DEVELOPMENT OF CORAL REEFS AND HUMAN SETTLEMENT: ARCHAEOLOGICAL RESEARCH IN THE NORTHERN COOK ISLANDS AND RAROTONGA

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ABSTRACT

People settled the Northern Cook Islands about 1000 years ago, after sea-level stabilised about its present height. Archaeological and geomorphological investigation indicates that every resource zone in the Northern Cooks and on Rarotonga was extensively exploited in the past and human settlement was closely related to late Holocene development of the atolls and fringing reefs.

INTRODUCTION

This paper is intended as an investigation of the relationship between development of the late Holocene reefs and human settlement on the newly-created geomorphological features. Examples from Tongareva, Manihiki, Rakahanga and Pukapuka in the Northern Cooks will be discussed as examples of the atoll type. Rarotonga, the main high island of the Southern Cooks, is presented as an example of a fringing reef. The data are based on the surveys which were conducted as a part of our archaeological research project during 1985 to 1991 (Chikamori and Yoshida 1988).

NORTHERN COOK ATOLLS

Generally, the reef flat of atolls occurs near the low-tide mark, because the vertical growth of coral reefs are usually limited by the mean low water level. In particular, the micro-atoll colonies of *Goniastrea* and *Porites* on a reef flat thrive close to the water-air interface at low water level. When remnants of emerged micro-atolls are found *in situ* beneath excavations, they are indicators of past sea levels. The differences in elevation between the fossilised micro-atolls and their living counterparts in the same locality are measured. Emerged wave notches were also found to indicate such sea-level changes. The results of our measurements are summarised in Figure 1. The post-glacial rise of sea-level occurred at a diminishing rate and reached slightly higher than the present level at around 4000 BP. Pirazzoli and Montaggioni (1986) arrived at the conclusion through field surveys in the Tuamotus, that mean sea-level during the late Holocene reached a maximum approximately 0.9 m above the present and remained so until ca. 1200 BP. They believe this trend may represent a regional eustatic pattern, because the area investigated seems to have been tectonically stable during the late Holocene period.

Our results basically coincide with the Pirazzoli and Montaggioni model. After 2000 BP the sea-level fell exposing the high stand parts of the reefs on which unconsolidated coral sand and rubble had started accumulating.

Figure 2 shows excavated beach-rock and lithified sand in the bottom of a trench in the Tautua Site, located on the lagoon side of Tongareva atoll. It dips 10 degrees seaward and its top surface is 0.6 to 0.8 m above the present high tide level. It has been dated to 1840 to 1360 BP. Therefore, the height difference with modern beach-rock that can be found elsewhere on the island within the present tidal limits may represent the height of the sea during that period. Soon after this the transgression ended and sea level stabilised at the present level. Traces of human settlement appeared around 1000 BP. This event could have coincided closely with the building up of the atoll islands. When enough sediments had accumulated, and the island was able to maintain its height and size, the water-table under the ground was formed. The island had by this time developed an ecosystem able to support terrestrial life forms.

