ECONOMIC GEOLOGY OF THE
RINCON PEGMATITES
SAN DIEGO COUNTY, CALIFORNIA

By
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Prepared in cooperation with the
United States Geological Survey
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ABSTRACT

The Rincon pegmatite district, San Diego County, California, is in the valley of the San Luis Rey River about 40 miles northeast of San Diego. It is an area of moderately strong relief, with an average altitude of 1,500 feet. The pegmatites contain the only known deposits of economic minerals in the district, especially gem beryl, kunzite, and gernourmalite.

John Mack first prospected and located the Mack, Clark, and Victor mines, which he worked in addition to other smaller mines from 1895 to about 1910. Since that time the district has been inactive except for intermittent prospecting and mineral collecting. No record of production could be obtained, but the incomplete information available indicates that only a small quantity of gem stones and other pegmatite minerals was ever produced.

The pegmatites are most abundant in a complex of igneous rocks that has intruded a series of metamorphic rocks. Both the metamorphic rocks and the igneous rocks have been covered locally by a younger series of sedimentary rocks. The wall rock of most pegmatites is the Bonita tonalite, the most widespread igneous rock.

The pegmatites in the Rincon district are similar in many respects to the pegmatites of the nearby Palomar district. Most of the Rincon pegmatites are mineralogically simple and contain only quartz, perthite, phlogopite, and garnet as essential minerals, with subordinate muscovite. A few contain schorl, beryl, and garnet as accessory minerals, and very few are lithium-bearing.

The pegmatites appear to have been intruded along regional joints and are not related to the primary internal structures of the wall rock. In general, the elongate dikes of pegmatite strike N. 25° W. and dip about 45° SW.

The most abundant lithologic units in the Rincon dikes are graphic granite pegmatite, quartz-perthite pegmatite, quartz pegmatite, fine-grained quartz-albite-perthite pegmatite, and fine-grained albite-quartz-perthite pegmatite (fine rock). Lithia-bearing units are rare. The dikes commonly show three zones—a border zone, a wall zone, and a core. In addition, three pegmatite units—the fine-grained quartz-albite-perthite pegmatite; the fine rock; and the lithia-bearing pegmatite, whose origin is obscure—occur in some of the dikes. Composite dikes are not common.

The Rincon pegmatites have little potential economic value except as possible sources of gem stones and fieldspar. Detailed geologic descriptions of all the productive mines and several prospects are given in the last section of this report.

INTRODUCTION

The Rincon pegmatite district, San Diego County, California, is in the valley of the San Luis Rey River about 10.5 miles southeast of the Pauma pegmatite district (fig. 2). It is about 40 miles northeast of San Diego, about 25 miles east of Oceanside, and about 20 miles by road from Escondido, the nearest city. It includes parts of secs. 19 and 30, T. 10 S., R. 1 E., San Bernadino base and meridian, parts of secs. 25, 26, 35, and 36, T. 10 S., R. 1 W., and part of the Pauma Grant. The district covers an area of about 10 square miles.

Most of the district is in the Rincon and La Jolla Indian Reservations, and the part outside of these reservations is mainly in the former Pauma Grant, which is now held by a few large owners and many small ones.

The district may be reached easily from San Diego by paved highway from Escondido to Rincon Springs, and from Los Angeles by State Highway 195 from Oceanside to Lake Henshaw. Within the district several dirt roads lead to the mountain areas in which the pegmatites occur. The most useful access roads are 1) the road along the east side of the Rincon Indian Reservation, 2) the road along the south side of the San Luis Rey River, and 3) the road through the La Jolla Reservation to the Johnson Ranch. In addition to the access roads, trails lead to some of the mines and cross parts of the district.

Physical Features

The most noticeable physical feature of the district is the broad, alluvial valley of the San Luis Rey River (pl. 1). This valley narrows abruptly in the southeastern part of the district. North of the valley the land is mountainous and rises rapidly to a gently sloping bench along the northern border of the district. This bench is just southwest of the steep slopes of Palomar Mountain, north of the mapped area. The most prominent mountains in the district are Mesa Mountain in the northwestern part and Rincon Mountain in the eastern part (fig. 1). These mountains are separated by a broad valley, partly filled by the Rincon fan. Rincon Mountain is separated from Ditch Mountain, just beyond the southern limit of the mapped area, by the narrow valley of the San Luis Rey River.
Figure 1. Aerial photograph of pegmatite dikes on Rincon Mountain, showing the location of (a) the Mack mine, (b) Calac prospect, (c) Cable Canyon, and (d) the grass-covered bench underlain by the Elsinore fault zone. The view is to the northeast. Photograph by Pacific Air Industries, Long Beach, California.
The district is an area of moderately strong relief, and has an average altitude of 1,500 feet. Most of the low land in the San Luis Rey River valley is below this altitude, but the mountains are much higher: Rincon Mountain has a maximum relief of 1,725 feet, and Mesa Mountain a maximum relief of 1,190 feet. Although the steep mountain slopes contrast strongly with the moderate slopes of the alluvial fans, there are small areas of gentle relief in the mountains, such as the tableland north of the crest of Rincon Mountain.

The land in the mountains is unsuitable for cultivation but in general is covered by dense brush. The gently rolling tableland on Rincon Mountain is open and grassy, and many live oak trees grow on it. Except on this tableland and along a few of the canyons, trees are scarce. Small areas in the mountains were burned over in the recent past, and some of them were relatively brushfree when the district was mapped in 1947 and 1948. Throughout the district the south slopes have a less dense brush cover than the north and northwest slopes, many of which are so densely covered with grassweed, sage, and manzanita that they could not be examined thoroughly.

Parts of the valley land are heavily cultivated. The Rincon fan supports large citrus groves, grain, and market garden crops. Market garden crops, walnuts, and alfalfa are grown on the bottom lands.

Mineral Resources

The pegmatites contain the only known deposits of economic minerals in the district. However, several types of sediments are used in local construction. Clay that underlies small sediment surfaces in the valley is used in making adobe brick, and the sand and gravel in the stream channels are also used as building materials.

History of District

Mining Development. In the early 1900's John Mack first prospected the district and located several claims, the most important of which are now named the Mack, Victor, and Clark. He also located at least eight other claims, and had agreements about the mineral rights with the owners of the Pauma Grant and with Feliz Calac, who owned the SW\SW sec. 25.

Most of Mack's mining was done from 1903 to 1910. Several different times since 1910 the old claims have been restaked, but these locations have not been followed by development work. The most recent period of renewed activity was in the late 1930's, when John W. Hilton and associates located a group of six lode claims and Alfred Johnson located five placer claims. Despite these locations, the district was nearly inactive until 1942, when an attempt was made to obtain quartz crystals from the Clark mine.

The district was inactive in 1948 except for small-scale prospecting by Indians on reservation land; some of the more prominent of the old mines were owned as parts of ranches to which the mineral rights had reverted.

Practically every mine in the district has been known as the Mack mine at some time in the history of the district, and in 1947 and 1948 it was impossible to identify each one of the various "Mack" mines referred to in the older published reports on the district.

Production of Pegmatite Minerals. No record of production of pegmatite minerals is available for the Rincon district. The fragmentary information that can be collected indicates that the total production has been a few tens of pounds of quartz crystals suitable for use in radio transmitters, a very small quantity of gem beryl of the aquamarine variety, and a negligible quantity of gem tourmalines and kunzite. The Victor mine, whose workings are the largest in the district, is rumored to have produced less than $1,000 worth of gem stones during the period of greatest activity.

Previous Investigations

Practically all the previous scientific investigations have been directed primarily to the general or detailed mineralogy of the pegmatites. The earliest mineralogical descriptions are those by Kunz, who described briefly the geology of one of the many "Mack" mines. Shortly after his report appeared, Waring and Ford published reports on special features of the mineralogy. In 1910 Rogers described the mineralogy of the Victor mine in detail. In 1935 Kennard reported on the spectrographic examination of quartz from the Clark mine, and in 1938 Murdoch and Webb described a mineral occurrence in the Rincon district. Tucker and Reed gave a brief and inaccurate description of the location, ownership, and number of workings on the Calac ranch under the name of the "Mack mine." The most recent references to the Rincon pegmatites are by Murdoch and Webb.

Recent field work by the U. S. Geological Survey in the Rincon district began in 1943, when D. Jerome Fisher examined briefly the Victor and Mack mines as possible sources of beryllium and tantalum minerals.

Present Investigation

The present investigation of the Rincon pegmatites is a part of the geologic examination of the pegmatite belt that extends from Pala through Rincon to Mesa Grande in San Diego County (fig. 2). It is a cooperative project of the U. S. Geological Survey and the California Division of Mines. The Rincon investigation was made intermittently from July 1947 to October 1948.

The geology of the district including the distribution of more than 250 pegmatites was mapped on aerial photographs. All pegmatites that did not appear clearly on the photographs were omitted, so that pegmatites less than 1 foot thick were not mapped. The emphasis of this investigation was on detailed mapping, structural studies, and petrographic studies to supplement the previously published mineralogical reports. As in the study of the pegmatites in the Pala district, particular attention was paid to the recognition of distinctive rock units within each district.

**Footnotes:**

dike and to such broader features as the relationship be-
tween the structure of the dike and the structural features
of the country rocks. The field examinations were supple-
mented by preliminary mineralogical studies.

The geology of Mesa Mountain was mapped by Wil-
liam P. Irwin. The part of the district south of the San
Louis Rey River was mapped by Irwin east of Paradise
Creek and by Miller W. Ellis west of Paradise Creek.
The rest of the district was mapped by J. B. Hanley with
the part-time assistance of Wayne E. Hall and Irwin.

Acknowledgments

Many common problems were discussed with R. H.
Jahns of the U. S. Geological Survey, who was in general
charge of the investigation and who was studying the
Pala district. Wayne E. Hall and William P. Irwin, both
of the Geological Survey, assisted in the detailed mine
mapping and the general geologic mapping as well as in
the mineralogical studies. Lincoln R. Page, of the Geolo-
gical Survey, visited the area and contributed many helpful
ideas and suggestions. The report was critically reviewed
by Lincoln R. Page, John H. Eric, R. H. Jahns, and Ward
C. Smith.

Olaf P. Jenkins, Chief, California Division of Mines,
rendered every possible assistance and greatly encouraged
the investigation by his personal interest.

The work has been materially aided by the coopera-
tion of the land owners in the district. Special acknowl-
dgment is due to Mr. Charles Hall, present owner of the
Mack mine; Mr. Jesse Cain, owner of the land on which
the Victor mine is located; and Mr. Donald V. Jamison
of Rincon.

GEOLOGY

The pegmatites in the Rincon district are most
abundant in the igneous rocks (pl. 1) that form part of
the batholith of southern California. These igneous rocks
were intruded probably into a metamorphic sequence of
quartz-mica schist, quartzite, and amphibole schist. Both
the metamorphic and igneous rocks have been covered in
places by a younger series of sedimentary rocks. The sedi-
mentary rock deposits separate the terrane underlain by
the older rocks into three distinct areas, and thus obscure
the age relationship between the metamorphic and the
igneous rocks and also between the different igneous
rocks in the batholith. The age sequence of the meta-
orphic and igneous rocks followed in this report was estab-
lished in other areas.

