



The 02/27/2010 Mw8.8 Chile Earthquake

Educational Slides

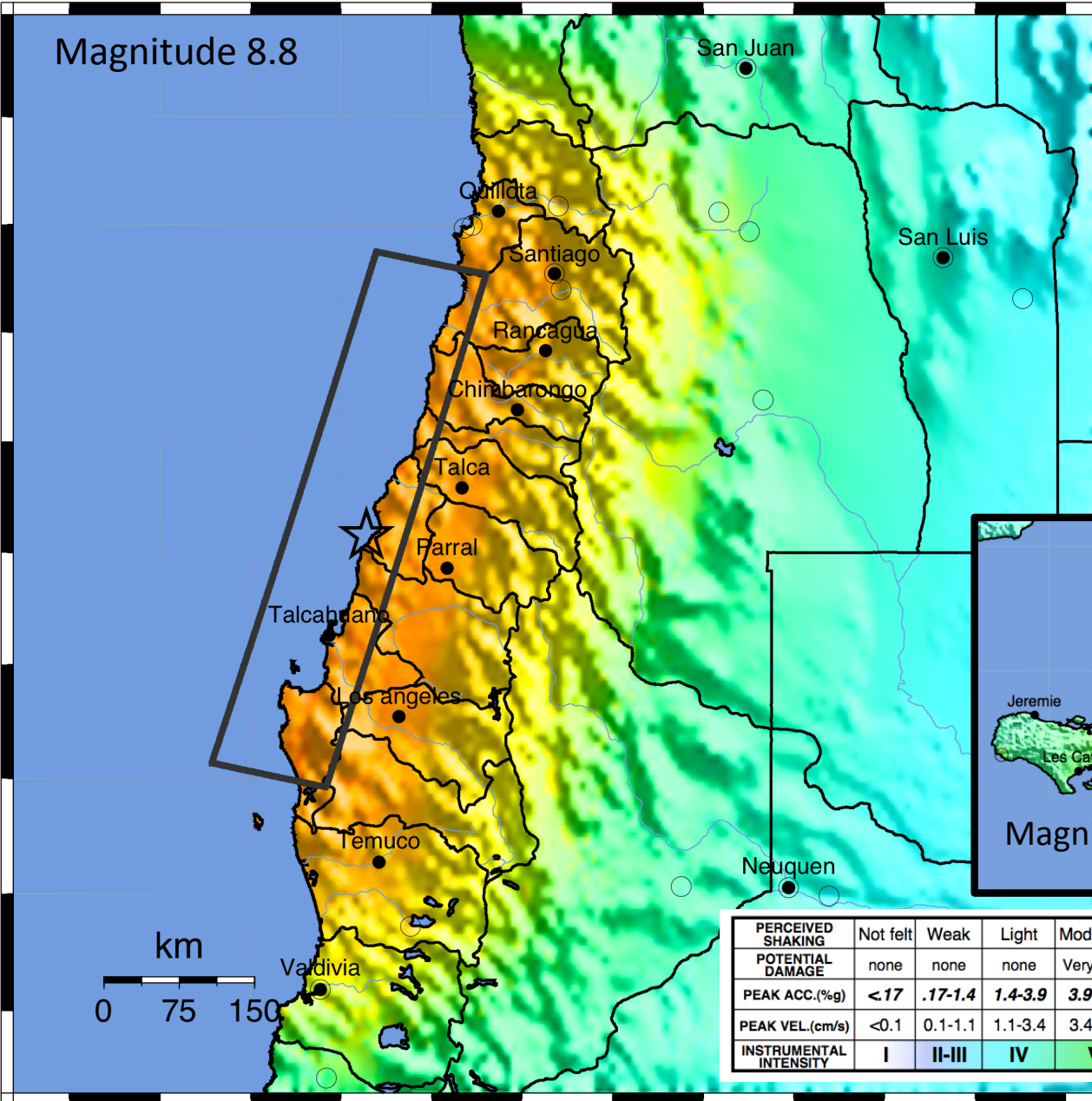
Created & Compiled by David J. Wald, Gavin P. Hayes, Kristin D. Marano
U.S. Geological Survey, National Earthquake Information Center

Contributions from: Susan Rhea, USGS NEIC
Stephen Kirby, USGS WEHT

USGS ShakeMap : OFFSHORE MAULE, CHILE



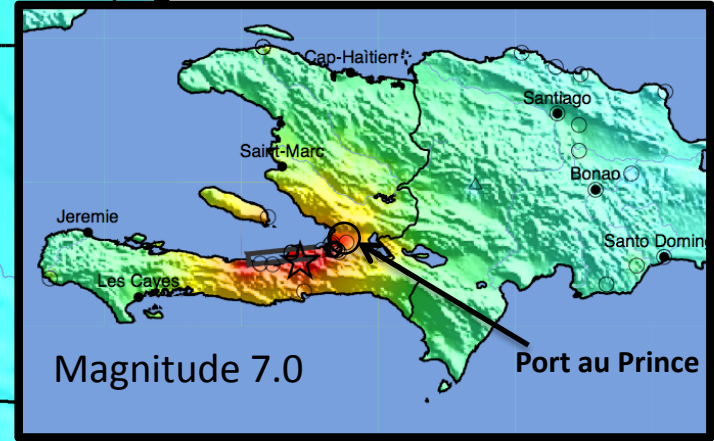
Sat Feb 27, 2010 06:34:14 GMT M 8.8 S35.85 W72.72 Depth: 35.0km ID:2010tfan



**USGS ShakeMap
Estimated Shaking
Intensities**

Same Map Scale!

Haiti, Jan 10, 2010



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

M 8.8, OFFSHORE MAULE, CHILE

Origin Time: Sat 2010-02-27 06:34:14 UTC

Location: 35.85°S 72.72°W Depth: 35 km

PAGER Version 7

Created: 14 hours, 10 minutes after earthquake

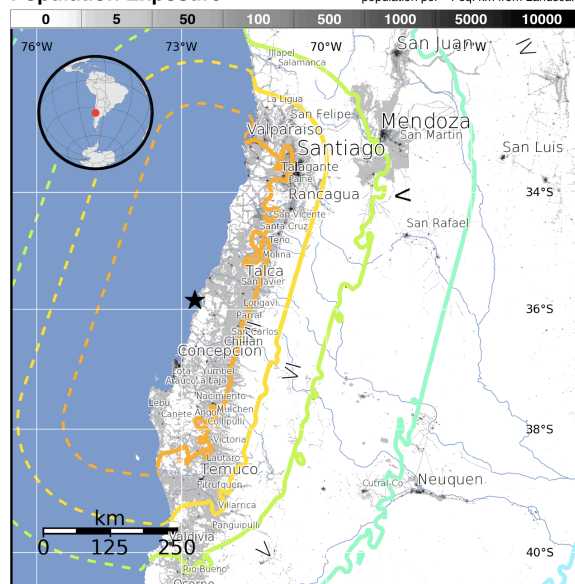
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	--*	0*	1,218k*	2,721k*	751k*	7,285k	5,480k	0	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
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 sq. km from Landsat

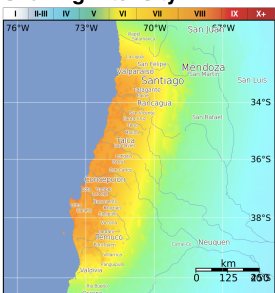


Selected City Exposure

MMI City	Population
VIII Talcahuano	253k
VIII Arauco	25k
VIII Lota	50k
VIII Chiguayante	83k
VIII Canete	20k
VIII San Antonio	86k
VII Talca	197k
VII Concepcion	215k
VII Rancagua	213k
VII Santiago	4,837k
VII Temuco	238k

bold cities appear on map (k = x1000)

Shaking Intensity



Overall, the population in this region resides in structures that are vulnerable to earthquake shaking, though some resistant structures exist. On May 22, 1960 (UTC), a magnitude 9.5 earthquake 273 km South of this one struck Valdivia, Chile, with estimated population exposures of 230,000 at intensity VIII and 216,000 at intensity IX, resulting in a reported 3263 deaths from the earthquake and tsunami. Recent earthquakes in this area have caused tsunamis, landslides, and liquefaction that may have contributed to losses.

This information was automatically generated and has not been reviewed by a seismologist.

<http://earthquake.usgs.gov/pager>

Event ID: us2010tfan

M 7.0, HAITI REGION

Origin Time: Tue 2010-01-12 21:53:10 UTC

Location: 18.45°N 72.57°W Depth: 13 km

PAGER Version 9

Created: 1 month, 2 weeks after earthquake

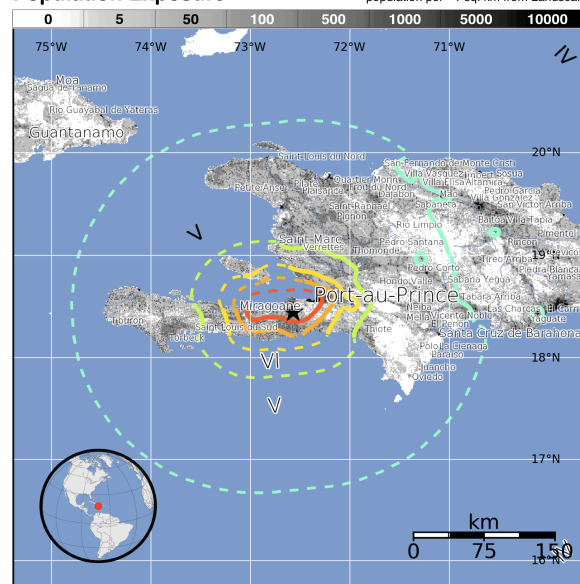
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	--*	50k*	7,176k*	5,887k	903k	558k	626k	2,387k	2k
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
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 sq. km from Landsat

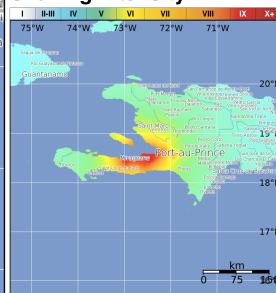


Selected City Exposure

MMI City	Population
IX Gressier	26k
IX Carrefour	442k
IX Leogane	134k
VIII Port-au-Prince	1,235k
VIII Petionville	283k
VIII Delmas 73	383k
VIII Miragoane	89k
V Verrettes	49k
IV Santo Domingo	2,202k
III Guantanamo	273k

bold cities appear on map (k = x1000)

Shaking Intensity



Overall, the population in this region resides in structures that are vulnerable to earthquake shaking, though some resistant structures exist. On June 24, 1984 (UTC), a magnitude 6.7 earthquake 329 km East of this one struck the Dominican Republic, with estimated population exposures of 320,000 at intensity VII and 2,964,000 at intensity VI, resulting in 5 reported fatalities. Recent earthquakes in this area have caused landslides that may have contributed to losses.

