DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

MISCELLANEOUS GEOLOGIC INVESTIGATIONS
MAP I-318

INTRODUCTION

The geologic map of the Central Aguirre quadrangle has been prepared as part of a project to make a detailed and systematic geologic survey of part of Puerto Rico. The purpose of this study is to appraise the mineral resources of Puerto Rico and to prepare detailed general purpose geologic maps that can be used as aids in engineering planning. This program has been undertaken by the U. S. Geological Survey in cooperation with the Economic Development Administration of the Commonwealth of Puerto Rico.

Field investigations began in March 1956 and were completed in September 1956. The field work in this quadrangle was done in conjunction with the field work in the adjacent Cayey quadrangle. Aerial photographs at a scale of approximately 1:15,000 were used in the field as a base for locating and plotting geologic features. In the laboratory the data were transferred from the aerial photographs to a topographic base map having a scale of 1:20,000.

The writer was assisted during the field investigations by Lynn Glover and Martin S. Tischler. The thin sections used in describing the rocks in the laboratory were examined by Carl H. Brendel and Martin S. Tischler. Thanks are extended to them and also to other individuals and to land owners whose cooperation was a great help during the field investigations.

GEOGRAPHY

The Central Aguirre quadrangle is located on the southern coast of Puerto Rico. Aguirre, the largest village in the quadrangle, called Central Aguirre on the topographic map, is 89 kilometers by highway south-southeast of San Juan and 42 kilometers by highway east of Ponce.

Highway 3 crosses the quadrangle from east to west, and paved roads extend from this highway south to Aguirre, Puerto Jobos, and Las Mareas. Light-duty roads and jeep trails extend from the paved roads to all parts of the quadrangle except to parts of Barrio Pozo Hondo near the northeastern corner. The swampy islands near the mouth of Bahía de Jobos are accessible only by boat. The narrow-gauge Ponce & Guayama Railroad is used to haul sugar cane from the fields to the processing factories, known as centrals.

The population of the quadrangle is approximately 8,500, concentrated mainly in the villages of Aguirre, Coquí, San Felipe, Jobos, Puerto Jobos, and Las Mareas. The density of population is approximately 200 persons per square mile. For the island as a whole the density of population is 640 persons per square mile.

The climate of this part of the island is semiarid because it is on the lee side of the Cordillera Central from the northeast trade winds. Although the average annual rainfall is about 42 inches, concentrated mainly in the period from May 1 to November 1, the high evaporation and transpiration by plants, combined with high temperatures, low relative humidity, and constant winds cause semiarid conditions. Agriculture, therefore, is dependent on irrigation. Two main irrigation canals carry water westward across the quadrangle. The southern canal, the larger of the two, brings water from Patillas, about 11 kilometers east-northeast of the northeast corner of the quadrangle. Water is impounded in Lago Melania in the northeastern quarter of the quadrangle and is fed into the Patillas canal as needed. Additional water for irrigation and for domestic use is supplied by deep wells within the quadrangle.

The average annual temperature is 79.1° F. The hottest month is August, which averages 82° F, and the coolest month is February, which averages 74.6° F.

Almost all the arable land is used for raising sugar cane. Two sugar centrals are located in the quadrangle. Central Aguirre, controlled by the Aguirre Sugar Corporation (Luce & Co.), is one of the largest sugar-processing factories in Puerto Rico. Much of the sugar produced there is loaded on cargo vessels that enter the harbor at Central Aguirre through the Boca del Infierno. The other sugar-processing factory is Central Guanaval, which is several kilometers east of Central Aguirre.

The hilly northern part of the quadrangle is covered by a mixture of tall grass, thorny bushes, timber, and cactus and is devoted entirely to cattle raising and dairying. The cattle feed mainly on the tall, lush grass that thrives during the rainy season. The thorny bushes and cactus, which also grow on the hills in the northern part of the quadrangle, are kept cut so that as much grass as possible can grow. Coconut palms cover the sandy part of the spit south of Bahía de Jobos from Las Mareas to Punta Rodeo.

