THE VAUGHN MINE, SANTA CLARA COUNTY, CALIFORNIA

By
Gail E. Dunning
773 Durshire Way
Sunnyvale, California 94087

Bay Area Mineralogists Report

INTRODUCTION

The Vaughn mine is located in the eastern corner of Santa Clara County (not San Benito County) along the Diablo Range (36° 58' N., 121° 16' W., MDM) in the low rolling hills off Highway 156. This small mine explores a low-grade siliceous serpentinite rock that hosts thin veins of cinnabar with minor metacinnabar, eglestonite, calomel, native mercury and an un-described mercury sulfide-chromate. The mine workings consist of a single inclined shaft about 10 meters deep with no drifts. The opening is mostly caved with loose soil and debris. The surrounding area is covered by scattered siliceous serpentinite with silica veins and coatings. These coatings are mainly composed of chalcedony with a later coating composed of complex cubic crystals of quartz pseudomorphs after melanophlogite.

In the late 1960's the author attained permission to visit the mine with two other collectors. Exploration of the surrounding area yielded only an occasional sample of cinnabar. The inclined shaft was explored to a depth of about 10 feet but due to the abundant dirt, no mineralized rock was noted.

HISTORY

Recorded mining history for this mine is lacking. The mine is not mentioned in any of the early mining history journals of California. From the size of the inclined shaft and the dump, there was very little ore recovered and was probably processed at one of the several retorts in the Stayton district, a few miles to the south (Dunning and Cooper, 1989).

GEOLOGY

Bailey and Meyers (1941) and Bailey et al. (1964) describe the general geology of the area, including the Stayton District, a few miles to the south. Tertiary igneous rocks that extend over an area of about 260 square kilometers underlie the surrounding area. Exposures of pre-Tertiary rocks are relatively small and lie mainly in the lowest canyon bottoms and around some volcanic plugs that have upturned the invaded rocks. Folded and faulted rocks of the Franciscan assemblage (pre-Tertiary) form the basement throughout most of the area but no dominant structural trend was recognized in them.

Another group of pre-Tertiary rocks includes serpentine and masses of silica-carbonate rock derived from alteration of the serpentine by siliceous solutions. This serpentine is intrusive into the Franciscan rocks but nowhere cuts the Cretaceous rocks. It is within these silica-carbonate

units that the mercury-bearing solutions invaded and formed cinnabar. Also, cinnabar invaded the weakly silica altered serpentine along thin fracture veins. Fractures within the silica-carbonate rock contain abundant quartz pseudomorphs after melanophlogite. Post alteration of selected zones of cinnabar by chloride-rich solutions formed minor eglestonite and calomel.

MINERALOGY

Several ore samples were made available for study, which were originally collected by Dennis Sorg, retired geologist of the USGS, Menlo Park. These samples were then given to the late Ed Oyler, an ardent explorer of mercury deposits of California. The Mineralogical Research Company eventually acquired these samples. The late Richard Erd identified several of the mercury minerals using X-ray powder diffraction methods.

Optical examination of these samples revealed mostly massive cinnabar with rare crystals lining small cavities. On several of the samples a fine-grained light yellow coating was noted that was identified as one of the unknowns from the Clear Creek mine, San Benito County. Also noted was a fine-grained gray coating on several samples of cinnabar. A transparent to white mineral was also noted that gave a red fluorescence under SWUV. Several of these questionable minerals were submitted for EDS analysis.

Mercury Minerals

Cinnabar HgS

Cinnabar was the principal mercury-bearing mineral mined at the Vaughn mine. It occurs as thin fracture fillings within the low-grade silicified serpentinite and associated with quartz in wider fractures up to several mm. Some crystallization was noted but the majority of the cinnabar is massive. The cinnabar is bright and shows little effect of alteration, such as a frosty appearance often noted in deposits where the Eh-pH levels have changed to a more basic condition.

Fluid conditions with more positive Eh values can slowly dissolve cinnabar and produce ions that can combine with other ions to form secondary phases, such as mercury oxychlorides and calomel. The rare areas of the examined samples that show minor dissolution have produced these secondary minerals.

Metacinnabar HgS

Black metacinnabar was identified from the ores by R. C. Erd using X-ray powder diffraction methods. No metacinnabar was noted on any of the current examined samples.

