A RECONNAISSANCE AMONG SOME VOLCANOES

of

CENTRAL AMERICA.

by

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I SCOPE OF THESIS

It is the purpose of this thesis:

A. To make a concise summary of the geology of the region between Venezuela and Mexico, as contained in the available literature, and supplemented where possible by data of the reconnaissance.

B. To make a petrographical study of specimens collected.

C. To make a limited chemical study of specimens collected.

D. To make generalizations from the data at hand, in the light of various hypotheses, and more particularly, in the light of information under "A".

E. To outline a course of future investigation.

F. To compile a bibliography of the region. This is to be found in Volume II.

II ACKNOWLEDGMENT

It is difficult for a pupil to express his admiration and his affection for his Master. Those who have not also felt the guiding hand will not understand, and the Master will be sure to minimize. Yet I can not allow this occasion to pass without making acknowledgment of the deep debt in which I feel myself placed toward Dr.Waldemar Lindgren. More patience, more understanding, more devotion toward the

men under his care can hardly be imagined. Perhaps my deepest sense of gratitude lies in the fact, that although Dr. Lindgren is always right, he never makes one uncomfortable by exposing the enormity of his stupidity on the spot. He arranges it so that full realization comes in the introspective hours of night, and not in the embarrassment of his presence. I can do little else than thank him heartily for his endless patience, and to register a sincere hope that in my application of his teachings nothing will transpire unworthy of his tradition - a high hope admittedly; but at least a hope towards which one may be permitted to strive.

III CAUSE OF RECONNAISSANCE

The reconnaissance was undertaken during the months of February, March and April of 1922, at the immediate suggestion of Professor W.F.Jones, and with the approval of Dr. Lindgren, as being the most fortunate use to which these months could be put, while waiting for the permission of the occulist to resume undergraduate work at the Institute.

IV SCOPE OF RECONNAISSANCE

Purpose

It was planned to make a cursory examination of the volcanoes studding the Pacific Coast of Central America, to collect specimens of various phases and periods of activity, to study these specimens chemically and petrographically, to make ascents, barometric measurements of altitude, plane table surveys of craters, and to take photographs. Personal obligations caused the reconnaissance to be abandoned after Ometepe had been visited and the notes from here North were made while attempting to reach New York as quickly as possible.

Route

The route followed is indicated on the accompanying sketch map of Central America (Plate XXVII). This map shows two routes, one followed in 1921 and one in 1922. The latter was, unfortunately, the itinerary of a "pleasure" trip, during which little, if anything, of a worth while nature was accomplished.

V ACKNOWLEDGMENTS

The idea of undertaking this work was Professor Jones', as were also the letters of introduction to people

in these parts, who, through their interest and hospitality, made the trip a possibility. To Professor Don J. Fidel Tristan, in San José, Costa Rica, Director del Colegio de Señoritas, is due a full measure of thanks, for his enthusiastic coöperation while in his country, and for his interested correspondence since. To the Secretary of War of Costa Rica, Don Julio Acosta, thanks are likewise due, for he was sufficiently interested in the work to present the author with a civil and military pass, and to enlist the coöperation of the Armed Forces of the Republic in the work, which, once, at least, proved useful. Don Ricardo Fernandez Peralta, a gentleman of leisure and scholarly attainment, was good enough to accompany the author up both Turrialba and Irazú, and further, made a presentation of bound copies of "La Revista" containing many articles on local volcanism.

Most earnest thanks are due Don Jorge Antonio Moreno of San José, Costa Rica, who obtained for the author the services of Felipe Guevarra, an Indian retainer of his, who probably possesses the reputation of being one of the most expert and daring bushmen in the tropics. Without this man, the reconnaissance would have been difficult.

Dr. Barrios, of Santa Rosa, was also good enough to supply mules for that part of the trip from Rincon de la Vieja to Rivas, in Nicaragua.

The Jefé Politico of Rivas was also most kind with assistance, and with the patronage which it was in his power to dispense. Again, the Minister of War of Nicaragua, and the Minister of Finance of Guatemala are to be thanked for their interest and official patronage and indeed, the general air of cordial hospitality extended throughout the length and breadth of this country leaves a very agreeable memory.

VI PREVIOUS WORK

There has been a general lack of interest on the part of scientists toward those regions between Guatemala City and Colon, and especially so upon the part of geologists. This is perhaps to be attributed to the general impression that the region is one of morass and malaria, in part to the fact that economically it is now unimportant in the general scheme of things, but probably the basic cause of this apathy is that it has not been the fad during the past three or four decades to explore Central America. We have had the "Darkest Africa" vogue, the "Land of the River of Doubt" vogue, the "Great Northwest" vogue, the vogue of the "South Sea Islands", and the "Friendly Arctic", but only very recently has the popular consciousness reacted to Central American stimuli.

In consequence, the country is blessed with the almost entire absence of the automobile, the motorcycle, the movie, the subway, the radio and the other abominations that modern devilish ingenuity has foisted upon us. The forests are virgin, the soils do not yet need potash, and the peasants are ignorant, dirty, syphillitic and undeniably happy. Of this region, the botanist may be said to know about 60 per cent (1), the zoölogist perhaps 30 per cent (2), and the geologist perhaps 5 per cent.

For these 5 per cent we are indebted to the labors of comparatively few men. An extended bibliography of the region forms Volume II of this Thesis, and it will be sufficient to mention here only a few of the more prominent workers.

Humboldt.

First of these was Baron Friedrich Alexander Heinrich von Humboldt, 9/14/1769 - 5/16/1859, who was the first trained traveller to become interested in the little known Central Americas. His travels were limited to Mexico, however, and were made in the earlier years of the Nineteenth Century. He gave fame to the birth of Jorullo (3),(1759), through his vivid, though almost certainly exaggerated account of this startling event. He also laid down the doctrine of the continuity of the Pacific Cordilleras from Alaska to Terra del Fuego, and his observations were far ahead of his

time, yet, apart from actual dimensional facts, there is little that a modern investigator is to gain from a perusal of his immortal "Cosmos" save reverence for a great traveller.

Dollfus et de Mont-Serrat

In the three decades following 1830, Dollfus and de Mont-Serrat carried out their "voyages géologiques" in the Republics of El Salvador and Guatemala, and observed and recorded much that is of general interest (4), Perhaps their best known contribution to vulcanologic literature is their description of the mighty and awe-inspiring explosive eruption of Cosegüina, in April of 1835. (5). Their work was not intended to be of a detailed nature, and they did little more than to sketch in the ground-pattern to be followed by later travellers.

Von Seebach

During the period of the Civil War, a German scholar and traveller, Karl von Seebach, made numerous travels through regions of Costa Rica, and neighboring parts, studying principally the volcanoes, and making numerous ascents and more or less general descriptions which are to be found in various references in Petermann's Mittheilungen for the years 1860-1870, and are further listed in the Bibliography.

Gabb

The first man to carry on an investigation in these parts who may be styled a trained geologist, was William Gabb

who, in 1873, (6) penetrated the hitherto unknown and forbidding tropical jungle of the Talamanca Valley, structurally separating the volcanic plateau of Costa Rica from the zone of Tertiary orogeny to the southward. He spent eight weeks making a reconnaissance, proving the absence of economic deposits, robbing Pico Blanco of its glamour of being a volcano, but at the same time allowing its summit to rob that of Irazú of the proud boast of being the only point from which one may view both the Atlantic and the Pacific. He also collected fossils, and laid the foundations for our present day sketchy knowledge of Talamancan geology.

Hayes

The first, and indeed only, reconnaissance of regional geology between Guatemala City and Bogotá, which maintains the standards of present day work, is that of C.W.Hayes, on southern Nicaragua, for the Nicaragua Canal Commission, in 1899 (7). It is practically the only authoritative report, made in the light of more modern theories and field technique, upon the Central American region.

Vaughan

In 1910, (8) acting under the cooperation of the Smithsonian Institution, the United States Geological Survey and the Isthmian Canal Commission, Vaughan, with the collaboration of others, began a work which culminated in 1919 in a

Bulletin of the National Museum, being a full report upon the Stratigraphy of the Canal Zone, and the Physiography of the Carribean in general. Frequent reference will be made to it.

Sapper

It is Karl Sapper to whom we owe most of our knowledge of Central American geology and physiography. He is primarily a geographer, and has covered a vast amount of territory in a general way, reporting his observations so as to be of service as the background for future work.

This distinguished traveller was energetically in the field for twenty years or more, covering all parts of Central America during the closing years of the old century, and the opening of the new. He seems to have been principally interested in Guatemala, Chiapas and Yucatan, however, and it is in his publications on these regions that one finds the most of value from a practical standpoint. His publications are several and are mentioned in the Bibliography.

There are many who have either treated of the region in a popular manner, as Squier, Stephens and others, or who have studied limited areas, as Romanes, Fletcher, Pittier, or MacDonald, to whom reference will be made from time to time, and to whom references will be found in the Bibliography.

VII GENERAL REGIONAL AND HISTORICAL GEOLOGY

The attempt to sketch the geological background for the volcanoes is fraught with difficulty. There exists no summary of Central American Geology which is known to the writer. The literature is scattered over a period of years, and in several tongues. The summary here given is based upon what material was available in the libraries of Boston. It is doubtless far from complete, and is certainly inadequate.

In the first place, as Hill (9) (10) has demonstrated, Humboldtian geography must be discarded. This great traveller was not able to observe farther south than Mexico, a fact which he deplored at the time and regretted later, and it is probably due to this that he taught the continuity of the North, South and Central American cordilleras from Alaska to Tierra del Fuego.

The cordilleras of Central America have a dominantly east-west trend (11). On the north they are abruptly separated from the Mexican plateau of Ransome (13) by the fault scarp (12) which traverses the greater part of Mexico in an east-west direction not far south of Mexico City. On the south they are separated from the trifurcated terminus (14) of the Andes by the mountainless district of eastern San Blas (in Panama). They are thus Antillean in affinity,

and to be considered as a tectonic system quite distinct from either of the great north-south cordilleras flanking them.

Further; the North American Cordillera dominates a continental land mass, and the Andes dominate a continental land mass, while the Antilles dominate an enclosed area of depression, the complex Caribbean basin (15).

These general distinctions are based upon structural relationships whose inception dates from the lower Paleozoic, or earlier.

Pre-Cambrian

The east-west lineaments in Oaxaca, along the eighteenth parallel, are granites and gneisses of Archean age (16), and constitute the most northerly of the east-west lineaments arranged en echelon throughout Central America. Between the fourteenth and sixteenth parallels, in Chiapas, and in Guatemala, Sapper (17) reports granites, talc and chloritic schists, quartzites and porphyries, capped by a Silurian limestone, and trending east-southeast. He considers them to be pre-Paleozoic, and in part Azoic. Willis (18) has mapped them as pre-Cambrian. They form the Sierra Madre del Sur, which numbers among its peaks that of Tacanà, the highest peak in Chiapas, (4,057 M (19), 3,990 M (20), and the northernmost volcano of Central America.

At the southern end of this orogenic belt Sievers (21) and others have described granitic ranges in the 7th longitude stretching from Porto Cabello on the Venezuelan Coast to the northeast end of Trinidad, to which they assign an Archean age.

Belt (22) describes Laurentian rocks in Nicaragua, whose age Hill (23) considers doubtful, but which Willis maps as pre-Cambrian. In Honduras and Nicaragua "fundamental granite" of Archean age is mentioned by Vaughan (24) and mapped by Willis (25) as pre-Cambrian. This is probably that to which Sapper refers as having an east-west trend.

In Costa Rica, débris determined as granitic by Wolff was found in Eocene sediments by Hill (26), who also found granitic material along the Rio Chagres in Panama, and Vaughan (81) considers these suggestive of further lineaments, presumably east-west, and perhaps of Paleozoic age. There seems to be no reason, however, why these might not just as well be Miocene, q.v.

Paleozoic

The lower Cambrian Paleogeographic map of Schuchert shows Honduria as a positive element, extending some 700 miles in an east-west direction, and about 250 from north to south, its center being considerably to the east of Tegucigalpa. It was separated from "Colombia" on the north by the shallow east-west sea of Tehuantepec, and

on the south by a shallow ? marine transgression as far as the present northern coast of South America.

Thus, the dominant tectonic characteristics of this region had become established, and its general outlines carved, before the lower Paleozoic.

During the Paleozoic (28), the region as a whole can be said to have been fairly stable. "Honduria" was a positive element throughout. Epicontinental seas came and went over the Isthmus of Tehuantepec, and over the region between the Lake of Nicaragua and the north coast of South America.

Carboniferous

In this northern trough, Paleozoics of undetermined age were laid down over Sonora, Chiapas, parts of Guatemala and in Honduras (29). Shallow water Carboniferous (30)(31) deposits to a maximum thickness of 1,100 meters were laid down over Chiapas and the Santa Rosa district of Guatemala:

(a) In either the lower Pennsylvanian or the upper Mississippian, and;

(b) In the upper Pennsylvanian (32).

Oscillations caused "Honduria" to be connected with "Antillia" and "Columbia" from time to time, but there was no Paleozoic landbridge into "Archiguiana" to the southwards. In the Devonian, sediments were laid down in northeastern Nicaragua, as reported by Mierisch (82).

Permian

In the lower Permian (33), the shallow trough of Tehuantepec was uplifted, while between Corinto and the north coast of South America the Caribbean Mediterranean was apparently in fairly constant connection with the Pacific throughout all Paleozoic time.

At the close of the Paleozoic, during the Permian, epirogenic movements of some magnitude took place in southern Yucatan, British Honduras, Guatemala and Honduras (34), - perhaps concomitant with granitic intrusions, and having a rough east-west alignment. It was then that the two ranges separated by the Rio Motagoa (83) had their birth, as also the Coxcomb mountains in Yucatan. It is to be noted that the major tectonic trends of Cuba are east-west, and probably Paleozoic, as also those of the Mosquito and Rosalind banks, Jamaica and the perimeters of the Gulf of Mexico and the Caribbean (35).

Mesozoic

The Mesozoic history of the region is likewise more or less shrouded in mystery (36).

Triassic

The Triassic was, in general, a period of emergence of North America, including Central America (37). Although an interoceanic connection in the lower Triassic has been urged, its need, on logical grounds, is not apparent (38), and

it seems doubtful at best (39). The same may be said of the middle Triassic, during which time the sea retreated somewhat farther, although J.P.Smith (40) has here again urged a connection. The upper Triassic saw marine deposits of Karnic age near Zacatecas (41), in Mexico, and this, in addition to certain faunal requirements (42), makes it probable that there was a connection (43) between the Atlantic and Pacific over a part of southern Mexico at this time, although Schuchert (44) prefers to make this connection over the long depressed Isthmian region. That there was a connection somewhere is nearly certain.

The upper Triassic submergence was of slight duration (45). Either the uppermost Triassic or lowest Jurasic, or both, were scenes of continental sedimentation. Newberry (46) (47) has described plants from this horizon in Honduras and Sonora as Rhaetic, while Wieland (48) has described somewhat similar[a] species from Oaxaca as lower Jurassic, as has Logan (49) from Vera Cruz and Pueblo. Similar non-marine deposits are recorded in Chiapas (50)(51), Guatemala (52)(53), Honduras (54)(55), and Nicaragua (56)(57)(58).

Jurassic

There is strong evidence (59) of an interoceanic connection in southern Mexico during the lower and middle

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[a] The correctness of this classification is doubted by Knowlton (61).

Jurassic, with a greater submergence in the upper Jurassic (60), the evidence being the presence of marine beds here, and foreign faunas in the collections.

Cretaceous

All the evidence (62)(63)(64) points to a continuous land barrier between North and South America, to the westward of the present Pacific coast line during the Cretaceous, since the greater part of Mexico is overlain by marine Cretaceous of Gulf affinities; this, despite the fact that the 100 fathom line lies only from 10 to 100 miles off the coast and the 1,000 fathom line is parallel, and only a little farther out. The 1,500 fathom line at the equator sweeps out beyond the Galapagos, while the 2,000 fathom line sweeps out opposite the Gulf of California as well as on the equator (65). These facts may be significant.

The Mesozoic came to a close with no great diastrophic movements in Central America, although the great chains of Mexican volcanoes were born either (66) then or in the very earliest Tertiary (67).

Cenozoic

Eocene

The lower Eocene was a period of emergence (68) of Central America, while in the middle (69), and especially in the upper Eocene there was extensive submergence, and inter-

oceanic connections over the Isthmian region (71), during which a few hundreds of feet of andesitic ejecta, flows, and mud-flows accumulated in shallow water (70), intercalated with coarse detritus, while just south of San José in Costa Rica, the shallow, impure, sandy Candellaria limestones were laid down under a shower of glassy andesitic ? "ash" (72), and farther north, the Brito formation of the Pacific Coast of Nicaragua, also characterized by andesitic ? ejecta and shallow water detritus, was being laid down. The latter was probably derived from land to the westward (84).

Vulcanism was active, not only in the Isthmus, but farther north, in Panama, and in Costa Rica, while Central Mexico, Washington, Idaho, Oregon, and parts of Utah and California were the scenes of intense, though not similar, phases of vulcanism (73). Cuba, Hayti and Porto Rico were also in travail at the time, the latter two being loci of submarine eruptions (74).

Oligocene

The lower Oligocene probably witnessed a lessening of the intensity of vulcanism throughout the Pacific Coast. In the United States it was restricted to an area in south-eastern Oregon, in Mexico it had ceased, and in the Isthmian region it was sporadically present at different horizons (75) (76), but had apparently ceased by the close of the upper Oligocene (77) (129). There may have been an interoceanic

connection at this time. During middle Oligocene the maximum submergence occurred, and there were many interoceanic connections (85). The Oligocene in Panama amounts to some 2,000 feet of fossiliferous shallow water and torrential deposits, with some andesitic material, indicating an interoceanic connection (78)(79). Paleobotanical evidence leads Berry to the conclusion that the Oligocene here was short, and the relief under 5,000 feet (80).

Diastrophism between the upper Eocene and the middle Oligocene was intense (86). The principal mountains of Jamaica, the Sierra Maestro of Cuba, and those of Hayti, Porto Rico, the Virgin Islands and Saint Croix, were formed then. Diastrophism also was active in Chiapas, Tabasco, near Peten in Guatemala, in Nicaragua, Costa Rica and Panama. In the Nicoya Peninsula of Costa Rica the folding was accompanied by intrusion of teschenite and limburgite (87), while a monzonite (88) was intruded into the Candellaria limestones to the southeast.

Miocene

There is no evidence of an interoceanic connection during the lower or middle Miocene in Panama (110), but Vaughan (89)(112) definitely postulates a restricted connection in southern Nicaragua and at other points northward during this time. Schuchert does not accept this, showing an invasion only as far as the Island of Ometepe in the Lake of Nicaragua.

The upper Miocene was a period of general emergence of Central America (90), connecting North and South America by a land bridge. Zoogeographic evidence (91) also demands a connection, either here, or in the early Pliocene, between Yucatan, Cuba, Haiti, Porto Rico and the Virgin Islands, and further, between Honduras and Jamaica, and between Anguilla and South America. In Chiapas and Guatemala this elevation reached the astonishing figure of 12,500 feet (92). In eastern Costa Rica (93) and in the Talamanca (94), the uplift was from 3,000 to 5,000 feet, while in Haiti, Cuba and Jamaica it was 10,300, 8,000, and 7,250 feet, respectively (95). It was also felt in Porto Rico, Anguella and Antigua (96). This emergence was characterized by a renewed intensity of vulcanism throughout the Isthmian regions (97), (there had been some in the lower Miocene (98)), where andesites, rhyolites (99) and basalts were extruded, as also in a broad belt reacing (100) from northern California to Dawson in the Yukon. Granite intrusions (101) also took place on an important scale in the great Antilles (102), the Caribbean, (103), eastern Costa Rican (104) and Panamic regions (105), and in the San Blas (106).

The intrusions in the Talmanca were accompanied by folding and metamorphism which progressively died away to the northward, until, on the northeast flanks of Turrialba, the Oligocene strata are horizontal (107).

In Panama the lithologic character of the Gatun beds, (middle and upper Miocene (108)) is such that a land mass to the westward must be postulated (109).

Pliocene

The Pliocene, and later, was a period of cataclysmic faulting (114), during which the Bartlett Deep was formed, Yucatan was separated from Cuba, Cuba was separated from Hayti, Hayti was separated from Porto Rico, and the West Indian islands were down-faulted from a larger land mass. The land bridge between Honduras and Jamaica also disappeared at this time. There was limited marginal submergence of the West Indies (115), and Panama and Costa Rica, and probably also a narrow interoceanic connection existed across the Isthmus of Tehuantepec(116)(117)(118)(119) . At this time also, there may have been some folding in Yucatan, Guatemala and Honduras. (120).

After the Miocene, vulcanism became quiescent in the Great Antilles and the Coastal Plain of Texas, but continued to the Present in four great foci of activity; (1) southern Mexico; (2) the northern Andes; (3) Central America; and (4) the Windward Islands, to which might be added, northern California and Washington (121). The volcanic heights of (3) and (4) are thought by some to have been piled up before the Pliocene, and all agree that the present craters are merely secondary and expiring phenomena (122).

Pleistocene

The Pleistocene was in general a period of emergence (123), probably due to the withdrawal of water by glaciation, and complicated by local differential movements at which time, possibly, the Toro (Pliocene) limestone in Panama was gently arched (124). Vulcanism in the four great foci was intense, perhaps most intense in Central America.

Recent

In the same way the Recent was in general a period of submergence (125)(126), probably due to deglaciation (127), complicated by local differential movements, as on the Caribbean coast of Guatemala and northern Honduras, where an uplift of 169 feet has recently taken place (128).

TABLE I.

Tabular summary of some of the important events in the geologic history of Central America and the West Indies.(a)

Epoch	Events
Recent	Submergence of land areas, probably resulting from deglaciation, except in local spots where differential crustal movement produced uplift. Vulcanism in four loci intense; waning ? in Central America.
Pleistocene	Emergence of large areas, probably due to withdrawal of water to form the continental ice-sheets; also oscillation of land areas by differential crustal movement. Vulcanism in four loci intense; perhaps most intense in Central America.
Pliocene	Limited marginal submergence of Costa Rica, Panama, and West Indies; period of cataclysmic faulting, breaking up a large land area and forming the Antilles nearly as they are at present. Folding in Yucatan, Guatemala, Honduras ?. Probably a narrow interoceanic connection that admitted an Atlantic fauna into the present site of the Gulf of California.

(a) Taken in part and modified from Vaughan, Bull.Geol. Soc.America, vol.29, 1918, pp.629-630.

Miocene	Upper	Extensive emergence of the land, joining North and South America through Central America; Greater Antilles joined to each other, and possibly to Central America, by bridges from Jamaica to Honduras and from western Cuba to Yucatan, and to South America along the Caribbean arc. All these supposed connections not necessarily contemporaneous. Central America extended to westward?.
	Middle	Extensive marginal submergence in some of the West Indies and on the Atlantic side of Central America. No known interoceanic connections. Central America extended to westward?.
	Lower	Extensive submergence in the West Indies and around the continental margins; narrow, areally limited interoceanic connections; land emerging in Central America.
Oligocene (It was short according to Berry)	Upper	Vulcanism ceased. Extensive submergence with interoceanic connections.
	Middle	Maximum areal submergence with extensive interoceanic connections. Vulcanism sporadic, on the wane.
	Lower	Extensive submergence in Central America and the southeastern United States. Interoceanic connection in Panama; local emergence in the West Indies.
		Extensive diastrophism and mountain-making by folding. Lessening of intensity of vulcanism throughout Pacific Coast.

Eocene	Upper	Extensive submergence with interoceanic connections. Vulcanism intense, especially on eastern shore of a Pacific land mass.
	Middle	Apparently interoceanic connection across Central America.
	Lower	Emergence of the Great Antilles and Central America. No known interoceanic connection. Intense ? vulcanism in Panama, Costa Rica, Mexican volcanoes born either here, or in latest Cretaceous.
Cretaceous	Upper	Extensive submergence, but without interoceanic connection. A Pacific land barrier ?
	Lower	Submergence in southern Mexico and Central America, especially in late Comanche time. Probable emergence in the Greater Antilles. No interoceanic connection. A Pacific land barrier ?
Jurassic	Upper	Submergence in western Cuba, eastern Mexico and western Texas without interoceanic connection, except possibly in late upper Jurassic time.
	Middle	Submergence in southern Mexico (Oaxaca and Guerrero), with rather probable interoceanic connection.
	Lower	Submergence in southeastern Mexico (Puebla, Vera Cruzm abd Hidalgo, possibly also in Guerrero), with rather probable interoceanic connection. Nonmarine plant-bearing beds in same region and also in Oaxaca. Possibly the latter may be of same age as the supposed Rhaetic plant-bearing beds of Honduras and Nicaragua.

