Deploy the Amphibious Array to the Alaska-Aleutian Subduction System

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In 2009, NSF provided ARRA funds to build an amphibious geophysical facility onshore and offshore, providing support for MARGINS (GeoPRISMS) and EarthScope science objectives. The facility included onshore seismographs similar to USArray-Transportable Array seismographs, upgrades to PBO-GPS facilities, and a fleet of 60 ocean bottom seismometers (OBS's), twenty of which are specially designed for shallow water use. All data from these instruments are open and freely available as soon as they are recovered, so the facility forms an excellent backbone to a community-based initiative. The Amphibious Array facility is now being deployed off the Cascadia margin, and it future use is to be reviewed before completion of the 4-year deployment. The Amphibious Array should move to the Alaska-Aleutian subduction system upon completion of Cascadia work, to provide a critical base data stream for GeoPRISMS and EarthScope science.

For details see the 2009 Planning Workshop report, and for updates on current activities and status, see Cascadia Initiative links, all from *www.geoprisms.org/cascadia.html*.

Overview. Much of the Alaska-Aleutian subduction system straddles the coastline. Critical targets for GeoPRISMS include the thrust zone, the sub-arc mantle wedge, volcanic arc and backarc, and the incoming plate seaward of the trench. Any successful science program addressing these targets will include sampling of the seismic wavefield both to characterize sources (earthquakes, tremor, etc.) and to image the Earth's interior. Combined onshore-offshore imaging will be necessary to (for example} sample seismicity and tremor at the downdip end of the megathrust, to sample deep roots of volcanoes in the Aleutians, and to systematically image the subducting plate from seaward of the trench to its deepest extent. These seismic observations will then provide basic constraints for a host of related geologic, tectonic, geochemical, and geodynamic studies. In Alaska (and nearly all subduction zones) such seismology requires both offshore and onshore array deployments, precisely the kind of deployment that the Amphibious Array is designed to achieve. In fact, with the its fleet of shallow-water-capable OBS systems, the Amphibious Array may be the only tool capable of conducting the kinds of seismic experiments needed to make GeoPRISMS in Alaska a success.

Megathrust. Many of the largest recorded earthquakes on the planet have taken place in the Alaska-Aleutian system, including the great 1964 Mw 9.3 earthquake. These earthquakes pose a major seismic and tsunami hazard. Relatively little direct seismic monitoring of megathrust seismicity has taken place in the last couple decades, and almost no OBS recording since early forays around 1980. Nevertheless, earthquakes are abundant, constituting 80% of U.S. seismicity, and direct onshore and offshore recording will be critical to address GeoPRISMS objectives. In the 2006-9 MOOS broadband experiment in Kenai Peninsula (Abers/Christensen), we recorded a locatable thrust zone earthquake every 10 minutes within a 200x300 km array.

Similar or higher seismicity rates were recorded during two 3-day active-source short-period deployments off the Alaska Peninsula in July 2011 (Shillington/Nedimovic/Webb). Nonvolcanic tremor has been well-recorded just downdip of Anchorage and more recently, near several volcano seismic stations in the Peninsula and Aleutians (Brown et al., Fall AGU 2010). Because much of the seismogenic zone is offshore, a shallow-water-capable OBS facility is essential to effectively capturing earthquakes. Unlike the Cascadia region, the Alaskan-Aleutian megathrust provides the opportunity to monitor small earthquakes and tremor along a thurst zone with highly variable coupling characteristics as determined by geodesy, ranging from stable sliding to locked.

