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Commentary: Early Diagenetic Imprint on Temperature Proxies in Holocene Corals: A Case Study From French Polynesia

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A Commentary on

Early Diagenetic Imprint on Temperature Proxies in Holocene Corals: A Case Study From French Polynesia

by Rashid, R., Eisenhauer, A., Liebetrau, V., Fietzke, J., Böhm, F., Wall, M., et al. (2020). *Front. Earth Sci.* 8:301. doi: 10.3389/feart.2020.00301

INTRODUCTION

Rashid et al. (2020) presented mid- to late-Holocene SST reconstructions obtained on fossil *Porites* corals from French Polynesia. They especially report centennial to millennial SST trends on the order of $\pm 2^\circ\text{C}$ and relate them to sea-level changes that were previously published by Rashid et al. (2014). The authors conclude that cyclic SST variations may superimpose Glacial Isostatic Adjustment (GIA)-controlled sea-level height.

Subsections Relevant for the Subject

The following discussion is focused on the paragraph 'Implications for the Sea Level and Temperature Relationships in the Pacific' and Figure 10 from Rashid et al. (2020).

DISCUSSION

During the mid- to late-Holocene, low-amplitude (~ 1 m) relative sea-level (RSL) changes were mostly governed by GIA processes (e.g., Camoin and Webster, 2015 and references therein). The reconstruction of RSL changes at high resolution requires the use of reliable sea-level indicators, including salt marsh microfossils, archaeological remains, vermetid constructions, and fossil corals. Among these indicators, coral microatolls represent unique archives of the mean low water springs (MLWS) level in open water settings.

The interpretation of the SST/sea-level relationship by Rashid et al. (2020) is based on a previously defined sea-level curve (Rashid et al., 2014), which includes only three coral microatolls from two islands. Furthermore, the relevant dataset is characterized by scattered data, with differences in elevation of up to 2 m for coeval corals from the same island. This indicates that the dated corals typify diverse palaeoenvironments and palaeowater depths and cannot be therefore regarded as accurate sea-level indicators to reconstruct the RSL changes at high resolution during that time window. Furthermore, such a reconstruction is additionally hampered by uncertainties related to elevation measurements that have been estimated to ± 0.4 m (Rashid et al., 2014).

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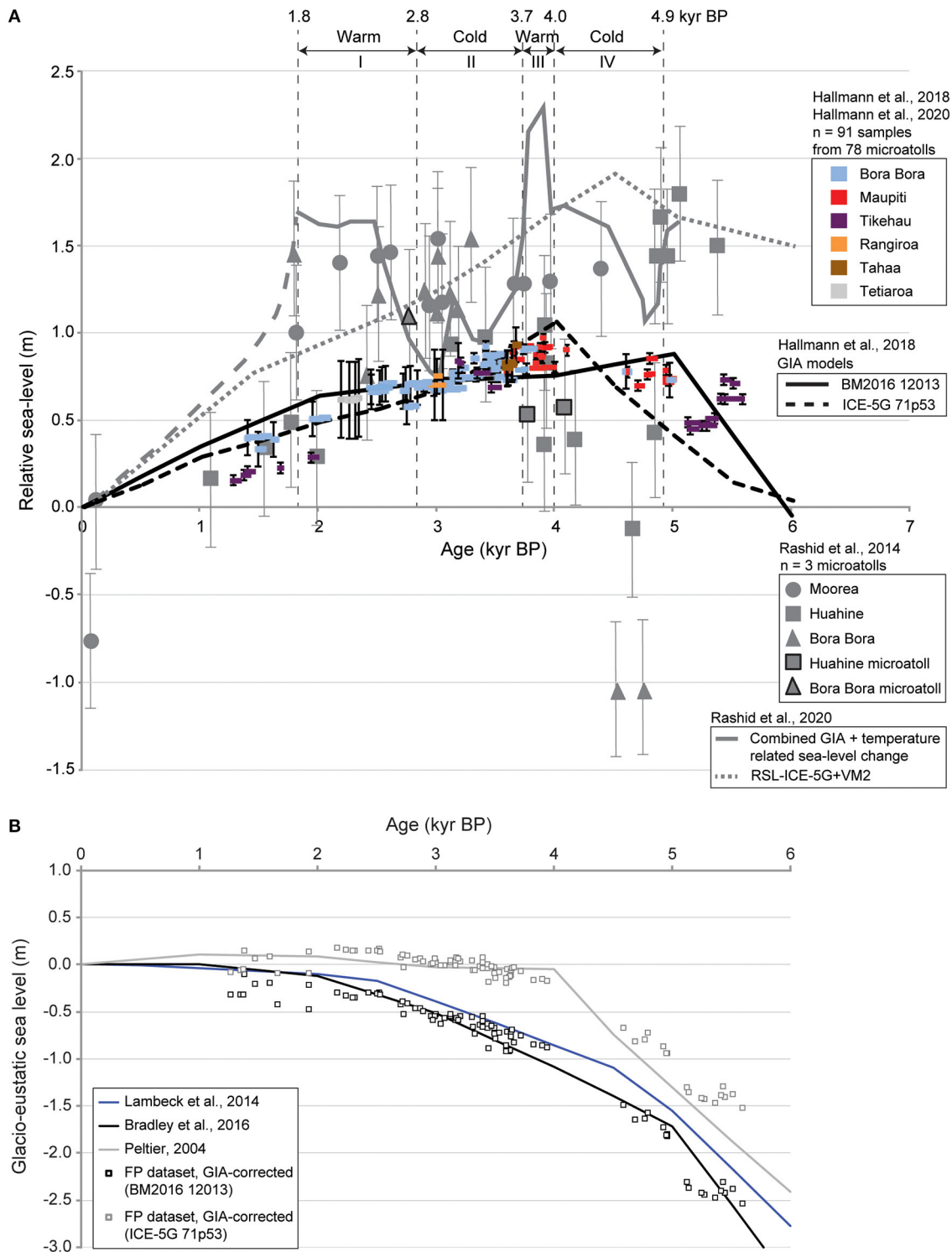


