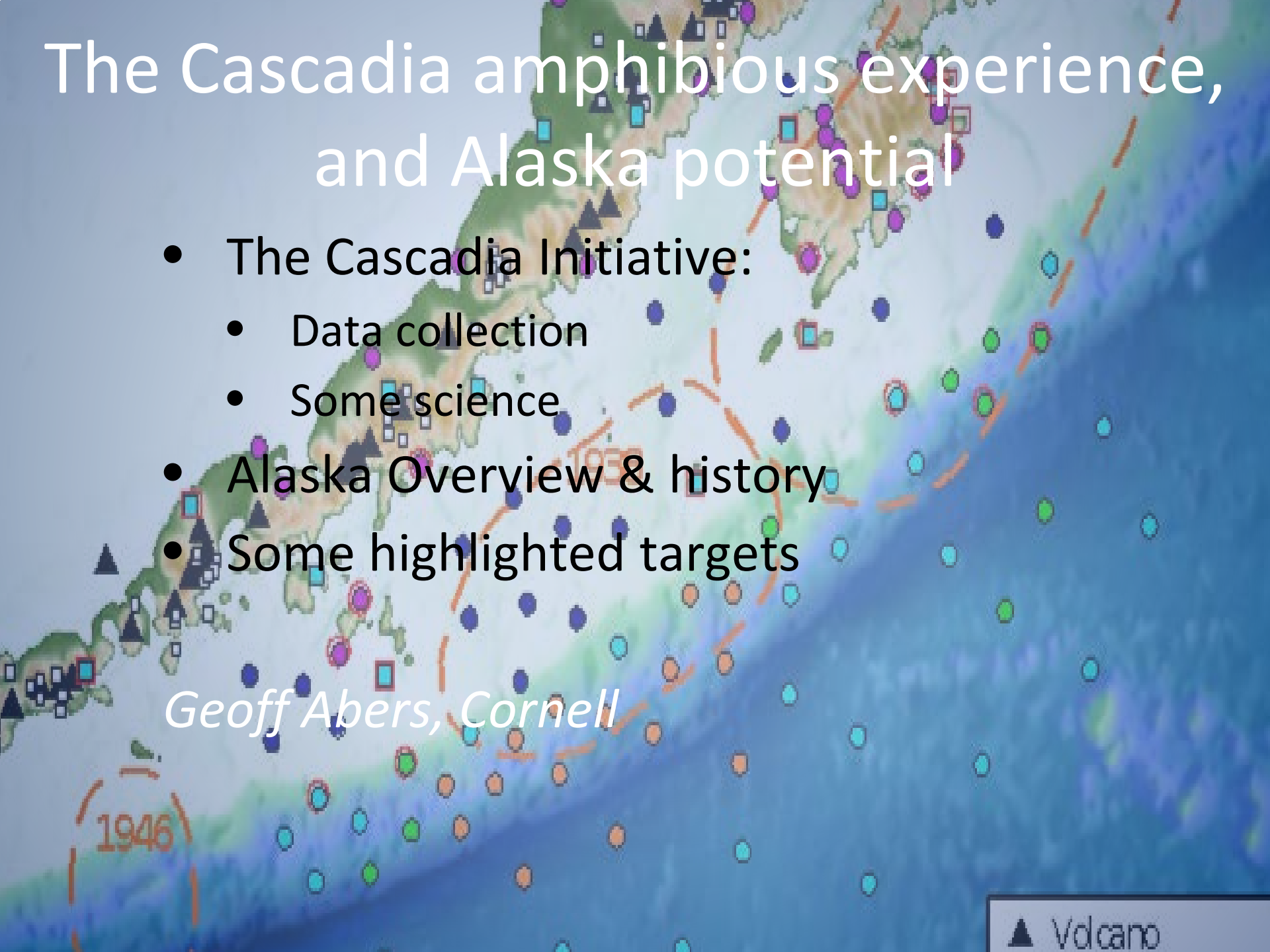


The Cascadia amphibious experience, and Alaska potential

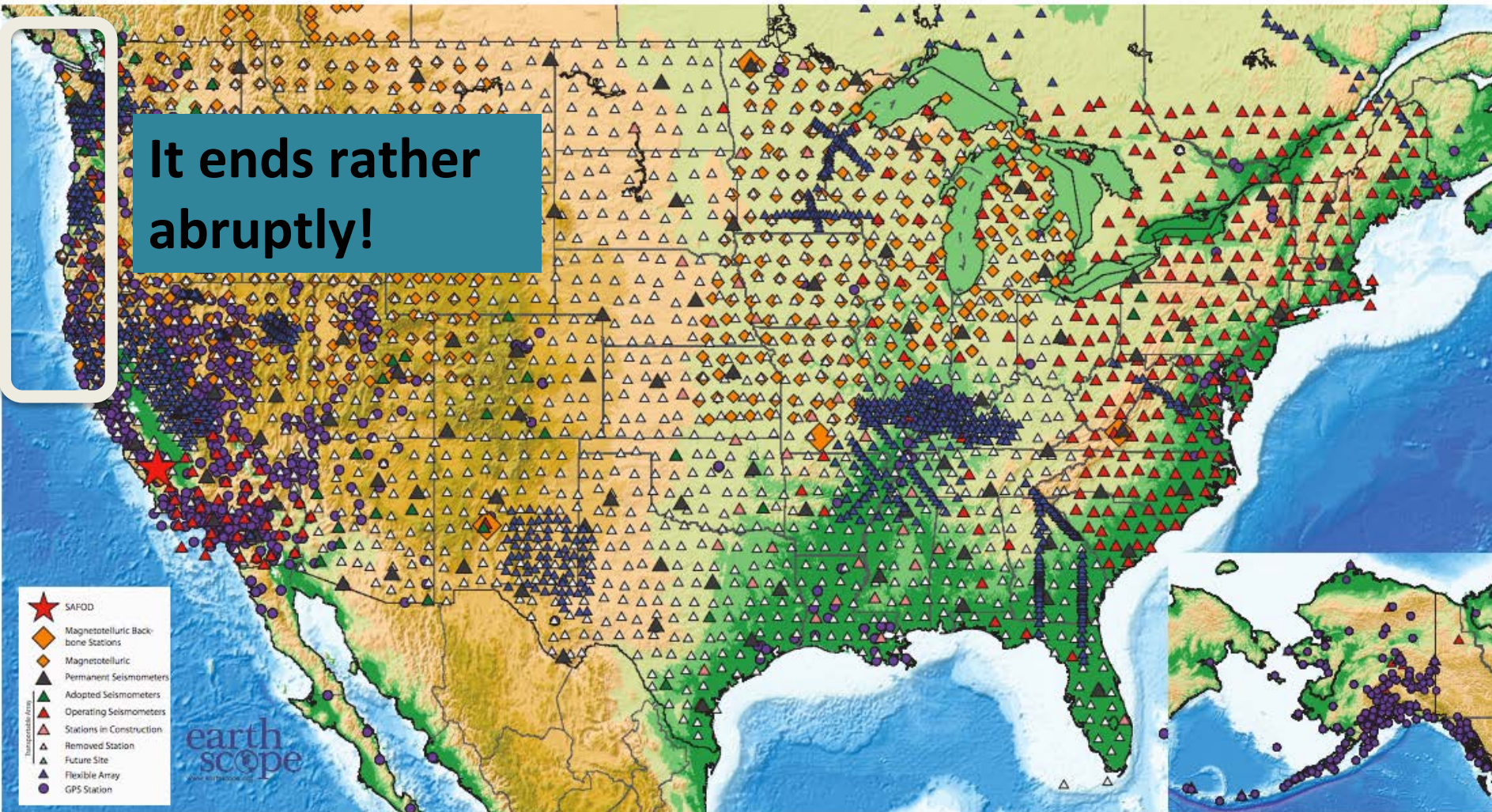
- The Cascadia Initiative:
 - Data collection
 - Some science
- Alaska Overview & history
- Some highlighted targets

Geoff Abers, Cornell



Earthscope USArray is spectacular but...

EarthScope Stations Status as of July 2014



“The #1 most epic project in the universe” – Popular Science

May, 2009: A \$10M investment of ARRA funds in geophysics to NSF Earth and Ocean Sciences:

60 ocean-bottom seismometers, 27 on land, 232 GPS upgrades

The Amphibious Array

100 RECOVERY ACT PROJECTS
THAT ARE CHANGING AMERICA



SEPTEMBER 2010

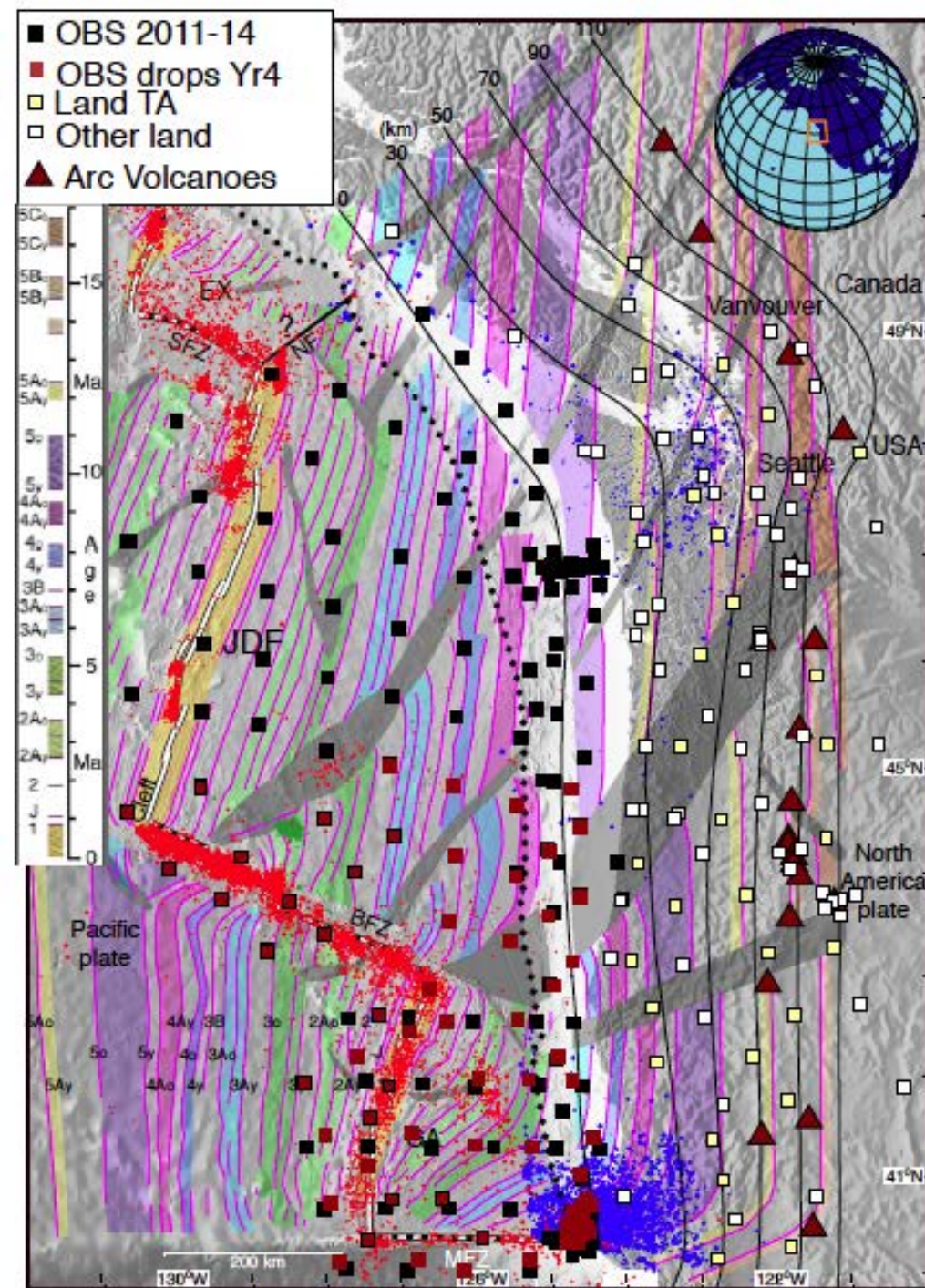
A community-led, open-access major project spanning the shoreline

#65. Research to Avert Disaster:
Understanding Earthquakes in the
Pacific Northwest -
Oregon, Washington, Northern
California - \$10 million

out of \$840B, tens of thousands of projects.

