GEOLOGICAL SURVEY CIRCULAR 596

Preliminary Results of Geological, Geochemical, and Geophysical Studies in Part of the Virginia City Quadrangle, Nevada

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PRELIMINARY RESULTS OF GEOLOGICAL, GEOCHEMICAL, AND GEOPHYSICAL STUDIES IN PART OF THE VIRGINIA CITY QUADRANGLE, NEVADA

By DONALD H. WHITEBREAD and DONALD B. HOOVER

Abstract

Geological, geochemical, and geophysical studies in the Comstock Lode district and adjoining parts of the Virginia Range near Virginia City, Nev., have resulted in recognition of two geophysical anomalies and several geochemical anomalies in an area north of Virginia City. The geophysical anomalies were found during an induced-polarization survey carried out to aid in tracing the Comstock fault, the principal structure localizing the bonanza silver-gold deposits of the Comstock Lode district, in an area of intensely altered rock and alluvial cover about 5 miles north of Virginia City. Geochemical anomalies showing mercury in excess of 5 ppm (parts per million) were found in altered rocks along the Comstock fault near Cornwall Knob about 5 miles north of Virginia City and in the Washington Hill area, 6 miles farther north.

INTRODUCTION

The bonanza ore bodies of the rich and highly productive Comstock Lode district, in the Virginia Range near Virginia City, Nev. (fig. 1), were in altered andesitic volcanic rocks along the eastward-dipping Comstock fault. This fault can be traced for a few miles north of Virginia City, but farther north its location is obscured by intense alteration of the enclosing rocks and by alluvial cover. Geological, geochemical, and geophysical studies are underway to determine whether the Comstock fault persists to the north of where it is last recognized at the surface and, if so, to ascertain if possible its attitude, the relations between the fault and rock alteration and mineralization, and the potential for the occurrence of concealed ore deposits along its extension.

The Virginia Range is one of several areas in western Nevada that contain epithermal deposits of gold, silver, and mercury in altered andesitic volcanic rocks.

The Comstock Lode district is one of the world's greatest precious-metal producers. From 1859 to 1940, the recorded production of silver and gold was $397,445,998 (Couch and Carpenter, 1943, p. 93–94; p. 133–136). The gold-silver ratio by weight was about 1:40

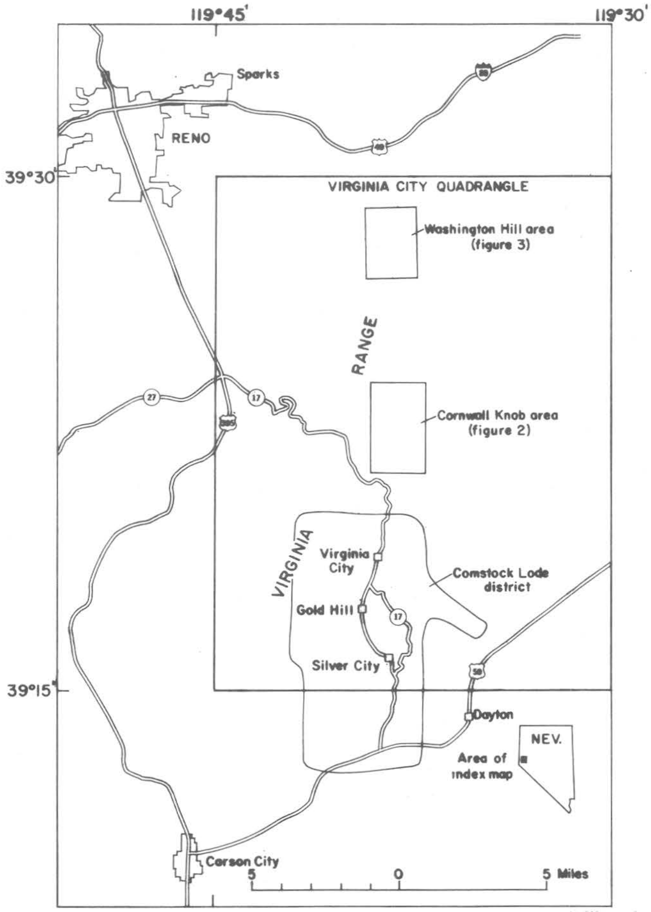

FIGURE 1.—Index map showing location of Virginia City quadrangle, Comstock Lode district, and limits of the Cornwall Knob and Washington Hill areas.

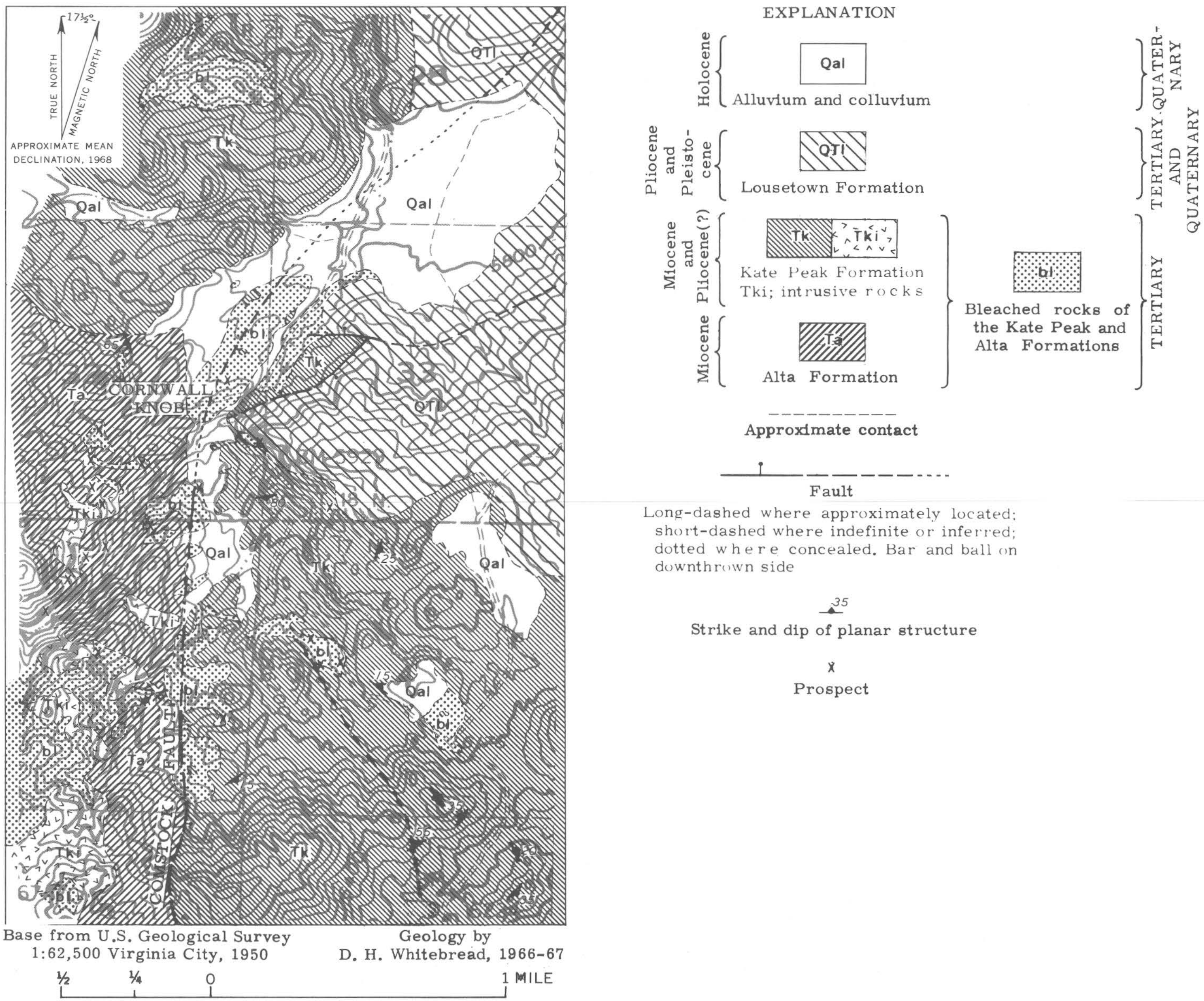

FIGURE 2.—Geologic map of the Cornwall Knob area.

(Nolan, 1933, p. 633). Argentite, gold, and polybasite occurred with sphalerite, galena, and chalcopyrite; gangue minerals were pyrite, quartz, and some calcite (Bastin, 1923, p. 44–45). Native silver locally replaced the argentite at shallow depths. Aguilarite, a silver sulfoselenide, was recognized in several specimens by Coats (1936, p. 532).

The Castle Peak mine, about 7 miles north of Virginia City, has yielded more than 2,500 flasks of mercury, and the Root mine, or Washington Hill prospect, 3 miles farther north, probably yielded a few flasks (Bailey and Phoenix, 1944, p. 184–187). At both localities, cinnabar occurs in intensely altered andesite.

The current geological studies, a part of the Heavy Metals program of the Geological Survey, have revealed several geochemical anomalies and two geophysical anomalies. Two areas in particular are attractive for further investigations: the Cornwall Knob area and the Washington Hill area, about 5 and 11 miles, respectively, north of Virginia City (fig. 1). The Cornwall Knob area is along the northern extension of the Comstock fault (fig. 2). The only indications of previous exploration in the area are widely scattered, shallow prospect pits. While using induced-polarization (IP) methods to aid in locating the northern extension of the Comstock fault in an area of altered volcanic rocks and alluvium, an anomalous area was found near Cornwall Knob. Geochemical sampling revealed high mercury values clustered near Cornwall Knob and about 1 mile south. Geological and geochemical studies here and in the Washington Hill area (fig. 3) have provided additional information on anomalous amounts of mercury reported by Cornwall, Lakin, Nakagawa, and Stager (1967, p. B11–B13). Mercury in excess of 6 ppm (parts per million) is distributed widely at Washington Hill, and in addition, many of the samples in a northeast-trending belt through the Root mine are high in mercury and also contain anomalous amounts of lead, silver, and bismuth.

Geologic core drilling is planned to obtain further information on the nature of the IP anomalies and on the relation of the geochemical anomalies to rock alteration and possible mineralization.

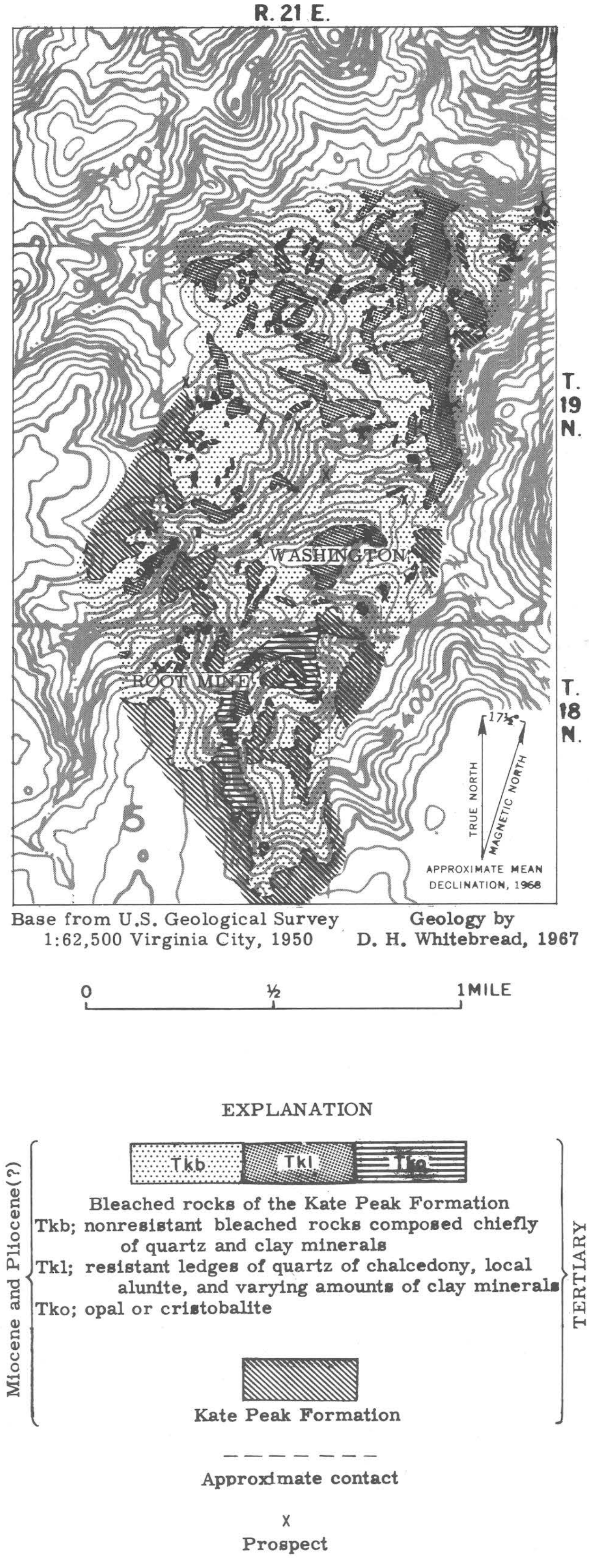

FIGURE 3.—Geologic map of the Washington Hill area.

