Reef response to sea-level and environmental changes during the last deglaciation: Integrated Ocean Drilling Program Expedition 310, Tahiti Sea Level

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ABSTRACT

The last deglaciation is characterized by a rapid sea-level rise and coeval abrupt environmental changes. The Barbados coral reef record suggests that this period has been punctuated by two brief intervals of accelerated melting (meltwater pulses, MWP), occurring at 14.08–13.61 ka and 11.4–11.1 ka (calendar years before present), that are superimposed on a smooth and continuous rise of sea level. Although their timing, magnitude, and even existence have been debated, those catastrophic sea-level rises are thought to have induced distinct reef drowning events. The reef response to sea-level and environmental changes during the last deglacial sea-level rise at Tahiti is reconstructed based on a chronological, sedimentological, and paleobiological study of cores drilled through the relict reef features on the modern forereef slopes during the Integrated Ocean Drilling Program Expedition 310, complemented by results on previous cores drilled through the Papeete reef. Reefs accreted continuously between 16 and 10 ka, mostly through aggradational processes, at growth rates averaging 10 mm yr^{-1}. No cessation of reef growth, even temporary, has been evidenced during this period at Tahiti. Changes in the composition of coralgal assemblages coincide with abrupt variations in reef growth rates and characterize the response of the upward-growing reef pile to nonmonotonous sea-level rise and coeval environmental changes. The sea-level jump during MWP 1A, 16 ± 2 m of magnitude in ~350 yr, induced the retrogradation of shallow-water coral assemblages, gradual deepening, and incipient reef drowning. The Tahiti reef record does not support the occurrence of an abrupt reef drowning event coinciding with a sea-level pulse of ~15 m, and implies an apparent rise of 40 mm yr^{-1} during the time interval corresponding to MWP 1B at Barbados.

INTRODUCTION

Studies of coral reef records from the last deglaciation (23–6 ka) are of pivotal importance in constraining the timing and magnitude of rapid sea-level rise, and also in unraveling the reef response to dramatic environmental perturbations.

Only four accurately dated reef sequences that have been attributed to the times reflecting the Holocene-Pleistocene boundary were previously investigated by drilling, i.e., Barbados (26–7 ka; Fairbanks, 1989; Bard et al., 1990; Peltier and Fairbanks, 2006), Papua New Guinea (13–6 ka; Chappell and Polach, 1991; Edwards et al., 1993), onshore Tahiti (13.85–2.38 ka; Bard et al., 1996, 2010), and Vanuatu (23–6 ka; Cabioch et al., 2003). However, the abrupt and significant environmental changes that accompanied the deglacial sea-level rise have been barely investigated, so the accurate reconstruction of the event is obscured.

The Barbados record suggests that the last deglaciation was punctuated by two brief intervals of extremely rapid sea-level rise (meltwater pulses MWP 1A and MWP 1B, 14.08–13.61 ka and 11.4–11.1 ka, respectively), as much as 16 m in <500 yr during MWP 1A. MWPs were originally detected as hiatuses between three separate submerged reef features. Each of these segments is offset from the next and coincides with the interpreted reef drowning events, thus hampering the accurate reconstruction of the reef response to sea-level change. Although the timing, magnitude, and even the existence of MWPs have been debated (see the review in Deschamps et al., 2012), those catastrophic sea-level jumps are thought to have induced reef drowning events (Blanchon and Shaw, 1995) that might have been followed by major nonconstructional periods (Montaggioni, 2005).

This study deals with reef response to sea-level and environmental changes between 16 and 10 ka, based on the more extensive and continuous coral reef offshore record obtained at Tahiti during Integrated Ocean Drilling Program (IODP) Expedition 310 (Co-chiefs : G. Camoin and Y. Iryu).

