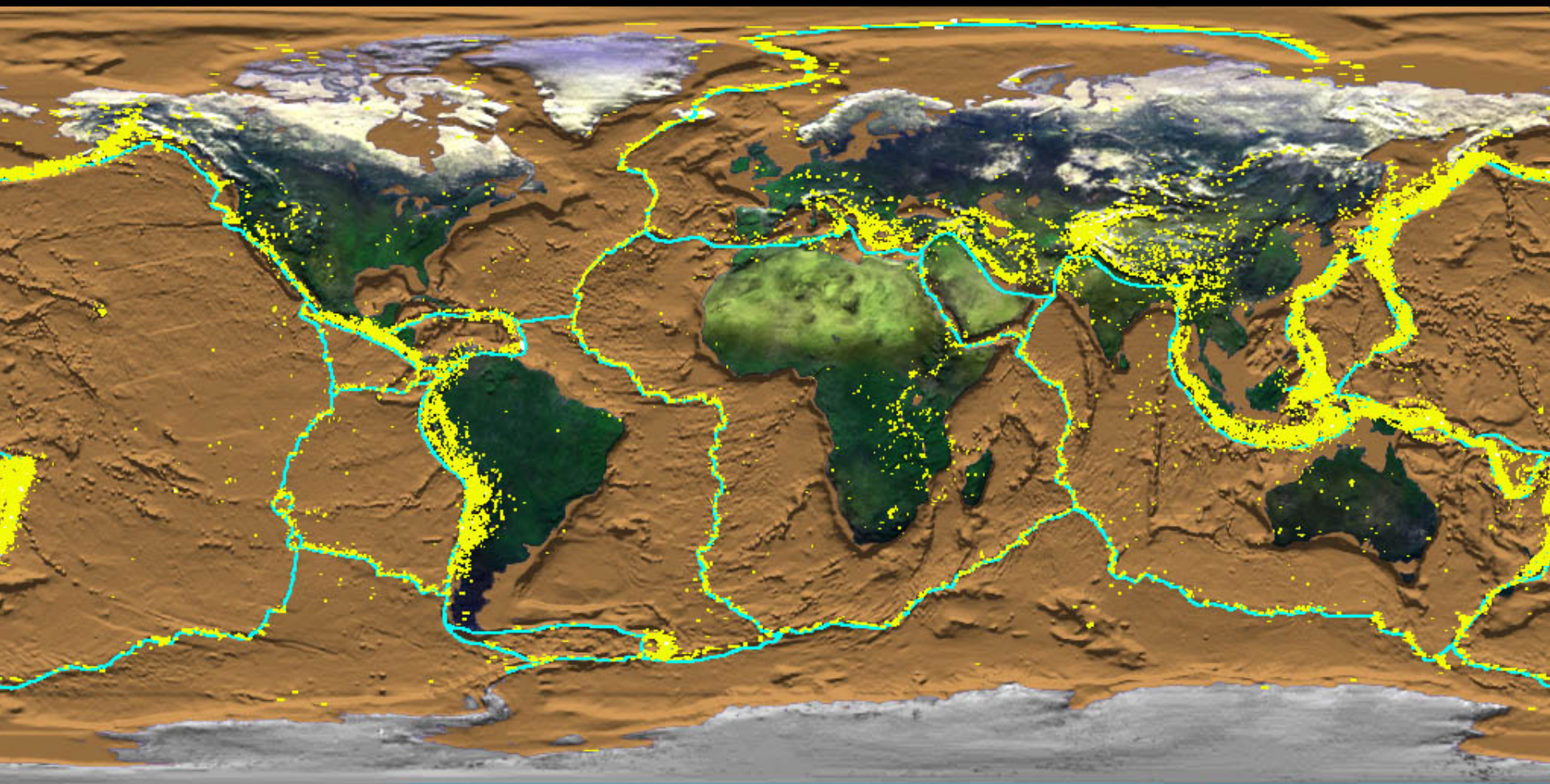
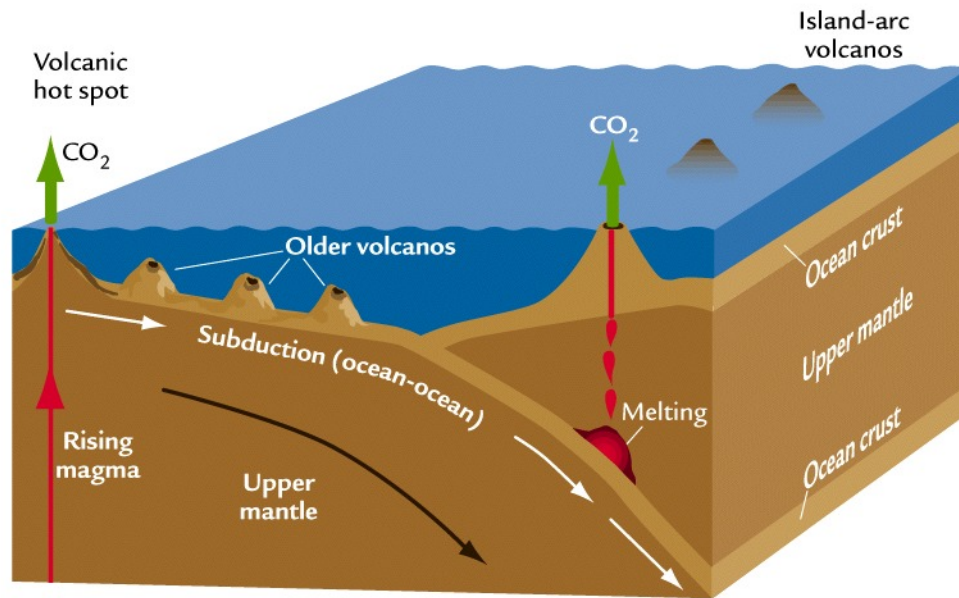
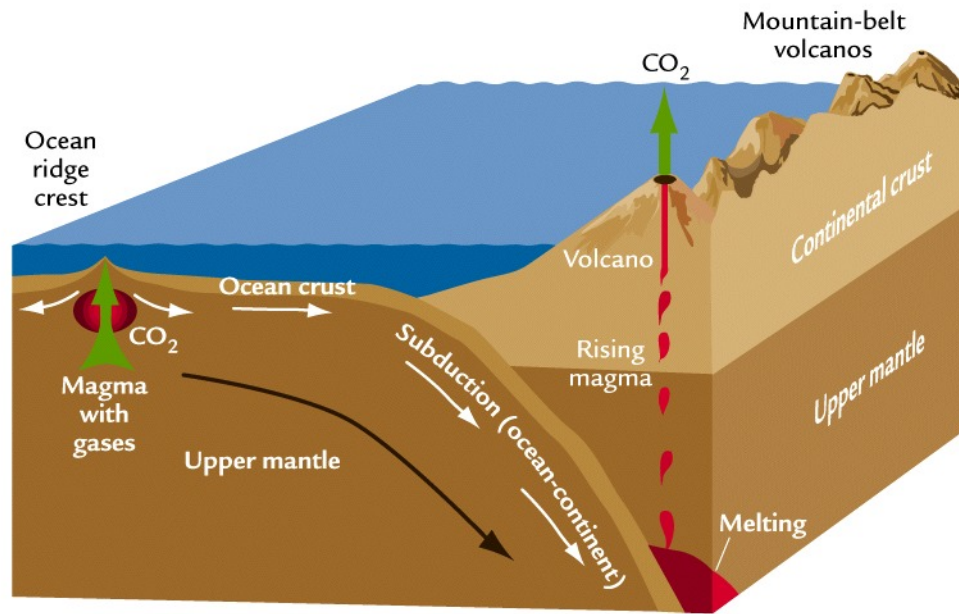
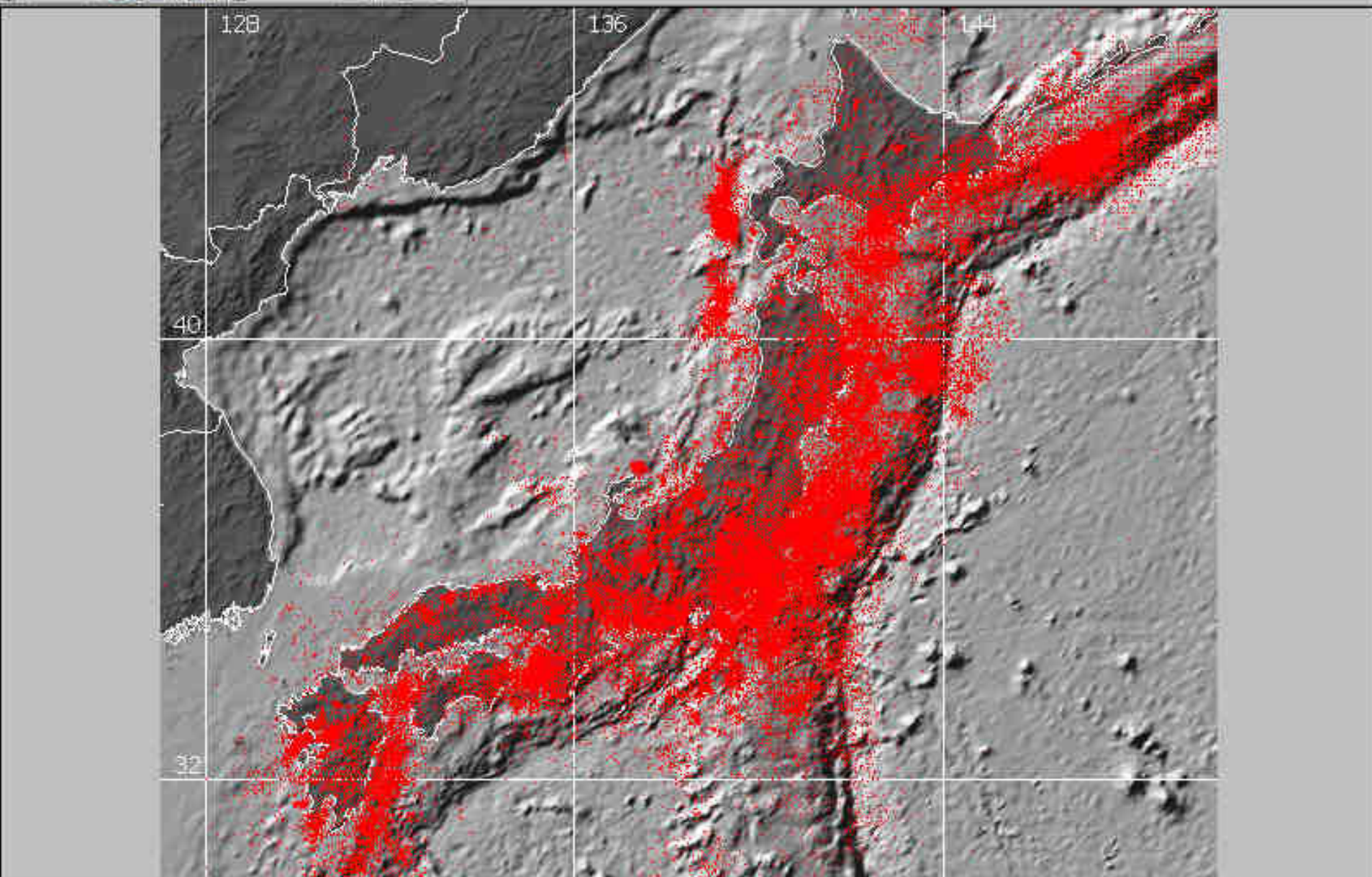




