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USGS Earthquake Hazards Work In Alaska

Peter Haeussler, USGS, pheuslr@usgs.gov

ASHSC meeting

Sept. 30, 2010

U.S. Department of the Interior
U.S. Geological Survey

USGS work

- Non-seismic network operations
- Funding: USGS earthquake hazards program and the coastal and marine geology programs
- Work is tied to funding sources and goals
- Most of the work I'll discuss are geologic studies, which get tied back into the National Seismic Hazard Maps

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Ongoing work

- Denali fault studies
- Post earthquake studies
  - GeoEarthScope LiDAR
- Earthquake-induced submarine landslides

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Seismological studies

- Installation of NetQuakes instruments
- 1 installed, 9 more permitted, and will be installed in the next month or so
- Sites will expand strong motion monitoring outside the Anchorage area to both sides of Cook Inlet to the Kenai area

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Seismology studies

- Tremor studies - Justin Brown, Stephanie Prejean, Joan Gomberg, Greg Beroza
- Tremor occurs down dip of historical megathrust ruptures
- Tremor occurs on or above the subducting slab
- As deep as 100 km or so, beneath arc volcanoes
- Hot topic, but significance???

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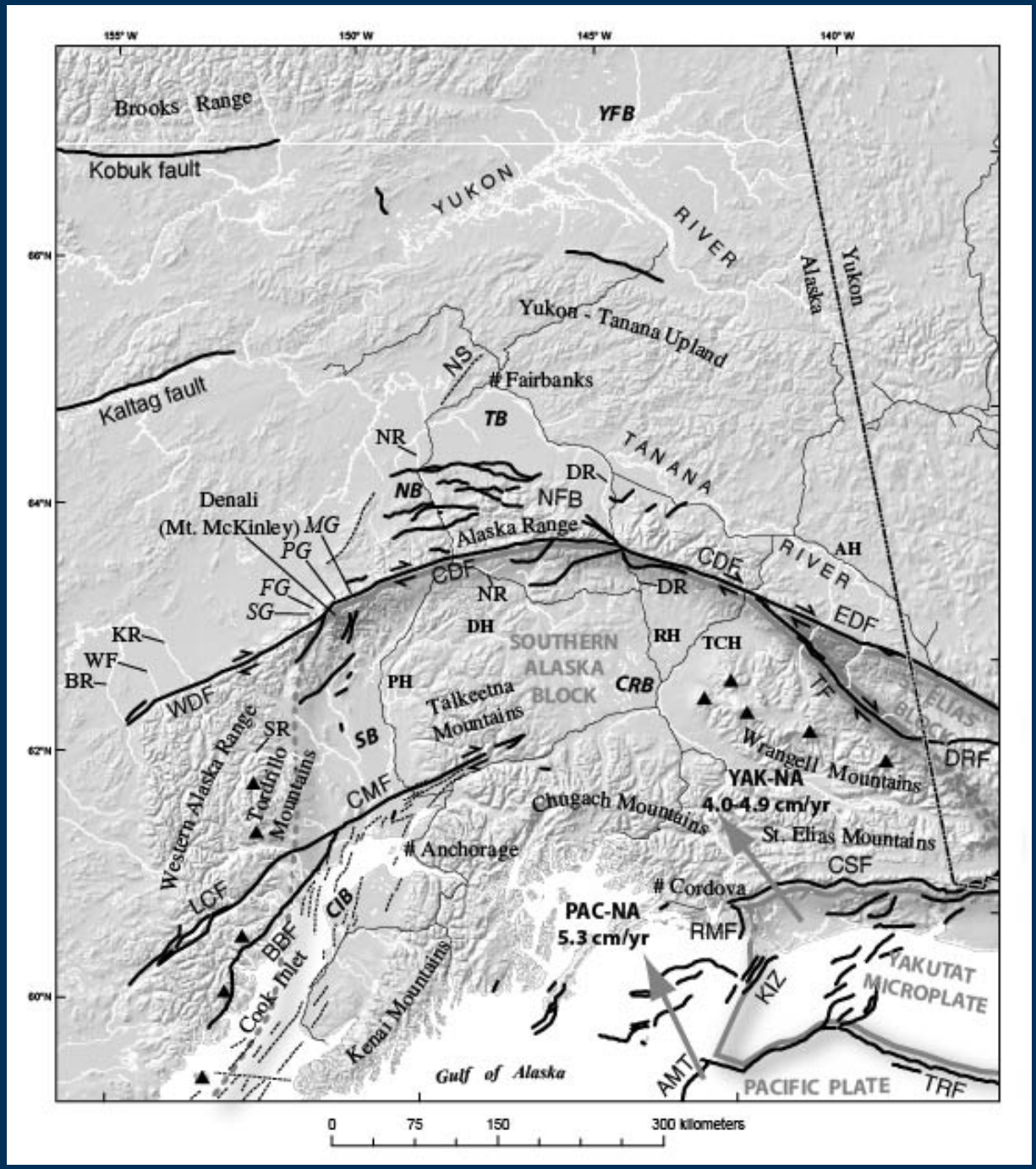
- **GeoEarth-Scope lidar**



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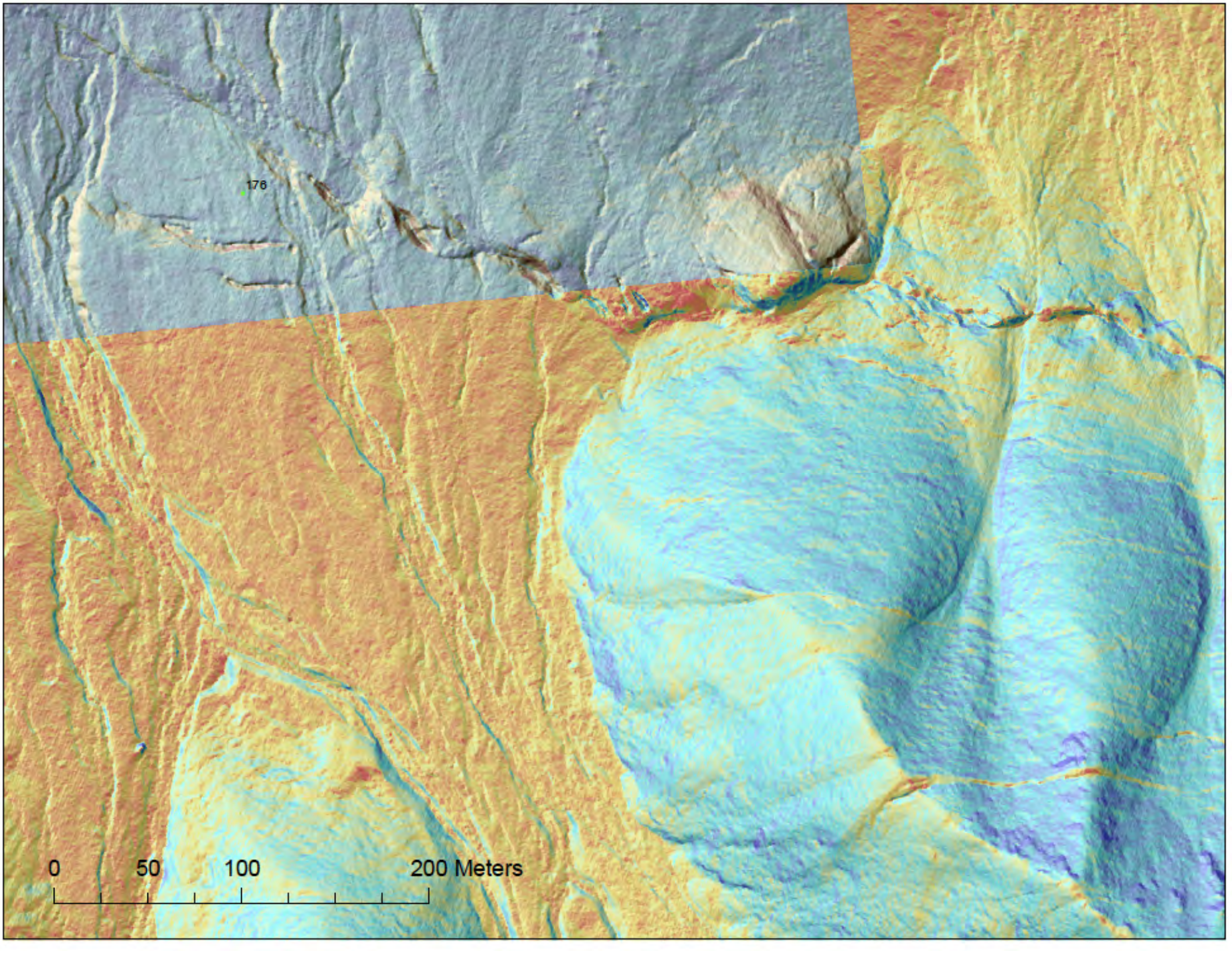
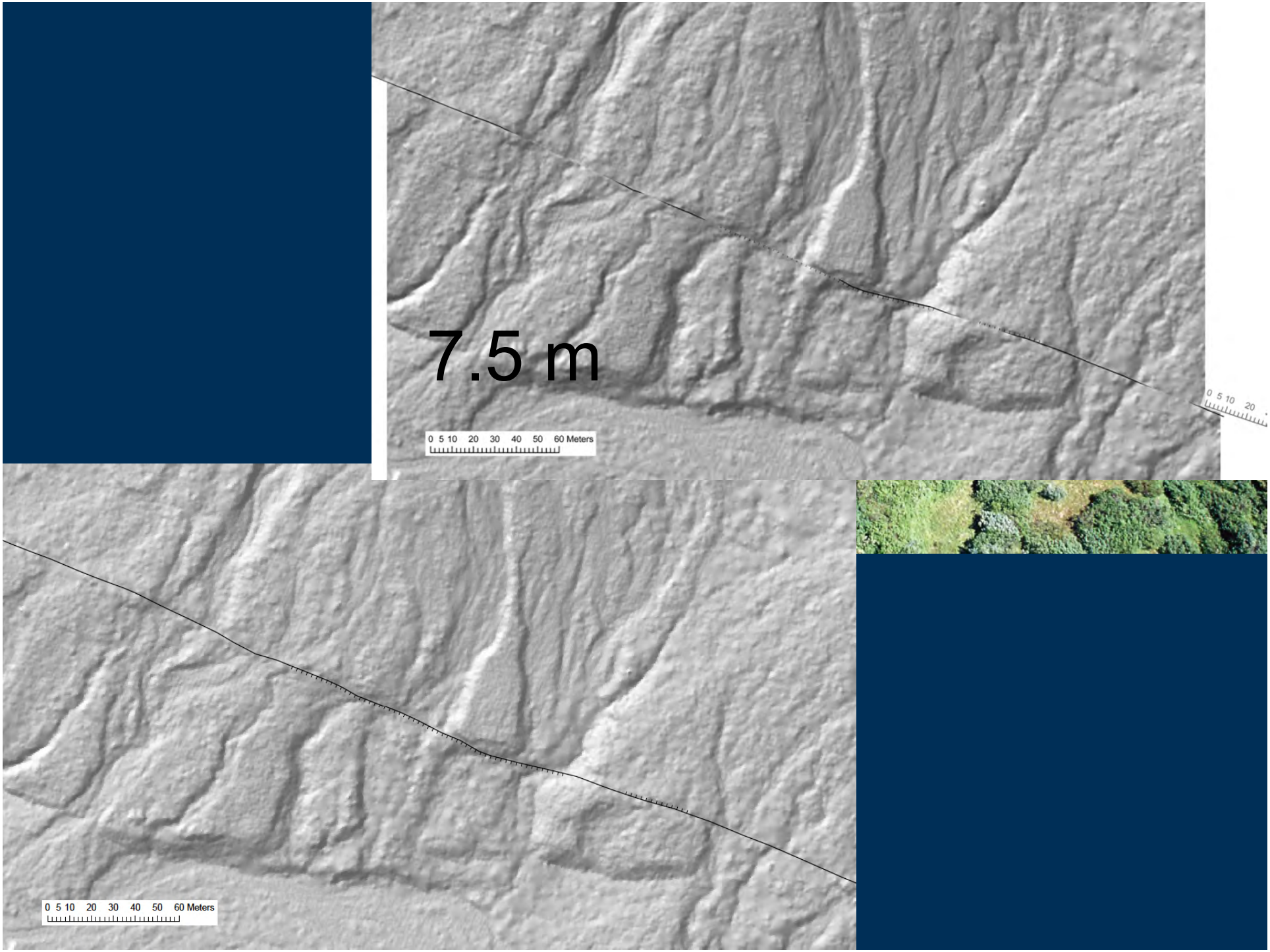
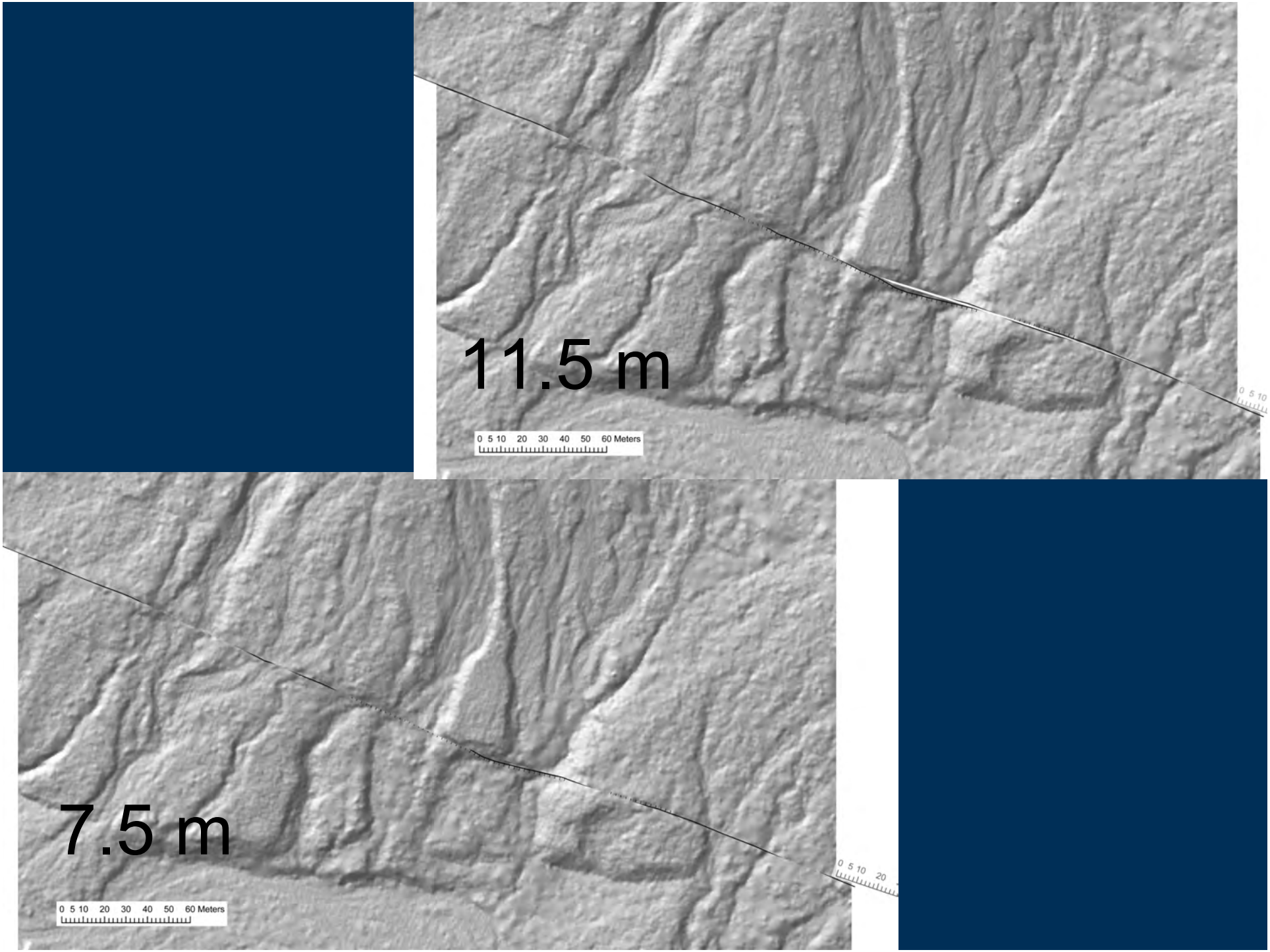
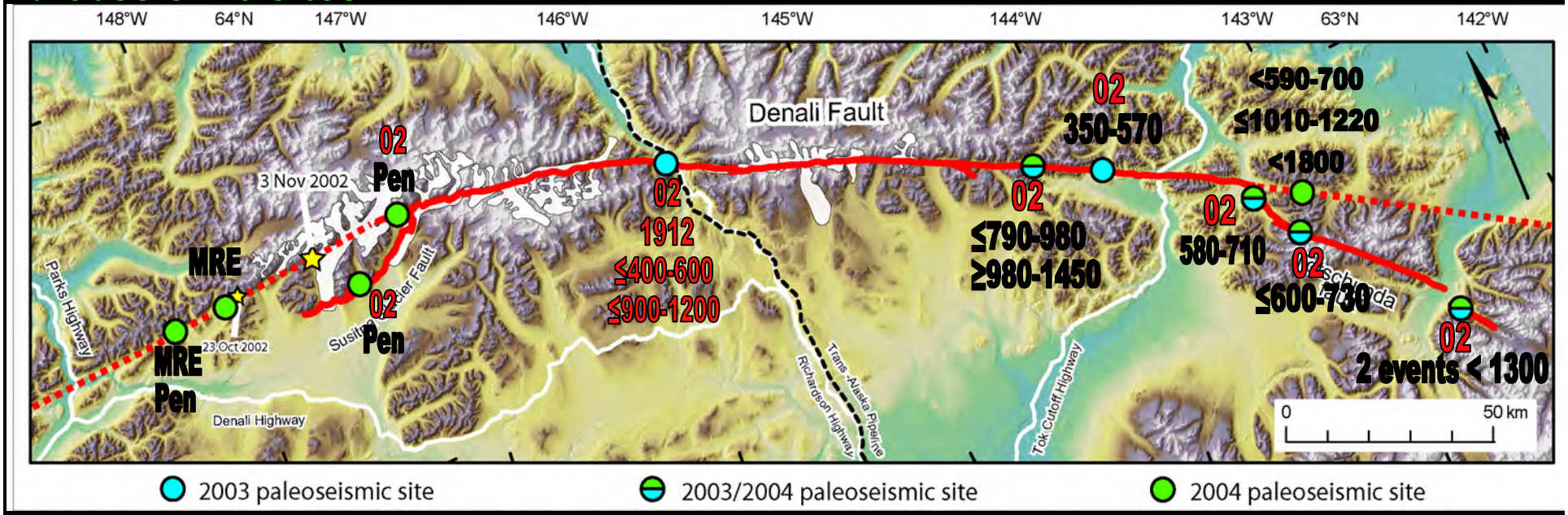

