

The age of the Port Morant Formation, south-eastern Jamaica

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ABSTRACT. Two coral samples from the Port Morant Formation in south-eastern Jamaica have been dated using electron spin resonance (ESR). Petrographic analysis showed some dissolution of the primary coralline aragonite as well as secondary mineral precipitation within the coral pore space in one sample, which also showed large associated uncertainties for accumulated doses calculated from the ERS growth curves. Therefore, the age, 125 ± 7 kyr, for the sample probably represents a minimum age, being a weighted average of the date of the original skeletal aragonite and that for the secondary mineral phase. The second specimen yielded a single age of 132 ± 7 kyr. Although we regard this as an accurate age, no single date can be considered to be totally reliable by itself. The ages suggest that at least part of the Port Morant Formation was deposited during the latest Isotope Stage 6 and probably earliest Stage 5e. More dates from the unit, however, are necessary to confirm this conclusion.

INTRODUCTION

ROBINSON (1969, fig. 5) recognised the presence of four units within the Coastal Group in the Port Morant-Bowden region of south-eastern Jamaica: the Buff Bay Formation, the Bowden Formation, the Old Pera beds of the Manchioneal Formation, and the Port Morant Formation. The Buff Bay Formation consists of planktic foraminiferal marlstones (Robinson, 1969). The Bowden Formation consists of a succession of deep-water marlstones and associated graded sandstones, interpreted as turbidites (Pickerill et al., 1998), with the well-known Bowden shell bed at the base (Donovan, 1998). The Old Pera beds consist of laminated sandstones and associated marlstones containing abundant scleractinian corals (Budd and McNeill, 1998) and rhodoliths. They are interpreted as a storm-dominated shelf succession (Donovan et al., 1994). The Port Morant Formation rests unconformably on the Old Pera beds, and contains three distinctive units. Unit 1 consists of a basal conglomerate, unit 2 consists of marlstones and sandstones and contains large coral heads which grew from the top surface of unit 1, and unit 3 consists of pebbly grits (coarse sandstones and conglomerates) and yields a diverse fauna including abundant crabs and barnacles (Collins et al., 1996; Collins and Donovan, 1997), corals, bivalves and gastropods. Although not formally defined, the name Port Morant Formation is now well-entrenched in the literature (e.g., Donovan et al., 1994, 1997; Collins et al., 1996; Collins & Donovan, 1997; Pickerill et al., 1998). The

Port Morant Formation has been correlated (e.g., Collins et al., 1996) with the Sangamonian interglacial, the same age as the Falmouth Formation which is well exposed on the north coast of Jamaica between Falmouth and Discovery Bay (Moore and Somayajulu, 1974). In this contribution we present and discuss the significance of preliminary electron spin resonance (ESR) dates obtained using fossil corals collected from the Port Morant Formation.

METHODS

Corals are abundant and relatively diverse in the Port Morant Formation and include: *Solenastrea bournoni* (Edwards), *Montastrea cavernosa* (Linnaeus), *Agaricia* spp., *Diploria strigosa* (Dana), *Porites* spp., and *Siderastrea radians* (Pallas). Two coral samples, QC1 and QC2, were collected from the Port Morant Formation exposed on the coast to the south of Old Pera (Fig. 1). The samples were chosen so as to be as fresh and unweathered as possible and to preserve a primary aragonitic composition. Sample QC1 was collected from a large *S. bournoni* coral head associated with a patch reef dominated by *S. bournoni* and *M. cavernosa*, which grew on the basal conglomerate of the Port Morant Formation (i.e., the corals shown in unit 2 by Pickerill et al., 1998, fig. 10). Sample QC2 was collected from a medium-sized *S. radians* colony that was attached to an adult example of the gastropod *Strombus gigas* (Linnaeus). Pickerill and Donovan (1997) described a similar