The rocks in the district, in order of decreasing age,
are 1) Julian schist, probably of Triassic age; 2) San
Marcos gabbro, Bonsall tonalite, Woodson Mountain
granodiorite, and pegmatites of the batholithic magnu-
mae series of Cretaceous age; and 3) fanglomerate, pediment
clays, alluvium, and sand and gravel of Quaternary
age. Because the sedimentary formations probably were
deposited about the same time, the age sequence cannot
be established definitely.

During the time of deposition of the sedimentary
rocks the area was intensively deformed and large-scale
faulting took place along the Elsinore fault zone, which
trends northwestward and is just north of the district.

The geologic map of California 11 shows another large
probable fault that trends northeastward through the dis-

11 Hanley, J. B., and Hall, W. E., Geology of the Pala-Mesa
Grande pegmatite belt, San Diego and Riverside Counties, California:

12 Larsen, E. S., Jr., Batholith and associated rocks of Coronas,
Elsinore, and San Luis Rey quadrangles, southern California: Geol.
forms the west half of Mesa Mountain. On the east it is in contact with the Bonsall tonalite; on the south, west, and north it is in contact with fanglomerate. The contact with the tonalite is not exposed as it is along a steep slope that is covered by thick gabbro float.

The gabbro disintegrates into small, round cobbles and a deep reddish-maroon soil. Outcrops are very sparse. The depth of weathering throughout the gabbro terrane is at least 30 feet. The best exposure of the gabbro is in the highway cut on the south nose of Mesa Mountain.

The fresh gabbro is a light-gray, medium-grained, feldspar-rich rock with a low proportion of mafic minerals. It is composed chiefly of calcic plagioclase with subordinate dark-green hornblende, augite, hypersthene, and dark-brown biotite. Magnetite and apatite are common accessory minerals. Other types of gabbro occur in this body, but could not be separated from one another in the field mapping. The composition of this gabbro indicates that it is part of the San Marcos gabbro as defined by Miller.¹³

In general the gabbro is internally structureless, and as exposures other than rubble are few, no conclusion can be reached as to the internal structure of the gabbro pluton. The only primary structural element observed was a discontinuous banding, caused by the alternation of dark and light bands. This banding dips steeply to the northwest, but may be only local.

**Bonsall Tonalite.** The Bonsall tonalite, the most widespread igneous rock, underlies about 80 percent of the mountain areas. It forms the east half of Mesa Mountain, all of Rincon Mountain, and most of the mountain slopes south of the San Luis Rey River. These tonalite bodies are probably parts of a single mass, of much greater extent outside the district.

The contacts of the tonalite with the other rocks are exposed in a few places only. The age of the tonalite is difficult to establish but the rock normally contains inclusions of mafic material. Some of these inclusions have been shown by Hurlbut to come from the San Marcos gabbro, hence the tonalite must be younger than the gabbro. However, the tonalite approaches the gabbro in composition, and seems to be gradational into the gabbro in parts of the district. The tonalite probably is the same as the Bonsall tonalite defined by Larsen.¹⁵

The tonalite crops out typically as low rounded ledges that do not protrude much above the surrounding land surface. On the weathered surfaces of such outcrops the rock is dark brownish-black and appears to contain much hornblende and biotite; on freshly broken surfaces it is a light gray-white, coarse-grained rock in which feldspar, hornblende, biotite, and quartz can be recognized with the unaided eye. Inclusions are scarce and common are only vague clots of mafic minerals.

In large parts of the district the only exposures of the tonalite are boulders formed by disintegration. These boulders are scattered on the surrounding land surface, and may be as much as 30 feet in maximum dimension; the average is about 10 feet in diameter. Boulders are common along the crest and sides of the western ridges of Rincon Mountain, particularly on Hall Ridge.

The tonalite further disintegrates to a buff sandy material that preserves the texture of the rock to a remarkable degree. This disintegrated tonalite is technically called gruss; locally it is called "decomposed granite." Continued weathering results in a light brownish-gray soil on the steep slopes where disintegration is dominant, and in a reddish-brown soil on the gentle slopes where decomposition is dominant. As the tonalite is less resistant to weathering than the gabbro, on gently sloping surface the float commonly is gabbroic and represents the more resistant inclusions. This float, in combination with the dominant red soil, complicates the identification of the underlying rock.

The composition of the tonalite varies from one locality to another, but in general is reasonably uniform. In some localities, such as the south end of Mack Ridge, the tonalite approaches the gabbro in composition and seems to be gradational into the gabbro. Microscopic examination of the more uniform tonalite shows that quartz commonly forms about 20 percent of the rock. Hornblende and biotite are essential minerals, and the hornblende commonly is more abundant than the biotite. Plagioclase, some of which may have a composition as calcic as An₂₀ forms the bulk of the rock.

Although the tonalite generally is poorly foliated, the inclusions commonly are parallel to the primary foliation and can be used to establish the internal structure of the pluton. This internal structure probably is parallel to the contacts, which thus would be steeply dipping or nearly vertical.

**Woodson Mountain Granodiorite.** The Woodson Mountain granodiorite occurs in the eastern part of the district, and extends for a great distance outside. Its contact with the other rocks is exposed in a few places only where thin granodiorite dikes cut across the structure of the Bonsall tonalite. In contrast with the other igneous rocks the granodiorite is well exposed and crops out over most of the area that it underlies. The characteristic outcrops are rugged, craggy ledges and boulders.

The granodiorite is a light buff, medium- to coarse-grained quartz-rich rock. The essential minerals—quartz, orthoclase, plagioclase, and biotite—can be identified readily by the unaided eye. In some parts of the pluton the orthoclase forms pale-pink phenocrysts that commonly are twice as large as the other minerals in the rock. The light-buff color of the fresh rock, easily visible quartz, and low content of mafic minerals, as well as the virtual absence of hornblende, make this rock distinctive.

The granodiorite is structureless except for a crude primary foliation in a 500- to 1000-foot wide band adjacent to the contact. Thin, lenticular inclusions of the injection gneiss variety of the Julian schist near the present granodiorite-tonalite contact indicate that this contact probably occupies much the same position as the former contact between the Bonsall tonalite and the Julian schist. The granodiorite contact is believed to dip steeply east, parallel to the attitude of the foliation.

The granodiorite cuts the Bonsall tonalite and the Julian schist. Only the pegmatites intrude the granodiorite. The lithology and the age relationships indicate that it probably is the Woodson Mountain granodiorite described by Larsen.¹⁶

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¹⁵ Larsen, E. S., Jr., op. cit., pp. 58-61.

¹⁶ Larsen, E. S., Jr., op. cit., pp. 76-82.
Pegmatite. As the pegmatites are described in detail in a later section, only a brief statement is given here. The pegmatites are the youngest of the crystalline rocks, as they cut all the other igneous rocks and the Julian schist. They probably represent the last stages of the batholithic intrusion.

The pegmatites form very thin dikes of relatively great strike length. In general these dikes strike north-west and dip gently to moderately southwest.

Sedimentary Rocks

Fanglomerate. The most widespread sedimentary rock is the fanglomerate in the Rincon fan. This fan extends around the north end of Rincon Mountain and also around the end of Mesa Mountain, but the main fan lies between these two mountains (pl. 1). The southern end of the fan is along the present channel of the San Luis Rey River.

The coarse material in the fanglomerate is chiefly boulders, which range from 1 foot to 5 feet in size, of tonalite and granodiorite, and a smaller number of gabbro and schist. The fine material, which occurs as small lenses in the coarser material, is sand and gravel that probably was derived mainly from granodiorite and tonalite. The surface of the fan is underlain by several feet of sandy soil.

The distribution of the fanglomerate indicates that the fan is composed of several smaller coalesced fans along the front of Palomar Mountain, which is north of the area.

Although the age of this fan is not known, similar fanglomerates in other large fans in the San Luis Rey Valley have been shown to be middle Pleistocene in age. Other Sedimentary Rocks. The other sedimentary rocks underlie small areas only. The thin deposit of pediment material just east of the Rincon Indian Reservation extends along the base of Rincon Mountain from the south end of Hall Ridge nearly to the present channel of the San Luis Rey River. The material in this deposit is mainly soil derived from decomposed tonalite, some of which has been transported and redeposited. Stream channels that have cut through this deposit in places expose the underlying tonalite. A few pegmatite dikes crop out through this pediment deposit.

A relatively extensive alluvial deposit of silt, containing isolated lenses of sand and gravel and beds of woody material, underlies most of the lowlands along the San Luis Rey River. It seems probable that this deposit was laid down in a short-lived lake in the river channel.

The most recent sedimentary rocks in the district are the sand and gravel deposits in the stream channels. The largest of these deposits is along the present channel of the San Luis Rey River. The material in this deposit ranges from sand size to small cobble size. The fragments are predominantly granodiorite in composition and undoubtedly were derived from the large granodiorite pluton along the east edge of the district.

Pegmatites

The pegmatites in the Rincon district are similar in many respects to the Pala pegmatites. In order to avoid duplication, the features that are common to both districts are not emphasized in this report, and the reader is referred to the report by Jahns and Wright for the detailed discussion. The general emphasis is on characteristic features of the Rincon pegmatites and on the differences between the Rincon and Pala pegmatites.

Most of the pegmatites are mineralogically simple, and contain only quartz, perthite, and plagioclase as essential minerals, and muscovite as a subordinate mineral. A few pegmatites contain schorl, beryl, and garnet as accessory minerals. Lithia pegmatites are scarce in the district; only four have been found.

Pegmatite dikes are particularly abundant on Rincon Mountain as shown on figure 1, and on Mesa Mountain and occur in lesser number south of the San Luis Rey River. The greatest concentration of dikes is on Rincon Mountain, and their abundance decreases away from the mountain. Most of the prospecting and mining has been done on this mountain. Outside the district pegmatites are rather sparse and are smaller.

The pegmatites appear to have been intruded along a set of pre-existing, secondary joints in the wall rock. These joints are exposed only where they have been filled with pegmatite dikes. None of the primary structural features of the wall rocks, such as foliation of the igneous rocks, schistosity of the schists, joints, or contacts between different kinds of wall rock, appears to have controlled the emplacement of the pegmatites.

External Structure

The Rincon dikes are characterized by great length as compared with thickness. Surface lengths in excess of half a mile are common, even in pegmatites less than 10 feet thick. In the eastern part of Rincon Mountain the pegmatites appear to be highly branching. The Mesa Mountain pegmatites are tabular bodies, as are the pegmatites in the western half of Rincon Mountain. The pegmatites gradually narrow and pinch out along both strike and dip.

The general strike of the dikes is about N. 25° W., and the general dip is about 45° SW. A few dikes strike at nearly right angles to this general direction, and these dikes from 10° to 65° southward. Minor rolls and structural terraces on the pegmatite contacts, particularly in those on the eastern side of Rincon Mountain, cause abnormal flattening and even reversals of dip.

