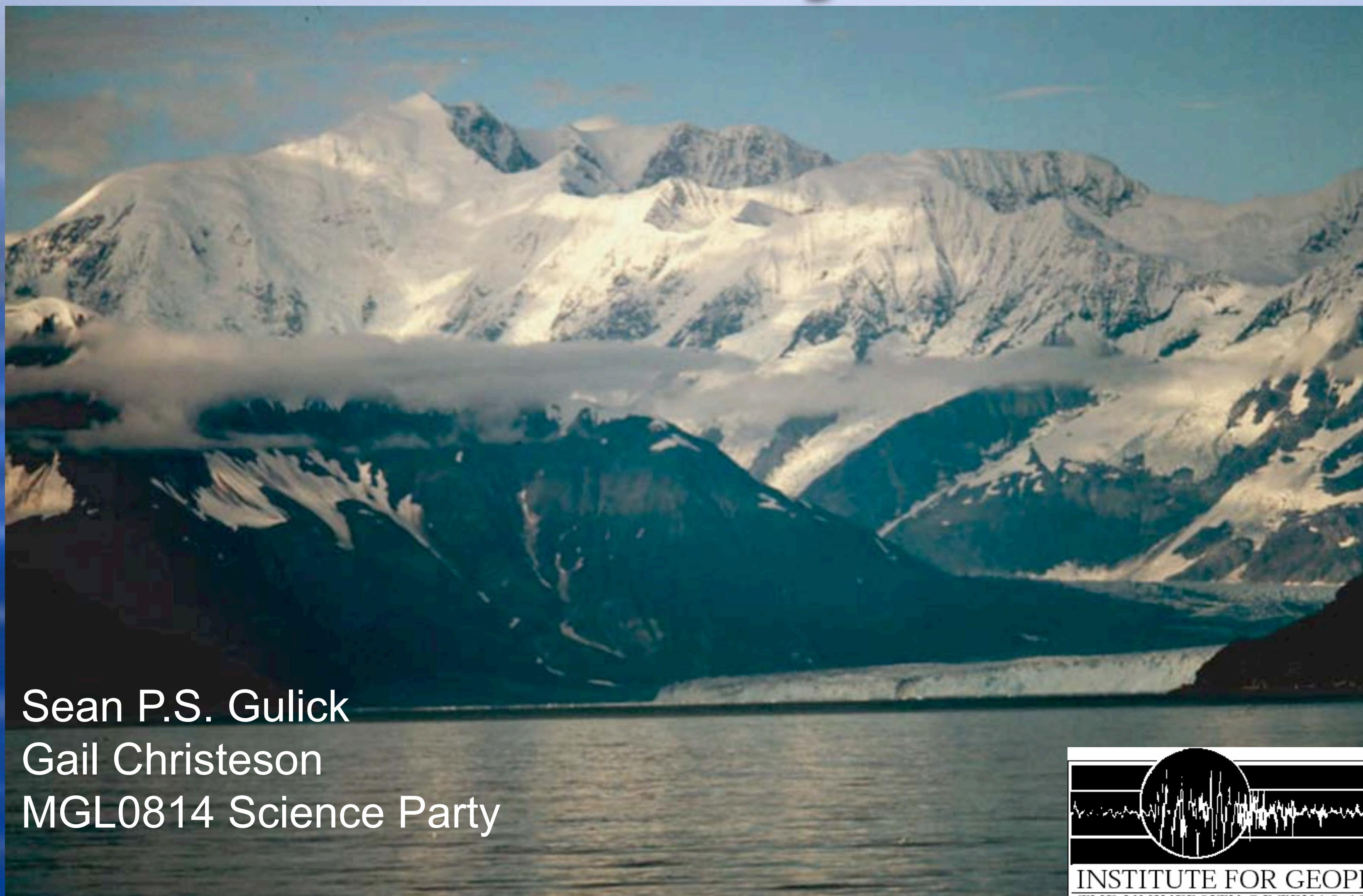
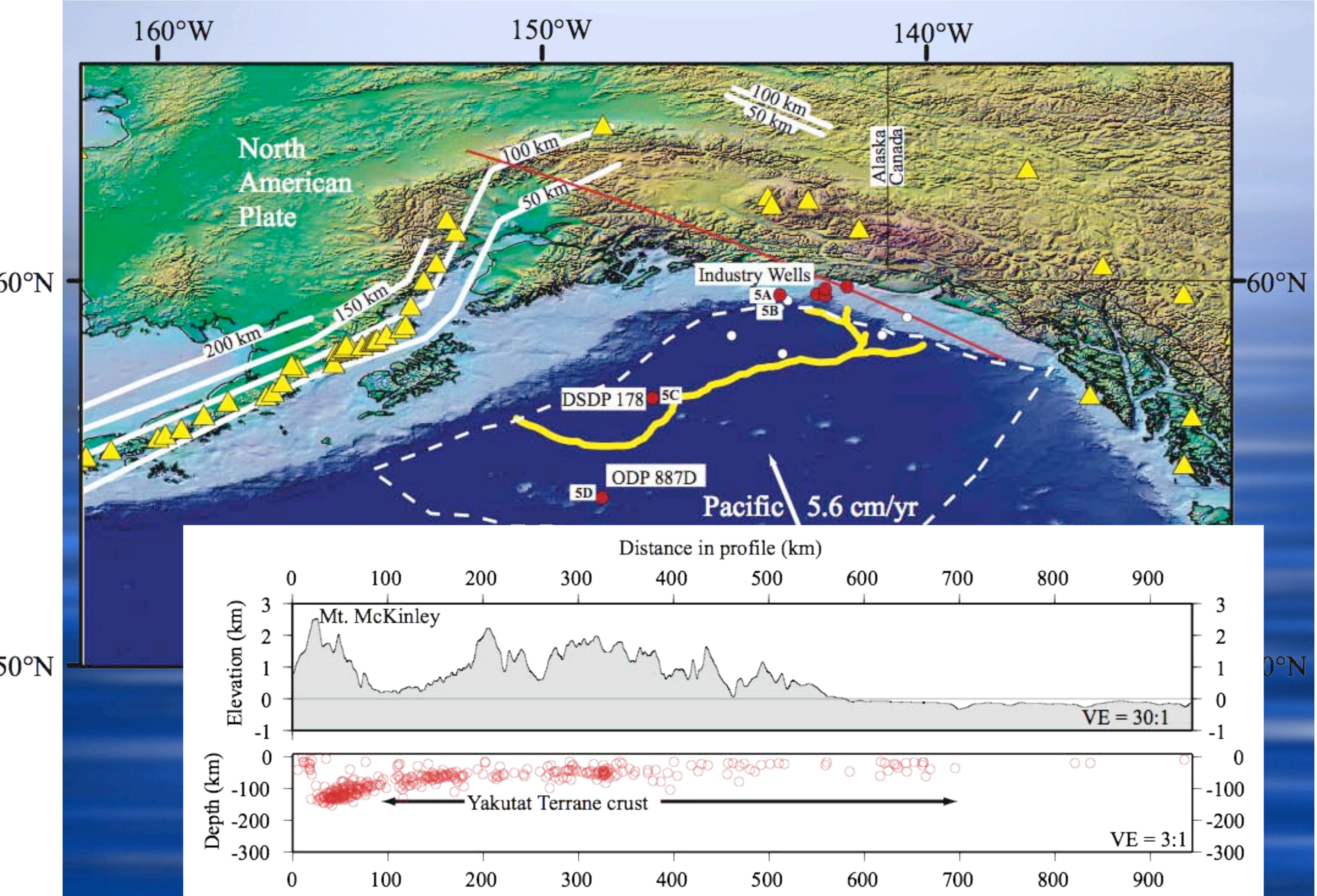
Imaging and Mapping Tectonic-Climate Interactions in the Gulf of Alaska: How did it go?

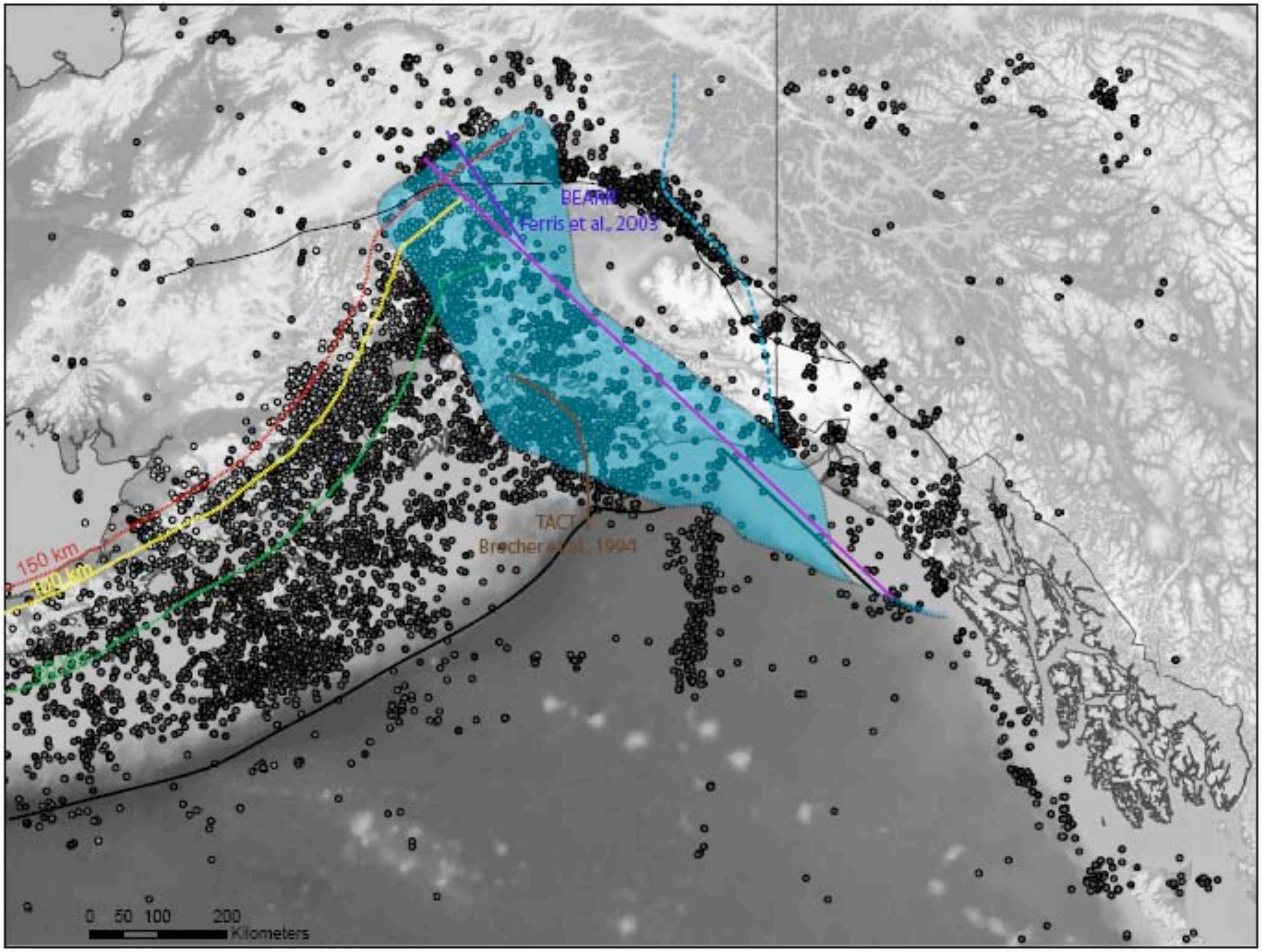


Sean P.S. Gulick
Gail Christeson
MGL0814 Science Party

INSTITUTE FOR GEOPHYSICS
THE UNIVERSITY OF TEXAS AT AUSTIN

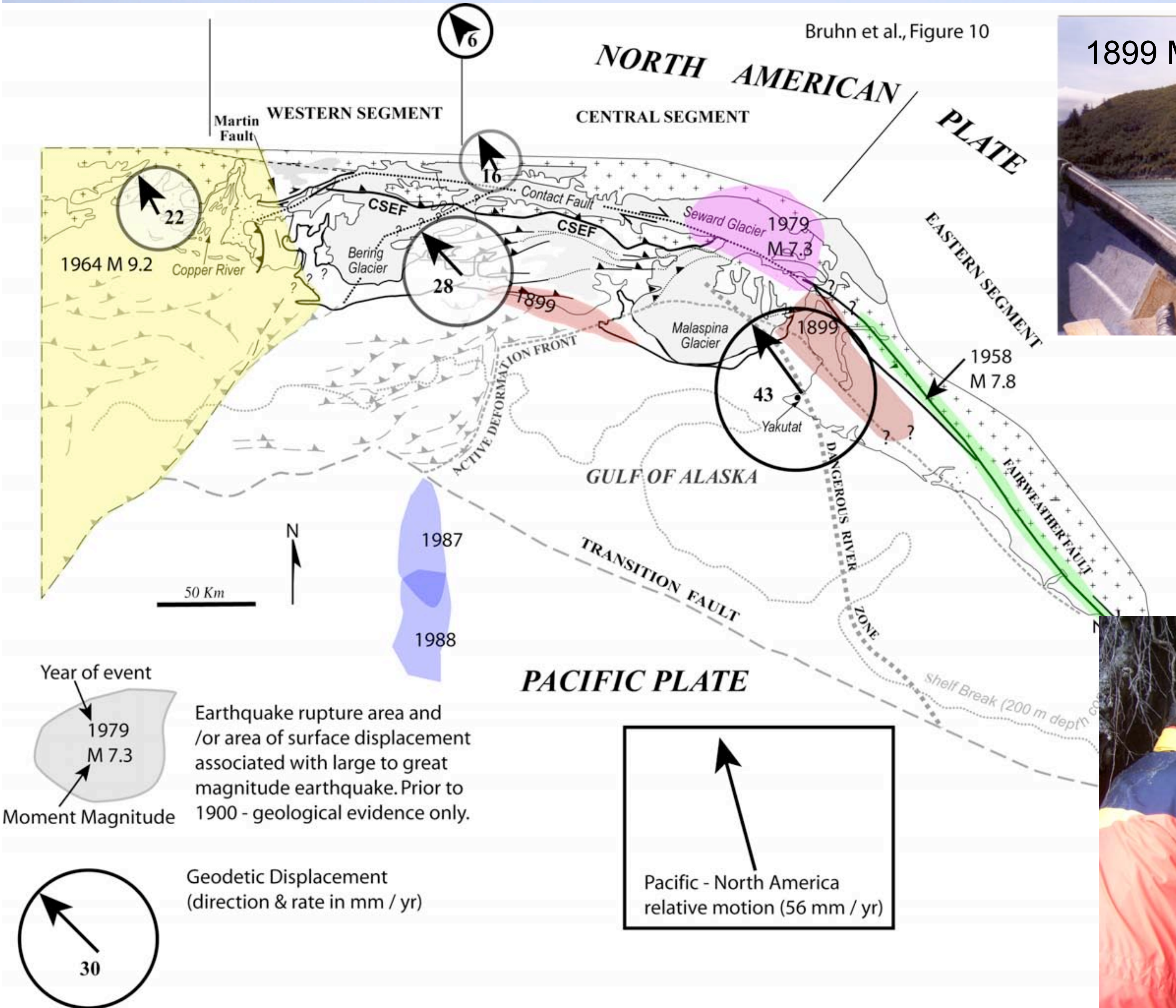


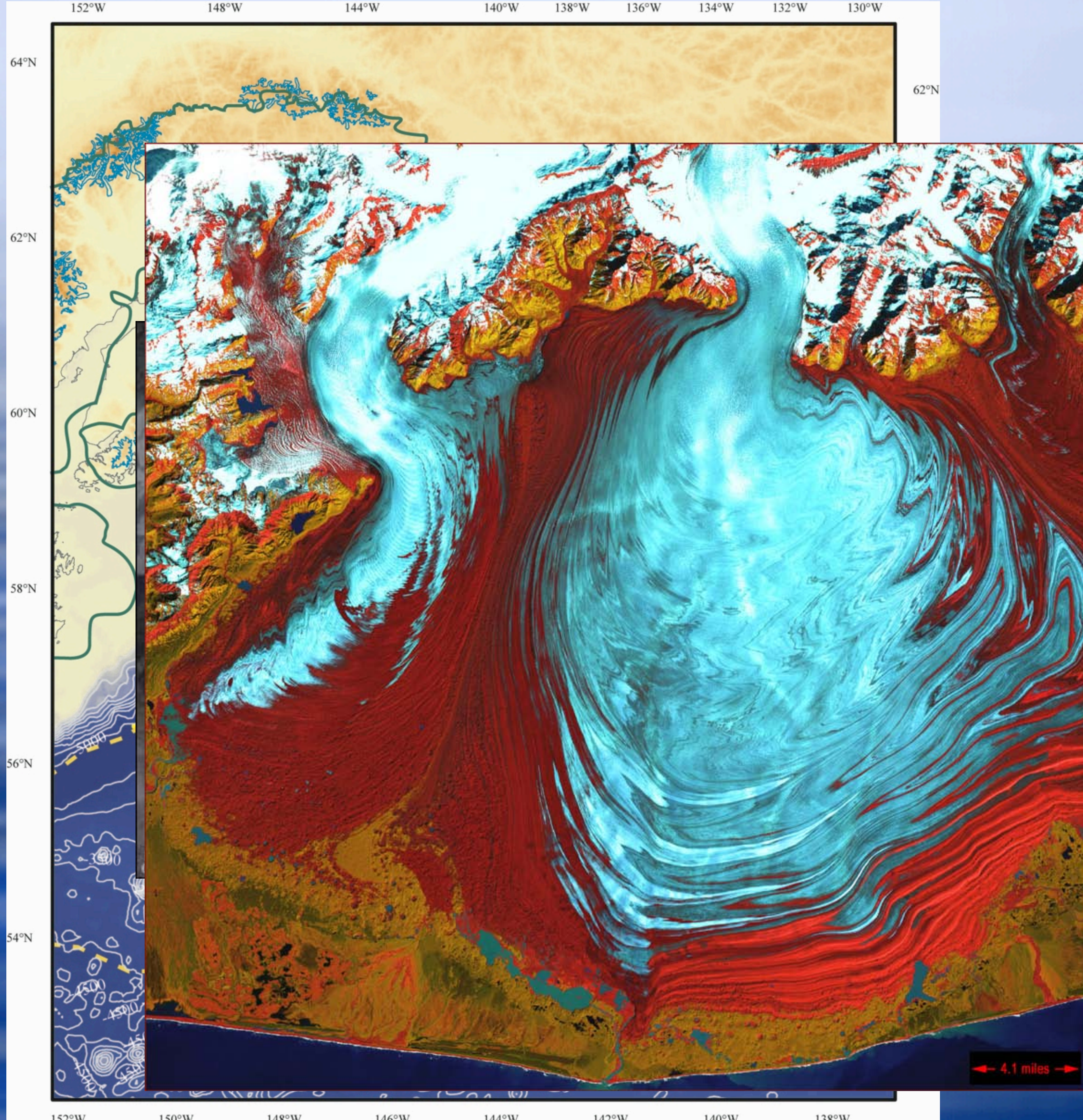
Gulick et al., Geology 2007



After Eberhart-Phillips et al., 2006; Page et al., 1989

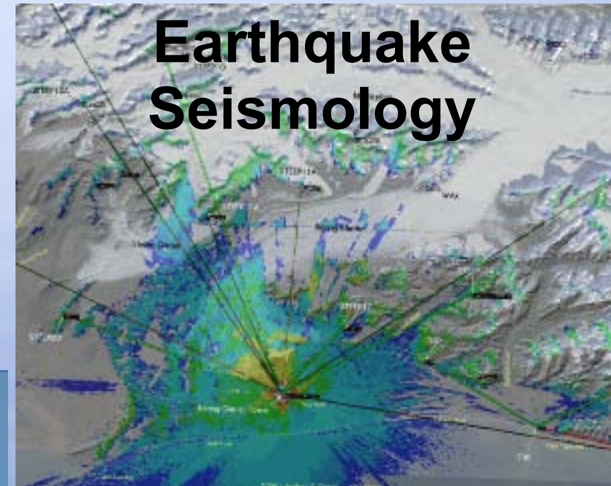
Earthquake & Tsunamic Hazards – One Practical Application of STEEP Research