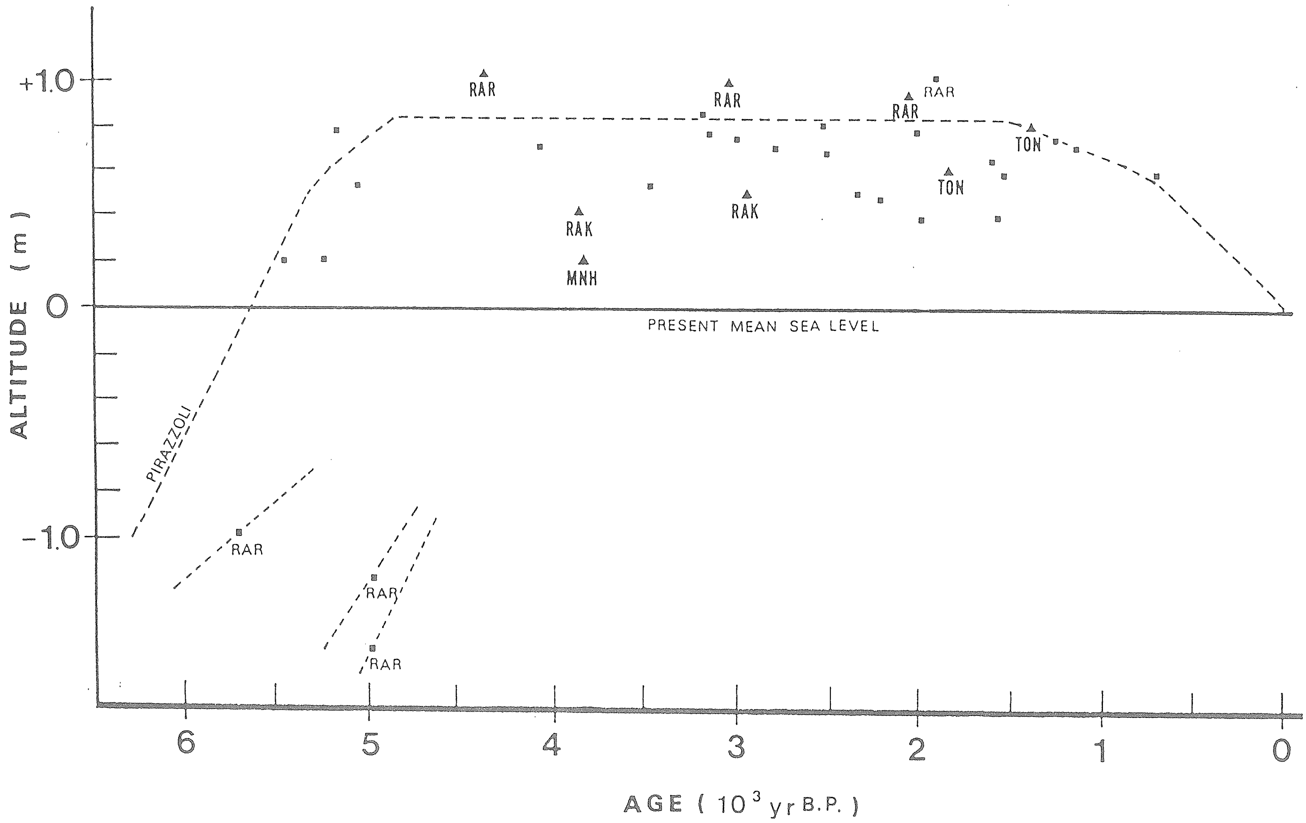

Figure 1: Reconstructed sea level chart for Manihiki, Rakahanga, Tongareva and Rarotonga in the Cook Islands. Dotted lines and squares indicate Tuomotu reconstructions by Pirazzoli and Montaggioni (1986). MNH = Manihiki, RAK = Rakahanga, TON = Tongareva, and RAR = Rarotonga.

These three atolls have shown evidence of very similar dates for coral island development. However, the possibility remains of a very early initial settlement on Pukapuka at nearly 2300 BP. In Pukapuka, beneath the conglomerate bench, old reef rock of probable Pleistocene age commonly stands 1m above the present high tide level. It is possible then that the age of emergence of this island was earlier than the other atolls, although more detailed scrutiny is needed.

Figure 3 shows the locations of excavated areas on Motu Hakamaru islet of Manihiki atoll. Transects were selected to cross the island from the ocean side to lagoon side with good representation of geomorphological sequences and chronology of the island formation. The island was formed primarily by the deposition of a shingle ridge as a rampart placed by high energy waves upon the reef flat. Site D shows the sediment of coral boulders and gravel which built up at about 4m above sea level. The decreased energy of the waves on the lagoon side deposited relatively fine-grained sand. Site C shows that a process of coral boulder deposition inside of the rampart has continued intermittently, perhaps with periodic addition during large storms.