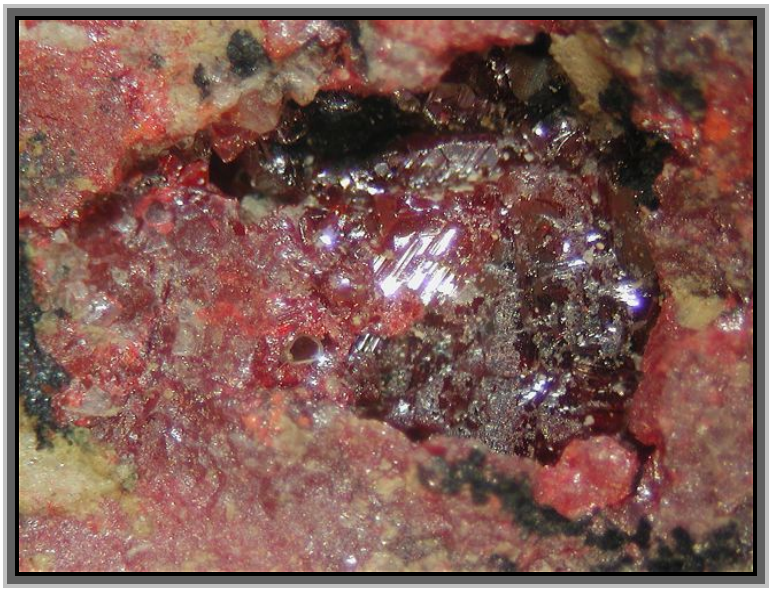

Figure 1. Embedded cinnabar crystal in massive cinnabar. The black coatings are pyrolusite. FOV = 4.5mm

Eglestonite $Hg_6Cl_3O(OH)$

Yellow coatings of eglestonite micro crystals were noted on a several samples examined during this study. It also occurs as rounded masses with a dark brown-yellow color, the result of exposure to sunlight. The eglestonite was identified by EDS and X-ray powder diffraction.

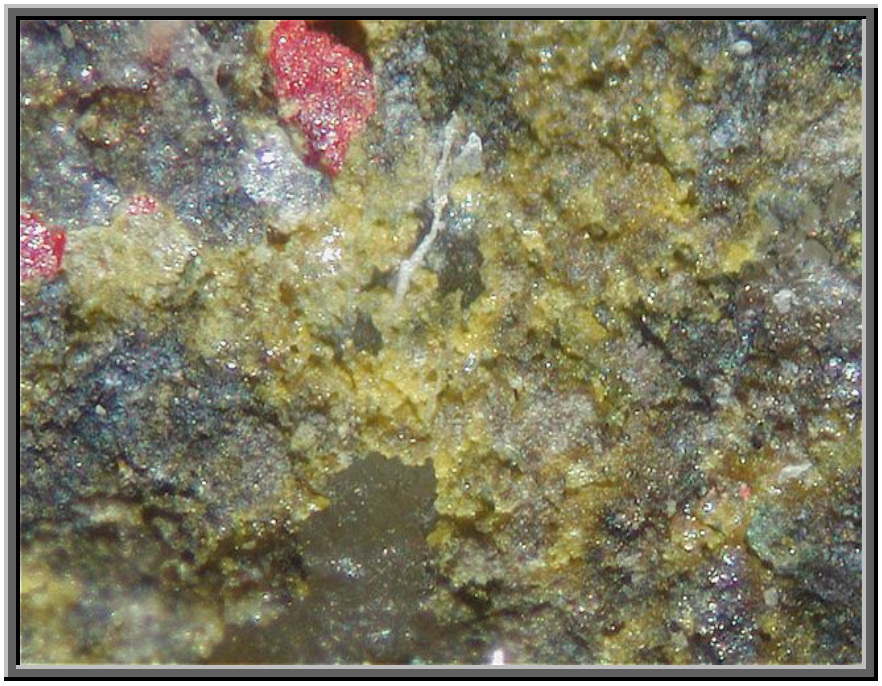

Figure 2. Subhedral to anhedral coatings of eglestonite on quartz with cinnabar. FOV = 3mm

Figure 3. Rounded masses of eglestonite on quartz. FOV = 2mm

Figure 4. Rounded masses of eglestonite on quartz. FOV = 3mm

Edoylerite $Hg_3CrO_4S_2$
Small masses and partial crystals of edoylerite were identified by R. C. Erd from shallow cavities within cinnabar and associated with ccuk-8. The edoylerite is quite rare in the ore. No edoylerite was noted in the samples examined during this study.

