3. THE PHYSICAL LANDSCAPE

3.1 INTRODUCTION

The objectives behind describing the physical landscape of the research area are two-fold. On the one hand, an attempt is made to describe the present natural situation of the area, in order to outline the context in which the fieldwork took place and to evaluate conditions for site survival. On the other hand, an attempt is made to give an idea of how the environment may have looked in pre-Columbian times, in order to be able to evaluate conditions for Amerindian settlement and exploitation of the environment.

In order to be able to fully appreciate the local conditions encountered by pre-Columbian inhabitants of the area, detailed paleoenvironmental information should be presented. Information is needed that focuses on environmental changes that are thought to have taken place since the start of the pre-Columbian period. It is important to know to what extent the landscape has changed during the last millennia compared to the present-day situation to attain an understanding of changes in the presence of natural resources, the accessibility of the shore and the preservation of archaeological sites, caused by erosion, sea level changes, and tectonic movements.

Only since very recently have such studies been carried out in the Caribbean, focusing to a significant degree on coastal dynamics (e.g. Delpuech 2004; Delpuech *et al.* 1999; Keegan 1992[b]; Watters *et al.* 1992) or on paleoclimate (e.g. Curtis and Hodell 1993). Region-wide studies on island

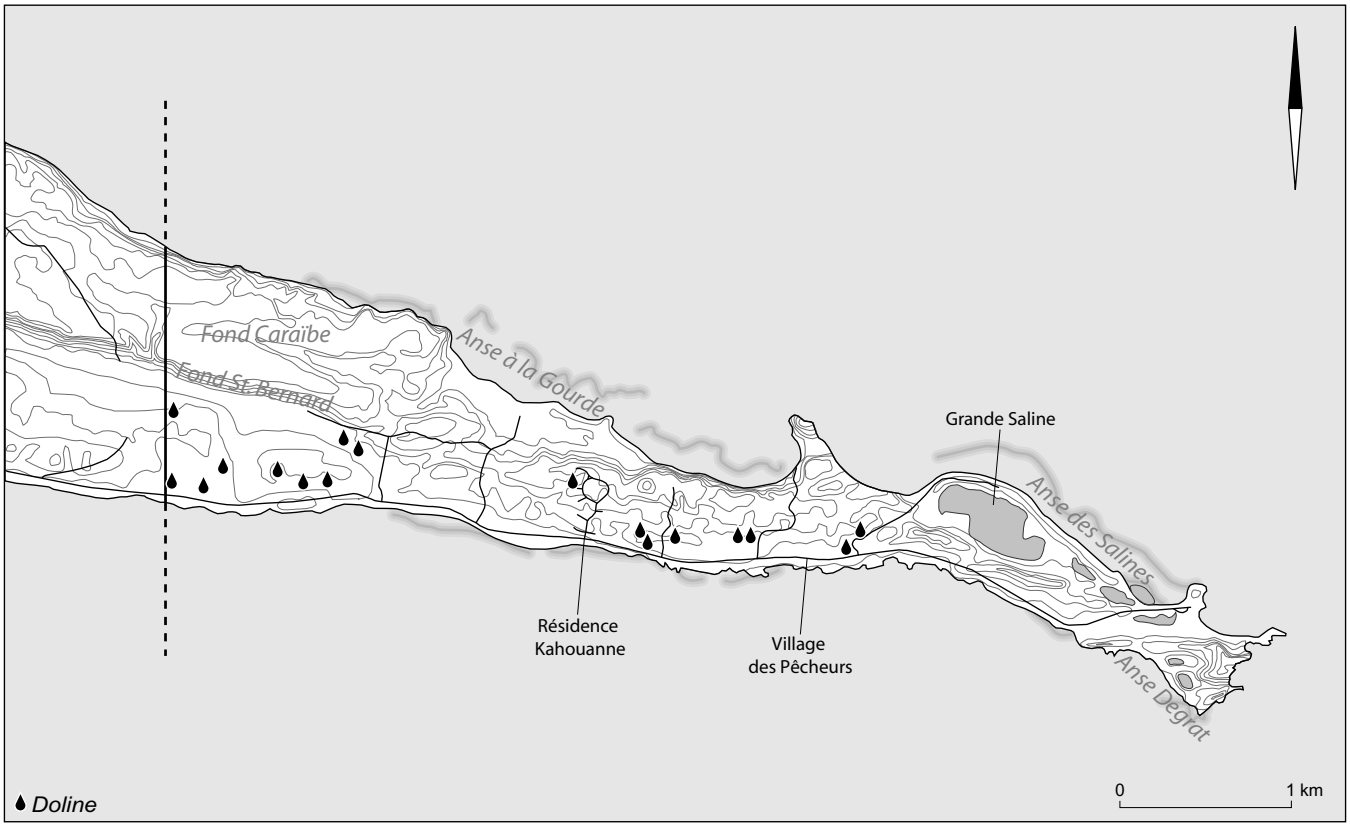

Fig. 3.1. The Pointe des Châteaux study area.

vegetation and related Amerindian plant use within pre-Columbian times are not yet available although a promising start has been made by Newsom (1993).

Fortunately, for the eastern part of Guadeloupe, field studies, related to the Anse à la Gourde excavations and the present project, could be carried out by a team of geologists from the *Vrije Universiteit* of Amsterdam in 1999 and 2000 (Troelstra and Beets 2001[a-b]). The section on coastal dynamics is largely based on their observations, and the description of other aspects of the physical environment greatly profited from their fieldwork as well. For most topics in this chapter, descriptions of the present-day natural environment prevail, since information regarding the past situation is less complete. These are complemented by data that have been collected from other parts of the Caribbean as well.

3.1.1 The Lesser Antilles

The research area includes the Pointe des Châteaux peninsula, which is the easternmost part of Guadeloupe, and the islands of La Désirade and Petite Terre. These are among the least known parts of the eastern Caribbean (fig. 1.1). The Caribbean islands extend in an arc from the South-American mainland, separating the Caribbean Sea from the Atlantic Ocean. Most of the islands are within view of each other. They are divided in the Lesser Antilles and the Greater Antilles. The Lesser Antilles include the Windward Islands, extending from the island of Trinidad to Guadeloupe, and the Leeward Islands, ranging from Montserrat and Antigua to the Virgin Islands.[1] The Greater Antilles, located in the northwestern part of the Caribbean Sea, are connected to the South-American mainland by the Lesser Antillean chain.

North of Dominica, the volcanic chain of islands splits in a volcanic inner-arc, extending from south to north from the Basse-Terre part of Guadeloupe to Saba, and a calcareous outer-arc, ranging from Marie-Galante in the south to Sombrero in the north.[2] The volcanic islands were formed as a result of tectonic movements of the Caribbean plate, forcing itself over the Atlantic plate around 45 million years ago. This caused radial cracks through which the plastic interior, which formed the volcanoes, could escape (Fox and Heezen 1975:444-445). This process also created the volcanic bases of the outer-arc islands that were later covered by marine sediments (Fox and Heezen 1975:444; Uchupi 1975:28).

Guadeloupe comprises the volcanic island of Basse-Terre (950 km^2), dominated by its 1.5 km high volcano and its tropical rainforest, and the relatively dry and flat, calcareous island Grande-Terre (590 km^2). A small salt-water stream, *La Rivière Salée*, separates Basse-Terre and Grande-Terre. The other islands of the Guadeloupe archipelago, including the islands of Les Saintes, Marie-Galante, Petite Terre and La Désirade, are situated at very close distance. Administratively, St. Barthélemy and the French part of St. Martin also belong to the French overseas department (*Département d'Outre-Mer*) Guadeloupe.

3.1.2 Pointe des Châteaux

The Pointe des Châteaux peninsula is the easternmost tip of Grande-Terre and administratively it belongs to the municipality of St. François. Pointe des Châteaux is approximately 9 km long and its width varies between 50 m in its eastern part and 2.5 km in its western part. The study area, however, is smaller, covering almost 7 km from east to west (fig. 3.1).

