

SOME NOTES ON THE GEOMORPHOLOGY OF THE SHELF OF ST. EUSTATIUS (NETHERLANDS ANTILLES)

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ABSTRACT

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During the year 1972 H.Ms. "Luymes" of the Royal Netherlands Navy made a hydrographical survey in a part of the N. E. Caribbean. The resulting echograms and maps allowed a more detailed impression of the topography of the sea bottom in this area to be made.

In this paper the relief of the shelf of St. Eustatius, with its submarine terraces and ridges, is discussed.

INTRODUCTION

The island of St. Eustatius consists of two extinct volcanoes. In the southern part of the island the Quill, which is the younger volcano, still displays a practically unaffected conical form. In the northern part, however, a rough and irregular hilly landscape represents the ruins of a volcano that must have experienced its last eruption very long ago. The hill called "Bergje" can be regarded as a kind of neck.

The difference in "freshness" between these two volcanoes manifests itself in the shoreline of the island. In southern St. Eustatius the coastline is relatively smooth; in the other part, however, it is much more irregular, showing many promontories and small bays.

St. Eustatius is surrounded by a broad shelf, the depth of which is not more than 50-60 m. From the edge of the shelf the sea-bottom slopes down steeply (the dip is approx. 25-30°) to a depth of 600 m and more. The shelf must have been emergent during the glacial periods of the Quaternary, when the sea-le-

vel was lowered considerably. St. Eustatius was then connected by the emerged shelf to the neighbouring islands of St. Christopher (St. Kitts) and Nevis (cf. Fig. 1).

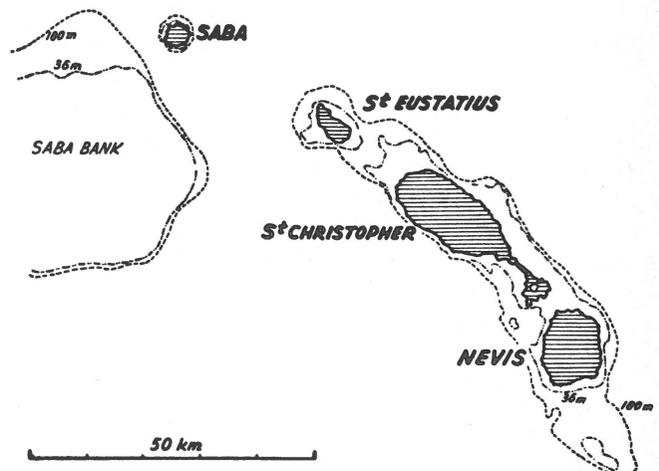


Fig. 1
St. Eustatius and the adjacent islands.

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In 1972 the hydrographical vessel H.M.s "Luymes" of the Royal Netherlands Navy carried out a hydrographical survey in the surroundings of St. Eustatius, Saba and St. Maarten. During these activities echosoundings were made by means of a Precision Depth Recorder and an M33 that could be mounted in a smaller boat. In some places bottom samples were collected by means of a simple dredge.

RESULTS

It appeared that in the topography of the St. Eustatius shelf some distinct features could be discerned. These features have been indicated on the map of Fig. 2.

The coastline of the recent island is accompanied by an outward sloping zone, consisting of sand in which volcanic minerals like magnetite, ilmenite and hypersthene are very abundant. The same sand also occurs in the beaches near Oranjestad at the western coast and Concordia at the opposite side of the island. Most of the sand is supplied by the volcanic sediments (tuffs etc.) present in the cliffs that are washed by the waves, a minor part consists of organic calcareous material like broken shells, coral sand etc. The beaches are locally black due to the concentration by surf wash of the heavy minerals. During the hurricane season, when the surf action can be very severe, parts of the beaches sometimes disappear; they are restored gradually under more normal conditions. This exchange of sand between the beaches and the sea bottom is restricted to the sloping zone immediately surrounding the island, it reaches down to approx. -20 m.

Locally on the shelf S.W. of Oranjestad a spit-like form was found at a depth of -20 m, encompassing a small lagoon-like area. This part of the shelf, moreover, shows some very conspicuous terraces at depths of -30 and -50 m respectively. The edges of the latter are accompanied by ridges, protruding some 10 m above the adjacent terrace surfaces. S.E. of the present island the situation is comparable. In the straits between St. Eustatius and St. Kitts, for instance, a profile running SW-NE shows distinct levels as well as ridges at the same depths. North and east of the island terraces and ridges are also present, but their boundaries are locally less distinct and the surface of the shelf is on the whole lower than near Oranjestad. A rather interesting form is the isolated platform at a depth of -55 m, situated not far from the Quill, the younger volcano of St. Eustatius. Unfortunately the hydrographical data concerning this phenomenon are rather scanty, but they seem to permit the conclusion that no ridges are present on the platform.

