Geochemical Reconnaissance of the Santa Rita Mountains, Southeast of Tucson, Arizona

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GEOLOGICAL SURVEY BULLETIN 1365

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March 3, 1849

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By HARALD DREWES

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Trace elements in alluvium and altered rock, recognized by geologic investigation previously reported, indicate some areas of potential economic interest along faults or near ore-associated intrusives

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GEOCHEMICAL RECONNAISSANCE OF THE SANTA RITA MOUNTAINS, SOUTHEAST OF TUCSON, ARIZONA

By HARALD DREWES

ABSTRACT

A geochemical reconnaissance, undertaken in conjunction with a more detailed general geologic study of the Santa Rita Mountains, reveals that base metals and noble metals and some other rare metals have been mobilized and have accumulated locally near certain rocks or structural features. Some geochemical anomalies delineate known mining camps; others suggest additional exploration targets. Several targets are reviewed in this report, but two other, more interesting targets have been described in previous reports.

A fairly weak geochemical anomaly in the alluvium along a few miles of Josephine Canyon is marked by about 100–200 ppm (parts per million) of copper and of lead; this anomaly compares favorably in areal extent with the stronger anomaly downstream from the main part of the Alto mining camp, and it compares favorably in intensity with the more widespread anomaly downstream from the Mansfield camp. The sources of two other anomalies were studied further. One of them, east of the Ivanhoe Mine, proved to be an area of disseminated-sulfide mineralization; this area was discussed in detail in another report. The other source, near the Salero Ranch, proved to be a silicified zone that contains base metals and silver.

Mineralized rocks from the Helvetia and Rosemont mining camps contain anomalous concentrations of gold (in the range of 0.1–5.6 ppm), tellurium (5–44 ppm), mercury (0.2–7 ppm), bismuth (100–1,000 ppm), antimony (20–200 ppm), and arsenic (20–160 ppm), in addition to the more highly concentrated base metals and silver, which have been mined in the area. The base metals and silver were concentrated chiefly in impure limestones and along faults, and particularly along faults near a group of quartz latite porphyry plugs that were emplaced during the late Paleocene.

Mineralized rocks in part of the Sycamore Canyon area contain anomalous amounts of gold and silver. These rocks consist of sheared limestone that forms a gently plunging syncline, the axis of which is intruded by another plug of quartz latite porphyry, suggesting that the mineralized ground may extend into a favorable subsurface location.

INTRODUCTION

The Santa Rita Mountains, in Pima and Santa Cruz Counties, 20–40 miles southeast of Tucson, Ariz. (fig. 1), are underlain by complexly deformed and intruded rocks of Precambrian to Holocene age. Many of these rocks are altered, and some are mineralized, chiefly by base and noble metals. Mines and prospects are

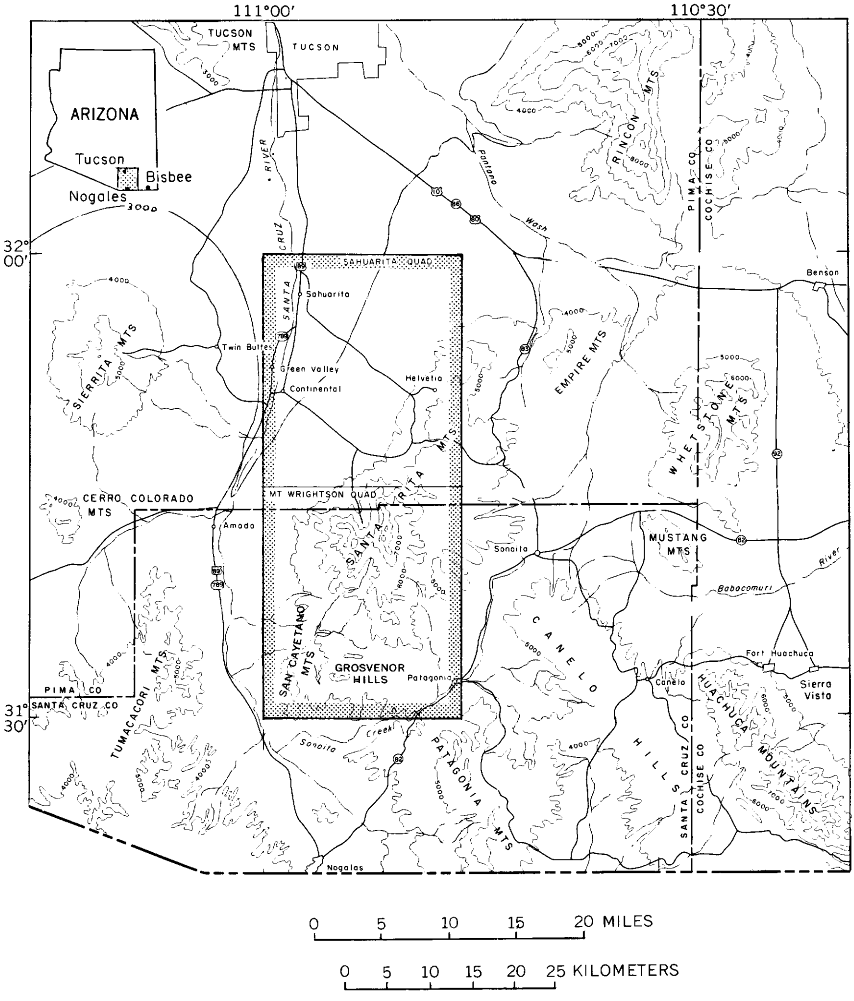


FIGURE 1. — Index map showing the location of the Santa Rita Mountains and the Sahuarita and Mount Wrightson quadrangles (stippled).

widely scattered in the mountains and are particularly numerous in the Helvetia, Wrightson, and Tyndall mining districts. During the 1960's, however, ore was produced on only a modest scale from but one mine. Mineral exploration has increased during the past decade, perhaps stimulated by development of several major copper mines in the Sierrita Mountains, across the valley west of the northern part of the Santa Rita Mountains. Results of a geochemical reconnaissance and a detailed structural study of the Santa Rita Mountains suggest that the area still has considerable economic potential, and several exploration targets are particularly promising.

The Santa Rita Mountains are a moderately rugged range surrounded by broad lowlands. Most of the mountains are 6,000–7,000 feet high; and the highest peak, Mount Wrightson, has an altitude of 9,453 feet. The broad plains of the Sonoita area to the east lie at an altitude of about 4,500 feet, but the equally broad valley of the Santa Cruz River to the west is at an altitude of only 3,000 feet. The mountains are drained to the northwest by the Santa Cruz River and its tributaries, to the north by Pantano Wash, and to the south by Sonoita Creek.

As a result of the large range in altitude, the amount of precipitation varies widely; and the vegetation reflects this variation closely. The yearly precipitation probably ranges from 10 to 25 inches, depending on altitude. Much of it falls during heavy thunderstorms in the summer. Sonoita Creek flowed continuously from the town of Patagonia almost to its junction with the Santa Cruz River before it was dammed about midway along this stretch. Many mountain streams are perennial, but most of the washes in the foothills and all of those at the foot of the mountains are ephemeral. The mountains receive sufficient moisture to support an extensive forest. The plains to the east are a grassland, fringed by open stands of scrubby woods. The Santa Cruz River valley is covered with mesquite and cactus typical of the Sonoran Desert plant assemblage.

The rugged core of the Santa Rita Mountains is surrounded by a discontinuous belt of foothills and a zone of alluvial fans. In places, the fans end abruptly against the steep flanks of the mountains, but in others, they extend irregularly a few miles into the foothills. Some fans merge upslope with pediments, which rarely are more than 2 miles wide and which commonly are discontinuous around the mountains. The fans coalesce downslope into alluvial aprons. The entire piedmont area—fans, pediments, and alluvial aprons—is cut by numerous drainages flanked by stream terraces.

OBJECTIVES

A detailed geologic investigation was made of the Mount Wrightson and Sahuarita quadrangles during 1962–69 (Drewes, 1971a, b). These quadrangles cover almost all the Santa Rita Mountains; only the northeasternmost tip of the mountains extends beyond the edge of the Sahuarita quadrangle (fig. 1). The Mount Wrightson quadrangle also covers the Grosvenor Hills and San Cayetano Mountains, which lie southwest of the Santa Ritas and which are separated from them by lowlands containing only small alluvial deposits. For convenience, reference henceforth to the Santa Rita Mountains will imply the area covered by these quadrangles.

Although the main effort of the geologic investigation was directed toward studying the rocks and structural features of the Santa Ritas, the study was extended to cover the general features of the mineral deposits. Inasmuch as this part of the investigation was subordinate to the main effort, reconnaissance field methods and semiquantitative analytical methods were employed. The study was directed toward determining what elements were mobilized, where and when they were concentrated, and what controlled their concentration. The question of the controls of mineral accumulation is inseparable from the main geologic investigation. Concepts obtained from this reconnaissance geochemical study suggest several exploration targets. Descriptions of two promising exploration targets have been reported already (Drewes, 1967, 1970); some targets of probably lesser potential are described in this report.

The reconnaissance geochemical study of the Santa Rita Mountains employed two sampling methods. A cursory census of mineral concentrations was obtained by chemical and spectrographic analyses of samples of alluvium from fairly widely spaced sites. This census was augmented by an inventory of the common ore-associated minerals occurring in the hundreds of mines and prospects of the area. Where the results were encouraging, a more detailed sampling was made of the altered source rocks. This more detailed sampling was also reconnaissance type; it was designed to identify the elements that were mobilized and the locus of concentration within a geochemically anomalous area and not to provide a basis for quantitative evaluation.

SUPPORTING WORK

The geologic investigation of the Santa Rita Mountains was preceded by other studies and is augmented by studies recently completed, or almost completed, in adjacent mountains. Schrader (1915) made a reconnaissance geologic map of the Santa Rita Mountains and described the mineralogy of many mines. Creasey and Quick (1955) described the geology in and around some of the mines of the Helvetia district in greater detail. At least 10 theses and dissertations submitted to the University of Arizona cover parts of the Santa Rita Mountains, and several of them are referred to below in connection with the Helvetia district.

The geologic investigation of the Santa Rita Mountains is part of a larger U.S. Geological Survey program to map and interpret the geologic history of the ranges between Tucson and Bisbee, Ariz. (fig. 1). Many geologists are involved in this program, and most of their field studies are completed. J. R. Cooper (1970) has mapped the Sierrita Mountains, T. L. Finnell (1971) the Empire Mountains, S. C. Creasey (1967) the Whetstone Mountains, R. B. Raup (unpub. data) the Canelo Hills, F. S. Simons (1971a, b) the Patagonia Mountains, P. T. Hayes and R. B. Raup (1968), respectively, the Huachuca and Mustang Mountains, and P. T. Hayes and E. R. Landis (1964, 1965) the Mule Mountains (northwest of Bisbee).

The main geologic investigation of the Santa Rita Mountains, of which the geochemical reconnaissance reported here is only a part, is presented in a series of topically oriented reports. The basic geology is shown on the Sahuarita and Mount Wrightson quadrangle maps (Drewes, 1971a, b). Cenozoic sedimentary, volcanic, and hypabyssal intrusive rocks are described separately (Drewes, 1972a) from the Mesozoic rocks (Drewes, 1971c). The structural geology is reviewed independently (Drewes, 1972b). Additional reports cover restricted geologic topics in the area (Drewes, 1969; Drewes and Finnell, 1968; Marvin and others, 1969; Hayes, 1970; Hayes and Drewes, 1968; Simons and others, 1966; and Lovering and others, 1970).

ACKNOWLEDGMENTS

The field investigation in the Santa Rita Mountains was facilitated by many people. Assistance in mapping and sampling was provided by G. C. Cone, Bruce Hansen, C. W. Norton, F. W. Plut, J. R. Riele, R. A. Rohrbacher, Albert Sutheimer, and W. M. Swartz between 1963 and 1968. Discussions in the field with R. E. Wallace, M. D. Crittenden, Jr., J. H. Courtwright, and P. H. Pickard helped in clarifying some problems and in raising others; I am particularly grateful for these exchanges. The courtesies of Messrs. George Bradt, Roy Green, Dewey Keith, and George Yakobian and of Profs. J. W. Anthony, D. L. Bryant, Evans Mayo, and S. R. Titley, all of the University of Arizona, and of E. S. Davidson, M. E. Cooley, Fred Pashley, and S. C. Martin are also acknowledged. The constant close cooperation with other geologists who were mapping in the adjacent mountains during the Santa Rita investigation provided an opportunity to test interpretations and to consider alternate interpretations not obtainable from my own local observations.

Valuable support was given by many laboratories. Some radiometric dates were obtained from Prof. P. E. Damon, University of Arizona, and many others were provided by R. F. Marvin, T. W. Stern, S. W. Creasey, and their colleagues. The numerous chemists and spectrographers who contributed data are acknowledged in the analytical tables.

GEOLOGY

The mineral deposits of the Santa Rita Mountains are more closely related to some rock units, such as a swarm of quartz veins or a particular intrusive rock, than to others, and they are also related to some structural features. In this report, a brief summary of the areal geology is given, as well as a more detailed description of some of the salient geologic features related to mineralization. Later in the text, the geology of a few small areas is described in greater detail. Frequent reference is made to the collateral reports to give the reader sources of additional information.

GEOLOGIC FORMATIONS

The oldest rocks in the Santa Rita Mountains are schist and gneiss that correlate with the Precambrian Pinal Schist. They are intruded by one or more large plutons of Continental Granodiorite, also of Precambrian age. The Precambrian rocks are unconformably overlain by Paleozoic shallow-water marine deposits 5,000–6,000 feet thick. In rising order, this sequence includes Middle Cambrian Bolsa Quartzite; Middle and Upper Cambrian Abrigo Formation of shale, quartzite, and limestone; Devonian Martin Formation of dolomite, limestone, and sandstone; Mississippian Escabrosa Limestone; Pennsylvanian Horquilla Limestone; Pennsylvanian and Permian Earp Formation, of siltstone and sandstone; and several Permian formations — Colina Limestone; Epitaph Dolomite, which contains dolomite, marlstone, siltstone, limestone, and a little gypsum; Scherrer Formation, of quartzite, siltstone, and dolomite; Concha Limestone; and Rainvalley Formation, of limestone, dolomite, and a little sandstone. The stratigraphic continuity of the Paleozoic sequence is broken by several disconformities, the largest of which spans at least Ordovician and Silurian time.

The Paleozoic rocks are unconformably overlain by the Mount Wrightson Formation, of Triassic age, which consists of rhyolitic rocks and some dacitic to andesitic rocks, sandstone, and conglomerate. The Mount Wrightson Formation is overlain by red beds of the Gardner Canyon Formation and is intruded by the Piper Gulch Monzonite, both of Triassic age. A little tuff and sandstone of the Canelo Hills Volcanics, of Triassic and Jurassic age, lap into the area. The Squaw Gulch Granite, of Jurassic age, forms a large stock in the southern part of the mountains and is unconformably overlain by volcanic and sedimentary rocks of the Temporal and Bathtub Formations, of early Early Cretaceous age, and by the Bisbee Group, of late Early Cretaceous age. The Bisbee Group consists of the basal Glance Conglomerate; the Willow Canyon Formation, of arkosic sandstone; the Apache Canyon Formation, of arkosic sandstone, siltstone, shale, and a little limestone; the Shellenberger Canyon Formation, of siltstone, shale, and a little limestone; and the Turney Ranch Formation, of sandstone and siltstone. The Bisbee Group is unconformably overlain by conglomerate and siltstone of the Fort Crittenden Formation, which, in turn, is overlain by volcanic and clastic rocks of the Salero Formation, both of late Late Cretaceous age. At the close of the Cretaceous, composite stocks of Josephine Canyon Diorite, Elephant Head Quartz Monzonite, and Madera Canyon Granodiorite intruded the rocks of the core of the mountains.

The Gringo Gulch Volcanics, of probable Paleocene age, overlie the Cretaceous stocks. Small stocks, plugs, and dikes of granodiorite, dacite porphyry, and quartz latite porphyry, largely of late Paleocene age, occur throughout the area. These include a group of barren stocks of Helvetia and a group of ore-associated plugs of Greaterville. A swarm of mineralized quartz veins was emplaced in the southern part of the Santa Rita Mountains during the late Paleocene–late Oligocene interval. Rhyolite and rhyodacite volcanic rocks and some basal sedimentary rocks, all of which compose the Grosvenor Hills Volcanics, were deposited over much of the southwestern part of the range and the outlying hills during the late(?) Oligocene. Dikes and laccoliths were injected into the volcanics, and two swarms of rhyolite dikes and a plug were injected into the central and northern parts of the range penecontemporaneously with the Grosvenor Hills Volcanics. Gravels were deposited on the flanks of the mountains during the late Tertiary and Quaternary.

The amounts of trace elements in the unaltered and relatively widespread igneous rocks help to estimate background values of these elements in the altered rocks and their detritus. Table 1 lists the typical abundance of eight of the more interesting elements. More complete analyses than those shown in table 1 are included in companion reports (Drewes, 1970, 1971c, 1972a). Except for the Greaterville plugs, each of the igneous rocks in table 1 underlies a fairly extensive area. Because the abundances of seven other elements in unaltered rocks are below the thresholds of detection, only their background maximums are known. These are, in parts per million: bismuth, 10; cadmium, 20; mercury, 0.01; antimony, 100; tin, 10; tungsten, 20; and zinc, 200. One analysis of metamorphosed Precambrian granodiorite is included in the table for comparison with the analysis of an unmetamorphosed specimen.

TABLE 1. — *Semiquantitative spectrographic analyses of selected elements (in parts per million) in some typical igneous rocks of the Santa Rita Mountains*

[Analysts: J. L. Harris, J. C. Hamilton, W. V. Crandell, and A. L. Sutton]

Formation, age, and rock	Sample No.	Ag	B	Ba	Be	Cu	Mo	Pb	V
Grosvenor Hills Volcanics, Oligocene, rhyodacite	382	0	20	1,000	3	20	15	15	100
Greaterville plugs, Paleocene, quartz latite porphyry	1185	0	0	700	3	500	3	7	15
Helvetia stocks, Paleocene, granodiorite	1337	0	0	700	3	2	0	7	15
Elephant Head Quartz Monzonite, Late Cretaceous	876	0	0	700	1.5	7	0	30	0
Josephine Canyon Diorite, Late Cretaceous	316	0	0	1,000	0	150	7	20	200
Salero Formation, Late Cretaceous:									
Rhyodacite	599	0	0	1,000	3	15	....	15	100
Dacite[1]	1095	0	100	2,000	1.5	7	0	15	100
	1095	0	50	1,000	1	2	0	30	100
Squaw Gulch Granite, Jurassic	282	0	0	700	3	7	10	20	20
Mount Wrightson Formation, Triassic:									
Rhyolite	57	0	<30	700	2	20	0	0	50
Andesite	141	0	0	1,000	1	50	3	20	300
Continental Granodiorite, Precambrian:									
Unmetamorphosed	104	5	0	2,000	0	1,000	0	700	70
Metamorphosed	1406	0	0	1,000	3	10	0	10	30

[1] Replicate analyses.

STRUCTURE

The succession of rocks summarized above is abundantly faulted and in places is also folded. Large fault displacements, probably mostly normal, deformed the rocks several times during the Triassic through Early Cretaceous interval. The rocks were even more severely deformed during the Laramide orogeny, which began in the Late Cretaceous and lasted approximately through the Paleocene. The Laramide orogeny, as it affected this region, is separated into a stronger and more widespread Piman phase that culminated with the emplacement of the late Late Cretaceous composite stocks and a weaker and more local Helvetian phase that occurred during the late Paleocene. The Paleozoic and Mesozoic rocks were thrust faulted, tear faulted, and folded, with tectonic transport directed northeastward during the Piman phase of the orogeny. Some rocks at the north end of the Santa Rita Mountains were further thrust faulted and tear faulted with transport directed northwestward during the Helvetian phase. Normal faults also cut the rocks at several times during the Tertiary, and range-front faults on the northwest sides of the mountains cut gravel as young as late Pleistocene.

Many mineral deposits are hydrothermal veins, and some are metasomatic deposits; some placer deposits occur in the streams draining the hydrothermally altered areas. Most deposits probably are related genetically to magmatic events of the Laramide orogeny, but some predate the Laramide, and others may postdate it slightly. In the following sections, the geologic features related to rock alteration, ore porphyry, and mineralized quartz veins are described in greater detail than in the report by Schrader (1915).

ROCK ALTERATION AND METAMORPHISM

Many rocks of the Santa Rita Mountains have been altered; argillic-pyritic hydrothermal alteration and intense contact metamorphism were closely related to mineralization. The most common alteration, however, was a mild thermal metamorphism which was more regional than local and which was not restricted to the contact of a particular intrusive body. This subregional metamorphism epidotized, chloritized, kaolinized, and albitized many volcanic and sedimentary rocks of Cretaceous or older age. A milder alteration was more common in the Paleocene(?) Gringo Gulch Volcanics than in the pre-Laramide rocks, and it seems to have been transitional with the diagenetic argillic alteration common to even the youngest pyroclastic rocks. Alteration of the particularly susceptible rocks increased in intensity near the contacts of some Laramide plutons. For example, rocks at midslope on the east wall of Madera Canyon are schistose metavolcanic rocks and metaquartzite in which secondary biotite and schorlitic tourmaline are fairly common. Elsewhere, siltstone and tuffaceous sandstone of the southern San Cayetano Mountains and in the lower Agua Caliente Canyon area are markedly hornfelsed. The intensity of alteration also increased in the northern Santa Rita Mountains, where Paleozoic rocks are relatively abundant. The purer limestones, such as the Escabrosa and the lower half of the Horquilla, were conspicuously recrystallized to marble; the less pure carbonate rocks, such as the Abrigo and Martin Formations, were metamorphosed to calc-silicate rocks, an alteration commonly occurring in rock sequences that are thinner than nearby unmetamorphosed correlative sequences. Many of the siltstones of the northern part of the range were slightly hornfelsed, and some of them close to large thrust or tear faults were also dynamically metamorphosed to form phyllite or hornfels that shows cleavage and crenulated foliation. The Precambrian granodiorite is also slightly altered in and north of Box Canyon; biotite was recrystallized into a mosaic of small grains that were formed from the original large grains. During this recrystallization, the contents of copper and other metals in the biotite were markedly decreased (table 1; Lovering and others, 1970).

Most of the mild subregional metamorphism is probably of early Laramide age, but part of it may be older, and some of it definitely is younger. An early Laramide, or approximately latest Late Cretaceous, age for the metamorphism is suggested by the abundance of 68-m.y.-old stocks intruded into the altered metamorphic rock terrane and by the apparent gradation of some mildly metamorphosed rocks into intensely metamorphosed rocks near the borders of some stocks. An early Laramide metamorphic episode is also suggested by the diverse radiometric ages of several minerals concentrated from two samples of the Elephant Head Quartz Monzonite, north of the upper reaches of Agua Caliente Canyon. Biotite from the samples has a potassium-argon age of about 68 m.y. (Drewes, 1968, 1971b), whereas zircon has a lead-alpha age of about 170 m.y. (Drewes, 1971b). Despite the absence of petrographic data to support an interpretation of recrystallization of all but the most refractory minerals, such as zircon, the dating results suggest that the stock may have been emplaced during the Jurassic and possibly metamorphosed, mobilized, and almost completely recrystallized during the Late Cretaceous.

Contact metamorphism and subregional metamorphism probably also occurred during the Jurassic, adjacent to bodies of Squaw Gulch Granite. About 1½ miles southwest of the junction of Mansfield Canyon with Temporal Gulch in the west-central part of the Wrightson district (pl. 1; Drewes, 1971b), a zone of hornfelsed and epidotized volcanic and sedimentary rocks as much as half a mile wide lies adjacent to the Jurassic stock and is far from the younger stocks. Near the Glove mine in the west-central part of the Tyndall district, the intensely contact-metamorphosed Paleozoic rocks form an aureole around a body of quartz monzonite that is correlative with the Jurassic Squaw Gulch Granite. Both the quartz monzonite and the contact aureole are unconformably overlain to the southeast by a part of the Salero Formation which is dated as 72 m.y. old, providing geologic evidence in support of a greater-than-68-m.y. age of the intrusive. Anthony (1951) and Olson (1961) have described the geology near the mine, and Drewes (1972b) has reviewed and illustrated the critical field relations. Metamorphism of Jurassic age also occurred in a zone of granodiorite ¼–1½ miles west of the intersection of the Salero fault zone with Josephine Canyon (pl. 1; Drewes, 1971b). The granodiorite resembles the Precambrian Continental Granodiorite except that it is an unaltered hypidiomorphic granular rock, rather than a slightly altered one with a meshwork of chlorite between the other minerals. Biotite concentrated from the granodiorite gives an age of 159 m.y. ±3 percent (R. F. Marvin, H. H. Mehnert, and Wayne Montjoy, written commun., 1965), an age close to that of the adjacent Squaw Gulch Granite.

Some contact metamorphism and other alteration is of late Laramide (late Paleocene) age. The stocks and plugs of the northern part of the mountains are of this age; and the rocks they intrude are altered, presumably by these intrusives. Biotite from recrystallized Continental Granodiorite has been radiometrically dated as late Paleocene (Drewes, 1968); however, a lead-alpha age on zircon and a rubidium-strontium age on the whole rock indicate that the rock is Precambrian, as do its geologic relations.

