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A stick-slip movement mechanism for submarine landslides generated by elevated pore fluid pressure

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Despite their importance to offshore hazards, submarine landslide mechanisms and styles of failure are not well characterized when compared to terrestrial landslides. Both slow and rapid movement (strain) events have been observed in terrestrial slopes depending on the material response to elevated pore pressures. The mechanisms controlling the transition from slow movement to rapid failure, therefore, are likely to be key drivers in determining the behavior of any given submarine landslide but remain poorly understood.

We use novel laboratory testing in a Dynamic Back-Pressured Shearbox to accurately replicate in-situ stresses in submarine slopes and explore strain development under changing stress conditions in a submarine landslide. Testing was conducted on gravity core samples from the Tuaheni Landslide Complex, collected from the seafloor off the east coast of North Island, New Zealand. We used both water and nitrogen gas as pore fluids, and observed similar responses in both cases, indicating that behavior is dominated by the normal effective stress state rather than pore fluid properties. Shear strain accumulation, representing landslide movement, shows a stick-slip pattern, in common with many terrestrial landslides. Our results suggest that this is due to localized generation of high pore fluid pressures as the shear stress initiates deformation (generating the observed slip phase), and then localized dissipation as the shear zone expands (generating the observed stick phase).

We conclude that some submarine landslides may show similar stick-slip behavior to terrestrial landslides during periods when the effective stress is sufficiently reduced. Through this stick-slip mechanism, the landslide may be able to accumulate large shear strains without developing a phase of catastrophic movement. This indicates that, in certain conditions, long term, slow deformation of submarine landslides is a viable movement mechanism.