The pegmatites commonly form riblike walls above the surrounding surface; these ribbed walls and the white color of the rock, make the pegmatites conspicuous features on the mountain slopes. Many large dip slopes occur on the western and southern sides of the mountains. On the tableland at the crest of Rincon Mountain the dikes are gently dipping, and have many structural rolls and terraces. Consequently many dikes are exposed in part as large dip slopes. In some places these are covered by residual soil pockets, and in others abrupt changes in dip or slope have left a thin veneer of tonalite wall rock on the pegmatite. The resulting outcrop pattern is branched and braided. An excellent example of this outcrop pattern is at the Calac prospect.

The dip slopes furnish some information as to the third dimension, but when compared with the great length of these dikes, even the largest dip slope is relatively shallow. Some of the pegmatites that crop out on Hall Ridge pinch out in depth as well as in length; as exposed, the length appears to be about 5.5 times the depth. None of the mine workings is deep enough to ex-

17 Hanley, J. B., and Hall, W. E., op. cit.
pose as much of the third dimension of the dikes as the outcrops.

Petrographic Features

As pegmatites commonly are irregular in grain size and extremely coarse-grained, the normal grain-size classification of igneous rocks does not apply. For this reason the following special grain-size classification for pegmatites has been adopted.

<table>
<thead>
<tr>
<th>Term</th>
<th>General grain size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine</td>
<td>Less than 1 inch</td>
</tr>
<tr>
<td>Medium</td>
<td>1 inch to 4 inches</td>
</tr>
<tr>
<td>Coarse</td>
<td>4 inches to 12 inches</td>
</tr>
<tr>
<td>Very coarse</td>
<td>Greater than 12 inches</td>
</tr>
</tbody>
</table>

The normal pegmatite dikes in the Rincon district are not widely diversified in type. Rocks that correspond closely in mineralogy and texture to the graphic granite, very coarse-grained pegmatite, and fine-grained granitoid pegmatite, including "line rock," ** of the Pala dikes are the most abundant lithologic units. **Pocket pegmatite** occurs in only a few dikes, and even where best developed it is of minor importance. In the Rincon dikes graphic granite pegmatite corresponds to the graphic granite of the Pala district; quartz-perthite pegmatite, quartz-spodumene pegmatite, and quartz pegmatite correspond to the very coarse-grained pegmatite of the Pala district, although in the Rincon district these types of pegmatite are medium- to coarse-grained; and fine-grained quartz-albite-perthite pegmatite and albite-quartz-perthite pegmatite (line rock) correspond to the fine-grained granitoid pegmatite, including line rock, of the Pala district.

The most common types of pegmatite are described below; emphasis has been placed on the characteristic features of the Rincon dikes.

Graphic Granite Pegmatite. Graphic granite pegmatite is the most widespread type in the Rincon dikes, and generally forms the hanging-wall part of the dike. It commonly is an aggregate of perthite crystals, each of which contains abundant quartz rods and plates that are more or less parallel, and are oriented within the perthite crystal. Sections at right angles to the length of the quartz rods and plates show the characteristic rumic or euneiform features. The interstitial minerals between the perthite crystals commonly are quartz, which in places may make up 15 percent of the pegmatite; less abundantly muscovite and biotite, which together may form 10 percent; and least abundantly albite, schorl, and garnet, which generally constitute less than 5 percent. A plumeose intergrowth of quartz and muscovite is common in the interstitial material, and in a few dikes quartz and biotite form plumeose intergrowths.

The graphic granite intergrowths have the form of microcline crystals and are generally white. These crystals are subhedral to euhedral, and most commonly taper in one direction. They generally range from 4 inches to 14 inches in maximum dimension. Many crystals show faint lines, caused by slight color differences, that are parallel to the crystal faces and probably represent growth lines. Perthitic stringers of albite occur in practically all the crystals, and these are commonly less than 1 millimeter in width, but tend to be wider in larger crystals. The perthite

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* Line rock and pocket pegmatite are local terms. Line rock is fine-grained, banded albite-quartz-perthite pegmatite; pocket pegmatite refers to a part of a pegmatite dike that contains gem-bearing pockets.

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crystals characteristically are oriented at right angles to the walls of the dike with the narrow end near the wall and the thick end toward the center.

The most common type of pegmatite outcrop, particularly on the dip slopes, is a checkerboard mixture of graphic granite crystals, commonly about an inch square, in a groundmass of quartz, mica, and albite. This groundmass may constitute as much as 50 percent of the exposed area, but the proportion of groundmass decreases rapidly toward the center of the pegmatite, and the quartz, mica, and albite together rarely form more than 15 percent of the rock. In these smaller crystals the graphic intergrowth is not readily apparent. The surface of this type of outcrop is generally less than half an inch below the original position of the hanging-wall contact, as is indicated by the size of the crystals. Where the wall-rock contact is exposed, the narrow end of the crystals almost invariably is not more than one-eighth of an inch from the contact, and commonly is one-half to three-quarters of an inch square. Crystals that are half an inch square at the narrow end generally have a cross-section more than an inch wide at a distance of 1 inch from the contact. Hence, the size of the section through the crystal can be used in estimating the probable position of the contact in the places where the wall rock and part of the dike have been removed by erosion.

Other Coarse-Grained Types of Pegmatite. Quartz-perthite pegmatite, quartz-spodumene pegmatite, and quartz pegmatite closely resemble the "giant pegmatite" types of the Pala district and occur in the centers of the Rincon dikes. Quartz-perthite pegmatite is most common and quartz pegmatite is present in only a few dikes. Quartz-spodumene pegmatite forms the center in only the Clark pegmatite.

The common quartz-perthite pegmatite is a mixture of anhedral to subhedral milky quartz and euhedral, white perthite crystals. In most dikes the perthite crystals are about 4 inches across; in a few they are as much as 8 inches across. In some dikes the outer parts, or margins, of the quartz-perthite pegmatite are marked by concentrations of muscovite books, up to 6 inches long; euhedral crystals of schorl, as much as 2 inches in diameter, and irregular small clots of albite.

Typically the centers of the Rincon dikes do not contain other minerals, but in a few beryl is an accessory mineral. It most generally is in light-green to pale-blue euhedral crystals less than an inch in diameter. The crystals are commonly as much as four times as long as they are thick. Beryl is associated with all the other minerals of the quartz-perthite pegmatite, but is most common in those pegmatites that have local concentrations of muscovite. Garnet is a relatively rare constituent of these units, as it has been found in only a few dikes.

The quartz-spodumene pegmatite is poorly exposed in the Clark dike. It consists mainly of milky quartz and grayish-white spodumene; petalite, helvite, apatite, and heulandite are rare accessories. Although the spodumene crystals exposed in this unit are less than 4 inches long, quartz occurs in anhedral crystals as much as 10 inches across.

Quartz-Albite-Perthite Pegmatite. Quartz-albite-perthite pegmatite with typical granitoid texture occurs in some of the Rincon dikes. The grain size ranges from about 1 inch to slightly less than 1 inch. This type of
pegmatite is not widespread, but it is common in composite dikes and also occurs associated with the line rock, a layered, garnet-bearing variety in which albite predominates over quartz. The fine-grained quartz-albite-perthite pegmatite occurs commonly in the footwall part of the dikes. In many dikes it merges upward into graphic granite pegmatite, and in some it is in contact with quartz-perthite pegmatite or quartz pegmatite. Most commonly it grades upward into the line rock variety.

The normal mineral composition is estimated to be quartz (25 to 35 percent), albite (25 to 35 percent), perthite (25 percent), muscovite (3 to 5 percent), biotite (3 to 5 percent), and garnet (1 to 3 percent). This pegmatite is generally light gray and even grained. Bands of coarser material that are roughly parallel to the walls of the dike occur in places within this type of pegmatite. These bands commonly are composed of quartz and perthite, and in a few dikes graphic granite is an abundant constituent of the bands. Muscovite is a common accessory in some bands.

**Albite-Quartz-Perthite Pegmatite.** The albite-quartz-perthite pegmatite is a fine-grained banded pegmatite, in which the banding is caused by an alternation of garnet-rich layers with albite-rich layers. These bands range in thickness from 0.5 millimeter to about 10 millimeters, with an average thickness of about 2 millimeters. Locally this type of pegmatite is called line rock because of the sharp lines formed by the intersection of the garnet-rich bands and the major joint surfaces, which most commonly are at right angles to the banding.

The line rock occurs most commonly in the footwall part of the dikes, and generally is adjacent to the footwall. In a few dikes it occurs near the center of the dike, and in some it is both underlain and overlain by graphic granite pegmatite. One characteristic of the line rock in the Rincon district is the uneven distribution within many dikes. For example, line rock may occur in small isolated pods in graphic granite pegmatite and is not always continuous in any one dike.

The line rock is best exposed in the dikes on the eastern side of the Rincon Mountain. One exceptionally good exposure, beside the west trail along Cable Canyon, shows line rock in which the bands have been brought into sharp relief by differential weathering; the garnet-rich bands are the more resistant. Although present in almost every dike, the line rock is poorly developed in the dikes on the western side of Rincon Mountain and on Mesa Mountain. In many dikes that crop out on the western side of Rincon Mountain graphic granite is abundant in the line rock, and the uniform spacing of the garnet-rich bands persists to the faces of graphic granite crystals and continues across them along the growth lines. In the crystals the bands are wider spaced than normal. This produces a wavy pattern in the line rock, and the continuity of the garnet bands appears to be disrupted by the graphic granite.

**Pocket Pegmatite.** Pocket pegmatite is not a type of pegmatite according to strict scientific terminology. Rather it is that part of the dike that contains the gem-bearing pockets, or that can be expected to contain undiscovered pockets. The pocket pegmatite in most Rincon dikes is part of the quartz-perthite pegmatite near the lower margin of the layer, in which gem beryl may be expected. In a few dikes the pocket pegmatite is a distinct type of pegmatite in which albite and lepidolite are the only essential minerals. The albite is of the cleavelandite variety, and can be identified readily by the platy or tabular shape of the crystals. Lithia tourmaline, of both the green and red varieties, and muscovite are the most common accessory minerals.

Pocket pegmatite is best developed in the Victor dike. However, only a few thin patches of this pegmatite are now exposed in the mine workings. These patches are small and fragmentary; the origin, the position within the dike, and the complete mineral assemblage of the pocket pegmatite is unknown.

**Lithologic Arrangement of Types of Pegmatites.** The mineralogic types of pegmatite that occur in the Rincon dikes have a systematic arrangement within each dike. The most common arrangement is in layers that are essentially parallel to the walls of the dike. The simplest arrangement, which occurs in very few dikes, is that in which the dike is composed entirely of graphic granite pegmatite.

In a more widespread, slightly more complex arrangement both the hanging-wall and the footwall layers are of graphic granite pegmatite, separated along the medial plane of the dike by a relatively thin layer of quartz-perthite pegmatite, which in some dikes contains accessory muscovite, beryl, and schorl. In a large number of dikes the arrangement is more complex and the normal sequence is: 1) a line rock layer at the footwall, 2) quartz-perthite pegmatite in the central part of the dike, and 3) a graphic granite pegmatite layer at the hanging-wall. In some dikes the graphic granite pegmatite occurs between the line rock and the quartz-perthite pegmatite; in others the line rock in the footwall part of the dike is between two layers of graphic granite pegmatite. In a smaller number of dikes fine-grained quartz-albite-perthite pegmatite, which may be in contact above with line rock or quartz-perthite pegmatite, forms the footwall layer.

