

Chapter 6

Volcano-Only Scenario

In order to begin correlating 3rd Nephi events to locations on the ground, there are three potential primary hazards to consider that will drive all of the secondary hazards and damage: (1) volcanic activity, (2) earthquake activity, and (3) large storm/hurricane.

At the outset, in evaluating all of the events described in 3rd Nephi it is apparent that a volcano is an essential element, as there is really no other reasonable explanation for the mist and vapor of darkness that was widespread in the land northward and the land southward.

Most serious previous inquiries have included volcanic activity as a necessary element. However, it has been proposed in one of the more extensive inquiries that a volcano could explain *all* of the hazard types and damage elements (Kowallis, 1997, 142). This argument is based on the premise that volcanic activity can exclude the necessity of considering the addition of non-volcanic earthquakes and non-volcanic storm events. This premise will be examined in this chapter as we consider geophysical analysis in conjunction with the actual description of destruction described in 3rd Nephi. It will also be compared with the actual geology of the Isthmus of Tehuantepec to determine if the premise is valid.

Volcanic Earthquakes

As has been briefly mentioned in chapter 4, volcanoes typically generate earthquakes. However, 3rd Nephi does not contemplate just any magnitude of earthquake, it requires an earthquake of sufficient size to cause the “plains of the earth to be broken up” and cities to “tumble to the earth,” with “many great and notable cities sunk” and “shaken till the buildings thereof had fallen to the earth and the inhabitants slain” while leaving the remaining cities with exceedingly great damage.

Volcanic eruptions have been associated with earthquakes anciently. Pliny the Younger wrote of numerous earthquakes when he described the eruption of Vesuvius in 79 AD. Increase of earthquake activity before an eruption is caused by magma and volcanic gas forcing their way up through shallow underground fractures and passageways. This movement will either cause rocks to break or cracks to vibrate, triggering high frequency earthquakes. Most volcanic-related earthquakes are less than a magnitude 2 or 3 and occur less than 10 km beneath a volcano. The earthquakes tend to occur in swarms consisting of dozens to hundreds of events.

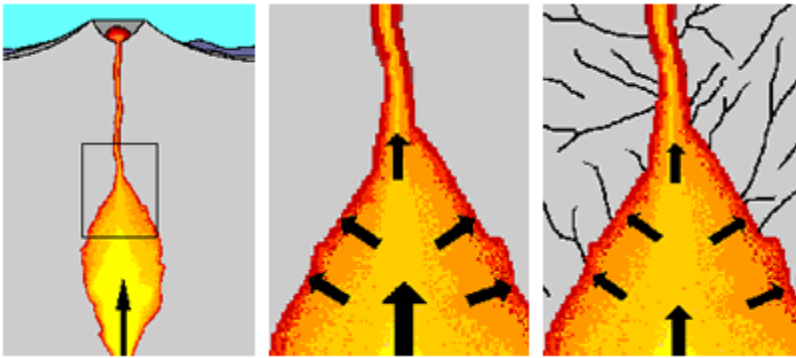


Figure 55. Volcanic earthquake propagation (USGS, 2014)

Scientists have been studying the seismic characteristics of volcanic earthquakes since the early 1900s. They have identified four types of earthquakes associated with a volcanic eruption (Zobin, 2003, 134–35, 192–93).

A-type. Earthquakes that originate from the base of a volcano, with typical depths of 1 to 20 km. They take place in swarms previous to and in the first stage of the eruption. They are generally less than a 6 in magnitude.

B-type. Earthquakes that are within 1 km of the radius of the active crater. These also take place in swarms and occur at a shallower depth than A-type earthquakes. Their magnitudes are typically extremely small.

Explosion earthquake. These are earthquakes that accompany the explosive eruption. The center is located beneath the active crater floor. The amplitude of the earthquake is dependent on the amplitude of the explosive eruption. The initial motion is not directed but pushes in all directions. Explosion earthquakes may occur as a single event or as long sequences.

Volcanic pulsation or continuous volcanic microtremors. The main part of these earthquakes are surface waves, the earthquakes being of a small amplitude.

Recent monitoring of volcanic eruptions has recorded the maximum amplitude of the volcanic earthquakes during eruptions. For example, three volcanic eruptions rated with a Volcanic Explosive Index (VEI) of 5 did not generate explosion earthquakes above 5.4 (M_w) in magnitude (Zobin, 2003). The volcano El Chichón, which has had one of the largest recorded eruptions in 1982 in what would be considered part of or near to the Book of Mormon land southward, did not even reach above an earthquake magnitude of 4:

Volcano	Earthquake Range of Magnitude (M_w)
El Chichón, Mexico, 1982	0-4.0
Bezymianny, Kamchatka, Russia, 1955–56	0-5.2
Mount St. Helens, United States, 1980	0-5.4

Volcanic earthquakes of any tectonic significance are extremely rare. There have been only three volcanic earthquakes with a magnitude of 7 (M_w) measured anywhere on earth in the past century (Zobin, 2001). These volcanoes were ones that had laid dormant for thousands of years and then suddenly erupted, not a known scenario for any of the volcanoes in lands related to the Book of

Mormon. The famous 1991 Mt. Pinatubo eruption, of which many are aware, only exhibited an earthquake of 5.6 (M_w).

Volcanic earthquakes behave differently than standard tectonic earthquakes (i.e., non directional, single point of explosion, not a movement of large sections of the earth's crust along a long fracture) so actual historical measurements have been utilized to develop predictions for volcanic eruptions. As previously discussed, there are different scales of measuring earthquakes, the M_w scale being based on seismic data. In order to convert this scale to the Modified Mercalli (MM) intensity scale and apply the historical data to a distance from a volcano, an equation was developed using historical volcanic earthquake data by Vyacheslav M. Zobin in 2003:

$$I = 0.66M_w - 1.13\text{Log}R - 0.0072R + 3.73$$

I: Intensity in Modified Mercalli

R: the distance away from the hypocentral point of the earthquake (the point on the surface immediately above the earthquake epicenter).

M_w : Intensity in Moment Magnitude Scale

Assuming the maximum volcanic earthquake measured, 7.1 M_w , and assuming that the earthquake is centered at the base of the volcano under the crater, then a distance can be calculated away from the volcano within which one might expect the type of damage described in the Book of Mormon. Table 3 shows the Modified Mercalli (MM) scale and related earthquake damage. The building and earth rupture damage described in the Book of Mormon would be at least an VIII on the Mercalli scale.

Table 3. Modified Mercalli Intensity Damage Scale

I. Instrumental	Generally not felt by people unless in favorable conditions.
II. Weak	Felt only by a couple of people who are sensitive, especially on the upper floors of buildings. Delicately suspended objects (including chandeliers) may swing slightly.
III. Slight	Felt quite noticeably by people indoors, especially on the upper floors of buildings. Many do not recognize it as an earthquake. Standing automobiles may rock slightly. Vibration similar to the passing of a truck. Duration can be estimated. Indoor objects (including chandeliers) may shake.
IV. Moderate	Felt indoors by many to all people, and outdoors by few people. Some awakened. Dishes, windows, and doors disturbed, and walls make cracking sounds. Chandeliers and indoor objects shake noticeably. The sensation is more like a heavy truck striking building. Standing automobiles rock noticeably. Dishes and windows rattle alarmingly. Damage none.

**V. Rather
Strong**

Felt inside and outside by most or all. Dishes and windows may break and bells will ring. Vibrations are more like a large train passing close to a house. Possible slight damage to buildings. Liquids may spill out of glasses or open containers. None to a few people are frightened and run outdoors.

VI. Strong

Felt by everyone, outside or inside; many frightened and run outdoors, walk unsteadily. Windows, dishes, glassware broken; books fall off shelves; some heavy furniture moved or overturned; a few instances of fallen plaster. Damage slight to moderate to poorly designed buildings, all others receive none to slight damage.

**VII. Very
Strong**

Difficult to stand. Furniture broken. Damage light in building of good design and construction; slight to moderate in ordinarily built structures; considerable damage in poorly built or badly designed structures; some chimneys broken or heavily damaged. Noticed by people driving automobiles. Small landslides.

**VIII.
Destructive**

Damage slight in structures of good design, considerable in normal buildings with a possible partial collapse. Damage great in poorly built structures. Brick buildings easily receive moderate to extremely heavy damage. Possible fall of chimneys, factory stacks, columns, monuments, walls, etc. Heavy furniture moved. Large landslides.

IX. Violent

General panic. Damage slight to moderate (possibly heavy) in well-designed structures. Well-designed structures thrown out of plumb. Damage moderate to great in substantial buildings, with a possible partial collapse. Some buildings may be shifted off foundations. Walls can fall down or collapse.

X. Intense

Many well-built structures destroyed, collapsed, or moderately to severely damaged. Most other structures destroyed, possibly shifted off foundation.

XI. Extreme

Few, if any structures remain standing. Numerous landslides, cracks and deformation of the ground.

**XII.
Catastrophic**

Total destruction – everything is destroyed. Lines of sight and level distorted. Objects thrown into the air. The ground moves in waves or ripples. Large amounts of rock move position. Landscape altered, or leveled by several meters. Even the routes of rivers can be changed.

When applying the equation to a 7.1 M_w earthquake, which is the biggest observed in a century, Level VIII earthquake damage occurs from the center of the volcano to a distance of 2.3 kilometers. A lower Level VII damage level occurs from 2.3 kilometers to 15 kilometers away from the volcano. It is clear that volcanic earthquake damage is very much limited to the proximity of the volcano itself. For most volcanoes, the range for significant volcanic earthquake damage is much less than the expected extent of lava or pyroclastic flows.

Even assuming that volcanic earthquakes were equivalent to tectonic earthquakes, because of the variable conditions of earthquake epicenter depth, soil, rock, and topography, all of which can accentuate, deflect, or diminish the damage potential of a given earthquake, it is useful to try to analyze the results of actual earthquakes in the area of geographic interest, which in this case is the area of the Isthmus of Tehuantepec.

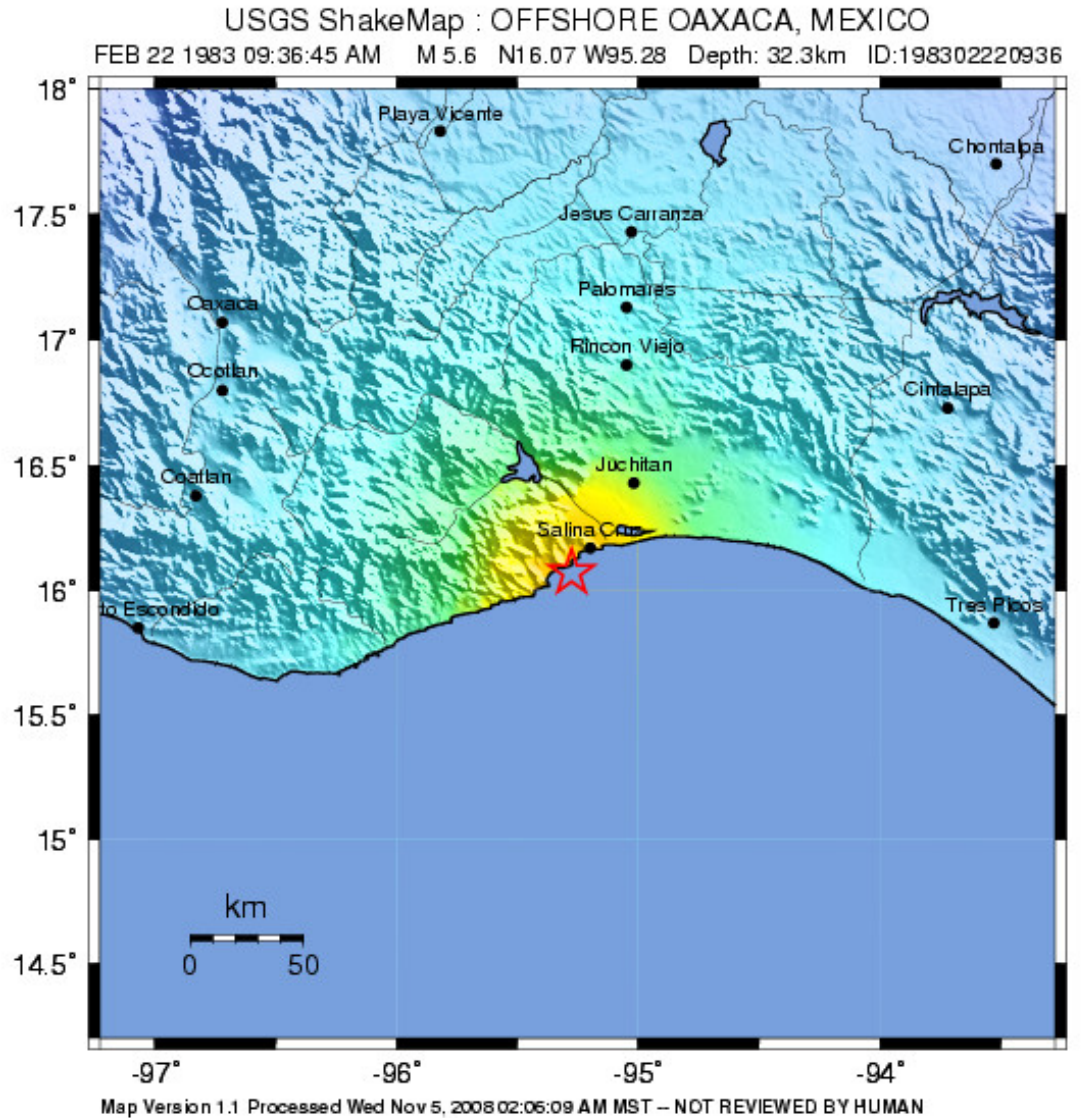
For some time, the United States Geological Survey, in conjunction with other countries, has developed “Shakemaps” that are derived from actual earthquake data. A ShakeMap is a representation of ground shaking produced by an earthquake. The information it presents is different from the earthquake magnitude and epicenter that are released after an earthquake because ShakeMap focuses on the ground shaking produced by the earthquake, rather than the parameters describing the earthquake source. So, while an earthquake has one magnitude and one epicenter, it produces a range of ground shaking levels at sites throughout the region depending on distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the earth’s crust.