Triassic	Upper (Rhaetic)	Plant-bearing beds in Honduras and Nicaragua, above mentioned, bespeak land conditions in latest Triassic or earliest Jurassic.
	Upper (Karnic)	Submergence of slight duration in Central Mexico (Zacatecas) with probable interoceanic connection, either here, or across Panama.
	Middle	Probably more extensive land conditions throughout Mexico and Central America.
	Lower	Probable land conditions throughout Mexico and Central America.
Permian		Diastrophism in southern Yucatan, British Honduras, Guatemala, and Honduras. Cuba?, Mosquito?, and Rosalind Banks?, Jamaica?, permeters of Gulf of Mexico and Caribbean, with east-west trend.
	Lower	Tehuantepec uplifted.
Carboniferous		Submergence of Isthmus of Tehuantepec. Interoceanic connection.
Devonian		Submergence of northeast Nicaragua. Interoceanic connection. "Honduria" a positive element throughout Paleozoic.

Pre-Cambrian	Inception of Antillean structure. Archean granites and gneisses in Oaxaca, east-west; chloritic schists in Chiapas and Guatemala, east-west, (perhaps in part Azoic?) Archean granites on north coast of Venezuela, east-west. "Fundamental granite" in Nicaragua and Honduras, east-west.

VIII VULCANOLOGY AND SEISMOLOGY

General Résumé

Geographical.- It has been shown that the dominant tectonic trends in the Caribbean are east-west. They are very old, being probably in part pre-Cambrian. These various roughly parallel lineaments, lying en echelon from Oaxaca and Cuba to Venezuela and Trinidad, are truncated on the east by a belt of fire in the form of the Antillean arc of active volcanoes, and are truncated on the west by an erstwhile mighty zone of volcanism, now languishing. It is this latter zone which is to be considered here.

Roughly speaking, this zone extends in a northwest-southeast direction, along the Pacific coast of Central America, from Tacaná in Chiapas, to Irazú in Costa Rica, a distance of 1,009 kilometers measured along the chord of the arc.

Vulcanism in this region was certainly active in the Eocene, and possibly in the uppermost Cretaceous. It languished in the Oligocene, to culminate in a high point of explosive fury during the troubled times of Miocene orogeny. The volcanic basements of the present cones are quite possibly Pliocene, while the cones themselves probably range from the early Pleistocene or earlier to the last decade of the Eighteenth Century.

In general they may be said to be built of ejectamenta, resting upon a basement of flows while occasional flows have breached the weak walls of the cones in recent times. Their activity has been largely explosive, with several notable exceptions. This explosive activity has, in cases, caused the truncation of the cone, which has been spread over the surrounding country-side in small and large fragments. They are now chiefly extinct, or in a solfataric or quiescent state. As exceptions may be mentioned picturesque Ometepe, in the Lake of Nicaragua, and Izalco, born on a cattle hacienda in northern Salvador about 1770 (130), and now 6,000 feet high. Both of the latter are not known to have had other than intermittent activity during historical times.

Previous Work.- They have from the earliest attracted the attention of the traveller. Oviedo (131) gives a most spirited account of an ascent of Masaya made in July of 1529. At that time the volcano was in the same state of activity as Kilauea today. He describes how the Indians would hold communion with a withered hag whose home was in the crater. This same superstition holds today, and a great many Indians believe firmly that any volcanic crater is inhabited by "the old one". He further relates how two monks attempted to delude the people into believing that the molten magma was in reality gold and silver in a state of fusion, and how Charles

V granted them permission to open the volcano and procure the gold that it contained. They formed a stock company for the purpose, but, being the sons of Heaven, were not themselves required to put up any stock!

From that time to the present they have engaged the attention of the chronicler (132), and Karl Sapper's "Die Mittelamerikanschen Vulkane", 1913 (133), contains an admirable descriptive account of them, together with what few petrographical references exist. To write a further account would be idle repetition. His references are included in the Bibliography.

Tectonics.- Too little is known concerning their structural relationships and their magmatic chemistry to hazard a valid guess as to the tectonic control which has produced their alignment.

Geographically, they obviously do not form a continuous, unbroken line, but rather a series of parallel, offset lines, trending in general more to the eastward than the coast line. Sapper (134) has recognized this arrangement, and has subdivided these sections as follows:

1.	Tacaná	92°	6' W.	to	Tajamulco	91°	54'W.
2.	Lacandon	91°	42' 50" W.	"	Pacaja	90°	36'W.
3.	Tucuamburo	90°	26' W.	"	Conchagua	87°	50'W.
4.	Coseguina	87°	35' W.	"	Madera	85°	27'30"W.
	Orosí	85°	29' W.	"	Turrialba	83°	49'W.
	and, after a considerable break,						
				to	Chiriquí	82°	30'W.

Suess (135) is inclined to accept these, with the possible exception of the differention between Nos. 1 and 2.

Suess (136) further points out that Sapper's (137) attempt to demonstrate the analogy between the tectonic lines of Central America and the arcuate lineaments of Eurasia is not quite sound, since the latter are convex toward the deep, while this structure is concave toward the deep or of the Appalachian type, and therefore, essentially dissimilar to the Laramide or Coast Range structure. It is difficult to follow Suess in this with a map in hand (See map, Pl. XXVII) The individual arcs are assuredly convex toward the Pacific, although the entire trend, from Tacaná to Turrialba, made up of convex virgations en echelon, is admittedly concave.

It should be further pointed out that the southernmost end of this line of volcanism sweeps around to the eastward, abandons the Pacific Coast, crosses the divide, and

appears upon the Atlantic side of the continent in Costa Rica. The significance of this is not obvious.

Volcanoes

Panama -

Chiriquí (11,265 feet) (138), Rovala (7,021 feet) (139), Ujum and Chiripo (each about 10,000 feet) (140), all in the central Cordillera of the Talmanca, have been reported (141) to be of volcanic origin. This seems certain of Chiriqui (see Pl.), but the nature of the others is not beyond doubt, and Sapper (142) strikes them from the list. Pico Blanco (11,743 feet, 9,652 feet)(143)(144) had long been thought to be of volcanic origin, but Gabb (145) has conclusively shown that it is not.

In a private letter (146) to Dr.Sapper, Montessus de Ballore tells that in September, 1882, on the Rio Sucio, forty miles from the Atlantic coast, in the neighborhood of Atrato, a new explosive crater was opened, with earthquakes.

Costa Rica -

Costa Rica is divided into two parts, by the great depression commonly called the San Jose valley, which runs approximately northwest-southeast between the two oceans and which, at its highest point, near Cartago, has an elevation of about 1,450 meters (147). This valley pinches out on the east in the gorge of the Reventazon, which has cut its way

through the contorted middle Tertiary strata and later overlying volcanics to a depth of 500±m. To the west it is constricted between the Aguacate Hills on the north and the Candellaria limestone mountains on the south. Between the two, the Rio Grande has cut a magnificant gorge, 200± meters deep, in the lower reaches of which are exposed the basement flows of the valley. The Aguacate Hills are composed largely of andesitic tuff, breccia and flows. Their structure is unknown to the author. They lie on the western flanks of Póas, and run to the northward for a matter of 20 or 30 kilometers. But the grandest feature which greets the eye when viewing the scenery from San José is the range of four mighty volcanoes which forms the north wall of this valley. On the east is Turrialba; to the east and a trifle to the south lies Irazú, a volcano whose summit has been truncated and which now lies as débris on its flanks and far out into the valley. Next to the west, and a little north, is the extinct volcano Barba, and beyond it again Póas. These four are grouped so close together (lying in a line barely 70 kilometers long), that they hold the lower reaches of their flanks in common. (See map, Pl. XXVII).

Turrialba (3,825 m)(148), (3,360 m)(149), (3,342 m)(150), (3,325 m)(151). Turrialba may be taken as the southernmost extension of the volcanic chain of Central America. It is somewhat elongate on a northeast-southwest axis, but is

symmetrical when viewed from the southwest (152). It is covered with profuse highland tropical vegetation to near its summit, and possesses no striking features. Its angle of slope is about 29°, its relative height is about 2,500 meters, and the maximum diameter of its elliptical crater is perhaps 1,800 meters (153). This is largely composed of red and brown colored lapilli, some brecciated flows in subordinate amount, a great many bombs scattered here and there, and some vestigial solfataric action is present near the bottom of the compound crater. It is apparently a good example of a volcano whose eruptive center has moved toward the Pacific (154). On the far eastern flank of this vast crater is seen the faulted remnant of a still earlier crater more vast still, and now thoroughly timbered with a heavy forest. Clouds on this flank prevented determining more precisely the nature of the slumping of that part of the old cone. That the activity has moved progressively towards the southwestward is evidenced by the compound nature of the crater which shows six (155) well-defined nested (156) craters, somewhat elliptical and strung out along a northwest-southeast axis, the ones to the east being older physiographically and those to the west still giving off a little sulphur and steam. Further, the western flank of the mountain near the summit appears very recent in terms of erosion, and no plant life has as yet been able to take hold.

The volcano itself, apart from its actual summit, is younger physiographically than Irazú, and considerably younger than Poas, and although it has doubtless lost various portions of its extreme summit from time to time, yet it is not to be considered as a truncated cone in the sense in which Coseguina and Irazú are.

The only recorded (157) activity of Turrialba was a mild explosive eruption in May of 1855, which was followed at intervals until 1866 by other outbreaks of a similar nature, principally from the westernmost crater, and it is the material of this period of activity that is shown in the photographs (158).

On the high ridge connecting Turrialba with Irazú are to be noted three ancient craters, one at 2,700 meters (159), the other two at 2,600 meters (159), roughly 750 to 1,000 meters in diameter. They probably have subsequently been lakes which have been drained and now afford excellent pasturage, since their northern lips have either been blown away or have slumped off.

Irazú (11,450 feet)(160), (3,452 meters)(161), (3,482 meters)(162). Irazú ("Trembling Mountain") is a truncated cone with a broad, irregular summit. The countryside is strewn with fragments of andesite (latite?), some of which attain to a considerable size. One or two were noted rather far out in the valley, to the southward, roughly

spherical in shape, and about 20 meters in diameter. The lower flanks of these have suffered considerable erosion and steep ravines, 30 to 40 meters deep, whose sides slope up to 50°, are common. Its southern flanks are studded with a dozen or more nearly perfectly hemispherical hills, 50 or 75 meters in height. These were assumed to be parasitic cones, and their steepness is such that it is thought they are composed of ejectamenta, although none was investigated. Although vegetation is fairly luxurious and cultivation is pushed to within a few hundred meters of the summit (163), the profusion of recent fragments, apparently of the lost summit, is not yet covered with vegetal accretion, whereas the last pronounced activity of Póas is covered by 6 feet of vegetal accretion. The conditions at Póas, however, are such as to stimulate organic growth somewhat more than that at Irazú. The crater is complex (164), being made up of nested craters, both ancient and fairly recent, and the present activity is confined to the evolution of respirable steam from two or three chimneys, whose space relationship probably has not significance, since they have simply been opened in the throat of the volcano proper through the mass of fine lapilli, which has fallen back into the opening. A sketch map of these craters is shown in ~~Fig~~ Plate XXVI. The north side of the crater has slumped away, leaving a most precipitous wall of unconsolidated material, 300 to 400 meters in height. The

base of the wall is punctured by a swarm of so-called solfataras, which were not visited.

Within historical times (165) Irazú's activity has been typical of old age. Mud flows, ash explosions, solfataric action, and geysers have been its chief mode of expression.

Barba (2,898 meters)(166). The crater of this volcano is reported to be thoroughly grown over and forested, and Humboldt (167) mentions many little lakes on the summit. It likewise is truncated, and at the present shows no signs whatever of activity. It was not visited.

Póas (2,678 meters (168), 10,500 feet (169), 2,620 meters (170)). The lower flanks of Póas are considerably dissected and many small and picturesque gorges are present. At the very foot of Póas and just to the north of the cities of Alahuela and Heredia occurs a vertical scarp in an andesite? flow, a hundred or so meters in height, and perhaps 5~~10~~-10 kilometers long, striking about N. 70° W., which has been variously interpreted. Atwood (171) and Hill (172) thought that it was a lake terrace. Sapper (173) considers it to be the work of running water. Romanes (174) has called it a fault. And if as cursory an examination as was made by the writer entitles him to an opinion, he would say that he thinks that in all probability the latter interpretation is correct. As mentioned before, vegetal accretion to a depth of 6 feet overlies the last evidence of great activity on the flanks of

Póas. The summit of Póas reveals a history somewhat similar to that of Irazú. The present complex crater system would seem to be a purely secondary affair, lying in the throat of a cone which at one time was perhaps 500 or more meters higher. Two of the craters of Póas are characterized by containing lakes. The lower crater lake, at 2,277 meters (175), is reported (176) as being charged with sulfuric acid. Explosions of mud and steam occasionally take place in this lake. See ~~photographs~~ Plates XVIII, XIX, and XX. The other lake, at 2,560 meters (177), is somewhat smaller and is filled with clear, fresh water from the precipitation at the summit.

Between this group of four volcanoes and the next volcanoes to the northwest, there is a hiatus[a] of about 80 kilometers, occupied by the low-lying Aguacate Hills, which stretch from Póas to Tenorio (2,042 m), the southernmost of this chain of four closely spaced volcanoes studding the plain of Guanacaste. To reach these it is necessary to go by boat from Puntarenas (where there is a good example of a sand-spit formed by the interaction of the two factors; silting up, and shore currents), up the Gulf of Nicoya to the mouth of the

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(a) Since this was written, the author has found in the literature (178) reference to the volcano Canaste (1,900 m. estimated) tricked in behind the Aguacate hills, and of whose existence he was unaware while in the district. Its lava is amphibole andesite, according to Klautsch (179), but this would seem to need confirmation.

Tempisque River. One passes the rugged skyline of the peninsula of Nicoya on the left, which Romanes and Fletcher say is largely made up of much faulted and folded fragmental shallow water andesitic detritus, perhaps partly of Miocene and partly of Pliocene or Pleistocene age. The Tempisque is a meandering tidal river draining the level and low-lying plain of Guanacaste. This plain is composed laterally, and to an observed thickness of 150 meters, of an acid pumicious tuff containing biotite (see pp 78-82). This is the southernmost exposure of a formation which was intermittently observed as far north as Tapachula in Chiapas, a distance of more than 900 kiolmeters, and which has a lateral extension as great as 75 kilometers at Guatemala City, and 50 kilometers in the Guanacaste. Lithologically and chemically this occurrence is strikingly homogeneous, as shown under Part IX. This tuff is used for street paving and for building stone in Bagaces and Liberia, and under the noon-day sun these towns possess a dazzling whiteness.

These four volcanoes are apparently considerably older than the group in the southeast, for even with the lack of precipitation on their western flanks, they show considerable dissection, and the gullies and gorges which once adorned their flanks have been widened out into shallow barrancos. Sapper has also recognized this. Tenorio, the southernmost (a)

(a) Op. cit.

one, was not visited.

Miravalles, 5 kilometers to the northwest, was visited, but not ascended due to the excessively bad weather. It rises abruptly from the plain of Guanacaste and at points there seems to be distinct evidence of lacustrine benches of short duration. Around its base are numerous solfataras and springs of boiling water. It is a rather low-lying cone, with a flat back, and has apparently lost its summit. It is not known to have been active in historical times.

Rincon de la Vieja ("about" 1,500 m (180), 2,040 m (181)). Twelve or fifteen kiolmeters to the northwest in a straight line, lies the quiescent volcano Rincon de la Vieja. This possesses the same general outline as its neighbor to the south, and likewise shows some evidence of lacustrine terraces, also of short duration. An ascent[(a)] was made under rather unfavorable conditions.

It is a cinder cone, the immediate configuration of whose summit has been controlled by the trade winds, which here blow with considerable ferocity, being able to transport fragments of andesite 10 centimeters in diameter. Due to the

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(a) Prof.Tristan has pointed out thatthis is the first undoubted ascent of this volcano. Karl von Seebach described an ascent made in 1865 of a volcano to which he gave the same name, but Sapper considers that in reality he ascended one of the others of this group.

presence of an all enveloping cloud, and partially, it must be admitted, to the fear of renewed activity from a crater which could not be seen, a stay of only three hours was made, and the complete circumambulation of the summit was not effected. The cone seemed to be a composite one somewhat elliptical in outline, and extended in a northwest-southeast direction. It is made up entirely of lapilli, whose inward slope towards the throat was about 50°. Belches of whitish steam accompanied by dull rumblings occasionally rolled up out of the throat and were distinguished from the enveloping cloud by their greater density and much higher temperature. They were found to be completely respirable and a painstaking nasal analysis failed to reveal anything save water.¶ At the foot of the volcano, six or eight kilometers out into the plain, is a small hill called Góngora (1,499 m (182)), of whose origin the author is in doubt. It possessed no semblance of a crater, and was made up of bedded tuff, and apparently represents a disturbance in the plain of Guanacaste since the tuff was laid down.

The tuff is interesting. It is water laid, but probably was in the form of a mud flow. Erosion has not proceeded to any great extent, several of the stremas having cut gullies 5 or 10 meters deep. It presents flow structure, the individual flows being from 5 to 50 centimeters in thickness,

and showing on their upper surfaces sun-cracks and other configurations suggestive of sub-aerial dessication. The author /v belies that the plain of Guanacaste has been formed by the silting up of the head of the Gulf of Nicoya, by volcanic ejecta.

Seismology

Earthquakes of which we have record have shaken this region since 1608 and have twice caused the destruction of the picturesque city of Cartago. The enlightened government of Costa Rica has established a seismograph in order to keep itself informed of Isthmian and local disturbances. A very complete summary of such matters may be found in Cleto Gonzales Vicquez's "Temblores, terremotos, inudaciones, y eruptiones vulcanicas, en Costa Rica, de 1608 to 1910", San José de Costa Rica, 1910. As also in Montessus de Ballore's "Tremblements de terre et éruptions volcaniques en centre amérique depuis la conquête espagnoles jusqu'à nos jours." Dijon, 1888.

It is interesting to note that this Republic was visited by a further catastrophe this winter, when a destructive earthquake partially destroyed the beautiful capital city of San José.

Summary of the Costa Rican Virgation

These nine explosive vents, which have built up cones of ejectamenta to heights of 2,000 or more meters, are apparently situated on an irregular fissure, perhaps in part in an underlying granitic massif.

The underlying magma has been essentially homogeneous during its more recent phases, with the possible exception of that beneath Turrialba. A variation of 4 per cent in the silica content of two partial analyses would not be commented upon, save for the fact that the petrographic study tends to confirm the slightly more basic character of the magma here as compared with that at Irazú and Poás. Until more work is done, however, a speculation would hardly be justified.

The cones would seem to be older towards the northwest, while the series terminates at the the souteast with the youngest of the group, Turrialba. The individual craters, however, show no such tendency. Indeed, in the case of Turrialba, there has been a marked precession towards the Pacific, the most recent crater being on the western lip.

Their present state of activity is confined to solfataric and fumerolic action, with the development of thermal springs.

Nicaragua -

Ometepe.- Leaving the four volcanoes of the Guanacaste we strike to the northwest toward the Nicaraguan boundry over a narrow strip of land which separates the Pacific Ocean from the Lake of Nicaragua. This is the southern extremity of the range of low hills which makes up the backbone of this Pacific segment of Nicaragua. The surface here is still covered with recent ejectamenta but the taffaceous mud flows are no longer seen and pass over into the folded and faulted beds of the Brito formation of Hayes (183). These are in general shallow water deposits with some sandy limestone horizons which are highly fossiliferous. They contain a great deal of volcanic ejectamenta and their position is such that Hayes was led by necessity to suppose the existence of land to the westward in the Pacific, along whose Caribbean shore these late Eocene volcanoes had their existence.

The coast at San Juan del Sur has recently suffered drowning, well exemplified in the little harbor here, and by the narrow beaches and many off-shore islands.

Crossing the Nicaraguan boundary we push on for 35 or 40 kilometers across the low Rivas peneplain, dotted with abrupt hills, to the town of Rivas ten kilometers from the shores of the Lake of Nicaragua. The relief between the lake and the Pacific at this point is very slight, being the "low-

est gap in the continental divide to be found between the Arctic Ocean and the Straits of Magellan" (184), and it is at this point that the proposed Nicaraguan canal was to have been, and perhaps will be, cut through. Hayes believes that the two bodies of water were in connection across this zone until the lake was drained to its present level by the gorge-cutting of the San Juan River on its eastern side. The precipitation is now in equilibrium with the discharge and the evaporation.

From the little port of San Jorge one has an impressive view of the volcano Ometepe and its sister volcano, Madeira, inactive at the moment, both situated well out in the lake, 20 kilometers off shore.

Ometepe is a symmetrical cinder cone (1,752 m (185)), whose activity is of the intermittent type. It has been breached from time to time by inconsequent flows since exposed by erosion, but it is in the main built up of ejectamenta and its base, so far as could be learned, was of the same material. A descent into a well at Moyogalpa to a depth of 55 meters, that is, 7 meters below the level of the lake, proved of some interest. The well was quite dry and bottomed in finely bedded medium-grained, hard, non-fossiliferous sandstone of undetermined age.

The descent was made but one month after the rains, yet the bottom was not even moist, and three large frogs, one enormous cockroache and one large flea were found at the

bottom. Excited by the torch-light the frogs and cock-roaches attempted to get out but fell back from the steep sides into the bottom. Examination of the frogs revealed no trace of injury. How they got there without falling 55 meters and how they lived without moisture is a curious problem. A further point of interest concerning this well is the fact that the bottom is 7 meters below the level of the lake and although not more than a kilometer from the shore, is yet quite dry. No evidence of an impervious stratum outcropping between the well and the lake was noted.

Lying conformably on the sandstone is a 2 meter bed of very finely divided volcanic dust which graded upward into somewhat coarser angular fragments of volcanic origin. This was overlain unconformably by 52 meters of horizontally bedded fine-grained ejectamenta. Various horizons showed the characteristic "andesitic" weathering to a white matrix. No coarse fragments nor fresh material was seen in this exposure.

The present activity of the volcano is not impressive. At irregular intervals of from 5 to 20 minutes an up rush of vapors swirls out of the throat through a subsidiary orifice on the lip of a larger crater, carrying with it fragments and blocks of material torn from the lower reaches of the passageway. A great deal of this material is finely pulverized by attrition during its upward rush, and the trade winds are

constantly carrying to leeward a cloud of steam? heavily charged with dust which is being precipitated upon the pineapple plantations in the lee of the volcano for a distance of 60 kilometers, somewhat to the chagrin of the owners. A bit of canvas 180 by 65 centimeters was, exposed to the ash fall in a plantation 8 or 10 kilometers distant from the crater. In nine hours enough ash had fallen to fill a 65 cubic centimeter bottle, and this was described as a mild fall.

The heavy cauliflower cloud that hangs over the summit just after an explosion is probably largely composed of dust and to a less extent of water and perhaps other gases. This heavy cloud in descending takes on compound motion, that behind slipping down faster than that in front. The action is sluggish and does not suggest steam.

Within historic times there have been no catastrophic eruptions of Ometepe, although several of rather more than usual violence have occurred. A study of what records are available shows no apparent seasonal control over its activity.

The sister volcano, Madeira, which is linked to Ometepe by a narrow isthmus composed of ejectamenta, was not visited and is not known to possess any features unusual in a cindercone.

The beach surrounding the base of the volcano is in places 50 meters wide on the southwest side, and on the

northeast side wave erosion has prevented the formation of a beach and here the shore line is jagged and irregular, and is made up in part of parasitic flows. On the southwest and south side an older beach mark at an elevation of 2 meters, and 10 meters in from the shore, is well developed.

On the southeast flanks and extending nearly to the shore, were noted three or four curious ridges made up of volcanic fragments. These ridges were perhaps 15 meters high and 2 or 3 kilometers long and in plan view converged toward the crater as a common point. They were quite level and from a distance looked not unlike railroad embankments. The material of which they were made was essentially homogeneous throughout. Several hours' work with a machete failed to place us in position to study their point of contact with the base of the cone, and their origin is not easy to conceive.

Ometepe has many points of considerable interest and should repay further study[a].

Sailing up the Lake of Nicaragua one passes on the left hand side the volcano of Mombacho (1,603 m) (192), on the promontory just south of Granada, a volcano now inactive which has recently suffered a huge landslide on its northeastern flank, half the volcano apparently having slumped away.

Landing at Granada one stands on the spit of ejecta-menta which has interposed itself between the Lake of

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(a) Here the reconnaissance was broken off, and subsequent observations were only incidental to travel.

Nicaragua and the Lake of Managua, which latter stands at a slightly lower elevation than the former. In the south-central part of this spit is the complex volcanic system, Masaya-Nindiri which was not visited, but, of which an inaccurate map is given by von Seebach (186) and a good description by Sapper.

At the northeast end of Lake Managua begins the interesting range of volcanoes which studd the plain of Leon. From Momotombito on the southeast, to Coseguina on the northwest, they are 10 in number, in a distance of 70 kilometers, and rise to an average height of about a thousand meters. The evidence points to the fact that they had their origin on the floor of a shallow arm of the sea, and that they gradually built up the plain of Leon to a height considerably above what it is now by addition of ejecta. Down-faulting placed it just beneath the waters of the Pacific, and subsequent slight uplift has given it its present inconspicuous elevation.

Momotombo is active and Squier (187) gives a spirited account of the bursting forth of a parasitic cone on the lower flanks of Telica in the middle of the last century.

They form a remarkably straight line which is slightly offset from the Madeira-Masaya line.

