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MINERAL RESOURCE POTENTIAL OF THE SUPERSTITION WILDERNESS AND CONTIGUOUS ROADLESS AREAS MARICOPA, PINAL, AND GILA COUNTIES, ARIZONA

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GEOLOGY AND MINERAL RESOURCES

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STUDIES RELATED TO WILDERNESS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Superstition Wilderness (NF 3080) and contiguous roadless areas, Tonto National Forest, Maricopa, Pinal, and Gila Counties, Arizona. The area was established as a wilderness by administrative discretion by the Chief of Forest Service in February 1939. It was ratified by the Wilderness Act (Public Law 88-577, September 3, 1964.

SUMMARY

On the basis of geologic studies and mineral evaluations made between 1973 and 1977, most of the Superstition Wilderness and contiguous roadless areas are judged to have little promise for occurrence of mineral resources. However, two areas in an east-trending zone near the southern margin of the area, marked by spotty occurrences of mineralized rock, prospect pits, and a band of geochemical anomalies that coincides with alined magnetic anomalies, are considered to have possible mineral-resource potential. A small isolated uranium anomaly was found in the northeastern part of the wilderness, but no evidence of other energy resources, such as petroleum, coal, or geothermal, were found.

The Superstition Wilderness in south-central Arizona includes about 194 mi^2; an additional contiguous area of about 50 mi^2 was included in the study for a total of about 244 mi^2. The Superstition Mountains rise as a spectacular range front above the desert to the south and west, and a ruggedly dissected landscape makes up the interior of the wilderness. Altitudes range from 1,660 to 6,266 ft; local relief between canyon bottoms and ridge tops ranges from a few hundred to a thousand feet, and the relief between the desert and the summit of the Superstition Mountains is 3,500 ft.

The wilderness is in a region of highly diverse rock types and complex geologic structure. Rocks range in age from Middle Proterozoic to Quaternary and includes metamorphic, sedimentary, and both intrusive and extrusive igneous rocks. The geology of the eastern half of the wilderness differs

distinctly from that of the western half. The eastern half includes mainly Proterozoic rocks of different types that have been pervasively faulted. The rocks include schist and granite of Proterozoic age unconformably overlain by Middle Proterozoic sedimentary rocks that have been intruded by massive sills and dikes of diabase. These, in turn, are unconformably overlain by isolated remnants of Paleozoic sedimentary rocks. All these rocks have been extensively faulted on an intricate scale by discontinuous high-angle normal faults, and fault blocks have been tilted in diverse directions. They are locally overlain by volcanic rocks of Tertiary age.

The western half of the wilderness consists chiefly of Tertiary volcanic rocks of many different types. The most abundant are thick deposits of ash-flow tuff; these are overlain, underlain, and intruded by rhyolitic, dacitic, and basaltic lavas. The volcanic rocks were erupted from many different vents that lie within or near the wilderness, and the rocks are locally highly contorted and bear complex relationships with one another. As many as three calderas, the source of the ash-flow, lie within the wilderness. Spectacular canyons have been cut into the volcanic rocks, and in some places erosion has carved intricate and fantastic forms.

The southern and eastern boundaries of the wilderness are within 6 mi of large copper mines; the mines of the Globe, Miami, and Superior areas, which have had copper and precious-metal production exceeding $2 billion, lie within 20 mi of the wilderness. In spite of this proximity and intensive prospecting, little mining activity has resulted within and adjacent to the wilderness. Legal records reveal that no mining claims have been patented or mineral leases effected within the wilderness or the adjoining areas. Notices of claims filed indicate a low level of prospecting activity, and relatively few claims have been maintained. Only in an east-west zone along the southern margin of the wilderness are a number of pits, shafts, and adits found. Material from dumps shows that the workings encountered appreciable mineralized ground, particularly in two areas designated here as the JF area (SE part of wilderness) and the Peralta Canyon area (SW part of wilderness). Although most workings are inaccessible and could not be examined, both areas have a probable mineral-resource potential. In the JF area, hydrothermal alteration and copper, lead, zinc, and silver mineralization are found in both schist and granite in an elongate zone extending for about 4 mi in an east-northeast direction by about 1.5 mi wide. In the Peralta Canyon area, mineralized ground in an east-northeast trending zone about 4 mi long has been explored by several small operations. Alteration and mineralization of base and precious metals occur both in Proterozoic granite and Tertiary volcanic rocks, and they are associated, at least in part, with an east-northeast trending range-front fault.

An important control of ore deposits in the Globe-Miami mining district (6-20 mi east of the wilderness) is postulated to be the east-northeast trending contact between Proterozoic schist and granite. Granitic stocks of Laramide age intruded this ancient zone of weakness, carrying mineralizing fluids that formed the ore deposits. This study showed that the contact between the schist and granite extends westward across the southern part of the wilderness. A band of geochemical anomalies with high values of copper, lead, zinc, silver, and other metals straddles the ancient contact. An east-west series of magnetic low anomalies is also alined roughly along the contact. No large intrusive bodies of Laramide age were found near the contact, although a north-trending dike swarm has intruded schist just north of the contact in the JF area. These dikes could be outliers of a larger concealed intrusive body. Owing to these combined factors, the two areas along the southern margin of the wilderness are designated as having possible mineral-resource potential.

Another possibility for undiscovered minerals would be a deposit concealed beneath the Tertiary volcanic rocks. The only hint of such a deposit is a tongue-like geochemical anomaly extending north-northwest from the Peralta Canyon area, and no resource potential is identified.

Although the Superstition Mountains are well known for legends of lost gold, the general geologic environment holds little promise for an important gold deposit that could have been found using the techniques of 19th century prospecting. The Lost Dutchman mine can likely be relegated to the store of folk tales that extend and embellish historical reality.

Most of the wilderness holds little promise for identification of mineral resources. The areas indicated as having probable mineral-resource potential will need detailed geologic mapping and exploration to determine the feasibility of realizing this potential.

INTRODUCTION

Location and geography

The Superstition Wilderness area includes parts of Maricopa, Pinal, and Gila Counties in southeast-central Arizona (fig. 1) and is entirely within the Tonto National Forest. The area studied for this report includes the officially designated Superstition Wilderness of 194 mi^2 and an additional area of 50 mi^2 of roadless areas which was included in the study at the request of the U.S. Forest Service, for a total area investigated of 244 mi^2. In this report, "study area", "vicinity", and "wilderness" refer to the entire area covered in the investigation, and "Superstition Wilderness" refers only to the specific area already designated as wilderness.

The study area lies within the Basin and Range physiographic province, which is generally characterized by north to northwest-trending faulted mountain ranges separated by narrow and wide valleys. It is entirely within a mountainous segment of the province and is characterized by steep ridges and peaks separated by narrow rugged canyons. The drainage divide between the Salt River to the north and the Gila River to the south passes through the southern part of the wilderness.

All streams in the area are intermittent (fig. 2). The streams in the short steep canyons along the south margin of the area drain into Queen Creek, which lies 2 to 5 mi south of the boundary and flows westward to join the Gila River. Streams in most of the remainder of the area flow northward to northwestward, and some of them have carved spectacular canyons. These streams flow into the Salt River, which lies just north of the wilderness boundary. Along the east edge of the study area, the streams flow eastward and northeastward into Pinto Creek, which is also tributary to the Salt River.

Altitudes range from a high of 6,266 ft at Mound Mountain in the eastern part of the area to a low of about 1,660 ft along arms of Canyon Lake, a reservoir on the Salt River, that extend into the study area near the northwest corner (fig. 2). The Superstition Mountains proper comprise a northwest-trending range along the southwest margin of the area. Their highest point stands at 5,057 ft, and the range forms a spectacular front rising over 3,000 ft above the alluvial desert valley to the south and west; views of the range are favorite subjects for photographers and travel folders. Although topographers apply "Superstition Mountains" only to the clearly defined northwesterly trending range block about 10 mi long and 3 mi wide, the term is loosely applied by local convention to embrace much of the deeply dissected country northward from the range front as far as the Salt River, and eastward from the west edge of the range as far as the Fish Creek drainage system in the north and to about Hewitt Canyon in the south, an area of about 10 to 15 mi wide (north-south) by 20 mi long (east-west). Thus defined, the Superstition Mountains make up roughly the western half of the wilderness.

Some of the prominent landmark peaks in the extended Superstition Mountains include Weavers Needle, Tortilla Mountain, Coffee Flat Mountain, Geronimo Head, Fish Creek Mountain, and LaBarge Mountain (fig. 2); the highest of these reaches 5,077 ft in altitude, and the various peaks stand as much as 2,000 ft above neighboring canyons. Particularly noteworthy canyons include Boulder Creek, La Barge, Fish Creek, and Rogers; their clefts reach as much as 2,000 ft in depth, and the canyons are remarkable for their narrow gorges, steep slopes, and fantastic and grotesque landforms. Most of the country comprising the extended Superstition Mountains is underlain by Tertiary volcanic rocks, including lava flows, ash flows, and pyroclastic rocks (pl. 1). It is the effect of erosion on these hard but brittle, heavily jointed rocks that imparts the unusual roughness and characteristic landforms to the region.

Eastward from the vague east boundary of the extended Superstition Mountains the topographic level rises higher, and several peaks exceed or nearly reach 6,000 ft in altitude, including Iron Mountain, White Mountain, Pinto Peak, and Mound Mountain (fig. 2). Maximum local relief remains at about 2,000 ft, and although the country persists in its highly dissected character and remarkable lack of flat surfaces, the landforms tend to be less rugged and have more conventional shapes. Eastward from the cluster of highest peaks the land slopes downward, and streams crossing the east margin of the study area are from 2,600 to 4,000 ft in altitude, and local relief is from 600 to 1,300 ft.

With an altitude range of some 4,600 ft, the study area shows considerable variation in both climate and vegetation. The lower altitudes, up to about 3,000 ft, are typified by the climate of the Arizona Sonoran Desert, with scorching hot summers and pleasant mild winters. Above about 5,000 ft the climate is more like that of the Arizona mountains, with warm summers and cool winters and with nighttime freezing temperatures common between November and March. Rainfall is scant in the desert portions, averaging as little as 10 in. annually in the lowest areas, whereas at least double that amount falls in the uplands. This area, just as most of Arizona, has two distinct rainy seasons, with about half the rain falling during winter storms and the other half during summer thunder showers and occasional extensive tropical storms. Light snowfalls are not uncommon during the winter above 5,000 ft, and occasionally the snow reaches the lower desert country. Spring and autumn are normally dry.

The vegetation clearly reflects the variations in climate. The desert is characterized by a wide variety of cactus and by sparse growths of palo verde, creosote bush, and other drought-resistant and heat tolerant plants. Types of cactus are highly varied and include saguaro and several different species of cholla, prickly pear, barrel, hedgehog, and pincushion. Cactus persists upward into the middle altitudes, where a variety of chaparral shrubs, scrub oak, and mesquite become common. From 4,000 to 5,500 ft vegetation may become very dense, particularly on north-facing slopes, and some stands of chaparral are practically impenetrable. Above about 5,000 ft pinyon pine and juniper are abundant, and in the vicinity of some of the highest peaks, stands of Arizona cypress and ponderosa pine appear.

Access

Access to the Superstition Wilderness is by several spur roads leading from major nearby highways (fig. 2) and by a network of U.S. Forest Service trails extending throughout the wilderness. U.S. Highway 70 crosses south of the area in a east to west direction, and several gravel and dirt roads lead from the highway to the wilderness boundary. One major access point is via Forest Service Road 77, which leads 7 mi from the highway to the Dons Camp where Peralta Canyon emerges from the Superstition Mountains. This point is the head of several trails that lead into the wilderness. Another major entry point is at Rogers Trough, about 15 mi from the highway via Forest Service roads 357 and 172. Arizona State Highway 88, the Apache Trail, skirts the west and north boundaries of the area and provides several other points of access. The most heavily used is along the west boundary at First Water Ranch, about 2.5 mi east of the highway via Forest Service Road 78. Several rough jeep trails lead to the boundary at various points around the wilderness periphery (fig. 2; pl. 1).

Access for treasure hunting, prospecting, and mining within the Superstition Wilderness is subject to the terms and conditions set forth in the Wilderness Act (Public Law 88-577), and to the rules and regulations promulgated by the U.S. Forest Service.

The study area lies within parts of eight 7 1/2-minute quadrangle maps, published by the U.S. Geological Survey. The location of these quadrangles and their relation to the area are shown in figure 2.

Previous studies

Part of the study area has been the subject of previous studies, but other parts have not been studied prior to the present investigation. The first work was in the Haunted Canyon quadrangle, which was geologically mapped in detail (Peterson, 1960); part of this quadrangle comprises the southeastern part of the study area. The adjoining areas to the east and south have been extensively studied during various U.S. Geological Survey projects, and selected reports with information pertinent in providing background for the general geologic setting of the study area include Peterson (1962, 1963), Peterson and others (1951), Peterson (1961, 1966, 1968, 1969), Shride (1967), and Hammer and Peterson (1968).

The western part of the area has been the subject of detailed investigations by M. F. Sheridan of Arizona State University and several of his students. Published reports include Sheridan (1968, 1971), Sheridan and others (1970), Royse and others (1971), Stuckless and Sheridan (1971), Stuckless and Naeser (1972), and Stuckless and O'Neil (1973); abstracts include Sheridan and Fodor (1968), Sheridan and Stuckless (1969), Malone (1972b), and Suneson and Sheridan (1975). Unpublished theses covering parts of the study area include Stuckless (1969, 1971). Additional theses covering areas adjacent to the study area include Fodor (1969), Malone (1972a), and Suneson (1976).

The U.S. Bureau of Mines has not previously investigated the Superstition Wilderness; however, Stewart (1955) and Harrer (1964), respectively, have described occurrences of chrysotile asbestos and iron in and near the study area.

Present investigations

Investigations in the study area by the U.S. Geological Survey were made in 1975, 1976, and 1977. In 1975, the geologic studies were carried out by D. W. Peterson, D. L. Gaskill, and M. L. Sorensen, assisted by K. L. Stark and N. H. Suneson. In 1976 the studies were continued by Peterson, Gaskill, Sorensen, and W. E. Yeend, assisted by G. D. Johnpeer. Peterson made additional studies in 1977. An aeromagnetic map of the area was made in 1974 and 1976 by the U.S. Geological Survey. J. C. Wynn made a gravity survey in 1976; his interpretations of the gravity and aeromagnetic data are included in a section of this report. A total of approximately 15 man-months was spent in the field investigations. The geologic fieldwork was accomplished by foot traverses throughout the area, and in 1976 and briefly in 1977 the party used a helicopter, which provided transportation to the more remote areas. Fieldwork included reconnaissance geologic mapping (pl. 1) and collection of samples for geochemical analysis (pl. 2). New mapping was performed through the entire area except for the portion within the Haunted Canyon quadrangle. Stream-sediment samples were collected at intervals of 1/4 to 1/2 mi along all major streams and many tributaries. Samples were also collected of all rock types, from outcrops showing evidence of alteration or mineralization, and from fault and shear zones. A total of 1,231 rock and 1,038 stream-sediment samples were collected and analyzed by spectrographic and atomic-absorption methods. Most of the samples were analyzed in U.S. Geological Survey mobile laboratories under the direction of J. M. Motooka; he was assisted in 1975 by D. G. Murrey and R. N. Babcock, and in 1976 by R. F. Sanzolone and C. A. Curtis. The samples collected in 1977 were analyzed in Denver under Motooka's supervision. Samples of water were collected for radon analysis by W. R. Miller, J. B. McHugh, and H. N. Barton in 1977 to supplement the investigation of possible uranium occurrence. Analytical data have been presented by Motooka and others (1978); the geochemical data are interpreted in this report in a section by Miller and Motooka.

Members of the U.S. Bureau of Mines began fieldwork in October 1973, continued into March 1974, stopped during the warmer months, resumed in late September, and continued into December. Fieldwork during 1973 and 1974 was conducted by Frank E. Williams and Henry C. Meeves. Additional fieldwork was done by Jimmie E. Jinks, assisted by Lynn S. Griffiths in October and December 1976, and by J. A. Tony Fallin in January 1977. The U.S. Bureau of Mines studied mining-claim and mineral-lease records, examined mining claims, and mapped and sampled mine workings and prospects. The locations of 129 samples taken within the study area are shown on plate 3.

Acknowledgments

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We extend special thanks to Mr. Bill Martin of Superior for his many courtesies that greatly aided the logistics and the progress of fieldwork.

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GEOLOGY

Geologic setting

The Superstition Wilderness is in a region that is remarkable for its diversity of rock types and complex geologic structure. Rocks range in age from Early Proterozoic to Quaternary and include metamorphic, sedimentary, and both intrusive and extrusive igneous rocks (pl. 1). The major structural complexities are the result of pervasive faulting, chiefly high-angle normal faults that form intricate patterns. Major blocks, bounded by the relatively few faults that are continuous for more than a few miles, are broken into smaller blocks by abundant faults of diverse orientation and movement. Layered rocks have been tilted rather than folded; the attitude of strata within individual small blocks may be relatively uniform, but attitudes vary widely from one block to another. Ransome (1903, p. 99) descriptively characterized the structure as "regional brecciation."

The general geology of the eastern half of the wilderness is quite distinct from that in the western half. The eastern half consists chiefly of Proterozoic rocks of several different types that in most places have been subjected to the characteristic intricate faulting of the region. The relations could be portrayed only in the most generalized way during the brief time available for the wilderness study, and the reconnaissance geologic map (pl. 1) provides only a hint of the complexities. A larger scale geologic map (Peterson, 1960) covers the southeastern part of the area and provides a more detailed example of the nature of the complexities. The western half of the wilderness consists chiefly of volcanic rocks of Tertiary age and discontinuous outcrops of sedimentary rocks at the base of the Tertiary section. This area also has been cut by many faults, but not on the intricate scale of the older rocks in the eastern half. However, the complex relations among the various volcanic rocks point to a highly involved history with details which can only be briefly treated here.

The Superstition Wilderness lies along the north margin of the great copper province of Arizona, one of the world's most prolific copper-producing regions. Figure 3 shows the location of the wilderness and its relation to the major copper deposits of Arizona. Other metallic commodities produced from areas near the wilderness include silver, gold, lead, zinc, molybdenum, manganese, and uranium; nonmetallic commodities, other than sand and gravel, include perlite, asbestos, and limestone.

Rocks of the Superstition Wilderness and vicinity

The lithologic characteristics of the rocks of the Superstition Wilderness and contiguous roadless areas are summarized in plate 1; more detailed descriptions of some of the rock units can be obtained by consulting the references. The text that follows discusses the general relations among the rock units and aspects that are pertinent to the mineral appraisal of the wilderness; plate 1 also shows the distribution in the wilderness.

Proterozoic rocks

Pinal Schist

The Pinal Schist of Early Proterozoic age is widely distributed throughout southeastern Arizona and is the oldest rock unit of the region.

Within the wilderness it crops out chiefly in the southeastern part, but a few isolated patches appear farther west near the southern boundary of the wilderness. The schist has been intruded by plutonic rocks of younger Proterozoic age--the Madera Diorite and Ruin Granite; intrusive contacts are sharp and distinct but also sinuous and contorted. The Pinal Schist is one of the important host rocks to ore deposits in the copper mines at Ray, Superior, and in the Globe-Miami district.

Madera Diorite

Locally foliated (gneissic) rocks that intrude the Pinal Schist are here assigned to the Madera Diorite of Early or Middle Proterozoic age because of their resemblance, both lithologically and in geologic relations, to the Madera in the Pinal Mountains. The Madera is darker and finer grained than the Ruin Granite. From its mineralogy the Madera can be designated a granodiorite or tonalite. Its distribution within the wilderness is confined to the same general area as the Pinal Schist.

Ruin Granite

The Ruin Granite of Middle Proterozoic age, the other plutonic rock that intrudes the Pinal Schist, is lighter colored and coarser grained, and totally lacks foliated textures. From its mineralogy it may be classed as either granite or quartz monzonite. It intrudes both the Pinal Schist and Madera Diorite in the southeastern part of the wilderness, and, in turn, is cut by locally abundant dikes of aplite and pegmatite that formed during late stages of its emplacement. Some of these dikes continue into adjacent schist and diorite. These dikes were not separated in mapping from the younger dikes of Laramide age that occur in the same area. The contacts of the granite with the schist and diorite are complex and intricate. To the north, the Ruin Granite comprises the basement rock throughout the northeastern part of the wilderness, and it crops out across very large areas. It also crops out in several places along the west and southwest margins of the wilderness, appearing beneath the overlying volcanic rocks. East of the wilderness, the Ruin Granite lies north of the major mines of the Globe-Miami district. It is not a known host rock to ore minerals; however, it closely resembles in composition and texture the Lost Gulch Quartz Monzonite, recently considered to be of Precambrian Y (=Middle Proterozoic) age by Creasey (1981), which in several mines comprises an important host rock for porphyry copper ore in zones of hydrothermal alteration.

Apache Group

The Apache Group is widely distributed throughout the eastern half of the wilderness. The rocks were deposited on a deeply eroded surface of low relief cut into Pinal Schist, Madera Diorite, and Ruin Granite. The Apache Group consists of (ascending order) the Pioneer Formation, Dripping Spring Quartzite, and Mescal Limestone. The rock types of each of the formations that make up the group are summarized on plate 1; rock types include conglomerate, sandstone, quartzite, arkose, siltstone, shale, dolomite, and limestone. Furthermore, where the section is nearly complete, an unnamed basalt is found at the top of the group. Extensive dikes and sills of diabase have intruded the Apache Group, and it is unlikely that any section of the Apache Group can be found in the wilderness that is not interrupted by one or more sills of diabase. Time did not permit delineating all the abundant and intricate contacts with diabase in more than a simplified way.

The Dripping Spring Quartzite is of particular interest in a mineral resource appraisal, because in areas to the northeast it has yielded substantial amounts of uranium ore (Granger and Raup, 1959, 1969).

Certain beds in the Mescal Limestone contain asbestos deposits where they lie near diabase. An important asbestos-producing district lies northeast of the wilderness, within a few miles to 25 miles north of Theodore Roosevelt Lake. Although several asbestos prospects lie within and near the southeastern part of the wilderness in the Mescal Limestone, production has been negligible (Peterson, 1960). Small irregular bodies of magnetite-hematite lie near limestone-diabase contacts in the southeastern part of the wilderness, but they are not of sufficient size or value to have been mined.

Diabase

Dikes and sills of diabase are distributed throughout the eastern half of the wilderness. Although they are ubiquitous within the Apache Group, substantial volumes of diabase are present in most of the other Proterozoic formations. These bodies are the result of a widespread intrusive episode of diabase that extended through a broad region of south-central Arizona. Although no radiometric ages have been obtained from diabase from within the wilderness, age determinations on diabase from nearby localities range from 1,075 to 1,200 million years (m.y.) (=Middle Proterozoic) (Silver, 1960; Shride, 1967, p. 77; Banks and others, 1972, p. 867). Diabase is an important host for copper mineralization in the mines of the Globe-Miami district and at Superior and Ray.

Paleozoic rocks

Thick sections of Paleozoic sedimentary rocks are found in areas east and southeast of the Superstition Mountains, but only a few small isolated faulted blocks lie within the wilderness. These blocks, consisting of rocks of Cambrian, Devonian, and Mississippian age, are found near the southeast edge of the study area. It is likely that the Paleozoic rocks had originally been deposited throughout much or all of the area of the Superstition Mountains, but they were removed by erosion along with parts of the Proterozoic rocks during Mesozoic time prior to deposition of volcanic and sedimentary rocks of Tertiary age, which generally rest directly on Proterozoic rocks.

Mesozoic and (or) Tertiary rocks

Although several granitic stocks of late Mesozoic and (or) early Tertiary (Laramide) age crop out in areas east and southeast of the wilderness, the only rocks that may be of this age within the wilderness are found in a dike swarm that has intruded some of the Proterozoic rocks in the southeastern part of the area. These dikes cut the Ruin Granite, Madera Diorite, and Pinal Schist in an area of about 2 to 5 mi south and west of Iron Mountain, termed in this report the JF area, after the nearby JF Ranch. The dikes are vertical or steeply dipping and they strike north-northwest. Their width ranges from 3 to 16 ft and averages about 6 ft. The dike rocks are light colored, some are porphyritic and others nonporphyritic; they have been pervasively altered, and little of their initial mineralogy or texture can be discerned.

Similar-appearing dikes are common in mining districts throughout Arizona, and they are commonly peripheral to stocks of Laramide age. Diagnostic age relations are lacking here, but because of the resemblance to similar rocks elsewhere, a Mesozoic or early Tertiary age is provisionally assigned to the dikes. The presence of the dikes also leads to speculations that a pluton of Laramide age may lie concealed somewhere nearby; a high metallic content of some rock samples from this area adds further interest to this speculation.

Interspersed with these dikes and lying on the same trend are aplite dikes of Proterozoic age associated with the emplacement of the Ruin Granite. The two types of dikes cannot be distinguished from a distance or from aerial photographs, and they have not been separated on the reconnaissance map (pl. 1). In outcrop, however, the rock types are readily distinguished, and the task of identifying each dike will be a part of any detailed study of this area.

Tertiary rocks

Rocks of Tertiary age, chiefly volcanic rocks, occupy nearly all of the western half of the wilderness and cover substantial areas in the eastern half. They were deposited on an eroded surface with moderate to high relief. The contact at the base of the Tertiary section represents a profound unconformity, for with minor exceptions, the Tertiary rocks lie directly on rocks of Proterozoic age throughout the wilderness. Only near and beyond the southeast wilderness boundary do Tertiary rocks overlie rocks of Paleozoic age.

Whitetail Conglomerate

Gravel deposits of local extent lie at the base of the Tertiary section in a few areas, chiefly at the west end and near the northeast and southeast margins of the wilderness (pl. 1). This gravel was evidently deposited in fluvial basins of local extent, possibly during times of structural deformation. The gravel is of highly varied lithology, commonly reflecting the type of nearby bedrock. In the upper part of most gravel sections, tuff beds are intercalated with the sediments, and upward tuff becomes increasingly abundant.

In the eastern part of the wilderness, the gravel is definitely assigned to the Whitetail Conglomerate of Oligocene age, whose type locality lies only 5 to 6 mi east of the boundary (Ransome, 1903). In the western part of the wilderness, the correlation with the deposits, some 25 mi distant, is somewhat questionable. However, because these deposits occupy the same stratigraphic position and have the same type of origin as the Whitetail Conglomerate, the deposits are tentatively assigned to the Whitetail. The Whitetail Conglomerate is considered to be of Oligocene age based on K-Ar dates of about 32 m.y. (Cornwall and others, 1971).

Volcanic rocks

The region around the Superstition Mountains includes multiple important eruptive centers of Tertiary age, and the relations among the different volcanic rocks are complex. Names of volcanic rocks are field designations and are based on megascopic estimates of phenocrystic composition and abundance. Silicic lava with more than about 20 percent phenocrysts is called rhyodacite; that with few or no phenocrysts is called rhyolite. Rocks with 10 to 20 percent phenocrysts are arbitrarily assigned one or the other name, depending on gradations to nearby rocks or degree of contortion. Flow banding in rhyolite is generally more contorted than that in rhyodacite. Individual lava units are complex in outline and in relation to one another.

Lava of diverse composition lies at the base of the volcanic section at various places throughout the wilderness. In the southeastern part of the area the oldest lava is rhyolite (Trl), whereas through the central area extending from south to north and northeast, a broad basal band is composed predominantly of basalt (Tbl) and andesite (Ta). Throughout much of the western part, the oldest lava is designated as dacite (Td). Each of these lava units may be interspersed with thin beds of tuff, although only within the basalt (Tbl) do tuff units (Ttl) reach mappable dimensions. Although these assorted lava units are not found in contact with one another, they all lie beneath a widespread unit of ash-flow tuff (Tafl). For purposes of this study, therefore, they are regarded as approximately contemporaneous with one another, even though their precise relations are not known.

Next in succession are voluminous layers of ash-flow tuff (Tafl), which blanketed the entire region and which locally reach thicknesses exceeding 2,000 ft. The ash-flow tuff, of rhyodacitic composition, is a composite sheet made up of a succession of separate ash flows and in some places of several distinct cooling units. The lava beneath did not cover the entire region, and in some places the ash-flow tuff was deposited directly on the pre-Tertiary rocks. The ash-flow tuff is the youngest volcanic rock in the eastern half of the wilderness, but in the western half the ash flows are locally overlain and, in part, intruded by silicic lavas (Trd, Tr, Tmr), which include flows, domes, and a few dikes (Tp) of rhyolite and rhyodacite.

