Mineral Deposits of Central America

GEOLOGICAL SURVEY BULLETIN 1034

Prepared under the auspices of the International Cooperation Administration, U. S. Department of State

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By RALPH J. ROBERTS *and* EARL M. IRVING

With a section on

MANGANESE DEPOSITS OF PANAMA

By FRANK S. SIMONS

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MINERAL DEPOSITS OF CENTRAL AMERICA

By RALPH J. ROBERTS and EARL M. IRVING

ABSTRACT

The mineral deposits of Central America were studied between 1942 and 1945, in cooperation with the United States Department of State and the Foreign Economic Administration. Emphasis was originally placed on the study of strategic-mineral deposits, especially of antimony, chromite, manganese, quartz, and mica, but deposits of other minerals that offered promise of significant future production were also studied. A brief appraisal of the base-metal deposits was made, and deposits of iron ore in Honduras and of lead and zinc ores in Guatemala were mapped. In addition, studies were made of the regional geology of some areas, data were collected from many sources, and a new map of the geology of Central America was compiled.

Central America comprises three principal physiographic belts: a northern belt of folded mountains extending through central Guatemala and northern Honduras and into Nicaragua, a middle belt occupied by a dissected volcanic plateau extending from Guatemala eastward through El Salvador and across southern Honduras into Nicaragua, and a southern belt of folded strata and volcanic rocks in Costa Rica and Panama.

In northern Central America the folded mountains are composed of gneiss, schist, quartzite, and marble, which have been intruded by granitic rocks. These rocks are overlain by Permian(?) and Permian sedimentary rocks and are cut by later granitic rocks and serpentine of supposedly late Permian or early Mesozoic age. Marine and continental sediments of Jurassic, Cretaceous, and Tertiary age, and lavas and pyroclastic rocks of Cretaceous and Tertiary age, overlie the rocks of Paleozoic age.

The volcanic plateaus in middle Central America consist mostly of late Mesozoic and Tertiary lavas and pyroclastic rocks, but older rocks are exposed locally where erosion has been deep or where these rocks were never completely buried. Volcanic activity began in Cretaceous time and continued intermittently during the Tertiary, probably reaching a maximum during the Miocene and becoming less intense during the Pliocene and early Quaternary. Several volcanoes are still active.

In southern Central America folded Tertiary marine and continental sediments rest on a basement complex of pre-Eocene sedimentary, metamorphic, intrusive, and extrusive rocks. The Tertiary basins varied greatly in form, and the rock units deposited in them are so highly lenticular that it is difficult to correlate from one basin to another.

Antimony deposits are found in Honduras and adjacent parts of Guatemala, in central Guatemala, and in western Nicaragua. Only the Honduras deposits have thus far been productive; the total production has been about 700 tons of metallurgical and chemical ore. The El Quetzal mine in western Honduras has yielded more than 80 percent of this total. Here the antimony ore is in fault zones that cut graphite schist and intrusive rocks.

Chromite deposits have been found in the Jalapa, Cabañas, and Santa Rosa districts in Guatemala. These have yielded about 9,850 long tons of chromite ore of metallurgical grade, containing from 48.31 to 59.97 percent Cr_2O_3 and with a chromium-to-iron ratio of from 2.70 to 3.96. The ore forms lenses that contain from a few tons to 2,000 tons each in sheared serpentine.

Copper properties are known in Guatemala. Honduras, Nicaragua, and Costa Rica. The Rosita properties in eastern Nicaragua had reserves in 1955 totaling about 2 million tons that averaged 3.9 percent copper. The deposit was formed by contact matesomatism, and ore was concentrated by oxidation and supergene enrichment.

Iron deposits are found in Guatemala, Honduras, Nicaragua, and Costa Rica, but only the Agalteca deposits, in central Honduras, have a notable reserve. The ore is magnetite and hematite which replace limestone and hornfels adjacent to intrusive diorite. The inferred reserves total about 8 million tons, averaging about 53 percent iron, 0.01–0.08 percent phosphorus, 0.02 percent sulfur, and 10 percent silica. Because of their remoteness from the coast and the lack of transportation facilities, the deposits have not been exploited, but an increase in the market price may make the deposits workable in the future.

Lead-zinc deposits are being worked in the Departamentos de Huehuetenango and Alta Verapaz in Guatemala. The Chiantla district in Huehuetenango has been mined intermittently since colonial days, and the San Miguel district, also in Huehuetenango, has been worked since about 1915. The lead-zinc ore bodies replace limestone and dolomite of Permian and Cretaceous age. Near the surface the ore has largely been oxidized to lead and zinc carbonates, but primary sulfides are found at depth. The outlook for future production is promising, provided transportation facilities are improved. Lead-zinc deposits near Cobán in Alta Verapaz were being explored in 1946, and shipments were started early in 1949. Deposits are also known in the Departamento de Chiquimula and adjacent parts of El Salvador; one deposit in the Metapân district was put into production in 1950.

Deposits of manganese ore in Costa Rica and Panama have been worked intermittently and have yielded about 97,000 long tons of metallurgical ore. The ore bodies consist principally of manganese oxides derived from manganese carbonates and silicates. Individual ore bodies contain from a few tons to several thousand tons. As the known ore bodies of commercial grade have been mostly mined out, the outlook for future production is not promising.

Mica deposits were mined in central Guatemala between 1918 and 1942; the production, about 100,000 pounds of sheet mica, was used largely for electrical purposes. Most of the mica is green or bottle green and undesirable for use in condensors. A small quantity of ruby and rum condensor mica was also produced.

Under the stimulus of high prices between 1941 and 1944, about 1,000 pounds of radio quartz was produced in Guatemala. The quartz was in lenticular veins in metamorphic rocks; the usable crystals ranged in weight from less than a pound to 52 pounds. Most of the quartz was classified as grade 2 or 3.

Production of gold and silver in Central America during recent years has been greatest in Nicaragua, where the total value is about $8 million yearly, chiefly gold. Honduras is second, with a production of about $3 million yearly, chiefly silver. Most of the veins are of Tertiary age and were probably related to middle Tertiary volcanism. Some of the veins are older and were probably formed during the intrusive periods of Paleozoic and Mesozoic time.

INTRODUCTION

This report is based on investigations carried on by the Geological Survey (U. S. Department of the Interior) under the auspices of the Interdepartmental Committee on Scientific and Cultural Cooperation (U. S. Department of State) and the Foreign Economic Administration. The function of the last two agencies is presently carried on by the International Cooperation Administration. Roberts is responsible for the text of this report and for the compilation of the geologic map (pl. 1). He was in Central America from January to April 1942 under a program of scientific and technical cooperation with the American Republics sponsored by the Department of State, and mapped manganese deposits in Costa Rica and manganese and antimony deposits in Honduras. From December 1942 to May 1945 he was assigned by the Geological Survey to the Central American Minerals Mission of the Foreign Economic Administration under the direction of William C. Schmidt, and mapped deposits of lead, zinc, mica, and quartz in Guatemala; antimony, iron, and mercury in Honduras; lead, zinc, and copper in El Salvador; and iron, copper, and antimony in Nicaragua.

Irving, attached to the Foreign Economic Administration, was in Central America from December 1942 to February 1945. He mapped copper deposits in Guatemala and Costa Rica and chromite and iron deposits in Guatemala, and assisted Roberts in mapping iron deposits in Honduras and lead-zinc, mica, and quartz deposits in Guatemala. Prior to World War II Irving had been engaged in gold mining in Honduras. His first hand knowledge of many mines has been incorporated in the present report, and it has been supplemented by the published data available.

In addition, the work of many others is included in this report. Among the contributors are William C. Schmidt and Lawrence G. Houk, mining engineers, attached to the Central American Minerals Mission, who each contributed several reports which are incorporated here. Philip W. Guild and Frank S. Simons of the Geological Survey did field work in Central America under the program sponsored by the Department of State. Guild examined chromite and antimony deposits in Guatemala in 1942, and Simons mapped manganese deposits in Panama during 1942 and 1943. Fred H. Dakin, consulting engineer, examined antimony deposits in Honduras in 1941 and made his reports available to the Foreign Economic Administration.

In accordance with the program for procuring strategic minerals in Latin America, carried on between 1942 and 1945 by the Foreign Economic Administration under the direction of Alan M. Bateman, the writers visited many mines, prospects, and deposits in mineralized areas. For the most part only brief examinations were made, although some promising properties and districts were mapped or studied in detail. The main emphasis was on the examination of deposits containing strategic minerals, but some other deposits that offered hope of postwar development were also studied, and a few gold and silver mines were visited during the course of other work. Descriptions of the deposits are arranged alphabetically according to commodities and are subdivided on the basis of geographic location.

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Officers of the United States Department of State and of the Foreign Service, without exception, cooperated wholeheartedly with the authors in working with government officials of the Central American countries.

Officials of the governments of the countries of Central America gave unfailing cooperation and placed all possible facilities at the authors' disposal. At times they furnished guides, field assistants, and transportation when these were not otherwise available.

GEOGRAPHY

Central America (pls. 1, 2) comprises the six independent republics of Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama; the British colony of British Honduras; and the Panama Canal Zone. These countries extend southeastward in an S-shaped curve from lat 18°3′–7°12′ N. and from long 77°15′–95°10′ W. Central America is 1,300 miles long (see Metric Equivalents, p. 199) measured along its axis, and its width ranges from 31 miles at the narrowest part of the Isthmus of Panama to about 300 miles across the widest part of Nicaragua and Honduras.

The populations, areas, and capital cities of the Central American countries are summarized below (U. S. Bureau of Foreign and Domestic Commerce, 1942, 1943a).

Country	Area (approximate)		Population (1940)	Capital
	Sq mile	Sq km		
Guatemala	48, 290	125, 071	3, 284, 269	Guatemala City.
Honduras	46, 332	120, 000	1, 105, 504	Tegucigalpa.
El Salvador	13, 176	34, 000	1, 787, 930	San Salvador.
Nicaragua	49, 200	127, 430	1, 380, 287	Managua.
Costa Rica	23, 160	60, 000	639, 197	San José.
Panama	33, 667	86, 902	631, 637	Panamá.
Canal Zone	502	1, 300	51, 287	
British Honduras	8, 598	22, 270	45, 000	Belize.

SURFACE FEATURES

Central America may be considered, for convenience, as comprising three principal physiographic units (pl. 2): a northern unit of mountains of old folded rocks, extending through northern Guatemala and northern Honduras into Nicaragua; a middle unit consisting of a dissected volcanic plateau, extending from central Guatemala eastward through El Salvador and southern Honduras; and a southern unit of folded strata and volcanic rocks in Costa Rica and Panama.

Each of these major units can be subdivided into physiographic provinces. The northern unit contains the Petén lowland and the Antillean cordillera; the middle unit, the upper Pacific cordillera and the Guatemala-El Salvador coastal plain; and the southern unit, the Nicaraguan lowland, the Costa Rica coastal plain, the central cordillera of Costa Rica and Panama, and the Pacific coastal plain.

The Petén lowland, which is underlain by folded Tertiary rocks, ranges in altitude from about 500 feet on the west to 2,000 feet on the east and south where it merges with the Antillean cordillera.

The Antillean cordillera is a belt of folded Cretaceous and older rocks that extends through central Guatemala and Honduras into

Nicaragua. These mountains rise to about 13,400 feet in western Guatemala, and they everywhere constitute rugged, deeply dissected ranges whose average altitude is more than 4,000 feet.

The upper Pacific cordillera is a dissected volcanic plateau extending from Chiapas, Mexico, through southern Honduras and El Salvador into central Nicaragua. The altitude of this plateau ranges from 10,000 feet in western Guatemala to 8,000 feet in Gracias, Honduras; it drops to 4,000 feet in Nicaragua, where the upland slopes southward to the ocean. Volcanoes built upon this plateau by Tertiary and Quaternary volcanism are alined along its southwestern border; the highest is Tacaná, 13,816 feet in altitude, at the Mexico-Guatemala boundary line. The plateau is only partly dissected in Guatemala, whereas in El Salvador and Honduras its dissection is so advanced that few remnants of the original upland surface remain. The plateau is bordered on the north in Honduras and Nicaragua by a coastal plain, which, although absent in the places where the ranges are truncated at the coastline, elsewhere ranges in maximum width from 15 miles in Honduras to 50 miles in Nicaragua (Bengston, 1926, p. 403–413).

The broad alluvial plain extending southward up the Río Ulúa valley is a graben, which is part of the prominent transverse fault system extending southward into the Golfo de Fonseca.

The Guatemala-El Salvador coastal plain, which borders the volcanic belt on the southwest, ranges in width from 35 miles at the Mexican border to 10 miles at the El Salvador border; the plain widens again in eastern El Salvador and ends near the Golfo de Fonseca, where volcanoes occur in the coastal area.

The southern part of Nicaragua is separated from the northern part by the Nicaraguan lowland, which Hayes (1899, p. 347) interpreted as a peneplain cut on Eocene and younger rocks. Lago de Nicaragua occupies the western part of this depression, having been dammed by the volcanoes of the Pacific coastal area. The ranges that make up the southwest volcanic chain of the central cordillera rise from the Nicaraguan lowland.

Costa Rica is bordered on the north by a coastal plain of variable width which joins the Nicaraguan lowland on the north and continues southward into Panama. The Cordillera Central de Costa Rica is in part a volcanic plateau above which volcanoes rise as high as 11,326 feet. Southward the plateau grades into the rugged and dissected Cordillera Central de Talamanca, which is composed of intrusive igneous rocks and sediments and which continues southeastward into Panama.

The Pacific coastal plain varies in width but is mostly less than 5 miles wide. Three peninsular ranges, the Nicoya, the Osa, and the Burica, are connected with the mainland by low alluvial plains (Schuchert, 1935, p. 593). On the north these peninsulas are bounded by volcanoes.

Panama is a continuation of the Cordillera Central de Talamanca. Except for a narrow coastal plain in some places, the isthmus consists mainly of discontinuous ridges, but a number of volcanoes rise above the ridges in northwestern Panama.

The Pacific coastal plain in Guatemala is prograding because of the enormous volume of detritus that is being carried southward by streams draining the volcanic chain. Farther southeast, in El Salvador, the coastal plain is narrow and has a rugged shoreline that is being actively eroded, although raised terraces at about 40 and 100 feet above sea level indicate that the most recent movements have been emergent.

The Caribbean coastal plain also has recently been uplifted. Near Livingston, Guatemala, coral reefs of Pleistocene age are several hundred feet above sea level, and along the north coast of Honduras and the east coast of Nicaragua, uplifted terraces show evidence of Pleistocene and Recent emergence. In Costa Rica and Panama the principal movements have been submergent, although local Recent emergence is indicated by raised terraces.

CLIMATE AND VEGETATION

The climates of Central America are varied: a tropical rain-forest climate on the Caribbean coast, a savanna climate on the Pacific coast, and a highland climate in the interior uplands (Trewartha, 1943, p. 317–356, 501–513). These variations, caused by the high rugged mountains that follow the axis of Central America, make most parts of the region both pleasant and healthful.

In Central America, three temperature zones are commonly recognized: the tierra caliente (hot region), generally extending from sea level to about 2,500 feet; the tierra templada (temperate region), extending from 2,500 feet to about 6,500 feet; and the tierra fría (cold region), which extends from 6,500 feet to 14,000 feet. However, in southeastern Central America the hot region extends to about 4,000 feet, and although some mountains reach 8,000 feet in altitude they are still in the temperate region, there being no cold region.

The tropical climate of the Caribbean coastal belt is characterized by a high annual rainfall, which ranges from about 80 inches to as much as 297 inches. The rain is brought in by the trade winds from the Caribbean Sea; the rainfall is distributed throughout the year, but the months with heaviest precipitation are from June to December. The vegetation of the coastal belt is a tropical rain forest containing an evergreen broadleaf flora that includes tree ferns, palms, mahogany, chicle, and many other species. Trees as much as 150 feet

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high are common, and climbing vines, lianas, and parasitic vegetation, together with a heavy undergrowth, create a dense canopy of shade with only a subdued light beneath.

The temperature range in the tropical rainy belt depends upon the altitude: at the coast the mean temperature is about 80° F., and the annual range is 65°–95° F.; in the mountains the mean temperature range is 65°–75° F. Streams are abundant in this zone and flow year round; on the lowlands and coastal plains, broad flood plains are characteristic (Reed, 1923, p. 133; Shelford (chm.) and others, 1926, p. 596–622).

On the Pacific slope the rainfall is unevenly distributed throughout the year and there are distinct wet and dry seasons. The annual rainfall ranges from 60 to 100 inches. The heavy rains fall between May and November, when southerly winds prevail; during the intervening months some places are completely without rain, although light rains generally fall in the months just after and before the heavy rains. In many places a 2-week dry spell, the canícula or veranillo, breaks the rainy season in August.

The seasonal distribution of rainfall gives rise to a savanna climate. The savanna is principally a grassland with scattered clumps of trees. On the margins the clumps become closer, forming a forest that merges on its borders into the tropical rain forest. In most places the trees are deciduous, but, where rainfall is light, they give way to cactus and scrub brush.

Temperatures in the savanna are comparable to those of the tropical rainy belt but rise somewhat higher during the dry months. Streams show marked seasonal fluctuation, and many dry up during the dry season. During the rainy season the streams occasionally become flooded and inundate wide areas of valley bottom. Water supply is often a serious problem during the dry season in the savanna areas, although in most places adequate supplies can be developed.

The highland climates of Central America prevail in the mountains and plateaus rising above the tropical lowlands. Generally the tropical climate extends up the flanks of the highlands to altitudes of about 3,000 feet. The rainfall is very unevenly distributed in the highland areas, ranging from a few inches a year in some interior valleys to as much as 80 inches on the margins of the highland. As on the Pacific coast, the wet and dry seasons are distinct, but the climate is cooler; in the mountains the minimum temperature is 30° F., and during the warmer months maximum temperatures may be 80°–90° F. The vegetation of the highlands is similar to that of many parts of the United States: open pine and oak forests characterize the slopes, and many high plateau areas are covered with grass. Along the margins of the highlands, where the rainfall is greatest, the oak and pine forest merges with the rain forest.

In northern Honduras and northwestern Nicaragua the oak and pine forest is largely confined to the zone between 1,000 and 4,000 feet in altitude, and above 4,000 feet the slopes are covered with dense evergreen broadleaf forest. To the south, in central Honduras and western Nicaragua, the pine forest is best developed between 3,500 and 5,000 feet above sea level.

The highland rivers that head in the mountainous areas are commonly perennial, and water supplies are abundant; streams heading in plateau areas may be intermittent, and water may be scarce in those areas during the dry seasons.

TRANSPORTATION

One of the principal problems affecting mining in Central America is transportation. Parts of Central America have been developed recently by systems of roads, railroads, and airlines so that movement is much less a problem than formerly, but poor transportation is still one of the principal deterrents in developing mining properties in remote areas.

In remote areas, supplies for the mines, as well as the minerals produced, have to be transported by slow, costly methods. The foot trails followed by the Indians and later by the Spaniards were gradually widened and made passable for cars and trucks. In most places no attempt has been made to relocate the roads, and consequently they are winding and steep where they traverse the rugged mountains of the interior. Torrential showers make maintenance difficult, as most of the roads are not surfaced and become badly gullied during wet weather. During the worst part of the rainy season, therefore, most roads are impassable, and the best of them are unfit for heavy hauling. The Inter-American Highway and feeder roads connecting with it are designed for all-weather traffic. The low grades on this highway will greatly cut the cost of transportation and make possible the use of heavy hauling equipment.

Railroads have been built in many parts of Central America, principally during the period 1890–1920, when transcontinental lines were built cross Panama, Costa Rica, and Guatemala (U. S. Bureau of Foreign and Domestic Commerce, 1943b, 1945). The other countries, with the exception of British Honduras, are partly covered by railway networks.

The most spectacular development in Central American transportation followed the development of commercial aviation. The airplane offers speedy travel to remote areas, many of which had no other means of access, and has played a major role in developing mining operations in Honduras and Nicaragua.

BRITISH HONDURAS

British Honduras has no railways, and access to the interior is by roads or shallow-draft boats. As the rivers are navigable only in their lower courses, much of British Honduras is difficult of access and is only sparsely settled. A road has been built from Belize northward by way of Orange Walk to Consejo, and branches continue westward. During the dry season vehicles can travel westward to the Guatemalan border. Other short roads extend inland from the coast from Stann Creek, Placentia Lagoon, and Punta Gorda.

GUATEMALA

The International Railways of Central America owns the narrow-gage railroad that serves most of Guatemala. The main line runs from Puerto Barrios on the Caribbean coast through Guatemala City to Ayutla on the Mexican border; branches extend to the ports of San José, Champerico, and Ocos on the Pacific Coast. The El Salvador Division extension of the International Railways turns south at Zacapa and enters El Salvador near Metapán.

The Verapaz Railway, now operated by the Guatemalan government, serves the Departmento de Alta Verapaz. A combined water and rail system transports freight by barge from Puerto Barrios and Livingston by way of Lago de Izabal to Panzós, a distance of 110 miles, then by railroad 29½ miles to Pancajché. Truck roads passable the year around connect Pancajché with ranches in the area.

The principal highways of Guatemala are in the southern and central parts of the country. The Inter-American Highway extends from Ayutla at the Mexican border eastward to Escuintla; another highway leads from Tapachula through Quetzaltenango to Guatemala City and thence eastward to El Salvador. Connecting roads link these highways in several places. Secondary roads extend into the highlands from several points on the Inter-American Highway: one runs northward from Guatemala City to Semococh and another from Guatemala City to Río Hondo, paralleling the railroad; another extends from Quetzaltenango to Tojquíáj; and still another from Los Encuentros to Cunén.

Work on the Inter-American Highway was not carried on in Guatemala between 1941 and 1945. A new route which leads from the State of Chiapas in Mexico through Huehuetenango and thence to Guatemala City is now contemplated for this highway. Aerovías de Guatemala operates frequent air service to Quetzaltenango, Cobán, and Flores.

EL SALVADOR

There are two railway lines in El Salvador. One, the El Salvador Division of the International Railways of Central America, enters El

Salvador near Metapán, runs southeastward to San Salvador, and continues across the entire length of the country to the port of Cutuco on the Golfo de Fonseca. The other railroad, owned by the Salvador Railway Company, Ltd., extends from San Salvador southwestward to the port of Acajutla and northwestward to Santa Ana. Both railroads are narrow gage.

The Inter-American Highway passes through El Salvador, extending from San Cristobal on the Guatemalan border, through San Salvador to Cutuco, and thence to Goascoran, Honduras. Over part of the distance the highway parallels the railroads. Secondary roads passable most of the year extend southward and northward from the main highway, giving El Salvador the best-developed road network of all the Central American countries.

HONDURAS

The railroads of Honduras are all on the north coast; they run along the coastal plain and up into the broad valleys. Three principal railroad systems cover the area. The National Railway, operated by the Tela Railroad Co., runs between Puerto Cortés on the Atlantic coast to Potrerillos, a distance of 59 miles. The Tela Railroad Co. also operates connecting lines to Tela and Ulua, which serve the banana plantations of the United Fruit Co. on the north coast of Honduras. The railroad of the Standard Fruit and Steamship Co. extends from the port of La Ceiba eastward and westward along the coast, then inland to connect with lines of the Trujillo Roalroad, a subsidiary of the United Fruit Co. The Trujillo Railroad extends from the port of Trujillo up the Río Aguán to Olanchito; in 1942 a part of the railroad was torn up.

The highways of Honduras cover only the central and southern parts of the country, but they connect with the railroad at Potrerillos to permit travel to the north coastal area. A few short roads extend out from the railroads on the north coast.

The Inter-American Highway enters Honduras near Goascoran on the El Salvador border and continues eastward, entering Nicaragua at El Pino. From San Lorenzo, on the Bahía San Lorenzo, a road extends northward to Tegucigalpa, crossing the Inter-American Highway near Nacaome. From Tegucigalpa a road extends northward through Comayagua, Potrerillos, and San Pedros Sula to El Paraíso; a road extends westward from San Pedro Sula to Macuelizo.

NICARAGUA

Transportation facilities are best developed in the western part of Nicaragua because both industry and population are concentrated in that area. The National or Pacific Railroad extends from the port of Corinto through Managua to Granada on Lago de Nicaragua.

Branch lines extend to Jinotepe, Puerto Morazan, and El Sauce. Another section of the railroad, separated from the main line, runs between San Jorge and San Juan del Sur, a port on the Pacific Ocean.

The Inter-American Highway enters Nicaragua at El Pino, from which it extends southeastward to Managua and thence to the Costa Rican border at Peña Blanca. Secondary roads extend eastward from Managua to La Libertad, and others from several points on the highway into western Nicaragua.

The eastern part of Nicaragua can be reached only by air or by trails from the western part. The TACA Co (Transportes Aéreas Centroamericanos) operates frequent flights from Managua to eastern Nicaragua and northern ports. Shallow-draft boats can travel from the Caribbean Sea up the principal rivers as much as 50 miles.

COSTA RICA

Most of Costa Rica's population is concentrated on the central plateau; therefore, transportation facilities are best there. Two railroads extend to San José, the capital—the Northern Railway, which runs from Puerto Limón on the Caribbean coast, and the Pacific Railway, which runs from Puntarenas on the Golfo de Nicoya. In addition, a railway network owned by the United Fruit Co. covers part of the Atlantic coastal plain to the northwest and south of Puerto Limón. On the Pacific coast, two short railroads serve banana plantations in the Puerto Quepos and Golfito areas. The principal routes of transportation are in a belt extending east and west across the country. The highway system also is best developed on the central plateau. Roads radiate from San José eastward as far as Guacima and westward to Puntarenas. The Inter-American Highway extends into Costa Rica from Nicaragua to Las Cañas, but the section into San José is not complete. From San José the highway extends to San Isidro. A gap still exists between San Isidro and the Panama border. The Península de Nicoya and parts of northwestern Costa Rico are served by the TACA Co. The only airport in eastern Costa Rica is at Puerto Limón.

PANAMA AND THE CANAL ZONE

The transportation routes of Panama are best developed in the Canal Zone, which bisects the country, and in the southwestern coastal area.

Three railroads are operated in Panama. The line of the Panama Railroad Company parallels the Panama Canal from Colón to Panamá and crosses the isthmus. Another, the Ferrocarril Nacional de Chiriquí (Chiriquí National Railroad), extends from Port Armuelles through David to Boquete and Pedregal in central western Panama. The third, the United Fruit Company Railway, extends from Almirante on Laguna de Chiriquí to Suretka in Costa Rica.

Most of the Inter-American Highway in Panama is passable the year around, but a section from the Panama border to San Isidro, Costa Rica, is not yet complete. The highway has been constructed only to Chepo, east of Panamá. A transisthmian highway roughly parallels the canal from Panamá to Colón.

The Chiriquí Land Company Railway from Puerto Armuelles to Progreso connects with the lines of the Chiriquí National Railroad. In the province of Colón, two short railroad spurs are used for hauling bananas.

GEOLOGY

The geology of Central America is still far from being completely known. In much of the region widely separated traverses have given only a glimpse of the complex stratigraphy and structure, and vast areas have never been visited by a geologist. Central America offers a promising field for geologic study, for, contrary to the general concept of tropical jungle being everywhere, many of the highland and savanna areas have exposures comparable to those in our Western United States. Travel in Central America is still difficult in most places, and due care should be taken to plan for traveling in the proper season.

The geologic map of Central America (pl. 1) shows the geology as based on the best information now available. The map includes data obtained from many reports, which vary widely in the scale of their maps and the fullness of their descriptions.

PREVIOUS WORK

Dollfus and Montserrat (1868, p. 270f) were the first geologists to visit Central America who made any attempt to map the rocks and to describe them systematically. Their map, although generalized, gives a good idea of the stratigraphic sequence in Guatemala and El Salvador.

In the 1880's the noted German geologist and volcanologist Karl Sapper began the work that laid the foundation of the study of Central American geology. Sapper made a series of trips through all parts of Central America, gathering geologic data. In 1899 he published the first of his summary works dealing with the geology of northern Central America, which included a geologic map on a scale of 1:1,100,000. His summary of the geology of southern Central America followed later (Sapper, 1906). Subsequent work by Sapper and others modified in many details the maps accompanying these reports, and in 1937 Sapper published a revised account of the geology of Central America. Müllerried (1942a, 1944) has also made many valuable contributions to the geology of northern Central America.

Many other geologists have contributed to our knowledge of the geology of Central America, although little regional mapping has been done. Oil companies interested in petroleum in Central America have done detailed work in some areas, but most of this work is not yet available for publication.

STRATIGRAPHY OF NORTHERN CENTRAL AMERICA

PRE-PERMIAN ROCKS

In Guatemala, Honduras, and Nicaragua, metamorphic rocks are widespread; they include gneisses, schists, quartzites, marbles, and phyllites that form the cores of the principal ranges. The degree of metamorphism varies from place to place, and there is probably a great time interval between the youngest and oldest rocks; however, they are grouped in three units in plate 1. Sapper (1937, p. 23), Müllerried (1942b, p. 472), and the writers consider that these metamorphic rocks may include some pre-Cambrian formations and that the youngest may well be of late Paleozoic age. All that has thus far been proved is that the metamorphic rocks in some places underlie fossiliferous Permian (?) strata and are therefore pre-Permian (Schuchert, 1935, p. 342).

The metamorphic rocks crop out in a belt extending eastward from Chiapas, in Mexico, through Huehuetenango in western Guatemala, and make up the Sierra de Chuacús, the Sierra de las Minas, the Sierra del Espíritu Santo, and the coastal ranges of northern Honduras and Nicaragua. These rocks consist of a great thickness of garnetiferous and micaceous gneiss, mica schist, hornblende schist, andalusite and garnet schist, quartzite, and marble. In places the metamorphic gneiss grades into intrusive granite gneiss and granite.

Metamorphic rocks of lower grade, such as phyllite, quartzite, schist, and marble, are also found within this belt, especially in Honduras and Nicaragua; some of these rocks may belong to a younger series. They may be of late Paleozoic or even early Mesozoic age, and may have been metamorphosed during orogenic movements and by granitic intrusions accompanying the orogenies.

Müllerried (1942b, p. 474) suggests that Central America had a geologic history similar to that of northern Mexico and the southwestern United States, where sedimentary rocks of early Paleozoic age were metamorphosed during orogenic movements of middle and late Paleozoic time. This may well be true, but only detailed geologic work will solve the many problems that these rocks present.

ROCKS OF PALEOZOIC AGE

Rocks of Paleozoic age are widespread in northern Central America and form a belt as much as 22 miles wide adjoining the metamorphic belt on the north in Guatemala and extending eastward to Puerto Barrios. In British Honduras, lithologically similar strata make up the Maya Mountains, and in northern Honduras and Nicaragua they crop out in the coastal ranges.

PERMIAN SYSTEM

In Guatemala the strata of Paleozoic age that have been dated consist of two formations of Permian age: the Santa Rosa formation of Permian(?) age and overlying limestone and dolomite beds which we propose calling the Chochal limestone.

SANTA ROSA FORMATION

Santa Rosa formation was the name applied by Dollfus and Montserrat (1868, p. 270f) to strata exposed near the village of Santa Rosa in the Departamento de Alta Verapaz, Guatemala. The formation consists of interbedded sandstone, shale, limestone, puddingstone, and marl. Its upper beds grade into the overlying limestone, which was referred to by Sapper (1899, p. 64) as the Carbonkalk.

The Santa Rosa formation is deeply weathered at the type locality, and the base is not exposed. However, near Sinanja in Alta Verapaz, according to Sapper (1937, p. 24) the Santa Rosa formation rests unconformably on the folded pre-Permian(?) rocks, and its lowest members contain fragments of these rocks. It is likely that the basal beds of the Santa Rosa formation rest unconformably everywhere on the pre-Permian(?) rocks.

Sapper described the basal part of the Santa Rosa formation as consisting of coarse clastic rocks, which become progressively finer upward and are interbedded with increasing amounts of shaly limestone. The formation is exposed almost continuously westward into Mexico. The thickness of the section in Chiapas, Mexico, is reported to be 1,000–3,300 feet (Müllerried, 1942b, p. 472; Thompson and Miller, 1944). Thompson and Miller measured several sections in Chiapas and made a tentative correlation with part of the Santa Rosa formation. They called the lower clastic beds the Santa Rosa(?) formation and named the upper beds the Grupera, the La Vainilla, and the Paseo Hondo formations. According to them, the Grupera formation consists of 400 feet of interbedded shale and sandstone which contains many invertebrate fossils. They correlated these beds with the Hueco limestone of west Texas of Wolfcamp age. The Grupera formation is overlain by the La Vainilla limestone, about 300 feet thick, which contains *Schwagerina figueroai* and appears to be younger than upper Wolfcamp, but pre-Leonard (Thompson and Miller, 1942). The La Vainilla limestone is overlain by 475 feet of interbedded limestone and shale which Thompson and Miller named the Paseo Hondo formation. Fusulinids collected from these rocks are correlated with those of the Leonard formation of west Texas.

In the Chiantla-San Sebastián area in the Sierra de los Cuchumatanes in western Guatemala, which was mapped by Roberts (pl. 9), no complete section of the Santa Rosa formation is exposed, but a lower unit of interbedded sandstone, shale, and conglomerate and an upper unit of red, brown, gray, and black shale with interbedded shaly limestone, sandstone, and dolomite were mapped. The lower unit is exposed only in a fault block at the foot of the range, but a few miles to the west it is several thousand feet thick. The upper unit, which is well exposed on the middle slopes of the range, has a thickness of about a thousand feet. The upper 400 feet of the section is composed mainly of interbedded shale, limestone, and shaly sandstone. The limestone members range in thickness from a few feet to more than 75 feet; they are lenticular and pinch and swell along the strike. No attempt was made to subdivide these rocks, but units equivalent to the Grupera and La Vainilla formations of Miller and Thompson (1944, p. 481–504) probably occur there.

Fusulinids collected from the upper part of the Santa Rosa formation near Chochal (pl. 9) were determined by Lloyd G. Henbest to be of Permian(?) to middle Permian age (Wolfcamp and Leonard). The collections were reported on as follows:

Specimens from the upper part of the Santa Rosa formation, near Chochal

44–C–47 (from Torlón mine).

Schwagerina or possibly *Parafusulina* sp. (material insufficient for determination. but there are indications that *Schwagerina gruperaensis* Thompson and Miller is represented)

Grupera formation is suggested, but the evidence is very meager. Early to middle Permian age is rather definitely indicated.

44–C–45 (half mile northwest of peak, altitude 7,442 feet, southwest of Torlón mine).

Schwagerinid fragment.

Material insufficient to determine other than that it indicates Permian age.

The limestone and shale beds in the upper part of the Santa Rosa formation also contain many poorly preserved larger invertebrate fossils. These were studied by J. E. Smedley and found to contain productid, spiriferid, derbyid, and chonetid brachiopods, as well as an avicular pectinid and other pelecypods, corals, gastropods, and bryozoans. For the most part specific determinations of these fossils were not possible, but Smedley stated that the fauna could well be of Permian age.

CHOCHAL LIMESTONE

The limestone units that Sapper (1899, p. 64) referred to as the Carbonkalk were never precisely defined. He apparently used this term to include all the units between the Santa Rosa formation and the Todos Santos formation. In places the boundary between the Santa Rosa formation and the overlying limestone is sharp, but generally these limestone units interfinger with the upper shales of the Santa Rosa formation, and the contact is gradational.

When the Chiantla-San Sebastián area was mapped (pl. 9) the massive, cliff-forming limestone units that form the upper slopes of the range were distinguished from the interbedded limestone and shale units of the middle slopes. Fusulinid collections from these upper limestone beds near Chochal have been studied by Henbest, who determined them to be of Leonard and possibly Word age. The limestone units would therefore be in part correlative with the La Vainilla and Paseo Hondo formations of Miller and Thompson, but the fusulinids indicate that the units also contain beds younger than the Paseo Hondo formation. As the limestone at Chochal is a mappable unit and is not specifically correlative with the Paseo Hondo formation, it is proposed that it be named the Chochal limestone.

The section selected as typical is 1½ miles north of the La Esperanza mine and 2½ miles east of Chochal, where the limestone is well exposed in steep cliffs. This section includes the following units:

Section of the Chochal limestone, 1½ miles north of the La Esperanza mine and 2½ miles east of Chochal

	Thickness (feet)
Erosion surface.	
Limestone, gray, thin to medium thickness beds; contains dolomite, shale, and shaly limestone beds. Forms craggy outcrops and steep cliffs	350
Limestone, gray, cliff-forming	95
Limestone, gray, shaly	30
Limestone, thin to medium thickness beds, with shale partings	50
Limestone and dolomite, gray; shale units with chert nodules and abundant crinoid stems, brachiopods, bryozoans, and fusulinids	75
	600

This section is incomplete; higher units are present outside the mapped area, and it is estimated that the formation may be as much as 2,000 feet thick. Fusulinids collected from the lower part of this section were studied by Henbest and reported on as follows:

Specimens from the Chochal limestone, 2½ miles each of Chochal

44–C–37 (two and a half miles northeast of Chochal, at an altitude of about 11,000 feet).

Eoverbeekina americana

?Parafusulina australis

Preservation of the fossils is poor. Correlation with the Paseo Hondo of Thompson is indicated.

44–C–11 (a mile northwest of Chochal at an altitude of about 10,500 feet).

Parafusulina sp. (large form 16–19 mm long, with phrenotheca closely coiled)

Word age, Permian seems represented.

Collections from other localities in the Chochal limestone were obtained in the middle slopes of the range. On the basis of very small and more or less metamorphosed samples, Henbest gives the following report:

Specimens from the Chochal limestone, middle slopes of the Sierra de los Cuchumatanes

44–C–30 (Las Manzanas, altitude 8,400 feet, about three-fourths mile northwest of houses).

Endothyra sp.
Eoverbeekina americana Thompson and Miller
Schwagerina sp. or *Parafusulina* sp.
Parafusulina sp.

Apparently correlative with the Paseo Hondo formation. Middle Permian age is indicated rather definitely but the possibility of Hueco early Permian (?) age, cannot be ruled out.

44–C–31 (Las Manzanas, altitude 8,500 feet, about a mile northwest of houses).

Eoverbeekina americana Thompson and Miller
Parafusulina sp. (possibly *Schwagerina* sp.)
?Parafusulina australis Thompson and Miller

Apparently correlative with the Paseo Hondo formation. Middle Permian indicated but might possibly be of Hueco, early Permian (?) age.

44–C–33 (half-mile southwest of La Esperanza mine).

Cornuspira sp.
Endothyra sp.
Eoverbeekina americana Thompson and Miller
Schwagerinid or parafusulinid (not identifiable)

Apparently same age as 44–C–30 and 44–C–31.

44–C–78 (on trail at 8,100 feet, about a mile south of Las Manzanas).

Parafusulina sp.

Specimens intensely distorted by rock flow. Species appear to be as young or younger than the Paseo Hondo formation and differ from any of the faunas discussed above. The great uncertainity of evidence must be emphasized.

HU–266 (near trail about a mile southeast of Chochal).

?Parafusulina guatemalaensis Dunbar (material insufficient for a positive determination but appears to be within the limits of the species as defined by Dunbar)

Sponge spicules very abundant. Correlation with 44–C–11 is suggested but must be regarded as very uncertain. With the material at hand it could not be proved that this form does not belong to an earlier Permian species of *Schwagerina*.

The Chochal limestone extends eastward from the type area and forms prominent cliffs in the ranges near San Cristobal, Cobán, and Panzós. Dunbar (1939, p. 344–348) redescribed three lots of fusulinids collected by Sapper from limestone in north-central Guatemala near Cobán. Two species were recognized: *Parafusulina sapperi* from Trece Aguas and Panzal was determined to be middle Permian, Leonard, or possibly Word in age, and *Parafusulina guatemalaensis* from Purulhá was determined to be of Leonard age. The limestone that yielded these collections is lithologically similar to the Chochal limestone and is probably correlative.

Strata of Paleozoic age are reported in other parts of Central America but have not been studied in detail. In northwestern Guatemala, Termer (1931, p. 244), found plant remains in dark shales that were assigned to the Permian. These beds may be a facies of the Santa Rosa formation. Strata of Paleozoic age that extend into northern Honduras and western Nicaragua have been described by Sapper (1937, p. 24, 25), Mierisch (1895, p. 56–57) and others. The strata consist of interbedded slate, phyllite, limestone, quartzite, and quartzite conglomerate. These rocks may in part be equivalent to the Santa Rosa formation and Permian limestone of Guatemala, but may well include older strata. The fossils found thus far in these rocks have been too poorly preserved for specific determination.

PRE-CRETACEOUS ROCKS

Because of the uncertainty of the age of the metamorphic rocks that underlie the Metapán formation in eastern Honduras and Nicaragua, these rocks have been labeled pK on plate 1, signifying only that they are pre-Cretaceous in age. They probably include rocks of Jurassic, Triassic, and Paleozoic ages, and may even include rocks of pre-Cambrian age as well.

ROCKS OF MESOZOIC AGE

Rocks of Mesozoic age underlie much of the northern part of Central America, especially north of the belt of rocks of Paleozoic and pre-Paleozoic age in Guatemala and Honduras. The sections of Mesozoic age generally include basal redbeds, overlain by interbedded limestone, dolomite, and shale. The stratigraphic succession has been ably summarized by Schuchert (1935, p. 237) and Imlay (1943, p. 1499, 1501, and 1505; 1944, p. 1113–1120).

The Paleozoic era ended in Central America with an orogeny during which the rocks of Paleozoic age and older rocks were folded and cut by granite and serpentine intrusive bodies. The earliest Mesozoic formations are terrestrial deposits composed mainly of coarse clastic rocks, but they also locally interfinger with beds of shale, marl, and limestone that may have been deposited in marine or lacustrine environments. On plate 1 the older Mesozoic rocks have been assigned to the El Plan (Tegucigalpa), Todos Santos, and Metapán formations. Most writers have correlated these formations because they are lithologically similar, but they are not equivalent in age and were probably deposited in separate basins.

One of the confusing problems in Central American geology is the terminology used for the redbeds and associated rocks in central Honduras. The Tegucigalpa formation is one of the formations that has long been involved in controversy. Near the Rosario mine at San Juancito, plant remains collected from shales were regarded by Newberry (1888, p. 324–351) to be of Rhaetic (Late Triassic) age but were later redetermined by Knowlton (1918, p. 607) to be of Early and Middle Jurassic age. Sapper (1937, p. 27) referred to these plant-bearing shales as the Tegucigalpa formation and believed that they might be in part equivalent to the Metapán formation. Weaver (Schuchert, 1935, p. 36) described the Tegucigalpa formation as consisting of about 800 feet of dark-brown sandstone and dark-gray to black carbonaceous shale and argillite; he stressed the fact that these rocks were more indurated than the strata of the Metapán formation. As far as the writers know there are no dark shale and sandstone beds near Tegucigalpa that are correlative with the Jurassic rocks near San Juancito. To avoid the confusion caused by the use of the term Tegucigalpa formation, Carpenter (1954, p. 25) proposed that the plant-bearing beds at San Juancito be named the El Plan formation. He described the formation as consisting of alternating members of dark-gray shale and siltstone with some argillaceous sandstone and pebbly conglomerate. The thickness shown on Carpenter's figure 2 is about 3,000 feet.

Carpenter (1954, p. 27) also mapped the geology of the Rosario mine area in central Honduras and divided the Cretaceous rocks there into five formations. The oldest, the Cantarranas formation, consists of a lower member of limestone and shale 132 feet thick; a middle member of calcareous shale, sandstone, and limestone, 345 feet thick; and an upper member of limestone, calcareous siltstone, and sandstone, 125 feet thick. Fossils found in the upper member include *Ostrea*, *Gryphaea* cf. *G. corrugata*, *Pholadomye*, and *Crassatellites?*; the formation was considered to be in part equivalent in age to the Metapán formation in the northern part of the Departamento de Tegucigalpa. The next younger formation was named the Colonia andesitic tuffs and breccias. Near the Rosario mine these rocks rest unconformably on the Triassic El Plan formation and are about 3,000 feet thick. The Colonia formation interfingers laterally with the Crucero tuffaceous dacite flows, which total more than 400 feet in thickness. The next younger Cretaceous formation is the Plancitos formation, which consists of medium- to coarse-grained grit, sandstone, siltstone, and shale, and is about 1,900 feet thick. Inasmuch as these Cretaceous units have not been mapped separately outside of the Rosario mine area, they are assigned to the Metapán formation on plate 1.

The Todos Santos formation, named by Sapper (1899, p. 65; Müllerried, 1942b, p. 474–475) after a village in the Departamento de Huehuetenango, Guatemala, comprises about 1,200 feet of interbedded reddish-brown sandstone, shale, and conglomerate; in places green shales and gray limy shales are intercalated, and thin limestone lenses are present locally. The Todos Santos formation rests unconformably on folded and metamorphosed rocks of the Santa Rosa and older formations and is overlain by limestone of Albian to Cenomanian age (late Early Cretaceous to early Late Cretaceous) according to Müllerried (1942b, p. 476).

At Todos Santos, Müllerreid found plant remains of Early and Middle Jurassic age in the lower part of the Todos Santos formation, and he considered it likely that the basal part of the formation might be Late Triassic, but, as the Todos Santos strata overlap an older land mass, the basal beds in one place may differ in age from those in another. In Chiapas the upper Todos Santos strata have yielded Neocomian (Lower Cretaceous) fossils. On plate 1 the Todos Santos formation is designated as Jurassic and Cretaceous.

Near San Miguel Acatán the Todos Santos formation is overlapped by limestone and dolomite probably of Early Cretaceous age. The overlap is an angular unconformity and shows that the uplift of the Sierra de los Cuchumatanes had continued during the Late Jurassic and Early Cretaceous. The Todos Santos formation in this area is probably not more than 400 feet thick, and west of San Miguel it is entirely absent in places, either because it was not deposited or because it was eroded before the Cretaceous limestone was deposited.

At San Mateo Ixtatán, Guatemala, and in Estado de Chiapas, Mexico (Sapper, 1937, p. 27), the upper Todos Santos strata are marl, shale, and sandstone, and include interbedded gypsiferous and salt-bearing strata, indicating a change northward from terrestrial to marine conditions of deposition. In Chiapas, beds of comparable age (Imlay, 1944, p. 1118) contain marine fossils that have been listed by Müllerried (1936, p. 36).

In eastern Guatemala, El Salvador, and Honduras, redbeds lithologically similar to the Todos Sandos strata have been named the Metapán formation by Sapper (1899, p. 65; 1937, p. 27). The type locality is at Metapán, in northwestern El Salvador. No section has been measured there, but the strata are estimated by the present writers to be 1,500 feet or more in aggregate thickness. Where the base of the section is exposed near Concepción in nearby Guatemala, the Metapán formation rests on contorted schist that has been assigned to the Paleozoic. (See pl. 8.) The lower part of the Metapán formation includes interbedded sandstone, conglomerate, shale, volcanic tuff, and marly beds. The beds are mostly dark red, but some are purple, dark green, and yellow and brown. The coarser members show poor sorting and were evidently derived from nearby sources. The upper part of the formation is composed of interbedded red, yellow, and gray shales with thin limy shale and limestone beds; the highest member is a cliff-forming limestone 100 feet or more thick which is exposed east of Metapán and at El Sillón near Concepción. The limestone contains poorly preserved fossils of indeterminate age. The Metapán formation is not highly fossiliferous, but red shale beds associated with volcanic tuff near Metapán yielded fossils determined by Ralph Imlay to be *Exogyra arietina* Roemer of late Comanche (early Late Cretaceous) age.

In eastern Guatemala and western Honduras Sapper (1899, p. 65) described limestone that rests concordantly on shale, sandstone, and conglomerate that he called the Metapán beds. The limestones were differentiated by Sapper (1899, map; 1937, table 6). He considered the limestone to be of Cretaceous age but did not collect diagnostic fossils from it. Subsequently Müllerried (1942a, p. 125) and others established a middle Cretaceous age (now known to be early Late Cretaceous) for the limestone units that overlie the redbeds of the Metapán formation in eastern Guatemala and Honduras. The limestone is therefore only slightly younger than the Metapán formation. On plate 1 the limestone is included with the Metapán formation near Metapán, but throughout central Honduras and Nicaragua it is shown separately.

Weaver (1942, p. 179–180) proposed the name Esquías formation for the upper part of the sequence of interbedded limestone, conglomerate, sandstone, and shale that overlie the Metapán formation in central Honduras. Fossils that Weaver found in the Esquías formation were poorly preserved and not diagnostic, so he could not determine how much of Cretaceous time was represented by these beds. This formation is therefore not differentiated on plate 1 but is grouped with the Upper Cretaceous limestone unit. It seems likely that a considerable thickness of limestone and shale may lie between the Metapán formation and the Esquías formation. Further study of the sections in central Honduras will be required before the stratigraphic successions can be determined.

Although the Todos Santos formation and the Metapán formation are similar in lithologic composition, they are not of the same age, as suggested by several authors (Müllerried, 1942a, p. 129; Sapper, 1937, p. 26, 27, 109), for the fossils collected in the Todos Santos formation are Early Cretaceous (Neocomian) or older, and those collected in the Metapán formation are early Late Cretaceous. It is possible, however, that older beds may be found in the Metapán formation that are equivalent in age to the beds in the upper part of the Todos Santos formation.

In northwestern Guatemala the Todos Santos formation is overlain by limestone, which Termer (1932, p. 247; 1936, p. 142) named the Ixcoy formation and correlated with the Cobán limestone of Sapper (1899, p. 65; 1937, p. 28–29). Termer found no diagnostic fossils in the Ixcoy but thought it might be correlative with middle to Upper Cretaceous limestone in Estado de Chiapas, Mexico. The Ixcoy formation comprises over 2,000 feet of interbedded limestone and dolomite and is the host rock of the lead-zinc deposits of the San Miguel district. For the most part the beds are thick to massive and light to dark gray. In many places the formation contains thick intraformational conglomerates and breccias, possibly formed during periods of minor crustal movements.

In northwestern Guatemala (pl. 1), the Ixcoy formation is shown by Termer to be in fault contact with the Cobán formation, which contains late Early Cretaceous fossils in its lower beds (Müllerreid, 1942a, p. 134, 136). The Cobán formation was estimated to be more than 1,000 feet thick. North of Cobán, the Cobán formation is overlain by Upper Cretaceous limestone similar to Upper Cretaceous beds in Chiapas.

Termer assigned all the limestone of the Sierra de los Cuchumatanes to the Ixcoy formation, but inasmuch as Sapper (1899, p. 67) mapped two areas of Sepur rocks (of Eocene age) at the crest of the range, it seems certain that the Upper Cretaceous is present there also, beneath the Sepur beds. The higher beds in the range are composed of massive craggy-weathering limestone with thick-bedded and thin-bedded members, which are unlike the porous coarse-grained breccia and conglomerate that occur in the Ixcoy formation. The upper limestone is dense and fine grained and ranges from light gray to brownish gray. These beds may be 500 feet or more in thickness in this area.

TERTIARY SYSTEM

The Tertiary rocks of northern Central America comprise marine and continental formations that range in age from Eocene to Pliocene. The marine beds are well exposed in northern Guatemala, where they overlap the Cretaceous beds.

No recent comprehensive accounts of the Tertiary stratigraphy of northern Central America are available, but Schuchert (1935, p. 332, 390, 556–564) and Sapper (1937, p. 31–32) summarize published information up to 1937.

The oldest Tertiary rocks in Guatemala are in the Sepur formation, of Eocene age, exposed in the northern part of the Republic (Sapper, 1937, p. 31). These beds consist chiefly of red sandstone, conglomerate, and shale, with local interbedded limestone and marl members. Near Cahabon, beds of terrestrial conglomerate and sandstone predominate, but to the north and west the coarse facies grades into red and yellow marine clay and marl that are interbedded with yellow sandstone, conglomerate, and limestone. The conglomerate beds are composed of pebbles of andesitic volcanic rocks, limestone, schist, and quartzite. Judging from the increase in coarseness of the Sepur strata southward, they were probably derived from highland areas in central and southern Guatemala and western Honduras.

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Wadell (1938, p. 341) has described the basal part of the Tertiary section in the southern part of the Departamento de Petén, Guatemala, as consisting of sandstone and sandy marl of the Sepur formation, resting on fossiliferous Upper Cretaceous limestone. To the north the Cretaceous rocks are overlapped by Upper Eocene (?), Oligocene, and Miocene rocks, largely limestone, marl, gypsum, and limestone breccia and conglomerate.

Carpenter (1954, p. 28) reports that red shale, siltstone, and sandstone estimated to be 10,000 feet thick make up the southern third of the Sierra San Juancito north of Tegucigalpa. He named this sequence the Valle de Angeles formation and thought that it might be Late Cretaceous or early Tertiary in age. This formation is overlain by younger pyroclastic and volcanic rocks.

Woodring (1928, p. 67) mentions the occurrence of lower Miocene molluscs in beds exposed on the Río Dulce in northeastern Guatemala. Van den Bold (1946, p. 43–48, 52–57, 126) studied ostracoda collected from Tertiary strata in Guatemala, British Honduras, and Cuba by geologists of the Bataafsche Petroleum Maatschappij. He found that some of the ostracodes resembled those reported from beds in the Southern United States. Van den Bold lists ostracodes and Foraminifera of Paleocene, early and middle Eocene, and Miocene ages from Guatemala and British Honduras.

Flores, who carried out field studies in northern British Honduras during 1950–51 (1952, p. 404–413), found that Upper Cretaceous, "Paleocene-lower Eocene," middle Eocene, and "Mio-Pleistocene" sedimentary rocks were present there. The Upper Cretaceous rocks include limestone, dolomitic limestone, dolomite, and a thin sandstone unit at the base of the exposed section. The "Paleocene-lower Eocene" rocks are limestone and dolomitic limestone which in places contain secondary black chert and a few bentonitic layers. The middle Eocene limestone is dense, commonly fragmented, and contains large chert inclusions. The "Mio-Pleistocene rocks" that overlie these formations include bentonitic clays with gypsum veins and poorly consolidated sands overlain by white sandy marls. No fossils of Oligocene age were identified, and Flores considers that the Oligocene was a period of general emergence in this area.

QUATERNARY SYSTEM

Quaternary deposits underlie large areas in northern Central America (pl. 1). The wide Pacific coastal plain is composed of interbedded gravels and sands derived principally from the volcanic upland areas, and most large valleys are floored with alluvium (Sapper, 1937, p. 36). The belt of Quaternary deposits along the Atlantic coast is narrower, and marine terraces are found in some places. In British

Honduras and Honduras, quartzose sands underlie savannas along the coast; in part these sands are Pliocene, but they also include Quaternary beds (Sapper, 1937, p. 84).

In Guatemala, Honduras, and El Salvador, pyroclastic and volcanic rocks of Quaternary age are widespread in the upland and Pacific coastal areas and represent the continuation of volcanic activity that began in the Tertiary. Some of the volcanoes are still active, and ash falls have contributed large volumes of material to the soils and recent deposits. (See Sapper, 1937, p. 10–22, for a detailed description of volcanic activity in Central America.)

IGNEOUS ROCKS

INTRUSIVE ROCKS

Intrusive rocks form a considerable area within the belt of pre-Permian metamorphic rocks that crosses northern Guatemala, Honduras, and Nicaragua. The intrusive rocks are chiefly granite and quartz monzonite but include a little granodiorite and diorite, and serpentine forms two belts that crop out discontinuously across Guatemala. Smaller bodies, composed chiefly of diorite, granodiorite, quartz monzonite, and granite porphyry, are scattered over central Guatemala, Honduras, and Nicaragua, south of the metamorphic-rock belt.

The granite and quartz monzonite are generally coarse grained and light to medium gray; biotite is their chief dark mineral. In places these rocks are massive, but for the most part they show a well-defined foliation parallel to the structure of the enclosing rocks. Their age is not known. Near San Miguel Acatán, Departamento de Huehuetenango, Guatemala, unfoliated granite cuts shale of the Santa Rosa formation and is thus younger than Permian(?); the granite may have been intruded at the close of the Paleozoic. However, some of the foliated granite contributed pebbles and boulders to the conglomerate of the Santa Rosa formation, indicating that this granite is pre-Permian(?).

Bodies of serpentine are found north of the metamorphic belt from the Departmento de Huehuetenango eastward nearly to Puerto Barrios; these are lenticular and are distributed along faults. Serpentine also occurs east of Saltán, in the southern part of the metamorphic belt. Serpentine intrusions form an important part of the central ranges of Guatemala. Two principal serpentine belts have been mapped (Sapper, 1899, p. 71; 1937, p. 102): one on the north of the metamorphic belt extends from San Sebastián eastward to Salamá, then from Panzós nearly to Puerto Barrios; the other, in the southern part of the metamorphic belt, extends from Saltán eastward, separating the metamorphic rocks into two parts. Both belts follow zones of strongly deformed rocks, probably along major faults, and therefore outline the principal structural features of Guatemala. The age of the serpentine is not definitely known, but it intrudes the Chochal limestone of Permian age and is overlain by the Todos Santos formation of Late Jurassic and Cretaceous age. The serpentine was therefore intruded sometime between the middle Permian and Late Jurassic. The serpentine intrudes the foliated granites but has been recrystallized locally by later intrusions.