The northernmost of this group, Coseguina (1,169 m(188)) lost its summit in an eruption in April of 1835. This eruption has been well described by Galindo (189) and

apparently must take rank with that of Krakatoa and Katmai. Coseguina is on the southern side of the Gulf of Fonseca which was Drake's headquarters while he was harassing the South Seas. Across the gulf from Coseguina, but belonging to another line, is the volcano Conchagua, now inactive and with a breached crater. Its base is made up of flows, some of which were apparently quenched by the waters of the gulf.

El Salvador -

Passing now by boat from the port of La Union, on the north side of the Gulf of Fonseca, to La Libertad, one may motor to the city of San Salvador over the vast flows of pumicious tuff into which rivers have cut gorges up to 250 meters in depth and into which the Pacific has cut a cliff some 20 or 30 meters high. This rolling plain of white tuff gradually increases in altitude from the coast to the interior until at San Salvador an elevation of nearly a thousand meters is reached.

A volcano of the same name is in more or less activity and in 1917 a flow breached the northeast flank of the mountain about half way up and spread destruction over considerable territory in its path. The summit of the volcano appears to have been truncated, (not in 1917), and the present crater is of secondary origin.

The railroad from San Salvador to Sonsonate has been relaid across this flow. From Sonsonate one may go by mule tram to the village of Izalco at the foot of the volcano

of the same name, the description of whose birth in the latter part of the Eighteenth Century is given by Dollfus et de Montserrat. It is a perfectly symmetrical cindercone now reaching to a height of 1,865 meters (190) and in a state of intermittant activity.

Guatemala -

Leaving El Salvador at the port of Acajutla one arrives at San José de Guatemala, the Pacific terminus of the Atlantic-Pacific Railroad. Here again one finds a gently sloping plain of white friable pumicious tuff, of an exposed thickness of two or three hundred meters, until at Guatemala City one reaches a height of 2,000 meters.

Here again marine erosion has cut a low cliff along the coast line. This plain bordering the coast is not a coastal plain in the sense that it is one of recent uplift. It is a plain of volcanic aggradation and probably had a considerable westward extension fairly recently, which has since been down-faulted. Very recently, of course, there has been slight apparent subsidence due to deglaciation.

The railroad into Mexico runs along the volcanic plain at the foot of the great volcanoes Agua, Fuego, and Acatenango and passes into Mexico at the river Suchiate south of the volcano Tacaná which is the northernmost volcano of the Central American series and whose summit (4,060 m (191)) forms one of the points of the Guatemala-Mexico boundary. At

Tapachula in Chiapas to the southwest of this volcano more pumicious tuff was exposed and indeed, intermittent exposures of it had been noted along the entire 150 kilometers from San José to Tapachula.

Thus between Tacaná and Turrialba, a distance of more than a thousand kilometers, we have an even one hundred volcanoes of the first order, or an average of one every ten kilometers, and of these forty are over 1,000 meters in height. Their activity has been largely of the explosive type, generally upon a basement of flows. During their history they may or may not have been breached, and towards the close of their history they generally suffered a violent explosion due to the accumulation of energy beneath a cold cone, and were truncated, their cone being deposited as coarse fragments over the country side (Irazú) or as extremely fine ash and pumice which caused no fatalities, (Coseguina).

IX PETROGRAPHY AND PARTIAL ANALYSES

The literature on the petrography of Central America, more particularly of the volcanoes, is scanty. It is to be found under the headings "Petrography" in the Index to the Bibliography, Vol.II.

In the following discussion, a latite will be any rock in which the femic constituents are from 62.5 per cent to 37.5 per cent of the whole, and in which normative orthoclase is from 62.5 per cent to 37.5 per cent of the total feldspar. The plagioclase may vary from oligoclase to anorthite, but will normally be andesine-labradorite. Further, an andesite will be any rock in which the femic constituents are from 62.5 per cent to 32.5 per cent of the whole, and in which normative orthoclase is less than 12.5 per cent of the total feldspar. The plagioclase may vary between oligoclase and bytownite, but is normally andesine-labradorite.

No name is proposed for those rocks having the same percentage of femics but in which the orthoclase makes up between 37.5 per cent and 12.5 per cent of the total ~~plagioclase~~ feldspar. It will be seen that nearly all the rocks here described fall in the latter category.

In this collection we have two types to consider. The first is the more completely represented by specimens, and is the dark to black, phyric or aphyric lava, in general

characteristic of the most recent activities of the volcanoes. It differs considerably in physical appearance from place to place, and is deceiving in the field. It may be black or grey, dense or highly vesicular. It often shows very fluid flow structure. "Andesitic" weathering completely leaches it, and it becomes white, compact, and friable. The second is the pumicious tuff, nearly white, extremely friable, which is apparently older than the dark lavas, and which is well exposed in the Guanacaste of Costa Rica; at Masaya in Nicaragua; from Acajutla toward San Salvador, the capital of El Salvador; from San José de Guatemala to Guatemala City; and finally, near Tapachula, in Chiapas. The tuff will be considered last.

The significance of the slides is purely statistical save in one or two instances. The specimens were taken at random from various exposures on flank and summit, and in general it is not practicable to read any age relationship between them, due to the abundance of vegetation. Should a dozen such random selections prove to have nearly identical composition, it would be a fair inference that that represents approximately the mean composition of the magma for that period of activity of that cone.

As for the partial analyses;no such virtue may be attached to them. They do not represent composite samples, but each was made of one specimen, judged to be representative

of that volcano. In so far as they approximate to a mean, this may probably be taken as a rough indication of the comagmatic province as a whole, but in so far as they show slight deviations from this mean, probably little significance is to be attached.

The study is progressively from south to north.

Part A - The Recent More Basic Lavas

Turrialba

Summary

A study of eighteen thin sections and one partial analysis of specimens of the recent flows and ejectamenta of Turrialba shows that the dominant magma here was essentially on the border line between the latities and the basalts. It was rich in iron, perhaps also in phosphorous, and a trifle lower in silica than would be expected from the alkali content. One or two slides apparently showed andesitic and acid-basaltic facies, but as these groundmasses were not resolvable, and no analyses made, these latter results are not certain, and quite possibly wrong.

The essential phenocrysts are labradorite, augite, and hypersthene, with somewhat less olivine. Magnetite is an abundant, and apatite a minor, accessory.

The groundmass is usually trachytic, quite often with a glassy base, and generally full of minute magnetite grains. Some of the base is apparently birefringent with low refractive index, and presumably is orthoclase.

The maximum variation noted in the Ab-An ratio was from $Ab_{36\pm}$ to $Ab_{38\pm}$.

The presence of orthoclase, as equidimensional euhedra lacking albite twinning, with low birefringence, optically (-) and 2V small, was strongly suspected in a number of slides. Their index in relation to Canada Balsam could not be determined.

The olivine shows very distinct relief, and is in part optically (-), indicating an FeO content approaching that of fayalite. This, together with the high magnetite content, suggests a magma fairly rich in iron.

A zonal and crystallographically oriented intergrowth between hypersthene and augite is characteristic, in which the hypersthene is the core (No.57 and No.60).

Untwinned labradorite is not uncommon (No.62).

Some optically negative labradorite ? was found (No.60).

A partial analysis (194) of No.71, a typical specimen, gave the following:

SiO_2	=	51.55	±	0.07 per cent
CaO	=	9.91	±	0.04 " "
K_2O	=	2.39	±	0.12 " "
Na_2O	=	2.53	±	0.13 " "

The plagioclase here was of the approximate composition $Ab_4\ An_6$, and on the assumption that all the soda is attributable to plagioclase, calculation shows that (normative) orthoclase is 20± 2 per cent by weight of the total feldspar. This is in accord with the optical testimony, and places the rock provisionally between the andesites and the latites.

There is no possibility of determining the relative time of ejection of the various specimens.

Detailed Petrography

The following detailed petrographic descriptions may be taken as representative of the comagmatic province as a whole. In so far as local deviations from this mean occur, they will be mentioned under that specific volcano.

Thin section and specimen No.57. A flow from the base of a parasitic cone on the southern flank of Turrialba at 2,230 meters in field to east of trail.

Megascopic. A medium textured phyric andesite? showing some parallelism of the feldspars. The latter show

their albite striae, and likewise the labradorite sheen. Ferromagnesian phenocrysts are not so numerous as those of the feldspar. The groundmass is perhaps 70 per cent of the whole, is fairly fresh, and finely vesicular.

Microscopic. Essentially phenocrysts of labradorite and colorless augite in equivalent amounts, in a fine trachytic groundmass. Nearly colorless, hypersthene is present in some quantity, while fayalite? is sparingly so. Apatite and magnetite are the accessories. (The groundmass is 50 to 60 per cent of the whole).

Plagioclase. The phenocrysts. They correspond to Ab_{36} in their more basic members (max. sym. ext. 010 = 34° ± R and 39°L = 36.5 ± 0.5°, (+), biref. = 0.008 ± 0.001, C.B.), but are not homogeneous, and show abundant irregular zoning, the outer layers probably approximating to about $Ab_{60\pm5}$. Normal twinning after the Carlsbad and Albite laws is common. Well-zoned crystals are at times twinned after the Albite law, the laths being unzoned, probably about $Ab_{40\pm5}$, and cutting across the zoned areas. The crystals are not clear, but are fully intergrown with inclusions of the groundmass, often arranged zonally or graphically. These are either glassy, occasionally devitrified, or identical in texture with the trachyte groundmass, and are commonly square

in outline. Frequently the outermost margin of the crystals is free from these inclusions, the transition being sudden.

Other inclusions, more or less irregularly arranged, are apatite, in grains and minute needles, grains of magnetite, (altering to pseudomorphous specular hematite), augite and liquid, as well as combined liquid and gaseous, inclusions. Orthoclase? One subhedron untwinned, (-), low bi-ref. with apatite needles and bits of glassy groundmass as inclusions, was noted. It may be orthoclase.

Augite. It is nearly, if not quite, colorless and non-pleochroic. It is often irregularly twinned, and crossed by many coarse cracks. Inclusions are numerous, sometimes stocky prisms of plagioclase, more often primary magnetite (altering to specular hematite). Apatite needles are not uncommon, while intergrowths with rhombic pyroxene parallel to c, and such that the latter may nearly constitute the whole kernal, and the augite, the rim, are common.

Olivine. Phenocrysts are sparingly present, free from inclusions and quite fresh, though narrow resorption rims are present. The index is rather high, probably above 1.75, the sign is both negative and positive and the bi-

refringence high, about 0.040 ± 0.005, indicating that this member is perhaps fairly close to fayalite in composition.

Hypersthene. It is distinctly subordinate to the augite. The phenocrysts are nearly colorless, yet show more color than the augite and show distinct though feeble pleochroism.

= An exceedingly pale green.
= A slightly richer yellow tone than
= An exceedingly pale yellow.

The optic angle is at times small.

Intergrowths with augite are characteristic, in which hypersthene forms the core, and the augite forms a narrow rim about the whole. Glomero-porphyritic texture is developed, the individual grains of an aggregate showing striking vermicular intergrowth of the groundmass. Other inclusions are magnetite, apatite, plagioclase, and gaseous and liquid bubbles and irregular glassy and devitrified fragments.

Magnetite occurs sparingly as a coarse constituent, generally altered pseudomorphically to specular hematite, but as a fine-grained accessory to the groundmass, it is fairly plentiful, and its oxidation and hydration has lent a reddish tone to the rock.

Apatite occurs as inclusions in the feldspars and in the pyroxenes, and as a minor accessory in the groundmass.

The groundmass is trachytic, rather fine-grained, the fluidal structure not pronounced, the base is glassy, and somewhat stained with limonite, while magnetite (specular hematite), with less apatite, are accessories. The presence of some orthoclase in equi-dimensional plates or as a bi-refringent constituent of the base, while not proven, is strongly suspected.

Classification. Provisionally this rock would fall among the latites poor in potash.

Thin section and specimen No.60. A fragment found at 2,360 meters, on the south flank of Turrialba.

Megascopic. Very similar to No.59, but somewhat more weathered, and a bit darker as to groundmass. A normal phyric andesite?

Microscopic. In order of abundance essentially plagioclase, colorless augite and hypersthene phenocrysts, in a glassy groundmass, with considerable apatite and magnetite as accessories.

Plagioclase. The facts concerning the plagioclase are discordant, and interesting.

A. The greatest symmetrical extinction angle found 010 was 36°, indicating about Ab_{38}.

B. The indices are:

α = 1.558 - 1.559
β = 1.563 - 1.565
γ = 1.565 - 1.568

(judging from liquids at 1.560 and 1.570), indicating about Ab_{42}.

C. The bi-refringence is thus 0.006 - 0.010 (calculated), and about 0.010 (observed), indicating about Ab 30.

D. The optic sign measured on the same crystals from which indices were determined is (-), indicating Ab 32.

Thus the extinction angles and the indices indicate about Ab_{40} or a normal labradorite, while the bi-refringence and the optic sign indicate about Ab_{28-30}, or an acid bytownite. To be sure, the implied magmatic difference is slight, but the fallibility of Rosenbusch's table (195) is instructive.

Dr. Lindgren would place full value upon the indices, disregarding the optic sign and call the feldspar a labradorite.

It shows considerable graphic and zonal intergrowth with the groundmass.

Hypersthene. The hypersthene is (as in No.59), but distinctly subordinate to the augite. The indices are approximately:

α = ?
β = Somewhat above 1.695, not so much.
γ = Somewhat above 1.695.

Its composition, therefore, following Winchell (196), is approximately between 27 and 30 per cent $FeSiO_3$, or about 20 per cent FeO and 20 per cent MgO.

It often forms a kernal, surrounded by a narrow parallel zone of augite, and also occurs embedded in plagioclase subhedra.

Augite. The augite is as in No.59, is often twinned, and sometimes occurs embedded in a plagioclase subhedron.

Magnetite grains and small euhedra are abundant, altering to specular hematite.

There is considerable apatite, generally associated with the plagioclase, sometimes in well-developed euhedra.

Groundmass. The groundmass is trachytic, with abundant magnetite, and a glassy base.

Classification. This would seem to fall between a latite and an andesite.

Thin section and specimen No.71, found as a fragment at 3,040 meters, on the southern margin of the crater of Turrialba, and typical.

Microscopic. Plagioclase. The phenocrysts are poorly developed, shattered and small. They approximate to Ab_{38}, probably $Ab_{36\pm}$ (max.sym.ext. 010 = 35°R - 38°L = 36.5 ± 0.5° (+), biref. = 0.007 ± 0.001 C.B.) but are not homogeneous, being abundantly zoned. Carlsbad and Albite twins are present. Irregular inclusions of augite and of apatite are frequent, as are magnetite grains, while zonally arranged inclusions of groundmass, framed in an outermost zone of clear feldspar, are common.

Orthoclase? Small phenocrysts, nearly equidimensional (-) and zoned, may be orthoclase. They are sparingly present, and fairly free of inclusions.

Augite. The phenocrysts are small and shattered; nearly colorless, non-pleochroic, extensively and complexly twinned, and containing many inclusions of magnetite, apatite, and olivine.

Olivine. In small grains with heavy cracks, is present in some quantity, having crystallized out earlier than the augite. It is rather free from inclusions. It is both (+) and (-).

Hypersthene is subordinate to the augite, is often twinned, and encloses many inclusions, partly of olivine, partly of augite.

Magnetite is an abundant accessory, in small grains probably largely in the hematitic state of oxidation.

Apatite is an abundant minor accessory, disseminated throughout the feldspar phenocrysts, and in the groundmass.

The groundmass is sensibly trachytic, but with a good many admixed shreds of augite. The feldspar is perhaps partly equidimensional orthoclase.

Provisionally this rock would appear to be a latite rather poor in potash.

Analysis. A partial analysis (194) of this rock gave:

SiO_2	51.55 ± 0.07	per cent
CaO	9.91 ± 0.04	" "
K_2O	2.39 ± 0.12	" "
Na_2O	2.53 ± 0.13	" "

which agrees well with the petrographic evidence that this rock, while containing a fairly basic plagioclase, yet is high enough in normative orthoclase, to fall outside the andesites, yet between them and the latites.

Irazu

A study of fourteen sections from Irazu, together with one partial analysis, leads to the conclusion that, although the magma here is essentially identical with that at Turrialba, yet it is distinctly higher in potash, slightly higher in silica, and sensibly lower in iron. Magnesium and calcium are probably also somewhat lower. It would thus approach more nearly to a latite.

Hypersthene does not appear to have been so abundant nor was the zonal intergrowth between it and augite noted.

The magnetite is not so profuse as at Turrialba.

The olivine is probably largely (+).

Untwinned labradorite is of frequent occurrence.

The extreme variation noted in the Ab-An ratio was from $Ab_{42\pm}$ to $Ab_{50\pm}$. This agrees with the greater amount of silica shown by the analysis.

A partial analysis (194) of No.36 gave:

SiO_2 = 55.00 ± 0.07 per cent

CaO = 7.96 ± 0.04 " "

K_2O = 4.41 ± 0.12 " "

Na_2O = 2.58 ± 0.13 " "

The Ab - An ratio of this specimen was in the neighborhood of $Ab_4\ An_6$, which, by calculation, shows that

normative orthoclase was 31 ± 3 per cent by weight of the total feldspar.

This would place the rock somewhat nearer the latites than the andesites.

Poas

A study of fourteen slides and one partial analysis from Poas shows that here the magma was probably higher in iron than at either Irazu or Turrialba, and that it contains less (normative) orthoclase, (only 15 per cent), than either of the other two, while in silica content it is more acid than at Turrialba, but nearly the same as at Irazu. Magnesium is probably relatively low.

Mineralogically, this magma is characterized by being low in pyroxenes, and high in magnetite, while a good deal of the olivine is (-), indicating fayalite.

The plagioclases range from bytownite to a normal labradorite, the range being from $Ab_{30\pm}$ to $Ab_{40\pm}$.

Hypersthene intergrown, but not in parallel orientation, with augite, was noted.

The groundmass is usually trachytic, often glassy.

A partial analysis (194) gave:

SiO_2 = 55.36 ± 0.07 per cent
CaO = 7.18 ± 0.04 " "
K_2O = 2.46 ± 0.12 " "
Na_2O = 3.39 ± 0.13 " "

On the assumption that some, at least, of the feldspar is an acid bytownite, of the approximate composition, Ab_{20}, An_{70}, we find that normative orthoclase makes up about 18 ± 2 per cent of the total feldspar present.

The magma is probably fairly high in iron, as evidenced by the abundance of magnetite and the optical character of the olivine, and is of the same type as the others, that is, somewhere between the latities and the andesites.

Miravalles

A study of twelve sections and one partial analysis leads to the conclusion that the magma here is essentially identical with that last studied 30 kilometers to the southeast, which is to say, intermediate between an iron-rich latite and an iron-rich andesite.

The zonal intergrowth between hypersthene and augite is here well illustrated. The other minerals differ little in habit from those already described, with the exception of the hypersthene, whos optic angle is quite small

and which at times is sensibly optically positive, or enstatite.

A partial analysis (194) gave:

SiO_2 = 55.18 ± 0.07 per cent

CaO = 8.40 ± 0.04 " "

K_2O = 3.03 ± 0.12 " "

Na_2O = 2.55 ± 0.13 " "

The plagioclase approximating to Ab_{45}, we find that normative orthoclase makes about 26 ± 3 per cent by weight of the total feldspar, and provisionally this rock, therefore, joins hands with the others in falling between the latities and the andesites.

Rincon de la Vieja

A study of sixteen slides and one partial analysis shows that here again the magma is essentially identical with those already studied, being intermediate between an iron-rich latite and an iron-rich andesite.

Zonal intergrowth between hypersthene and augite is common. Crystallographic c of the hypersthene is not always parallel to that axis of the augite, however. The two axes may make angles of 15° to 20° with each other. Some of this

hypersthene is feebly pleochroic and is apparently on the border line towards enstatite, at times appearing sensibly uniaxial.

A partial analysis (194) gave:

SiO_2 = 55.49 ± 0.7 per cent

CaO = 7.67 ± 0.4 " "

K_2O = 2.10 ± 0.12 " "

Na_2O = 2.78 ± 0.13 " "

and since the plagioclase approximates to Ab_{40-50}, An_{50-40}, normative orthoclase amounts to 19 ± 2 per cent by weight of the total feldspar present, again placing this rock provisionally between the latites and the andesites.

Ometepe

A study of twenty-eight slides and one partial analysis leads us to the belief that here, as on the mainland, the magma is intermediate between an iron-rich latite and in iron-rich andesite. The habit of the plagioclase is a little more basic, the range being from Ab_{30} to Ab_{50}. The hypersthene, as before, has a small optic angle, and is usually rimmed by augite, and as before, the crystal axes are not always parallel. As phenocrysts it is slightly more abundant than the augite, which latter mineral is fairly plentiful in

the groundmass, giving rise to a sub-basaltic texture. Olivine may or may not be present, and usually shows heavy resorption rims.

A partial analysis (194) gave:

SiO_2 = 55.62 ± 0.7 per cent
CaO = 8.29 ± 0.4 " "
K_2O = 2.39 ± 0.12 " "
Na_2O = 4.10 ± 0.13 " "

On the assumption that the plagioclase approximates to Ab_{45} to An_{55}, we find that normative orthoclase makes up 18 ± 2 per cent by weight of the total feldspar, placing this rock provisionally between the latites and the andesites.

Masaya

Only one specimen of the recent activity of Masaya was collected, and this was distinctly weathered, but seemed to fall in line pretty well with the others, the only difference being an apparent absence of hypersthene.

Conchagua

A study of six slides and one partial analysis leads to the conclusion that here the magma is sensibly more

basic than the average of those described. The groundmass contains considerable augite, the magnetite is abundant, olivine is largely (-), and hypersthene is practically absent. The specimen which was probably quenched by sea water shows a noticeable amount of olivine.

A partial analysis (194) gave:

SiO_2 = 46.76 ± 0.7 per cent
CaO = 9.71 ± 0.4 " "
K_2O = 1.98 ± 0.12 " "
Na_2O = 2.21 ± 0.13 " "

It will be noted that silica is nearly 10 per cent below the average, while lime is higher, and the combined alkalies are low, although the orthoclase-plagioclase ratio remains undisturbed.

Since the time spent at Conchagua was only two and one-half hours, and taking into consideration the paucity of slides and the nature of the analysis, it would seem wise to wait for further study before venturing a conclusion.

San Salvador

But two specimens were collected here, both of which prove to be essentially identical with the others. Mineralogically they offer no striking differences to those collected 150 kilometers to the south.

A partial analysis (194) gave:

SiO_2 = 57.89 ± 0.7 per cent

CaO = 5.68 ± 0.4 " "

K_2O = 3.66 ± 0.12 " "

Na_2O = 3.74 ± 0.13 " "

Since the plagioclase approximates $Ab_{45}An_{55}$, the normative orthoclase amounts to 23 ± 2 per cent by weight of the total feldspar present, placing this rock provisionally between the latities and the andesites.

TABLE II.

Partial analyses of Recent more basic lavas

	I	II	III	IV	V	VI	VII	VIII	IX
SiO_2	51.55	55.00	55.36	55.18	55.49	55.62	53.53	46.76	57.89
CaO	9.91	7.96	7.18	8.30	7.67	8.29	8.31	9.71	5.68
K_2O	2.39	4.41	2.46	3.03	2.10	2.93	2.11	1.98	3.66
Na_2O	2.53	2.58	3.39	2.55	2.78	4.10	3.24	2.21	3.74
Or	20%	31%	15%	26%	19%	18%	17%	20%	23%

The precision reported in each case is:

$SiO_2 \pm 0.07$

$CaO \pm 0.04$

$K_2O \pm 0.12$

$Na_2O \pm 0.13$

The precision of the Or percentages is $\pm$10 per cent of the values given. Or is the percentage of total normative feldspar present, which is represented by normative orthoclase, on the assumption that all the K_2O goes into the Or molecule and all the Na_2O goes into the plagioclase molecule whose Ab-An ration is calculated optically.

I Specimen 71, a fragment found on the surface on the southern margin of the crater lip of Turrialba, at 3,040 meters. Simpson and Mitchell, Analysts, Dept. Chemistry, Mass.Inst.Technology, May, 1924.

II Specimen 36, a fragment from the side of a spring found at 2,924 meters on the side of the trail going up the southwestern flanks of Irazú. This is the highest source of water on the volcano. Simpson and Mitchell, Analysts, Dept.Chemistry, Mass.Inst.Tecnology, May, 1924.

III Specimen 15, a fragment taken from the southern flanks of Póas, near roadside, not far from Alajuela. Simpson and Mitchell, Analysts, Dept.Chemistry, Mass.Inst.Technology, May, 1924.

IV Specimen 124, a fragment at 740 meters, 0.5 kilometers south of the solfataros at foot of Miravalles. Simpson and Mitchell, Analysts, Dept.Chemistry, Mass.Inst. Technology, May, 1924.

V Specimen 155, a fragment in hill of fragments, 3 kilometers south of Rincon de la Vieja. Simpson and Mitchell, Analysts, Dept.Chemistry, Mass.Inst.Technology, May,1924.

