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Timing of the Last-Interglacial High Sea Level on the Seychelles Islands, Indian Ocean

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Corals from the Seychelles Islands, Indian Ocean, occur mainly as small coralline algae–vermetid remnants found in cavities adhering to the rock surface, and they rarely attain more than 2 m^2 in area. Samples of *Goniastrea* and *Porites* from elevations between 1.7 and 6 m above present mean sea level were dated by TIMS ^{238}U–^{234}U–^{230}Th techniques. The ages from well-preserved corals lie between 131,000 and 122,000 yr B.P., in agreement with most other observations of the last-interglacial sea level. Field evidence and dating from high marine limestones from two sections at La Digue Island indicate a period of coral buildup until 131,000 yr B.P., followed by a drop in sea level between 131,000 and 122,000 yr B.P.

Key Words: **last interglaciation; sea level; U–Th dating; corals; Seychelles; Indian Ocean.**

INTRODUCTION AND BACKGROUND

The duration and timing of the last interglaciation is still widely debated, despite considerable numbers of U–Th dates of corals, calcite veins, and marine sediments (Szabo *et al.*, 1994; Stirling *et al.*, 1995; Slowey *et al.*, 1996; Eisenhauer *et al.*, 1996; Edwards *et al.*, 1997; Winograd *et al.*, 1997). Most previous studies of interglacial corals and reefs are from ocean islands and atolls where the carbonates overlie a volcanic basement. The geologic history of these types of reefs has been completely different from that of the granitic Seychelles Islands, which probably have a more stable tectonic history. This history, in combination with the occurrence of well-preserved corals, means that the Seychelles Islands are suitable for the study of eustatic sea-level changes.

The Seychelles Islands are situated in the western Indian Ocean at 4–11°S and 45–56°E. They are composed of 115 islands and islets spread over an area of approximately 1.4 million km^2 (Fig. 1A). The main islands, the Mahé–Praslin group, rise from the Seychelles Bank, which forms the northern arc of the Mascarene Ridge. The average water depth of the Seychelles Bank, which is surrounded by ocean 1 to 5 km deep, is ca. 20 m and does not exceed 100 m. The outer islands—the Amirantes, Farquhar, and Aldabra groups—lie to the west and southwest, off the African coast and north of Madagascar (Fig. 1A).

Following Baker (1963) and Braithwaite (1984), the Seychelles can be divided into three geological groups: the high granitic islands of the Mahé–Praslin group (Fig. 1B), the low-lying coral islands of the Amirantes group, and the high-limestone islands of the Aldabra–Astove group (Fig. 1A). A series of younger, Early Tertiary volcanic intrusions (62–34 and 52–48 myr) cut through the Precambrian granites (650–647 myr) of the Mahé–Praslin group (Baker and Miller, 1963). The absence of post-Middle Eocene igneous rocks is taken as evidence that the last major tectonic activity affecting the Seychelles region ended during the Late Eocene (Mart, 1988). The erosion of the rock surfaces has led to inselberg-like rock masses and gently rounded outcrops, broken by narrow, flute-like gullies. The eroded surfaces of the granites extend below sea level (up to 30 m below the reefs in some areas).

On the coasts of Mahé, Praslin, La Digue, and some small surrounding islands, so-called high marine limestones (HML) adhering to granite blocks have been observed (Montaggioni and Hoang, 1988; Braithwaite, 1984; Lewis, 1969; Veeh, 1966; Baker, 1963). They consist of coral or mollusc debris in a fine calcarenite matrix with scattered quartz grains (Braithwaite, 1984). The first ^{230}Th–^{234}U alpha-spectrometry ages that were obtained for these HML gave ages of 140,000 ± 50,000 yr B.P. for samples situated at 9 m above mean sea level (MSL) on Mahé Island; samples from +6 m on Praslin Island gave the same ^{230}Th age (Veeh, 1966). Montaggioni and Hoang (1988) redated several coral samples from sections on La Digue, Praslin, and Curieuse Islands (Fig. 1B), also using alpha-

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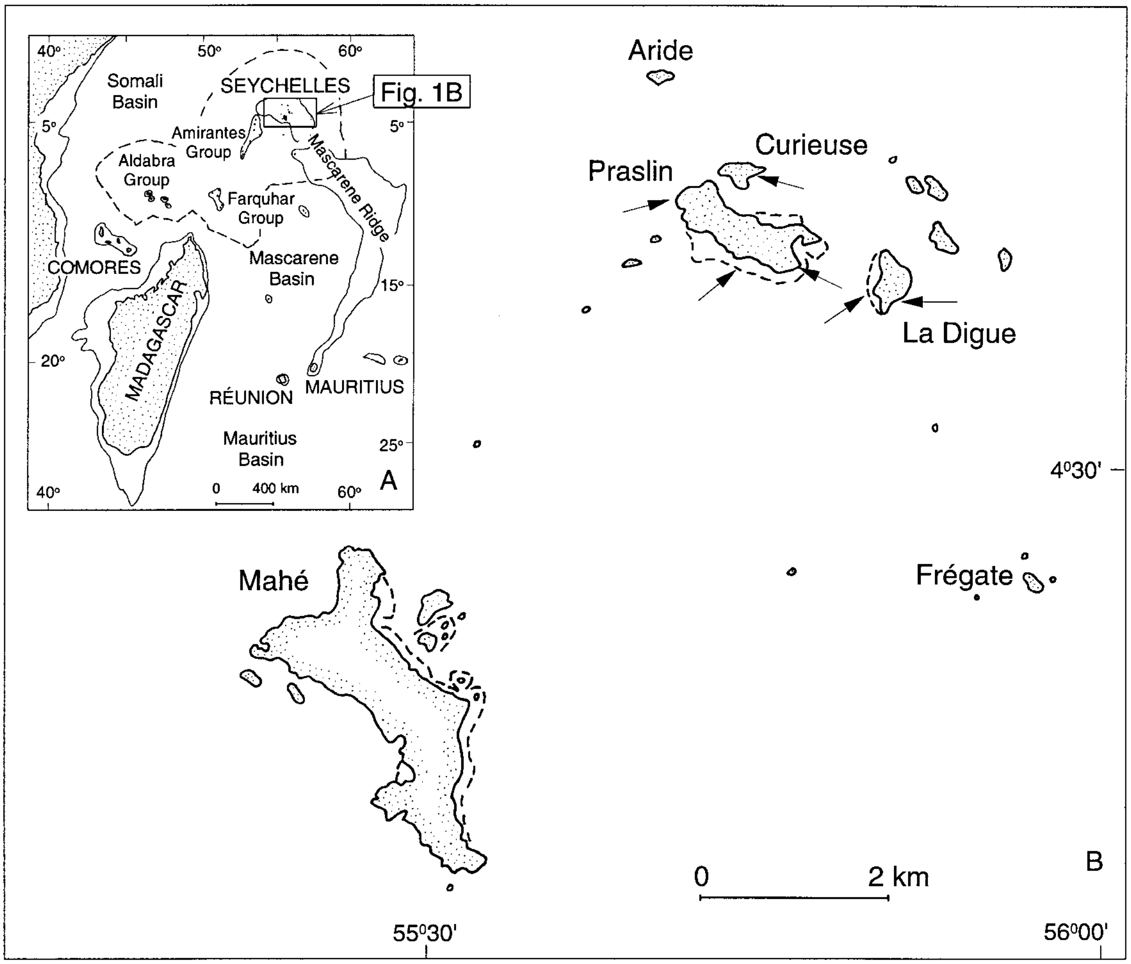