SETTING

Unlike islands located in active margins, like Barbados or Vanuatu, Tahiti is a volcanic island characterized by slow and regular subsidence rates estimated as 0.25 mm yr^{-1} (Bard et al., 1996) and located at a considerable distance from the major former ice sheets (i.e., a far-field site). It therefore provides an ideal setting to reconstruct sea-level rise and to constrain short-term environmental changes that are thought to have punctuated the period between the Last Glacial Maximum and the present.

During IODP Expedition 310, 37 holes were drilled at 22 sites (M0005–M0026) along transects at depths ranging from 41.6 to 117.5 m below sea level (mbsl) in 3 areas around Tahiti: offshore Faaa, Maraa, and Tiarei (Camoin et al., 2007a, 2007b) (Fig. 1). The drilling targets were mostly focused on the two prominent terraces that occur at 50–60 mbsl and 90–100 mbsl, respectively, that support abundant relict reefs that rise at 30–45 m above the seafloor (Camoin et al., 2006). The Tiarei area is characterized by the occurrence of 2 successive ridges seaward of the living barrier reef at 60 and 90–100 mbsl (Fig. 2). Those ridges compose a line of isolated or fused pinnacles that were previously recognized as reef features exhibiting an original irregular morphology, and corresponding therefore to primary records of reef development (Camoin et al., 2006). Similar reef features have been recognized on many modern reef slopes (see reviews in Dullo et al., 1998; Camoin et al., 2006; Abbey et al., 2011a), but were drilled previously only in Barbados (Fairbanks, 1989).

More than 600 m of reef cores displaying an exceptional recovery (>90%; Inwood et al.,

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GEOLOGY doi:10.1130/G32057.1; 2 figures.

