Landslide Hazards Associated with Subduction-Zone Earthquakes

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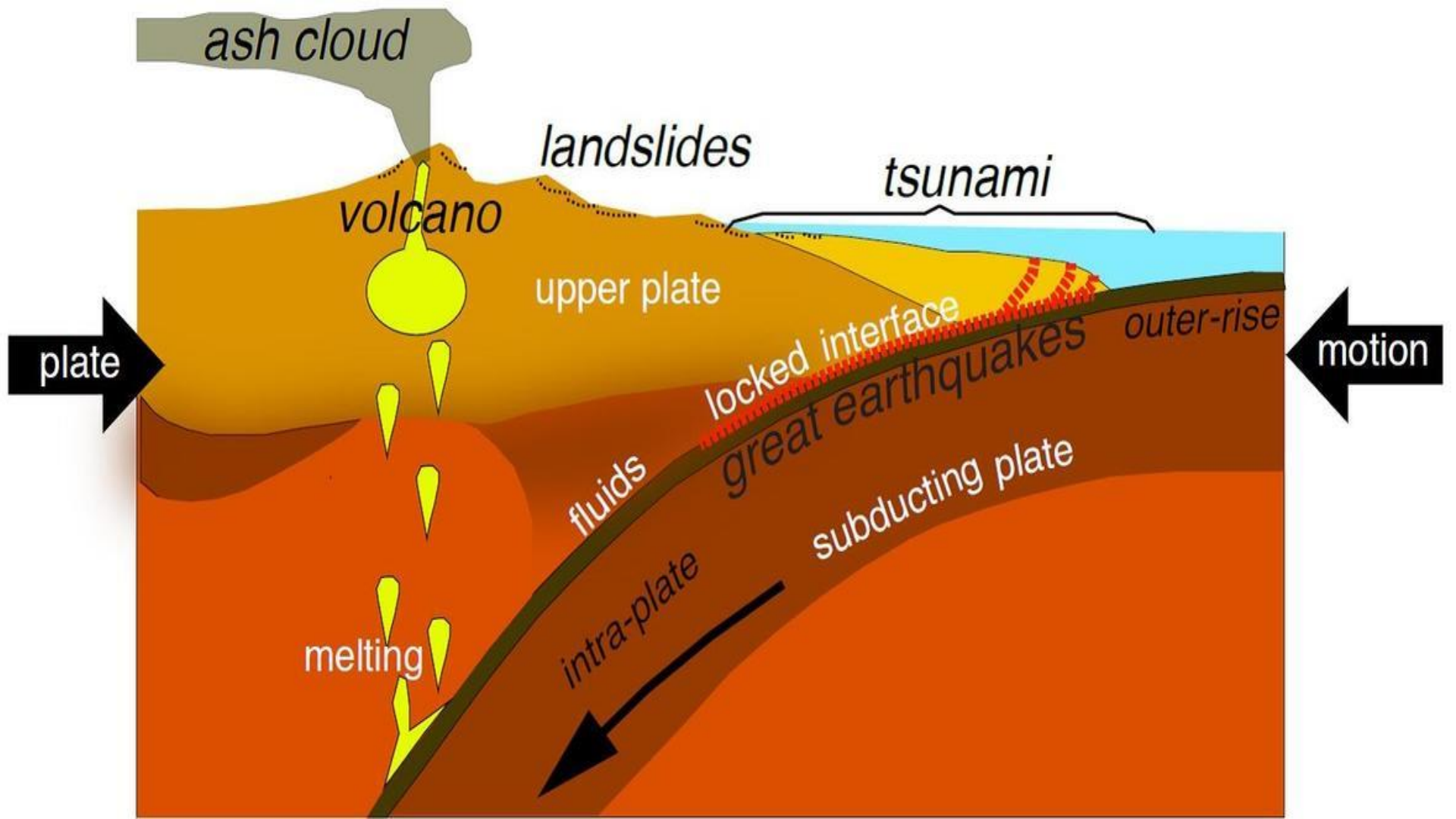
