Proceedings of the Seventh International Coral Reef Symposium, Guam, 1992, Vol. 2

Preliminary Data On The Sediments Of The Uvea Lagoon (New Caledonia)

C. CHEVILLON, J. CLAVIER AND C. GARRIGUE

OSTOM, BP A5, Noumea, New Caledonia.

Abstract. Uvea atoll is situated in the Eastern part of New Caledonia. The lagoon has a maximum depth of about 40m, and covers an area of 850 km². In the course of the first general study of the marine resources of Uvea lagoon, scuba divers collected sediment samples from 62 evenly distributed stations. The main sedimentological characteristic of the Uvea lagoon is the paucity of soft substrata (mean thickness = 5.4cm). Sediments always present a light colour, a high carbonate content, and a low mud percentage. The general characteristics of the lagoon speak for homogenous and moderate hydrodynamic conditions, a sediment production of low volume but well balanced between fine and coarse particles, and low sediment displacement. However, the inner barrier reef bottoms and the coastal strip differ from the general conditions.

Introduction

The atoll of Uvea together with the islands of Lifou, Mare and Tiga, form the Loyalty Island Group, a part of the Territory of New Caledonia (Fig. 1). The atoll of Uvea is situated 100 km North-East of the main island of New Caledonia, on the Loyalty Ridge. It is located between latitudes 20°23′S and 20°44′S, and longitudes 166°10′E and 166°40E, is roughly triangular in shape, and covers an area of 850 km². The Eastern part of the lagoon is bounded by the coral island of Uvea, while the other limits consist of a discontinuous barrier reef. This barrier reef is formed by the Northern and Southern Pleiades reefs that are separated by the 5 km wide Anemata Pass at the western end of the lagoon. The depth increases evenly from the shore to 50 m in the western part. Three quarters of the lagoon is less than 30 m deep. Apart from a narrow coastal strip under the lee of the island, the major part of the lagoon is exposed to the South East trades winds.

The present study is a part of the first general study of the atoll of Uvea aimed at assessing the commercial resources of the lagoon. It also fits within a general sedimentological study of New Caledonia's lagoons, including the Northern (Chevillon and Clavier, 1988; Chevillon, 1990a and b), the Eastern (Chevillon, 1989), and the Southern (Chevillon, 1986; Chevillon and Richer de Forges, 1988) lagoons of the main Caledonian island, and of the Chesterfield Plateau (Richer de Forges et al., 1988; Chevillon and Clavier, 1990). The data were collected on board R.V. ALIS during August and September 1991.

Methods

Systematic sampling was carried out over a two-mile grid. Sediment samples were taken during scuba dives, using a hand-operated 10 cm² corer, from 62 stations (Fig. 1). Sediment colour was immediately identified according to Munsell soil color charts. Percentage of hardground cover was estimated visually along a 100 m transect, and sediment thickness was measured using a graduated gauge. Samples were oven-dried in the laboratory at 60 °C for three days. They were then weighed a first time, then the sandy fraction was separated from the fines by manual wet sifting using a 63 μm sieve. The sandy fraction was dried and weighed again. The percentage of mud (grouping silt and clay) was assessed from the difference in weight. The fine fraction was collected in order to determine the carbonate content by calcimetry (Bonneau and Souchier, 1979). The sandy fraction was then