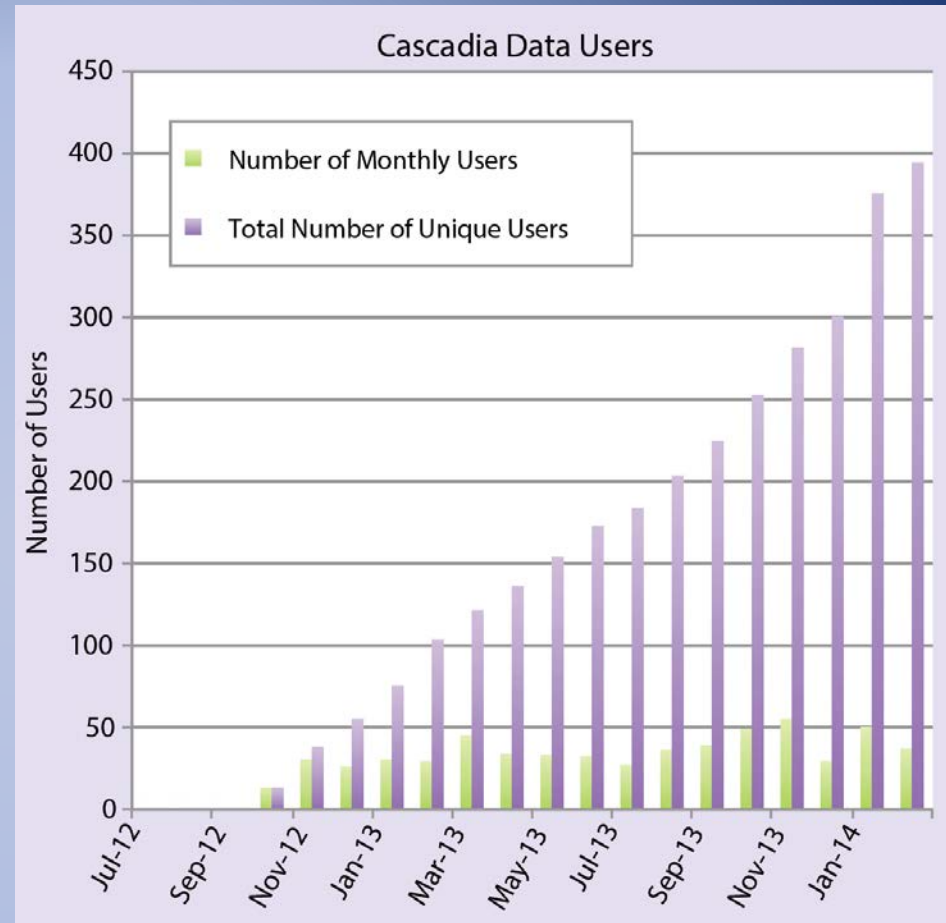
Seismic Deployment

- **Onshore:** Fixed 27 stations at TA spacing (70 km)
- **Offshore:** 4 one-year deployments
 - Plate-spanning grid at 70 km spacing
 - Densified in forearc
 - Two focused arrays on thrust zone
- *Years 1 (2011-12) and 3 (2013-14) in north*
- *Years 2 (2012-13) and 4 (2014-5) in south*
- **A community experiment: Pls just collect data. All data open & available at IRIS DMC**



Highlight: Community Growth

- All cruises included berths for new/first-time OBS scientists
- Workshops engaged community in planning and follow-up
- Open data provides access to anyone
- *one result: Large growth in number and diversity of people using marine seismic data*



after Toomey et al. 2014

Typical seismometers

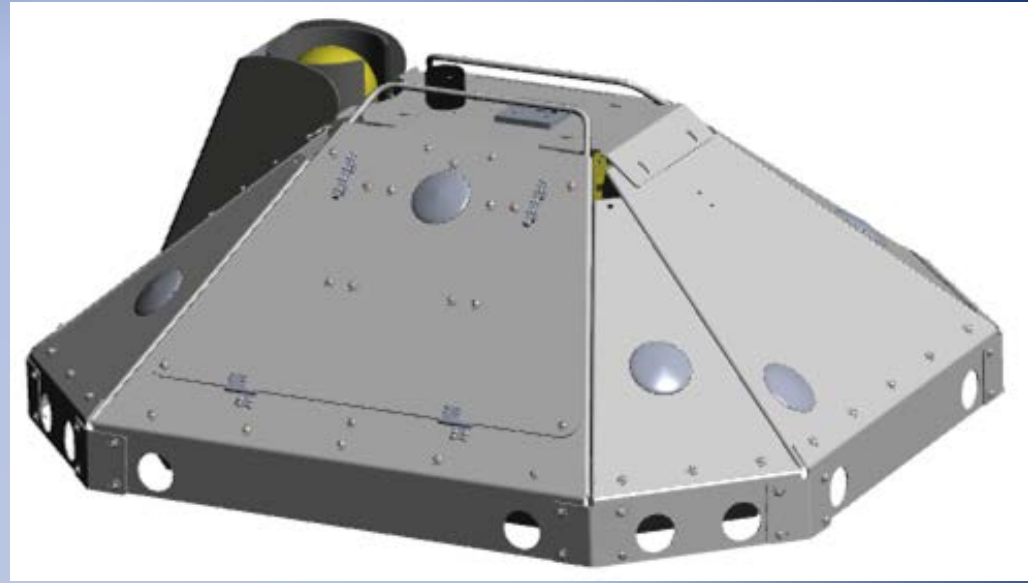


TA site



WHOI OBS

New “Trawl-Resistant Mount” for shallow water



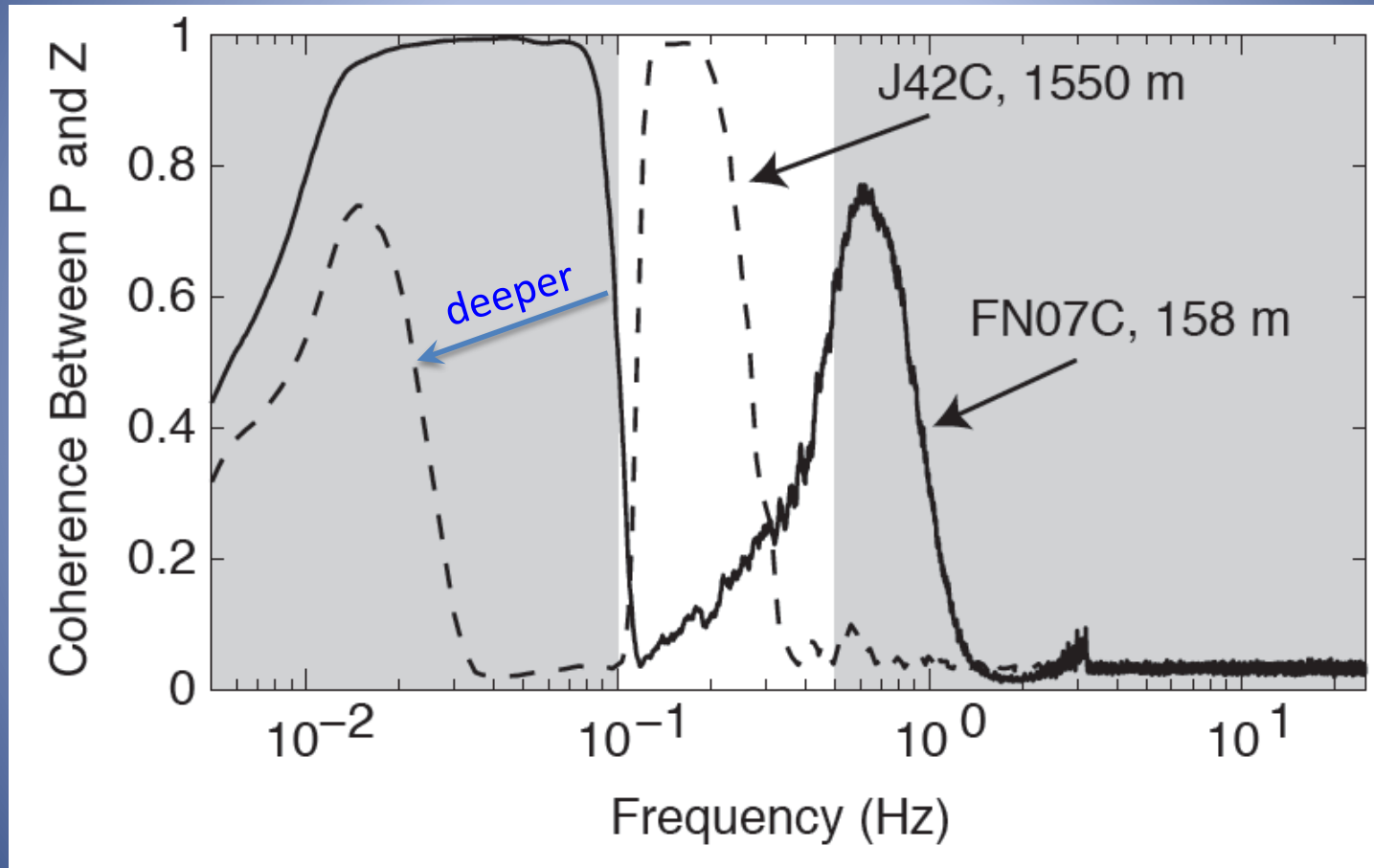
Site M09B showing evidence of having been hit by a trawler.



First practical broadband in shallow water

Challenges in shallow water

- Infragravity wave periods scale to water depth
- Wave noise larger at shallow depth: Coherence corrections fail



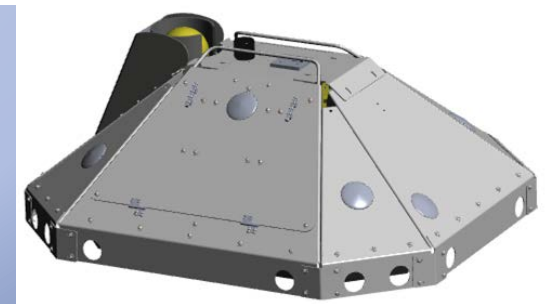
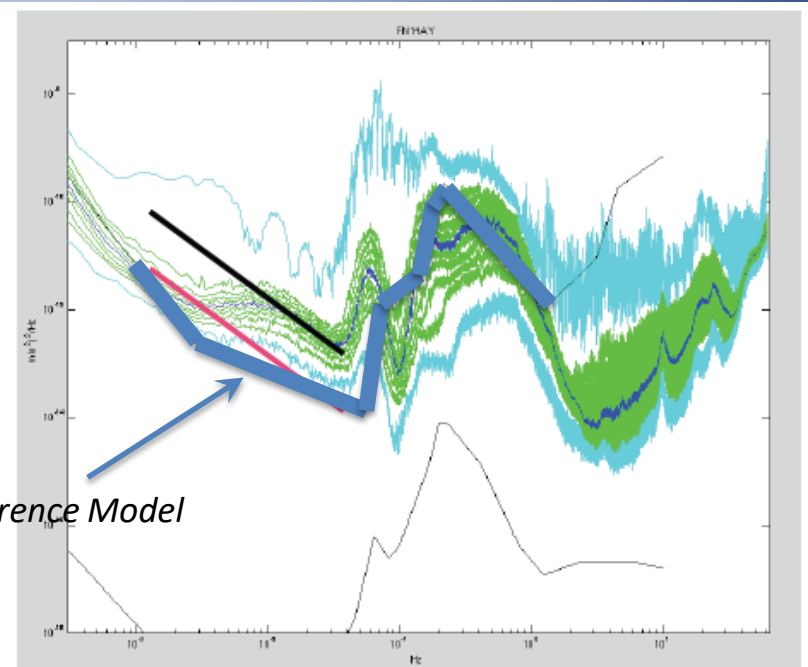
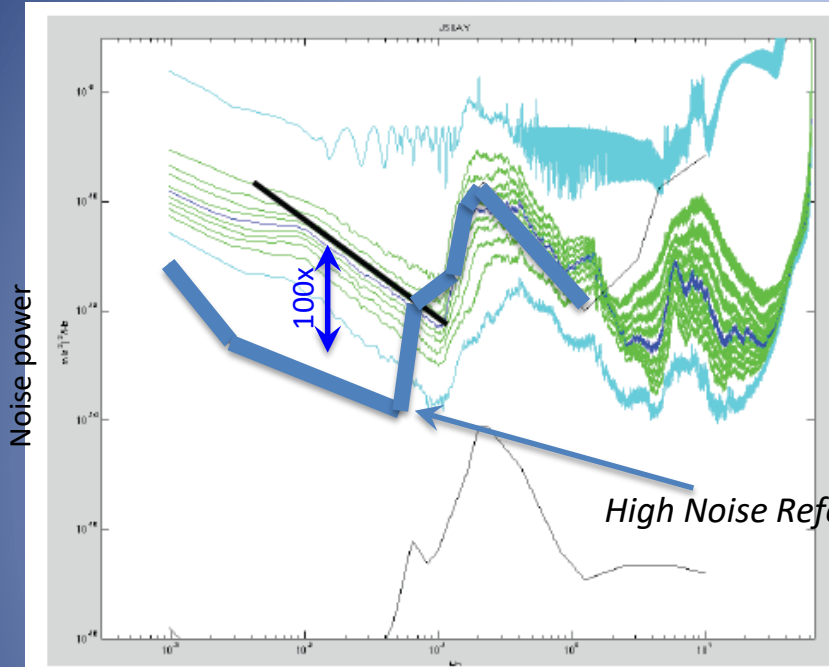
White band: frequencies used for receiver functions

Shallow-water TRM – quieter horizontals

Noise spectra

J50 1908 m standard design

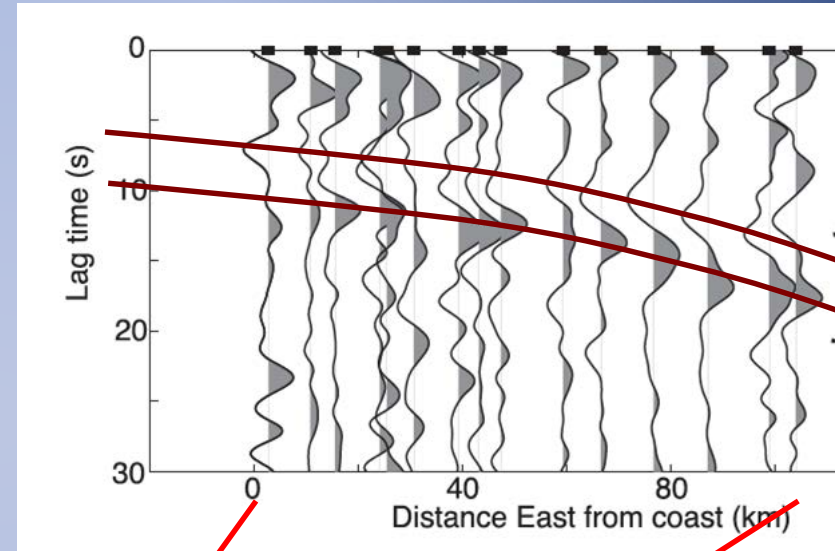
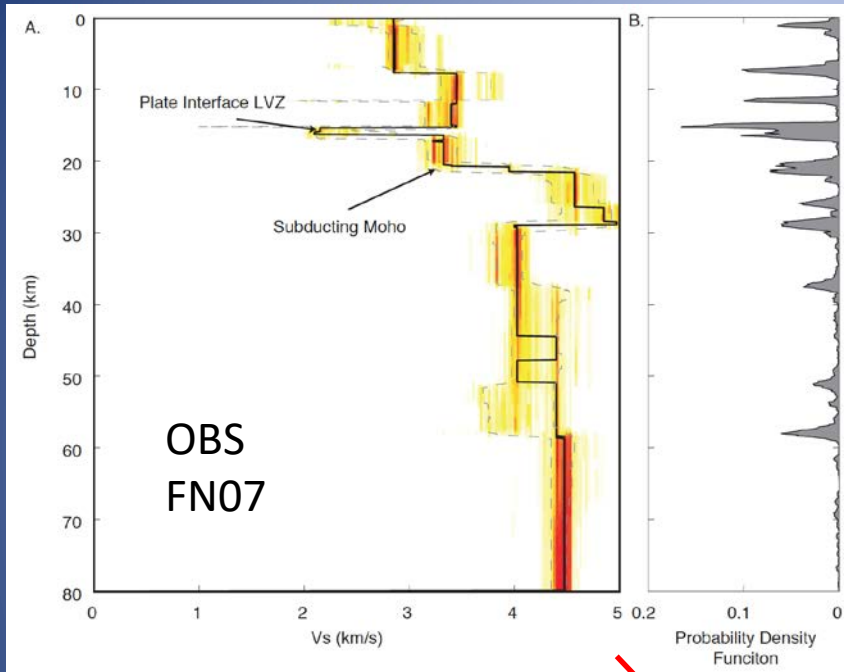
FN14 173m Trawl Resistant



