SURVEY OF THE GEOLOGY OF HAITI

GUIDE TO THE FIELD EXCURSIONS IN HAITI

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Foreword, Introduction through Physiography
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FOREWORD

The purpose of this field guide is to provide a general view of the geology of the Republic of Haiti, including some aspects of the geology of the island of Hispaniola as a whole. It is by no means an exhaustive look at the geology of the area. Nonetheless, the transects cover enough of the main geologic features of Haiti to allow a good appreciation of its geology and its relation to the remainder of the island as a whole. I will also discuss some of the new data available on the areas covered, and their implications concerning the geologic history of Hispaniola.

SYNOPSIS OF THE GEOLOGY OF HAITI

INTRODUCTION

The island of hispaniola is the second largest of the Greater Antilles after Cuba. It lies between parallels 17°39′ and 20° north latitude and meridians 68°20′ and 74°30′ west (Figure 1). The Atlantic Ocean lies at its northern side while the Caribbean Sea is at its southern side. It is separated from Cuba by the Windward Passage, and from Puerto Rico by the Mona Passage. A submerged ridge complex extends from the Southern Peninsula of the Republic of Haiti westward toward Jamaica, whereas another prominent ridge complex (The Beata Ridge) extends southward from the Barahona Peninsula in the Dominican Republic. The latter ridge complex actually subdivides the main part of the Caribbean Sea into two major basins: The Venezuela Basin to the east and the Colombia Basin to the west (Figure 1).

The island of Hispaniola as a whole is extremely mountainous. It includes the highest elevation of the Caribbean islands at Peak Duarte, which culminates at 3087 meters in Central Dominican Republic (Figures 2, 3). History reports that when Christopher Columbis, upon returning from his first discovery trip to the New World, wanted to describe Hispaniola, he crumbled a piece of paper which he said may best explain the geography of the island. Columbus graphic representation cannot be more correct indeed. The earlier inhabitants of the island, the now extinct Arawaks, in fact called it "Haiti" which meant mountainous land in their language. Thus the name Haiti adopted for the western side of the island is an original Arawak name. The island was also known by the Arawaks as Bohio (land with numerous villages) or Quisqueya (large land). The name Hispaniola (Espanola) was given by Columbus to mean