176
0
50
100
200 Meters


7.5 m
0 5 10 20 30 40 50 60 Meters
0 5 10 20 30 40 50 60 Meters

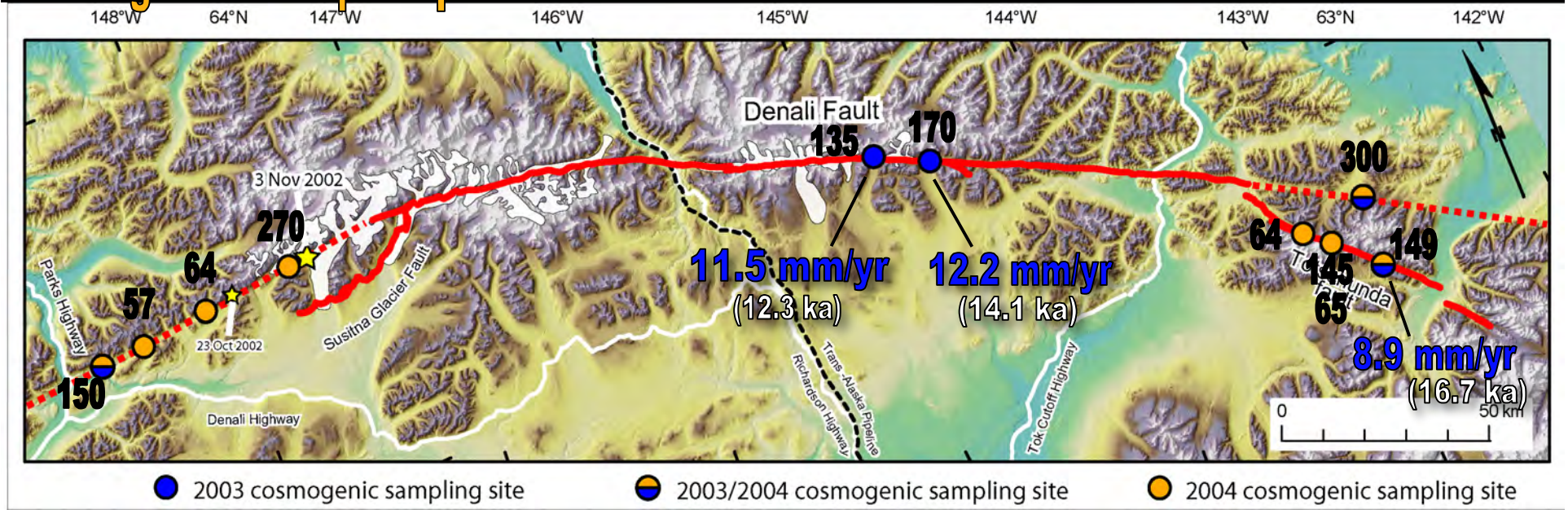

11.5 m
0 5 10 20 30 40 50 60 Meters
7.5 m
0 5 10 20 30 40 50 60 Meters

Paleoseismic sites

DENALI FAULT FIELDWORK 2003-2004



Cosmogenic isotope/slip rate localities



Locally generated tsunamis

- In Alaska, 106 of 122 deaths were tsunami related
- 85 of these 106 deaths were related to submarine landslide generated tsunamis
- The fjords of coastal Alaska are an ideal geologic environment for producing submarine landslides

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Fjord processes

- Steep topography
- Erosion by streams
- Erosion by glaciers
- Deposition of sediment into margins of fjords
- Lies above megathrust

"the fjord has sediment and it's got a gun!"