3.1.3 La Désirade

La Désirade is situated 12 km east of the Pointe des Châteaux peninsula. The island is an 11 km long and 2 km wide calcareous table mountain that has a volcanic substratum. It is dominated by its 6.5 km long uninhabited limestone plateau, which is locally called *La Montagne* (Barrabé 1954:614; Lasserre 1961:885). The north coast of the island is rather difficult to reach from the sea, as a result of its extremely steep cliffs and the strong and unpredictable sea currents. The south part of the island is characterised by a gentler slope between the plateau and the southern coastal plain that extends along the entire southern coastline. This coastal plain is sheltered from the wind and the reefs that border the coastline protect it from strong sea-currents (fig. 3.2).

3.1.4 Petite Terre

The islands of Petite Terre, Terre de Haut in the north and Terre de Bas in the south, administratively belong to the municipality of La Désirade.[3] They are situated at approximately 12 km south of La Désirade and at 7.5 km south-east of Pointe des Châteaux. Terre de Bas measures 2.5 km by 600 m, and Terre de Haut measures 1.1 km by 200-300 m (fig. 3.3).

Nowadays, the islands of Petite Terre are state property. The so-called *50 pas géométriques*, representing a coastal zone of approximately 80 m wide, are managed by the ONF. The remainder of the islands has been controlled by the *Conservatoire de l'Espace Littoral et des Rivages Lacustres* (CELRL) and by the *Direction Départementale de l'Équipement* (DDE), ever since it was expropriated from its Desiradien owners in 1994. In this year, the *Direction Régional de l'Environnement* (DIREN) declared the islands of Petite Terre to be a nature reserve (Barré *et al.*1997:6; Conservatoire du Littoral 1997:6).

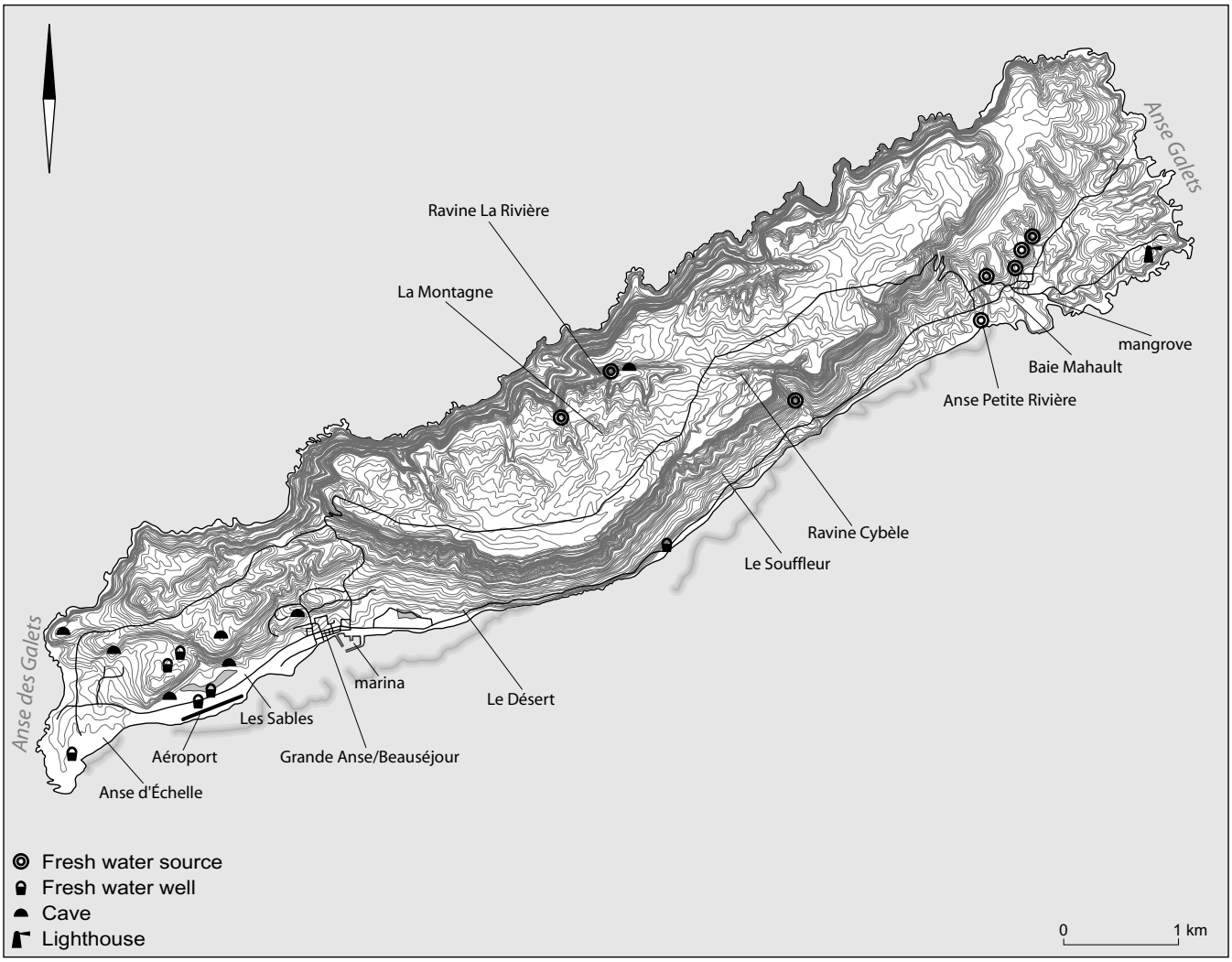

Fig. 3.2. La Désirade.

Fig. 3.3. Terre de Haut and Terre de Bas, Petite Terre.

3.2 NATURAL SETTING

3.2.1 Geology and geomorphology

Pointe des Châteaux, La Désirade and Petite Terre are calcareous islands, belonging to one platform (Butterlin 1956:274; Westercamp and Tazieff 1980:123). As a result, they are rather similar in appearance, particularly Pointe des Châteaux and Petite Terre. Nowadays, they are characterised by calcareous plateaus bordered by uplifted reefs, salinas, dunes and sandy beaches protected by reef barriers. Today, mangrove areas are largely absent in this area. The coasts in the research area offer many locations where canoes can land and navigation around the islands is relatively easy for people accustomed to the local situation. The influence of volcanic eruptions is thought to be modest, especially when compared to the volcanic Basse-Terre part of Guadeloupe. This was probably true for the pre-Columbian period as well.

Pointe des Châteaux (fig. 3.1 and 3.4) is situated on the calcareous St. François plateau, which is intersected in its western part by a large, flat-bottomed valley. Local relief is modest. Today, the northern coast consists for more than 50% of beaches, with a mean width of 18 m, behind which dunes are situated. Those dunes have been built-up from eroded material from the reef barrier through high-energy storm floods and wind-action (Troelstra and Beets 2001[b]). The southern coast consists of uplifted reefs and beaches, which have a mean width of 4.8 m, and there are no dunes. Abundant coral and gastropod fragments on these beaches demonstrate the presence of gaps in the reef barrier caused by tropical storms and hurricanes (Troelstra and Beets 2001[b]). Beach-rock formation processes, resulting in the lithification of sediment particles, are common along the northern coast. Beach-rock formation is typical for tropical beaches where calcium carbonate touches salt and fresh water interfaces (Troelstra and Beets 2001[b]). Beach-rock formation processes take place rather fast, evidenced by the existence of beach-rock with very recent inclusions, such as beer bottle caps. Pre-Columbian pottery sherds are often