CCUK-8 Hydrous Mercury Sulfide Chromate
Several samples of cinnabar with cavities show very thin coatings composed of dull light yellow micro crystals were identified as ccuk-8, one of the remaining mercury-bearing unidentified minerals first noted at the Clear Creek mine, San Benito County, California (Dunning et al. 2005).

Figure 5. Fine-grained masses of CCUK-8 on cinnabar. FOV = 2mm

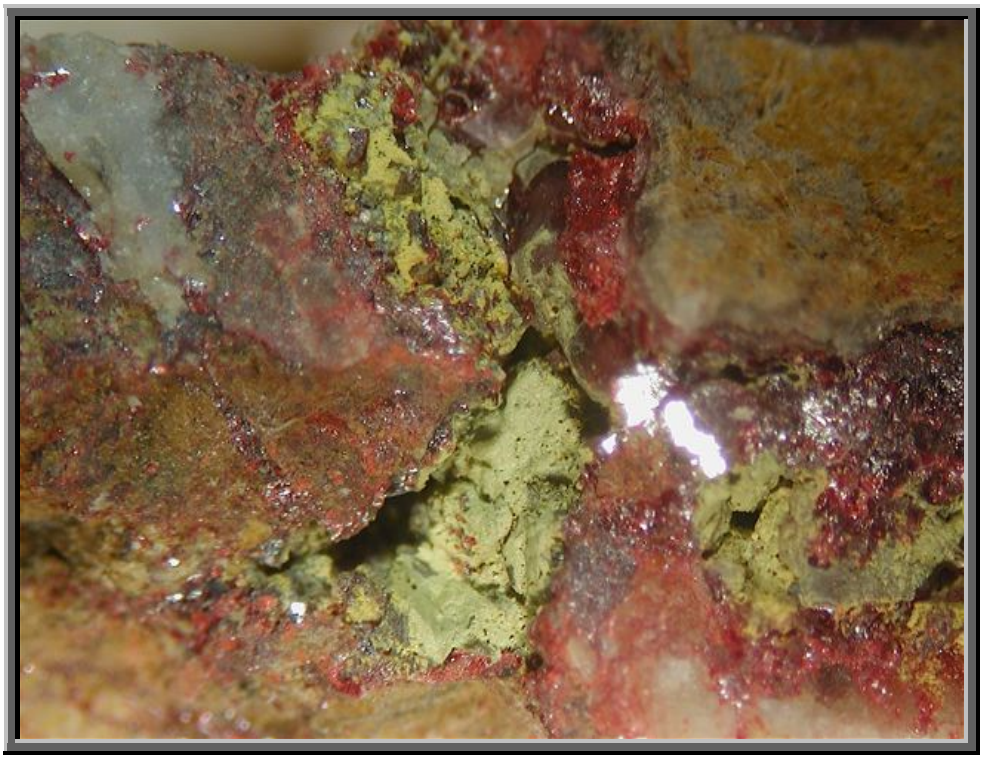

Figure 6. Fine-grained masses of CCUK-8 on cinnabar. FOV = 4mm

CCUK-14 A mercury silicate (?)

Several cavities in massive cinnabar were noted coated with a dark gray, massive material that was locally further coated with a much lighter gray, fine-grained material. An EDS of the two mixed coatings showed major Hg, Si, O, C and Cl. The consistency of Hg and Cl peaks were noted after several individual scans. The coating area was not found to be fluorescent, indicating the absence of calomel. The lighter material would suggest a mercury silicate very similar to that discovered at the Clear Creek mine and also at the Picacho mine. The darker material beneath the lighter coating may represent a fine-grained eglestonite, indicated by the consistent levels of Hg, O, and Cl. The carbon remains unresolved and is not related to calcite because no Ca was noted in any of the scans. A carbonate of Hg may be realized but has yet to be established. A carbonate of Hg was noted by EDS and X-ray powder diffraction from the Challenge Prospect, Redwood City (Dunning, 2009). Since the coating appears to be a mixture of the above phases, it would be difficult to separate the individual phases to confirm the existence of a carbonate of Hg.

