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Formation and preservation of marine terraces during multiple sea level stands

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Marine terraces are a cornerstone for the study of paleo sea level and crustal deformation. Commonly, individual erosive marine terraces are attributed to unique sea level high-stands. This stems from early reasoning that marine platforms could only be significantly widened under moderate rates of sea level rise as at the beginning of an interglacial and preserved onshore by subsequent sea level fall. However, if marine terraces are only created during brief windows at the start of interglacials, this implies that terraces are unchanged over the vast majority of their evolution, despite an often complex submergence history during which waves are constantly acting on the coastline, regardless of the sea level stand.

Here, we question the basic assumption that individual marine terraces are uniquely linked to distinct sea level high stands and highlight how a single marine terrace can be created By reoccupation of the same uplifting platform by successive sea level stands. We then identify the biases that such polygenetic terraces can introduce into relative sea level reconstructions and inferences of rock uplift rates from marine terrace chronostratigraphy.

Over time, a terrace’s cumulative exposure to wave erosion depends on the local rock uplift rate. Faster rock uplift rates lead to less frequent (fewer reoccupations) or even single episodes of wave erosion of an uplifting terrace and the generation and preservation of numerous terraces. Whereas slower rock uplift rates lead to repeated erosion of a smaller number of polygenetic terraces. The frequency and duration of terrace exposure to wave erosion at sea level depend strongly on rock uplift rate.

Certain rock uplift rates may therefore promote the generation and preservation of particular terraces (e.g. those eroded during recent interglacials). For example, under a rock uplift rate of ca. 1.2 mm/yr, Marine Isotope Stage (MIS) 5e (ca. 120 ka) would resubmerge a terrace eroded ca. 50 kyr earlier for tens of kyr during MIS 6d–e stages (ca. 190–170 ka) and expose it to further wave erosion at sea level. This reoccupation could accordingly promote the formation of a particularly wide or well planed terrace associated with MIS 5e with a greater chance of being preserved and identified. This effect is potentially illustrated by a global compilation of rock uplift rates derived from MIS 5e terraces. It shows an unusual abundance of marine terraces documenting uplift rates between 0.8 and 1.2 mm/yr, supporting the hypothesis that these uplift rates promote exposure of the same terrace to wave erosion during multiple sea level stands.

Hence, the elevations and widths of terraces eroded during specific sea level stands vary widely from site-to-site and depend on local rock uplift rate. Terraces do not necessarily correspond to an elevation close to that of the latest sea level high-stand but may reflect the elevation of an older, longer-lived, occupation. This leads to potential misidentification of terraces if each terrace in a sequence is assumed to form uniquely at successive interglacial high stands and to reflect their elevations.