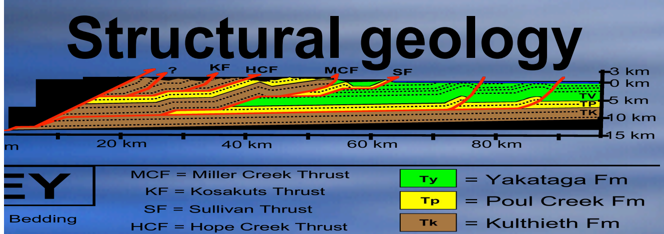


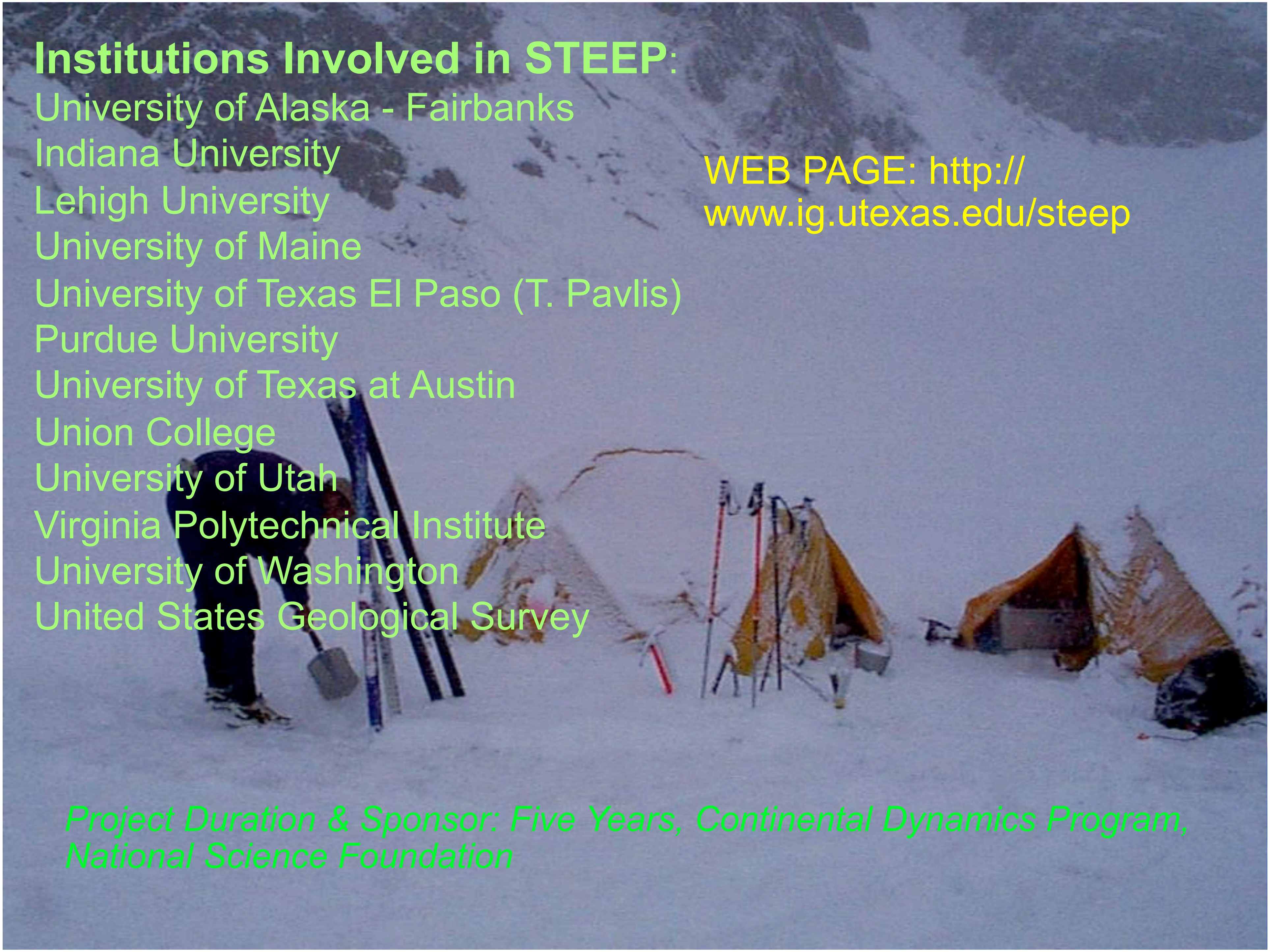

152°W
148°W
144°W
140°W
138°W
136°W
134°W
132°W
130°W
64°N
62°N
60°N
58°N
56°N
54°N
62°N
150°W
146°W
142°W
4.1 miles

St. Elias Erosion and tectonics Project (STEEP)

Aimed at getting data
that will constrain evolution of
the St. Elias orogen







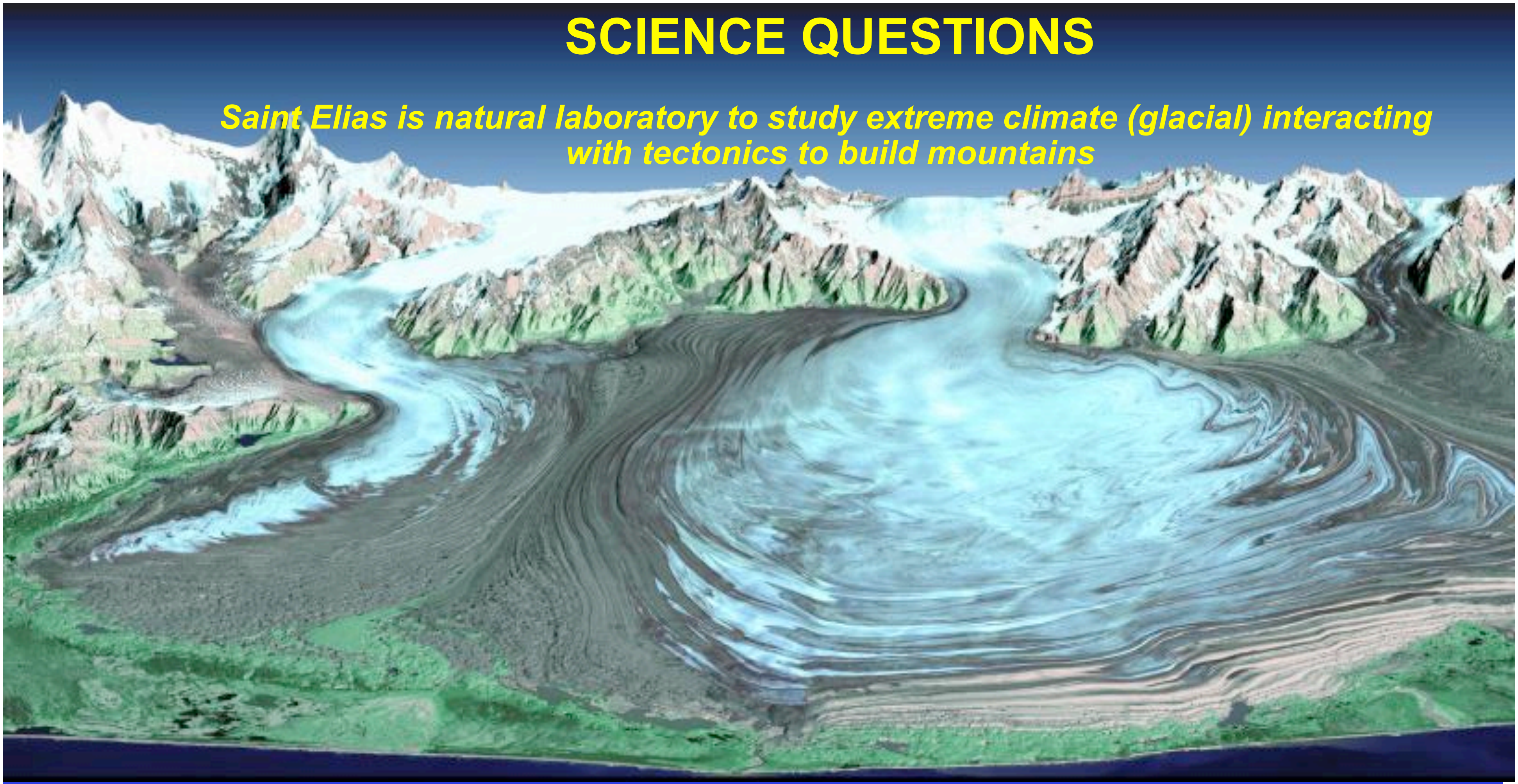
Institutions Involved in STEEP:
University of Alaska - Fairbanks
Indiana University
Lehigh University
University of Maine
University of Texas El Paso (T. Pavlis)
Purdue University
University of Texas at Austin
Union College
University of Utah
Virginia Polytechnical Institute
University of Washington
United States Geological Survey

WEB PAGE: http://www.ig.utexas.edu/steep

Project Duration & Sponsor: Five Years, Continental Dynamics Program, National Science Foundation

SCIENCE QUESTIONS

Saint Elias is natural laboratory to study extreme climate (glacial) interacting with tectonics to build mountains

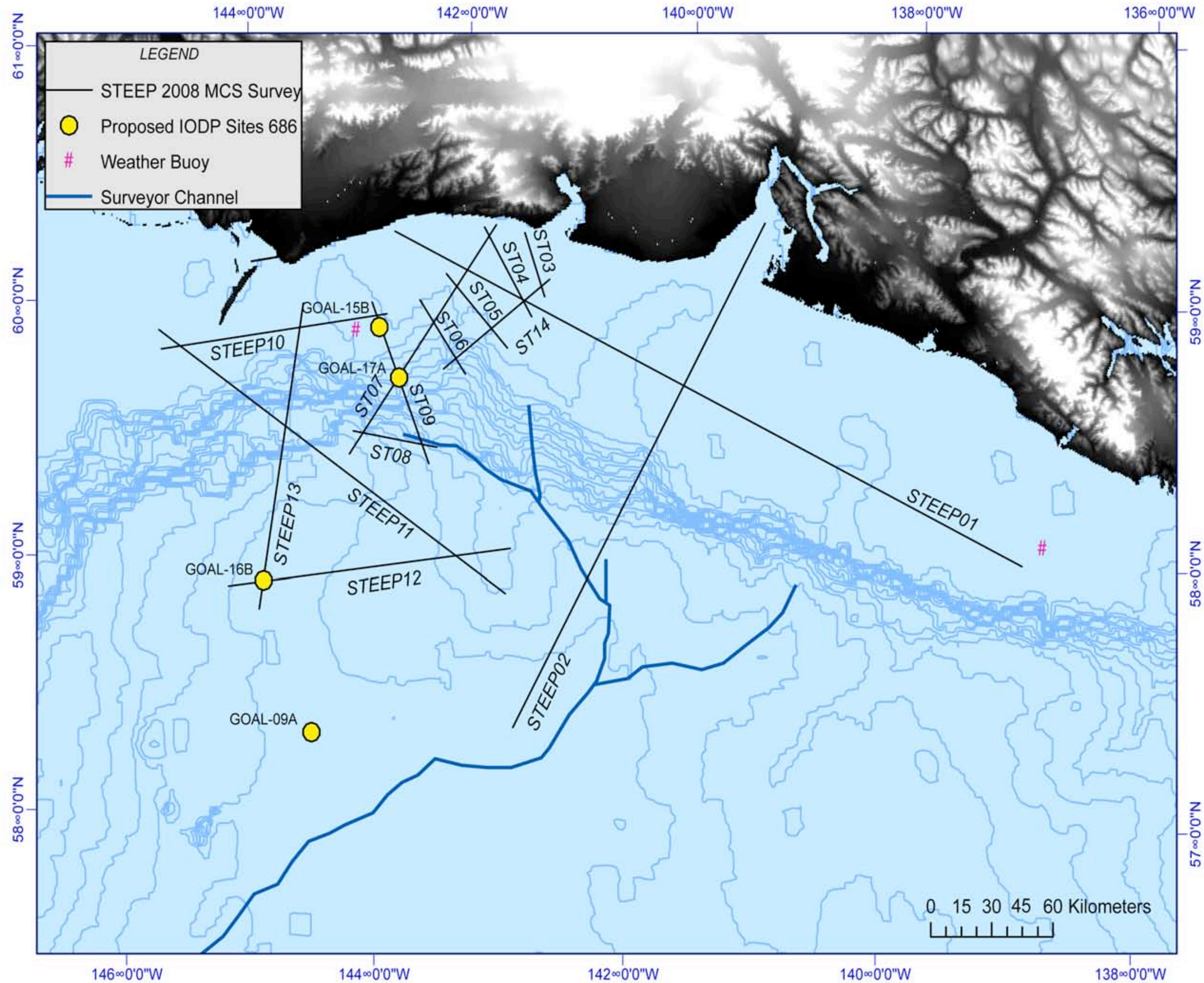


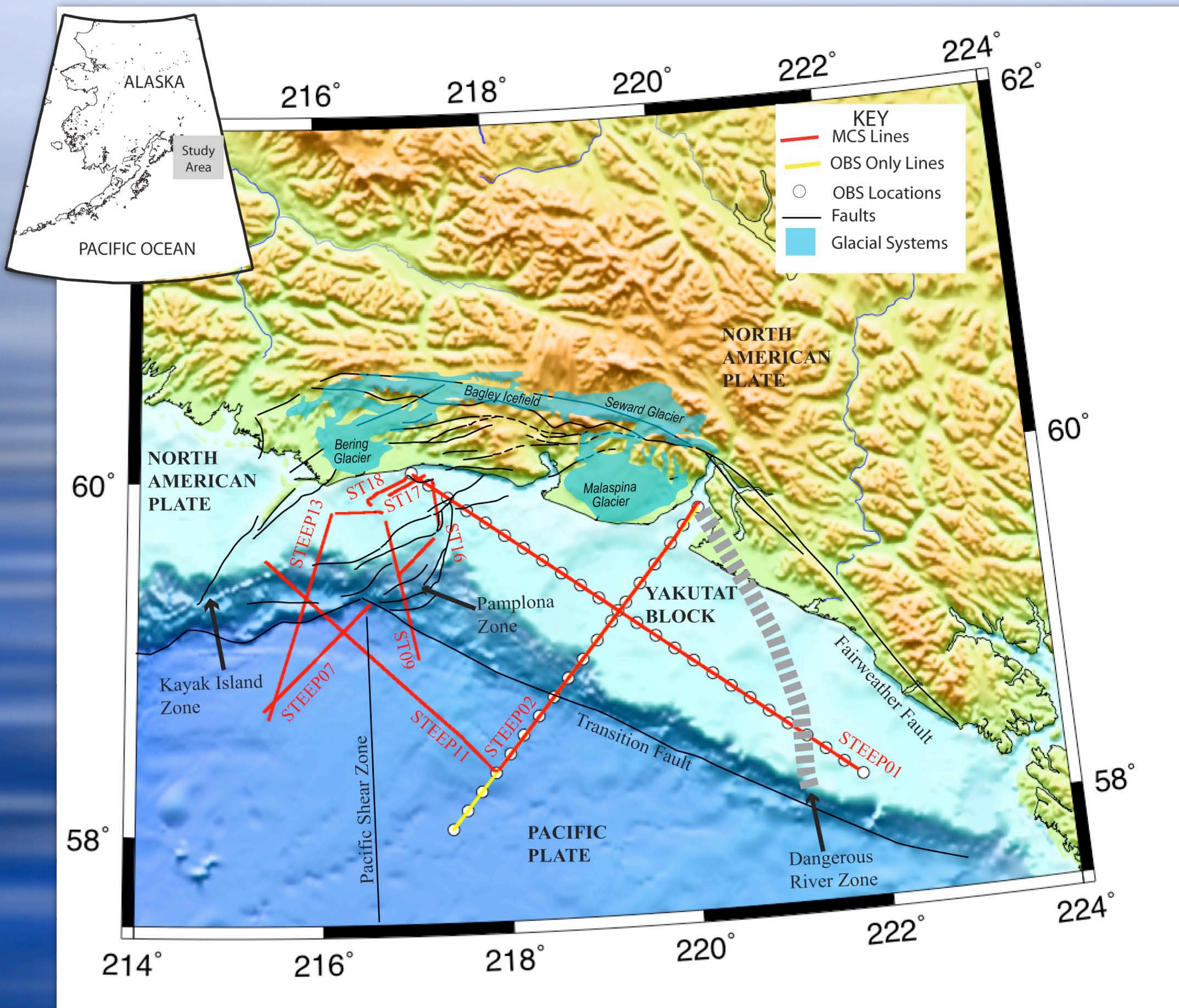
1. Has intense glacial erosion redistributed mass in the mountain range to change regional deformational patterns, and has erosion along deep glacial valleys been sufficient to localize crustal strains?

2. Is the mountain building driven primarily by underthrusting of a buoyant oceanic plateau or by collision of a small continental block attached to 'far traveled' ocean crust?