FIG. 1. (A) Map showing location of the Seychelles Islands in the western Indian Ocean. (B) Map of the main islands of the Seychelles group. The arrows indicate where high marine limestones occur on the islands of La Digue, Curieuse, and Praslin.

spectrometry ^{230}Th–^{234}U methods, in order to construct a relative paleo-sea-level curve. According to their ages for corals from between 2 and 8 m above MSL, the HML were formed between 140,000 and 120,000 yr B.P., and sea level reached its maximum altitude ca. 135,000 yr B.P.

During field work in 1989 and 1990, we mapped the occurrence of the HML on Praslin, La Digue, Curieuse, and some of the surrounding smaller islands (Fig. 1B). The lithology of larger outcrops was described in the field and selected corals were sampled for U–Th measurements.

Developments in thermal ionization mass spectrometry (TIMS) now allows more precise U–Th dating of corals (Edwards *et al.*, 1986). The precision of TIMS is on the order of $\pm$1000–2000 yr (2σ errors) for interglacial corals, compared to alpha-spectrometry measurements, which typically have error limits of approximately $\pm$6000 yr.

Here we present results of new TIMS ^{238}U–^{234}U–^{230}Th measurements on coral samples from the islands of La Digue and Curieuse and discuss their ages in relation to elevation and the last-interglacial sea level.

OCCURRENCE AND LITHOSTRATIGRAPHY OF HIGH MARINE LIMESTONE

Limestone outcrops are often found in cavities between huge granite boulders. Such outcrops are frequent along the coast at elevations between MSL and ca. 6 m but they can also be found further inland along the 10-m contour line. On Praslin Island, HML occurs along the southern coast, mainly as small coralline algae–vermetid remnants that rarely attain more than 2 m^2 in area (Fig. 1B). Larger complexes (2–4 m^2) were observed along the southwestern and southeastern coasts of La Digue Island, between Pte. Source d'Argent and Anse Bonne Caret, in Grand' Anse, and along the 10-m contour line in the central part of the island (Fig. 2). On Curieuse Island, larger outcrops are concentrated in eastern and southeastern areas below the 10-m contour line (Fig. 1B). The most complete sections from La Digue Islands (Pte. Source d'Argent, Grand 'Anse) were described and selected for sampling (Fig. 2). In addition, two samples were obtained from Curieuse Island (Fig. 1B).