This information was automatically generated and has not been reviewed by a seismologist.

<http://earthquake.usgs.gov/pager>

Event ID: us2010rja6

M 8.8, OFFSHORE MAULE, CHILE

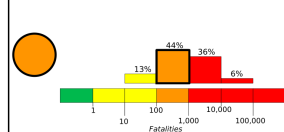
Origin Time: Sat 2010-02-27 06:34:14 UTC (03:34:14 local)

Location: 35.85°S 72.72°W Depth: 35 km

PAGER Version 4

Created: 14 hours, 10 minutes after earthquake

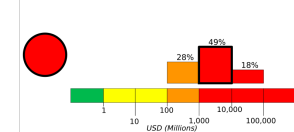
Estimated Fatalities



Red alert level for economic losses. Widespread damage is likely and the disaster is potentially widespread. Past events with this alert level have required a national or international level response.

Orange alert level for fatalities. Significant casualties are likely.

Estimated Economic Losses

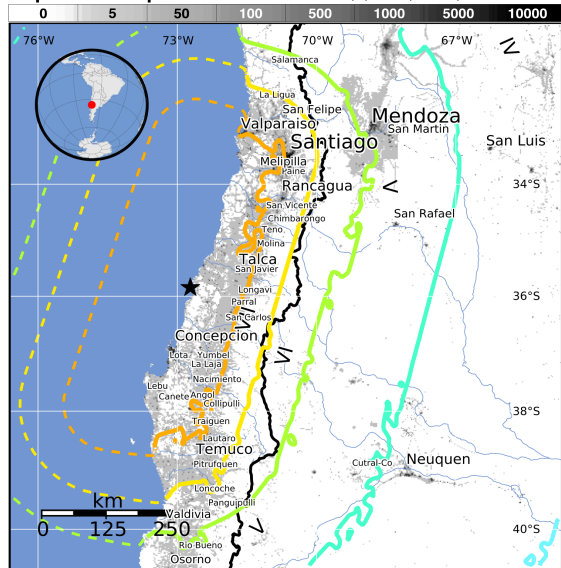


Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	--*	0*	1,223k*	2,735k*	758k*	7,361k	5,537k	0	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



This information was automatically generated.

<http://earthquake.usgs.gov/pager>

Structures:
Overall, the population in this region resides in structures that are vulnerable to earthquake shaking, though some resistant structures exist. The predominant vulnerable building types are low-rise reinforced/confined masonry and adobe block construction.

Historical Earthquakes:
On March 3, 1985 (UTC), a magnitude 7.9 earthquake 311 km North of this one struck Valparaiso, Chile, with estimated population exposures of 5,449,000 at intensity VII and 2,647,000 at intensity VI, resulting in a reported 177 fatalities. Recent earthquakes in this area have caused tsunamis, landslides and liquefaction that may have contributed to losses.

Selected City Exposure

MMI City	Population
VIII Talcahuano	253k
VIII Arauco	25k
VIII Lota	50k
VIII Chiguayante	83k
VIII Canete	20k
VIII San Antonio	86k
VII Talca	197k
VII Concepcion	215k
VII Rancagua	213k
VII Santiago	4,837k
VII Temuco	238k

bold cities appear on map

(k = x1000)

Event ID: us2010tfan

M 7.0, HAITI REGION

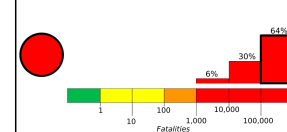
Origin Time: Tue 2010-01-12 21:53:10 UTC (16:53:10 local)

Location: 18.45°N 72.57°W Depth: 13 km

PAGER Version 4

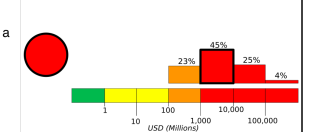
Created: 1 month, 2 weeks after earthquake

Estimated Fatalities



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

Estimated Economic Losses

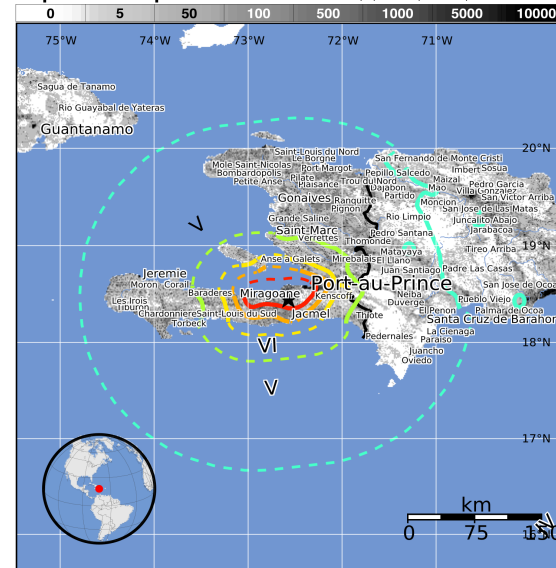


Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	--*	50k*	7,272k*	6,149k	867k	513k	706k	2,370k	3k	
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



This information was automatically generated.

<http://earthquake.usgs.gov/pager>

Structures:
Overall, the population in this region resides in structures that are vulnerable to earthquake shaking, though some resistant structures exist. The predominant vulnerable building types are concrete/cinder block masonry and mud wall construction.

Historical Earthquakes:
On June 24, 1984 (UTC), a magnitude 6.7 earthquake 342 km East of this one struck the Dominican Republic, with estimated population exposures of 320,000 at intensity VII and 2,964,000 at intensity VI, resulting in a reported 5 fatalities. Recent earthquakes in this area have caused landslides that may have contributed to losses.

Selected City Exposure

MMI City	Population
IX Gressier	26k
IX Carrefour	442k
IX Leogane	134k
VIII Port-au-Prince	1,235k
VIII Petionville	283k
VIII Delmas 73	383k
VIII Miragoane	89k
V Verrettes	49k
IV Santo Domingo	2,202k
III Guantanamo	273k

bold cities appear on map

(k = x1000)

Event ID: us2010rja6

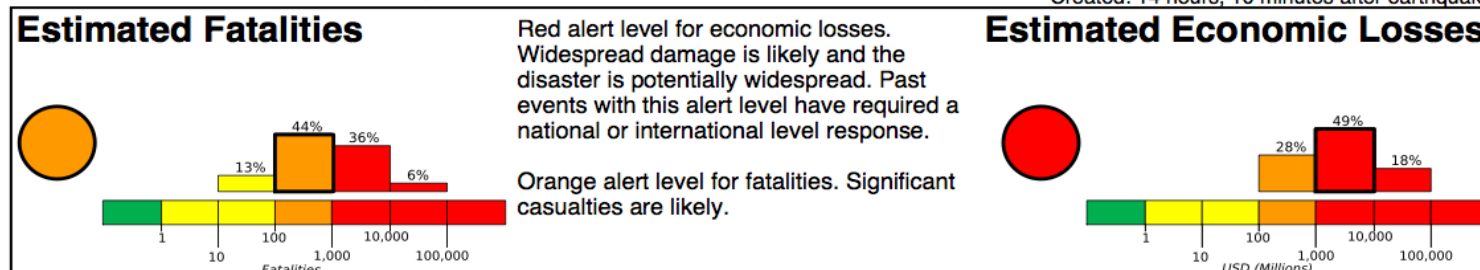
M 8.8, OFFSHORE MAULE, CHILE

Origin Time: Sat 2010-02-27 06:34:14 UTC (03:34:14 local)

Location: 35.85°S 72.72°W Depth: 35 km

**PAGER
Version 4**

Created: 14 hours, 10 minutes after earthquake



Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	--*	0*	1,223k*	2,735k*	758k*	7,361k	5,537k	0	0
ESTIMATED MODIFIED MERCALLI INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