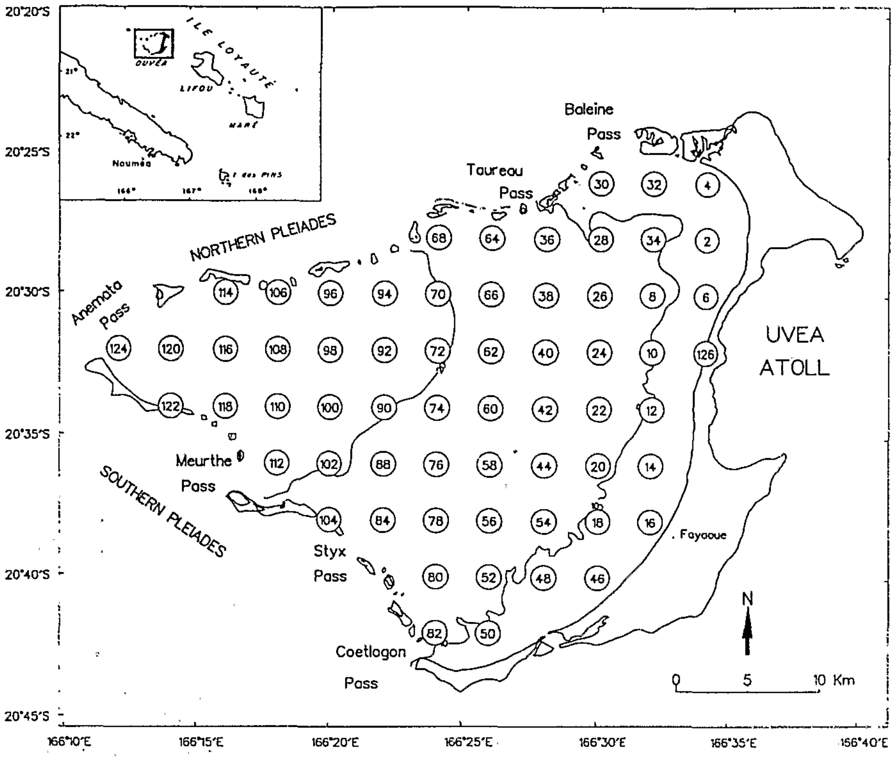


Fig. 1. Study area and samples location.

introduced into a granulometric column, with mesh sizes 0.063, 0.125, 0.25, 0.5, 1, 2, 2.5, 4, 5, 8, 10, 16 and 20 mm. The fractions obtained were weighed and expressed as a percentage of the initial sample (Buchanan, 1984). These values were used to determine textural groups according to Folk textural classification (Folk, 1954), and Wentworth grade scale (Wentworth, 1922). Semi-logarithmic cumulative curves were constructed to calculate grain parameters: mean size, sorting, skewness (Folk and Ward, 1957).

Results and Discussion

Sediment colour

Four distinct colours, always light, were identified: light gray (10 YR 7/2 and 2.5 Y 7/2) on 89% of samples; very pale brown (10 YR 7/3) on 5%; pale yellow (5 Y 7/3) on 4%; and yellowish brown (10 YR 6/4) on 2%. The light colour of the sediments may be related to the well oxygenated environment and to the absence of terrigenous influence, as observed in the Chesterfield lagoon (Chevillon and Clavier, 1990).

Sediment thickness and hardground distribution

The lagoon is characterized by the low thickness of the sedimentary cover (an average of 5.4 cm), excepting near Northern Pleiades barrier reef where it frequently exceeds 20 cm (Fig. 2). The lowest thicknesses (<1 cm) were observed near Southern Pleiades barrier reef. Hardground areas, which mostly take the form of limestone slabs or, more rarely, of coral formations, are widespread. Their distribution is tied to the thickness of the sediment layer. The percentage of hardground over the greater part of the lagoon bottom is under 20%, but reaches 60% along the edge of Southern Pleiades barrier reef. The overall mean percentage of hardground (31%) is higher than that of the South lagoon of New Caledonia (5%) (Chardy et al., 1988) and that of Chesterfield lagoon (20%) (Chevillon and Clavier, 1990).

Mud and carbonate content

According to Maxwell (1968) and Flood et al. (1978), two facies and four subfacies, respectively based on carbonate and mud content, were recognized. High-carbonate and pure carbonate facies

