Geodynamic Processes at Rifting and Subducting Margins

GeoPRISMS: Amphibious Continental Margin Studies – at Cascadia

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... investigate the coupled geodynamics, earth surface processes, and climate interactions that build and modify continental margins *over a wide range of timescales (from s to My), and cross the shoreline, with applications to margin evolution & dynamics, construction of stratigraphic architecture, accumulation of economic resources, and associated geologic hazards and environmental management.*

What is GeoPRISMS

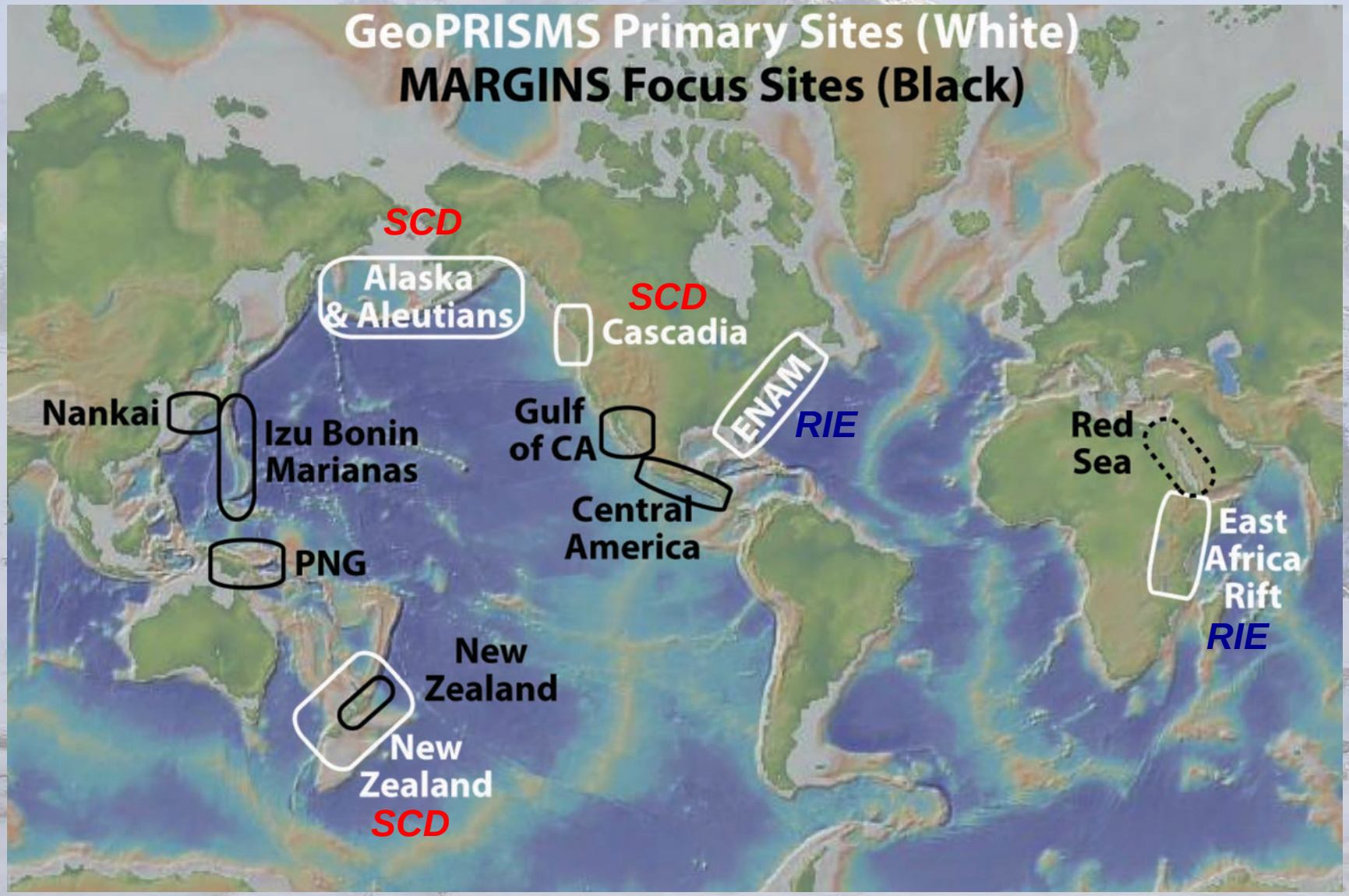
- **Successor to the decadal NSF MARGINS Program**
- **Studies of origin & evolution of continental margins**
  - Community-driven, interdisciplinary, cross-divisional NSF-funded
  - Integrating field, theory, experiment, and modeling
- **Focus on rifts and subduction zones**
  - Geodynamic processes most active; continental crust formed
  - Where geology and society intersect; economic resources
- **Two broadly integrated initiatives**