FIGURE 1 | (A) Reconstructed mid- to late-Holocene RSL changes in French Polynesia (Hallmann et al., 2018, 2020; in color) compared to model outputs based on BM2016 (black solid line) and ICE-5G ice models (black dashed line). This reconstruction overlies sea-level estimates from Rashid et al. (2014; in gray), their ICE-5G model output (gray dashed line) and the combined GIA-temperature related sea-level change presented in Rashid et al. (2020; gray solid line). For the Hallmann et al. (2018, 2020) dataset, the BM2016 model captures the older data better than ICE-5G as it produces an earlier highstand, however, the curve produced by ICE-5G better tracks the observations for the period after 4 kyr BP. This is also reflected in the consistency between the model curves (black and gray lines) and the model-corrected data (black and gray boxes) in **(B)**. In contrast to the 1-m sea-level highstand revealed by Hallmann et al. (2018, 2020), the ICE-5G model by Rashid et al. (2014) results in a ~2-m sea-level highstand. However, the Rashid et al. (2014) dataset is scattered and only one microatoll from Bora Bora is consistent with the *(Continued)*

FIGURE 1 | Rashid et al. (2020) ICE-5G curve. The viscosity profiles that minimized the Hallmann et al. (2018) data-model misfit are: (1) for BM2016: lithosphere thickness (LT) of 120 km, upper mantle viscosity (UMV) of 10^{21} Pa.s and a lower mantle viscosity (LMV) of 3×10^{21} Pa.s; and (2) for ICE-5G: LT = 71 km, UMV = 0.5×10^{20} Pa.s and LMV = 3×10^{21} Pa.s. In contrast, Rashid et al. (2014) used the viscosity profile for ICE-5: LT = 100 km, UMV = 5×10^{20} Pa.s and LMV = 5×10^{21} Pa.s. **(B)** Comparison of glacio-eustatic sea-level change estimates. Glacio-eustatic sea-level changes (changes in ice volume only) as represented in BM2016 (Bradley et al., 2016 in black) and ICE-5G (Peltier, 2004 in gray). Observations (black and gray squares) corrected for GIA based on the best-fitting model (in black: BM2016; LT = 120 km; UMV = 10^{21} Pa.s; LMV = 3×10^{21} Pa.s; in gray: ICE-5G; LT = 71 km; UMV = 0.5×10^{21} Pa.s; LMV = 3×10^{21} Pa.s). Glacio-eustatic history inferred by Lambeck et al. (2014) is shown in blue. This figure has been published in Hallmann et al. (2018).

The sea-level curve published by Rashid et al. (2014) has been challenged recently by the reconstruction of mid- to late-Holocene RSL changes based on high-precision GPS positioning and precise U/Th dating of 78 samples of *in situ* coral microatolls from five French Polynesian islands (Hallmann et al., 2018)—unfortunately not quoted in Rashid et al. (2020), then extended to 91 samples of *in situ* coral microatolls (Hallmann et al., 2020). This sea-level dataset is therefore robust enough both to reconstruct the evolution of MLWS through time and to track regional sea-level trends and climatic oscillations on interannual to millennial time scales. This RSL curve is shown in **Figure 1** below and compared to model outputs based on BM2016 and ICE-5G ice models to illustrate the contribution of GIA to the temporal variability of sea-level changes at the millennial scale (see details in Hallmann et al., 2018). The relevant RSL curve documents a short-lived, ~ 700 years, sea-level highstand of less than a meter between 4.10 and 3.40 kyr BP, following an overall sea-level rise from 6.0 to 4.10 kyr BP and preceding a fall in sea level between 3.40 and 1.26 kyr BP (Hallmann et al., 2018, 2020). The vast majority of our coral microatoll data—typifying the MLWS—plot significantly below (up to 1.3 m) the former sea-level data published by Rashid et al. (2014) and considered in Rashid et al. (2020).

Rashid et al. (2020) aims at demonstrating that cyclic SST variations may superimpose GIA-controlled sea-level height

based on sea-level data published by Rashid et al. (2014). The authors especially estimate that during the defined “warm” intervals (1.8–2.8 and 3.7–4 ka), empirical sea-level estimates are on average about 0.4 m higher than the sea level corrected from GIA processes and therefore deduce sea-level change caused by SST variations. The identification and quantification of such relationships must rely on an accurate reconstruction of RSL changes at high resolution. However, as mentioned above, the dated corals reported by Rashid et al. (2020) seemingly typify diverse palaeoenvironments and palaeowater depths and cannot be therefore regarded as accurate sea-level indicators. Furthermore, direct relationships between sea-level changes and SST variations can be hardly identified in Figure 10 from Rashid et al. (2020), due to the relatively large scattering of sea-level estimates.

Figure 1A displays the Hallmann et al. (2018, 2020) dataset (in color) overlying the data and interpretation presented by Rashid et al. (2020). This comparison implies that no direct relationship between the SST variations and sea-level changes can be identified in the relevant time window.

AUTHOR CONTRIBUTIONS

GC and NH wrote the article and conceived the figure. NH designed the figure.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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