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# Stratigraphic and Tectonic Implications of Uranium-Series-Dated Coral Reefs from Uplifted Red Sea Islands

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Corals from raised reef terraces on two islands (Zabargad and Northern Brother), considered to have been tectonically uplifted in connection with the Red Sea rifting, were dated with the U-series method. At Zabargad, there are at least three systems of raised coral reefs. The oldest terrace (>290,000–300,000 yr B.P.) is found at + 10 to + 15 m. A 200,000 yr B.P. high-sea stand is recorded by a terrace relict at + 17 m on peridotite bedrock; the youngest system (125,000–138,000 yr B.P.) is very well represented around the island, with terraces at about +6 to +8 m. Corals from Northern Brother yield ages of 132,000–135,000 and 204,000 yr B.P. suggesting the existence of two systems of interglacial raised reefs. Both islands appear to have been tectonically quite stable since at least 125,000 yr B.P. 

## INTRODUCTION

Quaternary uplifted coral reefs are a common coastal feature along the Earth's tropical belt and their study offers an independent and unique tool for better understanding some geological events, primarily paleoclimatic and sea-level changes (e.g., Aharon and Chappell, 1986).

Much attention has been devoted to the precise dating of coral terraces in order to evaluate relative sea-level changes in regions considered tectonically "stable" or affected by a known and constant uplift rate. The most reliable method rests on the dating of unrecrystallized scleractinian corals by the U-disequilibrium method (e.g., Bloom *et al.*, 1974). Precise dating of raised coral reefs, however, can be also useful in the evaluation of negative or positive vertical movements of a given coastline with respect to a known paleo-sea level, thus assuming the role of a geodynamic tool (e.g., Marshall and Launay, 1978; Montaggioni and Hoang, 1988). Unfortunately, this can be done only with respect to the last interglaciation, the sea-level position of which at about 125,000 yr B.P. has been assessed with relative confidence; the general consensus is that sea level was then approximately 6 ± 2 m higher than today (e.g., Matthews, 1973; Bloom *et al.*, 1974).

In this study, we have applied the $^{230}Th/^{234}U$ method to date the raised coral terraces of some Red Sea islands (Zabargad-Rocky island, Northern Brother) whose origins have recently been inferred to be linked directly to rifting of the Red Sea. Furthermore, we have also dated a coral terrace from the Egyptian mainland at Ghardaqa in order to have a comparative example from a presumably more stable area located directly on the Nubian plate.

Our goals were (i) to establish a more precise chronology of the geologically young and poorly defined raised reef terraces for a better stratigraphic assessment of these Red Sea islands, and (ii) to test their tectonic "vertical" behavior at an intermediate time-scale in light of the suggestion that both islands originated in response to compressional forces active within a transform fault domain (see below). In this respect, strong vertical tectonism in a similar structural setting is well documented on Tiran Island, at the intersection between the Red Sea and the Dead Sea–Gulf of Aqaba transform, where Quaternary coral terraces are



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hundreds of meters above the present sea level (Y. Bartov, pers. comm., 1982).

## ZABARGAD ISLAND

The tiny island of Zabargad (or St. John's) is located at 23°37′N, about 50 km off the Red Sea axial trough. The island, with the satellite islet of Rocky Island, represents the subaerial expression of a large submarine structure largely peridotitic in nature and extending to a depth of at least 8 km (Styles and Gerdes, 1983). Zabargad lies close to the northern boundary of the Red Sea transition zone (Cochran, 1983), that is, the region roughly lying between 20° and about 24°N where seafloor spreading is now occurring only in separate cells (Bonatti, 1985).