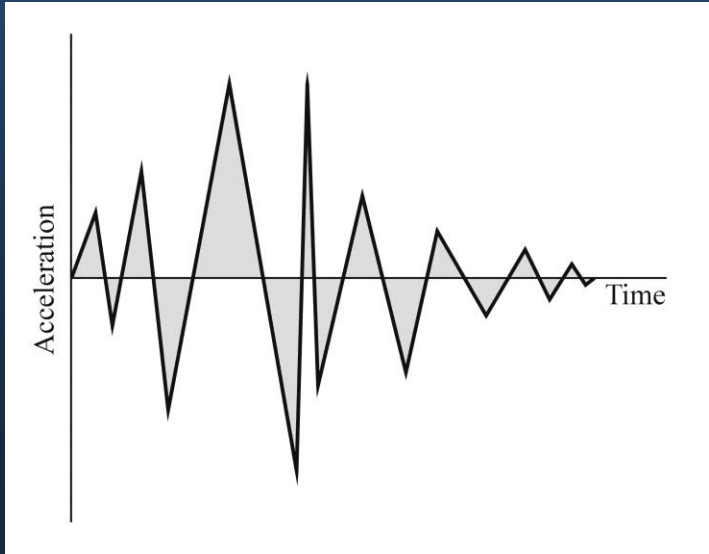
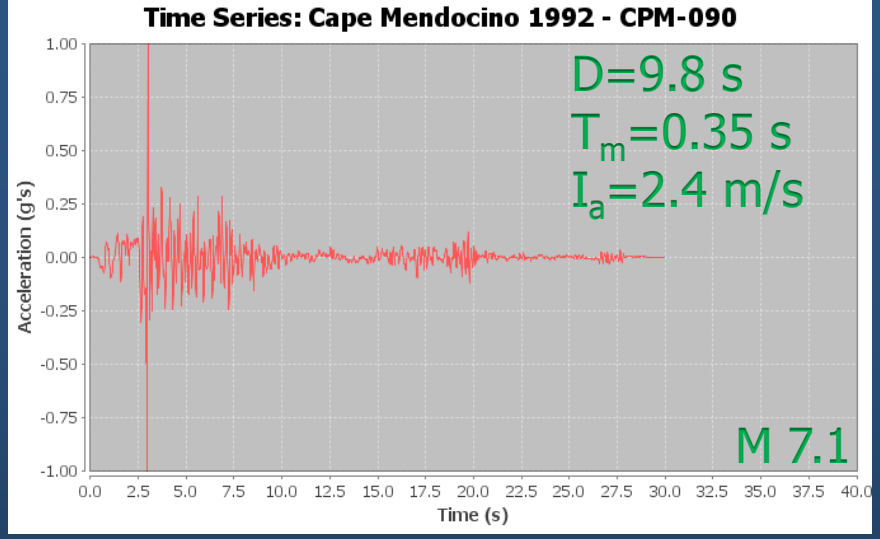
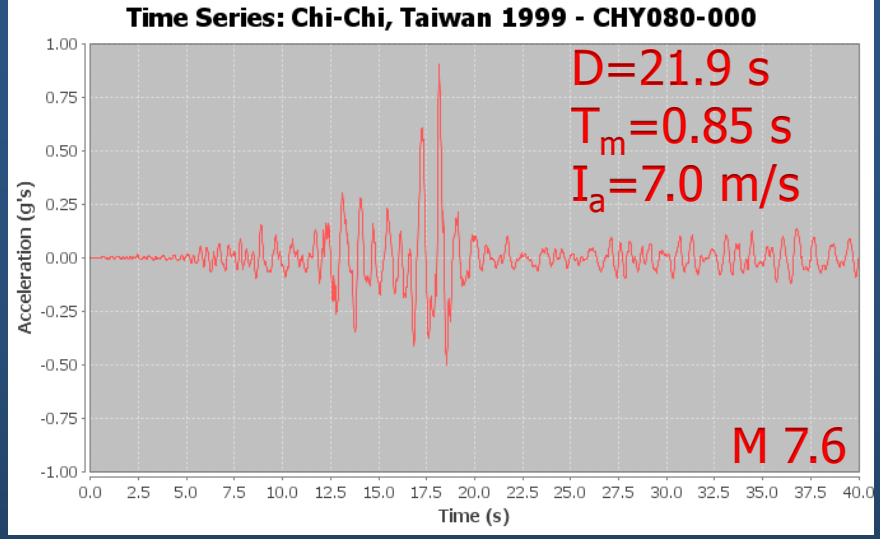

