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FOSSIL AND RECENT SHALLOW WATER CORALS FROM THE ATLANTIC ISLANDS OFF WESTERN AFRICA

CANCAP-contribution no. 56

by

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and

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Miocene hermatypic corals are listed from Madeira and Porto Santo. Pleistocene and recent shallow water corals are described from the Cape Verde archipelago. The Miocene fauna was part of the Western Tethyan reef association, which went nearly completely extinct by the development of a cool water current in late Miocene times. The Cape Verde fauna immigrated from the Carribean, presumably by way of a compressed subtropical gyre during a mid Pleistocene glacial phase. The fauna was found in a beach terrace, formerly considered Tertiary, on the island of São Tiago. A lava flow directly above this deposit was radiometrically dated 700.000 ± 200.000 years B.P.

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INTRODUCTION

The Cancap-expeditions around the eastern Atlantic islands (fig. 1) (Den Hartog, 1984; Van der Land, 1987) offered a good opportunity to study fossil and recent coral faunas in this region. In the course of the cruises of HNLMS "Tydeman" (1978-1986) hundreds of exposures in sedimentary rocks were inspected by the authors for their fossil content. The recent corals were investigated by SCUBA diving at 29 stations. Exposures on the Azores (Miocene and

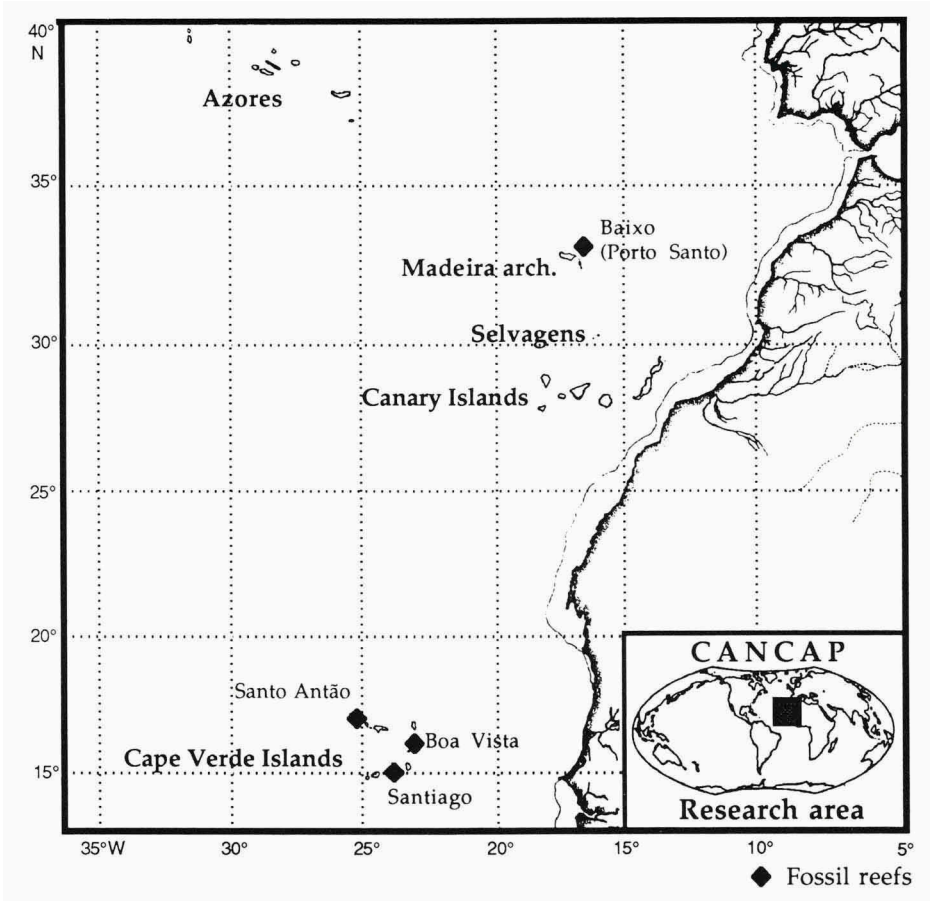

Fig. 1. CANCAP research area.

younger) did not produce any fossil corals. From the Canary islands Zibrowius & Brito (1986) described Pliocene and Pleistocene *Siderastrea*. The coral faunas from the Miocene of Porto Santo and Madeira were described in our previous papers (Boekschoten & Best, 1981; Best & Boekschoten, 1982).