In the past few years, the geology of the island has received considerable attention due to its importance in understanding the rifting dynamics of the Red Sea (Bonatti, 1988, and references therein). Abandoning an earlier suggestion that the island was a fragment of Precambrian basement (El Shazly and Saleeb Roufaiel, 1979), Bonatti *et al.*, (1983) have proposed that Zabargad represents an uplifted fragment of Red Sea sublithosphere, an hypothesis which has been favorably received. While the asthenospheric intrusion (mantle diapirism) during the early Red Sea rifting seems well supported by geological, petrological, structural, and kinematic data (Bonatti *et al.*, 1983, 1988; Nicolas *et al.*, 1987), the final mechanism of formation of the island, i.e., its subcrustal motion and its "uplift" as a cooled block above sea level, is still debated. One hypothesis links this second event to a compressional regime developed between a paleoshear zone (Zabargad Fracture Zone) and the Red Sea propagating rift (Bonatti *et al.*, 1984; Crane and Bonatti, 1987). This model implies that the island formed in response to compressional stresses in a transform fault domain. A second hypothesis contends that the mantle prism to which Zabargad belongs did not subside during the stretching of the basin, because of its greater strength with respect to the surrounding crust (Nicholas *et al.*, 1987). According to this view, the island acted as a rather passive block; thus, vertical tectonism is not expected to be as prominent as in the previous case, but possibly limited to minor isostatic readjustments. However, it is very difficult to explain how the denser, cooled peridotites were able to almost reach the surface through Cenozoic sedimentary rocks (including Miocene evaporites) without any major compressional event.

The major premodern units cropping out at Zabargad are (Bonatti *et al.*, 1983):

(1) Fresh, largely unserpentinized peridotites;

(2) Metamorphic rocks (gneiss and amphibolites);

(3) Doleritic-basaltic dikes;

(4) Sandstone, limestone, and black shale of the Zabargad Formation (post-Jurassic);

(5) Evaporites (Miocene);

(6) Old Reef Limestones;

(7) Old conglomerates and breccias; and

(8) Young Reef Limestones.

Sedimentary units 4 and 5 were deposited before the beginning of true seafloor spreading in the Red Sea, which started about 5 myr ago (Cochran, 1983) in the southern part but is only incipient in the sector of the Red Sea transition zone where Zabargad Island is located (Bonatti *et al.*, 1984; Bonatti, 1985). Sedimentary units 6 to 8 represent the first unequivocal proof that the Zabargad peridotitic block was already an island at the time of their deposition.

Unfortunately no definite age can be assigned to units 6 and 7. The Old Reef Limestones are represented by biocalcarenites and reefal limestones attesting to shallow depositional environments. Although very fossiliferous, this unit has been strongly recrystallized and most of its fossil content is now represented by molds of corals, mollusks, and echinoids. The Old Reef Limestones are tentatively assigned to the Pleistocene (Bonatti *et al.*, 1983), but the lack of any clear biostratigraphic marker leaves the stratigraphic age open. In spite of extensive efforts, no unrecrystallized corals have been found, so it has not been possible to date them radiometrically.

The Old conglomerates and breccias are generally barren of fossils and believed to be older than the Young Reef Limestones because they lack clasts from this latter unit.

The last premodern unit, a series of raised terraces informally grouped under the name of Young Reef Limestones (YRL), is represented by uncemented reefal and lagoonal deposits forming terraces at various sites and altitudes around the island. Bonatti *et al.* (1983) proposed a latest Pleistocene (Eemian) age for this unit by analogy with similar deposits cropping out elsewhere in the Red Sea coastal region.

## NORTHERN BROTHER

Northern Brother, one of the two islets known as The Brothers, is located in the northern Red Sea at 26°18′N, within the "late stage continental rifting" region of Martinez and Cochran (1988) where seafloor spreading oceanization cells have not yet developed. The geology of the island has been described by Taviani *et al.* (1986). The bedrock consists of gabbroic rocks intersected by doleritic dikes and directly capped by Quaternary reef carbonates.

Taviani *et al.* (1986) have hypothesized that The Brothers represent a sliver of lower crust tectonically uplifted in response to localized compressional forces that are related to a presumed transform fault (Brothers Fracture Zone of Crane and Bonatti, 1987), a setting roughly similar to the one proposed for Zabargad by Bonatti and co-workers. On the other hand, Nicolas *et al.* (1987) considered that their alternative model of a "subsidence-resistant" block within the stretching regime can also be safely applied to The Brothers.

