DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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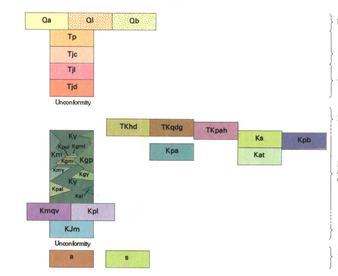
MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1147

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

af — ARTIFICIAL FILL (HOLOCENE AND PLEISTOCENE)—Rock, gravel, and sand from various sources.

Qb — BEACH DEPOSITS (HOLOCENE)—Includes beach, dune, and coastal-swamp deposits. Composed chiefly of fine- to medium-grained clasts of volcanic rocks, limestone, and shell. Dark-gray to black mud and sand in mangrove swamps. Thickness 0–10 m

Ql — LANDSLIDE DEPOSITS (HOLOCENE)—Angular blocks of the Ponce Limestone

Qa — ALLUVIUM (HOLOCENE)—Sandy clay, pebbles, and cobbles derived chiefly from volcanic rocks. Thickness 0–30 m. Caliche (not separated on the map) overlies most Tertiary limestone and calcareous clay, and consists of banded white to light-brown chalk that contains scattered pieces of the underlying limestone; upper part commonly indurated to a soft limestone. Thickness 1–4 m

Tp — PONCE LIMESTONE (MIOCENE)—White to dark-yellowish-orange biomicrite in which voids are lined with sparry calcite, and containing, in the lower part, abundant internal molds of mollusks and solitary corals; also shells of the echinoid *Cylpeaster cubensis* oysters, and tests of Foraminifera such as *Marginopora* and *Gypsina*; locally contains scattered grains of quartz; near coast contains as much as 7 percent Mg. About 200 m thick

JUANA DÍAZ FORMATION (MIOCENE AND OLIGOCENE)

Tjc — Chalk member (Miocene)—Chalky white to very pale orange chalky limestone, locally clayey; present only in the eastern part of the Yauco quadrangle; contains *Marginoporus* sp. and other fossils of Miocene age. About 50 m thick

Tjl — Limestone member (Oligocene)—Grayish orange to very pale orange thin- to thick-bedded biosparite limestone, commonly contains *Lepidocyclina undosa* and other fossils of Oligocene age. In the eastern part of the Yauco quadrangle, it is a thick-bedded to massive reef biosparite limestone of recrystallized reef materials containing abundant large corals and algal plates. To the west, this member becomes a biomicrite that is locally arenaceous and argillaceous. Thickness about 350 m in the valley of the Río Macaña, but thins to 80 m or less west of the Central San Francisco in the Punta Verraco quadrangle

Tjd — Madatone and basal conglomerate member (Oligocene)—Lenticular deposits of sand and gravel and gray- to grayish-orange mudstone and sandstone. The latter are poorly consolidated and commonly contain beds composed chiefly of *Lepidocyclina undosa*. Gravel and mudstone in the Punta Verraco quadrangle locally contain abundant to sparse cobbles and pebbles of serpentinite. Thickness about 130 m in the valley of the Río Macaña, but thins to about 50 m west of Central San Francisco in the Punta Verraco quadrangle

TKqdg — QUARTZ DIORITE-GRANODIORITE (EOCENE TO MAESTRICHTIAN?)—Light- to pale-greenish-gray, light-yellow-brown weathering, biotite-augite-hornblende quartz diorite-granodiorite. Conspicuous sparse to locally abundant golden-brown to pale-reddish-brown anhedral biotite with sparse magnetite and apatite inclusions; sparse deeply corroded and embayed augite generally riddled with inclusions of plagioclase, magnetite, biotite, and apatite; and sparse corroded pale-green hornblende in an abundant subhedral to anhedral mass of plagioclase (oligoclase-sodic andesine) with interstitial anhedral and untwinned albite, sanidine, and well-crystallized magnetite. The texture of the rock is fine-grained granitic. Although minerals of the intrusive body are neither widely nor intensively chloritized or replaced by calcite, plagioclase is generally clouded and partly sericitized. The plagioclase-sanidine ratio may exceed 9:1 in all but the most coarse phases of the intrusive rocks. The major part of the intrusive rock is therefore quartz diorite, granodiorite is subordinate

