Asia-Pacific Economic Cooperation

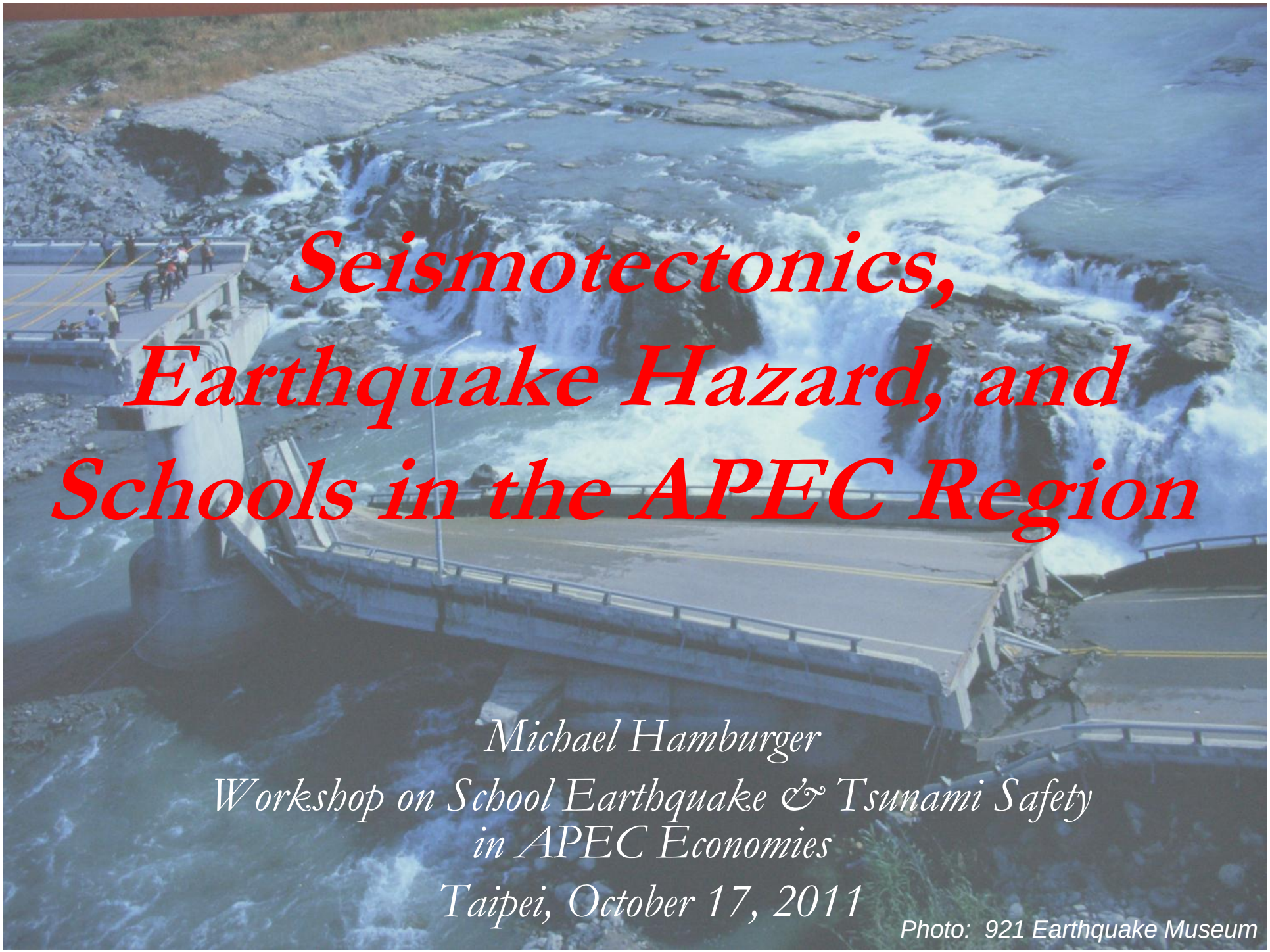
2011/EPWG/WKSP3/002

Seismotectonics, Earthquake Hazard, and Schools in the APEC Region

Submitted by: Indiana University (IU)

APEC USA 2011

Workshop on School Earthquake and Tsunami Safety in APEC Economies: Reducing Risk and Improving Preparedness
Taipei, Chinese Taipei
17-19 October 2011



Seismotectonics, Earthquake Hazard, and Schools in the APEC Region

Michael Hamburger

Workshop on School Earthquake & Tsunami Safety in APEC Economies

Taipei, October 17, 2011

Photo: 921 Earthquake Museum

Sumatra, Indonesia December 2004

Sichuan, China May, 2008


Port-au-Prince, Haiti January 2010
RUE JOSE MARTI
courtoisie
INUTECH
http://haitigps.wordpress.com/

Maule, Chile, February 2010

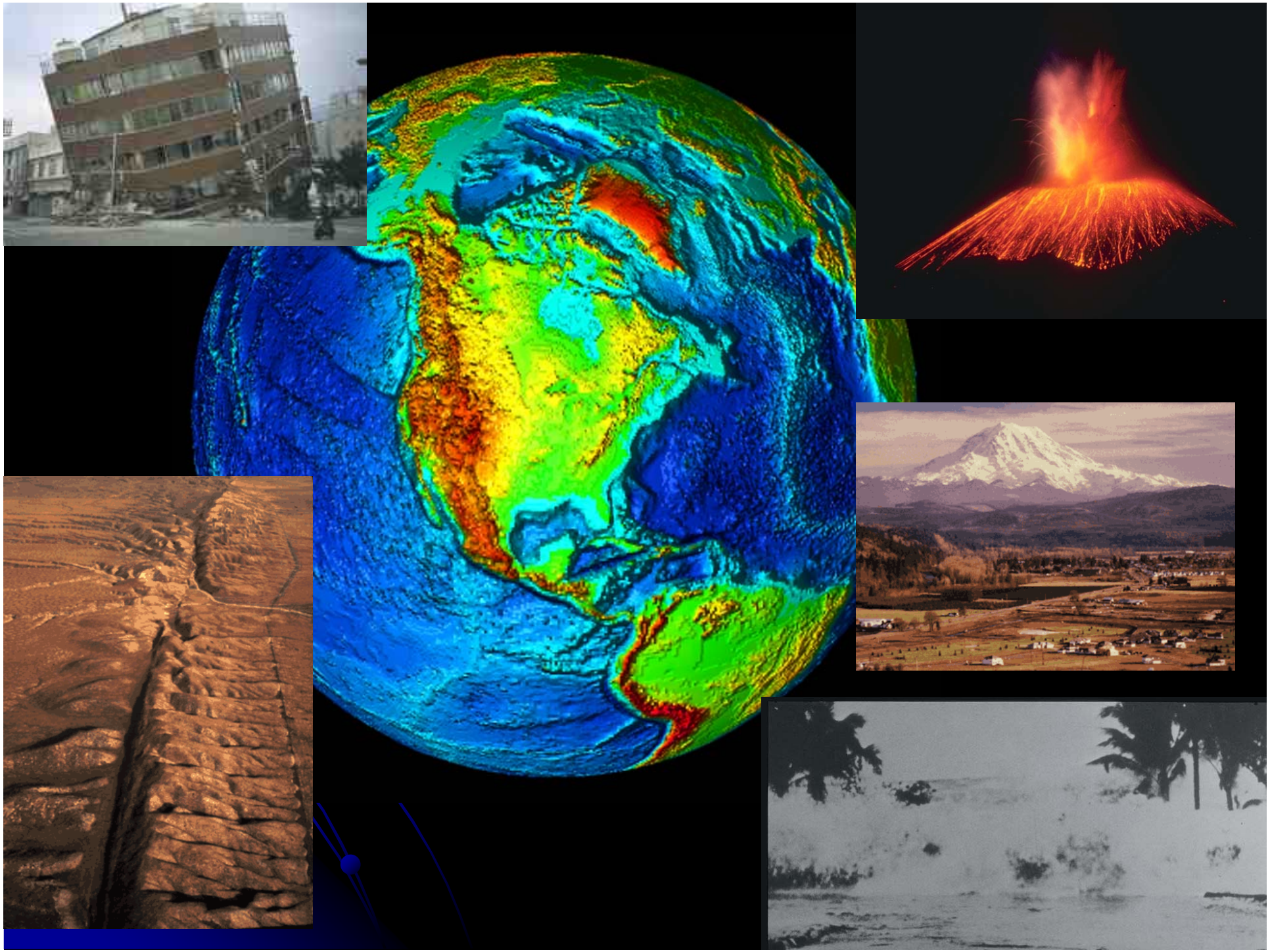
Christchurch, NZ, February 2011

http://boston.com

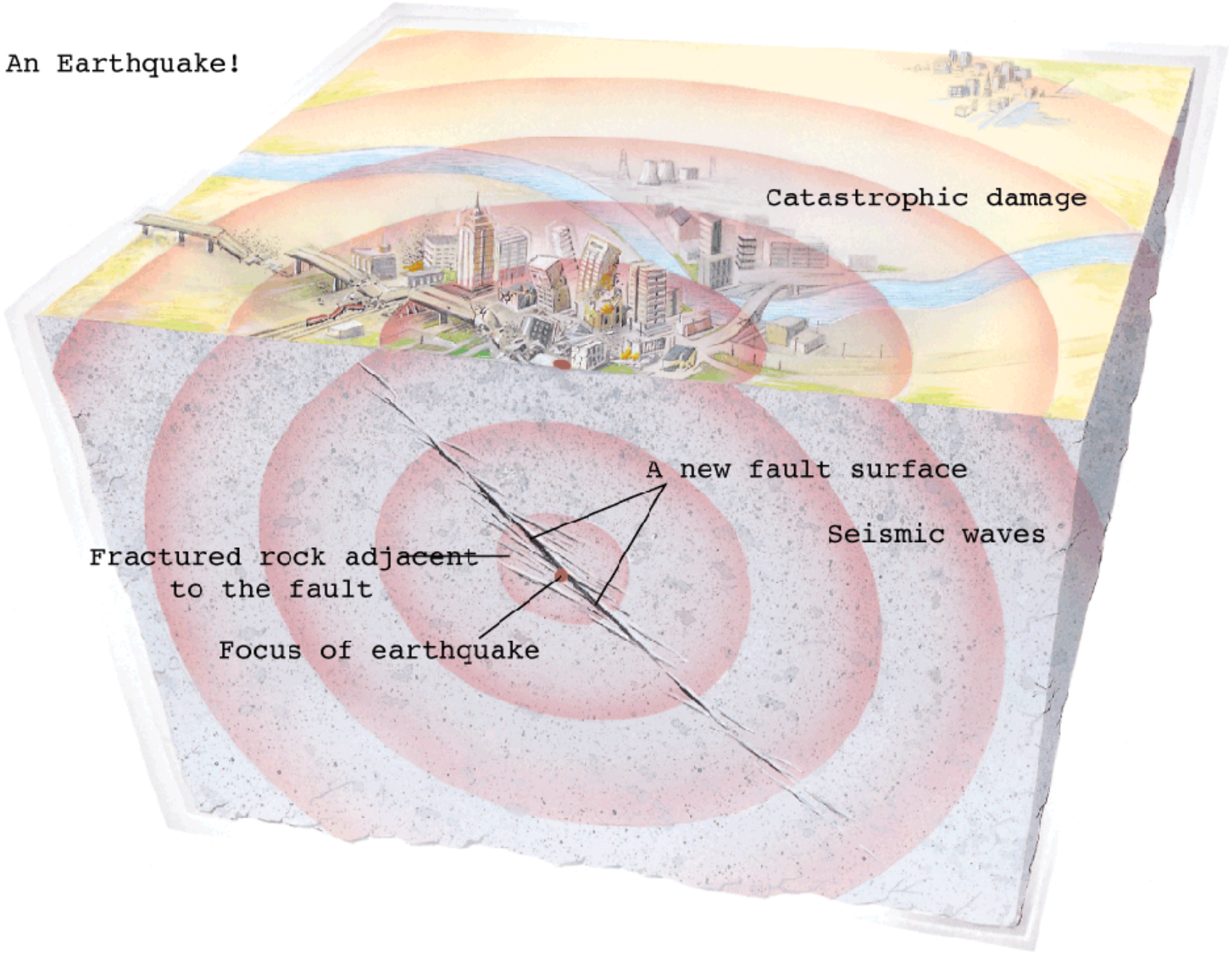
Tohoku, Japan, March 2011

Misconception #1:

Earthquakes represent random, incomprehensible acts of nature’s violence.