VI Specimen 168, common type, found as fragments with wide distribution about lower reaches of Ometepe. Simpson and Mitchell, Analysts, Det.Chemistry, Mass.Inst. Technology, May, 1924.

VII Specimen 253, collected by Indian Felipe Guevarra, from cut in railroad 10 kilometers ? south of Granada, and presumed to have emanated from Masaya. The cut was observed by the author from the train en passeut. Simpson and Mitchell, Analysts, Dept.Chemistry, Mass.Inst. Technology, May, 1924.

VIII Specimen 262, taken from a flow on the northeast flanks of Conchagua, where they entered the Gulf of Fonseca. The specimen was taken from below the low-tide mark, and is though to have been quenched, and the abundant and well-developed olivine present is though to be due in part to the Bowen-Anderson effect. Simpson and Mitchell, Analysts, Dept.Chemistry, Mass.Inst.Technology, May,1924.

IX Specimen 258, a fragment collected from the right of way of the railroad 10 kilometers ? northwest of the city of San Salvador, from the midst of the flow of 1917, over which the temporary tracks were laid. The flow had moved slowly across wet ground, was perhaps 10 meters thick, and of extreme texture. Simpson and Mitchell, Analysts, Dept.Chemistry, Mass.Inst.Technology, May, 1924.

Summary of Petrography - Part A.

The Recent more basic lavas.

With the exception of the specimens collected at Conchagua, a striking homogeneity is shown in the magmas from San Salvador to Turrialba, a distance of kilometers; a homogeneity confined not to chemical composition alone, nor even to mineral composition, but applying also to mineral habit. Although without complete analyses and further study, it would be hazardous to risk a classificatory judgment upon the magma, yet the author is regretfully led to the conclusion that the magma is neither an andesite nor a latite, but is almost exactly between these two types, conforming to the unnamed effusive equivalent of Johannsen's (197) syenodiorite. A search throughout Washington's (198) analyses failed to reveal a type already described which was similar to that here found.

It is not proposed, however, to coin a new name to be added to petrographic dictionaries, at least until complete analyses are available, and there is more agreement among petrographers themselves as to what is what.

In Dr.Sapper's (199) enumeration of determinations of lavas from the volcanoes here studied, he makes frequent

reference to "amphibole andesit", a classification made by several authors. No amphibole has been found in any of the specimens of this collection. Practically all the other references are to "pyroxene andesit", which, without analyses, and without rigorous petrographic methods, is where the majority of the specimens would fall.

The habit of olivine is such as to suggest that it is under the control of the Bowen and Anderson (200) effect, and is, therefore, of little or no classificatory value when present in the quantities here found.

The association of hypersthene with the more acid types is here well exemplified.

It is recognized that the analyses from both Conchagua and Turrialba agree with the petrographic studies of these two volcanoes, in indicating a magma of sensibly greater basicity than the average of the others, and that each of these volcanoes is, respectively, at the southern terminus of a fracture zone, and that each is situated at a critical tectonic point.

Part B - The more acid pumicious tuffs and mud flows.

As already mentioned (page 53) rocks of this type have a wide occurrence along the Pacific Coast of Central America, and so far as is known to the author, have never received attention.

In the hand specimens the tuffaceous character is apparent. The rock appears white, or nearly so, is light and extremely friable. Small subhedra of quartz are visible, but the distinguishing mineral is a brown-black biotite, fairly evenly disseminated in small cleavage flakes. Pumicious inclusions are common. They are generally drawn out into sheafs of glassy fibres with the lustre of silk. The cement of the rock is finely comminuted pumicious dust. In the field it occasionally shows its bedded character, and, especially in the Guanacaste, it occurs as thin mud flows, showing sun cracks on the upper surfaces. Where thermal solutions are in contact with it, it reverts to the state of an exceedingly fine, grey-white mud, of low viscosity. Its extent has already been mentioned, and is indicated on the map, Plate XVIII. The hand specimens from Guatemala can not be distinguished from those of the Guanacaste.

The thin sections of this type were few in number, and some turned out badly. Biotite, hornblende, and magnetite,

all distinctly, but not seriously altered, together with some plagioclase, make up the phenocrysts and subhedra. Quartz is present. Pumicious inclusions are common.

The groundmass is rather fine, and contains spherulites, some devitrified glass, a great deal of comminuted plagioclase, and some glass. Orthoclase is probably present, but was not postively identified.

TABLE III.

Partial Analyses of the older, more acid, tuffs.

	I	II	III
SiO_2	67.53	67.06	70.93
CaO	2.13	3.41	1.14
K_2O	4.47	2.09	4.21
Na_2O	2.26	4.71	4.29
Or			

The precision reported is:

I, same as Table II.

	II	III
SiO_2	±0.04	±0.07
CaO	±0.03	±0.03
K_2O	±0.09	±0.06
Na_2O	±0.10	±0.10

Or is as in Table I.

I Specimen 126, from the streets of Bagaces, in the Guancaste. Bagaces is built of this material. Simpson and Mitchell, Analysts, Dept.Chemistry, Mass. Inst. Technology, May, 1924.

II Specimen 256, from near right of way at Apopla, El Salvador. It is continuous from San Salvador to beyond here, bedded, and at least 30 to 50 meters thick. L.F.Hamilton, Analyst, Dept.Chemistry, Mass.Inst.Technology, May, 1924.

III Specimen 267, from Mazatango, Guatemala. Little else seen from San Jose to Guatemala City, which stands at 910 meters. L.F.Hamilton, Analyst, Dept.Chemistry, Mass.Inst.Technology, May, 1924.

Summary of Petrography - Part B.

The more acid tuffs.

It is regrettable that no more specimens of this rock were collected, and quite possibly the evidence here adduced is far from the mean of actuality. It will be noted that the analyses do not agree so closely as did those of the nameless, more basic rocks. This may, in part, be due to sampling, since the rock is essentially heterogeneous in texture and it was practibable to take only 50 gram samples. The slides are also unsatisfactory, and the results on the whole are deplorably inconclusive, yet it is a fact, that in

the Guanacaste, in Nicaragua, in El Salvador, in Guatemala, and in Chiapas, considerable exposures are to be seen of a pumicious tuff.

The hand specimens are indistinguishable the one from the other. Three partial analyses show that three isolated samples, taken at random and each separated from the others, by upwards of 300 kilometers, show distinct magmatic affinities. The field habits of the two are similar. The sum total of the evidence, therefore, would seem to indicate that these various exposures are more probably derived from the same magmatic chamber than from different magmatic chambers, and the author is inclined to agree with this emphasis.

SUMMARY AND CONCLUSIONS

The Cordilleras of Central America lie across the path of the North American Cordillera and the Andean system. Central American structure is Antillean. It is very old. Its inception dates in part from the Pre-Cambrian. It was further developed during the closing scenes of the Paleozoic, and was re-emphasized during the Tertiary and perhaps during the Recent.

A belt of vulcanism truncates the parallel Antillean systems on the east, in the shape of the volcanic arc of the lesser Antilles, and another belt, of larger dimensions, truncates these systems on the west. This latter belt is 1,009 kilometers in extent, from Tacana, in Chiapas, to Turrialba in Costa Rica. Its form, viewing it as a unit, is arcuate, and concave towards the deep. It is made up of many segmental virgations, some of which show no marked lineal arrangement; others of which are concave, and still others of which are convex towards the deep. Its lineal arrangement is pronounced towards the southeast, and obscured towards the northwest.

Vulcanism in this belt was present in the Eocene, at which time the volcanoes lined the Caribbean shores of the Cretaceous Pacific land mass. Andesites, basalts, rhyolites were extruded, and formed tuffs of ejectamenta. Activity

languished in the upper Oligocene, burst forth with renewed vigor in the period of Miocene diastrophism. The basements of the present cones quite possibly date from the Pliocene, while the cones themselves probably range from the Pleistocene (or earlier) to the Nineteenth Century.

The activity may be classified as dominantly explosive, and of the intermittant type. The significance of observed phenomena is, therefore, largely statistical.

Two lava types are recognized. One is the normal product of present activity, but is not here classified, since it is intermediate between the latites and the andesites. It runs 55 per cent silica, 8 per cent lime, 2 to 3 per cent potash, and 2 to 4 per cent soda, while normative orthoclase makes up 15 to 25 per cent of the total feldspar. Hypersthene, augite, and magnetite are the important minerals. Its habit is dense or vesicular, phyric or aphyric, grey or black, and it usually possesses trachytic or sub-basaltic texture.

The other type is more acid, and has wide occurrence as pumicious tuffs and mud flows. It is white and friable. It is apparently bracketed in age by the first described material, since none of it is known to have been laid down in Recent times, except perhaps at Coseguina in 1835. It runs 67 to 73 per cent silica, 1 to 2 per cent lime, 2 to 4 per cent potash, 2 to 4 per cent soda, and contains quartz,

biotite and hornblende besides andesine ? plagioclase.

It presents striking simularity of habit and texture over wide areas.

The activity of a cone even in close juxtaposition to other cones is independent of the state of its neighbors.

A cursory examination of the records shows no marked seasonal variation on the intensity of vulcanism. This result may be reversed by further study.

It is a common local idea that seismic disturbances are seasonal, being most intense in spring and fall.

The purely secondary, geyser-like activity of such volcanoes as Rincon de la Vieja and Poas would appear to be in part seasonal, but this has by no means been thoroughly investigated.

Volcanic activity may or may not be accompanied by seismic disturbances, and seismic disturbances may or may not be accompanied by vulcanism.

The sedimentary record as so far revealed indicates no undoubted progressive differentiation in this comagmatic region during the Tertiary.

Conclusions.

The origin of the volcanoes is probably the most interesting geologic problem of this region, and one whose solution would doubtless prove to be of considerable aid in deciphering the continental and orogenic structures to the north and south.

In the first place, they should not be assigned to the type which occurs on the inner arc of a tectonic virgation, as in Hungary or Japan, for their origin was apparently at a time when a land mass existed in the Pacific to the westward, and the volcanoes of Mexico, Nicaragua, Costa Rica, and Panama then formed a lineament which was convex towards the deep (the Caribbean) and not concave towards it. Further, they have little apparent direct structural relationship to the present ranges to the eastward, since they cut across the strike of their lineaments indifferently. If there is a range of mountains parallel to them, that range now lies drowned in the Pacific. Perhaps the folds of Nicoya, Golfo Dulce, and Azuero are shoreward foothills of this range.

In the second place, their origin can hardly be assigned to isostatic readjustment following differential erosion, that is, the transfer of material from a high mountainous tract on the west to a low-lying tract on the east,

which would cause the mass to rotate about a North-South axis, developing vertical tension faults along the Pacific. The "high mountainous tract on the west" is the debris of the volcanoes themselves, and further a large number of them (Coseguina to Madeira inclusive) had their origin on the sea-floor.

In the third place it does not seem profitable to consider them as the volatile phases of magmatic stoping attendant upon batholithic intrusion. The present activity would appear to date at least from the Pliocene, and the extrusions have been exceedingly irregular, tapping different parts of the zone at different times. It seems very improbable that assimilation would have been so uniform over a distance (observed) of at least 500 kilometers throughout as long a period of time as that between the Pliocene and the Present, as has been indicated under the heading "Petrography".

With so little data to go on, the author does not care to offer an hypothesis even tentatively, but for the sake of going on record, he would like to take the liberty of indicating that he is aware of the following possibility: The individual lineaments are arranged roughly en echelon from northwest to southeast. The Pacific land mass has down-faulted, and this fault zone is one of lateral tension, giving

rise to many offset tension cracks. The direction of this tension is northwest-southeast.

These tension cracks are fundamental, and as such, offer a means of egress to the magma beneath, which is not itself in general near the surface, thus giving rise to activity of a dominantly explosive type, with flows generally localized to the period of initial rending of the surface.

Profitable lines of study, aimed at the solution of the structural history of the region, are suggested in the following points:

1. A full investigation is badly needed of the petrology of this comagmatic province, from Tacana to Turrialba.

2. Gas and water analyses are also badly needed. Quantitative spectroscopy might prove useful for the analysis of hot gases from an active vent.

3. A structural map is practically totally lacking. Drill-hole and well data have not been correlated.

4. The existing bathymetric maps are unsatisfactory.

5. A critical survey of the material compiled by Montessus de Ballore and Cleto Gonzales Viquez concerning earthquakes and volcanic activity in this region during historic times, would be very helpful.

6. A study of the seismic records of the seismographs in Panama, Costa Rica, and Guatemala has not, as yet, been made, and could hardly fail of being instructive.

7. A careful survey of the literature on the region would almost certainly add materially to our statistical knowledge of historical vulcanology. Untouched material, probably rich in data, is to be found in the archives of church and state, both in Central America and in Spain.

The author hopes that he has been able to demonstrate the truth of his belief that here lies a field for research, rich in promise, and that the problems here presented are of far-reaching significance, since Central America has been part of a pivotal unit, recording the strains and stresses set up between those two active continents, North America and South America.

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145		Ibid.
146	Montessus de Ballore	"Erupciones", S 179, 183 u. 187. Quoted by Sapper (133), footnote p.127,
147		The author's barometer. Precision is 1100± ?
148	I.C.Russell	(138) p.137.
149		The author's barometer. Precision is 3360± 20 m.
150	H.Pittier	Karte von Kostarika. Petermanns Mitt. Erg.Heft, No.176,1911.
151	K.T.Sapper	(133) p.121, and sketch map of summit, p.122.
152		See Pl.
153	K.T.Sapper	Sapper gives 1400 m. on p.123 of Die Mittelamerikanischen Vulkane. My figure is based on a plane table survey whose base line was 86± 5 meters, and the probable precision of my figure is 1800± 180 m. The survey itself was halted by weather, and is not sufficiently complete to reproduce here.

154	E.Suess	(136) p.454.
155		Five of these, omitting the old one to the east, are indicated on Sapper's sketch map of the summit. Vgl. Zeit. d Deut.Geol.Gesell.1901, S.42, and also in (133), p.122.
156		See Plates
157	K.T.Sapper	(133) p-.150-151.
158		See Plates
159		The author's barometer.
160	I.C.Russell	(138) p.137.
161	H.Pittier	(150).
162		The author's barometer.
163		The Republic of Panama was for some years supplied with potatoes grown on a finca not 200 meters below the summit of this volcano.
164		See Sketch Map, Pl.
165	K.T.Sapper	(133) pp.150-152.
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179		Quoted by K.T.Sapper (178), p.158.
180		The author's barometer. Precision = 2,040 $\pm$ 20 meters.

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184		Ibid p.286.
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PLATES AND MAPS.

PLATE I.

The Atlantic coastal plain
at Limon. Pleistocene.

PLATE II.

Turrialba, looking northeast from the ridge between it and Irazu. Three extinct craters are on the north of this ridge- not visible.

PLATE III.

The summit of Turrialba meters. Attempting a sketch in bad weather; it proved impossible. Don Ricardo Fernandez Peralta.

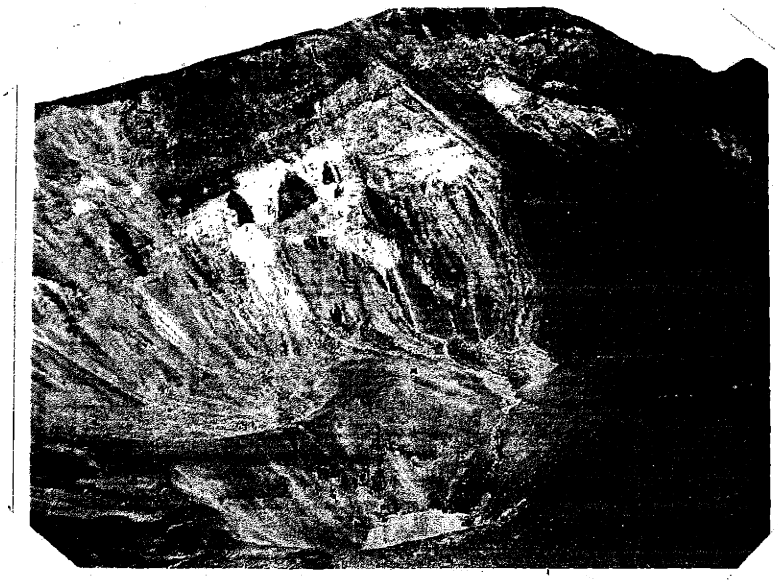


PLATE IV.

A secondary crater of Turrialba, looking west, from a ridge in the floor. From 'x' to the bottom of the Tertiary crater is a matter (estimated) of 100 meters. This view is of the far northwestern corner of the elliptical primary crater, Note the stratification of unconsolidated ejectamenta.

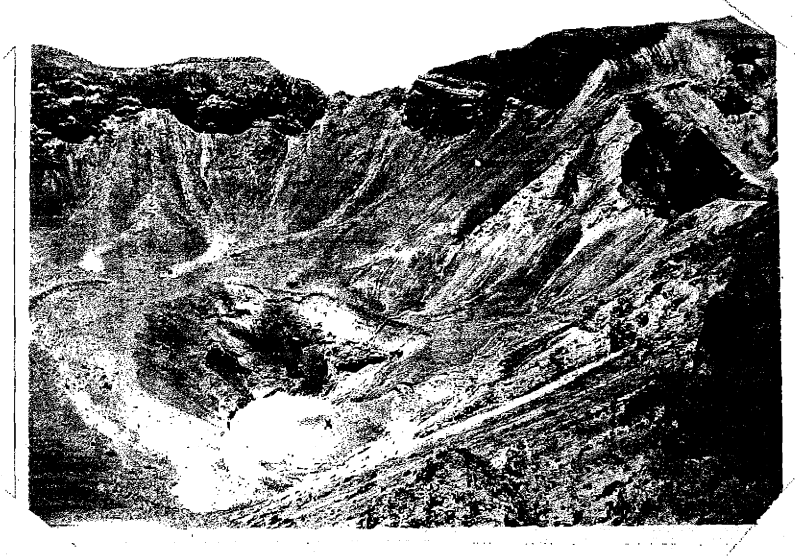


PLATE V.

The western secondary crater of Turrialba, from the summite (Plate III), looking west showing the Tertiary crater, about 230 meters in diameter. No flows are visible. Note the sharpness of the hog-back in the upper right corner. This is exposed to the steady action of the Trade Winds sweeping down across the San Juan valley of Nicaragua.

PLATE VI.

The solfataric pile marked x in Plates IV and V. The Tertiary crater is to the reader's left.

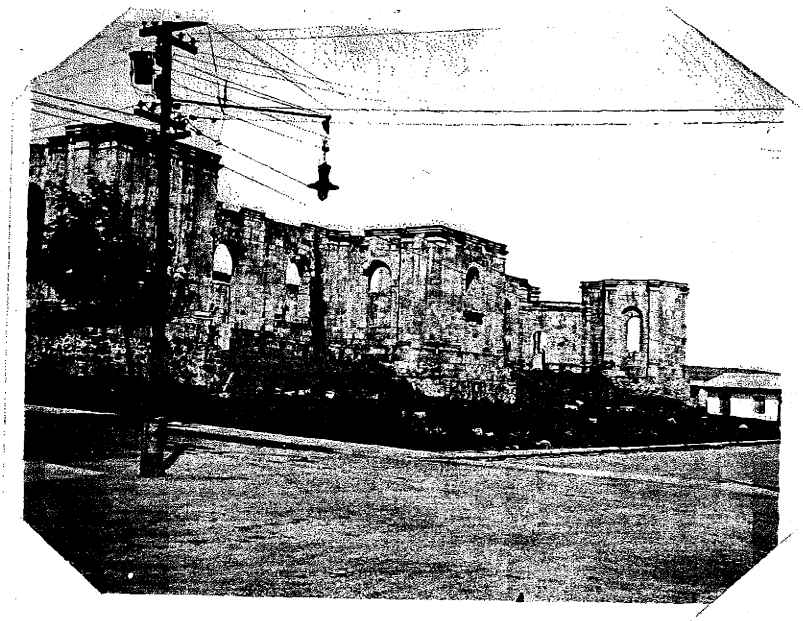


PLATE VII.

A church in Cartago. Destroyed in the earthquake of 1910. This is at the foot of Irazu.

PLATE VIII.

More ruins of the 1910 earthquake. Near Tierra Blanca, on the lower flanks of the volcano. Note the growth of vegetation in twelve years.

PLATE IX.

Looking southwest, on the lower flanks of Irazu. In the foreground fragments of phyric and aphyric andesite lavas, which sometimes reach considerable proportions, and which are strewn across the valley as far as Aguas Calientes, in the foothills of the Sierra Candellaria, a distance of 15 to 20 kilometers from the summit of Irazu. They have been held to be glacial till, but it is here believed that they are portions of the ancient summit of Irazu, since truncated in the same manner as that of Cosequina, or Krakatoa. They have subsequently been abraded by torrential action.

PLATE X.

Tierra Blanca, on the lower flanks of Irazu. This is the ancient post-road of the Conquistadores, leading to Blewfields, in Nicaragua.

PLATE XI.

The ancient post-road, paved with blocks probably of the summit of Irazu.

PLATE XII.

The crater of Irazu, looking north from point C of the sketch. This is the highest point. In the lower foreground, its edge marked by a band of white, is the floor of the oldest visible crater, perhaps that formed after the truncation of the cone, and later filled with water, as at Barba, Poas, and others. This was later partially cleared out, leaving only a shelf at the southern margin to mark its passing. Three to four hundred meters below this is seen the confused throat of the present activity, nearly choked with lapilli, but containing three open chimneys, and two completely clogged up. Hot water is the principal material now given off.

PLATE XIII.

Irazu, looking north from point "B" of sketch. The finely divided state of the ejectamenta is illustrated by the soggy foot-prints.

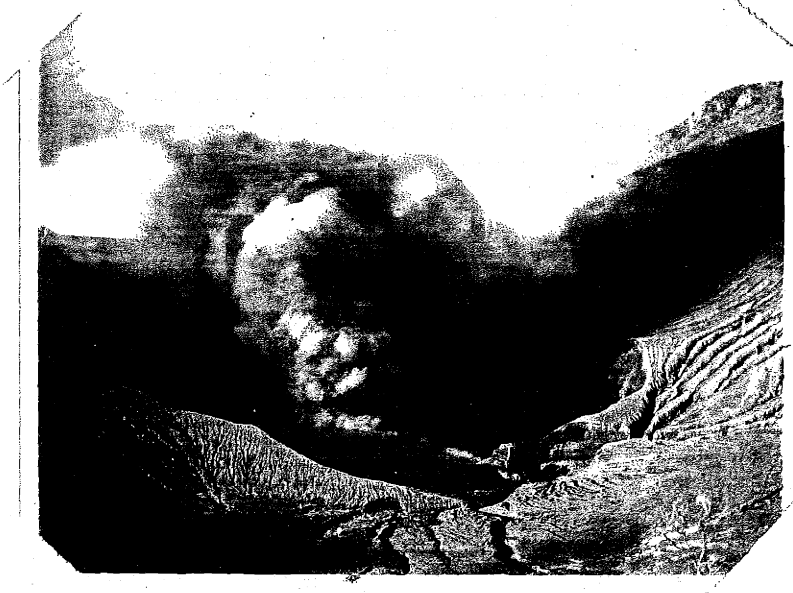


PLATE XIV.

Irazu, looking northwest.
The erosion features are here
well brought out.

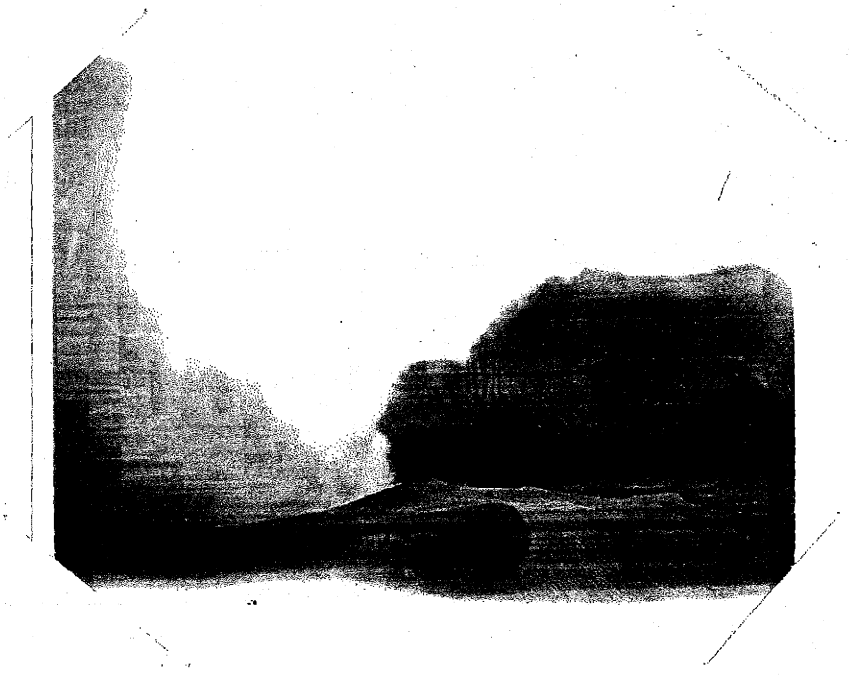


PLATE XV.

Irazu, looking east. These fumes are respirable.

PLATE XVI.