ACKNOWLEDGMENTS

The cooperation of the Curtiss Wright Corp., on whose property the investigations were conducted, and the Duval Corp., which is engaged in geological studies in the area, is gratefully acknowledged.

In the geophysical work described, G. I. Evenden, assisted by C. L. Tippens, was responsible for the gathering and compilation of the electromagnetic data. D. R. Schoenthaler, R. N. Babcock, and E. D. Seals assisted with the IP surveys. To these coworkers, we extend our appreciation.

GEOLOGY

Thompson (1956) and Thompson and White (1964) have described the geology within the Virginia City quadrangle, and their geologic maps have been used extensively during the present investigation. The most detailed reports on the geology of the Comstock Lode district are by Becker (1882), Gianella (1936), and Calkins (1944).

Volcanic rocks of Tertiary and Quaternary age cover most of the Virginia Range. The Alta and Kate Peak Formations are the most widespread and together with the Lousetown Formation constitute the bedrock in the areas of this report. According to Thompson and White (1964, p. A14–A15) the upper part of the Kate Peak Formation is probably of Pliocene age. Recent potassium-argon age determinations by J. C. Engels (written commun., 1968) show that part of the Kate Peak, the Alta, and the underlying Hartford Hill Rhyolite Tuff are of Miocene age. Triassic(?) metamorphosed sedimentary and volcanic rocks and Cretaceous granodiorite underlie the Hartford Hill Rhyolite Tuff.

ALTA FORMATION

The Alta Formation is the principal extrusive rock unit in the Comstock Lode district and was the host for the bonanza deposits; for several miles north of Virginia City it makes up much of the footwall block of the Comstock fault. The Alta consists mainly of andesitic flows and flow breccias, but where the rock is altered, the flows and breccias are difficult to distinguish. Calkins (1944, p. 12–15) described four members of the Alta, but they were not recognized outside the Comstock Lode district. In the Cornwall Knob area (fig. 2), the Alta is principally medium-light-gray hornblende-pyroxene andesite. More altered varieties are commonly shades of green or bluish gray, and some fresh varieties are dark gray. Phenocrysts of plagioclase 1–3 mm (millimeters) in length are conspicuous, and phenocrysts of hornblende, commonly 3–5 mm long, are more than 10 mm long in some places. The pyroxene is not readily visible in hand specimen. The Alta is cut by numerous dikes and other small intrusive bodies. Some of these younger rocks can be distinguished from the Alta by their textural differences or by the presence of biotite; others are nearly indistinguishable, owing to variations in the degree of alteration and other factors.

KATE PEAK FORMATION

The Kate Peak Formation is composed of flows, flow breccias, intrusive bodies, and tuff breccias; it ranges in composition from andesite to rhyodacite (Thompson and White, 1964, p. A13). Flows predominate within the areas of this report, although flow breccias are especially common north of Cornwall Knob (fig. 2). Flow banding is locally well developed but is quite variable in attitude.

In the Cornwall Knob area, the most readily recognized varieties of the Kate Peak are porous to dense, medium-dark-gray, light-gray, or pale-red rocks with conspicuous phenocrysts of plagioclase 5 mm or more in length. Hornblende is the most common dark mineral and is present in all the specimens examined. Biotite occurs as large prominent books or scattered small flakes in some specimens and is absent in others. Where present, it can be used to distinguish the Kate Peak from the Alta. Pyroxene is plentiful in some specimens, but the small green crystals are difficult to detect with a hand lens. Hornblende, biotite, and pyroxene occur together in some specimens. Scattered phenocrysts of quartz are not uncommon. Hornblende-pyroxene andesite in the basal Kate Peak northwest of Cornwall Knob is characterized by smaller and less conspicuous plagioclase phenocrysts and by the absence of biotite. This rock closely resembles the underlying Alta and is locally indistinguishable from it. Several intrusive bodies of Kate Peak were mapped within the Alta, and some may be present within the areas shown as Kate Peak. In particular, a biotite-rich unit underlying the prominent hill on the west side of sec. 4 may intrude adjacent flows, but relations at the contacts are inconclusive.

Outcrops of the Kate Peak in the Washington Hill area (fig. 3) are dense, dark-gray pyroxene-hornblende andesite in which the plagioclase phenocrysts are small and relatively inconspicuous. Pyroxene is more abundant than hornblende, and biotite is lacking.

LOUSETOWN FORMATION

The Lousetown Formation is made up of well-defined lava flows of medium-gray to dark-gray basalt and basaltic andesite. Individual flows range in thickness from about 5 to 30 feet and have vesicular tops. The flows exposed in the area of figure 2 came from a vent about 1 mile northeast of the map boundary. The Lousetown unconformably overlies the Kate Peak Formation, and in many places a few feet of fluviatile deposits separate the two formations. To the north, fluviatile and lacustrine deposits of the Truckee Formation underlie the Lousetown. Small grains of olivine and phenocrysts of green pyroxene are commonly visible in many flows, and in some places the alinement of plagioclase laths is pronounced. The attitude of platy parting and flow banding does not coincide with that of the gently inclined flows. The Lousetown shows none of the alteration that is typical of much of the underlying Kate Peak and Alta Formations.

Potassium-argon dating of flows near the base of the type Lousetown Formation in the Virginia Range gave an age of 6.9 ± 0.19 m.y. (million years) (Dalrymple and others, 1967, p. 165). Birkeland (1963, p. 1456–57) correlated these flows with flows in the Truckee area that range in age from 1.2 to 2.3 m.y. Thus, the age of the Lousetown is considered to be Pliocene and Pleistocene.

ALTERATION

Propylitization and intense bleaching are widespread types of alteration in the Alta and Kate Peak Formations. The Alta Formation is generally more altered than the Kate Peak, and prior to the regional studies of Thompson (1956), the extensive alteration was considered to be restricted to the Alta and older rocks. Becker (1882, p. 81–90) first recognized that the rock, earlier named propylite in the Comstock Lode district, was a variety of altered andesite rather than a distinct type of volcanic rock. The widespread propylitic alteration in the district was later described by Coats (1940), who redefined propylitization as alteration characterized by epidote and albite replacing plagioclase and by chlorite, calcite, and epidote replacing ferromagnesian minerals. Altered rocks containing epidote were noted in the Alta and intrusive bodies of the Kate Peak in a few places along the west edge of figure 2, but a less intense alteration, characterized by chlorite-calcite assemblages, is more widespread. The ferromagnesian minerals typically are thoroughly altered, but plagioclase appears fresh or only slightly altered. Weak alteration in much of the Kate Peak Formation is denoted by alteration of the hornblende. Zeolites are locally abundant in the Kate Peak Formation near the Comstock fault south of Cornwall Knob.

Calkins (1944) and Thompson (1956) mapped areas of intensely altered Alta and Kate Peak Formations as bleached rocks. Generally, the two formations cannot be distinguished where they have reached such an advanced stage of alteration. Typical bleached rocks are white to grayish yellow and are irregularly stained by brown, red, and yellow iron oxide. Fractures are commonly coated with dark iron oxide. The porphyritic texture of the original rock ordinarily can be distinguished except in the most intensely silicified varieties. Much of the bleached rock is relatively soft and does not form coherent outcrops. Kaolinite, quartz, and alunite are the most common constituents of the bleached rocks, but other clay minerals, pyrophyllite, jarosite, cristobalite, gypsum, and diaspore occur locally. More resistant altered rocks commonly contain a larger percentage of quartz or alunite. The proportions of silica minerals, alunite, and clay minerals vary widely in resistant ledges like those delineated in figure 3. The most resistant parts, however, are composed entirely of chalcedonic quartz.

In the mines of the Silver City area, about 3 miles south of Virginia City, the bleached rocks commonly grade downward into propylitized rocks peppered with small crystals of pyrite (Gianella, 1936, p. 53). At Virginia City and Gold Hill the intense bleaching apparently persisted as deep as the ore bodies (about 1,500 feet), and Becker (1882) indicated that bleached rocks extend downward to the level of the Sutro tunnel. Thompson and White (1964, p. A28) reported that in a drill hole 4 miles north of Virginia City the bleached rock extends to a depth of 50–75 feet, where it grades downward into altered andesite with pyrite and zeolites. In the areas of this report, disseminated pyrite was found in only a few places in the Alta and the Kate Peak intrusive bodies, and in small dark-gray highly silicified pods in the bleached rock. Gianella (1936, p. 53) and Thompson and White (1964, p. A27) proposed that the bleaching is a near-surface supergene alteration due to the action of sulfuric acid produced when the pyrite was oxidized. At least part of the bleaching, however, probably is the result of hypogene alteration.

STRUCTURE

According to Thompson and White (1964, p. A35), the Virginia Range consists of tilted blocks bounded by normal faults. The Comstock fault, which can be traced for about 8 miles, is the principal fault in the range. Mine workings in the Comstock Lode district show that the fault dips eastward about 45°. There the fault has an estimated throw of 2,500–3,450 feet (Gianella, 1936, p. 85; Thompson, 1956, p. 66), but the throw may diminish to the north. Gianella (1936, p. 81–87) gave evidence for movement along the fault both before and after ore deposition. The fault can be traced north from Virginia City for about 5 miles, and spatial relations between the Alta and Kate Peak define the approximate trace of the fault as far north as the prospect pit about one-fourth mile south of Cornwall Knob (fig. 2). Its position north of that point is inferred from geophysical data. The fault in the Lousetown Formation at the northeast corner of the map area, however, probably reflects later movement along a northward extension of the Comstock fault. The two faults east of Cornwall Knob developed during a period of faulting and gentle tilting that occurred after the Lousetown flows. Prominent north- and east-trending resistant ledges in the Washington Hill area (fig. 3) may be alined along faults or fractures. Thompson and White (1964, p. A26) suggested, however, that the ledges are erosional remnants of tabular zones in which nearly all constituents except silica have been removed.

GEOPHYSICAL STUDIES

Limited geophysical studies were made in the Virginia City quadrangle in conjunction with the more extensive geological mapping and sampling program. Because the northern extension of the Comstock fault was of prime importance as a guide to further investigations, most of the geophysical work was concentrated in the region of Cornwall Knob (fig. 2). One of the authors (Whitebread) has been able to map the Comstock fault as far north as a small prospect pit about one-fourth mile south of the crest of the Cornwall Knob (fig. 2). Beyond this point, the fault trace was lost in an area of bleached rock and alluvial cover. Faults have been traced by IP surveys (Šumi, 1959), and this was considered as a possible way of tracing the Comstock fault. Thus IP and electromagnetic surveys were used in an attempt to trace the fault zone through this difficult area.

