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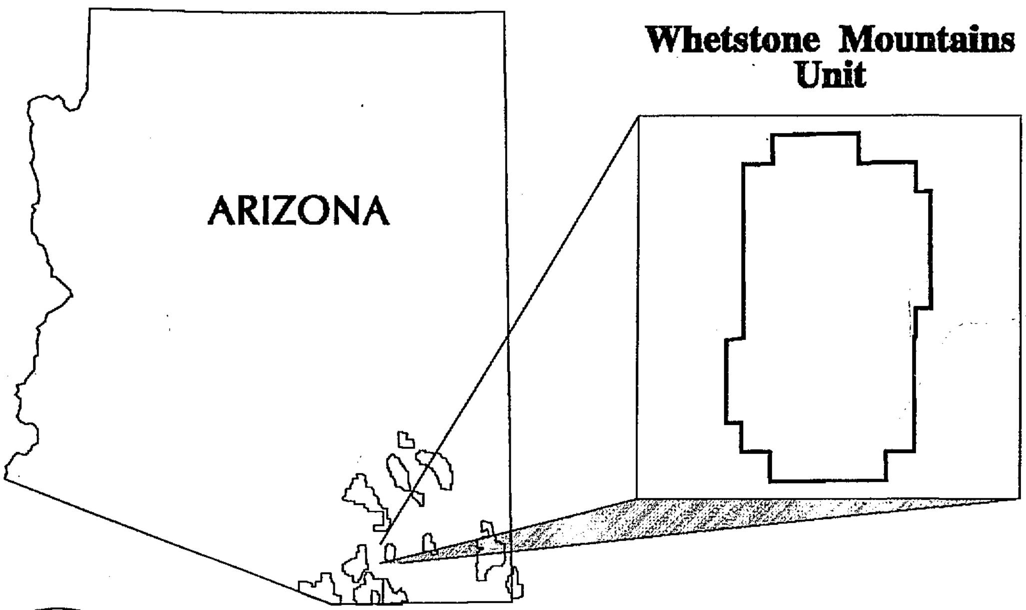
MINERAL APPRAISAL OF CORONADO NATIONAL FOREST, PART 11

Whetstone Mountains Unit
Cochise and Pima Counties, Arizona



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This report addresses the 44,345-acre Whetstone Mountains Unit of the Forest. The work included inventorying and mapping of mines and prospects. Rock-chip samples from mineral zones were assayed; assay data are tabulated. Metallic mineral deposits are genetically and spatially related to two intrusions that cut or underlie Paleozoic-age sedimentary rocks. One deposit is a 22 million short ton inferred resource of 0.31 percent copper in veinlets and disseminations of sulfide minerals; past production has been very small. A Precambrian-age quartz-monzonite/alaskite intrusion hosts a fluorite vein, several quartz-tungsten veins, and sparse, uraniferous fractures. No resources of those commodities are present. A massive quartz dike, probably syngenetic with the Precambrian intrusion of quartz-monzonite/alaskite, was mined for about 300,000 short tons of copper-smelter flux; at least 8 million short tons of indicated silica-flux resources remain, but development is unlikely because they lack any appreciable precious metals content, a requisite in current markets. Sedimentary strata host 137,000 short tons of low-purity, indicated, subeconomic gypsum resources with limited application. They are unlikely to ever be developed, based on steep terrain and unfavorable geologic structure, which would increase mining costs and reduce recoverability.

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MINERAL APPRAISAL OF CORONADO NATIONAL FOREST, PART 11

WHETSTONE MOUNTAINS UNIT
COCHISE AND PIMA COUNTIES, ARIZONA

by

MARK L. CHATMAN
U.S. BUREAU OF MINES

MLA 2-94
1994

Intermountain Field Operations Center
Denver, CO

U.S. DEPARTMENT OF THE INTERIOR
Bruce Babbitt, Secretary

BUREAU OF MINES
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PREFACE

A January 1987 Interagency Agreement among the U.S. Bureau of Mines (USBM), U.S. Geological Survey, and the U.S. Dep. of Agriculture, Forest Service describes the purpose, authority, and program operations for forest-wide studies. The program is intended to assist the Forest Service in incorporating mineral resource data into forest plans as specified by the National Forest Management Act (1976) and Title 36, Chapter 2, Part 219, Code of Federal Regulations, and to augment the USBM's mineral resource data base so that it can analyze and make available minerals information as required by the National Materials and Minerals Policy, Research and Development Act (1980). This report is based upon available information, extensive field investigations to verify or collect additional information, and contacts with mine operators and prospectors active on lands administered by the Coronado National Forest.

This open-file report summarizes the results of a USBM forest-wide study. The report is preliminary and has not been edited or reviewed for conformity with the USBM editorial standards. This study was conducted by personnel from the Intermountain Field Operations Center, P.O. Box 25086, Building 20, Denver Federal Center, Denver, CO 80225-0086.

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

Acre(s)	ac
Counts per second	cps
Degree	°
Inch(es)	in.
Foot (feet)	ft
Mile(s)	mi
Ounce(s)	oz (troy)
Part(s) per billion	ppb
Part(s) per million	ppm
Percent	%
Pound(s)	lb (avoirdupois)
Short ton(s)	st (2,000 lb)
Square mile(s)	mi^2

MINERAL APPRAISAL OF CORONADO NATIONAL FOREST, PART 11
WHETSTONE MOUNTAINS UNIT

by Mark L. Chatman[1]

SUMMARY

U.S. Bureau of Mines personnel studied mineral resources of the Coronado National Forest to appraise the resources present and determine areas for possible future mineral exploration and development. This report addresses the 44,345-acre Whetstone Mountains Unit of the Forest, Cochise and Pima Counties, AZ. The work included inventorying and mapping of mines and prospects; maps follow the references section in this report. Rock-chip samples from mineral zones were assayed; assay data are tabulated in appendixes.

Metallic mineral deposits in the Unit are genetically and spatially related to two intrusions that cut or underlie Paleozoic-age sedimentary rocks. A Tertiary-age granodiorite stock hosts a subeconomic, 22 million short ton *inferred* resource of 0.31 percent copper in veinlets and disseminations of sulfide minerals; the deposit continues to attract minor interest from the mining industry. Past production of copper from this deposit and past production from adjacent, very low-tonnage, uneconomic skarns (copper, lead, silver), has been insignificantly small. The skarns are too low in tonnage to be economically viable.

A Precambrian-age quartz monzonite/alaskite intrusion hosts a fluorite vein, several quartz-tungsten veins, and sparse, uraniferous fractures. No resources of those commodities are present. The known extent of the fluorite vein was mined out, producing 20,000 st of fluorspar. Exploration for an extension of the vein is unlikely, considering market conditions, foreign competition, and thinness of the known part of the vein. A massive quartz dike, probably syngenetic with the Precambrian intrusion of quartz-monzonite/alaskite, was mined for about 300,000 short tons of copper-smelter flux; at least 8 million short tons of indicated silica-flux resources remain, but development is unlikely because they lack any appreciable precious metals content, a requisite in current markets.

Sedimentary strata host 137,000 short tons of low-purity, indicated, subeconomic gypsum resources with limited application. They are unlikely to ever be mined, based on steep terrain and unfavorable geologic structure, which would increase mining costs and reduce recoverability.

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INTRODUCTION

The U.S. Bureau of Mines (USBM) effort in the Whetstone Mountains Unit of Coronado National Forest is one part of a comprehensive effort to inventory, map and sample mines and prospects in the Forest, in order to assess mineral resources. Geologic and economic modeling were completed for certain sites with identified mineral resources. Results of the economic modeling can be used to help predict where future mineral exploration would most likely occur, and predict the scale of that mineral development. This report addresses economic characteristics of the major mines and prospected areas in the Whetstone Mountains Unit. Supporting sample descriptions and assay data are compiled in appendixes A-C. Appendixes are ordered by sample numbers, which carry a "WH" prefix. Mine maps have been created for many sites; those figures follow the references section of this report. Inset maps, enlarged sections of topographic maps which display locations for concentrated mine workings, are also in the group of figures which follow the references section. Use plate 1 (in pocket) as a quick reference for the relative locations of inset maps, mine maps, and samples.

Geographic setting

The Whetstone Mountains Unit, Cochise and Pima Counties, AZ, is about 5 mi southwest of Benson, AZ, and 13 mi north of Sierra Vista, AZ. The Unit comprises 44,345 ac (fig. 1), or all but about 8 mi^2 of the southernmost part of the Whetstone range. Within that acreage, are about 463 ac of private land (homesteads and mineral patents). Most of the Unit is within Cochise County (37,012 ac); remaining acreage is in Pima County (7,333 ac). Locations of main roads, public land survey lines, nearby towns, and major geographic features are on pl. 1. Few roads are available for access to the northwest and west-central parts of the range and there are no routes over the backbone of the range, which is dominated by Apache Peak (7,711 ft) and French Joe Peak (7,675 ft). The other sections of the Unit are readily accessible by vehicle, but cross-country traverses are impeded in many places by thick brush and steep slopes. A railroad line is within 5 mi of the northern boundary of the Unit.

Geologic and mineral setting

The northeastern part of the Whetstone Mountains Unit is underlain by a Precambrian-age, porphyritic, quartz monzonite pluton (pl. 1), and alaskite. These

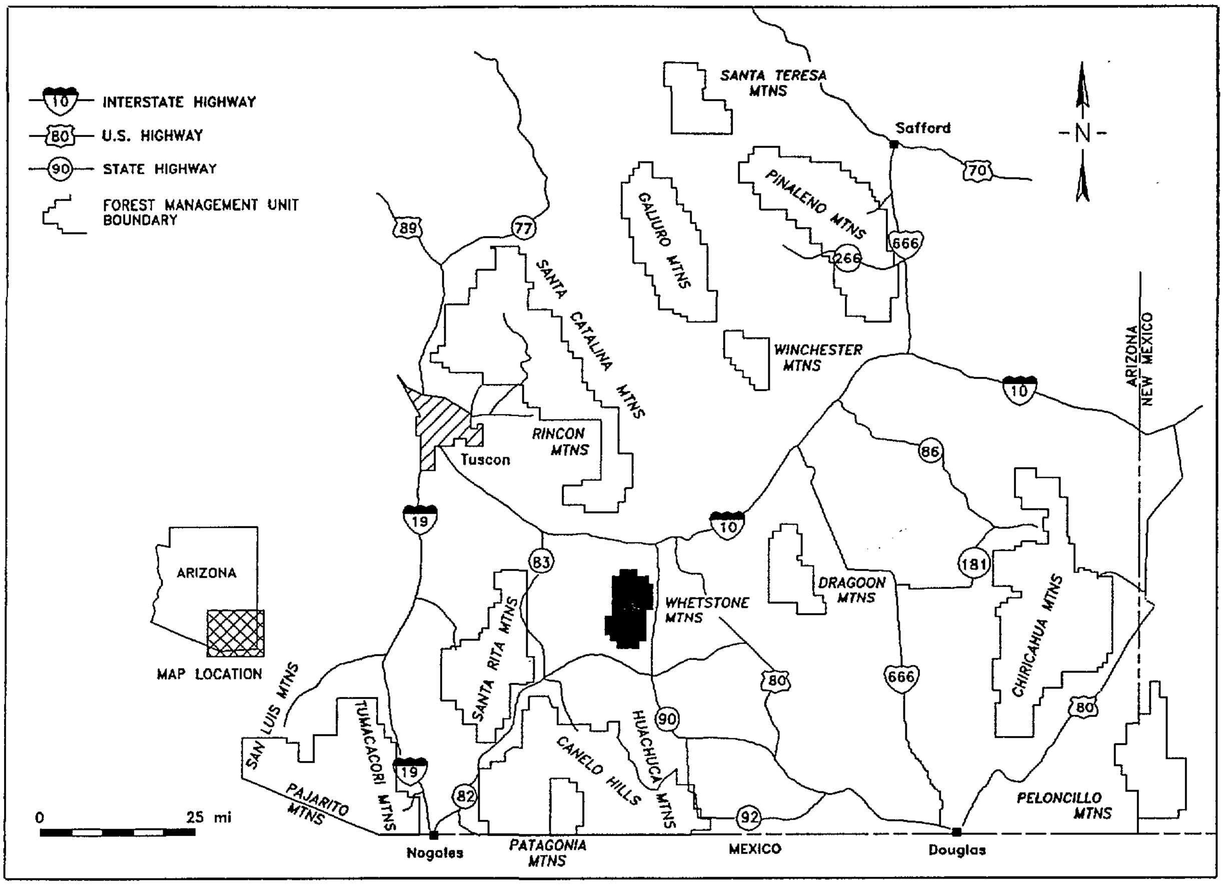

Figure 1.--Location map of the Whetstone Mountains Unit, Cochise and Pima Counties, Arizona.

rocks host fluorite, tungsten (scheelite, wolframite), and uraninite deposition in fractures and veins. The Precambrian plutonic rocks also include a few aplite dikes. The aplite dikes, in places, contain small tungsten or base metal concentrations. A small part of the Precambrian rock exposure is Pinal Schist.

On the vast majority of the acreage in the Whetstones Mountain Unit are exposures of southwestward-dipping[2] Cretaceous-, Permian-, and Pennsylvanian-age sedimentary rocks, including the middle member of the Permian Epitaph Formation, which, in places, contains low-purity gypsum beds. Four formations deposited in Mississippian, Devonian, and Cambrian times also crop out in the Whetstone Mountains Unit; Cambrian-age Bolsa Quartzite and Abrigo Limestone are the oldest sedimentary formations known there.

The sedimentary strata was intruded by two granitic bodies (pl. 1). The Tertiary-age Granite Peak stock is composed of granodiorite and is cut by co-magmatic basaltic and silicic dikes. Skarns with base metal sulfides formed where the granodiorite intruded carbonate sedimentary rocks. Within the granodiorite intrusion are zones of sulfide copper minerals in both veinlet and disseminated forms. A Cretaceous-age igneous intrusion is in the west-central part of the Unit (pl. 1); it may be the mineralizing agent responsible for a mercury anomaly immediately to the north. Some fine-grained intrusive rhyolite dikes in the east-central part of the Unit may be the cause of minor metallization found along a fault there. The definitive geologic mapping for the range is by Creasey (1967); that work, with some modifications, can be found in Wrucke and others (1983) and Wrucke and McColly (1984). Those works provided the data used to compile this geologic setting.

Mining and prospecting history

A brief synopsis of mining in the Unit follows. The reader can find more details, and all appropriate reference citations in this report, under specific mine headings in the "mineral deposit appraisal" section.

The Granite Peak stock continues to be of some interest to industry today (1992) for copper deposits. The stock's metallization was discovered about 1870, but was worked primarily in the period of 1918 to 1929, for at least 2,100 st, and more likely for about 5,000 to 10,000 st of ore. Skarn deposits peripheral to the stock and in carbonate xenoliths within the stock supplied the vast majority of production. This yielded copper and lead, with byproduct silver and trace gold. Minor production from

[2] Most dips in the range of 30° to 40°.

veinlet/disseminated deposits occurred. Sporadic mining of the Two Peaks Mine, a veinlet/disseminated property, took place as late as the 1960's.

Precambrian-age intrusive rocks host mine sites for several commodities. The only commodity of economic note is the Lone Star fluorspar mine, where a single, narrow, high-grade quartz-fluorite vein was mined on several underground levels for 20,000 st of ore from 1946 to 1967, at which time the known resources at the site were exhausted. Several discontinuous fracture zones in granitic rocks were investigated for uranium via prospect excavations (1950's) and exploration drill holes (1970's to early 1980's); negligible amounts of uraninite were produced. Other granitic rocks were worked sporadically for scheelite- and wolframite-bearing quartz veins when tungsten mining was promoted in the U.S. (early 1900's, WWI, WWII, and the 1950's). Total tungsten production, very poorly documented, is small. About 300,000 st of a massive quartz dike (probable Precambrian age) was quarried in the 1950's and used as copper-smelter flux.

Previous investigations

The major report covering geology of the Whetstone Mountains Unit is Creasey (1967); that work, with some modifications, is reproduced in more recent publications by Wrucke and others (1983) and Wrucke and McColly (1984). Other recent work includes the USBM RARE II (Roadless Area) study of part of the range, done in 1980 and 1981 (McColly and Scott, 1982) under authority of the Wilderness Act (Public Law 88-577). Only 36,610 ac were studied under RARE II, as lands with significant established mining or prospecting, and established roads were not included within the Whetstone Mountains RARE II area. Other work, focused on geology and/or mineralization of specific parts of the range include DeRuyter (1979), Burnette (1957), and Schreiber and others (1990); Graybeal (1962) studied gypsum deposits immediately south of the National Forest, in the southernmost part of the range. Other work on specific mines or prospects in the range has been done; those works are cited under sections that deal with specific mines and prospects. The regional geologic setting of the range is presented in Krantz (1989).

Present investigation

The USBM mineral appraisal of the Whetstone Mountains Unit was carried out sporadically over several years. Work was undertaken in brief trips during August 1989, and August, October, and November of 1992. This study involved comprehensive literature search and field investigations, which focused on mine and prospect localities. An inventory of mines and prospects was compiled for the Whetstone Mountains Unit and field locations were verified. A total of 105 rock-chip samples were collected from the mines and prospects and from related mineralized structures to augment an appraisal of the mineral resources. Sample descriptions are in appendix A. Samples were analyzed for two different suites of elements, one by Bondar-Clegg and Co., Ltd. (results in appendix B), and another by Chemex Labs, Inc. (results in appendix C). Detection limits and analytical methods are listed with the respective appendixes. Gypsum samples were tested by Hazen Research, Inc., Golden, CO; results are offered in table 3. Sampling methods and sample preparation methods are detailed in appendix D. Maps created as a result of visits to many of the mine and prospect sites are included with this report, following the references section.

Economic modeling was applied where copper resources in the *identified*[3] resource categories are thought to be present. The economic model is based on PREVAL, the USBM prefeasibility mineral property evaluation software program designed for general economic valuation of properties about which very limited details are known. Results can be considered as a screening to help rank sparsely quantified mineral exploration targets, but costs should not be used as definitive numbers (Smith, 1992, p. 1, 2). Further details on PREVAL parameters are enumerated in appendix D. Economic modeling of tungsten, uranium, silica flux, and gypsum sites is based on a study of prevailing (1993) market conditions because PREVAL functions do not address these commodities.

MINERAL DEPOSIT APPRAISAL

Mine and prospect sites that are appraised in this section are depicted on detailed topographic inset maps and/or mine maps. Plate 1 (in pocket) shows topographic inset locations and locations of isolated mines and prospects. Individual maps are presented as figures, following the references section.

Tertiary-age copper deposits

Whetstone Mountains Unit copper deposition is in or very near the Granite Peak stock. The copper occurs in three forms: 1) veinlet or disseminated sulfides

[3] "Resources [for which] location, grade, quality, and quantity are known or estimated from specific geologic evidence ... To reflect varying degrees of geologic certainty ... can be subdivided into measured, indicated, and inferred." (U.S. Bureau of Mines and U.S. Geological Survey, 1980, p. 1-2).

associated with igneous phases and faults through the stock; 2) sulfides in calcic skarns formed where the stock intruded calcareous rocks; 3) one, isolated, siliceous copper deposit, about which little is known.

Granite Peak stock

USBM work on the Tertiary-age Granite Peak stock (fig. 2) was very limited. Field data from the USBM RARE II study (McColly and Scott, 1982) and from a brief August 1989 visit was relied on exclusively. Those efforts consisted of examination and sampling of a few specific mine and prospect workings. After completion of the Coronado National Forest field study in the Whetstones in November 1992, it was learned that 40 Granite Peak stock mineral excavations (including the Nevada Mine) (fig. 2), all within the RARE II boundary, were not investigated during the RARE II or 1989 USBM field efforts; the geologic and mine location work by DeRuyter (1979) was used to close this data gap.

Granite Peak stock is primarily a granodiorite intrusion into carbonates and other Paleozoic-age lithologies of the Bisbee Group. This stock was intruded and metallized by younger Tertiary dikes that have been classed as rhyodacite or quartz monzonite porphyry. The porphyry dikes and fault zones that cut the stock usually trend northeast and dip at high angles (60° to 80°), a structural characteristic related to the regional tectonics (Keith, 1973, p. 91; DeRuyter, 1979, ch. 6, fig. 5).

<u>Copper porphyry deposit possibilities</u>

Several characteristics of the Granite Peak stock are indicative that it is *permissively* a copper porphyry deposit host, though no copper porphyry deposit is exposed or known at the site. These characteristics, pointed out by DeRuyter (1979, p. 111-113) include:

* Age of the stock and its metallization;
* Location in Arizona's copper porphyry belt;
* Bulk composition in the granodiorite-quartz monzonite range;
* Presence of a porphyritic phase and of some brecciation in the stock.

These permissively favorable characteristics are countered by the absence of key, pervasive alteration zones that characterize copper porphyry deposits. Potassic alteration is found only with the highest-grade metallized zones. Sericitic alteration is present in only minor amounts, and there are no known pyrite-rich zones. Argillic alteration is absent, and zones of propylitic alteration (the most extensive in copper porphyry deposits) are spatially restricted. Base-metal sulfide zones are also spatially restricted. No zone of secondary chalcocite enrichment has been located, even though the deposit was drilled by two companies (DeRuyter, 1979, p. 111-113, fig. 5). The secondary enrichment zones are usually the major ore zones in copper porphyry deposits.

Copper resource estimates made at the property by DeRuyter (1979) were cited in later literature as a *copper porphyry occurrence* (Wrucke and others, 1983, p. 5, pamphlet). It appears that this was a misinterpretation of DeRuyter's work, because DeRuyter (1979, p. 112, 113) discusses only the *possibility* of finding a copper porphyry deposit at depth below the known copper-sulfide bearing skarns and veinlet/disseminated zones in and around the stock; DeRuyter's resource estimates were specifically for veinlet/disseminated zones. Perhaps most conclusive in the copper porphyry deposit question is the fact that drilling of the intrusion by New Jersey Zinc Co. and Duvall Corp. (DeRuyter, 1979, fig. 5) detected no copper porphyry deposit. Time of the mineral exploration drilling is not known by USBM.

<u>Veinlet and disseminated deposits of copper</u>

In the Granite Peak stock, where faults, granodiorite, and younger dikes (rhyodacite, quartz monzonite porphyry) coincide, veinlet and disseminated deposits of copper sulfides and oxides have been found, some with about 1% to 2% copper[4] (DeRuyter, 1979, ch. 6). A study of drill core by DeRuyter (1979, fig. 2, 5) led that researcher to conclude that 32 million st of 0.3% copper (Cu) and 0.01% molybdenum (Mo) are present in six separate zones, delineated around drill holes 2-7 (see fig. 2, this report). DeRuyter's method of tonnage estimation was to define columnar resource zones; columnar widths were defined by mineralized, angled, core intercept lengths. The same grade was then projected above the core intercept to the topographic surface, and also downward and equal distance below the core intercept. The total columnar volume was thus defined, and converted to a tonnage.

USBM studied DeRuyter's (1979) core data, which is abridged, and modeled the deposit geometry quite differently. There is only a singular, linear zone of veinlet/disseminated copper sulfides in the Granite Peak stock for which resources can be estimated (fig. 2). This zone is an 1,800-ft-long trend that includes Two Peaks Mine and surrounding rock[5]; it contains an inferred, subeconomic, 22 million st copper resource (weighted average grade of 0.31% Cu), based on summaries of drill logs and

[4] The average copper content in the veinlet and disseminated copper occurrences is about 10% of the mined grade, or about 0.1% to 0.2% Cu.

[5] Resource estimates were made for 4 contiguous resource blocks, not individually delineated on fig. 2. The blocks occur between the 2 points indicated on fig. 2. The vast majority of the resource zone is 270 ft in width and 900 ft down dip, with an average dip of 80°.

assays in DeRuyter (1979), and supplemented by USBM samples and data from mine maps. Data are too limited to suggest resources at other known copper-bearing localities in the stock (drill sites 4-6 and 7, fig. 2), primarily because no other sites are known to contain sufficient tonnage to support resource estimates.

Total past production from the USBM resource zone was negligible. The Two Peaks Mine *adit* was worked for about 200 st, based on the size of the excavated mineral zone; other tonnage may have come from the shaft on the site (WH88-89, fig. 2). The site was mined for "one carload" of 4% copper ores in 1916 by the Two Peaks Mining Co., Turner, AZ, from 1,500 ft of excavations, but the firm was defunct by 1924 (Weed, 1922; 1925). There was other intermittent (probably minimal) production in the 1960's (ADMMR files, Phoenix, AZ).

Economics. Hypothetical mining of the USBM 22 million st inferred subeconomic copper resource would not be economic at late 1993 copper prices. Molybdenum concentrations were considered too low for resource estimations. The hypothetical mine would be a small open pit, operating at 6,100 st of ore and 10,600 st of waste per day, with a 1.75:1 stripping ratio. These rates would provide for a 15-year mine life (including two pre-production years). However, no profit would be realized at $1.00/lb copper. Net present value (NPV) of the hypothetical mine is *negative* $113 million at a 15% rate of return. Through the life of the mine, mining would cost $4/st of ore (including overburden moving), and milling by flotation for copper would cost $7 per st of ore. But the cumulative revenue from the mine, about $107 million, would not meet cumulative costs, royalties, taxes, etc. The break-even condition (in terms of NPV) is $4.895/lb copper, a copper price that is not anticipated in the foreseeable future. The cash-flow situation is detailed further in appendix D.

<u>Skarn-hosted base-metal sulfides</u>

At sites in and near the Granite Peak stock where xenoliths or in-place outcrop of the carbonate rocks spatially coincide with faults, granodiorite, and dikes, the metallization is hosted in skarn. Some copper, lead, and silver have been recovered, historically. Skarn occurrences of base-metal sulfides account for most of the mineral excavations in and near the stock, based on DeRuyter's (1979, fig. 2) mapping, but remaining deposits are of minor tonnage.

Total production from these skarn deposits is not well documented. Metallic mineral deposits of the Granite Peak stock were discovered about 1870 (McColly and Scott, 1982, p. 3); the majority of ores were mined from about 1918 to 1929, when

100,000 lb of copper, 900,000 lb of lead, and about 37,500 oz silver[6] were recovered (Elsing and Heineman, 1936, p. 91). Most of that likely was from skarn. An average grade of 1% Cu would allow a production tonnage from that era of 5,000 st, and an average lead grade of 9%. It is not unusual to find such high grade, low tonnage lead deposits locally in skarns. Another period of mine production ensued from 1955 to 1961, when skarns of the Nevada and Mascot Mines, and possibly the David Lee Mine and an unnamed skarn deposit (WH86-87) were worked. Another 36,000 lb copper, and 600 oz silver were recovered[7], though some unknown part of that total came from the Two Peaks Mine, which is not a skarn, but a veinlet/disseminated type deposit (McColly and Scott, 1982, p. 5). Total production from the Granite Peak stock is probably higher than the 2,100 st reported by Keith (1973, p. 90), and is more likely in the range of 5,000 st to 10,000 st of ore.

Resources. Skarn resources, in the inferred category (U.S. Bureau of Mines, and U.S. Geological Survey, 1980), are small. The Mascot Mine contains about 1,200 st with 1% Cu, and may have been mined for about 1,400 st, based on dimensions of the excavated mineral zone. The David Lee Mine is smaller, with about 1,100 st of 0.4% copper resources and 300 st of production, based on dimensions of the excavated mineral zone. Excavation dimensions suggest about 140 st were mined from skarn in an unnamed adit (WH86-87). No information is available for the Nevada Mine. Deposits of this size are not economical to capitalize and mine under 1993 market conditions.

<u>Gold concentration levels in the stock</u>

A study of gold concentrations did not locate any sites of economic interest. Of the 26 USBM rock-chip samples from the area, 16 contain detectable gold, (6 ppb to 320 ppb Au), but only three of those samples exceed 100 ppb Au (equivalent to 0.003 oz Au/st). See samples WH77-103, appendixes B and C. The highest gold concentration is 320 ppb (equivalent to 0.009 oz Au/st).

<u>Siliceous copper deposit</u>

The open-pit Copper Plate Mine (pl. 1, WH103) may be genetically related to the Granite Peak stock, although it is west of the stock perimeter by more than a mile.

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[6] Elsing and Heineman (1936, p. 91) report production as $30,000 in silver. The weight was estimated, based on an average silver price of $0.80/oz over that time period.

[7] Also 8 oz gold.

Descriptions from the literature (sometimes conflicting) and the USBM RARE II study (1980-1981) are the only available data on the site and are presented here. Malachite, in a horizontal, 2.5-ft-thick silicified zone hosted by porous Bisbee Group sandstone, was mined by open-pit methods by International Mines, Inc., of Las Vegas, NV in 1957 and 1958 for 1,600 st of 1.2% Cu and 0.6 oz Ag/st ores. The 20 "carloads" of ore mined in 1958 averaged 80% SiO_2, 1.6% Cu, and 1 oz Ag/st. That material was sent to the Phelps-Dodge smelter, Douglas, AZ as flux. The deposit has also been described as a series of lenses, 5-ft- to 8-ft-wide, oriented N. 40° to 60° W., dipping SW. 20° to 35°, controlled by a fault. Final pit dimensions were 70-ft-long, 30-ft- to 50-ft-wide, and 15-ft to 30-ft-deep. By 1960, the property was idle (Johnson, 1958, p. 1; 1960, p. 1; ADMMR files, Phoenix, AZ; McColly and Scott, 1982, p. 6, 12). The USBM estimated 2,000 st to 4,000 st of remaining inferred subeconomic resources of low-grade copper material at the site, northward from the pit wall for 50 ft to 100 ft; a collected sample represented the highest grade of copper-bearing rock that was exposed (WH103; 0.79% Cu) (McColly and Scott, 1982, p. 6). The copper grade of that rock is interesting, but the estimated tonnage is too small to consider mining for copper under mid-1993 economic conditions. The material could still be used as copper smelter flux because it has precious metals content (see market conditions in "silica section", this report), but the small tonnage (and distance from smelters) again would preclude further development.