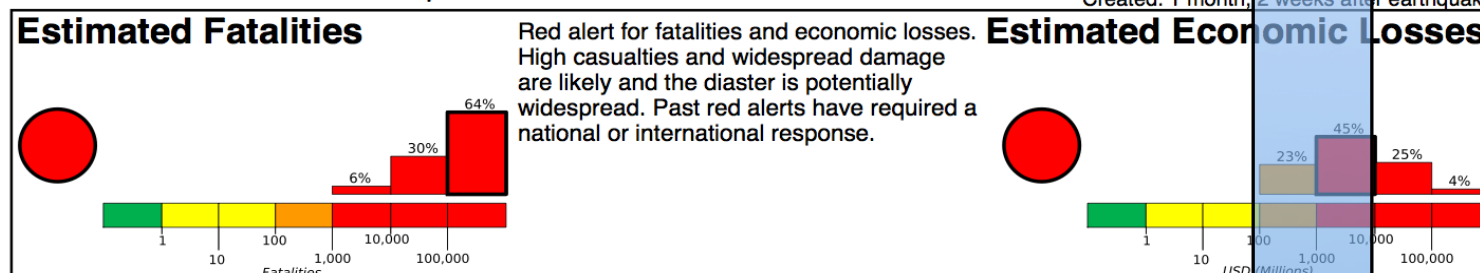
M 7.0, HAITI REGION

Origin Time: Tue 2010-01-12 21:53:10 UTC (16:53:10 local)

Location: 18.45°N 72.57°W Depth: 13 km

**PAGER
Version 1**

Created: 1 month, 2 weeks after earthquake



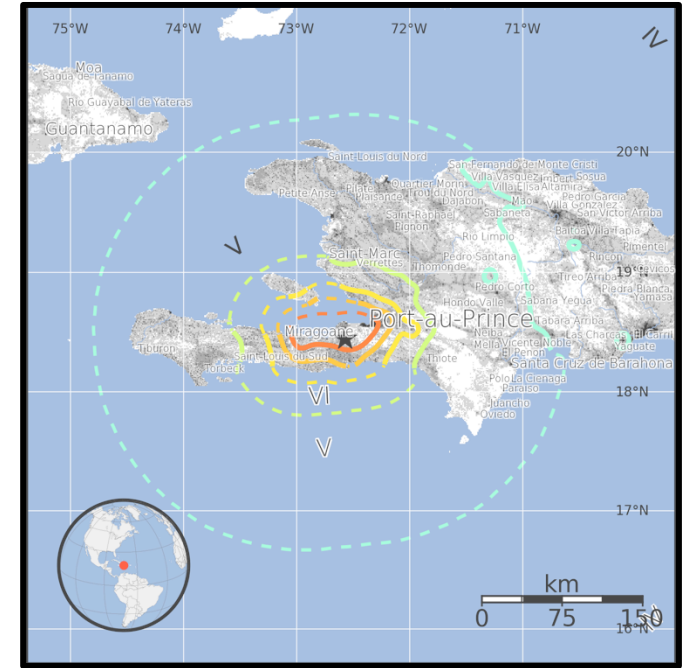
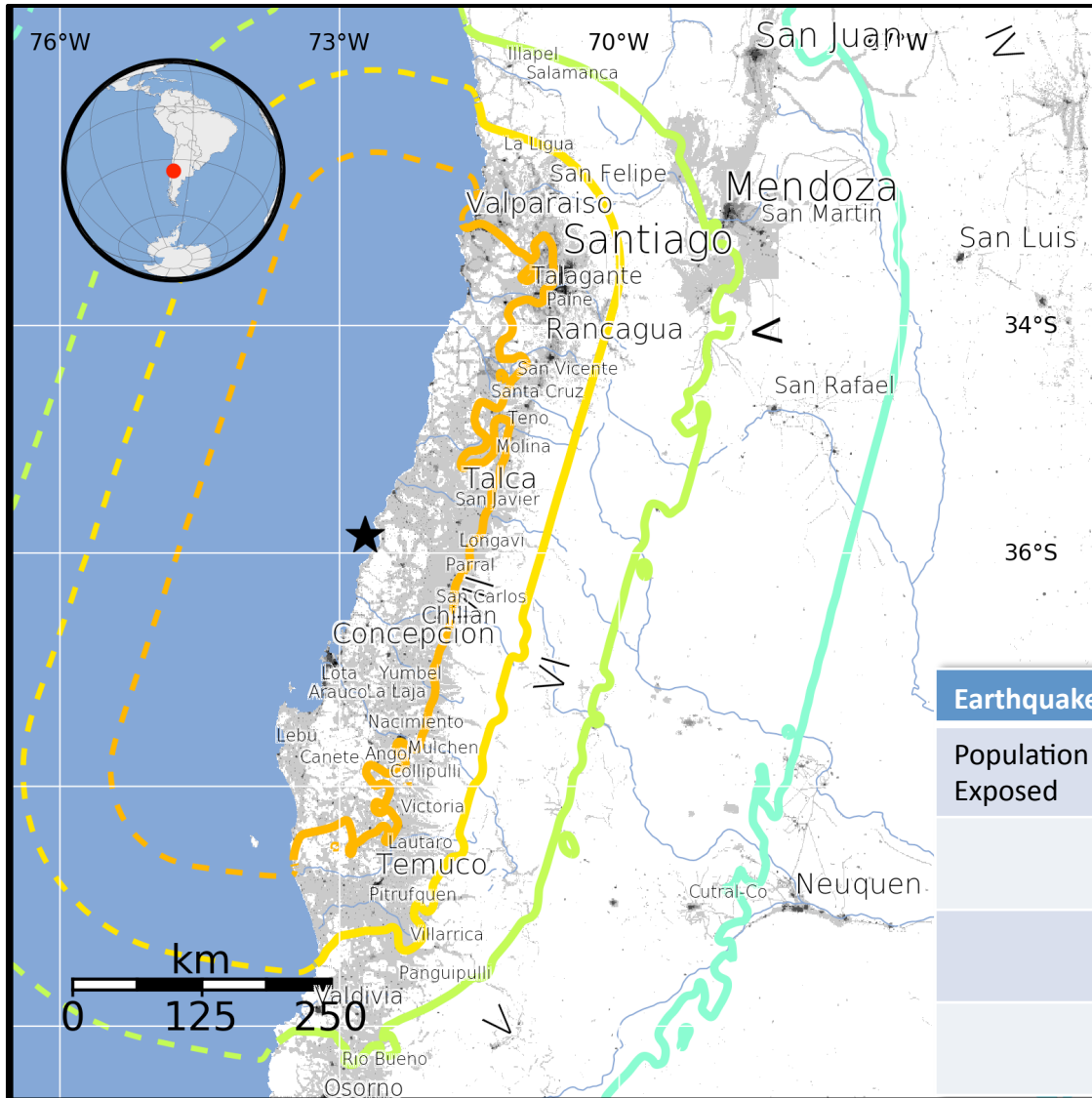
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	--*	50k*	7,272k*	6,149k	867k	513k	706k	2,370k	3k	
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

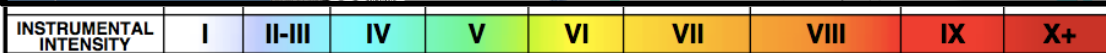
Population & Shaking Intensity

Chile

Haiti



Earthquake	Intensity	Chile	Haiti
Population Exposed	Violent Shaking (IX)	0	2,400,000
	Severe Shaking (VIII)	5,540,000	700,000
	Very Strong Shaking (VII)	7,360,000	510,000
	Strong Shaking (VI)	758,000	870,000