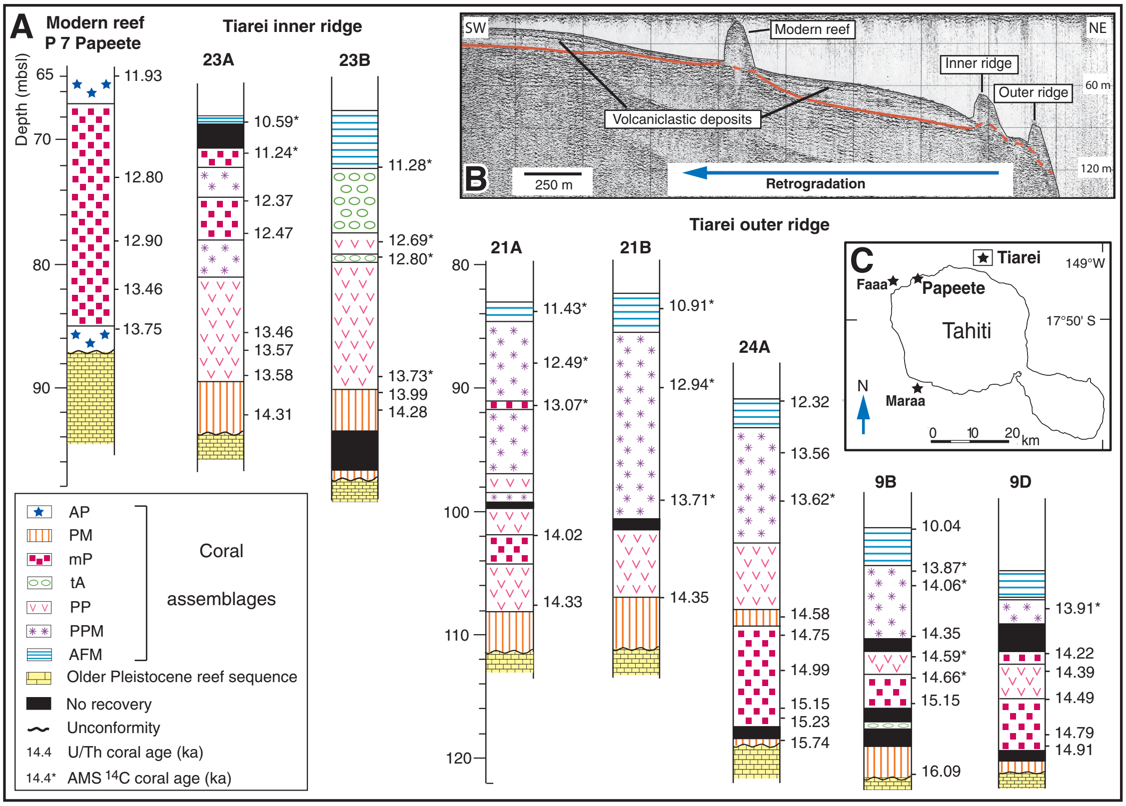

Figure 1. A: Lithologies, selected U-series and accelerator mass spectrometry (AMS) ^{14}C ages, and distribution of coralgal assemblages at Papeete and Tiarei drill sites (mbsl—meters below sea level). B: Seismic line across Tiarei area displaying two ridges drilled during Integrated Ocean Drilling Program (IODP) Expedition 310 and modern reef. C: Offshore (Tiarei, Maraa, and Faaa) and onshore (Papeete P cores) drill sites at Tahiti. Coral assemblages: AP—branching *Acropora* and *Pocillopora*; PM—branching *Pocillopora* and massive *Montipora*; mP—massive *Porites*; tA—tabular *Acropora*; PP—branching *Porites* and *Pocillopora*; PPM—branching *Porites* and encrusting *Porites* and *Montipora*; AFM—encrusting agaricids and faviids.

2008) and quality were retrieved; combined with the high-resolution downhole measurement data, they constitute unique archives to resolve in unprecedented detail the reef response to the last deglacial sea-level rise and coeval environmental changes.

COMPOSITION OF THE LAST DEGLACIAL REEF SEQUENCE

The fossil reef systems around Tahiti are composed of two major chronological and lithological sequences (Camoin et al., 2007a, 2007b) that are attributed to the last deglaciation (Deschamps et al., 2012) and to older Pleistocene time windows (Thomas et al., 2009; Iryu et al., 2010). The contact between those sequences is characterized by the occurrence of an irregular unconformity that ranges in depth from 94 to 122 mbsl on the Tiarei inner and outer ridges (Fig. 1), indicating a rugged morphology of the pre-deglacial surface prior to the reef initiation and growth during the last deglaciation.

The last deglacial sequence is mostly composed of coral frameworks generally thickly encrusted by coralline algae that are locally associated with encrusting foraminifers and sessile vermetid gastropods. The dominant coral morphologies (branching, robust branching, massive, tabular, foliaceous, and encrusting) and the abundance of associated builders and encrusters determine distinctive frameworks displaying a wide range of internal structures, from loose to dense. Primary cavities in coralgal frameworks are partly to entirely occluded by abundant microbialite crusts ranging in thickness from a few centimeters to 20 cm and displaying a wide range of growth forms (Seard et al., 2011). The coralgal frameworks are associated or interlayered locally with skeletal limestone, volcaniclastic sediments, and/or loose skeletal sediments (rubble, sand and silt), which represent only a minor component of the Tahiti cores, implying a low skeletal production of the frameworks.

Six distinctive coralgal assemblages have been identified in the Tiarei cores and are indicative of a range of modern reef environments,

