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Geomorphology and soils of Apid Island, Inopacan, Leyte, Philippines

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ABSTRACT

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The island of Apid was most probably formed during the Upper Pleistocene as a barrier reef resting on volcanic rock. Two main types of soil can be found there: Rendzic Leptosols in the rocky interior and Arenosols on the sandy beach. Soil samples taken on the island showed low nutrient contents and a very low capacity to store plant-available water. Therefore, conditions for agricultural land-use are not very favorable.

Keywords: Apid Island. ecological properties. geomorphology. soils.

GEOMORPHOLOGY

Apid and the other islands of the "*Cuatro Islas*" appear to be parts of a barrier reef off the coast of Inopacan and Hindang. Most probably, these coral reef islands are resting on a volcanic basement as can be inferred from the topography of the islands particularly in relation to the Leyte mainland (Figure 1). The occurrence of the volcanic basement is probably related to the extinct volcano, Mt. Sacripante, in the mainland opposite the

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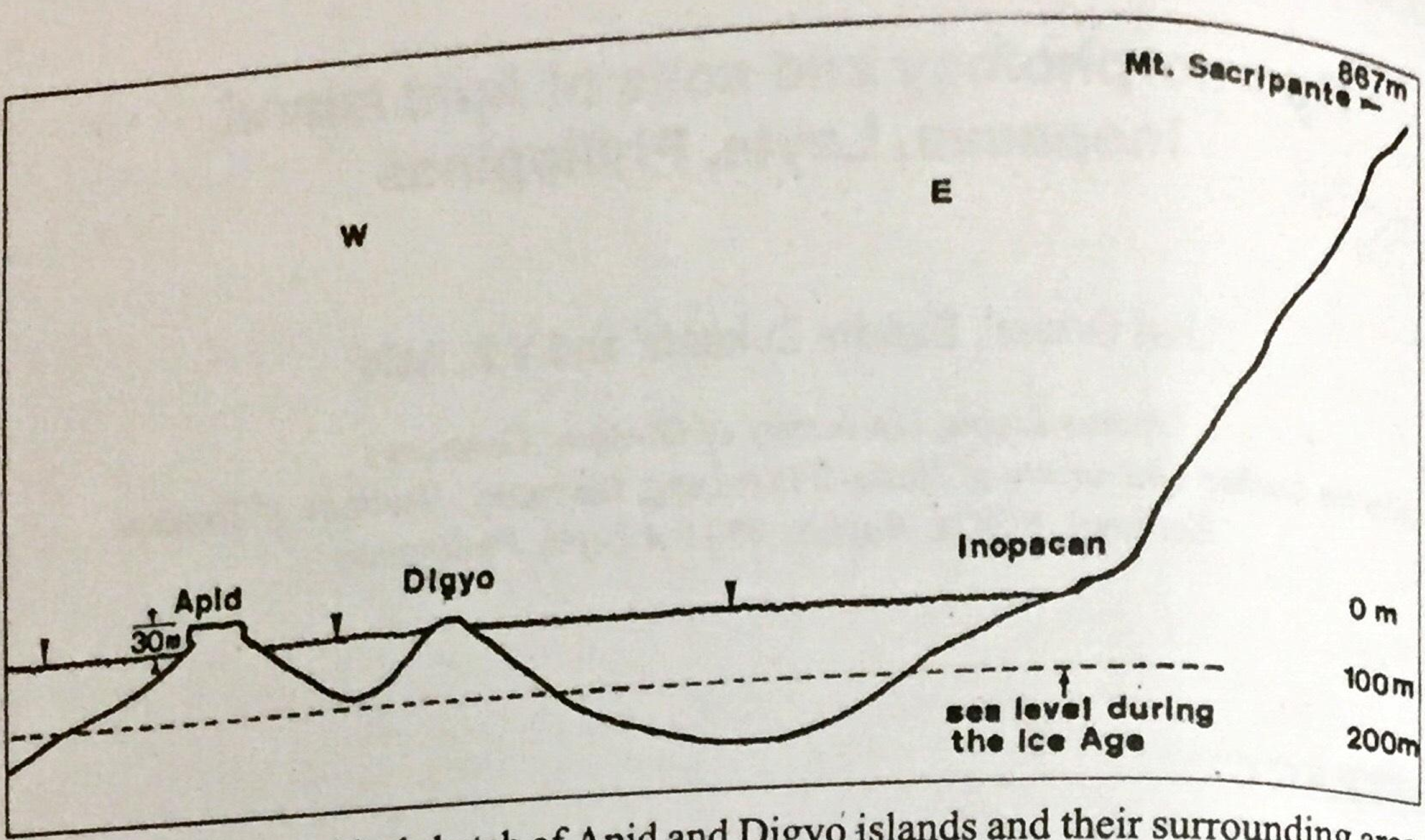