Included are all of the available Shakemaps for the Isthmus of Tehuantepec by nominal order of magnitude and within each magnitude by date. Shakemaps are not included for earthquakes below a magnitude of 5 M_w , hence the 1982 eruption of El Chichón is not included. Also included is the Shakemap for the destructive earthquake that occurred in 1985 in Mexico City, which shows that in unique soil and ground structure situations, some earthquakes can be severely amplified at a distance. In the case of Mexico City, because it was built on a filled-in lake that also has ground structure that creates harmonic amplitude in earthquake waves, an earthquake that caused virtually no damage between it and Mexico City, ended up being very destructive when the waves arrived at Mexico City.

Please note that the Shakemap uses the letter “M” instead of “ M_w ”; these are abbreviations for the same thing in seismic abbreviation schemes. Also note that the color coding on each Shakemap denotes orange for a damage of Level VIII; the damage described in the Book of Mormon is a Level VIII or higher.

Figure 56. Shakemap Series

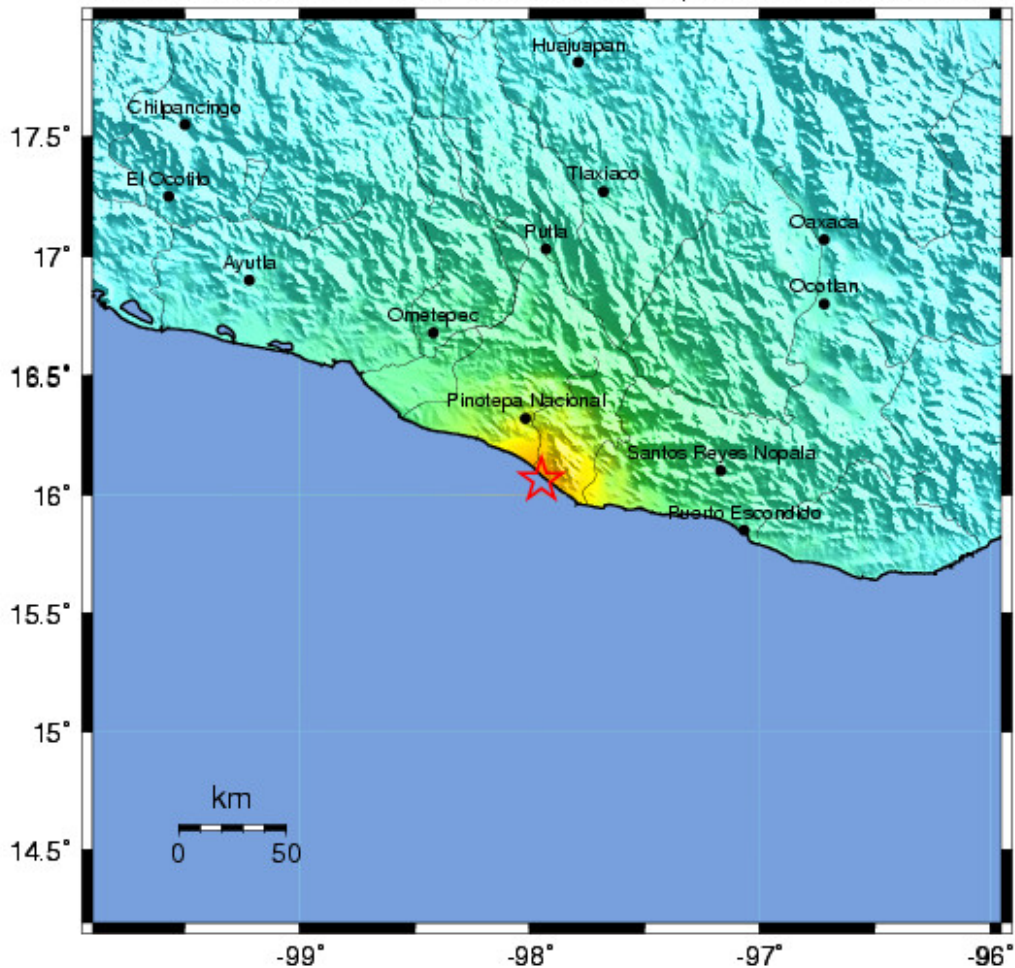
M_w 5 to 6 Earthquakes



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+

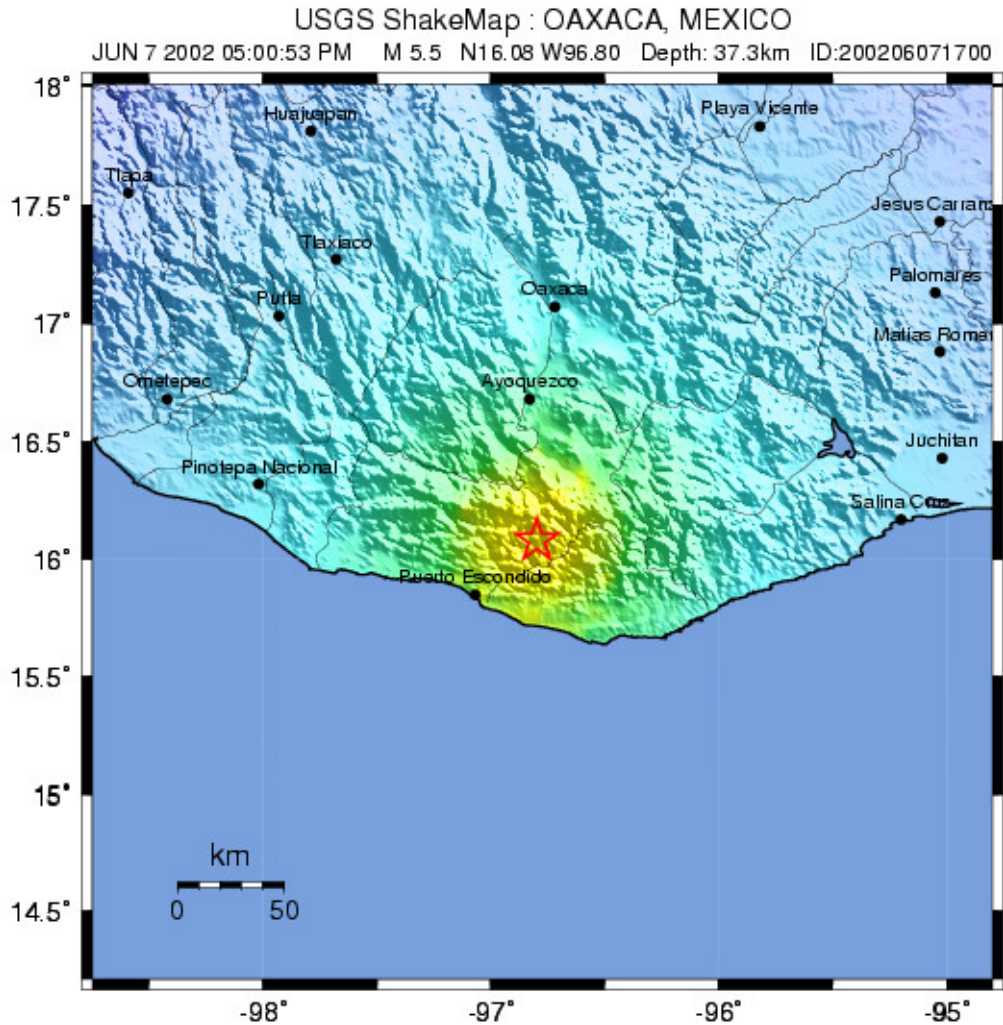
USGS ShakeMap : OFFSHORE OAXACA, MEXICO

FEB 25 1996 09:17:58 AM M 5.9 N16.06 W97.95 Depth: 15.9km ID:199602250917



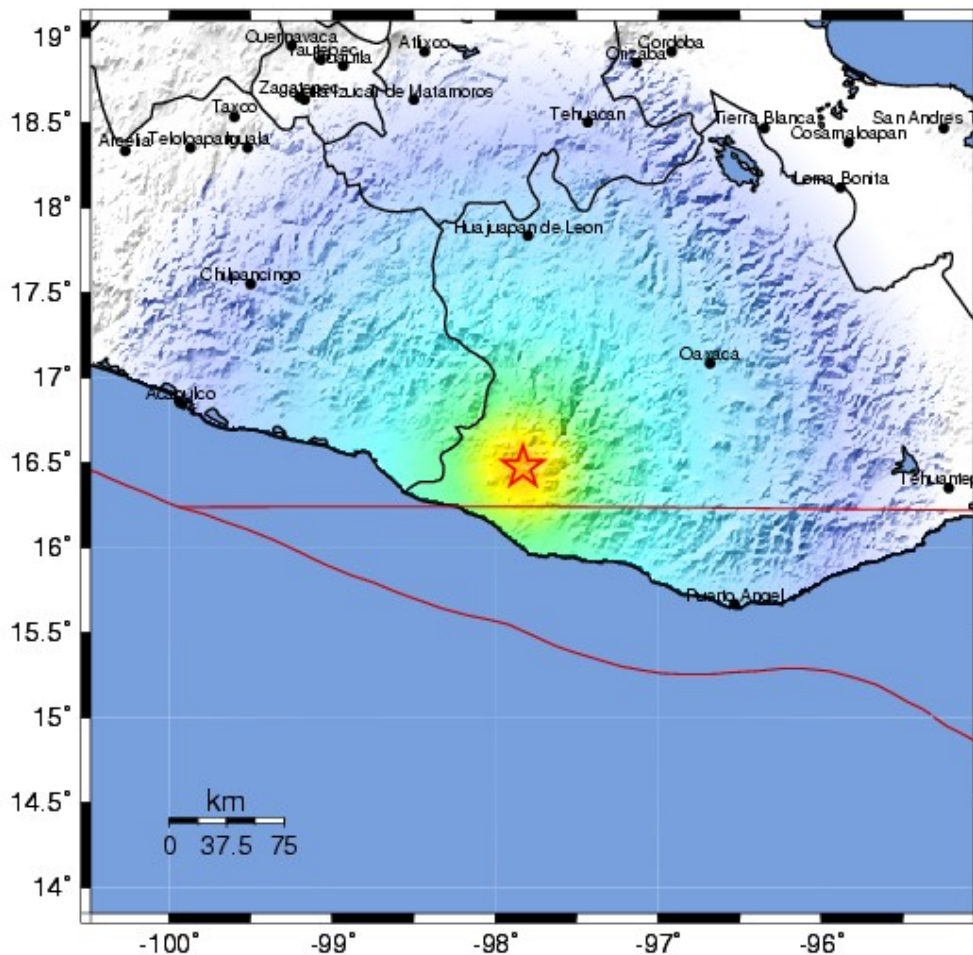
Map Version 1.1 Processed Thu Nov 6, 2008 07:47:11 AM MST - NOT REVIEWED BY HUMAN