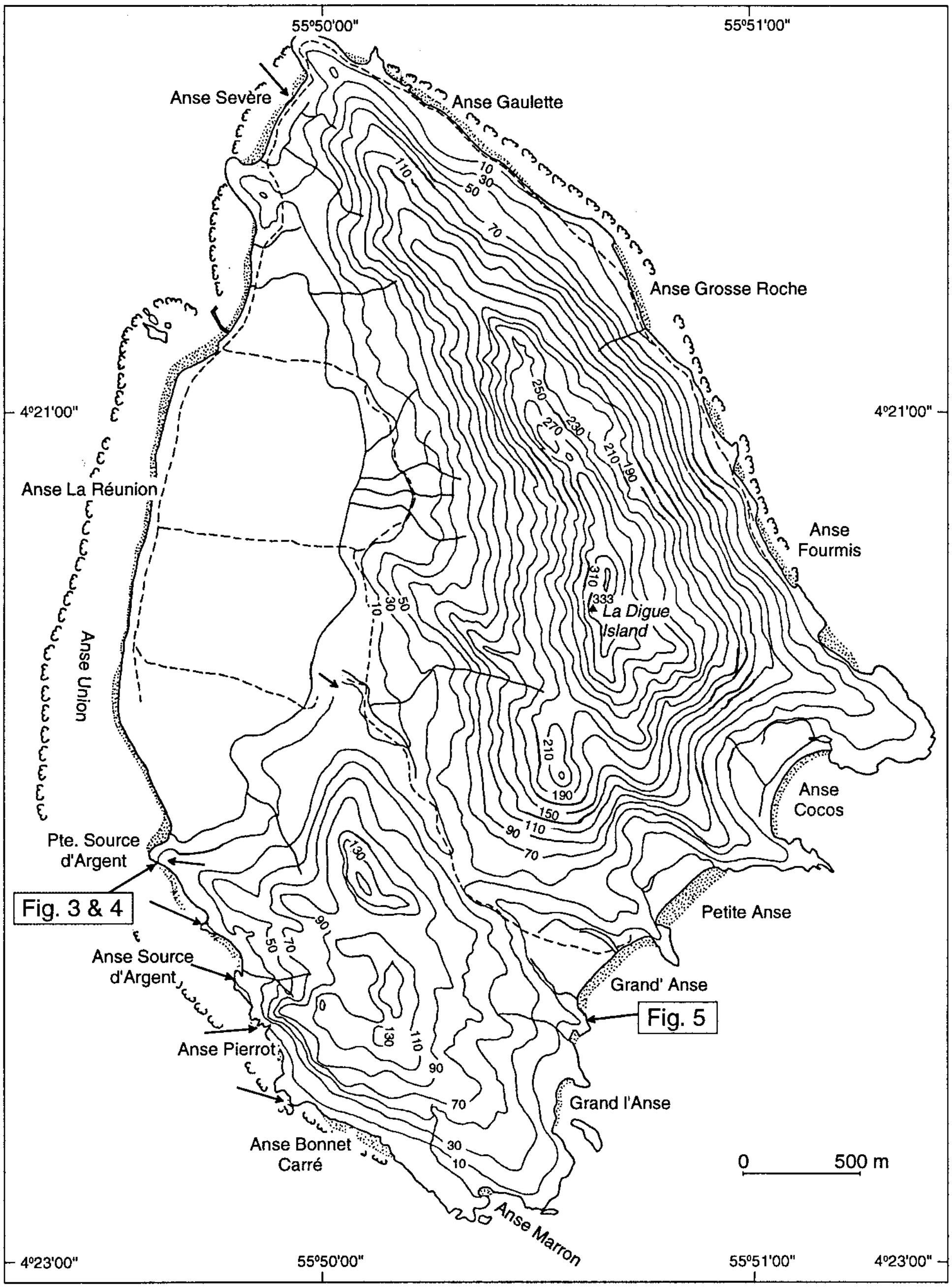

FIG. 2. Topographic map of La Digue Island. The arrows mark where high marine limestones occur. The subsampled sections are located at Pte. Source d'Argent and Grand' Anse.

Generally, the HML can be divided into organic constructs (coral-coralline/algae assemblages) and cemented skeletal rubble (*rubbly deposit*). Montaggioni and Hoang (1988) gave a detailed description of these deposits, including fabric analyses of thin sections from samples on Praslin, La Digue, and Curieuse Islands, and interpreted these in terms of sea-level changes. We, therefore, present only a summarized lithostratigraphic description of two subsampled sections (Tables 1 and 2; Figs. 4 and 5).

The general development of these organic accumulations starts with two different generations of laminated coralline algae–vermetid boundstones that are directly attached to the granite surface and seem to enclose the main part of the HML complex (Fig. 3 and unit 1 in Figs. 4 and 5). Within the main complex, thin coral layers alternate with laminated coralline algae or coralline algae–vermetid layers of varying thickness (units 2–11 in Fig. 4 and units 2–3 in Fig. 5). In the upper part of the section, coral growth decreases and is replaced by

TABLE 1
Lithostratigraphic Description of the Point Source d'Argent Section

Units	Thickness (cm)	Lithostratigraphy
1	10	Laminated coralline algae–vermetid boundstone attached to granite boulder surfaces
2	10	Single coral colonies with coralline algae
3	6	Laminated coralline algae–vermetid layers
4	0–5	Single coral colonies with coralline algae
5	0–20	Weakly to firmly cemented clast-supported *rubbly deposit* with weakly rounded coral and mollusc fragments (*Turbo, Tridacna*), coralline algae crusts, foraminifers, and quartz grains
6	0–10	Massive rounded coral colonies
7	5	Laminated coralline algae layers
8	5	Massive rounded coral colonies
9	25	Alternating layers of domal coral colonies and laminated coralline algae (0.5–3 mm)
10	0–10	Laminated coralline algae layers
11	6–10	Alternating layers of coral colonies (4–30 mm), coralline algae–vermetids (4–40 mm) and coralline algae–foraminifers (6 mm)
12	15–20	Laminated coralline algae–vermetid layers
13	0–15	Laminated coralline algae layers
14	14	Weakly to firmly cemented clast-supported *rubbly deposit* with weakly rounded coral and mollusc fragments (*Turbo, Tridacna*), coralline algae crusts, foraminifers, and quartz grains
1	0–8	Laminated coralline algae–vermetid boundstone attached to granite boulder surfaces

laminated coralline algae–vermetid layers (units 11–13 in Fig. 4 and unit 4 in Fig. 5). Following Montaggioni and Hoang (1988), the biotic communities of these accumulations were originally confined to marine cliffs and overhangs within the subtidal zone and developed vertically rather than building true fringing reefs. These authors refer to the presence of *Leptastrea*, which preferentially inhabits vertical submarine slopes, and compare the coral accumulations with eastern Mediterranean corraline algae–vermetid pavements.

The top of the sections consists of a weakly to firmly cemented clast-supported conglomerate (unit 14 in Fig. 4 and unit 5 in Fig. 5). This poorly sorted unit is composed of weakly rounded coral and mollusc fragments (*Turbo*, *Tridacna*), coralline algae crusts, foraminifers, and quartz grains. This unit can be compared to reef-associated, intertidal to supratidal conglomerates and may be interpreted as an ancient-storm-generated feature (Montaggioni and Hoang, 1988).

In the section at Pte. Source d'Argent, the coral accumulation between units 2–4 and 6–11 (Figs. 3 and 4) is interrupted by the deposition of another conglomerate (unit 5), which shows erosive lower and upper boundaries. The corals in units 2–4 are mainly composed of small colonies with a more planar growth, whereas those in units 6–11 developed as rounded, domal corals (Table 1). In contrast, the section at Grand'Anse shows fairly large domal coral colonies in its lower part (unit 2) that become gradually smaller and covered by coralline algae farther up the section (Table 2). All coral colonies sampled for analyses are in a growth position.