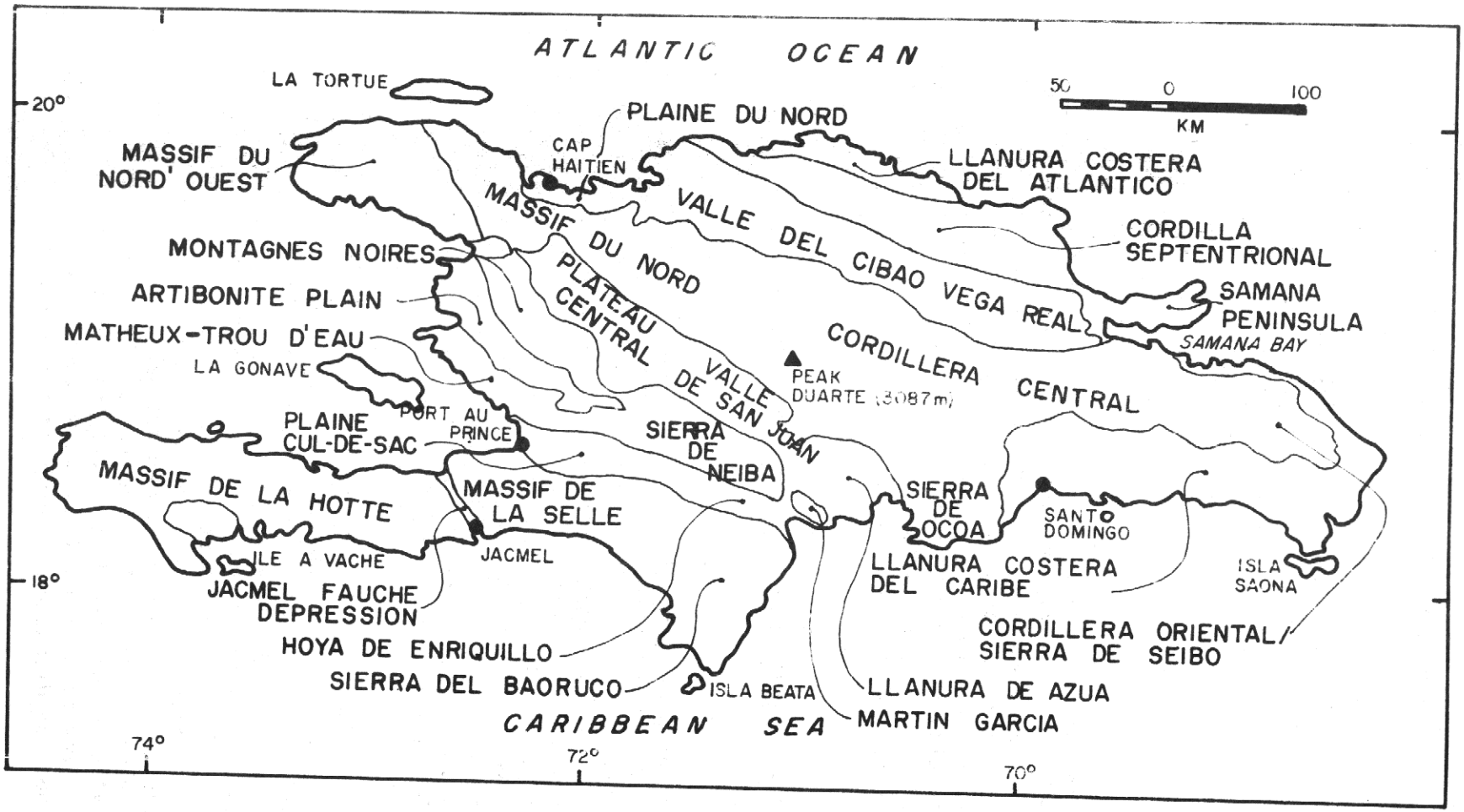


FIGURE 2 : General Physiographic Provinces of Hispaniola.

"little Spain". It should also be remembered that when the first Spanish settlers reached the island in 1942 a rich and peaceful Arawak civilization was flourishing there. The island was divided into five Kingdoms called "Caciquats": The Marien in the Northwest, the Magua in the Northeast, the Maguana in the Central regions, the Higue in the Southeast, and the Xaragua in the Southern Peninsula.

After a rather tumultuous colonial history, punctuated by heroic revolutions, two nations of Afro-European stocks emerged from the island where the Arawaks were virtually exterminated. The Republic of Haiti became independent in 1804, and the Dominican Republic in 1844.

The Republic of Haiti occupies approximately the western third of the island (28,700 km^2), and the Dominican Republic the eastern two thirds (48,500 km^2).

GENERAL PHYSIOGRAPHIC SETTING OF THE ISLAND OF HISPANIOLA

Geomorphologically the islands can be divided into two major portions separated by the prominent Cul-de-Sac/Enriquillo depression (Figure 2, 3). Relief north of this depression exhibit a prevailing northwest- Southeast trend, whereas those south of the depression exhibit a prevailing east-west orientation swinging to a northwest-southeast trend in the Barahona region (Figure 2).

On the whole ten main physiographic units can be recognized from North to South:

The northermost physiographic unit consists of a quasi rectilinear mountain range about 200 kilometers long, along the north coast of the Dominican Republic. It is referred to as the Cordillera Septentrional or Monte Cristi Mountains. The Llanura Costera del Atlantico and the Samana Peninsula can be added to this physiographic unit, although the latter is separated from the Cordillera by a marked depression called the Gran Estero, which was a seaway in recent geologic times.

This physiographic unit is bounded to the north by the Camu fault system (Figure 3), to the South by the most conspicuous Magua fault whose sharp escarpment gives rise to sudden relief changes toward the Cibao Valley to the South (Figures 2, 3). The maximum elevation of this unit is 1249 meters, reached at Peak Diego de Campo northwest of the city of Santiago. The eastern portion shows smoother relief, and the transition is rather progressive toward the valley which is often called Vega Real in the area (Figure 2).

