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Erosion and deformation processes associated with the transport of debris-flows - The example of the Matakaoa Debris Flow, offshore New Zealand

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East of the North Island of New Zealand, the Pacific plate subducts beneath the Australian plate along the Hikurangi active margin. There, the continental slope was repeatedly affected by mass-transport processes facilitated by high seismicity, tectonic deformation and high sedimentation rates resulting from the erosion of rapidly-uplifting ranges onland. Several major (>500 km3) mass-transport deposits have been identified in the fore-arc basin north-east of New Zealand.

This study uses seismic reflexion profiles collected over the ∼1250 km3 Matakaoa Debris Flow (MDF) deposits, dated 100-38 ky, to understand the processes of erosion and deformation occurring during transport of a major debris flow. We show why the identification of these processes is critical to analyze accurately the volume balance between failed and deposited material.

The MDF deposits show the following typical zonation:
1/ Proximal deposits exhibit a semi-transparent, chaotic seismic facies, characteristic of a debrite. Seismic reflections of the underlying sedimentary series are conspicuously truncated, demonstrating that the debris flow eroded and incorporated ∼ 150 m of sediments during transport. Along the eastern edge of the MDF deposits, rotated sediment slabs demonstrate that the sedimentary substrate was eroded laterally.
2/ Distal deposits exhibit a coherent seismic facies with flat-and-ramp structures interpreted as imbricate thrusts affecting the basin sediments. These thrust structures demonstrate that basin sediments were deformed in compression as a result from a "bulldozing" process triggered by the debris flow.

Because the identified eroded and deformed basin sediments do not come from the MDF failure scar, erosive and deformational processes contribute to explain the great difference between the total volume of material transported during the MDF event (>1000 km3) and the limited volume of the failure scar (∼100 km3).

Geophysical tests of pre-stack depth migration were performed on multichannel seismic reflexion profiles in order to provide a fine analysis of P wave-velocity and give insight into the physical characteristics of some distinctive reflectors or units. The distal thrust structures of the MDF deposits propagated over a very continuous, sub-horizontal, high-amplitude reflector interpreted as a décollement. The geophysical analysis revealed a negative velocity anomaly along that décollement, suggesting that variations in porosity and/or fluid content may have favored the formation of a low-friction surface that enabled the propagation of thrust structures over long distances (>100 km).