The most complex sequence, observed in only a few dikes, is 1) a footwall layer of line rock, 2) a graphic granite pegmatite layer, 3) a discontinuous layer of cleavelandite-lepidolite pegmatite, 4) a layer of quartz-perthite pegmatite in part of the dike, and 5) a graphic granite pegmatite hanging-wall layer that in parts of the dike is directly above the cleavelandite-lepidolite pegmatite.

**Internal Structure.** As has been set forth in the preceding section, many of the Rincon dikes are made up of two or more pegmatite units of distinctive lithology, and these units are spatially related to the structure of the dike. As used in this report, a pegmatite unit is any distinct, mappable part of a pegmatite body. Extensive studies of pegmatites since 1938 by geologists of the U. S. Geological Survey have shown that three fundamental types of pegmatite units can be distinguished on the basis of differences in mineralogy, or texture, or both.29 These types are described as follows:


1. Zones are successive units that have the form of shells and lenses that reflect the shapes of the pegmatite walls. In the tabular bodies of the Rincon dikes they appear as simple layers. Many zones are discontinuous, and form straight or curving lenses or chains of lenses. Zones are believed to have formed by fractional crystallization from a pegmatite magma in situ.

2. Fracture-fillings are units, generally tabular, that fill fractures in pre-existing solid pegmatite.

3. Replacement bodies are units formed primarily by hydrothermal replacement of parts or the whole of pre-existing zones in the pegmatites. In many replacement bodies the structural control is related to fractures or to the zones; in some the control is not evident.

A fourfold classification of the zones in pegmatites has been used by the geologists of the U. S. Geological Survey. This classification is as follows:

1. Border, or outermost zone.
2. Wall zone.
3. Intermediate zone.
4. Core, or innermost zone.

Contacts between pegmatite units that differ markedly from one another in composition or texture commonly are sharp, but contacts between units of similar composition or of similar texture are commonly gradational. However, in most pegmatites all contacts are clear enough to be mappable on scales as large as 1 inch equals 20 feet.

Zones. Few of the Rincon pegmatites contain more than three zones, namely, a border zone, wall zone, and core. The few that contain an intermediate zone seldom have more than one intermediate zone, although any number of intermediate zones is theoretically possible.

The border zone in the Rincon district generally is extremely thin and very inconspicuous. In most pegmatites this zone is about 1/2 inch thick, but in some it is as much as 1 inch. It is the least resistant to weathering of all the zones, and commonly has been eroded from the outcrop. Where exposed it is composed mainly of fine-grained graphic granite pegmatite, with accessory quartz, biotite, and muscovite.

The wall zone commonly is composed of graphic granite pegmatite, and is very continuous in most pegmatites. It occurs as layers both above and below the core, or the core pods. In pegmatites composed entirely of graphic granite the coarser-grained graphic granite could be considered as a core rather than part of the wall zone, and these pegmatites would thus contain only two zones.

In many of the more complex pegmatites, especially in those that contain line rock, the graphic granite pegmatite zone in the footwall part of the dike is not apparent.

Only a few of the Rincon pegmatites contain intermediate zones, and these zones are poorly developed at best. The most common intermediate zone is composed of albite (40 to 60 percent), quartz (35 to 45 percent), and muscovite (5 to 15 percent), with accessory beryl, schorl, and garnet. This type normally occurs as discontinuous lenses between the graphic granite pegmatite wall zone and the quartz-perthite pegmatite core, and is best exposed in the Mack mine and the Calac prospect.

The core in most of the Rincon pegmatites is composed of the quartz-perthite pegmatite. In many dikes the core is a series of isolated pods along the medial plane of the dike, and in others it is a continuous layer.

Fracture-Filling Units. Fracture-filling units are scarce in the Rincon pegmatites. These units contain quartz, with accessory perthite, albite, and muscovite. Practically all the fracture-filling units cut the wall zone and merge into the core. A few also cut the border zone, but none has been seen that extends into the wall rock. Most of these units are along cross joints that formed as tension cracks in the late stages of consolidation of the dike.

Other Units. Three pegmatite units have been recognized in the Rincon dikes that do not fit clearly the definitions for zones, replacement bodies, or fracture-fillings. These are the fine-grained quartz-albite-perthite pegmatite, the line rock, and the cleavelandite-lepidolite pegmatite type of pocket pegmatite. The relationship of the cleavelandite-lepidolite pegmatite to the other pegmatite units is not known, as only thin, isolated patches are exposed, and these do not provide sufficient evidence for any valid conclusions as to the relationship of this unit.

In many dikes a close spatial relationship has been observed between line rock and the fine-grained quartz-albite-perthite pegmatite. Line rock commonly occurs immediately above quartz-albite-perthite pegmatite, and the boundary between the two types is gradational. Minute crystals of garnet are widespread in both types of pegmatite, and garnet is a diagnostic mineral. The main difference between the two types seems to be in the proportions of quartz and albite, although this difference cannot be established without bulk sampling of representative dikes. The perthite content of each type is variable, but the range is estimated to be similar. Although the available evidence is fragmentary and inconclusive, these two rock units are believed to have formed by much the same process.

These two units form tabular bodies in the footwall part of the dikes, and are about as extensive as the graphic granite pegmatite in the hanging-wall zones. They appear to have much the same structural relationship as the hanging-wall zone. If these units are primary zones, the pegmatite dikes would be asymmetrically zoned, and zoning of this type is not widespread in other pegmatite areas. Although abnormal zonal arrangements are possible, the origin of such an abnormal sequence is difficult to explain by fractional crystallization. The only evidence that might indicate a primary nature of these units is the occurrence of the wedge-shaped graphic granite crystals through which the garnet bands of the line rock pass along growth lines of the crystals. Indisputable evidence for the primary nature of these units was not found in the Rincon dikes.

These rock units have been explained as replacements of pre-existing pegmatite by many geologists who have examined the Pala district. Schaller 21 has collected evidence from many dikes in the Pala district that may be interpreted as proving that the line rock and the fine-grained quartz-albite-perthite pegmatite were formed as replacements of pre-existing graphic granite pegmatite. If this theory of origin is correct, these units in the Rincon dikes should also be replacement bodies.

Clear-cut textures indicative of replacement, such as pseudomorphic texture, veining texture, and embaying texture, are not widespread in the Rincon dikes, and these textures were observed only between minerals and not between pegmatite units. As replacement textures occur between minerals in any pegmatite and are to be expected as deuteric effects of the crystallization of a magma, the

existence of these textures does not establish definitely the replacement origin of these units. Sufficient critical evidence that conclusively establishes the origin of these two units was not found.

**Composite Dikes.** Composite dikes appear to be a single body, but they are actually composed of two or more parallel dikes without wall rock between them. Such dikes are not common in the Rincon district. In some dikes the border zone of adjoining pegmatites is preserved, and a knife-edge separation between the two parts of the composite dike can be seen. In other dikes the two parts have coalesced, and the composite nature of the dike is shown by the repetition of a typical footwall unit, such as line rock, quartz-albite-perthite pegmatite, or graphic granite pegmatite, above the hanging-wall unit of the lower part.

In composite dikes in which graphic granite pegmatite lies immediately above another graphic granite unit, the composite nature of the dike is revealed by the occurrence of a band of graphic granite, in which the narrow ends of the tapered crystals point toward the narrow ends of the crystals in an adjacent band. Commonly a thin band of finer-grained graphic granite marks the plane of separation of the two parts in such a composite dike. In a few places examination along the trace of a composite dike reveals that it splits into two separate dikes.

**Origin**

**Source of the Pegmatites.** The igneous rocks in the immediate vicinity of the Rincon pegmatites are not closely related in time or in composition to the pegmatites. The large plutons in and adjacent to the district range in composition from gabbro to granodiorite, and the pegmatites are believed to approximate the composition of a potash-rich granite. Much of the garnet and biotite in the pegmatites may be the end product of resorption of gneissic inclusions by the pegmatite magma. The inclusions in the Victor and Clark dikes are altered tonalite, in which the hornblende and biotite are changed to chlorite and garnet. Adjacent to these inclusions biotite and garnet are more abundant in the pegmatite than in the inclusion-free parts of the dikes. These reaction phenomena are additional evidence of the difference in composition between the pegmatites and the wall rocks, and although they do not prove the granite composition of the pegmatites, they suggest that the pegmatites are more nearly related in composition to granite than to granodiorite. No granite plutons have been found near the Rincon district, and as in the Pala district, a gap exists in the igneous rock sequence between the granodiorite and the pegmatites.

The pegmatites are clearly younger than all the other igneous rocks, and appear to have been emplaced in the batholithic rocks when these rocks were relatively cool, as is indicated by the increase in grain size from the walls of the pegmatite dikes toward the centers. The pegmatites probably represent the final stage in the consolidation of the batholith.

**Emplacement.** Most of the Rincon pegmatites have been emplaced along pre-existing, parallel joints in the host rocks. The attitude of the pegmatites is not controlled by internal structural elements in the host rocks. The dikes undoubtedly formed, for the most part, by crystallization in fractures rather than by replacement of the wall rock. Evidence for this method of emplacement is: 1) the walls of the dikes are generally straight and parallel; 2) the dikes cross contacts between different types of host rocks without any change in shape, attitude, or composition; 3) the zones paralleled the wall rock contacts, and elongate minerals, such as schorl, mica, and the graphic granite intergrowths, appear to have grown inward from the contacts; and 4) the zonal sequence in the Rincon dikes is the same as in pegmatite dikes in Colorado, South Dakota, Wyoming, and other places where the emplacement of the pegmatite dikes along pre-existing planes of weakness in the host rocks can be demonstrated.

The origin of the joints along which the dikes have been emplaced is not known definitely. These joints are not primary structures of the host rocks; they occur in all the metamorphic and igneous rocks in the district without regard to the shape and structure of the individual bodies. Hence, these joints are regional structures and must have been formed at an extremely late stage in the batholithic emplacements when the batholith was sufficiently crystallized to act as a solid or after the batholith had solidified completely. The joints do not appear to be related to any of the major faults of the region.

These joints may have been caused by contraction resulting from the cooling of the batholith, and if so, the joints would be primary joints of the batholith, although the same joints would be secondary in relationship to the plutons that make up the batholith. These joints probably are comparable to the primary flat-lying fractures described by Balk as being shown by flat-lying aplites, pegmatites, quartz dikes, basic dikes, or subhorizontal masses of microgranite. The present westerly dip of the joints may have been caused partly by tilting of this part of southern California during middle and late Tertiary time, or it may be the original attitude of the joints.

**Origin of Pegmatite Units.** The history of the pegmatites after they had been emplaced in the wall rocks is not understood completely. The zones which were formed by fractional crystallization from the walls inward, are cut by fracture-fillings that are extensions of the inner zones into the outer zones of the dikes. The zones show consistent changes in composition and texture from the walls inward, and are consistent in sequence in all dikes in the district, even if the whole sequence does not occur in an individual dike.