Approximately half of the Central Aguirre quadrangle is covered by the Caribbean Sea and by bays and lagoons bordering the sea. A long spit, which extends westward from Las Mareas to the Boca del Infierno, contains several beach ridges a few meters high that in general parallel the present coast line. Several small swampy mangrove-covered islands, the Cayo Caribes, extend southwestward from Punta Posuelo at the southwestern end of the spit. Similar islets, the Cayos de Barca, extend westward from Boca del Infierno to the western edge of the quadrangle. Coral reefs fringe the seaward side of the Cayos de Barca and the Cayos Caribes, and also the seaward side of the spit west of Las Mareas.

North of the large spit are two shallow bodies of water known as Bahía de Jobos and Laguna de Las Mareas. These are bordered by mangrove swamps, except at the village of Aguirre where the sea has cut small sea cliffs. East of Las Mareas the sea is actively cutting into the mainland and a low sea cliff has been cut at several places.

North of the coast the land surface rises regularly across a narrow coastal plain to an average altitude of 30 to 70 meters, where the coastal plain ends at the edges of hills that rise abruptly to altitudes of as much as 300 meters. This coastal plain consists of coalescing alluvial fans. The largest of the fans are those at the mouths of the Río Guamanal and the Río Seco, but all the smaller streams have similar but smaller fans at their mouths.

One marine terrace covered by a thin veneer of pebbles and cobbles was observed in the quadrangle at an altitude of 30 meters; however, a number of hills have altitudes of 70–90 meters. The altitudes of these hills correspond roughly to the altitudes of terraces that lie along the Río Lapa and the Río Majada in the vicinity of Baño del Reno in the adjacent Cayey quadrangle. The tops of these hills may represent planation during a higher stand of sea level.

The hills along the northern border of the quadrangle are part of a narrow plateaulike belt that lies between the coastal plain and the Cordillera Central and Sierra de Cayey, which reach altitudes of nearly 900 meters in the adjacent Cayey quadrangle. The highest altitude in the Central Aguirre quadrangle is 320 meters above sea level.

Short, intermittent, consequent streams that flow directly into the Caribbean Sea drain the coastal plain of the Central Aguirre quadrangle. The part of the quadrangle that lies to the north of the coastal plain is drained principally by the Río Guamanal, the Río Seco, the Quebrada Cimarrón and several unnamed streams whose headwaters lie in the adjacent Patillas and Cayey quadrangle. The flow along these streams is also intermittent. During the dry season, the small amount of water carried by the streams from the areas to the north quickly seeps into the unconsolidated sand and gravel of the fan deposits. From May 1 to November 1, however, when rainfall is heavier, the flow is usually continuous. After torrential rains in the mountains, these streams flood parts of the coastal plain.

GENERAL GEOLOGY AND STRATIGRAPHY

The rocks exposed in the Central Aguirre quadrangle are of five general types: (1) volcanic rocks including lava flows and volcanic breccia; (2) sandstone and siltstone derived primarily from volcanic rocks; (3) limestone, some of which is in part interbedded with the sandstone and siltstone; (4) igneous dikes; and (5) surficial deposits.

The volcanic rocks are exposed on the hills along the northern border of the quadrangle, and they also crop out on the isolated hills that stick up through the surficial deposits. Lenticular siltstone and sandstone lenses are interbedded with volcanic rocks in the northeastern part of the quadrangle, and interbedded siltstone, sandstone and limestone form the hills at Aguirre and also the one near Coquí. The oldest rocks crop out along the northeastern edge of the quadrangle, and progressively younger rocks are exposed southwestward. The volcanic rocks, sandstones and siltstones are products of part of a prolonged period of volcanism that characterized the early geologic history of Puerto Rico. The limestones are in part reef-type deposits, which accumulated periodically around the source areas. The lithologic variations in these rocks are in general a result of variations in the nature and intensity of the volcanic activity from time to time and also a result of periodic shifts in the geographic positions of the centers of volcanic activity.