Volcanic arc, magmas and volatiles. The transport of volatiles to depths in subducting slabs, the melting and flow in mantle wedges and the delivery of that melt to arc volcanoes all leave potential imprints in seismic images. Much of this plumbing remains poorly constrained, and a major motivator of MARGINS and GeoPRISMS has been resolving pathways, rates, and physical process of magma and volatile transport. The Aleutian Arc was chosen as a primary site in part because the arc has a long but fairly stable post-Eocene history while plate inputs (obliquity, convergence rate, sediment supply) vary in systematic ways along the arc, so models of the plumbing can be tested in fairly constrained ways. One of the main tools for evaluating structure at these scales has been deployment of fairly dense seismic arrays, such as has been done in MARGINS Focus Sites (Marianas, Central America) and a few other subduction zones around the planet. To do any kind of imaging deployment in the Aleutians will require both seismometers on the islands and extensive OBS arrays in the forearc, arc and back-arc. Even simple observations, such as constraining Wadati-Benioff Zone geometry, will require amphibious seismic arrays. Such deployments typically take 1-2 years, to record sufficient data, and given the typical station spacing in imaging arrays (10-50 km), a substantial investment in OBS deployments over the life of GeoPRISMS will be needed to achieve objectives.

Deployment Strategies. As with Cascadia, we envision a community process whereby a sequence of OBS (and on-shore) deployments are planned over the ~5 year duration of data collection in Alaska. Much will be learned from Cascadia that will inform any planning, but several issues seem obvious. One is that the 3000 km long Aleutian arc is large compared to the size of the available array, and focus corridors will be needed. Also, unlike Cascadia, seismicity is abundant and experiments can be designed to more directly target local earthquakes (and tremor-related phenomena). Finally, the oceanic nature of the (robust) Aleutian arc dictates OBS deployments to image magmatic systems, tightly linked to shore-based arrays, combining relatively low-noise land sites on islands and peninsulas to areally extensive offshore stations. The open-access data agreement for the Amphibious Array ensures maximal and rapid use of these observations.

In summary, a well-coordinated deployment of the Amphibious Array including onshore seismic and geodetic stations will be crucial to the success of Alaska/Aleutians as a Primary Site. At the same time, this setting offers phenomenal potential for scientific return from the array facility.

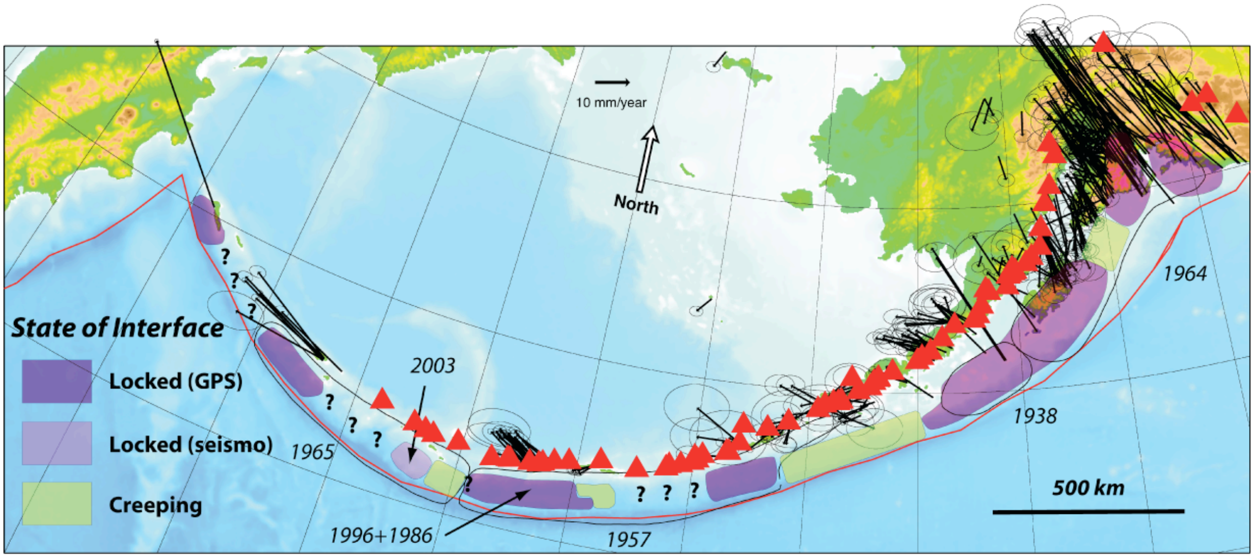

Figure 1. Alaska, volcanoes (triangles), and great earthquake rupture zones showing estimated geodetic locking and GPS-derived velocities relative to North America (after Freymueller et al., 2008, AGU Monogr. 179, p. 1-42).