Subduction Cycles & Deformation

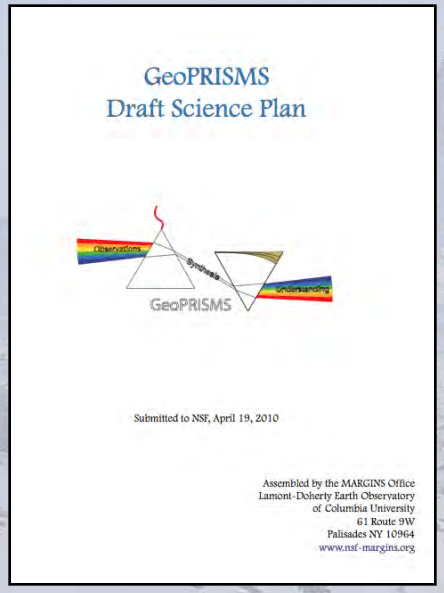
Rift Initiation & Evolution

- **Research at Primary Sites & through Thematic Studies**
- **Shoreline-crossing, i.e., "amphibious"**
  - Where most rifts and subduction zones occur
  - Geologic & geodynamic processes span the shoreline
  - Where focused, cross-divisional efforts most needed

Where GeoPRISMS Works



How Community Science is Done
(The GeoPRISMS Model)


GeoPRISMS
Draft Science Plan

Submitted to NSF, April 19, 2010

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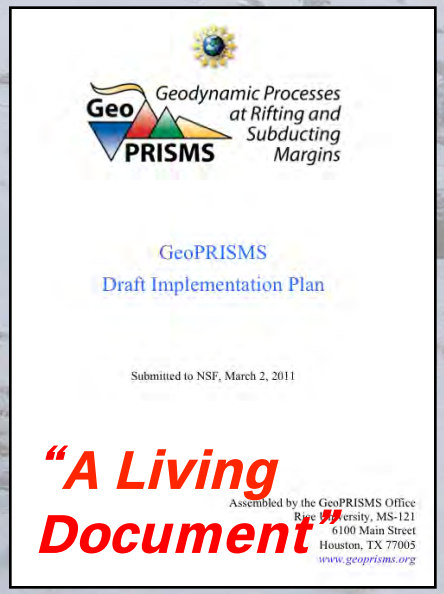
Geodynamic Processes at Rifting and Subducting Margins

GeoPRISMS
Draft Implementation Plan

Submitted to NSF, March 2, 2011

Assembled by the GeoPRISMS Office
Rice University, MS-121
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"A Living Document"

- **Community planning at workshops**
  - MSPW – Feb 2010
  - RIE IW – Nov 2010
  - SCD IW – Jan 2011
  - Alaska – Sep 2011
  - ENAM – Oct 2011
  - Cascadia – Apr 2012
  - EARS – Oct 2012
  - NZ – Apr 2013
- **Science Plans w/ research objectives**
- **Proposals guided by SP** (Deadline: ~July 1)
  - PI-driven proposals (individual, team, postdoc)
  - Community-driven proposals (e.g., Amph. Array)
  - Workshop proposals (planning, science, synth.)
- **Leveraging new opportunities**
  - New facilities and infrastructure
  - International and agency collaborations
  - Relevant research efforts at primary sites
- **GeoPRISMS is open, all can participate!!**

GeoPRISMS @ Cascadia

- First primary site to come on-line = three years of funding
  - Lots of ongoing work to build upon; immediate opportunities
  - ARRA-funded Amphibious Array & Cascadia Initiative (w EarthScope)
  - Clear objectives; direct relevance to GeoPRISMS SCD questions
- Lots of non-GeoPRISMS research in Cascadia – critical datasets and excellent leveraging opportunities
- Cascadia Science Workshop (April 2012) – to organize & plan

>> Updated Implementation Plan released June 2012

Outline of Casc. IP – Questions, Opptys

- *Controls on size, frequency of earthquakes & slip behavior of subduction plate boundaries*
  - Large megathrust events; near end of seismic cycle; ETS well expressed
- *Spatial-temporal deformation patterns during the seismic cycle*
  - Segmentation in ETS & seismicity; what are causes for different data sets?
- *Volatiles & the rheology/dynamics of the plate boundary interface*
  - Hot-slab end-member, opportunity to understand role of volatiles on slip
- *Storage, transfer & release of volatiles through subduction systems*
  - Hot-slab end-member, how affects volatile cycling, magmatism, mantle wedge
- *Geochemical products of subduction & creation of continental crust*
  - Migration of arc left plutonic record of temporal changes in continental growth
  - Causes of along-strike variability in volcanism re crustal structure & origin
- *Subduction zone initiation & arc system formation*
  - Determine origin of the earlier Siletz and Crescent terraness
  - How influenced by surrounding terranes, e.g., Yakima FTB, JdF Ridge, etc.
- *Feedbacks between surface processes & subduction dynamics*
  - Interplay between earthquakes, surface elevations, landscape, and surface processes; role of sediments (and fluids) on downgoing slab on slip behavior