The island of La Tortue (Figures 2,3) may also be considered as part of this physiographic unit. It lies off the north coast of Haiti from which it is separated by an 8.9 to 15 Kms wide and 1400 meter-deep structural strait, called the "Canal de la Tortue" or La Tortue Channel. The island is 37.5 Kms long and is about 7 Kilometers wide, its maximum elevation is of 340 meters at Morne La Visite. Most of the

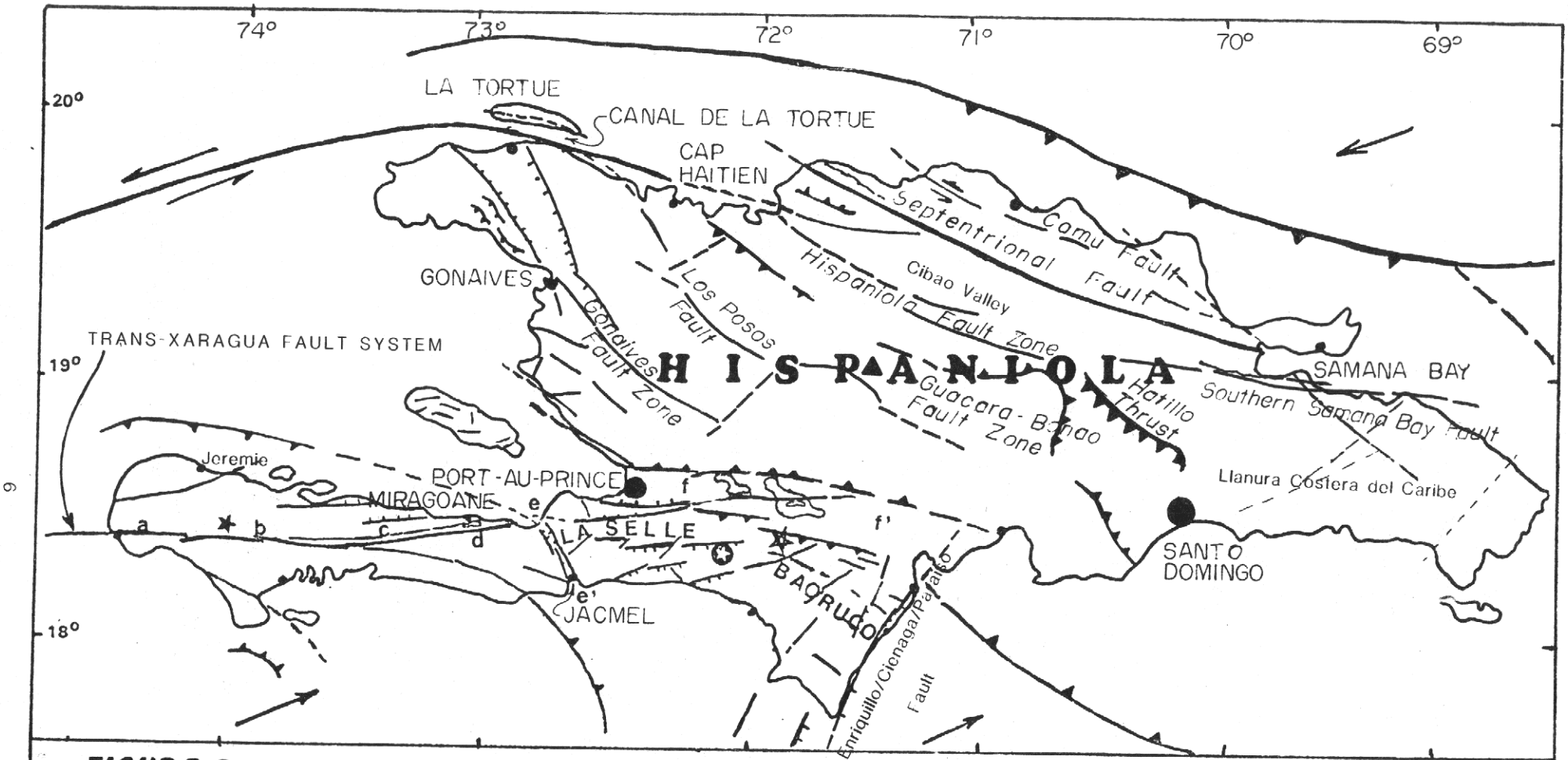


FIGURE 3 - General structural setting of Hispaniola.

