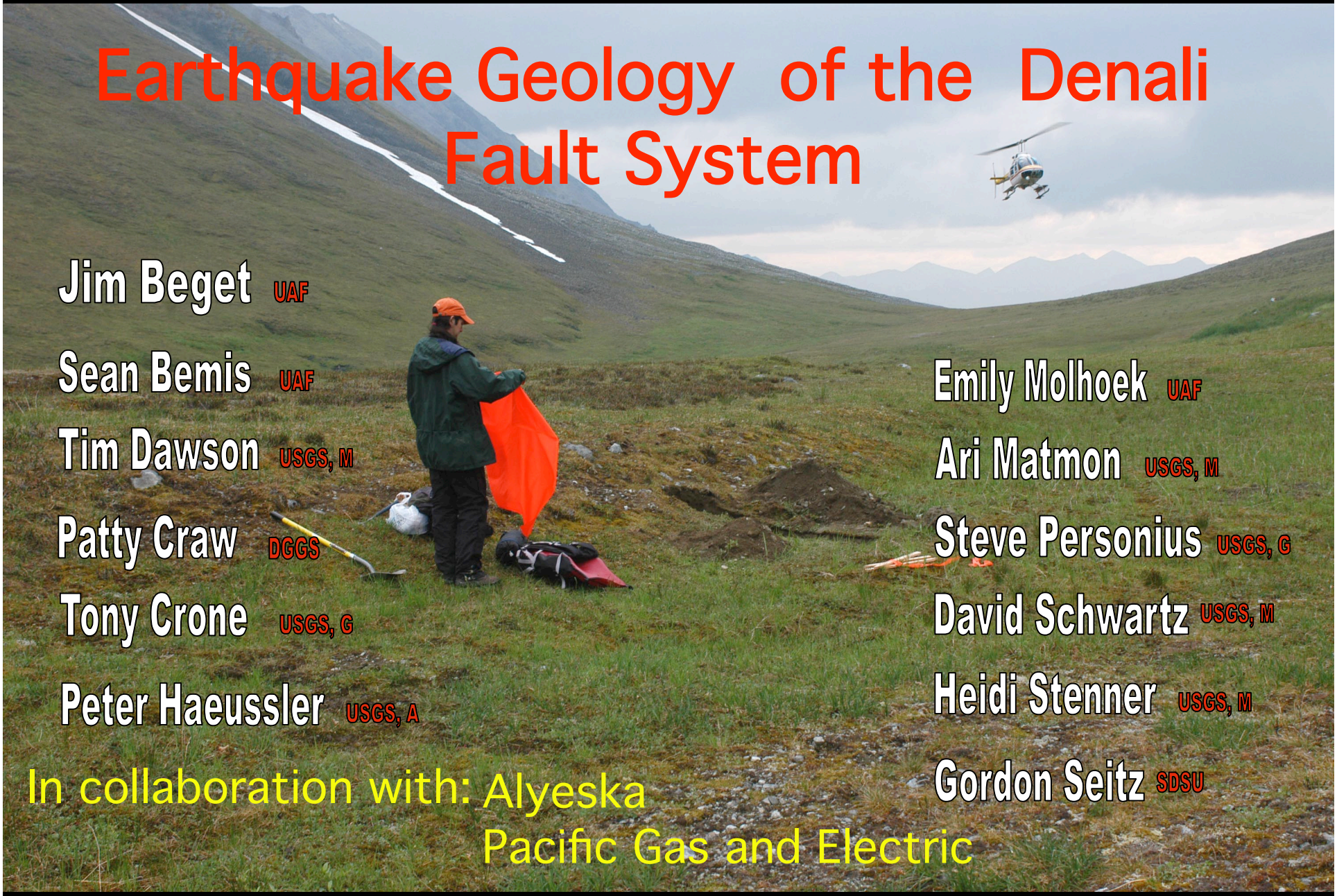
Earthquake Geology of the Denali Fault System



Jim Beget UAF

Sean Bemis UAF

Tim Dawson USGS, M

Patty Craw DGGS

Tony Crone USGS, G

Peter Haeussler USGS, A

Emily Molhoek UAF

Ari Matmon USGS, M

Steve Personius USGS, G

David Schwartz USGS, M

Heidi Stenner USGS, M

Gordon Seitz SDSU

In collaboration with: Alyeska

Pacific Gas and Electric

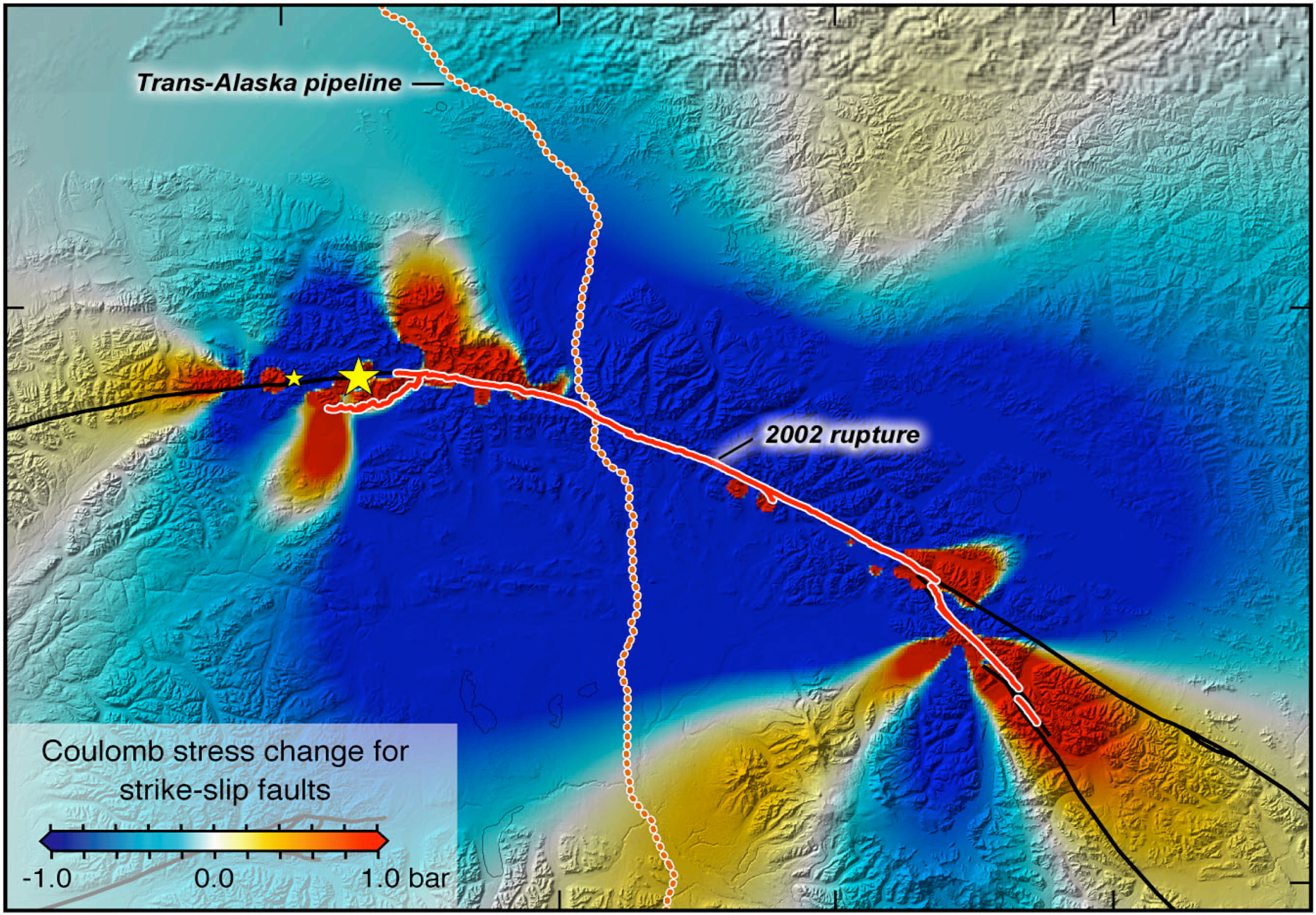
Why Denali? Behavior of large strike-slip systems

Large historical event for slip distribution
Environment of geomorphic preservation
Ubiquitous datable material



