Mechanics, structure, and evolution of forearcs: the Aleutian margin as seen from a global perspective

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What do other convergent margins tell us about the Aleutians?

- Coulomb wedge mechanics - minimum and maximum taper
- Accretionary vs. non-accretionary (or erosive) margins - wedge taper
- Accretionary examples - Taiwan, N. Sumatra
- Erosional examples - Costa Rica, Northern Japan
- The Aleutian trench - Basal dip, topographic slope - What do Coulomb wedge mechanics tell us?
Coulomb Wedge Theory—How does surface slope relate to principal stress orientations and wedge strength?

- If material and basal detachment are Coulomb, principal stress orientation and taper angle are constant. (Dahlen, 1984)
How do long term processes in the forearc relate to or reflect plate boundary coupling?

**Mass Balance**
Ranero, C.

**Seismic Coupling**
Peterson and Seno, 1984
Pacheco, Sykes, and Scholz, 1993
Forearc Slope and Wedge Taper for accretionary and erosional margins

Clift and Vannucchi, 2004
Taiwan—an accretionary wedge backed by a non-accretionary wedge.
Ammon et al., 2005,
Science

Sumatra
Sumatran Forearc Plateau- coincidence of an asperity with a positive TPTA

Graindorge et al., 2008
Deformation at long wavelengths-two forearc highs- regularly spaced (~13 km) ridges

Fisher, Mosher, Austin, Gulick, Masterlark, Moran, 2009
Convex-up profiles and horizontal wedge tops

Wells, Blakely, Sugiyama, Scholl Dinterman, 2003

Zhao Davis, Dahlen, Suppe, 1986

Fuller, Willett, Brandon, 2006

Wang and Hu, 2006
Backthrusting and arcward vergent folding

Mosher, Austin, Fisher, Gullick, 2008

The Toe

Seconds (2-way travel time)

7.0
6.0
5.0

10 km
Mountain Fronts

The problem: Vann, Graham, Hayward, 1986

The solution: Vann, Graham, and Hayward, 1986

Mackenzie Mts.: Vann et al., 1986

Pakistan, Alberta, Taiwan: Humayon Lillie, Lawrence, 1991
Costa Rica-outer forearc subsidence (erosion) coupled to uplift of the inner forearc and arc
Northeast Honshu, Japan

Regalla, Fisher, and Kirby, 2010
Long Term active shortening across the arc and back arc
Permanent uplift of the coast

Interseismic onland shortening
Coseismic onland subsidence and extension
Basal dip and Surface slope

ETopo1 - NOAA

Hayes and Wald, 2009
Aleutian trench

Freymuller et al., 2008
ETOPO1- NOAA

Freymuller et al., 2008

Hayes and Wald, 2009
Kodiak Archipelago

- Episodic accretion—record of Mesozoic and Paleogene accretion
- Penetrative ductile deformation and folding occurred less than 10 Ma years after deposition
Kodiak Archipelago

- Underplated rocks (red)- lower greenschist facies, slaty cleavage, southeast vergence
- Offscraped rocks (blue)- unmetamorphosed, weakly cleaved, both

Rowe, Moore, Meneghini, and McKeirnan, 2009
Conclusions

- Strength of the forearc wedge can be linked to topography through Coulomb wedge mechanics.
- Most non-accretionary margins evolve beyond the minimum taper (Hmm, the western Aleutians?).
- Regions of high coupling can be associated with flat areas of the forearc - both positive and negative TPTAs.
- Portions of the forearc composed of underplated rocks are deformed early but subsequently provide a buttress as they are exhumed during continued underplating and outboard accretion (experienceing elastic strain related to the seismic cycle a la Wang and Hu, 2007).