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GENETIC HYPOTHESIS ON THE ANCIENT AND RECENT REEF COMPLEXES IN NEW CALEDONIA

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INTRODUCTION

New Caledonia is an island stretched NW-SE, 400 km long by 50 km wide in the South West Pacific. The whole island is surrounded by a barrier reef enclosing a very wide lagoon, especially in the south western and northern parts of the island (see fig.1). The flat reef is sub-outcropping and emerging on lowest low tide in the western part of the island ; on the other hand, in the eastern part the bar-

sporadic traces of ancient sea levels have been radiocarbon dated. It will be shown that, these dates, attributed to a high sea level at approximately 30,000 BP (LAUNAY and RECY, 1972), must be seriously re-examined.

I - AGES OF THE REEF COMPLEXES

A) - Uplifted reef complexes.

B) - Data on the barrier reef

All the available data on the barrier reef originate from a unique borehole, 9 m deep, on Tenia Islet (Western Barrier Reef). The formations are non indurated and holocene in age. They overlay a 120,000 year old coral formations (COUDRAY, 1973). The sea-level, at that time, is assumed to be 5 or 6 m higher than the present one (BLOOM et al., 1973,1974). The resulting subsidence of the western barrier reef appears to have been about 14 m for the last 120,000 years according to the Tenia Islet data, if it is assumed that the upper parts of this formation represent a flat reef which was near sea-level, i.e. + 5 m at 120, 120,000 years B.P.

Observations carried out on the shores and in the lagoon support this hypothesis. They reveal that the living reefs are found very slightly below sea-level. The flat reefs, only partially active, are found in the tidal range. Their tops could have formed during the higher sea-levels of the Holocene, explaining why the majority now lie above current mean sea-level. On the other hand, observations made in the south east of New Caledonia, on the Isle of Pines and in the Loyalty Islands (all uplifted reefs) show thy are not dismantled by erosion. They behave just as karsts ; run-off is absent and infiltration prevents surface erosion. In the context of the sea-level chronology of BLOOM et al.,1973, 1974, the resistance of the reef to erosion, implies that the ancient reef, which should be

flat reef, was found to have an age substantially older than core drilled samples from the upper part of that formation. This indicates that interpretations of radiocarbon ages of isolated coral samples should be made with caution. For example, the newly determined core age series in this area shows that one cannot conclude that the south eastern part of New Caledonia was uplifted during the Holocene, as previously supposed by LAUNAY and RECY (1972).

b) Core survey of the upper part of the Touho fringing reef.

1. Composition

In the Touho area, about ten core drillings from 5 to 10 m (1), were made in the fringing reef which is several hundred meters wide there (see fig. 2). In general, the flat reef elevation varies from 0.2 m to 1 m between the falling slope of the fringing reef and the shore. Some of the drillings are in shallow depressions 0.5 m deep. From the study of the cores it can be ascertained that the upper part of the fringing reef, at least to the bottom of the deepest core (-12 m), consists of organogenous sands and coral debris interspersed with continuous coral masses. These are unusual in the inner part of the reef (near the shore) and increase in number and thickness toward its outer part. Correlations between the lithological sequences of the different drillings are not easily discernable.

Touho S 4 (lagoon side) lithological depth	
00-0.40	flat reef
0.40-0.60	debris of coral branches
0.60-0.90	indurated organogenous sand
0.90-1.00	coral mass
1.00-2.20	indurated organogenous sand and coral branches
2.30-2.40	coral mass
2.40-3.10	indurated organogenous sand
3.10-4.50	coral mass

2. Age determinations and stable isotope measurements (table II).

Samples to be radiocarbon dated were selected in the massive coral from the cores. The samples are of aragonite without any trace of calcite. Measurements of isotopic ratios of $^{16}O/^{18}O$, $^{12}C/^{13}C$ were also made. The following conclusions can be drawn from these results :

- The samples are all holocene in age. There is no continuous age variation with depth.