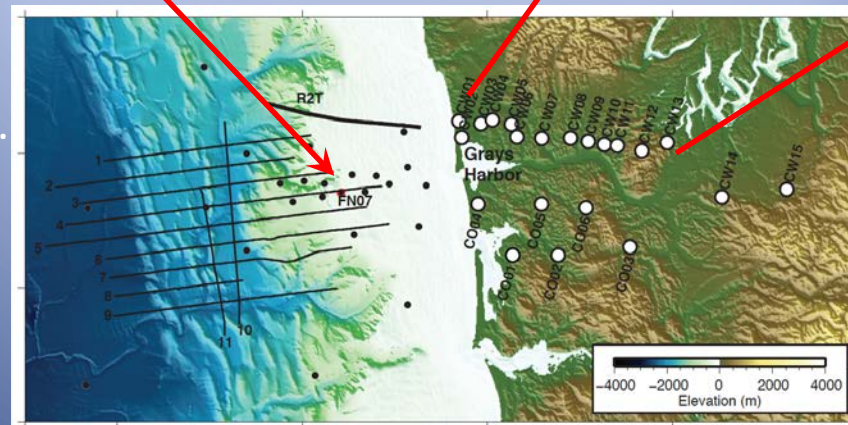
15-20 db quieter

Use of horizontal motion: Receiver Functions

Low velocity channel observed onshore (*the megathrust?*) mapped offshore with receiver functions



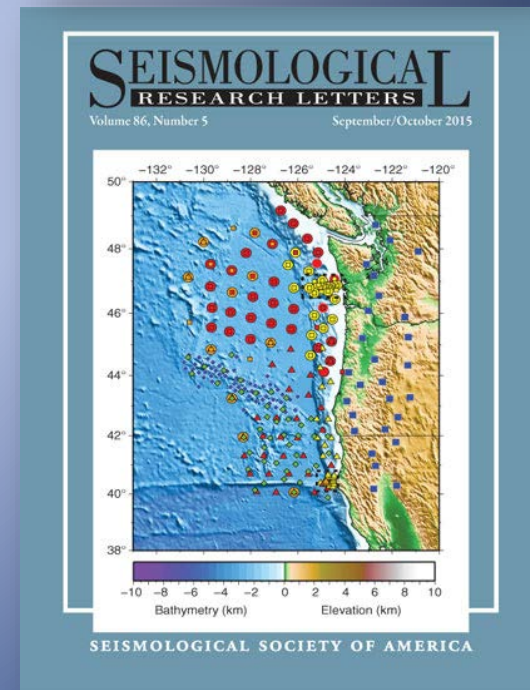
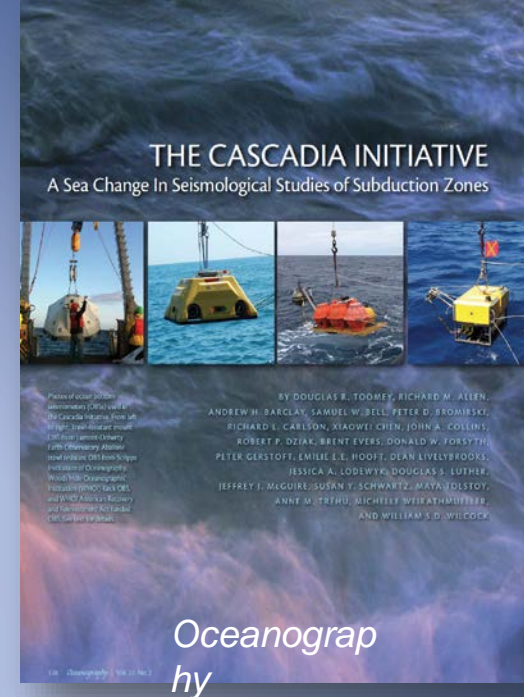
offshore
Janiszewski et al., in prep.



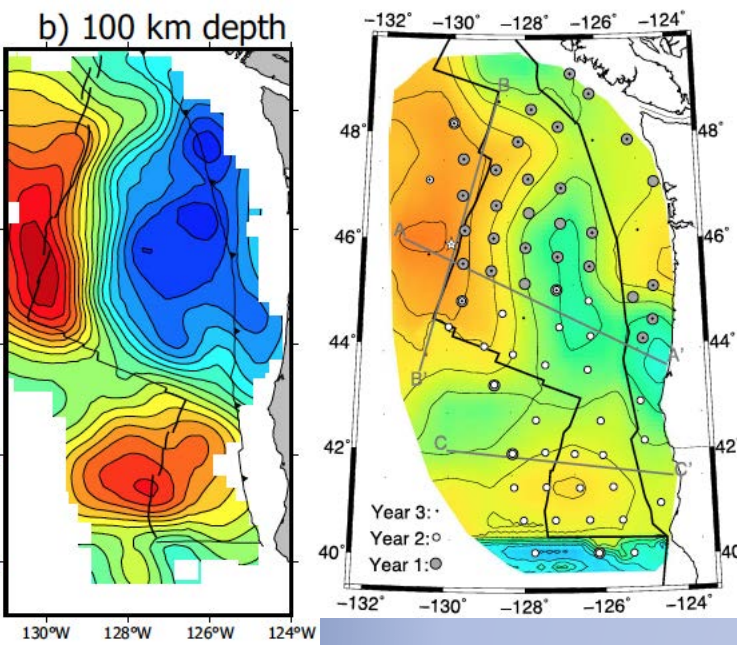
onshore
(Abers et al., 2009)

Publications from the C.I. (partial list)

- Array assessment (Toomey et al.; *Oceanography* 2014)
- Special issue of **Seismological Research Letters** (Sept 2015) – 7 papers
- Some subsequent science papers:
 - Anisotropy & Flow (Martin-Short et al., *Nat. Geosci* 2015; Bodmer et al., *Geology* 2015; VanderBeek & Toomey *GRL* 2017)
 - Ambient noise & earthquake surface waves (Tian et al., *Gcubed* 2013; Tian and Ritzwoller, *GJI* 2015; Bell et al., *JGR* 2016; Janiszewski et al., in prep)
 - Attenuation (Eilon and Abers, *Sci. Adv.* 2017)
 - Body waves (Byrnes et al., *GCubed* 2017; Hawley et al., *Science* 2016)
 - OBS techniques (Bell et al., *BSSA* 2015; Audet, *GJI* 2016)

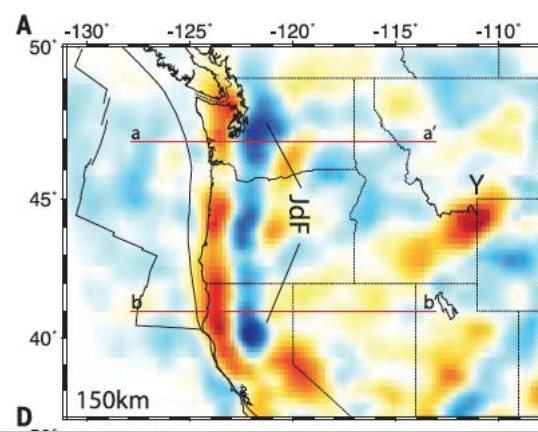


Images

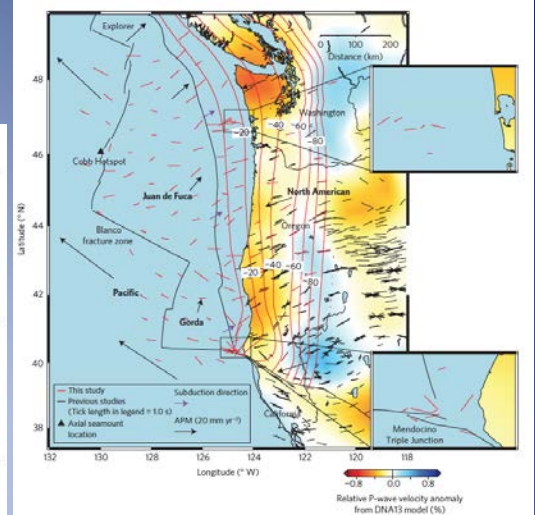


Byrnes et al 2017
Vp 100km

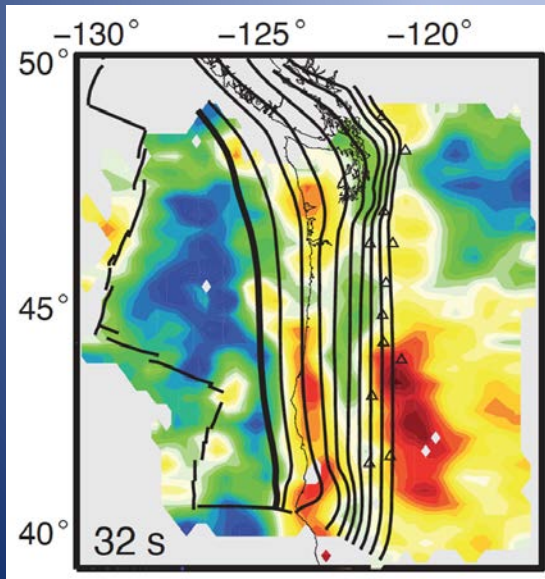
Bell et al 2016
Vs 55km



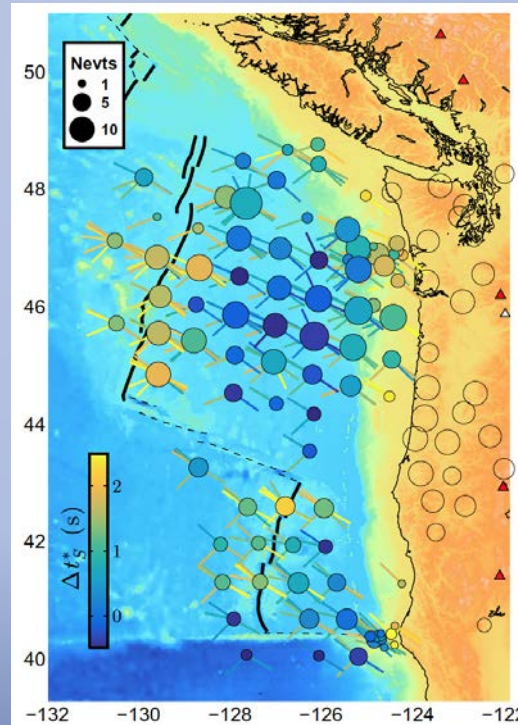
Hawley et al. 2016



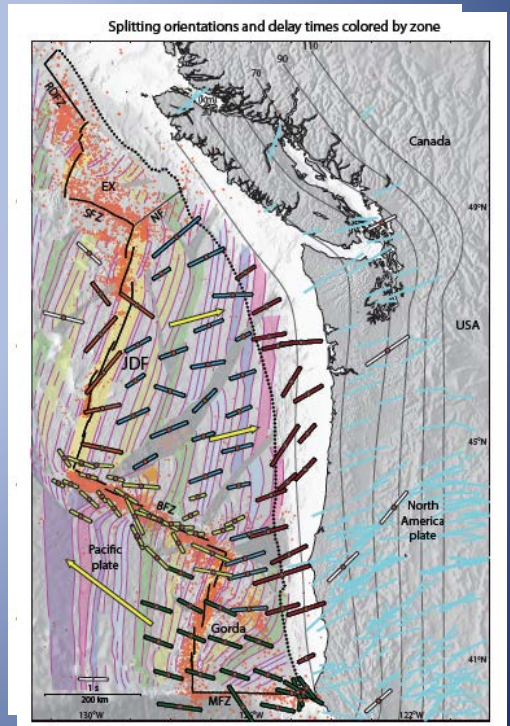
Martin-Short et al. 2015



Janiszewski et al. in prep.