Subdivision of the volcanic rocks into formations is based partly on data collected in this quadrangle and partly on data from the adjacent Cayey and Guamo quadrangles where outcrops of some of these rocks are more extensive. Seven formations have been recognized. These have been traced into the Central Aguirre quadrangle. The youngest well-bedded sequence of rocks in the Central Aguirre quadrangle and in the formations that have been named the Caribbean and Robles formations. The other massive volcanic rocks in the Cayey quadrangle are subdivided into four formations that have been designated by the letters A to D, with formation A representing the oldest. Letters were used rather than names for the massive volcanic rocks because the validity of these formations as mappable units has not yet been determined on a regional basis.

The Robles formation and formations A, B, and C have been mapped in the Central Aguirre quadrangle, but formation D and the Caribbean formation, which overlies the Robles formation in the Cayey quadrangle, do not crop out. The Robles formation includes five members in the Cayey quadrangle but is represented in the Central Aguirre quadrangle solely by the Lapa lava member.

The Coamo formation crops out in this quadrangle only on the hill near Coquí, but it covers a large area in the Coamo quadrangle to the northwest. The age of the Coamo formation is believed to be Late Cretaceous on the basis of megafossils. The rocks stratigraphically below the Coamo formation in the Central Aguirre quadrangle are probably also Cretaceous in age, although no evidence was found for dating them precisely.

The rocks on the hills at and near Central Aguirre contain no megafossils and studies of the microfossils have not been completed. Therefore, the exact age of these rocks has not been determined, therefore they have been designated on the map by the symbol TK. These rocks are possibly of Late Cretaceous age, but some of them may have been deposited during the early Tertiary period in either the Paleocene or Eocene epoch.

A small deposit of limestone cobbles containing large coral heads of Oligocene age caps one of the hills west of Central Aguirre. This deposit has been tentatively correlated with the Juana Díaz formation, which crops out extensively about 20 kilometers west of Central Aguirre.

Limestone containing coral of Oligocene age was found at one locality just west of the village of Aguirre, where it rests on the Late Cretaceous or early Tertiary rocks.

The surficial deposits that underlie the entire coastal plain are believed to be of Quaternary age and are probably in part late Pleistocene and in part Recent.

STRATIFIED ROCKS
CRETACEOUS SYSTEM

Formation A (Ka).—Rocks comprising the upper part of this formation crop out in the hills in the northeastern part of the quadrangle from the east edge westward almost to the Río Seco and from the north edge southward to the coastal plain where formation A is covered by alluvial-fan deposits. Rocks of similar lithology and structure crop out in the adjacent Guayama and the Cayey quadrangles. The part of formation A exposed in the Central Aguirre quadrangle is approximately 1,675 meters thick.

Formation A is made up primarily of volcanic breccia, but it also contains layers of sandstone and siltstone. This flows are interstratified with the clastic member, especially in the upper 600 meters of the formation, but they are generally lenticular, and no attempt was made to map them in this quadrangle.

The diagnostic feature of formation A in the Central Aguirre quadrangle are the cyclic repetition of its clastic members and the uniform gradation upward from coarse to fine particle size within each cycle of deposition. The cycle at the base is made up of volcanic breccia, which grades upward into volcanic sandstone, which in turn grades upward into volcanic siltstone. The overall thickness of the cycles is variable, but in general it averages about 30 meters in the Central Aguirre quadrangle. The thickness of the cycles in the lower part of the formation, which crops out in the Guayama quadrangle, is about 4 to 6 meters. The outcrops that best show the cyclic character of the rocks in formation A are in the Guayama quadrangle, especially along the unpaved streets on the south side of the small hill that lies just west of Highway 3 at the southeast corner of the town of Guayama.

The volcanic breccia that comprises the lower part of each cycle are thick-bedded and are made up of fragments that vary in shape from angular to subrounded. The size in general decreases, but the size of the fragments is also variable, ranging from 2 millimeters to 4 centimeters or more, the coarser particles occurring in the basal parts of the breccia units. The fragments in most of the breccias are highly compacted, and the matrix generally makes up 25 percent or less of the total mass. The composition of the fragments is almost entirely andesitic, and they are probably remnants of andesitic flows and basaltic andesite flows.

