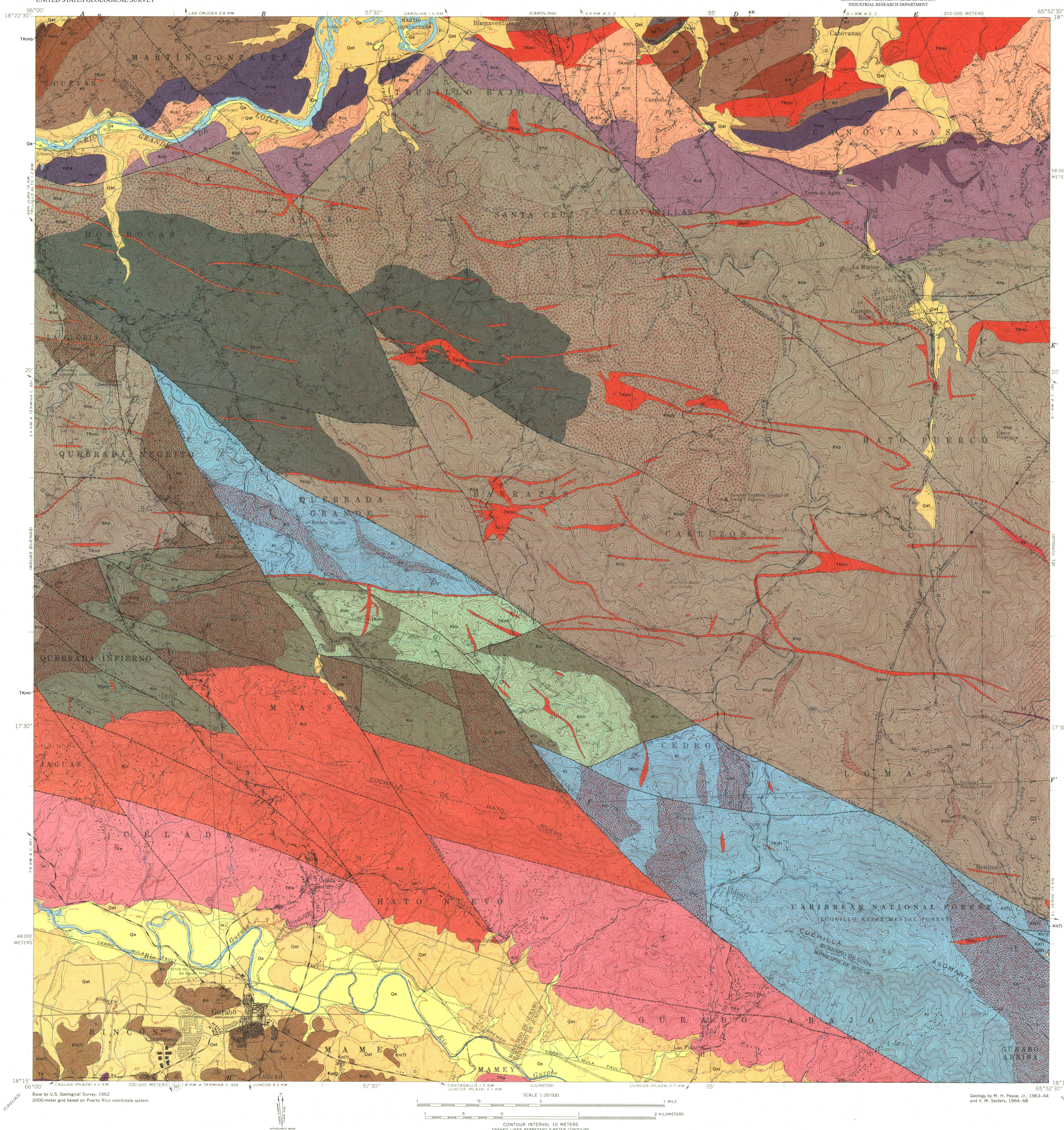
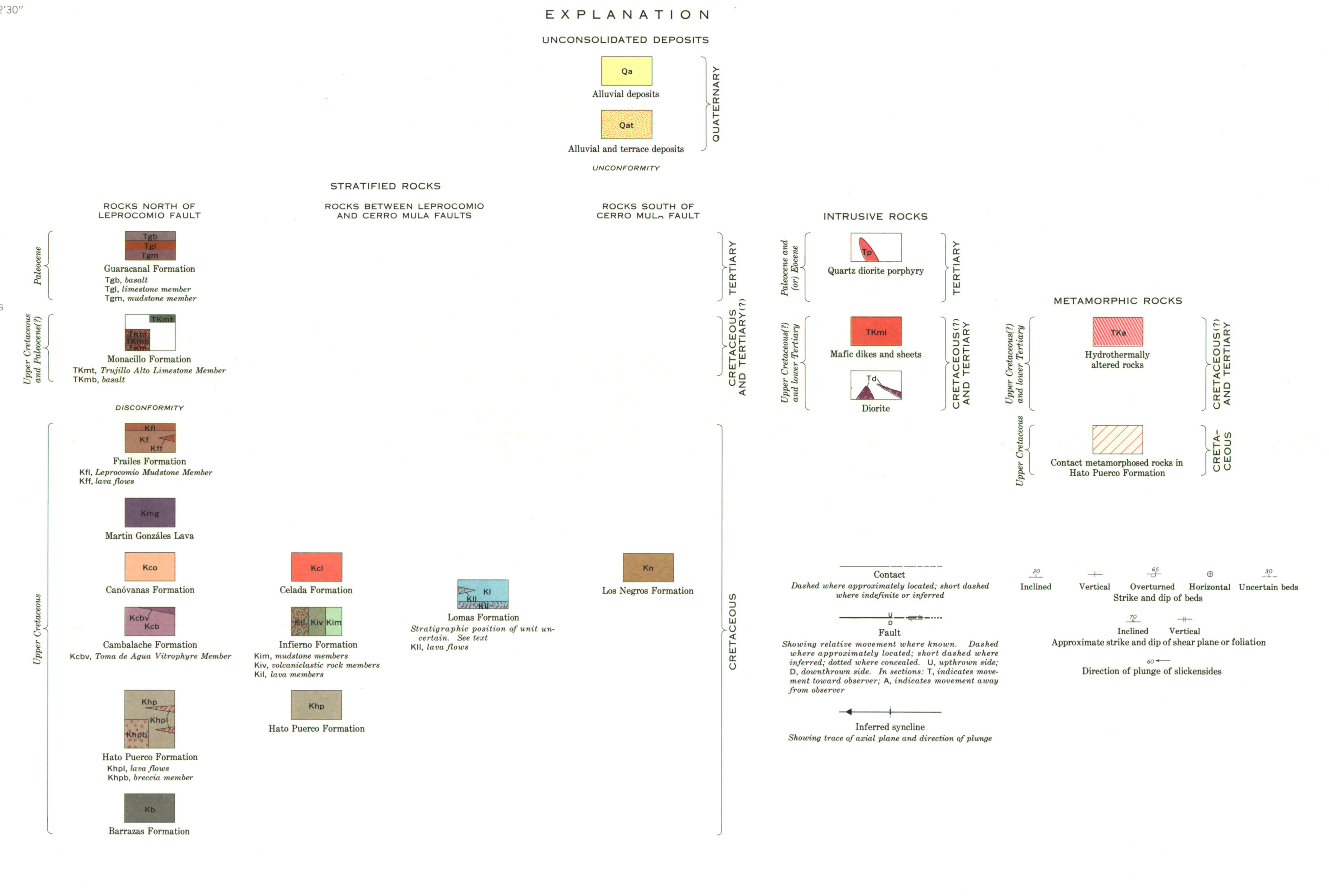
PREPARED IN COOPERATION WITH
THE COMMONWEALTH OF PUERTO RICO
ECONOMIC DEVELOPMENT ADMINISTRATION
INDUSTRIAL RESEARCH DEPARTMENT