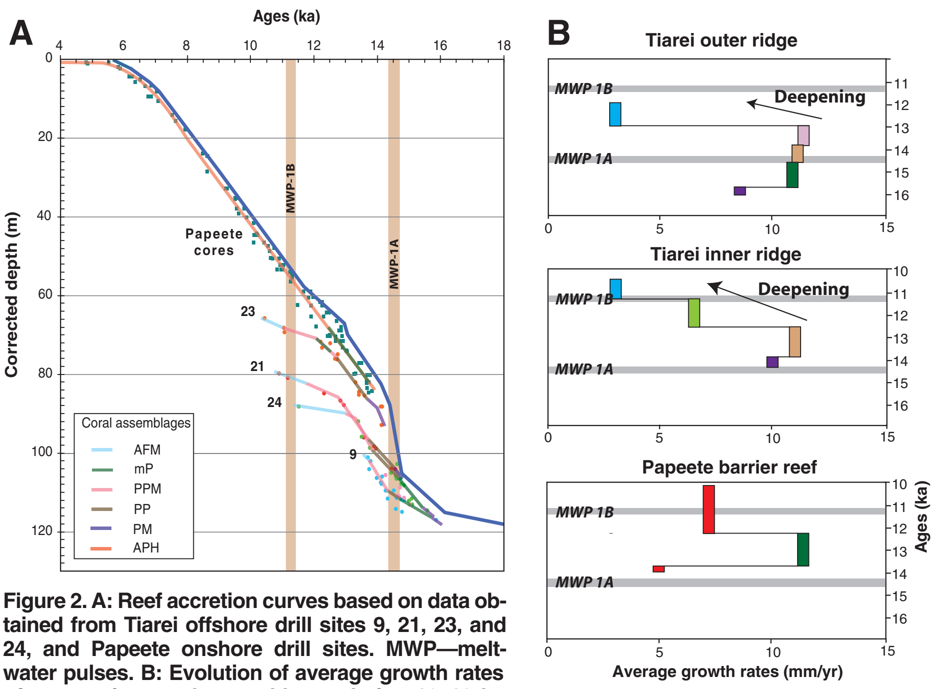

Figure 2. A: Reef accretion curves based on data obtained from Tiarei offshore drill sites 9, 21, 23, and 24, and Papeete onshore drill sites. MWP—meltwater pulses. B: Evolution of average growth rates of successive coral assemblages during 16–10 ka time window for Tiarei and Papeete drill sites. Timing of MWP 1A and MWP 1B based on data from Deschamps et al. (2012) and Peltier and Fairbanks (2006), respectively. Abbreviations of coral assemblages as in Figure 1.

ranging from the reef crest to the reef slope (see Camoin et al., 2007a, 2007b; Abbey et al., 2011b, and references therein), in agreement with earlier studies on Tahiti and other Indo-Pacific reef sites (see review by Montaggioni, 2005). They form a continuum, and most of them overlap in bathymetric range (Fig. 1).

The robust branching *Pocillopora*–massive *Montipora* (PM) assemblage includes a coralline algal association dominated by *Hydrolithon onkodes* and *Mastophora pacifica*, and characterizes reef edge environments in water depths <10 m. The assemblage characterized by robust branching *Acropora* of the *robusta-danai* group (AP) that dominates frameworks younger than 12 ka both in Papeete (Fig. 1) and Maraa drill cores does not occur in the Tiarei cores, probably due to local environmental conditions in that area (see also Abbey et al., 2011b).

The other end member of that continuum consists of an encrusting agaricids and faviids (AFM) assemblage bearing a coralline algal association dominated by *Mesophyllum funafutiense* and *Lithoporella*, indicating depths >20 m. The massive *Porites* (mP) and the tabular *Acropora* (tA) assemblages tend to dominate semiexposed to sheltered environments of the upper and mid-forereef slope and backreef zones, within the 0–25 m depth range for the mP and not deeper than 20 m, with a common occurrence between 5 and 15 m for the tA. The depth range of these two assemblages can be restricted to 5–10 m when thick *Hydrolithon onkodes* crusts are associated.

Branching *Porites* are the most abundant corals observed in the Tiarei cores and dominate two distinctive assemblages typifying semiexposed to sheltered environments of the mid-forereef, inner reef flat, and backreef zones with moderate energy conditions and reduced light intensity. The branching *Porites-Pocillopora* (PP) assemblage developed at depths to 20 m, but more frequently between 5 and 10 m, as indicated by the occurrence of thick *Hydrolithon onkodes* crusts. The branching *Porites*–encrusting *Porites* and *Montipora* (PPM) assemblage probably developed in a larger depth range (5–25 m), as indicated by the associated coralline algae characterizing either shallow water, i.e., <10 m (*Hydrolithon onkodes* and *Mastophora pacifica*), or deeper water environments; i.e., between 15 and 25 m (*Lithophyllum prototypum–Mesophyllum erubescens–Lithothamnion prolifer* assemblage).