- Normal faults
- Thrust faults
- Unspecified faults
- Localized direction of strike-slip motion
- Main direction of crustal displacement
- ▲ Peak Duarte : 3087 m
- ★ Peak Macaya : 2347 m
- ✪ Peak de la Selle : 2674 m
- ☆ Loma del Toro : 2367 m

a) Rivière des Anglais et de Tiburon; b) Vallée de l'Asile; c) Vallée de Fond des Nègres; d) Etang de Miragoane; e-e') Jacmel-Fauché dépression; f-f') Cul-de-Sac - Enriquillo Graben.

(Modified after Maurrasse et al., 1982 ; Lewis, 1980)

land lies between 240 and 300 meters with a characteristic northward dipping plateau showing extensive Karst features. The plateau consists of successive terraces which are of Pleistocene age. Two of these elevated reef terraces are particularly conspicuous as they form sharp escarpments. Metamorphic rocks are present under the coral cap, and in the south facing escarpment of the island.

The second physiographic unit of Hispaniola consists of a structural low-land immediately south of the Cordillera Septentrional. It is bounded to the South by the foothills of the Cordillera Central (Figure 2). The northwestern end of the depression is called Plaine du Nord in Haiti, and the Cibao Valley in the Dominican Republic. The extreme southeastern end is also known as Vega Real in the Yuna River area adjacent to Samana Bay (Figure 2). This depression is about 290 Kilometers long and varies in width from about 5 to 40 Kilometers. Two major rivers, the Yaque del Norte and the Yuna flow respectively northwest (to the Atlantic) and Southeast (into Samana Bay) within the Cibao Valley. Both rivers show signs of recent rejuvenation as they are now flowing at levels 15 to 30 meters below the main level of the depression. The southwestern portion of the Cibao Valley south of the Yaque del Norte and northwest of Santiago includes a smooth, hilly topography about 200 meters high dissected in Neogene marine deposits. These series are composed of polygenic conglomerates sandstones, marls, sandy clays and coralliferous limestones that unconformably overlie older metamorphic rocks. These neogene deposits have been known as Cercado Formation (Maury, 1919 p. 591), Gurabo Formation (Cooke, 1920) and Mao Formation (Vaughan et al. 1921, p.80), from older to younger respectively.