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+



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+

JSGS Rapid Instrumental Intensity Map Epicenter: 87 miles WSW of Oaxaca, Oaxaca, Mexico
 JUN 14 2004 22:54:23 GMT M 5.9 N16.47 W97.83 Depth: 10.0km ID:jsbn

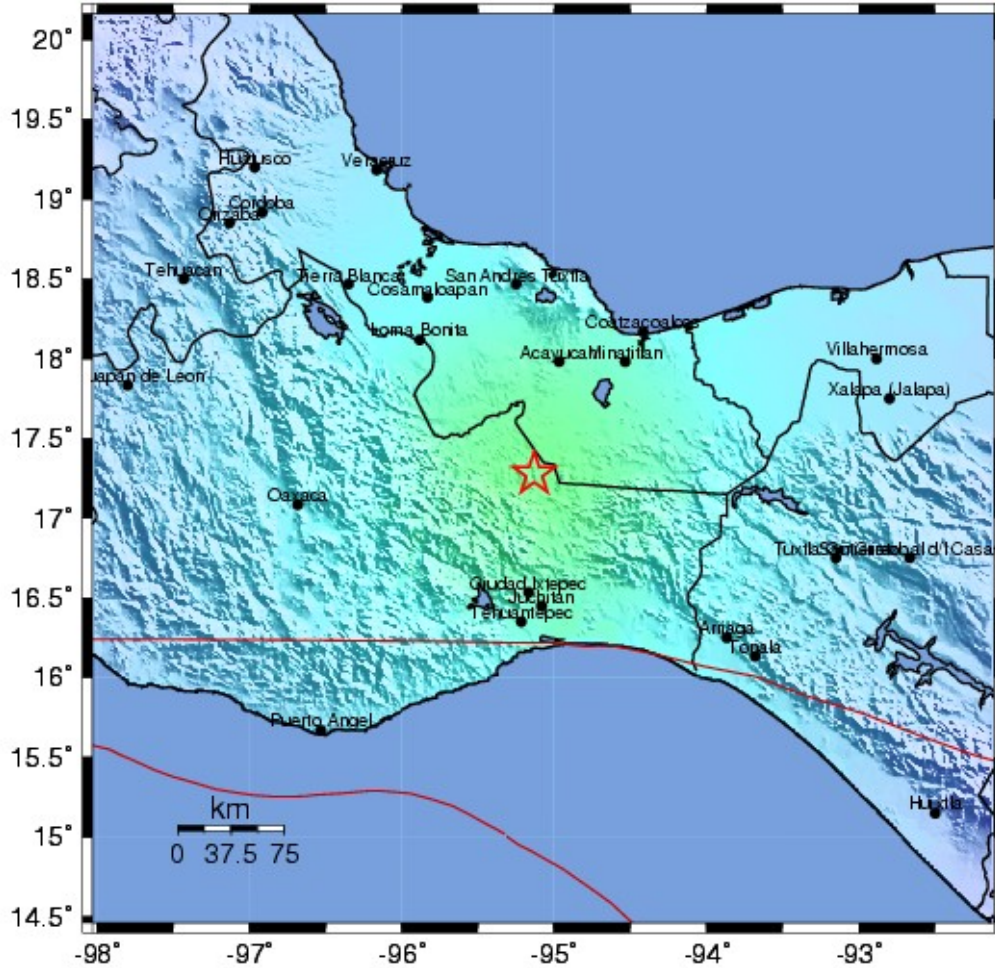


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PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC (%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>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+

3GS Rapid Instrumental Intensity Map Epicenter: 50 miles SSW of Acayucan, Veracruz, Mexi

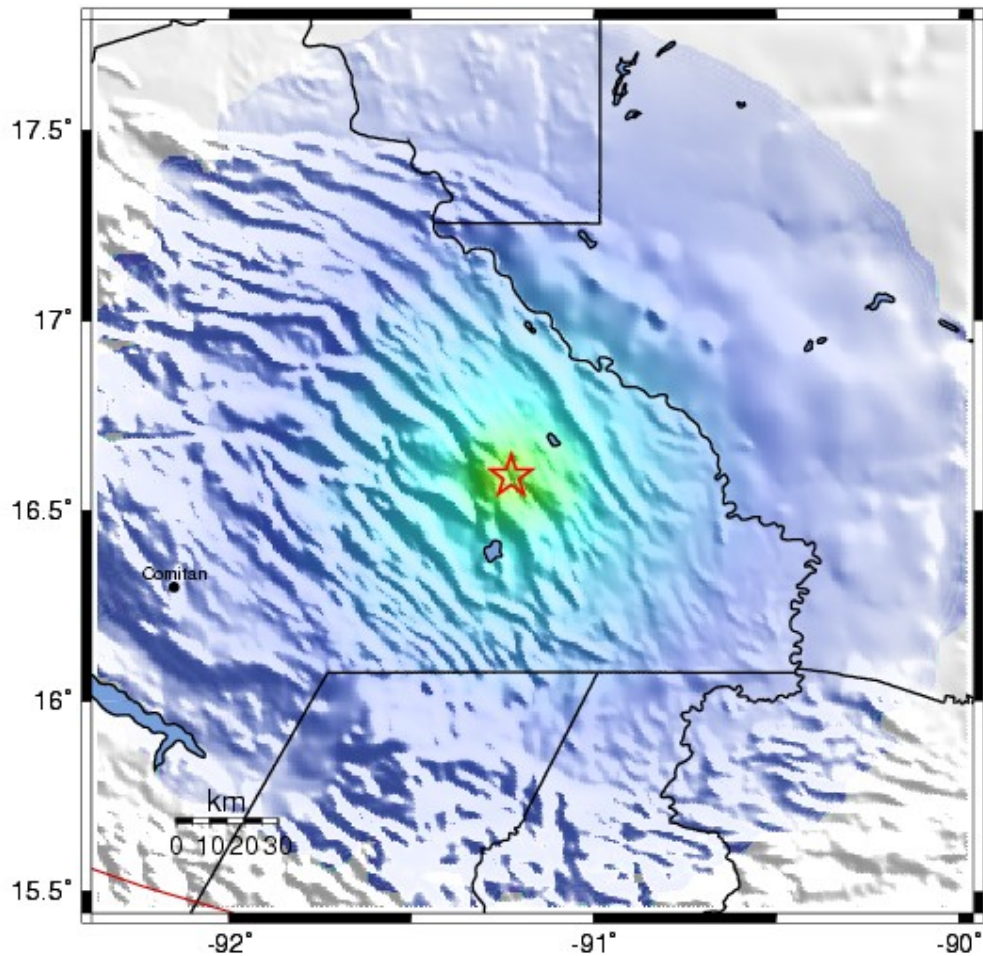
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PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC (%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>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+

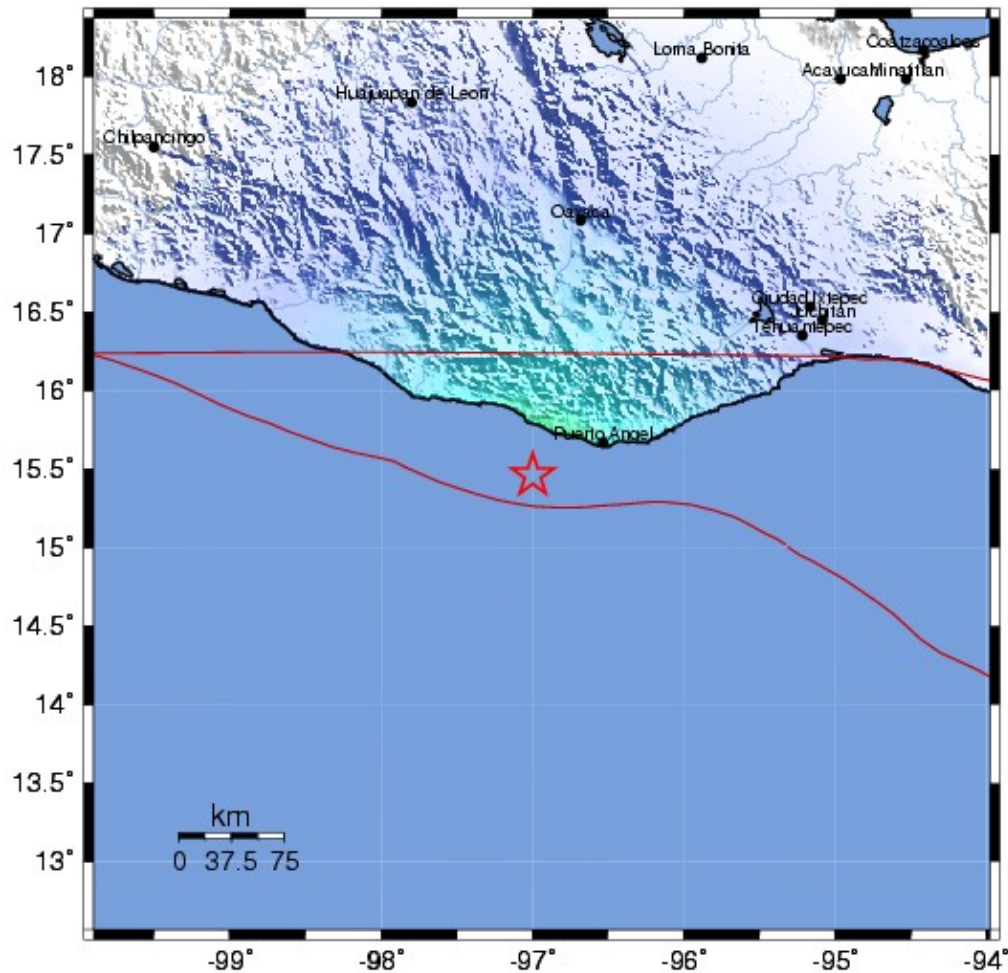
JSGS Rapid Instrumental Intensity Map Epicenter: 64 miles ENE of Comitán, Chiapas, Mexico
 Fri Sep 17, 2004 11:43:22 PM PDT M 5.1 N16.59 W91.23 Depth: 10.0km ID:nmcl



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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+

GS Rapid Instrumental Intensity Map Epicenter: 34 miles WSW of Puerto Angel, Oaxaca, Me)
 Fri Dec 10, 2004 10:32:27 AM PST M 5.2 N15.46 W97.00 Depth: 41.9km ID:rwav

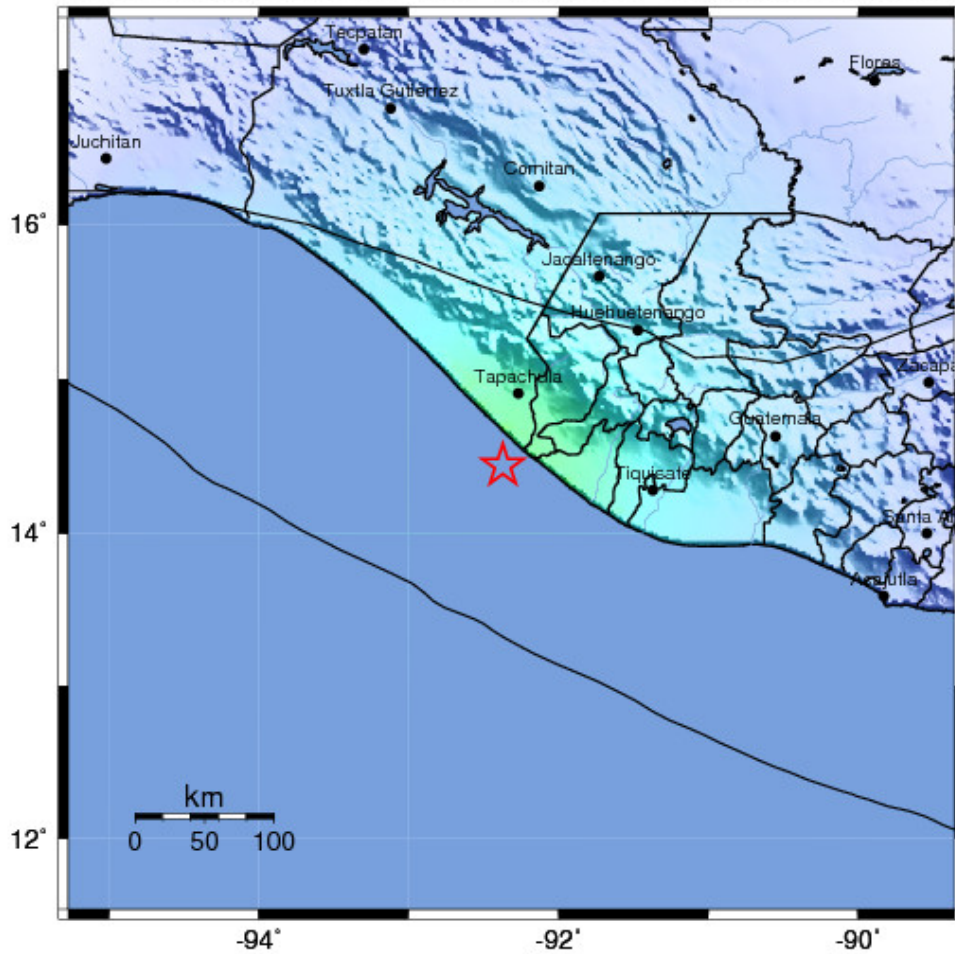


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PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC (%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>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+

