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UPDATE ON THE MINERALOGY OF THE MAJUBA HILL MINE, PERSHING COUNTY, NEVADA

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INTRODUCTION

Based upon the observed increase in interest and collecting activity at the Majuba Hill mine since the publication of the initial article on the locality (Jensen, 1985), it appears valuable to contribute both on new discoveries at the mine, as well as to clarify certain aspects that were unfortunately vague earlier. At the present time, (October, 1991), access to the mine is tenuously unrestricted. Several companies have held the property since Gulf Chemical, hoping that it could be in-situ leached for its silver values. With the increase in environmental controls in recent years, however, combined with the decrease in silver prices, the target has become less attractive. Thus, the only real activity at Majuba has been that of mineral collectors, the locality having become very popular lately.

Three different but interrelated general topics are covered in this update discussion: 1.) the status of mine access, 2.) minerals previously unreported from the locality, and 3.) notes on previously reported minerals, including significant new discoveries.

As noted above, access to the mine is possible. Until just recently, the doors to both the lower and middle adit portals, as well as the gate on the main road, were open and unlocked. On a visit made to the middle adit on 10 August, 1991, however, other collectors were working in the mine, even though the door now had a fresh lock. The subsequent and last visit to the mine (on 15 October, 1991) was startling, in that the locked door to the middle adit had been ripped apart in two pieces and was now open, hanging only on its hinges. This type of action is unnecessary and will undoubtedly lead to severe reaction from the current property owners. There is now, however, no longer a caretaker below the mine. Dick Bailey, the last caretaker, moved away at least five years ago. The cabin which he occupied has also been burned and leveled, a sight occurring more and more often at old Nevada mining camps and ghost towns. In addition, the immediate region surrounding Majuba has become a very popular area for bird and deer hunters at various times of the year, and it is not uncommon to see up to a dozen other campers and groups around during these periods. The mine itself is being visited on a regular basis by mineral collectors and, on almost any weekend now, one should not be surprised to be joined by others.

Since the publication of the mineral species list in the Mineralogical Record in 1985, 33 new species for the locality have been added, bringing the total from 52 up to 85. The current list, although accurate, is probably incomplete, for it is this authors opinion that still other species will continue to be discovered and studied from the site. Fortunately, many of the newly described species are probably already represented in most collections, having been either overlooked in the past (such as langite, sphalerite, or atacamite) or occurring in too small of crystals to be seen without the aid of at least a binocular microscope. In this latter category, methods such as reflected light ore microscopy, scanning electron microscopy (SEM) with energy dispersive spectrometer (EDS) X-ray chemical microanalysis, or X-ray diffraction (XRD) are needed to verify phases.

The mineral summary which follows has been compiled over a period of many years and has been gathered during the examination of many hundreds of kilograms of material. Representative specimens of all newly verified species have been donated to the current Mackay School of Mines museum curator. The author also maintains a fine and complete collection of minerals from the Majuba Hill mine. All specimens photographed (by the author) for this discussion are from this collection, and are available for examination by prior approval.

All locations for specimens which are given in coordinates in the text are in reference to the excellent and detailed mine map included as Plate 9 in the paper of Trites and Thurston (1958). (Since this reference uses English units for measurement, this format has been followed for the locations only. Otherwise, the more current metric units are used throughout). The lesser map (figure 3, page 59) of Jensen (1985) was actually from the M.S. thesis of Stevens (1971), and was slightly modified by Wise.

Throughout the current study of Majuba, certain observations have come to light which need comment. Today, with the widespread closure of mines, both abandoned and active, and the passing of many localities into the archival references only, Majuba is beginning to stand out. It is now unusual to be able to drive to the portal of a locality, walk in, and have an excellent chance of collecting good material. Even more outstanding is the fact that, after many years of collecting, one can still discover new locations for good specimens, as exemplified by the excellent clinoclase discovery described below. Most localities that have been heavily collected are now either unproductive or require the use of blasting techniques. Fortunately, Majuba fits into neither of these categories. Perhaps the single most dangerous factor which could limit collecting at Majuba is the influence of environmentalists and lawyers with liability lawsuits - these are more likely to end the locality (and the only question is when) rather than depletion of fine mineral specimens.

At present, however, there is still a good supply of material available, both in the mine and on the market. To paraphrase, "Enjoy it while it lasts". For those who wish only attractive specimens of the more common minerals, they are obtainable. If one desires to "complete the suite" and have at least one example of each species represented from the locality, this is also a possibility, and one which has many rewards to go with it. There are few localities with such diverse mineralogy where this goal can be achieved. By so doing, the collector then has a very valuable record, both scientifically and aesthetically, of the mineralogy of an important and complex ore forming system. In fact, any locality with the mineralogical potential for producing such quantities of aesthetic and academically intriguing species and associations cannot help but to arouse the intense interest of the true collector. The current study has been this type of a continually entertaining and ultimately gratifying project for the author and it is his sincerest wish that other collectors be able to enjoy similar rewards in their mineralogical pursuits.

MINERALOGY

Species Previously Unreported from the Locality

AGARDITE-(Ce) $(Ce,Ca)Cu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$

Agardite-(Ce), a new member of the mixite group, occurs sparingly in the Tin stope, at two locations: 1.) at coordinates 1965N, 515W, 15 feet above the level, and 2.) at coordinates 1980N, 530W, 25 feet above the level. As with mixite (which also occurs in the same locations), agardite-(Ce) forms excellent sprays to 2 mm of radiating, delicate needles. The color is diagnostic, being an odd, light olive-green, as is the paragenesis, in which agardite-(Ce) was formed very early, being locally even included within quartz crystals. It ranges in composition from a pure cerium/calcium member on through to a variety containing substantial aluminum and bismuth. Care should be used in cleaning for, unlike mixite, agardite-(Ce) fibers will clump if immersed in water.

AGARDITE-(Y) $(Y,Ca)Cu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$

Specimens of pure agardite-(Y) collected from a new occurrence on the rib of the Copper stope at coordinates 1695N, 370W, about 35 feet above the level, provide very impressive views in the optical microscope. The most pleasing samples consist of drusy green agardite-(Y) needles associated with, and locally resting upon, radiating clusters of prismatic, apple-green arthurite crystals. Spheres of light green, terminated strashimirite needles may also be associated, as well as ubiquitous brown-black patches of tenorite mixed with manganese oxides. Agardite-(Y) is rare at the locality, although selected surfaces to 10 x 10 mm totally covered with drusy coatings have been collected.

ALLANITE-(Ce) $(Ce,Ca,Y)_2(Al,Fe)_3(SiO_4)_3(OH)$

At least some of the inclusions, albeit a small proportion, of dark minerals within quartz crystals from the Tin stope (at coordinates 1965N, 515W, 15 feet above the level) are crystals of allanite-(Ce). They exhibit the typical elongated and flattened morphology of this species, and are most easily detected through the use of the SEM.

ATACAMITE $Cu_2Cl(OH)_3$

The largest exposure of atacamite is on the back of the drift by the "K" raise in the middle adit level below the Copper stope, although the species has also been observed elsewhere in the mine. It has formed subsequent to mining on a large surface of heavily altered, bleached white, sericitized rhyolite and fault gouge and is present as a light green, thin veneer that completely covers an area about 1 m^2 in size. Crystals are very minute and are intimately associated with gypsum, both species being resolved only with the aid of the SEM.

BISMUTH Bi

Native bismuth occurs quite commonly as isolated grains to 50 microns within felsite samples from deep drill holes. It is most prevalent in areas containing grains of molybdenite, chalcopyrite, and bismuthinite, and is verifiable with either the ore microscope or the SEM.