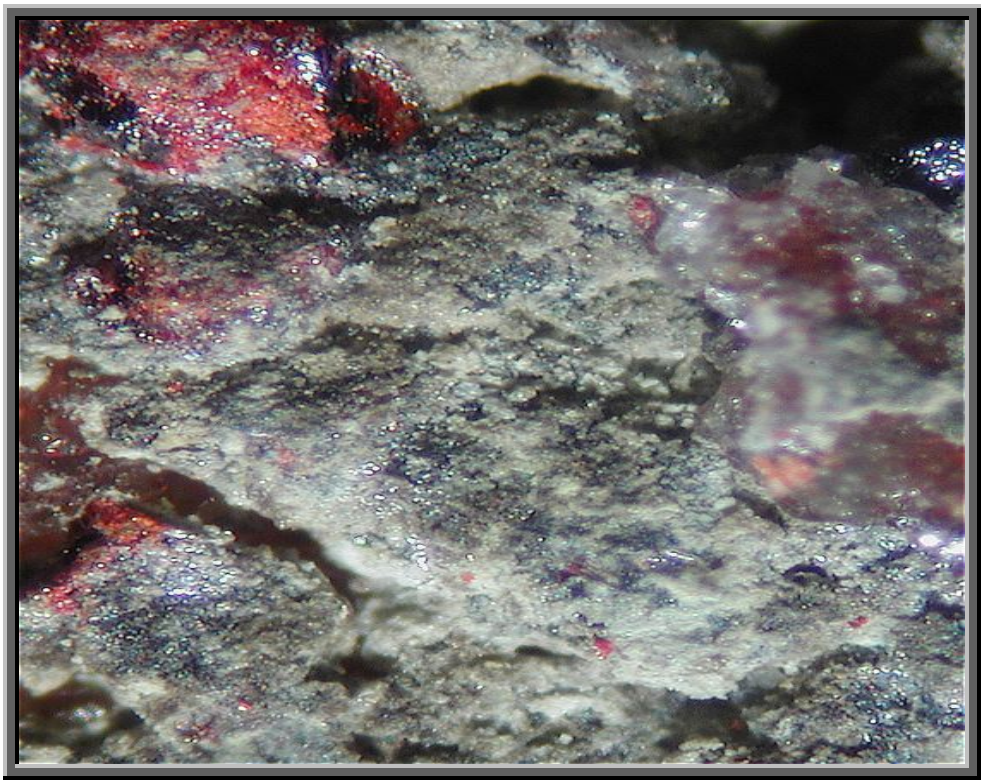

Figure 7. Thin coating of light gray CCUK-14(?) and eglestonite(?) and a mercury carbonate(?). FOV = 3mm.

