The 02/27/2010 Mw8.8 Chile Earthquake

Educational Slides

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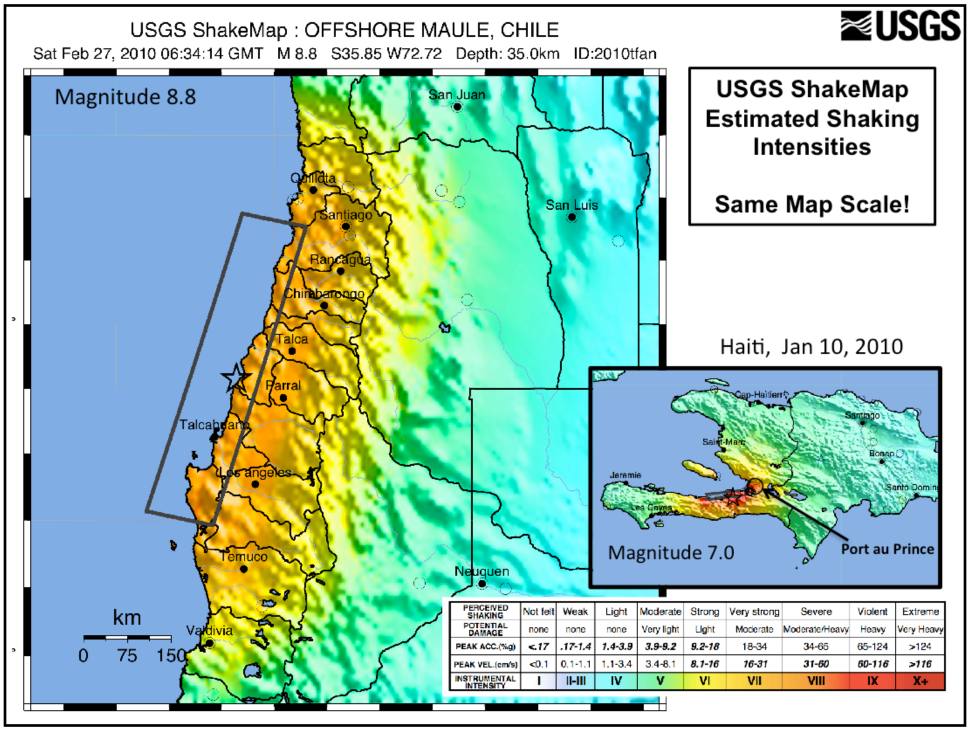
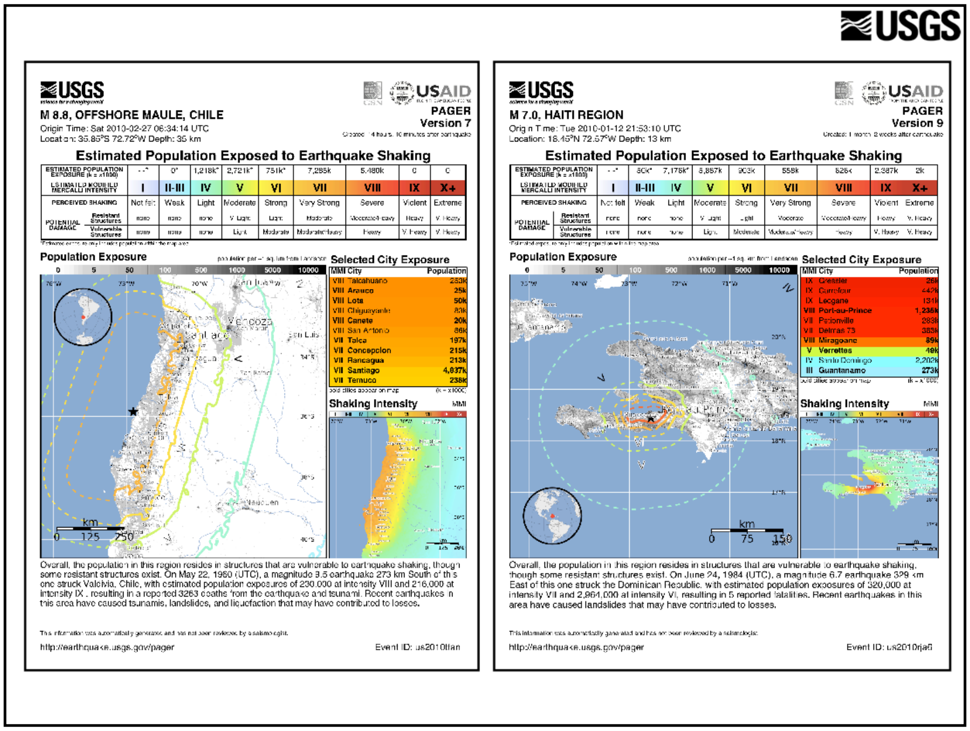


Comparison of distributions of the **ESTIMATED** shaking intensity for the magnitude 8.8 Chile and 7.0 Haiti earthquakes. The fault area for the Chilean event, shown by a rectangle,

