UNITED STATES
DEPARTMENT OF THE INTERIOR
Geological Survey

December 1945

THE TEMESCAL TIN DISTRICT, RIVERSIDE COUNTY, CALIFORNIA

by

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Introduction and history of mining

Very small quantities of tin have been found in a large number of tourmaline-rich veins which occur principally in quartz monzonite, in the northeastern and easternpart of T. 4 S., R. 6 W., and in the western edge of T. 4 S., R. 5 W., Southeast of Carona, in Riverside County. The tin-bearing area is south and west of Lake Mathews, a reservoir of the Metropolitan Water District of Southern California, and is served by paved roads from Corona and Arlington. The Cajalco mine in this district is one of the few tin occurrences in the United States that has been productive, although the total yield has been only 125 to 150 short tons of metallic tin.

Tin, in the form of cassiterite, was discovered in the veins about the middle of the last century, probably between 1840 and 1856 1/. In 1860, Don Abel Stearns, owner of El Rancho Sobrante de San Jacinto, leased the tin-bearing area to S. C. Bruce who, backed by the Phelps Dodge Corp., started exploration at the Cajalco mine in September. A vertical shaft (the Robinson) had been sunk 95 feet when the outbreak of the Civil Wat stopped the work. Exploration was resumed in 1868 by the San Jacinto Tin Mining Co. after acquisition of 49,000 acres of the ranch, and in 1869 15.34 tons of ore shipped to San Francisco was said to have yielded 6,895 pounds of tin. According to Craze 2/and Crossman 3/litigation arose in 1869 and little additional work was done before the property was sold to the San Jacinto Estate, an English company, in 1890. The English company began a 6-1/2 mile tunnel in Temescal Canyon to crosscut about 40 of the main veins, but the project was soon abandoned. After refinancing, a mill and smelter were built at the Cajalco mine, 4/, and in 1891-92, production amounted to 125 to 145 tons of tin. Operations were suspended in 1892 and the property was sold to the San Jacinto Land Company.

1/ Bancroft, H.H., The Works of Herbert Howe Bancroft, vol. XXIV, History of California, vol. 7, p. 660. (San Francisco, History Co.), 1860-1890.
Cronise, T.F. The Natural Wealth of California, p. 103 (San Francisco; H.H. Bancroft and Co.), 1868.
Furness, J.W., Tin; Mineral Resources, U.S., 1925, pt. I, p. 68, 1928.
Hanks, H.G., Cassiterite: California State Mining Bureau. State Mineralogist's Report 4, p. 120, 1884.

2/ Craze, Capt. Charles, Private report, June 1888.

3/ Crossman, H.H., Mining and Scientific Press, Sept. 6, 1890 (San Francisco).

4/ Benedict, W. de L., The San Jacinto (California) Tin mines: Eng. and Mining Jour., vol. 50, pp. 450-453, 1890.

Between 1892 and 1927 the Cajalco mine was pumped out and examined several times but no attempt at mining was made until the Temescal Syndicate acquired the mine in 1927. The syndicate was reorganized as the American Tin Corporation in 1928 and an extensive program of development and prospecting was undertaken under the direction of George W. Bryant. The veins near the Cajalco mine were prospected, the Cajalco mine was deepened, and many drifts were driven in search of new ore shoots. Many veins in the district were stripped and thousands of samples were taken; wherever high assays were obtained, shafts or adits were dug. A small mill was set up and runs were made on ore from the higher-grade veins. Every possible attempt was made to develop a mine, but, after spending many thousands of dollars in sampling and exploration, the project was abandoned. The American Tin Corporation was reorganized about 1930 as the Temescal Corporation and again in 1943 as the Tinco Company.

Investigations of the deposits in the last decade have consisted primarily of surface sampling. The veins in the area now covered by Lake Mathews and in the immediate vicinity were extensively sampled in connection with a condemnation suit by the Metropolitan Water District about 1934. In 1943, Dodge Construction, Inc., as agent for the Metals Reserve Company, erected a mill near the Cajalco mine and milled 14 100-ton lots taken from carefully laid out trenches on Cajalco Hill, from veins No. 4 and 5 east of Cajalco Hill, and from a small blowout in the Black Rocks area. These tests showed that cassiterite could not be concentrated from the tourmaline-bearing rock in any appreciable quantities by commercial gravity methods.

The entire production apparently came from a single cassiterite ore body in the Cajalco mine, which was worked at three different periods. As shown in the following table, the main activity was during 1891 and 1892, when 97 to 98 percent of the total tin was mined and the main ore body was mined out. Later efforts to produce tin on a commercial scale have been unsuccessful.

Production of tin from the Temescal district, California

Date	Pounds of metallic tin
Prior to 1890 (probably 1868 - 1869)	6,895 a/
1891	121,108 a/
1892	163,131 a/
1928-1929	1,188 b/
	292,322

a/ Rolker, C. M., The production of tin in various parts of the world: U. S. Geol. Survey 16th Ann. Rept., pt. 3, p. 537, 1895.

b/ Segerstrom, R. J., Tin in California: California Div. of Mines, Jour. Mines and Geology, vol. 37, p. 543, 1941. Production in 1891 and 1892 stated as 56 and 56.2 long tons, respectively.

Field Work and Acknowledgments

The principal tourmaline-bearing veins in the district were mapped in detail by L. R. Page, Theodore Lance, Gordon Bell, and Raymond M. Alf, of the Geological Survey, between October 1940 and February 1941. About 6 square miles in the vicinity of the Cajalco mine and the Black Rocks are was mapped on a scale of 400 feet to the inch with plane table and telescopic alidade, about one-third on a topographic base made at the time, and two-thirds on a base furnished by the Metropolitan Water District. Although most of the underground workings were inaccessible, many of the veins were mapped in detail on the surfaces or in accessible underground workings. Page, assisted by Alf, did additional mapping in April 1943; in August of the same year, T. P. Thayer mapped Cajalco Hill and the Metals Reserve Company trenches in great detail, while the sampling was being done. During the milling, the Cajalco mine was partly unwatered and Thayer and the Metals Reserve Company Engineers went down into the upper part of the old stope. John H. Wiese spent two months in the spring of 1945 on petrographic examination of concentrates.

During the course of the Geological Survey work more than 125 samples of vein material were collected for chemical and microscopic study. Lance, in 1940-1941, crushed about 110 of the samples and separated fractions with heavy liquids in the geological laboratories of the California Institute of Technology, and in the Survey laboratories in Washington. Twenty-two samples were analyzed spectroscopically in 1940 by the Applied Research Laboratories of Los Angeles, and 43 samples or fractions were analyzed in 1945 by Charles Bentley at the Mining Experiment Station, South Dakota School of Mines, at Rapid City. Samples collected by D. F. Hewett in 1938 were examined in detail by J. J. Glass, of the Geological Survey.

George Bryant, who was concerned with all of the properties as engineer and geologist for 20 years, accompanied the writer in the field many times and kindly furnished copies of all of his maps, several of which have been used in this report. The officials of the American Tin Corporation and owners of the other properties supplied maps and other information. The Metropolitan Water District gave permission for use of some of its topographic maps as a base and gave the writer free access to engineering reports on the area.

The field work was done under the general supervision of D. F. Hewett, who first visited the district in 1938, and the report was revised and critically reviewed by T. P. Thayer, D. M. Lemmon, and M. E. Dorr.

Geology

The tin deposits in the Cajalco district are associated with tourmaline rocks in veins and irregular pipe-like masses which cut nearly all the main rock units in the district. The oldest rocks are the Elsinore metamorphic series, 5/ probably of Triassic age, which were intruded by the Temescal porphyry 5/ and Cajalco quartz monzonite 5/. Three distinct varieties of the quartz monzonite —coarse-grained,

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5/ Dudley, P. H., and Sampson, R. J., Geology of the Perris block, Southern California: California Div. of Mines, Jour. of Mines and Geology, vol. 31, pp. 487-506, 1935.

porphyritic, and fine-grained—were mapped in the field, in addition to closely related pegmatites and aplites. Trachyte porphyry dikes, younger than the veins, occur northeast of the Cajalco mine.

Rocks

Elsinore metamorphic series

The Elsinore metamorphic series, probably of Triassic age, the oldest rocks in the map area (fig. 2), consist mainly of argillites and quartzites, and some mica schist and greenstone. They occur in the southern part of the area.

The metamorphosed sedimentary rocks are dark gray to green or black, are thinly laminated, and have a dense texture. They consist of various proportions of quartz, orthoclase, plagioclase, biotite, and muscovite, with accessory titanite, apatite, zircon, magnetite, pyrite, and tourmaline. The greenstones are dark greenish chloritic rocks, that were probably basalt flows. Near the tin-bearing veins, all these rocks are bleached and are irregularly impregnated with quartz and tourmaline.

Dacite porphyry.

Dacite porphyry crops out along the western edge of the district, about 2,000 feet west of the Cajalco mine. It is an aphanitic to medium-grained, dark gray to greenish porphyry that contains phenocrysts of feldspar and quartz rarely exceeding 1/4 inch in length, in a dark fine-grained to aphanitic ground-mass. Some parts rich in quartz have not been separately mapped because they form dike-like masses which have indefinite contacts and are poorly exposed. Dudley states that the composition of the dacite porphyry averages 38 percent andesine, 24 percent orthoclase, 30 percent quartz, 6 percent biotite, and 1 percent hornblende 6/. The phenocrysts, mainly of andesine, are estimated to constitute 40 percent of the rock. Small amounts of magnetite, ilmenite, apatite, titanite, and rutile are also present. The porphyry is bleached at contacts with younger igneous rocks and veins and contains epidote which gives the rock a variety of yellowish-green colors.

Diabase, diorite, and gabbro.

Inclusions of diabase, diorite, and gabbro occur throughout the quartz monzonite, but none of them are sufficiently large to be shown on the smaller-scale geologic maps. They range from fresh, black, medium-or coarse-grained diorite or gabbro to brownish quartz monzonite. Where cut by tourmaline veins, in which epidote is abundant, these basic rocks are changed to a dark epidote-rich rock. The inclusions are undoubtedly related to the gabbros and other basic rocks mapped to the south and east by Dudley.

Large masses of these basic rocks are exposed in the lower levels of the Cajalco mine and in some of the other workings. The inclusions in places make up 50 to 75 percent of exposures, and are particularly abundant about 2,000 feet

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6/ Dudley, P. H., and Sampson, R. J., op. cit., p. 497.

south of Cajalco mine, in Mine Creek and in Cajalco Canyon for a distance of 1,500 feet below the toe of the Lake Mathews dam. Below an altitude of about 1,150 feet they are fairly common but above that they are widely scattered; their abundance in Cajalco Canyon and Mine Creek suggests that the floor of the quartz monzonite is not far below.

Quartz monzonite.