An Earthquake!

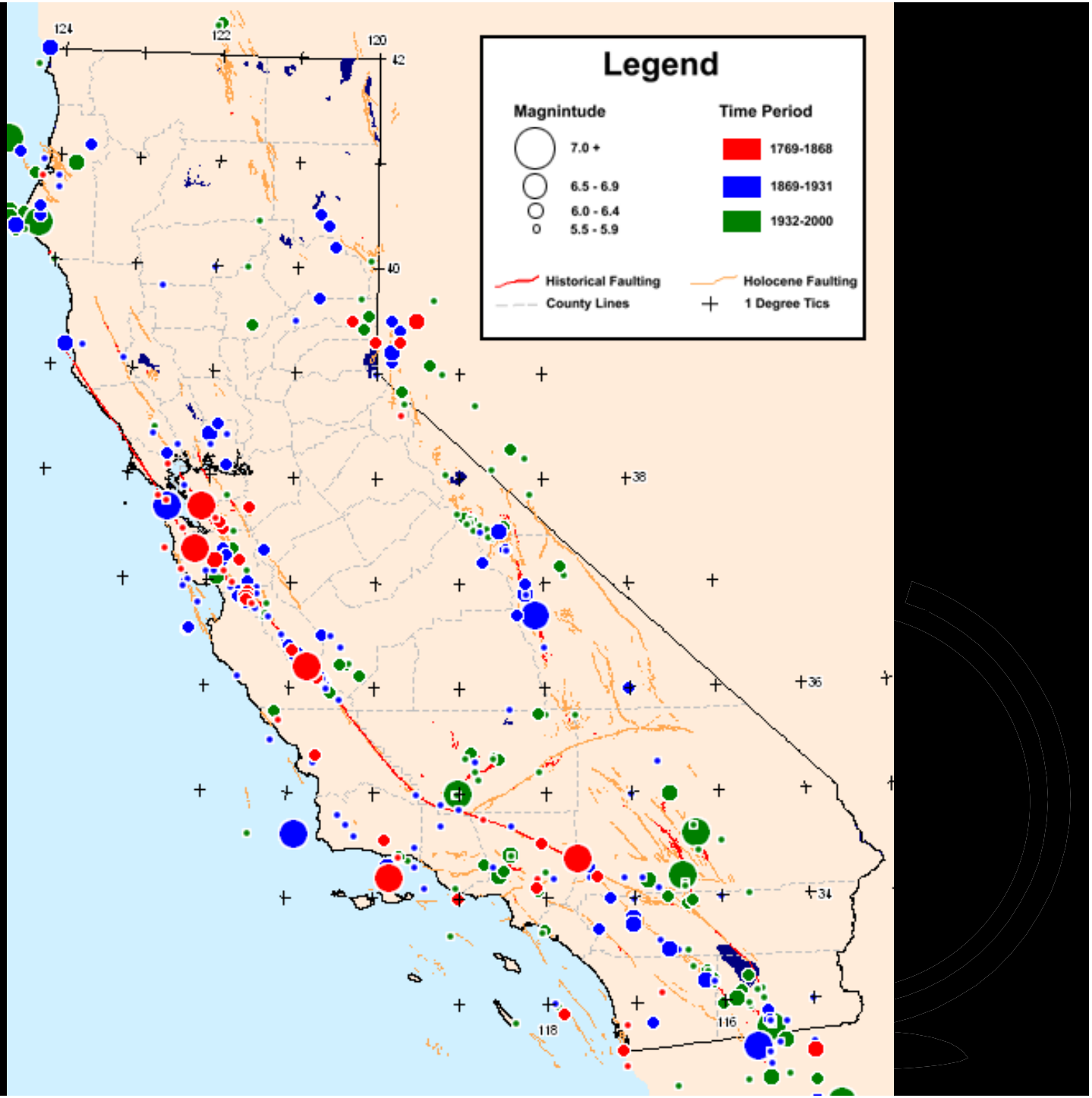


G.K. Gilbert (1906)