BISMUTHINITE Bi_2S_3

Bismuthinite is common within most samples of chalcocite from the Copper stope, but is present as extremely minute grains no larger than 10 microns. It occurs primarily as small inclusions within arsenopyrite grains, and is detectable only with the aid of the SEM. Larger examples, exhibiting cleaved, elongated grains to 0.15 mm, occur quite commonly in selected samples of drill core from deep holes into the felsite. Associated minerals include native bismuth, molybdenite, chalcopyrite, and monazite-(Ce).

CALCITE $CaCO_3$

Calcite is present at Majuba along the ribs of the lower adit at a point 260 m in from the portal. Individual crystals range up to 3 mm and occur as brilliant, glass-clear, simple rhombs scattered upon joint surfaces of the Triassic argillite.

CONICHALCITE $CaCu(AsO_4)(OH)$

Conichalcite at Majuba occurs as typical, apple-green, botryoidal coatings on massive white quartz from prospect pits on the north side of the dirt road which leads from the lower adit up to the middle adit. Associated minerals may include cuprite, azurite, malachite, goethite, muscovite, and chrysocolla.

CONNELLITE $Cu_{19}Cl_4(SO_4)(OH)_{32}\cdot 3H_2O$

Extremely attractive radiating spheres of deep blue connellite have been found within chalcocite pods from two occurrences in the middle adit: 1.) at coordinates 1740N, 415W, about 10 feet above the level, and 2.) in a pillar remnant at coordinates 1700N, 380W. The species is scarce, perhaps two dozen specimens having been recovered, and occurs in association with chrysocolla, brochantite crystals, pharmacosiderite cubes, minute balls of pale green malachite, and rare posnjakite crystals. Individual sprays of connellite may range up to 0.2 mm in diameter and are composed of lustrous, spear-shaped needles. Although the species has been found before in Nevada, this discovery represents the first documented occurrence.

CUBANITE $CuFe_2S_3$

Cubanite occurs rarely, as small blebs to 20 microns, in intimate association with early chalcopyrite, both of which are enclosed within arsenopyrite grains. About 25% of samples of chalcocite from the Copper stope observed under the ore microscope exhibit this phase.

IODARGYRITE AgI

Hexagonal tabular crystals of pure iodargyrite (no bromine or chlorine) up to 80 microns have been found sprinkled upon clinoclase crystals and cornwallite from the Tin stope (at coordinates 1980N, 530W, 25 feet above the level). The iodargyrite crystals are lustrous and pale yellow in color and tend to cluster along the {100} faces (the thin prism faces) of the clinoclase in an almost epitaxial manner. The specimens were produced from a narrow zone of small vugs and clearly represent a rather unusual mineralogical association.

LANGITE $Cu_4(SO_4)(OH)_6 \cdot 2H_2O$

Langite is found in the Copper stope, associated with cuprite and parnauite, from a zone located at coordinates 1760N, 370W, about 55 feet above the level. Common vugs to 3 cm are distributed irregularly throughout altered rhyolite and may locally be lined with thin, light blue to turquoise-blue, botryoidal coatings of langite encrusting red cuprite needles. Selected examples, when examined with the SEM, show ideal, pseudohexagonal, twinned crystals (to 10 microns) typical of the species. It is unlikely that the mineral has been recovered by many from the deposit, but it has probably been mistaken for chrysocolla.

LAVENDULAN $NaCaCu_5(AsO_4)_4Cl \cdot 5H_2O$

Lavendulan from Majuba had been offered by dealer Bruce Runner (Mineralogical Record, 1985, p. 100), which he had reportedly collected from one boulder found on the dump of the middle adit. In addition to this occurrence, lavendulan has been collected in-situ near the bottom of the Copper stope at coordinates 1740N, 415W, about 10 feet above the level. It is very rare and occurs either as beautiful blue spheres to 1 mm or as massive vug fillings to 2 mm of somewhat flaky cleavages associated with minor chrysocolla and chalcophyllite. It is believed that this occurrence may also represent the first documented notation of this species from Nevada.

LUETHEITE $Cu_2Al_2(AsO_4)_2(OH)_4 \cdot H_2O$

Unusual tan coatings on joint surfaces, discovered at the foot of the large pillar in the Copper stope, have been identified as an iron- and light rare earth element-bearing luetheite (the aluminum analog of chenevixite). The identity has been confirmed by SEM with EDS, and by XRD (W.S. Wise, Santa Barbara, California), and may possibly mark the second world occurrence of this species. The coatings, comprised of druses of spherical groups of thin-bladed crystals, are earlier than the associated crystals of pharmacosiderite, arthurite, scorodite, chenevixite, and zeunerite, which occur sprinkled upon the luetheite.

MAGNETITE $Fe^{+2}Fe_2^{+3}O_4$

Crude crystals of magnetite to 20 microns have been noted in small vugs of porphyritic rhyolite samples from the Majuba Fault Zone exposed 460 m back in the lower adit. Better examples of the species occur as inclusions in transparent quartz crystals from the Tin stope, middle adit (at coordinates 1965N, 515W, 15 feet above the level).

MONAZITE-(Ce) $(Ce,La,Nd)PO_4$

Monazite-(Ce), as a minor accessory mineral, is widespread at Majuba and may occur as subhedral grains to 10 microns "frozen" within the rhyolite, as inclusions to 50 microns within quartz crystals, and as discrete grains associated with bismuth and molybdenite in felsite samples from deep drill holes. In the Tin stope at coordinates 1965N, 515W, 15 feet above the level, the species is particularly common, associated with crystalline quartz and later agardite-(Ce).

MONTMORILLONITE $(NaCa)_{0.33}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$

Montmorillonite is present in the same vicinity and environment as calcite in the lower adit, and occurs as bright pink to white, powdery coatings and joint fillings to 1 cm in thickness.

POSNJAKITE $Cu_4(SO_4)(OH)_6 \cdot H_2O$

In addition to brochantite, chalcanthite, and langite, another hydrated copper sulfate, posnjakite, also occurs at Majuba. Crystals of posnjakite from the Copper stope have been confirmed by SEM and XRD methods and have provided the first reported examples of this mineral from Nevada. The finest specimens have been produced from vuggy chalcocite pods collected at coordinates 1740N, 415W, about 10 feet above the level. Here, posnjakite occurs as lovely deep blue, transparent, lustrous, platy to elongated crystals to 0.1 mm, either resting upon pharmacosiderite crystals, or as an associated mineral on specimens with connellite crystals.

PYROLUSITE MnO_2

Pyrolusite is present at Majuba as typical black "dendrites" to 1 cm on joint surfaces of gray Triassic argillite exposed along the ribs of both the middle and lower adits.

RHABDOPHANE-(Ce) $(Ce,La)(PO_4) \cdot H_2O$

An interesting occurrence at Majuba, and for Nevada, is that of euhedral rhabdophane-(Ce) crystals in vugs from two locations:

1.) the Majuba fault zone exposed in the lower adit, and 2.) the rib of crosscut 216 in the middle adit. Although small and best observed with the aid of the SEM, rhabdophane-(Ce) crystals occur quite commonly. Attaining sizes of up to 30 microns, specimens from the middle adit location are superior, especially when found in combination with the abundant anatase crystals which also occur here.

SPHALERITE ZnS

Grains to 18 microns of zinc sulfide (with minor iron) had been noted rarely in porphyritic rhyolite samples from the Tin stope, but were considered anomalous until actual, verifiable grains were found, some quite commonly, within chalcocite pods from the Copper stope. Sphalerite occurs as cores to 150 microns (0.15 mm) surrounded by chalcocite rims to 20 microns, or as very attractive stellate exsolution features in "late" chalcopyrite. Widely distributed, it contains about 20% Fe, and minor Cd, and is present in the majority of polished sections examined.

STANNITE Cu_2FeSnS_4

In selected samples of chalcocite pods from the Copper stope, the occurrence of stannite has been noted. It is present as grains to 100 microns commonly rimmed by later chalcocite. Determinations were made by SEM with EDS and confirmed by reflected light characteristics under the ore microscope.