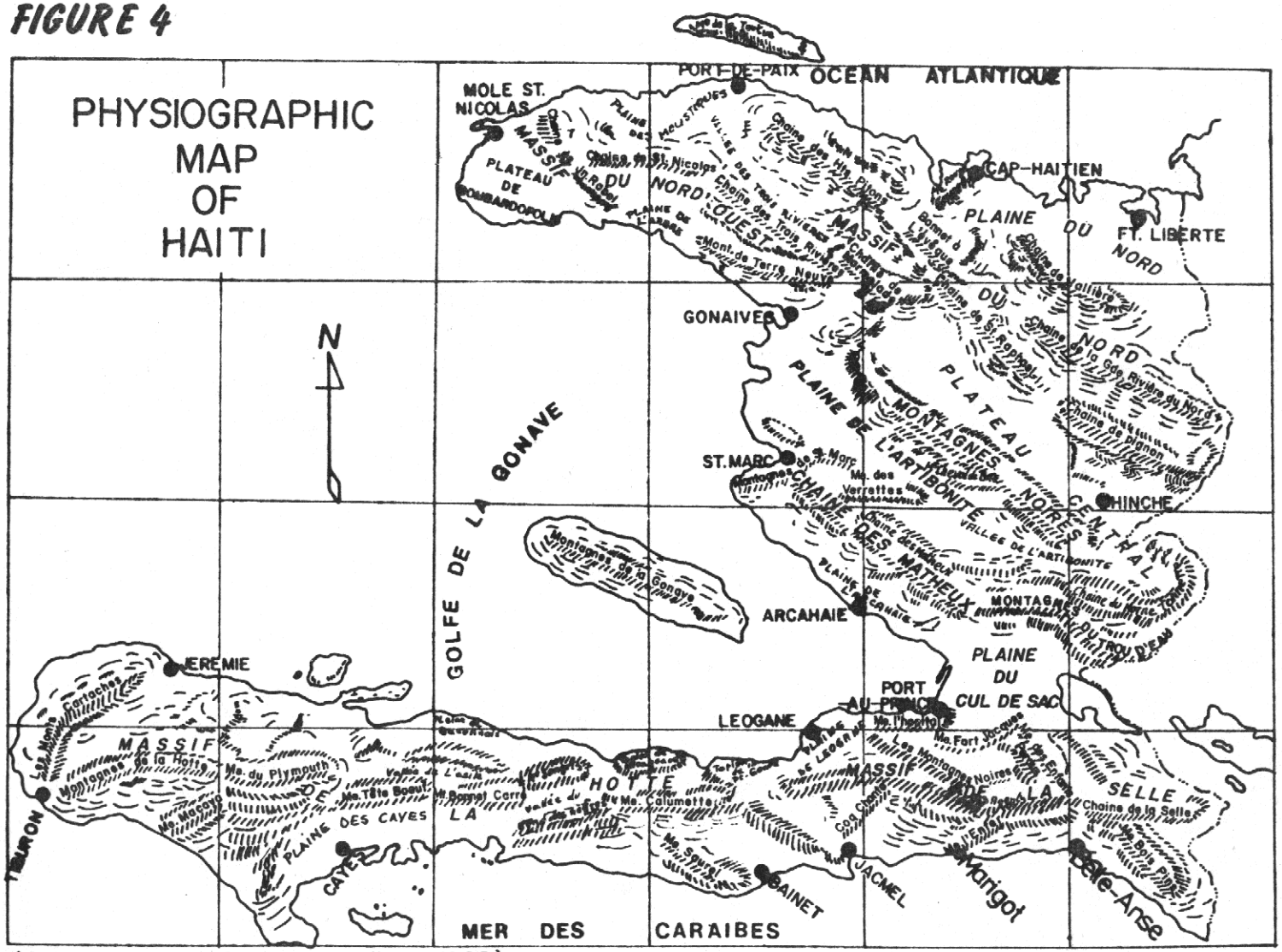
The third physiographic unit of Hispaniola includes the most important mountain system of the island. It constitutes the backbone of the portion of Hispaniola north of the Cul-de-Sac/Enriquillo depression. The northwestern regions/ are called Massif du Nord in Haiti, and the remaining southeastern regions form the Cordillera Central in the Dominican Republic (Figure 2). This mountain system is the most impressive of the whole island and of all the antilles as well. It comprises the tallest elevation (Peak Duarte 3087 meters) of all the Caribbean islands. The width of the third physiographic unit varies from less than 25 Kilometers to more than 90 Kilometers toward the southeast where it bifurcates south. The southern branch is known as the Sierra de Ocoa, whereas the easternmost branch is known as Sierra de Seibo or Cordillera Oriental (Figure 2). This physiographic unit is also characterized by sharp relief dissected by the river's drainage systems. In addition, the southeastern areas adjacent to the Vega Real exhibit extensive karst features which have developed over a small 200 meter-high plateau of biocalcirudite. These areas are known as Los Haitises, from the original Arawak word as previously mentioned. The central mountain range plays a very important hydrologic role on the island as its four major rivers: Artibonite, Yaque del Norte, Yaque del Sur, and Yuna, have their headwaters on its slopes.

Two prominent fault zones, the Hispaniola and Bonao Faults, form important topographic features in the central and eastern Cordillera. The Bonao Fault forms a prominent escarpment southwest of Bonao where it has a marked and continuous curvature, and separates the highly elevated mountains of the Cordillera from the Bonao Valley (Lewis, 1980). The southern boundary of this physiographic unit is somewhat diffuse, as it grades into the Plateau Central/ Valle de San Juan and Llanura de Azua physiographic unit (figure 2). The western boundary may be taken as the los Posos San Juan Fault (Figure 3), whereas an apparent fault to the east is not yet defined. (Lewis, 1980)

The Central Cordillera system includes the oldest rocks on the island. They vary from metasediments to igneous intrusives (tonalites, gabbros), and extrusives believed to be of at least Early Cretaceous age (Bowin, 1966; Kesler et al., 1977). Ultramafics such as serpentinized peridotites are also known within this area. Although most of the Central cordilleran system is composed of metamorphic and igneous rocks, the northwest Hispaniola Fault zone forms a graben which contains Oligocene clastic deposits (Lewis, 1980). Tertiary sediments also occur at the southern end of the Sierra de Ocoa, and in the Cordillera Septemtrional, region of los Haitises.