The silicic lavas, rhyolite and rhyodacite, are interspersed with tuff, some of which is fairly widespread nonwelded ash-flow tuff (Tafm) and some of which is near-vent air-fall tuff (Ttm) intercalated in complex ways with contorted lava flows. An additional ash-flow tuff overlies the silicic lava along the northwest boundary and covers a large area north and west of the wilderness (Tafu). A prominent basaltic lava flow (Tbu) in the west-central part of the wilderness is probably roughly contemporaneous with the younger ash-flow tuff. The youngest volcanic rock is an upper tuff composed of epiclastic breccia that crops out in the north-central part of the wilderness and is largely derived from nearby volcanic units.

The stratigraphic names used for the volcanic units by Stuckless and Sheridan (1971) and Stuckless (1971) have not been used in this report. Our interpretations differ from theirs in certain respects, but a thorough discussion of the stratigraphic problems is beyond the scope of this report, so only compositional rock names are used.

Quaternary deposits

Fanglomerate and colluvium of local derivation cover substantial areas and obscure underlying geologic relations, chiefly in the northeastern part of the wilderness. Several large landslide blocks, chiefly composed of ash-flow tuff, also lie in the northeastern part of the area. Small deposits of talus and alluvium are abundant, but only a few are of mappable size.

Volcanic cauldron structures

Three structures interpreted as volcanic cauldrons have been provisionally identified within the study area (fig. 4). These cauldrons presumably mark centers from which some of the extensive ash-flow tuffs of the region were erupted during the Miocene. During voluminous eruptions of ash-flow tuff, portions of the crust at the eruptive vents may collapse to form a caldera, which is a large, generally circular, topographic depression. If subsequent erosion destroys the topographic form, the structure is designated as a cauldron. The original topography of these structures has been totally removed, and the cauldrons have been interpreted from geologic relations. The margins and centers of some of the cauldrons have been locally intruded and partly covered by later volcanic rocks. However, because of the complex postvolcanic deformation and the extensive erosion of many critical areas, the geologic relations have not yet been totally deciphered. Therefore, the identification of each of the cauldrons is here regarded as provisional, and the interpretations are subject to revision and modification. Data from the section "Geophysical Investigations" are compatible with the cauldron interpretation.

Sheridan and others (1970) proposed a cauldron complex within and adjacent to the Superstition Mountains which later, on the basis of additional work, was revised and modified (Sheridan, 1978). The Superstition cauldron is the only cauldron of Sheridan's complex, as revised, to lay within the wilderness; its diameter is about 7 to 9 mi, and its approximate outline is indicated on figure 4. Sheridan (1978) based the identification of the cauldron on thick deposits of ash-flow tuff within the indicated boundaries and on assorted faults that roughly parallel the boundary. The ash-flow deposits now stand topographically high above the adjacent Proterozoic rocks to the south and west.

During the present study an additional cauldron has been provisionally identified in the wilderness; it lies east of the Superstition cauldron and intersects its east margin and has a diameter of about 7 to 9 mi (fig. 4). It is designated here as the La Barge Canyon cauldron after the largest canyon that lies within it. Thick deposits of ash-flow tuff occupy much of the cauldron; these have been intruded and overlain in part by silicic lavas extending north-northwest through the cauldron. The boundary of the cauldron is identified by a series of faults lying along interrupted sectors of a circle, and by a series of silicic volcanic centers that lie along other parts of the circle (compare fig. 4 with pl. 1).

The Haunted Canyon cauldron lies at the southeast corner of the study area (fig. 4). It has a diameter of 3 mi, contains both ash-flow tuff and rhyolitic lava, and its boundary is marked by a zone of complex faulting and tilting involving both the volcanic rocks and the older Paleozoic and Proterozoic rocks (Peterson, 1961, 1968).

The ash-flow tuffs within all three cauldrons, as well as those lying outside the cauldrons, are chemically similar to one another. Radiometric age determinations and certain petrographic differences among the ash-flow tuffs, however, both within and outside the wilderness boundaries, will be useful in ultimately helping to decipher the complex volcanic history of the region.

INTERPRETATION OF GEOCHEMICAL DATA

By

W. R. Miller and J. M. Motooka

INTRODUCTION

Samples collected during fieldwork in the Superstition Wilderness and vicinity include 1,231 rocks and 1,038 minus-80-mesh stream sediments (pl. 2; figs. C1, C8). Most of the samples were prepared and analyzed on location using mobile chemical laboratories. A description of sampling and analytical techniques and the locations and analytical results of the rock and stream-sediment samples are given in Motooka and others (1978).

Analytical results of the samples were entered into the U.S. Geological Survey's computer storage system-RASS II and manipulated using statistical evaluation library-STATPAC programs. Maps of selected elements were computer generated by T. M. Billings.

GEOCHEMICAL INTERPRETATION OF ROCK SAMPLES

Rock samples were collected at a density of 4.7 samples per mi^2 (fig. C1; pl. 2); table C1 summarizes the analyses. Samples include fresh unaltered rocks, iron-manganese-stained rocks from fault and shear zones, material from veins, and altered rocks from mines and prospects. The rock samples represent a mixture of populations, corresponding to different geologic units and also to rocks affected by later mineralization. Therefore, the trace-element content of the rocks represents both the original background concentrations and, in some cases, elevated concentrations due to later mineralization. The anomalous values of trace metals, such as copper and molybdenum, occur with many rock types but are not associated with any particular rock types. For a certain rock type, the anomalous values commonly occur in a scattered nature and in proximity to faults and dikes. In many places the anomalies showing high concentrations of certain trace metals are probably the result of mineralization processes that occurred later than the formation of the rocks. Because lithology is probably not as important as structural controls such as faults and dikes, the rocks were not geochemically separated according to geology, but were treated as one population for the interpretation.

To detect patterns of possible mineralization, maps have been constructed by plotting the locations of rock samples with various concentrations of selected elements. Maps showing the distributions and histograms of copper, lead, zinc, silver, and molybdenum are shown in figures C2-C6. The area showing the highest concentration of the selected elements is in the southern part of the study area, southwest of Iron Mountain, designated as the JF area. Concurring with these results were analyses of a water sample collected from the well of Woodbury tank, located 1 mi northwest of JF ranch, where concentrations of copper, zinc, and molybdenum were 44, 166, and 6.9 mg/L, respectively. These high values suggest the possibility of subsurface mineralization. Additional scattered high values occur along the south edge of the area in a belt extending westward from the JF area and scattered also along the west edge of the area. The JF area is clearly anomalous, but a distinct pattern corresponding to the other high values is not readily discernible on these maps.

Relations among elements were investigated to determine if the data would reveal possible underlying patterns. Correlation coefficients were determined for all elements with valid pairs of data. In some cases, the number of valid pairs is small and therefore of questionable value. The correlation matrix (table C2) shows that certain elements such as copper, lead, and zinc display significant correlation with each other and are therefore interrelated. To investigate relations among groups of elements, R-mode factor analysis techniques were applied. R-mode factor analysis is a statistical technique that attempts to explain the variation among variables by redistributing the variation among relations or factors. One of the more important characteristics of factor analysis is its data-reduction capability which enables the user to see possible underlying patterns that were originally obscured by the volume of data. Background information on the use of factor analysis for geochemical studies is included in Spencer (1966), and Cameron (1967), and Davis (1973). Input for R-mode factor analysis for a seven-factor model is the matrix of correlation coefficients (table C2). Varimax rotation was applied and a seven factor model was selected. Of the seven factors, 2, 4, and 7 are composed mostly of elements which are often associated with mineralization. These three factors are assumed to be related to mineralization and are the only factors discussed here. The remaining four factors are composed of rock-forming elements and are thought to reflect different rock types. Factor 2 is composed mainly of molybdenum, lead, copper, and silver; factor 4 is composed mainly of flourine, zinc, and manganese; and factor 7 is composed mainly of mercury, silver, and boron. Silver is present in both factors 2 and 7, indicating that two separate controls are responsible for its distribution. The factors may represent either different mineral suites of a single episode of mineralization, zoning of one episode of mineralization, or several episodes of mineralization.

Because the purpose of the interpretation is to detect possible patterns of mineralization, a simple means was devised to plot the three factors. Weighted-sum equations were derived by using the varimax-rotated factor-loading matrix (table C3). The elements with the highest loading for each of the three factors were used as weighting coefficients in the equations and are underlined on table C3. Each element was then normalized by dividing the concentration of an element by its geometric mean (table C1). The equations for the three weighted sums corresponding to factors 2, 4, and 7 are as follows:

$$\text{Weighted sum 1 (factor 2)} = \frac{0.91\ \text{Mo}}{2.31} + \frac{0.67\ \text{Pb}}{22.7} + \frac{0.66\ \text{Cu}}{9.15} + \frac{0.65\ \text{Ag}}{0.28}$$

$$\text{Weighted sum 2 (factor 4)} = \frac{0.72\ \text{Zn}}{119} + \frac{0.72\ \text{F}}{1.61} + \frac{0.66\ \text{Mn}}{526}$$

$$\text{Weighted sum 3 (factor 7)} = \frac{0.86\ \text{Hg}}{.020} + \frac{0.65\ \text{Ag}}{0.28} + \frac{0.46\ \text{B}}{12.5}$$

Distribution plots of the three weighted sums are shown on figure C7. The plots indicate zones of mineralized rock along the south and west edges of the study area. The JF area is particularly anomalous within the southern east-west trend. The consistency of the three plots suggests that favorable mineralization processes have been concentrated by some underlying cause, such as structural weakness in proximity to a source. Weighted sum 3, composed mainly of mercury, silver, and boron, defines the widest zone along the east-west trend, indicating that the mineralization reflected by these three elements was more pervasive than the mineralization associated with the other two weighted sums. Highly anomalous areas are located within these favorable areas. The weighted sum plots of the three factors are somewhat similar to the distribution plots of selected trace elements (figures C2-C6), except that the trends revealed by the weighted sum plots are continuous and more easily seen.

GEOCHEMICAL INTERPRETATIONS OF STREAM SEDIMENTS

The minus-80-mesh stream-sediment samples were collected throughout the area at a density of 3.9 samples per mi^2 (pl. 2; fig. C8). The localities and results of the chemical analyses of 1,038 stream sediments are given in Motooka and others (1978) and are summarized in table C4. The stream-sediment samples represent a mixed population similar to the rock samples. For this reason they were treated as a single population, and the method of interpretation was the same as that used for the rock samples. Computer-generated distributions and histograms of selected elements which are commonly associated with mineralization are shown in figures C9-C13.

Generally the most anomalous areas for most of the elements occur along the south edge of the area along an east-west trend, particularly the JF area. In addition, high concentrations of copper are present in the southeastern area. The Globe-Miami copper district lies directly east of the study area. Anomalous concentrations of zinc and molybdenum are more scattered than anomalous concentrations of copper, silver, and lead. Lead concentrations also are anomalous in the northeastern area. Anomalous concentrations of trace elements in stream-sediment samples are more scattered than in the rock samples. The anomalous metal concentrations in the rock data are confined mainly to the southern east-west trend and western north-south trend. The same multivariant techniques have been used to interpret the stream-sediment data as were used for the rock data.

The correlation matrix for the 1,038 stream-sediment samples is shown on table C5. Pairs of elements such as silver and boron or molybdenum and zinc exhibit significant correlation indicating similar controls on the distribution of these pairs of elements. The varimax-rotated factor-loading matrix derived by R-mode factor analysis for an eight-factor model, which accounts for 80 percent of the total variation, is shown in table C6. Factors 4, 5, and 6 are composed of elements commonly associated with mineralization and are the only factors discussed here. The remaining factors are composed of rock-forming elements and probably reflect the dominant lithologies of the area. Factor 4 is composed mainly of zinc, molybdenum, and manganese; factor 5 is composed mainly of silver and boron; and factor 6 is composed mainly of beryllium, copper, boron, and lead. These factors represent the same mineralization processes that affected the geochemistry of the rocks but were modified by later physical and chemical processes. Weighted sums for factors 4, 5, and 6 were derived in a manner similar to that used for interpretation of the rock data so that the three factors could be plotted. Using the results from tables C4 and C6 the three weighted sum equations corresponding to factors 4, 5, and 6 are as follows:

$$\text{Weighted sum 1 (factor 4)} = \frac{0.92\ Zn}{114} + \frac{0.72\ Mo}{2.72} + \frac{0.39\ Mn}{1162}$$

$$\text{Weighted sum 2 (factor 5)} = \frac{0.88\ Ag}{0.26} + \frac{0.84\ B}{20.3}$$

$$\text{Weighted sum 3 (factor 6)} = \frac{0.67\ Be}{1.28} + \frac{0.53\ Cu}{29.8} + \frac{0.41\ B}{20.3} + \frac{0.35\ Pb}{33.3}$$

Distribution plots of the three weighted sums are shown on figure C14. All three distribution plots for the stream sediments indicate a favorable zone for mineralization along the south edge of the study area along an east-west trend similar to the distribution plots for the rocks. Highly anomalous areas within this trend, particularly the JF area, are the most favorable areas for mineralization. In addition, the plot of weighted sum 1, which is composed of zinc, molybdenum, and manganese, shows a large circular feature in the south-central western half of the study area. This circular feature, emphasized by a dashed line (fig. C14), roughly coincides with the boundary of the Superstition cauldron, described previously in this report. The stream-sediment geochemistry may reflect low-grade mineralization which took place in the zone of structural weakness around the periphery of the cauldron. Scattered low-grade anomalies occur within the northeastern area but no distinct trends can be seen.

GEOCHEMICAL INVESTIGATION FOR URANIUM AND THORIUM MINERALIZATION

The uranium and thorium contents of 35 selected rock samples and 38 selected stream-sediment samples were determined by neutron activation. The uranium concentrations ranged from 0.33 to 17.46 ppm for the rocks, and from 1.56 to 123 ppm for the stream sediments. The thorium concentrations ranged from 0.21 to 58.7 ppm for the rocks and from 3.59 to 1,262 ppm for the stream sediments. Because the rock and stream-sediment samples that were analyzed for uranium were not systematically sampled throughout the area and because the number of samples analyzed for uranium and thorium was small, no attempt was made to geochemically map these elements for rock samples.

Thorium concentrations were determined spectrographically for the 1,038 stream-sediment samples collected throughout the area. Thorium was detected in 64 samples (fig. C15) by this method, in which the senstivity is 100 ppm. The highest concentrations of thorium occur in the central northern part of the study area, much of which is underlain by the Ruin Granite. It is common for high thorium values to be associated with granites; however, the distribution of thorium in the Ruin Granite is not uniform but localized in certain areas. Dissolved radon gas was determined on water samples collected from springs and small streams from eight sites in the northeastern part of the study area, which is underlain by the Ruin Granite and the Apache Group. The Dripping Spring Quartzite of the Apache Group is a known host for uranium mineralization north and east of the study area. The two samples with the highest concentrations of radon were found to contain extremely high amounts of uranium for spring waters with moderate conductivities (table C7). The high concentrations of uranium in water and the association of high concentrations of thorium in stream sediments and radon in water suggest that the area may possibly have potential for subsurface uranium mineralization, probably associated with either the Ruin Granite or the Dripping Spring Quartzite of the Apache Group. Because only a few samples were collected in one area, the extent of the anomalous areas for uranium and thorium is not known.

SUMMARY OF THE GEOCHEMICAL INTERPRETATION

There are no known mineral deposits of significance in the study area. Exposed mineralization is spotty and occurs mainly along veins, faults, shear zones, and dikes; if significant deposits are present in the area, they remain concealed. On the basis of geochemical interpretations of 1,231 rock and 1,038 stream-sediment samples, areas of anomalously high metal content were defined and their relative importance approximated (fig. C16). The major geochemical feature is an east-west trend along the southern part of the area which continues into a north-south trend along the western part of the area. Highly anomalous areas are present within these trends, particularly in the JF area southwest of Iron Mountain; they possibly could be associated with a concealed pluton. The anomaly patterns probably reflect mineralization which cuts across many rock types along the east-west trend, indicating a zone of structural weakness below the surface which served as pathways for the mineralization. The association of elements, such as copper, molybdenum, lead, and zinc, and the nearness of the Globe-Miami copper district makes porphyry-copper-type deposits the most likely to occur along this east-west trend.

Gold was detected in only 30 of the 1,231 rock samples and ranged in concentration from less than 0.05 to 5 ppm. The highest values occur in the JF area. There is no evidence of potentially favorable economic gold mineralization in the study area.

On the basis of only a few samples, there is indication of possible subsurface uranium mineralization in the northeastern part of the study area. This mineralization may be associated with the Ruin Granite or with the Dripping Spring Quartzite of the Apache Group which is a favorable host for uranium mineralization north and east of the study area.

GEOPHYSICAL INVESTIGATIONS

By

Jeffrey C. Wynn

INTRODUCTION

Regional-scale gravity and magnetic studies were made in the Superstition Wilderness study area to assist with and contribute to geologic and geochemical studies. Since the purpose of this study is to assess the mineral resources of the study area, this geophysical analysis concentrates on those anomalies thought to have possible resource potential. Gravity and magnetic measurements generally do not directly indicate mineralization, except in certain limited targets such as massive deposits of sulfides or iron ore. In most cases, gravity and magnetic measurements are used to add supplemental information about subsurface structures that are already under investigation because of suggestive geochemical or surface geologic evidence. Direct sulfide exploration methods, such as electromagnetics or induced polarization, were not used in this study because the cost per area covered and the time required are enormously greater than for gravity and magnetic studies.

AEROMAGNETIC DATA

The aeromagnetic data were collected in two different surveys, the first in November 1974 and the second in May 1976, both by Aerial Surveys of Salt Lake City, Utah. The regional field was removed from each data set using an updated IGRF. The surveys were flown at 6,000 ft above sea level, in an east-west direction, with a flight-line spacing of one mile. The resulting data sets were then joined together using spline functions, and the fields were recalculated for a surface parallel everywhere to the topography by parallel-surface continuation. Parallel-surface continuation was described by Bhattacharyya and Chan (1977) and Wynn and Bhattacharyya (1977). Basically, the process extends the measured field upward above the topographic peaks (but no higher above the valleys) to give a calculated field theoretically equivalent to a perfectly draped flight. The effect of topography on the aeromagnetic data is thus minimized. The resulting aeromagnetic map is shown in figure P1, and the major magnetic anomalies are numbered consecutively roughly from east to west.

Anomaly M-1 is a magnetic high on the southeast edge of the study area and is centered approximately over Government Hill. This anomaly is believed to be related to the Haunted Canyon cauldron (fig. 4), which is even more clearly evident in the gravity data. The underlying rocks are the lower ash-flow tuff (Tafl) and lower rhyolite units (Trl), but the source of the magnetic high is beneath the surface and centered slightly east of the cauldron as outlined by gravity and geologic considerations.

Anomalies M-2a and M-2b lie on the northwest edge of the Haunted Canyon cauldron and form a pronounced double magnetic low. M-2b lies over the Kennedy Ranch, and rocks underlying these anomalies are highly complex, including large amounts of the Proterozoic Y diabase. The boundary between anomaly pairs M-2a, M-2b and M-3a, M-3b appears to follow the Kennedy fault, which trends roughly northeast. Taken in this broader context, anomalies M-2a and M-2b are intriguing; in some ancient volcanic environments, a magnetic low this large on a fault/caldera margin may be indicative of extensive subsurface alteration and possible mineralization (see, for example, Wynn and Bhattacharyya, 1977).

Anomalies M-3a and M-3b are separate distinct magnetic highs, but both are underlain by the Ruin Granite. M-3a lies over the JF area, which includes several mineral prospects and which coincides with a distinct geochemical anomaly (figs. C7, C14, C16). From known mineral occurrences and geochemical anomalies, the JF area appears to have the highest potential and most extensive alteration of any in the study area. However, hydrothermal alteration normally causes a relative magnetic low. There is no indication of the presence of skarns, which usually give rise to magnetic highs, or even of sedimentary rocks in the vicinity, so the source of this magnetic high is not completely clear.

Anomaly M-4, a magnetic low, is elongated and lies west of M-3a; its east edge lies near the JF area, and it extends 6 to 8 mi to the west-southwest. It, too, coincides with geochemical anomalies (figs. C7, C14, C16) and with local surface alteration and mineralization. It roughly parallels a broad, east-northeast trend on which major ore deposits occur beyond the limits of the study area. This anomaly may be indicative, like M-2a and M-2b of buried hydrothermal alteration.

The La Barge Canyon cauldron lies in the west-central part of the study area with a diameter of about 7 to 9 mi. Anomaly M-5a is a large magnetic high that lies over this cauldron and is probably caused by it. The anomaly appears to be centered between two unnamed faults of unknown displacement that are postcaldera in relative age. The underlying rock is the lower ash-flow tuff. Anomalies M-4, M-5c, M-7a, and M-7b are magnetic lows that almost encircle the cauldron along its boundary. This association may be significant, for a similar relation has been observed in volcanic centers in the San Juan Mountains of Colorado and elsewhere (Wynn and Bhattacharyya, 1977). In these areas, the surrounding lows appear to be caused by hydrothermal alteration along ring fractures related to the caldera collapse, and in some places the alteration is associated with mineralization. However, the only evidence of rock alteration in the areas of anomalies M-5c, M-7a, and M-7b was that associated with cooling processes of silicic lava flows (D. W. Peterson, written commun., 1981). Insufficient fieldwork was performed to determine whether or not alteration patterns in the volcanic rock are correlative with these magnetic anomalies.

Anomaly M-6a is a strong magnetic high strikingly similar to anomaly M-5a. The anomaly lies on the crest of the layered ash flows of the Superstition Mountains and is probably still enhanced somewhat by the topography. (Despite the topographic correction, there remains a larger volume of volcanic rocks there than in the surrounding areas.) M-6b is a magnetic low, unusual in that, with anomaly M-5c, it appears to be a dipolar low of anomaly M-6a. It may instead be a dipolar low (or a remanently polarized hidden mass) associated with only the western tip of M-6a, which might be a separate high that appears only as a small bulge on the northwestern contours of M-6a. The similarity between M-5a and M-6a suggests that they have similar causes, and indeed, M-6a lies within the bounds of the Superstition cauldron (Sheridan, 1978) near its south margin. M-6b, the possibly matching dipolar low, lies near the west margin of the cauldron centered over a zone where a northwest-trending medial graben within the cauldron intersects the margin. There is a marked structural jog (pl. 1) in the western front of the Superstition Mountains beneath anomaly M-6b. There is also a marked gravity low at this point.

Anomaly M-7a is a magnetic low that lies just north of the projected intersection of the margins of the Superstition and La Barge Canyon cauldrons over a thick body of postcaldera silicic volcanic rock. Anomaly M-7b, a southeastward extension of M-7a, lies over another postcaldera rhyolite center along the northeast margin of the La Barge Canyon cauldron.

GRAVITY DATA

The gravity map of the Superstition Wilderness study area (fig. P2) was prepared by collecting and processing the gravity data, as described in Wynn and Manydeeds (1978). Dominant features are the low over the Haunted Canyon cauldron (G-1), the lows around part of the La Barge Canyon cauldron (G-2a, b, c, and d), and the low over the Superstition cauldron (G-3). Anomalies G-1 and G-2a, b, c, and d were modeled using the three-dimensional gravity modeling program of Cordell and Henderson (1968). This program constructs a model of vertical prisms 2 km (1.2 mi) on a side (the grid spacing) and adjusts the depth extent of each of these prisms in an attempt to create a calculated field as close as possible to the observed field. The program iterates until a specified minimum difference between the calculated and observed fields is reached, or until a limiting number of iterations has occurred.

In the southeast corner, anomaly G-1 is believed to be the gravity expression of the Haunted Canyon cauldron. The anomaly is underlain by silicic lava flows and ash-flow tuffs which show moderate alteration. A three-dimensional model of the anomaly gives an excellent fit to the observed field for a density contrast of -0.2 g/cm^3. This model may be seen in figure P3 and shows a feature about 2 mi in diameter and 2 mi deep, filled with material which has the density of ash-flow tuffs.

Anomalies G-2a, b, c, and d include part of the La Barge Canyon cauldron and form a roughly northwest-southeast trough trending across much of the study area. G-2a lies over White Mountain, which contains a thick section of rhyolite and is the possible location of a volcanic vent. A magnetic high and an underlying complex including Proterozoic rocks appear to separate the source of this feature from the Haunted Canyon and La Barge Canyon cauldrons. Geologic evidence indicates it may be an external, thick, and complex flow from a caldera ring-fracture vent.

Anomalies G-2b and G-2c lie within the La Barge Canyon cauldron near its north margin. The underlying rocks include both the rhyodacite and upper rhyolite units, and the anomaly shape implies a much more complex structure than the Haunted Canyon cauldron. A model of the subsurface of this cauldron, calculated from the gravity data for a density contrast of -0.2 g/cm^3, is shown in figure P4. The cauldron is probably filled chiefly with ash-flow tuff (fig P4), which has locally been intruded and partly covered by postcaldera rhyolite and rhyodacite, both in the center and around the margin. This may cause the rather complex gravity pattern which still does reflect the cauldron outline.

Anomaly G-3 lies within the Superstition cauldron near the southwest margin, over a thick section of ash-flow tuffs and between magnetic anomalies M-6a and M-6b. It may be the result of an exceptionally thick portion in the pile of ash flows. Much of the remainder of the cauldron is marked by moderate- to high-gravity gradients with rather complex patterns, reflecting, perhaps, high-density postcaldera basalt in the northern part of the cauldron, and a high-density contrast with the Proterozoic rocks that crop out just to the south. Anomaly G-3, while compatible with the interpretation of the Superstition cauldron, can also be compatible with a thick deposit of ash-flow tuff.

Anomaly G-4, a gravity high, lies south of the study area beyond the area of geologic mapping. However, the Pinal Schist and other Proterozoic rocks are known to compose much of the surface in this area, and the anomaly may be the effect of density contrast with the lighter volcanic rocks to the north and northeast.

SUMMARY

Neither aeromagnetic nor gravity methods are suited for directly exploring for the kinds of mineral deposits likely to be found in the geologic environment of the study area. However, both methods may be useful in identifying certain kinds of structures that might, in turn, be associated with deposits of interest. Interpretations of the results of these techniques each depend heavily on relations revealed by geologic mapping.

The area of greatest potential interest as deduced from geologic mapping, mineral prospects, and geochemical studies is the JF area. Indeed, both magnetic and gravity anomalies are centered in this area, but their causes are difficult to interpret. If the mineralization is of the type associated with a porphyry sulfide system, as seems most likely, substantial hydrothermal alteration could be expected, which generally causes magnetic lows. However, at the JF area, the magnetic anomaly M-3a is a distinct magnetic high. With the information presently available, the character of the anomaly cannot be clearly explained, except as a possible stock having only weak alteration associated with its emplacement. A small gravity high, G-2d, also coincides with the JF area, supporting this contention.

The results of the geophysical studies are more readily interpreted in regard to structures associated with the volcanic rocks. At least three volcanic cauldrons, which could be only tentatively identified by geologic studies, receive further support and more clearly defined boundaries from the geophysical results. Distinct magnetic lows mark part or all of the margins of the two largest cauldrons, each of which also has a large magnetic high within the interior. A magnetic low further designates the extensively altered small cauldron. Similarly, the major gravity anomalies can be interpreted as associated with tuff-filled collapse structures of the same three volcanic cauldrons.

MINES AND MINERALIZATION

By

Jimmie E. Jinks

MINING HISTORY AND PRODUCTION

According to J. B. Tenney (Wilson and others, 1967), Spanish and Mexican miners in Arizona mined some silver but no appreciable gold prior to the acquisition of the territory by the United States. Except for some prospecting and mining near Tubac and Tucson prior to the Civil War and some prospecting and mining of rich gold placers in the central part of the State during the Civil War, little prospecting and mining were done in Arizona before the establishment of peace with the Indians about 1872. The silver deposits of Silver King, Globe, and Superior, east and south of the Superstition Wilderness study area, were discovered about 1874; presumably, the Superstition area was prospected at the same time or shortly thereafter.

The Goldfield Mine, about 2 mi west of the study area (pl. 3), is reported to have been worked during the early 1890's (Wilson and others 1967). At about the same time, initial work at the Palmer Mine, located inside the contiguous roadless area west of the Superstition Wilderness, was begun. The Palmer Mine has produced gold. The asbestos and iron prospects outside the southeast boundary of the Wilderness have no recorded production. The adits in upper Rogers Canyon (samples 11-13) and the workings in upper Whetrock Canyon (samples 45-55,60) may have produced silver but there is no official record of such production.

During the time of the field investigations, there were no producing mines within the Superstition Wilderness or the contiguous roadless areas.

