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AGE OF SLOPE BRECCIA AND CALICHE CAPPING THE AEOLIANITES IN THE BAY OF SAINT VINCENT, WEST COAST OF NEW CALEDONIA

F. BALTZER [1] and F. DUGAS [2]

Résumé

Les restes de dunes d'eolianite en Baie de Saint Vincent (côte Ouest de la Nouvelle-Calédonie) sont affectés par des brèches de pente et des croûtes calcaires. Des coquilles de Bulimes associées aux brèches de trois sites ont été datées 22.000, 18.000 et 6.500 ans B.P. Ces datations permettent de montrer que les dernières eolianites se sont accumulées avant le minimum de la dernière regression marine glacio-eustatique et que la formation des croûtes calcaires s'étend sur une longue période qui commence avant le minimum de la regression glacio-eustatique et s'est poursuivie pendant l'holocène.

Abstract

Aeolianite dune remnants show exposures of caliche and slope breccia in the Bay of Saint Vincent (West Coast of New Caledonia). The radiocarbon ages of terrestrial Gastropod (Placostylus) shells from 3 different situations in the breccia were measured : 22.000, 18.000 and 6.500 years B.P. They proove that the last period of caliche formation extends over a long span of time, beginning about 4000 years before the lowest glacial sea level was reached and continuing during the Holocene. The accumulation of aeolianites was completed by that time, and if some aeolianites accumulated during the last glacial epoch, it was long before the sea level retreat reached maximum. These facts suggest a long duration of arid and subarid climatic conditions during the last glacial epoch.

The aeolianites of the Bay of Saint Vincent (Fig. 1 and 2), first reported by Avias and Coudray (1965) were recently studied in more detail by Coudray (1975) who divided them in two (probably Riss and Wurm) bodies. The purpose of this paper is a study of the slope breccia made of aeolianitic debris, which is the most recent sediment (except for present marine beach sands) on some aeolianitic islets of the Bay of Saint Vincent. (N'Dukué, Hugon, Isié). That breccia is closely related to the process of formation of caliche and contains many shells of the Gastropod Placostylus Mariei. Radiocarbon dating of the shells brings valuable information about the age of the breccia, of the caliche and of the upper part of the aeolianite.

The aeolianites of the Bay of Saint Vincent are made partly of calcareous bioclasts from the adjacent reefs and partly of ultramafic debris carried by fluvial transport from the main island and accumulated in dunes during the low sea level epochs of the Quaternary.

The dune structure is easily recognized thanks to the distribution of sand bodies in which laminar beds are made visible by changes in grain size repeated every ten centimeters or so, and by cross bedding. On the islets, these beds figure wide round structures shown by dip distribution in the

(1) Laboratoire de Sédimentologie, Université Paris Sud, 91405 Orsay

(2) Office de la Recherche Scientifique et Technique Outre-Mer, B.P. A5, Noumea Cedex, New Caledonia

quarries (Ile Grande Moro), on coastal cliffs (Pointe Le Guillois in Hugon, Iles Puen et Isié) or on some strands (Ile Puen). On Ile Puen, wide concentric orbs cut through a fossil dune by modern marine erosion are also a result of the dune structure.

The grain size characteristics of these fine sands and their good sorting is in agreement with their interpretation as dune sands although they show marks of serious weathering. The median grain size varies from 130 to 180 um, according to our analysis and, according to Coudray there are two modes one at 100 to 160 um and the other at 250 to 400 um, which is not inconsistent with our results. The sorting index varies from 1.6 to 1.9.

The formations older than the aeolianites and the aeolianites themselves, after every step of accumulation, were affected by caliche formation, as described by Coudray (1975). In many places, at the lower part of dunes, a breccia lays over the caliche. It is made of angular aeolianite and caliche debris, of various sizes from gravels to blocks, in a sandy and dusty matrix of ochraceous colour. At Ile Hugon, near Pointe Le Guillois (Fig. 3) the breccia formation makes a terrace. It lays over the caliche on top of the aeolianites and contains caliche layers of two sorts. First, it is distributed in several layers, one centimeter thick, and, secondly in a crust 50 centimeters thick, which divides in two the breccia formation. Placostylus shells are found in two locations with respect to that crust. Being found below and above it, the shells provide a means for the datation of the internal crust. Before we deal with that question, we shall try and define the palaeoclimatic significance of these formations.

