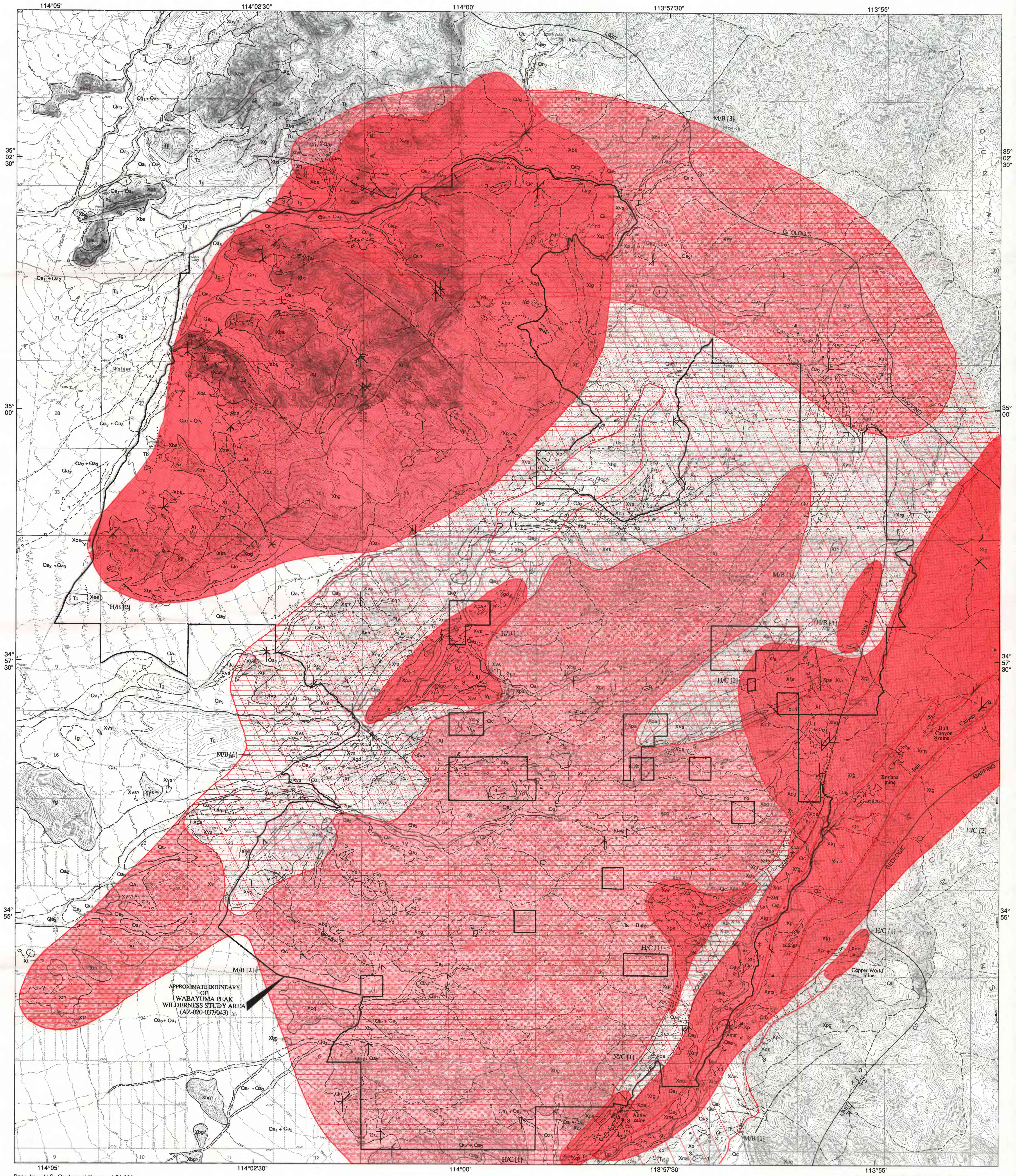
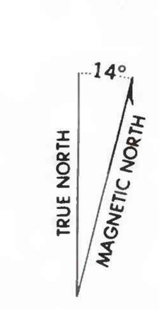
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