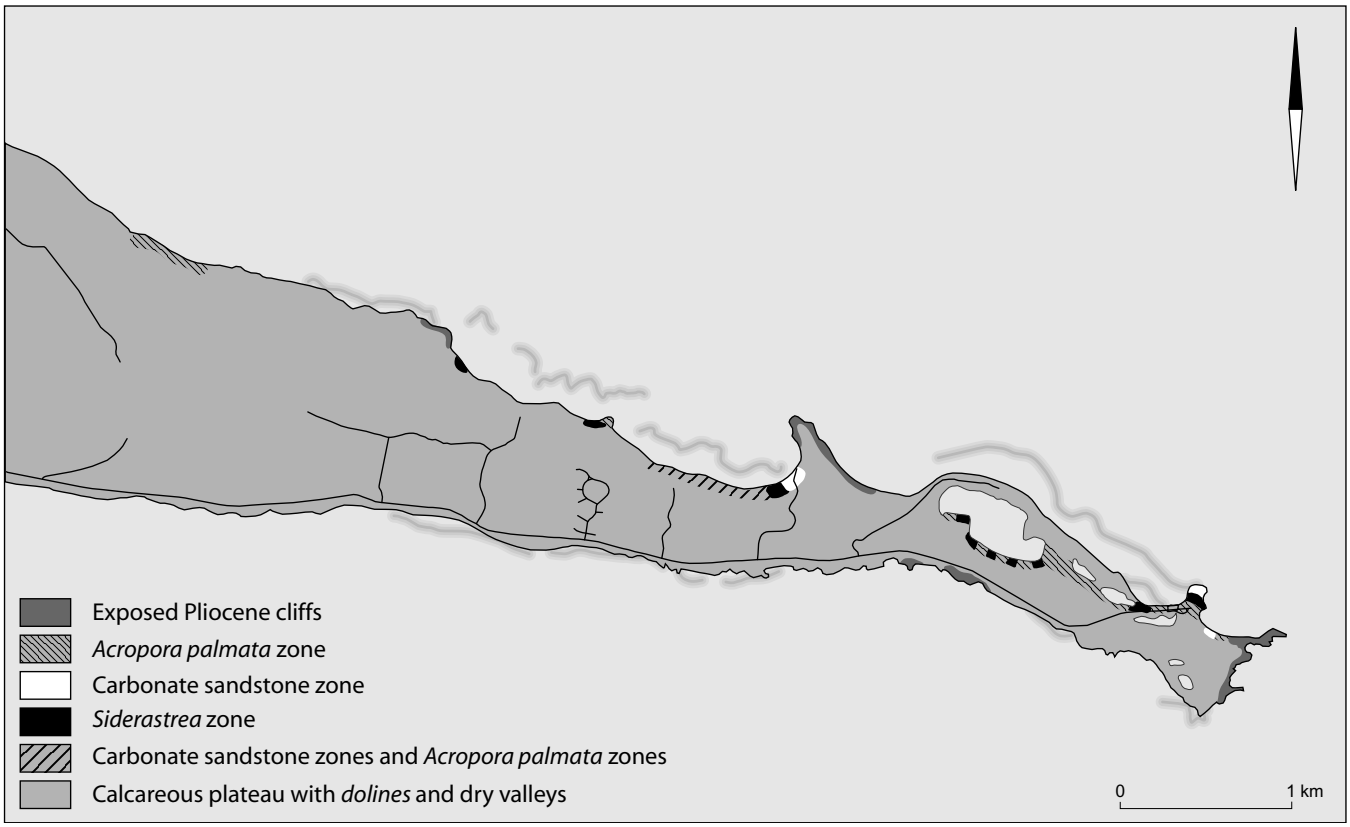

Fig. 3.4. Geological map of Pointe des Châteaux (after Troelstra and Beets 2001[b]).

embedded as well. Beach-rock formation poses a significant threat to the preservation of archaeological sites, although in some instances it stimulates their survival by decreasing the effects of erosion. At Morel on Grande-Terre, for example, pre-Columbian burials have been conserved in bedrock concretions that would have been eroded if not protected by this hard coating. Furthermore, Pointe des Châteaux is characterised nowadays by the presence of *dolines*, small rounded and flat bottomed natural water basins (Lasserre 1961:52), which are typical for karst regions, and, in the easternmost part, by its seven salinas.[4] Most of these contain water throughout the year, even during the dry season. Four types of salinas can be identified at Pointe des Châteaux. The Grande Saline is an enclosed, permanently filled salina. It is characterised by the presence of algae and its extremely high salinity (Troelstra and Beets 2001[b]). It remains unclear whether this salina existed in pre-Columbian times or not (Troelstra personal communication 2002). The Grande Saline is fed by marine transgressions from the Atlantic through the beach and dunes. The two small salinas at the south-eastern part of Pointe des Châteaux, near Anse Degrat, are enclosed salinas located along a tectonic fault. Wind and wave action gradually deposit sedimentary material, which will eventually result in a complete in-filling and subsequent coverage by vegetation. The easternmost salina on the north coast is semi-enclosed; it has an open connection to the sea. Another salina, situated south-east from this semi-enclosed one, is presently mainly fed by rainfall as evidenced by the presence of abundant fresh water calcareous algae in the recent setting. However, the water is brackish and not suitable for human consumption (Troelstra and Beets 2001[b]).

La Désirade (fig. 3.2, 3.5 and 3.6) is characterised by its well-exposed volcanic basement, consisting of lava with greenschist, interbedded chert and radiolarite (Barrabé 1954; Donnely 1975:672-674; Fink 1972:275; Uchupi 1975:28). This basement eroded into a platform on which a

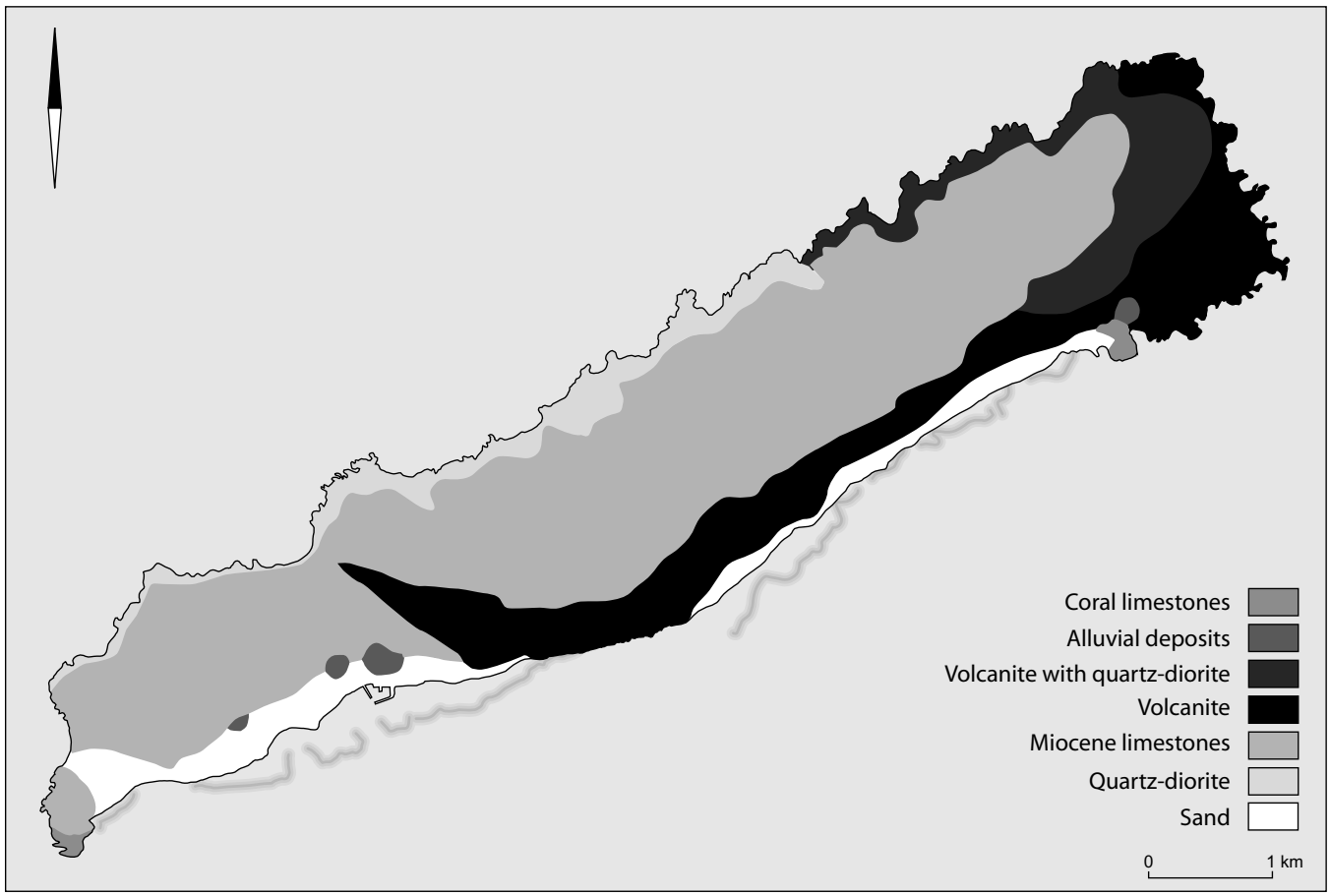

Fig. 3.5. Geological map of La Désirade (after Weyl 1966:259).