ash cloud
landslides
tsunami
volcano
upper plate
plate
motion
locked interface
great earthquakes
outer-rise
fluids
subducting plate
intra-plate
melting

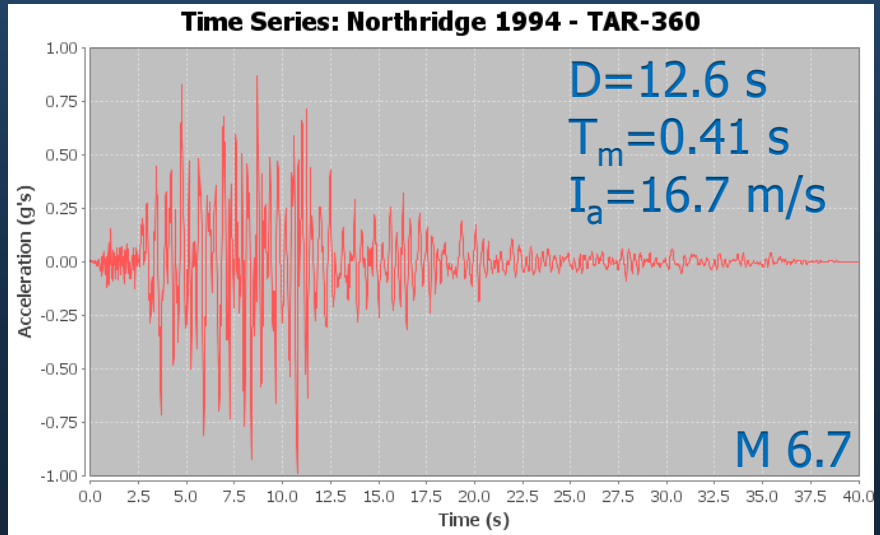
Seismic Landslide Analysis

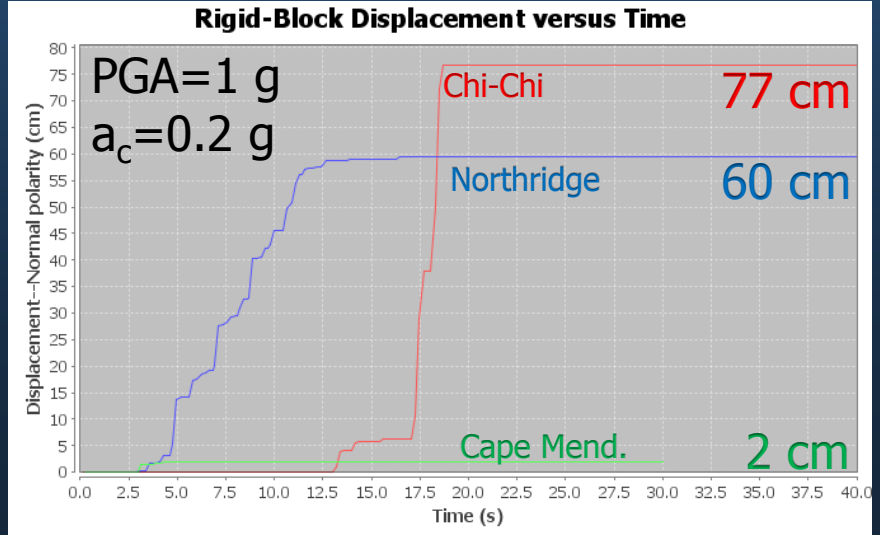
- Peak ground acceleration (PGA) commonly sole seismic input
- PGA does not adequately characterize earthquake shaking
- Duration and frequency content also important
- Arias intensity (I_a)




Time Series: Cape Mendocino 1992 - CPM-090
D=9.8 s
T_m=0.35 s
I_a=2.4 m/s
M 7.1
Acceleration (g's)
Time (s)


Time Series: Chi-Chi, Taiwan 1999 - CHY080-000
D=21.9 s
T_m=0.85 s
I_a=7.0 m/s
M 7.6
Acceleration (g's)
Time (s)


Time Series: Northridge 1994 - TAR-360
D=12.6 s
T_m=0.41 s
I_a=16.7 m/s
M 6.7
Acceleration (g's)
Time (s)


Rigid-Block Displacement versus Time
PGA=1 g
a_c=0.2 g
Chi-Chi
77 cm
Northridge
60 cm
Cape Mend.
2 cm
Displacement--Normal polarity (cm)
Time (s)

Compare Earthquake Types

	Shallow crustal earthquake
Frequency (Hz)	1-10
Period (s)	0.1-1
Duration (s)	5-30

Compare Earthquake Types

	Shallow crustal earthquake	Deep subduction-zone earthquake
Frequency (Hz)	1-10	0.1-1
Period (s)	0.1-1	1-10
Duration (s)	5-30	30-120+