Dynamic metamorphism has affected some of the rocks, probably mostly during the Laramide. Sheared and recrystallized rocks along the lower reaches of Sawmill Canyon (NW.) (two canyons with identical names are distinguished from each other in this report by their relative positions, NW. and SE.) were more intensely deformed close to the Sawmill Canyon fault zone than away from it. The intensity of the deformation also diminished southeastward along the fault, where the various movements were spread among many subsidiary fault planes that form a zone several miles wide. The shearing, the spatial relation of metamorphosed rock to the fault zone, and the absence of nearby stocks younger than the deformed rocks suggest that the metamorphism was dynamic. In the same area, rocks correlated with the Pinal Schist are strongly foliated; and the layers are crinkled, flow folded, and cut by a cleavage. This deformation was probably of Precambrian age, for its style and intensity are typical of the kind of deformation in the basement rocks of southeastern Arizona. Some other rocks in the northern part of the mountains were also dynamically, as well as thermally, metamorphosed. Among these rocks are limestone and limestone conglomerate along thrust faults immediately north of Box Canyon; and limestone, siltstone, and argillaceous rocks in klippen of Triassic and Jurassic strata along Sycamore Canyon. The presence of phyllite that has a cleavage and the strong spatial relation of the deformed rocks to major thrust faults rather than to a large intrusive body indicate that the rocks were affected by dynamic metamorphism. The distribution of tactite zones along stratigraphic units of a suitable lithology may also have been facilitated by thrust faults. Many of the gypsum pods near the Helvetia townsite were emplaced by rock flowage (Drewes, 1972b, pl. 4).

Some hydrothermally altered rocks differ from the surrounding rocks because of the kind of intensity of alteration that affected them, although in general they blend into the subregional mild thermal metamorphism. Along the crest of the southern part of the Santa Rita Mountains there is a north-northwest-trending string of somewhat elliptical areas of strongly argillized and generally pyritized rock. The weathered rocks of these areas are brightly colored in shades of yellow and red, presumably as a result of the oxidation of widely disseminated pyrite. Similarly altered rocks are common east of the Paleozoic rocks near the

Rosemont camp in the northern part of the Santa Rita Mountains and also in the Patagonia Mountains, shown in the lower right corner of the larger map on plate 1. The altered and iron oxide-stained rocks grade into the less discolored and more typically epidotized and chloritized rocks; and in some places, such as along Mansfield Canyon, the gradational zone is very broad. The hydrothermal alteration did not occur before the subregional thermal metamorphism, and some alteration, such as that affecting the Gringo Gulch Volcanics, cannot have occurred before late Laramide (late Paleocene).

Virtually all the mineral deposits occur in rocks that have been thermally or dynamically metamorphosed or hydrothermally altered. Some mineral deposits are disseminated in, or are replacements of, favorable lithologies in these rocks, but other deposits occur as epigenetic veins. Although the incidence of mineralization was greatest in the altered rocks, the intensity of mineralization varied significantly. Many of the calc-silicate-rich thermally metamorphosed zones contain noteworthy concentrations of metals as replacement and disseminated deposits. The Glove mine area and parts of the area near Helvetia townsite are examples of such mineralization. The intensely altered argillic and pyritic areas also contain anomalous amounts of metals other than iron. Two bands of dynamically metamorphosed limestone in the Sycamore Canyon area provide further examples of the association of metamorphic rocks with mineral deposits. Mineral deposits are also concentrated in the Alto vein swarm and along faults around the ore porphyry plugs.

ALTO VEIN SWARM

A swarm of more than 300 quartz veins, referred to as the Alto vein swarm, is clustered in the southern part of the Santa Rita Mountains. The veins are most abundant and largest on the flanks of the mountains in the central parts of the Tyndall and Wrightson mining districts (pl. 1), where they cut mainly volcanic and sedimentary rocks of Mesozoic age. They are fewer and smaller in the southern parts of the Tyndall and Wrightson districts, as well as along the crest of the mountains, and a few miles north of the upper reaches of Josephine Canyon and Temporal Gulch, where they cut the stocks. The relation of the smaller quartz veins that are widely scattered in the northern part of the mountains to the veins of the Alto swarm is unknown.

The Alto veins commonly strike about east-west and dip from 70° N. to 70° S. However, their trend is not quite parallel throughout the area, for eastward they fan out slightly.

The veins are commonly tabular bodies about 5 feet wide and

2,000 feet long, which weather out as low ribs of nearly white rock but whose fracture surfaces are stained brown by iron oxides. Near Sonoita Creek and locally along the complex Salero fault zone (Drewes, 1972b), veins are not everywhere sharply bordered, and altered rocks related to the vein swarm appear as thick lenticular silicified pods laced, in part, with quartz veinlets. The siliceous pods are believed to be associated with the vein swarm because of their close spatial, structural, and mineralogical relations to the swarm. Typical quartz veins feather out from some of the siliceous pods, and south and west of the Salero mine (pl. 1) they seem actually to grade laterally into the pods. In places the pods are subtly brecciated, and the fragments are thoroughly cemented by more quartz, perhaps reflecting recurrent movements along the Salero fault zone.

The Alto veins are of interest mainly for their silver and base-metal content. Primary minerals, more commonly seen on the dumps than in outcrops or prospect pits, are galena, sphalerite, chalcopyrite, and pyrite and, less commonly, molybdenite, barite, tetrahedrite, and specular hematite. Oxides of iron and manganese are widespread among the outcrops and prospects, and malachite, azurite, chalcocite, and cerussite occur in many places. Silver is presumably associated with the lead minerals. Additional details on the mineralogy at many of the mines were given by Schrader (1915).

The distribution of some common minerals in the vein swarm suggests a broad zonation from northwest to southeast. Sulfide minerals in general, and galena in particular, seem to be more common to the northwest, whereas barite is more abundant to the southeast. Because of an areal extent of about 50 square miles for the vein swarm and a vertical relief of as much as 1,500 feet and because of an indication of gross mineral zonation, a paragenetic study of the veins may be of practical significance.

The veins have tentatively been assigned to the Eocene on structural considerations (Drewes, 1972a), although their geologic relations would permit a slightly older or younger age. The veins intrude rocks as young as the Gringo Gulch Volcanics of Paleocene(?) age, and clasts believed to have been derived from the veins occur in the basal conglomerate of the Grosvenor Hills Volcanics of late(?) Oligocene age.

Most likely the veins were emplaced in a set of tension fractures during latest Laramide or early post-Laramide time. These fractures were developed better in bedded than in massive rock and were controlled locally by some of the older major structural features, such as the Salero fault zone. After emplacement of the veins, the area was tilted gently southeastward, thereby permitting deeper erosion of the northwestern veins than of the southeastern veins. Perhaps the silicified pods along Sonoita Creek, just south of the southernmost quartz veins, were formed by near-surface leakage of the hydrothermal solutions that emplaced the veins into a tuff which was near the surface and, hence, too poorly consolidated to fracture.

QUARTZ LATITE (ORE) PORPHYRY

Six plugs and associated dikes of quartz latite porphyry intrude the rocks of Greaterville and Helvetia mining districts. The intrusives are locally called the "ore porphyry" because the surrounding rocks are commonly mineralized. The intrusives have been described and have been variously dated by Schrader (1915), Creasey and Quick (1955), Heyman (1958), and Michel (1959), but they are now believed to be Paleocene (Drewes and Finnell, 1968; Drewes, 1972a).

The plugs are highly irregular or ameboid in plan, with tongues of porphyry extending along many of the faults that are intruded by the plugs. Most dikes are 10–15 feet wide and about 500 feet long; they pinch and swell and change strike more than the other dikes of the northern part of the mountains. The plugs vary in resistance to weathering; some underlie lowlands, others underlie moderately high hills, and one underlies a rugged knob. They cut Paleocene and older faults, and they are locally brecciated by the latest structural movements of the Helvetian phase of the Laramide orogeny (Drewes, 1972b).

The ore porphyry is a closely fractured rock (fracture spacing commonly ¼–2 in.) that is characterized by sparse small biotite crystals and conspicuous stubby bipyramidal quartz crystals. The porphyry commonly contains traces of disseminated sulfide minerals, the alteration products of which stain the normally pale-brownish-gray rock a yellowish brown to grayish orange pink. The plugs commonly have a porphyritic idiomorphic granular texture, with phenocrysts making up 20–40 percent of the rock; a few plugs contain granophyrically intergrown quartz and feldspar. The smaller bodies have a sparsely porphyritic aphanitic texture, and some dikes contain an altered glass matrix.

Modal and chemical analyses of the ore porphyry were reported by Drewes (1972a). A typical specimen contains about 25 percent modal quartz, 40–50 percent plagioclase, 20–30 percent of either orthoclase or sanidine, 3 percent biotite, 1 percent magnetite, and traces of apatite, sphene, and zircon. A few specimens also contain a trace of allanite. A typical specimen contains about 72 percent

SiO_2, 15 percent Al_2O_3, 1.5 percent FeO plus Fe_2O_3, 0.5 percent MgO, 2 percent CaO, and 4 percent each of Na_2O and K_2O. Part of a spectrographic analysis of a porphyry specimen is given in table 1. Of special importance is the occurrence of copper in amounts one or two orders of magnitude greater in the ore porphyry than in most of the other intrusive rocks. Unaltered primary biotite from the porphyry contains an even greater concentration of copper (Lovering and others, 1970).

Three biotite concentrates from ore porphyry have been radiometrically dated as 55.7–56.3 m.y. old, or late Paleocene (Drewes and Finnell, 1968; Drewes, 1972a). The geologic relations show that the plugs postdate most of the Helvetian-phase faulting and also the barren stocks of Helvetia, which are of Paleocene age. The close spatial association of the plugs with mineral deposits of the northern Santa Rita Mountains dates that mineralization as late Paleocene. The ore-porphyry bodies were probably emplaced at shallow depths from fairly fluid magmas, as indicated by their fine grain size and their habit of intruding faults.

FAULTS

Faults are another important geologic feature that affected the distribution of mineralization. Regional faults probably controlled the distribution of mineralization in the southern part of the mountains more than in the northern part. A strong northwest-trending structural grain is apparent on plate 1 and is even more obvious on the main geologic maps of the Santa Rita Mountains (Drewes, 1971a, b). Most of the complex and recurrent faults and many stocks trend northwestward. This structural grain extends northwestward into the Sierrita Mountains (Cooper, 1970) and southeastward into the Canelo Hills (R. B. Raup, unpub. data), the Huachuca Mountains (Hayes and Raup, 1968), and the Patagonia Mountains (Simons, 1971a, b). The northwest alinement of the intensely altered areas roughly located along the crest of the southern Santa Rita Mountains may have been controlled at deep-seated levels by the Santa Rita fault zone, of which only a few remnants (Drewes, 1972b) appear at the surface because of the many postfault intrusive rocks along the fault zone.

Local fault control of mineral deposits is even more apparent than regional control. For example, a string of mines and prospects lies almost entirely in the sheared rock along the fault that bounds the western edge of the Paleozoic rocks immediately north of Box Canyon, much generalized on plate 1. Similarly, many of the mines and prospects in the Helvetia klippe (pl. 1) occur along the thrust fault underlying the klippe or in altered limestone directly above it. Significant mineral deposits also occur along the Salero fault zone and along the short northeast-trending tear fault 1 mile east of the Glove mine. The mineral-bearing hydrothermal fluids apparently circulated along these faults and along others not specifically mentioned above but shown on the detailed maps of areas described later. The solutions deposited sulfide minerals where they reached lithologically or structurally favorable places. This pattern of fault control is so consistent that the potential for blind ore bodies along favorably located faults was earlier pointed out in the Greaterville area (Drewes, 1970) and is equally valid in other areas.

MINING DEVELOPMENT

Many parts of the Santa Rita Mountains have been prospected, and base and noble metals worth an estimated $10–15 million (Schrader, 1915; Creasey and Quick, 1955, p. 304) have been recovered from the Helvetia, Greaterville, Tyndall, Old Baldy, and Wrightson mining districts (pl. 1). Little has been produced from the few prospects in the corners of the Palmetto and Harshaw districts that extend into the southeast corner of the Mount Wrightson quadrangle southeast of Sonoita Creek, although the main parts of these districts have had considerable production. Silver, lead, copper, and gold were the chief metals produced in the Santa Rita Mountains, and a little zinc and molybdenum also were recovered.

Mineral exploration began about 1705, shortly after the first visits of Father Kino to the Indian villages along the Santa Cruz River. Silver may have been produced before the close of the 18th century from such mines as the Montosa, Alto, Salero, and Montezuma, along the west flank of the southern part of the range. Exploration activity was increased after the Gadsden Purchase in 1853, when the region was transferred from Mexico to the United States. Modest amounts of lead and silver ore were shipped from the Wrightson and Tyndall districts during the last half of the 19th century; and toward the end of that time gold was produced from the placers of Greaterville, and the copper, lead, and zinc deposits of the Helvetia district were developed. Production in the Tyndall, Wrightson, and Greaterville mining districts dwindled during the first decades of this century, and the last significant production from the Helvetia and Rosemont camps of the Helvetia district occurred before the present study began. Exploration activity, however, continues throughout the range, with the major efforts being centered around the Rosemont and Helvetia camps.

GEOCHEMICAL RECONNAISSANCE OF ALLUVIUM

Sampling of the alluvial deposits on the flanks of the Santa Rita Mountains provides the quickest and most economical way to obtain geochemical information about the rocks from which they are derived. The composition of the alluvium that is derived from drainage basins underlain by a single rock type gives a relatively close approximation of the chemistry of the rock, a chemistry that is modified chiefly by chemical weathering processes. Geochemical analyses of such alluvial samples provide background values of elements present in the source rock. Deviations from the background values are considered to be anomalies, and a sufficiently strong and extensive anomaly of certain elements may be a clue to the presence of mineralized ground in the basin above the sample site. In addition, the Santa Rita Mountains offer the possibility of evaluating anomalies not linked to known mining areas because these anomalies can be compared with the anomalies related to the several mining areas whose extent and mineralogy are already known.

A geochemical study of alluvium, however, is not free of problems. Implicit in the sampling approach is the basic assumption that an alluvial sample represents an average of the source material, but should the last heavy rainfall have caused only one tributary of a large drainage basin to flow as far as the sample site, that assumption would be invalid. Most likely, however, very few of the samples are biased in this way. Another problem arises in adequately representing on a map the downstream cumulative aspect of samples taken within a single basin. The farther downstream one sample of a series is taken along a given drainage, the larger is the source area represented by the sample. In the method of illustration used on plate 2, the downstream cumulative effect cannot be shown graphically—each sample is tied only to the segment of a basin lying immediately upstream. Nevertheless, the method has the advantage of relating a sample with an area rather than with a single point.

Contamination may also affect the samples. In the semiarid climate of southern Arizona, the contribution of eolian material to the alluvium may be significant. In the Santa Rita Mountains themselves, the vegetation is probably heavy enough to minimize local contamination, and wind-blown material from farther away would probably modify rather than obliterate anomalies. Eolian contamination may increase in the future, as the area occupied by the wastes of the many new copper pits a few miles west of the Sahuarita quadrangle increases and as the dumps receive more tailings than waste overburden.

Geochemical masking is more serious near known mining districts within the Santa Rita Mountains. The alluvium downstream from mine dumps that cover a considerable part of a drainage basin, and especially from those that have accumulated along canyon bottoms, contains a greater accumulation of metals than was present in the alluvium prior to mining. Under these conditions it is very difficult or impossible to recognize subtle anomalies that reflect local mineralized rock which has escaped the attention of prospectors.

Analytical problems may also be a difficulty in evaluating geochemical analyses. The presence of even a moderate amount of carbonate, organic material, or barium in the alluvium may affect the mobility of certain metals and may produce chemical complexes not amenable to the field-method wet tests that were used in this study (Ward and others, 1963).

Despite these problems, the geochemical testing of alluvium is a practical reconnaissance tool, particularly when used with geologic mapping and with a study of dump mineralogy. This summary of some problems besetting an alluvial study explains the choice of sampling procedures described below.

METHODS AND RESULTS

Altogether, 270 samples of alluvium were collected over an area of about 350 square miles that comprise the Santa Rita and San Cayetano Mountains and their intervening and surrounding foothills and pediments. Most samples were taken in drainage basins, or segments of drainage basins having areas of about 1–2 square miles, as outlined on plate 2. If results reported by different kinds of analyses are conflicting, the highest value is used. A few additional samples were taken in smaller basins when justified by the analyses of the first suite of reconnaissance samples. Other samples were more widely spaced, either because of the unpromising aspect of the rocks in the basin which had been sampled elsewhere, or because of an extensive thick cover of gravel derived from a large and uncertain source area, or because of oversight resulting from the situation of making the geochemical study incidental to other geologic efforts.

Each sample consisted of about 1 cup of alluvium taken as a composite of several spots across a drainage. Nearly all samples were taken from the youngest alluvium in the bottoms of dry washes or from sand bars built along flowing streams. In a very few places alluvium of low terraces was sampled to avoid contamination by garbage or the recent effects of drainages that were artificially localized below small dams. Two samples shown in parentheses on plate 2 were taken of different components of a higher alluvial terrace near the mouth of Flux Canyon, in order to check the mineral content of alluvium that was stained black (sample 321) and of alluvium that was almost free of black material (sample 322). The black coating probably was deposited by ground water that was charged with metals derived from the strongly mineralized upper reaches of Flux Canyon before the incision of the terrace. Flux Canyon and the middle reaches of Temporal Gulch usually contain flowing water which is strongly discolored and which is probably highly charged with metals derived from the dumps in the mining camps a few miles upstream.

Each scoop of alluvium was obtained from the finest grain size available—commonly silt or very fine sand—from which the uppermost half inch of material was removed to minimize the influence of locally derived windblown material. Organic detritus and concentrated black sand rich in iron minerals, and probably also in other heavy minerals, were avoided. The samples were sieved, and the minus-80-mesh fractions used for analysis.

Separate splits of each sample were analyzed by chemical and semiquantitative spectrographic methods (table 2). Laboratory techniques and personnel changed during the years 1963–70, introducing more uncontrolled variables to the study. The chemical methods probably varied least and are the field methods described by Ward and others (1963). The spectrographic methods used at various times tested 29–39 elements. Only those elements which are not major rock constituents and which generally occur in concentrations above their threshold of detection are reported in table 2 The detection thresholds are typically those values in the table occurring with the "less than" sign. The elements usually looked for but not found and their threshold-of-detection values, in parts per million, are: Arsenic, 500; bismuth, 10; cadmium, 20; antimony, 100–200; tin, 10; and tungsten, 20–200. For antimony and tungsten, the lower of the two values shown is characteristic of the more recent analyses.

Some analytical results are plotted on plate 2. Metal concentrations are shown by several broad value ranges, and the entire area represented by an analysis is shown to have such a degree of concentration. A given metal concentration in the alluvium may, of course, reflect the presence of a few grains derived from perhaps a single source of high concentration or the presence of many grains derived from perhaps many sources of lower concentrations. The maps only suggest that certain areas have a greater potential for metal enrichment than others and may deserve further exploration, especially if other geological considerations such

TABLE 2. — *Chemical and spectrographic analyses (in parts*

[N, not detected. Analytical methods and accuracy discussed in text. Analysts: R. N. Babcock,
McHugh, E. L. Mosier, J. M. Motooka, S. E.

	Chemical analyses			Semiquantitative spectrographic analyses							
	(ppm)			(ppm)							
Sample	Cu	Pb	Zn	Ag	B	Ba	Be	Co	Cr	Cu	Ga
5	20	25	50	<1	50	1,000	2	7	15	15	15
10	40	25	100	<1	30	1,000	2	7	15	20	10
27	10	25	150	<1	50	500	2	7	10	20	15
29	10	25	50	<1	30	500	2	7	20	10	10
33	15	50	150	<1	30	700	2	10	20	10	15
36	15	75	100	<1	20	500	3	5	7	5	10
39	30	100	200	<1	30	200	5	7	20	20	10
40	60	100	200	<1	30	300	3	10	10	50	10
51	40	100	100	<1	20	500	2	5	7	10	7
63	<10	25	50	<1	20	300	2	7	10	7	7
79	10	25	50	<1	20	300	2	7	15	7	7
89	10	25	100	<1	30	500	2	7	20	15	10
95	15	50	100	<1	15	700	<2	7	20	10	10
107	20	50	100	<1	15	1,000	5	20	70	30	20
111	150	75	350	<1	20	1,000	2	15	20	100	15
112	40	150	150	<1	50	700	2	7	10	20	20
113	15	75	150	<1	50	700	3	10	20	15	20
122	20	50	100	<1	10	700	2	10	50	15	10
123	20	25	100	<1	15	500	2	7	20	7	10
140	10	25	50	<1	100	500	2	<5	5	7	15
147	60	25	100	<1	100	1,500	1	10	15	30	15
154	40	25	200	<1	100	1,500	1	10	15	30	20
170	60	25	200	<1	50	1,500	2	15	15	30	20
175	20	50	150	<1	50	1,500	1	10	7	20	20
176	30	50	200	<1	30	1,500	1	10	15	20	20
178	15	25	100	<1	30	1,500	1	10	5	20	15
191	15	25	100	<1	20	1,000	2	7	5	15	20
200	20	25	100	<1	20	1,000	2	7	10	20	15
216	60	75	100	<1	10	1,500	1	10	15	50	20
218	10	125	250	2	10	700	2	7	5	15	20
220	40	50	150	<1	20	1,500	1	10	10	50	20
230	60	200	500	2	10	1,500	2	15	10	70	15
231	110	75	200	<1	20	1,500	1	15	15	100	15
244	60	150	300	1	15	1,000	2	7	5	70	15
253a	15	50	250	<1	<10	700	2	<5	5	15	20
256	75	25	100	<1	10	1,500	1	15	20	100	15
275	60	50	150	<1	10	1,500	1	7	10	70	20
288	60	25	150	<1	<10	1,000	<1	20	100	100	20
289	60	75	150	<1	<10	1,500	<1	20	70	100	20
291	60	25	100	<1	10	2,000	<1	10	15	70	20
296	75	25	100	<1	10	1,500	<1	15	30	70	20
304	40	50	150	<1	10	1,500	1	15	20	30	20
307	40	75	200	<1	10	1,000	2	10	50	50	15
312	225	25	100	<1	20	1,500	1	20	30	150	20
321	2,200	50	1,500	5	100	2,000	3	>500	50	>1,000	15
322	225	200	500	<1	150	1,000	3	50	20	150	30
328	150	750	750	7	30	1,500	2	20	70	150	20
329	110	400	400	1	50	1,000	3	20	20	150	30
331	75	50	100	1.5	20	1,500	2	30	150	150	50
333	40	50	100	<1	15	1,000	2	15	70	70	20
346	110	100	200	<1	15	1,500	2	15	20	100	30
347	75	25	50	<1	20	1,000	<2	15	50	100	20
354	75	25	50	<1	150	1,500	<2	20	50	100	30
356	110	50	150	<1	100	1,500	2	50	70	150	30
357	75	25	50	<1	150	1,500	2	20	100	100	30
358	225	25	50	<1	100	1,000	<2	20	70	200	30
364	60	25	100	<1	150	1,500	2	50	70	150	30
369	30	25	50	<1	10	1,500	<2	15	70	70	30
370	40	25	50	<1	30	2,000	2	15	30	70	30
372	60	100	150	<1	100	1,500	2	20	50	100	20

per million) of alluvium from the Santa Rita Mountains

Ahmed Behi, G. W. Day, M. De Valliere, C. L. Forn, David Grimes, Elizabeth Martinez, J. B. Papp, S. H. Truesdell, and G. H. VanSickle]