Earthquakes

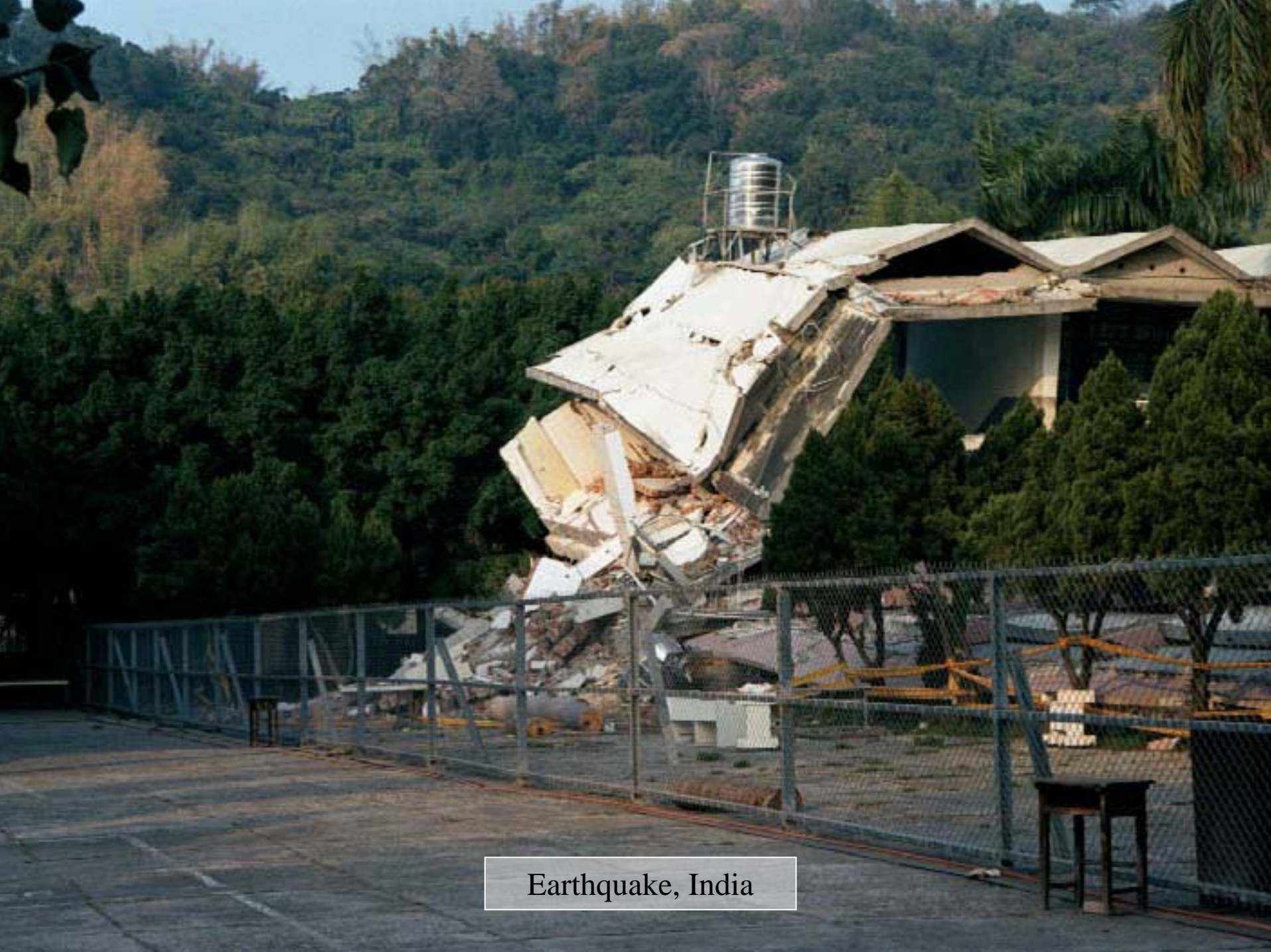








Earthquake, Japan

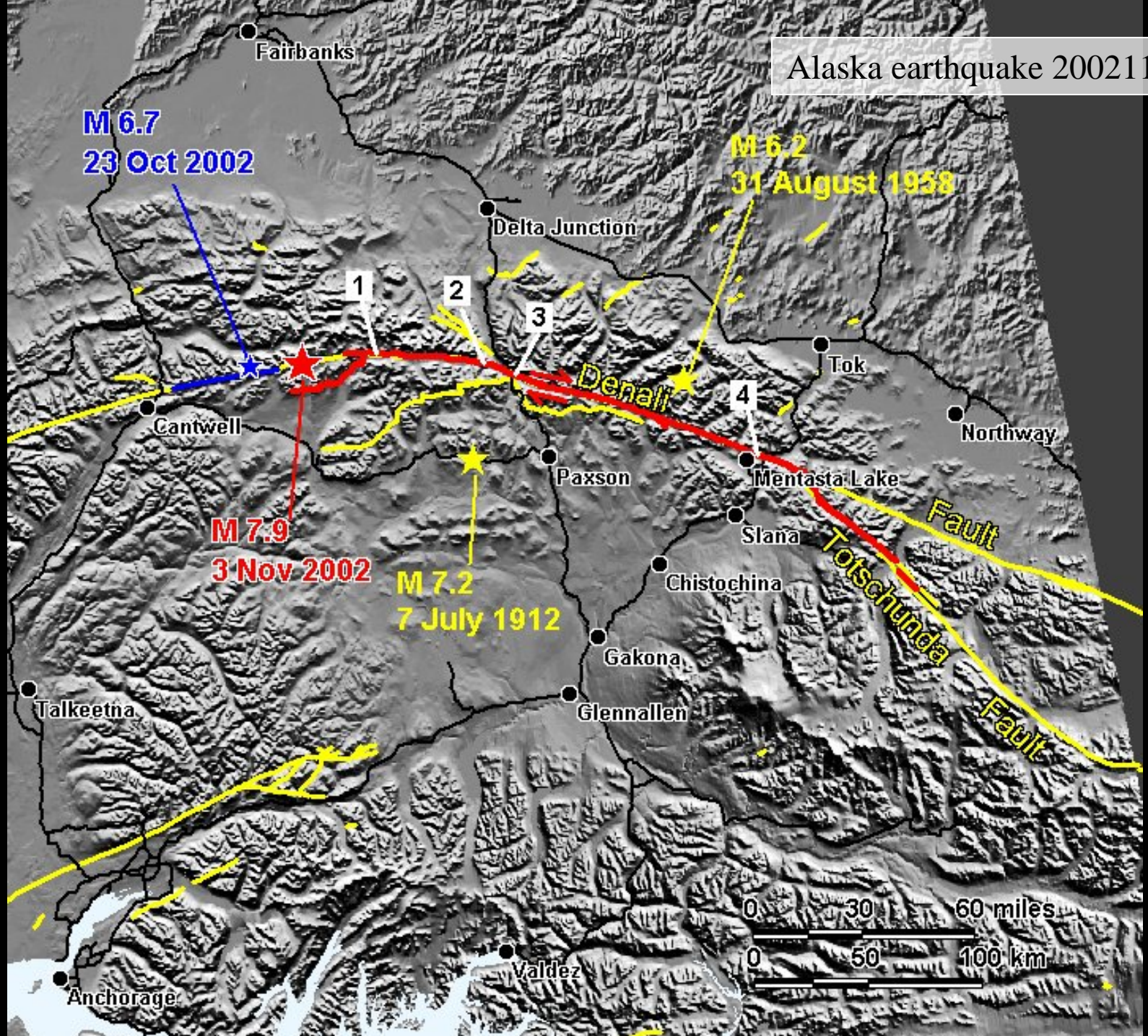


Earthquake, India



Earthquake, Hawaii

Alaska earthquake 20021102



M 6.7
23 Oct 2002

M 6.2
31 August 1958

M 7.9
3 Nov 2002

M 7.2
7 July 1912

0 30 60 miles
0 50 100 km



Alaska Earthquake 20021102



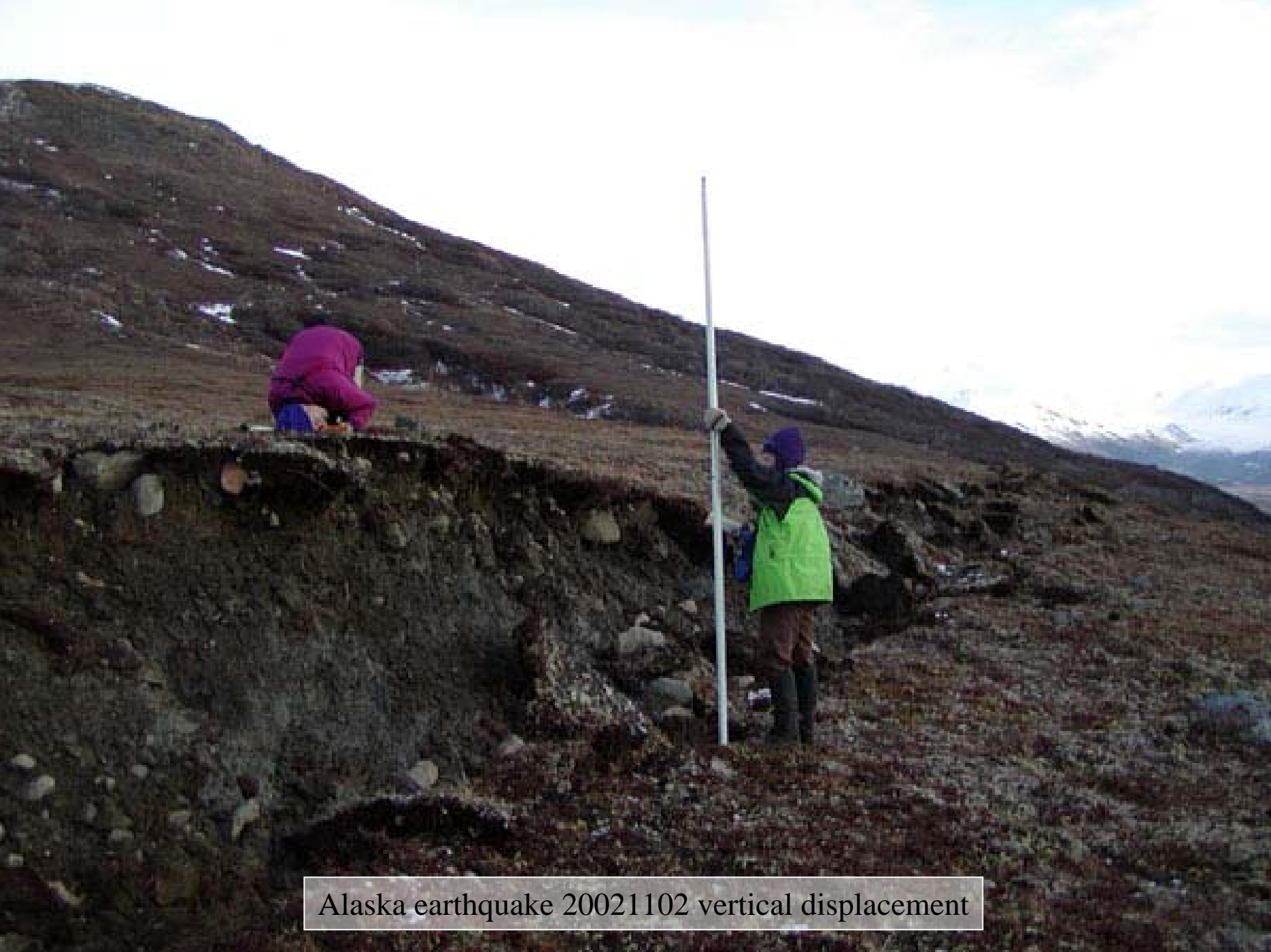
Trans-Alaska Pipeline and Richardson Highway 3m displacement



Trans-Alaska pipeline showing displacement and collapse



Alaska Earthquake 20021102 Cooper Creek scarp



Alaska earthquake 20021102 vertical displacement



Alaska earthquake
20021102 avalanches,
debris flows and
rockfalls



Alaska earthquake 20021102 Lost Creek slide



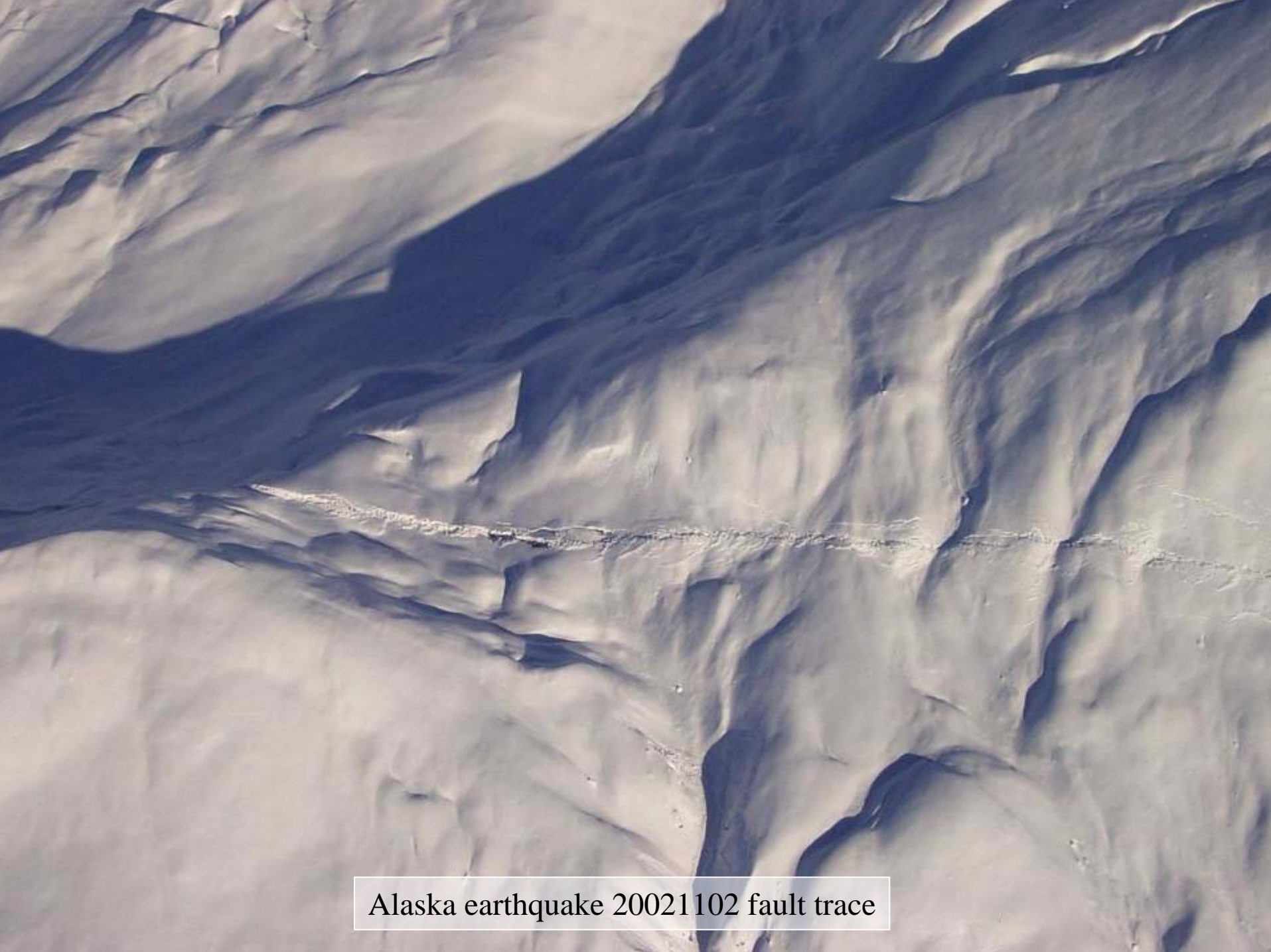
Alaska earthquake 20021102 ridge spreading due to earthquake motion



Alaska earthquake 2021102 liquefaction at Fielding Lake



Alaska earthquake 20021102 liquefaction at Fielding Lake



Alaska earthquake 20021102 fault trace



Alaska earthquake 20021102 fault trace near Chistochina Glacier



Alaska earthquake 20021102 fault trace on Chistochina Glacier



Alaska earthquake 2021102 Gakone slides on glacier



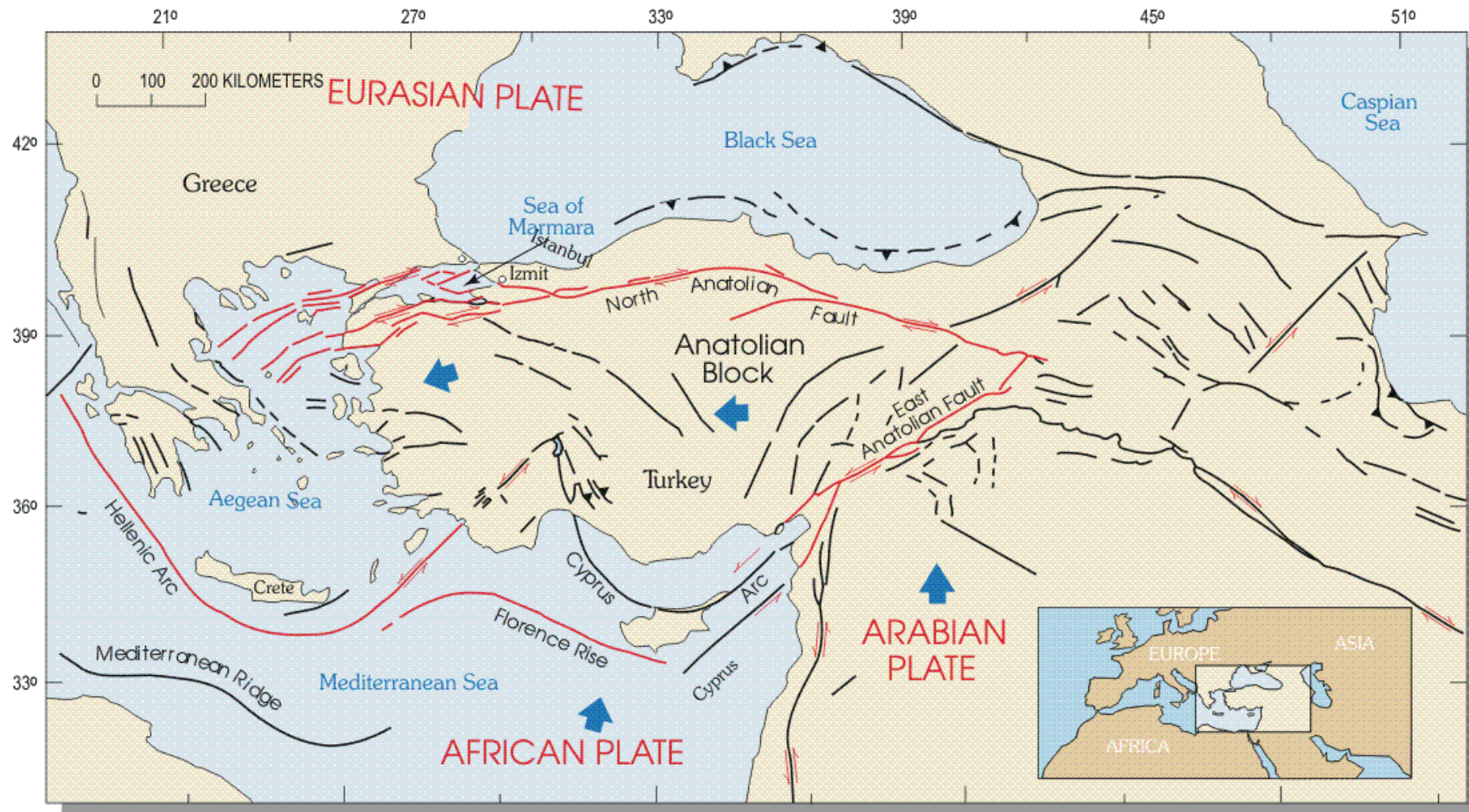
Alaska earthquake 20021102 Gakone slides on glacier