In central Guatemala, Honduras, Nicaragua, and El Salvador, small intrusions of diorite, granite porphyry, granodiorite, and quartz monzonite cut sedimentary rocks as young as Cretaceous. These intrusive rocks are entirely unfoliated and may be of Late Cretaceous or early Tertiary age. Typical intrusions may be found at Metapân in El Salvador and at Agalteca in Honduras. Dikes and sills of fine-grained and porphyritic rocks related to these intrusive bodies are widespread. Carpenter (1954, p. 29–31) has described the intrusive sequence at the Rosario mine, San Juancito, Honduras, in detail. He recognized hypersthene andesite, dacite, and granodiorite in the mine area.

In southern Guatemala, southern Honduras, El Salvador, and Nicaragua, intrusive igneous rocks, chiefly andesitic in composition but including rhyolite and latite, form small irregular bodies, dikes, and sills. These rocks are related to the flows and pyroclastic rocks that make up the thick Tertiary cover, and some may have been the feeders for the flows and volcanic centers that were the source of the pyroclastic rocks. For the most part they are probably early Tertiary in age.

VOLCANIC ROCKS

Except for boulders of lava in Cretaceous conglomerate, the extrusive rocks known in northern Central America are of Tertiary and Quaternary age. They are chiefly andesite, basalt, rhyolite, and latite, and occur as interbedded flows, generally interlayered with pyroclastic rocks. Most of the volcanic activity took place during Miocene and Pliocene time (Sapper, 1937, p. 40), when predominantly rhyolitic pyroclastic rocks and andesitic flows appear to have been extruded, but volcanism has continued into the Quaternary, and some volcanoes are still active. The early volcanoes, which gave rise to the bulk of the pyroclastic material and flows, have largely been eroded so that only their roots remain. The chain of later volcanic cones that borders the Pacific slope of Central America is built upon the eroded earlier volcanic plateau, much as Mount Rainier and Mount Baker in the Cascade Mountains of the State of Washington are built upon uplands composed of volcanic rocks. The later volcanoes bordering the Pacific in Central America were probably formed for the most part during late Pliocene and Quaternary time, for many of them are very little eroded. In all, 61 principal volcanoes, and other smaller cones, are known to have been formed (see Sapper, 1927; also, other papers of his that describe Central American volcanoes). Activity still continues at several places, and Izalco in El Salvador and Santa María in Guatemala are spectacularly active. The pyroclastic rocks and flows forming these cones are largely andesitic in composition, but some cones in eastern Guatemala are basaltic. The maximum thickness of the volcanic section of the underlying plateau is not known; in many places, however, it is more than 3,000 feet thick.

In western Honduras, in the Departmento de Grácias, part of the Tertiary sequence has been studied by Olson and McGrew (1941, p. 1219–1244). The succession is 600–1,000 feet thick and consists of clay, sandstone, volcanic ash, and conglomerate, and some marl. The beds contain lower Pliocene vertebrate fossils, among them *Pliohippus hondurensis.*

Sayre and Taylor (1951, p. 170–185) have given a general account of the geology of El Salvador with emphasis on the geology of the valleys. They divided the volcanic rocks into 2 units of Tertiary age, 3 units of Pleistocene age, and 1 unit of Recent age. The Tertiary rocks include early(?) Tertiary basic lavas and felsites with intercalated pyroclastic rocks and sediments, and late Tertiary pyroclastic deposits intercalated with andesitic and basaltic lava flows. The oldest Pleistocene unit consists of water-laid clay, silt, and sand that were deposited as lake beds; these rocks interfinger with pyroclastic rocks and lavas. Basaltic and andesitic lava flows and pyroclastic rocks that make up the volcanoes of the central highlands in El Salvador have been assigned to the middle unit of the Pleistocene (older Quaternary lavas and pyroclastic deposits). The youngest Pleistocene unit includes sands and gravels that form terraces on the Río Lempa and its tributaries. The Recent volcanic rocks include basalt and andesite that were extruded from vents on the flanks of the larger volcanoes and pyroclastic deposits derived from central eruptions.

Sayre and Taylor (1951, p. 186–221) give also a detailed discussion of the ground-water conditions in each rock unit and discuss the ground-water hydrology in El Salvador, where studies were made of the water supplies of 30 towns and cities.

During recent years Meyer-Abich has also carried on reconnaissance mapping of a considerable part of El Salvador and has published detailed maps of several areas (1952, 1953). The results of this work are incorporated in the geologic map (pl. 1). The Tertiary and Quaternary rocks have been grouped into units which include older Tertiary volcanic rocks (probably pre-Pliocene) that contain rhyolitic and andesitic flows and pyroclastic rocks in northern El Salvador; younger Tertiary andesitic lavas and pyroclastic rocks of probable Pliocene age; andesitic and basaltic lavas and pyroclastic rocks mainly of

Quaternary age which form the chain of volcanoes that extends northwestward through the country; lacustrine beds, tuff, and ash deposits in some of the valleys; and andesitic and basaltic volcanic rocks in some volcanoes, such as Guazapa about 15 miles north of San Salvador, which are more deeply eroded than the youngest volcanoes and may be of early Pleistocene or even Pliocene age.

STRATIGRAPHY OF SOUTHERN CENTRAL AMERICA

Southern Central America, which comprises Nicaragua, Costa Rica, and Panama, is connected with South America by the Panama-Costa Rica isthmus, which is a submarine swell that is 200 miles wide at a depth of 6,000 feet below sea level, and 100–130 miles wide at a depth of 600 feet. The land width is 31–120 miles. The basement complex of the isthmus consists of Cretaceous(?) and pre-Cretaceous igneous, metamorphic, pyroclastic, and sedimentary rocks. Marine formations, largely clastic rocks, were deposited on these basement rocks beginning in Late Cretaceous time in southern Nicaragua and western Costa Rica and in Eocene time in Panama. Volcanic and pyroclastic rocks interfinger with the marine sediments, indicating concurrent volcanic activity.

At the end of early Miocene time strong deformation was accompanied by the intrusion of granite and syenite; less intensive deformation continued into late Miocene and Pliocene.

PRE-TERTIARY ROCKS

The pre-Tertiary rocks that form the basement complex in southern Central America are quite different from those of northern Central America. They consist of a complex of igneous and metamorphic rocks, of Cretaceous(?) and pre-Cretaceous age, which is shown on plate 1 as a single unit. The basement complex forms the principal axis of southern Central America, although over wide areas it is covered by younger sedimentary and volcanic rocks. The sediments that locally overlap the axis range in age from Cretaceous(?) to Pliocene; the seaways in which these sediments were deposited were stable in some places but highly unstable in others. On the whole, individual basins were small, and the sedimentary units deposited in them were highly lenticular.

In western Costa Rica the basement complex is composed chiefly of basaltic volcanic rocks, including flows, pyroclastic rocks, and pillow lavas. Diorite and diabase intrude these rocks in places and make up the axis of the Península de Nicoya, which trends northwestward (Roberts, 1944, p. 389). On the northeast and southwest, Late Cretaceous, Eocene, and Oligocene sediments overlap the basement complex. On the east the marine sediments are covered by volcanic and pyroclastic rocks which were derived from the chain of volcanoes of the middle cordillera of Costa Rica. At the Nicaraguan border the principal peaks are on the Pacific side of the isthmus, but to the south, in central Costa Rica, they are on the Caribbean side.

The Cordillera Central is a thick series of interbedded pyroclastic rocks and lavas forming a plateau upon which volcanic cones have been built. Irazú, the highest of these cones, reaches an altitude of 11,300 feet.

In Panama the basement complex is composed of indurated sedimentary rocks, intrusive and extrusive igneous rocks, and metamorphic rocks. Jones (1950, p. 899) noted basalt, metabasalt, metatuff, hornfels, dacite porphyry, and other rock types near the Canal Zone; these rocks have been complexly faulted, closely folded, tilted, and highly altered. Olsson (1942, p. 233) mentions andesite associated with greenstone and sandstone that may be of pre-Tertiary age near Punta Cambuyal on the Península de Los Santos.

ROCKS OF MESOZOIC AGE

The only rocks of Mesozoic age definitely known in southern Central America, in southern Nicaragua, have been described by Wegemann (Schuchert, 1935, p. 607). They consist of shale and sandstone with much volcanic material, are 6,800 feet in aggregate thickness, and contain Late Cretaceous fossils. Cretaceous fossils are also reported in northwestern Panama (M. L. Thompson, written communication), but thus far the fossils have been found only in boulders, whose source is not known.

TERTIARY SYSTEM

The Tertiary system of southern Central America includes formations as old as Paleocene, and the succession represents the whole of the Tertiary with fair completeness. Woodring and Thompson (1949, p. 223–247) have studied the Tertiary formations of the Canal Zone and adjoining parts of Panama. They prepared a chart, which is reproduced below, showing the correlation of formations in four areas in Panama and the Canal Zone.

The 3,000-foot thick Gatuncillo formation of middle(?) and late Eocene age, the oldest known Tertiary formation in Panama, consists of mudstone, siltstone, impure bentonite, and limestone lenses.

The Bas Obispo, Las Cascadas, and Bohío formations, of Oligocene age, include much pyroclastic material. The Bas Obispo formation is chiefly agglomerate composed of fragments of andesite and basalt imbedded in hard tuff; pebbles and cobbles are locally present, and in places the unit is rudely bedded. The overlying Las Cascadas agglomerate is less indurated and contains more fine-grained material. Both formations contain intercalated lavas. The Bohío formation, *Suggested correlation of Tertiary formations in the Panama Canal Zone and adjoining parts of Panama*[1]

Age		Gaillard Cut and Pacific Ocean side of isthmus, Canal Zone	Gatun Lake area and Caribbean Sea coast, Canal Zone	Madden basin, Panama	Quebrancha syncline, Panama
Early Pliocene			Chagres sandstone Toro limestone member		
Miocene	Late				
Miocene	Middle		Gatun formation		
Miocene	Early	La Boca formation, Pedro Miguel agglomerate, Panama tuff Cucaracha formation Emperador limestone member(?) Culebra formation		Caimito formation: Alhajuela sandstone member Calcareous sandstone member Chilibrillo limestone member	
Oligocene	Late		Caimito formation: Upper member Middle member	Caimito formation: Pyroclastic rock and clay member Limestone lens(?) Calcareous sandstone-siltstone member	Caimito formation: Calcareous siltstone member Quebrancha limestone member
Oligocene	Early	Las Cascadas agglomerate Bas Obispo formation	Las Cascadas agglomerate / Caimito formation, Lower member Bas Obispo formation / Bohio formation	Bohio formation	Bohio formation: Volcanic-rock member Gritty sandstone member
Middle(?) and late Eocene		Basement complex	Gatuncillo formation	Gatuncillo formation	Gatuncillo formation
Cretaceous(?)			Basement complex	Basement complex	Basement complex

[1] Broken horizontal lines indicate that top, or base, of formation in question is not exposed. Vertical ruling indicates hiatus; omitted between Gatuncillo formation and basement complex. Age of Las Cascadas agglomerate is questionable. (Woodring and Thompson, 1949, p. 223–247.)

estimated to be about 1,000 feet thick, consists of conglomerate, tuffaceous sandstone, and tuffaceous siltstone. It is largely nonmarine and is equivalent in age either to the Bas Obispo or both the Bas Obispo and the Las Cascadas formations, depending on the area, as shown in the chart on page 30.

The Caimito formation, of Oligocene and Miocene age, has been divided into 2 to 5 units. In the Gatun Lake area the lowest member is conglomerate and tuffaceous sandstone; the middle member is tuffaceous sandstone, tuff, and thin beds of limestone; and the upper member is predominantly tuffaceous sandstone, siltstone, and agglomeratic tuff. Elsewhere the formation consists of limestone and tuffaceous sandstone and siltstone.

In the Gaillard Cut area (the part of the Panama Canal across the continental divide), rocks equivalent to the upper part of the Caimito formation east of the Canal Zone have been divided into the Culebra, Cucaracha, and La Boca formations. The Culebra formation consists of carbonaceous shale and mudstone, tuffaceous clastic rocks, and calcareous rocks; a massive lenticular limestone member, the Emperador limestone, is present near the top of the unit. The Cucaracha formation is composed chiefly of bentonitic clay; other constituents of the formation are shale, siltstone, sandstone, tuff, and conglomerate. The La Boca formation consists chiefly of silty or sandy tuffaceous mudstone, but in places it contains sandstone, limestone, and conglomerate; members of the formation present locally are the Pedro Miguel agglomerate and Panama tuff.

The Gatún formation, in the Gatún Lake area and along the Caribbean coast of the Canal Zone, consists of massive sandstone, siltstone, conglomerate, and tuff, and is considered to be of middle Miocene and possibly late Miocene age. Its thickness probably exceeds 1,400 feet.

The Gatún formation is overlapped by the Chagres sandstone, which includes the Toro limestone member, a basal lime-cemented coquina. Fossils in these units indicate that they are of early Pliocene age.

Olsson (1942, p. 231–235) has summarized the Tertiary geology of the remainder of Panama; he has pointed out that the Tertiary rocks occur mainly in elongate marginal belts or embayments in the Isthmus of Panama. The rocks range in age from Eocene to Pliocene. The Eocene rocks in the Tonosí Valley in south-central Panama consist of limestone, shale, sandstone, conglomerate, and volcanic material, and have an aggregate thickness of about 2,000 feet. Near David, in western Panama, algal and foraminiferal limestones of late Eocene age are exposed. Oligocene rocks are widely distributed throughout Panama and include coarse clastic rocks as well as limestone and shale. The Miocene rocks in Panama consist of shale, sandstone, and limestone; local unconformities within the section show that orogenic movements were contemporaneous with marine deposition at many places. Following the Miocene the seaways in Panama were greatly reduced in extent. Pliocene and Pleistocene formations are known in only a few places, principally along the present coastlines (see Terry, 1956; the geologic maps are much more detailed than pl. 1 of this report).

The succession of Tertiary rocks in the coastal areas of Costa Rica is similar to the succession in Panama. The Atlantic slope of Costa Rica, according to Olsson (1922, p. 181–183), is underlain by Tertiary sedimentary rocks whose main dip is northward. The succession includes rocks ranging in age from Oligocene to Pliocene. The Oligocene rocks are mainly sandstone, shale, and limestone. The Miocene rocks, whose thickness ranges from a few hundred to several thousands of feet, include sandstone, dark shale, lignitic shale, conglomerate, and coralline limestone. Olsson (1922, p. 205–206; see also Woodring, 1928, p. 68, 88) pointed out that during the Miocene much of Costa Rica was largely submerged; during the early Miocene a sea extended across Costa Rica, connecting the Atlantic and Pacific Oceans. Disturbances during the later Miocene resulted in partial closing of the seaway, and in the Pliocene the area was elevated.

Williams (1952) has summarized the geology of the central plateau of Costa Rica. He pointed out that the plateau consists mainly of volcanic and pyroclastic rocks which rest on a basement of marine sedimentary rocks that range in age from Eocene to Miocene. The early volcanic eruptions in the Cordillera Central began in the late Pliocene or early Pleistocene and filled valleys cut in the pre-Pliocene rocks. The flows consist of pyroxene andesites and related lavas and pyroclastic rocks. After an interval of erosion and weathering of these rocks, part of the Meseta Central was covered by lava that was probably derived from two volcanoes, Poas and Barba, probably in the Pleistocene. Subsequently, andesitic and basaltic lavas and younger mudflows and residual deposits largely covered the older volcanic material.

QUATERNARY SYSTEM

In southern Central America Quaternary rocks form a wide coastal plain in eastern Nicaragua and part of Costa Rica, and, as in northern Central America, there is no coastal plain in much of eastern Panama. Major volcanism extended from the Tertiary into the Quaternary, but little volcanic activity has continued until Recent time except in southern Nicaragua and southern and central Costa Rica.

IGNEOUS ROCKS

Igneous rocks form an important part of the ranges of eastern Costa Rica and Panama, where they make up part of the basement complex. Granite, diorite, and granodiorite are the principal intrusive igneous rocks; syenite, monzonite, and other varieties also are reported

(Sapper, 1937, p. 120, 134). According to Woodring (oral communication), in Panama there were two periods of intrusion: probably Late Cretaceous, and Oligocene and early Miocene. Jones (1950, p. 901) has described plugs and dikes of basic rock of early Miocene age near Colón. Altered lavas and pyroclastic rocks, predominantly basaltic and andesitic, also form part of the basement complex.

The volcanoes of southern Central America, like those of northern Central America, are andesitic. Schuchert (1935, p. 568) pointed out that volcanoes in Costa Rica and Panama are only mildly active, and that they become progressively more active to the west in Nicaragua, El Salvador, and Guatemala.

GEOLOGIC STRUCTURE

Central America has been divided into two main geologic and tectonic regions: nuclear Central America, which comprises Guatemala, Honduras, El Salvador, and northern Nicaragua; and the Isthmian link, which comprises Panama, Costa Rica, and southern Nicaragua (Schuchert, 1935, p. 6; Sapper, 1899, p. 73–80; 1937, p. 49–65). These two regions are separated by the Nicaraguan lowland. Nuclear Central America includes the mountain ranges of ancient folded rocks that extend eastward across Guatemala, Honduras, El Salvador, and northern Nicaragua, and form the structural framework of northern Central America. The Isthmian link has a basement of igneous rocks with a veneer of Late Cretaceous and Tertiary strata and forms the young land bridge that connects Central and South America.

The ancient anticlinal core of the pre-Permian crystalline rocks is exposed in Estado de Chiapas, Mexico, where it is overlapped on the north by sedimentary rocks of late Paleozoic and Mesozoic age. The crystalline core extends southeastward, entering Guatemala near Huehuetenango, where it curves southward in a broad arc whose center is near Rabinal, and continues eastward into the coastal ranges of northern Honduras and Nicaragua, finally passing out into the Caribbean Sea. It is inferred from exposures of these rocks on the Isla Roatán that the core continues toward Jamaica, bounding the Cayman Trough on the south.

Sapper (1937, p. 41, 42) has emphasized that the major structures of Central America were formed before Permian time and may be as old as pre-Cambrian. The oldest trend lines of nuclear Central America are still evident in the alinement of major ranges and have probably to some extent controlled the more recent orogenic movements.

The Cockscomb Mountains in British Honduras are parallel to the ranges of Guatemala. Submarine ridges connecting the Misteriosa and Cayman Banks may be a submerged eastward continuation of the Cockscomb Mountains, bounding the Cayman Trough on the north.

The rocks of Paleozoic age that flank the anticlinal core are folded in western Guatemala and seem to be progressively more metamorphosed to the east, so that the shale of the Santa Rosa formation in the west becomes phyllite and schist near Puerto Barrios, in eastern Guatemala, and in Honduras.

The rocks of Paleozoic age were folded and eroded in pre-Jurassic time, for the Todos Santos formation everywhere rests on folded Permian rocks of the crystalline basement. Intrusions of granite and serpentine, probably related to this orogeny, cut the Permian and crystalline rocks and may have been emplaced between late Permian and late Triassic time.

The El Plan formation and possibly the lower part of the Todos Santos beds were deposited in terrestrial basins which covered much of Central America during the Jurassic, and continental deposition probably prevailed throughout the Jurassic and Early Cretaceous. Toward the close of the Early Cretaceous, submergence changed the continental basins to marine embayments, and marine limestone and dolomite were deposited over an area roughly coextensive with the underlying terrestrial beds. Deposition continued in most places into the Late Cretaceous. Imlay (1944, p. 1090, 1104) clearly shows the probable extent of the Cretaceous seas on his paleogeographic maps of Central America.

The earliest Tertiary beds are coarse clastic rocks of the Sepur formation, whose composition shows that they were derived from a wide variety of sources including crystalline rocks, Permian limestone and quartzite, and limestone and volcanic rocks of Mesozoic age. The Sepur strata were probably deposited during orogenic movements in Late Cretaceous and Eocene time. Intrusions of granodiorite and diorite that accompanied the orogeny cut the Cretaceous rocks throughout eastern Guatemala and Honduras. Folds, largely trending eastward, were developed in the Cretaceous rocks and appear also to have involved rocks as young as those of Sepur age.

The orogenic movements culminated in thrust faulting, first mapped in the Departamento de Huehuetenango (pl. 9), which thrust the Permian rocks over the Todos Santos formation and the Cretaceous limestone. The extent of the thrusting is not known, and many such faults may be present in central Guatemala. Faulting shown by Sapper (1899, table 1) in the northern part of the Sierra de los Cuchumatanes may include thrust as well as normal faults.

The Sepur strata, exposed in Guatemala in the Departamentos de Huehuetenango, Alta Verapaz, and Petén, were involved in the folding and the thrusting, and the orogenic movements must therefore be as late as Eocene and are possibly in part post-Eocene. However, by Miocene time the Petén area had become more stable, for Miocene sedimentary rocks overlapping the earlier Tertiary units are hardly deformed.

Uplift of the ranges in nuclear Central America continued during the Tertiary, and the volcanic activity which had begun in Early Cretaceous time (Schuchert, 1935, p. 33–36) reached its full force in mid-Tertiary time. The distribution of the early volcanoes is not well known. Bodies of intrusive rock in the principal mine areas may well indicate centers of former volcanic activity. The lava and pyroclastic rocks that accumulated south of the older ranges have an aggregate thickness in some places of more than 3,000 feet.

One of the most striking features of the Caribbean Sea is the Cayman (Bartlett) Trough (Taber, 1922, p. 91–113; 1934, p. 614–615; Woodring, 1928, p. 414–415). It is interesting to note that this trough is alined with the southern part of the Petén lowland, which is bounded on the south by the complex ranges of central Guatemala. The northern borders of these ranges are major faults, possibly of both thrust and normal type. Hess (1933, p. 34–36; 1938, p. 86–87) interpreted the Bartlett Trough as a downfaulted graben block formed by shearing in the basement rocks during Miocene time. He postulates that the block south of the fault moved eastward horizontally; then, relief of compression permitted complex block faulting south of the fault. It seems more likely, however, that the major tectonic elements of northern Central America were probably formed before the Permian. The deformation that caused the present submarine relief is, as Hess suggests, probably younger; the deformation may have started in the Cretaceous and have culminated late in the Tertiary.

Bucher (1947, p. 112–113) has also considered the problems of the Caribbean Sea basin structure. He pointed out that the region underwent intense compression in Late Cretaceous time; the east side of the basin yielded much more than the west side, presumably due to the influence of structures of Paleozoic age on the west in Guatemala and Honduras.

In Honduras, valleys transverse to the eastward-trending ranges were formed by block faulting (Redfield, 1923, p. 474–493). Among these is the Valle de Comayagua, which is part of a block-faulted area extending from the Pacific Ocean northward to the Caribbean Sea. Parallel structures along the coast of British Honduras and in northern British Honduras may well be related to these transverse faults. Inasmuch as these faults cut across the trend of the Cayman Trough, they are probably of late Tertiary age.

Meyer-Abich (1952, 1953) has described the structural features of El Salvador and has discussed the relationship of these features to the distribution of volcanoes. He has shown that the principal faults trend northwestward, parallel to the major volcanic chain and to the coastline of El Salvador, and that other fault sets strike about N. 30° E. and north-northwest. Hot springs and fumaroles in El Salvador are thought by Meyer-Abich (1953) to be related to structural features that trend northwestward, parallel to the zones of major faulting.

Williams and Meyer-Abich (1953) have shown that Lago de Ilopango in El Salvador occupies a graben that developed over a long period of time and was partly filled by a succession of lavas and pyroclastic rocks during the stages of its formation. Other lake basins in Central America are also believed by the present writers to have been formed, in part at least, by collapse. Among the most notable of these are Lago de Atitlán and Lago de Amatitlán in Guatemala.

ORE DEPOSITS

The principal objective of the Central American Minerals Mission was to evaluate the deposits of strategic minerals in Central America. Deposits of antimony, chromite, manganese, mercury, mica, and quartz were examined, and some of them were mapped in detail. Studies of deposits of other minerals, especially of iron and base metals, which offered hope of postwar production were also undertaken. In addition, a short account of the gold and silver deposits of Central America is included.

The purpose of this report is to give a general picture of the mineral resources of Central America. Because of time limitations, no exhaustive regional studies were attempted. In some areas only a few typical deposits were examined in order to gain an idea of the potentialities of the areas. Actual mapping was carried on chiefly in districts of known reserves or in producing areas reasonably close to routes of transportation.

In this part of the report, following the history of mining, the deposits are arranged alphabetically according to commodities. The commodities are in turn subdivided geographically from northwest to southeast, and are further subdivided into areas or districts and individual deposits.

HISTORY OF MINING

Long before the discovery of America by Columbus, gold was prized by the Mayans and other Indian races that inhabited Central America. In Costa Rica, Panama, and Honduras, gold ornaments fashioned in various forms have been discovered in tombs and at sites of worship. When Columbus came to Honduras on his fourth voyage, in 1502, he was greatly interested in the gold ornaments worn by the natives (Wells, 1857). The first settlers in northern Honduras, in 1509, must have had as one of their objectives the search for the source of the gold. Exploring parties penetrated far inland, but it was not until about 1524 that Olancho, the principal source of the placer gold, was visited; the Spaniards began placer operations soon afterward. Presumably the Spaniards attempted to enlist the voluntary aid of the Indians in increasing the production of gold, and when that attempt failed they enslaved them and forced them to work in the mines. As the Indians were given little except their food, which was largely available nearby, mining costs were low. Low-grade deposits, containing only small pay streaks not now profitable to mine, were worked down to the water table and, in places, below it.

The Spaniards were trained in lode as well as placer mining and during the few decades after 1524 must have discovered most of the known gold-bearing lodes in Honduras while searching for additional placer fields. Only a few of the mineral deposits examined during the past 50 years do not show signs that they were known to the Spaniards. In some places the principal ore shoots of large ore deposits were not found because of the lack of facilities for deep mining, but since the slave labor supply was nearly inexhaustible, great effort was expended on veins too low grade or too narrow to be exploited by present methods. The Spaniards were not bound by present considerations of the cost of operations, for any production above administrative costs, however small, was profit. To say, therefore, that a property has merit simply because it was worked by the Spaniards may be misleading.

The Spanish domination continued for nearly 3 centuries, but although church chronicles and political archives contain numerous references to mining, few data are available on actual production. However, judging from the extent of the workings left by the Spaniards, it seems that the production must have been substantial.

As time went on, the bonds between Spain and Central America became weaker, and insurrections that began early in the 18th century finally culminated in the renouncing of Spanish authority in 1821. From 1821 to 1839 the Central American countries were united in a loose confederation; this period was characterized by a succession of local uprisings fomented by different groups attempting to gain power. These uprisings were interspersed with quiet periods, but little organized mining was carried on because of the instability of the local governments. In 1839 the confederation was dissolved and the Central American countries were outlined in approximately their present form. During the 1840's and 1850's local strife prevailed everywhere and mining virtually stopped. After the early 1850's, when the Central American governments became stabilized, the political climate again favored foreign investments.

The discovery of gold in California must have renewed interest in the gold deposits of Central America, for many of the miners bound for California passed through Central America on their way north.

In 1856 an English and French company began to mine the rich silver veins of the Concepción district in eastern Guatemala. Shortly afterward, foreign investors, spurred by the writings of Wells (1857), Dollfus and Montserrat (1868), and Belt (1888), became interested in Central American mining, and operations were begun in the Jabalí and Chontales districts of Nicaragua and the Aguacate district of Costa Rica. Later, the Rosario and Yuscarán mines of Honduras came into production.

The construction of railroads, which began in the 1870's in several Central American countries, also aided mining activities. The peak of mining was reached between 1880 and 1910 when other properties in Costa Rica and El Salvador began production. Many of the bonanza shoots were mined by 1910, and, although the introduction of the cyanide process prolonged the operation of many of the mines, production dwindled and reached a low point between 1920 and 1932.

In 1932, when the price of gold was increased to $35 an ounce in the United States, many mines were reopened and some new properties were put into operation. By 1938 the Neptune, La Luz, La India, and other deposits in Nicaragua; the Monte Cristo, Potosí, and San Sebastián mines in El Salvador; and the Abangares, La Unión and others in Costa Rica were in operation.

World War II caused some properties to close down and others to decrease production, but on the whole production was fairly well maintained. Increased activity in mining in Central America has been shown in the postwar years, and it is probable that any property with merit will be thoroughly tested. It is especially noteworthy that base-metal deposits are receiving more attention, and three lead-zinc operations—in Guatemala, in El Salvador, and in Honduras—were producing concentrates in 1951. Tests were being made in 1952 preparatory to installation of copper concentrating and smelting equipment in Nicaragua.

ANTIMONY DEPOSITS

Antimony deposits are known in Guatemala, Honduras, and Nicaragua. All the deposits are associated with Tertiary rocks exposed in regions of mid-Tertiary volcanic activity. For the most part they form pods or narrow veins, and individual ore bodies are small. The antimony deposits do not occur in well-defined districts, but appear to be widely scattered throughout the dissected volcanic plateau.

Although attempts have been made to produce antimony in the three countries mentioned, ore has been shipped only from Honduras. Total production amounts to about 700 short tons, of which the major part has come from the El Quetzal mine in the Departamento de Copán. Because of the remoteness of the deposits and the consequent high shipping costs, attempts at exploitation of the deposits have not been encouraging. Some of the mines can be profitably operated on a small scale in times of high prices, but no large production can be expected from deposits thus far discovered.

The information from which the following section on antimony deposits was compiled was furnished by several geologists. Roberts mapped the El Quetzal, Las Flores, San Fernández, and La Unión deposits in Honduras and the La Cadena deposit in Nicaragua. Fred H. Dakin (1939, unpublished report) kindly furnished the data for descriptions of other deposits in Honduras. Irving and P. W. Guild (1942, unpublished report) described the deposits in Guatemala.

HONDURAS

EL QUETZAL MINE

The El Quetzal mine (lat 14°47′ N., long 88°58′ W.), in the Departamento de Copán, Honduras, is 3 miles south of San Agustín near the summit of the Sierra del Gallinero, at an altitude of 5,500 feet (fig. 1). Trails extend from the mine to Copán, the nearest shipping point, and also to Santa Rosa.

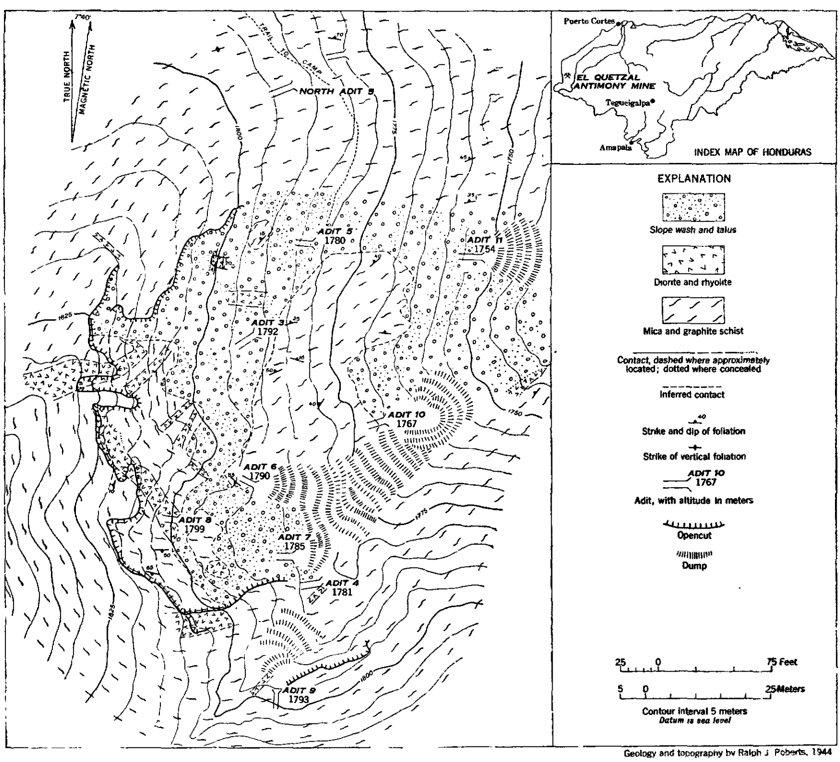

FIGURE 1.—Geologic map of the El Quetzal antimony mine, Departamento de Copán, Honduras.

The mine began production in December 1941 and up to October 1944 had yielded 575 short tons of chemical-grade antimony ore, averaging about 62 percent antimony (see table below). The bulk of this ore was shipped to the Wah Chang Trading Corp. in New York, but the last 100 tons produced in 1944 was shipped to the Harshaw Chemical Co. in California.

Antimony ore produced from the El Quetzal mine, Honduras, 1942–44 [1]

Year	Weight (short tons)	Antimony (percent)	Remarks
1942	201. 6	61. 32	Includes 2.13 tons of ore from the Las Flores mine.
1943	200. 31	62. 20	
1944	175. 0	62. 0	Estimated.

[1] Data published with permission of mine owners.

The owners report that exploratory work was carried on during 1947, 1950, and 1951, but no shipments were made. The workings consist of 11 adits and several opencuts which follow the ore zone for a total length of 420 feet and a depth of 151 feet (pl. 3).

Geology

Graphite and mica schists of unknown age which strike westward and dip steeply (pl. 4; fig. 1) have been cut by dikes and sills of diorite and felsite. In the mine area the rocks have been highly sheared and fractured along faults that trend north to N. 10° E. and dip steeply westward; the shearing extends over a width of 50 feet or more. The shear zone contains the ore bodies, which are commonly in fault slivers and in fragments of intrusive rock.

Description of the ore bodies

The ore bodies are lenticular pods and veins. Stibnite is the most abundant antimony mineral except near the surface, where it has been partly altered to antimony oxides; it is locally accompanied by small quantities of pyrite, arsenopyrite, and sphalerite. Generally the ore consists of almost solid stibnite with little gangue, but in some places quartz and a carbonate—probably dolomite—are found in cavities and also crystallized with the stibnite. The ore minerals in part fill cavities in the fractured schist and igneous rocks, and in part replace the rocks. Euhedral stibnite needles partly fill cavities in many places in the shear zone, indicating that cavity filling was the principal vein-forming mechanism.

The ore zone extends along the strike for 420 feet and in 1944 had been mined more or less continuously for 300 feet of this distance. Stopes extended up to the surface from a depth of 151 feet in the north-central part of the workings. The ore was mined by overhand stoping followed by filling. Because of the friable nature of the ore, the loss in the fine fractions was as much as 40 percent. Moreover, owing to irregularities in the veins and lenses, pillars of ore have had to be left in some places, and local caving of stopes has caused further losses. Two principal ore zones, 1 north and 1 south of the winze in adit 6, have been mined (pl. 4; fig. 2). The north zone comprises a series of lenses, some of them overlapping, that range in thickness from 3 to 18 inches. The ore has been mined almost continuously along the strike for 200 feet and downdip from the surface nearly to level 11, a vertical distance of 151 feet. The zone was in the sheared schist of the footwall of the principal dike; in some places it was in contact with this dike, but in most places a foot or more of sheared schist separated them. The ore shoot narrowed downward, and above level 11 the stope length was only 50 feet. Here the ore body consisted of 2 veins, each 2 inches wide, separated by a dike 3 feet wide. One vein widened upward and was a foot wide at level 5. Between winzes 3 and 6 ore was first mined in an opencut, but in 1942 the cut was abandoned because of slides, and underground mining began on levels 3, 6, and 7. The ore was stoped upward to the cut and was then followed northward and downward. Later, levels 4, 5, 10, and 11 were driven to explore the ore shoots at depth.

The major part of the ore mined came from the stopes south of winze 6. The ore was stoped discontinuously along the strike for 200 feet and from the surface downdip to level 10, a vertical distance of 100 feet. The ore pods were 20–40 feet long, were as much as 30 inches thick, and were composed of solid stibnite. The principal stopes were mined from lower level 4 to the open-pit level south of shaft 3. As shown in plate 4, some of the ore pods overlapped, and locally 2 or 3 parallel pods were mined together.

The stibnite ore bodies occur in crushed schist and also in dike rock. The major part of the faulting probably preceded the deposition of stibnite, furnishing channelways for introduction of the ore-forming solutions; however, shearing continued after deposition of stibnite, for in many places the stibnite has been fractured and crushed.

The dike rocks played an important role in the localization of the ore bodies. Shearing stresses caused minute fracturing of the dikes and adjacent schist, providing open spaces through which solutions were able to move freely. The open spaces were filled with stibnite, and continued fracturing reopened the fissures and again permitted the entrance of antimony-bearing solutions.

No ore was found in adit 9, which is east of the principal ore zone. A small pocket was found at shallow depth beneath the stream channel in front of the adit portal. Adit 4 was originally driven to intersect ore bodies exposed in the bottom of the pit, but it led to the discovery

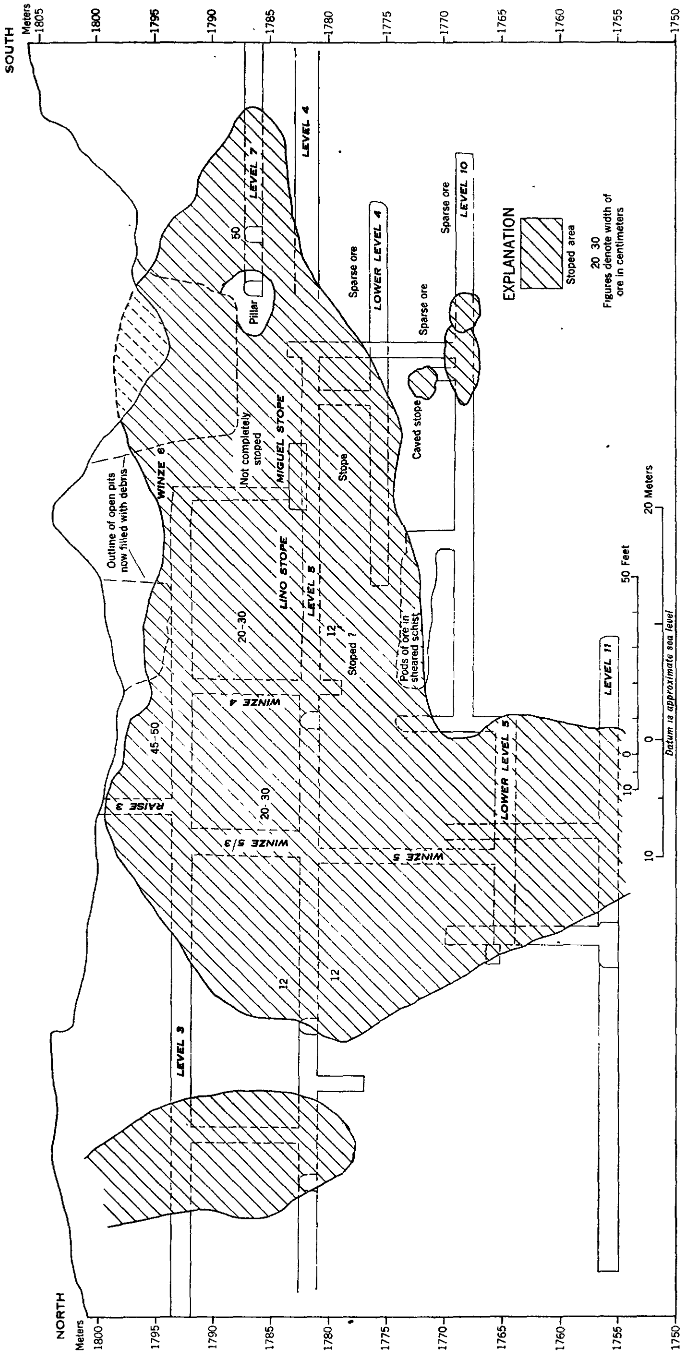

FIGURE 2.—Projected longitudinal profile of the El Quetzal antimony mine, Departamento de Copán, Honduras.

of several new ore bodies which account for a considerable part of the ore mined. Eighty feet from the portal a lens as much as 24 inches thick was mined; this lens was followed northward and 2 ore bodies were stoped from the level upward to the pit. These stopes were on ore bodies that dipped steeply east, presumably along minor shear zones in the main zone, which dips steeply west. Winze 4 was sunk on ore in a parallel lens west of stope 2 and was used to remove ore from the Miguel and Lino stopes. The Miguel stope contained a body of ore as much as 30 inches wide that was composed of solid stibnite in schist between parallel segments of a dike. This ore was mined downward to the Lino level, where it narrowed to about 12 inches. In the Lino stope, an ore body averaging 6 inches in thickness was mined down to lower level 4. Adit 7 was driven below the surface pit to mine ore from a lens that was 24 inches wide in some places. The ore lay between dike rock and sheared schist that contained much pyrite. Exploration south of the crosscut and to the west was not encouraging. In September 1944 the stope from level 10 had been extended to about 15 feet above level 10, but only small pockets of stibnite had been found.

In the stope between winzes 3 and 6 the ore lens at level 5 was 2–3 inches thick. Upward it thickened, becoming 12 inches thick near level 3 and 18–20 inches thick from there to the surface. Near winze 3 there were two parallel lenses of ore. With the exception of the block below level 10 and west of winze 3, the ore has been stoped to the surface. None of these workings were accessible at the time of the authors' visit.

In the stope between adit 5 and winze 3 the ore occurred in lenses ranging from 3 to 12 inches in thickness; in several places the lenses overlapped. Some of the ore lay between the dike and sheared schist, and some was in the shear zone near the dike. The ore shoot pinched to a few inches in thickness at shaft 5 but became thicker at raises 5 and 3 and was as much as 12 inches thick above level 5. Ore at depth and north along the drift is not promising.

Below level 5 the ore shoot was explored by means of winze 5; stibnite needles and occasional small pockets of stibnite were found along the dike contact, but none were large enough to be stoped. Raise 11/5 was run from level 11 to stope an ore shoot that extended upward from the level. Although the ore shoot rarely exceeded 6 inches in thickness, it was continuous and of uniformly high grade.

Suggestions for further prospecting

All the easily available ore at the El Quetzal mine above level 11 (5,754.5 feet elevation) has been stoped. Exploration along the strike south and north of the principal ore bodies has not been promising, but, as it has not been thorough, further work may be warranted.

Exploration should also be extended west of the present workings to see whether other parallel mineralized shear zones are present. Up to 1951, new ore discoveries on the lowest levels were reported to be small, but other ore bodies may exist at depth.

Promising discoveries were made in 1948 west of the present workings described, and other antimony deposits are known in the vicinity of El Quetzal, but none of them have been explored. The following occurrences were reported by Mr. Nater: Rafael Cuesta, who lives in the village of Santa Cruz, reports stibnite on his property; antimony ore is reported near La Encarnación; and stibnite veins as much as an inch in width were discovered in dike rock at the water intake for the San Andrés power plant. Antimony ore is reported also in the mountain range west of El Quetzal and in adjacent parts of Guatemala.

BENJAMÍN MINE

The Benjamín mine is about one-half mile from a boat landing at Pedernales, near the southwest corner of Lago de Yojoa, at an altitude of 2,800 feet, about 300 feet above the lake. The property is owned by Eduardo da Costa Gómez, Andrés Leiva, and Dr. S. M. Waller of San Pedro Sula.

The ore is composed of mixed antimony sulfide and oxides accompanied by witherite and quartz; it forms pockets in shear zones that trend N. 20°–70° E. and cut limestone. The pockets are small, widely separated, and do not appear promising. Antimony is also reported nearby, at Santa Lucía.

SÍRIA MINE

The Síria mine is at Suyatal, Departamento de Tegucigalpa, about 50 miles north of the town of Tegucigalpa. It can be reached by automobile during the dry season. The property is owned by Gen. Pedro Triminio and Marco Carla Raudales of Tegucigalpa. The workings are shallow cuts and a short adit.

The ore, stibnite in black slate, is associated with intrusive basalt which also contains a little stibnite. The pockets of ore are small and widely scattered. Two shipments were made in 1935: 21.65 tons containing 52.49 percent antimony was sent to London, and 11.3 tons containing 47.18 percent antimony was sent to New York. In 1941 a shipment of 5 tons was sent to El Segundo, Calif.; this ore contained 56.15 percent antimony and 0.025 percent arsenic.

Other antimony deposits are reported near Cedros, Departamento de Tegucigalpa, but these were not visited by Mr. Dakin.

LOS HORNITOS MINE

The Los Hornitos mine is 9 miles east of Yoro, Departamento de Yoro, at an altitude of 3,400 feet. Olanchito, the nearest shipping point, is about 45 miles to the northeast. The mine is owned by Miguel

Cubero, Andrés Leiva, and Dr. S. M. Waller of San Pedro Sula, but in 1944 it was leased to Dr. P. Jorda Kahle of New Orleans.

The ore forms stringers and pockets in a shear zone 10 feet wide which strikes N. 81° W. and dips 40° NE. It is mainly stibnite, with some antimony oxide and barite. Shallow cuts extend for about 400 feet along the shear zone. Twenty-seven tons of ore was shipped by Sr. Cubero in 1938, 25 tons of it to Germany and 2 tons to Italy. The German shipment contained 48.8 percent antimony. The ore was shipped by airplane from Yoro to Olanchito, and thence over the Standard Fruit Co. railroad to the port of La Ceiba.

Stringers of stibnite in granodiorite and diorite are reported in prospects at Sierra Prieta and Puertecito, about 3 miles from the Los Hornitos mine.

LAS FLORES DEPOSITS

The Las Flores denouncement,[1] 4 miles west of Copán, Departamento de Copán, is near the Guatemalan border. The property is owned by Manuel Bueso of Santa Rosa de Copán and Rafael Villanel, Enrique Segura, and Armando J. Castajones of Copán. So far as is known only 5 tons of ore had been shipped from these deposits up to 1943. It was sent to the Harshaw Chemical Co., Los Angeles, Calif., and contained 37 percent antimony.

The country rock is rhyolite, which may be intrusive or extrusive. Tuffs and clastic sedimentary rocks crop out near Las Flores.

Antimony deposits have been explored at three places in the area. One, at an altitude of 4,950 feet, consists of small pockets of stibnite in rhyolite along a fracture zone trending N. 45° W. Twenty or thirty tons of ore estimated to contain 20–30 percent antimony was mined in the course of exploration. The fracture zone has been explored to a depth of 24 feet and for 30 feet along the strike, but no material of shipping grade has been found. Other workings are at altitudes of 4,690 feet and 4,300 feet. The highest opening is a shallow cut in rhyolite; although some float of good grade was found near this opening, the ore has not been found in place. The other workings explore a stibnite vein in rhyolite. The vein strikes north and dips 35° E., nearly parallel to the slope; it was as much as 8 inches thick and was mined for 50 feet along the strike and as much as 30 feet downdip. The 5-ton shipment of ore, containing 37 percent antimony, came from this vein.

Although no promising ore bodies have been found in the Las Flores area, further prospecting may be warranted because of the widespread shows.

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[1] A mining-law term that refers both to a claim made on land to which the government holds mining rights and the act of making (denouncing) the claim.

SAN FERNÁNDEZ MINE

The San Fernández property, owned by Arturo Laínez and others of Talanga, Departamento de Tegucigalpa, is about 2 miles north of the village of Jalaca. About 5 tons of float ore was shipped from the property by the Casa Uhler (a business house) in 1941. The workings consist of 2 shafts, 15 and 20 feet deep, and shallow opencuts. The ore occurs in and adjacent to fractures trending N. 10°–30° W. in limestone. Up to 1945 only small pockets had been found, and the outlook for future development is not promising.

SAN FRANCISCO MINE

The San Francisco mine is near the head of the Río Guaymas, at an altitude of about 2,600 feet, 50 miles by trail from El Progreso. From El Progreso, the nearest rail shipping point, ore goes to Puerto Cortés for shipment by steamer. Miguel Cubero of San Pedro Sula owns the mine. In 1941 he shipped to France 5 tons of ore, which assayed 51 percent antimony. In 1944 he is reported to have shipped 40 tons to the United States, but its tenor is not known.

The ore is in pods associated with quartz that cuts schist in a shear zone striking N. 47° W. and dipping 72° SW. The pods are as much as 18 inches wide but are generally no more than 3 or 4 feet in length. The ore zone crops out on both sides of the Río Guaymas.

LA UNIÓN MINE

The La Unión mine, 3 miles northwest of the town of La Unión, Departamento de Olancho, is near the headwaters of the Río Mangulile at an altitude of 3,800 feet. The area is accessible by plane or by trail from Coyoles, a shipping point on the Standard Fruit Co. railroad. The property, originally denounced by Francisco H. Antúnez and Francisco García, was owned in 1944 by Eleazar F. Vargas of Tegucigalpa. In 1941 27 tons of ore containing about 40 percent antimony was produced and shipped to New York. Sr. Vargas leased the property in 1943 to Manuel Bueso and Rudolf Nater of Santa Rosa de Copán. During late 1943 and early 1944, 30 tons was mined and sent on muleback by way of Coyoles to La Ceiba for shipment to the United States.

The rocks in the area are interbedded red sandstone, conglomerate, and shale of the Metapán formation. In the vicinity of the antimony deposits these rocks lie nearly flat, but elsewhere they are gently folded. The deposits occur in a fault zone, trending N. 30° E., that cuts these rocks.

The workings consist of several shallow trenches and opencuts and three short adits. An adit at the south end shows a few small veinlets and pockets of stibnite in fractures that strike N. 30° E. and dip 55°–70° SE. The trenches above and below the adit are in silicified rock, but they show no stibnite. The central workings are in barren red pebbly sandstone. The north workings show stibnite on fractures trending northward and eastward; the veins are as much as 6 inches wide but are discontinuous. The open pit that yielded the 27 tons of ore mined in 1941 was caved at the time of Roberts' visit in 1943, and no ore could be seen. Subsequently an ore body was discovered that yielded 30 tons of ore, which was sorted to a grade of 62 percent antimony.

With further exploration, other ore bodies may be found, but it appears that this mine will be productive only during times of high prices.

GUATEMALA

LAS TABLAS DEPOSIT

The Las Tablas antimony deposit is about 6 miles east of Palencia, Departamento de Guatemala. Palencia can be reached by car from Guatemala City, a distance of 22 miles. The property, owned by Manuel Franco, is at an altitude of about 5,400 feet. The workings consist of a caved adit, said to be 7 feet long, in volcanic rock and clay. The material on the dump and on a nearby bank shows disseminated stibnite needles. It is reported that a pocket of ore was mined and shipped, but the amount is unknown. A bin nearby contained 5 tons of ore, largely fine material, when visited by Guild. Other antimony prospects are reported nearby, but none of them have been explored.

EL CARRIZAL PROSPECT

The El Carrizal antimony prospect is about 10 miles by trail northeast of Olapa, Departamento de Chiquimula. The deposit was explored in 1936 by an English company, but no shipments have been reported. The antimony ore is in volcanic rocks; only a small pocket was found. All the ore has been mined out except for a few remnants in the workings. The outlook for further production is not promising.

EL HORNO PROSPECT

The El Horno prospect is 18 miles east-northeast of Olapa and about 5 miles northeast of Carboneras, near the Guatemala-Honduras border. No production is reported.

The antimony ore is in veins in granodiorite, which in this area intrudes phyllite. The veins are narrow, commonly ½–6 inches wide. A vein 2 feet in maximum width is said to have been found in the area. Such a vein might be profitably mined during times of high prices for antimony ore.

NICARAGUA

LA CADENA PROSPECT

The La Cadena antimony prospect is 90 miles north of Managua in the Departamento de Nueva Segovia, near the Honduras border. To reach the property, one must go west 2 miles by road from the village of Palacaguina, then 1 mile northwest by trail. The Inter-American highway passes about 1 mile south of the property. The owners are Pio Castellón and others of Managua. No ore has been shipped.

Palacaguina is surrounded by rolling hills that rise about 2,500 feet above sea level; some peaks to the east, north, and west rise to 4,000 feet. The hills are for the most part volcanic flows and pyroclastic rocks, but in the more deeply incised valleys the underlying schist is exposed.

The mine workings, which consist of 2 pits—25 feet deep and 15 feet deep—and 3 short adits, are in mica schist that has been cut by quartz veins and is complexly sheared. Dikes of altered igneous rock, probably andesite, intrude the schist and were probably channels for the volcanic flows exposed in the hills nearby.

The ore bodies consist of stibnite with a little antimony oxide, pyrite, and quartz. Although the stibnite is in some places nearly pure, it is generally intergrown with the quartz and contains pods and fragments of the enclosing rock. The ore bodies are lenticular or irregular in shape and occur in the dikes and in the adjacent schist. The largest body mined was about 10 feet long, 5 feet deep, and as much as 3 feet thick.

At the time of visit in 1942, only a little ore showed in the workings. A few tons of siliceous ore was piled near the workings. Careful sorting would be required to obtain a product of shipping grade.

CHROMITE DEPOSITS

Chromite deposits in Central America have been exploited only in Guatemala. Here the deposits are associated with intrusive serpentine and peridotite, which form two discontinuous belts extending from the Mexico-Guatemala border eastward to Puerto Barrios (pl. 1).

GUATEMALA

Chromite deposits have been found in three areas in Guatemala: in the Jalapa district, in the Cabañas district, and near Morazán. Of the three, the Jalapa district has been the most productive.

PRODUCTION

Chromite was first discovered in Guatemala by Fred Cutforth in 1917 at the Corona deposit near Jalapa. Later this deposit was purchased by the International Railways of Central America and its development was begun. Other deposits were found nearby, and between 1918 and 1920 about 2,700 long tons of high-grade metallurgical chromite was produced. In 1930 the Jalapa deposits were leased to the Vanadium Corporation of America, which since then has operated the mines on a small scale. Between 1930 and 1943 about 6,300 long tons of chromite was shipped from the deposits. (See table below.)

The ore in the Cabañas district was discovered by Mariano Eskanasy in 1918. As the deposits were small they were not immediately developed, but when prices of chromite ore increased in 1943 the properties were brought into production, and 850 long tons of metallurgical chromite was shipped in 1943 and 1944.

Production and partial analyses of chromite ore from Guatemala, 1918–45

[Data furnished by Vanadium Corporation of America]

Mine	Tons (long)	Cr_2O_3 (percent)	FeO (percent)	Cr:Fe
Corona	[1] 3, 465	52. 56	14. 01	3. 50
La Gringa	[1] 5, 357	55. 30	14. 14	3. 00
La Paz no. 1	491	58. 00	13. 12	3. 35
La Independencia	272	55. 70	13. 16	3. 16
La Esperanza	268	56. 02	12. 50	3. 17
La Joya	[2] 500	51. 00	----------	2. 7
La Corona	[2] 100	----------	----------	----------
Buenos Aires	[2] 75	53. 00	----------	2. 8

[1] Some of the tonnage included was produced between 1918 and 1921, but the assays are of material shipped only after the property was acquired by the Vanadium Corporation of America in 1930.
[2] Estimated.

Sr. Eskanasy shipped two lots of ore from the deposits of the Cabañas area in 1945; the analyses in percentages are as follows:

Production and partial analyses of chromite ore, Cabañas area, Guatemala, 1945 [1]

Tons (long)	Cr_2O_3	FeO	SiO_2	Al_2O_3	MgO	S	P	Cr:Fe
634. 34	50. 41	12. 74	4. 80	9. 60	15. 65	0. 1	Tr.	2. 70
160. 63	48. 31	11. 97	6. 71	9. 52	15. 94	. 014	Tr.	2. 76

[1] Names of mines not known.

GEOLOGY

The chromite deposits are in serpentine and peridotite that crop out in two roughly parallel bands extending eastward across Guatemala. The peridotite and serpentine cut sedimentary and metamorphic rocks of Paleozoic and pre-Paleozoic age and were probably intruded at the close of the Permian period.

The peridotite, where fresh, is generally dark green or black. When altered to serpentine it is commonly greenish, in places a light yellowish green, but for the most part medium to dark green. Slopes developed on the serpentine in low dry areas are generally smooth, with a thin soil that supports only grasses and shrubs; in high moist areas conifers generally predominate.

Because of shearing, most of the serpentine is highly slickensided and minutely fractured; locally a schistosity trends eastward. Dikes of basalt, andesite, and diorite associated with later volcanism intrude the serpentine.

DESCRIPTION OF THE ORE DEPOSITS

The chromite deposits occur in serpentine as irregular masses, lenticular bodies, and disseminated nodules. The ore bodies are generally small, containing from a few pounds to several hundred tons. At the La Gringa mine several adjoining ore bodies which were mined together yielded 5,357 long tons of ore (pl. 5). The ore is generally massive black chromite whose texture ranges from fine to coarse. In places serpentine and grains of other silicates are sparsely disseminated in the massive ore. Some ore bodies are bounded by shear zones, but others show a gradation from nearly pure chromite through a transitional zone, a few inches to several feet wide, that consists of a mixture of silicates and chromite grains and nodules, to wallrock containing only sparse chromite. In addition to chromite, the deposits contain the chromium-bearing garnet uvarovite and the chromium-bearing chlorite kammererite.

The chromite, relatively high in Cr_2O_3 and low in Fe, meets the requirements for metallurgical use. A series of partial analyses made by Stevens (1944, p. 14–15) on ores collected from the Jalapa district in Guatemala by W. D. Johnston, Jr., in 1941, is shown below.