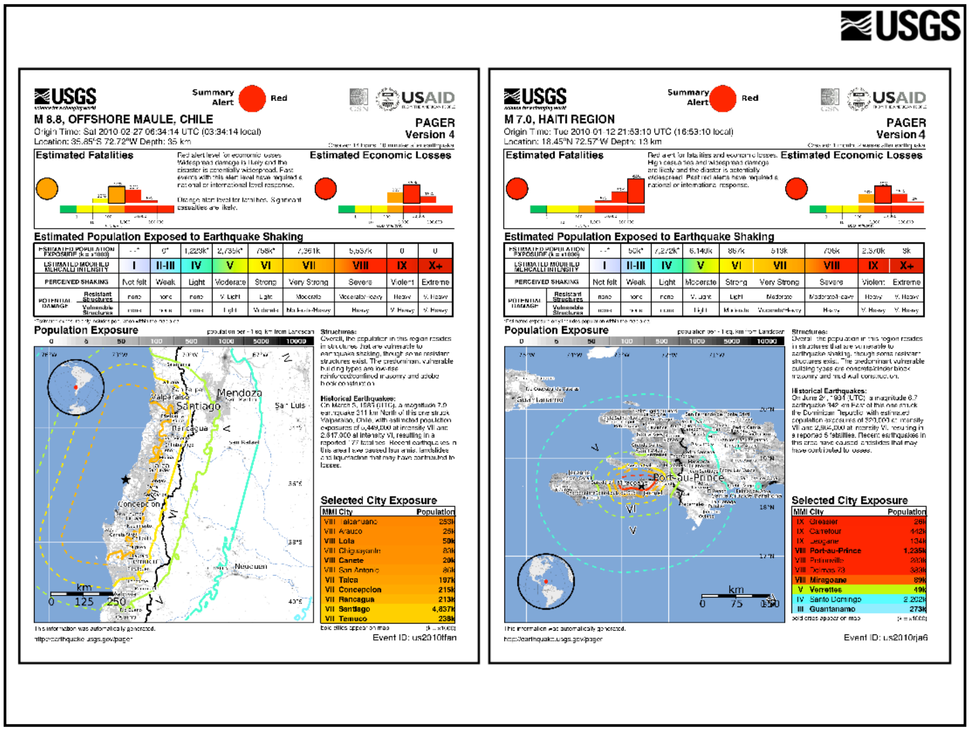
is roughly 200 times larger than the Haiti fault (rectangle) and has higher slip. However, the Chile fault plane is buried deeper beneath the Chilean cities so the shaking is

lower (MMI VII to VIII) on average than in Haiti, particularly near Port au Prince (MMI XIII – IX). Shaking durations were much longer in Chile than in Haiti but were likely at lower

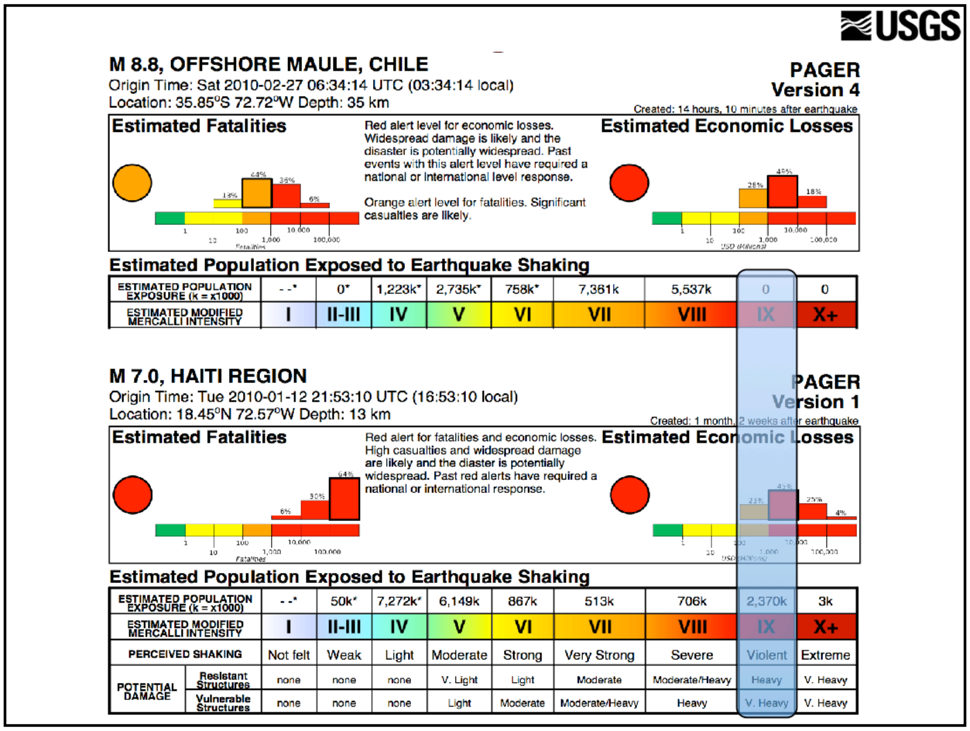
shaking levels. Recorded ground motions for Chile will be added when the become available; there are no known recordings in the source area of the Haiti earthquake.



Exposure PAGER estimates of shaking intensity and population exposure (http://earthquake.usgs.gov/pager/)



LossPAGER Estimated impacts.