Alteration zones appeared to be promising areas to study with IP surveys owing to the presence of clay minerals in the bleached outcrops and the gradation downward into propylitized rocks with pyrite, as described by Gianella (1936) and Thompson and White (1964). If the clay mineral content or pyrite content were high enough, it would be possible to map altered zones beneath the extensive Lousetown flows in the northern part of the quadrangle.

INDUCED-POLARIZATION SURVEYS

Colinear dipole-dipole electrode geometry was used on all the IP traverses. Measurements were made in the frequency domain using Burr-Brown models 9740 and 9741 equipment, with frequencies of 0.05 and 5.0 Hz (hertz). Data reduction was made in the conventional manner, with apparent resistivities computed in ohm-feet/2π ($\rho a/2\pi$), IP values in percent fre-

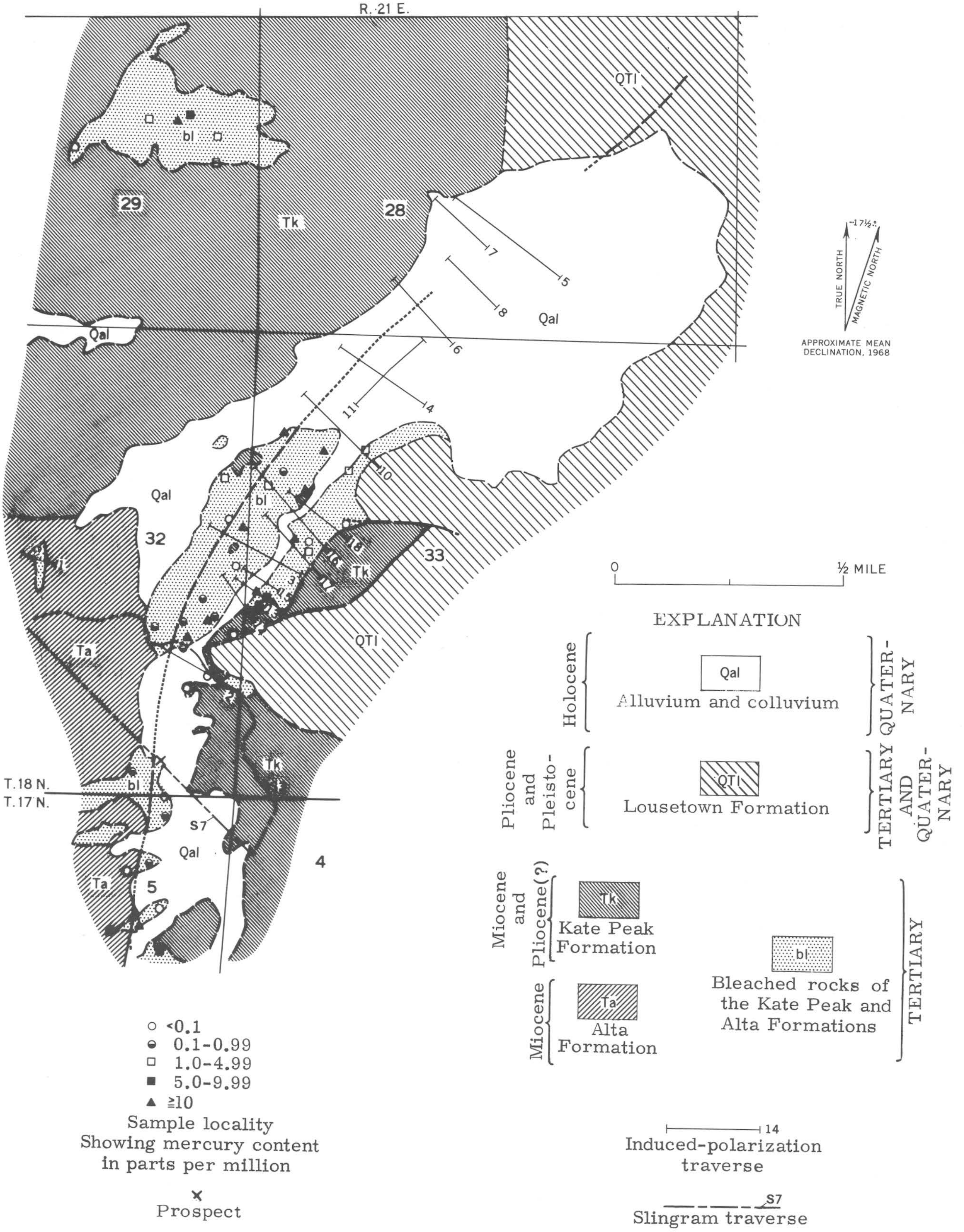

FIGURE 4.—Map of part of the Cornwall Knob area showing location of geophysical traverses and mercury distribution.

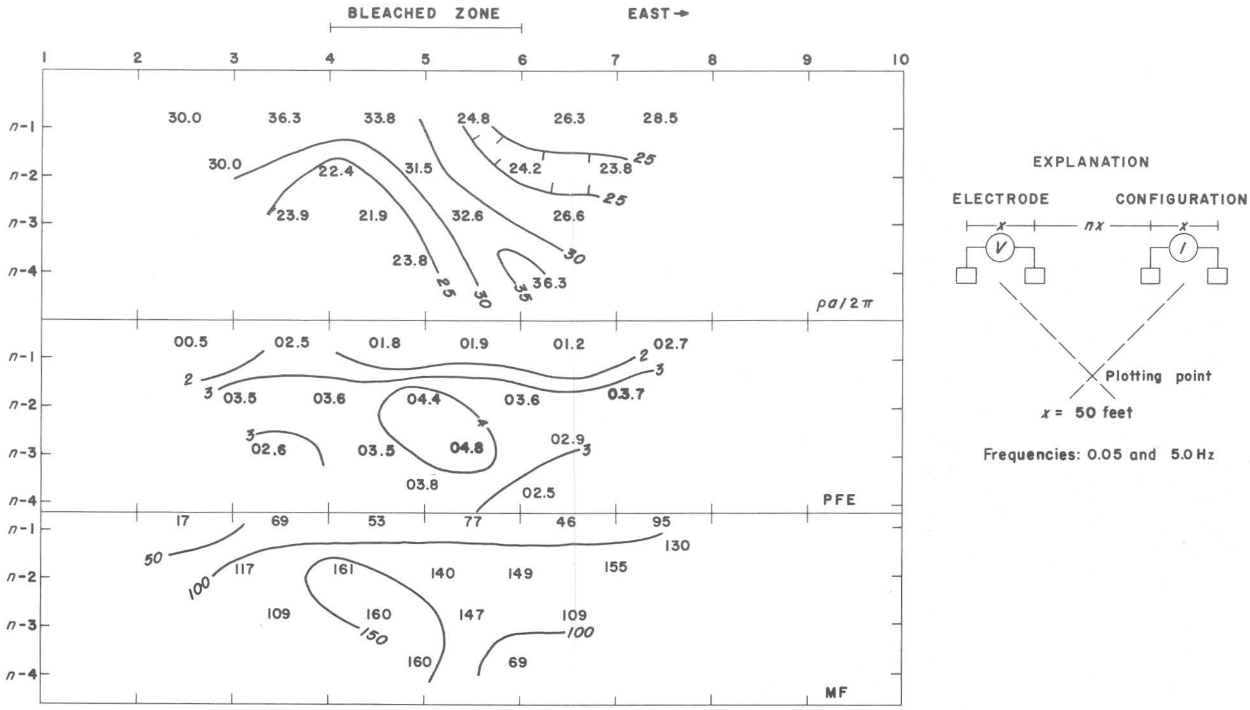

FIGURE 5.—Induced-polarization results, Cornwall Knob area, traverse 1.

quency effect (PFE), and metal factor (MF) in reciprocal ohm-feet.

A small, but well-defined, bleached area (fig. 4) about one-half mile west of Cornwall Knob was selected as the first area to study. The bleached zone, alined in a north-south direction, is about 100 feet wide and 500 feet long. A shallow prospect pit on the north end of this zone contains some pyrite-bearing dark chalcedonic quartz and copper-stained altered rock. The pyrite, in euhedral crystals, is for the most part completely surrounded by silica.

Owing to the small size of the bleached zone, a 50-foot dipole length was used on traverse 1 (fig. 4) perpendicular to the long dimension of the zone. A weak anomaly, which correlates well with the outcrop of bleached rock, can be seen in both the resistivity and the PFE data plots (fig. 5). The anomaly is characterized by both higher resistivity and higher PFE. Both anomalous values, however, are only slightly higher than background, and the PFE is lower than would be expected from the pyrite present in the outcrop. Although the pyrite-bearing rock exposed in the prospect pit may not be representative of the rock mass sampled by the traverse, the close proximity (20 feet south) makes this supposition doubtful. These data are consistent with an interpretation of a narrow altered zone containing principally silica and some pyrite and clay minerals. The extensive silicification as seen in the prospect pit could give rise to higher values of resistivity, and the pyrite, to higher PFE. The almost total insulation of pyrite grains by silica would explain the slight increase in PFE above background.

Traverse 2 (fig. 4) was run just south of Cornwall Knob in an area of intensive alteration of both the Alta and Kate Peak Formations. The traverse, which was run from the unaltered Kate Peak on the east toward the Alta on the west, crossed the projection of the Comstock fault. The data from traverse 2 (fig. 6) shows, as on traverse 1, a small PFE anomaly, but associated with this is a broad zone of reduced resistivity. The metal factor anomaly is narrow, well defined, and suggests an east dip if it is assumed that a narrow tabular body gives rise to this anomaly.

Interpretation of the resistivity data is difficult because of topographic variations on the traverse. The increase in resistivity at both ends, however, is real since the topographic effect would tend to decrease the apparent re-

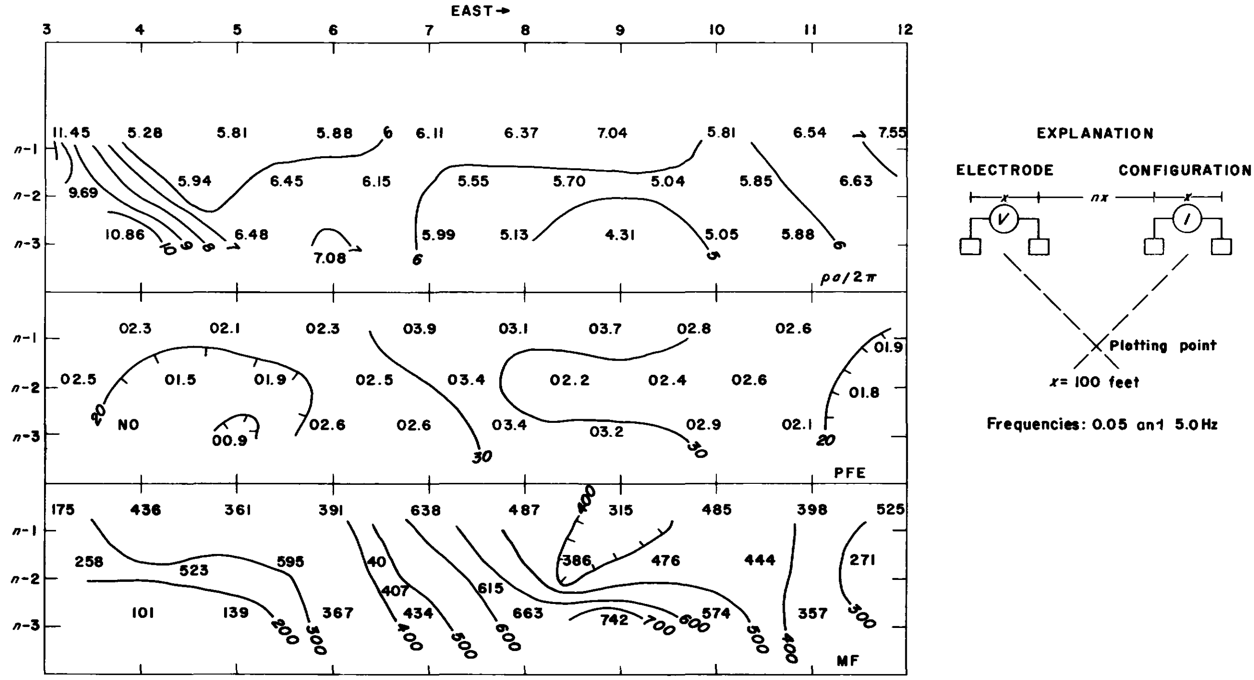

FIGURE 6.—Induced-polarization results, Cornwall Knob area, traverse 2.