To this physiographic unit can also be attached the Llanura Costera del Caribe (Figure 2), which is underlain by rocks of the Cordillera. Eight of these terraces can be recognized between Punta Palanque and la Romana, and may reach height of 80 meter or more above present sea level (Schubert, 1980). They gradually blend with the foothills of the Cordillera Central. The relative height of the terraces from each other end of this physiographic province clearly indicates the difference in uplift rate between the northwestern and southeastern parts of the island, as suggested by Horsfield (1977). In fact, while the first three lowest terraces in this area occur at 3 - 6 meters, 8 - 9 meters and 16 - 17 meters respectively (Schubert, 1980), in the Northwestern Peninsula of Haiti similar prominent terraces occur at 16± 3 meters, 28± 3 meters and 52 meters respectively (Dodge et al., 1983). Furthermore, radiometric dating of these terraces also shows significant differences between the two areas. The lowest terraces along the southeastern coast of the Dominican Republic yielded a Th-230/U-234 date of 121,000 ± 9000 to 155,000 ± 13,000 years (Schubert, 1980). Similar dating of the terraces along the coast of the Northwestern Peninsula of Haiti produced average ages of 130,000, 108,000 and 81,000 years B.P. from the hightest to the lowest terrace respectively (Dodge et al., 1983). It is thus evident that the lowest terrace (3-6 meters) in the Llanura costera (figure 2) corresponds approximately to the third (52 meters) terrace near Mole Saint Nicolas, a difference of about 46 meters. Considering that when the lowest terrace of the southeastern regions was being formed (about 125,000 years B.P.) sea level was 6 meters higher than it is today, it is clear that uplift there has been partically negligible. Rapid uplift of one region while another one stays stationary is possible in Hispaniola because of extensive dislocation caused by major fault zones. The Pleistocene case is an illustration of the main tectonic history of the whole island throughout time, as I will point out further during the transects.

FIGURE 4



(Adapted from Maurrasse, editor, 1982)

The fourth important physiographic unit of the island consists of the low-land called Plateau Central in Haiti and Valle de San Juan and Llanura de Azua in the Dominican Republic (figure 2). The altitudes in this unit vary from sea level to 400 meters in the Valle de San Juan, and to slightly more (405 meters) in the center area of Plateau Central at the structural dome of Potosuel, north of Maissade (Figure 4). This whole physiographic unit shows extensive youthful drainage systems, which are particularly conspicuous in the Plateau Central. The southern boundary of this unit is defined by high relief formed by the Montagnes Noires and the Sierra de Neiba (figure 2). High-angle south dipping reverse faults are also associated with the southern boundary of this physiographic unit where sediments at the edges of the low-land show nearly vertical to slightly overturned structures.

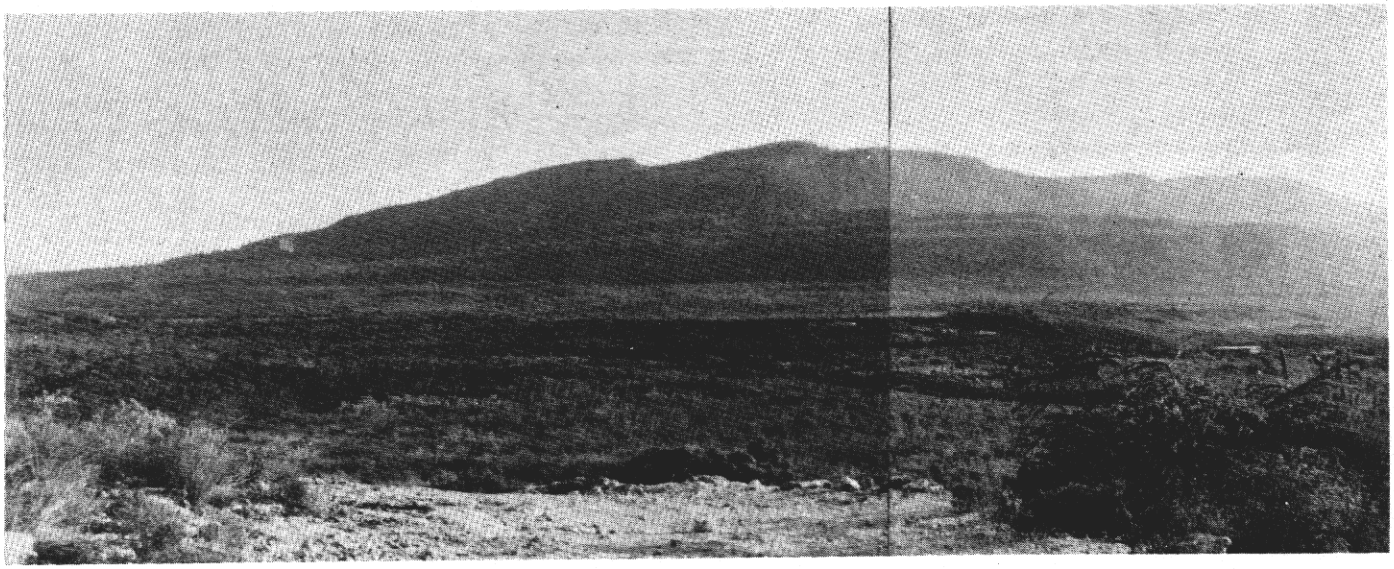
Sediments of Tertiary age filled these basins in which they may reach thicknesses greater than 5000 meters (Rigaud and Pierre-Louis, 1982).