Other metallic mineral occurrences of probable Cretaceous/Tertiary origin

A few isolated prospect sites in the Whetstone Mountains Unit are distant from the Granite Peak stock, yet are still probably genetically related to Cretaceous/Tertiary-age intrusive activity in the mountain range.

Gold Cristle Mine

The Gold Cristle Mine (fig. 11) is a northeast-trending shear through Abrigo Limestone. A Cretaceous-age, fine-grained granodiorite sill mapped nearby (Wrucke and others, 1983, map) is the likely mineralizing agent. Gold in amounts of $100/st was reported to be contained in the gouge and broken limestone of this shear zone (Dale, 1957b, p. 1). The site was developed sometime prior to 1957 by a trench (fig. 11) and a 20-ft-deep shaft (not found; possibly concealed by slough in the trench sometime before 1989). The USBM examiner on the site 36 years ago, when workings were less sloughed, estimated that total production was less than 30 st of ore-bearing rock. The time of mining is not known. J. M. Wilson, of St. David, AZ, owned 3 claims on this site in 1957 (Dale, 1957b, p. 1).

USBM samples (WH53-55) of the shear and adjoining limestone contain at most trace amounts of gold and silver. Sampling by USBM in the 1980-1981 RARE II study consisted of a sample down the full length of the trench on both the northwest side and the southeast side (McColly and Scott, 1982, pl. 1, samples 16, 17). The sample on the southeast side reportedly contains 0.02 oz Au/st and 0.1 oz Ag/st. The sample is not available for re-assaying. The sample from the northwest side of the trench reportedly is barren of gold and silver. The low metal concentrations support no resource estimates at this site. Unless higher precious metal concentrations than those reported can be found, there is no likelihood that the property will be mined.

Montosa-Willow Canyon mercury anomaly

A mercury anomaly (see pl. 1), with 0.13 to 2.5 ppm elemental mercury (Hg), was reported after studying results of reconnaissance geochemical sampling (heavy mineral concentrate) within part of the Whetstone Mountains Unit; mercury in the form of cinnabar was reported. A slightly lower concentration level of mercury (0.1 ppm) was detected in the geochemical sampling in areas on the east side of the Whetstone Mountains, in Middle Canyon (Wrucke and others, 1983, p. 3, 6, 8). All the mercury concentrations are far less than economic levels. They are attributable to a 5 mi^2 outcrop area of Cretaceous-age granitic rock which underlies the southwest part of the mercury anomaly area, and is continuous southward into Apache Canyon. The mercury is not thought to be genetically related to the Precambrian-age mineralization on the east side of the range, which has formed fluorite, silica, tungsten, and uranium deposits (Wrucke and McColly, 1984, p. 126, 129).

The Montosa-Willow Canyon mercury probably reflects concealed hydrothermal alteration, perhaps with metallization. No prospects or mines are currently in the area (1993). The cinnabar form of mercury (mercury sulfide, in the form HgS), in particular, is associated with lower-temperature range (50° C. to about 100° C.) hydrothermal solutions related to igneous rock bodies (Goldschmidt, 1958, p. 276-277). Hydrothermal gold deposition is favored by that same temperature range. However, the USBM suite of samples (appendix B) are generally lacking in gold content, particularly samples away from the Granite Peak stock.

About 25% of the USBM samples (appendix C) from the Whetstone Mountains Unit contain 1 ppm Hg or more. These samples are nearly all from areas containing some metal or mineral of economic interest. Samples from the most-intense Tertiary-age mineralization (Granite Peak stock) have the highest concentrations of mercury (as much as 64 ppm Hg, sample WH87). The Montosa-Willow Canyon anomaly could therefore be the geochemical expression of a concealed, mineralized stock of the size, type, and tenor of the Granite Peak stock. Future exploration to discover new metalliferous deposits of such a scale is unlikely to take place.

Unnamed prospect (sample WH105)

Small-scale excavation on a fissure vein is hosted in Abrigo Limestone was observed in the northwest part of the Whetstone Mountains Unit (pl. 1). This narrow vein (3-ft-wide) contains calcite, but no silica; it was traced along strike for 100 ft. The sample (WH105) contains no appreciable metallic concentrations or other elements that would suggest any economic interest.

Minerals hosted in Precambrian rock

Wrucke and others (1983, p. 2) suggest a genetic as well as a spatial relationship between Precambrian granitic rock and alaskite in the northern part of the Whetstone Mountains and vein-type occurrences of fluorite, tungsten, and uranium. The alaskite is considered to be the youngest and most silica-enriched of the Precambrian rocks exposed in that part of the range. Other trace elements present in the geochemical suite from this area include beryllium, columbium, and yttrium, though no mineral deposits of those three trace elements are known. A large silica (flux) deposit in this area may also be genetically related to these Precambrian igneous rocks. (See Wrucke and others, 1983, p. 2, 3.)

Fluorite

The Lone Star fluorspar mine (fig. 5, 6) is the only known fluorite occurrence in the Whetstone Mountains Unit. It is, however, somewhat remarkable in that it is one of the State's largest fluorite mines, in terms of composite past production (20,000 st of fluorspar from 1946 to 1967) (Elevatorski, 1971, p. 10; Keith, 1973, p. 91). The fault-controlled fluorspar vein, averaging 2 ft in width, strikes N. 30° to 35° W., dips NE. 84°, and was mined along strike for 200 ft from the shaft; the vein pinches out 50 ft southeast of the shaft, but may continue farther to the northwest than the distance along which it was mined. Ore grade averaged 85% CaF_2, with a fairly low content (1.5% to 2%) of SiO_2, an impurity. The production has variously been used for a) making acid grade fluorspar; b) Federal Government stockpile purchases in the 1950's; c) upgrading Arizona Eastern Fluorspar Corp's. run-of-mine production from their Duncan, AZ, mine in the 1950's. The fluorite, which is free of sulfides, was deposited alternately with sheets of silica in multiple depositional cycles (Johnson, 1952, p. 1; Burnette, 1957, p. 25-28).

Claims were first staked for fluorspar at the site by Alvin Green of Benson, AZ, in 1946, who sold the property to Cooper Shapley. Shapley worked the mine for 5,400 st of ore from 1946 to 1950, selling then to Fluorspar Producers Corp., Culver City, CA. Pepperdine Foundation (a lessee) produced 1,200 st from 1950 to 1951. The mine was refurbished by Fluorspar Producers Corp. in 1952 and then leased to Lone Star Mining Co., Benson, AZ, and Culver City, CA. Lone Star deepened the inclined shaft to the 300-ft level, and continued drifting on the northwest ends of the 100-ft and 250-ft levels of the mine, and planned to build a mill in Benson, AZ (Johnson, 1952, p. 1-2). Apparently, most of the mine production took place from 1952 to the summer of 1953, after which the mine was closed, though no detailed production records are known by the USBM for that time. During that period, the mine ownership transferred to Arizona Eastern Fluorspar Corp, Duncan, AZ (Johnson, 1954a, p. 1). The 60-ft level was eventually caved into the 90-ft level for additional ore recovery. The 300-ft level was worked for a time, then allowed to flood (Burnette, 1957, p. 25-26). The Lone Star Mine may have been inactive during the entire span of 1953 to December 1963, when Gabriel Camara, Phoenix, AZ, shipped 34 st of fluorspar to Allison Steel, Phoenix, AZ; the mine was closed due to legal entanglements in April 1964 (Johnson, 1964, p. 1). The flooded mine was pumped out in early 1967 and plans laid by George Peverill, Benson, AZ, and C. L. Whitelock to mine more fluorspar (Irwin, 1967, p. 1). Ore was exhausted by Whitelock by early December 1967, when the mine was closed again (ADMMR files, 1967). By 1978 the buildings at the site had been destroyed, and by 1980, the headframe had been demolished, the shaft backfilled, and the subsidence collapse of the mine workings had opened to the surface (see fig. 5) (ADMMR files, 1978; McColly and Scott, 1982, p. 7).

No resource estimates were attempted, because the fluorspar vein is inaccessible. The old report of having exhausted the ore is not encouraging, though more fluorite-bearing vein material may be discovered to the northwest of the mine limits. Surface drilling would be the only feasible way to verify fluorspar continuity, without costly, unwarranted, mine rehabilitation. Current market conditions suggest that further exploration for a fluorspar vein extension as thin as the Lone Star's is not economically warranted, and unlikely to occur. Currently (1993) there is no fluorspar production reported in Arizona (Greeley and Kissinger, 1992; Phillips and others, 1992, p. A8). All domestic production of fluorspar comes from one mine in southern Illinois, in which veins many times wider and longer than the Lone Star vein are mined. Very heavy U.S. reliance on imported fluorspar (87% of the domestic consumption), and the primary import sources (Mexico, Republic of South Africa, China) (U.S. Bureau of Mines, 1992, p. 62-63) are indicative of low prices on imported fluorspar that could not be matched by U.S. producers except with the most viable of deposits.

Mine subsidence

The State Mine Inspector's Office had classified the Lone Star Mine as "extremely hazardous" by 1975 (ADMMR files, 1975). Caving of the underground workings has opened a linear subsidence hole to the surface (fig. 5). The mapping of the middle 3 levels of the mine (fig. 6) was done in 1957; the level maps were reconstructed based on Johnson's (1952, p. 2) report of the shaft orientation for an approximation to aid in understanding where future subsidence may occur. It should be noted that other, differing, citations of the shaft orientation have been reported: "about 75° to the east" (Irwin, 1967, p. 1); and "80° from horizontal" (Burnette, 1957, p. 25). This would change the relative location of the different mine levels from those reconstructed on fig. 6. Most importantly, no map of the 60-ft level was made, and it is most likely that the 60-ft level is the one that has caved through to the surface.

A review of field notes taken by USBM during the RARE II study in October 1980 indicates that the main shaft had been backfilled by a bulldozer. In November 1992, the un-fenced shaft collar was open to a depth 75 ft, at which point it appears to be caved or debris-filled. The backfill has evidently fallen down the shaft, re-opening the upper part of the shaft to the surface. This site is just 75 ft from the main road that traverses Middle Canyon.

Silica

The land patented by Phelps-Dodge Corp. in 1923 is known as the Ricketts Mine (fig. 7, 8), which, based on USBM mapping of the pit, was quarried for about 300,000 st[8] of silica flux. Quarrying was done during the 1950's, and supplied the Douglas, AZ copper smelter (McColly and Scott (1982, p. 8). The supposed Precambrian-age quartz dike averages 70 ft in width in the pit (fig. 7), but may reach as much as 1,000 ft in width, about 500 ft west of the quarry; drilling is not available to verify that potential width.

Indicated silica resources remaining on the site, directly below the pit, probably equal the total past production in amount. However, none of this material may be minable without significant, uneconomic, pit reconfiguration, due to conditions existing

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[8] Keith (1973, p. 90) reports an estimate of at least 50,000 st of silica flux production from the quarry.

in the pit: the site was mined on 40-ft benches, with 40-ft highwalls (fig. 8), to maintain an ultimate pit slope of 45°. The rock may not be stable enough to support removal of more rock from existing benches, with the subsequent increase in highwall height and pit slope. The approximately 300,000 st of silica resources below those benches, therefore, could be un-minable. The USBM estimated that silica flux in the range of 5,000 st to 6,000 st would be available for each vertical foot excavated below the present surface, a factor of note, should deepening of the present quarry be attempted.

A new quarry could be started about 500 ft west of the existing quarry, where a 1,000 ft by 1,250 ft outcrop area of the same quartz dike has been mapped (fig. 7). Shape of the base of this dike is uncertain, due to lack of drill data. If the dike is 70-ft-wide, as it is in the existing pit, then at least 8 million st of indicated silica resources are present. However, the limited structural data available suggest that the dike actually widens to about 1,000 ft in this outcrop area. If that is the case, then approximately 30 million st of silica material are present from the 5,000 ft elevation contour up to the ridge line (the southwestern outcrop edge of the dike, fig. 7). Not all of that material could be mined; easily half the material could be unrecoverable due to the need of maintaining stable pit slopes. Therefore, the indicated silica resources in this area are more likely 15 million st.

It is most important to note that in 1993 markets, companies with smelters are buying only flux with significant precious metals content. Minimum concentration levels are in the approximate amounts of 0.2 oz gold/st and 0.5 oz silver/st. USBM samples representative of the quartz dike in the existing pit (WH21-22) contain no gold or silver. There are few structures through the massive dike that have evidence of metallic concentration. One such sample, fault zone WH20, has 0.01 oz silver/st. Another narrow zone of alteration (WH18-19) has no precious metals in a representative sample, but one sample with supergene enrichment has 0.17 oz silver/st and trace gold (79 ppb Au). Precious metals influx in this dike is thus very small.

Historically, the quartz dike material has been shown suitable for use as silica flux. However, the barren nature of the quartz dike itself, with respect to precious metals, strongly suggests that no further mining will take place here for silica flux. Nationally, the reduced copper smelter capacity further reduces potential future needs for silica flux. The markets will therefore likely be able to maintain the stringent 1993 precious metals requirements applied to fluxes.

Tungsten

Fifteen different quartz veins and one quartz-rich aplitic vein were investigated (fig. 5) at the James Mine (a.k.a. Ricky Dale, Nunnelley), Evening Star (a.k.a Houston) claims, and Chadwick Mine (see samples WH29-49), and at 3 prospect sites peripheral to these mines (WH28, 50-51, fig. 5). The veins are, in general, in an east-west alignment, and may be part of a single formational event. The veins have long strike lengths, with several reaching 200 ft in length, and one over 900-ft-long. However, most of the veins are very thin (less than 2-ft-wide) and contain little tungsten (see table 1). The veins follow a northeast trend with dips to the northwest, with few exceptions. The mining targets were disseminated scheelite and wolframite in quartz veins (McColly and Scott, 1982, p. 12-13); traces of iron and copper sulfides were noted with the wolframite (Wilson, 1941, p. 46). Production records are incomplete.

The Chadwick Mine (fig. 5) was worked for a "few hundred tons" of tungsten concentrate about 1905 or 1906 by Euclid Mining Co. Dewey Chadwick took over at an unknown date, and set up a gravity concentrator on the property. Much of the mining took place during WWI; other mining took place in the 1930's. From 1943 to 1944, an estimated 1,200 lb to 1,600 lb of WO_3 were produced. More exploratory trenching was done in 1952 by Minerals Development Corp., but no ore was produced. Del Webb Construction Co. built a road on the site in 1953 and excavated some open pits, shipping 3 "carloads" of ore at a loss (Hess, 1909, p. 164; Wilson, 1941, p. 45; Wilson, 1950, p. 9-10; Dale and others, 1960, p. 54-55). The production likely came from the WH42-43 and WH46-49 quartz veins, based on the facts that: 1) the only appreciable tungsten concentrations found in USBM samples at the Chadwick Mine (1,120 ppm W maximum) came from those veins (see assays in appendix B); and 2) Wilson's (1941, p. 46) notation of scheelite in the "grayish white" quartz vein of extensive strike length on the property is a description fitting only these veins. No reserves were encountered in a late 1950's examination of the site, at which time the resource estimate was made that inferred reserves in all the mines do not exceed 1,000 st or 0.5% WO_3 (Dale and others, 1960, p. 54).

The Evening Star claims, which are west of the Chadwick Mine, were worked on a small scale during WWI, and then taken over by J. Cristie in 1937 and worked for "a few thousand pounds of tungsten ore" from 1937 to about 1940. Wolframite was noted during a 1940 examination in both the aplitic rock (such as dike WH31-33) and in grayish quartz, where tungsten concentrations of 1.5% to 1.9% WO_3 were found in "grayish-white" quartz exposed by an inclined, 37-ft-deep shaft (Wilson, 1941, p. 46). This described site is most suggestive of the shaft between sample sites WH47 and WH48 (fig. 5), which is on the WH46-49 vein of the *Chadwick* area, not the

Table 1.--Evaluation of quartz veins for tungsten content, Whetstone Mountains Unit.

Mine/sample nos.	Vein length/width (ft)	Tungsten content (ppm)
VEINS WITH NOTABLE TUNGSTEN CONCENTRATIONS		
Chadwick; WH46-49	270 long/1.5 wide	1,120 ppm W, maximum
Chadwick; WH42-43 (aligns with WH46-49 vein)	185 long/1.2 wide	190 ppm W, maximum
VEINS WITH VERY LOW TUNGSTEN CONCENTRATIONS		
Chadwick or Evening Star; WH36	925 long/2 wide	6 ppm W, maximum
Evening Star; WH31-33	600 long/2.4 wide	14 ppm W, maximum
Chadwick; WH37-39	445 long/1 wide	14 ppm W, maximum
Chadwick; WH40	350 long/1.2 wide	8 ppm W. maximum
Chadwick; WH45	200 long/1 wide	5 ppm W, maximum
Chadwick; WH35	150 long/9 wide	4 ppm W, maximum
Chadwick; WH41	125 long/0.8 wide	4 ppm W, maximum
Chadwick; veinlet zones WH44 and sample site 12 from McColly and Scott, 1982, pl 1	n/a	19 ppm W, maximum
James; WH29-30	not well exposed[1]	210 ppm W, maximum
VEINS PERIPHERAL TO THE MINE AREAS		
Unnamed prospect: WH28	50 + long/1.7 wide	87 ppm W, maximum
Unnamed prospect; WH50	300 long/2 wide	2 ppm W, maximum
Unnamed prospect; WH51	245 long/2 wide	None

[1] The veins were better exposed in the 1950's, when Dale and others (1960, p. 56) described the veins as "very narrow and can be traced by outcrops for a few hundred feet."

Evening Star. This illustrates a long-standing problem for the properties: the Evening Star claim group (in part known as the Houston claim) overlaps the Chadwick Mine area (Dale and others, 1960, p. 54). The overlap problem was never resolved by mining interests; no claim maps are available.

The James Mine (the most recent name given to the site, after George James, a mid-1950's owner from Benson, AZ), was worked in the early 1900's along with the Chadwick property (Hess, 1909, p. 164; Johnson, 1954b, p. 1). It has also been known as the Nunnelley claim group and the Ricky Dale group. The principal ore mineral is wolframite, with lesser amounts of scheelite (Dale and others, 1960, p. 55-56). The deposit, when better exposed by un-sloughed excavations, was described as 2,000-ft-long on strike, about 50-ft-deep, and having a width of 1-in. to 12-in. (Dale, 1957a, p. 1). Production in 1943 and 1944 was several hundred lb of tungsten concentrates with more than 2.0% WO_3, which were beneficiated by Nunnelley's gravity concentrator on the San Pedro River at St. David, AZ (Dale and others, 1960, p. 55-56). The site was worked by Frank and Richard Bales, Benson, AZ, for about 200 lb of 30% to 40% WO_3 concentrates (Johnson, 1954b, p. 1). Indicated tungsten resource estimated at the site in the late 1950's was "a few hundred pounds" of 1.0% WO_3 (Dale, 1957a, p. 1). Reserves were considered exhausted by 1960 (Wrucke and others, 1983, map). Production likely came from the longest trench and the connecting short adit on the property (fig. 5, 9; WH30). At one time, the trench was as much as 50-ft-deep (Dale, 1957a, p. 1), but had partly sloughed in 1992. Two USBM samples collected at the adit portal (not accessible in 1992) during the 1980-1981 RARE II study assayed 0.06% WO_3 (shear zone hosting quartz vein) and 0.25% WO_3 (the probable mined quartz vein itself) (McColly and Scott, 1982, p. 9).

No resources were estimated for any of the tungsten sites by USBM during this Coronado National Forest study, due mainly to extreme narrowness of the veins (often less than 2-ft-wide), low tungsten grade in current samples, and negative grade and tonnage information from earlier USBM work when the veins were better exposed (Dale and others, 1960). However, it should be noted that no black-light lamping of this area was done during the current USBM study. Systematic lamping could delineate some higher-grade tungsten zones within certain veins; none was attempted because the objective was to determine, on a reconnaissance level, if any veins are continuous and wide enough to mine, and to gain an approximation of their tungsten tenor. Additional lamping work is not warranted, considering the status of tungsten markets. The current (August 1993) tungsten market in the U.S. is not open to additional tungsten supply. Demand is down, worldwide, and there are essentially no

U.S. raw materials being supplied[9]. Raw tungsten from China supplied about 53% of the U.S. imports for several years. The Nation is 85% to 90% reliant on imports for its total tungsten supply. China was penalized, starting in 1992, by a 151% antidumping tariff, but the net change to the U.S. raw materials suppliers was nil, because there are no import restrictions on downstream tungsten products, such as ammonium paratungstate, sodium tungstate, and tungsten oxides (U.S. Bureau of Mines, 1992, p. 186-187; G. R. Smith, USBM, oral commun., 1993). Should the market conditions improve for suppliers, there is idle capacity at numerous U.S. mines and deposits that would be put on line before any further exploration at the sparse, low-grade Whetstone Mountains occurrences would be attempted. It does not appear likely that the National Forest properties will be explored or mined again in the foreseeable future.

Uranium

Uranium minerals[10] are associated with fractures in the Precambrian-age porphyritic quartz monzonite pluton that crops out over 20 mi^2 in the northeastern part of the Whetstone Mountains Unit (see pl. 1) (Creasey, 1967, map); one uranium occurrence, the Bluestone Mine, is hosted in shears in a Precambrian alaskite that is probably related to the quartz monzonite pluton (Wrucke and others, 1983, map). Nearly the entire outcrop area of both of these Precambrian-age uranium host rocks is within the National Forest boundary. The background uranium content of these two rocks types is 2 ppm to 4.5 ppm uranium (or about 0.0004% U_3O_8) (Staatz, 1982, p. 4). The USBM radiometric surveys over the quartz monzonite determined that background radiometric readings are 50 to 60 cps (scintillometer parameters in table 2), although different radiometric equipment, with different crystal size can register a different background level. For example, another study reported 120 to 300 cps as the background radiometric reading (Staatz, 1982, p. 4).

Uranium prospecting took place in the Whetstone Mountains Unit at least as early as 1950, and consisted of claim-staking, opening of the Windmill No. 1 and

[9] There are two operating tungsten mines in the U.S.: the Pine Creek Mine of U.S. Tungsten Corp, in Bishop, CA, and the Andrews Mine, Upland, CA in the San Gabriel Mountains, north of Los Angeles, which is operated by Curtis Tungsten, Inc. *Their combined production, which is confidential, is small relative to the total domestic consumption* (Carrillo and others, 1993, p. 8, 11; G. R. Smith, USBM, oral commun., 1993).

[10] Uraninite is the only primary uranium mineral identified at the Windmill No. 1 Mine (Staatz, 1982, p. 3). Secondary uranium minerals autunite, tyuyamunite have been noted at the Bluestone Mine; other uranium, in an unidentified form, has been associated in the northern Whetstone Mountains Unit with the molybdenum mineral wulfenite, the fluorspar mineral fluorite, and with hematite (Miller, 1955, p. 1) (specific location not known by USBM).

Bluestone underground mines, and excavating a few test pits (pl. 1; table 2). Claim groups staked by 1955 included the Windmill, Lucky Seven, Lost Apache, St. David, Lost Apache Girl, First Chance, and Little David claim groups, and the Neglea claim; no precise locations of these claims can be determined with available data. A second era of uranium interest took place from the mid-1970's until at least 1981, when mining and energy companies staked large blocks of claims. Principal players in the later uranium exploration effort were Kerr-McGee Corp. and Rocky Mountain Energy Corp., which together blanketed most of the Precambrian rock outcrop with 579 claims. The companies tested faults and shears in those rocks for uranium content near the water table (Scarborough, 1981, p. 86-87; Staatz, 1982, p. 1; McColly and Scott, 1982, p. 10). No production resulted. Neither claim maps nor drill data from the work were available to USBM for this study.

Production consisted of 47 st of "low grade uranium ore" from the Bluestone Mine during 1958 to 1960 (Keith, 1973, p. 91). Also, 16 st of 0.11% U_3O_8 was mined, probably prior to 1957, from the Windmill No. 1 Mine (pl. 1; fig. 5, 10) and shipped to the Atomic Energy Commission's depot in Cutter, AZ. The estimated uranium reserve (circa 1957) at the Windmill No. 1 site was 110 lb U_3O_8 from 600 st of 0.11% U_3O_8 rock (Staatz, 1982, p. 1; Wrucke and others, 1983, p. 6). It is not known if any of those "reserves" (fig. 10) were later mined. The Windmill workings were all caved by 1982; by 1992, the short adit (above WH10) was obliterated by erosion and bank slough.

<u>Resources</u>

Staatz's (1982, p. 4-5) assessment of these small uranium occurrences is that the uranium distribution is erratic along the fracture zones and the fracturing itself is lacking in continuity; resource quantities, if present, are therefore likely to be small amounts of uranium. A claimant working the Windmill No. 1 Mine reported that the uranium-hosting fracture extends along strike for about one mile to the west of the mine site (Royston, 1957, p. 3). This claim was based on lineaments seen in aerial photos of the vicinity. The supposedly extensive fractures are not readily seen on the ground. No resources of uranium are estimated by the USBM for any of the sites in the Whetstone Mountains Unit. Should the price and desirability of uranium as a commodity rise once again to levels of the late 1970's, it would be wise to obtain and assess the available drill data gathered at these sites by industry. Uranium prices have continued to fall in recent years, to about $7.00/lb (July 1993)[11] (Mining Journal,

[11] The price of uranium has fallen nearly 17% in less than two years (Phillips and others, 1991, p. 4; 1992, p. A8).

Table 2.--Evaluation of uranium mines and prospects, Whetstone Mountains Unit.

Name/samples/fig.	U_3O_8 production, host rock	U_3O_8, determined via chemical analysis	Radiometric[1] reading at site (cps) At waist level (background reading in parenthesis)	Description
Unnamed prospect pit WH1 pl. 1	None, Qtz. monz.	None	75, (60)	Pit in quartz monzonite, 12-ft by 12-ft, 4-ft-deep, exposes fracture (N.42° E., vertical); covered beyond pit.
Unnamed prospect pit in T.17S., R.19E., sec. 31; no sample pl. 1	None, Qtz. monz.	n/a	80 (cut), (60)	Open cut in granitic rock, 10-ft by 10 ft, dug into slope.
Unnamed prospect pit in T.18S., R.19E., sec. 6; no sample pl. 1	None, Qtz. monz.	n/a	60 (in pit), (60)	Test pit in granitic rock, 15-ft by 11 ft, 3-ft-deep; no structure; minor limonitic stain.
Unnamed prospect pit in T.18S., R.19E., sec. 5; no sample pl. 1	None, Qtz. monz.	n/a	75 (in pit), (50-60)	Test pit in granitic rock, 15-ft by 15 ft, 5-ft-deep; no structure; minor limonitic stain.
Unnamed prospect WH2-3 pl. 1	None, Qtz. monz.	WH2 0.072% WH3 None	100-130 (dump, qtz. monz.) 90 (dike) (60)	Two shallow shafts on aplite dike in quartz monzonite; probably a metals prospect; later re-examined for U_3O_8. Quartz monzonite with chloritic alteration has the highest radiometric readings.
Windmill No. 1 Mine WH9-10 pl. 1, fig. 10	16 st of 0.11% U_3O_8, Qtz. monz.	WH9[2] 0.028% WH10 None	450 (qtz monz at WH10) 350 (qtz monz at shaft dump, WH9) 100 (shaft collar) (50)	Exposed irregular shear zone (N. 55° W.). All workings caved or buried, 1992. Unknown if 600 st "reserve" in adit (circa 1957; with est. contained 110 lb uranium) was ever mined. Uraninite. Quartz monzonite on dump with chloritic alteration has the highest radiometric readings.
Bluestone Mine (west group of adits) WH23-24 pl. 1, fig. 5	47 st "low grade" U_3O_8, Alaskite	WH23[3] 0.026% WH24[4] 0.023%	1,000 (WH23[5] and WH24[6] portals)	Two NW.-trending bluish-black mafic dikes excavated by 4 short adits. WH23 dike is 75-ft to 80-ft-long, 1.3-ft to 2-ft wide; WH24 dike 55-ft-long, 4-ft-wide (Staatz, 1982, p. 3).

Table 2.--Evaluation of uranium mines and prospects, Whetstone Mtns. Unit, continued

Name/samples/fig.	U_3O_8 production, host rock	U_3O_8, deter-mined via chemical analysis	Radiometric[1] reading at site (cps) At waist level (background reading in parenthesis)	Description
Bluestone Mine (east group of adits) WH25-27 pl. 1, fig. 5, 10	None, Alaskite	Maximum (at WH27): 0.002%	35-40 (at site WH26-27) (35-40)	Shear (N. 60° W., NE. 36°) in granitic rock, argillaceous alteration. Strike length 39 ft in adit; extent beyond adit not known.