Paleoearthquake ages
Paleo-offsets,slip/event
Slip rates

Recurrence models
Fault segmentation
Time-dependent behavior/hazards



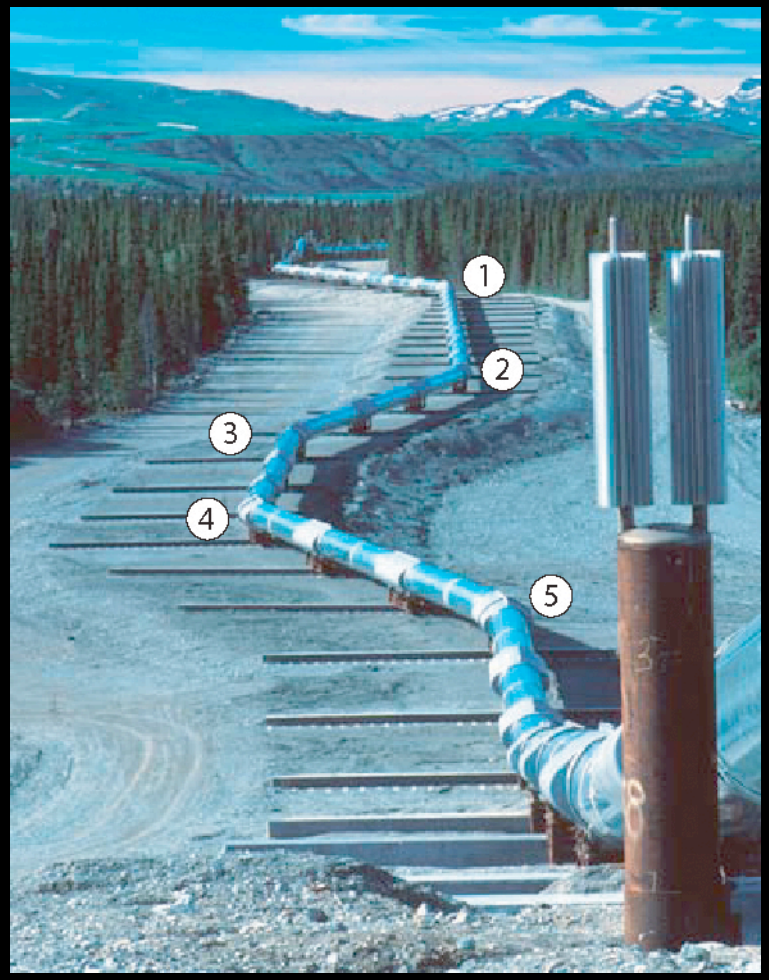
Stress changes caused by the Denali rupture


Km 140
Slate Creek
July 2004


Km 123
Canwell Glacier
November 2002


Km 179
Gillett Pass
July 2003

Before



After



Denali fault at Trans Alaska Pipeline

Slip Distribution: 2002 Denali-Totschunda Rupture

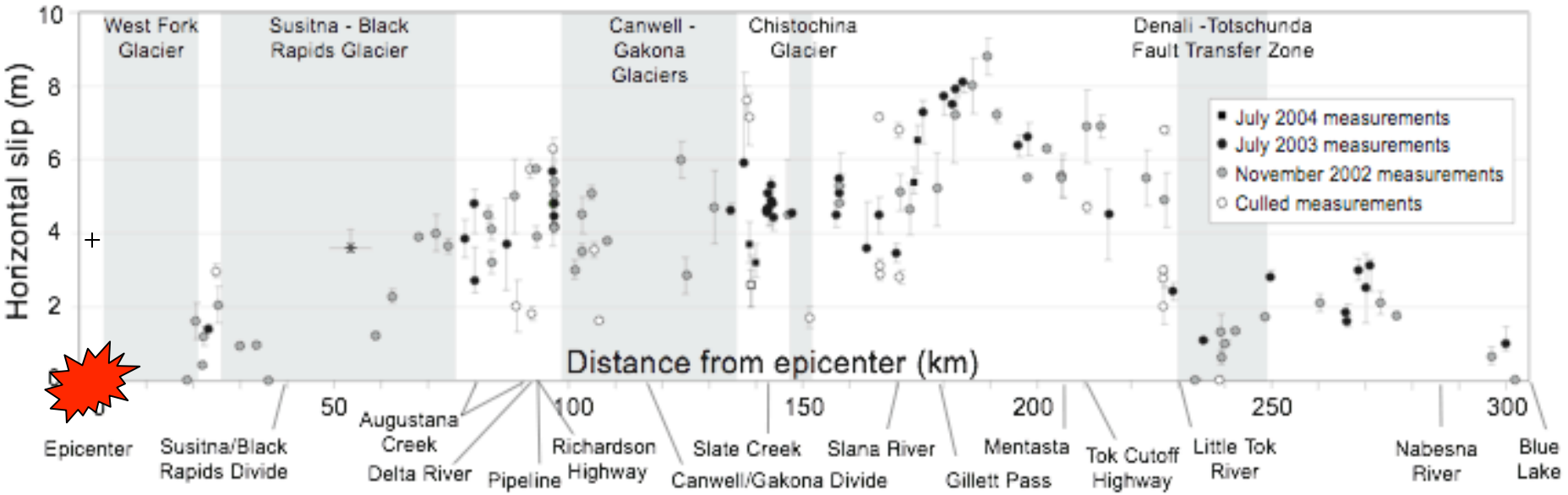


Figure 9.

Haeussler et al (in press)

