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FIRST SEDIMENTOLOGICAL AND PALEOECOLOGICAL RESULTS FROM A DRILL-HOLE THROUGH A FRINGING CORAL REEF, S.E. OF NEW CALEDONIA : EVIDENCE OF THE HOLOCENE-PLEISTOCENE DISCONTINUITY

PREMIERS RESULTATS SEDIMENTOLOGIQUES ET PALEOECOLOGIQUES D'UN FORAGE SUR LA COTE S.E. DE LA NOUVELLE-CALEDONIE : MISE EN EVIDENCE DE LA LIMITE HOLOCENE-PLEISTOCENE

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ABSTRACT

A drill through the fringing reef of Ounia (Mamié-Yaté région) at 50 m behind the reef front reached a depth of 10.5 m. It clearly shows a major discontinuity between 6.5 to 7.5 m deep characterized by lithological, textural and mineralogical changes.

The upper reef formation of Holocene age is represented by a 7 m thick layer. Qualitative inventory of macro- and microbiotic species and assemblages make it possible to establish the sequence of communities through time. A vermetid unit and encrusting coralline algal/vermetid occurrences were recorded at depths of 6.5; 4.7; 4.5; 3.3; 0 m. The material is totally aragonite or high magnesian calcite.

The lower reefal formation, from 7 m down to 10.5 m deep, is probably of Pleistocene age. It is characterized by distinctive changes in facies (petrotypes, biological assemblages), mineralogy (extensively calcified rocks) and texture (dissolution-recrystallisation features) . All this strongly supports subaerial exposure during a late Pleistocene low sea sand. The Halimeda-rich facies which is of common occurrence, probably indicates an environment of moderate energy, by comparison with the younger formation.

Qualitative and quantitative microfacial, textural and mineralogical analyses allowed the Holocene-Pleistocene discontinuity to be defined. This study put in evidence the occurrence of some typical assemblages and minor discontinuities in Pleistocene times.

RESUME

Un forage réalisé sur le récif frangeant de Ounia (région de Mamié-Yaté) à 50 m environ en arrière du front récifal, a atteint la profondeur de 10,50 m. Entre -6,50 et -7,50 m il présente une nette discontinuité, marquée par des changements lithologiques, texturaux et minéralogiques.

Dans l'ensemble supérieur Holocène, un inventaire qualitatif des espèces et des associations a permis d'établir la succession des peuplements. Une formation à Vermetidae ainsi que des niveaux à Rhodophyceae-Vermetidae ont été reconnus aux côtes: 6,50 m; 4,70 m; 4.50 m; 3,30 m; 0 m. La nature minéralogique de cette formation récifale est aragonitique ou calcitique magnésienne.

L'ensemble inférieur au-dessous de la discontinuité, a été attribué au Pléistocène. Il est marqué par de nets changements faciologiques (nature des pétrotypes, des associations biologiques et des produits diagénétiques). La nature calcitique stricte et les phénomènes de dissolution-recristallisation observés suggèrent une évolution en milieu sub-aérien. Les microfaciès à Halimeda sp. qui caractérisent cet ensemble dénotent probablement un milieu d'énergie modérée contrairement au précédent d'énergie élevée.

Des analyses qualitatives et quantitatives des microfaciès, des analyses minéralogiques et texturales précisent la position de la discontinuité Holocène-Pléistocène, elles mettent également en évidence des associations spécifiques et des discontinuités mineures du Pléistocène.

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INTRODUCTION

The coral reef complexes around the island of New Caledonia (cratonic to oceanic in origin) are spread over a large insular shelf.That extends along an N.W.-S.E. axis (Chevalier,1973 ; C dray, 1982).It is almost continously bordered at the shelf edge (100-150 m deep) by a barrier reef line cut by passes (submarine valley openings) and large passages (tectonic features) (Thomassin and Vasseur 1981).New caledonian coral reef systems offer analogies with those from the Great Barrier Reef on the other side of the Coral Sea (Hopley,1982)

The history of the Quaternary barrier reef growth and inferred interpretations of the morphological features of the backreef areas are only known respectively from the study of the "Grand Ténia" borehole and near-shore observations (synthesized in Coudray,1976,1977).Comprehensive explanations of the lagoonal coral build-ups and of sedimentological and diagenetic features from the southwestern lagoonal areas have been recently revealed by sedimentological maps (Dugas and Debenay, 1978,1980,1981,1982),by analysis of seismic profiles (Dugas and al.,1980) and by observations of hardgrounds (Thomassin and Coudray,1982).