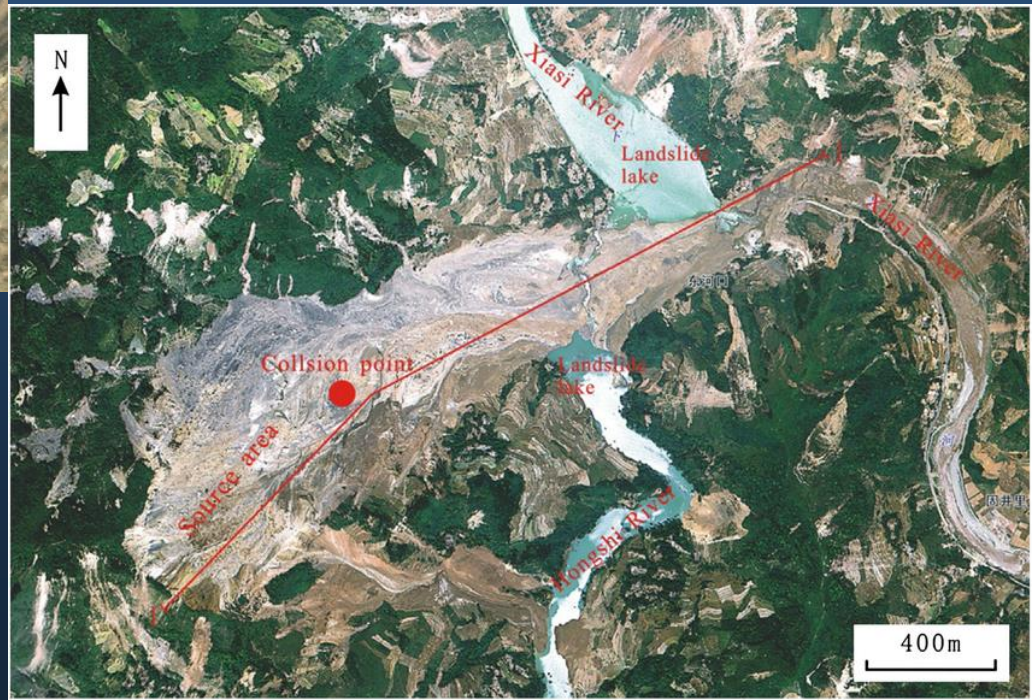
1994 Northridge earthquake
M 6.7

Rich in high-frequency shaking
Shallow, disrupted landslides

2002 Denali fault earthquake
M 7.9

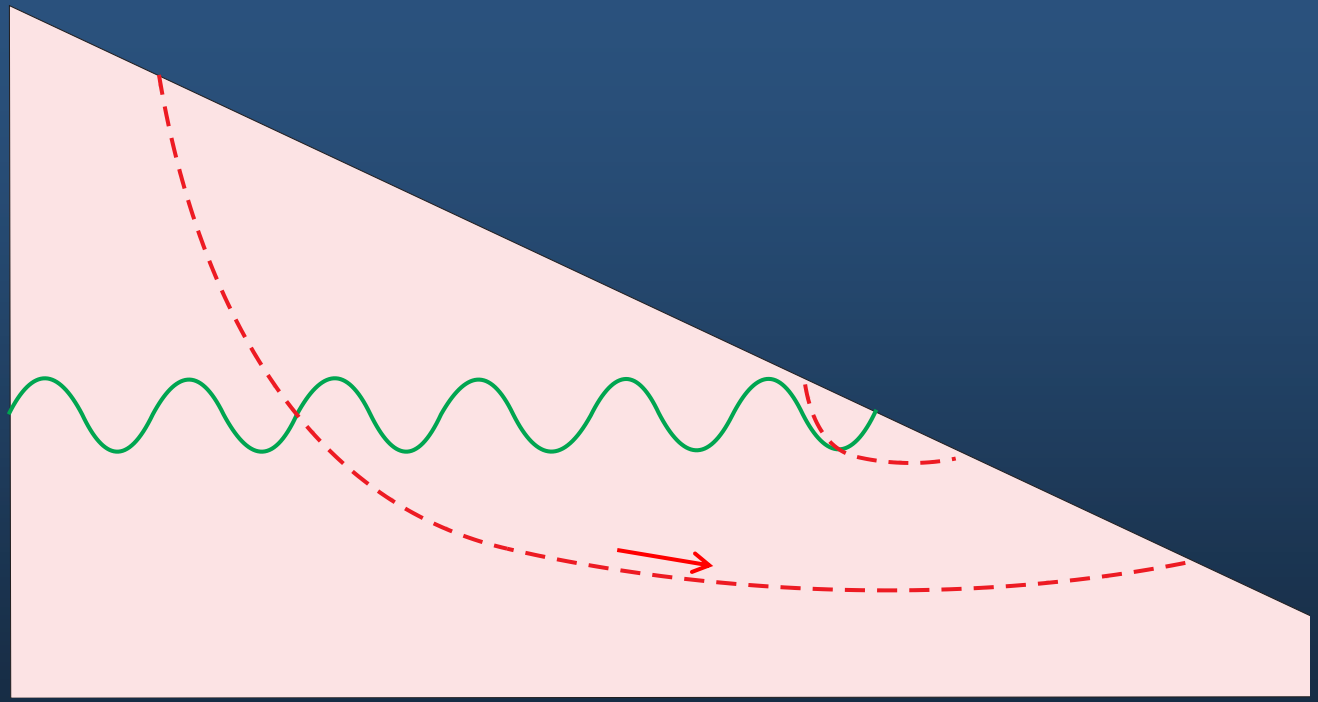
Poor in high-frequency shaking
Huge, deep rock avalanches

