Tips and Trips

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THE MINERAL HERITAGE PROJECT

A Unique Zeolite, Quartz, Tourmaline Occurrence in the Western San Gabriel Mountains, Los Angeles County, California

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PREFACE

The information in this paper was first discovered while I was an undergraduate student in Earth Science at California State University, Northridge. At the time it was the subject of an independent mineral exploration in the western San Gabriel and Sierra Pelona Mountains of Southern California; undertaken during the summer of 1973. Shortly after all the research and exploration notes were collected they were misplaced and were believed to be lost. Thirty six years later they were found while cleaning out boxes of old records. Because this mineral occurrence is so unusual the decision has been made to publish the findings, even though late by thirty six years!

INTRODUCTION

During the summer of 1973, while engaged in exploration of the western San Gabriel and Sierra Pelona Mountains, Los Angeles County, California; I discovered a small tourmaline, quartz, zeolite deposit. The mineral occurrence is in an Angeles Forest Highway road cut in the San Gabriel Anorthosite. Location of the deposit is in the south-west corner of the Acton 15 minute quadrangle; north-west corner of the Chilao Flats 7.5 minute quadrangle.

A number of occurrences of schorl tourmaline are known from this region. Most notable among these tourmaline occurrences is schorl occurring as isolated crystal groups and radial sprays of crystals in the granite pegmatite swarms which intrude pre-Cambrian gabbro in the Sierra Pelona Mountains.

The zeolite laumontite occurs in this area as dusty or druzy coatings on altered anorthosite in the San Gabriel anorthosite body. The occurrence of other zeolites have not been reported from this area.

Six unique features distinguish the deposit described in this paper from previously known tourmaline or zeolite occurrences in the San Gabriel anorthosite:

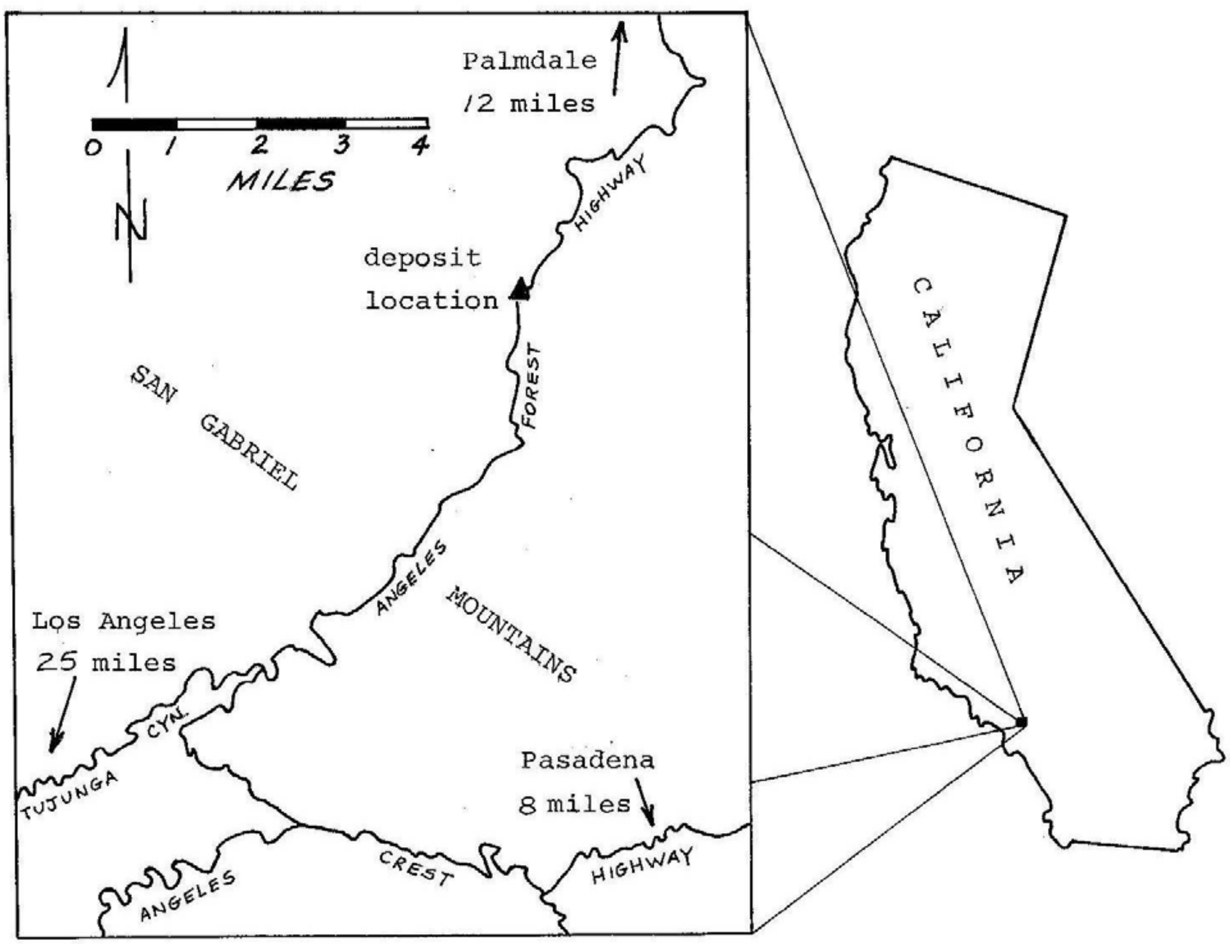
1. This tourmaline occurrence is not associated with granite pegmatite.
2. Tourmaline is present as both dravite and schorl varieties.
3. The zeolites: laumontite, natrolite, chabazite and mesolite are present in the deposit.
4. Oxidized pyrite occurs with the schorl tourmaline and laumontite as scattered crystals and irregular blebs.
5. A pegmatite-like zonal arrangement characterizes the distribution of minerals.
6. Minor amounts of epidote and zoisite occur in the upper portion of the mineral occurrence.