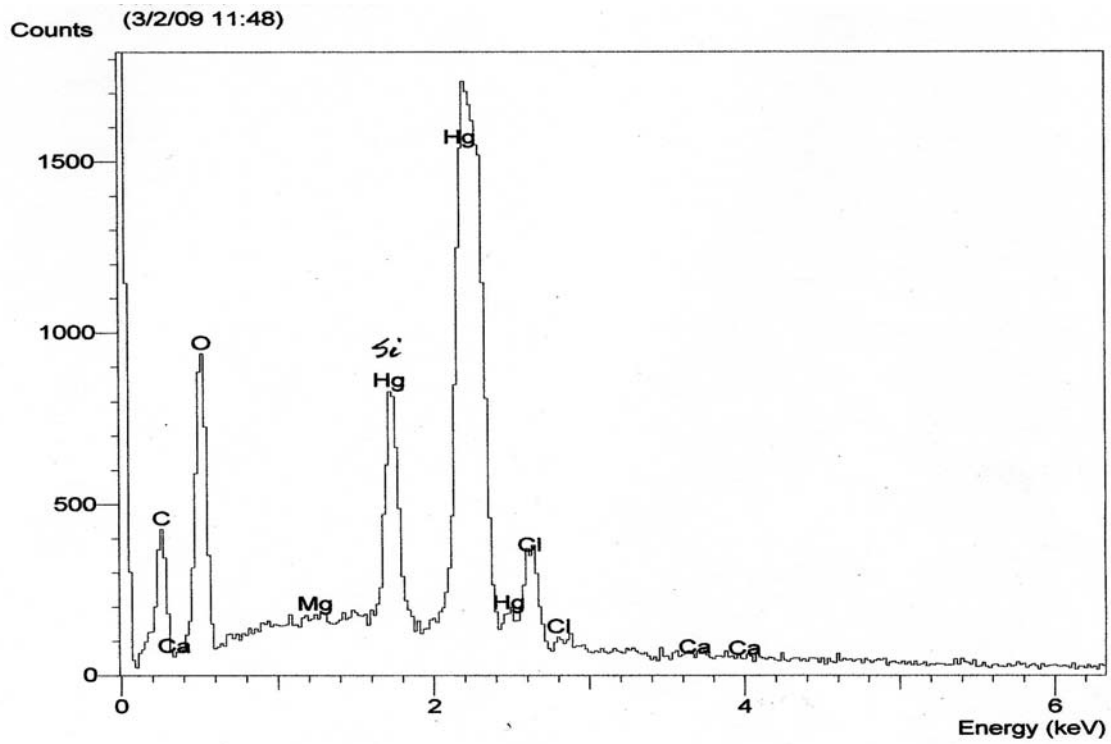

Figure 8. EDS chart for the gray coatings on cinnabar showing appreciable levels of Hg, Cl, Si, O, and C. 10 KeV excitation.

Calomel Hg_2Cl_2

Calomel has been identified in the samples as compact, subhedral to anhedral grains associated with cinnabar and rare native mercury. It was identified by its red fluorescence under SWUV light and by it distinctive EDS spectrum. In one sample it occurs with a mixture of eglestonite against a layer of cinnabar. Calomel is confined to a region of the pH-Eh chart with high Eh and low pH where Hg^{1+} is stable and cinnabar is not. The oxychlorides of Hg are also stable in this region.

Figure 9. Complex mass of subhedral to anhedral grains of calomel in cinnabar. FOV = 4mm

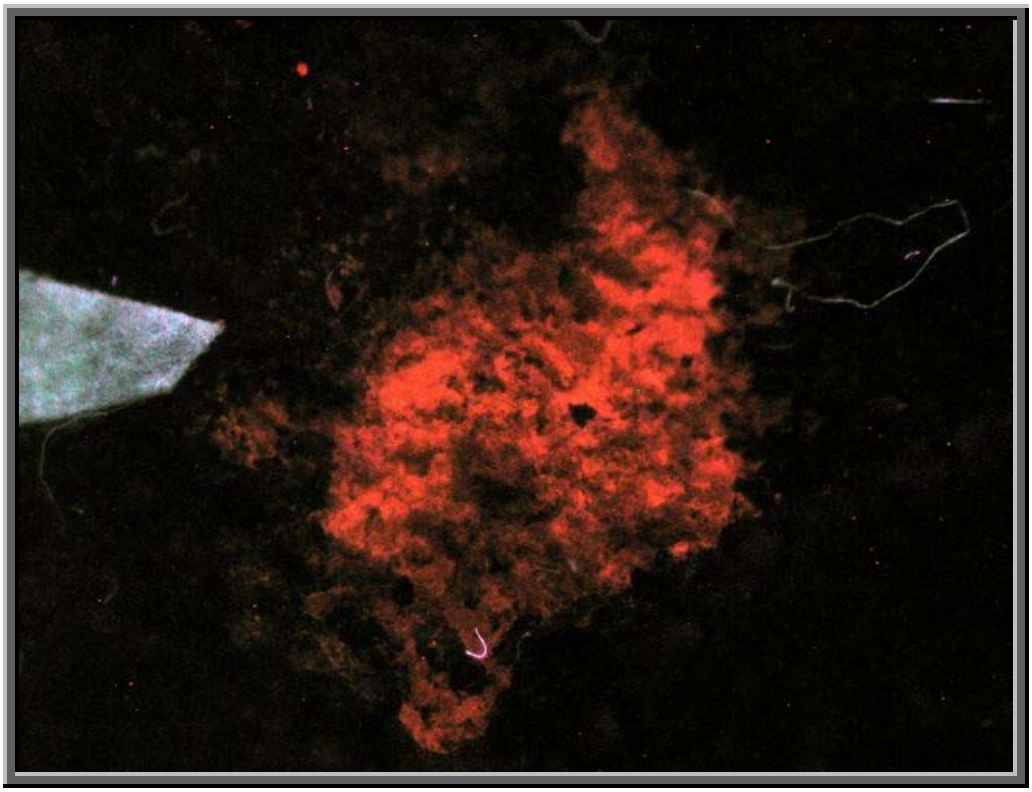

Figure 10. Calomel (Figure 9) as seen under SWUV light.