THENARDITE Na_2SO_4

The epsomite reported as a post-mining efflorescent (Jensen, 1985, p. 66), is instead thenardite. The identity has been ascertained both by SEM and EDS and by XRD on material from coordinates 1920N, 210W in the northeast workings of the middle adit level. This is an unexpected and unusual occurrence, the species occurring as an efflorescent on mine openings, and it is doubtful if this occurrence has ever before been documented. As for epsomite, there is none, nor are there any other Mg-bearing efflorescents anywhere else in the mine.

TENORITE CuO

Selected fracture surfaces exposed throughout the upper portions of the Copper stope may exhibit sooty black patches and coatings of tenorite mixed with varying percentages of unidentified manganese oxides and local concentrations of cobalt (unidentified phase). The species occurs strictly upon joint and fracture surfaces, and may be locally abundant.

UNKNOWN-1

A new mineral species has been found in the Copper stope and is currently being studied further. It is an hydrated copper arsenate and occurs as light green spherules to 2 mm, associated with pharmacosiderite and other minerals.

XENOTIME YPO_4

Xenotime, as with zircon and monazite-(Ce), is a minor accessory mineral within the intrusive rhyolite. Its occurrence is widespread and it has been noted in all rhyolite samples yet examined. It forms euhedral, tetragonal, flattened crystals in vugs, the largest crystal yet seen being 60 microns. As a constituent of the host rock, it is interesting, and one is tempted to suggest that it was this phase which provided the Y found in agardite-(Y) and goudeyite.

ZIRCON $ZrSiO_4$

Zircon is also a common accessory mineral in the intrusive rhyolite exposed throughout the Majuba Hill mine workings. It has been noted in samples from both the lower and middle adits, where it typically occurs as well-formed tetragonal crystals to 50 microns. Individual crystals occur in small vugs and may locally exhibit metamict texture.

New Data on Species Previously Reported from the Locality

ANATASE TiO_2

Anatase was originally reported by Wise (personal communication) as being distributed throughout altered rhyolite (Jensen, 1985, p. 62). The mineral is widespread, but is elusive without knowing what to look for and where. Perhaps the most abundant and finest crystals are found along the rib of crosscut 216 (at coordinates 1855N, 470W) in a zone of intensely altered rhyolite. Forming replacements after feldspar phenocrysts, extremely unusual vugs, often containing spherical radiating sprays of schorl needles with hollow centers lined with quartz crystals, give the bleached white rhyolite a speckled appearance. Within about 10 percent of the vugs, anatase occurs, either as singles to 0.1 mm, or as clustered groups to 1 mm of lustrous, black, equant crystals. Abundant, but extremely minute rhabdophane-(Ce) crystals are typically associated with the anatase.

ARSENOPYRITE FeAsS

Actual crystals of arsenopyrite have been found at the locality, at coordinates 1740N, 415W, about 10 feet above the level, in the Copper stope. Individuals vary in size from 1 mm up to a maximum of about 6 mm, and commonly exhibit complex forms, none being simple prismatic crystals. They may occur either frozen within rhyolite, in which case they are very lustrous, or as crystals in pods and vugs, where they are commonly coated with a thin veneer of chenevixite and are somewhat dull. Along with rare pyrite crystals, these represent the only true crystallized sulfides yet known from the deposit.

ARTHURITE $CuFe_2^{+3}(AsO_4,PO_4,SO_4)_2(O,OH)_2 \cdot 4H_2O$

In the Tin stope, at coordinates 1965N, 515W, 15 feet above the level, arthurite occurs very sparingly as typical yellow-green spheres to 0.5 mm resting upon finely crystallized scorodite. Prior to the knowledge of this occurrence, the species had been known only from the Copper stope.

BROCHANTITE $Cu_4(SO_4)(OH)_6$

In slabs that have fallen from the back of the Copper stope, no brochantite has been seen, thus casting doubt on the statement that the species occurred there in abundance (Jensen, 1985, p. 63). Brochantite has been found in minor amounts, however, as extremely attractive crystals from the fault zone on the floor of the Copper stope at coordinates 1760N, 370W, about 55 feet above the level.

Here, it occurs within vugs to 3 cm as lustrous and perfectly formed, radiating, needle-like, deep green crystals to 1 mm. For the collector, this location has furnished the finest examples of this mineral yet encountered from the mine.

A second habit, and much more recent growth of brochantite, typified by pale green to green, translucent to transparent microcrystalline crusts, is present throughout much of the area exposed by the lower reaches of the Copper stope. Here, the species appears to be occurring as an efflorescent. It is found encrusting fracture surfaces in the rhyolite, admixed with chalcanthite in the "chalcanthite winze", as a coating on crystallized arsenates within chalcocite pods, and even on fracture surfaces of broken chalcocite.

BROOKITE TiO_2

In addition to the single specimen of brookite found by Wise and reported in Jensen (1985, p. 62), additional crystals have since been discovered in the Tin stope. The occurrence is at coordinates 1965N, 515W, 15 feet above the level, where the species is found very rarely, resting upon colorless, euhedral quartz crystals. Single brookite crystals seen so far are dark brown to black, no larger than 0.1 mm, and might at first be mistaken for "needle tin" cassiterite, which also occurs in this zone. By conducting painstaking examination of material from this location, the species can be found. However, brookite will remain one of the most difficult species for the collector to acquire from the locality.

CHALCANTHITE $CuSO_4 \cdot 5H_2O$

Inside the "K" raise on the middle adit level below the Copper stope, actual crystals (not fibrous growths) of blue chalcanthite have precipitated rather abundantly on the wood and splinters. Crystals up to 8 mm have been collected and represent a rather unusual occurrence for this species as true crystals "in nature".

CHALCOMENITE $CuSeO_3 \cdot 2H_2O$

The single known specimen of chalcomenite described by Wise (personal communication) in Jensen (1985, p. 63) collected by J.L. Parnau from the dump of the middle adit has also been examined as part of this study. The matrix consists of brecciated and silicified porphyritic rhyolite and is coated by a varying thickness of sericite muscovite and chrysocolla. The only sulfides observed consist of small grains to 0.5 mm of chalcocite. Chalcomenite occurs as deep blue glassy blebs to 5 mm, very similar in appearance to chalcanthite, distributed randomly upon the surface of the specimen. Judging from the mineralogical characteristics of the sample, it is not from the Tin stope, but could have originated from any other exposures of the Majuba fault where there is mineralization. Although additional examples of this species have not yet been found, it is hoped that the above description may help others in locating it in the future.

CHALCOPHYLLITE $Cu_{18}Al_2(AsO_4)_3(SO_4)_3(OH)_{27} \cdot 33H_2O$

Exceptional chalcophyllite specimens have been discovered at two locations in the Copper stope: 1.) at coordinates 1720N, 400W, about 20 feet above the level, and 2.) at coordinates 1740N, 415W, about 10 feet above the level. Within pockets to 5 x 5 cm, lustrous, transparent, deep green, hexagonal, platy crystals to 7 mm have been observed. In selected instances during collecting, the crystals were so large and thick that they appeared to be almost black. All specimens have subsequently become opaque and turquoise-blue upon exposure to the typical dry Nevada climate. (Oddly, it would seem that no one has yet described the new mineral "meta-chalcophyllite" that is formed when the dehydration process occurs, similar to that of torbernite/metatorbernite, etc.)