The close association of the breccia with the caliche formation suggests that they are a result of the seasonal or cyclic pluriannual variations of one climate. Coudray (1975) named "coulées boueuses" (I.e. mud avalanches) these breccias. He correctly reported that they contain caliche debris and that caliche layers were present in them. But, he suggested that they were due to a warm and humid climate, in contrast with is general remark that the upper body or aeolianites is related to dryer climatic conditions than the lower one. He also states that the "coulées boueuses" contain attapulgite and halite.

The latter minerals suggest rather dry conditions. The presence of halite only could be a definite proof for arid conditions, but the sea is so close to the exposures that this mineral is likely to be a more result of salt water spray. Attapulgite, a quasi evaporitic clay common in calcareous soils seems to be in total disagreement with the hypothesis of these breccias being formed under very humid conditions. The great number of caliche layers in the breccia and, for some of them, their thickness are also suggestive of a rather dry climate. The moderate tropical climate with alternative seasons which presently prevails in New Caledonia is dryer on that part of the west coast than anywhere else in this island. In Noumea, about 60 km south, the mean annual temperature for 40 years is 23°.1 C and the mean annual rainfall is 1064 mm. De Martonne's index of aridity for one year is 32.1

$$\left(I = \frac{\text{Mean Rainfall in mm}}{\text{Temperature + 10 in C}^\circ} \right).$$

For November, one of the warm months and the dryest of the year (rainfall 45 mm, temperature 23°.9) the index falls to 15.9. At pointe Ma, a meteorological station in a situation closely resembling that of the islets of the Bay of Saint Vincent, but unfortunately with uncomplete records, de Martonne's index for the year can be estimated 27 for the year, a figure which confirms the trends towards dryness in the area under examination. There is no evidence of wetter conditions during Holocene and Glacial times in this area of Saint Vincent Bay, in contrast with the mountain range, a few kilometers inland.

For the formation of breccia, the palaeoclimate which seems most probable is a moderately dry climate, warm, with comparatively wetter periods providing water for the lithification and the caliche formation. After lithification of the dune surface, it is suggested that the relief was buried under deposition of slope breccia with dusty and sandy matrix, similar to some modern deposits under mediterranean climate. Then, it is likely that the slope breccia associated with the aeolianites were formed under a climate similar to the climate, probably arid, which prevailed while the aeolianites and their caliches formed themselves. The numerous Placostylus shells associated with some levels in the slope breccia lived during periods when aeolian sedimentation being not too fast, the dunes were covered with vegetation. The slope breccia accumulation was fed by exfoliation of the lithified sands of the high parts of the dunes, under dry conditions. The small amont of water available in the dune concentrated towards the lower part of the dunes where it was associated with the mixture of fine and coarse

debris, distinctive of the slope breccia. Placostylus Gastropods found there conditions favouring their life thanks to an adequate supply of food by vegetation. The presence of vegetation itself is confirmed by several exposures with fossil calcareous tubes around peaty remnants of roots, in vertical or radial situations.

As was noted by Coudray about Isié (1975) marine organisms are locally associated with the breccia near the present mean High Tide Level. Similarly, in Hugon Islet, a beach rock made of aeolianite and caliche debris mixed with marine shells are slightly uplifted and presently exposed to wave erosion. It contains marine shells such as Murex, Tridacna Conus and, again, shells of the terrestrial Gastropod Placostylus. They are included in a matrix which closely resembles the caliche covering the slope breccia. That associations of coastal marine sediments and land deposits in the same cement, makes it difficult to define a fine stratigraphy. It shows, in any case, that the caliche formation was active recently and participated in the cementation of Holocene deposits.

The radiocarbon dating of Placostylus shells from Isié islet gave an undeterminate age, older than 30 000 years B.P. (Coudray, 1975). On the islets Hugon and N'Dukué, we obtained definitely more recent ages on Placostylus shells associated with the slope breccia. On Hugon islet, the Placostylus shells (P. Mariei, Crosse and Fisher, according to Yoshio Kondo, Museum of Honolulu) which are cemented in the breccia under the main layer of intra-breccia body of caliche are 22 000 years ± 800 B.P. old. The Placostylus shells from the breccia above the main body of caliche have an age 6550 ± 100 years B.P. On N'Dukué, the Placostylus shells of a breccia found under a main caliche layer were dated 18 000 ± 225 years B.P. (Radiocarbon datings by J.C. Fontes, Laboratoire de Géologie Dynamique de l'Université de Paris).