TKhd — PORPHYRITIC HORNBLENDE DACITE (EOCENE? TO MAESTRICHTIAN)—Light- to medium-grayish-green or rarely pale-bluish-green where least altered, pale-gray to pale-yellow, medium-pinkish-gray or dark-reddish-brown where saprolitized, porphyritic hornblende-plagioclase dacite. Generally sparse but locally common to abundant, small (<4 cm long), tabular, pale-brown to pale-green plagioclase (sodic andesine) and rarely pale-brown biotite phenocrysts in a groundmass that ranges from hyalopilitic-pilotaxitic to felsophyric. The finer grained groundmass consists of abundant plagioclase and sparse hornblende microlites and sparse granules of magnetite suspended in a sparse pale-brown glass matrix. The coarse crystalline groundmass, chiefly that in the Cerro de las Avispas, consists of anhedral twinned and nontwinned oligoclase-albite, sanidine, and quartz, accessory apatite and rare well crystallized to rounded and corroded quartz phenocrysts. Hornblende is commonly replaced by chlorite (penninite) and calcite. Both the least altered hornblende and pseudomorphs of calcite-chlorite after hornblende are bordered by fine-crystalline magnetite. Pseudomorphs of limonite after hornblende are retained in the sapprolitized rock; they are the most convenient means of identifying the rock in the field. Plagioclase phenocrysts commonly are partly replaced by both chlorite and calcite, and rarely by pistacite. All groundmass minerals except magnetite are widely replaced by both chlorite and calcite. Chilled, apparently marginal facies of the dacite are locally brecciated. Clasts and the enclosing matrix in these breccias are petrographically similar, both contain hornblende-plagioclase phenocrysts in a pilotaxitic-hyalopilitic groundmass. They differ only in the greater degree of fluidal flow structure in the groundmass microlites of the matrix enclosing the clasts, and in the greater quantity of accessory magnetite in the groundmass of the clasts. Locally, the dacite is pyritized and has largely undergone argillization

TKpah — HORNBLENDE ANDESITE-DIORITE (EOCENE? TO MAESTRICHTIAN)—Medium-gray-green, light-brown weathering porphyritic hornblende-augite-plagioclase andesite near intrusive contacts, ranging to hornblende-augite diorite away from contacts. Common to abundant dark-brown to black euhedral (2–5 cm long) hornblende phenocrysts with prominent selvedge structure suspended together with sericitized plagioclase (andesine?) phenocrysts in an abundant glassy matrix crowded with plagioclase and sparse hornblende microlites. Away from intrusive contacts the same mafic phenocrysts are suspended in a microgranitic groundmass of subhedral plagioclase. Sparse amygdules near contacts are filled with chlorite-pistacite

Kpb — TWO-PYROXENE OLIVINE BASALT (UPPER MAESTRICHTIAN THROUGH CAMPANIAN?)—Very dark-gray to black, dark-purple-gray weathering porphyritic augite-hypersthene-olivine basalt. Abundant unaltered and large (.5–.8 cm long) augite phenocrysts characteristically with pronounced compositional color zoning and twinning, common and smaller plagioclase (labradorite), sparse pertitic orthoclase(?) to unaltered and distinctly pleochroic hypersthene, and rare iddingsite pseudomorphs after olivine held in a hyalopilitic to pilotaxitic groundmass of abundant plagioclase microlites and sparse to common granular to well crystallized magnetite in a cryptolesic and apparently chloritized matrix, probably once glass. Pseudomorphs after olivine because of their rarity in these rocks are not present in every thin section examined from a particular intrusive body. They are, however, present in all bodies mapped

Ka — SERPENTINITE (MAESTRICHTIAN)—Serpentinite, believed to have been emplaced tectonically in the Maestrichtian, is lithologically like that of the pre-Tithonian serpentinite(s), and is described here with that unit, light-green, light-bluish-green, and dark-green where least weathered, dark-greenish-brown or yellowish-brown where weathered, commonly closely sheared, contains irregularly shaped but generally rounded knobs of less sheared serpentinite that include common to sparse basite pseudomorphs after orthopyroxene. Magnetite-chromite-spinel of undetermined composition is the only accessory. The bulk of the rock consists of chrysotile and serphophite. Evidence in this section of a former clinopyroxene is invariably absent

Kat — AUGITE TRACHYBASALT (UPPER MAESTRICHTIAN THROUGH CAMPANIAN)—Dark-green or dark-bluish-green, light-brown weathering, abundantly porphyritic augite trachybasalt. Characteristically contains abundant and conspicuous large (1–3 cm long) deep-green augite and rare to sparse small (<.5 cm) tabular and generally dark inconspicuous appearing plagioclase (labradorite-andesine) phenocrysts held in a felted trachytic groundmass composed of abundant microphenocrysts and microlites of plagioclase and some augite in a sparse to common chloritized glass. Granular magnetite in the ground mass is an abundant accessory. Intrusive contacts are chilled and show fewer plagioclase phenocrysts than rock away from contacts. Chilled contacts, smaller stocks, and some widespread areas of the intrusive rocks are widely brecciated. Three generations of brecciation are locally evident in the field. Clasts are mineralogically and texturally alike; they differ only in the degree of crystallization, crystal size, amount of magnetite, and, consequently, color. Locally, contact zones are vesicular and amygdaloidal (calcite and chlorite) and adjacent country rock (chiefly the calcareous siltstone-claystone of the Yauco Formation) is depleted in calcite. Augite is generally fresh, but groundmass glass is invariably chloritized. Areas of alteration show a progressive replacement of groundmass, plagioclase phenocrysts, and augite by chlorite, calcite, and rarely by pistacite. Plagioclase phenocrysts are commonly partly sausseritized. Typically only stubby pseudomorphs of limonite after augite and clay-calcite after plagioclase remain visible in saprolitized augite trachybasalt