The most conspicuous human alteration of island geomorphology is the digging of pits for cultivation of *Cyrtosperma* (an aroid) along the depression in the central portion of the islet. This can be seen at Site B. The bottoms of these pits reached the level of the fresh water lens. The soil contains large quantities of grey-brown organic matter and sand, pH is 6.4 to 6.5. A rather compact layer of silt or clay texture with a higher pH of 8.2 overlies the coral substratum. Site A was the habitation area where initial human settlement took place. It is likely that when the first people arrived on the islet around 620 BP, the terrestrial ecosystems were still fairly simple and immature. Important evidence that the island

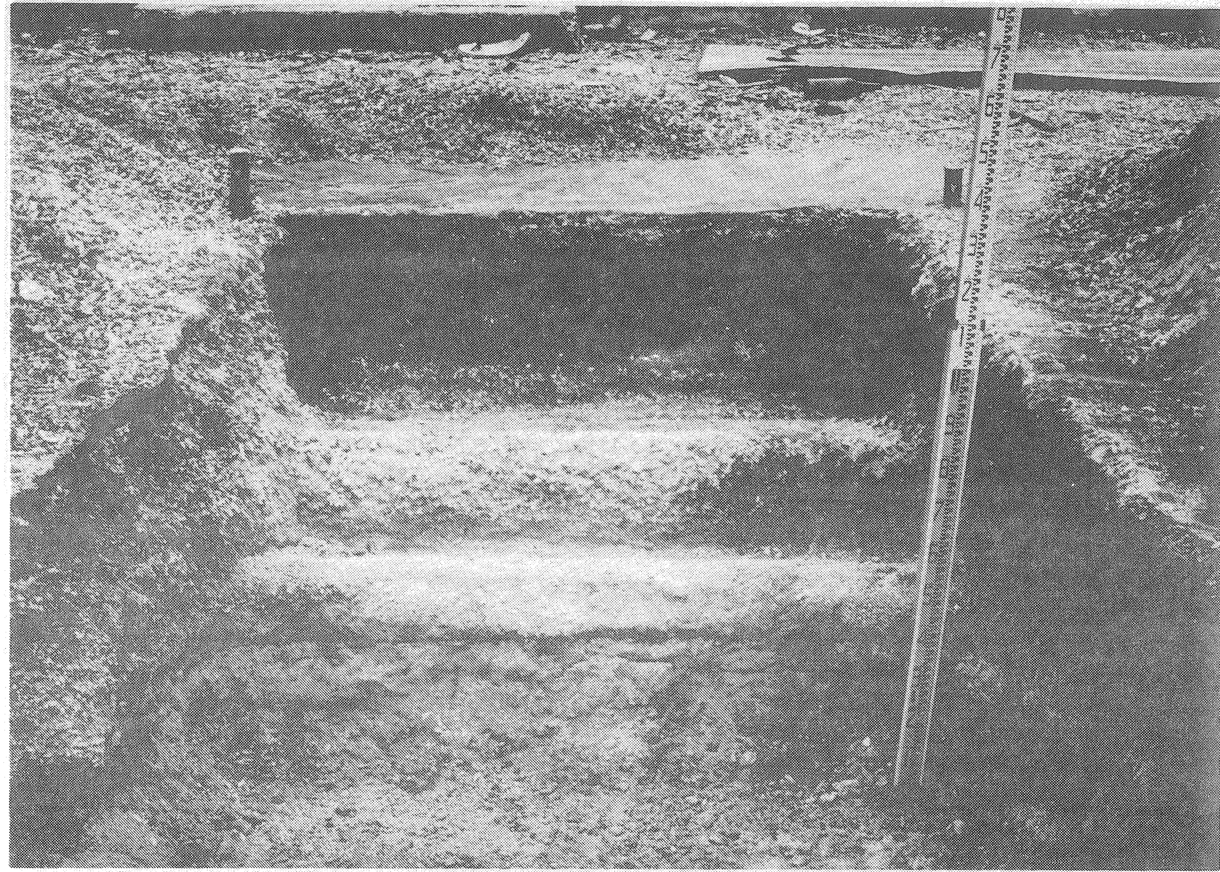

Figure 2: Excavated beach rocks in the Tautua site, Tongareva.