Based on a fabric analysis of thin sections, Montaggioni and Hoang (1988) interpreted the coral–coralline algae–vermetid complexes as reflecting a gradual rise in sea level (coral growth), which was interrupted several times by a relative sea-level stability (coralline algae–vermetid layers, partly with encrusting foraminifers). The fabrics of the uppermost con-

TABLE 2
Lithostratigraphic Description of the Grand' Anse Section

Units	Thickness (cm)	Lithostratigraphy
1	35	Laminated coralline algae–vermetid boundstone attached to granite boulder surfaces
2	25	Fairly large coral colonies
3	35–42	Alternating layers of corals (2–8 cm), coralline, algae–vermetids (0.5–3 cm) locally with quartz grains, laminated coralline algae (0.2–0.5 cm), encrusting foraminifers (0.5 cm) and coralline algae–foraminifers (3 cm)
4	20	Laminated coralline algae–vermetid layers
5	30	Weakly to firmly cemented clast-supported *rubbly deposit* with weakly rounded, reworked, and fragmented corals, *Turbo, Tridacna, Trochus, Cornus, Natica, Cyprea,* coralline algae, encrusting foraminifers, and quartz grains
1	50	Laminated coralline algae–vermetid boundstone attached to granite boulder surfaces

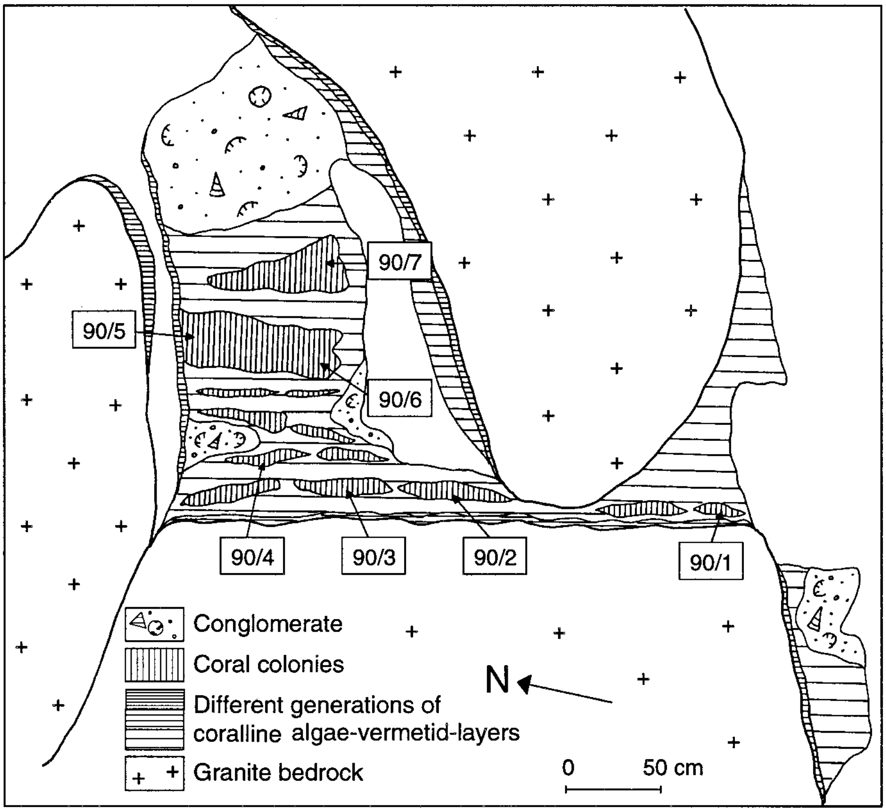

FIG. 3. Schematic drawing of the high marine limestone section at Pte. Source d'Argent and sampling points for corals (90/1 to 90/7). The three coralline algae–vermetid layers indicate different growth generations. See Figure 2 for location of the section.

glomerates, the so-called rubbly deposit, show a transition from intertidal/supratidal to subtidal zones (i.e., they indicate submergence of these sediments during a continued sea-level rise). Gravitational freshwater cement in the uppermost part of the conglomerates or, when this deposit is absent, in the laminated coralline algae–vermetid boundstone indicates a later drop in sea level (Montaggioni and Hoang, 1988).

Montaggioni and Hoang's (1988) model of a gradual sea-level rise followed by a drastic drop in sea level seems to compare fairly well with the development at Grand' Anse. However, it does not account for the intercalation of the intertidal/supratidal conglomerates (unit 5) in the lower part of the section at Pte. Source d'Argent, which seem to divide the sequence into two parts. The stratigraphic position of these reef-associated and possibly storm-generated conglomerates indicates that they may have been deposited prior to the coral growth in units 6–11. However, an alternative possibility is that they were deposited during the same storm event, which formed unit 14, and their deposition eroded the lower part of the section. This latter hypothesis might explain the difference in size and growth of the corals compared to the sequence at Grand' Anse and would imply that the age of the corals in units 2–4 is younger than that of the corals in units 6–11.

SAMPLING

Corals were sampled in the section at Pte. Source d'Argent (7 samples) and at Grand' Anse (3 samples) on La Digue Island (Figs. 3–5). One additional sample was obtained from Curieuse Island (Table 3). Except for sample 90/4, the same coral species was subsampled in all three sections. The elevations above MSL are given in Tables 3 and 4 for all samples, and their positions are indicated in Figs. 3–5.

Corals for isotopic analyses were examined first by X-ray diffraction (XRD) and then visually with a microscope. XRD analyses were made on bulk coral samples that included walls, septa, and possible cements or sediments trapped in the septa (Table 3). Most samples contained less than 5% calcite (the detection level is about 1%). Signs of recrystallization and secondary calcite were visible under the microscope in several cases, which made it possible to avoid sampling the most obvious calcite. For isotopic analyses, the samples were gently crushed, and only pristine aragonitic coral fragments were used. For samples with more than 5% calcite, special care was taken to avoid calcite when picking fragments for isotopic analyses. However, some calcite may have been included in the analyses.