50-70 m cap of limestone was deposited. The upper part of this cap consists of nodular massive limestone, whereas the lower 35 m come close to marl and contain coral fragments (Troelstra and Beets 2001[b]). Tectonic movements lifted the platform to more than 200 m high, folded the limestone and created cracks that resulted in the Rivière and Cybèle ravines and the plateau's western border.[5] A thick limestone cornice borders the plateau (Barrabé 1942:150; Butterlin 1956:278; Lasserre 1961:887; Mitchell 1953; Weyl 1966:259-261). At the plateau, karst processes created small basins that are filled with shallow decalcification clay deposits and that conserve rainwater (Lasserre 1961:887). A characteristic feature of La Désirade is the presence of caves used by inhabitants of the island in pre-Columbian as well as in recent times. The western part of the plateau is bordered by limestone hills reaching 150 m in height and in the east by a series of plateaus, at 35 m, 75 m and 95 m, consisting of limestone that covers accumulations of volcanic boulders in limestone and coral cement (Barrabé 1954:618; Lasserre 1961:887). Whereas the northern and eastern part of the island consist of volcanic material, the southern coastal plain has a limestone covering and consists of elevated reefs on conglomerates of water-worn pebbles (Lasserre 1961:84; Westercamp and Tazieff 1980:125). Near Anse Galets, in the north-eastern part of La Désirade, the volcanic basement is covered by calcareous sandstone, with numerous *Cittarium pica* fossils in its upper part. Near Baie Mahault, the volcanic basement is covered by a conglomerate in the deeper parts and by *Siderastrea siderastrea* fossils in the higher parts. The carbonate sequence on top of the volcanic base appears to consist of calcareous packstone, often containing shell fragments, massive coral boundstones and coral conglomerates. The Pliocene reefs

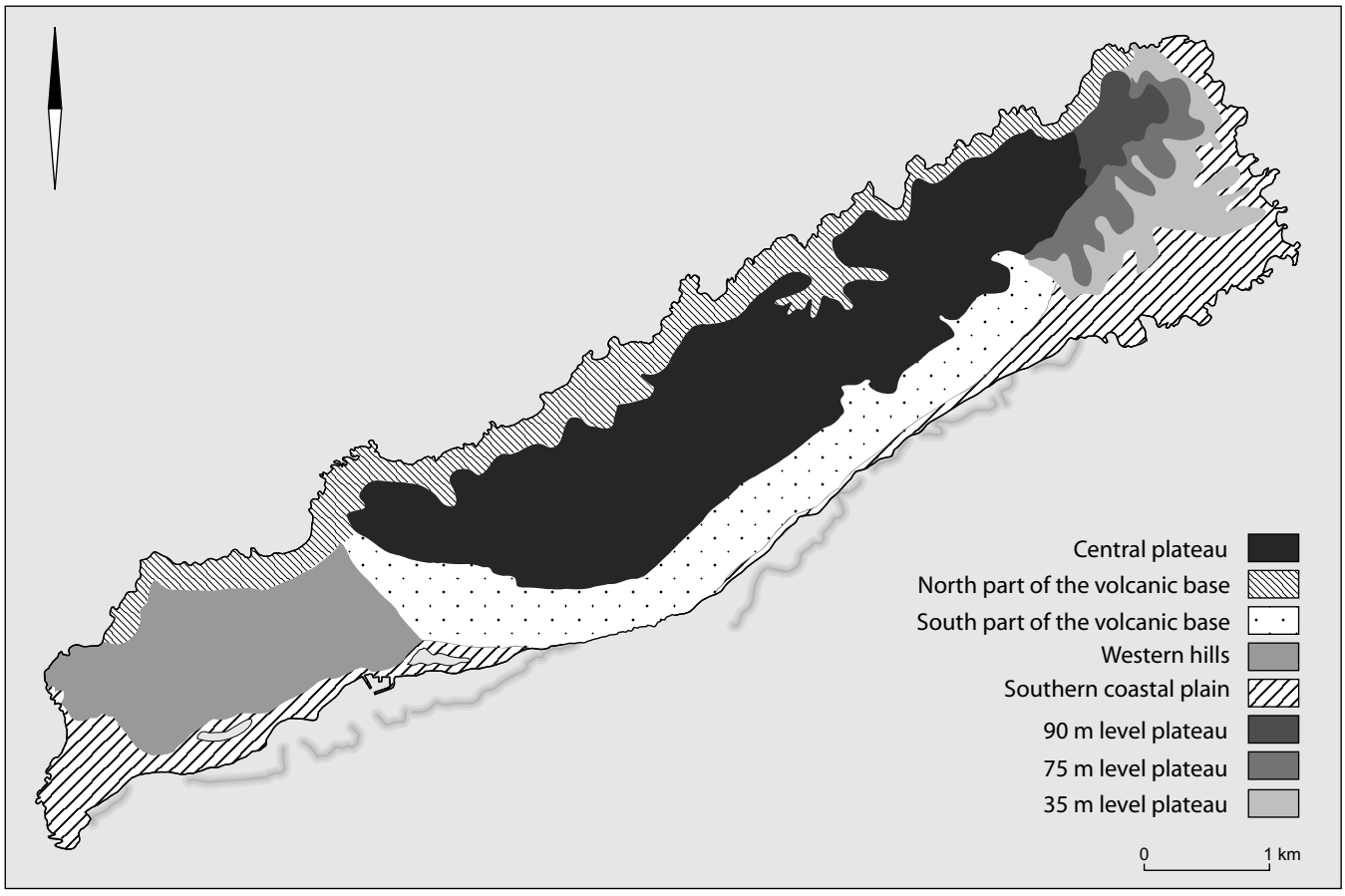

Fig. 3.6. Geomorphological map of La Désirade (after Lasserre 1961:886).

near Les Galets in the south-western part of La Désirade are covered by a reef sequence containing typical Eemien corals, which in turn is covered by a volcanic conglomerate (Troelstra and Beets 2001[b]). The unusual composition of La Désirade, being partially volcanic and partially limestone, provides a unique possibility for the exploitation of raw materials for the production of stone tools in the largely limestone study area that is devoid of suitable rocks.

The islands of Petite Terre (fig. 3.7) are flat west-east oriented islands that originally consisted of one elevated coral plateau. They show a general inclination in west/north-western direction, which is the result of the same tectonic processes as those at Grande-Terre (DIREN Guadeloupe 1994:6). A 150 m wide channel, which is 7 m deep at most and which is enclosed on the eastern side by an impressive reef barrier, separates the islands. The islands are almost completely enclosed by coral reefs (DIREN Guadeloupe 1994:6). Abrasion of these reefs by sea action has created sandy zones that dominate the beaches in the low northern and western parts of Terre de Bas. These are easily influenced by wind and sea action, thus creating dynamic dune formations bordering a depression that nowadays contains salinas (Conservatoire du Littoral 1997:8; DIREN 1994:6). At high sea, for example during hurricanes, the easternmost of these salinas is in open connection to the sea. Therefore, it is always filled with water, whereas the two others are periodically dry (Rousteau 1995:8). The more elevated south and east coasts of Terre de Bas are rocky with limestone outcrops, as is most of Terre de Haut.