DESCRIPTION OF MAP UNITS

UNCONSOLIDATED DEPOSITS

Qa ALLUVIUM, sand, gravel, silt, and clay in flood plains along major streams.

Qat ALLUVIAL AND TERRACE DEPOSITS, sand, gravel, silt, and clay in flood plains along minor streams and in terrace deposits in major valleys.

STRATIFIED ROCKS

GUARACANAL FORMATION

Tgb Basalt, amygdaloidal lava with pilotaxitic groundmass of plagioclase, clinopyroxene, chlorite, iron oxide, and sparse biotite, with sparse phenocrysts of clinopyroxene and hornblende. About 43 m thick.

Tgl Limestone member, medium- to very thick-bedded, medium-light-gray limestone composed of abundant algal fragments, orbitoid Foraminifera, and less abundant volcaniclastic debris. About 75 m thick.

Tgm Mudstone member, thin- to medium-bedded, calcareous and volcanic mudstone. About 50 m thick.

TKm MONACILLO FORMATION, volcanic mudstone and sandstone. About 80 m of lower part of unit is very poorly exposed in northwestern corner of quadrangle.

TKmt Trujillo Alto Limestone Member, very thick bedded, light-gray, fine-grained limestone containing abundant miliolid Foraminifera and less common fragments of corals, algae, and echinoids. About 10 m exposed in north-central part of quadrangle where lower parts of unit are absent or very thin and covered by alluvium.

TKmb Basalt, grayish-green lava with sparse plagioclase phenocrysts and amygdules of laumontite and chlorite. Less than 10 m exposed in northwest corner of quadrangle.

Kf FRAILES FORMATION, marine-deposited, grayish-green, medium- to very thick-bedded, clinopyroxene-bearing andesitic to dacitic volcanic sandstone, in part pebbly, and fine to medium volcanic breccia and breccia-conglomerate. Less abundant dark-gray to grayish-green calcareous and volcanic mudstone. Sparse volcanic quartz crystals and detrital epidote grains occur in many volcaniclastic rocks. About 900 to 1,100 m thick including Leprocomio Mudstone Member.

Kfl Leprocomio Mudstone Member, thin- to thick-bedded, medium-gray, calcareous, foraminiferal mudstone and less abundant grayish-green volcanic mudstone and sandstone. About 220 m thick.

Kff Lava flows, basaltic to andesitic pillow lavas. Present only in northeastern part of area.

Kmg MARTÍN GONZÁLEZ LAVA, grayish-green to dusky-green, locally pillowed, basaltic andesite with abundant large plagioclase phenocrysts. Locally contains sparse phenocrysts of clinopyroxene, orthopyroxene, and phyllosilicates after orthopyroxene. Minor volcaniclastic rock locally interbedded. Ranges in thickness from 0 to about 700 m.

Kco CANÓVANAS FORMATION, marine deposited, medium- to dark-gray, medium- to thick-bedded, basaltic volcanic sandstone relatively rich in clinopyroxene grains. Less abundant medium-dark-gray calcareous mudstone. Sandstone generally calcareous, composed chiefly of angular volcanic rock and mineral grains commonly with less abundant rounded grains and pebbles of the same composition. Rare beds of hornblende andesitic volcanic sandstone locally occur in upper part of unit. Thickness about 100 to 450 m.

Kcl CELADA FORMATION, basaltic pillow lava and volcanic breccia generally rich in clinopyroxene. Includes subordinate volcanic sandstone and mudstone. Rare lavas contain plagioclase as the principal phenocryst. Exposed thickness about 600 m.

Kn LOS NEGROS FORMATION, basaltic volcanic sandstone and breccia relatively rich in clinopyroxene and fragments of scoria. In large part sheared and contact metamorphosed; in part hydrothermally altered. Exposed only near Gurabo. Thickness uncertain.

Kcb CAMBALACHE FORMATION, marine-deposited, pale-green, grayish-blue-green, and grayish-green clinopyroxene-bearing, andesitic volcanic breccia and sandstone with subordinate calcareous and volcanic mudstone. Volcaniclastic rocks are characterized by variable amounts of altered vitric debris, especially long-tube pumice and perlite, are moderately to very poorly sorted, and commonly contain chips and slabs of mudstone. Thickness is about 350 to 450 m including Toma de Agua Vitrophyre Member.