USGS ShakeMap : OFFSHORE CHIAPAS, MEXICO

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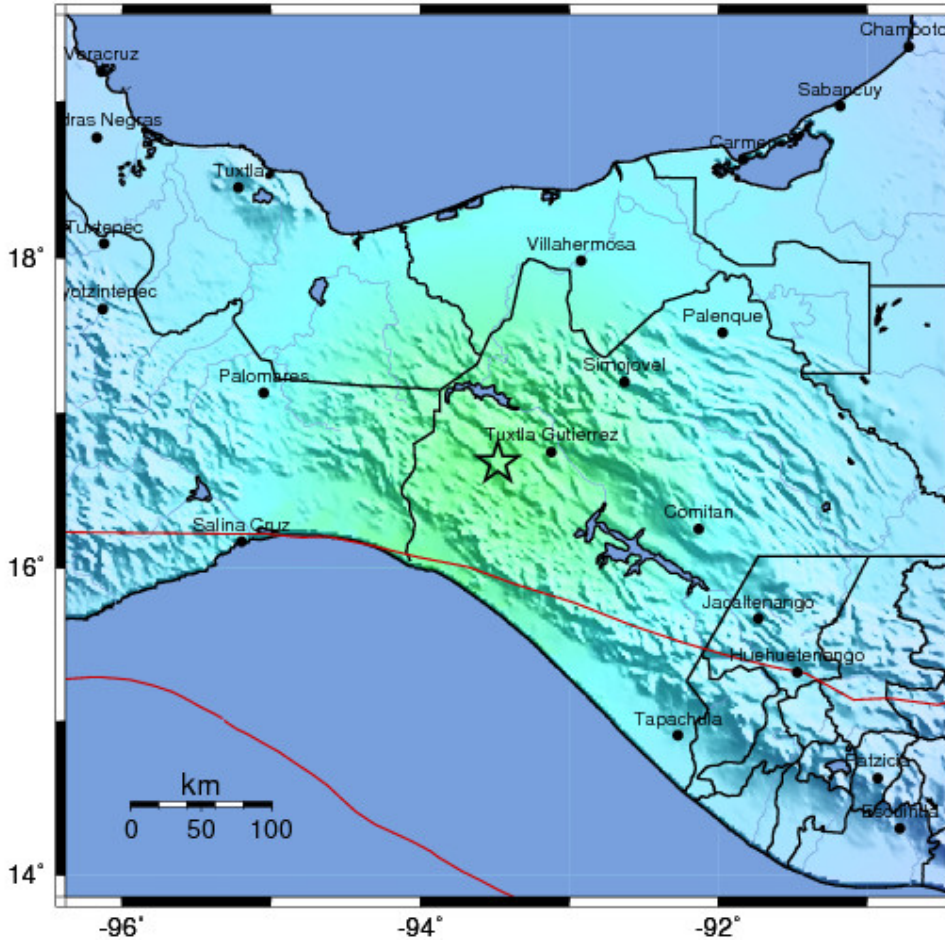


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PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>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+

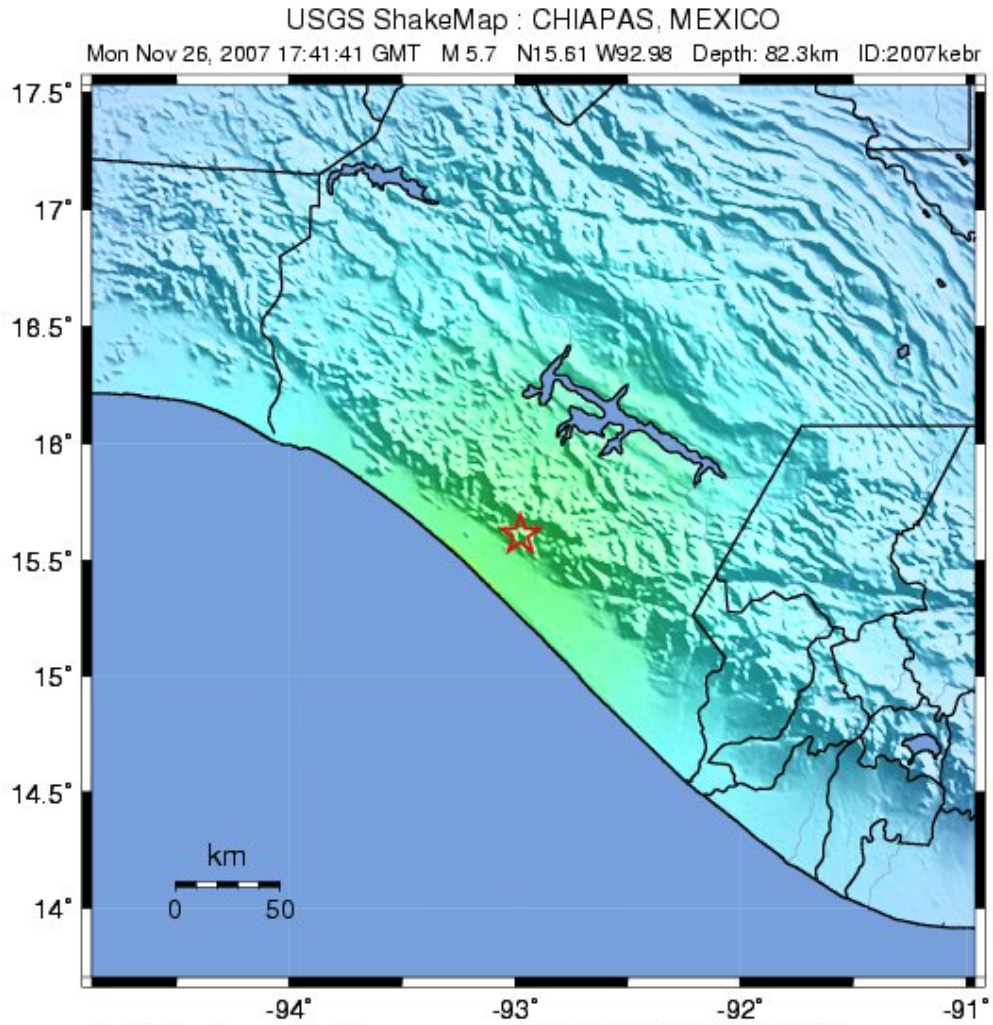
USGS ShakeMap : CHIAPAS, MEXICO

Fri Jul 6, 2007 01:09:21 GMT M 6.1 N16.68 W93.48 Depth: 124.8km ID:2007elac



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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
POTENTIAL DAMAGE Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. 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
ESTIMATED INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

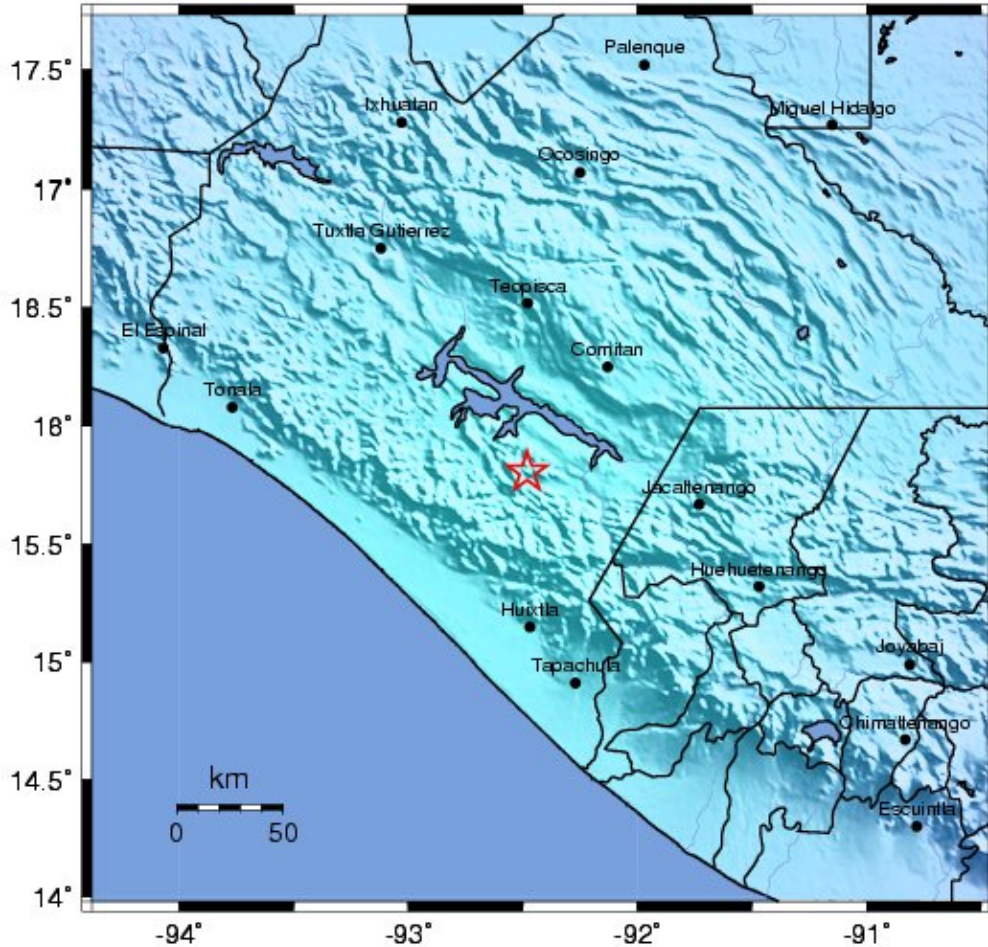


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PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>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	60-118	>118
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