Partial analyses of chromite ore from the Jalapa district, Guatemala

[R. E. Stevens, analyst]

Mine	Cr_2O_3	Cr	Fe	Cr : Fe
La Paz	60. 26	41. 24	12. 12	3. 40
La Esperanza	61. 10	41. 81	11. 20	3. 73
Do	60. 82	41. 63	10. 51	3. 96
Salvador	59. 39	40. 63	11. 91	3. 41
Corona	56. 15	38. 41	11. 13	3. 45

Samples of chromite ore from some of the deposits of the Cabañas district were collected by Irving in 1943 and 1944 for comparison with the Jalapa ores. They were analyzed with the results shown below.

Partial analyses of chromite ore from the Cabañas district, Guatemala

Mine or prospect	Cr_2O_3	FeO	Fe	SiO_2	Cr : Fe
El Corral Viejo	53. 66	14. 51		2. 44	3. 21
San Víctor	50. 68	15. 34		4. 60	2. 86
Buenos Aires	53. 84	16. 62			2. 81
San Antonio no. 2	46. 07	20. 87			1. 91
San Antonio no. 3	49. 01	17. 99			2. 36
La Corona no. 2	57. 81	15. 11			3. 30
El Guapinol	51. 27		13. 6		2. 58
La Ceiba	42. 74		11. 5		2. 55
San Pedro no. 2	50. 79		16. 2		2. 16
San Juan	54. 18		13. 0		2. 85
El Audiencio	40. 52		14. 2		1. 95
San Juancito	41. 71		15. 3		1. 87
San Augustín	42. 56		13. 0		2. 24
El Inocente	41. 16		11. 4		2. 46
La Joyita	50. 79		14. 0		2. 49

Comparison of the analyses of ore from the two districts shows that the chromite of the Jalapa district has a high chromium-to-iron ratio and a uniformly low iron content, whereas the Cabañas chromite has a lower chromium-to-iron ratio, but the iron content is low in some samples and high in others.

JALAPA DISTRICT

The Jalapa district, about 9 miles north of Jalapa, Departamento de Jalapa, includes the Corona, La Gringa, and La Paz mines, which are major producers, and the La Esperanza, Loreto, Salvador, and La Independencia deposits, which have yielded small tonnages.

The chromite deposits are in serpentine which forms the summit of the range lying between the Río Motagua valley on the north and a high volcanic plateau on the south. The ranges in this area rise to altitudes of 7,000 feet and are extremely rugged, having been deeply dissected by streams. Most of the deposits are on the southern flank of the range, at altitudes of 5,500–6,500 feet, but 2 of them are at lower elevations on the northern flank of the range.

LA GRINGA MINE

The La Gringa mine is in the western part of the Jalapa district, about 7 miles north of Jalapa (pl. 5). It is in serpentine, which is generally blocky but has locally been highly sheared along faults. The principal ore body, which cropped out, is a thick lens 75 feet long and 6–12 feet wide that strikes N. 25° W. and dips steeply northeastward. Several smaller lenses of ore were discovered below the surface. The ore is cut by several low-angle faults which displace the contacts a few feet.

The La Gringa mine is the largest producer in Guatemala. It was worked during World War I, but the principal production was by the Vanadium Corporation of America during the 1930's. In all, 5,357 tons of ore averaging 52–57 percent Cr_2O_3, with a chromium-to-iron ratio ranging from 2.8 to 3.2, has been produced since 1930.

CORONA MINE

The Corona mine is 2 miles east of the La Gringa deposit, in the southern part of the Jalapa district (pl. 5). The ore bodies consisted of several narrow lenses striking N. 65° E. and dipping steeply southeastward. The lenses were in a shear zone and were offset by several cross faults of small displacement. The largest ore body mined was 120 feet long and, at the northeast end, extended to a depth of 40 feet below the outcrop; its width ranged from 3 feet on the southwest to as much as 6 feet on the northeast.

The deposit is now completely mined out, and only a large pit and underground workings in barren serpentine were accessible in 1944. The mine produced 3,465 tons of ore averaging 52–56 percent Cr_2O_3, with a chromium-to-iron ratio ranging from 3.45 to 4.2. Some shipments are said to have contained as much as 62 percent Cr_2O_3.

LA PAZ MINE

The La Paz mine is about 2 miles northwest of the La Gringa mine, on the ridge southwest of Quebrada de los Magueyes which forms part of the Finca (Ranch) Incienso (pl. 5). The workings are at an altitude of about 5,400 feet.

The La Paz no. 1 ore body strikes N. 60° W. and dips 60°–70° NE. The workings were caved when seen in 1944, and the original dimensions of the ore body could not be obtained. Production during World War I amounted to 491 tons of ore averaging 58.00 percent Cr_2O_3, with a chromium-to-iron ratio ranging from 3.2 to 3.6.

The La Paz no. 2 ore body is about 100 feet northeastward from and 150 feet below the no. 1 ore body and has a similar strike and dip. This ore body may be a faulted segment of the no. 1 ore body, as the contacts of both are sheared. The no. 2 ore body, where cut in the workings, is 8 feet thick. The ore pinches out about 30 feet above the crosscut level.

CABAÑAS DISTRICT

The Cabañas district is in a belt of serpentine 12 miles long and 2–5 miles wide that extends from the Río Chimilapa to the village of San Antonio. Summits in the area rise to about 4,000 feet in altitude; the streams are deeply entrenched, and the terrain is extremely rugged. The mines are in an area about 8 miles long and ½ mile wide, about 12 miles south of the station of Cabañas on the International Railways of Central America. The ore is shipped on muleback from the mines southward to the end of a road extending 7 miles from Cabañas, thence by truck the remaining 5 miles to the station where it is transshipped to Puerto Barrios. (P. W. Guild, 1942, unpublished report).

The oldest rocks of the Cabañas area are crystalline limestone, quartzite, hornfels, schist, and gneiss that have been mapped by Sapper (1937, table 6) as chiefly pre-Cambrian, although they may well contain units of Paleozoic age. For the most part the rocks strike northward and dip steeply east or west. They have been cut in some places by pegmatite and quartz veins. The peridotite and dunite which intruded all these rocks have been largely serpentinized; intense shearing and recrystallization have produced in the serpentine a schistosity that trends eastward. Dikes of andesite, dacite, and diabase, probably of Tertiary age, cut the older rocks. Southwest of the area, flows of basalt and silicic volcanic rocks are interlayered with pyroclastic rocks.

The chromite occurs in the serpentine as pods or lenses; the dimensions of the smallest are measurable in inches, while the largest are as much as 8 feet thick and 30 feet long. The ore bodies usually consist of massive black chromite, but in some the chromite is disseminated in a matrix of serpentinized olivine, and a few show a rudely nodular texture. Several bodies consist of disseminated ore near their periphery and grade into massive ore near their center. Serpentine is the principal gangue mineral; uvarovite is found in many deposits, and kammererite is found in a few. The ore bodies are commonly distributed as a series of lenses along more or less parallel zones that follow the shearing. The lenticular form of the original ore bodies has been accentuated by shearing, which has produced slickensided surfaces at the contacts.

LA JOYA MINE

The La Joya mine is on the west side of the ridge between the Río Chimilapa and Quebrada Enseñada (pl. 5). It is the largest producing deposit in the district and up to 1944 had yielded about 500 long tons of ore averaging 51 percent Cr_2O_3, with a chromium-to-iron ratio of 2.7. The deposit consists of 2 lenses of ore, striking N. 70° W. and dipping 60° SW, which are separated by a layer of serpentine 2–3 feet thick. The lenses have been mined for a length of about 40 feet and to a depth of 25 feet. In the bottom of the workings the ore appears to be pinching out.

Other deposits, about half a mile to a mile southeast of La Joya, include the El Pino Seco, El Guapinol, Adán, and Tuno prospects, which all seem to be along the same eastward-trending shear zone at intervals of a few hundred feet. They consist, for the most part, of clean ore in sheared serpentine, but all the ore bodies discovered are small and have yielded only a few tons to 25 tons each.

The Don Enrique deposit nearby is composed largely of disseminated ore in schistose serpentine. A little high-grade float is scattered near the principal shows. The La Ceiba, San Pedro, Gracias á Dios, Santa Vincenta, and Jabalí deposits occur within a radius of 3 miles from the La Joya deposit. Production from these deposits ranged from a few tons to 75 tons each.

LA CORONA DEPOSITS

The La Corona deposits are on the east side of the Río Chimilapa valley, in the western part of the district (pl. 5). The production from the deposits amounted to about 100 tons up to 1943, chiefly from boulders weathered out of the serpentine.

The La Corona no. 1 deposit consists of boulders of chromite; the largest is 8 by 9 by 12 feet, and several others are only slightly smaller. As the boulders of chromite are underlain by serpentine that contains a little chromite, the boulders are probably not far from their source.

The La Corona no. 2 deposit consists of several boulders of solid chromite in a gully about 600 feet east of the La Corona no. 1. The boulders, the largest of which is 10 by 6 by 8 feet, probably rolled into the gully from a nearby source.

The La Corona no. 3, eastward from and about 250 feet above the La Corona no. 2, is an outcrop 4 feet long and 1 foot thick with a few pieces of float ore.

Another group of deposits lies about 3 miles east of the La Joya deposit on a prominent ridge that trends northward between Quebrada Enseñada and the Río San Diego; on the ridge is the Los Pinos mining camp.

BUENOS AIRES MINE

The Buenos Aires mine is on the ridge half a mile east of the Los Pinos camp (pl. 5). Float ore extends about 150 feet down the slope, and excavations 6–10 feet deep at the head of the float show chromite fragments in sheared serpentine. About 75 tons of ore from the surface was shipped prior to 1943; analyses showed 53 percent Cr_2O_3 and a chromium-to-iron ratio of 2.8. Other shows of chromite have been found nearby, but none of them appears promising.

SAN JUAN PROSPECT

The San Juan prospect is on the east side of the ridge at the Los Pinos camp. A lens of chromite 13 feet long and 7 feet thick in the center has been exposed in cuts 8 feet deep on both sides of the deposit. At the east end another lens, 3 feet long and 1 foot thick, wedges out into the serpentine, and on the west end the ore body grades into low-grade material consisting of lumps of good ore in serpentine. On the margins of the ore body, chromite is disseminated in serpentine. A pocket 50 feet to the north yielded a ton of ore.

SAN JUANCITO PROSPECT

The San Juancito prospect, about 500 feet northeast of the San Juan deposit, is a lens 15 feet long, 12 feet deep, and 4 feet wide which yielded a small tonnage of low-grade ore prior to 1943. Nodules occur at intervals in the shear zone along the strike beyond the main deposit, but no ore bodies of commercial size have been found.

EL AUDIENCIO DEPOSIT

The El Audiencio deposit, a quarter of a mile north of Los Pinos, shows only low-grade ore, but it contains a notable amount of the chromium-bearing garnet uvarovite. The ore occurs in a series of lenses extending more or less continuously for 150 feet along a shear zone striking N. 75° W. and dipping 75° NE. Some of the lenses are as much as 4 feet thick, although most are narrower. Most of the ore appears to be too low grade for metallurgical chromite.

SAN ANTONIO DEPOSITS

The San Antonio deposits (pl. 5) are 5 miles northeast of San Diego. These have not been exploited because of their low grade and their distance from the railroad, but they are said to contain reserves totaling 200 tons.

OTHER DEPOSITS

Other deposits in the area, including the El Chico, Agustín, El Cuervo, and San Víctor, have yielded 10–75 tons each. All these deposits are lenses in sheared serpentine, although some float ore was included in the shipments.

PASASAGUAS DISTRICT

Chromite deposits are exposed in the low hills north of the Río Motagua near Morazán in the Pasasaguas district (pl. 5). Several deposits were explored by Fred Cutworth and others during World War I, but no shipments were made. These deposits were examined by P. W. Guild (1942, unpublished report).

Most of the exploratory work done in the district was at the Australia mine. At the Australia no. 1 deposit, a shallow pit yielded about 10 tons of ore which is piled near the pit. At the no. 2 deposit, 2 pits about 50 feet apart have yielded a few tons of ore. At the no. 3 deposit an outcrop of chromite a foot in its longest dimension was noted in sheared serpentine.

Chromite has been reported elsewhere in the area, but none of the deposits have been explored to any extent. Samples from some of the deposits have been analyzed and indicate that they are for the most part low in grade. On the whole the serpentine area north of the Río Motagua appears to contain few chromite pods, and since the area is well inhabited and probably already explored, the outlook for the discovery of large ore bodies is not promising.

EL RETIRO DISTRICT

The El Retiro district is 10 miles north of Salamá, in the hills west of the Salamá-Cobán highway (pl. 5). The deposits are on the Finca El Retiro of Adán Morales at La Cebadía.

The deposits are in the middle of the serpentine belt, which here is about 12 miles wide. Chromite is exposed on the surface in massive serpentine in three areas. No exploratory work has been done at depth, but the exposures indicate that chromite is present over an area of about 100 square feet. Analyses of the ore show 48–51 percent Cr_2O_3 and a chromium-to-iron ratio of 2.75. As the deposits are 50 miles from the nearest railroad shipping point, they could not be worked profitably during World War II.

COPPER DEPOSITS

Copper production in Central America has been principally as a byproduct of precious-metal mining and consequently has been small. The Rosita mine in Nicaragua has notable reserves, however, and may be put into large-scale production at some future date.

GUATEMALA

SAN MATEO PROSPECT

The San Mateo prospect is half a mile south of the village of San Mateo Ixtatán, Departamento de Huehuetenango, and about 51 miles north of the town of Huehuetenango. A highway passable for light trucks throughout the year extends from Huehuetenango northward to Tojquiáj, a distance of 25 miles, and a fair trail covers the remaining distance. The property is owned by Virgilio Recinos and others of Huehuetenango.

The oldest rocks in the area are mica and hornblende schists which have been intruded by diorite and are overlain by interbedded sandstone and shale beds of the Todos Santos formation. The copper minerals are in schist that is exposed in a stream bed on Cerro Bobí at an altitude of 8,300 feet. Here the schist strikes westward and dips steeply. The copper ore is in a shear zone that strikes N. 15° W. and dips northeastward. A diabase dike about 2 feet wide follows the footwall of the shear zone for about 20 feet.

The vein minerals are pyrite, specularite, and chalcopyrite, in a gangue of crushed and silicified schist. The chalcopyrite occurs in pockets and veinlets which replace the pyrite and specularite. The vein is 6–18 inches wide and can be traced for 30 feet along the strike. An adit 20 feet long has been driven into the schist just above the vein outcrop. The material on the dump is schist impregnated with pyrite, but as the vein is covered with vegetation and soil beyond the stream bed, its total length is not known.

Shows of copper reported to be in nearby streams were found to consist of schist impregnated with pyrite. Quartz-pyrite-epidote veins locally cut the rock, but none were found that contained copper minerals.

MATAQUESCUINTLA MINE

The Mataquescuintla copper-silver mine is about 45 miles southeast of Guatemala City and 2½ miles southeast of the village of Mataquescuintla. The workings are on the west slope of the Sierra de Mataquescuintla at an altitude of 5,500–5,700 feet above sea level. The property in 1943 was owned by Mr. E. W. Crowe of Guatemala City (Lemus, 1917, p. 960). The deposit has been worked on a small scale since 1694. Jesuit priests are reported to have mined oxidized ore shoots for silver until 1871. In 1885 a 20-stamp mill was installed by Conde and Cabarrus, and its production in the 2 years following is reported to have been 40,000 ounces of silver. Since then, ownership of the mine has passed through many hands, and the production has been small. The Westend Consolidated Mining Co. explored the property in 1917 and 1918.

The rocks are volcanic tuffs and intercalated rhyolite and andesite flows of Tertiary and Quaternary age. The ore deposit is in silicified rhyolite tuff, which is cut by veins chiefly of pyrite with a little chalcopyrite and chalcocite and scattered grains of galena. The veins are mostly less than 4 inches wide, but a few are as much as 1 foot wide, and at vein intersections masses of sulfides as much as 3 feet wide have been found. The veins are erratically distributed throughout the rock and are generally several feet apart. The silicified tuff between the veins is impregnated with pyrite and sparse chalcopyrite. The workings, although partly caved, indicate that the mineralized block is about 150 feet wide, 600 feet long, and at least 475 feet thick; the block trends northeastward and is bounded laterally by fracture zones. Not all of this block can be considered commercial ore, however, for it contains some low-grade ore and barren ground. The ore is oxidized to a depth of about 100 feet. Much of the pyrite has been leached, but some copper has been redeposited as malachite and chrysocolla. The ore below the oxidized zone is highly pyritic.

The ore reserves are not known, but a considerable tonnage of material containing about 2.5 percent copper and 10 ounces of silver to the ton could be selectively mined from the area explored by the present workings. Further exploratory work would be needed to block out the ore.

LOS SANDILLALES PROSPECT

The Los Sandillales prospects are 2½ miles south of the town of Chiquimula, on the property of Cecilia v. de Cuellar. The workings are shallow cuts in granodiorite which explore a quartz vein about 2 feet wide. The vein strikes northward and dips steeply westward, and can be traced for about 50 feet. The quartz contains iron oxides, with veinlets and pockets of malachite and azurite that were probably formed by the oxidation of chalcopyrite. The ore is estimated to contain 3–5 percent copper.

ZUHÓJ DEPOSITS

The Zuhój deposits are 7 miles southeast of Cahabón, in the Departamento de Alta Verapaz, on the Río Oxek at an altitude of 800 feet. A trail extends from Cahabón to within 1½ miles of the prospect, and the remaining distance must be covered on foot. The property can also be reached by trail from Sepcuyté, 12 miles to the south.

The oldest rocks in the area are mica schist and hornfels which have been intruded by diorite and serpentine; these rocks are overlain by limestone and dolomite of the Cobán formation and by sandstone, shale, and conglomerate of the Sepur formation.

The vein is in the hornfels and follows a fault zone that strikes N. 50° W. and dips 55° SW. The ore mineral is chalcopyrite, with pyrite and quartz. A little malachite coats the chalcopyrite at the outcrop. The chalcopyrite occurs in veinlets and pockets within the shear zone and is also disseminated throughout the crushed hornfels. The vein crosses the Río Oxek; on the south bank it can be traced for 50 feet, but only boulders show on the north bank. Soil and heavy vegetation conceal the vein on the slopes above the river. A chip sample taken from the outcrop on the south bank assayed 12.7 percent copper and 0.03 ounce of gold and 1.1 ounces of silver to the ton Further exploration along the strike of the vein will be needed to determine whether the property warrants development.

CERRO VIVO PROSPECT

The Cerro Vivo copper prospect is on the Río de las Vacas, about 2 miles southeast of the town of Chinautla. Two adits, 45 and 80 feet long, and some shallow pits explore copper shows along eastward-striking faults in diorite. The fault fissures contain calcite and iron oxides and scattered grains of chalcopyrite, which is partly altered to malachite and azurite. Further exploration does not appear warranted.

OTHER DEPOSITS

Copper deposits are also found near Trapiche Grande, Departamento de Baja Verapaz, a village about 30 miles north of Guatemala City. They are on the Fincas El Tamarindo, Santa Bárbara, and El Pórvenir.

The Tamarindo deposit is 2½ miles northeast of Trapiche Grande. A short adit, which was caved in 1943, is in altered serpentine that contains a few calcite veins stained with malachite. Grains of a sulfide, probably chalcopyrite or bornite, are sparsely disseminated throughout the calcite. The material is too low in grade to be mined.

Three shallow pits in andesite 2 miles east-northeast of Santa Bárbara expose narrow veins of malachite and azurite in fractures. Half a mile northeast of these shows are others, also in andesite, but these, too, appear to be of low grade.

At the Finca El Pórvenir a 30-foot shaft was sunk on malachite and azurite outcrops, but the results were not promising.

HONDURAS

The following descriptions of copper deposits are based on examinations made largely by P. W. Hyde, formerly exploration geologist with the New York and Honduras Rosario Mining Co. Mr. Hyde visited most of the known deposits and his reports were made available to the authors by the company.

EL AMATILLO PROSPECT

The El Amatillo prospect is about 2 miles southwest of the Finca Valladares, which lies about 6 miles southwest of the village of Ojojona, Departamento de Tegucigalpa. Several short adits, spaced 400–500 feet apart, explore shows of copper and manganese. Two adits to the west show only a few copper stains, but a third shows pockets of copper carbonates along fractures that strike N. 70° E. and dip 50° SE.

Manganese oxides are found with the copper minerals in some of the workings. Most of the material is low grade and siliceous. A knoll to the east is capped with manganese oxides; the outcrop is about 600 feet long and as much as 150 feet wide. A sample taken from surface material by Hyde [2] contained 24.39 percent manganese and 3.1 ounces of silver per ton. He thought it likely that the material would decrease in manganese content with depth.

PETOA DEPOSITS

Copper deposits near Petoa, Departamento de Santa Bárbara, are about 30 miles southwest of San Pedro Sula (pl. 1). An improved road extends from San Pedro Sula to San Francisco, but the last 4 miles to Petoa are unimproved and may be impassable during some parts of the rainy season. The principal copper deposits are on Waller Hill, about a mile east of Petoa, and can be reached over a steep trail. The deposits have been known since colonial days. Some small high-grade pockets were mined during the 19th century, and the copper was used in the local manufacture of bells. Guy R. Molony denounced the property in 1926, and in 1942 the United Fruit Co. did a little exploratory work there under the direction of A. L. Bump, but no ore was shipped.

The copper deposits are in limestone and shaly limestone near contacts with diorite porphyry. The limestone exposed in the workings appears to strike northwestward and to dip gently northeastward. The copper minerals include chalcopyrite, azurite, and malachite. Chalcopyrite was seen in only one place, the Santo Domingo shear zone; elsewhere the ore has been completely oxidized.

The Santa Inés workings consist of several trenches and an adit at an altitude of about 1,500 feet on Waller Hill. The top of the hill is silicified limestone stained with iron oxides. Small pockets of copper ore are scattered throughout the limestone, but on the whole the material is low grade. The underground workings, about 25 feet below

[2] Hyde, P. W., 1942, Report to New York and Honduras Rosario Mining Co., San Juancito, Honduras.

the summit, explore a gently dipping shaly limestone bed which contains sparse copper carbonates.

Several shallow empire-drill holes along the diorite porphyry contact east of the Santa Inés workings in the 1930's revealed only low-grade or barren rock.

The Los Mangos workings, which are about 800 feet east of those on Waller Hill and about 300 feet lower, consist of several shallow pits and a trench about 15 feet deep. A vein of quartz and copper carbonates 1–2 feet wide which strikes N. 60° W. and dips 65° SW. is exposed in the trench but has not been explored beyond it.

The Santo Domingo workings are about 1,000 feet east of the Los Mangos workings, on the banks of the Río Tascalapa. The workings are 3 shallow pits along a shear zone striking N. 25° E. in limy argillite and limestone. Locally the shear zone contains small veinlets and pockets of chalcopyrite and malachite.

Shows of copper near Petoa are widespread, but exploratory work up to 1944 had disclosed only small low-grade ore bodies, which do not appear promising.

MACUTLA PROSPECT

The Macutla prospect is about 2½ miles southwest of Petoa, on the west bank of the Río Macutla. The rocks in the area are diorite, porphyry, and limestone; tactite has been formed in places along contacts between these rocks and is accompanied by shows of copper. An adit 25 feet long has been driven along a vertical 50-foot-wide fracture zone that trends westward and contains pyrite, chalcopyrite, sphalerite, and specularite and other iron oxides. The fracture zone could be traced westward for 350 feet from the workings. Assays of the vein material show a copper content averaging about 2 percent, with 0.016 ounce of gold and 0.78 ounce of silver to the ton.

LOMA CHAMUSCADA DEPOSIT

The Loma Chamuscada copper-zinc deposit is 5 miles by trail south of Níspero, Departamento de Santa Bárbara. The rocks are red to buff sandstones which in general strike eastward and dip about 55° S. Thin seams of chalcopyrite, pyrite, and sphalerite are present in the sandstone. At one place a stringer zone 3–4 feet wide parallels the bedding, which strikes N. 85° W. and dips 75° S. The copper content of samples collected by Hyde [3] ranges from 1.0 to 3.6 percent and the zinc content from 4 to 12 percent.

LAS CHACARAS MINE

The Las Chacaras mine is a mile east of Comayagua, Departamento de Comayagua, on the north bank of the Río Chiquita. The property is owned by Salvador López of San Pedro Sula. The copper minerals

[3] Hyde, P. W., op. cit.

are chiefly carbonates, with sparse chalcopyrite and galena, in a quartz vein that follows a fracture zone about 50 feet wide in limestone. The zone strikes N. 45° E. and dips 60°–75° NW. Parts of the old workings extending 600–800 feet along the vein are still accessible. Samples taken from the dump show a content of 2.8–23.9 percent copper and 0.98–7.58 ounces of silver to the ton, with a trace of gold.

Other copper deposits are reported at San Rafael Paraíso, about 2 miles upstream from the Las Chacaras mine.

SANTA CRUZ PROSPECT

The Santa Cruz prospect is on the trail to Yoro, about 30 miles from Progreso, in the Departamento de Yoro. Narrow oxidized copper veinlets less than 2 inches wide strike N. 60° E. and dip 50° NW. A vein nearby, the Lagunitas, has been worked for gold and silver; locally it contains oxidized copper minerals.

OTHER DEPOSITS

Raymond M. Brown, mining engineer in Honduras, says there are shows of copper near Minas de Oro, Departamento de Comayagua. Manuel Bueso, of Santa Rosa de Copán, reports copper shows in the Cordillera de Merendón, Departamento de Copán. No exploratory work has been done on these, but boulders of high-grade ore as much as 50 pounds in weight, containing chalcocite and azurite, have been found. Hyde examined the shows in 1942 and reports that the rocks nearby are limestone and conglomerate, and that poor exposures prevent examination of the ore in place. Trenching will be needed to determine the source of the copper ore.

COSTA RICA

AGUACATE DISTRICT

MONTE DEL AGUACATE MINE

The Monte del Aguacate copper-zinc mine is in the Aguacate mining district, about 3½ miles north of Concepción, a station on the Pacific Railroad. The rocks are horizontally layered andesitic lavas, which are cut by banded quartz veins trending northeastward. Gold has been mined from these veins for many years, and in some of the veins there are ore shoots containing copper and zinc minerals, with manganese minerals, principally rhodonite. The known copper-zinc shoots are small, and none discovered prior to 1944 warranted stoping. However, since the amount of base metals seems to increase with depth, it is possible that larger shoots may be discovered in future operations.

PURISCAL AREA

Copper deposits have been known for many years in the Puriscal area near the villages of Guayabo and San Rafael, Provincia de San

José. The rocks in the area are andesitic and basaltic lavas that commonly are nearly horizontal but are locally folded and have dips as steep as 30°.

GUAYABO DEPOSITS

The Guayabo deposits are about a mile southwest of Guayabo. The copper occurs as thin sheets of native copper that fill fractures in the lava; the sheets average about one thirty-second of an inch in thickness, and some are as much as a square foot in area. The shows are exposed for about 125 feet in a stream cut, and placer copper can be panned from gravels for about 1,500 feet downstream from these exposures. The sheets are commonly 6 inches to several feet apart, and the grade of the ore in place is judged to be low, probably not more than 1–3 percent copper even in the richer areas, and probably averages less than 0.2 percent. On the slopes a heavy soil mantle covers the outcrops.

SAN RAFAEL DEPOSITS

The San Rafael deposits are about a mile northwest of San Rafael. Here also there are thin sheets of native copper in lava. The mineralized zone trends northward, dips steeply westward, and is about 25 feet wide where it is exposed in a small stream bed; as its extensions are covered on both sides with soil, its full length is not known. The fractures containing the sheets are commonly several feet apart, and the material is low grade.

NICARAGUA

A copper deposit has been known for many years in eastern Nicaragua at Rosita. The property has not been put into production because of the high cost of transport of supplies, equipment, and concentrates. However, the higher value of copper prevailing in 1956 may offset these high costs, and plans to begin operations were being considered.

ROSITA MINE

The Rosita mine (also known as the Santa Rita mine) is in the district of Tunki, Departamento de Zelaya, about 3 miles east of the village of Monte Carmelo. The principal workings are on Cerro Santa Rita about three-fourths of a mile north of the Río Bambana. The property consists of 18 claims and can be reached by plane which lands at an airport 1½ miles to the northwest.

No copper has been produced, although between 1906 and 1912 parts of the gossan and oxidized zones were mined and milled for gold. It is reported that 40,000 tons of ore was treated, but the production is not known. The Tonopah Mining Co. acquired the property in 1916 and in 1949 sold a part interest to Ventures, Ltd.; in 1954 the property was acquired by La Luz Mines, Ltd. Additional exploratory work was done between 1951 and 1955, and mill and metallurgical tests were being made on the ore preparatory to installation of a treatment plant. The workings in 1942 at the time of the visit consisted of 23 short adits with connecting workings and 96 churn-drill holes. Since then additional underground workings have been driven and a diamond-drilling program has been carried on.

The principal copper-ore body is on Cerro Santa Rita, which is largely underlain by rock composed of orthoclase, quartz and garnet. Huston[4] considered this rock to be intrusive alaskite, but Roberts in 1942 collected specimens in the workings that are nearly pure garnet and are considered to have been formed by metamorphism of limestone. No unmetamorphosed limestone was seen in the workings, but 1½ miles to the north limestone is being quarried for the Neptune mine. The limestone, which strikes northwestward and dips steeply southwestward, is probably correlative with the limestone beds that are associated with the Metapán formation in northeastern Nicaragua (pl. 1).

The ore body on Cerro Santa Rita appears to be in a contact zone adjacent to an andesitic intrusive body. The upper part of the ore body is oxidized and forms a conspicuous iron oxide gossan that according to Huston is 30–230 feet thick. The iron oxides contain disseminated malachite, azurite, cuprite, and chrysocolla. The oxidized carbonate ore comprises nearly two-thirds of the ore reserves known up to 1943 (see table below). The lower part of the ore body is a sulfide zone reported to be 10–30 feet thick that is composed of pyrite partly replaced by chalcocite and bornite. The ore reserves calculated by him are summarized in the table below.

Summary of copper-ore reserves and partial analyses, Rosita mine, Nicaragua[1]

	Reserves (short tons)	Cu (percent)	Au (oz)
Sulfide ore:			
High grade	163, 556	10. 29	0. 17
Low grade	308, 800	3. 37	. 013
Total or weighted average	472, 356	5. 76	0. 068
Carbonate ore (oxidized zone)	984, 232	4. 83	0. 03
Tailings	35, 500	1. 97	. 13
Grand total or weighted average	1, 492, 088	5. 06	0. 045

[1] Mines Handbook, 1920, p. 1757.

Additional reserves discovered by diamond drilling during recent years bring the total to 2 million tons averaging about 3.9 percent copper.

[4] Huston, M. B., 1918, Report to the La Luz Mine, Ltd., Siuna, Nicaragua.

IRON DEPOSITS

Iron ore is reported to occur in all the Central American countries except British Honduras, but no deposits have been productive on a large scale. Two iron-ore deposits, the Agalteca in Honduras and the Rosita (Silak) in Nicaragua, may be productive if transportation facilities are improved so that the ore can be economically shipped.

HONDURAS

AGALTECA DEPOSITS

The Agalteca iron-ore deposits are on the Finca Santa Clara, which is in the foothills of the northern flank of the Sierra de Comayagua, in the Departamento de Tegucigalpa (pl. 6). The nearest settlement is the village of Agalteca (approximately lat 14°30′ N., and long 87°16′ W.), which lies a mile north of the mine area. Tegucigalpa, the capital of Honduras, is 24 miles to the south.

The Agalteca deposits have been known for many years, but because of their inaccessibility no attempt has been made to work them. Some exploratory work has been done during the course of examinations by various groups including the Bethlehem Steel Co. and Gen. R. Streber and some associates between 1910 and 1922. For the most part the workings consist of shallow trenches and pits, but 2 adits, 30 and 180 feet long, and a 70-foot shaft were driven. Philip Chase conducted exploratory work at Agalteca for the Oliver Iron Mining Co. in 1946. The results of his work have not been published.

The deposits are remote from the principal routes of travel and transportation in Honduras. A fair road extends from Tegucigalpa for 30 miles northward to Talanga, and a dirt road, passable during the dry season, from May to November, extends from Talanga for 12 miles westward to Agalteca. A highway from Tegucigalpa to Potrerillos is the route along which most of the freight moves from the north coast of Honduras to Tegucigalpa. This highway passes through Comayagua, 18 miles west of Agalteca, but construction of a connecting road through the rugged country between it and the deposits would be difficult. The most favorable route for shipment of ore would be down the Río Sulaco to the railroad at Potrerillos, which extends to the principal Caribbean shipping point, Puerto Cortés. From Puerto Cortés ore could be transshipped to United States ports.

Geology

The Sierra de Comayagua trends northwestward across the central part of Honduras. The lowest altitude within the range is 2,400 feet, at the Finca Santa Clara in the foothills, and the highest is about 6,500 feet. On the summit and southwest flank the rocks are Tertiary lavas and pyroclastic rocks that dip gently southwestward. On the northeast flank the rocks are older and partly covered by Quaternary sand and gravel; these older rocks contain the iron ore.

The rocks on the north flank of the range in the area mapped (pl. 6) consist of five principal units. In order of age they are (1) quartzite; (2) conglomerate and sandstone, and limestone, dolomite, and shale; (3) diorite which intrudes rocks of unit 2; (4) rhyolite dikes; and (5) Tertiary and Quaternary sand and gravel which overlie the older rocks. Except in the higher parts of the area mapped, exposures are poor and the slopes are mantled by soil 1–20 feet thick. Test pits were dug in many places to determine the location of contacts, particularly along the borders of the ore bodies.

The quartzite crops out northwest of the ranch near ore body Q (pl. 7). As the quartzite is in fault contact with hornfels on one side and is overlapped on the other sides by Quaternary gravel, its relation to the other rocks is not definitely known; but as the quartzite is more highly indurated and deformed than the other rocks in the area, it is probably older and may be of Paleozoic age and correlative with crystalline rocks exposed elsewhere in northern Honduras.

The conglomerate and sandstone crop out in a small area between the groups O and C ore bodies and on the slope south of the area mapped (pl. 6). They are composed of poorly sorted detritus and are commonly reddish brown to brown because of their iron oxide cement. The pebbles of the conglomerate are chiefly sandstone, quartzite, and quartz, with a minor amount of schist, phyllite, and limestone.

The conglomerate and sandstone are conformably overlain by limestone, dolomite, and shale. At the contact the 2 units interfinger in a transitional zone that is generally less than 30 feet thick. The limestone and dolomite are thick bedded to massive for the most part, but where they are intercalated with shale and limy shale they are thin bedded. This unit has been intruded by diorite and has been metamorphosed to hornfels and tactite, which contain the iron-ore bodies. No fossils have been found in either the conglomerate and sandstone unit or in the limestone, dolomite, and limy shale unit, but elsewhere in Honduras similar rocks contain fossils of early Late Cretaceous age and are correlated with the Metapán formation. These rocks are therefore assigned to the Metapán formation.

The diorite underlies much of the area mapped. It is exposed in all the valleys that drain the area, and although outcrops are poor on the slopes, pits have disclosed diorite close to the ore in several places. The diorite is fine to medium grained, light to dark gray, and is composed chiefly of hornblende and plagioclase; it weathers to a yellow or brown clayey soil. The diorite cuts limestone, dolomite, and shale which have been metamorphosed to tactite and hornfels near the contacts and in roof pendants in the diorite. The tacite, formed by the metamorphism of limestone and dolomite, is moderately to coarsely crystalline and consists chiefly of garnet, epidote, hornblende, calcite, and plagioclase. The hornfels, formed by the metamorphism of shale and calcareous shale, is commonly fine grained and is composed of epidote, quartz, calcite, garnet, and hornblende. A few small ore bodies are found in the limestone and dolomite, but most of the ore occurs in the hornfels and tactite. These rocks are altered near the ore bodies to a brown or yellow clayey soil, which in some places cannot readily be distinguished from soil derived from diorite; usually a pit must be dug in order to definitely identify the bedrock.

The rocks in the foothills of the Sierra de Comayagua have been compressed into folds with a northwestward trend and plunge. The folds generally appear to be open, but are locally tight and in a few places overturned.

Three sets of faults have been mapped in the area (pl. 6): one of them trends northwestward, parallel to the folds; another trends northward, cutting the folds diagonally; and the third trends northeastward, normal to the folds. Movement on these faults has caused repetition of the beds throughout the area; the displacements range from a few feet to several hundred feet. Some of the ore bodies have been cut by faults and are displaced, but so far as is known these displacements are small. It is therefore inferred that most of the faulting took place before formation of the ore bodies.

The ore bodies crop out in the foothills of the range south and west of the Finca Santa Clara, and, as most of the ore is more resistant than the associated rocks, the ore bodies generally form ridges rising a few feet to 200 feet above the surrounding area. Plate 6 shows the general distribution of the ore bodies. The ore bodies are tabular, lenticular, or irregular masses of iron oxides, mainly in the hornfels but partly in tactite and limestone. In some places the ore has replaced these rocks along the bedding, but generally the ore cuts the bedding; in detail the contacts are irregular.

Hematite and magnetite are the principal ore minerals; the proportion of these minerals is variable, but commonly the hematite predominates. It is thought that the hematite may have been in part formed by oxidation of the magnetite near the surface. The magnetic variety of magnetite, commonly called lodestone, is present on the southeast end of group O. Pyrite is a minor constituent of the ore; veinlets of pyrite in hornfels were noted in a trench on the north end of group B and in samples collected from the adit driven into the group C ore body. The ore is principally hard, tough iron oxides which form craggy outcrops, but locally this ore is weathered and is altered to soft, earthy material which forms smooth slopes. Where the ore is of the latter type, test pits are generally needed to prove whether a slope is underlain by soft ore or hornfels.

The ore exposed in the outcrops and workings at Agalteca is for the most part of good grade; the iron content in almost all of it is between 40 and 66 percent and averages about 53 percent. The phosphorus content ranges from 0.010 to 0.082 percent and averages about 0.037 percent, and the sulfur content ranges from 0.005 to 0.058 percent, with an average of 0.020 percent. The amount of silica in the ore is variable, ranging from 3.5 to 39 percent, and averages less than 10 percent in samples cut from surface trenches. It is quite likely that the low silica content of the ore on the surface is due to leaching, and the average silica content at depth may be found to be considerably higher. The alumina content of the ore is commonly below 2 percent, and the manganese content is between 0.01 and 0.28 percent.

The underground workings show that the ore bodies locally contain layers and masses of low-grade ore formed by incomplete replacement of the host rock; this ore is generally softer than the high-grade ore and could probably be discarded in mining. In this way the grade of ore mined could be increased, possibly to 55 or 56 percent iron.

More than 35 ore bodies have been mapped in the area; about 20 of the larger ore bodies were mapped in detail. These are designated on plate 7 as groups P, O, Q, C, and B.

The ore bodies range from a few feet to 1,100 feet in length, and some are as much as 350 feet wide. The maximum depth of the ore is not known, but at group C the ore is exposed over a vertical range of at least 200 feet, and at group B, 230 feet.

The workings that explore the ore bodies are for the most part shallow; however, 2 adits, 40 and 180 feet long, have been driven, and these furnish valuable information concerning the ore below the surface.

Group P

The main part of group P (pl. 7), which crops out on a ridge 5,000 feet southwest of the Finca Santa Clara buildings, is chiefly magnetite and hematite which replace hornfels and limestone. It is 480 feet long, 260 feet wide, and about 120 feet thick. On the west it is probably cut off by a fault, for it ends abruptly against tactite and limestone. On the east this ore body pinches out, but other lenses continue on the same strike.

The northwest side of a trench across the deposit shows ore of good grade (samples 44, 49, 59, and 67), intermixed with some clayey ore, but on the southeast side of the trench the ore is low grade and encloses considerable hornfels. The chip samples (11 and 59) were taken along the outcrops. (See table below.)

A lens of low-grade ore as much as 25 feet wide crops out east of the main ore body. This lens appears to dip southward, parallel to the dip of the limestone nearby. Other ore bodies occur on the ridge to the south and west of group P, but they are all small.

Partial analyses of iron ore from the group P ore bodies, Agalteca deposit, Honduras

[Birger Sundström, Mexico City, Mexico, analyst]

Sample no.	Fe	P	S	Mn	Al_2O_3	SiO_2	CaO	MgO	Ti
11	64.55	0.023	0.037	0.11	0.28	5.99			
44	61.84	.021	.010						
49	65.06	.009	.058	.01	.05	3.93			
59	61.98	.024	.038						
67	61.38	.014	.013						

Group Q

Group Q is 4,500 feet northwest by west of the Finca Santa Clara buildings, on a low ridge west of the Río Aguacate (pl. 7). It is in hornfels, but diorite shows in the stream valley south of the ore body, and Quaternary gravel overlaps the diorite and ore on the west. On the north and east, quartzite is in fault contact with the hornfels that encloses the ore. Tuff overlaps the fault in the valley.

The ore body is exposed more or less continuously for a length of 900 feet along the ridge and has an average width of about 75 feet. A trench showed ore of good grade (samples 47 and 48, table below). Although the roof pendant of hornfels containing the ore may extend to a considerable depth, the presence of diorite so close to the outcrop is not encouraging, and the ore cannot be projected more than 50 feet below the surface.

Partial analyses of iron ore from the group Q ore bodies, Agalteca deposit, Honduras

[Birger Sundström, Mexico City, Mexico, analyst]

Sample no.	Fe	P	S
47	64.12	0.030	0.016
48	63.75	.013	.005

Group B

Group B is 2,000 feet west of the ranch buildings (pl. 7). The principal outcrops are on a ridge trending northwestward, and others are found southwest and northwest of the ridge. The enclosing rock is hornfels, but diorite is exposed nearby in two pits and in the stream valley southwest of the ridge.

The principal ore body is 750 feet long, as much as 160 feet wide, and is exposed vertically for 230 feet. It is explored by shallow trenches and a short adit, which shows fair-grade ore that is locally siliceous. Another ore body, 80 feet wide and 180 feet long, lies to the north.

The ore, exposed in a long trench, is of fair grade, siliceous, and locally contains a little pyrite. An adjoining area, mapped as landslide ore, is ore that has slumped from the main body.

The slopes around group B are mantled with a few inches to 5 feet or more of slope-wash ore. Two test pits were dug to a depth of 3 feet in this material; 1 pit yielded 17 pounds of ore per cubic foot, and the other 32 pounds per cubic foot. Similar yields appear likely in other parts of the area covered by such slope wash.

Partial analyses of samples from group B are described in the table below.

Partial analyses of iron ore from the group B ore bodies, Agalteca deposit, Honduras

[Birger Sundström, Mexico City, Mexico, analyst]

Sample no.	Fe	P	S	Mn	Al_2O_3	SiO_2
39	57.85	0.055	0.029			
40	61.22	.052	.041			
41	53.52	.041	.030			
42	45.26	.042	.018	0.06	2.99	26.12
43	63.07	.021	.010			
45	53.00	.022	.050			
50	59.13	.017	.006			
51	63.33	.019	.017	.05	.07	3.93
60	64.25	.041	.035	.23	1.14	5.04

Group C

Group C is about 3,500 feet northwest of the ranch buildings (pl. 7). The ore is in hornfels, but tactite is exposed in the southwestern part of the area, and a small outcrop of limestone was mapped in the southeastern part.

There are two principal ore bodies. Ore body 1, the northern of the two, is 900 feet long and as much as 350 feet wide, and it crops out vertically for 200 feet. It has been explored by shallow trenches, shafts, and an adit 180 feet long. The trenches on the west side of the outcrop show ore through a vertical distance of 55 feet. Although the trenches cut the contact of ore and hornfels in several places, the contact is not well exposed. The contact is commonly gradational, locally sheared, and in general appears to dip steeply. The adit at the northeast end of the deposit shows a good cross section of the ore for a distance of 180 feet. Samples cut along the walls indicate that the grade is variable, and the ore is too lean on the average to be mined as a single ore body, so that selective mining or concentration will be necessary. The ore near the portal is low grade and siliceous, fair-grade material occurs at the bend, and the ore at the face is high grade. This adit gives an idea of the probable variation in composition to be found in any marginal facies of these ore bodies. (See table below.)

Ore body 2 is 280 feet long and 170 feet wide at the widest point. It caps a small hill and appears to be relatively thin.

Partial analyses of iron ore from the group C ore bodies, Agalteca deposit, Honduras

[Birger Sundström, Mexico City, Mexico, analyst]

Sample no.	Fe	P	S	Mn	Al_2O_3	SiO_2	CaO	MgO	Ti
1	58.55	0.019	0.045	------	------	------	------	------	------
2	60.62	.024	.019	0.22	0.48	8.47	------	------	------
3	63.85	.021	.017	------	------	------	------	------	------
5	60.88	.010	.008	.05	2.53	9.16	0.22	0.14	0
6	55.45	.035	.011	------	------	------	------	------	------
8	58.55	.028	.010	------	------	------	------	------	------
10	31.80	.025	.010	.06	13.13	39.27	------	------	------
12	61.65	.030	.010	------	------	------	------	------	------
14	31.85	.046	.013	------	------	------	------	------	------
16	47.20	.059	.010	.15	.75	24.91	------	------	------
17	45.45	.059	.073	------	------	------	------	------	------
18	59.25	.050	.041	------	------	------	------	------	------
19	63.25	.080	.056	------	------	------	------	------	------
20	61.55	.034	.015	------	------	------	------	------	------
21	63.37	.036	.019	.06	.58	11.09	.27	.33	0
22	37.05	.040	.012	------	------	------	------	------	------
23	55.65	.048	.015	------	------	------	------	------	------
24	50.14	.059	.015	------	------	------	------	------	------
25	45.20	.070	.023	------	------	------	------	------	------
26	47.70	.060	.018	------	------	------	------	------	------
27	52.48	.032	.006	------	------	------	------	------	------
28	51.45	.048	.036	------	------	------	------	------	------
52	59.30	.029	.006	------	------	------	------	------	------
53	66.35	.028	.037	.06	.05	6.99	------	------	------
61	64.55	.036	.015	.28	1.28	6.82	------	------	------

Group O

The ore bodies of group O (pl. 7) are 9 in number, but only 3 are large enough to warrant description. They are in altered hornfels that is in fault contact with limestone that strikes northwestward and dips 30°–80° NE. The principal ore body, exposed in the eastern part of the area shown in plate 7, is 440 feet long, as much as 230 feet wide, and has an exposed thickness of 75 feet. A mantle of residual ore extends down the slope northwest of it; locally this mantle is 20 feet thick, and aside from a little intermixed soil it is composed of iron oxide fragments. Landslide ore extends down the slope to the northeast and east.

Another ore body, 200 feet to the west, is 200 feet long and 50–100 feet wide. A trench cut in the ore and limestone on the south side of this ore body shows low-grade ore which has partly replaced limestone and shaly limestone. The trench on the west side shows that the ore grades into the hornfels down the slope.

A third ore body, in the southwestern part of the area mapped, is 160 feet long and as much as 120 feet wide. A long trench which crosses the outcrop shows ore that is of good grade on the average, but it contains masses and layers of low-grade material.

Analyses of samples taken from group O are given in the table below.

Partial analyses of iron ore from the group O ore bodies, Agalteca deposit, Honduras

[Birger Sundström, Mexico City, Mexico, analyst]

Sample no.	Fe	P	S	Mn	Al_2O_3	SiO_2	CaO	MgO	Ti
29	57.46	0.062	0.014						
30	63.12	.087	.009						
31	64.62	.058	.011						
32	59.53	.051	.004	0.12	1.51	12.92	0.32	0.41	
33	54.38	.047	.009						
34	57.58	.023	.010						
35	62.70	.011	.003	.03	.25	8.02			
36	65.93	.025	.013						
37	61.98	.039	.017						
46	60.27	.050	.010						

RESERVES AND OUTLOOK FOR ADDITIONAL DISCOVERIES

A general idea of the surface extent of the ore has been obtained by trenching. Preliminary calculations indicate that about 8 million long tons of ore averaging about 53 percent iron may be expected in the ore bodies exposed in the Agalteca area between the surface and a depth of 200 feet. There is no reason why ore cannot extend to greater depth as the ore is in roof pendants of hornfels and limestone, which may well extend below the average altitude of the top of the diorite body. In addition, some ore bodies may now be concealed by alluvium or barren rock; a program of prospecting by magnetic methods could be undertaken to determine whether the district contains any such buried ore bodies. In addition, exploratory work should be extended into adjacent areas covered by younger rocks.

ARAMECINA DEPOSITS

Small deposits of iron ore are found 3 miles east of Aramecina, Departamento de Valle, Honduras, on the south slope of Cerro Colorado at an altitude of 2,600 feet. Granodiorite, the principal bedrock in the area, is the host rock of the iron ore. The hills south of Cerro Colorado consist of Tertiary lavas and tuffs.

The iron ore is intergrown magnetite and hematite and forms a lenticular body in the granodiorite. The lens strikes north and appears to dip steeply. It is about 30 feet long, as much as 10 feet wide, and is exposed for a vertical distance of about 15 feet. The ore in the central part of the lens appears to be nearly pure iron oxide, but near the edges it contains unreplaced inclusions of granodiorite and crystals of feldspar and quartz.

Other deposits of iron ore are reported in the area, but accounts indicate that they, too, are small.

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NICARAGUA

ROSITA AREA

Iron ore is reported to occur in a belt 40 miles long extending southeastward from a point east of Pis Pis to the lowland of the Río Songuas, a tributary of the Río Bambana. In the vicinity of the Rosita copper mine, iron deposits of commercial size, low in phosphorus and sulfur and with an iron content of as much as 65 percent, are reported (Garbrecht, 1920, p. 791–797). The ore bodies occur along contacts between limestone and intrusive diorite. As none of them have been explored, the tonnage of ore is not known. Some of the outcrops cover as much as 10 acres, and the outlook for developing commercial iron-ore reserves seems promising.

OTHER AREAS

Iron ore is also reported in the Boaco area, Departamento de Chontales, about 45 miles northeast of Managua. Ore samples from the area consist of siliceous specular hematite. The deposits are said to replace quartzite beds. Magnetite has been reported from the Achuapa area in the Departamento de León.

GUATEMALA

Iron-ore deposits are reported in several areas near Chiquimula, Departamento de Chiquimula. Of these deposits only 1, at El Panteón de San José de Arada, 5 miles south of Chiquimula, was visited. The iron ore is hematite, which forms veins in limestone. The ore appears to be of good grade, but because of soil cover the extent of the deposit was not determined.

Other localities where deposits are reported are at El Moral, on the west side of the Cordillera del Sauce, where float boulders in soil were being mined on a small scale in 1945 by Alejandro Synegub for use in the cement industry; the Finca Las Minas, on the property of Cecilia v. de Cuellar, near the summit of the Cordillera del Sauce; El Chanco, 2 miles south of Cerra de Ticanlú, on the road from Chiquimula to Olopa, where ore is said to occur as float boulders in soil; El Tituque, 3½ miles northwest of Olopa; and Camotán, between the village of Camotán and the Honduras border.

Although none of these deposits may contain a large tonnage of iron ore, their nearness to the railroad which passes through Chiquimula makes them attractive to operators using the ore locally and to manufacturers who need small quantities of ore.

COSTA RICA

Iron-ore deposits have been reported near San Ramón, in Costa Rica. The deposits have not been explored and the reserves are not known, but the ore is said to be of good quality.

LEAD-ZINC DEPOSITS

GUATEMALA AND EL SALVADOR

The Alotepeque and Metapán districts of Guatemala and El Salvador are near the junction of these countries and Honduras. They are in an area of Cretaceous rocks, which is surrounded by Tertiary volcanic rocks. The two districts are described together, as their ore deposits and general geology are similar.

GEOLOGY

The rocks in the area belong to four main groups. The oldest group includes interbedded shale, sandstone, conglomerate, and limestone which belong to the Metapán formation of early Late Cretaceous age. These rocks have been intruded by small bodies of diorite and quartz monzonite, and both the sedimentary and the intrusive rocks are overlain by volcanic rocks of Tertiary and Quaternary age. The youngest is the alluvium, of Quaternary and Recent age.

The Metapán formation was named by Sapper (1937, p. 65; Müllerried, 1942a, p. 129) from exposures in this area. This formation is described earlier in this report, but may be summarized briefly as consisting mainly of red shale, sandstone, and conglomerate with interbedded layers of limy shale and limestone.

East of Metapán, on the peaks of El Sillón and at other places throughout the area, the youngest rock unit is a massive limestone bed 100 feet or more thick which is distinguished in plate 8 as the limestone unit of the Metapán formation. The upper part of the section has been eroded, and the Metapán strata are overlain by pyroclastic rocks and lavas of Tertiary and Quaternary age.

The Metapán formation is cut by diorite, quartz monzonite, and granodiorite which occur as dikes, sills, and small intrusive masses. These rocks are generally fine to medium grained, but in places the granodiorite is coarse grained. The intrusive bodies are closely spaced and may make up 50–75 percent of rock outcrops. Where the intrusive rocks cut limy shale and limestone, such minerals as garnet, diopside, epidote, hornblende, and related minerals were formed; in places lead-zinc ore bodies occur in the contact-metamorphic zones. Some of the finer grained dikes are andesitic in composition and may be related to the volcanic activity that later gave rise to flows and pyroclastic rocks which cap the other rocks in the area. Silver-bearing veins cut these volcanic rocks and are evidently younger than the contact ore bodies.

DESCRIPTION OF THE ORE DEPOSITS

The ore deposits of the Metapán and Alotepeque districts contain silver, lead, zinc, copper, gold, and tungsten, but only silver, lead and zinc have been mined. The deposits are irregular replacement bodies and veins.

The replacement bodies were formed in contact zones between limestone and intrusive igneous rocks, especially diorite and granodiorite. For the most part they contain lead and zinc sulfides and a smaller quantity of copper sulfides. Pyrite, hematite, and magnetite are found in some deposits. The precious-metals content is generally low, and the deposits have been worked for their base metals.

The veins range in width from an inch or less to 6 feet, but they are commonly narrow, averaging probably less than a foot, and pinch and swell along the strike and down the dip. They are composed of quartz and sulfides, among which pyrite, sphalerite, galena, and chalcopyrite are the most common, but tetrahedrite, stibnite, pyrargyrite, and polybasite also are reported. The lead, zinc, and copper minerals are erratically distributed, and the veins are valuable chiefly for their silver content, which may be as much as 400 ounces to the ton. The most productive vein in the area has been the San Pantaleón.

METAPÁN DISTRICT

The Metapán district is in the northwestern part of El Salvador, in the Departamento de Santa Ana; it lies just south of the junction of El Salvador, Guatemala, and Honduras. Metapán is on the El Salvador branch of the International Railways of Central America, 178 miles from the east terminus at Puerto Barrios and 83 miles from San Salvador.

There has been intermittent activity in the Metapán district since colonial days, although production has been small. Iron ore was mined and smelted for local consumption until about 1890. Attempts have been made to mine silver-bearing galena veins and copper deposits, but production in the early days was not recorded. In 1917 a small shipment of sorted lead ore was sent from the San Juan mine to New Jersey. Later attempts were made to smelt the ore locally, but the operation was not profitable. It is reported that René Keilhauer of San Salvador installed a mill at the San Juan mine in 1950 and that production began in 1951. No details of the operation are available.

SAN JUAN MINE

The San Juan mine is at the village of San Juan, 7 miles southeast of Metapán on the Río Casaquaste, at an altitude of 1,800 feet (fig. 3). The property covers an area of about 180 acres and is owned by René Keilhauer of San Salvador. In 1917 a shipment of 55 tons of sorted lead ore was made to New Jersey. This ore assayed 38.14 percent lead, 12.76 percent zinc, and 6.65 ounces of silver to the ton. In 1931 a small smelter was installed on the property. The smelter worked successfully, but since iron-ore flux had to be transported from El

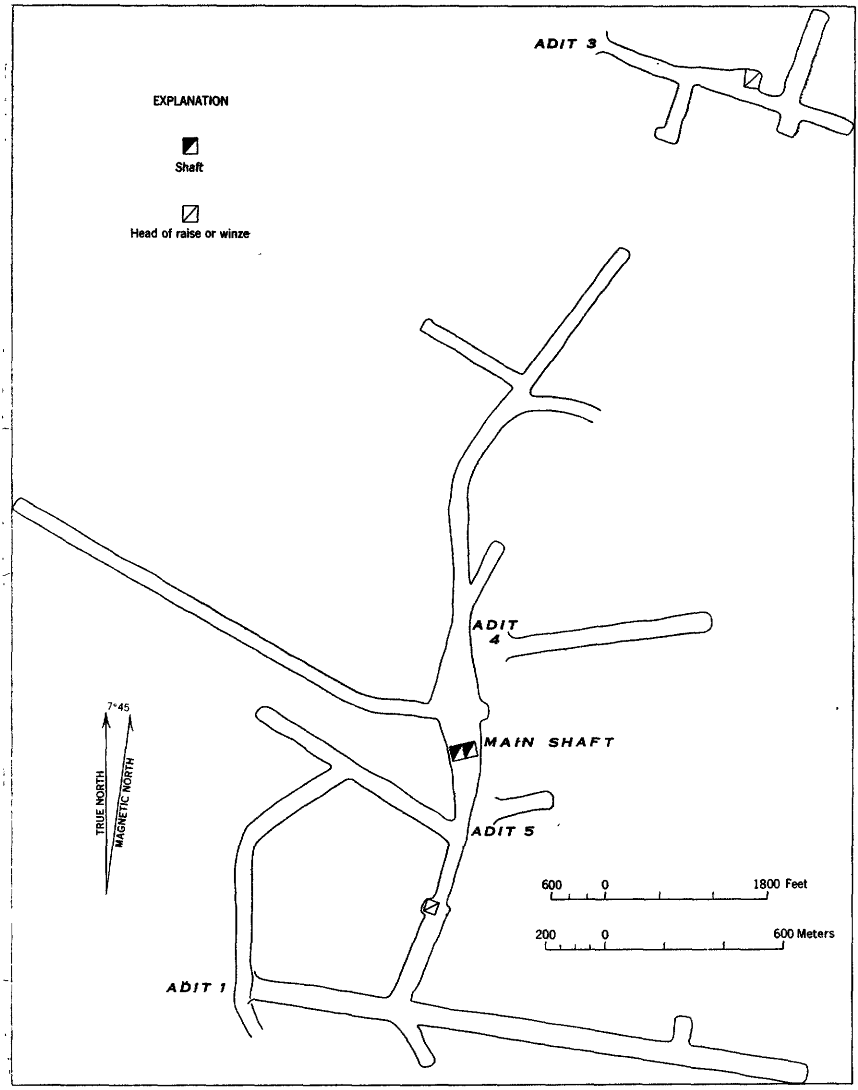

FIGURE 3.—Map of the San Juan mine workings, Departamento de Santa Ana, El Salvador.