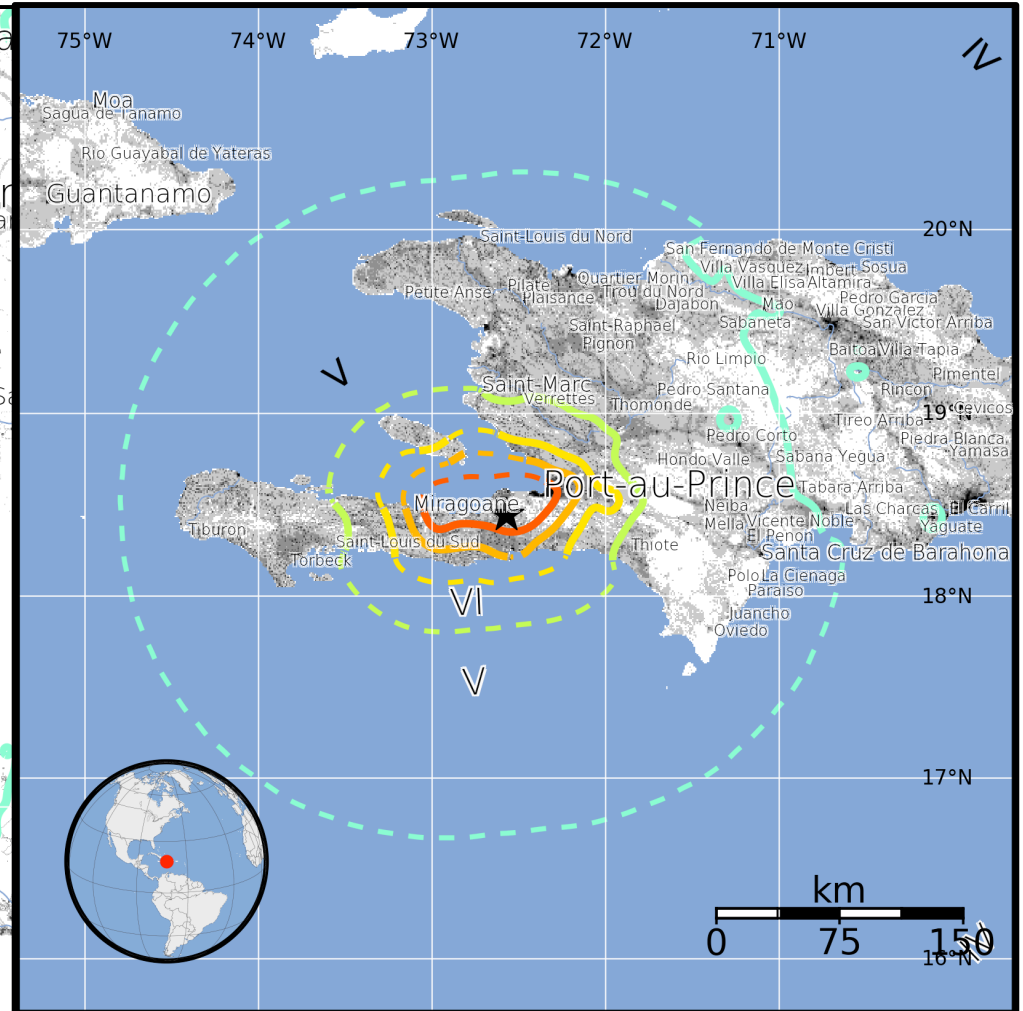
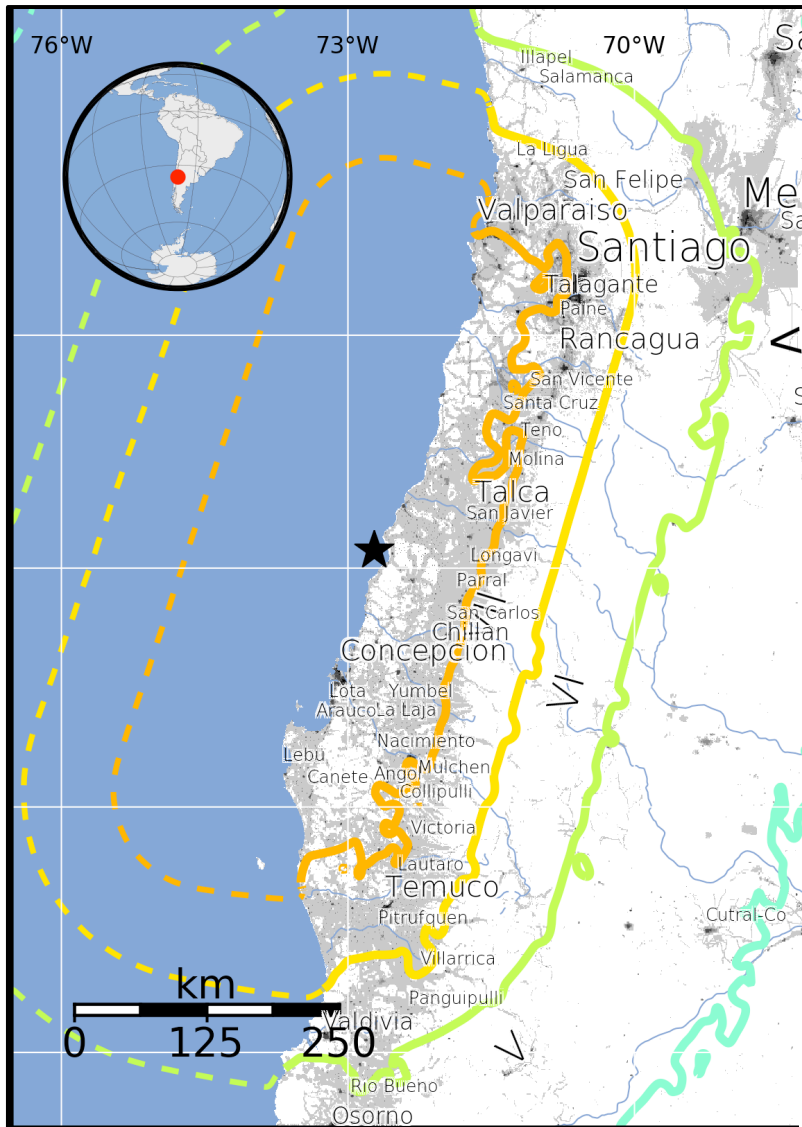


[Maps on approximately same scale]

Population & Shaking Intensity

Chile

Haiti



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.17	0.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Magnitude 8.8 OFFSHORE MAULE, CHILE

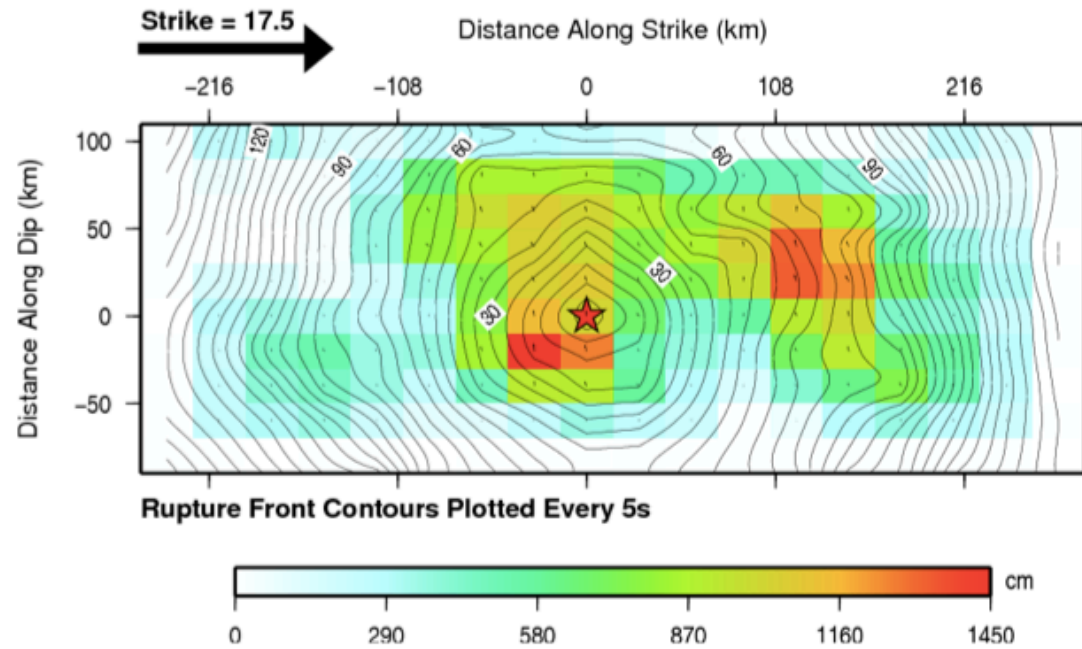
Saturday, February 27, 2010 at 06:34:17 UTC



Figure modified from IRIS

Chile

Same Length Scale!



Haiti



2010 Chile & Haiti Earthquake Fault Facts

The Facts	Chile	Haiti
Magnitude	8.8	7.0
Maximum Estimated Shaking Intensity	~ VIII	~ IX
Fault Size Area (km ²)	80,000 sq km	600 sq km
Maximum Slip (meters)	12	5
Average slip (meters)	7	2
ave. slip x area	560,000	1,200

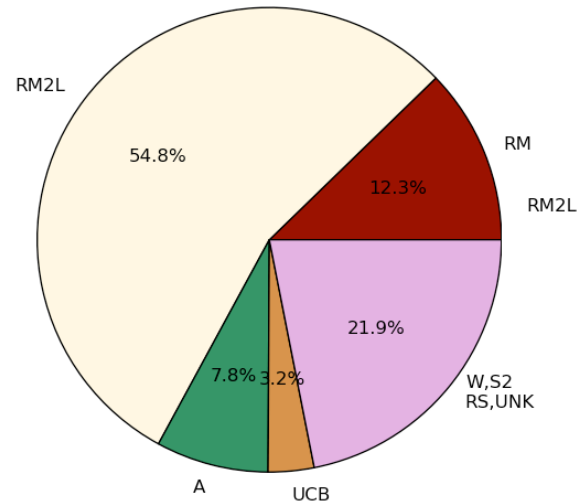
560,000/1,200 ~ = 500 times energy release

PAGER estimates of buildings contributing to casualties

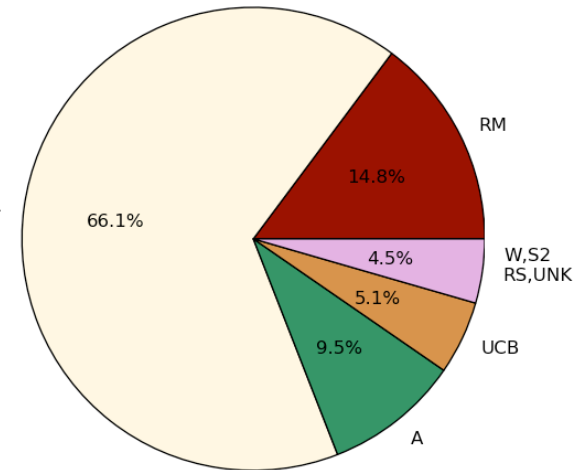
Chile

RM & RM2L – Reinforced masonry (commonly low-rise) and masonry with frames (dual)
RS – Rubble stone masonry (hybrid)
S2 – Steel frame
A – Adobe block