This mineral assemblage and its zonal arrangement make the mineral occurrence described in this paper truly unique for this area of the San Gabriel anorthosite in the western San Gabriel Mountains.

In order to better understand this unique mineral occurrence, a detailed account of the minerals present is preceded by a brief discussion of the geographic and geologic setting.

GEOGRAPHIC SETTING

The area of investigation is located in the Mill Creek – Monte Cristo region of the Angeles National Forest, in the western San Gabriel Mountains of Southern California. The mineral occurrence is found in a road cut on the Angeles Forest Highway, at an elevation of 3800 feet, three miles north of the Monte Cristo Forest Service station. Topography in the area is characterized by moderate to high relief, with slopes averaging thirty to fifty degrees. Vegetation cover is dense, consisting largely of manzanita, California juniper and minor amounts of yucca and annular grasses.



GEOLOGICAL SETTING

The area of investigation is in the eastern portion of the San Gabriel anorthosite body. This anorthosite is a pre-Cambrian plutonic body, the surface expression of which approximates an oval sixty square miles in area. Granite and granidiorites of Mesozoic age surround the anorthosite body. Oakeshott (1958) has determined the composition of the anorthosite in this area to a combination of andesine and labradorite feldspar.

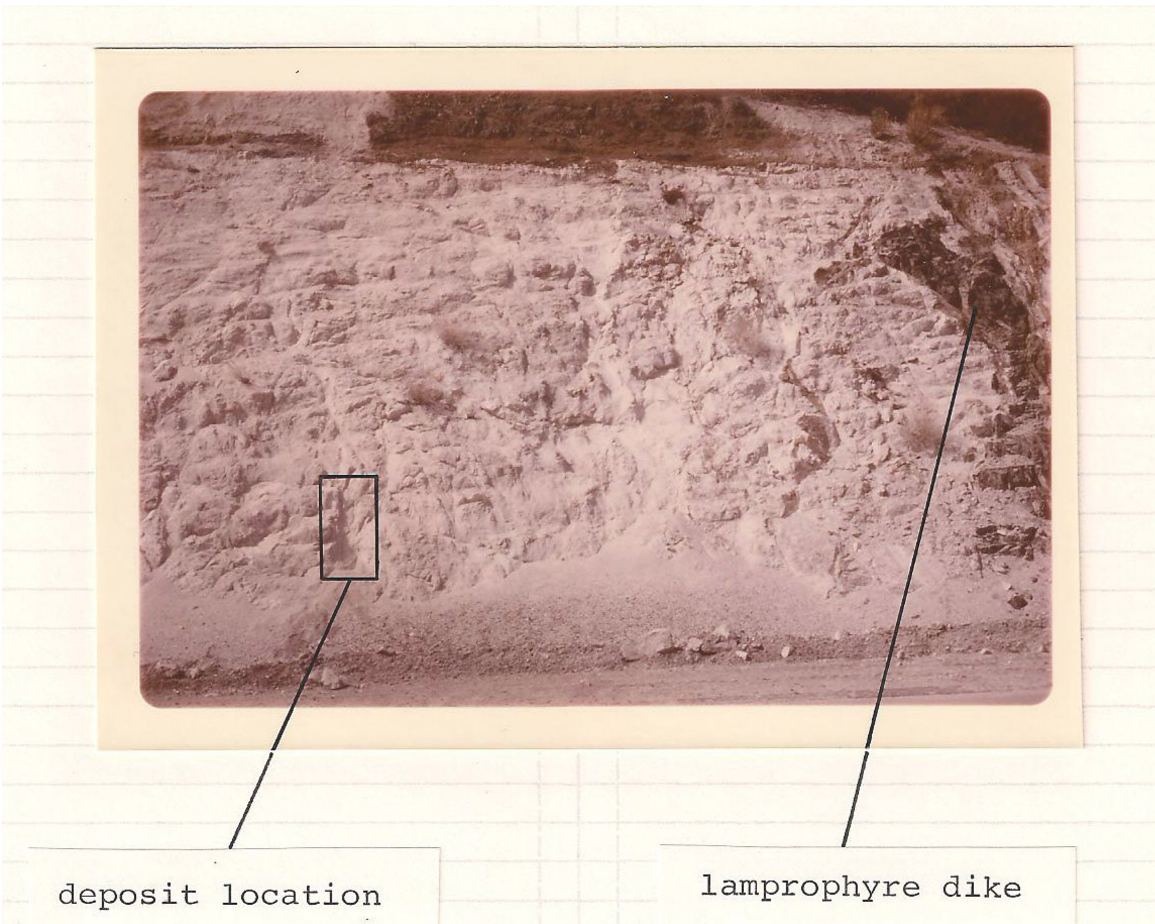
Lamprophyre dikes and magnetite-ilmenite lenses interlace the boundary regions of the anorthosite body. These lamprophyre dikes were formed by the injection of residual mafic magma into the crystallizing and crystallized anorthosite. Oakeshott (1958) gave the age of these dikes as Cretaceous or possibly Tertiary. The magnetite – ilmenite lenses are primary in origin; deposited from the residual iron rich fraction of the anorthosite parent magma.