CHLORARGYRITE AgCl

Chlorargyrite from Majuba had been tentatively identified on a specimen of native silver collected (by R.W. Thomssen) from the dump of the middle adit (Jensen, 1985, p. 63). An actual, verifiable, in-situ occurrence for the species has been discovered, which produces euhedral and lustrous crystals in relative abundance. In the Tin stope at coordinates 1965N, 515W, 15 feet above the level, a zone of mineralogically very interesting material is exposed. Portions of this zone consist of spongy finely-crystalline scorodite pods to 40 cm, while other areas are characterized by hydrothermally rounded cobbles of silicified rhyolite set loosely in a matrix of considerably abundant powdery black schorl. Isolated crystals of chlorargyrite occur sporadically throughout this zone, either within the porous scorodite masses, or as larger crystals on fracture surfaces of silicified rhyolite cobbles. Specimens with areas up to 3 x 3 cm totally sprinkled with excellent crystals have been found. Crystals are typically brown-green cubes modified by the first order octahedron and all examples yet seen contain substantial amounts of bromine (about 2:1 chlorine to bromine). Individuals range in size from 0.05 mm up to a maximum of about 2 mm and are easily observable with a hand lens. Flat-lying olivenite crystals, which sporadically occur in joint surfaces in this area, almost always exhibit associated chlorargyrite, a feature which is both attractive, as well as useful in locating the species.

CHRYSOCOLLA $(Cu,Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$

There is such a wide variation in the colors of chrysocolla at Majuba that it is helpful to describe the species a bit further. Rarely, if ever, is the species present as its characteristic "robins-egg-blue" color. Instead, the more common colors include green, avocado-green, brown, white, or even colorless. The most reliable feature to aid in identification is the ubiquitous presence of numerous random cracking lines, similar to a broken auto windshield.

CLINOCLASE $Cu_3(AsO_4)(OH)_3$

A major discovery of clinoclase was made recently and represents probably the single most exciting development in many years at this locality. By digging down through muck in an area in the Copper stope centered at coordinates 1760N, 370W, about 55 feet above the level, a very large area was uncovered which produced considerable material, some of very fine quality. The zone consisted entirely of loose rock, as if it had been broken up and moved, but only less than a meter or two. This feature served greatly to facilitate collecting, as all material could be gathered by hand.

Clinoclase occurred commonly, both within vugs, as well as upon joint surfaces, and matrix specimens to 30 cm were obtained. All clinoclase was lustrous and occurred as deep blue-black curving aggregates up to 7 mm of crystals. Rare, but exceptional, hemispherical, ball-like groups were also found, which ranged up to 11 mm in size. Olivenite, as very pale blue powdery coatings and patches (leucochalcite variety) was a common associated mineral, with deep green cornwallite being rarer. With clinoclase resting upon the latter, a very pleasing and classic association resulted.

Based upon the quality of the material of this find, truly outstanding specimens must have been produced during the days of active mining, although it sadly appears that none were preserved.

Clinoclase crystals associated with strashimirite needles have also been discovered at the top of the Copper stope on the opposing rib of the small stope where excellent olivenite crystals were produced (Jensen, 1985, p. 67). Neither species here attains sizes larger than 2 mm, but the association with one another, both in well-formed crystals, provides attractive specimens.

COPPER Cu

Although Wise (personal communication) stated native copper to be very rare and occurring only on the dump of the upper adit (Jensen, 1985, p. 67), the species appears to be much more common. Since most of the material on the dump of the upper adit is actually from the Copper stope, a number of massive specimens (up to 15 cm) of cuprite were collected from this opening underground and later examined in the laboratory. By cutting flat and grinding smooth any surfaces of the most coarse-grained cuprite, abundant native copper can easily be seen; samples of the more compact and fine-grained cuprite do not seem to exhibit the copper nearly as well.

CORNWALLITE $Cu_5(AsO_4)_2(OH)_4 \cdot H_2O$

From a small area on the north rib of the entrance to the Tin stope at coordinates 1970N, 500W, numerous greenish stains are present on the dark rhyolite. These stained areas are actually composed of crystalline cornwallite, chenevixite, pharmacosiderite, and zeunerite, and are of interest in that discernible and euhedral monoclinic crystals of cornwallite occur, although very small. These are tabular, rounded, and up to 20 microns in size, either resting upon highly modified fluorite crystals or impaled upon schorl needles.

COVELLITE CuS

Covellite crystals have been found within muck from an ore pass at coordinates 1780N, 340W, in the middle adit. The mineral occurs as recent growths, a phenomenon that has also been observed on +100 year old Comstock Lode specimens in the Mackay School of Mines collections. It is present on exposed surfaces of ore fragments as black spots to 5 mm of thin, platy, hexagonal crystals to 10 microns. This occurrence is in addition to the relatively common covellite which is present in almost all chalcocite pods from the Copper stope. By polished section examination, the indigo-blue color of covellite is easily seen, most specimens having at least some of the mineral as a constituent.

CUPRITE Cu_2O

Very fine euhedral and lustrous cuprite crystals have been found at coordinates 1760N, 370W, about 55 feet above the level, in the Copper stope, and have provided actual crystallized examples of this species. Two different variations have been observed: 1.) lustrous, transparent, deep-red, sharp octahedrons to 3 mm, and 2.) more common, highly elongated, black, spike-like crystals that form intricate networks of reticulate growths. Overall, this second type of crystallization is more visually appealing, forming truly spectacular specimens in both the optical and scanning microscopes.

ENARGITE Cu_3AsS_4

After an in-depth, comprehensive, and exhaustive ore microscopy study, no enargite has been found from the locality. The original reference to this species (MacKenzie and Bookstrom, 1976, p. 22) states enargite as occurring in minor amounts in pods of chalcocite from the Copper stope, but the establishment of this phase at the locality cannot be verified. Thus, the species must be relegated to being reported, but unconfirmed.

FLUORITE CaF_2

Actual euhedral crystals of fluorite have been found at Majuba. In addition to the earlier description of anhedral grains (Jensen, 1985, p. 71), there occur small, but attractive crystals in the extreme northeast workings of the middle adit level (at coordinates 1920N, 210W) in a zone with considerable crystallized malachite and azurite. Here, purple, lustrous, cubic crystals to 1.5 mm are found sprinkled upon black, heavily iron-stained rhyolite joint surfaces. Locally, the purple cubes may be aesthetically associated with small tufts to 2 mm of bright green malachite sprays.

Fluorite crystals have also been found sparingly in the Tin stope, at coordinates 1965N, 515W, 15 feet above the level, as slightly corroded, pale green to purple octahedrons to 10 mm resting upon quartz crystals.

GYPSUM $CaSO_4 \cdot 2H_2O$

In addition to its association with atacamite, gypsum occurs as white, silky efflorescent fibers and groups to 2 mm lightly sprinkled upon fault surfaces and gouge exposed at various locations at the bottom of the Copper stope.

JAROSITE $KFe_3^{+3}(SO_4)_2(OH)_6$

Jarosite from Majuba was reported by Wise (personal communication) as occurring in the upper levels of the mine (Jensen, 1985, p. 66). Indeed, the species occurs sparingly on the dump and in the upper adit, but much better examples can be found in the Tin stope (at coordinates 1965N, 515W, 15 feet above the level). In all instances, it is fine-grained and bright yellow in color, and is the pure potassium end-member. Jarosite is distinguishable by its spongy appearance and tendency to form blotches and coatings, and is a late mineral paragenetically.

MIXITE $BiCu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$

Within the Tin stope, two specific occurrences for mixite have been located, although the species is difficult to recognize at first because of its small size. It is, however, locally abundant and occurs only as needle-like crystals. Two locations have been confirmed: 1.) at coordinates 1980N, 530W, 25 feet above the level near the clinoclase zone, and 2.) at coordinates 1965N, 515W, 15 feet above the level. The species occurs only as beautiful radiating sprays (similar in form to aurichalcite) up to 1 mm of delicate, fibrous crystals ranging in color from white through light blue to blue-green. Chemically, it is not a pure bismuth mixite, but instead has minor substitutions of aluminum and calcium. Positve correlation between color variation and composition has not been established. Hand-size specimens (10 x 10 cm) liberally dusted with crystals have been recovered, although much smaller pieces are the rule. Associated minerals may include crystals of quartz and olivenite, powdery goethite, and rarely chlorargyrite (second locality).