Tajado, more than a mile to the southeast, and the ore was of low grade, the operation was not profitable. In 1951 the property was again put into production, by Mr. Keilhauer, who installed a small mill and was producing concentrates for shipment to Mexico.

The San Juan mine is in tactite which was formed by metamorphism of limestone along a contact with granodiorite. The tactite is composed mainly of garnet, epidote, calcite, and quartz; pockets, nodules, and veinlets of pyrite, galena, and sphalerite are distributed erratically throughout the rock. The ore is reported to average about 4.7 precent lead, 2.5 percent zinc, and 1.5 ounces of silver to the ton.

The ore body has been explored for a length of 260 feet, a width of 110 feet, and to a depth of 75 feet by a 75-foot shaft and 750 feet of underground workings. The workings are on 2 levels, four adits at the surface level, and the 50-foot level, connected by the main shaft and by a winze.

Only the surface-level workings were accessible in 1944 because the lower levels were flooded. They include adits 1, 3, 4, and 5. Adit 1 was caved in 1944. Adit 3 is in barren garnet rock from the portal to the crosscut to the south, but the rock from the crosscut to the face is mineralized. Adits 4 and 5 are both in rock that appears to be mineralized.

The workings on the 50-foot level extend to the north, south, and west from the shaft and nearly connect with a drift from adit 3. The main shaft continues 25 feet below this level and is said to be in mineralized rock at the bottom.

SAN CASIMIRO MINE

The San Casimiro mine is 2½ miles north of San Juan, at an altitude of about 1,900 feet. The property has an area of about 138 acres and is owned by René Keilhauer of San Salvador. No production was reported. The workings consist of a 50-foot shaft and several hundred feet of drifts and crosscuts which were partly caved at the time of visit in 1943.

The rocks in the area are shale, sandstone, and limestone of the Metapán formation that strike nearly north and dip 40°–60° E. They have been sheared and fractured parallel to the bedding, and some of the shale has been metamorphosed to hornfels.

The ore is pyrite, sphalerite, galena, chalcopyrite, and arsenopyrite, which replace hornfels along the bedding. The sulfides are accompanied by small quartz veins, and in places the hornfels is silicified. The ore is reported to contain as much as 30 ounces of silver a ton and 0.3 ounces of gold a ton.

The principal workings are adit 3 and connecting workings on the 50-foot level. This adit is in siliceous hornfels; the rock is sparsely mineralized at the portal, but it locally contains pockets and small veins of sphalerite and galena. The drift shows low-grade ore and some pockets of sphalerite and galena south of the adit crosscut. The 50-foot level, flooded in 1943, is in limestone and barren hornfels for the most part, but the crosscut east of the shaft is in ore containing sphalerite and chalcopyrite. The higher workings include 2 caved adits, each about 150 feet long, and several shallow pits.

EL TAJADO MINE

The El Tajado mine is a mile southeast of San Juan, near the village of La Cerbita. The property belongs to René Keilhauer of San

Salvador. The workings consist of several opencuts at the summit of a small hill and a crosscutting adit about 20 feet below.

The pits explore a contact zone between limestone and granodiorite. The limestone has in most places been silicified and metamorphosed to garnet rock, which locally contains specularite, magnetite, and a little copper stain. A block of calamine is said to have been found in one pit; it was presumably derived from the alternation of sphalerite. The adit was about 260 feet long in 1943 and was being driven in granodiorite to intersect the ore at depth.

SAN ISIDRO MONTAÑITA PROSPECTS

The San Isidro Montañita deposit, about a mile northwest of Metapán, is on the Finca Santa Rosa. Shows of copper on a ridge, presumably in granodiorite, have been explored by an adit that was caved in 1943. Specimens on the dump contain quartz veins, as much as 4 inches wide, in which there is a little chalcopyrite, galena, and pyrite. At San Isidro, half a mile north of San Isidro Montañita, a short adit has been driven into garnet rock locally stained with copper carbonates.

EL BRUJO MINE

The El Brujo mine is 10 miles north of Metapán, near the El Salvador-Guatemala border. Old workings, which cover an area about 300 feet long and extend as much as 100 feet up the slope, explore a contact zone between limestone and granodiorite. Iron ore was mined from this deposit during Spanish colonial days, but the production is not known. The ore consists of magnetite and a little copper carbonate in a gangue of garnet, epidote, and calcite.

LA ESPERANZA PROSPECT

The La Esperanza prospect is a mile northwest of Metapán on the road to La Joya, on land owned by Reginalda v. de Menéndez. The workings consist of 2 trenches and a pit 15 feet deep in limestone and shaly limestone striking N. 60° W. and dipping 20° SW. Nearby a granite porphyry is exposed. Small veins and pockets of galena, partly altered to cerussite and anglesite, are found in the walls of the pit.

CHAGUITE DEPOSITS

The Chaguite copper deposits are on the farm of Félix Heredia, about 4¼ miles north of Metapán and a quarter of a mile north of the village of Chaguite. Several veins of calcite, copper carbonates, and chalcocite, none more than an inch wide, cut andesite and red sandstone.

At El Carmen, half a mile south of the Chaguite deposit, small pockets of copper carbonates in calcareous red conglomerate occur along fractures and are disseminated throughout the rock. The material is of low grade.

MONTE VERDE DEPOSIT

The Monte Verde deposit is about 28 miles east of Metapán, near the Honduras border. The property was not visited, but specimens show copper carbonates in a gangue of garnet, epidote, calcite, and quartz. Picked samples are reported to assay as high as 10 percent copper.

OTHER DEPOSITS

In the course of field work other deposits were examined. At Cañas Dulces, about 4⅓ miles northeast of Metapán, argillite and granodiorite with disseminated pyrite are exposed along the banks of the Río San Miguel. At San Rafael, shale containing disseminated pyrite crops out in a small stream. At Quebrada del Tigre, 1⅕ miles north of Metapán, galena and pyrite occur in argillite. Fleury (1917, p. 435) mentions other shows in the district.

ALOTEPEQUE DISTRICT

The Alotepeque district in Guatemala adjoins the Metapán district on the north (pl. 8). It is named for the village of Alotepeque, which lies about 2 miles southwest of the principal mines, and covers an area 6 miles long by 1⅘ miles wide. The district can be reached by trail from points on the International Railroad to the west; it lies only about 18 miles east of the station of Agua Blanca from which roads passable by cars could easily be built. Concepción, 3 airline miles north of Alotepeque, can be reached by car from Chiquimula during the dry season and is only about 5 miles from the mines by a fair trail.

The ore deposits in the Alotepeque districts have been exploited since Spanish colonial times. The San Carlos, San Rafael, San José, and San Pantaleón veins were the most productive and are said to have been worked to a maximum depth of 500 feet. In 1844 the Central American Mining Co., an English company, acquired 17 properties in the district. By 1847 this company was operating the San Carlos, San Pantaleón, Santa Rosalía, Guadalupe, Atutlilico, San José, San Vincente, and Adilio mines. The production is not accurately known but is estimated by some to have been 20 million–40 million ounces of silver between 1847 and 1867, chiefly from the San Pantaleón and San Carlos veins. The company ceased operations in 1867 because of lower grade ore and high costs of pumping water from the deeper workings. Local operators continued production on a small scale until 1896 but with only a small output. In 1911 the Guatemala Mining and Development Co., Inc., acquired the properties, and between 1912 and 1914 this company drove the San José adit to intersect the San Pantaleón veins below the deepest workings. The project was abandoned before completion. In 1927 the claims passed to the Guatemala Mining Co. and in 1931 were acquired by the Empresa Guatemalteca de Minas, S. A. This company also acquired the mine holdings of the International Railways of Central America. During recent years the only activities in the area have been small-scale operations by José Iten on the San Vincente veins. A French company, Horta Cía., denounced 14 claims in 1896 and did considerable exploratory work but shipped only a few tons of ore. In 1913 Minor C. Keith, acting for the International Railways of Central America, took an option on the Horta properties and did further exploratory work on them. A small mill was built in 1915 at La Cañada on the Río de las Minas, in which about 1,500 tons of zinc ore, principally from Tajo de Montenegro, was treated. In addition, 500 tons of high-grade oxidized zinc ore was shipped from the El Chorro mine.

SAN PANTALEÓN MINE

The San Pantaleón mine, near Socorro in the western part of the Alotepeque district, was the most productive property in the area and was operated by the Central American Mining Co. between 1847 and 1867. According to some estimates the production from this mine and nearby properties was 20 million–40 million ounces of silver, the bulk of which came from the San Pantaleón vein. The mill was at an altitude of 3,000 feet on the Finca San José about 1⅓ miles northeast of the mine. Here the ore was dried, crushed, and roasted, then chloritized and amalgamated. Some high-grade ore was shipped directly to Swansea, Wales.

The workings explore the veins along the strike for about 3,000 feet and are reported to extend to a depth of 550 feet from the collar of the shaft, which is 4,429 feet above sea level. Operations are said to have ceased because the flow of water at the 550-foot level was so great that available pumps could not handle it. None of the workings were accessible in 1944, and little information is available on the vein system and the ore mined. The vein system is said to consist of several parallel veins striking N. 75° W. and dipping steeply southward. The ore minerals are pyrite, galena, sphalerite, stibnite, tetrahedrite, arsenopyrite, and silver sulfides; the gangue minerals are quartz and a little calcite. The tenor of the ore is not known, but ores mined from nearby veins are reported to contain 45–1,000 ounces of silver to the ton.

The San José adit, driven southward in Tertiary(?) pyroclastic sediments and volcanic rocks to intersect the San Pantaleón veins at an altitude of 3,510 feet, penetrated these rocks for 2,450 feet but was abandoned before the vein was reached. In 1944 the adit was open for about 1,700 feet. It is in Tertiary sedimentary and pyroclastic rocks to the caved area. It is reported that a vein was cut near the present face, but its width is not known.

SANTA ROSALÍA MINE

The Santa Rosalía mine is northwest of the San Pantaleón mine. The upper workings, which yielded the ore mined, are now largely caved, but the workings 30 feet below are accessible. Although the production is not known it must have been small, judging from the amount of work done.

The lower adit is in interbedded tuff and shale which strike nearly north and dip 25°–30° E. The vein was intersected 85 feet from the portal; it strikes east and dips 60°–70° S. The vein zone is from a few inches to 3 feet wide and consists mainly of quartz and pyrite. In places there is a little sphalerite. Pyrite is also disseminated throughout the altered wall rock. Assays of the vein zone show that the gold content is generally less than 0.04 ounce to the ton, and silver ranges from less than an ounce to more than 60 ounces a ton.

PLOMOSA GRANDE MINE

The Plomosa Grande mine is in the southwestern part of the area, half a mile southwest of El Socorro, at an altitude of 4,000 feet. The amount of ore mined is not known; it was treated in the mill of the Central American Mining Co. The workings include a shaft and adit, both of which are caved.

Specimens found in the dumps show that the ore consisted of galena, sphalerite, chalcopyrite, and pyrite, in calcite and chloritized limestone and shale. It is reported that the vein was about 2 feet wide in the shaft and dipped steeply, but the strike is not known.

TAJO DE MONTENEGRO MINE

The Tajo de Montenegro mine is in the southeastern part of the area, on the headwaters of the Río de las Minas, at an altitude of 4,925 feet (pl. 8). Because of landsliding which took place principally in 1938, many of the workings are caved and inaccessible. An unknown tonnage of ore was mined from these workings and was treated in the La Cañada mill during the 1930's.

The rocks in the area are shale, limy shale, and limestone which have been altered to hornfels, and an epidote-amphibole rock containing disseminated sphalerite, galena, chalcopyrite, and pyrite. The structure in the ore zone cannot be determined because of landsliding, but east of the workings the rocks strike northwestward and dip 30°–45° NE. At the portal of adit 6 the ore zone is 30 feet thick, but it is of low grade, for the sulfides are erratically distributed throughout the rock.

LA BALLENA MINE

The La Ballena mine is at an altitude of 5,000 feet and is north of the Tajo de Montenegro mine. The workings are caved and no ore could be seen in place. About 100 tons of ore on the dumps show pyrite, galena, and sphalerite, in a gangue of epidote, chlorite, and actinolite. None of the ore appeared to be of high grade.

Shows of copper were seen in the stream valley east of Ballena at the contact of limestone and intrusive porphyry. The ore is of low grade, but it could be sorted to a product containing 5–10 percent copper.

SAN JOSÉ GRANDE MINE

The San José Grande mine is on the trail from Socorro to the Río de las Minas, at an altitude of 3,950 feet. Shallow surface workings expose silicified limestone, which is partly altered to epidote-garnet rock. The workings follow a fault zone which strikes N. 80° W., and dips 75° SW., averages 2 feet in width, and contains iron and manganese oxides. No sulfides were seen in the fault zone, but specimens from the workings show sphalerite, galena, and pyrite. The ore is disseminated throughout the rock and for the most part is low grade.

The upper adit, above the trail, extends N. 55° E. for 50 feet; it cuts altered and silicified limestone that contains pockets of iron oxide. The lower adit trends N. 8° E. and is 96 feet long, with a crosscut to the east 33 feet from the portal. The limestone in this adit strikes N. 50° E. and dips 10° NW. In places it contains pockets of iron oxide.

SANTA SOFÍA MINE

The Santa Sofía mine is among the most accessible in the district, and the ore is well exposed in seven short adits and several shallow opencuts. Ore was sorted for treatment in the mill at La Cañada, but only a small amount was milled. The workings are in limestone, in part metamorphosed by intrusive granodiorite porphyry. South of the workings the limestone strikes N. 55° W. and dips 70°–75° NE., but in the upper adits it appears to dip gently northward.

The uppermost adits, 2, 7, and 8, appear to be in the same replaced limestone bed. The mineralized rock contains oxides of iron and manganese, erratically distributed. Sulfides, including sphalerite, galena, chalcopyrite, and pyrite, occur in pockets. The ore body is exposed to a depth of as much as 20 feet and averages 3 feet in thickness. Adit 1, the lowest, is open for a length of 90 feet. Its walls are garnet rock that contains disseminated galena, sphalerite, and pyrite. Granodiorite porphyry is exposed on the slope 40 feet south of the portal.

SAN FERNANDO MINE

The San Fernando mine is on the east side of the Río Concepción at an altitude of 5,225–5,300 feet. An adit, 12 feet long, and several opencuts are the only accessible workings. A small production is reported.

The deposits are veins and pockets of iron and manganese oxides and zinc carbonate in limestone. One vein, 4–18 inches wide, strikes

N. 40° W. and dips 40° NE., apparently parallel to the bedding. However, on the whole the ore is erratically distributed throughout the zone.

EL CHORRO MINE

The El Chorro mine adjoins the San Fernando mine on the east, at an altitude of 5,200 feet. Shallow cuts and underground workings extend over an area 400 feet long by 250 feet wide down the slope that contained pockets of zinc carbonate. In 1916 and 1917 the ore was concentrated in log washers and calcined in furnaces nearby. The product was shipped to the United States.

The ore was in pockets in limestone, which strikes N. 75° W. and dips 10° NE. In places there was a gossan of iron and manganese oxides, and the pockets of zinc carbonate occurred in this gossan and in the adjacent limestone. Judging from the size of the shallow pits, the individual pockets contained only a few tons of ore.

SAN BARTOLO MINE

The San Bartolo mine is north of the San Fernando mine, at an altitude of 4,800 feet. A series of cuts is along the west slope of a small valley, where shallow ore bodies were found in limestone that strikes eastward and dips 20° S. The ore was in the limestone and consisted of pockets of lead and zinc carbonates; it is reported to have contained much more lead than zinc.

OTHER MINES

The San Carlos mine is at an altitude of 5,000 feet, near the summit of the Monte Cristo ridge. The workings are now completely caved, but the dumps show silicified volcanic rock impregnated with pyrite and stained with iron oxides. Calcite seams cut the rock in places. The property was first worked by Spaniards during colonial days and later by the Central American Mining Co.

The Providencia prospect is on the San Vincente denouncement, at an altitude of 4,700 feet. An adit in argillized volcanic rock shows a shear zone that strikes N. 25° E., dips 65° SE., and contains copper and iron-stained vein material 2–6 inches wide.

The San José mine is at an altitude of 4,500 feet. A vein, an inch to 6 inches wide, of sphalerite, pyrite, and malachite stain in a quartz gangue is exposed.

The Atutilco mine adjoins the San José on the north. The principal workings are in altered volcanic rocks, which have been silicified and partly replaced by pyrite. The production is not known.

The San Rafael mine is on the southwest side of a ridge, southwest of the La Ballena workings. The workings cover a wide area, but except for opencuts they were not accessible in 1944. The veins are in shale, sandstone, and conglomerate of the Metapán formation. In places these rocks are calcareous and have been metamorphosed to garnet rock by porphyry intrusions exposed nearby. The mine was productive during Spanish colonial days and at intervals since then, but no records of the production remain.

GUATEMALA

Lead-zinc deposits are known in Guatemala in a belt that extends from the Mexican border eastward through the Departamento de Huehuetenango and the Departamento de Alta Verapaz. The principal deposits are in three areas: the Chiantla-San Sebastián district (pl. 9), the San Miguel district, and the Cobán district (fig. 4).

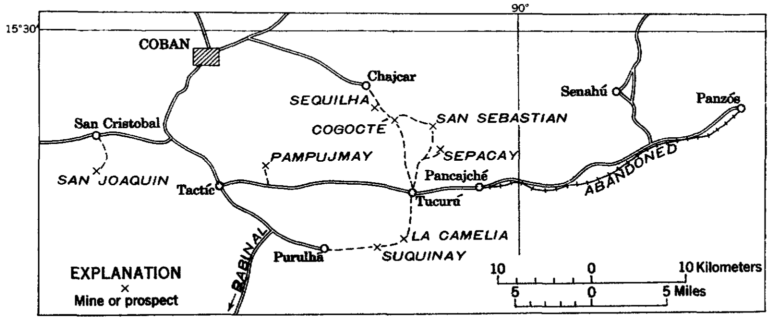

FIGURE 4.—Index map showing locations of mines in the Cobán district, Departamento de Alta Verapaz, Guatemala.

Those in the Chiantla-San Sebastián and San Miguel districts were being worked for lead in 1944 when the properties were visited, although only on a small scale and for local use.

The high price of lead in recent years has stimulated interest in the Guatemalan lead deposits, and exploratory work has been carried on in the three districts. Because the Cobán district was more favorably situated than the other districts with respect to transportation, it was put into production first, and shipments were made in 1947. Preparations were underway in 1950 by an American company to begin production in the San Miguel district.

TREATMENT OF THE ORE

Treatment of lead ore in this area has followed a method brought from Spain by the Spanish priests of the colonial period. There has been no essential change in the method as it passed down from father to son to the present day.

If the ore mined is high grade, it can be smelted directly; if it is low grade, it is first washed to remove as much limestone, clay, and iron oxides as possible. The washing is done in an inclined trough or log washer, where the fragments of limestone are picked out and the clay and iron oxides are carried off in suspension, leaving the heavier lead and zinc minerals as concentrates. This concentrating process is inefficient, and the tailings contain considerable lead, but the resulting product is well suited for the furnace.

The Spanish furnace is a simple blast furnace consisting of a vertical chimney into whose top a mixture of ore and charcoal is charged. Air compressed by a column of water falling down a closed tube into a pressure chamber is directed into the bottom of the chimney. When the compressed air strikes glowing charcoal, a blast flame sufficient to smelt the ore is generated. The slag and molten lead run out of a small opening in the bottom of the chimney and are collected in a basin. The furnace can be operated continuously for 6 or 8 hours and can yield from 1,200–2,000 pounds of lead, depending upon the grade of the ore. The lead is generally cast into bars weighing a pound or two each.

LOCAL TERMINOLOGY OF THE ORES

Miners in the Huehuetenango area have developed a local terminology for the ores of the area. The oxidized ore is mostly porous iron oxides with variable amounts of lead and zinc carbonates. The ore is generally medium brown but varies from white or light yellow to nearly black. The miners have divided the ores into four general groups: quemazón, mineral de carbonato, mineral blanco, and mineral de lava. Quemazón is dark brown to black, generally because of a high limonite content. Most of it is porous and contains relict galena in places. Quemazón is ordinarily low grade and may have been derived from ore with a high pyrite content. Mineral de carbonato is soft, porous, sandy ore, commonly yellow to light brown, that forms lenses, layers, and irregular masses in quemazón and limestone. It is high grade and generally can be smelted without washing; the source material was high in galena and may have contained some sphalerite and pyrite. Mineral blanco (lija, if hard) is white to light-yellow ore composed almost entirely of cerussite and anglesite. Mineral blanco forms in lenses and veinlets in quemazón and mineral de carbonato, and appears to be carbonate that has been carried in solution and redeposited. This ore can be smelted without concentration. Mineral de lava is a general name for low-grade quemazón or mineral de carbonato which has to be washed before smelting.

CHIANTLA-SAN SEBASTIÁN DISTRICT

The Chiantla-San Sebastián district is in the Departamento de Huehuetenango, northwest of the village of Chiantla and on the south slope of the Sierra de los Cuchumatanes (pl. 9). These mountains are a partly dissected late-mature upland whose summits range in altitude from 11,000 to more than 12,000 feet above sea level; their drainage is for the most part radial.

GEOLOGY

The rocks forming the south flank of the Sierra de los Cuchumatanes (pl. 9) include most of the stratigraphic units known in northern Guatemala. Granite and gneiss of pre-Permian(?) age are exposed along the range front. These rocks are separated by a fault from sedimentary rocks belonging to the Santa Rosa and Chochal formations of Permian(?) and Permian age which have been cut by serpentine and form the south slope of the range. Near the summit, the Permian rocks are in thrust-fault contact with red shale and sandstone of the Todos Santos formation, which to the north is overlapped by limestone of Cretaceous(?) age. Pyroclastic rocks and alluvium of Pleistocene or Recent age are present in the foothills of the range.

The granite and gneiss of pre-Permian(?) age form the low foothills just north of Huehuetenango. They are largely concealed by pyroclastic rocks and alluvium, but exposures in road cuts and on the higher slopes show that the gneiss is intimately intruded by the granite. The foliation of the gneiss is locally contorted but generally trends eastward and dips steeply.

The oldest sedimentary rocks in the area belong to the Santa Rosa formation (see p. 15). This formation consists of a lower unit of interbedded sandstone, shale, and conglomerate, and an upper unit of red, green, gray, and black shales with interbedded shaly limestone, sandstone, and dolomite. The lower unit is mapped only at the foot of the range where beds totaling about 50 feet in thickness are exposed. The upper unit is well exposed on the middle slopes of the range. Because of complex faulting and close folding, the thickness of the upper unit cannot be determined accurately, but it appears to be about 1,000 feet near the La Esperanza mine. These beds appear to be similar in lithologic composition and fauna to the Grupera formation and possibly part of the La Vainilla formation in Estado de Chiapas, eastern Mexico (Thompson and Miller, 1944, p. 481–504).

In the Chiantla-San Sebastián district, limestone and dolomite beds of the Chochal limestone (see p. 16) overlie the upper part of the Santa Rosa formation and form the upper slopes of the range from an average altitude of 8,500 feet to the summit. A downfaulted block of the limestone also occurs in the foothills of the range, where the limestone has been cut by serpentine and is complexly faulted. Because of its resistance to weathering, the limestone crops out as prominent cliffs. The limestone is well exposed near the Finca Chochal, the source of its name.

The Todos Santos formation of Jurassic and Cretaceous age, which unconformably overlies the Chochal limestone, is chiefly composed of interbedded red sandstone, shale, and conglomerate. For the most part these rocks have not been metamorphosed, but near faults the shale locally has a slaty cleavage. The pebbles making up the conglomerate include quartzite, granite, sandstone, limestone, dolomite, schist, and gneiss, all probably derived from the underlying Permian and older formations.

The limestone unit resting upon the Todos Santos formation north of Chochal is light gray, dense, fine grained at the base, for the most part thick bedded or massive, and weathers in rough, craggy outcrops. It contains many sinkholes, and in places a karst topography has been developed. This limestone is lithologically similar to the Upper Cretaceous limestone (see p. 23), with which it is therefore tentatively correlated.

The granite and gneiss that form the belt between Huehuetenango and Chiantla are not in contact with the Permian strata except where they are brought together by faulting, and their relative age is therefore not certainly known. Since pebbles and boulders of granite, gneiss, and schist are found in the lower beds of the Santa Rosa formation, the granite and the metamorphic rocks are probably for the most part pre-Permian. However, near San Miguel Acatán granitic rocks cut Santa Rosa strata and are therefore younger, and Termer (1932, p. 246) found diorite dikes that cut Permian slates near El Quetzal, Huehuetenango. At least two periods of intrusion must be represented in the Sierra de los Cuchumatanes, and there may well be others not yet recognized.

Serpentine forms a wide zone along the foothills of the southern flank of the mountains. On the south the serpentine is in fault contact with the granitic rocks, but elsewhere it is intrusive into the Santa Rosa and Chochal formations. Generally the intrusive contacts are concordant with the structure in these rocks, but in places they are discordant. Magnesite veins and pods occur locally in the serpentine and are for the most part small and irregular. Generally the serpentine is altered, sheared, and foliated; it weathers to a thin poor soil that supports only sparse vegetation.

Three principal sets of faults have been mapped in the area. The faults of the major set trend westward, dip steeply southward, and are reverse faults. The faults at Las Manzanas and the Finca Chochal belong to this set. Another set, which includes the La Sara and La Esperanza faults, consists of normal faults that trend westward. The third set consists of normal faults that trend northwestward and cut across the general strike. A few other minor faults of small displacement also trend northwestward and northward. The westward-trending reverse and normal faults have the greatest displacement. Some of these faults are mineralized and may have been the channels for ore-bearing solutions.

DESCRIPTION OF THE ORE DEPOSITS

The lead-zinc ore bodies of the Chiantla district are replacement deposits in limestone of Permian age. They may be divided into two types: those that extend along faults, and those that follow the bedding. The two are generally found together, and the fault zones may have been the channelways for the solutions that formed both kinds of ore bodies.

The primary minerals of the ore bodies are galena, sphalerite, and pyrite. These minerals have been oxidized—the galena to anglesite and cerussite, the sphalerite to smithsonite and calamine, and the pyrite to iron oxides. The oxidized ore is generally a boxwork of porous light-brown limonite containing variable amounts of lead and zinc minerals. Galena is the only sulfide found in the oxidized ore; it occurs as small kernels surrounded by anglesite and cerussite, its oxidation products.

The ore bodies that follow faults are lenticular and discontinuous along the strike. Figure 5 shows one of these ore bodies at the La Esperanza mine; it was mined from an open pit that was 80 feet long, as much as 35 feet wide, and more than 25 feet deep in 1943. The shallow pits and the shaft near the main pit explore a mineralized bed extending out from the fault. This bed has been mined for about 300 feet west of the fault (fig. 5) and more than 100 feet down the dip. The Torlón ore bodies (pl. 10) appear to be a combination of the two types defined above, having resulted from irregular replacement along bedding adjacent to a fault zone. The ore zone is 1,400 feet long, as much as 350 feet wide, and has been mined to a depth of 120 feet. Mineralization is not continuous; the ore appears to be in several shoots, some of them as much as 200 feet long and 30 feet wide.

Except for a few relict kernels of galena, oxidation is complete in the workings visited. The only primary ore seen—fine-grained sphalerite, pyrite, and galena—came from the Santa Rosa workings of the Torlón mine, about 100 feet below the surface. This probably represents the minimum depth of the oxidized zone, for elsewhere at this depth the ore is commonly oxidized.

As the miners have sought only lead ore, the ground rich in zinc has not been explored. Although some zinc minerals are found in the oxidized zone, the bulk of the zinc was probably leached and transported downward; part of it may have been precipitated as smithsonite and calamine in the lower levels and on the borders of the ore bodies and the remainder carried out in ground water.

TORLÓN MINE

The Torlón mine (pls. 9, 10) is 15 miles northwest of Chiantla, in the foothills of Sierra de los Cuchumatanes. The workings are at

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altitudes of 6,600–7,300 feet (pl. 10). The property, owned by the Recinos family of Huehuetenango, has been productive for more than 200 years. The ore is mined, washed, and smelted by primitive methods, and the pig lead is sold in Guatemala. The rate of production in 1944 was about 5 tons of lead a month.

The lowest opening at the Torlón mine is adit 1, which is entirely in serpentine; it was driven for about 300 feet but is caved from the 200-foot mark to the face. A raise extending 75 feet up from the face is reported to have cut ore.

Workings 2, at an altitude of 6,840 feet, are in serpentine and limestone on the hanging wall of the Torlón fault. Two adits, one extending westward and the other northwestward from the portal, explore flat or gently dipping ore bodies in fractured and brecciated limestone. At the portal the south adit is in rubble, and for 60–80 feet from the portal it is in sheared serpentine, which is in fault contact with limestone that extends to the face. Little ore was seen in 1943 on the drift level, but a raise 90 feet from the portal shows ore. Another raise 15 feet to the west connects with the stope above. In this stope the ore occurs in pockets in limestone. A sample (T14) collected on the south side of the stope gave the following assay: 9.1 percent lead, 18.7 percent zinc, and 1.3 ounces of silver to the ton. The high zinc content may indicate that this ore was transported by oxidizing solutions and precipitated here.

The north adit is in rubble, pyritic clay, and limestone breccia. Irregular ore bodies were mined in the limestone breccia beginning about 140 feet from the portal; a section 60 by 70 feet was partly stoped in a vertical range of about 20 feet. Sample T13 was collected in the south end of the stope (see table).

The San Juan workings explore an irregular ore body in limestone. Two adits connect with the workings, one at an altitude of 6,933 feet and the other at an altitude of 6,953 feet. The workings are extremely irregular, and as they follow the richer zones they give little idea of the ore body as a whole. The ore appears to replace limestone along fractures and faults extending northwestward. Two principal stopes, the La Iglésia and the San Juan, are accessible. Other ore bodies were mined to the northwest, but in 1943 the workings were caved and inaccessible. Irregular stopes extend out from the drifts and the crosscuts in the mine. In places the stoping extended nearly to the surface, which is at an altitude of 7,000 feet in the western part of the mine area. Assays of nine samples collected in the workings are listed below. These samples indicate the grade of ore to be expected in the walls of the stopes and workings sampled. However, the miners have avoided lower grade material and as far as possible the workings were kept in ore.

Assays of lead-zinc ore from the Torlón mine, Guatemala

[Birger Sundström, Mexico City, Mexico, analyst]

Sample no.	Pb (percent)	Zn (percent)	Ag (oz per ton)
T2	7.1	10.0	----
T3	10.3	7.3	1.3
T4	8.8	9.2	----
T7	4.7	36.0	.8
T9	17.3	13.3	1.4
T10	10.7	14.9	2.3
T13	12.3	2.9	.27
T14	9.1	18.7	1.3
T15	17.4	1.8	6

The portal of Galería Nueva (also called the La Cañada adit), north of the San Juan workings, is in serpentine. The adit trends westward and at 135 feet from the portal crosses the Torlón fault, which here dips westward. Iron-stained limestone forms the hanging wall, but the adit rises after passing through about 20 feet of limestone and enters limestone rubble probably related to faulting and slumping of leached limestone.

The Los Ramos workings, west of the Galería Nueva, explore an ore body along a northward-trending fault zone which dips 65°–80° E. An ore body has been mined along the fault, and pockets of ore extend irregularly out into the adjacent limestone and also follow parallel fractures. Stoping has been carried on over a length of 165 feet, a width as great as 35 feet, and to a depth of about 60 feet at the south end of the workings. Samples T9 and T10 were collected at the south end.

The adit F workings to the west incline downward to the northwest and then curve back eastward; they explore ground that is probably in the upper part of the Los Ramos fault area.

Adit 3 explores ore bodies that extend along steep fractures and also along the bedding adjacent to the fractures. The principal faults trend northward to northwestward and most dip steeply eastward, although some dip steeply westward. The ore bodies that have been mined irregularly replaced the fractured limestone in and adjacent to the fault zones. As shown by the stoping, the mineralized zone has been explored for 160 feet along the strike and as much as 80 feet in width. The deepest workings were 35 feet below the adit level in 1943.

The Verde adit is entirely in serpentine except for a crosscut to the south that passes below adit 3. Near the face of the crosscut the serpentine is in fault contact with the limestone. The contact dips 60° S. The face is caved, but ore is said to have been found a short distance beyond.

Adit 4, which is in limestone, was driven 295 feet westward but is caved 75 feet from the portal. Ore is said to have been cut in the adit 135 feet from the portal, more or less on strike with the projection of the Los Ramos fault, and to continue westward nearly to the face and northwestward along the crosscut.

Adit H, 80 feet west of the adit 4 portal, is in limestone rubble, but adit A, 60 feet farther west, exposes ore of fair grade in limestone, with galena veins and pockets at the face. Adit B, 50 feet north of adit A, is in altered limestone containing veinlets of galena and carbonate ore. A sample of this material assayed 13.6 percent lead and 25.2 percent zinc.

Adit N, at an altitude of 7,154 feet, shows porous oxide and carbonate ore locally containing concretionary iron oxides; sample T7 is from the northern part of the workings. The high zinc content is notable. Adit M contains massive carbonate ore which locally also has a high zinc content.

Exploratory work at the Torlón mine has thus far been to only a shallow depth, and stoping has been confined almost entirely to soft oxidized ore. According to available information, the main ore shoots are parallel to the Torlón fault.

CHOCHAL PROSPECT

The Chochal prospect is about 2 miles northwest of the Finca Chochal, at an altitude of 10,000 feet (pl. 9). Two short adits and several shallow pits explore ore that replaces limestone along the bedding. The property has been worked intermittently, and some ore from the workings has been treated in the furnace at the Tziminas mine and in a furnace built at the Finca Chochal. Because the ore contains a little lead and much zinc, the test runs were not satisfactory.

The adits show ore which replaces limestone and dolomite along wavy bedding surfaces. The ore consists chiefly of compact zinc and lead carbonates, but some relict galena can be found. Iron oxides are present in places, but on the whole they are less abundant than in nearby ore deposits.

The ore body in adit 1 had been explored for about 100 feet along the strike and about 40 feet down the dip in 1943. It ranges in thickness from 6 to 48 inches and becomes narrower down the dip but is locally irregular. In adit 2 the ore is irregularly distributed throughout fractured limestone. The assays listed below were made of ore samples collected from adit 1.

Assays of lead-zinc ore from the Chochal mine, Guatemala

[Birger Sundström, Mexico City, Mexico, analyst]

Sample no.	Pb (percent)	Zn (percent)	Ag (oz per ton)
Ch1	14. 3	24. 2	1. 80
Ch2	15. 5	23. 1	----
Ch3	3. 6	30. 4	. 87

MINERAL DE OCRE MINE

The Mineral de Ocre mine is at an altitude of 10,350 feet and about 500 feet west of the Chochal prospect (pl. 9). The workings consist of several pits, now caved, in the Chochal limestone. The property was last operated in 1938, when the ore was treated in the furnace at the Tziminas mine.

The mineralized zone trends N. 70° W., is about 40 feet wide, and has been explored for about 200 feet along the strike. The ore is composed of iron oxides and lead and zinc carbonates in veins and irregular pockets in the limestone and dolomite.

TZIMINAS MINE

The Tziminas mine is about 800 feet west of the Mineral de Ocre mine, at an altitude of about 10,000 feet (pl. 9). The workings include many shallow pits and an adit in gossan which crops out prominantly. At one time ore from this and nearby properties was smelted in a small furnace on a stream nearby. The production is not known, but judging from the size of the slag pile only a few tons of ore was treated. The volume of water available is small except during the rainy season.

The gossan averages 60 feet in width and extends along the strike for about 400 feet. Many shallow pits show that the lead and zinc carbonates making up the ore occur in veins and pockets throughout the gossan and in the adjacent limestone and dolomite. An adit nearly 200 feet long was driven by the American Metals Co. into the gossan, but the ore found was mostly low grade, indicating that the original sulfide was largely pyrite.

Notwithstanding the low grade of the material exposed in the workings, further exploratory work may be warranted in the Chochal-Tziminas-Mineral de Ocre area. The deposits are all in the same fault zone, and ore bodies may be present at depth and in areas that have not yet been explored.

LA SARA MINE

The La Sara mine is on the boundary between the municipalities of San Sebastián and Todos Santos, at an altitude of 10,625 feet, on the peak west of Chochal (pl. 9). Ore from the La Sara workings was treated in the Tziminas furnace during the 1920's, but the mine was not active in 1944.

A 220-foot long pit with an average width of 20 feet and a depth of 20–30 feet trends N. 55° W. and follows a shear zone nearly parallel to the bedding in limestone, which dips 70° SW.

The ore consists mainly of banded lead and zinc carbonates mixed with iron oxides and contains relict crystals of galena. Pyrite was noted in some specimens on the dump, and thin crusts of malachite on carbonate ore are found in a few places. The workings in 1943 were partly filled with waste rock, and the ore was covered in most places.

LA ESPERANZA MINE

The La Esperanza mine (fig. 5) is on the ridge above Las Lavaderas, about 2½ miles east of the Finca Chochal (pl. 9; fig. 5); the workings are at the base of a limestone cliff, about 9,700 feet above sea level. The mine has been in operation since Spanish colonial days, and since 1914 has been controlled by Benjamin West and his family. Production was high during the period when ore was being mined from the opencut, but since then the mine has been worked only intermittently. Mr. West installed a mechanized treatment plant about 1920, but it was not successful. Since then ore has been intermittently treated in a furnace (chimbo) and oven (horno ocote) constructed in the valley below the mine.

The ore at the La Esperanza is for the most part porous lead and zinc carbonates formed by the oxidation of galena and sphalerite. The oxidation is nearly complete, although relict galena is found locally. Iron staining is not pronounced in most places. Solution of the adjacent limestone accompanied the formation and alteration of the ore, and considerable slumping has occurred, as a result of which the ore layer is wavy and irregularly banded.

One of the ore bodies, which has been mined in an open pit, followed a steep fault striking N. 40° E. The ore has been mined for a length of 120 feet, a width of as much as 40 feet, and a depth of 60 feet. Pockets of carbonate ore were mined from partly replaced and fractured limestone and dolomite on both sides of the pit.

Ore occurs also along the bedding and in fractures parallel to the bedding, striking northwestward along the base of the cliff west of the pit. Several irregular workings follow the ore zone for a distance of 400 feet or more, as shown in figure 5. Because of leaching and slumping, the exact nature of ore deposition could not be learned, but

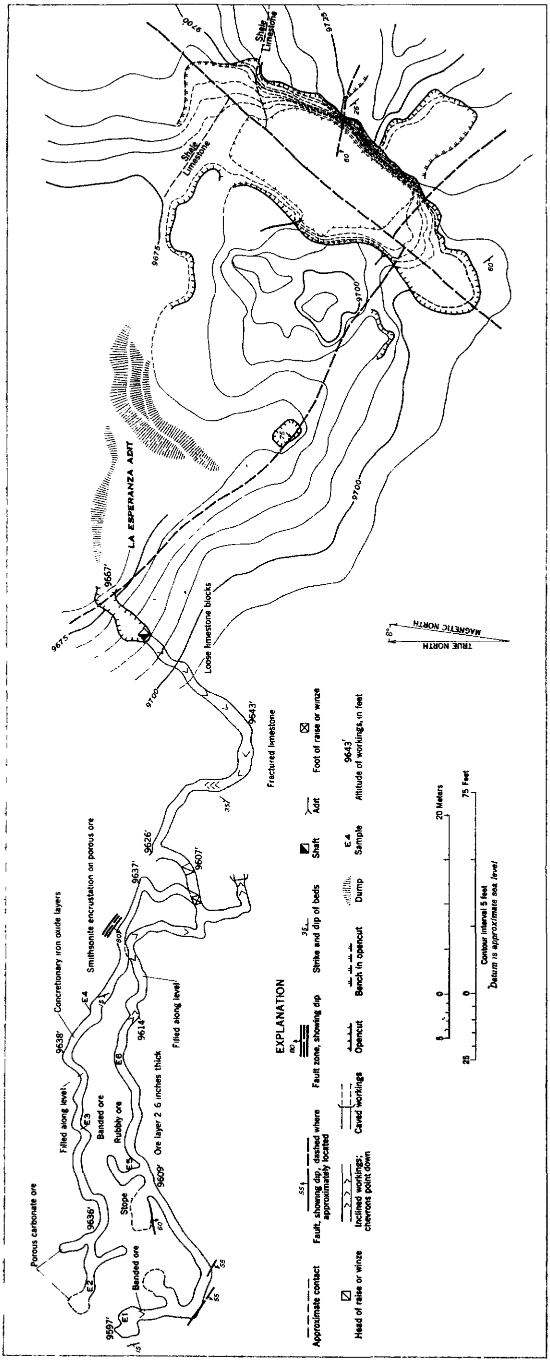

FIGURE 5.—Map of the La Esperanza mine workings, Departamento de Huehuetenango, Guatemala.

generally the ore appears to replace a layer of massive limestone interbedded with shaly limestone.

Assays of the ore show wide variation in the lead and zinc content (see table below). Samples E1 through E6 were collected in the underground workings at localites indicated on the map, and sample E7 was taken from the dump.

Assays of lead-zinc ore from the La Esperanza mine, Guatemala

[Birger Sundström, Mexico City, Mexico, analyst]

Sample no.	Pb (percent)	Zn (percent)	Ag (oz per ton)
E1	17. 9	1. 3	3. 51
E2	28. 6	1. 0	----
E3	11. 5	1. 9	2. 74
E4	5. 9	20. 7	----
E5	19. 3	1. 5	4. 55
E6	1. 4	33. 6	----
E7	1. 2	14. 3	. 39

The miners are fairly skilled in selecting good lead ore and have followed the high-grade shoots as far as possible. Abandoned workings are backfilled with waste and low-grade material.

OTHER MINES

The Almengor mine, about 2 miles southeast of the La Esperanza mine, was productive during colonial days, but the workings are now caved and were inaccessible in 1943.

The Buena Vista mine, about 4 miles southwest of the Finca Chochal, is also credited with a small production. The workings were inaccessible in 1943.

SAN MIGUEL DISTRICT

The San Miguel district is about 30 miles north-northwest of Huehuetenango, near San Miguel Acatán, a village on the Río Santa Catarina. The district could most easily be reached in 1944 by driving northward from Huehuetenango to Tojquiáj, a distance of 26½ miles, and thence 5 miles on horseback over steep trails westward to the Villa Linda mine. Because of the high altitude of Tojquiáj, which is 11,500 feet above sea level, lead from the district was formerly transported by pack animals over a lower route to the west through the villages of Concepción and Todos Santos to Huehuetenango where it was transshipped by truck to Guatemala City.

In 1948 it was reported that C. F. and F. M. Corzelius and W. J. Hill organized the Compañia Minera de Huehuetenango and acquired the Villa Linda and Rosario mines. Work was begun in 1949 on a truck road from Tojquiáj to the mines and was said to be near completion in 1951. A mill is planned at Villa Linda for concentrating ore from the two mines. The concentrates will be shipped by truck to San

Felipe, a station on the railroad near Quetzaltenango, then by train to the smelter at Torreon, Mexico.

Considering the size and grade of the ore bodies found in the Rosario and Villa Linda mines, the San Miguel district may develop into an important lead and zinc producer when transportation facilities are improved. Despite the long distance from shipping points, the district warrants further exploration.

GEOLOGY

In the San Miguel district the lead-zinc deposits are in the Ixcoy formation, 500–1,500 feet above its base. In this area the lower part of the Ixcoy formation includes interbedded dolomite and massive limestone, which for the most part are poorly bedded. Members consisting chiefly of dolomitic breccia and conglomerate are common and in places are 50 feet or more thick. Karst topography has been developed in some areas, and sinkholes as much as 300 feet in diameter have been formed. The Ixcoy formation rests on shale, sandstone, and marl of the Todos Santos formation, a quarter of a mile west of the Rosario mine; the contact dips gently westward and appears to be an angular unconformity. Between San Miguel and Villa Linda the Todos Santos formation is again exposed where it has been brought to the surface in an anticline. The basal limestone beds of the Ixcoy here overlie the Todos Santos formation, which has been truncated by erosion, with an angular unconformity of about 15°. The uplift and erosion clearly occurred in the interval between the deposition of the Todos Santos strata and the overlying Ixcoy formation.

The structure of the central part of the Sierra de los Cuchumatanes is not well known. The older rocks that make up the west flank include shale and sandstone which are probably part of the Santa Rosa formation, and they have been intruded by granite and serpentine. The overlying Todos Santos formation and limestone of the Ixcoy formation rest unconformably on these rocks and dip westward at low angles. The Todos Santos beds are exposed from San Miguel Acatán to a point 5 miles to the east, where they are overlapped by limestone of the Ixcoy formation. In this area the dip appears to be gently eastward, and gentle dips predominate to the crest of the range. Near Tojquiáj and Chemal at the crest of the range, beds correlated by Sapper (1937, p. 31) with the Sepur formation of Eocene age have been preserved from erosion by downfaulting. Between Chemal and the west slope of the range the Cretaceous rocks have locally been sharply folded along northwestward-trending axes.

DESCRIPTION OF THE ORE DEPOSITS

The lead-zinc deposits in the district are replacement bodies along faults and along the bedding in the limestone and dolomite of the Ixcoy formation. As exploratory work had reached a relatively shallow depth in 1944, the downward extent of the ore bodies was not known, but several have widespread outcrops. The ore from the surface downward to depths of 75 feet or more is almost entirely oxidized except for relict galena. Below 75 feet sulfides are found, including pyrite, sphalerite, and galena.

ROSARIO MINE

The Rosario mine is at an altitude of 6,300 feet on the Río Coyá, about 3½ miles southwest of San Miguel (pl. 11). The deposit was discovered about 1917 by Cipriano Gonzalez, who later sold the mine to Santiago Molina, by whom it was sold in 1924 to the American Metals Co. of New York. Between 1925 and 1927 this company explored the property, but its plans for exploitation were not carried through because of high transportation costs. About 1930 the mine was leased to Virgilio Recinos of Huehuetenango, who erected a small furnace on the property. Production was reported to be 8–12 tons of lead a month in 1944, and the total production for an 18-year period is estimated to be about 2,000 tons.

The Rosario mine is in the Ixcoy formation, which is well exposed in the mine area. This formation consists chiefly of massive limestone and dolomite but includes layers of conglomerate and breccia. North of the mine the limestone strikes westward and dips gently northward. Faults in these rocks trend northward, westward, and northwestward. The magnitude of the displacements is not known, but on some of the faults striking westward it may be several hundred feet. A third of a mile west of the mine the underlying shales of the Todos Santos are exposed.

The limestone and dolomite have been partially replaced by lead and zinc sulfides, now largely altered to lead and zinc carbonates. Assays of the ore show that on the whole the zinc content is low; its principal constituents are cerussite and iron oxides. Samples collected in the workings in 1944 assayed as shown in the table below.

Assays of lead-zinc ore from the Rosario mine, Guatemala

[Birger Sundström, Mexico City, Mexico, analyst]

Sample no.	Pb (percent)	Zn (percent)	Ag (oz per ton)
R1	1. 9	3. 5	0. 10
R2	3. 7	2. 6	----------
R3	10. 6	3. 9	. 97
R4	42. 9	1. 8	----------
R5	19. 8	2. 9	2. 03
R6	30. 8	2. 7	3. 51
R7	2. 7	5. 1	----------
R8	23. 3	2. 2	6. 42
R9	24. 8	2. 3	3. 52

Two principal ore bodies have been explored in the workings. The eastern ore body follows a fracture zone striking N. 15° W. and dipping 80° SW. Ore has been stoped 25 feet above the 6,132-foot level along the fracture zone and out along extensions of the ore body parallel to the bedding. The western ore body below the opencut has been explored downward to an altitude of 6,214 feet. The central part of this ore body shows high-grade ore over a width of 40–60 feet and a length of as much as 100 feet, with projections northwestward 70 feet and northeastward along fractures for 120 feet. The northwestward projection seems clearly to follow fracture zones, but the northeastward projection may follow bedding as well as fractures. In a winze sunk 33 feet below the lowest level in the western part of the mine, sphalerite, galena, and pyrite that replace limestone are found. Assays of this ore are reported to show 18–20 percent lead and as much as 37 percent zinc.

Both ore bodies should be explored further; it seems likely that the Rosario property will develop into an important producer of lead and zinc. However, with the exception of pockets of carbonate ore, the ore below 6,200 feet in altitude will probably be largely sulfides, and the zinc content will be higher than in the carbonate ore. In deeper exploration, account should be taken of the fact that the base of the Ixcoy formation may lie about 500 feet below the surface. The ore may not end downward against this contact but may break up into fissure or lode veins below, although where marly beds are present in the Todos Santos formation, replacement bodies may be formed.

BOLA DE ORO MINE

The Bola de Oro mine property, which adjoins the Rosario mine on the east (pl. 11), is owned by Virgilio Recinos of Huehuetenango. Ore mined here has been treated in the Rosario furnace. The production has been small, probably less than 100 tons of lead. The property was idle when visited in 1944.

The workings are in the Ixcoy formation. Underground the rock is a sandy and clayey breccia enclosing residual fragments of limestone. The workings slope downward to the north and probably follow a northward-dipping bed that strikes N. 70°–80° E. The stope width ranges from about 20 feet near the surface to 60 feet in the lower workings, although the ore is only 2–6 feet thick. A sample from a pillar in the western part of the mine assayed 17.1 percent lead, 5.1 percent zinc, and 1.9 ounces of silver per ton. On the whole the ore appears to be erratically distributed.

VILLA LINDA MINE

The Villa Linda mine (pl. 12) is 3½ miles east of San Miguel, on a tributary of the Río Santa Catarina. The property includes the Villa

Linda, Felicidad, and Argentina denouncements, with a total area of about 200 acres. The Villa Linda denouncement contains the San Juan, San Miguel, and Rosario workings, all at an altitude of about 8,600 feet. Shows of lead ore were discovered in 1912 by Miguel Gómez, who sold the property soon afterward to Lucas Escobedo, Federico Calderón Herrera, and Federico Calderón Pérez, who operated it until 1915 and then sold it to Aurelio, Marcos, and Teodoro Recinos, who worked the mine intermittently until 1925. In 1925 and 1926 the American Metals Co. optioned the property and completed about 175 feet of adit and shaft. Since 1926 the property has been operated continuously on a small scale by the Recinos family. The lead production of the mine in short tons, as estimated by Humberto Recinos, the mine manager, is 1912–15, 900 tons; 1915–20, 38 tons; 1920–44, 2,880 tons. The lead is transported by pack trains to Huehuetenango and thence by truck to Guatemala City.

The Villa Linda mine is in the Ixcoy formation, which in this area appears to dip gently, although the bedding is obscure in most places. The formation is chiefly limestone conglomerate and breccia with interbedded layers of massive limestone. The fragments of conglomerate and breccia range in diameter from a fraction of an inch to more than 2 feet. These rocks have been cut by eastward-trending faults and fractures which appear to control the ore in the San Miguel workings. The Rosario and San Juan ore bodies appear to follow the bedding.

The San Miguel workings are shallow excavations that follow faults and fractures striking eastward and dipping steeply southward. They are reported to have yielded much high-grade carbonate ore shortly after the Villa Linda deposit was discovered. Ore is still available in the workings, but none is being stoped because of difficult access to the lower stopes. A sample collected in a short adit assayed 18.9 percent lead, 3.5 percent zinc, and 3.7 ounces of silver per ton.

The Rosario workings are west of those of the San Miguel and explore an ore body developed by inclined workings and a level 26 feet below the portal. The ore body appears to follow the bedding, which dips 45° SW; it has been stoped for a length of 60 feet. A sample from the walls of the lower level contained 19.4 percent lead, 3.3 percent zinc, and 4.9 ounces of silver a ton.

The San Juan workings (pl. 12), which are east of those of the San Miguel, explore an ore body striking northwestward, probably parallel to the strike of the enclosing limestone. The part of the ore body explored up to 1944 was 135 feet long, had a maximum width of 85 feet, and had a thickness of about 48 feet. The ore consists for the most part of porous carbonates (quemazón and mineral de carbonato) and is rather uniformly distributed throughout the workings. Except for the presence of limestone and dolomite at the portal and on the northeast side, the workings are in carbonate ore. Whether the work of the American Metals Co. outlined the boundaries of the ore is not known, for the upper portals were caved in 1944 and the workings could not be examined. The ore in the San Juan ore body is all of good grade, and some of it is of high grade (see table below).

Assays of lead-zinc ore from the Villa Linda mine, Guatemala

[Birger Sundström, Mexico City, Mexico, analyst]

Sample no.	Pb (percent)	Zn (percent)	Ag (oz per ton)
VL1	30.8	5.3	2.68
VL2	29.0	3.6	----
VL3	40.8	2.4	4.55
VL4	37.4	2.3	----
VL5	31.5	4.1	3.21
VL6	27.7	2.9	----
VL7	25.0	2.7	1.93
VL8	24.7	2.1	----
VL9	49.6	1.4	3.80
VL10	18.9	3.5	3.68
VL11	19.4	3.3	4.85
VL12	25.9	2.9	3.22
VL13	39.9	2.8	3.90
VL15	19.1	----	----

Other workings in the Villa Linda mine are on the Felicidad and Argentina denouncements. The Felicidad workings are about 1,000 feet east of the San Juan workings, at an altitude of 9,100 feet. An incline 15 feet deep and as much as 7 feet wide is reported to have yielded ore from which 304 pounds of lead was smelted. The ore zone now exposed in the workings is a vein 6 inches to a foot wide containing iron oxides and carbonate ore. The vein strikes N. 70° E. and dips 20° NW.

The Argentina workings are about 1,200 feet west of the Rosario workings at an altitude of 8,500 feet. The rock exposed in shallow cuts is crushed limestone with narrow seams and small pockets of galena and cerussite.

OTHER DEPOSITS

The Candelaria prospect, about 2 miles east of the Rosario mine, is reported to be promising. Other deposits are said to lie west of the Rosario mine.

COBÁN DISTRICT

The Cobán district, in the Departamento de Alta Verapaz, contains shows of lead and zinc distributed over a wide area (fig. 4). Several deposits in the district have been explored, and two of them, the San Joaquín and Caquipéc mines, have produced ore.

Transportation of ore from the mines to shipping points does not offer the same difficulties in the Cobán district as in the Huehuetenango area. A road passable by truck the year round goes from Cobán to Pancajché, whence freight can be transported by the Verapaz Railway 29½ miles to Panzós and then by barge 110 miles by way of Lago de Izabal to the port of Livingston. Exploration was being carried on in 1948 at several places in the Cobán area by the Compañía Minera de Guatemala, a company financed in the United States.

GEOLOGY

The rocks in the Cobán area include gneiss and schist of pre-Permian age, which are overlain by Permian shale, sandstone, conglomerate, limestone, and dolomite. All these rocks have been intruded by granitic rocks and serpentine. Younger sedimentary rocks of Cretaceous age overlap the older rocks on the north. The gneiss and schist are part of the belt of basement rocks extending eastward through Guatemala along the valleys of the Río Salegua, Río Negro, and Río Polochíc. In the Cobán area these rocks are exposed north of Tucurú, where they have been brought to the surface by faults.

Shale, sandstone, and conglomerate of the Santa Rosa formation are exposed in many places in the valleys of the area south of Cobán. The formation is lithologically similar to the Santa Rosa of the Huehuetenango area but contains a greater proportion of coarse sandstone and conglomerate. However, the upper beds are more shaly, and intercalated limestone beds containing fossils grade upward into limestone correlative with the Chochal limestone.

This limestone, together with some interbedded dolomite, caps the main ranges in the southern part of the Departamento de Alta Verapaz. These rocks form bold cliffs which are somewhat higher on the south side of the range than on the north side, and everywhere they form rugged terrain. Much of the limestone and dolomite is massive, but in places the members are medium to thin bedded. In the Cobán area these rocks are the hosts of part of the lead-zinc ore bodies.