BULLETIN 1737-E
PLATE 1



Base from U.S. Geological Survey, 1:24,000: Wabayuma Peak and Kingman Southeast, 1967; Hualapai Peak, 1968; Yucca Northeast, 1970; Universal Transverse Mercator Projection

Geologic mapping by C.M. Conway, D.A. Gonzales, and K.R. Chamberlain, 1987-88. Geology in parts of lower Boriana Canyon modified from More, 1980



APPROXIMATE MEAN DECLINATION, 1991

SCALE 1:36 000

1 MILE

1 KILOMETER

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

AREA OF MAP

EXPLANATION

Area having high (H) mineral resource potential for deposit type shown

Area having moderate (M) mineral resource potential for deposit type [3]

Area having moderate (M) mineral resource potential for deposit type [2]

Area having moderate (M) mineral resource potential for deposit type [1]

Deposit types and commodities contained
[Commodities present in minor amounts in parentheses; commodities that may be present in brackets]

[1] Massive sulfide deposits
- Copper (Silver)
- Zinc (Gold)
- (Lead)

[2] Tungsten-polymetallic vein deposits
- Tungsten [Thorium]
- Copper [Niobium]
- (Beryllium) [Lanthanum]
- (Gold) [Yttrium]
- (Silver) [Scandium]
- (Arsenic) [Tantalum]
- (Bismuth) [Rhenium]
- (Molybdenum) [Zinc]
- (Tin) [Lead]
- (Indium) [Iron]

[3] Polymetallic-vein deposits
- Gold (Lead)
- Copper [Tungsten]
- (Silver) [Molybdenum]
- (Zinc)

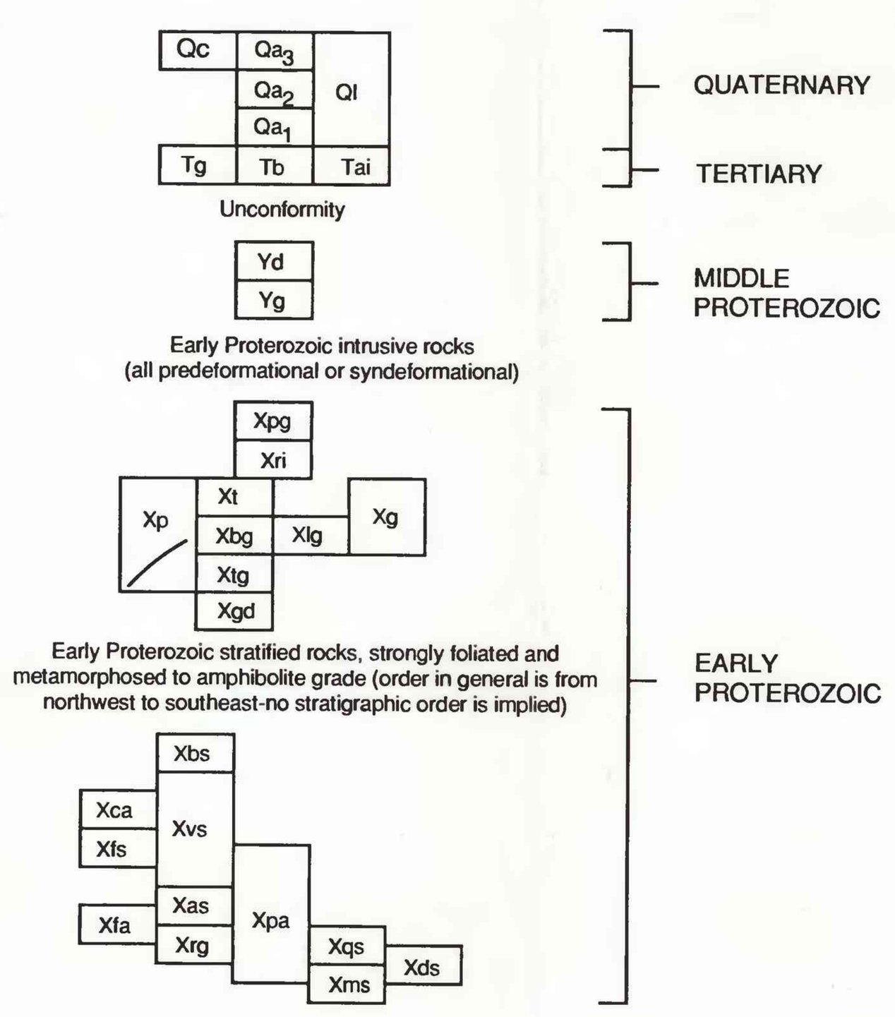
Mine having identified resources—See text for discussion