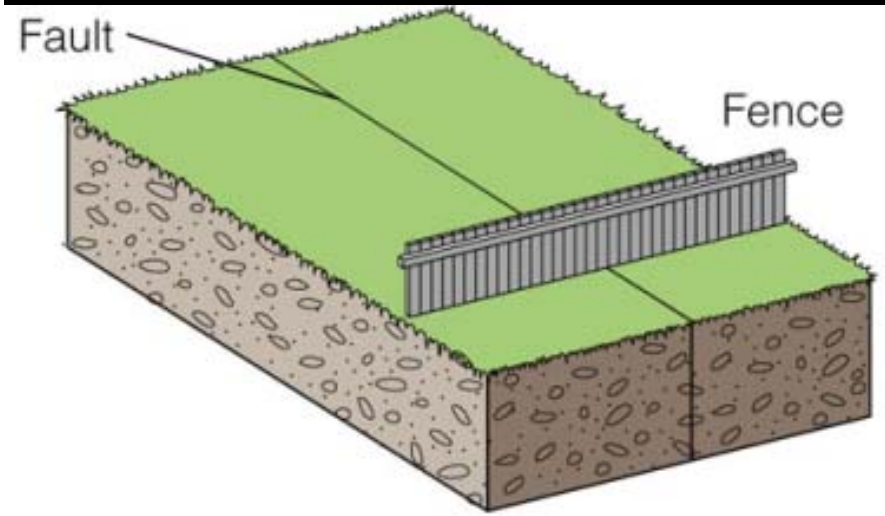
The San Andreas Fault

R. Wallace (USGS)

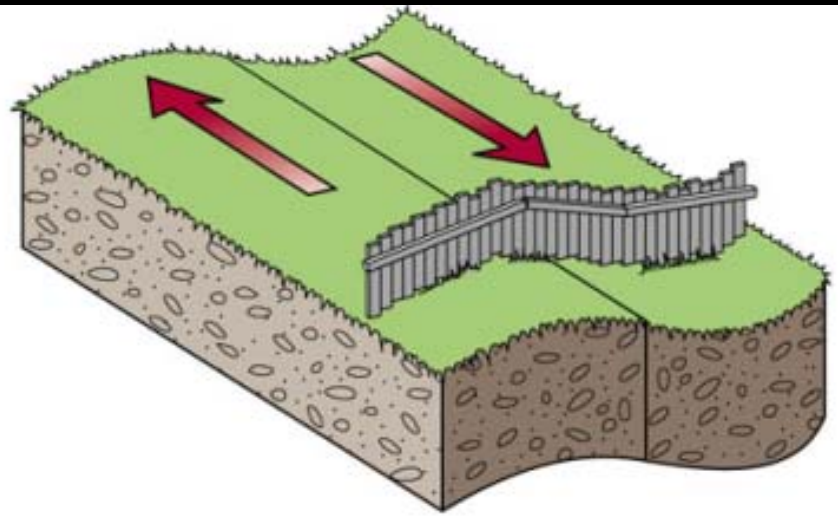
Earthquakes in California 1800 - 1999



California Geological Survey

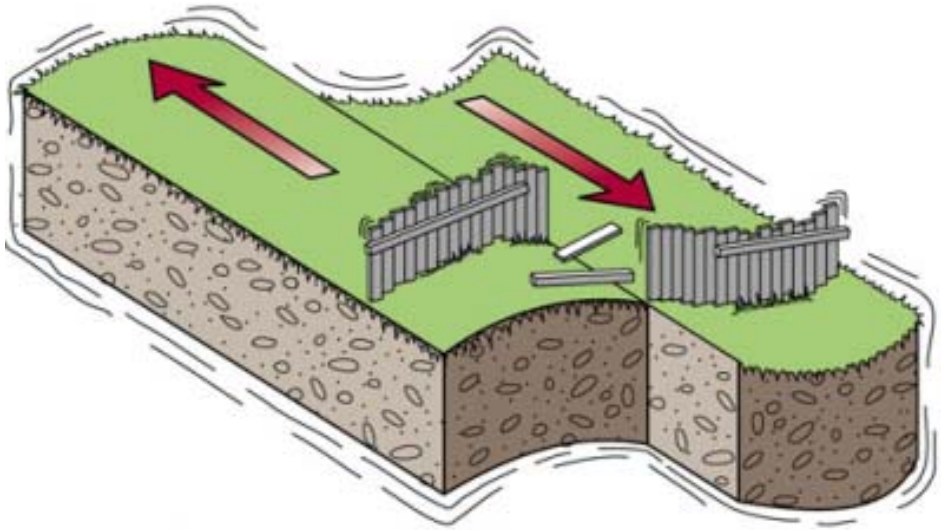


(a) Original position

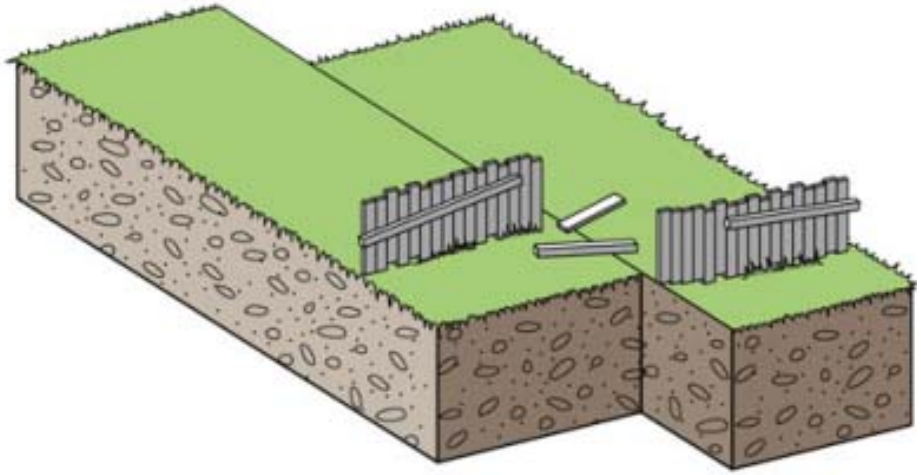


(b) Deformation

Elastic Rebound Theory

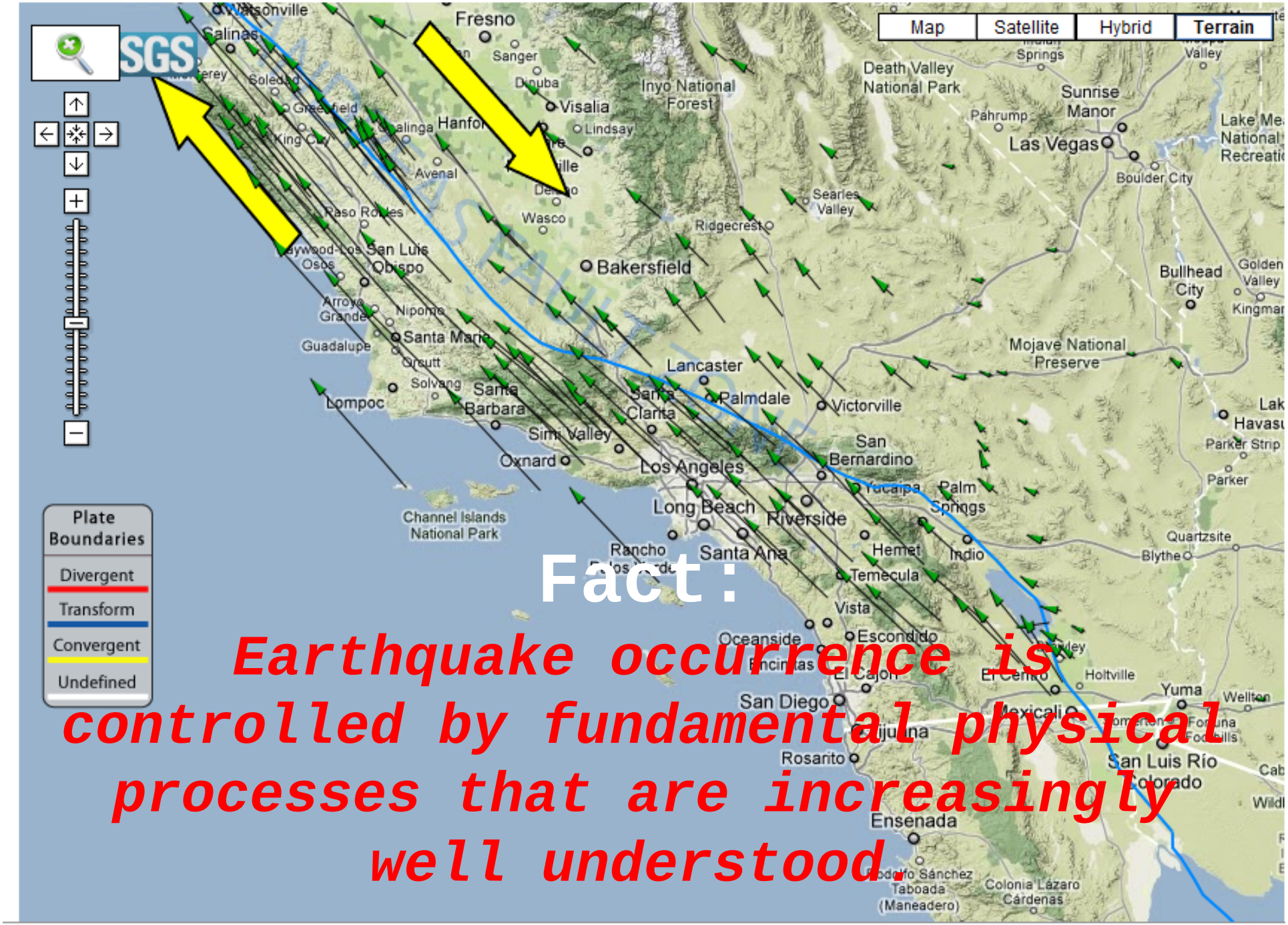


(c) Rupture and release of energy



(d) Rocks rebound to original undeformed shape

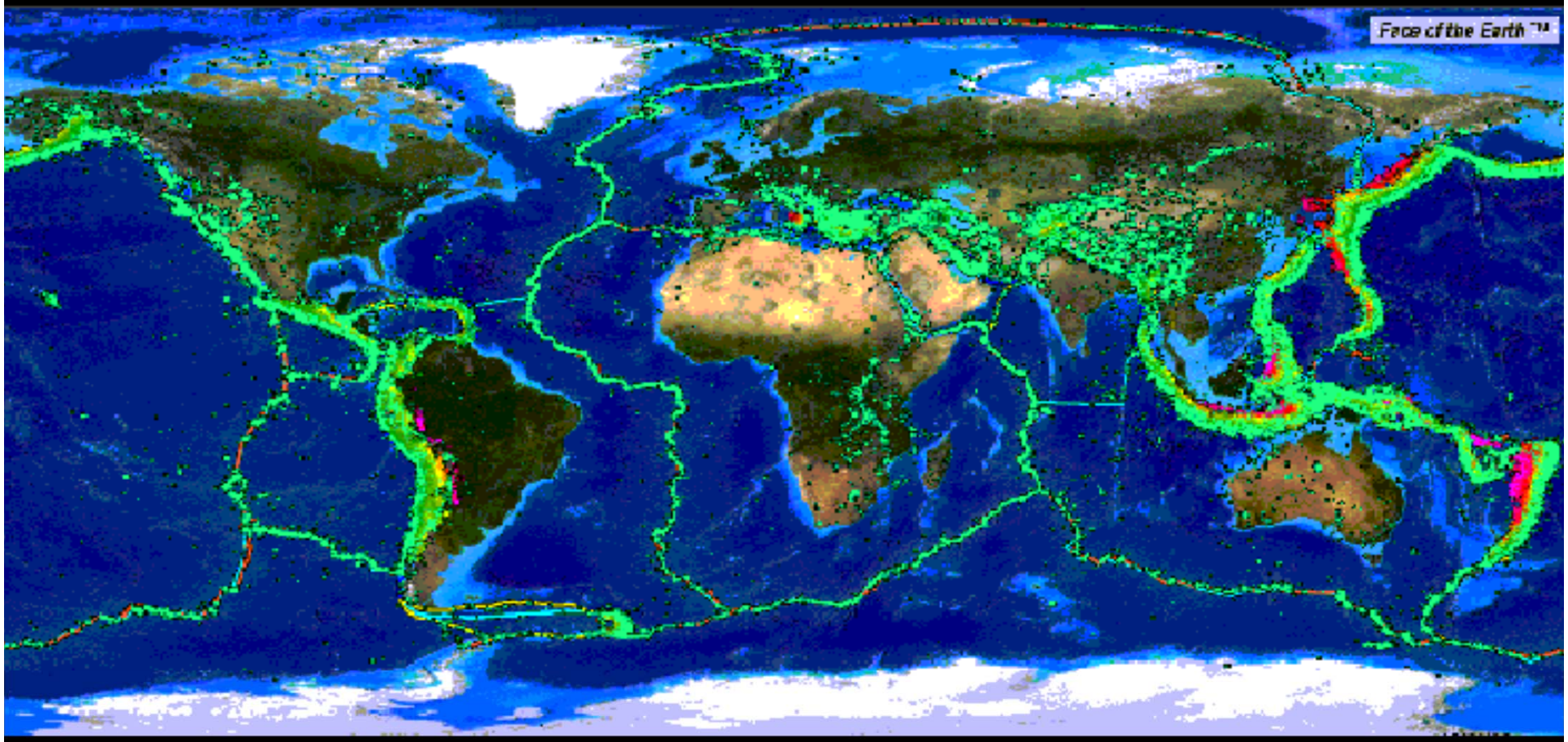
Monroe et al. (2007)


Map
Satellite
Hybrid
Terrain
SGS
Plate Boundaries
Divergent
Transform
Convergent
Undefined
Fact :
Earthquake occurrence is controlled by fundamental physical processes that are increasingly well understood

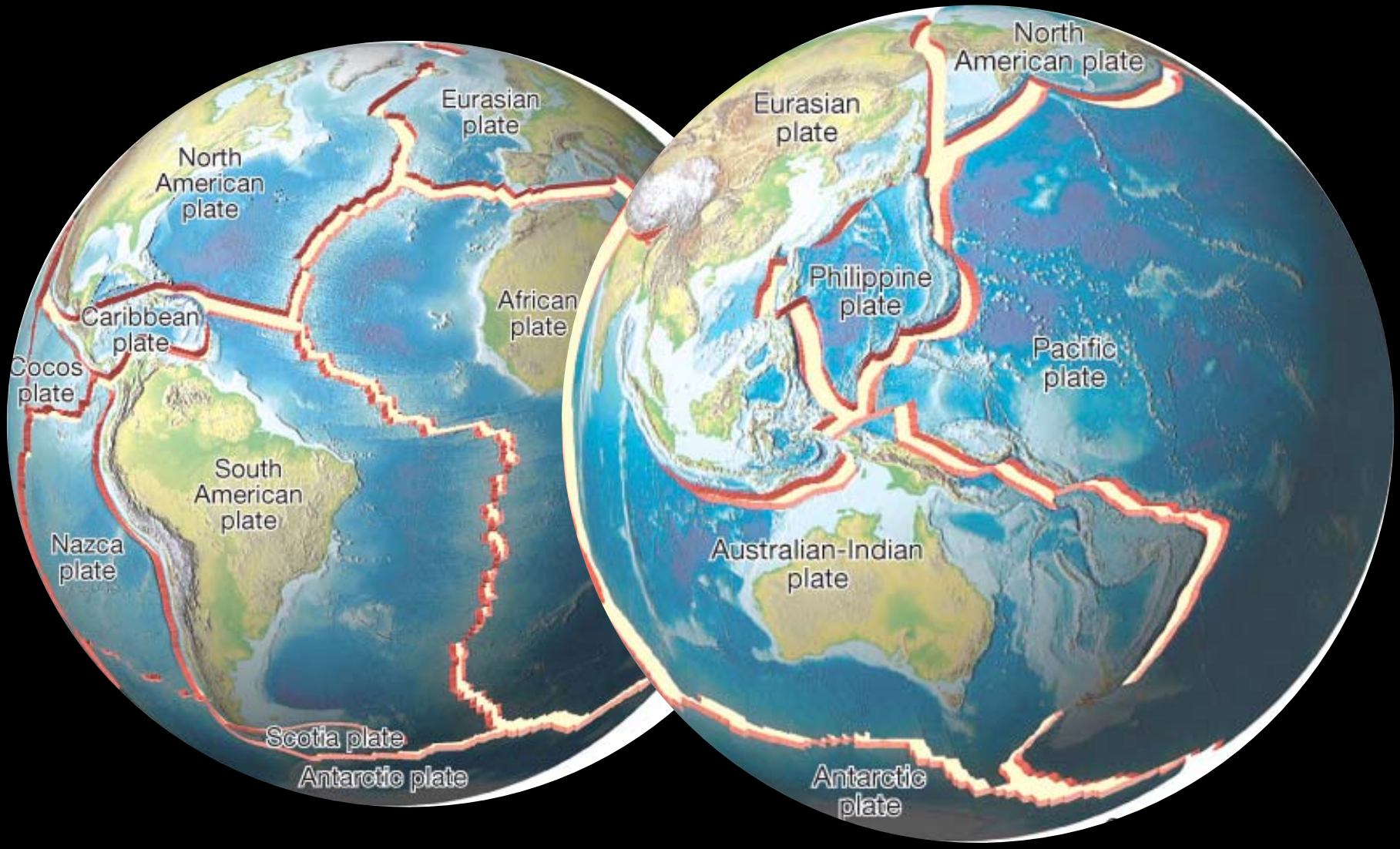
Misconception #2:

Destructive earthquakes can occur virtually anywhere, any time.