Results shown in the following table give the extreme values :

Sample number	$\delta^{18}O$ coral/PDB	$A^{18}O$ water/PDB	calculated t°C	Age B P
Touho S9 (1)	-3.34 (max)	-0.2*	38°1	3140±160
		-0.7**	35°5	
Touho S4 (5)	-4.64 (min)	-0.2*	31°3	
		-0.7**	28°9	2660± 60

* average isotope composition of the oceanic sea water (CRAIG, 1961).

** isotopic composition of the Pacific sea water measured in the approaches of Noumea.

Since the calculated temperatures are reasonable, with respect to the present temperature of the coral environment, it appears that the coral carbonate crystallised under conditions near equilibrium with dissolved

D) - Data on the fringing reef of the western coast.

a) Core drillings from Poya.

In the Prowy bay area (Poya), not very far from the Croix-Haute cape, a series of continuous core drillings were made to determine a place to build a wharf (1) (see fig. 3).

These drillings showed (see fig. 4) the existence of an ancient rise modeling thin and more or less indurated detritial materials (sands and sandstone).

When submerged, the depressions of this rise were filled with primarily clay material, while the upper parts gave bases for coral growths.

Core S 9, particularly rich in well preserved coral material, has been chosen for a more detailed study.

That core, located on the flat reef side and isolated from the fringing reef by a channel, encountered 8.70 m of coral formation (see detailed section fig. 5). This formation consists alternately of massive coral banks and of detritic layers containing shell and coral debris. The samples studied come from both these levels (see fig. 5).

b) Age determinations and stable isotope measurements (table III).

The age profile is roughly coherent with depth and deals with the interval 5,400 to 1,300 BP corresponding to the growth of approximately 7 meters of coral. The lowest sample, S 9 (H) at -24,9 m, il older than the radiocarbon detection limit. The oxygen 28 content variation is on the order of 0.5 ‰. Calculated temperatures fall within the same range as the preceeding samples. The carbon 13 contents as well as the mineralogical assays of coral, containing exclusively aragonite, show that the original isotopic compositions has been conserved.

II - DISCUSSION

A general tandancy for age to correspond with depth may be observed in the cores from the Touho and Poya fringing reefs. But the lack of a rigourous chronological order as a function of the sample depth is characteristic of reworkings and of allochtonous inputs, which may occur during the construction of a coral flat. Age anomalies in the coral mass proper may be explained by the growth of recent coral in the depressions in older coral flats e.g. Touho S 4 (6), and also by the accumulation of shell material from above which is trapped in crevasses in the coral, e.g. Poya S 9 (F).

The growth of a reef complex takes place during several thousand years. During this period significant reworking may occur in the solid phase or even in the liquid phase (bicarbonate produced by the dissolution of preexisting material). Thus coral is a marker not easily used in the stude of sea leval changes during the Holocene. Since coral growth occurs at various depths, it is apparent that only ages found for samples of the highest elevations should be considered in sea-level studies of the Holocene. Nevertheless it is a good marker in the age determination of ancient high sea levels. In this case the inaccuracy due to the mixing of coral of different ages is of the same order as the error in radiometric dating.

At Touho a level which dates from 5.000 years BP at the bottom to 1.500 years BP at the top is found between -8 m and the surface at +0.8 m. These same ages are found between -13.3 m and the submerged surface of the reef at -6.3 m. Thus the dated holocene profiles at Touho S 4 and Poya S 9 are of virtually the same thickness and correspond to the same range of ages. The profiles are not found on the same level at these tow locations since core S 9 is from the slope of the reef.

The flat reef surfaces are of dead coral. The present profils of the flats reefs were formed about 1500 years ago. Thus it appears that sea-level has slightly decreased since then. This agrees with the drop in sea-level of one to two meters between approximately 500 to 1500 years BP froun by previous authors (BALTZER, 1970 ; LAUNAY and RECY, 1970, 1972; COUDRAY and DELIBRIAS, 1972).

Six thousand years ago, the fringing reef was still growing at approximately -8 m. In light of the velocity of the holocene sea-level rise before 6000 years BP, it is improbable that reef growth began long before this date and at a far lower level. Drillings and observations made by divers show the outer side of the fringing reef on the east coast of New Caledonia is thicker than 15 m.