Three textural varieties of quartz monzonite were mapped in the district, coarse-grained, porphyritic, and fine-grained. The coarse-grained quartz monzonite underlies most of the tin-bearing areas. In some places it appears to grade into a medium-grained pink to brownish porphyritic variety, which in turn grades into the fine-grained quartz monzonite. Where the fine-grained and coarse-grained varieties of the quartz monzonite are in contact, the boundary is usually well defined.

The coarse-grained quartz monzonite is about 35 percent plagioclase (oligoclase-andesine), 35 percent microcline and orthoclase, 20 percent quartz, and 10 percent hornblende and biotite, and contains magnetite, apatite, titanite, zircon, and other accessory minerals. The texture is sub-porphyritic or monzonitic and the grains average about 1/4 inch. The quartz grains commonly are rounded and where the feldspars are completely altered, the rock appears porphyritic. The plagioclase feldspars are conspicuously zoned and have been partly replaced by epidote and a fine-grained aggregrate of granular quartz. The biotite is partly altered to chlorite.

The porphyritic quartz monzonite consists of elliptical grains of feldspar and quartz about the same size as those in the coarse-grained quartz monzonite, set in a fine- to medium-grained groundmass.

The fine-grained quartz monzonite contains less plagioclase than the coarser varieties. It is an even-grained rock in which the minerals average 1 to 2 mm. It crops out as an irregular body in the hills just west of the Lake Mathews reservoir, and also along the east side of the map area (fig. 2). The position of the outcrops strongly suggests that it is the upper part of the Cajalco quartz mass described as monzonite by Dudley. 8/. However, dikes resembling this rock and also the porphyritic variety cut the coarse-grained quartz monzonite.

Aplite and pegmatite.

Irregular masses of aplite and pegmatite are exposed near the contact between the dacite porphyry and coarse-grained quartz monzonite in secs. 3 and 10, T. 4 S., R. 6 W. The largest of these is about 400 feet long and may be as much as 250 feet wide. Narrow dikes of aplite cut all varieties of the quartz monzonite, the dacite porphyry, and the metamorphic rocks. The larger aplitic masses include irregular segregations of pegmatite, in which quartz and feldspar crystals range up to 2 or 3 inches in size. The aplite in most places is a sugary, fine-grained, pink to brown rock composed of feldspar (55 percent), quartz (40 percent), and biotite (5 percent). Some of the aplite dikes appear to grade into fine-grained or porphyritic monzonite and others grade into pegmatite.

8/ Dudley, P. H. and Sampson, R. J., op. cit., pp. 502-503.

Monzonite porphyry

A lenticular body of monzonite porphyry, about 1,000 feet long and 400 feet wide is exposed in the western edge of the Black Rocks area (fig. 4). It is a light gray, very coarse-grained rock composed chiefly of feldspar phenocrysts up to 1 inch long, in a fine-grained matrix containing ferro-magnesian minerals and scattered grains of epidote. An inclusion of coarse-grained quartz monzonite was found in a boulder of this porphyry and at one place aplite appears to intrude it.

Trachyte porphyry

Trachyte porphyry dikes as much as 6 feet wide occur northeast of the Cajalco mine (fig. 3), and one of them follows and cuts vein No. 5 (fig. 3). These rocks are dark grey to greenish-black, finely banded and consist of phenocrysts of white feldspar up to 1/4 inch long in an aphanitic matrix.

Surficial deposits.

Unconsolidated sedimentary material that obscures the bedrock is found in numerous places west and south of Lake Mathews. Placer deposits of cassiterite, rather significantly, are conspicuously absent. West of Lake Mathews the lower parts of the valleys contain remnants, up to a dozen feet thick, of poorly sorted, obscurely bedded arkosic material that apparently represent stream deposits. These, for the most part, have been removed by recent erosion along the main drainage lines.

South of Lake Mathews, well-sorted sands and gravels apparently underlie large flat areas. South and east of the Black Rocks these sediments are very thick, and appear to represent a deltaic deposit the top of which is at an altitude of about 1,540 feet. On the southwest side of the Black Rocks map area, in secs. 13 and 24, T. 4 S., R. 6 W., a shingled beach gravel occurs at an altitude of about 1,400 feet, and gravels containing numerous boulders of vein material are widespread at or below this altitude. These deposits which may be of Pleistocene age or older have been partly reworked by recent streams.

Structural features

The rocks of the Elsinore metamorphic series strike N. 65° - 75° W. and dip 70° - 80° NE toward the quartz monzonite which was intruded into them. Exposures of these rocks are poor, and structural details could not be mapped, but local variations in structure were seen. The contact of the coarse-grained quartz monzonite dips steeply westward under the metamorphic rocks, and seems to flatten to 35° to 55° under the dacite porphyry (fig. 2). The coarse-grained quartz monzonite also appears to dip eastward under the fine-grained quartz monzonite on the eastern side of the Black Rocks area and on the hills north and west of Lake Mathews. The small patch of metamorphic rocks surrounded by quartz monzonite in sec. 13 of the Black Rocks area appears to be a roof pendant. Predominance of fragments of metamorphic rock in the tourmaline breccia in sec. 24 suggests that the Elsinore metamorphic series may be near the surface there.

The tin-bearing deposits occupy well-defined fractures or systems of fractures which consist of closely spaced small en echelon fractures. Many of the fracture zones can be traced for several hundred feet by the tourmaline in them. Movement along the fractures has probably been slight, for they pass through basic inclusions and aplite dikes without apparent displacement.

The main vein systems are not all parallel, and the dips of the veins vary from place to place. Most of the veins occur in the coarse-grained quartz monzonite in a belt, up to 2,400 feet wide, which extends from the SE$\frac{1}{4}$ sec. 19, T. 4 S., R. 5 W. northwestward to the SW$\frac{1}{4}$ sec. 2, T. 4 S., R. 6 W. Beyond Cajalco Hill, the major veins in quartz monzonite trend northeast over the entire area, though they range in strike from about N. 20° E. to N. 50° E., and dip 50° to 85° NW. The veins in the Black Rocks area in general strike parallel to those west of Lake Mathews, but they dip southeast. The veins in secs. 13 and 18 strike about N. 30° E. and dip about 60° SE. Two systems of fractures, both dipping 60° - 80° SE., are apparent in sec. 19; one system strikes N. 40° E. and the other strikes N. 60° E., and there are several pipelike masses of tourmaline breccia. The veins in dacite porphyry southwest of the Cajalco mine show wider divergence in attitude; some of the larger ones strike N. 35° - 40° E., and dip 65° - 75° NW, but most of them strike nearly north and dip 50° - 70° W. Minor cross-fractures intersect many of the larger veins at various angles, apparently without any system.

TIN-BEARING VEINS AND PIPES

Tin, in the mineral cassiterite and possibly also chemically combined in tourmaline, is associated with veins and pipe-like masses of tourmaline-quartz rock, principally in the coarse-grained quartz monzonite. Although veins cut the other rocks, they are narrow and discontinuous, particularly in the fine-grained quartz monzonite. The only minable ore shoot found in the district was in the Cajalco vein, and except for a few pillars it has been stoped out. Assays of samples from almost any of the veins show 0.03 to 0.1 percent tin, but samples assaying more than 0.1 percent have been found in very few places except the Cajalco Mine.

Four varieties of tourmaline-bearing rock have been recognized and distinquished in the mapping; mottled, porphyritic, fine-grained, and tourmaline breccia. The mottled tourmaline rock is pink, white, grey, or black, depending on the proportions of tourmaline, feldspar, and quartz, and containing radiating clusters or small felt-like masses of tourmaline which have replaced the feldspar. The porphyritic tourmaline rock is characterized by large elliptical quartz grains in a black glassy matrix of fine-grained tourmaline and quartz. The fine-grained tourmaline rock is composed almost entirely of minute black tourmaline needles. The tourmaline breccia consists of angular or rounded fragments of mottled or porphyritic tourmaline rock in a matrix of fine-grained tourmaline. Although some contacts between the varieties are well defined, in most places the different varieties intergrade.

Form, size and structure

The tourmaline rocks of possible economic interest are restricted to veins and blowouts, and tin has been mined only from two shoots in the Cajalco vein. Although the Cajalco vein has been explored continuously over a length of 1,000 feet, and the system which comprises veins No. 7 and 8 is about 4,800 feet long, most of the veins are 1,000 feet or less in length and are discontinous. The veins are very irregular, for two reasons: (1) they were formed along irregular fractures, and (2) replacement of the country rock was very erratic. The average width of the veins, including spotted tourmaline rock and silicified rock, probably averages 1 - 2 feet, although some of the veins are 6 feet wide, and in places a few are 15 - 20 feet wide. The Cajalco vein was followed to a depth of 690 feet, and was not bottomed; it therefore seems likely that the other veins extend to considerable depths.

The veins are commonly zoned or banded from the center outward. Most veins a foot or so wide are made up entirely of mottled tourmaline rock or silicified rock which represents partly replaced country rock. In the wider parts of the veins where mineralization was more intense and replacement was more complete, the center of the vein is occupied by a streak of fine-grained tourmaline a few inches wide. The fine-grained tourmaline grades into the mottled or porphyritic rock, and never forms more than a small fraction of the entire vein width. In the east end of No. 2 stope of the Cajalco mine, for example, the hanging wall split of the vein is about 5½ feet wide, and the fine-grained tourmaline, which contains the only visible cassiterite, is about 6 inches wide. In a few places white quartz occupies the center of the veins. The veins widen at intersections with cross fractures to form masses similar to blowouts, and a close genetic relation between veins and blowouts seems indisputable. Bryant indicated that the Cajalco vein runs into the Cajalco Hill blowout in the lower levels of the Cajalco mine.

The tourmaline rock pipes or blowouts are irregular pipe-like masses which are known to range in size up to 500 to 600 feet across and some of those which are partly covered may be considerably larger. The blowouts in the Black Rocks area appear to be made up largely of tourmaline breccia, but the Cajalco Hill blowout, as shown in plate 4, consists essentially of mottled and porphyritic tourmaline rock. The blowouts in the Black Rocks area consist of blocks of the old metamorphic rocks as well as of the quartz monzonite, in a matrix of fine-grained tourmaline. Some of the breccias in the vicinity of the Cajalco mine are believed to contain fragments of dacite porphyry.

The veins are clearly related to fractures, which for the most part are well defined, but the structural relations of the blowouts are not clear. Some of the smaller ones appear to be related to interesecting or converging fractures, but many of the larger ones, such as Cajalco Hill and North Black Rocks, apparently are not. The breccia pipes are regarded as probably of explosive origin, and the others appear to have been formed by solutions moving along minute fractures and joints. The borders of the Cajalco Hill blowout grade into quartz monzonite in a distance of a few inches, and the contacts appear to be essentially vertical where not faulted.