Figure 11. Enlargement of Figure 9 showing the subhedral to anhedral calomel associated with cinnabar. FOV = 2mm

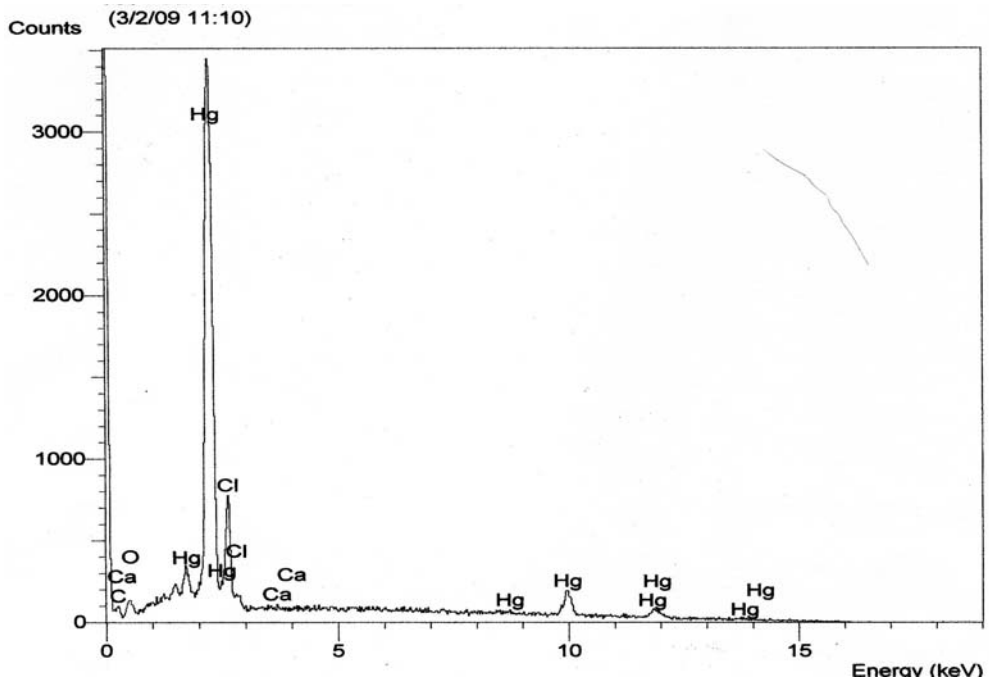

Figure 12. EDS scan of calomel showing major Hg and Cl. 20 KeV excitation.

Mercury Hg
Rare native mercury was identified associated with calomel within enclosed elongated cavities along seams rich in cinnabar. In some instances minor eglestonite is associated with the calomel.

Associated Minerals

Pyrite FeS
Some massive pyrite was noted by R. C. Erd from samples he examined.

Pyrolusite MnO_2
Pyrolusite dendrites are common in the samples examined and occurs as shinny black coatings along fractures in the serpentinite associated with cinnabar.

Quartz SiO_2
Minute cubic crystals covering cavities in the weathered silica-carbonate rock have been identified as quartz pseudomorphs after melanophlogite by optical and X-ray diffraction methods.