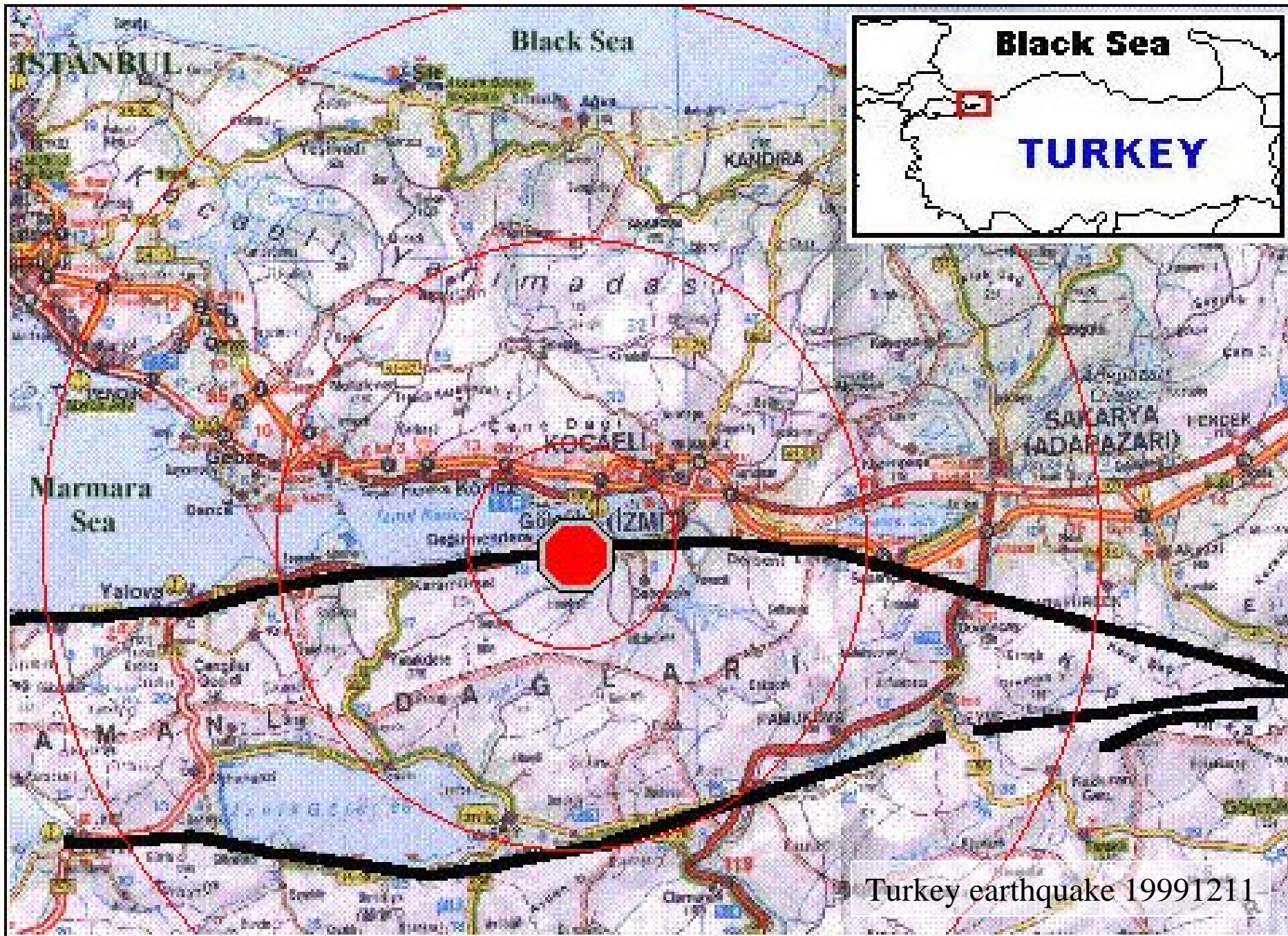


Alaska earthquake 20021102 rock avalanches across Black Rapid Glacier



Alaska earthquake 20021102 rock avalanches overriding Black Rapid Glacier





Turkey earthquake 19991211



Turkey earthquake 19991211



Turkey earthquake 19991211

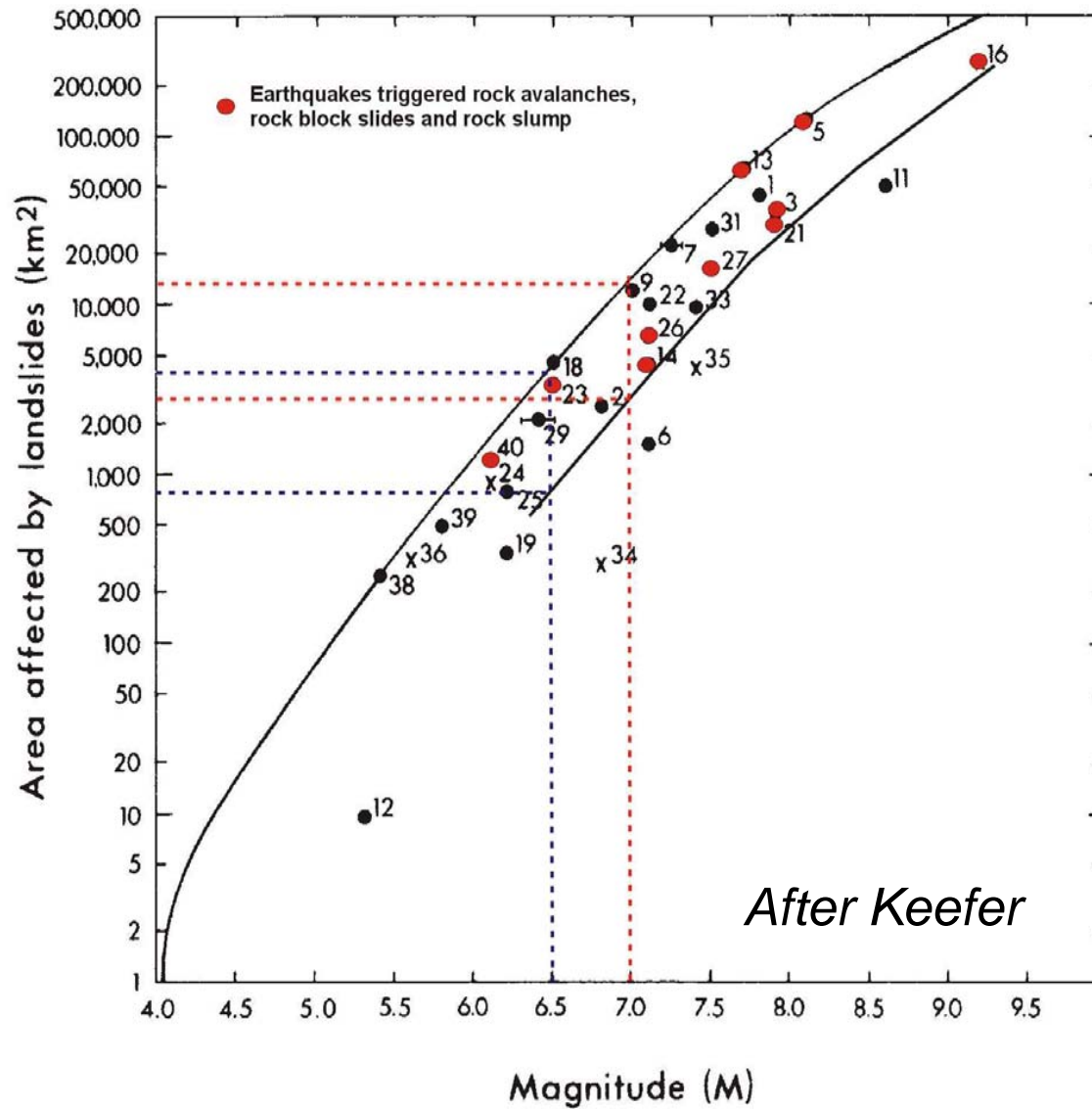


Turkey earthquake 19991211



Turkey earthquake 19991211

Earthquake magnitude vs area affected by landslides



| Richter Magnitudes | Effects Near Epicenter | Estimated Number per Year |
|--------------------|--|---------------------------|
| <2.0 | Generally not felt, but recorded. | 600,000 |
| 2.0–2.9 | Potentially perceptible. | 300,000 |
| 3.0–3.9 | Felt by some. | 49,000 |
| 4.0–4.9 | Felt by most. | 6200 |
| 5.0–5.9 | Damaging shocks. | 800 |
| 6.0–6.9 | Destructive in populous regions. | 266 |
| 7.0–7.9 | Major earthquakes. Inflict serious damage. | 18 |
| ≥8.0 | Great earthquakes. Destroy communities near epicenter. | 1.4 |

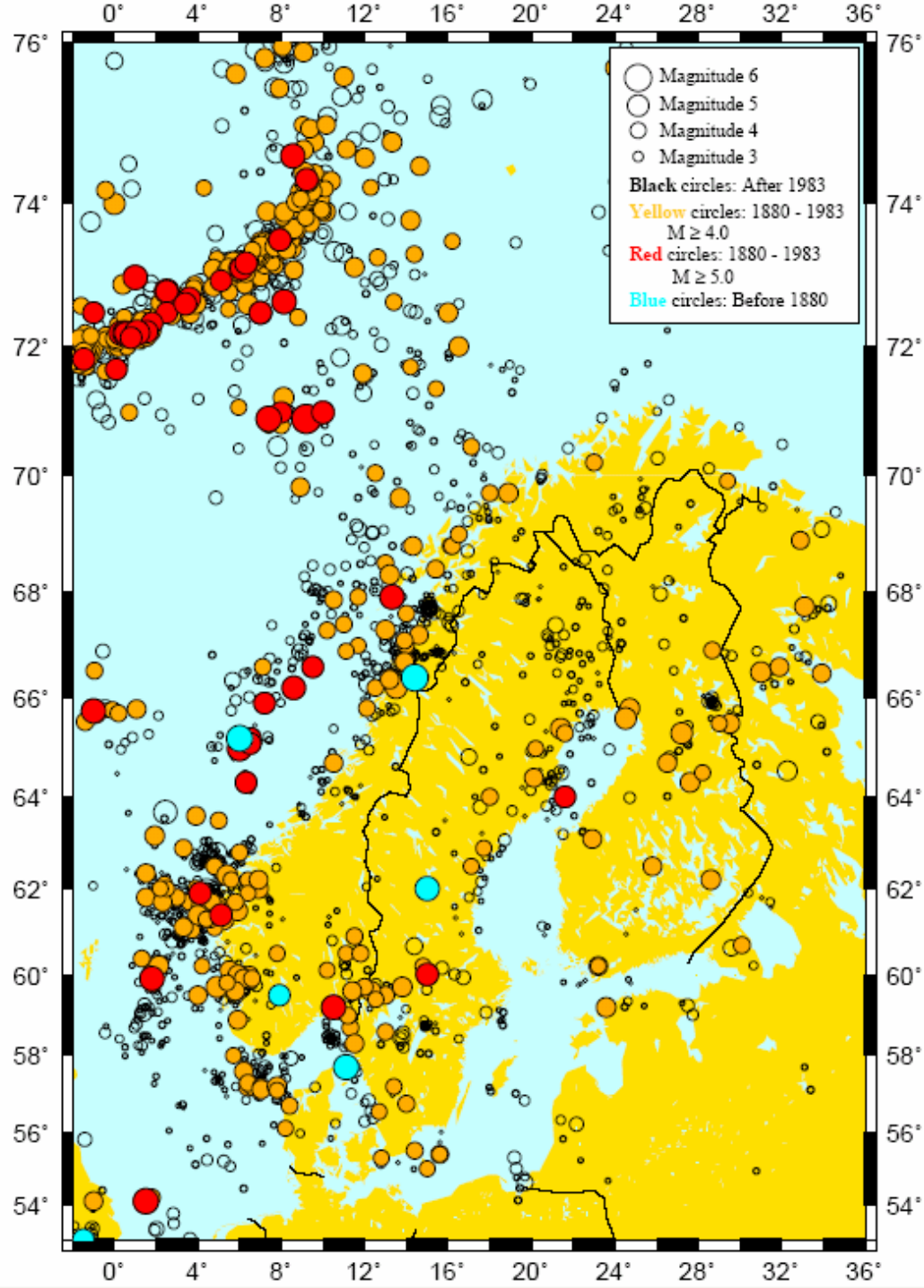
Earthquakes in Norway

The History of Earthquakes

The most famous Norwegian earthquake occurred in the outer Oslofjord in 1904. The earthquake had a strength of 5.4 on the Richter scale, and caused masonry building walls to crack and chimneys and roof tiles to fall off the houses in the city of Oslo. Panic was widespread.

Almost one hundred years earlier, in 1819, an even more powerful earthquake occurred in northern Norway, near the town of Mo i Rana. This earthquake is estimated to have had a strength of 5.8-6.0 on the Richter scale and is considered to be the strongest earthquake in northern Europe in historical time.