Kpa — PLAGIOCLASE-AUGITE ANDESITE (UPPER MAESTRICHTIAN THROUGH CAMPANIAN)—Dark-gray or bluish-gray, dark-red, or dark-brownish-red weathering abundantly porphyritic plagioclase-augite andesite. Composed of abundant plagioclase (labradorite-andesine) and conspicuous sparse to common augite phenocrysts (.5–1 cm long) held in a generally sparse groundmass of smaller plagioclase phenocrysts and microlites and abundant and well crystallized magnetite in a generally chloritized glass matrix. Plagioclase phenocrysts are partly replaced by chlorite and calcite, but the augite is typically unaltered. Locally, augite is replaced by chlorite and pistacite

Kpol — TWO-PYROXENE OLIVINE BASALT LAVA FLOWS (UPPER MAESTRICHTIAN THROUGH CAMPANIAN)—Very dark-gray to black, hematite-red weathering, abundantly vesicular and amygdaloidal porphyritic augite-plagioclase-hypersthene-olivine basalt. Abundant unaltered and large (.5–.8 cm long) augite, common to sparse generally pale-brown sericitized plagioclase (labradorite?), sparse to rare small partly chloritized pleochroic hypersthene, and iddingsite pseudomorphs after olivine phenocrysts are held in a glassy matrix crowded with microphenocrysts and microlites of plagioclase and abundant granules of magnetite. Vesicles are commonly filled with calcite. Flow tops in outcrop have a clinkery or blocky form typical of aa flows. Pillow structures are absent. Texture in thin sections ranges from sub-trachytic to pilotaxitic. Interbeds of volcaniclastic breccia are dark-red-brown, dark purple, and dark red; characteristic of the Pastillo Member of the Lago Garzas Formation (Kgp). Lava flows of the two-pyroxene olivine basalt are mineralogically identical to rock mapped as the two-pyroxene olivine basalt stocks in the Yauco quadrangle

Kgm — LAGO GARZAS FORMATION AND MARICAO BASALT, INTERBEDDED (UPPER MAESTRICHTIAN THROUGH CAMPANIAN)—Volcaniclastic rocks, dark-green, yellow-brown weathering, massive to very thick-bedded porphyritic augite trachybasalt breccia typical of the Maricao Basalt, containing abundant and characteristic coarse (1–3 cm long) augite and smaller (.5–.7 cm long) sparse to common plagioclase (labradorite-andesine) phenocrysts. Interbedded with dark-red-brown, dark-red, purple, and dark- to medium-green andesitic volcaniclastic breccia characteristic of the Pastillo Member of the Lago Garzas Formation (Kgp) and with dark- to light-green hornblende-augite-bearing volcaniclastic breccia, probably tuffaceous sandstone, and rare siltstone characteristic of the Santas Paculas Member (not mapped separately in report areas) of the Lago Garzas

Kgml — Limestone—Irregularly interbedded throughout the Maricao-Lago Garzas sequence noted above are laterally limited thin (<5 m) internally massive and non-graded lenses of pale gray-brown to light-brown, pale-gray weathering calcarenite. Most are biosparite and composed of generally angular fragments of rudists, other pelecypods, calcareous algae plates, and large foraminifers in a generally sparry matrix. Angular volcanic lithic and crystal clasts range from abundant to sparse in the thinner lenses. Exceptionally they are so plentiful as to form a calcareous volcanic breccia. Thicker lenses such as that 2 km north of Guayanilla contain only a coarse and angular volcaniclastic basal breccia

Kgv — LAGO GARZAS FORMATION (UPPER MAESTRICHTIAN THROUGH CAMPANIAN)—Pastillo Member, generally massive to thick-bedded volcaniclastic breccia and lava with subordinate interbedded sandstone, conglomerate, and limestone. Breccia composed predominantly of dark-red, dark-red-brown, purple, and subordinate gray and gray-green angular clasts (3–6 cm on a side) of porphyritic plagioclase augite-andesite held in a sandstone matrix of the same lithic types. Relatively abundant lava is dark red-brown and consists of common small (<.5 cm long) augite and abundant small (.5–.7 cm long) plagioclase phenocrysts in an abundant fine-crystalline dense to abundantly vesicular groundmass. Includes thin and impersistent dark-red-brown to dark-brownish-green sandstone and conglomerate with dark-red-brown lithic clasts like those described above. Rare beds of pale-yellowish-gray-brown siltstone of the Yauco Formation are interbedded with the finer-grained sedimentary rocks