On the north the Chochal limestone is in fault contact with the Cobán formation, of Cretaceous age. The Cobán is probably equivalent to the Ixcoy, for they both contain Early Cretaceous fossils and consist of interbedded massive limestone and dolomite, limestone breccia, and conglomerate (Imlay, 1944, p. 1117). The limestone of the Cobán is overlain in some places by Upper Cretaceous limestone and in other places by the Eocene Sepur formation. The lead-zinc ore bodies at Caquipéc are in the Cobán.

The structural pattern of the Cobán area is not well known. Sapper (1937, pp. 50, 51) has shown that the rocks are folded and cut by eastward-trending faults, of considerable displacement, which are parallel to the strike of the rocks. In part these faults are normal, but some may be thrust faults related to Late Cretaceous and Early Tertiary orogenic movements.

SAN JOAQUÍN MINE

The San Joaquín mine (fig. 6) is 1⅓ miles by trail south of San Cristóbal, on the south slope of Cerro Cajój, at an altitude of 4,900 feet. The mine is on the Finca San Joaquín, owned by Edith v. de Hesse. It was operated for several years prior to 1920, and a small amount of lead is said to have been smelted in a furnace on the property.

The workings consist of two groups of openings, the San Joaquín (fig. 6) and Mina Vieja. The San Joaquín workings furnished most of the ore mined; they include 2 open pits and about 200 feet of underground workings, which explore ore bodies following steep fractures that strike N. 55° W. The shallow lower pit shows a few irregular pockets of oxidized ore. The upper pit and connecting underground workings explore an ore zone 40 feet wide and more than 100 feet long. The ore bodies that have been mined are as much

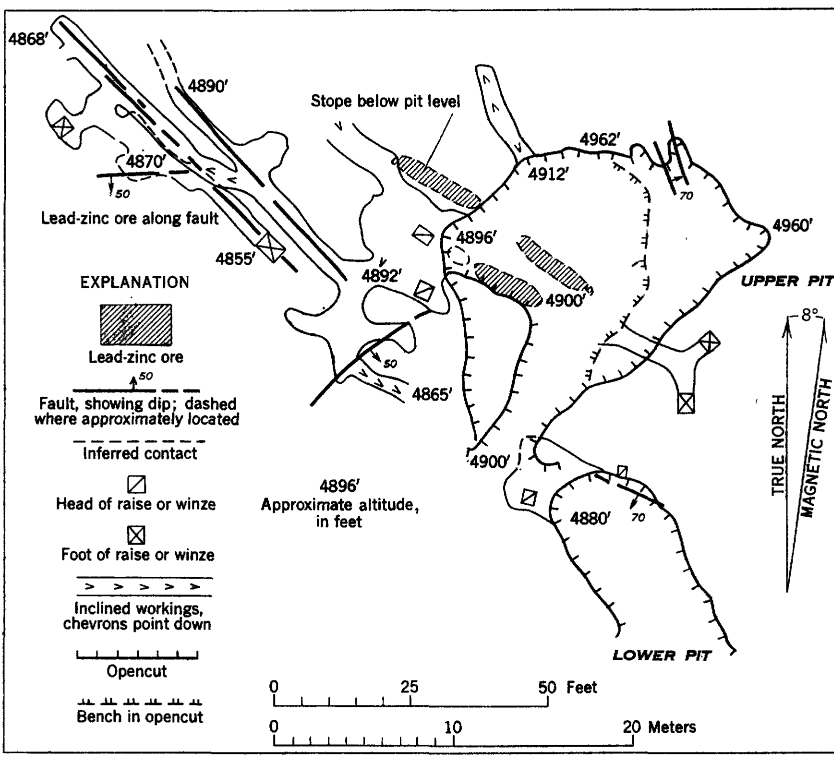

FIGURE 6.—Geologic map of the San Joaquín mine workings, Guatemala.

as 25 feet long and 10 feet wide and are scattered throughout the ore zone over a vertical range of about 70 feet.

The Mina Vieja workings, a quarter of a mile to the northwest, appear to be along the strike of the San Joaquín workings. Irregular underground workings and shallow open pits explore an ore zone trending northwestward, 50 feet or more in width, in which the ore pockets are erratically distributed throughout.

SANTO DOMINGO MINE

The Santo Domingo mine, which is on land owned by Braulio Cuestas, is about 1⅓ miles southwest of San Cristóbal. It is reported to have yielded a small, although unknown, amount of lead. The workings, in limestone of Permian age which is for the most part highly fractured and highly iron stained, are an opencut 140 feet long and as much as 60 feet wide, and several pits and trenches. In 1943 the opencut showed little mineralized rock, but low-grade ferruginous lead ore was exposed on the north side of the cut. The property was reopened in 1949 by the Compañía Minera de Guatemala as a source of iron ore for smelter flux, but only a small tonnage was mined.

PAMPUJMAY MINE

The Pampujmay mine is 3 miles northeast of Tactíc, in the Sierra Xucaneh. The property is reached by going 2 miles eastward by road from Tactíc to the Panzós road and then following a foot trail for about a mile northeastward. The ore is in the limestone, which strikes N. 60° W. and dips 30° SW.

An open pit about 60 feet long extends back under a cliff for about 40 feet. It was originally part of a solution cave in the limestone and was enlarged by mining operations and by collapse of the roof. Small low-grade pockets of lead carbonate mixed with iron oxide were seen on the walls of the cave. Two adits leading from the pit to underground workings were caved in 1943 and partly filled with waste.

Other lead-zinc deposits are reported near Santo Domingo, about 2 miles southwest of San Cristóbal, and near Aguas Blancas, 7 miles west of San Cristóbal on the Río Chixoy. None of these have been explored.

SEPACAY DEPOSIT

The Sepacay lead-zinc deposit is on the Finca Buenos Aires owned by Esperanza Cortina de Aguilar, 7 miles from Pancajché, the terminal of the Verapaz Railway. Half the distance from Pancajché to the mine is over the Cobán highway, and the remainder is over steep mountain trails that rise to a 2,800-foot altitude at the ranch. The deposit is a quarter of a mile north of the ranch buildings, at an altitude of 2,925 feet. The deposit was explored by Manuel and Miguel Ocampo about 1930, but no production is reported.

The ore at Sepacay is in limestone and dolomite of the Chochal limestone and is exposed in a prominent outcrop that trends N. 30° E. along the slope. The ore appears to be chiefly smithsonite and calamine, accompanied by cerussite and other oxidized lead and zinc minerals. The principal ore body is 30 feet long by as much as 15 feet wide, with smaller parallel lenses nearby. As slope wash conceals any extensions of the ore that might be present, further exploration along the strike seems warranted.

SUQUINAY PROSPECT

At Suquinay, about 1½ miles east of Purulhá, boulders of lead and zinc carbonates, galena, and iron oxides form a zone 15 feet wide that extends for a distance of 150 feet up the mountain side. Because of a widespread soil cover and landsliding in the area, no outcrops were seen. The Compañía Minera de Guatemala has been carrying on exploratory work in the area since 1949, and it is reported that the results of the work are encouraging.

LA CAMELIA PROSPECT

On the Finca La Camelia, near Purulhá, shows of lead and zinc are found a quarter of a mile northeast of the buildings. Exposures in a field show lead and zinc carbonates with iron oxides in a zone 10–12 feet wide and 40 feet long that trends N. 20° E. The rest of the zone is covered with soil. The Compañía Minera de Guatemala is reported to have driven an adit 200 feet long under the deposit in 1949, but no ore bodies of commercial size were discovered.

SEQUILHÁ PROSPECT

The Sequilhá lead-zinc mine is about 15 miles north of Tucurú, on the Finca Coyocté. The property may be reached most easily from Cobán by car to the Finca Chajcar, then on horseback southward about 5 miles to the mine, which is on the trail to Tucurú. Lead and zinc carbonates, with a little relict galena, occur in Permian limestone and dolomite.

Several trenches and 2 adits, 33 feet long and 20 feet long, on a small knoll rising 60 feet above the valley, explore an ore body that trends eastward for about 320 feet along a fracture zone. The trenches at the east end show lead and zinc carbonates, in places making up the major part of the rock over a width of 10–30 feet and extending along the strike for about 100 feet. Adit 1 was driven for 33 feet under the outcrop at this place, which is about 20 feet vertically below the top of the knoll; the adit shows low-grade ore and barren rock. Beyond adit 1 the ore zone continues, but the ore is low grade, containing only erratically distributed veinlets and pockets of lead and zinc carbonates. Ae the west end of the desposit another short adit shows only low-grade material.

Judging from the occurrence of the ore, alteration of the sulfides to carbonates must have occurred almost in place. Although here the ore seems to be shallow, further exploratory work at depth may be warranted, for the fractures that localized the ore may well continue downward.

CAQUIPÉC MINE

At Caquipéc, 2½ miles west of Sequilhá, the Compañía Minera de Guatemala since 1946 has been exporing lead-zinc deposits. In 1949 the company completed a 10-mile section of road which connects the mine with San Pedro Carchá and Cobán, thus providing a transportation outlet either by El Rancho, or by the Río Polochíc and Lago de Izabal. A modern camp has been established at the mine and a 100-ton mill was put into operation in 1952. The underground workings consist of several thousand feet of tunnels, raises, and crosscuts.

The ore is said to occur as replacement ore bodies adjacent to fissures in limestone, dolomite, and shale which have been identified as the Early Cretaceous Cobán limestone. The fissures strike N. 30° E. and dip steeply southeastward. The ore produced at first consisted of carbonate ore from surface workings, but more recently sulfide ore has been reached in the underground workings. The depth of oxidation is about 100 feet.

SAN SEBASTIÁN MINE

The San Sebastián deposits are about 5 miles by trail north of Tucurú, on the Finca Vinaroz, which is owned by the Artola family. Lead and zinc carbonates were seen at the San Sebastián deposit at an altitude of 5,150 feet and at the Sierra de San Sebastián deposit at an altitude of 6,350 feet. Neither has been explored.

The San Sebastián deposit, on the south side of a sinkhole, consists of a vein 5 feet in average width that is composed largely of lead and zinc carbonates. The vein strikes N. 30° E. and can be traced for a distance of 80 feet. A sample of the ore is reported to contain 15.8 percent lead, 36.7 percent zinc, and 10.3 ounces of silver to the ton.

The Sierra de San Sebastián deposit is in the cliff-forming limestone of the Chochal formation of Permian age that caps the range; the limestone strikes N. 80° E. and dips 10°–15° NW. Exposures on the slope show fractured limestone containing erratically distributed galena crystals. On the whole the rock is of low grade, but in places it contains 20 percent or more galena. Exploratory work in the San Sebastián area may be warranted.

MANGANESE DEPOSITS

Manganese deposits are known in Guatemala, Honduras, Costa Rica, and Panama, but only some of those in Costa Rica and Panama have been exploited. The production was noteworthy during the 1890's in Panama and during World War I in both Panama and Costa Rica when most of the known deposits of good grade ore were mined. Since 1920 there has been little exploratory work.

COSTA RICA

The manganese deposits of Costa Rica have been described by Sears (1920, p. 61–83) and by Webber (1942, p. 339–345). Roberts (1944, p. 387–414) visited the manganese districts in 1942 and brought the maps of the deposits up to date. As there had been little activity in the area since 1942, no further visits were made during the present study.

The manganese deposits of Costa Rica are on the Península de Nicoya on the Pacific coast, in the Provincia de Guanacaste. Between 1915 and 1920, nearly 32,000 long tons of high-grade ore was shipped from them to the United States. Attempts were made to put the mines in production again in 1943 and 1944, but shipping and loading difficulties prevented this.

GEOLOGY

The rocks of the Península de Nicoya are principally pre-Tertiary and Tertiary. The pre-Tertiary rocks are composed chiefly of basalt flows—in part pillow lavas—and pyroclastic rocks, with some intercalated sedimentary material. These rocks have been intruded by diabase and diorite. The Tertiary rocks include interbedded shale, sandstone, and limestone of Eocene and Oligocene age; sediments of Miocene and Pliocene age are found in the northwestern part of the peninsula and on islands in the Golfo de Nicoya. The manganese deposits are for the most part in pre-Tertiary rocks, but a few of them are in Tertiary rocks.

DESCRIPTION OF THE ORE DEPOSITS

The manganese deposits are of hypogene, supergene, and residual origin. The hypogene deposits are composed of the manganese silicates braunite, bementite, and rhodonite; these minerals occur in jasper that has replaced sedimentary and igneous rocks along the bedding and in fault zones. Braunite predominated in ore mined from the deeper workings at the Curiol mine. These deposits are tabular, lenticular, or irregular in shape. Some of them are as much as 120 feet long, 20 feet wide, and 100 feet deep, but their average dimensions are smaller.

The supergene and residual deposits are mainly pyrolusite, wad, and psilomelane, which were formed by weathering of the silicate minerals. These deposits are extremely irregular in form. The depth of oxidation ranges from a few feet to more than 75 feet.

About 1,000 long tons of ore, containing between 30 and 50 percent manganese, was estimated to be blocked out or in the dumps in 1941, and 1,800 tons may reasonably be expected in extensions of known ore bodies. A total of possibly 10,000 tons may be found in known ore bodies, extensions of known ore bodies, and new ore bodies that were too lean to be worked during World War II. New discoveries may even increase these figures considerably, and production might reach 20,000 tons if ore containing as little as 30 percent manganese is mined. Some of the ore can be sorted by hand or concentrated in simple washers; the rest, perhaps more than half of it, will have to be crushed and concentrated by more costly methods.

PANAMA

By Frank S. Simons

Manganese deposits are known in five areas in Panama. They are Bahía de Mandinga, Nombre de Dios, Río Boquerón (Hyatt), Calzada Larga, and Bahía de Montijo. Of these the Nombre de Dios area has been the most productive, having yielded roughly 40,000 long tons of high-grade ore. It seems reasonable that ore bodies of fair size will be discovered by further exploration, but, since mining and shipping costs in Panama are high, the deposits cannot be mined at a profit except during the periods of high manganese prices.

The manganese deposits of Panama were studied in the field from December 1942 to late April 1943 under the program of cooperation with the American Republics sponsored by the United States Department of State. The assistance of various officials of the Republic of Panama is gratefully acknowledged, and the cooperation of many officers of the Canal Zone and the United States Army, who assisted Mr. Simons in many ways, made possible the completion of the work during the dry season.

BAHÍA DE MANDINGA AREA

The Bahía de Mandinga manganese deposits (fig. 7) are in the extreme western part of the Provincia de San Blas, in the low hills northwest of Bahía de Mandinga at the west end of the Golfo de San Blas. The deposits are near lat 9°31′ N. and long 79°5′ W., in an area that is about 60 miles east of the Caribbean terminus of the Panama Canal and accessible only by boat and airplane. The Golfo de San Blas and Bahía de Mandinga, although studded with coral reefs and islands, are deep enough to permit the passage of large boats to within a few hundred yards of the shore in the vicinity of the manganese deposits. The surrounding country is sparsely settled, but most of the islands in the gulf are inhabited by the San Blas Indians, who operate small plantations on the nearby mainland, and there are small native settlements at Nicuesa and Mandinga.

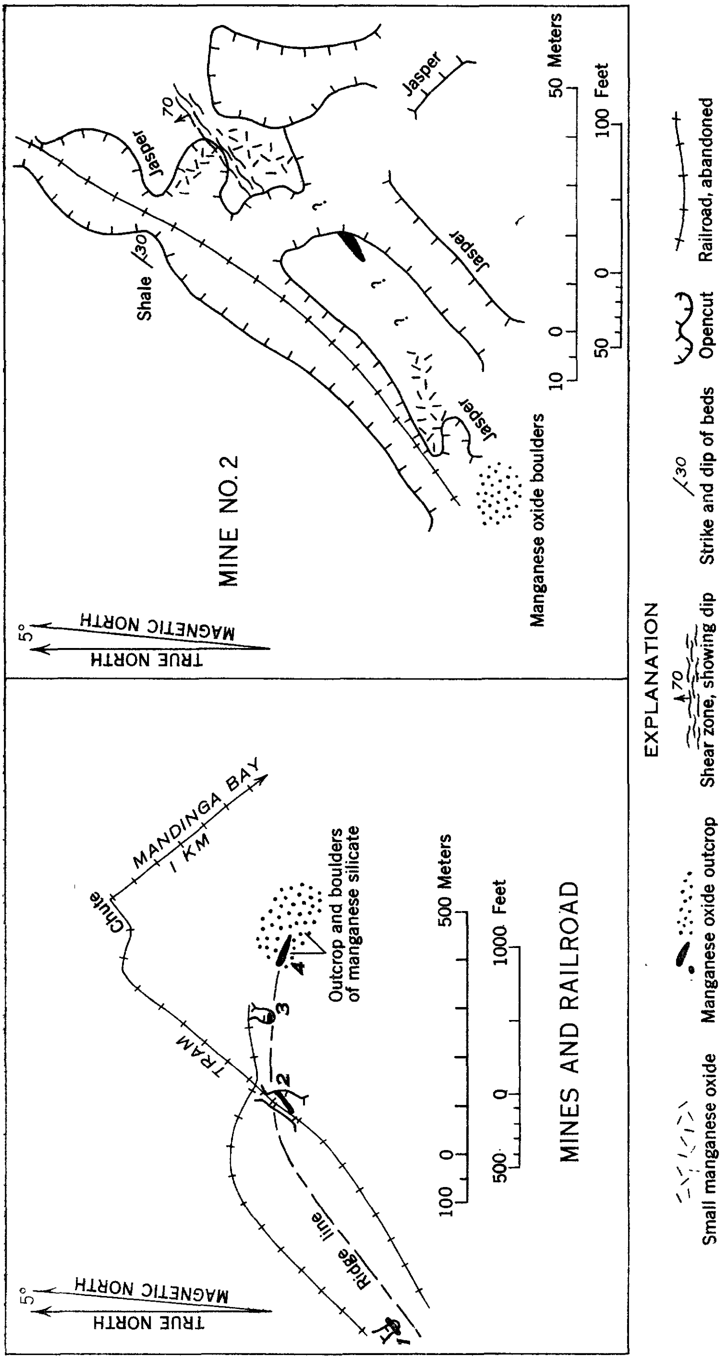

FIGURE 7.—Sketch maps of the Bahía de Mandinga manganese deposits, Provincia de San Blas, Panama.

The Bahía de Mandinga deposits, together with the Soledad deposits at Nombre de Dios, are the only manganese deposits in Panama which have been in production.

During 1916 and 1917 the deposits were operated by James Hyatt and William Powellson, who exported to the United States 21,309 long tons of ore valued at $691,488. Some of the ore is said to have been worth $104 per ton. Statistics on imports of manganese ore from Panama by the United States during the year 1916–19 are given in the table below. All this ore was produced from the Mandinga mines.

Manganese produced from the Bahía de Mandinga mines, Panama, 1916–19

Year	Tons (long)	Value (dollars)
1916	10, 498	265, 772
1917	5, 202	163, 120
1918	5, 608	262, 520
1919	2	76
Total	21, 310	691, 488

The ore was mined from many open pits in four general areas. It was sorted by hand and then carried by tram from the mines down to a railroad, which took the ore to a short pier where it was loaded on boats for shipment. The mines have been inactive since 1919. The tramline, railroad, and pier are almost completely in ruins; a few rusty rails and remnants of ore cars are the only evidence of former activity.

The Bahía de Mandinga deposits examined are estimated to contain manganese ore averaging 25 or 30 percent manganese and 40 or 50 percent silica. This ore is largely in the form of the hydrous manganese silicates bementite and neotocite. The writer heard vague reports of other deposits farther inland in the same general area but could find no one who had any accurate knowledge of them.

GEOLOGY

The manganese deposits are located on the crest of a low ridge that trends about north-northeastward, roughly parallel to the shoreline of Bahía de Mandinga (fig. 7). They are all about half a mile inland at altitudes of 160–330 feet.

The predominant country rock is a soft deeply weathered shale or mudstone which crops out in a few places along stream courses. On the geologic map (pl. 1) these rocks are included in the complex group of Cretaceous(?) age. Nearly everywhere a thick mantle of clay obscures the bedrock, but along the crest of the ridge there are numerous prominent outcrops of red and yellow jasper; shale is exposed near the jasper at a few places, mainly in prospect pits.

DESCRIPTION OF THE ORE DEPOSITS

The manganese ore in the Bahía de Mandinga area is closely associated with red and yellow jasper. This rock is fine grained, massive, and entirely devoid of bedding. It is considerably jointed and faulted, and the few visible contacts of shale with jasper appear to be faults. The jasper has probably been produced by silicification of shale or mudstone, either along the bedding or in shear zones.

Most of the manganese oxide is very hard and heavy psilomelane, but small quantities are soft and powdery. It appears to have replaced the jasper along faults and fractures, for the ore bodies are elongate and irregular and often contain masses of jasper surrounded by oxide. The writer was told by men who had worked in the mines that the ore bodies mined were usually small and difficult to separate from the jasper.