Estimates of Average Slip

M 7.8

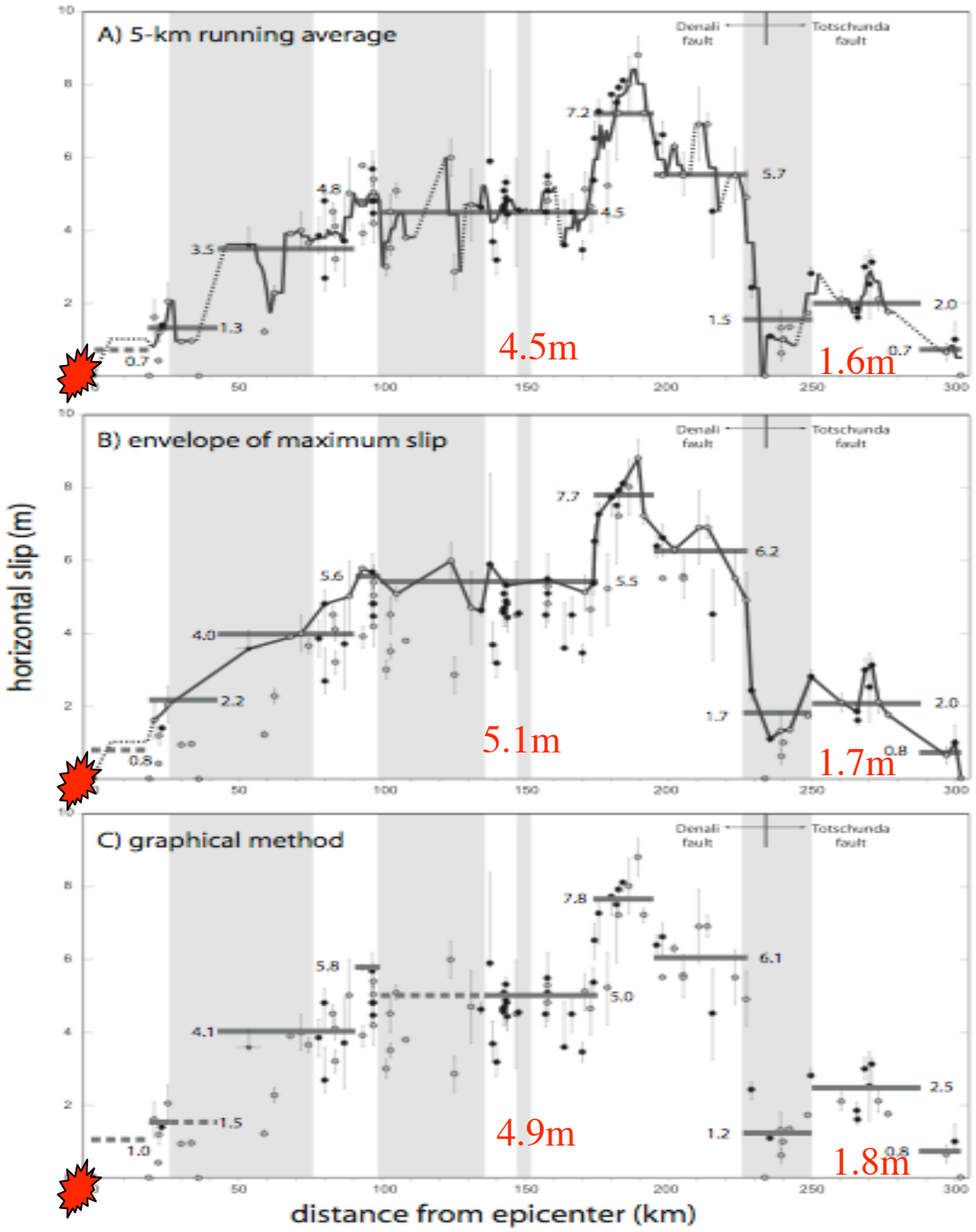
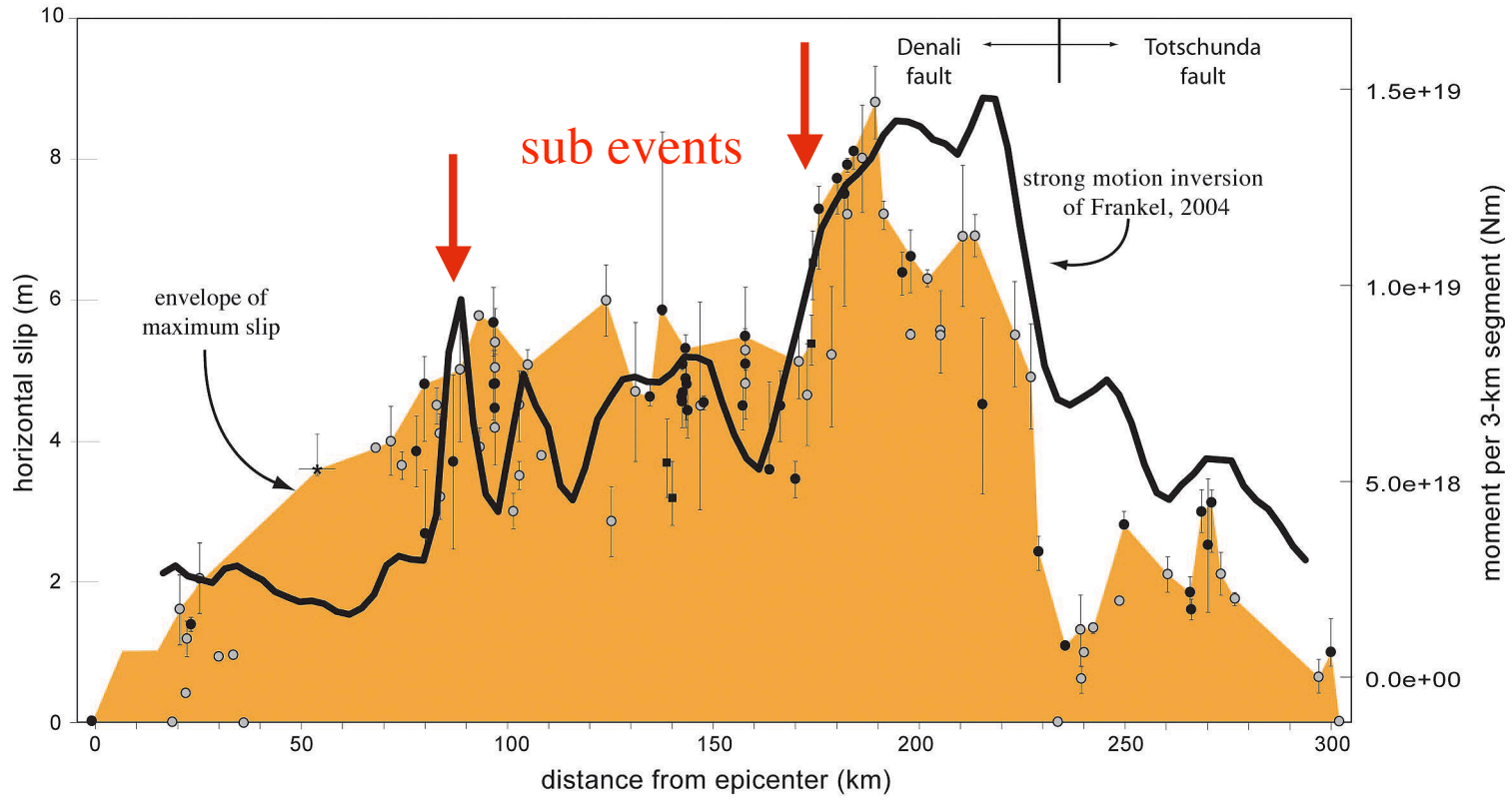


Figure 12.

Haeussler et al (in press)

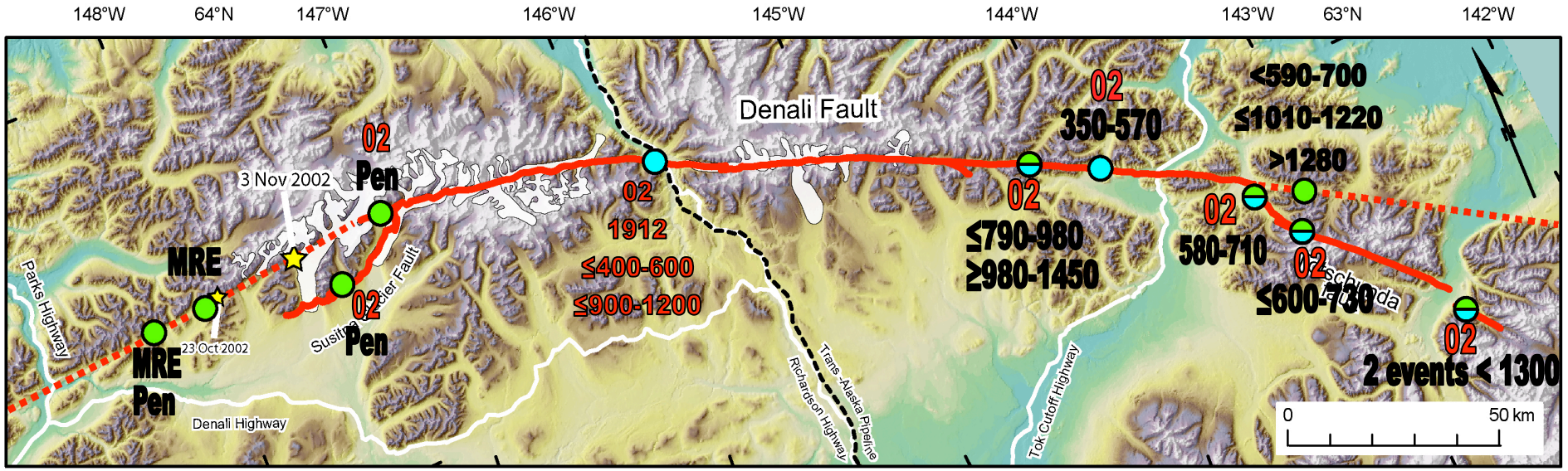
Slip and Moment Release



Haeussler et al (in press)

