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Far-field stress changes and progressive rock slope instability resulting from fluvial incision at the axis of a major Alpine valley

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Geomorphic processes alter both the form and near-surface structure of alpine rock slopes. These processes drive progressive changes in the magnitude of shear, normal, and tensile stresses, and where *in situ* stresses exceed intact or rock mass failure envelopes, can lead to local rock mass destabilization. Such destabilization is most commonly attributed to 'debuttressing' causing a loss of support from adjacent bodies, or a reduction in effective rock mass strength as critical planes of weakness are 'undercut' by erosional processes. Where stress changes are lower in magnitude, progressive rock slope failure is often attributed to a shift in near-critical stresses toward the brittle failure envelope, allowing local stress concentrations to propagate existing fractures or weaken existing joints. We model the development of long-term *in situ* stresses within an alpine valley affected by ongoing tectonic and erosional processes. We allow for the mechanical effects of long-term bedrock strength limits, and analyze the magnitude of far-field stress changes associated with 100 m of fluvial incision at the axis of a 3000 m wide, 2500 m deep alpine valley. Our model configuration mirrors the erosional history of the Matter Valley (southern Swiss Alps) at the location of the 30 x 10^6 m^3 Randa rock slope failure. We find that incision focuses stresses at the valley floor, reducing stress magnitudes throughout the remainder of the landscape. This effect is particularly strong near the valley shoulder, where decreases in shear stress are approximately half those of normal stresses. Although the magnitude of changes are relatively low (10's to 100's of kPa), we find incision may have had a negative impact on the stability of rock slopes over 1000 m from the valley axis, perhaps initiating progressive failure of the Randa rock slope. This proposition is supported by the presence of glacial striations within large tension cracks above the Randa rock slope failure. These formed during, or prior to the Last Glacial Maximum, indicating progressive rock slope failure was already well underway by this time, and along with an analysis of temporal fluvial incision, suggest destabilization most likely initiated during the interglacial at MIS 3. Such progressive failure is particularly important in alpine regions, as its initiation requires relatively minor morphological change, and the resulting strength degradation modulates temporal increases in rock slope sensitivity.