Mineralogy

Most of the tourmaline veins and pipes are composed essentially of tourmaline and quartz. The principal vein minerals are black tourmaline, quartz, dumortierite, muscovite, bastnäsite, and epidote, which are associated with quartz, feldspar, biotite, apatite, zircon, and hornblende derived from partly altered country rock. Cassiterite, mostly in very small grains, has been recognized in hand specimens from veins No. 1, No. 2, and No. 8. and in heavy-liquid concentrates from a number of veins. Minute grains of cassiterite also have been observed in thin sections of vein material. Small quantities of chalcopyrite, pyrite, arsenopyrite, galena, sphalerite, magnetite, limonite, hematite, and malachite are also present. Copper is most abundant in the underground workings of vein No. 5, according to assays made by the American Tin Corporation, and galena and sphalerite were observed only in the vein prospected by adit No. 46. Arsenopyrite was observed in vein material on the Cajalco mine dump and from veins in the dacite porphyry.

Cassiterite.-- The cassiterite is chocolate-brown to red-brown in hand specimen. Specimens of high-grade ore collected by Thayer from pillars in the No. 2 stope of the Cajalco mine, show clusters of grains and crystals which are a millimeter or less in size, scattered through a fine-grained, felted mass of tourmaline crystals. Many of the cassiterite grains are clustered around small vugs into which they project as euhedral crystals. Thin sections show these grains to be twinned and characterized by concentric zones which range from colorless to deep red-orange or yellowish-brown. Some of the cassiterite appears interstitial to the tourmaline and some occurs as small crystals along the edges of quartz grains. Magnetite is interstitial to cassiterite and tourmaline. Some specimens, probably from vein No. 2, show brecciated cassiterite and tourmaline cemented by epidote and quartz. In these specimens, Miss Glass found cassiterite crystals penetrated by tourmaline crystals which themselves were cut by veinlets of cassiterite, suggesting over-lapping periods of deposition of the two minerals. Bell tentatively identified fluorite and axinite associated with cassiterite as inclusions in quartz. Quartz is not abundant in cassiterite-rich parts of the vein.

Tourmaline.-- Tourmaline is the most abundant vein mineral. Although it appears black in hand specimens, in thin section it is commonly zoned and may be colorless, blue-black, indigo, brown, green, blue-green, or greenish-brown. Miss Glass determined the refractive index of the extraordinary ray (E) as ranging from 1.60 to 1.655. Individual crystals are rarely over 3 mm. in length. The mineral usually occurs as a felted mass of crystals with interstitial quartz, but in some veins radiating needles form spherical masses up to $\frac{1}{2}$ inch in diameter. The tourmaline replaces all the original minerals of the wall rocks, and much of it is earlier than the cassiterite and other vein minerals.

Epidote.-- An iron-poor variety of epidote is common in the veins, and is most abundant in those veins that cut inclusions of diabase, diorite, or gabbro. It is apparently later than the tourmaline and probably formed as a result of the alteration of feldspars and other calcic minerals. Veinlets of iron-rich epidote cross the tourmaline-quartz-cassiterite veins and are in turn cut by veinlets of white quartz.

Dumortierite.-- Dumortierite was found in some of the veins southwest of Cajalco Hill, in veins northeast of Black Rocks, and is a prominent constituent of a vein which is well exposed in the road cut just north of the dam across Cajalco Canyon, in the NW$\frac{1}{4}$ sec. 12. This vein is well banded, with a central core of quartz surrounded by dense black tourmaline rock which grades into mottled tourmaline rock containing dumortierite. The parts of the vein richest in dumortierite are pink to lavender. Miss Glass determined the refractive indices of the dumoritierite to be $\alpha = 1.676$, $\beta = 1.694$, and $\gamma = 1.698$. The tourmaline associated with this mineral is blue-black, lavender, or pale yellow in thin section. The dumortierite occurs only in the wall rocks, and was not found in the central parts of veins.

Wall Rock alteration.

The veins and blowouts alike seem to have been formed by processes of replacement in which tourmalinization, saussuritization, and silicification were most important. The hydrothermal solutions which introduced the vein-forming minerals along the fractures penetrated the wall rocks for considerable distances, for alteration may extend several feet beyond the walls of fractures less than one-fourth of an inch wide, and breccia fragments several feet across commonly are almost completely tourmalinized. In some of the pipes the channelways for solutions are obscure.

<u>Tourmalinization</u>:— Tourmalinization is the most prominent wall rock alteration. The degree of alteration differs not only from vein to vein, but also within a single vein. Most veins show small scattered tourmaline aggregates which decrease in number from the fracture outward into the walls. Plagioclase appears to be replaced first, then potash feldspar and, finally, quartz; the texture of the host rock is preserved until all minerals have been replaced. Although quartz probably was deposited shortly after the earliest tourmaline, silicification appears to be dominant only where the feldspars were completely tourmalinized. The mottled tourmaline rock represents the early stages in the replacement process, the porphyritic rock represents the stage at which all but quartz had been replaced, and the fine-grained tourmaline appears to be the end product. Most of the porphyritic tourmaline rock was probably derived from coarse-grained quartz monzonite.

<u>Silicification</u>:— Deposition of quartz accompanied tourmalinization in most places after introduction of the early tourmaline and before deposition of the last tourmaline. Fine-grained aggregates and wormy intergrowths of late quartz replace the feldspars and original quartz and fill the spaces between tourmaline crystals. As a result the host rocks and earlier loose-textured tourmaline rock are changed to hard, grey, glassy rocks. In the Black Rocks area part of the quartz monzonite has been silicified but not tourmalinized. Two veins near the west edge of SE¼ sec. 2, show silicification only, and the vein material resembles white, fine-grained pebble quartzite. The feldspars were completely replaced by a fine-grained granular aggregate of quartz and sericite which surrounds the rounded quartz grains of the original quartz monzonite. The walls of the vein grade into unaltered coarse-grained quartz monzonite.

<u>Saussuritization</u>:— Alteration of the plagioclase in the rock bordering the veins to epidote is best shown where the veins cut basic inclusions. The plagioclase of the quartz monzonite commonly is partly replaced by low-iron epidote, and the rock takes on a bleached appearance, being greenish, buff or dull white. In the basic rocks the epidote is much richer in iron, and in epidote commonly forms veins which cut across and replace the tourmaline-rich vein material. The iron-rich epidote clearly is later than the tourmaline and cassiterite.

Origin

The systematic distribution of the tin-bearing rocks in the Temescal district shows clearly that they were localized along fractures or in brecciated portions of the quartz monzonite and older rocks. The gradational relations of the several varieties of tourmaline rock with each other and with the various country rocks is good evidence that replacement had a dominant part in the process of vein formation, and only a very small part of the vein material shows definite evidence of deposition in open fractures. Although some of the fine-grained tourmaline rock may have been deposited as vein filling, most of it appears to be the end product of the replacement process. The concentration of cassiterite around minute cavities and as veinlets in the tourmaline rock shows that it was formed later than much of the tourmaline, although some tourmaline followed the cassiterite in specimens from the Cajalco mine adds emphasis to the importance of replacement in the process of vein formation.

The deposits are believed to have been formed at great depth soon after the quartz monzonite had crystallized and while it was still very hot, for the association of cassiterite with tourmaline, arsenopyrite, and dumortierite is characteristic of deposits formed under high temperature and pressure. The restriction of the main veins to the coarse-grained quartz monzonite also is evidence that the principal deposition occurred before the vein-bearing emanations reached the cooler rocks surrounding the quartz monzonite.

RESERVES AND GRADE OF TIN BEARING ROCK

Grade of the deposits and recoverability of the tin

The veins in the Temescal district have been thoroughly sampled and their grade is accurately known. The American Tin Corporation collected and assayed thousands of samples; a large proportion of them showed 0.03 to 0.1 percent of tin, a few showed more than 0.5 percent tin, and many were reported as barren. Where assays of 0.5 percent or more were obtained the veins were explored by underground workings, with uniformly discouraging results. Their assays indicate that the average grade of the vein material is between 0.03 and 0.05 percent, or 0.6 to 1 pound of tin per short ton. The results obtained by other private companies and engineers are comparable. The ore mined in the Cajalco vein is said to have averaged about 2 percent tin.

In 1943 the Metals Reserve Company, acting through Dodge Construction, Inc., of Fallon, Nevada, mined and milled about 1,400 tons of tin-bearing rock. The samples consisted of 14 lots of about 100 tons each, from trenches laid out essentially in accordance with recommendations by Bryant, as follows: eleven from various parts of the Cajalco Hill blowout, two from veins Nos. 4 and 5, and one from the blowout on the NW$\frac{1}{4}$ sec. 18, T. 4 S., R. 5 W. The geology of the areas sampled was mapped in detail by T. P. Thayer of the Geological Survey at the request of the Metals Reserve Company (see figs. 5, 6, 7). As the following table shows, the samples represent all the principal types of tin-bearing rock. During the mill tests some of the samples were ground finer than others, and all were concentrated on Deister tables. The company assayer found traces of tin in a few samples, and could find no appreciable difference between the grade of heads and concentrates. Three samples were analyzed spectrographically in the Geological Survey laboratory with the following results, in percent Sn:

Lot No.	Heads	Middlings	Concentrates
4	0.007	0.01	0.02
6	0.005	0.007	0.01
11	0.006	0.01	0.02

Superpanner tests of screened fractions of the mill products from samples T-2, T-3, and B-7 showed fewer grains of cassiterite in the plus 100 mesh material than in the finer sizes, and the proportion of visible cassiterite in all fractions was very small. Similar tests on tailings from the old mill showed abundant cassiterite grains averaging about 0.02 mm in the minus-200 mesh fraction.

The apparent wide distribution of small quantities of tin in the veins of the district led the Geological Survey to a program of detailed sampling of all the types of vein material and wall rock. In all, 116 samples, some from specimens and from channels, were examined petrographically. From the crushed smaples, 100 gram fractions were taken with a Jones splitter and these fractions were screened. The minus-80 plus-200 mesh material was separated in bromoform (sp. gr. 2.8), and the heavy fraction was separated again in methylene iodide (sp. gr. 3.3). The heavy minerals were separated magnetically, and part of the non-magnetic fraction (about 0.008 g.) taken out with a Jones-type microsplit was mounted in balsam for petrographic examination.

Cassiterite was identified in 55 of 113 samples prepared in this manner, but none of the slides contained cassiterite equivalent to 0.01 percent tin in the original sample. The results of this work are given in table 2. Concentrates and minus-200 mesh fractions of several samples analyzed by Charles Bentley at the South Dakota School of Mines, Mining Experiment Station, were found to contain only traces of tin -- less than 0.05 percent. Qualitative spectrographic analyses were made of 25 samples, including 9 used in the heavy mineral study, with the results shown in table 3. The analyses, made by M. F. Hasler of the Applied Research Laboratories, Los Angeles, show a range in tin content from 0.04 to 0.25 percent.