Kcbv Toma de Agua Vitrophyre Member, massive andesitic lava with glomeroporphyritic plagioclase and clinopyroxene. Groundmass is in part black glass but is widely devitrified to grayish-green felsite. Thickness ranges from 0 to about 50 m.

INFIERNO FORMATION, complexly faulted, interfingering marine-deposited mudstone, volcaniclastic rock, and lava members. Total thickness locally about 600 to 900 m; generally total thickness indeterminate.

Kim Mudstone members, dark-gray to grayish-green, thin- to medium-bedded calcareous and volcanic mudstone interbedded with less abundant volcanic sandstone.

Kiv Volcaniclastic rock members, andesitic volcanic sandstone and breccia with less abundant mudstone. In part rich in fragments of altered pumice and perlite. Rocks similar to those of Cambalache Formation.

Kil Lava members, andesitic to basaltic pillow lava and less abundant breccia with minor mudstone. Phenocrysts are chiefly only plagioclase, less commonly plagioclase and clinopyroxene, rarely only clinopyroxene.

Kl LOMAS FORMATION, very thick bedded, poorly sorted, clinopyroxene-bearing, andesitic to basaltic volcanic breccia and sandstone and less abundant moderately sorted volcanic sandstone; locally includes minor amounts of pillow lava. Volcaniclastic rocks are variable in composition, in part are rich in clinopyroxene, in part in plagioclase: commonly contain altered pumice with globular but not attenuated vesicles. Minimum exposed thickness is about 1,500 m.

Kll Lava flows, andesitic to basaltic lava flows with plagioclase and, in part, less abundant clinopyroxene phenocrysts; in part pillowed.

Khp HATO PUERCO FORMATION, chiefly marine-deposited grayish-green very thick bedded, moderately sorted, clinopyroxene-bearing, andesitic to basaltic volcanic sandstone and breccia with less abundant thinner bedded sandstone and mudstone. Commonly contains oxidized grains and sparse fragments of shallow-water limestone. Maximum exposed thickness about 1,500 m including breccia member.

Khpl Lava flows, basaltic to andesitic lava, including pillow lava, massive lava, and minor flow breccia.

Khpb Breccia member, chiefly very thick bedded, medium- to very coarse-volcanic breccia; minor volcanic sandstone and mudstone. Distinguishable only in north-central and northwest parts of quadrangle. Maximum thickness about 750 m; thins westward to about 200 m.

Kb BARRAZAS FORMATION, marine-deposited, medium-gray, thin- to very thick-bedded, moderately sorted, clinopyroxene-bearing, andesitic to basaltic(?), calcareous volcanic sandstone and less abundant volcanic breccia and calcareous mudstone. Maximum exposed thickness is about 1,100 m.

INTRUSIVE ROCKS

Tp QUARTZ DIORITE PORPHYRY, dike of light-gray aphanitic rock with 0.2 to 0.5 mm phenocrysts of plagioclase, chloritized hornblende, and quartz. Exposed only in east-central part of quadrangle. Dike is probably an apophysis of a stock not yet bared by erosion which is responsible for local area of contact metamorphism.

TKmi MAFIC DIKES AND SHEETS, chiefly fine- to coarse-grained diabase and diabase porphyry, locally varying to minor hornblende porphyry with very coarse hornblende phenocrysts. Only the larger dikes are mapped; many thinner dikes are present but are not shown. Most dikes are early Tertiary in age and younger than the major folds and faults. Includes some andesitic and basaltic dikes related to Cretaceous and lower Tertiary volcanic rocks.

TKd DIORITE, medium-grained hornblende diorite. Exposed only in east-central and southwestern parts of quadrangle.

METAMORPHIC ROCKS

TKa HYDROTHERMALLY ALTERED ROCKS, hard, light-gray and grayish-green altered, metamorphosed, and sheared volcanic and plutonic rocks. Primary textures largely absent or obscure. Exposed chiefly on north side of Gurabo valley. West of Quebrada Grande fault rock is largely light-gray, fine-grained, strongly silicified; possibly altered felsic intrusive rock. East of Quebrada Grande fault rock is chiefly grayish-green, less commonly light-gray. Obscure primary textures indicate volcanic breccia, sandstone, and lava. Possibly may be altered strata of the Lomas and Celada Formations and subordinate intrusive rocks.