3. How does history of uplift & erosion affect climate along Gulf of AK margin, and over remainder of North America?

STEEP2008 - Offshore Seismic
Sept. 10- Oct. 6th


LEGEND
STEEP 2008 MCS Survey
Proposed IODP Sites 686
Weather Buoy
Surveyor Channel
144∞0'0"W
142∞0'0"W
140∞0'0"W
138∞0'0"W
136∞0'0"W
61∞0'0"N
60∞0'0"N
59∞0'0"N
58∞0'0"N
59∞0'0"N
58∞0'0"N
57∞0'0"N
146∞0'0"W
144∞0'0"W
142∞0'0"W
140∞0'0"W
138∞0'0"W
GOAL-15B
GOAL-17A
GOAL-16B
GOAL-09A
STEEP10
STEEP11
STEEP12
STEEP13
STEEP01
STEEP02
ST03
ST04
ST05
ST06
ST07
ST08
ST09
ST14
0 15 30 45 60 Kilometers


ALASKA
Study Area
PACIFIC OCEAN
KEY
MCS Lines
OBS Only Lines
OBS Locations
Faults
Glacial Systems
216°
218°
220°
222°
224°
62°
60°
58°
214°
NORTH AMERICAN PLATE
Bagley Icefield
Seward Glacier
Bering Glacier
Malaspina Glacier
ST18
ST17
STEEP13
ST16
ST09
STEEP07
STEEP11
STEEP02
STEEP01
YAKUTAT BLOCK
Pamplona Zone
Kayak Island Zone
Pacific Shear Zone
Transition Fault
Fairweather Fault
PACIFIC PLATE
Dangerous River Zone

Source

+Linear arrays produce a very clean source with excellent penetration

+Gunners were superb

-Only 3 gunners onboard

-No spares!

-Need to work on clusters

-Compressor issues

Recommend that the Langseth always sail with 5 gunners: 2 per shift and a head gunner

Recommend that there be a spare onboad for all single point of failure components (guns, compressors, etc.)

Streamer

+Recorded beautiful data in good and moderate weather

+Plenty of spares

+Excellent streamer handling + navigation

-Balance is vital as in poor weather a light, solid streamer can easily end up on the surface

-Sensitive to tension

Recommend a white paper be produced with specifics of operations including turning radius, deployment and recovery times, etc, so that future users can propose adequate contingency time

Numbers: ~10-14 hrs to deploy 8 km, ~6 hrs to recover but can go faster, turns 3 deg per min

Instrument Lab

+The instrument lab and associated systems were in good working order

+Past problems such as instability of the instrument rack in high sea states had been solved

+Technicians for the seismic recording system and navigation were a good mixture of extremely experienced staff originating in industry (Steinhaus and Martinson) and new homegrown staff that were learning rapidly from their more experienced colleagues

Recommend making the electronic display of shot gathers as acquired routine and not something the PI has to request


SYNTH

Onboard Processing

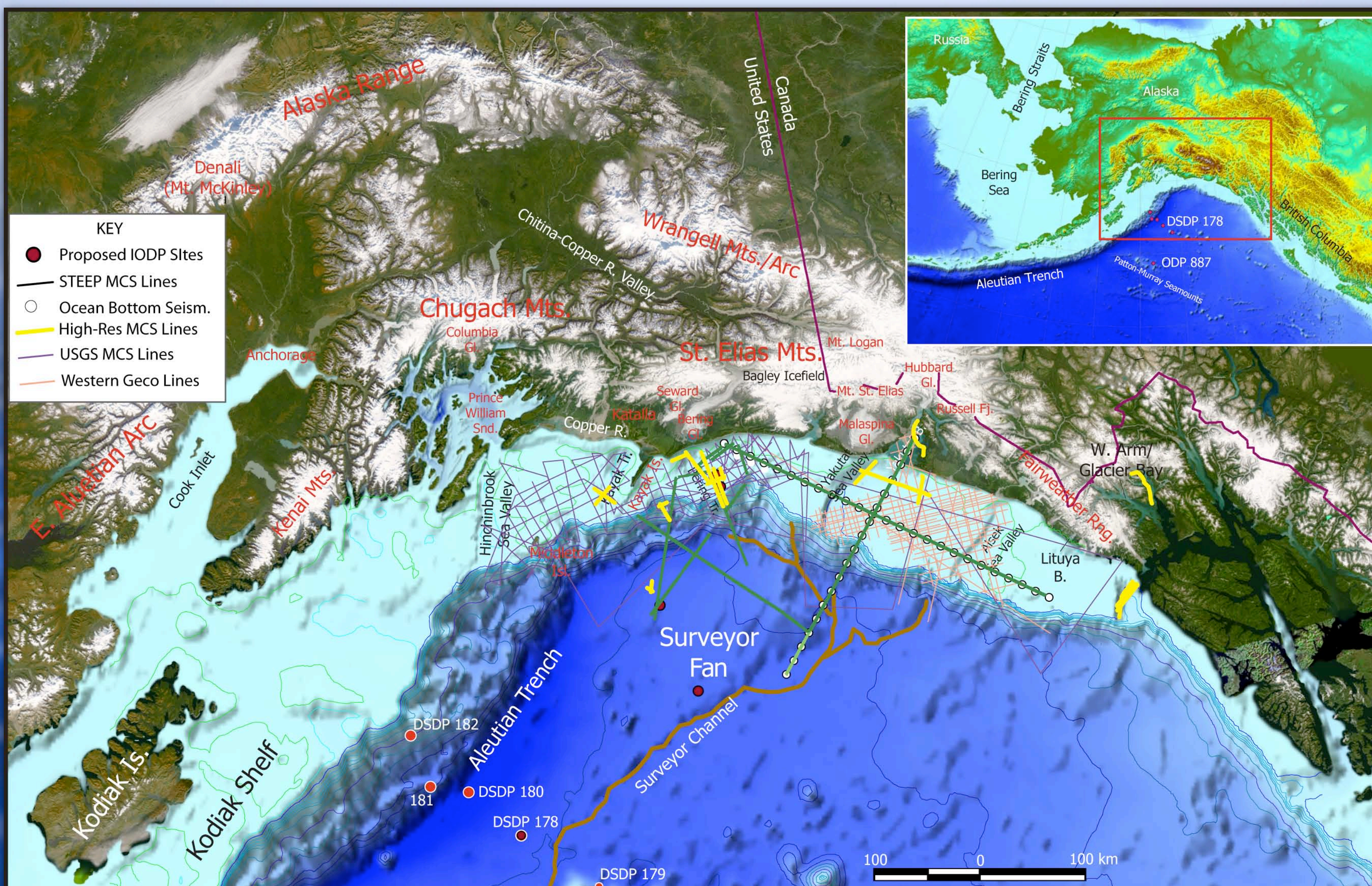
+Despite some data accessibility issues between certain machines, we in general were able to access the MCS and bathymetry data and process onboard

-A certain streamlining of the data archiving and reporting system with more transparency to the user would help operations

Recommend the creation of cookbooks for how a PI interfaces with the Langseth systems to retrieve each type of data

Recommend that LDEO have software in place to process gravity data upon the final gravity tie at the dock – STEEP data still at LDEO…

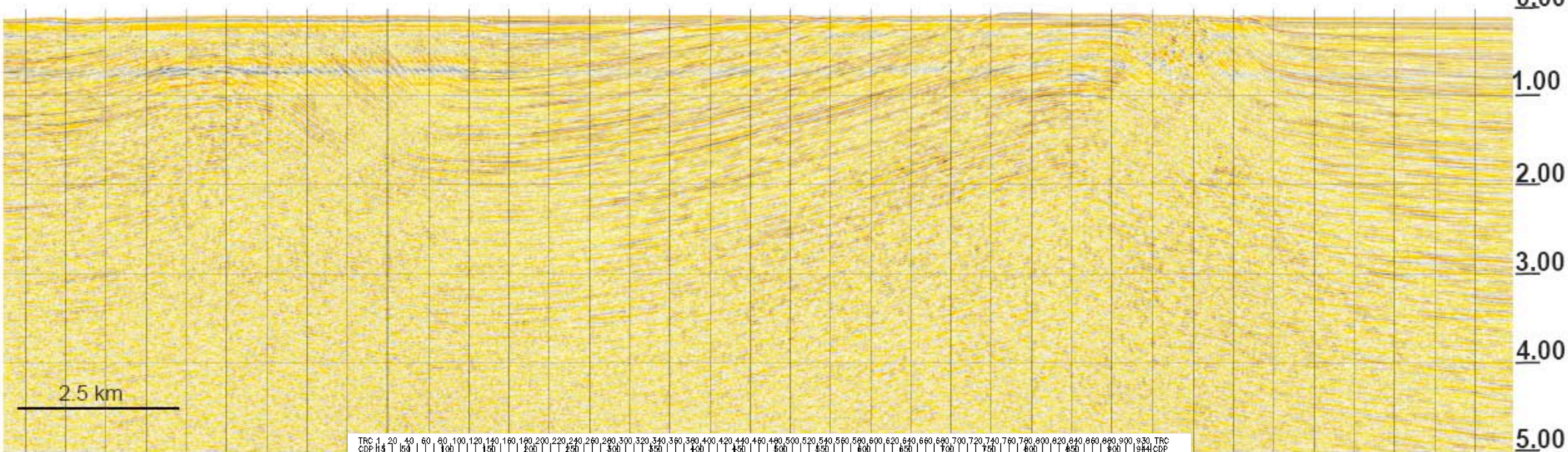
It is worth assuming that PIs will want all data as soon as possible after they are acquired

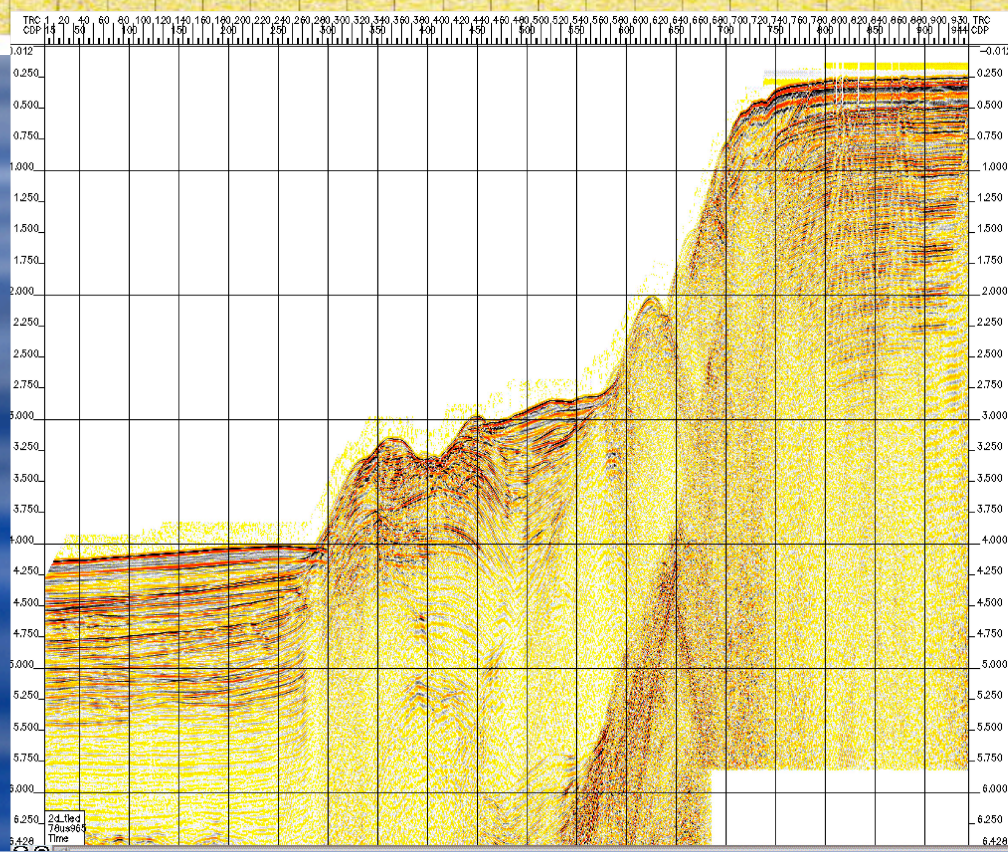


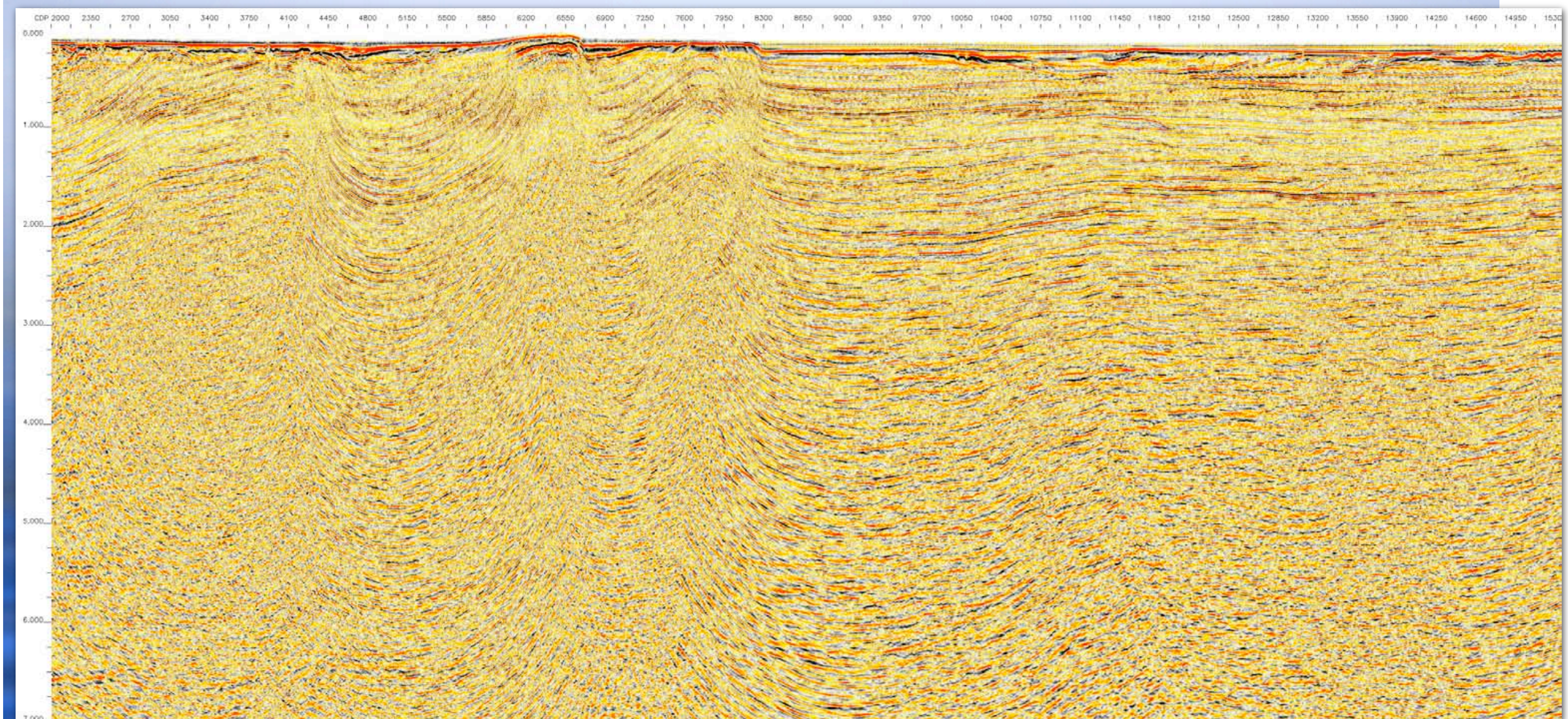
KEY
Proposed IODP SItes
STEEP MCS Lines
Ocean Bottom Seism.
High-Res MCS Lines
USGS MCS Lines
Western Geco Lines
Alaska Range
Denali (Mt. McKinley)
Chitina-Copper R. Valley
Wrangell Mts./Arc
United States
Canada
Chugach Mts.
Columbia Gl.
St. Elias Mts.
Mt. Logan
Bagley Icefield
Mt. St. Elias
Hubbard Gl.
Russell Fj.
Anchorage
Prince William Snd.
Seward Gl.
Katalla
Bering Gl.
Copper R.
Malaspina Gl.
W. Arm/ Glacier Bay
Fairweather Rng.
E. Aleutian Arc
Cook Inlet
Kenai Mts.
Hinchinbrook Sea Valley
Kayak Is.
Middleton Isl.
Yakutat Sea Valley
Alsek Sea Valley
Lituya B.
Surveyor Fan
Aleutian Trench
Surveyor Channel
Kodiak Is.
Kodiak Shelf
DSDP 182
181
DSDP 180
DSDP 178
DSDP 179
100
0
100 km
Russia
Bering Straits
Alaska
Bering Sea
DSDP 178
ODP 887
British Columbia
Aleutian Trench
Patton-Murray Seamounts