Although earlier reports suggest otherwise (see Mitchell-Thomé, 1976, 1983), no shallow water deposits older than Quaternary were found in the Cape Verde archipelago. Only a few exposures contained coral fossils, belonging to the same genera as found living in this region. The present paper gives data on our Cape Verde collections, and summarizes biogeographic conclusions.

THE MIOCENE FAUNA OF PORTO SANTO AND MADEIRA

This fauna was already discussed in detail in our papers of 1981 and 1982 (see above). The following species were found: *Stylophora* cf. *reussiana* Montanaro Gallitelli & Tacoli; *Pocillopora madreporacea* (Lamarck); *Madracis fromenteli* (Mayer); ?*Isastrea orbignyana* Mayer; *Porites collegniana* (Michelotti); *Solenastrea turonensis* (Michelotti); *Montastrea* aff. *thyrsiformis* Michelin; *Tarbellastrea reussiana* (Milne Edwards & Haime); *Lithophyllia* cf. *ampla* Reuss; *Isophyllastrea madeirensis* Chevalier.

The fauna is closely related to the western Tethyan reef coral association as extensively described by Chevalier (1961). In the late Miocene, the Mediterranean part of this association became extinct during the Messinian salinity crisis. Data, presented by Van den Hoek (1982a, b) on benthic algae already suggested an eastern Atlantic extinction wave at that time. Thunnell & Belyea (1982), on the strength of 96 DSDP deep sea cores, identified a late Miocene cold water tongue proceeding along the European and African coasts as far south as 10°N. This cold water tongue is a plausible reason for the nearly complete extermination of the eastern Atlantic outposts of the Tethys reef coral fauna. The shallow, soft sediment coasts of tropical western Africa did not provide refuges. The only Pliocene hermatypic coral from eastern Atlantic deposits in the region studied is *Siderastraea*, from the Canary islands, a genus tolerant of environmental changes.

THE QUATERNARY CAPE VERDE FAUNA

The localities (fig. 2)

Marine deposits in the largely volcanic Cape Verde Islands consist of rare and scattered lenses of beach material, or shallow water rhodolite limestone, preserved underneath volcanics. Only on the easternmost islands of Maio, Boa Vista and Sal quaternary marine terrace deposits cover appreciable surfaces. These three islands seem geologically the oldest, and show less signs of recent volcanicity than the others.

Santo Antão. — At the northern side of the Ponta da Salina, 0.5 km south of Tarrafal de Monte Trigo, a lens of up to 10 m thickness overlies older lava flows. These marine deposits consist largely of gray sands with horizons of waterworn hauyn basalt pebbles. The uppermost two meters contain many fragments of rhodolites, the corals *Porites* and *Siderastrea* (rare), and molluscs (*Chama, Ostrea, Fissurella, Patella, Cypraea, Conus*), all much altered by diagenesis. The marine deposit is overlain by a scree-like agglomerate of volcanic material.

