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COMMENTS ON THE RELATIONSHIP BETWEEN SOILS, GEOMORPHOLOGY AND STRATIGRAPHY IN NORTHERN CENTRAL AMERICA

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I. Soils

In Northern Central America, the best agricultural soils, that is, those soils adapted to intensive use for producing annual and perennial crops, occur on Pliocene to recent colluvial deposits derived from Quaternary and Tertiary volcanic formations which are largely rhyolitic and andesitic in composition. With the exception of low-lying coastal Quaternary colluvial deposits, which by and large are poorly drained, one can make a general statement that good agricultural soils are found in Northern Central America wherever Quaternary colluvium is found. In Guatemala, other soils of good agricultural potential are also developed over the Sepur red beds of Eocene Age and the Toledo limestone also of Tertiary Age. Some soils of good potential are found developed over the Cretaceous Cobán and Ixcoy formations which are largely limestones and dolomites. It is interesting to note that essentially no soils of good agricultural potential are developed over metamorphic rocks, even though large amounts of these are exposed in the central portions of Guatemala.

Chemical analyses of rhyolites and andesites, which are the parent materials for the most extensive areas of agriculturally important soils in Northern Central America, reveal for rhyolites1/. K_2O, 4.0%; P_2O_5, 0.1%; MgO, 0.4%; CaO, 1.3%; and MnO, 0.1%; and, for andesites2/, K_2O, 2.4%; P_2O_5, 0.2%; MgO, 2.5%; CaO, 5.5%; and MnO, 0.1%. It is interesting to note that foliar deficiency symptoms for P and Mg are quite universal in the Pacific coastal plain soils which are derived from these materials; Zn, B, S, Mn and Fe deficiencies are also sometimes imagined but it is a difficult task to be certain when faced with an apparent multitude of deficiency symptoms in a single plant. Certainly, in view of the composition of the parent materials, deficiencies of the latter five elements would not be surprising.

II. Geomorphology3/

Central America comprises three principal physiographic units; 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 to El Salvador and Southern Honduras; and a Southern unit, of folded strata and volcanic rocks in Costa Rica and Panamá.

1/ Mean of 64 analyses, Daly, Igneous Rocks and Their Origin, 1914, p. 19.

2/ Biotite and hornblende andesites, mean of 18 analyses. Osann-Rosenbusch, Gesteinslehre, 1923, p. 405.

3/ Direct quotes or loose paraphrases from:
U. S. Geologic Survey Bulletin 1032; "Mineral Deposits of Central America", Ralph J. Roberts & Arvel M. Irving, U. S. Government Printing Office, Washington, D. C., 1957, 205 pp.

Each of these three major units can be subdivided into physiographic provinces. The northern unit contains the Petén lowland and the Antillean Cordillera; the middle unit comprises the upper Pacific Cordillera and the Guatemala-El Salvador Coastal Plain. The southern unit contains the Nicaraguan lowland, the Costa Rica coastal plain, the Central Cordillera of Costa Rica and Panamá, and the Pacific coastal plain.

The Northern Unit

The Petén lowland, which is underlain by folded tertiary rocks ranges in altitude from about 500 ft. on the west toward Mexico, to 2,000 on the east and south, where it merges with the Antillean Cordillera.

The Antillean Cordillera, a belt of folded Cretaceous and older rocks that extend through Central Guatemala and Honduras into Nicaragua comprises rugged, deeply dissected ranges whose average altitude is more than 4,000 ft. In Western Guatemala the Cordillera rises to about 13,400 feet.

The Middle Unit

The upper Pacific Cordillera is a dissected volcanic plateau extending from Chiapas, México to Southern Honduras and El Salvador into Central Nicaragua. The altitude of this plateau ranges from 10,000 ft. in western Guatemala to 8,000 ft. in Gracias, Honduras. It drops to 4,000 ft. in Nicaragua where the upland slopes southward toward the Pacific Ocean. Volcanoes built upon this plateau by Tertiary and Quartinary eruptions are aligned along the Pacific coast; the highest of these volcanoes is Tacaná, 13,816 ft. in altitude, at the Mexico-Guatemala border. This volcanic plateau is only partially dissected in Guatemala, but in El Salvador and Honduras its dissection is so advanced that only few remanents of the original upland surface remain. This volcanic plateau is bordered on the Caribbean side in Honduras and Nicaragua by a coastal plain, which, although absent in the places where the ranges are truncated at the coastal line, elsewhere ranges in maximum width from 15 miles in Honduras to 50 miles in Nicaragua.

The broad colluvial plain extending southward up the Río Ulúa Valley is a graben, which extends from near the Caribbean coastline in Honduras southward into the Golfo de Fonseca. This graben is part of the prominent transverse valley which extends across Honduras.