Several conclusions result from these ages. The last soft layer of caliche at the top of the breccia in Hugon islet is younger than 6550 years B.P. The breccia with aeolianitic debris and Placostylus shells was already forming 22 000 years B.P. on Hugon and 18 000 years B.P. on N'Dukué. These ages are an indication that during the last great glacio-eustatic regression, roughly 18 000 years ago, the summits of the dunes were exposed to climatic conditions able to lithify their sands and weather the new so-formed rocks in blocks and dust forming a slope breccia downhill. As was said before, the climate was almost certainly arid. This word does not exclude the exceptional heavy rains which were necessary for the lithification and caliche formation processes. A study of the palaeoclimatic conditions in South East Australia (Derbyshire, 1969) suggests that New Caledonia was covered from 26 000 to 20 000 years B.P. by an extension of the wide anti-cyclonic area which covered central Australia in winter. These indications agree with world data, reported by Coudray (1975) according to which the climates of the tropical areas of the world were dryer during ice ages. An Australian example is given by a calcarenite dune studied by Gill and Hopley (1972) and dated 25 150 (± 1050 years B.P.). The world wide importance of that arid aeolian accumulation phase is well known (Sayles, 1929, Fairbridge, 1950).

Our radiocarbon ages suggest that the period following the last glacial marine low level (about 18 000 years B.P.) participated to a very small extent in the building of the aeolianite dunes, if ever it participated in it. At the same time, it is evident that aeolianite were deposited during stages of comparatively low sea levels, as it is demonstrated by the way these aeolian deposits are presently wave cut. The caliche which affects the upper part aeolianites began to form long before last glacial low level reached its maximum (22 500 years : age of the shells under the main body of caliche in Hugon : 18 000 years : lower sea level). It is a set of convincing arguments that the aeolianites of New Caledonia formed while the sea was retreating and before it reached its lowest level. This conclusion supports Coudray's view (1975) that the aeolianites of the Bay of Saint Vincent were formed during regressions. In addition it demonstrates the early character of their formation. In fact, the aeolianites probably began to form soon after the beginning of marine retreat. The radiocarbon dates of Placostylus from Hugon and N'Dukué demonstrate that the formation of the slope breccia was underway during the last stage of low sea-level. The coastal sediments including terrigenous and bioclastic sands (Foraminifera), emerge first during marine regressions in New Caledonia, therefore, they give the first contribution to aeolian transport at this stage (Baltzer 1965, 1970, Dugas, 1974). This point, supported by the stratigraphic record reported by Coudray (1975) confirms that the setting of aeolianites during regressions was an early process in New Caledonia.

As a conclusion, in Hugon and N'Dukué islets, the age of the formation of the main caliche layer which affects the slope breccia is known with good precision. It took place from 22 500 to 6 500 years B.P. During all that period, it is likely that an arid and then subarid climate predominated in this region and the present climate is a continuation of the latter. Some vegetation developed down the active dunes. We do not think that, at any time, there was a period of long duration with a climate humid enough to produce mud avalanches in this low restricted area. Moreover, the pervious character of the sand of the aeolianites is not likely to help the formation of such soil conditions. Coudray himself (1975) reports that the older aeolianites, which are not considered here, were affected by karstic underground water circulations during former interglacials. This is a more likely effect of humid climatic conditions of these rocks. During the last marine regressive episode, aeolianites formed only while the sea was retrating and especially at the beginning of the retreat. Even the formation of the slope breccia and of caliche began before the sea was at its lowest level.