VE~3x

Pamplona Zone



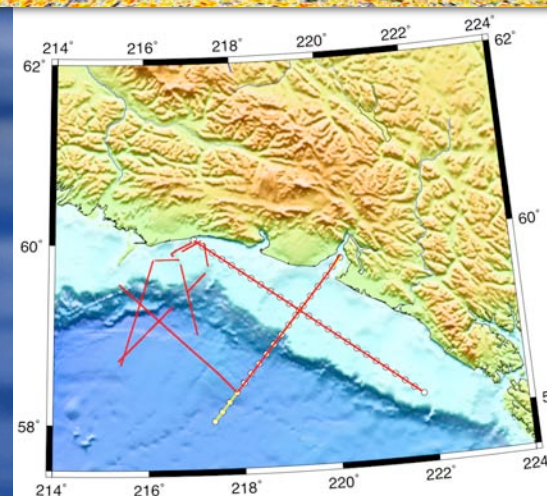


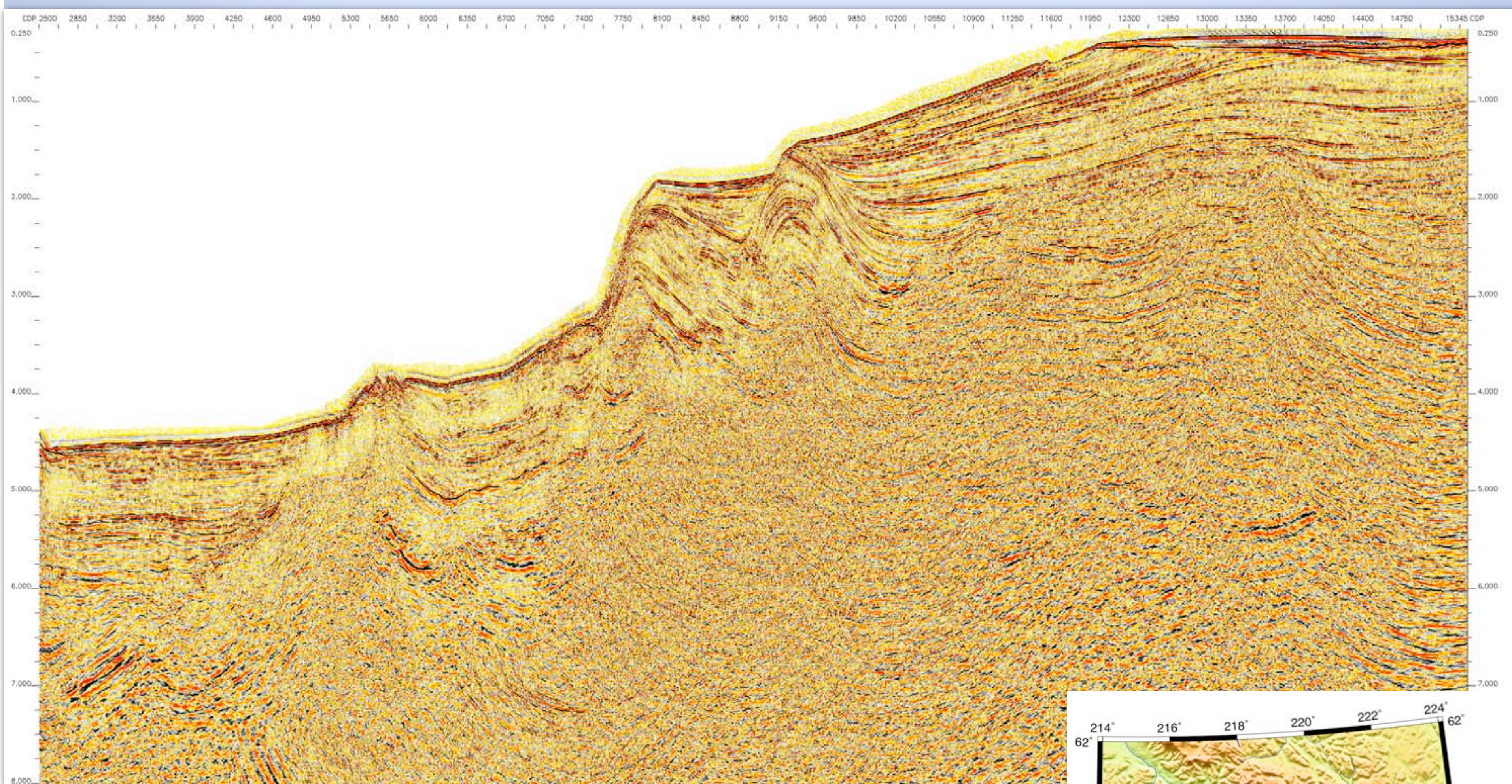


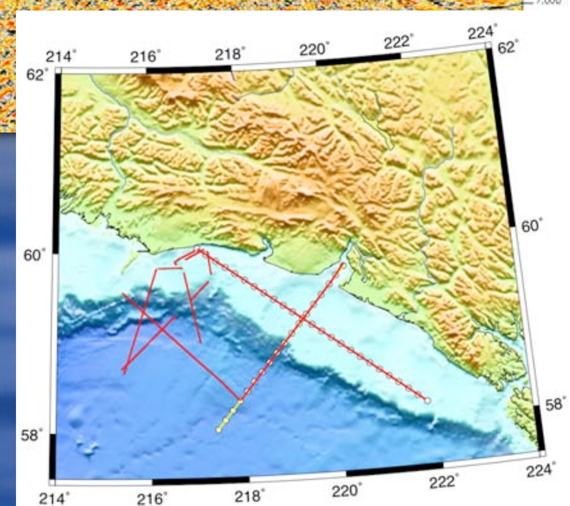
5 km

1.1 km

Sed Thickness = ~12 km



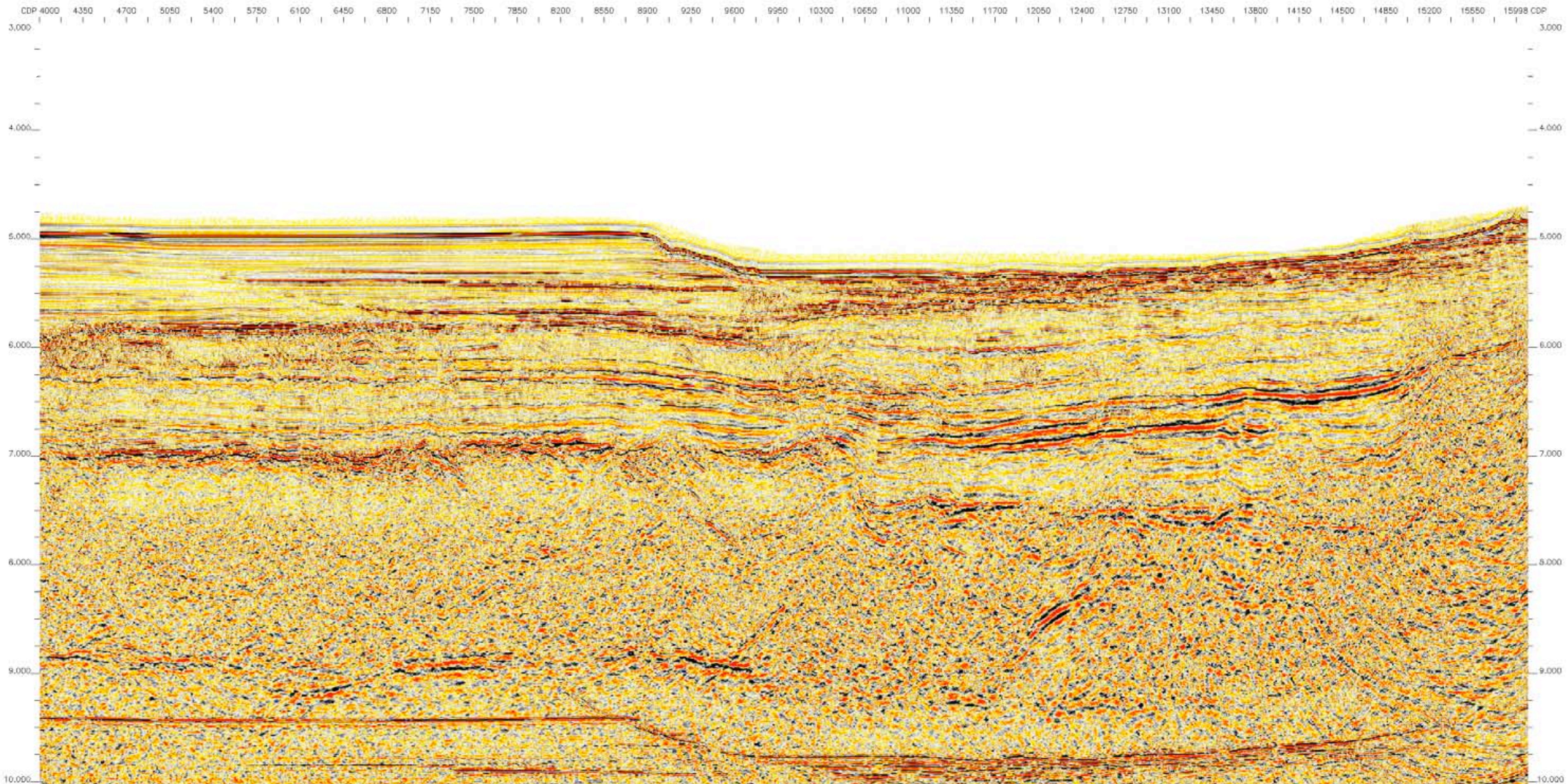


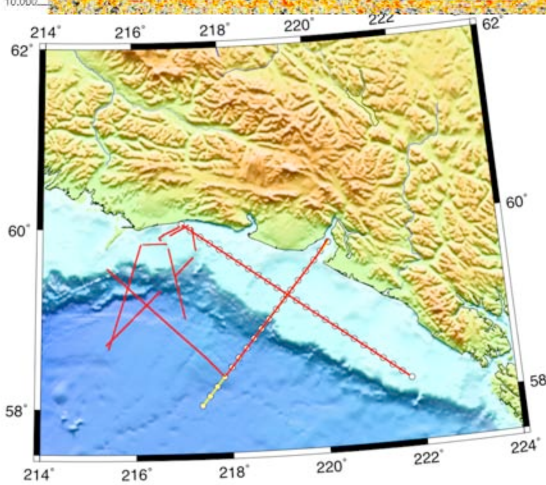


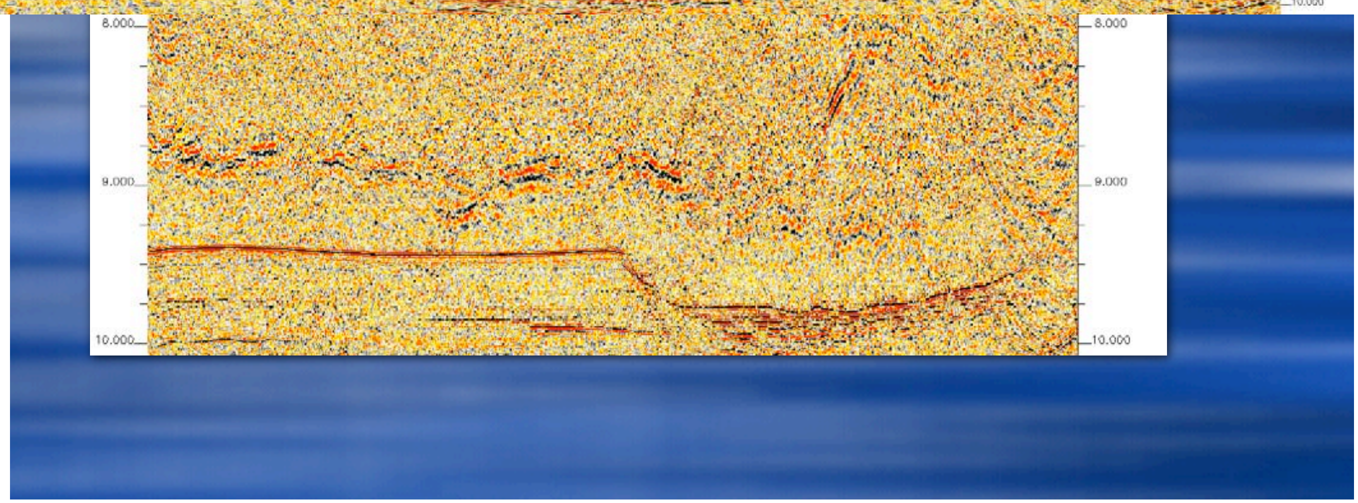
5 km

1.1 km

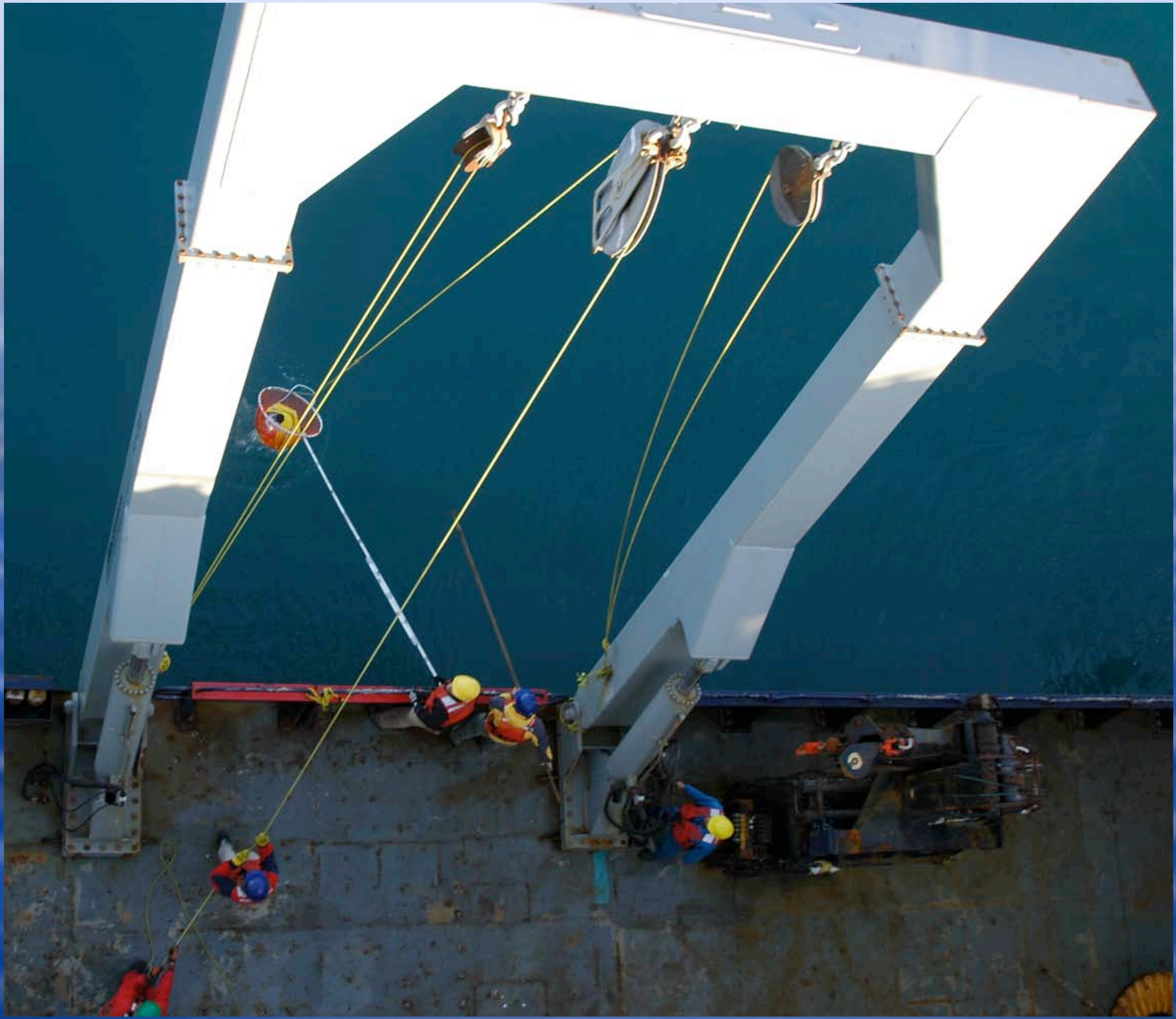
Sed Thickness = ~4.5 km (fan) and ~10 km (shelf)


CDP 4000 4350 4700 5050 5400 5750 6100 6450 6800 7150 7500 7850 8200 8550 8900 9250 9600 9950 10300 10650 11000 11350 11700 12050 12400 12750 13100 13450 13800 14150 14500 14850 15200 15550 15998 CDP
3.000
4.000
5.000
6.000
7.000
8.000
9.000
10.000


214°
216°
218°
220°
222°
224°
62°
60°
58°


8.000
9.000
10.000


A-72SVL



Starboard Deck Ops

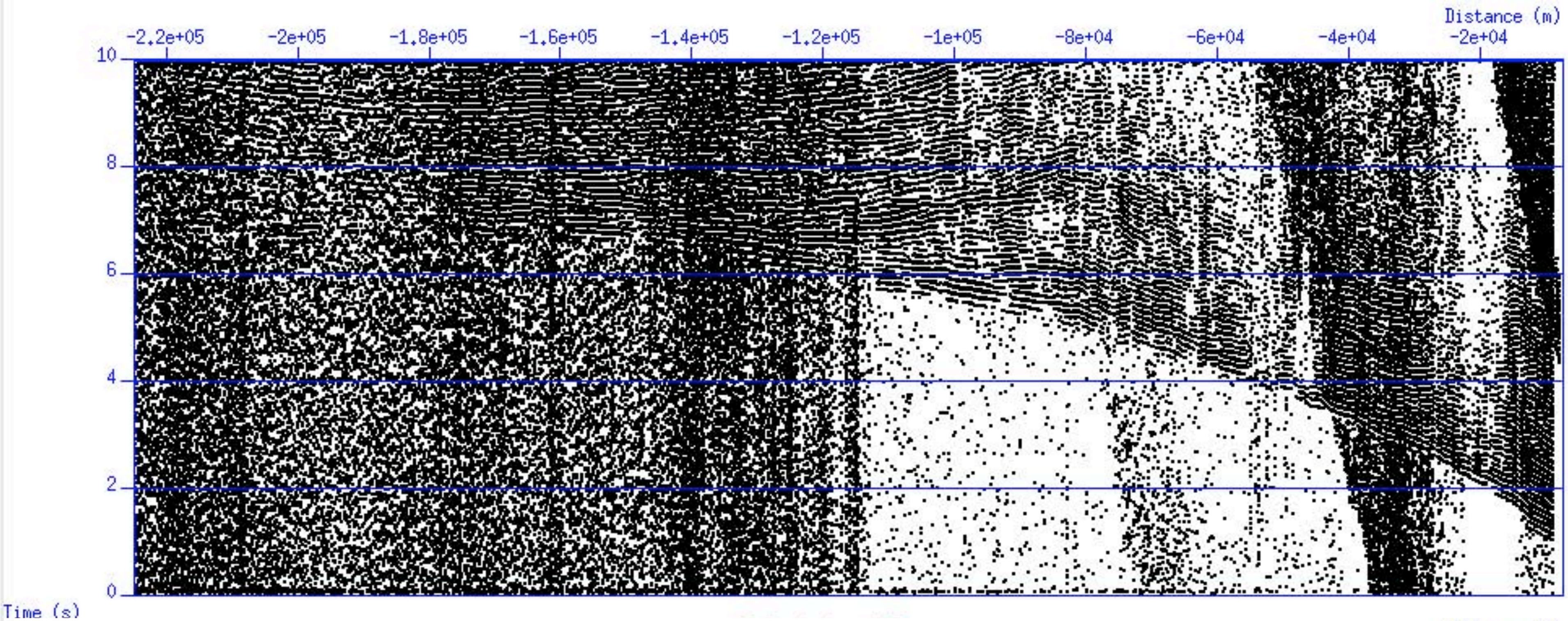
+Ship handling for OBS pickup was adequate and improved greatly throughout the cruise

