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Invited research article

Episodic reef growth in the granitic Seychelles during the Last Interglacial: Implications for polar ice sheet dynamics

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A R T I C L E I N F O

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A B S T R A C T

We present a detailed taxonomic and lithologic analysis of fossil reefs in the Granitic Seychelles to improve constraints on global mean sea level behavior during the last interglacial sea-level highstand, ~129,000–116,000 years ago. In particular, we have assessed the coralgal reef outcrops for any sedimentalogic evidence of sub-orbital sea level oscillations that may have occurred during this warm, interglacial period. At the outcrop scale, we observe at least three distinct episodes of reef growth punctuated by two discontinuities that typically manifest as coral rubble layers or extensive lateral encrustations of the hydrozoan coral *Millepora exaesa*. Hiatuses in reef growth at other sites around the world have been interpreted as relative sea level falls and/or environmental disturbances. We have tested the hypothesis that these discontinuities, that we refer to as disturbance horizons, are related to ephemeral drops in sea level that have been inferred at last interglacial reef sites from other sites around the globe. At two sites, there is sedimentological evidence in the form of extensive dissolution and freshwater cements associated with the disturbance horizons that would require subaerial exposure followed by marine inundation. At the remaining sites, evidence is consistent with, but not necessarily indicative of, an ephemeral drop in sea level. To establish if these disturbance horizons are coeval between the outcrops and if they are local or global features, requires high-precision dating of the disturbance horizons along with a critical analysis of sedimentary and chronological evidence from other sites around the globe. If the disturbance horizons observed in the Seychelles represent transient sea-level falls or still stands during the last interglacial, this would imply a dynamic behavior of the polar ice sheets during this past warm period.

1. Introduction

Understanding the dynamic behavior of the large polar ice sheets in response to rising global temperatures is critical to projecting future sea-level change (*e.g.* DeConto and Pollard, 2016). Models aid in the projection of future global sea-level changes under different climate scenarios, but constraining the rate and magnitude of polar ice sheet retreat remains challenging (Rahmstorf, 2007; Grinsted et al., 2010). Empirical records of sea level from previous warm interglacials provide quantitative control on the behavior of polar ice sheets during periods warmer than present (*e.g.*, Dutton et al., 2015a). In particular, the last interglacial (LIG) period, also known as Marine Isotope Stage (MIS) 5e, has been widely studied to understand near-future conditions because the ice sheets were in a similar configuration to the present while polar temperatures were at least several degrees (°C) warmer, according to ice core reconstructions from Greenland (North Greenland Eemian Ice Drilling (NEEM) community members, 2013) and East Antarctica (Jouzel et al., 2007; Sime et al., 2009; Stenni et al., 2010). Peak global mean sea level (GMSL) elevation during the LIG has been constrained to ~6–9 m above present using global databases (Kopp et al., 2009, 2013; Dutton and Lambeck, 2012).

While most sea-level projections define a smooth progression of sea-level rise into the future, there is some evidence from the LIG period that the sea-level highstand that was associated with polar ice sheet retreat was punctuated by multiple, meter-scale sea level oscillations (Chen et al., 1991; Thompson and Goldstein, 2005; Hearty et al., 2007;

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Rohling et al., 2008; Blanchon et al., 2009; O'Leary et al., 2013). However, both the presence and the nature of millennial-scale variations in sea level during the LIG sea-level highstand are debated (Chen et al., 1991; Stirling et al., 1995, 1998; Thompson and Goldstein, 2005; Hearty et al., 2007; Rohling et al., 2008; Blanchon et al., 2009; Thompson et al., 2011; O'Leary et al., 2013; Kopp et al., 2013). Existing studies do not agree on the number or timing of sea-level fluctuations that have been inferred from LIG reconstructions. The interpreted evolution of LIG sea level has been variously characterized as (i) stable throughout the LIG (Stirling et al., 1998), (ii) stable at the beginning of the LIG followed by a rapid rise (Blanchon et al., 2009; O'Leary et al., 2013), (iii) containing two distinct sea-level peaks separated by a transient drop in sea-level (Hearty et al., 2007), or (iv) containing multiple sea-level oscillations with several distinct peaks (Rohling et al., 2008; Thompson et al., 2011).

The primary goal of this work is to assess whether there is sedimentary evidence (*e.g.* stratigraphic unconformities, evidence of freshwater exposure *etc.*) for sea-level oscillations during the LIG in the Seychelles. The Seychelles are a useful region for LIG sea-level studies as they are a far-field site with well-preserved fossil reef material. To achieve this, we generated a complete taxonomic and lithologic profile of several emergent marine limestone outcrops containing *in situ* coralgal framework located in the high granitic islands (Mahe-Praslin group, Fig. 1). We examined the taxonomy, preservation, and associated lithologies of the emergent limestones in the context of previously published U-Th ages, to understand the relative sea level (RSL) history for the region, including estimates of paleowater depth of the observed reef biota, in order to test the hypothesis that the LIG sea level highstand contained sub-orbital sea level oscillations.