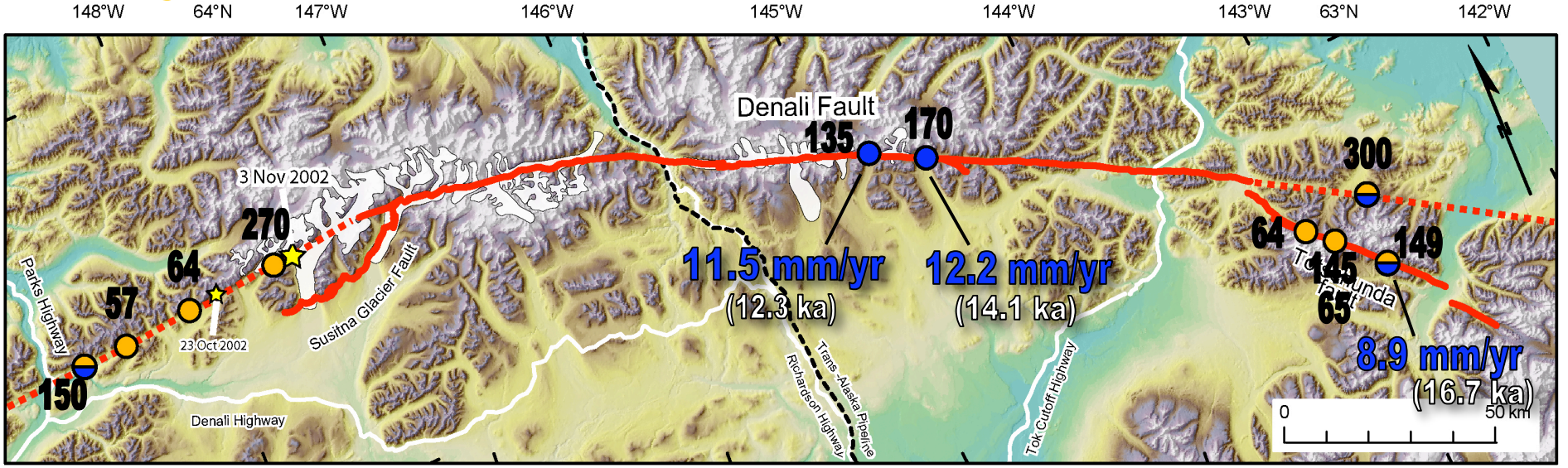
Paleoseismic sites

DENALI FAULT FIELDWORK 2003-2004

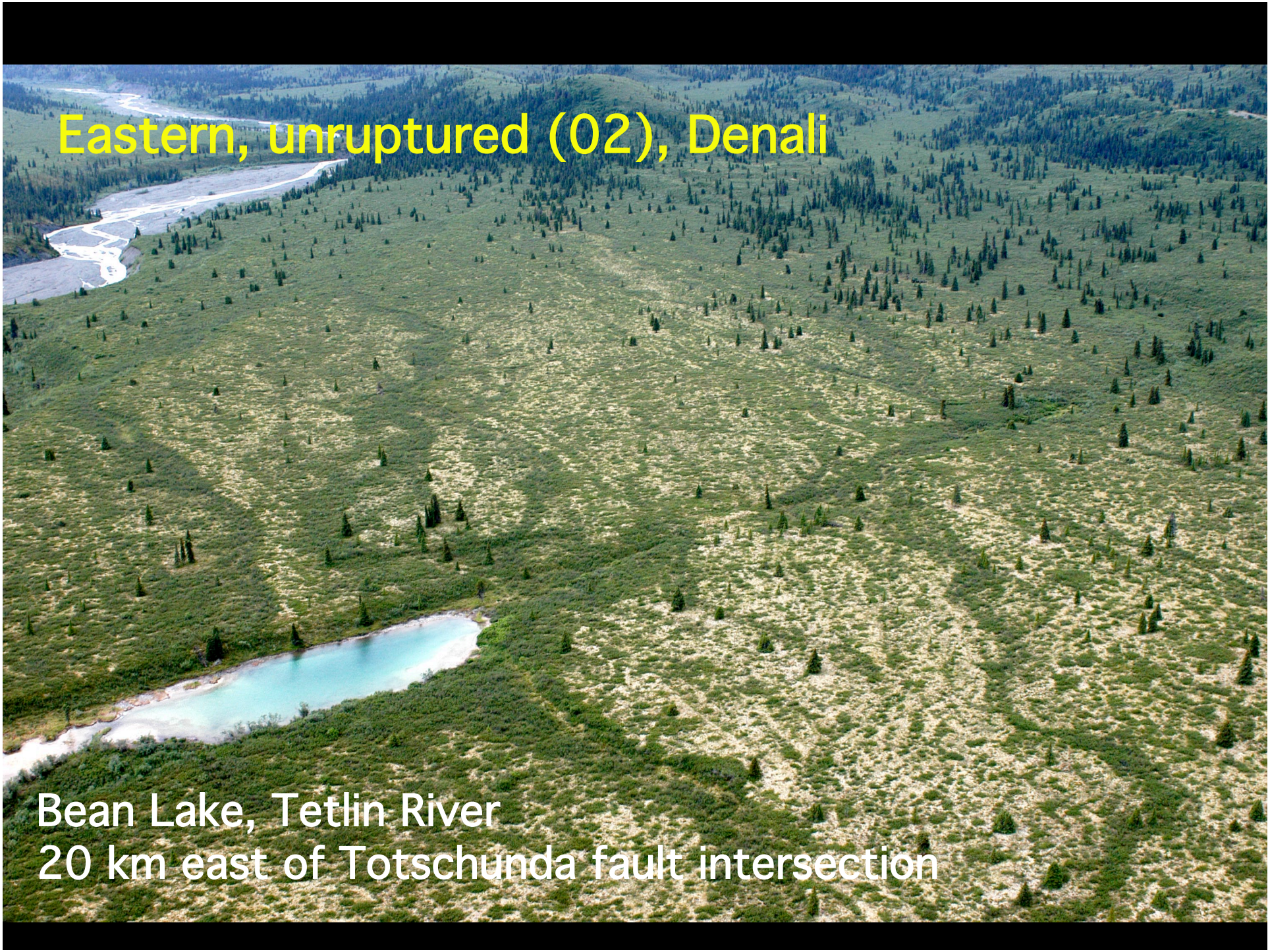


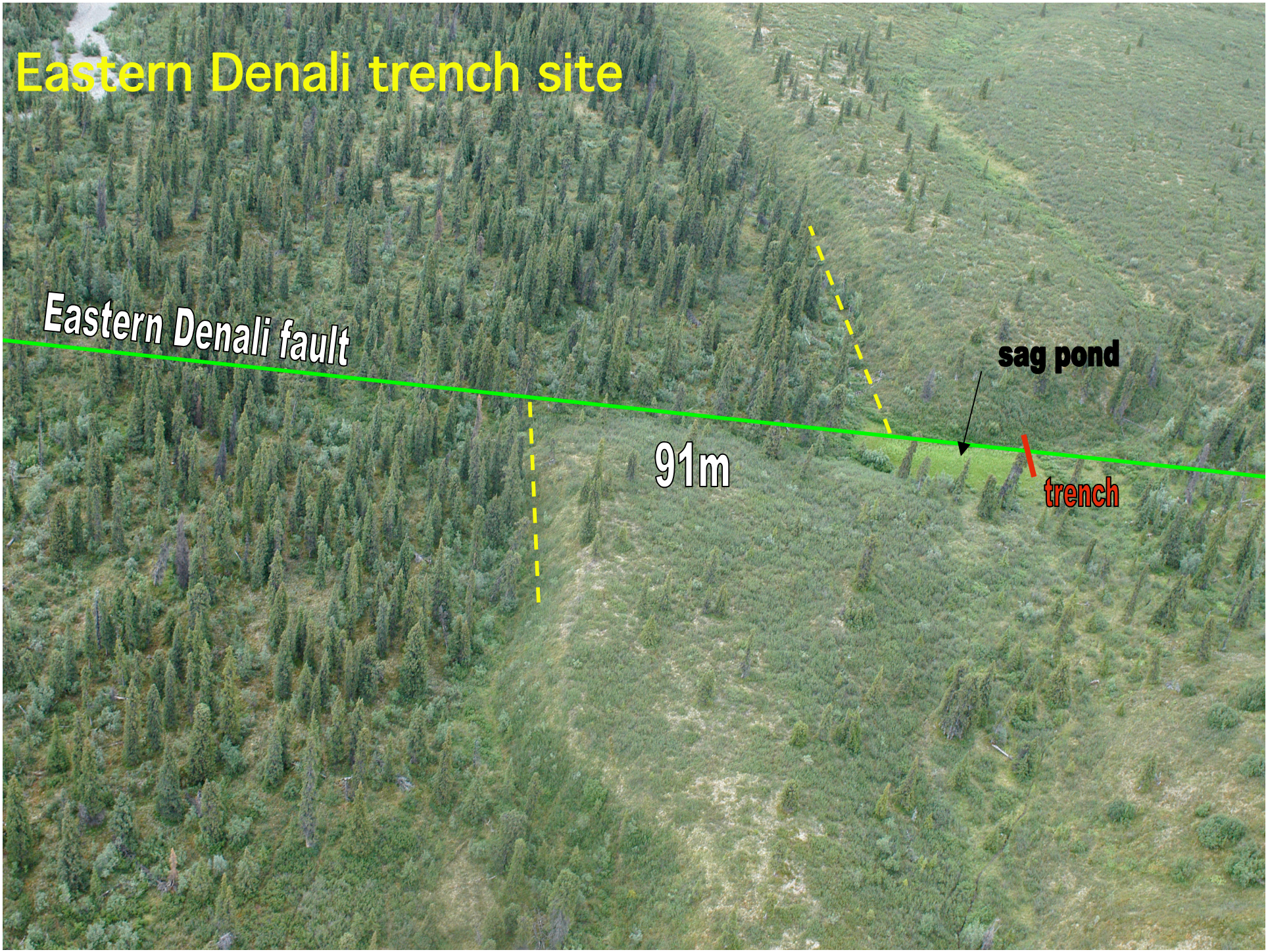
2003 paleoseismic site | 2003/2004 paleoseismic site | 2004 paleoseismic site