Methods of cleaning, including water washing, or brief ultra-sonic cleaning, do not cause the fibers to clump together and may be considered safe.

MOLYBDENITE MoS_2

Further examination of material from Majuba Hill has clarified the occurrences of molybdenite. The best examples are seen in drill core from deeper intervals where "moly paint" is present on fracture surfaces to at least 20 cm in diameter. The species has also been verified, however, as rare grains to 0.1 mm within chalcocite from the middle adit level at coordinates 1700N, 380W.

PARNAUITE $Cu_9(AsO_4)_2(SO_4)(OH)_{10}\cdot 7H_2O$

Exceptional parnauite specimens have been recovered from a zone of altered rhyolite in the center of the Copper stope at coordinates 1760N, 370W, about 55 feet above the level. These consist of clusters of very dark green, lustrous, spherical aggregates to 3 mm of excellent crystals. (In the original description of the species, Wise (1978, p. 704) reported crystals and groups to 1 mm). Although the species is common at the locality, these large groupings are the finest examples of the species known currently.

As an added note, the SEM photo of parnauite in figure 19 on p. 69 of Jensen (1985) is incorrectly labeled; it is, instead, a photo of goudeyite.

PYRRHOTITE $Fe_{1-x}S$

Although previous reports have stated that pyrrhotite is relatively common at Majuba, it appears to be decidedly rare within sulfide pods (chalcocite) from the Copper stope. It may be much more common in samples from drill holes or from other areas of the mine, but there has been very little yet seen, at least in the samples from the Copper stope used in this study.

TYROLITE $CaCu_5(AsO_4)_2(CO_3)(OH)_4 \cdot 6H_2O$

Tyrolite has been verified from a zone at the base of the large monolith at coordinates 1760N, 370W, about 55 feet above the level, in the Copper stope. Its color is distinctive, being almost identical to chrysocolla. Morphologically, however, it is crystalline, micaceous, and forms spheres (in open spaces) and flattened radiating sprays (to 5 mm) on joint surfaces where it has grown across. Parnauite may be similar in appearance, but does not exhibit the porous and micaceous texture of tyrolite.

DISCUSSION

Sulfide mineralogy of the Copper Stope

A detailed examination was made of a wide range of "chalcocite" samples collected over a protracted period of time from various locations in the Copper stope. Standard ore microscopy (reflected light) techniques, combined with SEM and EDS, were employed. During the study, a number of phases new to the locality were found, in addition to verifying those already known.

The most immediate conclusion to be made from the analyses is that, in the majority of "chalcocite" pods, it can be assumed that the following assemblage is present: arsenopyrite, chalcocite, digenite, covellite, chalcopyrite, and pyrite. If specimens greater than 1 cm in size are available, they almost certainly will have these constituents. Minerals present in significantly lesser amounts - sphalerite, stannite, bismuthinite, and cubanite - would need to be verified analytically in any particular sample.

A rarer sulfide/sulfosalt phase, noted in two different sections, has not yet been fully characterized due to its small size. Grains are gray-white in reflected light, range up to 60 microns, are early (being totally enclosed within arsenopyrite), and are chemically a copper bismuth sulfide with lesser iron, arsenic, silver, and selenium. The latter element is of interest as it provides a possible source for the very rare secondary mineral chalcomenite. In addition, other uncharacterized sulfides occur rarely and are either new minerals or extremely rare species. It is the opinion of this author that the sulfide/sulfosalt mineralogy of Majuba may prove to be almost as complex and varied as the secondary assemblage.

Sulfide Mineralogy of the Tin Stope

The only sulfides yet found in the Tin stope are those preserved on small grains and inclusions in quartz. Panning loose material from breccia zones to yield concentrates for SEM examination discloses only olivenite, chlorargyrite, and cassiterite, and a total lack of any sulfides whatsoever. Oxidation in this area may have been particularly intense, possibly obliterating all of the paleo-exposed sulfide minerals. In fact, the only sulfides seen to date in the Tin stope have come from one small area at coordinates 1965N, 515W, 15 feet above the level. These occur as disseminated grains to 1 mm distributed throughout quartz and include the following species: arsenopyrite, chalcopyrite, sphalerite, and pyrite. Surely, other phases must be present as well, but these will require significantly more analytical time to discover.

Mineralogy of the Country Rocks

Petrographic thin section examination by Stevens (1971) of the various rocks exposed throughout the mine workings at Majuba has fully characterized their mineralogy. These species are here included simply for the sake of completeness, and almost any sample of the specific rock types is likely to contain all of the respective minerals. Within the Triassic argillite, the following constituents are present: quartz (to 40 percent), chlorite (varietal species chamosite), sericite (muscovite), heavy minerals less than 1 percent (rutile, sphene (titanite), and tourmaline (schorl)), carbonate to 5 percent (calcite), and clay minerals. The rhyolite exposed throughout most of the mine workings (older rhyolite of Stevens (1971)) consists of the following: quartz (10 to 15 percent), sericite (muscovite), sanidine (0.5 to 1 mm grains), plagioclase (albite, 0.5 to 1 mm grains), tourmaline (schorl), and clay minerals.

At local exposures of the Triassic argillite along the ribs of the lower adit, small, thermally metamorphosed pods to 10 cm have been noted. These possess assemblages characteristic of contact environments and consist of granular chamosite chlorite, fibrous laumontite, rare clinozoisite crystals, quartz, and clays.

Revised List of Unconfirmed Minerals

In addition to the species listed as unconfirmed earlier (Jensen, 1985, p. 71) several other minerals have been mentioned by others, but have either not been detectable as part of the current study or are unavailable for examination and verification. These include the following: halloysite (Bruce Runner advertisement, Mineralogical Record, 1985, p. 100), hematite replacing arsenopyrite in the Tin stope (Stevens, 1971, p. 72), and enargite as a minor constituent of chalcocite pods from the Copper stope (MacKenzie and Bookstrom, 1976, p. 22). The three species listed as unconfirmed earlier (Jensen, 1985, p. 71), cornetite, libethenite, and rosasite, remain so.

Rumors, and that is all that they can be called, of grandiose crystals and specimens of various species from the locality continue to be dispersed. Stories describing balls to 2.5 cm of clinoclase from the Copper stope, and pharmacosiderite cubes to the same size, are totally unfounded and utterly incorrect. The sizes for all species reported in the original article on the locality, as well as this update, should be considered accurate and realistic. These are the dimensions best used for future reference.

ACKNOWLEDGEMENTS

Assistance from a number of individuals has been rendered and is greatly appreciated. First and foremost, Dr. Eugene E. Foord is to be thanked for all efforts in studying, testing, and describing the various minerals he has examined. Dr. Bill Wise provided XRD data and confirmation of luetheite. Sharon Cisneros, Juanita Curtis, and Dave Lehecka all generously provided specific expertise and exemplary specimens for examination. In addition to editorial and collecting assistance, Madson Doggrell provided numerous and highly varied contributions. Craig Gibson aided with ore microscopy examination of many polished sections. David Davis prepared the selfsame samples. Melissa Forson provided excellent typing skills. Appreciation is also extended to three separate referees, whose comprehensive editorial reviews of the manuscript improved it greatly.

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TABLE 1. Revised list of species known from the Majuba Hill mine(s), Pershing County, Nevada.