[1] USBM radiometric readings gathered with a Geometrics, Exploranium Div., Model GR-101A portable, gamma-ray scintillometer, which has a 1.5-in.-long, 1.5-in. diameter sodium iodide crystal detector sensitive to the following radioactive atoms: Potassium 40 and potassium 40 daughter product; uranium 238 and bismuth 214 daughter product; thorium 232 and thallium 208 daughter product.
[2] Sample from radiometric high off the dump has 0.038% U_3O_8; analysis by multichannel gamma-ray spectrometer (Staatz, 1982, p. 2).
[3] Sample from radiometric high part of dike has 0.096% U_3O_8; analysis by multichannel gamma-ray spectrometer (Staatz, 1982, p. 2).
[4] Sample from radiometric high part of dike has 1.11% U_3O_8; analysis by multichannel gamma-ray spectrometer (Staatz, 1982, p. 2).
[5] Radiometric reading, WH23 dike, from another study: 400 to 4,000 cps (Staatz, 1982, p. 3); scintillometer type, crystal size not known to USBM.
[6] Radiometric reading, WH24 dike, from another study: 600 to 9,500 cps (Staatz, 1982, p. 3); scintillometer type, crystal size not known to USBM.

London, 1993). As a result, all four of Arizona's uranium mines are on care-and-maintenance status (Phillips and others, 1992, p. A8).

Miscellaneous prospects for metals

Three northeast-trending aplite dikes hosted in Precambrian-age quartz monzonite were examined by USBM (WH2-3; WH4-8; WH14-17, pl. 1). All have been excavated by shafts. The dikes have appreciable strike lengths and, in some cases, widths, but there is no evidence of persistent metallization along strike. The metal anomalies themselves are usually below economic concentration levels.

The dike at sample site WH2-3 is 5-ft to 6-ft-wide, and has a strike length of about 100 ft. It contains elevated uranium (0.8% U_3O_8), molybdenum (0.3% Mo) and lead (> 1%) in one place, and geochemically anomalous levels of gold (811 ppb) and tungsten (30 ppm). However, most of the dike does not appear to be abundantly metallized, and the concentrations reported above are likely maximums for the structure.

The dike at sample sites WH4-8 is in part at least 25-ft-wide and has a minimum strike length of 1,650 ft. Average width is less: about 10-ft to 15-ft. The dike appears to be pinching out at both ends, but may extend farther on the southwest end beneath soil and talus cover. A concordant fracture zone within the dike was prospected by a shaft (pl. 1), and was the focus of USBM sample WH5. That sample contains 0.7% Cu. The rest of the dike appears to have little metal content. This copper-enriched zone within the dike does not extend beyond the shaft area, and does not represent a mineral resource.

The WH14-17 aplite dike is narrow, averaging less than 5-ft in width. It is continuous for 1,000 ft along strike, extending northeast of site WH17 for 150 ft and southwest of site WH14 for 50 ft. No anomalous base or precious metals are apparent in the sample assays.

Gypsum

The USBM estimates about 137,000 st of low-grade, indicated gypsum resources inside the Whetstone Mountains Unit at one site (fig. 12). Others may be concealed, in particular, around sample site WH74 (fig. 12). Mineralogically, the resources are rock gypsum (massive and coarse-grained material) with minor amounts of the selenite form of gypsum. Gypsum occurrences inside the National Forest have never been mined. Gypsum resources have been known in the southernmost Whetstone Mountains (outside of the National Forest) (pl. 1) since the early 1960's; 19.7 million st of low-purity gypsum resources were estimated there in earlier work (Graybeal, 1962, p. 66, pl. 1, 4). Development work on gypsum resources outside the National Forest has been limited to a few prospect trenches (USBM field data, unpub., 1981).

Geology of the Whetstone Mountains Unit gypsum

The gypsum is an evaporite, deposited in an arid, Late Permian age supratidal depositional environment (Wrucke and others, 1983, p. 2). Stratigraphically, it is within the middle member of the Epitaph Formation (Wrucke and others, 1983, map), a formation which, in general, crops out along the center of the Whetstone Mountains Unit, and in places, crops out just east of the backbone of the range (see pl. 1). The on-strike extent of the gypsum beds is highly irregular, in part due to faulting (Graybeal, 1962, pl. 1), but also due to deformation in response to mountain-building stresses. Evidence has been presented that some gypsum "beds" have actually "flowed" into their present positions via plastic deformation (Graybeal, 1962, p. iii, 49). That condition adds a considerable undependability to the continuity of gypsum resource beds along strike and down the dip slope. Gypsum forms in the following way: the $CaSO_4$ evaporite (anhydrite) is deposited, and then, over time and in the presence of meteoric waters, the anhydrite is hydrated, forming gypsum ($CaSO_4 \cdot H_2O$).

The hydration process can continue to depths of 1,000 ft, or perhaps even as much as 2,000 ft below the surface (see Davis, 1992, p. 2; Appleyard, 1983a, p. 778).

Gypsum resources inside Whetstone Mountains Unit

Areas targeted for the USBM evaluation of gypsum were the outcrop areas in the Whetstone Mountains Unit of the middle member of the Epitaph Formation (pl.1); Wrucke and others (1983, map) concluded that these areas have high potential for the occurrence of gypsum. Results of the USBM work are that most of the "gypsum potential" areas shown in Wrucke and others (1983, map) have no gypsum. There is an interlayering of limestone and some gypsum in most of the areas Wrucke and others (1983, map) pointed out as being potentially gypsiferous. The rocks have physical properties and weathering characteristics highly suggestive of gypsum. Chemical analyses, however, show clearly that these rocks are limestone, and not gypsum (see sample descriptions, appendix A, and chemical analyses, table 3 for samples WH56-69, 71-76). Three localities were found that do contain gypsum. Site WH74 (fig. 12) contains a gypsum layer of appreciable thickness, but it could not be traced along strike due to extensive talus and soil cover. No resources were estimated there. Site WH75 (fig. 12) contains significant quantities of anhydrite, a detrimental component (Appleyard, 1983b, p. 183) that makes this bed unusable. Only site WH56-63 (fig. 12) has gypsum resources (137,000 st total), which are low-grade resources in the *indicated* resource category, and have limited utilization and value. The detrimental characteristics and conditions applicable to the Whetstone Mountains Unit gypsum are: 1) low purity (i.e. low gypsum content); 2) difficult-to-mine geologic structure; 3) difficult-to-mine terrain; 4) remote location from markets; 5) significant competition already in place in the market; 6) undeveloped deposits in the region that are closer to markets and that may be of comparable quality and purity.

The gypsum area WH56-63 (fig. 12) contains all the 137,000 st indicated gypsum resources delineated in the Whetstone Mountains Unit (see table 3 and appendix A for data on individual samples). A tonnage factor of 13.8 ft^3/st was used (Moyer, 1939, p. 27). The larger part of the resources, a 91,000 st block with 70.7% purity, is within a lower gypsum bed, sampled at sites WH57, 60-61. The beds strike slightly west of north and dip about 20° *into* the hillside (southwest), a highly detrimental orientation when considering open pit mining. The resource block is 90 ft

Table 3.--Evaluation of gypsum beds and associated rocks, Whetstone Mountains Unit.

Sample	Purity[1] %	Anhydrite %	Free water[2] %	Combined water[3] %	Sulfate as SO_3 %	CaO %	$CaCO_3$ %	Description
WH56	74.0	4.8	0.13	15.5	37.2	30.5	9.3	Not included in resource zone due to irregular outcrop and probable irregular structure; gypsum appears to be pinching out here.
WH57	71.2	4.6	0.09	14.9	35.8	27.1	3.6	Part of 91,000 st resource zone (WH57, 60, 61). Average 70.7% purity.
WH58	72.6	4.9	0.06	15.2	36.7	31.8	12.5	Part of 46,000 st resource zone (WH58, 62). Average 73.9% purity.
WH59	35.2	4.1	0.08	7.36	18.8	28.7	27.7	Too impure to be included in resource zone.
WH60	71.7	4.1	0.10	15.0	35.7	27.0	3.4	Part of 91,000 st resource zone (WH57, 60, 61). Average 70.7% purity.
WH61	65.4	4.9	0.11	13.7	33.3	25.5	3.9	Part of 91,000 st resource zone (WH57, 60, 61). Average 70.7% purity.
WH62	74.5	3.9	0.08	15.6	37.0	32.2	11.2	Part of 46,000 st resource zone (WH58, 62). Average 73.9% purity.
WH63	49.2	4.6	0.06	10.3	25.6	31.2	23.7	Too impure to be included in resource zone.
WH64	1.6	0.0	0.15	0.33	0.05	33.4	58.7	Limestone with minor gypsum; weathers distinctly like gypsum.
WH65	1.0	0.0	0.07	0.20	0.08	28.3	50.0	do.
WH66	0.8	0.0	0.08	0.17	0.43	45.2	80.1	Limestone
WH67	1.6	0.0	0.13	0.33	0.44	34.8	61.2	Limestone with minor gypsum; weathers distinctly like gypsum.
WH68	25.9	3.1	0.18	5.43	13.9	34.3	43.9	Too impure to be included in resource zone.
WH69	0.6	0.0	0.01	0.13	0.06	35.2	62.5	Limestone with minor gypsum; weathers distinctly like gypsum.
WH71	1.0	1.0	0.04	0.20	1.00	48.4	85.5	Limestone with minor gypsum; weathers distinctly like gypsum.

Sample	Purity[1] %	Anhydrite %	Free water[2] %	Combined water[3] %	Sulfate as SO_3 %	CaO %	$CaCO_3$ %	Description
WH72	1.3	0.2	0.17	0.27	0.72	47.4	83.7	Limestone with minor gypsum; weathers distinctly like gypsum.
WH73	0.8	0.0	0.07	0.16	0.31	46.2	81.9	do.
WH74	73.6	6.3	0.15	15.4	37.9	31.8	9.3	Gypsum. Not included in resource due to lack of exposure along strike (40 ft), and absence of other gypsum in this stratigraphic horizon (WH71-74, 76).
WH75	62.1	32.4	0.20	13.0	48.0	39.0	9.8	Gypsum and anhydrite. The anhydrite concentration makes this bed unusable.
WH76	0.5	0.0	0.04	0.10	0.08	51.1	90.8	Limestone with minor gypsum; weathers distinctly like gypsum.

Table 3.--Evaluation of gypsum beds and associated rocks, Whetstone Mountains Unit, contin.

[1] Equals % $CaSO_4 \cdot 2H_2O$. [2] @45°C. [3] @215°C.

Note: Free water content determined by ASTM Standard C 471, no. 5; combined water content determined by ASTM Standard C 471, no. 6. Calculations based on ASTM standard C 22 - 77 (ASTM, 1980, p. 282). Purity = product of combined water(%) and 4.778. Percent SO_3 combined as gypsum = product of combined water(%) and 2.222. Total SO_3(%) subtracted from SO_3(%) combined as gypsum = excess SO_3. Excess SO_3(%) multiplied by 1.700 = anhydrite(%). Purity multiplied by 0.3257 = CaO(%) combined as gypsum. Anhydrite(%) multiplied by 0.4119 = CaO(%) combined as anhydrite. Sum of CaO combined as gypsum and CaO combined as anhydrite subtracted from total CaO(%) = excess CaO(%). Excess CaO multiplied by 1.7847 = $CaCO_3$(%).

thick[12], extends along strike for 700 ft, and is estimated to have recoverable gypsum to an average depth of 40 ft down the dip slope. This depth is untested by drilling, but is quite modest. Deeper mining would be impractical as it would require unstable height on the highwalls or economically intolerable stripping of overlying rocks. The total estimated tonnage contained in the described resource block was reduced by 50% to account for the recovery factor, which would be low when attempting to open pit mine this relatively narrow bed in such steep topography. The other resource block is a gypsum bed overlying the WH57, 60-61 bed. The two blocks are separated by a 30-ft to 60-ft-thick shale bed (not shown on fig. 12). This upper resource block, represented by samples WH58, 62, contains 46,000 st of 73.9% purity gypsum in the indicated resource category. Bed orientation, detrimental dip situation (into the hillside), and detrimental steep topography conditions are all identical to those described for gypsum bed WH57, 60-61. The upper resource block is 90-ft thick (average of samples WH58, 62), extends for 350 ft along strike, and was considered recoverable for an average 40 ft down the dip slope (for the same reasons explained for resource block WH57, 60-61). A recovery factor of 50% was again applied, for the same reasons applicable to block WH57, 60-61.

<u>Application and value</u>

The purity of these gypsum resources places them in the low-grade range (Appleyard, 1983a, p. 784), and limits their application to a few low-unit-value uses: low-grade soil conditioner, and low-grade fertilizer. Gypsum is used as a soil conditioner in western states to break up the clay soils into less-compact particles and thus increase soil permeability; it also is useful in treating alkaline soils, reducing alkalinity by reacting with sodium carbonate in the soil to form calcium carbonate and sodium sulfate (Moyer, 1939, p. 14; Appleyard, 1983a, p. 784; Davis, 1992, p. 3). Golf courses are large consumers of this type of gypsum in urbanized parts of the western states, using between 2 st and 8 st/ac per year (the amount used varies with the gypsum grade and is increased when lower purity gypsum is used). The gypsum resources also could be used as a low-grade fertilizer, usually applied through irrigation systems as a dissolved fertilizer product, which provides sulfur and increases the nitrogen-fixation capabilities in leguminous crops (Pressler, 1985, p. 7; Davis, 1992, p. 3).

[12] 90 ft was used as the resource bed thickness because that is the thickness observed at site WH57, where the complete gypsum section is exposed. The other sample sites, WH60, WH61, have one or both bed contacts covered, and the judgement was made in the field that both WH60 and HW61 could be considerably thicker than what was exposed. Therefore no averaging of thickness of the three samples was done.

These low-grade gypsum products are sold for about $13 to $18/st at the quarry. Truck transportation costs to markets, which are passed on to the consumer, are calculated in the range of $1.50 to $1.75/st per mi. Nevertheless, the upper-end of the selling price range for these gypsum products is about $32/st, delivered. Mining costs are in the range of $6 to $10/st on flat-lying, easily-worked deposits, that are simply excavated by a bulldozer, and screened. There would be no other beneficiation needed. Blasting is not economical. Gypsum absorbs much explosive force without much fracturing (Appleyard, 1983a, p. 788). The mining costs in the difficult terrain of the Whetstone Mountains Unit would certainly drive mining costs higher, but it is clear, that if these resource blocks could be mined at $10/st, transporting the product to the nearest market, Sierra Vista, AZ, a 20-mi trip, one-way, would drive the product price much above what is paid under mid-1993 market conditions. In reality, these gypsum beds would not be mined, based solely on the difficult topography.

Outcrop of the Epitaph Formation by Apache Peak

A large area of outcropping middle member of the Epitaph Formation has been mapped by Wrucke and others (1983) just east of the backbone of the Whetstone range (pl. 1). It was not examined during the USBM work in the Whetstones to determine whether or not any gypsum is present. The site called "Lone Pine Saddle" (pl. 1), based on topography, is one of the most favorable to explore for the presence of gypsum. However, any gypsum that might be present would likely be un-minable, due to steep topography and lack of access. There is no access to the Epitaph Formation outcrop area from the south, west or east, due to cliffs and very steep slopes. The northwest end of the outcrop area is more readily accessible, but any gypsum that might be found there would have to be hauled out of the National Forest along a long access route through private land. Such access may not be available. The low gypsum purity in samples collected from the gypsum deposits in the National Forest suggest that further work on the outcrop area by Apache Peak is not warranted.

Competition from other deposits

Other deposits in the region would supply nearly overwhelming competition to the gypsum resources in the Whetstone Mountains Unit, should significant close markets be developed, or more economical transportation methods derived. The most obvious of the competitor deposits are the two gypsum resource areas in the southernmost part of the Whetstone Mountains, outside of the National Forest. Those gypsum deposits are within the same stratigraphic unit as the resources within the

Whetstone Mountains Unit, but have higher grade, much higher tonnage, are closer to *existing highways, and have somewhat more favorable topography for mining.*

Graybeal (1962, p. 65-66) examined three separate gypsum bodies outside and south of the National Forest (see pl. 1, this report), and estimated a 10.9 million st gypsum resource in the central gypsum body. That includes 7.2 million st of measured gypsum resources[13]; Graybeal placed the remainder in the categories equivalent to the indicated and inferred resource categories used by USBM. The average grade of these resources was calculated at 80.2% purity (or percent gypsum, $CaSO_4 \cdot H_2O$). Graybeal estimated an indicated gypsum resource of 8.8 million st at 80.2% purity in a second gypsum body, about 0.5 mi farther north from the 10.9-million st deposit (pl. 1). For the southernmost gypsum body outside of the Whetstone Mountains Unit that Graybeal examined (pl. 1), no resources were estimated due to high silt content.

All those estimates were based on unproven (un-drilled) projections of the gypsum beds to a depth of 200 ft (Graybeal, 1962, p. 65); considering the topographic slopes and dips of the gypsum beds (Graybeal, 1962, pl. 4), it appears that the gypsum, if present, could be mined to depths of 200 ft down dip from the outcrop of the bottom of the bed, without the need for any stripping of overlying rock layers. Such stripping could not be done economically. Graybeal's gypsum deposits have slightly more favorable topography than those inside the Whetstone Mountains Unit, but they still dip into the hillside, reducing the serviceable acreage. The average purity (80.2% gypsum) places these southern Whetstone Mountains resources within the low grade category. The mid-grade purity gypsum sold in the U.S. goes into wallboard manufacture; no gypsum with less than 88% purity is used for that purpose.

There are two small gypsum deposits about 1 mi west of the Whetstone Mountains Unit (pl. 1) in T. 18 S., R. 18 E., sec. 10 and 15. These are on State of Arizona land. The northern deposit contains an exposed 200,000 st (*measured* resources), in an outcrop area 650 ft by 250 ft and 22.5 ft thick that is about 25% removed by erosion; the base of the deposit is *not* exposed. An estimated tonnage factor of 13.8 t^3/st was used. The gypsum deposit extends to the southeast, but is buried by overlying strata. A buried deposit equal in area to the measured resources (650 ft by 250 ft and 22.5 ft thick) would allow additional *inferred* resources of 270,000 st. If the unexposed base of the gypsum (directly below the *measured* resources) is continuous to a depth of 40 ft, an additional 200,000 st of inferred resources may be present. The southern gypsum deposit contains a measured resource of 5,800 st, based on an exposure that is 200 ft by 100 ft and 8 ft thick and

[13] See resource classifications defined, footnote 3, p. 6, this report.

half removed by erosion. The deposit extends to the northeast, but is buried. If an area equal to the measured resources is buried there, an additional 12,000 st (*inferred* resources) exist. Neither site was tested for purity, as they are not on National Forest land. Both appeared comparable, in hand specimen, to the purity of the gypsum resources delineated on the National Forest. These deposits are noted because they are both flat-lying and could be readily mined. Erosion down through the center of the northern deposit has removed about one-fourth of the exposed gypsum, and has created a more difficult mining situation. Topography at these sites is low, rolling hills. Access routes would be long, and would require gaining access through private lands, which may not be possible.

Other competition could come from a low-grade, undeveloped gypsum occurrence 2 mi south of Benson, AZ (in T. 17 S., R. 20 E., sec. 21, and 22) (Keith, 1969, p. 377). That site is just 2 mi from a rail line, which puts it in favorable position with respect to transportation. Little is known about the occurrence.

Of Arizona's 3 active gypsum mining companies in 1993 (Phillips and others, 1992, p. A9-A19), 2 are already on-line as suppliers of lower grade gypsum products: Pinal Gypsum Corp.'s White Cross Mine, near Mammoth, AZ, and Western Organics, Inc.'s Salome Gypsum Mine, near Salome, AZ. The lower grade gypsum products are not a mainstay of either company.

CONCLUSIONS

Future mineral development of the known deposits in the Whetstone Mountains Unit is not likely. The veinlet/disseminated copper-sulfide-type mineralization in the Granite Peak stock is the occurrence type that appears most viable today (1993) because of moderately high tonnage and copper grade. The one deposit to which PREVAL economic modeling was applied by USBM (Two Peaks Mine and vicinity) is not economic under 1993 prices; the break-even price for mining the deposit is an estimated $4.895/lb Cu. High-grade but very low tonnage zones in skarns in the Granite Peak stock provided copper, lead, byproduct silver, and trace gold that accounts for nearly all the stock's historical metal production. No additional very-high-grade zones in the skarns were found through this USBM work. The low tonnage of the skarns precludes further development for copper, lead, and silver now and likely precludes future development as well.

There are several mineral occurrence types hosted in the Precambrian-age igneous rocks in the northern part of the Whetstone Mountains Unit (fluorspar, tungsten, silica, uranium), but only the silica has estimated mineral resources. Uranium and tungsten deposition appears to be too low grade, too sporadically distributed, and too small to be developed further. Known fluorspar resources are apparently exhausted.

The large resource of silica, which has historically been used as copper smelter flux, is adjacent to the Ricketts Mine. The rock's deficiency in precious metals content does not meet precious metals requirements for smelter flux that are currently in place in the industry. Unless these industry requirements change, no new quarrying will be undertaken at the site. The resources are essentially all on a mineral patent.

Exploration for extension of the Lone Star fluorite vein could be undertaken to the northwest of the old mine site, but the narrowness of the known vein is a detrimental factor, because mining costs would be high when working a vein so narrow. All U.S. fluorspar production comes from one mine in Illinois, which can produce about 50,000 st of fluorspar per year from veins with widths measured in tens of feet. Nevertheless, the U.S. is reliant on foreign imports, mostly from Mexico, South Africa, and China, for about 87% of its annual fluorspar needs (U.S. Bureau of Mines, 1992, p. 62). Should supply disruption develop, it probably still would not create market conditions wherein it would become economically attractive to explore for a Lone Star vein extension. The National Defense Stockpile contains over a million st of acid grade and metallurgical grade fluorspar, all of which the Government is considering for disposal in response to legislation designed to modernize the stockpile (U.S. Bureau of Mines, 1992, p. 63).

Resources of gypsum are small and low grade. The unfavorable structure of the deposits and detrimental topographic conditions will likely prevent these deposits from ever being mined. They have not been developed in any way to date. Should future shifts in market centers or major transportation routes increase the economic viability of these Whetstone Mountains gypsum resources, development interests would surely favor nearby, higher grade, larger gypsum deposits that are outside the National Forest.

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EXPLANATION OF SYMBOLS FOR REPORT FIGURES AND PLATES, INCLUDING:
Inset maps at various scales and 1:126,720-scale plates.

APPROXIMATE BOUNDARY OF THE FOREST MANAGEMENT AREA

APPROXIMATE BOUNDARY OF WILDERNESS

NATIONAL MONUMENT BOUNDARY

6000 TOPOGRAPHIC CONTOUR–Showing elevation in feet above sea level

STATE LINE

COUNTY LINE

PRIMARY SECONDARY ROADS

UNIMPROVED ROADS TRAILS

INTERMITTENT STREAMS

MINING CLAIM BOUNDARIES

GRID TICK MARK

PATENTED MINING CLAIM

SURFACE OPENINGS–Showing sample number(s); symbols may represent more than one working. Also, VARIOUS REPRESENTATIONS OF SAMPLE SITES:

616 Rock sample locality–Showing sample number

or or Adit open (left); Adit, inaccessible (right)

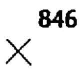
Trenches

Open cut

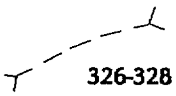
Glory hole, open pit, or quarry

EXPLANATION OF SYMBOLS FOR REPORT FIGURES AND PLATES, INCLUDING:
Inset maps at various scales and 1:126,720-scale plates–Continued.

SURFACE OPENINGS–Showing sample number(s);
symbols may represent more than one working. Also,
VARIOUS REPRESENTATIONS OF SAMPLE SITES–Continued:

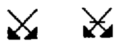


Prospect (pit, open cut, or small trench)



Tunnel

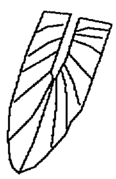

Mine or quarry (active, left; inactive, right)

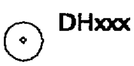

Placer mine or gravel pit (active, left; inactive, right)


Shaft, open to surface (left);
Shaft, inclined (right)


Shaft, water filled (left);
Shaft, caved (right)

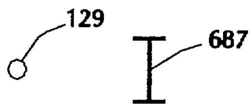
Shaft, reclaimed


Mine dump

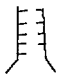


Drill hole collar

EXPLANATION OF SYMBOLS FOR REPORT FIGURES, INCLUDING:
Features of detailed mine maps, both surface and underground,
at various scales (larger than 1:24,000).

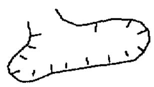


ROCK SAMPLE LOCALITY--Showing sample number

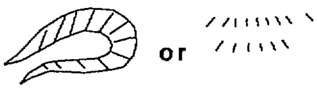


TRENCH

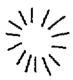
PITS



OPEN CUT



DUMPS

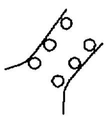


STOCKPILE

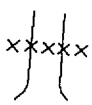
ADIT PORTAL (left);
ADIT PORTAL WITH TRENCH OR OPEN CUT (right)

LEVEL WORKING--Dashed and/or queried where uncertain

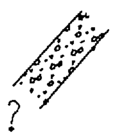
INCLINED WORKING--Showing degree of inclination, chevrons pointing down; queried where uncertain or inaccessible



TIMBERED (Vertical timbers and/or lagging)

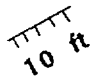


CAVED



RUBBLE (BACKFALL) FILLED, MUCK-FILLED, OR BACKFILLED WORKING--Queried where uncertain or inaccessible

EXPLANATION OF SYMBOLS FOR REPORT FIGURES, INCLUDING:
Features of detailed mine maps, both surface and underground,
at various scales (larger than 1:24,000)--Continued.



STEP DOWN IN SILL--Showing drop in feet; hachures on down side

RAISE, head (left); RAISE, foot (right)

RAISE GOING UP AND WINZE GOING DOWN

WINZE--Noted if water filled

MANWAY (left); CHUTE (right)

SHAFT, open at surface (left);
SHAFT, bottom (right)

P

PILLAR

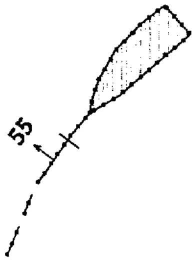
GEOLOGIC SYMBOLS

Strike and dip of bedding

Fault--Showing strike and dip (inclined or vertical, degrees); dashed where approximate

Fault zone or shear zone--Showing strike and dip (inclined or vertical, degrees); dashed where approximate

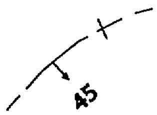
Thrust fault--Sawteeth on upthrown side



Vein--Showing strike and dip (inclined or vertical, degrees); dashed where approximate

EXPLANATION OF SYMBOLS FOR REPORT FIGURES, INCLUDING:
Features of detailed mine maps, both surface and underground,
at various scales (larger than 1:24,000)--Continued.

GEOLOGIC SYMBOLS--Continued

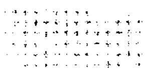


Contact--Showing strike and dip (inclined or vertical, degrees); dashed where approximate

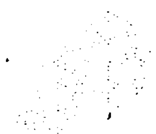
Dike--Showing strike and dip (inclined or vertical, degrees); dashed where approximate

Shattered zones

Brecciated zones



Igneous rock zone or structure

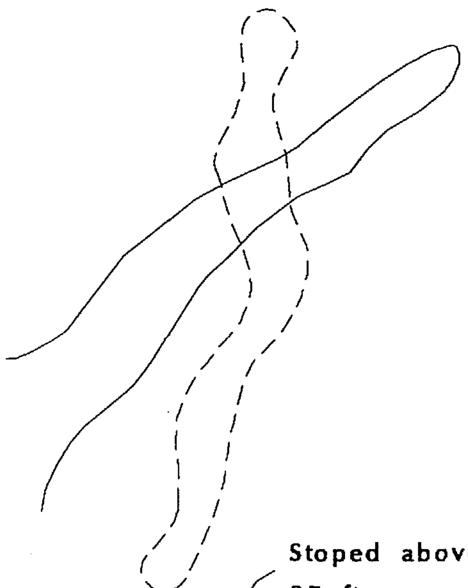


Mineralized zone, disseminated

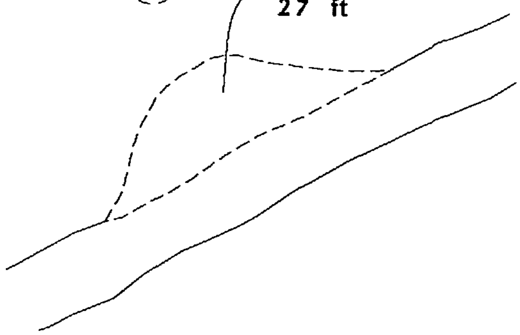
Mineralized zone, localized

Zone containing resources

EXPLANATION OF SYMBOLS FOR REPORT FIGURES, INCLUDING:
Features of detailed mine maps, both surface and underground,
at various scales (larger than 1:24,000)--Continued.