3.2.2 Erosion and sedimentation

The local relief, occasional heavy rains, high winds and

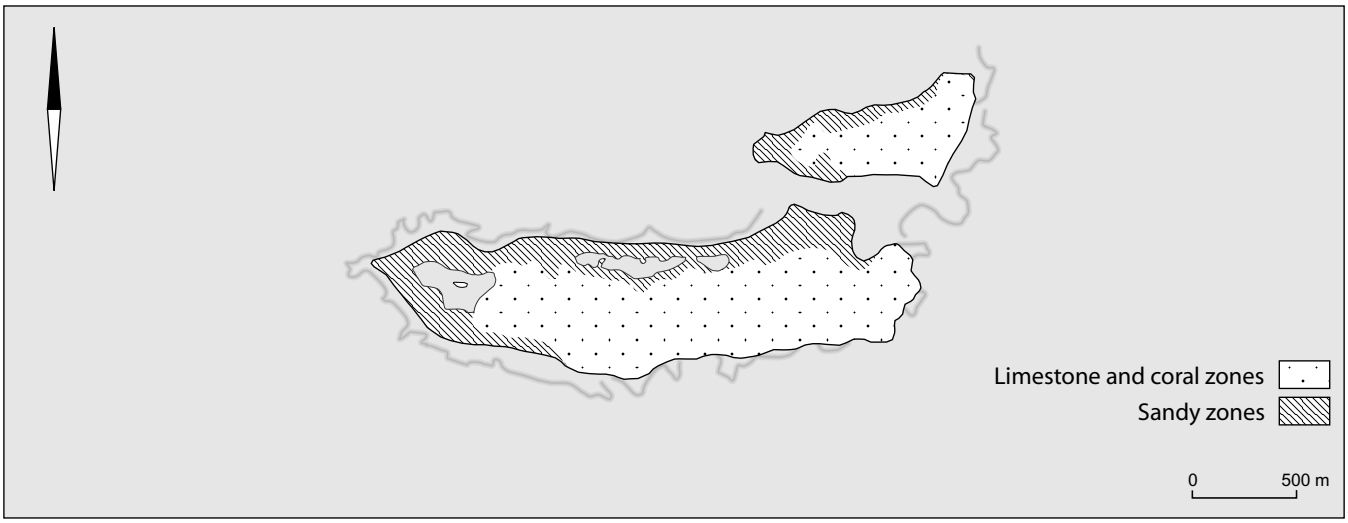

Fig. 3.7. Geological map of Petite Terre (after Conservatoire du Littoral 1997:Carte A.II.4).

the lack of substantive vegetation within the study area encourage erosion and sedimentation processes. These are reinforced by human factors, of which removal of vegetation from slopes, overgrazing by goats, farming of dry land, and shifting cultivation practices which, with short recovery periods, may destroy the vegetation and the soil structure, are the most important.

At present, and this is probably true for the pre-Columbian period as well, Pointe des Châteaux does not appear to be greatly influenced by landslides, soil creep or mudflows. Rockfalls, however, do occur, but only at the extreme edges of elevated cliff coasts. Modest but continuous superficial slope erosion, aeolic erosion in flat areas, and resulting sedimentation appear to be of more significance, at Fond St. Bernard in particular. However, this has minor effects on the displacement of sediment.

La Désirade's relief and its presently modest vegetation cover encourage slope erosion and aeolic erosion to a greater degree. This process particularly affects the thin layer of loose soil, which covers the limestone bedrock at the borders of the plateau. Eroded sediments are deposited on the western, eastern and southern slopes, where soil creep at the surface moves them further down. The thin sedimentation layer on the southern coastal plain demonstrates the slow nature of this process. Faster displacement of sediments occurs on the western hills and the eastern plateaus, through gullying, which is caused by excessive runoff of water during the wet season. Landslides or mudflows do not appear to be significant processes. Rockfalls occur only at the edges of ravines and the steep northern coast.

At Petite Terre, slope erosion and aeolic erosion in the present as well as in the past appear to be modest as a result of the flat character and the dense vegetation of the islands. The only significant impact of erosion may be found in the area north-west from the lighthouse on Terre de Bas, where sediments may be moving downwards to the beach in the northeast.

3.2.3 Coastal dynamics

Coastal dynamics drastically altered important parts of the research area. Wave action, of which the effects are largely dependent on wind action, accounts for the most dramatic coastal changes. The resulting degree of coastal erosion is mostly dependent on whether or not waves are broken on a reef system. The effects of coastal erosion are modest in parts of the study area that are protected by fringing reef systems. Coastal areas with reef-passages or which lack reef protection, however, are heavily subjected to coastal erosion. Wave action in reef areas is also responsible for the fine sand deposits that, influenced by wind processes, may play a part in coastal dune formation processes. Tropical storms and hurricanes greatly accelerate these processes. It is clear that areas with salinas and sand beaches are the least stable and most vulnerable to erosion and covering by pioneer dunes. The effects of erosion of sandy beaches through wave action are reduced by the presence of beach-

rock formation processes, which consolidate the sand, but this does not actually stop erosion. At Anse à la Gourde even hard beach-rock erodes very fast (Troelstra and Beets 2001[b]). Archaeological sites are greatly damaged by such processes. Coastlines consisting of conglomerates and fossil coral reefs have eroded to a lesser extent, being only affected by caving in of the coast and by rock falls as a result of strong wave action.

The *Vrije Universiteit* geological team, besides its work of investigating climatic change, tried to estimate the rate and impact of coastal dynamics in the research area, by mapping elevated reefs at Pointe des Châteaux and coring salinas at Pointe des Châteaux and La Désirade (Troelstra and Beets 2001[a-b]). The team found peat, dated 4473 BP, at 195-200 cm depth in the La Désirade salina cores, and algae, dated 2544 BP, at 126-130 cm depth in the Grande Saline at Pointe des Châteaux. Furthermore, they collected organic material deposits, dated 1760 BP, immediately underneath Anse à la Gourde beach-rock. On the basis of these finds they conclude that around 4473 BP sea level was 2 m below the present level, while around 2544 BP, sea level was approximately 130 cm lower than it is now.[6] Around 1760 BP, the sea level equalled the present one (Troelstra personal communication 2002).

According to Feller *et al.* (1992), sea level for the Grand Cul-de-Sac Marin, to the west of Grande-Terre, rose approximately 3.4 m per 1000 years between 7000 and 4000 BP. Between 4000 BP and AD 1000 it rose 0.8 m per 1000 years. After the year AD 1000 it rapidly rose 1.8 m.[7] This largely coincides with sea levels estimated for Barbuda and the Bahamian archipelago. At Barbuda it was estimated that for the period of initial Ceramic Age occupation, around 300 BC, the sea level was very close to its present state (Watters *et al.* 1992:15). But for the period of 3700 to 3800 years ago, it is suggested that it would have been 5 m lower than today (Watters *et al.* 1992:47). For the Bahamian archipelago, sea level changes are reported to be insignificant for the period AD 700 to 1500 (Keegan 1992[b]:5). Rise of sea level greatly changed the stability of the coast. Troelstra and Beets (2001[b]) suggest that the first development of salinas and dunes at Pointe des Châteaux probably started about 5000 years ago, while a stabilisation in sea level occurred until approximately 1000 years ago.

At Pointe des Châteaux, the northern coast with its salinas and sand beaches presently is, as it probably was in the past, most vulnerable to coastal changes. These changes have been described for Anse à la Gourde (Delpuech *et al.* 1999; Hofman *et al.* 1999[a]; Troelstra and Beets 2001[a-b]). According to Troelstra and Beets (2001[b]) originally there was a wide coastal plain with semi-enclosed salinas at the location of this site, separated from the sea by beach and dune formations, instead of the present beach and dune formations. Delpuech *et al.* (1999) suggested that before AD 600 the sea level was 1 to 2 m lower, and that the actual bay was a salina that was invaded by the sea as a result of the rise of sea level between AD 600 and 1000. This also resulted in the development of a mangrove area.[8] Recent data from Anse à la Gourde, however, (see above) demonstrate that in this period sea level approximately equalled the present sea level, but a gradual displacement of the local system, as described by Delpuech *et al.*, did take place. Troelstra (personal communication 2002) proposes that destruction of the coastal dunes affected this process. After AD 1000, only a reef barrier remained and a sandy beach, together with the present coastal dunes, appeared on the southern shore of the former salina. Hofman *et al.* (1999[a]) hypothesised that during the Early Ceramic B occupation of Anse à la Gourde, between AD 500 and 700, the coastline was probably located between 50 to 100 m more northward.[9] The present situation at the Grande Saline is rather similar, which suggests a comparable process through time. This, however, may be a little slower since the Anse à la Gourde beach is presently undergoing dramatic erosion, as a result of a passage in the coral reef barrier that is located in front of the site. In 2000, a significant change could be noted compared to the situation in 1999. Large parts of the beach and beach-rock had been eroded and the sea almost reached the Anse à la Gourde site (Troelstra and Beets 2001[b]). The beach in front of the Grande Saline appears to be better protected by the reef barrier and by wash-over deposits. The situation near the salina that is in open connection with the sea is disastrous as large parts of the beach and the dunes are rapidly disappearing. The surrounding areas are being threatened by marine breakthroughs as well. They continue to be protected by the dunes that result from sedimentation of eroded reef particles. The moment that those reefs or parts of the reefs are destroyed, dune formation will stop at those locations, while dune erosion, which is rapid, will continue.

