ETS along the length of Cascadia
Observations and implications for seismic hazard

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Two main points...

1. Segmentation of ETS
   - 3 zones with similar recurrence intervals
   - 7 segments which can slip independently
   - 22 ETS events from 2000 to 2006
     ➔ every 3.3 months

2. Structural controls
   - “Zones” correlate with geologic terrain of the continental plate
   - “Segments” correlate with forearc basins interpreted as indicators of megathrust structure
Tremor and slow slip

Automated detection:
- Seismic data: tremor
- GPS data: slow slip events

Three zones
Recurrence intervals
- 14 months ± 2 – Wrangellia
- 19 months ± 4 – Siletzia
- 10 months ± 2 – Klamath
Segmentation

Three "zones"

Topography is proxy for terrain blocks
Klamath, Wrangellia: Older, more felsic, weaker
Siletzia: Younger, more mafic, stronger

Rheology may control ETS recurrence
– fluids as a catalyst for ETS?

Segmentation

Three "zones"

Seven "segments"

Individual patches with the same recurrence interval but different phase
Time history
2000 to 2006

Black: ETS event
Grey (10 months)
White (20 months)

10 months ago
17 months ago
Most recent event

ETS events
2000 Mar Aug Dec
2001 Feb Apr Aug Nov Dec
2002 Feb Dec
2003 Feb Oct Dec
2004 Apr Jun Jul Nov
2005 Jan Jun Sep Nov Dec

⇒ 22 events in 6 years
⇒ 1 event every ~3.3 months
Segmentation

Three "zones"

Seven "segments"

Tentative correlation with forearc basins?

Segmenetion

Three "zones"

Seven "segments"

Wells et al. 2003

Latitude

Wangella Zone

Sitka Zone

Kamiah Zone

Tentative correlation with forearc basins?
Forearc basins
= fault plane asperities

Wells et al., 2006

Numerical models
Slow slip would be favored at the base of the seismogenic zone

Seismogenic zone
Peak-to-peak shear stress
Lowry, 2006
Summary

Three coherent zones with similar recurrence
- rheology of the overriding plate may be controlling; fluid content perhaps important
- younger, stronger more “oceanic” continental crust having longer hold times

Seven slip segments
- segments may relate to seismogenic asperities

ETS events every ~3.3 months
- does each event represent increased hazard?
- of what value would such frequent seismic alerts be to the public?

Studying ETS

New seismic deployments to investigate ETS

CAFÉ
PIs: Creager, Malone, Abers, Rondeny, Melbourne

FACES
PIs: Brudzinski, Allen

Mendocino
PIs: Levander, Humphreys, Allen
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<th>Year</th>
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ETS event table

North South

- 22 events in 6 years
- 1 event every 3.3 months
Arc segmentation – fluids

Melting
- dry melting
- wet melting

wet

dry

dry

dry

wetter
Shasta has highest H₂O

Arc melting and ETS

Melting
- dry melting
- wet melting

wet

dry

dry

dry

wetter
Shasta has highest H₂O

Schmidt 2005
Arc melting, ETS and interface earthquakes

Tremor and slow slip?
– A new view of subduction and metamorphism

Slow slip events beneath Vancouver Island

Non-volcanic tremor

14 month recurrence
Tremor and slow slip?
– A new view of subduction and metamorphism

Episodic tremor and slip in northern California
11 month recurrence

Five segments with different recurrence intervals
1: 14 months
2: independent short bursts
3: 12.5 months
4: one burst
5: 11 months

Szeliga et al. 2004

Resonant slip
at base of seismogenic zone

Lowry, 2006
• Climatic loading responsible for periodic behavior of ETS
• Slow slip would be favored at the base of the seismogenic zone

Seismogenic zone Peak-to-peak shear stress

Lowry, 2006
ETS and forearc basins

Wells et al., 2006

Figure 17. Subduction zone cartoon summarizing observations of 29 of the largest Circum-Pacific megathrust earthquakes. S is seismogenic zone, with downdip limit of coseismic slip from thrust focal mechanisms, thermal or geodetic models, or mantle depth. The DSTL comprises on average 41% of S but contains 71% of an earthquake’s seismic moment and 79% of its asperity area (area of highest slip). Mapped forearc basins comprise 21% S and contain 57% of an earthquake’s asperity area, on average.

Wells et al., 2006
Cascadia

Slab contours from McCrory et al, 2006

Arc segmentation

Physical (vent distribution)

Guffanti & Weaver 1988

Isotopic

Schmidt 2005
Earthquakes

– The fate of the Juan de Fuca plate

ANSS catalog
1970 – present

Slab contours
from McCrory et al, 2006
Cascadia subduction earthquakes volcanoes tsunamis

Source | Affected area | Max. Size | Recurrence
--- | --- | --- | ---
Subduction Zone | WA, OR, CA | M 9 | 500-600 yr
Deep Juan de Fuca plate | WA, OR, CA | M 7+ | 30-50 yr
Crustal faults | WA, OR, CA | M 7+ | Hundreds of yr?

Cascadia earthquakes

what is the seismicity telling us?

green: crustal orange: deep

Modified from Weaver and Shadloo, 1996