Semiquantitative spectrographic analyses--Continued

Sample	La	Mn	Mo	Ni	Pb	Sc	Sr	Ti	V	Y	Zn	Zr
	(ppm)											
5	50	500	<2	5	20	7	100	5,000	100	20	<100	200
10	50	500	<2	7	20	7	100	3,000	70	15	<100	150
27	70	500	2	5	30	5	100	3,000	100	15	<100	200
29	50	500	<2	7	20	7	100	3,000	70	15	<100	200
33	50	500	2	10	30	5	300	2,000	100	10	<100	100
36	50	1,000	<2	7	30	<5	<100	2,000	20	15	<100	300
39	70	1,000	2	10	50	7	<100	2,000	30	50	100	200
40	70	1,000	2	10	50	7	100	3,000	50	50	100	200
51	50	700	<2	5	50	5	100	3,000	20	10	<100	200
63	<50	300	<2	7	15	5	<100	2,000	50	10	<100	700
79	<50	300	<2	7	10	5	<100	2,000	50	15	<100	200
89	<50	500	<2	7	20	7	100	5,000	70	10	<100	300
95	<50	500	<2	5	15	7	100	2,000	70	10	<100	300
107	70	700	5	15	30	15	150	7,000	150	50	<100	2,000
111	50	700	5	15	30	10	200	3,000	70	20	200	200
112	<50	2,000	<2	5	100	<5	100	2,000	50	10	<100	150
113	50	1,000	3	10	50	7	150	5,000	200	20	200	200
122	50	500	<2	7	20	10	100	5,000	50	30	<100	500
123	50	500	<2	10	15	7	200	3,000	70	20	<100	200
140	<50	500	<2	2	20	<5	70	1,500	20	5	<200	70
147	<50	1,500	2	7	50	7	300	7,000	100	20	<200	100
154	<50	1,500	3	10	50	10	500	10,000	150	20	<200	300
170	<50	1,500	2	10	20	7	500	7,000	100	15	<200	100
175	<50	1,500	<2	5	30	5	500	5,000	100	20	<200	150
176	<50	1,000	<2	10	50	<5	300	5,000	100	15	<200	150
178	<50	1,000	<2	5	30	5	300	7,000	100	15	<200	100
191	<50	700	<2	5	15	<5	300	3,000	50	10	<200	70
200	<50	1,000	<2	5	30	5	200	5,000	70	15	<200	200
216	<50	1,000	<2	15	100	5	700	5,000	200	10	<200	150
218	<50	1,500	<2	5	150	<5	100	3,000	50	15	500	200
220	<50	1,000	<2	10	70	7	200	5,000	100	15	<200	150
230	50	3,000	2	15	200	7	200	7,000	150	20	700	500
231	<50	1,500	2	15	50	5	200	10,000	200	15	200	300
244	<50	3,000	<2	7	150	5	100	5,000	50	15	500	300
253a	<50	700	<2	3	70	<5	100	3,000	30	10	200	300
256	<50	1,000	<2	20	20	7	500	7,000	200	10	<200	200
275	<50	500	<2	5	50	5	500	7,000	150	10	<200	300
288	<50	1,500	<2	70	20	7	300	10,000	1,000	15	<200	300
289	<50	1,000	<2	30	30	5	300	10,000	700	10	<200	200
291	<50	300	<2	10	30	5	500	5,000	150	10	<200	200
296	<50	700	2	20	20	7	500	7,000	200	15	<200	200
304	<50	1,500	2	15	50	10	500	7,000	100	15	<200	150
307	<50	1,500	2	20	50	5	200	10,000	200	20	300	500
312	<50	700	5	20	30	10	500	7,000	200	20	<200	200
321	<50	>5,000	50	500	100	15	200	7,000	200	50	2,000	200
322	70	5,000	10	30	200	10	500	5,000	200	30	700	200
328	70	2,000	<2	30	1,000	10	300	5,000	200	30	1,000	200
329	70	3,000	<2	15	500	5	200	5,000	150	50	500	200
331	<50	1,500	<2	50	70	10	700	10,000	500	20	200	300
333	50	1,000	<2	30	70	5	300	10,000	200	20	100	200
346	50	1,500	<2	15	150	5	700	5,000	150	20	100	200
347	50	1,000	<2	20	10	5	500	5,000	200	20	<100	150
354	50	1,000	<2	20	50	10	500	5,000	200	30	<100	150
356	50	1,000	<2	20	70	10	500	10,000	200	20	100	300
357	<50	1,500	<2	20	10	20	700	10,000	300	30	100	200
358	<50	1,000	<2	20	70	10	500	7,000	200	20	100	200
364	<50	1,000	<2	20	50	20	500	10,000	300	30	100	300
369	<50	1,500	<2	20	20	5	500	10,000	200	20	150	300
370	50	700	<2	15	70	<5	700	7,000	150	20	150	150
372	70	1,500	<2	15	100	15	500	7,000	150	30	200	150

TABLE 2. — *Chemical and spectrographic analyses (in parts per*

	Chemical analyses (ppm)			Semiquantitative spectrographic analyses (ppm)							
Sample	Cu	Pb	Zn	Ag	B	Ba	Be	Co	Cr	Cu	Ga
373	20	50	250	<1	100	700	2	10	20	20	20
374	60	50	100	<1	70	1,500	<2	30	100	100	30
375	10	25	50	<1	30	1,500	2	10	15	20	30
376	20	25	50	<1	50	1,500	<2	10	5	15	30
377	75	100	200	<1	70	2,000	2	20	50	150	30
378	110	200	200	<1	50	1,500	2	15	50	150	20
380	10	<25	25	<1	10	50	<2	<5	20	5	20
389	40	50	100	<1	20	1,500	<2	15	15	50	20
390	75	200	200	1.5	15	1,000	2	20	50	100	20
392	60	300	250	<1	20	1,500	2	20	20	100	20
394	225	600	500	5	50	1,000	2	5	15	300	15
396	110	100	400	1	30	1,500	2	20	30	150	20
398	20	50	100	<1	30	1,500	2	15	30	30	20
399	75	500	300	<1	30	1,500	2	15	50	100	20
400	225	200	250	<1	30	1,000	2	10	50	200	20
401	75	25	50	<1	70	1,000	2	30	50	150	30
413	10	25	25	<1	15	1,000	<2	10	150	7	30
419	40	25	50	<1	20	1,500	<2	15	30	70	30
423	10	<25	25	<1	10	700	<2	15	150	7	30
424	10	<25	25	<1	10	700	<2	<5	70	5	20
435	10	<25	25	<1	10	700	<2	7	70	10	30
436	10	<25	25	<1	10	700	<2	5	50	5	30
438	10	<25	25	<1	20	1,000	2	7	100	15	30
439	10	<25	25	<1	10	700	2	7	70	5	30
444	30	50	150	<1	20	1,000	3	10	15	70	20
445	40	150	150	<1	20	1,000	2	15	20	70	20
448	15	50	100	<1	20	1,000	2	10	30	20	20
449	75	75	200	<1	70	1,500	2	20	50	100	30
451	10	25	25	<1	20	1,000	2	10	10	10	20
459	10	1,000	400	5	70	1,000	2	20	15	150	20
463	110	1,000	600	1.5	30	3,000	2	20	200	200	30
464	225	300	150	1	30	1,500	2	10	100	500	30
465	30	100	100	<1	15	1,500	2	10	15	50	20
469	40	25	50	<1	20	1,000	<2	15	20	70	20
475	450	7,500	3,000	20	50	1,000	2	20	70	1,000	30
477	225	300	250	2	20	1,000	2	10	20	200	20
478	20	25	50	<1	20	1,500	2	10	20	50	20
479	10	25	50	<1	30	1,500	2	10	15	10	20
481	110	100	200	<1	30	700	3	15	15	150	20
482	60	400	400	<1	30	70	2	7	15	70	15
483	60	100	250	<1	20	1,000	2	10	20	100	20
484	60	125	300	<1	30	1,000	3	15	100	150	20
485	60	50	100	<1	30	700	2	5	7	100	20
487	75	150	400	<1	50	700	3	15	30	100	20
488	20	50	200	<1	20	700	2	5	10	50	20
489	30	50	50	<1	70	500	2	<5	10	100	20
490	110	150	400	<1	30	700	2	15	50	150	20
492	75	50	100	<1	50	500	3	10	10	150	20
493	75	150	700	<1	30	1,000	2	20	70	150	20
495	30	100	200	<1	30	700	3	5	20	70	20
496	60	200	400	<1	30	1,500	2	15	15	100	30
497	110	150	400	<1	20	700	3	15	50	150	30
500	40	50	100	<1	100	1,500	2	15	20	70	20
501	20	150	200	<1	30	700	3	20	50	70	30
502	15	150	100	<1	20	500	3	10	30	20	20
503	20	150	400	<1	20	500	3	10	30	30	20
504	10	50	100	<1	20	500	2	<5	7	7	20
505	15	75	400	<1	20	500	2	5	10	15	20
506	30	50	100	<1	15	700	2	<5	5	30	30
510	15	25	50	<1	15	1,000	2	15	100	30	30

million) of alluvium from the Santa Rita Mountains — Continued

Semiquantitative spectrographic analyses--Continued

	(ppm)											
Sample	La	Mn	Mo	Ni	Pb	Sc	Sr	Ti	V	Y	Zn	Zr
373	70	1,000	<2	10	100	7	150	5,000	150	50	700	200
374	50	1,500	<2	30	70	10	500	7,000	300	20	200	200
375	50	1,000	<2	15	30	7	500	5,000	150	30	100	150
376	50	700	<2	7	<10	<5	700	5,000	70	7	100	100
377	70	2,000	<2	20	200	10	500	7,000	200	20	500	200
378	50	1,500	<2	15	200	10	200	7,000	200	30	500	150
380	<50	15	<2	15	<10	<5	700	1,000	15	<5	<100	50
389	50	1,000	<2	10	100	5	500	3,000	70	10	100	100
390	<50	2,000	<2	20	300	7	500	5,000	200	15	300	150
392	70	2,000	<2	15	500	10	500	5,000	150	20	200	150
394	70	1,000	<2	7	1,000	10	700	5,000	70	20	500	200
396	50	2,000	<2	20	500	10	300	5,000	100	15	700	150
398	50	1,500	<2	10	100	7	500	7,000	100	15	<100	150
399	50	2,000	<2	15	700	10	500	7,000	150	20	300	150
400	50	2,000	<2	10	300	5	500	5,000	100	15	300	150
401	70	1,000	<2	20	30	7	500	7,000	200	20	<100	500
413	50	200	<2	50	20	5	1,000	2,000	30	50	<100	50
419	70	700	<2	15	50	10	700	7,000	100	15	<100	150
423	<50	500	<2	50	<10	10	1,000	3,000	50	7	<100	70
424	<50	200	<2	20	<10	5	700	1,500	15	<5	<100	20
435	<50	200	<2	20	<10	<5	700	2,000	30	<5	<100	70
436	<50	200	<2	20	10	<5	700	2,000	30	<5	<100	100
438	<50	200	<2	50	10	5	1,000	5,000	50	5	<100	100
439	<50	150	<2	30	10	<5	1,000	2,000	30	5	<100	70
444	50	700	<2	7	70	<5	700	3,000	100	10	200	150
445	50	1,000	<2	15	200	<5	700	5,000	150	10	150	150
448	50	700	<2	10	50	5	700	5,000	100	7	200	70
449	70	1,000	<2	20	100	10	1,000	5,000	150	15	200	150
451	50	500	<2	10	15	5	700	3,000	100	10	<100	150
459	70	5,000	<2	70	>1,000	10	<100	5,000	70	30	500	150
463	50	2,000	<2	50	>1,000	20	500	7,000	300	20	1,000	200
464	100	1,000	30	20	300	20	700	7,000	200	20	100	200
465	<50	1,000	<2	10	100	10	700	3,000	70	10	150	100
469	<50	1,000	<2	20	30	<5	500	5,000	150	10	<100	150
475	70	5,000	<2	30	>1,000	15	300	7,000	150	30	7,000	200
477	50	1,000	<2	15	300	5	500	3,000	70	10	500	150
478	50	500	<2	15	30	5	500	5,000	100	10	150	150
479	50	300	<2	10	15	<5	500	3,000	70	10	<100	100
481	150	3,000	<2	10	100	15	<100	10,000	100	70	300	700
482	70	5,000	<2	10	300	5	100	500	50	30	500	500
483	100	2,000	<2	15	100	10	100	2,000	50	50	500	200
484	150	3,000	<2	10	200	20	100	2,000	100	70	500	>1,000
485	100	500	<2	7	100	15	100	3,000	20	50	300	500
487	70	5,000	<2	20	200	5	<100	1,000	100	50	500	500
488	100	2,000	<2	5	70	10	<100	500	70	50	200	500
489	70	2,000	<2	10	100	5	<100	1,500	70	30	<100	200
490	50	5,000	<2	20	200	5	<100	2,000	100	30	500	300
492	50	1,000	<2	10	100	5	100	1,500	30	50	100	200
493	50	3,000	<2	30	200	7	<100	1,500	100	20	700	300
495	100	2,000	<2	5	150	10	100	1,500	100	70	500	500
496	50	5,000	<2	15	300	10	200	1,000	100	20	700	200
497	100	5,000	<2	15	300	15	150	2,000	300	70	500	>1,000
500	50	1,000	<2	15	70	7	500	1,500	100	10	200	150
501	300	5,000	<2	15	200	20	100	1,500	150	70	500	1,000
502	50	1,500	<2	10	150	10	<100	1,500	50	15	300	150
503	70	5,000	<2	10	200	15	<100	1,500	30	30	700	200
504	50	700	<2	7	70	7	<100	1,500	15	30	100	150
505	<50	1,000	<2	10	100	5	<100	2,000	30	15	700	150
506	<50	1,000	<2	10	70	5	<100	500	15	20	150	150
510	50	700	<2	50	50	10	500	5,000	100	15	<100	200

TABLE 2. — *Chemical and spectrographic analyses (in parts per*

	Chemical analyses (ppm)			Semiquantitative spectrographic analyses (ppm)							
Sample	Cu	Pb	Zn	Ag	B	Ba	Be	Co	Cr	Cu	Ga
514	15	25	50	<1	20	1,500	<2	15	70	30	30
526	10	<25	25	<1	10	1,000	<2	5	20	7	30
532	10	<25	25	<1	20	1,500	2	10	50	10	30
538	110	25	50	<1	70	1,000	<2	30	200	150	30
540	20	25	25	N	20	1,000	N	5	20	10	20
548	20	50	25	N	20	1,000	N	5	20	20	20
549	10	25	25	N	20	1,000	N	5	20	30	20
554	20	25	25	N	20	1,000	N	5	15	15	20
555	30	50	25	N	50	1,000	N	5	30	20	20
569	30	25	25	N	20	1,000	N	5	30	20	20
573	20	25	25	N	20	1,000	N	5	30	5	20
590	40	50	50	N	20	1,000	N	5	10	2	20
591	10	25	25	N	20	1,000	N	5	15	30	20
592	20	25	25	N	20	1,000	N	5	10	10	30
600	20	25	25	N	20	1,000	N	5	10	10	20
603	20	25	25	N	20	1,000	N	5	10	10	20
616	20	25	25	N	20	1,000	N	5	5	7	20
617	10	25	25	N	20	700	N	10	7	5	10
625	10	25	<25	N	20	700	N	N	5	20	10
628	20	25	25	N	20	1,000	N	5	5	5	15
632	20	25	25	N	20	700	N	7	7	5	15
633	30	50	50	N	20	700	N	7	7	10	15
635	20	25	50	N	50	1,000	N	5	5	5	10
638	40	50	50	N	20	700	N	5	7	10	15
642	20	50	50	N	70	700	N	7	5	5	15
649	60	50	75	N	N	700	N	15	30	30	20
658	30	100	300	N	100	700	N	10	10	30	20
665	10	100	75	N	70	700	N	10	15	15	20
666	10	50	50	N	150	500	N	5	7	5	15
671	30	25	25	N	20	500	N	10	15	20	20
674	30	300	125	N	200	300	1	5	20	15	15
675	60	75	100	N	70	700	1	5	7	30	20
681	10	75	25	N	70	700	N	5	15	10	15
683	20	75	25	N	70	1,000	2	7	7	20	20
690	40	25	25	N	30	700	1	10	15	50	20
696	15	25	25	N	20	700	2	N	3	5	20
702	15	<25	25	<1	20	700	1	N	2	7	20
713	350	300	150	1	20	1,000	1	5	5	300	20
714	350	200	150	N	10	1,500	N	5	3	300	15
721	20	50	125	N	30	1,500	1	5	10	20	20
729	30	75	100	N	50	700	3	10	7	30	20
739	40	25	75	N	10	1,000	N	5	7	30	20
760	40	400	25	N	20	1,000	3	N	5	30	20
768	30	<25	<25	N	N	1,000	N	5	15	30	15
775	15	25	25	N	15	700	N	5	7	10	15
788	20	50	50	N	10	700	5	7	10	30	20
789	15	25	50	N	N	300	2	N	N	1	20
797	30	25	100	N	15	300	N	7	10	30	20
798	30	50	75	N	10	1,000	N	7	10	20	20
799	225	150	150	1	20	1,000	N	7	7	200	20
801	20	25	25	N	N	700	2	N	3	10	20
816	20	25	25	N	20	1,000	3	7	10	15	20
856	10	25	50	<1	50	700	3	7	10	50	15
871	75	75	50	<1	100	700	3	20	70	150	15
875	30	<25	25	<1	10	1,000	3	15	20	100	15
878	60	25	50	<1	15	1,000	2	5	10	100	15
882	10	<25	25	<1	10	700	3	5	15	70	15
883	10	<25	25	<1	<10	700	3	<5	<5	70	10
884	<10	<25	25	<1	<10	700	3	<5	10	30	15
891	60	50	75	<1	50	1,000	2	20	50	100	15

million) of alluvium from the Santa Rita Mountains — Continued

Semiquantitative spectrographic analyses--Continued

	(ppm)											
Sample	La	Mn	Mo	Ni	Pb	Sc	Sr	Ti	V	Y	Zn	Zr
514	50	700	<2	50	20	7	500	5,000	100	10	<100	100
526	<50	200	<2	20	10	<5	700	3,000	30	<5	<100	50
532	<50	300	<2	30	10	5	700	5,000	70	5	<100	100
538	<50	1,500	<2	50	70	10	500	7,000	1,000	15	200	300
540	50	700	N	10	10	7	700	5,000	100	10	N	150
548	50	500	2	15	10	7	500	5,000	100	15	N	200
549	50	300	N	15	10	7	500	5,000	100	10	N	100
554	50	500	N	10	10	5	300	5,000	70	7	N	200
555	50	500	1	10	10	7	300	10,000	200	10	N	200
569	50	700	N	20	10	10	300	7,000	150	10	N	300
573	50	500	N	15	10	7	500	5,000	100	10	N	150
590	<50	200	N	10	N	5	200	3,000	70	7	N	70
591	50	500	1	10	20	7	200	7,000	150	10	N	200
592	50	1,000	N	7	N	10	500	5,000	150	15	N	150
600	50	700	N	7	N	10	500	5,000	100	15	N	100
603	50	700	N	7	N	7	300	7,000	100	15	N	300
616	<50	500	N	2	N	5	200	3,000	50	10	N	50
617	50	500	N	5	10	7	200	7,000	100	20	N	300
625	50	200	N	2	10	N	300	2,000	50	10	N	50
628	50	300	N	2	10	5	200	3,000	50	10	N	200
632	50	700	N	5	10	7	150	5,000	100	20	N	200
633	50	1,000	N	5	20	7	300	5,000	100	15	N	30
635	N	500	N	3	15	5	200	3,000	100	10	N	200
638	N	700	N	5	20	5	300	3,000	100	10	N	20
642	50	700	N	3	20	7	200	7,000	100	15	N	300
649	N	1,500	1	10	20	15	500	>10,000	500	15	N	200
658	50	1,500	N	5	50	10	300	5,000	100	20	N	300
665	N	2,000	N	5	50	5	200	5,000	150	15	N	300
666	N	2,000	N	5	30	N	150	3,000	50	15	N	200
671	N	1,000	N	5	15	10	200	5,000	150	15	N	300
674	30	3,000	2	7	150	5	200	3,000	70	20	300	300
675	50	1,000	2	5	100	10	300	5,000	150	20	N	300
681	30	700	N	7	70	10	150	2,000	100	15	N	100
683	30	1,500	N	5	30	10	200	5,000	100	20	N	300
690	30	1,000	2	7	15	15	200	5,000	150	20	N	100
696	30	500	N	1	20	5	200	3,000	50	15	N	200
702	30	700	N	2	15	3	150	3,000	30	15	N	30
713	30	1,000	N	3	200	5	300	5,000	70	10	500	200
714	N	700	N	2	100	3	200	2,000	50	7	500	50
721	50	1,000	N	3	30	10	300	3,000	100	15	N	100
729	50	1,500	N	3	50	15	200	>10,000	200	30	N	500
739	30	700	<1	5	N	5	200	3,000	100	20	N	100
760	50	1,000	1	2	150	5	200	3,000	70	20	N	500
768	N	500	<1	7	10	5	200	2,000	100	10	N	50
775	N	500	<1	3	10	3	200	2,000	100	10	N	150
788	50	700	2	5	30	5	200	10,000	200	50	N	>1,000
789	N	200	N	1	20	N	150	1,500	20	15	N	200
797	N	1,500	N	5	30	7	150	5,000	500	10	N	700
798	N	500	<1	7	50	5	300	5,000	300	10	N	300
799	30	700	2	7	100	5	200	5,000	200	10	300	300
801	30	300	1	N	10	3	150	3,000	50	20	N	500
816	30	1,000	<1	5	20	10	150	10,000	100	30	N	700
856	50	1,000	<2	<2	100	20	300	3,000	30	30	<200	300
871	100	2,000	5	20	150	30	500	7,000	70	30	<200	200
875	50	700	5	15	70	30	300	2,000	30	20	<200	50
878	50	300	2	10	70	20	700	3,000	30	20	<200	100
882	70	500	2	10	100	15	500	3,000	30	20	<200	200
883	70	300	<2	5	50	10	200	1,500	15	20	<200	30
884	70	300	<2	3	70	15	200	1,000	30	15	<200	100
891	100	700	3	15	150	15	200	3,000	30	20	<200	150

TABLE 2. — *Chemical and spectrographic analyses (in parts per*

	Chemical analyses			Semiquantitative spectrographic analyses							
	(ppm)			(ppm)							
Sample	Cu	Pb	Zn	Ag	B	Ba	Be	Co	Cr	Cu	Ga
903	150	<25	50	<1	100	1,500	1	15	30	300	15
904	30	<25	25	<1	20	700	1	7	20	50	10
912	<10	<25	25	<1	20	1,000	1	15	30	70	15
926	20	25	100	<0.5	30	1,000	2	10	50	50	30
954	30	25	100	1	30	300	1.5	5	10	70	20
955	110	50	150	2	20	300	2	7	10	200	15
963	20	50	100	.7	50	200	1.5	<5	5	50	15
964	30	125	200	.5	30	200	1.5	7	10	70	20
972	30	75	50	.7	20	300	2	5	7	70	30
995	<10	<25	50	<.5	20	1,000	1.5	5	10	30	30
1008	20	25	50	<.5	20	700	1	5	20	30	20
1011	10	25	50	<.5	15	700	1	5	20	20	20
1018	10	25	50	<.5	20	700	1	5	15	10	20
1019	10	25	50	<.5	30	700	1	5	20	10	20
1023	10	25	25	<.5	10	1,000	2	5	5	20	20
1027	<10	<25	25	<.5	10	700	1.5	10	20	20	20
1028	10	25	100	<.5	20	700	2	5	5	10	20
1037	10	25	50	<.5	20	700	1	5	20	10	20
1042	20	25	100	<.5	15	700	1.5	5	5	20	20
1055	10	25	50	<.5	15	1,000	1	7	15	30	30
1103	40	25	<25	N	10	300	1	7	30	30	---
1164	250	<25	<25	N	<10	500	1	10	30	150	---
1165	1,500	40	80	.5	<10	200	1.5	5	20	1,000	---
1205	40	<25	<25	N	10	700	1	10	10	20	---
1206	75	<25	<25	N	10	150	<1	5	30	50	---
1241	3,000	50	100	3	<10	300	1	10	30	1,500	---
1339	100	<25	<25	N	<10	100	N	5	70	50	---
1343	1,500	25	50	.5	<10	300	1	10	30	1,500	---
1371	40	<25	<25	N	10	300	1	5	20	50	---
1372	40	<25	<25	N	10	500	<1	7	20	20	---
1382	1,500	50	75	2	10	500	1.5	7	30	1,000	---
1383	400	150	75	1	<10	500	<1	10	20	200	---
1384	800	450	120	1.5	10	500	<1	20	50	1,000	---
1385	250	250	100	2	20	500	<1	7	30	200	---
1392	150	<25	25	N	<10	300	<1	7	50	100	---
1421	40	<25	<25	N	<10	500	1	10	15	30	---
1423	40	25	<25	N	20	300	1	5	30	30	---
1432	1,500	25	25	.5	<10	200	<1	5	30	1,500	---
1433	40	<25	<25	N	<10	300	<1	7	50	20	---
1544	25	35	<25	<.05	10	1,000	1	7	10	70	---
1545	30	25	<25	<.05	10	1,000	1	N	<5	50	---
1547	25	25	<25	<.05	10	1,000	1	10	30	50	---
1548	25	25	<25	<.05	15	1,000	1	5	20	20	---
1549	35	35	<25	<.05	20	1,000	1	5	20	30	---
1586	60	50	80	N	10	700	<1	10	70	30	---
1587	55	35	50	.5	10	700	<1	10	100	30	---
1588	120	30	75	N	10	700	<1	20	150	100	---
1589	330	40	85	<.05	20	700	<1	10	20	200	---
1590	80	200	450	.7	30	700	1.5	5	10	50	---
1591	40	40	200	N	15	1,000	1	10	20	15	---
1592	70	140	210	N	10	700	<1	50	500	100	---
1593	70	55	130	<.05	20	500	1.5	5	10	50	---
1594	100	85	180	<.05	30	1,000	1.5	10	15	100	---
1595	60	90	180	<.05	15	700	1.5	5	30	50	---
1596	120	320	360	<.05	30	700	1	5	10	70	---
1597	150	610	530	5	20	1,500	1	10	50	100	---
1598	110	140	280	<.05	20	700	1.5	10	20	100	---
1599	110	110	180	.5	30	1,500	<1	10	30	100	---
1600	500	670	650	<.05	20	700	1	5	15	70	---
1601	80	130	190	N	20	1,000	1	10	50	30	---

million) of alluvium from the Santa Rita Mountains — Continued

Semiquantitative spectrographic analyses--Continued

(ppm)