A borehole program was recently conducted by the ORSTOM center (geol.sect.) in order to collect data on the internal stucture of the Pleistocene-Holocene fringing reefs off both coasts.Cores were obtained from the Mamié reef,Yaté region,S.E. coast where an uplifted Pleistocene coral reef is observed (this paper) and from Nouméa.

LOCATION OF THE MAMIE BOREHOLE NC.14.OU. (fig.1)

The island coral reef formations in the Mamié region are limited to a submerged barrier reef line and fringing reef systems,that include an open lagoon,6 km in width.

The Mamié-Ounia region is the northern limit of the uplifted fringing reef terrace that extends southward along the coast for 30 km.Whereas the top of this Pleistocene formation reaches on altitude of 15 m in the Yaté-Tara region,at Mamié it is about at present-day mean low tide level.

The fringing reef flat transect (fig.2) (about 1 km wide) occurs in front of the littoral plain and sandy terraces : (i) an inner dead microatoll reef flat,covered landwards by scattered seagrass beds and mangroves ; (ii) seawards ,from a median narrow Chama ridge,a dead reef flat (with only an algal turf cover and small sand pockets) extended towards the high energy surf zone.A narrowly built outer reef slope,of butress and valley system,extends downwards to 22 m depth.Several terraces at 17-15 m depth,12-10 m and 6-5 m are observed along the buttress profile.Moreover,on the bottom profile of an outer re-entrante cutting the outer reef flat several well marked steps were recogized at 11-10 m, 8 m,6.5-6 m (with caves) and 3 m deep (Thomassin,pers.obser.).

The borehole was drilled through this outer flat (fig.2),50 m back of the reef front and laterally close to this outer re-entrante.

MATERIAL AND METHODS

The drill-hole was made using a SLN adapted engine during spring low tides by R. Lienhard and M. Bernat in 1982.The core barrel was 10.5 m in length and 4.5 cm in diameter,and core recovery ranged from 32 to 81 %.Observations from hand-specimens and thin-sections were made and X-ray analysis were performed.Point-counting method

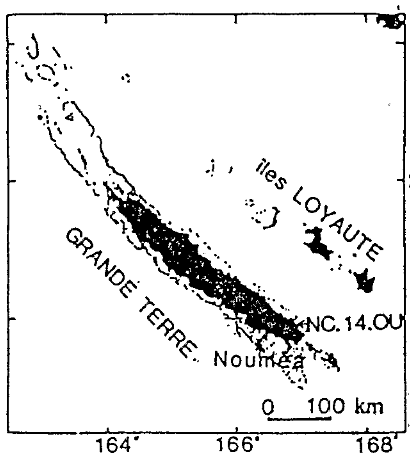

Fig.1-Location of the borehole NC.14.OU.

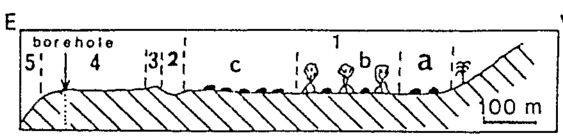

Fig. 2 - Transect of the fringing reef flat.
1. inner dead microatoll reef flat
(a- with Avicennia ; b- with Rhizophora; c- sensu stricto) ; 2. Turbinaria hollow with Acropora ; 3. Chama ridge ; 4. dead reef flat ; 5. outer reef slope.

(400 points) with statistical tests was used in the microscopic-slab study to quantify carbonate components (calcareous red and green algae,corals, spicules,encrusting forms,mollusks and echinids), diagenetic features (primary and secondary cements ,matrices,internal sediments),and porosity (Montaggioni,1978 ; Flügel,1982).

