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New dates and revelations on the last interglacial terrace, Barbados, West Indies

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1 Abstract

Twenty-three new samples from the last interglacial terrace on Barbados reveal a well-preserved mid-last interglacial deposit. The fossil coral deposit lies ~20 m below the top of the last interglacial terrace, which underlies the University of West Indies on the southwest side of Barbados. Seven of the twenty-three samples measured with U-Th methods (Edwards et al., 1987) by ICP-MS (Finnigan ELEMENT; Shen et al., 2002) have initial $\delta^{234}U$ values within error of the modern value (145.8 ± 1.7‰ Cheng et al., 2000), suggesting that they provide accurate and reliable ages (Gallup et al., 1994; Thompson, et al., 2005).

The base of the outcrop is a mix of Acropora palmata (Ap) and head corals such as Porites. Ap is usually a reef crest coral, but the presence of head corals may indicate growth in deeper waters. New dates from this unit are 126.8 ± 0.8 ka (Porites); 125.1 ± 0.8 ka (Ap); and 120.1 ± 0.8 ka (Ap). This unit is overlain by a lense of coral cobbles containing one head coral tilted on its side that computes an age of 125.6 ± 0.7 ka (Siderastrea). Overlying the cobble unit is a fore-reef unit of Acropora cervacornis; within this unit is a 1.5 m tall sea cave ~1-2 m above the cobble unit, indicating a sea level drop that carved a notch into the deposit of Acropora cervacornis and presumably created the cobbles from the mixed Ap/head coral deposit.

The top of the last interglacial terrace at the University of the West Indies has been dated extensively (Gallup et al., 2002). Though none of the samples have initial $\delta^{234}U$ values within error of the modern value, the last interglacial U-Th ages and the ~10 m thick deposit of Ap establish that the top of the terrace is the main crest of the last interglacial deposit at this location. Thus, given the mixed species assemblage of the new deposit and its location 20 m below the crest, we conclude that it grew in deeper water during the last interglacial period. The cobble deposit and the sea cave suggest that this deeper-water, mid-last interglacial deposit was eroded as sea level fell. The new dates within the lower units indicate that this sea level change and erosion occurred after 118 ka, the youngest age in the deposit.

2 Previous results from the Last Interglacial Terrace

Previous work on the middle unit of the last interglacial terrace on Barbados (Fig. 1) has yielded some insight into the events of the penultimate deglaciation (Termination II)(Gallup, et al. (2002); Speed and Cheng, (2004)). The few samples that have been analyzed provide evidence of rising sea levels at ~135 ka, when insolation was near minimum values. These studies also show the early sea level rise was punctuated by a short regressive event then a rapid rise to interglacial sea levels (+6 m) at ~129ka (Fig. 2).

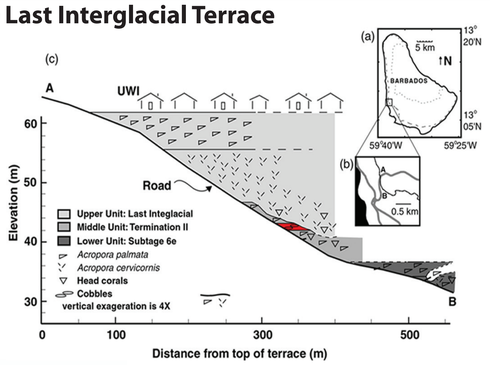


Fig 1. Location map of the Last Interglacial Terrace on (a) Barbados. (b) shows map detail of University of West Indies (UWI) outcrop and the cross section (A to B) shown in (c). The cross section shows the middle unit (medium gray) that is examined in this study and the cobble unit (red). Figure modified from Gallup, et al. (2002).

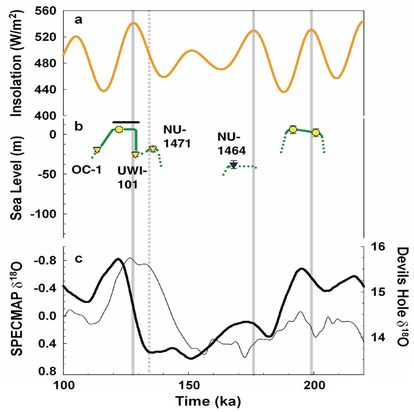


Fig 2. (a) shows 65°N June insolation, the solid gray vertical lines indicates peak insolation values and the dotted gray vertical line indicates the middle of the rise to maximum insolation value. (b) The sea level curve calculated in Gallup, et al. (2002). (c) The bold black line is the SPECMAP benthic $\delta^{18}O$. The gray line is the Devil's hole $\delta^{18}O$ record. Figure modified from Gallup, et al. (2002).