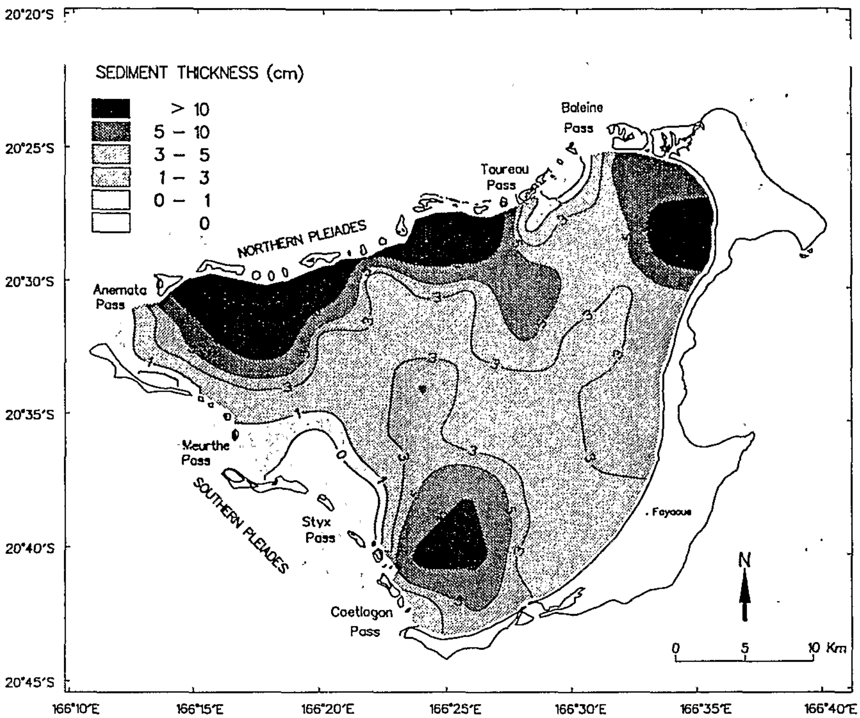


Fig. 2. Sediment thickness distribution map. Thickness equal zero refer to hardground.

represent respectively 33% and 67% of the samples. Extreme values for carbonate content are a minimum of 86%, and a maximum of 96%, with a mean value of 91% (pure carbonate facies). Non-mud subfacies, low-mud, moderate-mud, and high-mud subfacies represent respectively 11.8%, 71.2%, 13.6%, and 3.4% of samples. Mean value for mud content is 5.6% (low-mud), with minimum and maximum respectively 0.1% and 22.1%. Therefore, pure carbonate facies (>90% $CaCO_3$) and low-mud subfacies (1%–10% mud) are the most representative of the Uvea lagoon.

Highest mud content was observed along the shore, the distribution following the −10 m contour (Fig. 3), whereas low values are widespread over most of the lagoon (<5%) and near the passes (<1%). This distribution differs from the structure usually observed on atolls, where the highest mud content percentages are found in the middle of the lagoon (Maxwell et al., 1964; Guilcher et al., 1969), as is found in the northern part of the Chesterfield lagoon (Chevillon and Clavier, 1990), and in the northern lagoon of New Caledonia (Chevillon and Clavier, 1988). Yet the observed structure is similar to that found in the Great Barrier Reef lagoons (Maxwell, 1868; Flood and Scoffin, 1978; Flood et al., 1978; Flood and Orme, 1988), and in the coastal lagoons of New Caledonia (Debenay, 1987; Chevillon, 1989). However, mud distribution is probably governed by the geomorphology of the atoll: on the one hand, the emerged part of the atoll, sheltering coastal waters from the trade winds, is the major source of fine particles; on the other hand, the discontinuous barrier reef offers but limited protection from the washing away of particles.

Textural classification

Using Folk's textural classification (Folk, 1954) as reference, eight textural groups were identified in this lagoon: gravels, sandy gravels, muddy sandy gravels, gravelly sands, gravelly muddy sands, slightly gravelly sands, and slightly gravelly muddy sands; hardground areas came under the classification of "boulders". The most common groups were the slightly gravelly sands (50.9%), these being representative of the lagoon plain, with the gravelly sands (25.4%) as characteristic of the area near the barrier reef and the passes (i.e. the fringes of the lagoon plain), and finally the slightly gravelly muddy sands (11.9%), found exclusively in the more silted coastal strip (Fig. 4).

