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Formation and evolution of the Waiho Loop terminal moraine, New Zealand

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The terminal moraine of the Franz Josef Glacier in New Zealand, known as the Waiho Loop, has been subject to intense scientific research since it was identified as potential evidence of a Southern Hemisphere Younger Dryas ($\sim$12000 yrs BP) event in the late 1980s and early 1990s. As a result, the large, arcuate moraine has been interpreted to indicate inter-hemispheric connectivity and synchronicity of climate change, and in turn has been inferred to indicate a major late-glacial cooling event in New Zealand. In recent times, it has been postulated that the Loop moraine may not reflect climate variation at all, but rather it may have been the result of a landslide sourced from the upper Franz Josef catchment due to its rock-avalanche-debris-dominated composition.

New evidence from shallow seismic studies between the Loop and the range front ($\sim$3 km) suggests (i) that the presence of an overdeepened trough may be a critical component influencing glacier behaviour and moraine formation; and (ii) that the volume of the Waiho Loop is significantly greater than previously thought. Using a one-dimensional flowline model, two rock-avalanche-based scenarios for the formation of Loop are tested: first, that a rock avalanche generated a significant advance of the glacier terminus from a location within the confined mountain valley to the Loop; and second, that the rock avalanche occurred while the glacier was retreating from its long-occupied terminus at the distal margin of its overdeepened trough close to the position of the Loop during the Last Glacial Interglacial Transition (LGIT) 13000–11000 yrs BP.

Results from the first test demonstrate that a rock avalanche could not have generated a significant advance of the Franz Josef Glacier terminus from a location within the confined mountain valley to form the Loop, because most of the rock avalanche debris could not be advected to the terminus to form a sufficiently high moraine before the ice in the upper catchment becomes relieved of debris and ablation returns to pre-rock avalanche rates. Modelling from the second test indicates that a rock avalanche occurring while the glacier was beginning to retreat from its long-occupied LGIT position could sufficiently build up the 140 m thick terminal moraine. The rock avalanche debris effectively halts the glacier retreat, and leads to glacier thickening which in turn allows a relatively constant terminus position to be maintained until the moraine is formed over a period of about 30 years.

The evolution of this large terminal moraine does not reflect a climate-driven glacier advance; it actually represents no advance whatsoever, contrary to the conclusions of all previous research.