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Punctuated progradation of the Seven Mile Beach Holocene barrier system, southeastern Tasmania

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ABSTRACT

Prograded barriers are depositional coastal landforms which preserve past shoreline locations and have been studied in order to understand the fundamental drivers of barrier formation. This paper reconstructs the Holocene history of the Seven Mile Beach, prograded barrier in Tasmania, Australia using optically stimulated luminescence (OSL) dating, ground penetrating radar (GPR), light detection and ranging (LiDAR) elevation models and sedimentological analyses. Shoreline progradation of the barrier commenced around 7300 years ago and continued to near present despite a ~3000 pause in deposition between 6700 and 3600 years ago indicative of substantial changes in sediment availability. GPR imaged subsurface structures contain a record of seaward dipping reflectors preserved as sediment supplied beaches and dunes leading to shoreline progradation. In the past 500 years a large transgressive dune has formed, built from reworked barrier sands, and now dominates the eastern portion of the barrier implying that shoreline progradation has ceased. This study reaffirms the notion that relict foredune ridges are strongly aligned with modal wave refraction patterns in planform and emphasises the importance of sediment delivery as a key driver of shoreline progradation through beachface and dune accretion. The substantial pause in shoreline progradation on this barrier system, as observed on others around the world, requires further explanation. Although changes in sediment delivery have been inferred, it may also be appropriate to reopen the debate on Holocene sea-level change in Tasmania.

1. Introduction

Prograded barriers commonly comprise a series of shore-parallel relict foredune ridges or 'beach ridges' sensu stricto (Hesp, 2006) which preserve past shoreline positions (Taylor and Stone, 1996; Otvos, 2000) while also commonly containing other dune elements such as parabolic dunes, blowouts and transgressive dunes (Dillenburg et al., 2004; Hesp et al., 2007). Investigation of the processes involved and the chronology of formation of these ridges provides information on coastal landform evolution at decadal to millennial timescales (e.g. Hede et al., 2015; Rémillard et al., 2015). Studies from around the world have demonstrated the validity of using optical luminescence dating to determine the timing of deposition of individual ridges (Timmons et al., 2010; Guedes et al., 2011; Reimann et al., 2011). Geophysical and sedimentological techniques provide further potential to investigate prograded barriers as repositories of paleoenvironmental information from which it may be possible to reconstruct sea-level changes (Tamura et al., 2008; Clemmensen and Nielsen, 2010; Hede et al., 2015), storm erosion histories (Bristow et al., 2000; Dougherty, 2014) and coastal response to regional climatic changes (see Tamura (2012) for review).

Several prograded barrier sites in southeastern Australia. have been constrained by radiocarbon dating which indicates their history of progradation (Thom et al., 1981a, 1981b). More recently the chronology of some of these barriers has been more accurately determined using optically stimulated luminescence (OSL) dating of quartz grains. OSL dating allows the time since deposition of sediment to be determined whereas radiocarbon dating of biological materials dates the cessation of radiocarbon uptake (e.g. the death of the organism) which may predate the sedimentary event. Since the first use of OSL to supplement a radiocarbon chronology and reconstruct the depositional history of Guichen Bay, South Australia (Murray-Wallace et al., 2002), several other coastal plains around Australia have been investigated using OSL. Sites such as Cowley Beach (Nott et al., 2009), Keppel Bay (Brooke et al., 2008), Iluka-Woody Bay (Goodwin et al., 2006), Moruya (Oliver et al., 2015) and Admiral Bay (Engel et al., 2015) have provided important contributions to understanding Australian coastal morphodynamics and palaeoenvironmental changes on local to regional scales adding to a larger body of international research. In contrast to

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mainland Australia, the Late Quaternary coastal landforms of Tasmania have not received comparable attention, despite being both geographically extensive, and internationally significant in inspiring the early insights into ridge formation processes (Davies, 1957, 1958, 1961; Oliver et al., 2016) (Fig. 1c). Detailed chronological studies of Tasmanian coastal deposits are concerned with uplifted marine deposits of neotectonic significance (e.g. Murray-Wallace and Goede, 1991, 1995) and terrestrial dune activity (Duller and Augustinus, 1997, 2006); see also McIntosh et al. (2009) for a review.

This study uses OSL dating, ground penetrating radar (GPR), airborne Light Detection and Ranging (LiDAR) elevation data and sedimentological analyses to reconstruct the Holocene deposition of the Seven Mile Beach barrier and describe the Late Quaternary landforms against which it is emplaced. These datasets provide an opportunity to explore the importance of various drivers of progradation and their influence barrier on morphology in a deeply embayed coastal setting. This study also tests the hypothesized influence of modal wave refraction patterns controlling barrier planform configuration proposed by Davies (1958, 1959) (Fig. 1c). The study constitutes the first OSL chronology of a Holocene ridge sequence in Tasmania and enables the first direct comparison with similar barriers around mainland Australia and the world.