was already colonised by coconut trees during this stage was found. Human activities are apparent in the stratigraphy of the site, as indicated by the vertical stripes in Figure 3. These layers indicate cultural activities and contain a maximum of 15% organic material with the incorporation of humus. The black colour mainly resulted from the mixture of charcoal from cooking fires. pH readings of their soils are lower, around 7.2 to 6.4.

Since the establishment of initial human settlement, sediment has continued to accumulate with successive layers, indicating an increase in organic material accompanying the cultural remains from site A. These include coconut graters, scrapers, fish hooks and a digging spade made of pearl shell. It can be estimated that the sedimentation of organic soils proceeded at a rate of 21 to 23 cm per century in the layers of site A. These deep organic deposits sharply contrast with the sedimentation rates of areas lacking archaeological deposits where such layers are shallow and weakly developed. A sedimentation rate of only 2.5 cm per century is indicated from uninhabited areas.

RAROTONGA

Rarotonga is a typical Oceanic high island with deeply dissected volcanic mountains which rise to over 600 m sur rounded by a coastal alluvial plain and a fringing reef. A beach-ridge encircles the shoreline of almost all of the island between the alluvium and the reef. This beach-ridge consists of sand and rubble deposited up to 3 to 7 m above the present sea level.

Our excavations at sites Ngt 1 and 2, located on the beach-ridge in the Ngatangi'ia area, revealed that an old reef flat underlies the deposited sand. The fossilised micro-atolls which we found beneath the site were situated at an average of 0.9 m above the present low sea-level. They date between 4000 and 3000 BP. An ancient beach, deposited between 4000 and 3000 BP, extends further inland below the flood plain. On Figure 4, Mu, the de-