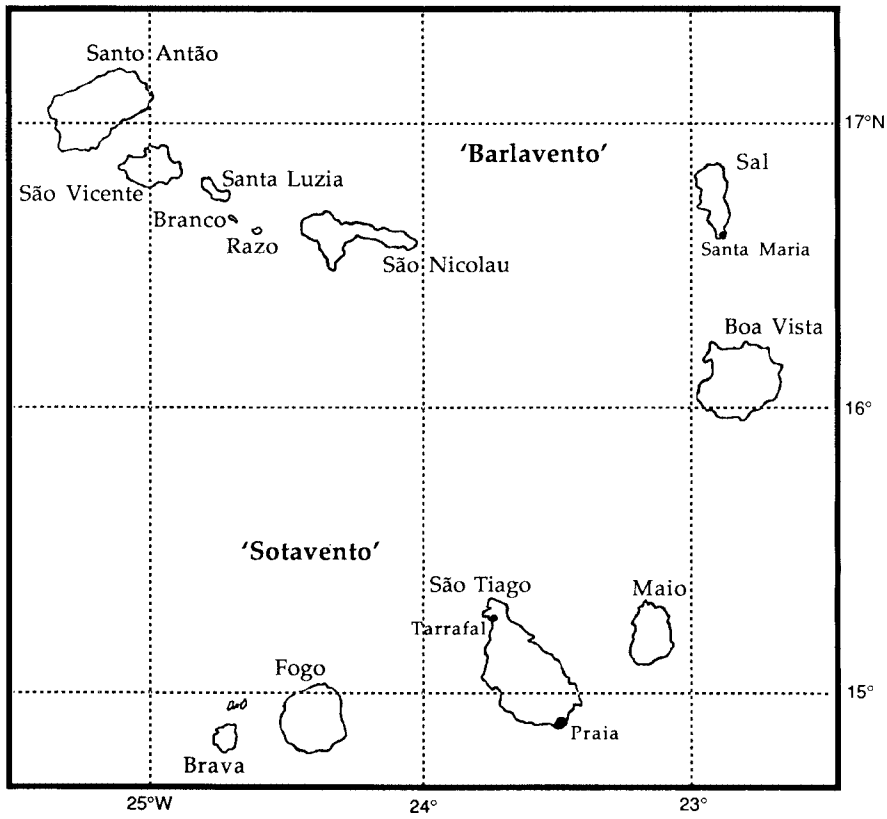

Fig. 2. Map of Cape Verde Archipelago.

São Vicente. — Beach terraces up to 3 m above sea level west and north of the Baia das Gatas consist of conglomerates and coquinas (with fossil *Millepora*). They overly fresh lava's, produced by the Morro da Salamaza volcano, and grade into aeolianite caprock.

Santa Luzia and Branco. — The quaternary beach terraces seen by us did not contain corals.

Razo. — Along the entire northern coast of the island indurated beach sands and conglomerates are intercalated between two lava flows. These contain many *Tubastrea* colonies, and also shells of *Spondylus, Patella, Fissurella* and *Cypraea*.

São Nicolau. — The rhodolite lenses of Riba do Farolim and Preguiça did not produce fossil corals; their mollusc fossils, as well as those from the faulted deposit at Monte Fucinho, suggest Pleistocene ages for these deposits which

have sometimes been regarded as Mesozoic.

Sal. — We found *Favia* and *Siderastrea* corals in the lowermost terrace of sands and coquinas of the three main terrace deposits on this island. These fossils were collected near the cemetery of Santa Maria, together with *Arca* and *Strombus* shells. Friedländer (1913) described stray cobbles of granite and gneiss brought to the island from the America's as ballast during the formerly important salt trade. We observed many of these boulders in the harbours of Santa Maria, Palmeira and Pedra Lume. The finds of loose colonies, identified as *Diploria clivosa* (Ellis & Solander, 1786) by Chevalier (1966), from Palmeira, Pedra Lume, and from the Ponta do Sal, on Santo Antão, may belong to this import ballast.

Boa Vista. — The calcarenite terrace, about 5 m above sea level along the western shore of Calheto do Velho islet contained some *Favia* and *Tubastraea* colonies, as well as *Ostrea, Purpura* and *Conus* shells. Among loose beach pebbles, preserved as shingle zones up to 20 m above sea, a rolled *Schizoculina* colony was collected.

Many Brazilian cobbles were found in the harbour of Sal Rei, some still in wrecks of wooden barges used in the salt trade; one calcarenite pebble contained a *Favia* colony. In addition some *Favia* colonies were collected in a beach terrace several meters above sea level at the landward side of the salina eastward of the deserted village of Curral Velho. This terrace, capped by extensive eolianites, contains also a trivial mollusc fauna.

Friedländer (1913) described a deposit, preserved under a lava flow, from Punta do Rife, containing coral fossils; the same species which still live in the area. We could not visit this locality.

Maio. — The extensive quaternary beach deposits in the southern part of the island did not yield any fossil corals.

São Tiago. — This island was the first to be studied geologically, by Charles Darwin, who arrived at Praia 16th of January 1832 and remained there till the 7th of February (F. Darwin, 1887). He noted in his autobiography: "The geology of St. Jago is very striking, yet simple: a stream of lava formerly flowed over the bed of the sea, formed of triturated recent shells and corals, which it has baked into a hard white rock. Since then the whole island has been upheaved". Curiously, fossil corals are not mentioned in Darwin's much more extensive description of the exposure on the volcanic islands visited during the voyage of the Beagle (Darwin, 1891: 4-26). First, the volcanic series below the marine intercalation at Praia is described. The deposit itself is very conspicuous because of its white colour. Its upper limit lies at approximately 20 m above sea level, and its greatest thickness is estimated to be 7 m. At Santa Maria island (called Quail island by Darwin), the rhodolite limestone is