MINING CLAIMS AND MINERAL LEASES

Bureau of Mines personnel searched Federal public land records and county courthouse records for information on mining claims and mineral leases within the Superstition Wilderness study area in 1973. Public land records of the U.S. Bureau of Land Management at the Arizona State Office in Phoenix showed no patented mining claims and no mineral leases, past or present, within the study area. Notices of location of mining claims and affidavits of annual labor on file at the Pinal County Courthouse in Florence and the Maricopa

County Courthouse in Phoenix indicate continuing low-level mineral activity in the study area. A search of the mining records of Gila County at Globe revealed few notices of location for claims in or adjacent to the study area.

Most of the mining claims filed over the years have not been maintained by the filing of affidavits of annual labor or assessment work. Some of the mining claim notices refer to lost mines or lost treasures, and many more notices have names which suggest that the claimant was primarily interested in legendary mines. Scattered older mining claims in and near the southeast corner of the wilderness were staked on showings of asbestos and iron.

Blocks of mining claims held by major mining companies near the Superstition Wilderness include claims connected with the Pinto Valley mine (fig. M2) east of the Wilderness and claims connected with porphyry copper exploration southeast of the wilderness between Miami and Superior. The boundaries of the blocks of mining claims extend roughly along the west side of Pinto Creek valley and along Haunted Canyon.

SAMPLING AND ANALYTICAL METHODS

Chip samples were taken across mineralized, altered, and sheared zones, and across country rock in accessible workings. But, many working visited during the present survey were inaccessible and could not be sampled. Where a mine dump was associated with an inaccessible working, a sample was taken of each rock type exposed on the dump at an appropriate grid spacing. If altered or mineralized fragments were present on the dump or near the working, specimen samples were taken of such material. But because the origin of these samples is uncertain, their significance cannot be determined.

All samples were fire assayed for gold and silver and analyzed spectrographically for copper, lead, zinc, tungsten, and chromium. Samples taken in zones of visible copper mineralization which assayed 0.3 percent copper or less spectrographically and which showed trace amounts or less of other metals were not analyzed further. Where the spectrographic analyses indicated lead or zinc values greater than 1 percent, the samples were analyzed by atomic absorption. Locations of the samples are shown on plate 3, and results of the analyses are shown in table J1. Holes dug by treasure hunters were not sampled. Most of these holes lie in the western part of the study area.

LOCAL PROSPECT AREAS

Prospect workings containing anomalous amounts of metals were found along the southern border within and adjacent to the Wilderness, within the western contiguous roadless area, and at the southeastern corner of the Superstition Wilderness (pl. 3).

Copper, silver, lead, and zinc are found along the south border in the vicinity of the JF Ranch and Peralta Canyon. Gold and copper occur at the Palmer Mine, which is within the western contiguous roadless area. Asbestos and iron are present near the old Kennedy Ranch at the southeast corner of the wilderness.

JF area

The JF area (fig. J1) is named after the JF Ranch whose buildings and windmill are located in Fraser Canyon in the protracted SE1/4 sec. 21, T. 1 N., R. 11 E. (unsurveyed, Protraction no. 61). The JF Ranch covers the southwestern part of a pocket of land excluded from the Superstition Wilderness along the southeast boundary.

The JF area is accessible from U.S. Highways 60 and 70 via the Queen Creek Road 3.5 mi west of Superior or 2 mi east of Florence Junction and the Hewitt Canyon Road which runs 8.7 mi north into the area. The Queen Creek Road is regularly maintained, but the Hewitt Canyon Road is not. Jeep trails facilitate access to many of the workings outside the Wilderness.

Mining claims have, at one time or another, covered all the workings in the JF area. The largest current group of mining claims in the area is the Lazy Mule Group, held by Carl Smith of Mesa, Arizona. It includes the Lazy Mule, Golden Rule, and Sky Blue mining claims. In late 1976 and early 1977, the Lazy Mule group was under option to Dual Resources, Inc., of Arizona and Canada. In January 1977, Dual had a diamond-drill rig working within the study area in Hewitt Canyon. A smaller group of claims, the Enterprise group, is held by George W. Gerhart of Mesa. Other mining claims have been staked in the area, but as of January 1977, current affidavits of labor had not been filed in the Pinal County courthouse in Florence.

Sample assays indicate that the mineralization in this area lies both inside and outside the wilderness and extends at least from prospects 1.5 mi south of the JF Ranch to adits and prospects in Rogers Canyon 2.7 mi northeast of the JF Ranch. Mineralization extends as far as 4.3 mi east of the JF Ranch to a caved adit on the northeast side of Montana Mountain. Evidence of mineralization was not found northwest of the JF Ranch.

The JF area has three apparent zones of mineralization; one of silver-lead-copper, one of silver-copper, and one of lead-zinc-copper (pl. 3). The three zones are postulated on the basis of old prospects and mine workings, chip samples from accessible workings, and grab samples of selected material believed to have come from the inaccessible workings. Because many of the workings are not accessible, however, the inference of mineralized zones is uncertain.

The lead-zinc-copper zone centers around the Lazy Mule No. 1 inclined shaft which lies 1.3 mi N. 42° E. from the JF Ranch (fig. J1). The timbered shaft was filled with water to within 30 ft of the collar, and the shaft ladder above the water level was in disrepair at the time of this field examination. Samples 24 and 25 (table J1) were taken from selected mineralized material lying near the collar. The dump lies along a wash, and most of it has been eroded.

The northeastern silver-copper zone extends along a ridgetop and eastward into Rogers Canyon. The zone is inferred from dump samples and samples of quartz veins up to 3 in. wide and stained with malachite.

The southwestern silver-lead-copper zone lies near the head of Whetrock Canyon, 0.9 mi south of the JF Ranch headquarters. Most of the workings are within the Wilderness boundary which follows the ridge line. The workings are old and, where accessible, expose malachite and chrysocolla along shear planes in Proterozoic rocks. The dominant mineralized shear attitude strikes N. 3° W. and dips 73°W.

Peralta area

The Peralta area (fig. J2) lies along the southwest border of the Superstition Wilderness in secs. 27, 28, 29, and 30, T. 1 N., R. 10 E. Secs. 27, 28, and 30 are within the Wilderness, and sec. 29 is part of the contiguous study area. Access from Apache Junction is southeast via U.S.

Highways 60-70-80-89. At 8.5 mi the Peralta Road, a maintained gravel road, leads 7 mi northeast to the Peralta Canyon Campground in sec. 29.

The Peralta area contains three groups of current mining claims: the Dacite Cliff claims, recorded by Andy Synbad; the Casi claims in the N1/2 sec. 28, recorded by Charles M. Crawford; and the Silver Eagle claims, also in the N1/2 sec. 28, recorded by Carl H. Clay.

Mineralization in the Peralta area appears to be associated with a frontal fault zone that strikes N. 75°-80° E. and dips 65°-85° N. The zone contains lead, copper, and minor zinc, silver, and gold values. Chromium is present in trace amounts (up to 0.01 percent by spectrographic analysis) in many of the samples. The fault zone separates cliff-forming Tertiary dacite and other volcanic rocks on the north from valley-forming Proterozoic schist and granite on the south.

Pits, trenches, open cuts, shafts, and adits occur along the fault zone from the Dacite Cliffs Mine northeast 2.4 mi to prospects just south of Miners Needle. The Dacite Cliffs Mine is the largest group of workings in the area, and the upper working is the most heavily mineralized.

Dacite Cliffs Mine

The Dacite Cliffs Mine consists of two workings, in the SE1/4 sec. 30, T. 1 N., R. 10 E., one at the base of the cliffs at about 2,460 ft elevation, and the second in the cliffs at about 2,985 ft elevation (fig. J3).

The upper working explores a vein of quartz, calcite, barite, chrysocolla, and malachite which strikes N. 85° E. and dips 85° N., ranges from 4 to 36 inches wide, and occupies a fracture zone. The dacite agglomerate wall rock in the vicinity of the working contains sparse to locally abundant fragments of fresh granitic rock. Two adits in the upper working are connected by a drift and a raise. The top adit was driven eastward on the vein, the bottom one northward to intersect the vein. A 30 in. wide chip sample (103) was cut across the vein in the back of the top adit 82 ft from the portal. It assayed 0.01 oz gold per ton, 0.9 oz silver per ton, 1.3 percent copper, and 1.5 percent lead.

The top adit contains a stoped area of about 200 cu yd, indicating that as much as 400-440 tons of material may have been shipped from it.

Where the bottom adit intersected the vein, a drift was driven westward along the vein. A raise driven on the vein from the drift to the top adit was not accessible. In the drift, the vein has pinched to a 4-in fracture zone with no copper staining.

The lower working at the base of the Dacite Cliffs consists of an adit, a drift, a raise, and several crosscuts (fig. J3). The adit intersects a fracture zone 689 ft from the portal. The strikes of the fractures vary from S. 80° E. to N. 80° E. and the dips vary from 75° N. to vertical, with the dominant strike being N. 85° E. and the dip 80° N.

The drift trends easterly along the fracture zone. A stringer vein in this zone is generally 1 in or less wide, except in a 20-ft raise near the west end of the drift where it widens to 6 in. The vein is composed of quartz, barite, and calcite. The entire working is in dacite agglomerate with no metallization observed. Essentially, no dump remains, and little material in the wash can be identified as coming from the working.

The attitude of the fracture zones in both workings, their relative positions, and the barium content of the samples indicate that the vein followed by the drift in the lower working of the Dacite Cliffs may be the same as the one explored by the upper working.

Other Peralta area prospects

Malachite, chrysocolla, and copper oxides occur in pits in Proterozoic granite south and east of the Peralta Canyon Campground. North of the campground and northeastward into the NW1/4 sec. 28, copper oxides are exposed in shafts, cuts, and pits in Tertiary volcanic rocks. Prospects south of Miners Needle are in Proterozoic rocks and also show copper mineralization.

Palmer mine

The Palmer mine area (pl. 3) is outside the west boundary of the Superstition Wilderness, but inside the contiguous roadless area, in N1/2 sec. 7, T. 1 N., R. 9 E. It can be reached via Arizona State Highway 88. In the vicinity of Goldfield, 5 mi north of Apache Junction, several maintained and unmaintained roads lead eastward to the Tonto National Forest boundary. At one time, a road led to the Palmer Mine. The mine dump beneath the high cliffs of the Superstition Mountains can be seen from Highway 88.

The Palmer mine was developed on a 2 to 14 in. siliceous vein within a breccia zone in dacite. The breccia zone, trending generally north-south and dipping vertically, is at least 50 ft wide. North-northwest-trending shears within the breccia are mineralized with limonite and malachite. The main vein and other quartz stringers in the breccia zone carry gold values. Though the mines at Goldfield are in Proterozoic granite, the Palmer mine may be located on the outer fringe of the Goldfield gold-mineralized zone.

Goldfield was already a booming mining camp when mineralization at the Palmer Mine was located and worked during the 1890's. Several times over the years, the shaft was rehabilitated and deepened and drifts were driven, but it appears that production was limited to a few tons. The shaft is now caved and filled with debris to within about 30 ft of the surface.

Two samples were taken at the Palmer mine. Sample 110, from the dump, was composed of selected pieces of quartz float with copper oxide staining and assayed 0.8 oz gold per ton, 0.1 oz silver per ton, 4.6 percent copper, and 0.08 percent tungsten. A chip sample (111) was taken at the north edge of the caved shaft across a 4.5 ft shear zone which has been altered to sericite and clay with limonite and malachite staining. It assayed a trace of gold, 1.6 oz silver per ton, 2.1 percent copper, 0.35 percent lead, and 0.025 percent tungsten.

A trench approximately 330 ft north of the Palmer mine exposes a 2 ft quartz vein striking N. 10° W. and dipping 81° W. A chip sample across the vein (112), assayed 0.11 oz gold per ton, 0.1 oz silver per ton, 1 percent copper and 0.04 percent tungsten. No other indication of metallization was found in the area.

Kennedy Ranch area

The Kennedy Ranch area lies southeast of the old Kennedy Ranch at the southeast corner of the Superstition Wilderness (pl. 3). Access from U.S. Highways 60 and 70 is by the Pinto Valley road to Pinto Creek, then west on a maintained ranch road 5 mi to the ranch headquarters. Chrysotile asbestos and magnetite-hematite iron deposits in the Kennedy Ranch area are briefly described by Peterson (1960). The asbestos deposits are discussed more fully by Stewart (1955), and the iron deposits by Harrer (1964). All of the reported asbestos and magnetite occurrences are outside the Superstition Wilderness.

Asbestos occurs in veinlets that pinch, swell, coalesce, and split within 2 in. The veinlets are generally 0.4 in or less wide rarely swelling to 3.2 in. Although some unweathered fibers are semisoft with fair tensile strength, most are harsh with little tensile strength.

Magnetite occurs in small irregular contact metamorphic and metasomatic replacement deposits. Harrer (1964) suggests that an aggregate of these small deposits represents a small source of iron.

Both asbestos and magnetite are associated with diabase sills and dikes in the Proterozoic Mescal Limestone. The known deposits total only a few tons, and the limited extent of limestone outcrops suggests that there is little potential for larger deposits. No production of asbestos or iron from the prospects in the Kennedy Ranch area has been reported.

William E. Bohme of Miami, Arizona, owner of the old Kennedy Ranch, maintains a few isolated mining claims in the vicinity of the ranch. Mining claims and millsites held by Cities Service Company and used in connection with the Pinto Valley copper mine to the east reach across Pinto Creek. Mining claims located along the copper-mineralized trend between Miami and Superior extend northwestward to Haunted Canyon. Both of these claim areas are at least 2.5 mi outside the Wilderness.

Other prospect workings

Numerous other prospect workings were examined and sampled, including Miller mine, Reeds Camp area at Coffee Flat Mountain, Williams Camp area at Bluff Springs Mountain, and Indian Paint mine area near Battleship Mountain. No evidence from these workings suggests the presence of mineral resources at these sites or elsewhere in the study area.

MISCELLANEOUS MINERALS

The geology and geologic history of the Superstition Wilderness study area are not conducive to the presence of oil, gas, or coal, and no indication of such deposits was found. No evidence of the existence of a geothermal resource has been found in the Superstition Wilderness.

Minable uranium deposits occur within several miles of the Superstition Wilderness in Dripping Spring Quartzite, but none have been reported within the wilderness. During the course of this study, the U.S. Geological Survey outlined a uranium anomaly in the northeastern part of the study area. However, the Bureau found no mining claims, prospect pits, or evidence of drilling in the vicinity of the anomaly.

Abundant granitic sand and gravel, both weathered granite and wash material, are present in and near outcrops of the Ruin Granite. Limited amounts of impure marble and bedded quartzite are in outcrops of the Apache Group and in outcrops of undivided Paleozoic rocks. Some rock suitable for building stone is present in areas of volcanic rock outcrops.

CONCLUSIONS

The occurrences of base and precious metals in prospect workings along the south border of the Superstition Wilderness in the Peralta and JF areas could be related to deep-seated metal deposits. Only a thorough core drilling program would determine whether such deposits occur.

Other prospect workings within the Wilderness; Reeds Camp, Williams Camp, Indian Paint mine, Miller mine, and others that are unnamed, are barren.

MINERAL RESOURCE POTENTIAL

By

Donald W. Peterson

INTRODUCTION

The location of the Superstition Wilderness study area, adjacent to Arizona's great copper province, dictates that thoughtful consideration be given to geologic conditions that might suggest the presence of mineral deposits. This consideration should include deposits of potential value not only under current economic conditions, but also those that might become valuable during a changed economic climate or more advanced technology. Figure 3 shows the relation of the wilderness study area to major copper deposits throughout Arizona, and figure M1 shows its position relative to nearby mines. The boundary of the study area reaches to within about 6 mi of two major copper mines, Pinto Valley to the east and Magma to the south, and lies within 20 mi of mines whose total production has exceeded a value of $2 billion.

In spite of this proximity, however, and in spite of intensive prospecting throughout the past century of the same kind that led to the major discoveries nearby, little mining activity has resulted in the study area. Even the persistent searching spurred by ubiquitous legends of lost mines has led to profits only for the writers and purveyors of the tales. The most important prospects and the recent exploration activities are summarized in the section dealing with the Mines and Mineralization by Jinks. Those small deposits have not prompted sustained interest by industry.

The discussion here focuses on the questions of whether or not valuable mineral deposits actually might lie within the Superstition Wilderness or adjacent study areas. Do geologic relations suggest that it is unlikely that mineral deposits of value lie within the area? Or, is there a reasonable possibility that future exploration, land-use regulations permitting, might reveal concealed deposits that have hitherto defied discovery? This evaluation is based on the combined results of the reconnaissance geologic mapping, the mineral examination of known prospects, and the geochemical and geophysical surveys, all of which are described in other sections. The interpretations made here must be judged in reference to the character, scope, and limitations of these studies.

GEOLOGIC CONTROLS OF NEARBY ORE DEPOSITS

An essential step in evaluating the potential for mineral deposits in the wilderness is to compare general geologic relations with those of the nearby productive areas, particularly those factors believed to be related to concentration of valuable deposits. Peterson (1962, p. 142-145) summarized the importance of a prevailing northeasterly structural trend on the ore deposits of the Globe-Miami district and showed that this trend continues southwestward to include the deposits at Superior and vicinity (fig. M1). It has been noted that the ore deposits at Poston Butte and Sacaton also lie on this trend (fig. 3). Peterson further demonstrated that the large deposits of disseminated copper are distributed near the outer margins of the stock of Schultze Granite of Laramide age. The productive vein deposits near Globe and Superior lie equidistant northeast and southwest, respectively, from the center of the stock. Northeast-trending structures characterize most of these deposits, although in some deposits the mineralized structures assume an east-northeastward or eastward trend. Peterson (1962) further pointed out the proximity of the Globe-Miami deposits to the intrusive contacts (largely concealed) of the Ruin Granite with the Pinal Schist (fig. M2). He speculated that this contact constitutes a zone of weakness along which Cretaceous or Tertiary intrusive rocks and their related ore deposits were emplaced. The deposits near Superior, however, while following the east-to-northeast structural trend, do not lie near this Proterozoic igneous contact. The contact, however, does cross the southern part of the Superstition Wilderness.

SUPERSTITION WILDERNESS COMPARED WITH GLOBE-MIAMI DISTRICT

The Superstition Wilderness study area is northwest of and distinctly outside the bounds of the productive Globe-Miami-Superior mineral belt (fig. M1). However, certain conditions in the study area resemble the geology of the mineral belt, such as complex fault patterns and an assemblage of the same rock units that are host rocks for known ore deposits. Most intriguing, however, is the east-northeast-trending band of geochemical anomalies (figs. C7, C14, C16) that closely parallels the Proterozoic igneous contact of granite intrusive into schist (fig. M2). The anomalies coincide, furthermore, with the east-northeast row of mineral prospects (see section "Local Prospect Areas") that lies near the south margin of the study area, and with a series of alined magnetic anomalies (fig. P1).

One factor lacking in the wilderness which would complete the analogous conditions is a pluton of Laramide age. If such a pluton were present, its periphery would present an attractive exploration target. The Arizona State geologic map (Wilson and others, 1969) shows a small Laramide pluton in the area just south of Iron Mountain, but a diligent search during fieldwork failed to identify igneous rocks other than those illustrated in plate 1. However, the swarm of highly altered felsite and porphyry dikes in the JF area suggests the possibility of a nearby concealed Laramide pluton. A distinct geochemical anomaly roughly coincides with the area in which the dikes crop out (fig. C7). A concealed pluton is not likely to be revealed by gravity because of a lack of density contrast between such a pluton and the granite and the schist exposed at the surface. However, the east-northeast-trending negative aeromagnetic anomaly closely paralleling the schist-granite contact (fig. P1) can be interpreted as associated with hydrothermal alteration, which possibly was produced during emplacement of a concealed pluton. The association of sporadic rock alteration, geochemical anomalies, and scattered mineral prospects suggests the possible existence of additional mineralized ground. While highly speculative, as are most mineral prospects, the JF area and the belt extending along the south margin of the wilderness constitute typical targets of interest for mineral exploration under an appropriate economic climate and metallic commodity demand.

The thick cover of volcanic rock in the western part of the wilderness conceals from view a large area of older rocks. Do geologic conditions indicate the likelihood that the eruptive products covered pre-Tertiary mineral deposits? Within the area of thick volcanic cover no windows of older rock crop out that might provide hints to the character of the concealed bedrock. However, the west-southwest-trending belt of geochemical anomalies in pre-Tertiary rocks persists westward from the JF area parallel to the south boundary of the volcanic rocks. In addition, several geochemical anomalies in the eastern half of the Goldfield quadrangle are entirely within the outcrop area of Tertiary volcanic rocks (fig. C7). One possible cause of these anomalies would be upward migration of mineral-bearing fluids from mineralized bodies buried beneath the volcanic rocks. In most places, however, the depth to pre-Tertiary bedrock is not known. The exposed bedrock to the northeast and east is chiefly the Ruin Granite and the Apache Group, both of which lie north of the mineralized belt. The granite bedrock exposed west of the Superstition Mountains suggests that the rocks underlying the volcanics are similar to those to the northeast. If these are the only rocks present, they likely are barren. If, however, they were intruded by a stock of Cretaceous or early Tertiary age, mineral deposits might have formed. No specific evidence for such a stock beneath the volcanic rocks was found during this project, but a concealed stock would provide a speculative explanation for the geochemical anomalies in the eastern half of the Goldfield quadrangle. The highly speculative nature of this possibility, the thick volcanic cover, and the established designation of wilderness combine to reduce the attractiveness of this area for mineral exploration.

MINERAL ASSOCIATION WITH VOLCANIC CAULDRONS

Volcanic cauldrons provide ore controls for deposits in several mining areas, such as the San Juan Mountains of Colorado and the McDermitt district of Nevada. Major cauldrons in many other volcanic areas, however, do not seem to be associated with ore deposits. Reasons underlying the differences are not yet well understood; hence, in the absence of evidence indicating mineralization, volcanic cauldrons represent highly speculative targets for mineral exploration.

Cauldrons in Arizona have, thus far, elicited little interest as potential targets. The main reason for the lack of interest is that most volcanic rocks and their source areas are of middle to late Tertiary age, and although some ore deposits are in Tertiary volcanic rocks, their importance is relatively small. Most major ore deposits in Arizona are of Late Cretaceous or early Tertiary age and are associated with stocks. Hence, major searches are normally focused on totally different geologic terrane. In addition, until recently, few cauldrons had been recognized because deep erosion and postvolcanic structures have obscured their nature. As cauldrons are identified in the future, each will probably be studied for possible association with mineral deposits.

In this respect, the cauldrons in the Superstition Wilderness (fig. 4) merit some interest. In particular, the east-northeast-trending belt of mineral prospects and geochemical anomalies involving both Tertiary and pre-Tertiary rocks lies roughly tangent to both the Superstition cauldron (Sheridan, 1978) and the La Barge Canyon cauldron. Although the east-northeast trend coincides with the general trend of known, earlier formed deposits in nearby districts, the proximity of the mineralized belt to the cauldrons suggests a possible alternative interpretation that mineralization in the study area is of Tertiary age and is related to the volcanic activity. A more detailed geologic and mineralogic study will be required to reveal the most likely interpretation. If the cauldrons should be identified as the probable source for the mineralization, the other margins of the cauldrons to the west, east, and north, where potential host rocks are more deeply buried, would also become exploration targets. On the basis of present knowledge, however, such an interpretation must be regarded as highly speculative.

The Haunted Canyon cauldron, part of which lies within the southeast corner of the wilderness, is adjacent to mineralized zones along its south margin, outside the wilderness (J. D. Lowell, oral commun., 1976). No mineralization was recognized at the surface along the west and north margins of this cauldron within the wilderness, but complex structures and spotty alteration suggest an environment of possible future interest.

In summary, calderas and volcanic cauldrons, largely unrecognized in Arizona, remain essentially untested for their mineral potential. The origin of already known ore deposits in Arizona can be readily ascribed to other causes. However, as improved and more detailed studies of volcanic terranes are carried out and cauldrons are identified, each of them will represent a potential target for mineral exploration.

URANIUM ANOMALY

Only a small selected group of samples collected in this study was tested for uranium, but several samples in the northeastern part of the wilderness yielded high values. The occurrence is not yet understood and needs further study before it can be determined if it represents a potential commercial deposit.

The Dripping Spring Quartzite of the Apache Group is a host for uranium deposits in the region north and northeast of the wilderness (Granger and Raup, 1959, 1969), and the Dripping Spring crops out extensively in the eastern part of the wilderness. However, most of the anomalous uranium values were found in areas underlain by the Ruin Granite. It is not yet known whether the high values represent migration and deposition of uranium along faults cutting the granite from a source in the Dripping Spring, now eroded away, or whether the uranium had a different origin.

THE LEGEND OF THE LOST DUTCHMAN

Stories of lost mines impart significant elements of charm and enchantment to the southwestern desert, and the Superstition Mountains are the site of some of the most persistent of these tales. Perhaps the most famous of these fabled mines is the Lost Dutchman, and for many years treasure seekers have combed the rugged terrain of these mountains seeking its elusive riches. Occasional announcements of success have been proclaimed, but none have led to productive operations. Even today prospectors toil, convinced that they have properly read and interpreted the enigmatic signs and directions from one or another of the dozen or so "legitimate" maps that portray the evasive trove.

The searchers persist in spite of the near-unamimous opinion of geologists and mining engineers that the Superstition Mountains are an unlikely locality for a rich gold deposit that could have been found with the tools and techniques available during the 19th century. Of greater credence is the possibility that gold from elsewhere may have been carried into and concealed in these mountains, for potential hiding places abound. Geologic relations, of course, will have no bearing whatever on finding a hidden cache. However, even the possibility of a cache may be remote, as elements of the legend are at some variance with documented facts.

Many versions of the Lost Dutchman legend are available, and any novice treasure seeker faces the task of selecting the most appealing. None of the versions are recounted here. A scholarly account of the facts behind the legend, the adventures and misadventures of some of the more prominent treasure seekers, and comprehensive reference citations have been prepared by Blair (1975). His report advances the thesis that whatever gold the "Dutchman" produced was from a source far from the Superstitions. It also reviews the actions and antics of an assortment of colorful individuals that led to the widespread but probably erroneous belief that the Superstition Mountains are the site of the Lost Dutchman--mine or cache. It seems unlikely, however, that either historical fact or scientific opinion will completely cool the ardor of dedicated argonauts, and the Superstitions will almost certainly continue to carry connotations of romance, mystery, and latent bonanza.

SUMMARY OF MINERAL POTENTIAL

Mine prospects and anomalously high mineral values lie in an east-northeast belt extending along the south margins of the Superstition Wilderness and adjacent study areas. These areas can be variously interpreted: (1) mineralization occurs as random spotty concentrations, typical of thousands of prospected areas throughout Arizona; (2) the trend of the anomalies is similar to significant mineralized zones in the nearby Globe-Miami and Superior mining districts, and thus the belt of prospects may represent emanations from an inferred body of buried intrusive rocks that represents a possible source of mineralization; (3) the proximity of the anomalous belt to volcanic cauldrons suggests an alternative interpretation that volcanic processes are the source of the mineralization.

Interpretation (1) implies but little potential for significant mineralization in the wilderness. Interpretations (2) and (3) both imply potential for more extensive mineralization. To test this potential, however, more detailed studies and subsurface exploration will be required.

The uranium anomalies in the northeastern section of the wilderness represent a possible area for further study and testing.