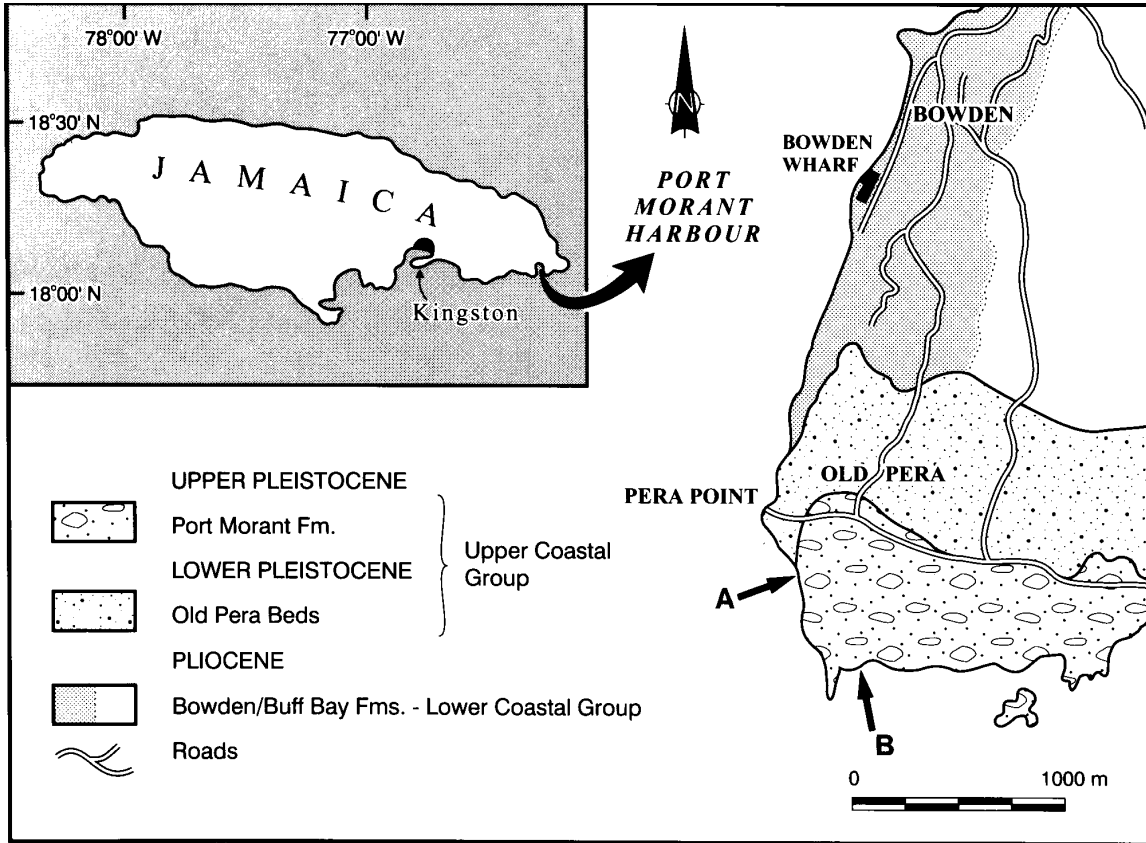


Figure 1. Location and simplified geological map of the eastern side of Port Morant Harbour, southeast coastal Jamaica. Coral sample points shown: A (QC1); B (QC2).

gastropod, but with smaller coral colonies, from the Port Morant Formation. Both these specimens originated in the pebbly grits in the upper part of the Port Morant Formation (unit 3 of Pickerill et al., 1998, fig. 10).

ESR dating uses a stable radiation-sensitive ESR signal created when unpaired electrons are trapped within crystal defects in the coralline aragonite. Natural radioactivity in the environment from uranium, thorium, potassium, and cosmic sources gives these electrons the energy to escape the valence bond to be trapped in the more energetic traps. Since the size of the resultant ESR signal depends on the total radiation experienced by the sample during its geological history, the sample can be dated if the dose rate generated from the coral itself and its environment can be measured accurately. For corals, ESR dates can usually be calculated using:

$$t = \frac{A_{\Sigma}}{D_{\Sigma}(t)} = \frac{A_{\Sigma}}{D_{int}(t) + D_{ext}(t)}$$

where t = the age of the sample

A_{Σ} = the total accumulated dose in the sample

$D_{\Sigma}(t)$ = the total environmental radiation dose rate

$D_{int}(t)$ = the internal radiation dose rate arising from the coral itself

$D_{ext}(t)$ = the external radiation dose rate derived from the coral reef matrix

For this equation to apply, however, the total environmental radiation dose rate, $D_{\Sigma}(t)$, must have remained constant over the sample's geological history. Corals usually contain no thorium or potassium, and rarely lose radon (Skinner, 1985). Because coralline aragonite absorbs 2-4 ppm of uranium geologically quickly (Swart and Hubbard, 1982; Radtke et al., 1988; Skinner, 1988), corals are assumed to follow an early uranium uptake model (EU). Although some corals as old as 800 kyr seem to be reliably dated by ESR (Radtke et al., 1988), it can certainly date corals reliably that range from 500 yr to 250 kyr in age (Smart, 1991; Blackwell, 1995).