Contact metamorphosed rocks in Hato Puerco Formation, dark grayish-green strongly jointed rocks commonly showing primary textures but containing metamorphic hornblende and (or) epidote, abundant iron sulfides, and common quartz and aplitic veins.

STRATIGRAPHY

Many of the stratigraphic units in the Gurabo quadrangle have been defined and described recently by Seiders (1971 a).

The nongenetic classification of volcaniclastic rocks proposed by Fisher (1961) is used here. Most of the volcaniclastic rocks are of primary and reworked pyroclastic origin and of mixed pyroclastic and epiclastic origin.

In the northwestern part of the quadrangle the Barrazas Formation is overlain conformably by the Hato Puerco Formation. In this area both formations have yielded late Cenomanian fossils. To the east in the El Yunque quadrangle (Seiders, 1971 b) the lower part of the Hato Puerco contains early Cenomanian fossils and is underlain by the Tabonuco Formation (Albian). Therefore, in the subsurface of the Río Canóvanas syncline the Barrazas and Hato Puerco Formations probably interfinger and the Barrazas is replaced to the east by the Hato Puerco. The Hato Puerco Formation south of the Leprocomio fault in the west-central part of the quadrangle contains Cenomanian fossils at several localities, and Turonian fossils occur near the top of the Hato Puerco just west of the quadrangle border (Seiders, 1971 a).

The Hato Puerco Formation is overlain by the Cambalache Formation north of the Leprocomio fault and by the Infierno Formation south of the Leprocomio fault. The correlation of the Cambalache and Infierno Formations is indicated by their stratigraphic positions, the lithologic similarity of their pumice-rich volcaniclastic rocks, and by the presence of Turonian fossils in each formation. The stratigraphic positions of informal members within the Infierno Formation are in large part uncertain because of rapid facies changes and abundant faults. In the Infierno Formation east of the Quebrada Grande fault mudstones are much more abundant than they are to the west.

The Cambalache and Infierno Formations are overlain, respectively, by the Canóvanas and Celada Formations. Correlation of the Canóvanas and Celada Formations is indicated by their stratigraphic positions and by their clinopyroxene-rich mineralogy. The thick Celada Formation contains lavas and coarse volcaniclastic debris which show that the formation was deposited very near volcanic vents. The Canóvanas, composed chiefly of volcanic sandstone and mudstone, was deposited relatively far from vents. It is probable that some of the volcanic ash of the Canóvanas was derived from the same vents that supplied the volcanic rocks of the Celada Formation. Very small amounts of hornblende andesite volcanic sandstone in the upper part of the Canóvanas Formation probably were derived from remote sources. No fossils have been found in the Celada, but the Canóvanas contains Turonian, Coniacian, and Santonian fossils. The Los Negros Formation in the southwestern part of the quadrangle is in the upper part of the Río Orocovis Group of probable Albian to Santonian Age (Pease, 1968a). The clinopyroxene-rich mineralogy and probable age of the Los Negros suggest correlation, at least in a general way, with the Celada and Canóvanas Formations.

The Lomas Formation occurs only in fault blocks and is not observed in depositional contact with other formations. One collection of late Cenomanian fossils from near the Quebrada Grande fault may belong to the Lomas. However, the stratigraphic assignment is uncertain as are the age and correlation of the Lomas. Unlike most other formations in the quadrangle, the volcaniclastic rocks of the Lomas are very poorly sorted and may have been deposited in a shallow-water environment.

The Canóvanas Formation is overlain by the Martín González Lava and the Frailes Formation (Campanian), whereas strata younger than the Canóvanas Formation do not occur in the quadrangle south of the Leprocomio fault.

The Monacillo Formation marks the only important disconformity or broad unconformity in the quadrangle. Strata exposed in the northwestern corner of the quadrangle are the basal part of a largely clastic sequence which is about 400 m thick in the Aguas Buenas quadrangle to the west (Pease, 1968b). In the north-central part of the Gurabo quadrangle these beds are either absent or very thin, and only the upper Trujillo Alto Limestone Member of the Monacillo is exposed. The Monacillo is probably largely Maestrichtian in age but the uppermost part could be as young as early Tertiary. The overlying Guaracanal Formation is probably of Paleocene age (Pease, 1968b).