The origin of some pegmatite units cannot be explained by any single theory, nor by the evidence observed in the Rincon district. Much of the evidence seems contradictory. The uneven distribution of the line rock in different dikes, or even in the same dike, and the irregular position of this unit within a dike or several dikes do not fit the concept of the mechanics of formation by fractional crystallization. On the other hand, the peculiar interruption of garnet and albite bands in the line rock by graphic granite crystals that appear to be primary is not in accord with the theory of formation of hydrothermal replacement, as no selective control has been found that would govern the replacement of some graphic granite crystals and not others. As the line rock and the fine-grained quartz-albite-perthite pegmatite are closely related in composition, texture, and space, these two types

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of pegmatite are believed to have had a common origin. A satisfactory theory of origin should explain the characteristic banding, composition, uneven distribution, and irregular position of these pegmatite units. Hence, the origin of line rock and fine-grained quartz-albite-perthite pegmatite is obscure.

The cleavelandite-lepidolite pegmatite type of pocket pegmatite is too poorly developed and exposed in the district to permit any conclusion as to its origin. Jahns has provisionally termed similar units in the Pala district "replacement units (possibly in large part of deuteric origin)," because they differ from the typical zonal units in age, texture, and structure.

**ECONOMIC FEATURES**

The chief potential economic value of the pegmatites in the Rincon district is as a source of semiprecious gem stones and possibly of feldspar. The economic features can best be summarized by a consideration of each mineral that might be of commercial interest. The rare minerals that occur only in extremely small quantities are not described. Most, if not all, of these have been described in detail in previous papers, which are cited in the introduction of this report. The Rincon district has produced an unknown but undoubtedly small quantity of gem stones, particularly aquamarine beryl.

The essential minerals of the dikes in the Rincon district, quartz and perthite, are associated with beryl, muscovite, columbite-tantalite, spodumene, tourmaline, lepidolite, albite, and garnet. The rarer minerals of the dikes include amblygonite, apatite, bismite, cookeite, epidote, gastahilite, helvite, heulandite, hyalite, lamontite, petalite, pleonaste, stiltite, and verniculite. These minerals occur in such small quantities as to be of mineralogical interest only and have no economic significance.

**Essential Minerals**

**Perthite.** Perthite is the most abundant mineral in the pegmatites and occurs in all the dikes. It is abundant in the graphic granite pegmatite, where it surrounds quartz rods and plates, and in the quartz-perthite pegmatite, where it occurs as subhedral to euhedral crystals. The graphic granite crystals are commonly less than 1 foot in length and have an average diameter of 4 inches. The quartz rods and plates in these crystals generally constitute 15 to 25 percent of the crystal. The average size of the perthite crystals in the quartz-perthite pegmatite generally is smaller than that of graphic granite; the largest observed was 8 inches long. The perthite in both types of occurrence is ivory or creamy white.

The most common use of perthite is by the ceramic industry, where it is utilized in glass making and in pottery. Both uses require a large tonnage and steady supply of high-grade feldspar. No one dike or closely spaced group of dikes in the district was found which contains sufficient tonnage for a successful mining venture for these uses of the mineral.

None of the potash feldspar seen by the writer in the Rincon district has been identified as orthoclase but some of the feldspar in the small pockets in the lithia-bearing pegmatites might be orthoclase. The quantity of pocket feldspar in the district is extremely small.

**Quartz.** Quartz occurs in all the pegmatites in the district, and is only slightly less abundant than perthite. In most dikes the quartz is in milky or light-gray translucent masses that are interstitial to other minerals in the graphic granite pegmatite of the wall zones, or is a milky or dark-gray, opaque to transparent groundmass of the perthite crystals in the quartz-perthite pegmatite. It also occurs in fine-grained, particle-filled quartz-perthite pegmatite and the line rock. In a few dikes, particularly in the Clark, it occurs in well-formed, transparent, euhedral crystals in vugs in the core. Some of these crystals are smoky, but others are water-clear. No crystal crystals more than 1 inch in length were seen in the dikes, although larger crystals have been found in the past.

Euhedral crystals are the only form of quartz of any commercial value in the district. Some of the crystals are reported to have been used as sources of oscillator plates in the radio industry during World War II, and it is possible that a very small quantity of quartz suitable for this use might be recovered by future mining.

Another use of water-clear and transparent smoky quartz is as a source of gem-cutting material, but this use does not command high prices. A small quantity of the quartz crystals in the district might be used as a gem-cutting material.

**Accessory Minerals**

**Beryl.** Although not abundant as an accessory mineral, beryl is the mineral that has been sought in most of the past mining in the Rincon district. It occurs in yellowish, blue-green, and bright blue euhedrons that range in size from 1/25 inch to almost an inch in diameter. Most of the beryl seen was opaque to subtransparent, but a few crystals were found that had transparent areas. The crystals generally are frozen in the rock and will not yield gem stones. Beryl most commonly occurs with muscovite, albite, and schorl at the edges of quartz-perthite pegmatite. It less commonly occurs in the quartz-perthite pegmatite cores of some dikes. No beryl was seen in the graphic granite pegmatite wall zones, line rock units, or fine-grained quartz-albite-perthite pegmatite units.

Beryl is in great demand as the principal source of beryllium and beryllium oxide, which is used in making beryllium alloys. It has a minor use as a glazing material in the ceramic industry. The percentage of beryl is too low in the Rincon pegmatites for successful mining.

The transparent beryl crystals that occur in some of the dikes yield excellent semiprecious gems, especially of the aquamarine variety, and more of these crystals might be found by continued search. These gemmy crystals are most commonly found in small vugs, generally less than 4 inches in maximum dimension, that occur along the margin of the quartz-perthite pegmatite cores in a few dikes such as the MacK dike. The crystals in most of the vugs are attached at one end only, and extend into the open space of the vug. Crystals have been found loose inside the vugs, and these are reported to have yielded the best gem stones. Many of the crystals are partly in the vugs and partly in the enclosing rock.

Gem beryl is the most abundant mineral of economic importance that might be recovered successfully from the Rincon pegmatites. As the gem beryl occurs in these dikes with minerals that are of no commercial value, any mining would be wholly dependent on the recovery of enough gem

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material to pay the mining costs. Very few dikes contain gem beryl, and even those in which gem beryl occurs contain only an extremely small proportion of the mineral. Although new finds of gem beryl will undoubtedly be made by mineral collectors and prospectors, the Rincon district does not appear to be promising for commercial gem-stone mining.

**Muscovite.** The most abundant of the accessory minerals is muscovite. It generally occurs as silvery-green or light-gray plates, most of which are less than 3 inches long and less than 2 inches wide. It is found in all types of pegmatite, but is most abundant and attains the largest grain size at the margins of the quartz-perthite pegmatite. All the muscovite plates observed contained "A" structure and are not suitable for use as sheet mica. The muscovite could be used as scrap or grinding mica, but none of the Rincon pegmatites is rich enough in muscovite or contains sufficient tonnage for successful scrap-mica mining.

**Albite.** Albite occurs as white blebs and aggregates of small size in the fine-grained quartz-albite-perthite pegmatite and the line rock. It also occurs in small white blebs in the graphic granite pegmatite, where it forms part of an interstitial aggregate between graphic granite crystals. It is most abundant as anhedral grains as much as 2 inches in maximum diameter in the margins of many quartz-perthite pegmatite cores. Plates of albite, of the cleavandite variety, occur sparingly in the albite-epidote pegmatite of a few dikes. Albite is not in commercial demand in the small tonnages that are available in the Rincon district.

**Other Minerals.** The other accessory minerals—columbite-tantalite, spodumene, tourmaline, lepidolite, and garnet—are not exposed in sufficient quantities to be of economic importance. In all the dikes in which these minerals, except sehorl (black tourmaline) and garnet, have been observed the exposures are so poor, because of the removal of most of the host rock either by mining or by erosion, that no positive evaluation of the past economic significance of these minerals is possible.

School is fairly common in the core margins of some dikes, and also occurs in the graphic granite pegmatite. Minute crystals have been found in the line rock and fine-grained quartz-albite-perthite pegmatite. All the school crystals are either too small or too highly fractured to be of any commercial value.

Very small garnet crystals are common in the line rock. Garnet occurs less abundantly in all the pegmatite units, and sparingly in the cores of a few dikes. In the Rincon dikes it is too fractured and flawed to yield gem stones, and does not occur in sufficient quantity to allow economic recovery alone or in combination with any other pegmatite mineral.

### MINES AND PROSPECTS

Descriptions of the three largest mines and two prospects follow; the district contains many small test pits, short adits, and shallow open cuts as much as 30 feet long and 15 feet wide. The locations of most of these minor prospects have been mapped (pl. 1). The mines described include all those from which production has been reported and illustrate the different types of pegmatite deposits in the district.

The Mack mine, in the SW1/4 sec. 25, T. 10 S., R. 1 W., is on the ranch owned by Mr. Charles Hall of Rincon. The mine workings are on both walls of a small arroyo a few hundred feet northwest of the ranch house.

The mine workings (fig. 3) consist of a series of three open cuts, the largest of which has maximum dimensions of 61 feet in length, 32 feet in width, and 16 feet in depth. These workings have been abandoned for many years and consequently are slightly caved and overgrown. The dumps, which formerly were in the arroyo bottom, have been almost completely removed by flash floods.

This mine undoubtedly is one of the earliest gem beryl workings made by John Mack under the terms of his agreement with Feliz Caluc, the former owner of the Hall Ranch. Although no information was obtained on the past mining history and production of this mine, the small size of the workings indicates meager production; the mine probably should be called a prospect. The mining method followed was the removal of the overburden and the top half of the pegmatite, exposing the beryl-bearing part of the dike.

The Mack pegmatite is in deeply disintegrated tonalite in the deeper parts of the workings. In the shallower parts it is in residual tonalitic soil. The nearest outcrop of Bonsall tonalite is about 115 feet upstream from the pegmatite. Although the structure of the tonalite cannot be established definitely, the pegmatite appears to be a cross-cutting dike.

Two thin pegmatite dikes, separated by about 1 foot of tonalitic soil, occur 4 to 5 feet vertically above the Mack pegmatite. These dikes are exposed in the west wall of the large cut and do not crop out beyond the limits of the cut. The lower of these two dikes ranges from 8 inches to 18 inches in thickness, strikes approximately north parallel to the Mack dike, and dips 43° SW. The upper one is 6 to 8 inches thick and also parallels the Mack. Both dikes have graphic granite pegmatite wall zones in which school is common, and thin quartz-perthite pegmatite cores. No beryl or line rock was observed in either dike.

About 100 feet to the east of the Mack dike a fourth dike is poorly exposed in the arroyo walls. This dike probably is parallel to the Mack dike, but may dip less steeply. It also contains graphic granite pegmatite wall zones and a quartz-perthite pegmatite core. No beryl was seen in this dike.