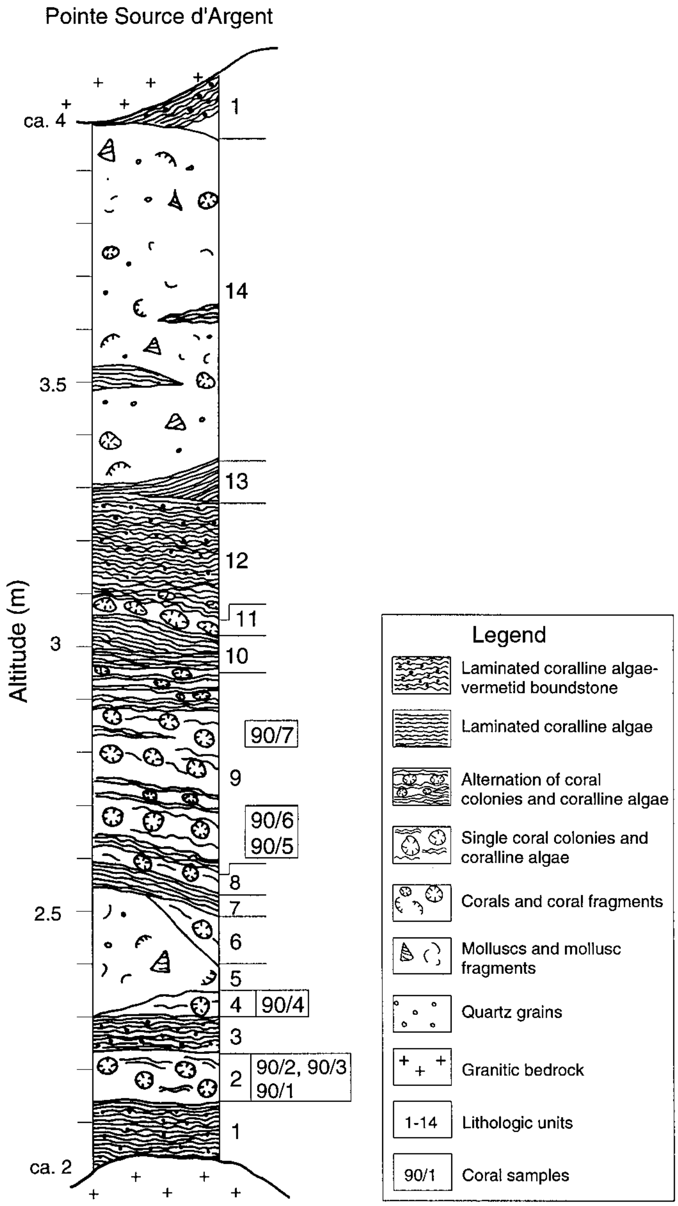

FIG. 4. Detailed lithostratigraphy of the section at Pte. Source d'Argent. Numbers 1–14 denote the different lithostratigraphic units, and 90/1 to 90/7 refer to the sample numbers. See Table 1 for a lithostratigraphic description. The laminated coralline algae–vermetid boundstone of unit 1 is directly attached to the granite boulder surface. See Figure 2 for location of the section.

ANALYTICAL TECHNIQUES FOR U–Th MEASUREMENTS

Uranium and thorium isotope measurements were performed at the Danish Center for Isotope Geology. Between 0.6 and 2.5 g of the sample was dissolved in nitric acid and a mixed ^{229}Th–^{236}U spike was added. Uranium and thorium were chemically separated using anion exchange columns (BioRad, AG 1-X8). The U and Th fractions were loaded separately on zone-refined graphite-coated Re filaments and analyzed in a VG Sector 54-30 mass spectrometer equipped with an ion counter and a 30-cm energy filter. Uranium was typically analyzed at 1650°C and Th at 1780°C. The (^{234}U/^{238}U) activity ratios were calculated using the measured ^{234}U/^{236}U and ^{235}U/^{236}U atomic ratios, assuming a ^{235}U/^{238}U ratio of 137.88 (where parentheses signify activity ratios). The (^{230}Th/^{232}Th) ratio was calculated from the measured ^{232}Th/^{229}Th and ^{230}Th/^{229}Th. The

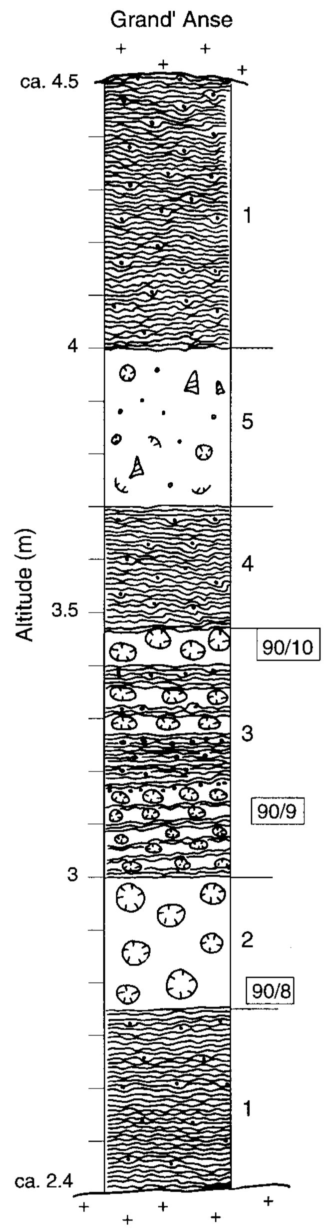

FIG. 5. Detailed lithostratigraphy of the section at Grand' Anse. Numbers 1–5 denote the lithostratigraphic units, and 90/8 to 90/10 refer to the sample numbers. See Table 2 for a lithostratigraphic description. The laminated coralline algae–vermetid boundstone of unit 1 is directly attached to the granite boulder surface. See Figure 2 for location of the section and Figure 4 for legend.