STRUCTURE

The dominant structural features in the Gurabo quadrangle are faults. The most important fault is probably the Cerro Mula fault which is covered by alluvial deposits in the southwestern part of the quadrangle. This fault marks the northern limit of the extensive Río Orocovis Group. It is bordered by a broad zone of steeply dipping sheared beds and can be traced many kilometers to the west (Pease, 1968a, 1968b, 1968c). The Cerro Mula fault is probably a transcurrent fault but the sense of movement is not clear. Pease (1968a, 1968b, 1968c) has suggested left-lateral movement but Berryhill's (1965, p. 88–98) analysis indicates right-lateral displacement.

The Leprocomio fault trends N. 55° W. through the middle of the quadrangle. About 2 km of right-lateral movement of this fault is suggested by offset of an upper Campanian stratigraphic unit in the Aguas Buenas quadrangle (Pease, 1968b). Major pre-Campanian movement is possible and is suggested by the relatively large differences in older stratigraphic units on opposite sides of the Leprocomio fault. The structure of the highly faulted terrain between the Leprocomio and Cerro Mula faults is obscure. Some of the faults may be second-order shears related to the Leprocomio and Cerro Mula faults but others could be unrelated faults of relatively large displacement.

Almost everywhere folding is rather gentle. Except near faults the dips of beds rarely exceed 60 degrees and most commonly are less than 30 degrees. South of the Leprocomio fault bedding attitudes vary from fault block to fault block but in a crude way define a broad synform opening to the south.

North of the Leprocomio fault the major fold structure is the broad Río Canóvanas syncline, the axis of which trends north-northeast in the east-central part of the quadrangle. Even more gentle northeast-plunging anticlines occur on the west flank of the major syncline. These folds are cut off on the north by a system of northwest- and east-northeast-trending faults. North of these faults is a monoclinal sequence of beds dipping north-northwest. The curious juxtaposition of the north-northeast trending syncline with the north-northwest dipping monocline cannot be the result of long distance transport of previously formed structural elements along transcurrent faults. Such an interpretation would require horizontal displacement of many kilometers along an east-northeast trending fault followed by right-lateral displacement of that fault by about 6 km along the northwest-trending Buenaventura fault. However, the Buenaventura fault does not appreciably offset the axis of the Río Canóvanas syncline and its displacement must be largely vertical. The two different fold trends may have formed side by side in response to differential vertical movements at depth. The fold structures at the surface probably represent tilted fault blocks and strata draped over fault blocks.

In the northern half of the area diabase dikes have a pronounced N. 80° W. trend unrelated to fold structures in the country rocks. Some dikes are emplaced along faults, cut faults, or terminate against faults. Most diabase dikes are clearly of Tertiary age and are younger than the major folding and faulting. In the east-central part of the quadrangle a dike of quartz diorite porphyry, probably an apophysis of a small buried stock, is also younger than the fault that it cuts. Likewise, the hydrothermal alteration of rocks in the Gurabo valley probably is also younger than the major faulting. The faults bounding the areas mapped as hydrothermally altered rock define the limits of rocks unrecognizable as to origin or stratigraphic assignment. Contact metamorphism and spotty hydrothermal alteration extend across these faults into areas where stratigraphic assignment is possible. Hydrothermal alteration within the quadrangle and in adjacent areas has been described by Pease (1960) and Hildebrand (1961).

ECONOMIC GEOLOGY

Metallic minerals.—Pyrite and pyrrhotite are sparsely distributed in the hydrothermally altered rocks in the Gurabo valley and in contact metamorphic rocks of the Hato Puerco Formation on the east border of the quadrangle. Traces of chalcopyrite occur west of the former area in the Aguas Buenas quadrangle (Pease, 1968b) and east of the latter area in the El Yunque quadrangle (Seiders, 1971 b).

Stone, sand, and gravel.—Sand and gravel have been extracted on a large scale from terrace deposits along the Río Grande de Loíza. Similar deposits occur along the Río Gurabo in the southern part of the quadrangle but so far have been little exploited.