REEF RESPONSE TO SEA-LEVEL AND ENVIRONMENTAL CHANGES

The U-series and accelerator mass spectrometry ^{14}C analyses carried out on the corals from the IODP cores provided reliable and stratigraphically consistent ages ranging from 16 to 10 ka, and complement the results obtained on the Papeete drill cores that encompass the 13.8–3 ka time window (Bard et al., 1996; Montaggioni et al., 1997; Camoin et al., 1999; Cabioch et al., 1999). The study of the offshore drill cores has demonstrated the occurrence of MWP 1A with a well-constrained chronology (14.65–14.3 ka) and amplitude (16 ± 2 m; Deschamps et al., 2012). Recent investigations on onshore drill cores report a relatively smooth sea-level rise, with no significant acceleration during the time interval corresponding to MWP 1B at Barbados (Bard et al., 2010).

The anatomy of reef systems from the Tiarei area indicates that their development has been controlled by the progressive flooding of the Tahiti slopes and the coeval increase in accommodation. At all drill sites, chronological and sedimentological data do not support any unconformity in the cored reef sequences, thus implying that reefs accreted continuously, and mostly through aggradational processes between 16 and 10 ka.

The formation of the successive ridges, which characterize that area, is seemingly related to local topographic and substrate conditions provided by the older Pleistocene carbonate sequence in such a region dominated by volcaniclastic sediments. No similar ridges were reported in other drilled areas around Tahiti.

On the outer ridge of the Tiarei area, the last deglacial reef sequence provides stratigraphically consistent ages ranging from 16.09 ± 0.04 ka at 121 mbsl in Hole M0009B to 10.91 ± 0.13 ka at 82.7 mbsl in Hole M0021B (Fig. 1), with an overall aggradation rate of 7.4 mm yr^{-1}. On the inner ridge, it is 24–29 m thick in Holes 23A and 23B, and ranges in age from 14.31 ± 0.04 to 10.59 ± 0.10 ka, respectively (Fig. 1), implying an overall aggradation rate of 6.5 mm yr^{-1} in Hole 23A. However, the major part of the reef accretion curve expresses maximum growth rates >10 mm yr^{-1} during the 16–10 ka time window. At each individual drill site the last deglacial reef sequence is continuous and displays a general deepening-upward trend (Fig. 1). Changes in the composition of coralgal assemblages coincide with abrupt variations in reef growth rates (Fig. 2) and characterize the response of the upward-growing reef pile to nonmonotonous sea-level rise and coeval environmental changes.

The pre–MWP 1A period (16–14.65 ka) is characterized by a moderate rise in sea level with a magnitude of ~10 m, implying an average rate of 7.4 mm yr^{-1}. The first assemblage to colonize the Pleistocene carbonate substrate corresponds to the PM assemblage, which developed during the 16.09 to ca. 15.5 ka time window (Fig. 1). The subsequent development of the mP assemblage, composed of turbidity-tolerant corals, occurred during an ~500 yr period (i.e., from 15.23 ± 0.03 ka to 14.75 ± 0.03 ka) at the deepest sites of the outer margin. Reef growth rates range from 6 to 9 mm yr^{-1} during the pre–MWP 1A period, and imply that reefs kept pace with the rising sea level (Fig. 2).

