The Gulf of Alaska shear zone: a potential future Amphibious Array scientific target
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Scientific Justification

The Gulf of Alaska shear zone (GASZ) is a linear belt of intraplate seismicity in the Gulf of Alaska that has been moderately active in the last 20 years. Significant seismicity occurred in the late 1980s and early 1990s, and continues to this day. The north-striking belt of seismicity is bounded by the eastward extent of the Aleutian arc and the Yakutat collision to the north and the Kodiak-Bowie Seamount Chain to the south. It represents an intraplate zone of weakness and possibly represents one mode for tectonic plate creation – the tearing apart of an existing plate. Having hosted a series of medium-sized magnitude earthquake (Mw 7.2, 7.8, 7.7) during late 1987 and early 1988 (Pegler and Das, 1996), this suture zone or tear in the plate is probably well-developed.

Seismicity studies offer important glimpses into active deformational processes at plate margins and intraplate zones. Figure 1 depicts the seismicity map of earthquakes in the AEC (Alaska Earthquake Center) since 1965. The figure shows a clear linear zone of seismicity, striking northward, known as the Gulf of Alaska Shear Zone (GASZ). The GASZ exhibited significant activity in the late 1980s and early 1990s (Pegler and Das, 1996), and features medium-sized earthquakes (> magnitude 6) as recent as last year. Figure 1b includes the seismicity within the inset box on Figure 1a. It should be noted that the instrumental record was greatly improved in the 1990s with the advent of digital data, and it is likely that abundant seismicity occurs today, though smaller events are difficult to detect with the

Figure 1: (Top panel) Map of historical AEC seismicity (1965-2013) and Global CMT larger earthquakes. The GASZ consists of a north-striking belt of seismicity and includes many mapped features identified as faults (Reece et al., 2013). (Middle panel) Seismicity rate during the time period 1965-2013. (Lower panel) Earthquake magnitudes during that time period.
current permanent land-based network.

The Transition fault in the Gulf of Alaska separates the thick Yakutat block (crystalline crust thickness 15-30 km; Christeson et al., 2010; Worthington et al., 2012) from oceanic crust of the Pacific plate (Figure 2). The deformation front, along which the Yakutat block subducts beneath the North American plate, has moved to the east with time from the Kayak Island fault to the Pamplona zone (Figure 2a) as the Yakutat block resists subduction (Gulick et al., 2013). The GASZ is approximately aligned with the Pamplona zone, and separates two localized blocks of the Pacific plate (Figure 2; Gulick et al., 2007). Reece et al. (2013) interpret the GASZ faults as increasingly transpressional to the north and responsible for formation of the basement high, but note that there is no transpression observed in the reported focal mechanisms of the GASZ. Reece et al. (2013) argue that the GASZ is directly inline with the boundary between the subduction and collision regions and a present-day GPS study (Elliott et al., 2013) confirms that the GASZ aligns with the onshore separation of deformation styles. Reece et al. (2013) suggest that the boundary between the subduction and collision regions became enhanced as the collision progressed and the thickest part of the Yakutat (which thickens from west to east; Worthington et al., 2012) encountered the North American margin during the Pleistocene, and that the increased stress may have initiated the GASZ.

The GASZ robust activity is rather surprising as it occurs along an intraplate region rather than at the plate boundary. This complex region is interpreted to have transpression increasing from south to north along the GASZ (Reece et al., 2013), yet only strike-slip focal mechanisms are observed. Transpression and strike slip events would be expected along the Transition fault (Gulick et al., 2007), which instead exhibits little seismicity compared to the GASZ (Figure 1). Plausibly there may exist a misalignment between regional stresses and some of the transpressional features and thus the GASZ is an excellent opportunity to test theories about off-fault damage in an area that has been mapped from multiple multi-channel seismic reflection surveys (e.g. Reece et al., 2013). Close-by station spacing (e.g. ~25 km station spacing) should address which percentage of seismicity occurs along the fault zone or “off the fault.” Just where are the regions of active deformation and how does a plate break apart? The GASZ offers the opportunity to address some of these fundamental questions in situ.

Oceanic intraplate zones are capable of producing some of the largest recorded strike-slip earthquakes, for example, the Mw 8.7 April 11, 2012 earthquake in the Indian Ocean (Yue et al., 2012). Detecting the smallest magnitude earthquakes and building a robust seismicity catalog

**Figure 2: Proposed tectonic model of Gulick et al. (2007).** Strike-slip deformation is propagating westward along the Transition fault facilitated by a seaward extension of Queen Charlotte–Fairweather fault system. The thick Yakutat block, interpreted as an oceanic plateau, resists subduction unlike the Pacific plate to the south. The GASZ divides western and eastern blocks of the Pacific plate.
would allow investigation of some fundamental processes related to intraplate deformation. In order to better study the GASZ and provide insight into the mechanics of intraplate shearing, we urge the community to install an amphibious, dense (e.g. ~25 km station spacing) network of OBSs in areas surrounding the GASZ and encompassing its juncture with the Transition Fault. An OBS network would leverage USArray Transportable Array (TA) stations that will densify the land-based seismic network throughout Alaska and the region (Southern Alaska).

Short Summary

In order to better study this deformational feature and provide insight into the mechanics of intraplate shearing, we suggest that the GASZ be considered for a future OBS experiment. The extension of USArray’s Transportable Array into Alaska offers a further complement to closely study this feature. Such an experiment would allow delineation of seismicity along the extent of the GASZ, to better understand micro-plate formation, as robust seismicity provides a proxy for active brittle deformation. The location is unique in that it is one of the few places in the world where micro-plate formation is likely ongoing and allows us to address fundamental questions about how this tearing occurs. For example, do earthquakes occur along pre-existing features or do they occur as off-fault damage – actively breaking the rock? Also, it could address the role that far-field stresses play in determining the seismicity behavior on the heterogeneous segments of the GASZ and the complicated junction with the Transition Fault. A number of unforeseen discoveries may occur, such as delineating seismicity productivity differences, the presence/absence of tidal triggering, and identifying zones that may experience tremor accompanying slow slip. These and other first-order studies have implications for micro-plate formation and for understanding earthquake rupture processes.

References