replaced in the lowermost part by unconsolidated brown sand, full of *Turritella*, passing into beds of sandstone and conglomerate. These contain numerous rhodolites and other fossils such as echinid coronas and crab claws. Mollusc shells are common; the abundance of *Patella* proves that all this material was accumulated close to an ancient' exposed shore. In an appendix to Darwin's book, G. G. Sowerby (p. 171-172) presented a description of fossil shells from the "tertiary" deposit beneath a great basaltic stream on São Tiago; new species of *Littorina*, *Cerithium* and *Venus* are described and fifteen other molluscs from the same bed are listed, known to be recent species. Lecointre and Serralheiro (1966) found *Semele modesta* Adams at this locality, a species already collected there by Darwin. This is the only mollusc from the Praia deposit that is no longer found as a recent species in the Cape Verdes; it is still known as such from St. Helena Island. Lecointre (in Mitchell Thomé, 1976: 296) expressed the view that perhaps all supposed Cape Verde Miocene (as Darwin dated the Praia deposit, a dating still upheld by Part, 1951) is of Quaternary age. The important lava flow that covers the Praia sedimentary has solidified when the sediments were still below sealevel. Radioactive dating of this lava flow, therefore, was an ideal method to fix the age of the Praia fossils. The exposure at the west beach of Ilhéu Santa Maria is shown in fig. 3.

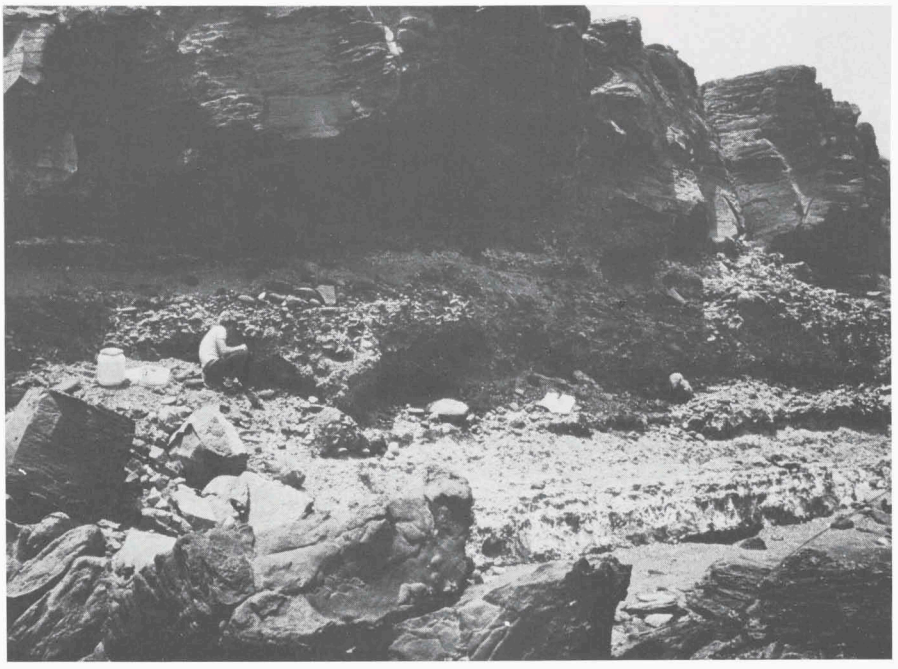

Fig. 3. Exposure at west side of Ilhéu Santa Maria, São Tiago.

Potassium-Argon dating was performed by Dr. E. H. Hebeda, of the Z.W.O. Laboratory of Isotopic Geology, Amsterdam. The age found, 700.000 ± 200.000 years, agrees with the view expressed by Lecointre. As all older deposits we have seen on the Cape Verde islands are identical to members of the Praia sequence both geologically and paleontologically, there is no reason to ascribe an older age to any of them.

The Praia deposits contain fossils of *Siderastrea, Porites, Favia* and *Tubastraea*. Deposits similar to those at Praia are present at Tarrafal, in the northernmost part of the island. Bebiano (1932) has described these and mentioned the occurrence of fossil corals. Torres (in Bebiano, 1932: 185-187) gives a heteroclite listing of names of molluscs suggesting a Middle Miocene age. Lecointre & Serralheiro (1966) report the extinct *Venus perrefossa* Dautzenberg & Fischer from this locality. In this Pleistocene deposit we found the same mollusc fauna as in Praia, but no corals; neither at São Francisco and Praia Baixo (both on the east coast), nor at Ciudad Velho (on the west coast).

Fogo and Brava. — No exposures of marine sediment were found during our visits.

Cima. — None of the two marine terraces that were inspected produced any fossil coral.