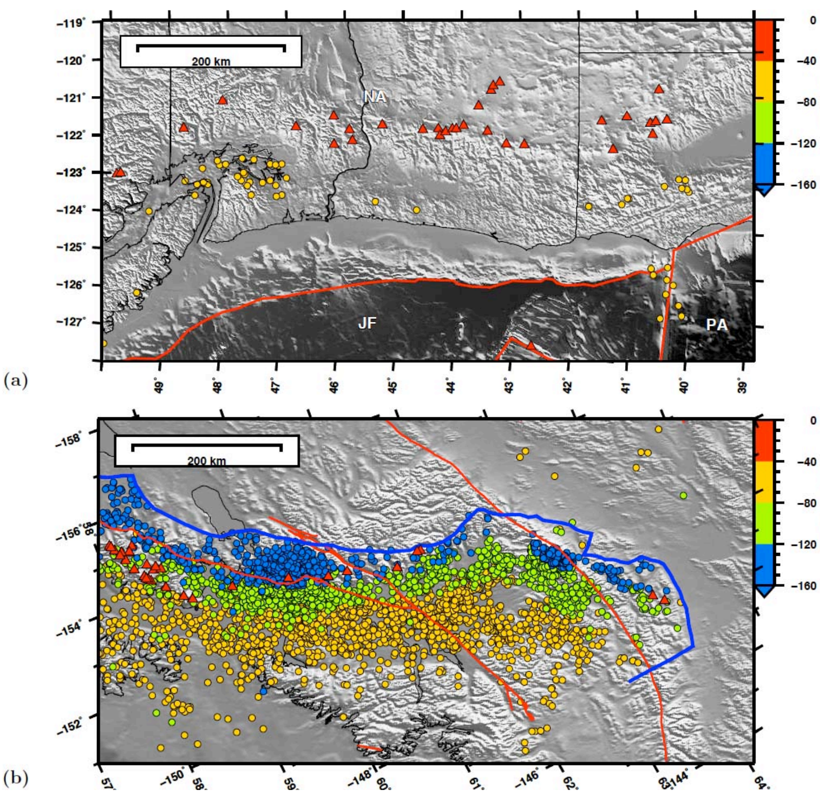

Figure 2. Scaled comparison between the Cascadia subduction zone and the eastern segment of the Alaska-Aleutian system. Seismicity, circles, show earthquakes with depth > 40 km, M > 3, 1900-2010. Red triangles denote active volcanoes.

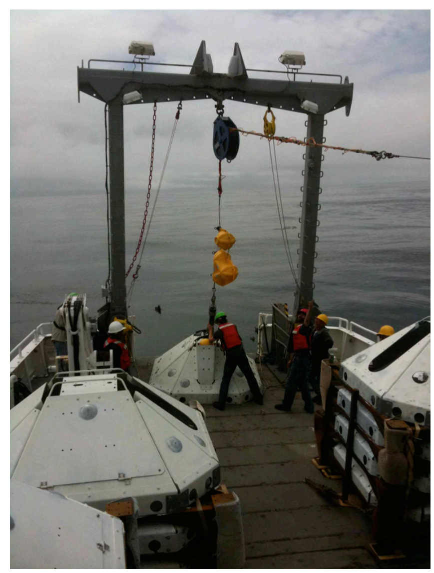

Figure 3. New trawl-resistant OBS's being deployed off Cascadia. From July, 2011 cruise report (Tolstoy, Trehu). http://pages.uoregon.edu/drt/CIET/doku.php