Figure 1. Topographical sketch of Apid and Digyo islands and their surrounding area (based on topographical maps of NAMRIA, Manila)

coral reef islands. Apid probably formed during the Upper Pleistocene epoch of the Quaternary period as evidenced by the age of its coralline limestone rock formation which is dated to be Quaternary (Bureau of Mines, 1950). According to Kadomura (1995), the sea level in Southeast Asia dropped by about 100 m during the last Glacial Maximum (during the Upper Pleistocene). This condition may have favored the barrier reef formation presumably due to the shallow sea water in the area where the coral reef islands are now located. The raised or elevated nature of Apid is an evidence of the geologic uplift of Leyte and other Philippine islands which, according to Rammlmair (1993), is continuing up to the present time. In fact for the same reason, raised coral reefs are also widespread in the northwestern and southwestern portions of Leyte. The flat and low morphology of Digyo island (about 2-3 m above sea level) clearly indicates that it is a much younger geologic formation than Apid.

The relatively fast dissolution of the coralline limestone imparts Apid its rugged terrain. The rocks generally show solution-etched surfaces giving them a rough appearance with abundant cracks and irregular pores. The island's terrain is marked by intensive network of sinkholes, tunnels and irregular passages and caverns. The important contribution of the roots of trees both in enhancing the physical disintegration of the limestone, on the one hand, and in holding and preventing the collapse of boulders, on the other hand, is very noticeable in many parts of the island. Drainage appears excessive due to the extensive sinkholes. Freshwater is very limited near the shores because of sea water intrusion, but it can be found several meters below the ground surface (for instance in caverns) in the interior portion of the island. Soil formation is at a very young stage, apparently due to the youthfulness of the rock formation and the instability of geomorphic surfaces.

SOILS

To identify the soil types and evaluate their characteristics, several walks were done across the whole island. Soil profiles were examined and soil samples were taken at several sites (Fig. 2).Soil samples were analyzed in the field using a Rapid Test Kit and the laboratory particularly for organic matter content.

As described above, the island is basically composed of coralline limestone. The most important characteristic of this material in relation to soil formation is its high content of calcite ($CaCO_3$), mostly accompanied by clay