Kgs — LAGO GARZAS AND YAUCO FORMATIONS, INTERBEDDED (UPPER MAESTRICHTIAN THROUGH CAMPANIAN)—Characteristic light-yellow-brown weathering, thin-bedded calcareous siltstone and claystone of the Yauco Formation irregularly interbedded with coarse-grained, augite-bearing sandstone, tuffaceous sandstone of the Pastillo Member of the Lago Garzas Formation (Kgp)

Km — MARICAO BASALT (UPPER MAESTRICHTIAN THROUGH CAMPANIAN)—Chiefly thick-bedded (1 m–±1 to massive volcaniclastic breccia composed of dark-green, dark-brownish-green, and subordinate dark- to light-gray and dark-red angular to well rounded clasts (predominantly 3–15 cm on a side, rarely to 3 m on a side) of generally dense porphyritic augite trachybasalt held in a clay-sandstone or in a coarse sandstone-conglomerate or lithic-crystal tuff matrix. Breccia clasts are composed of conspicuous, abundant, and large (1–3 cm long) augite and smaller (.2–.5 cm long) plagioclase (labradorite-andesine) phenocrysts in a trachytic groundmass composed of abundant microphenocrysts and microlites of plagioclase and augite in a sparse chloritized glass. Typically, the groundmass is dark colored because of abundant granules of magnetite. Breccia ranges from fresh to deeply weathered and mostly replaced by clay, calcite, and chlorite. Outcrops in the central and southern part of the Yauco quadrangle show breccia interbedded with massive dark-green and dark-brownish-green sandstone and subordinate siltstone. These are composed of rounded to angular lithic and mineral (chiefly augite and plagioclase) clasts and generally unweathered clasts. These rocks are tuffaceous sandstone-siltstone or more probably tuffs. Weathered surfaces of the breccia clasts are studded with conspicuous limonite coated augite phenocrysts weathered into positive relief. Widespread areas of the Maricao are deeply saprolitized; these show little or no breccia texture, but large limonite pseudomorphs after augite are commonly present and diagnostic. Laterally restricted lenses of pale-pink or light-brownish-gray biosparite are composed of angular to rounded fragments of rudists, other pelecypods, plates of calcareous algae, and large foraminifers in a generally sparry matrix. A thick sequence of such calcarenite and interbedded volcaniclastic breccia comprises the summit of Cerro Rodadero. The Maricao locally includes 7–10 m thick fine crystalline sparsely vesicular nonpillowed basalt flows. These lack the coarse augite phenocrysts characteristic of the Maricao Basalt. Volcaniclastic breccia in the stratigraphically upper part of the Maricao includes sparse clasts of angular to subrounded hornblende dacite

Kmy — MARICAO BASALT AND YAUCO FORMATION, INTERBEDDED (UPPER MAESTRICHTIAN THROUGH CAMPANIAN)—Typical light- to medium-yellowish-gray-brown weathering thin- to medium-bedded calcareous fine- to coarse-grained sandstone, some siltstone, and rare claystone of the Yauco lithofacies is irregularly interbedded with dark-green fine- to coarse-grained generally thick-bedded sandstone, conglomerate, breccia, and locally lava of the Maricao. Characteristically, lithic clasts in the Maricao volcaniclastic breccia contain abundant coarse augite phenocrysts that weather into positive relief. Some tuffaceous beds of the Maricao contain abundant angular unweathered augite and plagioclase crystal clasts. Commonly the sandstone facies of the Maricao contains both weathered and unweathered lithic and mineral grains. Breccia clasts and the enclosing sandstone matrix of the Maricao in the northern part of the Yauco quadrangle contain sparse hornblende as phenocrysts or crystal clasts. Basaltic lava flows interbedded with the Maricao-Yauco in the fault block north of Cerro El Alto contain only sparse small (.4–.7 cm long) augite and smaller plagioclase phenocrysts