The holocene growth probably rests on an ancient reef whose age is not known. The similarity of the Tenia islet to the barrier reef would suggest that this ancient fringing reef was formed 120,000 years ago corresponding a high sea level of +5 m (BLOOM et al., 1973).

(1) Drillings were performed by the BACHY Company for De ROUVRAY's firm.

Neglecting the effect of erosion on the coral elevation it seems that the subsidence of approwimately 14 m in the lost 120,000 years is not confined to the area of continental flexure seen on the barrier reef, but would have affected all of New Caledonia. This would not include the southern part and the Islet of Pines which were uplifted. Such an interpretation would not agree with the age of 105,000 years measured at +3.2 m on the coral from a remnant flat reef at Hienghene, but this result is questionable, as discussed above. Only a drilling survey on the fringing reef and the determination of ages with Ionium-Uranium on the lower levels would solve this problem with more accuracy.

CONCLUSIONS

This study, which needs further informations on several points, suggests the following hypotheses :

- A general subsidence of approximately 14 m may have affected the entire continental plateau of New Caledonia during the last 120,000 years. This subsidence represents the last part of a general quaternary episode of 200 m which could have the formation of the barrier reef, the inondation of the lower valleys and major coast line retreat (phase III of the physiographic model of ROUTHIER, 1953).

- The holocene reef, 15 m in thickness, is underlain by a subsided ancient reef platform.

- Although the holocene deposits are found or 2 meters above the current sea-level, there is no evidence which proves that these deposits have undergone significant vertical displacement since they may have been formed during the period of high sea-level which came to a close near 1.500 BP.

REFERENCES

AVIAS J., 1949 - Note préliminaire sur quelques phénomènes actuels ou sub-actuels de pétrogenèse et autres dans les marais côtiers de Moindou et Canala, Nouvelle Calédonie. C.R.somm.Soc.Géol.Fr., p.277-280.

AVIAS J., 1959 - Les récifs coralliens de la Nouvelle-Calédonie et quelques-uns de leurs problèmes. Bull.Soc.Géol.Fr., p.424-430.

BALTZER F., 1970 - Datation absolue de la transgression holocène sur la côte ouest de la Nouvelle-Calédonie. C.R.Acad.Sc.Paris Série D, t.271, p.2251-2254.

BERNAT M., LAUNAY J., RECY J., 1976 - Datation à l'Ionium de quelques formations coraliennes émergées de Nouvelle-Calédonie et des îles Loyauté. C.R.Acad.Sc.Paris, Série D, t.282, p.9-12.

BLOOM A.L., BROECKER W.S., CHAPPEL J.M.A., MATTHEWS R.K., MESOLELLA K.J., 1973 - Quaternary Sea-Level Fluctuations on a Tectonic Coast : New Th^{230}, U^{234} dates from the Huon Peninsula, New Guinea. Abstracts of Ninth Congress International Union for Quaternary Research. Christchurch, 2-10 December.

BLOOM A.L., BROECKER W.S., CHAPPEL J.M.A., MATTHEWS R.K., MESOLELLA K.J., 1974 - Quaternary Sea-Level Fluctuations on a Tectonic Coast : New $^{230}Th/^{234}U$ dates from the Huon Peninsula, New Guinea - Quaternary Research., 4, p.185-205.

COUDRAY J., 1971 - Nouvelles données sur la nature et l'origine du complexe récifal côtier en Nouvelle-Calédonie. Quat.Res., vol.1, n°2, p.236-246.

COUDRAY J., 1973 - Reef deposit, sedimentology and quaternary events in New Caledonia. Abstracts of Ninth Congress International Union for Quaternary Research. Christchurch, 2-10 December.

COUDRAY J. et DELIBRIAS G., 1972 - Variations du niveau marin au-dessus de l'actuel en Nouvelle-Calédonie depuis 6000 ans. C.R. Acad.Sc.Paris, Série D, t.275, p.2623-2626.

CRAIG H., 1961 - Standard for reporting concentration of deuterium and oxygen 18 in natural waters. Science, 133, p.1833-1834.

CRAIG H., 1965 - The measurement of oxygen isotope paleotemperatures. in "Stable Isotopes in Oceanographic Studies and Paleotemperatures". Proceed.Symp.Spoleto 1965. E.Tongiorgi ed.,Consiglio Nazionale delle Ricerche, p.161-182.