RESULTS

Two major lithologic formtions are recognized from facial and mineralogical analysis.

A-The upper unit (0-7 m deep) includes in situ and various detached organisms,slightly to intensely cemented grainstones to mudstones and fragments.

Corals are mainly branched acroporids and massive poritids and favids.Massive colonies are observed in upper levels (Platygyra sp. between 0-1.5 m ; Favia sp. between 1.5-2.5 m ; Porites sp. between 3.5-4.5 m).Coral assemblages are characteristic of high energy zones (reef front,upper slope and outer flat.).Cyphastrea sp. and Galaxea sp. debris at 1.5,3.2 and 6.5 m come probably from inner flat biotopes.

Other organisms in decreasing order of abundance are : encrusting red algae (melobesians),encrusting foraminifera (Homotrema rubrum),mollusks

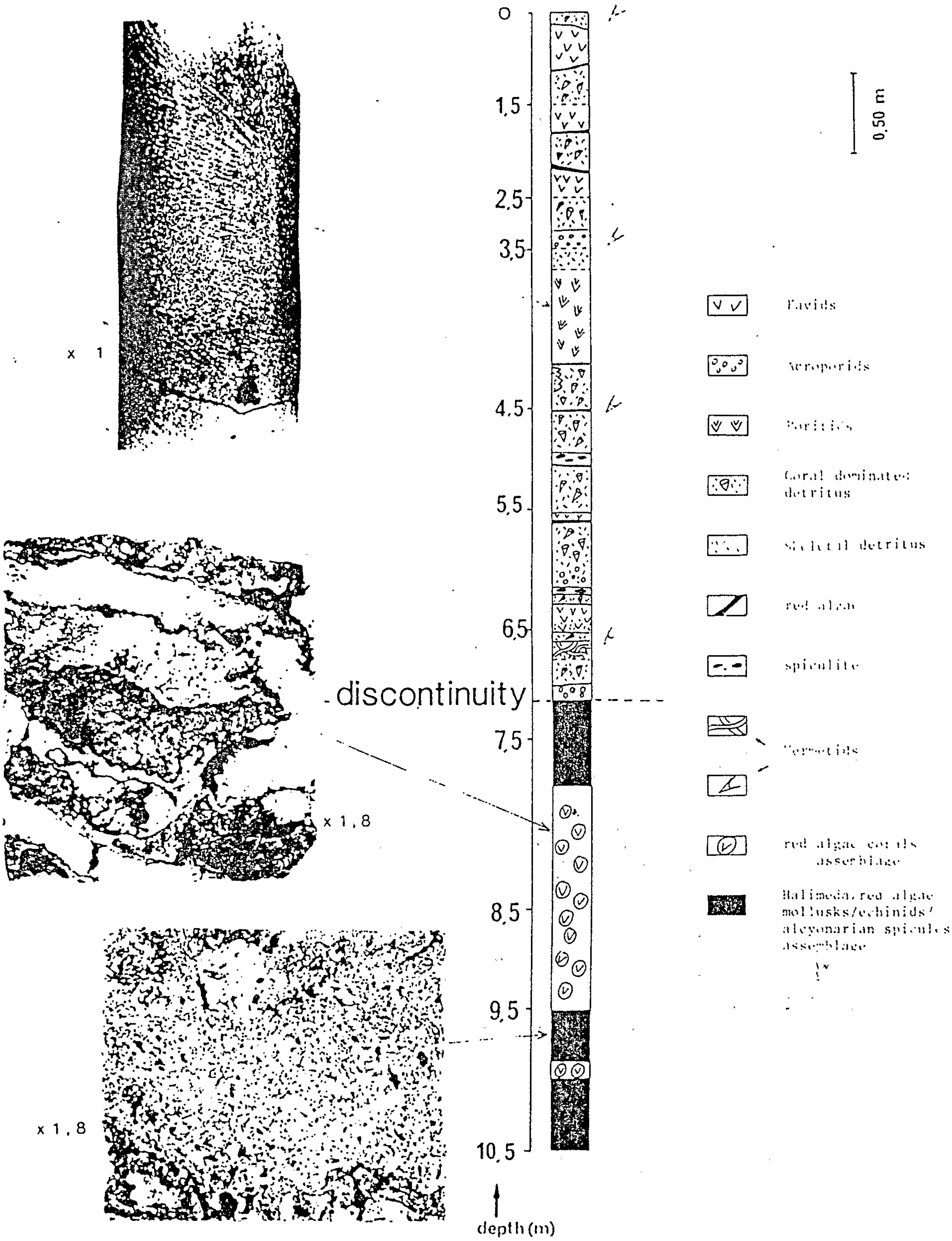

Fig.3-Log of the borehole NC.14.OU. on Mamié reef. (SE New Caledonia)

(vermetids,Acar,Pyrene,turbinids and trochids),spicules (alcyonarian),echinid spines (Heterocentrotus mammillatus,Echinometra mathaei),serpulid tubes and xanthid crab fragments.They belong to upper infralittoral hard-bottom biota (epi- and cryptic fauna) and live generally in wave beaten zones (Taylor, 1968 ; Morton and Challis,1969 ; Peyrot-Clausade, 1977 ; Thomassin,1978 ; Vasseur,1981).Several "small vermetids/laminated melobesians" levels occur at various depths (0,3.3,4.5 and 6.5 m deep) ; according to their places in the indopacific coral reef zonations they could indicate levels of the upper infralittoral stage limit (=mideulittoral zone) at various reef building steps (Picard,1967 ; Morton, 1973 ; Pichon,1978).

Microfauna of the detritus-infilled microcavities is composed of foraminifera and ostracods mixed with bioclasts.The benthic foraminifera are dominant and belong mainly to miliolids,glabratellids,elphiids,eponidids and amphisteginids.This assemblage is also characteristic of the outer reef front (upper and middle outer slope,outer reef flats) with some inputs from the inner reef flats (Monier,1973 ; Le Calvez and Salvat,1980 ; Montaggioni,1981). Influence of the open sea is corroborated by the presence of rare planktonic forms (Globigerina sp.) and deep (?) benthic forms (buliminids,bolivinitids, glandulinids).This is also confirmed by the occurence of the deep ostracod Cytheropteron sp.

Microfaciologically,it is clear that encrusting organisms and micrites bind and cement the primary (corals,red algae) and secondary (mollusks,echinids, foraminiferids) frame builders,inducing a high residual porosity.Boundstone textures are dominant formed mainly by corals/red algae and small vermetids/ laminated melobesians.However in the uppermost level a Carpenteria monticularis boundstone is present and indicates an outer reef flat cryptic biotope.