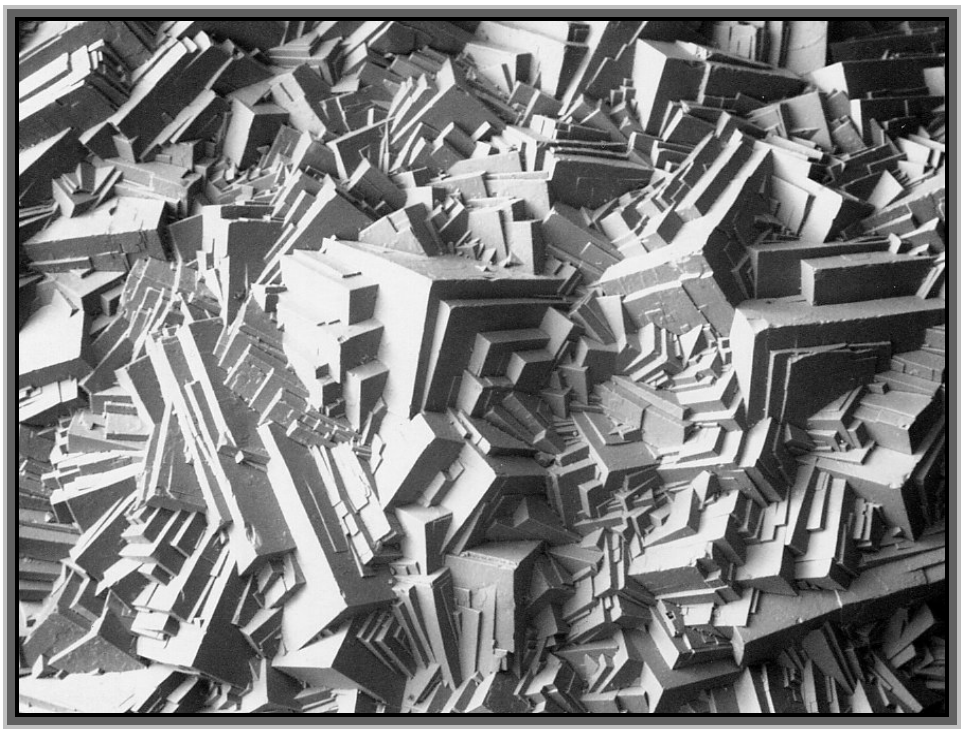

Figure 13. Complex intergrowth of quartz pseudomorphs after melanophlogite. FOV = 0.25 mm

PARAGENESIS

The paragenesis sequence for the Hg mineralization of the Vaughn mine is straightforward. Initial mercury mineralization along the fractures of the low-grade silicified serpentinite consisted of cinnabar with minor metacinnabar and possible native mercury. The majority of the cinnabar is quite shinny, suggesting that post-depositional pH-Eh conditions were moderate, localized and of short duration. Moderate to high pH conditions existed along some serpentinite fractures to alter the magnesiochromite, producing small amounts of chromate, which formed isolated edoylerite and later, CCUK-8. Also during this latter period of mineralization, thin coatings of pyrolusite formed along seams containing cinnabar. The dendritic structure of the coatings would confirm the identification. The lack of carbonates within the mineralized zone kept the pH moderate (below 4) and favored the formation of calomel and eglestonite. The Hg^{1+} specie may be the product of disproportionation of cinnabar. The suspected existence of the Hg silicate, CCUK-14, coating what appears to be eglestonite is interesting and may represent a final alteration of selected cinnabar rounded grains (crystals?) in cavities.

Table 1. Paragenetic timeline for the Vaughn mine mercury mineralization.

Mineral	*Early* *Late*
Cinnabar	————
Metacinnabar	————
Mercury	————
Calomel	————
Eglestonite	————
Edoylerite	————
CCUK-8	————
CCUK-14(?)	————
Hg Carbonate(?)	————
Pyrolusite	————

ACKNOWLEDGMENTS

The author gratefully acknowledges the photographic skills of William Lechner in providing the photos shown. Also Don Howard is thanked for providing the EDS scans to complete this study. The late Dr. Francis Jones provided the optical identification of the quartz pseudomorphs after melanophlogite.

REFERENCES

BAILEY, E.H. and MEYERS, W.B. (1941) Quicksilver and antimony deposits of the Stayton district, California. *U.S. Geological Survey Bulletin* **931-Q**, 405-432.

BAILEY, E.H., IRWIN, W.P., and JONES, D.L. (1964) Franciscan and related rocks and their significance in the geology of western California. *California Division of Mines Bulletin*, **183**, 177 p.

DUNNING, G.E. and COOPER, J.F., Jr. (1989) Stibnites of the Stayton District, Hollister, California. *Mineralogical Record*, **20**, 427-438.

DUNNING, G.E. and COOPER, J.F., Jr. (2002) Pseudomorphic Melanophlogites from California. *Mineralogical Record,* **33**, 237-242.

DUNNING, G.E., HADLEY, T.A., CHIRSTY, A.G., MAGNASCO, J. and COOPER, J.F., Jr. (2005) The Clear Creek Mine, San Benito County, California: A Unique Mercury Locality. *Mineralogical Record*, **36**, 337-363.

DUNNING, G.E. (2009) The Challenge Mercury Prospect, Redwood City, San Mateo County, California. *BAM Journal*, **10.**