Geosciences Journal
Vol. 19, No. 3, p. 575 − 578, September 2015
DOI 10.1007/s12303-015-0029-y

DISCUSSION AND REPLY

Comments on the paper "Stratigraphy and geochronology of Quaternary marine terraces of Tasmania, Southeastern Australia: implications on neotectonism" by Jaeryul Shin, Geosciences Journal, 17, 429–443

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ABSTRACT: The uplift rates calculated for Tasmania by Shin (2013) are not supported by the data presented in his paper. The OSL ages obtained indicate a Last Glacial age and fluvial origin for many of the deposits analysed. OSL ages obtained on sediments at Mary Ann Bay in southern Tasmania confirm recent research indicating a Last Glacial age and aeolian deposition of the sands rather than marine (Last Interglacial) deposition. Anomalously high uplift rates for southern Tasmania, proposed by earlier researchers and Shin (2013), are discounted.

Key words: Quaternary marine terraces, OSL dating, Tasmania, Mary Ann Bay, uplift rates

1. INTRODUCTION

The eight optically stimulated luminescence (OSL) ages for Tasmanian sediments sampled by Shin (2013), are useful for understanding the major erosion and accumulation events in Tasmania. However the author's stratigraphic interpretation of the ages he obtained and his use of the ages to calculate uplift rates in Tasmania (Shin, 2013, Figs. 8–10) require comment. In the discussion below sites are considered in the sequence presented by Shin (2013).

2. DISCUSSION

2.1. Site Selection

All four of the author's sampling areas are located adjacent to estuaries of large rivers and their tributaries: the George River, Mosquito Creek and Flagstaff Creek at St Helens; the Derwent River at Hobart; the King and Gordon Rivers at Strahan; and the Blythe River at Heybridge. Bays and inlets can be useful for preserving marine terraces because they provide these terraces with more protection from degradation than sites facing the open sea. But where these bays and inlets have rivers flowing into them the question of differentiating marine and fluvial features and sediments arises. This issue is not discussed by Shin (2013), and the author has not explained how and why he selected sites for sampling.

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2.2. East Coast, St Helens

Terrace ET1 has been mapped by Shin (2013) near sea level at a few sites south of St Georges Bay, St Helens, where steep stream-dissected hills of weakly consolidated Cenozoic sediments occur. Although a marine origin for the lowest terrace (ET1) cannot be ruled out, no evidence is given for this proposition. A plausible alternative origin for the terraces is fluvial deposition of low-angle fans during times of reduced vegetation cover. At some mapped locations terrace ET2 (at slightly higher altitude: 8–10 m asl) may have a similar origin, but the dated site, in north St Helens township, occurs on a flat site less than 100 m from Mosquito Creek and is probably a fluvial terrace, as Shin (2013, p. 436) points out. The OSL age obtained for the deposit (18 ± 2 ka) indicates that the terrace was aggraded by Mosquito Creek at the close of the Last Glacial Maximum (LGM) (dated ca. 23.5–17.5 ka in Tasmania; McIntosh et al., 2012) when the catchment was still poorly vegetated, erosion was more marked than at present, and sea levels were much lower. The ET3 terrace deposit adjacent to Flagstaff Creek (but not mapped as an ET3 terrace by Shin (2013, Fig. 3)), has a similar age (22 ± 3 ka) and a similar origin is likely. Terraces ET5–ET8 are distinguished only on slope criteria; Shin (2013, p. 431) remarked "it is difficult to find typical marine deposits on terraces", so presumably marine deposits were absent. Individual sites have not been checked, but all mapped terraces in this sequence are in granodiorite terrain and this rock weathers to broad rounded hills in which flattish areas can easily be confused for terraces. In the absence of evidence for marine sediments at any location labelled ET5–ET8 the conclusion that these terrace-resembling landforms have a marine origin is problematic.

In interpreting the ages obtained for the dated deposits ET2 (fluvial) and ET3 (probably fluvial) Shin (2013, p. 436) writes "it is proposed that the formation time of ET2 terrace is the MIS 5e (ca. 120–130 ka BP)". However, the terrace deposits have an LGM age, so presumably Shin (2013) means that a conjectural and undescribed surface underlying the ET2 terrace is allotted to MIS 5e. But the depth or nature of this conjectural underlying surface is nowhere described. In Figure

8, Shin (2013) plots the *present-day* surface height of the deposits dated 18 ka as being the MIS 5e surface, which is a serious error. In a similar error, the ET3 surface (12–16 m asl) is assigned a MIS 7e age, even though the deposits forming this surface are dated 22 ka. The plotting of the ET4 terrace, for which no deposits are described and no ages obtained, as ca. 380 ka is conjectural to say the least. As the two terraces dated by OSL techniques are probably fluvial, and no marine terraces have been identified with certainty, and no marine deposits have been described or dated, the uplift rate of 56 m/Myr calculated for eastern Tasmania by Shin (2013, Fig. 8) cannot be taken as derived from the author's data.