sistivity at these places. The regions of higher resistivity at the ends of the traverse correlate well with outcrops of unaltered rock. As observed on traverse 1, the frequency-effect anomaly was only slightly above background. The dipole length used in this traverse was 100 feet, which in this location would give penetration below the expected water table. Thus, the depth of penetration was presumably greater than the depth of the zone of pyrite oxidation and acid-leaching effects. No noticeable change in either resistivity or PFE with depth can be seen within the broad altered zone on this traverse. This may be indicative of a bleached zone shallower than the electrode spacing. A short series of measurements made along this traverse using 50-foot dipole separations and an n spacing of 1 showed no significant changes in resistivity or PFE in comparison to the 100-foot, $n = 1$ values.

Traverses 1 and 2 show the marginal utility of IP surveys for mapping of altered volcanic areas in this region. Where bleached rocks are exposed on the surface, no difficulty is experienced in mapping, but if the bleached rocks are buried under much cover, the low anomalous PFE values would make their detection difficult and require very careful surveying. This would be especially true in most areas covered by alluvium, where the presence of clay minerals would result in low resistivities. The superficial nature of the bleached rocks is suggested by the lack of a discernible layer on traverse 2 and by a shallow, low-PFE region associated with the altered region on traverse 1. If bleaching, in contrast to propylitization, is due to surface oxidation of pyrite and not to hypogene alteration, then the depth of bleached rock is shallower than the electrode separation. This finding is in accord with that of Thompson and Sandberg (1958), who on the basis of gravity work concluded that the bleached zones are superficial.

On traverse 2 a narrow PFE anomaly stands out in the metal-factor plot. Because the anomaly coincides with the Comstock fault, if extended along strike from the south, and because no evidence for faulting exists in the rock on either side of the broad bleached zone, we believe this anomaly defines the fault zone. This is further established by electromagnetic work described later. Since the results on traverse 2 offered some hope that IP surveys could be used to trace the Comstock fault, an effort was made to locate the fault farther north by this method. The remainder of the IP traverses in this region

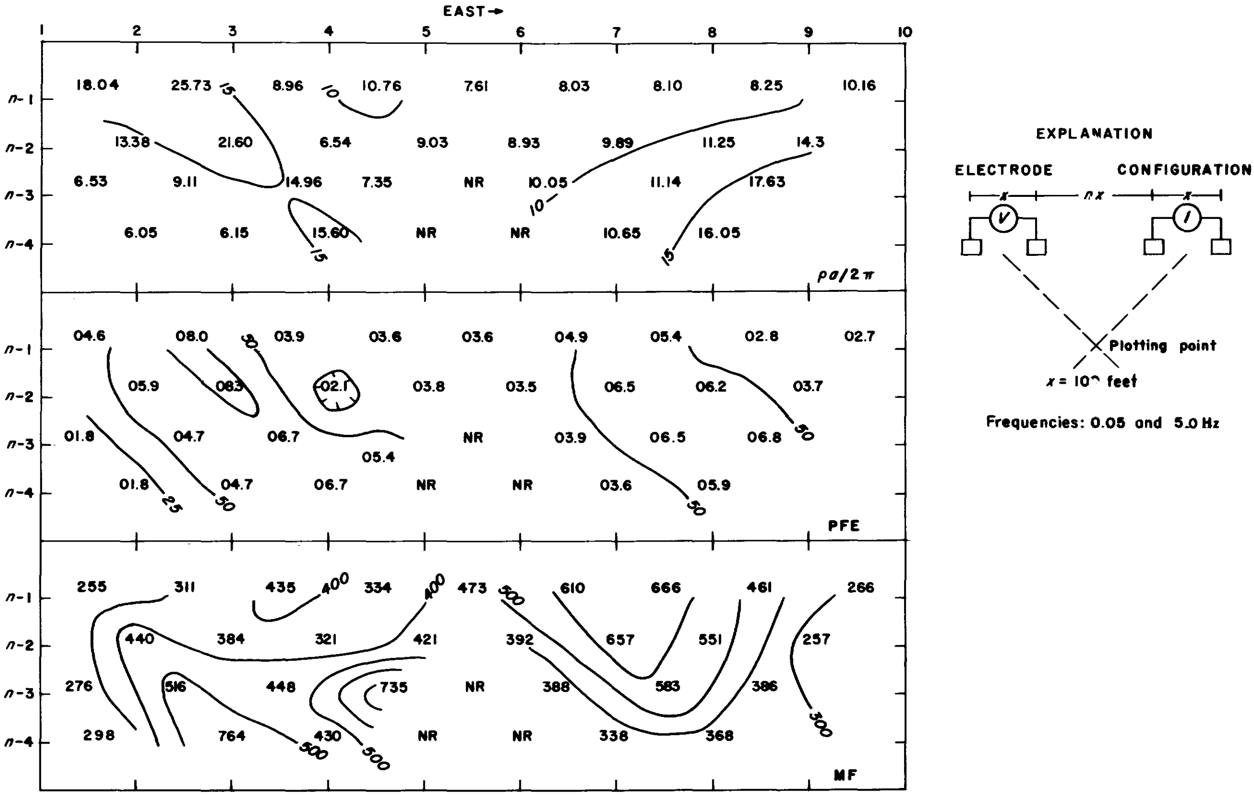

FIGURE 7.—Induced-polarization results, Cornwall Knob area, traverse 3.

were made in an attempt to map the Comstock fault and to test for other faults in a nearby area of anomalous mercury values.

Along traverse 3 (fig. 7), about 0.3 mile north of traverse 2, two narrow anomalous zones were discovered. The westermost anomaly is similar to that found on traverse 1, in that higher PFE values are associated with a zone of higher resistivity. A well-defined metal-factor anomaly is also indicated in this region. This anomaly coincides with projections from previous geologic mapping and is believed to be the most probable location of the Comstock fault.

The less well defined anomaly near station 7 on traverse 3 appears to be associated with a spur ridge branching east from the main crest of Cornwall Knob halfway between traverses 2 and 3. Additional profiling in the area, however, was not dense enough to reveal the true nature of this anomaly.

A frequency-effect map was made (fig. 8) for an *n* separation of 3, which shows the northeast-trending zone identified with the Comstock fault. Additional traverses would be desirable to unequivocably relate this zone to the Comstock fault, but in the absence of conflicting information, the present supposition is most tenable. This linear PFE anomaly dies out to the north, where conductive alluvium overlies the bedrock to greater depth. Extension of this trend along strike coincides with a fault cutting the Lousetown Formation. This fault was earlier mapped by Thompson (1956) but not identified by him as the Comstock fault. Because Gianella (1936) found evidence for post mineralization movement along the Comstock fault, this extension into the Lousetown is possible.

Near the north end of the area covered by the PFE map (fig. 8), a strong anomaly associated with the assumed fault zone was discovered. Profile data on traverse 4 (fig. 9) show a strongly anomalous zone with minimum depth of less than 100 feet and probable eastward dip. Here again the PFE anomaly is associated with a zone of slightly increased resistivity. A traverse with 200-foot dipole spacing and *n* separation up to 4 indicated no apparent depth limit

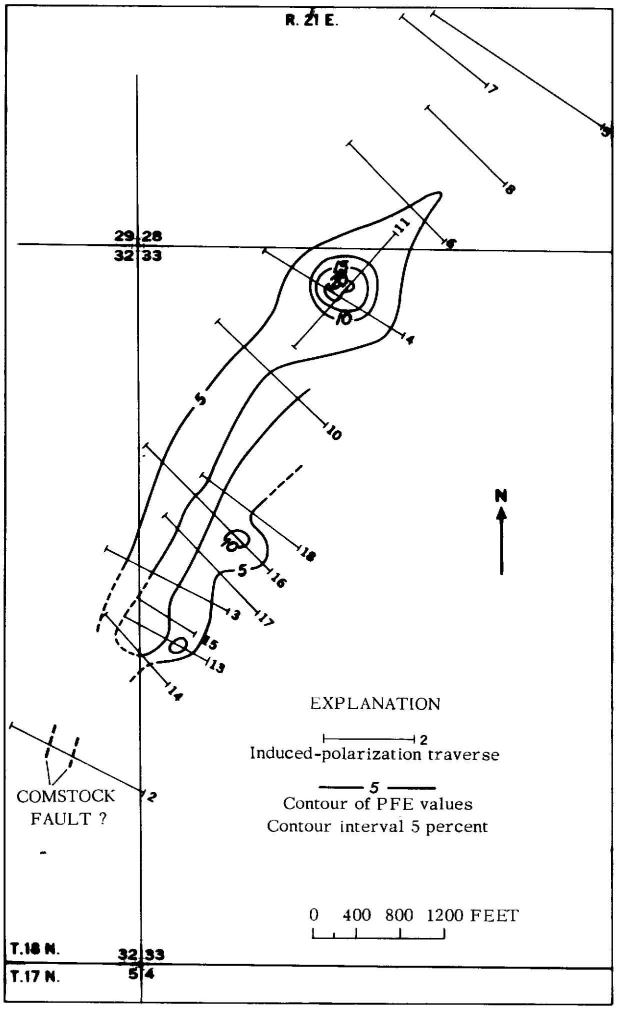

FIGURE 8.—Induced-polarization (PFE) map, Cornwall Knob area.

to this anomaly. The high PFE values are indicative of sulfide mineralization.

In order to ascertain if high mercury values might also be associated with PFE anomalies, several profiles were run east of Cornwall Knob where particularly high mercury values were found. Traverse 13 (fig. 10) was made across a bedrock outcrop which showed greater than 10 ppm mercury. A moderate PFE anomaly correlates well with the high mercury value in outcrop. Topographic effects on this traverse preclude an exact resistivity interpretation; however, the PFE values are again associated with a zone of slightly higher resistivity. The profile shows the anomalous zone to be virtually at the surface.

ELECTROMAGNETICS

Slingram and turam electromagnetic methods were tried in the Cornwall Knob area. One of the two slingram traverses (fig. 4, S7) crossed the Comstock fault zone one-fourth mile south of Cornwall Knob; the other (S3) was run along the road just south of Cornwall Knob, along nearly the same ground as IP traverse 2. These traverses were made using a coplanar horizontal loop configuration with a 200-foot coil separation and station intervals of 100 feet. The frequency used was 1,800 Hz.