At mine 4, manganese silicate, either bementite or neotocite, has replaced jasper and has been slightly oxidized where exposed at the surface. No hypogene replacement bodies of manganese oxide were seen at mine 4, but at mine 2 the oxide has replaced the silicate to a small degree. The complete paragenesis is not shown at any one locality, but the sequence appears to be:

```
                  ↗ Manganese oxide
Shale → Jasper                              ↗ Oxide (replacement)
                  ↘ Manganese silicate
                                            ↘ Oxide (surficial)
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Wherever both manganese oxide and manganese silicate are present, the oxide appears to be later than the silicate.

The manganese deposits described below are in the order of their occurrence from southwest to northeast.

RÍO NAVAGANA DEPOSITS

Manganese ore crops out about a mile from the mouth of the Río Navagana on both sides of a small tributary. On the northeast side of the stream the outcrop is about 130 feet long and 10–16 feet thick. It strikes about N. 50° E. and is vertical. About 200 feet southwest across the creek there is a small outcrop of ore approximately parallel to the main outcrop. No ore is exposed between the two outcrops, and the ore body is probably not continuous. The wall rock, exposed in three shallow pits, consists of shale whose attitude is uncertain.

The manganiferous material is almost entirely a brown manganese silicate, but it includes a very small amount of manganese oxide, all of which appears to be at or near the surface. Probably at least 5,000 long tons, and possibly as much as 10,000 long tons, of ore that will average not more than 30 percent manganese and not less than 50 percent silica is available, but the low grade of the ore and the predominance of manganese silicate make the deposits worth little now.

MINE 1

Mine 1 is about half a mile northeast of the Río Navagana deposits. Development work consists of an opencut 165 feet long and 80 feet deep, heavily overgrown with jungle. The walls of the cut were so steep that they could not be climbed for inspection.

Most of the rock exposed is red or brown jasper cut by numerous small quartz veins. The only ore in sight was a flat-lying seam, 1½–3 feet thick, of high-grade hard manganese oxide in the lower face of the cut. The wall rocks are considerably sheared and the ore seems to have been deposited along a shear zone.

MINE 2

Mine 2, the largest one at Bahía de Mandinga, lies about 1,640 feet northeast of mine 1 on the crest of the ridge. The workings, all opencuts, cover an area 390 feet long by 250 feet wide and reach a maximum depth of 80 feet (fig. 7). Although some of the cuts are completely overgrown with jungle, the mine affords by far the best exposure in the area.

The rock exposed in the cuts is largely red and yellow jasper, which in places is considerably sheared and brecciated. In the northwestern part of the mine area there is an outcrop of shale or mudstone. Deep weathering has nearly obliterated the bedding, which appears to strike nearly northeast and dip about 30° SE. The rock is closely jointed and weathers into tiny irregular red, yellow, or gray columns and pinnacles. The jasper in this mine probably formed by silicification of an argillaceous rock, and in this locality the silicification apparently worked along the bedding of the shale.

The ore consists largely of hard blue-black psilomelane, but there is also a small amount of soft coarser grained oxide material. The oxide occurs as thin veins in jasper and as irregular lenticular bodies replacing jasper. One lens of ore contains some brown manganese silicate that is partly replaced by manganese oxide.

The predominant shearing in the jasper has a northeastward trend, and the general northeastward course of the workings indicates that this is also the trend of the ore zones. It appears likely that ore deposition was controlled, at least in part, by shear zones, but postmineralization shearing has occurred to such an extent that all premineralization structures are obliterated.

At least 1,000 long tons of high-grade oxide ore is probably available in this mine, some of it in place and the rest occurring as float on the southeast side of the ridge. However, any ore mined would have to be carefully hand sorted.

MINE 3

Mine 3 is on the north side of the ridge, about 650 feet east of mine 2. Development work consists of a semicircular opencut about 165 feet in diameter and 65 feet deep. The rock exposed is jasper, which is red, orange, or yellow in fresh exposures and is commonly weathered yellow. The deposit has been virtually mined out, the only ore in sight being a 6-inch seam of hard manganese oxide that occupies a brecciated zone in jasper. The ore has partly replaced the breccia fragments, some of which are entirely surrounded by manganese oxide.

MINE 4

Mine 4 lies on the crest of the ridge, about 490 feet southeast of mine 3. Very little mining has been done, and the only exploratory work consists of a few shallow prospect pits. The wall rocks are not exposed in the vicinity. The deposit is a lens of manganese ore about 330 feet long and 15–25 feet thick, striking about N. 70° W. and dipping vertically. The ore is largely brown manganese silicate, which is oxidized to shallow depths. It is cut by numerous quartz veins as much as half an inch in thickness and is somewhat faulted and brecciated. Some of the ore contains small fragments of jasper surrounded by manganese silicate, which appears to have replaced the jasper.

Probably at least 10,000 long tons of ore is in place, with an average grade of 25 percent manganese and about 50 percent silica, and at least 5,000 tons of similar ore is in boulders scattered over the northeast side of the ridge. Some of these boulders weigh more than 100 tons. Because of the low grade of the ore and the predominance of manganese silicate as the ore mineral, the deposit has little commercial value.

NOMBRE DE DIOS AREA

Manganese deposits in the hills south of Nombre de Dios, a small town on the north coast of Panama about 30 airline miles northeast of Colón, lie between lat 9°30′–9°35′ N. and long 79°33′–79° W. in the Provincia de Colón (fig. 8).

Nombre de Dios is on the south shore of Bahía Nombre de Dios, a semicircular open bay about 38 miles by boat from Colón. The town is separated into two parts by a channel excavated by dredges at the time of the building of the Panama Çanal; the sand was used in the construction of the Gatun locks. During the dry season, from January until May, the bay is swept by the trade winds and may become very rough. At such times the only safe anchorage is at Playa de Damas, about 1½ miles north-northeast of the town. From Nombre de Dios

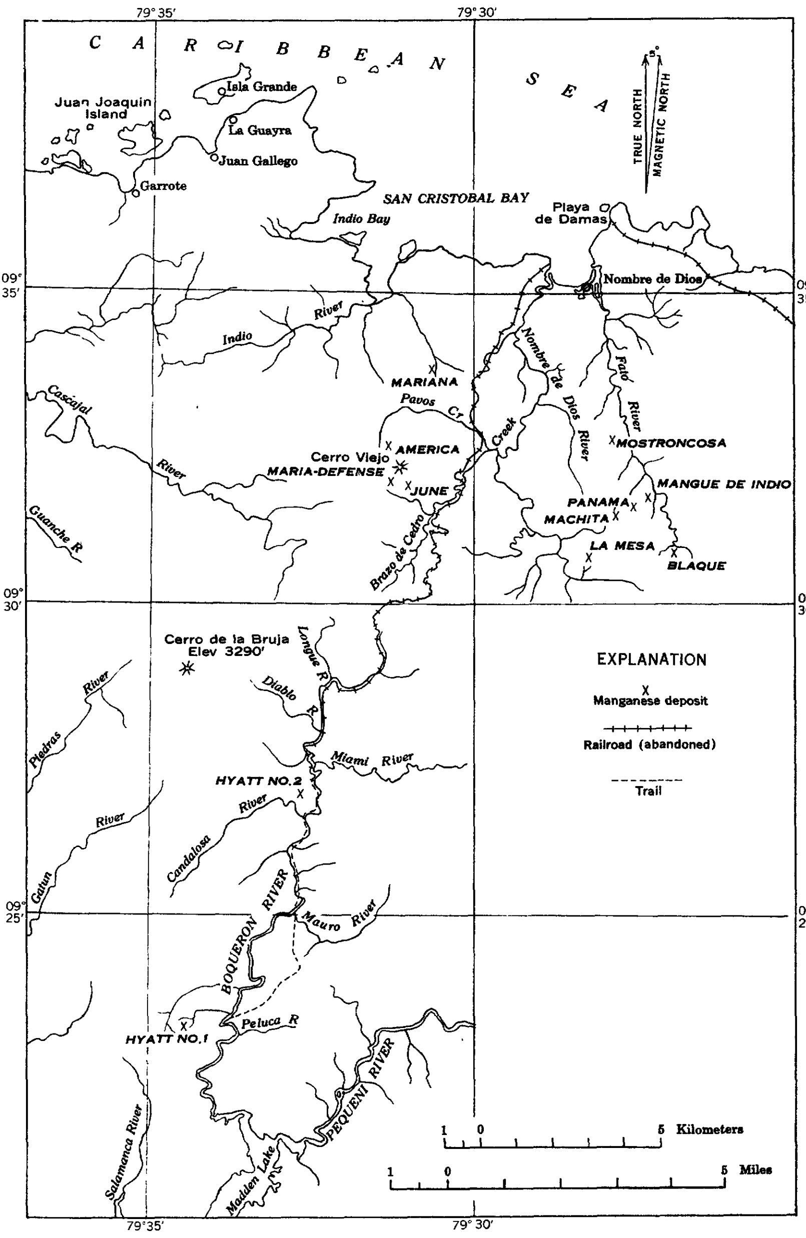

FIGURE 8.—Manganese deposits in the Nombre de Dios and Río Boquerón areas, Provincia de Colón, Panama.

trails lead to Porto Bello, 13 miles to the west, and to several small villages along the coast to the east.

The Nombre de Dios area has a very heavy rainfall, the yearly average being about 160 inches, most of which falls between May and December. During the rainy season the Río Nombre de Dios and Río Fató are navigable by small boat for many miles; during the rest of the year this type of travel is impracticable.

Nombre de Dios has been closely connected with manganese mining in Panama since the industry's beginning, about 66 years ago. In 1895 the Caribbean Manganese Co. built a narrow-gage railroad from Playa de Damas to the Soledad mine, south of Viento Frio, and between 1895 and 1902 it shipped about 40,000 tons of high-grade ore. Political unrest, culminating in Panama's secession from Colombia in November, 1903, led to the closing of the mines, and the railroad has been abandoned ever since.

In 1920 the Hyatt Panama Manganese Co. began construction of a narrow-gage railroad from the west side of the bay to their Hyatt no. 2 mine on the Río Boquerón, 15 miles to the south. Before the railroad was completed the line was abandoned, and it now serves as a trail to the Río Boquerón and Madden Lake.

GEOLOGY

The plain south of Nombre de Dios is drained by the Río Nombre de Dios and Río Fató. Many low hills rise from the plain, and the foothills of the Cordillera de San Blas are reached about 2 or 3 miles inland.

The areal geology has not been thoroughly studied, but a few generalizations can be made. The rocks are largely sandstone and shale, which on the geologic map (pl. 1) are included in a unit classified by Thompson as of Cretaceous(?) age. In a few places limestone and tuff were seen. These rocks are more or less flat lying near the coast; farther inland the dips become generally steeper, although usually less than 45°. In general the sedimentary rocks dip southward, at least wherever attitudes were observed in the vicinity of the deposits. No intrusive rocks were seen in place, but diorite float was found near Blaque Peak, and igneous rocks may form the cores of some of the high peaks. All the deposits examined except the Mariana are in the watersheds of the Río Fató and Río Nombre de Dios.

MINES ALONG THE RÍO FATÓ

MOSTRONCOSA DEPOSIT

The Mostroncosa deposit is on the steep hill between Quebrada Mostroncosa and Quebrada Mostroncosita, about half a mile south of the confluence of Quebrada Mostroncosa and the Río Fató and 3 miles south of Nombre de Dios.

The hill is blanketed with angular boulders of jasper and chert in clay. No rock in place was found, but the source of the boulders must be near the hilltop, as they cover the entire north and east slopes. The area of float is roughly 650 feet in diameter. Although some of the boulders contain small quantities of partly oxidized manganese silicate, not more than 20 percent of the manganese is present as oxide.

The writer was told by his guide that a similar deposit lies farther south, but owing to bad weather it was not examined. The Mostroncosa deposit is believed to have little or no commercial value because of the extremely low grade of the material available.

MANGUE DE INDIO PROSPECT

The Mangue de Indio deposit is about 5 miles south of Nombre de Dios, in the low hills along Quebrada Mangue de Indio. A body of very siliceous manganese oxide, 80 feet long and 7 feet in average thickness, crops out along the bank of a small fork of Quebrada Mangue de Indio. It strikes N. 70° E. and dips 55° SE. The wall rock is rusty-colored clay containing fragments of tuff or shale. The manganese occurs in thin veins of soft oxide and numerous small rosettes of crystalline pyrolusite. Remnants of tuff in the jasper indicate that jasper has replaced tuff.

The hill to the south is covered with boulders, which are embedded in clay. The boulders are composed of rock varying from a coarse-grained quartzitelike mixture of manganese silicate and quartz to fine-grained chert of similar composition; many of them are nearly pure chert. Some of the boulders have small rosettes of pyrolusite, and the more manganiferous ones are coated with layers of manganese oxide as much as 2 inches thick.

The hill is capped by a flat bed of manganiferous jasper or cherty manganese silicate which is about 7 feet thick and covers an area of 270 square feet. Joint and fracture faces in the rock are filmed with manganese oxide, but no significant amount of oxide was seen. A similar flat bed 170 feet to the south crops out along a canyon wall for 70 feet; the bed is about 7 feet thick and consists entirely of very low grade manganiferous jasper. It has been explored by several trenches, which have uncovered no good ore.

PANAMA (VENTURA) PROSPECT

The Panama, or Ventura, prospect is on the southwest bank of Quebrada Ventura, a small tributary of Quebrada Macho about 1,640 feet southwest of the Mangue de Indio deposit.

An area about 330 feet in diameter is blanketed with boulders of a siliceous rock that is either manganiferous jasper or a mixture of jasper and manganese silicate. Several shallow trenches show a mantle more than 3 feet thick of boulders embedded in clay, but they expose no rock in place. Although the boulders are cut by veins of manganese oxide, none of them contains more than 20 percent manganese; the average is about 15 percent, largely in the form of manganiferous jasper or manganese silicate.

MACHITA DEPOSIT

The Machita deposit is on a small branch of Quebrada Macho, about a mile from the Río Fató and 2,300 feet southwest of the Panama deposit.

Interbedded shale and sandstone are exposed along the stream. The strike varies from northeast to east, and the dip ranges from 20° to 40° southeast and south. An area of about 32,300 square feet on the northwest side of the creek is sparsely covered with boulders of manganese oxide and jasper; some of the jasper is cut by veinlets of manganese oxide and by quartz veins as much as an inch thick. Near the top of the float area is an outcrop of jasper that strikes N. 25° E. and dips 55° NW. Just below the outcrop is an area of about 1,100 square feet showing some float of fairly good oxide.

The best material is a rock in which jasper has been largely replaced by manganese oxide. The jasper probably formed by replacement of shale or sandstone, but no manganese silicate has been definitely identified at this deposit. No outcrop of the oxide has been found, but oxide in place is probably concealed near the small area of float.

BLAQUE PROSPECT

The Blaque prospect is 8 miles southeast of Nombre de Dios on a low ridge between Quebrada Blaque and the Río Fató. Two shallow pits 16 feet apart have been dug about 165 feet above the Río Fató. The pits expose small bodies of jasper cut by veinlets of manganese oxide, in clay country rock. The rocks strike northeastward and dip 35° SE. Some of the material exposed in the east pit contains about 40 percent manganese, but the amount of this material is very small. Fifty feet to the southwest another pit shows a small boulder of siliceous oxide, and the slope below, toward the Río Fató, shows a few small boulders of similar rock. A few pieces of diorite were found near the base of the hill.

Two hundred and thirty feet to the southwest, on the northwest side of Quebrada Blaque, is an area of about 5,400 square feet covered with boulders of brown chert embedded in clay. Some of the chert is cut by thin parallel veins of quartz. A few small pieces of mixed manganese oxide and clay were seen, but most of the rock contains little or no manganese.

Just south of the float-covered area, Quebrada Blaque has cut through a bed of coarse-grained arkosic sandstone that strikes N. 60° E. and dips 45° SE. Bedding surfaces in the sandstone are covered with plates of chlorite as much as an inch across. A part of the sandstone has been replaced by a vein of jasper at least 8 feet thick; the contact between jasper and sandstone is very irregular but sharp, and dips in the opposite direction to the sandstone.

Practically no ore in place is exposed anywhere on the Blaque claims, and the scarcity of manganese oxide in the float indicates that there are probably no deposits of any size in the area.

LA MESA PROSPECT

The La Mesa prospect is about 5 airline miles and 9 miles by trail south of Nombre de Dios on a broad ridge on the west flank of Mesa Peak. It lies between Quebrada Mesa and Quebrada Moro, nearly 2 miles southeast of the junction and 490 feet higher. The trail from the junction follows a steep narrow ridge on which limestone boulders were seen at 3 places—1,480, 2,460, and 2,560 feet northwest of the deposit. Tightly folded shale crops out in a small canyon to the southwest. These were the only rocks except clay seen in the vicinity of the deposit.

Manganiferous rock is found near the junction of a broad ridge that trends southeastward and two narrow ridges that trend northwestward and southward. At the junction, 2 pits, both about 3 feet deep, reveal fragments of manganese oxide and jasper as much as 3 feet in diameter, embedded in clay. A trench 26 feet to the southwest reveals a mantle about 12 inches thick of manganese oxide fragments, lying in and on clay; about 10 percent of this mantle is manganese oxide. The manganese-bearing rock is largely sugary brown manganiferous jasper or manganese silicate, the smaller fragments of which have been well oxidized. The large boulders have cores of unaltered siliceous material. The best material seen contains about 35 percent manganese, but there is very little of it in sight.

On the northwest ridge, 130 feet from the pits, a shallow trench shows a few boulders of siliceous oxide and jasper in clay. Fragments as much as 12 inches in diameter make up about 10 percent of the surface mantle to a depth of 2 feet. A few pieces of float are found in the area between the pits and the trench. Just northwest of the trench are a few boulders of siliceous manganese oxide, and to the east is an area of about 1,100 square feet covered with similar boulders.

The largest area of float is about 100 feet east of the pits, on the west side of a small canyon. Here a narrow bench is covered with boulders, weighing as much as several tons each, over an area 115 feet long by 65 feet wide. The float is mostly jasper and slightly oxidized manganese silicate or manganiferous jasper. No rock definitely in place was seen; the area is completely unexplored. The ground between this area and the ridge top is practically devoid of float. Several tons of rock averaging about 15 percent manganese are in sight here and on the steep slope below, but lack of outcrops makes it impossible to predict that any more will be found.

CERRO VIEJO DEPOSITS

Three deposits, the América, María Defense, and June, are found near the summit of Cerro Viejo, a prominent hill 5 airline miles southwest of Nombre de Dios. Cerro Viejo is 4 miles by trail from the nearest point on the abandoned Hyatt Railroad and 8½ miles by trail from Nombre de Dios. It is reached by traveling south along the railroad to a point just south of the junction of Quebrada de Pavos and Brazo de Cedro, from which a trail leads over a low divide back to Quebrada de Pavos and from there to the foot of Cerro Viejo. Cerro Viejo can also be reached from Garrote by taking the Ferrari banana railroad to the Río Indio, from which a trail is said to lead to Quebrada de Pavos, but this route is longer and perhaps more difficult.

Just downstream from the old Pavos mining camp is an outcrop of thickbedded purplish shaly limestone that strikes N. 70° W. and dips 25° SW. Near the camp is a very siliceous 5-ton boulder which has probably come from the América deposit on the ridge above the camp.

AMÉRICA PROSPECT

The América prospect is on Cerro Viejo, about 400 feet southeast of the mining camp, which is at an altitude of 260 feet. The altitude of the deposit is 460 feet at the north end and 575 feet at the south end. The area has been cleared, but no other evidence of prospecting was seen.

The deposit consists of boulders of very siliceous manganiferous rock, in clay, along the steep narrow crest of Cerro Viejo. As the ridge is very steep, there has been little opportunity for the accumulation of a large amount of float. The boulders at the north end of the area are largely a quartzitelike rock composed of an intimate mixture of jasper and manganese silicate or manganiferous jasper. Most of them are coated with a thin film of manganese oxide. No good oxide ore was seen, the average manganese content of the boulders being only 10 or 15 percent.

The boulders can be traced southeastward and southward along the ridge crest for 400 feet. Near the south end are two concentrations that probably mask the site of a concealed body of manganiferous jasper. At the extreme south end is a small area of float of soft crystalline manganese oxide averaging about 45 percent manganese, but no outcrop of this material was found.

MARÍA-DEFENSE PROSPECT

The María-Defense prospect is about half a mile south of the América deposit, on the crest of Cerro Viejo at an altitude of 1,000 feet. It lies about halfway between Cerro Viejo and a slightly lower summit to the north.

An area about 100 feet long and 65 feet wide has been thoroughly cleared and scraped. Two outcrops of manganese oxide are exposed; the north outcrop has an area of 180 square feet and the south outcrop covers about 130 square feet. The centers of the outcrops are 60 feet apart, and the intervening ground shows a light mantle of float but no outcrops. A shallow trench just north of the south outcrop shows numerous small fragments of manganese oxide in clay, and a trench along the east side of the outcrop shows a thin irregular layer of jasper, 1–12 inches thick, between oxide and clay. The jasper is cut by quartz veins. An opencut below the outcrop shows an 8-foot vertical face of manganese oxide containing some admixed clay and a few small pockets of brown jasper. Just below the cut is a 10-ton boulder of jasper, which may have rolled down from the hill 300 feet to the north. This boulder and smaller ones nearby are cut by many veinlets of quartz.

The manganese oxide is largely soft crystalline material that shows much variety. Most of the oxide is finely crystallized, usually containing bundles of radiating prisms of pyrolusite as much as half an inch in length. Some of the material is finely banded with thin layers of quartz and manganese oxide. At the south end of the north outcrop the rock is a hard mixture of crystalline oxide and quartz full of small vugs which are lined with tiny quartz crystals and striated cubes or short prisms of a manganese oxide, probably pyrolusite. The oxide appears in general to contain considerable silica, largely free. Some of the pebbles of oxide found in the clay appear to have formed in place; they have the typical irregular rounded shapes of small concretions and show a roughly concentric structure, with crystalline centers and massive rims.

Little can be said about the origin of the manganese oxide, because there are few exposures of anything but oxide and clay. The south outcrop, which shows isolated irregular pockets of jasper surrounded by oxide, and also a belt of jasper along the east contact with clay, suggests that the jasper has been at least in part replaced by manganese oxide. The origin of the jasper is not known, but, to judge from similar deposits in other parts of Panama, it may have replaced shale or tuff, the unreplaced part of which is now altered to clay.

On the steep slope north and west of the main outcrops are several boulders and one outcrop of purplish manganese silicate or manganiferous chert. Some of the rock has been brecciated, and the fragments are cemented by veinlets of quartz and chalcedony. A few boulders in the opencut northwest of the north outcrop have been well oxidized, but most of them carry little manganese. The María-Defense deposits are considered the best of those examined in the Nombre de Dios area, since they are the only ones in which an appreciable amount of good oxide ore was seen. The area between the two outcrops and also to the north of them should be deeply trenched, in order to establish whether the outcrops are connected and whether there is an extension of the ore body northward. Until this is done, the deposits must be considered as no more than fair prospects.

MARIANA DEPOSIT

The Mariana deposit is on Quebrada Mariana, which flows into Bahía de Indio 3½ miles west of Nombre de Dios. It is most easily reached from Nombre de Dios by way of the Hyatt Railroad and Quebrada Marianito, a distance of 4 miles.

Numerous small fragments of manganese oxide are found on a low ridge west of Quebrada Mariana, and a boulder weighing about a ton lies in the creek. This boulder is mentioned in several earlier reports and has evidently furnished material for several assays. Float ore is found over an area about 230 feet long and 100 feet wide, but at only 1 locality near the west end of the area was any ore seen that might have been in place. Several trenches show fragments of manganese oxide in clay that contains small pieces of decomposed shale; the fragments are found to depths of 3 feet but in no great concentration. Near the center of the area a concentration of small boulders suggests an undiscovered ore body nearby.

The oxide is a massive finely crystalline hard black mineral of the psilomelane type, cut by thin veins of pyrolusite. The massive oxide contains numerous small vugs filled with tiny striated prisms of pyrolusite. The oxide contains on the average about 45 percent manganese. Much of the float shows pockets of clay from which the oxide has been removed by leaching.

JUNE PROSPECT

The June prospect is on a bench high above Quebrada Luis, on the east side of a small tributary of that stream, where an area about 250 feet long by 165 feet wide has been cleared. Well-bedded shale and sandstone striking north and dipping 25° W. crop out in the west wall of the canyon. The area is strewn with numerous large and small boulders of red and brown jasper cut by veinlets of quartz. One outcrop of jasper, 50 feet long and more than 10 feet thick, is found in the cleared area. The jasper strikes north, but its dip is uncertain. Some of it is manganiferous, many boulders of it being coated with manganese oxide, but all the material in sight is of very low grade.

HYATT AREA

The Hyatt manganese deposits are about 28 miles east-northeast of Colón, in the Provincia de Colón on the west side of the Río Boquerón, which flows into the extreme north end of Madden Lake (fig. 8). The no. 1 mine lies at lat 9°23′ N. and long 79°34′ W. between 2 forks of Mine Creek, a small tributary that enters the Río Boquerón from the west about 4 miles from its mouth. The no. 2 mine lies at lat 9°27′ N. and long 79°33′ W., on a high ridge between the Río Boquerón and the Río Candalosa, about 5 airline miles north-northeast of the no. 1 mine. The distance along the Río Boquerón between the 2 mines is about 5 miles.

The deposits can be reached from Panamá or Colón by way of Madden Lake. The recently completed Trans-Isthmian Highway, which connects Panamá with Colón, skirts the south end of Madden Lake at Madden Dam. The Río Boquerón enters the lake about 13 miles north of the dam and can be reached by launch. The river is navigable by small power boats for about a mile and a half from its mouth; beyond this point are many rapids which can be traversed only by native canoe. During the dry season, from January until April, the Río Boquerón may at times be so low that even canoe travel is difficult.

The deposits can also be reached by trail from Nombre de Dios, a small village on the north coast of Panama about 34 miles by boat northeast of Colón. The no. 2 mine is about 15 miles south-southwest of Nombre de Dios, and the no. 1 mine is about 5 miles farther south. The trail follows the route of the old Hyatt Railroad.

The Hyatt deposits are in a deeply dissected, rugged terrain of deep, narrow canyons and sharp ridges. The highest point in the vicinity is Cerro de La Bruja, 3,200 feet in altitude, on the divide between the Río Chagres drainage basin and the Caribbean slope. The maximum relief at the no. 1 mine is 260 feet and at the no. 2 mine, it is 400 feet.

The Hyatt deposits were discovered about 1915 and in 1917–18 were explored briefly under the direction of James Hyatt. In 1920 the Hyatt Panama Manganese Co. was organized, and a narrow-gage railroad was built from the west side of Bahía Nombre de Dios to within a mile of the mouth of the Río Candalosa. The railroad is 16 miles long and crosses a gap in the divide at an altitude of 885 feet. Maintenance of the road in this rough country of heavy rainfall proved so difficult that the line was abandoned a few years later. In 1942 the railroad was in complete disrepair; all the bridges, of which there were a great number, were useless, and much of the track had been buried by landslides. The rails were in fair condition, but many of the ties were completely rotted away.

The only ore produced by either mine is a few tons said to have been taken from the no. 1 mine and shipped by small boat to Colón for assay.

HYATT NO. 1 MINE

The Hyatt no. 1 mine is on a steep asymmetrical ridge between two forks of Mine Creek, about half a mile west of the Río Boquerón (fig. 9). Most of the area is covered with red and brown clay, but along the north fork are many exposures of fine-grained gray and white quartzite that shows no bedding. This rock is overlain by a deeply weathered gray schist, which strikes north and dips 45° W. The contact is not exposed but is probably near the headwater fork of Mine Creek, just north of the main ore body. Near this ore body several pits expose a highly micaceous schistose gray rock containing numerous round and elongate nodules of pink and gray sandy material. This rock, which is thought to be a metamorphosed tuff, forms the walls of the deposit. The rocks are probably pre-Eocene in age.

The main outcrop exposes a sheet of manganese oxide that strikes northwestward, dips 50° SW., and forms a dip slope on the south side of the ridge. Its visible thickness ranges from 3 to 10 feet and is assumed to average about 7 feet. The position and shape of the outcrop are shown on the map (fig. 9). On the ridge below the outcrop is a heavy blanket of float, which extends all the way down the canyon to the fork. Two parallel trenches, each 100 feet long, are cut through the crest of the ridge. The upper edge of the oxide sheet is shown in place at the south end of each trench, where the manganese oxide is in contact with jasper and appears to have partially replaced it. Elsewhere both of the trenches are in clay and jasper which are cut by a few thin stringers of manganese oxide. The clay was probably formed by the weathering of the schistose rock exposed in nearby pits.

The ore is hard blue-black psilomelane-type material containing numerous small pockets of soft oxide, and along the west side of the outcrop there are pockets of rhodonite and piedmontite. Some of the ore, especially at the south end of the west trench, is crudely banded with alternate layers of manganese oxide and quartz. The oxide is generally somewhat siliceous and averages about 40 percent manganese. The outcrop covers an area of 5,800 square feet and has an assumed average thickness of 7 feet, thus containing about 3,000 long tons of ore. Also, 500 tons of similar rock crops out on the slope below this outcrop and along the canyon bottom.

A hundred feet northeast of the main outcrop is another, which strikes N. 30° W. and dips 70° SE. This outcrop is 33 feet long and as much as 7 feet thick but pinches out at both ends. A pit on the southeast side shows solid oxide, in contact with red clay, to a depth of 16 feet. The oxide is hard, pure, psilomelane-type material, which appears to be of somewhat higher grade than that of the main outcrop. Three hundred tons of this material is in sight and as much more can be expected. Numerous boulders of similar oxide lie on the flat area

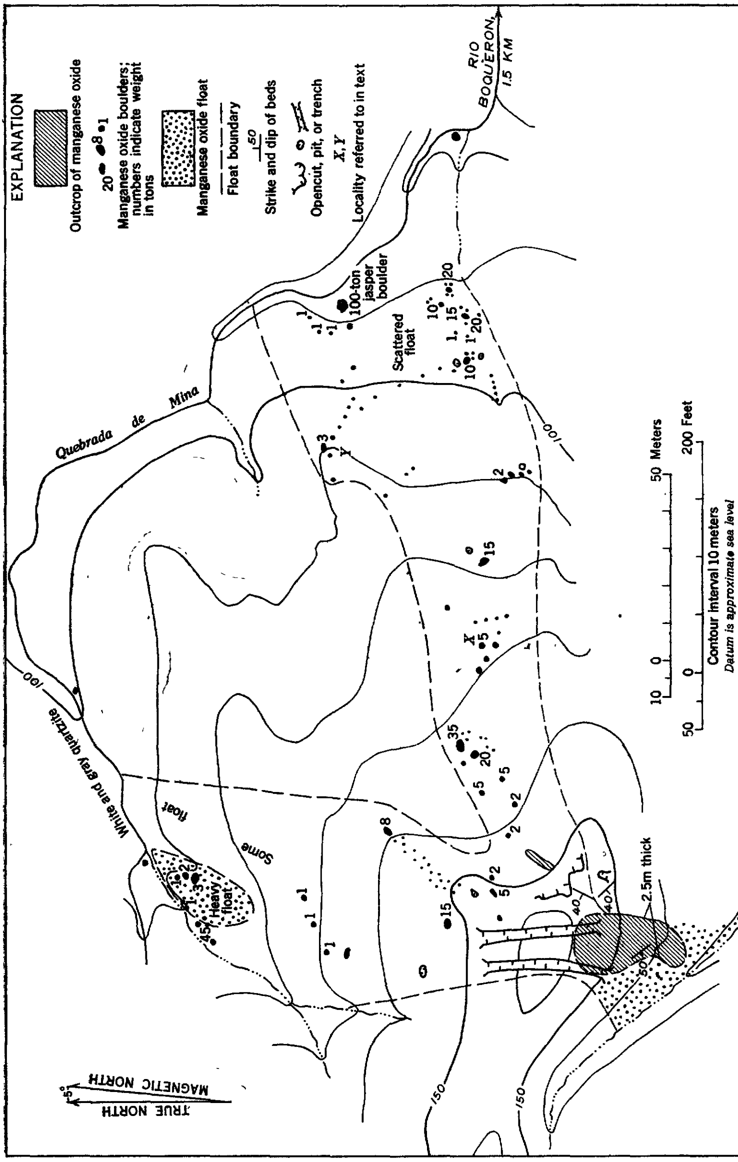

FIGURE 9.—Map of the Hyatt no. 1 manganese mine, Provincia de Colón, Panama.

below the outcrop; 1 boulder weighing about 35 tons has been exposed on 2 sides by trenches and is embedded in clay that contains numerous fragments of manganese oxide to a depth of nearly 3 feet.

Other shows of manganese in and near the no. 1 mine consist of 2 elongate areas of float, 1 extending 400 feet north from the main outcrop and the other trending about east-northeastward down the main ridge to Mine Creek, a distance of about 650 feet. The area between these two tongues is nearly devoid of float. The northward-trending tongue ranges in width from 100 to 165 feet and contains only widely scattered float. A few large boulders weighing as much as 15 tons are found on the slope immediately below the ridge top and were probably derived from the main outcrop. At the bottom of the hill, on the south side of Mine Creek, is a heavy concentration of boulders of manganese oxide in an area of 29,000 square feet. These boulders, some of which weigh as much as 5 tons, probably represent a small eroded nearby outcrop, for the slopes above are practically barren. The boulders have cores of dark-brown manganese silicate surrounded by hard oxide that contains small pockets of porous silica, which may have been freed by the oxidation of the silicate. The material is not high grade, averaging only 30–35 percent manganese. Several hundred tons is in sight, and exploration by trenching near the upper end of the float area might uncover the parent ore body. The rest of the north slope is only sparsely covered with float, and no other concentration suggesting an undiscovered ore body was found.

The eastward-trending tongue shows considerably more float. Some 300 feet northeast of the main outcrop (*X* on fig. 9), many boulders that weigh as much as 15 tons are found in an area of about 500 square feet. The boulders consist of hard oxide mixed with considerable free silica and appear to be of lower grade than the material from the ore body to the west. They may represent the eroded outcrop of another small ore body. The average grade is perhaps 35 percent manganese.

At point *Y* on the map there are several boulders of manganese oxide on the crest of a narrow ridge trending northeastward, and from this point a train of boulders extends eastward and southeastward nearly to Mine Creek. These boulders have probably come from an ore body, somewhere near point *Y*, that is either concealed or completely eroded, for the area between *X* and *Y* is nearly barren of float. Some of the boulders contain a mixture of high-grade oxide and oxide containing a little free silica; others are mixtures of jasper and oxide, and 1 boulder, weighing about 100 tons, consists entirely of banded green and gray jasper. Most of the boulders, however, are mainly hard bluish-black manganese oxide and average 40 per cent manganese. An area of 21,500 square feet is more or less covered with these boulders. In Mine Creek just above the forks on the east side of figure 9 is a boulder of hard oxide, weighing about 100 tons, whose source is unknown.

The main outcrop appears to be chiefly manganese oxide and finely crystallized rhodonite but contains scattered crystals of piedmontite and a few isolated patches of some carbonate, probably manganiferous. The origin of the rhodonite is not known; in the one thin section examined it appears to replace a carbonate. The rhodonite-piedmontite rock was seen at only a few places along the west side, and the deposit is thought to consist almost entirely of oxide. The siliceous nature of the oxide suggests that it may have originated by the oxidation of a manganese silicate such as rhodonite, which may either in turn have been formed by metamorphism of a vein or bed of manganese carbonate or be a primary hydrothermal mineral.

No manganese minerals other than oxides were seen anywhere else in the area except in the boulders near Mine Creek north of the main outcrop; these are composed of a dark-brown partly oxidized manganese silicate, either bementite or neotocite.

HYATT NO. 2 MINE

The Hyatt no. 2 mine (fig. 10) is divided into two parts by the high ridge between the Río Boquerón and Río Candalosa (the use of this name follows the nomenclature of the U. S. Army Engineer map of the Pequení quadrangle; other reports have called this river the Diablo, which is shown on the Army map as entering the Boquerón several miles farther north). The south deposits are near the headwaters of Manganese Creek, a small tributary of the Candalosa, and the north deposits are at the headwaters of Copper Creek, which flows into the Río Boquerón. As at the no. 1 mine, the area is blanketed with a thick cover of clay, and the few outcrops are either along stream courses or in pits near the deposits. Along the Río Boquerón above and below the mouth of the Candalosa are exposures of thin-bedded siliceous gray limestone, which is tightly folded and contorted but in general strikes northeastward and for the most part has steep dips. Along Manganese Creek are outcrops of sheared greenish highly altered volcanic breccia. The breccia fragments are largely amygdaloidal andesite in which the amygdules are composed of calcite, limonite, and green opal. The breccia strikes northeastward and dips 40°–65° SE. It is in contact with shale about 230 feet from the mouth of the creek.

About 230 feet south of the main outcrop of manganese oxide a different kind of breccia forms a fault scarp 25–30 feet high. Most of the breccia fragments are less than 2 inches in diameter. The rock is too badly weathered to be definitely identified, but it appears to be silicic and is perhaps rhyolitic. Underneath the cliff-forming breccia,

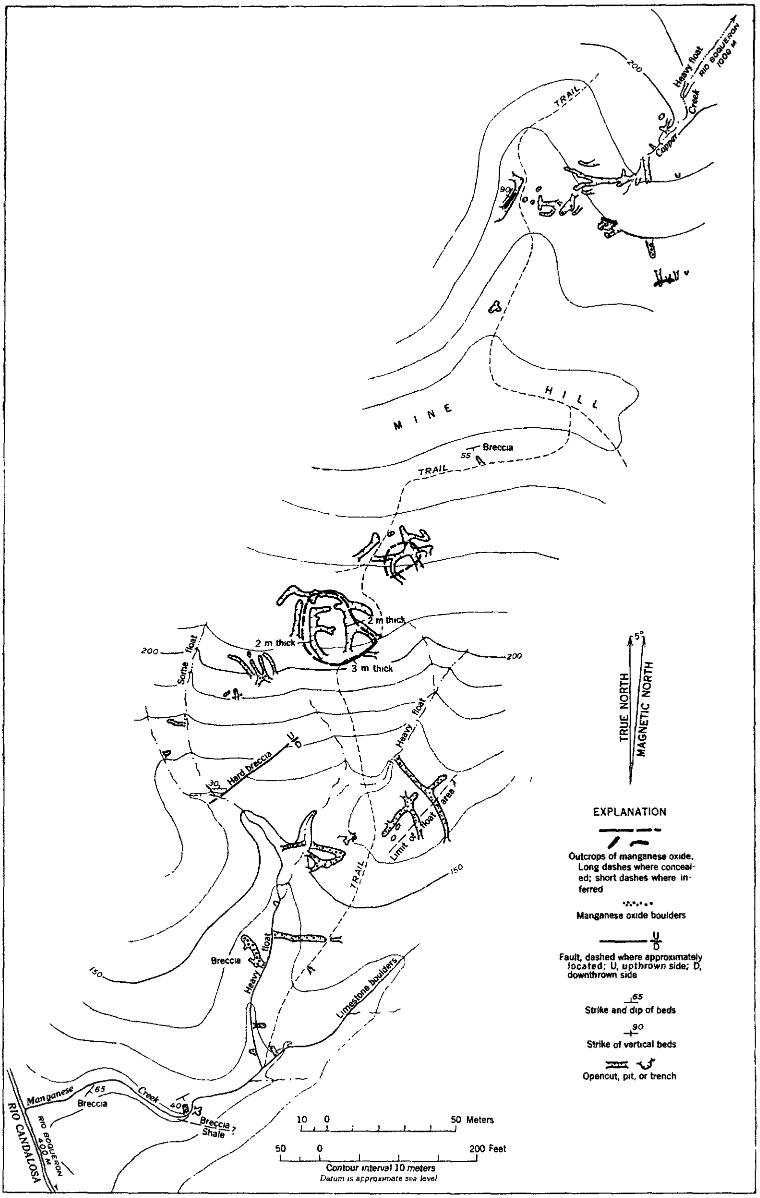

Figure 10.—Map of the Hyatt no. 2 manganese mine, Provincia de Colón, Panama.

soft, deeply weathered breccia is exposed near the base of the scarp. Decomposed breccia is also exposed in a few cuts along Manganese Creek and in a cut near the summit of Mine Hill. Manganese oxide appears to occur in this breccia, although the only rock exposed in contact with the oxide is red and brown clay containing small fragments of rock that is possibly shale but is weathered beyond recognition. The general structure of the area is obscure; dips are predominantly eastward and southward, and the breccia appears to be overlain by shale, which is turn is overlain by limestone.

The main outcrop of the south deposits is at the top of a steep hill 300 feet above the mouth of Manganese Creek and forms a steep cliff 15 feet high at the edge of a flat bench about 65 feet wide. The deposit, as determined by trenching and exposures in the cliff, covers an area of about 7,500 square feet. Most of the trenches are partly caved, and both the attitude and the total area of the ore body are uncertain, but the roughly circular shape of the outcrop, together with the bench at the top of the steep slope, suggests a flat-lying body. Thicknesses range from 6 feet in 2 of the trenches to 10 feet in the face of the cliff. According to reports shale was exposed in a cut, long since caved, at the base of the cliff and below the bench.

The cliff presents the best exposures. The upper 6 feet of the cliff consists of red clay, which is stained in places with black manganese oxide and contains considerable admixed specular hematite. The lower 10 feet is massive soft manganese oxide overlain by a thin uneven layer of specularite, and the slope below the cliff is spangled with tiny flecks of bright specularite. Some of the manganese oxide contains streaks of red clay or a few thin veins of specularite. The oxide is largely dull-gray pyrolusite of very high grade, averaging about 50 percent manganese. Near the base of the cliff is an irregular mass of brownish-black partly oxidized manganiferous calcite, cut by veins of calcite and malachite. Only small quantities of carbonate were found, and it is doubtful whether this is the primary mineral of the entire body. All analyses known to the writer show a small percentage of copper.

One hundred and sixty feet to the northeast, near the upper edge of the bench, another system of trenches outlines a small, apparently flat-lying, body of oxide about 1,100 square feet in area and probably not over 3 feet in average thickness. The oxide is soft pyrolusite similar to that of the main body.

Manganese oxide deposits crop out at several places southwest of the main outcrop, but exploration has shown them to be very small. Heavy float is found along the middle fork of Manganese Creek and along the nose between its 2 main branches, where the largest boulder seen weighed about 15 tons. Many of the trenches show rounded concretionary masses of mixed manganese oxide and clay in a clay matrix. These masses are thought to be concentrations of manganese oxide leached from outcrops above and redeposited by surface waters. The concretions are 1–12 inches in diameter and are found to a depth of at least 10 feet. The oxide is so soft that it can easily be cut with a machete. It averages about 40 percent manganese; clay is the principal impurity.

The north deposits lie on the north slope of Mine Hill, at the head of Copper Creek, about 650 feet north-northeast of the main south outcrop. Deeply weathered volcanic breccia is exposed on the hill between the north and south deposits, and no manganese oxide was seen near the summit on either side. The north deposit consists of several small oxide bodies and numerous boulders that are exposed in shallow trenches on a gently sloping bench. None of the outcrops appears to be connected with any other, and exploration has failed to find any appreciable amount of oxide.

Just west of the trail, at an altitude of 750 feet, an opencut exposes a body of manganese oxide 25 feet long and less than 3 feet thick which strikes N. 20° E. and is vertical. Eighty-five feet to the east a trench exposes several large boulders, and 70 feet farther on is an apparently flat-lying body about 15 feet long and 3 feet thick. About 100 feet to the southeast 2 trenches expose a few boulders which may indicate the presence of a small ore body. None of these bodies appears to be connected, for trenches between them are barren. Copper Creek carries heavy manganese-bearing float from near its head all the way to the Río Boquerón.

The oxide is very high grade soft bluish-gray pyrolusite, similar to that on the south side but perhaps even richer in manganese. Near some of the ore bodies the surrounding clay is heavily impregnated with manganese oxide. It has been suggested that perhaps the south and north deposits are connected as a flat-lying sheet under Mine Hill. Although this is possible, the small areas covered by the two deposits, as compared with the great distance between them, makes it decidedly improbable.

Little can be said about the origin of the oxide at the no. 2 mine. Exploration was inadequate; most of the old trenches are caved, and only clay is found in contact with the oxide. It is not known whether the primary mineral is manganese oxide. No other manganese mineral was seen, except for small quantities of what is probably manganiferous calcite. However, some boulders in Manganese Creek show irregular isolated patches of jasper surrounded by manganese oxide which has replaced the jasper; others have small clay-filled pockets that may represent leached jasper remnants. The oxide in these boulders is hard and siliceous, in contrast to the soft pure oxide of the main ore body. Some boulders show two generations of oxides, the earlier being brecciated and then cemented by the later. Much of the earlier oxide is more coarsely crystalline than the later.

Although the origin of the main ore body is not definitely known, the writer believes that the deposit is similar to other manganese deposits in eastern Panama in that the oxide is epigenetic and has been deposited by ascending solutions. The primary mineral may have been the hard psilomelane-type oxide that is commonly found in these deposits, and the soft pyrolusite may have been formed by alteration of the earlier oxide, perhaps by surface waters that removed part of the oxide and redeposited it in the concretionary masses found below the outcrop. The specular hematite is later than the manganese, for it is found along a shear zone and in thin veins in the main ore body, as well as along the upper contact of clay and oxide. The no. 2 mine is the only one in Panama, seen by the writer, at which specular hematite is found. The veinlets of malachite are confined to the irregular mass of manganiferous calcite found near the base of the main ore body, and both carbonates are thought to be later than the manganese oxide.

CALZADA LARGA AREA

The Calzada Larga area is in the Provincia de Panamá in the low hills south of Calzada Larga, about 2½ miles south of Madden Lake and 14 airline miles north of Panamá. It is 25 miles from Panamá over a road that passes through Chilibre.

The manganese deposit lies on the south flank of a low ridge between the Río Chilibrillo and a small creek. The ridge is composed of deeply weathered agglomerate and tuff, probably andesitic, with fragments as much as 16 inches in diameter.

A vein of manganese oxide, 1 to 16 inches thick and averaging about 4 inches, is exposed in several pits. The vein strikes northward for about 40 feet from its southernmost exposure, then east-northeastward for 30 feet. It dips 75° E. to 55° NW. The vein follows a fault in the agglomerate and cuts through boulders and matrix. In the cut at the bend in the vein, two small branch veins are exposed. In this cut the hanging wall is altered to a yellow clay for 2 inches from the vein. Numerous small pieces of float are found on the slope below the outcrop. The oxide is soft crystalline pyrolusite, some of which is finely banded parallel to the vein walls. No other manganese mineral was seen, and the oxide may be primary.

About 2 tons of oxide has been taken from the vein and the pits in the float area below the vein. The average manganese content is about 50 percent. Only a small amount of oxide is likely to be found here, as the vein has been well exposed and shown to be too narrow to provide much tonnage.

BAHÍA DE MONTIJO-PONUGA AREA

The Provincia de Veraguas manganese deposits described below are in the vicinity of Bahía de Montijo, a large shallow indentation on the Pacific Ocean side of the province. The largest towns in the region are Santiago, 175 miles southwest of Panamá on the Panamá-David highway, and Soná, 30 miles west of Santiago. A surfaced road runs from Santiago 8 miles southeastward to Atalaya, and from Atalaya a dry-weather dirt road leads to Ponuga, 15 miles south of Atalaya and 7 miles east of Bahía de Montijo. There is a fair landing field at Mariato, 10 miles south of Ponuga. The country between Ponuga and Atalaya is traversed by numerous trails, so that most of it is fairly accessible. The country around Bahía de Montijo is partly covered with heavy vegetation, but it includes some large areas of open grassland.

HARRIET PROSPECT

The Harriet prospect (fig. 11), also known as the Rosario prospect, lies west of Bahía de Montijo, on the west side of a prominent hill about half a mile north of Bahía Honda. The deposit is at about lat 7°47′ N. and long 81°31′ W., 155 airline miles southwest of Panamá.

Bahía Honda is a fine natural harbor and has been charted by the U. S. Navy Hydrographic Office (Chart no. 1040). It is about 250 miles by boat from Panamá, 70 miles by boat from Soná by way of the Río San Pablo and Bahía de Montijo, and 60 miles by boat from Puerto Real, which is 11 miles by road south of Santiago. A trail leads from Bahía Honda to Soná through country that is said to be difficult to traverse. The only native settlement in the vicinity is a small village on the north shore of Isla Talon, in the center of the bay.

The tides at Bahía Honda, as elsewhere along the Pacific coast of Panama, are very high, ranging from 10 to 18 feet, and at low tide mud flats 2,000–4,000 feet wide are exposed along the north shore of the bay. Between the manganese deposit and the bay is a belt of mangrove swamp 300–2,000 feet wide.

Prospecting was first begun in 1921, when a sizable outcrop is said to have been found along the bottom of a small tributary of the Río Luis, which flows into the bay directly north of Isla Talon. Further prospecting was done about 1935, when the entire area was cleared and a small amount of trenching was done on two outcrops on the west side of Harriet Hill. No further work has been done and no production has come from the deposit. At present the old prospect workings are completely covered by landslides and jungle. A small amount of material, perhaps 100 tons, has been transferred to Isla Talon for shipment, and a 500-pound sample of this material was taken for assay. This sample is said to have contained 47 percent manganese and 8 percent silica. There is also a good deal of ore in the foundations of some of the native houses on the island.

The deposit consists of 2 outcrops of manganese ore, 1 on either side of a small saddle on the west side of a prominent hill easily visible from the bay. Both outcrops lie at altitudes ranging from 200 to 330 feet and are a little more than a mile by boat and trail from the bay. The country is blanketed by dense jungle, and the area near the outcrops, cleared in 1935, is covered by an even denser second growth of small trees and shrubs. Only red clay is exposed near the north out-

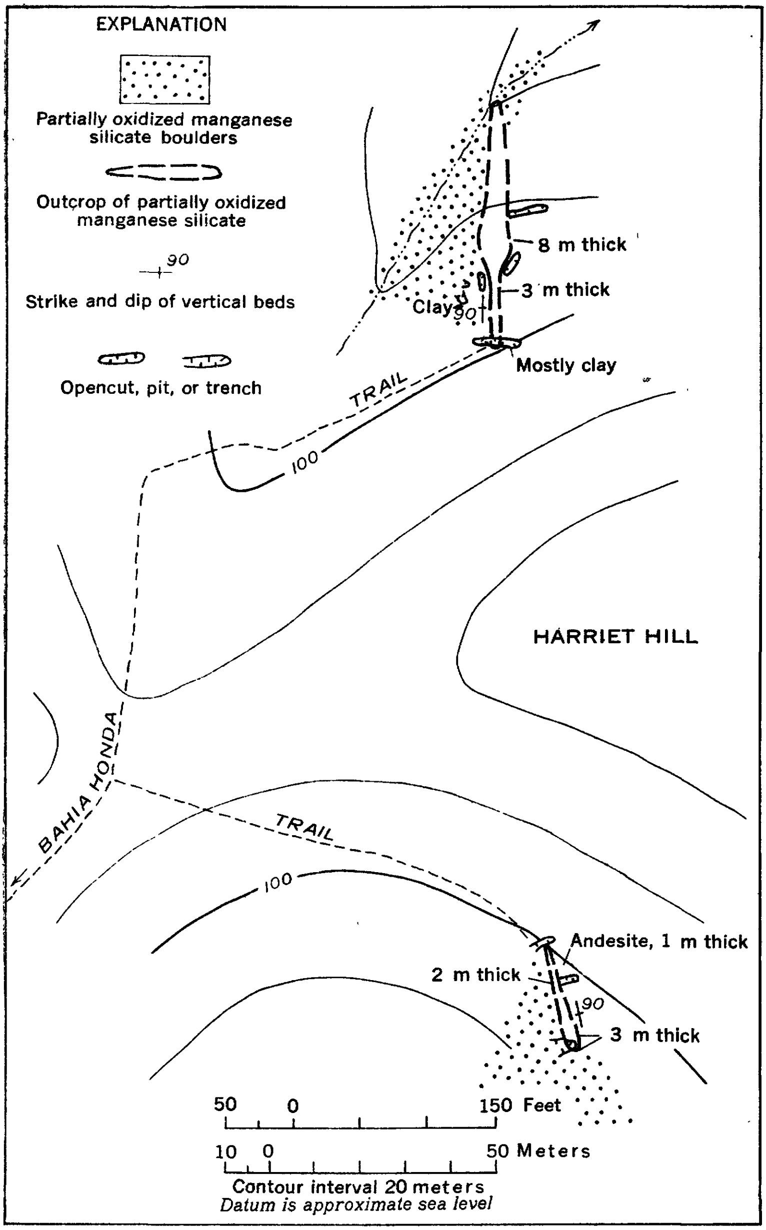

Figure 11.—Map of the Harriet manganese deposits, Provincia de Veraguas, Panama.

crop, but at the south outcrop one trench exposes a deeply weathered andesitic volcanic rock.

The north outcrop is on the east side of a steep canyon and consists of a lens of manganese oxide and silicate minerals that strikes north and dips vertically. The lens is exposed intermittently for 165 feet and ranges in thickness from 10 to 25 feet, with an average thickness of about 16 feet. It crops out over a vertical distance of 130 feet. The canyon at the lower end and a trench at the upper end clearly define the length of the lens. The canyon wall below the outcrop shows numerous small boulders of ore, as does the creekbed for a considerable distance downstream.

The manganiferous material consists of hard blue-black psilomelane that encloses some unoxidized manganese silicate and, to judge from the amount of limonite present, an appreciable amount of iron. The manganese oxide is the result of oxidation of a vein or bed of manganese silicate, either neotocite or bementite. The depth of oxidation is unknown, but the presence of unoxidized remnants in the surface material indicates that oxidation at depth is probably not complete.

The second deposit is about 500 feet farther south and lies approximately in the line of strike of the north deposit. There are no exposures between the two deposits, which appear to be entirely separate although perhaps localized along the same bed or shear zone. The deposit is a poorly exposed lens of siliceous manganiferous rock about 80 feet long and 3–10 feet wide. It strikes N. 15° W.; its dip is uncertain but probably steep. Manganese-bearing rock is exposed at only three places along the strike, and the ore body may not be continuous between them. On the hillside below are numerous boulders that have broken from the outcrop.

The rock consists largely of siliceous manganese oxide, both massive and in thin veinlets in jasper, similar to the material in the north deposit but more siliceous.

Exploratory work at the Harriet deposit has been inadequate and furnishes little information on which to base an estimate of reserves. Some of the ore that appears to be in place may be only large boulders, and the size of the ore body may be overestimated. Many small boulders occur along several stream courses, and although several hundred tons might be picked up along the tributaries of the Río Luis, the total tonnage to be expected is small.

LA MATILDE DEPOSITS

The La Matilde manganese deposits (fig. 12) are in a range of low hills about 5 miles north of Ponuga and 10 miles south of Atalaya, at about lat 7°53′ N. and long 80°54′ W., 15 miles south-southeast of Santiago and 120 miles southwest of Panamá. The main trail from Ocu to Ponuga passes along the valley south of the hills, and the trail from Ponuga to Cerros Altos and Atalaya crosses the ridge near the west end of the property. The dry-weather automobile road from Atalaya to Ponuga lies about 2 miles to the west. The surrounding region is a deeply dissected terrain of low steep-sided hills and many small canyons.

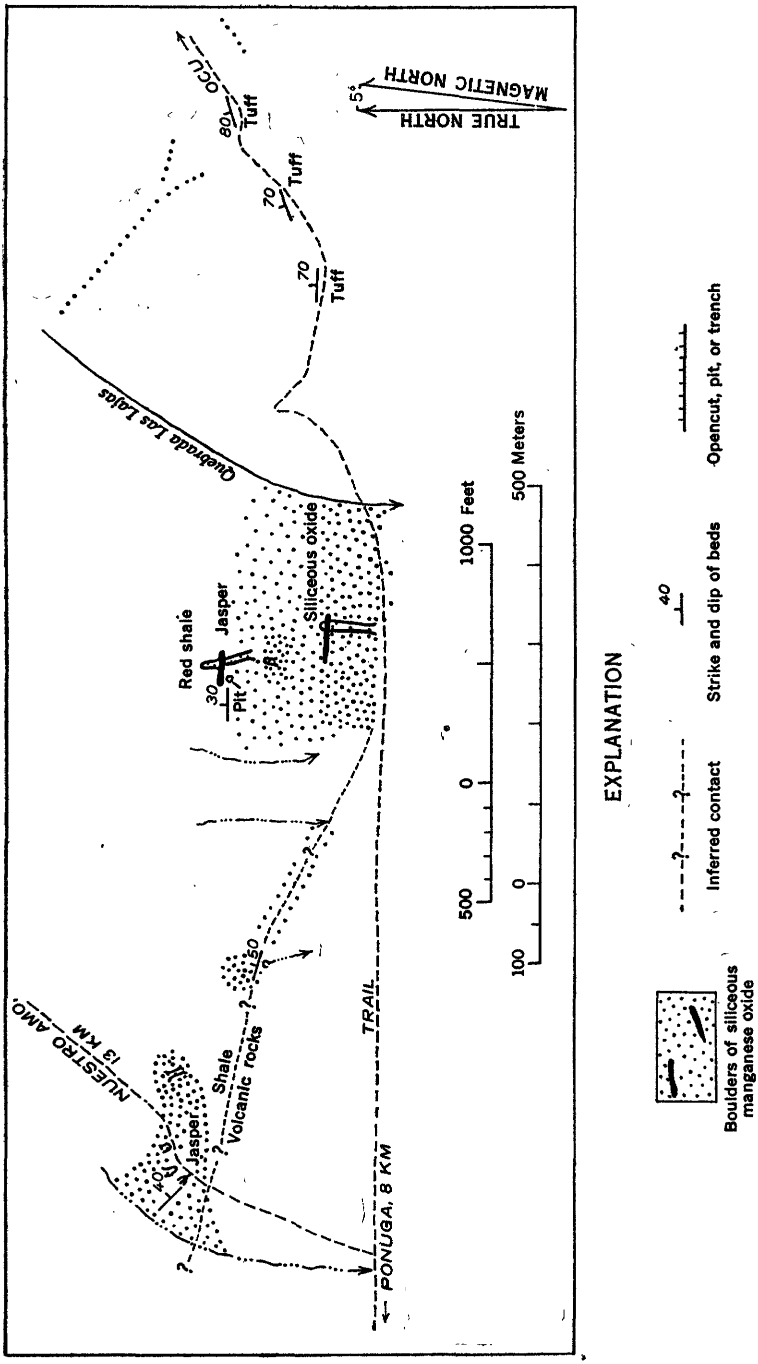

FIGURE 12.—Map of the La Matilde manganese deposits, Provincia de Veraguas, Panama.

The deposits have been explored from time to time since 1920 or 1921; the main development work is thought to have been done in 1921 and 1935. Although the area has been cleared at least once, much of it in 1942 was covered with a thick mantle of second growth, denser than the virgin jungle. No record was found of any commercial production from the property.

The La Matilde deposits occupy three low hills (fig. 12); the west and middle hills are separated by a broad valley, and the middle and east hills are separated by Quebrada Las Lajas. The manganese ore occurs in a thick belt of shale or mudstone and clay, probably of Oligocene age, that dips about 30° N. and overlies a series of volcanic rocks, which are well exposed along the trail at the base of the hills. The volcanic rocks include rhyolitic ash and tuff and andesitic and basaltic agglomerates. All these rocks are so deeply weathered that reliable petrographic determinations cannot be made in the field.

The north and west sides of West Hill are covered with boulders and nodules of manganese oxide over an area of roughly 5 acres. This float ore is further exposed in several trenches, and a thin bed of manganiferous jasper, striking northwestward and dipping 40° NE., shows in the westernmost trench. Near the east end of the float area is a trench in a thin mantle of high-grade manganese oxide nodules resting on clay and jasper. The layer of manganese-bearing rock is only about 10 inches thick, and not more than 25 percent of it consists of oxide. The oxide is heavy material of the psilomelane type and appears to be distributed over an area roughly 165 feet in diameter.

The remainder of the float and the material exposed in the trenches to the west consist largely of jasper and shale cut by thin veins of manganese oxide. Many other small bodies of manganese oxide were apparently formed by replacement of brecciated jasper. No estimate of the tonnage in the area has been made, since very little exploratory work has been done; the average manganiferous material appears to contain less than 20 percent manganese.

Near the base of the hill, about 500 feet southeast of the float area described above, is another heavy concentration of boulders of manganiferous rock, jasper, and dark chert, in an area that, like the other, is about 165 feet in diameter. About 1 boulder in 4 is manganiferous and consists largely of reddish-black manganese silicate. The boulders contain small pockets of soft gray pyrolusite in groups of radiating prismatic crystals, but not more than 5 percent of any specimen examined was manganese oxide. A few pieces of jasper occur along the base of the hill between the float area and the broad valley that separates the west and middle hills. No manganiferous boulders were seen there or in the valley itself.

The largest concentration of manganese ore on the La Matilde property is on the gentle slope near the base of Middle Hill, where a northward-trending trench 200 feet long has been cut in a mantle of boulders of manganse oxide and jasper. At the south end and near the middle of the trench are heavy concentrations of boulders, suggesting the possible presence of ore bodies nearby. The north end of the trench exposes a bed 23 feet thick which can be traced for 165 feet to the west. Some of this bed is heavy bluish oxide of the psilomelane type, but the predominant rock is a deeply weathered jasper cut by many veins of manganese oxide and coated along fractures with films of manganese oxide. The float covers an area about 650 feet long by 250 feet wide and probably extends to a depth of at least 3 feet.

Beyond the north end of the trench the slope of the hill steepens abruptly. Another trench, 160 feet up the slope, exposes a similar mantle of boulders nearly 2 feet thick. About a quarter of the boulders, some of which weigh more than a ton, are composed of manganese oxide. Although it is possible that an ore body may be near the upper end of the trench, no rock was seen that was known to be in place. As the ground around the trench was covered with a dense blanket of fallen timber at the time of examination, the total area of float could not be determined, but float is probably present to a depth of 2 feet in an area 165 feet long and 80 feet wide.

A 16-foot-deep pit 130 feet northwest of the second trench exposes bright-red shale that strikes eastward and dips 30° N. The shale contains many small interbedded lenses of jasper but no manganese ore. Fifteen feet east of the pit a shallow trench 200 feet long cuts across a bed of jasper 6 feet thick which strikes eastward and appears to dip northward. This bed can be traced westward to a point just above the pit, where its continuation, if one exists, is buried. The wall rock is red shale similar to that in the pit. The jasper contains a good deal of iron and very little manganese.

On the west slope of East Hill, between the trail to Ocu and Quebrada Las Lajas, a few boulders of nearly pure manganese oxide were seen; this area is entirely unprospected, and the source of the boulders has not been found. The ore was of higher grade than that seen anywhere else on the La Matilde property, but the amount of manganese oxide was very small.

NUESTRO AMO PROSPECT

The Nuestro Amo deposit is at the top of a low ridge nearly 2 miles west of the small village of Nuestro Amo, which is 2½ miles south of Atalaya and can be reached by automobile during the dry season. The trail from the village to the deposit passes over fairly level country that offers no serious obstacle to roadbuilding.

This property was prospected in 1928 at the same time as the La Matilde deposits to the south, but the writer saw no evidence of any former work. It is said that a pit 16 feet deep was in good manganese oxide for its full depth; if so, the pit is now completely filled and even its location is uncertain. There has been no production from the deposit.

Along the trail from the village to the deposit are exposures of andesitic and basaltic tuff and agglomerate and many residual boulders of weathered agglomerate. In the vicinity of the deposit, amygdaloidal andesite is exposed in a trench, and andesite tuff crops out near a small canyon on the south edge of the property.

Manganese-bearing rock was seen at two places on the property. A trench 65 feet long exposes a lenticular body 10 feet long and with a maximum thickness of about 1½ feet which strikes north and dips 35° E. The walls are deeply weathered porphyritic amygdaloidal volcanic rock, probably andesitic; the amygdules consist of calcite or greenish opal. A few small pieces of float ore were found in the area between the trench and the trail to the north.

The lens is deep-red to reddish-black manganese silicate, which has been superficially altered to a heavy bluish oxide of the psilomelane type enclosing small pockets of soft, powdery black oxide. The oxide is of high grade, containing more than 50 percent manganese, but the amount in sight is very small. Some high-grade float occurs in the canyon on the south edge of the property, but here also the quantity is small.

HONDURAS

Although many manganese deposits are known in Honduras, no ore has been shipped from them. In 1942 several of them were explored, but none appeared likely to be workable at a profit, even under the stimulus of high prices. The deposits examined are in upper Tertiary lavas and pyroclastic and sedimentary rocks which cover much of central and southern Honduras (pl. 1). These rocks commonly strike eastward, dip gently southward, and are locally folded into broad anticlines and synclines. Faults were seen in several places, but none appeared to be of large displacement.

The manganese of the ore bodies appears to occur entirely as oxides, chiefly pyrolusite and psilomelane. Chalcedony is a constituent of most of the ore bodies, and some of it is intimately mixed with the manganese oxides. The iron content of the ore appears to be low.

The ore bodies may be classified into flat or gently dipping bodies parallel to the bedding, and steeply dipping veins that follow faults or fractures. The veins are commonly small or lean; they are not persistent and none of them discovered up to 1941 is likely to yield ore bodies of commercial size and grade. The flat or gently dipping ore bodies have not shown great promise, although some of them may prove to be worth mining. The Tendal ore body in the La Mesilla area is at least 140 feet long and from 6 inches to 3½ feet thick and has been explored down the dip for nearly 50 feet. The ore as mined probably does not contain more than 30 percent manganese, but a product of shipping grade can be obtained by sorting. The other deposits had not been explored sufficiently to permit estimates as to tonnage and grade.

LA MESILLA AREA

The La Mesilla area is 18 miles east of Pespire, Departamento de Choluteca. In 1941 it was under option to Dr. Diáz Pardo of Havana, Cuba. Manganese deposits have been discovered over a wide area, but those that have been explored—the Tendal, Rubén, Malachate, and Cerro Bonito—are all near the top of the La Mesilla mesa. The road from Pespire to Tamarindo, 9 miles distant, is suited for oxcarts with light loads and could be improved at small expense for truck traffic. The 9-mile section from Tamarindo to La Mesilla, however, is steep and rocky, and a considerable expenditure would be necessary to make it passable for trucks.

Hardly enough ore has been mined in this area to give an idea of mining costs under operating conditions, but in 1942 the average cost of mining and sorting was about $8 a long ton. The cost may become less as local labor becomes more efficient, but any reduction for this reason will be offset to some extent by increased costs as mining progresses down the dip. The estimated cost of transporting a long ton to Amapala, the nearest port, was about $14.

TENDAL MINE

The Tendal ore body (fig. 13) is the largest discovered in the La Mesilla area up to 1941. The ore follows bedding in tuffs that strike east and dip 20° S. It consists of wad and pyrolusite associated with chalcedony, and it replaces a thin bed of tuff.

The ore body has been traced along the strike for 250 feet and has been explored for 140 feet to a maximum depth of 50 feet down the dip. Its thickness ranges from 6 inches to as much as 3½ feet. On the west side of the open pit the ore layer averages 2 feet in thickness and consists largely of black chalcedony, partly replaced by irregular veins, pockets, and layers of pyrolusite. A thin layer of oxide is commonly found at the base and top of the chalcedony bed, and manganese oxides locally replace the tuff above and below the chalcedony. On the east side of the open pit the ore bed is 2–3½ feet thick and is of good grade, consisting of nearly equal parts of black chalcedony and manganese oxide. At one place the bed contains a little limonite, but for the most part the iron content appears to be low.

In 1941 a shaft was being sunk 250 feet south of the main pit to explore the ore zone at depth. The shaft was then 24 feet deep and was expected to penetrate the ore at a depth of 90 feet. The outcrop of the zone west of the main pit shows only low-grade siliceous float.

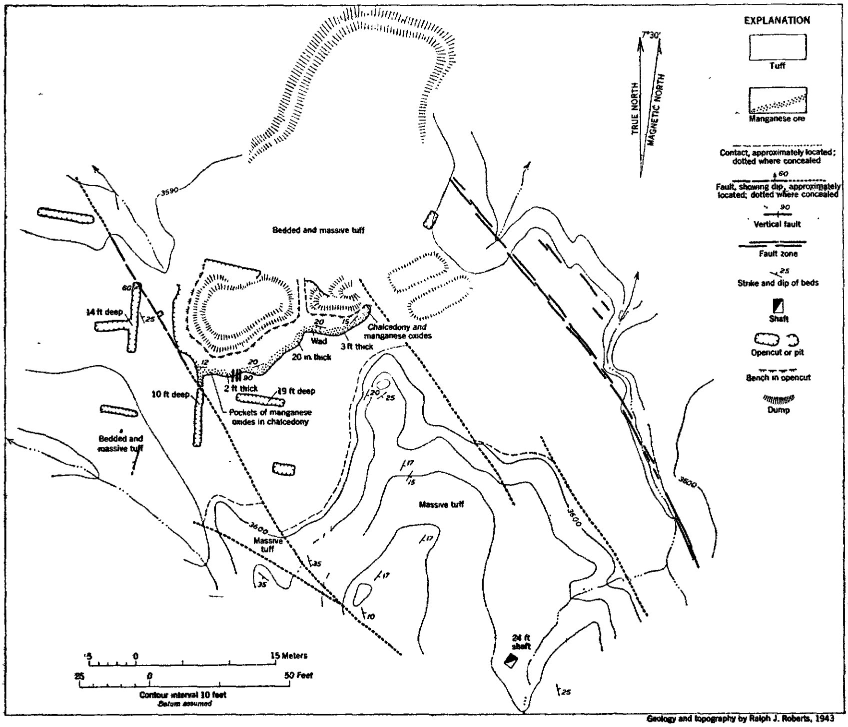

Figure 13.—Map of the Tendal workings, La Mesilla area, Departamento de Choluteca, Honduras.

It is impossible to predict the grade of the material that may be found at depth.

The manganese content of the ore mined ranges from 10 to 50 percent and probably does not average more than 30 percent. The ore was being hand sorted to the grades shown in the assays below.

Assays of manganese ore from the Tendal mine, Honduras

Sample No.	Mn (percent)	Fe (percent)	Silica and insoluble residue (percent)	Remarks
Mn2	22.87	2.24	52.44	Siliceous ore, rejected.
Mn3	42.62	1.42	25.16	Dense oxides, selected for shipment.
Mn4	42.01	2.73	17.54	Wad.
Mn5	34.63	1.05	33.68	Porous and dense ore, selected for shipment.

QUEBRADA DE RUBÉN PROSPECT

At Quebrada de Rubén, about half a mile south of Tendal, a small pit in tuff shows an ore body of soft wad about 5 feet wide that strikes N. 20°–40° E., dips steeply northwestward, and appears to follow a fault. A sample of sorted ore was analyzed with the following results: 52.55 percent manganese, 0.47 percent iron, and 4.76 percent silica and other insoluble material. A large tonnage is not likely to be found, for bedrock is well exposed so nearby along the strike that the ore body may be less than 50 feet long.

MALACHATE PROSPECT

Workings in the Malachate prospect, about 500 feet northeast of Quebrada de Rubén, explore a lens of manganese oxide and chalcedony that is parallel to the bedding of the enclosing tuff, which strikes north and dips 30° W. The lens is about 50 feet long and at least 6 feet thick and has been uncovered down the dip for 10 feet.

The chalcedony is gray or black because of finely disseminated manganese oxides, which also form small veins and irregular pockets and locally replace the tuff adjacent to the chalcedony. As the ore is of low grade because of its high silica content, and as it contains only a small tonnage, the deposit is probably not of commercial importance.

CERRO BONITO PROSPECT

The Cerro Bonito prospect is a third of a mile southwest of the Tendal deposit. The workings explore small discontinuous manganese oxide veins in tuff, ranging in width from a fraction of an inch to 6 inches. As the ore is of low grade and the available tonnage is small, the deposit has no commercial value.

SABANAGRANDE AREA

Several prospects have been opened up near the 61-kilometer post on the San Lorenzo highway south of Tegucigalpa, and 2 of them were examined. One, 300 feet west of the highway, shows veins of manganese oxide as much as 6 inches wide in rhyolite. The veins are lenticular, and although some of the ore is nearly pure pyrolusite, most of it is so low in grade that the prospect does not appear to have any commercial possibilities. At the other prospect, which is about 2 miles west of the highway, manganese oxides are irregularly distributed throughout tuff. The material is low grade and only a few tons appear to be available.

VILLA NUEVA AREA

Near Villa Nueva, a village about 6 miles southwest of Tegucigalpa, Robert Hickish has denounced 2 manganese deposits. In 1 of them, 500 feet west of Villa Nueva, a fault zone in conglomerate trends N. 70° W. and dips northeastward, and the fractured rock in the zone is locally stained by low-grade manganese and iron oxides. In the other, about 1,000 feet northeast of Villa Nueva, manganese oxide is sparsely distributed in conglomerate, but the grade and tonnage are so low that the deposit has no commercial value.

FLOR AZUL PROSPECT

The Flor Azul prospect, owned by Robert Hickish, of Tegucigalpa, is about 6 miles north of Morocelí. The property was under option to Dr. Diáz Pardo, of Havana, Cuba, in 1941.

Four shallow cuts explore a fractured zone containing manganese oxide veins and pockets. The zone crops out for 260 feet along the strike and in its widest part is as much as 90 feet wide. The pockets and veins of manganese oxides commonly contain fragments of rhyolite and unreplaced crystals of quartz and feldspar. A sample of the ore was assayed by the Geological Survey with the following results: 19.75 percent manganese, 2.35 percent iron, and 58.90 percent silica and insoluble residue. In some places the ore may be of higher grade, but in others it appears to be leaner; moreover, below the surface, the percentage of oxide minerals is likely to decrease.

OJOJONA DEPOSITS [5]

Manganese deposits occur 9 miles south of Ojojona, on the Finca Valladares. A road passable during the dry season extends from the Tegucigalpa-San Lorenzo highway to Ojojona, but travel southward to the ranch is possible only over a rough trail.

The rocks in the area are interbedded porphyritic andesite and ash beds of Tertiary age that dip southward at low angles. These rocks have been gently folded and have been broken by faults that trend northwestward and northeastward. The manganese ore consists of pyrolusite and other manganese oxides, generally mixed with much waste rock; it is associated with veins that contain copper, gold, lead, and silver. At the Amatillo no. 5 and the Pozo no. 2 workings the manganese ore bodies appear to be thin, surficial deposits formed by mechanical and chemical concentration from older deposits, possibly veins.

The Amatillo nos. 1, 2, 3, and 4 workings are about 2½ miles south of the Finca Valladares house. Several adits and shafts explore copper ore on northeastward-trending fractures. In a mineralized zone about 600 feet long the fractures are locally stained with manganese oxides, but the material is low grade. The Amatillo no. 5 workings are on the crest of the ridge about 400 feet northeast of the no. 4 workings. The manganese ore is exposed over an area about 600 feet long by 150 feet wide. Although no exploratory work has been done to determine the depth to which the material extends, the deposit is thought to be shallow. A sample of picked ore yielded 24.39 percent manganese and 3.1 ounces of silver to the ton.