Comparison of heavy mineral studies of samples P35, P47, and P48, with spectrographic and chemical analyses suggests that part of the tin may be contained in minerals other than cassiterite. Microscopic examination of grain mounts of the plus-200 mesh fraction of the concentrates revealed only one grain of cassiterite in each, equivalent to less than 0.01 percent tin. The spectrographic analyses of the whole samples, however, indicate 0.08 to 0.25 percent tin. The failure to concentrate the tin in the heavy fractions may be explained in two ways: (1) the tin is chemically combined with the tourmaline, or (2) it is in fine-grained cassiterite which is so intimately intergrown with the tourmaline that it cannot be effectively separated, even with heavy solutions. In view of the impossibility of sampling the veins quantitatively by thin sections, the problem of distribution of the tin where it is present only in small quantities must remain unanswered for the present, but it is obvious that separation of most of the tin from average tourmaline rock is not economically feasible.

The absence of placer deposits of cassiterite in the district is a general confirmation of all the sampling programs. If moderately coarse-grained cassiterite occurred in appreciable quantities in the veins, placers of economic interest would almost certainly have been formed.

Size and localization of ore shoots

The only known minable ore in the Temescal district occurred in two shoots in the Cajalco mine. Maps of the mine (figs. 10 & 11) indicate that the shoots were about 70 and 160 feet, respectively, in strike length, and the larger one had a dip length of about 240 feet. The stopes were inaccessible when most of the Geological Survey mapping was done, but Thayer was able to get into stope No. 2 during the Metals Reserve Company milling tests. He collected some samples of high-grade ore, and made the following observations regarding ore left in the pillars:

"Specimens of high-grade cassiterite were obtained from the smaller of the two pillars shown on Bryant's map in stope No. 2 at the first level. The high-grade streak of coarse-grained cassiterite is 5 to 6 inches wide and was traced about 3 feet down the dip. It is 1 - 1.5 feet from the hanging wall of the vein, which here consists of two splits, the hanging wall split being somewhat over 4 feet wide. The cassiterite is in dense black tourmaline rock which contains scattered clusters of quartz grains and grades into mottled tourmaline-quartz rock along the edge of the vein. The cassiterite lens lies at a slight angle to the main vein, so that the lower end impinges against the mottled rock. Specimens from the lower end show euhedral cassiterite replacing the large quartz grains in the mottled rock. The cassiterite grains are irregularly disseminated and show no evidence of having been deposited along a fracture. Two similar masses of cassiterite an inch or two across were found elsewhere on the same pillar, also in the dense tourmaline rock. The coarser cassiterite commonly forms crystals lining minute cavities, in some of which slender tourmaline needles have grown on the cassiterite.

"Four facts seem clear: (1) the high-grade ore is localized in or near the dense all-tourmaline portion of the vein; (2) the cassiterite is disseminated in the tourmaline rock and was not localized along fractures; (3) cassiterite has replaced the original quartz grains; and (4) it is older than the last tourmaline. The scattered clusters of quartz grains in the tourmaline facies are regarded as incompletely replaced remnants of country rock quartz monzonite. It seems probable that the cassiterite was emplaced simultaneously with the tourmaline where mineralization was most intense, and that the dense tourmaline rock itself was formed by replacement.

"The genetic relation between disseminated cassiterite and that deposited along fractures in tourmaline rock found on the old dump is not known, but it probably is very close. The writer is inclined to believe that the amount of disseminated cassiterite probably far exceeds that deposited along fissures as fillings."

Efforts to find other ore shoots have been unsuccessful, as all concentrations of high-grade material explored by the American Tin Corporation were found to be very small. The factors controlling concentration of the cassiterite are therefore very imperfectly known.

Most of the cassiterite is disseminated in the velvety fine-grained tourmaline which occupies the center of some of the veins. The richest concentrations are in the wider parts of the veins, but they may be scattered anywhere in those parts, and in the absence of obvious structural controls, would be hard to find. The wide parts of veins at intersections with minor fractures do not appear to be especially promising, for they closely resemble the pipes, which have been shown to be essentially barren. Some of the more promising parts of the veins appear to be in northward bends, but the evidence for using this as a guide in the search for ore is meager.

Future of the District

The geologic monotony of the veins over an area of several square miles and a vertical range of 400-500 feet shows that the conditions under which the tin-bearing deposits were formed were not conducive to rapid changes in the character of the veins, and the potentialities of the district as a producer of tin may therefore best be judged by the available surface and underground exposures of the veins.

The lack of minable ore shoots exposed at the surface, despite the thousands of linear feet of exposed veins, is not conducive to optimism about the future of the district. Ore shoots, to be of commercial size in veins of the width encountered in the Cajalco mine, would have to be hundreds of feet in length and depth, and if many were present within reasonable distances of the surface, a few might be expected to crop out. The lack of exposed ore bodies, shown by consistenly low assay values of the veins, and the absence of placer deposits may be interpreted in two ways: (1) the entire vein system is very poor in tin; or (2) the main zone of tin deposits has not yet been reached by erosion and underground exploration. Hope for the district obviously lies in the second alternative.

Tin-bearing quartz-tourmaline veins, where mined elsewhere in the world, have been found to persist through vertical ranges of hundreds or thousands of feet, and the Temescal veins probably also persist downward for long distances. The Cajalco mine workings, however, show that the veins pinch and swell downward as they do horizontally; it would appear, therefore, that the character of the veins does not change appreciably within a few hundred feet of the surface.

The geological structure of the district indicates that the veins now exposed at the surface represent a much greater geological range than the surface exposures would suggest. Since the veins are genetically related to the quartz monzonite, their distance from the original surface of the quartz monzonite mass, rather than their present topographic position, is the controlling factor in predicting their behaviour at depth. The distance erosion has cut into the quartz monzonite cannot be accurately measured, but it may be several thousand feet, for the contacts dip 30° or more under the older rocks, and the quartz monzonite is exposed over a width of two miles in the vicinity of the Cajalco mine 9/. If the contact with the dacite porphyry west of the Cajalco mine be projected eastward at an angle of 45°, the average dip of the contact, it would pass about 2,000

9/ Dudley, P. H., and Sampson, R. J., op. cit., map facing p. 506.

feet above the mine, and would be much higher above the veins to the east. Even if the contact were assumed to flatten toward the east in a broad arch, it would pass many hundred feet above the mine. The contact with the old metamorphic rocks dips much more steeply, and some of the rocks exposed in the Black Rocks area may be much farther below the original surface of the quartz monzonite. It seems probable, therefore, that the veins in the dacite porphyry and near the margins of the quartz monzonite were formed many hundreds or thousands of feet higher in the quartz monzonite than those exposed in the central parts of the mass. The uniformity of the veins, accordingly, is regarded as evidence that they probably will not materially improve in grade with depth.

All the available evidence, geological and otherwise, indicates that although the tourmaline-quartz veins of the Temescal district consistently carry small amounts of tin, the veins are not likely to improve in grade with depth, and their economic possibilities are accurately indicated by the present exposures. The probability of finding minable ore bodies by underground exploration is believed to be slight.

Mines and Prospects

The following description of individual mines and prospects is based on surface mapping by the Geological Survey. Only adit No. 3 and adit No. 9 were accessible at the time the work was done, and information furnished by Mr. George Bryant was used in describing the other underground workings. American Tin Corporation assays and vein widths have been used, except where noted.

Cajalco or No. 1 Vein

(Cajalco mine)

The Cajalco mine is in the NW$\frac{1}{4}$, SW$\frac{1}{4}$, of sec. 2, T. 4 S., R. 6 E, on the Cajalco or No. 1 vein. The workings consist of an adit at an altitude of 1,159 feet*, a vertical shaft (the Robinson) now caved, an inclined shaft (the Williams or No. 1) that extends to a vertical depth of 540 feet, a raise to the surface from stope No. 1, and more than 5,800 feet of drifts and crosscuts on seven levels. The extent of workings on different levels and the range in thickness of vein are shown in table XX, compiled from maps by Bryant.

Table XX. Length of workings and thickness of vein in the Cajalco mine

		Extent of workings (in feet)		Thickness of
Level	Altitude	Drifts	Cross cuts	vein (feet and inches)
1	1,150	480	40	2 in. - 5 ft.6 in.
2	1,080	735	185	2 in. - 4 ft.6 in.
3	1,030	880	780	
4	990	135	40	8 in. - 4 ft.
5	905	425	20	6 in. - 4 ft.2 in.
6	830	880	130	1 in. - 5 ft.10 in.
7$\frac{1}{2}$	690	360	735	
		3,895	1,930	

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* Bryant's map shows an altitude of 1,150 feet. Geological Survey altitudes are based on altitude of Cajalco dam of Metropolitan Water district.

On the surface, vein material is exposed discontinuously over a length of 550 feet, and ranges in thickness up to 5 feet. The vein is 5 feet thick at the Robinson shaft, pinches out at the road, is 1 foot thick at the portal of the No. 1 adit, farther northeast ranges from a few inches to 5 feet, is 2.5 to 3 feet thick at the Williams shaft, and pinches out a few feet beyond. It is composed mainly of mottled tourmaline rock, with a narrow band of black tourmaline in the center. Surface samples taken by the American Tin Corporation assayed 0.08 to 0.20 percent of tin. In the workings of the Cajalco mine, the vein seems to have about the same range in thickness.

In spite of all the workings in the Cajalco vein, only 2 small shoots of ore were discovered, and both of these were above the third level. The larger ore body was removed in No. 2 stope, which had a strike length of about 70 feet and a pitch length of 240 feet. The No. 1 stope had a strike length of 160 feet, and was mostly between levels 1 and 2. The average grade of the ore removed was approximately 2 percent of tin. Samples cut from the walls of these stopes showed commercial ore in only a fewplaces. The remainder of the vein, exposed in thousands of feet of drifts, contains no commericial ore, and the average grade is less than 0.15 percent of tin.

When the mine was partially dewatered in 1943, Thayer examined stope No. 2, and made the following observations. The eastern edge of No. 2 ore body lensed out rapidly. Although the footwall split of the vein is 5.5 feet wide, including 6 to 8 inches of dense tourmaline rock, at the east edge of the stope at the first level, it pinches out completely 50 to 55 feet east in the drift. The hanging wall split, though 3 to 4 feet wide in the edge of the stope, does not extend to the short crosscut 10 feet farther east. Fifteen feet below the floor of level No. 1 the vein pinches from 5.5 feet to 6 inches in a strike distance of 6 feet, partly as a result of minor faulting.

Other workings connected with vein No. 1 include the No. 3 tunnel (fig. 10), 275 feet long, in the pipe called the Cajalco Hill "blowout". This adit is in various types of tourmaline rock cut by a fault zone. Samples taken by the Survey contained only traces of tin (samples TDL-22C to 29C; 40, table 2) though the American Tin Corporation obtained assays of as much as 0.10 percent of tin. The Metals Reserve Company's sampling of the surface of this "blowout" indicated a grade of less than 0.01 percent of tin.

A 50-foot vertical shaft, No. 4, 180 feet south of Shaft No. 1, is on a small vein that may connect with the Cajalco Hill pipe at adit No. 3.

East of the No. 1 shaft, the Cajalco vein pinches out, but another group of veins striking in a more easterly direction and dipping 50 to 55° NW continues for another 600 feet. These are exposed in inclined shaft No. 3 and in a number of trenches.

