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Development of a glacially dominated shelf-slope-fan system in tectonically active southeast Alaska: Results of IODP Expedition 341 core-log-seismic integrated studies at glacial cycle resolution

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Collision of the Yakutat microplate with North American formed the St. Elias Mountains in coastal Gulf of Alaska. While the tectonic driver for orogenesis has been ongoing since the Miocene, results from the Integrated Ocean Drilling Program Expedition 341 suggests that direct climatic perturbation of active orogenesis through glacial erosion is non-linear. Geophysical studies of the glaciated continental margin, slope, and adjacent deep-sea Surveyor Fan allow examination of the glaciated orogen from source to sink. Using high-resolution and crustal-scale seismic data and through comparison with other glaciated margins, we can identify key diagnostic seismic morphologies and facies indicative of glacial proximity and sediment routing. Expedition drilling results calibrated these images suggesting a timeline for initial advances of the Cordilleran ice sheet related glacial systems onto the shelf and a further timeline for the development of ice streams that reach the shelf edge.
Comparisons can be made within this single margin between evolution of the tectonic-glacial system where erosion and sediment transport are occurring within a fold and thrust belt versus on a more stable shelf region. Onshore the Bering-Bagley glacial system in the west flows across the Yakataga fold and thrust belt, allowing examination of whether glacial erosion can cause tectonic feedbacks, whereas offshore the Bering-Bagley system interacts with the Pamplona Zone thrusts in a region of significant sediment accommodation. Results from Expedition 341 imply that timing of glacial advance to the shelf edge in this region may be driven by the necessity of filling up the accommodation through aggradation followed by progradation and thus is autogenic. In contrast the Malaspina-Hubbard glacial system to the east encountered significantly less accommodation and more directly responded to climatic forcing including showing outer shelf glacial occupation since the mid-Pleistocene transition-MPT to 100 kyr glacial-interglacial cycles.
Examination of the sink for both of these systems, which includes the Surveyor Fan and Aleutian Trench wedge, demonstrates a clear climatic driver for sediment flux to the deep sea. The first appearance of ice-rafted debris at our distal drill site closely approximates the start of the Pleistocene and a doubling of sediment accumulation accompanies the MPT. Converting sediment volumes just within the deep-sea sinks back to erosion rates in the orogen and correlating with changes in exhumation rates from thermochronology demonstrates a lack of accelerated tectonic response to the intensification of Northern Hemisphere glaciations at the start of the Pleistocene but increased shortening and exhumation of sediments at the MPT. The form of tectonic response differs between out-of-sequence thrusting or antiformal stacking within the fold and thrust belt to the west and a near vertical advection of material in a tectonic aneurysm in the core of the orogen to the east.