Ky — YAUCO FORMATION (UPPER MAESTRICHTIAN THROUGH CAMPANIAN)—Dark-gray-brown to dark-bluish-gray where least weathered, light- to medium-yellowish gray-brown where weathered, irregularly interbedded calcareous siltstone and claystone, subordinate sandstone and mudstone, and minor limestone. Siltstone and claystone, the predominant facies, are commonly laminated to thin-bedded (.3–10 cm), less commonly medium- to thick-bedded (10–75 cm, rarely 100+ cm). In a siltstone-sandstone sequence, the sandstone beds are generally thicker. Siltstone, mudstone, and sandstone consist chiefly of angular to well rounded generally well sorted weathered or altered volcanic lithic and mineral clasts and sparse to rare unweathered angular lithic and mineral clasts. Uncommonly they contain abundant unaltered angular volcanic clasts; these rocks are tuffaceous. In the northwest corner of the Yauco quadrangle, the Yauco Formation consists of a very fine-grained ancillitized tuff. Small scale ripple bedding and flaser bedding are common in the siltstone-claystone facies in the eastern and west-central parts of the Yauco quadrangle and uncommon to rare in Yauco outcrops in the northwestern part of the quadrangle. Graded bedding in thick sandstone beds becomes increasingly common toward the northwest corner of the quadrangle. Limestone in the Yauco consists chiefly of lenses of well sorted, coarse-grained biosparite uncommonly ranging to biomicrite, and generally composed of angular fragments of rudists, other pelecypods, rounded to angular fragments of calcareous algae, and abundant large foraminifers in a clear calcite matrix, or less commonly in a tuffaceous matrix. Interbeds of sandstone and rarely breccia of the Lago Garzas Formation and Maricao Basalt are separated where possible, or are indicated where conspicuous in the field, but too thin or impersistent to map separately

Ksl — LIMESTONE OF SANTO DOMINGO (UPPER MAESTRICHTIAN THROUGH CAMPANIAN)—Massive very fine crystalline dark-gray argillaceous limestone

Kpal — PARGUERA LIMESTONE [1](UPPER MAESTRICHTIAN THROUGH CAMPANIAN)—Pale-yellow-brown to pale-pinkish-gray coarse sand-size, generally well sorted biosparite composed of 85 percent or more of angular fragments of reworked rudists and other pelecypods, angular to rounded fragments of calcareous algae and intraclasts, and abundant specimens of large foraminifers, all held in a sparse generally clear calcite cement. Contains, south of Paloma in the southwest corner of the Yauco quadrangle, sparse discrete, generally flattened dark-red clayey volcanic lithic clasts that lie in a single plane and define bedding in an otherwise massive-appearing nongraded rock. The pinkish color of the rock is produced by thin "veinlets" of red or yellow ocher or by a sprinkling of the same throughout the rock. About 500 m thick near Palomas. Mapped by Slodowski (1958, pl. 1) as the andesite member of the "Ensenada Formation"

Kmqv — SEQUENCE OF MEDIA QUIJADA (MAESTRICHTIAN? AND CAMPANIAN?)—Volcanic breccia, lava, and limestone, predominantly dark-red, purple, or medium-pinkish-gray volcaniclastic breccia composed of angular porphyritic hornblende-andesite and minor hornblende-augite-andesite breccia and lava. Breccia clasts are held in an abundant unsorted and coarse-grained volcanic sandstone matrix of lithic and mineral clasts like those noted above. Irregular vesicles and amygdules of calcite are common both in breccia clasts and lava flows. Both clasts and lava flows show trachytic texture in thin sections and less commonly in the hand specimen. The fault block including the La Covana area includes minor dark-red abundantly amygdular porphyritic hornblende-augite-plagioclase andesite lava. At the top of the exposed sequence in the eastern part of the La Covana block, volcaniclastic breccia is interlayered with 2–6 cm-thick light-yellowish-brown arenaceous limestone and pale-gray calcarenite. Augite in breccia clasts and lava flows is resistant to alteration and weathering, whereas hornblende is indicated only by outlines of magnetite or pseudomorphs of chlorite, calcite, and quartz bounded by magnetite. Uncommonly hornblende is preserved as very dark-brown strongly pleochroic acicular phenocrysts. Plagioclase (andesine) phenocrysts are abundant to sparse and commonly partly replaced by chlorite and calcite. The groundmass consists chiefly of microphenocrysts and microlites of plagioclase and magnetite granules. Mapped by Slodowski (1958, pl. 1) as the andesite member of the "Ensenada Formation"

Kpl — AUGITE ANDESITE LAVA FLOWS (UPPER CRETACEOUS?)—Dark-purplish-brown or dark-reddish-brown, massive, amygdaloidal lava flows, weathers light-yellowish-brown. Composed of common dark-green pigeonitic augite phenocrysts and abundant pseudomorphs of an unidentified andite after plagioclase held in an abundant dark-red or dark-brown, sparsely microlitic, pilotaxitic to hyalopilitic glass matrix. Irregularly shaped calcite amygdules are common. Pigeonitic augite is unaltered and free of inclusions. Outcrops are massive, non-sheared, and show no metamorphism. Outcrops are highly restricted and fossils are not known from the unit