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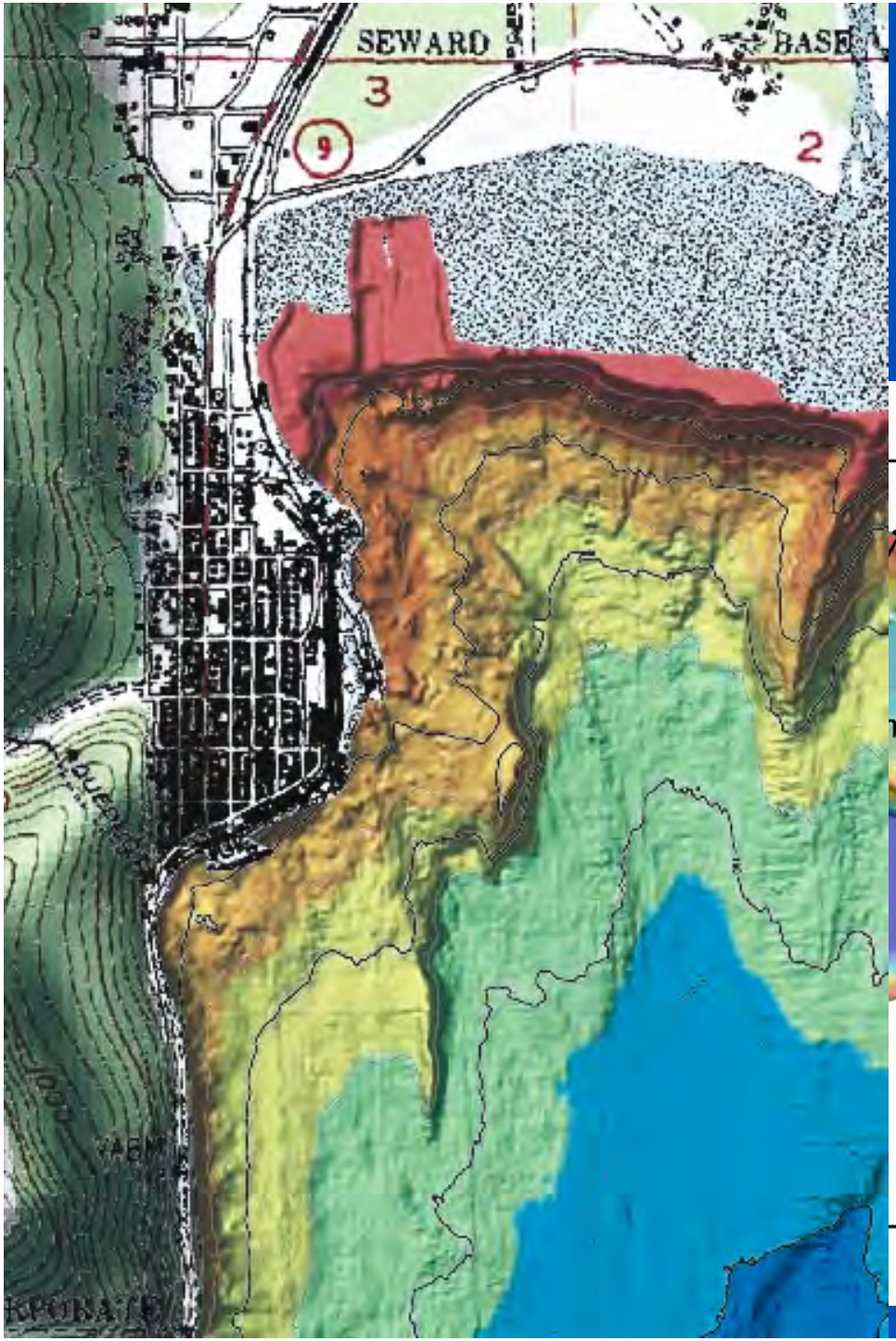
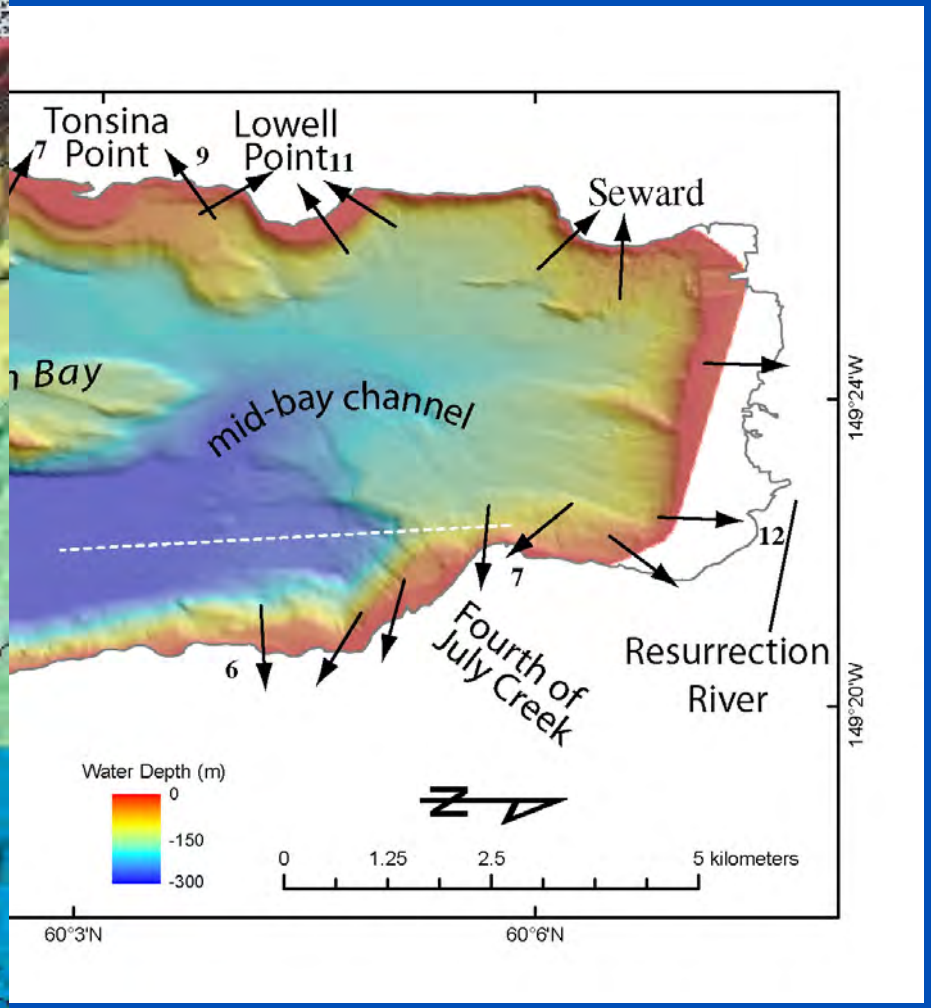
- **2001 NOAA multibeam survey**

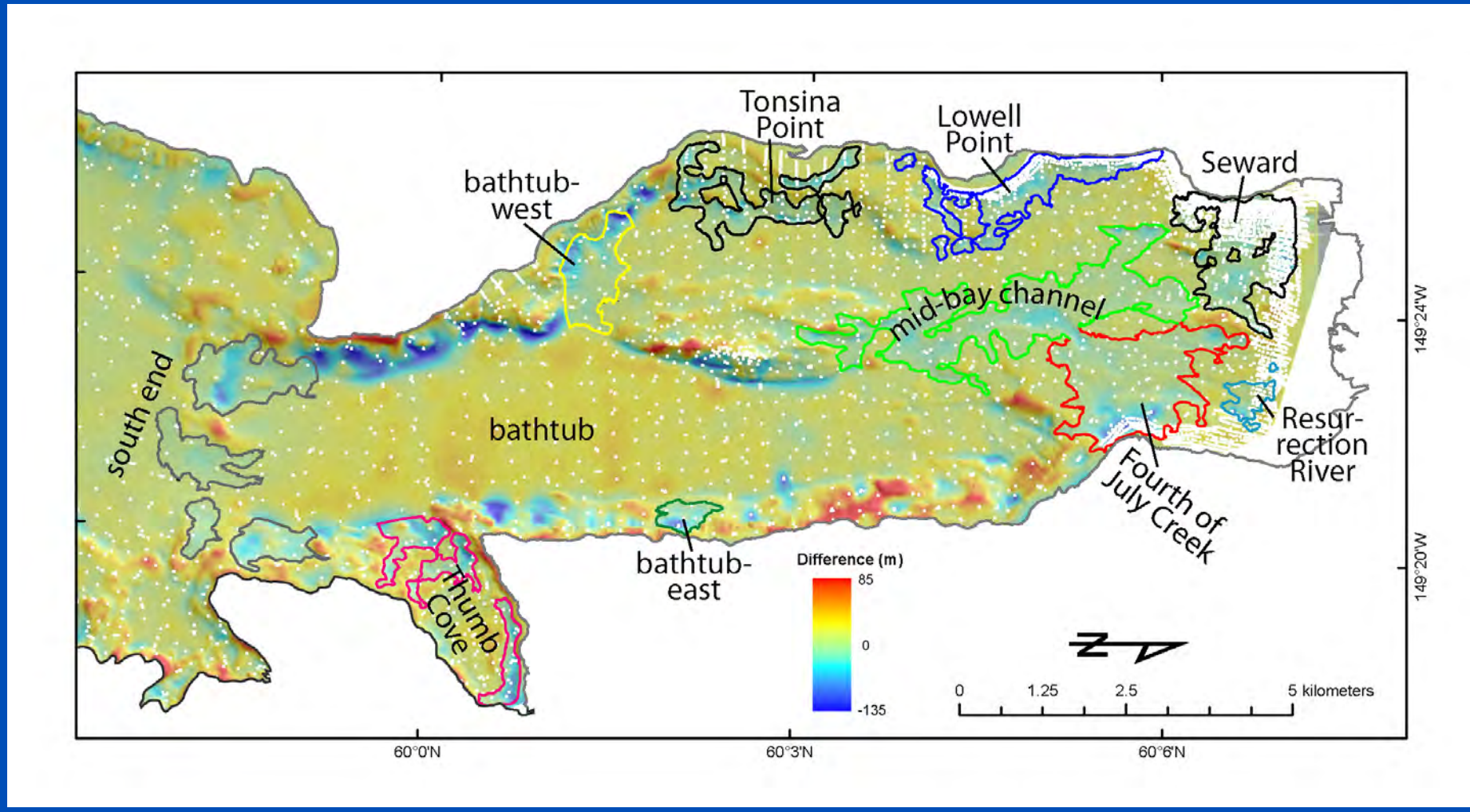




Inferred 1964 submarine landslides

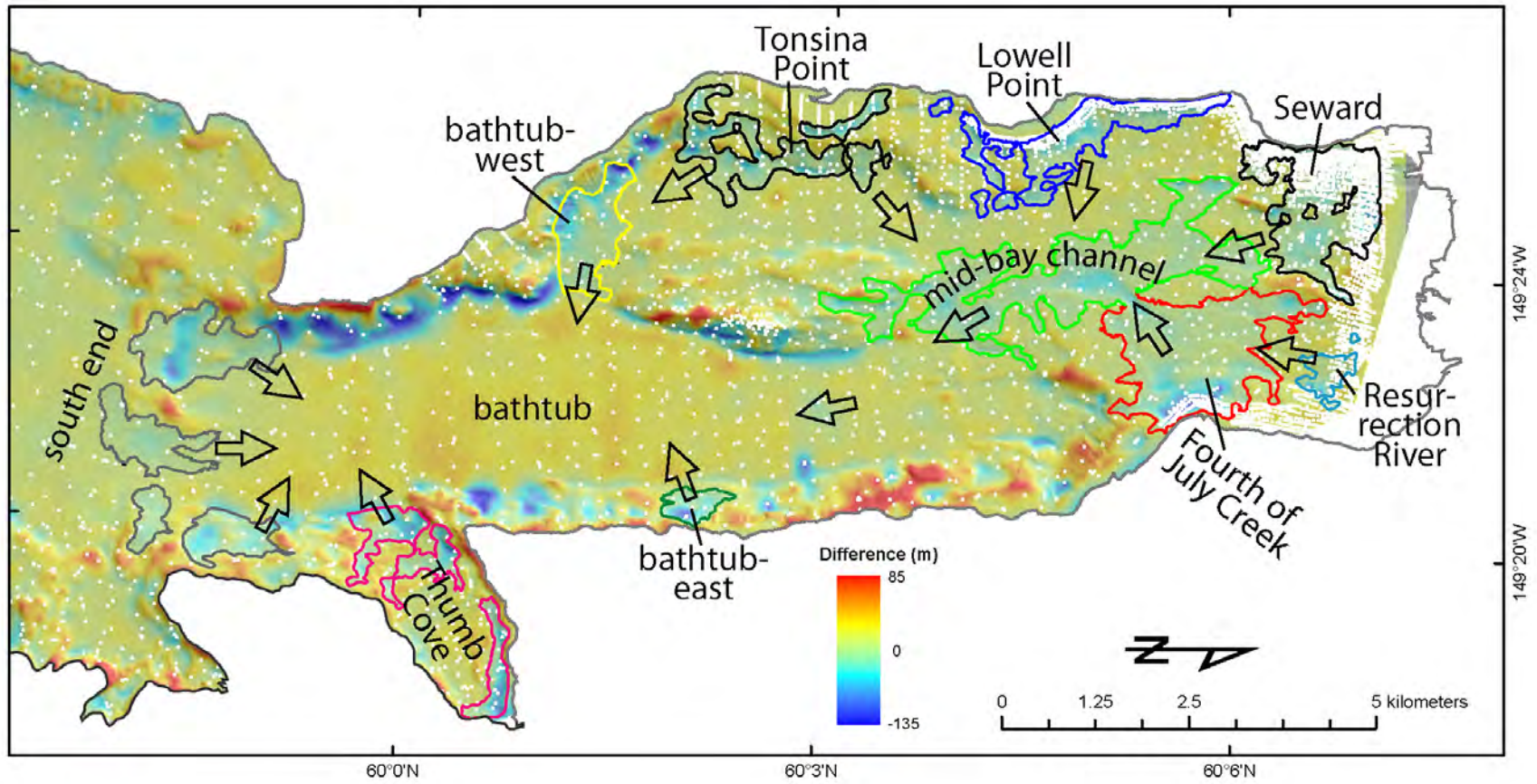
Our criteria:

- **Areas where >=5m change in depth (wanted to get out of the 2-3 m noise)**
- **And with multiple pre-1964 soundings**