The matrix that binds the large fragments of the breccia together has been altered in part but seems to be primarily andesitic and crystals of plagioclase and pyroxene that range from less than 0.05 millimeter to about 1 millimeter in diameter. Sparsely disseminated pieces of punicoceous ash also occur in the matrix, but the total amount of material that can be recognized as ash is small. In many of the breccias the particles and minerals that make up the matrix have been so thoroughly replaced by chlorite and other secondary minerals that their original character cannot be recognized. Chloritization is common also around the edges of the large fragments. Interstitial calcite is almost always present in the matrix, but free quartz is absent. Specularite and pyrite are disseminated locally through both the fragments and the matrix.

The high degree of chloritization that many of these rocks have undergone gives them a greenish color. The individual fragments of andesite and basaltic andesite that have not been chloritized range from olive black to grayish brown and grayish red. Fragments that are brownish or reddish were probably oxidized before deposition.

The volcanic breccias in formation A are variable in thickness, but in general they make up about two-thirds to three-fourths of the total thickness of each depositional cycle. Some of the breccias in the upper part of the formation are more than 50 meters thick.

Sandstone is present in many of the cycles of deposition as a thin gradational unit between the volcanic breccia below and the siltstone above. The sandstone occurs in lenticular beds and is composed chiefly of tightly compacted particles of andesitic rock and small crystals and pieces of crystals of plagioclase and pyroxene. Chlorite is disseminated throughout the volcanic sandstone as interstitial material. The color of the volcanic sandstone varies from dark olive to dark greenish gray.

The siltstone that composes the upper part of the depositional cycles is thin- to medium-bedded and contains laminae of sandstone that are thicker and more numerous in the basal part of the units. The siltstone is even bedded, and, although slightly contorted laminae are present, there is little evidence of large-scale penecontemporaneous slumping. The upper part of the siltstone units is very fine grained and locally is a white claystone.

The mineralogic composition of the siltstone is similar to that of the sandstone. The plagioclase and mafic minerals, however, tend to separate somewhat into distinct thin layers or laminae. Laminae having a high concentration of plagioclase are almost white, and those that contain large amounts of mafic minerals and chlorite are dark green.

Siltstone makes up about one-fourth to one-third of each cycle, and in a few places is 10 or more meters thick. Like the other units, however, the siltstones are lenticular and locally pinch out, particularly in the upper one-third of formation A where the siltstones are relatively thin.

The flows that are interbedded with the breccias and siltstones in the upper half of formation A seem to be chiefly andesites; some are probably basaltic andesites. The texture of these flows is porphyritic; euhedral crystals of plagioclase, chiefly labradorite, and pyroxene form phenocrysts in a microcrystalline groundmass. The size of the phenocrysts is generally less than 2 millimeters. The proportion of plagioclase phenocrysts to pyroxene phenocrysts varies, but plagioclase is predominant in most of the flows. Many of the pyroxene phenocrysts and also some of the plagioclase phenocrysts have been either completely or partly altered to chlorite or epidote. Some of the plagioclase phenocrysts have been partly altered to calcite.

A flow that differs somewhat from the other in formation A crops out across the south side of the small hill that lies 0.45 kilometer east of the sharp bend in the Río Seco. This flow lacks phenocrysts but contains amygdules that range in size from about 5 to 15 millimeters. The conspicuous features of these amygdules are their relative large size and their almost perfect roundness. The amygdules are composed of epidote, which probably replaced a primary mineral.

The cyclic beds of volcanic breccia, volcanic sandstone, and volcanic siltstone that make up most of formation A were deposited in water, probably in shallow parts of the ocean not far from source areas. Most of this material is lava-flow debris that was carried into the basin of deposition in part by streams and in part by large-scale mudslides from the steep slopes of volcanoes. Pyroclastic debris blown from the volcanoes probably fell into the water and was mixed with the water-transported debris. From time to time tongues of lava reached the water and flowed into the basin of deposition.

Fragments of large pelecypod shells and tests of foraminifera were found in this formation in the Cayey quadrangle.

Formation B (Kb).—Rocks making up formation B in the Central Aguirre quadrangle crop out in the hills in the north-central part of the quadrangle from the Río Seco westward to Cimarrón. A short distance south of the northern edge of the quadrangle, these rocks are covered by alluvial-fan deposits. The small hills that stick up through the surficial deposits just northeast of Jobos are underlain by rocks of formation B.