3 The New Data

Newly dated samples from the mid-last interglacial outcrop of Barbados provide some exciting new data and possible insight into the sea level fluctuations of the Last Interglacial period. Several samples show signs of closed system behaviour with initial $\delta^{234}U$ values within error of the modern value (145.8 ± 1.7‰ Cheng et al., 2000) (Fig 3), Samples not within error of this value have similar ages to the surrounding samples and should be considered within the larger context. The evolution plot (Fig 3) provides an estimate of a corrected age for any sample plotted. The locations of the "closed system" corals are marked on Fig 4 (a). The outcrop also shows two erosional features that may hold further evidence in determining the sequence of events recorded in this outcrop.

Sample UWI-00-	238U (ppb)	±	230Th (pg/g)	±	232Th (pg/g)	±	230/238 activity	±	d234 ‰	±	d234initial ‰	±	230Th Age	+	-
43	2654.2	4.6	33.8647	0.0902	86.8	10	0.77947	0.00248	109.5	2	157.4	2.9	128.37	910	903
44	3012.9	5.6	38.1439	0.0906	28.4	9.1	0.77344	0.00233	106.4	2.1	152.4	3	127.30	879	872
45	3095.5	4.8	39.0797	0.0942	140.3	9.5	0.77126	0.00221	98.7	1.7	141.9	2.4	128.53	803	798
46	3036.5	4.8	39.5718	0.0851	31.2	5.7	0.79615	0.00213	110.8	1.8	161.5	2.6	133.23	830	824
47	2948.9	5.8	38.5811	0.994	22	8.3	0.79929	0.00259	113	2.4	164.8	3.5	133.68	1046	1037
49	3003.2	5.5	37.8812	0.1056	29	10	0.7706	0.00257	102.1	2.1	146.3	3	127.48	940	932
50	3032	5.4	38.4946	0.0856	710.9	6.2	0.77564	0.0022	101.9	2.1	146.7	3.1	129.08	896	862
51	2988.1	4.7	39.0043	0.0916	43.8	11.6	0.79744	0.00226	113.8	2.1	165.7	3.1	132.86	905	898
52	3163	6.6	40.7185	0.102	37.8	9.7	0.78646	0.00256	107.1	2.3	155.2	3.4	131.13	1008	1000
53	3018.5	5.2	38.6345	0.1323	408.1	11.4	0.78193	0.003	104.9	2.1	151.6	3.1	130.27	1089	1079
56	2734.7	3.8	35.111	0.0826	191.3	11.1	0.78436	0.00214	112.7	1.8	162.3	2.6	129.08	795	789
57	2492.4	3.2	32.0594	0.0736	54.9	11.3	0.78581	0.00207	113.2	1.7	163.1	2.5	129.40	770	765
58	2761.8	3.6	35.9929	0.0852	45.8	10.2	0.79616	0.00215	110.4	1.7	161	2.4	133.34	814	808
59	2570	3.5	32.1872	0.0755	1070.6	11.2	0.76513	0.00207	100.2	1.8	143.1	2.6	126.27	768	763
59(replicate)	2846.2	4.7	35.7124	0.0796	1537	11.9	0.76654	0.00212	101.2	2	144.6	2.8	126.45	804	798
59(replicate)	2780.5	4.3	35.0747	0.1257	802.3	4.4	0.77065	0.00301	102.6	1.6	147.1	2.3	127.36	1001	993
66	3186.4	6.2	41.9779	0.1488	646.4	10.3	0.80483	0.00325	114.9	2.2	168.2	3.2	134.94	1202	1190
67	2487.3	3.8	30.5852	0.0657	52.9	5.8	0.75121	0.00198	116.9	2	163.4	2.8	118.44	693	689
68	2487.6	3.5	31.7888	0.0807	587	10.3	0.78069	0.00227	106.8	1.6	153.9	2.4	129.42	814	809
69	2264.7	3.1	28.3772	0.065	143.8	12.1	0.76549	0.00205	103.3	1.7	147.4	2.5	125.62	745	740
70	2274.4	3.6	28.8334	0.0656	38.4	10.8	0.7745	0.00214	105.7	2	151.6	2.9	127.80	821	815
60	2811.3	4.2	36.3015	0.0812	37.5	7.6	0.78885	0.00212	118.8	1.7	171.1	2.5	128.94	772	767
61	1198.7	5	42.8938	0.1058	2326.7	11.5	0.77101	0.00222	112.5	1.7	160.2	2.5	125.09	773	768
63	2152.5	3.5	26.8401	0.064	303.2	8	0.76178	0.0022	103.4	2.1	147	3	124.50	825	819
63.5	2471.7	3.7	29.5874	0.0722	46.5	11.8	0.73131	0.00209	101.3	2.1	140.7	2.9	116.21	730	725
64	2896.2	4	34.1813	0.0826	139.4	11	0.721	0.00201	102.3	1.7	140.9	2.4	113.17	644	641
65	2370.4	3.1	29.1847	0.0636	105.3	12.6	0.75216	0.00191	104.2	1.8	146.9	2.5	121.48	685	681
65(replicate)	2700	4.4	32.9067	0.1148	4664.7	15.8	0.74456	0.00286	102.1	1.8	143.2	2.5	199.72	913	906

Table 1. Uranium-series information for samples UWI-00-43 to UWI-00-70. Samples are in geographic sequence from the southern end of the outcrop (UWI-00-43) to the northern end (UWI-00-65). Blue shaded areas indicate samples within error of the modern $\delta^{234}U$ value. Samples from the cobbled unit are shaded red. Italics indicate error values.