2. Study site

The Seven Mile Beach barrier system is located approximately 15 km ENE of Hobart in southeast Tasmania and comprises approximately 30–40 sub-parallel relict foredune ridges around 4–6 m above mean sea level (MSL) that form a low-lying coastal plain at the head of Frederick Henry Bay (Fig. 1). The barrier is situated

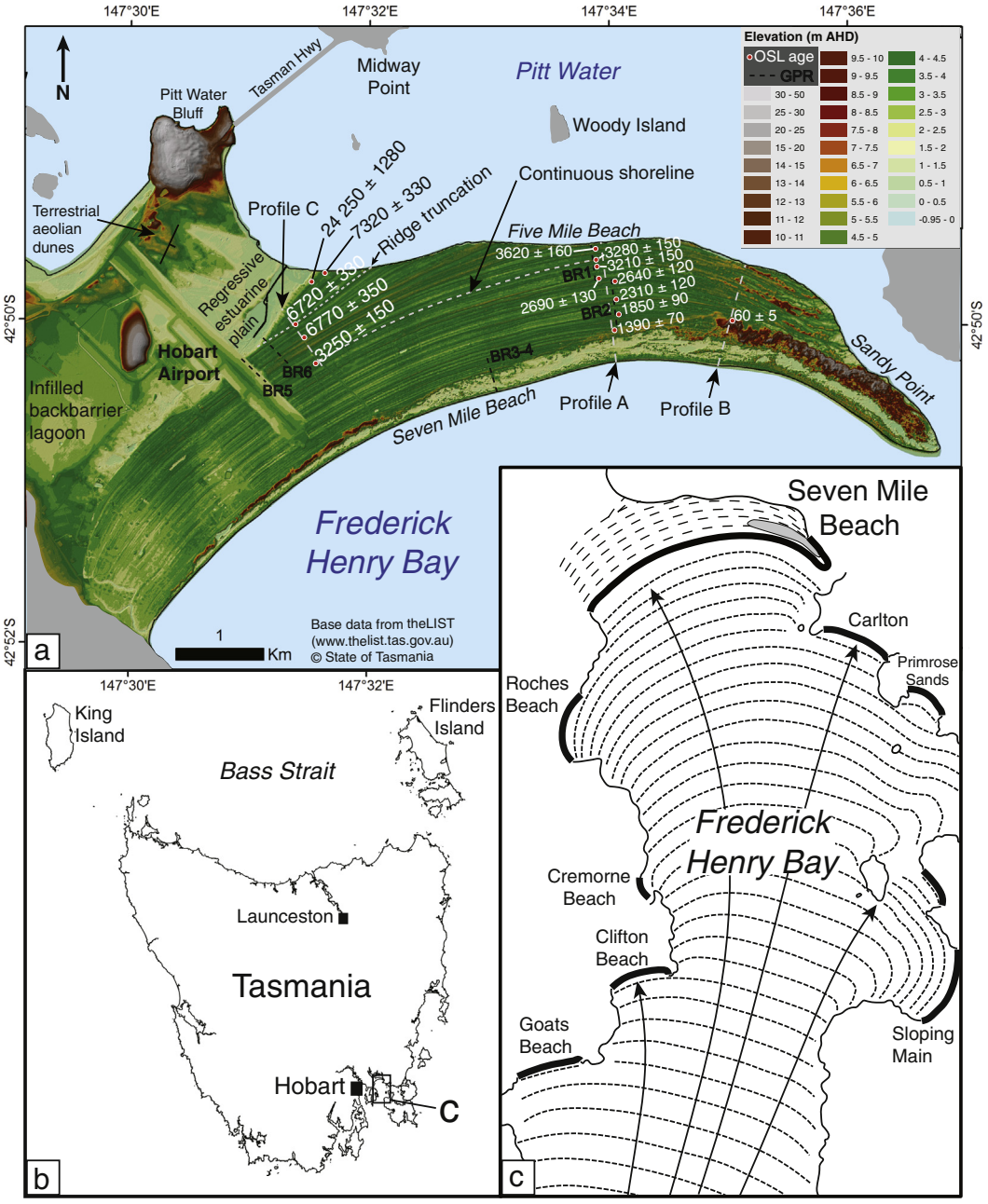

Fig. 1. a) Map of the Seven Mile Beach barrier derived from airborne LiDAR showing the major geomorphic features, OSL ages and GPR transect locations, b) map of Tasmania showing location of Frederick Henry Bay, c) inset map showing Frederick Henry Bay wave refraction patterns and resultant shoreline alignment of Seven Mile Beach relict ridges and other sandy beaches (bold lines) within the bay; modified after Davies (1958) and Oliver et al. (2016).