DAVIS W.M., 1925 - Les côtes et récifs coralliens de la Nouvelle-Calédonie. Ann.Geogr. t.XXXIV, n°191, p.244-269 ; 332-359 ; 521-556.

DUBOIS J., LAUNAY J., RECY J., 1973 - Les mouvements verticaux en Nouvelle-Calédonie et aux îles Loyauté et l'interprétation de certains d'entre eux dans l'optique de la tectonique des plaques. Cah.ORSTOM,Sér. géol., vol.5, n°1, p.3-24.

DUBOIS J., LAUNAY J., RECY J., 1974 - Uplift movements in New Caledonia - Loyalty Islands area and their plate tectonics interpretation. Tectonophysics, vol.24, p.133-150.

LAUNAY J. et RECY J., 1970 - Nouvelles données sur une variation relative récente du niveau de la mer dans toute la région Nouvelle Calédonie - îles Loyauté. C.R.Acad.Sc. Paris, Série D, t.270, p.2159-2161.

LAUNAY J. et RECY J., 1972 - Variations relatives du niveau de la mer et néotectonique en Nouvelle-Calédonie au Pléistocène supérieur et à l'Holocène. Rev.Géogr.Phys.Géol. Dyn., vol.XIV, fasc.1, p.47-65.

ROUTHIER P., 1953 - Etude géologique du versant occidental de la Nouvelle-Calédonie entre le col de Boghen et la pointe d'Arama. Thèse. Mém.Soc.Géol.Fr., n°67.

TABLE I

Mineralogic, isotopic and radiometric radiocarbon data, on the fringing reef of the New Caledonia South Eastern Coast.

Sample n° Place Nature	Altitude zéro S H en m	Calcite-Aragonite C %	Calcite-Aragonite A %	$\delta^{18}O$/ P D B	$\delta^{13}C$/ P D B	Age mesuré ^{14}C(ans BP)	Référence
'69 Tou 10 coral Touaourou in growth position	+1.8±0.2					4380±110 (A)	COUDRAY et DELIBRIAS 1973
Tara 2 coral sub in situ	+1 ±0.3	0	100 (D)	-3.10(C)	-0.72(C)	7340±140 (B) 4970±120 (C)	
Tara 3 coral in growth position	+0.6±0.2	0	100 (D)	-4.03(C)	-0.75(C)	6300±140 (B) 5470± 90 (C)	
Tara 1 coral in growth position	+2.1±0.2	0	100 (D)	-3.53(C)	+0.59(C)	7360±170 (B)	LAUNAY et

TABLE II

Sample n°	Depth in m of the sample in the drilling	Level in meter	% Calcite % Aragonite	$\delta^{18}O$/ PDB	$\delta^{13}C$/ PDB	Age ^{14}C years BP
TOUHO S4 (1) coral	0.08	+ 0.18	0 C 100 A	- 4.69	- 0.73	1540 ± 120
TOUHO S4 (2) coral	0.35	- 0.09	0 C 100 A	- 4.38	- 1.02	2580 ± 90
TOUHO S4 (3) coral	0.95	- 0.69	0 C 100 A	- 4.25	- 1.99	2110 ± 140
TOUHO S4 (4) coral	2.15	- 1.89	0 C 100 A	- 4.04	- 1.15	2200 ± 130
TOUHO S4 (5) coral	3.15	- 2.89	0 C 100 A	- 4.64	- 1.50	2660 ± 90
TOUHO S4 (6) coral	4.20 to 4.30	- 3.94 to - 4.04	0 C 100 A	- 4.42	- 0.45	2170 ± 120
TOUHO S4 (7) coral	7.70	- 7.95	0 C 100 A	- 3.64	- 0.29	6025 ± 200
TOUHO S6 (1) coral	1.00 to 1.50	- 0.40 to - 0.90	0 C 100 A	- 3.57	+ 0.34	5730 ± 150
TOUHO S6 (2) coral	3.10	- 2.50	0 C 100 A	- 3.97	+ 0.14	4070 ± 100
TOUHO S6 (3) coral	3.95	- 3.35	0 C 100 A	- 3.89	- 1.56	5470 ± 130
TOUHO S8 (1) coral	7.95	- 8.43 (+0.5 -0.1)	0 C 100 A	- 3.85	- 0.39	5500 ± 110
TOUHO S9 (1) coral	0.20	- 0.98 (+0.7 -0.1)	0 C 100 A	- 3.34	- 0.05	3140 ± 160
TOUHO S9 (2) coral	2.90	- 3.68 (+0.7 -0.1)	0 C 100 A	- 3.95	- 1.35	3190 ± 200