USGS ShakeMap : CHIAPAS, MEXICO

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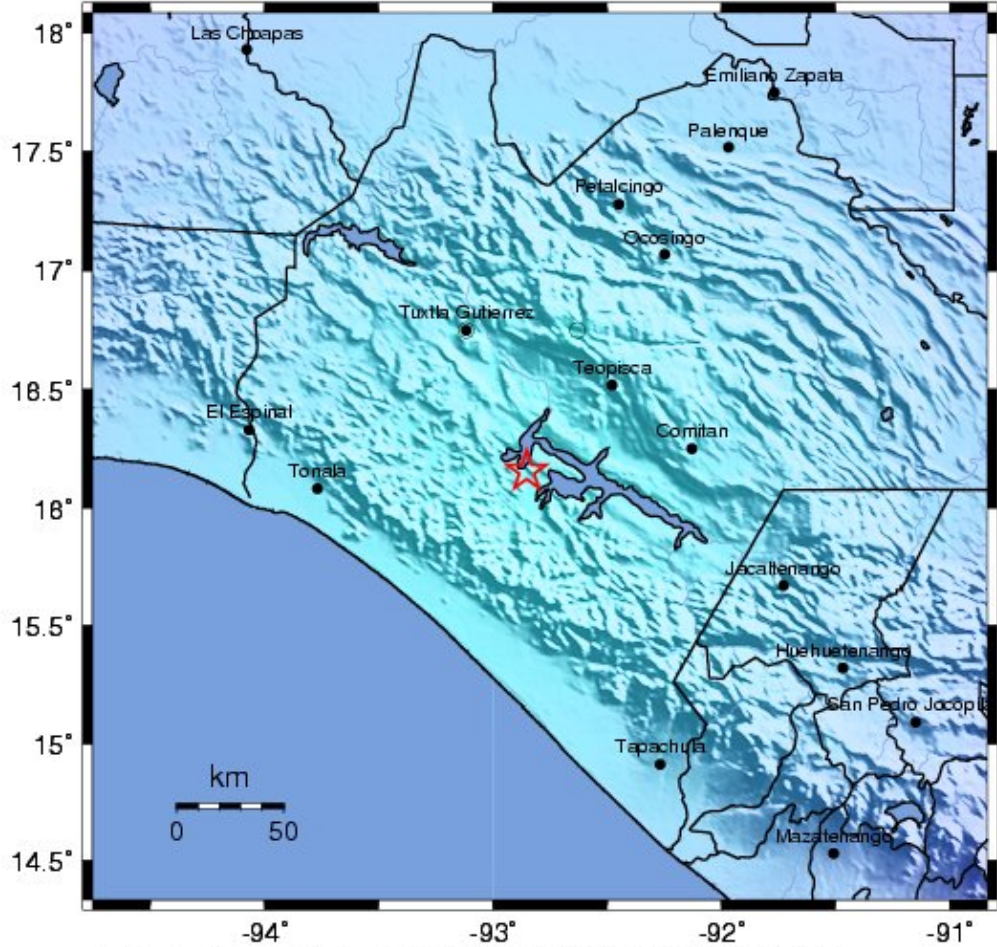


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PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>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+

USGS ShakeMap : CHIAPAS, MEXICO

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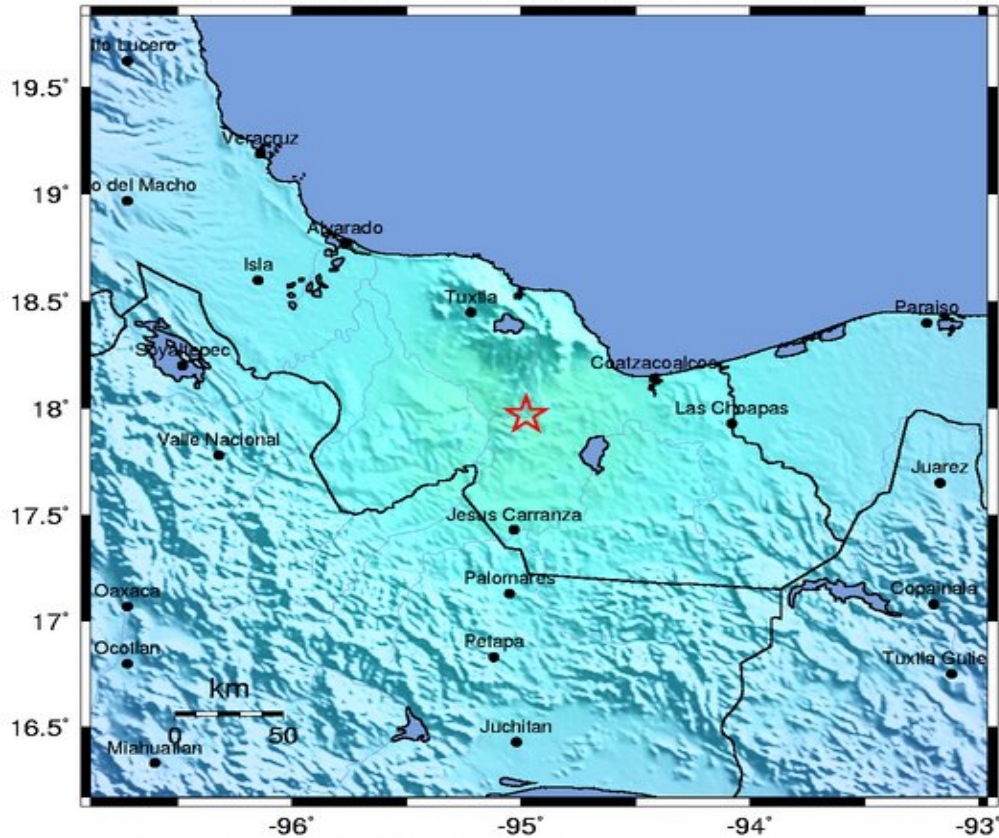


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PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>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+

USGS ShakeMap : VERACRUZ, MEXICO

Fri Feb 25, 2011 13:07:28 GMT M 5.7 N17.97 W94.98 Depth: 132.9km ID:b0001kjt

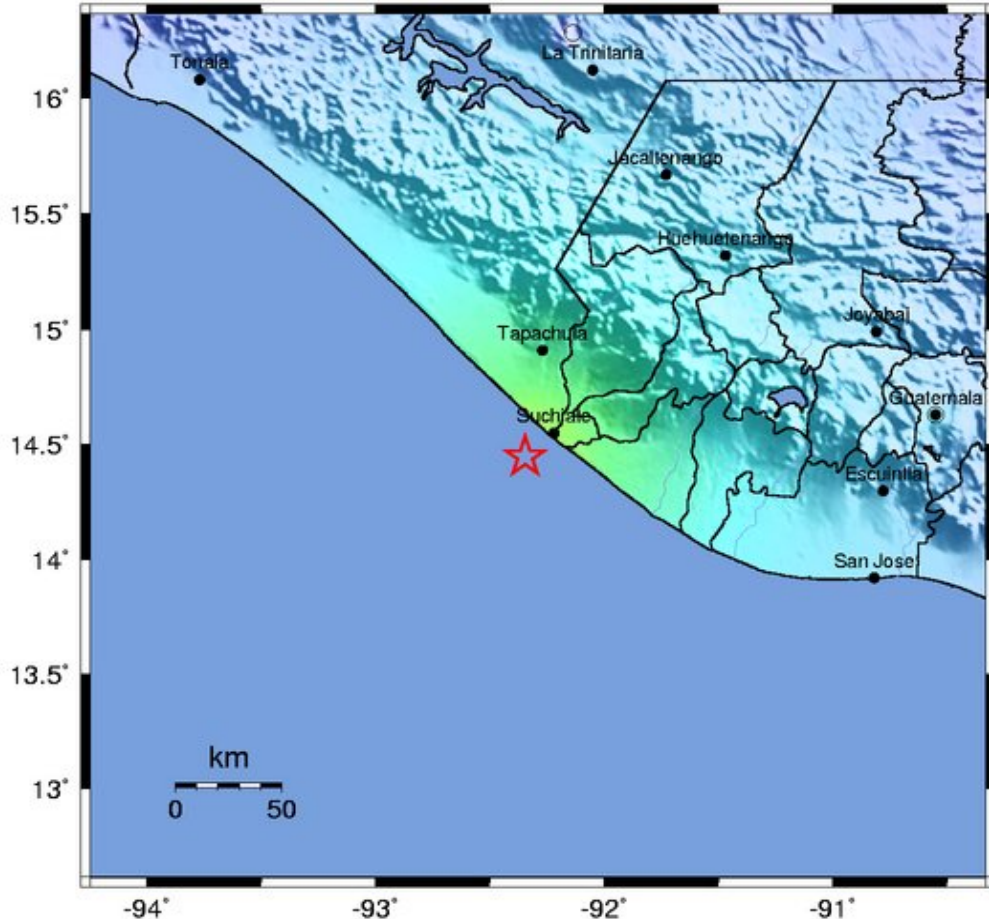


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PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>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+

USGS ShakeMap : OFFSHORE CHIAPAS, MEXICO

Sun Mar 27, 2011 06:20:57 GMT M 5.7 N14.45 W92.35 Depth: 44.9km ID:c0002che

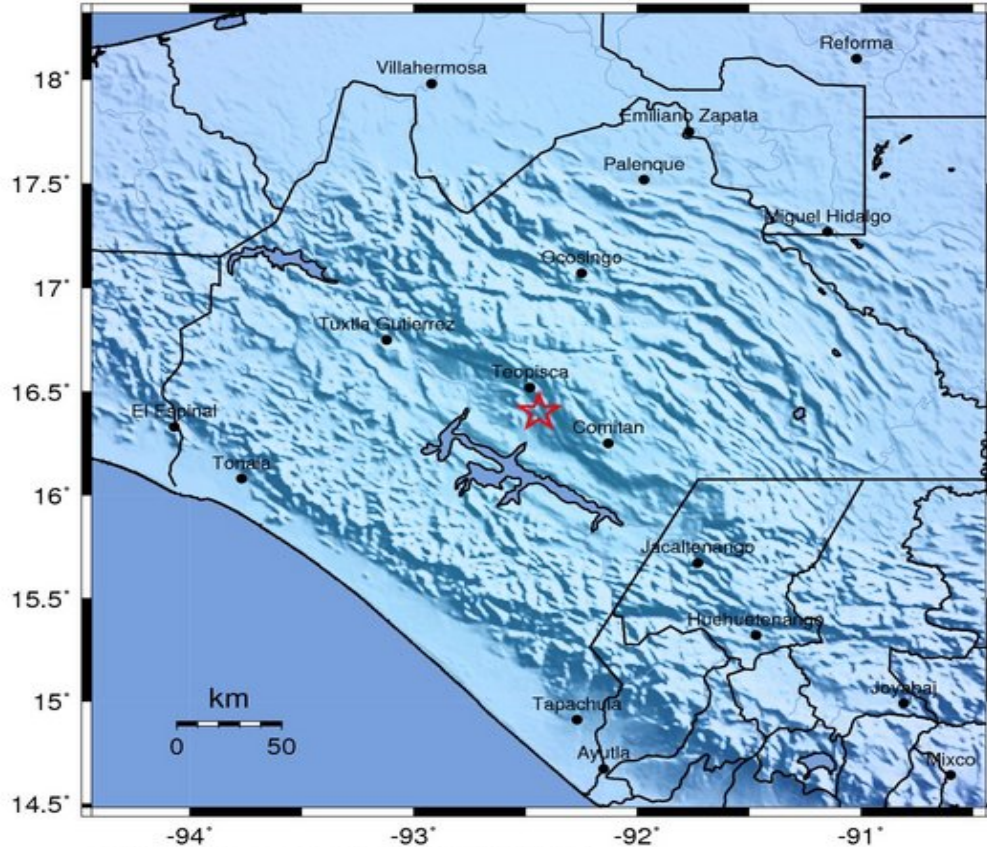


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PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>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+

USGS ShakeMap : CHIAPAS, MEXICO

SEP 1 2012 06:01:48 PM GMT M 5.5 N16.40 W92.44 Depth: 252.3km ID:c000cd93



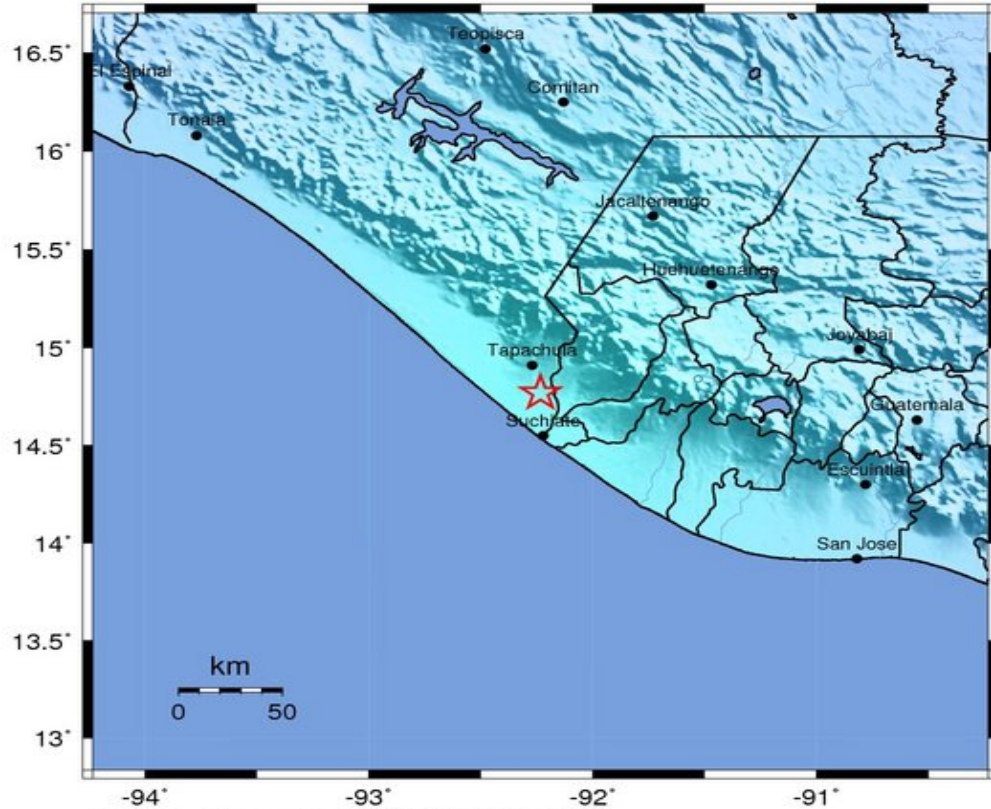
Map Version 1 Processed Sun Sep 9, 2012 06:02:14 AM MDT