Both of these earthquakes are located in areas of relatively high seismic activity compared to elsewhere in Norway. A map of known earthquakes above magnitude 3.0 on the Richter scale, which is about the limit of what may be felt by humans, is shown in Figure 1. The map also shows that the offshore and coastal areas are more earthquake prone than the Norwegian mainland.

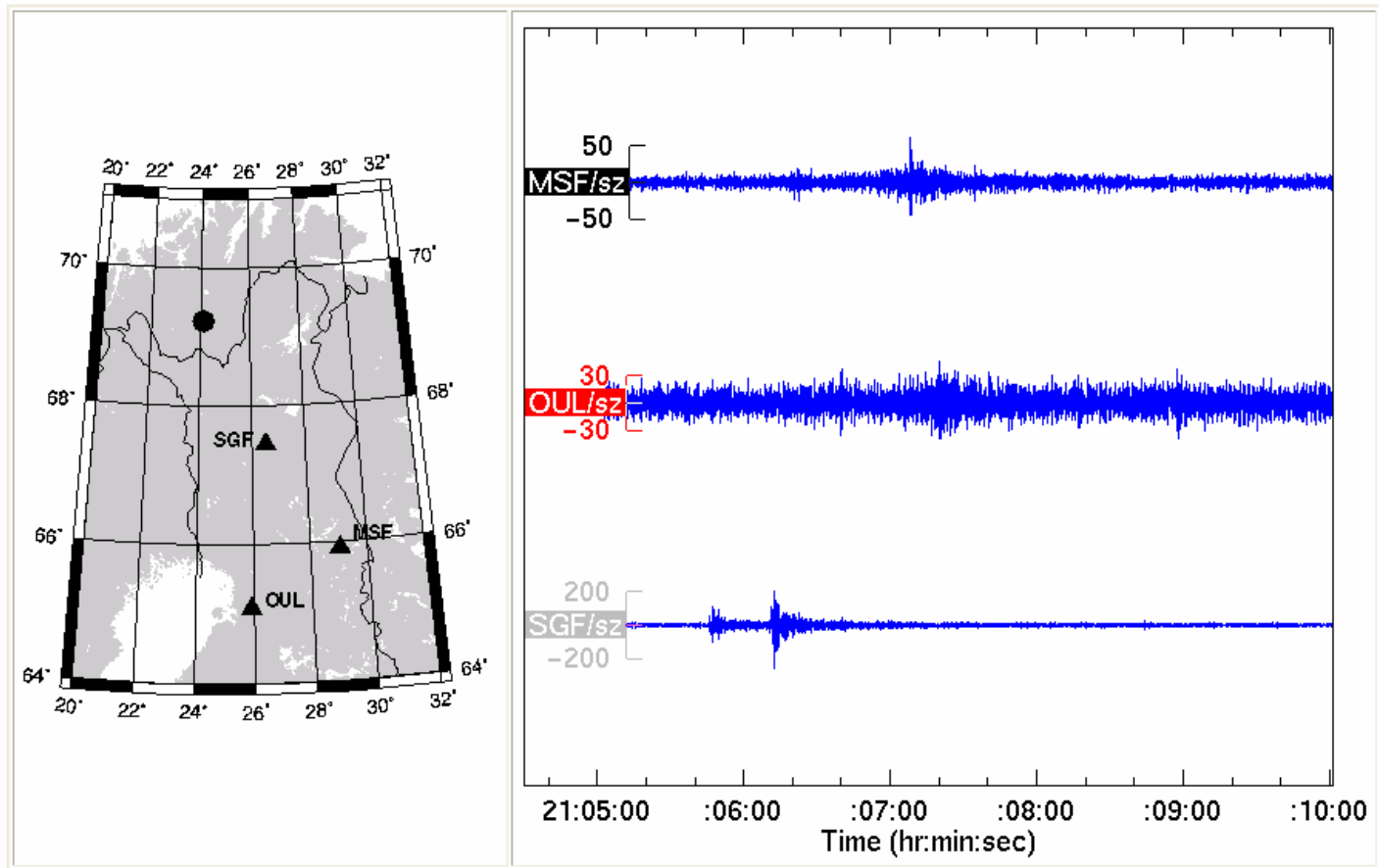


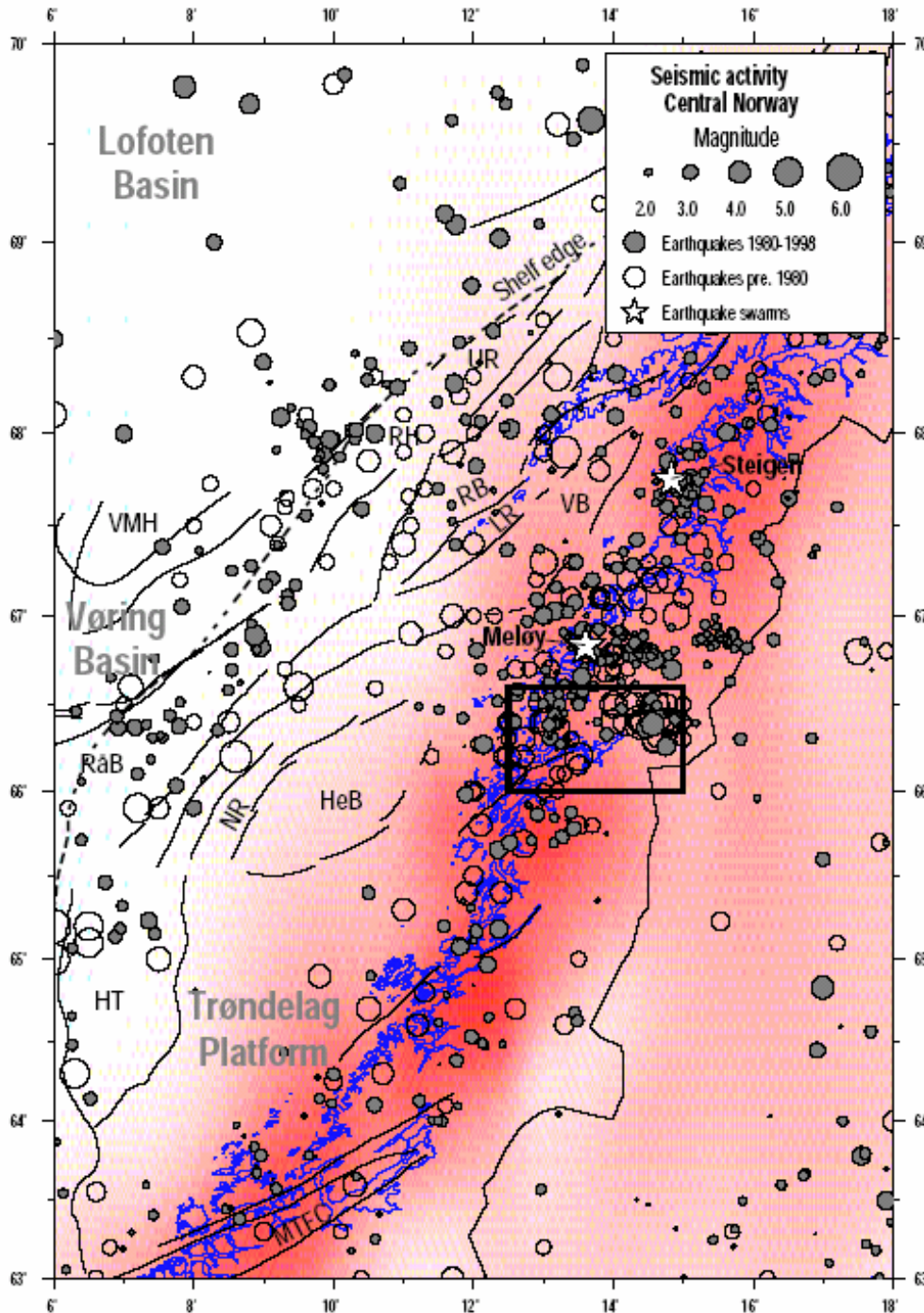
Earthquakes in and around Norway

Earthquake in Norway (GMT): May 19 2001 21:05:11.8

The epicentre information has been computed using Finnish seismic stations by Institute of Seismology at the University of Helsinki.

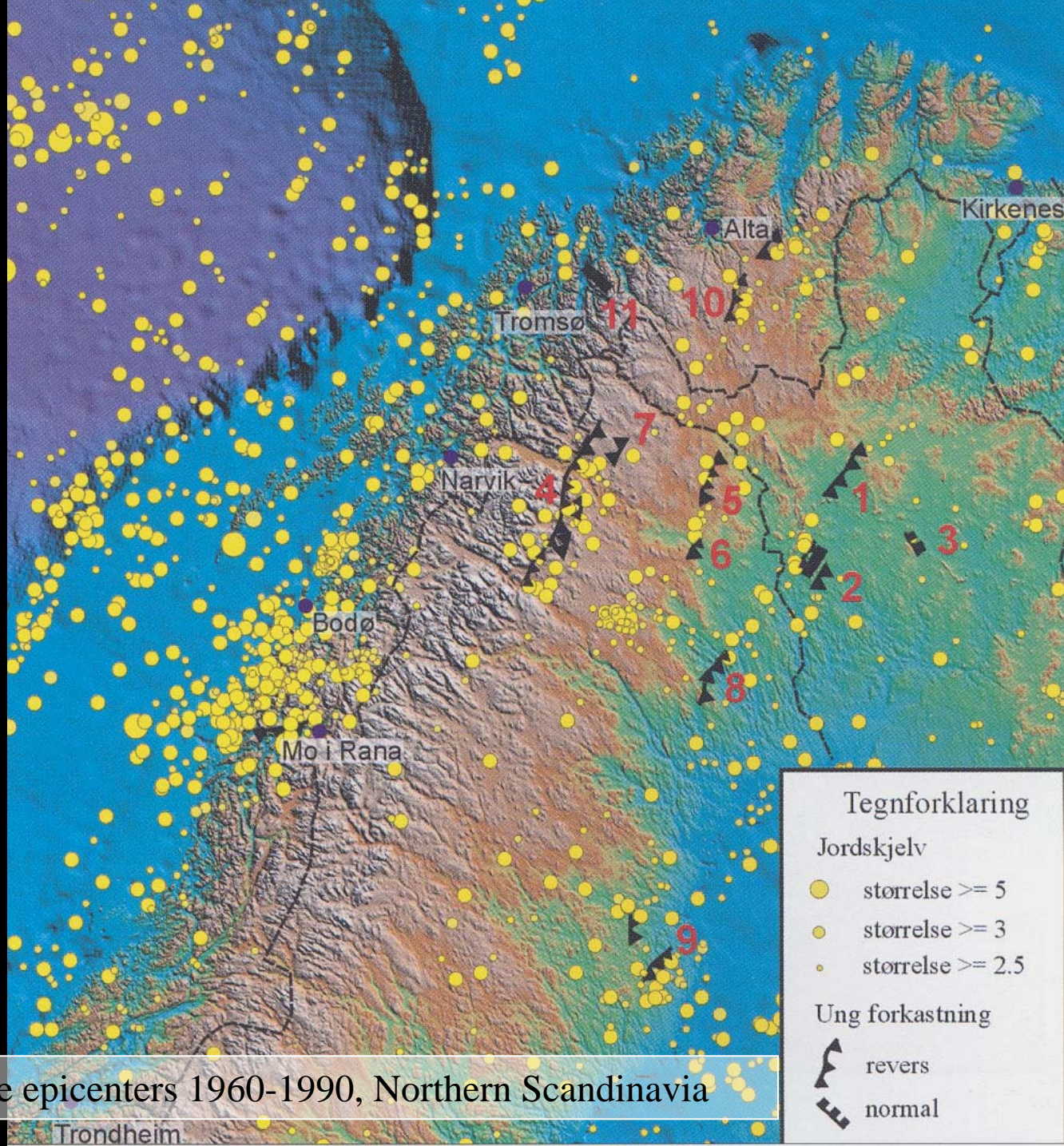
- Origin time (GMT): May 19 2001 21:05:11.8 Local time May 20 2001 00:05:11.8
- Latitude: 69.230N Longitude: 24.102E Depth: 10.0km Local Magnitude: 1.5L
- Below is shown Norway earthquake as recorded by permanent seismograph station of Sodankylä Geophysical Observatory at the University of Oulu. Stations are Maasselkä, Oulu and Sodankylä.





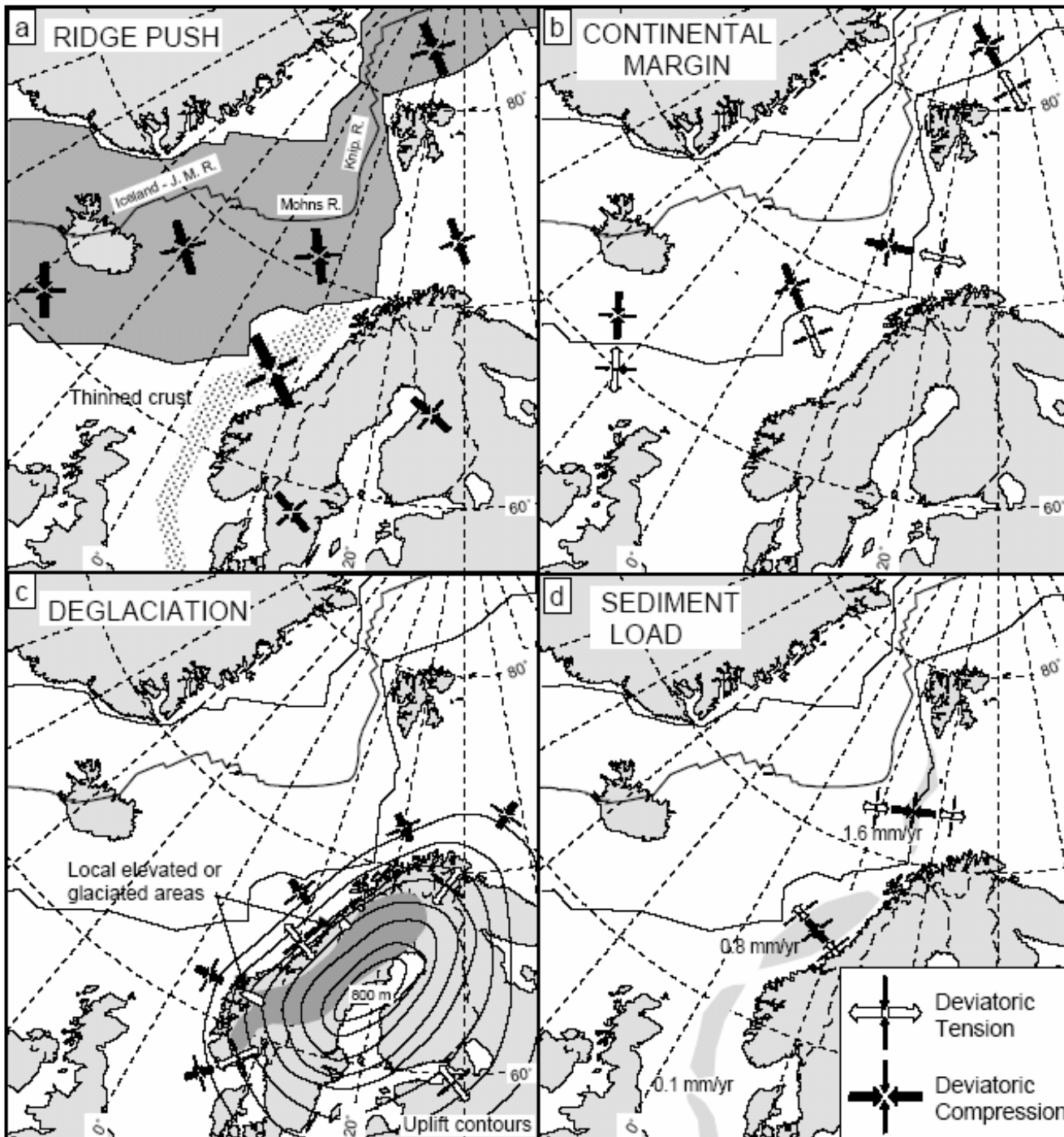
Regional seismic activity from pre-1980 (open circles) and 1980-1998 (grey circles).