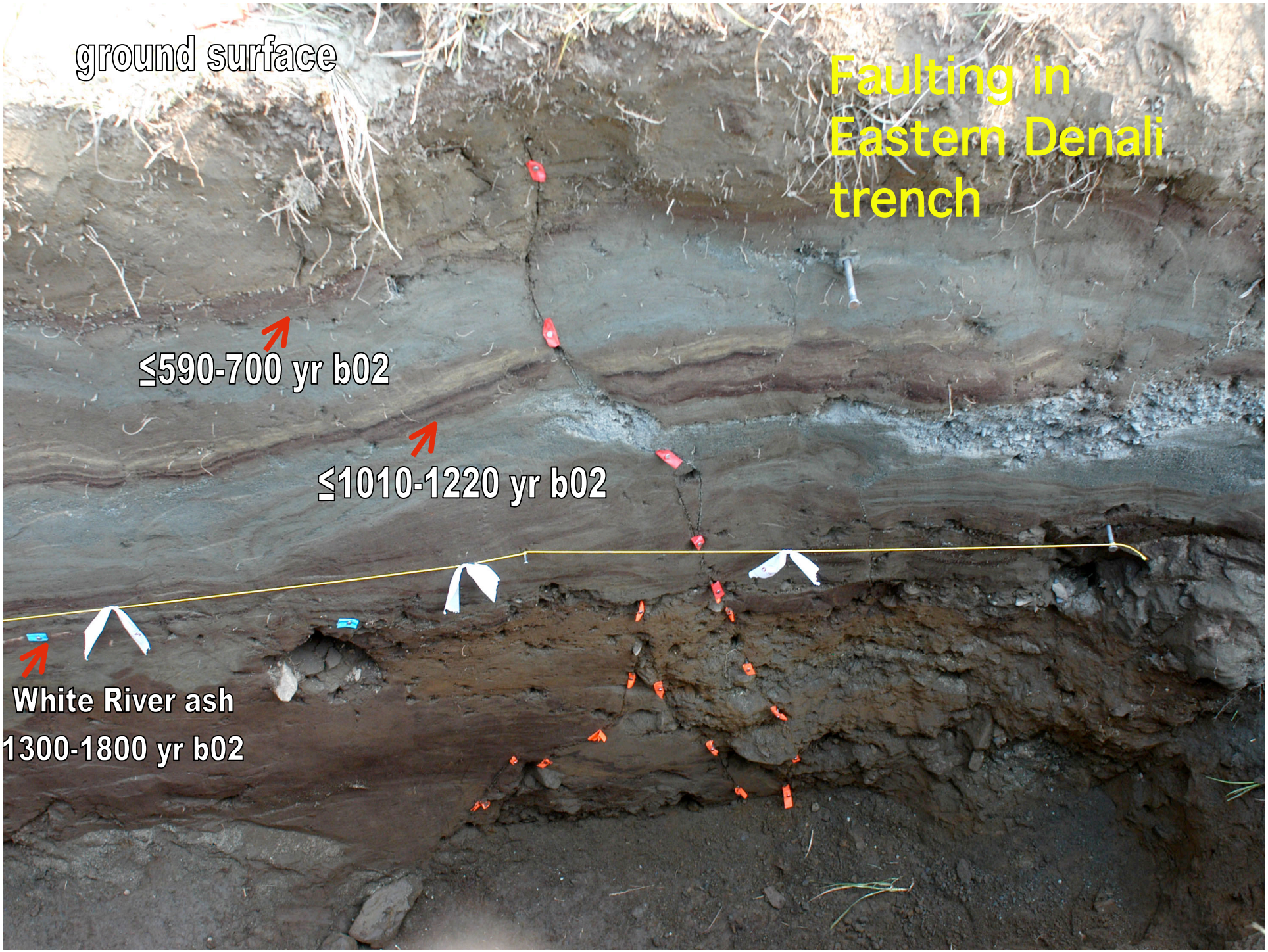
Cosmogenic isotope/slip rate localities



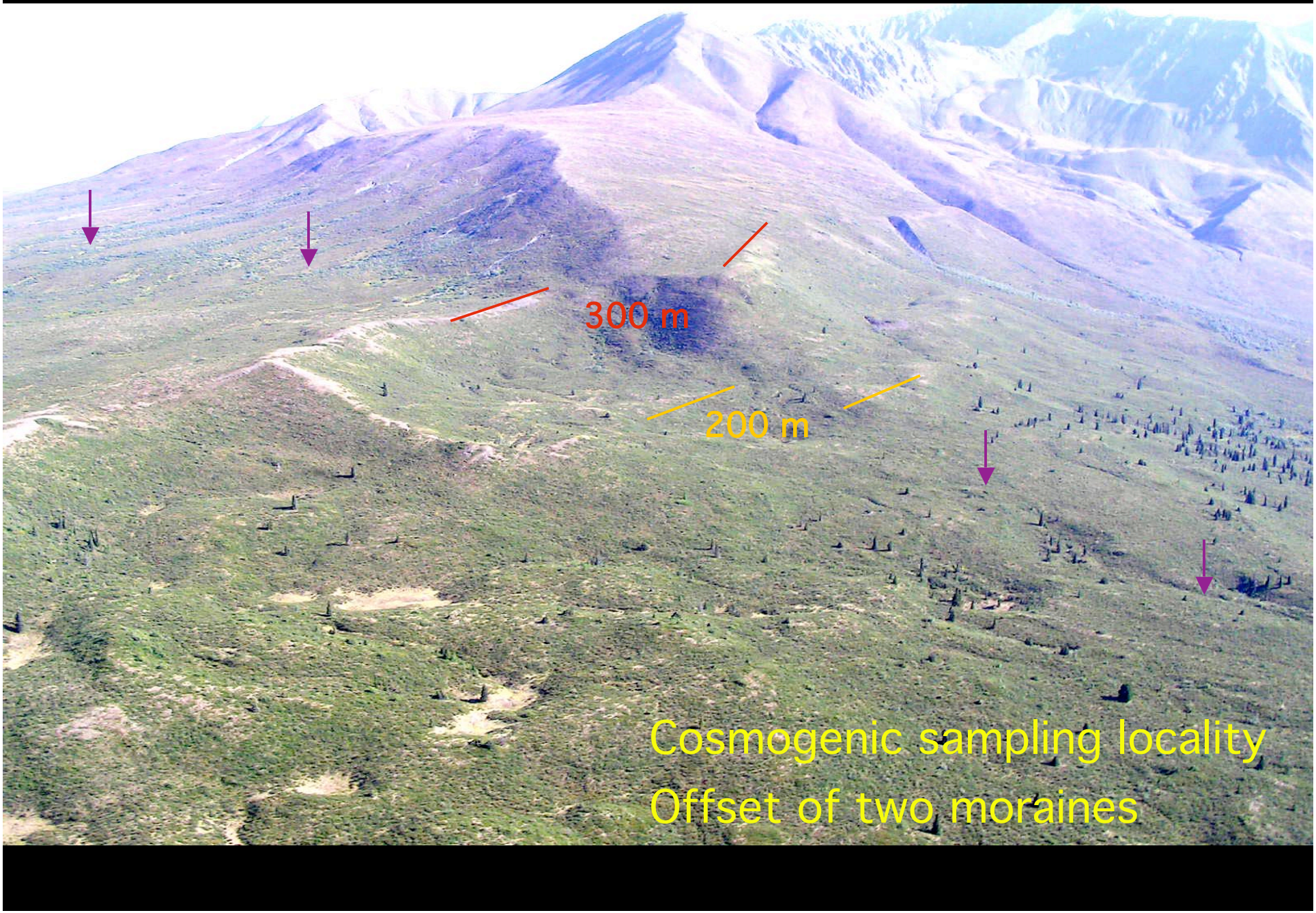
2003 cosmogenic sampling site | 2003/2004 cosmogenic sampling site | 2004 cosmogenic sampling site


Eastern, unruptured (02), Denali
Bean Lake, Tetlin River
20 km east of Totschunda fault intersection


Eastern Denali trench site
Eastern Denali fault
91m
sag pond
trench


ground surface
Faulting in Eastern Denali trench
≤590-700 yr b02
≤1010-1220 yr b02
White River ash
1300-1800 yr b02