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)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	<0.02	0.1	1.4	4.7	9.6	20	41	86	>178
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2011)

USGS ShakeMap : CHIAPAS, MEXICO

OCT 14 2012 10:41:26 AM GMT M 5.5 N14.77 W92.23 Depth: 101.7km ID:b000d5nl

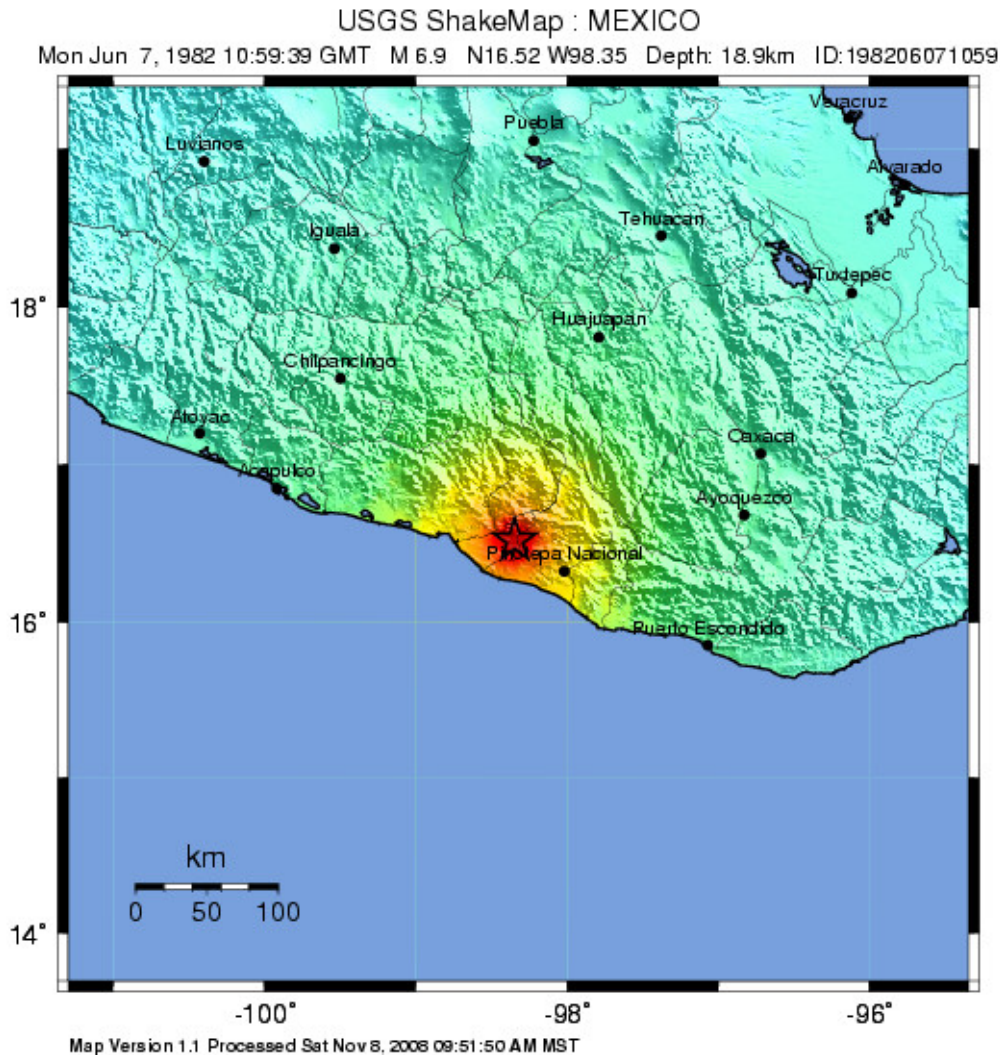


Map Version 1 Processed Mon Oct 22, 2012 06:44:21 AM MDT

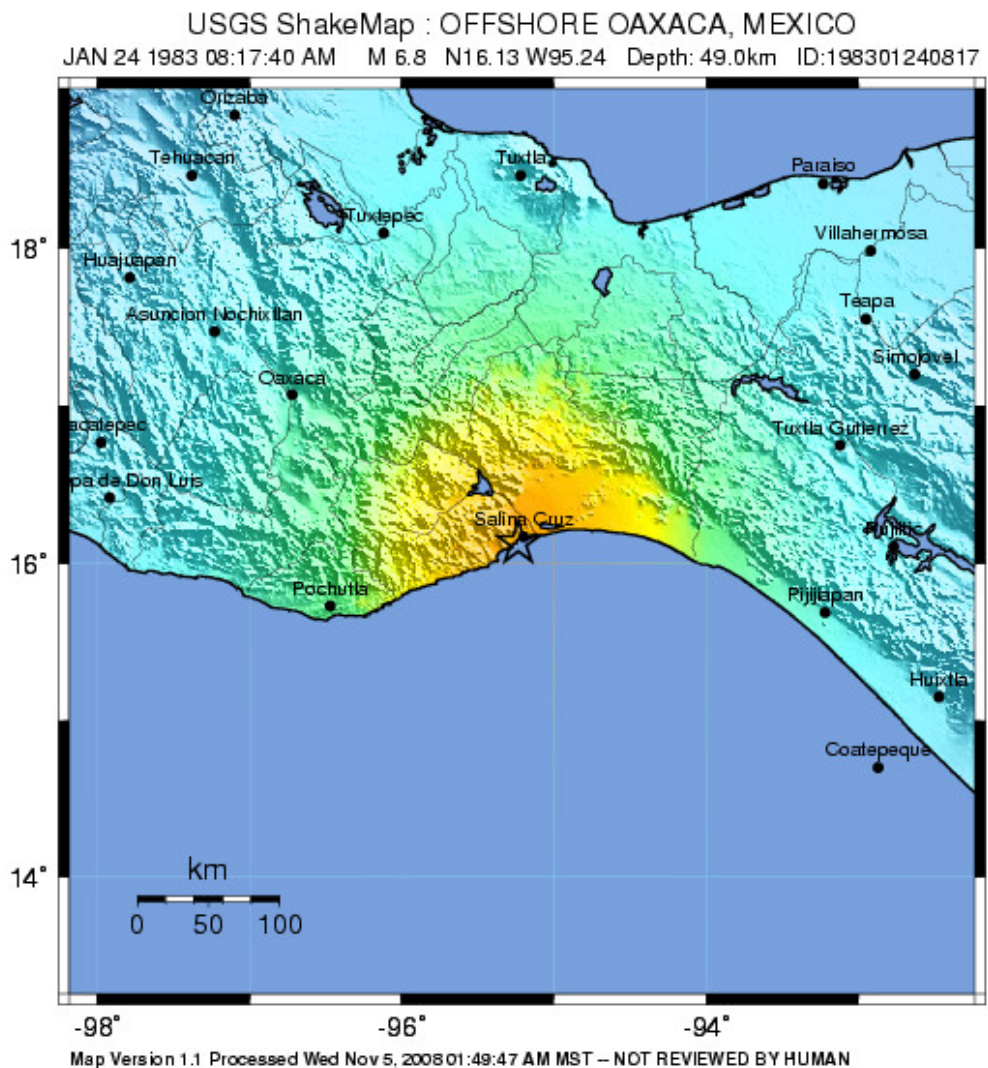
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	<0.02	0.1	1.4	4.7	9.6	20	41	86	>178
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2011)

M_w 6 to 7 Earthquakes



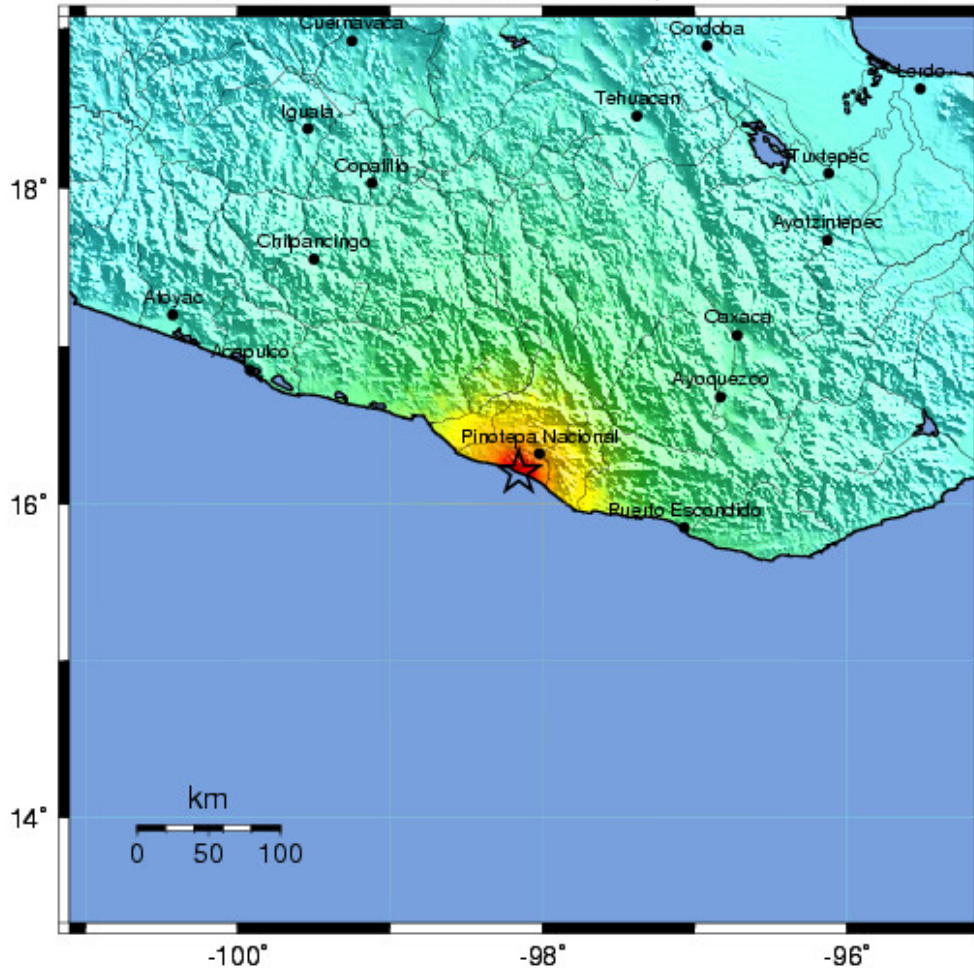
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC (%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL (cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16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