## DESCRIPTION OF SAMPLES

The coral samples were collected by one of us (MT) in 1979 and 1983 (CNR Red Sea Cruises MR 79 and MR 83) and in 1980 (CNR Egypt expedition). Their exact locations are listed below. Approximate altitudes above present mean sea level were determined by using a metric line and were recorded on a 1:10,000 scale topographic base derived from Moon's (1923) geologic map. Proposed reefal facies were derived from field observations and mostly based on scleractinian corals and molluscs.

*Zabargad Island.* Samples were collected at the following stations (Fig. 1):

(a) Western side of Aragonite Point, terraces at ca. 6- to 8-m altitude; backreef lagoon to reef crest complex (estimated paleodepth 1 ± 1 m); bedrock: Zabargad Fm;

(b) Dike Beach, terraces at ca. 6- to 8-m altitude; probably reef crest (estimated paleodepth 1 ± 1 m); bedrock: dolerite;

(c) Southern side of Peridot Point at about 17-m altitude; exposure is rather poor and life-position of the coral questionable; reefal facies uncertain, possibly reef crest (paleodepth uncertain but shallow); bedrock: peridotite;

(d) Turtle Beach at about 12- to 15-m altitude; uppermost part of reef slope (estimated paleodepth 2–4 ± 1 m); bedrock: peridotite;

(e) Southwesternmost part of Turtle Point at ca. 10- to 12-m altitude; uppermost part of reef slope (paleodepth 2–4 ± 1 m); bedrock: Old Reef Limestones;

(f) Rocky Island, a small islet about 5 km southeast of Zabargad, but belonging to the same structural block (Styles and Gerdes, 1983); terrace at about 2- to 3-m altitude; reef flat to reef crest complex (estimated paleodepth 1 ± 1 m); bedrock: probably Old Reef Limestones.

*Northern Brother.* A lithified coral reef limestone caps the gabbroic bedrock reaching an altitude of about 10 m; *in situ* or little-displaced loose corals, from unlithified raised reefs not clearly arranged in distinct terraces, were collected from about 6- to 8-m altitude; reef crest to uppermost part of reef slope (estimated paleodepth 1–2 ± 1 m); bedrock: gabbro.