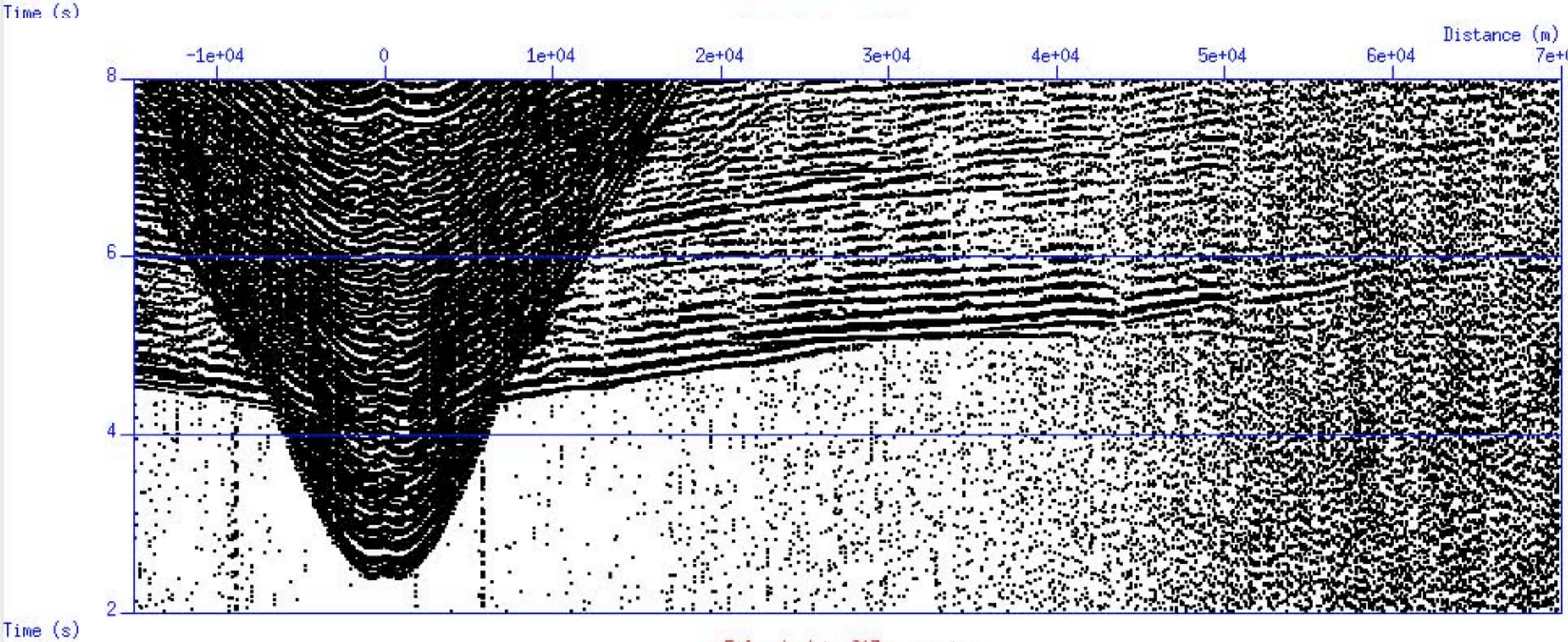
+Dry Lab and Wet Lab arrangement superb for OBS work

+Deployments with crane were smooth and safe

+/- Recovery by hand through A-frame was fine for these light weight instruments

Recommend a tugger line run through a block on the A-frame be set up for heavier deployment/recoveries





- File obsdata.217.segy.win -

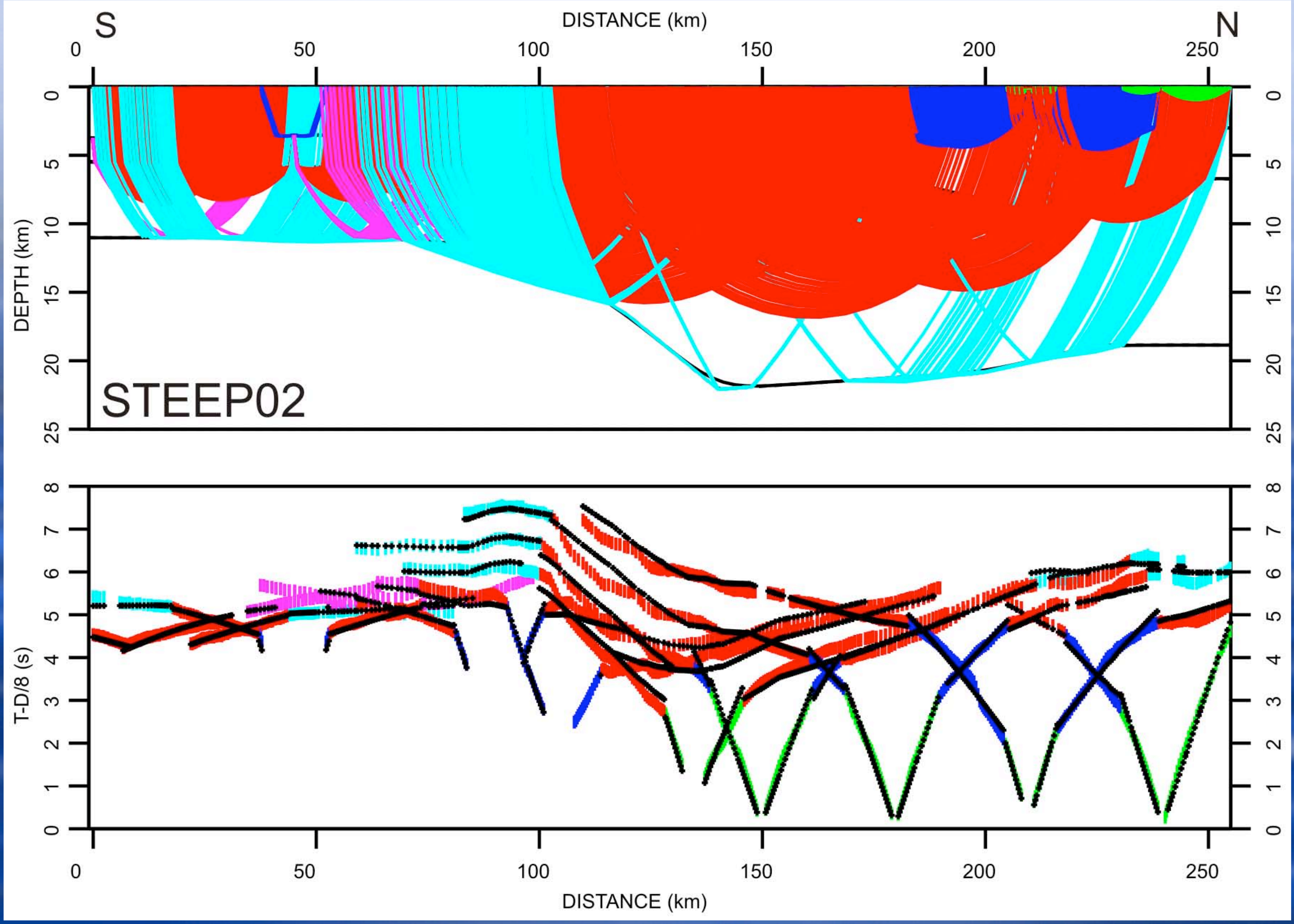
OBS Recording

+Sources provided excellent long offset data

-One issue that persisted from previous cruises was the generation of accurate shot times required for OBS data processing
-The recorded shot time files from Wet Lab feed were found to be inaccurate

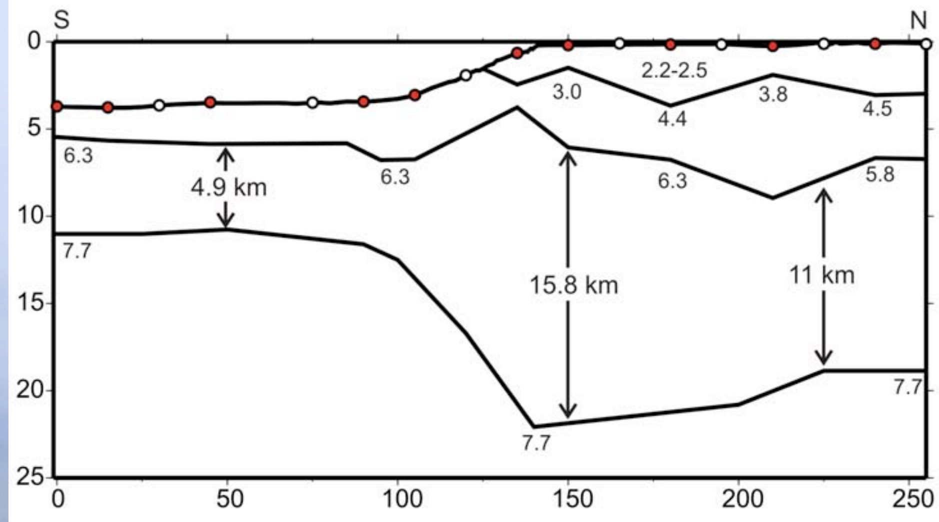
+/-We eventually obtained shot times using Spectra header files and code written by Dan Lizaralde (kindly provided via e-mail during the cruise)

However we do understand that LDEO is working on addressing this issue during the transit

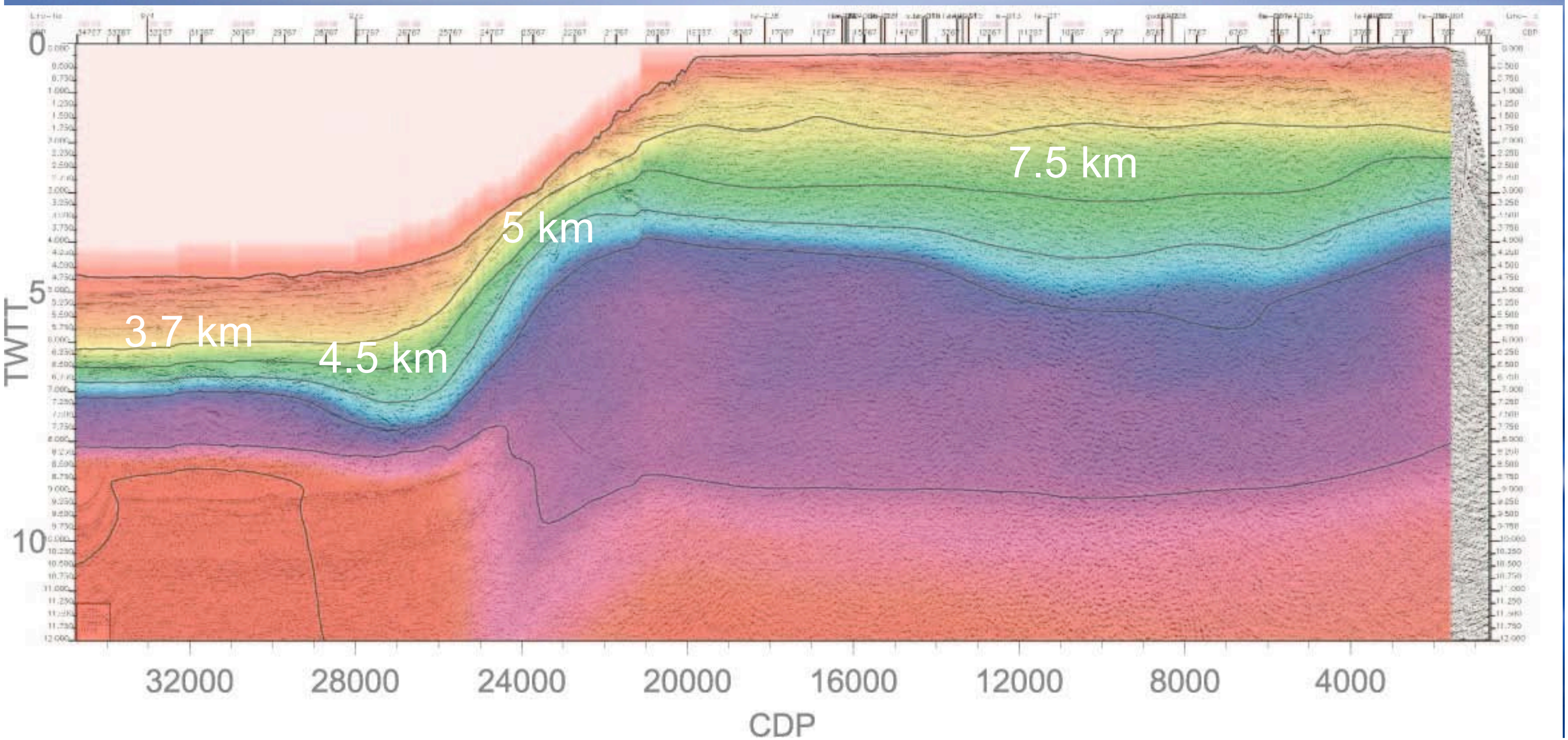


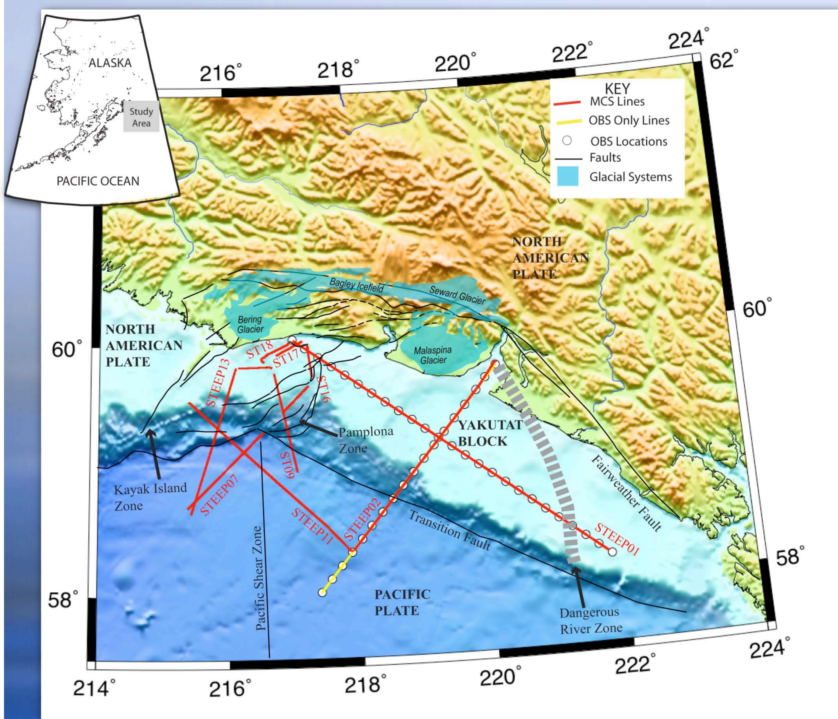
S
N
DISTANCE (km)
0
50
100
150
200
250
DEPTH (km)
0
5
10
15
20
25
STEEP02
T-D/8 (s)
0
1
2
3
4
5
6
7
8
DISTANCE (km)

Avg: 3.3 km/s



Avg: 3.7 km/s





Operational Planning and Chain of Command

Programs such as STEEP planned years in advance and in concert with onland operations down to the minute; changes need to be suggested well in advance of cruise; unless there is an incident at sea, operational decisions should be left to Captain, Tech-in-charge, and Chief Scientists who are fully informed of events

Marine mammal mitigation strategies should be worked out prior to the cruise and in questions of interpretation be a dialogue between MMOs, Captain, Tech-in-charge and Chief Scientists

Habitability and Safety

+Food was excellent

+Quarters more than adequate; could use some cleaning and updating

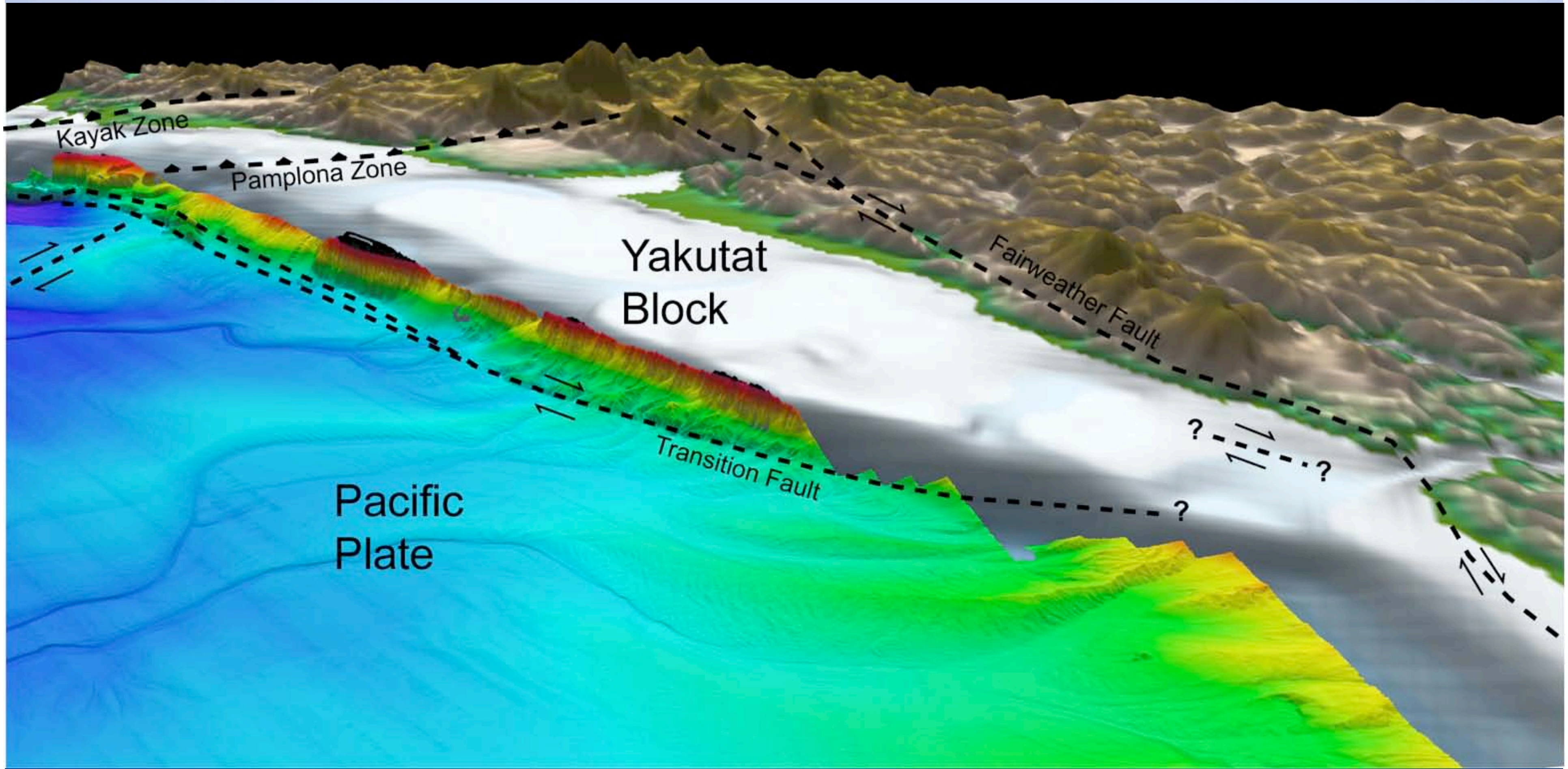
+Offtime activities nice

-AC in lab (choice between freezing or getting gassed out)

-No heat!