Infratidal aragonite cement (fibrous or spherolitic) is observed everywhere, and corals show recrystallization of aragonite I to aragonite II (with dust-line).Grey-brown micrite has generally a pelleted texture.However at the core-top it is darker and mixed with oxidized grains,showing land influence.

The material of this unit consists of aragonite and high magnesian calcite in various ratios according to the nature of the frame-builders and of the marine cements.

B-The lower unit (7-10.5 m deep) is easily distinguished from the upper one by the following characteristics : a change in colour (orange-brown),materials are more concolidated and have a better hardness and a lower porosity,the lack of easily recognized organisms (corals are recrystallized and internal casts are observed) and sequences of numerous cement-filled cavity.Boundstones or packstone-wackestones are dominant.Microfacies are different from those of the upper unit and are characterized by their component distribution and main diagenetic features.They are : (i) the abundance of Halimeda segments and alcyonarian spicules and associated with red algae,mollusks,and echinid tests.The distribution of these bioclasts indicates a moderate energy in comparison to the present one.(ii) The dissolution-recrystallization (in low-magnesian calcite) phenomena of the coral and green algae aragonite tests into sparry cement.That has resulted from processes associated with meteoric water action (Coudray,1976 ; Purser,1980).(iii) The presence of various sparry cements (drusy mosaic,dog-tooth,syntaxial,zonate fibrous types).They substantiate an origin in a meteoric environment.But zonate fibrous sparite could be similar to those described by Froget (1974) or Kendall and Broughton (1978) and could be related to alternative influence,during seasonal or tidal periods (for the first author) or an interruption of the superficial or internal fresh-water flow effect,due to a variation of the thickness of this water layer (for the last ones). (iv) The occurence of oxidizing features such as films deposited between sparry crystals.(v) The presence of two generations of micrite.the first is a calcitic matrice affected by diagenesis.The second is formed after the sub-surface sparitization.It is presumably of marine origin (relative abundance of associated didemnid spicules that could suggest to sheltered environments (Thomassin and Coudray,1982) and unaltered presence of high magnesian calcite content.).