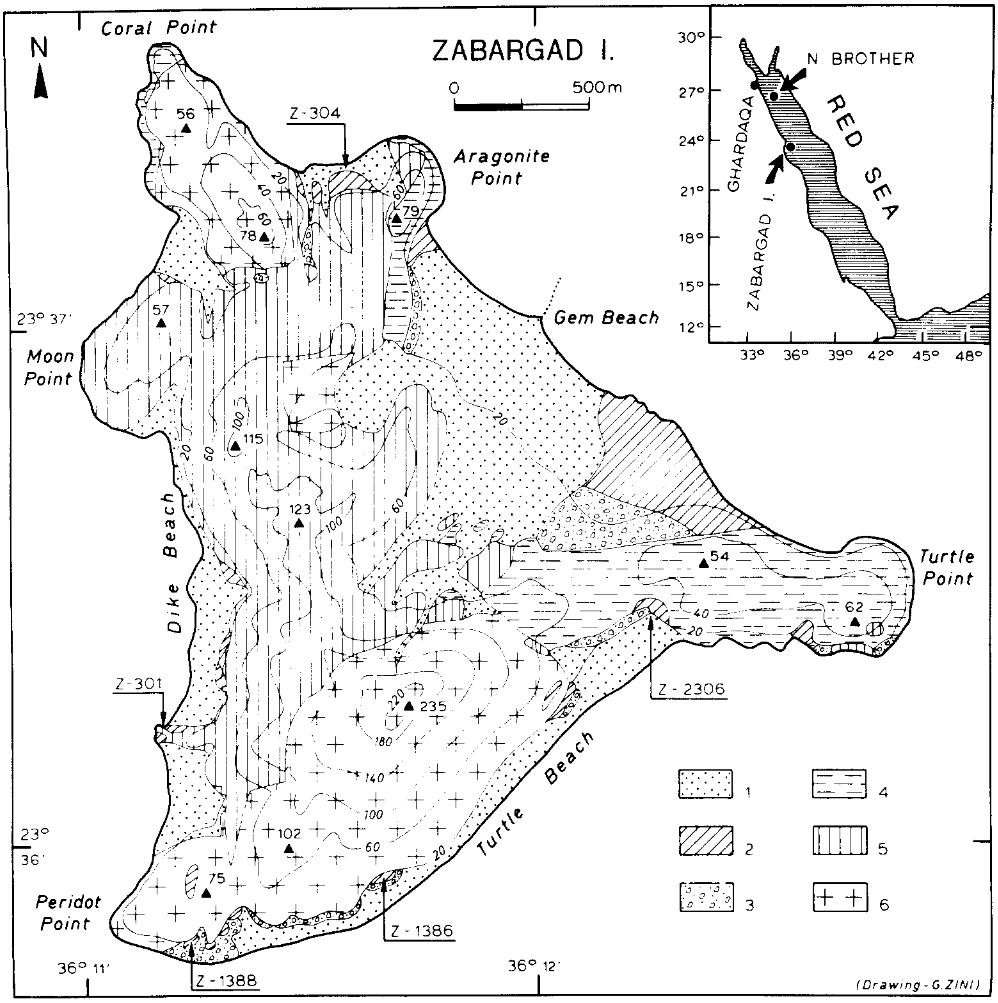


FIG. 1. Geologic map of Zabargad Island, Red Sea (modified from Bonatti *et al.*, 1983). Symbols are as follows: (1) Alluvium; (2) Young Reef Limestones; (3) Old conglomerates and breccias; (4) Old Reef Limestones; (5) Pre-Quaternary units; (6) Peridotites. Toponomastic names from Zabargad Island are introduced by the authors of the present paper.

*Ghardaqa* (*Egypt*). Near the Sheraton Hotel, raised coral reef at about 6- to 7-m altitude; backreef lagoon to reef crest complex (estimated paleodepth 1 ± 1 m); bedrock: unknown.

## ANALYTICAL METHODS

Samples were cleaned by ultrasonic scrubbing, dried at 100°C, ground into a fine powder, and then ashed for about 8 hr at 700°C. Because recrystallized corals are notoriously unreliable age-indicators (Chappell *et al.*, 1974), the relative abundance of calcite in each sample was determined by X-ray diffractometry. This operation, however, does not reveal the potential contamination of secondary aragonite cements (e.g., Taviani and Rabbi, 1984) which may affect the age of the sample. Examination under a binocular microscope did not show any visible trace of secondary cement. The radiochemical procedure used here is essentially that described by Ku (1965) with minor modifications. The method of Ku (1965) is generally accepted as a standard procedure for noncarbonate sediments and modifications to it can be applied to the analysis of different matrices, e.g., $CaCO_3$ speleothems (Harmon *et al.*, 1975). It consists of total dissolution of the samples to be analyzed. At the beginning, the powdered samples were slowly dissolved by 8 *N* HCl until effervescence ceased. $^{232}U$–$^{228}Th$ in radioactive equilibrium, used as a spike, was then added to the solution, together with a $Fe^{3+}$ carrier. Any acid insoluble residue was destroyed by the addition of a mixture of concentrated $HNO_3$–$HClO_4$–HF acids. This acid mixture was evaporated to dryness on a hot plate and then leached with 6 *N* HCl and $H_2O$. The leachates were added to the first solution. Iron hydroxide (which will have absorbed almost all the U and Th) was precipitated using $NH_4OH$. The uranium and thorium were separated and purified by a combination of ion-exchange and solvent extraction techniques. They were then plated on stainless disks or aluminum foils and analyzed by alpha spectrometry using silicon barrier surface detectors.

## RESULTS

Analytical results are shown in Table 1. Almost all the analyzed samples contain only traces of calcitic recrystallization (<3%), with the exception of samples Z-1386/B and RI-3 that contain 6% calcite. The radiometric dates of those samples, however, are stratigraphically consistent, although it does not automatically validate their accuracy (Stearns, 1984).

$^{232}Th$ in all cases is under the detection limit. Uranium concentrations are in the range of the values usually observed in fossil corals (2–4 ppm), except for sample Z-1386/B which is considerably lower in uranium (0.72 ppm).