**Structural Features.** The Mack dike is exposed in the workings and at the surface for a length of 170 feet, and can be traced by means of intermittent outcrops for an additional 120 feet to the south. To the north it is covered by a pediment deposit several hundred feet wide. A dike which may be the Mack dike is exposed on the small knoll north of the pediment deposit; this northern dike can be traced for several hundred feet beyond the knoll.

The Mack dike is a thin, tabular body with a maximum exposed thickness of 3.25 feet. For most of its length its thickness is about 2 feet. The large open cut was made at the thickest part; the dike thins to the south where the outcrops indicate a thickness of less than 1 foot. The general strike is N. 15° W., and the general dip is 40° SW. The variation in strike on the hanging wall in the large
Figure 3
The dike in the large cut is broken into roughly rectangular blocks by many joints. One subparallel group of joints strikes about N. 25° W., and dips 40°-60° NE.; and the other group strikes about N. 60° E. and dips very steeply. The steeply dipping joints of the second group are tension joints, some of which have been filled and healed by pegmatitic material. The large number of joints (see fig. 3) aided the mining, as many of the blocks could be removed by hand tools. In one place within the large cut the entire thickness of the dike between four joint planes has been mined out, and the Bousell tonalite at the footwall is exposed.

In the arroyo south of the large cut the dike has been displaced by a concealed fault that has an apparent horizontal displacement of about 18 feet. The hanging wall of the dike north of this fault strikes N. 10°-20° W. and dips 33°-42° SW., whereas south of this fault it strikes about north and dips about 45° W. Therefore, the fault probably had a small rotational component.

Petrographic Features. The Mack dike contains three definite zones and four other pegmatitic units. The zones are: 1) the border zone, 2) graphic granite pegmatite wall zone, and 3) quartz-perthite pegmatite core. The other pegmatitic units are: 1) the fracture-filling unit of quartz-perthite-muscovite pegmatite, 2) the fine-grained quartz-albite-perthite pegmatite unit, 3) the line rock unit, and 4) the pocket pegmatite. A typical sequence through the dike in the large cut is:

<table>
<thead>
<tr>
<th>Hanging wall</th>
<th>Average thickness (in inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border zone (very fine-grained)</td>
<td>0.5</td>
</tr>
<tr>
<td>Fine-grained quartz-albite-perthite pegmatite unit</td>
<td>3.0</td>
</tr>
<tr>
<td>Graphic granite pegmatite wall zone</td>
<td>6.0</td>
</tr>
<tr>
<td>Quartz-perthite pegmatite core</td>
<td>6.0</td>
</tr>
<tr>
<td>Line rock unit</td>
<td>10.0</td>
</tr>
<tr>
<td>Fine-grained quartz-albite-perthite pegmatite unit</td>
<td>3.5</td>
</tr>
<tr>
<td>Border zone (very fine-grained)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Footwall

The pocket pegmatite is not a true type of pegmatite. It is a band, made up of the lower part of the quartz-perthite pegmatite core and the upper part of the line rock, that contains a great many small vugs. The dike south of the fault contains neither the fine-grained quartz-albite-perthite pegmatite nor the pocket-bearing unit, and the line rock is less strongly developed.

The border zone is composed essentially of very fine-grained graphic granite pegmatite, with accessory biotite plates, some of which are as much as 1 millimeter in size. These biotite plates commonly are oriented perpendicular to the walls of the pegmatite dike.

The wall zone is predominantly graphic granite with accessory muscovite, garnet, quartz, and sparse scheelite. It is best exposed on the hanging-wall side of the dike and is obscured by the fine-grained quartz-albite-perthite pegmatite unit and the line rock on the footwall side. The graphic granite pegmatite is finer-grained near the border zone and has an average grain size of slightly less than 1 inch, and is coarser-grained adjacent to the core. The individual crystals are wedge-shaped and are perpendicularly to the dike walls. All the crystals thicken toward the center of the dike. The greenish-gray muscovite plates have a maximum dimension of 10 millimeters. Garnet crystals, generally less than 1 millimeter in diameter, are scattered throughout the zone, but are most abundant along the cleavages and crystal faces of the graphic granite. Only a very few schorl crystals were seen and these normally occurred at the inner edge of the zone.

The core is composed of quartz and perthite with accessory muscovite, albite, garnet, beryl, and columbite. It is poorly developed in the large cut and is better developed south of the fault. The minerals that make up the core merge into those of the adjacent zones. For example, perthite crystals in the core have the same crystal faces and orientation as graphic granite crystals in the wall zone, and the only difference is the absence of quartz rods and plates in the core mineral.

The white perthite crystals may be as much as 6 inches across. Gray, slightly smoky quartz generally occurs as anhedral crystals interstitial to the perthite. Along the margin of the core, particularly on the footwall side, the abundant quartz and perthite of the core are accompanied by accessory greenish-gray muscovite in books as much as 1.5 inches in length, by small, irregular clots of white albite, by many minute garnet crystals, by sparse beryl, and by rare columbite. Beryl occurs in greenish-blue euhedrons that generally are less than 13 millimeters in diameter. Columbite occurs in very small tabular grains widely dispersed in the other minerals.

The fracture-filling unit is composed of fine-grained quartz, perthite, and muscovite. It occurs as a thin filling with sharp walls, in a branching fracture at the northern end of the large cut, and cuts the graphic granite pegmatite wall and border zones. This unit can be traced into the core and undoubtedly represents the last stage of consolidation of the pegmatite, because the material that now fills the fractures must have been fluid when the border and wall zones were strong enough to yield by fracturing.

The fine-grained quartz-albite-perthite pegmatite unit is composed essentially of quartz, albite, and perthite, with accessory biotite, muscovite, and garnet. It has a typical grain size of about 2 millimeters. This unit occurs adjacent to the border zone on both the hanging-wall and footwall sides of the dike. It is characteristically banded, and the bands commonly are spaced 6 to 8 millimeters apart. These bands are caused by the alternation of finer and coarser-grained material and do not seem to represent any concentration of a specific mineral. Most of the perthite crystals are graphic granite.

The quartz-albite-perthite pegmatite is in contact with the graphic granite pegmatite toward the center of the dike on the hanging-wall side and grades into the line rock on the footwall side. The line rock is characterized by sharply defined, garnet-rich bands in a matrix composed essentially of albite and quartz. The bands are sharpest just below the core. Wedge-shaped graphic granite crystals as much as 1 foot long and 5 inches wide extend through this unit from the border zone to the core. Most of these crystals are not corroded, and the most noticeable change is the occurrence, in the graphic granite, of many minute garnet crystals along the crystal faces and along ghosts, particularly on the domal ghost.
faces. The garnet bands are much sharper between the
graphic granite crystals than within the crystals.

The pocket pegmatite, which is made up of the lower
4 to 6 inches of the core and the upper 6 inches of the line
rock, is the only mineral deposit in the dike. It contains
many vugs, a few of which may be as large as 12 inches
across and 6 inches deep but most of which are about 3
inches across and 3 inches deep.

The vug walls generally are lined with euhedral crys-
tals of muscovite as much as 10 millimeters wide and
albite crystals that commonly are 5 millimeters thick and
10 millimeters wide. Quartz crystals of similar size are
less abundant. Euhedrons of beryl and garnet are least
abundant. The vug-lining minerals occur on quartz,
perthite, albite, muscovite, and graphic granite that form
the walls of the vugs. No intense corrosion of the wall
minerals has been observed. Commonly, however, the vug
wall shows different degrees of corrosion on a single crys-
tal, particularly perthite crystals, with some faces of the
crystal corroded to a depth of 10 millimeters and other
faces completely untouched.

Economic Features. The beryl crystals in the vugs
are the only source of gem material in the Mack dike. None
of the other minerals in this dike occurs in sufficient quan-
tities or is of high enough grade to be mined under the
conditions prevailing in 1948.

The beryl in the vugs is commonly an extension of
beryl crystals formed in the wall of the vug. The greenish-
blue to blue beryl, which forms the largest crystals in the
vugs, may be as much as 13 millimeters across. It common-
ly is a transparent aquamarine of gem quality. The part
of the crystal that extends into the walls is generally
opaque to subtransparent and fractured. It is frozen to
the surrounding minerals. On rare occasions loose beryl
crystals have been found in the vugs, and these are re-
ported to have yielded the best gem stones. Few beryl
crystals were found in vugs when the mine was examined,
but crystals were found in the vug walls.

The ratio of all the beryl in the pegmatite to the quan-
tity of rock that would have to be moved to recover the
beryl is extremely low, and is estimated to be about
1:50,000 to 1:100,000. In addition, gem beryl forms only
a very small part, estimated to be less than 1 percent, of
the beryl in the dike.

The only possible prospecting in the Mack dike
should be for gem beryl of the aquamarine variety. Any
future operations for this mineral will be faced with
sharply increased costs as the cheaply mined, favorable
ground has already been exhausted. The most probable
extension of the pocket pegmatite is down the dip of the
dike, and prospecting of this extension would be expen-
sive as the tonnage of barren rock that would have to be
moved in an open cut operation, such as would be neces-
sary, would be constantly increasing with depth.

Victor Mine

The Victor mine, in the SE\(\frac{1}{4}\)NW\(\frac{3}{4}\) sec. 36, T. 10 S.,
R. 1 W., is on land owned by Mr. Jesse Cain of Rincon,
but the mineral rights are reported to be owned by a Mr.
Kip. The mine workings are on the west slope of Mack
Ridge at an altitude of 1,220 feet, and can be reached only
by two foot trails (pl. 1).

The mine (fig. 4) is an open cut, 60 feet long, 45 feet
wide, and 25 feet in maximum depth. From this open cut
small underground workings explore the pegmatite. The
largest underground working is an irregular group of
adits, inclines, and rooms, having a total length of 30 feet,
at the south end of the open cut. A small aditlike room in
the east side, near the north end of the cut, exposes the
footwall of the dike. At the junction of the entryway and
open cut a narrow inclined shaft, 18 feet long, has been
sunk on a thin pegmatite that probably is an offshoot of
the main dike. The workings have been abandoned for
many years and are badly caved. In places they are com-
pletely covered by heavy brush, and the dumps are al-
most completely overgrown.

This mine, like the Mack mine, is one of the earliest
workings made by John Mack. The mineralogy of the
pegmatite was described by Rogers\(^2\) in 1910. No informa-
tion as to the detailed mining history and production
of this mine was obtained in 1948. At some period since
Mack's activity the mine is reported to have been owned by
Mr. Eric Hindorf under the name of "Big Buck mine," and
it is rumored that a small quantity of kunzite, gem tour-
maline, beryl, and garnet was recovered during Hind-
orf's ownership.

The same method of mining was followed in the Vic-
tor mine as at the Mack mine, with the addition of under-
ground work. Roughly the top half of the dike down to
and including most of the pocket pegmatite has been
removed.

The Victor pegmatite dike cross cuts the structure of
highly disintegrated Bonsall tonalite. The pegmatite is
exposed only in the open cut and underground work-
ings and cannot be traced beyond the limits of the work-
ings. A rubble outcrop of quartz-perthite pegmatite about
45 feet northeast of the open cut may represent an exten-
sion of the dike, but no connection between this outcrop
and the dike is exposed. The relatively great depth of
weathering near the mine has resulted in intensive down-
hill slump, which may have buried the pegmatite to the
north and south of the workings.