-Water...

+/-Safety in general up to standards however...would be nice to have a working rescue boat!



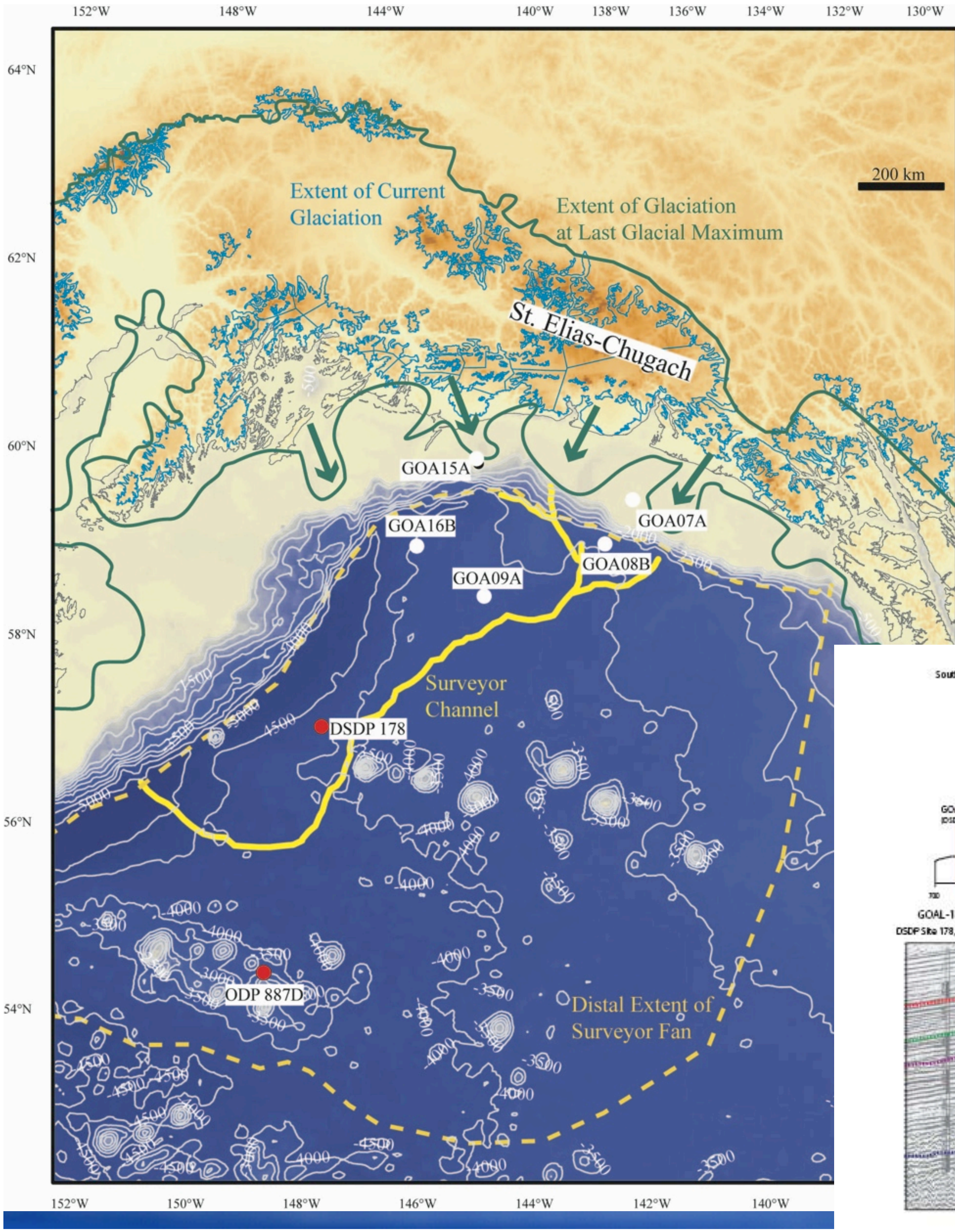
Produced new images of Pamplona Zone, Dangerous River Zone, and Transition fault

Penetrated to basement for the first time in the Gulf of Alaska

Recorded arrivals through entire thickness of Yakutat Block

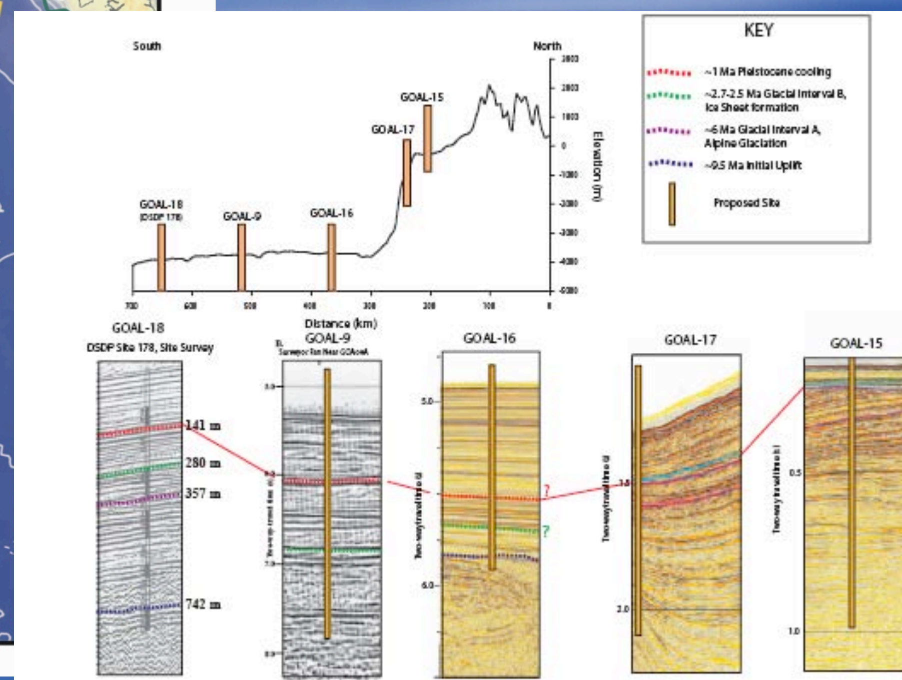
See posters on Friday for science results (T53B-1941, T53B-1942)

Image from Gulick et al., Geology 2007



Extent of Current Glaciation
Extent of Glaciation at Last Glacial Maximum
St. Elias-Chugach
200 km
GOA15A
GOA16B
GOA09A
GOA07A
GOA08B
Surveyor Channel
DSDP 178
ODP 887D
Distal Extent of Surveyor Fan
152°W
148°W
144°W
140°W
138°W
136°W
134°W
132°W
130°W
64°N
62°N
60°N
58°N
56°N
54°N
150°W
146°W
142°W

JOIDES Resolution



South
North
KEY
~1 Ma Pleistocene cooling
~2.7-2.5 Ma Glacial Interval B, Ice Sheet formation
~6 Ma Glacial Interval A, Alpine Glaciation
~9.5 Ma Initial Uplift
Proposed Site
GOAL-18 (DSDP 178)
GOAL-9
GOAL-16
GOAL-17
GOAL-15
Elevation (m)
Distance (km)
GOAL-18
DSDP Site 178, Site Survey
141 m
280 m
357 m
742 m
GOAL-9
GOAL-16
GOAL-17
GOAL-15

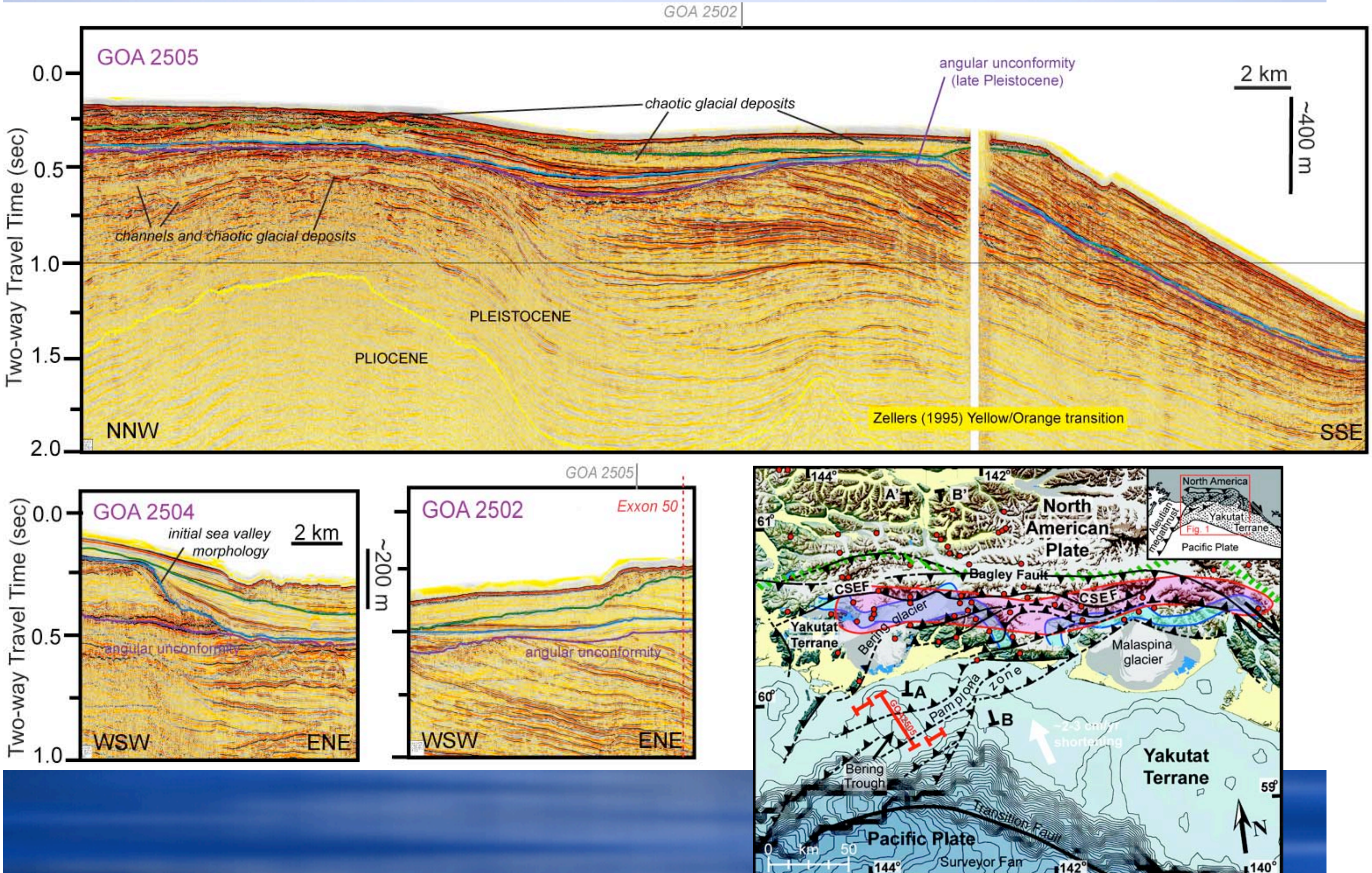
For Your Consideration, Recommend that

1. the Langseth always sail with 5 gunners: 2 per shift and a head
2. there be a spare onboard for all single point of failure items
3. a white paper be produced with specifics of operations including turning radius, deployment and recovery times, etc,
4. the electronic display of shot gathers as acquired be routine
5. LDEO create cookbooks for how a PI interfaces with the Langseth systems to retrieve each type of data
6. LDEO have software in place to process gravity data upon the final gravity tie at the dock
7. a tugger line run through a block on the A-frame be set up for heavier deployment/recoveries
8. the correct shot times be logged in the lab and made available in the wet lab for OBS clock corrections
9. water, AC in lab, lack of heat issues be handled
10. the recue boats be repaired
11. timing of cruise plan changes, operational decisions and chain of command issues be discussed

Thanks to Captain, Crew and Techs of the R/V *Marcus G. Langseth*!