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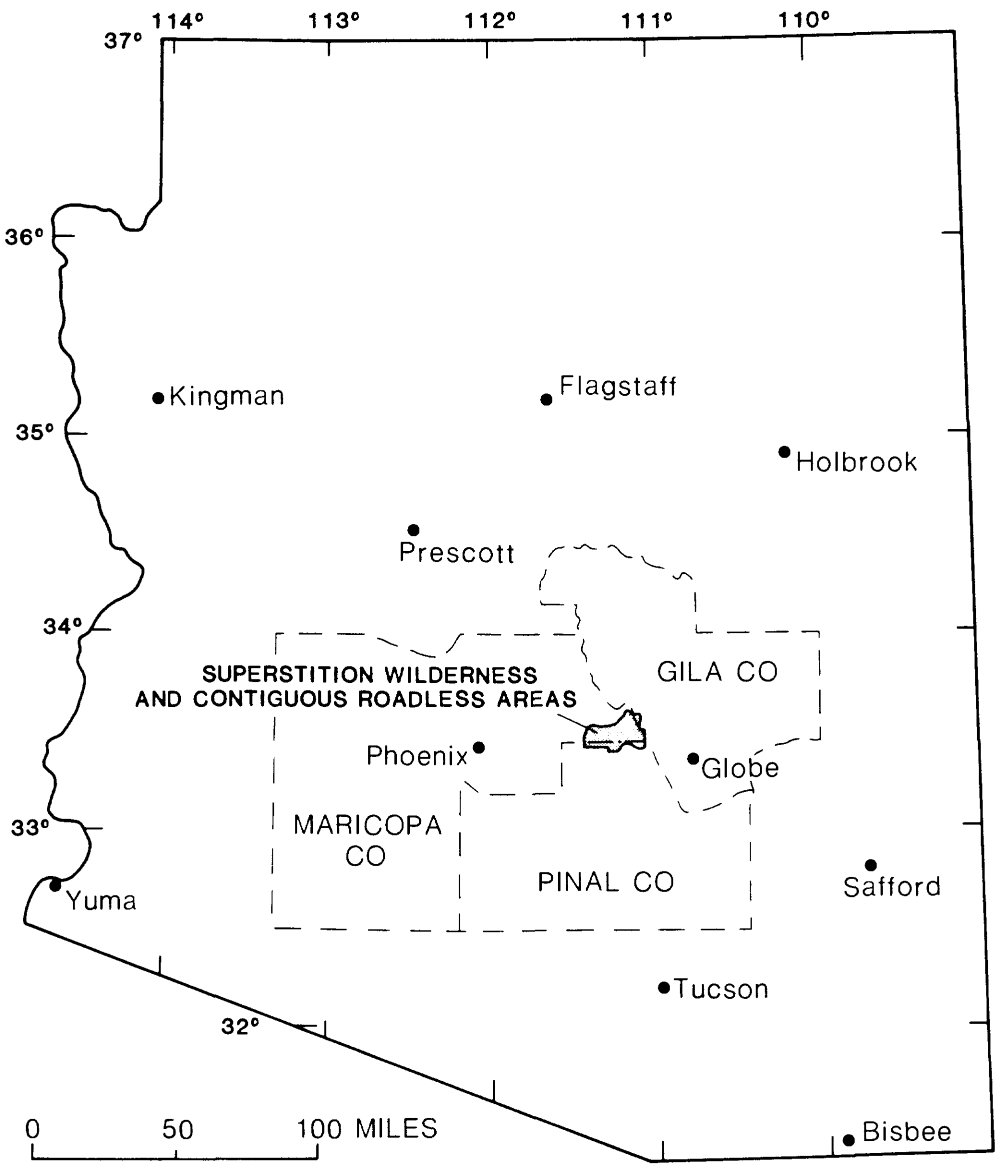


Figure 1.--Index map of Arizona showing approximate location of Superstition Wilderness and contiguous roadless areas.

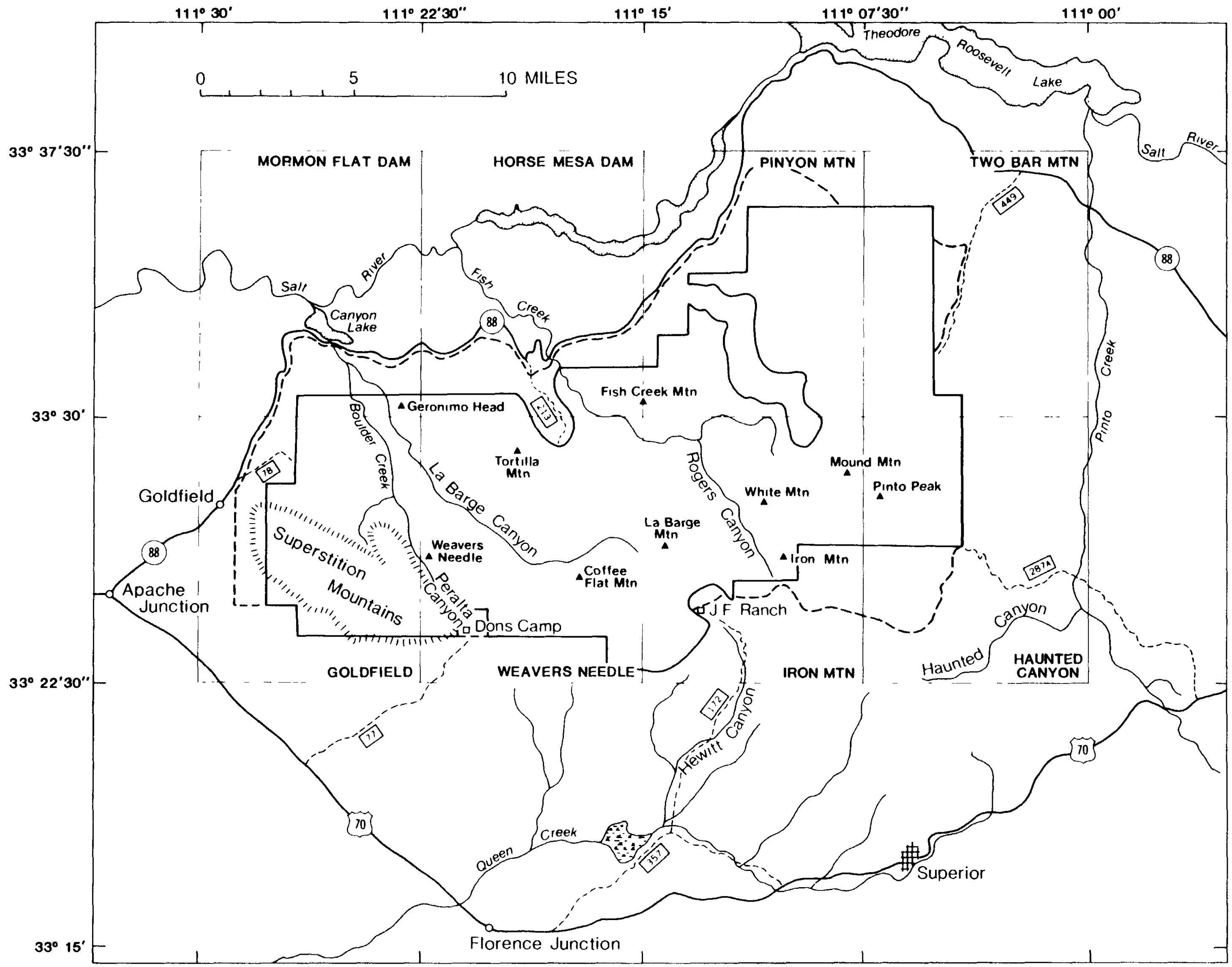


Figure 2.--Superstition Wilderness study area, showing boundaries of wilderness (solid line) and contiguous roadless areas (dashed line) and locations of major geographic features, routes of access, and U. S. Geological Survey 7 1/2 - minute quadrangles.

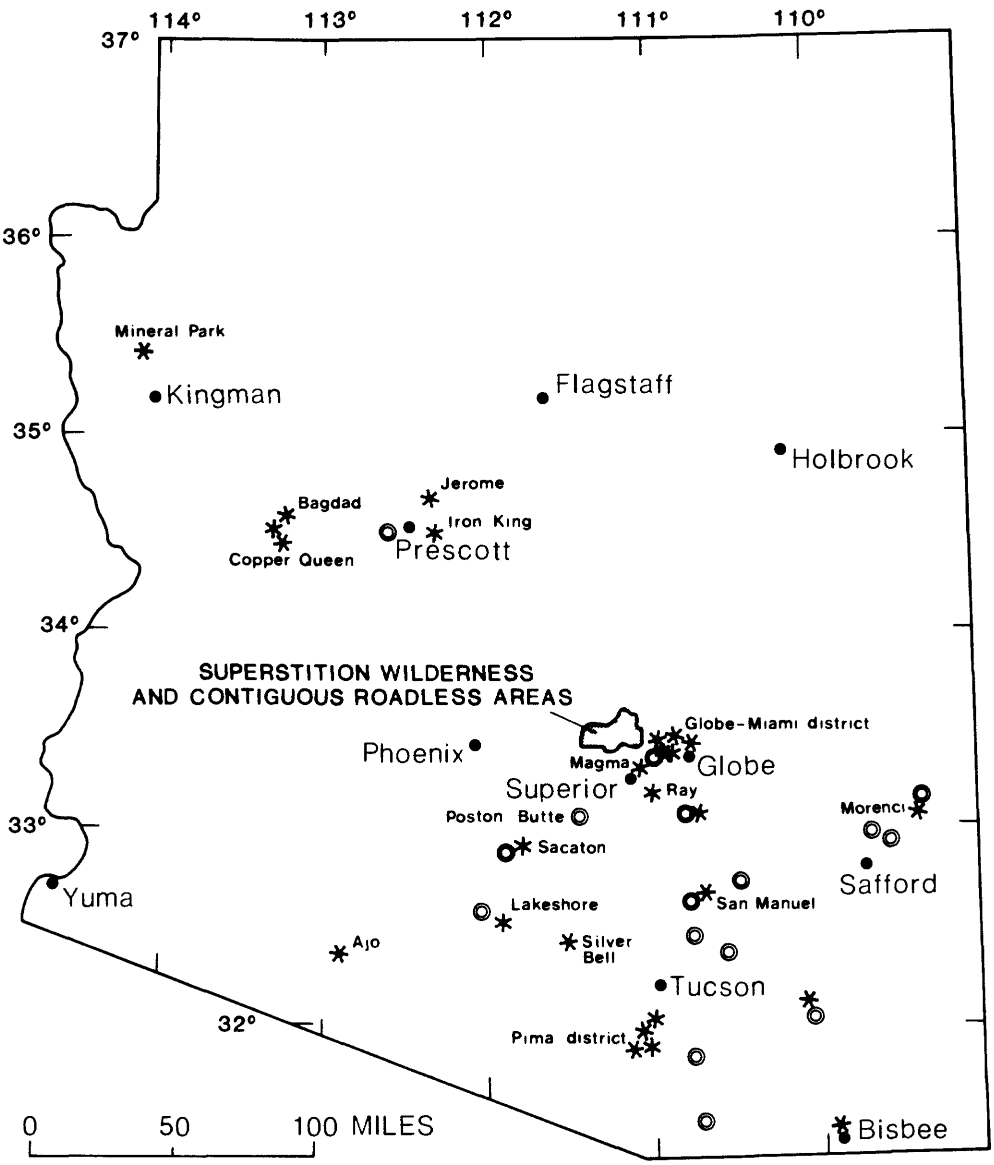


Figure 3.--Arizona, showing relation of Superstition Wilderness study area to known major copper deposits. *, past or presently producing deposit; O, known deposit not yet producing.

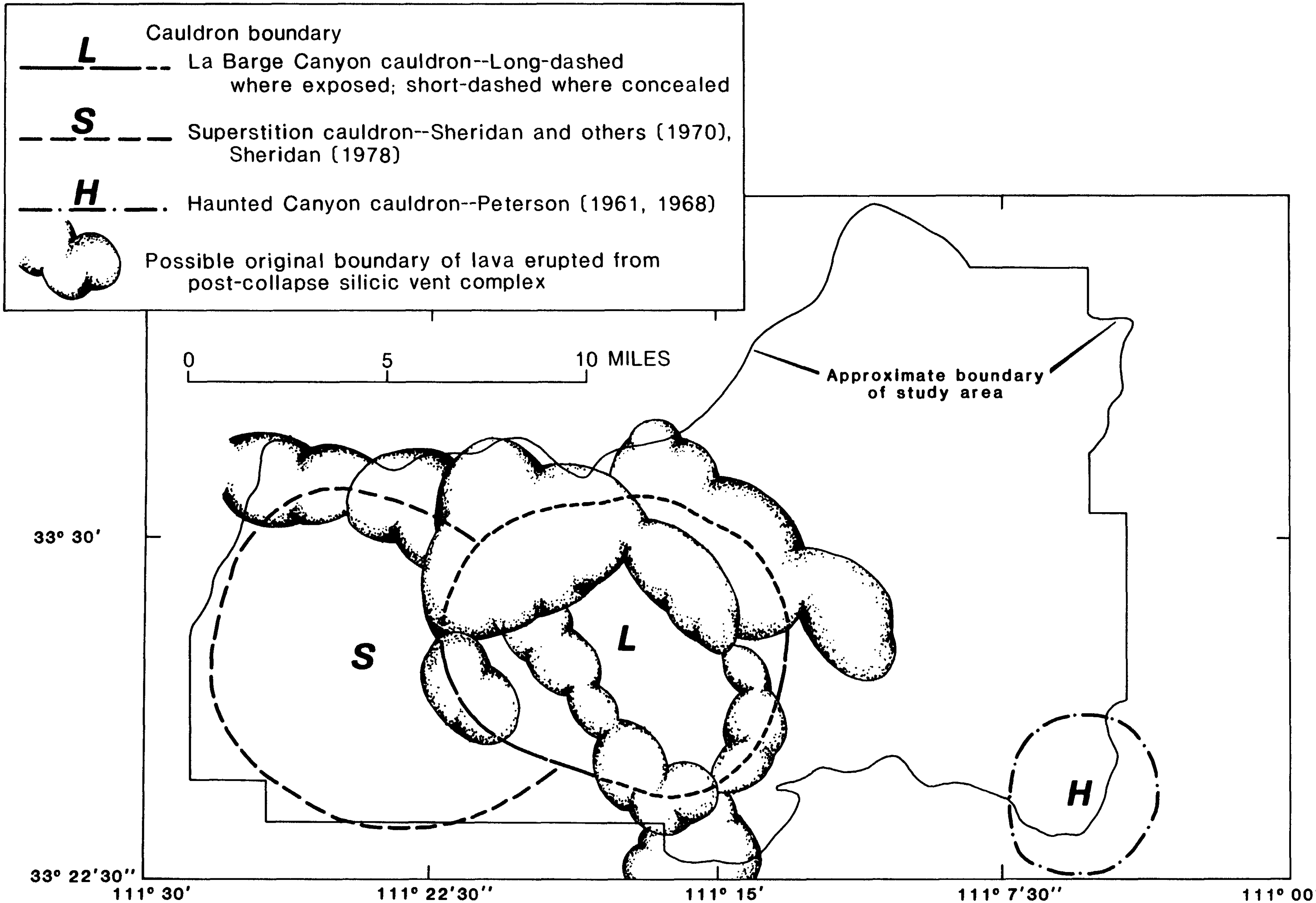


Figure 4.--Approximate locations of cauldrons in the Superstition Wilderness study area.

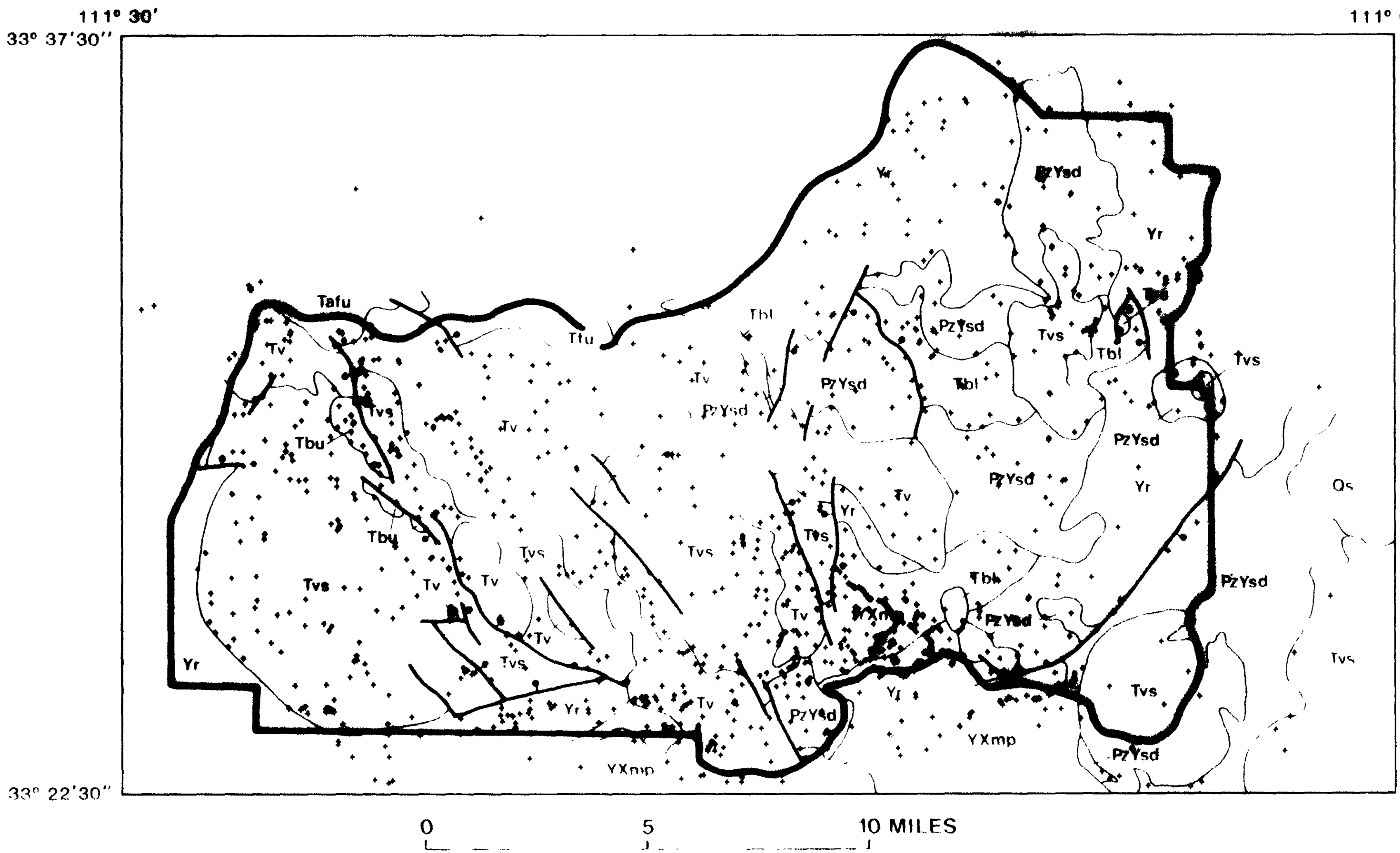


Figure C1.–Localities of 1,231 rock samples in the Superstition Wilderness and vicinity, Arizona. See following page for explanation of geology.

EXPLANATION OF GEOLOGY

Qs

Surficial deposits
(Quaternary)

Ttu

Upper tuff
(Tertiary)

Tafu

Upper ash-flow tuff
(Tertiary)

Tbu

Upper basalt
(Tertiary)

Tv

Volcanic rocks
(Tertiary)

Tvs

Volcanic and sedimentary rocks
(Tertiary)

Tbl

Lower basalt
(Tertiary)

PzYsd

Sedimentary rocks and diabase, undivided
(Paleozoic and Middle Proterozoic)

Yr

Ruin Granite
(Middle Proterozoic)

YXmp

Madera Diorite and Pinal Schist
(Middle and Early Proterozoic)

Contact

Fault--Ball and bar on downthrown side

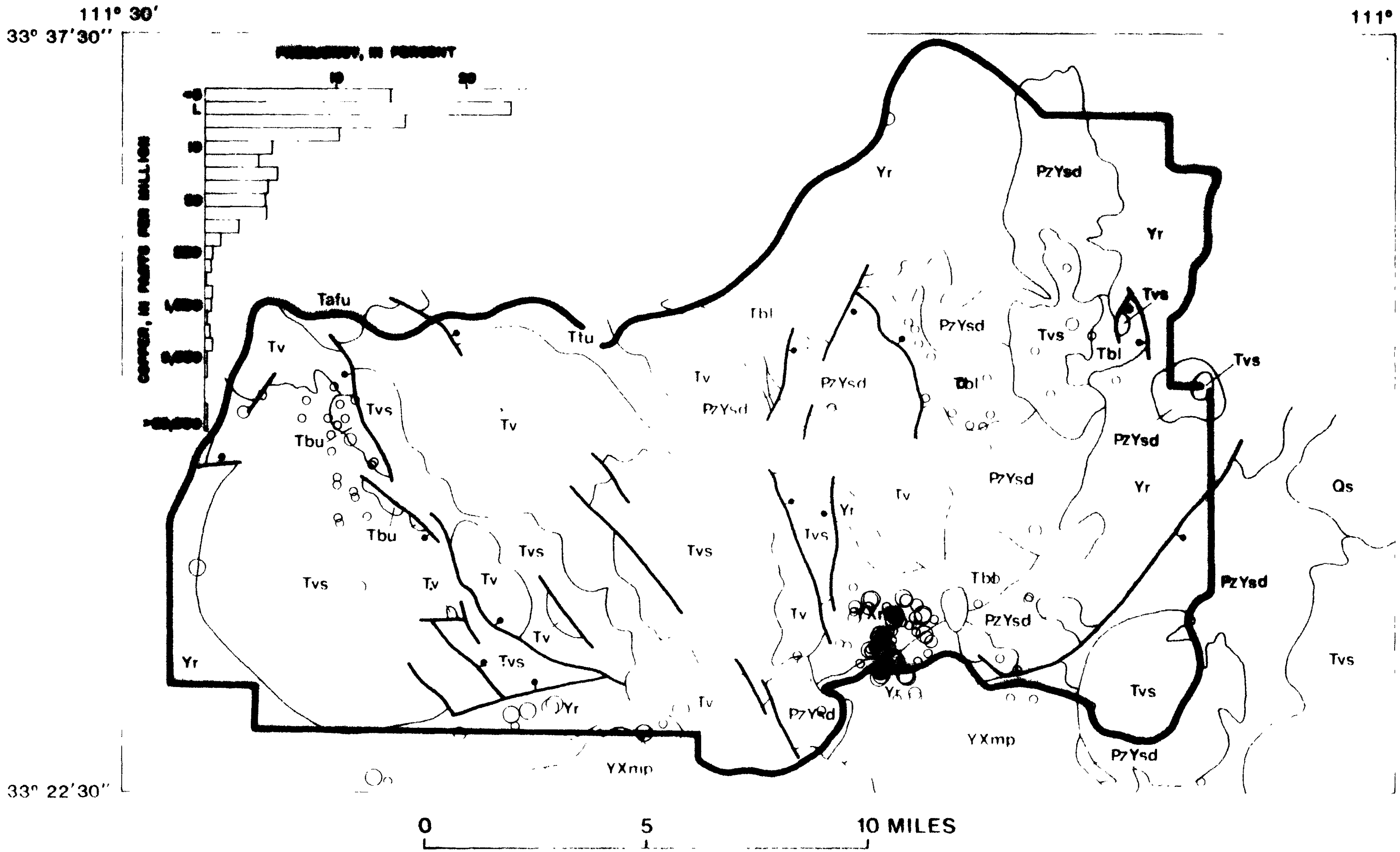


Figure C2.--Distribution of copper in rocks, Superstition Wilderness and vicinity. Copper, in parts per million: o, 70-100; ○, 150-300; ◯, 500->20,000. L, detected but less than analytical sensitivity. See figure C1 for explanation of geology.

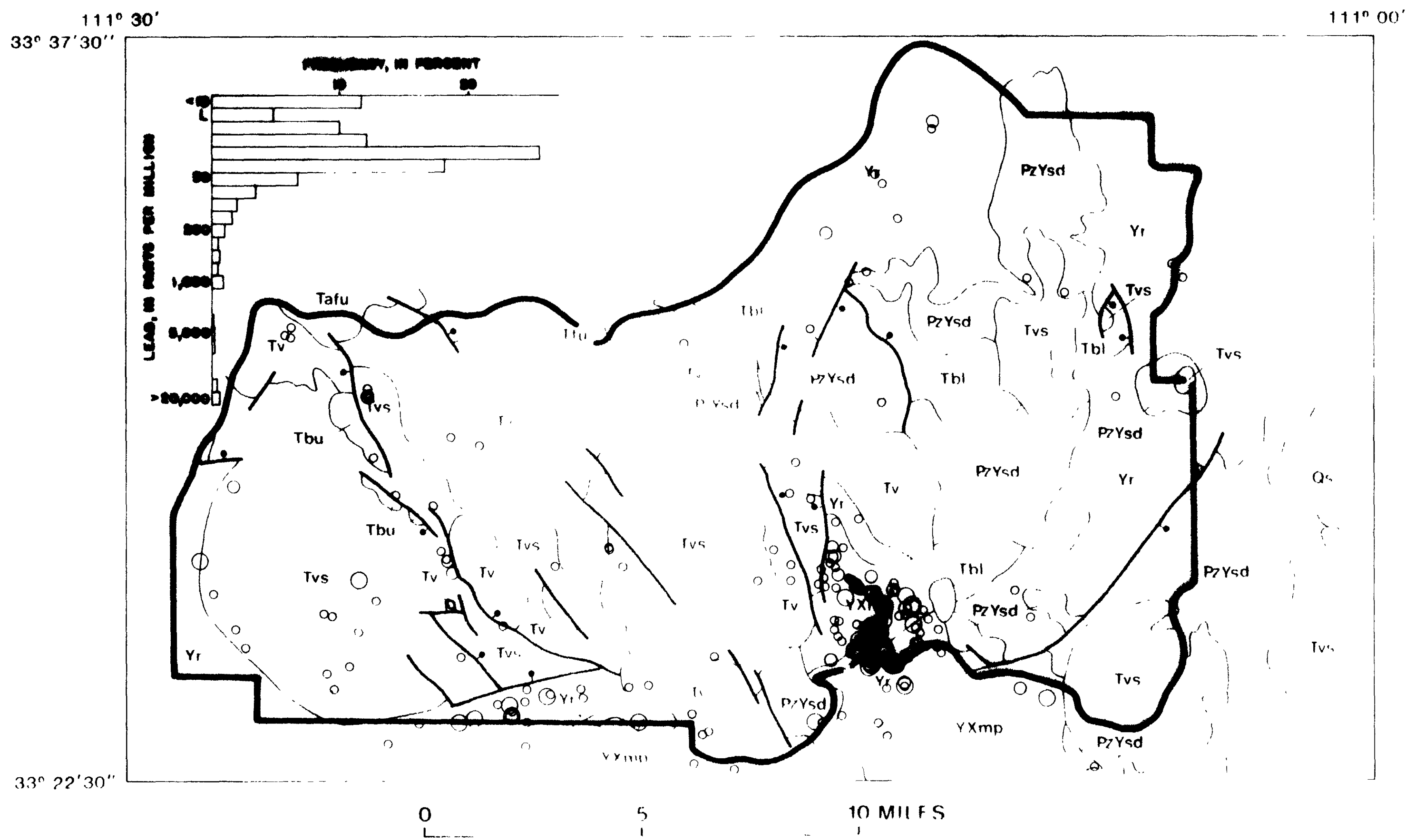


Figure C3.--Distribution of lead in rocks, Superstition Wilderness and vicinity. Lead, in parts per million: ○, 50-100; ○, 150-200; ○, 300->20,000. L, detected but less than analytical sensitivity. See figure C1 for explanation of geology.

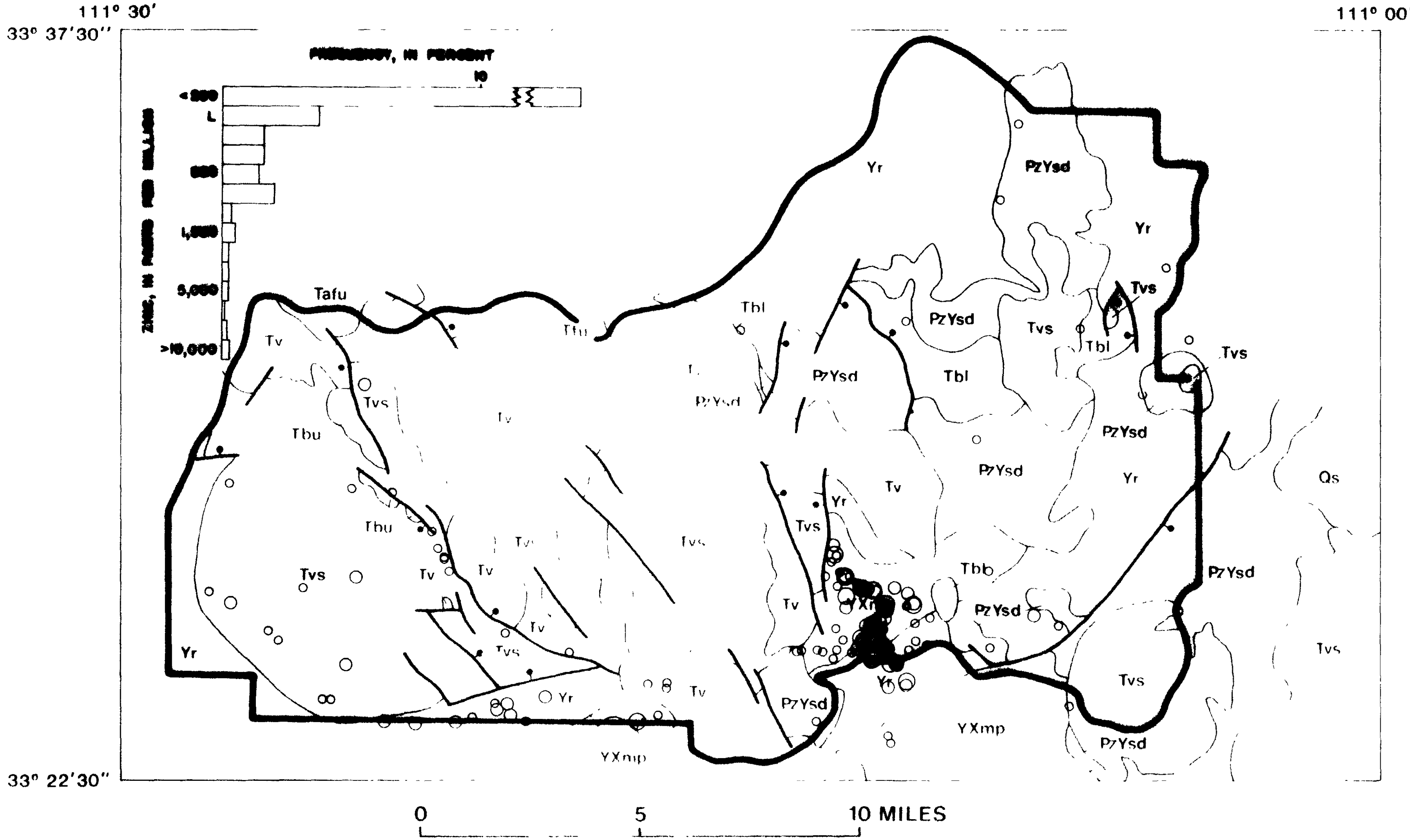


Figure C4.—Distribution of zinc in rocks, Superstition Wilderness and vicinity. Zinc, in parts per million: o, L(200)-300; o, 500-700; ◯, 1,000->10,000. L, detected but less than analytical sensitivity. See figure C1 for explanation of geology.