The corals

The living coral fauna of the Cape Verde archipelago was recently reviewed by Laborel (1974). Our survey did not add hermatypic species to those already reported in that paper. Below, the species are listed with the localities where we collected fossil or living material. We did not find *Diploria*. Cape Verdian corals were identified as such by Chevalier (1966). These look similar to the meandroid form of a *Favia* living in Brazilian waters and along the coast of West Africa, described by Laborel (1974) as *Favia gravida* (Verrill, 1901). The specimens may have been imported in ballast by salt vessels as already stated above. In view of our own subfossil and recent material of the genus *Favia* from the Cape Verde Islands, we assume that only one species, *Favia fragum* (Esper, 1788), is involved. When eroded or fossilized this coral appears more meandroid, because of the gradual dissolution of thin septa and thin newly formed thecae (figs. 4-6). Commercial trade may also have brought an isolated *Colpophyllia* colony to Selvagem Grande (Gagel, 1910). Fischer (1874) briefly mentions *Pocillopora* colonies, not collected by himself, supposedly collected as fossils in northern São Tiago.

Siderastrea radians (Pallas, 1766)

Pleistocene: RGM 299818. One cast in rhodolite limestone, Baia de Achada 4 km east of Praia, São Tiago.; RGM 299816. One small colony in beach terrace, Tarrafal de Monte Trigo, Santo Antão; RGM 211212. Colony in lowermost terrace, Santa Maria, Sal.

Holocene: Common in beachrock, southern coast of Santa Luzia.

Living: RMNH 16945, 16946, 16947, 16948, 16953. Common in Praia embayment and at Santa Clara, off São Tiago; RMNH 16958. Some specimens on the western coast of Brava; RMNH 16963, 16964. Some specimens from the western and southern coast of Fogo; Common on southwestern coast of Santa Luzia; Some specimens off Tarrafal de Monte Trigo, Santa Antão; RMNH 16976, 16982, 16987, 16992, 16993. Some specimens from the southern coast and in the Baia Sao Pedro, very common in the Baia das Gatas, São Vicente; RMNH 22219, 22220. Some specimens from the western coast of Boa Vista; RMNH 22222. Specimens from the western coast of Sal; RMNH 22221. Specimens from the southeastern coast of São Nicolau.

Porites astreoides Lamarck, 1816

Pleistocene: RGM 299815. One colony in beach terrace, Ilhéu de Santa Maria, São Tiago; RGM 299811, 299812. Eight colonies from Tarrafal de Monte Trigo, Santo Antão.

Living: RMNH 16960. Some specimens on the western coast of Brava; RMNH 16961, 16966. Some specimens on the western and southern coast of Fogo; RMNH 16971. Common off São Nicolau; Common off the southern coast of Santa Luzia; RMNH 16974, 16979, 16988, 16989. Common on the South coast, common in the Baia São Pedro, very common in the Baia das Gatas, São Vicente; Common off Tarrafal de Monte Trigo, Santo Antão.; RMNH 16950, 16954, 22226 common off Praia, São Tiago; RMNH 22223, 22225. Off western Boa Vista; RMNH 22224. Off western São Vicente.

Porites porites (Pallas, 1766)

Pleistocene: RGM 299810. Eight colonies in beach terrace, Ilhéu de Santa Maria, São Tiago.

Living: RMNH 16970, 22232. Common off Sao Nicolau; RMNH 16977, 16991. Common in the Baia Sao Pedro and in the Baia das Gatas, Sao Vicente; RMMH.22234, 22227. Off southwestern Sal; RMNH 22233, 22228. Off southwestern Sao Tiago; RMNH 22229, 22231. Off western Sao Vicente; RMNH 22230. Off western Boa Vista.

Favia fragum (Esper, 1797)

Pleistone: RGM 299814. One specimen in beach terrace, Ilhéu de Santa Maria, Sao Tiago.; RGM 299809. Two specimens in beach terrace, Curral Velho, Boa Vista; RGM 299806. Thirty-six specimens in beach terrace, Tarrafal de Monte Trigo, Santo Antao; RMNH 16992. One specimen in beach terrace, Baia das Gatas, Sao Vicente; RGM 211205, 211213. Three specimens from beach terrace. Caheta do Velho, Boa Vista; RGM 211206. One specimen in rolled calcarenite; beach of Sal Rei, Boa Vista.; RGM 211207, 211212. Four colonies from lowermost terrace, Santa Maria, Sal;

Holocene: Common in beach-rock, south coast of Santa Luzia.

