The 2020-2021 Alaska Earthquake Sequence: Coupling Segmentation, Stress Loading, and Slip Behavior

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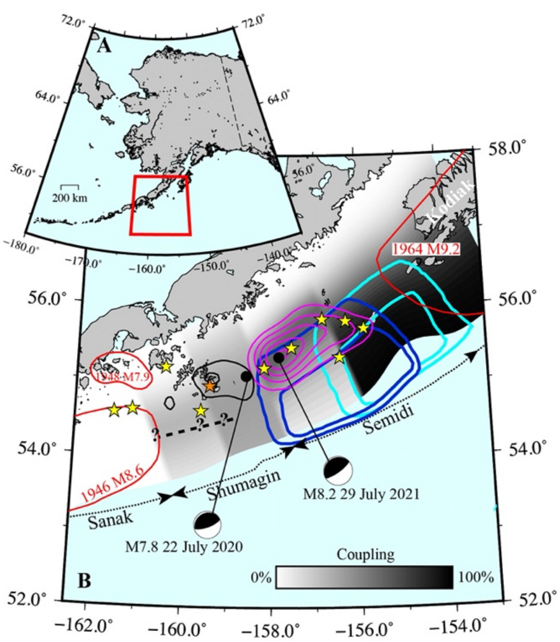
During 2020-2021, a series of large earthquakes occurred within the Alaska-Aleutian subduction zone offshore of the Alaska Peninsula. The July 2020 M7.8 Simeonof earthquake and the July 2021 M8.2 Chignik earthquake were megathrust events that ruptured two neighboring segments of the interface while the October 2020 M7.6 Sand Point earthquake was a dominantly strike-slip event that ruptured within the downgoing Pacific plate. The spatial and temporal proximity of these earthquakes and their relation to interseismic coupling boundaries and previous events provide opportunities to investigate stress loading and earthquake triggering, conditions required for rupture propagation, and why some areas may be more prone to generating predominately M7-8 rather than large M8.5-9+ earthquakes.

Using a combination of static and high-rate GNSS, InSAR, and seismic waveform data, we have developed coseismic slip models for the Simeonof, Chignik, and Sand Point earthquakes. The Simeonof earthquake nucleated near a transition from low to moderate coupling between the Shumagin and Semidi segments of the interface and propagated to the southwest. The majority of the slip occurred at depths between 20-40 km. The Chignik event originated at the northeast edge of the 2020 rupture and propagated to the northeast and, as with the Simeonof event, the majority of slip was between 20-40 km. The Sand Point event ruptured within the subducting Pacific slab along a north-south striking plane that roughly aligns with a coupling transition within the Shumagin segment. Although the geodetic and seismic data for the Sand Point event are fit well by solely strike-slip motion, the observed tsunami data are not predicted by strike slip motion. Tsunami data might be explained by limited slip on the megathrust, but the geodetic displacements are not consistent with significant megathrust slip in the epicentral area. Almost all of the Chignik rupture was contained within the Semidi segment while the Simeonof rupture largely stayed within the neighboring Shumagin segment. This, along with the alignment of Sand Point with a coupling transition, suggests that lateral coupling boundaries along the megathrust in this region may influence earthquake rupture nucleation and arrest. The west-to-east increase in coupling and changes in interface properties may encourage partial interface ruptures.



Coulomb stress changes show that the Simeonof event increased the stress in the hypocentral region of the Chignik event. A re-evaluation of the M8.3 1938 earthquake suggests that most of the slip occurred closer to the trench, outboard of the Chignik and Simeonof ruptures, and may have increased stress in the area of Simeonof slip. Given these stress changes and the fact that the 2020-2021 ruptures did not substantially overlap with the updated 1938 rupture zone, the Simeonof and Chignik earthquakes may be part of a cascade of megathrust earthquakes that ruptured almost the entire margin during the 20th century.

We will be talking with students in several local schools about GNSS, earthquakes, and Alaska tectonics during fieldwork and remotely during the project. Materials based on this work are being contributed to a course developed by the Alaska Earthquake Center for continuing teacher education.