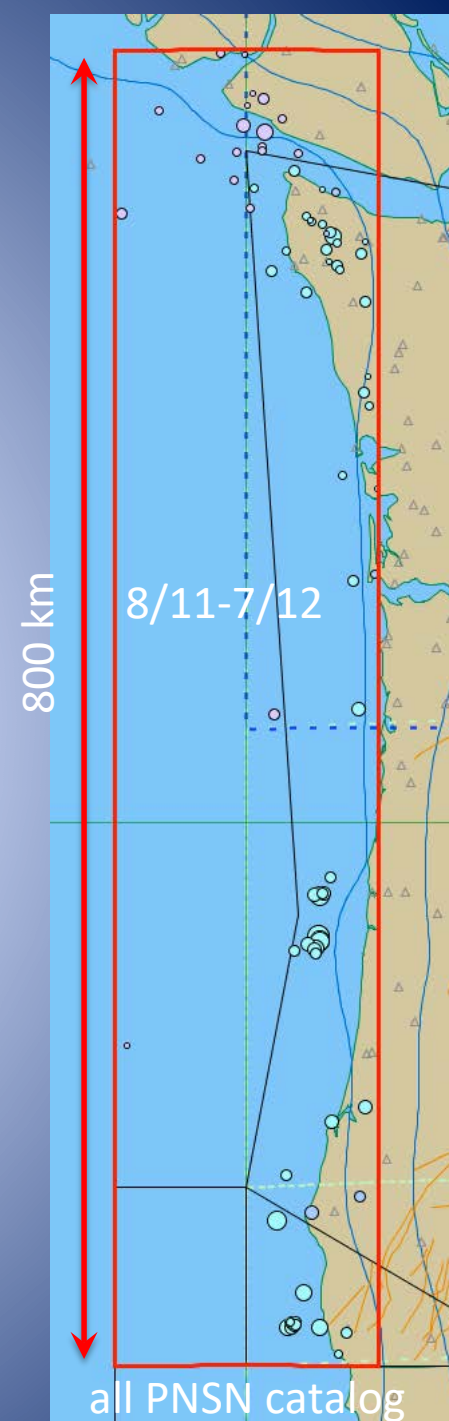
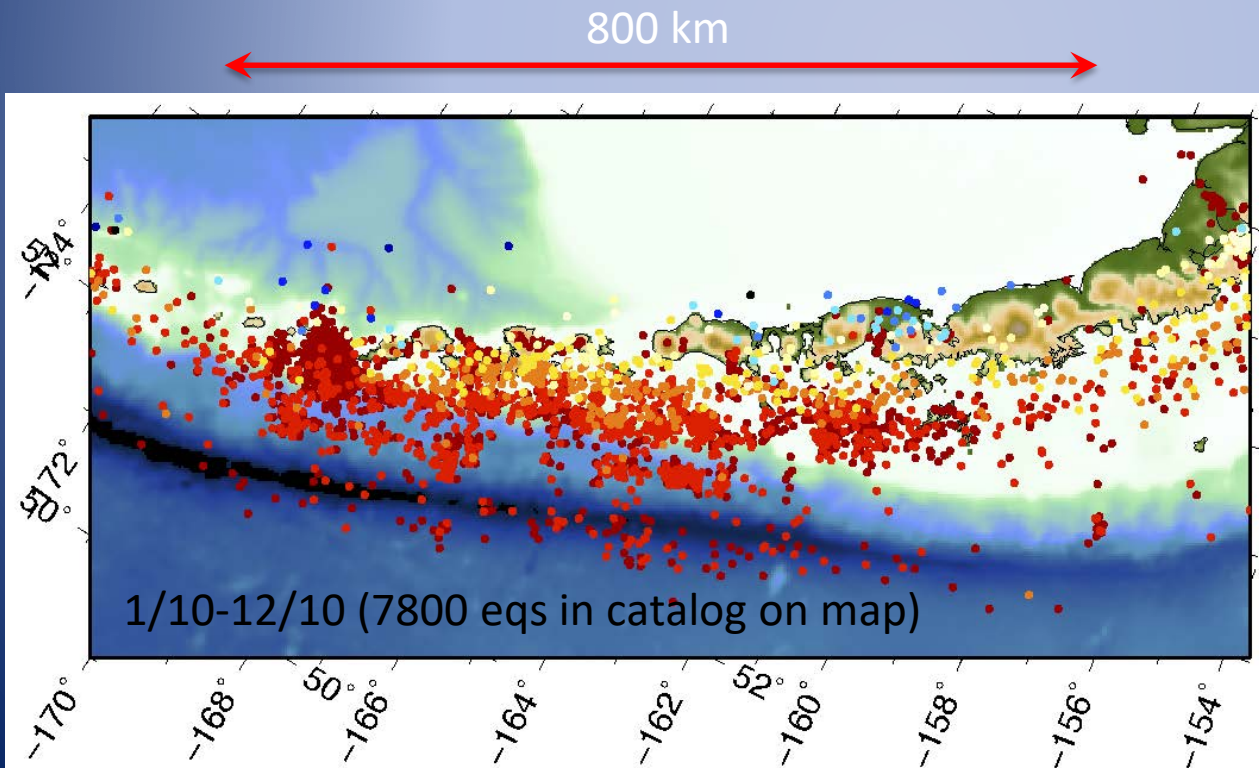
Eilon & Abers 2017: Qs



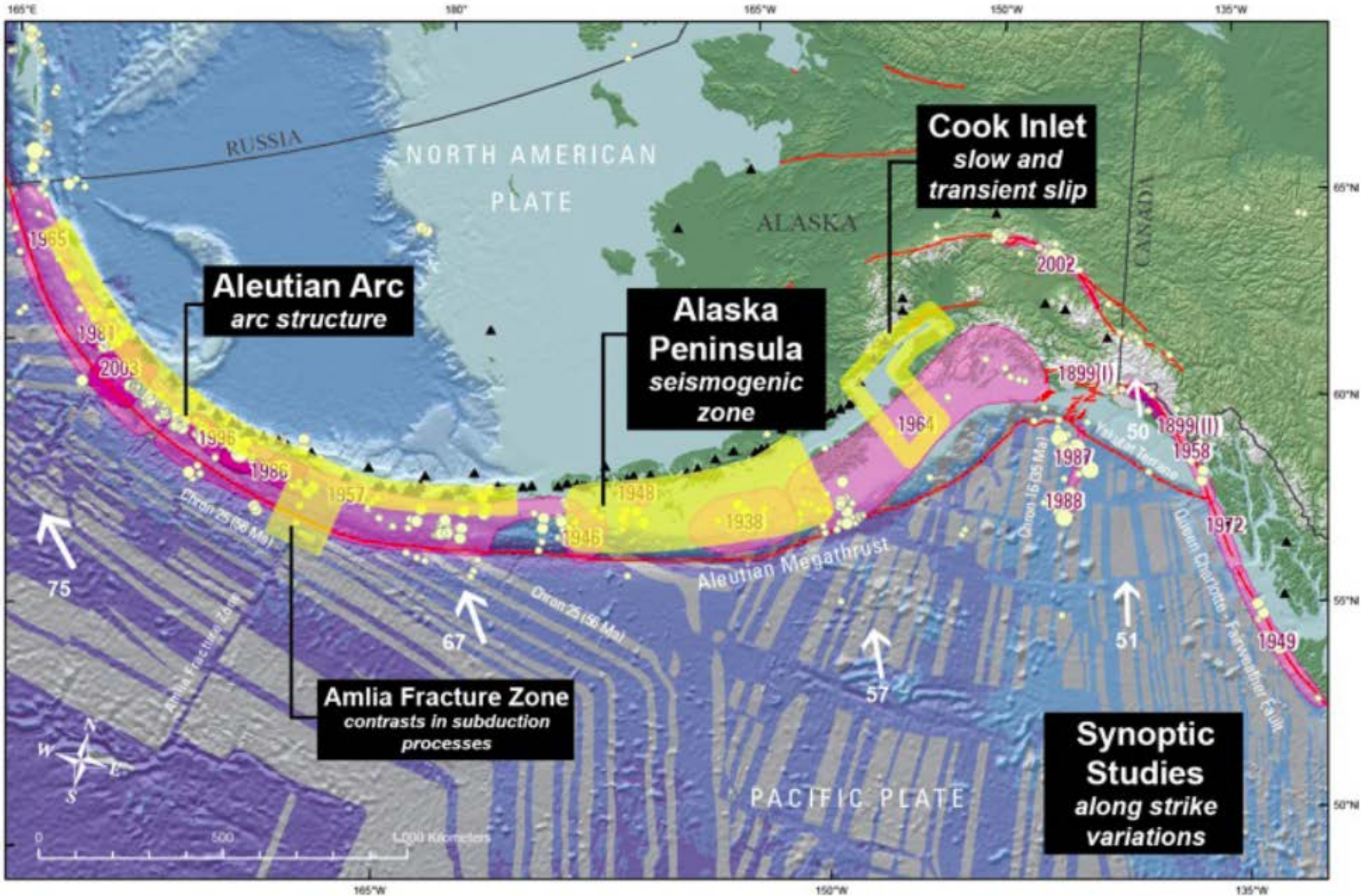
Bodmer et al., 2015

But: very feeble seismicity!

- Cascadia has almost no interplate thrust earthquakes
- There are other places to learn about earthquake process