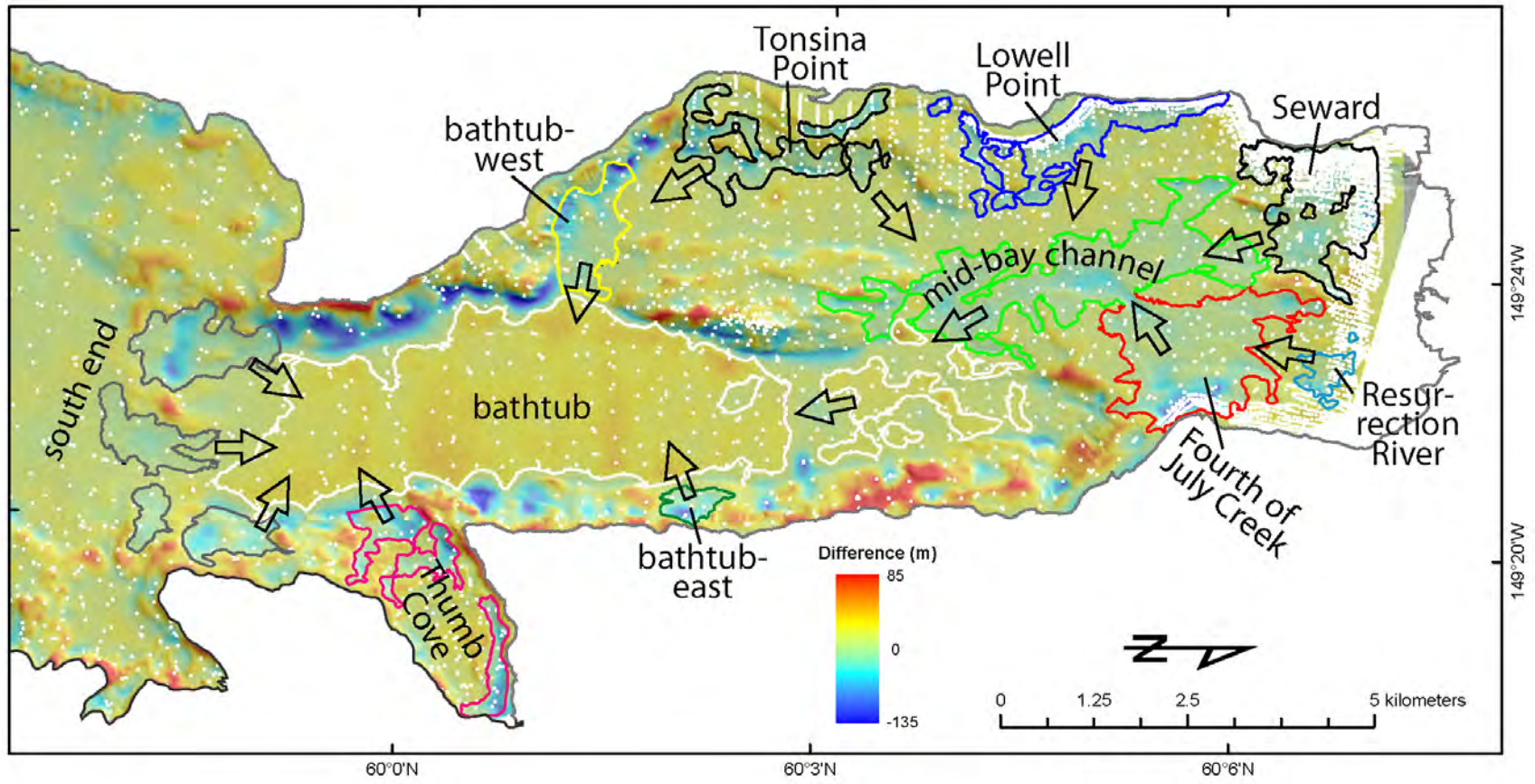
Inferred 1964 sediment transport directions

- Based on bathymetry
- Flow toward the bathtub
- mid bay channel?



Landslides and Sediment transport to the bathtub

- Bathtub depth decreased an average of 3.5 m
- Sill at south end prevented sediment from leaving



Tsunami Modeling

- Used the 2001 bathy-metry
- Put the inferred 1964 slide areas on top
- Let it run
- Model assumes slide is an incompres-sible viscous fluid

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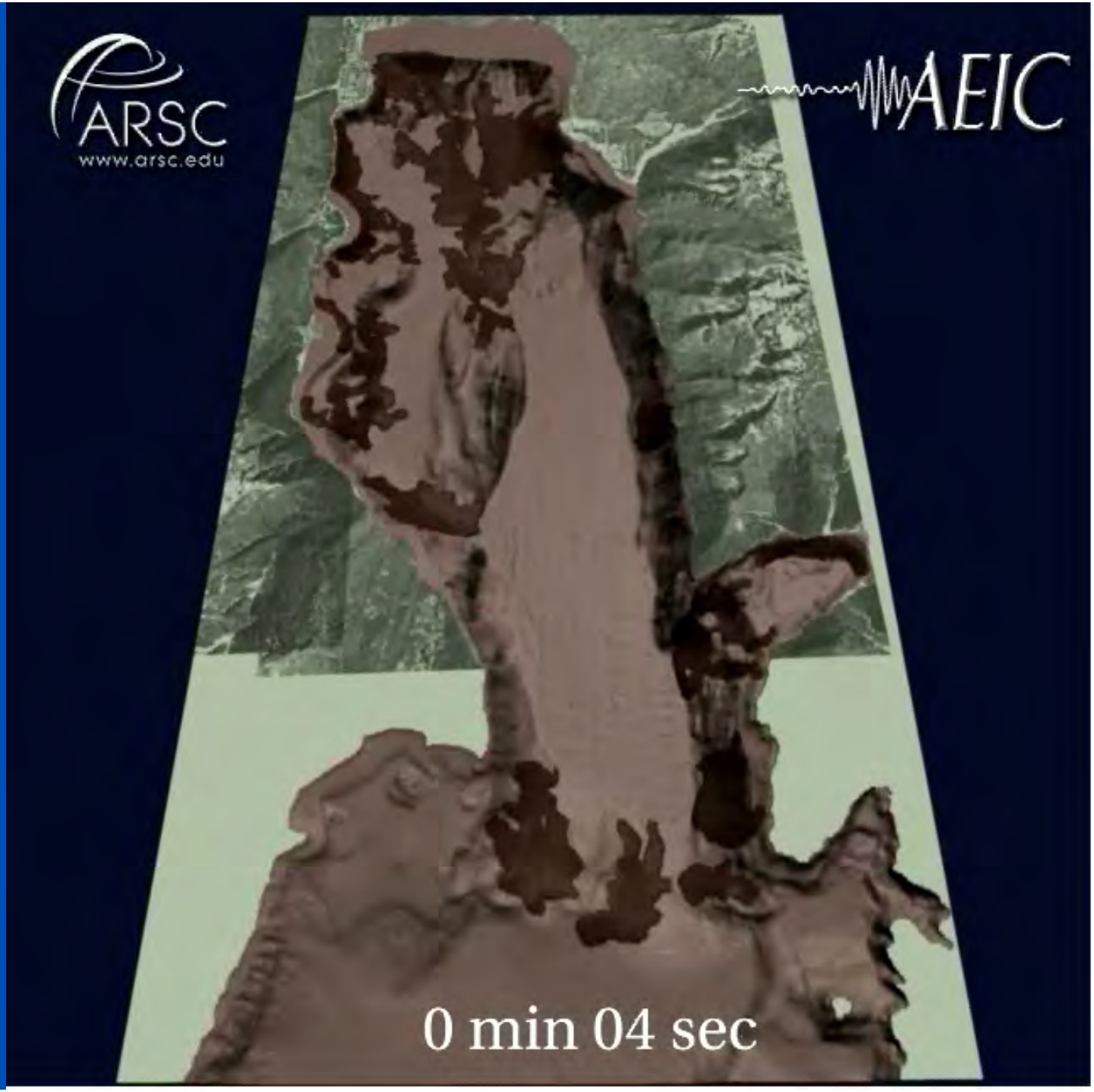

Tsunami Modeling

- Northward traveling wave hits Seward after about 1.5-2 minutes
- Consistent with observations
- Source from 4th of July Creek

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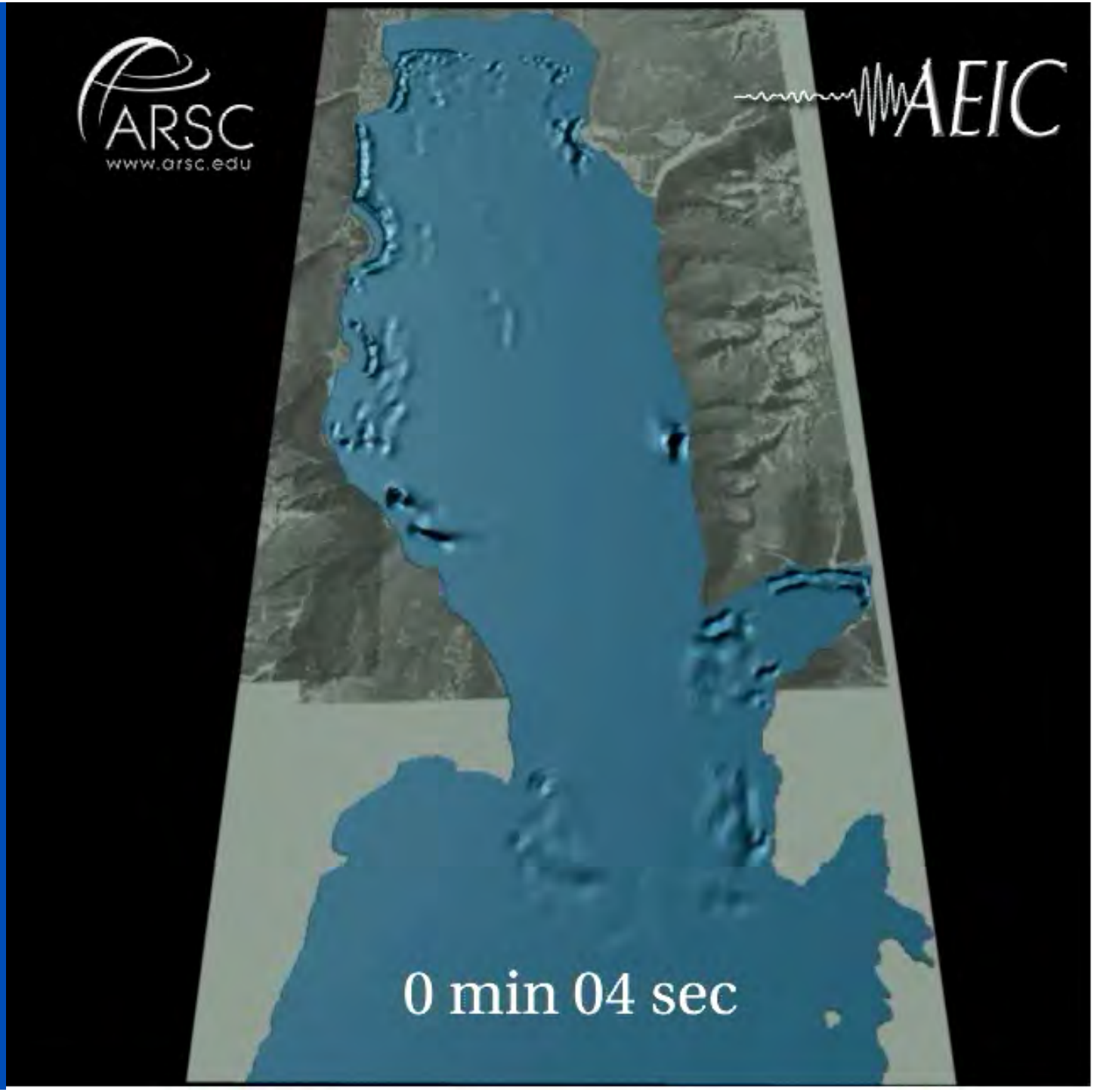

Conclusions - Seward

- Resurrection Bay is an excellent place for landslide/tsunami studies - many factors are relatively well constrained
- We have a basic understanding of the location and size of the slides triggered in the 1964 earthquake
- There were many more slides and sediment transport was over a larger scale than previously appreciated
- The wave generated by the Fourth of July Creek slide caused the most damage at Seward
- Preliminary modeling results successfully hindcast observations of the 1964 tsunamis

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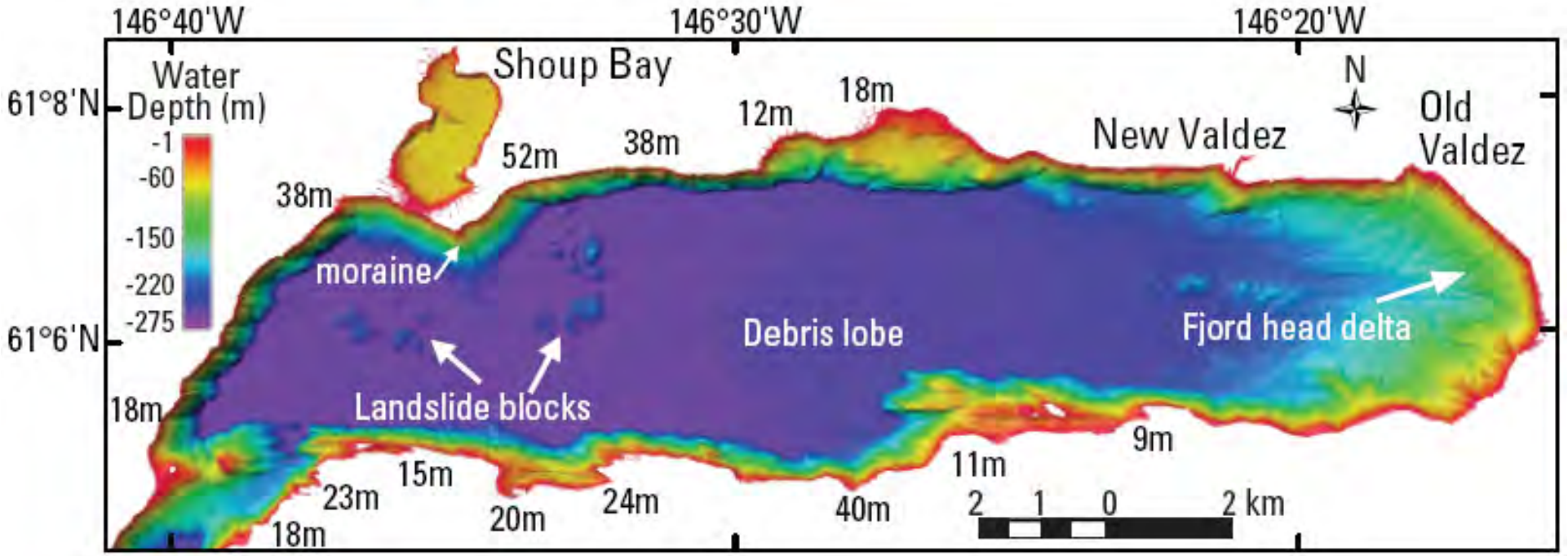
Multibeam image of Port Valdez



