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Geomechanical controls on fluvial erosion and sediment transport in a plate corner: Southeast Alaska

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The mechanical properties of rock and soil play a critical role in orogenic landscape evolution by supporting a positive feedback between strain and erosion, localized within fault damage zones. Strain-induced damage can permanently reduce brittle rock strength by more than three orders of magnitude. As a result, faults can more efficiently localize tectonic strain, but fluvial processes of erosion and transport are also sensitive to a significant local increase in erodibility attributed to rock disaggregation and a comparatively smaller critical discharge required to transport fine grained fault gouge. We combine geomechanical, fluvial, and orographic climate models to investigate the influence of fault damage on the rates and patterns of landscape erosion and sediment transport in a tectonically active plate corner. Model results suggest a heterogeneous erosional response emerges, driving the rapid erosion of fault damage zones and the formation of deep structurally confined valleys buttressed by adjacent intact rock. The resulting topographic pattern amplifies strain localization by unloading the topographic stresses that resist shear failure right above the shear zones. The network of damaged rock associated with strain weakening also leads to faster landscape response times, but also longer sediment residence times. We compare model results to Southeast Alaska, where large glacial valleys, originally generated by fluvial incision, follow the complex pattern of deformation associated with plate corner collision.