KJm — MARIQUITA CHERT [2](UPPER TITHONIAN THROUGH HAUTERIVIAN)—Generally dark-gray to black, pale-gray, and rarely dark-greenish-gray, massive chert, interbedded locally near the base of the sequence with pale-gray, laminated to medium-bedded (.5–6 cm) tuffaceous siltstone or tuff and angular moderately to poorly sorted volcaniclastic lithic sandstone, both largely replaced by silica. At the base of the sequence east of Media Quijada, medium- to thick-bedded pale-green to dark-yellowish-brown siltstone, sandstone, and conglomerate composed of detrital serpentinite are interbedded with thin-bedded to laminated chert and volcaniclastic siltstone-sandstone. Serpentinitic conglomerate-siltstone beds show sharp non-sheared contacts with adjacent chert beds, and none are graded or show internal shearing. Chert throughout the sequence is commonly very closely fractured and the resulting angular clasts are cemented with fine crystalline quartz or more commonly with chert. South of Media Quijada, serpentinite is overlain directly by massive chert with no intervening detrital serpentinitic rocks or demonstrable volcaniclastic rocks

s — SERPENTINITE (PRE-TITHONIAN)—See description under Maestrichtian serpentinite (Ka)

a — AMPHIBOLITE (PRE-TITHONIAN)—Dark-gray, nonfoliated amphibolite composed of about 45 percent anhedral and rarely subhedral xenoblastic and poikiloblastic dark-reddish-brown pleochroic hornblende, about 8–10 percent light-green non-pleochroic anhedral and apparently relict pigeonite, and about 45 percent generally prehydrated non-twinned plagioclase, and sparse to rare clear anhedral with prominent albite twinning. Lineation of hornblende and, to a lesser extent, pyroxene, is moderately developed in the hand specimen and in thin section. Hornblende and pigeonite occur as discrete, poorly formed crystals with well developed cleavage. Pigeonite is generally free of inclusions, but the hornblende ranges from that which is inclusion free to that riddled with inclusions of accessory magnetite-ilmenite, apatite, and very rare sphene, as well as the more common small rounded grains of pigeonite. Quartz is absent. Contacts of the amphibolite and serpentinite in the largest block of amphibolite southeast of Media Quijada are finely brecciated and closely veined with calcite. Clasts of the amphibolite in this brecciated zone show no evidence of contact metamorphism or calcite metasomatism

[1]Parguera Limestone of Mattson (1960) herein adopted for U.S. Geological Survey usage.

[2]Mariquita Chert of Mattson (1973) herein adopted for U.S. Geological Survey usage.

Note: Commonly used geologic symbols are printed on the map jacket; a separately printed list is available on request from the U.S. Geological Survey.

Contact—Long dashed where approximately located; short dashed where inferred, dotted where concealed

Fault—Long dashed where approximately located; short dashed where inferred, dotted where concealed. Bar and ball on downthrown side; wrench faults and relative direction of movement shown by arrows, fault trace quartied where doubtful

Folds showing crestline or troughline and direction of plunge or plunge where known, long dashed where approximately located; short dashed where inferred, dotted where concealed

Anticline

Syncline

Bearing and plunge of minor fold axes

Anticline

Syncline

Shear zone

Strike and dip of beds—Top of beds determined from crossbedding or graded bedding are shown by ball where known

Inclined

Overturned

Conspicuous beds of the Pastillo Member of the Lago Garzas Formation in the Yauco Formation (in plan view only)

Cu — Secondary copper minerals along fault plane

INTRODUCTION

Rocks of the Late Cretaceous and possibly also of early Tertiary age, chiefly volcaniclastic-epiclastic rocks of the Maricao Basalt (Mattson, 1960, p. 337), the Yauco Formation (Mitchell, 1922, p. 249; Hubbard, 1923, p. 29; Mattson, 1960, p. 331; Krushensky and Monroe, in press), the Parguera Limestone (Mattson, 1960, p. 333; Almy, 1965, p. 11, 57) the Lago Garzas Formation (Mattson, 1968; Krushensky and Monroe, in press), flows of two-pyroxene olivine basalt, serpentinite, and stocks of basalt, andesite, dacite, quartz diorite, granodiorite crop out over the northern two thirds and very locally elsewhere in the Yauco quadrangle. Overlying this older and more deformed sequence, with an angular unconformity, are rocks of Tertiary age, chiefly limestone and epiclastic rocks of the Juana Díaz Formation and Ponce Limestone. These rocks crop out chiefly in the southern third of the Yauco quadrangle and over most of the land part of the Punta Verraco quadrangle. Pre-Upper Jurassic amphibolite and serpentinite, the Mariquita Chert, (Upper Jurassic and Lower Cretaceous), and Cretaceous limestone, and volcaniclastic and extrusive rocks crop out only in highly restricted areas of the Punta Verraco quadrangle. Sedimentary, and intrusive rocks of the mapped area are folded, and offset by two sets of high-angle normal faults: a prominent northwest trending set, and a subordinate north- and northeast-trending set.