At La Désirade, the situation in 2000 has been compared to 1983 aerial photographs and coastal erosion was found to be rapid. It ranges between 1 to 21 m and for some parts of the island it even involves 34 m for this short period of time (Troelstra and Beets 2001[b]); (fig. 3.8). Recent human action dramatically affects the beaches as well. This includes the creation of the island's marina in the capital Grande Anse, for which a large beach has been completely dug out (APEPAD nd:28), and bulldozing activities at the airport and at the beach of Anse Petite Rivière.[10] Although the beaches appear to be relatively well protected by the coral reef barriers that extend all along the southern coastal plain, they do rapidly erode. In the Les Galets area, in the south-eastern part of La Désirade, this is evidenced by the

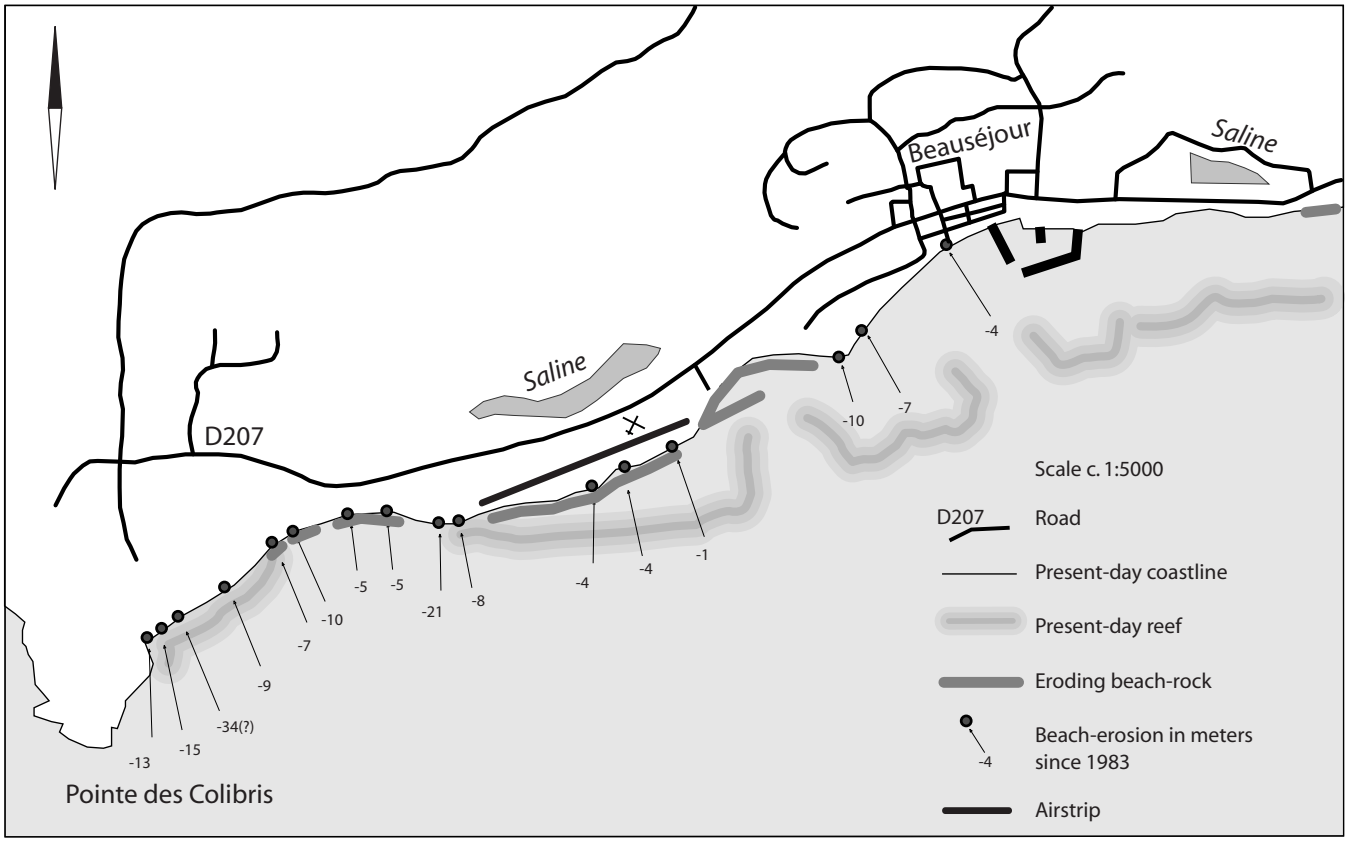

Fig. 3.8. Coastal erosion at south-western La Désirade (after Troelstra and Beets 2001[b]).

near complete disappearance of the Anse d'Échelle beach cemetery that was used for victims of the 1865-1866 cholera epidemic. The bulldozing of this area in order to destroy what was left of the cemetery and to flatten the terrain to allow construction works did not enhance protection either. The small beach strip south of the airport, which is only a few meters wide, completely disappeared after some weeks of heavy tropical storms (personal observation 2002). The coast south of the easternmost salina presently appears to be badly protected as well. Although a small channel running from the sea normally feeds this salina, the dune fringe is so narrow at this point that breakthroughs easily occur. Another obvious coastal development was noted at the west of the marina. A layer of fine clay was found at the waterside, which must have been deposited when there was stagnant water, allowing the finest sediment particles to settle (personal observation 2000).

On Petite Terre, the northern and the western coast of Terre de Bas are presently unstable, a situation that is probably representative for the pre-Columbian period as well. Large parts of the beach and the dunes are rapidly eroding. This is evidenced by steep, almost vertically eroded, slopes of the dunes (personal observation 1997-2000). Although a lot of the sandy coast disappears, an important part is displaced inland as well. The dunes on Petite Terre are relatively young and characterised by pioneer vegetation, and they appear to be moving a lot. The salinas are gradually being filled up with sand; a process that is clearly visible at the easternmost of the three principal salinas of Terre de Bas (Rousteau 1995:8).

3.2.4 Climate

For the Guadeloupe archipelago, three seasons can be distinguished nowadays. From January to April, it is dry and rather fresh with a moderate northeastern wind. In May and June, the season is tropical with moderate rainfall and with

strong eastern winds and the rainy period, between July and December, is extremely warm and humid, with subsiding trade winds (Bouchet 1992:3). One of the most important impacts on the natural environment is the almost annual passage of tropical storms and hurricanes during this season. They may cause tidal waves, heavy rains, and on Basse-Terre, mud streams and land slides.

The research area is situated in the driest and warmest part of Guadeloupe. Only 959 to 1014 mm of rain has been measured on a yearly basis between 1951 and 1993 for Petite Terre and La Désirade respectively (Conservatoire du Littoral 1997:7). The annual average temperature is above 27° C and stable during the year, while the relative humidity of the air is high, with an average of 81% (Bouchet 1992:3-6; Lasserre 1961:143-210; 1961[b]:767-806).

Information on seasonality, precipitation, insolation, temperature, humidity and winds in pre-Columbian times is important since climatic change is closely associated with the rate of coastal erosion, rate and impact of dune generating and eroding processes, and stability of the salinas. Even small-scale changes may cause changes in the balance between evaporation and precipitation, salinity variations, currents and wave activity and hurricane frequencies. These, in turn, may influence fresh water supplies, water level in the salinas, tolerance of food resources such as gastropods and coastal erosion processes. Increased hurricane intensity also strongly limits human occupation. Therefore, the *Vrije Universiteit* team placed a special emphasis on the recovery of high-resolution sediment cores deposited during the last 5000 years (Troelstra and Beets 2001[a-b]). Troelstra and Beets (2001[b]) present data of stable isotope analyses on carbonate shells of land snails from the site of Anse à la Gourde indicating that before AD 900 the climate was variable with rapid dry and wet sequences.[11] Between AD 900 and 1300 conditions changed from dry to distinctly wet and the period between AD 1300 and 1600 was characterised by a development towards dryer conditions. They conclude that dry periods centre around AD 950 and AD 1400 and wet periods around AD 750 and AD 1300. Curtis and Hodell (1993:135) suggest on the basis of isotopic, trace element and pollen analysis for samples from Lake Miragoane (Haiti) that the period from 7000 to 4000 years BP was relatively humid. From approximately 4000 to 2500 years BP the climate became drier, while from approximately 2500 to 1500 years BP it was exceptionally dry, until around 1000 BP, when wetter conditions briefly returned. Since then, a general return to drier conditions was witnessed. Such climatic changes surely influenced the soils, vegetation and water supplies of the study area, but unfortunately it is not known to what extent.