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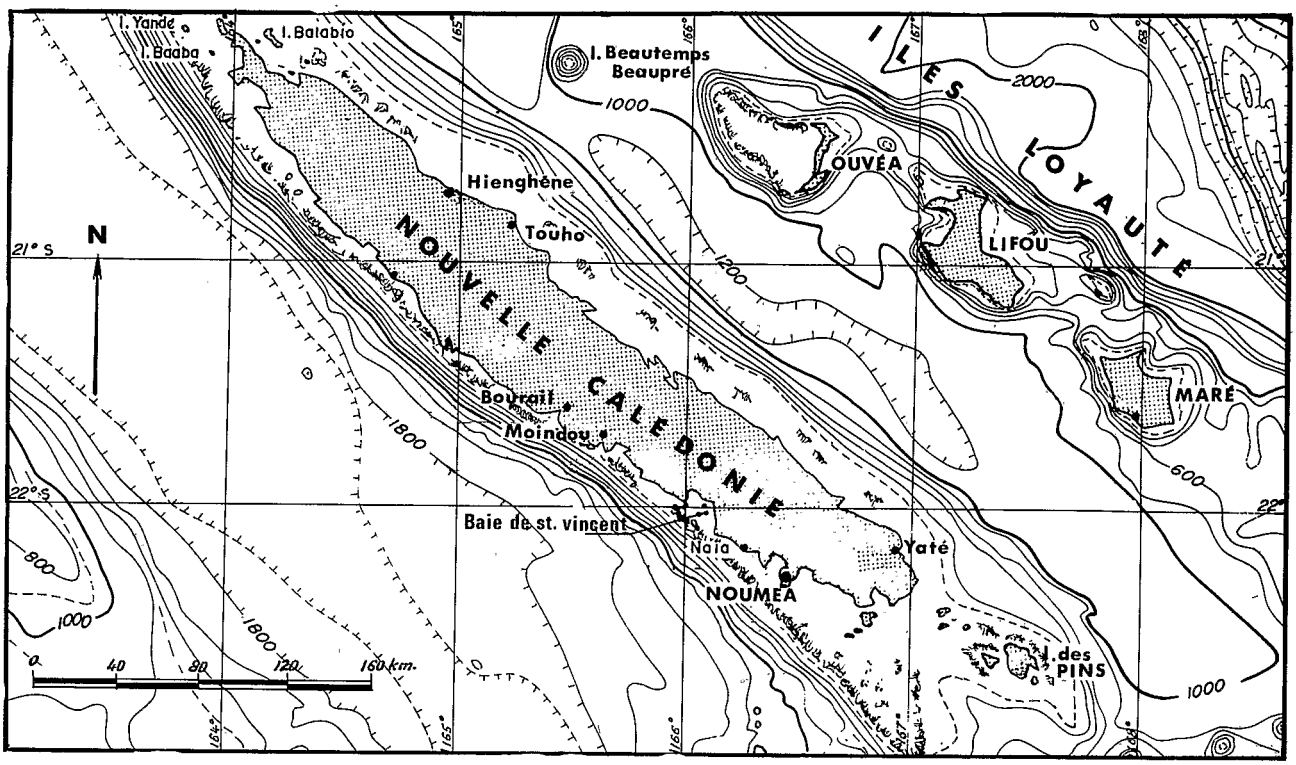


Fig. 1 - Location of Baie de Saint-Vincent in New Caledonia on Scripps O.I. bathymetric map.