TABLE 3
Samples, Locations on the Seychelles Islands, Coral Species, Elevation, and X-Ray Results from Corals Used for U–Th Isotope Analyses

Sample	Site	Coral species	Elevation[a]	Aragonite/calcite
90/2	Point Source d'Argent/Sec. 1	*Goniastrea*	2.7	100/0
90/3 *wall*	Point Source d'Argent/Sec. 1	*Goniastrea*	2.7	100/0
90/3 whole	Point Source d'Argent/Sec. 1	*Goniastrea*	2.7	100/0
90/4	Point Source d'Argent/Sec. 1	*Porites*	2.9	96/4
90/5	Point Source d'Argent/Sec. 1	*Goniastrea*	3.5	96/4
90/6	Point Source d'Argent/Sec. 1	*Goniastrea*	3.75	91/9
90/7	Point Source d'Argent/Sec. 1	*Goniastrea*	4.0	93/7
90/8	Grand Anse/Sec. 2	*Goniastrea*	2.8	100/0
90/9	Grand Anse/Sec. 2	*Goniastrea*	3.1	100/0
90/10	Grand Anse/Sec. 2	*Goniastrea*	3.45	65/35
90/47	Curieuse	*Goniastrea*	10	91/9

Note. The X-ray analyses were made on bulk samples. Samples for isotope analyses were picked to consist of pure aragonite.
[a] Meters above mean sea level.

mean single-analysis in-run precision (counting statistic) was 0.6% (2 S.E.) for $^{234}U/^{238}U$ and 0.7% for $^{230}Th/^{234}U$. External precision was calculated by repeated measurements of the NBS 960 standard (U 112A). The average $^{234}U/^{238}U$ values were $(5.29 \pm 0.031) \times 10^{-5}$ (2σ, $N = 7$). This corresponds to a $\delta^{234}U$ value of -33 ± 3‰, which is identical within error to results measured in other laboratories (Edwards *et al.*, 1993; Eisenhauer *et al.*, 1993; Henderson *et al.*, 1993; Stirling *et al.*, 1995; Hillaire-Marcel *et al.*, 1996). As external errors are close to the precision for internal errors, we have used internal errors to calculate the ages shown in Table 4. Total procedural blanks were 10 pg for U and 5 pg for Th. The detectable Th blank was only ^{232}Th, and no ^{230}Th was measurable at normal running conditions.

RESULTS OF U–Th MEASUREMENTS

The results of the U and Th isotopic measurements are shown in Table 4. The U contents for all samples but one are between 2 and 3 ppm, which is in the range of what is anticipated for corals (Edwards *et al.*, 1987; Eisenhauer *et al.*, 1993; Henderson *et al.*, 1993; Stirling *et al.*, 1995). Sample 90/4, with a U content of 4.488 ppm stands out and is also the only *Porites* species analyzed. The U content is almost twice as great as for the other corals, and it also appears to be more porous than the other analyzed corals. Therefore, the age obtained should be interpreted with care.

The $\delta^{234}U(t)$ value is the time-corrected apparent initial U isotopic composition. Given that the $\delta^{234}U$ value of seawater

TABLE 4
U–Th Isotope Data and Concentrations from Seychelles Corals

Sample[a]	Elevation (m MSL)	^{232}Th (ppb)	^{238}U (ppm)	$\delta^{234}U(0)$[b]	$\delta^{234}U(t)$[b]	$(^{230}Th/^{238}U)$	Age (yr B.P.)[c]
90/2	1.7	0.56	2.803	110 ± 4	157 ± 4	0.7676 ± 0.0029	123,600 ± 1100
90/3 *wall*[d]	1.7	9.19	2.030	114 ± 4	160 ± 4	0.7645 ± 0.0041	122,500 ± 1400
90/3 *whole*[d]	1.7	95.42	2.338	113 ± 3	160 ± 3	0.7645 ± 0.0026	122,500 ± 1100
90/4	1.9	44.66	4.488	113 ± 7	165 ± 7	0.8037 ± 0.0106	(134,500 ± 2800)
90/5	2.5	0.28	2.818	101 ± 8	145 ± 8	0.7768 ± 0.0038	129,200 ± 2200
90/6	2.75	0.53	2.526	110 ± 5	158 ± 5	0.7786 ± 0.0035	127,500 ± 1700
90/7	3.0	1.19	2.495	114 ± 7	165 ± 7	0.7921 ± 0.0038	130,700 ± 2100
90/8	2.9	0.79	2.735	110 ± 9	157 ± 9	0.7723 ± 0.0074	125,600 ± 2800
90/9	3.1	12.90	2.914	109 ± 4	158 ± 4	0.7821 ± 0.0042	128,700 ± 1600
90/10	3.45	127.02	2.494	109 ± 6	157 ± 6	0.7794 ± 0.0082	127,900 ± 2800
90/47	6.0 ± 1	24.15	2.932	103 ± 5	148 ± 5	0.7741 ± 0.0038	127,700 ± 1800

[a] *Whole* corals are wall and septa.
[b] $\delta^{234}U = [(^{234}U/^{238}U)/(^{234}U/^{238}U_{eq})] - 1) \times 10^3$. Parentheses on ratios signify an activity ratio. $(^{234}U/^{238}U_{eq})$ is the activity ratio at secular equilibrium.
[c] The ages are calculated using the equation $(^{230}Th/^{238}U) = (1 - e^{-\lambda 230 t}) + [(^{234}U/^{238}U) - 1]\ [\lambda_{230}/\lambda_{230} - \lambda_{234}][1 - e^{-(\lambda 230\ -\ \lambda 234)t}]$.
[d] Errors are expressed as 2σ. Analyses were made at the Department of Earth Sciences, The Open University, using the same mixed ^{239}Th–^{236}U spike.

should not have changed much over at least the last 200,000 yr, this value should be close to the modern isotopic composition of seawater ($\delta^{234}U = 149$‰). (Henderson *et al.*, 1993; Gallup *et al.*, 1994). It has been observed previously that interglacial corals often have $\delta^{234}U(t)$ values higher than those of modern seawater. High initial $\delta^{234}U$ could be the result of diagenetic processes (Hamelin *et al.*, 1991; Stein *et al.*, 1993; Bard *et al.*, 1996; Gallup *et al.*, 1994). The corals in this study have $\delta^{234}U(t)$ values between 145 ± 8 and 165 ± 7‰, but no connection exists between high $\delta^{234}U(t)$ values and age. Other authors have concluded that there is no simple relationship between higher-than-modern $\delta^{234}U$ values and the age of corals. Bard *et al.* (1996) simply considered that U–Th coral ages are most reliable when $\delta^{234}U(t)$ values are between 145 and 165‰. This conclusion is also supported by combined U–Th and U–Pa analyses of corals from Barbados, which showed that ages were concordant when the $\delta^{234}U(t)$ values were less than 165‰ (Edwards *et al.*, 1997). Based on the initial U isotopic composition criteria, none of the coral ages in this study should be disqualified.