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

The Pacific coastal plain in Guatemala is prograding because of the enormous volume of detritus that is being carried southward by streams that drain the volcanic chain. Farther southeast, in El Salvador, the Pacific coastal plain is narrow and has a rugged shoreline that has

been actively eroded, althoug raised terraces at about 40 and 100 ft. above sea level indicate that the most recent coastal movements have been emergent.

The Caribbean coastal plain has also been recently uplifted. Near Livingston, Guatemala, coral reefs of Pleistocene Age are several hundred feet above sea level, and along the Caribbean coast of Honduras and Nicaragua, uplifted terraces show evidence of Pleistocene and recent emergence. In Costa Rica and Panamá, on the other hand, the principal movement has been submergent, though in places. Recent emergence is indicated by raised terraces.

Southern Unit

The southern part of Nicaragua is separated from the Northern part by the Nicaraguan lowland, which Hayes in 1899 described as a peneplain cut on Eocene and more recent rocks. The lake of 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 continue southward into Panamá. The Cordillera Central of Costa Rica is, in part, a volcanic plateau above which volcanoes rise to a height of 11,326 ft. Southward, this plateau grades into the rugged and dissected Cordillera Central of Talamanca, which is composed of intrusive igneous rocks and sediments and which continue Southeastward into Panamá where the Pacific coastal plain varies in width but is mostly less than five miles wide. Three peninsula ranges, the Nicoya, the Osa and the Burica, are connected with the mainland of Panamá by low colluvial plains. On the North these peninsulas are bounded by volcanoes. Panamá is a continuation of the Cordillera Central of Talamanca. Except for a narrow coastal plain in some places, the isthmus consists mainly of discontinuous ridges. A number of volcanoes rise above the ridges in north western Panamá.

III. Stratigraphy[1/]

Pre-Permian Rocks: Metamorphic rocks are widespread in Guatemala, Honduras and Nicaragua where they crop out in a belt extending eastward from Chiapas in México through Huehuetenango in western Guatemala, making up the Sierra de Chuacús, the Sierra de las Minas, the Sierra del Espíritu Santo, and the Caribbean coastal ranges of Honduras and Nicaragua. These metamorphic rocks comprises thicknesses of garnetiferous and micaceous gneiss, mica schist, andalucite and garnet schist, quartzite, and marble. In places the metamorphic gneiss grades into intrusive granite-gneiss and granite. Lower grade metamorphic rocks such as phyllite, quartzite, schist, and marble are also found within this belt, especially in Honduras and Nicaragua.

1/ Direct quote or loose paraphrase from:
U.S. Geologic Survey Bulletin 1032; "Mineral Deposits of Central America", Ralph J. Roberts & Arvel M. Irving, U.S. Govt. Printing Office, Wash., D.C., 1957. 205 pp.

Rocks of Paleozoic Age: Rocks of Paleozoic Age, primeraly limestones and associated sedimentary rocks, are widespread in Northern Central America and form a belt as much as 22 miles wide adjoining the metamorphic belt on the Caribbean side of Guatemala and extending eastward to Puerto Barrios. In British Honduras, lithologically similar strata make up the Maya Mountains and in Honduras and Nicaragua they crop out in the Caribbean coastal ranges. In Guatemala, the strata of Paleozoic Age that have been dated consists of two formations of Permian Age: the Santa Rosa formation of Permian Age, and overlying limestone and dolomite beds called the Chochal limestone.

The Santa Rosa formation is the name applied to strata exposed near the Village of Santa Rosa in the Departamento of Alta Verapaz in Guatemala. The formation consists of interbedded sandstones, shale, limestone, puddingstone and marl, grading upward into overlying limestone which Sapper called the Carbonkalk. The Santa Rosa formation is exposed almost continuously westward into Mexico, where in Chiapas its thickness is reported to be from 1,000 to 3,000 feet.

Chochal Limestone: The Chochal limestone of the Sierra de los Cuchumatanes extends eastward (toward the Caribbean) from the Santa Rosa Formation area and forms prominent cliffs over 500 feet thick in the ranges near San Cristóbal, Cobán, and Panzós.

Rocks of Mesozoic Age: Rocks of Mesozoic age underlie much of the northern part of Central America; especially on the Caribbean side North of the belt of rocks of Paleozoic and pre-Paleozoic age in Guatemala and Honduras. Sections of Mesozoic age generally include basal redbeds overlain by interbedded limestone, dolomite, and shale. The Paleozoic age ended in Central America with an orogeny during which the rocks of Paleozoic age and older were folded and cut by granites and serpentine intrusive bodies. The older Mesozoic rocks have been assigned to the El Plan (Tegucigalpa), todos Santos and Metapán formations. The sections are revealed near Tegucigalpa and San Juancito, Honduras, consist of alternating members of plant-bearing dark gray shale and siltstone with some argillaceous sandstone and pebbly conglomerate. The thickness is about 3,000 feet. The Todos Santos formation is named after a village in the Departamento of Huehuetenango in Guatemala. It comprises about 1,200 ft. of interbedded reddish-brown sandstone, shale and conglomerate. In places, the green shales and gray limy shales are intercalated and thin limestone lenses are present. The Todos Santos formation rests unconformably on folded and metamorphosed rock of the Santa Rosa and older formations. In San Miguel, Acatán, the Todos Santos formation is overlapped by limestone and dolomite of early Cretaceous age. 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, the upper Todos Santos strata are marl, shale, and sandstone and include interbedded gypsiferous and salt bearing strata indicating a change northward toward Mexico from terrestrial to marine conditions of deposition. In eastern Guatemala, El Sálvador, and Honduras, redbeds lithologically similar to the Todos Santos strata have been named the Metapán formation. Near Concepción, in Guatemala, the Metapán formation rests on con-

