richest sample of the suite came from that creek—and in molybdenum.

TABLE 5.—*Comparison of analytical results for gold and platinum plus palladium in various sample media in the vicinity of the New Rambler mine*

[Analyses by C. E. Thompson, R. L. Turner, and J. B. McHugh, reported in parts per million]

| Sample No. for concentrate | Gold | | | Platinum plus palladium | | |
|---|---|---|---|---|---|---|
| | Bulk | | Concentrate | Bulk | | Concentrate |
| **Tailings** | | | | | | |
| AAE 650 | 1.0 | | 67 | 0.4 | | 3 |
| 657 | 2.5 | | 160 | 1.7 | | 2 |
| 665 | .3 | | 38 | 1.0 | | 19 |
| 671 | .3 | | 12 | 1.0 | | 4 |
| **Contaminated stream sediment** | | | | | | |
| | Coarse | Fine | Concentrate | Coarse | Fine | Concentrate |
| AAE 692 | 0.08 | 0.4 | 4 | 0.05 | 0.4 | 4 |
| 734 | .2 | .2 | 5.6 | .1 | .07 | 5.4 |
| **Uncontaminated stream sediment** | | | | | | |
| AAE 725 | 0.02 | 0.06 | 0.2 | 0.5 | 0.05 | 0.4 |
| 728 | .04 | .04 | .2 | <.05 | <.05 | .5 |
| 731 | .04 | .04 | .1 | .05 | <.05 | 1.5 |
| 739 | .06 | .06 | .1 | .07 | .07 | .4 |

There is evidently another economic target somewhere in the Dave Creek drainage.

The second row of elements from the top are those commonly associated with mafic rocks of the type exposed in these drainage basins. As expected, the modes are high, even for heavy-mineral concentrates. The contaminated drainage below the New Rambler mine has even more of these elements than the mode. Samples 717 and 719 were collected northwest of a major shear zone in quartz monzonitic terrane and contain somewhat less of these elements than the mode. Surprisingly, Dave Creek appears to be even leaner in these elements than the quartz monzonitic terrane.

The third row shows elements commonly associated with a felsic terrane. These are enriched in the two samples from the quartz monzonitic terrane. Boron is enriched in the entire Elk Creek drainage; two other samples with more than 20 ppm suggest that there has been redistribution of this element either outward from the quartz monzonite gneisses or along the major shear zone. Dave Creek exhibits a felsic association.

The bottom row is largely self explanatory. Scandium exhibits no variation. The mine drainage is unusually poor in manganese, perhaps owing to supergene leaching. Dave Creek is unusually poor in barium; barite is evidently not a gangue mineral. Despite the lack of evidence of zinc enrichment in soil and tailings at the mine, zinc is enriched in the heavy-mineral concentrates in the drainage below the mine and also on Dave Creek.