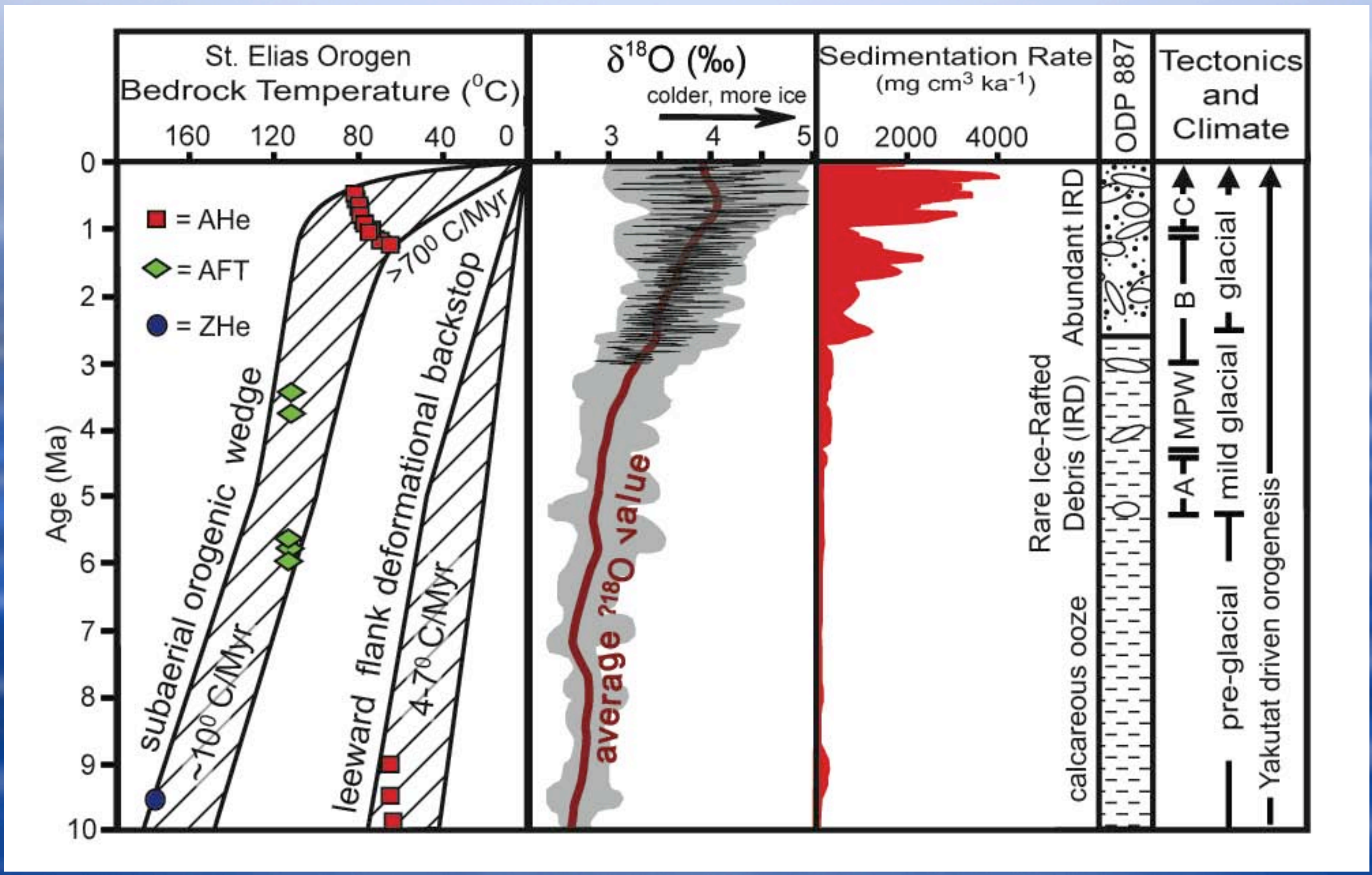
Quaternary Tectonic Model

Berger et al., Nature Geosciences, 2008

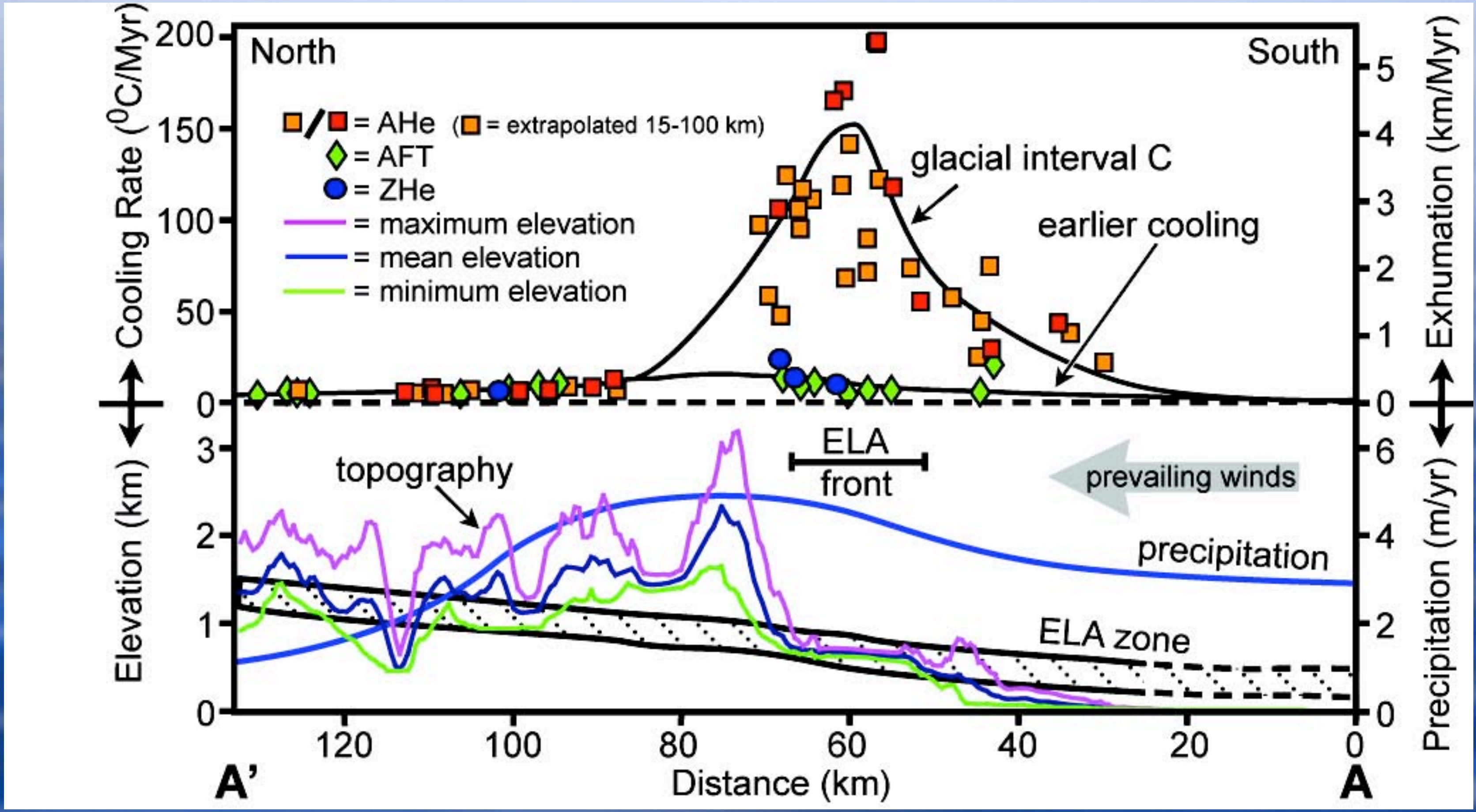


Berger et al., Nature Geosciences, 2008

Increase in Cooling rate at ~1-0.7 Ma corresponds to glacial interval C

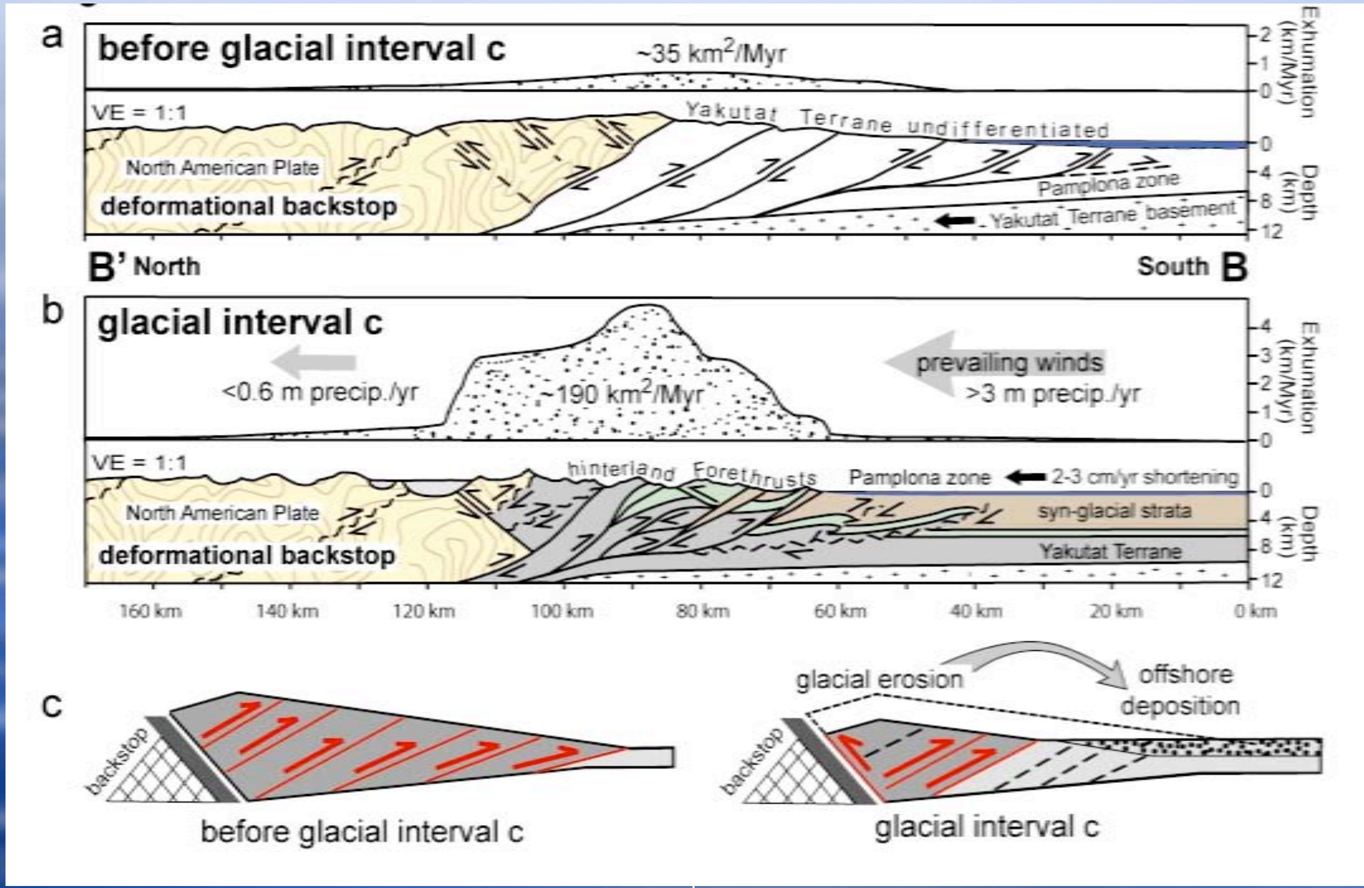


Berger et al., Nature Geosciences, 2008



Berger et al., Nature Geosciences, 2008

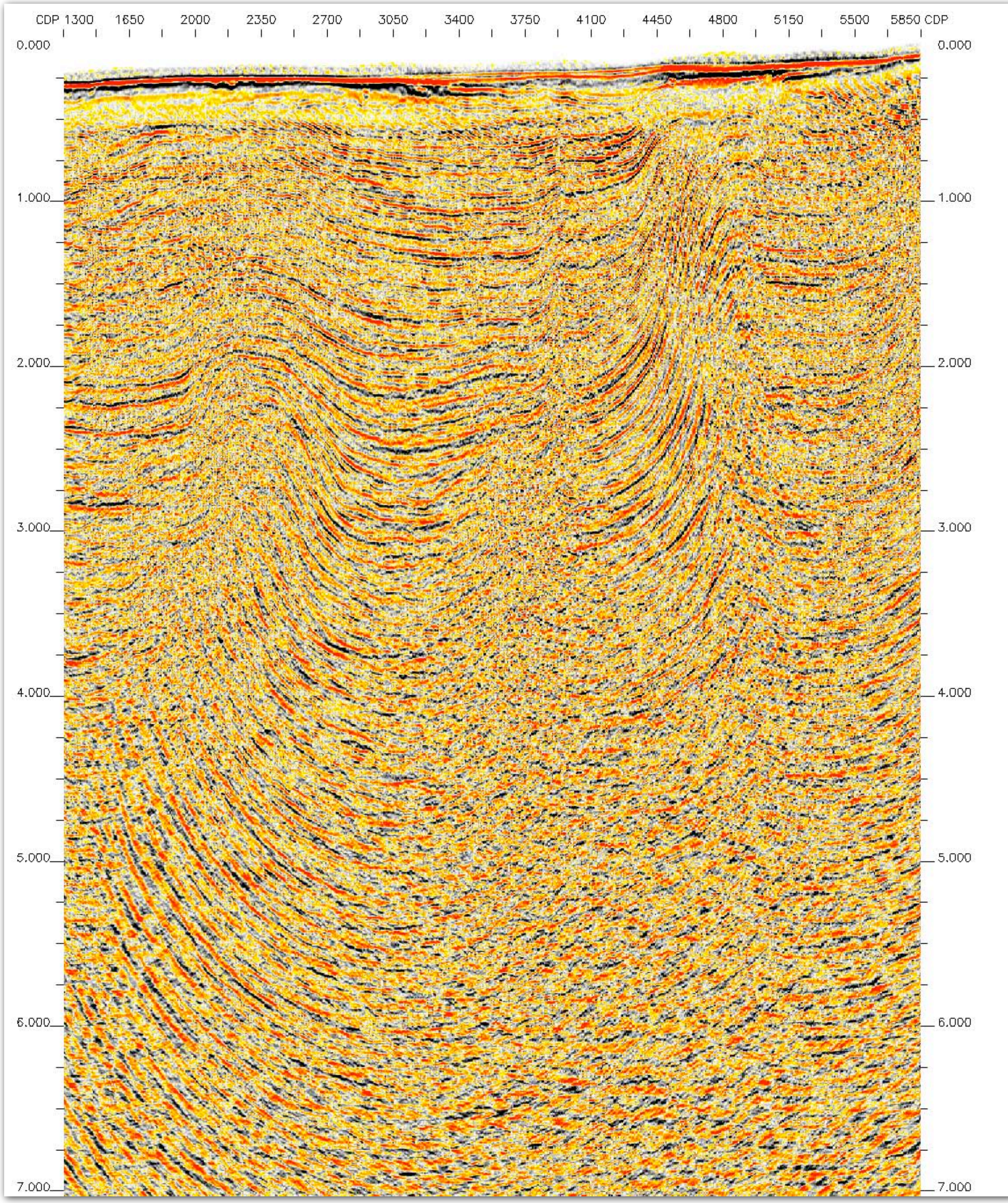
Proposed model of orogen kinematics as influenced by climate change in a glaciated wedge



- Singly-vergent system
- Deformation distributed over a wider zone
- Foreland propagation of thrust sheets

- Active backthrust
- Seaward deformation front largely inactive
- Deformation focused beneath ELA front

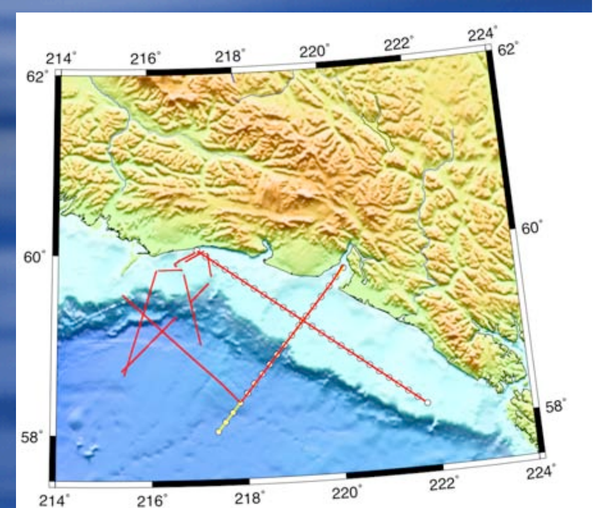
Refines the classic "buzz saw" model and demonstrates the importance of climate during orogenesis