The results of both traverses (fig. 11) show a distinct anomaly on crossing the projected position of the fault just south of Cornwall Knob. On the east side, in the Kate Peak Formation, a very low resistivity, flat-lying conductive layer is indicated. The presence of bleached or altered rock cannot be detected by this method, as there is no evident change in conductivity in passing through the several altered zones. Smaller anomalies could not be correlated with any surface geologic features. Because of the irregular terrain, noise was introduced into the real component through the inability to maintain coplanar coils. The noise may have masked more subtle conductivity changes related to the alteration zone. The west side of each traverse shows less conductive rock associated with the Alta Formation and rock of about the same resistivity as obtained throughout the IP work (15 and 50 ohm-meters). No such clearly defined resistivity change was noted on the IP profiles, but as Hallof (1967) has pointed out, the two methods sample the environment in decidedly different ways. The slingram anomaly is due to differences in electrical properties of the Alta and Kate Peak Formations and offers a relatively inexpensive means of verifying the fault trace south of Cornwall Knob. To the north of Cornwall Knob, the fault would be in the Kate Peak Formation, and this method may not be as effective.

A turam survey (Frischknecht, 1959) was conducted in areas where strong IP anomalies were found to see if this method could supplant the more expensive IP surveys. The turam method has greater depth of penetration than the slingram method, which would be important in trying to get below the highly conductive alluvium in much of the region. All turam trav-

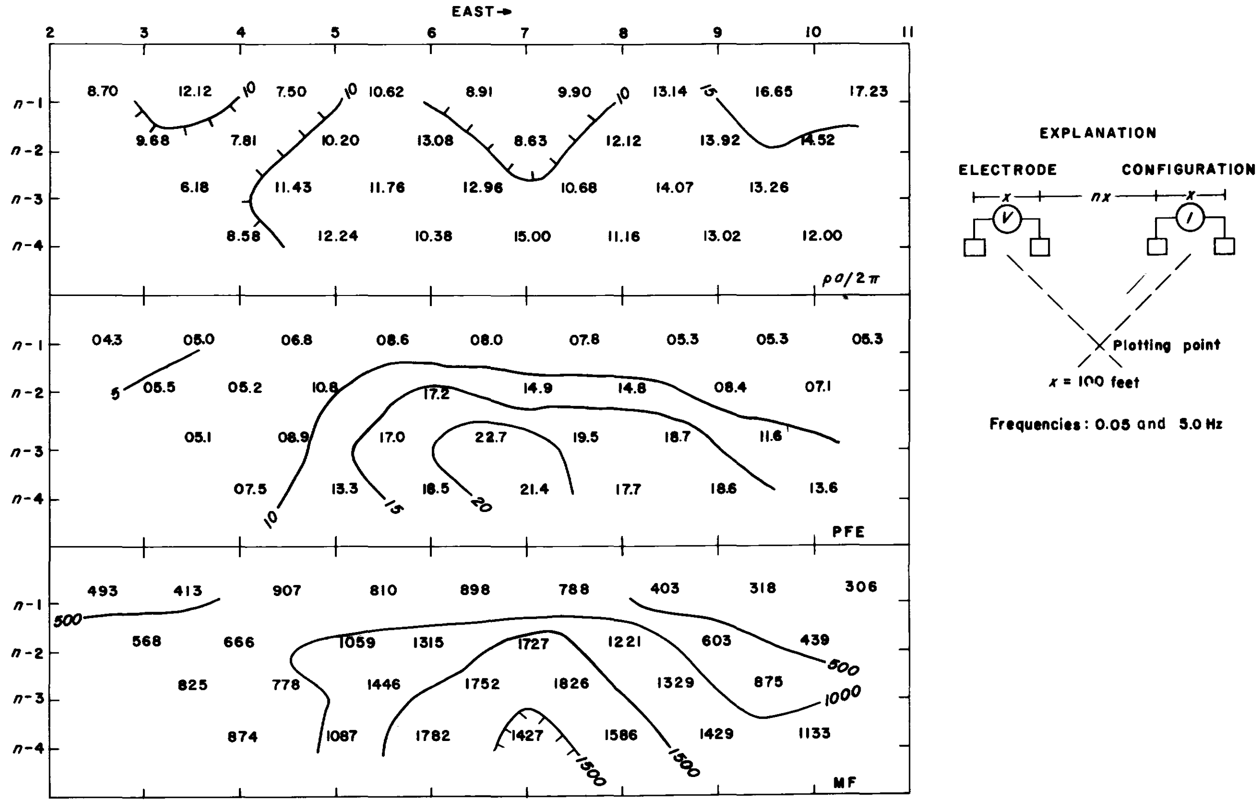

Figure 9.—Induced-polarization results, north end of Cornwall Knob area, traverse 4.

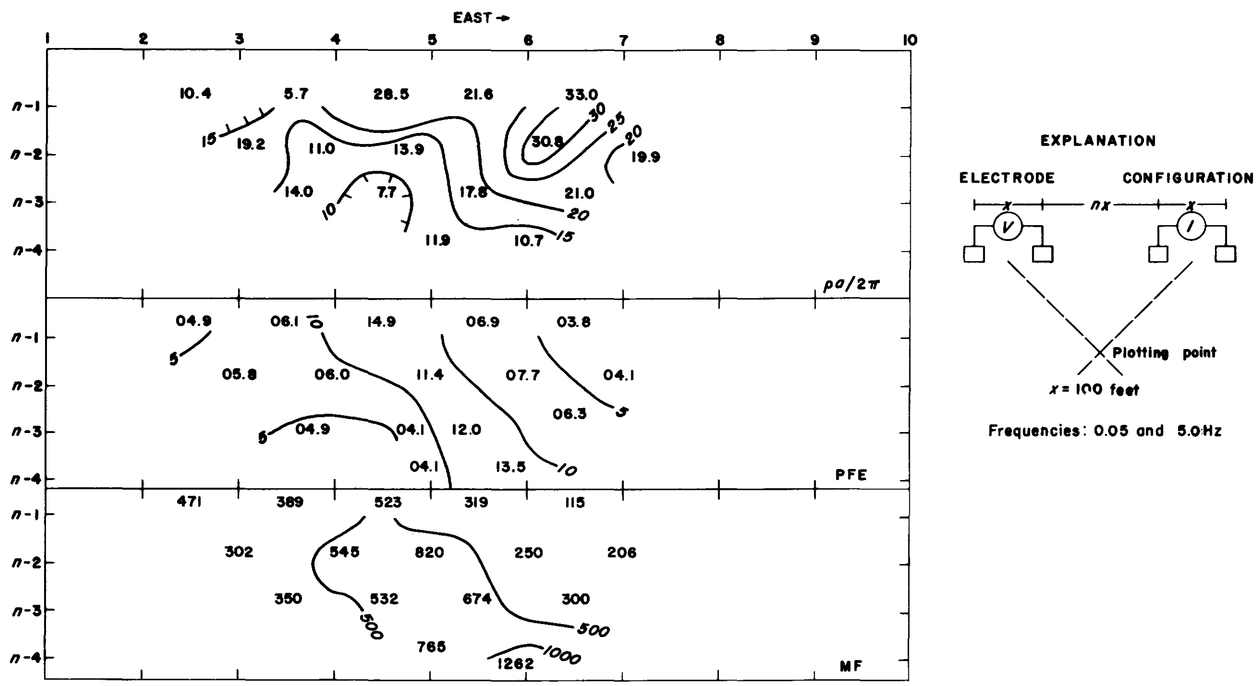

Figure 10.—Induced-polarization results, north end of Cornwall Knob area, traverse 13.

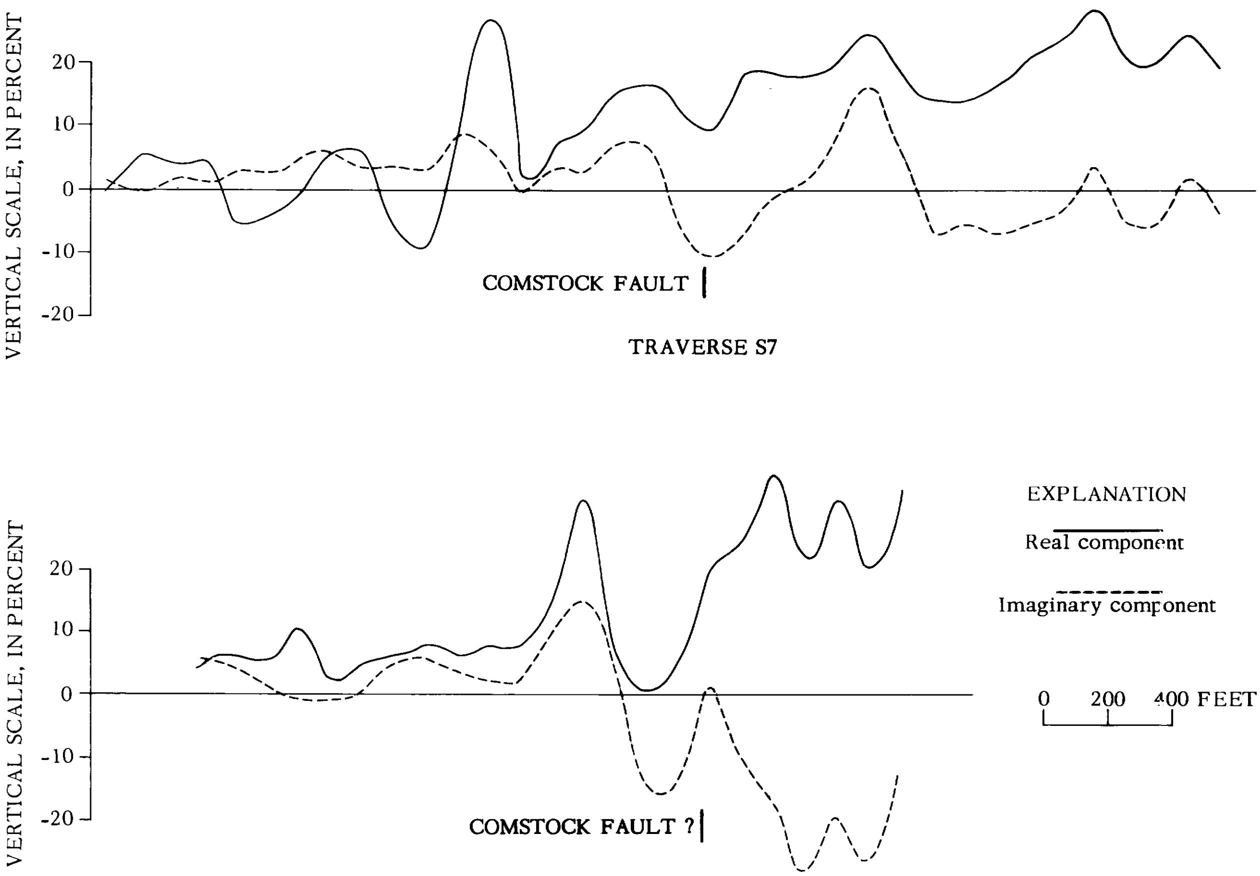

Figure 11.—Slingram profiles south of Cornwall Knob.

erses were made with horizontal coplanar coil configuration and 50-foot station intervals; an operating frequency of 500 Hz was used.

The turam map (fig. 12) shows no distinct anomalies, but background noise is high and tends to mask any effect that may be coming from the source of the IP anomaly. The noise on all the turam traverses is attributed to variations in salinity and porosity in the bleached rock and alluvial fill, which make up a highly conductive surface layer. Hallof (1967) has previously reported difficulties with electromagnetic methods in semiarid regions where ion-charged ground water can cause anomalies indistinguishable from shallow sulfide bodies. Lines 20S and 28S show anomalies on the east end which may correlate with smaller IP anomalies found on the east side of Cornwall Knob.