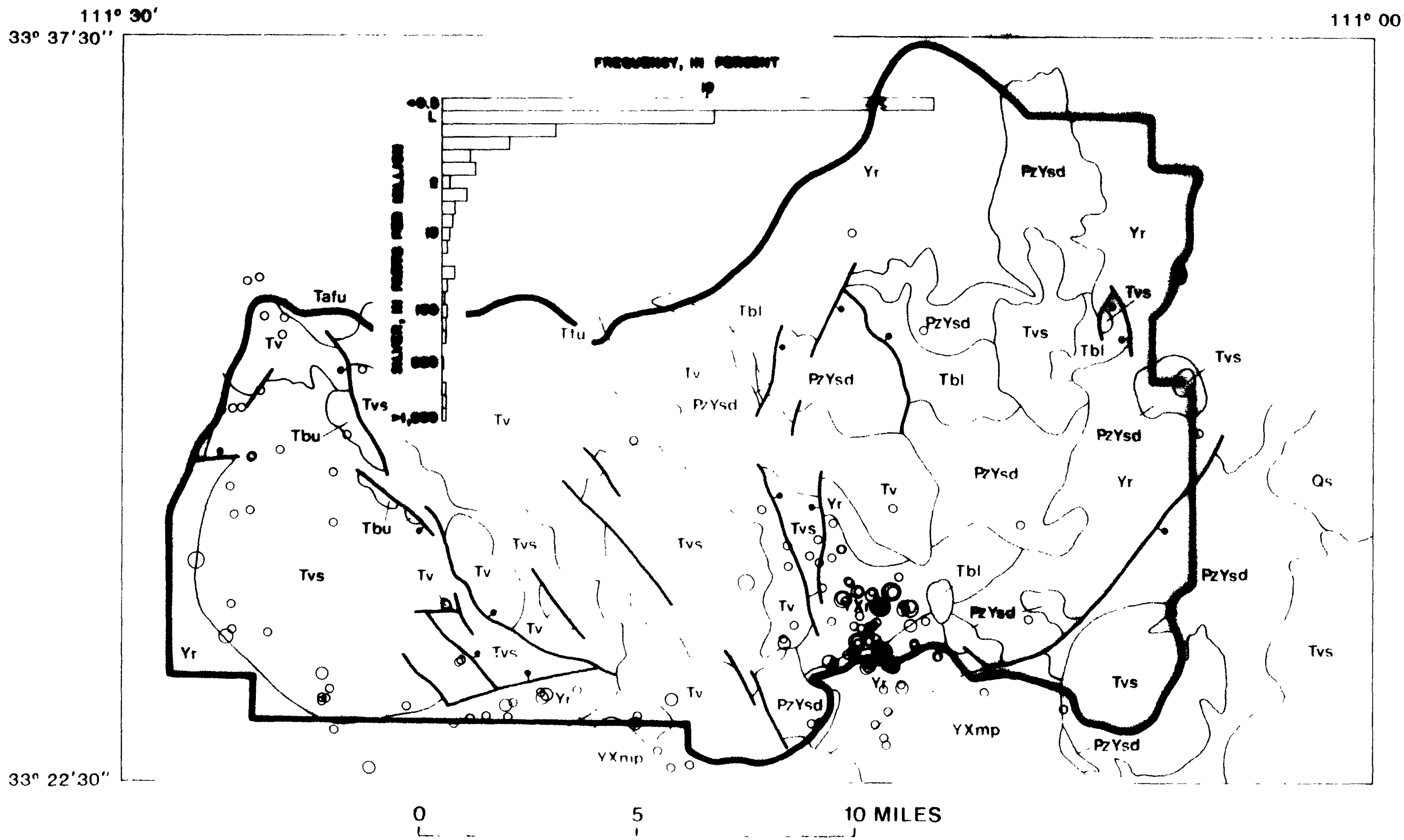


Figure C6.—Distribution of silver in rocks, Superstition Wilderness and vicinity. Silver, in parts per million: ○, 0.5-2; ○, 3-15; ◯, 20->1,500. L, detected but less than analytical sensitivity. See figure C1 for explanation of geology.

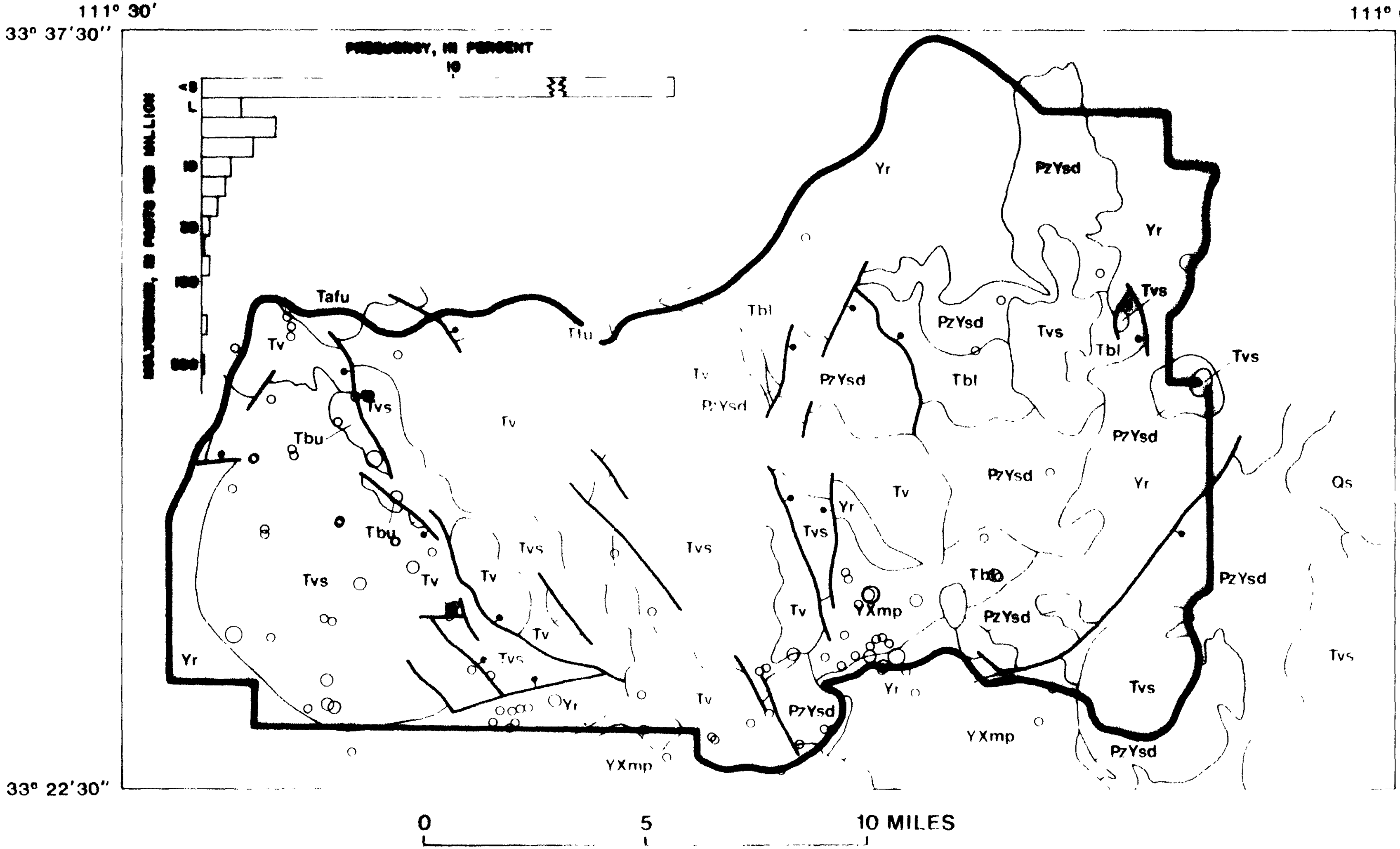


Figure C6.–Distribution of molybdenum in rocks, Superstition Wilderness and vicinity. Molybdenum, in parts per million: ∘, 5-15; ○, 20-50; ◯, 70-500. L, detected but less than analytical sensitivity. See figure C1 for explanation of geology.

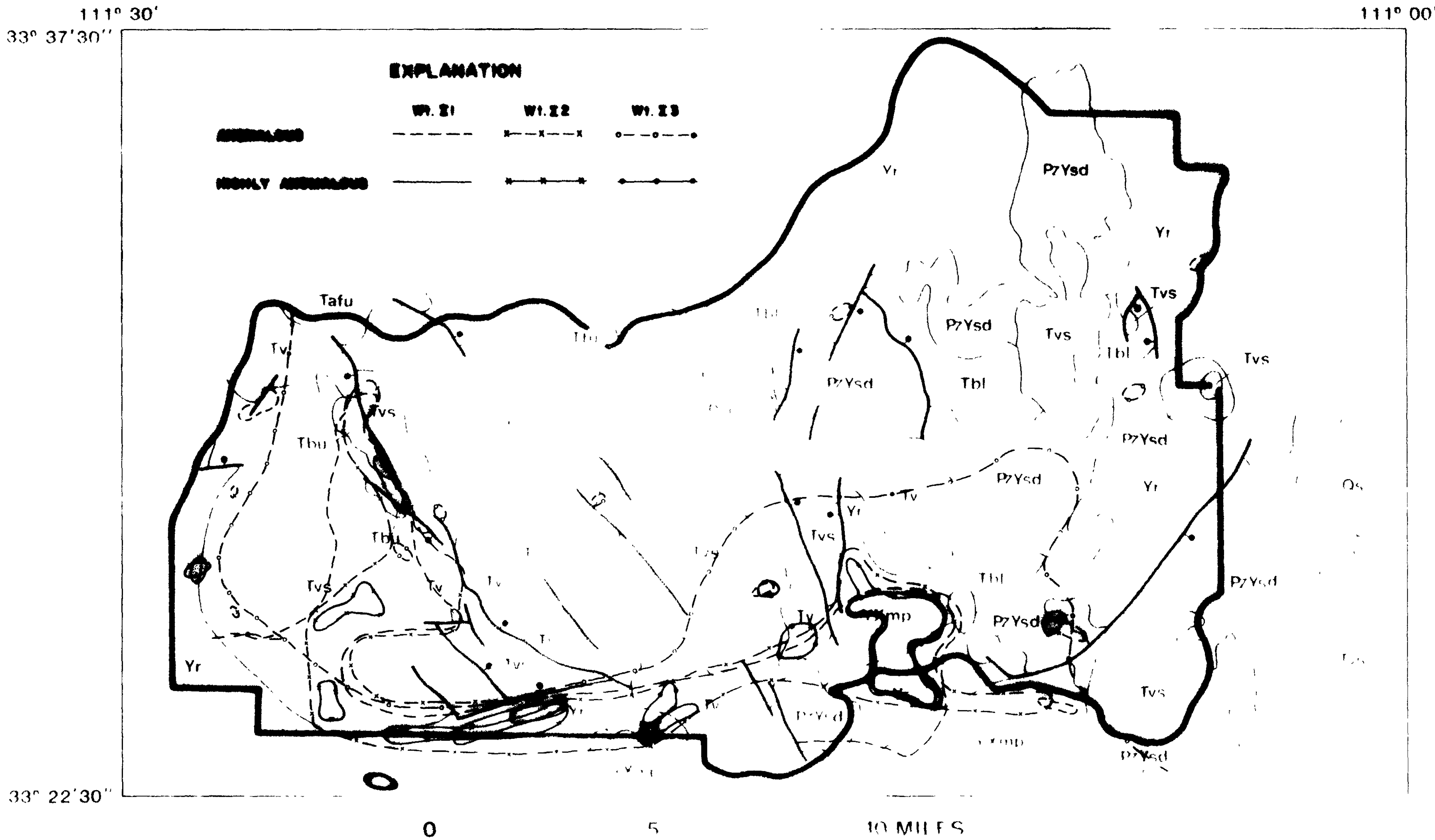


Figure C7 --Distribution plots of the weighted sums (wt.Σ) for rock samples in the Superstition Wilderness and vicinity. Wt.Σ1, molybdenum, lead, copper, and silver; wt.Σ2, flourine, zinc, and manganese; wt.Σ3, mercury, silver, and boron. See figure C1 for explanation of geology.

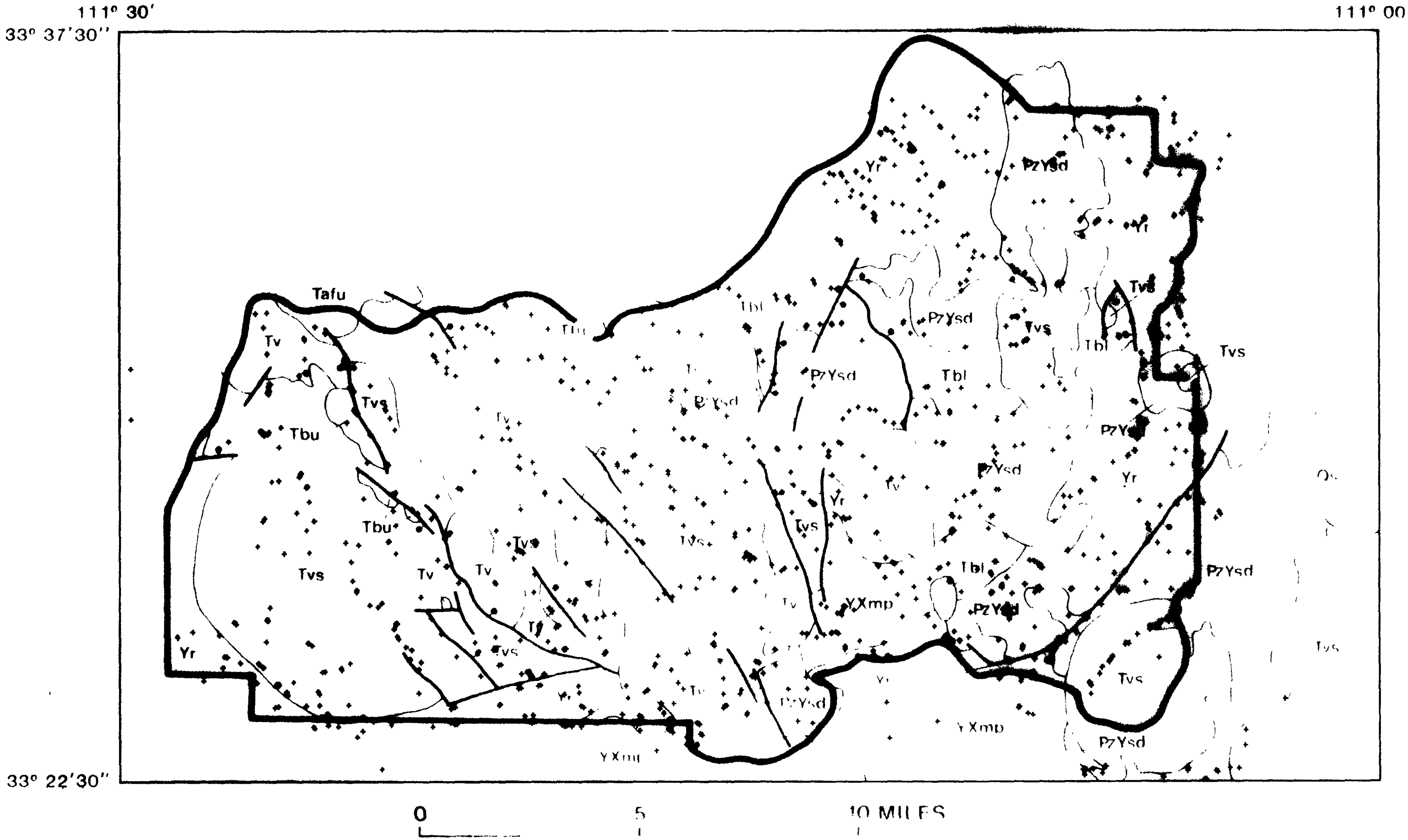


Figure C8.—Localities of 1,038 stream-sediment samples in the Superstition Wilderness and vicinity, Arizona. See figure C1 for explanation of geology.

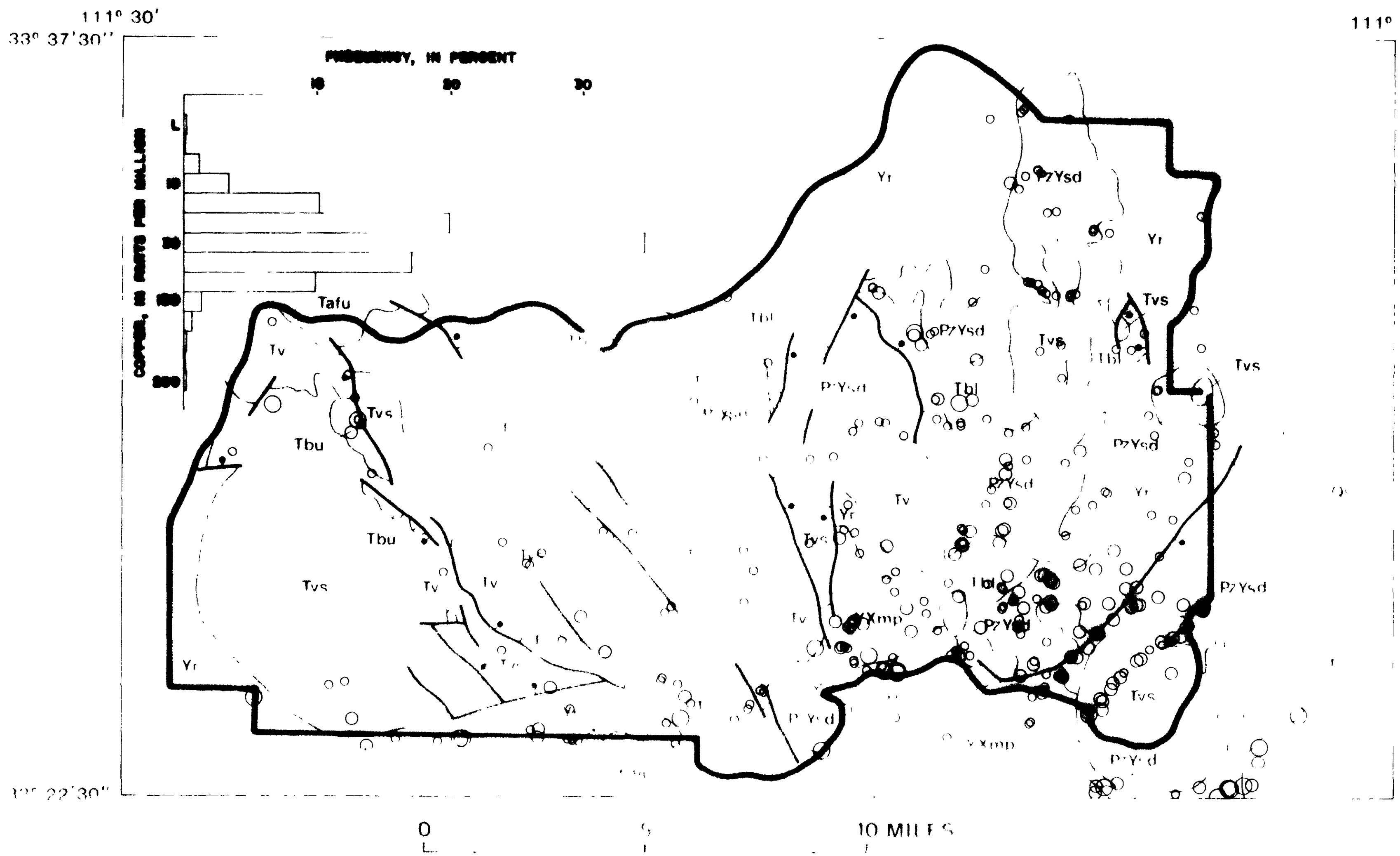


Figure C9.--Distribution of copper in stream-sediment samples, Superstition Wilderness and vicinity. Copper, in parts per million: ○, 50; ○, 70; ◯, 100-500. L, detected but less than analytical sensitivity. See figure C1 for explanation of geology.

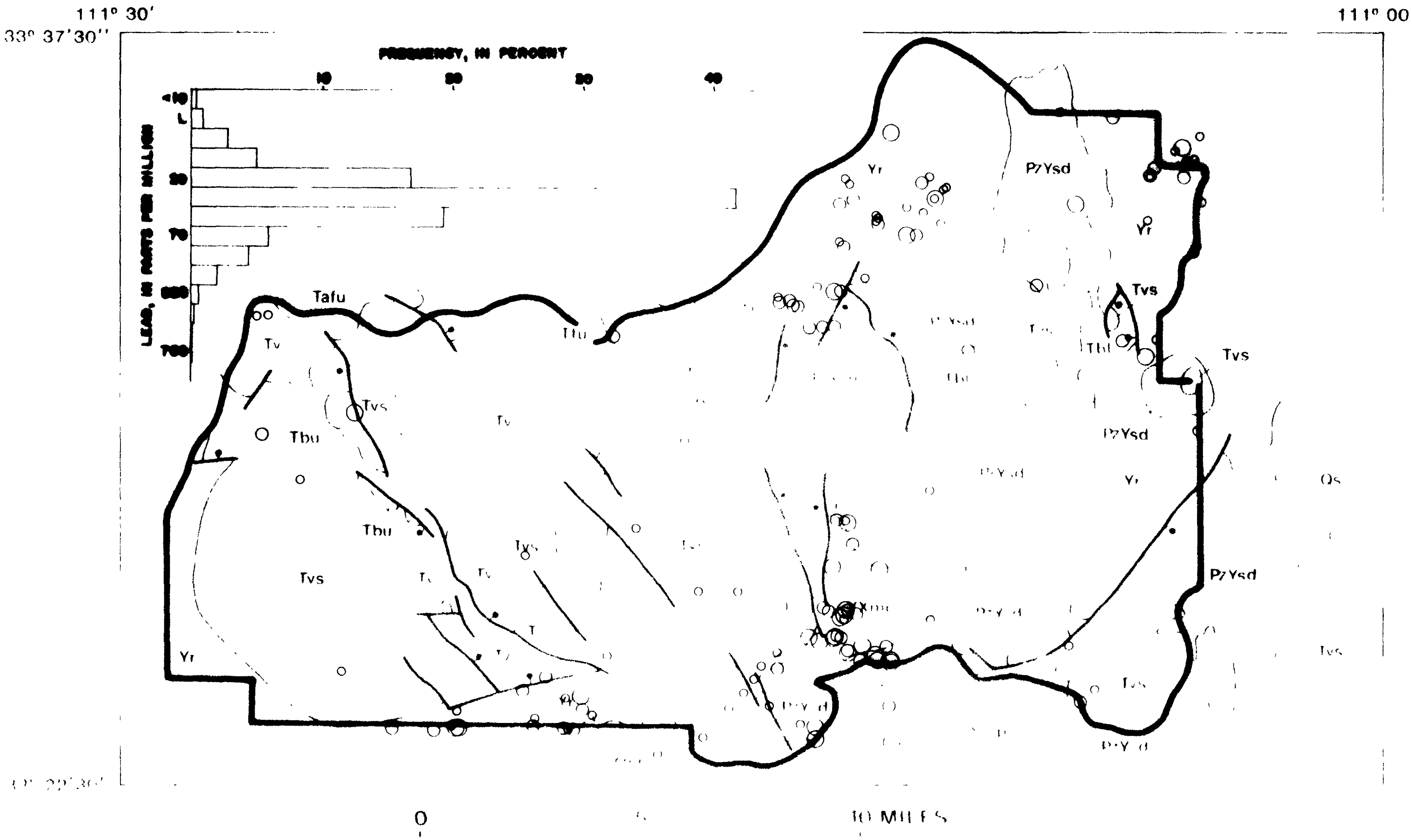


Figure C10.--Distribution of lead in stream-sediment samples, Superstition Wilderness and vicinity. Lead, in parts per million: o, 70; ○, 100; ◯, 150-700. L, detected but less than analytical sensitivity. See figure C1 for explanation of geology.

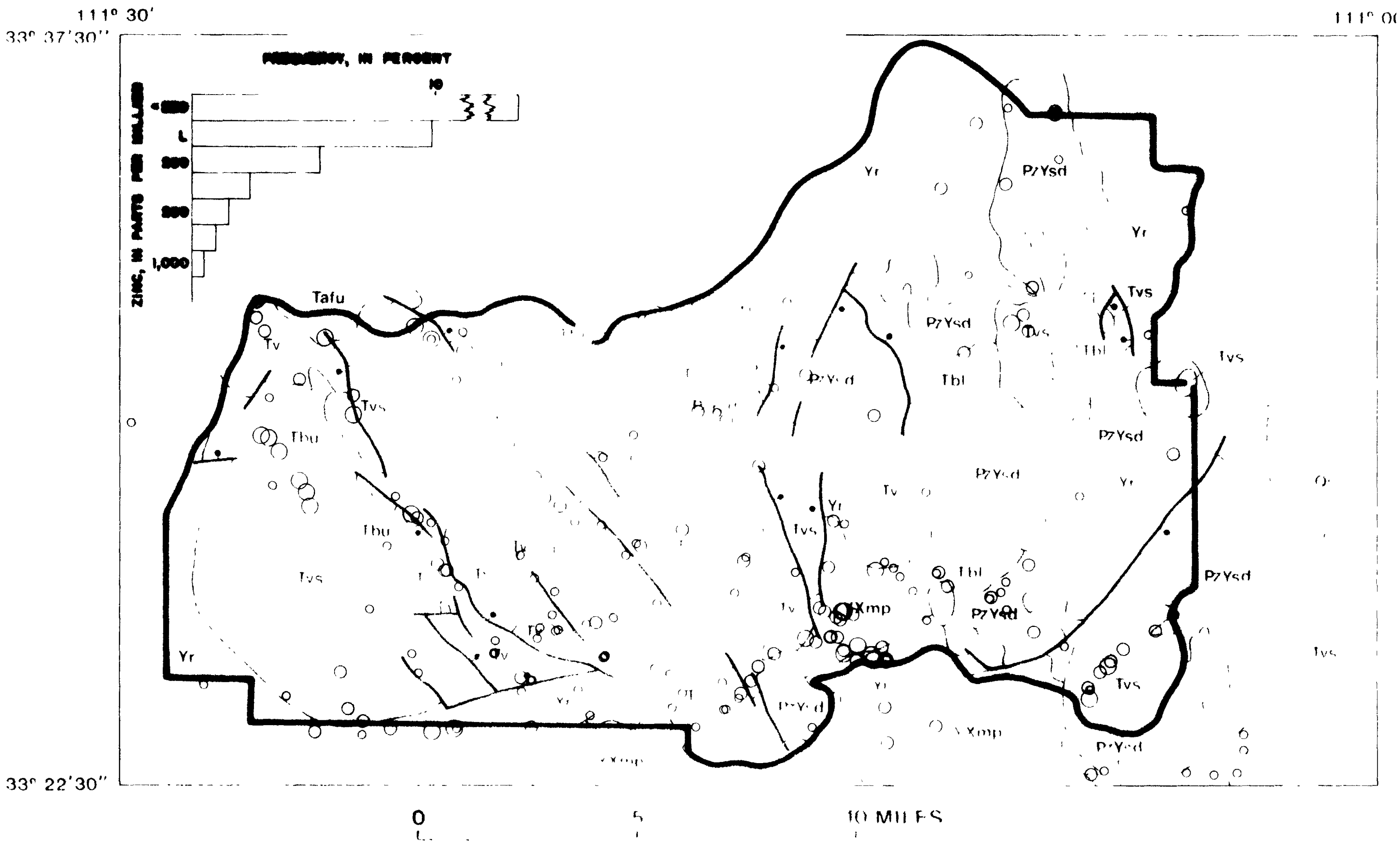


Figure C11.--Distribution of zinc in stream-sediment samples, Superstition Wilderness and vicinity. Zinc, in parts per million: ○, L(200); ○, 200-300; ◯, 500-1,000. L, detected but less than analytical sensitivity. See figure C1 for explanation of geology.