Structural Features. The Victor dike is exposed in the
open cut and underground workings for a total length of
84 feet, and for a distance of 35 feet down the dip. It is
a tabular body with a maximum exposed thickness of
8 feet, but before mining was probably as much as 12 feet
thick near the center of the open cut. The general strike
is N. 10° W., and the general dip is 55° SW. The strike
on the footwall exposed in the small adit is north, and the
dip changes from 48° W. at the back to 63° W. at the
floor. In the inclined workings the footwall strikes N.
13° W., and dips 53° SW.; the hanging wall appears to
be parallel.

The dike ends in a blunt nose along the east side of
the lower adit in the inclined workings, but where this
adit joins the inclined workings the dike appears to con-
tinue in depth. Inasmuch as the adit and most of the in-
clined workings are badly caved and washedfill it was not
apparent whether the blunt end represented faulting, a
roll in the dike, or the original end of the dike.

Petrographic Features. The part of the Victor dike
exposed in the inclined workings is composed of a unique
mixture of graphic granite, albite, plumeose muscovite,
and quartz, with accessory schorl and garnet. Many al-
tered tonalite inclusions, which commonly are 2 to 4 inches

\(^2\) Rogers, A. F., op. cit.
Figure 4. Geologic map of the Victor pegmatite, Rincon, San Diego County, California.
thick and 3 feet long, occur in this pegmatite. The largest inclusion exposed is 8 inches thick and 5 feet long. Many of the inclusions are at right angles to the dip of the pegmatite, although a few are parallel to the walls. These inclusions are estimated to make up 20 percent of the pegmatite exposed in the face of the upper adit. Around the inclusions the pegmatite is fine-grained and garnet- and biotite-rich. The grain size increases and the garnet and biotite content decreases away from the inclusions.

The large quantity of inclusions in this part of the dike probably disrupted the normal processes of crystallization and caused a fairly homogeneous pegmatite to form instead of the zoned pegmatite exposed in the open cut.

In contrast to this type of pegmatite, the part of the dike in the open cut contains three zones, and three other units of obscure origin. The zones are: 1) the border zone, 2) the graphic granite pegmatite wall zone, and 3) the quartz-perthite pegmatite core. The other units are: 1) a quartz-albite-muscovite pegmatite unit, 2) a line rock unit, and 3) a cleavelandite-lepidolite pegmatite unit.

The border zone is composed chiefly of very fine-grained graphic granite containing small plates of accessory biotite oriented perpendicular to the pegmatite walls. This zone is not developed uniformly in the dike and does not occur all along the contact with the wall rock.

The graphic granite pegmatite wall zone is best exposed along the hanging-wall side of the dike. Grayish-white graphic granite in wedge-shaped crystals makes up 75 to 90 percent of the zone and is associated with quartz (5 to 15 percent) and accessory scapolite, garnet, and muscovite. In the outer foot or so of this zone muscovite commonly occurs in plumose or spraylike intergrowths with quartz and graphic granite, and is a distinctive feature. The muscovite plates in this intergrowth generally are small. In the inner part of the zone the muscovite occurs as books of wedged, "A" mica that are as much as 3.5 inches long. Schorl and garnet crystals increase in size from the outer to the inner part of the zone.

The core is best exposed along the eastern rim of the open cut, where it is composed of light-gray to dove-gray perthite subhedrons and euhedral and light-gray to white quartz. At the rim the core is about 4 feet thick. Two small veneerlike patches of the core were found down the dip in the open cut, but in the lowest exposures the core is absent. Muscovite, albite, beryl, garnet, and schorl are accessory minerals along the core margin on the footwall side. The muscovite books are larger than in the wall zone, and may be as much as 6 inches long. Deep red garnet crystals as much as 1 inch in diameter are associated with the muscovite. White albite occurs as small, irregular clots in the core margin. Pale bluish-green, opaque, euhedral beryl crystals, as much as 1.5 inches across, are sparse. Schorl euhedrons up to 12 inches long and 1.5 inches in diameter are abundant.

The quartz-albite-muscovite pegmatite unit is composed mainly of milky quartz anhedrons, as much as 2 inches in size; white albite in patches half an inch or less across; and silvery-gray muscovite in books about 1 inch long, with accessory scapolite and small garnet crystals. This unit occurs in the footwall part of the dike and corresponds in position and thickness to the wall zone of graphic granite pegmatite. In the lower part of the cut the quartz-albite-muscovite pegmatite lies directly below the graphic granite pegmatite wall zone, and the core and other units that occur between these two rock types in other parts of the dike are missing. This unit is similar in composition to the unzoned pegmatite exposed in the inclined workings and forms the bulk of the rock exposed in the open cut, as mining has removed most of the overlying pegmatite. In a few places the quartz-albite-muscovite pegmatite contains abundant graphic granite, but this part makes up only a small portion of the whole.

Biotite, in plates as much as 2 inches long, is abundant near the border zone but decreases both in size and in abundance within a short distance toward the center of the dike.

The line rock is very poorly developed and exposed in this dike. A few isolated, tabular patches were seen in the quartz-albite-muscovite unit and in the graphic granite pegmatite wall zone. Commonly the line rock is less than 6 inches thick, and is completely surrounded by graphic granite pegmatite or by the quartz-albite-muscovite pegmatite. In general the line rock patches occur near the center of the dike, but they were too thin and too irregular to be mapped.

The cleavelandite-lepidolite pegmatite exposed consists of small, thin patches of cleavelandite and lepidolite with accessory muscovite, quartz, green and red tourmaline, garnet, and beryl. Five patches of this pegmatite are shown on the map (fig. 4). The largest of these is 4 feet long and 3 feet wide, but is not more than 6 inches thick. It can not be determined from the present exposures whether this unit was continuous throughout the open cut or originally occurred only as small pods along the medial plane of the dike as reported by Rogers. Practically all this pegmatite has been mined out and even the position within the dike is uncertain. It is underlain by the quartz-albite-muscovite pegmatite and probably was overlain by the quartz-perthite pegmatite, but nowhere is the quartz-perthite pegmatite exposed adjacent to the cleavelandite-lepidolite pegmatite.

This pegmatite was the source of all the gem minerals produced from the mine. Rogers reports the occurrence of bismuth, bismite, and kunzite from it. He also reports hyalite, spinel (variety pleonaste), epidote, stilbite, heulandite, laumontite, cookeite, and amblygonite from the Victor mine, and most if not all of these minerals probably occurred in this pegmatite or in pockets within it. Fisher reports that a few plates of tantalite were found in this pegmatite, but none was found in place when the mine was mapped.

Economic Features. The Victor dike has been almost completely mined out, and no geologic evidence could be found that would indicate any possible extension of the cleavelandite-lepidolite pegmatite, the only source of the gem minerals found in past mining. None of the other minerals in the dike occurs in sufficient quantity to be mined successfully under the conditions prevailing in 1948.

Clark Mine

The Clark mine, in the NE4SW4 sec. 36, T. 10 S., R. 1 W., is on the east side of Mack Ridge at an altitude of 1180 feet (see pl. 1). The present ownership of the mine is not known.

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26 Rogers, A. F., op. cit., p. 268.
27 Rogers, A. F., op. cit.
Figure 5. Geologic map of the Clark pegmatite, Rincon, San Diego County, California.
The mine workings (fig. 5) consist of two groups of open cuts. The northern group is composed of six open cuts along the trace of the dike, and the southern group of two open cuts. The northern group is made up of the main cut, which is 47 feet long, as much as 23 feet wide, and 16 feet deep; the south cut, 65 feet long, 20 feet wide, and 8 to 11 feet deep; and four small open cuts. Two tiny adits are connected with the south cut. All these cuts are badly caved and overgrown.

The mine undoubtedly was one of the early developments by John Mack. No information as to the past history or production was available at the time of this investigation. Recently the mine was worked as a source of quartz crystals of 'radio' grade for use in oscillator plates. Mr. William McGee of Pala, California, was in charge of these operations. According to Mr. McGee several tens of pounds of quartz crystals were recovered by these operations, but the percentage of usable material is not known.

Northern Group of Workings

The Clark dike cuts across the structure of the Bon-sall tonalite wall rock that crops out extensively on the hillside around the mine. The dike is well exposed only in the open cuts, as a heavy cover of tonalite talus blocks and soil conceal it between the open cuts, except in a few small scattered outcrops.

Structural Features. The Clark dike is exposed in open cuts and as small outcrops for a length of 240 feet. It probably extends an additional 150 feet to the north, and has been traced along scattered outcrops for several hundred feet to the south. It has not been exposed for more than 10 feet down the dip. The Clark dike is a tabular pegmatite with a maximum exposed thickness of at least 8 feet, but the whole thickness is not exposed at any one place. The general strike is N. 20° W., and the general dip is about 40° SW. A possible split in the dike is poorly exposed in the two small cuts just north of the main cut, but the upper split may not be in place.

Petrographic Features. Although a complete sequence of the pegmatite units in the Clark dike cannot be established, the petrographic features are indicated by descriptions of the pegmatite units as exposed in some open cuts.

Near the hanging wall in the northwest corner of the main cut two subrounded inclusions of tonalite have been altered in part to a felted aggregate of chlorite-albite-garnet rock. The inner parts of these inclusions are less altered and resemble more closely the tonalite from which they came. Biotite and garnet are more abundant adjacent to these inclusions than in other parts of the dike.

The most complete section through the dike is in the main cut, where a wall unit, 6 to 8 inches thick, of fine-grained quartz-perthite-albite-mica pegmatite occurs at the hanging wall. Both biotite and muscovite are present in this rock, and schorl in crystals 1 millimeter across is the most abundant accessory. Minute garnet crystals occur throughout the unit.

Below the hanging-wall unit is a second unit, 4 to 6 inches thick, composed essentially of quartz, perthite, and albite, with accessory muscovite, schorl, and garnet. The second unit is much richer in muscovite than the other units in the dike. Silvery-gray muscovite commonly occurs in wedge-shaped books, with strong "A" structure, as much as 4 inches long. Schorl crystals may be 5 millimeters across.

The central unit, which probably is the core of the dike, is composed of subhedral, white perthite crystals and anhedral milky to colorless quartz crystals. Near the outer edges of this unit some graphic granite crystals have been observed, but they are not abundant. Albite occurs in the quartz in white clots, less than 3 inches in maximum diameter, and as clots and veins in the perthite. The most common interstitial material between the perthite crystals is a fine-grained aggregate of grayish to milky quartz, muscovite books 1 inch in diameter, small irregular blebs of albite, and accessory schoorl and garnet. In some of these aggregates muscovite also occurs as irregular masses, up to 6 inches in maximum dimension, made up of rosettes of greenish-gray flakes 1 millimeter to 2 millimeters in size. These masses enclose the vugs in which the quartz crystals are found. No large vugs were exposed when the mine was examined, but many small ones, less than 2 inches across, were seen.