Irazu, showing the extreme western end of the oldest visible crater, in which there has been no activity for some time.

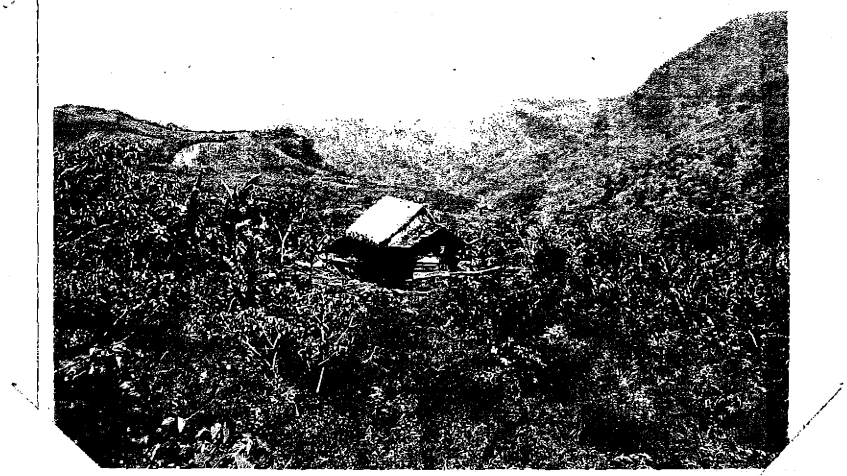


PLATE XVII.

The Reventazon valley, looking west by south. The lower flanks of Irazu and Turrialba here comingle, on the readers left. To the south, are the spurs of the Sierra Candellaria.

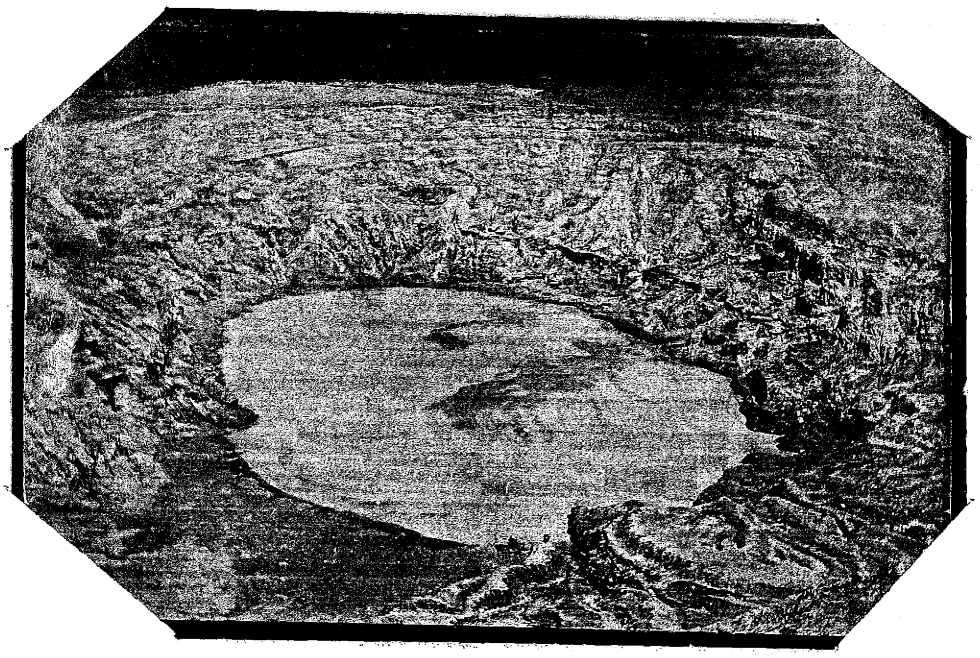


PLATE XVIII.

The mud lake, highly charged with sulfuric acid, in the active crater of Poas. The vertical distance from the water to the first lip is about meters. The outer lip is seen, partly forested, rising in the background.

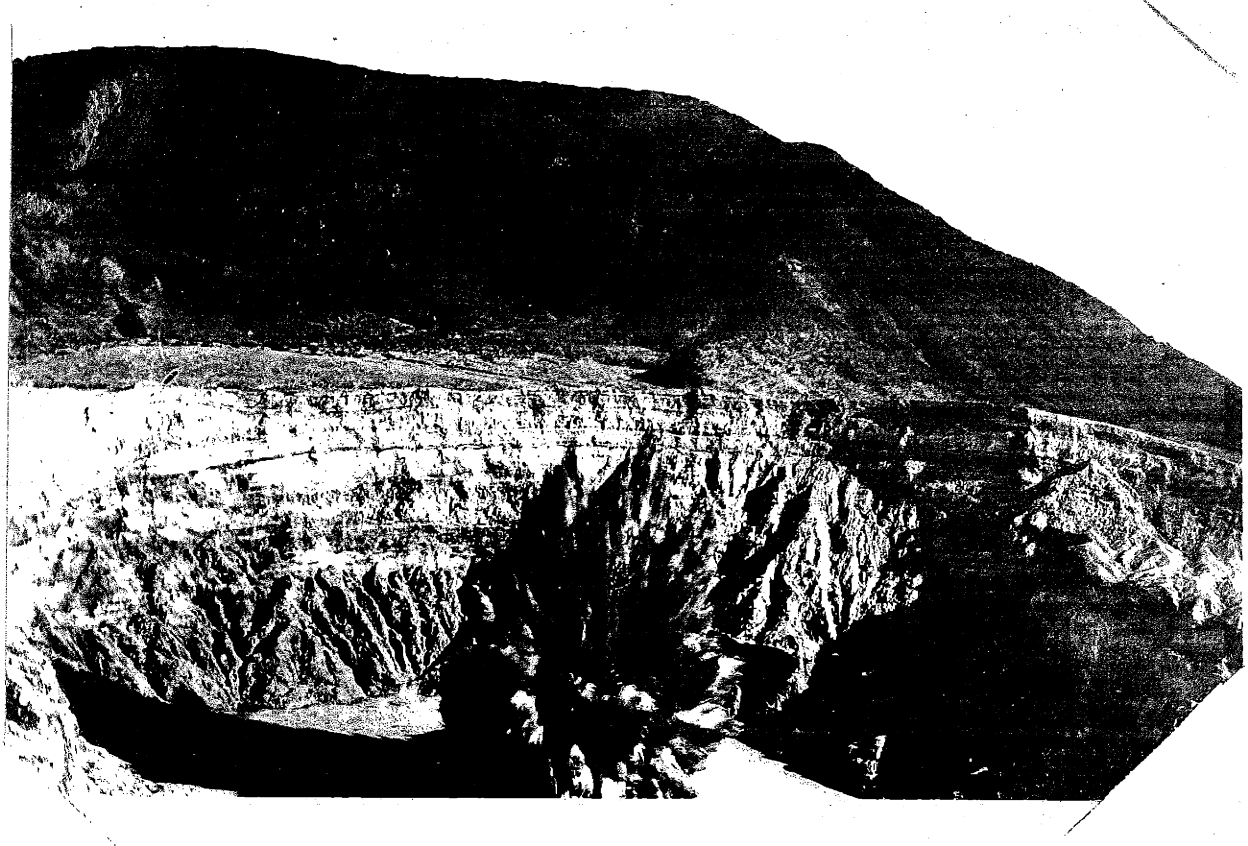


PLATE XIX.

A geyser-like explosion of mud and steam in the sulfurous lake at the summit of Poas. The compound nader of the crater is well shown. Note the stratification of mud flows below the horizon of the older lake bed. Above this is the dip of the secondary crater. The extreme vertical distance here visible is meters. The primary crater can not be comprehended from a single photograph.

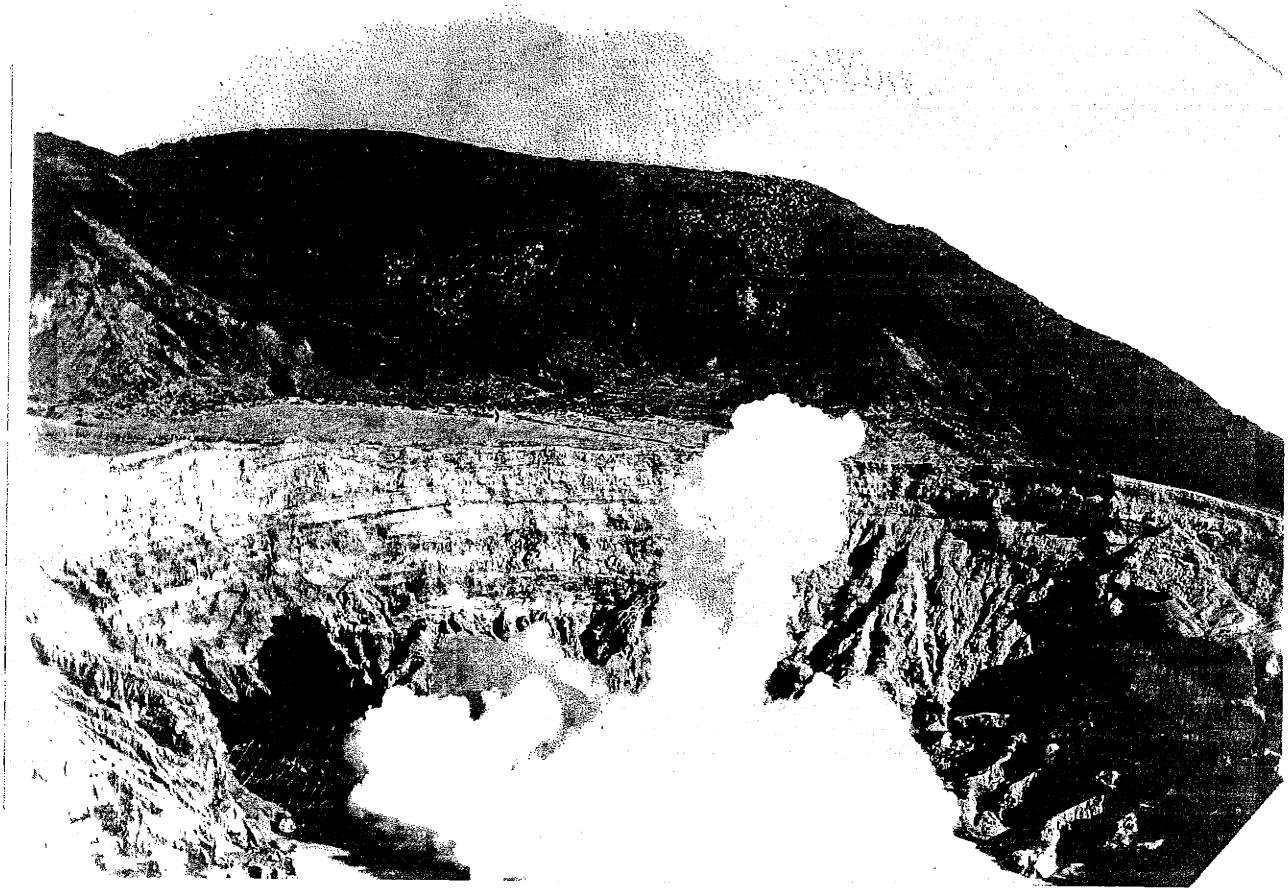


PLATE XX.

A geyser-like explosion of steam and water in the crater of Poas, at meters.

PLATE XXI.

Miravalles, looking north-east. A dry lake-bed is visible at the foot, this cone is older in terms of erosion than those to the southeast. It is probably composed of a greater proportion of flows than the others.

PLATE XXII.

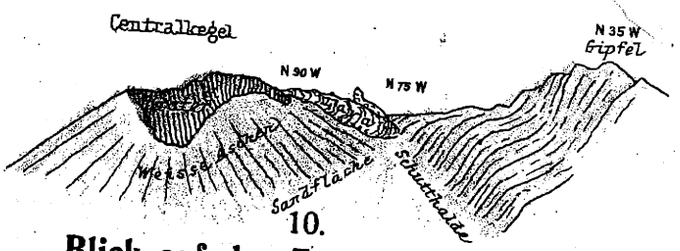
Rincon de la Vieja, looking northeast. A lacustral basin in the foreground. The cloud obscures an extremely steep, secondary ? cone on the summit. The wind velocity makes climbing interesting.

PLATE XXIII.

A combined thermal spring and nearly extinct solfataras near Guachipilin, at the foot of Rincon de la Vieja.

PLATE XXIV.

Boiling water breaking up the pumicious tuff, and again making it into a mud with low viscosity. A few kilometers to the southeast of Plate XXIII.



10.

Blick auf den Zentralkegel des Chiriqui (Panama) von Osten (Ringwall)

PLATE XXV.

Evidence as to the origin of Chiriqui taken from Sapper's "Die Mittelamerikanischen Vulkane", Petermanns Mitt. Erz. 178, 1913.

PLATE XXVI.

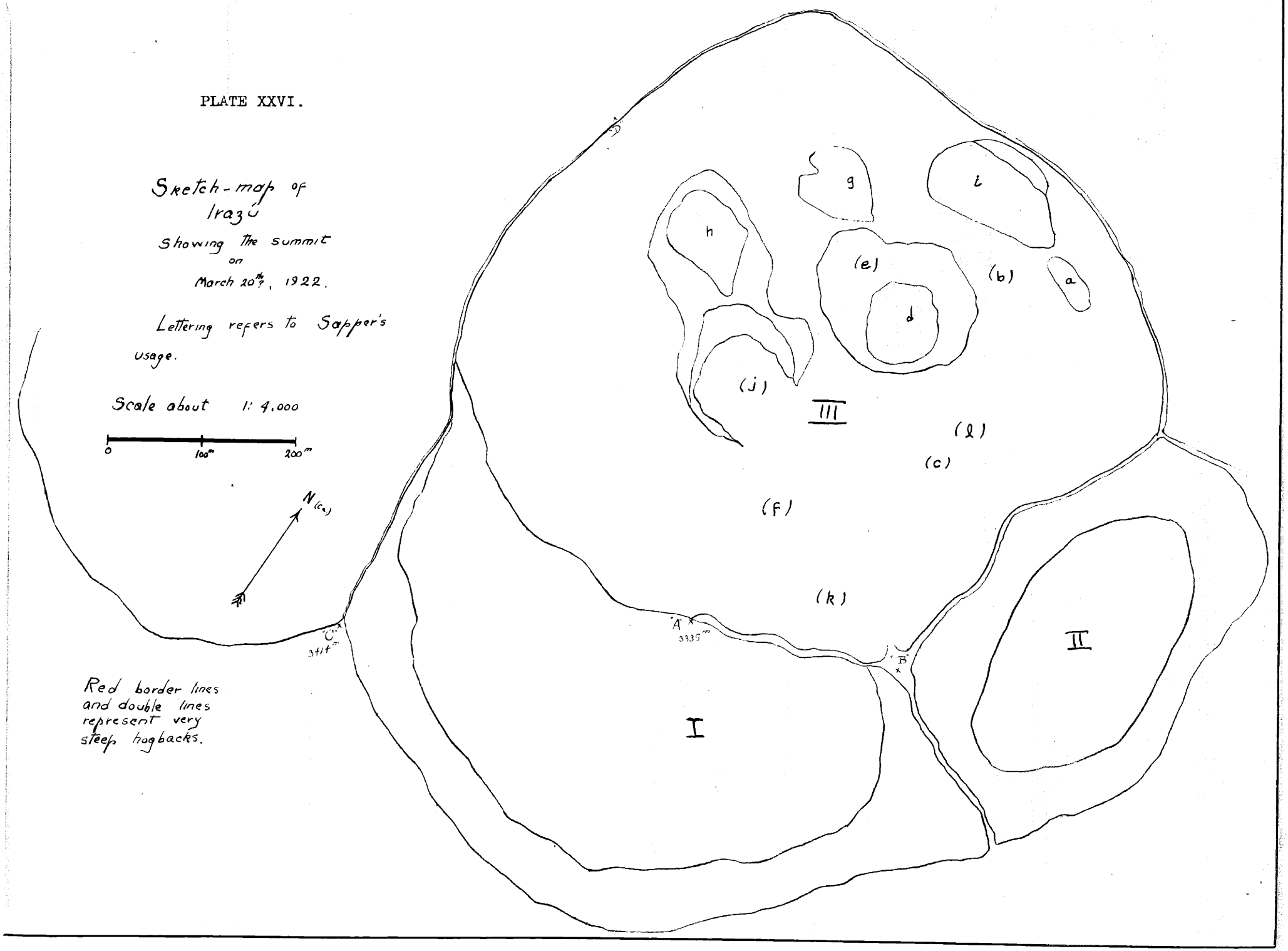
Sketch-map of Irazú

Showing the summit on March 20th?, 1922.

Lettering refers to Sapper's usage.

Scale about 1: 4,000

0 100m 200m



Red border lines and double lines represent very steep hogbacks.

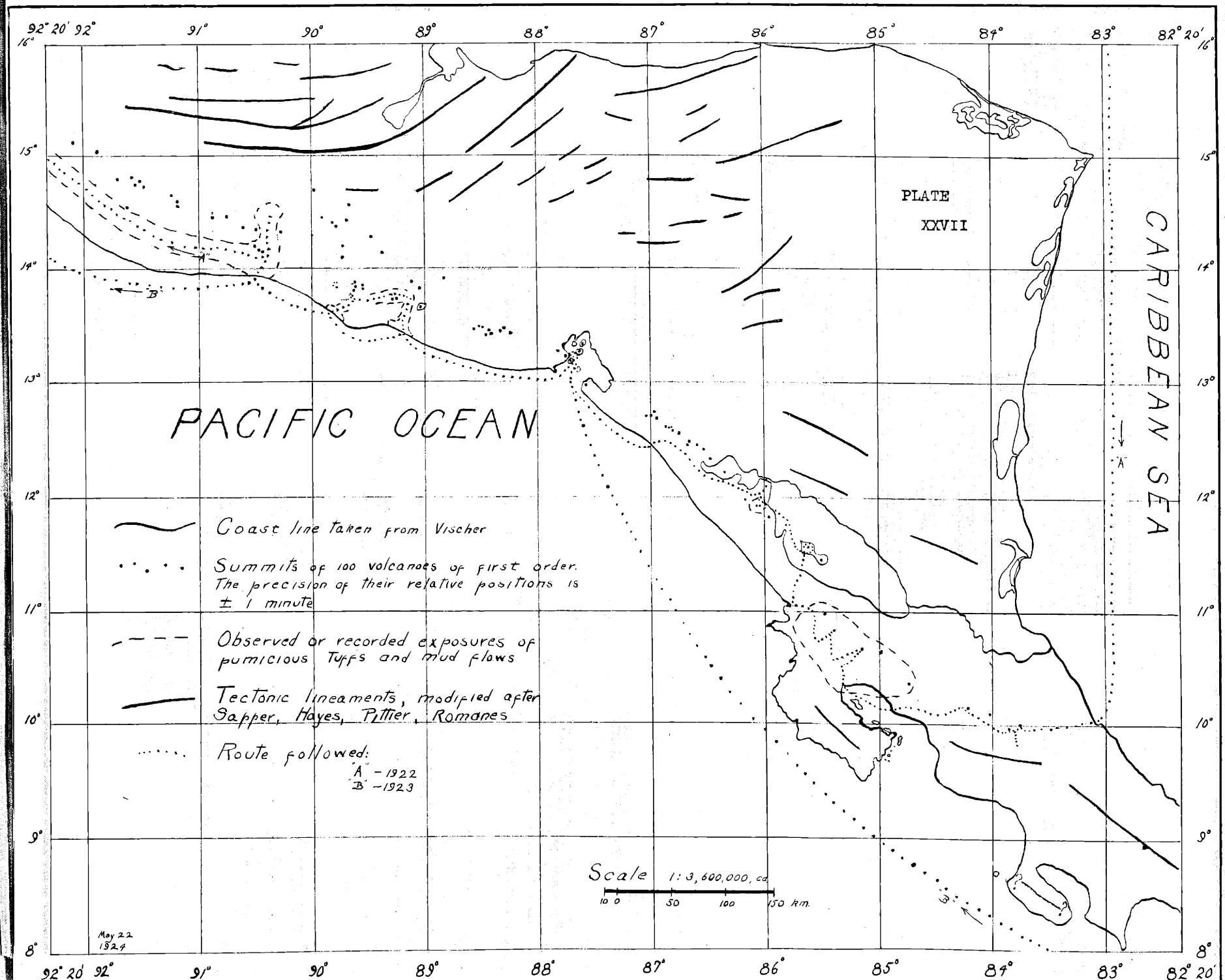
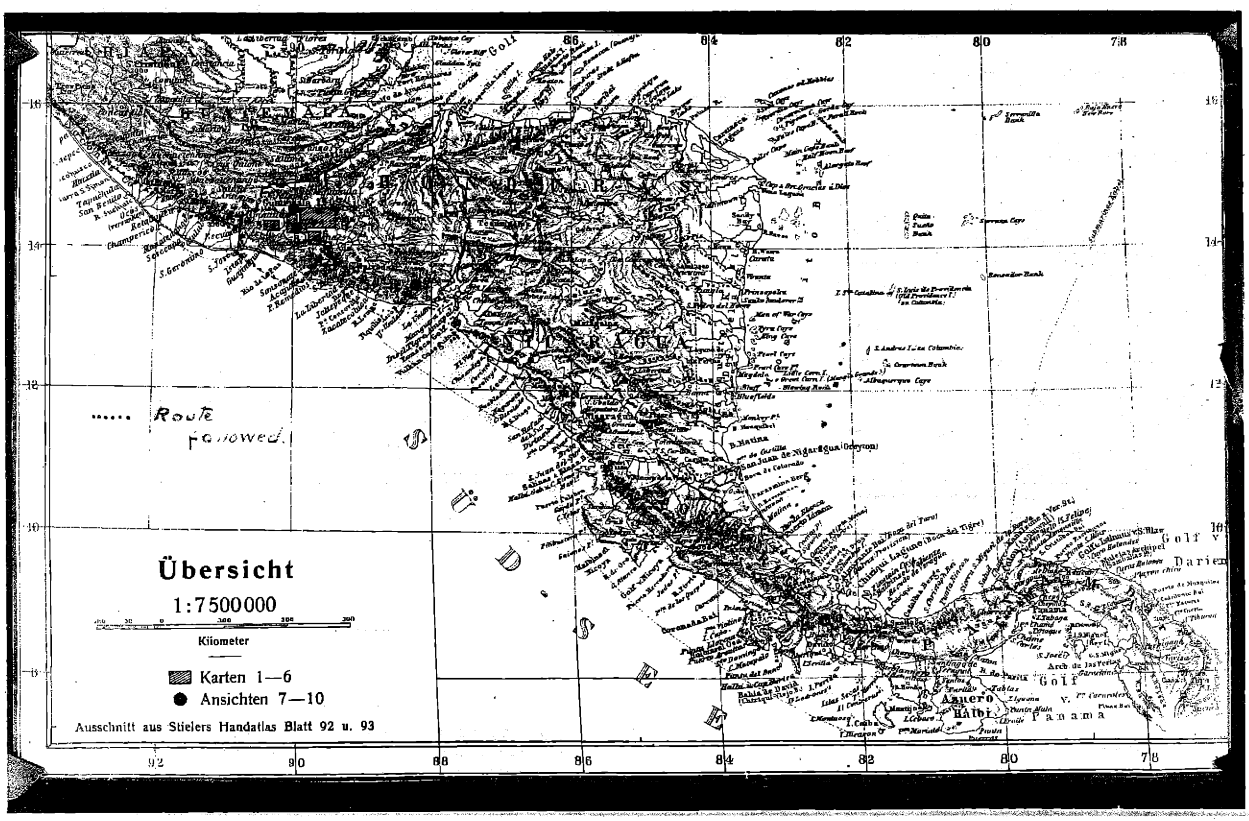

92° 20' 92° 91° 90° 89° 88° 87° 86° 85° 84° 83° 82° 20'
16° 15° 14° 13° 12° 11° 10° 9° 8°
PLATE
XXVII
PACIFIC OCEAN
CARIBBEAN SEA
A
B
Coast line taken from Vischer
Summits of 100 volcanoes of first order. The precision of their relative positions is ± 1 minute
Observed or recorded exposures of pumicious Tuffs and mud flows
Tectonic lineaments, modified after Sapper, Hayes, Pittier, Romanes
Route followed:
"A" - 1922
"B" - 1923
Scale 1: 3,600,000, ca.
100 0 50 100 150 Km.
May 22 1924

PLATE XXVIII



MAP OF CENTRAL AMERICA

Geographic positions of the Central American volcanoes.