MWP 1A occurred in ~350 yr (14.65–14.3 ka time window) and induced a sea-level rise of 16 ± 2 m (Deschamps et al., 2012). The reef response to this accelerated rise in sea level is characterized by significant changes in coral assemblages, especially involving the development of loose frameworks of fast-growing corals (PP assemblage) with a high primary porosity (averaging 50%; Seard et al., 2011) at the deepest sites of the outer margin (Site 9). The PP assemblage aggraded at average vertical rates <10 mm yr^{-1} during MWP 1A, implying that reef growth was insufficient to balance the sea-level rise that ultimately induced a gradual deepening and an incipient reef drowning; however, no cessation of reef growth, even temporary, has been evidenced during this period. The sea-level rise during MWP 1A was sufficient to displace the PM assemblage out of its 10 m or less habitat zone and to induce its relocation upslope, on the inner part of the outer ridge (Site 21) and then on the inner ridge (Site 23; Fig. 1), implying the retrogradation of this shallow-water assemblage at average rates >700 mm yr^{-1} during that time. At the end of MWP 1A, ca. 14.3 ka, the Tiarei reefs exhibited a clear lateral zonation, from the inner ridge characterized by the growth of the PM shallow-water assemblage, to the outer ridge characterized by the development of deeper water coral assemblages (PP and PPM).

The reef sequence from the inner ridge records a continuous reef growth from 14.3 to 11.2 ka characterized by a gradual deepening through time typified by a vertical succession involving the PM and the PP assemblages for >1500 yr, followed by the development of tA, mP, and PPM assemblages, while the coeval outer ridge sequences are mostly composed of PPM and AFM assemblages. The transition from mP to AFM coral assemblages may characterize a slight deepening (i.e., a few meters) ca. 11.2 ka, within the timing of MWP 1B (11.4–11.1 ka; Peltier and Fairbanks, 2006). However, no significant acceleration during the time interval corresponding to MWP 1B at Barbados is recorded in the Papeete cores (Bard et al., 2010). The continuous development of shallow-water coral assemblages (i.e., at depths <6 m) at nearly constant reef accretion rates for the past ~13.9 ka (Montaggioni et al., 1997; Camoin et al., 1999; Cabioch et al., 1999) does not support the occurrence of an abrupt reef drowning event coinciding with a sea-level pulse of ~15 m at an apparent rise of 40 mm yr^{-1}, as deduced from the Barbados record (Blanchon and Shaw, 1995).

At all sites, the upper part of the last deglacial sequence corresponds to the development of the slowly growing (average 3 mm yr^{-1}) AFM assemblage at depths generally >20 m, and ranging in age from 12.32 ± 0.03 ka on the outer ridge to 10.59 ± 0.10 ka on the inner ridge.

The top 2–3 m of the sequence exhibit platform drowning signatures characterized by a suite of biological, sedimentary, and diagenetic features, including extensive bioerosion, manganese and iron staining of the rock surface, and submarine hardgrounds. This condensed deep-water sequence developed when the reef features dropped to a depth where carbonate production was limited as a consequence of continued sea-level rise and coeval environmental changes (e.g., light availability, water quality) during Holocene time (see also Camoin et al., 2006).

CONCLUSIONS

Tahiti reefs accreted continuously at growth rates averaging 10 mm yr^{-1} during the 16–10 ka time interval.

The overall reef sequence typifies the retrogradation of shallow-water coralgal assemblages.

The two Tiarei ridges are characterized by deepening-upward sequences, while the Papeete sequence is characterized by the continuous development of shallow-water coral assemblages.

The sea-level jump during MWP 1A induced the retrogradation of shallow-water coral assemblages but no cessation of reef growth, even temporarily.

The Tahiti reef record does not support the occurrence of an abrupt reef drowning event coinciding with the MWP 1B defined in Barbados.

ACKNOWLEDGMENTS

We acknowledge support from the European Science Foundation EuroMARC EUROCORES Programme, and from the Centre National de la Recherche Scientifique, Institut National des Sciences de l'Univers (CNRS-INSU) ECLIPSE Programme.

REFERENCES CITED

Abbey, E., Webster, J., and Beaman, R.J., 2011a, Geomorphology of submerged reefs on the shelf edge of the Great Barrier Reef: The influence of oscillating Pleistocene sea-levels: Marine Geology, v. 288, p. 61–78.