Living: RMNH 16944, 16949, 16951, 16967, 22211, some colonies in Praia embayment, and at Santa Clara, off Santiago; RMNH 22212, 22213, 22215, 22216. Common off western Boa Vista; RMNH 22217. Off western Sao Vicente; RMNH 16959. Some colonies on the western coast of Brava; RMNH 16962, 16965. Some colonies on the western and southern coast of Brava; RMNH 16962, 16965. Some colonies on the western and southern coast of Fogo; RMNH 16969, 22209,

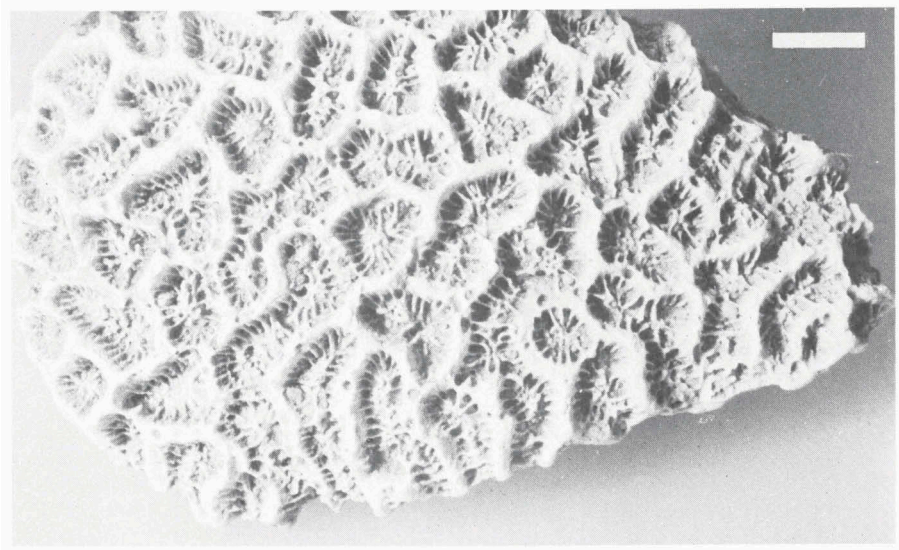

Fig. 4. *Favia fragum* (Esper). RMNH 16992. Slightly eroded colony. São Vicente (scale bar 5 mm).

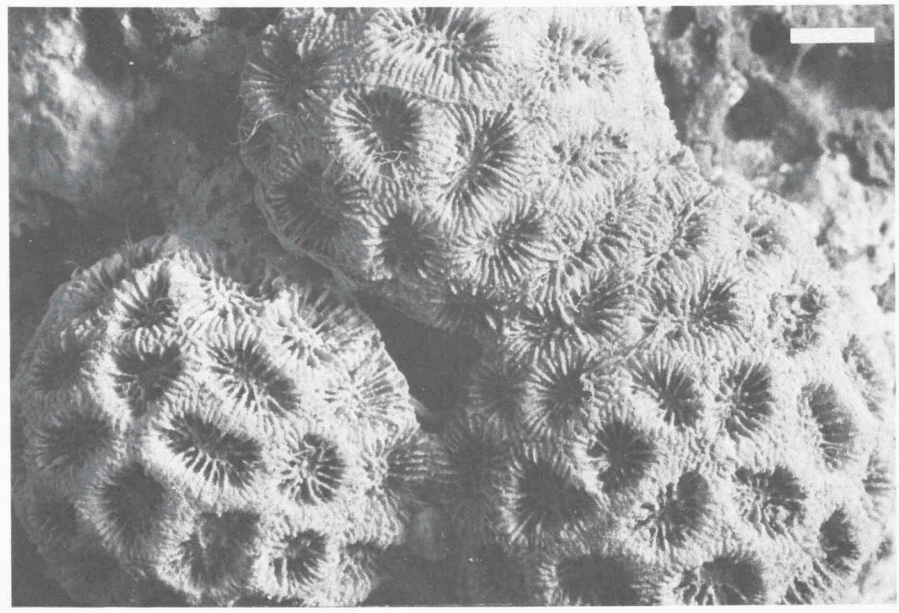

Fig. 5. *Favia fragum* (Esper). RMNH 16990. Fresh skeleton adhering to eroded skeleton. Baia das Gatas, São Vicente (scale bar 5 mm).