2008 Wenchuan, China earthquake
M 7.9

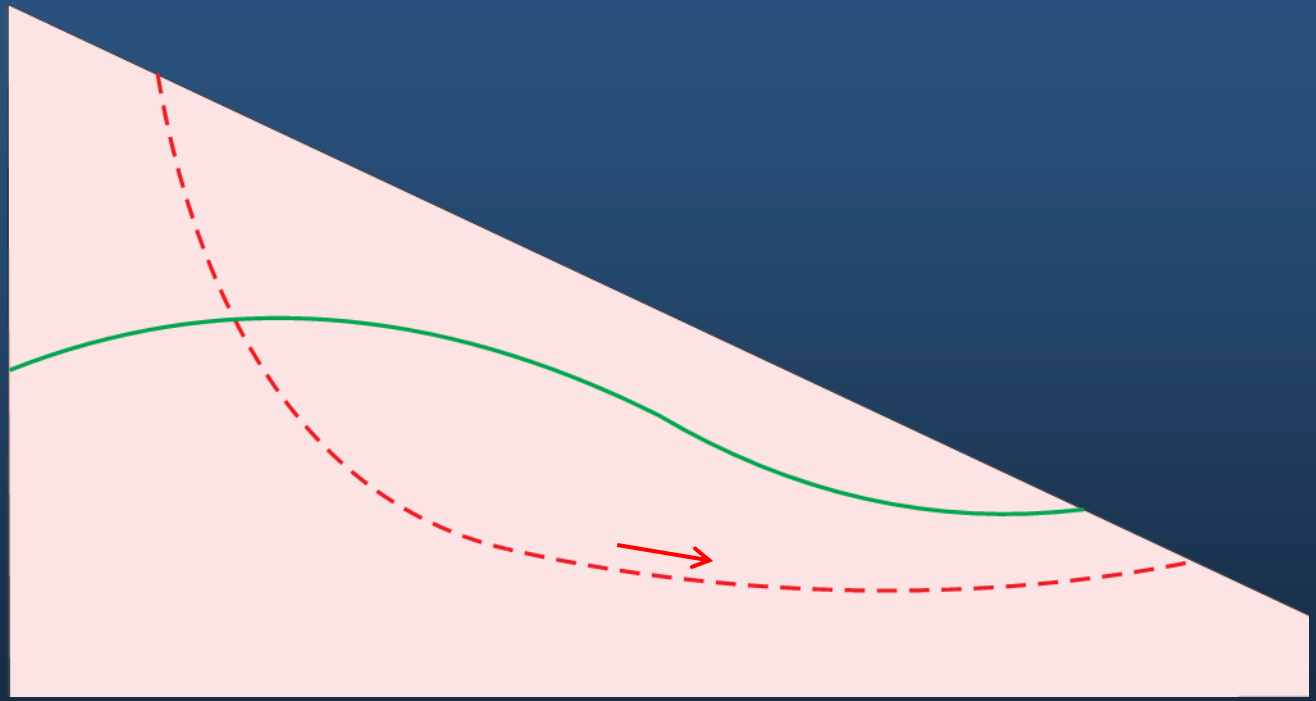


Broad frequency shaking
Full range of landslide sizes

Seismic Incoherence



Seismic Coherence



1964 Alaska Earthquake (M 9.2)

Duration in Anchorage

- Strongest shaking 2-3 minutes
- Felt shaking 4-7 minutes

1964 Alaska Earthquake (M 9.2)

4th Avenue landslide

1964 Alaska Earthquake (M 9.2)

L Street landslide

1964 Alaska Earthquake (M 9.2)

L Street landslide

1964 Alaska Earthquake (M 9.2)

Turnagain Heights landslide

1964 Alaska Earthquake (M 9.2)