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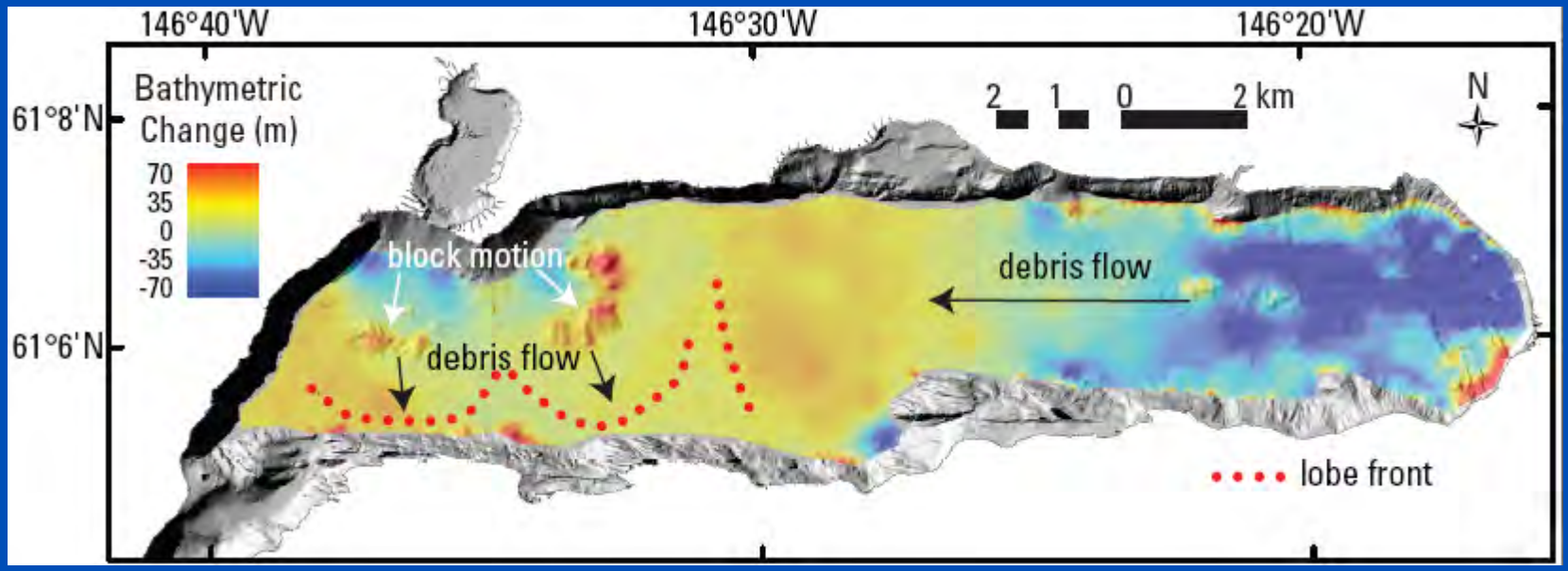
Landslide geometry from bathymetric change



Net volume gain = 329 million m^3
Net volume loss = 241 million m^3
+ 70 million m^3 (source region) =
311 million m^3 (0.3 km^3)

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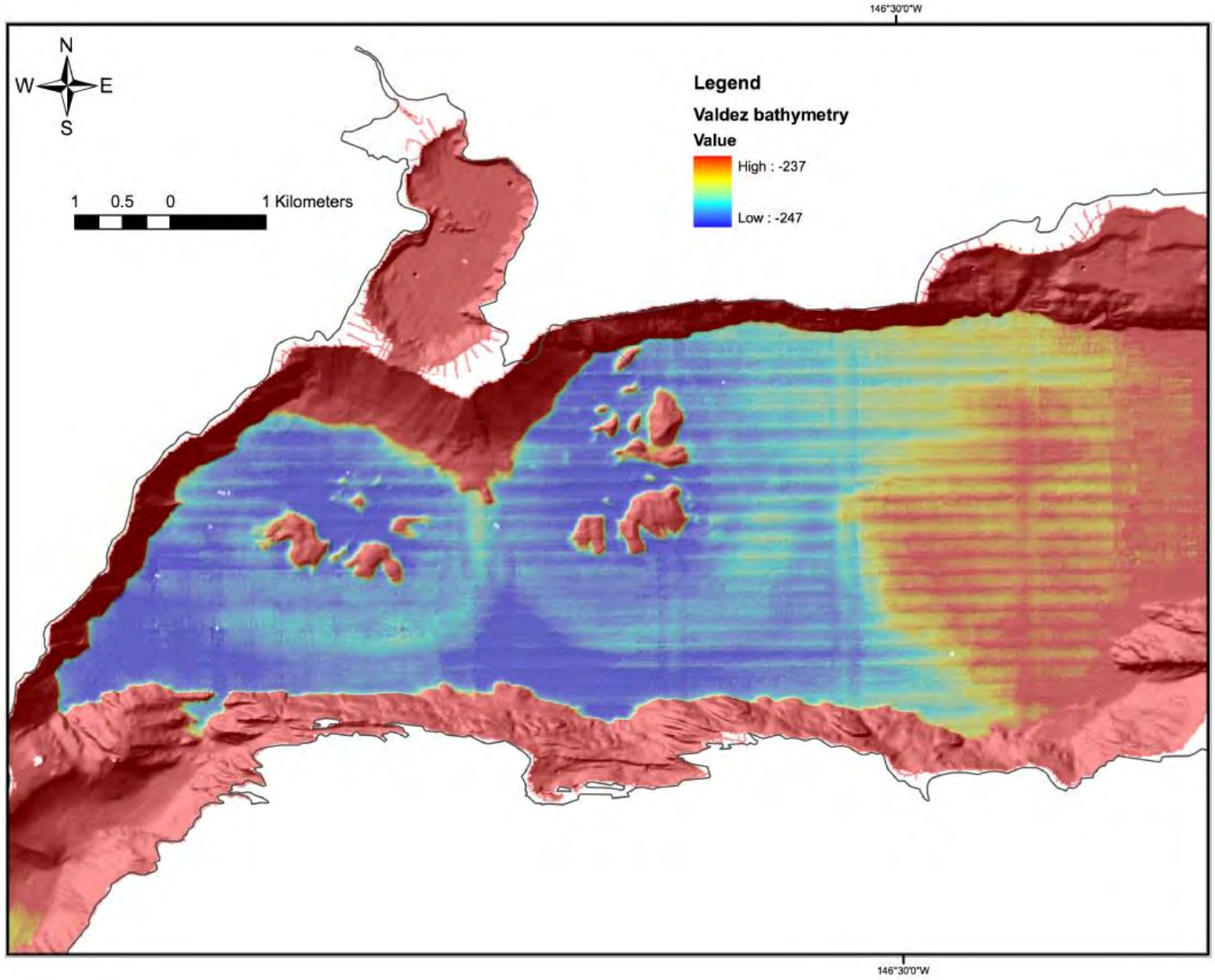
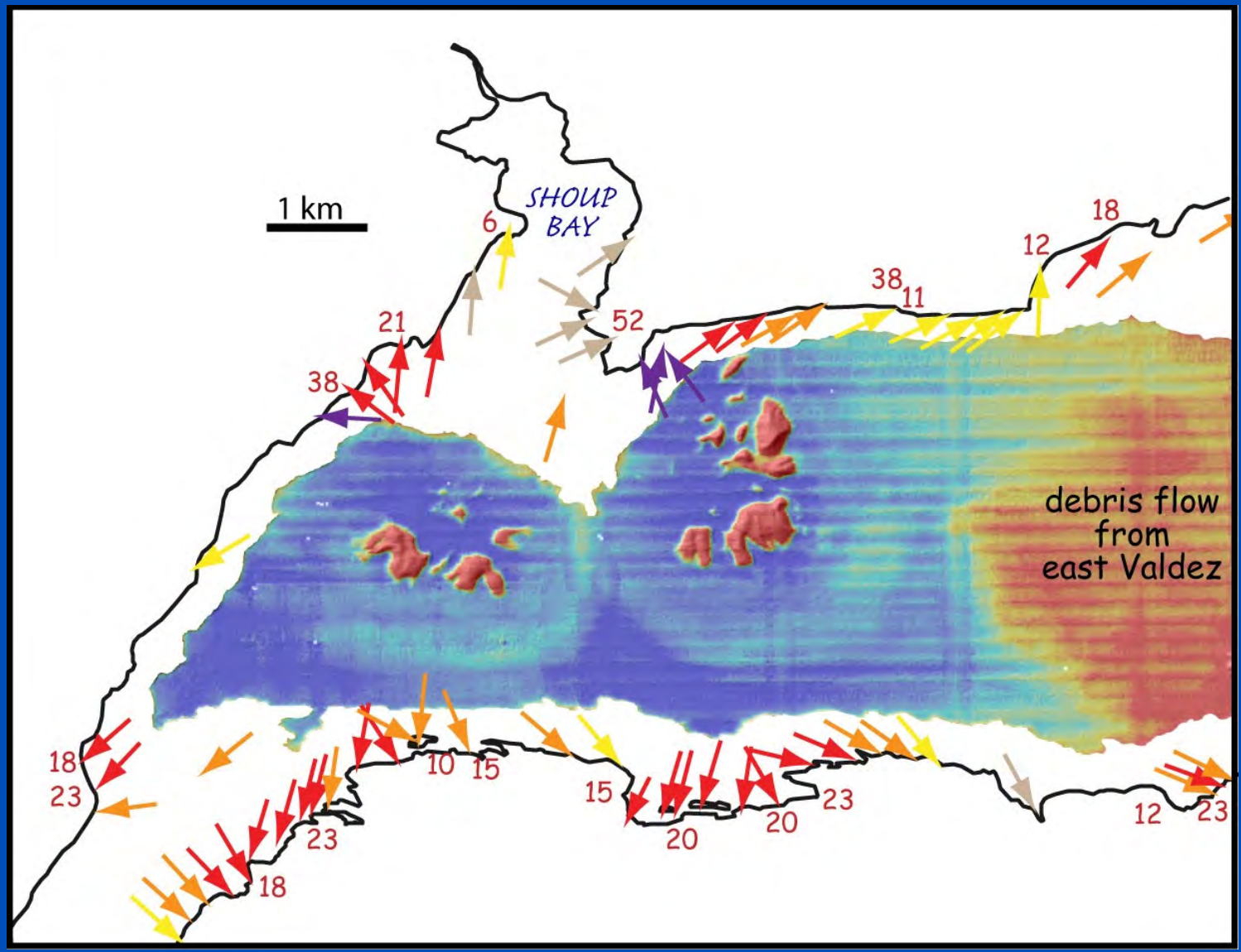
Multibeam image of Port Valdez



What caused the tsunamis in Port Valdez?