Sample	La	Mn	Mo	Ni	Pb	Sc	Sr	Ti	V	Y	Zn	Zr
903	100	1,500	5	15	50	15	700	10,000	50	20	<200	100
904	70	500	<2	15	70	15	500	3,000	30	20	<200	100
912	150	300	7	10	70	15	300	10,000	150	30	<200	300
926	50	1,000	<5	15	30	15	150	5,000	150	30	<200	200
954	50	300	<5	5	50	5	100	2,000	50	30	<200	300
955	100	1,500	<5	10	200	7	100	3,000	70	50	200	500
963	50	100	<5	5	50	7	100	2,000	50	30	<200	300
964	70	300	5	5	50	7	100	2,000	50	50	<200	500
972	50	150	5	5	70	7	100	2,000	50	30	<200	200
995	100	700	<5	10	30	15	200	10,000	200	50	<200	300
1008	30	500	<5	10	30	10	150	5,000	100	20	<200	500
1011	50	500	<5	10	20	10	100	7,000	150	30	<200	500
1018	50	500	<5	10	20	10	100	5,000	100	30	<200	200
1019	50	500	<5	10	30	7	100	5,000	100	30	<200	300
1023	50	500	<5	10	30	10	100	5,000	100	30	<200	300
1027	100	1,000	<5	10	20	15	150	10,000	200	50	<200	1,000
1028	50	500	<5	10	30	10	100	7,000	100	30	<200	300
1037	50	500	<5	10	20	10	150	5,000	150	30	<200	700
1042	50	500	<5	5	20	10	100	7,000	100	30	<200	500
1055	100	700	<5	10	30	10	200	10,000	150	50	<200	700
1103	70	500	N	5	10	15	100	7,000	150	30	N	300
1164	50	1,000	30	7	50	10	100	1,000	150	50	N	>1,000
1165	30	1,500	30	5	10	10	100	5,000	100	50	200	200
1205	30	100	N	7	<10	10	100	7,000	70	20	N	500
1206	30	500	N	10	<10	<5	200	3,000	50	10	N	150
1241	30	1,500	20	5	20	5	<100	5,000	100	50	500	500
1339	20	300	N	20	10	<5	200	2,000	70	10	N	150
1343	100	1,500	15	10	15	10	100	5,000	150	70	200	200
1371	30	500	N	7	<10	10	150	5,000	100	20	N	500
1372	30	500	N	7	<10	10	150	3,000	50	20	N	200
1382	30	1,000	15	10	30	7	150	3,000	50	20	300	200
1383	30	1,000	5	10	100	7	300	3,000	100	20	200	150
1384	30	1,500	50	20	200	15	300	5,000	150	20	500	150
1385	30	1,000	15	15	200	5	150	3,000	100	20	300	150
1392	100	500	N	10	20	5	150	3,000	150	30	N	1,000
1421	30	700	N	7	<10	7	300	3,000	70	15	N	150
1423	30	700	N	10	15	5	200	3,000	70	20	N	150
1432	30	1,000	15	10	10	5	100	3,000	70	20	N	150
1433	30	500	N	10	10	7	100	2,000	70	20	N	200
1544	50	700	10	5	15	10	150	5,000	100	50	N	200
1545	20	300	N	5	15	<5	150	1,500	20	15	N	200
1547	50	700	N	15	20	10	500	5,000	150	30	N	200
1548	30	500	N	15	20	7	300	2,000	100	15	N	200
1549	30	500	<5	10	20	10	200	3,000	100	20	N	300
1586	20	700	N	30	70	10	300	7,000	200	20	N	150
1587	20	700	N	30	50	10	300	7,000	200	20	N	150
1588	20	700	N	30	50	15	300	7,000	500	20	N	150
1589	30	700	N	20	50	10	200	5,000	150	20	N	150
1590	20	1,500	N	15	200	5	150	3,000	70	20	300	150
1591	20	700	N	30	50	7	200	5,000	100	20	<200	150
1592	20	3,000	N	30	150	30	N	>10,000	1,000	70	N	>1,000
1593	20	1,000	N	15	150	7	200	3,000	70	20	<200	150
1594	30	1,000	N	20	300	7	200	5,000	100	20	200	200
1595	30	700	N	20	150	7	300	5,000	100	20	<200	200
1596	20	700	N	5	150	5	100	3,000	70	20	300	150
1597	30	1,000	N	30	700	10	150	5,000	200	20	500	150
1598	20	700	N	30	300	7	500	5,000	70	20	300	150
1599	30	700	7	15	300	10	500	5,000	100	20	N	200
1600	20	500	N	15	200	7	300	5,000	70	15	N	150
1601	20	1,000	N	15	150	10	150	5,000	300	20	200	700

TABLE 2. — *Chemical and spectrographic analyses (in parts per*

	Chemical analyses			Semiquantitative spectrographic analyses							
	(ppm)			(ppm)							
Sample	Cu	Pb	Zn	Ag	B	Ba	Be	Co	Cr	Cu	Ga
1602	120	450	2,000	0.7	10	500	1.5	7	20	100	---
1603	60	85	80	2	15	700	1	7	30	200	---
1604	50	100	130	N	10	1,000	1	10	30	30	---
1605	30	35	55	N	15	1,000	1	5	30	15	---
1606	75[1]	150[1]	150[1]	.5	10	700	<1	5	15	50	---
1609	900	1,200	740	7	20	700	1.5	5	15	700	---
1610	100	110	95	<.05	20	700	1	5	20	100	---

[1] Values estimated from analytic results of cold heavy-metals test plus spectrographic analyses.

as rock types and structural features are favorable. Reviews of several such areas follow.

EVALUATION AND INTERPRETATION

Areas of know mineralization, such as the Helvetia-Rosemont area to the north and the Alto-Temporal area to the south, produced anomalies of various intensities in the alluvium. Alluvium in the Rosemont and Helvetia areas contains especially high values of copper (pl. 2) and reflects the fact that mainly copper was produced from these camps. Alluvium from the Alto Gulch and Temporal Gulch areas contains more lead and zinc (pl. 2) than copper and reflects the fact that these camps were mainly lead and zinc producers. Silver in alluvium is about equally abundant in both the north and the south. Slightly anomalous amounts of molybdenum appear mainly in the northern and central parts of the mountains, roughly athwart the mouths of Madera and Sawmill (NW.) Canyons, where other base metals are sparse. Molybdenum has a byproduct potential to the north, where it is associated with disseminated-copper deposits; but it seems less likely to have significant economic potential in the central area, which has so little copper and contains mainly vein deposits. Beryllium is weakly concentrated in the central area, and tin occurs to the north, in somewhat erratic distribution.

The base-metal anomalies in the alluvium near Greaterville are not very widespread. Perhaps this condition reflects the absence in the Greaterville area of abundant mine dumps and shallow mineral deposits.

The anomalies along Sonoita Creek and the foot of the Patagonia Mountains are probably derived from the known mineral deposits in the area of Red Mountain and the canyons in the northern part of the Patagonia Mountains. The older terrace gravels contain abundant base metals and silver, and the movement of this material into younger alluvium seriously masks any anomaly which might reflect local mineralized ground.

million) of alluvium from the Santa Rita Mountains — Continued

Sample	Semiquantitative spectrographic analyses--Continued (ppm) La	Mn	Mo	Ni	Pb	Sc	Sr	Ti	V	Y	Zn	Zr
1602	50	1,000	N	10	500	7	100	5,000	200	50	1,500	700
1603	20	700	N	10	500	7	200	5,000	200	20	700	700
1604	20	700	N	15	100	10	300	5,000	200	20	N	150
1605	20	500	N	15	50	7	300	5,000	150	15	N	700
1606	20	700	N	15	100	5	200	3,000	100	15	<200	200
1609	30	1,500	200	15	1,500	7	150	3,000	70	20	500	100
1610	20	700	N	20	100	7	100	3,000	70	30	N	100

Several anomalous areas not associated with known mining camps or mineralized areas deserve further consideration. A more detailed study (Drewes, 1967) was made of the rocks near the anomalous area southeast of the Ivanhoe mine (pl. 2) because the rocks contain only few prospects and were found to be strongly altered by disseminated-sulfide mineralization. Another area of potential interest was indicated by the downstream increase in the content of lead, zinc, and silver in the alluvium between Josephine Canyon and the Salero mine. A siliceous pod crossing the area was then sampled and found to be slightly mineralized, as described in the section of this report on the Salero Ranch area.

Minor geochemical anomalies also occur in alluvium derived from the upper reaches of Josephine Canyon and in alluvium derived from the upper parts of the valleys across the crest of the range east of upper Josephine Canyon; both these areas contain few rocks that are obviously mineralized. Copper values are fairly high in the alluvium from Josephine Canyon, both upstream and downstream from the northernmost conspicuous mineralized quartz veins. The upper parts of the valleys east of the upper reaches of Josephine Canyon lie about 1,500 feet above the level of upper Josephine Canyon (fig. 2). Alluvium in these valleys contains slightly anomalous amounts of lead and zinc that are about as extensive and as strong as the anomalies downstream from the Alto mine and the Mansfield mining camp (pl. 2). Contacts between late Late Cretaceous stocks to the west and the Triassic Mount Wrightson Formation to the east trend northward at about midslope on the east wall of Josephine Canyon. The distribution and kinds of alluvial anomalies could be explained by a zonation of base-metal mineralization with respect to distance from the stocks, with copper abundant closer to the contacts and the lead and zinc abundant farther away (fig. 2). This speculation is intriguing because the Mount Wrightson volcanics here are part of a little-deformed, homoclinally eastward-dipping structural

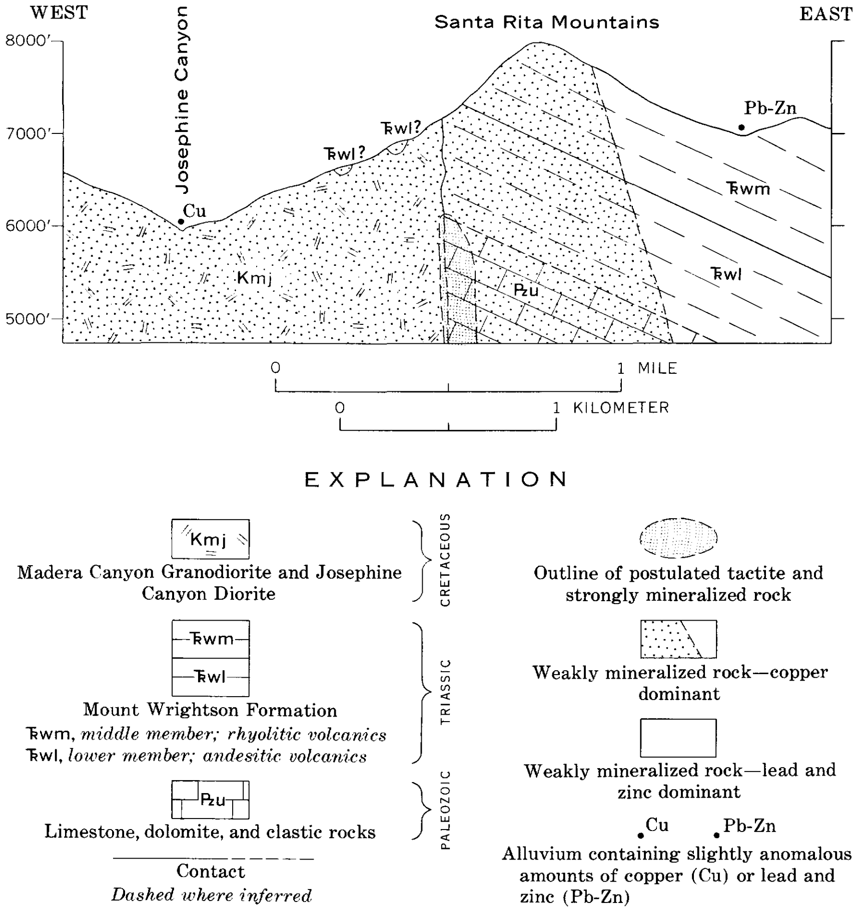


FIGURE 2. — Diagrammatic section through the upper part of Josephine Canyon, showing the contact between stocks and bedded rocks and the distribution of base metals in alluvium.

block. Paleozoic rocks are thought to underlie the volcanics and to also be a part of this block, because of its structural simplicity. Paleozoic rocks are intensely contact metamorphosed and strongly mineralized near stocks at several places in the Santa Rita Mountains. The depth at which the postulated Paleozoic rocks lie depends on the thickness of the lower member of the Triassic Mount Wrightson Formation which is unknown because the base of the section is everywhere concealed. Even should this member be as much as 1,000 feet thick, the Paleozoic rocks might still be within reasonable reach of an eastward-inclined exploratory hole drilled from the east side of the upper reaches of Josephine Canyon. By comparison, vertical drilling within the basin is likely to locate only mineralized inclusions or veinlets within the stocks.

GEOCHEMICAL RECONNAISSANCE OF ALTERED ROCKS

Geochemical studies were made of some areas of altered rocks which were thought to be of possible economic interest because of the intensity of the argillic alteration or because of the anomalous content of metals in the alluvium derived from them. Such investigations were made in the Greaterville and Ivanhoe areas and, in a more cursory way, in the Helvetia-Rosemont, Sycamore Canyon, and Salero Ranch areas. Other scattered localities were sparsely sampled. The preliminary results in the Greaterville and Ivanhoe areas justified additional sampling there, and the results were described in separate reports (Drewes, 1967, 1970). The results of work in the other areas are given in this report.

Different sampling procedures were used from place to place because the geologic situations varied. These procedural variations complicate the comparison of results. Samples were taken of rock thought to be most strongly mineralized, although such a sampling procedure may have drawbacks, such as being dependent upon exposed rocks, the metals content of which may be atypical of the rocks of the area as a whole. This sampling procedure, however, was considered the most practical approach to obtaining some idea of what metals were mobilized and of how they might be distributed. Perhaps this reconnaissance will help to define areas where additional study would be useful.

HELVETIA-ROSEMONT AREA

GEOLOGIC SETTING

The Helvetia and Rosemont camps of the Helvetia mining district have yielded chiefly copper, some lead, silver, and zinc, and a little gold. The mining camps lie in low hilly areas on opposite sides of a rugged ridge; the areas are contiguous, but Rosemont lies south of Helvetia. All parts of the mineralized area are readily accessible as a result of early mining and recent exploration activity.

Complexly faulted Paleozoic and Mesozoic sequences overlie a Precambrian crystalline basement in this area. These rocks are intruded by the barren quartz monzonite and granodiorite stocks of Helvetia, and by the quartz latite porphyry plugs of Greaterville which are shown on plate 1. The structural complexity of the area is the result of the Helvetian-phase deformation being superimposed upon the Piman-phase deformation (Drewes, 1971a, 1972b). Thrust faulting occurred during both phases but was directed first to the northeast and then to the northwest. Many thrust faults are steeply inclined toward the east, but some are nearly flat lying. Tear faults are interspersed with the thrust faults and merge with some of them.

Most of the pre-Tertiary rocks were metamorphosed or otherwise altered. Commonly the Paleozoic carbonate rocks were marmorized, and those with impurities were metamorphosed into tactite that contains garnet, diopside, actinolite, wollastonite(?), and tourmaline. Siltstone and shales were hornfelsed. Mesozoic arkosic rocks were strongly argillized, especially in the central part of the Rosemont area.

Some mineral deposits occur coextensively with these altered rocks, but the most abundantly mineralized ground and most of the old mines are located along faults near the ore porphyry plugs. The tactites, especially of the Abrigo and Martin Formations, contain contact metamorphic deposits and replacement bodies, and along most faults and throughout the central part of the Rosemont area they contain disseminated hydrothermal deposits. Locally, mineral deposits occur in a breccia zone (Creasey and Quick, 1955) next to a plug. Oxides and carbonates of copper, iron, and manganese are fairly common in outcrop, and those of lead and zinc also occur locally. Sulfide minerals are less common in outcrops than underground, as seen by their relative abundance on the mine dumps, but pyrite and chalcopyrite and, less commonly, galena and sphalerite do occur at the surface. Fluorite is present in two shallow prospects (pl. 1).

METHODS AND RESULTS

Most samples in the Helvetia-Rosemont area were taken from mine dumps or pit walls; a few were taken from mineralized outcrops away from prospects. Each sample consisted of four to about 10 chips 1–2 inches thick of mineralized or altered rock that was typical of the locality or mine. An effort was made to include a variety of altered rock types rather than ore only, but mineralized chips were preferred. Sixty-four samples were collected. All chips were split into subequal parts, and half of each chip was combined with halves of the other chips of that sample, finely ground and mixed in preparation for analysis. The second set of half chips was set aside.

One split of each pulverized sample thus prepared was analyzed spectrographically for 29 elements by the six-step semiquantitative method (Myers and others, 1961). Analyses are reported in parts per million, using the numbers 1, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, and so forth, which are approximate midpoints of group data on a geometric scale. The precision (or reproducibility) of a reported value is approximately plus or minus one interval at 68-percent confidence or two intervals at 95-percent confidence.

Other splits were analyzed by nonspectrographic methods for mercury, gold, tellurium, antimony, and arsenic. Mercury determinations were obtained by instrumentation methods. Gold and tellurium analyses were acquired by atomic absorption spectrometer. Antimony and arsenic were analyzed by colorimetric tests. The values of these five elements could not have been obtained, or would have been obtained less accurately, by the six-step semiquantitative spectrographic method, because of the low amounts in which the elements commonly occur. For example, by nonspectrographic methods the lower measurable limit of mercury is 0.01 ppm, and that of antimony is 0.5 ppm. Mercury cannot be readily analyzed semiquantitatively by spectrograph; the detectable spectrographic limit for antimony is 150 ppm.

Results of the analyses of the mineralized samples are listed in table 3. A few elements that were spectrographically analyzed, such as tin, were detected infrequently and were so close to the lower threshold of detection as to be of limited value. The major rock constituents are also omitted. The distribution of selected elements is shown in figures 3–13.

EVALUATION AND INTERPRETATION

The concentrations of many elements in the altered and mineralized rocks are greater, and those of some elements are less, compared with concentrations in unaltered rocks. A summary of the few available analyses of the unaltered rocks is shown in table 1, and more complete analyses are given in reports on the Cenozoic rocks (Drewes, 1972a) and on the plutonic rocks (Drewes, unpub. data). The average trace-element composition of unaltered shale, reported by Krauskopf (1967, p. 639–640), may be used to supplement the background values shown in table 1. Samples of mineralized rock from the Helvetia-Rosemont area are the most strongly enriched in copper, silver, manganese, molybdenum, lead, and zinc. They are moderately enriched in boron, bismuth, cadmium, cobalt, chromium, nickel, vanadium, and tungsten. Samples from some places are significantly enriched in arsenic, gold, tellurium, antimony, and mercury, but these samples are partly depleted in titanium and lanthanum. All these elements, then, likely were mobilized during the time of alteration and metamorphism. In all samples the contents of niobium, scandium, yttrium, and zirconium remain virtually unchanged; therefore, it is less likely that they were also mobilized elements. Metals, such as arsenic, bismuth, cadmium, gold, tellurium, tungsten, and

TABLE 3. — *Chemical and spectrographic analyses (in parts per*

[N, not detected. Analytical methods and accuracy discussed in text. Analysts: W. W. Janes,

Sample	Chemical analyses (ppm)					Semiquantitative spectrographic analyses (ppm)								
	Au	As	Hg	Sb	Te	Ag	B	Ba	Be	Bi	Cd	Co	Cr	Cu
						Helvetia-Rosemont area								
1120	0.06	<10	<0.01	3.0	0.1	0.5	<10	200	3	N	N	10	10	700
1121	.04	20	.01	8	.2	.5	<10	200	3	N	N	<5	70	500
1122	.6	10	.01	10	10	700	20	50	5	>1,000	N	5	15	>20,000
1125	.2	80	1.6	75	.4	150	<10	3,000	5	50	N	5	N	>20,000
1126	.2	10	<.01	10	6	70	50	70	2	100	N	15	50	>20,000
1128	.04	20	<.01	20	.2	7	100	500	3	N	N	5	5	20,000
1131	.2	10	.015	.5	.6	300	15	1,000	7	N	N	30	150	>20,000
1132	.06	<10	.015	.5	1.1	30	<10	2,000	<1	30	N	50	100	>20,000
1133	.08	80	.025	1	9.8	7	15	500	2	30	50	100	10	10,000
1134	.04	10	<.01	35	<.1	1.5	<10	700	5	N	N	200	50	15,000
1136	.08	160	.015	1	1.6	30	<10	150	N	N	N	15	10	200
1138	.5	10	<.01	2	25	70	<10	1,000	<1	N	N	150	50	>20,000
1141	.06	<10	<.01	<.5	<.1	10	<10	N	10	N	N	10	15	>20,000
1147	.08	<10	.1	<.5	.4	5	<10	50	1	N	N	15	7	>20,000
1148	.1	20	.03	2	.2	7	<10	200	5	N	N	10	10	20,000
1150	.06	80	.17	4	6.7	200	150	1,000	3	300	N	20	10	>20,000
1158	.04	40	<.01	8	.8	1	10	700	2	N	N	<5	10	300
1160	.5	80	<.01	150	.6	1.5	20	20	7	30	N	7	10	>20,000
1166	.04	10	.015	<.5	.5	30	50	N	1	N	N	<5	30	>20,000
1167	.3	10	<.01	<.5	6	200	20	N	N	1,000	N	5	7	>20,000
1176	.04	10	<.01	.5	.2	10	<10	50	5	N	N	10	50	>20,000
1177	.1	20	<.01	4	.5	10	<10	70	3	N	20	15	50	>20,000
1194	.06	40	.01	3	.8	15	<10	N	<1	N	N	30	50	>20,000
1200	.04	10	.025	<.5	1.6	30	<10	70	50	N	500	10	15	>20,000
1211	.08	10	.01	.5	1	15	30	100	1	10	20	5	50	>20,000
1212	.3	80	.01	.5	.1	10	50	150	15	N	N	<5	30	>20,000
1214	.06	<10	.01	1	.1	5	<10	70	7	N	N	20	20	20,000
1215	.2	10	.04	<.5	.1	5	<10	150	10	N	N	20	100	>20,000
1217	.04	20	<.01	4	.1	2	<10	70	1	N	N	100	50	1,000
1218	.06	<10	.04	2	.4	1.5	30	N	7	20	N	30	30	2,000
1219	.1	10	.05	4	.5	30	<10	N	3	N	30	15	50	>20,000
1226	.06	<10	<.01	<.5	1.1	20	<10	700	10	50	20	10	15	10,000
1232	.4	10	.1	.5	.2	10	<10	N	2	N	>500	150	150	>20,000
1235	.08	10	.025	.5	.5	7	<10	700	1	N	50	20	70	15,000
1237	.4	20	1.6	200	1.7	70	<10	50	5	300	300	70	15	>20,000
1238	.8	10	.015	10	44	1,000	20	100	3	>1,000	20	10	5	>20,000
1240	.1	20	.1	4	.3	30	<10	70	10	N	N	7	15	>20,000
1242	.04	<10	<.01	1	.1	7	<10	50	2	N	N	5	15	5,000
1243	.2	10	<.01	.5	1.2	30	30	N	1.5	30	N	5	7	20,000
1246	.04	<10	.025	3	.3	5	10	300	10	<10	N	7	10	>20,000
1247	.06	10	.015	<.5	21	3	10	300	7	<10	N	7	7	20,000
1248	.06	<10	.025	<.5	.2	50	<10	N	2	70	N	10	20	>20,000
1290	.04	<10	.05	.5	.3	7	<10	500	2	N	N	10	7	10,000
1291	.04	80	.04	15	.1	7	15	N	5	N	150	5	20	>20,000
1292	.04	<10	.03	2	.2	1	<10	N	1.5	N	N	10	10	7,000
1293	.1	<10	.09	<.5	.1	1.5	20	N	2	N	N	5	50	>20,000
1294	.08	<10	.04	.5	.7	7	<10	N	1.5	N	N	7	20	10,000
1295	.04	10	<.01	2	.8	10	20	700	N	15	N	15	15	>20,000
1296	.3	10	<.01	8	3.3	30	30	N	1	150	N	10	10	>20,000
1297	.4	<10	.04	<.5	2.9	30	20	N	<1	50	N	10	20	>20,000
1298	.08	<10	.04	3	.1	7	30	N	5	N	N	5	10	>20,000
1314	.06	10	.025	3	.3	15	10	1,000	2	N	N	10	200	7,000
1315a	<.02	30	<.01	1	.1	10	30	N	3	N	N	100	100	>20,000
1316	.06	10	.025	10	<.1	20	20	N	3	N	N	5	20	15,000
1317	.04	10	.03	<.5	.4	7	15	300	7	N	N	10	5	10,000