The cartography of the different textural types shows the transfer locations that are essential to the

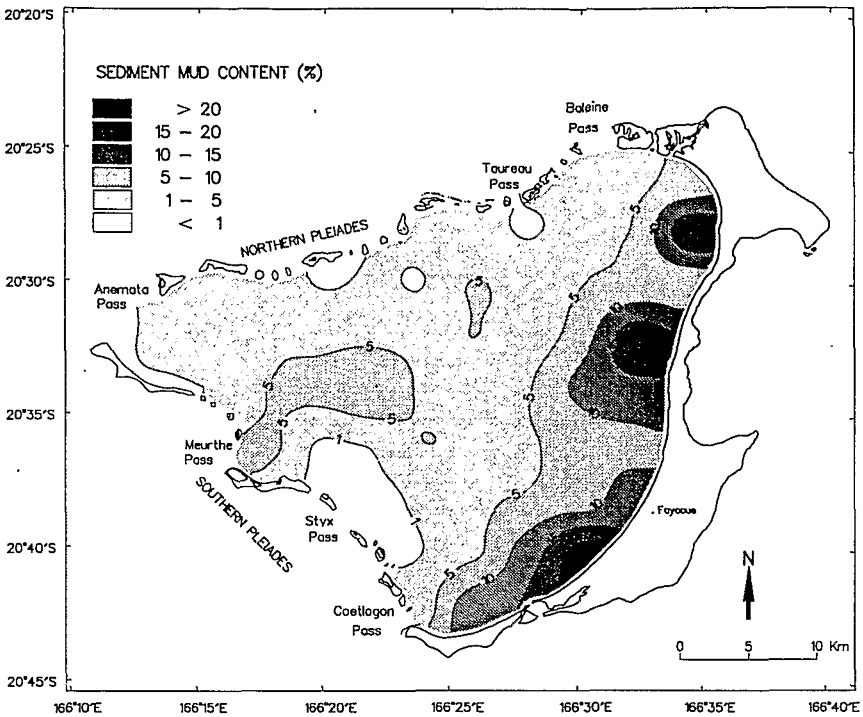


Fig. 3. Variation in sediment mud content (<1% = non-mud; 1–10% = low mud; 10–20% = moderate mud; 20–40% = high mud).

lagoon/ocean exchanges: the passes of Taureau, Meurthe, Styx and Anemata. The numerous other openings in the barrier reef do not have a significant effect on the lagoon sediment layer. It also brings to light the difference between the two barrier reefs which enclose the lagoon: one can easily see the different impact on sedimentology between Anemata pass and Taureau pass in the Northern Pleiades barrier reef, and between Anemata pass and Styx pass in the Southern Pleiades barrier reef.

Grain size parameters

The distribution frequency for mean size values (Folk and Ward, 1957), classified in reference to Wentworth's grade classification (Wentworth, 1922), shows two groupings of unequal magnitude (Fig. 5a). The first corresponds to fine to coarse sands (Mz = 0 to 3 ϕ), and represents 92% of the samples. These consist mostly of medium sands, which cover the greater part of the lagoon bottom (61% of samples). We also noted the presence of an area of fine sands opposite Fayaoue, the island's main village. The second grouping corresponds to the pebbles category (Mz = -2 to -6 ϕ), which only account for 8% of the samples taken, and is characteristic of the vicinity of the major passes.

Nearly all sorting values (Folk and Ward, op. cit.) fall between 1 and 2 ϕ (80% of samples), which corresponds to poorly sorted sediments. This noticeable predominance of poorly sorted medium sands is characteristic of little-evolved sediments, and indicates a low activity of the hydrodynamic agents (little transfer of material). According to Weydert (1976), these values indicate a rapid sedimentation in an homogenous hydrodynamic environment. The only notable variations are observed, once again, in the vicinity of the major passes where the sediments are very poorly sorted (7% of samples), and along the Northern Pleiades barrier reef where the bulk of the moderately sorted sediments are to be found (12% of samples). The most highly hydrodynamic area (well sorted pebbles) would appear to be Taureau Pass (station n° 36).