Eastern Denali: 30 km east of Totschunda fault intersection







310 km east of 02 epicenter

3 events exposed



Totschunda fault

250 km east of 02 epicenter

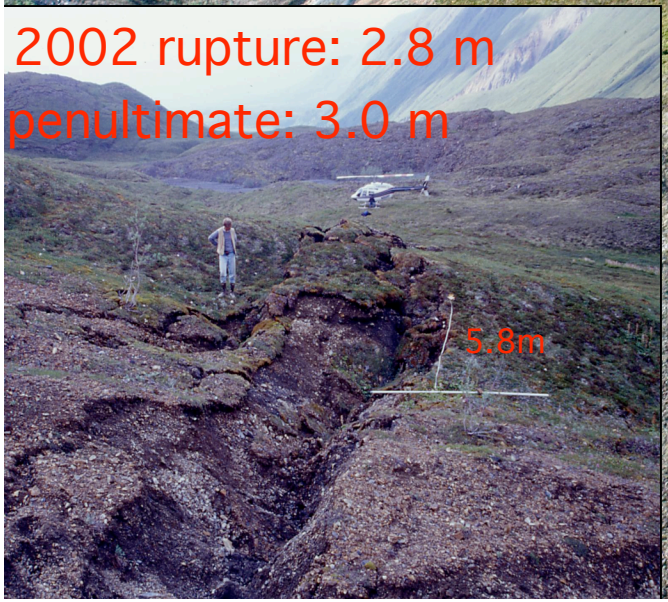


trench site

64 m

2002 rupture: 2.8 m

penultimate: 3.0 m



moraine sampled for cosmogenic dating

Totschunda : Transfer Zone

Trench exposes forest floor with fallen trees buried after penultimate earthquake



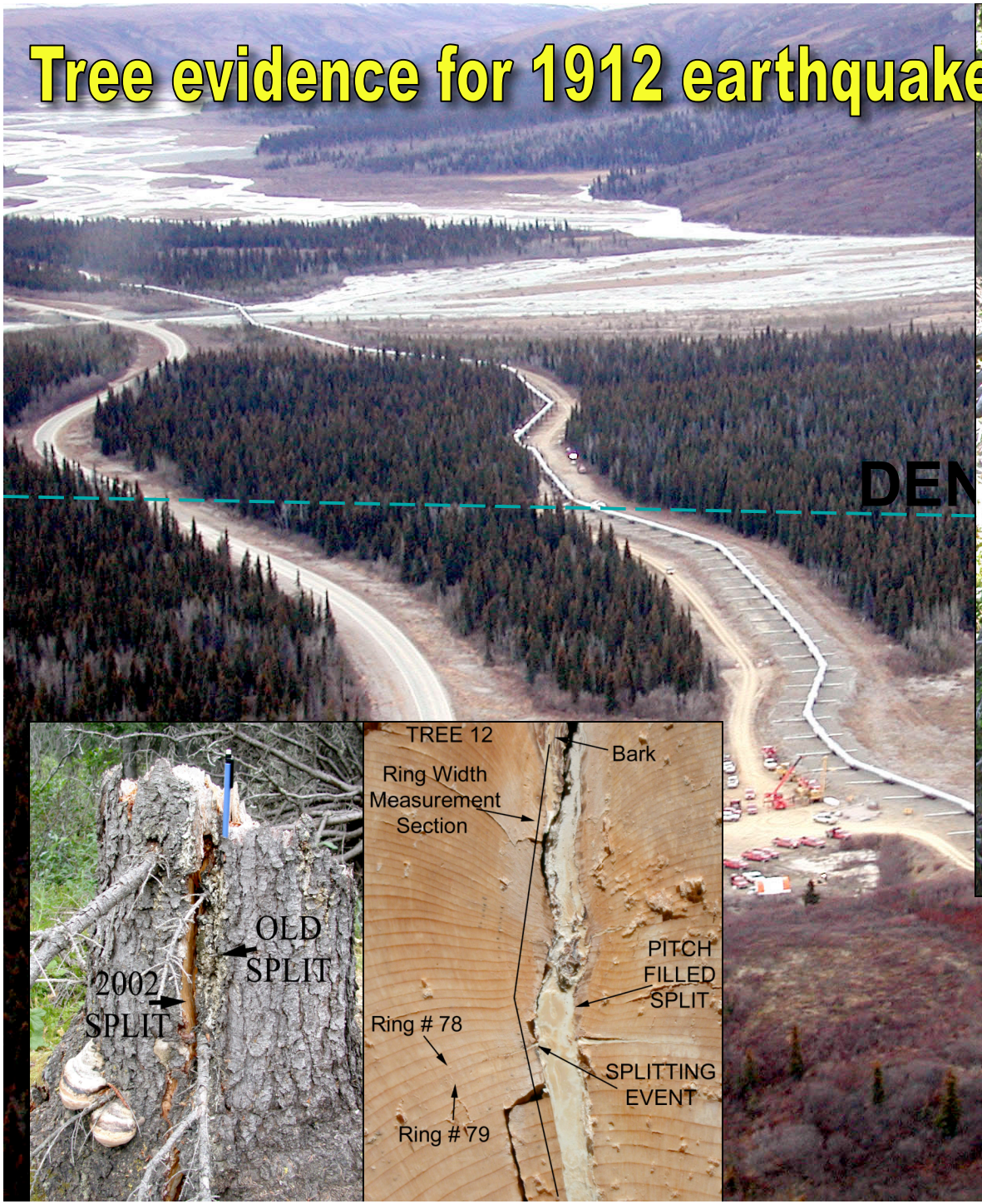
buried tree

02 rupture

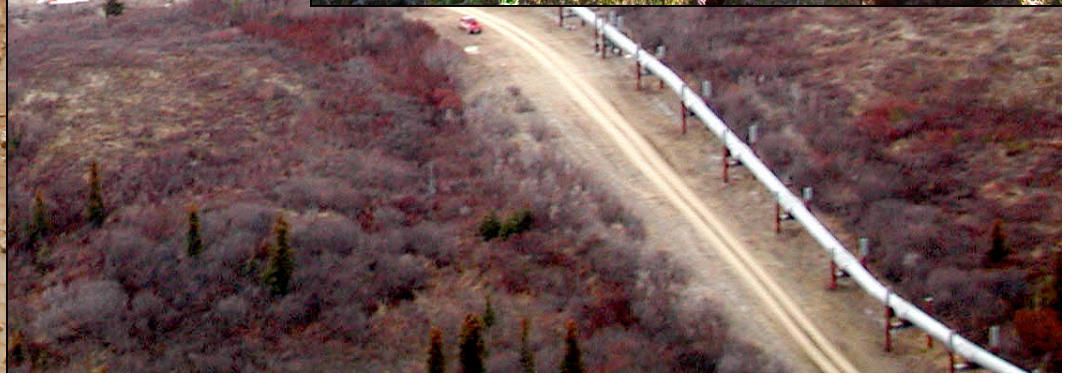
buried tree

580-710 yrb02

Tree evidence for 1912 earthquake (?)