	N. Lat.			W. Long. Gr.		
Tacana	15°	07'	22"	92°	06'	17"
Tajumulco	15	02	02	91	54	02
Lacandon	14	48	35	91	42	50
Chicaval	c14	33		c91	37½	
Siete Orejas	c14	48	55	c91	35	15
Santa María (Exancul)	14	44	56	91	32	55
Cerro Quemado	14	47	22	91	30	56
Zunil	14	42	13	91	28	37
San Pedro	14	38	55	91	15	50
Atitlan	14	34	32	91	11	05
Toliman	14	36	19	91	11	13
Fuego	14	28	03	90	52	48
Acatenango	14	29	39	90	52	30
Pico Chico (Tres Hermanas)	c14	30	06	c90	52½	
Agua	14	27	29	90	44	33
Pacaya (Pecul)	14	22	28	90	36	03
Cerro Alto	c14	21		c90	29	
Jumay	14	19	53	90	16	21
Flores	14	17	58	89	59	53
Jalapa (Jumay)	14	42		89	59	30
Tahual	14	27		89	54	
Retana	14	24	30	89	48	45
Suchitan	14	23	26	89	46	57
San Diego	14	17	30	89	28	
Capullo	14	09	09	89	22	57
Guazapa	13	53	39	89	07	01
Tecomatepe	13	50	08	89	03	20
Ipala	14	34		89	40	
Iztepeque	14	26		89	41	30
Viboras	14	13		89	43	30
Chingo	14	06	44	89	43	41
Cerro de la Gavia	c14	12		90	30	15
Raxon	14	10		90	29	
Tecuamburro	14	09	04	90	26	05
Moyuta	14	01	23	90	05	40
Cerro Grande de Apaneca	13	51	10	89	48	53
Lagunita	c13	52	30	c89	48	
Laguna Verde	c13	53		89	47	
Cuyotepe (Savana)	c13	50	30	89	47	15
Cuyanausul	c13	43	45	89	44	30
Agüilas	c13	43	45	89	43	10
Tamagas	c13	43	10	89	42	12
Laguna de la Rana	c13	43	50	89	41	40

Naranjo		13	51	55	89	41	27
Mala Cara	c.	13	53		89	39	48
Santa Ana		13	50	54	89	37	53
Izalco		13	48	30	89	38	07
Cerro Verde (Cuilotal)	c.	13	49	20	c. 89	37	30
Laguna de Coatepeque		13	51	45	89	33	
Boqueron		13	43	44	89	17	20
San Salvador		13	44	16	89	15	34
Ilopango	c.	13	40		89	03	
San Vicente		13	35	24	88	50	31
Tecapa		13	29	19	88	30	26
Cerro Verde		13	28	12	88	31	37
Taburete		13	25	55	88	32	22
Jucuapa		13	27	41	88	25	56
Santa Elena		13	25	48	88	26	47
Usulutan		13	24	52	88	28	39
Limbo	c.	13	27	?	88	21	?
Chinameca		13	28	20	88	19	30
San Miguel		13	25	43	88	16	29
Conchagua		13	16	27	87	50	08
Conchaguita	c.	13	13	30	87	46	30
Meanguera	c.	13	11		87	43	30
Cerro del Tigre (Amapala)		13	16	02	87	38	45
Sacate Grande		13	20		87	37	
Coseguina		12	58	07	87	35	11
El Chonco		12	42		87	03	20
El Viejo		12	42	01	87	01	03
El Obraje		12	44	15	86	59	48
Chichigalpa		12	41		86	58	
Portillo		12	37		86	53	12
Telica		12	36	04	86	51	20
Santa Clara (San Jacinto)		12	34	36	86	49	30
Rota		12	33		86	46	10
El Liston		12	36	20	86	50	
Las Pilas		12	29	11	86	40	52
Asososco		12	27		86	41	15
Cerro Montoso		12	27	40	86	36	
Momotombo		12	25	12	86	33	03
Momotombito	c.	12	20		86	30	
Cerros Guapos	c.	12	13		c. 86	21	
Masaya		11	58	30	86	10	30
Pacayita (Catarina)		11	55		86	05	
Laguna de Apoyo		11	55		86	03	12
Mombacho		11	49	30	85	58	48
Zapatera		11	45		85	49	
Ometepe		11	33	36	85	37	10

Madera	11	27		85	31	
Orosi	10	59		85	29	
Gongora	10	56		85	56	
Rincon de la Vieja	10	50		85	22	
Cuipilapa Miravalles	10	41		85	09	30
Tenorio	10	39	30	84	59	30
Canaste (Pelon)	c.10	23?		84	43?	
Poas	10	10		84	14	
Barba	10	06	30	84	92	30
Irazu	9	59		83	52	
Turrialba	10	01		83	46	30

VOLUME II.

GEOLOGIC LITERATURE

on

CENTRAL AMERICA

1529-1924

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Part III

Maps

P. C. Putnam

Central America.

1818

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1826

Map of Guatemala. Reduced from the survey in the archives of that country, 1826. 24½ x 30. London, A. Arrowsmith, 1826.
Note: The name of Guatemala was formerly applied to the whole of Central America. L.C.

1832.

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1832

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1832

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1836

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1839-42.

Outline map of Central America & Yucatan shewing the situation of the ruined cities & monuments visited by messr. Stephens & Catherwood in the years 1839, 1840, 1841, 1842. 14 x 12.
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1844

Central America, and the West Indies, from the latest and best authorities. Engraved by Charles Copley. N. York. 12 x 19½
(In McCulloch (J.R.) McCulloch's universal gazetter. 8°. New York, Harper & Brothers, 1844).
Note.- Inset map of "The harbour and city of Havana", "Jamaica", &c. L.C.

1847

(Map of the tract of land to which New Granada and Central America, lay claim),
T. R. Harrison, lith. 12½ x 16.
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1847

States forming the republic of Central America. 11x12½.
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1850

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1850

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1850

Central America, shewing the proposed junctions of Atlantic & Pacific oceans. Constructed and engraved by G. H. Swanston. 9 x 5½. 8°
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1850

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1850

Map of Central America including the states of Guatemala, Salvador, Honduras, Nicaragua & Costa Rica, the territories of Belise & Mosquito, with parts of Mexico, Yucatan & New Granada. Shewing the proposed routes between the Atlantic & Pacific oceans by way of Tehuantepec, Nicaragua & Panama. Engraved from the original drawings of John Baily of Guatemala; with additions from the latest surveys of the admiralty, S. Moro, col. Lloyd, Garella, &c. 26 x 32. London, T. Saunders, (1850).

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Map of Central America, shewing the different lines of Atlantic & Pacific communication. By James Wyld. 1850. Ex. doc. no. 75. 1st sess. 31st cong. col. 23 x 32. Baltimore, lith. by E. Weber & co.(1850).
Note: Inset of "Isthmus of Panama".

1850

A new map of Central America, shewing the different lines of Atlantic & Pacific communication. 23 x 33. New York, J. Disturnell, 1850.
Note: Insets of "Isthmus of Panama" and "Map of the isthmus of Tehuantepec. Reduced from the original made by order of Jose de Garay." L.C.

1851

Carte du grand isthme de l'Amerique Centrale dressée par Arrowsmith, en 1851. 7½ x 11½.
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1851

Maps of the West Indies & Central America, shewing the countries where the Mahogany and other fine forest trees abound; also the projected passages across the great American isthmus. Drawn & engraved for Chaloner & Fleming, by Trelawny Saunders. 1851. 18x25.
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1851

A new map of Central America shewing the different lines of Atlantic & Pacific communication. 22x32. New York, J. Disturnell, 1851.
Note: Insets of "Map of the isthmus of Tehuantepec. Reduced from the original made by order of Jose de Garay" and "Isthmus of Panama."

1852

Map of Central America, shewing the different lines of Atlantic & Pacific communication. By James Wyld. 22½ x 31. London, J. Wyld, 1852. L.C.
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Note: Inset of "Isthmus of Panama."

1853-1854

Karte von Central-America zur übersicht der stattlichen verhältnisse und der reisen von dr. C. Scherzer und dr. M. Wagner, 1853 & 1854. Gezeichnet von Herm. Berghaus. Massstab 1/8000000. 9½ x 8.
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1854

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1854

Central America. West Coast. Sheet 3. Parida (Panama, S.A.) to gulf of Nicoya (Costa Rica). Surveyed by capt. Henry Kellett, 1849. 25 x 19. London, 1854, (Great Britain. Admiralty. Chart No. 2265).

1856

Map of Central America. Compiled from materials furnished by the committee on foreign relations of the senate of the U.S. Executed at the office of the U.S. coast survey, under special direction of capt. W.R.Palmer, U.S. topl. engrs. March 1856. L.D. Williams, draughtn. U.S. c.c. Scale 1/2500,000. 41x43. New York, lith. by J. Bien, (1856).
Note: Insets of "Bay of Fonseca", "Port of San Juan de Nicaragua, or Grey Town" and "Nicaragua from San Juan to Fonseca bay". L.S.

1856.

Map of Central America (etc). Shewing the routes between the Atlantic & Pacific oceans. Edited by Trelawney Saunders from the original drawings of John Bailey with additions (etc). London, E. Stanford, 1856. Reproduced in 1879.
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1857.

Carte du grand-isthme de l'Amerique Central pour servir a l'intelligence des differents projects de communication interoceanique par V. A. Malte-Brun, 1857. 9½ x 13.
(In Nouvelles annales des voyages 6m3 serie. 8°, Paris, 1857 v. 9. p. 5.
Note: Insets of "Carte de l'Atrato et du Truando pour l'intelligence du projet de M. F. Kelly of New York. (Cette carte est empruntee a une carte Espagnole)" and "Chemin de fer de Panama."

1857.

Central America. 11½ x 15½.
(In Wells (William V.) Walker's expedition nach Nicaragua. Aus dem Englischen. 12°, Braunschweig, 1857).
Note: Insets of "Isthmus von Panama#, "Hafen von San Juan de Nicaragua" and "Die Nicaragua-Route."

1857

Map of the United States, British & Central America. From state documents & unpublished materials by professor H. D. Rogers, of Boston, U. S. and A. Keith Johnston, geographer to the queen. 1857. Engraved by W. & A.K. Johnston. Scale: 1-3,540,000. Col. 54 x 67. Edinburgh, W. & A.K. Johnston, (1857).

1857

Übersicht der hauptverbindungs-wege des Atlantischen- und stillen-oceans durch Central America entworfen von H. Kiepert, 1857. 16 x 18½.
(In Gesellschaft für erdkunde zu Berlin. Zeitschrift. Neue folge. 8°. Berlin, D. Reimer. 1857. v. 2. pl.4.)

1858

H. Kiepert's karte des nördlichen tropischen America- A new map of tropical America north of the equator, comprising the West Indies, Central America, Mexico, New Granada, and Venezuela. col. 38 x 36. Berlin, D. Reimer, 1858. L.C.

1858

H. Kiepert's neue karte von Mittel-America. A new map of Central America. Engraved on stone by Ed. Kolitz. col. 36 x 40. Berlin, D. Reimer, 1858. L.C.

1858

Map showing the proposed routes of interoceanic communication.
(In Squier (E.G.) The states of Central America. 8°. New York, Harper & brothers, 1858). L.C.

1858

Mexico und die republiken von Central America. Bearbeitet con C. Gräf. 22 x 25. Weimar, geographisches, institut. (1858)

1859

Colton's map of Central America. By Fermin Ferrer, member ofthe American geographical society of Nicaragua. Scale of 60 geographical miles. 35 x 47. New York, J. H. Colton & co. 1859.
Note,-Insets of "Harbour of Realejo", "Isthmus and railroad of Panama" and "Harbour of San Juan Del Note."

1859

More's map of Central America. 13 x 15.
(In Stout (Peter F.) Nicaragua. 16°. Philadelphia, J. E. Potter, 1859.) L.C.

1860

Colton's Nicaragua, Guatemala, Honduras, San Salvador, & Costa Rica. Revised, enlarged and published by S. H. Goetzel & co. Mobile, Ala. 12 x 15.
(In Walker(William). The war in Nicaragua. 12°. Mobile, S. H. Goetzel & co. 1860). L. C.

1862

Carta de los estados de Centro-America con todos los proyectos de las diversas vias de communicacion inter-oceanica desde la punta de Anton-Lizardo en Vera-Cruz hasta el cabo Corrientes en Nueva-Granada. Formada por A'tin. E van de Gehüchte, segun et orijinal a el dejado por su difunto padre. Manuscript. 36 x 40½. Guatemala, 1862.

1863.

Central America and the West Indies, 8¾ x 11½.
(In Bartlett (W.H.) and Woodward (B.B.)The history of the United States. 8°. London, Virtue & co.(1863). v.2, p. 432.

1866

General map of the American isthmus showing the various lines proposed for interoceanic communication. Compiled by admiral C. H. Davis, 20 x 24.
(In Davis (Charles H.) Report on interoceanic canals and railroads between the Atlantic and Pacific oceans. 8°. Washington, 1867. map 1). L. C.

1867

Johnson's Central America. col. 11x16. New York, A.J. Johnson, (1867). Note: From Johnson's family atlas.

1874.

The granger's map of the United States, British provinces, West Indies, Mexico and Central America. (By Gaylord Watson, anon). 38 x 50. Chicago, Watson(s Chicago branch, 1874.

1876.

Central America. (Northern Part). Comprising Mexico, Guatemala, Honduras, San Salvador, and Nicaragua. 12 x 17.
(In Jones (Charles H.) Historical atlas of the world. fol. Chicago, Higgins, bro. ' co. 1876. no. 39.) L. C.

1876.

Central America. (Southern Part). Including the United States of Colombia. 12 x 17½.
(In Jones (Charles H.) Historical atlas of the world. fol. Chicago, Higgins, bro. & co. 1876. no. 46). L.C.

1876.

Williams' (G.W.) copper-plate map of the United States, Canada, Mexico, Central America, West Indies, &c. col. 63 x 63. Philadelphia, J. M. Atwood (1876).

1876-1877.

Estudios y proyectos para el canal interoceanico 1876-1877. 1/1.000.000. 1½ x 18½.
(In Sociedad geografica de Madrid. Boletin. Julio-dic. 1877. 8°. Madrid, Fortanet, 1877. v.3 at end.) L.C.

1877.

Map of the Mexican Pacific railway, connecting ciudad Yucatan with Merida, Campeche, Vera Cruz, Mexico and Acapulco and of the Central American Railway, connecting ciudad Yucatan with Valladolid, Belize, (etc). Prepared by G. W. & C. B. Colton & co. 21½ x 28. New York, G.W. & C.B. Colton & co. (1877). L.C.

1878

Map of the isthmus of Central America. To illustrate the paper by rear admiral D. Ammen, U.S.N. 1878. 7¼ x 11.
(In American (The) geographical society of New York. 1878. 8°. New York, for the society. (1878). v. 10 p. 142). L.C.

1879.

Mapa general del istmo Americano indicando los projectos de canales inter oceanicos examinados por el congreso internacional de 1879. Escala de 1.7000.000. 10 x 12.
(In Sociedad geografica de Madrid. Boletin. Enero, febrero y marzo, 1888. 8°. Madrid. Fortanet, 1888. v. 24. no. 1-3).

1880.

Map of the isthmus of Central America, 1880. 7½ x 11.
(In American (The) geographical society of New York. Bulletin. 1879. 8°. New York, for the society,(1880). v. 11. p. 112.
Note:-Accompanying paper on "The interoceanic ship canal", read before the society, December 9, 1879.

1881-1882.

Central-America und Westindien entworfen und gezeichnet von dr. Joseph Chavanna. Maasstab-1:6,500,000. Druck v. Jos. Eberle & co. Wien. 40 x 17½
(In Deutsche rundschau für geographie und statistik, Oct. 1881-sept. 1882. 4 jahrg. 8°. Wien, A. Hartleben, 1882, v. 4. p. 22).
Note: Inset maps of the "Isthmus von Darien" - "Isthmus von Tehuantepec" - "Isthmus von Panama"- "Des plateau v. Mexico."

1883.

Colton's Central America. Scale of statute miles 60 to one inch. = 1:3,800,000. 14 x 26. New York, G. W. & C.B. Colton & co. 1883. L. C.

1885.

Colton's Central America. Scale of statute miles 45 to one inch = 2.900,000. 20 x 35. New York, G.W. & C. B. Colton & co. 1885.

1885.

East coast of Central America. Cape Gracias a Dios to gulf of Darien. Compiled from latest British surveys. 1885. 29 x 34½. Washington, 1885.
(United States. Navy department. Hydrographic office. Chart no. 945). L. C.

1886.

Amerique Centrale. Echelle du 10,000.000e. Grave et imp. par Erhard. 1886. 8½ x 5¼.
(In grande (La) encyclopedie. 8°. Paris, H. Lamirault, & cie. (1885-98). v. 2, p. 698.

1886.
Central America. West coast. Corinto harbour (Port Realejo). Surveyed by commander C. E. Clark, U.S.N. and the officers of the U. S. S. Ranger, 1884. 12 x 19. London, admiralty, 1886.
(Great Britain. Admiralty. Chart No. 1927).

1886.
West coast of Central America. Gulf of Fonseca (Salvador, Honduras, Nicaragua). 22 x 29¾. Washington, 1886.
(United States. Navy department. Hydrographic office. Chart no. 973.) L. C.

1887.

America Central y las Antillas. Escala 1:9.250.000. 9½ x 7½.
(In Diccionario enciclopedico Hispano-Americano. 8° Barcelona, Montaner & Simon, 1887. v. 2, p. 314.

1887.
Pacific coast of Mexico and Central America. San Blas to Panama. 29½ x 40½. Washington, 1887.
(United States. Navy department. Hydrographic office. Chart no. 1007). L. C.

1887.
Ports and anchorages on the west coast of Central America. From the latest surveys by the United States government to 1887. Libertad anchorage (Salvador). San Juan del Sur (Nicaragua). Port Elena. Uvita bay. Piedra Blanca bay (Costa Rica). 17 x 25. London, 1887.
(Great Britain. Admiralty. Chart no. 868). L.C.

1888.
West coast of Central America. Burica Point (Costa Rica) to Morro Puercos (Panama). 25½ x 40½. Washington, 1888.
(U.S. Navy department. Hydrographic office. Chart 1018).

1889.
Central America. Cape Mala (Panama) to Elena Bay (Costa Rica) with the northern coast from Chagres to Greytown. 25½ x 39. London, 1889.
(Great Britain. Admiralty. Chart no. 2145.). L.C.

1889.
Central America. West coast. Burica Point (Costa Rica) to Mangrove Bluff (Mexico). 1882. Corrected to 1888. Large corrections march 1886, july 1889. 25½ x 39. London, 1889.
(Great Britain. Admiralty. Chart no. 587).

1889

Mapas de Colton. Mapa de America Central. Escala 1:1,705,000. 31½ x 39½. Nueva York, G. W. & C. B. Colton & cia. 1889.
Note: See 1898 for a new edition of this map.

1889

Ports and anchorages on the west coast of Central America. From the latest surveys by the United States Government to 1887. Large corrections, may 1889. El Rincon harb'r Golfito anch'e, approaches to San Domingo (Costa Rica). Libertad anchorage (Salvador). San Juan del sur(Nicaragua) Port Elena Uvita bay Piedra Blanca bay (Costa Rica). 17 x 25½. London, 1889.
(Great Britain. Admiralty. Chart no. 868)

1892.

Plans of the west coast of Central America - San Salvador. Acajutla anchorage.- Nicaragua. Corinto harbour (Port Realejo). 26 x 29. London, admiralty, 1892.
(Great Britain. Admiralty. Chart no. 1927) L. C.

1892.

(Railroads in operation and projected in Central America and South America. By W. D. K., Wash., D. C. 1892 anon). 5 sheets. 7 x 10. Washington, 1892. L. C.

1895.

Centralamerika, die staaten, Guatemala, Honduras, Salvador, Nicaragua, Costarica, Massstab 1:6000,000. 8½ x 10½. (In Brockhaus' konversations-lexikon. 14te aufl. 8°. Leipzig, F.A. Brockhaus, 1895. v.4, bet. pp. 34-35). L.C.

1895.

Mexico and Central America. West coast. Index to coast, special, and harbor charts. 10 x ;4¼. Washington, 1895.
(United States. Navy department. Hydrographic office. No. F) L. C.

1896.

Verteilung des regenfalls im nördlichen Mittelamerika. Entworfen von dr. Carl Sapper, mai, 1896. Massstab. 1:4.000.000-Regenfall in der Verapaz in den monaten januar u. juli. Entworfen von dr. Carp Sapper, mai 1896. Massstab 1:10000000 9¼ x 14½.
(In Petermann's Mittheilungen. 1897. 4°, Gotha, J. Perthes, 1897). v. 43. pl. 10. at end) L. C.

1897

West coast of Central America. Ocos river to San Juan del Sur. Surveyed by the officers of the U. S. S. Tuscarora in 1880. 24 x 43. Washington, 1897. (United States. Navy department. Hydrographic office. Chart no. 931). L. C.

1897.

Westindien und Zentral-Amerika. Massstab 1:12000000. 8 x 10½ (In Meyers konversations-lexikon. 5te aufl. 8°. Leipzig und Wien, bibliographisches institut, 1897. v. 17. bet.pp 690-691.) L. C.

1898

Central America. Rand, McNally & company's indexed atlas of the world. pp. 190-191. Statute miles, 69.16= 1 degree. 19 x 26. (Chicago, Rand, McNally & co. 1898.)
Note:-Inset "Map showing proposed line of Nicaragua canal." L.C.

1898.

Mapa de America Central. Escala 1:1,705,000. 30 x 39. Nueva York, Colton. Ohman & cia. 1898.
Note: Insets of "Trazado del canal de Nicaragua, "El golfo de Fonseca", &c. L. C.

COSTA RICA.

1825.

Carta esferica desde el golfo Dulce en la Costa Rica hasta Sn. Blas en el estado de Xalisco. Comprehendida entre los paralelos de 7°30, y 99.35 occidental de meridiano de Cadiz. Publicada por orden del escmo. sor d. Guadalupe Victoria, primer presidente de la republica Mexicana. 22 x 35. Mexico, 1825. L.C.

1825-1851.

Map of the republic of Costa Rica as it acutally is in 1851 and has been since 1825. 8 x 10.
(In Molina (Felipe). Memoir on the boundary question. 8°. Washington, Gideon & co. 1851). L.C.

1829

Chart of the bay of Limon, or Navy Bay. Surveyed in h.m.s. Victor. By J. A. Lloyd, 1829. 9¾ x 7½. (1829)

1836

Sketch of the state of Costa Rica in Central America by col'l don Juan Galindo. 1836. 7½ x 10.
(In Royal geographical society. Journal. 1836. 8°, London, J. Murray, 1836. v. 6. at end.) L.C.

1838

Mapa del Golfo de Nicoya en la republica de Costa Rica levantado por el capt. sir Edw. Belcher,c.b. 1838.8x8½.
(In Molina (Felipe). Bosquejo de la republica de Costa Rica. 8°. Nueva York, S. W. Benedict,1851. p. 56.)

1839.

Mapa de la Bahia de Boca Toro en la republica de Costa Rica levantado por el comandante Edward Barnett,1839. 7½ x 8½.
(In Molina (Felipe). Bosquejo de la republica de Costa Rica. 8°. Nueva York, S. W. Benedict, 1851. p. 59)

1846-1848.

La partie central du Costa Rica. Par A.S. Orsted. 8½x11.
(In his L'Amerique Centrale. fol. Copenhague F. S. Muhle, 1863.)

1847.
(Costa Rica canal). 7½ x 5¼.
(In Colonial (The) magazine and East India review. 1850. 8°. London, J. Mortimer, 1850. v.19. p.470.)

1849
Gulf of Nicoya in the province of Costa Rica. Surveyed by capt. sir Edward Belcher, 1838. 36½ x 25. London, 1849.
(Great Britain. Admiralty. Chart no. 1931.) L.C.

1850-1851.
Plano de la colonia de Miravalles en la republica de Costa Rica, America Central, levantado por Adolfo Gerkowski, 1850-51. 12½x18.
(In Molina (Felipe). Bosquejo de la republica de Costa Rica. 8°. Nueva York, S. W. Benedict, 1851.p.126.

1851.
Mapa de Costa Rica. 8 x 8½.
(In Molina (Felipe). Bosquejo de la republica de Costa Rica. 8°. Nueva York, S. W. Benedict, 1851. front). L.C.

1851.
Mapa del Puerto de Bolanos o sea bahia de las Salinas levantado por el capt. sir Edw. Belcher. 7½ x 9.
(In Molina (Felipe). Bosquejo de la republica de Costa Rica. 8°. Nueva York, S. W. Benedict,1851. p.91). L.C.

1851.
Mapa del Puerto de la Culebra levantado por el capt. sir Edw. Belcher. 8 x 9. L. C.
(In Molina,(Felipe). Bosquejo de la republica de Costa Rica. 8o. Nueva York, S. W. Benedict, 1851. p. 104).

1851.
Mapa del Rio de San Juan por el baron A. de Bülow. Berlin, 1851. 7½ x 18½. L. C.
(In Molina (Felipe). Bosquejo de la republica de Costa Rica. 8°. Neuva York, S. W. Benedict,1851. p.54.)

1851.
Survey for a canal by the Sopoa to Port Salinas, in Costa Rica to illustrate mr. Oersted's paper. 1851. 4½x7½.
(In Royal Geographical society. Journal. 1851. 8°. London, J. Murray, 1851. v. 21, p. 96.) L. C.

1852.
Central America. West coast. Cape Elena (Costa Rica) to Cape Desolado (Honduras). Shett 26. Survey by sir Edw. Belcher and the lake by capt. E. Barnett. 1840. 18½x24½. London, 1852.
(Great Britain. Admiralty. Chart no. 2146). L.C.