torted schist which has been assigned to the Paleozoic Age. The lower part of the Metapan formation includes interbedded sandstone, conglomerate, shale, volcanic tuff, and marly beds. The beds are mostly dark red but some are purple, dark green, yellow and brown. 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 in El Salvador and at El Sillón near Concepción in south-central Guatemala near Jutiapa. In Northwest Guatemala, the Todos Santos formation is overlain by limestone which is called the Ixcoy formation. The Ixcoy formation comprises over 2,000 ft. of interbedded limestone and dolomite and is the host rock for 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 interformational conglomerates and breccias possibly formed during periods of minor crustal movements. In northwestern Guatemala, the Ixcoy formation is in fault contact with limestone and dolomite of the Cobán formation.

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. The oldest Tertiary rocks occur in northern Guatemala and comprise the Sepur formation of Eocene age. This formation consists 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 (toward El Petén and Mexico) the coarse facies grades into yellow marine clay and marl that are interbedded with yellow sandstone, conglomerate, and limestone. The conglomerate, and limestone. The conglomerate beds are composed of pebbles of andesitic volcanic rock, limestone, schist, and quartzites. Judging from the increasing coarseness of the Sepur strata southward, they were probably derived from highland areas in Central and Southern Guatemala and western Honduras.

Quaternary System: The Quaternary deposits underlie large areas in Northern Central America. 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. The belt of Quaternary deposits along the Atlantic Coast is narrower, and marine terraces are found in some places. Quartzose sands underlie Caribbean coastal savannas in Honduras and Brithish Honduras.

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 Age. Some of the volcanoes are still active and ash falls have contributed large volumes of material to the soils and recent deposits.

Igneous Rocks

Intrusive Rocks: Intursive rocks form a considerable area within the belt of pre-Permian metamorphic rocks that crosses Northern Guatemala, Honduras, and Nicaragua. 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 prophyry are scattered over Central Guatemala, Honduras and Nicaragua on the Pacific side 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.

Near San Miguel Acatán, Departamento de Huehuetenango, Guatemala, unfoliated granite cuts shale of the Santa Rosa formation. Bodies of serpentine are found on the Petén side of the metamorphic belt from the Departamento de Huehuetenango eastward nearly to Puerto Barrios; these are lenticular and are distributed along faults. Serpentine intrusions form an important part of the Central Ranges of Guatemala. Two principal serpentine belts have been mapped--one on the north of the metamorphic belt extends from San Sebastián (near Huehuetenango) eastward to Salamá, then from Panzós nearly to Puerto Barrios; the other, in the southern part of the metamorphic belt, extends from Saltán eastward toward El Salvador, separating the Metamorphic rocks into two parts. Both belts follow zones of strongly deformed rocks, probably along major faults, and therefore otuline the principal structural features of Guatemala. In Central Guatemala, Honduras, Nicaragua and El Salvador, small intrusions of diorite, granite prophyry, granodiorite, and quartz monzonite cut sedimentary rocks as young as Cretaceous. In southern Guatemala, southern Honduras, El Salvador, and Nicaragua (on the Pacific sides) 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.

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 when predominantly rhyolitic pyroclastic rocks and andesitic flows appear to have been extruded. The early volcanoes which gave rise to the pyroclastic material and flows have largely been eroded so that only their roots remain. The chain of recent volcanic cones which borders the Pacific slope of Central America is built upon the earlier eroded volcanic plateau much as Mt. Ranier 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 the late Pliocene and Quaternary time, for many of them are very little eroded. Pyroclastic rocks and flows forming these cones, many of which are still active, are largely andesitic in composition, but some cones in Eastern Guatemala are basaltic. In Western Honduras in the Departamento de Gracias, the Tertiary sequence is 600 to 1,000 feet thick and consists of clay, sandstone, volcanic ash and conglomerate along with some marl. In Salvador, Tertiary rocks include both early Tertiary basic lavas and felsites mixed with pyroclastic rocks and sediments and late Tertiary pyroclastic deposits mixed with andesitic and basaltic lava flows. 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.