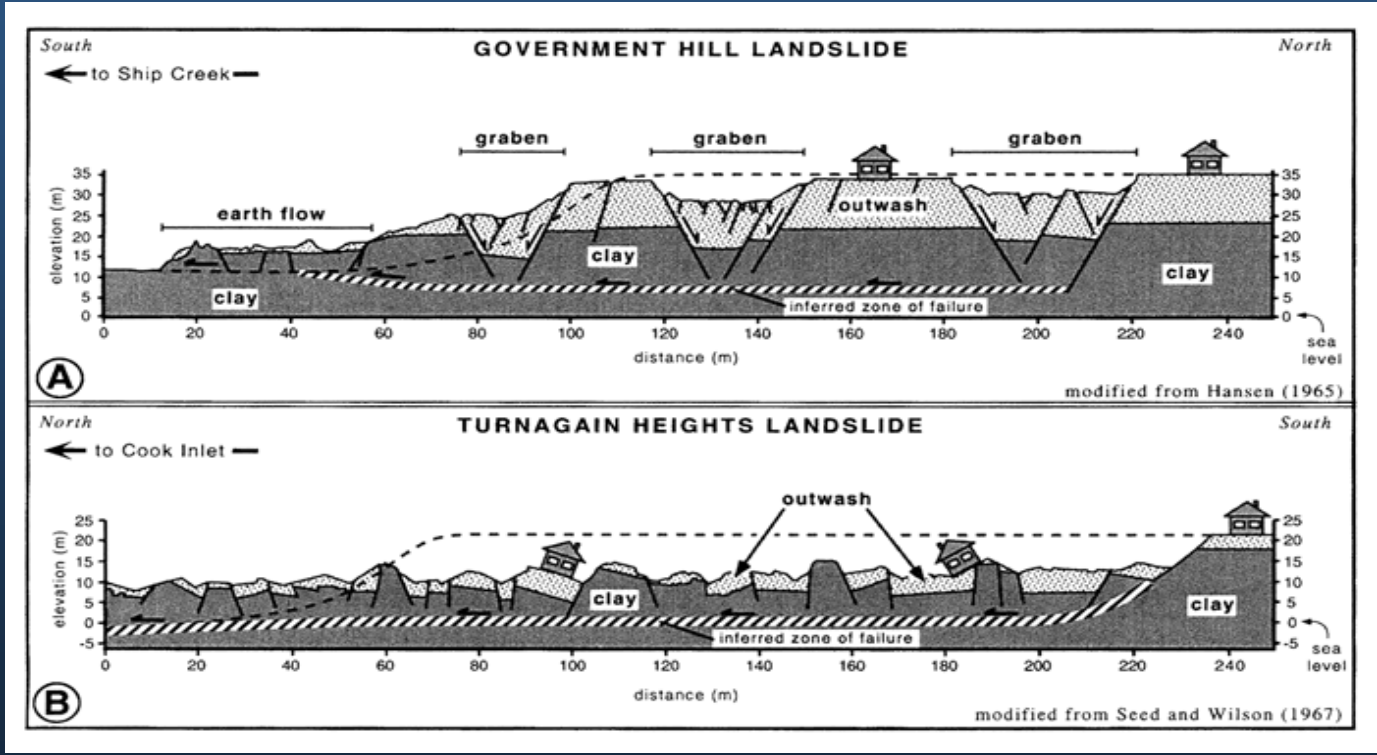
Turnagain Heights
landslide

1964 Alaska Earthquake (M 9.2)

Turnagain Heights landslide

1964 Alaska Earthquake (M 9.2)

Turnagain Heights landslide



1964 Alaska Earthquake (M 9.2)

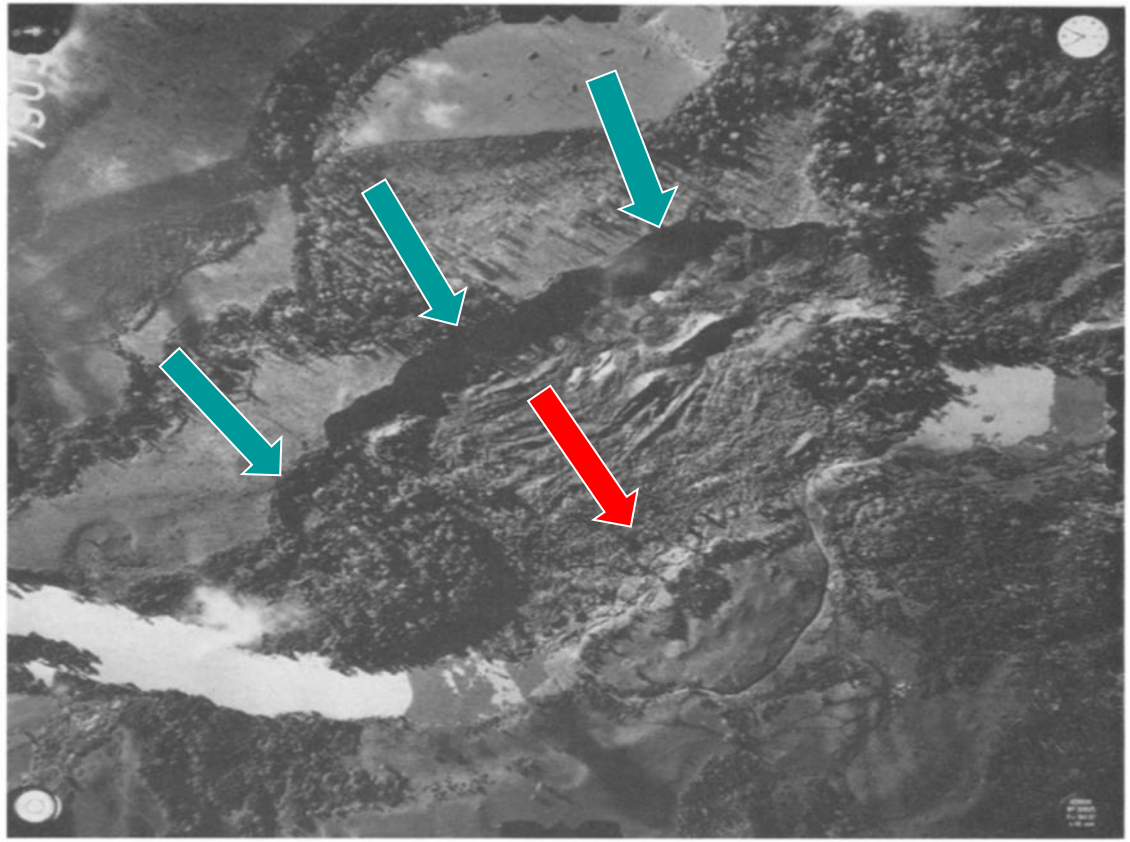
Seward

1964 Alaska Earthquake (M 9.2)

Seward

1964 Alaska Earthquake (M 9.2)

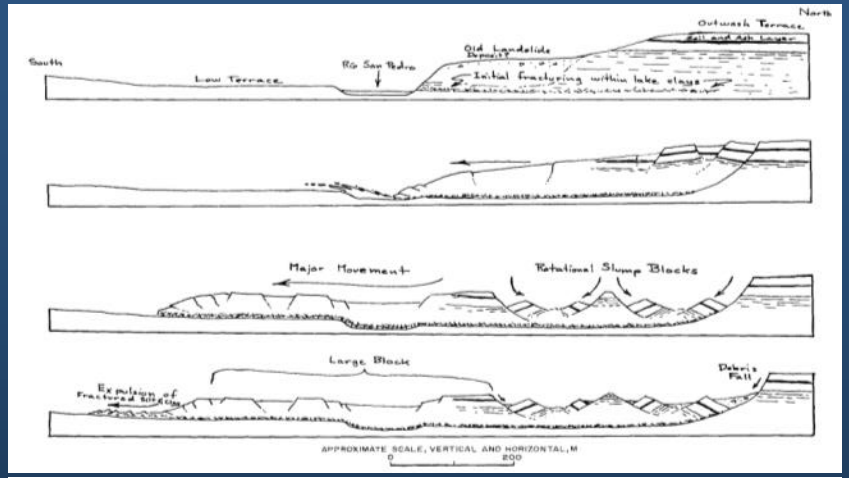
1960 Chile Earthquake (M 9.5)



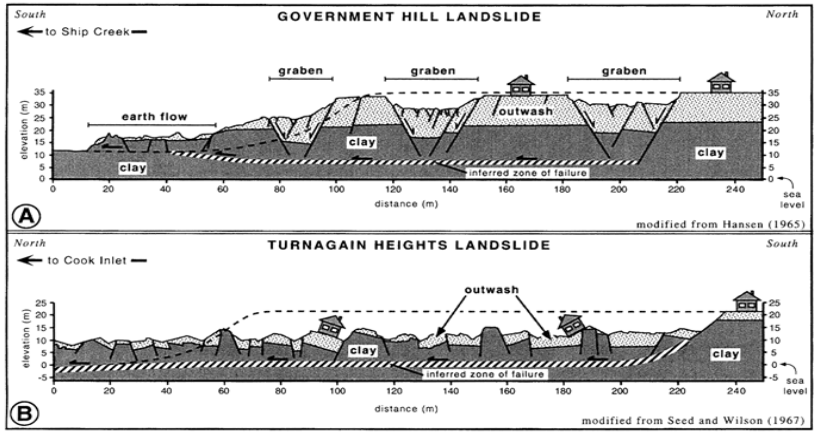
Area: 1.26 km^2
Volume: 30 million m^3
Runout: 300 m
Material: saturated sand, silt, ash