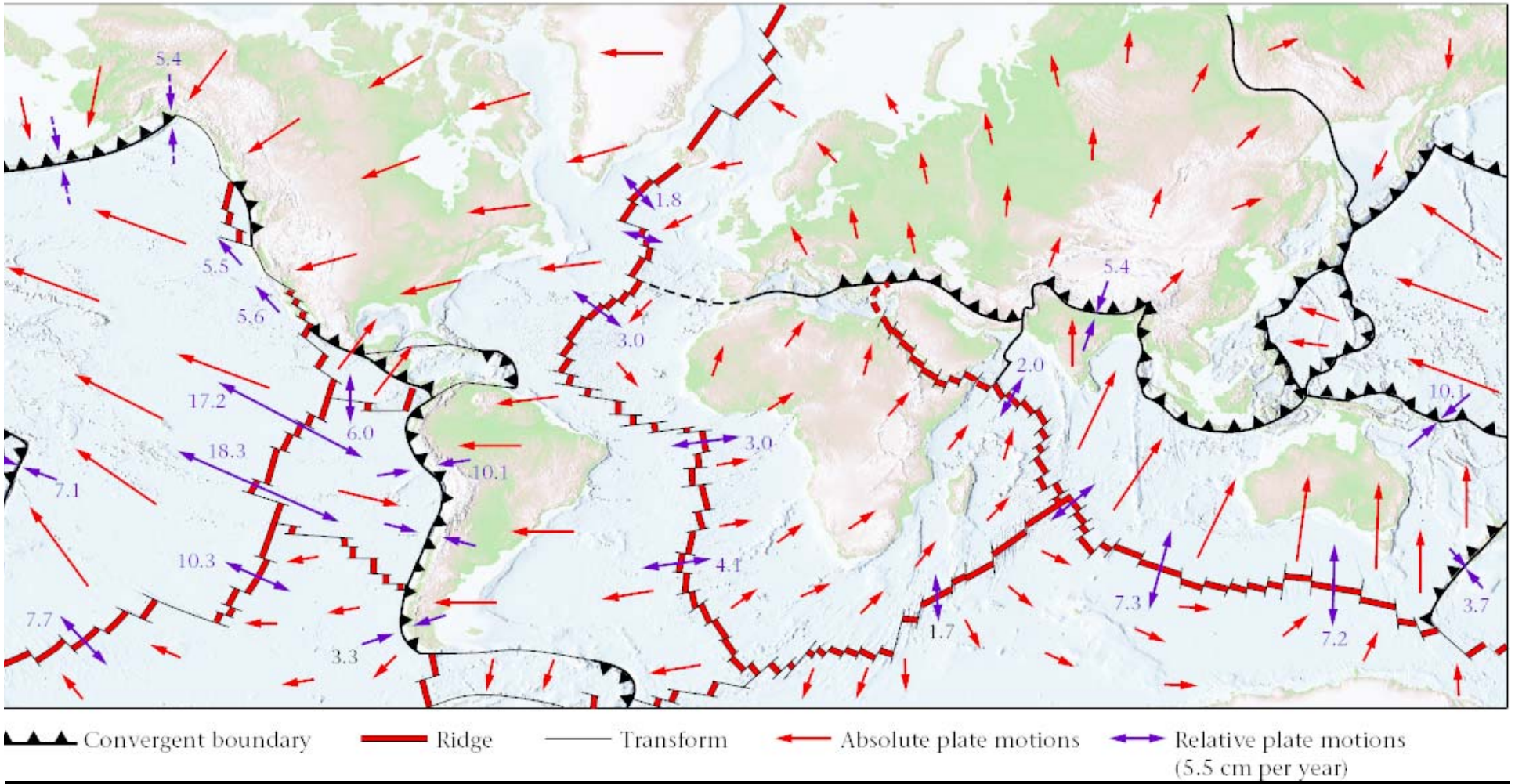
Global seismicity and plate boundaries

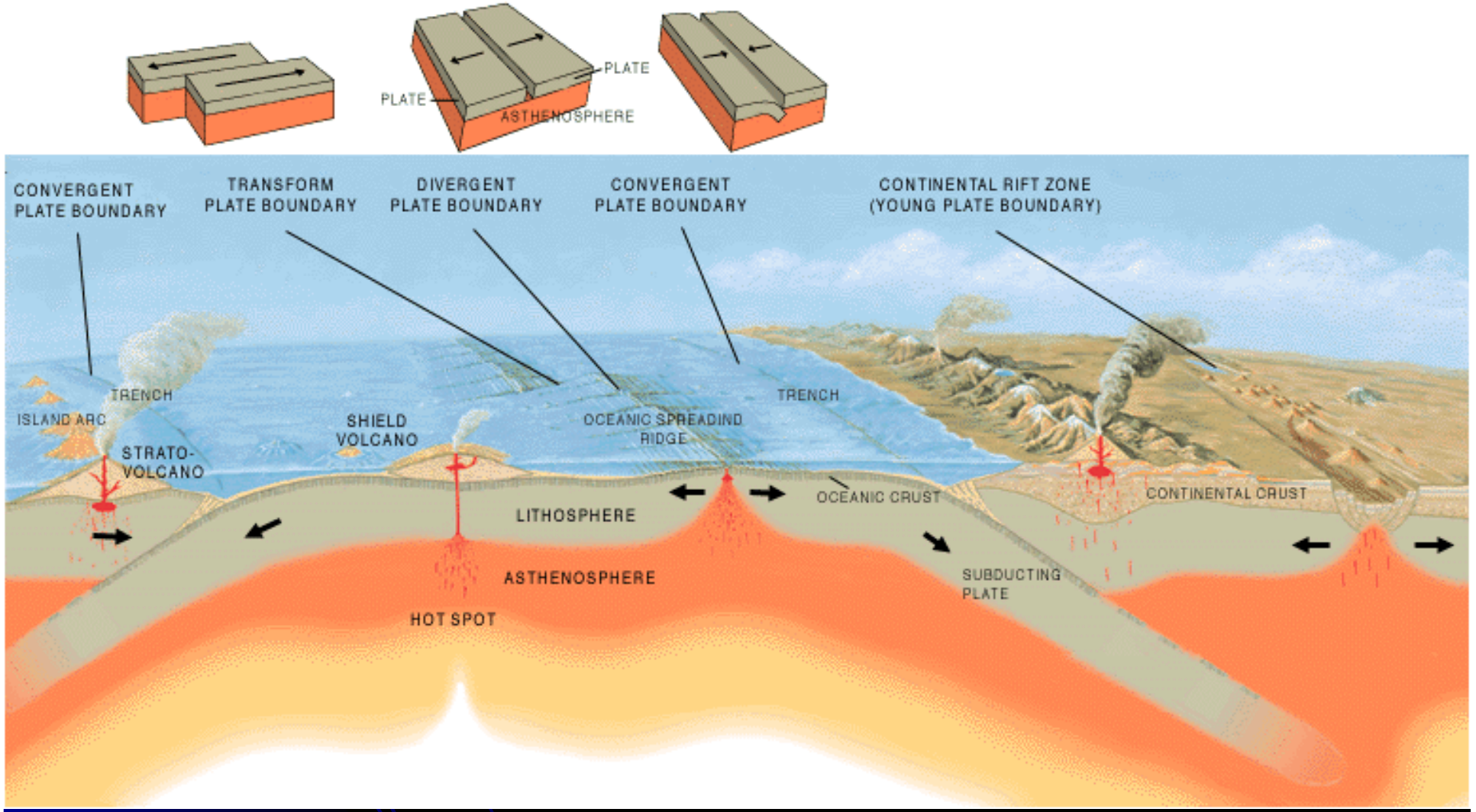


The Global Mosaic of Tectonic Plates

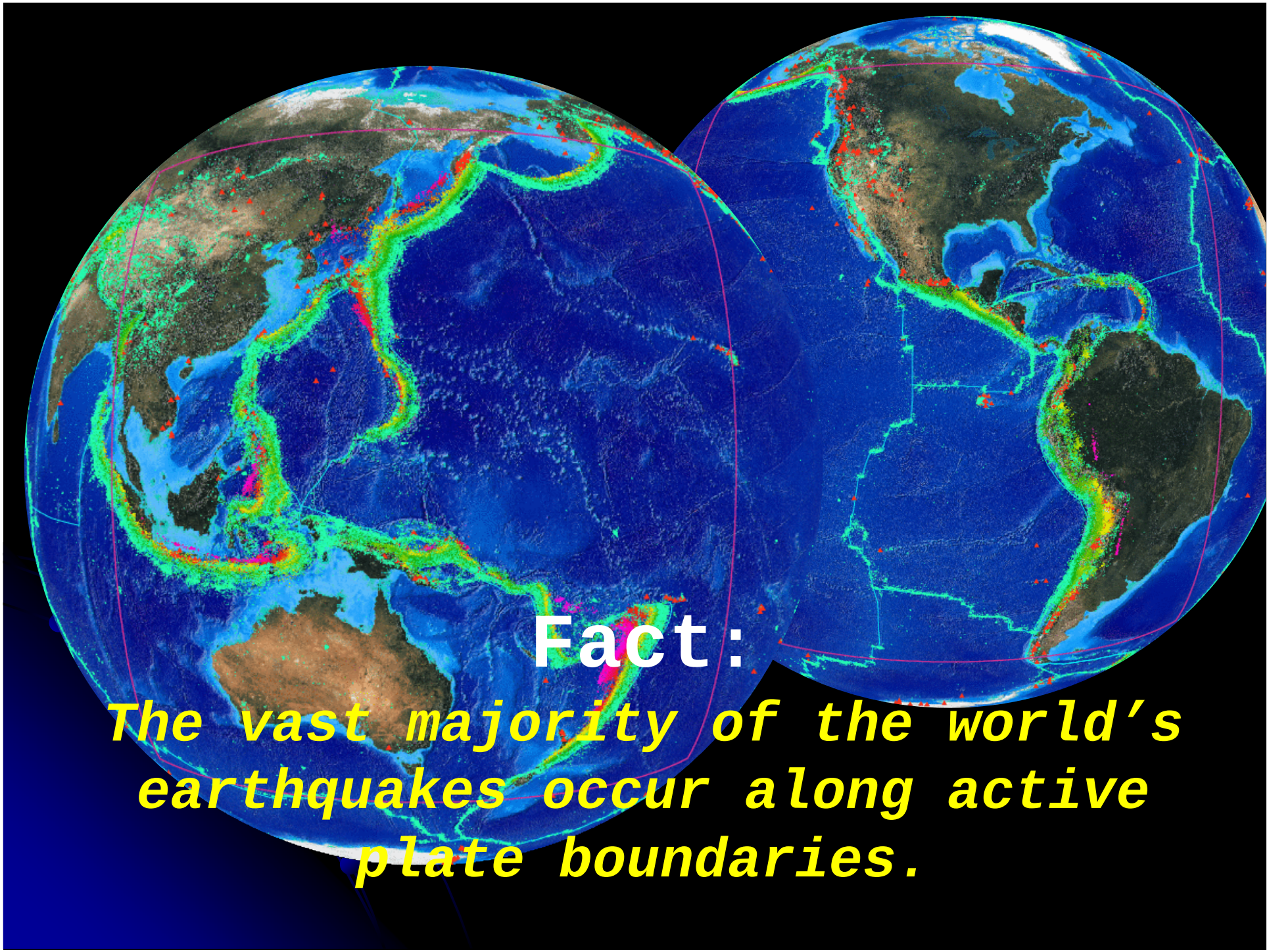


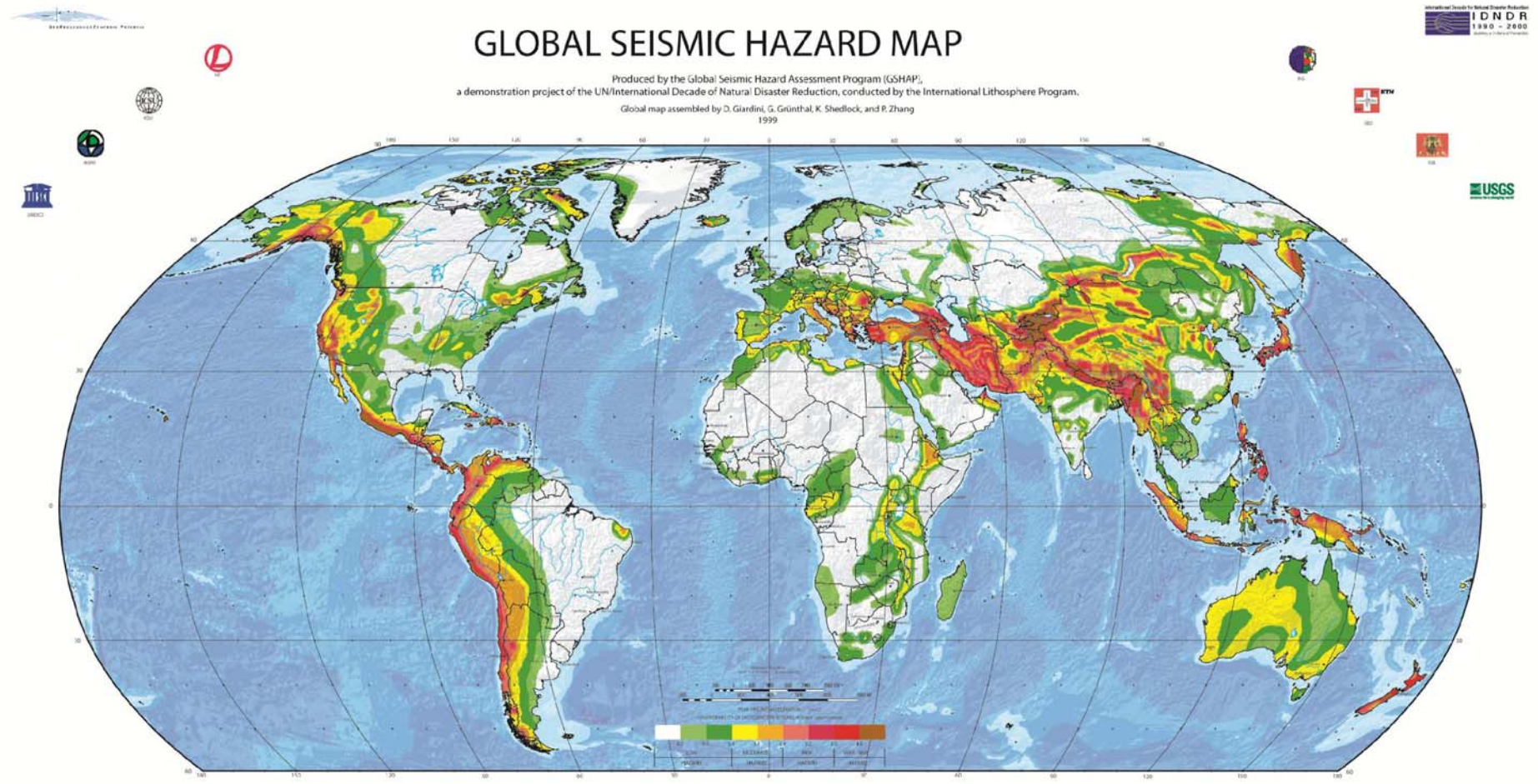
TASA Graphic Arts


5.4
5.5
5.6
17.2
18.3
6.0
7.1
10.3
7.7
3.3
10.1
1.8
3.0
3.0
4.1
