

UNDERSTANDING ALASKA TSUNAMIS GENERATED BY SLOPE FAILURE

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Proposed sites - geoscientific transects across the margin at Unimak Pass and Chirikof/Trinity Islands

Theme – Can areas of potential large landslip failures that could source tsunamis be recognized?

Some investigators have argued that earthquakes may trigger catastrophic slope failures large enough to source transoceanic tsunamis but observations are insufficient to confirm this. Documenting mass movement coeval with an earthquake involves considerable marine surveying and coastal investigations. A noteworthy earthquake during which mass movement probably sourced a tsunami was the 1946 Unimak Alaska event (Fryer et al, 2004, Lopez and Okal, 2006). A 42m runup destroyed the Scotch Cap lighthouse and a coeval transoceanic tsunami inundated south Pacific islands and Antarctica. Lopez and Okal (2006) revised the earthquake magnitude to possibly 8.6 which can explain the tsunami in the far field, but the huge runup at Scotch Cap seems to require an additional source such as an earthquake triggered slope failure (Fryer et al, 2004, Okal et al., 2003). Slope failure sources are limited to the upper slope by the time between shaking and inundation at Scotch Cap. Morphology at the constrained distance from Scotch Cap to the tsunami source contains upper slope failure features, but a slide volume estimated with modeling is insufficient to explain runup or a major transoceanic tsunami. Proposed alternatives are an unknown splay fault, or that a coeval slide and a tectonic shift of the seafloor occurred. A consensus explanation is still to be found. The compelling and broad scientific issue is recognizing environments in which a modest earthquake might trigger a slope failure large enough to produce local and perhaps transoceanic tsunamis. Slope failure features are common along convergent margins and particularly so where seafloor relief subducts. Deformation from subducting relief destabilizes the slope and by increasing slope steepness it enhances slope failure. Three extensive seamount chains and fracture zones subduct along the Alaska margin. This subducted seafloor relief destabilized the margin slope along sections that are oriented such that a transoceanic tsunami would be focused toward the US west coast.

Understanding the mechanics of the 1946 event requires further investigation to illustrate the character of past and the potential of future failure. Recent work indicates that the insights gained off Unimak Island can be applied to Alaska's other unstable slopes. The improved images from pre-stack-depth-migration revealed extensional deformation of the slope sediment apron presumably by increasing steepness. An upper layer of mobilized material and slide blocks were imaged. Rotational slumping of a coherent block 0.5km thick and over a ~20x22km area was imaged at the distance of the 1946 tsunami source in an area previously identified (Fryer et al, 2004). Vertical dislodgment of a large, coherent slump block would be much more efficient in generating a near-field tsunami than the displacement resulting from a fluidized debris flow as has been applied in previous tsunami modeling of the 1946 event. This adds a new dimension to investigation of the 1946 tsunami source and clarifies a direction for future work. Alaskan slope failure is similar to that of other margins where modern bathymetric

mapping has shown much larger slumps. Large slumps and slope failure off Costa Rica occur where abundant seafloor relief subducts. Subducting ridges and seamounts are associated with a slump 55km long and 35km wide whose head wall is from 350m to 1000m high. The search for pre-historic tsunami deposits has not yet been conducted in the area nor has a rotational block model been analyzed. Even such large features are not obvious in conventional bathymetry. Similarly, multibeam bathymetric mapping in the Unimak area and in other unstable areas of the Alaska and Aleutian margins promises to result in discoveries of past slope failure. The Pamplona Zone/Middleton Island slope where the Yakutat Terrane subducts is an unstable area where large slide scars occur (fig. 1). Multiple seamounts subduct along the Fifty-eight degree fracture zone, the Kodiak-Bowie seamount chain, and the Patton-Murray-Aja fracture complex (Fig. 2). The latter was co-located with a rupture boundary during the 1938 and 1964 earthquakes, a segment of the margin where geodetic monitoring indicates current strong locking. Understanding dynamics where the Alaska convergent margin is unstable is important to anticipating potential tsunami hazards and facilitate tsunami warnings for the coasts of North America.