Vein No. 2

Vein No. 2, 380 feet southeast from Shaft No. 1 (see fig. 3), is opened by 2 inclined shafts 150 feet apart. Shaft No. 5 is 100 feet deep on a 70 degree incline, and from the 85 foot point, it is connected by a drift with

with the bottom of Shaft 6, and by a crosscut with Shaft No. 4 on a different vein. Crosscuts driven south from the Cajalco mine exposed what was believed to be same vein on the No. 3 level and the No. $7\frac{1}{2}$ level. On the No. 3 level (equivalent to 185 Level of Shaft No. 5) drifts in No. 2 vein were extended 125 feet SW and 300 feet NE of the crosscut. The dip of the vein decreased from 70 degrees above the 50-foot level to 53 degrees between the 185- and 520-foot levels.

On the surface, vein No. 2 consists of three lenses connected by thin tourmaline stringers, and appears to feather out about 50 feet southwest of shaft No. 5. The vein strikes No. 50° - 55° E. and dips 65° - 70° NW. At shaft No. 5 it is cut by a normal fault of a few inches displacement that strikes N. 40° E. and dips 60° SE. At shaft No. 6 a normal fault, with 2 feet of vertical displacement, strikes east and dips 65° S. The vein is 2 feet thick at the west edge of shaft No. 5, but narrows abruptly in both directions; the average is about 8 inches. The vein appears to have been brecciated during mineralization and numerous epidote veins cut the tourmaline rock. Silicification is unusually strong; the lenses of fine-grained tourmaline in the center of the vein are very discontinuous and less than 3 inches thick. These pods probably furnished the high grade ore that was mined in 1929 from a pit 50 feet long by 10 feet deep, just northeast of shaft No. 6.

The weighted average of 46 samples taken by the American Tin Corporation on the 50-foot level excluding those mentioned below, was 0.12 percent of tin over a 16-inch width. Three assays showed 1 to 2 percent tin near the shafts and 1 percent at one spot on the 50-foot level. A specimen representing 2 inches of the vein assayed 67.87 percent and a 4-inch sample 4.96 percent. On the 185-foot level, southwest of the crosscut, the vein has an average width of 12 inches and 23 assays are said to have averaged 0.10 percent tin. Northeast of the crosscut the vein was said to be 6 inches thick and 40 samples averaged 0.06 percent of tin. On the 520-foot level the vein was 34 inches thick and assayed 0.08 to 0.10 percent of tin and 0.8 percent of copper (as chalcopyrite).

About 1,200 feet southwest of and in line with, vein No. 2 are two veins which have been exposed by stripping for 200 to 400 feet along the strike. These have been assumed to be part of vein No. 2, and likewise the veins 800 feet to the northeast have been assumed to be part of the same system. Geological Survey samples (P4 and P5) from these veins contained traces of cassiterite.

Vein No. 3

Vein No. 3, 210 feet southwest of vein No. 2, is exposed intermittently for 750 feet; about 370 feet was stripped and it was crossed by two trenches. Shaft No. 7 80 to 100 feet deep on a 65 degree incline, prospects the vein about 50 feet from its southwest end. The vein is also cut, at the 500-foot level, by the crosscut from the No. $7\frac{1}{2}$ level of the Cajalco mine.

On the southwest side of the shaft the vein strikes N. 50° E. and dips 72° NW and on the northeast side it strikes N. 60° E and dips 60° NW. It is cut by a gouge zone that strikes N, 65° E and dips 65° NW. At the shaft the hanging wall of the vein is aplite and the footwall is coarse-grained quartz monzonite. Southwest of the shaft, the vein consists of 6 to 18 inches of brecciated fine- to coarse-grained mottled tourmaline rock with a one to 3-inch fine-grained tourmaline rock with a one to 3-inch fine-grained tourmaline center, and appears to be faulted off. Northeast of the shaft the 12- to 30-inch vein lenses out within 20 feet and another starts 3 feet to the south. This strikes N. 47° E. and is largely brecciated fine, glassy, tourmaline rock and is up to 4 feet thick.

Of 21 assays from surface samples of this vein half contained no tin, and the others 0.05 to 0.29 percent of tin. The weighted averages of these showed 0.10 percent of tin over an average width of 16 inches. Four samples in the upper 80 feet of the shaft showed 0.08 to 0.18 percent of tin over 20-to 30-inch widths and at the 500-foot level the vein assayed 0.08 percent of tin over 38 inches.

About 1,000 feet to the northeast there is a group of small veins, one of which may be an extension of the No. 3 vein structure. Southwest of shaft No. 7, 1,100 to 1,400 feet and 2,050 to 2,350 feet, veins which may be part of the same vein structure have been prospected by trenches. The vein segment from 1,100 to 1,400 feet southwest of the shaft is 6 to 30 inches thick, and averages about 12 inches.

Assays ranged from nothing to 0.15 percent of tin. The other vein is 2 to 6 feet thick, and seven assays spaced over 300 feet of strike length averaged 0.23 percent of tin over an average width of 15 inches. Individual assays ranged from 0.05 to 0.40 percent.

Veins No. 4 and No. 5

Vein No. 4 extends 950 feet northeastward from a point about 250 feet southeast of Shaft No. 7 (Fig. 3); it crops out again 250 feet to the northeast for a distance of 700 feet. The southwest part of the vein consists of a series of overlapping and interlocking vein segments, individually as much as 15 feet wide, which have been exposed by stripping and by a series of cross trenches. This part of the vein is exposed underground in Shaft No. 12.

On the surface, southwest of Shaft No. 12, Vein No. 4 includes a group of mottled tourmaline veins of irregular strike and dip. Fine-grained tourmaline in the center of these veins is as much as 3 inches thick. The quartz monzonite walls and the vein itself contain abundant epidote probably derived from the numerous basic inclusions which occur in the area. Northeast of the shaft, the veins are more sharply defined although they commonly pinch and swell. In places the mottled tourmaline rock is 15 feet wide, but the fine-grained centers are at most only a few inches wide. Assays of samples taken from the surface on this southwestern part of Vein No. 4 gave the following results:

Southwest of shaft 12 - 0.05 - 0.10 percent tin
1 sample (30" width) - 1.10-1.73% copper

Near the collar of shaft No. 12 - 1.90 percent tin) 24 inch
1.75 percent tin) widths.

Northeast of shaft No. 12 -	1 sample	- 0.0 percent tin
	3 samples	- 0.25 percent tin
	2 samples	- 0.10 percent tin
	1 sample	- 0.08 percent tin
	1 sample	- 0.05 percent tin

Underground, the vein is reported to be from 4 to 24 inches wide. The weighted average of assays of 40 samples was 0.008 percent tin, 4.0 percent copper, 4.0 oz. silver, and 0.05 oz. gold over an average width of 12 inches. Individual assays showed as much as 0.15 percent tin, 8.2 percent copper, and 7.6 oz. of silver. Samples from the shaft where it cut the vein showed from 0.0 to 0.15 percent tin over widths of 6 to 40 inches.

The northeast extension of Vein No. 4 is 6 inches to 3 feet wide. Near its southwest end, at Geological Survey sample P9, the vein is composed of radiating tourmaline needles in quartz monzonite. Fifteen samples across 6- to 40-inch widths showed 0.0 - 0.10 percent tin and Sample P9 contained traces of cassiterite.

Vein No. 5 has been prospected by trenches and by shaft No. 8 (fig. 9). The vein is one to four feet thick but has been split over most of its length by a 2- to 6-foot trachyte porphyry dike. Ten assays from the southwestern 800 feet of the vein show an average of 0.22 percent of tin over an average width of 28 inches. Near shaft No. 8 the vein is up to 3 of 4 feet thick and assayed 0.05 to 0.25 percent of tin over 24-inch widths, though some parts were barren. Samples in the shaft to a depth of 130 feet showed 6 to 36 inches of vein assaying 0.03 to 0.10 percent, and one sample was barren. On the surface the vein appears to contain widths of fine-grained tourmaline rock and malachite stains are common.

Near the common corner of secs. 2, 3, 10, and 11 (fig. 3) two groups of veins are designated as vein No. 5a and No. 5b; they are not extensions of veins No. 4 or 5. Vein No. 5a consists of two segments, each 300 feet long, in the southwest corner of section 2. The eastern segment has been stripped and is 1 to 11 feet wide. The western part, 3 feet thick, strikes N. 68° E. and dips 70° NW. for about 25 feet; widens abruptly to 7 feet for about 30 feet along a N. 25° E. direction; then changes strike to N. 55° E and widens to 11 feet; splits into two parts which rejoin 50 feet farther northeast; and continues with an average thickness of 18 inches to the end of the exposure. According to Bryant, of 40 samples taken across 12 to 60 inch widths, 5 assayed 0.05, 10 assayed 0.02 percent of tin and the rest were barren. A Geological Survey sample (P49) of the fine-grained glassy tourmaline in the wide part of the vein showed less than 0.001 percent of cassiterite in the heavy concentrates of the plus 200 mesh fraction. The western exposure of vein No. 5a has been explored by 6 cross trenches and is 1 to 4 feet thick.

Vein No. 5b, which lies about 200 feet southeast of No. 5a, is a series of en echelon lenses trending N. 50° E., which has been explored by 20 trenches in a distance of about 2,000 feet between the dacite porphyry-quartz monzonite contact and Mine creek. American Tin Corporation assays of samples from these veins show zero to 0.20 percent of tin over widths up to 36 inches. The vein consists mostly of mottled tourmaline rock and attains a width of 10 feet in places. Heavy concentrates of Geological Survey samples P42-48, inclusive, yielded 2 grains or less of cassiterite per slide, indicating less than 0.001 percent of tin in the plus-200 mesh fraction of the sample. Qualitative spectrographic analyses of samples P47 and P48 showed 0.1 and 0.08 percent of tin respectively.

Vein No. 6

Vein No. 6 is about 520 feet southeast of vein No. 4 and includes a series of about 20 weak, discontinuous mineralized fractures that extend 4,000 feet northeast from the dacite porphyry contact. Although two of the mineralized areas are 30 to 40 feet wide, the individual veins are less than 300 feet long and the intervals between them are as much as 1,200 feet. The rock is mainly mottled tourmaline of which few American Tin Corporation samples assayed as much as 0.10 percent of tin. Workings in the veins consist of two 15-foot shafts and a number of trenches. One Geological Survey sample, P7, contained traces of cassiterite.

Veins No. 7 and No. 8

Veins No. 7 and 8 crop out about 1950 and 2,150 feet respectively southeast of shaft No. 1. These discontinous vein structures are the strongest in the Cajalco mine area (fig. 3). They appear to converge in the NW. ¼, sec. 11, but a vein continues southwest and converges with vein No. 6 near the dacite porphyry contact. The total length of this structure is 4,800 feet and over at least half the distance there are two distinct veins. About 4,200 feet of the vein has been stripped and it appears to be discontinuous.