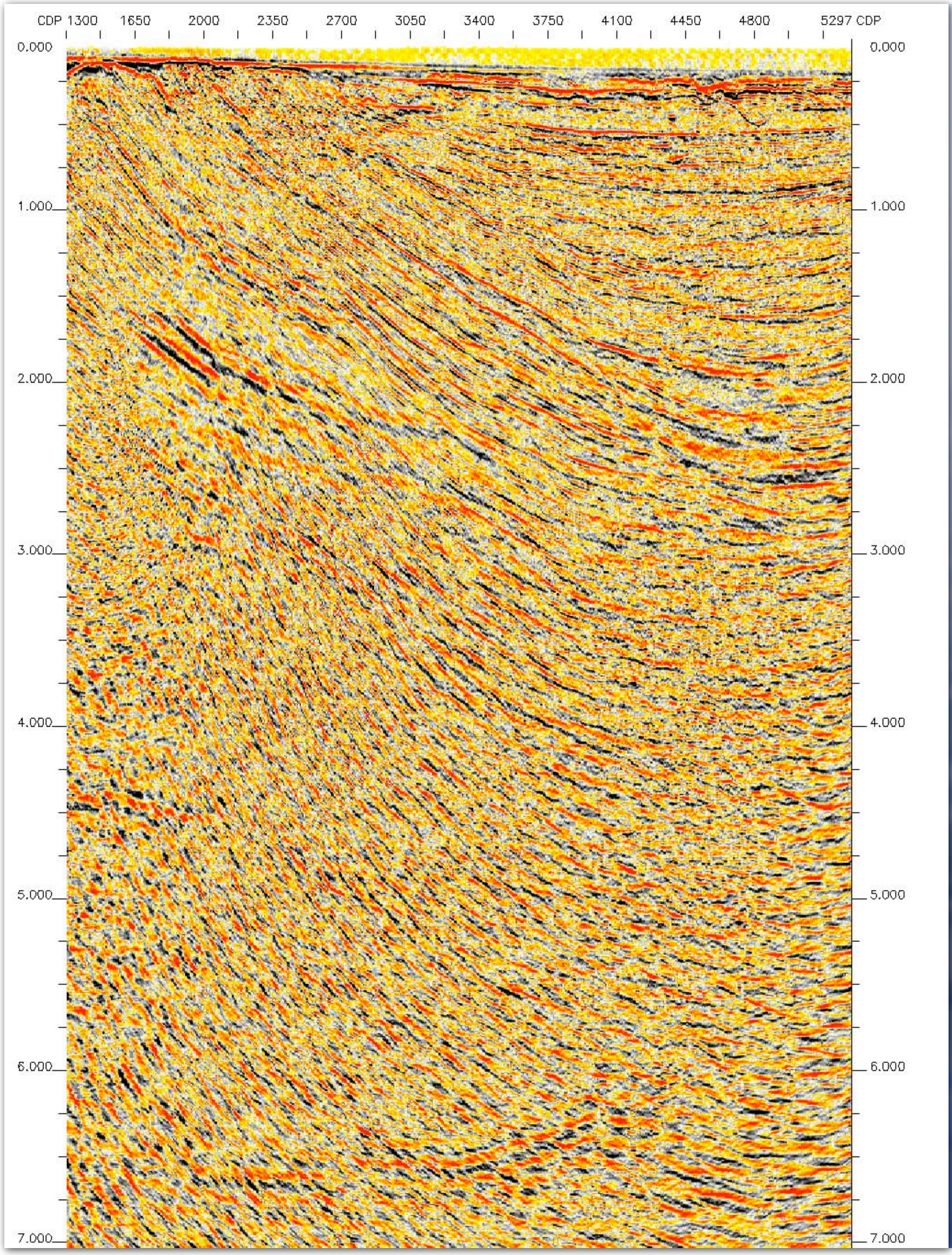


5 km

1.1 km

Sed Thickness = ~12.5 km

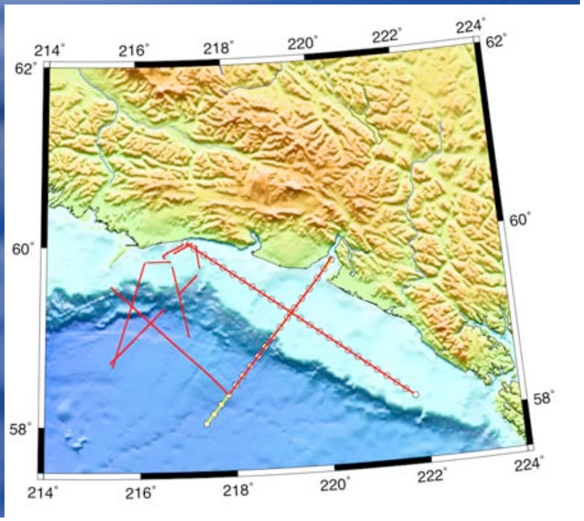


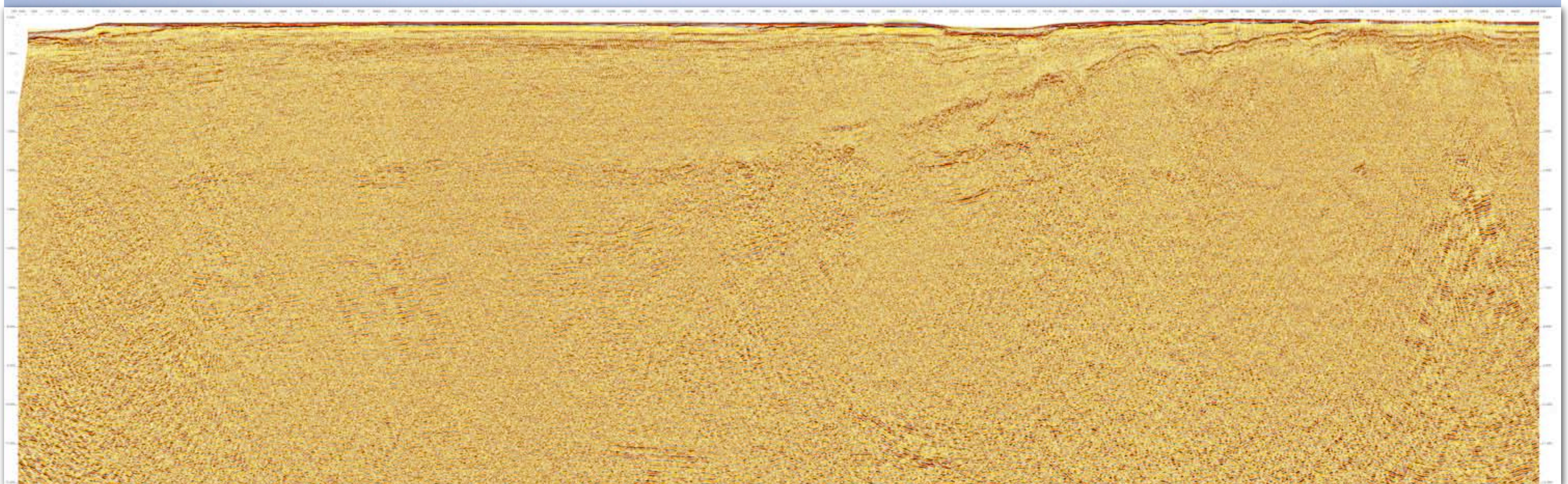


5 km

1.1 km

Sed Thickness = ~12.5 km

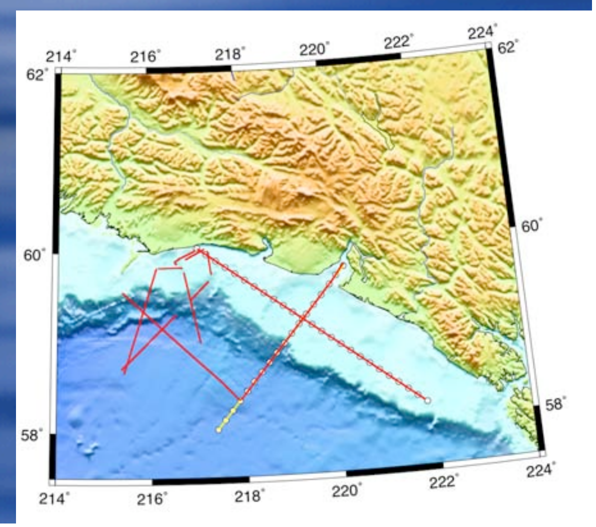


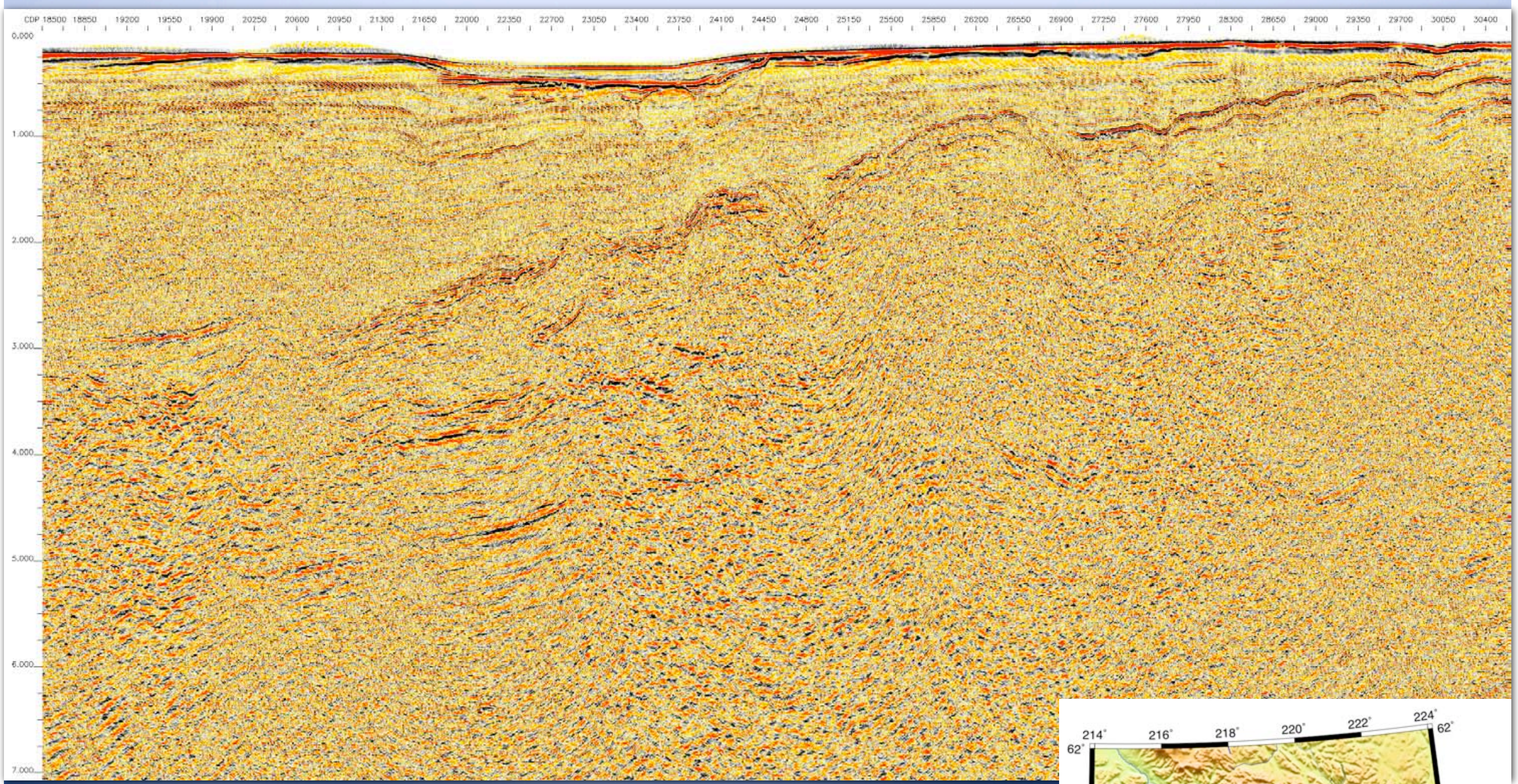


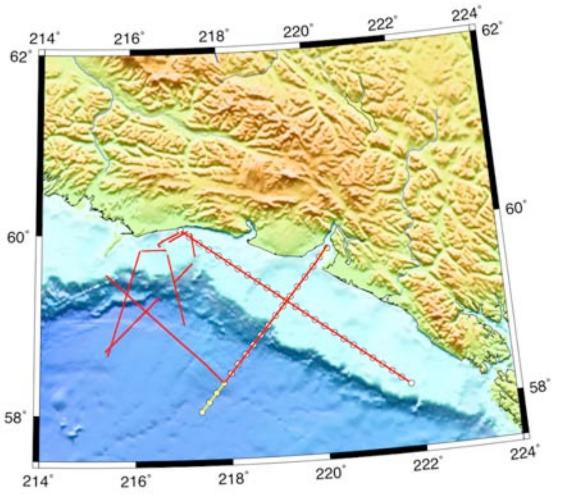
5 km

1.1 km

Sed Thickness = ~7.5 km



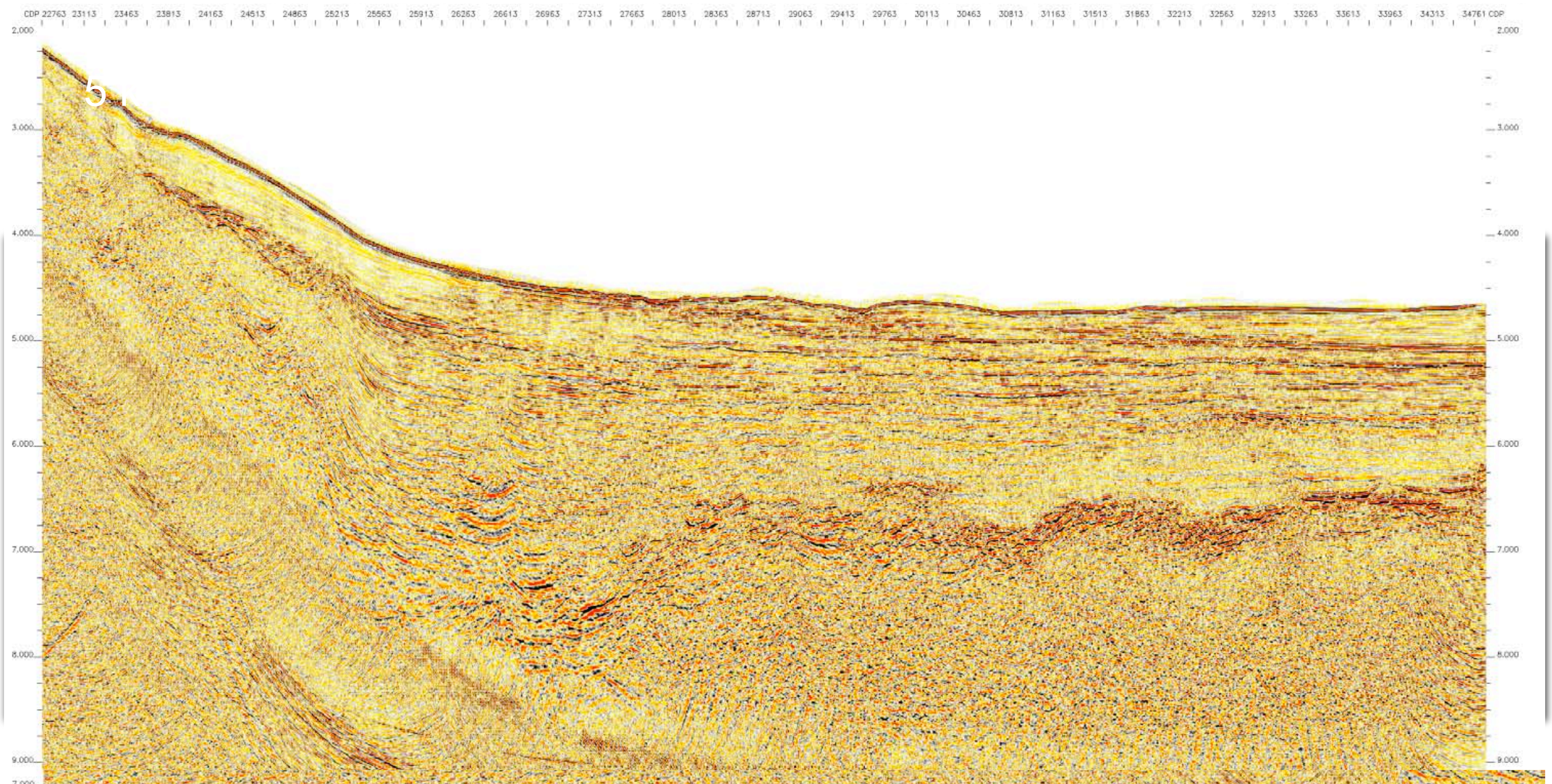


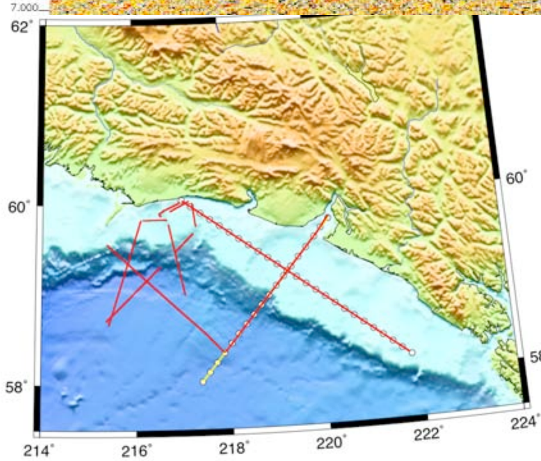


5 km

1.1 km

Sed Thickness = ~7.5 km





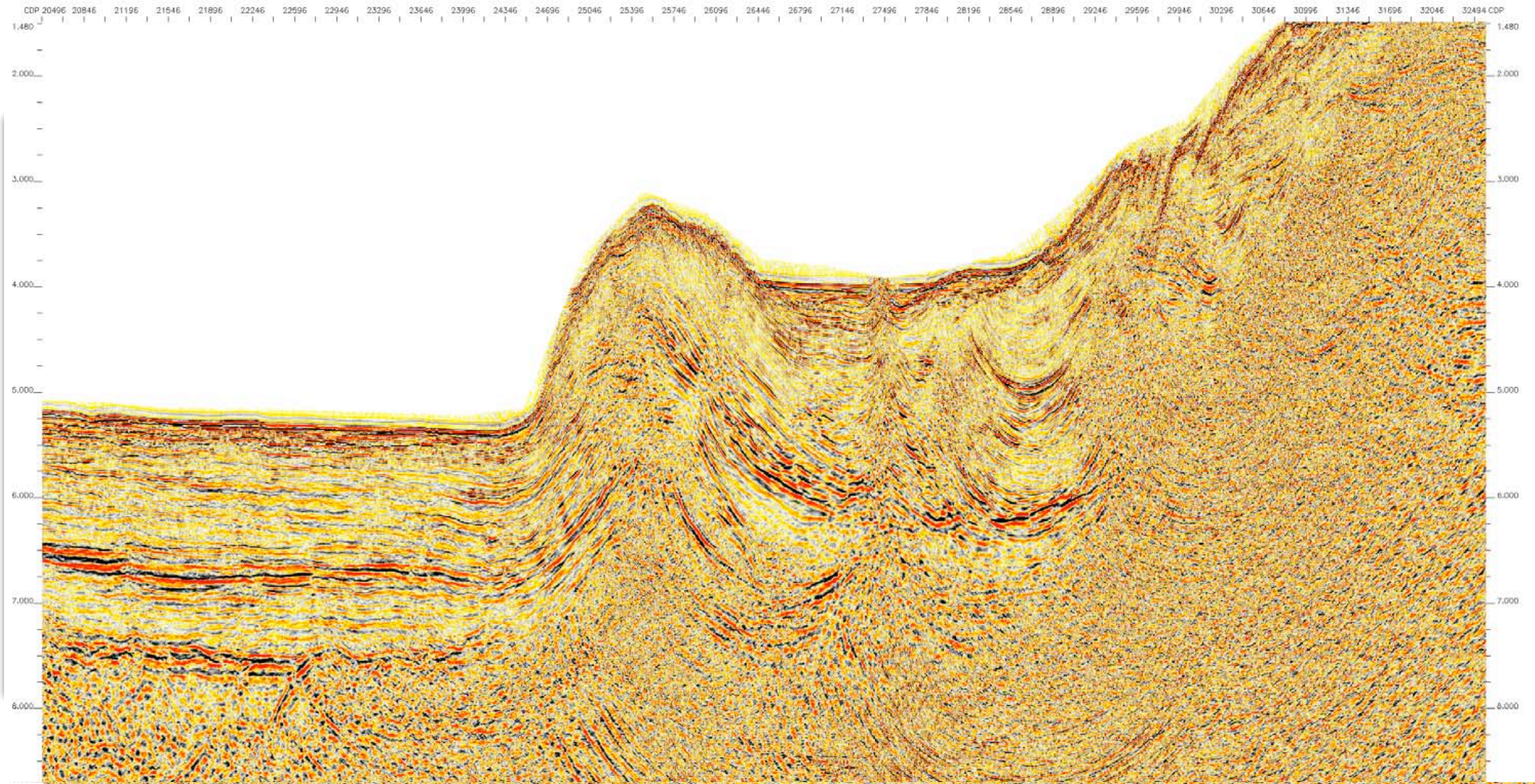
5 km

1.1 km

Sed Thickness Shelf = ~7.5 km

Sed Thickness Slope = ~5 km

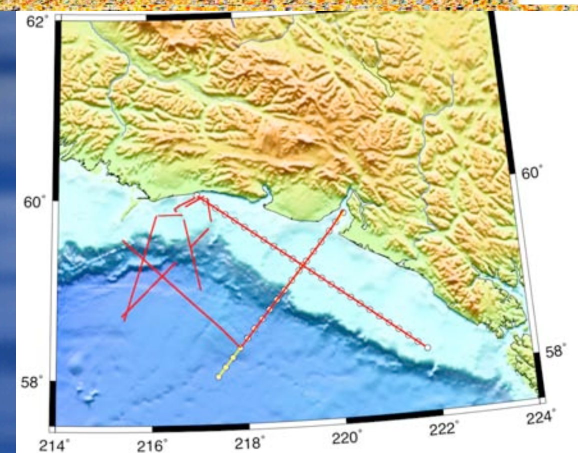
Sed Thickness Fan = ~3.3-5 km

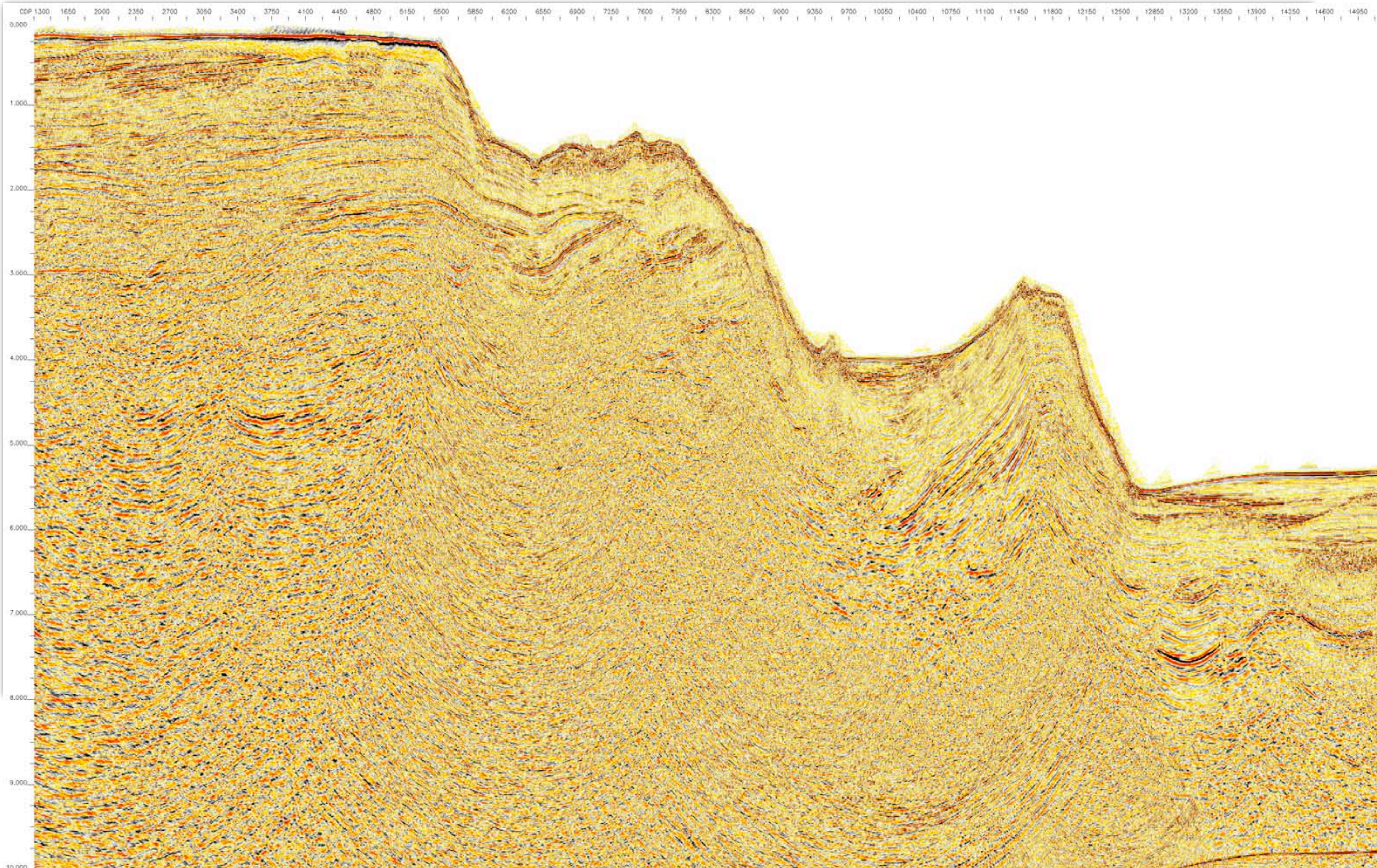


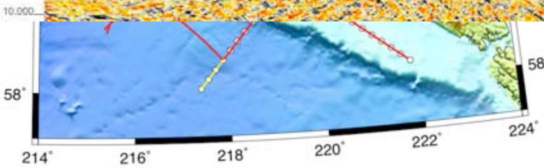
5 km

1.1 km

Sed Thickness = up to 4.2 km




CDP 1300
0.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
9.000
10.000


58°
58°
214°
216°
218°
220°
222°
224°