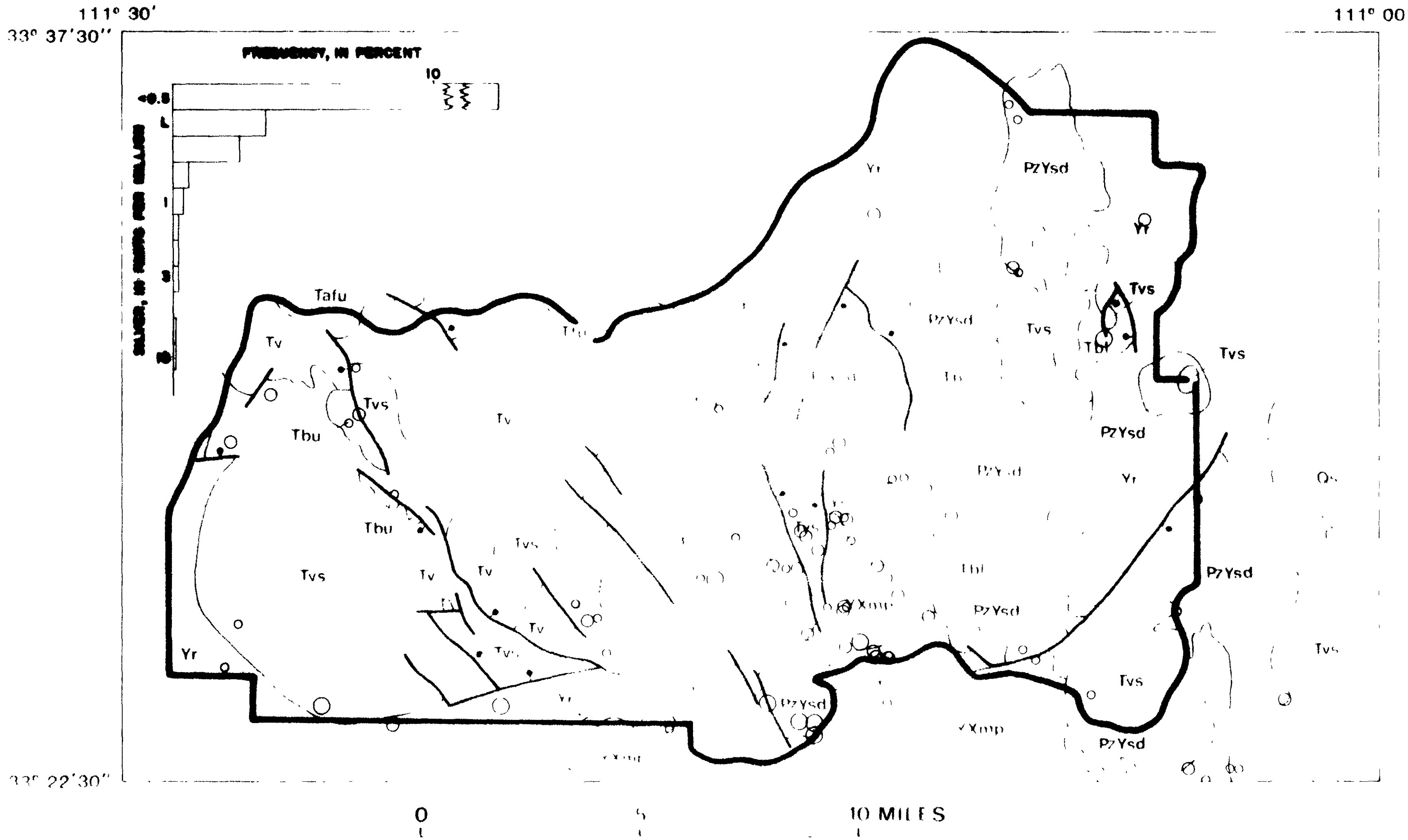


Figure C12.--Distribution of silver in stream-sediment samples, Superstition Wilderness and vicinity. Silver, in parts per million: ∘, L(0.5); ○, 0.5-0.7; ◯, 1-10. L, detected but less than analytical sensitivity. See figure C1 for explanation of geology.

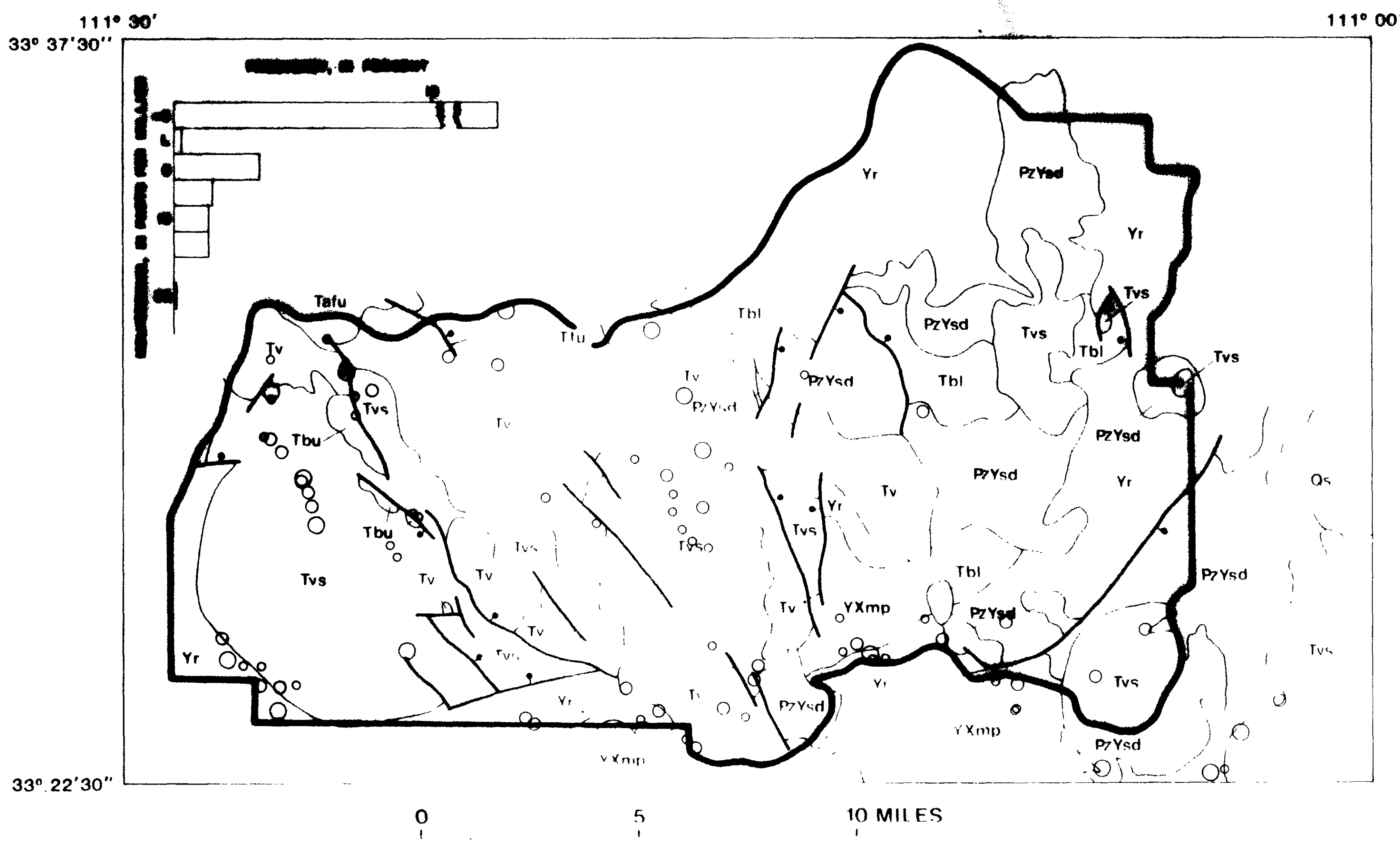


Figure C13.--Distribution of molybdenum in stream-sediment samples, Superstition Wilderness and vicinity. Molybdenum, in parts per million: ○, L(3)-5; ○, 7-10; ◯, 15-30. L, detected but less than analytical sensitivity. See figure C1 for explanation of geology.

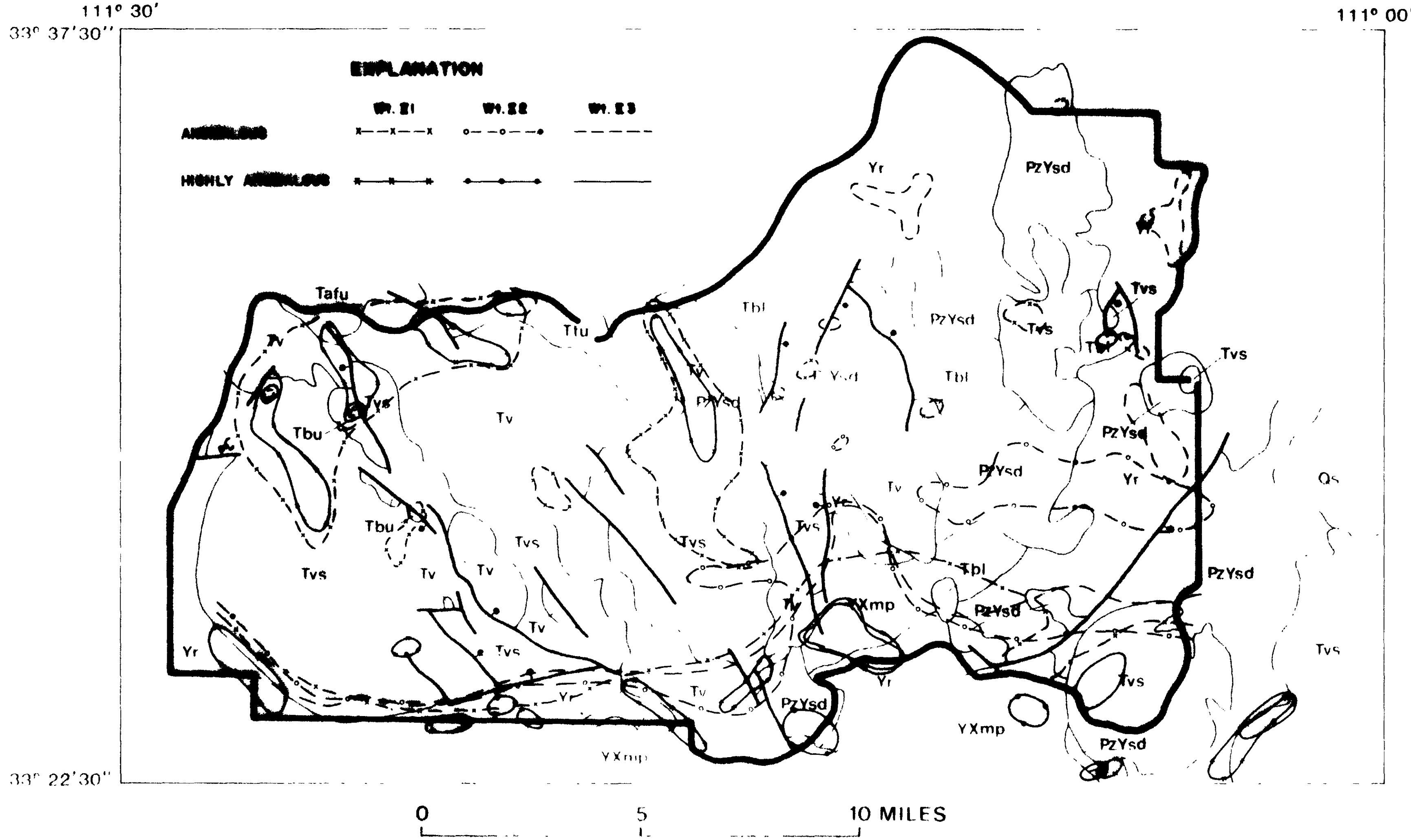


Figure C14.--Distribution plots of the weighted sums (wt.Σ) for stream-sediment samples in the Superstition Wilderness and vicinity. Wt.Σ1, zinc, molybdenum, and manganese; wt.Σ2, silver and boron; wt.Σ3, beryllium, copper, boron, and lead. See figure C1 for explanation of geology.

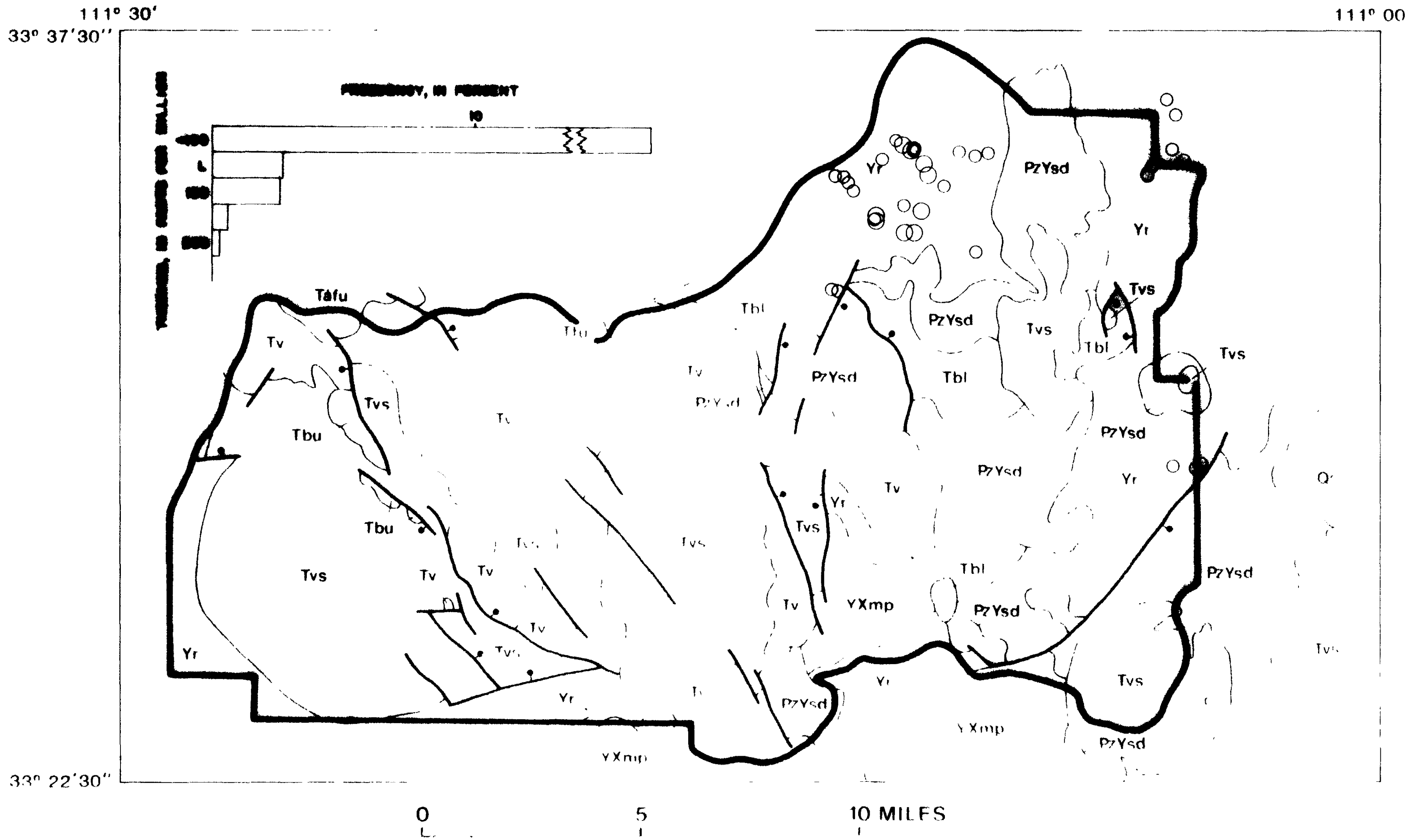


Figure C15.--Distribution of thorium in stream-sediment samples, Superstition Wilderness and vicinity. Thorium, in parts per million: ○, 100; ◯, 150-200. L, detected but less than analytical sensitivity. See figure C1 for explanation of geology.

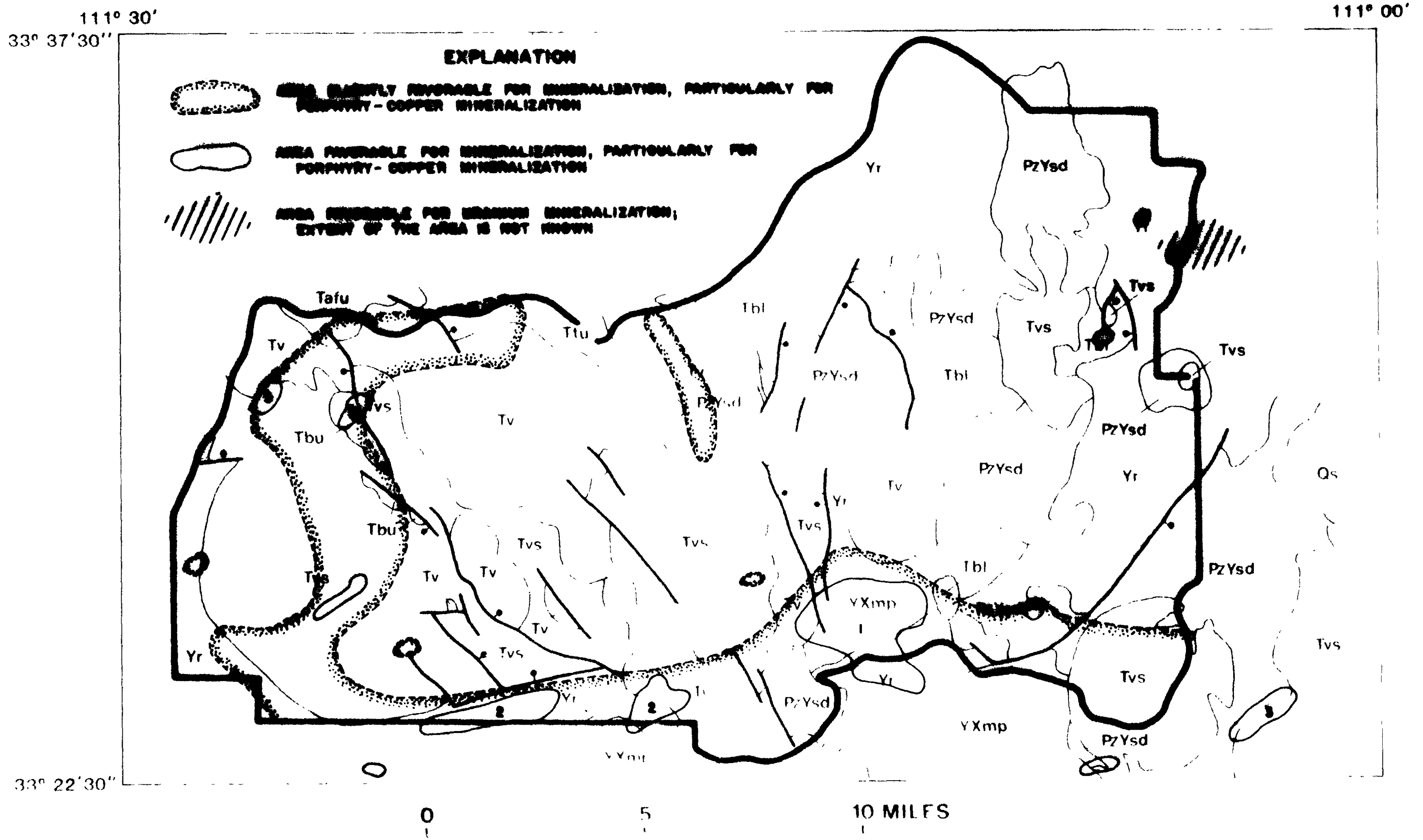


Figure C16.--Areas favorable for mineralization based on geochemical interpretation of spectrographic analyses of selected elements in samples from the Superstition Wilderness and vicinity. Numbers refer to approximate order of potential for mineral resources. See figure C1 for explanation of geology.

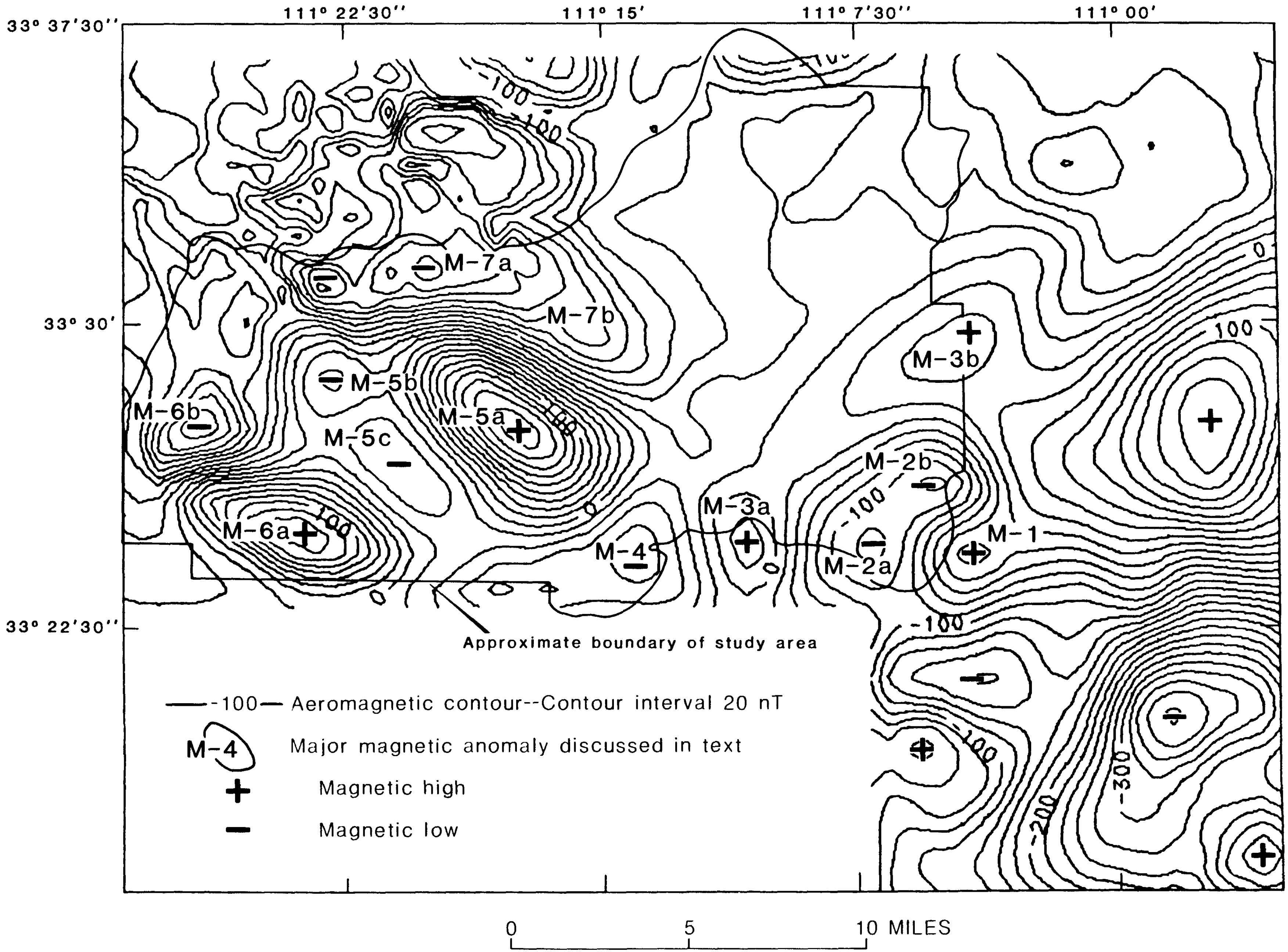


Figure P1.--Parallel-surface aeromagnetic map of the Superstition Wilderness and vicinity.

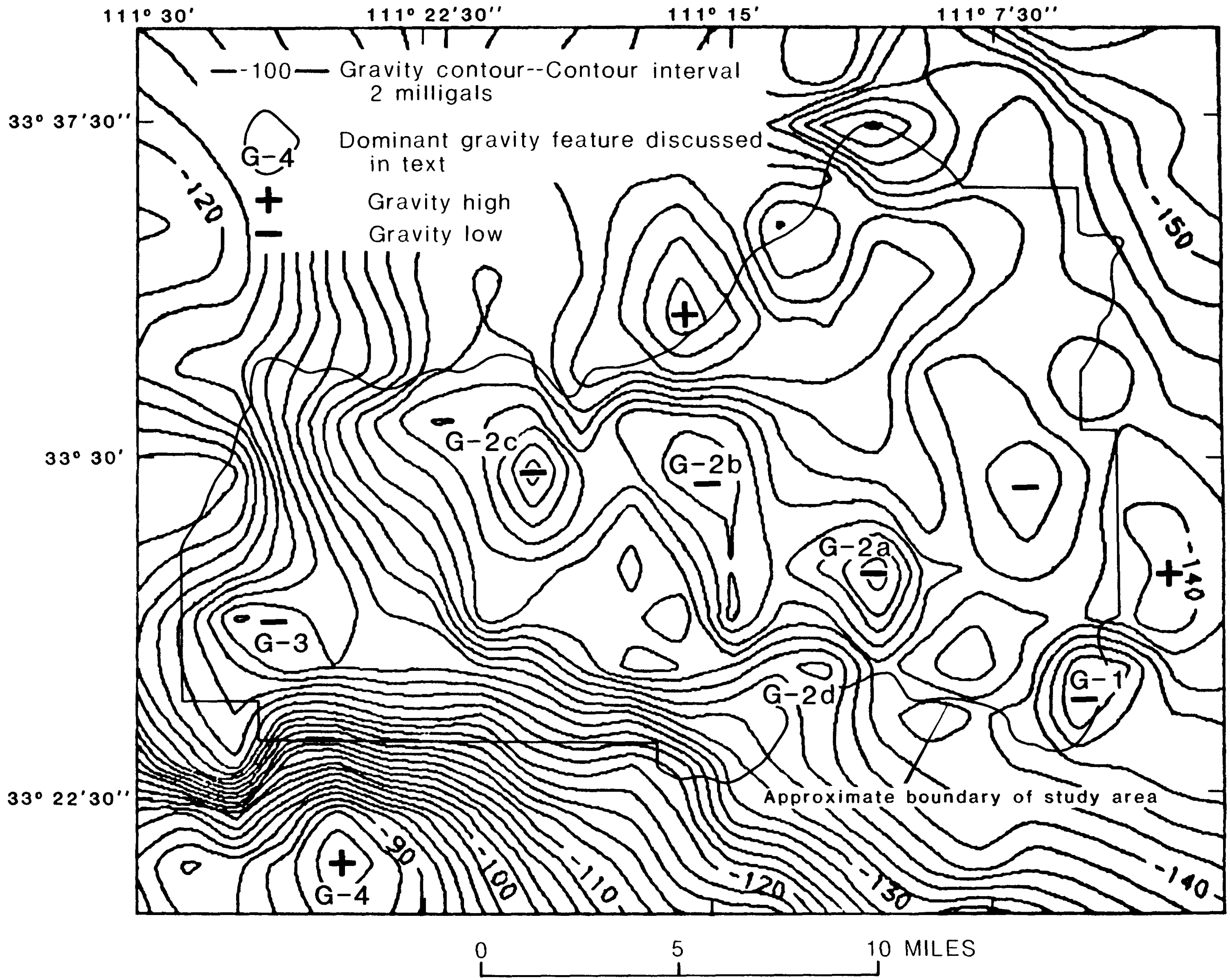


Figure P2.--Gravity map of the Superstition Wilderness and vicinity.