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+

USGS ShakeMap : OFFSHORE OAXACA, MEXICO

JUL 19 1997 02:22:07 PM M 6.7 N16.20 W98.16 Depth: 15.0km ID:199707191422

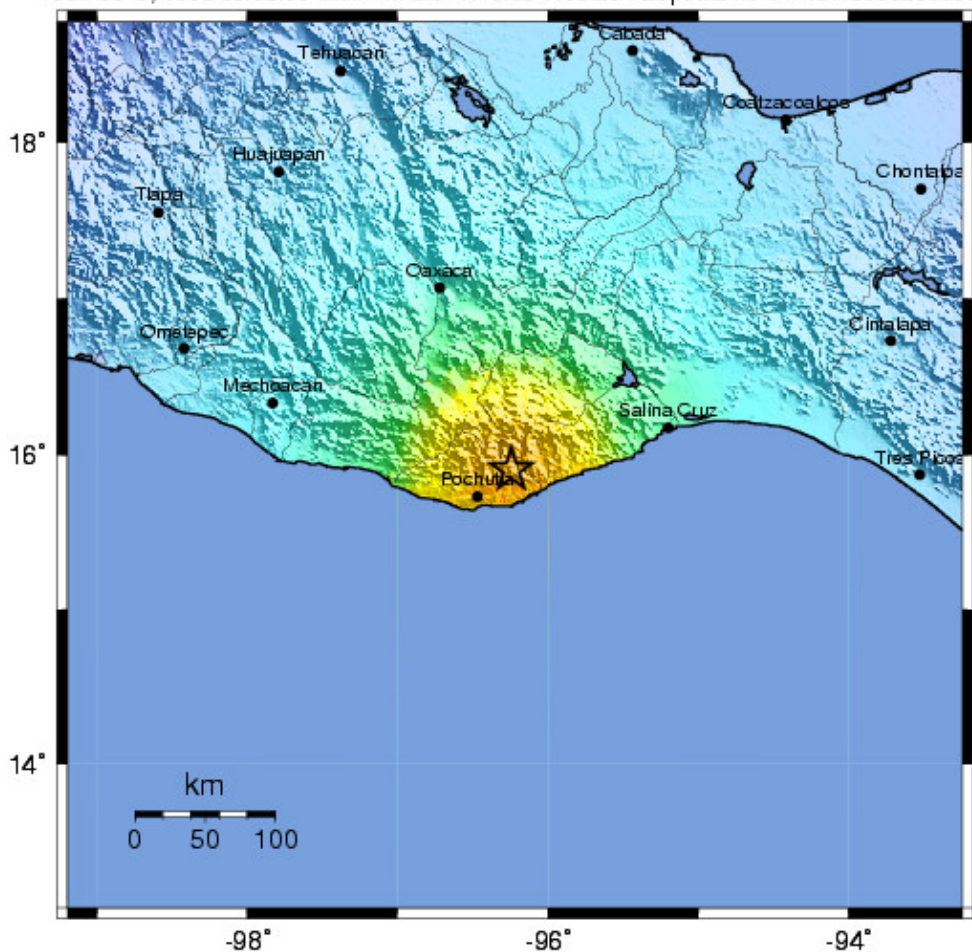


Map Version 1.1 Processed Thu Nov 6, 2008 12:08:14 PM MST – NOT REVIEWED BY HUMAN