AGARDITE-(Ce)
AGARDITE-(Y)
ALBITE
ALLANITE-(Ce)
ANATASE
ARSENOPYRITE
ARTHURITE
ATACAMITE
AZURITE
BISMUTH
BISMUTHINITE
BORNITE
BROCHANTITE
BROOKITE
CALCITE
CASSITERITE
CHALCANTHITE
CHALCOCITE
CHALCOMENITE
CHALCOPHYLLITE
CHALCOPYRITE
CHAMOSITE
CHENEVIXITE
CHLORARGYRITE
CHRYSOCOLLA
CLINOCLASE
CLINOZOISITE
CONICHALCITE
CONNELLITE
COPPER
CORNUBITE
CORNWALLITE
COVELLITE
CUBANITE
CUPRITE
CYANOTRICHITE
DIGENITE
FLUORITE
GOETHITE
GOUDEYITE
GYPSUM
IODARGYRITE
JAROSITE
KAOLINITE
LANGITE
LAUMONTITE
LAVENDULAN
LUETHEITE
MAGNETITE
MALACHITE
METATORBERNITE
METAZEUNERITE
MIXITE
MOLYBDENITE
MONAZITE-(Ce)
MONTMORILLONITE
MUSCOVITE (sericite)
OLIVENITE
ORTHOCLASE (adularia)
PARNAUITE
PHARMACOSIDERITE
POSNJAKITE
PYRITE
PYROLUSITE
PYRRHOTITE
QUARTZ
RHABDOPHANE-(Ce)
RUTILE
SANIDINE
SCHORL
SCORODITE
SILVER
SPANGOLITE
SPHALERITE
STANNITE
STRASHIMIRITE
TENORITE
THENARDITE
TITANITE
TORBERNITE
TYROLITE
UNKNOWN-1
XENOTIME
ZEUNERITE
ZIRCON

Figure Captions:

Figure #:

1. Entrance to the middle adit portal, Majuba Hill mine, 1991. Very little has changed here since the last mining occurred in the 1950's, especially the beautiful view and tranquil silence.

2. Agardite-(Ce) groups, average diameter 0.8 mm, on quartz and goethite, from the Tin stope, at coordinates 1965N, 515W, 15 feet above the level.

3. Black anatase crystals to 0.1 mm associated with radial aggregate of schorl needles and central core of quartz, from crosscut 216, middle adit.

4. Chlorargyrite crystal, 40 microns across, modified by the first order octahedron (typical for the locality), resting upon scorodite crystals, from coordinates 1965N, 515W, 15 feet above the level, Tin stope.

5. Connellite, 0.1 mm in diameter, on chrysocolla on arsenopyrite, from the Copper stope, coordinates 1740N, 415W, about 10 feet above the level.

6. Green, euhedral cornwallite crystal 25 microns in diameter, grown upon a schorl needle, from coordinates 1970N, 500W, middle adit.

7. Red to black cuprite crystals, two generations, from the Copper stope; width of view is 18 mm.

8. Cuprite, modified by the first- and second-order octahedrons, about 30 microns across, on top of elongated cubic cuprite crystal, from the Copper stope.

9. Turquoise-blue, pseudohexagonal twinned langite crystals to 9 microns, from the Copper stope.

10. Lavendulan, 1.0 mm across, on chrysocolla, from the Copper stope, at coordinates 1740N, 415W, about 10 feet above the level.

11. Tan spherical aggregates 10 microns across of tabular leutheite crystals from the Copper stope.

12. Dark forest-green, bow-tie group 0.5 mm across of parnauite crystals from the Copper stope.

13. Clustered group of rhabdophane-(Ce) crystals associated with schorl needles, from crosscut 216, middle adit; width of view is 90 microns.

FIG. 1

FIG. 2

FIG. 3

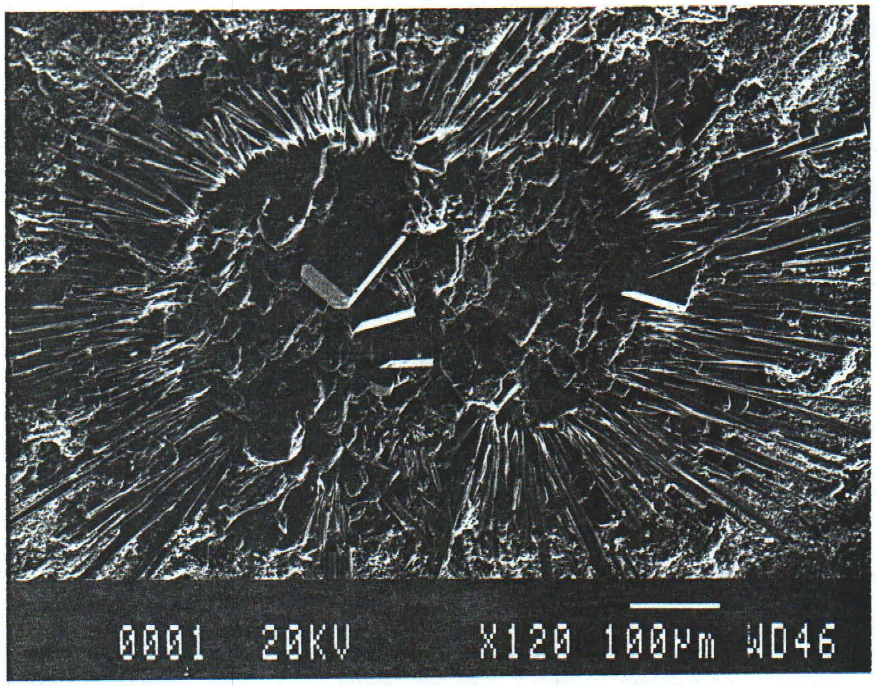
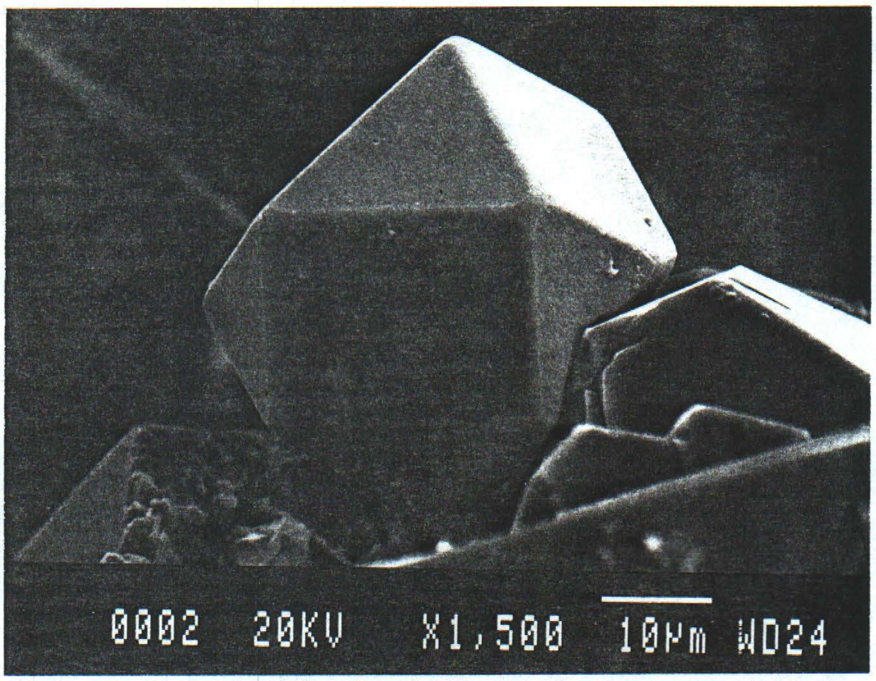