Coral samples were dated using the $g = 2.0036$ peak following procedures described in Skinner

TABLE 1. ESR DATING RESULTS FOR CORALS FROM THE PORT MORANT FORMATION, JAMAICA

Sample	Accumulated dose, A_z (Grays)	U concentration (ppm)	Internal dose rate, $D_{int}(t)$ (mGrays/y)	External dose rate, $D_{ext}(t)$ (mGrays/y)	Age, t (kyr)
QC1a	131.66 ± 7.71	3.05 ± 0.02	0.766 ± 0.040	0.291 ± 0.010	124.6 ± 8.8
QC1b	94.62 ± 7.63	3.25 ± 0.02	0.688 ± 0.038	0.291 ± 0.010	93.2 ± 8.3
QC2	125.48 ± 5.22	2.58 ± 0.02	0.663 ± 0.034	0.291 ± 0.010	131.7 ± 7.3

(1988) and Jones et al. (1993). The age calculation assumed that the α efficiency for coral is 0.06 ± 0.01 (Radtke et al., 1988; Grün et al., 1992) and that no radon or uranium was lost from the sample after burial. Dose rate calculations assumed that coralline aragonite had a density of 2.66 ± 0.02 g/cm³, and that 35 wt% water was present in the deposit for most of its history. Since the samples were buried by more than 10 m of overburden during most of their history, the cosmic dose was assumed to be 0.0 mGrays/year. *In situ* external γ doses were not measured, but were assumed to equal that generated by the uranium concentrations seen in the samples corrected for disequilibrium assuming $^{234}\text{U}/^{238}\text{U} = 1.144 \pm 0.004$ (Edwards et al., 1987). Uranium concentrations were measured by delayed neutron counting neutron activation analysis, using a 60 second irradiation, followed by a 10 second delay, and 60 second count time. No thorium or potassium was present in the samples' matrix.

RESULTS

Both analyses on two subsamples of coral sample QC1 gave poor results (Table 1). Thin section analysis showed that some dissolution of the primary coralline aragonite had occurred. A secondary mineral had been precipitated within the coral pore space. While the precipitate did not respond to any staining technique for identification, X-ray diffraction analysis showed only peaks associated with aragonite. Therefore, the secondary mineral could possibly represent finely crystallised aragonite or amorphous calcium carbonate. The secondary mineralization, however, means that any ESR date for the sample is at best a minimum age. It also resulted in very poor growth curves for the ESR signal for both subsamples. Because the secondary mineralization was so pervasive and so fine grained, it could not be removed from the original aragonite before ESR analysis. The older age, 125 ± 9 kyr for QC1a, probably represents the more reliable minimum age of the two, but neither should be considered the exact age.

Fortunately, sample QC2 yielded a more reliable result (Table 1). Under petrographic examination, this sample showed no secondary mineralization and no

recrystallization. Although we feel that this is an accurate age, no single date can be considered to be totally reliable in itself.

DISCUSSION

Sample QC1 contained an unidentifiable secondary mineralization, the date obtained, 125 ± 9 kyr, probably represents some average of the original skeletal aragonite and the secondary mineral phase. The secondary phase as the younger of the two would make any age obtained using such a mixed sample at best a minimum age. Therefore, QC1 must be $\geq 125 \pm 9$ kyr. Sample QC2 yielded an age of 132 ± 7 kyr.

Moore and Somayajulu (1974) dated corals from the Falmouth Formation collected along the north coast of Jamaica, mainly at Rio Bueno, within the range 120 to 140 kyr using α -counting $^{230}\text{Th}/^{234}\text{Th}$, $^{230}\text{Th}/^{227}\text{Th}$ and $^{230}\text{Th}/^{234}\text{U}$ dating. The Port Morant Formation and Falmouth Formation are considered to be penecontemporaneous (e.g., Collins et al., 1996) representing deposits from Isotope Stage 5e, the Sangamonian Interglacial high sea stand. Our dates from the Port Morant Formation agree well with Moore and Somayajulu's (1974) results. They indicate that at least part of the Port Morant Formation was likely deposited during the latest episode of Isotope Stage 6 and probably earliest Stage 5e.

CONCLUSIONS

We have obtained ESR dates of $\geq 125 \pm 9$ kyr and 132 ± 7 kyr for two samples from the Port Morant Formation, which agree well with dates obtained for corals of similar stratigraphic associations obtained by Moore and Somayajulu (1974). The Port Morant Formation was probably deposited at least partially during the transition from Isotope Stage 6 to 5e. More dates, however, are necessary to confirm this conclusion.

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