The presence of ^{232}Th indicates either the incorporation of detrital Th during the growth of the coral or later contamination by detrital material. The ^{232}Th contents of the corals (Table 4) are between 0.28 and 127.02 ppb with an average of 28.8 ppb. Low ^{232}Th concentrations could indicate uncontaminated corals, and some authors have demonstrated a relationship between ^{232}Th content and age (Stein *et al.*, 1991). Most of the samples analyzed in this study have a considerably higher ^{232}Th concentration than what is normally observed in corals from oceanic islands. Such corals typically have ^{232}Th contents of <0.5 ppb (Edwards *et al.*, 1987). The higher ^{232}Th contents in the Seychelles corals could be attributed to the granitic composition of the islands, i.e., a siliceous source is much closer to the corals than is normally the case for ocean islands or carbonate platforms. If the high ^{232}Th content is a result of the initial contamination of siliceous material and not later diagenesis, we can estimate the effect of correction for the initial Th. Following Stein *et al.* (1991), and assuming that the corals contain a detrital component with a Th/U ratio of 3.8 (average extraneous silicates) and with U-series isotopes in secular equilibrium, we can calculate the concentration of inherited ^{238}U and ^{230}Th associated with the ^{232}Th in the samples. If we correct the samples with the highest ^{232}Th concentration (127 ppb, Sample 90/10; Table 2), the calculated age after correction for initial U and Th is approximately 1500 yr younger than the uncorrected age. For all other samples analyzed in this study, the correction will be much less. Because there is a considerable uncertainty in estimating the detrital Th/U ratio, and the correction for all samples is smaller than the analytical precision, we did not correct any of our ages for inherited U and Th. In addition, Sample 90/3 (Table 4) gives the same age for both the *wall* and the whole coral, although the ^{232}Th content in the whole coral is 10 times higher. This result indicates that an elevated ^{232}Th content, at least for the corals in this study, is not important for the age estimate.

DISCUSSION

Previous studies of the last-interglacial corals showed that sea level was above modern levels between 130,000 and 117,000 yr B.P. and that a major reef-building event possibly occurred between 127,000 and 122,000 yr B.P. (see Stirling *et al.*, 1995, for an overview; Edwards *et al.*, 1997). Ten of the U–Th ages from the Seychelles Islands fall between 131,000 and 122,000 yr B.P. and are in good agreement with other observations of the last-interglacial high sea level. The only exception is Sample 90/4, which has an anomalously high U content and an age of 134,500 yr B.P.

The ages obtained from the Seychelles Islands compare well with U–Th ages obtained from the nearby Aldabra atoll (Fig. 1; Thomson and Walton, 1972). However, the reefs from Albabra overlie a volcanic basement, and its geologic and tectonic history is completely different from that of the granitic Seychelles Islands. Therefore, it is probably not appropriate to compare sea levels from the two sites.

The U–Th ages from the Seychelles Islands cluster into one age group. However, field evidence suggests that Samples 90/2 and 90/3 from Pte. Source d'Argent are somewhat younger than the other samples. These two samples are situated in the lower part of the section (unit 2, Fig. 4) and have ages between 122,500 ± 1100 and 123,600 ± 1100 yr B.P. The remaining samples from Pte. Source d'Argent (unit 9), as well as those from Grand' Anse and Curieuse Islands, give stratigraphically consistent ages ranging between 125,600 ± 2800 and 130,700 ± 2100 yr B.P. A characteristic feature of the section at Pte. Source d'Argent is the occurrence of possibly storm-generated conglomerates, which are intercalated between the coral layers of units 4 and 6. Furthermore, the coral colonies in the lower part of the section differ in size and growth from those in the upper part and also from those observed at Grand' Anse and on Curieuse Island. The U–Th ages (Table 4) of the corals in unit 2 are younger than those of corals at a higher stratigraphic level in the same section. A possible explanation for these *inverted* ages is that the lower part of the section was eroded during the storm event that generated the reef-associated intertidal to supratidal conglomerates of unit 14. Subsequent coral growth, but in the form of small colonies, later filled the generated cavities.

The U–Th measurements and the elevation of the corals from La Digue Island (Figs. 3–5), combined with the fabric analyses performed by Montaggioni and Hoang (1988), allow us to outline a tentative sea-level history (Fig. 6). The sections at Pte. Source d'Argent and Grand' Anse, where the oldest corals are found at an elevation of 3.45 m, indicate that coral reef buildup began no later than ca. 131,000 yr B.P. (Sample 90/7; Table 4). The general rise in sea level may have been punctuated by several periods of relative stability, during