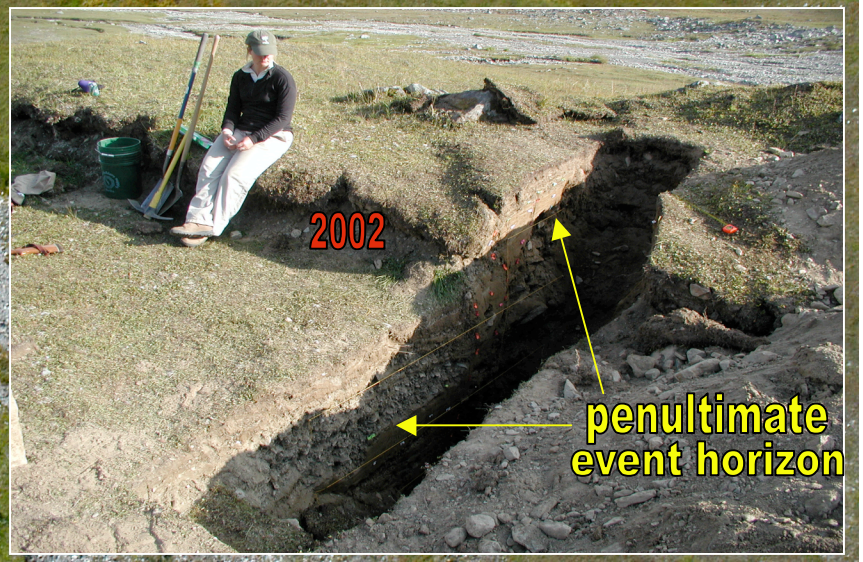




2002 Denali: 18 km east of 2002 epicenter

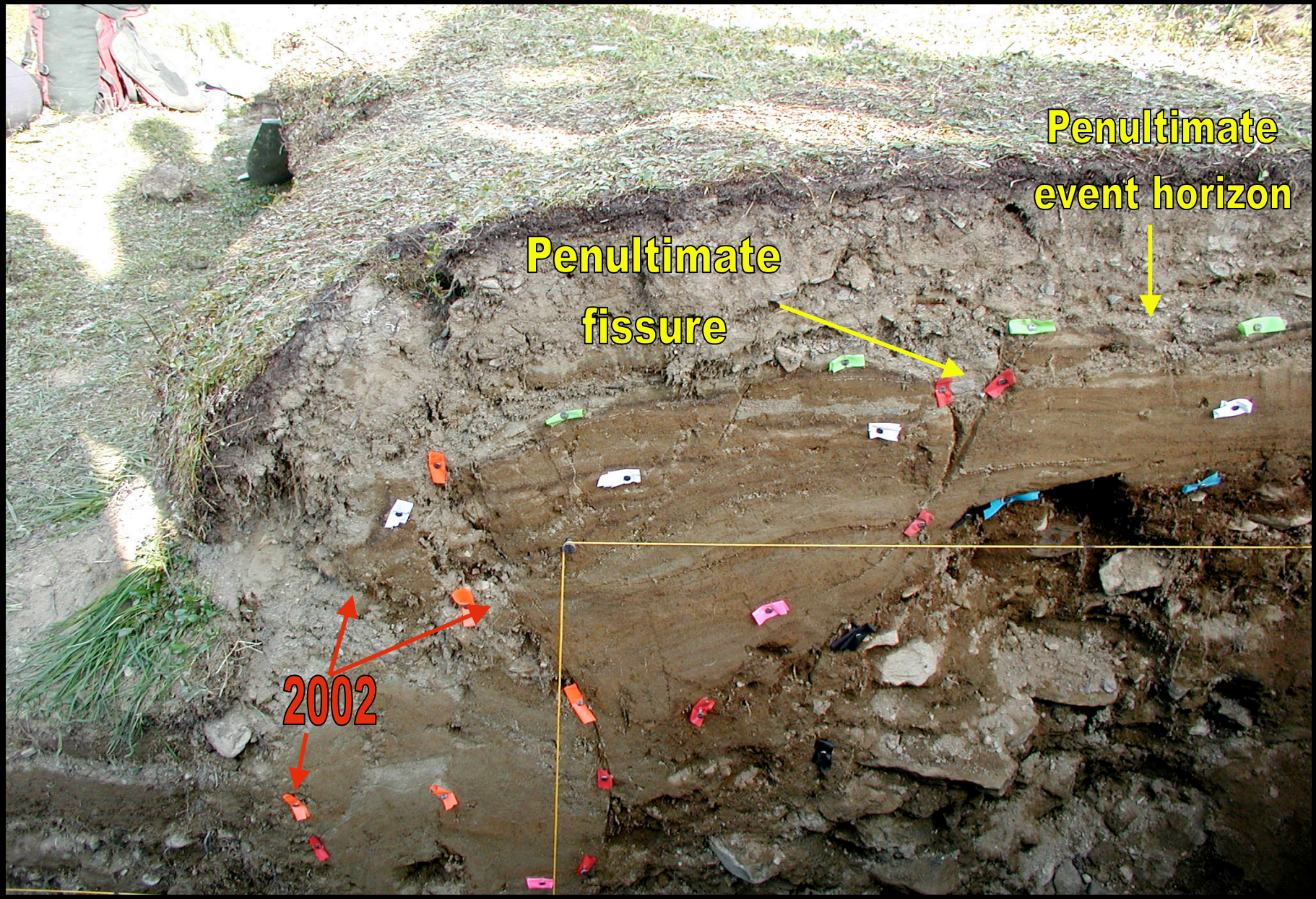
2002 rupture (1.4m)

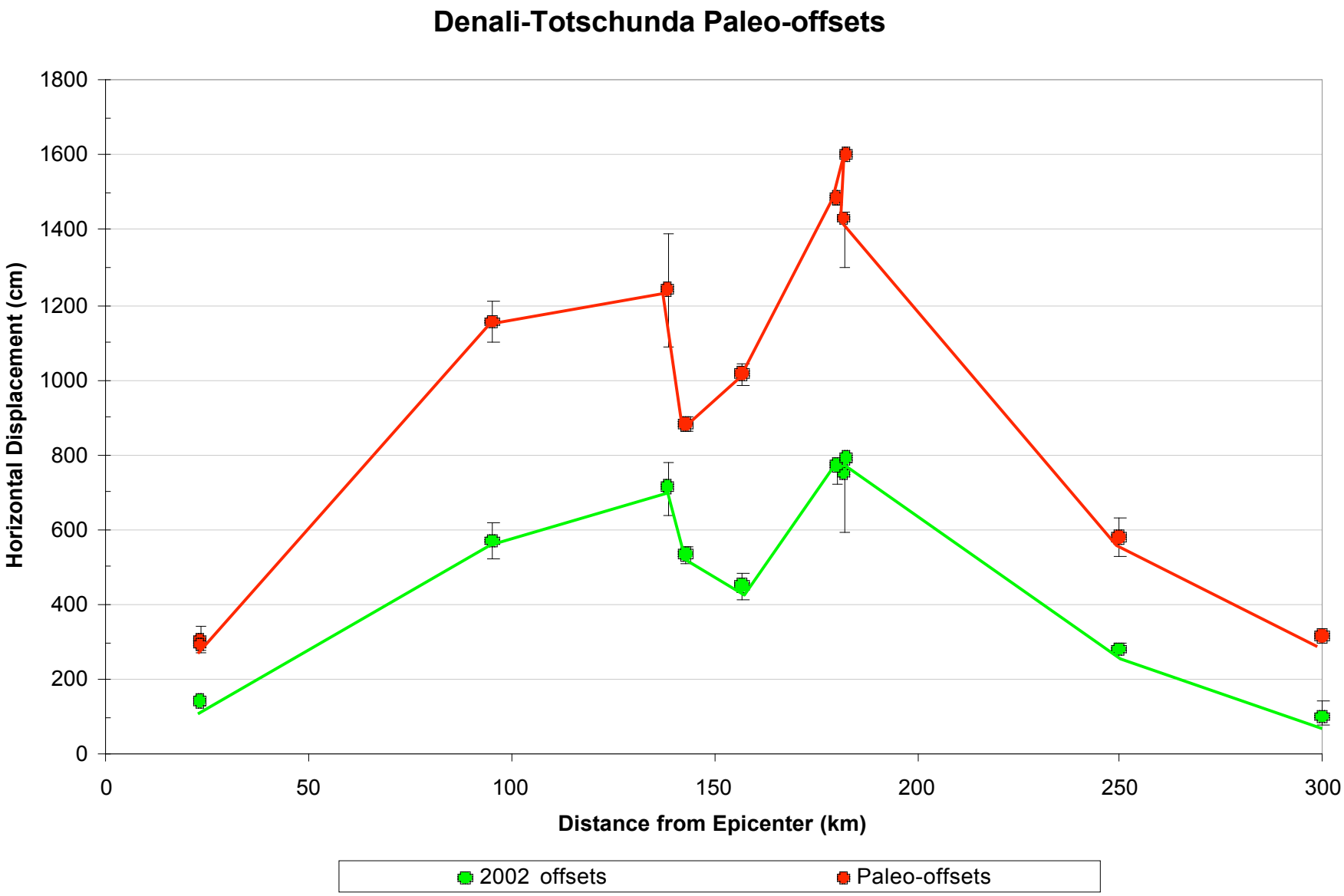
Penultimate event (1.5m)