1.7
5.4
2.0
7.3
7.2
10.1
3.7
Convergent boundary
Ridge
Transform
Absolute plate motions
Relative plate motions
(5.5 cm per year)



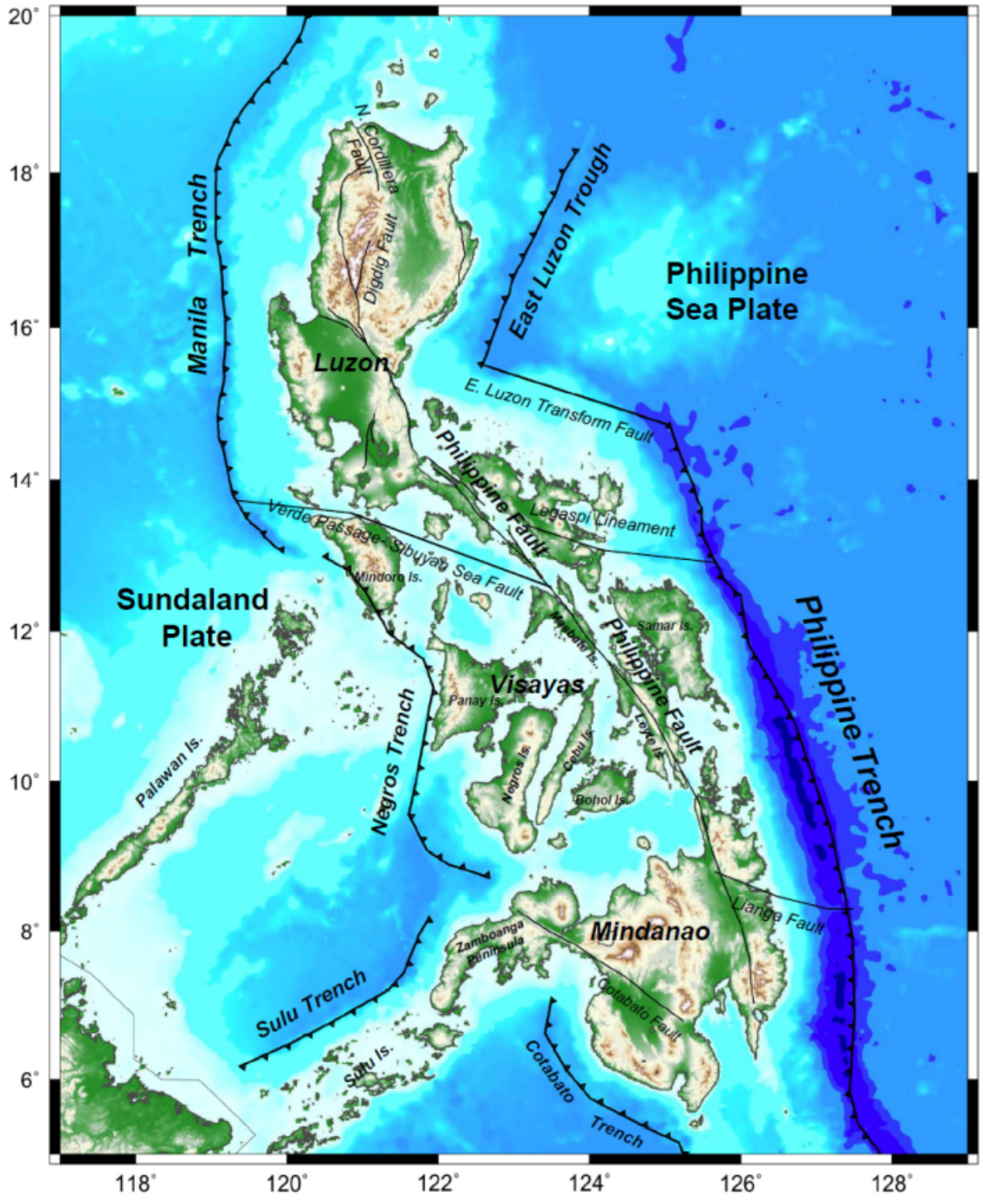
USGS – This Dynamic Earth

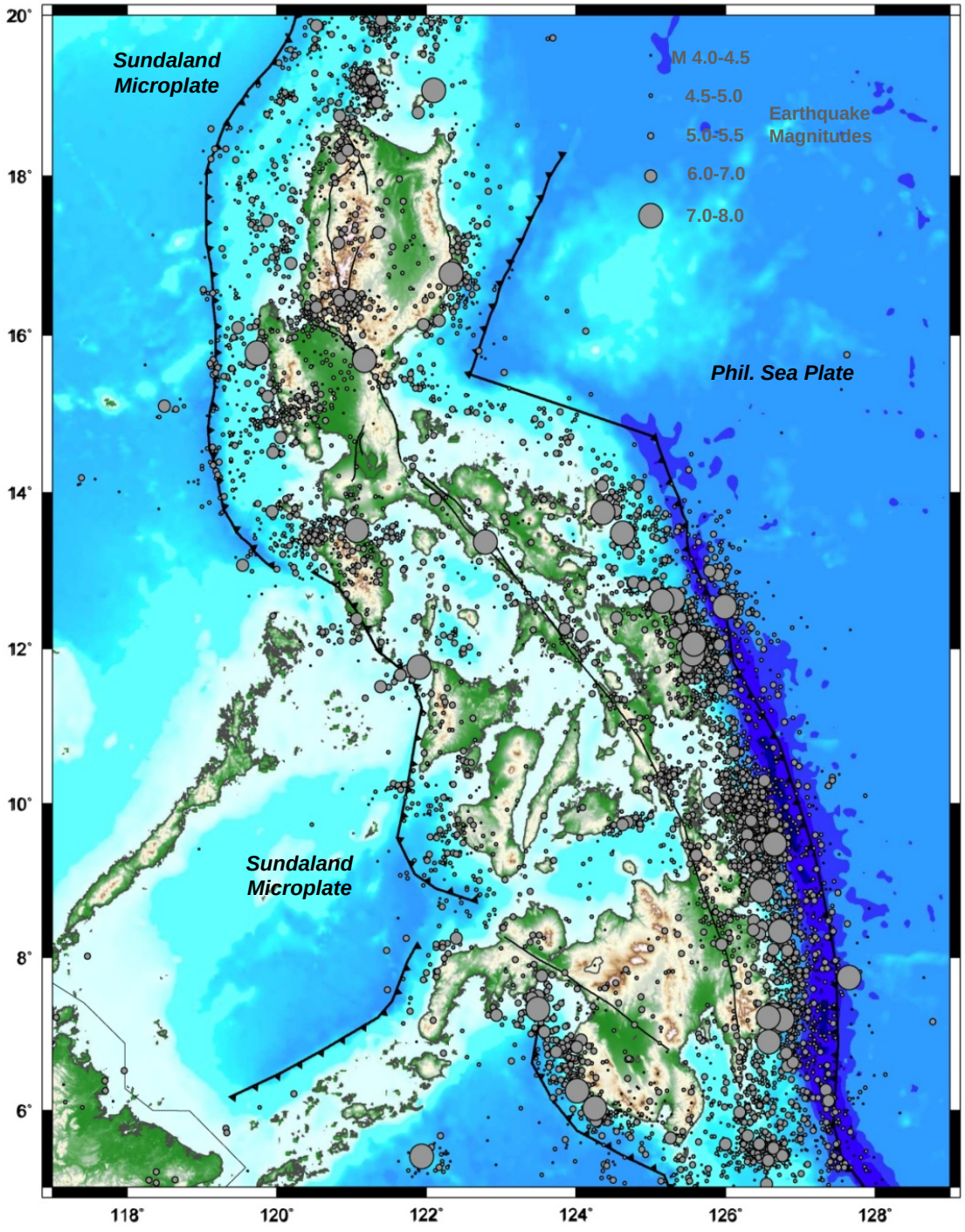

Fact:
The vast majority of the world's earthquakes occur along active plate boundaries.