Pre-Cretaceous and Cretaceous rocks in the mapped area are, from the oldest to youngest: amphibolite, serpentinite, Mariquita Chert, Yauco Formation, Parguera Limestone, limestone of Santo Domingo, Maricao Basalt, Lago Garzas Formation, unnamed two-pyroxene olivine basalt flows, serpentinite, and six types of intrusive rocks.

PRE-UPPER JURASSIC UNITS

AMPHIBOLITE

Amphibolite in the Yauco and Punta Verraco quadrangles is present only south of Media Quijada where it occurs as discrete blocks suspended in sheared serpentinite. This amphibolite, like that near Las Palmas (Tobisch, 1968, p. 565), contains plagioclase of two apparently different compositions. One, the predominant phase, is thoroughly altered to prehnite. The older phase, rarely present, consists of clear andesite with prominent albite twinning. Although Tobisch (1968, p. 565) suggested that tremolite/actinolite in the amphibolite near Las Palmas indicated contact metamorphism of the amphibolite by intruding serpentinite, tremolite/actinolite, and accompanying chlorite, and epidote are commonly considered indicative of retrograde metamorphism. Secondary tremolite/actinolite is not present in the amphibolite in the Media Quijada area. The amphibolite from this area is also unlike that reported by Mattson (1960, p. 324) at the easternmost end of the Peñones de Melones (near route 301) in that it contains brown rather than green xenoblastic hornblende. It is similarly unlike the amphibolite near Las Palmas (Renz and Vernyck, 1962, p. 319; Tobisch, 1968, p. 564-565), and in addition contains no quartz and about 10 percent relict clinopyroxene. Amphibolite in the Media Quijada area shows no compositional layering or foliation like that in the Las Palmas area (Tobisch, 1968, p. 560, 562).

Amphibolite blocks within serpentinite in southern and western Puerto Rico have been described (Renz and Vernyck, 1962, p. 319) as regionally metamorphosed carbonate-bearing sedimentary rocks or volcanic rocks, or as regionally metamorphosed ultrabasic rocks (Mattson, 1960, p. 326; 1973, p. 21–22) derived from oceanic crust. The amphibolite blocks in some or all areas in southwestern and western Puerto Rico could also have been derived from metamorphism of basaltic rocks that had intruded serpentinite/peridotite and subsequently had been disrupted or in part had undergone plastic flowage or extension during metamorphism. Reconnaissance geologic study by R. D. Krushensky and A. F. Curet (U.S. Geol. Survey, unpub. data) of a splitte, though by Mattson (1960, p. 324) to be possible parent of amphibolite elsewhere in western Puerto Rico (Mattson, 1960, p. 324, pl. 1) indicates that the original pre-spilitized rock here shows a chilled contact with the enclosing serpentinite. This chilled contact indicates that the original basaltic rock intruded the serpentinite/peridotite.

Hirsch and Ohle (1976, p. 55) suggest that, with the exception of certain relict textures, individual criteria, for example, local association with and even intermingling with obvious metasedimentary rocks, layering of mineralogically distinct units, major element abundances, petrographic character, and to some extent, trace-element chemistry, are equivocal; and that use of these criteria may lead to proposing conclusions regarding parentage of particular amphibolites. Variation in major element abundances, metamorphic fabric, and layering noted between the Las Palmas, Peñones de Melones, and Media Quijada areas favor neither one nor another mode of origin of the parent rock of the amphibolite in those areas. Recent work of Cann (1970, p. 7–11), Pearce and Cann (1973, p. 290–300), Winchester and Floyd (1976, p. 459–469), Floyd and Winchester (1975, p. 211–218), and Smith and Smith (1976, p. 114–120) suggests persistence of Ti, P, Zr, Y, and Nb during alteration and metamorphism—at least to low grades—in basalt and andesite. Cann (1970, p. 11) notes that "the definition. . . of a very restricted composition space which is strongly resistant to secondary changes, in terms of Ti, Zr, and Y, might allow recognition of original ocean-floor basalts even when they have become highly altered." The significance of trace element abundances in amphibolite and spilite in western Puerto Rico and constraints imposed in the determination of the tectonic setting of these rocks is under study, but they will not be discussed further here as such a discussion would exceed the scope of this text.