A small number of diklets and irregular masses of granite pegmatite also occur in this anorthosite body. I believe the deposit described in this report to be of this type. Oakeshott (1958) explained the formation of these pegmatites as the injection of silicious liquids along planes of weakness in the older rocks. Minor tourmaline (variety Schorl) occurs in only a few of the larger pegmatite masses. Zeolites have not been reported in any of these granite pegmatites.

In the area of investigation, the anorthosite has been severely shattered in a zone approximately one hundred feet wide and trending east – west. Due to heavy vegetation cover the lateral extent of this zone was impossible to trace. A small vein of clear quartz and schorl tourmaline, bearing N85°W occurs in the central portion of the shattered zone. Just below the surface of the road cut, the vein has expanded to fill a vertical zone of weakness. As a result, the entire deposit has the appearance of an almond shaped bulge surrounding the parent vein. Maximum dimensions of the mineral deposit are: 4 X 12 X 26 inches for the expanded portion and 2 inches for the width of the parent vein. Parallel to the mineral deposit and within four feet of it, are several discontinous vug filled veins of laumontite and veinlets of anhedral schorl tourmaline and epidote. Scattered throughout the shattered zone are small (less than one half inch in width) discontinuous tourmaline free quartz veinlets. Also scattered throughout this zone are small nodules and stringers of chlorite surrounded by a border of anhedral epidote and zoisite. Numerous pods of chlorite schist, associate with the large lamprophyre dikes, are also found in this area. The chlorite is believed to an alteration product of the lamprophyre material.

The shattered zone carrying the tourmaline-zeolite deposit may be related to a major left separation, N40°E trending, fault which lies in the Mill Creek-Monte Cristo area. Scattered throughout a zone, one quarter mile wide, extending approximately one mile north-east of the tourmaline-zeolite deposit (roughly coincident with the fault trace) are numerous very small (less than one-quarter inch in width) discontinuous, epidote and zeolite free shorl tourmaline bearing quartz veinlets. Scattered occurrences of epidote are found all along the fault trace.

Two miles east of this mineral deposit are the Monte Cristo and Black Cargo mines. Gold is found in both the Free State and substituting for iron in oxidized pyrite which is associated with a large quartz vein system. No tourmaline or zeolites have been reported from the Monte Cristo or Black cargo deposits. No mineralogical similarities could be found between the pyrite found in the deposit described in this paper and the pyrite found in the Monte Cristo-Black Cargo deposits. Figure – 2 shows the location of the deposit in the Angeles Forest Highway road cut.



SAMPLING EQUIPMENT AND METHODS

A succession of “slices” were taken from the exposed portion of the mineral deposit by superimposing a wire grid composed if 1 X 1 inch squares over the exposed surface. By sampling each square to a depth of 2 inches an accurate reconstruction of the deposit was created. Figure – 3, shown below, is a reconstruction of the deposit, to a depth of 2 inches and a detailed view of the location of the various mineral species.

