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Holocene canyon activity under a combination of tidal and tectonic forcing

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The majority of submarine canyon systems that are active during sea level highstands are coupled to terrestrial or littoral sediment transport systems (e.g. high sediment-yield rivers, wave-base sediment disturbance). However, non-coupled canyon systems can also exhibit sedimentary activity. Characterising the nature, origin, and spatial and temporal influence of the processes responsible for this sedimentary activity is important to understand the extent of sediment and carbon transfer to the deep sea, the impact of sedimentary flows on biological colonisation and diversity, and the control of recent seafloor processes on canyon morphology.

The Cook Strait canyon system, between the North and South islands of New Zealand, is a large (1800 km2), multi-branching, shelf-indenting canyon on an active subduction margin. The canyon comes within 1 km of the coast, but does not intercept fluvial or littoral sediment systems and is therefore defined as a non-terrestrially-coupled system. Sediment transport on the continental shelf, associated with a strong tidal stream, and seafloor disturbance related to numerous high-activity faults is known from previous studies. Little is known, however, about the rates of sedimentary activity in the canyon and the processes driving it. The canyon system therefore provides an excellent study area for understanding sediment transport in a non-coupled submarine canyon system.

Analysis of EM300 multibeam bathymetry, gravity cores, 3.5 kHz seismic reflection profiles, camera and video transects and current meter data reveals a system where oceanographic (tidal) and tectonic (earthquake) processes are moving sediment from the continental shelf, through the upper canyon, and finally to the deep ocean. Sediment accumulation rates may reach several mm/yr in the upper canyons, with data suggesting minimum rates of 0.5 mm/yr. We demonstrate that tidal currents are sufficient to mobilise fine to medium sand around and within the upper canyon heads, and transported sediment is accumulating in upper canyon depocentres. Based on pseudo-static stability modelling, and supported by sediment core records, we estimate that earthquake triggered failure occurs approximately every 100 years. Lower canyon geomorphology indicates that failed material is being conveyed down the length of the canyon system to the deep ocean. Thus, while flushing rates may be low, the Cook Strait Canyon system can be considered to be an active sedimentary system during the current sea level high stand.

The processes identified here are likely to be analogous to those occurring in many non-coupled shelf indenting canyons on tectonically active margins globally, and provide a framework within which the biological response to intermediate disturbance geomorphic processes in submarine canyons can be assessed.