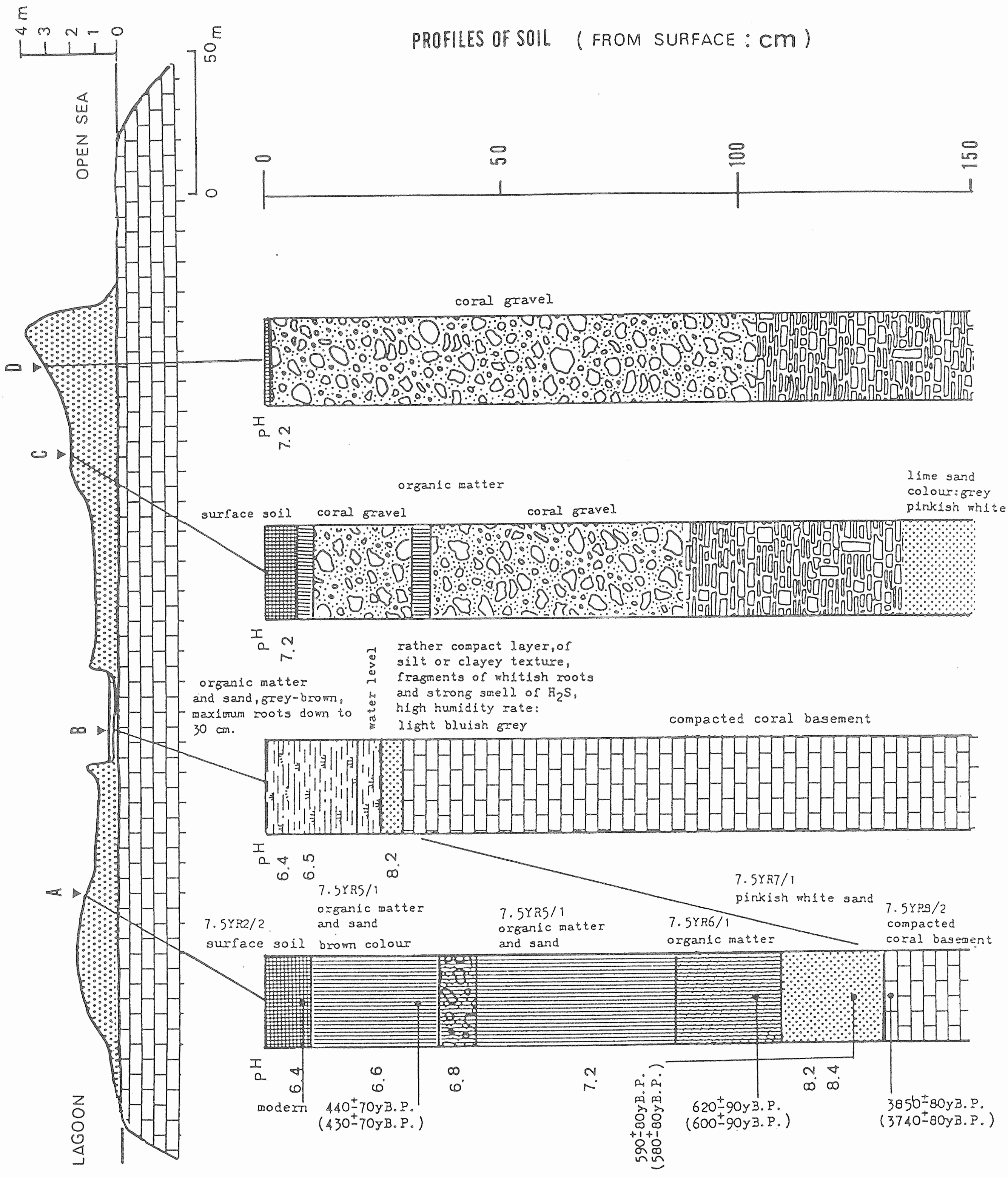

Figure 3: Profiles of soil sedimentation on Motu Hakamaru, an islet of Manihiki Atoll