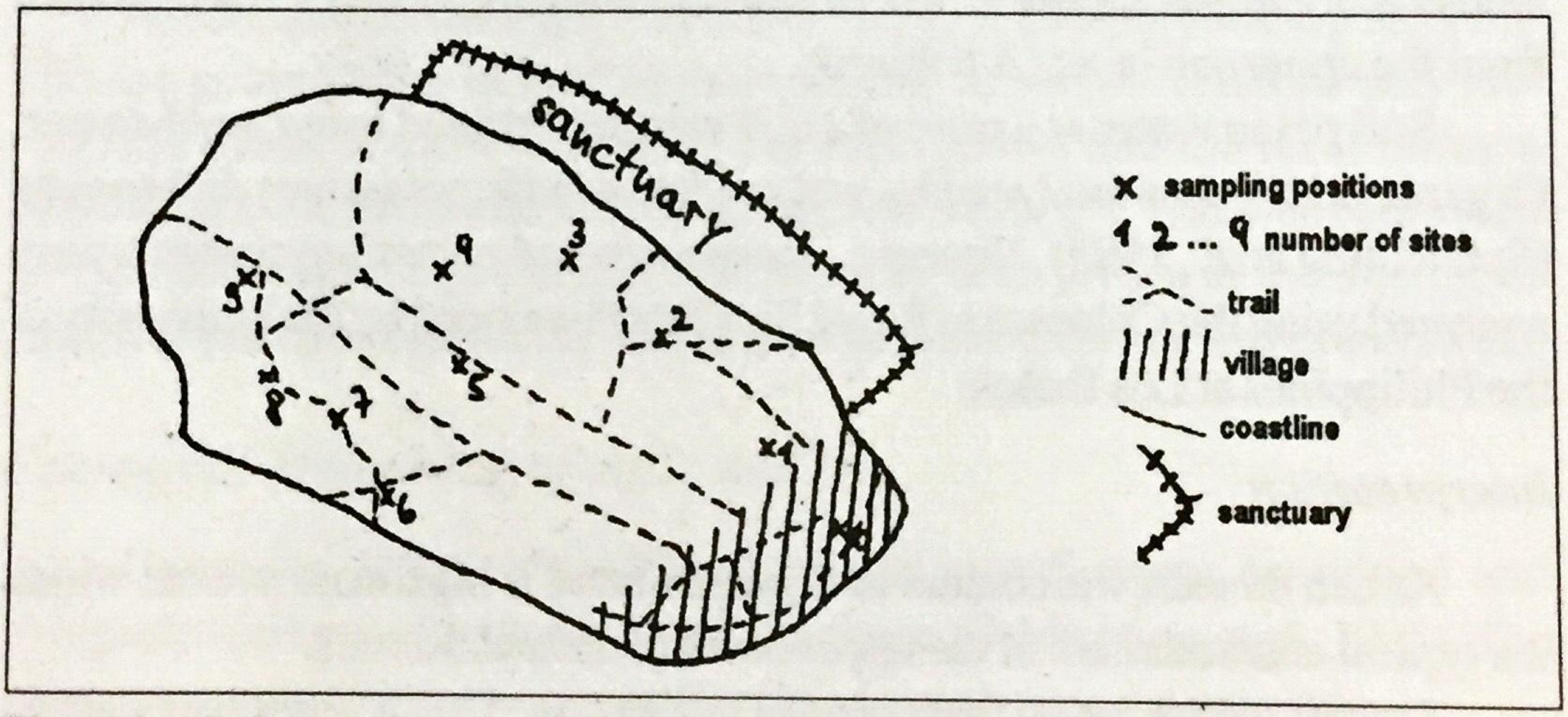

Figure 2. Soil sampling sites in the study area

minerals and, in lesser amounts, dolomite, quartz and other minerals (Maresch & Modenbach, 1987).

The soils of the island can be roughly divided into two categories:

a) *The thin young soil of the island interior.* The mostly uplifted coralline limestone of the island is, at most sites, covered with poorly developed soil classified as a endzic Leptosol according to the FAO classification (FAO, 1994). This means the soil was formed from a bedrock rich in carbonate, is relatively shallow and contains a high percentage of organic matter at the upper horizon.

b) *The sandy beach.* There is a fringe of white coarse sand, obviously originating from limestone, covering part of the island's coastline. This material also lies beneath the village near the shoreline showing no signs of pedogenesis. In the village, a distinction between an "A" horizon enriched in organic matter and a "C" horizon consisting only of the above-mentioned coarse calcaric sand can be made. This material is mostly an Arenosol according to the FAO classification system, meaning that it contains less than 8% clay and is mainly composed of sand.

Soil analysis

Table 1 presents the data obtained from potentiometric and colorimetric analysis of the soil samples. All samples, except 10, 11 and 13, were taken from the upper soil layer (A horizon).