Many of the volcanic rocks are suitable for use as crushed stone. In the past quarries have been opened in the Martín González Lava, the Infierno Formation, and the Hato Puerco Formation. At present, production of crushed stone is restricted to the Hato Puerco Formation.

REFERENCES CITED

Berryhill, H. L., Jr., 1965, Geology of the Ciales quadrangle, Puerto Rico: U.S. Geol. Survey Bull. 1184, 116 p.

Fisher, R. V., 1961, Proposed classification of volcaniclastic sediments and rocks: Geol. Soc. America Bull., v. 72, no. 9, p. 1409–1414.

Hildebrand, F. A., 1961, Hydrothermally altered rocks in eastern Puerto Rico: U.S. Geol. Survey Prof. Paper 424–B, p. B219–B222.

Pease, M. H., Jr., 1960, Structural control of hydrothermal alteration in some volcanic rocks in Puerto Rico: U.S. Geol. Survey Prof. Paper 400–B, p. B360–B363.

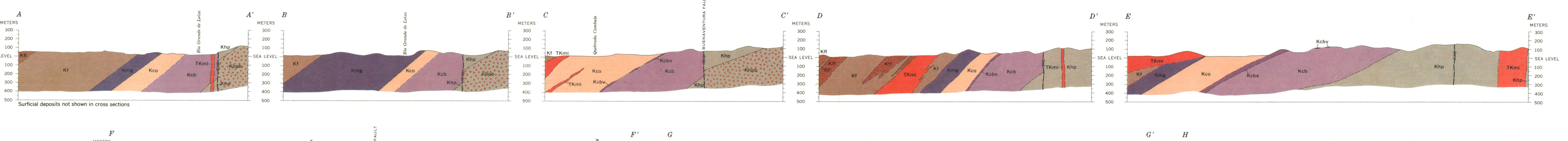
______1968a, Cretaceous and lower Tertiary stratigraphy of the Naranjito and Aguas Buenas quadrangle and adjacent areas, Puerto Rico: U.S. Geol. Survey Bull. 1257, 57 p.

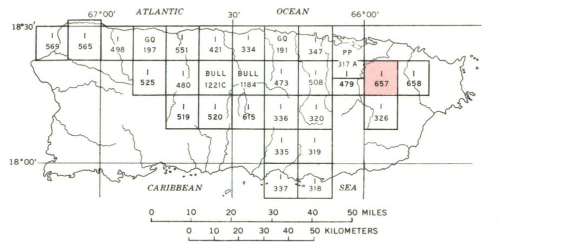
______1968b, Geologic map of the Aguas Buenas quadrangle, Puerto Rico: U.S. Geol. Survey Misc. Geol. Inv. Map I–479.

______1968c, Geologic map of the Naranjito quadrangle, Puerto Rico: U.S. Geol. Survey Misc. Geol. Inv. Map I–508.

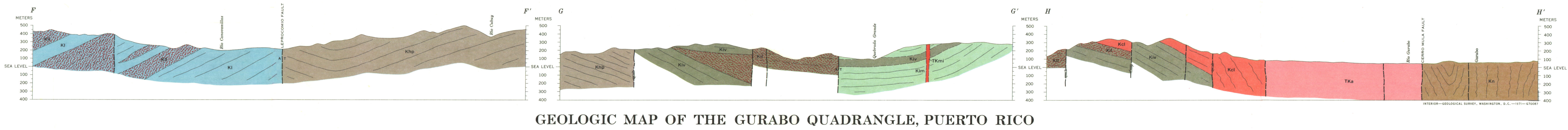
Seiders, V. M., 1971 a, Cretaceous and lower Tertiary stratigraphy of the Gurabo and El Yunque quadrangles, Puerto Rico: U.S. Geol. Survey Bull. 1294–F.

______1971 b, Geologic map of the El Yunque quadrangle, Puerto Rico: U.S. Geol. Survey Misc. Geol. Inv. Map I–658.





INDEX OF GEOLOGIC MAPPING IN PUERTO RICO



GEOLOGIC MAP OF THE GURABO QUADRANGLE, PUERTO RICO

By
Victor M. Seiders

1971