Red shading indicates uplift gradients, where dark red indicates the highest gradients. The box and the stars indicate areas where shallow earthquake swarms have been observed.



Earthquake epicenters 1960-1990, Northern Scandinavia

Trondheim



Driving forces
for earthquakes
in and around
Norway

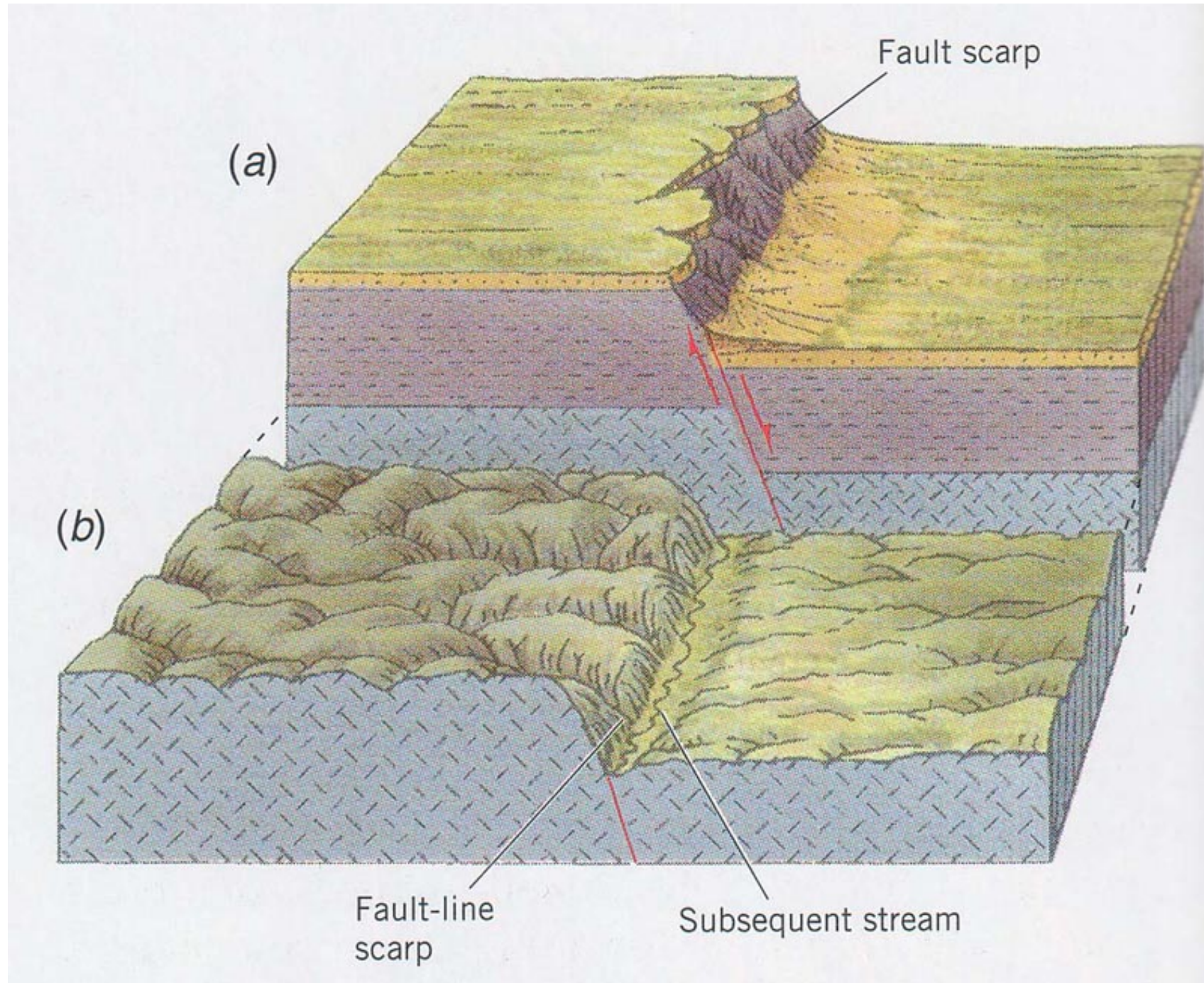
Fault scarp

(a)

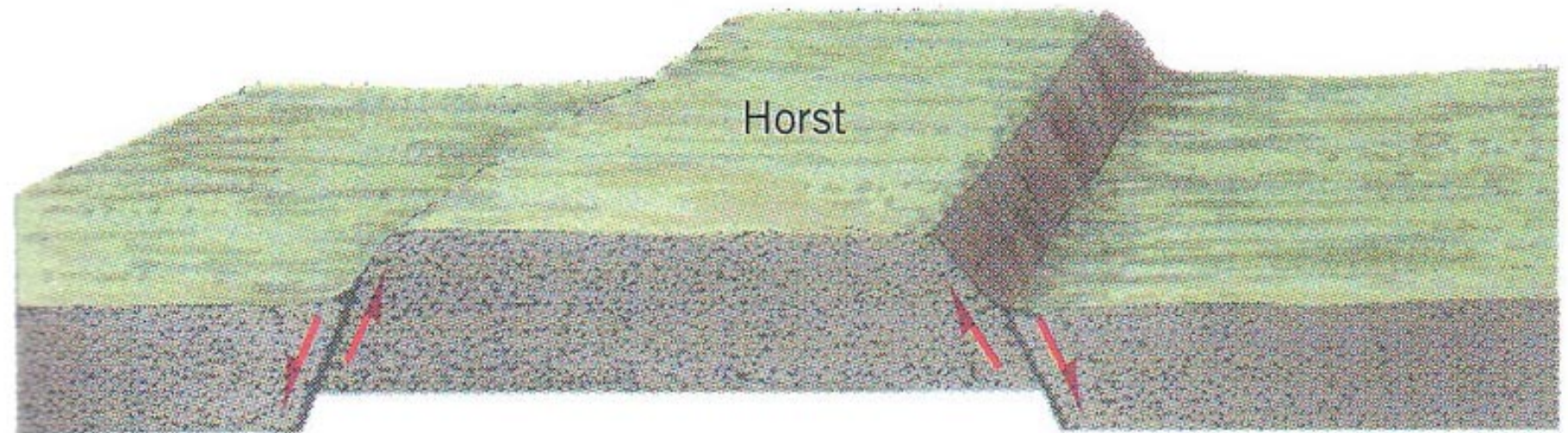
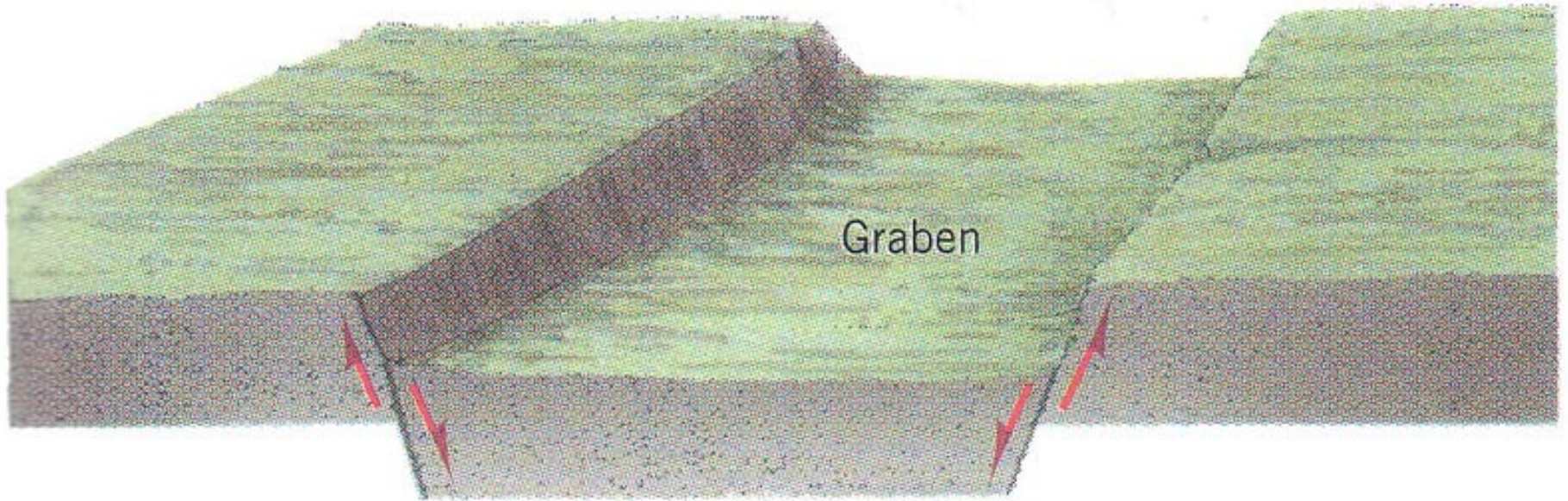
(b)