Multiple level workings



Stope

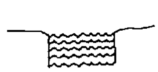
Symbols for vertical cross-section maps

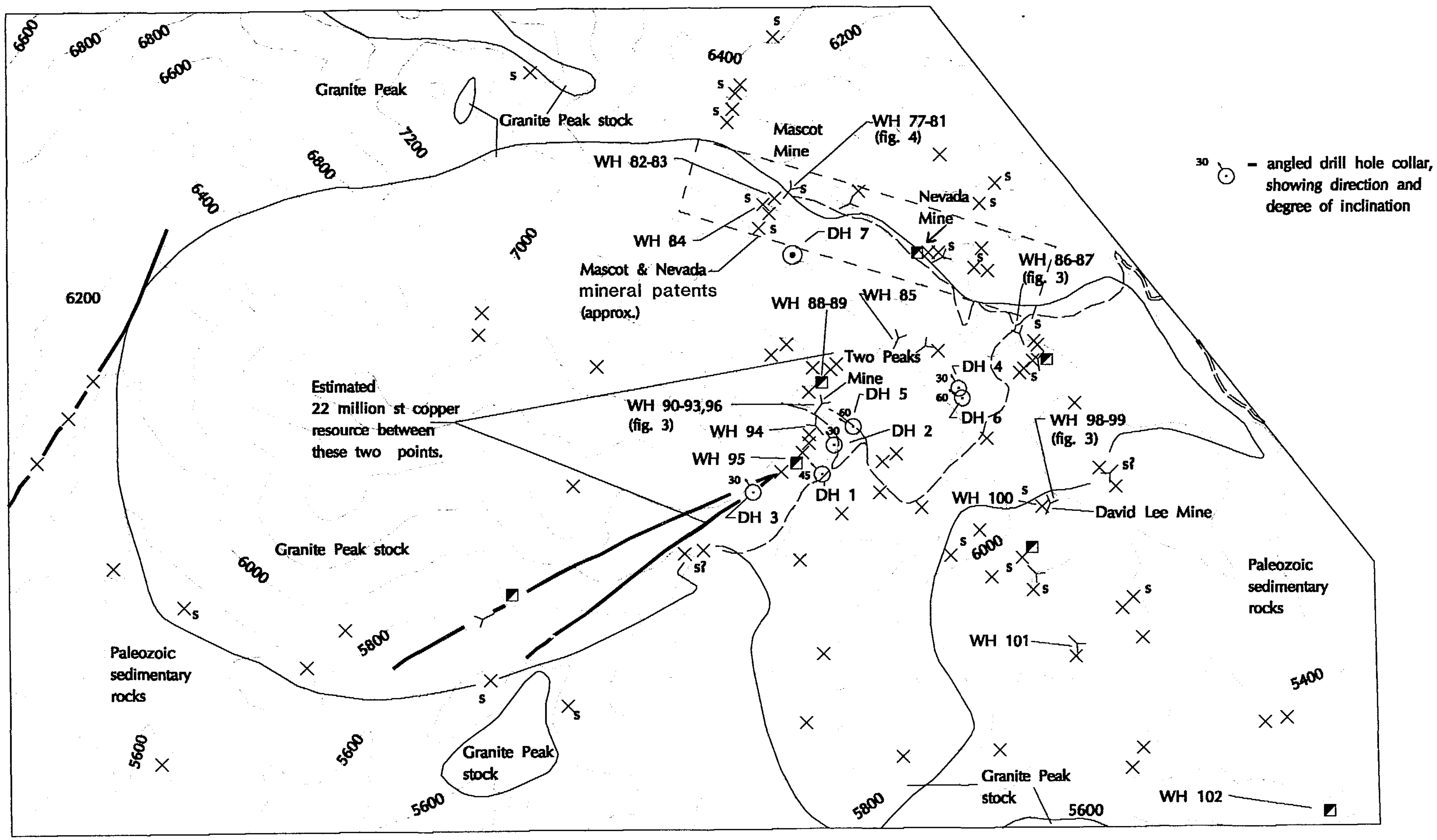
 Crosscut

 Drift into facing wall

 Drift into removed wall

 Drift into facing and removed wall

 Water-filled winze



s – mine or prospect on skarn.
Geology from Wrucke and others (1983, map) and De Ruyter (1979, fig. 2).
Locations of most unsampled prospect workings from De Ruyter (1979, fig. 2).

Scale 1"=1000'

0 FEET 1000 2000 3000 4000

-N-

Figure 2.– Mines and prospects of the Mine Canyon area, and outcrop area of the Granite Peak stock, with sample localities WH 77-96, WH 98-102, Whetstone Mountains Unit.

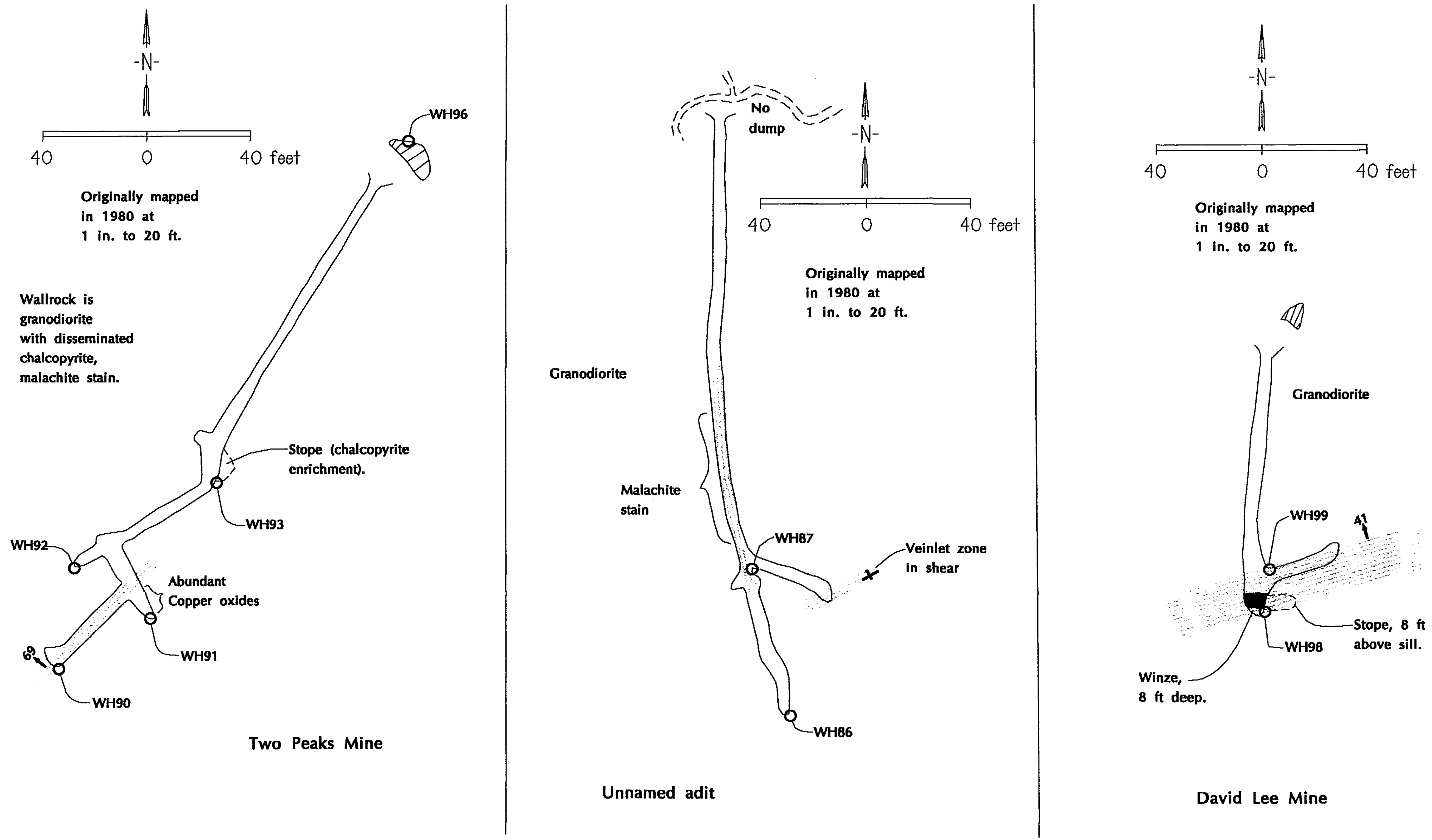


Figure 3.–Mine Canyon workings: Two Peaks Mine, unnamed adit WH 86-87, and David Lee MIne, with sample localities WH 86-87, 90-93, 96, 98-99, Whetstone Mountains Unit.

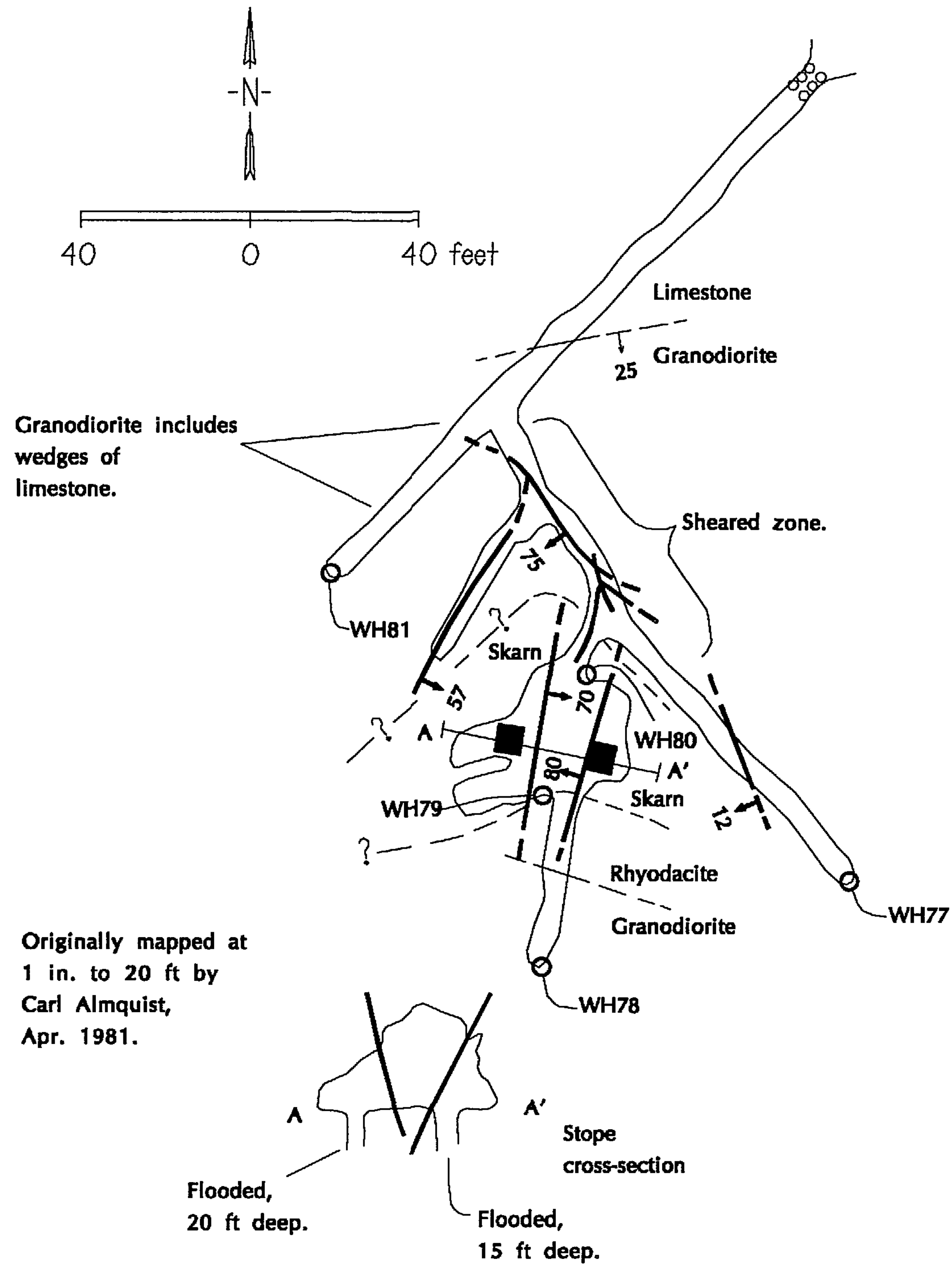


Figure 4.--Mascot Mine, with sample localities WH 77-81, Whetstone Mountains Unit.

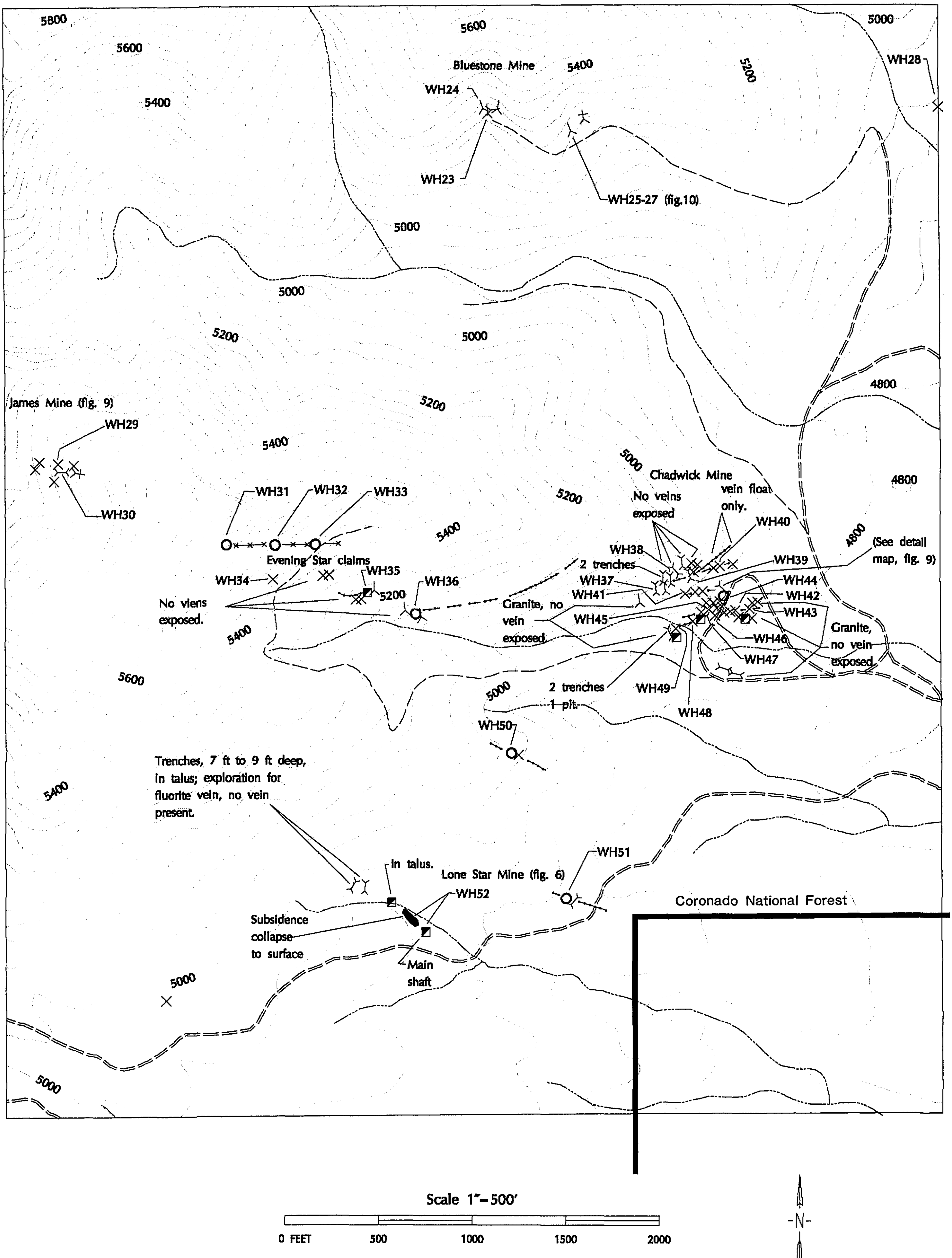


Figure 5.—James, Evening Star, Chadwick, and Lone Star Mines and prospects, with sample localities WH 23-52, Whetstone Mountains Unit.

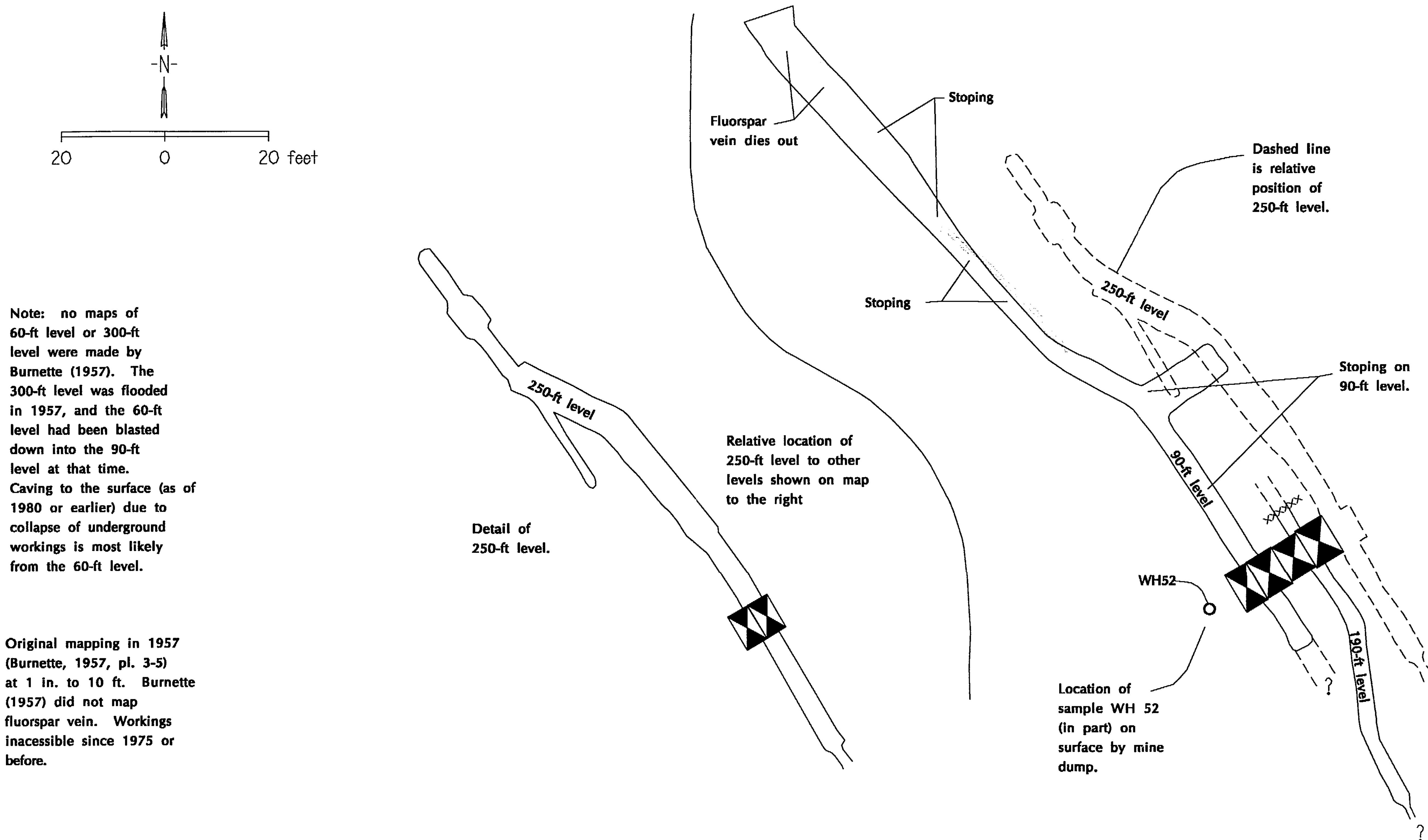


Figure 6.--Lone Star Mine, with sample locality WH 52, Whetstone Mountains Unit.

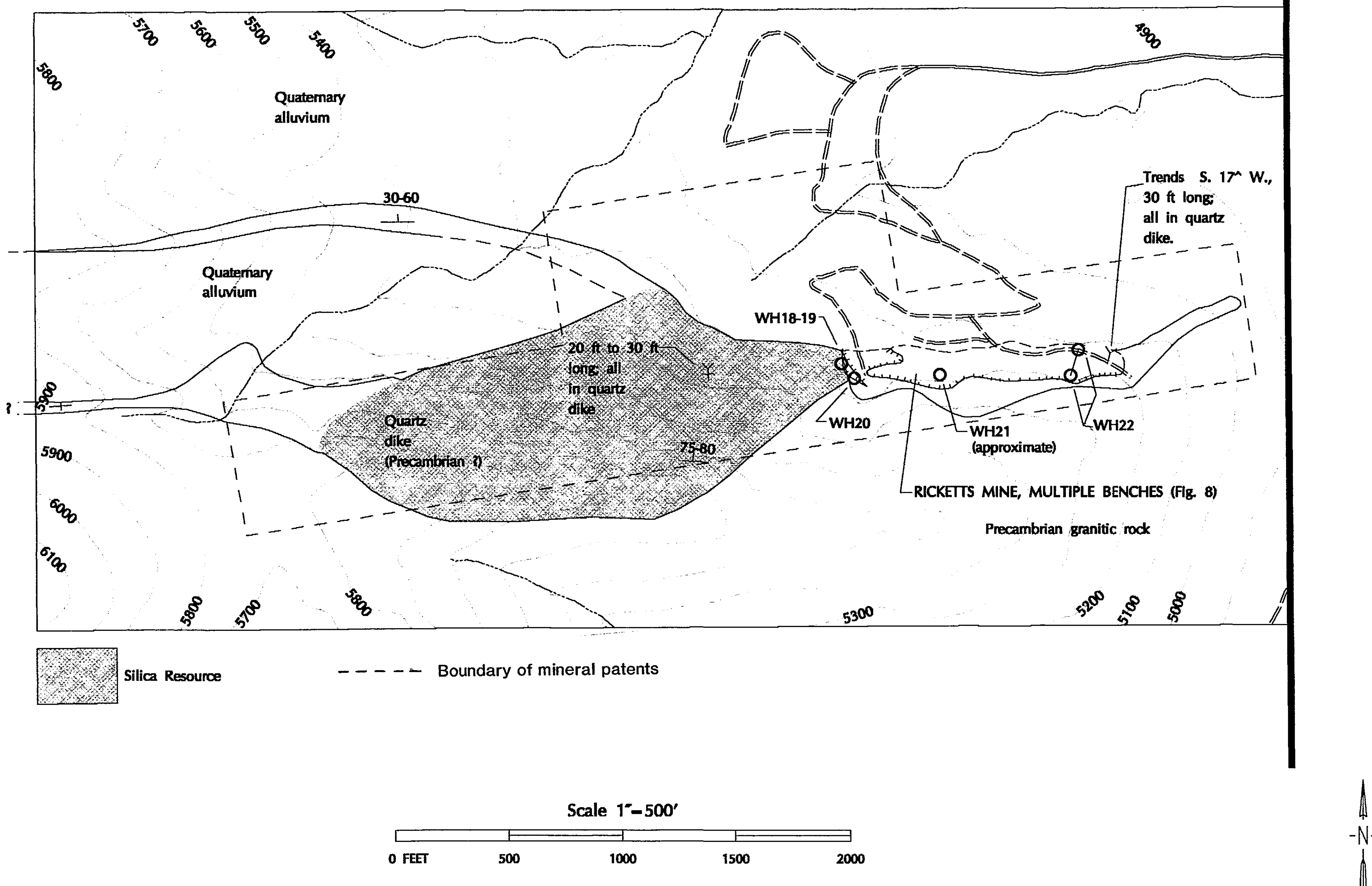
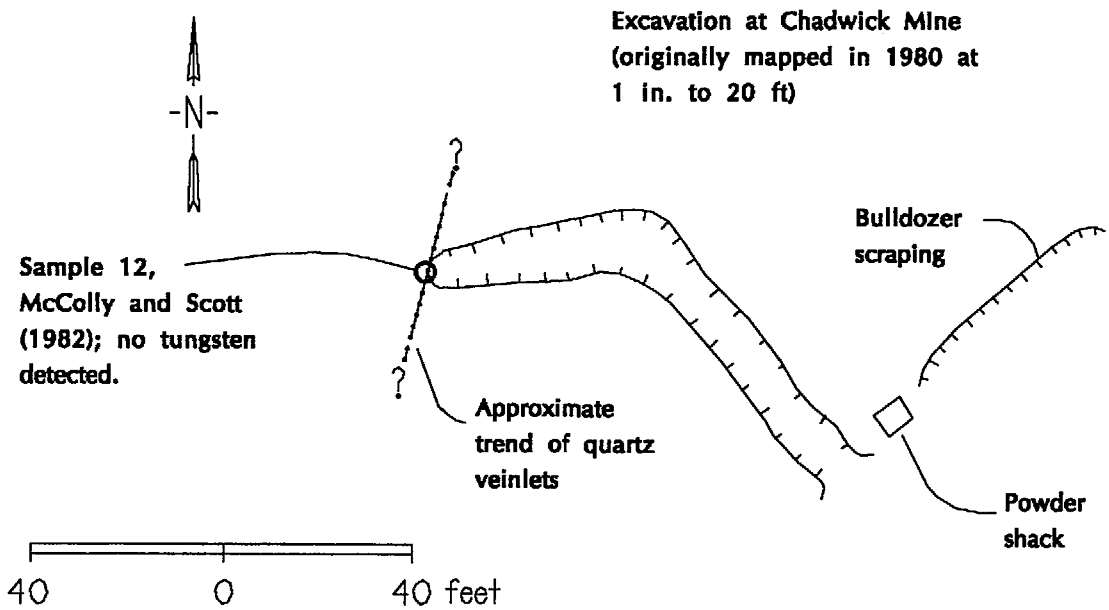


Figure 7.– Ricketts Mine, and Precambrian (?) quartz dike, with sample localities WH 18-22, Whetstone Mountains Unit.



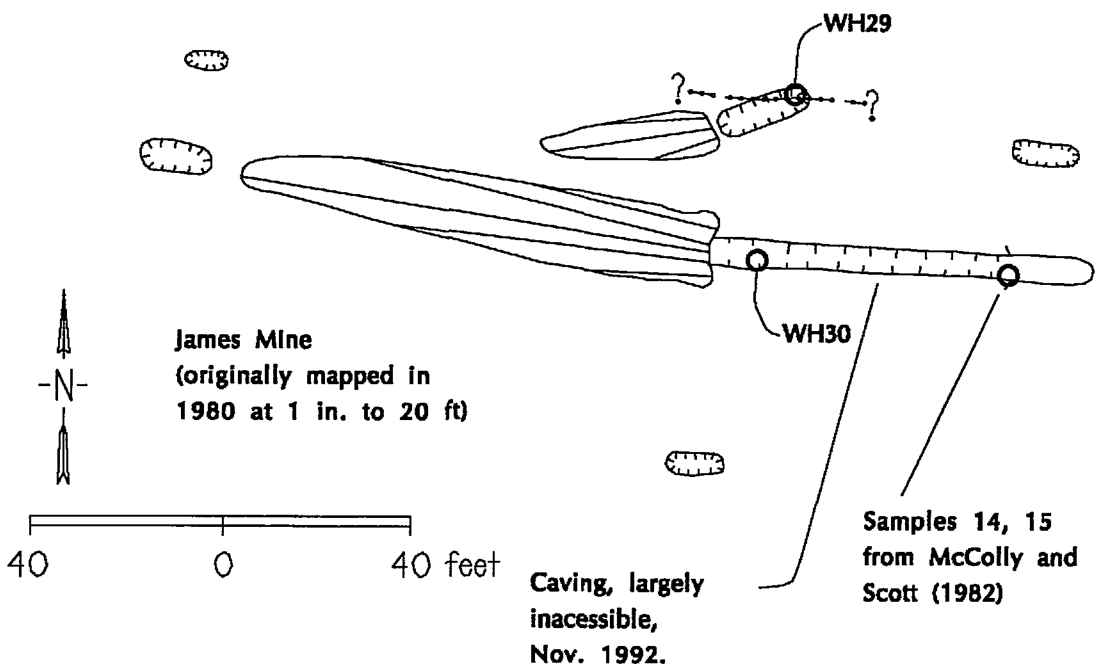


Figure 9.--Excavation at Chadwick Mine, and map of James Mine, with sample localities WH 29, 30, Whetstone Mountains Unit.