[5] Hyde, P. W., Report to the New York and Honduras Rosario Mining Co., Honduras.

The Pozo workings, about 2½ miles southwest of the Finca Valladares house, consist of several adits, which were caved in 1941, and a shaft, that explore silver-lead shows along northwestward-trending fracture zones. At the Pozo no. 2 workings manganese ore is exposed as a cap, about 500 feet long by 150 feet wide, on the side of the ridge. A picked sample of the material contained 25.43 percent manganese and 0.92 ounce of silver to the ton.

The Amatillo and Pozo manganese deposits are fairly extensive, but the grade of the ore on the whole is low, as even picked samples are too lean to make ore suitable for shipping. The tonnage available is not great enough to warrant installing a concentrator.

EL APINTAL PROSPECT

The El Apintal manganese prospect is 2½ miles northeast of Pespire, Departamento de Choluteca, on the ranch of Marcial Ramos. Two shallow cuts show that the ore extends to a depth of only 6 feet below the surface. The ore, soft wad, occurs in veinlets 1–2 inches wide in fractured andesite, which is intercalated with volcanic tuff and breccia.

OTHER DEPOSITS

Other deposits were called to the writers' attention, but because sufficient time was not available they were not examined. Specimens offered were for the most part wad and psilomelane, similar in general appearance to specimens collected at the deposits already mentioned, and descriptions of the properties suggested that for the most part tonnages were small. In addition, most of these deposits are so far from highways and from the seacoast that transportation costs would make it unprofitable to mine them at present prices.

The following properties, none of which have been developed, were reported:

Juan Avila Ruiz, Tegucigalpa; near Sabanagrande, Departamento de Tegucigalpa.

Ojojona, Departamento de Tegucigalpa. Deposit 1½ miles south of Ojojona on trail to Reitoca. Owner not known.

El Apintal, northeast of Pespire, Departamento de Choluteca. Owner not known.

Federico Kohn, San Lorenzo, Departamento de Valle.

Rubén Pineda P., Intíbuca, Departamento de Intíbuca.

Salvador López, San Pedro Sula; near Siguatepeque, Departamento de Gracias.

Manganese is also reported near Gracias, Departamento de Gracias.

GUATEMALA

PÉREZ PROSPECT

The Pérez manganese prospect, Departamento de Chiquimula, is 5 miles east of Chiquimula on the ranch of Anacleto Pérez, at an altitude of 1,600 feet. The deposit is exposed in a shallow pit along a sheared contact between limestone and phyllite that strikes N. 20° W. and dips 60° SW. The shear zone has a width of 6 feet and contains lenses of soft manganese oxides that are estimated to make up about 30 percent of the zone. The ore can be traced along the strike for a distance of about 50 feet; it pinches out at both ends.

A picked sample of the manganese oxides assayed 29.7 percent manganese, 2.76 percent cobalt, 2.94 percent nickel, and 2.3 percent copper. Although the content of nickel and cobalt is notably high, the tonnage available appears to be small.

BRENES PROSPECT

The Brenes prospect is about 700 feet southeast of the Pérez prospect, at an altitude of 1,750 feet. The manganese here also is at the contact of limestone and phyllite. The manganiferous material is mostly soft, brown, and earthy, but locally contains darker brown and black nodules. It covers an area about 50 feet long by as much as 25 feet wide; it has not been explored in depth. Presumably the ore was formed by weathering of manganiferous material in the limestone, and it may have been concentrated by solutions migrating downward along the contact of the limestone and the phyllite. Nodules of the best material assayed 11.2 percent manganese, 0.84 percent nickel, and 0.22 percent cobalt.

LA CUMBRE DEPOSITS

The La Cumbre deposits are a mile east of Rosario, Departamento de Zacapa, at an altitude of about 2,000 feet (P. W. Guild, 1943, unpublished report). The deposits can be reached by trail from Rosario. The nearest shipping point is Cabañas, a station on the International Railroad, 6 miles north of Rosario.

The rocks in the area are quartz and mica schists intruded by diorite. The schist is cut by four veins composed chiefly of rhodonite; quartz veins locally cut the rhodonite, which in places is intergrown with quartz. The rhodonite veins trend northwestward and dip steeply; they are nearly parallel and are spaced at intervals of about a thousand feet. Two of the veins are about 12 feet wide and can be traced for a distance of several hundred feet along the strike; another is 18 feet or more in width and several hundred feet long. The fourth vein is poorly exposed and its dimensions could not be obtained.

Near the surface the rhodonite is altered to manganese oxides. The extent of oxidation is variable; in some places the surface material is all oxide and in others it is all rhodonite. Possibly the oxidized ore could be sorted to give a product of fair grade, but hand cobbing would be necessary to remove quartz and rhodonite.

MICA DEPOSITS

GUATEMALA

Muscovite deposits occur in the Departamento de El Quiché and Departamento de Baja Verapaz in a belt 16 miles long by 3 miles wide that extends from El Chol, Baja Verapaz, nearly to Joyabáj, El Quiché (pl. 13) (L. G. Houk, 1943, unpublished report). The principal productive deposits are in the Agua Caliente district in the eastern part of the belt and in the Pachalúm district in the western part. Mica is known to occur outside these areas, but none has been exploited.

The mica deposits are on the southern flank of the Sierra de Chuacús, an eastward-trending range whose highest summit, Cerro de Tuncaj, has an altitude of more than 8,000 feet. The region is drained by tributaries of the Río Motagua, which at Concua is about 2,200 feet above sea level.

The area can be reached by roads to Joyabáj and El Chol that are passable the year round, but on the steep trails within the area travel is on foot or horseback. Freight from within the area is largely carried by pack animals to the roads and then by truck to railroad points.

The mica deposits of Guatemala were known prior to 1900 but were first explored in 1919 by Manuel Bergua and Leon Campanolle, who opened the Palibatz no. 2 mine. In 1922 the Palibatz no. 1 deposit was discovered, and since then it has produced continuously. The early production has not been recorded, but Manuel Bergua reports that it was high and that up to 1926 it may have exceeded 100,000 pounds of sheet mica.

Recorded production of sheet mica in Guatemala, 1926–42 [1]

Year	Weight (lbs)	Value (dollars) and country where sold		
		United States	Germany	France
1926	24, 719	9, 750. 00		
	2, 672		1, 054. 00	
1927	11, 029	6, 038. 08		
	3, 867		2, 211. 54	
1928	26, 598	14, 687. 68		
	2, 302		1, 271. 20	
1929	23, 265	12, 846. 96		
1930	0			
1931	1, 014		200. 00	
	467			92. 00
1932–38	0			
1939	3, 854	540. 00		
1940–41	0			
1942	6, 204	1, 235. 00		
Total	105, 991	45, 367. 72	4, 736. 74	92. 00

[1] Figures compiled by L. G. Houk from United States consular records.

GEOLOGY

The mica deposits are in pegmatite bodies that cut gneiss, schist, and granite. These rocks are part of a belt ranging in width from a few miles to 36 miles that extends across central Guatemala from Puerto Barrios on the Atlantic coast westward into Mexico. On the south this belt is overlapped by Tertiary and Quaternary lavas and pyroclastic rocks, whereas on the north it is in fault contact with sedimentary rocks of Permian(?) and Permian age. Serpentine masses whose long axes are roughly parallel to the belt intrude the schist.

Garnet-mica schist and gneiss form the bedrock of most of the region. These rocks are interbedded with smaller quantities of hornblende schist and gneiss, andalusite schist, and other metamorphic rocks, all of which generally trend westward to northwestward and dip steeply southward to southwestward, although locally they have been folded into northward-trending minor folds.

In the Palibatz area the metamorphic rocks are predominantly mica schist and gneiss, but layers of feldspathic gneiss and hornblende gneiss, most less than a hundred feet thick, are locally prominent. Limestone, now coarsely crystallized, is intercalated with the schist and gneiss along the Río Caquíl west of Palibatz. The thickness of the limestone unit varies widely but appears to average between 100 and 200 feet. The limestone interfingers with mica schist on both sides of its outcrop. Locally the coarsely crystalline limestone contains small crystals of phlogopite and muscovite. The age of these rocks is not known. Sapper (1937, p. 22–23) considered them to be pre-Cambrian but suggested that in part they may be of early Paleozoic age. On plate 1 they are included in the unit of pre-Cambrian rocks.

South of Pachalúm and San José Saltán the schist and gneiss are in fault contact with serpentine, which extends southward to the Río Motagua. The serpentine is mostly sheared and slickensided, and locally it contains roof pendants of limestone and shale belonging to the Santa Rosa and Permian limestone, which crop out widely in north-central Guatemala.

Granitic rocks form the core of the mountain range north of the mica districts. The granite intrudes the metamorphic rocks, and near its border the schist is recrystallized to coarse-grained gneiss. Numerous pegmatite dikes are associated with the granitic rocks. A few of the pegmatites are composed only of quartz and feldspar, but most of them contain mica as well. The pegmatites range from thin veinlets to bodies 100 feet or more in width, and some of them can be traced for hundreds of feet along the strike.

The pegmatites of the Agua Caliente district are irregular in shape and generally cut across the foliation of the enclosing rocks, although some tongues and projections extend from the pegmatites along the foliation. The pegmatites of the Pachalúm district, on the other hand, are for the most part parallel to the foliation of the schist, although locally they cut the foliation. Most of them are lenticular or tabular in shape.

The pegmatites are composed chiefly of feldspar and quartz with varying proportions of other constituents. Muscovite is commonly the most abundant minor constituent and may make up 15 percent or more of the pegmatite, but generally it does not average more than 4 percent. Biotite, although a prominent constituent of the enclosing schists, has not been seen in the pegmatites.

Feldspar is the chief constituent of the pegmatites; the most abundant kind is a white or pink potash feldspar—probably orthoclase, although plagioclase is present locally. The feldspar is commonly mixed with coarsely crystallized quartz, and only locally is it nearly pure or in a fine graphic intergrowth with quartz. In the Talaxcóc pegmatite the feldspar is euhedral against the quartz, although in other places both minerals are commonly anhedral. In most mines the mica is enclosed in fresh feldspar; in places, however, the feldspar has been altered to a clay mineral and the mica is soft.

The quartz associated with the pegmatites is of two generations. The early quartz occurs in irregular masses, veins, or lenses, and is also intergrown with feldspar. Generally the quartz occupies the middle part of a pegmatite body, and because it is resistant to weathering it makes bold, rugged outcrops. This quartz is fine to medium grained and milky. At the Zeabáj, Palibatz, and Ciprés mines the mica occurs partly in the quartz core, and the two minerals appear to have crystallized contemporaneously.

The later quartz occurs in veinlets which cut the early quartz, the orthoclase, and the mica. This late quartz everywhere fills fractures that formed later than the mica. Locally the quartz was deposited in layers as much as a quarter of an inch thick between the sheets of mica. It is commonly fine grained and some resembles chalcedony.

Epidote is an accessory in some of the pegmatites. Wedge-shaped crystals 4–6 feet long are abundant in the Constancia mine, and large crystals are found also in the Palibatz no. 2 mine. The crystals commonly have their long axes normal to the contact.

Most of the pegmatites mapped in the Agua Caliente and Pachalúm districts are zoned. The zoning is best developed in the larger pegmatites but is generally shown to some extent even in the smaller bodies. Commonly the zoning consists of a central core of milky quartz which is surrounded by an outer zone of feldspar and quartz. The feldspar and quartz in the outer zone are generally intergrown; in places this zone can be subdivided into an inner zone of plagioclase and quartz and an outer zone of graphic granite or orthoclase-quartz intergrowth. Zoning is well shown in the Palibatz no. 1 pit (pl. 14).

Many of the pegmatites in Guatemala contain mica crystals intergrown with the quartz and feldspar. The mica commonly makes up less than 15 percent of the rock, and it averages between 4 and 10 percent. The books range from a fraction of an inch to 5 feet in diameter and average between 6 and 12 inches. Green mica generally forms larger books than rum and ruby mica.

Some of the mica is disseminated throughout the pegmatite, while some is concentrated in shoots that can be divided into two principal types: ore shoots on the hanging wall or footwall of the pegmatites and ore shoots adjacent to or within quartz masses in the pegmatite.

Most of the best and largest mica crystals are found along the borders of the pegmatites or along and partly within quartz veins that are closely associated with the pegmatites. The muscovite may be green, brownish green, ruby, rum, amber, or clear. Colors ranging from light clear green to dark brownish green are the most common and grade into each other. Ruby, amber, and rum mica commonly occur in feldspar pegmatites that are not associated with massive quartz veins or that do not contain quartz masses or lenses, as for example in the Liberated, Anono no. 1, and Talaxcóc deposits.

Although the color of the mica found at any one mine is likely to be nearly uniform, it may show variations. Some pegmatites contain mica of two colors and others contain crystals that show zonal growth. At the Anono mine, one crystal of rum mica was noted which had an outer zone of green mica. At the Palibatz no. 1 mine, the mica in the quartz core is lighter green than that in the enclosing quartz-feldspar pegmatite. In the pit below the Palibatz no. 1 mine, the mica, presumably in the same pegmatite, is zoned; it shows an inner light-green zone surrounded by an outer zone that is dark brownish green. Mica from the contact zone of this pegmatite is brownish green and forms crystals as much as 4 inches in diameter. At the Nueva Wellington mine the mica in a quartz lens near the pit is lighter green than that from the pegmatite in the pit.

PROPERTIES OF GUATEMALAN MUSCOVITE

Guatemalan muscovite has been marketed chiefly in the United States. Although formerly some of it was cut into washers and similar forms, the bulk of the material has been sold as sheet mica of various sizes.

The properties of mica have been well described by Sterrett (1923), Wierum (1938), Kesler and Olson (1942), and others, and only factors particularly affecting the value of Guatemalan mica are emphasized here. The properties of selected samples are tabulated in the following table.

Properties of certain Guatemalan micas [1]

[Symbols: F, fair; G, good; M, medium; P, poor; S, soft; H, hard]

Mine	Quality	Hardness	Flexibility	Color	Thickness (mm)	Power factor (percent) [2]				Remarks
						As received		After drying 6 hours at 300° F		
						100 kc	1000 kc	100 kc	1000 kc	
Tzitzil	Stained A	H	G	Light green	0.12	0.08	0.02	0.05	0.02	Slight ruling and few cracks.
Do	Good stained	H	G	do	.16	.02	.01			No imperfections; from center of same piece as preceding sample.
Do	Stained B	H	P	do	.08	.04	.02	.03	.02	Many hairline cracks.
Chacón	Stained A	S	F	Brownish green	.14	.03	.01			Wavy (slight brown line staining middle).
Paój	Stained B	M	G	Bottle green	.15	.04	.02	.03	.01	Slight "A" ruling.
Do	Good stained	M	F	do	.23	.01	<.01			Slight hairlining on sides.
Do	Red stained	M	F	do	.11	.03	.01			Light-red dotted; not flat.
Do	Good stained	M	F	do	.16	.02	<.01			
El Ciprés no. 1	do	M	G	Reddish rum to bottle green.	.20	.02	.00			From badly ruled "A" mica, under the apex.
Do	do	S	G	Colorless to bottle green.	.14	.01	.01			Do.
El Ciprés no. 2	do	M	F	Brownish green	.13	.22	.03	.05	.01	
Do	Stained A	M	P	do	.19	.22	.03	.12	.02	Much wedge and "A" structure; slight hairlining.
El Anono no. 1	Stained B	H	G	Rum	.19	.05	.02	.08	.03	No imperfections.[3]
Do	Good stained	H	G	do	.22	.01	.00			Do.[3]
Palibatz no. 1	do	S	P	Bottle green	.18	.05	<.01	.02	.01	Hairlines.
Do	Red stained	S	P	do	.17	.08	.02	.04	.01	Red stained, very light.
Palibatz no. 2	Good stained	M	F	Brownish green	.14	.06	.04	.18	.13	Some hairlines but not obvious.
Do	Stained A	M	F	Brown	.21	.02	.01			Light-brown spotted.
Do	Stained B	M	F	do	.23	.05	.02	.04	.01	Zoned coloring and organic staining.
Bergua no. 1	Stained A	H	G	Brownish rum	.17	.01	.00			Slight tendency to develop hairlines when cut.
Do	Good stained	H	G	do	.15	.00	.00			Do.
El Pérez no. 1	do	H	G	Rum	.17	.02	<.01			Zoned coloring.
Los Volcancillos	Stained B	M	G	Light green	.11	.02	.01			Tendency to develop hairlines.
Do	Good stained	M	G	do	.15	.02	<.01			No imperfections.
Santa Rosa	Stained B	F	F	do	.15	.12	.02	.03	<.01	Slight ruling.
El Jocote	Good stained	H	F	Light brown	.18	.04	<.01	.01	<.01	
Las Guayabas	do	H	F	do	.17	<.01	.00			No imperfections.

[1] Collection made and physical properties determined by Mr. Lawrence G. Houk.
[2] Determined by National Bureau of Standards.
[3] See table, p. 147.

Sprague fabrication tests by H. Brafman on good stained, stained A, stained B, and heavy-stained mica from El Anono no. 1 mine

Size	6, 5½, 5, 4
Color	Green brown to rum.
Splitting qualities	Good.
Dielectric strength	Do.
Power factor	Do.
"Q" qualifications:	
Good stained	About 2,500
Stained A	Do.
Stained B	Do.
Heavy stained, lower	About 2,000
Capacitor use:	
Good stained	Good.
Stained A	Do.
Stained B	Do.
Heavy stained	Too spotty, not recommended.

Cleavage.—The most important property of mica is its cleavage, which permits crystals of normal muscovite to be split into sheets of uniform thickness. For marketing, the sheets must be trimmed to eliminate marginal imperfections. In contrast to the smooth cleavage surfaces afforded by normal mica crystals, some incompletely developed crystals, called "A" mica, are commonly wedge shaped and irregular. Although some of these crystals have centers that yield flat mica, most of them must be discarded. A few Guatemalan deposits are made up entirely of "A" mica, but, fortunately, this variety is not of widespread occurrence.

Flexibility and elasticity.—For many electrical uses sheet mica must be flexible and elastic. Common flaws affecting these properties are extremely fine fractures called hairline cracks, which have random orientation. Mica from most Guatemalan deposits shows these flaws, and therefore may split poorly or be weak and brittle. However, hairline cracks are not present in all the mica crystals of a given deposit. Their cause is not definitely known but appears to be related to the growth of the crystals and not to later deformation.

Color.—Most deposits of Guatemalan mica contain green crystals ranging from pale to deep bottle green or brownish green. Deposits of white, rum, or ruby mica are much rarer. Nearly all the mica shipped thus far has been green.

Staining and inclusions.—Staining of either primary or secondary origin may impair the value of sheet mica. Primary mineral stains are generally spots or films of iron oxides between the sheets, whereas secondary stains are due to infiltration of clay in the weathered zone. Primary mineral stains are found in the mica from many Guatemalan deposits, but heavily stained mica is not common. Inclusions of quartz, feldspar, and epidote in mica crystals are found in several deposits. Of these minerals quartz is the most abundant and generally occurs in layers that range in thickness from a thin film to one-fourth inch. Mica containing inclusions is usually discarded.

Natural distortion.—Distortion of mica crystals resulting from rock movements causes bending and ruling. These effects are generally most pronounced near faults. Although faults of any considerable displacement are rare in the Guatemalan deposits, ruling and bending is present in some crystals from most deposits.

Power factor.—The power factor, or loss of electrical energy, in films of sheet mica used as the dielectric in condensers is expressed in percentage. A factor of 0.04 or less is usually required of mica for condensers. The power factors of Guatemalan micas that have been measured are generally low.

Water content.—Many Guatemalan micas when first quarried are quite soft because of water adsorbed between the sheets. The mica can be air dried or oven dried to remove the water, and it then becomes much harder. On cooling and standing, part of the water is again adsorbed, but the water content is lower than before. The origin of the adsorbed water is not clear. In part it may be water adsorbed during the rainy season.

Production of mica in Guatemala has been hampered by several conditions. One of the most important is that operators can market only sheet mica; they now have to discard material suitable for scrap and punch mica because of the high cost of transportation. Another is that no effective organization exists for properly preparing and marketing the mica, and skilled miners and trimmers are not available. Also, many restrictions are placed on the use of explosives in mining in Guatemala, making large-scale operations difficult. No quantitative data are available on the cost of producing mica in Guatemala, but from past experience it is inferred that mica prices will have to remain at a high level if mica is to be exported.

PACHALÚM DISTRICT

PALIBATZ MINES

The Palibatz mica mines (pl. 14), the most productive in Guatemala, have been credited with a yield of over 100,000 pounds of prepared sheet mica between 1918 and 1944. The mines, in the Departamento del Quiché, are the Palibatz no. 1, on a tributary of the Río Caquíl about 5 miles east of Joyabáj and 6 miles northwest of Pachalúm, and the Palibatz no. 2, nearly a mile southeast of the Palibatz no. 1 (pl. 13).

The deposits were first discovered about 1918 by Manuel Bergua and Ricardo Dubon. Mr. Bergua, with M. D. Heyman, Leon Campanolle, and others, began production from the mines in 1923 and continued until 1929. A small part of the mica was shipped to France and Germany, and the rest was shipped to the United States. The early shipments were of sheet mica, but later, when punching machinery had been installed, washers, circles, and iron-planchas also were shipped. Production was intermittent from 1929 to December 1940, when Manuel Bergua resumed operations and shipments until August 1944. The punching machinery is no longer in operation.

The mica from the Palibatz no. 1 mine is light bottle green. Although shipments from this deposit probably exceeded 60,000 pounds, the material was not of high quality because of its softness and hairline cracks. On the whole the mica splits well, but the sheets have only fair flexibility. The power factor of the mica as mined is high; however, that of the dried material is only 0.02–0.04 at 100 kilocycles.

The sizes cut from the mica from the no. 1 mine pit have varied from time to time, depending upon the size and imperfections of the books in different shoots. Some books that came from the south end of the pit were shipped as extra-special sizes as much as 5 feet in diameter, but the most common diameter was 8–18 inches. Recent work in the southwestern and northwestern parts of this pit have yielded books averaging 12 inches in diameter. A shipment made by Manuel Bergua had the size distribution shown in the table below.

Size distribution of sheet mica from the Palibatz no. 1 mine, Guatemala

Size [1]	Weight (pounds)	Percent of total weight
Special AA, A1	180	3.5
1	180	3.5
2	360	7.0
3	450	8.8
4	1,260	24.6
5, 5½, 6	2,700	52.6
Total	5,130	100.0

[1] Standard Indian grades (Houk, 1942, p. 10).

PALIBATZ NO. 1 MINE

The Palibatz no. 1 mine (pl. 14) has yielded the major part of the mica produced. The main pit and several shallow cuts explore a pegmatite striking northward and dipping steeply westward, nearly parallel to the foliation in the enclosing biotite-muscovite and garnet-andalusite schist and gneiss. Locally the pegmatite cuts the foliation and sends offshoots into the schist. The pegmatite has been explored in the main pit for 220 feet along the strike, for a width of 85 feet, and to a depth of 50 feet.

The pegmatite contains a footwall zone, a central quartz zone, and a hanging-wall zone. The footwall zone is feldspar intercrystallized with quartz and in graphic intergrowth with quartz. Mica is sparse in this zone and only one shoot has been mined (pl. 14, section *A—A′*).

This shoot was 4–5 feet wide by about 15 feet long and was in the pegmatite at its contact with the central zone. The central zone is a quartz lens, as much as 30 feet wide, which is parallel to the strike and dip of the pegmatite except in a zone in the north-central part of the pit. This lens is composed of massive white quartz and contains mica crystals of commercial size near its contacts with the enclosing pegmatite. When mining began, the quartz was exposed only in the northern part of the pit, but as the pegmatite was mined southward more quartz was exposed; when the pit was mapped the quartz lens was exposed for 140 feet.

The hanging-wall zone of intercrystallized coarse-grained quartz and feldspar contains the principal mica shoot, which was mined down the dip for 40 feet (80 feet below the surface). It ranged in width from 6 to 15 feet and was 40 feet long. In 1944 mica still showed in the face and bottom of the pit.

The feldspar in the pegmatite has been partly altered to clay minerals. This alteration is slight for the most part, but in the principal mica shoot much of the feldspar has been altered to soft clay minerals. As this alteration has no relation to the present surface, it is presumably related to the late-stage hydrothermal activity that introduced the mineral layers found in the mica books. Although the mica does not appear to have been much affected by this alteration, the softness and high water content may have been partly caused by it.

The mica shoot mined in the southern part of the pit, near the portal of the adit, yielded books more than 5 feet in diameter. This shoot was mined to a depth of 40 feet, where there was still some mica in sight in 1944. Work done since 1943, when plate 14 was mapped, has penetrated 25 feet below the workings in the southwestern corner of the pit, where mica books 8–14 inches in diameter are still exposed on the walls of the stope.

The mica shoot mined in the footwall of the quartz vein was narrow, ranging in width from 2 to 8 feet, but it had a total length of more than 60 feet. At the face of the pit the shoot was cut off by the quartz vein.

Mica continues into the shallow upper part of the pit, and stoping operations in 1944 deepened the pit about 10 feet more at the mica pocket shown in plate 14. Although the mica books averaged less than a foot in diameter, the material was relatively free from "A" and wedge structure and yielded a fair percentage of sheet mica.

At the south end of the pit the pegmatite narrows abruptly and may pinch out entirely. However, exposures south of the dump, on the slope 250 feet from the pit, show a pegmatite outcrop 30 feet wide, and a shallow cut 60 feet long and 6–8 feet wide explores a mica shoot on the hanging-wall side of this pegmatite. The mica in this cut is zoned; the crystals commonly show a light-green center zone 2–4 inches in diameter, parallel to the prism, surrounded by an outer zone of brownish-green mica. The crystals range in diameter from 1 to 12 inches and average 4 or 5 inches. Small crystals on the contacts of the pegmatite are greenish brown throughout. Although the mica in this cut is locally ruled and clay stained, it is fairly hard and splits well. It is of better quality than the light-green mica from the main pit, and further exploration may be warranted in the area south of the dump.

PALIBATZ NO. 2 MINE

The Palibatz no. 2 mine is nearly a mile east of the no. 1 mine and is reached by a steep trail (pl. 13). Mica was first discovered here in 1918, and sporadic attempts have been made to exploit the property. The property was idle from 1926 until 1942, when Manuel Bergua reopened the workings and mined mica from the north and south pits.

The workings (pl. 14), 3 open pits and several shallow cuts, explore a pegmatite sill striking nearly north and dipping 65°–75° W. in mica schist. Locally the contact follows the foliation of the schist, but more commonly it cuts the foliation. The mica zone is along the hanging wall of the pegmatite and is commonly confined to a zone 10 feet or less in width. The feldspar is commonly white, but pink areas were seen in the south pit. Graphic intergrowth with quartz is common. Epidote crystals a few inches to 2 feet long are abundant in the north pit, particularly in the zone 5–15 feet from the contact.

The mica is greenish brown and of medium hardness, and it splits well. It is superior in physical characteristics to the mica from the no. 1 mine pit, except that its power factor is high.

The north pit, 160 feet long, as much as 35 feet wide, and 30 feet deep, follows the hanging-wall contact of the pegmatite. Mica books 6–14 inches in diameter are erratically distributed along the contact. The mica is most abundant at the north end of the pit, but even here it does not make up more than 5 percent of the rock.

The central pit is 100 feet long but shows pegmatite for only 25 feet. The mica books are as much as 14 inches in diameter; they are wavy and ruled, however, so that none of them can be used for sheet mica. Many mica books contain films of quartz and chalcedony between the leaves. Epidote crystals as much as 14 inches long were noted in the walls of the pit.

The south pit is 80 feet long, as much as 50 feet wide, and its deepest part is about 50 feet below the surface. The pegmatite dike here is partly concordant and partly discordant with the foliation of the enclosing rocks (pl. 14, section *A–A′*). The mica shoot was about 60 feet long and 5–15 feet wide. The books ranged from 4 to 12 inches in diameter, and although the mica was of good quality the yield was not high.

EL ANONO NO. 1 MINE

The El Anono no. 1 mine is 2½ miles northeast of Pachalúm and 5 miles east of Joyabáj (pl. 13). The property was explored from 1925 to 1928 by Manuel Bergua, who produced three or four hundred pounds of mica during these years. No mica was produced from 1928 to 1942. During 1943 and until May 1944, Augusto Poitevín and associates resumed exploration and deepened the pit to determine the quality of the available mica. Work was continued slowly; about 200 pounds of sheet mica was produced and sold in the United States. As mining costs were high and the books yielded only small sizes, the operation was not successful.

The mine pit is 120 feet long, as much as 50 feet wide, and 65 feet deep (pl. 14). The pit explores a pegmatite zone about 40 feet wide which strikes north to N. 15° W. and is nearly vertical. The zone contains interfingered lenses of schist and pegmatite, and schist inclusions in the pegmatite have been feldspathized laterally from the feldspar veins.

In the south end of the pit the pegmatite zone is 12–15 feet wide and consists of 2 veins separated by a band of feldspathized schist. The pegmatite vein on the west contains a medial band of badly ruled and crushed mica 4–18 inches thick. The east vein is composed of coarse-grained white perthitic feldspar with sparse irregularly distributed mica books 6–8 inches in diameter and some smaller broken books.

At the north end of the pit the mica books are as much as 14 inches in diameter but are somewhat fractured and locally replaced by quartz and feldspar. Some books are almost entirely replaced, leaving oriented relicts of mica in the rocks; presumably the late solutions bearing quartz and feldspar came in along fracture zones and permeated the fractured areas. The mica books are irregularly distributed in small pockets and streaks in the pegmatite. Some hairline cracks are present in the mica, but "A" structure and ruling are not common.

EL ANONO NO. 2 MINE

The El Anono no. 2 mine (pl. 13), about 500 feet south of the El Anono 1, is at an altitude of about 4,250 feet. A trench 30 feet long and 20 feet wide, with an adit 8 feet long at the south end, explores a pegmatite 8–15 feet thick extending parallel to the foliation in mica schist, which strikes N. 15° W. and dips 30° E. The pegmatite is mainly intergrown quartz and feldspar cut by veins and masses of quartz as much as 8 inches wide; the feldspar has been kaolinized. Brownish-green mica occurs in irregular pockets and is disseminated throughout the pegmatite. Most of the books are less than 4 inches in diameter, and although the mica contains little clay and iron oxide, much of it shows wedge structure, so that only a small percentage of it can be used. The deposit does not appear promising.

XEABAJ MINE

The Xeabaj mine (pl. 13) is 3½ miles north of Caquíl, Departamento de Baja Verapaz, at an elevation of 5,950 feet. It was explored by Augusto Poitevín and his associates in April 1944 and produced 255 pounds of mica. The workings explore a pegmatite sill, which cuts mica schist that strikes northward and dips steeply westward; it appears to be parallel to the foliation. The pegmatite is as much as 50 feet wide where exposed in the pit. It is composed of intergrown quartz and feldspar; the feldspar has been completely altered to soft clay minerals, presumably by late hydrothermal solutions.

The mica is light green and forms books from 4 inches to as much as 3 feet in diameter, the average diameter being about 1 foot. Most of the books are enclosed in the quartz masses, but some are in the adjacent quartz-feldspar rock. The principal mica shoot is on the west side of the pit, near the contact of the quartz and the hanging-wall schist. The shoot has been explored for a length of 30 feet and is as much as 15 feet wide. Shearing in the quartz along the hanging wall has caused ruling, bending, and fracturing in the mica. Many of the mica books show "A" structure, in spite of which they yield small sheets of good mica. Although the mica is unevenly distributed, the face at the time of visit showed 6–10 percent mica. The size distribution of sheet mica from the pegmatite is shown in the table below. Production at the time of visit (1943) was at the rate of 500 pounds of sheet mica a month, but because of the difficulty in marketing the mica the mine was closed in 1944.

Size distribution of sheet mica from the Xeabaj mine, Guatemala

Size [1]	Weight (pounds)	Percent of total weight
Extra special	5	2.0
A1	6.2	2.4
1	10.3	4.0
2	16	6.3
3	24	9.4
4	47.3	18 5
5	84.5	33.0
5½	33.6	13.2
6	28.7	11.2
Total	255.6	100.0

[1] Standard Indian grades (Houk, 1942, p. 10).

EL CIPRÉS NO. 1 MINE

The El Ciprés no. 1 mine (pl. 13) is half a mile northwest of the El Anono no. 1 property, at an altitude of 4,600 feet. This mine was first explored during the 1920's by Manuel Bergua, who mined and shipped mica from several pockets. In 1943 the property was acquired by Augusto Poitevín and his associates, who did further exploratory work but made no shipments.

The pegmatite zone is 225 feet wide and contains 2 pegmatites. The principal pegmatite is 100 feet wide and parallels the foliation in the enclosing garnet-mica schist, which strikes N. 80° W. and dips 65° S. The pegmatite is mainly intermingled quartz and feldspar, but near the center it contains a quartz core about 20 feet wide that dips 50° S.

The mica is light green; the books are 2–14 inches in diameter and average about 8 inches. Much of the mica shows "A" structure and is iron stained in places. Mica shoots were mined on both sides of the quartz; the hanging-wall shoot was as much as 6 feet wide and 25 feet long, and the other comprised a series of irregular pockets. Mica made up 5–10 percent of the rock in the shoots, but amounted to only about 1 percent of the pegmatite as a whole.

Another pegmatite-quartz sill 10–18 feet wide is 75 feet west of the principal pegmatite. This sill shows mica in a shoot 2–6 feet wide, striking N. 60° W. and dipping 45° SW., parallel to the foliation of the enclosing schist. Part of the mica is in the quartz and part is in the pegmatite. The shoot has been opened for a length of about 60 feet.

EL CIPRÉS NO. 2 PROSPECT

The El Ciprés no. 2 prospect (pl. 13) is half a mile west of Pachalúm, Departamento de El Quiché, at an altitude of 4,000 feet. The pegmatite is explored by a cut 40 feet long and as much as 25 feet wide on land owned by Candelario Roca. No mica has been shipped from this mine.

The pegmatite exposed is 20 feet thick and parallels the foliation in the enclosing biotite schist, which strikes N. 50° W. and dips 40° SW. It is chiefly feldspar but also contains quartz masses as much as 3 feet wide and 10 feet long extending parallel to the strike. The mica is brownish green and occurs in books, 4–30 inches in diameter, which are for the most part associated with the quartz masses and contain quartz and some feldspar films between the leaves. Some books are replaced by quartz along their borders. Many of them are ruled and fractured and in some the mica is wavy. The mica is soft, and locally it is heavily stained with iron oxides; in some there is "A" structure. It is doubtful whether the deposit will yield commercial mica.

LOS VOLCANCILLOS PROSPECT

The Los Volcancillos prospect (pl. 13) is 2½ miles southwest of Pachalúm, at an altitude of 3,500 feet. The workings are 2 shallow cuts, 35 and 15 feet long, which explore 2 pegmatites 4–12 feet wide composed chiefly of massive feldspar and graphic granite. The pegmatites are parallel to the foliation in mica schist, which strikes N. 30° W. and dips 80° SW. The mica books are bottle green and as much as 18 inches in diameter, averaging about 8 inches. Most of the books are badly ruled and are stained with clay and iron oxides; in places they are sericitized and replaced by quartz. None of the mica seems to be of commercial grade.

SANTA ROSA PROSPECT

The Santa Rosa prospect (pl. 13) is about 800 feet west of Pachalúm, on land owned by Rosalío Estrada. A pegmatite dike of altered feldspar is explored in a shallow cut 12 feet long by 4 feet wide which was dug by Augusto Poitevín and his associates. Bottle-green mica occurs in books averaging 3 inches in diameter. Much of it is wedge shaped and has hairline cracks.

EL JOCOTE PROSPECT

The El Jocote prospect (pl. 13) is half a mile east of Pachalúm, on land owned by Simíon Elías. A pit 20 feet square and 8 feet deep was excavated by Augusto Poitevín and associates.

The pit explores a pegmatite, in altered gneiss, that contains sparse books of brownish-green mica that is heavy-stained to black-stained grade. Some books are a foot in diameter but have "A" structure imperfections and are ruled. The rest of them are small, averaging 2 inches in diameter, and it is doubtful whether they will yield other than sizes 6 and 7.

TZITZIL PROSPECT

The Tzitzil prospect (pl. 13) is on the Río Tzitzil, at an altitude of 5,350 feet. A pegmatite body, about 50 feet wide, can be traced for 500 feet along the strike. The pegmatite parallels the foliation in garnet-andalusite schist that strikes N. 75° W. and dips 65°–80° NE. Much of the body is concealed by vegetation and soil. Smaller pegmatite bodies are exposed nearby. A few shallow cuts have been dug, but no mica has been mined.

The mica is light green, forms books as much as 2 feet in diameter, and in places constitutes 2–5 percent of the rock. Most of the books are ruled and are stained with iron and vegetable matter. In places, thin quartz and feldspar layers appear between the sheets of mica and render the books useless. However, the mica is hard and flexible, and despite the low percentage of commercial mica in the outcrops and the cuts, further exploration of this deposit may be warranted.

SECHÚN PROSPECT

The Sechún prospect is a half mile northeast of El Pericón, at an altitude of 4,150 feet, on the land of Juan Mulal. The property was explored in 1943 by Manuel Bergua, but no mica was shipped.

The mica is in a pegmatite that parallels the foliation in garnet-mica schist and interbedded limestone striking N. 50° W. and dipping 50°–70° SW. The pegmatite consists of quartz and feldspar and is exposed for a length of 50 feet and for a width of about 20 feet. The mica is light green and forms books 2–8 inches in diameter. Some of the books are ruled and wavy, and others have inclusions of quartz and feldspar.

TALAXCÓC PROSPECT

The Talaxcóc prospect (pl. 13) is a half mile east of El Pericón, at an altitude of 4,800 feet, on the land of Pablo Quiroga.

A pegmatite sill, 10 feet wide, follows the foliation in mica schist for about 250 feet. The foliation strikes N. 55° W. and dips 50° SW. A few lenses 2–5 feet long contain books of rum-colored mica 2–6 inches in diameter. Most of the books are stained with iron oxides and some have "A" structure.

LOS TABLONES PROSPECT

The Los Tablones prospect is 1 mile southwest of the town of Volcancillos at an altitude of 3,400 feet. The prospect was explored by Augusto Poitevín and his associates in 1943, but no mica was produced.

Mica schist, striking N. 55° E. and dipping 40°–70° NW., is the wall rock of a pegmatite sill 30 feet wide than can be traced for 200 feet along the strike. The mica is light greenish brown and forms books, as much as 8 inches in diameter, which occur sporadically throughout the pegmatite. As most of the books are stained black and red and are wavy, the prospect does not appear promising.

QUIACÓJ PROSPECT

The Quiacój prospect (pl. 13) is just south of the Río Pasaguay, at an altitude of 4,650 feet. A cut 50 feet long and 10 feet wide which exposes pegmatite was dug by Manuel Bergua in 1943. No mica was shipped.

The pegmatite is chiefly feldspar with masses and lenses of quartz. It follows the foliation in mica schist striking N. 30° W. and dipping 35°–60° SW. At the cut the pegmatite is about 40 feet wide, and it can be traced for 100 feet in both directions along the strike. The mica is dark green and forms books as much as 12 inches in diameter, averaging about 6 inches. Much of the mica is heavily stained and shows ruling and some "A" structure. At the north end of the cut the mica has been sheared by a fault striking N. 70° E. and dipping 65° SE.

AGUA CALIENTE DISTRICT

The Agua Caliente district lies north of the village of Granadas, which is on the Cobán-Guatemala City highway. The mines (pls. 13, 15) can be reached by a trail that leaves the highway at the 80-kilometer post and continues up the valley of the Río Agua Caliente.

LA ADILIA MINE

The La Adilia mine is 3 miles southwest of El Chol, at an altitude of 3,700 feet (pl. 13). The workings (pl. 15), two groups of pits, are on a ridge south of the Río Agua Tibia. The property was worked intermittently during the 1920's and early 1930's but has since been idle. Eduardo Aparicio held the exploitation license in 1945.

The west group of workings consists of 2 opencuts, the main one of which is 400 feet long and explores a pegmatite of irregular shape enclosed in mica-feldspar schist striking northwestward and dipping steeply. The pegmatite, exposed over a width of 40 feet, is composed of an outer zone of feldspar and quartz and an inner core of quartz. The quartz core is as much as 17 feet wide and is exposed for 85 feet along the side of the opencut. The pegmatite on the east side of the quartz ranges in width from 4 feet to more than 15 feet and is the host rock for the mica that has been mined. The pegmatite narrows and pinches out at the south end of the cut but appears to widen at the north end. Most of the slope west of the cut is covered with soil, and the pegmatite can be seen only in the haulage portal. The principal mica shoot was mined from the pegmatite and adjacent quartz vein. The shoot was 80 feet long and as much as 20 feet wide and was mined to a depth of 40 feet in the southern part. Although the mica zone was not exposed in 1943 because the pit was caved, commercial mica is reported to occur at depth. Judging from reports, and exposures in the walls of the pit, the books were 6 inches to 2 feet or more in diameter and averaged about 12 inches.

The east workings are 4 shallow pits, which explore a pegmatite adjacent to 2 quartz lenses. The workings north of the main pit are partly caved and do not show any good mica.

The main pit, 45 feet long and 30 feet wide, shows a pegmatite striking northeastward and dipping gently northwestward that cuts mica and hornblende schist in which the foliation strikes northwestward and dips steeply southwestward. The pegmatite has yielded mica near the hanging wall from a shoot that is now covered with waste. Mica in pegmatite in the pit south of the main pit is of low grade.

LA CONSTANCIA MINE

The La Constancia mine is 2½ miles southwest of El Chol, on the land of Pedro Galiano (pl. 13). Arthur W. Chellis worked this mine in 1918 and for a few years afterward, and during the late 1920's it was exploited successively by R. A. Loomis, Sr. Bustamante, Juan Ureve, Juan Fricke, and Otto Tischler. The last shipments were made in 1929.

The workings (pl. 15) are in a flat-lying pegmatite that cuts mica schist, which strikes northwestward to westward and dips steeply southward. The pegmatite is exposed in the workings for a length of 350 feet, and outcrops to the east and west indicate that its length is about 2,000 feet. As the workings are on a terrace, the schist hanging-wall zone is thin, ranging from a foot or less on the south side of the pit to 6 feet on the north and east sides.

The mica is greenish brown for the most part, but some books in quartz are light green. The books are 2 to 18 inches in diameter and have yielded mica predominantly of sizes 3 to 6. The mica splits well but is soft, and hence it is suitable principally for electrical uses.

LA VIRGINIA MINE

The La Virginia property is a mile west of the La Constancia workings (pl. 13). Although the deposits have been known for many years, no mica has been produced from them. In June 1944 Eduardo Aparicio and José Montúfar began exploration on one of them.

The workings (pl. 15) comprise several shallow cuts in bodies of pegmatite and quartz whose form is not known, but the foliation of the enclosing schist strikes westward and dips southward 45°–70°, and presumably the pegmatite cuts the foliation. One of the quartz lenses trends northeastward and the other northward, crossing both the foliation and the pegmatite.

Exploratory work has revealed mica in the pegmatite along the quartz masses, and the most promising cut is adjacent to the quartz lens trending northeastward. There the pegmatite has been explored for 40 feet along the strike and for a width of 30 feet. The mica is brownish green and somewhat stained with clay and iron oxides at the surface; the books average about 12 inches in diameter. Ruling and "A" structure are present in places, and only a little good mica can be recovered. Not enough work has been done to determine the percentage of recoverable sheet mica.

LA ESPERANZA MINE

The La Esperanza mine is 2½ miles northwest of Granadas (pl. 13), on land owned by Tiburcio Xetumul, at an altitude of 4,600 feet. The mine was first operated in 1919 by Arthur W. Chellis and Adolfo Benz. Mica was shipped between 1919 and 1923; the exact production is not known. There was no activity from 1923 to 1942, and between 1942 and 1944 Adolfo Benz h. reopened the pit but produced no mica.

The mica is in a feldspar-quartz pegmatite as much as 75 feet wide which lies between a massive quartz vein and mica schist (pl. 15). On the west the pegmatite is locally faulted along the contact. The mica shoot is on the southwest side of the pegmatite, and where exposed in the workings it is 3 feet wide and 10 feet long. Near the fault the mica is ruled, but elsewhere there is little ruling. The mica is greenish brown and on the whole splits well. As only a few books were exposed in the pit, the average size is not known. Since a fair production is reported from this property, it seems reasonable that further work will yield electrical mica of marketable sizes. However, any future exploration will have to be underground.

NUEVA WELLINGTON MINE

The Nueva Wellington mine (pl. 13) is about 500 feet north of the La Esperanza mine, in the same pegmatite zone. The workings consist of an open pit 30 feet deep and several opencuts (pl. 15). The property was worked at the same time as the La Esperanza and by the same operators, and it has a similar history. In 1943 Adolfo Benz h. mined some mica from the pits but no shipments were made.

The pegmatite at the Nueva Wellington is in mica schist, which strikes northwestward and dips steeply southwestward. The pegmatite occupied nearly the whole of the main pit, but it narrowed downward, and what remains is now largely covered by waste rock in the bottom of the pit. At the south end of the pit the pegmatite is reported to have split, one tongue going westward and the other southward toward the quartz vein.

The mica from the pit is green. The books are heavily clay stained and, in places, heavily mineral stained. Exploration in 1943 had not reached unaltered pegmatite, so the quality of the mica at depth was not known. The books are as much as 2 feet in diameter, and where not clay stained have yielded mica of fair quality. The hardness is fair, but some books split poorly.

LA CABRERA MINE

The La Cabrera property is about 2½ miles northwest of the Nueva Wellington mine (pl. 13). Adolfo Benz h. explored the property in 1943, and from a cut 40 feet long and 6 feet wide recovered 800 pounds of book mica, which yielded 245 pounds of sheet mica.

The pegmatite is parallel to the foliation in the enclosing schist, striking N. 45° W. and dipping 40°–50° SW. The pit was filled in 1944, but judging from specimens on the dump some of the mica appears to have been ruled and bent. The mica is dark brownish green and is reported to average 12 inches in diameter; some books are as much as 18 inches across. Clay staining was noted in the surficial mica.

About 400 feet to the northeast a shallow cut exposes another pegmatite, which is 12 feet wide and 30 feet long. There are only scattered books of mica in the cut; the crystals seen were dark brownish green, fairly hard, and easy to split.

LIBERTAD AND MARGARETA PROSPECTS

The Libertad and Margareta prospects (pl. 13) are about 3½ miles northeast of San Rafael Saltán, on land owned by Domingo Soto and Luis Ortega. The workings consist of several shallow cuts in pegmatites, which crop out for a distance of 1,500 feet along a ridge trending northward, at an altitude of 4,750 feet on the south and about 4,900 feet on the north. In 1942, Emilio Estrada and Domingo Soto began to explore the deposits. In 1943 Augusto Poitevín continued exploratory work and made a shipment of 134 pounds of mica to be used for samples.

The pegmatite bodies appear to be sill-like and crop out in areas as much as 300 feet long by 60 feet wide. Forest cover and heavy soil prevent exact determinations of their size, but at the north end of the Libertad area 1 pegmatite body appeared to be about 100 feet thick. The pegmatites are chiefly feldspar with a little quartz. In places the feldspar is altered to clay minerals. The wall rock is chiefly hornblende schist and mica schist, which in this area strike N. 35°–70° W. and commonly dip northeastward.

The mica is rum colored and forms books that average 5 inches in diameter, with a maximum of 16 inches. It is sparsely distributed throughout most of the pegmatite but forms at least 1 shoot 40 feet long and 5 feet wide. Considerable clay and iron staining, ruling, wavy structure, and some wedge structure are present.

A shallow pit nearby may be in a pegmatite that is a continuation of those in the Libertad-Margareta group. The pegmatite contains a little rum mica, which is stained and shows hairline cracks.

EL PÉREZ NO. 1 MINE

The El Pérez mine (pl. 13) is 2 miles south of Saltán, on land owned by Flavio Elías. An opencut 8 feet wide by 12 feet long explores a quartz-feldspar pegmatite 3 feet wide in garnet schist. The rock contains about 1 percent white to light-green mica in books averaging 2 inches in diameter. The mica is stained, of "A" type, and principally size 6. In 1943 between 200 and 300 pounds of marketable material was produced.

EL PINO PROSPECT

The El Pino prospect (pl. 13) is 5 miles northeast of Saltán, on the land of the Elías brothers. Three shallow pits put down by Augusto Poitevín and his associates explore a soft altered pegmatite 8–20 feet wide, which crops out for 150 feet along its N. 25° W. trend. Rum-colored mica makes up as much as 7 percent of the rock. However, the crystals average only 4 inches in diameter and some of them are wavy and show ruling.

QUARTZ DEPOSITS

GUATEMALA

Deposits of quartz crystals in Central America have been exploited only in Guatemala. Although production has been small, the deposits are widely distributed throughout central Guatemala, chiefly in the Departamento de Baja Verapaz and Departamento del Quiché. The principal producing areas (fig. 14) are near the villages of Rabinal, Cubulco, and El Chol (L. G. Houk, 1943, unpublished report). Deposits are also found in the Departamento de Progreso, but only two have been in production.

Quartz mining first began in Guatemala in 1941, when some usable material was found in uncobbed crystals shipped to the United States on consignment, in response to the increased demand for quartz oscillator plates at the beginning of World War II. Early shipments to the United States brought little return because the material was of low grade and specifications at that time were high. Later, however, with lowered specifications and increased prices, quartz-crystal mining became profitable, and several producers operated properties during 1943 and 1944. Their product was purchased directly in Guate-

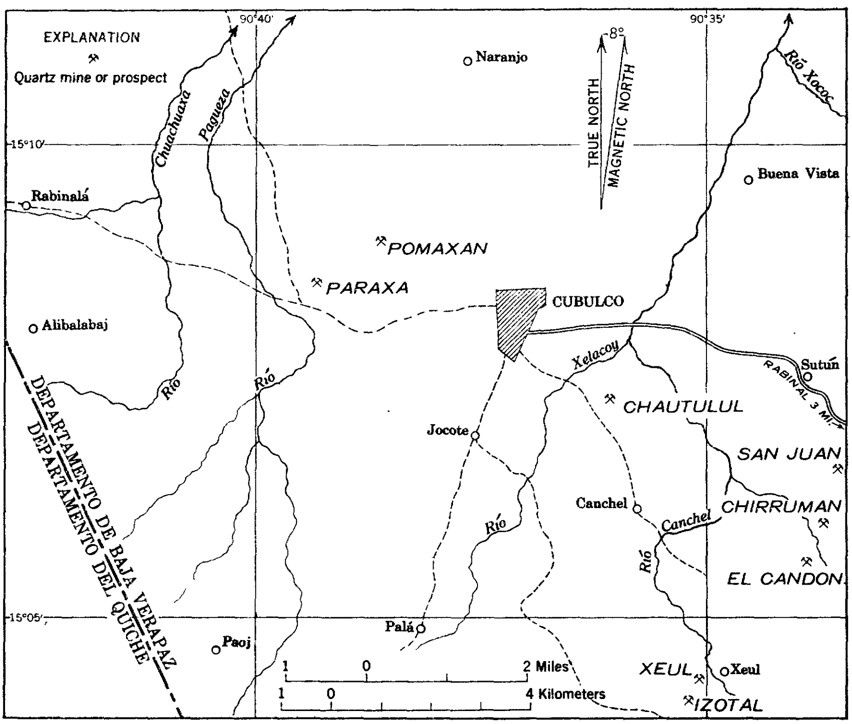

FIGURE 14.—Map of Cubulco, Guatemala, showing location of the quartz mines.

mala by the Foreign Economic Administration; production ceased early in 1945 when this program was discontinued.

The following table summarizes the production of radio quartz of grades 1, 2, and 3 in Guatemala from 1941 to 1944.

Radio-quality quartz produced in Guatemala, 1941–44 [1]

Year	Mine	Weight (pounds) by grade [2] [3]			Value [4] (dollars)
		1	2	3	
1941	Toloxcoco		8.17	13.04	142.61
1943	do	37.52	7.49	41.42	595.29
Do	Chipacapox			28.69	212.48
Do	El Chol (Santa Lucía)		6.75	166.66	381.32
Do	Xeul [5]	17.38	135.09	117.30	[6] 1,339.99
1944	do	5.22	72.93	11.23	539.92
Do	El Chol (Santa Lucía)	2.62	37.27	5.21	301.17
Do	Los Limones	13.56	187.41	36.62	1,635.38
Do	Los Cimientos	25.05	8.89		125.64
Do	Chinique	.50	7.77	9.16	37.16
	Total	101.85	471.77	429.33	5,310.96

[1] Data taken from Foreign Economic Administration reports.
[2] Grading was based on the following percentages of usable material: grade 1, more than 65 percent usable; grade 2, 40–65 percent usable, grade 3, 25–40 percent usable.
[3] Average weight of cobbed fragments was about 1.2 pounds each.
[4] Average price per pound was $5.29.
[5] Also includes some quartz from the Izotál, Rabinalá, and Dolores properties.
[6] Based largely on grading done in Guatemala City by the Foreign Economic Administration, which averaged about 2.0 percent higher than that graded by the National Bureau of Standards. Payment was on the basis of the grading by the Foreign Economic Administration.

GEOLOGY

The quartz deposits occur as veins and lenses in the pre-Permian belt of metamorphic rocks that make up central Guatemala. The wall rocks are garnet-mica schist and gneiss, hornblende schist, marble, and andalusite schist, which in places have been intruded by granitic rocks. A zone of pegmatite and aplite dikes extends southward and westward from the granite west of Cerro Tuncaj; the zone may be related to the granite. Quartz veins, some enclosing rutile crystals, are found with the pegmatites, but none of these veins have yielded commercial quartz crystals.

The quartz deposits are chiefly glassy crystalline quartz, which is commonly anhedral and is rarely euhedral. The euhedral crystals generally occur in vugs, but some are in veins whose crystals are arranged in parallel comb structure. Other crystals are isolated in altered wall rock.

Some of the anhedral crystalline quartz of the massive deposits is clear enough to furnish radio-quality material; however, much of it is worthless because of inclusions or fractures. The vugs in the massive quartz contain euhedral crystals weighing as much as 400 pounds apiece, but the largest crystal of commercial grade that was shipped weighed 52 pounds. Commonly the basal part of a crystal is milky or contains inclusions, and only the upper part yields radio-quality material.

Most of the Guatemalan quartz is colorless or milky white. Some smoky quartz was found at the Izotal deposit, and a little amethystine quartz is reported from a deposit near Rabinal. The amethyst is not of gem quality.

Most of the quartz deposits that have been mined are lenticular veins, but some are irregular masses and a few are veins of fairly regular thickness. The quartz fills fractures in the enclosing rock and to some extent replaces the rock adjacent to the fractures.

Although locally the veins follow the foliation, most of them cut across it. At the Toloxcoco mine (pl. 16) the quartz lenses cut the foliation and are distributed in echelon, which indicates that they may fill tensional gash fractures. The irregular masses generally occur at the intersections of fractures or fracture systems.

The euhedral quartz crystals are generally well developed hexagonal prisms with pyramidal terminations, and some show trapezohedral and rhombohedral faces. The ratio of diameter to length differs from one deposit to another; at Toloxcoco the average is about 1:4.

The accessory minerals that accompany the quartz veins include rutile, chlorite, orthoclase, plagioclase, ilmenite, and pyrite. The rutile forms prisms as much as 4 inches long, and also slender needles; most of the larger crystals are embedded in fine-grained quartz, whereas the needles are generally enclosed in quartz crystals. Ilmenite accompanies rutile in some veins. Chlorite is found as an alteration product of the hornblende and biotite in schist wall rock adjacent to veins and also as inclusions in the quartz crystals. Orthoclase and plagioclase are found locally in quartz veins; they may be intergrown with the quartz or may form euhedral crystals that lie between quartz crystals or coat the faces of quartz crystals in drusy cavities. Pyrite is a constituent of a few veins, especially at Los Limones.

Few of the quartz crystals found in Guatemala are perfect and clear. The imperfections that affect the value of the quartz are inclusions, minute fractures, and twinning. Some crystals are milky, owing to bubbles and clouds of inclusions. Stages in the growth of some crystals are marked by alinement of inclusions and vacuoles. Crystals from Toloxcoco contain chlorite inclusions alined parallel to former faces in the interior of the crystals. Hard blue needles of a mineral thought to be rutile are found in some crystals but are relatively rare. Besides the distinct fracturing found in nearly all deposits, the quartz from deposits at Santa Lucía, Los Limones, and Chinique shows minute fractures. Pieces as mined are clear and appear sound, but when cobbed they break with a hackly rather than conchoidal fracture;

the fracture surface is ruled by a rectangular network of fine grooves and ridges, probably caused by the intersection of minute fractures and conchoidal fracture surfaces. Some crystals disintegrate when struck lightly with a hammer, breaking into irregularly shaped fragments and slivers. In addition to the minute fractures, crystals from many deposits contain more marked fractures that cause the quartz to break when they are being cobbed; the fragments are too small for commercial use. Some crystals do not develop fractures when cobbed, but when sawed they may disintegrate and be worthless for radio work. Such crystals when placed in an oil bath and viewed under a strong light in a dark field show numerous fine parallel lines, which on rotating the crystal reflect light and prove to be minute fractures. Extremely fine fractures show hazy reflected light, similar to that shown by the blue needles, and it may not always be possible to determine which of the two is present.

Although twinning is not common in Guatemalan quartz, some crystals and parts of crystals are twinned, either optically or electrically. Optical twins, when placed in an oil bath and viewed in polarized light along the *c* axis, appear as triangular areas bounded by straight lines. Electrically twinned crystals show irregular boundaries when viewed the same way.

EL CHOL AREA

The Santa Lucía, Los Limones, and several small prospects in this area have yielded radio-quality quartz.

SANTA LUCÍA MINE

The Santa Lucía mine is half a mile east of El Chol, Departamento de Baja Verapaz, at an altitude of 3,700 feet (pl. 16). Two pits that explore quartz veins trending northwestward have yielded about 175 pounds of radio-quality quartz, mostly grade 3. The quartz shows minute fractures, bubbles, and random inclusions of chlorite. Production began in 1943, when Carlos Guzmán, of Guatemala City, opened the mine. Shipments ceased when the easily excavated material was quarried and it was learned that much of the quartz was not of radio quality because of minute fractures. The workings are in biotite schist; here the schist has been cut by small dikes of pegmatite and aplite.

Pit 1 yielded about 85 pounds of quartz from a pocket separate from the main zone, which is in the northwest corner of the pit. The face of the cut in 1944 showed branching veins of milky quartz along fractures in the schist. The veins are narrow and much fractured. Exploration along the strike of the float zone to the southeast was not promising.

Two quartz veins in pit 2 trend northwestward and dip steeply southwestward. Pit 2 yielded about 90 pounds of usable quartz at the junction of 2 veins, which were covered with debris in 1944. The crystals were embedded in brownish clay formed by alteration of the biotite schist wall rock.

LOS LIMONES MINE

The Los Limones quartz mine is 3½ miles southeast of El Chol, on the land of Agustín Córdoba (pl. 16). Carlos Guzmán explored this deposit in 1944 and shipped about 220 pounds of radio-quality quartz from a pit 40 feet long and 6–10 feet deep. The quartz was found in two oval-shaped pockets; the larger one was in the northwest corner of the pit.

The bedrock in the area consists of hornblende-mica schist which for the most part strikes northwestward and dips steeply southwestward. Near the quartz pockets and between them, the schist is altered to a reddish-brown clay. The quartz pocket has an outer zone of milky quartz and an inner core of euhedral crystals with some clear areas. One exceptional crystal weighed 52 pounds and was valued at $589. The quartz was mostly of grade 2. Some of it showed minute fractures and had to be discarded.

On the southeast side of the pit a quartz vein about 4 feet thick is exposed. The vein and the adjoining pocket is of milky quartz, and milky-quartz float continues north of the pit for 350 feet. Specimens collected on the surface showed muscovite crystals, as much as an inch in diameter, and a little ilmenite and rutile.

TRAPICHE VIEJO MINE

The Trapiche Viejo quartz mine is on the Río San Pedro, 5½ miles southwest of El Chol, at an altitude of 2,900 feet. The deposit was explored in 1944 by Carlos Guzmán, who opened a cut 50 feet long by 25 feet deep, in the face of which the vein is exposed. About 75 pounds of commercial quartz was produced from the property.

The vein strikes N. 15° E. and dips 80°–85° NW. in hornblende schist whose foliation strikes N. 80° E. and dips 40° SE. The vein is 2½–7 feet wide and has been sheared and broken by faulting. The quartz is for the most part milky or cloudy, but some crystals with clear areas have been found.

At Las Jobas, a mile west of Trapiche Viejo, a deposit of quartz crystals is said to have been found, but it had not been explored.

LOS AMATES DEPOSIT

The Los Amates quartz deposit is 3½ miles northeast of El Chol, at an altitude of 4,200 feet. At this place a quartz vein, judged from float on the slope to be about 10 feet wide, is poorly exposed in a cornfield. The quartz is milky but contains cavities lined with small clear crystals, none of which were large enough for commercial use. However, light-green muscovite crystals 1–6 inches in diameter are sporadically distributed throughout the quartz, and their presence indicates that the vein is a pegmatite.

RABINAL AREA

TOLOXCOCO MINE

The Toloxcoco deposit is near the village of Chirrúm, 7 miles southwest of Rabinal, Departamento de Baja Verapaz. The workings (pl. 16) are at an altitude of 4,500 feet on the slope of a hill known locally as Cumatzá. The deposit was worked intermittently from 1941 to 1944. The first shipment of Guatemalan quartz came from this deposit; it was made by Toriello Brothers, of Guatamala City, which sent a 500-pound lot of uncobbed material to the United States. In 1942 H. J. Nicol shipped 2,800 pounds, from which no usable crystal was recovered. In 1943, Raúl Perdomo and Carlos Guzmán began operations and shipped 136 pounds, from which 27.5 pounds of grade-1 quartz, 7.5 pounds of grade-2 quartz, and 41.4 pounds of grade-3 quartz were sorted. Since 1943 no quartz has been produced, principally because the easily recoverable quartz has been mined, and explosives would now be necessary to do underground and surface work.

The quartz is in lenses and veins that cut hornblende schist whose foliation strikes northward and dips 40°–60° W. The deposits are gash veins striking northeastward and dipping 30°–50° SE., nearly normal to the foliation and arranged in echelon.

The quartz bodies are lenses a few feet to 35 feet long and as much as 4 feet thick; they have been mined down the dip for as much as 25 feet. Commonly the lenses consist of finely to coarsely crystalline quartz with euhedral crystals lining the cavities. The wall rock around the quartz is generally altered to soft chloritic material, now partly oxidized. The alteration was part of the vein-forming process, for chlorite is enclosed in the quartz along the margins of the veins and in places occurs in crystals lining the vugs.

Quartz deposits on land of Ignacio Gonzáles, about a mile southeast of Toloxcoco, were explored in 1943 by Raúl Perdomo. Several smoky and cloudy crystals were found on the surface and in the soil mantle. A cut 30 feet long, 30 feet wide, and 12 feet deep was dug in altered mica gneiss to explore the deposit at depth. A quartz vein 6 inches wide, striking N. 40° W. and dipping 55° SW., shows in the pit; it contains fine-grained quartz in crystals that are too small for commercial use.

CHIPACAPOX MINE

The Chipacapox quartz deposit, 3½ miles east of Rabinal, was explored in 1943 by Raúl Perdomo. About 28 pounds of quartz crystals, of grades 2 and 3, was produced. Imperfections in the crystals include bubbles, clouds, and twinning. The outlook for future production is reported to be promising.

CUBULCO AREA

XEUL MINE

The Xeul mine is about 6 miles southeast of Cubulco, in the Sierra de Chuacús (fig. 14), at an altitude of 4,500 feet. It is on the property of Soledad Reyes Fernández de García and has been exploited since 1943 by Victoria Mota de Ruiz. The workings (pl. 16) consist of an opencut, 90 feet long and as much as 80 feet wide, which has produced about 350 pounds of usable radio quartz. Most of the quartz was of grades 2 and 3, but 22.5 pounds of grade 1 was included.

The quartz deposits are in hornblende schist, mica schist, and gneiss in which the foliation strikes N. 20°–50° E. and dips 40°–50° NW. These rocks are altered to a soft reddish-brown chloritic material near the veins and pockets in which the quartz crystals occur. The veins appear to strike northwestward and to dip steeply southwestward. The crystals range in weight from a few ounces to 500 pounds. Most of them are milky and enclose bubbles and chlorite flakes; in some crystals these inclusions are arranged in zones that outline early crystal faces.