Fault-line scarp

Subsequent stream











Hannover



Image © 2005 DigitalGlobe
Image © 2005 MDA EarthSat

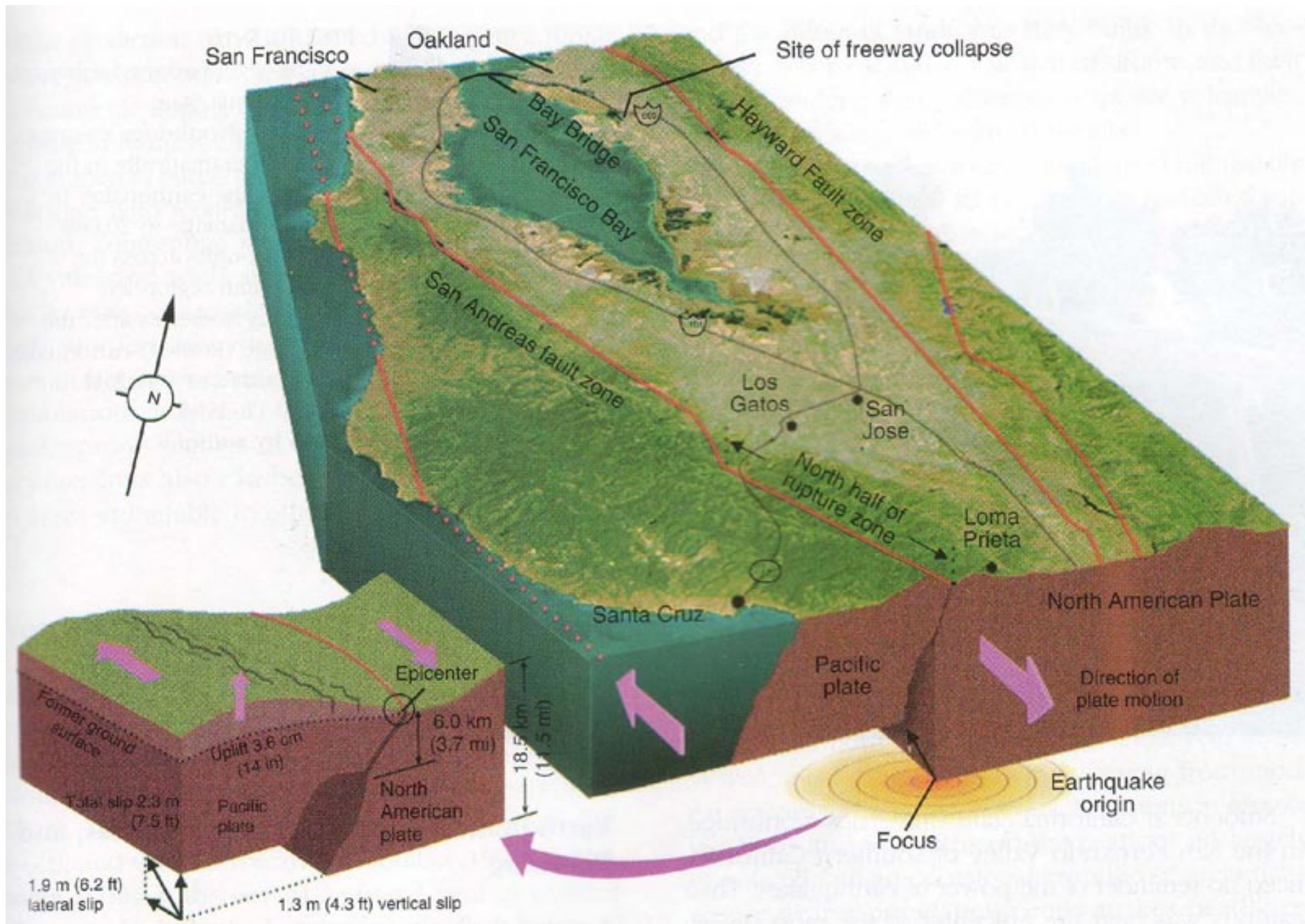
© 2005

Google

Pointer 52°26'47.17" N 12°17'35.53" E elev. 35 m

Streaming 3%

Eye alt. 49.1



Other landscape effects of earthquakes





Knossos 3500 BP; Minoian culture



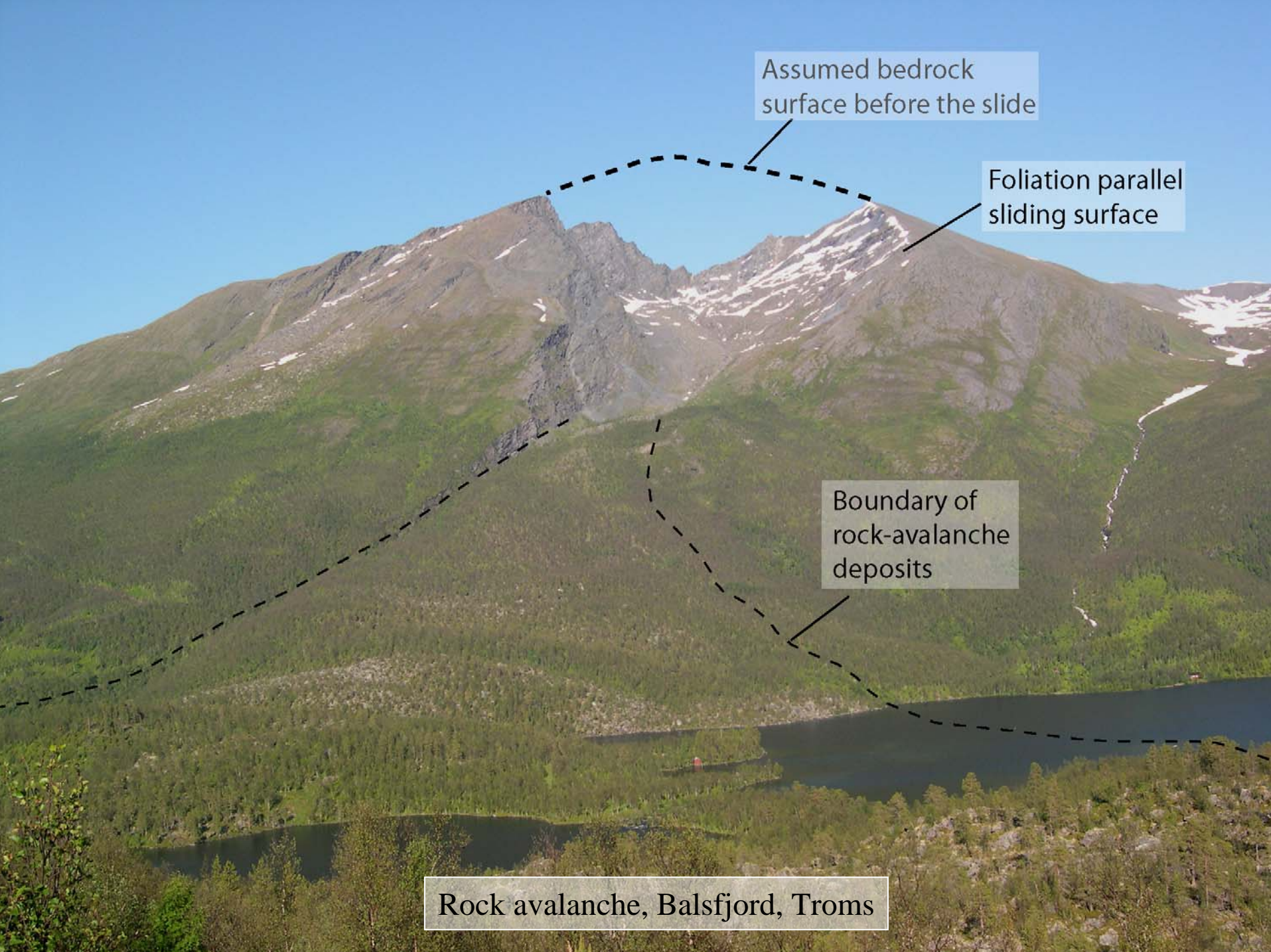


CRETE - MINOAN ART

Knossos 3500 BP; Minoian culture



**Knossos 3500 BP; advanced Minoian culture with water closets, etc.
Sudden decline from about 2500 BP. Loss of water due to earthquake?**



Assumed bedrock surface before the slide

Foliation parallel sliding surface

Boundary of rock-avalanche deposits

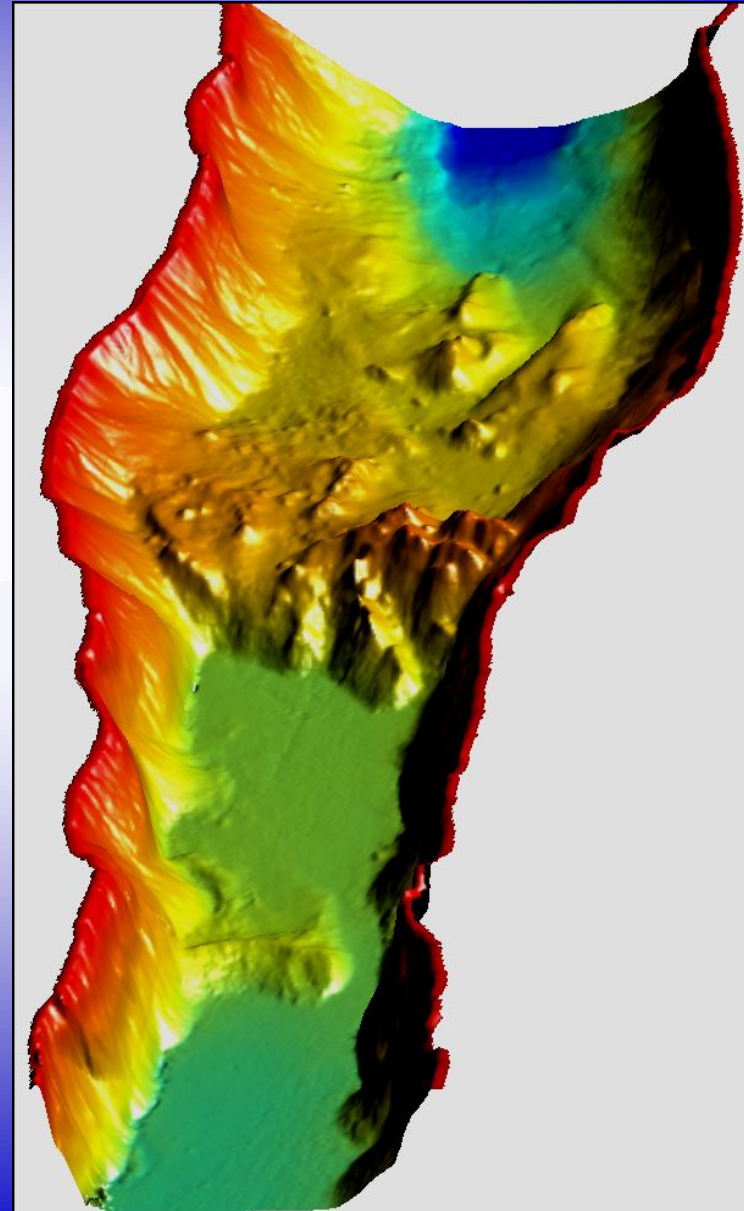
Rock avalanche, Balsfjord, Troms

Dating and spatial distribution of rockslope failures



Important for:

- Evaluation and quantification of hazard and risk level
- Triggering mechanisms

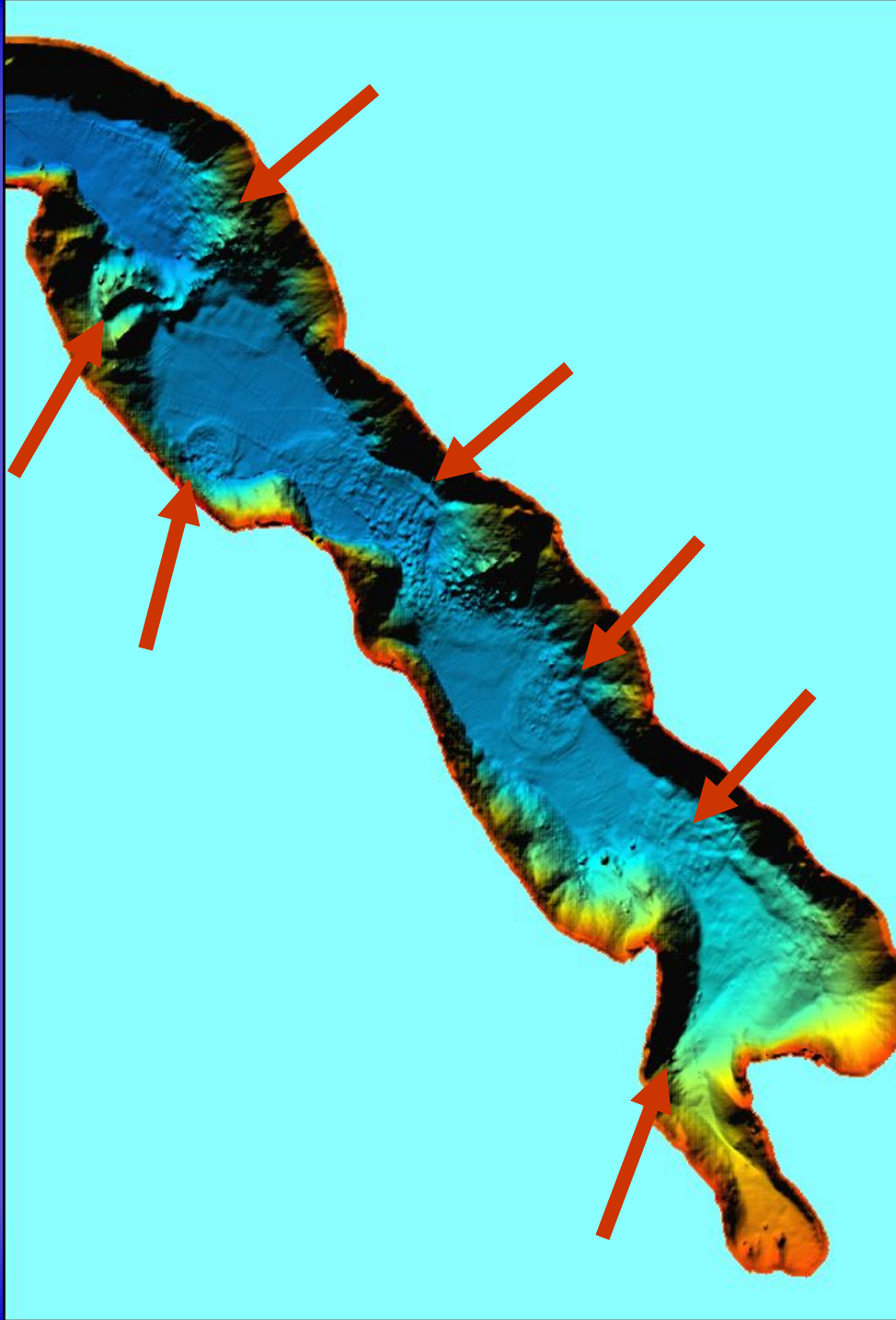




Tafjordulykka 7. april 1934

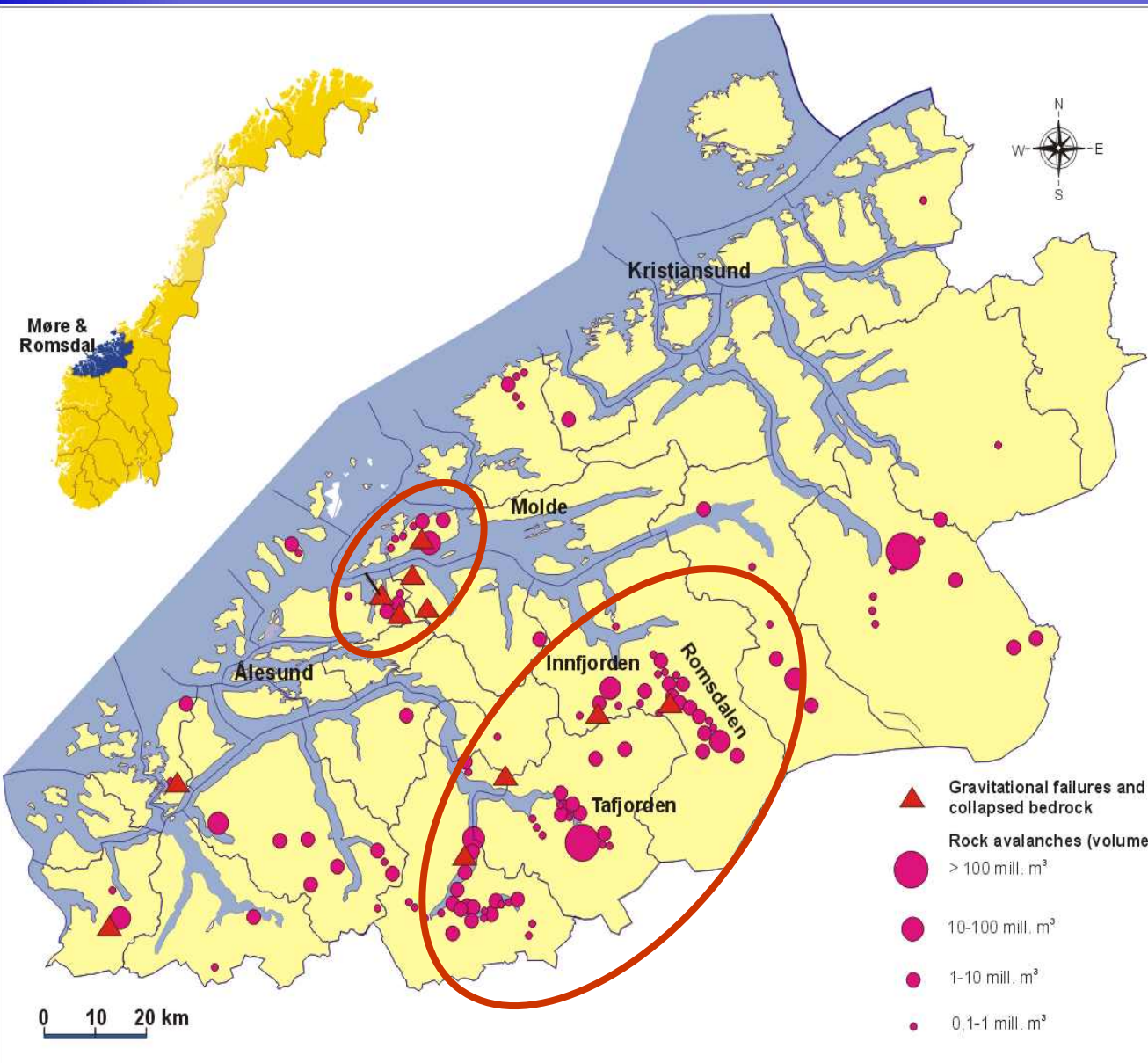
Natt til laurdag 7. April 1934 hende i Tafjorden ei av dei verste naturkatastrofene nokon gong i Noreg. Då losna Langhammaren, ei stor fjllblokk på nordsida av Tafjorden og reiv med seg Heggurda som låg under hammaren. Ein rekna med at ca. 3 millionar kubikkmeter stein fall ned i fjorden. Dei opp til 64 meter høge bølgiene som reiste seg , sopa med seg alt som kom i vegen, hus og meneske. I alt miste 40 menneske livet 23 i Tafjord og 17 i Fjørå. Et par attfunne ur hadde stansa på 03.10 ulukkesnatta.