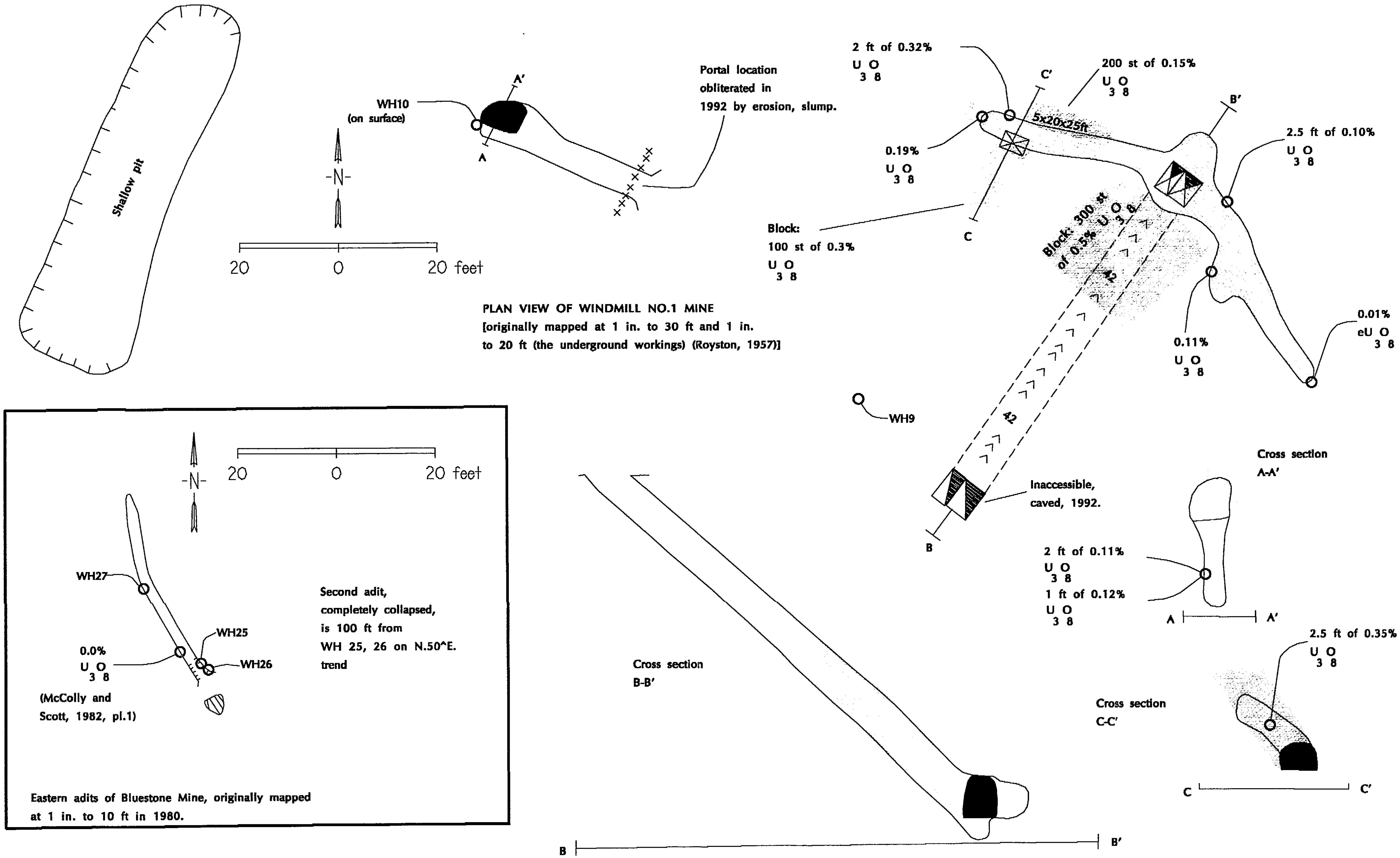


Figure 10.–Eastern adits of Bluestone Mine and workings, cross sections of Windmill No.1 Mine, with sample localities WH 25-27, WH 9-10, Whetstone Mountains Unit.

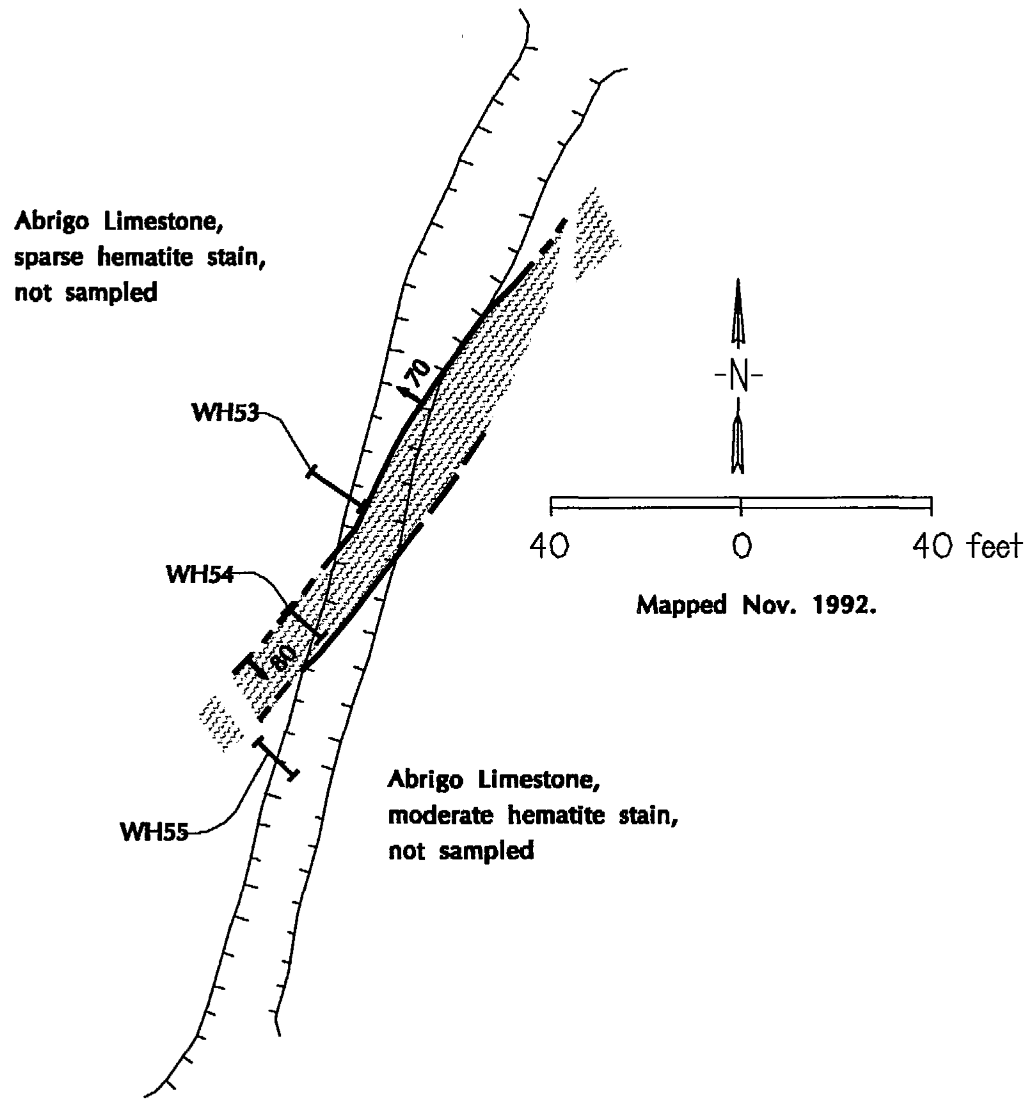
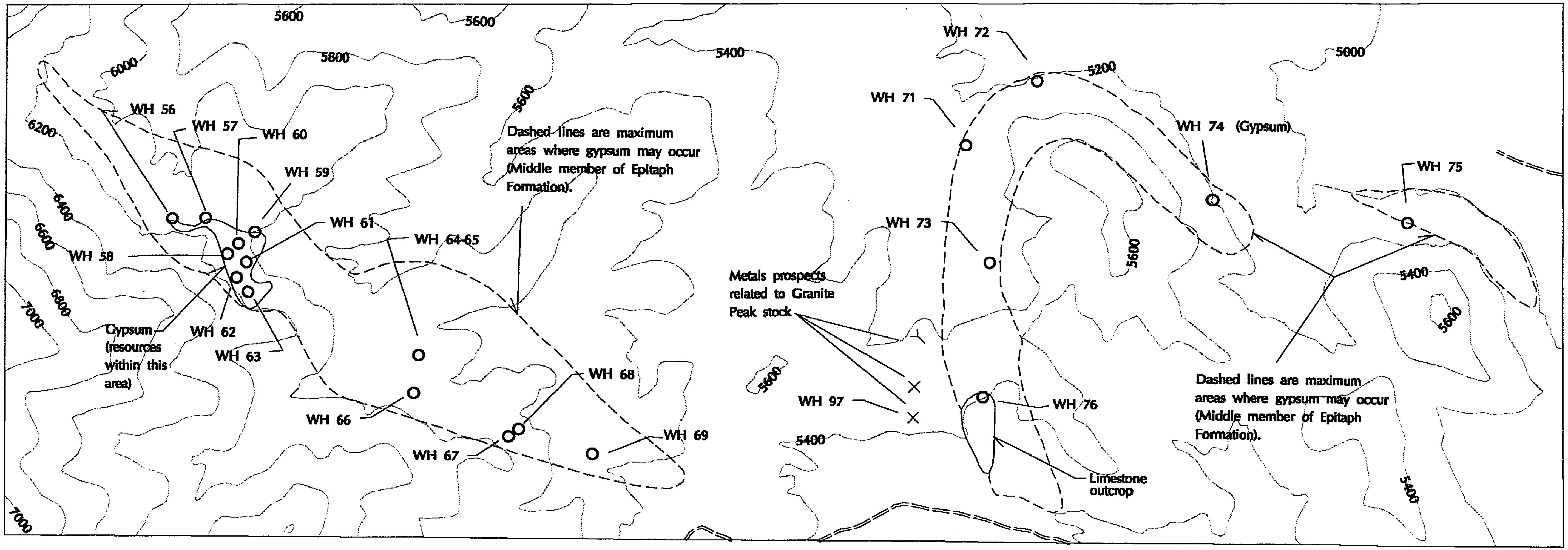


Figure 11.–Gold Cristle Mine, with sample localities WH 53-55, Whetstone Mountains Unit.



Boundaries of Middle member of Epitaph Formation from Wrucke and others (1983, map).

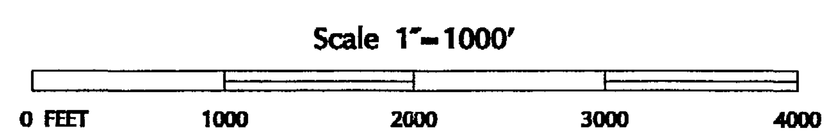


Figure 12.–Gypsum occurences, with sample localities WH 56-69, WH 71-76, and sample locality WH 97, (a prospect related to Granite Peak stock), Whetstone Mountains Unit.

Appendix A.--Descriptions of reconnaissance geologic rock-chip samples from Whetstone Mountains Unit, Coronado National Forest. Assays are in appendixes B, C. Note that gypsum sample analyses (WH56-69, 71-76) are listed in the text (table 3). Sample type definitions are as follows. Chip samples are a regular series of rock chips taken in a continuous (or semi-continuous) line across a mineralized zone or other exposure, and usually across the entire width or thickness of that exposure. Grid and grab samples are from mine/prospect dumps. The grid type are taken systematically over an area to convey possible mineral value distributed in a dump. The grab type are taken unsystematically, usually as a background check, where no specific mineral zone is known or expected. In some cases, grab samples may be collected from an outcrop, for similar reasons. Select samples are often from a mine/prospect dump and are select chips of a specific rock type; select samples can also be collected from an in-place mineral structure to convey assays for the specific zone. Samples noted as "high-grade" are select samples collected from the most intensely mineralized (usually metallized) rock available in dumps, outcrops, or other exposed mineral zones. "Length" is that of rock-chip measured intervals for applicable samples. None listed for select, high-grade, grid, or grab samples.

Number	Type	Length	Description
WH1	Chip	6 ft	U_3O_8 prospect pit, 12-ft by 12-ft and 4-ft-deep, in Precambrian quartz monzonite. Excavated on weak fracture, N. 42° E., roughly vertical, kaolinized. Fracture cannot be traced on strike due to soil cover. Scintillometer reading: 75 cps (background is 60 cps).
WH2	Select	n/a	Same locality as WH3. Shaft excavated on aplite dike in Precambrian quartz monzonite. Sample from 1980-81 RARE II study (no. 3 in McColly and Scott, 1982); pulp re-assayed in 1992. Sample of quartz monzonite from the dump. Dump size is negligible. Site excavated initially for base or precious metals.
WH3	Chip	6 ft	Two adjoining shafts on quartz-rich (60% to 70% SiO_2) aplite dike that cuts Precambrian quartz monzonite. Same locality as WH2 (see pl. 1). Dike: N. 24° E., NW. 68°, 5-ft to 6-ft wide, quartz-crystal-filled vugs, minor limonitic stain, trace hematite stain, trace muscovite. Full width of dike sampled between the shafts. Dike exposed on strike by workings for 33 ft; by float to the SW. for additional 35 ft, in outcrop to the NE. for 30 ft (at which point it is covered by talus. Total observed strike length: 98 ft. Float vuggy with hematite blebs, suggesting possible metallization. Moderate hematite staining on quartz monzonite wallrock. Southern shaft is 17-ft by 7-ft (maximum) and 18-ft-deep, sloughed, driven on the dike. Adjoining northern shaft (just 4 ft to the N.) is 12-ft by 6-ft and 8-ft-deep, sloughed.
WH4	Chip	5 ft	Near the northeasternmost exposure of quartz-rich aplite dike (see samples WH5-8, pl. 1), N. 61° E., NW. 72°. Composition: mostly white quartz with minor limonitic stain on fractures concordant with dike orientation.

Number	Type	Length	Description
WH5	Chip	3.5 ft	Aplite dike, N. 50° E., NW. 83°, over 25-ft-wide, in places; cuts through gneissic Precambrian rock. Same zone sampled by WH4-8 (see pl. 1). Fracture zone on hangingwall, 3.5-ft-wide, concordant with strike, was sampled: moderate limonitic stain, trace malachite stain, and was the prospecting target of the 6-ft by 5-ft, 20-ft-deep shaft at the site. Remainder of dike is white, quartz-rich, unfractured. West of the shaft by 20 ft is open cut, 20-ft by 12-ft and 10-ft-deep, exposing the same aplite dike (not sampled there).
WH6	Chip	15 ft	Same aplite dike as WH4-8 (see pl. 1), hosted in porphyritic Precambrian quartz monzonite; thickness here is 12-ft to 15-ft. Sampled maximum width. Feldspar crystals difficult to distinguish. Later quartz veining through the dike is common here (2-in.- to 3-in.-wide veins).
WH7	Chip	15 ft	Same aplite dike as WH4-8 (see pl. 1), trends N. 30° E., about vertical; minor unidentified iron-oxide stain (light tan color). Radiometric reading: 30 cps to 60 cps. Small prospect pit, 50 ft SE., is 10-ft by 15-ft and 4-ft-deep, excavated in Precambrian quartz monzonite, and is without structure or radiometric anomaly (radiometric reading: 50 cps). The pit is probably a U_3O_8 prospect site. The aplite dike was likely explored for metals.
WH8	Chip	9 ft	Same aplite dike as WH4-7 (see pl. 1), N. 40° E., vertical. Covered to the SW. No iron staining. Sampled full width.
WH9	Select	n/a	Windmill No. 1 Mine, U_3O_8 (see also WH10, pl. 1). Shaft, 18-ft by 14-ft and 4-ft deep (caved or backfilled). No structure or bedrock exposed around shaft, only colluvium. Dump (size negligible) is only 2-ft-thick, mostly eroded into adjacent gully and removed by stream action. Composition: quartz monzonite, apparently from shaft, heavy chloritic alteration, clayey, 350 cps radiometric reading. Sample from 1980-81 RARE II study (no. 2 in McColly and Scott, 1982); pulp re-assayed in 1992.

Number	Type	Length	Description
WH10	Chip	11 ft	Radiometric high on surface for Windmill No. 1 Mine area: 450 cps from Precambrian quartz monzonite outcrop, about 70 ft W. of shaft (WH9). Sample is full width of 11-ft-wide joint (possible shear) in the quartz monzonite, N. 50° E., SE. approximately 70°. Moderate limonitic stain in 4 ft of the width; another 2 ft has chloritic alteration. This weak structure is eroded to SW., covered by talus and soil to NE.
WH14	Chip	7.5 ft	Aplite dike, pervasive silicification; W. extent of poorly-exposed outcrop (covered by talus, soil further to the W.); cuts Precambrian quartz monzonite. Float suggests continuity for another 50 ft to W. beyond WH14. Same dike as WH15, WH17, pl. 1. Dike oriented N. 80° E., NW. 85°. Sampled full width. Minor limonitic stain, very minor secondary quartz veining. Possible shearing. No radiometric anomaly: registers 20 cps to 50 cps on scintillometer.
WH15	Chip	3.5 ft	Same aplite dike as WH14; sampled full width from outcrop. Composition: 60% quartz, finely crystalline, gray, vuggy, 40% aplite, trace amethyst. Exposure at shaft collar demonstrates secondary quartz influx into the aplite is vuggy, with boxwork structures, and predominantly white bull quartz in 1-in.- to 2-in.-wide veinlets, all paralleling strike of the aplite dike. Secondary quartz is on the dike footwall. Sample by shaft collar. Shaft: 3.5-ft by 5-ft and flooded at 25 ft depth; likely at least 30-ft-deep, based on dump size. Dump small, not measured. Heavily chloritized granitic rock on the dump (as at the Windmill No. 1 Mine) has highest radiometric readings: 100 cps.
WH16	Chip	6 ft	Quartz monzonite hangingwall adjoining aplite dike WH15. Does *not* include the contact zone (that rock is in sample WH15). Some compositional mixing with the aplitic material is apparent. A test for metallization beyond the dike.
WH17	Chip	3 ft	Same aplite dike as WH14-15. See pl. 1. Aplite and white secondary quartz, trace amethyst (purple, not gem quality); feldspars are chloritically altered; minor unidentified iron-oxide stain along fractures in dike. Continues for another 150 ft to NE, then covered. Excavated by small pit (dimensions not known). Scintillometer reading: 30 cps.

Number	Type	Length	Description
WH18	Chip	0.25 ft	Ricketts Mine (fig. 7, 8). Fracture, N. 30° E., SE. 85° through the quartz dike, exposed in open cut. Black mineral in fracture probably supergene Mn or carbon from nearby vegetation. Not exposed W. of the open cut boundary due to topography.
WH19	Chip	4 ft	Ricketts Mine (fig. 7, 8). Same fracture as WH18, only includes the full width of the zone, not just the Mn(?) rich part. Sample from 1980-81 RARE II study (no. 4 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH20	Select	n/a	Ricketts Mine (fig. 7, 8). Fracture zone (N. 40° E., NW. 60° to 85°) cuts quartz dike in the upper two benches of the open cut, westernmost end of the mine. Zone is as much as 45-ft-wide. Coincides with abrupt change in strike direction in the quartz dike outcrop, and is likely a fault of short strike length. Covered to NE. (topography); not seen to SW. Only structure exposed in the quartz unit that appears to be potentially metallized. Sample from Aug. 1989 visit is only select pieces of the zone from waste rock pile, *not the full structural width*; noted then were specular hematite(?) and unidentified red iron-oxide stain.
WH21	Grab	n/a	Ricketts Mine (fig. 7, 8). Grab of quartz dike material from the open cut area. Includes multi-phase quartz and iron-oxide stained quartzite (some specular hematite). A check for metallization, though results will be of limited utility due to mixing of rock types and non-specific locality from the field geologist during Aug. 1989 visit to the mine.
WH22	Grab	n/a	Ricketts Mine (fig. 7, 8). Representative sample of the quartz dike. A check for any pervasive metallization in the rock unit. Sample from 1980-81 RARE II study (no. 5 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH23	Chip	3 ft	Bluestone Mine (fig. 5, 10), within 1974 to 1975-era Star claims group; western group of adits, southern dike. Mafic dike (approximately N. 85° W., dip not known) cuts Precambrian granitic rock. Extends along strike for 75 ft. Sampled full width of dike, outside portal of 20-ft-long, north-trending adit (no map). Scintillometer reading: 1,000 cps.

Number	Type	Length	Description
WH24	Chip	4.2 ft	Bluestone Mine (fig. 5, 10), western group of adits, northern dike. Dike (probably chloritized; possibly mafic), oriented approximately N. 85° E. (dip not known) and cuts Precambrian granitic rock. Extends along strike for 30 ft. Sampled full width of dike, outside portal of 15-ft-long, approximately N. 10° W.-trending adit (no map). Scintillometer reading: 1,000 cps. Sample from 1980-1981 RARE II study (no. 9 in McColly and Scott, 1982); pulp re-assayed in 1992. There are two more prospect adits on this same dike, located 30 ft and 65 ft NE. of sample site WH24. Both these un-sampled adits are 20-ft-long; the easternmost is flooded. No dump sizes known for excavations at the Bluestone Mine.
WH25	Chip	3.5 ft	Bluestone Mine (fig. 5, 10), eastern group of adits. Altered (clay) shear zone, N. 60° W., NE. 36°, cuts granitic rock. Shear contains massive quartz and quartz veinlets (2-in. wide); minor unidentified iron-oxide stain; scintillometer reading: 35-40 cps. Sample of hangingwall of shear, which is excavated by adit, collected at adit portal.
WH26	Chip	3 ft	Bluestone Mine (fig. 5, 10). Footwall of same shear as WH25, collected adjacent to WH25. Shear has undergone argillaceous alteration, contains limonitic and fine-grained igneous rock.
WH27	Chip	3.3 ft	Bluestone Mine (fig. 5, 10). Same shear as WH25-26, collected in adit; sampled full width of shear. Shear contains massive quartz, quartz veinlets, abundant limonitic material. Sample from 1980-1981 RARE II study (no. 8 in McColly and Scott, 1982); pulp re-assayed in 1992. Another small adit, totally collapsed, is located 100 ft from WH25-27 adit portal on a N. 50° E. trend.
WH28	Chip	1.7 ft	Prospect pit (fig. 5) in granitic rock exposes zone with 4 quartz veins that trend N. 80° E. and are vertical, parallel, and 4-in. to 6-in.-wide. Vein zone extends 50 ft NE. of pit. Composite chip sample of the 4 veins collected. Float suggests strongly that more unexposed veins are present SE. of the pit.

Number	Type	Length	Description
WH29	Chip	2 ft	James Mine (fig. 5, 9); sampled full width of fractured quartz vein (N. 80° W., NE. 47°) exposed by pit; cannot be traced beyond pit (talus cover). Occurs at contact of granitic rock and schist.
WH30	Select	n/a	James Mine (fig. 5, 9); quartz vein material from end of collapsing, dangerously overhung trench; trend of vein (from McColly and Scott, 1982) is N. 80° W., NE. 48??°. Vein reportedly 6-ft-wide. Cannot be traced in outcrop SE. of this excavation, but 1-in.-wide quartz veins are common there. Sample has minor evidence (stain) of weathering sulfide minerals; possible pyrite.
WH31	Chip	1.3 ft	Evening Star quartz-rich aplitic dike (fig. 5), sampled where it pinches out on the western extent; strikes E.-W., dips N. 63°. Sampled full width; 30% is granitic rock. Host is granitic rock.
WH32	Chip	3 ft	Evening Star aplitic dike (fig. 5), oriented E.-W., dipping N. 84°; 70% to 80% quartz. Sampled full width. Hangingwall side is fault contact with phyllite (phyllite underlies granitic host of WH31) and footwall side is igneous or metamorphosed contact with granitic rock. The phyllite is not present at elevations higher than sample site WH32.
WH33	Chip	3 ft	Evening Star claim area (fig. 5); an old exploration drill pad, erroneously shown as a prospect pit on published 7.5 minute McGrew Spring topographic map. Aplitic dike (N. 85° W., NE. 64°) with 30% feldspars altered to chlorite, cuts granitic rock; sampled full width of dike. Center of dike has slickensides, secondary quartz growths with heavy limonitic material, and lamellae with hematite and possible huebnerite grains (0.004 in.- to 0.012-in.-wide). Contact of vein and granitic rock is probably igneous on footwall, but is faulted on hangingwall. Continues on strike in both directions.
WH34	Select	n/a	Evening Star? prospect (fig. 5); open cut trends due W. into steep hillside for 12-ft and is 3 ft wide. Exposes 3-in.-wide bull quartz vein (strikes E.-W., dips N. 85°), very sparse limonitic blebs. Cuts green granite with chlorite alteration and 2% to 5% muscovite. Vein cannot be traced from pit due to talus cover. Several, near-horizontal quartz veins (1-in. to 2-in.-wide) are present but are spaced 3-ft to 4-ft apart; no dense veining exposed. Dump size is negligible.

Number	Type	Length	Description
WH35	Chip	9 ft	Outlier of either Evening Star claims or Chadwick Mine (fig. 5). Shaft, 6-ft by 5-ft, 7-ft-deep to water; small dump suggests total depth <20 ft. Exposes quartz vein (N. 70° E., NW. 77°) with 150 ft total strike length (pinches out 20 ft E. of shaft WH35 and at W. end as mapped--see fig. 5). Vein hosted in granite, and composed of bull quartz, with trace metallics (specular hematite?), sampled entire width. Two pits immediately south of vein (see fig. 5) were driven on float and missed the vein (sunk too far into footwall). Both pits are 10-ft by 6-ft, 7-ft-deep. Adit 25 ft NE. of WH35 shaft is driven due N. for 9 ft into granite; it is E. of the eastern extent of the vein.
WH36	Chip	1.2 ft	Outlier of either Evening Star claims or Chadwick Mine (fig. 5). Outcrop of quartz vein (N. 75° E., NW. 84°); bull quartz, granite-hosted, average width 3-in. to 4-in., strike length 55 ft (only 25 ft in outcrop, rest float) in vicinity of the sample site, but the probable eastern extension of this same vein continues 925 ft on a N. 70° E. average trend; has a steep NW. dip; but is only 2-ft-wide. Adit 30 ft to SE. of WH36 (see fig. 5), bearing N. 5° W., 20-ft-long in granite; tried to undercut WH36 vein and missed it. Adit W. of WH36 (fig. 5) bearing due N. for 37 ft in granite; did not intersect WH36 vein; dump negligible in size.
WH37	Chip	1.3 ft	Chadwick Mine (fig. 5); trench, trends N.-S., 20-ft-long, 4-ft-wide, 5-ft-deep, exposes the sampled vein (N. 55° E., NW. 82°). Mostly clean bull quartz, traces of specular hematite, muscovite, clay. Vein continuous from a point 25 ft SW. of site WH37, and continuous northeastward as mapped (fig. 5), for another 420 ft. Sampled full width. A small pit (not shown), on a N. 30° E. trend, 15 ft from WH37 missed the vein, as did the two 12-ft-long trenches on a N. 30° E. trend, 40 ft from WH37 (see fig. 5).
WH38	Chip	2.2 ft	Chadwick Mine (fig. 5); trench, 12-ft-long, 4-ft-wide, 4-ft-deep, exposes same vein as WH37. Vein is N. 60° E., NW. 74°, composed of bull quartz, granite-hosted, with trace specular hematite. Footwall of WH38 is 3 ft of granite, and then 0.8 ft of splay? or second quartz vein. This 0.8 ft was included in sample WH38.

Number	Type	Length	Description
WH39	Chip	2 ft	Chadwick Mine (fig. 5); trench, trends N.-S., 10-ft-long, 4-ft-wide, 4-ft-deep, exposes same vein as WH37-38. Vein has thickened and flattened from site WH38. Vein: N. 70° E., NW. 50°, bull quartz. Vein continues to NE. (fig. 5) for another 220 ft, but narrows (9-in. to 14-in.-wide) along that extent.
WH40	Chip	1.3 ft	Chadwick Mine (fig. 5); pit, 4-ft by 7-ft, 5-ft-deep, exposes the southern splay? (or second) quartz vein noted at sample site WH38. Vein: N. 75° E., NW. 61°; bull quartz, no metallic minerals seen, granite-hosted; pinches out 40 ft NE. of sample site; sampled full thickness. Total strike length, site WH38 to NE. end, is 350 ft. Small pit on this vein, SW. of site WH40 is 7-ft by 4-ft, 4-ft deep. Pit SE. of site WH40 does not expose a southern-offset continuity of the vein, but hit only barren granite.
WH41	Chip	0.8 ft	Chadwick Mine (fig. 5); pit, 6-ft by 4-ft, 5-ft deep, exposes quartz vein (N. 80° E., NW. 70°). Vein: bull quartz, no visible metallic minerals, granite-hosted; sampled full width. Strike length: 125 ft.
WH42	Chip	1.3 ft	Chadwick Mine (fig. 5); pit, 8-ft by 4-ft, 3 ft-deep, exposes quartz vein (N. 60° E., NW. 75°). Vein: semi-translucent, grayish-colored quartz, minor limonitic material, granitic host; sampled full width. Same vein sample at site WH43. Total strike length of vein is 185 ft; lost in talus about 30 ft SW. of WH42.
WH43	Chip	1 ft	Chadwick Mine (fig. 5); pit, 8-ft by 8-ft, and flooded at 6-ft-deep level (dump suggests total depth no more than 10 ft); exposes quartz vein (N. 85° E., NW. 63°). Vein: bull quartz, minor brown, unidentified iron-oxide stain. Same vein as sampled at site WH42; covered by talus 50 ft NE. of WH43.
WH44	Chip	not record-ed	Chadwick Mine (fig. 5). Quartz veinlet zone outcrop; veinlets hosted in granitic rock. Veinlets compose 10% to 20% of the total sample.

