Selection Criteria for Future Geohazards-Motivated Research under the NSF MARGINS Successor Program

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Subduction zones by far present the greatest hazards to populations along continental margins, whether active or passive. During the last century giant ($M \geq 8.5$) subduction earthquakes and the regional and ocean-crossing tsunami waves that they spawn rank at the top in social impacts among geohazard events that occur off ocean margins. These impacts are likely to increase with time as population grows in coastal areas and as sea level rises during global warming.

Focus should therefore be directed to subduction zones that have produced giant ruptures during the seismic-instrumental and historical eras because earthquakes with established dates and magnitudes are reference events needed to compare with the actual consequent distribution and geochronologies of marine turbidite systems and on-land coastal tsunami deposits. Subduction systems that have produced mega-events during the instrumental and historical eras include Chile, Colombia, the central Kuriles and Kamchatka, the Indian-Ocean margin of Indonesia, Cascadia, continental Alaska and the Aleutians. The sediment record of these source regions provides the critical chronological record necessary for probabilistic hazard assessment. These records can be acquired by onshore sampling and offshore coring, drilling, and seismic reflection data.

Giant subduction earthquakes represent rupture zones that are elongate parallel to their respective trenches and resultant tsunamis tend to be of greatest wave amplitudes along azimuths perpendicular to the trench. This “beaming” effect is well known. Together with the detailed bathymetry along pathways between sources and receiving coastlines, and the distribution of coastal population and infrastructure, *beaming* largely dictates the potential human impacts of tsunami sources that cause ocean-crossing tsunamis. Tsunami modeling that identifies tsunami source regions threatening populated and built shorelines, an approach known as *disaggregation*, shows that certain subduction-zone sectors pose greatest danger to US coastal communities and their infrastructure. But little is known about the frequency of these events, evidence for which is stored in onshore and offshore sedimentary deposits and fault growth structures.

An important factor critical to dating turbidite and tsunami deposits is the presence of widespread tephra deposits from frequent caldera-forming arc eruptions, especially during Holocene times. Active explosive activity is therefore an important selection criterion that permits dating of offshore turbidite-and coastal tsunami deposits. A related factor relevant to dating coastal tsunami deposits is the degree to which biological activity disturbs or breaks down organic carbon needed for radiocarbon dating. This factor of preservation is not a concern for cool, high latitude subduction zones but may diminish the suitability of subduction systems in some tropical regions.

Another criterion to consider is whether large ‘slow-rupture” or *tsunami* earthquakes have occurred in a particular margin. It is presently unclear if particular geologic settings are required for these enigmatic events to occur or whether *tsunami* earthquakes occur over time in most subduction systems as part of the statistical variability of subduction rupture. Detailed investigations of the source zones of great destructive *tsunami* earthquakes in the instrumental era are therefore called for.

Most of the source regions of giant subduction earthquakes are dominated by sediment influx from land areas, trench-axis sediment transport and accumulation, and likely sediment ingestion into subduction channels. Thickly sedimented subduction channels are thought to smooth subduction-slip interfaces and promote long-runout, great-earthquake ruptures. Conditions that favor large sediment influx are not uniform over geologic time or space. In particular, climate, mountain building, and geography appear to be important in establishing modern sediment-dominated subduction systems. High rainfall in the tropics or high snowfall and glaciation at high latitudes combined with late-Cenozoic mountain building in subduction or collisional environments and high and sustained delivery of sediments to continental margins by rivers and glaciers appear to be factors that control whether a sediment-dominated subduction system develops. Submarine fan formation and long-distance down-trench sediment transport by turbidity currents, are processes that are evident in most of the subduction systems that have produced giant plate-boundary earthquakes.

Important questions about this classic sediment source-to-sink problem include: What is the time scale of sediment flux from source to seismogenic depths in subduction channels? Does sediment ingestion along subduction channels affect other physical expressions of the subduction processes, such as the structure of forearc basins, the eruptive activity, chemistry, spacing and eruptive style of arc volcanoes, and the fine structure of the Wadati-Benioff zone? Do giant subduction earthquakes themselves trigger long-run-out turbidite flows? Are these events essential for long-distance along-trench sediment transport? This climate/mountain-building/sediment/earthquake problem is truly a systems-level one with potential for engaging collaborative research with most components of the NSF MARGINS Program, for example S2S, Subduction Factory, and SEIZE, collaborative liaison studies are envisioned with NSF support of climate change research, and government agencies such as NOAA and the USGS and non-U.S. university and governmental partners.