The 1964 Great Alaska earthquake, megathrust splay faults, and focused exhumation in Prince William Sound, Alaska

This is the 50th anniversary of the M9.2 1964 Great Alaska earthquake. This earthquake remains the second largest ever recorded. Study of the quake played a key advance in the history of plate tectonics by revealing the pattern of deformation associated with a megathrust earthquake, which led to the concept of a convergent plate margin. The 1964 earthquake also exposed the first documented megathrust splay faults. These thrust faults are a common feature of accretionary prisms and can be important for generating tsunamis. Here we provide new U-Th/He and AFT thermochronologic evidence that the megathrust splay faults that ruptured in the 1964 earthquake, with local uplift to 10 m, were conduits for focused exhumation over the last 5 Ma. In the hanging wall of these splay faults, the region of rapid exhumation is separated from the region of slow exhumation by the newly-identified Montague Strait fault. New high-resolution bathymetry, seismic reflection profiles, and a 2012 earthquake show this feature is a 75-km-long high-angle active normal fault. There are numerous smaller active normal(?) faults in the region between the Montague Strait Fault and the splay faults. We believe this hanging wall extension developed between the rapidly uplifting sliver of younger and weaker rocks on Montague Island and the essentially fixed region to the north, which functions as a structural backstop. Deep seismic reflection profiles show the splay faults root into the subduction megathrust where there is probable underplating. Thus the exhumation and extension in the hanging wall are likely driven by underplating along the megathrust décollement, thickening by thrust faulting in the overriding plate, and a change in rheology across the Montague Strait fault. A comparison with other megathrust splay faults around the world shows significant variability in their characteristics, which cannot be accounted for in a simple model.