TABLE III

Sample n°	Depth of the sample in the drilling	Level in meter	% Calcite % Aragonite	$\delta^{18}O$/ PDB	$\delta^{13}C$/ PDB	Age ^{14}C years BP
Poya S9 (A) coral	1.05	- 6.30	0 C 100 A	- 3.92	- 0.65	1315 ± 170
Poya S9 (B) coral	1.30	- 6.55	0 C 100 A	- 3.84	- 1.08	1680 ± 50
Poya S9 (C) shell tests	1.60 to 2.70	- 6.85 to 7.95	0 C 100 A	- 1.29	- 1.06	1955 ± 165
Poya S9 (D) coral	3.05	- 8.30	0 C 100 A	- 2.58	- 0.48	1635 ± 220
Poya S9 (E) shell tests	3.25 to 6	- 8.50 to 11.25	0 C 100 A	- 0.84	- 1.64	1995 ± 165
Poya S9 (F) shell tests	6.5 to 7.25	-11.75 to 12.50	0 C 100 A	- 1.77	- 1.54	515
Poya S9 (J) coral	7.30	- 12.55	0 C 100 A	- 3.57	- 1.09	5330 ± 300
Poya S9 (F) coral	8.05	- 13.30	0 C 100 A	- 3.70	- 0.06	5410 ± 110
Poya S9 (H) indurated sand	19.65	- 24.90	0 C 100 A			