1960 Chile Earthquake (M 9.5)

Chile



Alaska

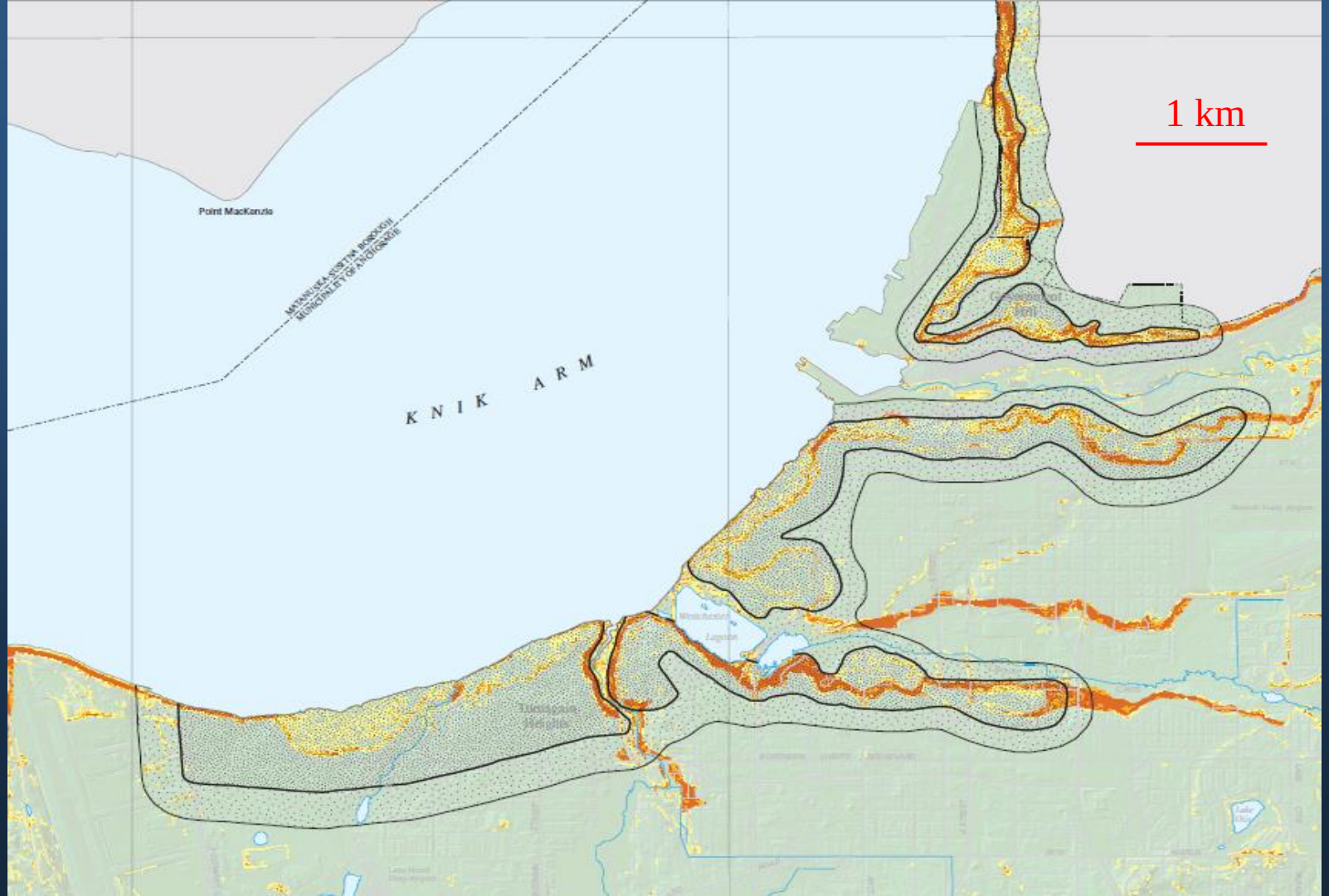


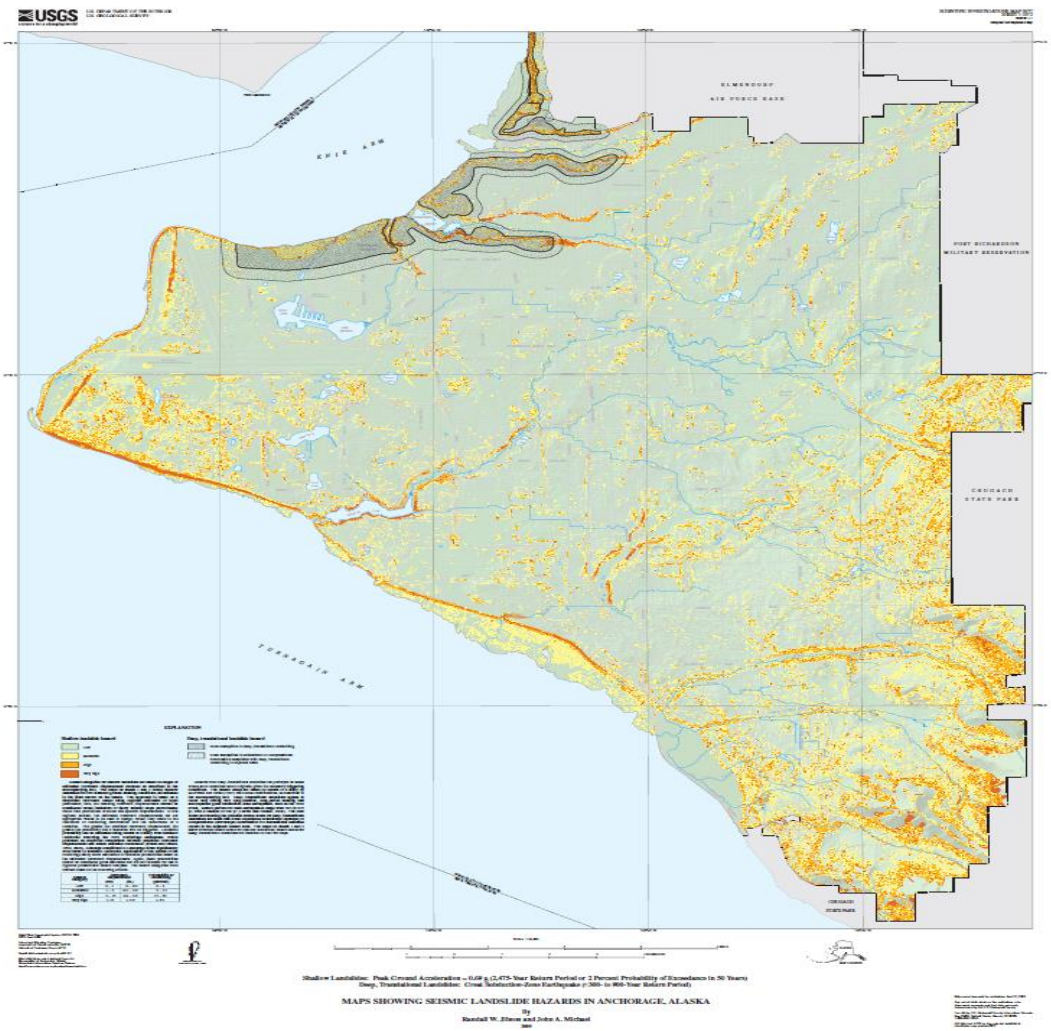
Hazard-Mapping Procedure For Shallow Landslides