Abbey, E., Webster, J., Braga, J.-C., Sugihara, K., Wallace, C., Iryu, Y., Potts, D., Done, T., Camoin, G., and Seard, C., 2011b, Variation in deglacial coralgal assemblages and their paleoenvironmental significance: IODP Expedition 310, Tahiti Sea Level: Global and Planetary Change, v. 76, p. 1–15, doi:10.1016/j.gloplacha.2010.11.005.

Bard, E., Hamelin, B., and Fairbanks, R.G., 1990, U-Th ages obtained by mass spectrometry in corals from Barbados: Sea-level during the past 130,000 years: Nature, v. 346, p. 456–458, doi:10.1038/346456a0.

Bard, E., Hamelin, B., Arnold, M., Montaggioni, L.F., Cabioch, G., Faure, G., and Rougerie, F., 1996, Deglacial sea level record from Tahiti corals and the timing of global meltwater discharge: Nature, v. 382, p. 241–244, doi:10.1038/382241a0.

Bard, E., Hamelin, B., and Delanghe-Sabatier, D., 2010, Deglacial Meltwater Pulse 1B and Younger Dryas sea levels revisited with boreholes at Tahiti: Science, v. 327, p. 1235–1237, doi:10.1126/science.1180557.

Blanchon, P., and Shaw, J., 1995, Reef drowning during the last deglaciation: Evidence for catastrophic sea-level rise and ice-sheet collapse: Geology, v. 23, p. 4–8, doi:10.1130/0091-7613(1995)023<0004:RDDTLD>2.3.CO;2.

Cabioch, G., Camoin, G.F., and Montaggioni, L.F., 1999, Postglacial growth history of a French Polynesian barrier reef (Tahiti, central Pacific): Sedimentology, v. 46, p. 985–1000, doi:10.1046/j.1365-3091.1999.00254.x.

Cabioch, G., Banks-Cutler, K., Beck, W.J., Burr, G.S., Corrège, T., Edwards, R.L., and Taylor, F., 2003, Continuous reef growth during the last 23 cal kyr BP in a tectonically active zone (Vanuatu, Southwest Pacific): Quaternary Science Reviews, v. 22, p. 1771–1786, doi:10.1016/S0277-3791(03)00170-7.

Camoin, G.F., Gautret, P., Montaggioni, L.F., and Cabioch, G., 1999, Nature and environmental significance of microbialites in Quaternary reefs: The Tahiti paradox: Sedimentary Geology, v. 126, p. 271–304, doi:10.1016/S0037-0738(99)00045-7.

Camoin, G.F., Cabioch, G., Eisenhauer, A., Braga, J.C., Hamelin, B., and Lericolais, G., 2006, Environmental significance of microbialites in reef environments during the last deglaciation: Sedimentary Geology, v. 185, p. 277–295, doi:10.1016/j.sedgeo.2005.12.018.

Camoin, G.F., Iryu, Y., McInroy, D.B., and Expedition 310 Scientists, 2007a, Expedition 310 summary: Proceedings of the Integrated Ocean Drilling Program, Volume 310: Washington, D.C., Integrated Ocean Drilling Program Management International, Inc., doi:10.2204/iodp.proc.310.101.2007.

Camoin, G.F., Iryu, Y., McInroy, D.B., and Expedition 310 Scientists, 2007b, IODP Expedition 310 reconstructs sea-level, climatic and environmental changes in the South Pacific during the last deglaciation: Scientific Drilling, v. 5, p. 4–12, doi:10.2204/iodp.sd.5.01.2007.

Chappell, J., and Polach, H.A., 1991, Post-glacial sea level rise from a coral record at Huon Peninsula, Papua New Guinea: Nature, v. 349, p. 147–149, doi:10.1038/349147a0.