The major part of the production came from the two pods exposed in the southwestern part of the pit. They are estimated to have yielded about 8,000 pounds of quartz. No quartz is now showing in this part of the pit, and the two veins in the northern part show only fine-grained quartz. All the easily accessible quartz has been mined, and the present shows are not promising. However, it seems likely that further exploration might yield pockets of usable quartz crystal.

IZOTAL MINE

The Izotal mine is 1,700 feet southwest of the Xeul deposit. A pit 50 feet long, 20 feet wide, and 12 feet deep was excavated in weathered gneiss striking N. 30°–40° E. and dipping 70°–85° SE. A few small quartz veins and lenses, which cut the foliation, were mined, yielding about 400 pounds of quartz crystal, which was cobbed to 75 pounds of usable material.

SAN JUAN PROSPECT

The San Juan prospect is a mile southeast of Sutún, a village on the Rabinal road, and is 2 miles southeast of Cubulco. A shallow pit, in schist and gneiss whose foliation strikes N. 30° W. and dips 55° SW., has yielded white milky quartz and two crystals of rose quartz. The deposit does not appear promising.

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CHIRRUMÁN PROSPECT

The Chirrumán prospect is a mile south of Sutún, on land owned by Ernesta Reyes. An opencut 10 feet long shows quartz fragments in a fracture in altered gneiss. A feldspar, probably albite, coats some of the quartz crystals. The foliation of the inclosing gneiss strikes N. 45° W. and dips 60° SW.

EL CANDÓN PROSPECT

The El Candón prospect is half a mile south of the Chirrumán deposit, at an altitude of 3,900 feet. Three narrow quartz veins dip northward at low angles in altered mica schist that strikes N. 30° E. and is vertical. Albite crystals as much as 4 inches long are associated with the quartz and occur as coatings on the faces of quartz crystals.

POMAXÁN PROSPECT

The Pomaxán quartz prospect is about 2 miles N. 60° W. of Cubulco, at an altitude of 4,250 feet. The exploratory workings consist of a shallow cut 20 feet long which shows a quartz vein, striking N. 75° E. and dipping 35° SE., that cuts augen gneiss. The vein is as much as 3 feet wide and, except for a few clear crystals less than 2 inches long, is fine grained and milky; therefore it is not radio-quality material.

PARAXÁ PROSPECT

The Paraxá prospect is a mile southwest of the Pomaxán prospect, at an altitude of 4,950 feet. The workings consist of two opencuts, which explore quartz in mica schist on a narrow ridge. The schist strikes N. 15° W., transverse to the ridge, and dips 40° SW. The quartz vein strikes N. 70° W., parallel to the ridge, and dips steeply; it ranges in width from a few feet to 20 feet and can be traced for 70 feet along the strike. Locally the vein contains feldspar, probably albite, which is intergrown with the quartz. The quartz is milky and fine grained. A few vugs contain clear crystals, but they are too small to be of value for radio quartz.

Other quartz deposits south of Paraxá have been explored by shallow cuts, but none of them are promising because the quartz in them is fine grained and milky.

CHAUTULUL PROSPECT

At the Chautulul prospect, a mile southeast of Cubulco, small quartz stringers striking N. 40° E. cut altered gneiss. All the crystals found thus far are small. Other quartz deposits about 1,500 feet to the northeast include veins and a mass of quartz 3 feet in diameter. No commercial quartz has been found in either deposit.

DOLORES DEPOSIT

At the Dolores deposit, 2½ miles southeast of Cubulco, 65 pounds of grade 3 quartz is reported to have been produced from 1 quartz vein. Most of the quartz showed clouds, blue needles, and twinning. The deposit is said to be mined out.

OTHER DEPOSITS

Quartz prospects near Rabinalá, a village about 8½ miles west of Cubulco, have been worked by Francisco Garciá. About 60 pounds of radio-quality quartz of grades 2 and 3 has been cobbed from shipments. Its imperfections include clouds, soft blue needles, and twinning. The deposit was not visited, but according to Senor Garciá the easily accessible material has been mined out.

A quartz deposit 8 miles north of Chinique, Departamento de El Quiché, was explored by H. J. Nicol in 1944. About 17 pounds of quartz, largely of grades 2 and 3, was produced. As the quartz showed minute fractures and the vein was small, the operation was abandoned.

Quartz deposits at Los Cimientos, 15 miles north of El Rancho in the Departamento de Zacapa, were explored in 1944 by Leopold Zeissig. About 40 pounds of quartz, chiefly grade 1 and of excellent quality, was produced from slope wash; the vein that yielded the material was not found, and the operation was abandoned.

QUICKSILVER DEPOSITS

Quicksilver deposits have been reported in Guatemala and El Salvador, but the only deposits for which production has been recorded are in Honduras.

HONDURAS

LOS IZOTES MINE

Cinnabar deposits at Los Izotes, Departamento de Tegucigalpa, are owned by the Compañía de Cinabrio de Honduras. The property covers 5,000 acres on a ridge about 3½ miles long, between the villages of Las Quebradas and Jalaca. It can be reached by car from Tegucigalpa by driving 33 miles on the Olancho highway and then westward 1 mile on a secondary road to the mine. The deposit was explored and mined between 1943 and 1945, and 23 flasks of mercury was produced in 1944 and 1945 from a 4-pipe retort.

The deposits are in limestone and shaly limestone which strike N. 40°–70° W. and dip steeply southwestward. Although no fossils have been found in them, they are assigned on the basis of lithogic similarity to the Metapán formation of early Late Cretaceous age. These rocks are conformably overlain by shale and conglomerate which are capped by Tertiary ash and tuff beds a few miles south of Jalaca.

The ore minerals are cinnabar and a little native mercury and calomel; these are associated with crystalline calcite, which forms veins and pockets distributed erratically throughout the rock. The ore bodies commonly follow fractures.

The workings consist of many shallow cuts and adits scattered over the limestone belt. Workings 1, on the Victoria claim about 3 miles east of Jalaca, show small discontinuous veins and pockets of cinnabar in fractured limestone. Much of the ore treated in the retort came from these workings.

One opening at workings 2, 500 feet west of workings 1, is a natural limestone cave in the walls of which are small discontinuous veinlets of cinnabar and native quicksilver. An adit nearby, in limestone that strikes N. 40° W. and dips vertically, shows small veinlets and pockets of cinnabar, native mercury, and calomel.

Workings 3 (Victoria) are half a mile east of Jalaca. Cinnabar in fractured limestone here yielded the bulk of the ore treated in the retorts. The workings include a lower adit and cut 35 feet long, an upper adit, and several shallow cuts. A fault trending northeastward separates the two sets of workings.

The Triunfo workings are 1,700 feet east of Jalaca; an opencut about 50 feet long shows a few discontinuous veins of cinnabar in limestone.

The San Estéban workings, about 1,000 feet northeast of the Triunfo workings, are in a natural limestone cave that has been enlarged by mining. The cave extends about 40 feet from the mouth, and its greatest width is about 25 feet. Small cinnabar veins have been found in a vertical shear zone trending N. 10° E.

LA CAÑADA MINE

The La Cañada quicksilver mine (fig. 15), 3½ miles west of Jalaca, is owned by Matilde de Castillo and other residents of Tegucigalpa. The mine is reported to have been worked on a small scale in colonial times, and in 1939 it was reopened by the New York and Honduras Rosario Mining Co. No production from the property had been recorded.

The hills west of Jalaca consist of shale and limestone of the Metapân formation that strike northwestward to westward. In the vicinity of the mine these rocks dip uniformly northeastward, but elsewhere they are folded and are locally contorted. There has been considerable solution of the limestone; the old stope was in part a cave, and two other caves were intersected by crosscuts into the hanging-wall limestone.

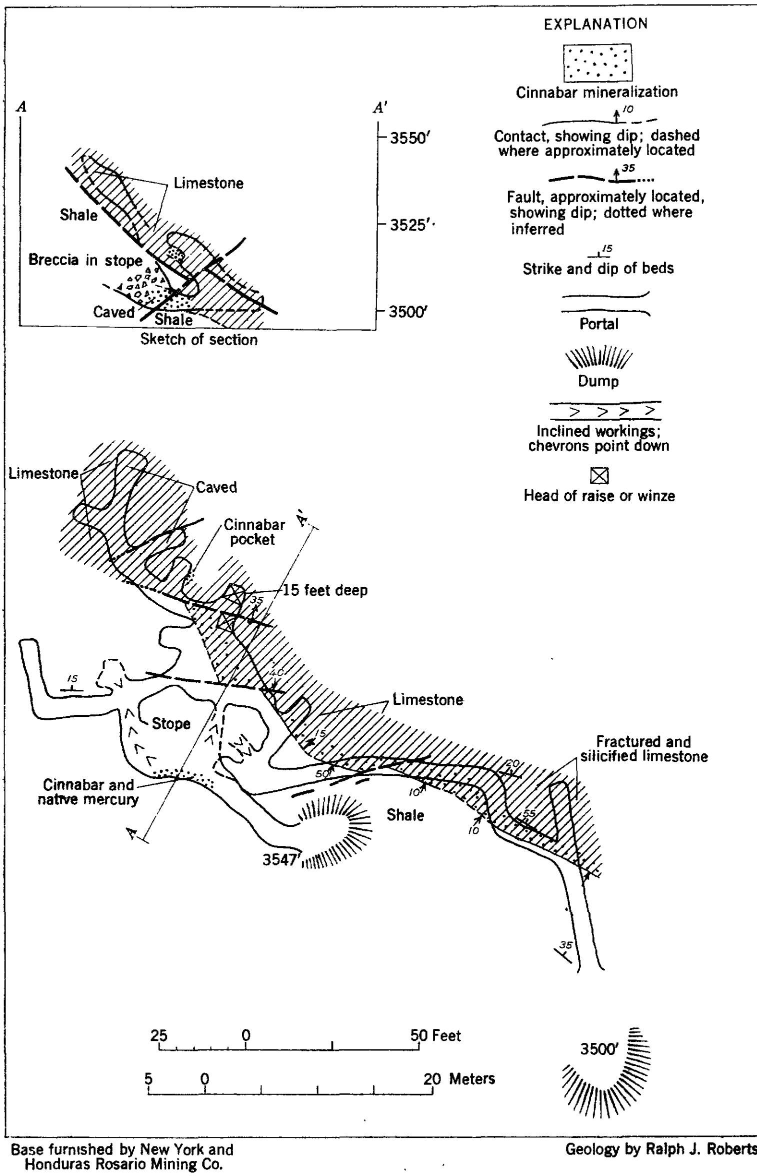

FIGURE 15.—Geologic map and section of the La Cañada quicksilver mine, Departamento de Tegucigalpa, Honduras.

The mine workings explore an ore body formed along a contact between shale and limestone. These rocks strike N. 45°–65° W. and dip northeastward; the dip above and below the adit level is steep, but in some places on the adit level it is nearly flat. The contact is in part sharp, but commonly the shale and limestone beds interfinger. The limestone, which has been silicified along the contact, is the host rock of the ore. The contact is sheared and is offset by several small faults, which in large part appear to be post ore, although some pre-ore movement may have taken place on some of them.

The ore minerals are cinnabar and a little native mercury. The cinnabar in the silicified limestone is associated with iron oxides, presumably derived from the oxidation of iron sulfides, and it also occurs locally in limestone and shale adjacent to the silicified zone. The cinnabar is in veins, lenses, and pockets that are distributed erratically throughout the silicified rock, which ranges from 3 to 5 feet in thickness between the portal and the old stope.

Deposition of the ore bodies appears to have been controlled by the interfingering of shale and limestone, which confined ore-bearing solutions to the contact zone, and by the local flattening in dip and the shearing along the contact. Cross faults which now offset the contact may have aided in confining the ore-bearing solutions laterally.

The ore body mined by the Spaniards extended down the dip for 50 feet, and in places it was as much as 40 feet wide and 8 feet thick; the average width, however, probably did not exceed 20 feet, and the average thickness was probably less than 5 feet. It is difficult to estimate the tonnage mined because of backfill and because the stope was originally in part a solution cave. It is doubtful whether more than 300 tons was stoped, and the amount may have been considerably less.

Four samples collected from the workings gave the following assays:

Sample no.	*Mercury (percent)*
S1	0.09
S2	.19
S3	.04
S4	.003

A little high-grade ore shows in the winze at the point where sample S1 was taken, and also in the crosscut west of the winze and in the old stope.

PAZ DEPOSITS

The Paz deposits, including the Coyolito, Venado, and Capitán prospects, are 15 miles northwest of Santa Bárbara and are reached by trail by way of the village of San Nicholás. The prospects are on the south side of the Río Jicatuyo, at altitudes of 1,400–2,400 feet. The property is now owned by Ponciano Paz, Julio Mendieta, and Eduardo de Costa Gómez, of San Pedro Sula. No production has been recorded, but according to report an English company mined several tons of ore in the 1880's from the Capitán prospect and shipped it to a mill in the Valle de Chamelecón.

The rocks in the area include an older group of limestone and dolomite beds of probable Paleozoic age, which are overlain unconformably by younger limestone, sandstone, conglomerate, and shale that probably belong to the Metapán formation and overlying limestone unit. The rocks of the older group are complexly folded, whereas those of the younger group have been thrown into broad open folds. Near the shows of quicksilver the rocks of the younger group strike northeastward and dip northwestward. Two sets of faults, one set trending northeastward and the other northward, cut both groups of rocks. The northeastward-trending faults contain the ore bodies of the Coyolito and Capitán prospects.

The ore bodies in the area are in the rocks of the younger group and consist of veins that extend along fault zones, and irregular ore bodies that extend along bedding. The ore minerals are native copper, tetrahedrite (probably schwazite, the mercurial variety), cinnabar, cuprite, malachite, and azurite. Of these minerals, only the tetrahedrite and possibly part of the cinnabar are of primary origin; the remainder of the cinnabar and the copper minerals were formed from the tetrahedrite during oxidation. Calcite and quartz are the gangue minerals.

COYOLITO PROSPECT

The Coyolito prospect is in the southwestern part of the area. Two shallow pits explore shows of copper along a shear zone that strikes N. 50° E. and dips 70° SE. in limestone, conglomerate, and sandstone. One of the pits shows a vein as much as 6 inches wide composed of quartz, azurite, and malachite. A sample taken across the vein gave the following analysis: 0.10 percent mercury, 8.85 percent copper, and 8.5 ounces of silver to the ton. The other pit, about 40 feet to the northeast of the first, is 10 feet deep. It shows copper carbonates distributed throughout a shear zone about 1 foot wide; the material is of low grade.

VENADO PROSPECT

The Venado prospect is half a mile northeast of the Coyolito prospect. The workings consist of a pit 6 feet wide, 12 feet long, and 6 feet deep, in limestone, conglomerate, and sandstone that strike N. 50° E. and dip 35°–40° NW. The lower 6–18 inches of limestone conglomerate is partly replaced by native copper, cuprite, cinnabar, malachite, and azurite. Two samples were taken across this layer and assayed 0.07 percent mercury, 1.66 percent copper, and 0.7 ounces of silver to the ton; and 0.05 percent mercury, 0.47 percent copper, and 0.3 ounces of silver to the ton. The mineralized bed does not crop out beyond the pit, but float found on the slope indicates that it extends about 300 feet northeastward. Exploratory work will be needed to determine whether the ore is continuous over this distance.

CAPITÁN PROSPECT

The Capitán prospect, nearly half a mile northeast of the Venado deposit, yielded all the ore that has been mined from the area. The workings consist of 2 pits, 1 of which was caved in 1943, about 15 feet apart in ferruginous limestone that strikes N. 45° E. and dips 35° NW. The accessible pit contained pockets and veinlets of tetrahedrite, cinnabar, malachite, and azurite, which replace the altered limestone. The size and shape of the ore body cannot be determined, but it appears to be a tabular body trending northeastward. The vein is said to be several feet wide at a depth of 30 feet in the caved pit. A sample taken from the open pit assayed 0.90 percent mercury, 1.82 percent copper, and 2.8 ounces of silver to the ton.

GUATEMALA AND EL SALVADOR

Persistent reports that quicksilver deposits are to be found in Guatemala have been heard from many sources. From time to time Indians come to Guatemala City with small quantities of mercury whose source they have refused to reveal, but as the Indians are generally from the volcanic area between Lago de Atitlán and Quetzaltenango, the source has been presumed to lie in that area. An area of fumarolic activity on the volcano Zuñil, about 6 miles south of Quetzaltenango, was visited, but no native mercury was seen. Vapor from some of the fumaroles deposited a coating on copper that on drying turned gray, then brown, and could be brushed off, but analysis of the coating showed that it contained no mercury; the material is apparently a chloride which attacked the copper. The source of the Indians' mercury is therefore still unknown.

Quicksilver deposits are reported also at several places in El Salvador, but none of these reports have been confirmed.

GOLD AND SILVER DEPOSITS

Although no special effort was made to visit precious-metal deposits, the writers were able to gather information on many districts. Some of this information was collected by the writers, some was supplied by operators in Central America, and some was obtained from published material. Although the data are by no means complete, they will convey a general idea of the ore deposits, their enclosing rocks, and the extent of operations.

The gold and silver deposits of Central America may be divided into deposits in Tertiary rocks and deposits in pre-Tertiary rocks. The deposits in rocks of pre-Tertiary age are related to the intrusive activity of early Paleozoic(?), late Permian, and Mesozoic time. The Agua Fría mine is an example of the pre-Tertiary deposits. The deposits in rocks of Tertiary age are related to intrusive activity that took place partly in early Tertiary time, probably beginning in the Eocene and continuing into the Miocene and Pliocene.

The Tertiary gold deposits account for most of the production of Central American gold and silver. They occur principally in eastern

El Salvador, western Guatemala, central Honduras, and northern Nicaragua. These districts are all in areas of Tertiary volcanism and are included in an eastward-trending chain of volcanoes, the Pacific coastal belt, and an older eastward-trending chain from which the widespread lava flows and pyroclastic rocks that mantle the middle part of Central America originated. The gold deposits of Costa Rica and Panama are separated from this belt by the Nicaraguan lowland.

PRODUCTION

The gold and silver production of Central America has passed through several stages. The first stage, the colonial period, was marked by production from a large number of properties, both placer and lode. Production was on a small scale, primitive methods were used, and the recovery was probably low; however, for nearly 300 years the annual production may have been worth from a few thousand to several hundred thousand dollars a year. The second stage, 1821–80, was characterized by erratic production for which few data are available, but it is inferred from available data that the value of the production during the 1860's, the period of greatest activity, averaged about $600,000 a year.

During the early part of the period from 1880 to 1933 the ores mined were of high grade, but the percentage of recovery of metals from the ores was small. Recovery was improved by the introduction of the cyanide process, but the grade of the ore declined gradually during the latter part of the period as the bonanza shoots were exhausted and leaner portions of the veins were mined. Greater mining and metallurgical efficiency permitted treatment of lower grade ores, and some old mines were reopened. The increase in production was most notable in Nicaragua, where the value of the annual production increased from about $500,000 in 1936 to more than $8 million in 1942.

HONDURAS

EL ROSARIO MINE

The El Rosario mine is on the east flank of the Sierra de Santa Lucía, about 16 miles northeast of Tegucigalpa, Departamento de Tegucigalpa, and at an altitude of 5,500 feet. A road passable the year round extends from Tegucigalpa to the mine. The mine is owned by the New York and Honduras Rosario Mining Co. and was in nearly continuous production from 1882 to 1954 (Leggett, 1889; Eng. and Min. Jour., 1920, p. 1163; Newberry, 1888; Matheson, 1942, p. 112; Eng. and Min. Jour., 1954). The value of the production from this mine, chiefly silver, totals about $75 million. The long period of operation and the high productivity make this one of the outstanding silver mines of the world. The table below gives its production during recent years.

Gold and silver produced from the El Rosario mine, Honduras, 1935–49 [1]

Year	Au (ounces)	Ag (ounces)	Value (dollars)
1935	12, 236	2, 646, 411	2, 019, 313
1936	17, 878	3, 104, 174	1, 953, 690
1937	21, 717	3, 574, 116	2, 113, 645
1938	19, 916	3, 335, 067	2, 053, 104
1939	17, 800	4, 118, 887	2, 205, 451
1940	23, 173	3, 889, 164	2, 175, 173
1941	22, 828	3, 448, 667	2, 019, 045
1942	22, 089	3, 478, 831	2, 187, 817
1943	18, 221	3, 168, 523	2, 056, 136
1944	19, 774	3, 115, 351	2, 093, 990
1945	17, 078	3, 003, 494	2, 383, 020
1946	12, 093	2, 682, 910	[2] 2, 826, 870
1947	11, 928	2, 403, 500	2, 168, 200
1948	13, 305	2, 389, 353	2, 354, 132
1949	----------	2, 276, 698	2, 329, 359

[1] Mines Register, 1937, 1940, 1942, 1946.
[2] Annual report of New York and Honduras Rosario Mining Co.

The workings consist of about 150 miles of underground workings over a vertical range of 1,400 feet. An average of 200,000 tons of ore containing 16–17 ounces of silver and about 0.08 ounce of gold to the ton was treated annually.

The oldest rocks in the mine area are gray shale, siltstone, and sandstone of Jurassic age (Knowlton, 1918) 3,000 feet in thickness (Carpenter, 1954, p. 25; Newberry, 1888). These rocks are overlain by siltstone, sandstone, limestone, and andesitic tuffs and breccias of Early Cretaceous age that are probably correlative in part with the Metapán formation. All these rocks have been cut by andesitic, dacitic, and granodioritic plugs and dikes. The silver-bearing quartz veins are in the dacitic intrusive rocks and form a complex pattern; the predominant systems trend roughly N. 70° W. Of the 85 known veins, 46 have yielded the major part of the production. Younger sedimentary, volcanic, and pyroclastic rocks of later Cretaceous and Tertiary age rest on the older rocks.

The ore minerals are pyrite, sphalerite, galena, chalcopyrite, stephanite, argentite, pyrargyrite, native silver, and electrum. Rhodonite is found in some of the ore. Most of the ore shoots are rich in silver, but some veins, including the Santa Fé and Colonia, contain ore shoots with a high gold content.

Most of the veins are less than 4 feet thick, are persistent, and for the most part are uniformly mineralized. As many as 35 veins are stoped at the same time, although generally 4 or 5 veins furnish the bulk of the ore mined.

AGUA FRÍA MINE

The Agua Fría mine is 5 miles north of Danlí, in the Departamento de El Paraíso, at an altitude of 3,200 feet in the Cordillera de Villa

Santa. An all-weather road extends from Tegucigalpa to the mine, and planes can land at an airport 3 miles north of the mine. The deposit was discovered in 1915, and for several years the oxidized ore from the upper part of the vein was mined and concentrated in an arrastre by the Gamero family of Danlí. In 1935 a combination cyanide and flotation mill of 120 tons daily capacity was put into operation by Earl P. Halliburton, of Los Angeles. The deposit was mined until June 1943; its production is shown in the table below.

Gold produced from the Agua Fría mine, Honduras, 1935–43 [1]

Year	Ounces	Value (dollars)
1935	3, 949	137, 384
1936	9, 824	343, 463
1937	12, 005	419, 108
1938	10, 252	357, 938
1939		
1940	34, 822	1, 215, 705
1941		
1942	6, 994	244, 196
1943 [2]	2, 640	92, 161

[1] Figures furnished by the Cia. Agua Fría.
[2] To end of June, when mining ceased.

The rocks in the area are alternating thin-bedded shales and massive gray quartzites striking N. 30°–45° E. and dipping 30°–50° NW.; they form the northwestern limb of a syncline that pitches southwestward. These rocks have a thickness of more than 4,000 feet. Just south of the mine they are intruded by a hornblende-biotite granodiorite stock about 2,000 feet in diameter. Porphyry dikes related to the granodiorite cut the shale and quartzite in the mine area. The mine is developed by adit levels in the upper part and by a shaft 370 feet deep with a 300-foot winze offset on the 400-foot level. The maximum vertical range developed is 760 feet.

The Agua Fría quartz vein, which cuts the shale and quartzite, strikes N. 25° E. and dips 70° NW. in the upper part of the workings, but downward the dip gradually flattens to 50° NW. The ore minerals are arsenopyrite, chalcopyrite, and pyrite, with minor quantities of pyrrhotite, sphalerite, galena, and marcasite; meneghinite commonly lines vugs in the ore. The gold is associated principally with the arsenopyrite.

The vein ranges in thickness from a foot to more than 6 feet. The ore shoot is in the form of a right triangle whose right angle is in the upper northern end of the vein and whose hypotenuse forms the bottom boundary of the ore. The ore shoot is 1,400 feet long in the upper workings and gradually shortens to 200 feet on the 600-foot level. On the north it is terminated by a bedding-plane fault filled with gouge derived from comminuted shale. This fault was premineral and may have aided in the localization of the ore shoot.

The ore shoot contains three zones: the lowest, arsenopyrite, is at the south end of the shoot; the middle part is arsenopyrite, chalcopyrite, and pyrite; and the upper part is chalcopyrite and pyrite with minor amounts of arsenopyrite. The ore mined, about 200,000 tons, contained an average of 0.55 ounces of gold and 0.70 ounces of silver to the ton and 0.75 percent copper.

Operations ceased in 1943 because all the commercial ore in sight had been stoped. Further exploratory work was continued during 1944 and 1945, and although low-grade ore was found in nearby veins, not enough tonnage had been developed to warrant reopening the mill.

SAN ANDRÉS MINE

The San Andrés mine is about 12 miles southwest of Santa Rosa de Copán, in the Departamento de Copán, at an altitude of about 3,500 feet on the west slope of Cerro de Magdalena. The mine was worked on a small scale by an English company in the 1920's, and production was correspondingly small. The property was formerly owned by Rudolf Nater, Manuel Bueso, and their associates, but in 1946 it was sold to the W. H. Gould Co., of San Francisco, Calif. A mill was installed in 1947 and has operated since then.

The ore deposit consists of gold quartz veins in rhyolite, which is in fault contact with mica schist. Calcite is locally abundant in the veins. The mineralized zone is 10–50 feet wide, 800 feet long, and has been developed for 300 feet down the dip. Pyrite is found locally in the wall rock at depth.

ANDERSON AND REY DEL ORO MINES

The Anderson and Rey del Oro mines, 7 miles southeast of Juticalpa in the Departamento de Olancho, contain small quartz veins in phyllite and quartzite. The veins are 2–3 feet wide and are exposed for several hundred feet along the strike. The gold in the veins is largely free milling, although associated with pyrite. The ore shoots are commonly small, containing from several hundred to a few thousand tons apiece.

MANGULILE MINES

The veins at Mangulile, about 45 miles northwest of Juticalpa, are similar in mineralogy to the Anderson and Rey del Oro veins but are narrower. Although some of them have been worked on a small scale, mining is difficult because of the erratic distribution of the gold in the quartz.

OPOTECA MINE

The Opoteca mine is 10 miles north of Comayagua. It was exploited in colonial times by the Spaniards, was explored from 1918 to 1921 by the West End Consolidated Mining Co. (Mines Handbook, 1925, p. 2267), and in 1946 was under option to Panaminas, Inc. The rocks in the area consist of Cretaceous limestone, which has been broken by steeply dipping fractures. Argentiferous galena veins replace the limestone along the fractures. The ore is reported to contain 2–40 ounces of silver to the ton.

OTHER DEPOSITS IN NORTHWESTERN HONDURAS

Other silver deposits near Comayagua, Yoro, and Mangulile consist of cupriferous veins that cut phyllite and limestone. Some of these veins have been exploited on a small scale, but none seem likely to become large producers. Silver occurs also in galena-sphalerite-quartz veins near Cedros and at Pino Alto, near the Agua Fría mine.

Other properties and prospects are situated in the headwaters of the Río Chamelecón near Macuelizo. Much exploratory work has been done on some of the veins, but none has yielded a profit.

Prospects in the headwaters of the Río Chancaya west of Yoro, Departamento de Yoro, in the Sierra Nombre de Dios south of Tela and La Ceiba, near Cedros and Minas del Oro in the Departamento de Cedros, and in the Sierra el Chile east of Talanga, Departamento de El Paraíso, have been explored intermittently since Spanish colonial times.

SAN FÉLIX MINE

The San Félix mine consists of several small gold and silver-bearing quartz veins about 6 miles north of Langué, Departamento de Valle. The veins cut andesite and rhyolite tuff. Some of them were exploited in the early 1920's, but because the ore remaining is of low grade there has been no recent activity in the area.

LA VICTORINA MINE

The La Victorina mine is 18 miles northeast of Langué. This property was exploited from 1910 to 1920, when 50,000 tons of ore, with an average value of $15 a ton, is estimated to have been milled. The ore body is a quartz vein trending northwestward and dipping 60°–70° NE. The ore shoot mined was 600 feet long and extended for 300 feet down the dip.

CONCHAGUA MINE

The Conchagua mine is 10 miles southeast of El Paraíso, in the Departamento de El Paraíso. The property was worked intermittently during the 1930's, and the ore was treated in a mill of 15–20 tons daily capacity which was equipped with amalgamation plates and tables. The deposits are narrow quartz veins containing gold that strike N. 65° E. and dip 70° NW. and that fill fractures in phyllite and limestone. The gold is reported to be coarsely granular.

LA ALHAMBRA MINE

The La Alhambra deposit is 30 miles northeast of Danlí, in the eastern part of the Villa Santa Cordillera. Quartz veins in phyllite and limestone have been exploited on a small scale, but the property is now inactive. Small gold quartz veins are known also in the Batea district nearby.

SANTA LUCÍA AND VALLE DE ANGELES MINES

The veins of the Santa Lucía and Valle de Angeles mines, a few miles south of the Rosario mine, are similar in mineralogy to the Rosario veins, but they cut rocks of the Metapán formation. Although some are of high grade, the veins are small and have been exploited only on a small scale.

The principal vein is the Las Animas, which was first opened by the Los Angeles Mining and Smelting Co. in 1888. The property passed to don Santo Soto in 1897 and was operated at intervals to 1927, when the mill burned. Paul Bundy estimated that possibly 3,000 tons had been mined from the vein, which averages about 3½ feet in width, strikes northeastward, and dips 24° SE. The Socorro vein nearby strikes N. 60° E. and dips 16° SE. It was first opened in 1882 and is reported to have produced a small amount.

MONTAÑITA AND SAN ANTONIO DE ORIENTE DEPOSITS

Veins in the Montañita area, about 7 miles east of Tegucigalpa, and in the San Antonio de Oriente area nearby, were exploited by the Spaniards before 1900, but both were abandoned in 1944. Pyrite-sphalerite-galena-quartz veins in the San Antonio area are in gently dipping rhyolite tuffs and lavas; some of the ore follows the bedding in the rhyolite. The veins in the Montañita area are in rocks of the Metapán formation.

YUSCARÁN DEPOSITS

The Yuscarán deposits are 30 miles east of Tegucigalpa, in the Departamento de El Paraíso, on the eastern flank of Cerro Montserrat. The area was actively worked in colonial times and also between 1850 and 1900. It is said to have yielded in all about $6 million worth of silver and gold, which came chiefly from the Veta Grande mine. In 1919 control of the area was acquired by the American and Honduras Mines Corp., but the mines were not exploited. In 1945 the New York and Honduras Rosario Mining Co. purchased the property.

The rocks in the area are andesites overlain by rhyolite and rhyolite tuffs. These rocks have been broken by 2 major post-ore northward-trending faults, half a mile apart, which divide the area into 3 blocks. The eastern block contains the Capiro, Guayabillas, and other veins; the middle block contains the Santa Elena, Mercedes, Veta Grande, Novillo, and Santa Fortuna veins; and the western block contains the Santa Margarita, San Isidro-Santa Gertrudis, and San Juan veins.

The quartz veins of all three blocks trend eastward and dip steeply northward. The Guayabillas, Santa Elena, and Santa Margarita veins are valuable principally for gold, but contain small quantities of pyrite, sphalerite, and galena. The rest of the veins contain a good deal of silver as well as gold, with higher percentages of the sulfides.

SABANA GRANDE MINES

The Sabana Grande silver-gold mines, in the Departamento de Tegucigalpa, were operated between 1919 and 1928 by the New York and Honduras Rosario Mining Co. The mines were inactive between 1928 and 1951 but were being reopened in 1951 by the company. The deposits consist of several quartz veins, which contain pyrite, sphalerite, galena, silver sulfides, and gold. The rocks in the area are andesitic and rhyolitic lavas and tuffs of Tertiary age.

EL PÓRVENIR MINE

The El Pórvenir gold mine is near the Honduras-El Salvador border, about 12 miles north of the village of Goascorán. The mine was exploited between 1880 and 1910 by English and American groups, but the production is not known. Attempts to reopen the mine in the late 1930's were not successful. At present, a few people living nearby crush surface ore and pan it for gold in a nearby stream. The ore bodies are short narrow quartz veins in andesite and in rhyolite tuffs. The ore shoots are said to have yielded bonanza pockets containing free gold.

EL TRÁNSITO MINE

The El Tránsito mine, 10 miles southeast of Goascorán, has been intermittently exploited and has yielded only a small amount of gold. The property was purchased in 1944 by the American Smelting and Refining Co. and was being reopened in June 1944. The deposit is a quartz vein, said to be 20–30 feet wide, containing pyrite and free gold.

SAN MARTÍN DEPOSITS

The San Martín deposits are 10 miles north of the Inter-American Highway, near the town of San Martín in the Departamento de Choluteca. Some of the veins were exploited in the 1880's by a French company but are now abandoned. The veins cut andesite and are developed by adit levels and shafts.

EL CORPUS DEPOSITS

The El Corpus deposits are 10 miles southeast of Choluteca, on the Inter-American Highway. They were exploited by British and American groups during the last part of the 19th century but were abandoned in 1944.

TATUMBLA MINE

Veins of gold ore near Tatumbla, 10 miles southeast of Tegucigalpa, were explored by the Agua Fría Co. in 1938 and by Herederos Santos Soto in 1941. Quartz stockworks in rhyolite tuff contain pyrite and gold, but the gold occurs in such small quantities that the ore is of low grade.

EL MOCHITO MINE

The El Mochito mine is 8 miles southwest of Jaral, a village on Lago de Yojoa, and can be reached by road from the Potrerillos-Tegucigalpa highway. The mine is at an altitude of 3,200 feet. The property was purchased in 1943 by the New York and Honduras Rosario Mining Co., which carried on exploratory and development work until 1949 when a 150-ton mill was installed and put into operation. In 1949, 36,917 tons having a gross value of $812,438 was milled; the ore yielded 1,083,560 ounces of silver. The ore also contained 0.02 ounces of gold a ton and 1.18 percent lead. The concentrates were shipped to El Paso, Tex.

The rocks in the area are interbedded sandstone, shale, and limestone of the Metapán formation. The ore bodies, which crop out along a fracture zone that trends N. 20° E. and dips steeply northwestward in the limestone, can be followed for more than 1,000 feet. They contain argentiferous galena, native silver, sphalerite, and chalcopyrite, in a gangue of schefferite (a manganese pyroxene), rhodochrosite, and calcite. The schefferite is altered to manganese oxides at the surface.

QUITAGANA MINE

The Quitagana mine is near El Corral in the Departamento de Grácias. The property was optioned in 1951 by the New York and Honduras Rosario Mining Co., and it is reported that exploratory work was being carried on in 1952. The ore is said to be zinc-copper-silver bodies in fissures and along bedding.

PLACER DEPOSITS

The placer mines of eastern and northern Honduras were the source of most of the placer gold being produced in Central America in 1944. These placers have been worked intermittently from the 16th century to the present. Although companies installed mechanized equipment to work the placers during the late 1940's, none of the operations has been successful.

RÍO GUAYAPE AND RÍO JALÁN PLACERS

The valleys of the Río Guayape and Río Jalán (Wells, 1857) are in the rugged mountains of the Departamentos de Tegucigalpa, El

Paraíso, and Olancho. Both rivers flow southeastward for 50 miles, then turn northeastward and join near Juticalpa; from here to the mouth of the Río Guayambre, the system comprising both rivers is called the Río Guayape; downstream, it is called the Río Patuca.

The gold placers along the Río Guayape occur between Paso de Compadre, east of Campamento, and the junction of the Río Guayape and Río Jalán at Juticalpa (pl. 1; also see Haley, 1941, p. 36). For 20 miles below Paso de Compadre the gold-bearing gravels are thin and are confined to a narrow stream valley, but farther downstream they become thicker, and below El Retiro they are more than 40 feet thick. Some tributary streams near El Rusio, Ocotal, and El Retiro also contain gold-bearing gravels. Placers are found along the Río Jalán from El Rosario to Teupacenti. In this segment the river is largely confined to a narrow gorge, and the placer gravels are consequently narrow and thin. Downstream from Teupacenti, where the valley broadens to a mile or more in width, the gold-bearing gravels interfinger with barren gravels from tributary streams. The Río Frío and La Vijao tributaries, 20 miles downstream from Teupacenti, also contain local placers.

The gold placer deposits have been derived from myriad small quartz veins that cut the phyllite and quarzite of central and eastern Honduras. Gold was concentrated in gravels during several cycles of erosion within Tertiary time. Although the details have not been worked out, some of the events during the Tertiary that influenced concentration of the gold can be described.

In early middle Tertiary time, prior to the volcanic eruptions, central and eastern Honduras was an area of low relief. Streams flowing over this area were probably adjusted to the structures, and some flowed eastward and some westward. When the surfaces became covered with lavas and pyroclastic rocks in later middle Tertiary time, consequent streams on the surface of the volcanic rocks flowed southeastward. Regional uplift probably accompanied the volcanism, and the streams cut downward through the volcanic rocks, again encountering the eastward-trending phyllite and quartzite beds beneath. The streams maintained their southeastward courses on these rocks, except where their courses were changed by capture.

The gold was probably first concentrated during the middle Tertiary erosion period, in gravels of the streams flowing eastward and westward. Then, after the period of volcanism, streams cut down through the older gravels and reconcentrated the gold in the present valleys, chiefly in those of the southeastward-flowing streams.

Drilling has shown that the Río Guayape and Río Jalán gold-bearing gravels are erratically distributed throughout the alluvium in the flood plains of these rivers. The most successful operators have become skilled at finding pockets of higher grade material, yet even under such circumstances the average daily earnings are generally small. It is doubtful whether large-scale operations would be profitable with gold worth $35 an ounce.

OTHER PLACERS

Other placers are reported in the upper parts of the valleys of the Río Sico and Río Paulaya in northeastern Honduras, and also in the tributaries of the Río Patuca above Guampú. Gold is also said to have been found in the upper part of the Río Segovia basin, along the border between Honduras and Nicaragua. Small placers occur near Minas de Oro in central Honduras, near San Martín and Langué in southern Honduras, and near Macuelizo in northern Honduras.

COSTA RICA

Gold production in Costa Rica has decreased in recent years, although deposits are still actively mined in many districts. The mines are in a belt 66 miles long that extends along the west slope of the Cordillera Central of Costa Rica. The Ferrocarríl al Pacífico runs south of the belt to Puntarenas, passing close to some of the mines. The other mines can be reached by roads connecting with the railroad or with docks on the Golfo de Nicoya.

In southern Costa Rica, as in Panama, the Indians began in prehistoric days to seek gold for ornaments, and placer mining has probably been continuous from the colonial period up to the present day.

AGUACATE DISTRICT

The Aguacate district (Huttle, 1942; Bennet, 1939; Malozemoff, 1942) on Cerro del Aguacate, about 30 miles west of San José between San Ramón and San Mateo, has been producing intermittently since gold was discovered there in 1822. Operations were on a small scale until 1907, when several properties were combined as the Aguacate Mines, Inc. From 1907 to 1927 there was little systematic exploration. Two mines were active in the district in 1945; the Compañía Aurífera Nacional was treating 40 tons of ore daily from the Oreamuno-Castro vein, and Srs. Juchem and Sanford were treating 40 tons of ore daily from the Unión vein. The Unión vein, which is about 2,000 feet northwest of the Sacrafamilia vein, has been explored for 2,000 feet along the strike and over a vertical range of 1,000 feet (Malozemoff, 1942).

ABANGARES DISTRICT

The Abangares district is 4 miles northeast of Las Juntas, in the Provincia de Guanacaste. Mining began in this district in the 1880's, but it was not until 1892, when Minor C. Keith acquired the San Rafael mine, that large-scale operations began. Keith later purchased the Tres Hermanos and Boston mines and operated all of them together under the name of Costa Rica Union Mines, Inc. Between 1892 and 1928 these mines are reported to have produced about $33 million in gold. After 1928 they were leased to individuals, and the ore mined was treated by the mill on a custom basis. In 1942 the company was reorganized and was later optioned to the Panaminas Co. of New York, a subsidiary of Ventures, Ltd.

The ore deposits are quartz veins in andesite flows. The veins strike N. 30° E. and dip steeply southeastward. They are generally 5–8 feet wide, although at some intersections with branch veins they are as much as 20 feet wide. They contain sparsely distributed sulfides, including pyrite, chalcopyrite, sphalerite, galena, and, locally, stibnite.

The Tres Hermanos vein can be traced on the surface for 6,000 feet and has been mined for 3,000 feet and to a depth of 500 feet. The San Rafael vein, a branch of the San Martín vein, contained several rich bonanzas; it was mined for 1,000 feet along its length and to a depth of 400 feet.

MIRAMAR AND ESPARTA DISTRICTS

In the Miramar and Esparta districts, which lie between the Aguacate and Abangares districts, many veins have been exploited intermittently. In the late 1930's the Albert Rudin Co. operated the Santa Elena, Trinidad, Bonanza, and El Encanto mines, which yielded 150 tons of milling ore daily.

The rocks in the Aguacate area are andesitic lavas and pyroclastic rocks which form part of the Cordillera Central of Costa Rica. Locally these rocks have been intruded by basalt. Three principal quartz veins—the Oreamuno-Castro, the Sacrafamilia, and the Unión—have been exploited in the district. These veins are nearly parallel, strike N. 30° E., and dip steeply northwestward.

The Oreamuno-Castro vein has been worked for a length of 3,000 feet and over a vertical range of 800 feet. It is 3–20 feet wide and contains narrow ore shoots that plunge steeply northward. The gold in the ore shoots in the southwestern part of the vein is associated with pyrite, arsenopyrite, and a minor amount of realgar. The ore shoots in the northeastern parts of the vein are smaller and of lower grade; the gold in them is associated with rhodonite, pyrite, sphalerite, chalcopyrite, and galena. Pockets of manganese oxide that are found in the oxidized zone were presumably derived from oxidation of the rhodonite. The Sacrafamilia vein, 1,500 feet west of the Oreamuno-Castro vein, contains sparse sulfides. Only a few ore shoots have been discovered in this vein.

The San Gerardo mine south of San Ramón, the Llano Brenes mine north of the Aguacate area, and the Bella Vista and Montezuma mines north of Miramar each produced 10–40 tons a day, although production has been intermittent. Most of the veins are narrow and contain erratically distributed ore shoots.

PENÍNSULA DE OSA AREA

The most important placer area is on the northern slope of the Península de Osa in southern Costa Rica (Malozemoff, 1942). Work is confined to the valleys of the Río Madrigal, Río Nuevo, and Río Tigre, which drain into the Golfo Dulce. In 1944, it is reported, 400–600 men were employed in primitive operations on the streams; how much they mined is not known.

NICARAGUA

Nicaragua is the principal gold-producing country of Central America. The 8 largest properties in production yielded over 110,000 tons of ore monthly in 1945, and this tonnage has probably increased since that time. During World War II the production dropped but little. It seems likely that many other properties will be tested to determine whether they can be operated profitably under postwar conditions.

Transportation is the principal problem in development of mines in Nicaragua. Good roads and railroads are found only in the western part of the country. The Inter-American Highway and feeder roads, which were completed in 1943, did much to improve transportation, but for the most part central and eastern Nicaragua are without roads and can be reached only by poor trails. Airports are scattered over the country, but as yet only high-value freight can be transported by airplane; the bulk of the material to be moved must be handled by slow, laborious methods.

LA LUZ MINE

The La Luz mine is in the Departamento de Zelaya, 95 miles west-southwest of Puerto Cabezas at the village of Siuna (Scobey, 1920; Garbrecht, 1920). The deposit was discovered by Spanish prospectors and was put into operation on a small scale in 1896 by José Aramburú. In 1919 the property was incorporated as the La Luz and Los Angeles Mining Co. From 1901 to 1926 the value of the recorded production amounted to about $5 million, which was obtained from 700,000 tons of ore (Mines Handbook, 1926, p. 2041). The property was partly destroyed by revolutionists in 1928 but was subsequently rebuilt; in 1938 it was acquired by Ventures, Ltd. and renamed La Luz Mines, Ltd. The mill was enlarged in 1945 and changed to a combination flotation and cyanidation plant treating 1,800 tons daily. The production from 1939 to 1945 is shown in the table below.

Gold and silver produced from the La Luz mine, Nicaragua, 1939–45 [1]

Year	Tons milled	Au (ounces)	Ag (ounces)	Value (dollars)
1939	10, 098	1, 124	361	39, 259. 65
1940	171, 551	35, 701	13, 698	1, 249, 482. 31
1941	367, 135	73, 033	34, 079	2, 553, 875. 00
1942	436, 125	79, 768	38, 866	2, 792, 257. 73
1943	369, 099	75, 965	32, 759	2, 659, 900. 08
1944	416, 024	67, 994	27, 168	2, 377, 878. 46
1945	425, 038	71, 856	22, 187	2, 513, 025. 44

[1] Figures furnished by La Luz Mines Ltd., Siuna, Nicaragua.

The rocks in the area are shale and limestone, graywacke, slate, and lavas which probably belong to the Metapán formation of Cretaceous age; all have been intruded by andesite (Graham A. Nelson, written communication). The ore occurs in the closely folded sedimentary rocks in a zone 300–400 feet wide and about 2,000 feet long, on the footwall side of a wide andesite dike. Small quantities of pyrite, chalcopyrite, galena, and sphalerite occur with the gold.

Underground exploration shows that the ore extends to a depth of at least 825 feet. Until 1944 the ore was mined mainly from an open pit, but since then much of it has been stoped from underground workings. In 1949 about 500 tons daily was mined from the open pit and 800 tons daily from underground workings.

Supplies for the mine are brought upstream to Alamicamba, on the Río Prinzapolka, in shallow-draft barges towed by launches, then flown 42 miles west to the mine.

PIS PIS DISTRICT

The Pis Pis district is about 75 miles west of Puerto Cabezas in the Departamento de Zelaya, 15 miles north of the La Luz mine. Gold mines have been exploited in the Pis Pis district since 1880, and up to 1920 the district had produced about $12 million worth of gold.

Because no roads or railways reach the district from either coast, transportation of supplies has always been a major problem. Before 1920 barges carried most of the freight up the Río Prinzapolka and the Río Bambana from the east coast. However, since 1935 freight has been brought in principally by air.

The mines in the Pis Pis district occur in a belt that is about 12 miles long and as much as 3 miles wide. The mines are grouped in three areas in the belt: the Neptune-Eden (Bonanza) group on the northeast, the Pioneer-Lone Star group in the middle, and the Constancia group on the southwest.

The mines were separately owned and operated prior to 1922. A 150-ton mill was installed at the Bonanza mine in 1923; ore from the Bonanza, Pioneer-Lone Star, and Constancia groups was treated in this mill. The Eden mine (Garbrecht, 1920) first began operation in the district in 1914; a 140-ton mill was put into operation in 1918, and production continued until 1922. Ore from the Eden, Culebra, Hidden Treasure, Philadelphia, and Morning Star veins was treated in this mill.

The mines were closed during the revolution in the mid-1920's. In 1934 they were acquired by the American Smelting and Refining Co., the New York and Honduras Rosario Mining Co., and others, and the Neptune Mining Co. was formed. A new mill of 500 tons daily capacity was built in 1938; in 1944 its capacity was increased to 800 tons.

The Bonanza vein had the highest production in the past, but in 1951 the principal producing veins were the Eden, Hidden Treasure, Neptune, Venus no. 2, Corral, Culebra, and Tesoro veins. None of the veins in the Constancia area were being stoped in 1951. The production from 1938 to 1950 is given in the table below.

Gold and silver production of the Neptune Mining Co., Nicaragua, 1938–50 [1]

Year	Tons milled	Au (ounces)	Ag (ounces)
1938			
1939	------------	35, 130	81, 873
1940	------------	------------	------------
1941	211, 600	49, 518	96, 319
1942	263, 280	65, 508	90, 930
1943	238, 735	59, 098	94, 681
1944	228, 533	52, 755	97, 328
1945	233, 669	50, 730	95, 877
1946	237, 502	55, 916	85, 908
1947	232, 463	57, 476	86, 295
1948	251, 767	61, 034	78, 792
1949	252, 560	66, 112	83, 713
1950	260, 129	71, 961	76, 122

[1] Data from annual reports of the Neptune Gold Mining Co., Nicaragua.

The ore bodies are in quartz veins that cut andesite, which probably includes both extrusive and intrusive facies. The veins belong to 2 sets: most of them strike northeastward, dip steeply, and follow faults of moderate to large displacement; 2 veins strike northwestward and follow faults of small displacement. The veins range in width from a few feet to 30 feet and have been traced for as much as 6,000 feet along the strike.

The ore minerals are pyrite, galena, chalcopyrite, and hematite. Generally the sulfides are sparse and occur in small pods or along narrow fractures in the veins. The gangue minerals are principally quartz with a little carbonate, rhodonite, and rhodochrosite. The tenor of the ore averages about 0.29 ounces of gold per ton.

CHONTALES DISTRICT

The Chontales district is in south-central Nicaragua, about 75 miles east of Managua. Mining in this district began about 1860. Gold-quartz veins occur in 2 areas about 5 miles apart: the Santo Domingo area, with the San Gregorio and Jabalí mines, and the La Libertad area, with the San Juan and Babilonia mines. In 1942 about 5,500 tons of gold ore was being mined each month at the Jabalí mine (Kettel, 1942, p. 114, 115).

Belt (1888) described the veins of the Santo Domingo area as being eastward-trending quartz veins of steep dip; they are 1–20 feet wide, their average width being about 7 feet. The veins extend along the strike for as much as 4,000 feet and are closely spaced in a belt a mile wide. The ore shoots are distributed erratically. The gold is generally associated with pyrite, chalcopyrite, sphalerite, and galena; manganese oxides occur in the oxidized zones.

The San Juan veins, in the La Libertad area, are 4–8 feet wide. The ores are similar in mineralogy to the ores of the Santo Domingo area, but they contain a higher percentage of silver. Supplies are generally transported by rail from the Pacific coast to Granada, then by boat to Puerto Díaz, and then by oxcart 50 miles eastward to the mines. An overland route passable only during the dry season extends around the lake.

MATAGALPA AREA

The mines in the Matagalpa district, about 80 miles north-northeast of Managua, are all controlled by the I. W. Bonbright Co., of New York. Supplies are brought to Managua on the Nicaraguan Railway and are then hauled by truck to the mines. The La Reina mine, 10 miles east of Matagalpa, has several quartz veins 2–6 feet in width containing small ore shoots. About 9,000 ounces of gold and 20,000 ounces of silver are produced annually from about 36,000 tons of ore.

LA INDIA MINE

The La India mine, operated by Compañía Minera La India (Spencer, D. N., oral communication), about 50 miles north of Managua in the Departamento de León, comprises 2 principal veins: the La India and the Guapinol, about 4,000 feet apart, which trend northeastward and dip 50°–70° NW. The La India vein is 6–15 feet wide and is composed of fine-grained quartz which encloses considerable clayey material. Sulfides are absent, and the gold occurs as fine particles in the quartz. The vein is mined by means of adit levels to a depth of 180 feet and for 2,600 feet along the strike. About 9,000 tons of ore is treated monthly, and the annual production is about 30,000 ounces of gold and 40,000 ounces of silver.

EL LIMÓN MINE

The El Limón mine, operated by the Empresa Minera de Nicaragua, is 25 miles northeast of León, in the lowland between Lago de Managua and the Golfo de Fonseca. The vein, discovered in 1940, is 15–25 feet wide and is traceable for nearly a mile along the strike; the wallrock is andesite. A treatment plant with a monthly capacity of 9,000 tons was put into operation in 1941. The production in 1945 was about 30,000 ounces of gold and 10,000 ounces of silver. The El Limón operation also includes the San Luis and Santa Francisca veins, which were worked early in this century and whose ore was treated in a 70-ton-per-day plant; this plant was closed in 1913. All the mines in the La India and El Limón districts are controlled by the Noranda Mines, Ltd., of Toronto, Canada. Freight is trucked from the Nicaraguan Railway to the mines.

VERDE MINE

The Verde mine, about 12 miles southeast of Matagalpa, was operated from 1920 to 1923 by J. A. Willey and others (Mines Handbook, 1925, p. 2264). Production totaling $15,000 net is reported to have been obtained with a 10-ton amalgamation plant. Two veins, each about 3½ feet wide, have been mined to a depth of 200 feet. One vein contains gold only, while the other also contains lead and copper minerals.

SAN ALBINO MINE

The San Albino mine is 23 miles east of Ocotal, in the Departamento de Nueva Segovia. The mine has been known since colonial days, but it was not until 1922 that Charles Butters and some associates put the property into production. The surface plant was largely destroyed by revolutionists in 1928, and the property has not been reopened since.

The ore body is a thick, lenticular quartz-pyrite vein several hundred feet long. It dips about 40°, parallel to the dip of the enclosing phyllites. Chalcopyrite is locally abundant in the lower levels. Other quartz veins are nearby.

OTHER AREAS

Placer-gold production in Nicaragua has been small but persistent; part of the gold is worked into filigree jewelry in the Caribbean coast towns. The principal placer areas are in the headwaters of the Río Pis Pis, the Río Bambana, and the Río Prinzapolka, but deposits are also known to have been worked in the streams of the Chontales district. In 1918 the Central American Exploration Co. (Mines Handbook, 1922, p. 1980) was formed to prospect in the gravels of the upper part of the Río Coco (also called Segovia and Wanks) between the villages of Bocay, at the junction of the Río Coco and the Río Bocay, and Huililli, about 40 miles upstream from the junction. The gravels were drilled during the 2-year exploration program, but the hydraulic program was not carried out.

EL SALVADOR

SAN SEBASTIÁN MINE

The San Sebastián mine is 3 miles west of Santa Rosa, a town on the Inter-American Highway, in the Departamento de La Unión (Wuensch, 1917). The mine is at an altitude of about 700 feet and can be reached by an all-weather road from Santa Rosa. Although the mine was probably known to the Spaniards and may have produced gold during colonial days, the first recorded production was by an American company in about 1890. Subsequently the mine passed to the Butters Salvador Mines, Ltd., and was in production from 1900 to 1920, when it was closed because of a decrease in the grade of the ore. The mill capacity was originally 1,200 tons a month and was later increased to 3,000 tons. In 1935 the mine was reopened, and production on a small scale has continued ever since. The mill capacity in 1945 was 40 tons a day. The recorded production of the mine up to 1945 was about $23 million worth of gold.

The adits, drifts, and winzes are about 20 miles long and extend along the strike for about 1,800 feet and down the dip for 800 feet. The rocks in the area are chiefly basaltic and andesitic lavas and pyroclastic rocks of Tertiary age.

The ore deposits are a series of branching quartz veins in a zone 50–200 feet wide which strikes eastward. Most of the veins dip northward at angles ranging from 40° to 70°; minor connecting veins dip steeply southward. The veins contain variable quantities of sulfides; the most abundant is pyrite, but there are minor quantities of chalcopyrite, chalcocite, bornite, tetrahedrite, molybdenite, and pyrrhotite. Small quantities of calcite, barite, and gypsum appear locally. Manganese oxides are present near the surface in some veins.

The ore shoots in the veins contained from a few tons to several thousand tons of ore. Most of the high-grade shoots were small and erratically distributed throughout the veins. Some shoots contained ore with 3–50 ounces of gold to the ton, but the average was only about 1½ ounces to the ton. Since the mine was reopened in 1935, the mill heads have been lower in grade, and some of the ore treated has come from old fills in the stopes which could be profitably treated when the price for gold went up to $35 an ounce.

DIVISADERO MINE

The Divisadero mine (Mines Handbook, 1925, p. 2259) is in the Departamento de Morazán, at the village of Divisadero on the Inter-

American Highway, about 18 miles west of Santa Rosa and 16 miles east of San Miguel, a station on the International Railways of Central America. The property was incorporated in 1905 as the Butters Divisadero Co., and between 1905 and 1918 it yielded 93,971 ounces of gold and 5,657 ounces of silver which together had a gross value of $5,194,967. Most of the ore came from the Divisadero, Matilde, San Francisco, Carolina, and Protectora veins, but a small tonnage came from the Gigante mine, 6 miles east of Divisadero. The value of the ore mined was reported to have ranged from $5 to $8 per ton. In 1919 the property was acquired by the El Salvador Silver Mines, Inc., and in 1923 it was sold to the Central American Mines, Inc. Except for an attempt to reopen the mine between 1933 and 1935, there has been no activity since 1923, and the mill, a cyanide plant of 350 tons daily capacity (Swanquist, 1941, p. 155), has been dismantled.

The workings extend to a depth of 700 feet down the dip of the Divisadero vein, which averages 65°, and for a length of more than 2,000 feet.

HORMIGUERO MINE

The Hormiguero mine (Mines Handbook, 1918, p. 1797) is 6 miles south of the Divisadero mine, in the Departamento de San Miguel. It comprises the Gallardo, Hormiguero, and Guadalupe veins. The property was controlled by the Comacaran Gold Mining Co. from 1909 to 1920, and from about 1914 to 1918 it produced 208,096 tons of ore yielding $1,478,824 worth of gold and silver. The ore was treated in a cyanide plant of 180 tons daily capacity.

The workings along the 3 veins are more than 37,000 feet in length. Mining extended 1,200–2,200 feet along the strike and to a depth of more than 460 feet. The ore is in quartz veins. The Hormiguero vein contains silver-bearing sulfides; the Gallardo and Guadalupe ores are gold bearing. The veins also contain pyrite, sphalerite, galena, and chalcopyrite; the chalcopyrite is locally altered to malachite and azurite, and the northern part of the Guadalupe vein contains considerable supergene manganese oxide.

MONTE MAYOR MINE

The Monte Mayor mine (Mines Handbook, 1925, p. 2264) is 14 miles northeast of the Divisadero mine. The mine is owned by Benjamín González, who was operating a plant with a capacity of 60 tons a day in 1945. The property comprises the Monte Mayor, Santa Gertrudis, Carao, Tempisque, Banadeto, and Las Tunas veins. The ore shoots developed were for the most part small, and the production over a 3-year period was worth $233,818. The ore was treated in a 10-stamp mill with a daily capacity of 60 tons.

POTOSÍ MINE

The Potosí mine is about 25 miles by road northwest of San Miguel. The property was first opened and explored by the Butters Potosí Co. in the early 1900's. In 1919 the mine was acquired by the El Salvador Silver Mines Co., and in 1923 it passed to the Central American Mines Co. In 1938 the property was taken over by the Compañía Minera de Oriente, and a 60-ton mill has been in operation since then. The ore is said to be in quartz veins in rhyolite and to be of high grade.

MONTE CRISTO MINE

The Monte Cristo mine is 15 miles east of San Miguel, on the Inter-American Highway, in the Departamento de Morazán. The property was put into production about 1933 by René Keilhauer and E. P. Thompson. The workings total 39,000 feet. A 100-ton cyanide mill powered by diesel-electric motors is used to treat the ore.

The ore is in several parallel quartz veins that trend northwestward and dip 50°–75° NE. in altered volcanic rock. Individual ore shoots are commonly small, but some contain as much as 100,000 tons with an average value of $10–$20 a ton, chiefly silver. The ore minerals are sphalerite, argentiferous galena, pyrite, and gold.

EL DORADO MINE

The El Dorado mine is about 8 miles west of Sesuntepeque, in the Departamento de Cabañas, on the road from San Rafael to Sesuntepeque. The property was acquired by the New York and Honduras Rosario Mining Co. in 1943, and since that time the company has been exploring a system of closely spaced parallel quartz veins, which strike northward in volcanic rocks. The principal mineral of value is gold, which accompanies sparse pyrite in the veins.

GUATEMALA

Gold placers are known in Guatemala along the Río Motagua, the Río Bobos, and also along smaller streams. Production at the present time is small, but between 1924 and 1933 a dredge at Las Quebradas is said to have produced as much as $250,000 worth annually.

LA CANOA PLACER DEPOSITS

The La Canoa placers are about 22 miles upstream from Progreso on the Río Motagua. The river at this point makes a bend several miles in radius and is intrenched in a narrow valley cut in serpentine and mica schist. The placer deposits are in the present channel and in gravel benches along the margin of the channel. Operations are generally carried on only during the dry season, between March and June. Attempts to employ mechanized equipment have been unsuccessful because of the short working season and heavy floods.

LAS QUEBRADAS PLACER DEPOSITS

The placer deposits at Las Quebradas are on the Río Bobos, a tributary of the Motagua, 35 miles southwest of Puerto Barrios. The Las Quebradas mines operated in 1917 and 1918. An area of about 300 acres, known as the Potts and Knight concession, was purchased in 1923 by the Guatemala Gold Dredging Co. This company (Ludlum, 1926) installed an 8-cubic-foot electrically operated dredge and began operations in December 1924. In the first 13 months of operation 1,312,000 yards of gravel was treated, with an average recovery of about $0.2124 a cubic yard, yielding a total value of $278,610 in gold bullion. Although much difficulty was experienced with heavy clay and large boulders in the gravel, operations continued until 1933, when the profitable gravels were exhausted.

The rocks in the headwater area of the Río Bobos are phyllite and schist intruded by granite and diorite (Sapper, 1937). Gold-bearing quartz veins are known to occur throughout this area, but none have been worked. These veins are probably the source of the placer gold that was concentrated where the Río Bobos emerges from the mountains.

PANAMA

Except for a small production from placers, no gold was being mined in Panama in 1945. Small-scale operations were formerly carried on in the Provincia de Veraguas and the Provincia de Darién.

VERAGUAS MINES

The Provincia de Veraguas contains the most productive gold properties in Panama. The Panama Corp., Ltd., acquired the properties in 1925 but later leased them to the Veraguas Mines, Ltd. Between 1934 and 1936 a total of 26,000 ounces of gold was produced from the Margaja and Cucuyo mines. The Remance and Mina Blanca properties also have been explored, but production figures are not available. The veins in the Provincia de Veraguas are in andesite. They contain gold associated with small quantities of pyrite, chalcopyrite, sphalerite, and galena.

PLACER DEPOSITS

Gold placers have been worked in the Provincia de Darién for many years. Before the arrival of the Spaniards in the 16th century, the Indians obtained gold from the stream gravels and fashioned it into ornaments. The Spaniards knew of these deposits and probably worked them, but in more recent times only the Indians have produced placer gold. From 1931 to 1941 the gold exported has averaged about 5,200 ounces a year according to the Section of Mines of the Ministry of Agriculture and Commerce, Republic of Panama. The greatest production was in 1934, when 13,895 ounces was exported.

Gold placers are also worked in the Provincia de Veraguas, in the streams below some of the gold mines.

TUNGSTEN DEPOSITS

Scheelite crystals were identified in a specimen of copper ore from the Metapán area. The locality was visited in November 1943 and was found to be just across the frontier in Guatemala, on the ranch of Felipe Herédia.

The rocks in the area are interbedded shale, sandstone, conglomerate, and limestone belonging to the Metapán formation of Cretaceous age. These rocks have been intruded by granite, granite porphyry, and granodiorite stocks. One of the granodiorite stocks that crops out on the Finca Herédia has intruded the shale and limy shale and altered them to hornfels, which is the host rock of the copper-tungsten deposits. Shear zones and fractures in the hornfels trend N. 50° W.

The ore minerals are chalcopyrite, pyrite, and scheelite, which occur in small pockets scattered throughout the hornfels, and also as disseminated grains. The scheelite grains range in diameter from the size of pinpoints to half an inch. Epidote, calcite, and quartz commonly occur with the ore-forming minerals. The sulfides are distributed erratically throughout a shear zone that is 8–12 feet wide, trends N. 50° W., and dips 60° NE. The copper content of the shear zone is low and is estimated to be less than 1 percent over a width of 8 feet. The outcrops were examined for scheelite at night with the aid of an ultraviolet lamp. Two rock faces were found to contain scheelite, but only a few crystals were seen. Elsewhere the rock is barren, but since much of the area is covered with soil and vegetation, other concealed occurrences may exist nearby. Many specimens of contact-metamorphosed rock from the Metapán and Alotepeque districts were subsequently tested for scheelite, but none was found.

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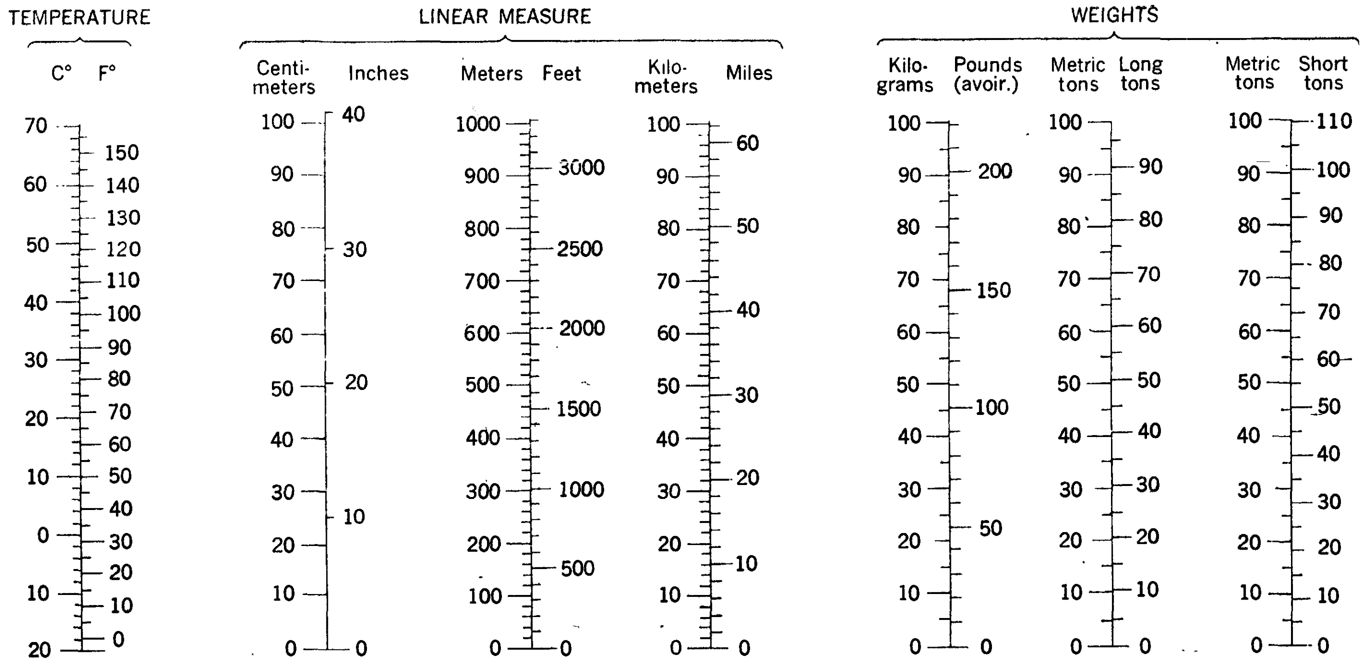
METRIC EQUIVALENTS



1 cm. = 0.3937 inch
1 inch = 2.5400 cm.

1 meter = 3.2808 ft.
1 ft. = 0.3048 meter
1 sq. meter = 1.20 sq. yd.
1 hectare = 2.47 acres
1 cu. meter = 1.31 cu. yd.

1 km. = 0.6214 mile
1 mile = 1.6093 km.

1 kg. = 2.2046 lbs.
1 lb. = 0.4536 kg.

1 metric ton = 0.9842 long ton
1 metric ton = 1.1023 short tons
1 metric ton = 2205 lbs.
1 long ton = 1.0161 metric tons
1 short ton = 0.9072 metric ton

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