USGS

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*	7,381k	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 Fatalities

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

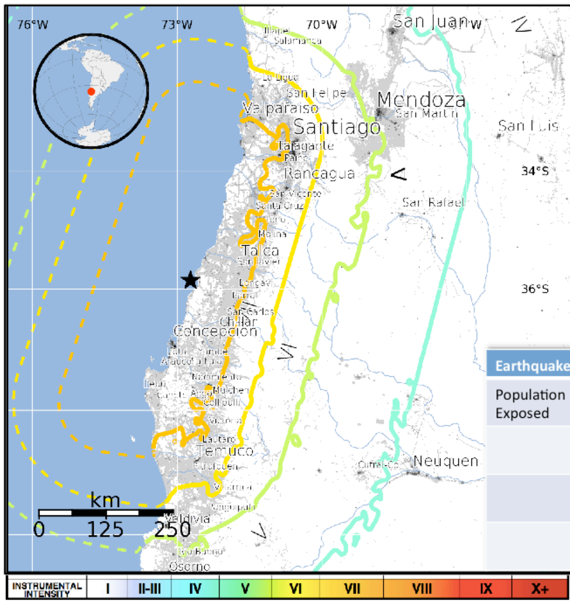
Estimated Economic Losses

Estimated Population Exposed to Earthquake Shaking

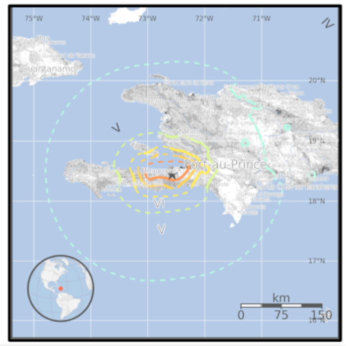
ESTIMATED POPULATION EXPOSURE (k = x1000)		--*	50k*	7,272k*	6,149k	867k	513k	706k	2,370k	3k
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

Population & Shaking Intensity

Chile

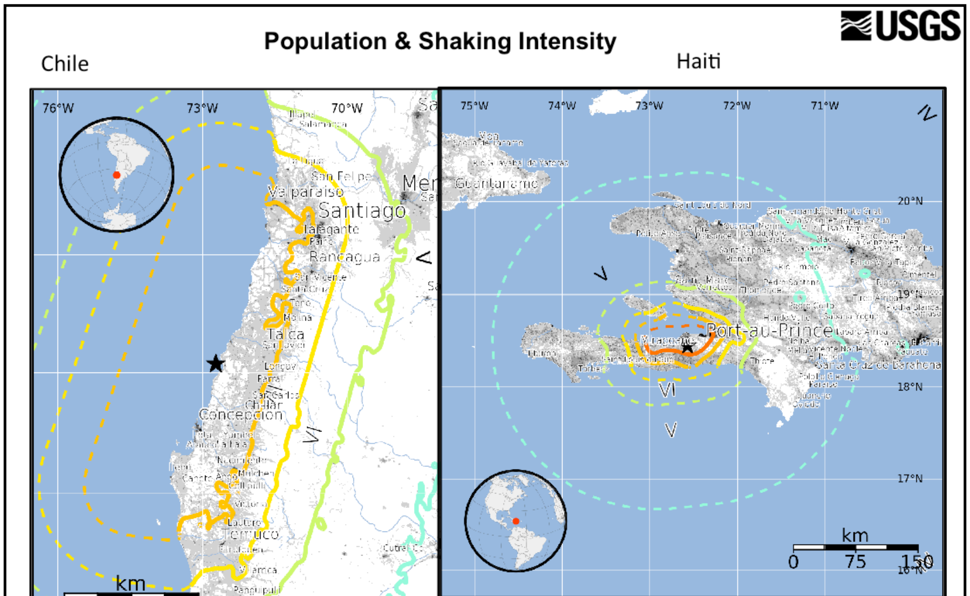


Haiti



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]



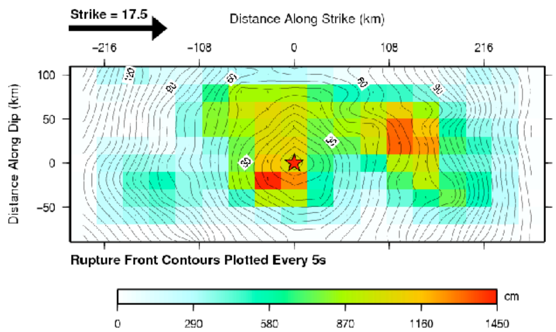
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16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

Magnitude 8.8 OFFSHORE MAULE, CHILE
Saturday, February 27, 2010 at 06:34:17 UTC

Figure modified from IRIS

Same Length Scale!