Two microfacies-types are recognized : a dominant "red algae/green algae" facies (with mollusks, echinids and alcyonarian spicules) and abundant micrite (at 7-8 m,9.5 m,10-10.5 m) and a dominant "coral/red algae" facies(at 8-8.5 m,9 m and 10 m) (see fig.3) ; they alternate through the lower unit.A vermetid/red algae level is also recognized about 9.5 m ; it may indicate a higher infralittoral stand of sealevel.

Low-magnesian calcite is generally predominant due to fresh-water diagenesis.

DISCUSSION-CONCLUSION

From biological and diagenetic criteria,two main lithologic units are distinguished separated by a major discontinuity between 6.5-7.5 m deep below the reef flat surface.Typical submarine aragonite and magnesian calcite cementation,along with a lack of diagenetic features affecting the skeletal grains,characterize the upper unit.By contrast,the lower unit is affected by fresh-water diagenetic processes (calcite sparry cements,dissolution and recrystallization of organic matrices) All these features resulting from a long subaerial exposure,indicating that the lower unit is of Pleistocene age.As a result the solution unconformity appears to be the Holocene-Pleistocene discontinuity about 7 m deep below the upper infralittoral limit on this fringing reef.This is supported by morphological features (terraces,cave-line) observed along the outer reef slope.

By comparison with the new caledonian S.W. coral reef complexes,the Holocene-Pleistocene discontinuity occurs : (i) at 8 m below the spring low tides on the barrier reef from "Grand Ténia" borehole in front of St-Vincent Bay (Coudray,1976; 1977) ; (ii) probably about 8 m below the spring low tides on windward slopes of some lagoonal reefs of Nouméa region (base of the branched Acropora zones) (Thomassin and Coudray,1982 ; Thomassin, unpublish. obs.).This seems to indicate similar Holocene transgressive levels at both island coasts.

In the Great Barrier Reef (Davies and Hopley, 1983 ; Marshall,1983) drilling investigations have shown that unconformity is recorded at depths ranging from 4 to 22 m,but in the Southern Region, it occurs at the same depth as that observed in New Caledonia.

In Mamié drill-hole,both units differ in their frame-building constituents.The hard-bottom high energy communities (outer reef flat and upper reef slope) consists of massive corals/red algae assemblages.They characterize the upper Holocene unit. By contrast,the Pleistocene unit shows a more diversified assemblage composed in the uppermost and lowermost layers of "Halimeda/red algae/mollusks/echinids and alcyonarian spicules". It attests to a lower energy (sheltered ?) environment during its time of genesis. This type of assemblage is recorded in the "Grand Ténia" drill-hole in the Pleistocene unit but at a depth of 20 m below low water spring tide. However Marshall (1983) observed in most of the bores drilled in the southern Great Barrier Reef that a similar Halimeda-rich reef rock is characteristic of the Pleistocene limestone and often underlies its upper boundary. But at Heron island, this assemblage is encountered deeper at 18-21 m (Richard and Hills, 1942) as in the S.W. New Caledonia barrier reef. A change in the environment of deposition from Pleistocene to Holocene times was also suggested by Thom and al. (1978).

All these data confirm the analogies in the recent coral reef building processes on both sides of the Coral Sea and the Great Barrier Reef systems (Coudray, 1982 ; Thomassin and Coudray, 1982 ; Hopley, 1983 ; Thomassin, 1984).

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