The IP profiles apparently show the trace of the Comstock fault as a zone of slightly higher resistivity relative to surrounding rock. Increased polarizability results from the higher percentage of clay minerals or sulfides associated with this zone. Electromagnetic techniques are not effective methods for tracing the fault except where it divides different rock units such as the Alta and Kate Peak Formations. In these areas, the slingram technique appears to be an effective aid to mapping, but it would not distinguish the fault from a simple formation contact. Neither electromagnetic nor IP methods appear to hold much promise as mapping tools for locating bleached zones in the Cornwall Knob area.

GEOCHEMICAL STUDIES

Geochemical samples were collected in several areas of altered volcanic rocks in the Virginia Range. Most samples have been collected in areas underlain by bleached rocks in an attempt

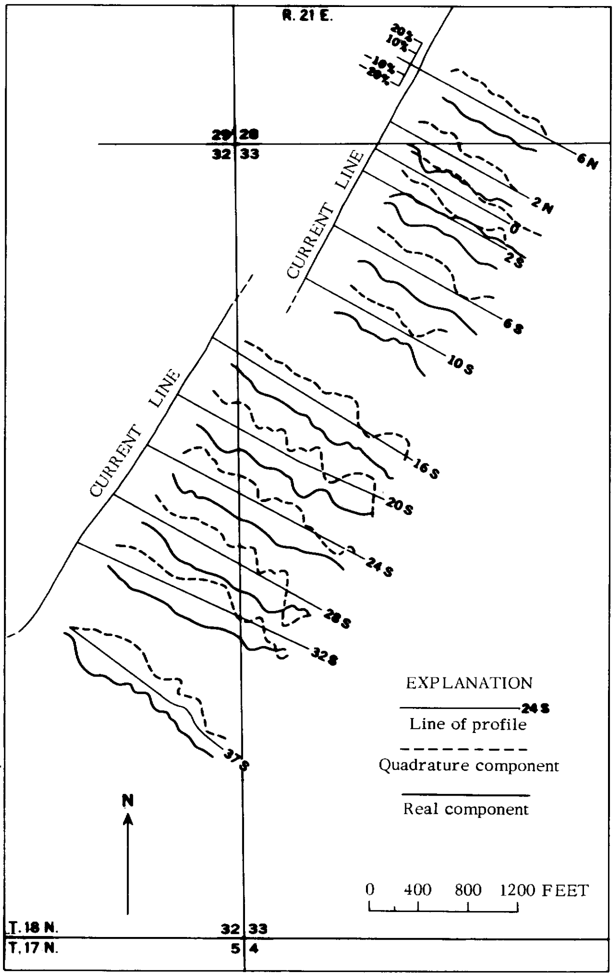

FIGURE 12.—Turam map of the Cornwall Knob area.

to determine whether trace-element distribution and abundance would be useful to define areas in which further exploration for concealed ore deposits might be warranted.

Gold was determined by a wet-chemical method using atomic-absorption spectrophotometry. Mercury was determined by a mercury-vapor detector. Other elements were determined by six-step semiquantitative spectrographic analysis. The analysts for gold were W. L. Campbell, M. S. Rickard, T. A. Roemer, G. H. VanSickle, T. G. Ging, Jr., R. B. Tripp, and T. M. Stein; for mercury, W. L. Campbell, W. W. Janes, H. D. King, K. R. Murphy, and S. L. Noble; for silver, lead, copper, and bismuth, D. J. Grimes, E. L. Mosier, J. M. Motooka, E. E. Martinez, and K. C. Watts, Jr.

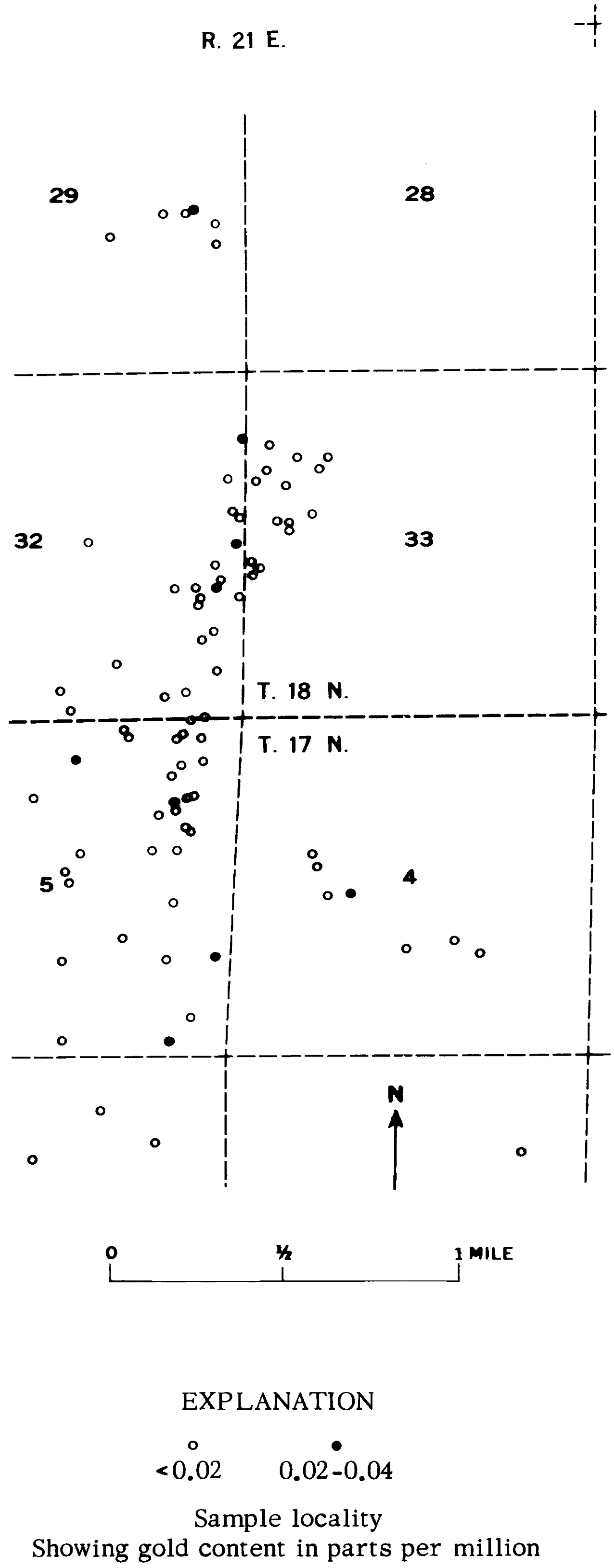

FIGURE 13.—Gold distribution, Cornwall Knob area.

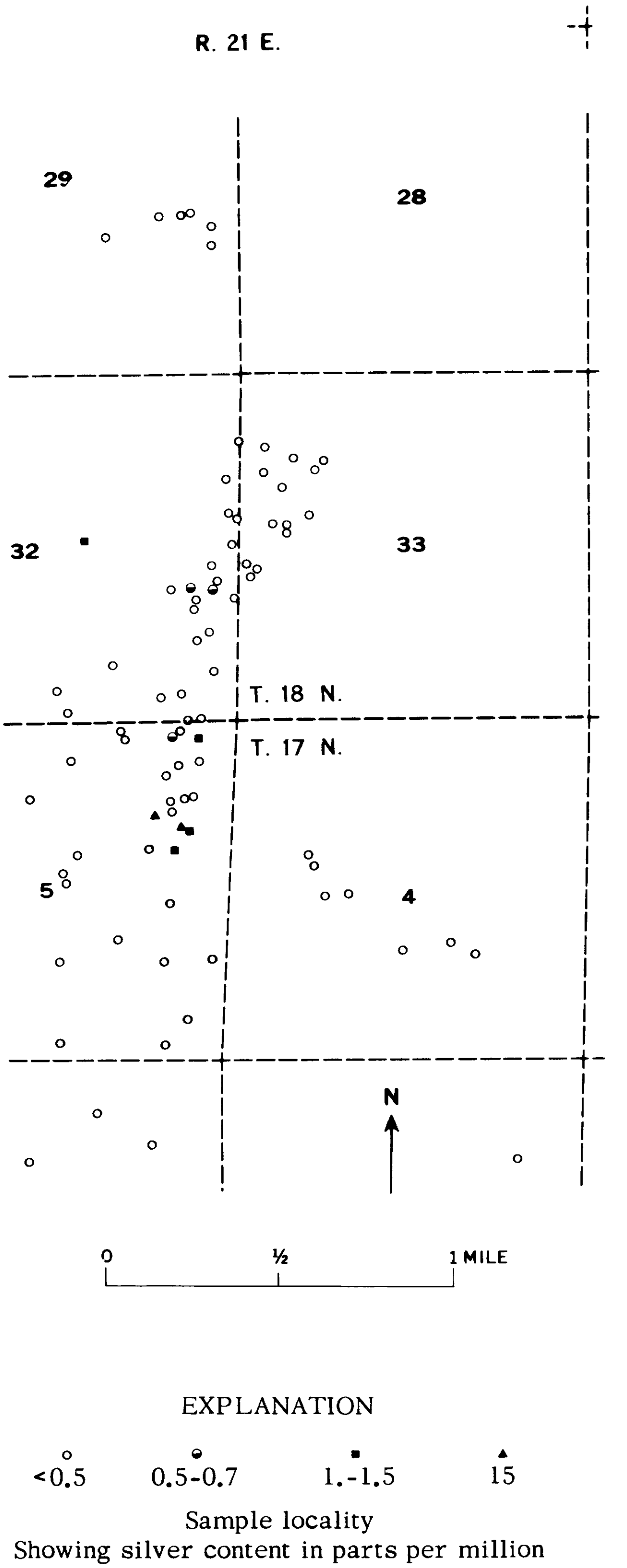

FIGURE 14.—Silver distribution, Cornwall Knob area.

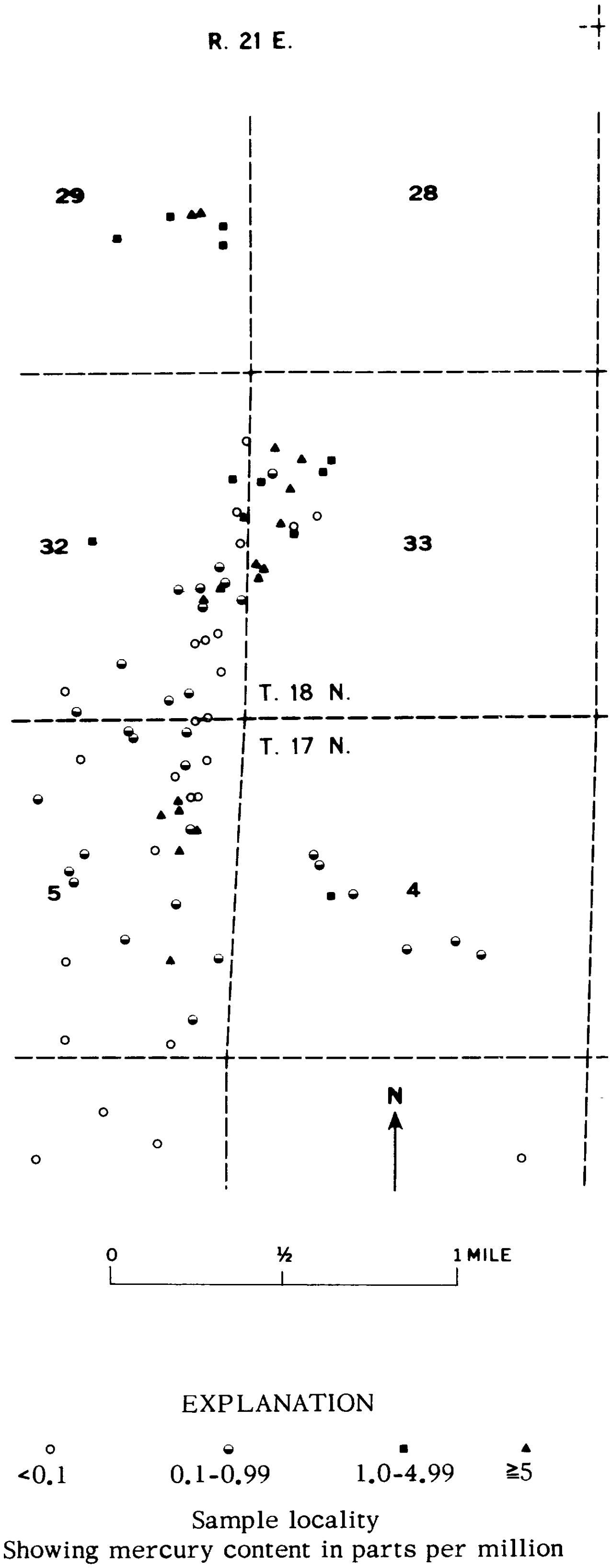

FIGURE 15.—Mercury distribution, Cornwall Knob area.