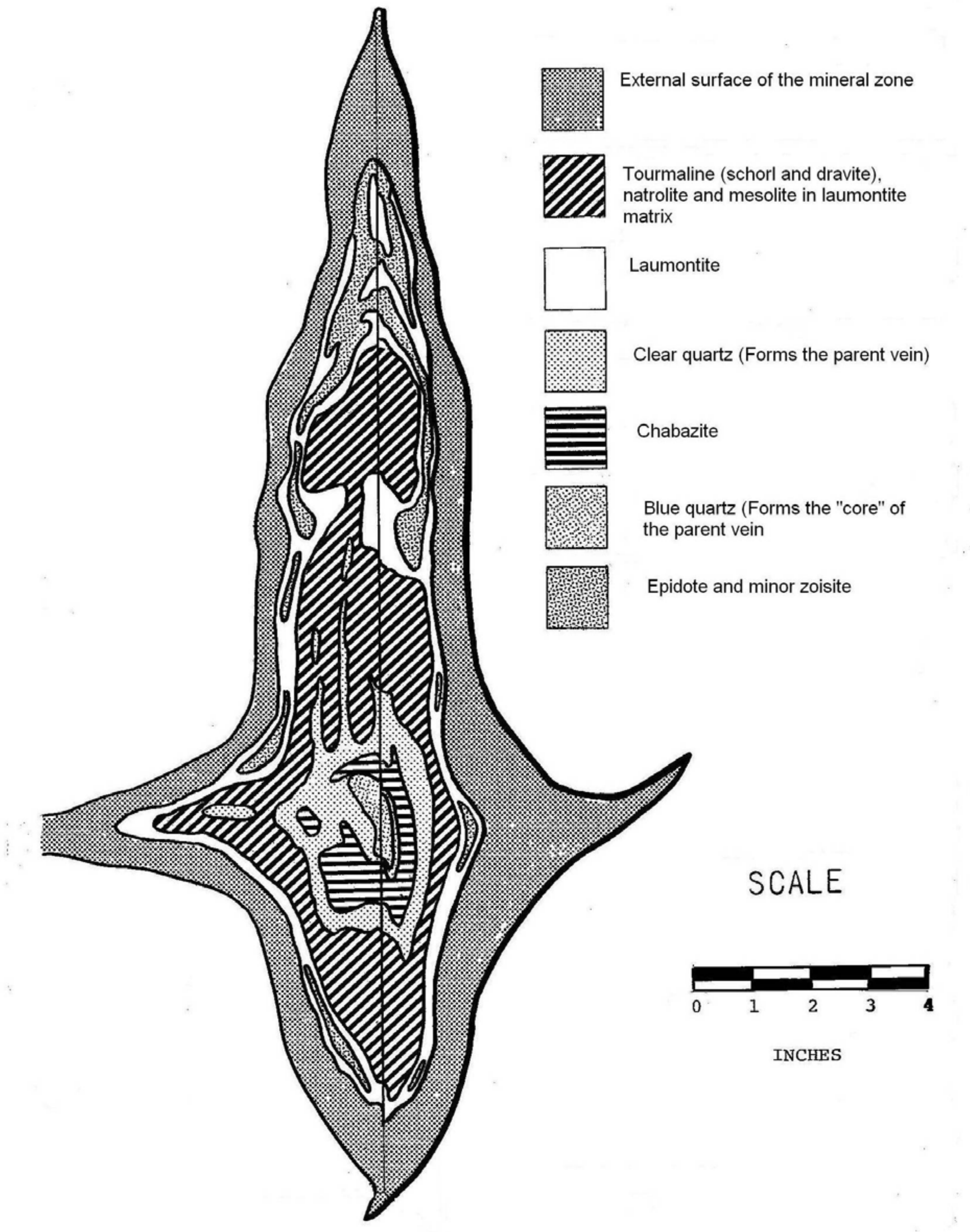


Figure – 3 Reconstruction of the mineral zone

The following analytical tools were used in the mineral analysis: A Zeiss petrographic microscope and the oil immersion method were used in conjunction with a Leica stereo microscope was used for optical analyses. X-ray diffraction and semi-quantitative spectroscopy were used for analysis of laumontite and pyrite and tourmaline. X-ray mounts were made by coating a glass slide with the powdered mineral (ground under acetone for 60 seconds). The semi-quantitative spectroscopy was done by Pacific Spectrochemical Laboratory Inc., Los Angeles, California.