2.3. South Coast, Hobart

The mapped ST1 terrace near Mary Ann Bay is misidentified as a marine terrace. It has the classic shape of a tombolo, a type of isthmus formed by tidal currents. The interpretation of higher benches (ST2 and ST3) as terraces (Shin, 2013, p. 433 and Fig. 4) must be treated cautiously, because the underlying rock of the Mary Ann Bay area of the South Arm peninsula is dolerite, and the sand-covered dolerite bedrock (originally a sill) forms a roughly planar surface in many places, which can easily be mistaken for a terrace landform. Shin (2013, Table 3) dated the ST3 deposits at 18 m asl as 25 ± 3 ka and those at 22 m asl as 31 ± 3 ka which is the reverse of the order expected from stratigraphic relationships. However, these ages are within 1 standard deviation of each other so are essentially the same, and date the sands as being deposited at ca. 28 ka. Similar ages (30.7 ± 1.9 ka and 30.3 ± 1.9 ka; mean 30.5 ka) from the same deposits were obtained by thermoluminescence (TL) methods (Slee et al., 2012; McIntosh et al., 2013). The approximate concordance of these ages obtained by two different methods is strong evidence that the sands were deposited in early MIS 2, as defined by Lisiecki and Raymo (2005). We note that both Shin (2013) and McIntosh et al. (2013) had confidence in their OSL and TL results: Shin (2013, pp. 438–439) remarks that "Equivalent radioactive dose (D_e) values for aliquots of MA02 and MA05 typically displayed normal frequency distributions, suggesting that significant incursions of grains younger than the burial event or incomplete resetting of luminescent signals prior to deposition had not occurred" and McIntosh et al. (2013, p. 7) remark that the length of temperature plateau comparisons demonstrated "excellent TL resetting during the final transport phase and stability of trapped electrons within the crystalline lattice and is typical of temperature plateaux found in aeolian deposits [and] lends considerable confidence to the validity of the TL ages obtained." The OSL and TL ages obtained therefore strongly support a ca. 28–31 ka age for the dated sands. As sea levels were ca. 100 m lower at the beginning of MIS 2 (Lambeck and Chappell, 2001) the sands cannot be marine or fluvial and must be aeolian, which is supported by the widespread occurrence of aeolian sands and silts in the immediate vicinity and in the wider region (Colhoun, 1977; McIntosh et al., 2004; Donaldson, 2010; McIntosh et al., 2012). As noted by Slee et al. (2012) and McIntosh et al. (2013) the stratigraphy of the site also supports an aeolian origin: the underlying weathered dolerite (with relic rounded corestones with onion-skin weathering, misinterpreted as a basal conglomerate by Shin (2013)) is a buried soil horizon, and this layer and other incompetent layers at the base of the sandy deposits would not have survived vigorous wave action, had the site been covered by Last Interglacial seas.

As stated by Slee et al. (2012) and repeated by McIntosh et al. (2013), the presence of Last Interglacial shells and shell fragments (Murray-Wallace and Goede, 1991) in the Last Glacial sands at Mary Ann Bay can be readily explained by erosion of a nearby shell bank (no longer extant) of Last Interglacial origin and transport of shells and shell fragments over dune surfaces by storm force winds. It should be noted that the land around Mary Ann Bay is exposed to winds from all quarters and the surface topography (visible on Google maps) indicates an aeolian (dune) palaeolandscape.

In view of this strong evidence for assigning ST3 deposits to MIS 2 it is remarkable and inexplicable that Shin (2013, p. 439), ignoring his own OSL dating in which he professes confidence, assigns the younger (lower) ST2 "terrace" to MIS 5e. With no field evidence other than a spot height and no OSL age he then labels a high point of the Mary Ann Bay landscape (40 m asl) as terrace ST4 and assigns it a date of 380 ka (Shin, 2013, Fig. 8). In the same diagram the "terrace" formed by the two dated ST3 deposits (both ca. 28 ka) are assigned without any explanation to two marine events separated by 100 000 years: MIS 5e and MIS 7d, while the previous assignment of terrace ST2 to MIS 5e (Shin, 2013, p. 439) is ignored.

It has to be concluded that (1) the uplift rates for the Tasmanian southeast coast portrayed in Figure 8 of Shin (2013) and proposed by earlier researchers (e.g., Murray-Wallace and Goede, 1991) are not supported by field and laboratory observations; (2) that none of the Mary Ann Bay landforms described by Shin (2013) can be described as marine terraces; and (3) "terraces" ST2, ST3 and ST4 are either aeolian landforms created in much the same way, and during a similar time period, as the extensive dated aeolian deposits documented in the region, or related to bedrock features.