Collapses by Building Type



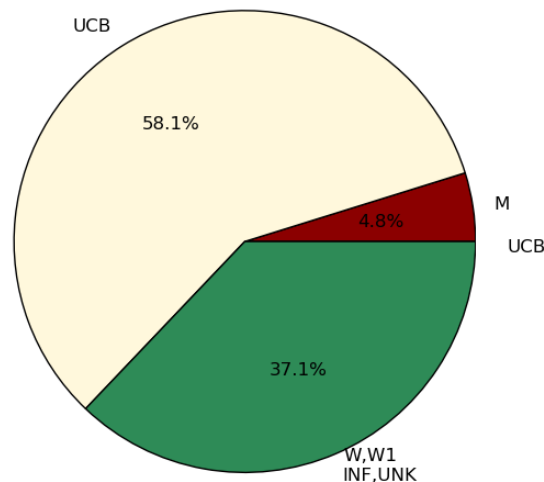
Fatalities by Building Type



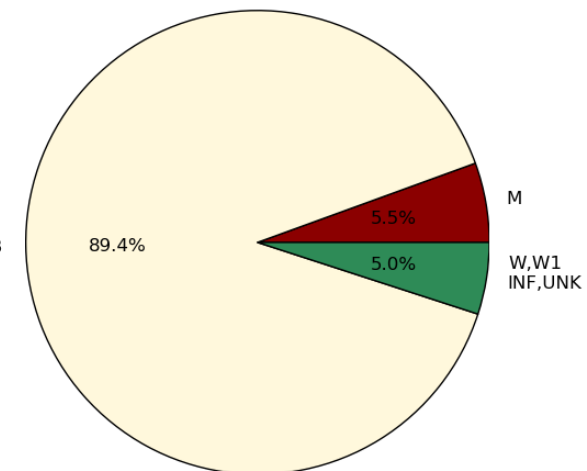
Haiti

UCB – Concrete block masonry & low rise non-ductile concrete frame
W or INF – Light timber or steel frame (informal/makeshift type)
M – Mud wall construction

Collapses by Building Type

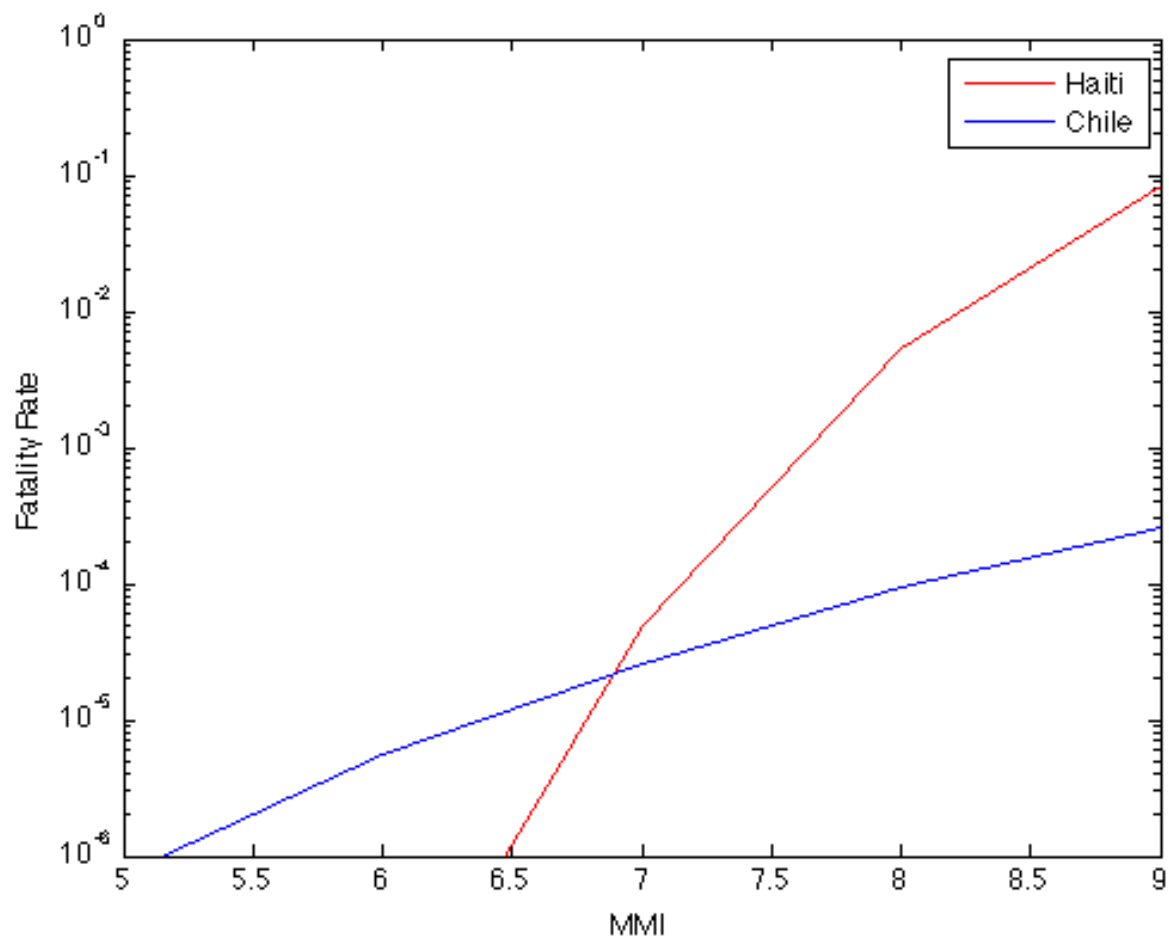


Fatalities by Building Type

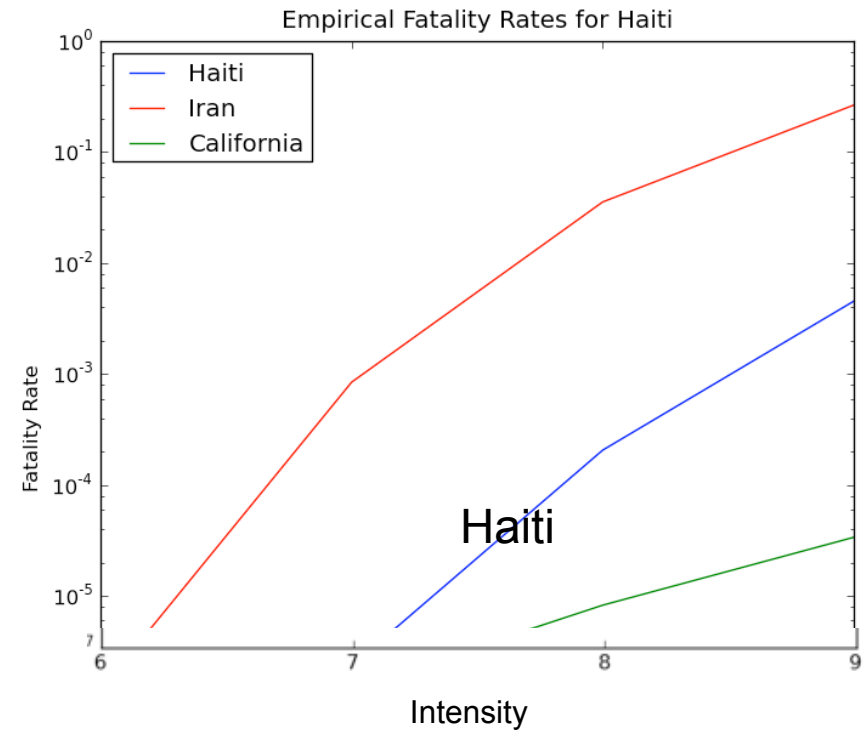
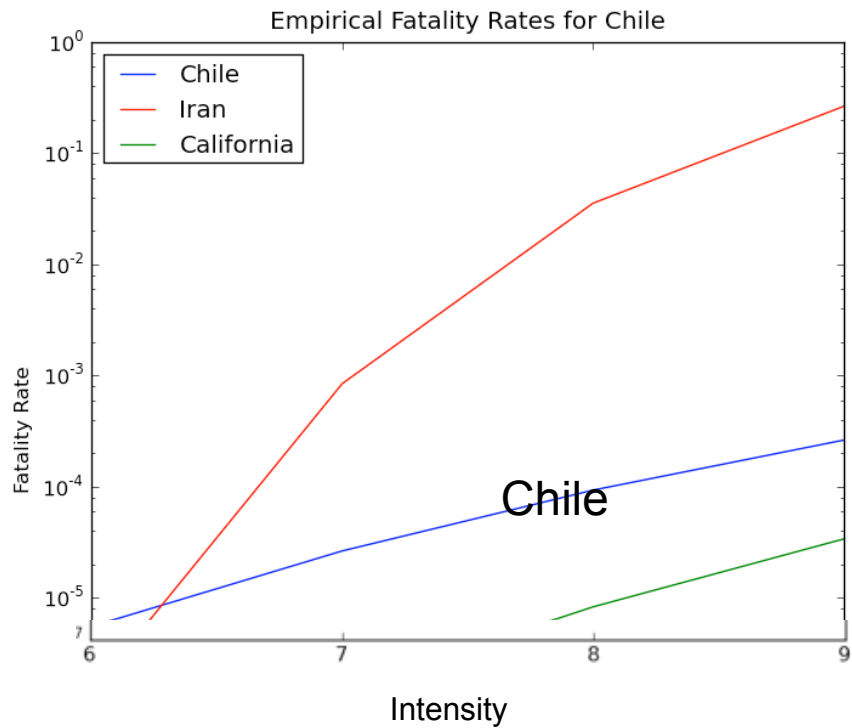