2. Study area

2.1. Geologic setting

The Seychelles is an archipelago of 115 islands located at 4–10°S and 45–56°E, approximately 1500 km east of Africa in the Indian Ocean (Fig. 1). The islands can be divided into three groups according to basement lithology: the granitic Mahé-Praslin group, the coral-dominated Amirantes group, and the Aldabra-Astove carbonate atoll group (Baker, 1963; Braithwaite, 1984). The Mahè-Praslin group (~4°S) on the Seychelles Bank is composed of Precambrian granite (Baker, 1963) and is considered tectonically stable since the late Eocene based on the absence of igneous intrusions after this time (Mart, 1988). In tectonically stable regions such as this, the RSL signal is primarily controlled by the GMSL and glacial isostatic adjustments (GIA), although additional factors such as dynamic topography (vertical motion of Earth's surface driven by mantle convection) may influence the RSL signal (Dutton et al., 2015a). While no locality is completely unaffected by the deformations of the solid earth and gravity field due to changes in ice and water loading on glacial-interglacial timescales, there are some regions, such as the Seychelles, where numerical models indicate that GIA corrections to RSL during the LIG will be both relatively small and relatively insensitive to model parameterization (Milne and Mitrovica, 2008; Lambeck et al., 2010; Dutton and Lambeck, 2012; Hay et al., 2014).

2.2. Emergent LIG limestones

The Mahé-Praslin group has a patchy veneer of emergent marine limestones that adhere to the granitic substrate on land, and have been dated to the LIG (Veeh, 1966; Montaggioni and Hoang, 1988; Israelson and Wohlfarth, 1999; Dutton et al., 2015b). Emergent limestones are

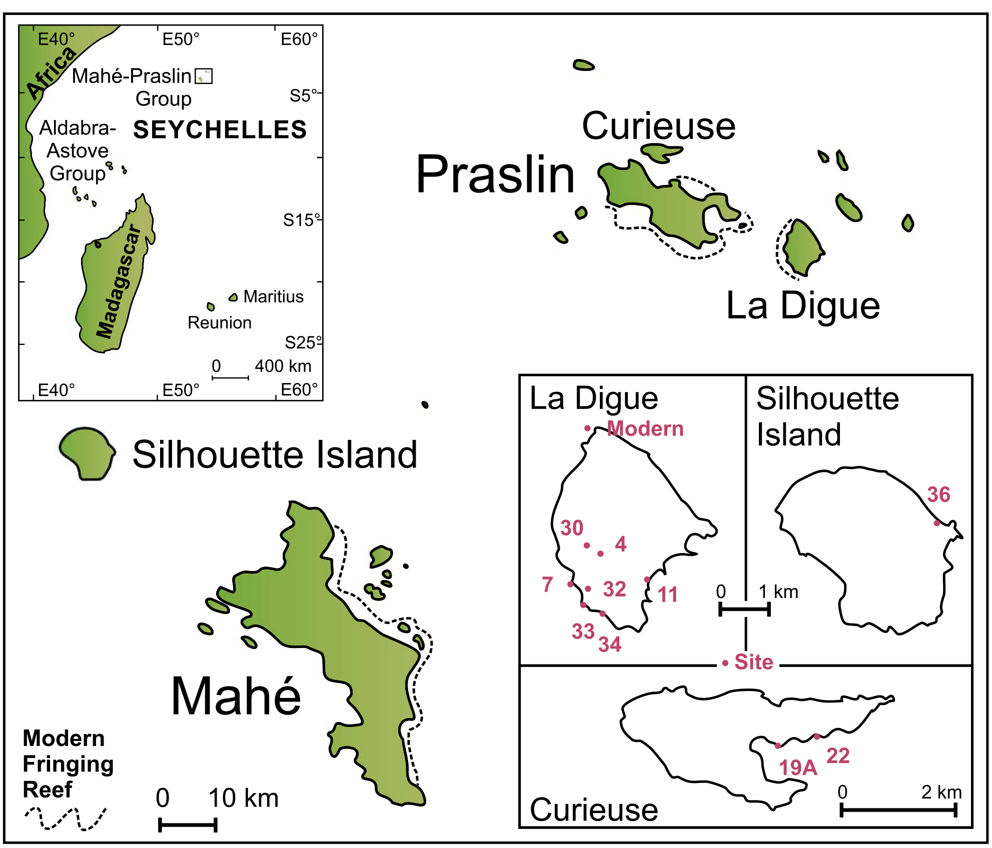

Fig. 1. Study Location. The Mahé-Praslin group in the Seychelles are the highest, and most tectonically stable islands in the archipelago. Modern fringing reefs occur on both windward (SE) and leeward (NE) sides of the islands, and the MIS 5e reefs are often found directly inland of the modern reefs. The sites detailed in this study are on Curieuse, La Digue, and Silhouette Island. Bottom right inset shows locations of study sites.