Chile



Haiti

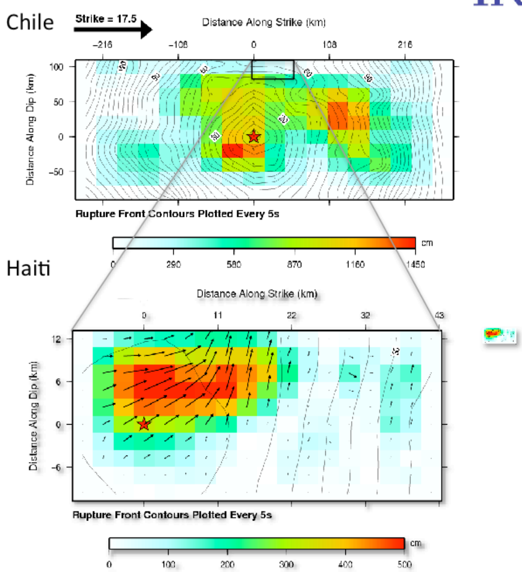
Finite fault models by Gavin Hayes, USGS
National Earthquake Information Center

Magnitude 8.8 OFFSHORE MAULE, CHILE
Saturday, February 27, 2010 at 06:34:17 UTC

Although magnitude is still an important measure of the size of an earthquake, particularly for public consumption, **seismic moment** is a more physically meaningful measure of earthquake size.

Seismic moment is proportional to the product of the slip on the fault and the area of the fault that slips

These "maps" of the slip on the fault surfaces of the January 12th M7.0 Haitian earthquake and the M8.8 Chilean earthquake show that although the slip in Chile was only about 50% greater, the fault area was vastly larger. This accounts for the release of approximately 500 times more energy in the Chilean earthquake.



Finite fault models by Gavin Hayes, USGS National Earthquake Information Center

2010 Chile & Haiti Earthquake Fault Facts

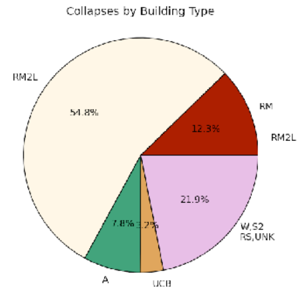
The Facts	Chile	Haiti
Magnitude	**8.8**	**7.0**
Maximum Estimated Shaking Intensity	**~ VIII**	**~ IX**
Fault Size Area (km^2)	80,000 sq km	600 sq km
Maximum Slip (meters)	12	5
Average slip (meters)	7	2
ave. slip x area	560,000	1,200

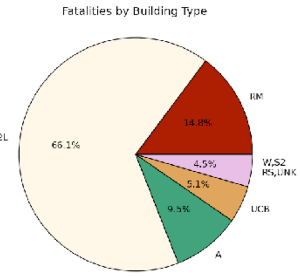
560,000/1,200 ~= 500 times energy release

PAGER **estimates** of buildings contributing to casualties

Chile

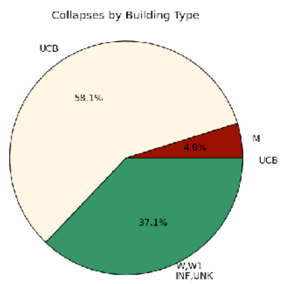
RM & RM2L – Reinforced masonry (commonly low-rise) and masonry with frames (dual)
RS – Rubble stone masonry (hybrid)
S2 – Steel frame
A – Adobe block

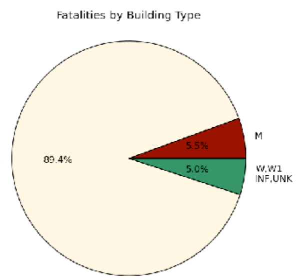




Haiti

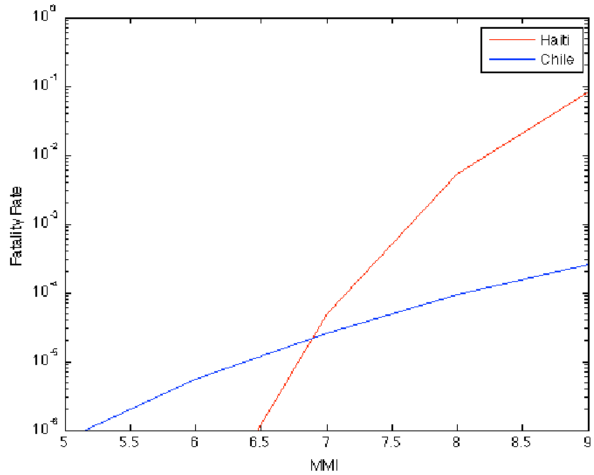
UCB – Concrete block masonry & low rise non-ductile concrete frame
W or **INF** – Light timber or steel frame (informal/makeshift type)
M – Mud wall construction