1852.

Sketch of Costa Rica and route between the Atlantic and Pacific from Boca del Toro and golfo Dulce. Published by James Wyld, London. 12 x 17.
(In Buckingham (James Silk). Colonisation of Costa Rica. 8°. London, E. Wilson, 1852. L. C.

1856.

Central America. West Coast. Nicoya gulf to Cape Elena (Costa Rica). Sheet 4. Surveyed by capt. sir Edward Belcher. 25 x 19. London, 1856.
(Great Britain. Admiralty. Chart no. 2145). L.C.

1856.

Karte von Costa Rica. 8 x 9
(In Wagner (Moritz) and Scherzer (Karl). Die republik Costa Rica. 8°. Leipzig, Arnold, 1856.) L. C.

1861.

Originalkarte des nördliche theils von Costarica. Nach einer original-zeichnung von dr. v. Frantzius mit benutzung anderen materials, von A. Petermann. Maassstab. 1:1,000,000. 9½ x 7½.
(In Petermann's Mittheilungen. 1861. 4°. Gotha, J.Perthes, (1861). v. 7. p. 368). L. C.

1864-1865.

Originalkarte des nordwestlichen theiles von Costarica zur übersicht der reisen dr. K. v. Seebach's dec. 1864-jan. 1865. Den küstenaufnahmen v. Belcher u. a. adjustirt von A. Petermann. Massstab 1:600,000. 9½ x 7½.
(In Petermann's Mittheilungen. 1865. 4°. Gotha, J.Perthes, (1865). v. 11. pl. 9. p. 280). L. C.

1867.

Carte de l'etat de Costarica par M. D. Kaltbrunner. 9 x 12.
(In Societe de la geographie de Geneva. Memoires. 8°. Geneve, 1867, v. 6.)

1869.

Originalkarte von Costarica von A. von Frantzius, enthaltend die resultate der neuesten aufnahmen & beobachtungen von Valentini, L. Daser, F. Kurtze, K. v. Seebach, Raf. Alvarado, A. Oerstedt, T. A. Hull, u. a. Redigirt von A. Petermann. Maassstab 1:1,000,000. 9½ x 16½.
(In Petermann's Mittheilungen. 1869. 4°. Gotha, J. Perthes, (1869). v. 15. p. 81). L. C.

1877.
Originalkarte des hauptgebietes von Costarica zur übersicht der aufnahmen von W. M. Gabb, Collins & Martinez. Von A. Petermann. Maassstab 1:600.000. 9½ x 16½. (In Petermann's Mittheilungen. 1877. 4°. Gotha, J. Perthes, (1877). v. 23. pl. 18. at end) L.C.

1887.
West Coast of Central America. Judas Point to Burica Point (Costa Rica). Surveyed by the officers of the U.S.S. Ranger in 1885. 33 x 27½. Washington, 1887. (United States. Navy Department. Hydrographic office. Chart no. 1017). L.C.

1887.
West coast of Costa Rica. Ballena bay. (Gulf of Nicoya). From a survey in 1865, by the officers of the U. S.s. Ranger. 12½ x 15. Washington, 1887. L.C.
(U. S. Navy Department. Hydrographic office. Chart #1033)

1887.
West coast of Costa Rica. Gulf of Dulce. Surveyed by the officers of the U.S.s. Ranger in 1885. 32 x 25. Wash. 1887. (U.S. Navy Dept. Hydrographic office. Chart no. 1037) L.C.

1887.
West coast of Costa Rica. Gulf of Nicoya. From a British survey in 1838, corrected by a partial survey in 1885. 30½ x 24. Washington, 1887.
(United States. Navy department. Hydrographic office. Chart no. 1034). L.C.

1887.
West coast of Costa Rica. Juanilla bay. From officers of the U.S.s. Ranger, 12½ x 15. Washington, 1887.
(United States. Navy department. Hydrographic office. Chart no. 1027). L.C.

1887.
West coast of Costa Rica. Murcielago bay. From a survey in 1885 by the officers of the U.S.s. Ranger. 12x16½. Washington, 1887.
(United States. Navy department. Hydrographic office. Chart no. 1028). L.C.

1887.
West coast of Costa Rica. Piedra Blanca bay. From a survey in 1885 by the officers of the U.S.s. Ranger. 15½ x 12. Washington, 1887.
(United States. Navy department. Hydrographic office. Chart no. 1032). L.C.

1887

West coast of Costa Rica. Port Culebra. Surveyed by the officers of the U.S.s. Ranger in 1885. 12½ x 15. Washington, 1887.
(United States. Navy department. Hydrographic office. Chart no. 1030.) L. C.

1887

West coast of Costa Rica. Port Elena (Elena bay). Froma survey in 1885. 15½ x 12. Washington, 1887.
(United States. Navy department. Hydrographic office. Chart no. 1026.) L. C.

1887.

West coast of Costa Rica. Potrero Grande bay. From a survey in 1885 by the officers of the U.S.s. Ranger. 12½ x 15½. Washington, 1887.
(United States. Navy department. Hydrographic office. Chart no. 1029). L. C.

1887

West coast of Costa Rica. Uvita bay. From a survey in 1885, by the officers of the U.S.s. Ranger. 12x15½. Washington, 1887.
(United States. Navy department. Hydrographic office. Chart no. 1035.) L. C.

1888

Central America. West coast. Elena bay (Costa Rica) to San Jose (Guatemala). 25½ x 39. London, 1888.
(Great Britain. Admiralty. Chart no. 1049.) L. C.

1888

West coast of Costa Rica. Potrero and Braxilito bays. From a survey in 1885, by the officers of the U.S.s. Ranger. 20 x 19¼. Washington, 1888.
(United States. Navy department. Hydrographic office. Chart no. 1031). L. C.

1888.

West coast of Costa Rica. Punta Arenas anchorage (Gulf of Nicoya). From a survey in 1885 by the officers of the U.S.s. Ranger. 16¾ x 22. Washington, 1888.
(United States. Navy department. Hydrographic office. Chart no. 1060) L. C.

1889.

Mapa de la republica de Costa-Rica (America Central). Dibujado y enmendado-por F. Montesdeoca 1889. Escala de 1:1,000,000e.
(In Schroeder (John). Costa Rica. 12°. San Jose, tip. nacional, 1894.)
Note: The same map found in Biolley's "Costa Rica und seine zukunft". Also in the English translation of 1889.

1890.

Atlas historico-geografico de la republica de Costa Rica, Veragua y costa de Mosquitos para servir al arbitraje de la cuestion de limites entre Costa-Rica y Colombia. Ordenado por d. Manuel M. de Peralta. title. 26 maps. fol. Madrid. Bruselas, instituto nacional de geografia, 1890. L. C.

1891.

Karte der berggruppen Buena Vista und Chirripo sowie der anliegenden thäler auf dem südwestlichen abhang der republik Costa Rica. Entworfen von prof. H.Pittier, direktor des physikalisch-geographischen instituts von Costa Rica, 1891. Massstab 1:500.000. 9¼ x 13½.
(In Petermann's Mitteilungen, 1892. 4°. Gotha, J. Perthes, (1892). v. 38. at end). L. C.

1891.

Map of the republic of Costa Rica. Drawn and corrected by F. Montesdeoca, 1889. Scale of 1:6,333,333. 5½ x 8. Philadelphia, W.M. Bradley & co. 1891. L.C.

1891.

Mapa de los Cerros Buena Vista y Chirripo y de los valles adyacentes, en la vertiente suroeste de la republica de Costa Rica. Por H. Pittier. Escala 1:500.000. 9½ x 13½.
(In his Viaje de exploracion al valle del Rio Grande de Terraba. 12°. San Jose, 1891.) L. C.

1892.

Mapa historico-geografico de Costa Rica del ducado de Veragua. Por d. Manuel M. de Peralta. Madrid, 1892. Endicion especial para el IV^e centenario del descubrimiento de America. 15½x23. Bruselas, instituto nacional de geografia, 1892. L. C.

1892.

Mapa historico-geografico de Costa Rica y del ducado de Veragua. Por d. Manuel M. de Peralta. Madrid 1892. 15½ x 23.
(In Barrantes (Francisco Montero) Geografia de Costa Rica. 8°. Barcelona. J. C. Sala. 1892.) L. C.

1895.

East coast of Central America. Costa Rica. Port Limon. From a survey in 1872. 15½x20. Washington, 1895.
(United States. Navy department. Hydrographic office. Chart no. 1293). L. C.

1895.

Ports on the east coast of Costa Rica. Port of Limon-Port Vargas. 25x19. London, 1895.
(Great Britain. Admiralty. Chart no. 2144).

1897.

Costa Rica from date presented to the Royal geographical society by colonel George Earle Church. Scale 1:1,000,000. 16 x 20.
(In Royal geographical society. Journal. 1897. 8°. London, 1897. v. 10. p. 128.) L. C.

Guatemala.

1823

A map of the kingdom of Guatemala. 14½ x 16.
(In Juarros (Domingo). A statistical and commercial history of Guatemala. Translated by J. Bailey. 8°. London, for J. Hearne, 1823). L. C.

1829.

Chart to accompany Thompson's official visit to Guatemala; shewing the division of the five states, and the proposed junction of the two seas. 1829. 9½ x 12. London, J. Murray, 1829.
(In Thompson(G.A.) Narrative of an official visit to Guatemala. 16°. London, 1829.) L. C.

1839.

Arrowsmith (John). The coasts of Guatemala and Mexico, From Panama to cape Mendocina; with the principal harbours in California, 1839. 14½ x 19. London, Smith, Elder & co. 1839. L. C.

1839.

Gulf of Dulce in Guatemala. Surveyed by com'r Richard Owen, 1834. 18½ x 24. London, 1839.
(Great Britain. Admiralty. Chart no. 1208.) L. C.

1839.

River Dulce in Guatemala. Surveyed by com'r Richard Owen, 1834. 18 x 24. London, 1839.
(Great Britain. Admiralty. Chart no. 1207). L. C.

1839.

The territory of Verapas (Guatemala) ceded by the federal government of Central America to the directors. 19 x 23½. London, A. Adlard, 1839.
(In Eastern coast of Central America commercial and agricultural company. Brief statement. 8°. London, Whittaker & co. 1839).
Note: The same map is found in Obert's Memoir &c.1840

1857.

Carte dy Yucatan et du Guatemala. Dressee par A.Morelet 24 x 28.
(In Morelet(Arthur). Voyage dans l'Amerique Centrale. 8°. Paris, Gide & J. Baudry, 1857, v. 2. at end). L.C.

1859.

Mapa general de la Republica de Guatemala. Publicado por Maxmilian v. Sonnerstein por orden del gobierno 1859. 32 x 35. East New York, Long Island,N.Y., G. Kraetzer, 1859.

1860

Carte de la republique de Guatemala indiquant la direction des principales chaines de montagnes, avec leurs pics les plus eleves celle des principaux fleuves &c., dresee par mr. Aug. Vandegehuchte 1860. Grav chez Erhard. 6⅝ x 8⅝. L. C.
(In Nouvelles annales des voyages. 6e serie. 8°. Paris, 1860. v. 22. p. 5).

1861.

General map of the country between Guatemala and the Atlantic coast to accompany major Wray's Report on the proposed road between those places. Manuscript on linen. 18¼ x 29. (1861). L. C.

1876

Mapa de la republica de Guatemala. Levantado y publicado por orden del s'mo gobierno por Herman Au, ing'o. 24½ x 29¼. Hamburgo, L. Friederichsen & co. 1876. L. C.

1881

Anchorages on the west coast of Guatemala. From a survey by commander J. W. Philips, U.S.N. and the officers of the U.S.S. Tuscarora. Champerico-San Jose. 14⅝ x 26. Washington, 1881.
(United States. Navy department. Hydrographic office. Chart no . 873). L. C.

1883.

Map of Guatemala to illustrate mr, A. P. Maudslay's paper. Scale 23 miles to 1 inch. H. Sharbau del. 19½x13.
(In Royal geographical society. Proceedings. 1883. 8°. London, 1883. v. 5. p. 248).
Note-Inset map of the "Plan of the ruined town on Usumacinta river." L. C.

1884.

Ethnographische karte von Guatemala. 14 x 14½.
(In Stoll(Otto). Zur ethnographie der republik Guatemala. 8°. Zurich, O. Füssle & co. 1884. at end).

1886.

Ethnographische karte von Guatemala. Massstab 1,500,000. 14½ x 14½. L. C.
(In Stoll(Otto). Guatemala. 8°. Leipzig, F.A.Brockhaus, 1886.*.

1886.

Karte der republik Guatemala. MassstabLl,472,000. 13 x 13½.
(In Stoll(Otto).Guatemala. 8°. Leipzig,F.A.Brockhaus,1886.

1886.
Plan of the principal group of ruins at Copan. 19¼ x 15½.
(In Royal geographical society. 1886. 8°. London, 1886. v. 8, p. 608.). L. C.
Note: Inset map of "Sketch map of the site of ruins at Copan."

1886.
West coast of Central America. Ocos river (Guatemala) to San Juan del Sur. 24 x 43. Washington, 1886.
(United States. Navy department. Hydrographic office. Chart no 931).
Note: On this chart in manuscript is the following, "To accompany letter from Wm. M. Stewart, 11th march, 1888, in relation to concessions made to Champerico & northern transportation co. by Guatemala." L. C.

1887.
Central America. West coast. San Jose.(Guatemala) to Port Angeles(Mexico). Surveyed by the officers of the U.S.S. Tuscarora, 1878, and of the U.S.S.Ranger,1882-84. 25 x 39. London, 1887.
(Great Britain. Admiralty. Chart no. 1050).

1887.
A map of Guatemala. 10½ x 7½.
(In Brigham (William Tufts). Guatemala the land of the quetzal. 8°. New York, C. Scribner's sons,1887).

1890.
Republique du Guatemala. Par F. Bianconi & Crisanto Medina. 1re ed. 31 pp. 1 map. fol. 4°. 27 x 30½. Paris, imprimerie Chaix, 1890.
(collection des etudes generales geographiques. 7me serie no. 2.). L. C.

1891
Commercial map of Guatemala. By F. Bianconi. 18 x 20½.
(In Bureau of the American republics. Guatemala. Bulletin no 32. Jan. 1892. 8°. Washington, 1892).
Note.- Same map "The republic of Guatemala. 1897. Special bulletin, feb. 1897", and in special form.

1892
Das flussgebiet des Rio Polochic. Entworfen von dr. C. Sapper, juni, 1892. Massstab: 1:6000.000 9¼x6.
(In Petermann's Mittheilungen. Ergauzungsband. 4°. Gotha, J. Perthes, 1894. mo. 113. pl. 4). L. C.

1892.
Karte der verbreitung der sprachen in Guatemala um's jahr 1892. Von dr. K. Sapper. Massstab 1:2,000.000 9½ x 12½.
(In Petermann's Mittheilungen. 1893. 4°. Gotha, J.Perthes,1893. v.39, pl. 1. at end. L. C.

1892-1893.

Krater-typen in Mexico und Guatemala. Nach aufnahmen von dr. Carl Sapper, 1892 und 1893. 12 x 8¾.
(In Petermann's Mittheilungen. 1894. 4°. Gotha, J. Perthes,(1894). v. 40. pl. 8. at end). L.C.

1894.

Die republik Guatemala. Nach eigenen aufnahmen gezeichnet von C. Sapper. Massstab 1:900.000. 3 sheets, each 22½x20.
(In Petermann's Mittheilunger Ergänzungsband. 4°. Gotha, J. Perthes, 1894. no 133. pls. 1-3). L.C.

1895.

Kartenskizze der vulkane in West-Guatemala. Von dr. Carl Sapper. Massst. 1:9000.000. 9¾ x 7¾.
(In Petermann's Mittheilungen. 1895. 4°. Gotha, J.Perthes, (1895). v. 41, pl. 7. at end). L.C.

1896

Central America. Guatemala. Honduras bay (Amatique gulf). Hospital Bight. From a survey in 1896. 15½x22. Washington, 1896.
(United States. Navy department. Hydrographic office. Chart no. 1573.). L. C.

1896.

Guatemala. Honduras bay (Amatique gulf). Port Livingston and approaches to Dulce river. From a survey in 1896 by the officers of the U.S.S. Dolphin, 30 x 22½. Wash. 1896.
(U. S. Navy Dept. Hydrographic office. Chart no. 1574).

1897.

Guatemala. Honduras bay (Amatique gulf). Santo Tomas bay with Puerto Barrios and Santo Tomas anchorage. From a survey in 1896. 38 x 30. Washington, 1897.
(United States. Navy department. Hydrographic office. Chart no. 1575).

1897.

Guatemala. Honduras bay (Amatique gulf). From a survey in 1896 by the officers pf the U.S.S. Dolphin, 35 x 30¾. Washington, 1897.
(United States. Navy department. Hydrographic office. Chart no. 1576.) L. C.

Date unknown.

Plano de la cindad de Guatemala. Dibujado por T. Herchue. Grabado dor M. Ayala. 22½ x 29. (n. p. n. d.) L. C.

Honduras

1831.
Belize Harbour on the coast of Honduras, by com. R. Owen 1830 and mr. John Fremby 1829. 24 x 17½. London, 1821.
(Great Britain. Admiralty. Chart no. 522). L.C.

1833.
Central America. East coast. Icacos (Honduras) Road. Surveyed by comm'r Richard Owen, 1830. 11x9. London, 1833.
(Great Britain. Admiralty. Chart no. 521. L.C.

1844.
Honduras gulf with the Zapotilla Cays. Surveyed by commr's R. Owen & E. Barnett 1835-41. 25 x 37. London, 1844.
(Great Britain. Admiralty. Chart no. 1573. L.C.

1847
Central America. Honduras bay. Hospital Bight. Surveyed by commander Edw'd Barnett. 1841. 17¾ x 23¾. London, 1847.
(Great Britain. Admiralty. Chart no. 1786.) L.C.
Note-Inset of "Omoa harbour".

1847.
The coast of Honduras. From Negro Head to the Turneff Cays. Surveyed by com'r Barnett and lieut's Smith & Laurence. 1830-41. 37½x25. London, 1847.
(Great Britain. Admiralty. Chart no. 1797). L.C.

1850.
Honduras Chinchorro bank. Surveyed by commander Edward Barnett. 1839. 25 x 18. Washington, 1850.
(Great Britain. Admiralty. Chart no. 1796.) L.C.

1852.
Central America. West coast. Fonseca gulf (Honduras) to Sonsonate road (Salvador). Sheet 28. Surveyed by capt. sir Edward Belcher. 18½ x 25½. London, 1852.
(Great Britain. Admiralty. Chart no. 2148). L.C.

1857.
Die goldregion in östlichen Honduras nach der karte von Wells reducirt. 6½ x 11.
(In Gesellschaft für erdkunde zu Berlin. Zeitschrift. Neue folge. 8°. Berlin, D. Reimer, 1857. v.3. pl. 6. L.C.

1857.

Map of eastern Honduras, showing the gold and silver regions of Olancho & Tegucigalpa; and valley of the Guayape. By William V. Wells. 1857. 14½ x 19.
(In Wells(William V.) Explorations and adventures in Honduras. 8°. New York, Harper & brothers, 1857.)L.C.

1858.

Map of Honduras and San Salvador, showing the line of the proposed Honduras interoceanic railway. Drawn by D. C. Hitchcock. 1858. 12 x 31.
(In Squier (E.G.) The states of Central America. 8°. New York, Harper & brothers, 1858). L. C.

1860?

British Honduras. Manuscript on linen. 38½x25½.(1860?) L.C.

1866.

Map and vertical section of the proposed Honduras interoceanic railway. Located 1857 & 58. Drawn by G. Thompson 1866. 14 x 26.
(In Davis (Charles H.) Report on interoceanic canals and railroads between the Atlantic and Pacific oceans. 8°. Washington, 1867. map 3.) L.C.

1879.

Map of British Honduras. Shewing mr. Fowler's track across previously unexplored territory. 15 x 12.
(In Great Britain. Parliament. Accounts and papers. 1880. v. 48). L. C.

1885.

Central America. West coast. Fonseca gulf (Honduras) to Sonsonate Road (Salvador). Sheet 7. Surveyed by commander E. Belcher. 18¾ x 25. London, 1885.
(Great Britain. Admiralty. Chart no. 2148. L. C.

1885.

Map of the republic of Honduras, Central America. By Abram Cutler amd J. W. Gallup, civil engineers, assisted by dr. R. Fritzgaertner, government geologist of Honduras. 36 x 47. Chicago, Rand, McNally & co. 1885. L. C.

1886.

Mapa de la republica de Honduras. Por A. T. Byrne, ingeniero civil del gobierno de Honduras. Escala 1: 1.000.000. 21½ x 23½. Nueva York, G.W. & C.B. Colton' & ca. 1886. L. C.

1886.

West coast of Central America. Gulf of Fonseca. San Lorenzo bay. (Honduras). Surveyed by the officers of the U.S.S. Ranger, 1884. 30½ x 25½. Washington, 1886. (United States. Navy department. Hydrographic office. Chart no. 974.) L.C.

1887.

Coast of Honduras. Approaches to Belize. Surveyed by commander Richard Owen, 1830. 32 x 26. London, 1887. (Great Britain. Admiralty. Chart no. 959.) L.C.

1888.

Honduras. Chinchorro bank. From a British survey in 1839. 30½ x 24 (Washington, 1888).
(United States. Navy department. Hydrographic office. Chart no. 1072.) L.C.

1888

Map illustrating the expedition to the Cockscomb mountains, British Honduras, april, 1888. By J. Bellamy. Wm. Jho. Turner, 8 x 6.
(In Royal Geographical society. Proceedings. 1889. 8°. London, 1889. v. 11, p. 542). L.C.

1891.

Map of the Perry grant in the department of Mosquitia, republic of Honduras-Map showing the distance from Chicago to the Perry grant, owned by the Honduras company, Chicago. 19 x 14½. Chicago, G. F. Cram, 1891. L.C.

1891.

Republiques de Honduras et du Salvador. Par F. Bianconi. Collaborateur pour le Honduras: Gaubert. 26pp. 1 map. 23½x33½. 4°. Paris, imprimerie Chaix, 1891.
(Collection des etudes geographiques. 7me serie, no.4)L.C

1894.

Karte der verbreitung der sprachen in Südost-Mexico und Britisch Honduras um's jahre 1894. Von dr. Karl Sapper. Massstab 1:400.000. 9¾ x 12½.
(In Petermann's Mittheilungen. 1895. 4°. Gotha, J. Perthes, (1895). v. 41. pl. 12. at end.) L.C.

1894.

Map of the republics of Honduras and Salvador. 9½ x 17.
(In Bureau of the American republics. Honduras. Bulletin no. 57. Revised to march 1, 1894. 8°. Washington, 1894).
Note: Same map in Salvador. Bulletin no. 58. L.C.

1896.
Central America. East coast of Honduras. From Negro head to Turneffe Cays. From British surveys between 1830 and 1841. 38 x 25½. Washington, 1896.
(United States. Navy department. Hydrographic office. Chart no. 1497.). L. C.

1897.
British Honduras. Belize Harbor. From a British survey in 1829 & 30. 24 x 20. Washington, 1897.
(United States. Navy department. Hydrographic office. Chart no. 1052). L. C.

1897.
Central America. Gulf of Honduras, with the Zapotillos Cays. From British surveys between 1835 and 1841. 25½ x 43. Washington, 1897.
(United States. Navy department. Hydrographic office. Chart no. 1496). L. C.

1897.
East coast of Central America. Gulf of Honduras and approaches. 30 x 24. Washington, 1897.
(United States. Navy department. Hydrographic office. Chart no. 1120). L. C.

1897.
Honduras. Bonacca island. From a British survey in 1840. 19 x 25. Washington, 1897.
(United States. Navy department. Hydrographic office. Chart no. 1643.) L. C.

1897
Honduras. Port Cortez. From a United States government survey, 1896. 25½ x 19. London, admiralty, 1897.
(Great Briatin. Admiralty. Chart no. 2988). L. C.

1897.
Honduras. Port Cortez. From a survey in 1896, by the officers of the U.S.S.Dolphin. 27½ x 33½. Washington, 1897.
(United States. Navy department. Hydrographic office. Chart no. 1572). L.C.

1897.
Honduras. Utilla island. From a British survey in 1835. 17¾ x 23¾. Washington, 1897.
(United States. Navy Department. Hydrographic office. Chart no. 1641.) L.C.

1898.

British Honduras. Belize Harbour. 26 x 39. London, admiralty, 1898.
(Great Britain. admiralty. Chart no. 522). L.C.

1899

British Honduras. Belize harbour. From a British survey in 1896 and 1897. 26½ x 39½. Washington, 1899.
(United States. Navy department. Hydrographic office. Chart no. 1799.) L. C.

1900

Colony of British Honduras. 7½ x 4½.
(In Colonial(The) office list for 1900. 8°.
London, Harrison & sons,(1900). p. 22) L.C.

1900

Mapa de la republica de Honduras. Por A. T. Byrne, ingeniero civil del gobierno de Honduras. Con adiciones y correcciones hasta la fecha por J. Francis Le Baron. Escala 1:1,000.000. 19½ x 32½.
Neuva York, Colton, Ohman & ca. 1900. L.C.