million) of mineralized rocks of the Helvetia mining district

J. B. McHugh, J. M. Motooka, E. L. Mosier, J. H. Turner, R. L. Turner, and J. G. Watterson]

Semiquantitative spectrographic analyses--Continued

	(ppm)													
Sample	La	Mn	Mo	Nb	Ni	Pb	Sc	Sn	Sr	Ti	V	W	Y	Zn	Zr
								Helvetia-Rosemont area							
1120	50	2,000	<5	20	<5	30	10	N	<100	5,000	50	<50	50	N	300
1121	30	70	70	20	5	30	15	N	N	>10,000	200	100	30	N	200
1122	N	>5,000	15	N	20	150	5	30	<100	500	50	500	15	2,000	50
1125	N	5,000	20	N	5	>20,000	<5	10	1,500	200	20	N	15	1,500	30
1126	20	>5,000	15	<10	30	1,500	10	N	<100	2,000	100	N	50	<200	100
1128	30	300	N	<10	5	1,000	5	N	<100	1,500	50	N	10	200	150
1131	20	50	50	N	100	2,000	7	N	500	2,000	150	<50	10	300	70
1132	20	1,000	N	<10	70	500	15	N	200	7,000	200	N	20	1,000	150
1133	N	>5,000	20	N	15	5,000	7	N	100	2,000	150	<50	50	>10,000	150
1134	50	2,000	50	30	30	70	10	N	N	7,000	200	70	70	N	1,000
1136	N	50	150	N	7	300	<5	N	300	700	100	N	N	N	30
1138	<20	5,000	N	<10	300	50	10	N	150	5,000	300	N	30	700	150
1141	N	1,500	200	N	10	50	<5	20	N	500	150	100	<10	700	20
1147	N	2,000	50	N	10	50	<5	30	N	300	100	70	15	<200	N
1148	20	1,000	200	N	7	50	5	20	200	1,000	70	50	20	300	100
1150	N	500	50	N	15	3,000	<5	N	N	300	300	<50	10	>10,000	20
1158	30	300	N	N	<5	150	5	N	500	2,000	70	N	15	500	300
1160	N	50	20	N	5	500	<5	N	N	300	50	100	10	700	20
1166	N	500	N	N	20	30	<5	N	N	200	30	N	10	200	10
1167	N	1,500	30	N	15	700	<5	50	N	100	30	N	<10	200	N
1176	N	1,000	N	N	5	30	<5	30	N	1,000	70	50	<10	200	50
1177	N	>5,000	20	N	10	200	<5	N	N	150	100	200	10	>10,000	N
1194	100	5,000	2,000	N	30	100	5	20	N	1,000	100	50	20	1,000	150
1200	N	>5,000	150	N	7	20	N	N	N	70	10	100	<10	>10,000	N
1211	N	3,000	300	N	20	3,000	<5	10	N	500	20	<50	10	>10,000	50
1212	20	700	200	N	5	150	5	N	500	700	50	50	15	300	70
1214	<20	>5,000	15	N	20	20	<5	N	N	500	50	<50	20	700	20
1215	<20	>5,000	20	N	30	30	7	20	N	1,000	100	<50	70	700	150
1217	N	700	150	N	20	20	<5	N	N	500	50	70	<10	200	50
1218	30	2,000	20	N	10	10	5	30	N	700	50	100	15	>10,000	70
1219	N	1,500	20	N	20	50	<5	30	N	500	100	70	<10	>10,000	20
1226	N	>5,000	10	N	20	1,000	<5	N	100	200	20	70	20	1,000	N
1232	N	5,000	15	N	30	30	<5	20	N	200	70	N	15	>10,000	20
1235	<20	1,500	50	N	30	50	10	10	100	3,000	100	N	30	>10,000	200
1237	N	1,500	>2,000	N	15	300	<5	70	N	200	20	100	<10	>10,000	10
1238	N	>5,000	150	N	5	>10,000	5	15	<100	500	20	<50	10	10,000	70
1240	N	>5,000	700	N	5	150	<5	30	<100	300	70	200	<10	1,500	15
1242	<20	3,000	20	N	5	20	<5	30	<100	500	150	50	30	<200	150
1243	N	5,000	100	N	<5	700	<5	20	<100	100	30	<50	<10	300	N
1246	N	3,000	100	N	20	100	5	N	150	700	30	100	10	>10,000	100
1247	N	3,000	70	N	15	70	<5	N	100	700	30	150	10	>10,000	200
1248	N	3,000	50	N	5	200	<5	30	N	150	30	100	10	10,000	N
1290	N	1,500	50	N	5	<10	<5	<10	N	500	50	N	<10	200	100
1291	<20	>5,000	30	N	7	70	5	30	N	500	50	500	20	>10,000	30
1292	N	5,000	20	N	7	<10	<5	20	N	150	100	50	<10	200	N
1293	N	5,000	70	N	7	10	<5	100	N	300	150	500	10	200	10
1294	N	>5,000	50	N	30	<10	<5	50	N	200	100	70	10	<200	10
1295	N	2,000	150	N	10	10	<5	10	N	200	20	N	<10	700	30
1296	N	3,000	100	N	10	100	<5	N	N	300	30	N	<10	<200	50
1297	N	5,000	20	N	30	30	<5	N	N	300	50	50	15	N	20
1298	N	3,000	150	N	5	10	<5	50	N	150	70	700	<10	300	20
1314	50	700	1,500	15	70	30	20	20	150	5,000	300	N	200	N	1,000
1315a	20	3,000	100	N	100	30	10	30	100	1,000	200	N	70	300	150
1316	N	1,000	500	N	5	300	<5	30	N	700	100	200	<10	700	30
1317	<20	1,500	150	10	7	150	<5	N	N	1,000	50	N	20	200	150

TABLE 3. — *Chemical and spectrographic analyses (in parts per million)*

	Chemical analyses (ppm)					Semiquantitative spectrographic analyses (ppm)								
Sample	Au	As	Hg	Sb	Te	Ag	B	Ba	Be	Bi	Cd	Co	Cr	Cu
						Helvetia-Rosemont area--Continued								
1318	0.04	<10	0.04	<0.5	0.1	0.7	10	1,000	3.0	N	N	70	10	>20,000
1319	.04	10	.03	<.5	.2	7	70	N	30	N	N	10	30	>20,000
1320	.06	<10	.015	.5	.1	30	10	300	3	N	N	10	15	>20,000
1331	.04	<10	.025	<.5	<.1	1	10	500	7	N	N	150	10	>20,000
1332	.04	<10	<.01	1	<.1	5	<10	700	1.5	N	N	7	10	>20,000
1333	.1	<10	<.01	<.5	.3	50	30	50	7	N	N	15	7	>20,000
1335	.02	<10	.015	.5	.1	30	20	1,000	7	N	N	30	50	>20,000
1336	.3	<10	<.01	4	2	50	50	50	1.5	150	N	5	15	>20,000
1338	.6	10	7	.5	1	30	<10	300	N	N	20	<5	5	3,000
1341	.04	20	.03	10	<.1	70	<10	3,000	3	N	50	30	50	200
1380	.8	20	.05	<.5	.8	50	<10	50	3	>1,000	N	100	70	>20,000
1385	5.6	10	.6	150	1.9	1,000	N	>5,000	<1	20	<500	<5	30	500
						Sycamore Canyon area								
1265	0.04	<10	0.04	2.0	0.1	1.0	<10	70	1.5	N	N	5	10	700
1285	.02	<10	.08	.5	<.1	.5	<10	200	2	N	N	150	100	10,000
1289	.04	<10	.025	<.5	<.1	30	<10	2,000	1	50	N	50	20	>20,000
1434	.02	15	.02	<.05	<.1	.5	<10	20	N	<1	N	5	5	20
1436	.02	40	.05	1	.1	N	50	150	1	10	N	10	30	30
1437	.62	30	1	200	.7	500	N	1,000	<1	10	300	N	20	2,000
1438	.02	30	.11	10	1.7	30	<10	2,000	<1	100	20	15	20	500
1439	.2	15	.18	2	.6	15	10	>5,000	<1	15	100	N	20	700
1440	<.02	10	.05	.5	.3	1	<10	700	<1	N	N	5	30	20
1441	.08	20	.04	.5	180	5	10	300	<1	500	N	N	N	10
1442	<.02	20	.03	1	<.1	.5	10	300	1	10	N	10	30	20
1443	<.02	15	.03	.5	.1	N	N	200	<1	<1	N	N	50	10
1444	16	40	4.2	100	.5	1,000	<10	5,000	1.5	<1	20	5	50	1,000
1445	.22	60	5	50	.1	1,000	10	3,000	1.5	N	>500	20	50	2,000
1446	.02	30	2.6	250	.1	1,000	<10	2,000	1	<1	100	5	70	1,000
1447	.12	60	.8	35	.2	200	10	>5,000	<1	N	150	5	30	200
1448	.46	60	.17	45	.4	70	<10	500	2	<1	N	N	30	50
1449	.92	15	1	15	.1	500	<10	100	1.5	N	50	10	50	200
1450	.04	10	.55	4	.7	100	50	300	1.5	15	50	10	100	500
1451	1.2	20	.8	10	3.7	30	<10	2,000	<1	<1	N	N	30	2,000
1452	.12	60	.26	15	1.3	10	10	70	1	<1	N	5	100	100
1453	<.02	10	.06	<.5	.1	1	<10	50	N	<1	N	N	50	20
1454	<.02	10	.08	.5	.5	7	<10	30	<1	<1	N	N	10	20
1455	<.02	10	.08	.5	.7	10	<10	300	<1	<1	N	N	70	20
1456	.02	60	.17	6	.2	15	<10	1,000	1	<1	N	15	50	70
1457	<.02	30	.07	1	.1	N	15	500	<1	N	N	5	70	20
1458	<.02	10	.03	.5	.1	.5	<10	200	<1	N	N	N	10	20

of mineralized rocks of the Helvetia mining district — Continued

Semiquantitative spectrographic analyses--Continued

Sample	(ppm) La	Mn	Mo	Nb	Ni	Pb	Sc	Sn	Sr	Ti	V	W	Y	Zn	Zr
Helvetia-Rosemont area--Continued															
1318	100	5,000	500	<10	15	50	10	<10	100	2,000	70	N	150	<200	20
1319	N	>5,000	50	N	15	20	5	100	<100	700	100	700	15	>10,000	30
1320	20	3,000	150	10	10	30	5	N	N	1,500	50	300	30	1,500	300
1331	<20	2,000	>2,000	N	10	10	<5	50	<100	500	20	N	200	N	70
1332	20	500	300	20	5	20	10	15	<100	5,000	100	N	50	N	300
1333	<20	700	200	N	5	10	<5	50	N	500	20	N	10	700	20
1335	20	>5,000	150	20	20	30	10	<10	<100	3,000	100	<50	30	700	200
1336	100	5,000	30	N	7	150	5	20	100	700	30	<50	20	200	50
1338	N	1,500	150	N	5	20,000	<5	N	N	50	10	N	15	>10,000	N
1341	30	>5,000	30	<10	30	>20,000	10	N	100	2,000	30	<50	20	>10,000	150
1380	30	5,000	N	N	15	700	10	30	<100	3,000	50	50	50	500	150
1385	<20	2,000	500	N	7	>20,000	5	N	1,000	150	100	N	<10	>10,000	N
Sycamore Canyon area--Continued															
1265	20	700	10	N	10	150	5	N	N	1,000	30	<50	15	<200	100
1285	20	>5,000	20	N	70	20	7	30	150	2,000	500	3,000	50	300	150
1289	N	1,500	N	N	20	150	<5	30	100	200	150	200	10	1,000	N
1434	20	700	N	N	10	30	<5	N	500	500	20	N	20	N	50
1436	N	1,500	5	<10	20	100	5	N	150	1,500	70	N	15	300	100
1437	N	>5,000	50	N	20	>20,000	<5	N	700	500	30	N	10	>10,000	30
1438	N	2,000	20	N	5	5,000	<5	N	150	500	50	N	10	1,500	50
1439	N	5,000	20	N	15	7,000	<5	N	500	500	50	N	10	1,500	50
1440	N	2,000	N	N	15	300	7	N	500	1,500	100	N	20	N	200
1441	N	100	N	<10	N	150	<5	N	N	500	10	N	N	N	<10
1442	20	1,000	N	<10	15	50	15	N	200	2,000	100	N	20	N	200
1443	N	700	N	N	15	70	N	N	200	700	50	N	10	<200	70
1444	N	700	300	N	15	10,000	N	N	300	200	30	20	10	5,000	10
1445	N	2,000	30	N	50	20,000	N	N	150	200	50	N	<10	>10,000	50
1446	N	1,500	50	<10	10	>20,000	N	N	200	200	70	N	N	5,000	10
1447	N	>5,000	1,000	<10	20	7,000	N	10	1,000	300	50	N	20	5,000	50
1448	N	1,000	10	N	10	500	N	N	N	200	50	N	20	500	10
1449	N	700	300	<10	50	10,000	5	N	<100	1,500	70	20	50	5,000	50
1450	N	1,500	20	10	30	1,000	5	N	<100	2,000	70	N	15	3,000	100
1451	N	300	300	<10	5	15,000	N	N	150	50	20	N	N	5,000	N
1452	N	3,000	5	<10	50	5,000	<5	N	N	1,000	200	N	N	1,000	50
1453	N	500	10	<10	20	200	<5	N	<100	1,000	70	N	15	N	70
1454	N	700	5	<10	<5	700	N	N	100	50	10	N	N	N	N
1455	N	1,500	5	<10	20	2,000	5	N	200	1,500	70	N	N	<200	100
1456	70	1,500	5	10	30	500	10	N	300	5,000	100	N	30	1,000	200
1457	20	>5,000	10	10	20	200	5	N	700	2,000	100	N	15	N	100
1458	N	300	5	<10	10	30	<5	N	150	1,000	20	N	10	N	100

tin, which have been mobilized but the presence of which has not been recognized during the review of the mineralogy of the mine dumps are of special interest because they suggest the occurrence in the known minerals of small amounts of other minerals.

An evaluation of the distribution of elements in the area requires some consideration of the quantitative values of the analytical data. Because the sampling procedure had a bias toward high values, the following evaluation is limited only to the gross aspects of distribution. Slight changes in the ranges of concentrations represented by each group of symbols shown in figures 3–13 change the distribution patterns very little. For example, with any minor change in the range of values selected to show minor anom-

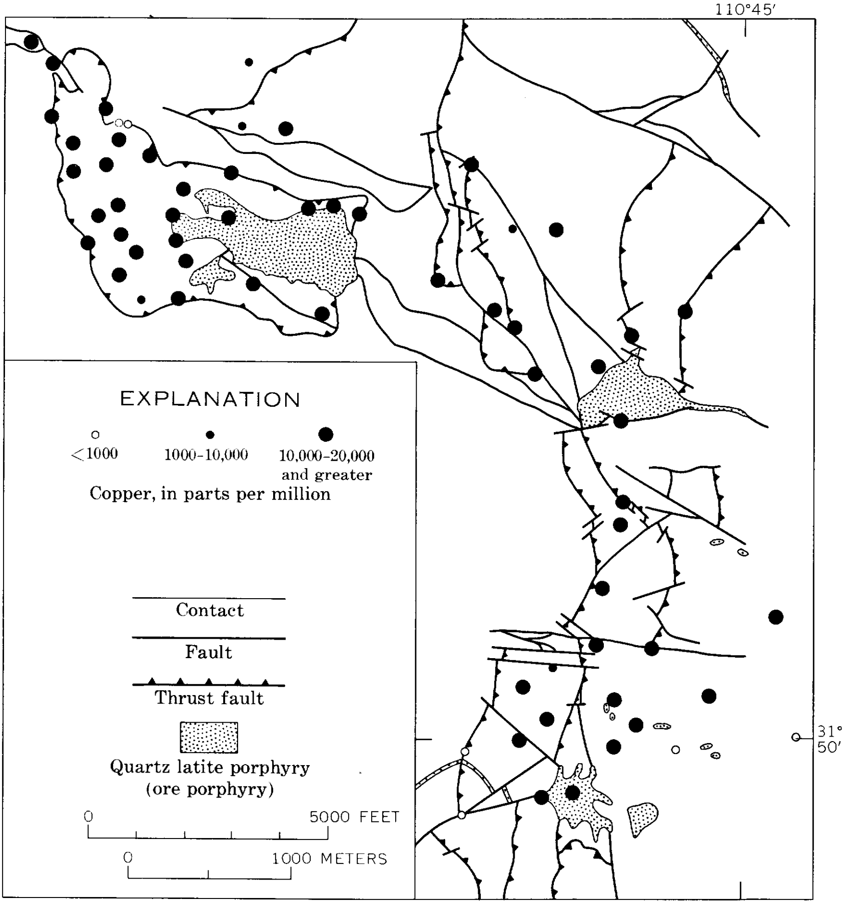


FIGURE 3. — Distribution of copper in altered rocks of the Helvetia-Rosemont area.

alies of arsenic—the large circles in figure 10—the gross distribution pattern would still show a concentration north of the plug at Rosemont and would still show only scattered minor anomalies elsewhere. This evaluation scheme is believed to be commensurate with the reconnaissance-oriented analytical techniques and sampling procedures used.

Geochemical reconnaissance shows that copper is a widespread abundant element (fig. 3), corroborating the field observations and mining history of the area. The high-copper area virtually delimits the mining camps and the sampled area, and it may well extend beyond the mining camps to the south and northwest along the zones of complex faulting.

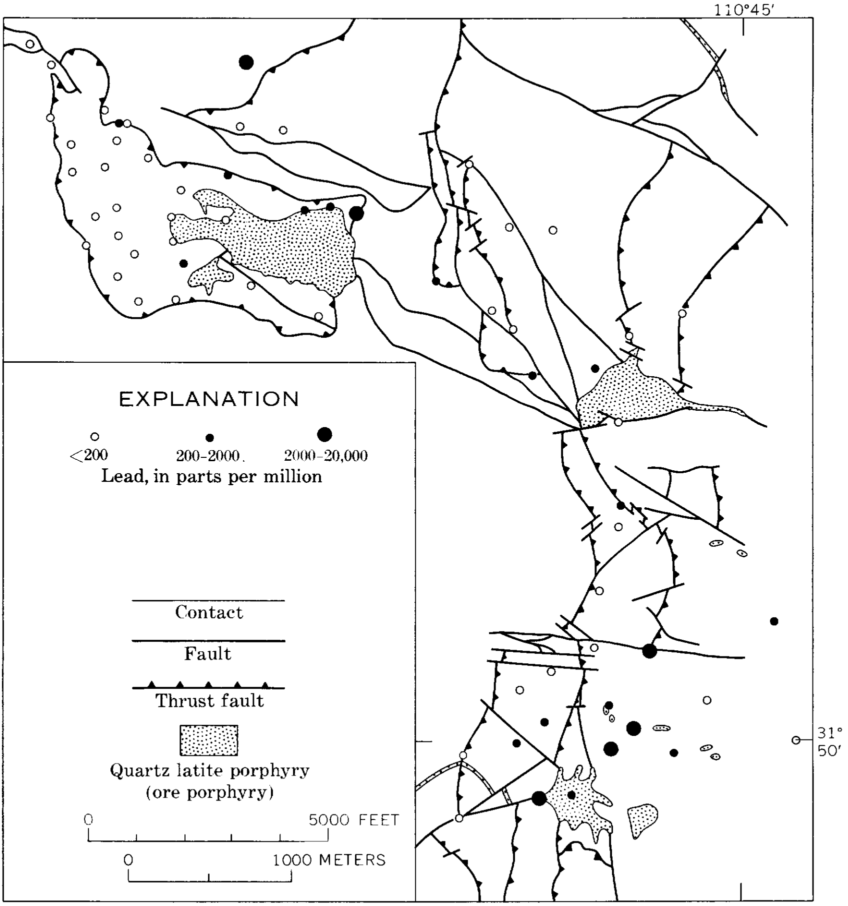


Figure 4. — Distribution of lead in altered rocks of the Helvetia-Rosemont area.

Base metals such as lead (fig. 4), zinc (fig. 5), and molybdenum (fig. 6) are less widespread and less strongly concentrated than copper. High concentrations of molybdenum occur mainly in the Helvetia klippe and near the Summit plug (pl. 1). Zinc concentrations are greatest in the central and eastern parts of the klippe, near the plug, and in a north-trending zone in the Rosemont area. Cadmium (fig. 5), a common associate of zinc, is concentrated only where high zinc values occur, but cadmium highs are not coextensive with zinc highs. Perhaps the geochemical mobility of zinc is greater than that of cadmium. High lead concentrations also appear in the north-trending zone at Rosemont. Bismuth (fig. 7), a common associate of lead, occurs in the Rosemont zone, but it

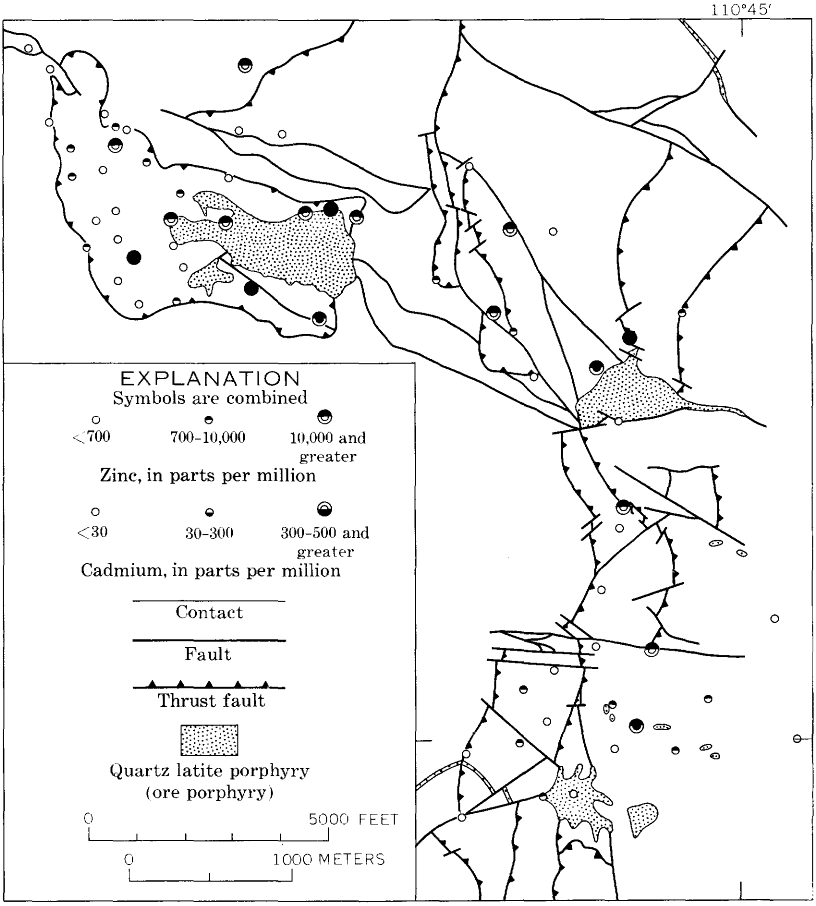


FIGURE 5. — Distribution of zinc and cadmium in altered rocks of the Helvetia-Rosemont area.

is also concentrated along the north edge and just east of the Helvetia klippe. The ratio of lead to bismuth is mostly about 10 to 1 and rarely is less than 1 to 1.

Other base metals are more randomly distributed, or are more locally concentrated. Most high values of tin (fig. 8) and tungsten (fig. 9) are found in the western part of the Helvetia klippe; a minor concentration of tungsten is found in the western part of Rosemont. Antimony and arsenic (fig. 10), in contrast, occur most abundantly at Rosemont.

Barium, beryllium (fig. 11), and boron (fig. 8) also show distributional patterns. Barium is chiefly concentrated at Rosemont. High values of boron are most common in the central part of Rose-

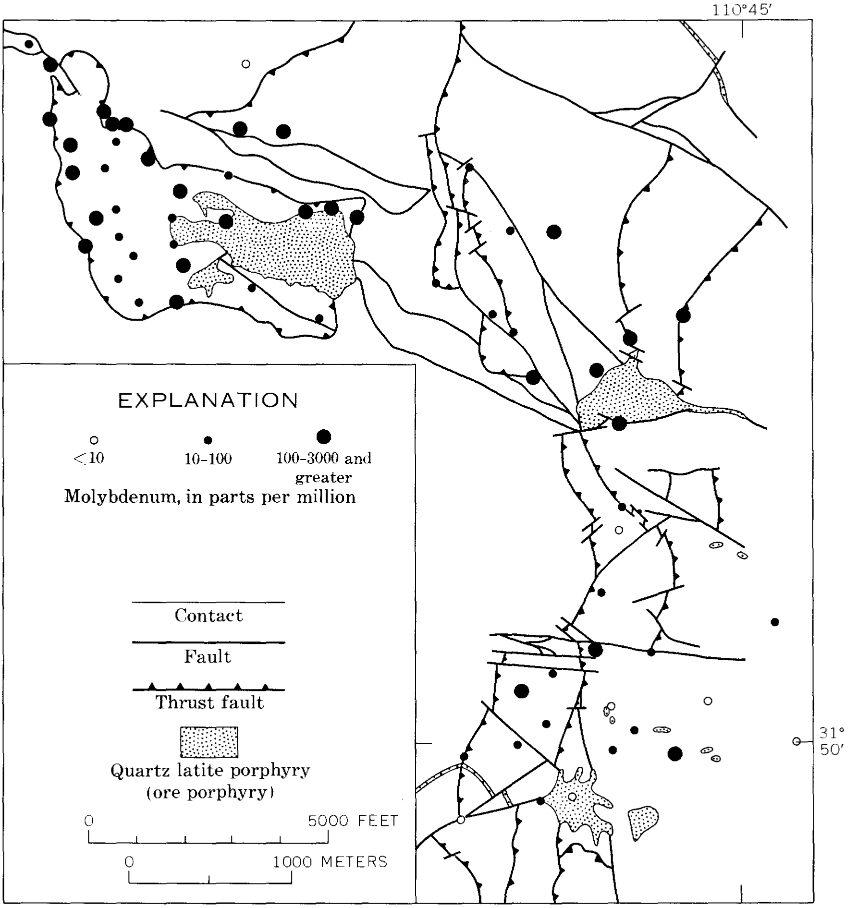


FIGURE 6. — Distribution of molybdenum in altered rocks of the Helvetia-Rosemont area.

mont and the central and western parts of Helvetia. Modest concentrations of beryllium occur in the western parts of both of these areas.