Number	Type	Length	Description
WH45	Chip	1 ft	Chadwick Mine (fig. 5); pit, 4-ft by 15-ft, 5-ft-deep exposes quartz vein (N. 80° E., NW. 45° to 70°). Vein: trace specular hematite; trace blue-green coloration (beryl?). This vein is thin but has continuity. Total strike length is about 200 ft. Vein continues from WH45 site to the SW. for 135 ft, where it apparently pinches out. Averages only 6-in.-wide along this trend. Vein continues NE. of site WH45 for 65 ft, and ends as a pod-like quartz body in a 8-ft by 5-ft, 6-ft-deep pit. Average vein width along that part of the strike length is 1.3 ft.
WH46	Chip	1.5 ft	Chadwick Mine (fig. 5); shallow pit exposes quartz vein (N. 65° E., NW. 73°). Same vein sampled at sites WH47-49. Vein: quartz, grayish, minor muscovite; granite-hosted; sampled full width; continues for 35 ft to NE. of WH46, then pinches out. Total strike length about 270 ft (see fig. 5).
WH47	Chip	1.5 ft	Chadwick Mine (fig. 5); trench, 22-ft-long, N. 10° E. trend, exposes quartz vein (N. 75° E., NW. 80°). Same vein sampled at sites WH46, 48-49. Vein: semi-translucent, grayish quartz, minor muscovite, trace specular hematite; granite-hosted; sampled full width.
WH48	Chip	1 ft	Chadwick Mine (fig. 5); pit, 7-ft by 4-ft, 4-ft-deep, exposes same quartz vein as sampled at WH46-47, 49. Vein: N. 72° E., NW. 82°, bull quartz, minor muscovite; granite-hosted; sampled full width. At shaft (un-sampled), 22 ft NE. from site WH48 (see fig. 5), same vein is 1.5-ft-wide. Shaft is flooded at 30-ft depth. Shaft probably greater than 50-ft-deep, based on dump size. Dump not measured.
WH49	Chip	1 ft	Chadwick Mine (fig. 5); pit, 8-ft by 8-ft, 5-ft-deep, exposes quartz vein (N. 72° E., NW. 83°) that was sampled at sites WH46-48. The vein is granite-hosted, and pinches out 10 ft SW. of site WH49 (total strike length 270 ft). Sampled full width.
WH50	Chip	4 ft	Unnamed prospect pit (fig. 5), 12-ft by 8-ft, 5-ft-deep, exposes schist-hosted quartz vein (N. 65° W., SW. 80°). Vein: white quartz with small xenoliths of the schist that have undergone chloritic alteration. Fracture surfaces within vein have minor, unidentified iron-oxide stain.

Number	Type	Length	Description
WH51	Chip	1 ft	Unnamed prospect pit (fig. 5), 50-ft by 10-ft and 3-ft-deep, exposes schist-hosted quartz vein (N. 71° W., vertical) that is between 0.5-ft and 1-ft-wide. Same altered xenoliths, iron-oxide stain as sample WH50.
WH52	Select	n/a	Lone Star Mine (fig. 5, 6). Select pieces of the mined fluorite vein collected at the dump of the main shaft and exposed, broken rock at the fenced-off surface-subsidence hole that exposes parts of the upper two levels of the underground workings. Sample: vein of quartz, opaline quartz and fluorite in thinly laminated schist; largest fluorite crystals 0.5-in.-across. Dump size is 25,000 ft^3 (about 1,200 st).
WH53	Chip	14 ft	Gold Cristle Mine (fig. 11). Limestone, abundant hematite stain, contorted beds, faulted, rotated blocks (200-1,000 st in weight), non-cemented crushed limestone in places. Sampled the full width of this zone, which parallels the shear zone in the Gold Cristle trench on the NW. side of the shear. Zone defined by hematite stain. Ended sample interval where hematite stain diminishes (see fig. 11).
WH54	Chip	8 ft	Gold Cristle Mine (fig. 11), shear exposed in 15-ft to 25-ft-deep trench. Shear with slickensides: 60% anastomosing calcite veinlets; 40% limestone, abundant hematite stain, contorted beds, crushed. No pyrite observed. Sampled full shear width. This structure is not exposed beyond the trench limits due to heavy talus and soil cover.
WH55	Chip	12 ft	Gold Cristle Mine (fig. 11). Limestone, abundant vertical calcite veinlets; hematite stain in about half the sample--the rest is green; contorted beds, some crushing. Sampled the full width of this zone, which parallels the shear zone in the Gold Cristle trench on the SE. side of the shear. Zone defined by hematite stain. Ended sample interval where hematite stain diminishes (see fig. 11).

Number	Type	Length	Description
WH56	Chip	12 ft	Gypsum (fig. 12) from outcrop, N. 10° W., SW. 25°. Intermittent chip sample of poor exposure. Sample 80% competent gypsum, 20% gypsite. Exposed bed is 16-ft-thick; maximum 25-ft-thick, based on evidence from float, gypsite-like soil. Unit overlain by gray, medium-grained limestone; below gypsum unit is yellow, gypsite-like marl. Traceable continuity of WH56 gypsum to north is 30 ft. Brushy vegetation cover here is very thick.
WH57	Chip	90 ft	Gypsum (fig. 12) from outcrop, N. 10° W., SW. 12°. See table 3 for analyses. Sample is full thickness of gypsum bed. Upper 3-ft is competent rock gypsum; remainder of sample is powdery to granular, weathered gypsum.
WH58	Chip	55 ft	Gypsum bed (fig. 12) from outcrop (includes 8-ft-thick interbed of gypsiferous limestone); gypsum bed strike approximately NW., dip SW. about 20°. Soft, porous, white gypsum. Total sample is 15% gypsite. Gypsum bed in overlain by gypsiferous limestone. The base of the gypsum is covered by talus around sample; true base is exposed elsewhere, showing that this gypsum bed is actually 70-ft-thick. At its base is a 30-ft to 60-ft-thick shale bed. From upper bed in WH56-63 gypsum unit.
WH59	Chip	20 ft	Gypsum and limestone bed from outcrop (fig. 12), oriented approximately N. 25° W., SW. 27°. Sampled full exposed thickness. Assumed continuous with overlying (WH60) gypsum bed. Sample: white gypsum with selenite crystals. About 50% of sample is gypsite. From lower bed in WH56-63 gypsum unit. Too impure to use as a gypsum resource.
WH60	Chip	60 ft	Gypsum bed (fig. 12) from outcrop. Orientation same as sample WH58. 30-ft-thick shale bed (not sampled) separates this WH60 gypsum bed from the WH58 gypsum bed. Sampled bed WH60 is: upper 20-ft section of 50% rock gypsum and 50% interbed of shale; middle 10-ft section of cover (not sampled); lower 30-ft section of soft, porous white gypsum. The base of this WH60 bed is covered. It is assumed continuous with WH59. From lower bed in WH56-63 gypsum unit.

Number	Type	Length	Description
WH61	Chip	20 ft	Gypsum bed from outcrop (fig. 12). Oriented about the same as WH58. Rock gypsum and interbed of green-gray marl, and also powdery, weathered gypsum. From lower bed in WH56-63 gypsum unit.
WH62	Chip	130 ft	Gypsum bed from outcrop (fig. 12). Oriented about the same as WH58. Most continuous thickness of gypsum found. Sample is 30% rock gypsum, 50% softer, porous, white gypsum, and 2% powdery, weathered gypsum. Overlying unit is gypsiferous limestone. Underlying are talus-covered section and other lithologies. From upper bed in WH56-63 gypsum unit.
WH63	Chip	200 ft	Gypsum bed from outcrop (fig. 12). Only one gypsum bed here (see samples WH58-62, where there are two beds separated by 30-ft to 60-ft-thick shale). Upper 30 ft is rock gypsum with selenite bands. Middle 70 ft is softer, white gypsum (60%) and rock gypsum (40%; no selenite). Lowest 100 ft is 50% rock gypsum (10% has selenite bands), 45% softer, white gypsum, and 5% marl interbed. Too impure to use as a gypsum resource.
WH64	Chip	60 ft	Limestone outcrop (fig. 12), apparently full thickness of this bed, which has physical and weathering characteristics *strongly* suggestive of gypsum. Broken into two samples (WH64 is upper part of section; WH65 is lower part of section). The bed strikes about N.-S., and dips west at 45°. Sample: upper 40 ft is weathering product that appeared to be *gypsite*; lower 20 ft is strata that appeared to be *rock gypsum*. Divided arbitrarily from sample WH65 at the base of this hard bed that appeared to be *rock gypsum*. This unit cannot be traced on strike due to heavy brush.
WH65	Chip	60 ft	Limestone outcrop (fig. 12), apparently full thickness of this bed, which has physical and weathering characteristics *strongly* suggestive of gypsum. Broken into two samples (WH64 is upper part of section; WH65 is lower part of section). The bed strikes about N.-S., and dips west at 45°. Sample: soft, white material that appeared to be a weathered *rock gypsum* bed; bottom 20 ft is sandy. A 10-ft-thick limestone interbed was not included in this sample (the total stratigraphic thickness thus is 70 ft). This unit cannot be traced on strike due to heavy brush.

Number	Type	Length	Description
WH66	Chip	5 ft	Limestone (fig. 12). Sampled all that was exposed. Stratigraphic contacts are buried. Orthoquartzite bed overlies this limestone. Was collected for assay to provide chemical evidence that much of what has been mapped as gypsum in this part of the Whetstones (Wrucke and others, 1983, map) is not gypsum. The porous, sugary texture of this rock and its color make it appear to be a gypsum bed.
WH67	Chip	10 ft	Limestone from outcrop. First 10 ft above sample WH68. No good exposure to measure strike and dip. Generally strike is N.-S., and dip is west. Was collected for assay to provide chemical evidence that much of what has been mapped as gypsum in this part of the Whetstones (Wrucke and others, 1983, map) is not gypsum. The porous, sugary texture of this rock and its color make it appear to be a gypsum bed.
WH68	Chip	53 ft	Outcrop of a rock intermediate between limestone and gypsum from outcrop (fig. 12). Top of this bed directly underlies WH67 and appears to be 70% *rock gypsum and softer, white weathered gypsum bed*, and 30% *gypsite*. The porous, sugary texture of this rock, its color, and its weathering characteristics are *strongly suggestive of a gypsum* bed.
WH69	Chip	1 ft	A limestone bed (fig. 12), as much as 50-ft-thick, N. 40° W., SW. 15°, from outcrop. Only 1 ft sampled; unit is largely inaccessible due to cliffs. Sample is from the bottom 1/3 of the total unit thickness. Was collected for assay to provide chemical evidence that much of what has been mapped as gypsum in this part of the Whetstones (Wrucke and others, 1983, map) is not gypsum. The porous, sugary texture of this rock and its color make it appear to be a gypsum bed.
WH70	Grab	n/a	Shaft (pl. 1), about 20-ft-deep, sunk on alluvial material in bottom of drainage. Possibly a well. Sampled limestone fragments from dump. Dump size not known.
WH71	Chip	10 ft	Limestone from outcrop (fig. 12) of the WH71-73, 76 bed. Sampled maximum that was exposed; the true unit thickness is probably more than 10 ft. Sample is soft, white, and has the sugary texture of gypsum; minor sulfur stain. Was thought to be gypsum with high percentage of carbonate impurity prior to chemical analysis.

Number	Type	Length	Description
WH72	Chip	4 ft	Weathered limestone from outcrop (fig. 12) of the WH71-73, 76 bed. Sampled maximum that was exposed; the true unit thickness is probably more. Poor exposure due to talus cover. Sample has all the physical characteristics of gypsite; was thought to be gypsite prior to chemical analysis.
WH73	Chip	4 ft	Weathered limestone from outcrop (fig. 12) of the WH71-73, 76 bed. Sampled maximum that was exposed; the true unit thickness is probably more. Poor exposure due to talus cover. Sample has all the physical characteristics of gypsite; was thought to be gypsite prior to chemical analysis.
WH74	Chip		Gypsum from outcrop (fig. 12). Sampled full thickness of the bed; only place this bed is fully exposed (exposed here due to gully dissection of the bed). Strikes N. 20° to 40° W., dips NW. 25° to 30°. Can be traced on strike for only 40 ft (poor exposure due to talus and soil cover). Overlain and underlain by limestone. Sample: 60% soft, white gypsum, sugary texture; 40% gypsite.
WH75	Chip	20 ft	Gypsum and anhydrite from outcrop (fig. 12). Soft, white, porous, with considerable component of gypsite (amount not estimated). Nearly 1/3 anhydrite. True bed thickness is about 50 ft; sampled maximum thickness that was exposed. Not traceable along strike due to cover.
WH76	Chip	15 ft	Limestone from outcrop (fig. 12) of the WH71-74, 76 bed. Sampled maximum that was exposed; at other locations in vicinity, 20-ft thickness was observed. Sample is soft, white, sugary-textured material with the physical and weathering characteristics of gypsum; was thought to be gypsum prior to chemical analysis.
WH77	Chip	4.5 ft	Mascot Mine, main adit (fig. 2, 4). Granodiorite, silicified, gray with abundant biotite; bornite present. Sample from 1980-81 RARE II study (no. 34 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH78	Chip	4.5 ft	Mascot Mine, main adit (fig. 2, 4). Granodiorite, silicified; copper sulfide minerals present. Sample from 1980-81 RARE II study (no. 35 in McColly and Scott, 1982); pulp re-assayed in 1992.

Number	Type	Length	Description
WH79	Chip	2.5 ft	Mascot Mine, stope in main adit (fig. 2, 4). Sample from skarn. Sample from 1980-81 RARE II study (no. 37 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH80	Chip	4.5 ft	Mascot Mine, main adit (fig. 2, 4). Sample from skarn; visible copper oxides. Sample from 1980-81 RARE II study (no. 36 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH81	Chip	6 ft	Mascot Mine, main adit (fig. 2, 4). Silicified limestone and adjacent bleached intrusive. Sample from 1980-81 RARE II study (no. 33 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH82	Chip	3 ft	Small open cut above main adit of Mascot Mine (fig. 2). Apparently the shear zone that was mined in Mascot Mine, main adit; shear oriented N. 75° E., SW. 81°. Shear cuts rhyodacite; contains copper oxides and coarse mica. Sample from 1980-81 RARE II study (no. 38 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH83	Chip	10 ft	Same open cut as WH82 (fig. 2). Examined and measured in 1989. Main part of cut is 50-ft-long, 8-ft-deep, 10-ft-wide, trending N.-S. Cross of the "T" in this cut is at S. end, trending E.-W., and about 55-ft-long. Sample of skarn with copper oxides and magnetite. Full width of skarn sampled.
WH84	Chip	2.5 ft	Pit (dimensions not known) above main adit of Mascot Mine (fig. 2). Sampled rock with unidentified, heavy, iron-oxide stain. Lithology is granodiorite, based on published geologic map (Wrucke and others, 1983, pl.). Sample from 1980-81 RARE II study (no. 39 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH85	Chip	1.2 ft	Prospect adit (fig. 2), 12-ft-long, driven S. 40° W. on fracture (N. 40° E.; dips NW. 85° to vertical), 0.5-ft- to 1.2-ft-width, through granite; minor copper oxide stain, limonitic stain. Sampled maximum width at face.
WH86	Chip	2 ft	Unnamed adit WH86-87 (fig. 2, 3). Granodiorite. Sample from 1980-81 RARE II study (no. 26 in McColly and Scott, 1982); pulp re-assayed in 1992. Erroneously referred to as the "Nevada Mine" in McColly and Scott (1982, fig. 2). No dump.

Number	Type	Length	Description
WH87	Chip	6 ft	Unnamed adit WH86-87 (fig. 2, 3). Granodiorite, abundant mica, with abundant malachite and azurite coatings and stain along fault. Bleaching of intrusive and presence of dark, unidentified alteration mineral noted along fault. Sample from 1980-81 RARE II study (no. 25 in McColly and Scott, 1982); pulp re-assayed in 1992. Erroneously referred to as the "Nevada Mine" in McColly and Scott (1982, fig. 2).
WH88	Grid	n/a	Two Peaks (Black Oak) Mine area (fig. 2). Shaft, 4-ft by 5-ft and 70-ft-deep, dry. Sunk on horizontal shear or breccia zone through granodiorite. Sample from dump: granodiorite with minor-to-moderate amounts of copper oxides. Extent of fracture not known. Examined in Aug. 1989.
WH89	Chip	not noted	Outcrop of shear or breccia adjacent to site WH88 (fig. 2). Brick-red and brown goethite, quartz veinlets. Extent of fracture not known. Examined in Aug. 1989.
WH90	Chip	3 ft	Two Peaks (Black Oak) Mine, main adit (fig. 2, 3). Shear in granodiorite with copper oxides. Sample from 1980-81 RARE II study (no. 29 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH91	Chip	5 ft	Two Peaks (Black Oak) Mine, main adit (fig. 2, 3). Granodiorite with "visible copper minerals". Sample from 1980-81 RARE II study (no. 30 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH92	Chip	4 ft	Two Peaks (Black Oak) Mine, main adit (fig. 2, 3). Shear zone (possibly same fracture as WH93) in granodiorite with "visible copper minerals". Sample from 1980-81 RARE II study (no. 31 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH93	Chip	4 ft	Two Peaks (Black Oak) Mine, main adit (fig. 2, 3). Fracture in granodiorite. Sample from 1980-81 RARE II study (no. 32 in McColly and Scott, 1982); pulp re-assayed in 1992.

Number	Type	Length	Description
WH94	Chip	4(?) ft	Prospect adit above Two Peaks Mine (fig. 2). Adit 25-ft-long, trending N. 35° E. along vertical fault through granodiorite. Fracture (with abundant gouge, limonitic- and copper-oxide stains) extends to the SE. for 485 ft to site WH95 shaft. Mineralogy at the portal: abundant copper-oxide staining; abundant limonitic material. Sample collected at face. Sample from 1980-81 RARE II study (no. 28 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH95	Chip	0.5 ft	Shaft (fig. 2), 3-ft by 6-ft and about 30-ft-deep, above Two Peaks Mine; excavated in granodiorite on N. 35° E., NW. 68° fracture that is continuous for 485 ft to site WH94. Sample: quartz with malachite and limonitic material at shaft collar. Fracture zone: 2 ft gouge, 0.5 ft copper oxides, and 0.5 ft to 0.33 ft of quartz (vein?); not found south of the shaft. Sample from 1980-81 RARE II study (no. 27 in McColly and Scott, 1982); pulp re-assayed in 1992. High-grade stockpiled on site is "half a pickup truck load".
WH96	Grid	n/a	Two Peaks Mine dump (fig. 2, 3). Examined in Aug. 1989. Dump size not known.
WH97	Chip	0.12 ft	Prospect pit (fig. 12), 3-ft by 10-ft, depth not recorded; in Colina Limestone; exposes parallel, healed fractures oriented N. 37° E., SE. 86°, with sulfides. Sample from 1980-81 RARE II study (no. 19 in McColly and Scott, 1982); pulp re-assayed in 1992. Zone apparently is continuous to the NE. for about 800 ft to the site of a 12-ft-long adit (un-sampled).
WH98	Chip	4 ft	David Lee Mine (fig. 2, 3). Granodiorite with copper-oxide stain from edge of stope. Sample from 1980-81 RARE II study (no. 24 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH99	Chip	4 ft	David Lee Mine (fig. 2, 3). Contact of granodiorite and rhyodacite dike(?) with "visible copper-oxide minerals". Sample from 1980-81 RARE II study (no. 23 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH100	Chip	4 ft	Pit (dimensions not known) above David Lee Mine (fig. 2) exposes rhyodacite with unidentified iron-oxide stain and "visible copper-oxide minerals". Sample from 1980-81 RARE II study (no. 22 in McColly and Scott, 1982); pulp re-assayed in 1992.

Number	Type	Length	Description
WH101	Chip	1 ft	Adit (fig. 2), 40-ft-long, trending N. 45° W., through fractured and sheared(?) limestone. Trace pyrite in the sampled strata-bound shear(?), oriented N. 45° W., SW. 13°. Sample from 1980-81 RARE II study (no. 21 in McColly and Scott, 1982); pulp re-assayed in 1992. Extent of the fracture, dump size, not known.
WH102	Select	n/a	Shaft (fig. 2), 30-ft- to 40-ft-deep in limestone. Sampled rock with moderate-to-strong, unidentified iron-oxides and minor copper oxides. Sample from 1980-81 RARE II study (no. 20 in McColly and Scott, 1982); pulp re-assayed in 1992. Extent of mineral zone, dump size not known.
WH103	Chip	9 ft	Copper Plate Mine (pl. 1). Open cut in Bisbee Group sandstone with "visible copper oxides". Sampled perpendicular to bedding. Sample from 1980-81 RARE II study (no. 40 in McColly and Scott, 1982); pulp re-assayed in 1992. Extent of mineral zone, dump size not known.
WH104	Grab	n/a	Pit (pl. 1), dimensions not known. Exposes carbonaceous shale. Sample from dump. Sample from 1980-81 RARE II study (no. 41 in McColly and Scott, 1982); pulp re-assayed in 1992.
WH105	Select	n/a	Fault (N. 70° E., NW. 75° to 85°) in limestone where excavated by 20-ft-deep shaft (pl. 1). Calcite fissure filling, 3-ft-wide, very vuggy, with heavy limonitic stain. No silica. Selected vuggy calcite from dump representative of the fault zone because rock not accessible in place. Limestone is red around the fault contact. Structural continuity: fault cut off 20 ft NE. of shaft by a horizontal fault, but continues 100 ft to SW. Dump size negligible.

APPENDIX B.

ASSAYS OF RECONNAISSANCE ROCK-CHIP SAMPLES FROM WHETSTONE MOUNTAINS UNIT, BY BONDAR-CLEGG AND CO., LTD. USING THE NEUTRON ACTIVATION METHOD

Element	Detection limit [lower/upper (if applicable)]
Ag (silver)	5 ppm/ -
As (arsenic)	1 ppm/ -
Au (gold)	5 ppb/ -
Ba (barium)	100 ppm/ -
Br (bromine)	1 ppm/ -
Cd (cadmium)	10 ppm/ -
Ce (cerium)	10 ppm/ -
Co (cobalt)	10 ppm/ -
Cr (chromium)	50 ppm/ -
Cs (cesium)	1 ppm/ -
Eu (europium)	2 ppm/ -
Fe (iron)	0.5%/ -
Hf (hafnium)	2 ppm/ -
Ir (iridium)	100 ppb/ -
La (lanthanum)	5 ppm/ -
Lu (lutetium)	0.5 ppm/ -
Mo (molybdenum)	2 ppm/ -
Na (sodium)	0.05%/ -
Ni (nickel)	20 ppm/ -
Rb (rubidium)	10 ppm/ -
Sb (antimony)	0.2 ppm/ -
Sc (scandium)	0.5 ppm/ -
Se (selenium)	10 ppm/ -
Sm (samarium)	0.2 ppm/ -
Sn (tin)	200 ppm/ -
Ta (tantalum)	1 ppm/ -
Tb (terbium)	1 ppm/ -
Te (tellurium)	20 ppm/ -
Th (thorium)	0.5 ppm/ -
U (uranium)	0.5 ppm/ -
W (tungsten)	2 ppm/ -
Yb (ytterbium)	5 ppm/ -
Zn (zinc)	200 ppm/30,000 ppm
Zr (zirconium)	500 ppm

Appendix B.-- Assays of reconnaissance rock-chip samples by Bondar-Clegg and Co., Ltd., using neutron activation method (Whetstone Mountains Unit).
(EXCLUSIVE OF GYPSUM SAMPLES)

[<, less than; >, greater than; *, less than this amount (the lower detection limit was elevated by interference from other elements present in the sample). Note: a transfer of land ownership that took place after this study was completed and after this manuscript was written resulted in loss of USBM permission to publish information concerning 3 samples that were collected (WH11-13). Therefore, all information on those 3 samples, including assays and locations, has been withheld.]

Sample No.	Ag (Ppm)	As (Ppm)	Au (Ppb)	Ba (Ppm)	Br (Ppm)	Cd (Ppm)	Ce (Ppm)	Co (Ppm)	Cr (Ppm)	Cs (Ppm)	Eu (Ppm)	Fe (Pct)	Hf (Ppm)	Ir (Ppb)	La (Ppm)	Lu (Ppm)	Mo (Ppm)	Na (Pct)	Ni (Ppm)	Rb (Ppm)	Sb (Ppm)	Sc (Ppm)	Se (Ppm)	Sm (Ppm)	Sn (Ppm)	Ta (Ppm)	Tb (Ppm)	Te (Ppm)	Th (Ppm)	U (Ppm)	W (Ppm)	Yb (Ppm)	Zn (Ppm)	Zr (Ppm)
WH001	< 5	8	< 5	270	2	< 10	59	< 10	220	22	< 2	1.4	< 2	< 100	23	< 0.5	2	0.11	< 20	420	0.6	7.2	< 10	4.9	< 200	3	< 1	< 20	10.0	11.0	6	5	< 200	< 500
WH002	< 5	78	811	* 2100	< 1	< 10	* 80	< 10	< 50	8	< 2	2.6	< 2	< 100	28	< 0.5	2700	< 0.05	< 20	170	13.0	2.7	< 10	* 17.0	< 200	1	1	* 100	5.4	701.0	5	< 5	700	< 500
WH003	< 5	4	200	< 100	< 1	< 10	16	< 10	400	8	< 2	1.2	< 2	< 100	10	< 0.5	< 2	< 0.05	< 20	280	2.4	3.6	< 10	2.1	< 200	1	< 1	< 20	4.4	5.4	4	< 5	< 200	< 500
WH004	< 5	3	< 5	< 100	< 1	< 10	< 10	< 10	520	< 1	< 2	0.9	< 2	< 100	< 5	< 0.5	3	< 0.05	< 20	15	1.2	< 0.5	< 10	< 0.2	< 200	< 1	< 1	< 20	< 0.5	1.4	< 2	< 5	< 200	< 500
WH005	< 5	37	6	< 100	2	< 10	16	< 10	410	2	< 2	2.4	< 2	< 100	< 5	< 0.5	3	< 0.05	< 20	47	14.0	0.8	< 10	* 1.1	< 200	< 1	< 1	< 20	0.9	40.0	< 2	< 5	< 200	< 500
WH006	< 5	8	< 5	< 100	< 1	< 10	11	< 10	450	1	< 2	0.9	< 2	< 100	< 5	< 0.5	3	< 0.05	< 20	78	6.7	1.1	< 10	0.6	< 200	< 1	< 1	< 20	2.1	4.6	< 2	< 5	< 200	< 500
WH007	< 5	2	< 5	< 100	< 1	< 10	< 10	< 10	490	1	< 2	0.8	< 2	< 100	< 5	< 0.5	< 2	< 0.05	< 20	57	0.8	0.9	< 10	0.5	< 200	< 1	< 1	< 20	1.3	1.0	< 2	< 5	< 200	< 500
WH008	< 5	2	< 5	< 100	< 1	< 10	< 10	< 10	460	2	< 2	0.9	< 2	< 100	< 5	< 0.5	< 2	< 0.05	< 20	70	0.5	0.8	< 10	0.5	< 200	< 1	< 1	< 20	1.4	0.6	< 2	< 5	< 200	< 500
WH009	< 5	7	78	* 900	< 1	< 10	110	< 10	< 50	53	< 2	2.0	2	< 100	42	< 0.5	100	0.46	< 20	450	1.2	12.0	< 10	* 8.9	< 200	3	2	* 48	17.0	287.0	< 2	< 5	< 200	< 500
WH010	< 5	2	< 5	380	< 1	< 10	90	< 10	320	20	< 2	1.8	4	< 100	30	0.6	< 2	1.20	< 20	450	0.9	10.0	< 10	7.9	< 200	2	1	< 20	17.0	6.8	4	8	250	< 500
WH011																	DATA WITHHELD																	
WH012																	DATA WITHHELD																	
WH013																	DATA WITHHELD																	
WH014	< 5	17	< 5	< 100	4	< 10	38	< 10	340	4	< 2	1.0	< 2	< 100	15	< 0.5	< 2	< 0.05	< 20	160	64.0	3.9	< 10	3.4	< 200	< 1	< 1	< 20	6.4	6.0	< 2	6	< 200	< 500
WH015	< 5	109	* 24	< 100	* 20	* 27	* 65	15	270	< 1	* 5	1.2	* 6	< 100	12	1.3	* 8	< 0.05	* 60	* 38	638.0	1.5	* 35	2.0	* 1400	< 1	< 1	* 100	* 3.0	28.0	4	23	< 200	< 500
WH016	< 5	26	< 5	180	5	< 10	44	< 10	330	6	< 2	1.1	3	< 100	19	0.6	< 2	< 0.05	< 20	190	64.2	5.7	< 10	4.7	< 200	1	< 1	< 20	8.9	6.3	3	6	< 200	< 500
WH017	< 5	68	< 5	< 100	6	< 10	< 10	< 10	530	2	< 2	1.0	< 2	< 100	< 5	< 0.5	3	< 0.05	< 20	44	79.6	1.3	< 10	0.8	< 200	< 1	< 1	< 20	1.1	3.8	< 2	< 5	< 200	< 500
WH018	6	45	79	2800	5	< 10	43	57	170	16	2	2.8	< 2	< 100	17	< 0.5	16	0.08	< 50	95	19.0	10.0	< 10	9.2	< 200	< 1	2	< 20	8.7	14.0	39	5	350	< 500
WH019	< 5	9	< 5	< 100	< 1	< 10	22	< 10	< 50	3	< 2	1.5	< 2	< 100	6	< 0.5	< 2	< 0.05	< 20	46	5.6	1.6	< 10	1.3	< 200	< 1	< 1	< 20	1.5	1.0	14	< 5	< 200	< 500
WH020	< 5	2	< 5	< 100	< 1	< 10	10	< 10	210	< 1	< 2	0.5	< 2	< 100	< 5	< 0.5	4	< 0.05	< 50	17	1.9	0.6	< 10	0.5	< 200	< 1	< 1	< 20	0.8	0.6	5	< 5	< 200	< 500
WH021	< 5	4	< 5	130	< 1	< 10	29	< 10	220	4	< 2	0.6	< 2	< 100	13	< 0.5	2	< 0.05	< 50	110	1.3	3.7	< 10	2.7	< 200	< 1	< 1	< 20	4.6	1.7	9	< 5	< 200	< 500
WH022	< 5	2	< 5	< 100	< 1	< 10	10	< 10	< 50	1	< 2	1.2	< 2	< 100	< 5	< 0.5	< 2	< 0.05	< 20	30	0.8	1.0	< 10	0.6	< 200	< 1	< 1	< 20	1.0	< 0.5	2	< 5	< 200	< 500
WH023	< 5	16	11	< 640	< 1	< 10	* 24	24	210	17	< 2	5.2	< 2	< 100	10	* 3.1	* 7	0.07	55	540	4.3	18.0	< 10	* 5.9	* 350	2	< 1	< 20	2.7	217.0	19	< 5	280	< 500
WH024	< 5	12	13	* 630	< 1	< 10	57	39	230	21	< 2	7.8	< 2	< 100	15	< 0.5	27	0.12	77	600	5.5	37.0	< 10	* 5.4	< 200	< 1	< 1	* 41	1.3	198.0	33	< 5	550	< 500
WH025	< 5	1	< 5	< 100	2	< 10	14	< 10	380	13	< 2	1.1	< 2	< 100	7	< 0.5	< 2	0.24	< 20	350	1.0	3.9	< 10	1.1	< 200	2	< 1	< 20	1.1	3.0	4	< 5	< 200	< 500
WH026	< 5	13	< 5	190	< 1	< 10	21	43	200	21	< 2	7.5	< 2	< 100	17	< 0.5	< 2	0.09	57	830	5.9	29.0	< 10	5.4	< 200	< 1	< 1	< 20	2.1	16.0	19	< 5	330	< 500
WH027	< 5	3	< 5	< 100	< 1	< 10	31	30	110	37	< 2	7.7	3	< 100	15	< 0.5	< 2	0.27	< 20	840	2.1	32.0	< 10	3.3	< 200	1	< 1	< 20	2.4	18.0	32	< 5	320	< 500
WH028	< 5	3	< 5	< 100	1	< 10	< 10	< 10	350	10	< 2	1.0	< 2	< 100	< 5	< 0.5	11	0.50	< 20	200	2.5	2.1	< 10	0.4	< 200	4	< 1	< 20	0.6	4.5	87	< 5	< 200	< 500
WH029	< 5	2	< 5	< 100	1	< 10	< 10	< 10	500	8	< 2	0.9	< 2	< 100	< 5	< 0.5	14	< 0.05	< 20	120	2.8	0.7	< 10	< 0.2	< 200	14	< 1	< 20	0.8	7.3	75	< 5	< 200	< 500
WH030	< 5	2	< 5	< 100	< 1	< 10	< 10	< 10	490	10	< 2	0.6	< 2	< 100	< 5	< 0.5	33	0.16	< 20	140	1.5	0.7	< 10	< 0.2	< 200	11	< 1	< 20	< 0.5	3.6	217	< 5	< 200	< 500
WH031	< 5	< 1	< 5	< 100	3	< 10	< 10	< 10	580	7	< 2	1.0	< 2	< 100	< 5	< 0.5	9	< 0.05	< 20	210	0.7	1.6	< 10	< 0.2	< 200	2	< 1	< 20	0.5	4.6	12	< 5	< 200	< 500
WH032	< 5	< 1	< 5	< 100	< 1	< 10	< 10	< 10	580	9	< 2	1.0	< 2	< 100	< 5	< 0.5	3	< 0.05	< 20	210	0.7	1.5	< 10	0.4	< 200	1	< 1	< 20	2.0	1.1	6	< 5	< 200	< 500
WH033	< 5	2	< 5	< 100	4	< 10	< 10	< 10	480	5	< 2	0.8	< 2	< 100	< 5	< 0.5	< 2	< 0.05	< 20	100	2.7	0.6	< 10	0.4	< 200	< 1	< 1	< 20	0.7	1.5	14	< 5	< 200	< 500
WH034	< 5	2	< 5	< 100	1	< 10	< 10	< 10	480	28	< 2	0.9	< 2	< 100	< 5	< 0.5	3	0.23	< 20	520	1.0	3.5	< 10	0.5	< 200	5	< 1	< 20	1.5	3.5	7	< 5	< 200	< 500
WH035	< 5	< 1	< 5	< 100	< 1	< 10	< 10	< 10	620	4	< 2	0.8	< 2	< 100	< 5	< 0.5	54	< 0.05	< 20	77	0.6	< 0.5	< 10	0.3	< 200	1	< 1	< 20	< 0.5	0.5	4	< 5	< 200	< 500
WH036	< 5	< 1	6	< 100	< 1	< 10	< 10	< 10	490	8	< 2	0.8	< 2	< 100	< 5	< 0.5	8	< 0.05	< 20	200	1.0	0.7	< 10	< 0.2	< 200	2	< 1	< 20	< 0.5	2.7	6	< 5	< 200	< 500
WH037	< 5	< 1	10	< 100	< 1	< 10	< 10	< 10	530	6	< 2	0.7	< 2	< 100	< 5	< 0.5	170	< 0.05	< 20	61	0.5	< 0.5	< 10	< 0.2	< 200	1	< 1	< 20	< 0.5	1.7	4	< 5	< 200	< 500