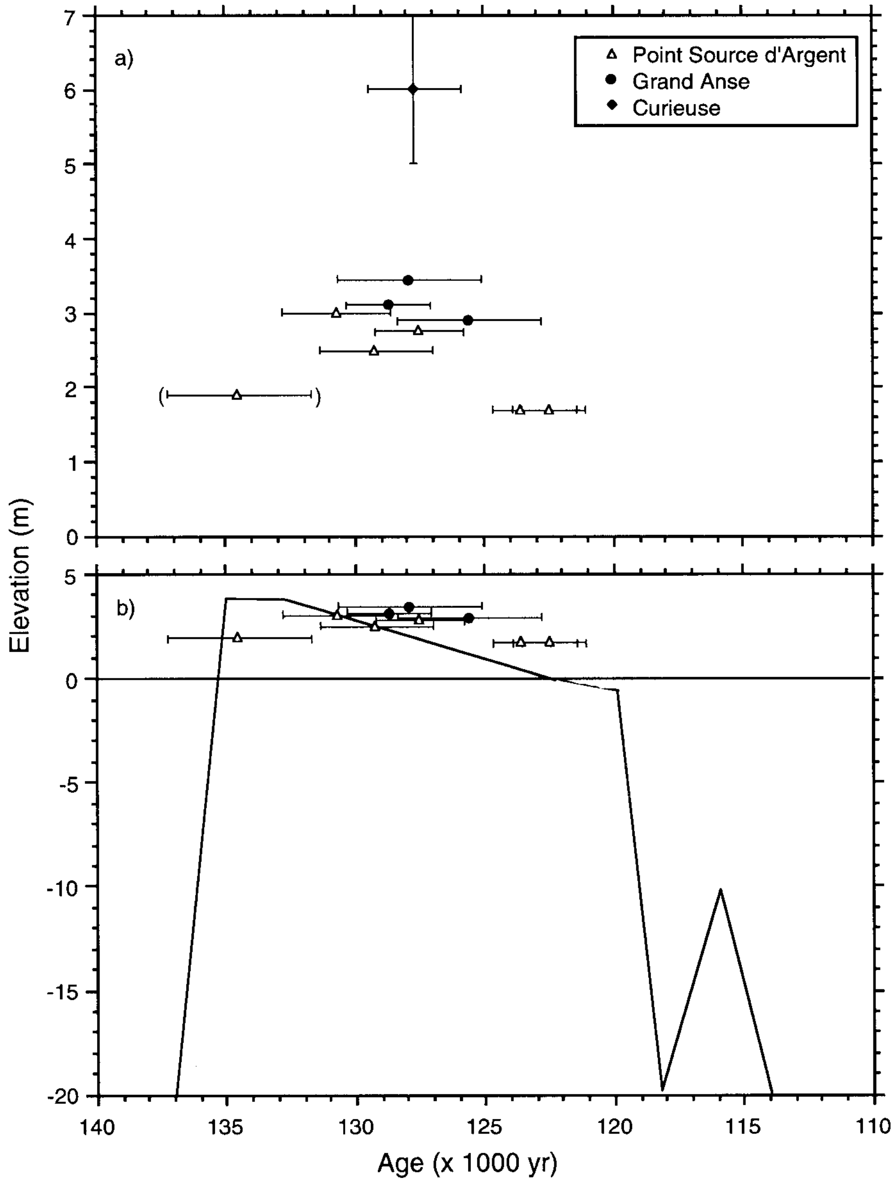

FIG. 6. (a) Plot of elevation vs age for the corals from the Seychelles Islands and analyzed in this study. The brackets on Sample 90/4 indicate that the age is less reliable because of the high U content. (b) The same data set as in (a), except for the sample from Curieuse Island, compared to the predicted relative sea level in western Australia (Lambeck and Nakada, 1992).

which the intercalated coralline algae–vermetid layers were formed (Montaggioni and Hoang, 1988). These assemblages can be found in the uppermost part of the subtidal zone in modern reefs. Their occurrence shows that sea surface repeatedly lay just above the present position of these layers (Montaggioni and Hoang, 1988). Storm-generated intertidal to supratidal conglomerates lie discordantly on top of the coral–coralline algae accumulations. During their deposition, the lower part of the section at Pte. Source d'Argent perhaps was eroded. Differences in cementation in the uppermost conglomerates indicate that they may have been situated in the subtidal zone before sea level finally fell (Montaggioni and Hoang, 1988). However, the submergence of the uppermost conglomerates cannot have been of long duration, because no coral colonies developed on top of unit 14 in any of the studied sections. Renewed coral growth in the eroded cavities in the lower part of the sequence at Pte. Source d'Argent (unit 2) between 123,600 and 122,000 yr B.P. more likely was related to a phase of general sea-level lowering, rather than to the short subtidal phase recognized in the conglomerates of unit 14.

Our data may be interpreted in terms of a general rise in sea level until ca. 131,000 yr B.P., followed by a fall in sea level between 131,000 and 122,000 yr B.P. (Fig. 6). This interpretation agrees with the predicted sea-level curve of Lambeck and Nakada (1992) for the last interglaciation and may be taken as support for their model of glacio-hydroisostatic rebound. This model indicates that the last-interglacial sea level was not the same for sites that lie far from the margins of the major ice sheets. This difference is due to the effect of isostatic uplift in response to changes in ice-sheet loading and implies that far-field sites, such as the Seychelles Islands, will experience a different sea-level history during an interglaciation than sites that lie close to the major ice margins (e.g., Bermuda and the Caribbean Islands). According to Lambeck and Nakada's (1992) model, the initial rise of the last-interglacial sea level occurred some time between 137,000 and 135,000 yr B.P. (Fig. 6). After a ca. 2000-yr period of stable sea level, a sea-level drop occurred between ca. 133,000 and 120,000 yr B.P. However, the Lambeck and Nakada model is based mostly on U–Th ages with large errors. Their model apparently has not been confirmed by more recent mass spectrometer U–Th ages.

Reconstructing the last-interglacial sea level from a given site is complicated because sea-level curves are a function of eustatic, tectonic, and gravitational parameters. However, the corals from the Seychelles Islands grew directly on granite surfaces. If we follow Mart's (1988) assumption that these islands were relatively stable tectonically since the Late Eocene, a sea-level curve based on corals from the Seychelles Islands should mainly reflect eustatic changes.

CONCLUSIONS

Selected last-interglacial corals from elevated reefs on the Seychelles Islands have U–Th ages between 131,000 and 122,000 yr B.P., which is in good agreement with previous dating of higher-than-present sea level. Elevation-age relations reveal a last-interglacial sea-level fall between 131,000 and 122,000 yr B.P., which could be the result of glacio-hydroisostatic rebound.

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