Of the noble metals, silver (fig. 7) is the most widespread, which is evident from the mining history of the area. Peak concentrations in both Rosemont and the eastern part of the Helvetia klippe exceed 100 ppm, and sample 1238 contains 1,000 ppm. The highest values of gold (fig. 12) commonly occur with high silver values. Mercury (fig. 13) has accumulated mainly in the western part and just east of the Helvetia klippe. Tellurium (fig. 12), which is associated with noble metals in many districts outside the Santa Rita Mountains, is not coextensive with gold and silver in

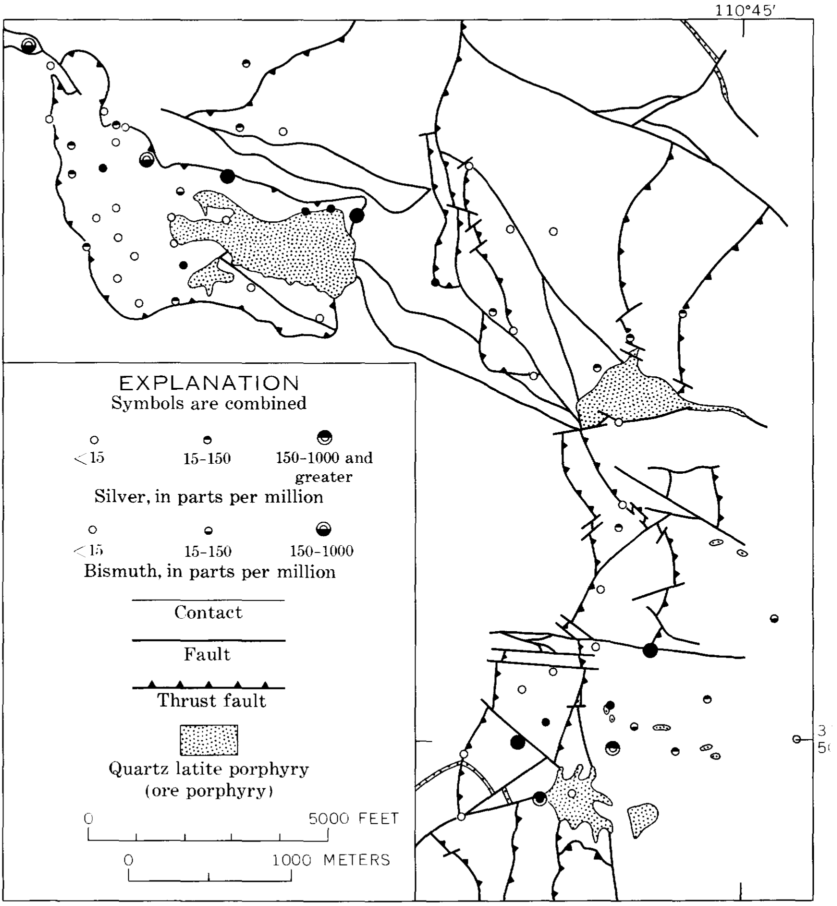


FIGURE 7. — Distribution of silver and bismuth in altered rocks of the Helvetia-Rosemont area.

the Santa Rita Mountains but is concentrated primarily in the Rosemont area.

The distribution maps suggest that mineral zonation occurs around some ore porphyry plugs, although other geologic features, such as faults, have had a major influence on zonation. For example, molybdenum, tungsten, and beryllium are concentrated farther from the northwest contact of the Rosemont plug than are lead, bismuth, silver, arsenic, and gold. Likewise, tin and mercury, and perhaps also beryllium and tungsten, are concentrated farther from the west contact of the Helvetia plug than are bismuth, silver, and antimony.

Three lines of evidence indicate that the mineralization of the

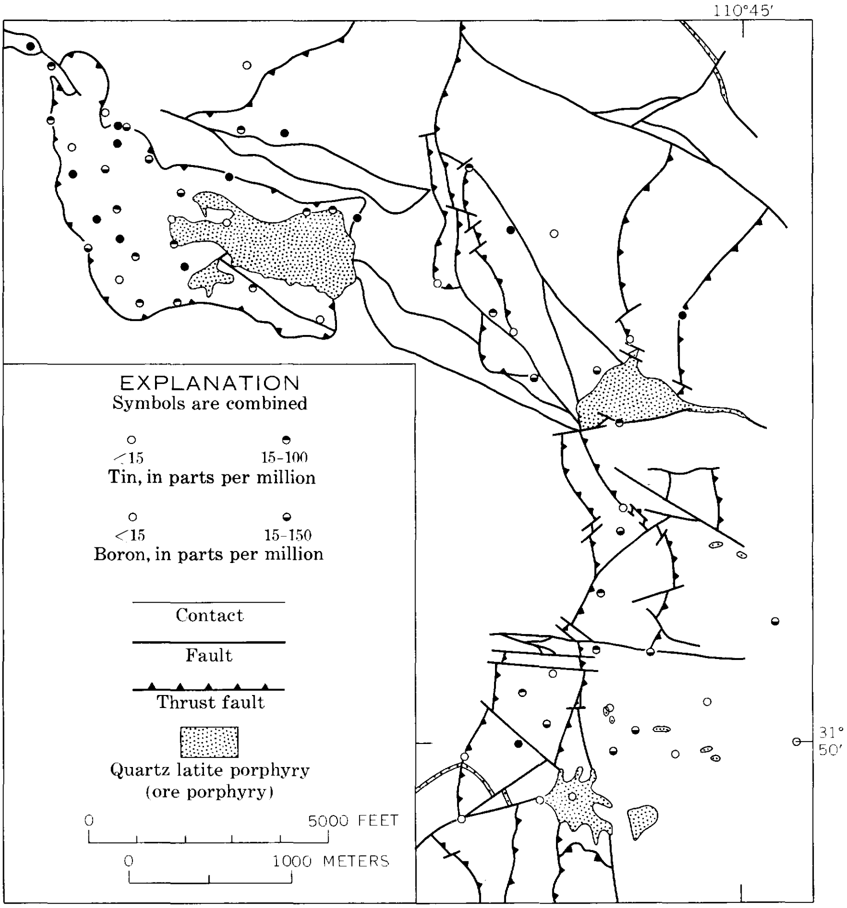


FIGURE 8. — Distribution of tin and boron in altered rocks of the Helvetia-Rosemont area.

district was genetically related to the ore porphyry: (1) consistent occurrence of mineralized rocks near ore porphyry plugs but not near other intrusives, (2) presence of mineral zonation around some of the ore porphyry plugs, and (3) restriction of copper-rich biotite to the ore porphyry.

Local variations in the pattern of distribution may provide some clues to concealed geologic features. The tendency for zinc, lead, bismuth, silver, arsenic, and antimony to be concentrated northeast of the Rosemont plug, where there are few prospects and only small mines, suggests that a more favorable geologic environment in which mineral deposits may have been emplaced may lie beneath the surface. Judged from the extensive argillic and iron

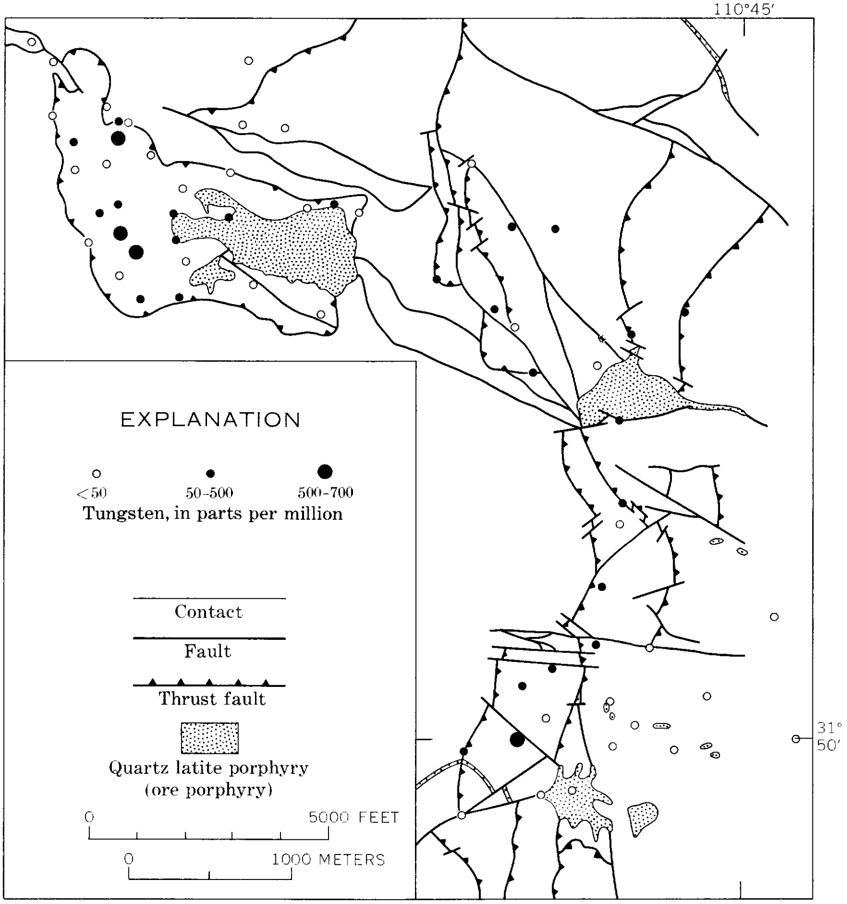


FIGURE 9. — Distribution of tungsten in altered rocks of the Helvetia-Rosemont area.

oxide alteration of the Mesozoic rocks there, and from the scattered dikelets of quartz latite porphyry, the quartz latite porphyry is likely more extensive in the subsurface than at the surface. If this is so, then the Paleozoic carbonate rocks that should underlie the Mesozoic rocks probably are strongly mineralized. Perhaps the considerable effort that has recently been expended in drilling part of this area may provide evidence to support these conjectures.

The pattern of distribution of the mineralized rocks in the Helvetia klippe also provides clues to the nature of subsurface geology. In general, the mineralization was coextensive with the klippe, which contains some rock types favorable for replacement

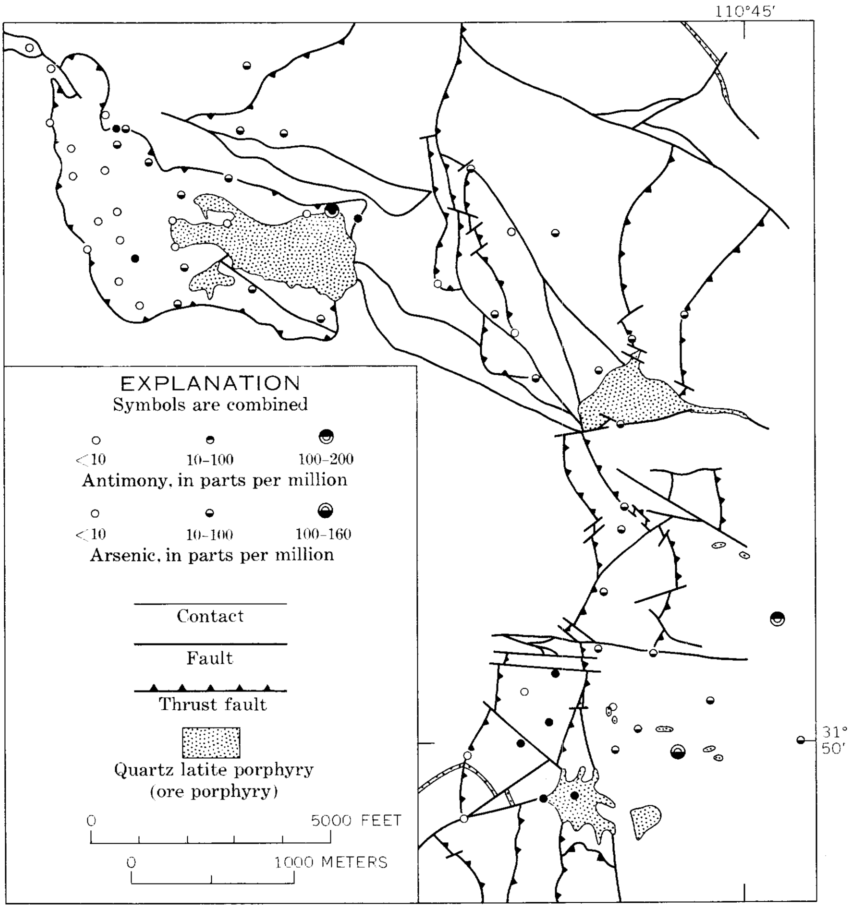


FIGURE 10. — Distribution of antimony and arsenic in altered rocks of the Helvetia-Rosemont area.

and which is underlain by a shear zone suitable for the spreading of hydrothermal fluids. The distribution of some elements, however, is not uniform within the klippe. High values of bismuth, silver, gold, and less commonly also of tellurium, lead, zinc, and cadmium are concentrated along a northwest-trending zone in the northern half of the klippe. This part of the klippe probably overlies a zone of northwest-trending tear faults (Drewes and Finnell, 1968; Drewes, 1972b). The concentration of these metals suggests that the tear fault zone may have channeled the hydrothermal fluids, and perhaps also the ore porphyry magma, and that the fluids then spread along the thrust fault, moving upward into the

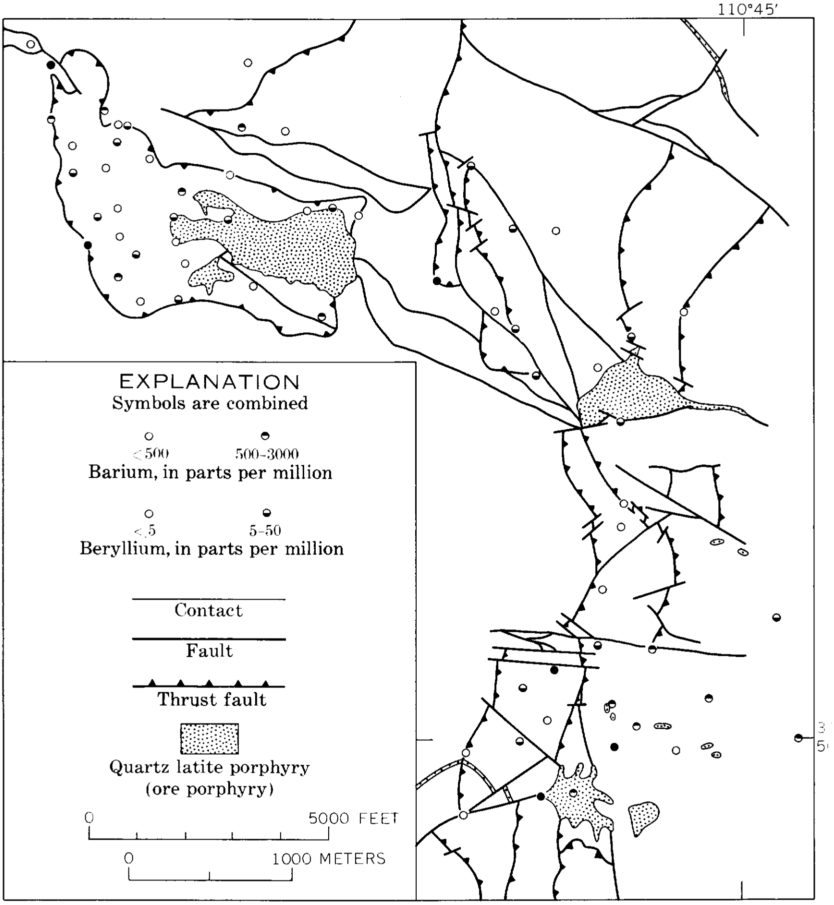


FIGURE 11. — Distribution of barium and beryllium in altered rocks of the Helvetia-Rosemont area.

ground above the zone more than into the ground southwest of it.

In the Helvetia area, thrust plates of Paleozoic rocks alternate with plates of Precambrian rocks, as had been recognized by Creasey and Quick (1955, pl. 28). From the available exposures northwest of Helvetia, it cannot be determined whether the structurally lowest Precambrian granodiorite is autochthonous or allochthonous. Another plate of Paleozoic rocks, possibly mineralized like the others, may lie beneath the granodiorite near the Helvetia klippe. Other favorable host rocks may occur northwest of Helvetia along extensions of the complex fault zone where the zone is concealed by gravel on the pediment.

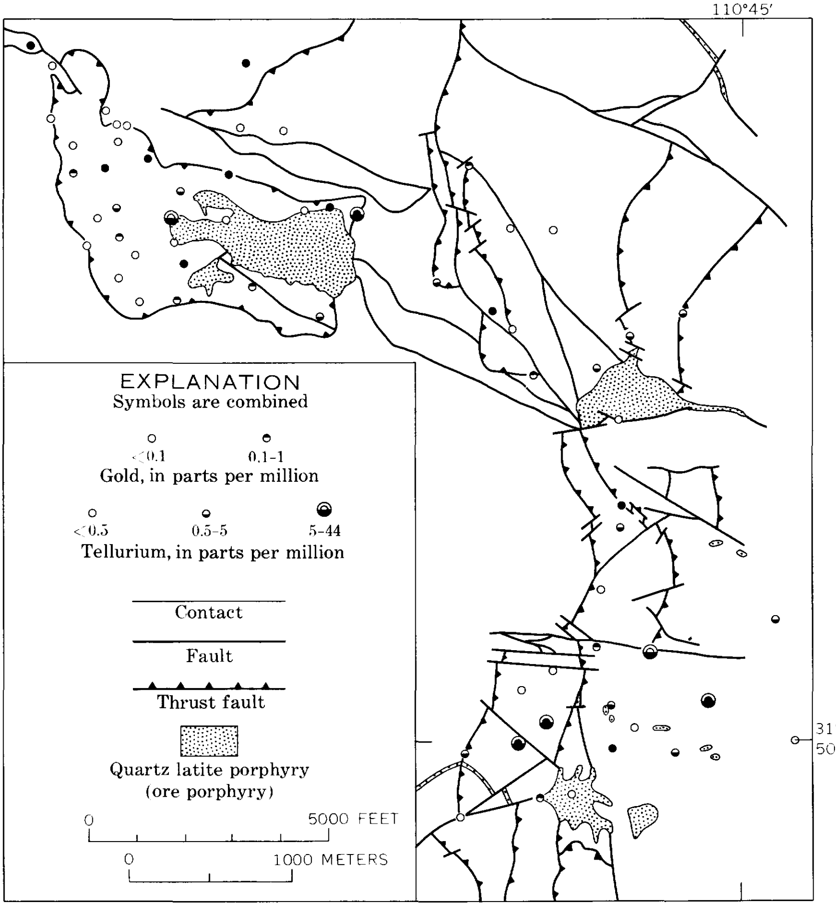


FIGURE 12. — Distribution of gold and tellurium in altered rocks of the Helvetia-Rosemont area.

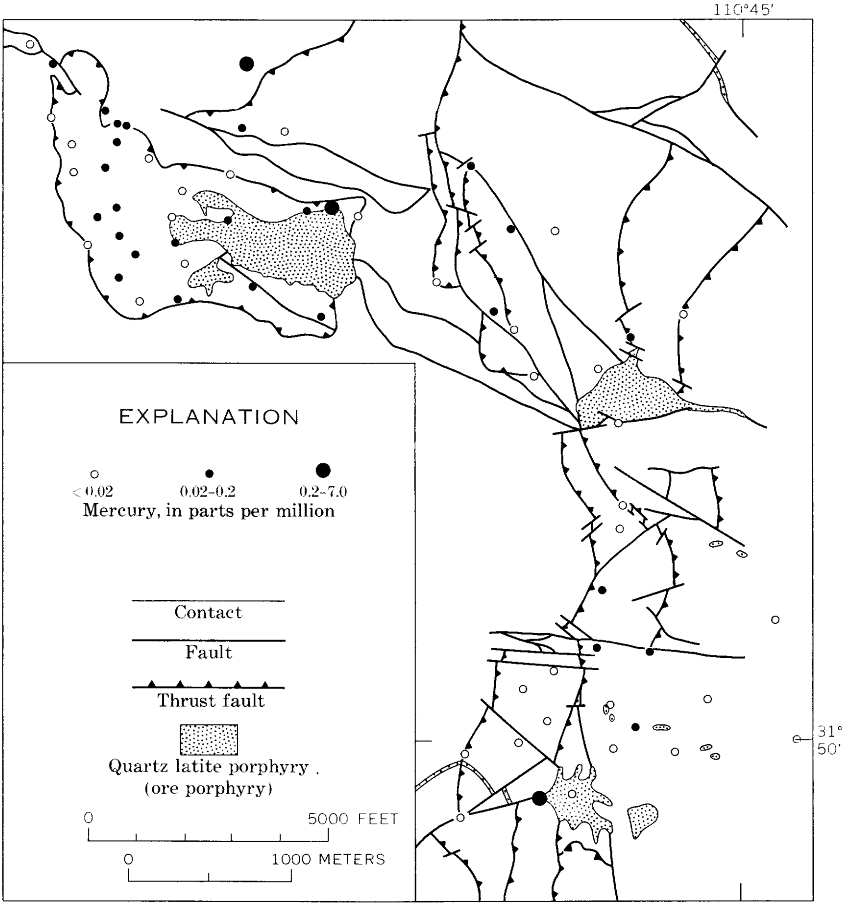


FIGURE 13. — Distribution of mercury in altered rocks of the Helvetia-Rosemont area.

SYCAMORE CANYON AREA

GEOLOGIC SETTING

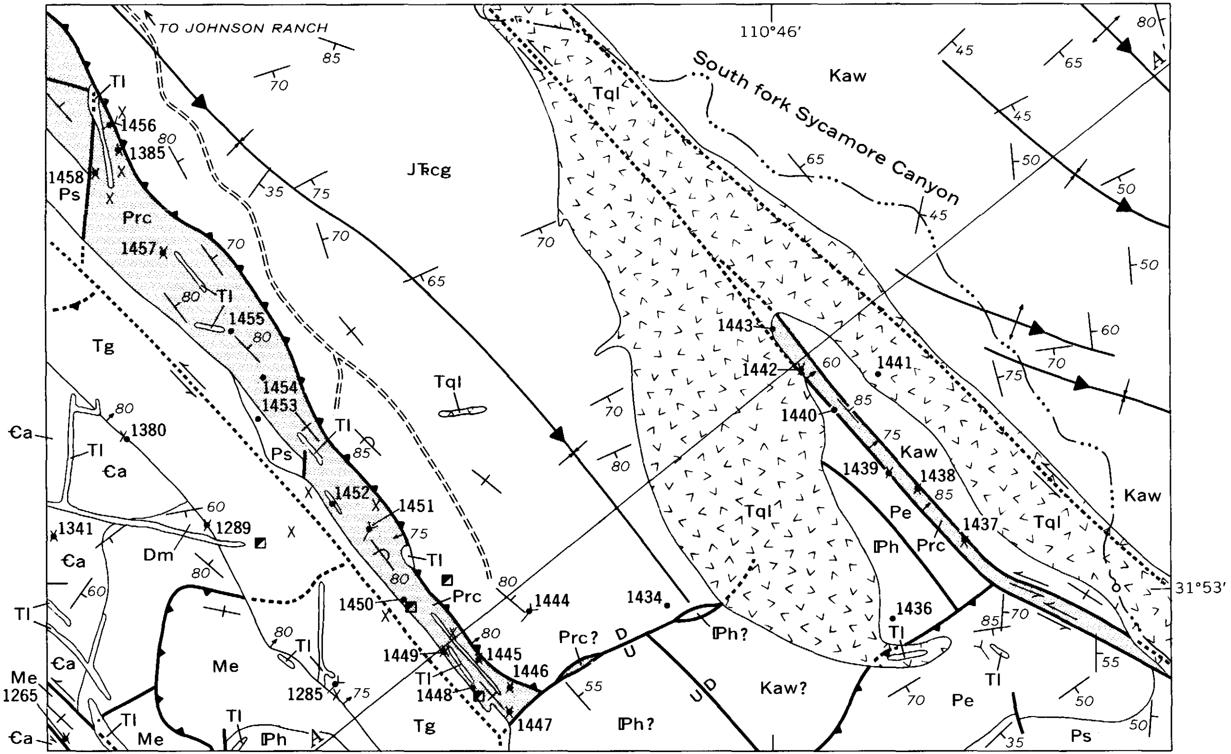
The mineralized area of Sycamore Canyon is in the northern part of the Helvetia mining district, about 2 miles northeast of Helvetia townsite. It is separated from the mining camp at Helvetia by about 1 mile of nearly barren ground. The Sycamore Canyon area is reached from the Johnson Ranch by a jeep road. The area may have been prospected as recently as the 1950's, but it seems unlikely that any significant amount of ore has been mined from the area.

The rocks in the mineralized area of Sycamore Canyon are similar to those in the Helvetia-Rosemont area. A sequence of

Paleozoic rocks is mostly restricted to the west and south; only the youngest of the Permian formations—the Scherrer Formation, Concha Limestone, and Rainvalley Formation—underlie two narrow northwest-trending belts near the center of the area (fig. 14). Of these Permian rocks, the Concha underlies most of the two belts, but because it is intensely sheared and recrystallized, it has lost many of its distinctive features, such as thick bedding and resistance to weathering. The Permian rocks are overlain by phyllitic red beds of the Gardner Canyon Formation and tuffaceous sandstone and arkose of the Canelo Hills Volcanics. Fairly unaltered rocks of the Willow Canyon and Apache Canyon Formations, both of the Bisbee Group, are the youngest bedded rocks of the area. The Paleozoic and Mesozoic sequences are intruded by a Paleocene granodiorite stock, an ore porphyry plug, and lamprophyric dikes. The ore porphyry of this area is slightly atypical in that the groundmass of the core of the body is coarser than that of the other plugs and the phenocrysts are slightly larger.