The material dredged from the terraces and the ridges consists completely of CaCO_3 . S.W. of Oranjestad on the terraces of -30 and -50m calcareous material was found in several places in which skeletal grains of coralline algae, *Halimeda*, small corals etc. could be discerned. The surface appeared to be locally incrustated by calcareous algae. A rather common phenomenon on the submarine terraces is the occurrence of

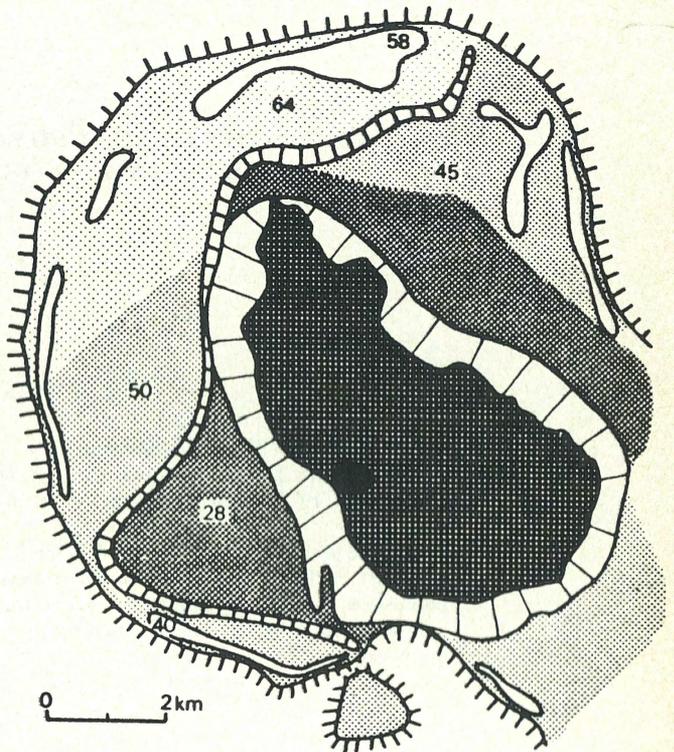


Fig. 2
A geomorphological sketch of the shelf area of St. Eustatius. The black dot near the western coast indicates the situation of Oranjestad.

smaller and larger spheroidal rhodolite-like forms. From the ridge near the shelf edge a distinct debris of hermatypic corals was collected. No terrestrial materials have been observed by the naked eye, on the terrace or in the ridge. It is not impossible, however, that during future detailed investigations of the sediments some volcanic minerals will be found. In terms of volume they are completely unimportant in relation to the calcareous organic material.

Comparison of the hydrographical data with those obtained from other shelf areas in the Eastern Caribbean leads to the conclusion that the levels are not restricted to the shelf of St. Eustatius; the shelves of other islands show comparable phenomena at corresponding depths (MACINTIRE, 1972).

DISCUSSION

(Sub)marine terraces and ridges may come into existence in different ways; they may have either an erosional or a depositional history. In some limestone areas in tropical regions terraces are the result of (marine) erosion in the form of biomechanical and biochemical attack by marine organism (FOCKE, 1977), causing a retreat of the coastal cliff. Other terrace surfaces originate by the growing up of a barrier reef and the subsequent filling in of the lagoon between this reef and the

proper coastline (DE BUISONJÉ; 1974).

As to the ridges present in a coastal environment several types can be distinguished:

(1) they can be built up at or slightly above sea-level as sand or shingle bars, that may display forms like spits, barriers or possible offshore bars;

(2) a second type is represented by the ridges composed of coral blocks and debris of coral limestone, deposited behind the proper coastline (sometimes thrown over a low coastal cliff) during periods of heavy surf action (DE BUISONJÉ & ZONNEVELD, 1960). After a rise of the sea-level these subaerial structures change into submarine ridges.

(3) Thirdly submarine ridges can be built up below the water-level as barrier reefs, separating a (more or less shallow) lagoon from the open sea.

One of the ridges that was mapped in fig. 2, the small one due south of Oranjestad, has the ground plan of a spit. It was obviously constructed during that period of the postglacial rise of sea-level in which a height of approx. -20 m was reached. The most conspicuous ridges, however, are those rising up from the "-50 m terrace". On most of them a depth of approx. -40 m was measured. The similarity of their occurrence along both the windward and the leeward edges of the St. Eustatius shelf is not in favour of the hypothesis that they were built up by (heavy) surf action, for these regions easterly trade winds are dominant and there is no reason to suppose that during earlier periods the conditions were very different. It is therefore improbable that the ridges belong to types 1 or 2, mentioned above.