These veins are explored underground by shafts No. 13 and No. 14 on vein No. 8 and by adit No. 46 on vein No. 7 southeast of its convergence with vein No. 8. Shaft No. 13 inclined 60° NW., was started where samples 8 to 60 inches long assayed from 1 to 2.10 percent of tin. At 15 feet below the outcrop the vein assayed 1.16 percent over 20 inches and at 30 feet 0.32 percent of tin. Below this part of the vein all but one of the samples assayed less than 0.03 percent of tin. Geological Survey samples L30 to 36 were taken in the area of the high assays but only 4 showed traces of cassiterite. According to Bryant the vein is cut off by a slip that strikes N. 40° E. and dips 14° NW. at the 50-foot level. Shaft No. 13 is 80 feet deep with 50 feet of crosscut at the base. At the 50-foot level drifts were made 65 feet to the southwest and 58 feet to the northeast.

Shaft No. 14, 820 feet northeast, also was sunk in a high-grade cassiterite pod which was exposed in the pit southwest of the shaft. The shaft is 103 feet deep and slopes 78° NW. At the 70-foot level drifts extend about 53 feet to both the northeast and the southwest. In the shaft the vein pinches and swells as it passes quartz monzonite and basic inclusions. Samples taken by the American Tin Corporation from the pit at the surface contained from 0.28 to 1.94 percent of tin over widths of 6 to 26 inches; the weighted average of 8 samples is 0.73 percent for a 12-inch width. Eight samples from the upper 25 feet of the shaft contained between 0.26 and 0.75 percent of tin; the weighted average was 0.43 percent tin over a 14-inch average width. The average weighted assay of 23 samples along the drift on the 70-foot level is 0.13 percent of tin over an average width of 19 inches.

Adit No. 46 prospects vein No. 7 on the southwest side of Mine Creek. The adit follows the vein southwest for 330 feet and at 150 feet there are 75 feet of crosscuts. The vein dips 68° NW at the surface and is from 6 to 60 inches wide. Above the adit it crops out as two separate lenses that pinch out at either end. The vein is largely mottled tourmaline rock with a narrow center of fine-grained tourmaline, but southwest of the adit the center consists of loose-textured tourmaline, fine-grained white mica, and iron sulphides. Galena and sphalerite were picked up on the dump from this vein. With few exceptions, the American Tin Corporation samples contained less than 0.10 percent of tin. Two of the four Geological Survey samples showed less than 0.001 percent of cassiterite in the concentrates, but spectrographic analysis of P-11 showed 0.15 percent of tin.

About 760 feet east of adit No. 46 there are exposures of a vein that has, in the past, been incorrectly correlated with vein No. 8. These appear to be part of a two parallel vein structures, 30 to 150 feet apart, which can be traced intermittently to the dacite porphyry contact, about 2,600 feet southwest. The average grade of these exposures is probably about 0.03 percent of tin.

Veins No. 9 and No. 10

Veins No. 9 and No. 10 crop out southwest of, and above, adit No. 9 which is 2,300 feet southeast of adit No. 46. The two veins are parallel and about 50 feet apart. On surface vein No. 9 is exposed continuously for 400 feet and had been stripped for 325 feet. American Tin Corporation samples from the northern part of the stripped area assayed from 0.30 to 1.60 percent of tin.

Vein No. 10 crops out almost continuously from 180 to 900 feet southwest of the portal of adit No. 9 and has been stripped for 500 feet at its southwestern end. For 300 feet at the southwest end of the trench the vein consists of two splits. It ranges from 8 inches to 6 feet in thickness and shows a large proportion of fine-grained tourmaline rock. That part of the vein from 800 to 1,100 feet southwest of the adit portal is 12 to 100 inches wide. Samples taken by the American Tin Corporation assayed 0.10 to 0.35 percent of tin.

Adit No. 9 prospects this vein. The underground workings include 135 feet of crosscut to vein No. 10, along which a drift was driven for 475 feet. A 6 to 12-inch vein, intersected in the crosscut 32 feet east of vein No. 10, was explored to the southwest by a 20-foot drift. At 400 feet on the main drift, a crosscut was driven 175 feet to the northwest. This cut vein No. 9 at 50 feet, where it was 10 inches thick. Vein No. 10 is irregular in width and consists of a series of lenses that are brecciated by a group of small strike faults. The northeast end of the vein may have been faulted off. The vein rock is largely mottled tourmaline rock, though in the wider parts fine-grained tourmaline, up to 2 feet thick, forms the center of the vein. Most of the assays recorded by the American Tin Corporation along the underground workings are from 0.03 to 0.05 percent of tin, though a 60-foot section of the vein, 175 to 235 feet southwest of the north end of the vein, assayed from 0.10 to 0.18 percent of tin for 18 to 24 inch widths. Vein No. 9 was cut underground, just northeast and below the point where high assays were obtained on surface but on the adit level it assayed only 0.05 percent of tin.

Numerous veins east of No. 9 and No. 10 in sec. 11 have been sampled but most assays show little, if any, tin.

Veins North and West of Cajalco Hill

A group of veins crop out intermittently for about 1,000 feet northeast of a point 2,780 feet north of the corner of secs. 2, 3, 10, and 11. These are similar to others in the district but are more irregular in strike and dip. They are rarely over 1 foot in width and show less than 1 inch of fine tourmaline in the center of mottled tourmaline rock. The northeastern ones show an unusual type of silicification which results in a greenish glassy quartz-rich rock at the edges of the mottled tourmaline rock.

Just west of Cajalco hill a branching vein has been stripped for 250 feet and has been explored by a pit at its northern end (fig. 12). Geological Survey samples P2 and P18-22 showed less than 0.001 percent of cassiterite in heavy concentrates and P22 contained 0.20 percent of tin according to spectrographic analyses. About 520 feet west of this vein is a small exposure in which cassiterite was recognized in hand specimen. Geological Survey samples P23-25 failed to show appreciable cassiterite in concentrates. P23 contained less than 0.0001 percent of cassiterite in the heavy concentrates, but by spectographic analysis contained about 0.1 percent of tin.

About 450 feet south of the branching vein are two other vein exposures. The northernmost and branching vein contains dumortierite with tourmaline. The southernmost vein outcrop is brecciated and veined with epidote. Southwest and west of this exposure a number of short veins in the monzonite have been explored by trenches and one shallow shaft. Only a few of the American Tin Corporation's assays showed as much as 0.10 percent of tin in these outcrops.

Veins in the Dacite Porphyry

The dacite porphyry near the section line between sec. 3 and sec. 10 contains a number of tourmaline veins which strike from N. 20° W. to N. 40° E. and in general dip from 25 to 80 degrees to the west, though a few dip to the east. Ten of these veins have been partly stripped, and three veins have been prospected by two inclined shafts (No. 15 and No. 17) and one vertical shaft (No. 16). Of about 100 samples taken by the American Tin Corporation on these veins, all except 4 taken near incline No. 17, and 9 taken near incline No. 15, contained less than 0.08 percent of tin.

Shaft No. 15, which slopes 15 to 20 degrees to the northwest, is on a 3 to 6 foot vein which differs markedly from the other veins of the district. It is a rubbly-appearing light buff to greenish grey rock in which nodular masses of fine-grained grey tourmaline-arsenopyrite masses up to 6 inches or more in diameter are enclosed in a white to buff talcose and micaceous groundmass. According to Bryant 8 samples, 12 to 60 inches in width assayed 0.24 to 1.62 percent of tin. One 2-foot channel sample collected by the Geological Survey from the upper part of the vein on the west wall of the shaft at the portal assayed 0.32 percent tin according to Charles Bentley of Rapid City, South Dakota. Spectrographic analyses of samples P34, P34A, and P35 from this vein showed 0.1, 0.2, and 0.25 percent of tin, respectively. The plus 200-mesh fraction of sample P35 between 2.8 and 3.3 specific gravity, contained 0.20 percent of tin, indicating its presence in minerals other than cassiterite.

Shaft No. 16 was sunk vertically to prospect the intersection of a group of north trending and west dipping veins with the vein followed by shaft No. 15. This was not successful in finding more than traces of tin. Results of microscopic study of Geological Survey samples (P28-33) from veins to the north are given in table 3. A spectrographic analysis of sample P33 showed about 0.25 percent of tin and the presence of cassiterite was confirmed by microscopic studies, though it was less and 0.001 percent of the heavy concentrates.

Shaft No. 17 was sunk on a vein dipping 35° W. which was assumed by Bryant to be the same one encountered in shaft No. 15. There is no evidence to prove that these two are connected. Seven assays of samples taken by the American Tin Corporation along the outcrop are reported to be 0.11 to 0.40 percent of tin. Traces of cassiterite was found in heavy concentrates of Geological Survey samples P38 and P39. Samples P39 contained 0.15 percent of tin according to spectrographic analysis.

Veins in Sections 1 and 12

A group of tourmaline veins in the SW ¼, sec. 1 and the NW ¼, sec. 12 trend about N. 20° E. and for the most part dip 50° to 80° NW. A few veins dip 60° to 65° SE. These veins are well exposed in the road cuts and the spillway of the Cajalco dam. According to Bryant about 210 samples from veins exposed in the NW ¼, sec. 12 contained less than 0.11 percent of tin. However, with but few exceptions the assays showed only 0.03 to 0.05 percent. The thickness of these veins are shown on figure 2. The extension of these veins in the SW ¼ of sec. 1 are of similar grade according to Bryant. Fifteen samples were taken by the Geological Survey and concentrated by means of heavy liquids. Samples P50, 51, 52, 53, 59, 61, and 62, contained traces of cassiterite (probably less than 0.001 percent).

Tourmaline Veins and Pipes of the Black Rocks Area

Three groups of tourmaline veins and pipes occur in the Black Rocks area (fig. 4). One group in the NW ¼ sec. 18, T. 4 S., R. 5 E. is known as North Black Rocks. Another group near the common corner of secs. 13, 24, 18, and 19 has no special designation. The third group in the NW ¼, sec. 19 are known as the South Black Rocks group. The name Black Rocks is derived from the outcrops of these tourmaline pipes which rise prominently above the flat country. The areas between veins are covered by alluvium or sands and gravel.

The Black Rocks Tin Syndicate thoroughly sampled about 40 veins in the NW ¼, sec. 18 in 1927-29. One inclined shaft (No. 8) and a few pits prospect the veins. Only part of this group is shown in figure 2, namely those in the immediate vicinity of shaft No. 8. Additional veins occur to the north, east, and south of those mapped. No mapping was done in sec. 18 east of the road to Black Rocks or inside the Metropolitan Water District fence in sections 12 and 7. Detailed geologic mapping was not carried out west of the area of Elsinore metamorphics in sec. 13.

About 310 samples were taken by the Black Rocks Tin Syndicate and only occasional assays showed more than 0.08 percent of tin. Most of the assays were black, trace, 0.03, or 0.05 percent. The highest was 0.18 percent.