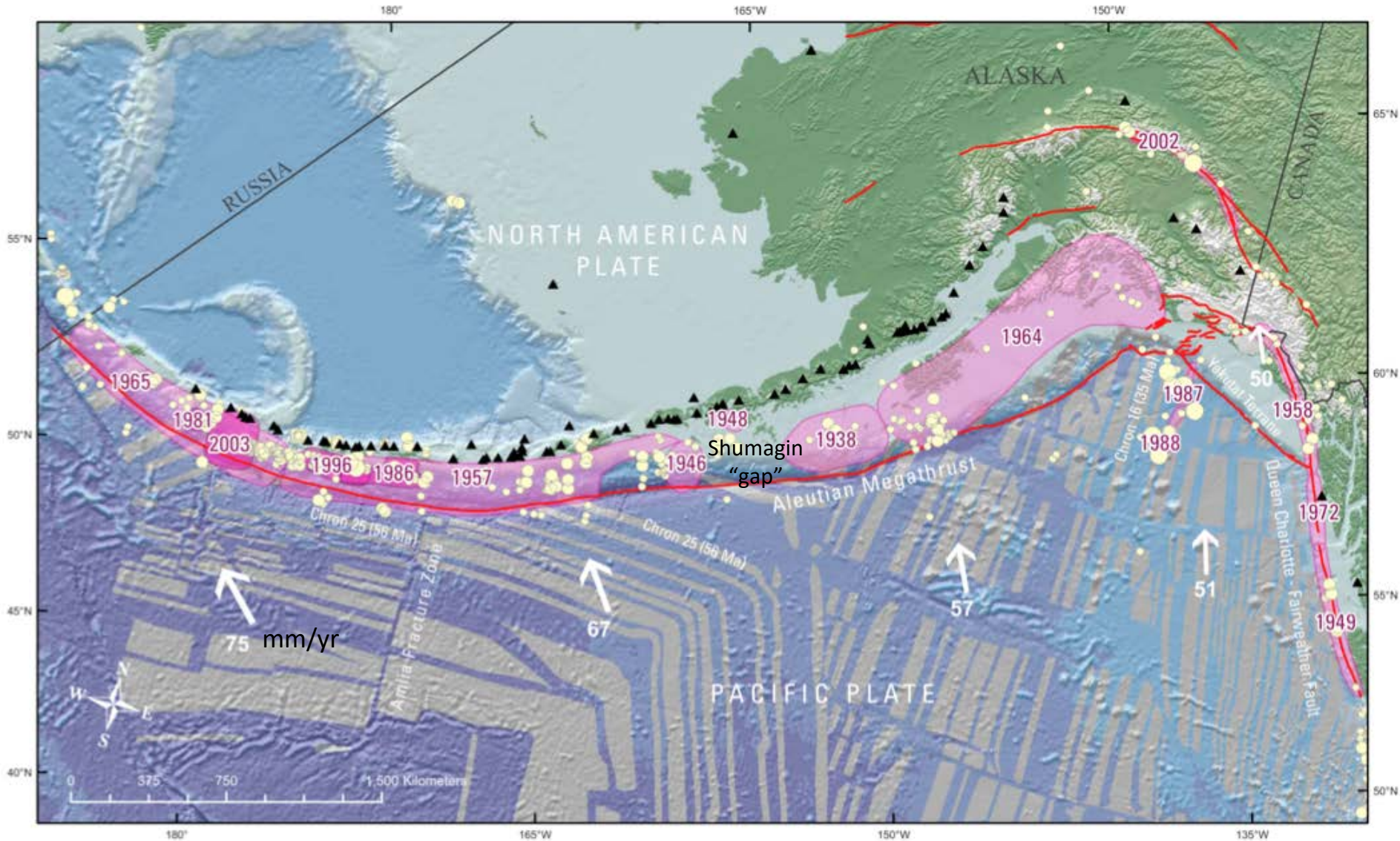


The Aleutians are North America's pre-eminent arc

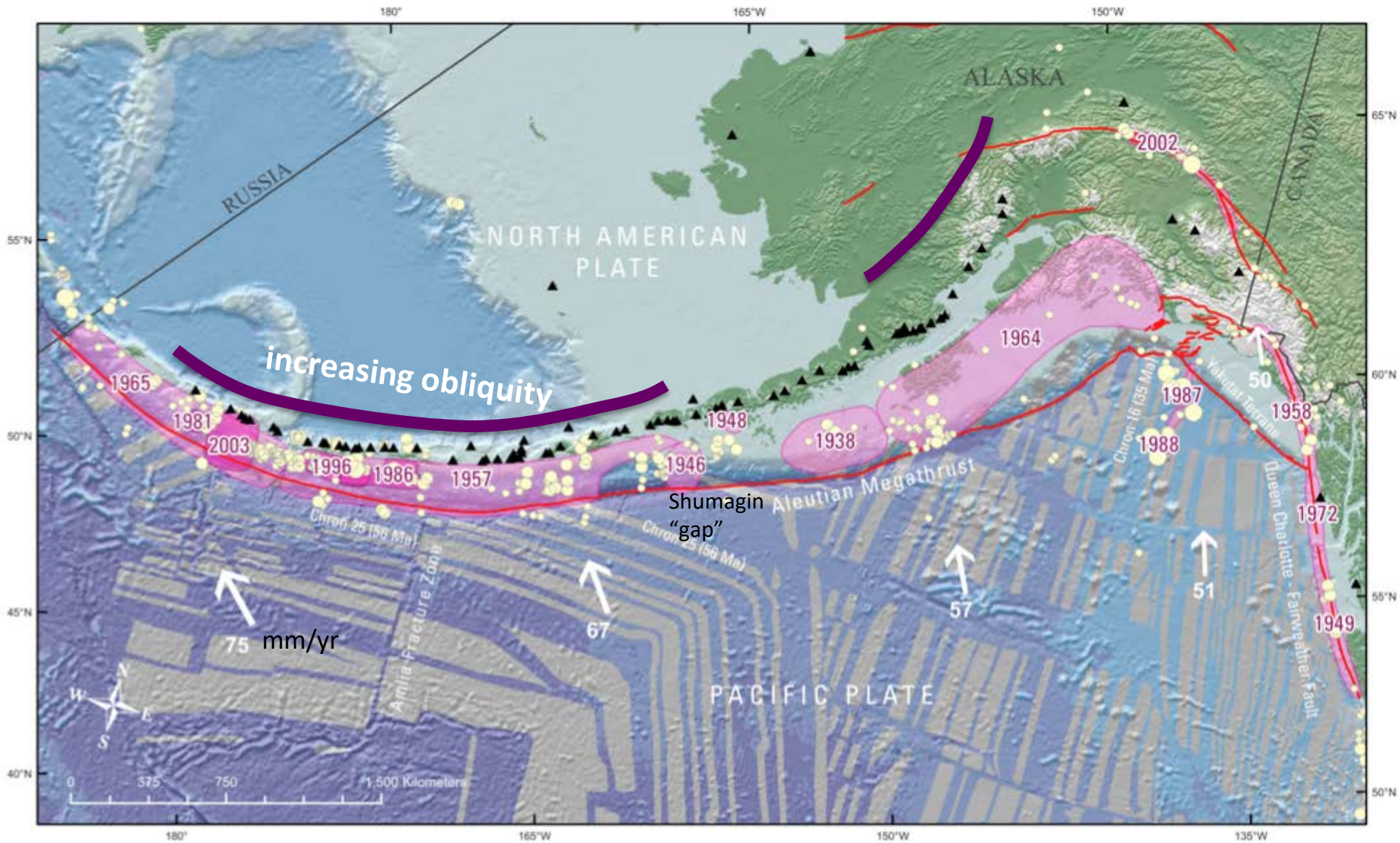


Pacific subduction beneath North America

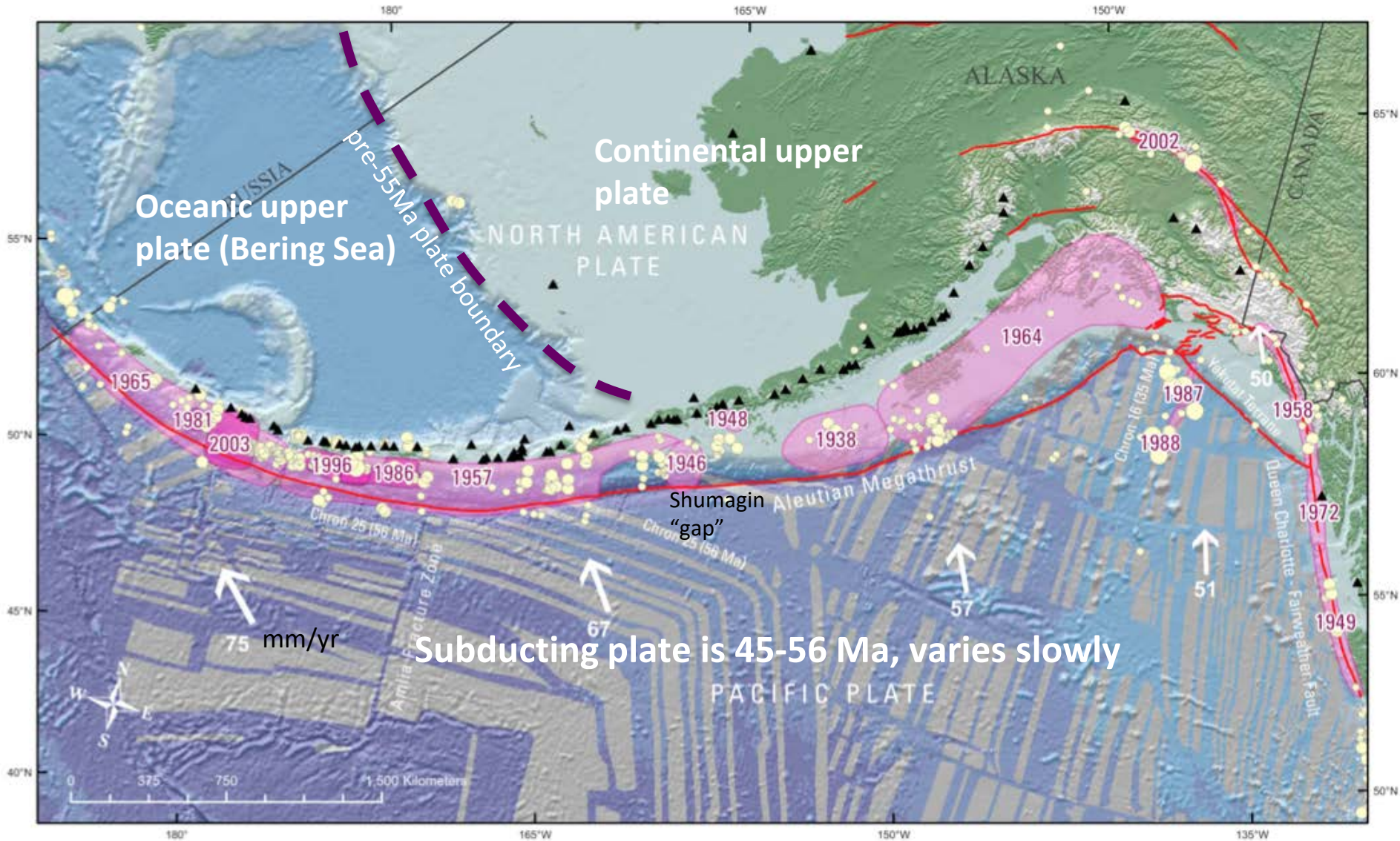
Great earthquakes, abundant volcanoes



Pacific subduction beneath North America

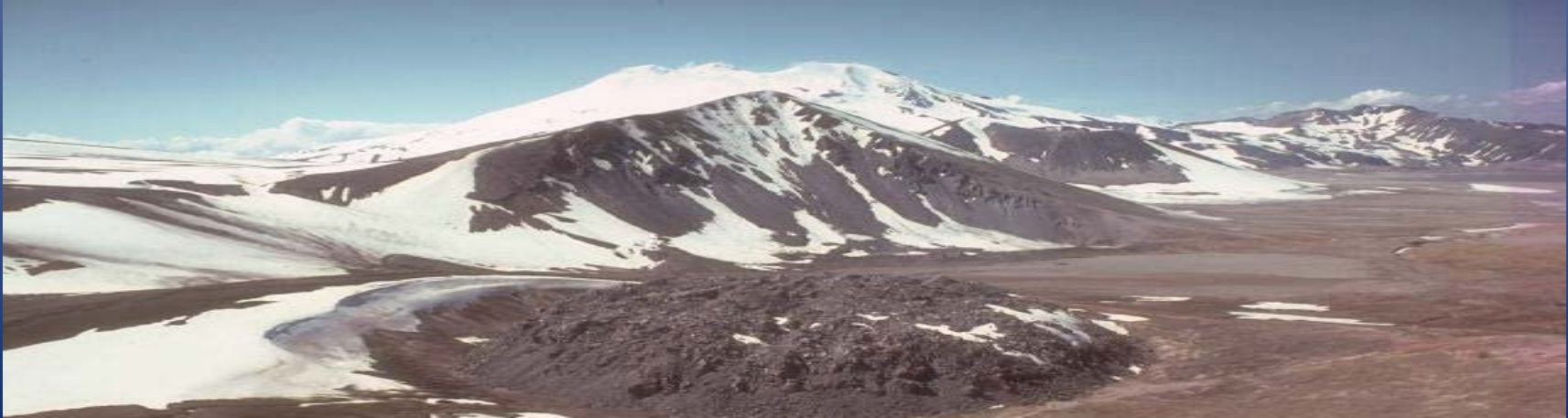
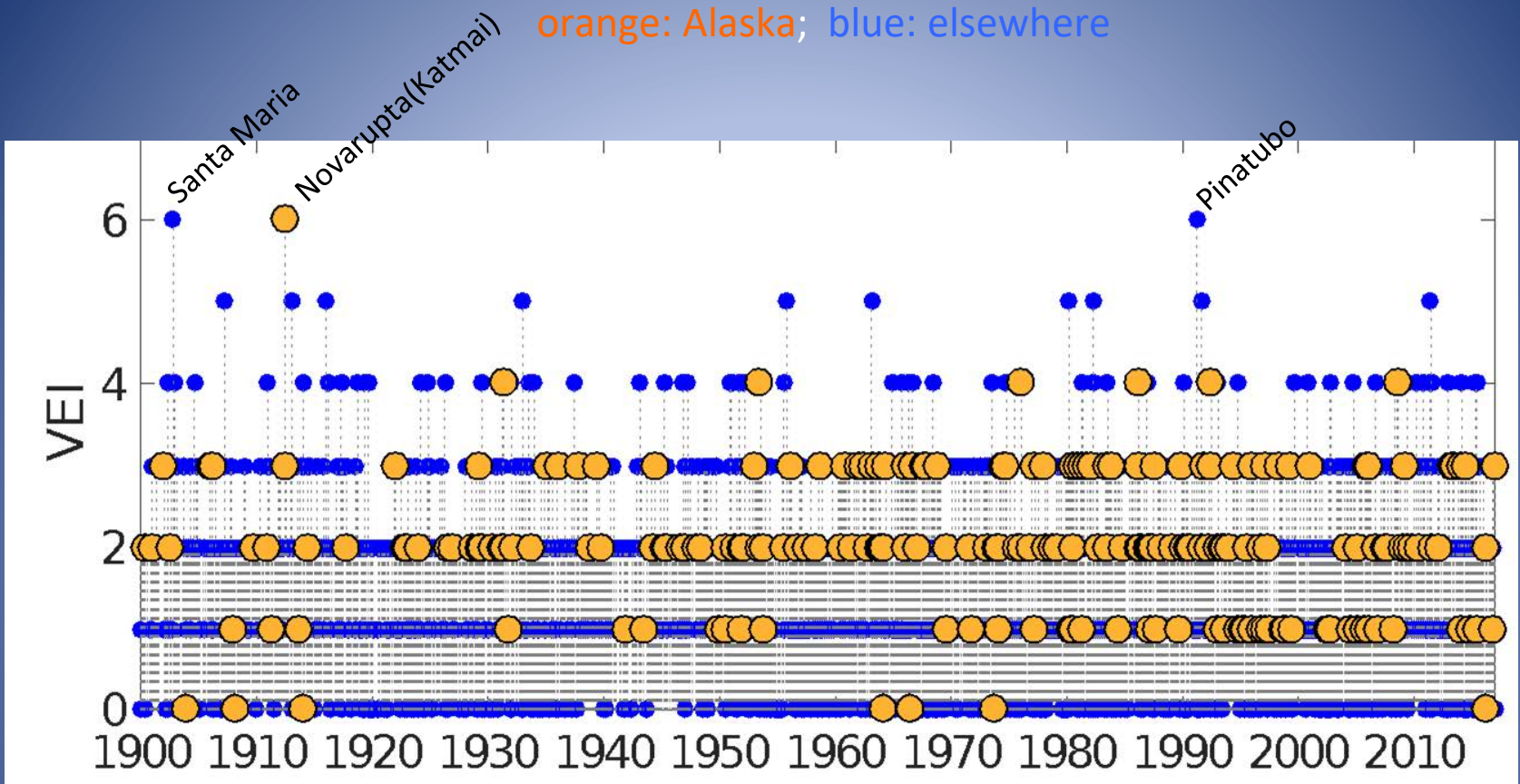


Pacific subduction beneath North America

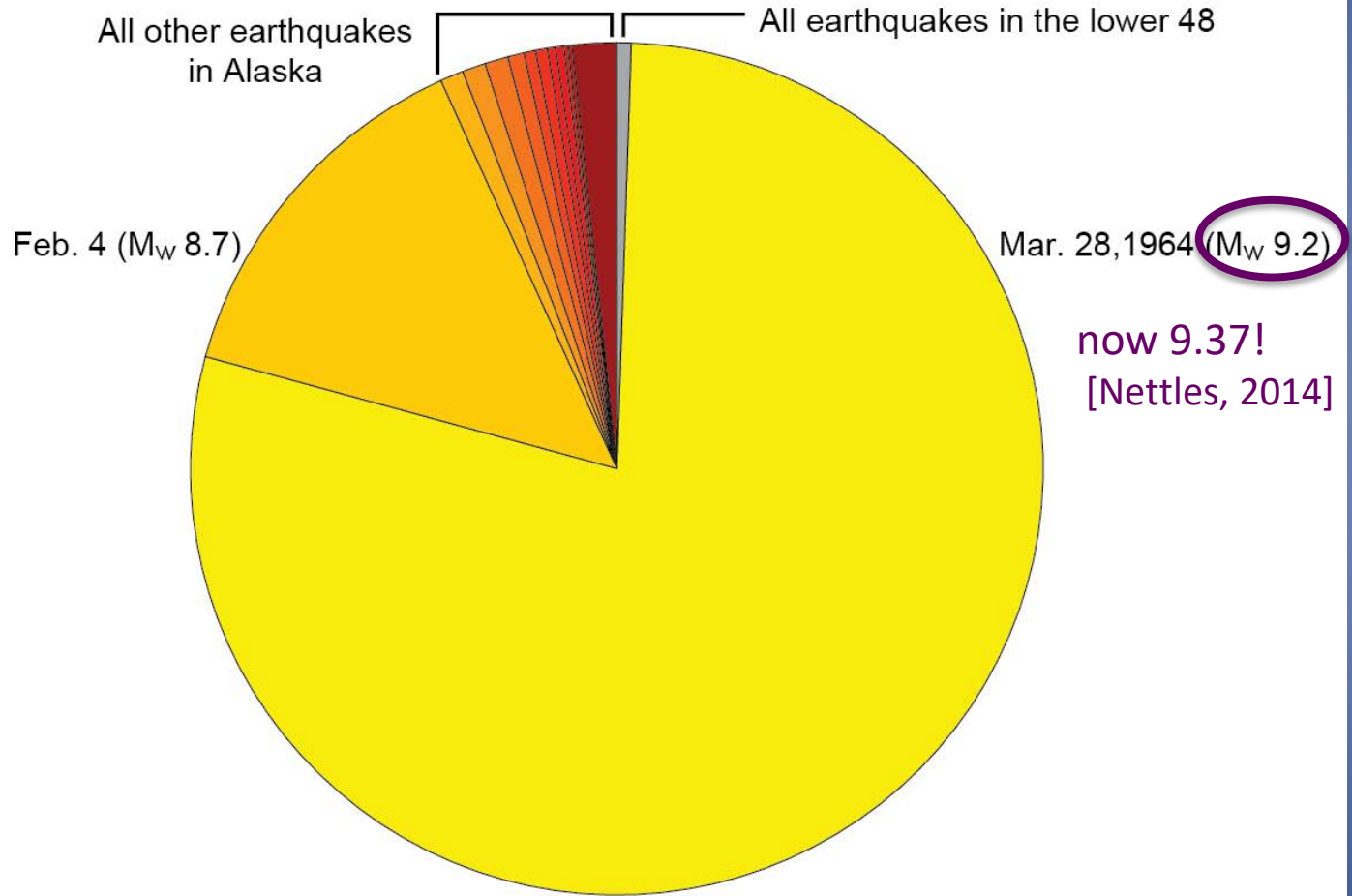


Global volcanism: Katmai is largest 20th century eruption(1912)

