

# Draft Panga Science Plan

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Please send your **comments and/or additions** to this draft!

## RATIONALE

Subduction zones are the most dynamic tectonic environments on earth. The fastest relative plate motions and the highest mass fluxes of sediment, magma, and related fluids into the continental crust and mantle occur at subduction zones.

Subduction zones are also the source of the world's largest earthquakes, characterized by minutes of shaking and associated large tsunamis. Seismic slip in a great subduction zone earthquake can exceed 15 m over 1000 km of fault length.

Long-term permanent deformation and seismicity of the convergent margin may extend far into the continent - by building mountain ranges through accretion, or dismembering continents through backarc spreading and migration of forearc slivers. The magmatic arc transfers mass and energy to the continent and plays an important role in accommodating tectonic strain in the upper plate.

## PACIFIC NORTHWEST PRIORITIES AND QUESTIONS

### 1) The plate boundary megathrust

What is the displacement field above the megathrust and how does it relate to the geometry of the plate boundary, and variations in convergence, strain rates, seismicity, and paleoseismicity?

What is the role of mantle flow and mantle-crustal viscosity?

Can we identify the landward limit of locking and characterize the geometry and physical properties of the megathrust?

Can we identify asperities (areas of maximum seismic moment release or interseismic loading) or barriers along the megathrust and characterize their physical properties?

What are the roles of transients, slow earthquakes, and post seismic slip in subduction zone seismic cycle? How can we describe transients -e.g., location, magnitude, recurrence, rate, source process?

Are there transients offshore in the shallow subduction zone? What is the contemporary offshore deformation field?

What is the convergence direction, really? Can we measure it directly? Does it vary with time in response to the seismic cycle?

### 2) Forearc structure and its relationship to intermediate-depth Wadati-Benioff zone seismicity

What is the upper plate signature of in-slab events?

Is there a causal relationship in the apparent correlation between the geometry and location of basins in the Georgia-Puget-Willamette Lowland and the locus and rate of in-slab seismicity?

How do recent large, in-slab events relate to the rupture areas and timing of megathrust earthquakes or silent slip events in Cascadia?

Is there a connection between megathrust processes and earthquakes within the slab?

What explains the seismic quiescence beneath Oregon, and conversely the concentration and location of damaging earthquakes beneath Puget Sound? Is there a geodetic signal related to possible variations in slab pull, interplate coupling, or Basin-Range mantle dynamics?

What causes intermediate-depth seismicity in the slab - phase changes and dehydration embrittlement reactions in slab crust, slab pull, or both?

Do the large earthquakes in the slab occur in slab crust or mantle? Do the small earthquakes occur in the slab crust or mantle? If these populations occur in different spatial volumes, why? Can we characterize the physical properties of slab mantle and crust well enough to elucidate the role of dehydration reactions in warm slabs?

What is the flow in the mantle wedge in 3 D? How does it control or impact forearc processes?

How does fluid flux occur? Does it go into the forearc? What is its relationship to forearc seismicity?

### 3) Forearc topography - How does the geodetic signature relate to mountain building and basin formation?

How does the architecture of the forearc evolve over many seismic cycles-*ie.*, how much interseismic and coseismic deformation is permanent?

How do forearc basins form? In some great earthquakes, seismic slip is concentrated beneath the forearc basins. Why? Are they simply strong crust, mafic underplates, or the loci of subduction erosion? Why do they subside? How do they subside above a subduction zone? What is the role of sediment input in the cycle of basin evolution?

What is the role of slab buoyancy, slab strength, and fluid flux in creating the Coast Range?

What is the role of accretion and steady-state mountain building, especially in the Olympic Mountains? Is it really steady state, or episodic?

Magmatic accretion?

Does variability in accreted terrane structure and composition affect the distribution of subsequent deformation, seismicity, and magmatism in the upper plate?

### 4) Migrating forearcs and backarcs - the margin-parallel component

What is the relative importance of Pacific-North America dextral shear, basin-range extension, and subduction in driving upper plate deformation in the Pacific Northwest?

How and where is the margin-parallel component of convergence accommodated along the subduction zone? What percentage is resolved by oblique slip on the megathrust versus migration of a forearc sliver? How does this behavior relate to the rheology of the forearc and the distribution and rate of upper plate seismicity?

How many crustal blocks are there in Cascadia? Where are they going and what is the nature of deformation along their boundaries?

What is the role of the magmatic arc in accommodating crustal strain and migration of the forearc? Why is the extensional arc nearly invisible to GPS at present?

How far inboard are crustal blocks migrating northward?

What causes the North Cascades?

Explore how PANGA can address these questions.

#### 5) Megathrust sub-array

What is the "elastic deformation": vertically and horizontally, along strike, downdip limits, double locked zone, and temporal variations?

Can leveling and tide gages characterize transients and provide constraints on processes detected by GPS south of Puget Sound?

What is an optimal strategy to densify GPS south of Puget Sound into Willamette Valley?

Compare contemporary strain with geologic rates.

How will the results from NEPTUNE interact with PANGA and whole plate system problems?

#### 6) Continental interior sub-array

Forearc

What are the "sliver" displacement/rotation rates and the strain-relation to backarc crustal faults and strain partitioning in the urban corridor crustal fault loading rates?

What is the relation to paleoseismic rates?

What is the Olympics/Klamaths- contemporary strain?

What is an optimal way to instrument topo gradients?

Is the Georgia-Puget-Willamette Lowland subsiding? Where?

The Arc

How are forearc-backarc kinematic/dynamic differences accommodated?

What are spreading rates and their variability during SZ cycle?

What is the along strike-relation to central vent complexes and central vent transients?

The Backarc

What is the comparison of simple shear and spreading in B-R and folding in the YFB?

What is the inboard limit to "cont. margin" deformation?

What are the implications for strength of lithosphere, inheritance, local forces, mantle dynamics?