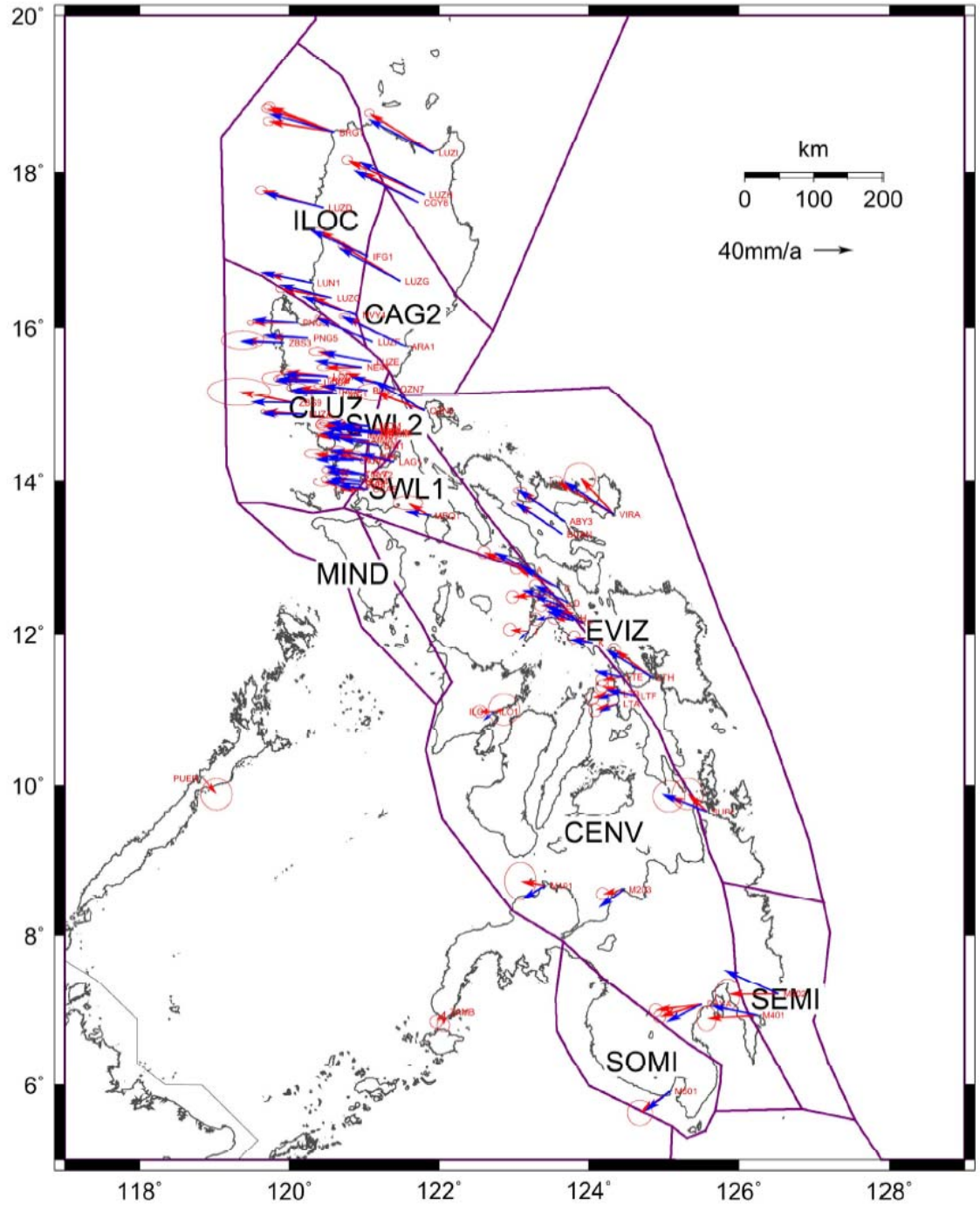

GLOBAL SEISMIC HAZARD MAP
Produced by the Global Seismic Hazard Assessment Program (GSHAP),
a demonstration project of the UN/International Decade of Natural Disaster Reduction, conducted by the International Lithosphere Program.
Global map assembled by D. Giardini, G. Grünthal, K. Shedlock, and P. Zhang
1999
IDNDR
1990 – 2000
USGS

Misconception #3:

Earthquake hazard is pretty much the same everywhere in _____.


20°
18°
16°
14°
12°
10°
8°
6°
118°
120°
122°
124°
126°
128°
Manila Trench
N. Cordillera Fault
Digdig Fault
Luzon
East Luzon Trough
Philippine Sea Plate
E. Luzon Transform Fault
Philippine Fault
Legaspi Lineament
Verde Passage
Sibuyan Sea Fault
Mindoro Is.
Sundaland Plate
Masbate Is.
Samar Is.
Visayas
Panay Is.
Leyte Is.
Cebu Is.
Negros Is.
Bohol Is.
Negros Trench
Palawan Is.
Philippine Trench
Mindanao
Zamboanga Peninsula
Agusan Fault
Cotabato Fault
Sulu Trench
Sulu Is.
Cotabato Trench


Sundaland
Microplate
M 4.0-4.5
4.5-5.0
5.0-5.5
6.0-7.0
7.0-8.0
Earthquake
Magnitudes
Phil. Sea Plate
Sundaland
Microplate
20°
18°
16°
14°
12°
10°
8°
6°
118°
120°
122°
124°
126°
128°


km
0
100
200
40mm/a
ILOC
CAG2
CLUZ
SWL2
SWL1
MIND
EVIZ
CENV
SEMI
SOMI
20°
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8°
6°
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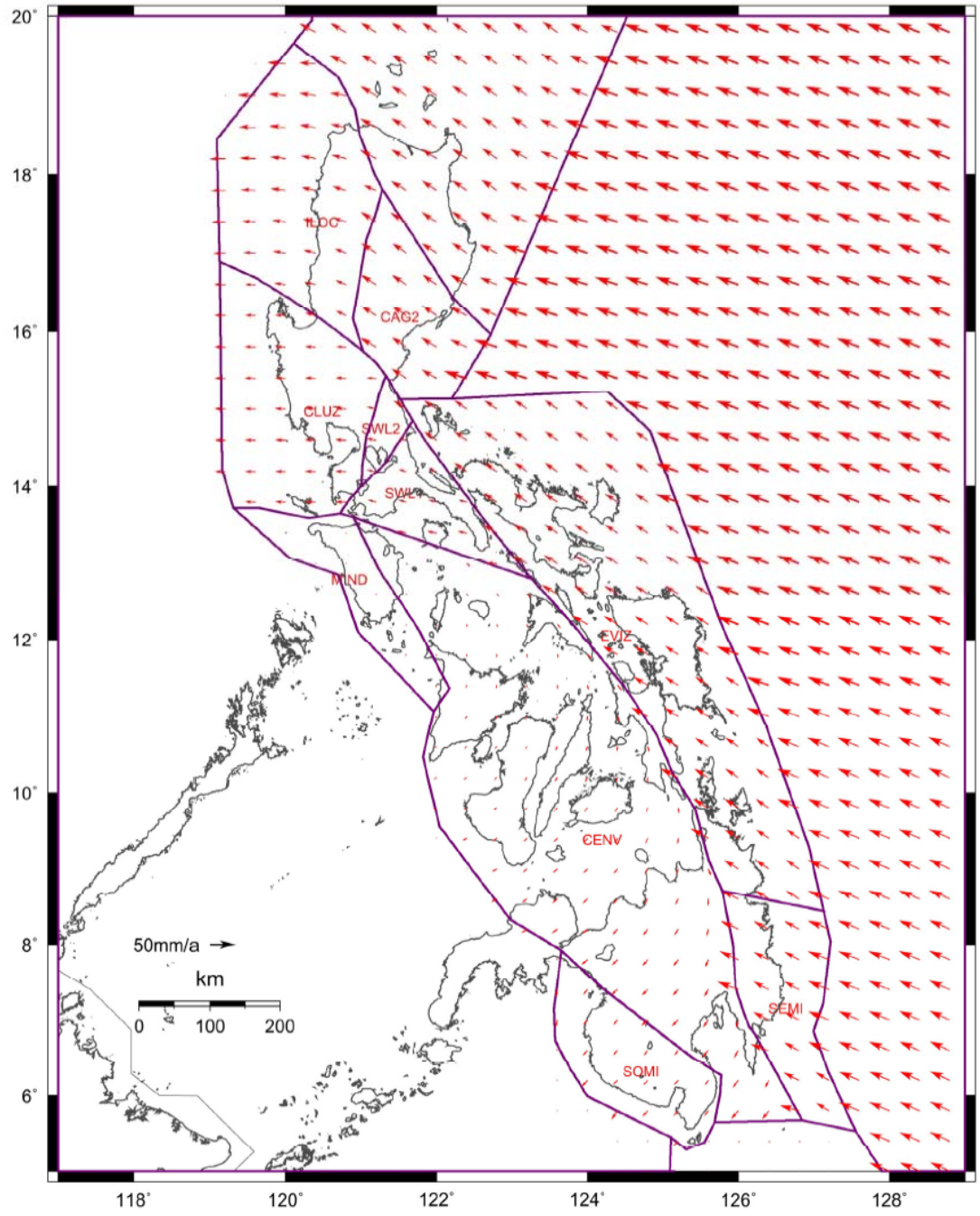
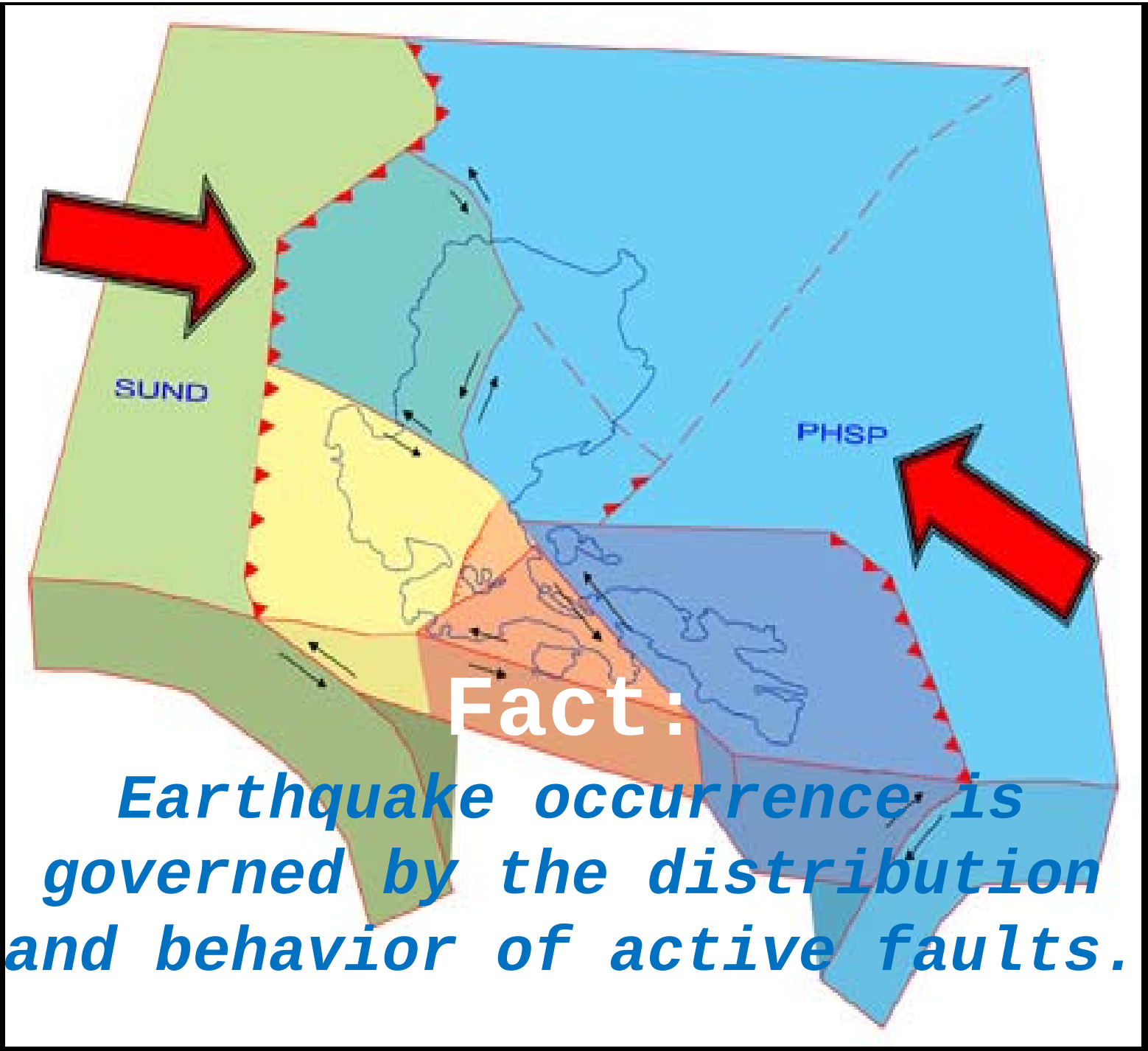
120°
122°
124°
126°
128°


20°
18°
16°
14°
12°
10°
8°
6°
118°
120°
122°
124°
126°
128°
ILOC
CAG2
CLUZ
SWL2
SWL1
MIND
EVIZ
CENV
SEMI
SQMI
50mm/a
km
0
100
200



Fact:

Earthquake occurrence is governed by the distribution and behavior of active faults.