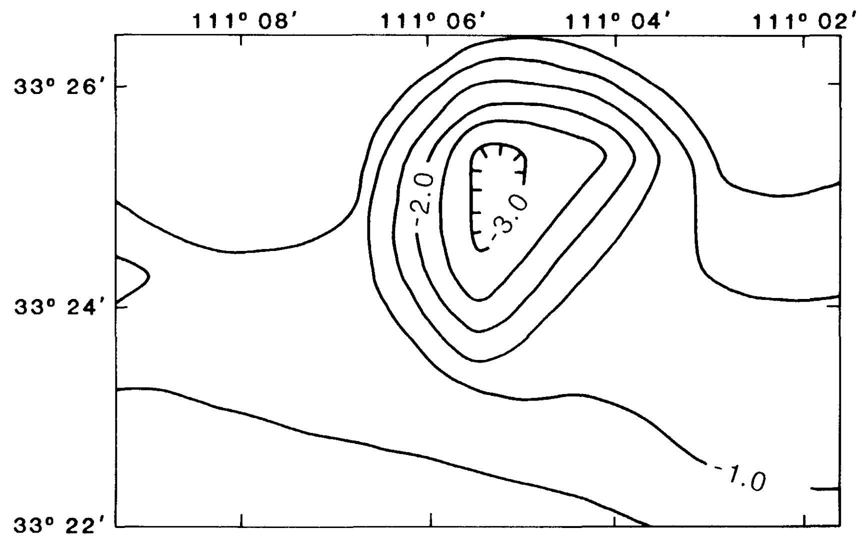


Figure P3.--Gravity model of the Haunted Canyon cauldron (anomaly G-1, fig. P2). Lines indicate depth contours at 0.5 km interval, hachures indicate gravity low.

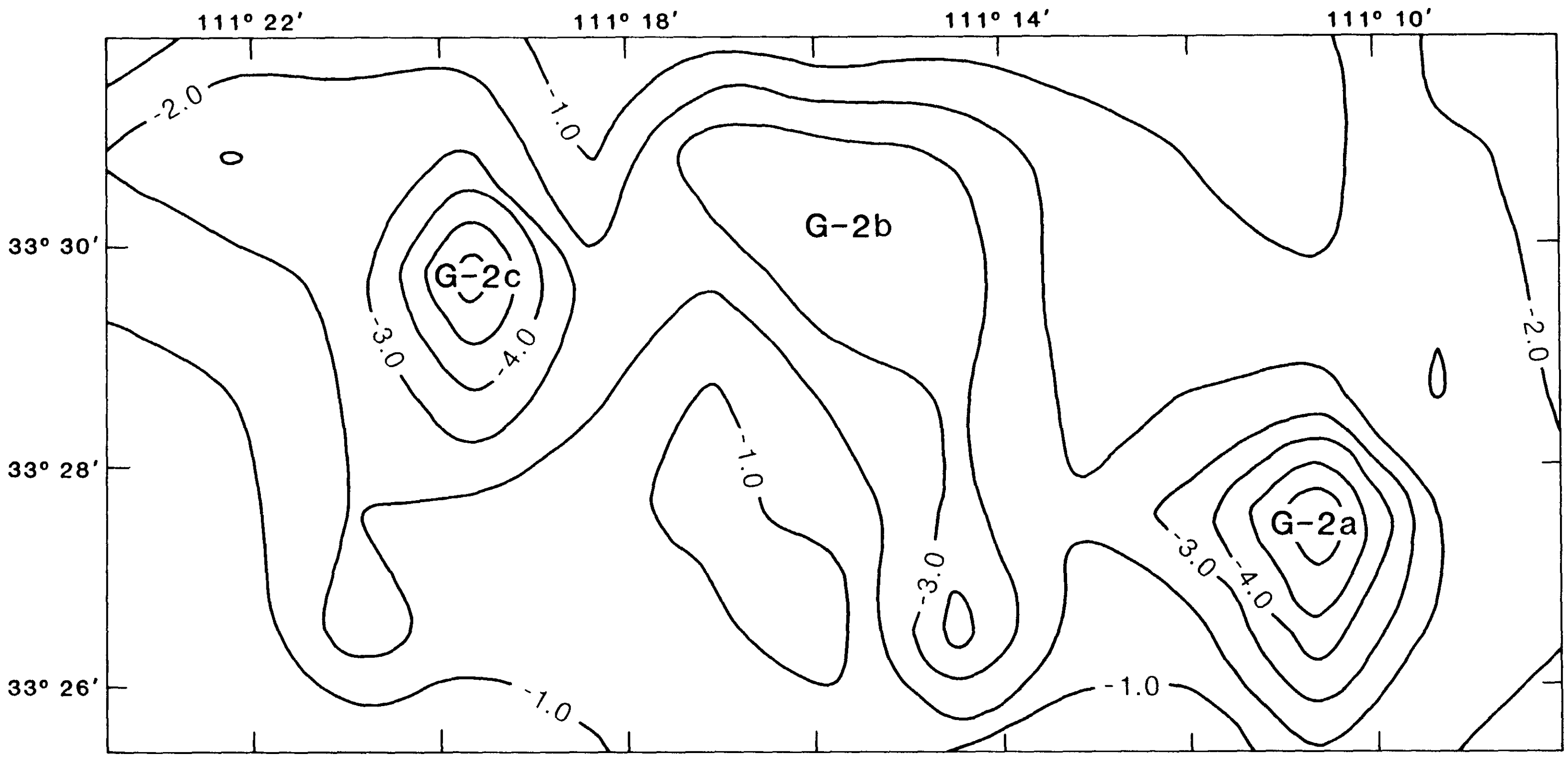


Figure P4.--Gravity model in vicinity of La Barge Canyon cauldron (anomalies G-2a, G-2b, and G-2c from fig. P2). Lines indicate 1 km depth contours below surface.

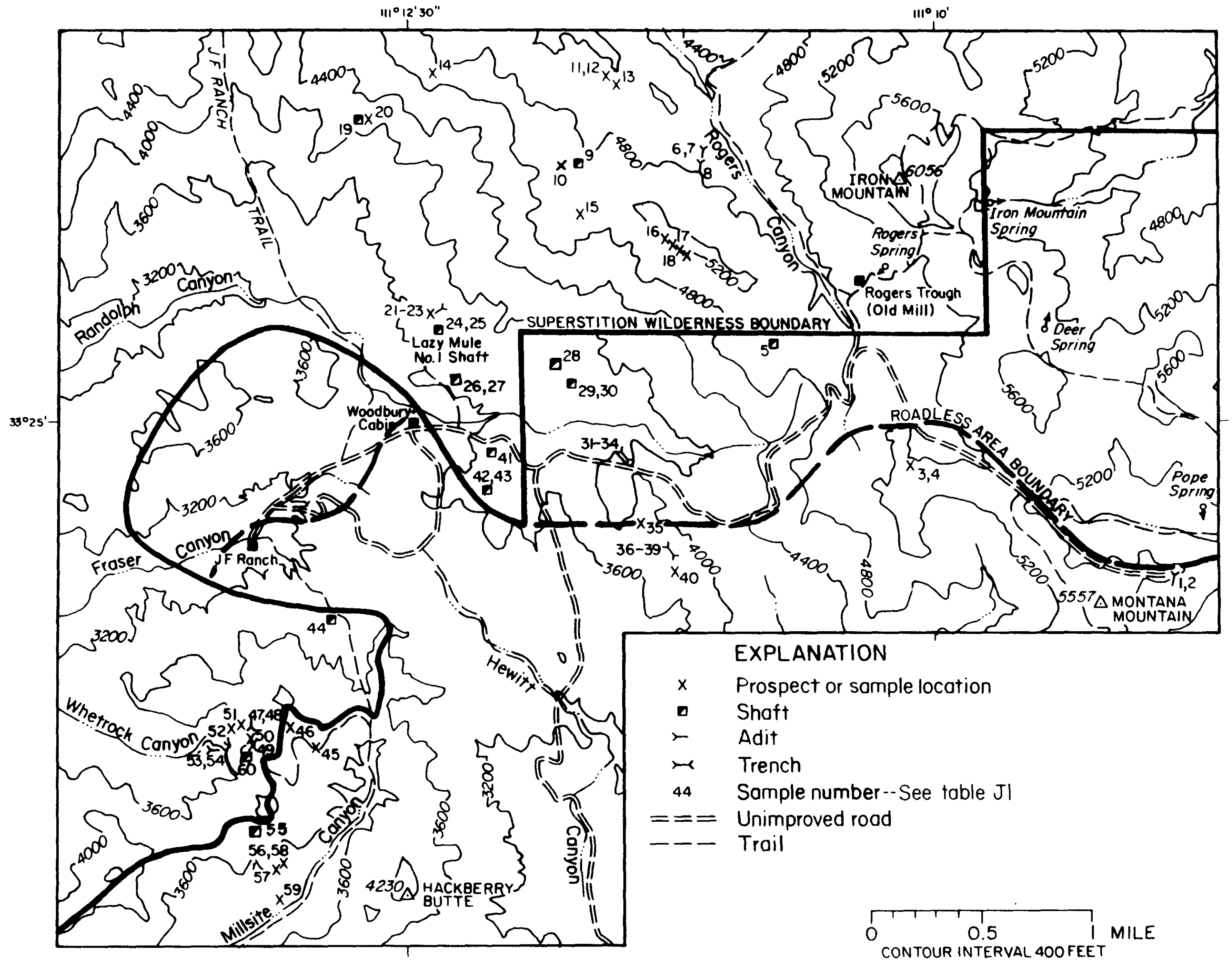


Figure J1.--Prospects and samples in the JF area, Superstition Wilderness vicinity.

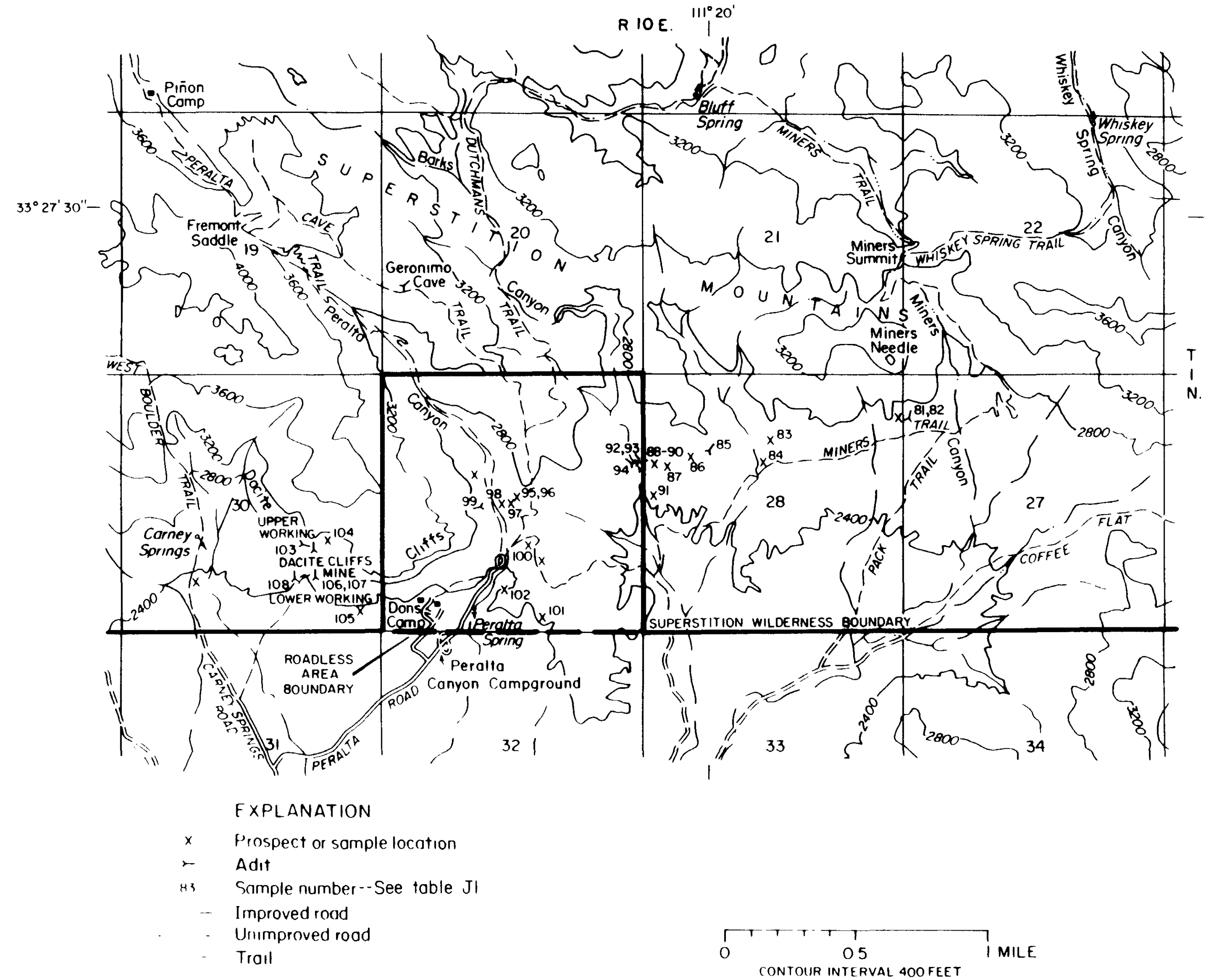
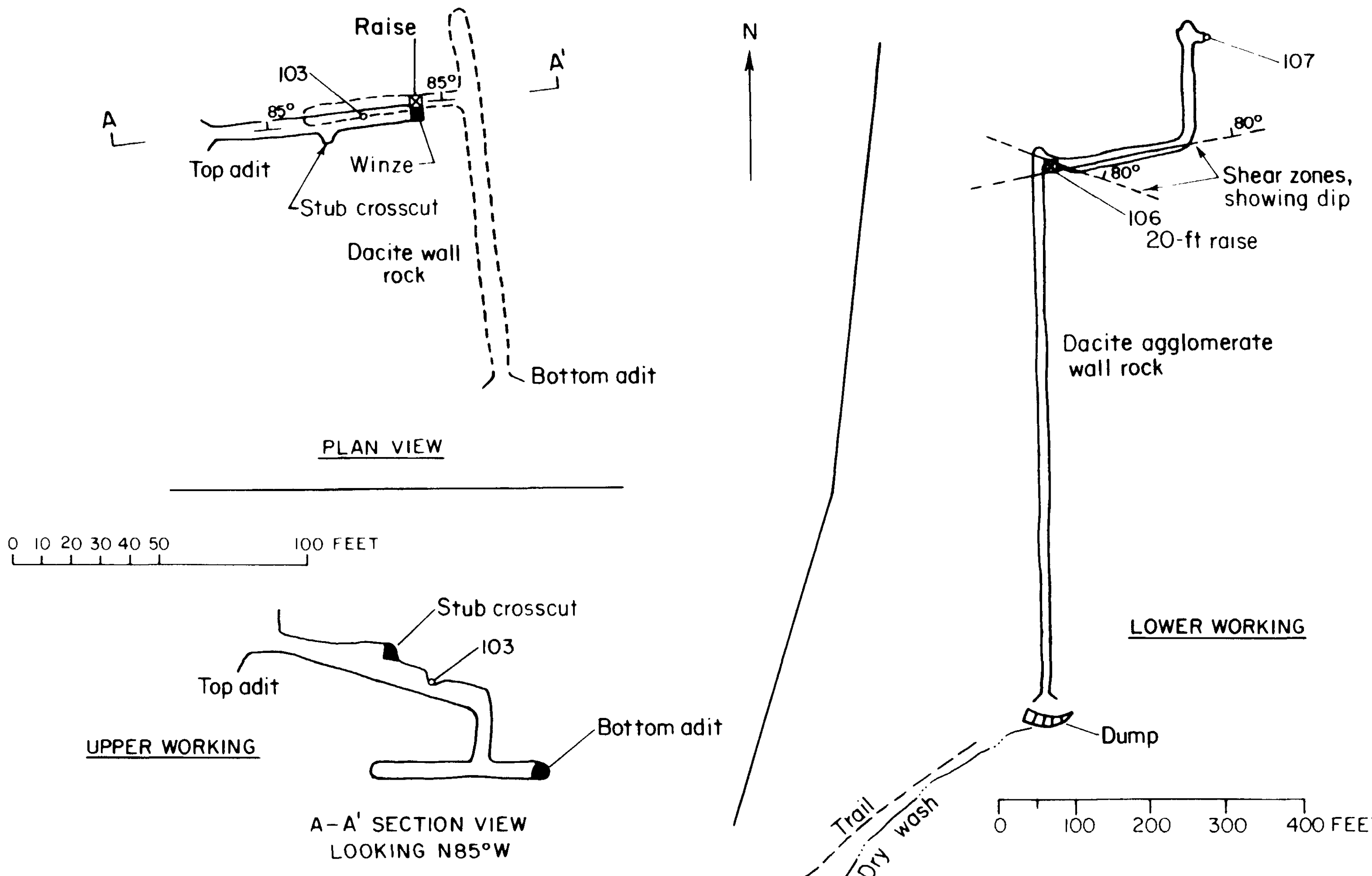


Figure J2.--Prospects and samples in the Peralta area, Superstition Wilderness vicinity.



Assays:

Sample No.	Ounces/ton		Percent		Width
	Gold	Silver	Copper	Lead	
103	0.01	0.9	1.3	1.5	2.5-ft chip

Assays:

Sample No.	Ounces/ton		Width
	Gold	Silver	
106	0.01	0.1	0.5-ft chip
107	Trace	0.1	4.5-ft chip

Figure J3.--Dacite Cliffs mine workings and sample localities. See figure J2 for location.

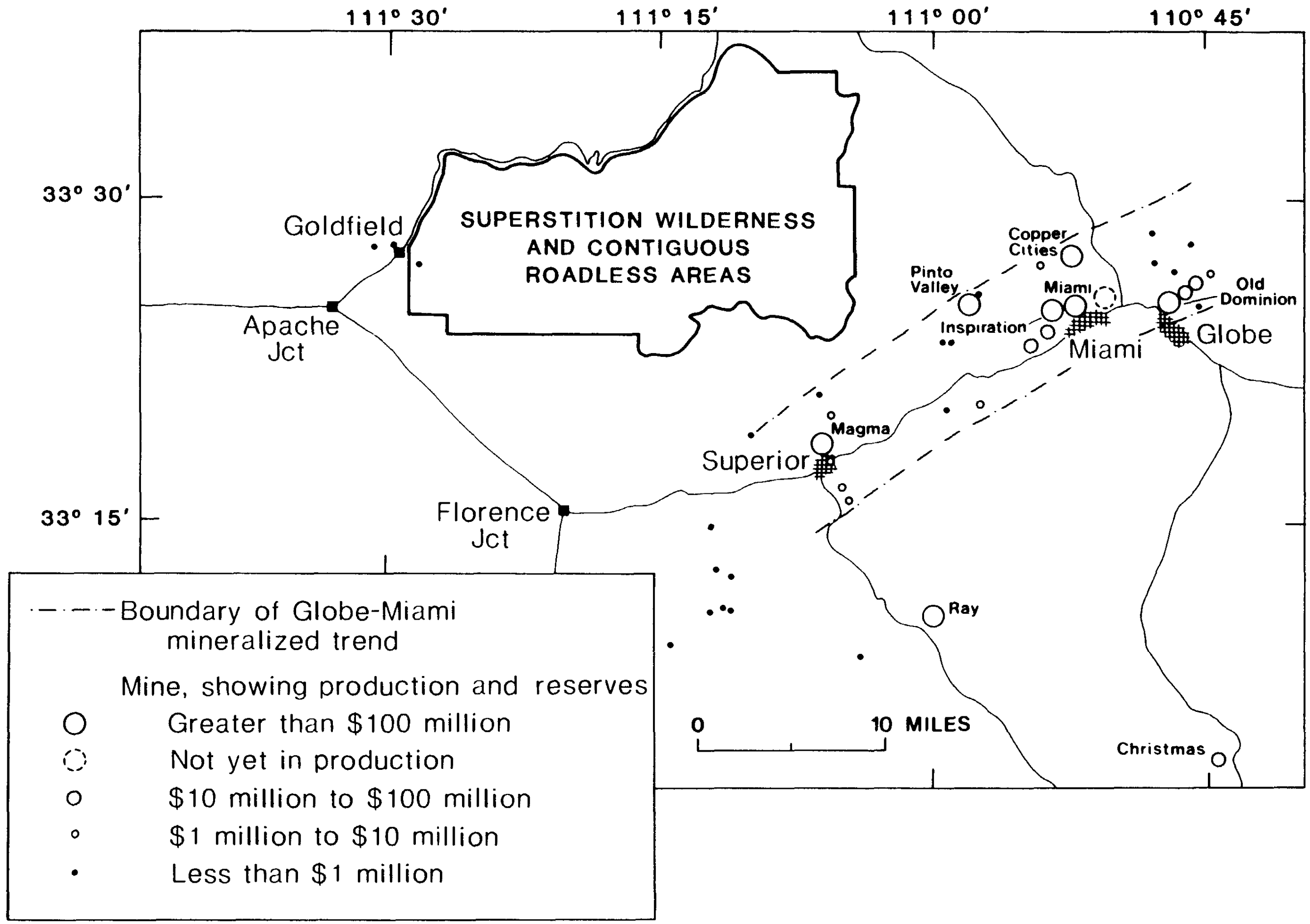


Figure M1.--Relation of Superstition Wilderness to east-northeast-trending mineral belt through Superior and the Globe-Miami district (adapted from Peterson, 1962, fig. 14) and other nearby mining districts.

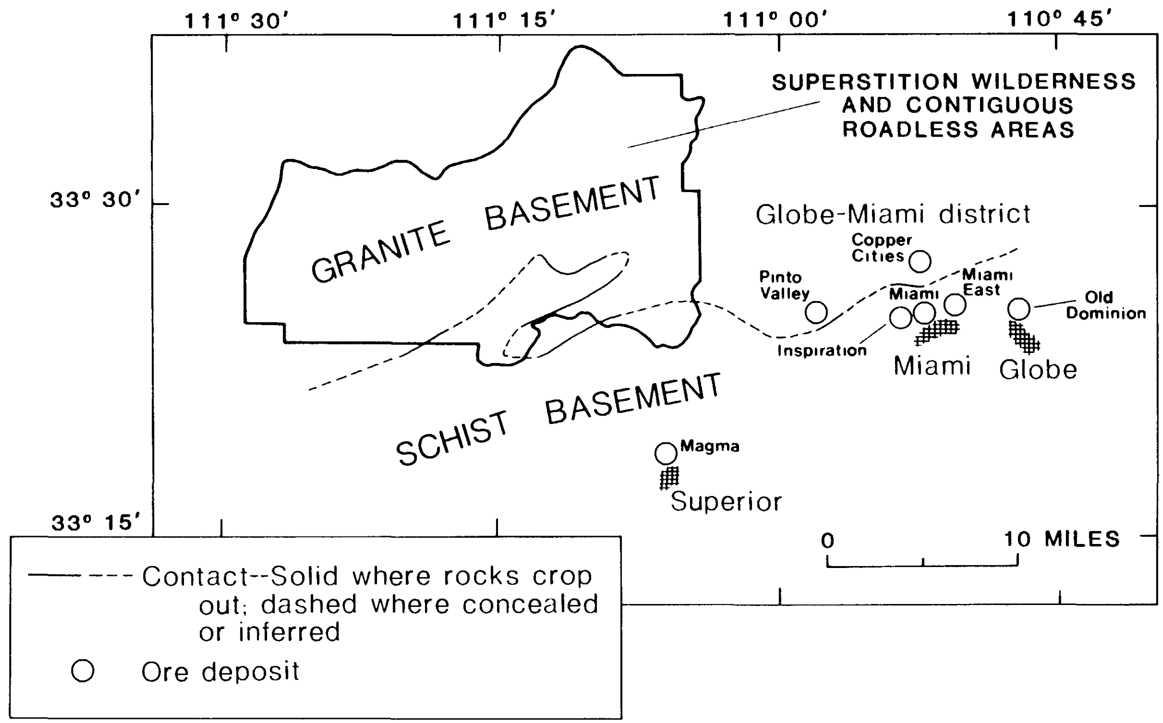


Figure M2.--Generalized contact between the Pinal Schist and Ruin Granite in the Superstition Wilderness and vicinity.

Table C1.--Summary of chemical analyses of 1,231 rock samples, Superstition Wilderness study area, Arizona

[In parts per million except as noted; N, not detected; --, not calculated]

Element	Minimum	Maximum	Geometric mean	Geometric deviation
Fe (percent)	N (.05)	>20	2.02	2.89
Mg (percent)	<0.02	10	.39	3.68
Ca (percent)	N (.05)	20	.51	4.60
Ti (percent	N (.002)	>1	.19	2.70
Mn	20	>5,000	526	2.88
Ag	N (.5)	>5,000	.28	2.62
B	N (10)	>2,000	12.5	2.07
Ba	N (20)	>5,000	591	2.88
Be	N (1)	70	1.60	1.90
Co	N (5)	100	6.23	2.72
Cr	N (10)	2,000	13.7	3.08
Cu	N (5)	>20,000	9.15	4.76
La	N (20)	700	35.1	2.06
Mo	N (5)	500	2.31	1.68
Nb	N (20)	70	15.4	1.43
Ni	N (5)	2,000	7.96	3.52
Pb	N (10)	>20,000	22.7	3.48
Sc	N (5)	70	6.56	1.99
Sr	N (100)	>5,000	176	2.63
V	N (10)	700	43.5	3.05
Y	N (10)	200	21.9	1.69
Zn	N (200)	>10,000	119	1.86
Zr	N (10)	1,000	121	2.27
Hg	N (.02)	1.8	--	--
F	10	227,000	--	--

Table C2.--Correlation matrix and number of valid pairs for 1,231 rock samples, Superstition Wilderness Area
[Below the diagonal are the numbers of valid pairs for the correlation analysis]

	Fe	Mg	Ca	Ti	Mn	Ag	B	Ba	Be	Co	Cr	Cu	La	Mo	Nb	Ni	Pb	Sc	Sr	V	Y	Zn	Zr	Hg	F
Fe ---	1.00	0.73	0.51	0.74	0.42	0.01	-0.01	0.35	-0.22	0.81	0.59	0.50	0.30	0.19	0.01	0.73	0.08	0.75	0.42	0.81	0.33	0.23	0.38	0.06	0.26
Mg ---	1,222	1.00	.70	.59	.53	-.08	-.01	.29	-.20	.76	.59	.35	.26	-.10	-.05	-.76	-.03	.68	.45	.70	.25	.25	.29	-.01	.26
Ca ---	1,158	1,159	1.00	40	.55	-.06	-.20	.20	-.08	.56	.37	.28	.29	-.14	-.08	.53	-.05	.49	.55	.54	.21	.02	.11	-.08	.28
Ti ---	1,199	1,196	1,135	1.00	.36	-.13	-.02	.52	-.32	.60	.47	.23	.33	-.09	-.07	.56	-.06	.69	.44	.75	.34	-.05	.60	-.02	.21
Mn ---	1,213	1,211	1,146	1,189	1.00	-.02	-.16	.31	.08	.40	.30	.26	.21	.09	-.08	.35	.16	.27	.13	.35	.24	.28	.15	.03	.34
Ag ---	159	161	149	158	157	1.00	.19	-.23	.07	-.08	-.13	.62	-.19	.45	-.14	-.05	.55	-.06	-.06	-.13	-.04	.16	-.18	.56	.32
B ----	806	805	776	798	797	100	1.00	-.12	.09	-.02	.00	.11	-.09	.02	-.02	.00	.07	.07	-.18	-.03	.02	.07	.02	.17	.01
Ba ---	1,210	1,208	1,145	1,186	1,204	157	798	1.00	-.27	-.08	.01	-.09	.42	.02	-.11	-.02	-.13	-.05	.30	.25	.11	-.08	.49	.00	.21
Be ---	1,016	1,014	973	1,009	1,003	143	701	1,006	1.00	-.26	-.14	.00	.00	.18	.11	-.27	.17	-.20	-.15	-.29	.13	.09	-.27	.10	.17
Co ---	764	766	745	743	759	114	519	759	618	1.00	.68	.55	.16	.05	.04	.87	.10	.82	.39	.82	.18	.14	-.05	-.05	.15
Cr ---	516	515	488	496	513	78	338	507	359	446	1.00	.32	.08	-.04	.05	.81	.05	.66	.25	.61	.06	.11	.02	-.08	.12
Cu ---	769	768	743	749	756	141	519	758	616	620	924	1.00	.02	.44	-.03	.54	.52	.49	.29	.41	.11	.47	-.10	.20	.45
La ---	998	996	967	986	989	121	676	992	876	668	405	654	1.00	.09	.12	.12	-.07	.15	.35	.29	.35	-.08	.32	-.02	.22
Mo ---	103	103	97	103	97	33	73	99	80	58	49	82	87	1.00	.03	-.06	.40	-.07	.08	.07	.10	.14	-.11	-.15	.00
Nb ---	351	352	343	345	349	48	231	353	309	210	125	211	331	49	1.00	-.03	.02	.08	-.01	-.02	-.01	-.18	.04	-.11	-.03
Ni ---	723	725	696	700	714	115	474	717	561	630	460	585	603	64	193	1.00	.06	.78	.41	.76	.13	.17	.02	-.05	.19
Pb ---	1,021	1,018	985	1,007	1,008	145	695	1,009	918	649	387	664	911	93	339	590	1.00	.08	-.21	-.01	.09	.42	-.11	.26	.18
Sc ---	947	946	920	924	937	131	645	939	786	722	475	691	836	85	293	655	820	1.00	.35	.79	.32	.13	.08	-.04	.09
Sr ---	890	890	879	869	880	99	585	880	742	652	393	633	810	70	272	583	794	769	1.00	.52	.04	-.30	.24	-.06	.23
V ----	1,140	1,139	1,095	1,118	1,131	153	759	1,129	939	763	513	754	950	99	322	717	959	920	861	1.00	.32	.08	.31	-.03	.23
Y ----	1,166	1,164	1,116	1,144	1,154	154	777	1,156	992	751	498	743	988	100	347	701	1,000	935	870	1,098	1.00	.07	.30	.01	.20
Zn ---	103	103	97	101	95	57	61	100	87	82	63	95	80	22	16	81	95	95	64	400	100	1.00	-.20	.14	.57
Zr ---	1,197	1,194	1,143	1,175	1,185	157	798	1,185	1,006	758	509	762	99	103	351	713	1,015	944	884	1,126	1,161	102	1.00	.04	.04
Hg ---	487	489	471	481	481	75	311	484	429	320	209	315	414	53	183	297	413	392	358	463	470	35	484	1.00	.14
F ----	444	446	416	425	438	69	261	437	347	287	216	268	335	63	228	272	364	353	290	418	419	39	430	231	1.00