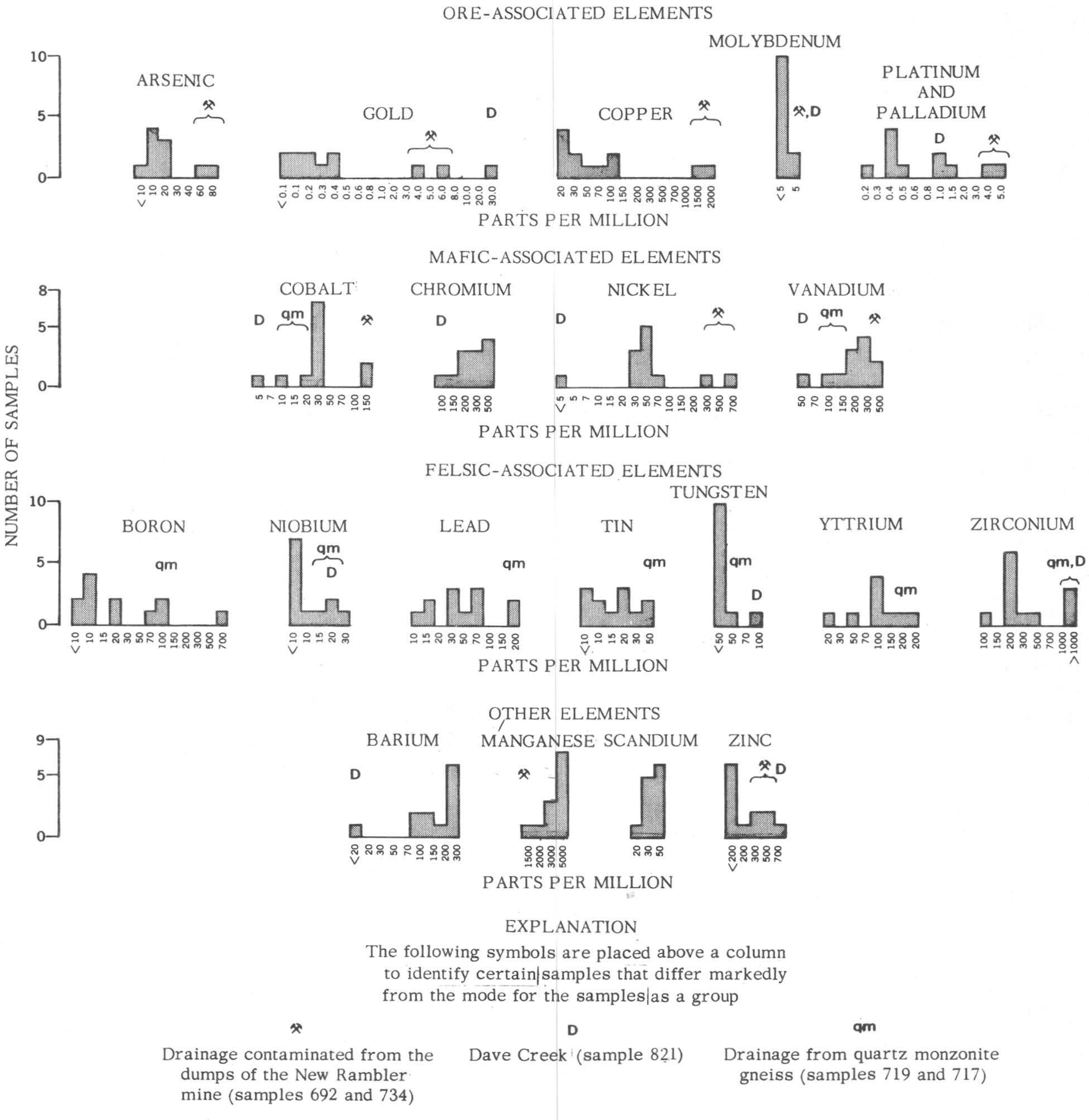


FIGURE 8.—Histograms of analyses of heavy-mineral concentrates from stream sediment in the vicinity of the New Rambler mine. Analyses by J. B. McHugh, E. L. Mosier, C. E. Thompson, R. L. Turner, and Eric Welsch.

The following conclusions seem warranted from these limited data on the heavy-mineral concentrates:

1. The drainage from the New Rambler mine is easily distinguished from the surrounding drainage.
2. The felsic and mafic source areas are separable.
3. The Dave Creek drainage has another economic target, probably one of a different nature from the New Rambler.

## ANALYSIS OF ROCKS

The paucity of outcrops in the wooded, till-blanketed highland of the Medicine Bow Moun-

TABLE 6.—*Analyses of rocks in the east-central part of the Medicine Bow Mountains, Albany and Carbon Counties, Wyo.*

[Rocks collected by M. E. McCallum. Analyses in parts per million by C. E. Thompson, Eric Welsch, and J. B. McHugh. Sample localities shown in figure 1]

| Field No. | Sample | Platinum plus palladium | Gold | Silver | Copper | Comments |
|---|---|---|---|---|---|---|
| I1 | 018 | 0.1 | 3.5 | 6 | 3,000 | Independence mine. |
| I2 | 019 | .4 | (1) | .9 | 300 | Do. |
| | | .6 | | | | |
| I3 | 020 | .05 | .02 | .4 | 50 | Do. |
| I4 | 021 | .1 | .1 | .6 | 160 | Do. |
| KD1 | 022 | <.05 | .04 | 1 | 10 | Kentucky Derby mine. |
| KD2 | 023 | .1 | .06 | 1 | 120 | Do. |
| M53 | 024 | .05 | <.02 | .2 | 10 | Shear zone. |
| | | .1 | | | | |
| ML1 | 025 | <.05 | <.02 | .6 | 10 | Mother Lode mine. |
| M46 | 028 | .2 | .02 | .2 | 10 | Phyllonitic dike rock. |
| M48A | 029 | <.05 | <.02 | .3 | 50 | Do. |
| M94B | 030 | .15 | <.02 | .2 | <10 | Coarse-grained amphibolite. |
| M125B | 031 | .1 | .02 | .6 | 100 | Fine-grained cataclasite. |
| | | | | .9 | | |
| M188 | 032 | .1 | <.02 | .4 | 160 | Sheared mylonite. |
| | | | | .6 | | |
| M193A | 033 | .1 | <.02 | .2 | 20 | Sheared, chloritized amphibolite. |
| M256 | 034 | .2 | .1 | .4 | 25,000 | Malachite-stained quartz-veined mylonite. |
| M259 | 035 | .1 | .02 | .3 | 20 | Mylonite. |
| M280 | 036 | .1 | <.02 | .3 | 80 | Chloritic phyllonite. |

[1] Insufficient sample.

tains makes systematic sampling of bedrock impossible. Furthermore, the few natural outcrops undoubtedly represent the least-altered, least-broken rock masses and are not likely to be enriched in the ore metals. Therefore, we made no attempt to seek outcrops for sampling purposes. During his geologic mapping of the area, however, M. E. McCallum collected as nearly a representative suite as he could obtain. He sorted through this suite and provided us with 17 specimens ranging, in his estimation, from the most likely to have unusual platinum content to the least likely country rocks. These specimens were crushed, pulverized, and analyzed for platinum plus palladium, gold, silver, and copper.