2.4. West Coast, Strahan

Other than quoting the results of Pole (1998) who described deposits of Eocene age, Shin (2013) provides no evidence that the Tasmanian west coast terraces he describes and dates are marine. As with the deposits on the west and east coasts of the South Island of New Zealand (e.g., Suggate, 1990; Gage, 1958) and deposits on the west coast of Tasmania dated by Augustinus and Macphail (1997), the major gravelly and sandy terrace deposits at Strahan are likely to be cold-climate outwash fans and terraces deposited by major rivers draining glaciated valleys. The dated deposits near Buoy Point (sample STR07, terrace WT2, sampled at 6 m asl) are opposite the entry of the King River into Macquarie Harbour and at one time (before Holocene sea level rise) could have been continuous with the King River deposits; they are not necessarily analogous to the deposits described by Pole (1998). The 111 ± 16 ka OSL age obtained by Shin (2013, Table 3) for this deposit indicates that it formed when temperatures were falling rapidly at the MIS 5e/5d transition (Liesecki and Raymo, 2005), which is consistent with these gravelly sands having accumulated by fluvial action in a cooling climate. "Good sorting and seaward imbrication" (Shin, 2013, p. 439) is insufficient proof of a marine (interglacial) origin and does not take precedence over the evidence of the OSL age which supports a fluvial origin. In addition, extensive flat areas of marine gravels are uncharacteristic of the present (interglacial) environment on the west coast of Tasmania and there is no reason to suppose that the marine processes in MIS 5e were different. Shin (2013, Fig. 8) plots ages and altitudes above sea level for three undated and undescribed terraces (each labelled WT3, possibly in error) and obtains an uplift rate of 40 m/Myr. While flights of terraces evident on the west coast of Tasmania appear to indicate regional uplift (Twidale, 1957), the data presented by Shin (2013, Fig. 8) seems to be unrelated to actual field evidence or ages obtained.

2.5. North Coast, Heybridge

It is regrettable that the terraces Shin (2013) chose to date on the North Coast were not undoubted marine terraces isolated from the action of rivers but instead terraces close to the Blythe River. Shin (2013, p. 439) assumes that his sample WB01, taken from 1 m below the soil surface on terrace NT3 and dated 164 ± 18 ka is fluvial, and this deduction is almost certainly correct, given the proximity of terrace NT3 to the river. Without good evidence to the contrary (which Shin (2013) does not provide), we must also conclude that sample WB02, taken from 3 m below the soil surface at the same location, and dated >164 ka is also fluvial. A reasonable conclusion is that the sediments forming the NT3 terrace are cool-climate deposits which accumulated between ca. 160 and 190 ka, in MIS 6. Whether these cool-climate sediments were deposited over older fluvial sediments, or a fluvial degradation surface developed in bedrock, or a marine wave-cut platform, or marine terrace deposits, cannot be determined from the data provided by Shin (2013). Despite the ages obtained, indicating probable accumulation of NT3 terrace deposits during MIS 6, Shin (2013, p. 439 and Fig. 8) assigns NT3 terrace formation to both MIS 7e (ca. 240 ka) and to ca. 375 ka but no justification for assigning the terrace to either of these periods is given. In addition, the older NT3 terrace is assigned a height of 24 m (Shin, 2013, Fig. 8) but in the text (p. 439) NT3 terraces are described as having a height range of 12–16 m asl. As the author provides no evidence to show that any of the dated terraces at Heybridge are marine or formed in interglacial conditions, his conclusion that his data support an uplift rate on the northern Tasmania coast of 64 m/Myr (Shin, 2013, Fig. 8) is not proven.

3. CONCLUSION

Although Shin (2013) presents useful information on the ages of cool-climate deposits that have accumulated between ca. 22 and 164 ka in coastal Tasmania, the interpretation of these ages in terms of marine uplift is deficient. All sampling sites were close to rivers or on present-day estuarine land previously adjacent to a major river. At no site are unequivocal marine sediments or surfaces described and for many sites the dated cool-climate deposits are interpreted, without supporting field evidence, to indicate that a conjectural underlying surface is of interglacial origin. A key figure in Shin's (2013) analysis is Figure 8, but none of the dated points in this diagram correspond to dated samples listed by the author and the assignment of many points to interglacial periods is not justified by field or laboratory evidence presented. Consequently the calculated uplift rates around Tasmania (Shin, 2013, Figs. 8 and 10) are considered erroneous.

Perhaps the most important results presented by Shin (2013), unfortunately not highlighted by the author, are the new OSL ages for the sands at the Mary Ann Bay site in the Derwent River estuary in southern Tasmania. Shin (2013) obtained ages of ca. 28 ka for these sands, and similar ages (ca. 31 ka) were obtained by Slee et al. (2012) and McIntosh et al. (2013) for sands in the same section. Both Shin (2013) and Slee et al. (2012) and McIntosh et al. (2013) expressed confidence in their luminescence ages. Thus there are now two OSL and two TL ages indicating that these sands are cold-climate deposits, with an aeolian origin supported by both the Last Glacial ages obtained and field evidence (Slee et al., 2012; McIntosh et al., 2013). Consequently the notion that Mary Ann Bay sands are marine and represent Last Interglacial high sea level deposits requiring anomalously high rates of local uplift, first proposed by Colhoun et al. (1982), developed by Murray-Wallace and Goede (1991), and most recently reiterated by Murray-Wallace et al. (2013), can be discounted.

ACKNOWLEDGMENTS: I would like to acknowledge valuable discussions in the field with Colin Mazengarb and Michael Stevenson, both from Mineral Resources Tasmania.

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Manuscript received March 22, 2015
Manuscript accepted May 6, 2015