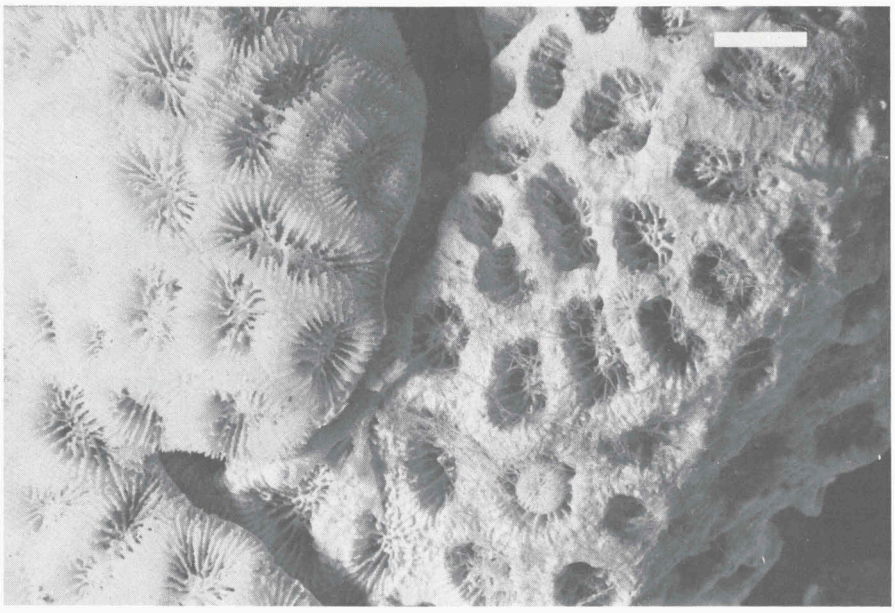

Fig. 6. *Favia fragum* (Esper). RGM 299809. Fossil specimen from Boa Vista. (scale bar 5 mm).

22218. Some colonies off Sao Nicolau; Some colonies off the southwestern coast of Santa Luzia; RMNH 16978, 16990, 16992. Some colonies in Baia de Sao Pedro, and common in the Baia das Gatas, Sao Vincente; RMNH 16986. Some colonies off the southwestern coast of Razo; RMNH 22210, 22214. Some colonies off western Sal.

Ahermatypic corals were also collected and observed. The following shallow water ahermatypes were collected:

Tubastraea coccinea Lesson, 1834

Pleistocene: RGM 299817. Seven specimens in beach terrace, Tarrafal de Monte Trigo, Santo Antao; RGM 299807. Three specimens in beach terrace, Punta da Mangoa, Sao Vincente; RGM 299813. Three specimens from Ilhéu de Santa Maria, Sao Tiago; RGM 211204, 211208. Three colonies from intercalated limestone, northern coast of Razo.

Living: RMNH 16946, 16952, 16955, 16956. Common in Praia embayment, and at Santa Clara, off Sao Tiago; RMNH 16957. Some colonies off the western coast of Brava; RMNH 16972. Common off Sao Nicolau; RMNH 16973. Common at Tarrafal de Monte Trigo, Santo Antao; RMNH 16980, 16983, 16984, 22236. Common in the Baia de Sao Pedro and at Mindelo, Sao Vicente; RMNH 22237. Off western Boa Vista; RMNH 22238. Off southern Sal.

Madracis pharensis (Heller, 1868)

Living: RMNH 16975. Some colonies off southern Sao Vicente.

Madracis asperula Milne-Edwards & Haime, 1849

Living: RMNH 22253, 22255. Some colonies off eastern Sao Nicolau. RMNH 22254. Off western Sao Vicente.

Astrangia solitaria (Lesueur, 1817)

Living: RMNH 16253, 22249. Some specimens off Mindelo, Sao Vicente; RMNH 22247. Off western Sal; RMNH 22248. Off western Boa Vista.

This species resembles the next fairly closely. Accordingly, Verheij & Best (1987) have placed both genera in the family Rhizangiidae.

Polycyathus atlanticus Duncan, 1876

Living: RMNH 22205. Off southeastern Sao Nicolau; RMNH 22206, 22207. Off western Sao Vicente; RMNH 22253. Off southeastern Cima.

Coenocyathus mouchezi Lacaze-Duthiers, 1897

Living: RMNH 16968, 22252. Some specimens from Sao Nicolau; RMNH 22251. Some specimens off Mindelo, Sao Vicente.

Schizoculina africana (Thiel, 1928)

Pleistocene: RGM 211209. Rolled specimen from beach terrace, Calheta do Velho, Boa Vista.
Living: RMNH 22201, 22202, 22203, 22204. Fairly common off western Boa Vista.