The common minerals in these vugs are euhedral crystals of clear and smoky quartz, glassy perthite crystals, and minute white albite crystals. Green epidote crystals up to 3 millimeters across were found in a few vugs; they seem to be of the same age as the quartz and perthite crystals. In general the rock that forms the walls of the vugs is much richer in albite than the rest of the central unit, and this albite has corroded the quartz and perthite.

Below the central unit is a unit 10 inches thick that has the same composition as the upper muscovite-rich pegmatite. The schoorl crystals in this lower unit are twice the size of the schoorl crystals in the upper unit, but the muscovite books are not any larger.

Below the lower muscovite-rich pegmatite a line rock unit grades downward into a fine-grained quartz-albite-perthite pegmatite which contains scattered patches of graphic granite with no preferred orientation.

A very fine-grained albite-quartz pegmatite that has characteristic dark streaks, swirls, and clots is exposed in a pit between the main and the south cuts. The dark streaks are roughly parallel to the contacts between this rock type and the adjacent pegmatite units. These streaks are commonly less than 2 millimeters thick and are separated from one another by bands of whiter material of similar thickness. Scattered augenlike pods of coarser granite material occur in this rock.

This albite-quartz pegmatite occurs in the central part of the dike. The incomplete sequence exposed in this cut is: 1) a graphic granite unit, 12 inches thick, along the footwall; 2) line rock 6 inches thick; 3) an albite-quartz unit, 12 to 16 inches thick; and 4) quartz-perthite-albite-mica pegmatite, 1 foot thick. The albite-quartz pegmatite unit is also exposed in the south cut, in about the same sequence. In this cut, however, it is at least 3 feet below the hanging wall of the dike.

Microscopic examination shows the albite-quartz pegmatite to be composed predominantly of elongate, tabular albite crystals that are less than 1 millimeter long, with less abundant quartz, and accessory tourmaline, microcline, muscovite, garnet, magnetite, and apatite. The dark streaks are caused by the concentrations of small, corroded crystals of black tourmaline in subparallel alignment.

The other exposures of the Clark dike show only one or two of the units described above. Throughout all the exposures zeolites occur as small crystals along late fractures in the dike.
Economic Features. As far as can be determined only quartz crystals have been produced from the northern group of workings. The geology as exposed does not indicate that future mining for this mineral would be successful.

Southern Group of Workings

The largest cut in the southern group of workings is 25 feet long, 8 feet wide, and as much as 10 feet deep. Another cut, about 10 feet to the south, is a shallow, irregular trench. Both cuts are caved and little of the pegmatite can be seen in place. The dike exposed in these pits is undoubtedly the Clark pegmatite, but it cannot be traced definitely between the northern and southern groups of workings. The pegmatite is fairly well exposed across the hillside to the south.

The hanging wall of the pegmatite strikes N. 4° W. and dips 37° SW. The footwall is buried under debris in the cuts and is not exposed elsewhere. The sequence of pegmatite units exposed in the larger pit is unique in the district. The border zone is about 1 inch thick and is a finer grained equivalent of the fine-grained quartz-perthite-muscovite pegmatite in the hanging-wall zone, which is 10 to 12 inches thick. Accessory graphic granite in wedge-shaped crystals, sehorl, and garnet are common. Immediately below the hanging-wall zone is a core, about 15 inches thick, composed essentially of subhedral to euhedral, light-to-dove-gray perthite crystals, as much as 6 inches in maximum dimension, and subhedral to subhedral milky quartz crystals of similar size. Greenish muscovite books as much as 1.5 inches long, white albite clots, milky quartz, and sehorl in crystals as much as 2 inches long, occur interstitially.

A pod of quartz-spodumene pegmatite is poorly exposed directly beneath the core. Opaque to subglassy, silky, white spodumene euhedrons, as much as 1 inch thick, occur in milky quartz. Some of the spodumene is pale pink, typical of the altered spodumene at Pala, and the quartz adjacent to some of the pink spodumene is stained pink. Associated with the quartz and spodumene is a very fine-grained gray-green mica that occurs in felted aggregates. Murdoch reported apatite, helvite, heulanite, and petalite in this quartz-spodumene rock, but none of these minerals was found in the course of this investigation. None of the minerals in this pod occurs in sufficient quantity to be of more than mineralogic interest.

The dike below the quartz-spodumene pod is not exposed in place, but several loose blocks below the cut indicate that it probably is line rock in which some of the bands are formed by concentrations of sehorl crystals instead of the more common garnet.

In that part of the pegmatite south of this group of workings the sequence through the dike is 1) very fine grained quartz-albite-perthite pegmatite at the footwall, 2) a very thin unit of line rock, 3) a unit of quartz-perthite pegmatite in which the perthite crystals are as much as 8 inches long, 4) a unit of albite-quartz pegmatite with the characteristic dark streaks, 5) a unit of quartz-perthite pegmatite with large crystals, and 6) a hanging-wall unit of quartz-perthite-muscovite pegmatite.

Clark Extension Prospect

Nearly on strike with the Clark dike, but on the south side of the San Luis Rey River (is a pegmatite about 5 feet thick that is exposed for a length of about 1,000 feet. This dike strikes N. 31° W. and dips 65° SW. It has been explored by three prospect pits about 200 feet apart along the trace of the dike. A pronounced similarity in mineral content and assemblages, as well as the alignment of the dike, indicates that this may be part of the Clark dike.

The north pit shows the dike to be composed of two units. The footwall unit, 2 feet thick, is very fine-grained line rock. The hanging-wall unit, 3 feet thick, is medium-to-coarse-grained quartz-perthite-albite-muscovite pegmatite with accessory tourmaline, lepidolite, spodumene, garnet, and beryl. The tourmaline crystals are black, indigo, green, pink, and colorless, but all are fractured and "frozen" to the adjacent minerals. The spodumene is concentrated in a pod several inches thick near the center of the hanging-wall unit. Pale greenish-blue beryl occurs sparsely in crystals as much as 8 millimeters across. An unidentified, black, metallic mineral occurs as pods 1 inch across and as small tabular crystals.

The central pit is in the hanging-wall unit, but no lithium minerals are exposed. Small vugs 2 to 4 inches across contain well-formed quartz crystals less than 1 inch long.

The southern pit exposes the same pegmatite units as the northern pit. Lithia minerals are less common, and spodumene and beryl were not found. Most of the pegmatite exposed in this pit is loose blocks that are not in place.

A few small quartz crystals might be found by a careful search, but the quantity of none of the minerals in this dike is great enough for successful mining.

Calac Prospect

The Calac prospect consists of a group of five small pits near the center of sec. 19, T. 10 S., R. 1. E., on the La Jolla Indian Reservation. The workings are on a gently rolling tableland and can be reached easily from the Johnson ranch road by an improved road and trails. The ownership of the land in which these workings have been made is not known; they may be on allotted or on tribal land.

The largest prospect pit, designated in this report as the Calac pit, is about 25 feet long, 15 feet wide, and about 3 feet deep. The other four pits are about 10 to 12 feet in maximum dimension and all are shallow. These pits have been made in two pegmatite dikes in the same tonalite as the other pegmatites.

In general attitude the pegmatites are parallel to each other but in detail may diverge widely. The general strike is N. 40° W., and the general dip is 15° SW. Many structural rolls in these dikes have axes parallel to the strike of the dikes, and these rolls cause sharp reversals of dip. Through most of the area adjacent to the prospect pits the slope of the land surface is just slightly less than the general dip of the pegmatites, and only in the walls of a few stream channels, where there is a local steepening of the slope, do the pegmatites crop out continuously for any distance down the dip. The combination of the structural rolls in the dikes, and the near-concordance of the dip of the dikes and the slope of the land produces an intricately branching outerop pattern. This outerop pattern may suggest a greater number of dikes than exist, as
a single pegmatite may have an outcrop pattern suggestive of five or six separate dikes. Detailed examination of the pegmatites in the vicinity of the prospect shows that only two dikes have been explored and that four of the prospect pits have been made in one dike, the northern one. Only one pit, the Line pit, has been dug in the southern dike.

Northern Dike. The northern dike is probably 3 to 4 feet thick, although a considerable range in thickness is not uncommon. The sequence of the internal pegmatite units in the dike is rather simple. Only fine-grained quartz-albite-perthite pegmatite with poorly developed patches of line rock near the footwall is exposed for most of the length of the dike. In the thicker parts, as at the Calac pit, core pods of quartz-perthite pegmatite occur erratically along the medial plane of the dike between a hanging-wall graphic granite pegmatite zone and a footwall unit of fine-grained quartz-albite-perthite pegmatite.

The quartz-perthite pegmatite core pods are economically the most interesting parts of the dike, as the beryl crystals in the prospect are most abundant in the margins of the core pods. The core pods are all thin, not more than 12 inches in thickness, and many stringerlike pods are less than 2 inches thick. An exceptionally thick core pod occurs in one of the rolls that is exposed about 500 feet south of the Calac pit. This core pod is essentially milky quartz with many perthite euhedrons, as much as 12 inches in size, in the outer part of the core. Large muscovite books occur at the margin and some albite was observed. Although the associations in this thick pod are favorable for beryl, none was seen.

In the Calac pit muscovite concentrations occur at the margins of the thicker core pods. No beryl was seen in place; one crystal of greenish-blue beryl, slightly less than 8 millimeters across, was found in the muck. The beryl content of the northern dike appears to be extremely low, and this prospect probably cannot be mined commercially for beryl.

Southern Dike. The southern dike as exposed in the Line pit, so named because of its position adjacent to the property line between the La Jolla Reservation and the Pauma Grant, is at least 3.5 feet thick. The total thickness is not known, as the hanging wall is not exposed in the pit. The dike crops out as a wall, 3 to 4 feet high, above the surrounding land.

The sequence of pegmatite units, from the footwall to the top of the exposure is: 1) line rock that is about 6 inches thick, 2) quartz-perthite pegmatite core (24 inches thick), and 3) graphic granite pegmatite zone (12 inches thick). Line rock, which is poorly developed in this dike, increases and decreases in thickness over short distances and contains many bands of coarser-grained material, composed of quartz, albite, and muscovite, with some graphic granite. In the places where the line rock is thickest the pegmatite between it and the core is graphic granite.

The quartz-perthite pegmatite core is composed essentially of white perthite euhedrons, as much as 9 inches long and 5 inches wide, and milky to clear, transparent quartz. At the margin of the core on both the hanging-wall and footwall sides is a narrow layer of quartz-albite-muscovite pegmatite, which may represent an intermediate zone, that contains accessory schorl, garnet, and beryl. Clots, a few inches in diameter, of small greenish-gray muscovite plates occur within this band and in the core. Some of the schorl crystals are glassy and almost completely unfractured; the crystals are generally less than 13 millimeters across. Bright blue, greenish-blue, and yellowish-green beryl crystals as much as 13 millimeters in diameter occur in the core margin, in the core, and in the graphic granite pegmatite wall zone. The largest crystals are associated with the quartz and perthite of the core.

The beryl content of the dike is extremely low, less than 1:100,000, but appears to be higher than in the northern dike.