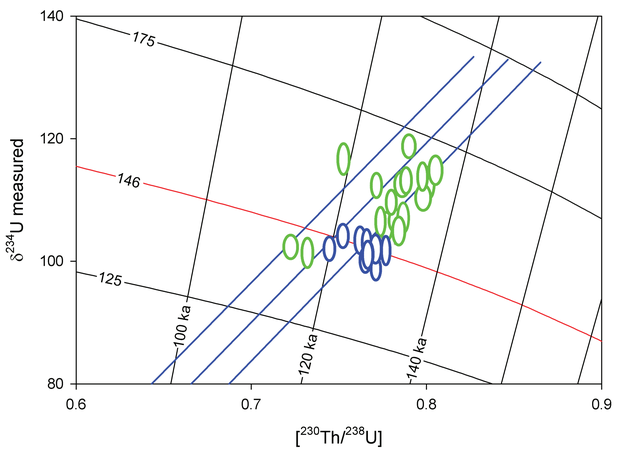
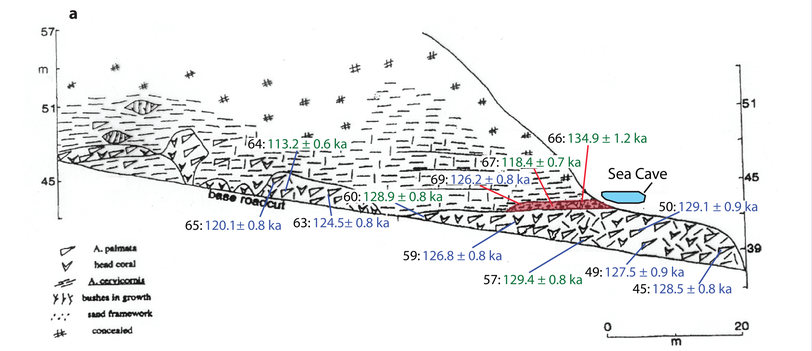
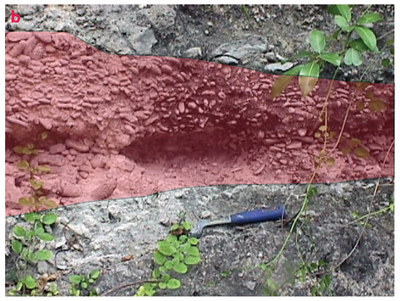


Fig 3. A plot of $\delta^{234}U$ versus $^{230}Th/^{238}U$ activity ratio. All of the new ICP-MS dated are shown. Red ellipses represent samples within error of the modern marine $\delta^{234}U$ value. The yellow ellipses represent samples that do not fall within error of the modern marine $\delta^{234}U$ value. The blue lines are recoil-based isochrons (115, 120, and 125 ka) and allow the estimation of a corrected age for samples that fall along each line (Villemant and Feuillet, 2003).

4 The Outcrop

Fig 4. (a) Outcrop cartoon showing the locations of several new samples and associated dates. Bright red text indicate closed system behavior, maroon text indicate open system behaviour. The cobble unit is shown in red. Sea cave adjacent to cobble layer is shown in blue. (a) Modified from Speed and Cheng (2004). (b) Photo of cobble layer, hammer for scale. Cobble unit is shown in red. (c) Photo of sea cave adjacent to the cobble unit, hammer for scale.





5 Discussion and Conclusions

The newly dated corals from the Last Interglacial Terrace of Barbados add a significant amount of difficulty to Last Interglacial sea level calculations for this outcrop. Previous evidence from this outcrop provided a simpler sea level history than the new data will allow (Fig. 2). The new dates offer a higher resolution look at the outcrop that includes both early Last Interglacial and late Last Interglacial corals. Key aspects of the stratigraphy include:

1) Sample ages decrease with increasing elevation on the outcrop.

2) The young sample dates (late last interglacial) occur at elevations equivalent or higher than the cobble unit.

3) The sea cave and late last interglacial samples lie at roughly the same elevation on the outcrop.

The stratigraphic evidence provided by the new dates indicate that sea level was below peak last interglacial sea level during the earliest last interglacial. The younger dates and erosional features indicate that sea level returned to this lower elevation during the lastest portion of the last interglacial period.

Further analysis of previously dated corals and expansion of the data set further up and down the outcrop should help to improve our understanding of these new dates.

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