The influence of the Yakutat microplate on the Alaska subduction zone

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The Gulf of Alaska margin is notable for the transition from 'normal' Pacific plate subduction along the Aleutian Trench to flat-slab subduction and oblique collision of the Yakutat terrane, an oceanic plateau. Crustal thickness of the Yakutat microplate ranges from ~15 km thick where it subducts beneath Prince William Sound to ~35 km thick where the collision is causing the uplift of the St. Elias Mountains. The 1964 Mw 9.2 Prince William Sound earthquake initiated on the Yakutat-southern Alaska plate boundary before jumping to the adjacent Aleutian megathrust and past earthquakes may have simultaneously ruptured the Aleutian megathrust and the Yakutat subduction interface between Prince William Sound and Icy Bay (Figure 1) [e.g., *Shennan et al.*, 2009]. Convergence between the Yakutat microplate and southern Alaska causes far-reaching impacts to both the subducting and overriding plates, and marks the end of the "simple" Aleutian subduction system. As the collision evolves with time, the Aleutian megathrust may extend to the east, initiating a new trench outboard of the Yakutat microplate.

The entire southern Alaska margin is made up of a set of blocks moving relative to North America. Immediately inboard of the Yakutat collision, the upper plate is rotating counterclockwise relative to North America [*Elliott,* 2011]. All of southern Alaska south of the Denali fault moves in a similar sense, although not as a single rigid block. GPS velocities from the Kenai Peninsula, Kodiak Island and Alaska Peninsula are consistent with lateral escape of a forearc block to the southwest at about 5 mm/yr. Combined with the evidence for a Bering plate farther to the west [*Cross and Freymueller,* 2008], these results mean that the overriding plate along the entire Aleutian megathrust is moving significantly relative to North America. In addition to the effects onshore, the Pacific plate in the Gulf of Alaska appears to be deforming in response to the Yakutat – southern Alaska collision. This deformation is highlighted by the formation of the Gulf of Alaska Shear Zone, a N-S oriented, mostly right-lateral zone of intraplate shear that extends over 200 km into the Pacific plate. Recorded seismicity at the shear zone began with a series of large M 7+ earthquakes that occurred from 1987-1992, and seismicity along the shear zone has continued to the present day. The Pacific plate may be reorganizing into blocks adjacent to and south of the Shear Zone, each moving and deforming independently, as evidenced by plate magnetic anomalies, seismic reflection data, and increased intraplate seismicity compared to the Pacific plate farther south.

The Alaska megathrust system incorporates both the Pacific and Yakutat plate interfaces with southern Alaska. The bathymetric expression of the Aleutian trench ends between Kayak Island and the Transition fault (Figure 1), which may be the northeastern extent of the Pacific-southern Alaska interface. However, the seismogenic subduction interface extends ~100 km to the east of this point. Offshore seismic data near Kayak Island as well as onshore geology show nearly vertical strata and steeply northwest dipping fault traces, defining a recently inactive fault zone. These observations indicate a possible evolution of faulting in the area that has resulted in the Yakutat-southern Alaska convergence primarily occurring at depth on the northeastern segment of the megathrust. This shallowly dipping (5 degree) subduction interface displays considerable variations in coupling, with the segments beneath the Bering Glacier, eastern Chugach Mountains, and northeastern Prince William Sound being nearly fully locked while central Prince William Sound and the Kayak Island area have between 40 -70% coupling. In addition, both the GPS results and geologic observations suggest that there is a fundamental change in behavior from slip on a single interface to distributed slip east of the Bering Glacier, but this change does not correlate to the change from Pacific to Yakutat basement. This abrupt shift in behavior may relate to differences in sediment input, erosion of the exhuming orogenic highland, variable thickness in the Yakutat microplate, or some combination of these factors, but this observation has important implications for how subduction systems operate at depth.

The recent results outlined above represent significant advances in our understanding of the Yakutat collision and the effects of the Yakutat microplate on the Alaska subduction system, but additional work is needed to resolve a number of remaining problems. Future efforts need to focus on improving the imaging of the subsurface Yakutat terrane within the 1964 earthquake rupture zone, particularly in the area where the western edge of the Yakutat terrane may link to the subducting Pacific plate. Within the apparently abrupt transition from collision-type distributed deformation to normal subduction, the locations of the active structures need to be more clearly delineated and their rates of motion more precisely determined. Throughout the region, the motions of the various segments of the upper plate should be better resolved. Another important question requiring further study is how surface geology and shallow structures correlate to deep structures.

References

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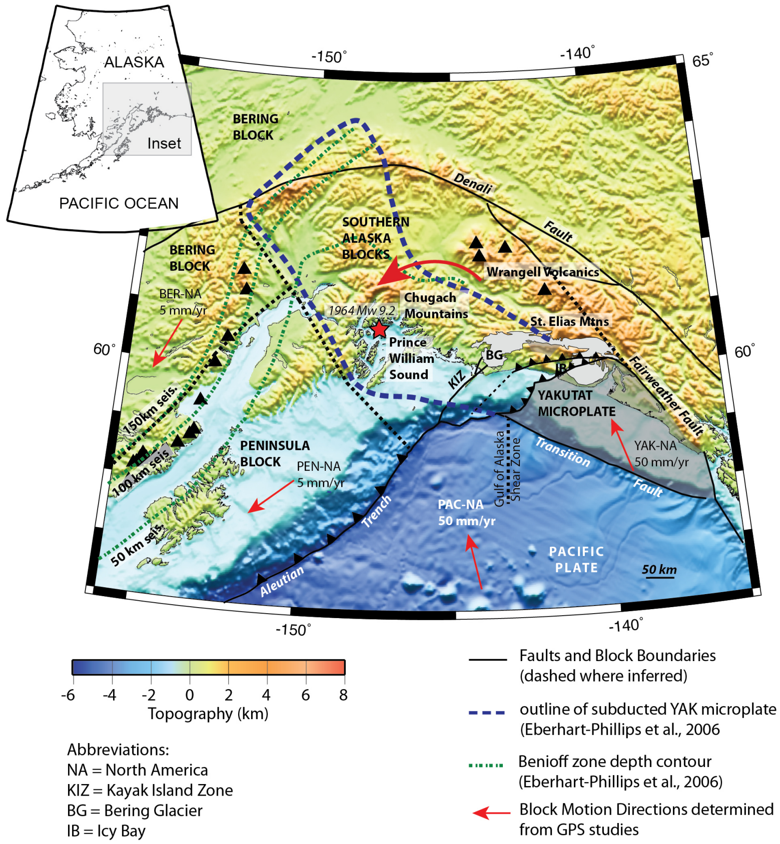

Figure 1. Tectonic Setting of the eastern Alaska subduction system. Modified from *Worthington et al.* [2010].