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Morphostructural evolution of the Pleistocene Hawke Bay active forearc domain in New Zealand: influence of tectonics and climate from 1 Ma to 10 ka timescales

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Tectonic deformation is known as a predominant control parameter in landscape and morphostructural evolution in active subduction margin settings. The role of climate and its interaction with tectonic deformation is less constrained or poorly (illustrated) understood. This results from the scarcity of well-preserved and suited study sites and/or from the lack of data.

The Hawke Bay forearc basin of the Hikurangi active margin in New Zealand is well suited for studying morphostructural and landscape evolution as it is well preserved, partly emerged and affected by active tectonic deformation during Pleistocene stage. Climate and eustasy are also well known for this period and key sedimentological sections are well-dated. Its specific configuration provides direct access to landscape markers and contemporaneous sedimentary record that allow onshore-offshore correlation.

This work presents the results of a quantitative and three-dimensional source-to-sink study of the Pleistocene Hawke Bay forearc domain based on the interpretation and integration of an extensive seismic data set coupled with sedimentological sections, well, cores, geomorphologic analyses and dated samples. It helps to identify the influence of tectonics, climate and eustasy on landscape evolution and how they can be recorded at different timescales.

The last 1.1 Ma stratigraphy is made up of eleven eustasy-driven 100 ka-type depositional sequences preserved in structurally controlled basins. Sequences show a complex stacking pattern characterized by a general retrogradational trend, an arcward migration of depocenters and the development of major tectonically induced unconformities. Preserved sediment volumes (PSV) have been estimated for each depositional sequence. The important increase of PSV since c. 430 ka reveals important changes in preservation ability of the basins and is attributed to documented tectonic reactivation. Tectonic deformation is believed to be the major parameter that controls, over climate, the long-term (0.1-1.0 Ma timescale range) morphostructural evolution of the forearc domain.

The detailed study of the last 150 ka allows obtaining results at the 10-100 ka timescale range. Climate and eustasy are identified as key parameters in sequence stratigraphy timing and landscape evolution. In the offshore part, climato-eustasy is responsible of both the depocenter locations and the stratigraphic pattern, therefore resulting in the development of depositional sequences. Inland, climate and eustasy are believed to influence the behaviour of rivers by controlling erosion, sediment fluxes and length of river profiles. This results in an unusual sediment partitioning characterized by aggradation during phases of sea level fall and climate cooling, and by river incision during phases of sea level rise – climate warming. Interpretations are supported by the results of preserved volume estimations that confirm a significant increase of sediment fluxes around climatic maximum. The distribution of active structures defines the areas subject to erosion or deposition and influences both the river and sediment pathways.