Prospect

Adit

Shaft

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

[Query denotes uncertain identification of unit]

Qc **Colluvium (Quaternary)**—Unconsolidated material, usually in fans and cones at the base of steep slopes. In some places merges imperceptibly with units Qa_3, Qa_2, or Qa_1 and in many such places is mapped with the respective alluvium unit

Qa_3 **Alluvium (Quaternary)**—Unconsolidated clay, silt, sand, and gravel in active drainage systems. Locally includes colluvium and stable soil

Qa_2 **Alluvium (Quaternary)**—Unconsolidated clay, silt, sand, and gravel in fans and flood-plain deposits that are generally present as terraces along active drainage systems. Generally undissected. Merges with unit Qa_3 in the Sacramento Valley plain 0.5 to 2 mi from range front. Locally contains colluvium

Qa_1 **Alluvium (Quaternary)**—Unconsolidated clay, silt, sand, and gravel in fans and flood-plain deposits that are generally present as terraces at a higher level than unit Qa_2. Generally undissected. Not readily distinguished from unit Qa_2 at many localities, particularly where more than several miles from range front. Locally contains colluvium

Ql **Landslide deposits (Quaternary)**—In north-central part of map area and near Copper World mine. North-central landslide composed largely or entirely of leucocratic biotite granite, probably derived from unit Xlg, which underlies much of landslide; angular, unsorted clasts range from pebble size to 15 ft in diameter

Tg **Gravel (Tertiary)**—Consolidated to unconsolidated, extensively dissected stream gravels or fan deposits, several hundred feet thick. Present only near western range front

Tb **Basalt (Tertiary)**—Mostly flows in northern part of map area. May include plugs and other rock types; mapped mostly from aerial photographs. Few small outliers on downfaulted block on west side of study area

Tai **Intrusive andesite (Tertiary)**—One small andesitic plug intruding biotite schist (Xbs) in northwestern part of study area

Yd **Diabase (Middle Proterozoic)**—Unmetamorphosed subhorizontal sheets, mostly in granite. Ophitic pyroxene gabbro

Yg **Granite (Middle Proterozoic)**—Granite forming large monadnock in Sacramento Valley a few miles west of study area. Not examined in this study but said to be unfoliated coarse porphyritic granite (K.A. Howard, oral commun., 1989). High radioactivity and lack of foliation suggest unit may be Middle Proterozoic

Early Proterozoic Intrusive Rocks
(all predeformational or syndeformational)

Xpg **Porphyritic granite (Early Proterozoic)**—Two types of biotite-bearing porphyritic granite, a coarse-grained variety containing 15-20 percent potassium-feldspar phenocrysts, and a darker, much finer grained variety containing 2-4 percent potassium-feldspar phenocrysts. Phenocrysts 0.5-2 in. long and usually elongate. Strongly foliated near contacts with stratified rocks in Boriana Canyon; unfoliated in interior

Xri **Intrusive rhyolite (Early Proterozoic)**—Quartz and feldspar porphyry dike in north-central part of study area. Dike is 10 to 15 ft thick. Also a small intrusive mass within muscovite schist (Xms) in southeastern part of map area

Xp **Pegmatites (Early Proterozoic)**—Mostly quartz, feldspar, and muscovite; may also contain biotite, hornblende, or magnetite. Mineral composition usually similar to spatially associated granite. Numerous pegmatites too small to show on map typically occur in swarms

Xt **Trondhjemite (Early Proterozoic)**—Fine- to medium-grained, tan, allotriomorphic-granular rock that commonly has layering or streaking defined by trains of magnetite and black hornblende. Consists of quartz and sodic plagioclase with minor potassium feldspar, hornblende, magnetite, epidote, and sphene. Accessory minerals are zircon, garnet, apatite, clinopyroxene, and biotite