FIG. 4



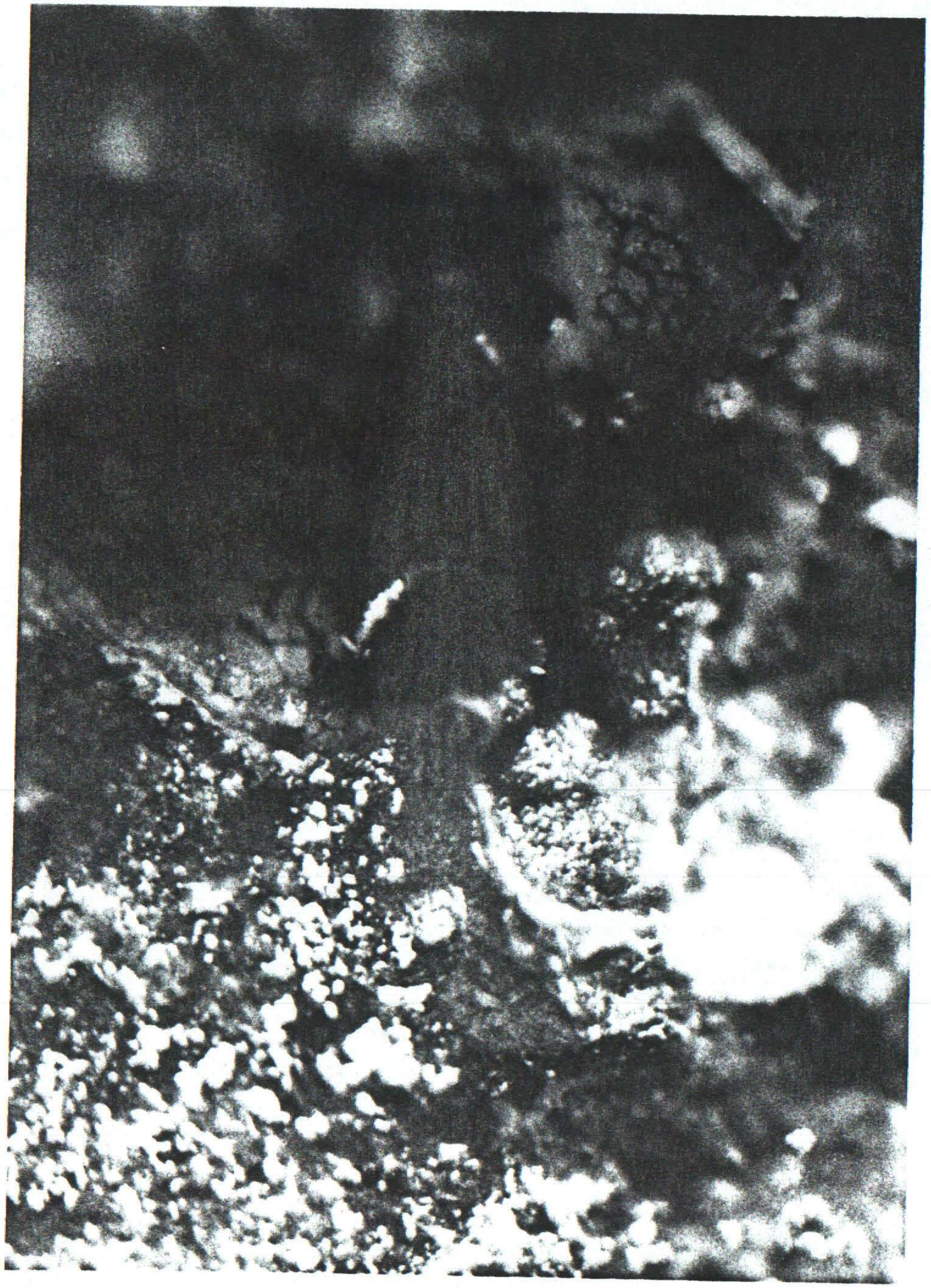


FIG. 5

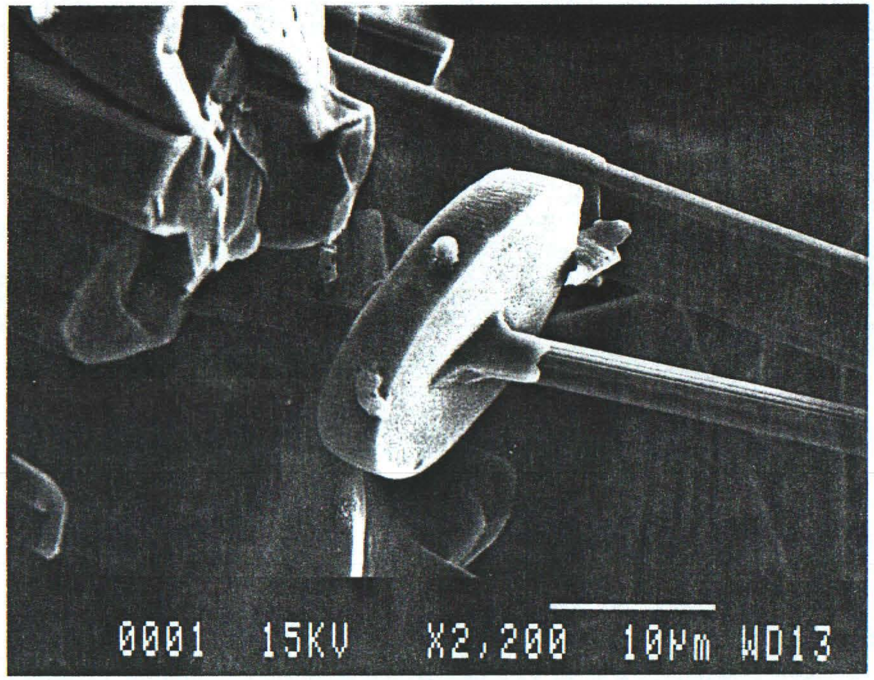


FIG. 6

FIG. 7

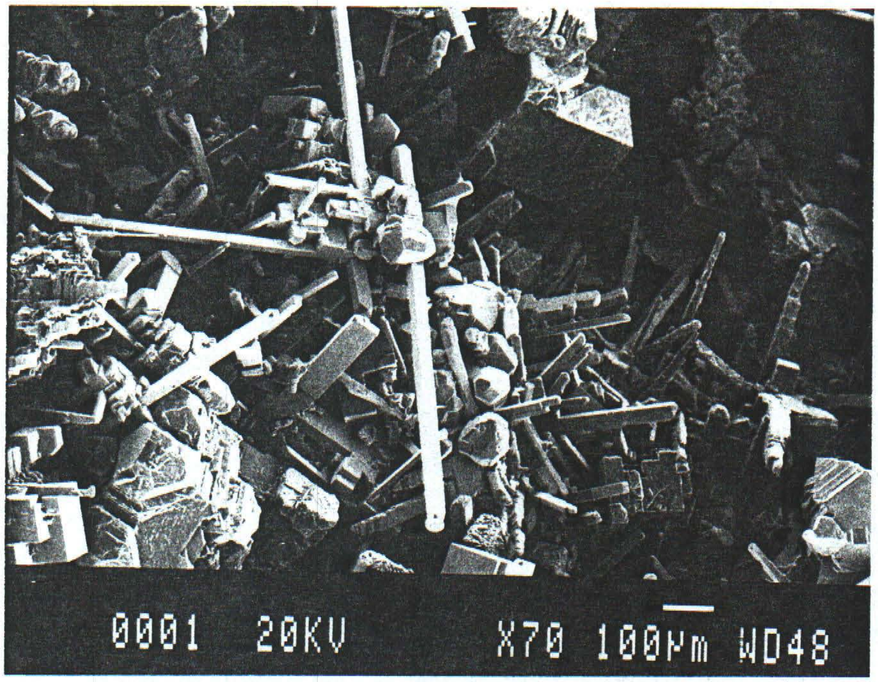
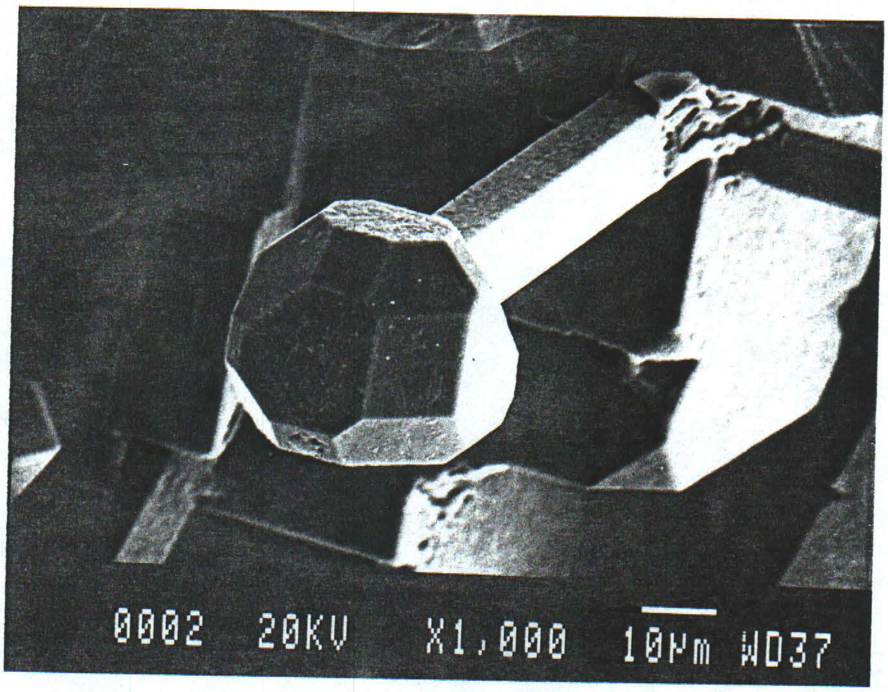