The localities are plotted on the geologic map (fig. 1), and the analytical results, along with a brief sample description, are given in table 6. Only sample 034 is outstanding, and it is outstanding only for copper. It was collected from a prospect pit on the major shear zone extending west from the New Rambler mine and serves to identify what appears to be a copper-rich trend, as well as another local target for further study. The most striking feature of the whole data set is the uniform presence of both the platinum group and silver in amounts an order of magnitude greater than estimated crustal abundance. This feature indicates that a platinum-silver province exists in this part of the Medicine Bow Mountains, but its full extent is not known as we have not done any systematic sampling beyond the area of this investigation. Because rocks similarly rich in platinum have been obtained from the Sierra Madre, the next range to the west, in a similar geologic environment, the overall province may be large.

## CONCLUSIONS

Reconnaissance examination in the vicinity of the New Rambler mine indicates a promising target for exploration for a complex ore body. Analysis of concentrates derived from stream sediment can define smaller targets within the platinum-rich province and can provide information on the nature of the target. We do not yet have a decisive means of moving from stream sediment to the target by geochemical means. Analyses of soils on the transported cover appear to be of little use. The thick cover of surficial debris has hampered, and will continue to hamper, exploration.

More geologic mapping is needed in the area in order to define further, and in more detail, the distribution of both the shear zones and the mafic-rock series; mapping as well as exploration will be hampered by cover, but perhaps geophysics and geochemistry can provide aids in crucial areas.

The marked physical and chemical differences of the felsic- and mafic-rock series should be detectable through the cover.

Systematic reconnaissance is needed to delineate the platinum-rich province and define the more promising targets within it. Where targets are identified, means are needed to more clearly define the surface expression of ore bodies. Although our attempts to utilize soils appear to have been ineffective, possibilities for geochemical exploration still exist with the use of concentrates from the soils, humus, or the vegetation itself. A variety of geophysical techniques appears promising, particularly for the more mafic, copper-sulfide-rich deposits like the New Rambler.

Large segments of the Medicine Bow Mountains and the Sierra Madre to the west are underlain by a mafic-rock complex that is unusually rich in platinum and associated metals. Within this complex, high-grade pockets of copper sulfides have been mined locally. Prospecting has continued sporadically over many years, but as noted by Emmons (1903), digging of test pits through 6–16 feet of overburden is costly and, we might add, statistically unlikely to be effective. Previous exploration has rarely been guided by sound geologic reasoning. We feel that systematic, geologically guided exploration in this province has a reasonable probability of discovering an ore deposit.

## REFERENCES CITED


Emmons, S. F., 1903, Platinum in copper ores in Wyoming: U.S. Geol. Survey Bull. 213, p. 94–97.

Finch, J. W., 1925, Platinum discoveries in Wyoming [Encampment district]: Eng. Mining Jour., v. 120, no. 3, p. 95–96.

Knight, W. C., 1901, The discovery of platinum in Wyoming: Eng. Mining Jour., v. 72, no. 26, p. 845.

Lakin, H. W., and Thompson, C. E., 1963, Tellurium—A new sensitive test: Science, v. 141, no. 3575, p. 42–43.

McCallum, M. E., 1964, Geologic map of the east-central portion of the Medicine Bow Mountains, Albany and Carbon Counties, Wyoming: Laramie, Wyoming Univ., Ph. D. thesis map.

——— 1968, The Centennial Ridge gold-platinum district, Albany County, Wyoming: Wyoming Geol. Survey Prelim. Rept. 7, 13 p.

McCallum, M. E., and Orback, C. J., 1968, The New Rambler Copper-gold-platinum District, Albany and Carbon Counties, Wyoming: Wyoming Geol. Survey Prelim. Rept. 8, 12 p.

Read, T. T., 1905, Platinum and palladium in certain copper ores: Eng. Mining Jour., v. 79, no. 20, p. 985–986.

Taft, H. H., 1918, A Wyoming platinum mine: Eng. Mining Jour., v. 106, p. 900.

Thompson, C. E., 1967, A spectrophotometric method for the determination of traces of platinum and palladium in geologic materials, *in* Geological Survey research 1967: U.S. Geol. Survey Prof. Paper 575–D, p. D236–D238.

Ward, F. N., Lakin, H. W., Canney, F. C., and others, 1963, Analytical methods used in geochemical exploration by the U.S. Geological Survey: U.S. Geol. Survey Bull. 1152, 100 p.

Wells, H. L., and Penfield, S. L., 1902, On a new occurrence of sperrylite [Wyoming]: Am. Jour. Sci., 4th ser., v. 13, p. 95–96.


GPO 868-143