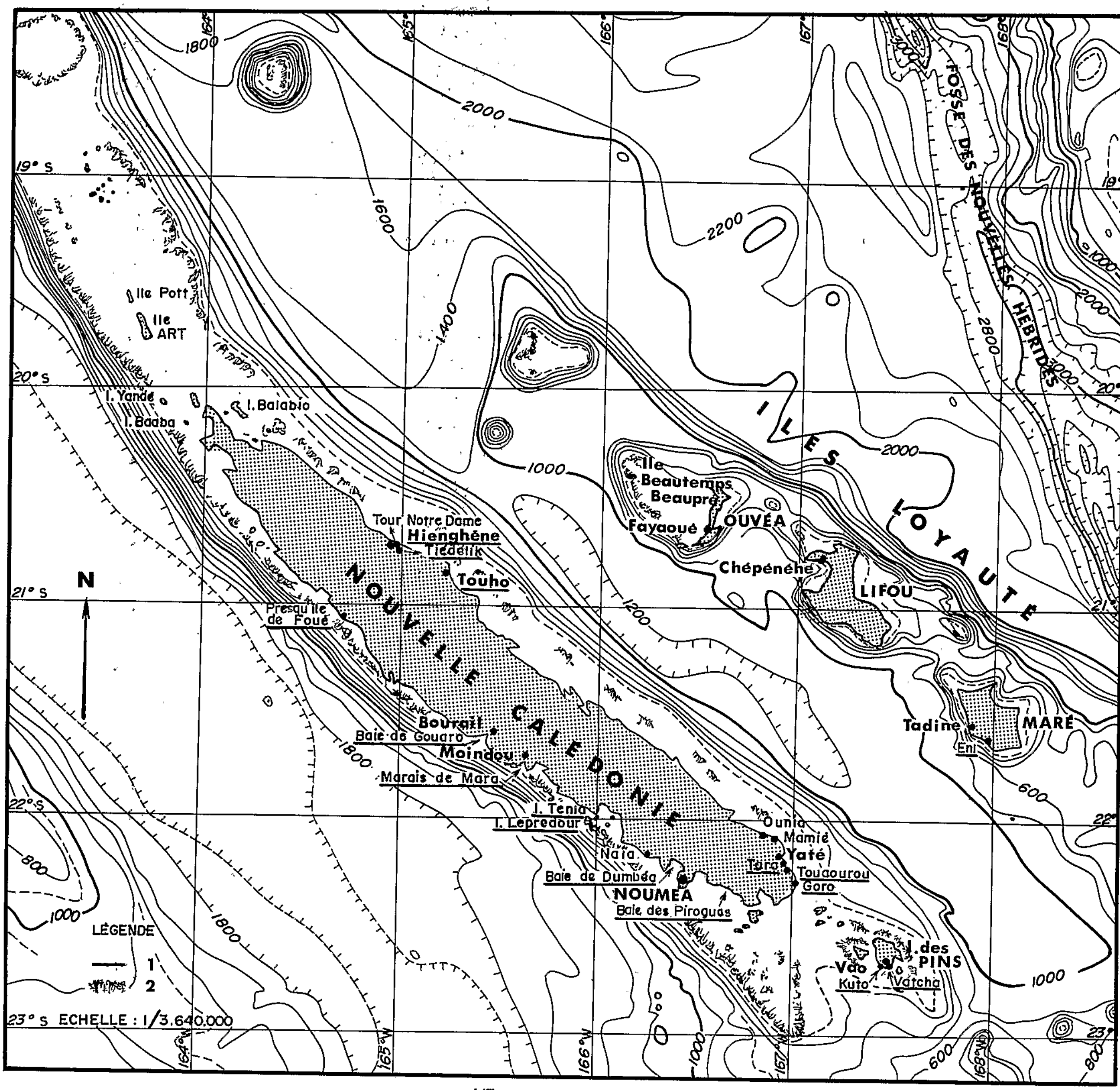
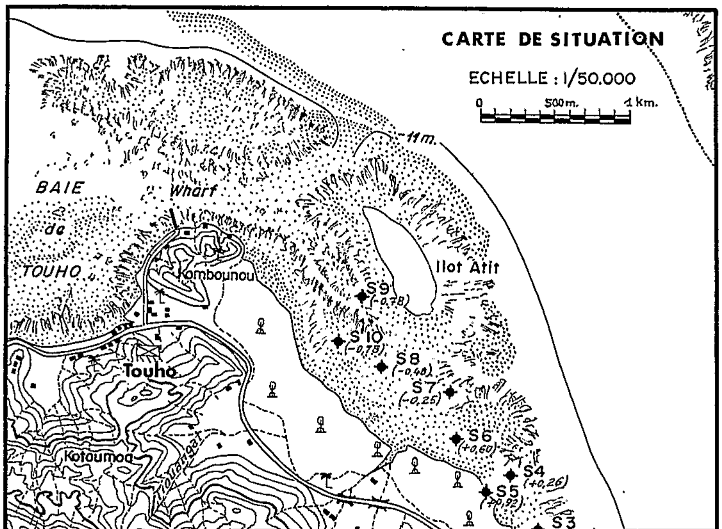
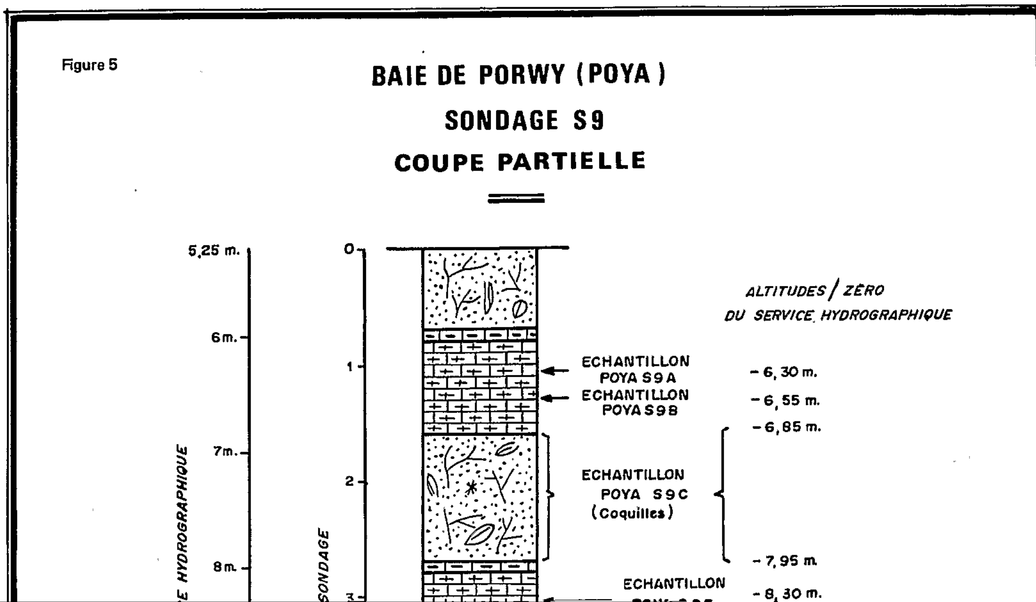
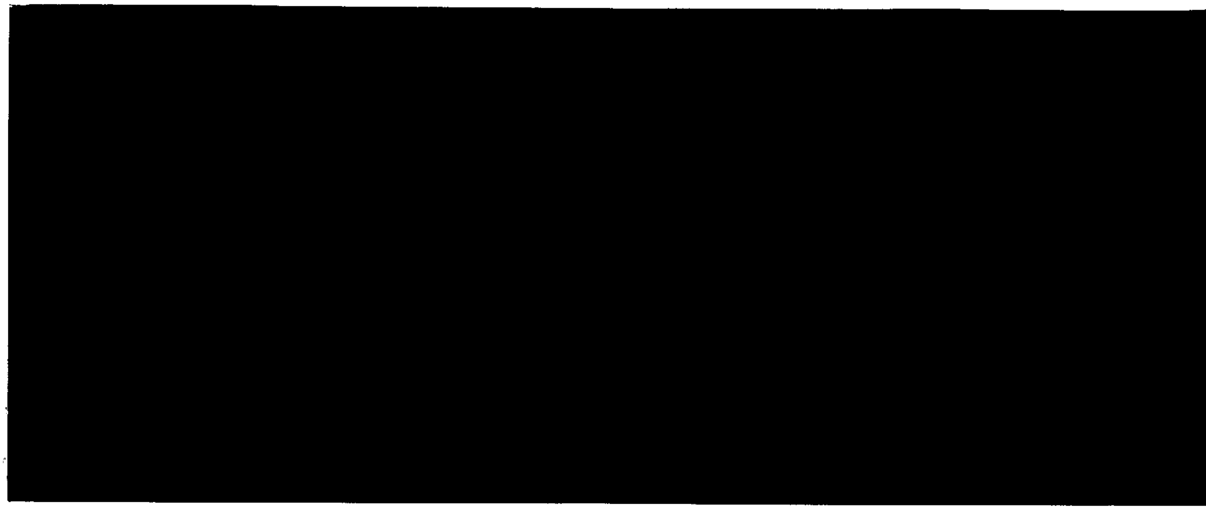


Fig. 1 - Locality map.


CARTE DE SITUATION
ECHELLE : 1/50.000
0
500m.
1 km.
11m.
BAIE
de
TOUHO
Wharf
Kombounou
Ilot Atit
Touho
Kotoumoa
S9 (-0,78)
S10 (-0,79)
S8 (-0,48)
S7 (-0,25)
S6 (+0,60)
S4 (+0,26)
S5 (+0,92)
S3


BAIE DE PORWY (POYA)
SONDAGE S9
COUPE PARTIELLE
ALTITUDES / ZÉRO
DU SERVICE HYDROGRAPHIQUE
5,25 m.
6 m.
7 m.
8 m.
HYDROGRAPHIQUE
SONDAGE
0
1
2
3
ECHANTILLON
POYA S9 A
ECHANTILLON
POYA S9 B
ECHANTILLON
POYA S9 C
(Coquilles)
ECHANTILLON
- 6,30 m.
- 6,55 m.
- 6,85 m.
- 7,95 m.
- 8,30 m.
Figure 5



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