Misconception #4:

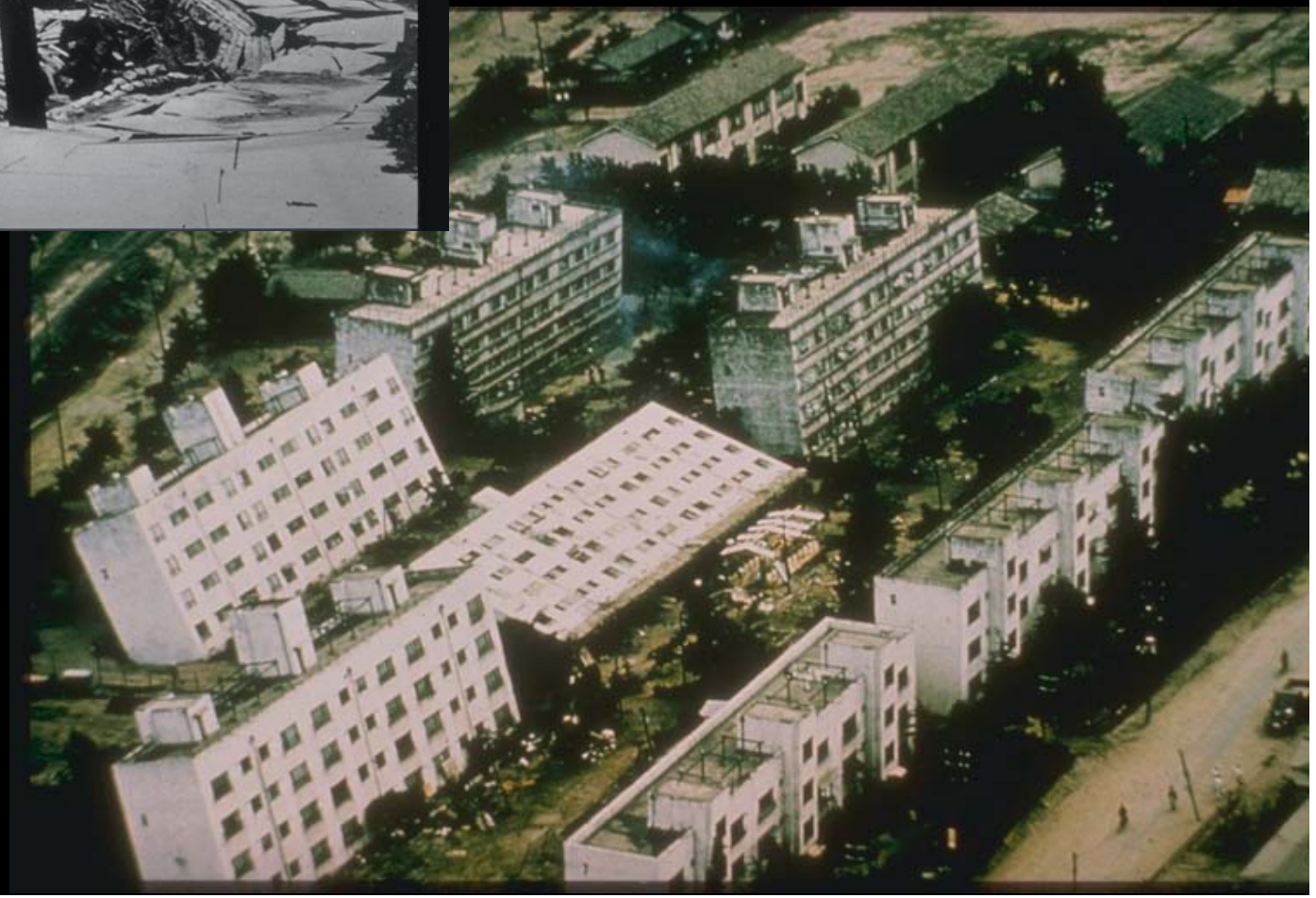
“Earthquakes kill people.”


CSD CANTEEN
KALA PAHAR BRIGADE
AFP


Fact:
Poorly built structures are responsible for deaths and injuries of the majority of earthquake victims.

Misconception #5:

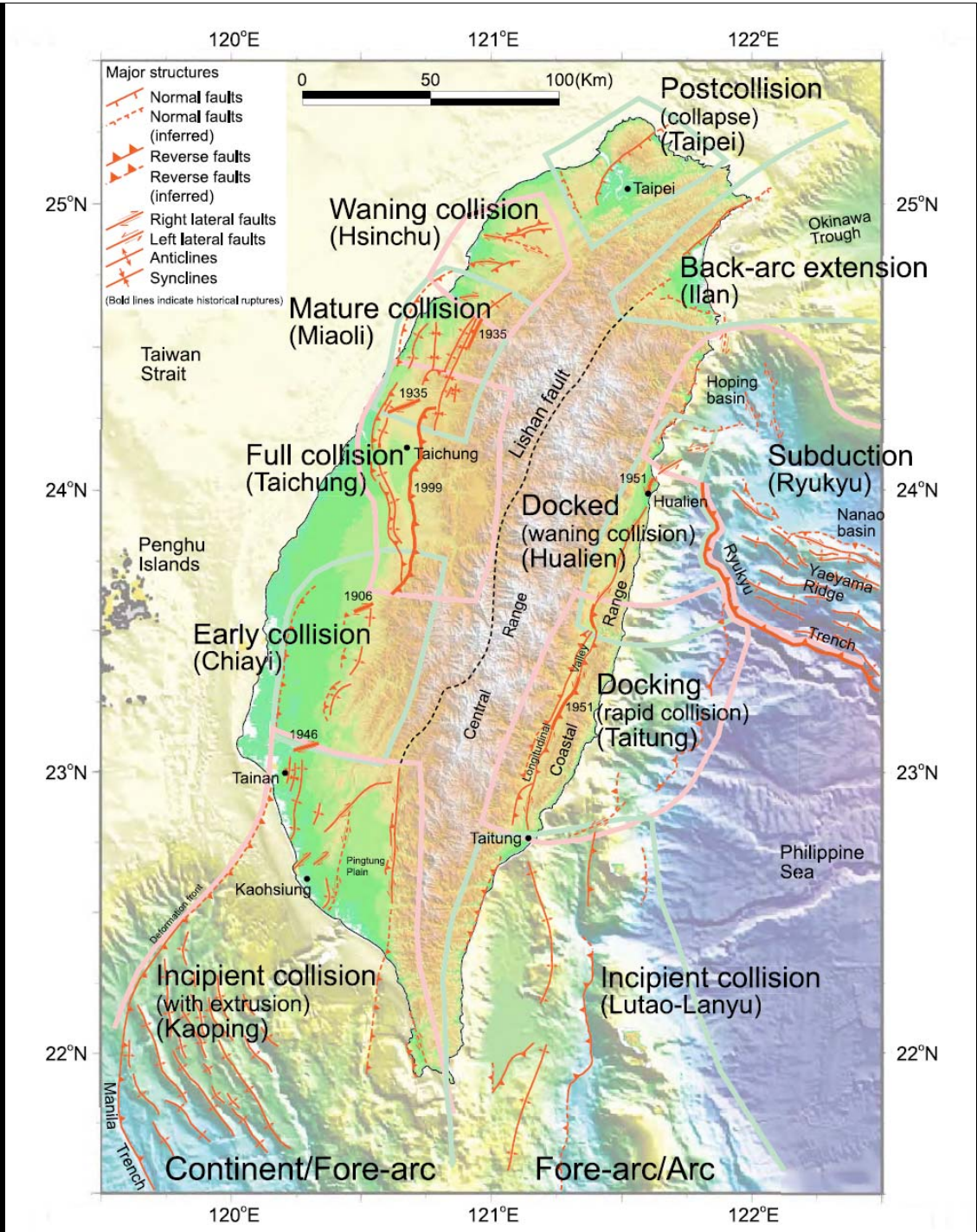
Earthquake-triggered ground shaking is directly responsible for most earthquake disasters




Fact:
A significant proportion of the earthquake impacts derive from their secondary effects.

Misconception #6:

We can’t anticipate the impacts of future earthquakes.

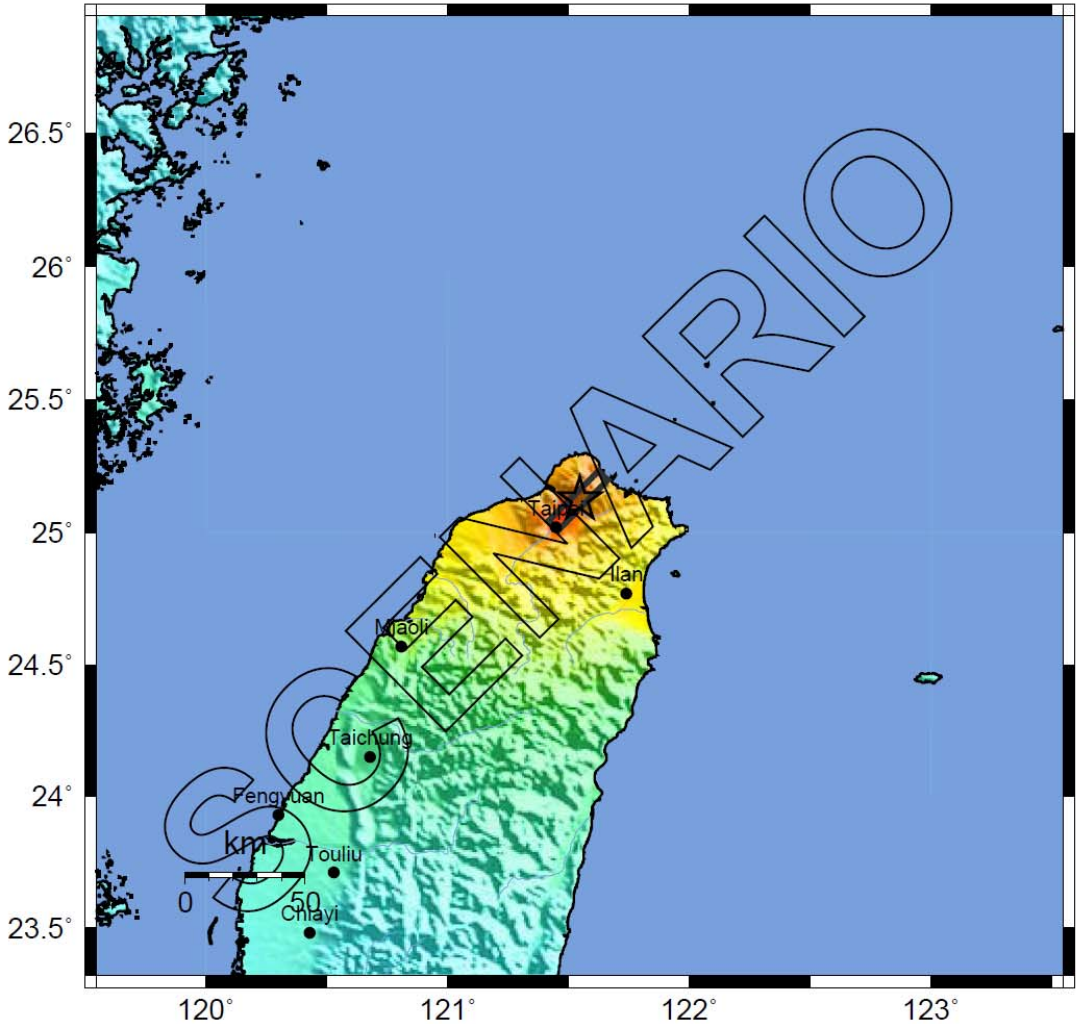


Shyu et al. (1995)