MINERALS PRESENT

The following minerals are found in the deposit. (The minerals are listed according to relative abundance and location within the deposit)

MINERAL SPECIES	RELATIVE ABUNDANCE	LOCATION IN DPOSIT
Laumontite	60%	Throughout the deposit
Schorl tourmaline	16%	Throughout the deposit
Dravite tourmaline	2%	Only in the central zone of the deposit
Natrolite	7%	Only in the central zone of the deposit
Mesolite	> 1%	Only in the central zone of the deposit
Epidote	8%	Throughout the deposit
Quartz	7%	Only in the central zone of the deposit
Chabazite	2%	Only in the bottom central zone of the deposit
Pyrite	2%	Only in the central and upper portions of the deposit

Table – 1 Mineral Relative Abundance

DETAILED DESCRIPTIONS OF THE MINERALS PRESENT

LAUMONTITE $CaAL_2Si_4O_{12}•4H_2O$

Laumontite occurs in three successive generations and is the dominant mineral species in the deposit. First generation laumontite is made up of interlocking subhedral crystals elongated on the C - crystallographic axis. These crystals average 0.2 X 0.05 inches and vary in color from pure white to a pale blue white. First generation laumontite forms the bulk of the deposit and acts as matrix for first generation tourmaline.

Second generation laumontite occurs as perfect terminated crystals lining vugs in first generation laumontite. Second generation crystals average 0.1 X 0.02 inches and vary in color from opaque white to translucent grayish white. Contact and penetration twins are common in the second generation crystals. In general, second generation laumontite occurs with but does not completely enclose second generation tourmaline.

Third generation laumontite occurs in minute euhedral crystals covering some of the second generation laumontite. It also occurs as minute doubly terminated crystals impaled on acicular crystal of natrolite and mesolite. Third generation crystals average 0.001 X 0.1 inches and vary in color from cloudy white to colorless. No twinning was observed in third generation laumontite. All of the laumontite alters readily to leonhardite after being removed from the deposit.

Figure – 4 Photomicrograph of First Generation Laumontite at 25X

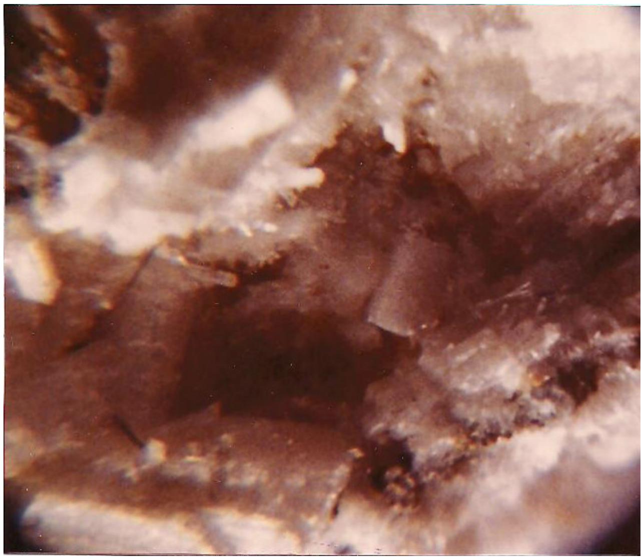


Figure – 5 Photomicrograph showing vug lined with first generation laumontite. These crystals are covered with second and third generation laumontite crystals. Image at 25X.

Figure – 6 Photomicrograph of third generation Laumontite crystals impaled on a single acicular crystal of natrolite. From a vug in the central zone of the deposit. Image at 40X.

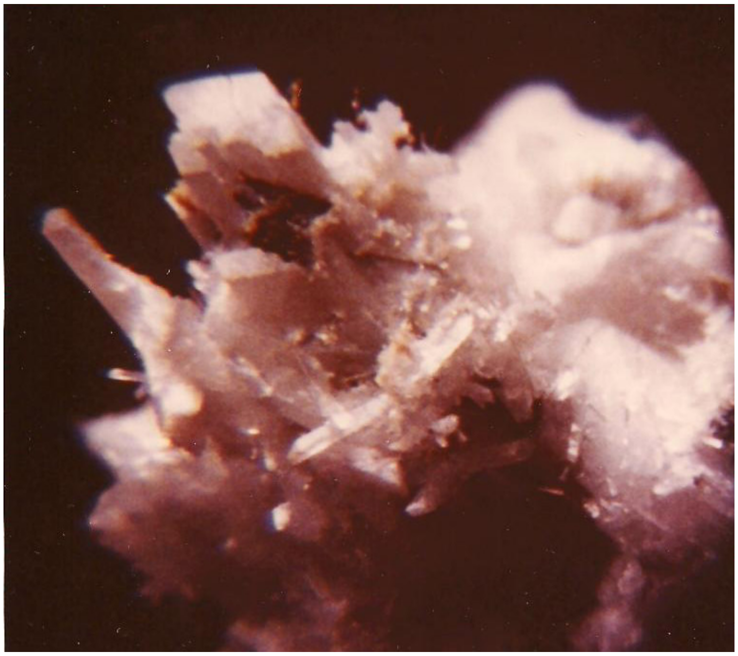


Figure – 7 Photomicrograph of a cluster of second generation laumontite with minor third generation crystals on a matrix of first generation laumontite. Specimen is from a vug in the lower central zone of the deposit. Image at 25X

X-ray diffraction and spectroscopic analyses were used to confirm the identity of this mineral. Results of these analyses are tabulated in table – 2 and table – 3.

peak intensity	100	60	35	20	30
angle 2θ	9.45	21.5	13.1	25.5	29.6
d - spacing	9.36	4.13	6.76	3.50	3.02
hkl values	110	130	200	002	420

X - ray anlysis of laumontite

(CuKα radiation)

X - ray powder pattern taken at University of California at Los Angeles, 1973.