Note: color scheme applies to different buildings for Chile & Haiti

PAGER Intensity-based Fatality Vulnerability Function Comparisons



PAGER Vulnerability Function Comparisons



Aftershocks:
Comparison with
previous events

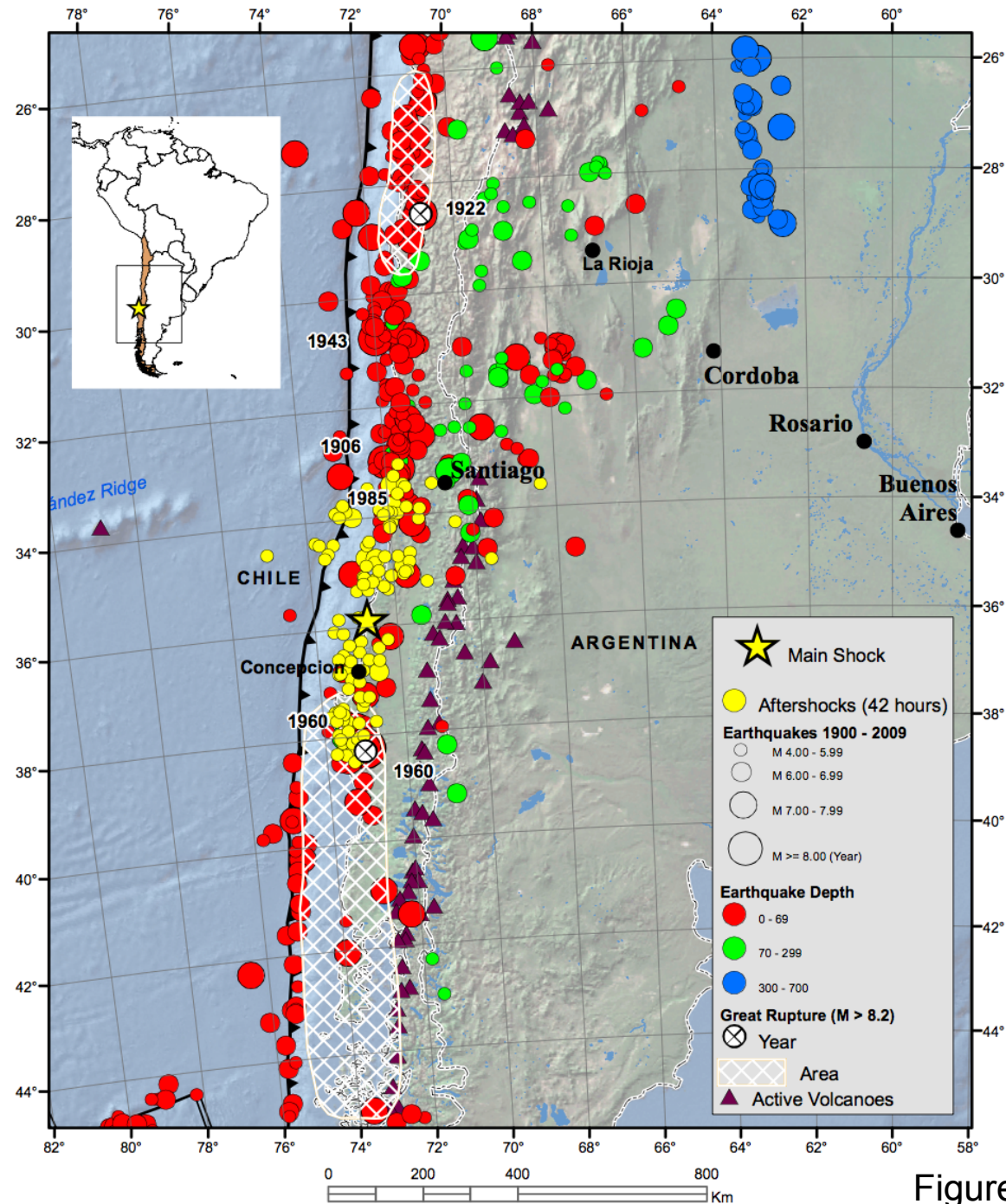
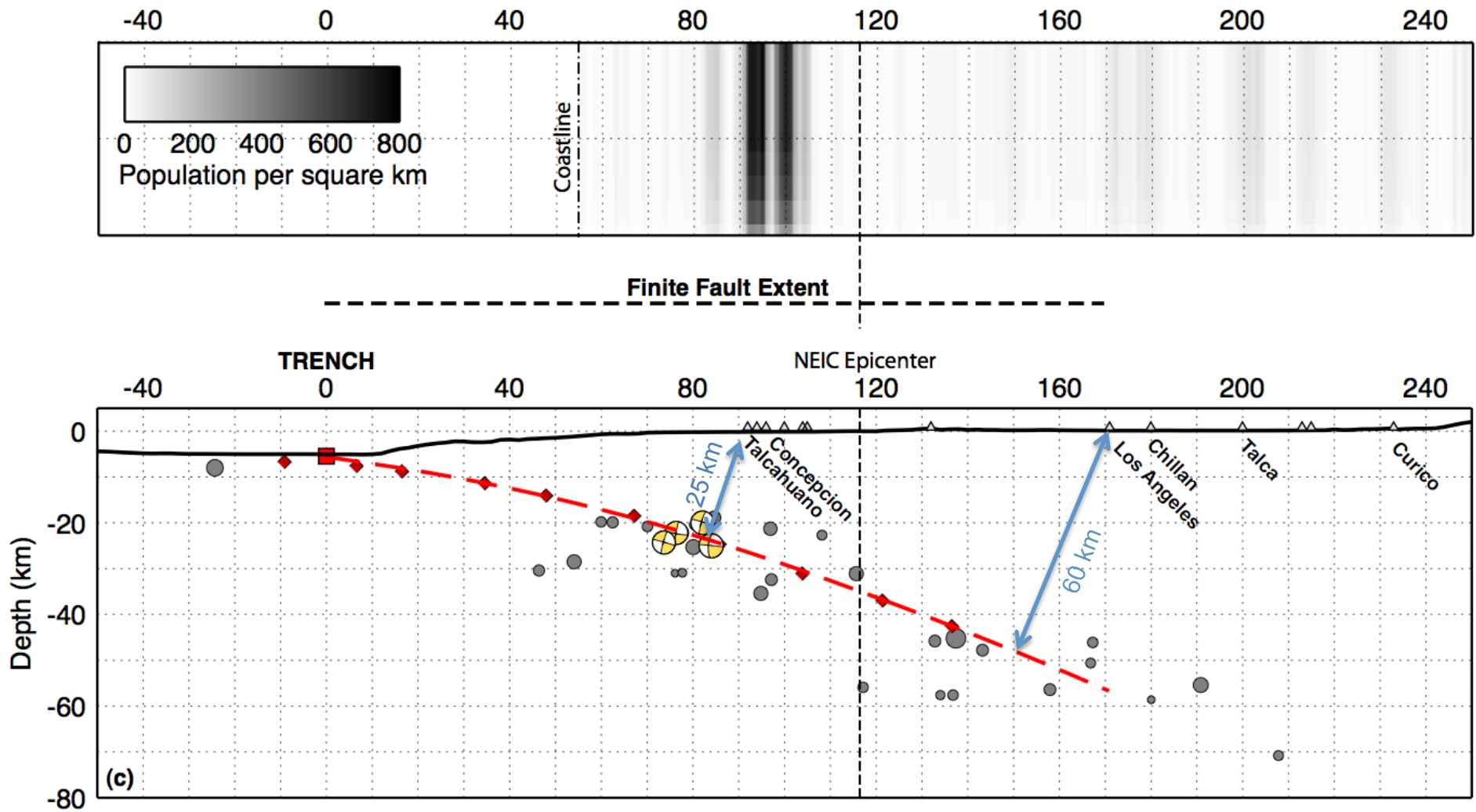


Figure by S. Rhea

Chile Earthquake: Depth extent of faulting

Closest cities to fault that slipped is about 25 km:

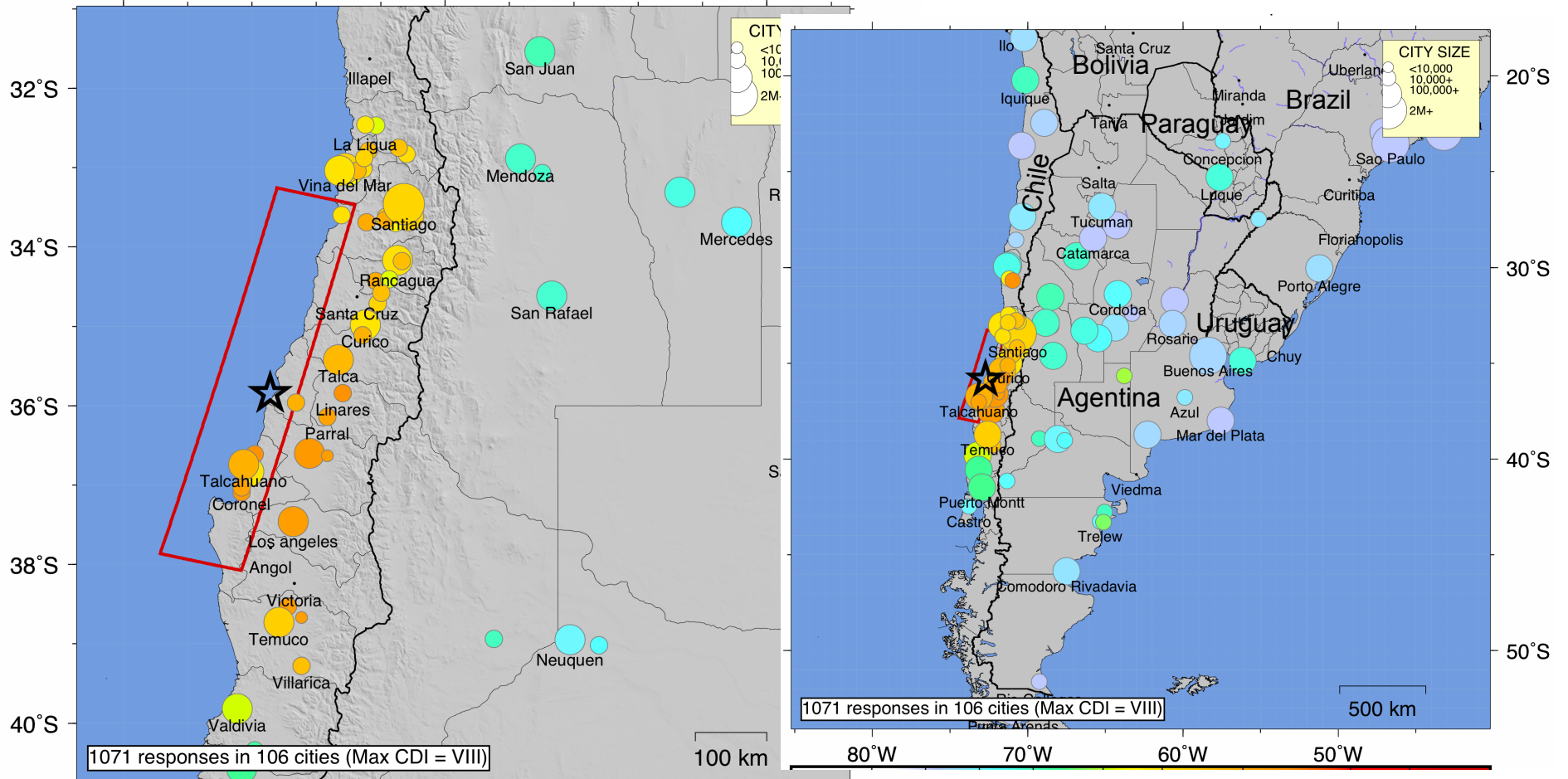


“Did You Feel It?” Reported Modified Mercalli Intensities



USGS Community Internet Intensity Map
OFFSHORE MAULE, CHILE

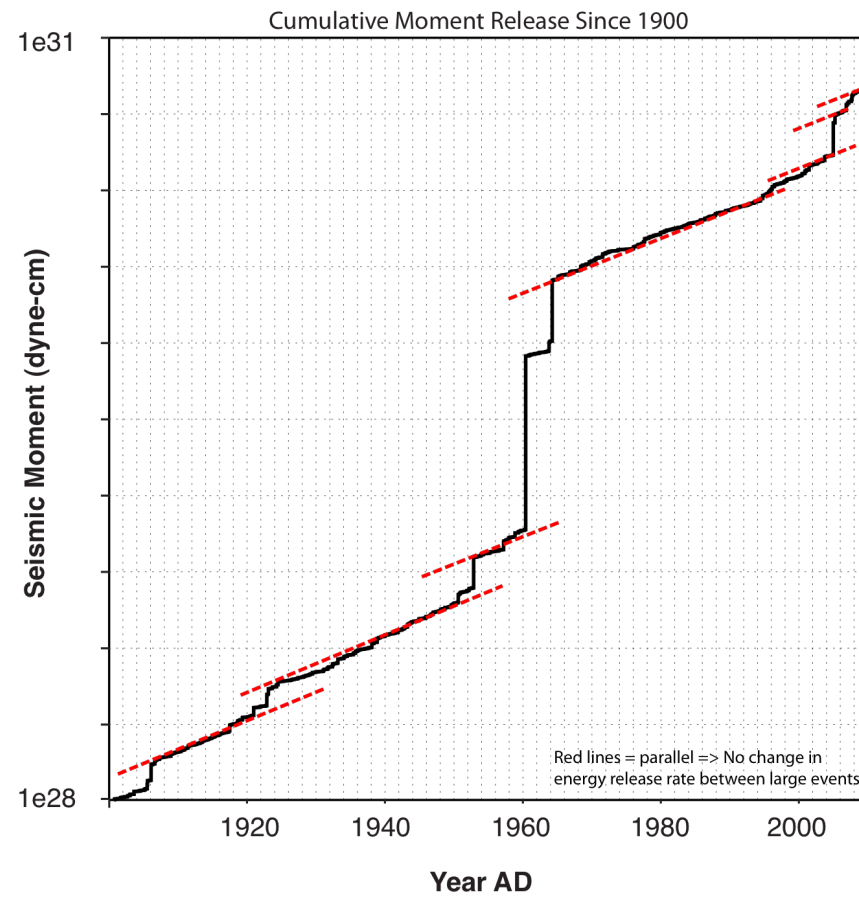
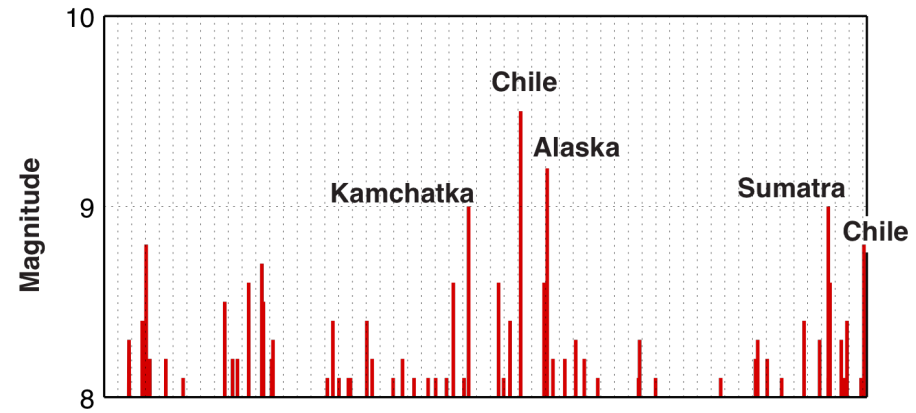
Feb 27 2010 03:34:14 local 35.8464S 72.7189W M8.8 Depth: 35 km ID:us2010tfan



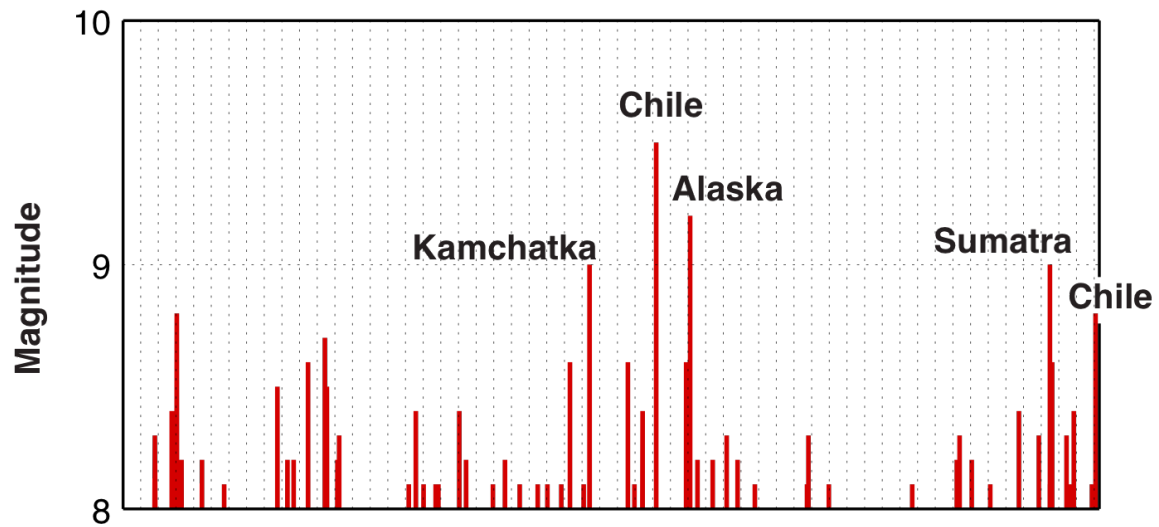
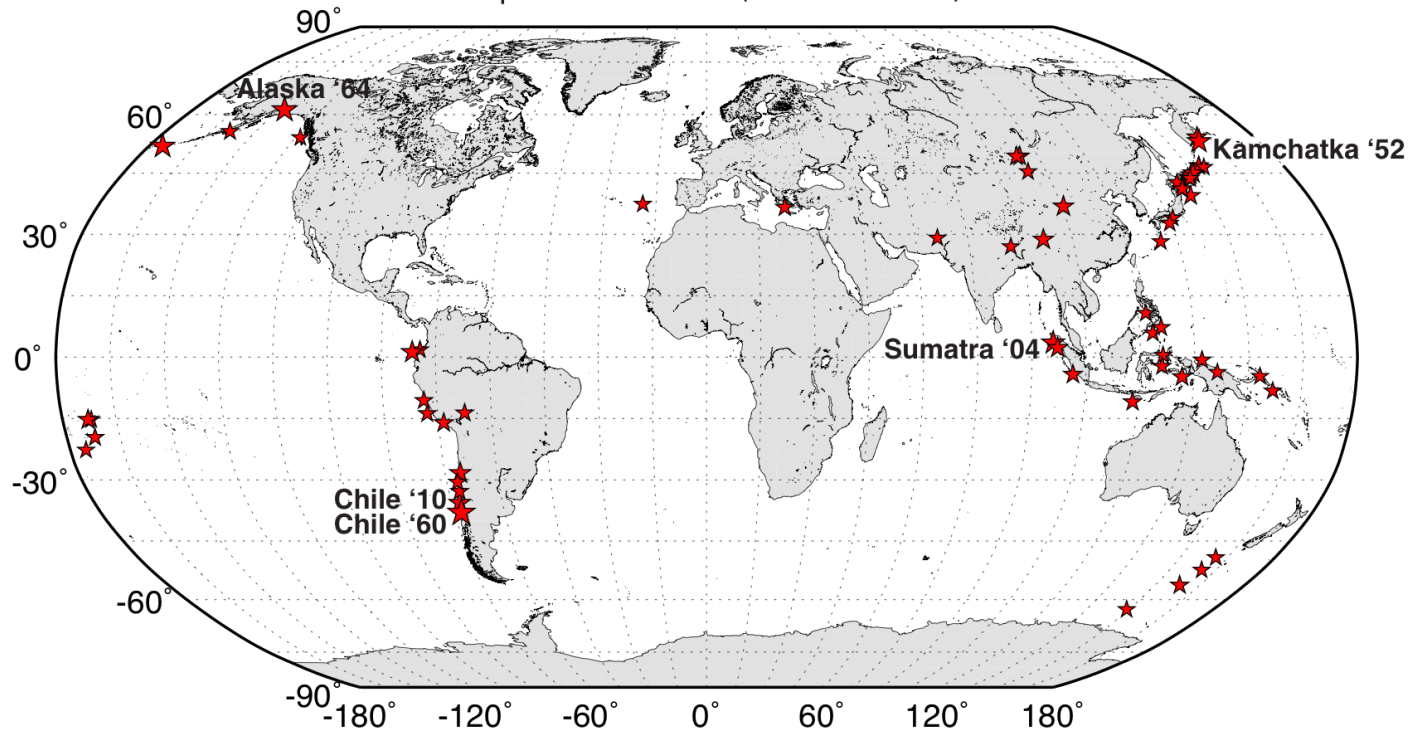
	75°W	70°W	65°W
INTENSITY	I	II-III	IV
SHAKING	Not felt	Weak	Light
DAMAGE	none	none	none
	V	VI	VII
	Moderate	Strong	Very strong
	VIII	IX	X+
	Severe	Violent	Extreme
	Moderate/Heavy	Heavy	V. Heavy