orange: Alaska; blue: elsewhere



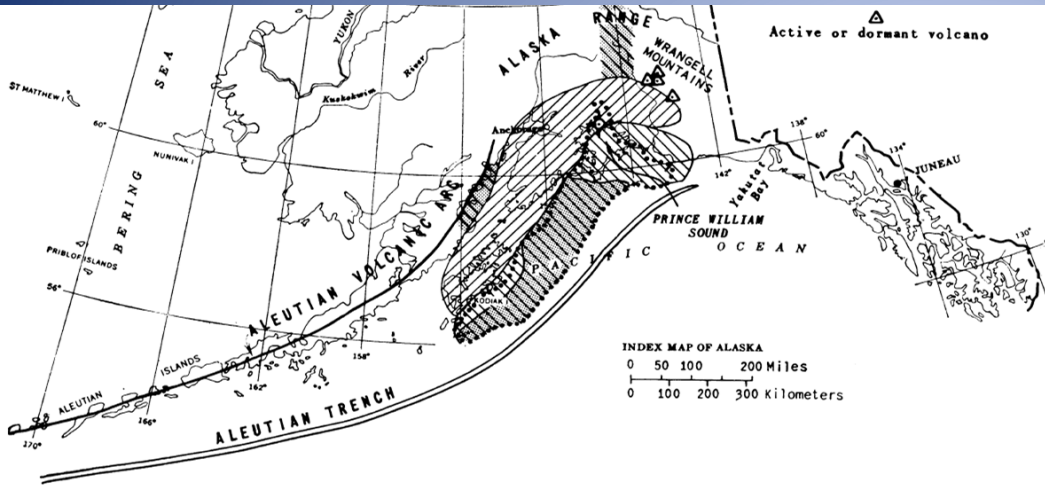
Total U.S. moment release 1960–2010



now 9.37!
[Nettles, 2014]

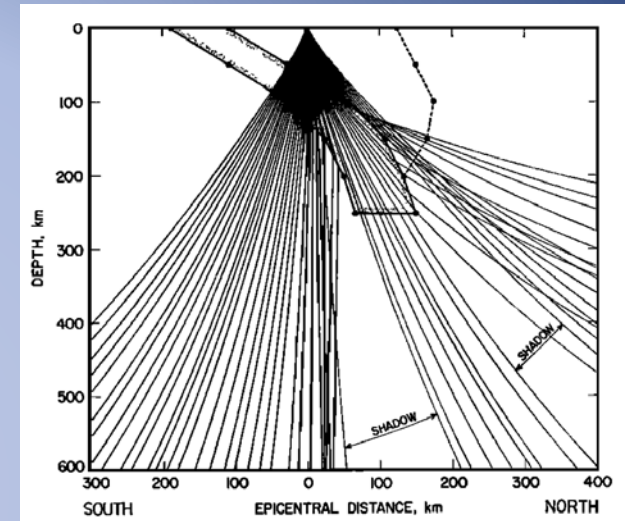
Classic Alaska contributions to subduction science

Protogeodesy: vertical motions from great 1964 earthquake



Plafker, 1965

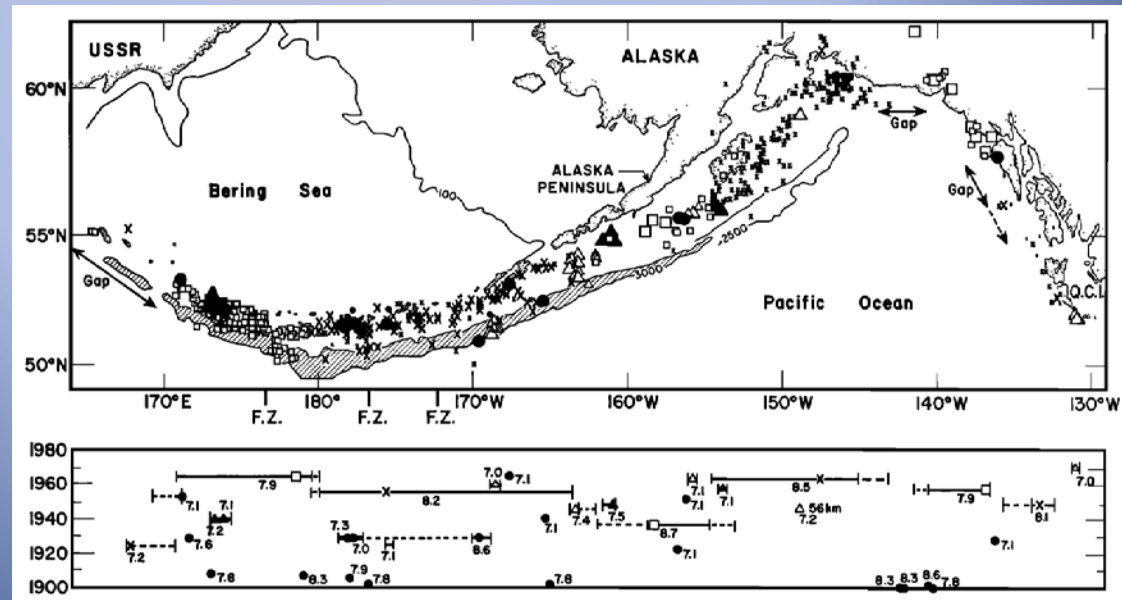
Prototomography: travel time variations from Amchitka nuclear tests



Jacob, 1972

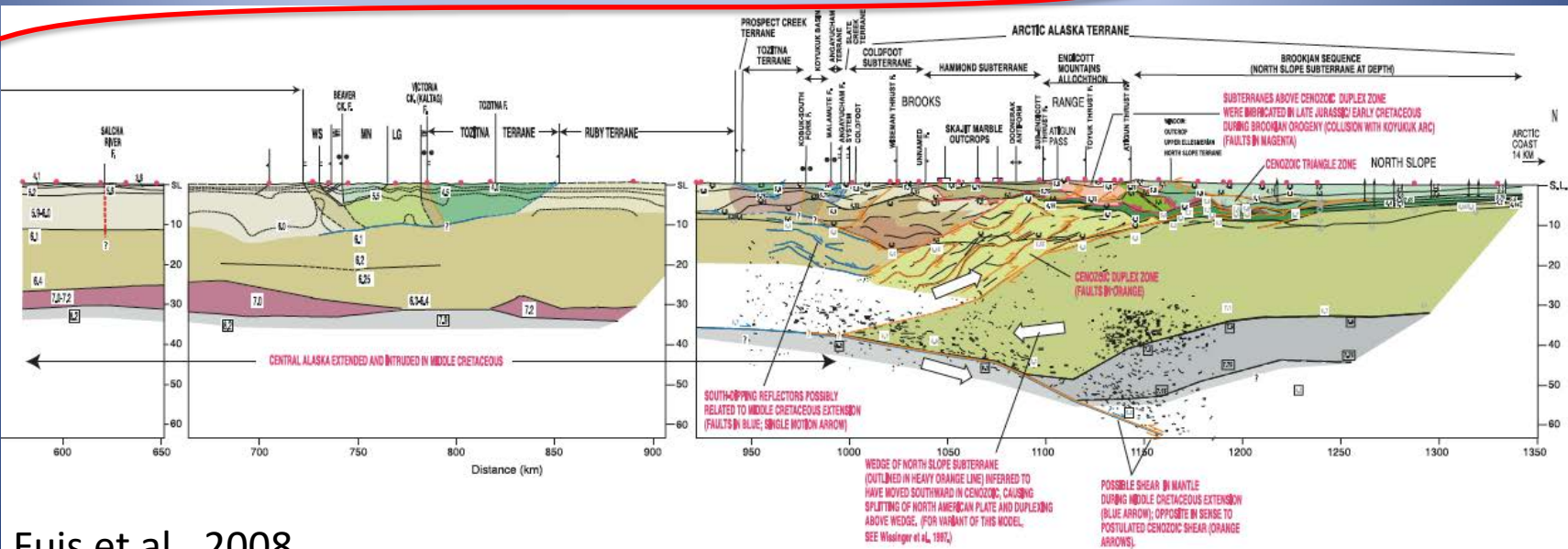
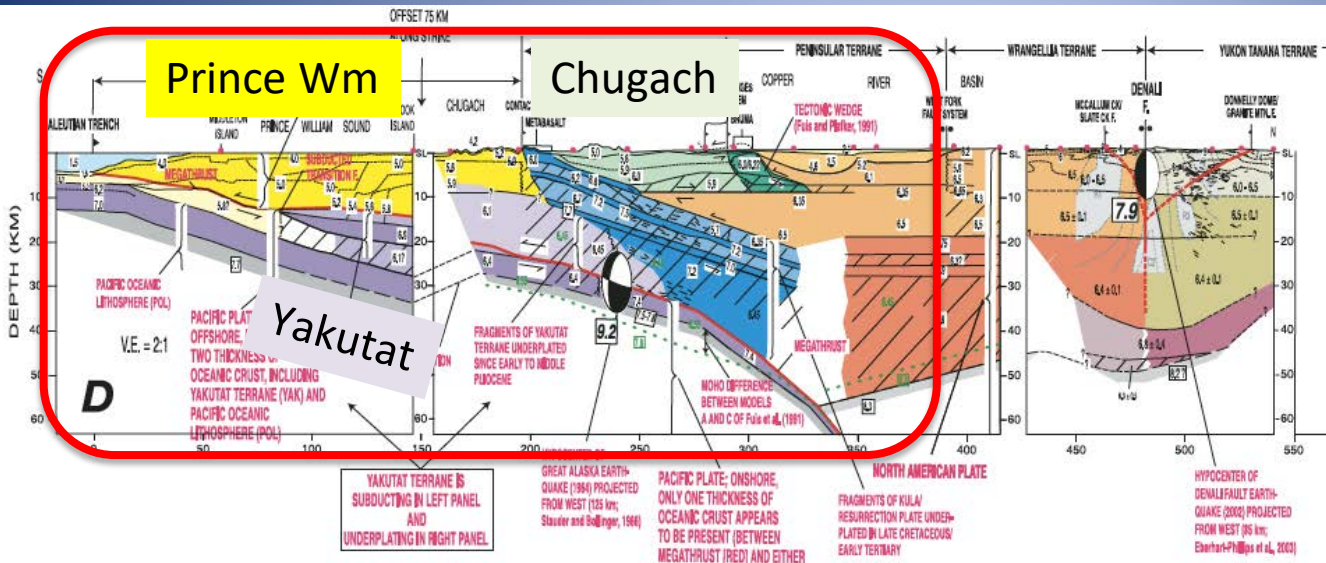
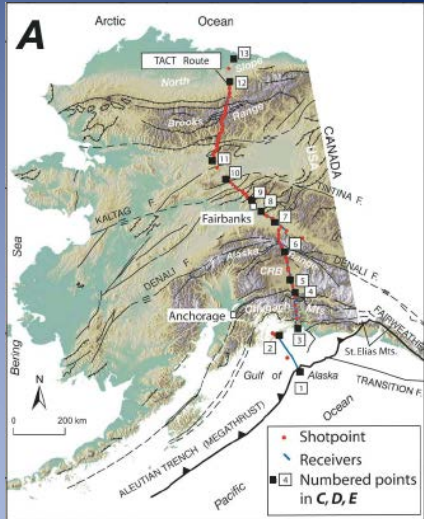
Origins of seismic gap theory