Deschamps, P., Durand, N., Bard, E., Hamelin, B., Camoin, G., Thomas, A., Henderson, G., Okuno, J., and Yokoyama, Y., 2012, Ice sheet collapse and sea-level rise at the Bølling warming, 14,600 yr ago: Nature, doi:10.1038/nature10902.

Dullo, W.-C., Camoin, G.F., Blomeier, D., Casanova, J., Colonna, M., Eisenhauer, A., Faure, G., and Thomassin, B.A., 1998, Sediments and sea level changes of the foreslopes of Mayotte, Comoro islands: Direct observations from submersible, *in* Camoin, G., and Davies, P.J., eds., Reefs and carbonate platforms of the Pacific and Indian Ocean: International Association of Sedimentologists Special Publication 25, p. 219–236.

Edwards, R.L., Beck, W.J., Burr, G.S., Donahue, D.J., Chappell, J.M.A., Bloom, A.L., Druffel, E.R.M., and Taylor, F.W., 1993, A large drop in atmospheric $^{14}C/^{12}C$ reduced melting in the Younger Dryas, documented with ^{230}Th ages of corals: Science, v. 260, p. 962–968, doi:10.1126/science.260.5110.962.

Fairbanks, R.G., 1989, A 17,000-year glacio-eustatic sea-level record: Influence of glacial melting rates on the Younger Dryas event and deep-ocean circulation: Nature, v. 342, p. 637–642, doi:10.1038/342637a0.

Inwood, J., Brewer, T., Braaksma, H., and Pezard, P., 2008, Integration of core, logging and drilling data in modern reefal carbonates to improve core location and recovery estimates (IODP Expedition 310): Geological Society of London Journal, v. 165, p. 585–596, doi:10.1144/0016-76492007-041.

Iryu, Y., Takanashi, Y., Fujita, K., Camoin, G., Cabioch, G., Matsuda, H., Sato, T., Suhihara, K., Webster, J., and Westphal, H., 2010, Sea-level history recorded in the Pleistocene carbonate sequence in IODP Hole 310–M0005D, off Tahiti: The Island Arc, v. 19, p. 690–706, doi:10.1111/j.1440-1738.2010.00737.x.

Montaggioni, L.F., 2005, History of Indo-Pacific coral reef systems since the last glaciation: Development patterns and controlling factors: Earth-Science Reviews, v. 71, p. 1–75, doi:10.1016/j.earscirev.2005.01.002.

Montaggioni, L.F., Cabioch, G., Camoin, G.F., Bard, E., Ribaud, A., Faure, G., Déjardin, P., and Récy, J., 1997, Continuous record of reef growth over the past 14 k.y. on the mid-Pacific island of Tahiti: Geology, v. 25, p. 555–558, doi:10.1130/0091-7613(1997)025<0555:CRORGO>2.3.CO;2.

Peltier, W.R., and Fairbanks, R.G., 2006, Global glacial ice volume and Last Glacial Maximum duration from an extended Barbados sea level record: Quaternary Science Reviews, v. 25, p. 3322–3337, doi:10.1016/j.quascirev.2006.04.010.

Seard, C., Camoin, G., Yokoyama, Y., Matsuzaki, H., Durand, N., Bard, E., Sepulcre, S., and Deschamps, P., 2011, Microbialite development patterns in the last deglacial reefs from Tahiti (French Polynesia; IODP Expedition #310): Implications on reef framework architecture: Marine Geology, v. 279, p. 63–86, doi:10.1016/j.margeo.2010.10.013.

Thomas, A.L., Henderson, G., Deschamps, P., Yokoyama, Y., Mason, A.J., Bard, E., Hamelin, B., Durand, N., and Camoin, G., 2009, Penultimate deglacial sea-level timing from uranium/thorium dating of Tahitian corals: Science, v. 324, p. 1186–1189, doi:10.1126/science.1168754.

Manuscript received 10 January 2011
Revised manuscript received 10 February 2012
Manuscript accepted 12 February 2012

Printed in USA