Rock avalanches into
Tafjord, Norway

Spatial distribution of rock-slope failures in Møre & Romsdal







- Clusters
- Shortly after deglaciation in coastal area
- Many events during the last 5000 years

Earthquake release ?

Earthquakes

Magnitude

-  2.5-3.0
-  3.0-4.0
-  4.0-5.0
-  5.0-6.0



Apparent postglacial uplift, mm/yr

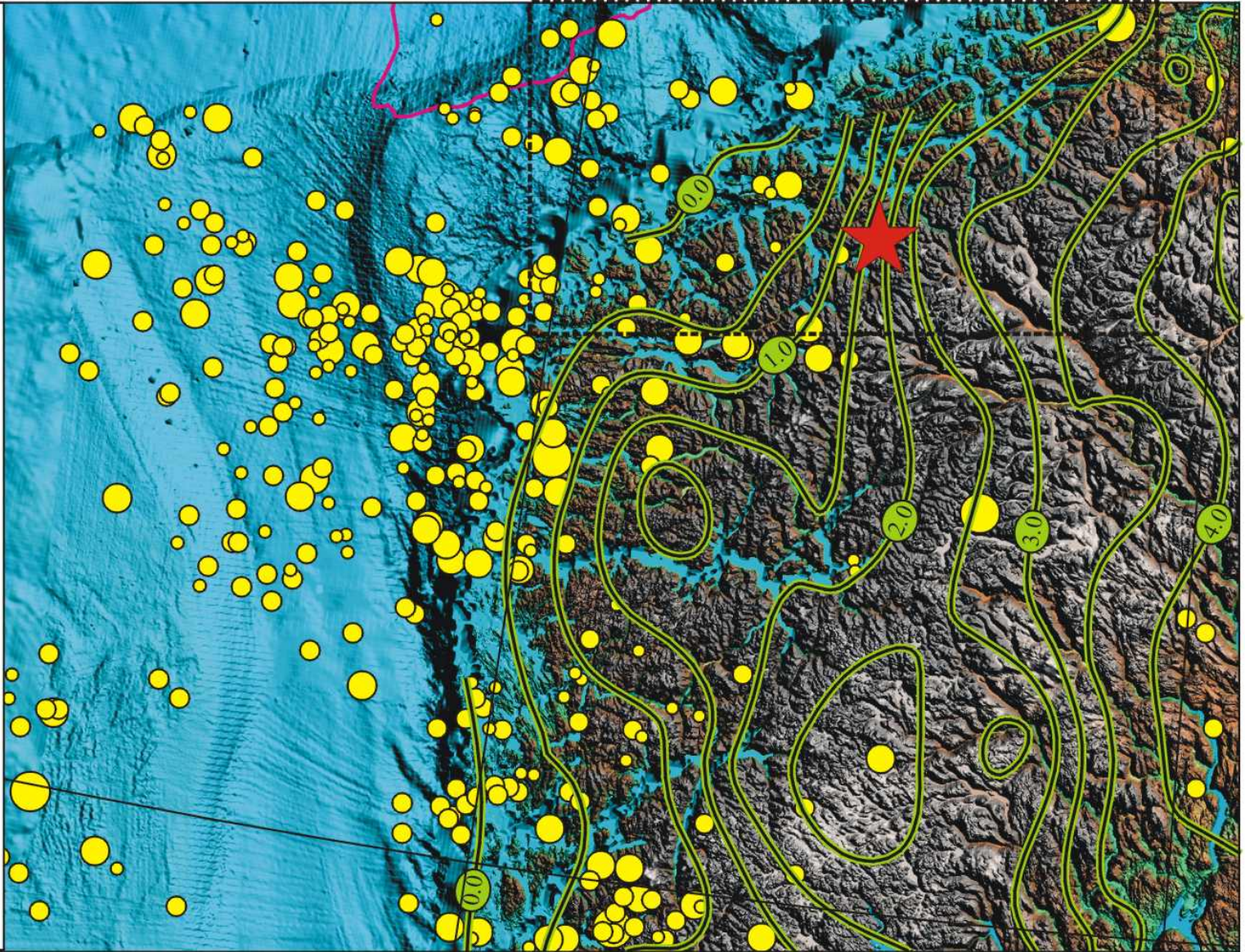


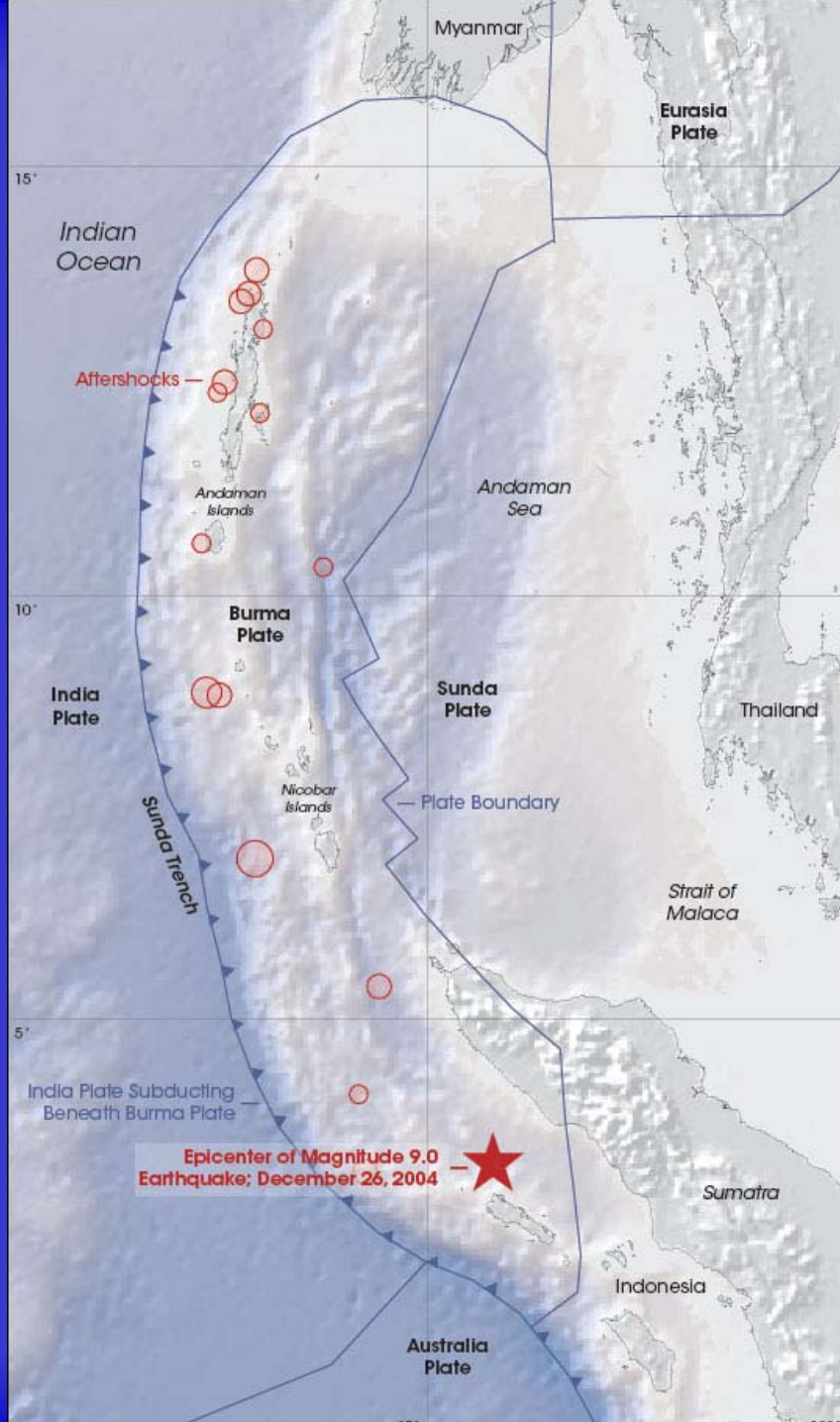
Backwall of the Storegga slide



Berill fault

25 km



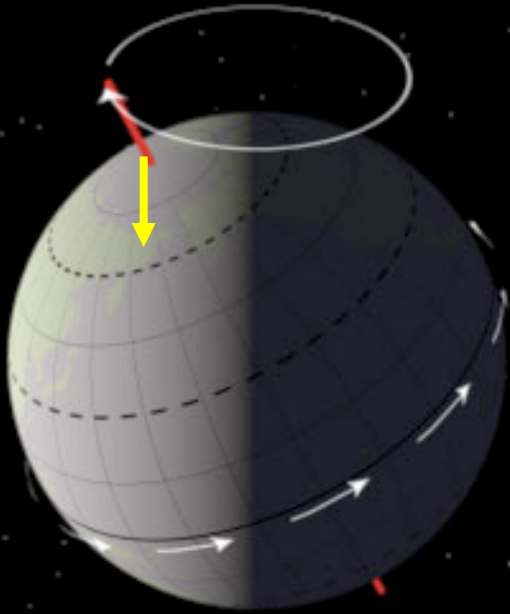


Sumatra earthquake 26. December 2004:

All earthquakes have some effect on Earth's rotation. It's just that the effects are, usually, barely noticeable.

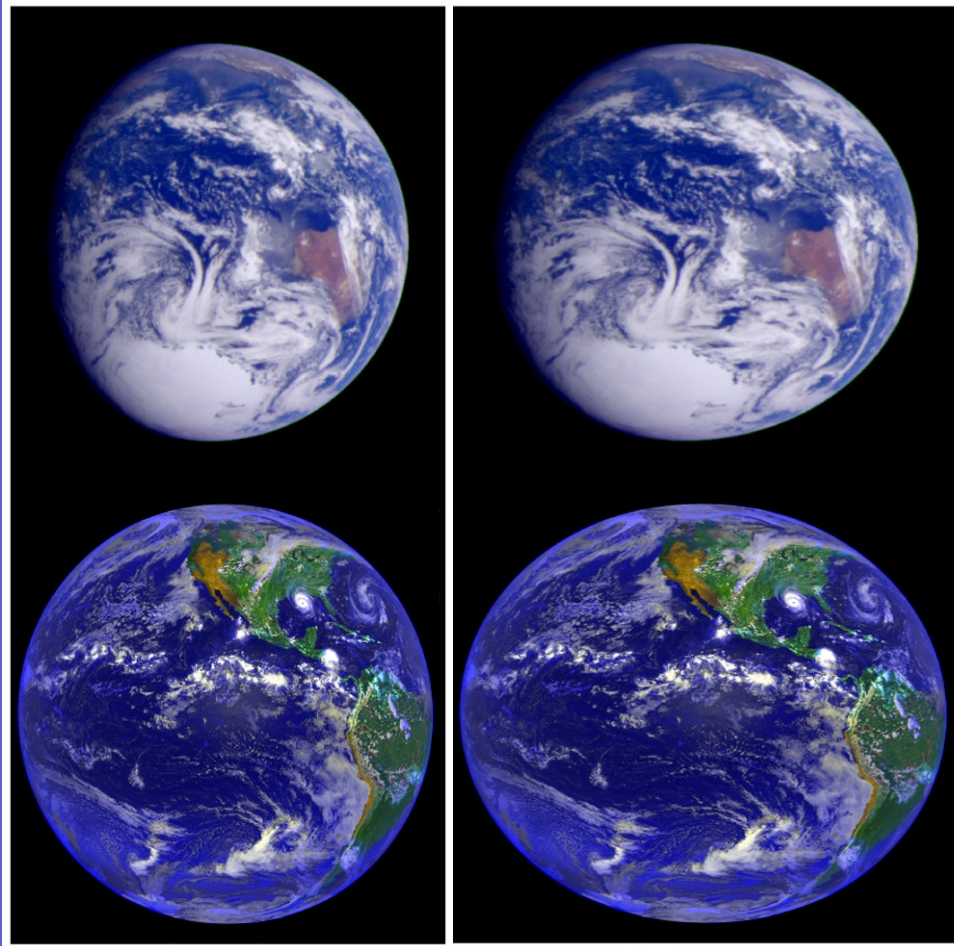
This one was not usual: The devastating megathrust earthquake registered nine on the new "moment" scale (modified Richter scale), making it the fourth largest 'quake in one hundred years.

Precession



Dr. B.F. Chao of NASA's Goddard Space Flight Center and Dr. R.Gross of NASA's Jet Propulsion Laboratory routinely calculate earthquakes' effects on Earth's shape and rotation. They also study changes in polar motion--that is, the shifting of the North Pole.

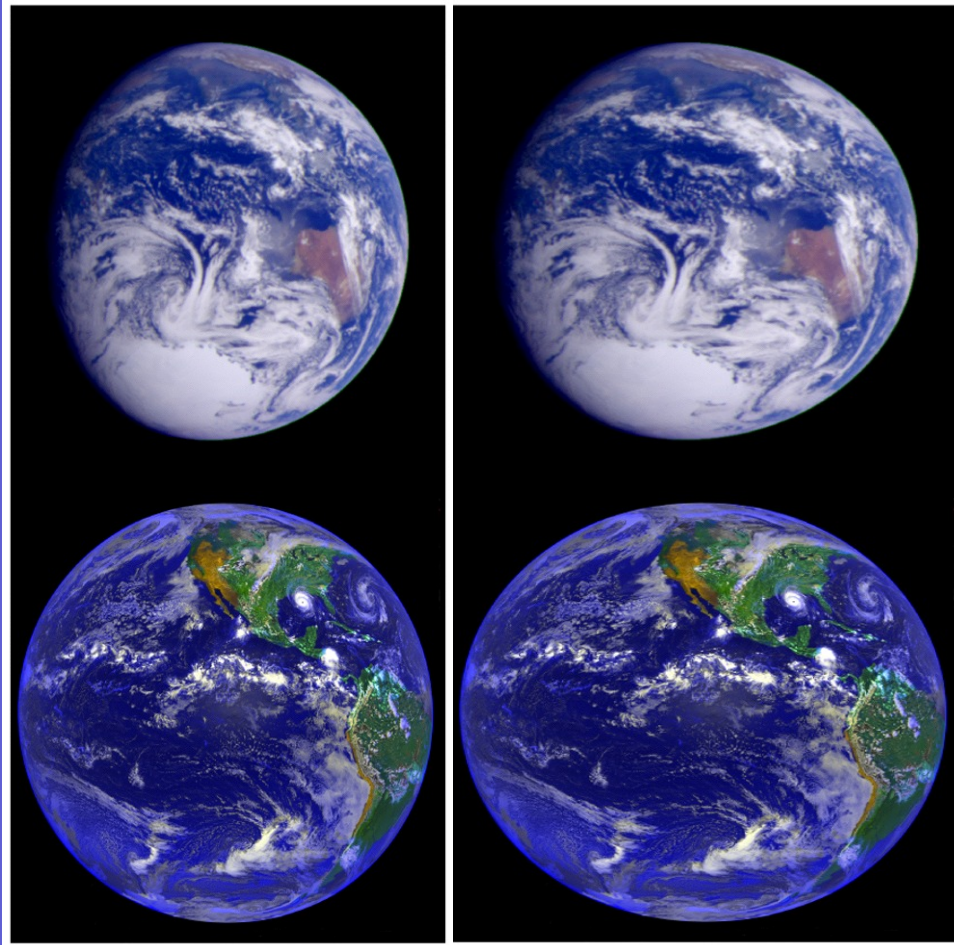
According to the latest calculations, the Dec. 26th earthquake shifted Earth's "mean North Pole" by about 2.5 centimeters (1 inch) in the direction of 145 degrees east longitude, more or less toward Guam in the Pacific Ocean. This shift is continuing a long-term seismic trend identified in previous studies.