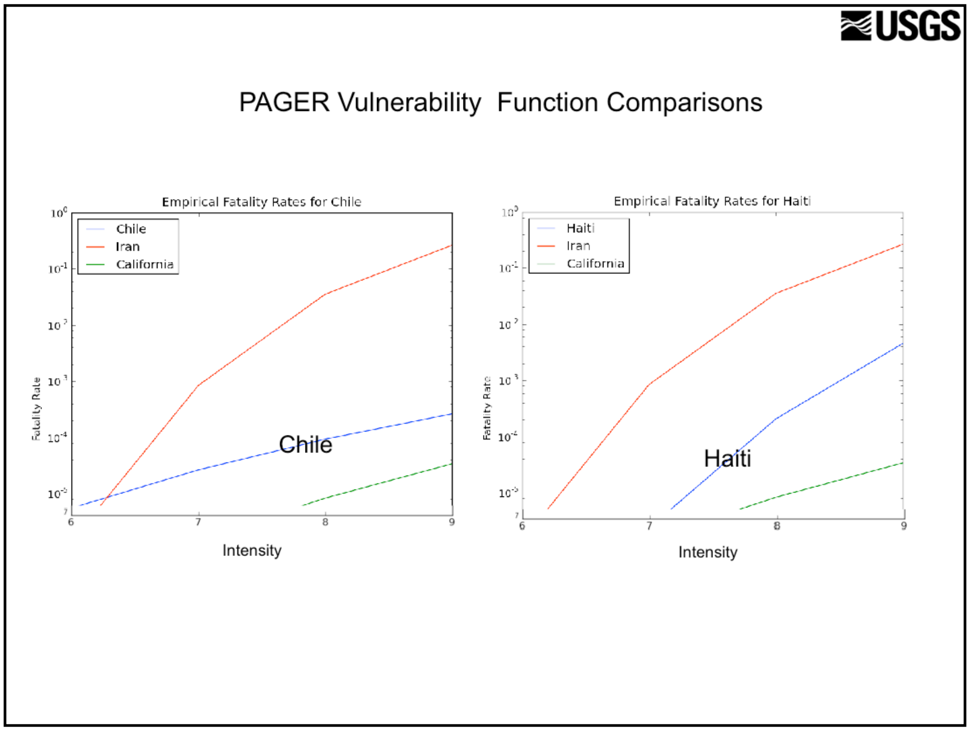




Note: color scheme applies to different buildings for Chile & Haiti

PAGER Intensity-based Fatality
Vulnerability Function Comparisons





Estimated fatality rates for Chile vs Haiti from the PAGER empirical loss model (Jaiwal and Wald, 2010).

Aftershocks: Comparison with previous events

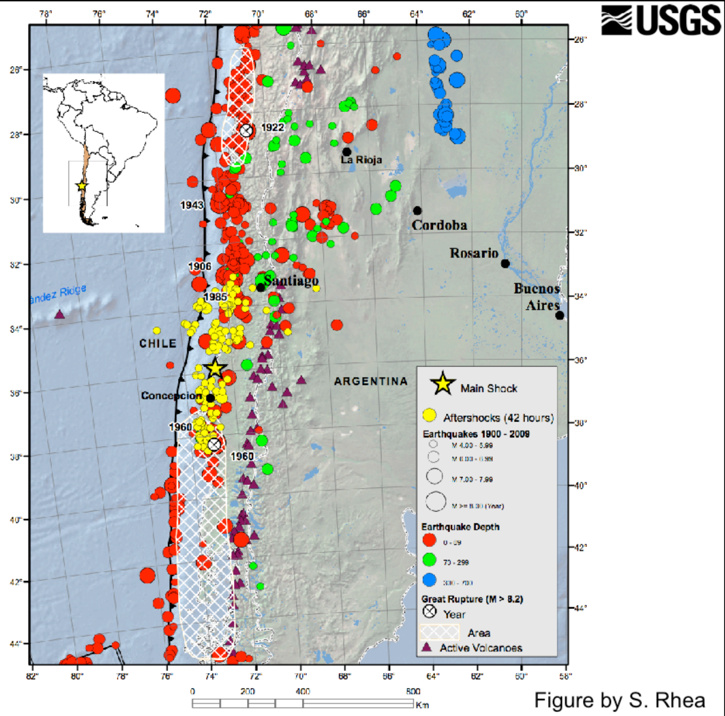
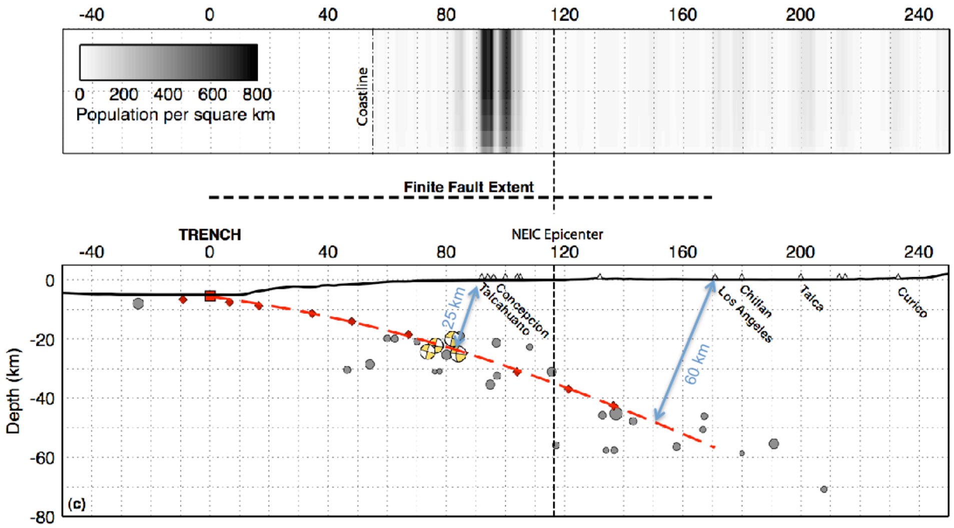