Site exposes 2002 and penultimate events

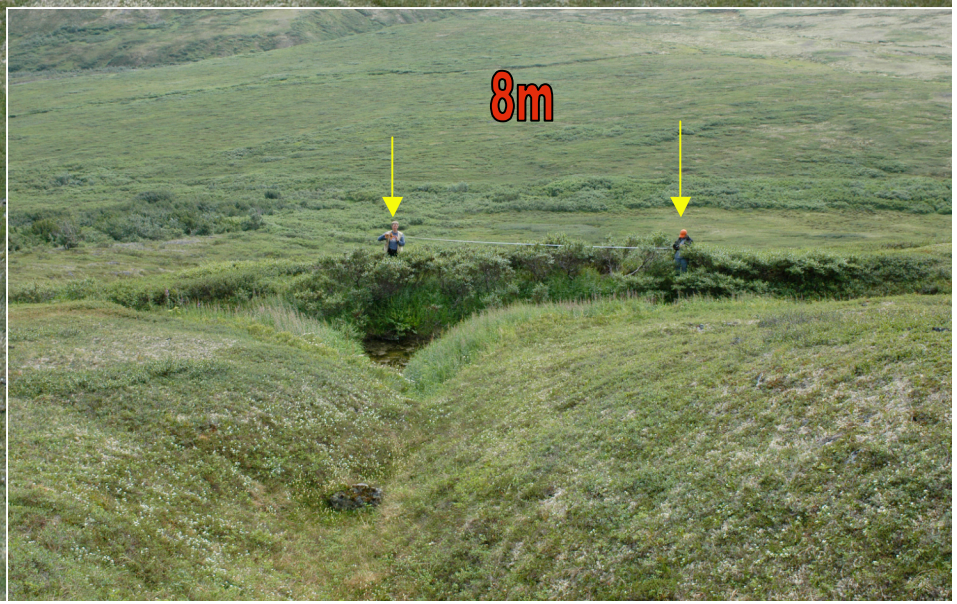
Test locality for westward extent of 1912


Penultimate
event horizon
Penultimate
fissure
2002


Denali-Totschunda Paleo-offsets
Horizontal Displacement (cm)
1800
1600
1400
1200
1000
800
600
400
200
0
0
50
100
150
200
250
300
Distance from Epicenter (km)
2002 offsets
Paleo-offsets

Western Denali

characterized by very youthful geomorphic expression



50 km west of 02 epicenter

8m in 2 events

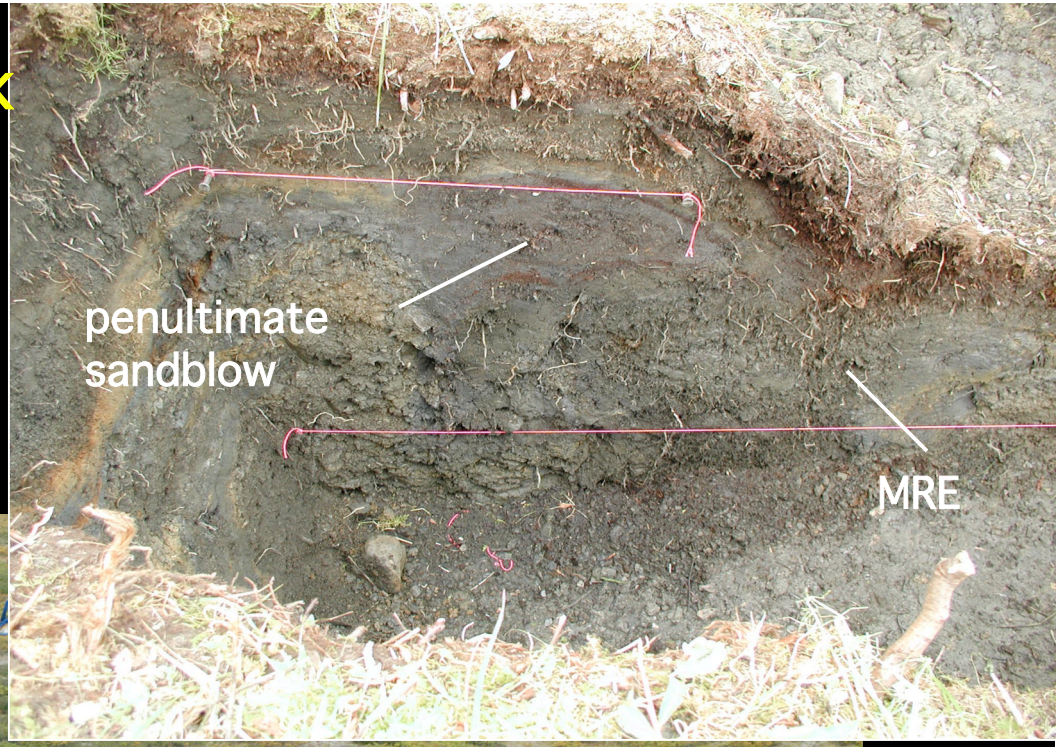
Western Denali: Wells Creek

40 km W of 02 epicenter

MRE

Penultimate: liquefaction/faulting

Bears!











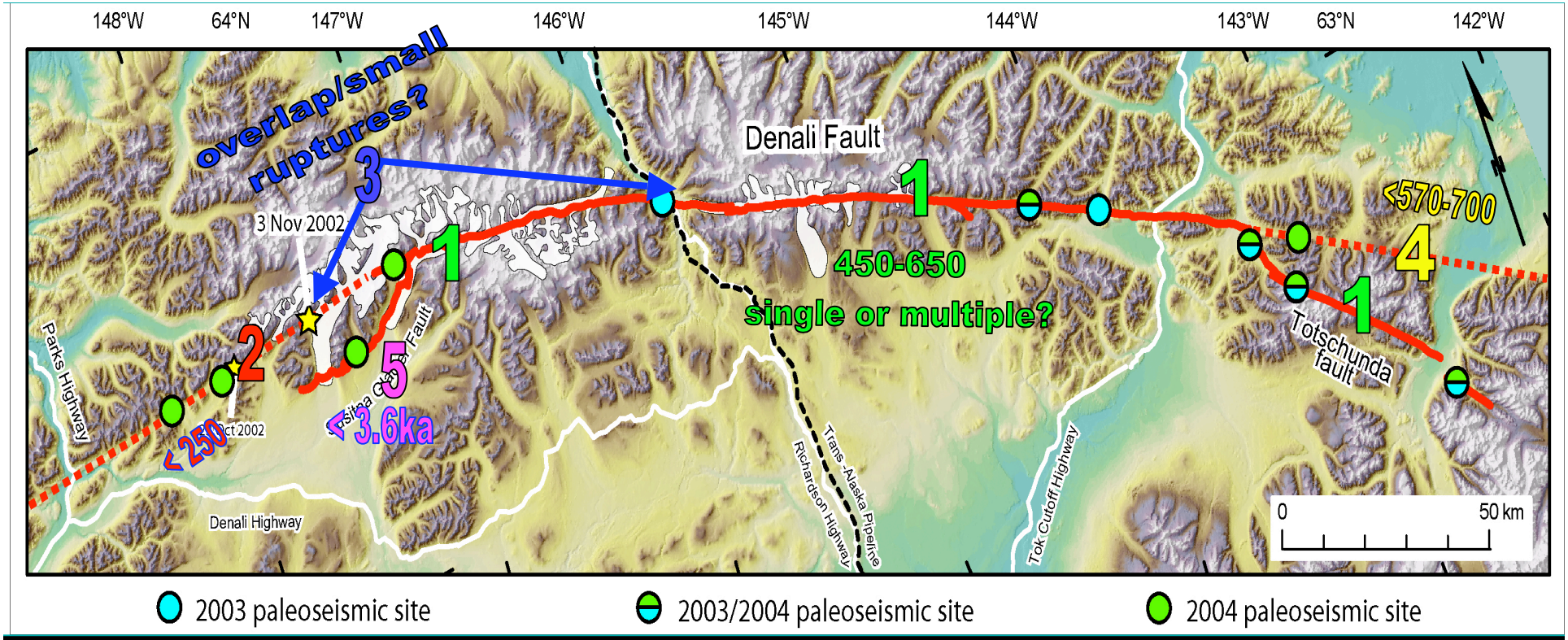
Western Denali



Denali 04

- ✓ 9 sites for new/revised earthquake event dating
- ✓ MRE and penultimate events for entire fault system, extending back 3-4 events at some locations
- ✓ 8 sites for new/revised slip rate from cosmogenic isotope dating; rates over multiple time scales
- ✓ New western Denali fault paleoffset data





1)Large events along the 2002 rupture occurred 450-650 yr ago, 900-1300 yr ago;

2) Western Denali fault geomorphically fresh, 4m, MRE may be ≤250 yr;

3) 120km section of Denali may be overlap zone for large events/contain smaller earthquakes (1912);

4) Eastern Denali MRE likely younger than penultimate Totschunda;

5) Susitna Glacier thrust penultimate <3.6ka; ruptures less frequently than strike-slip Denali

6) Denali slip rate 12mm/yr; Totschunda rate ≤9mm/yr