The quake also affected Earth's shape.

The Sumatra earthquake 26. Decmber 2004 had the effect that Earth's oblateness (flattening of the planet) decreased by a small amount--about one part in 10 billion. This continues the trend of earthquakes making Earth less oblate. Less oblate means more round.





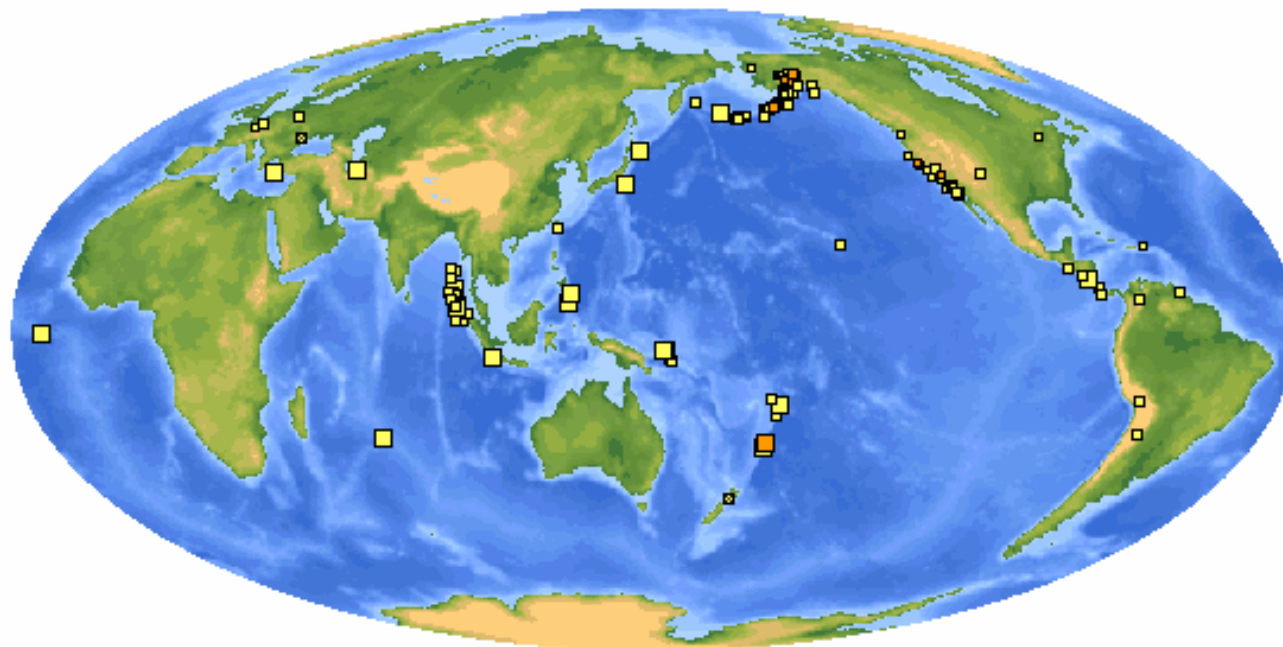
The quake also affected day length on Earth.

The earthquake decreased the length of the day by 2.68 microseconds. (A microsecond is one millionth of a second.) In other words, Earth now spins a little faster than it did before. This change in spin is related to the change in oblateness. It's like a spinning skater drawing arms closer to the body resulting in a faster spin.

World Map - Clickable to Regions

Sun Jan 16 19:00:03 UTC 2005

140 earthquakes on this map



ages

■ last hour

■ day

■ week

magnitudes

□ >7

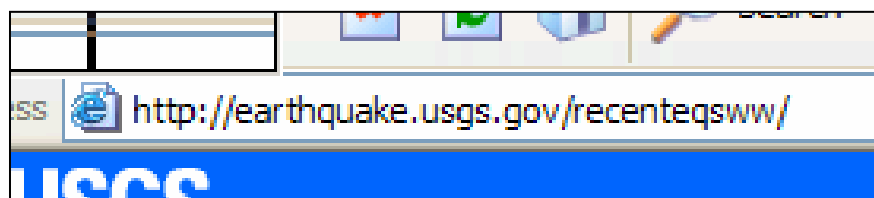
□ >5

□ >2.5

⊗ ?

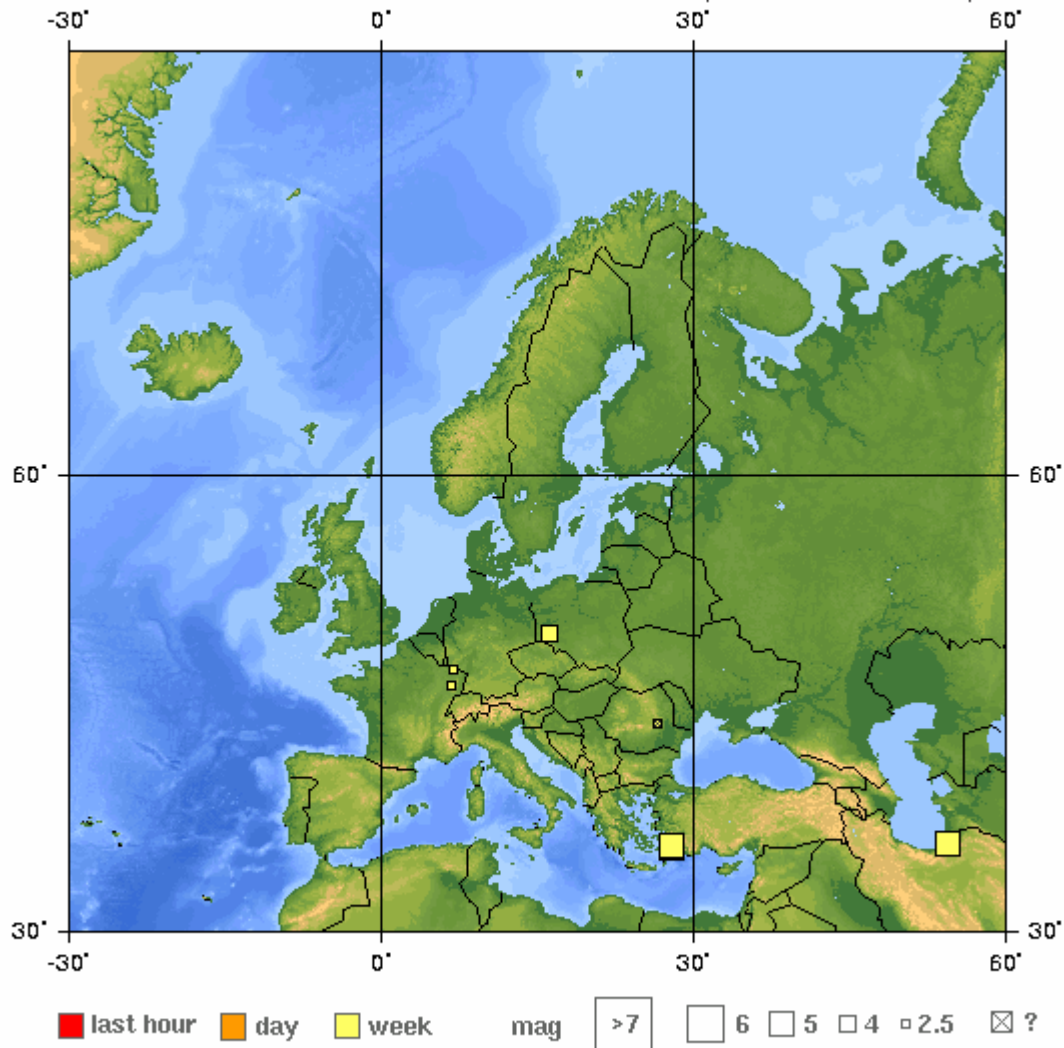
(not known)

Click on a point to go to a region map.



Europe Region

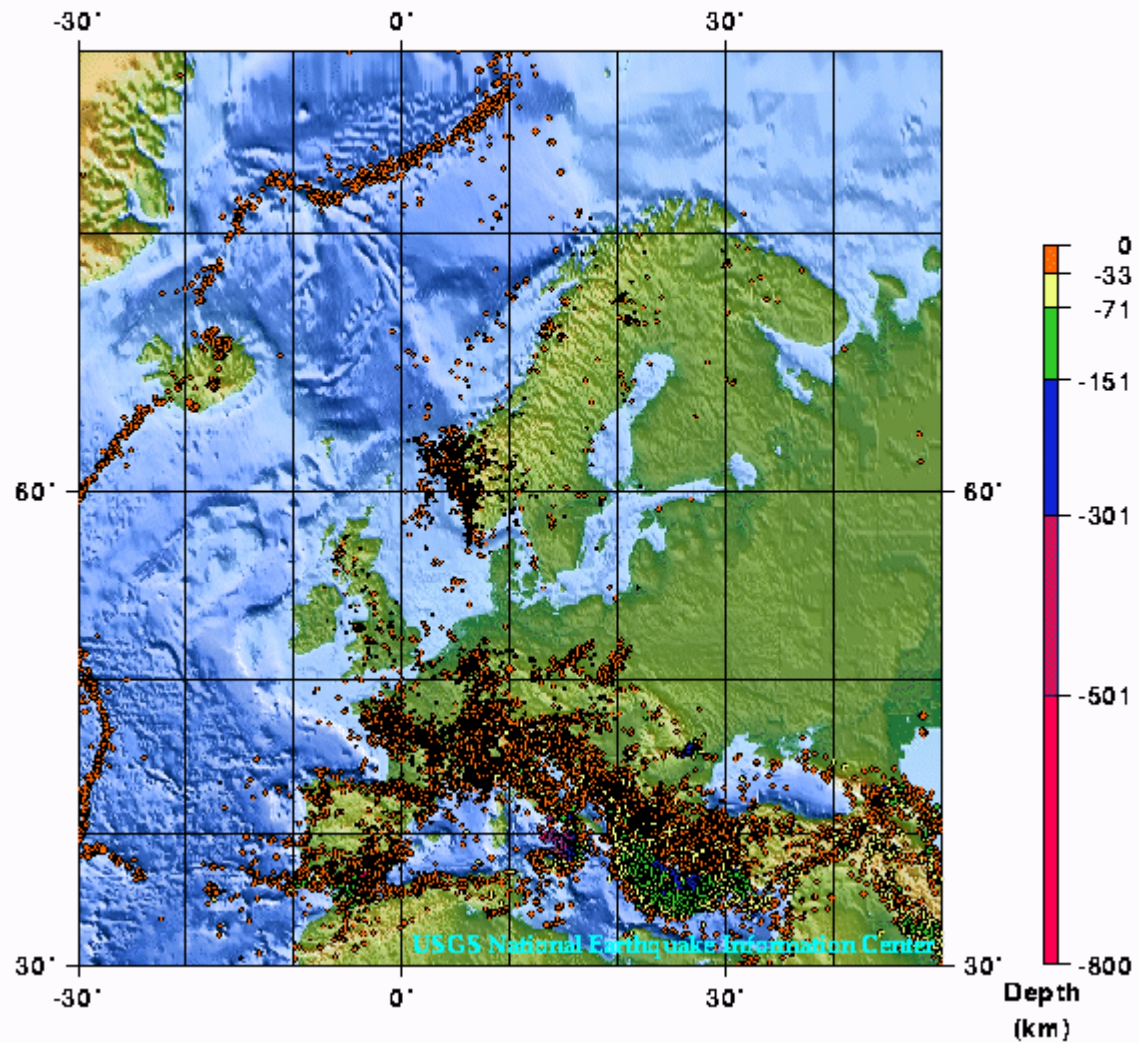
Sun Jan 16 19:00:00 UTC 2005 8 earthquakes on this map



Click on an earthquake for more information.
Click near an earthquake to go to a 10-degree map.

Seismicity of Europe

Seismicity of Europe: 1975 - 1995



Most Destructive Known Earthquakes on Record in the World

Earthquakes with 50,000 or More Deaths

Listed in order of greatest number of deaths

| Date | Location | Deaths | Magnitude | Comments |
|--------------------------|----------------------------------|----------------------------------|------------|---|
| January 23, 1556 | China, Shansi | 830,000 | ~8 | |
| July 27, 1976 | China, Tangshan | 255,000 (official) | 7.5 | Estimated death toll as high as 655,000. |
| August 9, 1138 | Syria, Aleppo | 230,000 | | |
| May 22, 1927 | China, near Xining | 200,000 | 7.9 | Large fractures. |
| December 22, 856+ | Iran, Damghan | 200,000 | | |
| December 16, 1920 | China, Gansu | 200,000 | 8.6 | Major fractures, landslides. |
| December 26, 2004 | Sumatra | 153,200 | 9.0 | Deaths from earthquake and tsunami. |
| March 23, 893+ | Iran, Ardabil | 150,000 | | |
| September 1, 1923 | Japan, Kanto (Kwanto) | 143,000 | 7.9 | Great Tokyo fire. |
| October 5, 1948 | USSR (Turkmenistan, Ashgabat) | 110,000 | 7.3 | |
| December 28, 1908 | Italy, Messina | 70,000 to 100,000 (estimated) | 7.2 | Deaths from earthquake and tsunami. |
| September, 1290 | China, Chihli | 100,000 | | |
| November, 1667 | Caucasia, Shemakha | 80,000 | | |
| November 18, 1727 | Iran, Tabriz | 77,000 | | |
| November 1, 1755 | Portugal, Lisbon | 70,000 | 8.7 | Great tsunami. |
| December 25, 1932 | China, Gansu | 70,000 | 7.6 | |
| May 31, 1970 | Peru | 66,000 | 7.9 | \$530,000 damage, great rock slide, floods. |
| 1268 | Asia Minor, Silicia | 60,000 | | |
| January 11, 1693 | Italy, Sicily | 60,000 | | |
| May 30, 1935 | Pakistan, Quetta | 30,000 to 60,000 | 7.5 | Quetta almost completely destroyed. |
| February 4, 1783 | Italy, Calabria | 50,000 | | |
| June 20, 1990 | Iran | 50,000 | 7.7 | Landslides. |
| December 26, 2004 | Sumatra | 280,000 | 9.0 | Large tsunami in Indian Ocean |

+ Note that these dates are prior to 1000 AD. No digit is missing.