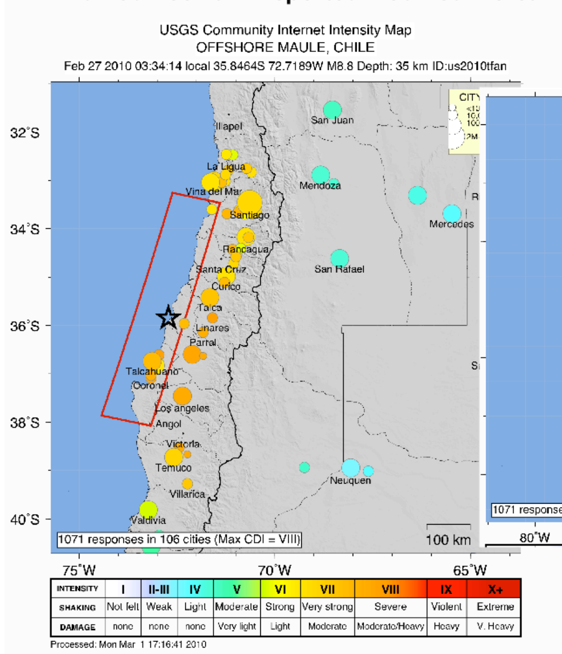
Figure by S. Rhea

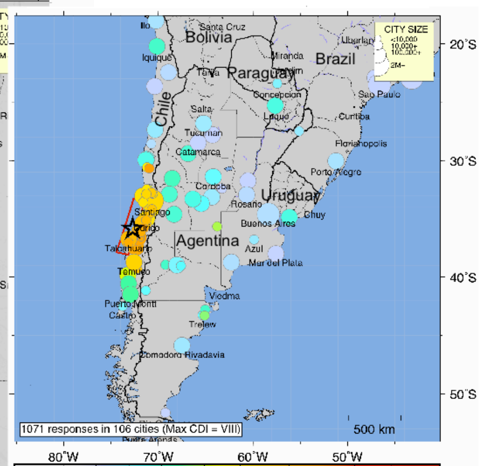
Chile Earthquake: Depth extent of faulting

Closest cities to fault that slipped is about 25 km:

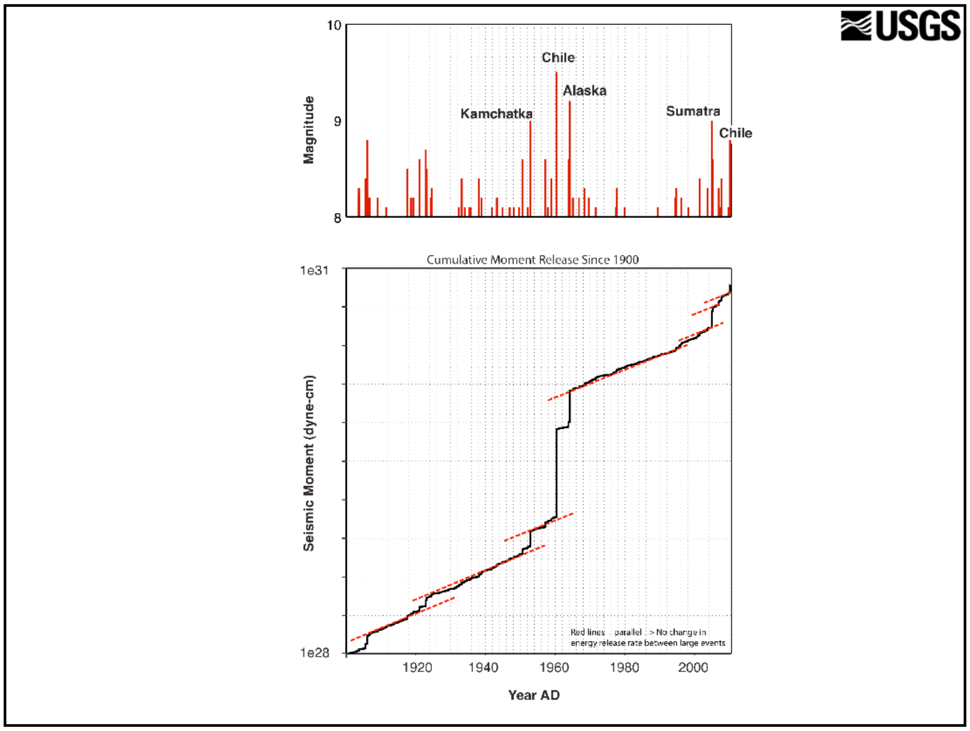


“Did You Feel It?” Reported Modified Mercalli Intensities

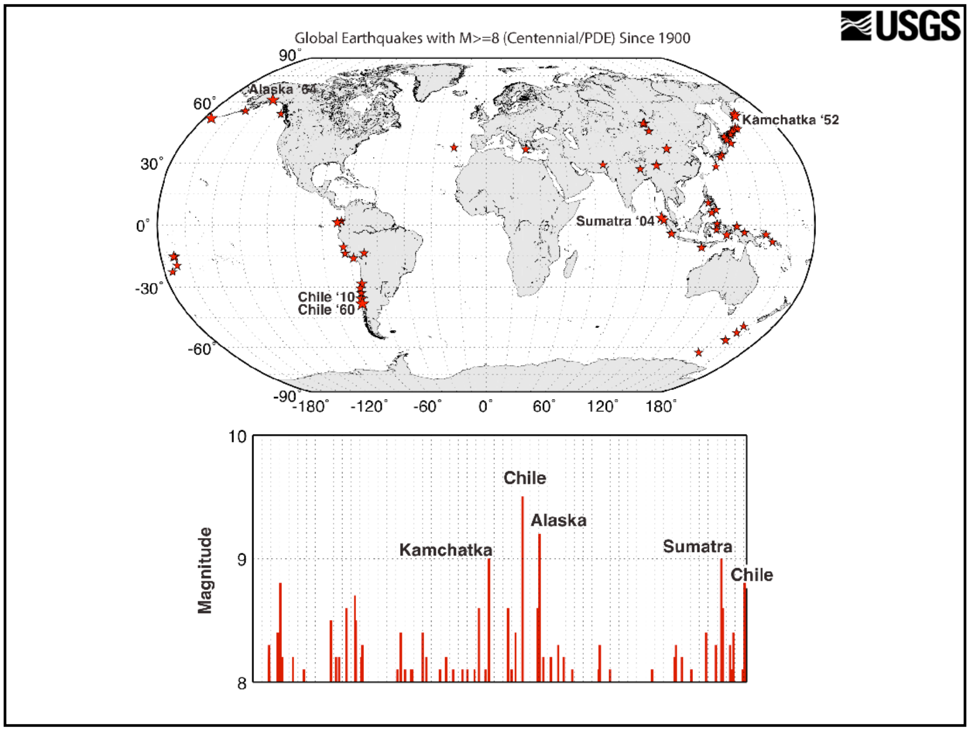




Red rectangle depicts faulting area



These plots and this map show the temporal and spatial distribution of earthquakes with a magnitude of M ≥ 8 since 1900. On the global map, earthquake locations are denoted by red stars; the largest five are labeled with their location names and year of occurrence. Below this map, earthquakes are displayed in graphic format; first as a bar graph of earthquake magnitude through time, and next as cumulative energy release (seismic moment) through time. For correspondence with the global map, the largest five earthquakes are also labeled on the bar graph. These plots show that while the largest earthquakes in the historic record have occurred close together in time - first during the 1950's and 1960's and again since the turn of the 21st century – there has been no appreciable increase in the rate of energy release between these large events, as indicated by the parallel red dashed lines. A statistical analysis of these data also shows that there is no meaningful, statistically significant clustering of M>=8 earthquakes in time.