SERPENTINITE

Serpentinite crops out in the western part of the town of Yauco, south of Media Quijada, in a small area within the two-pyroxene basalt stock near the western border of the quadrangle, and in an inlier on the same quadrangle border. Although the serpentinite on the western border of the town of Yauco and serpentinite elsewhere in the mapped area are believed to have been emplaced at different times, the rocks (Ks and a) are described as one lithic type. They may be related genetically.

Stratigraphic relationships and relative age of the serpentinite, the two-pyroxene olivine basalt stock, and the Yauco Formation in the western part of the town of Yauco are obscured because of forming and urbanization of the area. Serpentinite in that area is in a convoluted contact with the Yauco and the basaltic stock that intrudes the Yauco. A small area (unmapped) of coarsely crystalline dark-gray marble and a patchy and apparently thin deposit of clastic serpentinite mixed with various volcanic rocks lies within the outcrop area of the serpentinite in the southwest part of the town of Yauco. Neither the serpentinite nor the basaltic stock metamorphoses or recrystallizes the calcite cement of the adjacent Yauco Formation, nor does the basaltic stock metamorphose the serpentinite. Metamorphism of the dark-gray marble by the basaltic stock is therefore unlikely. The marble is probably a xenolith brought in and emplaced by and at the same time as the serpentinite. The clastic serpentinite may be analogous to clastic serpentinite reported by McIntyre (1976) on serpentinite in the Maricao quadrangle, it may be a pre-Yauco detrital deposit, or it may be part of the basal conglomeratic facies of the Juana Díaz Formation—a unit that crops out extensively in the surrounding area. A lithologically similar conglomerate crops out at the base of the Juana Díaz over serpentinite and the Mariquita Chert south of Media Quijada.

Two lines of evidence, although not completely convincing, suggest that the serpentinite in the western part of the town of Yauco is a protrusive rock (Lockwood, 1971a, p. 920), that is, a tectonic or "cold" intrusive rock. The geometry of the contact of the serpentinite with the basaltic stock and the Yauco Formation is curved and recurved far beyond the limits ordinarily set for a fault. In addition, the Yauco adjacent to the serpentinite on the east dips into the Yauco-serpentinite contact, a structurally improbable relationship if the Yauco were to stratigraphically overlie and onlap the serpentinite.

MARIQUITA CHERT

Serpentinite south of Media Quijada is largely overlain by or in fault contact with the conglomeratic or limestone members of the Juana Díaz. Significantly it is also locally overlain by a chert-dentral serpentinite sequence here correlated with the Mariquita Chert (Mattson, 1973, p. 23). Unlike the Mariquita of the type area, the chert at Media Quijada includes a thin to medium-bedded basal conglomerate-sandstone composed of well-rounded to subangular, moderately sorted serpentinite cobbles, pebbles, and sand-size clasts in a clayey calcite cement. Individual beds are not graded, the clastic texture is well preserved, and the coarse clastic facies of the rock show no evidence of shearing. Interbedded chert is, however, finely fractured and recemented with chert or fine-crystalline quartz. Shearing stresses apparently were taken up in the coarse clastic facies whereas the brittle chert fractured. In most areas the original texture of the chert and bedding appear to have been obscured or destroyed during silicification. Locally textures and bedding are preserved, and the chert is seen to have consisted of well-sorted, thin-bedded to laminated volcaniclastic sandstone or tuff. Contacts of the chert and the serpentinitic-conglomerate and sandstone are sharp and apparently were controlled by original interbedding of the dental serpentinite and volcaniclastic rocks. The character of the serpentinitic conglomerate-sandstone sequence suggests that it was deposited in shallow water, almost in the place of origin, as a transgressive basal conglomerate, not as either direct tectonic extrusion on the sea floor (Bailey and others, 1964) or as gravity glide or turbidity-current deposits (Lockwood, 1971a, p. 931; 1971b, p. 72).

Chert in the Media Quijada area is lithologically identical to that in the type area in the Sierra Bermeja (Mattson, 1973, p. 23). Although Mattson and Pessagno (1974, p. 859) described the Maiquita as an allochthon of regional extent, R. P. Volckmann (U.S. Geol. Survey, unpub. data) believes that a number of lines of evidence indicate that the Mariquita in the type area is autochthonous. The Mariquita south of Media Quijada, about 27 km east of the type area, is clearly authochthonous and in its original stratigraphic position above the serpentinite and amphibolite. The Mariquita Chert in the type area (Mattson and Pessagno, 1974, p. 859) contains radiolarian faunas of late Tithonian Age to Hauterivian Age. Presuming adequacy of correlation of the Media Quijada sequence and the Mariquita Chert, the chert at Media Quijada un