3.2.5 Hydrography

Surprisingly, considering the importance of fresh water in arid regions, the information on the possibilities for fresh water procurement within the research area is limited. This may be caused by the fact that most fresh water occurrences are not visible from the surface at present. Many of these are fresh water lenses, or aquifers, situated between chalky layers in the subsurface, or floating on saline groundwater as a result of their lower density. This phenomenon, fed by rainfall, has also been reported for other flat limestone islands, for example Barbuda (Watters 1980:64). According to Antczak (1998:109) Los Aves fishermen still excavate pits in the dunes to obtain brackish but drinkable water. Some of these pits provide water throughout the year. The presence of colonial and more recent wells at Pointe des Châteaux and on La Désirade and Petite Terre demonstrates the use of such lenses. In pre-Columbian times, the lenses could be exploited through digging as well. This should be done with care since lenses are often underlain by salty water. Careless exploitation causes the salty water to pollute the aquifer. Potstacks, made from bottomless vessels (Harris and Hinds 1995; Hinds and Harris 1995), may have been used in this process. Potstacks have been found on eroded coastlines at several Caribbean islands, such as Barbados (Hinds *et al.* 1997), Mustique and St. Vincent (Hinds and Harris 1995) and an Early Ceramic B potstack was discovered at Morel on Guadeloupe (Arts personal communication 2002). The direct collection and conservation of rainwater in ceramic vessels, causing serious limitations to the quality and quantity of fresh water, was probably of less importance.

Fresh water sources and streams are absent nowadays in the Pointe des Châteaux research area. In the pre-Columbian period, fresh water was probably collected from aquifers although it may have been collected from *dolines* as well (section 3.2.1; fig. 3.1).

At La Désirade, permanent fresh water sources exist under the cornice of the plateau and near the coasts (fig. 3.2). Those of Baie Mahault and the Cybèle and Rivière ravines are still in use (Lasserre 1961:890-891; Petit 1989:3). Several sources are known to have been used and to have supported the needs of La Désirade's 1600 inhabitants far into the 1960s (Lasserre 1961:900; Petit 1989). As a result of transportation through limestone, the water is calcareous and rich in minerals. Nowadays, only the water from the Baie Mahault sources is potable. The other sources do not have sufficient bacteriological quality (Petit 1989:11), although they were probably better in the past when there was less environmental pollution.

Since fresh water sources and water streams are now absent on Petite Terre, it is deemed that aquifers must have been exploited in pre-Columbian times. The presence

of a well, nowadays providing brackish water, near the lighthouse indicates that this was done until quite recently (fig. 3.3). In addition, on the limestone plateaus of the central parts of the islands of Petite Terre waterholes have eroded that contain rainwater (Rousteau 1995:9).

The pre-Columbian population of the research area must have had sufficient access to fresh water, although a considerable effort may have been involved in its procurement. There is no reason to assume that the above-mentioned sources did not exist in pre-Columbian times. If environmental conditions indeed were less arid in the pre-Columbian period (section 3.2.4), the situation was more favourable. However, Troelstra (personal communication 2002) warns that salt water, as indicated by geophysical studies, must have been present in the subsoil during dry periods in the pre-Columbian period as well, suggesting that the procurement of fresh water was probably always problematic in this region.

3.2.6 Pedology and agricultural potential

Nowadays, soils within the study area are poorly developed, the majority consisting of well-drained soils composed of coarse, loose sand, with or without humus component.[12] In some areas, on the southern coastal plain at La Désirade for example, soils are compact and clayish, which implies that they retain water without releasing it to plant roots easily.

The agricultural potential of the soils, however, is sufficiently promising. The area nowadays makes a poor impression in this respect, since hardly any cultivation takes place, except for the valley in the western part of the Pointe des Châteaux study area. In the past, however, the greatest parts of Pointe des Châteaux and Petite Terre were in use for large-scale cultivation of cotton and for small-scale horticultural practices. On La Désirade, slash-and-burn agriculture on the central plateau was common practice until the late 1960s (Bariteau 1968:21-22) and is still carried out now and then. The thin layer of decalcification clays, mixed with calcareous nodules, allows good yields (Lasserre 1961:906). On the southern coastal plain small fields are cultivated for household use only.

Extensive slash-and-burn horticulture, common to agricultural Amerindian societies, is possible in all of the study area as well, except of course in the sandy beach areas. This was probably also the case during pre-Columbian times, as it is likely that local circumstances were then less arid and that soils received more protection from a denser vegetation cover.

3.2.7 Vegetation and fauna

To obtain an insight into local vegetation in pre-Columbian times, the *Vrije Universiteit* team also conducted an investigation aimed at the recovery and analysis of pollen. Unfortunately, the preservation potential of the salinas at Pointe des Châteaux and La Désirade, where samples were taken, proved to be unsuitable for pollen. Only a few samples contained minimal amounts of badly preserved pollen. The peats in the La Désirade salina cores, however, point to considerable mangrove growth in the period before 4400 BP (Troelstra personal communication 2002). Present-day vegetation is described below.

Nowadays, the study area is covered by a coastal vegetation and a dry, thorny 'inland' vegetation, that is adapted to dry and sunny conditions, sea winds, and sandy and calcareous soils. The widespread occurrence of this thorny vegetation, while to some extent natural, is probably the result of long-term human intervention in the landscape (Rousteau 1995:9).[13]

At Pointe des Châteaux, a coastal zone mainly consisting of small trees and sea grape borders an area characterised by acacia and other types of low, dense and thorny shrub.

La Désirade's plateau and the hills in the western part of the island are presently also densely covered by thorny shrub. The sparse vegetation on the southern coastal plain consists of small-leafed thorny brushwood, acacia in particular, and cactaceous and herbaceous species. The sandy beaches along the south coast are covered by lianas and sea-grape (Bouchet 1992:11-12). The eastern part of the island is characterised by dense mancenilla growth and by a very small mangrove area near Baie Mahault. The ravines along the northern coast, however, are characterised by lush vegetation, consisting of large fruit-bearing trees and large trees that are potentially suitable for the manufacture of dug-out canoes (personal observation 2000).

Although very small, the islands of Petite Terre nowadays exhibit a relatively significant biological diversity as a result of the appearance of varied environments such as salinas, sandy beaches, rocky coastal zones and varied vegetation zones (Conservatoire du Littoral 1997:15). Beaches and coastal formations on sandy grounds are covered by 1 to 2 m high sea-grape. The dominant vegetation formation consists of low, impenetrable and very dense shrub of 1 to 1.5 m in height (Barré *et al.* 1997:7, 8 and map 2) and the western parts of the islands are densely covered by poisonous mancenilla trees (Conservatoire du Littoral:1997). The salinas are bordered by a small mangrove zone, then by a small zone of dense shrub of 3 to 4 m in height, and finally by 5 to 10 m high trees. Most remarkable is the presence of *Gaïac* trees, which are almost extinct on the Lesser Antilles and thus heavily protected. Since *Gaïac* is a hard quality wood, pre-Columbian Amerindians often used it for the manufacture of high-status artefacts.

It is generally assumed that in pre-Columbian times, vegetation within the research area was somewhat more abundant, as a result of less arid conditions. Large trees may have been present but they were probably intensively used for the building of houses and dugout canoes. The vegetation has been further threatened by large habitations and cultivated areas (e.g. sugar cane, indigo and cotton plantations), charcoal production, and the introduction of grazing domesticated animals, like sheep and goats, in colonial times.