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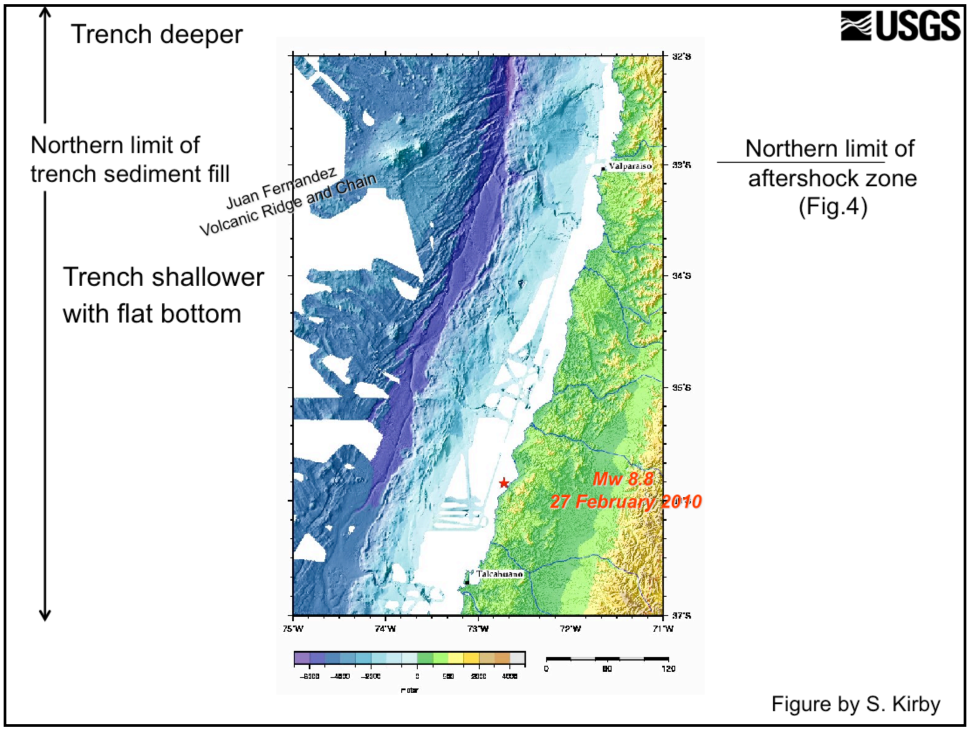
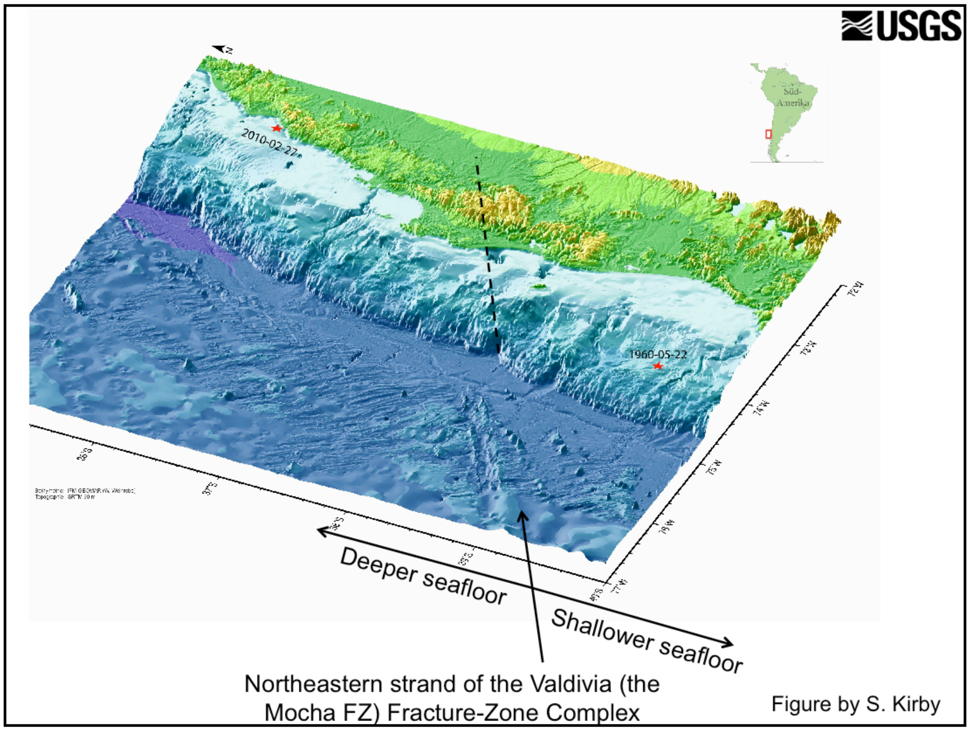
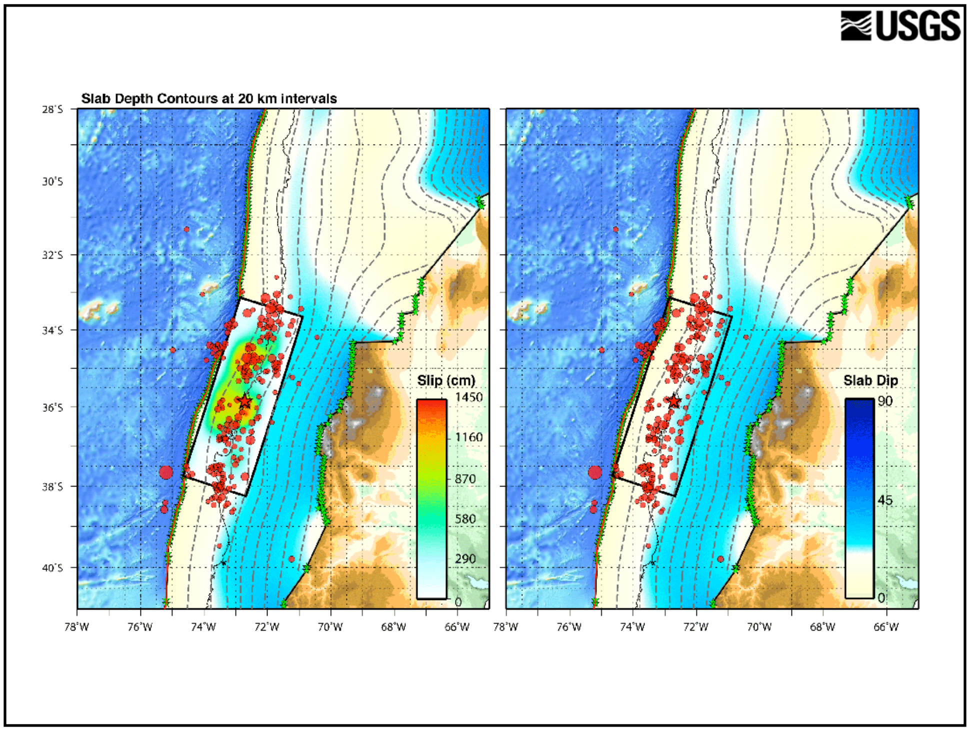


In the north, subduction of the Juan Fernandez Volcanic Ridge and chain, a bathymetric high, marks a fundamental change in the dip of the Nazca slab from normal dip in the south to shallow dip in the north (accompanied by disappearance of the volcanic chain) and also it forms northern limit of thick sediment fill by ponding sediments that have moved north by turbidity flows from glacial sources in the south. Many giant subduction earthquakes occur in sediment-dominated subduction systems where a thick sediment-filled "subduction channel" smooths the megathrust boundary and thereby permits long-runout ruptures by ruptures through the channel bypassing seafloor roughness (Fig. 2).



In the south, the seismogenic rupture limit appears to correspond to the landward projection of the fracture zone NE of the Valdivia Fracture Zone System (known as the Mocha Fracture Zone). The age offset of this fracture zone produces a step of up to 1 km in the seafloor entering the trench (shallower to the south) and this step may have represented a temporary barrier to rupture on the megathrust boundary.



Maps show the correlation of the current mainshock slip distribution, aftershock locations, and slab geometry (depth and dip), showing the transition to a 'flat slab' region of the subducting plate at the northern end of the 2010 rupture.