Table – 2 X-ray diffraction data for Laumontite from the central region of the deposit.

METALLIC ELEMENTS	ABUNDANCE IN %
Silicon	64
Calcium	8
Aluminum	24
Magnesium	trace
Manganese	trace
Iron	trace
Sodium	> 1
Titanium	trace
Strontium	trace
Copper	trace
Water	2

Table – 3 Spectrographic chemical analysis of first generation laumontite

TOURMALINE $Na(Mg,Fe)_3AL_6(BO_3)_3(Si_6O_{18})(OH)_4$

Tourmaline is the next most abundant mineral in the deposit. This mineral, like the laumontite, occurs in three successive generations. First generation tourmaline, in the lower portion of the deposit, is made up of interlocking radiating sprays of euhedral black schorl crystals. In the upper portion of the deposit, tourmaline occurs as more widely dispersed sprays and randomly oriented masses of schorl crystals. Crystals in the lower portion of the deposit average 0.05 X 0.5 inches, while schorl crystals in the upper portion average 0.06 X 0.6 inches. First generation laumontite and quartz act as the matrix for these crystals.

Second generation tourmaline occurs as free standing euhedral crystals of dravite. These crystals are only found associated with second generation laumontite and natrolite in vugs located in the central “core” of the deposit. These dravite crystals average 0.05 X 0.3 inches and are mostly acicular in nature. The dravite crystals are transparent and vary in color from dark to light honey brown.

Figure – 8 Photomicrograph of a single striated crystal of brown dravite with natrolite and second and third generation laumontite. Specimen is from a vug in the extreme central zone of the deposit. Image at 30X.

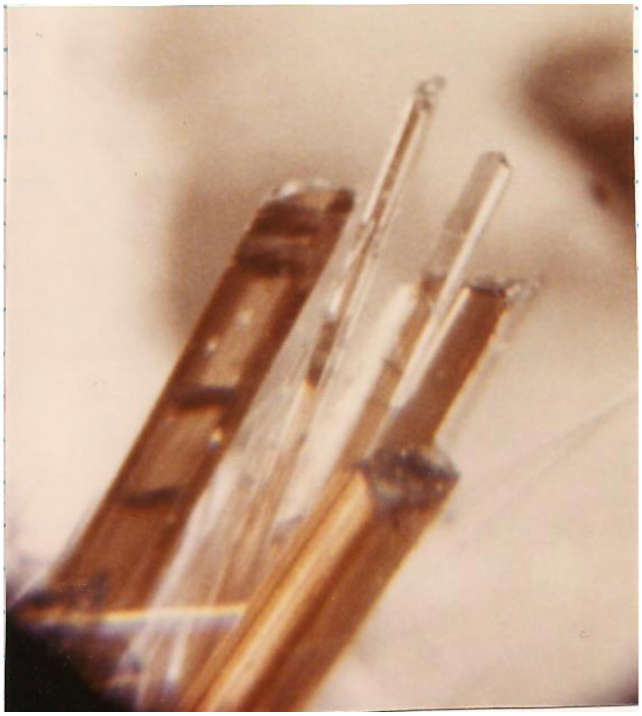


Figure – 9 Photomicrograph of transparent honey brown dravite with transparent crystals of natrolite. Specimen is from the extreme central zone of the deposit. Image at 40X.

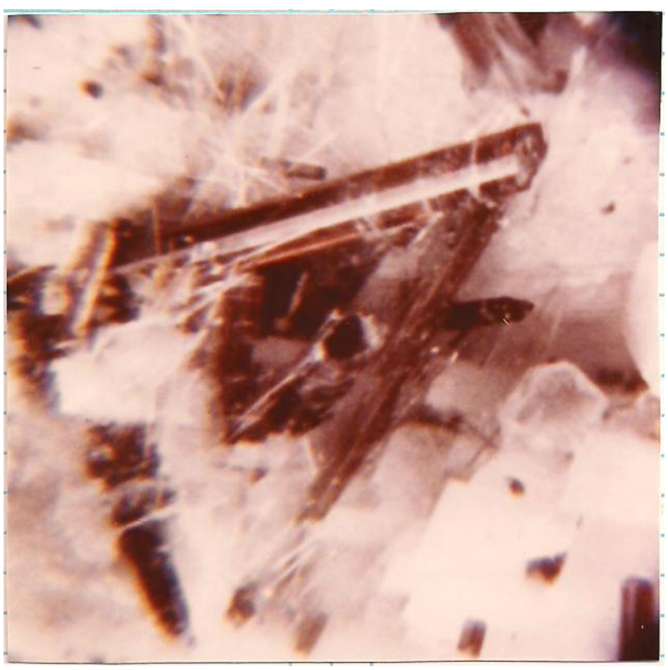


Figure – 10 Photomicrograph of a dravite crystal section with second generation laumontite, natrolite and first generation acicular schorl crystals. Specimen is from a vug in the central zone of the deposit. Image at 40X.