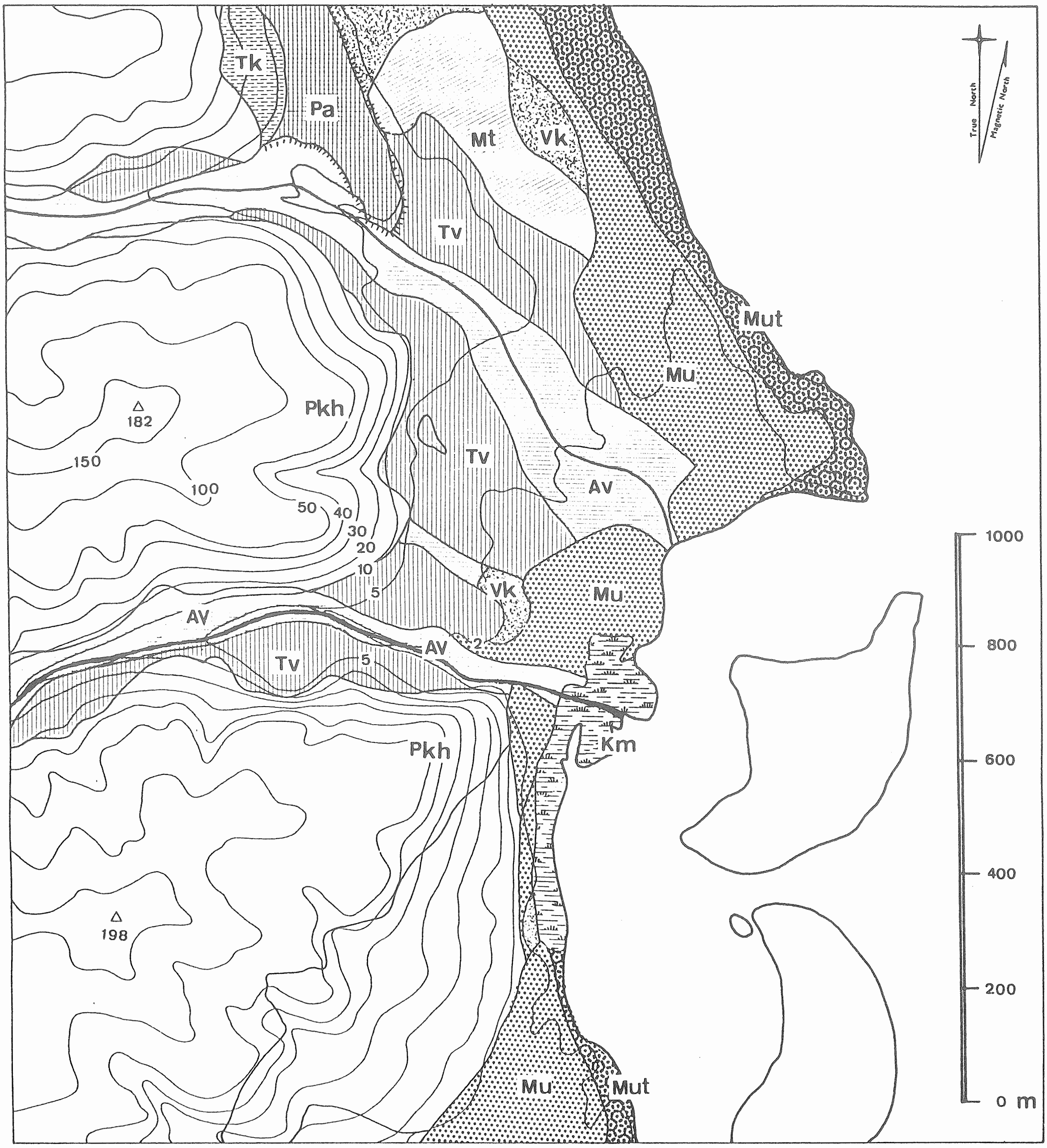

Figure 4. Geomorphological classification of the alluvial plain along the Avana River and adjacent coast, Ngatangi'ia District, southeastern Rarotonga. Key: Km = estuarine margins (Koromori soils); Mu = beach ridges (Muri soils); Mut = beach ridges (Muri stony soils); Vk = flood plains (Vaikai soils); Av = younger flood plains 1 (Avana soils); Tv = younger flood plains 2 (Takuvaine soils); Mt = old flood plains (Matavera soils); Pa = younger terraces (Pouara soils); Tk = fans (Tikioki soils); Pkh = hilly land (Pokoinu hill soils). After Soil Map 1980