Xbg **Biotite granite (Early Proterozoic)**—Fine- to medium-grained allotriomorphic-granular biotite granite. Consists of quartz, myrmekitic plagioclase, perthitic microcline, and biotite, as well as minor or accessory epidote, zircon, sphene, and apatite. The biotite granite mass in northwestern part of map area contains trace amounts of hornblende

Xlg **Leucocratic biotite granite (Early Proterozoic)**—Even-grained to seriate porphyritic (quartz phenocrysts) biotite granite similar to unit Xbg but has a lower color index. Present in north-central part of study area where it may grade into biotite granite

Xg **Granite (Early Proterozoic)**—Granite, largely in northwestern part of map area. Mapped mostly from aerial photographs. Most is probably trondhjemite or biotite granite. Contains sparse garnet 1/4 mi north of the road to Walnut Creek in northwesternmost part of map area

Xtg **Two-mica granite (Early Proterozoic)**—Medium-gray, allotriomorphic-granular, medium-grained, biotite-muscovite granite that forms two large elongate bodies in Boriana Canyon region. Characterized by ubiquitous, dark, mica-rich schlieren and seriate porphyritic texture (potassium-feldspar phenocrysts as long as 0.5 in.)

Xgd **Granodiorite, quartz monzonite, and diorite (Early Proterozoic)**—Small elongate masses in central part of map area are medium- and even-grained hornblende granodiorite to quartz monzonite. Body in northeastern part of map area is southern tip of a large body of biotite granodiorite and diorite that extends about 3 mi to southeast slope of Hualapai Peak

Early Proterozoic stratified rocks, strongly foliated and metamorphosed to amphibolite grade
(general order is from northwest to southeast—no stratigraphic order implied)

Xbs **Biotite schist (Early Proterozoic)**—Dark, fine- to medium-grained biotite-quartz-feldspar schist. Largely homogeneous mineralogically and texturally. Uncommon variants contain garnet or andalusite. No remnant sedimentary features observed; protolith probably graywacke. Crops out in northwestern part of map area

Xvs **Variable schist (Early Proterozoic)**—Heterogeneous unit that occupies central part of map area. Biotite schist, similar to unit Xbs is most common type, particularly in westernmost exposures. Other rock types include quartzofeldspathic schist with biotite and (or) muscovite and uncommon amphibolite (with or without biotite)

Xca **Coarse amphibolite (Early Proterozoic)**—Very coarse grained amphibolite. Consists of about equal amounts of anhedral plagioclase and hornblende in a coarse, irregular intergrowth. Either a sill or a flow, possibly with high water content that resulted in coarse metamorphic recrystallization

Xfs **Felsic schist (Early Proterozoic)**—Leucocratic quartz-feldspar-(muscovite) schist in west-central part of map area. Some of this unit may be trondhjemite

Xpa **Pillow-flow amphibolite (Early Proterozoic)**—Generally fine grained amphibolite with local coarse segregations. Pillows are readily recognized and locally are remarkably well preserved. Pillow preservation in areas of altered rock is enhanced by epidote-quartz replacement of original glassy pillow rinds

Xas **Andalusite schist (Early Proterozoic)**—Brown, coarse-grained, andalusite-biotite schist with subordinate quartz, feldspar, muscovite(?), and garnet(?) in northeastern part of map area. Generally deeply weathered. Andalusite in knots as much as 1 in. in diameter. Mostly homogeneous but contains fine-grained quartzofeldspathic interbeds locally

Xfa **Fragmental amphibolite (Early Proterozoic)**—Polymictic metaconglomerate in which most clasts are of basaltic and andesitic composition. Contains sparse beds of silt- to sand-size mafic material. East of Wabayuma Peak

Xrg **Rhyolitic gneiss (Early Proterozoic)**—Mostly leucocratic quartzofeldspathic gneiss that appears to have a rhyolite protolith. Phenocrysts not usually apparent in outcrop. Possibly rhyolite tuff. Coarse clastic texture (volcanic breccia?) observed at one locality. Generally fairly well preserved and highly resistant. East of Wabayuma Peak

Xqs **Quartzofeldspathic schist (Early Proterozoic)**—Quartz-feldspar-mica schist with local biotite- and hornblende-rich variants. Locally contains lenses of amphibolite, which are probably tectonically dismembered parts of unit Xpa. Gneissic locally, resembling unit Xrg. Hosts massive sulfides at Antler mine