Third generation tourmaline occurs as free standing euhedral acicular crystals of schorl. The crystals are transparent to translucent and blue-gray in color. These crystals average 0.01 X 0.1 inches and are found in only a few vugs in the extreme central “core” of the deposit. X-ray diffraction, optical and wet chemical methods were used to confirm identity of the tourmaline.

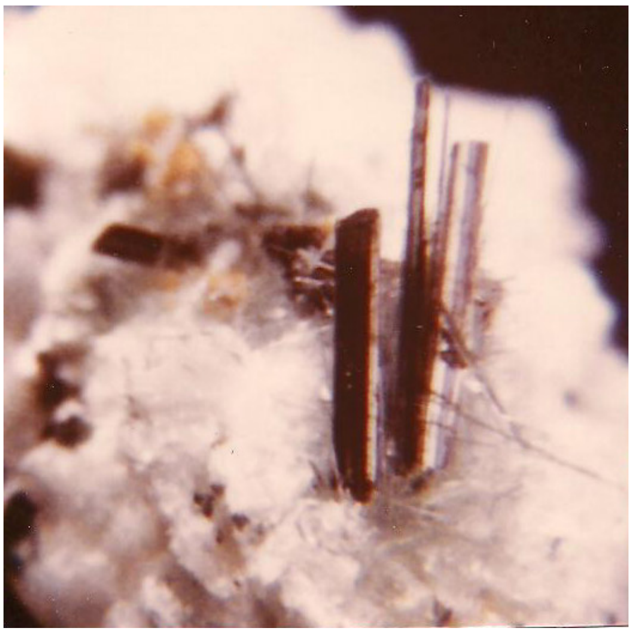


Figure – 11 Photomicrograph of a cluster of third generation tourmaline crystal sections associated with natrolite and second and third generation laumontite. Image at 40X.

Figure – 12 Photomicrograph of third generation tourmaline, natrolite and third generation laumontite encrusting a second generation laumontite crystal. Specimen is from a vug in the upper region of the central "core" of the deposit. Image at 40X.

NATROLITE $Na_2Al_2Si_3O_{10}$•$2H_2O$

MESOLITE Na2Ca2($Al_2Si_3O_{10}$)$_3$ •$8H_2O$

Natrolite occurs as randomly oriented and radial sprays of acicular crystals which line and fill vugs in the central portion of the deposit. Natrolite is associated with second and third generation laumontite and second generation tourmaline (dravite). Specifically, natrolite crystals were found covering second generation laumontite while crystals of third generation laumontite were found impaled on acicular crystals of natrolite. Natrolite also occurs with but does not enclose second generation tourmaline. Crystals of natrolite average 0.001 X 0,4 inches and always occur as water clear acicular crystals.

Figure – 13 Photomicrograph of a vug from the upper region central zone of the deposit. Second generation laumontite crystals are encrusted with acicular randomly oriented natrolite crystals. Image at 40X

Mesolite occurs as minute web-like masses of acicular crystals. This mineral was found in only a few vugs in the central core of the deposit.. Optical methods were used to confirm identity of the mesolite.

PYRITE FeS_2

Oxidized pyrite containing less than 1% cobalt, iridium and rhodium occurs as small isolated, striated, cubic crystals and irregular blebs in the central core of the deposit. In most cases pyrite from this deposit is associated with first generation laumontite, but not associated with tourmaline or quartz. This would suggest that the pyrite mineralization occurred after the influx of mineralizers responsible for tourmaline and quartz. A halo of pyrite alteration products stain the laumontite brown for an average distance of 0.2 inches from each pyrite location.

A spectrographic analysis of pyrite from this deposit showed greater than trace concentrations of the elements cobalt, iridium and rhodium. These elements are most likely substituting for iron in the pyrite structure. Average size of the pyrite crystals was 0.15 X 0.15 inches. Two miles east of this deposit, gold bearing oxidized pyrite occurs in a quartz vein system at the Monte Cristo and Black Cargo mines. Pyrite from these mines does not contain any significant concentrations of the element cobalt or elements of the platinum group. This suggests that the two deposits are unrelated.