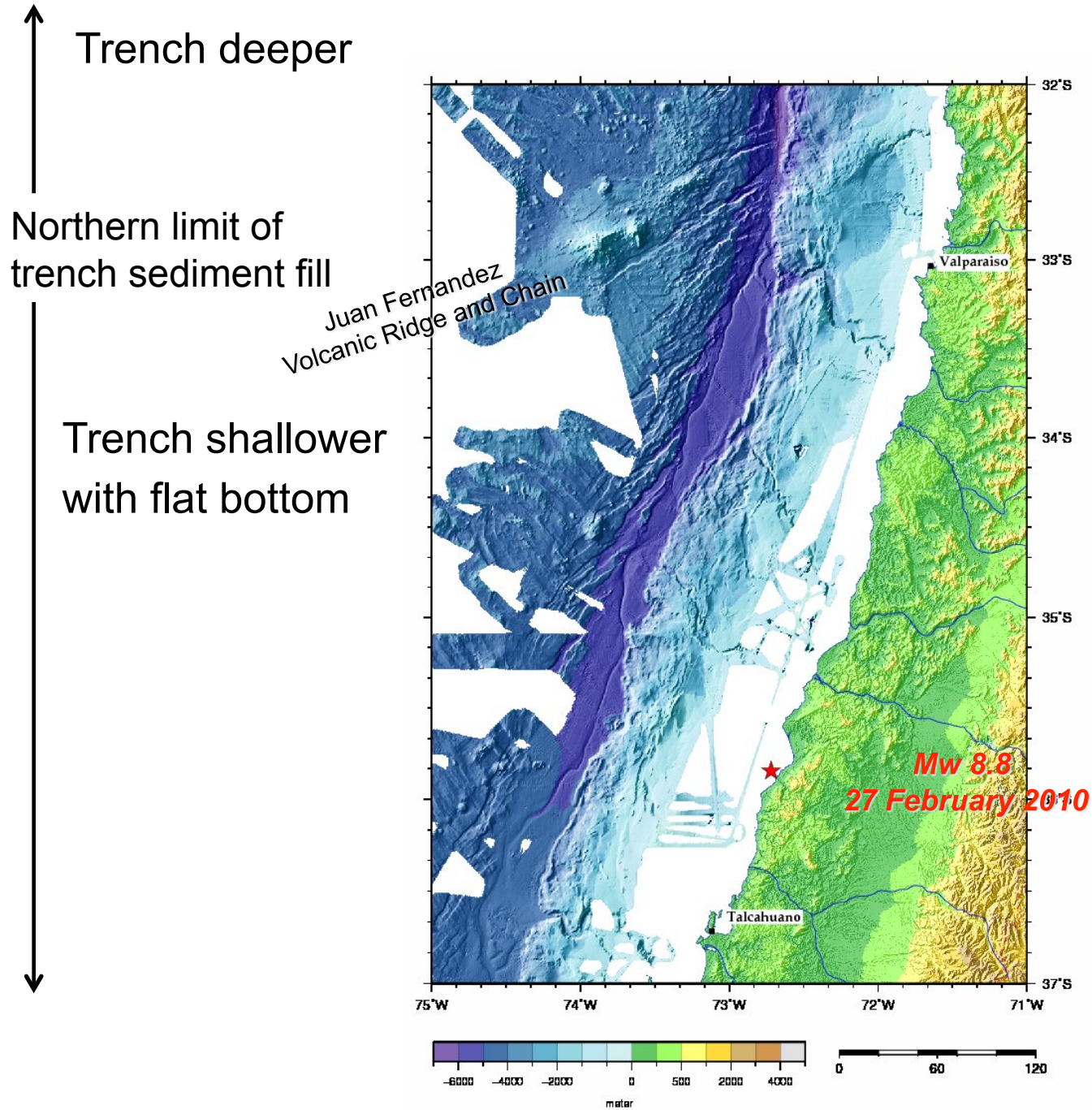
Red rectangle depicts faulting area

Processed: Mon Mar 1 17:16:41 2010



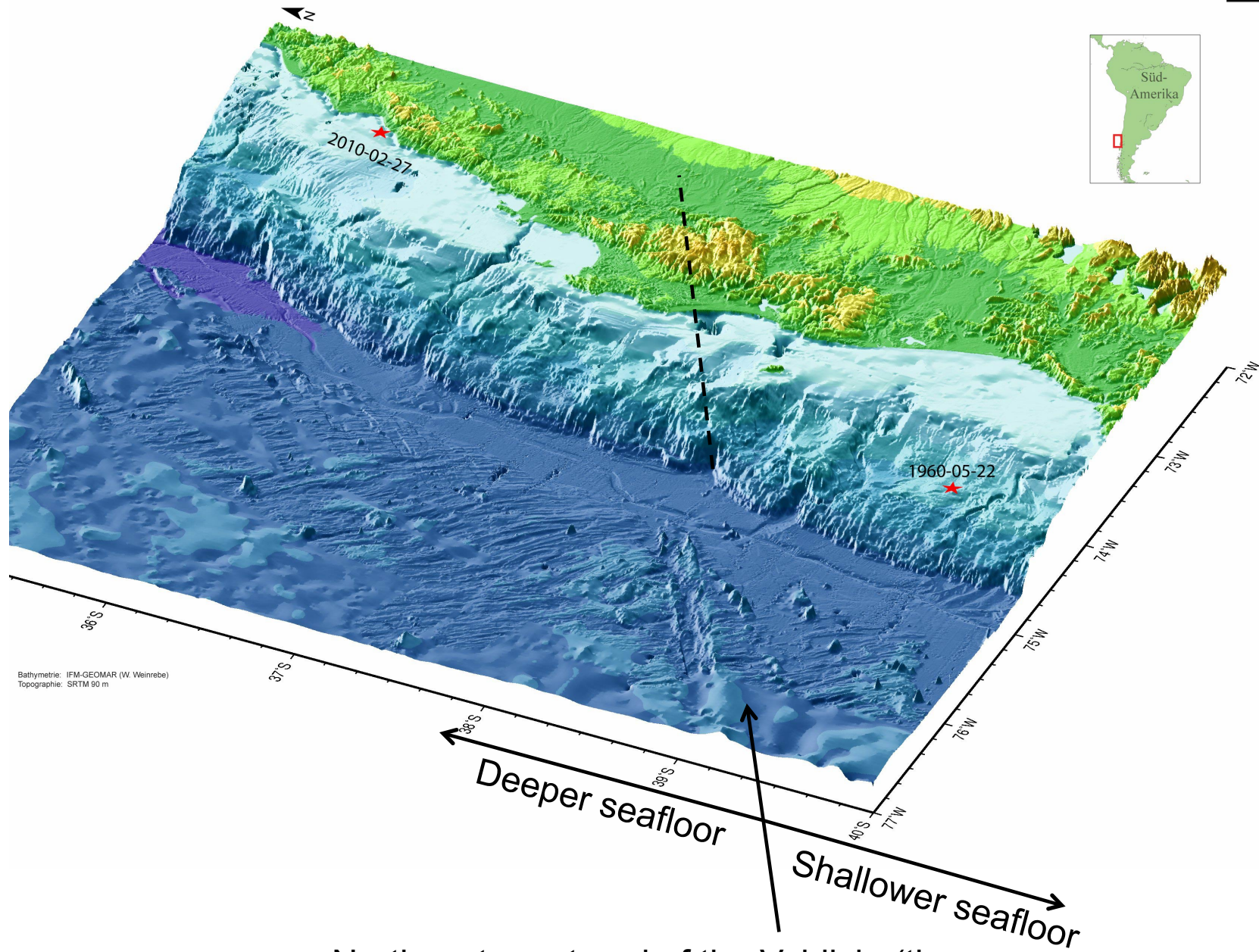
Global Earthquakes with $M \geq 8$ (Centennial/PDE) Since 1900





Northern limit of
aftershock zone
(Fig.4)

Figure by S. Kirby



Northeastern strand of the Valdivia (the Mocha FZ) Fracture-Zone Complex

Figure by S. Kirby

Slab Depth Contours at 20 km intervals