In this quadrangle the basal rocks of formation B appear to truncate the rocks of formation A along a line of sharp angular unconformity. Although the contact of the two zones is either obscured by weathering or is covered by surficial deposits at most places, the directions of strike of the rocks making up the two zones is so sharply divergent, that an angular contact can be postulated. Rocks of formation A strike rather uniformly N. 30° E. and dip toward the northwest. Rocks of formation B, however, strike almost N. 30° W. and dip toward the southwest. In the Cayey quadrangle to the north, the strike of the rocks in formation B changes from northwest to north, and the unconformity between formations A and B appears to be less angular.

The thickness of formation B in the Central Aguirre quadrangle is approximately 600 meters. The formation thickens northward, however, and in parts of the adjacent Cayey quadrangle is 1,400 meters or more thick.

The predominant type of rock in formation B is volcanic breccia, but the formation also contains siltstones, sandstones, flows, and flow breccias. The basal part of the formation is made up of volcanic breccias, sandstones, and siltstones that were deposited in cyclic patterns similar to those in formation A. In contrast to the volcanic siltstones of formation A, however, the siltstones of formation B were deformed by penecontemporaneous slumping and show marked evidence of deposition by turbidity currents. Graded bedding is a distinctive characteristic of these siltstones, but instead of being evenly bedded, the base of each graded layer is undulatory, a feature attributed to scour by turbidity currents. Deformed laminae in one layer are truncated by the base of the overlying layer.

The andesitic volcanic breccias in formation B, are similar to those in formation A. Chlorite and epidote are abundant as low-rank alteration minerals, and these rocks have a greenish color. The breccias in the lower and upper parts of formation B are bedded and are composed of smaller fragments than those in the middle part of the formation. Medium- to thick-bedded volcanic breccias crop out on the northeastern sides of the hills near Jobos, and on the hills adjacent to the Río Seco at the northern edge of the map. Thin, lenticular beds of sandstone are present in the volcanic breccias throughout the formation.

The siltstones are lenticular and are confined to the basal part of the formation in this quadrangle. In general, they are slightly more greenish than those in formation A indicating a higher chlorite content. Outcrops of typical siltstone can be seen on the northeastern sides of the hills just northeast of Jobos. The siltstones pitch out northward, and in the adjacent Cayey quadrangle they are absent from the basal part of the formation. In contrast to the pattern of deposition in the Central Aguirre quadrangle, however, sandstones and thin layers of siltstone make up the upper part of formation B in parts of the Cayey quadrangle.

A few flows and flow breccias occur in formation B. One flow crops out near the southeastern end of the elongate hill that lies just west of the Río Seco and 0.6 kilometer south of the north edge of the map. This flow is porphyritic with small plagioclase phenocrysts in a microcrystalline groundmass. Microscopic grains of hematite are disseminated throughout the rock, but they are most numerous in what appears to be ghost crystals of ferromagnesian phenocrysts that have been completely altered. The edges of these ghost crystals are very fuzzy and look as if they have been partially assimilated into the groundmass, probably as a result of deuteric alteration. This flow is grayish brown to grayish red because of the large amount of hematite in the rock. Fragments resembling this type of flow are common in the volcanic breccia of both formation A and formation B.

Another slightly different type of flow crops out on the west side of the westernmost knoll on the elongate ridge that lies 1.3 kilometers N. 10° E. of Villa Odas (central part of coastal plain). The road that goes across the saddle just southwest of the knoll crosses the upper part of this flow. A cross section is exposed from the road northeastward to the top of the westernmost knoll on the ridge. The flow is a dark greenish-gray porphyritic andesite or basaltic andesite, but near the top, which crops out in the road, it is an aphanitic amygdaloidal rock with no phenocrysts. The basal part of the flow is a fine-grained breccia which lies on stratified volcanic breccia.

The flow breccia that crops out on the southern sides of the hills 2 kilometers northeast of Jobos forms large float boulders, some of which are several meters in diameter.

No fossils were found in this formation but well-bedded sandstones and siltstones apparently deposited by turbidity currents indicate that at least part of the rocks were deposited in water.