Sykes, 1971



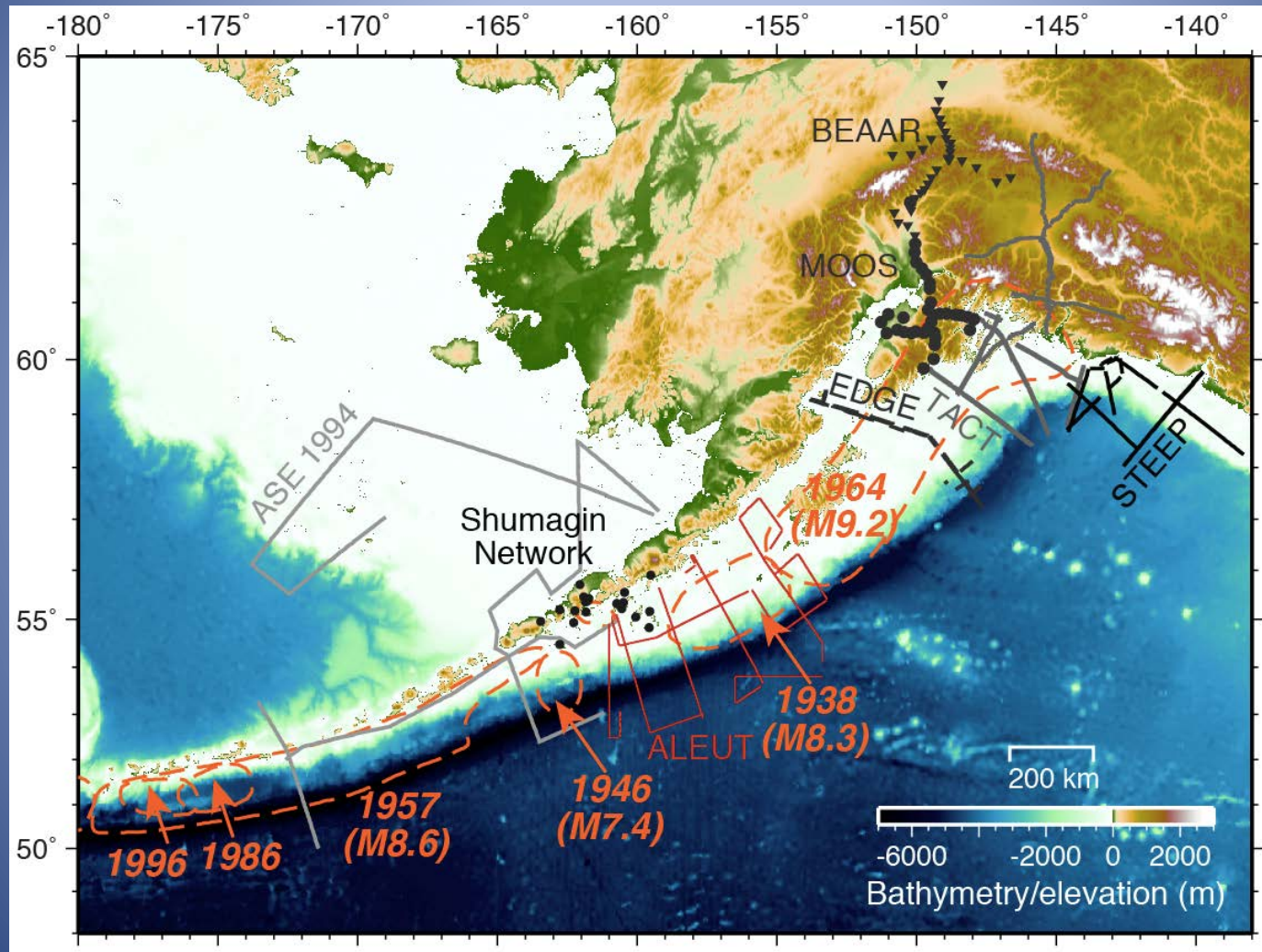
Active Source on land: TACT

1980's, follow pipeline, trench to Arctic coast

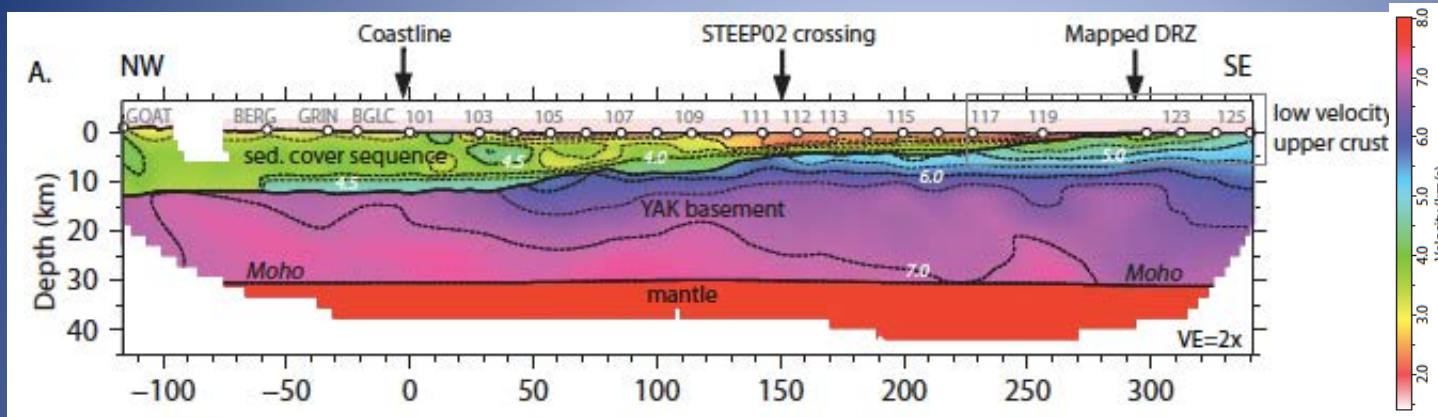


Fuis et al., 2008

Have things slowed down? Marine work last 30 years

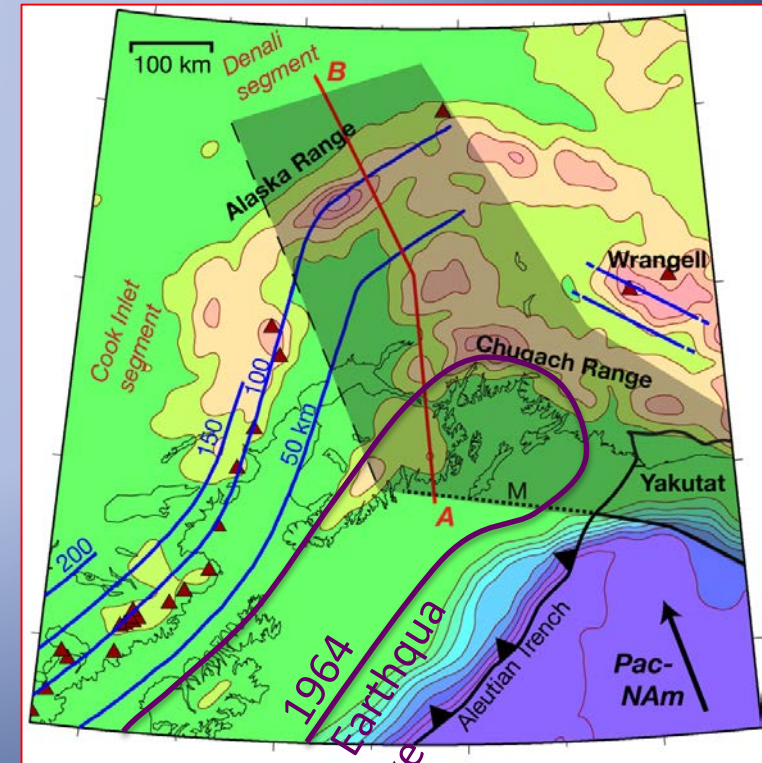


A discovery from recent marine work (STEEP, 2008): Yakutat Terrane is oceanic plateau



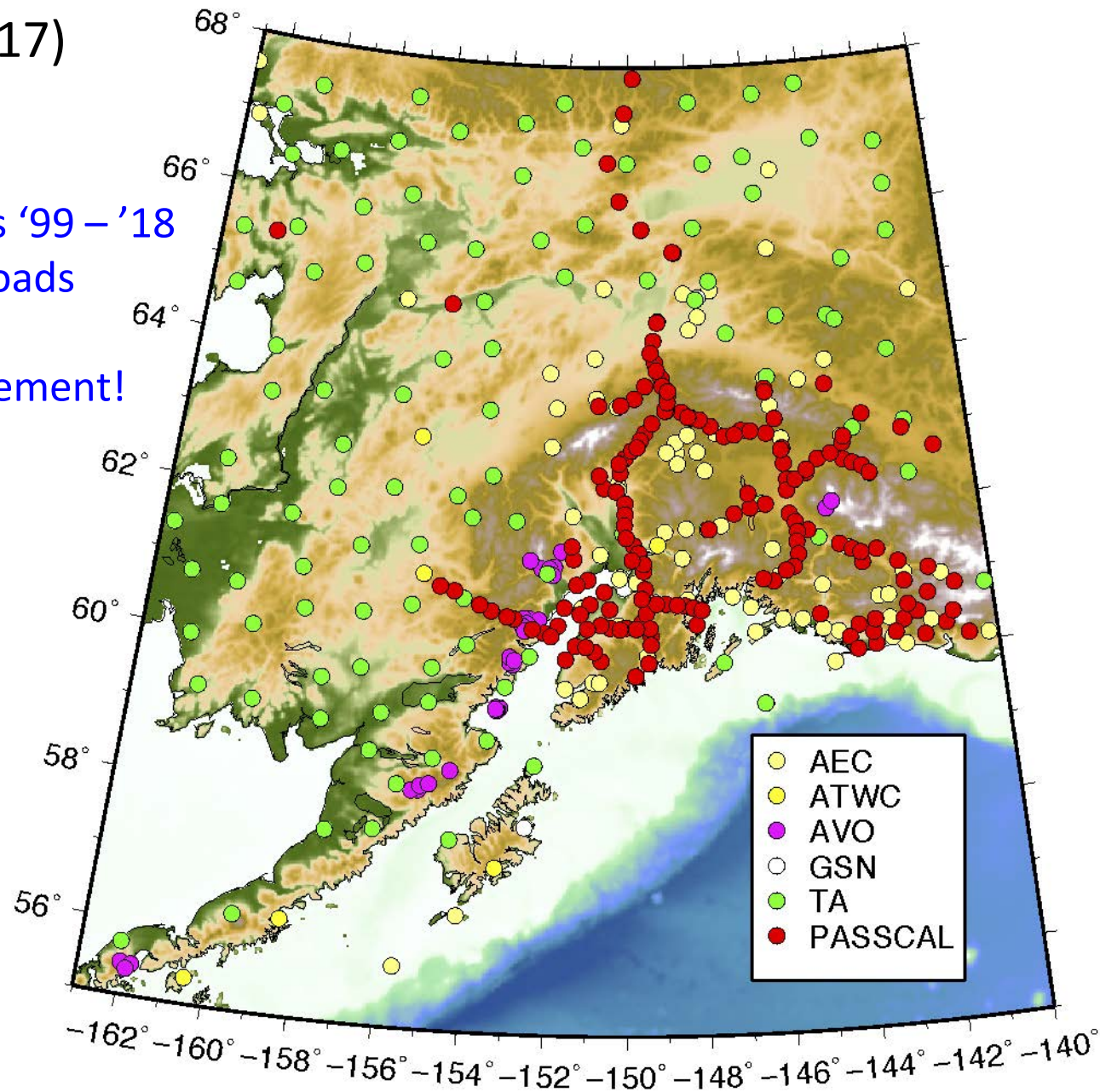
Abers 2008

Worthington et al., 2012; Christeson et al., 2010



Broadband Seismometers in Alaska (as of Dec. 2017)

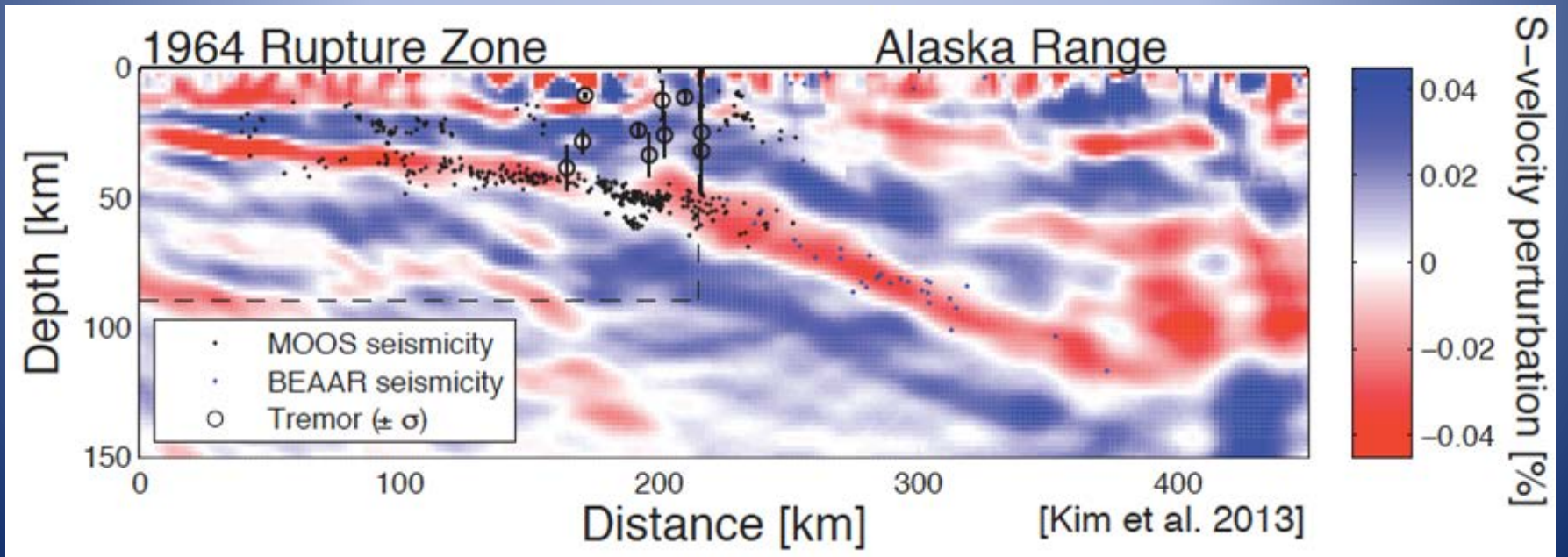
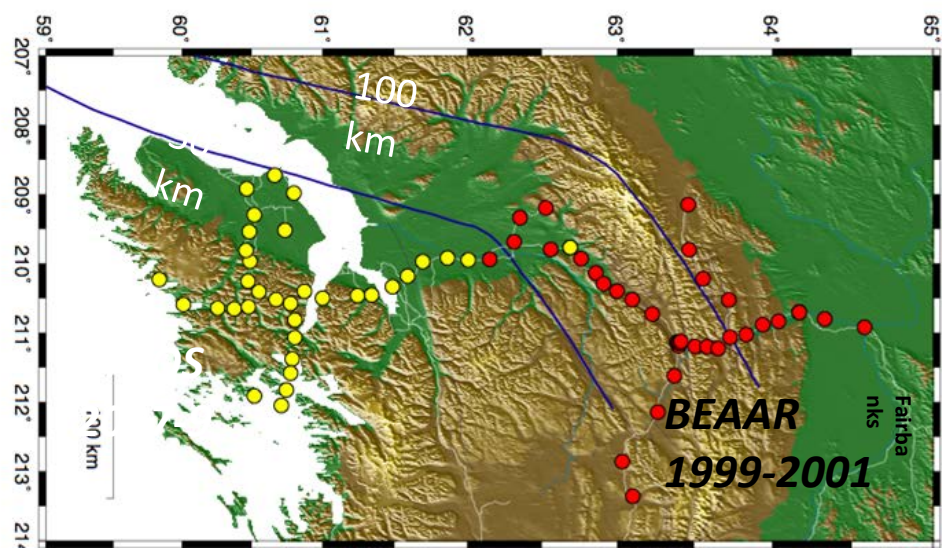
- about 6 PASSCAL arrays '99 – '18
- Mostly in south, near roads
- TA makes huge improvement!