-- Earthquake Planning Scenario --

ShakeMap for Taiwan_Shanchiao_Fault Scenario

Scenario Date: FEB 1 2012 12:00:00 AM GMT M 6.5 N25.13 E121.55 Depth: 5.0km



PLANNING SCENARIO ONLY -- Map Version 1 Processed Tue Sep 27, 2011 12:47:49 PM MDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<0.1*	*0.5*	*2.4*	*6.7*	*13*	24	44	83	>156
PEAK VEL.(cm/s)	<0.07	0.4	1.9	5.8	*11*	*22*	*43*	*83*	*>160*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Wald, et al.; 1999

USGS science for a changing world

Earthquake Shaking **Red Alert**

GSN ANSS USAID FROM THE AMERICAN PEOPLE

M 6.5, Shanchiao Fault, north of Taipei, Taiwan

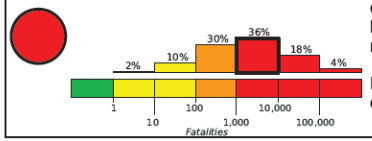
Origin Time: Wed 2012-02-01 00:00:00 UTC (08:00:00 local)

Location: 25.13°N 121.55°E Depth: 5 km

PAGER
Version 1

Created: 20 minutes after earthquake

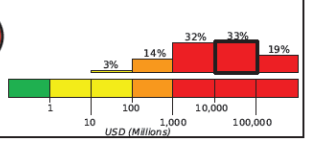
Estimated Fatalities



Red alert for shaking-related fatalities and economic losses. High casualties and extensive damage are probable and the disaster is likely widespread. Past red alerts have required a national or international response.

Estimated economic losses are 1-7% GDP of Taiwan, Province of China.

Estimated Economic Losses



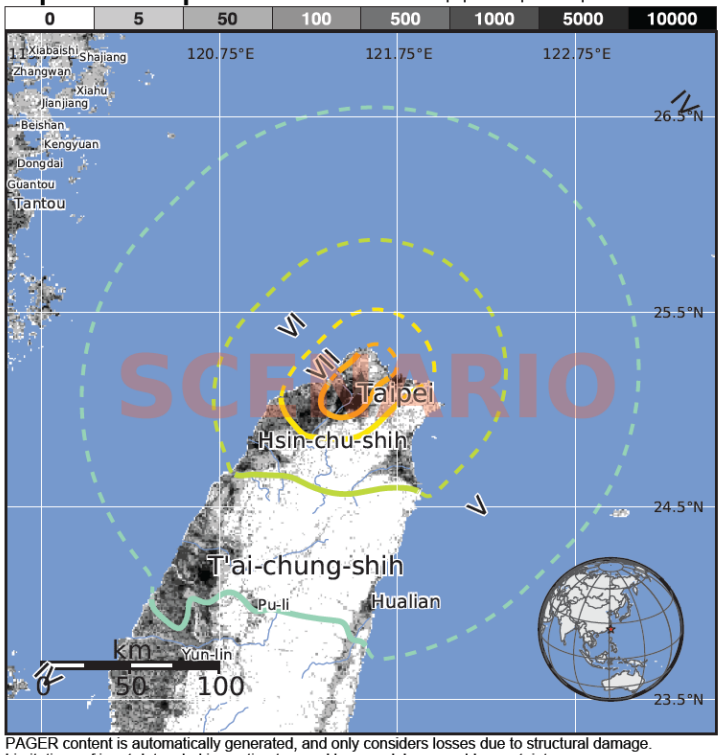
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		- -*	- -*	4,845k*	4,360k	1,731k	2,156k	5,135k	1,128k	0
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 sq. km from Landscan



PAGER content is automatically generated, and only considers losses due to structural damage. Limitations of input data, shaking estimates, and loss models may add uncertainty.

http://earthquake.usgs.gov/pager

Structures:
Overall, the population in this region resides in structures that are resistant to earthquake shaking, though some vulnerable structures exist. The two model building types that contribute most to fatalities are unreinforced masonry and nonductile reinforced concrete frame with masonry infill.

Historical Earthquakes (with MMI levels):

Date (UTC)	Dist. (km)	Mag.	Max MMI(#)	Shaking Deaths
1986-05-20	109	6.2	IX(185k)	1
1986-11-14	129	7.3	VIII(160k)	15
1999-09-20	160	7.6	IX(1,952k)	2k

Recent earthquakes in this area have caused secondary hazards such as landslides that might have contributed to losses.

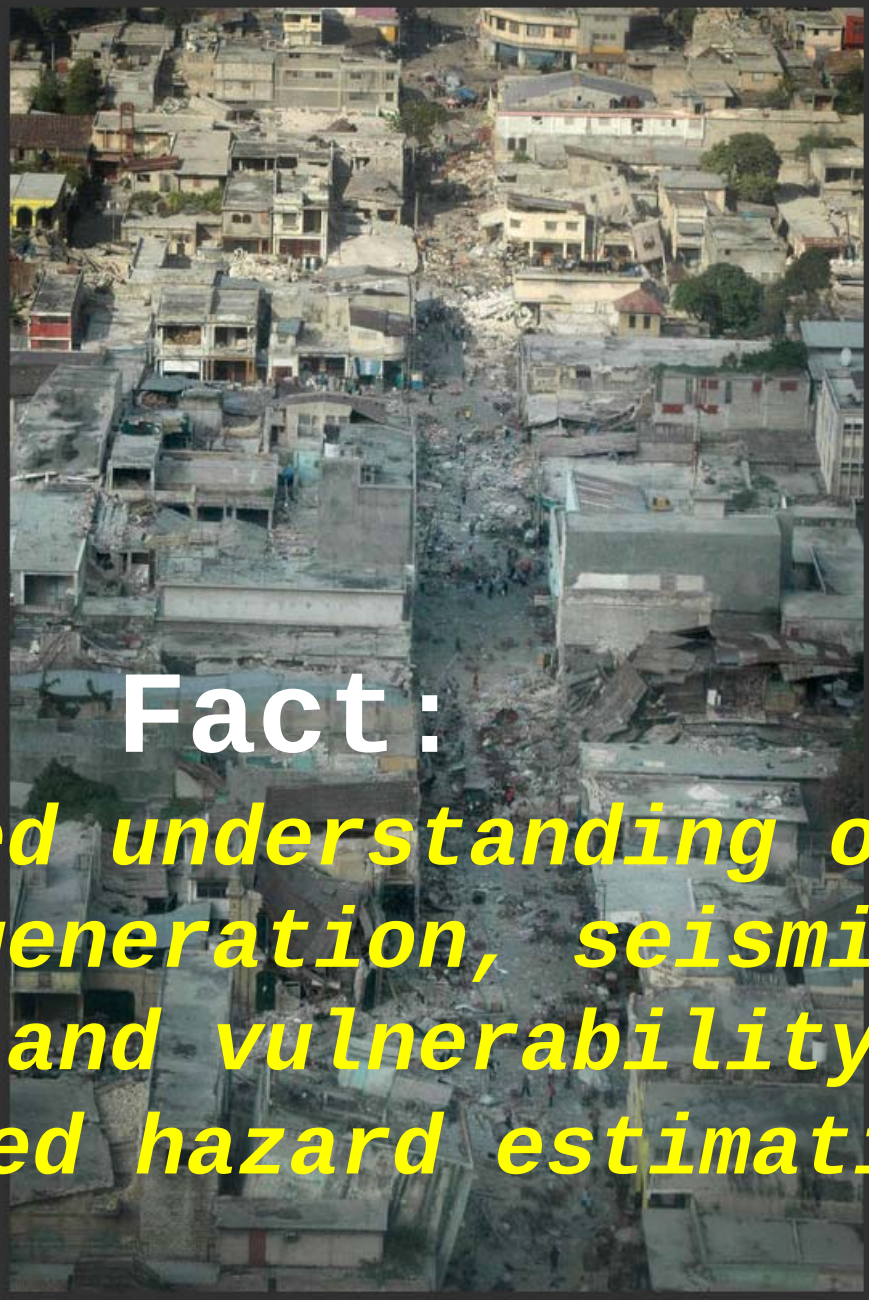
Selected City Exposure

from GeoNames.org

MMI	City	Population
VIII	**Taipei**	**7,872k**
VII	Chi-lung	398k
VI	I-lan	94k
VI	Ta-hsi-chen	85k
VI	**Hsin-chu-shih**	**404k**
V	**Hualian**	**350k**
V	**T'ai-chung-shih**	**1,041k**
V	**Pu-li**	**86k**
IV	**Yun-lin**	**105k**
IV	**Tantou**	**69k**
IV	**Xiabaishi**	**8k**

bold cities appear on map (k = x1000)

Event ID: usTaiwan_Shanchiao_Fault_se



Fact:

Improved understanding of earthquake generation, seismic wave propagation and vulnerability leads to improved hazard estimation.

American Red Cross / AP

Misconception #7:

There’s nothing we can do to prevent future disasters.

Earthquake Hazard Mitigation

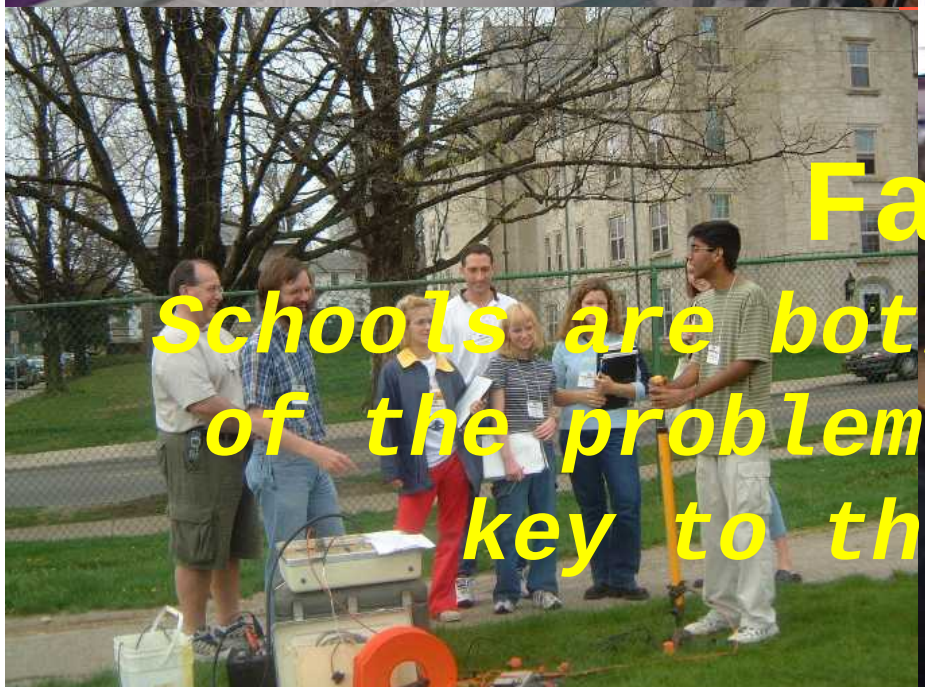
- Seismology research
- Building codes
- Retrofitting older buildings
- Land-use planning/zoning
- Earthquake education
- Earthquake prediction and warning
- Earthquake insurance
- Emergency Preparedness
- Disaster Response

http://www.graykode.com

Misconception #8:

Schools don’t have much to do with the earthquake problem.

Earthquake education



Fact:

Schools are both a critical part of the problem and a potential key to the solution.