Formation C (Kc).—This formation crops out on the hills along the northern part of the quadrangle from the Quebrada Aguas Verdes westward to the vicinity of Quebrada Aguas Verdes. Farther south, formation C is overlain by alluvial-fan deposits. The rocks comprising formation C are approximately 1,100 meters thick in this quadrangle, but in the adjacent Cayey quadrangle they attain a thickness of more than 1,500 meters.

Thick flows, including flow breccias, make up most of the formation, but volcanic breccias and tuffaceous breccias are also present in the formation. Formation B appears to grade almost imperceptibly into formation C through a breccia unit that is approximately 146 to 175 meters thick. The upper part of this breccia unit looks more like a flow breccia than a volcanic breccia, but the lower part is very similar to the volcanic breccias in formation B. To the north in the Cayey quadrangle there is some evidence of an unconformity between the two formations. There the base of formation C locally appears to truncate bedded breccia at the top of formation B.

The flows in formation C are andesites and basaltic andesites containing both plagioclase and pyroxene phenocrysts in a microcrystalline groundmass. Most of the phenocrysts are plagioclase, principally labradorite, but some pyroxene phenocrysts are present in all the outcrops. Chlorite is common in the flows as an alteration mineral after pyroxene and also to a lesser degree after plagioclase, which is generally zoned. The color of the flows ranges from dark greenish gray to brownish gray or dark red. The brownish-gray or grayish-red color of some of the flows comes from hematite, which has replaced some of the mafic crystals, and the greenish-gray color of the other flows comes from mafic minerals and chlorite.

On the cluster of small hills that lies 0.4 kilometer south of the north edge of the map at 66°12'30", W. long., flow breccia is intricately intertongued with flow. Both the flow and the flow breccia are predominantly brownish gray to grayish red and are identical in mineralogic composition. The northernmost and highest of the knolls making up the cluster of hills is underlain by tuffaceous breccia, which appears to intertongue southward with flow breccia. The tuffaceous breccia that crops out only on this hill is made up of andesitic fragments and some scoriaceous (highly vesicular) volcanic bombs that are chiefly subangular and coblelike in size. The matrix is composed of punicoceous tuff, plagioclase crystals, andesitic fragments, chlorite that may be a replacement of devitrified glass, and a small amount of interstitial calcite. The average grain size of the matrix is 0.5 millimeter. The overall color of the rock is brownish gray but the punicoceous tuff particles are pale reddish to moderate reddish brown.

Most of the upper third of formation C consists of amygdaloidal flows that are similar in mineralogic composition to the underlying andesitic flows in the formation. Both the size of the plagioclase phenocrysts and the size of the amygdules varies from one place to another. At the outcrops on the hillside near the north edge of the map, at a point 2.45 kilometers east of the northwest corner of the map and 0.4 kilometer north of Canal de Guamaní, the flow contains plagioclase phenocrysts as large 3 millimeters and plagioclase laths that average about 1.5 millimeters in length.

Interlayered with the amygdaloidal flow is a distinctive flow breccia that contains large blocks averaging 20 centimeters or more in diameter. This breccia lies within the flow at the north edge of the map at a point 2.6 kilometers east of the northwest corner of the map. A short distance to the south, however, formation C is truncated by the Robles formation, and from that point southeastward to Quebrada Aguas Verdes, the flow breccia is in contact with the Lapa lava member of the Robles formation.

The environment of deposition of formation C is questionable. The lack of stratification in the tuffaceous breccia indicates that it may be a subaerial deposit. In a small quarry near the northeastern end of the second hill southwest of the 37.5 meter road intersection, about 1¾ kilometers north-northeast of San Felipe, however, the amygdaloidal flow has crude pillow structure, which indicates that at that point, the lava probably solidified under water.