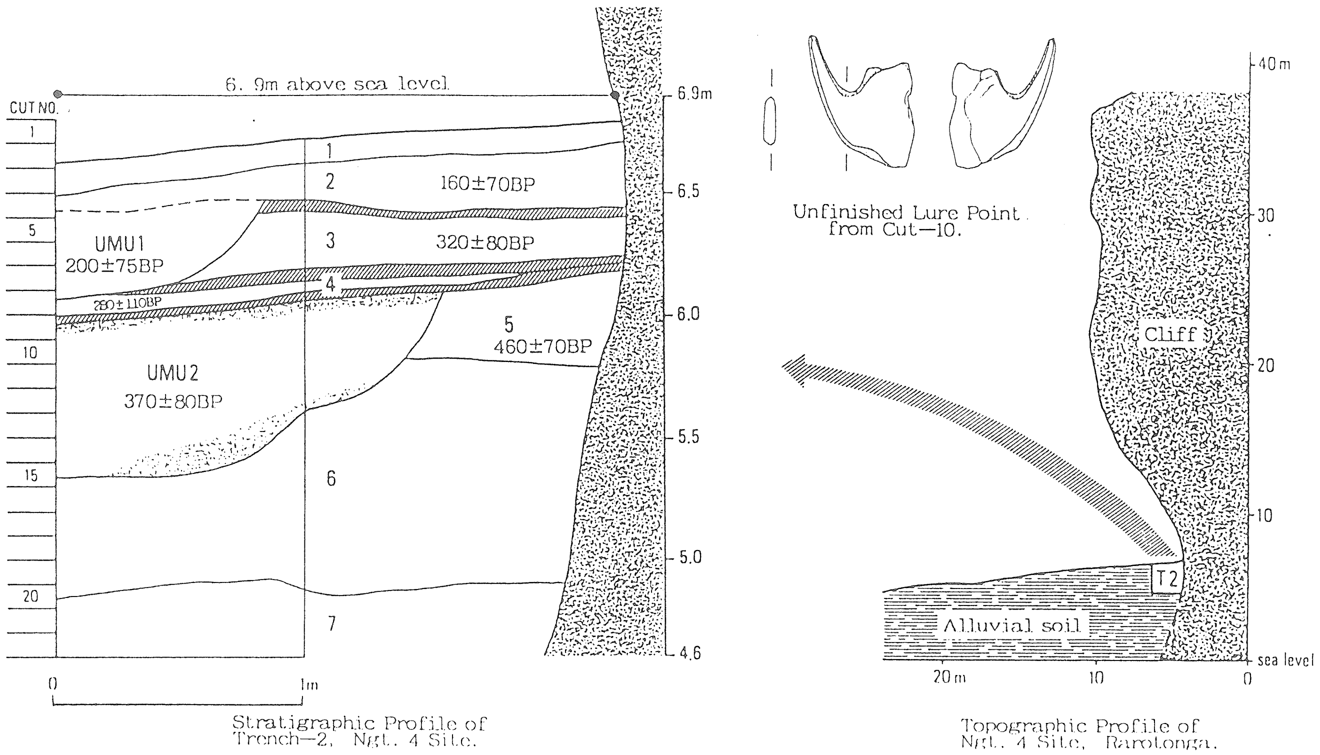

Figure 5: Stratigraphic profile of Trench 2, Site Ngt 4, Rarotonga Island

positional feature of the beach-ridge is estimated to be less than 2500 years old. This is in complete agreement with the date of 2030 BP it given to it by J. C. Schofield (1970). The beach-ridge has continued to grow through time to the present with the constant addition of cobble and sand by wave action, especially on the ocean side.

The newly formed beach-ridge provided enough protection from wave action for deposition of the large quantities of alluvial sediments which formed the flood plain. Three surfaces of alluvium, Mt. Tv and Av. that developed successively are defined on the coastal plain. Surface Mt occurs on broad low-gradient fans where small streams debouch from the interior of the island on to the coastal plain. Topography is nearly flat and the soils are mostly stable. The maturity of the flood plain soils can be regarded as the best for cultivation, at present, on Rarotonga. The surface Tv occurs further from the streams compared to surface Av. Topography is flat to gently sloping with an uneven micro-relief. The surface Av occurs on levees adjacent to contemporary streams that cross the modem flood plains. The soils are formed on fresh, weakly argillised and coarse textured basaltic alluvium. The topography is even and slopes gently toward the coast. There are no archaeological sites on this surface which is recent and unstable (Figure 4).

Between the beach-ridge (Mu) and the alluvia is a narrow depressed belt of swamp or back marsh (Vk), which represents one of the most important resource zones for the local economy since it is now commonly used for the cultivation of taro. On the basis of the results of our analysis of the diatoms, it is reasonable to conclude that these back-marshes changed into a freshwater environment after 1080 BP. The brackish species of diatom, *Rhopalodia,* still comprises 70% in the layer dated 1080 BP. It suggests that since the time of the transgression the water environment has been changed from salt to fresh by the infiltration of ground water from the alluvial plain.

An archaeological research program is in progress in Avana Tapere along the Avana river on the eastern side of Rarotonga. Our objective is to examine geomorphological processes and resource exploitation. Sites Ngt 1 and 2 are habitation sites located on the beach-ridge surface of unit Mu, 220 m inland from the coastline.