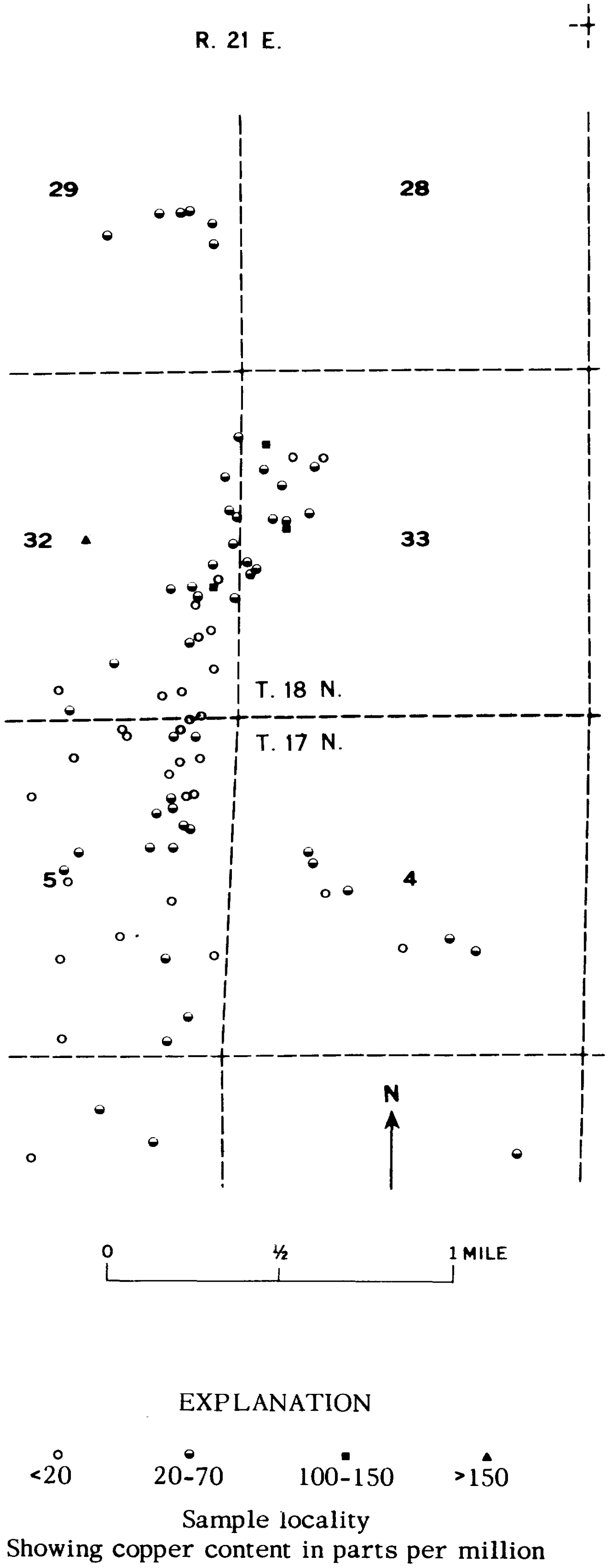

FIGURE 16.—Copper distribution, Cornwall Knob area.

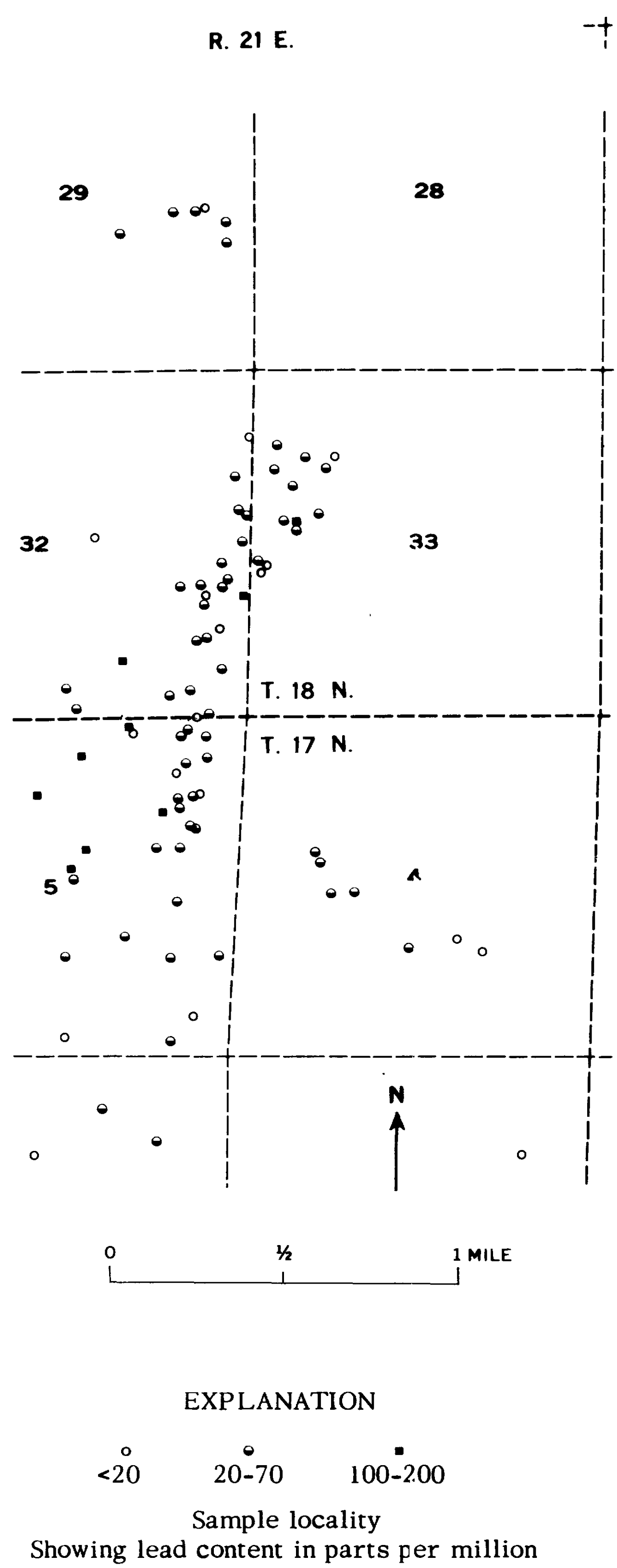

FIGURE 17.—Lead distribution, Cornwall Knob area.

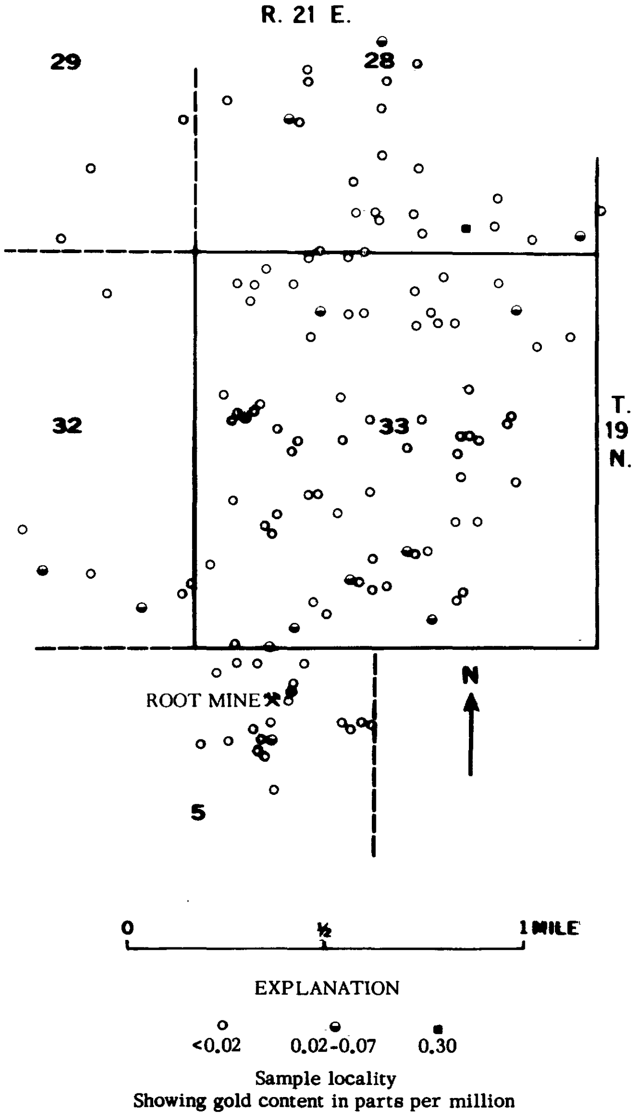

FIGURE 18.—Gold distribution, Washington Hill area.

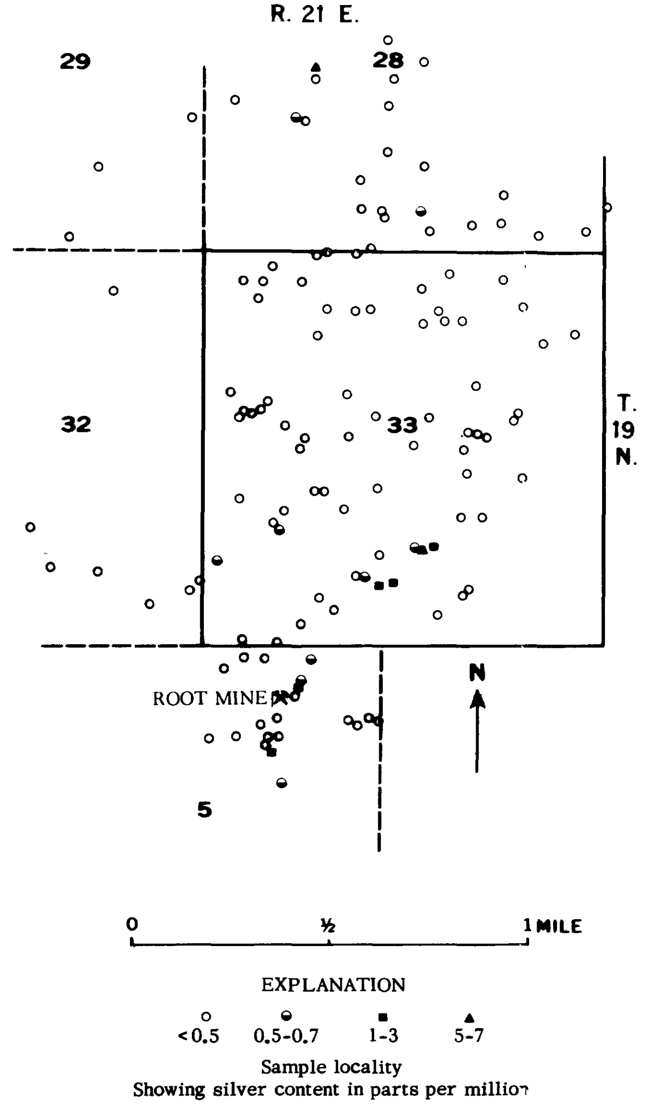

FIGURE 19.—Silver distribution, Washington Hill area.

