Terrestrial and coastal landscape evolution on tropical oceanic islands

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Viles, H.A. & Spencer, T. Terrestrial and coastal landscape evolution on tropical islands. *Scripta Geologica*, **142**: 7-8, Leiden, May 2011.
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Tropical oceanic islands owe their origin to volcanic eruptions, their location to plate tectonics, and their morphology to the interplay over time between a range of constructional and erosional processes. A broad distinction can be made between high volcanic islands, with summits up to 4,000 m, and low carbonate islands only a few metres above sea level. These island types form the end points of an evolutionary sequence first synthesised by Charles Darwin. However, within this sequence, islands may experience complex histories involving the interaction of submergence, tectonic uplift, sea-level change and the impact of extreme events. These interactions result in patchworks of submerged, near sea-level and raised reef constructions, and surface erosional and depositional landscapes. Herein, we focus on the causes and consequences of such morphodynamic histories over long, medium and short timescales.

Over long timescales (>10 million years) landscape evolution on oceanic islands is driven by basin-wide subsidence. In the tropics, geologically rapid island creation at locations of high magma production is followed by extinction and island erosion. This dynamic is accompanied by the progressive development of fringing and barrier reefs encircling volcanoes, and ultimately formation of coral atolls, driven by long-term plate cooling. Reef growth 'start up' and 'shut down' occurs as lateral plate movements bring volcanic islands into and out of the reef seas. The subsidence trend is modified by global eustatic sea-level change; thus, atolls may experience periods as high limestone islands characterised by karstification, soil development and terrestrial biota.

Over medium timescales (100,000 – 2 million years), and at more regional scales, basin-wide processes may be complicated by lithospheric flexure, whereby the growth of a volcano depresses the oceanic lithosphere around it, which is compensated by crustal uplift further away. Such processes lead to submerged reef terraces near to the load and raised reefs at the wavelength of the arch; these patterns are further influenced by glacial – interglacial variations in sea level. These controls are particularly complex in island chains where the growth of new volcanoes repeatedly propagates additional load down the chain.

Over short timescales (100 - 10,000 years) coral reefs show 'give-up', 'catch-up' and 'keep-up' responses to postglacial sea level rise, determined by the interaction of platform depth on flooding and regional sea level curves. Resultant reef surfaces are then differentially impacted regionally by hurricanes, cyclones and, exceptionally, tsunamis.

The interaction of these endogenetic and exogenetic processes over long, medium and short timescales has resulted in a great diversity of landforms in the contemporary terrestrial and coastal settings of tropical islands. The vulnerability of such systems to near-future global environmental change must be assessed in the context of this complex backdrop.