GeoPRISMS, Earthscope, and Cascadia

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Ken Dueker

University of Wyoming
Talk Outline

1. Earthscope and Cascadia Initiative Data: system-wide coverage
2. Marine and onshore-offshore active-source data: value added
3. COAST cruise, July 2012: a glimpse of what’s possible
4. Data examples and preliminary findings
   • Multibeam bathymetry & backscatter
   • Gravity & magnetic
   • Seismic
5. Notional Future Work
Publicly Available Seismic Data, as of 2015

Seismic stations that will have provided public seismic data as of 2015. Offshore triangles are Cascadia Initiative OBS’s; onshore circles are USArray stations; black triangles onshore are PASSCAL and Flex Array deployments.

Existing Active-Source MCS Data

Four main data sets:
- Sonne cruise (ORWELL)
- OR89 site survey data
- Industry data on shelf (USGS data base)
- COAST (2012)

NOTE, unlike Earthscope data:
- No continuous, margin-wide coverage
- (We will propose a margin-wide GeoPRISMS-funded survey of the Cascadia margin)
Marine Active-Source Data: A Critical Need

Marine Active-Source Data enable:

- Detailed images of forearc crustal structure
- Location (and, potentially, properties) of offshore plate boundary
- Characterization of subduction inputs updip of ETS zone
- Wide-angle reflection/refraction data (onshore-offshore and OBS) => large-scale crustal structure
Why Marine Active-Source in Cascadia?

• Numerous targets amenable to active-source imaging (plate boundary, accretionary wedge structures, shelf/slope stratigraphy, listric faults, methane hydrate system, methane vents).

• Synergies among major infrastructure and scientific initiatives (Earthscope, GeoPRISMS, ARRA Cascadia Initiative, OOI, IODP).

• Lies within U.S. territorial/EEZ waters (simplifies permitting).

• Close to major U.S. ports (at-sea transfers for cruise participants).
COAST: Cascadia Open-Access Seismic Transects

July 2012: a two-week cruise to image offshore subduction zone off Grays Harbor, WA. *This cruise provides a glimpse of what modern MCS data can provide in the subduction system offshore.*

This was the first open-access project in the U.S. active-source marine seismic community.
R/V Langseth cruise MGL1212

Astoria, Oregon - Astoria, Oregon
July 12-24, 2012

Vital Statistics:
- ~1100 km MCS data acquired
- Full coverage multibeam bathymetry in deeper water (>2 km)
- Gravity, magnetic data acquired
- No 3.5 kHz data (mech failure)

Seismic Acquisition:
- 8-km, 636-channel streamer (2D)
- 36-gun, 6600 cu. in. array
- Two tow depths for guns and streamer: 9 m and 15 m (data comparison)
- Onshore Reftek piggyback conducted (Trehu/Abers)
R/V Langseth cruise MGL1212

Scientific & Operational Goals:
• Locate the offshore plate boundary
• Identify downdip variations in plate boundary structure
• Determine the nature of the plate boundary interface (subducting sediment, etc.)
• Quantify upstream inputs to ETS zone (porosity, fluid pressure, etc.)
• Image offshore methane system
• Produce data in support of future 2D and 3D seismic surveys of Cascadia margin

Education & Outreach Goals:
1. Conduct an Open-Access cruise:
   • All geophysical data immediately available
     Migrated stacks: [www.ig.utexas.edu/sdc/cruise.php?cruiseIn=mgl1212](http://www.ig.utexas.edu/sdc/cruise.php?cruiseIn=mgl1212)

2. Conduct an Open-Participation cruise:
   • Shipboard party selected from ~60 applicants
   • Every available berth filled
Open Access: Download COAST Data!

Migrated stacks: [www.ig.utexas.edu/sdc/cruise.php?cruiseIn=mgl1212](http://www.ig.utexas.edu/sdc/cruise.php?cruiseIn=mgl1212)

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Open Access: Download COAST Data!


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R/V Langseth cruise MGL1212: Open-Participation
R/V *Langseth* cruise MGL1212: Open-Participation

**Pl’s:**
- W. Steven Holbrook, Univ. of Wyoming
- Graham Kent, Univ. of Nevada
- Katie Keranen, Univ. of Oklahoma

**Honorary Pl’s:**
- Harold Tobin, Univ. of Wisconsin
- Jackie Caplan-Auerbach, WWU

**Postdocs:**
- Emily Roland, USGS-Anchorage
- Danielle Sumy, USGS-Pasadena

**Students:**
- Kate Allstadt, Univ. of Washington
- Robert Anthony, New Mexico Tech
- Shahar Barak, Stanford Univ.
- Jeff Beeson, Oregon State Univ.
- Janine Buehler, Scripps Inst. of Oceanography
- Brian Covellone, Univ. of Rhode Island
- Brady Flinchum, Univ. of Nevada
- Ashton Flinders, Univ. of New Hampshire
- Will Fortin, Univ. of Wyoming
- Dalton Hawkins, Univ. of Oklahoma
- Annie Kell, Univ. of Nevada
- Dara Merz, Western Washington Univ.
- Marie Salmi, Univ. of Washington

**20 Participants:** 5 faculty, 2 postdocs, 13 grad students

**14 institutions** represented

**13 “newbies”**:
- 8 people had never been to sea
- 5 others had never participated in an MCS cruise
Cruise Overview
Magnetic Data
Backscatter Intensity Data

47°00'N

46°45'N

46°30'N

126°W

125°W
Preliminary Findings: A Brief Tour

1. Slope failures
2. Active normal faults
3. Accretionary wedge structure
   - Landward vergence
   - Undeformed zones
4. Plate boundary structure
   - Landward weakening of oceanic crust reflection
   - Where is the décollement?
Active Normal Faults
Active Normal Faults
Landward-Vergent Structures

Fault-plane reflections
Landward-Vergent Structures
Plate Boundary Structure
Landward-Weakening Top of Oceanic Crust Reflection
Plate Boundary Structure
Plate Boundary Structure

Where is the Décollement?

MacKay et al., 1995, Tectonics
Plate Boundary Structure

Where is the Décollement?
Plate Boundary Structure
Where is the Décollement?
Plate Boundary Structure
Plate Boundary Structure

The top of oceanic crust appears to be deforming with overlying accretionary wedge.
Plate Boundary Structure

Requirements for landward vergence:
1. Low basal shear stress (Byrne et al., 1993)
2. Landward-dipping décollement (MacKay et al., 1995)
3. Strong wedge, relative to weaker décollement (MacKay et al., 1995)

Paradox (?):
How can low basal shear stress be achieved, if the décollement is not in the sediments?
What Next?

Existing MCS Data

Four main data sets:
- Sonne cruise (ORWELL)
- OR89 site survey data
- Industry data on shelf (USGS data base)
- COAST (2012)
Other Major Offshore Cascadia Datasets

- Cascadia Initiative OBS data
- MOCHA magnetotelluric survey (funded; Schultz)

- Note that these all have spatial coverage along the entire Cascadia margin. We need the same in offshore active-source data.
Notional Open-Access 2D Survey ("COAST 2")

Rationale:
• Characterize offshore region over 400-km-long region
• Coverage commensurate with Cascadia Initiative and MOCHA study areas
• Ancillary OBS & onshore-offshore data highly desirable during shooting
  • Characterize crustal structure in much of Cascadia study area
  • Context for seismicity, ETS, SSE detected by TA and CI datasets

Survey Plan:
• Single 40-day leg of Langseth for airgun/MCS shooting
• Second ship for OBS deployments
Thank You
Challenges: The Usual Suspects
ORWELL Line 103 PSDM - zoom