The frequency distribution for skewness value (Fig. 5c) indicates that half of the samples show a grain distribution that is nearly symmetrical. Furthermore, we notice a relative equilibrium between the fine and strongly fine skewed sediments, and the coarse to strongly coarse skewed sediments. The whole of these data, looking at the proportions of fine to coarse particles, is characteristic of a balanced sedimentary distribution. The extreme values represent a low percentage of the whole which,

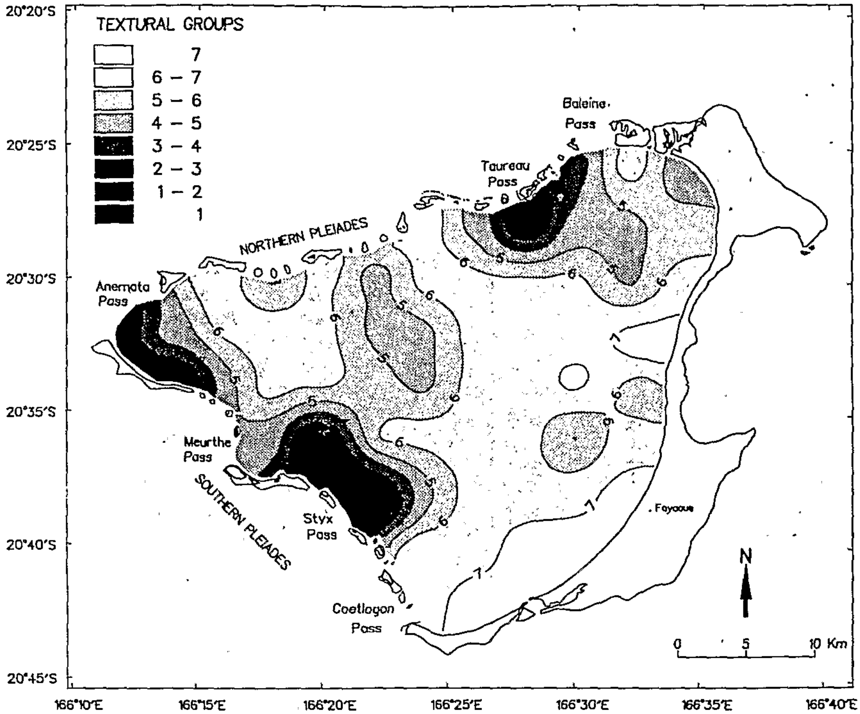


Fig. 4. Textural classification map (1: boulder; 1–2: gravel; 2–3: sandy gravel; 3–4: muddy sandy gravel; 4–5: gravelly sand; 5–6: gravelly muddy sand; 6–7: slightly gravelly sand; 7: slightly gravely muddy sand).

taken together with the low average thickness of the sediment layer, is indicative of a lowered overall sediment production and an absence of active deposit or material transfer areas. Once again, the greatest spatial variations are observed in the vicinity of the major passes (coarse to strongly coarse skewed sediments) and of the Northern Pleiades barrier reef where we found a large area of fine skewed sediments.

Conclusion

The whole of the lagoon characteristics speaks for the homogenous and moderate hydrodynamic conditions, a sediment production which is low but balanced in fine and coarse particles, and a low level of movement of sedimentary material. However, there are a few areas in the lagoon which differ from the prevailing conditions: mostly the inner barrier reef bottoms, which corresponds to areas of high sediment production. In the vicinity of the major passes, the sandy and fine fractions are washed away, and only the coarser fractions remain (Southern Pleiades barrier reef, and a part of the Northern Pleiades barrier reef). Away from the major passes, we observed substantial accumulations of sand (western portion of Northern Pleiades barrier reef). The coastal strip also shows particular characteristics: sheltered from the prevailing winds, it represents a little-active area of fine fractions deposit.

A forthcoming analysis of the bioclastic composition of the sediments should enable us to refine these hypotheses on the sedimentation mechanisms, and to specify whether the sediments in the deposit areas are of external or local origin.