One hydrocoral was found both fossil and living:

Millepora alcicornis Linnaeus, 1758

Pleistocene: RGM 299808. Many colonies in beach terrace Punta da Mangoa, Sao Vincente; RGM 211207. One fragment from lowermost terrace, Santa Maria, Sal.
Holocene: Many colonies in beach rock, south coast of Santa Luzia.
Living: RMNH 16996, 16997, 16998. Many colonies in Praia embayment, and at Santa Clara; RMNH 16999. Some colonies off the western coast of Brava; RMNH 17000. Some colonies off the western coast of Fogo; Some colonies off Sao Nicolau; RMNH 17001, 17002. Some colonies off Sao Vicente; RMNH 22240. Off western Boa Vista; RMNH 22241. Off southern Sal; RMNH 22244. Off southwestern Maio.

ZOOGEOGRAPHICAL ASPECTS

The oldest shallow water deposits known from the Azores, Porto Santo & Madeira and the Canaries are Middle to Upper Miocene in age. Moreover Lower Miocene shallow water Foraminifera were dredged from the Cruiser-Hyeres seamount complex, south of the Azores (Fermont & Troelstra, 1983).

The Cape Verde Islands may be younger than the other islands, because only Quaternary littoral deposits were found here. Miocene deposits from the Azores and the Canaries are devoid of corals. Miocene coral fossils from Morocco, Porto Santo and Madeira are, as already mentioned, Tethyan in character. The only later hermatypic corals in the eastern Atlantic with western Atlantic affinities are those from the Cape Verde Islands.

It is obvious that Mediterranean Tethyan corals could not survive the late Miocene salinity crisis. Most of the Atlantic outposts of the Tethyan fauna may have perished about the same time because of cool ocean currents running southward along the Eurafrican coast, and because of increased upwelling (Best & Boekschoten, 1982; Monteillet et al., 1982; Thunell & Belyea, 1982). A possible survivor on the Cape Verde islands is *Siderastrea.* As posed by Zibrowius & Brito (1986), the gap between its former Miocene range and its present confinement to lower latitudes along the African coast is filled in by lower Pliocene fossils from Fuerteventura, and three records from the late Pleistocene of Tenerife, Lanzarote and Fuerteventura. Muthiga & Szmant (1987) found *Siderastrea* to be remarkably tolerant of salinity changes. This leaves the origin of the other Quaternary shallow water coral fauna of the Cape Verde Islands to be explained. *Polycyathus atlanticus* is, thus far, not sufficiently known for zoogeographical appraisal. The other species may be grouped in four different categories: Circumtropical *(Tubastraea, Millepora*), Carribean (*Porites Favia, Madracis, Astrangia*), Mediterranean (*Coenocyathus*), and African (*Schizoculina*).

It is noteworthy that none of the coral genera and species endemic in Brazil (Leao, 1982) are represented in eastern Atlantic faunas studied by us.

The circumtropical *Tubastraea* occurs also in the Carribean, and may well have reached the Cape Verde Islands together with more strictly Carribean elements.

The Carribean element contains all hermatypic corals occuring in the region, and was already recognized by Molengraaff (1921) and Gerth (1925). The latter author suggested ocean currents as a distributive agent. Paleocurrent systems in the Atlantic were published by Cline & Hays (1976), for a period roughly 18000 years ago. A cold current ran along the Eurafrican coast as far south as Gambia, and the subtropical oceanic gyre was much compressed. The latter resulted into a shorter crossing of the Atlantic and a higher current velocity. Similar circumstances during early Pleistocene glacial stages may have made colonization by Carribean corals possible, and may also have caused a number of the amphi-atlantic mollusc occurrences described by Talavera (1983). Moreover, such a gyre may have made it possible for the American manatee to make its way across the Atlantic. In West Africa

Trichechus senegalensis Link evolved as an offspring of *Trichechus manatus* Linnaeus during the Quaternary (Domning, 1982).

The Mediterranean element *Coenocyathus* is also known from the Azores, Madeira, Portugal and the Canary Islands (Zibrowius, 1980). This warm-temperate species has its southernmost outpost in the Cape Verdes. But we did not find it fossilized, and it is possible, therefore, that *Coenocyathus* immigrated during a late Quaternary glacial phase in a cool water current running southward along the continental coasts. *Schizoculina* is identified by Laborel (1974) as African. Its distribution is patchy, and this is the case also in the Cape Verde archipelago, where known occurrences both recent and fossil are confined to Boa Vista. This seems an example of the erratic colonization of distant islands by an organism that is not a very versatile traveller.

ACKNOWLEDGEMENTS

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