Answer: The Blocks



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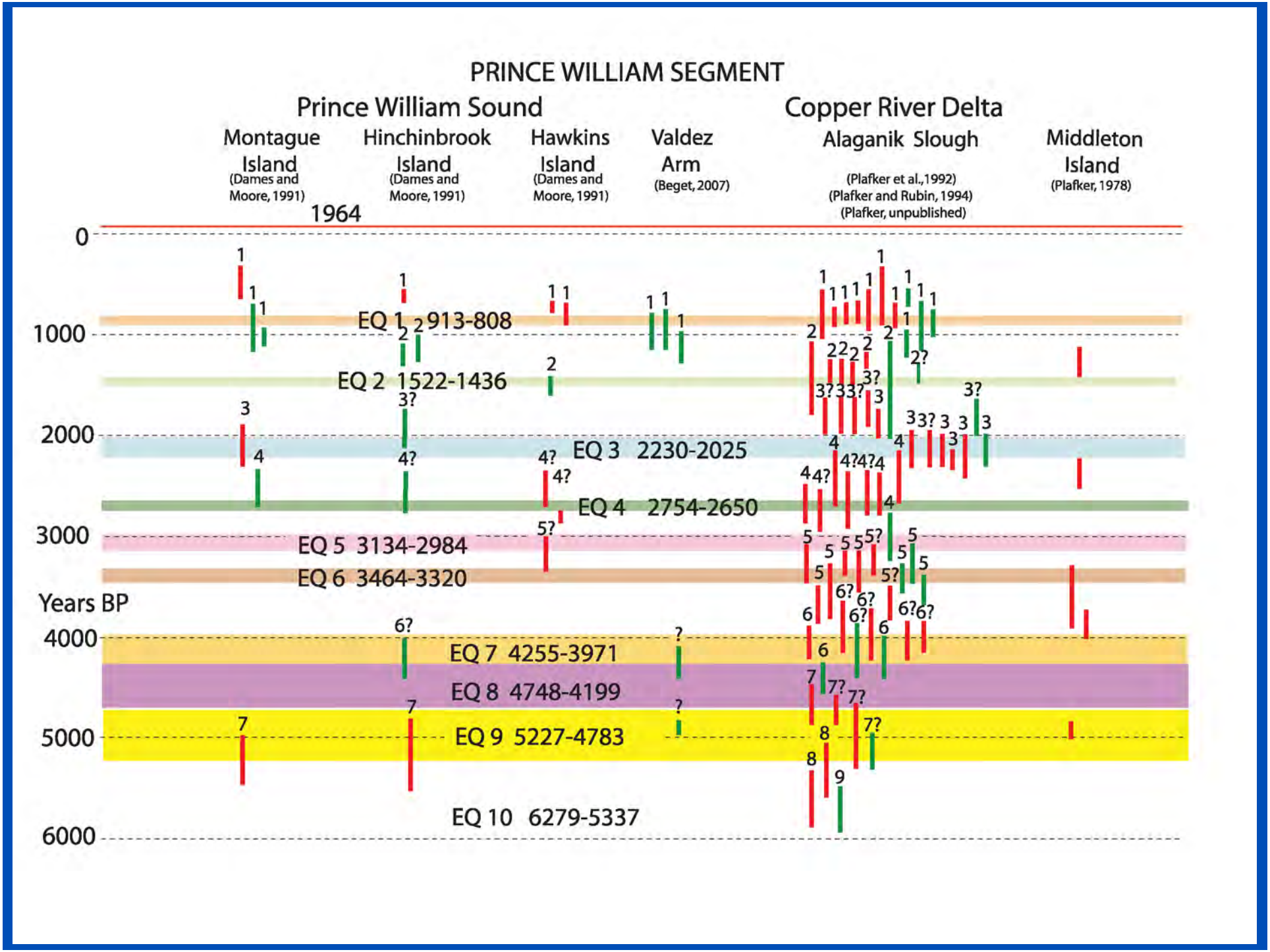
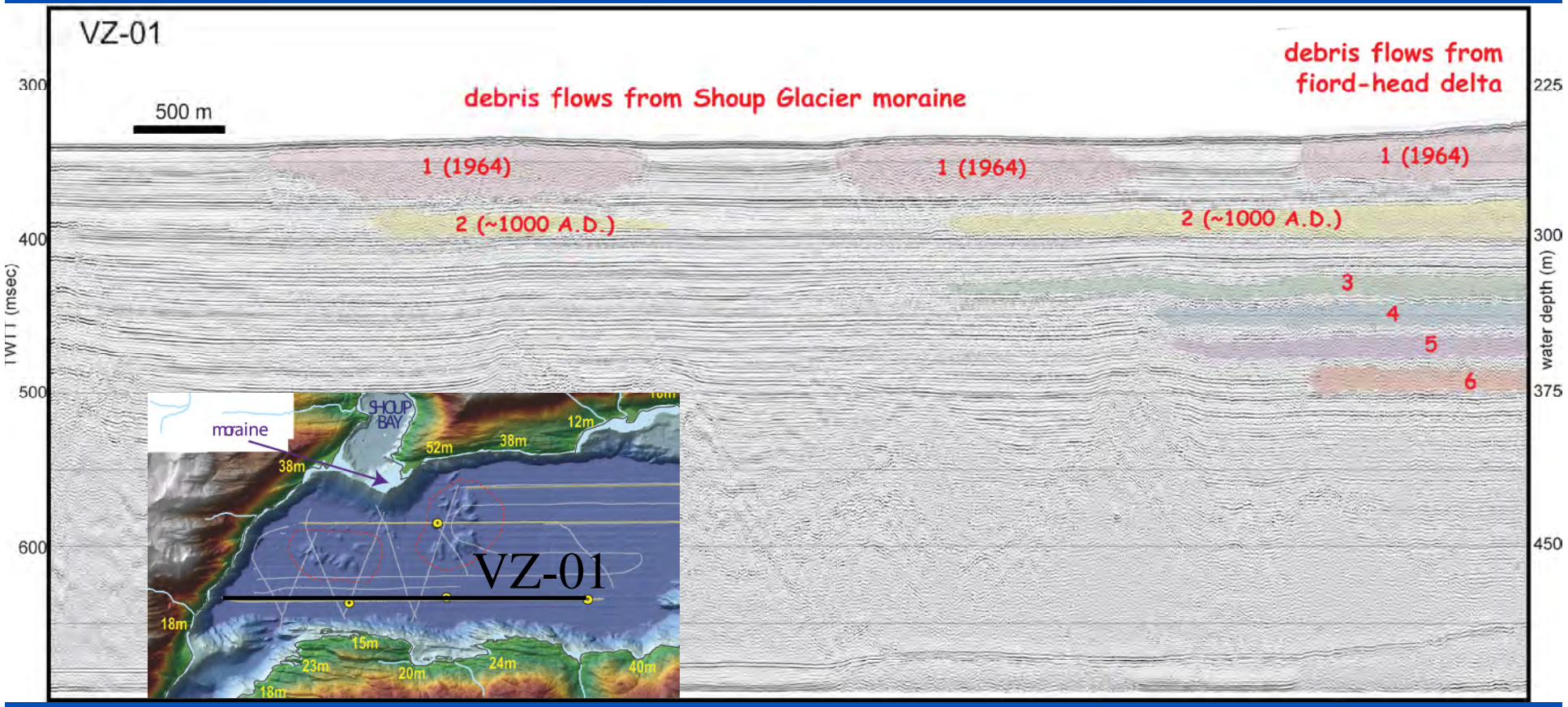

PRINCE WILLIAM SEGMENT
Prince William Sound
Copper River Delta
Montague Island
(Dames and Moore, 1991)
Hinchinbrook Island
(Dames and Moore, 1991)
Hawkins Island
(Dames and Moore, 1991)
Valdez Arm
(Beget, 2007)
Alaganik Slough
(Plafker et al.,1992)
(Plafker and Rubin, 1994)
(Plafker, unpublished)
Middleton Island
(Plafker, 1978)
1964
0
1000
2000
3000
4000
5000
6000
Years BP
EQ 1 913-808
EQ 2 1522-1436
EQ 3 2230-2025
EQ 4 2754-2650
EQ 5 3134-2984
EQ 6 3464-3320
EQ 7 4255-3971
EQ 8 4748-4199
EQ 9 5227-4783
EQ 10 6279-5337

Sub-bottom profiles show previous debris flows



- Failures that emanated from the fiord-head delta contributed to all the debris lobes
- Failures at Shoup Bay moraine only occurred during the 1964 and penultimate event
- The older debris flows (3-6) are thinner and less extensive than 1 and 2

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Findings Regarding Recurring Failures

- Apparently 6 major slope failure events have occurred in Port Valdez since deglaciation.
- All involved the fjord-head delta.
- The last two were the most extensive and the only ones that involved failures of the Shoup Glacier moraine.
- The increasing severity of earthquake-induced slope failures in Port Valdez likely relates to development and advancement of the fjord-head delta and retreat / advance of Shoup Glacier.

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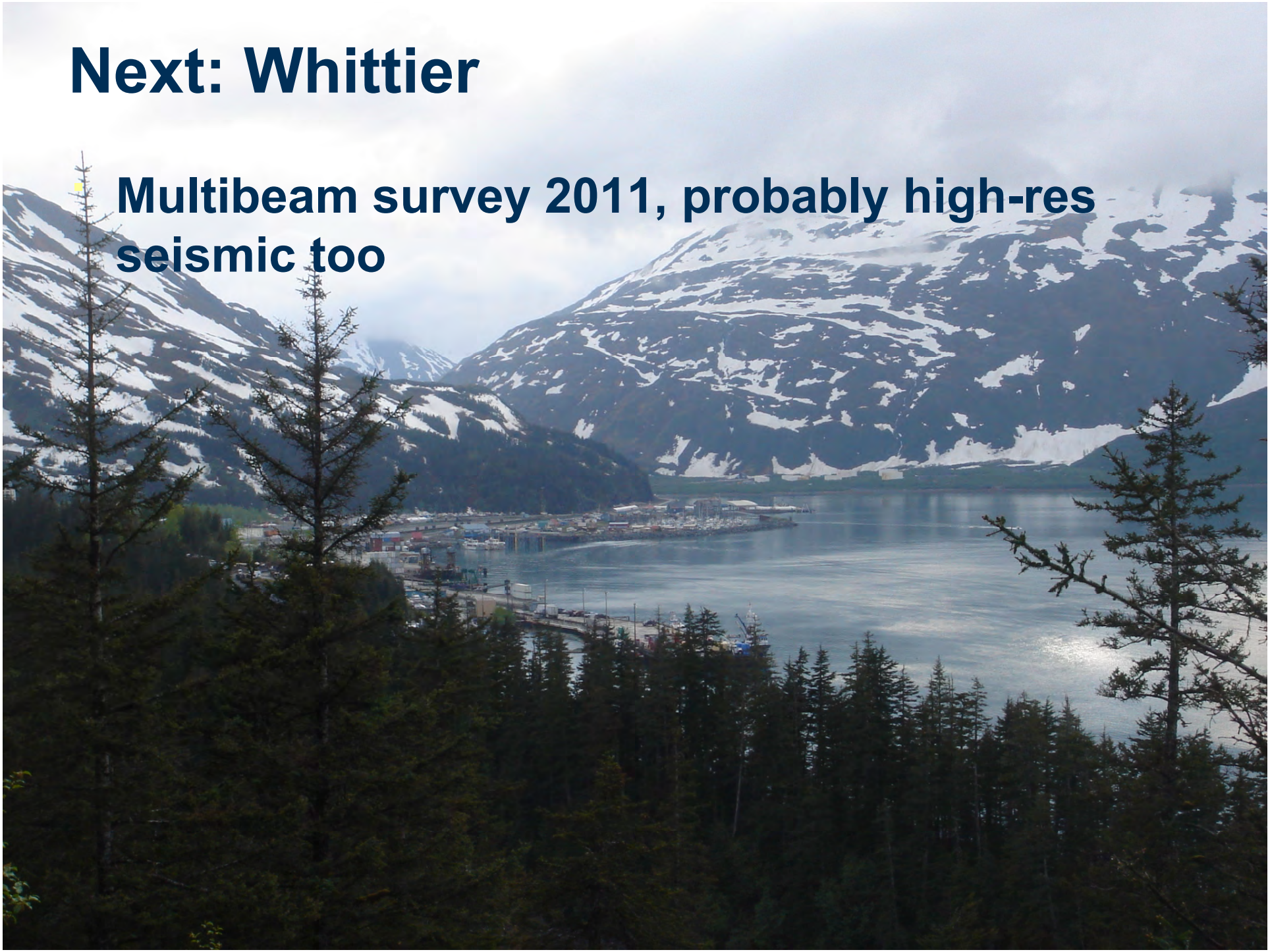
Next: Whittier

- Multibeam survey 2011, probably high-res seismic too



New Direction: Southern Alaska Margin

- Moving away from interior Alaska work
- New work will focus on:
  - Paleoearthquake record
  - Paleotsunami record
  - Forearc structure and tsunami generation (offshore reflection seismic data and interpretation)
- Long term goal: understand what controls megathrust ruptures and tsunami generation in Alaska
- We may receive additional dollars in FY2011 to help get this effort on its way