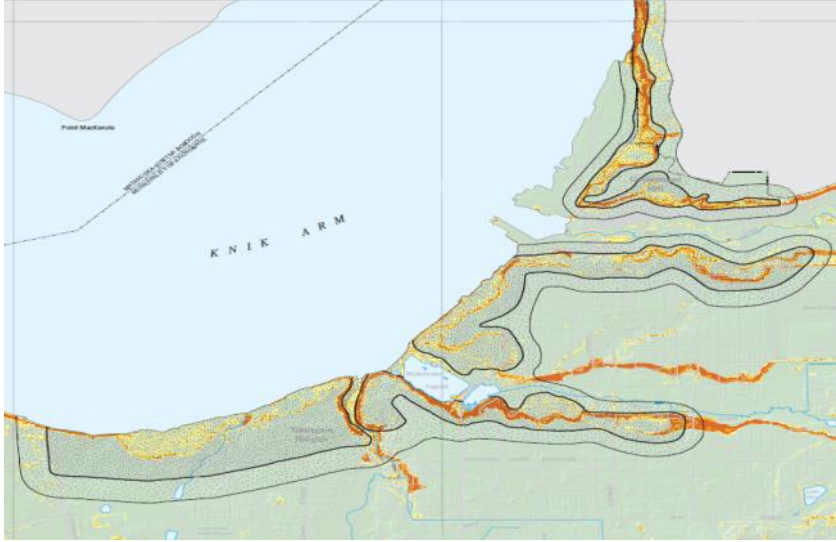
- Collect static data on slope, geology, material shear strength, and groundwater conditions
- Determine PGA of interest from probabilistic seismic hazard analysis (PSHA)
- Conduct Newmark sliding-block analysis
- Assign hazard level based on modeled displacements

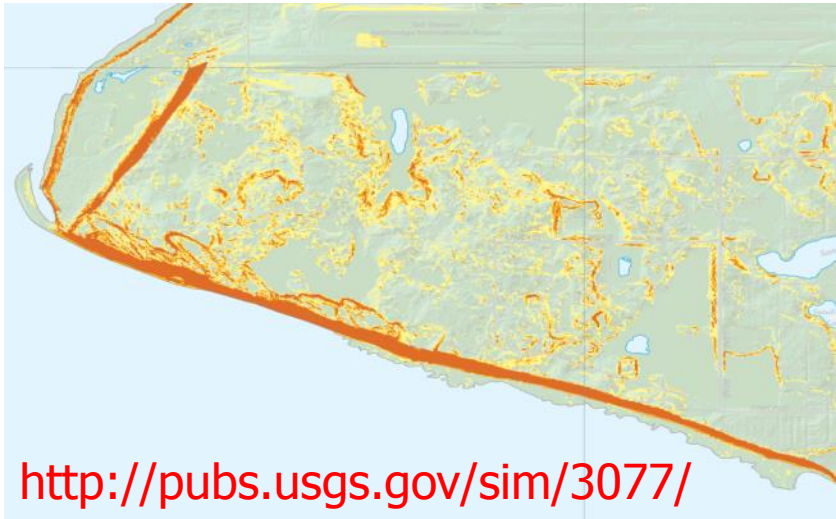
Hazard-Mapping Procedure For Deep Landslides

- Large, deep landslides require long shaking durations
- PGA is not the principle issue
- Only occur in megathrust events
- Hazard evaluation procedure:
  - Identify areas susceptible to deep landslides
  - Estimate return periods for megathrust events


1 km
Point MacKenzie
MATANUSKA-SUSITNA BOROUGH/
MUNICIPALITY OF ANCHORAGE
K N I K A R M







http://pubs.usgs.gov/sim/3077/


The Big One
January 26, 1700, ~9:00PM
1,000 km
Juan
de Fuca
Plate
EVIDENCE:
Native American oral history
Tsunami geology
Dating of "ghost forests"
"Orphan tsunami" in Japan
Seafloor turbidites