Many faults and some folds deform the rocks. A thrust fault separates the Concha, and locally also the Rainvalley, from the Gardner Canyon and Canelo Hills; the strong shearing in the carbonate rocks and the phyllitic development in the overlying red beds were probably the result of dynamic metamorphism caused by movement along the fault. The eastern belt of Concha and Rainvalley is flanked by tear faults, which to the north, beyond the area shown in figure 14, merge with a thrust fault. Fold axes trend northwestward; to the northwest, beyond the area shown in figure 14, the Permian rocks are warped into a syncline similar to, but not quite alined with, the syncline in the Triassic-Jurassic rocks (fig. 14; Drewes, 1971a, b). The folds and thrust faults and many of the other, less significant faults in the area are Piman-phase structures; the tear-fault zone along the south fork of Sycamore Canyon is Helvetian phase.

Most of the small mines and prospects of the area are along the two zones of sheared limestone. The rocks appear to be only sparsely or inconspicuously mineralized; but some of them contain small pods and veinlets of quartz and disseminated specks of sulfide minerals, and some fracture surfaces are coated with secondary minerals derived from these sulfides. Compared with the ratio in the Helvetia-Rosemont area, the ratio of copper minerals to lead and zinc minerals is lower. Although the mines are small, they seem unduly large in view of the paucity of base-metal minerals in the waste dumps, which suggests that noble metals may have attracted the exploration efforts.


TO JOHNSON RANCH
110°46′
31°53′
South fork Sycamore Canyon
A
A′
Kaw
Kaw?
JTRcg
Tql
Tl
Tg
Ps
Prc
Prc?
Pe
Ph
Ph?
€a
Dm
Me
D
U
1456
1385
1458
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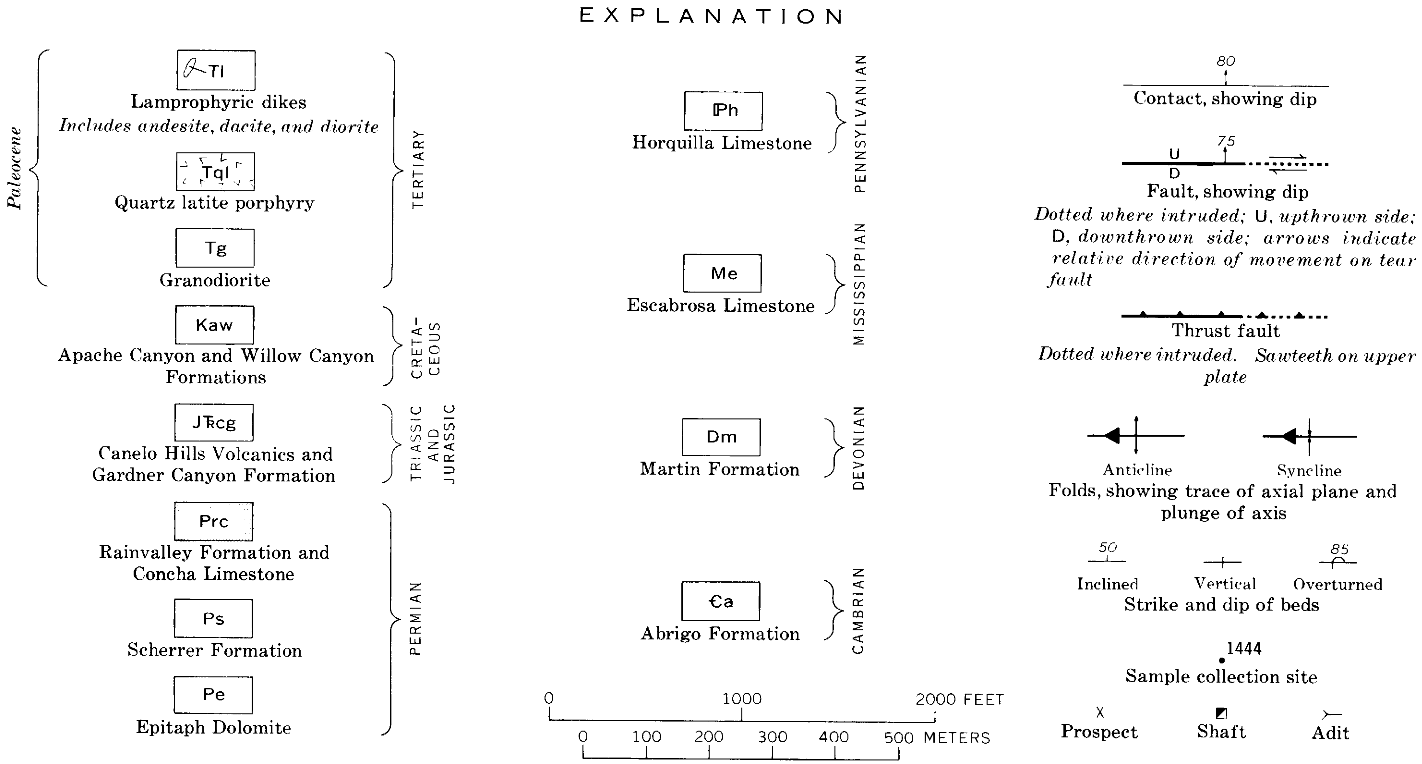

Figure 14. — The geology and the distribution of samples in the Sycamore Canyon area.

METHODS AND RESULTS

Sampling procedures and analytical methods used on the 27 specimens taken in the Sycamore Canyon area resemble those used on the Helvetia-Rosemont rocks. Because conspicuously mineralized rock is scarce in the Sycamore Canyon area, the amount of bias toward higher metal values is less than in the Helvetia-Rosemont area. The variety of mineralized chips composing each sample is also less near Sycamore Canyon than to the south because silicified rocks, oxidized rocks, and tactite are rarely present. Samples 1434 and 1441 were taken from quartz veinlets that seemed to be barren but that might offer a clue about mobile elements that were deposited outside of the belts of sheared limestone. Sample 1444 was selected from sheared limestone that formed a thin upper layer of waste on a small dump. The adit that supplied the dump material extended just far enough southwestward into a steep hillside to reach the Concha Limestone, at a level about 250 feet below the localities of samples 1445 and 1446.

The analytical results, reported in table 3, show concentrations of base and noble metals that differ in detail from the analyses of the Helvetia-Rosemont area. The degree of concentration of base metals is less in the Sycamore Canyon area than it is to the south, as already suggested by the sparsity of sulfide minerals on the dumps. However, in part of the Sycamore Canyon area, gold and silver concentrations are substantially greater than in the Helvetia-Rosemont area. Local values of bismuth reach 500 ppm; cadmium, more than 500 ppm; tellurium, 180 ppm; and tungsten, 3,000 ppm.

The distributions of some of the more significant metals in the Sycamore Canyon area are shown in figures 15–17.

EVALUATION AND INTERPRETATION

Despite the small number of samples analyzed, a few observations are offered because of the suggestive structural situation. The strong preference of gold and silver for the sheared Concha Limestone and Rainvalley Formation indicates that the subsurface extension of these rocks may deserve further attention as a potential source of these metals. Section *A–A′* (fig. 18) shows an interpretation of the local structure, and other structure sections through the fold are shown in another report (Drewes, 1972b, pl. 4, sections *C–C′* and *D–D′*). A structure section drawn along the fold axis would show a gently southeast-plunging group of Triassic-Jurassic beds and a thrust fault, which extend beneath the trace of the northeast-trending fault that truncates the main belt of sheared limestone. The northeast-trending fault is believed

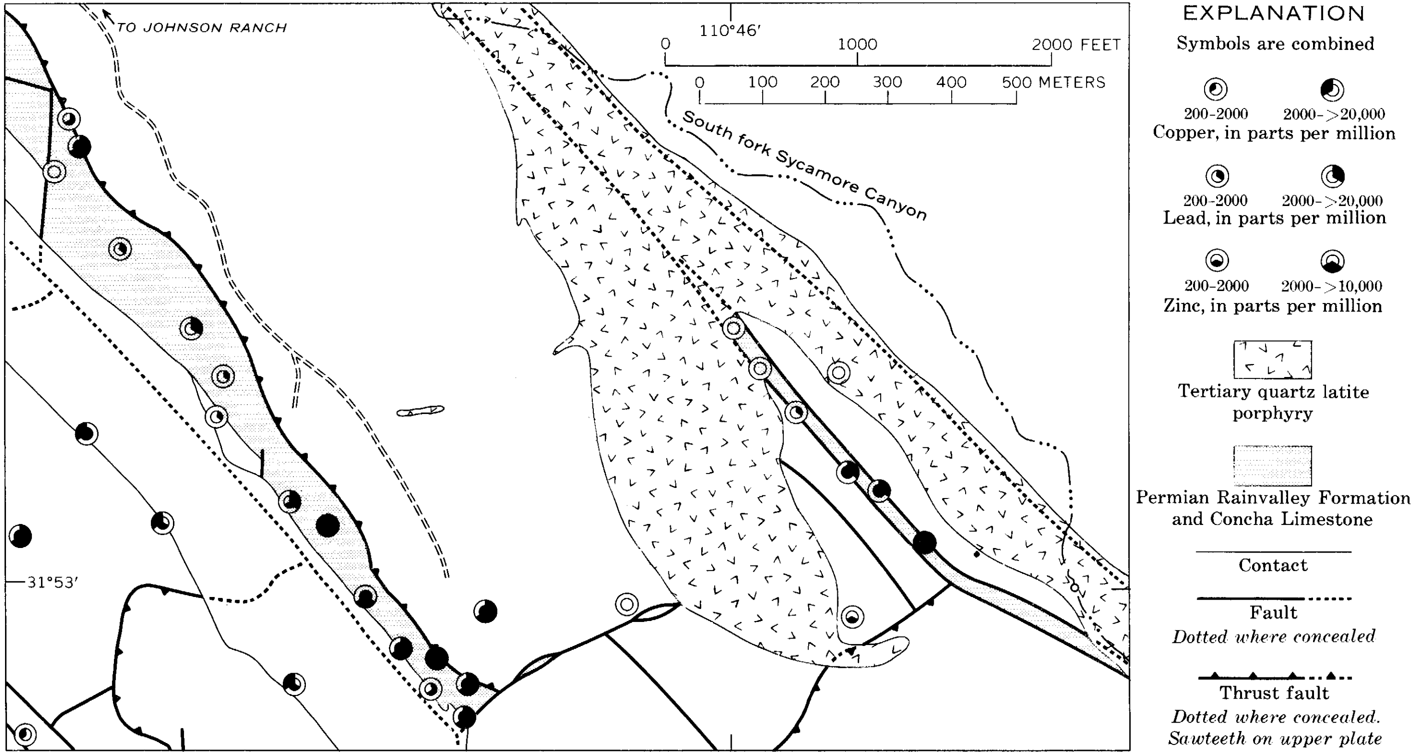

FIGURE 15. — Distribution of copper, lead, and zinc in altered rocks of the Sycamore Canyon area.

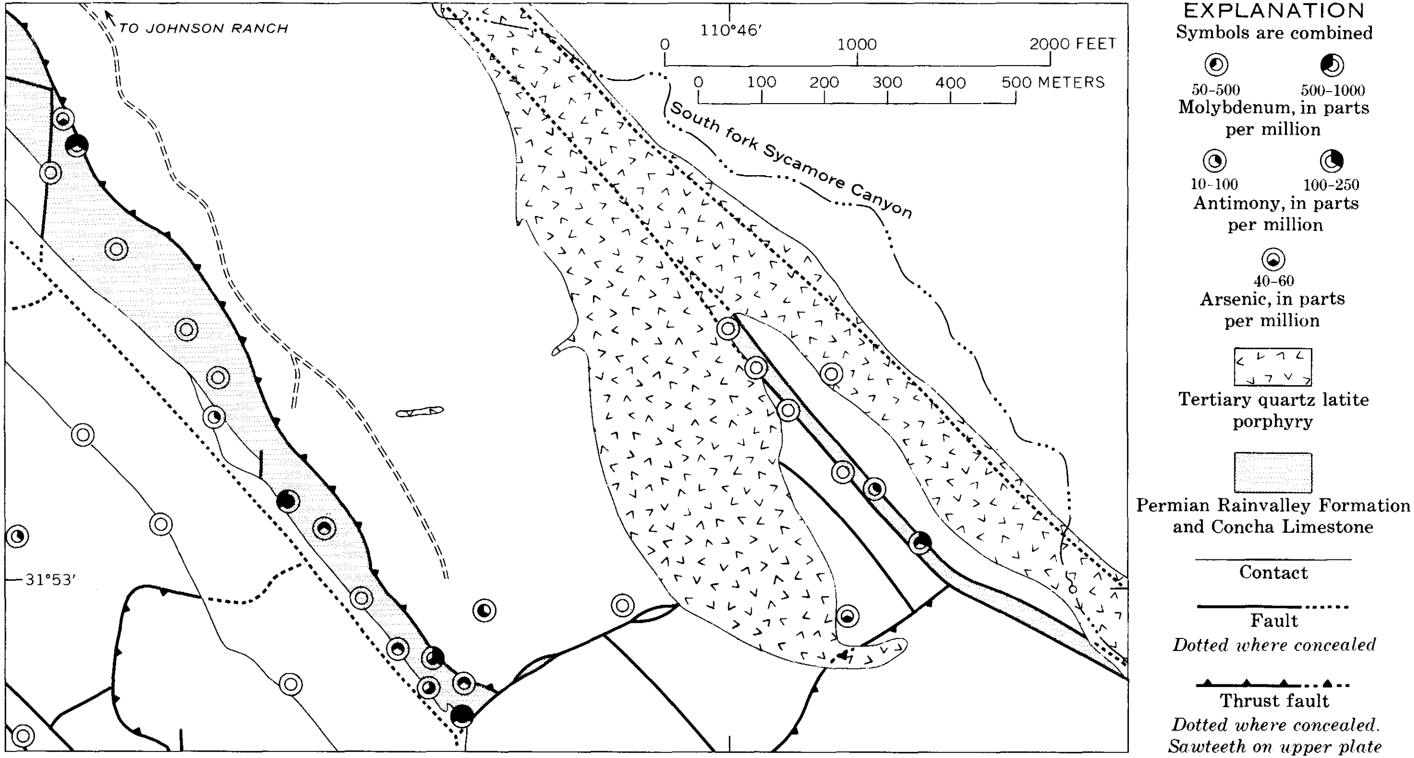

FIGURE 16. — Distribution of molybdenum, antimony, and arsenic in altered rocks of the Sycamore Canyon area.

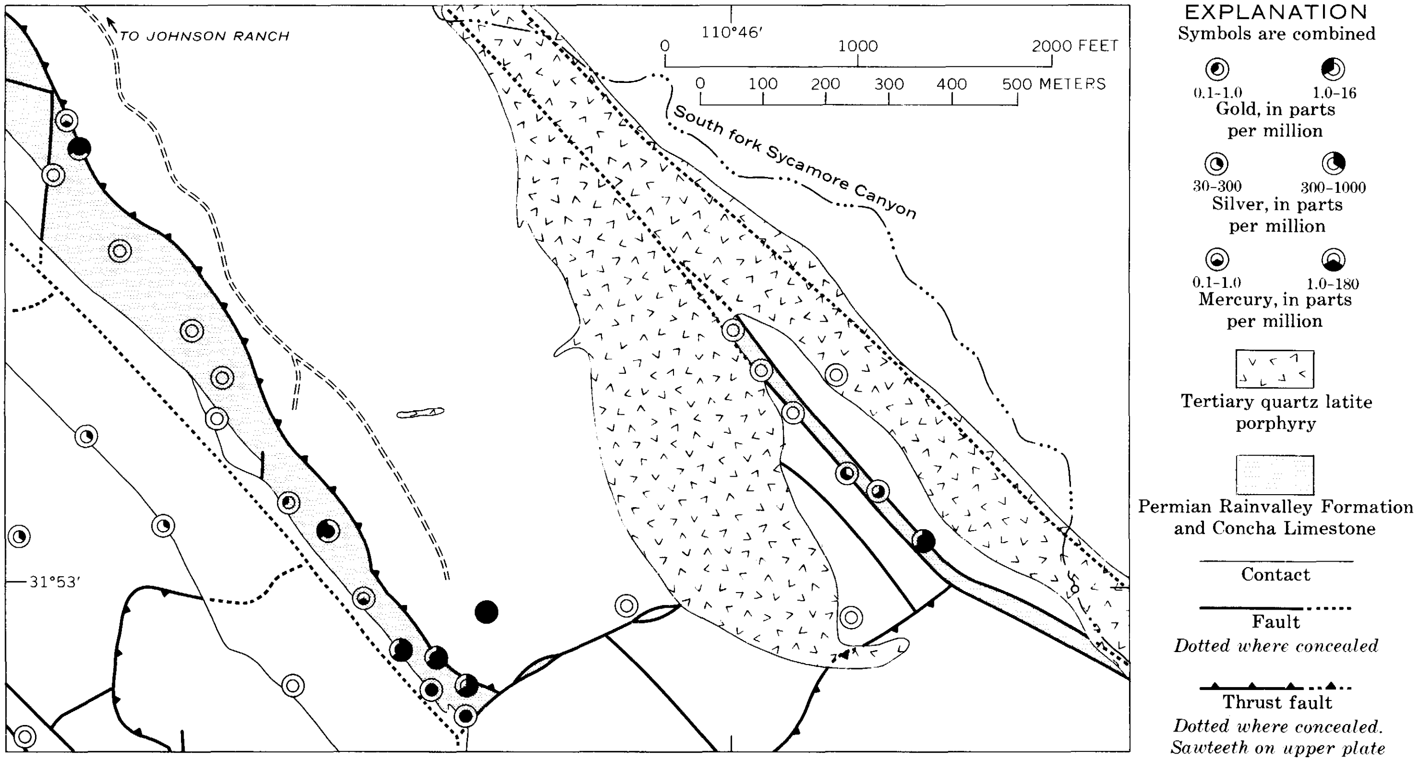

FIGURE 17. — Distribution of gold, silver, and mercury in altered rocks of the Sycamore Canyon area.

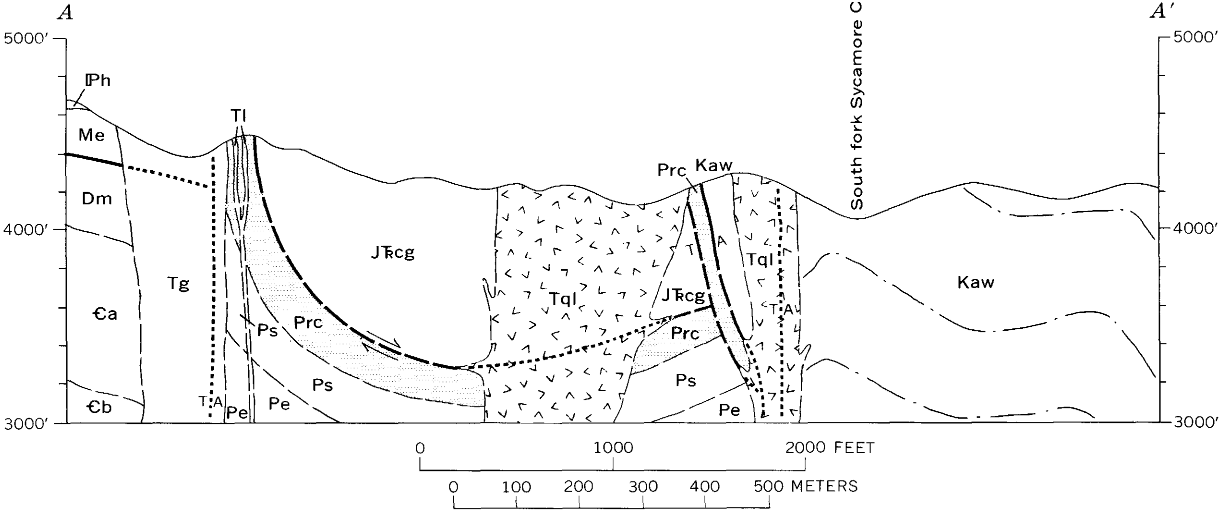

FIGURE 18. — Section *A–A′* across the south fork of Sycamore Canyon. Tl, lamprophyric dikes; Tql, quartz latite porphyry; Tg, granodiorite; Kaw, Apache Canyon and Willow Canyon Formations; JTR cg, Canelo Hills Volcanics and Gardner Canyon Formation; Prc, Rainvalley Formation and Concha Limestone; Ps, Scherrer Formation; Pe, Epitaph Dolomite; ℙh, Horquilla Limestone; Me, Escabrosa Limestone; Dm, Martin Formation; Єa, Abrigo Formation; Єb, Bolsa Quartzite. T, block of tear fault moved toward viewer; A, block of tear fault moved away from viewer. Line of section shown in figure 14.

to flatten at depth; if it does, the plunging fold probably extends a considerable distance farther southeast at depth than it does at the surface. Near the trough of the fold the thrust fault and the sheared limestone are intruded by the ore porphyry plug.

The intensity of mineralization increased toward the southeast in both belts of sheared limestone. The mineralization also seems to have been more intense in the western belt than in the eastern one, although this difference may reflect only a greater amount of prospecting and sampling in the western belt. The local evidence is not conclusive but supports the concept of a genetic relation of the ore porphyry plug to mineralization. If mineralization is related to the plug, the hydrothermal fluids possibly moved upward near the plug until they reached the thrust-faulted area and the sheared limestone and then spread laterally along these features. Subsurface exploration of this horizon closer to the plug may be warranted.

The coarser grain size of the ore porphyry and the different character of the mineral deposits in the Sycamore Canyon area with respect to the Helvetia-Rosemont area may be due to a more deeply exposed level of an otherwise identical geologic situation.

SALERO RANCH AREA

GEOLOGIC SETTING

A silicified zone makes a string of relatively bold outcrops in the low rolling terrain near the Salero Ranch in the south-central part of the Mount Wrightson quadrangle (pl. 1; fig. 19). The geochemical sampling of the alluvium indicates that the concentration of lead, silver, and other metals increases downstream from the silicified zone. This zone is of greater interest than other siliceous pods and veins of the area, many of which are shown on plate 2, because it lies in the Salero fault zone, along which there are several large silver mines, such as the Salero mine, and several areas of altered rocks (Drewes, 1971b). If the fault was the principal conduit for the mineralizing fluids near these mines, other deposits of silver may have been emplaced along it.

The siliceous rock forms a pod about 1,200 feet long and 60–120 feet wide, which tapers toward its ends. Several smaller pods and veins of quartz lie along the fault zone on the hill south of the ranch, and a thick calcite vein and altered rocks lie to the northwest along the fault beyond the area shown in figure 19. The silicified zone differs from the quartz veins which are so abundant in the nearby mining camp along Alto Gulch in that the zone consists of browish-gray silicified host rock commonly having a relict clastic texture, whereas the veins are of a nearly white quartz filling the

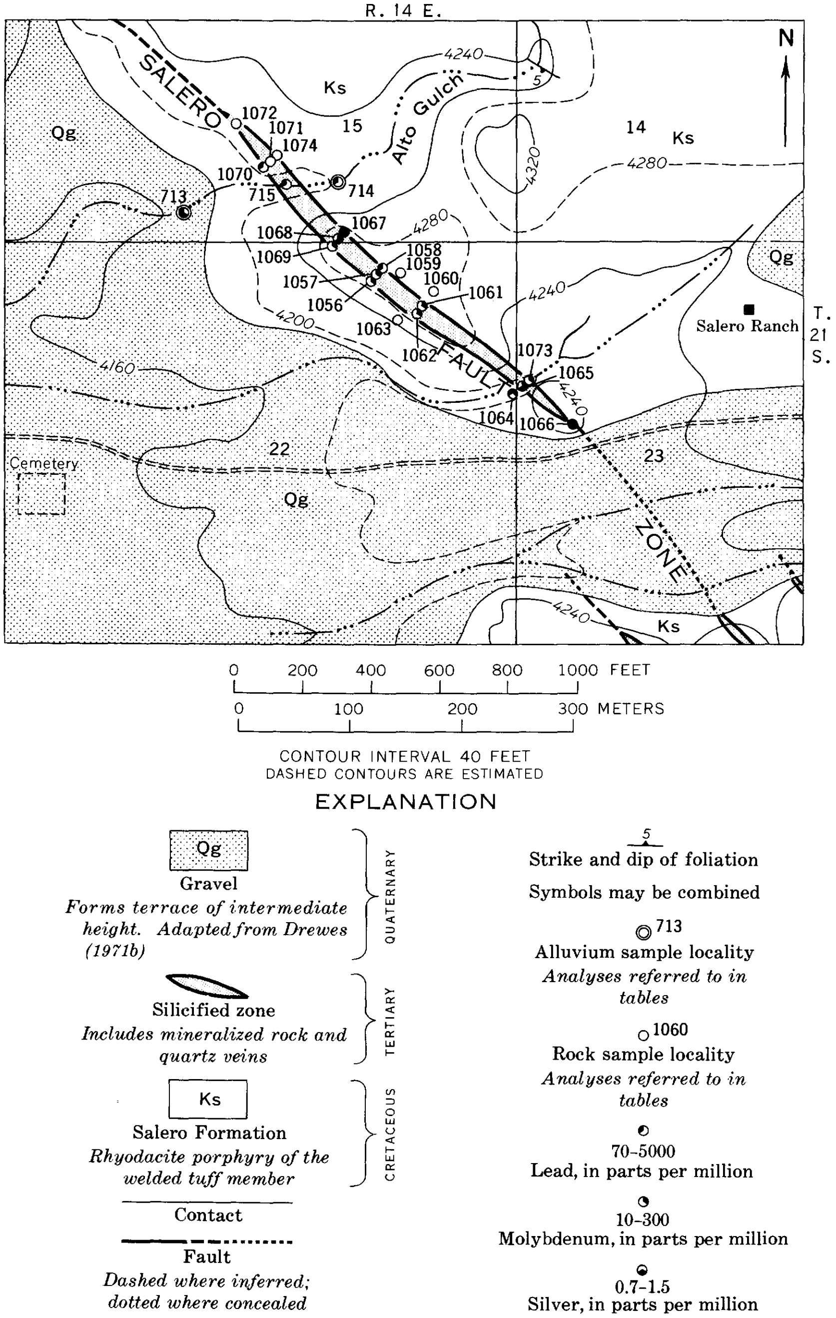

FIGURE 19. — The geology and the distribution of lead, molybdenum, and silver in silicified rocks near the Salero Ranch, southern Santa Rita Mountains.

fractures. Some of the rock, however, is so intensely silicified that remnants of primary clastic textures of the host rock are obliterated. In places the silicified rock is finely brecciated, and the fragments are cemented by additional siliceous material of a lighter color. Most of the silicified rock contains no evidence of mineralization other than the iron oxide staining, but in places there are traces of disseminated pyrite.