CORNWALL KNOB AREA

Of 125 analyzed samples from the Cornwall Knob area, 58 were collected from outcrop, 21 were from dumps of prospect pits, 38 were soil samples, and eight were iron-rich fracture fillings. Most of the samples were collected in areas underlain by bleached rocks that were apparently barren and unmineralized. The distribution patterns of gold, silver, mercury, copper, and lead are shown in figures 13 to 17. Where several samples of various types were collected at a single locality, the geochemical maps show the highest value obtained.

Only a few scattered samples contained gold or silver in detectable amounts, but mercury is present in amounts of 1 ppm or more in 29 of the 84 sample localities. The high mercury values occur mostly in two clusters along the Comstock fault, and the largest concentration is in the bleached rocks near Cornwall Knob. The other cluster of anomalous mercury values in the NE¼ sec. 5 also has four high (≧1 ppm) silver values. No geophysical traverses were made here. The distribution of copper is similar to mercury but more widely scattered. Unfortunately, the site of the IP anomaly northeast of Cornwall Knob is covered by alluvium;

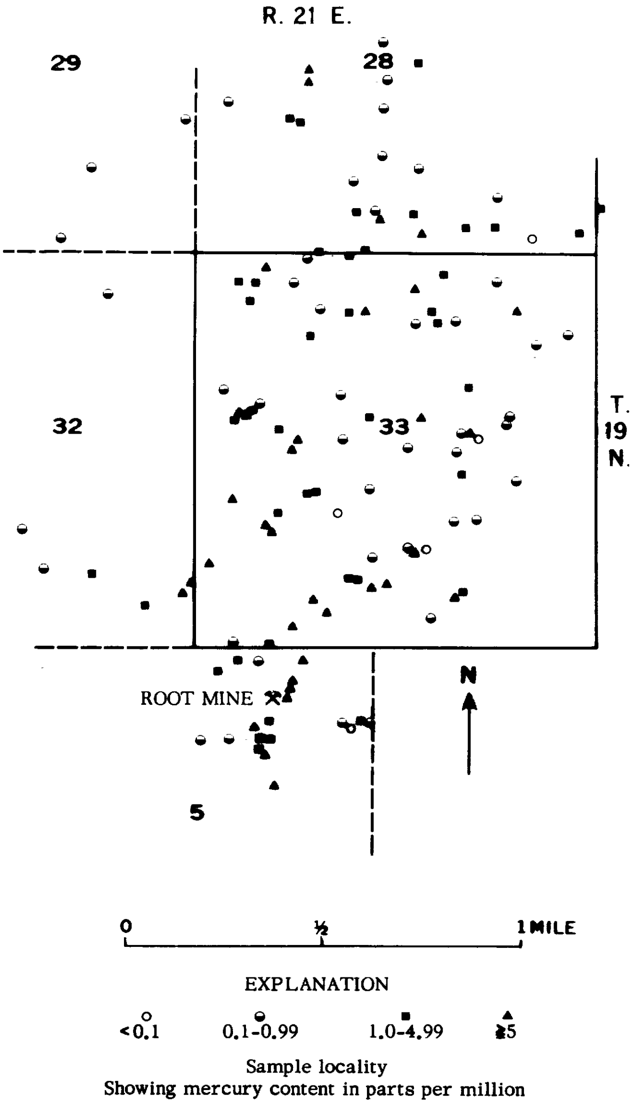

FIGURE 20.—Mercury distribution, Washington Hill area.

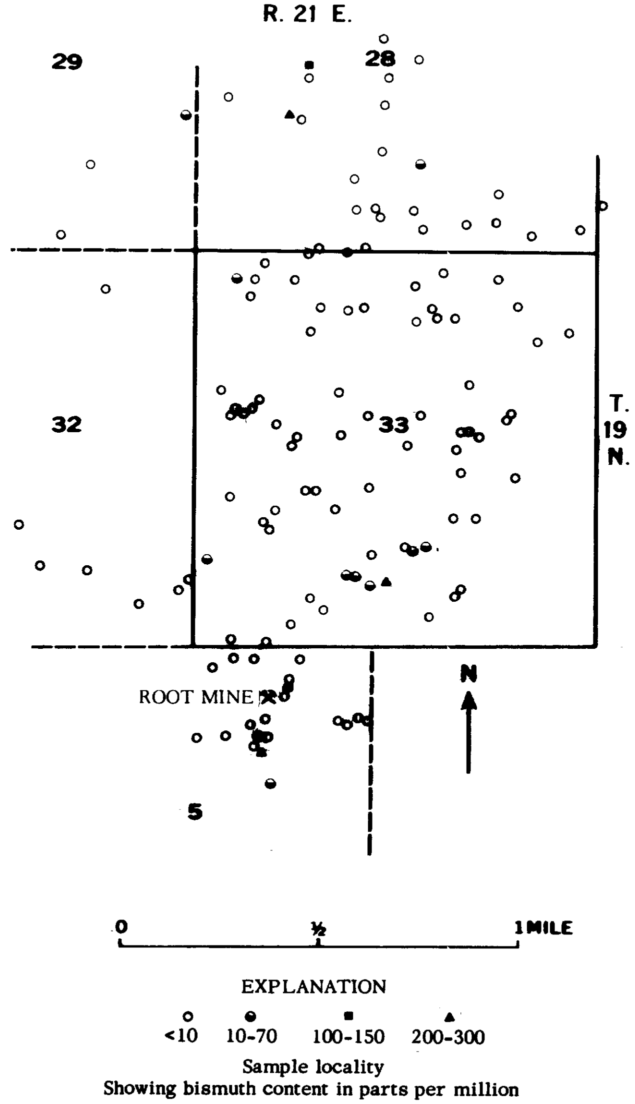

FIGURE 21.—Bismuth distribution, Washington Hill area.

therefore, no samples were collected, and a comparison with other areas is not possible.

WASHINGTON HILL AREA

The distribution patterns of gold, silver, mercury, bismuth, copper, and lead in the Washington Hill area (fig. 3) are shown in figures 18 to 23. Of 232 samples collected, 163 were from outcrops, 26 from dumps of prospect pits, 39 were soil samples, and four were iron-rich fracture fillings. Because of the extensive colluvium that covers most of the slopes underlain by nonresistant bleached rocks, many of the samples were collected along or near the resistant ledges delineated on the geologic map (fig. 3). The distribution patterns of the various elements therefore may be controlled to some extent by the outcrop patterns. Cornwall, Lakin, Nakagawa, and Stager (1967, p. B11–B13) reported the widespread anomalous mercury in the area. Figure 20 shows mercury values of 1 ppm or more in 75 of the 126 sample localities, and of these, 34 contain more than 6 ppm. High values for silver, bismuth, lead, and gold are mostly concentrated in a belt that trends northeast through the Root mine.

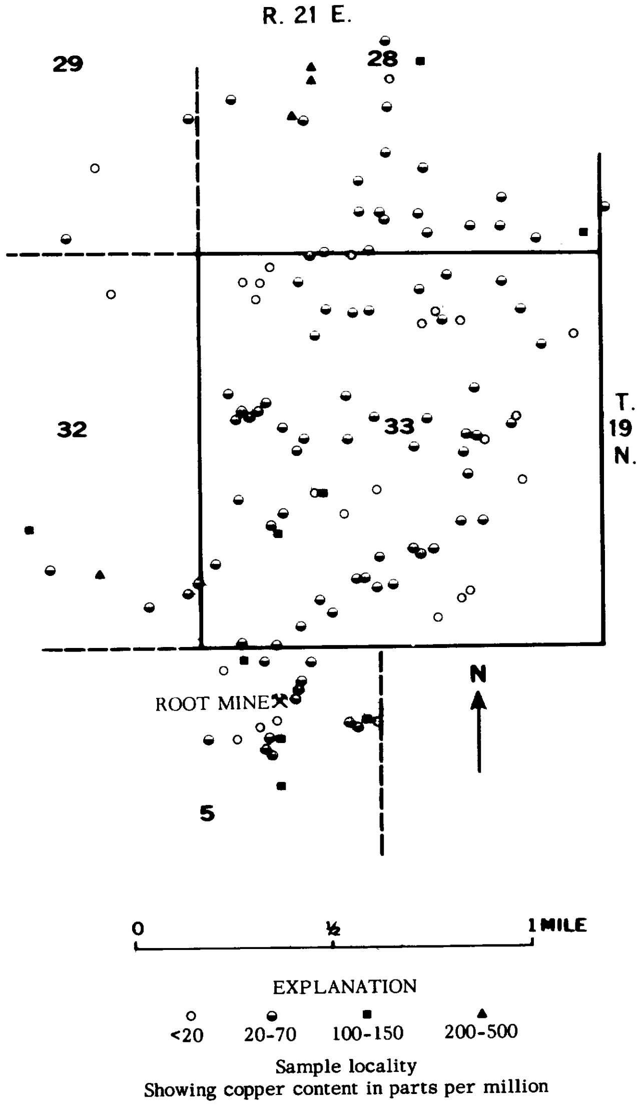

FIGURE 22.—Copper distribution, Washington Hill area.

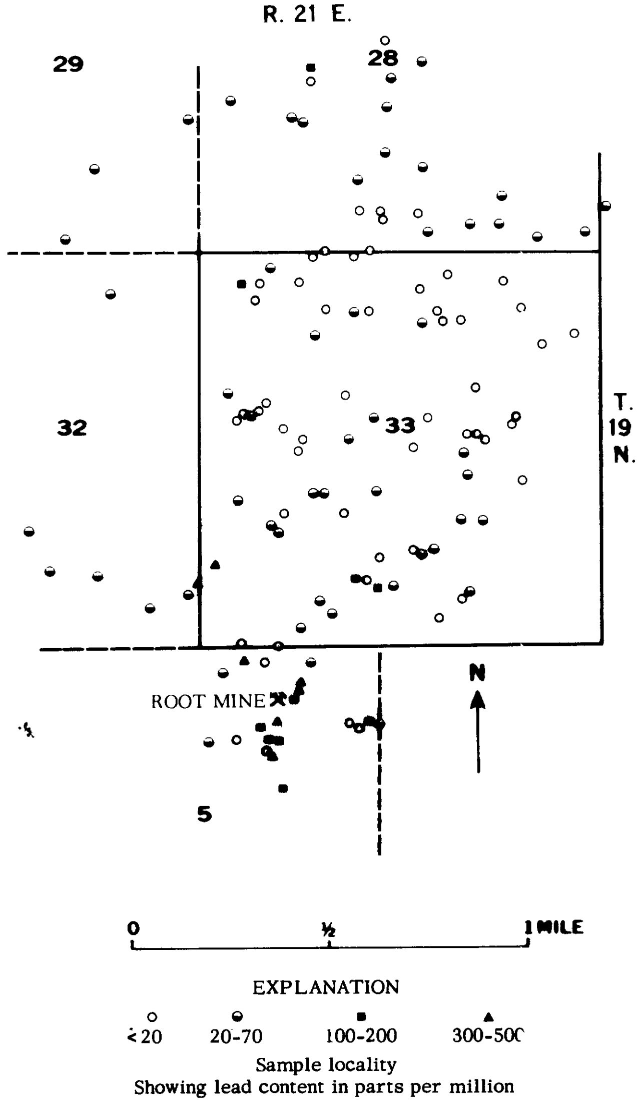

FIGURE 23.—Lead distribution, Washington Hill area.

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