Shaft No. 8 is reported to be about 180 feet deep and is inclined about 72° to the east. The vein is porphyritic tourmaline rock.

The group of veins near the common corner of secs. 13, 24, 18, and 19 lies northeast of a group of tourmaline breccias in sec. 24. A ringshaped and also a lenticular breccia pipe occur in the SW ¼ of sec. 18. The veins range in width from 6 inches to 15 feet in thickness. They strike from north to N. 60° E. Associated with the tourmaline veins are silicified monzonite veins or masses elongated N. 45° W. No cassiterite is visible in any of the outcrops, though these like other veins in the district have narrow seams of fine-grained tourmaline in the center. One of the largest veins is explored by a shallow shaft, inclined 70° SE. in the upper part, and vertical at the base. No assays are available to indicate the grade of these veins, but it would be surprising if they contained more tin than the other veins of the district.

The South Black Rock group of veins and pipes includes two veins that have been prospected by shafts No. 1 and No. 2 and others that were prospected by trenches. The veins strike N. 30° - 60° E. and, for the most part, dip 65° - 80° SE. In places they attain a width of 30 feet and are continuously exposed for as much as 800 feet. They show more branches than most of the veins in other parts of the district, but there is less fine-grained, loose-textured tourmaline rock than in veins No. 1 to No. 10 in the Cajalco mine area. Some of the vein material is breccia similar to that in the breccia pipes. The outcrops of the breccia pipes, as indicated on the maps, probably outline their shape rather closely because the tourmalinized rocks appear to be much more resistant than the surrounding monzonite. However, the intervening areas are in part gravel or alluvium which cover the details of the contacts. One small mottled tourmaline pipe north of the Black Rocks pipe shows about 5 feet of dumortierite rock on its southern contact.

One semi-circular pipe northeast of Black Rocks contains no breccia. It is made up of mottled tourmaline and porphyritic tourmaline rock. (fig. 4) Fractures with more intense alteration appear to have been the channelway for replacing solutions. The outline of this pipe has been mapped, in part, on the presence of float which appears not to have moved appreciable distances.

More than 150 assays of samples taken by the Black Rocks Tin Syndicate at the Black Rocks breccia pipe and the veins to the south and west indicate that the average grade of these veins is probably between 0.03 and 0.05 percent of tin. The upper 30 feet of shaft No. 2, which is inclined 75° SE averages about 0.10 percent of tin over an average width of 56 inches. This is the most promising place assayed.

(200) Mem (Mescal Tin)

Table 3 . Qualitative spectrographic analyses of Geological Survey samples a/

Map No.	Sample No.	Al	Fe	Si	Mg	As	K	Na	Ti	B	Ca	Zr	Sn	Ba	Sr	Mn	Cu	V	Bi	Cr	Ga	Co	Ag	Pb	Zn	Ni	Mo	Remarks
		Probable Percentages																										
P11	LRP- 660-40	10	10	10	2		.6	2	.6	.5	.4	.04	.15	.1	.02	.1	.1	.001		.06	.001		.002	.6	.02	.0006	.0005	Chip sample. Along N. side of 4"-vein. Tourmaline-quartz-mica greisen.
P75	LRP- 700-40	10	10	10	2		.1	1	2	.5	2	.04	.05	.1	.05	.2	.1	.001	.0004	.1	.001		.0002	.001		.001		Grab sample across mottled tourmaline rock vein.
P76	LRP- 750-40	8	10	10	2		.1	.5	2	.5		.04	.06	.002	.02	.1	.1	.001	.0004	.1	.001	.0005	.0002	.001		.0006		14" channel across mottled tourmaline rock vein.
P22	LRP- 810-40	10	10	10	4		.4	2	2	.5	1	.04	.2	.002	.02	.2	2	.002	.1	.2	.01	.002	.1	.1	.005	.002	.001	Specimen. Massive fine-grained tourmaline rock with molochite.
P23	LRP- 820-40	20	10	10	4		2	5	2	.5	.7	.04	.1	.1	.02	.2	.1	.001	.0002	.1	.01	.004	.0004	.002		.0006	.001	14" channel across vein.
P77	LRP- 870-40	12	10	10	4		.2	2	2	.5	1	.04	.05	.2	.02	.1	.1	.004		.1	.002	.0005	.0002			.0006		Fine-grained tourmaline veins in dacite porphyry.
P78	LRP- 880-40	20	10	10	10		.4	5	2	1	1	.04	.06	.001	.02	.1	.1	.06		.1	.01	.002				.0006		5"-channel at intersection of tourmaline seams.
P79	LRP- 900-40	10	10	10	4		1	10	2	.5	1	.1	.05	.2	.1	.1	.1	.004		.1	.001		.0001	.001		.0006		1'-channel across numerous tourmaline seams.
P80	LRP- 910-40	20	10	10	6		.1	5	2	.5	1	.1	.05	.0002	.02	.2	.1	.03		.06	.001	.0005	.0001	.004		.006		Specimen sample. Fine-grained 2"-tourmaline vein.
P81	LRP- 920-40	20	10	10	2		2	7	2	.2	2	.04	.04	.3	.1	.1	.1	.004	.0004	.1	.001	.001	.001	.01		.0006		Silicified dacite porphyry between tourmaline seams.
P33	LRP- 980-40	20	10	10	4	1	2	5	2	.5	.1	.1	.25	.1	.02	.2	.1	.01	.01	.1	.002	.001	.001	.002		.0006		Fine grained tourmaline rock with sulphides and mica.
P34	LRP- 990-40	10	10	10	2	2	2	.5	2	.1	.5	.04	.1	.3	.01	.05	.1	.004	.0004	.1	.001		.0004			.0006		Vein center at S. wall, shaft No. 15. Tourmaline-arsenopyrite nodules in micaceous matrix.
P34 A	LRP- 990(A)-40	10	10	10	2	1	2	2	2	.5	.5	.2	.2	.05	.02	.1	.1	.03	.006	.1	.002	.001	.002			.0006		Do.
P35	LRP-1000-40	20	10	10	4	2	1	2	2	1	.5	.1	.25	.006	.02	.1	.1	.06	.05	.06	.002	.0005	.01	.002		.0006		8" channel. Above P34. Iron stained, vuggy tourmaline rock.
P62	LRP-1030-40	10	10	10	2		.6	2	2	.5	1	.2	.06	.2	.02	.2	.1	.02	.0002	.06	.001	.001	.006	.001		.002		3' channel across tourmaline vein. S. side shaft No. 15.
P39	LRP-1050-40	10	10	10	4	2	2	2	2	1	1	.3	.15	.1	.1	.05	.02	.002	.001	.001	.001	.0005	.0001					Dumortierite and tourmaline in talcose, chloritic matrix.
P83	LRP-1080-40	10	10	10	4		.4	1	2	.5	.7	.04	.04	.2	.02	.05	.1	.002		.1	.0005	.0005	.0001	.002		.001		2" to 3"-vein along dacite porphyry - monzonite contact.
P84	LRP-1090-40	20	10	10	6		.2	5	2	1	.7	.2	.06	.003	.01	.2	.1	.06		.1	.01	.001	.0001	.004	.005	.01		Sample across vein.
P85	LRP-1100-40	10	10	10	2		.2	.3	1	.5	.5	.2	.05	.1	.01	.07	.1	.001		.1	.0005	.0005	.0001	.002		.002		Chip sample of 4 sq. ft. Hard, glossy tourmaline rock.
P86	LRP-1130-40	10	10	10	2		.6	7	2	.1	1	.04	.05	.2	.05	.05	.1	.001	.0002	.01	.0005	.0005	.0004	.002		.0006		Sample of weathered monzonite on footwall of vein.
P47	LRP-1160-40	20	10	10	6		1	5	2	1	1	.02	.1	.05	.05	.2	.1	.06	.02	.06	.007	.0005	.0002	.1	.01	.0006		Mottled and fine-grained tourmaline rock. Possibly cassiteritite.
P48	LRP-1170-40	10	10	10	2		.1	5	1	1	1	.1	.08	.006	.05	.2	.1	.01	.1	.1	.001	.0005	.001	.1		.001		Lens of vuggy mottled tourmaline rock.

a/ Analyzed by M. F. Hasler, Applied Research Laboratories, Los Angeles, California

(NO TABLE 1)

Table 2.—Results of heavy liquid separations on samples from the tin-bearing veins.