From the layer of kitchen midden in Ngt 1, dated 430 BP, basaltic stone tools were excavated. Site Ngt 3 is a *marae* or shrine. Oral history indicates that this *marae* was constructed by Kainuku *ariki* (chief) of Avana Tapere. Our excavation revealed that this *marae* was built by piling round cobbles on the Tv alluvium surface. A manufacturing site for stone tools, dated to 370 BP, was discovered at the base of the *marae*.

Sites Ngt 4 and 5 are rock shelters located on the right bank of Avana river, 650 m upstream from the shore line and 7 m above sea level. Cultural stratigraphy extends to a depth of 2.5 m below surface. Six *umu* or earth oven pits were excavated at Ngt 4 and a lure fishhook made of pearl shell was discovered in a layer dated to 560 BP, accompanied by midden consisting of fish bones, shells and chestnut (*Inocarpus*) shells. A series of cultural layers at the site provides a chronological framework for better understanding Rarotongan cultural history (Figure 5).

The existence of an irrigation system for taro, which is now abandoned, is known from the middle part of the Avana valley. The artificial transport of water by means of the channels fed a series of pond fields. We took a sample for pollen analysis at Site RAR 57 where Bellwood (1978) had previously mapped. The results show that bracken fern or staghorn fern spores and gramineae compromise 46% of the pollen in the bottom layer of the pond field. This serves as an indicator of the sequence of vegetation clearance and associated soil loss that occurred prior to the construction of the irrigation system. The soil movement may have induced, at the same time, an increase in alluvial land area through erosion and deposition in the valley bottom.

The most characteristic geomorphological surface (Km) appeared last at the mouth of the Avana river. This surface was developed on the estuarine muds and sands derived from alluvium and comminuted coral reworked by wave action and deposited at the height of the mean sea level. The area is small (4 ha) and is restricted to the landward margin of Ngatangi'ia. The soils are subject to diurnal tidal fluctuations and support a natural vegetation of halophytic plants and offer a habitat for some species of estuarine molluscs. The most conspicuous species to expand its habitat is *Volsella agripeta*, a species of Mytilidae which has been exploited for a food. Large quantities of *Volsella* shells were excavated at the rock-shelter Ngt 4 in cultural layers dated to 560 BP

Based on the results of our archaeological research, we can conclude that every resource zone in Avana Tapere, ranging from the outer slopes of hills to the fringing reef, was intensively and continuously exploited after approximately 1000 BP.

SUMMARY

The research results are summarised in the following eight points:

1) The post-glacial rise of sea level occurred at a diminishing rate and reached slightly higher than the present level around 4000 BP in the Northern Cook atolls. The maximum elevation was 0.4 to 0.5m higher than present levels at 3580 BP and 2930 BP in Manihiki and Rakahanga.
2) The beach rock excavated in a trench on Tongareva provide evidence that a high sea-level occurred again at around 1800 BP.
3) Human settlement appeared around 1090 BP in the Northern Cooks soon after transgression ended and sea-level stabilised. It coincided closely with the building up of the atoll islands.
4) The sea-level of the late Holocene on Rarotonga Island reached at 0.9m higher than the present mean sea-level between 4300 to 3000 BP. The depositional features of the beach ridge are estimated to date later than 2500 BP.
5) The newly formed beach ridge provided enough protection from wave erosion for large quantities of alluvial sediments to be laid on the coastal plain of Rarotonga.
6) Analysis of diatoms shows that the swamp or backmarsh between the beach ridge and the alluvium changed into a freshwater environment after 1080 BP.
7) We conclude that every resource zone of Avana Tapere, traditionally one of the oldest places of human occupation in Rarotonga, has been exploited extensively since at least 1000 BP.
8) Successful human settlement in the Cook Islands was closely related to the development of both the atolls and fringing reefs in the late Holocene period.

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