Soil pH in water at a ratio of 1:2.5 was determined using a pH-meter. Organic matter was analyzed by wet oxidation with potassium dichromate (Schlichting *et al.*, 1995). Nitorgen, phosphorus and potassium contents were analyzed using the Colometric Rapid Soil Test developed by the University of the Philippines at Los Baños.

Interpretation

As can be seen, the content of organic matter is high in most sites which is a typical characteristic of the upper horizon of rendzic soils.

The pH values range from neutral to alkaline. This is obviously caused

Table 1. The pH, organic matter (OM) and nutrient status of soils from different locations of the island

Site	Land use	pH	OM (%)	N	P	K
1	secondary growth	8.4	9.28	low	low	deficient
2	secondary growth	7.0	6.83	low	low	deficient
3	secondary growth	7.4	5.78	low	low	deficient
4	bushes & coconut	7.8	8.60	low	low	deficient
5	pandanus	7.0	8.93	low	low	deficient
6	secondary growth	7.6	9.20	low	low	deficient
7	cultivated	8.1	4.64	low	low	deficient
8	cultivated	8.0	8.0	low	low	deficient
9	cassava field, surface	7.2	n.a	low	low	deficient
10	cassava field, -32 cm	7.4	n.a	low	low	deficient
11	cassava field, -45 cm	7.4	n.a	low	low	deficient
12	village, 0-15 cm	7.8	n.a	low	low	deficient
13	village, below 15 cm	8.4	n.a.	low	low	deficient

n.a. The organic matter contents of samples 9 to 13 could not be analyzed due to lack of time. The terms "low" and "deficient" mean that if the crops should be grown on these soils, high amounts of fertilizer need to be applied (e.g. 80 to 100 kg N for Cassava).

by the high amount of carbonate in the underlying limestone which enables this soil to buffer high amounts of protons coming from humification and other processes.

All soil samples show low contents of nitrogen, phosphorus and potassium. This is a consequence of the fact that coralline limestone contains only low concentrations of these elements. This also shows that the local farmers cultivating the area may have scarcely applied fertilizers. This was confirmed by the observation that some of the cassava plants grown in the interior of Apid showed clear signs of nutrient deficiencies like chlorotic leaves and stems.

Ecological properties of Apid soils

The main parameters affecting plant growth were examined and interpreted following the method of Schlichting (Schlichting *et al.*, 1995). The soils were divided into two units: Rendzic Leptosols and Arenosols.

The effective depth describes the maximum depth to which roots can intrude without being hindered by physical or chemical constraints. The term "porosity" describes the percentage of the soil volume consisting of pores. The "air capacity" is a sub-unit of the porosity, containing only large pores in which water cannot be held and which are therefore filled with air. As plant roots need to be supplied not only with water, but also with air, a certain percentage of these large pores is needed for plant growth.

Soil pores contain either water or air; so the percentage of pores containing water (water holding capacity) can be expressed as porosity minus air capacity. However, water in very fine pores is strongly bound by adhesion and is, thus, not available to the plants. Therefore, the volume of these pores has to be subtracted from the water holding capacity to get the percentage of the soil volume that can be filled with plant-available water.

The erodibility expresses how vulnerable the soil is to water erosion. Finally, drainage means the capacity of the soil to allow water to pass through to the underground.

The soils of the interior of Apid Island contain a high amount of organic matter. Their texture is characterized by a clay content of about 30 to 40%, while the sandy soil near the shoreline is mainly consisting of sand. The main constraints for plant growth in the interior are the low nutrient contents and the limited rooting depth. This is illustrated in Figure 3, which shows soil depth along 3 transects.

On the shoreline of Apid, plant growth is constrained by the very low nutrient and available water contents. It might also be that the deeper soil layers in this area are being affected by seawater intrusion.