Acknowledgements. The present study was made possible through a State/Islands Province development contract named "Research into the fish resources of the Uvea lagoon". We are indebted to G. Bargibant and A. Di Matteo for diving and technical assistance.

References

Bonneau M, Souchier B (1979) Méthodes pratiques d'analyses des sols. In Pédologie: constituants et propriétés des sols, Masson, Paris, 2, pp 440–454

Buchanan JB (1984) Sediment analysis. In: Holme NA, McIntyre AD (eds.), Methods for the study of marine benthos. Blackwell Scientific Publications, 2nd ed., pp. 41–65

Chardy P, Chevillon C, Clavier J (1988) Major benthic communities of the south-west lagoon of New Caledonia. Coral Reefs 7: 69–75

Chevillon C, Clavier J (1988) Sedimentological structure of the northern lagoon of New Caledonia. Proc. 6th Int Coral Reefs Symp, Townsville, 3: 425–430

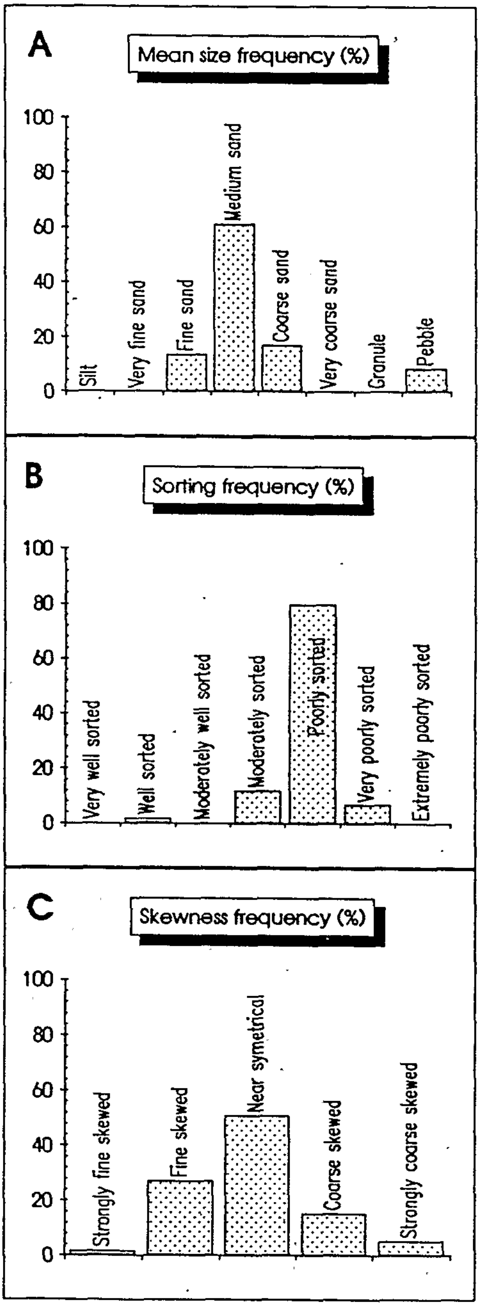


Fig. 5. Grain size parameters frequency distributions.

Chevillon C, Clavier J (1990) Preliminary sedimentological results on Chesterfield lagoon (New Caledonia). Proc. ISRS, Nouméa, 173–178

Chevillon C, Richer de Forges B (1988) Sediments and bionomic mapping on soft bottoms in the south-western lagoon of New Caledonia. Proc 6th Coral Reefs Symp, Townsville, 2: 589–594

Chevillon C (1986) Les sédiments de la corne sud-est du lagon néo-calédonien: missions de janvier à mai 19686, recueil des données. Rapp Sci Techn, ORSTOM, Nouméa, 40: 1–13

Chevillon C (1989) Sedimentologie descriptive et cartographie des fonds meubles du lagon de la côte est de Nouvelle-caledonie. Pub ORSTOM, Nouméa, 3 cartes

Chevillon C (1990a) Biosédimentologie du grand lagon nord de la Nouvelle-Calédonie. Thèse Doct Océano Bio, Marseille, 255 p