FIG. 8



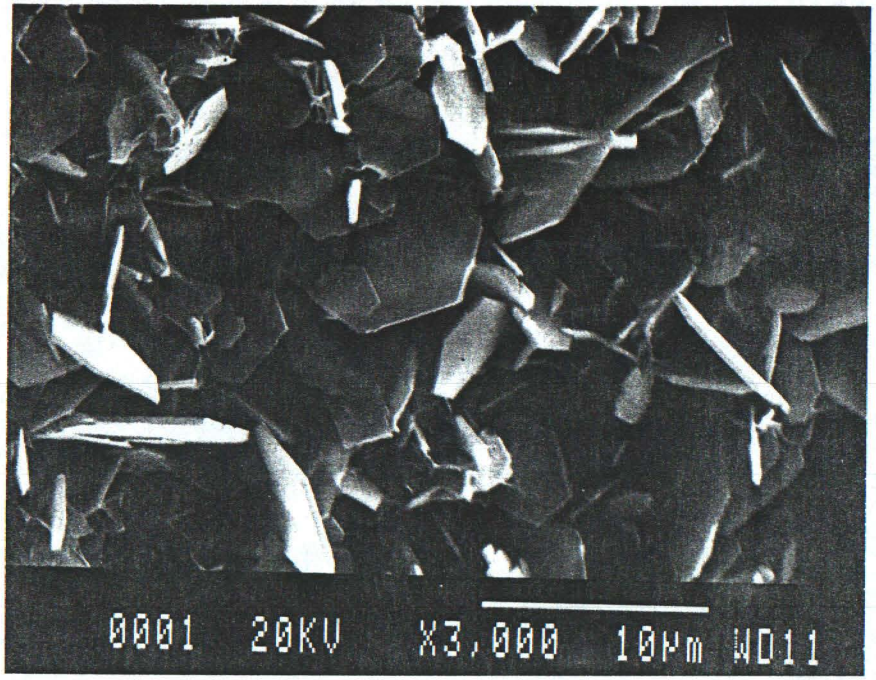


FIG. 9

FIG. 10

FIG. 11

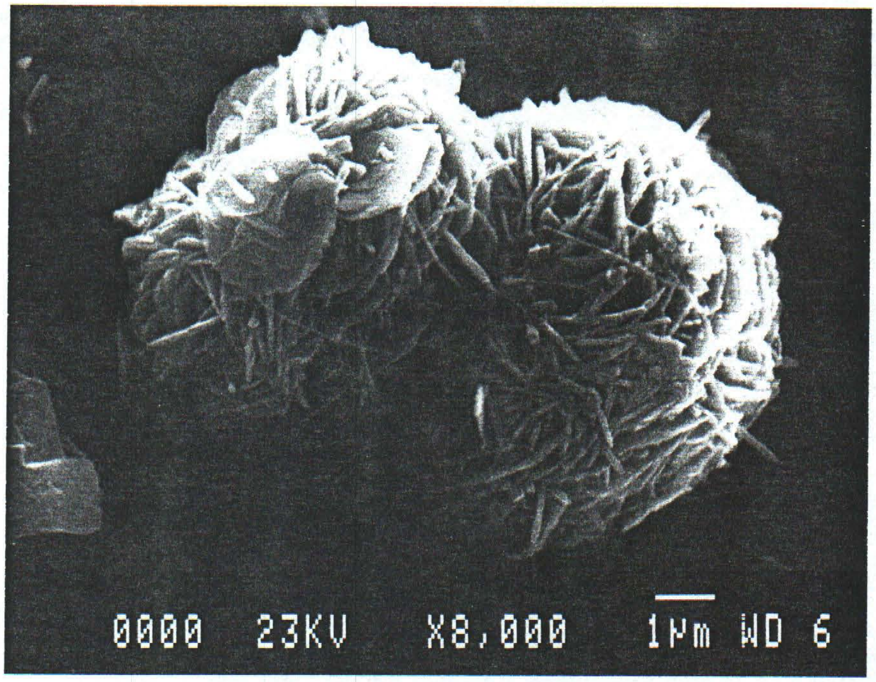


FIG. 12

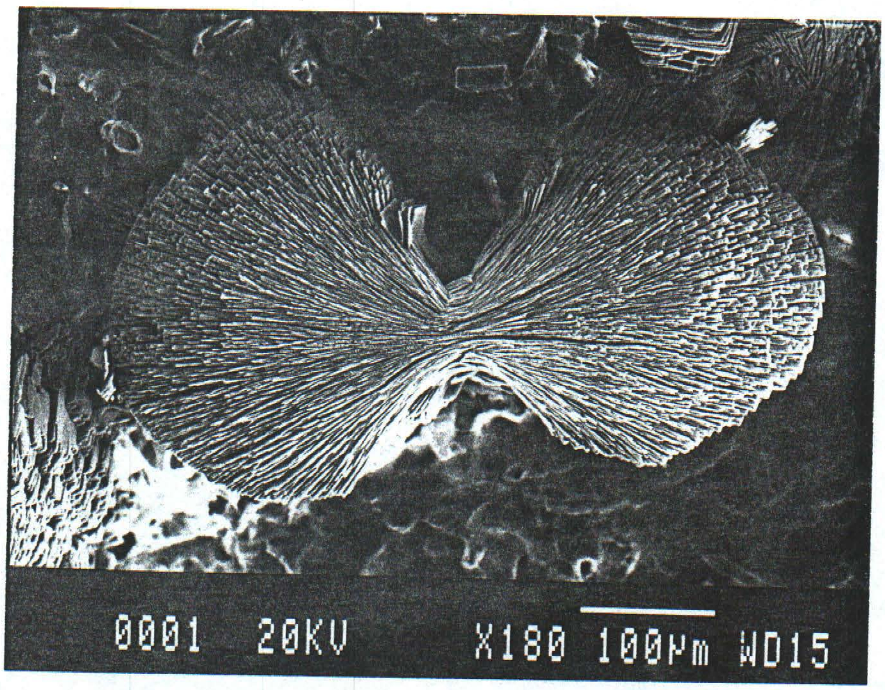


FIG.13