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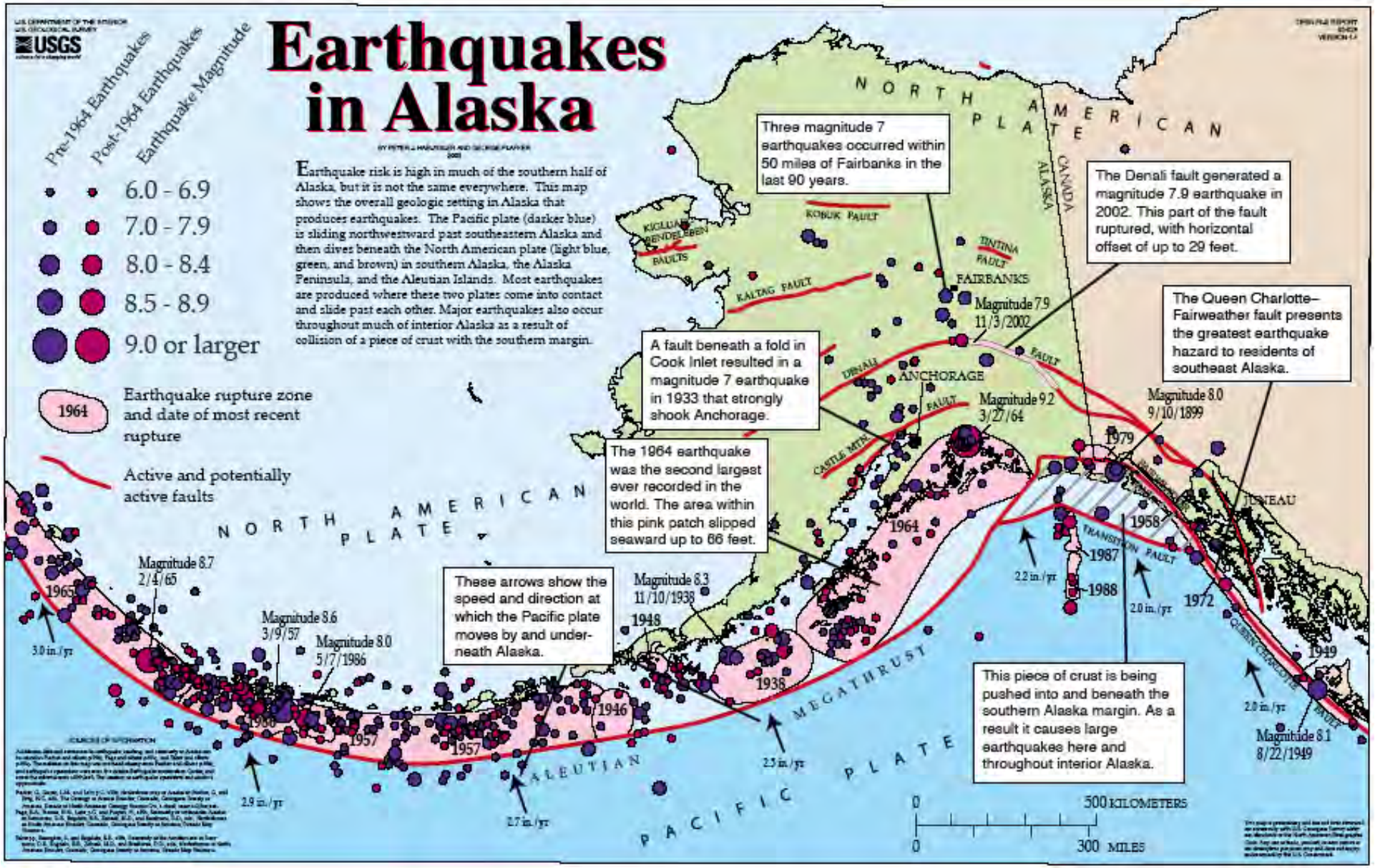

- All of plate boundary has ruptured in historical time

Other geologic studies

- USGS group on Chirikof
  - Paleotsunami and paleoearthquake studies
  - Identified 5 tsunami sands at 1 site, 7 at another
  - Bad weather
  - Next summer: additional work in this vicinity
- USGS external grants program
  - Kodiak paleoseismology - Ian Shennan
  - PWS high-resolution seismic - Lee Liberty

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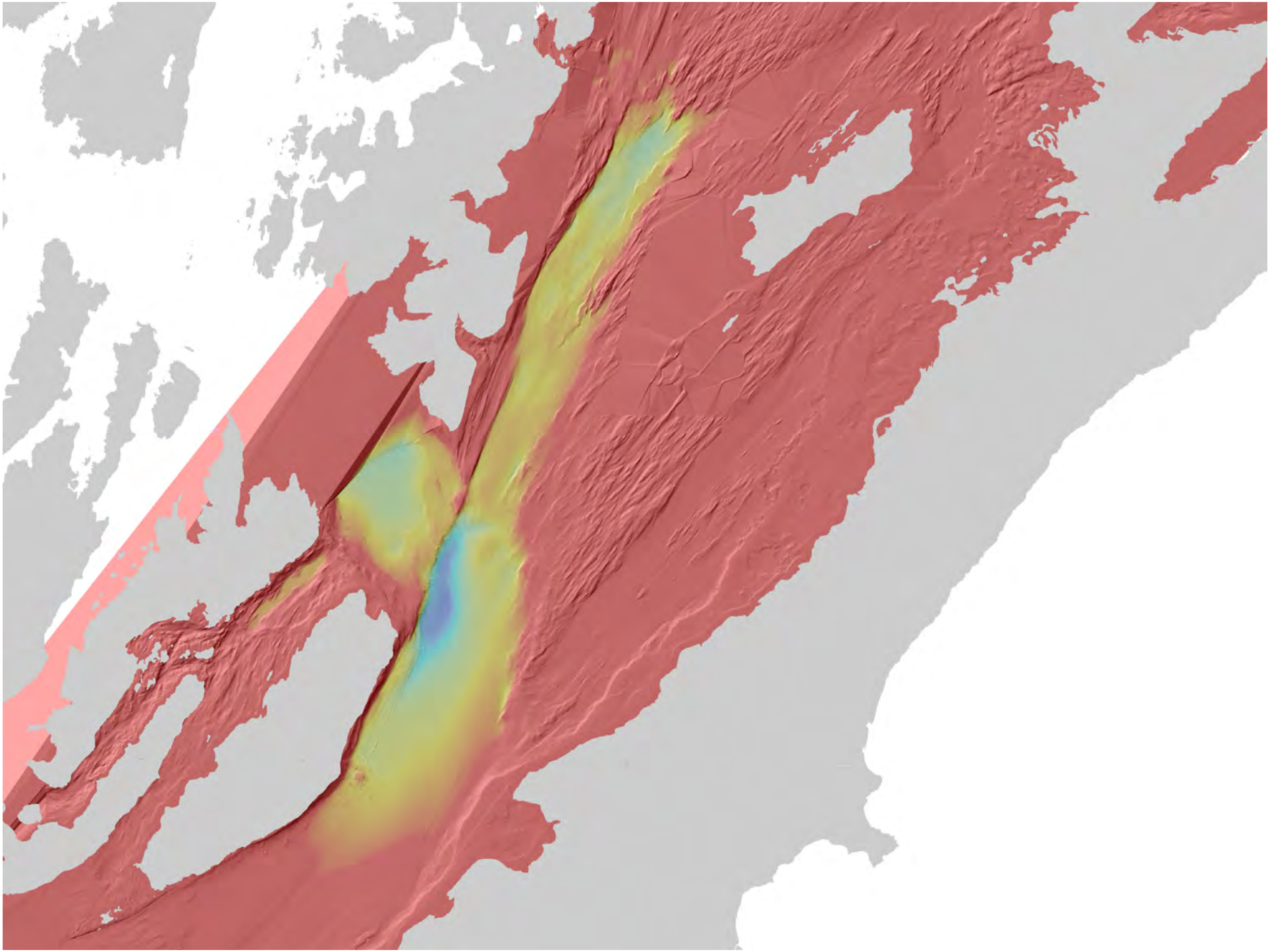

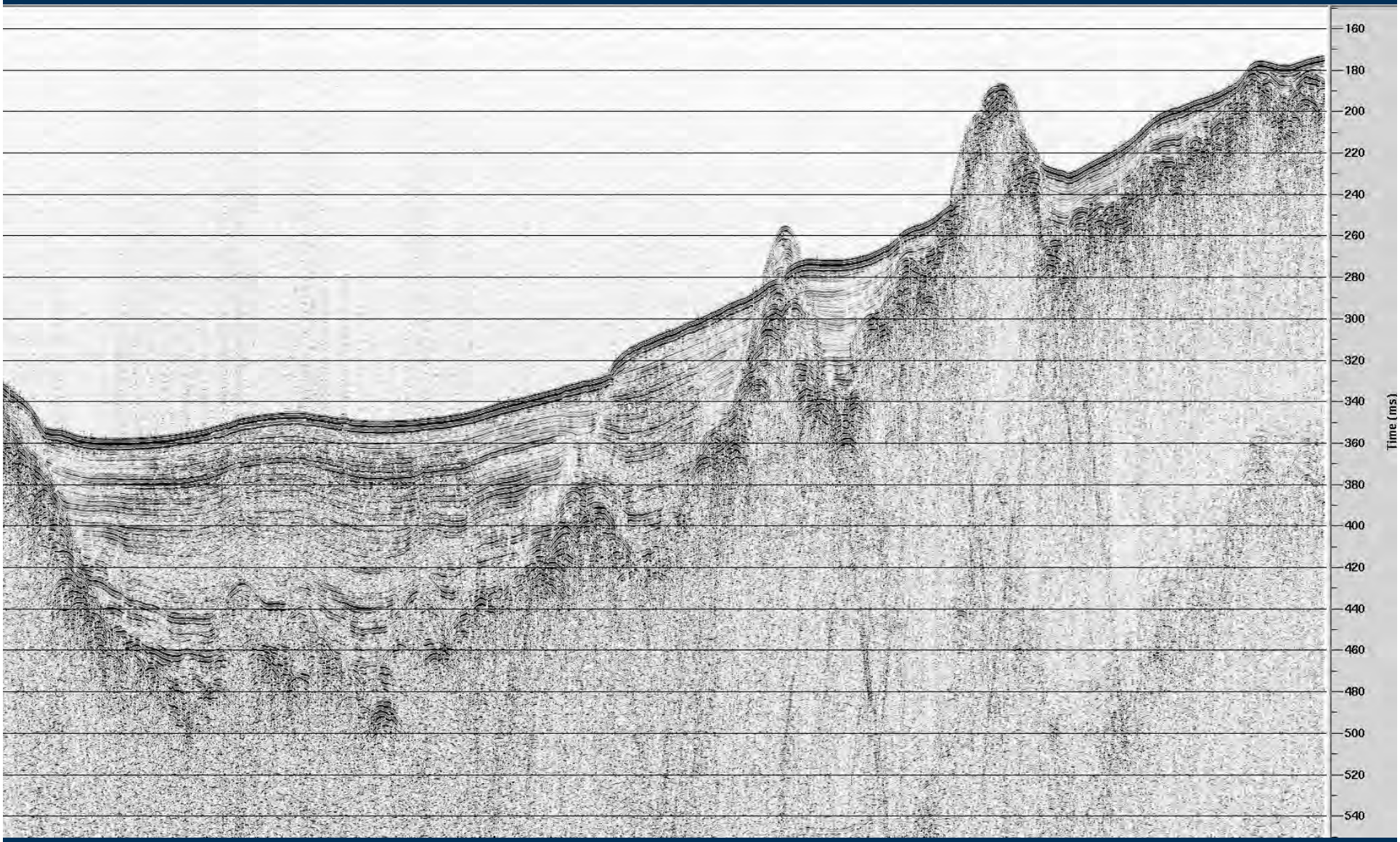
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
Time (ms)