Xds **Dark schist (Early Proterozoic)**—Biotite- and (or) hornblende-rich, muscovite-bearing schist that commonly contains garnet. Two small lenses mapped in Boriana Canyon

Xms **Muscovite schist (Early Proterozoic)**—Fine-grained leucocratic and muscovitic quartzofeldspathic schist. Highly foliated and multiply isoclinally folded (More, 1980). Protoliths are probably shale, siltstone, and tuff. This unit hosts predeformational quartz-wolframite veins of Boriana and Bull Canyon mines and massive sulfides of Copper World mine

Contact—Dashed where approximately located; short-dashed where inferred; queried where presence is highly uncertain

Fault—Dashed where approximately located; short-dashed where inferred; dotted where concealed. Ball and bar on downthrown side; arrows indicate relative lateral movement. Arrow indicates direction and amount of dip

Strike and dip of foliation

Bearing and plunge of lineation—May be combined with foliation symbol at point of observation

Strike and dip of vertical foliation

Bearing and plunge of minor fold; no sense of deformation indicated

Approximate trace of anticlinal axial plane showing direction of plunge—Long dashed where approximately located; short-dashed where inferred; dotted where concealed

Approximate trace of synclinal axial plane showing direction of plunge—Long dashed where approximately located; short-dashed where inferred

Rocks enriched in chlorite—Some sites are high-grade assemblage, cordierite-anthophyllite

Pegmatite vein

Chert or ferruginous chert lens

Quartz vein

Area of greisen zone in granite

Drainage basin with geochemical anomaly spar symbol at sample collection site

Geochemical anomaly spars showing positions for the metals tungsten (W), bismuth (Bi), molybdenum (Mo), tin (Sn), thorium (Th), niobium (Nb), lanthanum (La), and yttrium (Y)—On map, long spar indicates element is very strongly anomalous; short spar indicates element is strongly to moderately anomalous

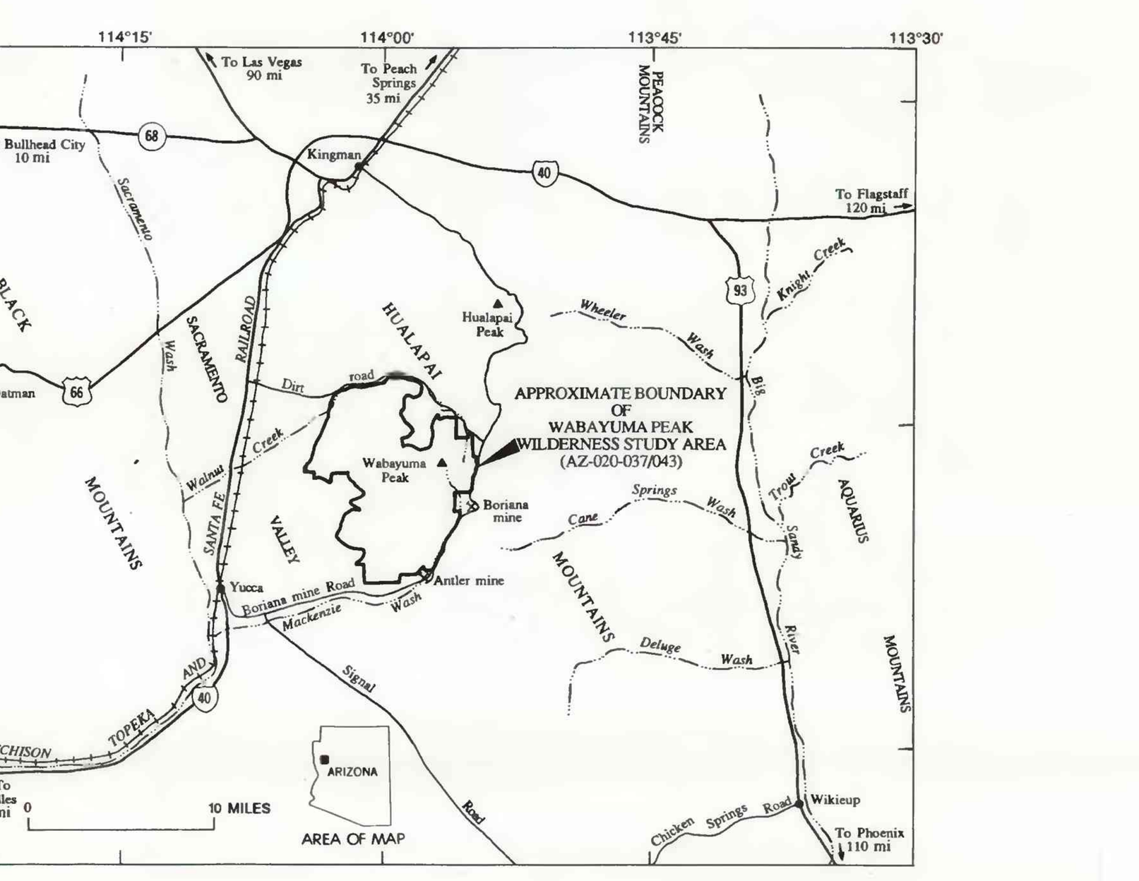
Area possibly containing altered rock, as determined from Landsat spectral data:

1. Group 1 minerals that may include hematite, goethite, lepidocrocite, and jarosite--See text for discussion
2. Group 2 minerals that may include clay minerals, micas, gypsum, alunite, jarosite, calcite, and dolomite--See text for discussion
3. Group 1 and 2 minerals--See text for discussion

Anomaly strength indicated by geochemical anomaly spar symbol

[Values in ppm by semiquantitative spectroscopic analysis of nonmagnetic heavy-mineral concentrates; N, not detected at value shown; <, detected but less than value shown; >, greater than value shown; blank, no analytical values at this level]

	Long spar	Short spar		No spar
	Very Strong	Strong	Moderate	Weak
W	5,000 - >20,000	1,500 - 3,000	500 - 1,000	N50 - 300
Bi	1,000 - >2,000	300 - 700	150 - 200	<10 - 100
Mo	>700	200 - 500	70 - 150	<10 - 50
Sn	1,000 - 2,000	200 - 500	100 - 150	<20 - 70
Th	>5,000	2,000 - 3,000	1,000 - 1,500	<200 - 700
Nb			100 - 200	<50 - 70
La		>2,000	2,000	1,000 - 1,500
Y		5,000	3,000	1,000 - 2,000



INDEX MAP

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

LEVELS OF RESOURCE POTENTIAL

- H **HIGH** mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data support mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.
- M **MODERATE** mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate reasonable likelihood for resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.
- L **LOW** mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is permissive. This broad category embraces areas with dispersed but insignificantly mineralized rock, as well as areas with little or no indication of having been mineralized.
- N **NO** mineral resource potential is a category reserved for a specific type of resource in a well-defined area.
- U **UNKNOWN** mineral resource potential is assigned to areas where information is inadequate to assign a low, moderate, or high level of resource potential.

LEVELS OF CERTAINTY

- A Available information is not adequate for determination of the level of mineral resource potential.
- B Available information only suggests the level of mineral resource potential.
- C Available information gives a good indication of the level of mineral resource potential.
- D Available information clearly defines the level of mineral resource potential.

LEVEL OF RESOURCE POTENTIAL ↑ / LEVEL OF CERTAINTY →	A	B	C	D
	U/A UNKNOWN POTENTIAL	H/B HIGH POTENTIAL	H/C HIGH POTENTIAL	H/D HIGH POTENTIAL
		M/B MODERATE POTENTIAL	M/C MODERATE POTENTIAL	M/D MODERATE POTENTIAL
		L/B LOW POTENTIAL	L/C LOW POTENTIAL	L/D LOW POTENTIAL
				N/D NO POTENTIAL

Abstracted with minor modifications from:

Taylor, R.B., and Steven, T.A., 1983, Definition of mineral resource potential: Economic Geology, v. 78, no. 6, p. 1268-1270.
Taylor, R.B., Stoneman, R.J., and Marsh, S.P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: U.S. Geological Survey Bulletin 1638, p. 40-42.
Goudarzi, G.H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84-0787, p. 7, 8.

MINERAL RESOURCE POTENTIAL AND GEOLOGY OF WABAYUMA PEAK WILDERNESS STUDY AREA, MOHAVE COUNTY, ARIZONA