The fifth physiographic unit of Hispaniola has a broad S-shape and includes three main subdivisions separated by major fault scarps and depressions. It includes the Massif du Nord'Ouest and Montagnes Noires in Haiti, and the Sierra de Neiba in the Dominican Republic (figure 2). The southeastern end of the Sierra de Neiba, namely the Sierra de Martin Garcia, is separated from the main mountain chain by a depression in which flows the Rio Yaque del Sur.

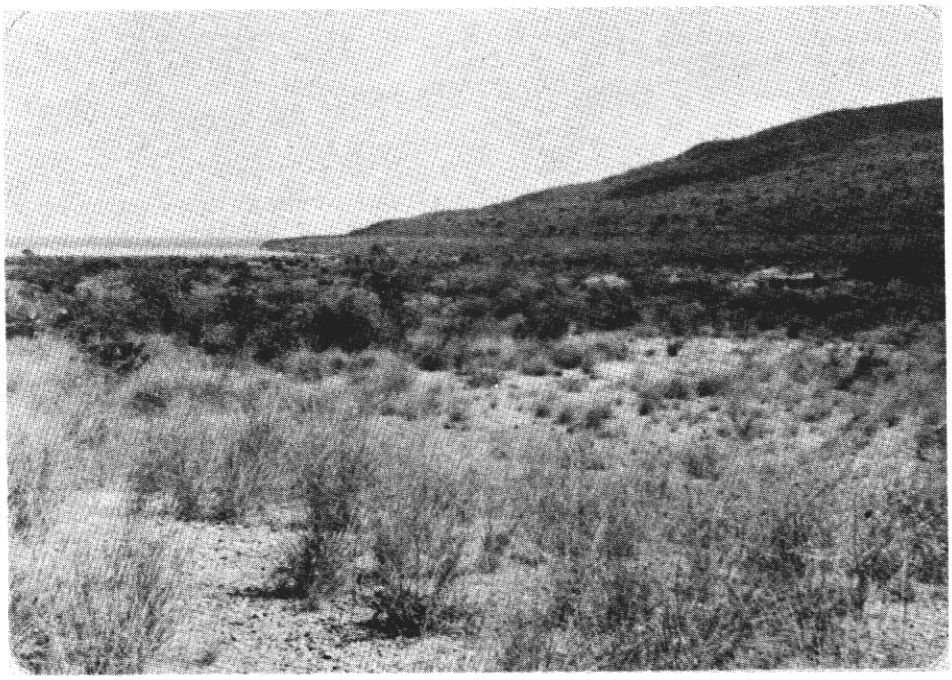
The northwestern Peninsula is separated from the Massif du Nord of the Central cordilleran system by a major structural depression associated with vertical faulting, the Gros Morne graben in which flows the Trois Rivières. The western end of the Northwestern Peninsula is characterized by extremely well developed raised reef terraces, (figure 5) which are also the best preserved Pleistocene terraces known in the Caribbean region. Their analogs can be found across the Windward Passage in southern Cuba, particularly at Point Masi (del Busto Alvarez, 1975). The top of the coralline limestone cap forms the Bombardopolis Plateau at a maximum elevation of approximately 600 meters. Oligocene pelagic limestones and volcanics, and Miocene hemipelagic marls to sandy marls underlie the coral rock. The southeastern portion of the Northwestern Peninsula consists of the Massif de Terre Neuve. It is a very steep and rugged relief with a maximum elevation of 1100 meters at Morne Goreille. This mountain range is also made up of limestones, igneous intrusives and extrusives (andesites, diorites) of Cretaceous and Tertiary ages. The Terre Neuve mountains include an extensive zone of porphyry copper mineralisation.