Table – 4 shows spectrochemical analysis of pyrite from the upper region of the deposit.

METALLIC ELEMENTS	PERCENTAGE CONSENTRATION
Iron	31
Silicon	12
Aluminum	3
Boron	trace
Manganese	trace
Magnesium	trace
Vanadium	trace
Copper	trace
Silver	trace
Zirconium	trace
Titanium	trace
Nickel	trace
Cobalt	> 1
Calcium	trace
Strontium	trace
Chromium	trace
Platinum	trace
Iridium	>1
Rhodium	>1

Table – 4 Spectrochemical analysis of pyrite
(Minor amounts of laumontite included with the sample)
Pacific Spectrochemical Laboratory, Inc., Los Angeles

EPIDOTE $Ca_2(AL,Fe)_3Si_3O_{12}$ (OH)

Epidote occurs as anhedral to subhedral grains and masses in the upper portion and on the margins of the deposit. Color if this epidote varies from dark yellow-green to almost colorless. However there is no apparent relationship between color and location within the deposit. The presence of epidote would suggest a [possible relationship with adjacent lamprophyre dikes which also carry epidote with identical properties.

QUARTZ SiO_2

Along with tourmaline, quartz is the primary mineral in the parent vein and forms an enlarged section in the center of the deposit. No crystals of quartz were observed; instead this mineral occurs as highly fractured water clear quartz laced with crystals of black acicular shorl tourmaline. A small amount of pale blue quartz occurs in the center of the enlarged center region. This pale blue color is due to minute randomly oriented acicular schorl crystals in the quartz.

CHABAZITE $CaAL_2Si_4O_{12}•6H_2O$

Chabazite occurs as clear euhedral, pseudocubic crystals which average 0.1 X 0.1 inch in size. These crystals line fractures in the central zone of the deposit. Some chabazite crystal were found enclosing sprays of natrolite and also were found encrusting some first generation schorl tourmaline crystals.

Figure – 14 Photomicrograph of cabazite crystals lining a small vug from the central region of the deposit. Image at 40X

ZOISITE $Ca_2Al_3Si_3O_{12}(OH)$

Zoisite is rare in this deposit, occurring in only the extreme upper portion of the mineralized zone. The zoisite occurs as orange-red anhedral grains with epidote and laumontite. However, in a few small vugs in the extreme upper reaches of the deposit, a few euhedral orange-red crystal clusters were found. Optical methods were used to confirm the identity of this mineral.

Figure – 15 Photomicrograph of a cluster of orange-red zoisite crystals from the extreme upper portion of the mineralized zone. Image at 40X

RELATIVE SEQUENCE OF CRYSTALLIZATION

QUARTZ	***********		
TOURMALINE	1 ************	2 ************	3*********
EPIDOTE	**********		
ZOISITE	*******		
LAUMONTITE	1 *************	2 ************	3********
PYRITE	******		
NATROLITE		*******************	
CABAZITE		********	
MESOLITE		*******	

Table – 5 Sequence of crystallization based on relative position on the mineralized zone.

CONCLUSION

The mineral deposit described in this report represents a unique occurrence in the San Gabriel anorthosite body. Although it has taken 36 years, it is hoped that publication of this report will encourage others to revisit the Monte Cristo – Mill Creek area in the western San Gabriel Mountains to try and find additional examples of this unique mineral assemblage. By adding this report to the collection of data with the Mineral Heritage Project, an understanding of this unique mineral occurrence will be preserved for future generations. Thanks are due to the staff in the Geology Department of California State University, Northridge for their assistance with optical methods while I was an undergraduate in Earth Science. Thanks are also due to the staff in the Geology Department at the University of California at Los Angeles for their kind assistance with the X-ray diffraction analysis of Laumontite.

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1944 -

Born September 23, 1944 in San Bernardino, California, David Babulski graduated in 1973 from California State University, Northridge with a B.A. degree in Earth Science. He also holds a M.A. degree in Education from the University of St. Thomas, St. Paul, Minnesota and an Ed. D. degree in Science Education from California Coast University, Santa Ana, California. David has been a mineral collector and a serious student of geology and mineralogy all his life. He is the chair of the Georgia Mineral Society Micromount Section and has published over 30 micromount and mineral related articles with the Society. He is currently retired from a career as a technical educator in industry and lives in Snellville, Georgia with his wife Karen. David is also a mineral artist, specializing in painting minerals from the microscope. You can see some of his work at his gallery web site: www.crystalpocketstudios.com

In addition to mineralogy and mineral art, Dr. Babulski is an active amateur radio operator, builds and flies model aircraft, writes children's books (The Adventures of Piffels the Elf) and volunteers in local schools with science education. Dr. Babulski can be reached via e-mail at: d.babulski@comcast.net

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