Nicaragua.

1822.

A map of Mosquitia (Nicaragua) and the territory of Poyais with the adjacent countries. Engraved by W. H. Lizars, Edin'r. 19 x 14.
(In Hodgson (Col.Robert. Some account of the Mosquito territory. 2d ed. 8°. Edinburgh. 1822). L. C.

1832.

San Juan de Nicaragua alias San Juan de Norte alias Greytown, levantado por George Peacock de la marina de S.M.B. en 1832. 8 x 9.
(In Molina(Felipe). Bosquejo de la republica de Costa Rica. 8o. Nueva York, S.W. Benedict, 1851). p. 54).L.C.

1838

Profile of that section of the country situated between lake Nicaragua and the South sea. From the table of levels given in Thompson's Guatemala referred to the plane of the sea. Bureau of U.S. topographical engineers. Wash. Hood del Doc. H.R. 322. 3d sess. 25th cong. 1838. 14 x 51. Washington, lith. P. Haas, (1838).
(In United States. Congress. A collection of maps, etc. published by order of congress fol. Washington, 1843. no. 118). L. C.

1838

San Juan de Nicaragua(And) Salinas Bai nach capt. sir Edw. Belcher, 1838. (And) Realejo nach capt. sir Edw. Belcher 1838. 7¼ x 13½.
(In Gesellschafr fur erdkunde zu Berlin. Zeitschrift. Neue folge. 8°. Berlin, D. Reimer, 1857. v. 2. pl.7)L.C.

1843.

West Indies. Mosquito coast. Bluefield lagoon. Surveyed by capt. Rich'd Owen. 1836. 24 x 18½. London, 1843.
(Great Britain. Admiralty. Chart no. 1504.) L. C.

1843.

West Indies. Mosquito coast. Pearl Cay lagoon entrance and the Corn islands. Surveyed by commander R. Owen. 1836. 18 x 24. London, Admiralty, 1843. (Great Britain, Admiralty. Chart no. 1476). L. C.

1844.

West Indies. Mosquito coast. Pearl Cays. Surveyed by commander R. Owen. 1836. 18 x 23¾, London, 1844.
(Great Britain. Admiralty. Chart no. 1503). L. C.

1845.

Winterfeidt (L. von) Karte des Mosquito-staates und der angrenzenden länder. Gezeichnet von H. Schmidt. Metallographie von C. Brugner. fol. Berlin, Schropp & co. 1845.

1847.

Map of the Mosquito coast. T. R. Harrison lith. 30 x 20½. L. C.
(In Great Britain. Parliament. Accounts and papers. State papers. 1847-48. v. 65.)

1847-1848.

Isthmus of Nicaragua. Scale of 5 centimetres to a degree. C. B. Graham's lith. Washington, 8 x 10. L.C.
(In 30th Cong. 1st sess. Senate. Miscellaneous no.80)
Note: To accompany Aaron H. Palmer's Memoir, geographical, political and commercial , on the present state, productions, resources...of Siberia.

1848?

Map of the river of San Juan de Nicaragua. Scale three miles to the inch. no. 3. 10 x 20. (1848?) L.C.

1849.

Gulf of Fonseca, province of Nicaragua. Surveyed by capt. sir Edward Belcher. 1838. 24½ x 36½. London, 1847.
(Great Britain. Admiralty. Chart no. 1960). L. C.

1849.

(Map of Nicaragua). 15¾ x 18½. L. C.
(In 30th Congress. 2d sess/ H. R. Report. no. 145)
Note: To accompany article entitled "Canal or railroad between the Atlantic and Pacific oceans. Feb. 20, 1849. Rockwell's Report.""The map contains insets of "Harbour of San Juan " and "Realejo harbour."

1849.

Nicaragua. Die küsten nach den besten charten terrain nach recognoscirungen und speciellen aufnahmen von Iohn Forster, esq. Englisch v. consul und B. A. v. Bülow , im mai, juni u. juli. 1847, gezeichnet Berlin, 1849. 13 x 18½.
(In Bülow(Alexander von). Die freistaat Nicaragua. 12°. Berlin, G. Hempel, 1849.) L. C.

1849.

Central America. Nicaragua. Port Culebra. Surveyed by capt. sir Edward Belcher, 1838. 37½ x 24¾. London, admiralty, 1849.
(Great Britain. Admiralty. Chart no. 1927). L. C.

1850.

Mosquito. Greytown harbour. Surveyed by comm'r M.S. Nolloth. 1850. 8 x 10. London, 1850.
(Great Britain. Admiralty. Chart no. 2012.) L. C.

1850-1851

Map and profile of the route for the construction of a ship canal from the Atlantic to the Pacific oceans, across the isthmus in the state of Nicaragua, C. A. Surveyed by O. W. Childs, 1850-51. 17½ x 33.
(In Davis (Charles H.) Report on interoceanic canals and railroads between the Atlantic and Pacific oceans. 8°. Washington, 1867, map 4.) L. C.

1850-1851.

Map of Brito harbor. The soundings taken at mean tide are marked in feet. 16 x 20. L. C.
(In Childs, Orville W.) Report of the survey and estimates of the cost of constructing the interoceanic ship canal from the harbor of San Juan del Norte, on the Atlantic, to the harbor of Brito, on the Pacific, in the state of Nicaragua, Central America, made for the Americans. Atlantic and Pacific ship canal co. in the years 1850-51. 8°. New York, W. C. Bryant & co. 1852, p.45)

1850-1851.

Map showing the location of dam at Buen Retiro and western termination of the summit level at lock no. 1. 12½ x 19.
(In Childs (Orville). Report on the survey and estimates of the cost of constructing the interoceanic ship canal from the harbor of San Juan del Norte, on the Atlantic, to the harbor of Brito, on the Pacific, in the state of Nicaragua, Central America, made for the American, Atlantic and Pacific ship canal co. in the years 1850-51. 8°. New York, W. C. Bryant & co. 1852. P. 21) L. C.

1850-1851.

Section of canal in rock. Scale - 24 feet to an inch. 9¾ x 7¼.
(In Childs (Orville W.) Report of the survey and estimates of the cost of constructing the interoceanic ship canal from the harbor of San Juan del Norte, on the Atlantic, to the harbor of Brito, on the Pacific, in the state of Nicaragua, Central, America, made for the American, Atlantic and Pacific ship canal co. in the years 1850-51. 8°. New York, W. C. Bryant & co. 1852, p. 57.) L. C.

1851.

Karte des Nicaraguasee's red. nach den aufnahmen J. Baily. 6¾ x 11.
(In Reichardt (C.F.) Centro Amerika. 8°. Braunschweig, 1851) L.C.

1851

Bülow (A. von). Karte des isthmus von Nicaragua und Panama in Mittel-America, mid den verschiedenen canalprojection sur verbindung des Atlantischen und Stillen oceans nach J. Baily und den besten quellen zusammengestellt. fol. Berlin, Besser. 1851.) L.C.

1851.
Panorama of Greytown. 4½ x 17¼.
(In Molina(Felipe). Bosquejo de la republica de Costa Rica. 8°. Nueva York, S. W. Benedict, 1851. p. 54) L.C.

1851.
Planto de San Juan llamado ahora Greytown. 3½ x 13½. L.C.
(In Molina(Felipe) Bosquejo de la republica de Costa Rica. 8°. Nueva York, S. W. Benedict, 1851. p. 54)

1852.
Central America. West coast. Cape Desolado (Nicaragua) to Fonseca gulf (Honduras). Sheet 27. Surveyed by capt. sir Edw. Belcher, 1840. 18½ x 24½. London, 1852.
(Great Britain. Admiralty. Chart no. 2147.) L. C.

1852.
Mapeand profile of the route for the construction of a ship canal from the Atlantic to the Pacific oceans, across the isthmus in the state of Nicaragua, Central America, surveyed for the American, Atlantic and Pacific ship canal company, by O.W. Childs, 1850-51. title. 1 map. 31 x 107. fold. 8°. New York, W. C. Bryant & co, 1852.
(American, Atlantic and Pacific ship canal company). L.C.

1854.
Karte zu Scherzer's u. Wagner's reisen in Nicaragua, Honduras und San Salvador im jahre 1854. 12½ x 14.
(In Scherzer(Karl). Wanderungen durch die mittel-amerikanischen freistaaten, Nicaragua, Honduras and San Salvador. 8°. Braunschweig, 1857.) L. C.

1854.
Nicaragua. 14½ x 19½.
(In Reichardt (C.F.) Nicaragua. 8°. Braunschweig, F.Vieweg & Sohb, 1854.) L. C.

1855.
Considerations sur la carte geographique du Nicaragua, par m. Myionnet-Dupuy.
(In Societe de geographie. Bulletin. 4e serie. 8°. Paris, 1855. v. 9. pp 97-105). L. C.

1855.
Geographical map of the republic of Nicaragua with three plans and views by Fermin Ferrer, governor of the western dep't, 1855. 28 x 21. (n.p. 1855). L. C.

1856.
Central America. Greytown harbour. Surveyed by John Richards, master assisted by William K. Bush, lieut. of h.m.s. Geyser, april, 1853. 25 x 37. London, 1856.
(Great Britain. Admiralty. Chart no. 2012. L. C.

1856.
Government map of Nicaragua from the latest surveys ordered by president Patricio Rivas and genl. William Walker. Executed under the supervision of the senor Fermin Ferrer, governor of the western department 1856. col. 29 x 20. New York, A. H. Jocelyn,(1856). L.C.
Note: Inset "Map of Central America."

1856.
Map of the Mosquito territory from surveys and sketches made during several years residence in the country, by Chas. N. Bell, esqr. 1856. 16¼ x 9¾.
(In Royal geographical society. Journal. 1862. 8°. London, J. Murray, 1862. v. 32. p. 242.) L.C.

1856.
Haven(George). Maps of Nicaragua, North and Central America, population and square miles of Nicaragua, etc. 30½ x 24. New York, J. Haven, (1856). L.C.

1858.
Carte d'etude dressee par mr. Thome de Gamond pour servir a l'avant-project du canal interoceanique de Nicaragua, par le fleuve Saint Jean et le col. de Salinas en execution du traite de concession conclu le ler mai 1858,entre les gouvernements de Nicaragua et Costa-Rica et mr. Felix Belly. 23 x 36.
(In Gamond(Thome de). Carte d'etude pour le trace et le profil du canal de Nicaragua. 4°. Paris, Dalmont & Dunod, 1858, at end. L.C.

1858
Carte d'etude pour le trace et le profil du canal de Nicaragua. Par m. Thome de Gamond, procedee de documents publies sur cette question. Par m. Felix Belly. 90 pp. 1 l. 1 fold map. 4°. Paris, Dalmont & Dunod, 1858. L.C.

1863.
Mapa de la republica de Nicaragua, levantado, por M. de Sonnenstern. 1863. Tres belle carte collee sur toile et pliee en carton, 92 sur 93 cent.

1858.
Mapa de la republica de Nicaragua. Levantado por orden del gobierno por Maximilian v. Sonnerstern. 1858. 21½ x 29. East New York, L.I., G. Kraetzer, (1858). L.C.

1867.
Nicaragua lake, 8½ x 8½.
(In Belly(Felix). A travers l'Amerique Centrale. 8°. Paris, 1867. v. 2. p. 405). L.C.

1867.

Isthme de Nicaragua. Echelle de 55 millimeters au degre. 12 x 14½.
(In Belly(Felix) A travers l'Amerique Centrale. 8°. Paris. 1867. v. 1, p. 1)
L. C.

1870.

Partie de l'isthme Nicaraguien comprise entre Nanddime et Rivas indiquant un trace de canal possible. Par la Bocana du Jiri Conzalez. Echelle de 1/560.000. 8 x 34.
(In Societe de geographie. Bulletin. 5e serie. 8°. Paris. 1870. v. 19. at end). L. C.

1874.

Sketch of the proposed ship canal at lake Nicaragua, by Maximilian von Sonnenstern, 8 x 12.
(In his report on the Nicaraguan route. 4°. Washington, government printing office, 1874.). L. C.

1879.

Bassin de Nicaragua. Echelle de 1/1500,000. 5½ x 8½.
(In Societe de geographie de Lyon. Bulletin. Avril-juin, 1879. 8°. Lyon, societe, 1879. v. 2, no. 14 at end) L.C.

1879.

Der isthmus von Nicaragua nach den aufnahmen der Amerikanischen expedition unter E. P. Lull, mit zuziehung anderer quellen gezeichnet von K. Zoeppritz, 1879. Massstab 1: 400 000. 8¾ x 7.
(In Gesellschaft für erdkunde zu Berlin. Zeitschrift. 8°. D. Reimer, 1879. v. 14. pl. 5) L. C.

1884.

Harbor of San Juan del Norte, Greytown. Surveyed by Passmore & Climie, aug. 1884, by order of the Nicaraguan government. United States. Senate Executive document 99, 491. Plate no. 2. 13 x 18½.
L.C.

1885.

Plan of the Nicaragua ship canal as relocated by the U.S. surveying expedition of 1885, civil eng'r A.G. Menocal, U.S.N. 4½ x 9.
(In American(The)geographical society of New York. Bulletin 1886. 8°. New York, for the society,(1885). v. 18. p.97)
Note:-To accompany an article on "The Nicaragua canal".
L. C.

1885.

Spezialkarte des Nicaragua-kanales. Nach der karte der Vern. Stn. vermessungs-wxpedition unter A.G. Menocal,U.S.N. 1885. Massstab. 1:600 000. 7½ x 20½.
(In Petermann's Mittheilungen. 1887. 4°. Gotha, J.Perthes, (1887). v. 33. pl. 8. at end) L. C.

1885.

West coast of Central America. Corinto harbor (Nicaragua). Surveyed by the officers of the U.S.S. Ranger, 1884. 15 x 21½. Washington, 1885.
(United States. Navy department. Hydrographic office. Chart no. 937). L. C.

1885-1888.

Nicaragua-janal. Nach den vermessungen v. Menocal 1885. u. Perry 1887-88. 1:1500.000. Im fürfmal kleineren masstab als Panama-kanal. 8¼ x 21½.
(In Meyers konversations-lexikon. 5te aufi. 8°.Leipzig und Wien, bibliographisches, institut, 1897. v.17. p.691.

1887.

Central America. West coast of Nicaragua. Salinas bay. From a survey in 1885 by the officers of the U.S.S.Ranger. 12 x 15¼. Washington, 1887.
(United States. Navy department. Hydrographic office. Chart no. 1025).
Note: With additional notes in mss. and descriptive text. L. C.

1887.

West coast of Central America. San Juan del Sur(Nicaragua) to Judas Point (Costa Rica). 33 x 27¼. Washington, 1887.
(United States. Navy department. Hydrographic office. Chart no. 1016).
L. C.

1889.

Central America. West coast of Nicaragua. Brito harbor. From a survey in 1888, by ensign W.J. Maxwell, U.S.N. and civil engineer, J. F. Perez of the Nicaragua canal construction company. 18 x 18½. Washington, 1889.
(United States. Navy department. Hydrographic office. Chart no. 1159).
L. C.

1889.

Mapas de Colton. America Central. Escala 1:1,705,000. 31½ x 39½. Nueva York, D. Appleton & cia. (1889).
Note:- Insets "Trazado del canal Nicaragua", "El golfo de Fonseca". "El istmo de Panama", &c.
L. C.

1891.

Bird's eye view of the maritime canal of Nicaragua. 6½ x 11⅛
(In Maritime Canal co. of Nicaragua. The interoceanic canal of Nicaragua. 4°. New York, 1891, p. 1.)
L. C.

1891

Central America. Nicaragua. San Juan del Norte or Greytown. Surveyed by ensign W. J. Maxwell, U.S.N. of the Nicaragua canal construction company, 1888. 18 x 24½. London, 1891.
(United States. Navy department. Hydrographic office. Chart no. 1292.) L.C.

1891

Nicaragua. Mosquito reservation. Bluefields lagoon. From a British survey in 1836. 24½ x 20. Washington, 1891. (United States. Navy department. Hydrographic office. Chart no. 1292). L. C.

1892

Rand, McNally & co's indexed atlas of the world. Map of America. Statute miles 69.16 = 1 degree. 19 x 26. (Chicago, Rand, McNally & co. 1892).
Note:- Inset "Map showing proposed line of Nicaragua canal." L. C.

1892-1893

Geologische karte des nördlichen theiles der republik Nicaragua. Im auftrage der regierung in den jahren 1892 und 1893 aufgenommen u. gezeichnet von dr. Bruno Mierisch. Massstab 1:7000.000 19 x 16½.
(In Petermann's Mittheilungen. 1895. 4°. Gotha, J.Perthes, (1895). v. 41. pl. 4 at end)
Note:Inset of "Ubersichtsskizze des Nicaraguakanals und der eisenbahn-projekte in Nicaragua." L. C.

1893.

Esquisse d'une carte politique du Nicaragua en 1893. Par D. Pector. Echelle de 1:2,500,000. 9½ x 8.
(In Pector(Desire). Etude economique sur la republique de Nicaragua. 8°. Neuchatel, 1893.) L. C.

1893.

Die goldminen-distrikte in den flussgebieten Prinzapolca und Cuculaia im östlichen Nicaragua. Auf befehl sr. exc. des präsidenten aufgenommen und gezeichnet von dr. Bruno Mierisch. Massstab. 1:700.000. 7 x 9½.
(In Petermann's Mittheilungen. 1893. 4°. Gotha, J. Perthes, (1893). v. 39. pl. 3. at end) L. C.

1893

The Mosquito coast of Nicaragua and adjacent territory. Design by Christ. Weber. 12 x 11.
(In American geographical society of New York. Journal 1893. 8°. New York, for the society, 1893. v. 25, p.288) L.C.

1893.

Panaramic view of the Nicaragua canal. 7½ x 15½.
(In Bureau of the American Republics. Nicaragua. Bulletin no. 51. Rev. to aug. 1, 1893. 8°. Washington, 1893. pp. 42-43.) L. C.

1894

Chart of the world showing distances saved by the maritime canal of Nicaragua. 16 x 16½.
(In Schroeder(John). Costa Rica. 12°.San Jose,tip. mac cional, 1894). L.C.

1894.
Map of the Mosquito coast. Nicaragua, C.A. Compiled by H. G. Higley, assisted by Sam D. Spellman. Bluefields, Nic'a, 1894. 40 x 26. New York, G.W. & C. B. Colton & co. 1894.
Note:-Inset "Plan of Bluefields", Nicaragua. L.C.

1894.
Map of the republic of Nicaragua. 18¾ x 18¾.
(In Bureau of the American Republics. Nicaragua. Bulletin no. 51. Revised to aug. 1, 1893. 8°. Washington, 1893.
Note:Copyrighted map in 1894 by Wm. M. Bradley & co. Philadelphia. L.C.

1895.
Central America. East coast. Nicaragua. Entrance to Pearl Cay lagoon. From a British survey in 1836. 15x22½. Washington, 1895.
(United States. Navy department. Hydrographic office. Chart no. 1510). D.C.

1895.
Central America. East Coast. Nicaragua. Pearl Cays and approaches to Pearl Cay lagoon. From British surveys in 1836. 23¾ x 36½. Washington, 1895.
(United States. Navy department. Hydrographic office. Chart no. 1517.) L.C.

1895.
Central America. West coast(Nicaragua). Corinto harbour (Port Realejo). Surveyed by commander C. E. Clark, U.S.N. &c. 1884. 24½ x 19. London, 1895.
(Great Britian. Admiralty. Chart no. 660). L.C.

1895
Nicaragua-und Panamakanal. Massstab 1:1500.000. 8¼x5½.
(In Brockhaus' konversations-lexikon. 14te aufl. 8°. Leipzig. F.A. Brockhaus, 1895. v. 12. p.314.) L.C.

1896.
Central America. Nicaragua harbor of San Juan del Norte or Greytown. From a survey in 1888 by ensign W.J. Maxwell, etc. Extensive corrections to 1896. 18 x 25½. Washington, 1896.
(United States. Navy department. Hydrographic office. Chart no. 1186). L.C.

1896.
Central America. West coast of Nicaragua. San Juan del Sur. Surveyed by the officers of the U.S.S.Ranger, commander C. E. Clark. 1883. 13 x 15. Washington,1896.
(United States. Navy department. Hydrographic office. Chart no. 934) L.C.

1897.

Century(The) Atlas. Central America. Scale 70 English Statute miles to one inch. 10½ x 15½. New York, the century co. 1897.
Note: Inset of "The country around lake Nicaragua, showing the route of the Nicaragua canal." L.C.

1897.

North east Nicaragua from a survey by John M. Nicol. c. e. 1897. Natural scale, 1:1,500,000 or 1 inch = 23.7 miles. 8 x 11½.
(In Royal geographical society. Journal. 1898. 8°. London. 1898. v. 11, p. 692.) L. C.

1898.

Official map of Nicaragua. Compiled by order of his excellency the president general don Jose Santos Zelaya, from surveys by Maximilian v. Sonnenstern, government civil engineer, assisted by William P. Collins. Revised to date 1898. L. C.

1900.

Topographical map of territory bordering the Nicaragua canal route. Compiled & drawn by Edw. Molitor. Supplement to Engineering news, july 12, 1900.
7¼ x 11½. L. C.

1900.

Nicaragua. Bluefields lagoon. From a survey in 1899, by the officers of the U.S.S. Vixen. 35½ x 38½. Washington, 1900.
(United States. Navy department. Hydrographic office. Chart no. 1858.) L. C.

Salvador.

1853.
Carte de l'etat de San Salvador et d'une partie de delui de Honduras, indiquant le trace du chemin de fer projete interoceanique de Honduras par E.G. Squier. 1853. 15¾ x 17¾.
(In Squier(E.G.) notes sur les etats du Honduras et du San Salvador. 8° Paris, L. Martinet, 1855.

1853.
Carte de l'etat de San Salvador et d'une partie de celui de Honduras (Amerique Centrale) indiquant le trace du chemin de fer projete interoceanique de Honduras par E.G. Squier, 1853. 15½ x 17⅜.
(In Societe de geographie. Bulletin. 4e serie. 8°. Paris, 1855. v. 10. p. 332). L.C.

1853.
Der staat San Salvador und die projectirte Honduras eisenbahn nach den aufnahmen von W. N. Jeffers, 1853. 13 x 12½.
(In Gesellschaft fur erdkunde zu Berlin. Neue folge. 8°. Berlin, D. Reimer, 1857. v. 3, pl. 3.) L.C.

1853.
The state of San Salvador and the proposed Honduras railroad, from the surveys made in 1853 by E.G. Squier and W. N. Jeffers.
(In Kiepert(H) H. Kiepert's neue karte von Mittel-America. fold. obl. 4°. Berlin, D. Reimer 1858) L.C.

1858.
Mapa general de la republica de San Salvador, levantado por Maximilian v. Sonnerstern por orden de su excelencia sr. don Rafael Campo. 21 x 29. East New York, Long Island, N. Y. G. Kraetzer, 1858. L.C.
Note-Inset "Plano de Nuevo San Salvador."

1859.
Karte des staates San Salvador im auftrage des praedidenten don Rafael Campo von Maxim. v. Sonnenstern aufgenommen nach der zu New York, 1859, erschienenen originalkarte auf den halben massstab verkleinert. Masstab in 1/900,000. 14½ x 7½.
(In Gesellschaft fur erdkunde zu Berlin. Zeitschrift. Neue folge. 8°. Berlin, D. Reimer, 1860. v.9.pl.5) L. C.

1871.
Watling island to accompany mr. Major's paper. 7½x4½.
(In Royal geographical society. Journal. 8°. 1871. London, J. Murray, 1871. v. 41. p. 193.) L. C.

1885.
West coast of Central America. Harbor of La Libertad (San Salvador). Surveyed by the officers of the U.S.S. Ranger, 1883. 20 x 14½. Washington, 1885.
(United States. Navy department. Hydrographic office. Chart no. 939). L. C.

1891
Republique de Honduras du Salvador. Par F. Bianconi. Collaborateur pour le Honduras. Gaubert. 26pp. 1 map. 23½ x 33½. 4°. Paris, imprimerie Chaix. 1891.
(Collection des etudes geographiques. 7me serie.#4). L.C.

1894.
Map of the republics of Honduras and Salvador. 9½ x 17.
(In Bureau of the American republics. Honduras. Bulletin no. 57. Revised to march 1, 1894. 8°. Washington, 1894)
Note. Same map in Salvador. Bulletin no. 58. :. C.

1897.
Centra; America. Salvador. Jiquilisco bay (Port El Triunfo) From a survey in 1897. 30 x 23½ . Washington, 1897.
(United States. Navy department. Hydrographic office. Chart no. 1677). L.C.

1897.

Übersichte-skizze der vulkane in San Salvador & Südost-Guatemala. Massstab 1:1.500.000 11 x 20.
(In Petermann's Mittheilungen. 1897. 4°. Gotha, J. Perthes (1897(v. 43. pl. 1. at end) L. C.

1898
Central America. Salvador. Jiquilisco bay (Port El Triunio). From a survey in 1897. 30 x 25½. Washington, 1898.
(United States. Navy Department. Hydrographis office. Chart no. 1677). L. C.