Appendix B.--Whetstone Mountains Unit--Contin.

Sample No.	Ag (Ppm)	As (Ppm)	Au (Ppb)	Ba (Ppm)	Br (Ppm)	Cd (Ppm)	Ce (Ppm)	Co (Ppm)	Cr (Ppm)	Cs (Ppm)	Eu (Ppm)	Fe (Pct)	Hf (Ppm)	Ir (Ppb)	La (Ppm)	Lu (Ppm)	Mo (Ppm)	Na (Pct)	Ni (Ppm)	Rb (Ppm)	Sb (Ppm)	Sc (Ppm)	Se (Ppm)	Sm (Ppm)	Sn (Ppm)	Ta (Ppm)	Tb (Ppm)	Te (Ppm)	Th (Ppm)	U (Ppm)	W (Ppm)	Yb (Ppm)	Zn (Ppm)	Zr (Ppm)
WH038	< 5	1	< 5	< 100	< 1	< 10	< 10	< 10	470	25	< 2	0.8	< 2	< 100	< 5	< 0.5	237	< 0.05	< 20	170	1.4	1.1	< 10	< 0.2	< 200	3	< 1	< 20	< 0.5	12.0	14	< 5	< 200	< 500
WH039	< 5	< 1	< 5	< 100	< 1	< 10	< 10	< 10	530	7	< 2	0.7	< 2	< 100	< 5	< 0.5	69	< 0.05	< 20	45	1.0	< 0.5	< 10	< 0.2	< 200	< 1	< 1	< 20	< 0.5	2.0	6	< 5	< 200	< 500
WH040	< 5	1	< 5	< 100	< 1	< 10	< 10	< 10	560	9	< 2	0.8	< 2	< 100	< 5	< 0.5	53	< 0.05	< 20	38	1.2	< 0.5	< 10	< 0.2	< 200	< 1	< 1	< 20	< 0.5	1.0	8	< 5	< 200	< 500
WH041	< 5	1	< 5	< 100	< 1	< 10	< 10	< 10	500	5	< 2	0.7	< 2	< 100	< 5	< 0.5	26	< 0.05	< 20	36	0.7	< 0.5	< 10	< 0.2	< 200	< 1	< 1	< 20	< 0.5	3.3	4	< 5	< 200	< 500
WH042	< 5	2	< 5	< 100	2	< 10	< 10	< 10	540	5	< 2	0.7	< 2	< 100	< 5	< 0.5	36	< 0.05	< 20	29	4.5	< 0.5	< 10	< 0.2	< 200	2	< 1	< 20	< 0.5	1.4	21	< 5	< 200	< 500
WH043	< 5	1	< 5	< 100	< 1	< 10	< 10	< 10	680	7	< 2	0.9	< 2	< 100	< 5	< 0.5	35	< 0.05	< 20	62	1.1	< 0.5	< 10	< 0.2	< 200	2	< 1	< 20	< 0.5	1.3	190	< 5	< 200	< 500
WH044	< 5	1	< 5	< 100	< 1	< 10	10	< 10	200	38	< 2	< 0.5	< 2	< 100	< 5	< 0.5	41	0.24	< 50	580	1.3	5.5	< 10	0.8	< 200	7	< 1	< 20	1.8	3.1	19	< 5	< 200	< 500
WH045	< 5	2	< 5	< 100	1	< 10	< 10	< 10	540	3	< 2	1.3	< 2	< 100	< 5	< 0.5	217	0.05	34	31	1.5	< 0.5	< 10	< 0.2	< 200	< 1	< 1	< 20	< 0.5	0.9	5	< 5	< 200	< 500
WH046	< 5	< 1	< 5	< 100	< 1	< 10	< 10	< 10	610	7	< 2	0.8	< 2	< 100	< 5	< 0.5	100	< 0.05	< 20	66	0.7	0.5	< 10	< 0.2	< 200	1	< 1	< 20	< 0.5	< 0.5	7	< 5	< 200	< 500
WH047	< 5	< 1	< 5	< 100	< 1	< 10	< 10	< 10	590	2	< 2	0.8	< 2	< 100	< 5	< 0.5	120	< 0.05	< 20	26	0.7	< 0.5	< 10	< 0.2	< 200	2	< 1	< 20	< 0.5	5.4	23	< 5	< 200	< 500
WH048	< 5	< 1	14	< 100	2	< 10	< 10	< 10	660	8	< 2	0.9	21	< 100	< 5	< 0.5	83	0.09	< 20	170	< 0.2	1.4	< 10	< 0.2	< 200	8	< 1	< 20	< 0.5	10.0	1170	< 5	< 200	< 500
WH049	< 5	< 1	< 5	< 100	< 1	< 10	< 10	< 10	610	5	< 2	0.7	< 2	< 100	< 5	< 0.5	19	< 0.05	< 20	46	0.5	< 0.5	< 10	< 0.2	< 200	1	< 1	< 20	< 0.5	0.9	49	< 5	< 200	< 500
WH050	< 5	< 1	< 5	< 100	< 1	< 10	< 10	< 10	500	11	< 2	1.0	< 2	< 100	< 5	< 0.5	< 2	< 0.05	< 20	150	0.4	1.2	< 10	0.5	< 200	< 1	< 1	< 20	1.1	0.7	2	< 5	< 200	< 500
WH051	< 5	< 1	< 5	< 100	< 1	< 10	< 10	< 10	560	5	< 2	0.9	< 2	< 100	< 5	< 0.5	< 2	< 0.05	< 20	93	0.3	0.8	< 10	0.4	< 200	< 1	< 1	< 20	1.5	< 0.5	< 2	< 5	< 200	< 500
WH052	< 5	24	45	350	< 1	< 10	21	< 10	170	13	< 2	0.9	< 2	< 100	10	< 0.5	150	< 0.05	< 50	110	4.3	2.6	< 10	1.7	< 200	< 1	< 1	< 20	2.4	1.3	6	< 5	< 200	< 500
WH053	< 5	20	22	300	< 1	< 10	58	13	< 50	21	< 2	3.1	< 2	< 100	27	0.6	< 2	0.08	< 20	210	3.1	8.2	< 10	5.7	< 200	< 1	< 1	< 20	7.6	2.0	18	< 5	< 200	< 500
WH054	< 5	17	< 5	180	< 1	< 10	64	11	< 50	21	< 2	2.3	2	< 100	32	< 0.5	< 2	0.06	< 20	150	3.0	7.1	< 10	5.8	< 200	< 1	< 1	< 20	7.2	2.3	18	< 5	< 200	< 500
WH055	< 5	13	< 5	390	< 1	< 10	73	< 10	57	12	< 2	2.6	4	< 100	29	< 0.5	< 2	0.12	< 20	180	2.3	8.3	< 10	5.9	< 200	< 1	< 1	< 20	8.4	2.5	22	< 5	< 200	< 500
WH070	< 5	12	< 5	210	< 1	< 10	42	< 10	99	15	< 2	2.1	3	< 100	19	< 0.5	< 2	0.11	< 20	86	1.7	5.6	< 10	2.9	< 200	< 1	< 1	< 20	4.6	1.0	2	< 5	< 200	< 500
WH077	< 5	2	< 5	820	1	< 10	83	< 10	< 50	33	< 2	4.7	5	< 100	34	< 0.5	10	3.80	< 20	150	0.6	7.1	< 10	4.7	< 200	< 1	< 1	< 20	4.8	3.5	51	< 5	< 200	< 500
WH078	< 5	2	7	960	1	< 10	85	25	< 50	7	< 2	7.2	7	< 100	37	< 0.5	50	3.80	< 20	150	0.4	14.0	< 10	5.7	< 200	< 1	< 1	< 20	7.5	5.3	7	< 5	< 200	< 500
WH079	12	24	320	930	1	< 10	84	11	57	15	< 2	4.8	10	< 100	26	< 0.5	31	3.60	< 20	250	1.6	6.3	22	3.1	< 200	< 1	< 1	< 20	4.9	2.2	110	< 5	< 200	< 500
WH080	< 5	1430	200	490	* 20	< 10	56	< 10	78	20	< 2	4.1	< 2	< 100	17	< 0.5	25	0.07	42	38	52.3	3.2	< 10	2.2	< 200	< 1	< 1	* 42	5.7	6.4	16	* 7	250	< 500
WH081	< 5	5	< 5	3000	1	< 10	100	10	78	23	< 2	4.3	8	< 100	45	0.5	7	1.90	< 20	110	1.0	10.0	< 10	6.5	< 200	1	< 1	< 20	12.0	3.4	4	< 5	< 200	< 500
WH082	7	26	52	490	5	72	44	25	< 50	10	< 2	7.7	6	< 100	13	< 0.5	11	0.31	< 20	99	30.3	4.0	< 10	3.0	< 200	< 1	< 1	< 20	5.6	5.7	271	< 5	3800	< 500
WH083	5	14	42	380	2	< 10	10	47	< 50	6	< 2	20.0	3	< 100	17	< 0.5	8	1.10	< 50	59	5.3	4.8	< 10	3.2	< 200	< 1	< 1	< 20	4.1	4.8	170	< 5	800	< 500
WH084	< 5	263	< 5	1100	13	< 10	72	< 10	< 50	14	4	>10.0	< 2	< 100	34	< 0.5	65	0.16	< 20	28	52.4	3.8	< 10	3.8	< 200	< 1	< 1	< 20	7.7	6.9	26	< 5	510	< 500
WH085	< 5	10	6	1100	< 1	21	40	15	190	15	< 2	3.4	4	< 100	24	< 0.5	71	1.60	< 20	290	4.7	5.4	< 10	3.0	< 200	< 1	< 1	< 20	12.0	7.8	27	< 5	1600	< 500
WH086	< 5	18	10	1100	2	< 10	62	15	< 50	14	2	3.8	5	< 100	27	< 0.5	< 2	3.80	< 20	210	19.0	6.6	< 10	3.5	< 200	1	< 1	< 20	9.3	3.6	2	< 5	< 200	< 500
WH087	* 14	712	* 56	* 690	* 104	* 66	* 100	* 46	* 220	44	* 9	3.4	< 9	* 260	30	* 1.7	* 18	* 0.38	* 89	* 180	1440.0	13.0	* 52	4.9	* 2000	2	< 1	* 260	7.2	3.4	73	* 27	540	< 1400
WH088	< 5	5	12	1100	< 1	< 10	49	< 10	110	14	< 2	2.2	3	< 100	26	< 0.5	9	2.30	< 50	170	4.1	5.3	< 10	3.2	< 200	1	< 1	< 20	11.0	3.0	35	< 5	260	< 500
WH089	< 5	194	< 5	490	10	< 10	26	< 10	< 50	11	< 2	4.6	3	< 100	20	< 0.5	6	0.16	< 50	100	95.2	4.1	< 10	2.7	< 200	< 1	< 1	< 20	6.7	3.2	18	5	< 200	< 500
WH090	10	85	77	1200	4	< 10	58	15	< 50	16	< 2	3.7	4	< 100	26	< 0.5	206	0.26	< 20	310	36.3	5.6	59	2.7	< 200	< 1	< 1	< 20	11.0	6.6	42	< 5	900	< 500
WH091	< 5	34	34	1000	3	< 10	58	17	< 50	15	< 2	3.7	4	< 100	25	< 0.5	27	2.60	< 20	260	24.5	5.8	< 10	2.7	< 200	1	< 1	< 20	13.0	4.6	34	< 5	320	< 500
WH092	< 5	30	55	980	4	< 10	57	14	< 50	16	2	3.5	5	< 100	27	< 0.5	45	2.20	< 20	290	32.0	6.0	< 10	2.9	< 200	1	< 1	< 20	12.0	6.3	47	< 5	240	< 500
WH093	< 5	108	49	1300	13	< 10	60	11	< 50	30	< 2	3.6	3	< 100	25	< 0.5	41	0.11	< 20	300	138.0	5.1	< 10	1.7	< 200	< 1	< 1	< 20	11.0	24.0	32	< 5	260	< 500
WH094	31	95	110	240	12	< 10	29	< 10	< 50	15	< 2	3.8	2	< 100	19	< 0.5	150	0.07	< 20	120	110.0	2.8	< 10	1.6	< 200	< 1	< 1	< 20	6.9	5.8	38	< 5	< 200	< 500
WH095	8	106	85	500	16	< 10	59	< 10	< 50	34	< 2	6.8	< 2	< 100	34	< 0.5	235	0.13	< 20	120	160.0	4.1	< 10	1.5	< 200	< 1	< 1	< 20	7.5	15.0	33	< 5	< 200	< 500
WH096	6	11	29	620	1	< 10	10	< 10	100	10	< 2	2.3	< 2	< 100	19	< 0.5	160	0.92	< 50	150	14.0	3.3	< 10	2.0	< 200	< 1	< 1	< 20	10.0	14.0	36	< 5	640	< 500
WH097	< 5	251	* 14	< 100	* 33	1000	* 25	< 10	< 50	4	< 2	1.4	< 2	< 100	< 5	0.7	18	< 0.05	< 20	46	395.0	1.3	< 10	0.8	* 520	< 1	< 1	* 61	< 0.5	2.1	12	* 10	>30000	< 500
WH098	< 5	1440	41	< 100	* 19	42	24	21	< 50	2	< 2	3.7	2	< 100	16	< 0.5	3	< 0.05	< 20	< 10	38.0	7.8	< 10	2.7	< 200	< 1	< 1	< 20	6.4	6.8	33	* 6	2300	< 500
WH099	9	3460	* 30	< 100	* 56	23	81	49	< 50	* 2	< 2	3.5	< 2	< 100	42	0.5	< 2	< 0.05	< 20	* 24	181.0	7.4	< 10	5.6	* 520	< 1	< 1	* 64	12.0	10.0	50	* 12	1700	< 500
WH100	< 5	2190	* 11	240	* 35	15	41	18	< 50	4	< 2	4.5	4	< 100	20	< 0.5	8	0.06	< 20	23	128.0	8.1	< 10	3.8	< 200	< 1	< 1	* 48	9.2	5.2	66	* 9	1000	< 500
WH101	< 5	951	< 5	2000	15	< 10	98	< 10	< 50	36	< 2	4.1	8	< 100	42	1.0	3	0.41	< 20	220	52.2	15.0	< 10	5.1	< 200	1	< 1	< 20	11.0	4.9	17	10	330	650
WH102	79	3240	* 18	830	* 66	66	* 49	< 10	< 50	* 3	< 2	4.0	< 2	< 100	20	< 0.5	16	0.17	< 20	* 41	333.0	3.4	< 10	1.7	* 630	< 1	< 1	* 110	2.4	< 0.5	* 5	* 18	1500	< 500
WH103	24	17	< 5	1300	< 1	< 10	61	20	< 50	2	< 2	1.4	7	< 100	27	< 0.5	2	0.35	< 20	94	1.2	5.3	< 10	3.6	< 200	< 1	< 1	< 20	6.6	8.8	< 2	< 5	< 200	< 500
WH104	13	24	< 5	470	1	< 10	120	13	68	11	2	5.6	7	< 100	56	< 0.5	7	0.52	< 20	200	1.9	18.0	< 10	8.0	< 200	2	1	< 20	17.0	12.0	5	6	270	< 500
WH105	< 5	40	< 5	< 100	2	< 10	< 10	< 10	< 50	2	< 2	1.0	< 2	< 100	6	< 0.5	< 2	< 0.05	< 20	< 10	12.0	1.7	< 10	1.4	< 200	< 1	< 1	< 20	1.1	0.9	15	< 5	< 200	< 500

APPENDIX C.

ASSAYS OF RECONNAISSANCE ROCK-CHIP SAMPLES BY CHEMEX LABS, INC. USING THE INDUCTIVELY COUPLED PLASMA METHOD

Element	Detection limit [lower/upper (if applicable)]
Ag (silver)	0.2 ppm/200 ppm
Al (aluminum)	0.01%/15.00%
As (arsenic)	2 ppm/10,000 ppm
Ba (barium)	10 ppm/10,000 ppm
Be (beryllium)	0.5 ppm/100.0 ppm
Bi (bismuth)	2 ppm/10,000 ppm
Ca (calcium)	0.01%/15.00%
Cd (cadmium)	0.5 ppm/100 ppm
Co (cobalt)	1 ppm/10,000 ppm
Cr (chromium)	1 ppm/10,000 ppm
Cu (copper)	1 ppm/10,000 ppm
Fe (iron)	0.01%/15.00%
Ga (gallium)	10 ppm/10,000 ppm
Hg (mercury)	1 ppm/10,000 ppm
K (potassium)	0.01%/10.00%
La (lanthanum)	10 ppm/10,000 ppm
Mg (magnesium)	0.01%/15.00%
Mn (manganese)	5 ppm/10,000 ppm
Mo (molybdenum)	1 ppm/10,000 ppm
Na (sodium)	0.01%/5.00%
Ni (nickel)	1 ppm/10,000 ppm
P (phosphorus)	10 ppm/10,000 ppm
Pb (lead)	2 ppm/10,000 ppm
Sb (antimony)	2 ppm/10,000 ppm
Sc (scandium)	1 ppm/10,000 ppm
Sr (strontium)	1 ppm/10,000 ppm
Ti (titanium)	0.01%/5.00%
Tl (thallium)	10 ppm/10,000 ppm
U (uranium)	10 ppm/10,000 ppm
V (vanadium)	1 ppm/10,000 ppm
W (tungsten)	10 ppm/10,000 ppm
Zn (zinc)	2 ppm/10,000 ppm

Appendix C.--Assays of reconnaissance rock-chip samples by Chemex Labs, Inc., using inductively coupled plasma-atomic emission spectroscopy method (Whetstone Mountains Unit).

(EXCLUSIVE OF GYPSUM SAMPLES)

[<, less than; >, greater than; *, less than this amount (the lower detection limit was elevated by interference from other elements in the sample).
Note: a transfer of land ownership that took place after this study was completed and after this manuscript was written resulted in loss of USBM permission to publish information concerning 3 samples that were collected (WH11-13). Therefore, all information on those 3 samples, including assays and locations, has been withheld.]

Sample No.	Ag (Ppm)	Al (Pct)	As (Ppm)	Ba (Ppm)	Be (Ppm)	Bi (Ppm)	Ca (Pct)	Cd (Ppm)	Co (Ppm)	Cr (Ppm)	Cu (Ppm)	Fe (Pct)	Ga (Ppm)	Hg (Ppm)	K (Pct)	La (Ppm)	Mg (Pct)	Mn (Ppm)	Mo (Ppm)	Na (Pct)	Ni (Ppm)	P (Ppm)	Pb (Ppm)	Sb (Ppm)	Sc (Ppm)	Sr (Ppm)	Ti (Pct)	Tl (Ppm)	U (Ppm)	V (Ppm)	W (Ppm)	Zn (Ppm)
WH001	< 0.2	0.81	14	20	2.0	< 2	1.84	< 0.5	3	142	57	1.16	< 10	1	0.32	20	0.48	335	2	0.02	8	470	18	< 2	1	16	<0.01	< 10	< 10	3	< 10	52
WH002	3.0	0.22	102	10	2.0	57	0.26	< 0.5	< 1	< 1	130	1.99	30	1	0.07	10	0.04	30	3019	0.02	< 1	5490	>10000	38	1	6	<0.01	20	610	27	30	476
WH003	0.2	0.38	< 2	< 10	0.5	< 2	0.04	< 0.5	1	285	20	0.87	< 10	< 1	0.26	10	0.02	60	2	0.02	6	200	224	< 2	< 1	3	<0.01	< 10	< 10	4	< 10	62
WH004	0.2	0.07	8	< 10	< 0.5	< 2	0.03	< 0.5	1	381	53	0.87	< 10	1	< 0.01	< 10	< 0.01	65	3	0.01	10	30	< 2	< 2	< 1	2	<0.01	< 10	< 10	2	< 10	4
WH005	0.8	0.22	42	10	1.5	118	0.44	< 0.5	2	337	7236	2.46	< 10	1	0.09	< 10	0.04	70	5	0.01	11	310	112	8	< 1	6	<0.01	< 10	30	4	< 10	62
WH006	< 0.2	0.19	10	30	< 0.5	< 2	0.07	< 0.5	1	308	40	0.77	< 10	< 1	0.09	< 10	0.01	70	1	0.01	8	110	18	2	< 1	13	<0.01	< 10	10	3	< 10	4
WH007	< 0.2	0.14	< 2	< 10	< 0.5	< 2	0.01	< 0.5	1	327	21	0.73	< 10	< 1	0.08	< 10	0.01	45	1	0.01	7	70	4	< 2	< 1	2	<0.01	< 10	< 10	1	< 10	2
WH008	< 0.2	0.12	4	< 10	< 0.5	< 2	0.01	< 0.5	1	336	15	0.75	< 10	< 1	0.06	< 10	< 0.01	75	1	0.01	8	70	< 2	< 2	< 1	1	<0.01	< 10	< 10	1	< 10	2
WH009	< 1.0	0.45	14	60	1.0	< 10	1.16	< 0.5	2	< 1	53	1.24	20	1	0.11	10	0.38	615	147	0.01	4	840	2360	< 2	2	16	<0.01	< 10	240	7	10	76
WH010	< 0.2	0.77	2	30	1.0	< 2	0.34	< 0.5	3	175	20	1.34	10	< 1	0.27	20	0.11	480	< 1	0.03	8	660	6	2	2	9	<0.01	< 10	< 10	7	< 10	30
WH011	DATA WITHHELD																															
WH012	DATA WITHHELD																															
WH013	DATA WITHHELD																															
WH014	< 0.2	0.41	10	30	< 0.5	16	0.06	< 0.5	1	220	43	0.73	< 10	< 1	0.26	< 10	0.03	85	1	0.01	6	210	82	34	1	8	<0.01	< 10	10	3	< 10	22
WH015	1.4	0.40	56	140	< 0.5	28	0.19	2.0	2	278	63	0.96	< 10	1	0.04	< 10	< 0.01	105	6	0.01	8	730	2860	368	< 1	47	<0.01	< 10	< 10	22	< 10	26
WH016	< 0.2	1.65	14	100	0.5	10	1.42	< 0.5	1	241	92	0.92	< 10	< 1	0.61	10	0.07	140	1	0.02	2	510	140	44	2	21	<0.01	< 10	< 10	8	< 10	52
WH017	0.2	0.83	54	20	< 0.5	22	8.70	< 0.5	2	428	84	0.77	< 10	< 1	0.25	< 10	0.03	205	2	0.15	7	60	62	74	1	6	<0.01	< 10	< 10	3	< 10	38
WH018	4.8	3.47	45	2930	7.5	< 2	0.03	1.0	47	141	205	2.71	10	1	0.38	10	0.29	>10000	15	0.04	16	980	512	5	9	19	0.02	< 10	< 10	43	20	228
WH019	< 1.0	0.14	10	90	0.5	< 10	1.67	1.0	< 1	< 1	94	1.06	20	< 1	0.03	< 10	0.95	695	< 1	0.01	7	30	110	< 2	< 1	10	<0.01	10	< 10	6	10	272
WH020	0.4	0.07	< 5	10	< 0.5	< 2	0.01	< 0.5	< 1	180	10	0.46	< 10	< 1	0.02	< 10	< 0.01	40	2	<0.01	5	< 10	74	5	< 1	1	<0.01	< 10	< 10	1	< 10	16
WH021	< 0.2	0.31	< 5	20	< 0.5	< 2	0.08	< 0.5	< 1	177	45	0.97	< 10	< 1	0.15	10	0.03	130	2	<0.01	4	150	58	5	< 1	3	<0.01	< 10	< 10	3	< 10	30
WH022	< 1.0	0.03	14	20	< 0.5	10	0.27	< 0.5	< 1	2	92	0.92	20	< 1	0.03	< 10	0.14	65	1	0.01	6	10	32	< 2	< 1	2	<0.01	< 10	< 10	2	< 10	44
WH023	1.0	2.33	16	110	4.5	4	0.31	< 0.5	22	120	47	4.32	10	< 1	0.59	10	0.84	815	6	0.02	37	1160	96	2	8	10	<0.01	< 10	210	56	10	212
WH024	< 1.0	2.96	22	90	3.0	< 10	0.41	< 0.5	28	97	236	5.30	10	2	0.41	< 10	1.19	945	21	0.02	53	1180	50	< 2	9	16	<0.01	< 10	190	68	20	250
WH025	0.4	0.45	< 2	< 10	0.5	2	0.03	< 0.5	2	241	7	0.88	< 10	< 1	0.28	< 10	0.03	110	2	0.02	6	140	22	< 2	< 1	2	<0.01	< 10	10	4	< 10	10
WH026	1.0	1.64	12	140	4.5	< 2	0.43	< 0.5	35	91	195	6.01	< 10	< 1	0.67	10	0.37	4765	2	0.02	48	1380	54	2	16	29	<0.01	< 10	20	46	20	208
WH027	< 1.0	1.17	2	50	5.0	< 10	5.95	< 0.5	19	23	105	4.70	< 10	< 1	0.58	10	0.32	3535	< 1	0.03	29	1320	26	10	14	39	<0.01	< 10	30	37	10	98
WH028	< 0.2	0.24	6	< 10	< 0.5	338	0.15	< 0.5	2	294	21	1.02	10	< 1	0.08	< 10	0.13	105	15	0.03	18	280	48	< 2	< 1	5	<0.01	< 10	< 10	2	50	4
WH029	0.2	0.15	6	10	< 0.5	50	0.02	< 0.5	1	301	14	0.78	< 10	< 1	0.07	< 10	< 0.01	55	17	0.01	7	100	32	2	< 1	2	<0.01	< 10	10	1	60	4
WH030	0.6	0.12	2	< 10	< 0.5	250	0.03	< 0.5	1	296	22	0.55	< 10	< 1	0.08	< 10	< 0.01	55	42	0.02	7	140	116	2	< 1	1	<0.01	< 10	< 10	1	210	12
WH031	0.2	0.16	6	< 10	< 0.5	348	0.02	< 0.5	< 1	313	8	0.63	< 10	< 1	0.11	< 10	< 0.01	60	11	0.02	9	100	34	2	< 1	1	<0.01	< 10	< 10	1	< 10	2
WH032	0.4	0.18	8	10	< 0.5	22	0.01	< 0.5	1	327	8	0.71	< 10	1	0.16	< 10	< 0.01	65	3	0.01	7	60	8	2	< 1	1	<0.01	< 10	10	2	< 10	2
WH033	< 0.2	0.13	2	< 10	< 0.5	20	0.02	< 0.5	< 1	278	10	0.65	< 10	1	0.10	< 10	0.01	60	3	0.02	9	40	8	< 2	< 1	2	<0.01	< 10	20	2	< 10	6
WH034	0.2	0.36	4	< 10	< 0.5	10	0.11	< 0.5	1	286	12	0.54	< 10	< 1	0.24	< 10	0.01	100	4	0.02	6	440	12	< 2	< 1	2	<0.01	< 10	< 10	1	< 10	6
WH035	3.0	0.09	12	< 10	< 0.5	74	0.10	< 0.5	1	383	11	0.70	< 10	1	0.04	< 10	< 0.01	85	63	0.02	7	390	38	< 2	< 1	1	<0.01	< 10	< 10	1	< 10	10
WH036	0.8	0.23	< 2	10	< 0.5	26	0.07	< 0.5	< 1	357	9	0.61	< 10	1	0.16	< 10	0.01	75	9	0.02	7	260	18	< 2	< 1	1	<0.01	< 10	20	2	< 10	2
WH037	2.2	0.10	4	< 10	< 0.5	522	0.06	< 0.5	1	411	17	0.68	< 10	1	0.02	< 10	< 0.01	40	222	0.02	7	70	290	2	< 1	1	<0.01	< 10	< 10	1	< 10	2
WH038	2.6	0.13	6	< 10	< 0.5	1070	0.03	< 0.5	< 1	302	18	0.62	< 10	< 1	0.09	< 10	< 0.01	50	311	0.01	8	150	436	2	< 1	1	<0.01	< 10	20	2	< 10	4

Appendix C.--Whetstone Mountains Unit--Contin.