Outline of Casc. IP – Potential Studies

- *Geophysical studies* – Seismic imaging to better characterize structure and composition of the onshore and offshore regions; Example studies include:
  - 3-D marine seismic and wide-angle surveys to resolve megathrust interface, structural architecture of subducting & overriding plates, and physical properties of plate boundary, crust, mantle, etc.
  - High-resolution onshore active source seismic experiments, embedded in a passive seismic network, coupled with MT data, to elucidate melt pathways and zones of magma storage within target arc volcanoes
  - Marine MT studies to extend the onshore grid of MT stations
  - Heat flow measurements across the entire margin: the incoming plate, across the accretionary complex, and within the volcanic arc.
- *Seafloor Geodesy*
  - To augment well-documented onshore surface displacements throughout the earthquake cycle.
- *High-precision isotopic, petrologic, and experimental studies of Cascade magmas*
  - Geochemical and petrological studies to reconcile with thermal models that predict a hot and dry subduction system.
- *Studies of subduction-related metamorphic and igneous processes*

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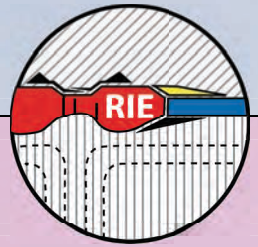
- Future GeoPRISMS funding – likely will focus on "data analysis" and "synthesis", rather than new "data acquisition"
  - Includes analysis of Cascadia Initiative data – see NSF DCL update
- New data acquisition funded by other NSF programs, e.g.,
  - SEES Hazards, FESD, Integrated Earth Systems, as well as Core
- Now, what will marine geophysics bring to Cascadia??

GeoPRISMS Structure & Topics



Rift Initiation and Evolution (RIE)

- Where and why continental rifts initiate
- Fundamental rifting processes; feedbacks in time & space
- Controls on the architecture of rifted continental margins
- Mechanisms & consequences of fluid & volatile exchange

Subduction Cycles and Deformation (SCD)

- Controls on size, frequency of earthquakes & slip behavior of subduction plate boundaries
- Spatial-temporal deformation patterns during the seismic cycle
- Linkages between volatiles & plate boundary rheology
- Volatile storage, transfer, & release in subduction systems
- Geochemical products of subduction; continent creation
- Subduction zone initiation and arc system formation
- Feedbacks between surface processes & subduction dynamics

Roadmap to the Future

- *The nature of segmentation along the subduction zone*
  - What are the controls on segmentation? Are they the same for different data?
- *Earthquakes and the turbidite record*
  - What is 3D distribution of turbidites, sedimentation & failure processes, etc.?
  - Do onshore records confirm interpretations based on offshore studies?
- *The hot and dry slab paradox* at Cascadia
  - Geochemical and petrological estimates of volatile fluxes need to be reconclied with thermal models that predict a hot and dry subduction system.
- *Distribution of volcanism along the arc*
  - What parameters produce large central volcanoes versus dispersed monogenetic volcanism between them? What are the roles of upper plate, slab or mantle wedge structure, and mantle fluxes and crustal magma processing?
- R*ole of surrounding regions on Cascadia evolution*
  - How was the evolution of Cascadia affected by surrounding geologic provinces, e.g., Yakima fold and thrust belt, Basin and Range, High Lava Plains, Klamath/ Sierra block, Yellowstone hot spot trail and Juan de Fuca ridge.
- *Imaging physical properties within the crust and upper mantle*
- *Sediment transport. – causes, controls, and processes*

Outline of Casc. IP – Example Topics

- *Great earthquakes, interseismic locking, and ETS*
- *The hot and dry slab paradox*
- *Role of volatiles in megathrust coupling / decoupling*
- *Imaging physical properties deep within the crust and upper mantle*
- *Along-strike compositional diversity of lavas and tephras and distribution of volcanism*
- *The nature of segmentation along the subduction zone*
- *Subduction initiation beneath Cascadia and the origin of the Siletzia terrane*
- *Short-term and long-term effects of sediment genesis and transport on accretion and erosion*
- *Earthquakes and the turbidite record*
- *Paleogeodesy applied to Cascadia*
- *Role of surrounding regions – how influenced Cascadia evolution*