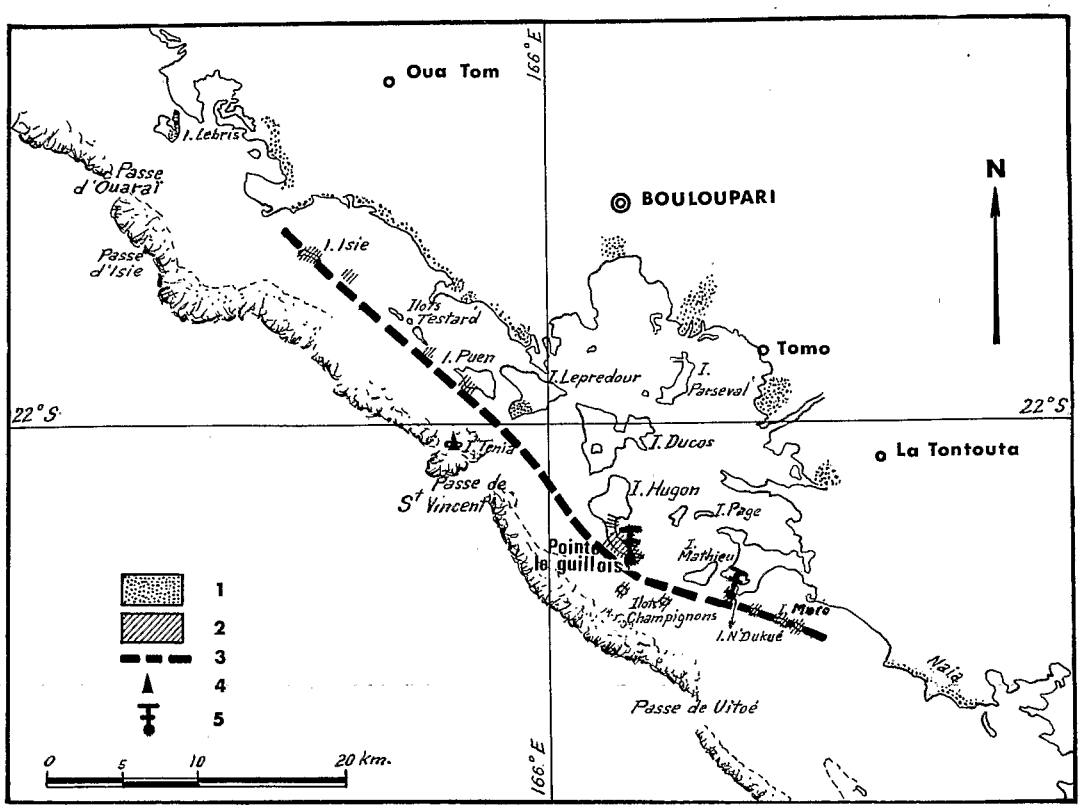


Fig. 2 - The Baie de Saint-Vincent - 1 : merged beaches and mangrove. - 2 : aeolianite sandstone. - 3 : axis of the dune system. - 4 : Singer Polignac drilling. - 5 : age determined fossils (Placostylus).

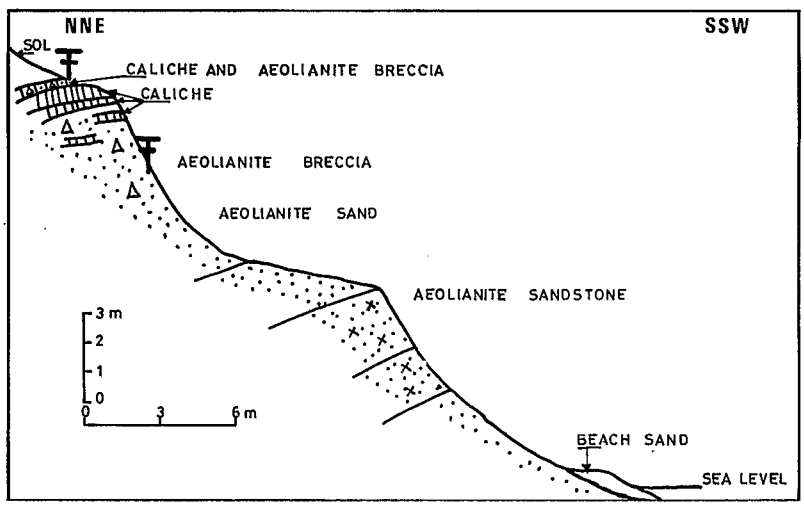
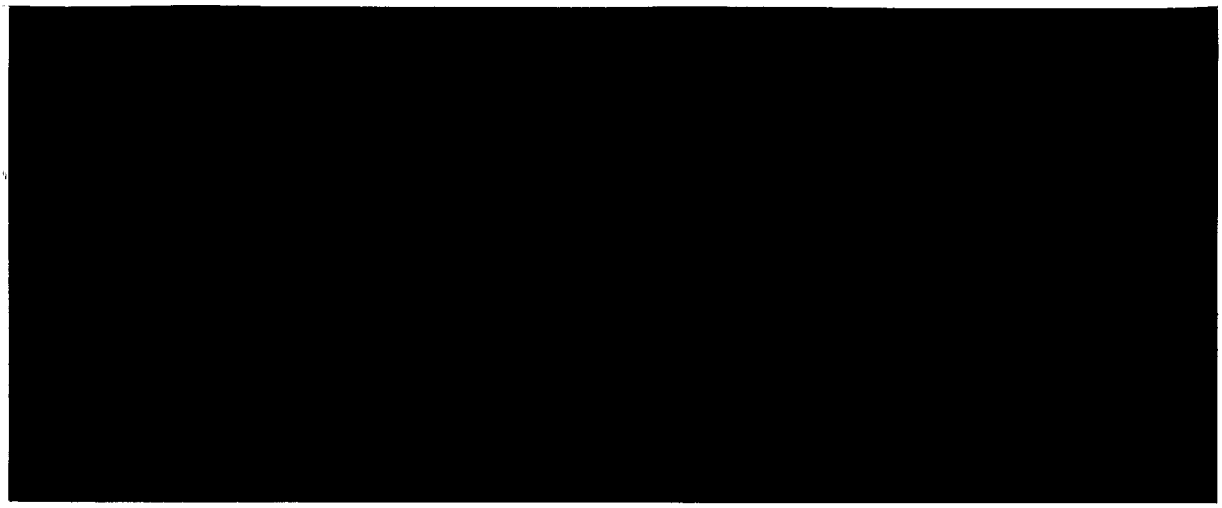


Fig. 3 - Cross Section in the aeolianite dune at Pointe Le Guillois in Hugon islet.



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