$^{234}U/^{238}U$ ratios for the 9 samples displaying finite $^{230}Th$ ages have been corrected for the decay of $^{234}U$ using their Th ages. The initial $(^{234}U/^{238}U)_0$ values are consistent, within experimental error, with the present-day sea water value of $1.15 \pm 0.03$; this is in agreement with Kaufman (1986) who reports that the distribution of $^{234}U/^{238}U$ ratios in 104 corals having an age of 125,000 yr shows a deviation of at least 3% from 1.15 in about one-third of all cases.

Samples Z-1386/A,B,C and Z-2306 present a $^{230}Th/^{234}U$ ratio equal or very close to unity. For these samples only minimum $^{230}Th$ ages can be given, but $^{234}U/^{238}U$ ages have been calculated assuming an initial $^{234}U/^{238}U$ ratio of 1.15. The dates thus obtained support the minimum $^{230}Th$ ages and confirm that the oldest YRL at Zabargad are older than 300,000 yr.

### *Zabargad Island*

The $^{230}Th/^{234}U$ ratios obtained from our study of Zabargad indicate three groups of ages.

(a) Terraces at about 2- to 3- and 7- to 8-m altitude (samples Z-301/B, Z-304/A and B; RI-3) yield ages from 125,000 to 138,000 yr B.P. indicating a last-interglacial age (oxygen isotope substage 5*e*). Two peaks for the last interglaciation, centered around 125,000 and 135,000 yr, are recurrent in the $^{230}Th/^{234}U$ records of raised coral reefs (e.g., New Guinea: Bloom *et al.*, 1974; Chappell, 1983); this evidence seems to be rather firm, although no recorded everywhere (Stearns, 1984). In the Red Sea, ages for the same time-span have also been obtained for coral samples from Pleistocene terraces more to the south, along the Red Sea coast of Sudan (C.T. Hoang, unpubl. data), Ethiopia and Djibouti (Hoang *et al.*, 1980; Faure *et al.*, 1980), at the Dahlak Archipelago (Conforto *et al.*, 1976), and in the northern part of the Red Sea, along the Sinai coast (Gvirtzman and Buchbinder, 1978, and references therein; Kronfeld *et al.*, 1982). Concerning Zabargad, where the overall exposure and preservation of raised reefs is relatively poor, it is difficult to establish unequivocally whether the two age clusters recorded by our analyses are real and indicate two distinct periods of high-sea-level reef growth. In addition, corals having discrepant ages were sampled from the same reefal deposits that likely represent a single morphostratigraphic unit.

(b) A single coral sample from a poor ex-

TABLE 1. RADIOCHEMICAL DATA AND AGES OF CORAL SAMPLES FROM RAISED REEFS OF RED SEA OFFSHORE ISLANDS (ZABARGAD, ROCKY ISLAND, AND NORTHERN BROTHER) AND EGYPTIAN MAINLAND