Table C3.--Varimax-rotated factor-loading matrix for 1,231 rock samples, Superstition Wilderness area
[Underlined loadings were used as weighting coefficient in the weighted sum equations]

Element	1	2	3	4	5	6	7
Fe ---	0.799	0.198	0.394	-0.146	0.026	-0.061	0.023
Mg ---	.775	-.112	.224	-.326	.067	-.160	.013
Ca ---	.535	-.155	.084	.390	.027	-.530	-.033
Ti ---	.652	-.050	.632	-.014	.116	-.062	.041
Mn ---	.322	.038	.207	-.659	.012	-.120	-.142
Ag ---	-.093	.647	-.179	-.089	.110	-.082	.652
B ----	.073	.013	.030	.167	-.136	.459	.463
Ba ---	-.032	-.053	.766	-.178	.292	-.227	-.117
Be ---	-.296	.079	-.227	-.348	-.636	.015	.067
Co ---	.945	..94	-.056	-.078	-.017	-.103	-.050
Cr ---	.803	-.039	-.073	-.054	-.009	.025	-.089
Cu ---	.497	.660	-.127	-.254	.026	-.106	-.310
La ---	.093	.018	.573	-.155	-.356	-.308	-.085
Mo ---	-.057	.911	.061	.039	-.074	-.057	-.213
Nb ---	.054	-.015	-.025	.237	-.647	-.019	-.064
Ni ---	.934	.009	-.070	-.102	.067	-.092	.005
Pb ---	.042	.667	-.097	-.251	-.042	.250	.215
Sc ---	.920	.022	.066	.008	-.121	.036	.050
Sr ---	.384	.036	.230	.086	-.016	-.792	.050
V ----	.842	.064	.322	-.046	.013	-.142	-.029
Y ----	.197	.084	.489	-.242	-.436	.120	-.017
Zn ---	.144	.254	-.157	-.716	.164	.417	.044
Zr ---	.092	-.122	.839	.111	.052	.019	.097
Hg ---	-.069	.015	.033	-.132	.063	.017	.856
F ----	.104	.133	.119	-.719	-.057	-.162	.265

Table C4.--Summary of chemical analyses of 1,038 minus-80-mesh stream-sediment samples, Superstition Wilderness area, Arizona
[In parts per million except as noted; N, not determined]

Element	Minimum	Maximum	Geometric mean	Geometric deviation
Fe (percent)	0.7	>20	6.30	1.82
Mg (percent)	0.15	7	1.02	1.68
Ca (percent)	0.07	10	1.00	2.04
Ti (percent)	0.03	>1	0.68	1.83
Mn	200	>5,000	1,162	1.51
Ag	N (0.5)	10	0.26	1.29
B	N (10)	50	20.3	1.81
Ba	50	>5,000	585	1.71
Be	N (1)	30	1.28	1.66
Co	N (5)	150	18.3	1.82
Cr	<10	3,000	69.4	2.71
Cu	<5	700	29.8	1.78
La	N (20)	1,000	52.1	1.83
Mo	N (5)	30	2.72	1.37
Nb	N (20)	200	21.9	1.63
Ni	N (5)	300	27.5	2.36
Pb	N (10)	15,000	33.3	1.83
Sc	<5	30	13.3	1.52
Sr	N (100)	1,000	169	1.90
V	N (20)	2,000	163	1.95
Y	N (10)	1,000	50.1	1.84
Zn	N (200)	1,500	114	1.42
Zr	10	>1,000	379	2.00

Table C5.--Correlation matrix of the 1,038 stream-sediment samples, Superstition Wilderness area
[Below the diagonal are the numbers of valid pairs of the correlation analysis]

	Fe (percent)	Mg (percent)	Ca (percent)	Ti (percent)	Mn	Ag	B	Ba	Be	Co	Cr	Cu	La	Mo	Nb	Ni	Pb	Sc	Sr	V	Y	Zn	Zr
Fe (percent) ---	1.00	0.49	.34	.55	0.60	0.01	-0.13	-0.17	-0.22	0.73	0.63	0.21	0.10	-0.22	0.19	0.50	0.06	0.61	-0.06	0.81	0.42	0.23	0.27
Mg (percent) ---	1,031	1.00	.69	.46	.28	.01	.05	.03	-.14	.63	.53	.44	-.20	.03	.00	.70	.07	.59	.12	.41	.03	-.04	-.06
Ca (percent) ---	1,031	1,038	1.00	.36	.34	.04	-.15	.19	-.27	.47	.38	.30	-.10	.06	.04	.55	.03	.44	.34	.28	-.08	.00	-.05
Ti (percent) ---	755	758	758	1.00	.46	-.16	.10	.16	-.09	.53	.50	.32	.05	-.01	.14	.46	.06	.58	.05	.58	.20	-.07	.25
Mn ------------	1,031	1,038	1,038	758	1.00	-.23	-.20	.07	-.07	.51	.48	.24	.10	-.03	.12	.36	.09	.47	-.03	.55	.19	.54	.16
Ag ------------	41	41	41	38	41	1.00	.55	-.25	-.18	.07	.01	-.14	.05	-.02	-.32	.12	-.06	.05	-.01	-.12	-.05	.09	-.18
B -------------	972	973	973	724	973	39	1.00	.12	.17	-.06	-.02	.23	-.12	-.09	-.05	.05	-.06	.02	-.13	-.19	-.07	-.08	-.07
Ba ------------	1,029	1,036	1,036	756	1,036	40	971	1.00	-.18	-.15	-.08	.15	.11	-.04	.01	.08	-.10	-.05	.52	-.29	-.34	-.15	.03
Be ------------	814	816	816	691	816	37	795	814	1.00	-.28	-.19	.01	.12	.05	-.04	-.27	.22	-.15	-.25	-.20	.22	.15	.05
Co ------------	1,028	1,033	1,033	755	1,033	41	973	1,031	813	1.00	.74	.40	-.14	-.16	-.2	.74	-.06	.76	-.03	.74	.16	.23	-.06
Cr ------------	1,028	1,035	1,035	755	1,035	41	972	1,033	813	1,032	1.00	.46	-.14	-.03	-.23	.73	-.08	.74	.06	.75	.10	-.03	-.04
Cu ------------	1,029	1,036	1,036	756	1,036	41	972	1,034	814	1,032	1,035	1.00	-.17	.07	-.18	.56	.09	.48	.02	.24	-.18	.01	-.19
La ------------	983	990	990	748	990	40	930	988	802	985	987	988	1.00	.17	.29	-.24	.24	-.04	.20	.01	.37	.42	.38
Mo ------------	77	78	78	70	78	6	73	78	71	78	78	78	78	1.00	-.12	-.07	.05	-.05	-.01	-.20	-.17	.49	-.11
Nb ------------	676	679	679	549	679	20	638	678	580	677	679	679	677	64	1.00	-.16	.12	-.09	.06	-.03	.26	.34	.21
Ni ------------	1,012	1,016	1,016	737	1,016	41	962	1,014	801	1,014	1,016	1,016	968	78	667	1.00	-.11	.69	.13	.05	-.16	-.03	-.16
Pb ------------	1,018	1,025	1,025	753	1,025	41	963	1,023	814	1,020	1,022	1,023	981	77	678	1,003	1.00	.04	-.18	.03	.39	.28	.31
Sc ------------	1,026	1,033	1,033	753	1,033	41	972	1,031	814	1,029	1,031	1,032	985	78	678	1,016	1,020	1.00	-.06	.64	.18	-.05	.01
Sr ------------	876	877	877	677	877	41	847	875	727	876	875	875	839	73	559	874	868	876	1.00	-.12	-.26	-.04	-.08
V -------------	1,031	1,038	1,038	758	1038	41	973	1,036	816	1,033	1,035	1,036	990	78	679	1,015	1,025	1,033	877	1.00	.42	.11	.20
Y -------------	1,030	1,037	1,037	758	1,037	41	973	1,035	816	1,032	1,034	1,035	990	78	679	1,015	1,025	1,032	876	1,037	1.00	.29	.52
Zn ------------	99	100	100	71	100	11	88	100	78	100	100	100	99	17	65	100	98	100	95	100	100	1.00	.01
Zr ------------	958	959	959	715	959	40	924	957	768	956	956	957	911	73	615	954	947	958	852	959	958	91	1.00

Table C6.--Varimax-rotated factor loading matrix for 1,038 stream-sediment samples, Superstition Wilderness area [Underlined loadings were used as weighting coefficients in the weighted sum equations]

Element	1	2	3	4	5	6	7	8
Fe ---	0.819	-0.270	-0.151	0.005	-0.170	-0.202	0.026	-0.195
Mg ---	.582	.083	.040	-.024	.109	.029	.690	-.053
Ca ---	.422	.063	.272	.073	-.054	-.194	.694	-.062
Ti ---	.679	-.181	.196	-.147	-.045	.213	.141	-.164
Mn ---	.689	-.122	.106	.388	-.223	.040	-.157	-.187
Ag ---	-.036	.006	-.153	.095	.878	-.327	.098	.252
B ----	-.011	.115	.061	-.163	.835	.405	-.076	-.101
Ba ---	-.053	.053	.893	-.107	-.056	.129	.010	-.055
Be ---	-.210	-.198	-.202	.106	.002	.671	-.130	.033
Co ---	.882	.094	-.132	.060	.062	-.152	.165	-.099
Cr ---	.870	.072	-.008	-.016	-.020	-.024	.062	.264
Cu ---	.508	.263	.219	.069	.064	.526	.193	.119
La ---	-.048	-.704	.301	.229	.127	-.140	-.259	-.111
Mo ---	-.163	.120	-.028	.721	-.130	.152	.229	.197
Nb ---	-.049	-.197	.022	.069	-.101	-.051	.054	-.934
Ni ---	.760	.269	.138	-.024	-.134	-.019	.330	.104
Pb ---	-.079	-.600	-.147	.205	-.049	.346	.368	.047
Sc ---	.831	-.030	-.020	-.053	.063	.081	.217	.119
Sr ---	-.029	-.001	.760	.040	-.020	-.357	.168	.029
V ----	.856	-.205	-.243	-.070	-.168	-.144	-.056	-.033
Y ----	.200	-.746	-.394	-.004	-.014	.027	-.039	-.160
Zn ---	.123	-.241	-.073	.919	.082	-.014	-.131	-.270
Zr ---	.056	-.766	.035	-.132	-.139	.057	-.038	-.085

Table C7.--Selected chemical analyses of waters collected from springs and small streams within the Two Bar Mountain quadrangle, Arizona

[--, not determined]

Sample number	Conductivity (mhos/cm)	pH	Radon (pCi/L)	U (μg/L)
100	670	7.05	2,050	--
105	520	7.40	386	--
106	490	7.60	184	--
109	410	8.15	45	--
201	730	7.30	700	--
203	1,340	7.25	39	--
204	530	6.85	4,710	34
205	540	7.10	10,450	64

Table J1.--Descriptions and results of analyses of samples from the Superstition Wilderness and contiguous roadless areas, Gila, Maricopa, and Pinal Counties, Arizona

[Gold and silver determined by fire assay; values reported in oz/ton. Copper, lead, zinc, and tungsten determined by chemical analysis; values reported in percent. Sample locations shown on plate 3. Spectrographic analyses results are available for public inspection at the U.S. Bureau of Mines, Intermountain Field Operations Center, Building 20, Denver Federal Center, Denver, Colorado. Tr, trace; -, not detected; ND, not determined]

Sample No.	Sample Type	Gold	Silver	Copper	Lead	Zinc	Descriptions
1	Specimen	-	0.1	0.68	ND	ND	Schist with malachite and azurite. Prospect dump.
2	Specimen	Tr	-	1.89	ND	ND	Do.
3	Chip	-	-	ND	ND	ND	Dacite with quartz stringers; minor limonite, otherwise no mineralization visible. Prospect wall.
4	1.5-ft chip	Tr	-	ND	ND	ND	Granite gouge at shear zone; no mineralization visible. Prospect wall.
5	2.0-ft chip	-	-	ND	ND	ND	Limonite fault gouge; no mineralization visible. Shaft wall.
6	9-in chip	-	Tr	ND	ND	ND	Quartzose shear zone in diorite. Adit face.
7	Grab	Tr	.9	.06	.05	ND	Diorite and quartz with minor malachite. Adit dump.
8	Specimen	Tr	11.3	ND	ND	ND	Altered granite showing secondary copper mineralization. Caved adit dump.
9	Grab	-	.2	ND	ND	ND	Drusy quartz with chlorite. Shaft dump.
10	Grab	.02	8.1	.02	.19	.03	Quartz. From dump north of prospect pit.
11	3-in chip	Tr	1.2	.05	ND	ND	Quartz vein with secondary copper in diorite country rock. Prospect wall.
12	Specimen	.03	27.3	1.5	.09	ND	Quartz with malachite and chrysocolla. Prospect dump.
13	Specimen	.02	48.0	ND	ND	ND	Quartz with malachite and azurite. Prospect stockpile.
14	Specimen	Tr	-	ND	ND	ND	Quartz zone in schist and diabase. Outcrop.
15	Grab	-	.1	ND	ND	ND	Quartzose shear zone in diorite. Prospect dump.
16	Grab	Tr	10.6	1.2	ND	ND	Quartz with malachite, azurite, and chrysocolla. Prospect dump.
17	1.2-ft chip	-	-	ND	ND	ND	Quartz vein in quartz diorite; no mineralization visible. Prospect wall.
18	Grab	.01	14.1	.28	2.0	0.30	Altered granite with malachite, azurite and chrysocolla. Prospect dump
19	1.2-ft chip	Tr	.1	ND	ND	ND	Altered diabase with intruded aplitic dikes 1 to 2 inch wide; no mineralization visible. Shaft collar.
20	Chip	Tr	.2	ND	1.3	2.20	Quartz with hematite stain. Near prospect.
21	1.3-ft chip	Tr	.2	.36	2.2	1.50	Diorite(?). Shear zone near prospect.
22	0.9-ft chip	Tr	Tr	.10	1.3	.90	Diabase, footwall of shear. Prospect wall.
23	Specimen	.02	2.4	.38	11.2	5.8	Copper mineralization at prospect.
24	Specimen	.01	.3	.18	1.3	2.7	Diabase; among last material removed from shaft. Visible malachite, azurite, chrysocolla, galena. Shaft dump.
25	Specimen	.03	1.6	.34	15.3	21.3	Diabase; shows galena, sphalerite. Shaft wall.
26	1.3-ft chip	Tr	.5	.66	ND	ND	Siliceous dike in granite; pyrite, malachite, chrysocolla, brochantite(?). Shaft wall.
27	3.0-ft chip	Tr	.1	ND	ND	ND	Decomposed granite; immediately west of sample 26. Shaft wall.
28	Grab	Tr	-	ND	ND	ND	Altered coarse-grained granite; minor iron oxides. Shaft dump.
29	Specimen	Tr	.6	1.2	.12	ND	Shear zone, with malachite and chrysocolla, in altered diabse. Shaft dump.
30	6.3-ft chip	Tr	.1	ND	ND	ND	Granite; shear zone with malachite and chrysocolla. Shaft wall.

Table J1.--Descriptions and results of analyses of samples from the Superstition Wilderness and contiguous roadless areas, Gila, Maricopa, and Pinal Counties, Arizona-Continued

Sample No.	Sample Type	Gold	Silver	Copper	Lead	Zinc	Descriptions
31	3.8-ft chip	Tr	Tr	ND	ND	ND	Granite with malachite, chrysocolla, and chalcopyrite. Trench.
32	Grab	-	-	ND	ND	ND	Quartz monzonite. Trench.
33	3.7-ft chip	-	-	ND	ND	ND	Do.
34	4.6-ft chip	-	-	ND	ND	ND	Chloritized granite. Trench.
35	Chip	-	-	.22	.70	.44	Granite with hematite and chlorite. Trench.
36	3.6-ft chip	Tr	-	ND	ND	ND	Decomposed granite; hematite stained. Trench.
37	1.9-ft chip	-	-	ND	ND	ND	Decomposed granite; chlorite alteration. Trench.
38	2.8-ft chip	Tr	-	ND	ND	ND	Altered granite with iron oxides. Trench.
39	Chip	-	-	ND	ND	ND	Decomposed granite; hematite stain. Trench.
40	12.0-ft chip	-	-	ND	ND	ND	Granite with hematite stain. Prospect.
41	Grab	.03	Tr	.20	1.1	.28	Shear zone in diabase. Shaft dump.
42	Grab	-	-	ND	ND	ND	Diabase; minor pyrite on dump. Shaft dump.
43	Specimen	-	.1	ND	ND	ND	Do.
44	Grab	Tr	-	ND	ND	ND	Diabase; no mineralization visible. Shaft dump.
45	2.5-ft chip	-	.1	ND	ND	ND	Siliceous glauconitic material; no mineralization visible. Prospect wall.
46	Specimen	Tr	-	ND	ND	ND	Contact between granodiorite and latite. Prospect dump.
47	2.5-ft chip	-	.5	.40	ND	ND	Vein. Adit rib.
48	4.0-ft chip	-	-	ND	ND	ND	Vein. Adit face.
49	7.0-ft chip	Tr	.9	.22	.52	ND	Quartz vein. Prospect wall.
50	Grab	Tr	6.5	.53	ND	ND	Altered granite with minor hematite and limonite. Adit stockpile.
51	1.3-ft chip	Tr	35.7	.57	ND	ND	Monzonite with malachite and chrysocolla. Prospect wall.
52	2.5-ft chip	-	5.8	.27	.34	ND	Shear zone in monzonite with malachite, azurite, and chrysocolla. Prospect wall.
53	Specimen	-	4.9	.82	ND	ND	Quartz from vein. Adit dump.
54	Grab	-	.4	.02	ND	ND	Dripping Spring Quartzite, with minor calcite and pyrite. Adit dump.
55	Grab	Tr	3.5	.31	.62	ND	Quartz. Shaft ore chute.
56	Chip	-	-	ND	ND	ND	Schist with malachite. Prospect wall.
57	Chip	-	-	ND	ND	ND	Do.
58	8.4-ft chip	Tr	Tr	ND	ND	ND	Schist with malachite, azurite, and chrysocolla. Prospect wall.
59	6.8-ft chip	-	.1	ND	ND	ND	Basalt(?); iron stained. Prospect wall.
60	6.0-ft chip	-	1.0	.14	.10	ND	Shear zone. Shaft collar.
61	7.3-ft chip	-	Tr	ND	ND	ND	Tuff breccia. Adit back.
62	2.9-ft chip	Tr	Tr	ND	ND	ND	Tuff; no mineralization visible. Adit face.
63	2.4-ft chip	Tr	.1	ND	ND	ND	Tuff; shear zone. Adit face.
64	4.0-ft chip	-	Tr	ND	ND	ND	Tuff; no mineralization visible. Adit face.
65	Grab	-	-	ND	ND	ND	Tuff. Caved adit dump.
66	Grab	Tr	-	ND	ND	ND	Do.
67	Grab	-	.1	ND	ND	ND	Welded tuff; no mineralization visible. Shaft dump.
68	1.8-ft chip	-	.1	ND	ND	ND	Silicified tuff. Prospect wall.
69	Grab	-	-	ND	ND	ND	Tuff; no mineralization visible. Prospect dump.
70	Chip	-	-	ND	ND	ND	Tuff. Outcrop.

Table J1.--Descriptions and results of analyses of samples from the Superstition Wilderness and contiguous roadless areas, Gila, Maricopa, and Pinal Counties, Arizona-Continued

Sample No.	Sample Type	Gold	Silver	Copper	Lead	Zinc	Descriptions
71	1.3-ft chip	-	.1	ND	ND	ND	Ash-flow tuff; no mineralization or alteration observed. Prospect wall.
72	Specimen	-	-	ND	ND	ND	Contact between dacite and tuff. Shaft dump.
73	1.8-ft chip	-	Tr	ND	ND	ND	Welded tuff. Adit back.
74	3.0-ft chip	-	.1	ND	ND	ND	Welded tuff. Adit right rib.
75	3.4-ft chip	-	-	ND	ND	ND	Welded tuff; no mineralization visible. Adit face.
76	1.6-ft chip	-	-	ND	ND	ND	Hematite-stained fault gouge. Adit.
77	Specimen	-	-	ND	ND	ND	Quartz at contact between granite and schist. Caved adit dump.
78	Grab	-	.1	.66	ND	ND	Schist and quartz with minor malachite and chrysocolla. Caved adit dump.
79	Specimen	-	-	ND	ND	ND	Bull quartz. Prospect dump.
80	4.8-ft chip	-	.1	ND	ND	ND	Schist with sericite. Prospect wall.
81	3.3-ft chip	Tr	-	ND	ND	ND	Granite; feldspars altered to clay and sericite; no mineralization visible. Adit face.
82	3.2-ft chip	Tr	.1	ND	ND	ND	Granite; shear zone with copper oxide. Adit.
83	3.4-ft chip	Tr	.2	ND	ND	ND	Altered granite with hematite stain. Prospect wall.
84	5.0-ft chip	-	Tr	ND	ND	ND	Granite. Prospect wall.
85	3.3-ft chip	-	-	ND	ND	ND	Andesite altered to clay. Adit face.
86	3.0-ft chip	Tr	.1	ND	ND	ND	Andesite altered to clay; minor malachite. Caved shaft.
87	2.3-ft chip	-	.1	ND	ND	ND	Altered dike in rhyolite(?). Prospect wall.
88	8.9-ft chip	Tr	.1	ND	ND	ND	Altered andesite with malachite and chrysocolla. Prospect wall.
89	1.6-ft chip	-	Tr	ND	ND	ND	Rhyolite; intrusive contact zone with minor malachite. Prospect wall.
90	4.3-ft chip	-	.1	ND	ND	ND	Rhyolite. Prospect wall.
91	4.0-ft chip	-	Tr	ND	ND	ND	Rhyolite. Prospect wall.
92	3.0-ft chip	Tr	Tr	ND	ND	ND	Altered volcanic breccia; no mineralization visible. Adit face.
93	Grab	Tr	.1	ND	ND	ND	Muck pile at adit drift face.
94	4.3-ft chip	-	Tr	ND	ND	ND	Rhyolite. Adit back.
95	1.0-ft chip	-	-	ND	ND	ND	Siliceous fault zone; malachite stain. Prospect wall.
96	1.2-ft chip	Tr	.3	.31	.53	ND	Rhyolite; minor malachite and chrysocolla in vicinity. Prospect wall.
97	0.7-ft chip	.02	.6	1.6	ND	ND	Rhyolite; fault gouge with malachite and azurite. Prospect wall.
98	4.5-ft chip	Tr	.2	ND	ND	ND	Rhyolite; hematite stained, minor malachite and chrysocolla in random 1/4-inch seams. Shaft wall.
99	3.5-ft chip	Tr	.1	ND	ND	ND	Silicified fault breccia, volcanic; hematite stained. Adit face.
100	1.0-ft chip	Tr	.1	.34	ND	ND	Weathered granite; moderate malachite and chrysocolla. Prospect wall.
101	1.2-ft chip	Tr	Tr	1.8	ND	.82	Argillic dike with malachite, azurite, and chrysocolla. Prospect wall.
102	0.7-ft chip	Tr	.1	.59	ND	ND	Schist with malachite and chrysocolla, some hematite. Prospect wall.

Table J1.--Descriptions and results of analyses of samples from the SuperstitionWilderness and Contiguous roadless areas, Gila, Maricopa, and Pinal Counties, Arizona-Continued

Sample		Gold	Silver	Copper	Lead	Zinc	Descriptions
No.	Type						
103	2.5-ft chip	.01	.9	1.3	1.5	ND	Dacite with malachite and chrysocolla in stringered veinlets. Adit rib.
104	0.3-ft chip	.01	.2	6.5	13.1	.60	Dacite agglomerate; malachite, azurite, and chrysocolla in vein. Discovery prospect wall.
105	2.8-ft chip	.02	Tr	ND	ND	ND	Rhyolite; hematite-stained and altered vein; no mineralization visible. Prospect wall.
106	0.5-ft chip	.01	.1	ND	ND	ND	Dacite agglomerate; vein. Adit raise.
107	4.5-ft chip	Tr	.1	ND	ND	ND	Dacite agglomerate. Adit crosscut face.
108	0.5-ft chip	Tr	.1	ND	ND	ND	Altered rhyolite; sample from faulted(?) location. Prospect wall.
109	4.0-ft chip	Tr	.3	ND	ND	ND	Dacite(?) breccia; shear zone. Shaft.
110	Specimen	.80	.1	4.6	.12	ND	Dacite; minor blebs of turquoise(?) and chrysocolla; 0.10% WO_3. Shaft dump.
111	Chip	Tr	1.6	2.1	.35	ND	Quartzose shear zone; some turquoise(?); 0.03% WO_3. Shaft collar.
112	Chip	.11	.1	1.0	.10	ND	Quartzose, oxidized material; 0.05% WO_3. Prospect wall.
113	3.2-ft chip	Tr	.1	ND	ND	ND	Dacite(?) breccia; shear zone, no mineralization visible. Adit rib.
114	0.5-ft chip	Tr	-	ND	ND	ND	Dacite tuff; siliceous fault zone. Prospect wall.
115	Chip	-	-	ND	ND	ND	Welded dacite tuff; siliceous fault zone. Prospect wall.
116	Grab	-	-	ND	ND	ND	Tuff. Adit dump.
117	Grab	Tr	-	ND	ND	ND	Ash-flow rhyodacite tuff. Prospect.
118	Chip	-	-	ND	ND	ND	Welded tuff; siliceous fault zone. Prospect wall.
119	5.0-ft chip	-	Tr	ND	ND	ND	Caliche-cemented surface detritus. Adit face.
120	Grab	-	Tr	ND	ND	ND	Red dirt; natural pothole in volcanic rock--"Indian paint"--near "Indian Paint Mine."
121	4.6-ft chip	-	-	ND	ND	ND	Dacite(?); bright red. Adit rib.
122	2.7-ft chip	-	.1	ND	ND	ND	Brecciated dacite; no mineralization visible. Adit face.
123	2.6-ft chip	-	-	ND	ND	ND	Brecciated dacite; fault gouge, no mineralization visible. Adit portal.
124	2.6-ft chip	-	.1	ND	ND	ND	Rhyolitic ash flow. Prospect wall.
125	Grab	Tr	Tr	ND	ND	ND	Altered rhyolite; no mineralization visible. Shaft dump.
126	Specimen	-	-	ND	ND	ND	Dacite tuff. Prospect dump.
127	Chip	No analysis					Serpentinized limestone with asbestos--1/2-inch harsh fiber. Outcrop.
128	Specimen	Tr	Tr	ND	ND	ND	Volcanic rock; highly mineralized and iron rich. Hillside float.
129	1.4-ft chip	Tr	Tr	ND	ND	ND	Diabase; highly altered. Prospect wall.