Basic to the organization of new work in areas of known unstable slopes is high resolution multibeam mapping (100% systematic coverage with ~10m resolution). The small areas surveyed with a 20 year old multibeam system indicates that with modern systems the mass wasting features of sub-km-scale can image significant failure features along the upper and middle slopes (Fig. 2). Mapping the Unimak and Chirikof/Trinity Islands areas can be accomplished in 2 to 3 weeks ship time. In the 1938 aftershock area, the reprocessing of existing USGS seismic data with modern depth migration seismic processing systems can improve resolution sufficient to image large slide deposits. In addition, there is a critical need for establishing a paleo-tsunami history for the Alaskan margin with conventional cores at sea and trenching in coastal areas on land such as has been demonstrated along the Cascadia subduction zone. Thus advances in understanding Alaska tsunami sources can be achieved with existing academic facilities and modeling can be greatly improved over past studies.

References

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- Fryer, Gerard, Philip Watts, Lincoln Pratson; 2004, Source of the great tsunami of 1 April 1946' a landslide in the upper Aleutian forearc; Marine Geology, 203, 201-218.
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Fig. 1 Slide scars on the continental slope where the Yakutat Terrane trailing flank subducts. Multibeam and conventional bathymetric images are combined. The vertical axis is ~ 200km

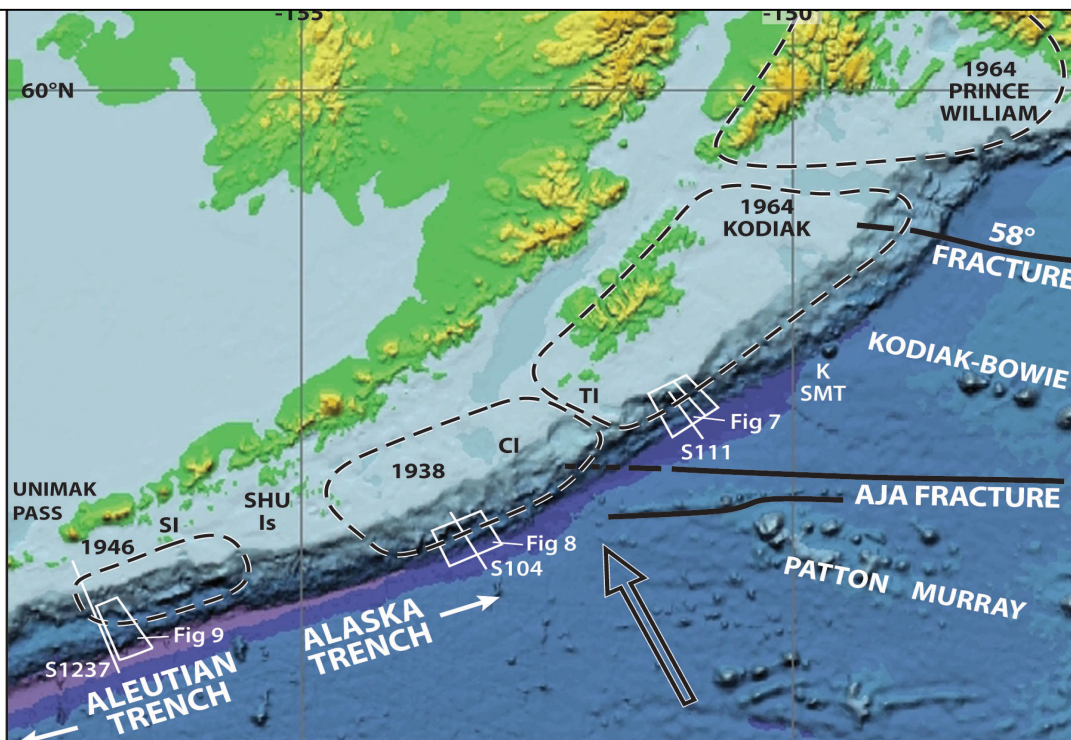


Fig. 2 Map from manuscript in review showing small areas of 16-yr.-old multibeam bathymetry (rectangles). Aftershock areas with dates, Lines with S-numbers are published seismic images. TI, Trinity I., CI, Chirikof I., Shu, Shumagin I., SI, Sanak I. K SMT, Kodiak Smt,