The Montagnes Noires range is separated from the Northwestern Peninsula by the Gonaives Plain, and continues southeastward into the Sierra de Neiba. The Maximum elevation in these mountains is reached at Peak Neiba, 2,279 meters. Their total length is about 120 kilometers, and their width varies between 3 and 20 kilometers. A major fault system, the Gonaives Fault Zone, limits the western and southwestern boundaries of the Montagnes Noires with the Artibonite Valley (figure 3). The Montagnes Noires and the Sierra de Neiba both contain Teriary limestones and volcanics.

FIGURE 5



a: Pleistocene reef terraces along the northern coast of the Northwestern Peninsula of Haiti, region of Mole Saint Nicolas.



b: Pleistocene reef terraces near Baie de Henne, southern side of the Northwestern Peninsula of Haiti.

The tenth physiographic unit of Hispaniola lies west of the Jacmel-Fauché depression. It is referred to broadly as the Massif de la Hotte (Figures 2,4). This unit is physiographically more complex than suggests the single name attached to it. In fact two distinct orographic sub-zones can be recognized north and south of the Trans-Xaragua fault which transects the area diagonally (Figure 3). This fault system includes from east to west, the low-land area of the Etang de Miragoãne, the Vallée de Fond des Nègres, Vallée de l'Azile, and the valley of Rivière des Anglais and Riviere de Tiburon.

North of the fault system, and in a similar direction, the mountains of Bonnet Carré, Plateau de Rochelois and Macaya Massif form a series of reliefs controlled by secondary fault systems. The highest elevation of the La Hotte Physiographic unit, Peak Macaya (2347 meters) is one of these uplifted blocks bounded by multidirectional or orthogonal fault systems. The Monts Cartaches at the extreme northwest end of the Peninsula is also a fault-controlled subunit, (Figures 3,4).

South of the Trans-Xaragua fault, other fault-controlled reliefs form the remainder of the La Hotte physiographic unit. They include Morne Saurel and Fond des Negres. Geologically the La Hotte physiographic unit is more complex than its eastern counterpart in the Southern Penninsula. It is more intensely deformed and its Lithofacies more diversified than those found in the La Selle-Baoruco block. Its basement is composed of intensely deformed rocks of the Dumisseau formation. In certain areas extreme multiphase deformations led to extreme dislocation of originally continuous lithologic unit giving rise to a tectonic melange, as can be seen on the road Carrefour Dufort - Jacmel (Figure 9).

GENERAL STRUCTURAL SETTING

Given its medial position relative to the major structural features of the Caribbean (Figures 1, 10), the island of Hispaniola may be considered the structural hub of the region. As can be seen in figure 1, Hispaniola lies at the intersection of the main tectonic features of the present Caribbean plate, and most of its major structures can be related to wrench-fault tectonism between the eastward moving Caribbean plate and the westward moving North American plate. Added complexity developed because of differential motions between the sub-blocks, and also changes in stress field during differential rotations between the major adjacent continental plates (Ladd, 1976). Consequently, a complex orthogonal fabric of dislocation has developed throughout the island, and in the adjacent Caribbean Sea as well (Case and Holcombe, 1980). Most of the major fault systems indicated earlier have been activated several times and diachronically, the latest cycle of activity was Late Pleistocene (Maurrasse, 1982). These fault systems have apparently played a major, if not the most important role, in the distribution of sedimentary environments throughout the geologic evolution of Hispaniola. Their differential motions through time led to the development of series of troughs and banks, sometimes individual islands. These early features heralded the present structural setting of the island, as defined by the major physiographic units discussed herein above.