At this moment we have the impression that the ridges of the -50 m terrace are (submerged) barrier reefs built up near the shelf edge during a period of rising sea-level (MACINTYRE, 1972). Apparently this rise was interrupted at -40 m. The reefs then had the opportunity to adjust themselves to that -40 m level. Afterwards, however, during the continued sea-level rise, the reef died and changed into a submerged reef. One might wonder why the reefs did not follow the rising sea-level and why the island of St. Eustatius is not surrounded by a recent barrier reef, based on the mentioned ridge. The answer will probably be found in the ecological situation in this part of the N.E. Caribbean, rather near to the outer border of hermatypic coral growth. Possibly life conditions for these corals are less favorable here than in lower latitudes; certainly during early Holocene times they were still worse. So it is conceivable that due to these relatively marginal conditions reef growth will not be optimum. It is known, moreover, that even under favourable conditions reefs have had the greatest difficulties in keeping up with the sea-level during the periods of maximum rise. The rate of this rise, during the first half of the Holocene period, was not less than 10 m/1000 years. The rate of reef growth, however, is estimated 2-6 m/1000 years (STODDART, 1973). GOREAU (1969) even concludes that reefs grew only during the temporary halts. According to Goreau the establishment of a coralline framework community probably

takes between 700 to 1500 years. A rapid sea-level rise will "drown" the structures, but a halt after a short vertical movement will allow the coral to grow up to sea-level again. Reef growth will succeed best if the ecological conditions are optimum; it is plausible that it fails in regions where growing conditions are worse.

In the light of these facts I assume that in the surroundings of St. Eustatius (and the other islands of the N.E. Caribbean) reef growth started near the edge of the -50 m plateau, shortly after its submergence during the postglacial sea-level rise and especially during a halt at approx. -40 m. During this halt the water over the edge of the drowned -50 m terrace was shallow and favourable to a relatively luxuriant reef growth. This stand-still at approx. -40 m coincided with the "Dryas periods" of Late glacial Wisconsin-Würm-Weichselien times and lasted from 12,000-10,000 B.P., a time lapse probably long enough for the construction of a complete reef structure. During the following sea-level rise, however, reef growth stayed behind and never had the opportunity to restore contact with the sea-level.

It is very difficult to ascertain if the terraces are erosional or depositional, no data being available concerning their internal structure. It is also impossible to make a reliable statement regarding their age. Although, probably during halts of the postglacial sea-level rise, erosion and/or accumulation caused terrace-like forms, the widths of the -50 and -30 m terraces are not in accordance with the relative shortness of these periods. Details like ledges, niches, narrow platforms and constructions like coral reefs can be ascribed to postglacial events, but many other phenomena like larger planations, terraces etc. might date from earlier Pleistocene periods. Purdey (1971, quoted by STODDART, 1973) could even establish that in British Honduras reef bodies were mere "continuations" of pre-existing structures. The peculiar isolated platform at -55 m south of St. Eustatius might be the truncated summit of a young submarine volcano. This statement, however, is not more than a speculation, only echo sounding tracks being available at this moment.

In the northern part of the shelf a submarine terrace with a depth of approx. -60 m could be mapped. Possibly this terrace is a separate unit, formed at a lower level than the -50 m terrace that was discussed above. But the possibility must not be overlooked that here a part of the -50 m terrace was lowered to -60 m by tectonic movements. Apparently the ridges present in this area are lower and less distinct than those in the western, southern and eastern parts of the shelf. Perhaps they are older (preglacial?) and *not* overgrown by more recent, postglacial, reef growth?

These notes on the geomorphology of the shelf of St. Eustatius give an impression of the submarine topography that can be studied on the platforms that surround St. Eustatius and most of the other islands in the N.E. Caribbean and of the speculations that can be made regarding the age and origin of the different forms. They have been written in the hope that in the near future further investigations regarding the sub-bot-

tom structures of these forms will reveal more data and give more insight into the problems regarding their origin and age.

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REFERENCES

- De Buissonjé, P. H. 1974 Neogene and Quaternary geology of Aruba, Curaçao and Bonaire – Ph. D. Thesis, Univ. Utrecht.
- De Buissonjé, P. H. & J. I. S. Zonneveld 1960 De kustvormen van Curaçao, Aruba en Bonaire – W. I. Gids 40: 121-144.
- Focke, J. W. 1977 Note on marine "tidal" erosion of limestone cliffs, notches and benches – Abstr. 8th Caribbean Geol. Conf. (Curaçao): 48-49.
- Goreau, T. F. 1969 Post Pleistocene urban renewal in coral reefs – Micronesia 5: 323-326.
- Macintyre, I. G. 1972 Submerged reefs of Eastern Caribbean – Amer. Assoc. Petrol. Geol. Bull. 56: 720-738.
- Stoddart, D. R. 1973 Coral reefs: the last two million years – Geography 1973: 313-323.