| Sample number | Location | Coral | Altitude (m) | Calcite (%) | U (ppm) | $^{234}U/^{238}U^a$ | $^{230}Th/^{234}U^a$ | $^{230}Th$ age[b] ($10^3$ yr) | $[^{234}U/^{238}U]_0$[c] | $^{234}U/^{238}U$ age[d] ($10^3$ yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| Z-301/B | Zabargad | Favidae | 6–8 | 2 | 2.39 ± 0.06 | 1.09 ± 0.03 | 0.705 ± 0.025 | 129 ± 10 | 1.13 ± 0.04 | |
| Z-304/A | Zabargad | *Acropora* | 6–8 | 0 | 3.19 ± 0.07 | 1.14 ± 0.02 | 0.700 ± 0.020 | 126 ± 7 | 1.20 ± 0.03 | |
| Z-304/B | Zabargad | Favidae | 6–8 | 0 | 2.67 ± 0.04 | 1.10 ± 0.01 | 0.730 ± 0.024 | 138 ± 9 | 1.15 ± 0.01 | |
| Z-1388/A | Zabargad | Undeterm. | ~17 | 0 | 2.82 ± 0.07 | 1.04 ± 0.02 | 0.850 ± 0.040 | $200^{+35}_{-25}$ | 1.07 ± 0.03 | |
| Z-1386/A | Zabargad | Undeterm. | 12–15 | 3 | 2.86 ± 0.06 | 1.02 ± 0.02 | 1.000 ± 0.030 | >345 | na[e] | $721^{+\infty}_{-248}$ |
| Z-1386/B | Zabargad | Undeterm. | 12–15 | 6 | 0.72 ± 0.02 | 1.05 ± 0.03 | 1.000 ± 0.040 | >305 | na | $393^{+328}_{-168}$ |
| Z-1386/C | Zabargad | *Acropora* | 12–15 | 4 | 3.29 ± 0.08 | 1.06 ± 0.02 | 0.980 ± 0.030 | >288 | na | $328^{+145}_{-103}$ |
| Z-2306 | Zabargad | Undeterm. | 10–12 | Traces | 2.94 ± 0.06 | 1.07 ± 0.02 | 0.990 ± 0.030 | >300 | na | $273^{+120}_{-90}$ |
| RI-3 | Rocky Island | *Acropora* | 2–3 | 6 | 2.68 ± 0.05 | 1.12 ± 0.02 | 0.693 ± 0.023 | 125 ± 8 | 1.17 ± 0.02 | |
| NB-34/B | N. Brother | Undeterm. | 6–8 | Traces | 3.23 ± 0.06 | 1.08 ± 0.02 | 0.720 ± 0.20 | 135 ± 8 | 1.12 ± 0.03 | |
| NB-34/C | N. Brother | Undeterm. | 6–8 | 0 | 2.73 ± 0.06 | 1.13 ± 0.02 | 0.718 ± 0.024 | $132^{+10}_{-8}$ | 1.19 ± 0.03 | |
| NB-34/D | N. Brother | Undeterm. | 6–8 | 1 | 3.15 ± 0.07 | 1.10 ± 0.02 | 0.865 ± 0.028 | $204^{+23}_{-19}$ | 1.18 ± 0.03 | |
| E-3/A | Ghardaqa | *Fungia* | 6–7 | 1 | 2.68 ± 0.06 | 1.11 ± 0.02 | 0.760 ± 0.025 | 150 ± 11 | 1.17 ± 0.03 | |

*Note*. The uncertainities quoted are deduced from 1 $\sigma$ counting errors.

[a] Activity ratio.

[b] Calculated using Kaufman and Broecker (1965) equation and half-lives of $^{230}Th$ and $^{234}U$ of 75,200 and 248,000 yr respectively.

[c] Initial $^{234}U/^{238}U$ ratio corrected for $^{230}Th$ age.

[d] Assuming an initial ratio of 1.15 equal to that of present day sea water.

[e] na, not applicable.

posure, possibly representing the remnants of a former terrace at about 17-m altitude (sample Z-1388 A), yielded an age of about 200,000 yr, corresponding to a high stand on the classical Barbados and Huon peninsula sea-level curves at 180,000–220,000 yr (e.g., Bloom *et al.*, 1974; Chappell, 1983) and equivalent to oxygen isotope stage 7. In the Red Sea, similar ages have been reported for coral reef terraces along the Sinai coast (Kronfeld *et al.*, 1982), Dahlak (Conforto *et al.*, 1976), and Afar (Hoang *et al.*, 1980).

(c) Terraces between ca. 10- and 15-m altitude yield ages of about 290,000–300,000 yr and older, and probably correspond to an earlier interglaciation (equivalent to isotope stage 9).

*Northern Brother*

Coral samples from this islet yield the same dates found at Zabargad, with a high-sea stand at about 200,000 yr (sample NB 34/D) and a last interglacial stand at about 132,000–135,000 yr (samples NB 34/C and B).