Sample number on map (figs. 2 and 3)	Type of sample	Weight (pounds)	Screen analysis after pulverizing (Weights in grams): 80-200 mesh (used in heavy mineral separations) (grams)	-200 mesh (discarded)	Magnetic separations of fraction 3.3 specific gravity: Non-magnetic Weight	Percent of original sample	Grains of cassiterite observed in mount a/	Remarks
P 1	Grab	3.0	34.2	44.4	1.46	3.04	0	Epidotized monzonite.
P 2	Specimen	2.5	53.8	44.7	0.30	0.56	1	Center of vein. Glossy, fine-grained rock tourmaline.
P 3	Specimen	3.0	47.1	52.3	0.21	0.44	0	Epidotized monzonite.
P 4	Specimen	2.0	53.75	42.55	0.21	0.39	20	Vein. Dull, fine-grained tourmaline-quartz rock.
P 5	Specimen	1.25	54.2	43.65	1.30	2.39	4	Three-inch vein. Micaceous, mottled tourmaline rock.
P 6	Specimen	2.0	48.5	41.05	1.25	2.58	0	Felted, fine-grained tourmaline.
P 7	Grab	2.0	48.3	50.7	0.39	.81	1	Average of 12"-vein, fine-grained tourmaline rock.
P 8	Specimen	3.5	54.82	40.0	0.22	0.41	0	Spots of tourmaline in aplite.
P 9	Grab	3.0	39.05	56.1	1.47	3.77	1	Three-foot vein. Radial tourmaline.
P10	Specimen	3.5	59.55	38.4	3.7	6.27	0	Vein seam. Brown, altered feldspar. No tourmaline.
P11	Chip	6.0	59.60	38.3	1.20	2.02	3	Along N. side 4-inch vein. Tourmaline-quartz-mica greisen.
P12	Chip	3.0	52.6	40.0	0.21	0.40	0	Across 18" on S. wall of vein. Mottled tourmaline rock.
P13	Chip	3.0	45.25	50.8	1.12	2.49	0	Center of vein.
P14	Chip	5.0	47.35	46.9	1.11	2.35	2	Eight inches across W. edge of vein. Vuggy, fine-grained tourmaline rock.
P15	1' channel	3.0	50.9	42.1	0.88	1.73	0	Along 3-inch center of vein. Tourmaline.
P16	1' channel	2.0	59.0	38.75	0.21	.36	22	Across unaltered footwall monzonite and thin tourmaline seams.
P17	1' channel	4.0	54.4	44.2	3.37	6.21	0	Along 6-inch hard, glossy tourmaline vein center.
P18	Chip	5.0	56.74	40.2	1.75	3.41	0	Along 6-inch fine-grained tourmaline vein center.
P19	14" channel	2.5	60.47	36.4	1.98	3.25	0	Across massive, hard, glossy, fine-grained tourmaline vein.
P20	2' channel	5.0	68.05	30.5	0.26	.38	1	Above hanging wall of vein. Slightly tourmalinized.
P21	4" channel	4.0	55.25	43.4	0.41	.75	0	Mottled tourmaline rock.
P22	Specimen	3.0	55.05	44.7	1.25	2.27	—	Massive, fine-grained tourmaline rock with malachite stains.
P23	14" channel	6.5	47.3	51.2	3.02	6.35	2	Across vein.
P24	12" channel	6.0	47.1	46.6	0.84	1.75	0	Across hard, fine-grained tourmaline rock of vein center.
P25	Specimen	2.0	47.0	47.8	0.87	1.86	1	Soft, fine-grained tourmaline rock.
P26	Chip	6.0	34.45	62.0	0.05	.14	0	Across dumortierite vein. Includes 2½" of fine-grained tourmaline rock.
P27	2" chip	6.0	45.55	51.0	0.35	.77	0	Along 15" dumortierite vein. Included fine-grained tourmaline rock.
P28	5" channel	5.0	49.8	48.75	0.29	.59	0	Hangingwall dacite. Some tourmaline.
P29	6' chip	4.5	40.1	58.3	0.54	1.36	1	Along vein. Fine-grained tourmaline rock.
P30	2" chip	4.5	42.95	55.6	0.41	.96	0	Down dip of 3" fine-grained tourmaline vein.
P31	Specimen	6.0	38.0	60.0	0.34	.80	0	Tourmaline seams in dacite porphyry.
P32	Grab	5.5	42.25	56.1	0.52	1.25	0	3' x 5' area. Dacite porphyry; silicified and tourmalinized.
P32	Grab	5.5	42.25	56.1	0.52	1.25	0	3' x 5' area. Dacite porphyry; silicified and tourmalinized.
P33	16" channel	8.0	40.25	57.95	0.59	1.47	2	Fine-grained tourmaline rock with sulphides and mica.
P34	8" specimen	3.5	52.05	46.0	0.06	1.25	3	Vein center at S. wall shaft No. 15. Tourmaline-arsenopyrite nodules in micaceous matrix.
P34a	—	2.0	47.6	50.8	0.82	1.69	1	Same as P34.
P35	8" channel	5.0	40.35	58.1	0.37	.96	0	Above P34, iron-stained, vuggy tourmaline rock.
P36	Specimen	5.0	45.8	52.55	0.36	.79	0	14" brecciated, quartz-mica-tourmaline vein. S. of shaft No. 15.
P37	3" channel	7.0	37.8	59.45	0.21	.57	0	Across tourmaline vein in dacite porphyry.
P38	4' channel	4.0	44.6	53.35	0.14	.32	1	Includes entire tourmaline vein.
P39	Chip	5.0	46.15	52.2	3.56	7.71	1	Dumortierite and tourmaline, in talcose, chloritic matrix.
P40	Chip	4.0	36.8	60.95	0.37	1.26	0	Center vein in brecciated and silicified vein zone.
P41	2" channel	5.5	33.35	64.8	0.25	.75	0	Across fine-grained tourmaline rock vein center.
P-42	1' channel	6.5	51.05	47.7	1.07	2.25	0	Across fine-grained tourmaline rock vein center.
P-43	—	10.0	53.4	29.55			0	Same as P42.
P44	Chip	3.0	56.35	40.0	0.53	.95	1	1½' cut in mottled tourmaline rock in the hangingwall.
P45	1' channel	3.5	49.45	49.45	1.28	2.65	0	Brown, red stained fine-grained and mottled tourmaline rock.
P46	8" channel	5.0	41.75	56.6	0.59	1.45	2	Similar to P45, but finer grained.
P47	Chip	3.0	43.6	58.9	0.62	1.43	1	Mottled and fine-grained tourmaline rock. Possibly cassiterite.
P48	Grab	9			0.83		1	Lens of vuggy mottled tourmaline rock.
P49	Grab				0.69		2	11' mottled and fine-grained tourmaline rock.
P50	18" channel	3.5	63.5	24.2	0.06	.20	1	Across radial tourmaline vein; quartz center.
P51	30" channel	4.5	94.2	26.8			1	Radial tourmaline at outer edge of vein.
P52	1' channel	6.0	40.1	19.3			1	Along 6" quartz center of vein.
P53	Chip	2.5	38.85	21.15			2	20" across W. side of vein at P52.
P54	1' channel	1.5	45.2	23.6			0	1½" zone along S. side of quartz vein center.
P55	Chip	3.0	39.15	31.3			0	Felted, radial tourmaline vein with 4" quartz center.
P56	24" channel	3.5	76.6	34.9			0	Weathered monzonite in hanging wall of vein.
P57	14" channel	3.0	41.7	28.2			0	Dumortierite zone; a few tourmaline seams, below P56.
P58	12" channel	4.0	60.15	34.3			0	Glossy, coarse mottled tourmaline seams, below P57.
P59	18" channel	2.5	41.95	29.1			1	Dumortierite zone; few tourmaline seams, below P58.
P60	6" channel	3.0	75.75				0	Weathered monzonite, below P59.
P61	1' channel	4.5	54.25	30.75			3	Silicified zone 7' above P56. Looks like 30 percent tourmaline pebble quartzite.
P62	12" channel	2.0	58.6	34.9			1	Along 4" vein, 13' W. of P60.
P63	3.5' channel	8.0	33.0	18.2			0	Across dumortierite vein.
P64	18" channel	5.0	36.5	36.2	0.22	.60	0	Dull, fine-grained, micaceous tourmaline vein center.
P65	4.5' channel	5.0	33.2	19.15			0	Mottled tourmaline, 2" vein center omitted.
P66	Grab	6.5	41.0	20.15			0	Tourmalinized (10-15 percent) monzonite.
P67	Specimen	7.0	38.8	22.1	0.19	.51	0	Mottled tourmaline rock.
P68	Chip	5.5	48.8	18.45	0.01	.04	0	White to brown quartz with 30 percent tourmaline.
P69	Chip	2.0	70.7	42.3	0.21	.31	0	Matrix of breccia. Fine-grained glossy tourmaline rock.
P70	Grab	7.5	63.1	38.6	0.04	.07	0	Average of mottled tourmaline rock of "blowout."
P71	Grab	4.0	55.7	52.2	0.02	.03	0	Average of grey tourmalinized monzonite of "blowout."
P72	Grab	8.0	57.4	45.25	0.04	.08	1	Hard, glossy, black tourmaline rock.
P73	Grab	8.5	68.65	36.65	0.04	.06	1	Glossy, fine-grained mottled tourmaline rock.
P74	Grab	5.5	63.95	51.6	0.01	.03	0	Fine-textured tourmalinized breccia.
L 1	1' channel	3.0	163.2	326.7			—	Hard, dull, fine-grained tourmaline rock of 5" vein in monzonite.
L1b	Do	4.5	49.4	49.0			—	Do.
L 2	Chip	7.0	255.75	236.85			3	E. side hanging wall vein at L 1.
L 3	Chip	4.0	252.4	233.6			2	W. side foot wall vein at L 1.
L 4	8" channel		56.3	38.15	0.50	.91	3	Iron stained gouge zone; footwall of fault.
L 5	Chip	6.5	53.5	42.4	0.59	1.11	3	Weathered mottled tourmaline rock; hanging wall of fault.
L 6	5' channel	6.0	51.1	44.1			5	Fine-grained, dark, tourmaline rock.
L 7	Grab	127.3 grams	49.8	69.15	4.54	9.08	0	Red to brown cavity filling in breccia.
L 8	Grab	6.0	271.5	225.0			3	Monzonite from dump of Robinson shaft.
L 9	Grab	8.5	54.3	40.2	1.19	2.19	0	Mottled tourmaline rock; vuggy breccia.
L10	4' chip	10.0	52.3	40.9			—	Do.
L11	3' chip	8.0	52.3	42.7			0	Brecciated, tourmaline breccia.
L12	Grab	10.0	48.8	44.7			0	5 sq. ft. area. Mottled tourmaline rock.
L13	Chip	1.5	48.1	45.7			0	Mottled tourmaline rock.
L14	Chip	8.0	44.7	49.4			0	Mottled tourmaline rock; 40 percent quartz.
L14a	Do	0.5	52.15	41.2			—	Do.
L15	Chip	9.5	54.15	40.35			1 ?	
L16	Chip	8.0	51.6	42.5			—	Coarse mottled tourmaline rock.
L17	Chip	± 829 grams	109.5	138.0			2 0	Dark, tourmalinized breccia fragment.
L18	Chip	6.0	43.7	51.6	0.58	1.33	1	Vuggy, porphyritic tourmaline rock.
L19	30" channel	11.0	51.15	42.7			10	Do.
L20	Chip	3.0	43.7	52.0			0	Vuggy porphyritic tourmaline rock.
L21	8" channel	3.0	280.4	205.7			0	Matrix of tourmaline breccia.
L22	Specimen	3.0	248.35	245.45			2	Mottled tourmaline rock; breccia fragment.
L23	Chip	5.0	229.7	264.95			2	Altered, clayey, monzonite.
L24	Specimen	287 grams	153.8	125.5			0	6" mass of soft, fine-grained tourmaline rock.
L25	Chip	4.5	41.7	53.4	1.51	3.51	2	2' x 4' pocket, fine-grained gougy material.
L26	Specimen	± 2400 grams	636.0	513.0			2	Vuggy, mottled tourmaline rock.
L27	2.5' channel	8.5	50.5	43.8			0	Across vein, south of shaft. Fine-grained tourmaline rock.
L28	6" channel	1.5	56.4	35.2			1	Narrow part of vein. Fine-grained tourmaline rock.
L29	30" channel	6.0	51.2	43.5			5	Weathered wall rock. Some fine-grained tourmaline seams.
L30	2' channel	5.0	53.6	42.0			1	Weathered wall rock. No tourmaline.
L31	15" channel	8.0	58.4	35.1			0	Do.
L32	Chip	8.0	49.8	46.3			0	10" vein of fine-grained tourmaline rock.
L33	2' channel	7.5	50.6	43.7			0	Dull, fine-grained tourmaline rock.
L34	3' channel	4.0	47.3	47.4			2 ?	Mottled and fine-grained tourmaline rock.
L34a	Do	4.5					0	Do.
L35	16" channel	7.0	52.6	45.8			2	Dull, fine-grained and mottled tourmaline rock.
L36	8" channel	1.5	54.8	38.6			3	Felted tourmaline. Same vein as L35.
L37	15" channel	3.0	53.2	41.35			5	Fine-grained tourmaline rock grading into monzonite.
L38	Grab		53.7	42.75			3	Felted tourmaline.

a/ Grain mounts contained 1000-4000 grains. The average weight of sample in each was about 0.008 gms.