At present, Petite Terre is characterised by an abundant and diverse terrestrial fauna, including iguanas (*Iguana delicatissima*), turtles (*Chelonia mydas*, *Eretmochelys imbricata* and *Lepidochelys* sp.), land crabs and rats (*Rattus rattus*). Very few insects have been reported for these islands (DIREN 1994:15). The central channel, today overexploited, has until recently been very rich in sea urchins, *Strombus gigas* and coral species such as *Diploria* sp. and *Acropora* sp. Along and near the bordering reefs parrot fish (*Sparisoma* sp.) and barracuda (*Sphyraena barracuda*) can be caught in abundance, although fishermen that frequent the area recently reported a general decline of fish populations. Sharks are usually found in the deeper areas south of the islands, and whales may pass the islands between March and May (DIREN 1994:17-20). The areas around the Petite Terre salinas are reputed to attract a lot of terrestrial sedentary birds and migrating birds (Barré *et al.* 1997:19, 24). This has also been reported for Pointe des Châteaux (Office National des Forêts nd:15).

Nowadays, La Désirade, because of its larger surface, has a richer terrestrial fauna compared to Petite Terre and Pointe des Châteaux. Agoutis in particular are abundant (personal observation 1999-2000). The south-eastern part of the island abounds in iguana. In addition, the ravines, thanks to their dense and rich vegetation, attract many birds (Lasserre 1961:904). The islands' environments have been reported to be well-stocked with fish (Lasserre 1961:915), crustaceans, marine molluscs and turtles.[14] Turtles regularly come on land to lay their eggs, for example at the Anse Petite Rivière beach.

Steadman *et al.* (1984[a]) demonstrated for Antigua that several vertebrate species were lost over the past 3500 years. These include reptiles, such as lizards and snakes, birds, and mammals, such as bats, rice rat, and manatee. They attribute this to human-caused environmental degradation that precipitated extinction in the pre-Columbian period already. Ethnohistorical accounts report species that have now become rare or extinct on Guadeloupe (Grouard 2001:70). These include pink flamingo (*Phoenicorpterus ruber*), pigeon and turtledove (*Columbidae*), parrot (*Psittacidae*), iguana (*Iguana delicatissima*), acouchi (*Myoproctaa acouchi*), sluggard (*Bradipus tridactylus*), manatee (*Trichechus manatus*), monk seal (*Monachus tropicalis*), and sea turtle (*Cheloniidae*). Although present-day situations probably reflect fairly well the fauna as they might have been on Petite Terre, at Pointe des Châteaux and on La Désirade during the pre-Columbian period, biodiversity was probably richer in the past.

3.3 CONCLUSIONS AND EXPECTATIONS FOR THE EAST-GUADELOUPE PROJECT

This chapter provided data needed to understand fieldwork conditions, site distributions and the general natural framework for pre-Columbian settlement within the research area. It made clear that local relief and vegetation in the research area are not very attractive but they do not hinder systematic surface surveys being carried out. Sedimentation is quite modest and mud streams or landslides, covering archaeological sites, are highly unexpected locally. However, conditions for the survival of coastal sites or parts of these sites seem to be less favourable as a result of coastal erosion. Other sites are partially destroyed by beach-rock formation processes. In addition, dune formations at the northern coasts of Terre de Bas and of Pointe des Châteaux may cover archaeological deposits, since these dunes are relatively young and characterised by pioneer vegetation. At the Anse à la Gourde site, evidence has been found that dunes gradually shifted over parts of the habitation area. Therefore, the Pointe des Châteaux beaches have been auger tested in order to investigate the presence of archaeological material underneath beach sand deposits (section 2.2.3).

Inland sites will be better preserved although they may have been damaged by human action, and, if situated at the borders of La Désirade's plateau, by erosion. At Morne Cybèle-1, for example, archaeological material is only conserved in natural depressions in the bedrock (Hofman and Hoogland 1994). This situation, however, does not appear to be exemplary for the border of the plateau, as at comparable site locations at Les Éoléens and Morne Souffleur large amounts of surface material were present. The Morne Cybèle situation may have been brought about by extensive excavation in the past.

Local conditions were probably favourable for pre-Columbian settlement and exploitation. The area is characterised by a lot of terrain suitable to habitation, small-scale horticulture and food gathering, and by small bays protected by coral reef barriers. They can be entered by canoe although it is difficult to pass the reefs. Marine food resources are easily and widely available.[15] The

richest marine biotopes that can be distinguished in the Caribbean are represented: coral reef areas, sea-grass beds and mangrove, while other biotopes such as sandy beaches, rocky coasts, and estuaries are nearby as well. In combination, these harbour a wide variety of mammals, birds, amphibians, reptiles, crustaceans, echinoderms, fish and shellfish (Grouard 2001:46). Terrestrial fauna appears to be only moderately abundant and diverse. Fresh water would have been available, although collection would have demanded some effort. This is also true for various shell species and coral species, lithics and *Gaïac* wood, which may have served raw material demands for tools and ornaments. It is not clear where wood used for dug-out canoes and houses was obtained, but giant postholes found at the site of Anse à la Gourde (Bright 2003; Duin 1998; Hofman *et al.* 2004) demonstrate that areas with large trees must have been exploited. Nowadays, large trees are only present in the La Désirade ravines. A less positive aspect of the natural environment is the almost annual passage of hurricanes. Considering the damage, chaos and panic they cause even nowadays, the situation in pre-Columbian times may have been more dramatic. It is possible that caves at La Désirade, of which the largest were reported in the La Rivière ravine and in the western hills, were used for shelter during such events (APEPAD 1995).

Considering the natural features of the area, certain areas appear to be more suited to pre-Columbian habitation or use than others. Most attractive appear to be flat coastal areas where fresh water can be found and where bays with coral reefs are close by. At Pointe des Châteaux these are expected at Anse à la Gourde, Anse Kahouanne, the Village des Pêcheurs, Anse Degrat and at Anse des Salines. On La Désirade, suitable areas are situated on the southern coastal plain and on Petite Terre at all the coastal areas. It is important to find out if archaeological sites are actually located at such attractive locations, but it is equally important to know whether sites are located in unexpected and maybe less favourable places. It is deemed important for the fieldwork to investigate all aspects of landscape use, an idea that is reflected in the survey design. What is needed ultimately is a combination of environmental and archaeological information. But before getting to this point, it should be outlined what could be expected with respect to the cultural setting of the research area.

NOTES

1 Guadeloupe is sometimes referred to as one of the Leeward Islands as well.

2 Sombrero is located to the north-east of Anguilla.

3 The islands of Petite Terre have been named after their positions related to the prevailing eastern trade winds. Terre de Haut has a windward location and Terre de Bas is a leeward island (Lasserre 1961:18, note 2).

4 Diameters of the Pointe des Châteaux *dolines* range between 2 and 5 m.

5 In its western part the plateau reaches 276 m in height, and in its eastern part it reaches 175 m.

6 This largely coincides with results from Curaçao, a stable tectonic area, where the sea level was found to be some 2 m below the present level for the period around approximately 4500 BP (Troelstra personal communication 2002).

7 The Cul-de-Sac situation is probably slightly different from the La Désirade situation, which can be explained by decline of the Cul-de Sac area and compaction of local peat (Troelstra personal communication 2002).

8 The shell material collected from Anse à la Gourde, however, does not support the idea of the existence of a mangrove area (Nieweg 2000:126).

9 At Morel, on the northern coast of Grande-Terre, the coastline has retreated 30 meters over the last 50 years (Delpuech *et al.* 1999, 2001). The Morel site appears to be more vulnerable to hurricane action and strong sea currents than other areas on Guadeloupe. Dramatic changes for other vulnerable parts of Guadeloupe, such as the Culs-de-Sac marins, have been presented by Delpuech *et al.* (2001).

10 The Grande Anse beach has actually disappeared (for the situation before construction of the marina, the reader is referred to Lasserre 1961: Plate LXXIII).

11 The carbon isotope variation is largely dependent on land snail diet.

12 No pedological maps exist for La Désirade and Petite Terre and no detailed soil information is available for Pointe des Châteaux.

13 This has also been suggested for St. Martin (Newsom and Molengraaff 1999:230).

14 To this day, for example, the Souffleur area at La Désirade is renowned for the enormous amounts of *Strombus gigas* that are being exploited (personal observation 1999-2000).

15 Nowadays, Anse à la Gourde at Pointe des Châteaux is still known for its large *Cittarium pica* populations.