The rock adjacent to the zone is welded rhyodacite tuff of the Salero Formation, of late Late Cretaceous age. The welded tuff is slightly but pervasively chloritized and kaolinized. A conspicuous foliation, paralleling the bedding of the sheet, dips gently southwest on both sides of the fault zone and, together with several nearly vertical joint sets, give some of the larger, less weathered outcrops along gullies a blocky appearance. Gravel is deposited on terraces along segments of the larger drainages. The erosional edge of the Grosvenor Hills Volcanics lies a quarter of a mile southwest of the cemetery shown in figure 19 (Drewes, 1971b).

Near the Salero Ranch the Salero fault zone is relatively inconspicuous, because the rocks on both sides are alike. Along the fault in both directions, however, stratigraphic offsets are more apparent than near the ranch. The direction and amount of movement are uncertain; movement may include both strike-slip and normal displacement. Movement along the fault zone probably was recurrent; most of the faulting was Laramide, some of it was mid-Tertiary or late Tertiary, and some may have been pre-Laramide (Drewes, 1972b). The alternation of fault segments showing marked stratigraphic offset with segments showing little offset probably reflects a complex structural history, as well as a complex depositional history, of the faulted rocks.

METHODS AND RESULTS

Samples were collected at about 50-foot intervals in a series of traverses across the silicified zone and the adjacent tuff. The traverses were spaced at intervals of 200–400 feet, depending mainly on the availability of outcrops. Inasmuch as outcrops were most common in the most intensely silicified rocks, the sampling is not representative of the entire zone, but the sampling bias is probably less than that of the other districts. Each of 21 samples consists of several small chips which are representative of rocks in an area 5–6 feet wide at the sample site and which have subtle variations in color, texture, and fracture conditions. Because the samples were not selected to include mainly conspicuously mineralized rock, the analytical results of these specimens are difficult to compare with the results of the specimens from the Helvetia-Rosemont and other areas.

Each sample was pulverized and mixed, and separate splits were analyzed by semiquantitative spectrographic methods and by chemical methods, whose procedures and accuracies have been described previously. The analytical results are given in table 4.

Several elements are significantly concentrated in some of the samples. Lead values reach 1,500 ppm; molybdenum, 300 ppm; barium, more than 5,000 ppm; and silver, 1.5 ppm. The distributions of lead, silver, and molybdenum are shown in figure 19.

EVALUATION AND INTERPRETATION

Despite the limited number of samples taken of the siliceous pod at the Salero Ranch, the analytical results show that the rock was enriched in base metals and silver, together with silica, much as elsewhere along the Salero fault zone and as exemplified by the Salero and Montezuma mines (pl. 1; Schrader, 1915). Probably the other siliceous pods, veins, and altered zones along the fault are similarly mineralized.

The intersection of the Salero fault zone with the Santa Rita fault is a target of potential economic interest. This area, along the lower reaches of Temporal Gulch and west of Patagonia (pl. 1), seems to have been the locus for upward-moving solutions and is an area containing many fault "splays." A short distance southeast of the intersection, for example, a breccia body (not shown on pl. 1) that may be a volcanic pipe lies within the Gringo Gulch Volcanics. The fault intersection lies a short distance southeast of the Ivanhoe altered area and is in line with the string of other altered areas. Rocks in the area of fault intersection are markedly altered, and rocks near some of the fault splays are slightly mineralized. Because of the favorable structural location, these signs of mineralization should be considered encouraging and may justify subsurface exploration. Perhaps more detailed mapping along the Salero fault zone would provide additional sites of potential economic interest.

OTHER AREAS

Areas of strongly altered rocks, other than those described in the section on geochemical reconnaissance or reported separately

(Drewes, 1967, 1970), appear in scattered localities in the southern Santa Rita Mountains (pl. 1). Some of these altered areas are mineralized; but either the areas are already known—for example, the area along Mansfield Canyon — or they are of such low tenor as to justify only minimal attention at present. A few of these areas were sampled to determine what metals might be present.

Samples were taken at outcrops because prospect pits are virtually absent. Commonly, individual samples were composed of about six chips taken of a variety of altered rocks along a traverse between stations 1,000–2,000 feet apart, shown by a brace-joined pair of points on plate 1. In most of the 92 samples, the individual chips were halved and analyzed separately by semiquantitative spectrographic methods, as described previously. In a few samples the half chips of a sample were combined, and a single analysis was made. Analytical results are shown in table 4.

Many samples were obtained from altered areas in the central parts of the Tyndall and Wrightson mining districts. They are altered volcanic or arkosic sedimentary rocks which form the wall rock of, or occur as large inclusions in, the Squaw Gulch Granite and the Josephine Canyon Diorite, and a few are altered rocks from the plutons themselves. Other samples are from altered Gringo Gulch Volcanics in the northwestern part of the Harshaw district and in the adjacent parts of the Palmetto and Tyndall districts. These samples are of a group of east-trending, vertically inclined, silicified pods, which were described previously and are probably related to the Alto quartz vein swarm.

In general, the kind and relative amount of metal enrichment of the scattered samples resemble the kind and amount of enrichment of the more thoroughly sampled areas. Some samples from the central Tyndall and Wrightson districts contain anomalous amounts of copper, lead, and molybdenum. In addition, a few of these samples were shown by X-ray diffraction methods to contain the sulfate-bearing alteration mineral alunite. Some samples of silicified pods in the Harshaw and adjacent districts also contain anomalous amounts of copper, lead, and silver, as well as alunite.

TABLE 4. — *Chemical and spectrographic analyses (in parts per*

[N, not detected. Analytical methods and accuracy discussed in text. Analysts: Maurice
S. E. Papp, R. L. Turner,

	Chemical analyses					Semiquantitative spectrographic analyses							
	(ppm)					(ppm)							
Sample	Cu	Pb	Zn	Au	Te	Ag	B	Ba	Be	Co	Cr	Cu	Ga
						Altered rocks of scattered areas							
161a	10	<25	25	---	---	<1	70	300	2	<5	10	20	50
161b	20	50	25	---	---	<1	50	2,000	2	<5	5	30	20
161c	5	<25	25	---	---	<1	30	500	2	<5	<5	5	20
161d	5	25	25	---	---	<1	70	3,000	2	<5	5	5	15
161e	10	<25	25	---	---	<1	100	2,000	5	<5	5	20	30
161f	5	25	25	---	---	<1	100	500	2	<5	<5	10	10
162a	5	<25	25	---	---	<1	30	150	<2	<5	<5	15	15
162b	5	<25	25	---	---	<1	20	150	<2	<5	<5	10	20
162c	<5	75	25	---	---	<1	100	100	2	<5	<5	7	20
162d	10	<25	25	---	---	<1	70	<100	2	<5	<5	10	20
162e	30	200	25	---	---	<1	200	500	7	<5	5	70	15
162f	5	<25	25	---	---	1.5	50	<100	<2	<5	<5	5	20
163a	5	50	25	---	---	1.5	50	200	<2	<5	<5	7	20
163b	40	<25	25	---	---	1.5	50	150	<2	<5	<5	50	20
163c	10	25	25	---	---	1.5	70	<100	<2	<5	<5	20	20
163d	10	<25	25	---	---	1.5	150	<100	2	<5	<5	20	20
163e	15	50	25	---	---	1.5	30	<100	<2	<5	<5	20	30
163f	60	1,000	250	---	---	5	20	1,500	2	10	10	100	30
163g	60	150	25	---	---	<1	50	500	<2	<5	5	70	30
163h	5	25	25	---	---	<1	50	200	2	<5	<5	5	20
168a	5	<25	25	---	---	<1	50	200	3	<5	<5	15	20
168b	5	150	25	---	---	<1	50	<100	2	<5	<5	15	20
168c	20	<25	25	---	---	<1	15	<100	<2	<5	<5	30	20
168d	5	<25	25	---	---	<1	20	<100	2	<5	<5	5	20
168e	5	<25	25	---	---	<1	50	<100	2	<5	<5	7	20
168f	<5	25	25	---	---	1	50	<100	<2	<5	<5	5	15
169a	<5	150	25	---	---	1.5	30	<100	<2	<5	<5	<5	15
169b	<5	75	25	---	---	1	100	150	<2	<5	<5	10	20
169c	5	25	25	---	---	2	100	<100	<2	<5	<5	30	20
169d	10	125	25	---	---	<1	100	<100	2	<5	<5	30	15
169e	10	25	25	---	---	<1	150	<100	3	<5	<5	50	15
169f	10	100	25	---	---	15	200	200	2	<5	<5	30	15
172a	---	---	---	---	---	N	10	5,000	N	20	5	50	20
172b	---	---	---	---	---	N	100	500	N	N	<5	10	30
172c	---	---	---	---	---	N	70	2,000	N	N	<5	5	30
172d	---	---	---	---	---	N	200	2,000	N	N	<5	1	20
172e	---	---	---	---	---	N	>200	200	N	N	5	1	30
265	---	---	---	---	---	N	70	500	N	5	N	200	20
305	---	---	---	---	---	N	N	300	N	N	N	20	50
306	---	---	---	---	---	N	N	200	N	N	N	10	30
319	---	---	---	---	---	N	N	50	N	N	N	1	10
324a	---	---	---	---	---	N	70	1,000	N	N	10	2	20
324b	---	---	---	---	---	N	50	1,000	N	N	5	30	15
324c	---	---	---	---	---	N	50	500	N	15	5	150	20
324d	---	---	---	---	---	N	50	>5,000	N	N	5	30	10
324e	---	---	---	---	---	N	50	>5,000	N	N	5	2	20
325	---	---	---	---	---	1	N	1,000	N	N	7	150	50
326a	---	---	---	---	---	N	50	1,000	N	N	N	20	N
326b	---	---	---	---	---	N	30	5,000	N	N	N	30	20
326c	---	---	---	---	----	2	50	1,000	N	N	N	7	15
327a	---	---	---	---	---	N	50	200	N	N	N	1	20
327b	---	---	---	---	---	N	50	700	N	N	N	10	30
327c	---	---	---	---	---	N	30	1,000	N	N	N	30	20
327d	---	---	---	---	---	N	50	1,000	N	N	N	10	20
349a	---	---	---	---	---	N	70	500	N	N	10	5	20

million) of mineralized rocks of the southern Santa Rita Mountains

De Valliere, T. F. Harms, K. W. Leong, Elizabeth Martinez, J. B. McHugh, E. L. Mosier, and E. P. Welsch]

Semiquantitative spectrographic analyses--Continued

	(ppm)											
Sample	La	Mn	Mo	Ni	Pb	Sc	Sr	Ti	V	Y	Zn	Zr
Altered rocks of scattered areas--Continued												
161a	50	50	<2	7	10	10	<100	5,000	150	5	<100	150
161b	50	100	<2	10	30	<5	<100	700	50	30	<100	100
161c	100	150	5	5	20	<5	<100	700	<10	15	<100	200
161d	100	50	3	5	50	5	700	7,000	150	20	<100	500
161e	<50	50	3	7	10	<5	<100	5,000	70	10	<100	300
161f	70	70	<2	5	50	<5	300	5,000	100	30	<100	500
162a	70	70	5	5	15	<5	<100	1,500	<10	20	<100	200
162b	50	50	3	5	20	<5	<100	1,500	<10	20	<100	200
162c	<50	50	50	7	100	<5	<100	1,500	<10	20	<100	150
162d	<50	70	2	7	10	<5	<100	1,500	<10	20	<100	200
162e	70	100	<2	7	300	<5	<100	2,000	50	20	<100	300
162f	<50	70	<2	5	10	<5	<100	1,000	<10	30	<100	200
163a	100	150	3	5	50	<5	<100	1,000	<10	30	<100	200
163b	50	70	2	5	30	<5	<100	1,000	<10	5	<100	200
163c	<50	70	3	7	50	<5	<100	1,500	<10	5	<100	200
163d	<50	50	2	5	<10	<5	<100	1,500	<10	<5	<100	300
163e	150	70	2	5	30	<5	<100	700	<10	15	<100	200
163f	50	1,000	5	10	1,000	10	<100	5,000	100	10	100	500
163g	70	100	<2	7	100	<5	<100	1,000	10	20	<100	200
163h	<50	300	<2	5	70	<5	<100	1,000	<10	15	<100	100
168a	150	300	<2	7	15	<5	<100	1,500	<10	20	<100	150
168b	70	70	5	7	150	<5	<100	1,000	<10	30	<100	150
168c	<50	300	5	5	10	<5	<100	700	<10	30	<100	100
168d	<50	70	<2	5	<10	<5	<100	1,500	<10	70	<100	200
168e	50	50	<2	5	<10	<5	<100	1,500	<10	50	<100	200
168f	<50	70	<2	5	<10	<5	<100	1,500	<10	50	<100	200
169a	70	70	<2	5	100	<5	<100	1,500	<10	50	<100	150
169b	100	50	3	7	70	<5	<100	1,500	<10	20	<100	150
169c	50	30	2	5	30	<5	<100	1,500	<10	<5	<100	100
169d	70	50	<2	5	70	<5	<100	2,000	<10	15	<100	100
169e	150	30	2	5	30	<5	<100	2,000	10	15	<100	150
169f	70	70	3	7	100	<5	<100	2,000	10	5	<100	200
172a	50	>5,000	2	10	N	10	500	3,000	100	15	N	100
172b	N	500	1	1	30	N	N	5,000	50	N	N	150
172c	N	150	1	N	10	5	300	7,000	100	N	N	200
172d	N	70	N	N	N	5	N	5,000	100	10	N	200
172e	N	200	10	N	N	7	N	5,000	70	5	N	200
265	70	5,000	N	5	50	7	N	3,000	15	30	1,000	300
305	N	50	N	N	20	5	N	1,500	70	N	N	300
306	50	100	N	N	50	5	200	2,000	20	N	N	300
319	N	N	N	N	10	N	N	2,000	20	N	N	150
324a	50	150	N	N	20	15	N	10,000	200	30	N	500
324b	N	500	1	N	50	10	N	5,000	100	20	N	300
324c	N	5,000	2	7	50	15	N	10,000	300	5	N	200
324d	N	100	N	N	15	10	N	7,000	70	20	N	500
324e	N	50	N	N	50	5	200	3,000	70	15	N	300
325	50	100	1	N	100	5	500	5,000	70	10	N	500
326a	N	70	N	N	50	N	300	300	10	N	N	10
326b	70	150	N	N	30	10	N	5,000	100	30	N	1,000
326c	70	150	N	N	100	10	N	10,000	100	30	N	1,000
327a	N	200	N	N	N	5	N	2,000	20	10	N	500
327b	50	200	N	N	30	10	200	10,000	150	30	N	1,000
327c	50	150	N	N	10	5	200	2,000	15	15	N	300
327d	50	200	N	N	30	5	N	2,000	15	15	N	700
349a	50	150	N	3	N	5	200	7,000	100	10	N	300

TABLE 4. — *Chemical and spectrographic analyses (in parts per million)*

Sample	Chemical analyses (ppm) Cu	Pb	Zn	Au	Te	Semiquantitative spectrographic analyses (ppm) Ag	B	Ba	Be	Co	Cr	Cu	Ga
						Altered rocks of scattered areas--Continued							
349b	---	---	---	---	---	N	200	300	N	N	10	30	15
349c	15	<25	25	---	---	N	50	70	N	N	10	5	15
349d	---	---	---	---	---	N	100	500	N	N	7	50	10
349e	---	---	---	---	---	3	>200	700	N	5	5	50	30
350a	---	---	---	---	---	N	150	150	N	N	10	100	50
350b	---	---	---	---	---	N	>200	1,500	N	N	7	100	20
350c	---	---	---	---	---	N	20	300	N	N	7	20	30
350d	---	---	---	---	---	N	>200	150	N	15	15	30	20
350e	---	---	---	---	---	N	150	300	N	N	30	2	20
350f	---	---	---	---	---	N	200	300	N	N	10	30	30
350g	---	---	---	---	---	N	150	70	N	N	50	2	100
360a	---	---	---	---	---	N	20	500	N	5	5	30	20
360b	---	---	---	---	---	N	50	N	N	N	5	30	N
360c	---	---	---	---	---	N	>200	70	N	N	5	5	20
360d	---	---	---	---	---	N	>200	300	N	N	15	10	30
360e	---	---	---	---	---	1	>200	50	N	N	5	30	20
360f	---	---	---	---	---	N	30	2,000	N	N	10	50	30
360g	---	---	---	---	---	1	>200	70	N	N	N	30	20
362a	80	25	50	---	---	N	20	1,000	N	10	7	50	20
362b	40	25	25	---	---	N	200	300	N	N	N	30	20
362c	60	50	25	---	---	2	200	1,500	N	N	5	30	15
362d	30	800	50	---	---	N	50	5,000	N	N	5	15	N
362e	80	250	50	---	---	N	70	70	N	N	N	30	20
362f	30	25	25	---	---	N	>200	70	N	N	10	30	30
362g	160	50	100	---	---	N	N	700	N	10	5	70	30
362h	30	50	200	---	---	N	100	200	N	N	5	20	20
402	---	---	---	---	---	N	20	2,000	N	5	N	30	15
427a	---	---	---	---	---	N	30	50	N	N	30	300	10
427b	---	---	---	---	---	N	20	1,500	N	5	5	30	15
427c	---	---	---	---	---	N	>200	1,000	100	N	30	200	30
427d	---	---	---	---	---	N	>200	200	N	N	20	100	N
427e	---	---	---	---	---	N	20	1,000	N	N	30	150	20
427f	---	---	---	---	---	1	70	300	N	N	15	150	15
427g	---	---	---	---	---	7	200	1,000	N	N	20	200	15
535	---	---	---	---	---	N	30	1,000	N	N	30	200	30
699	---	---	---	---	---	N	N	1,000	N	N	N	20	N
800	---	---	---	---	---	N	10	500	2	N	5	10	10
						Silicified rocks of Salero Ranch area							
391	---	---	---	---	---	<0.0001	15	1,000	2	15	30	50	20
715	---	---	---	---	---	N	10	1,500	1	5	5	50	10
1056	10	25	50	<0.05	0.3	.5	10	1,000	<1	<5	<10	20	10
1057	<10	25	50	<.05	<.05	.5	20	700	<1	<5	<10	10	<10
1058	20	600	100	<.05	<.05	<.5	<10	300	<1	<5	<10	7	<10
1059	10	25	25	<.05	<.05	<.5	20	500	<1	<5	<10	5	<10
1060	50	<25	25	<.05	.1	<.5	10	500	1	<5	<10	50	<10
1061	30	50	50	<.05	.1	<.5	50	700	1	<5	<10	20	<10
1062	20	<25	<25	<.05	.1	<.5	10	500	<1	<5	<10	10	<10
1063	40	<25	25	<.05	.1	<.5	70	>5,000	2	<5	<10	10	<10
1064	10	150	300	<.05	.05	<.5	50	500	1	5	10	20	10
1065	10	25	200	<.05	.05	.7	70	500	1	<5	<10	10	<10
1066	20	1,000	150	<.05	.2	1.5	50	1,000	1	<5	10	20	20
1067	40	500	100	<.05	.2	.7	10	500	<1	<5	<10	30	<10
1068	20	50	<25	<.05	.1	.7	10	300	<1	<5	<10	10	10
1069	10	<25	<25	<.05	.1	<.5	10	500	<1	<5	<10	5	<10
1070	30	100	50	<.05	.05	<.5	<10	1,000	<1	5	20	50	30
1071	40	25	50	<.05	<.05	<.5	<10	1,000	<1	5	15	20	20
1072	20	<25	25	<.05	.1	<.5	<10	700	<1	<5	10	10	10
1073	10	25	50	<.05	<.05	.5	20	1,000	<1	<5	20	30	20
1074	10	25	50	<.05	<.05	<.5	<10	1,000	1	5	20	20	20

of mineralized rocks of the southern Santa Rita Mountains — Continued

Semiquantitative spectrographic analyses--Continued

(ppm)

Sample	La	Mn	Mo	Ni	Pb	Sc	Sr	Ti	V	Y	Zn	Zr
Altered rocks of scattered areas--Continued												
349b	N	70	N	N	N	7	N	7,000	200	5	N	200
349c	N	10	N	N	N	10	N	7,000	200	N	N	150
349d	N	20	3	1	N	10	N	5,000	200	7	N	300
349e	N	100	2	2	10	10	N	5,000	200	5	N	200
350a	N	100	5	N	15	15	1,500	10,000	300	7	N	1,000
350b	50	10	5	7	15	15	500	10,000	200	10	N	300
350c	N	10	1	N	10	20	200	10,000	300	10	N	300
350d	N	100	20	20	20	20	N	10,000	300	15	N	150
350e	70	10	N	N	30	15	5,000	>10,000	500	20	N	500
350f	100	10	1	N	10	15	5,000	10,000	500	10	N	500
350g	N	10	N	2	N	30	300	7,000	700	20	N	100
360a	N	200	N	5	10	5	200	3,000	100	10	N	200
360b	N	100	N	N	30	N	N	7,000	10	20	N	30
360c	N	150	N	N	50	5	N	5,000	70	7	N	300
360d	N	150	1	5	50	20	300	>10,000	200	30	N	200
360e	N	100	5	N	10	5	N	7,000	150	5	N	500
360f	50	500	3	N	50	10	200	10,000	200	5	N	300
360g	N	200	2	N	30	7	N	3,000	50	N	N	300
362a	50	1,000	N	5	N	15	300	10,000	200	30	N	200
362b	50	100	1	N	N	10	N	7,000	50	10	N	>1,000
362c	50	150	N	N	30	5	N	2,000	20	10	N	300
362d	N	150	7	N	200	N	300	5,000	20	N	N	300
362e	N	70	N	N	100	5	N	2,000	20	15	N	500
362f	N	70	N	7	10	7	150	10,000	200	N	200	>1,000
362g	N	500	N	5	20	5	300	5,000	100	5	N	100
362h	50	150	N	N	10	10	150	7,000	70	30	N	>1,000
402	N	500	N	N	15	N	200	1,500	10	15	200	200
427a	N	1,000	2	N	150	10	200	7,000	1,000	5	N	500
427b	100	1,000	1	N	500	10	700	10,000	200	10	N	500
427c	N	500	3	N	>500	10	700	5,000	200	7	N	300
427d	N	100	1	N	100	15	1,000	10,000	200	5	N	500
427e	N	200	N	N	300	15	150	7,000	500	5	N	300
427f	50	200	N	N	500	5	200	5,000	200	7	N	200
427g	N	300	N	N	>500	15	150	10,000	500	10	N	500
535	50	150	N	N	10	30	N	>10,000	300	20	N	1,000
699	N	50	<1	N	10	N	N	1,000	N	5	N	200
800	N	500	N	3	10	N	N	2,000	50	5	N	30
Silicified rocks of Salero Ranch area--Continued												
391	50	500	2	15	70	7	500	3,000	100	15	100	150
715	50	700	N	2	70	3	200	3,000	50	10	N	100
1056	<20	300	50	<5	20	<5	<100	2,000	100	<10	<200	100
1057	<20	150	10	20	<10	<5	<100	2,000	100	<10	<200	100
1058	<20	500	5	5	150	<5	<100	200	20	<10	<200	15
1059	<20	150	<5	5	<10	<5	<100	1,500	50	<10	<200	100
1060	<20	500	<5	10	<10	5	<100	2,000	50	<10	<200	50
1061	<20	1,500	20	10	30	<5	<100	1,000	20	<10	<200	30
1062	<20	300	15	5	<10	<5	<100	1,500	30	<10	<200	70
1063	20	3,000	5	5	20	7	500	1,500	50	30	<200	100
1064	20	5,000	30	10	200	5	100	2,000	100	10	300	100
1065	<20	2,000	30	10	10	5	<100	1,500	50	<10	200	100
1066	20	300	300	5	1,500	5	100	3,000	70	10	200	100
1067	<20	300	100	5	200	<5	<100	700	20	<10	<200	30
1068	<20	300	10	5	15	<5	100	1,500	50	<10	<200	100
1069	<20	70	70	5	10	5	<100	1,500	50	<10	<200	300
1070	20	1,500	<5	10	150	7	150	3,000	150	10	<200	200
1071	20	300	<5	10	<10	5	100	3,000	150	10	<200	200
1072	20	500	<10	10	15	5	100	3,000	100	<10	<200	150
1073	20	500	30	10	50	<5	100	3,000	100	<10	<200	150
1074	50	1,000	<5	15	15	5	150	5,000	150	15	<200	200

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