Robles formation (Kr).—The Robles formation was named by Pease and Briggs (in press) for extensive outcrops of siltstone in Barrio Robles near the southeastern part of the Cayey quadrangle. In the Cayey quadrangle the Robles formation is made up primarily of flows, siltstone, and limestone and has been subdivided into five members, but only one of these, the Lapa lava member, crops out in the Central Aguirre quadrangle. In the Cayey quadrangle the lower tongue of the Cayey siltstone member pinches out in the southwestern part of the Cayey quadrangle. The interval within which the upper tongue of the Cayey siltstone member and the Las Tetas lava member would lie in the Central Aguirre quadrangle is covered by alluvial-fan deposits. This interval is thinner in the Central Aguirre quadrangle, indicating either that the members above the Lapa lava member thin towards the south or that they were removed by erosion before the deposition of the Caribbean formation. The apparent thinning of the Robles formation could be a result of faulting now concealed by the alluvial-fan deposits. The Lapa lava member underlies the low hills adjacent to the coastal plain in the northwestern part of the quadrangle. In the Cayey quadrangle this member consists of two similar flows separated in places by a thin tongue of the Cayey siltstone member, but in this quadrangle the siltstone was not deposited, and the two flows have not been differentiated. The total thickness of this member is not known in this quadrangle because its top is covered.

Chemical analyses of samples from the Cayey quadrangle indicate that the Lapa lava member is a basaltic andesite. It has a porphyritic texture and is composed of both plagioclase, principally labradorite, and pyroxene phenocrysts in a microcrystalline groundmass. The ratio of plagioclase to pyroxene phenocrysts varies in different parts of the flow. In the basal part, large tabular plagioclase phenocrysts as much as 6 millimeters or more in length are predominant. They occur both as individual crystals and in clusters. Upward in the flow, however, the pyroxene phenocrysts are larger and more numerous, and on the south side of the hill about 1.8 kilometers north-northeast of Coquí, pyroxene phenocrysts are predominant. Small, sparsely disseminated, calcite amygdules occur in this part of the flow. Other minerals in the rock in addition to plagioclase and pyroxene are ilmenite, magnetite, chlorite, calcite, and a very small amount of olivine. Because of the relatively high amount of iron in the flow, weathered outcrops are brownish gray.

This flow, which can be distinguished from other flows in the area by the size, distinctly tabular shape, and clustered nature of its plagioclase phenocrysts, is a distinctive stratigraphic marker and has been traced northward into the Cayey quadrangle along a continuous outcrop for a distance of 8.5 kilometers. It also crops out on the north side of the Cordillera Central and has been mapped across the southern part of the Barranquitas quadrangle to a point 24 kilometers northwest of the Central Aguirre quadrangle (R. F. Briggs, personal communication).

In the Cayey quadrangle the flow is characterized by pillow structure, which generally indicates that a lava solidified under water. Pillow structure was not seen in the Central Aguirre quadrangle, suggesting that in this area the lava may have solidified subaerially.

Coamo formation (Kcoa, Kcoa).—The Coamo formation was named by Glover (in press) for a thick sequence of tuff breccia, conglomerates, sandstones and lenses of limestone that crop out in the southwestern part of the Coamo quadrangle in the vicinity of Coamo. In the Central Aguirre quadrangle rocks of the Coamo formation crop out only on the small elongate hill just west of Coquí. Elsewhere in the quadrangle, this formation is covered by surficial deposits, and its thickness is not known. The Coamo formation is not represented in the Cayey quadrangle.

The outcrops west of Coquí consist of massive gray, reef-type limestone, Kcoa, and dense grayish-yellow to dusky-yellow calcareous siltstone, Kcoa, which may be in part interbedded with the limestone; because of faulting and because of limestone float that litters the slopes the stratigraphic relationship could not be precisely determined. The siltstone that crops out in the small quarry on the northeast side of the hill dips steeply toward the southwest. A weathered igneous rock containing prominent hornblende phenocrysts crops out in the bottom of the quarry, but its exact relationship to the siltstone was not determined. The entire southwestern two-thirds of the hill appears to be underlain principally by limestone that has been folded into a small synicline whose axis parallels the crest of the hill. The northeastern limb of this syncline has apparently been faulted so that the limestone and siltstone are in juxtaposition.

The limestone is somewhat variable in character. Along the basal part of the hill it is a calcirudite that shows little evidence of bedding. This phase of the limestone is now cavernous. An opening to a small cave is located on the geologic map. The limestone that crops out along the upper part of the hill is thickbedded and very thick bedded. Several of these beds as much as 3 to 4 meters thick form prominent outcrops on the hillside. In the