all BHZ channels at IRIS DMC, 1990-2017

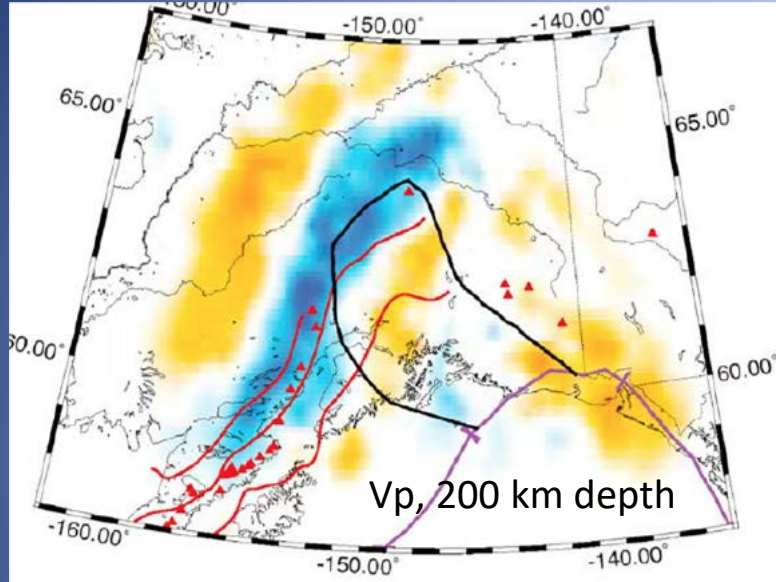
Example from PASSCAL projects: scattered-wave imaging

- BEAAR(99-01) + MOOS(07-09), 450 km at 10 km spacing
- Low-velocity thrust zone shallow, subducting crust deep
- What are mantle “things”?

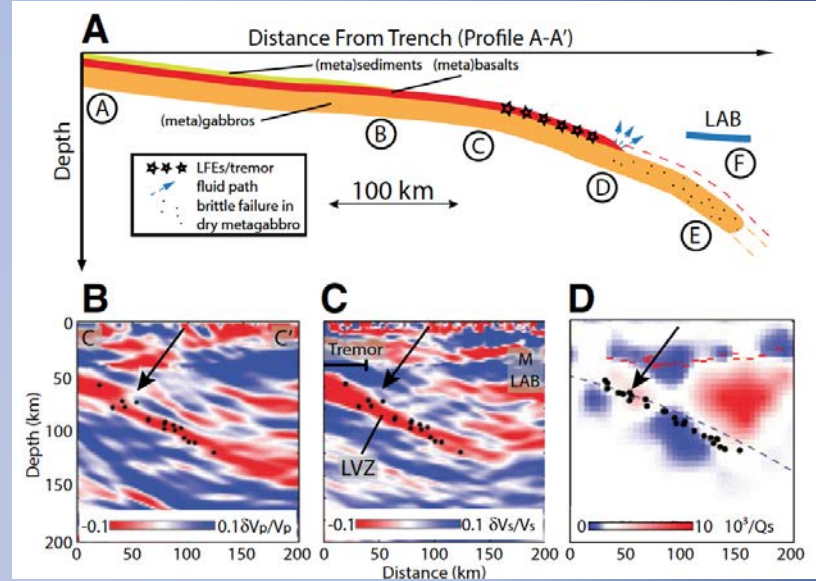


A few new results from the AK natural laboratory

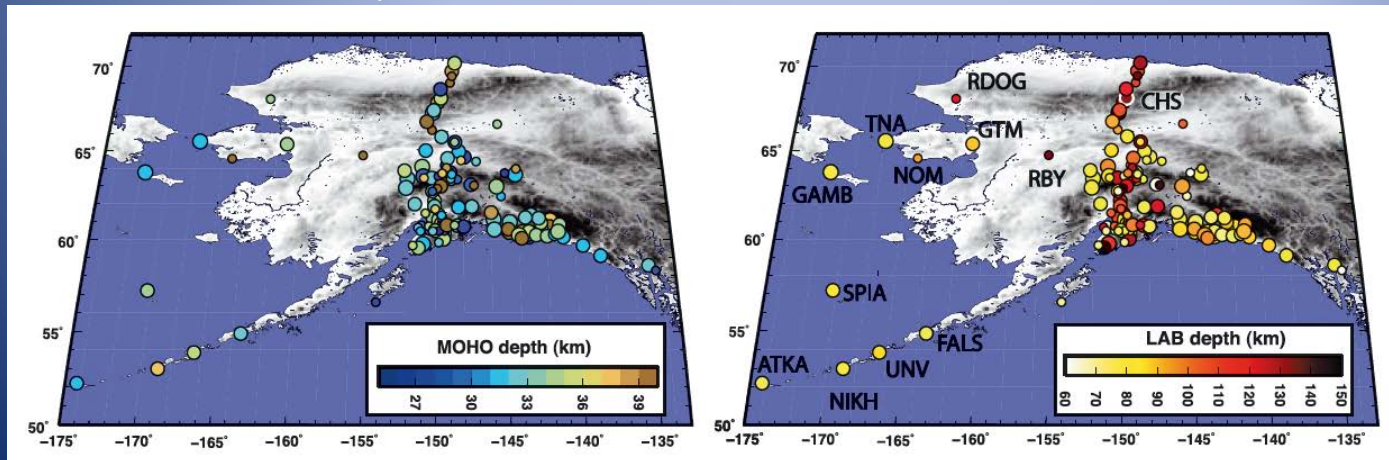
Martin-Short et al. 2016: TA-based tomog.



Chuang et al., 2017: Tremor vs. structure

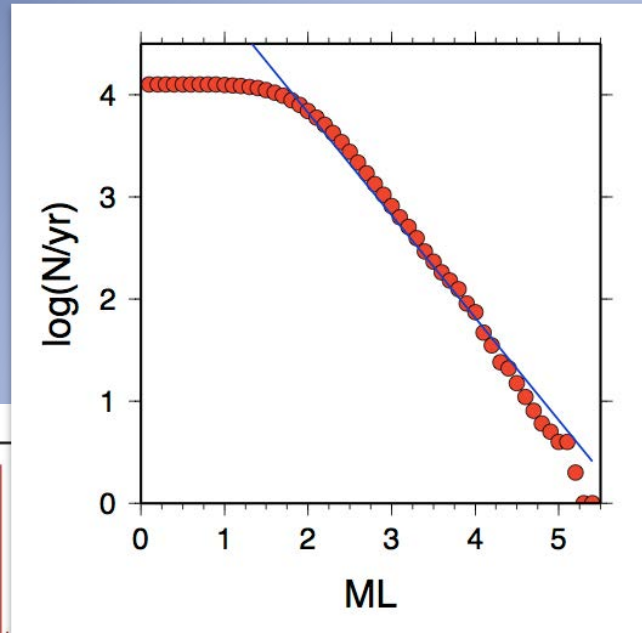


O'Driscoll & Miller, 2015: S receiver functions

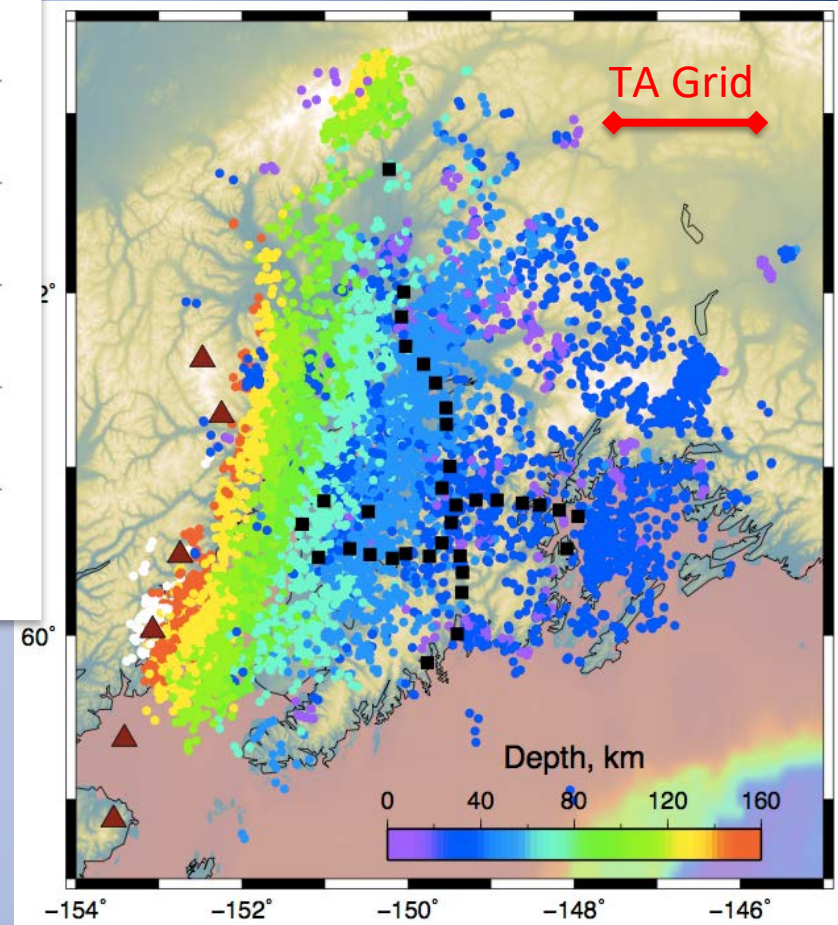
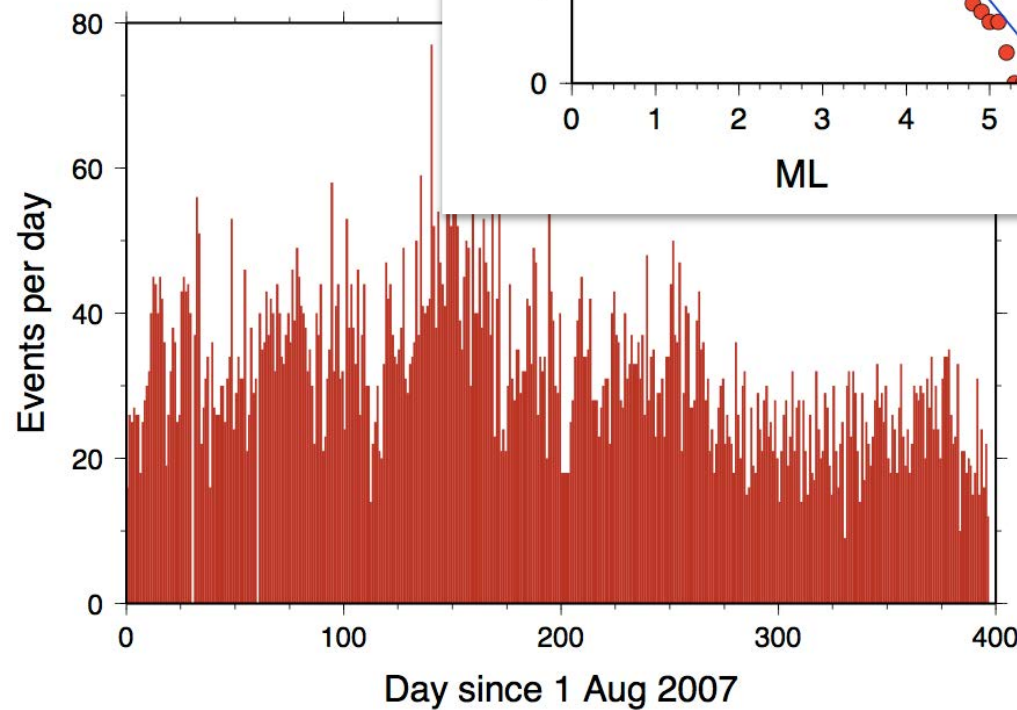


And yes, there are lots of earthquakes

MOOS-recorded seismicity, 8/07 – 8/08
(13 mo; 12,618 hypocenters)



just in Kenai region:
31/day on average



*Illuminates 1964 rupture zone
yet none have thrust mechanisms!*

Li et al. (2013, JGR)

Most recent work is onshore. Major questions remain. Examples:

- How does thrust structure extend offshore?
- Pre-conditioning of incoming plate – how does it affect subduction?
- What limits megathrust rupture, tremor, ...?
- How do subduction zone volcanics form at mantle depths? – most work has been in “weird” regions inland Alaska, or small-aperture arrays on islands.