Chevillon C (1990b) Sedimentology of the Great Northern Lagoon of New Caledonia: description of depositional environments using a principal componant analysis. Proc ISRS, Nouméa, 165–172

Debenay JP (1987) Sedimentology in the southwestern lagoon of New Caledonia, SW Pacific J Coast Res 3(1): 77–91

Flood PG, Orme GR (1988) Mixed siliciclastic/carbonate sediments of the northern Great Barrier Reef province, Australia. In: Doyle LJ, Roberts HH (eds) Carbonate-clastic transitions. Elsevier, pp 175–205

Flood PG, Scoffin TP (1978) Reefal sediments of the northern Great Barrier Reef. Phil Trans R Sco Lond A 291: 5–71

Flood PG, Orme GR, Scoffin TP (1978) An analysis of the textural variability displayed by inter-reef sediments of the Impure Carbonate Facies in the vicinity of the Howick Group. Phil Trans R Soc Lond A 29: 73–83

Folk RL, Ward WC (1957) Brazos river bar: a study of significance of grain size parameters. J Sediment Petrol 27: 3–26

Folk RL (1954) The distinction between grain size and mineral composition in sedimentary-rock nomenclature. J Geol 62: 344–359

Guilcher A, Berthois L, Doumenge F, Michel A, Saint-Requier A, Arnold R (1969) Les récifs et les lagons coralliens de Mopélia et Bora-Bora (îles de la Société) et quelques autres récifs et lagons de comparaison (Tahiti, Scilly, Tuamotu occidentales): morphologie, sédimentologie, fonctionnement hydrologique. Mém ORSTOM, Paris, 38: 1–103.

Maxwell WGH, Jell JS, McKellar RG, (1964) Differentiation of carbonate sediments in the Heron Island Reef. J Sediment Petrol 34 (2): 294–308

Maxwell WGH (1968) Atlas of the Great Barrier Reef. Elsv Publ Comp, Amsterdam, London, New York, pp 258

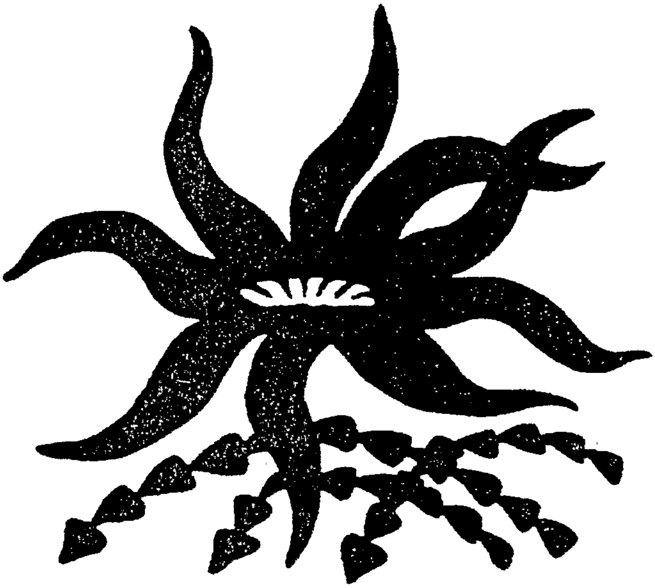
Richer de Forges B, Chevillon C, Laboute P, Bargibant G., Menou JL, Tirard P (1988) La campagne CORAIL 2 sur le plateau des îles Chesterfield (N.O. "Coriolis" et N.O. "Alis", 18 juillet au 6 août 1988). Rapp Sci Tech Sci Mer Biol mar, ORSTOM, Nouméa, 50: 1–68

Wentworth CK (1922) A scale of grade and class terms for clastic sediments. J Geol 30: 377–392

Weydert P (1976) Manuel de sédimentologie et d'arênologie. Pub Lab Sédim Mar Luminy, Marseille, 61p

7th INTERNATIONAL CORAL REEF SYMPOSIUM

22-26 JUNE 1992
Guam



~~Abstracts~~

IABO