*Ghardaqa*

Previously reported $^{230}Th/^{234}U$ ages of raised reefs along the Nubian shield are from terraces between +2 and +8 m in Egypt (Veeh and Giegengack, 1970) and a terrace at +16 m in Sudan (Berry *et al.*, 1966), both clearly belonging to the last interglacial system of shorelines (Faure, 1975). The only sample analyzed by us (E-3/A) from this locality of the Nubian shield yielded an age of about 150,000 yr. This terrace overlies another raised coral reef at about 2–4 m, perhaps formed during the last interglaciation; its age, however, is too great to belong to this period and too low to indicate that it belongs to the 180,000–340,000 yr sea-level stand. Available evidence suggests that the period between the Eemian high-sea stand and the 180,000–340,000 yr interglaciation was characterized by a sea-level low stand (Fairbanks and Matthews, 1978). Because this region of the Nubian shield is not known to have been substantially uplifted in the last 150,000 yr, the existence of raised reefs of this age is difficult to explain. On the other hand, raised coral reefs and beaches of about this age have been reported from Saurashtra (Somayajulu *et al.*, 1985), Guadeloupe (Battistini *et al.*, 1986), and Italy (Dai Pra and Stearns, 1977). Conforto *et al.* (1976) reported $^{230}Th/^{234}U$ ages of corals from the Dahlak Archipelago in the range of 150,000–170,000 yr B.P., but their samples show calcitic recrystallization higher than 4% making their age assessment suspect. However, this does not seem to be the case for our sample (calcite <1%) as well as for a part at least of those reported in literature. The indication of a high sea level at ca. 150,000 yr rests upon a few scattered datings which are openly in conflict with the widely accepted oxygen isotope record of Shackleton and Opdyke (1973).

## DISCUSSION

*Zabargad*

As shown by our data, the YRL of Zabargad Island are represented by at least three units. One was deposited during the last interglacial high-sea stand, as proposed by Bonatti *et al.* (1983), and displays a series of disconnected small terraces developed preferentially on nonperidotitic bedrocks. It is conventionally assumed that the mean sea level at 125,000 yr B.P. was about 6 m higher than today. Any positive or negative shift from this figure thus likely reflects net uplift or subsidence due to tectonic movements. Therefore, from our dating it appears that Zabargad has been tectonically a rather stable island at least since the last interglaciation.

The second unit within the YRL represents an older high-sea stand between 180,000–220,000 yr B.P. It is marked by an outcrop of questionable interpretation sitting on the main peridotite hill along the southern side of Zabargad. Its present altitude, higher than the older unit discussed below, indicates that its abnormal altitude may be linked to vertical movements of the peridotite substratum. However, the poor exposure does not permit more refined speculation.

The third unit (>290,000–300,000 yr B.P.) has been detected as a series of terraces on the southern side of Zabargad. The terraces belonging to this unit are found at comparably higher altitudes as one moves from east to west. However, the fact that their ages are only broadly the same does not allow assessment of possible tilting of Zabargad.

No last interglacial reefs have been positively identified from the region of peridotitic basement of Zabargad. This fact is very difficult to explain. Possibly coral reefs did not grow on the peridotites during the last interglaciation, either because of the nature of the substrate, or because of other yet-unknown unfavorable conditions for growth. Alternatively, they did form but have been eroded away.

*Northern Brother*

The U-series ages of corals from the raised coral reefs of Northern Brother indicate that the gabbroic block reached its present position at least 200,000 yr B.P. The net uplift rate of Northern Brother was, during the last interglaciation, broadly comparable to that of Zabargad Island, showing no significant vertical movement in the last 125,000 years.

## CONCLUSIONS

A detailed evaluation of small-scale vertical movements requires a new set of geodetic measurements of the altitudes of a number of raised reefs on the Nubian plate and on Zabargad, along with precise radiometric dating. However, from the findings of this study, the following facts seem established:

(1) We can confirm the late Quaternary age of the Young Coral Reefs Fm. of Zabargad Island where at least three systems of raised coral reefs occur, rather than a single unit as previously supposed. The best-developed system around the island dates to the last interglaciation (125,000 yr B.P.), with terraces at about 6- to 8-m altitude.

(2) Raised coral terraces from Northern Brother belong to at least two systems, one correlative with the 125,000 yr terrace and the second to an older one (~200,000 yr).

(3) Both Zabargad and Northern Brother islands appear to have remained tectonically stable since 125,000 yr B.P. Our data neither support nor disprove the hypothesis that Zabargad and Northern Brother islands originated from vertical tectonism within a transform fault domain; possibly the compressional forces thought to be at the origin of the two islands have either been quiescent or even terminated since 125,000 yr B.P.

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