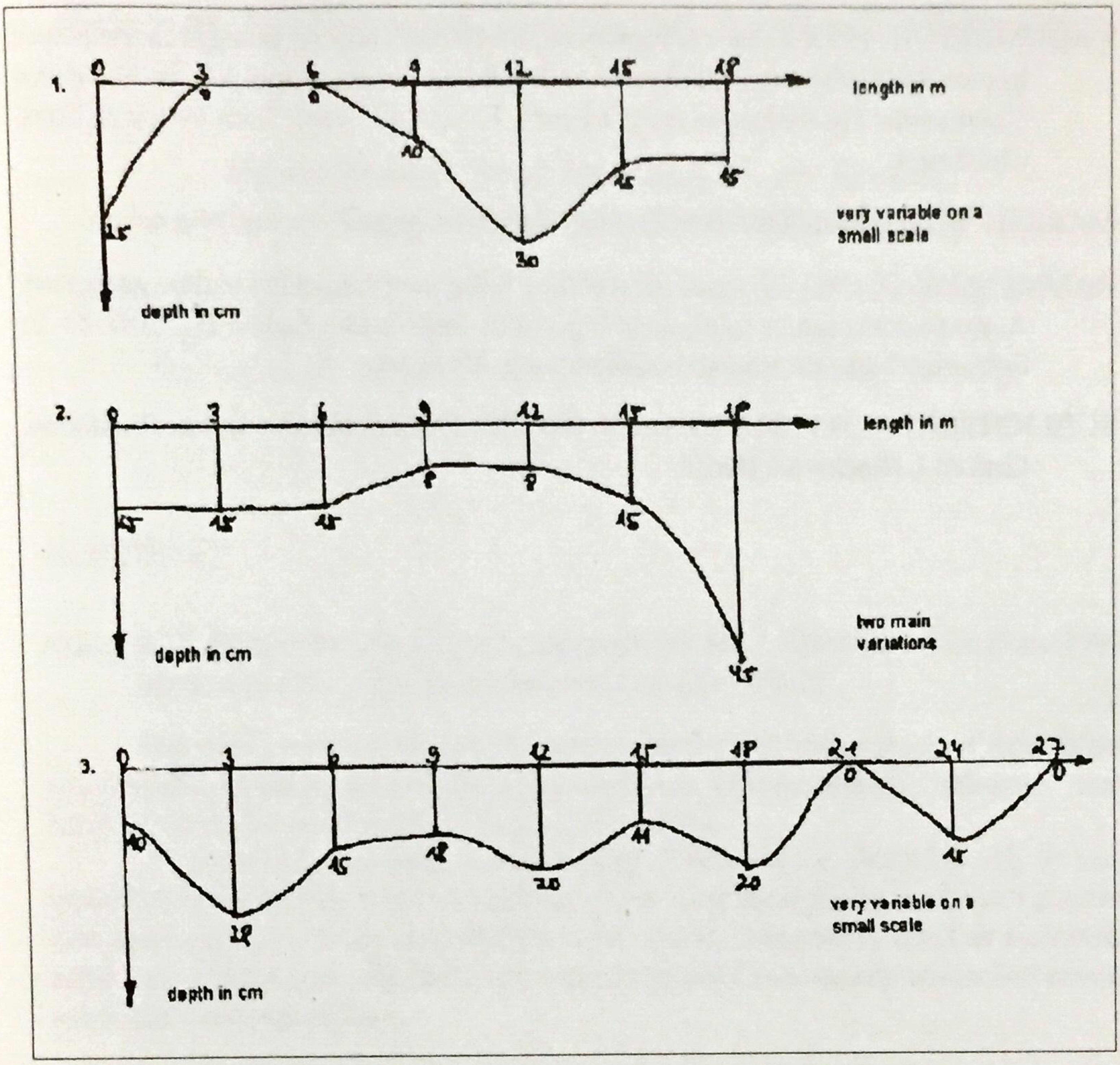

Figure 3. Soil depth along three transects in a cassava field on Apid Island

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