Sample No.	Ag (Ppm)	Al (Pct)	As (Ppm)	Ba (Ppm)	Be (Ppm)	Bi (Ppm)	Ca (Pct)	Cd (Ppm)	Co (Ppm)	Cr (Ppm)	Cu (Ppm)	Fe (Pct)	Ga (Ppm)	Hg (Ppm)	K (Pct)	La (Ppm)
WH039	1.2	0.03	2	< 10	< 0.5	322	< 0.01	< 0.5	1	307	10	0.66	< 10	< 1	0.02	< 10
WH040	1.6	0.03	12	< 10	< 0.5	208	0.01	< 0.5	< 1	323	15	0.72	< 10	< 1	0.03	< 10
WH041	2.4	0.05	4	< 10	< 0.5	486	0.01	< 0.5	1	349	19	0.72	< 10	< 1	0.04	< 10
WH042	< 0.2	0.06	12	< 10	< 0.5	188	0.02	< 0.5	2	388	15	0.74	10	< 1	< 0.01	< 10
WH043	< 0.2	0.14	2	< 10	< 0.5	336	0.04	< 0.5	2	507	21	0.88	10	< 1	0.06	< 10
WH044	0.6	0.37	< 5	50	< 0.5	12	0.14	< 0.5	1	158	17	0.22	< 10	< 1	0.21	< 10
WH045	0.6	0.08	12	< 10	< 0.5	46	0.06	< 0.5	4	418	24	1.20	10	< 1	0.03	< 10
WH046	1.2	0.08	< 2	< 10	< 0.5	16	0.03	< 0.5	2	438	12	0.74	10	< 1	0.03	< 10
WH047	3.0	0.03	< 2	< 10	< 0.5	392	0.01	< 0.5	1	431	12	0.77	10	< 1	0.02	< 10
WH048	0.4	0.25	< 2	< 10	< 0.5	458	0.16	< 0.5	2	458	16	0.79	10	< 1	0.13	< 10
WH049	< 0.2	0.07	2	< 10	< 0.5	64	0.03	< 0.5	1	421	9	0.75	< 10	< 1	0.01	< 10
WH050	< 0.2	0.24	4	20	< 0.5	8	0.11	< 0.5	3	347	8	0.68	10	< 1	0.17	< 10
WH051	< 0.2	0.20	2	20	< 0.5	28	0.01	< 0.5	3	406	19	0.80	10	< 1	0.14	< 10
WH052	< 0.2	1.64	35	320	0.5	2	7.15	< 0.5	1	146	49	0.69	< 10	< 1	0.97	< 10
WH053	0.4	2.01	26	20	1.0	< 2	>15.00	< 0.5	9	32	18	2.53	< 10	< 1	0.32	< 10
WH054	0.4	1.43	30	30	1.0	< 2	>15.00	< 0.5	8	32	13	1.88	< 10	< 1	0.34	< 10
WH055	0.8	1.93	18	10	1.0	< 2	>15.00	< 0.5	9	45	11	2.16	< 10	< 1	0.16	< 10
WH070	< 1.0	1.08	< 2	60	< 0.5	< 10	>15.00	1.0	1	38	27	1.17	< 10	< 1	0.23	10
WH077	< 1.0	0.98	4	200	< 0.5	< 10	1.59	< 0.5	4	36	787	3.41	< 10	< 1	0.64	10
WH078	< 1.0	1.03	< 2	240	< 0.5	< 10	0.84	< 0.5	11	23	469	4.75	< 10	3	0.66	10
WH079	17.0	0.71	< 2	70	< 0.5	103	0.84	< 0.5	6	35	>10000	2.99	< 10	< 1	0.38	10
WH080	12.0	0.46	1474	430	< 0.5	200	3.09	4.5	7	39	>10000	2.82	< 10	1	0.09	< 10
WH081	< 1.0	3.12	< 2	290	< 0.5	< 10	1.99	< 0.5	6	54	173	2.87	< 10	< 1	0.17	20
WH082	5.0	1.45	38	270	< 0.5	21	3.87	72.0	12	13	8993	4.68	20	4	0.41	< 10
WH083	10.8	1.43	5	90	< 0.5	16	1.26	1.0	31	47	>10000	>15.00	10	< 1	0.08	20
WH084	1.0	0.69	272	860	< 0.5	< 10	0.68	3.5	2	2	771	12.61	30	< 1	0.07	10
WH085	6.4	1.07	14	230	< 0.5	14	2.14	17.0	14	131	4481	2.72	< 10	2	0.35	10
WH086	< 1.0	0.87	12	180	< 0.5	< 10	0.94	< 0.5	11	38	208	2.90	< 10	< 1	0.23	10
WH087	11.0	0.75	532	370	< 0.5	200	7.53	3.0	34	8	5578	2.89	20	64	0.17	10
WH088	2.0	0.95	10	150	< 0.5	10	0.54	1.0	9	112	1864	2.31	10	1	0.34	20
WH089	< 0.2	0.53	170	240	< 0.5	< 2	8.20	< 0.5	5	58	383	4.44	< 10	2	0.09	< 10
WH090	8.0	0.30	106	500	< 0.5	119	1.80	11.0	12	< 1	5577	2.89	20	6	0.18	10
WH091	3.0	0.93	40	200	< 0.5	11	0.51	1.0	7	23	5411	2.69	20	< 1	0.22	10
WH092	3.0	0.91	40	130	< 0.5	14	0.44	< 0.5	10	16	9346	2.80	20	< 1	0.23	10
WH093	6.0	0.26	90	510	< 0.5	10	3.13	0.5	13	< 1	5880	2.72	20	< 1	0.16	< 10
WH094	24.0	0.34	94	110	< 0.5	258	0.10	< 0.5	4	< 1	5471	2.92	20	1	0.09	10
WH095	7.0	0.38	82	150	< 0.5	184	0.30	< 0.5	6	8	>10000	5.60	20	1	0.10	20
WH096	9.8	1.11	10	290	< 0.5	190	0.67	6.5	14	110	8503	3.08	10	1	0.29	20
WH097	7.0	0.17	186	20	< 0.5	< 10	>15.00	>100.0	2	18	1256	1.46	< 10	< 1	0.04	< 10
WH098	1.0	0.50	1464	50	< 0.5	220	>15.00	17.0	12	7	2155	1.16	10	2	< 0.01	10
WH099	14.0	0.51	3784	60	< 0.5	226	5.81	41.0	41	1	5765	2.08	30	2	< 0.01	30
WH100	4.0	0.53	2418	60	< 0.5	192	1.80	7.0	18	2	5416	2.33	20	1	< 0.01	10
WH101	2.0	1.92	1002	750	< 0.5	< 10	14.04	5.0	3	15	80	2.47	< 10	< 1	0.32	20
WH102	91.0	0.27	3872	820	< 0.5	< 10	0.89	>100.0	3	11	804	2.53	< 10	< 1	0.12	< 10
WH103	20.0	1.02	20	160	< 0.5	< 10	0.17	< 0.5	13	< 1	7917	1.02	20	< 1	0.15	10
WH104	1.0	2.34	20	180	1.0	10	0.49	< 0.5	8	12	4635	3.84	20	< 1	0.26	< 10
WH105	< 0.2	0.14	44	10	< 0.5	< 2	>15.00	< 0.5	4	17	46	0.97	< 10	3	0.01	< 10

Sample No.	Mg (Pct)	Mn (Pct)	Mo (Ppm)	Na (Pct)	Ni (Ppm)	P (Ppm)	Pb (Ppm)	Sb (Ppm)	Sc (Ppm)	Sr (Ppm)	Ti (Pct)	Tl (Ppm)	U (Ppm)	V (Ppm)	W (Ppm)	Zn (Ppm)
WH039	< 0.01	40	86	0.01	9	40	194	< 2	< 1	1	<0.01	< 10	< 10	< 1	< 10	4
WH040	< 0.01	45	65	0.01	9	50	168	< 2	< 1	1	<0.01	< 10	10	1	< 10	4
WH041	< 0.01	65	37	0.02	8	70	190	2	< 1	1	<0.01	< 10	20	1	< 10	4
WH042	< 0.01	55	51	0.02	8	60	106	4	< 1	1	<0.01	< 10	< 10	< 1	< 10	2
WH043	< 0.01	65	48	0.02	10	110	106	2	< 1	1	<0.01	< 10	< 10	< 1	170	2
WH044	0.02	300	38	0.01	2	570	136	5	< 1	4	<0.01	< 10	< 10	< 1	< 10	20
WH045	0.09	100	285	0.02	17	100	26	6	< 1	2	<0.01	< 10	10	1	< 10	2
WH046	< 0.01	55	132	0.01	9	110	222	4	< 1	1	<0.01	< 10	< 10	2	< 10	4
WH047	< 0.01	55	176	<0.01	10	50	162	4	< 1	< 1	<0.01	< 10	10	2	10	2
WH048	< 0.01	365	117	0.01	10	670	118	2	1	2	<0.01	< 10	20	3	1330	4
WH049	< 0.01	65	24	<0.01	6	120	46	< 2	< 1	1	<0.01	< 10	< 10	1	30	2
WH050	0.02	55	2	0.02	6	60	< 2	2	< 1	2	<0.01	< 10	< 10	2	< 10	< 2
WH051	0.01	60	3	0.01	7	80	8	< 2	< 1	1	<0.01	< 10	< 10	2	< 10	2
WH052	0.12	85	125	0.03	7	70	50	5	2	26	0.01	< 10	< 10	42	< 10	28
WH053	1.28	465	< 1	0.02	22	160	10	10	6	133	<0.01	< 10	< 10	23	20	56
WH054	0.89	465	< 1	0.02	18	90	14	8	4	156	<0.01	< 10	< 10	19	20	44
WH055	0.95	420	< 1	0.02	15	170	4	6	7	121	0.03	< 10	< 10	29	20	46
WH070	0.42	125	< 1	0.02	16	480	36	6	3	165	0.02	< 10	< 10	24	10	40
WH077	0.93	695	9	0.06	11	1000	< 2	8	5	29	0.19	< 10	< 10	46	40	38
WH078	0.93	400	50	0.06	13	1110	< 2	2	2	44	0.33	< 10	< 10	128	20	44
WH079	0.62	345	33	0.03	16	800	2	2	3	11	0.15	< 10	< 10	38	100	20
WH080	0.27	805	27	0.02	11	400	60	30	2	35	<0.01	< 10	< 10	7	* 50	148
WH081	0.55	365	11	0.14	18	370	6	< 2	3	147	0.06	< 10	< 10	22	10	18
WH082	5.03	1105	9	0.03	11	290	380	14	1	65	0.04	< 10	< 10	25	170	3278
WH083	3.31	3570	5	0.06	7	610	60	5	2	67	0.06	< 10	< 10	57	110	620
WH084	0.38	3530	66	0.12	7	1470	68	28	4	56	<0.01	< 10	< 10	90	10	424
WH085	0.33	380	78	0.06	20	570	1278	4	2	50	0.01	< 10	< 10	25	20	1386
WH086	0.91	215	< 1	0.07	17	640	8	4	2	26	0.17	< 10	< 10	69	< 10	50
WH087	0.31	760	14	0.02	8	1290	36	678	11	77	<0.01	< 10	< 10	46	< 10	482
WH088	0.74	345	7	0.05	15	620	50	5	4	14	0.11	< 10	< 10	58	20	248
WH089	1.96	1045	5	0.02	13	320	18	55	4	41	<0.01	< 10	< 10	29	10	90
WH090	0.27	670	201	0.02	12	540	370	20	2	30	<0.01	< 10	< 10	10	< 10	630
WH091	0.87	290	24	0.03	14	530	52	8	3	14	0.06	20	< 10	49	< 10	188
WH092	0.88	280	49	0.03	15	590	38	6	3	20	0.06	< 10	< 10	47	< 10	120
WH093	0.23	810	41	0.02	11	390	100	56	1	28	<0.01	< 10	< 10	7	< 10	204
WH094	0.08	40	146	0.01	7	420	326	46	1	15	<0.01	10	< 10	15	< 10	60
WH095	0.07	110	233	0.01	8	340	106	96	3	34	<0.01	10	< 10	19	< 10	98
WH096	0.49	435	220	0.02	11	600	378	5	3	14	0.04	< 10	< 10	34	20	756
WH097	1.44	1355	13	0.02	9	80	4846	176	1	543	<0.01	< 10	< 10	42	50	>10000
WH098	0.42	800	1	0.02	4	1590	1002	6	2	268	<0.01	< 10	< 10	9	< 10	1676
WH099	0.13	440	8	0.02	4	2670	98	90	1	49	<0.01	< 10	< 10	23	< 10	1166
WH100	0.12	220	6	0.02	8	2280	130	56	2	30	<0.01	< 10	< 10	16	< 10	730
WH101	0.78	320	< 1	0.08	4	740	410	40	6	324	0.03	< 10	10	13	10	122
WH102	0.08	80	13	0.02	< 1	760	>10000	314	1	49	0.01	< 10	10	10	10	1054
WH103	0.76	190	1	0.01	8	300	58	< 2	1	8	<0.01	10	< 10	14	< 10	34
WH104	0.69	225	9	0.02	14	550	218	< 2	6	25	<0.01	< 10	< 10	146	< 10	134
WH105	1.28	380	1	0.02	13	40	20	16	1	16	<0.01	< 10	< 10	14	10	24

APPENDIX D.

I. SAMPLING METHODS

II. SAMPLE PREPARATION PROCEDURES (FOR ASSAY)

III. PREVAL PARAMETERS AND BACKUP DATA FOR PREVAL MODELING, WHETSTONE MOUNTAINS UNIT.

I. SAMPLING METHODS. All samples collected and assayed during this study were composed of rock chips. The rock samples were most often collected from mineralized structures observed in the National Forest. Wherever possible, these samples were taken as continuous or semi-continuous chips *perpendicular* to the strike of the mineralized structure, thus representing a cross section through the structure. Samples represent reconnaissance-level sampling (i.e. low density of sample sites). Each rock-chip sample was 3 lb to 10 lb in weight. Sample type definitions are as follows. Chip samples are a regular series of rock chips taken in a continuous (or semi-continuous) line across a mineralized zone or other exposure, and usually across the entire width or thickness of that exposure. Grid and grab samples are from mine/prospect dumps. The grid type are taken systematically over an area to convey possible mineral value distributed in a dump. The grab type are taken unsystematically, usually as a background check, where no specific mineral zone is known or expected. In some cases, grab samples may be collected from an outcrop, for similar reasons. Select samples are often from a mine/prospect dump and are select chips of a specific rock type; select samples can also be collected from an in-place mineral structure to convey assays for the specific zone. Samples noted as "high-grade" are select samples collected from the most intensely mineralized (usually metallized) rock available in dumps, outcrops, or other exposed mineral zones.

II. SAMPLE PREPARATION PROCEDURES (FOR ASSAY). The rock samples were prepared for assay as follows. The entire sample was crushed to -20 mesh in size, with no sieving, via a jaw crusher and cone crusher, and then the entire crushed output was homogenized in a riffle splitter. A 200 gram to 300 gram split was segregated and pulverized in a shatterbox pulverizer to -125 mesh or smaller, with no sieving. The pulverized pulp was divided equally into two kraft paper envelopes, producing two 100-gram to 150-gram pulp splits. One pulp spilt was stored as an archive. The other was sent to laboratories for assay procedures.

III. PREVAL parameters. The composite valuation of a mineral property characterized through the PREVAL software program is expressed as *net present value* (NPV), an analysis equivalent to present worth of cash-flow minus the present worth of after-tax investment (Smith, 1992, p. 21). NPV is usually expressed at a 15% *rate of return* (ROR). Taxes factored into the NPV have been standardized for approximation purposes, but it should be recognized that true tax situations for mining properties will vary largely. Each property is considered individually, as a corporate entity, for tax purposes. The Alternative Minimum Tax rate of 20% is applied to all properties by the PREVAL program. Other parameters used to determine the NPV include: state tax rate of 5%, severance tax rate of 2%, property tax rate of 1.1% (based on capital costs), net proceeds tax rate of 2% of gross profits, royalty rate of 6% of net smelter return, depreciation by the Units of Production method, and a 5 year amortization period. Depletion rates of 15% or 22% are applied, depending on the commodity, and are based on production. In addition, NPV is determined by an assumed 60% debt of total capital costs, a loan interest rate of 10%, and a loan period of 5 years (Smith, 1992, p. 21-22).

Costs

PREVAL cost categories highlighted in this report include mine capital and operating costs, mill capital and operating costs, concentrate transportation charges (truck and rail), and smelter and refinery charges. Exploration costs are partially accounted for in mine capital costs. Acquisition costs are addressed partly as the royalty rate. Salvage value of mine and mill equipment is factored as zero to account for closure and reclamation costs. Costs are in *average* 1990 $US (Smith, 1992, p. 13, 20, 21).

Operation methods, mine life, material balances, prices

The PREVAL program determines optimum mine and mill methods, production and milling rates, and mine life, based on the following factors that are supplied by the PREVAL user: deposit orientation, tonnage, grade, type and number of commodities to be recovered, overburden, relative ore and wallrock strengths, and distance to smelters/refineries. The PREVAL program calculates material balances and the recoverable part of a deposit. Mining dilutions and recoveries applied by the PREVAL program are 90% recovery and 3% dilution for a small open pit mine. Flotation mill recovery used is 91% for copper; concentrate grade is 28% Cu. Beneficiation is on-site and all smelting/refining is off-site. Transportation is calculated to an assumed destination at San Manuel, AZ. Commodity prices are entered by the PREVAL user to reflect market fluctuations. The early March 1993 copper price ($1/lb) was used in PREVAL calculations for this report.

SUMMARY OF PREVAL ESTIMATES, USBM 22 MILLION ST INFERRED COPPER RESOURCE ZONE, WHETSTONE MOUNTAINS UNIT, COCHISE COUNTY, AZ

GEOLOGIC SUMMARY

In-situ resource	22.1 million st
In-situ grade	0.31% copper (Cu)
Ore dilution	3%
Ore recovery	90%
Calculated recoverable resource	20.5 million st
Calculated diluted feed grade	0.301% Cu
Metal price used, this evaluation	$1.00/lb Cu

MINING SUMMARY

Method	Small open pit
Rate (ore)	6,100 st/day
Rate (waste)	10,600 st/day
Operating days/yr	260
Preproduction	2 years
Mine life	13 years
Ore recovery	90%

MINERAL PROCESSING SUMMARY

Processing method	Flotation plant, one product
Processing rate	4,500 st/day
Operating days/yr	350
Recovery	91%, copper
Concentrate grade	28%, copper
Recoverable metal/yr (mill only)	15,400 st, copper

TRANSPORTATION SUMMARY (concentrate only)

Commodity	Copper
Truck distance	30 mi
Rail distance	237 mi
Total annual cost	$0.38 million

SMELTER AND REFINERY CHARGES

Commodity	Copper
Smelter charge	$1.3 million/yr
Refinery charge	$0.84 million/yr

MINE COST SUMMARY

Cost component	Annual operating cost	Capital cost
Labor	$ 2.4 million	$ 2.2 million
Equipment	1.1 million	18.2 million
Steel	.1 million	.5 million
Fuel/Lube	.9 million	.4 million
Explosives	.6 million	.3 million
Tires	.2 million	.1 million
Construction materials	.1 million	.8 million
Sales tax	.1 million	1.2 million
Total Cost	$ 5.6 million	$23.7 million

Operating cost per st ore	$ 4
Working capital	$2 million

BENEFICIATION COST SUMMARY

Cost component	Annual operating cost	Capital cost
Labor	$ 3.6 million	$ 3.6 million
Equipment	2.2 million	8.4 million
Steel	1.2 million	1.8 million
Fuel and lube	.2 million	NA
Reagents	1.2 million	NA
Construction materials	NA	10.2 million
Electricity	1.9 million	NA
Sales tax	.3 million	1.3 million
Total cost	$10.6 million	$25.3 million
Operating cost per st ore	$7	
Working capital	$2.7 million	

FINANCIAL ASSUMPTIONS SUMMARY

Inflation rate	0%	(0% commodity inflation)
Debt (amt. financed)	60%	
Loan interest rate	10%	
Loan term	5 years	
Federal tax rate	Alternative minimum tax	
Minimum tax rate	20%	
State tax rate	5%	
Severance tax rate	2%	
Depreciation method	Units Of Production	
Depletion rate	15% or 22%	
Property tax rate	1.10%	
Royalty rate (NSR)	6%	

CASH FLOW SUMMARY, cumulative

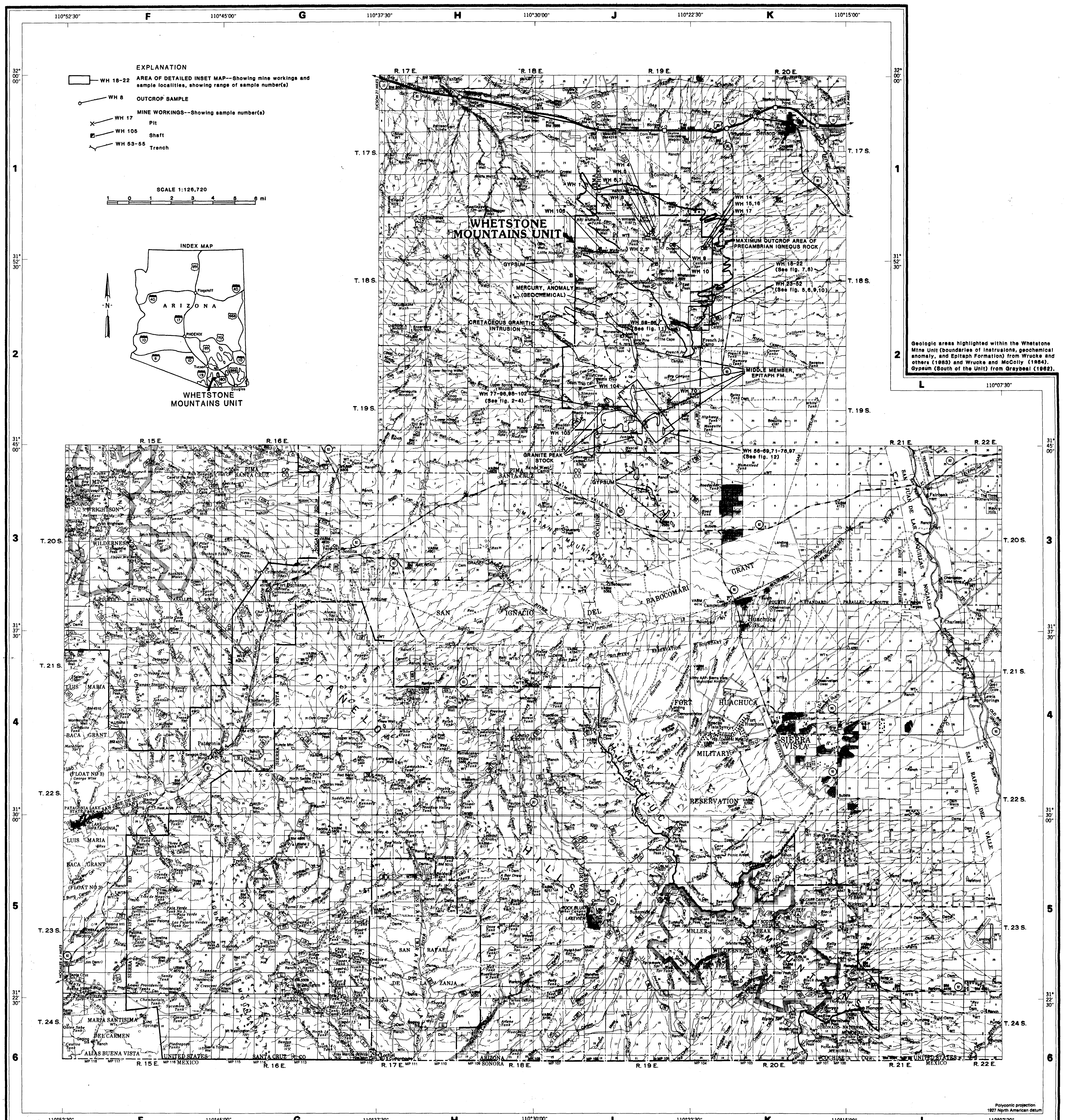
Revenue	$107.6 million
Royalty	- 4.5 million
Operating costs	-224.1 million
Loan payments (P+I)	- 42.5 million
Depreciation/ Amortization	0
Depletion	0
Tax loss carry forward	0
Net proceeds tax	- 3.9 million
Property taxes	- 6.8 million
Severance taxes	- 2.2 million
State taxes	0
Federal taxes	0

Net cash flow	-196.3 million
Net present value	-113.2 million.

100% of gross revenue from copper; annual value at the mill is $8.6 million.

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

OPEN FILE REPORT
MLA 2-94
PLATE 1



Base map compiled in the Regional Office, Albuquerque, New Mexico, in 1982 from U.S. Forest Service Primary Base Series Maps. Drafted in 1986 by U.S. Forest Service, Geometronics Service Center, Salt Lake City, Utah.

Field work completed in 1980-1981 by R.A. McColly and D.C. Scott; in 1989 by Robert C. Smith, R.C. Harris, and D.K. Marjaniemi; and in 1992 by R.C. Armstrong and M.L. Chatman.

SAMPLE LOCALITY MAP OF THE WHETSTONE MOUNTAINS UNIT, CORONADO NATIONAL FOREST, COCHISE AND PIMA COUNTIES, ARIZONA

BY

MARK L. CHATMAN, U.S. BUREAU OF MINES

1994

Figure 8.– Ricketts Mine, and cross-sections, with sample localities WH 18-22, Whetstone Mountains Unit.