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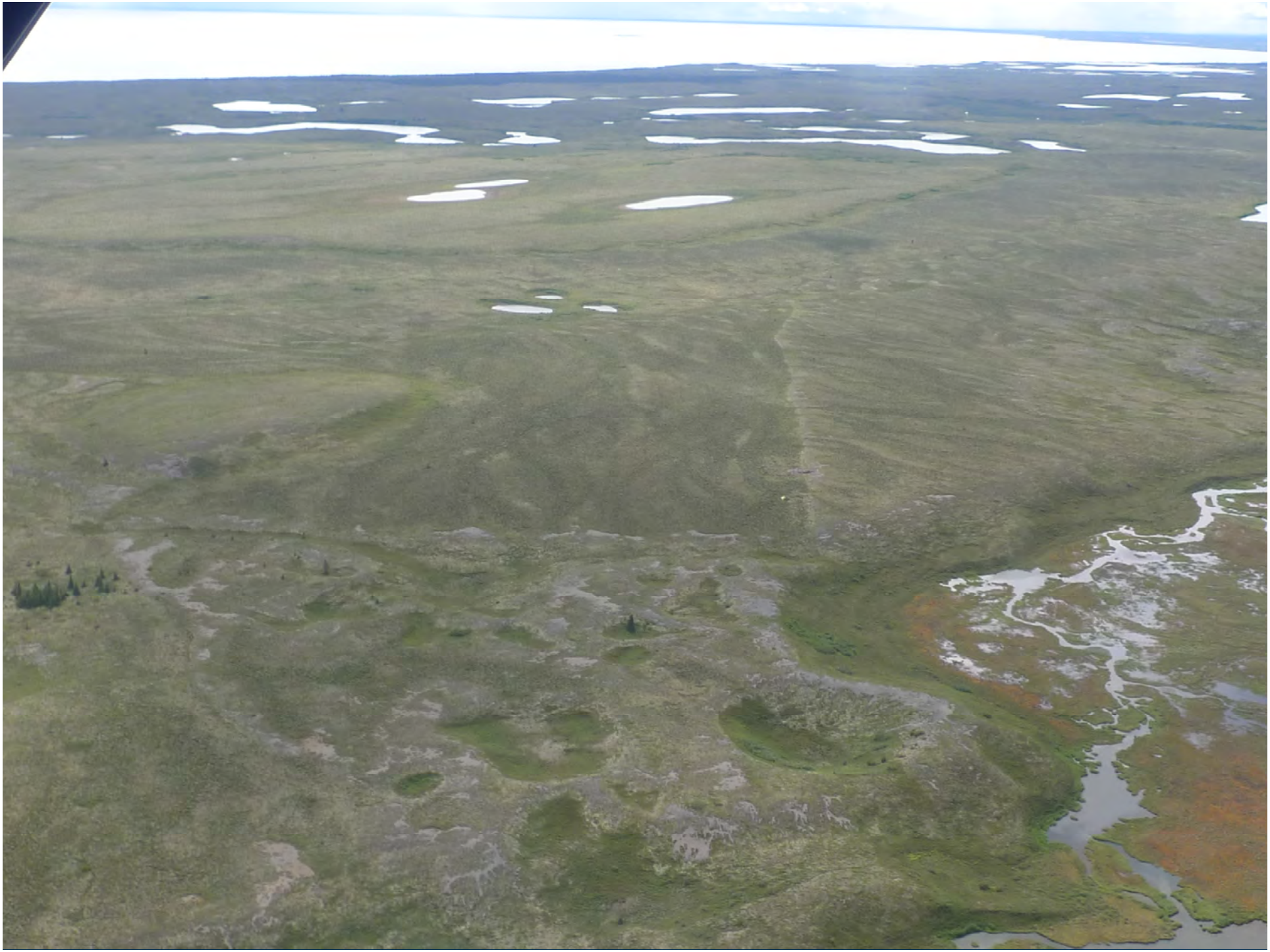
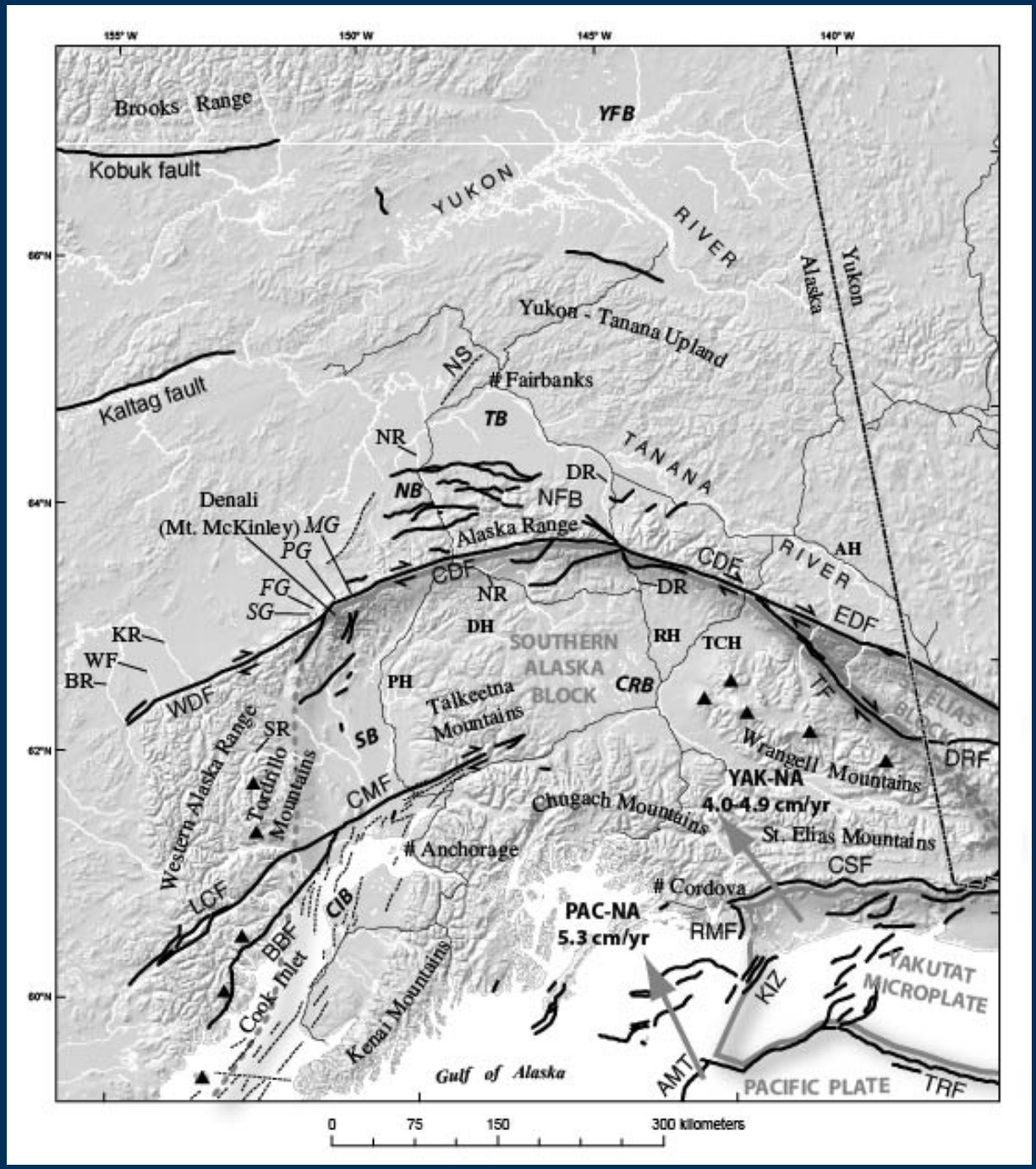


- **GeoEarth-Scope lidar**



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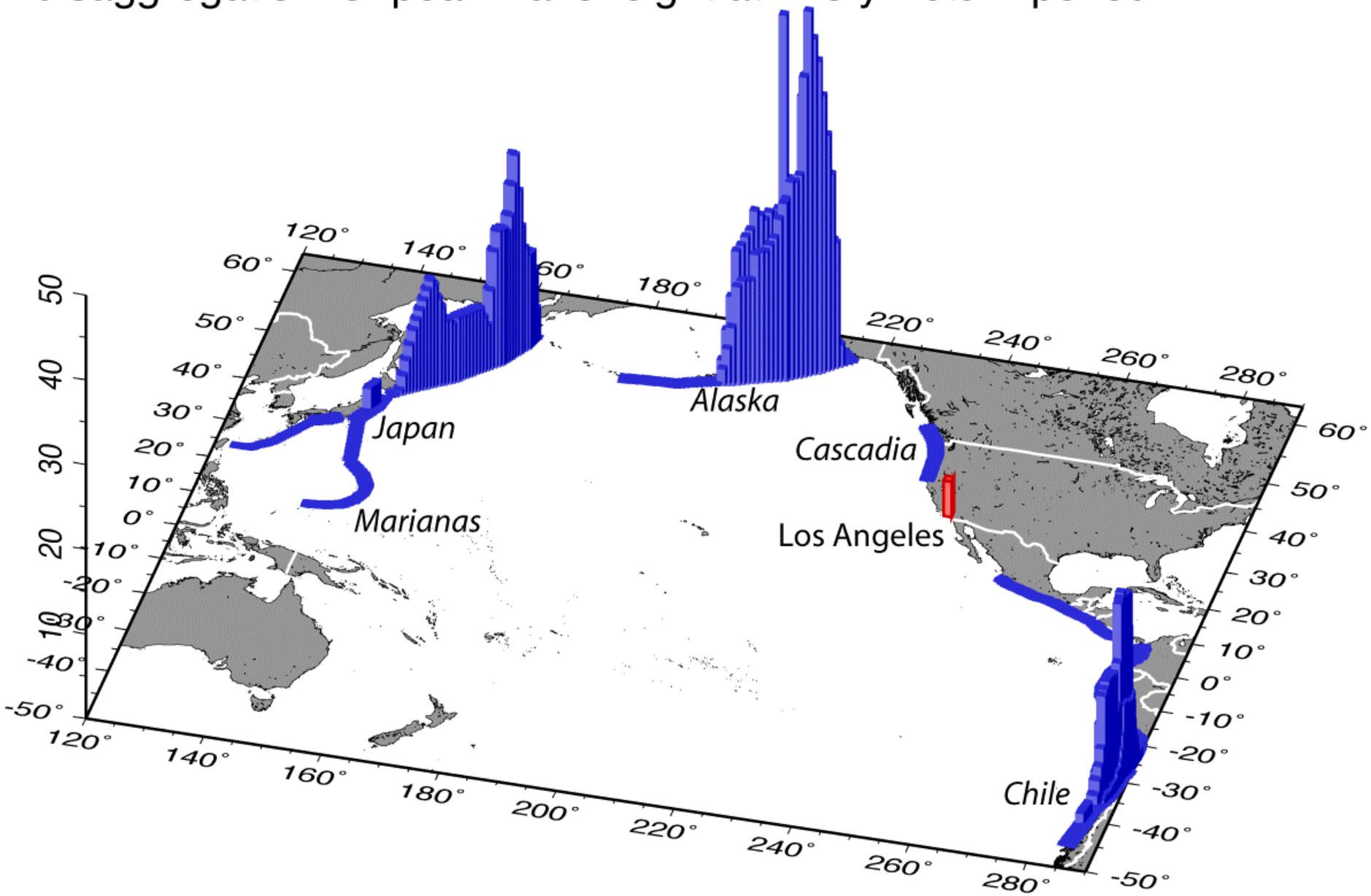
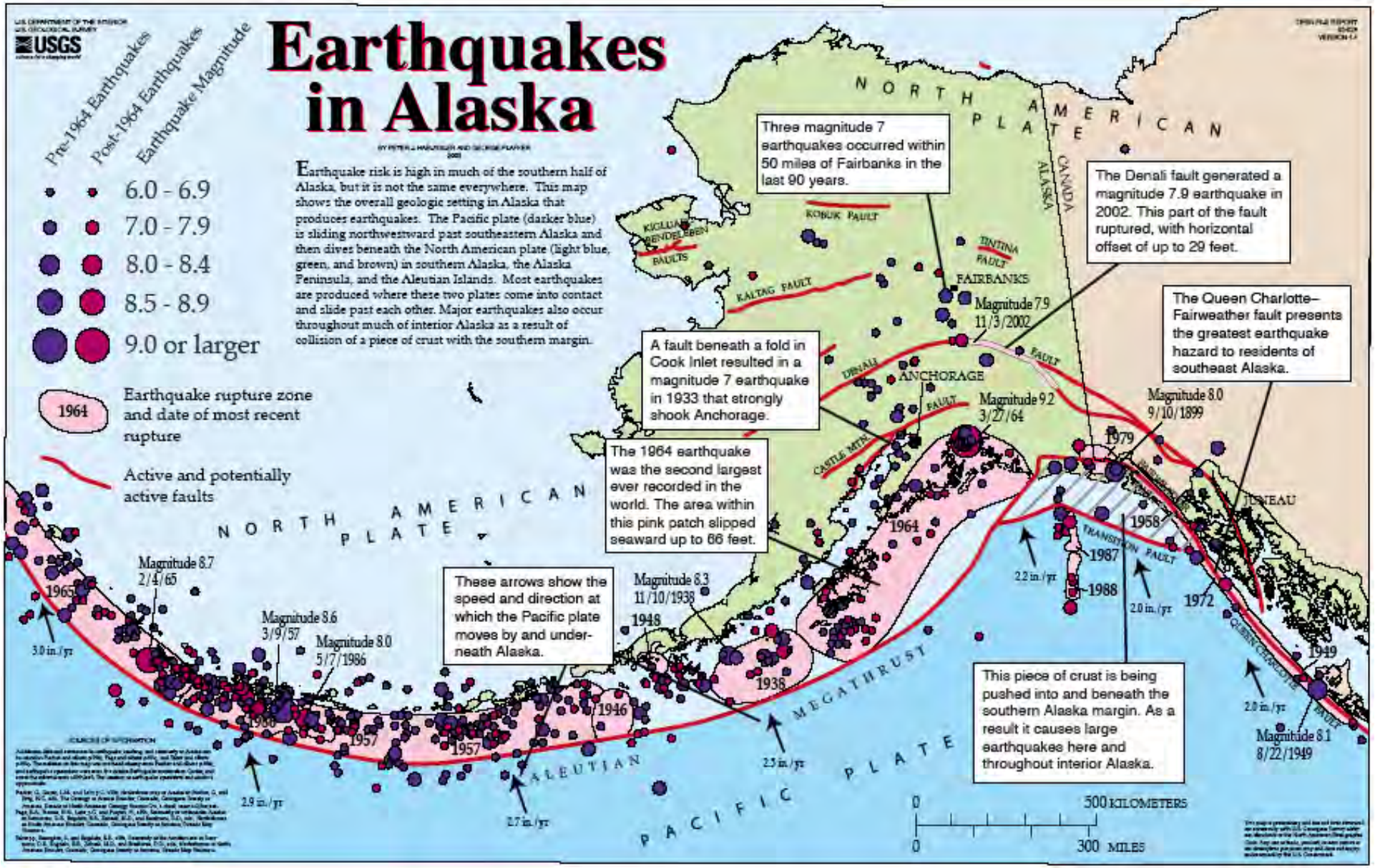
Source disaggregation for Los Angeles

disaggregation for peak waveheight at 475 yr return period





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