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+

USGS ShakeMap : Oaxaca, Mexico

Tue Feb 3, 1998 03:02:00 GMT M 6.3 N15.90 W96.25 Depth: 24.0km ID:199802030302

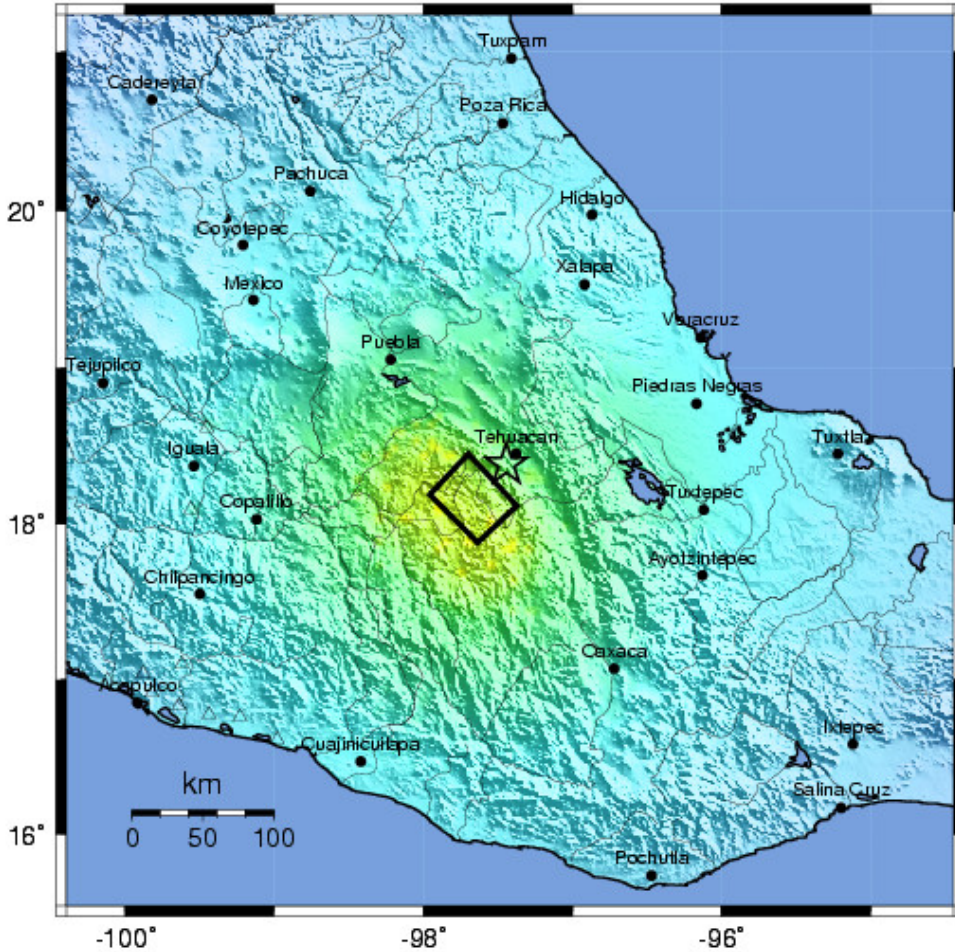


Map Version 1.1 Processed Sat Nov 8, 2008 07:32:44 PM MST

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+

USGS ShakeMap : Puebla, Mexico

Tue Jun 15, 1999 20:42:06 GMT M 6.9 N18.38 W97.44 Depth: 63.0km ID:199906152042

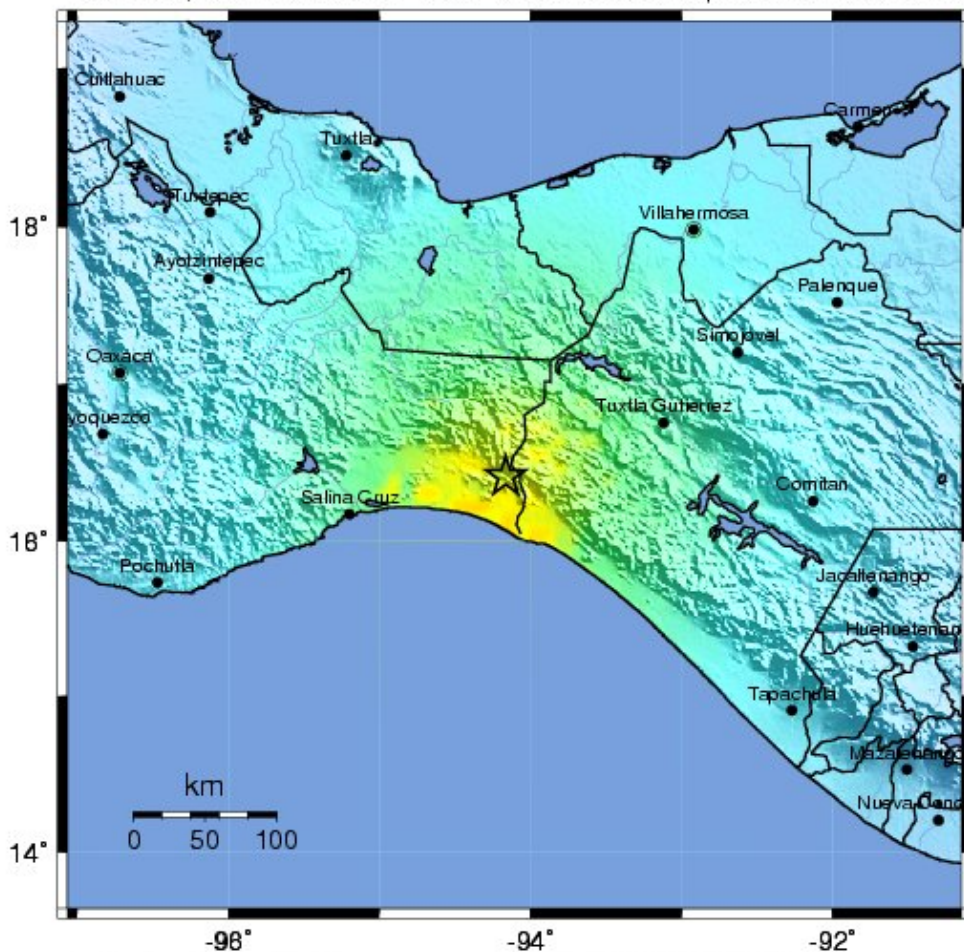


Map Version 1.1 Processed Sat Nov 8, 2008 08:14:16 PM MST

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+

USGS ShakeMap : OAXACA, MEXICO

Tue Feb 12, 2008 12:50:20 GMT M 6.4 N16.41 W94.16 Depth: 99.6km ID:2008niat

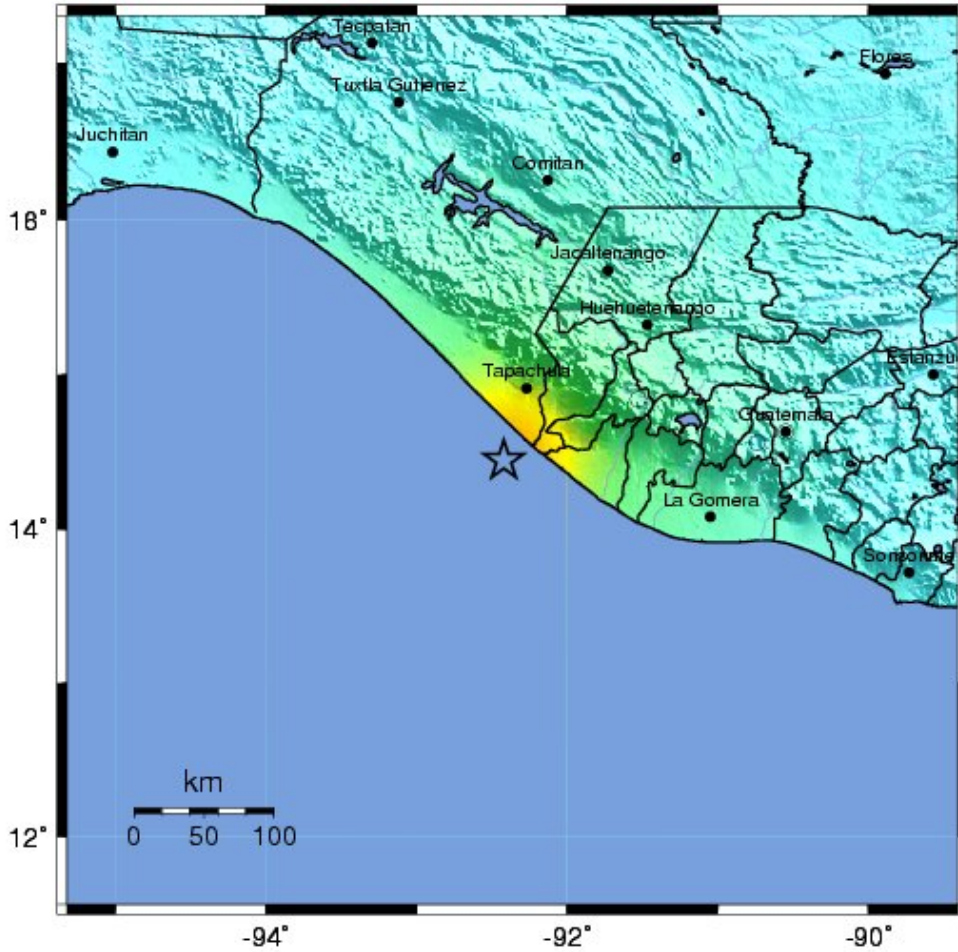


Map Version 2 Processed Tue Feb 12, 2008 12:21:13 PM MST – NOT REVIEWED BY HUMAN

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+

USGS ShakeMap : OFFSHORE CHIAPAS, MEXICO

Thu Oct 16, 2008 19:41:26 GMT M 6.6 N14.44 W92.42 Depth: 24.0km ID:2008yfbk

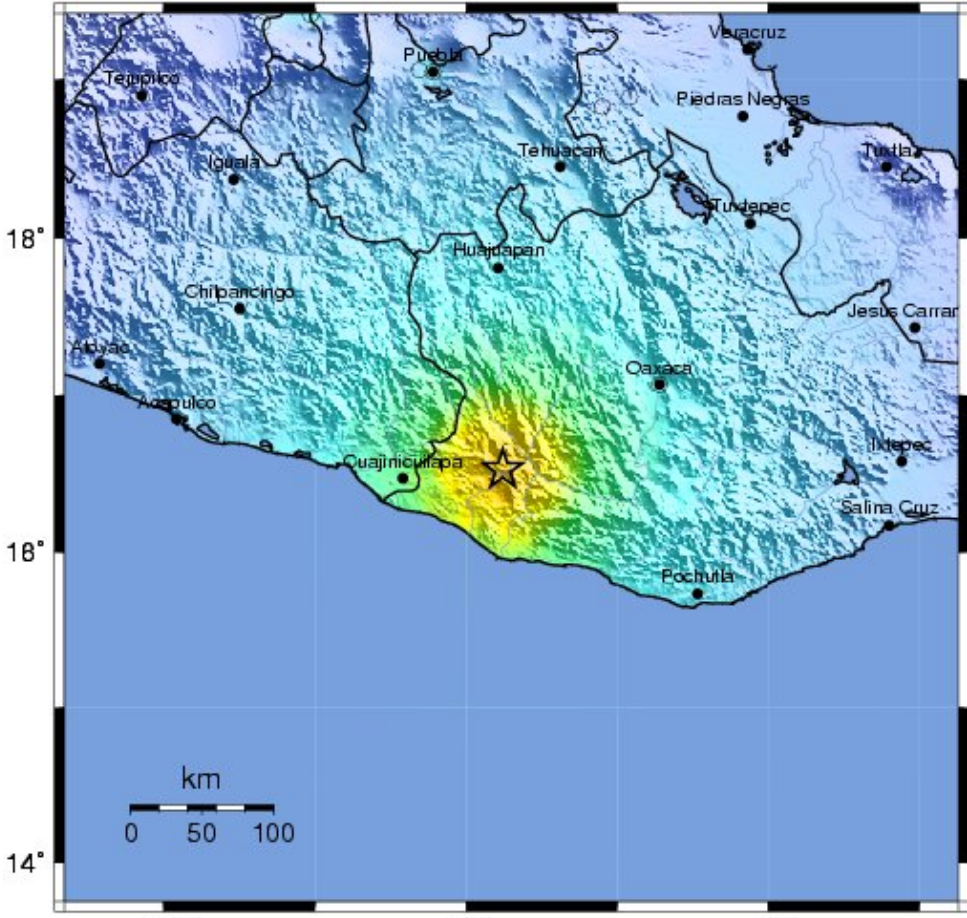


Map Version 5 Processed Mon Oct 20, 2008 10:30:08 AM MDT – NOT REVIEWED BY HUMAN

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+

USGS ShakeMap : OAXACA, MEXICO

Wed Jun 30, 2010 07:22:28 GMT M 6.2 N16.53 W97.76 Depth: 20.0km ID:2010yday

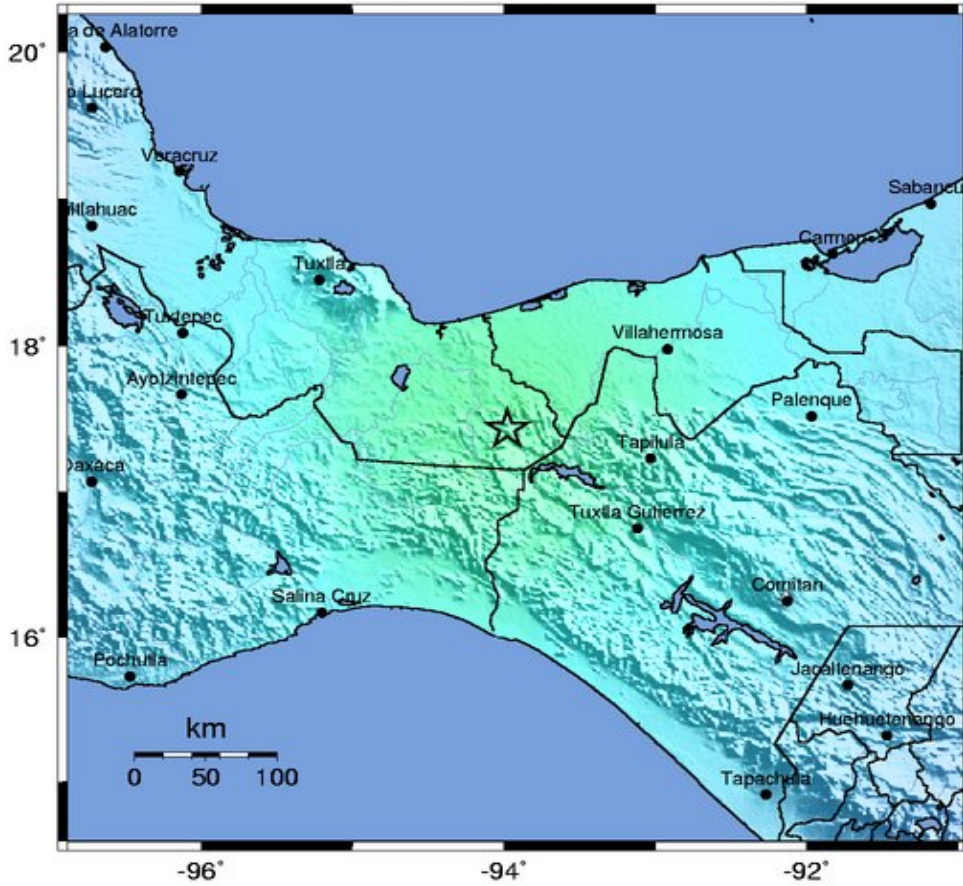


Map Version 2 Processed Wed Jun 30, 2010 02:34:06 AM MDT -- NOT REVIEWED BY HUMAN

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+

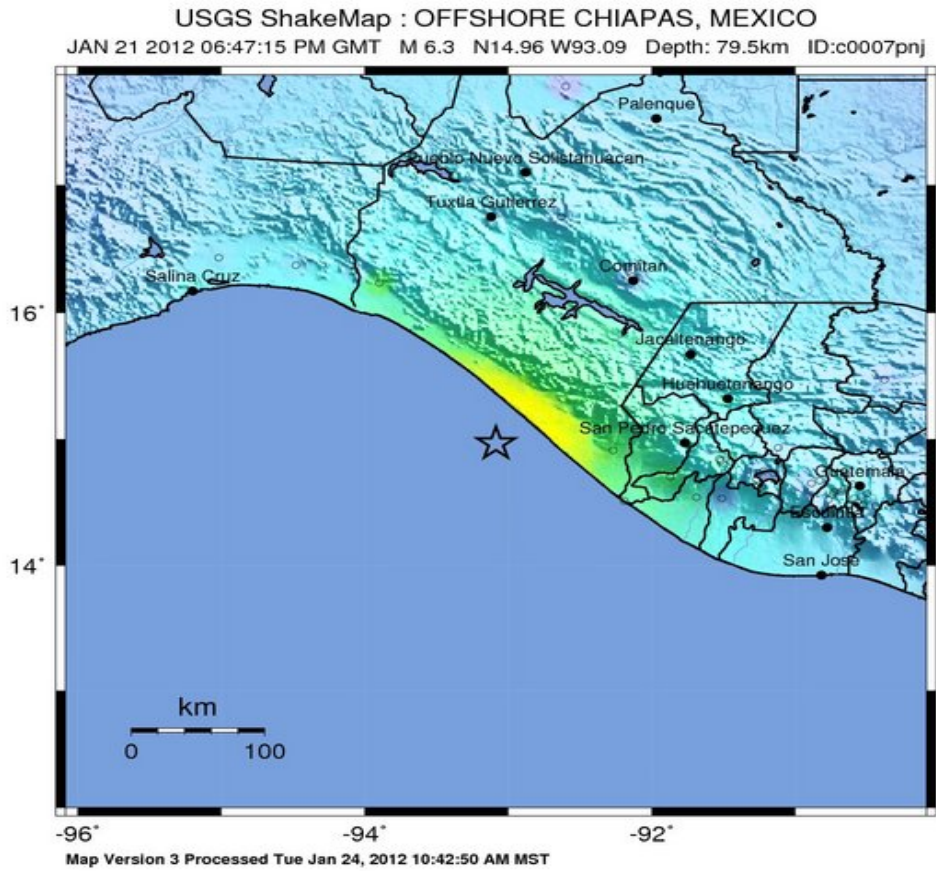
USGS ShakeMap : VERACRUZ, MEXICO

Thu Apr 7, 2011 13:11:24 GMT M 6.5 N17.43 W93.98 Depth: 167.4km ID:c0002kru



Map Version 1 Processed Thu Apr 7, 2011 07:25:29 AM MDT – NOT REVIEWED BY HUMAN

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+

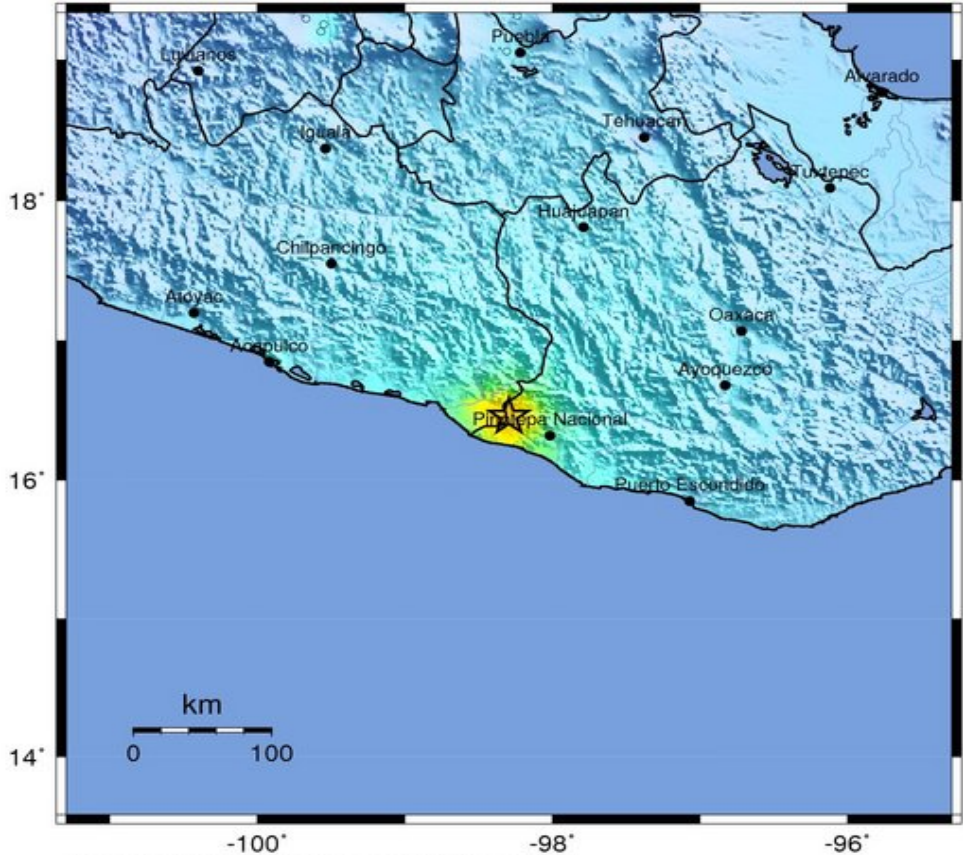


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.1	0.5	2.4	6.7	13	24	44	83	>156
PEAK VEL.(cm/s)	<0.07	0.4	1.9	5.8	11	22	43	83	>160
INSTRUMENTAL INTENSITY	I	II-III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

Scale based upon Wald, et al.; 1999

USGS ShakeMap : OAXACA, MEXICO

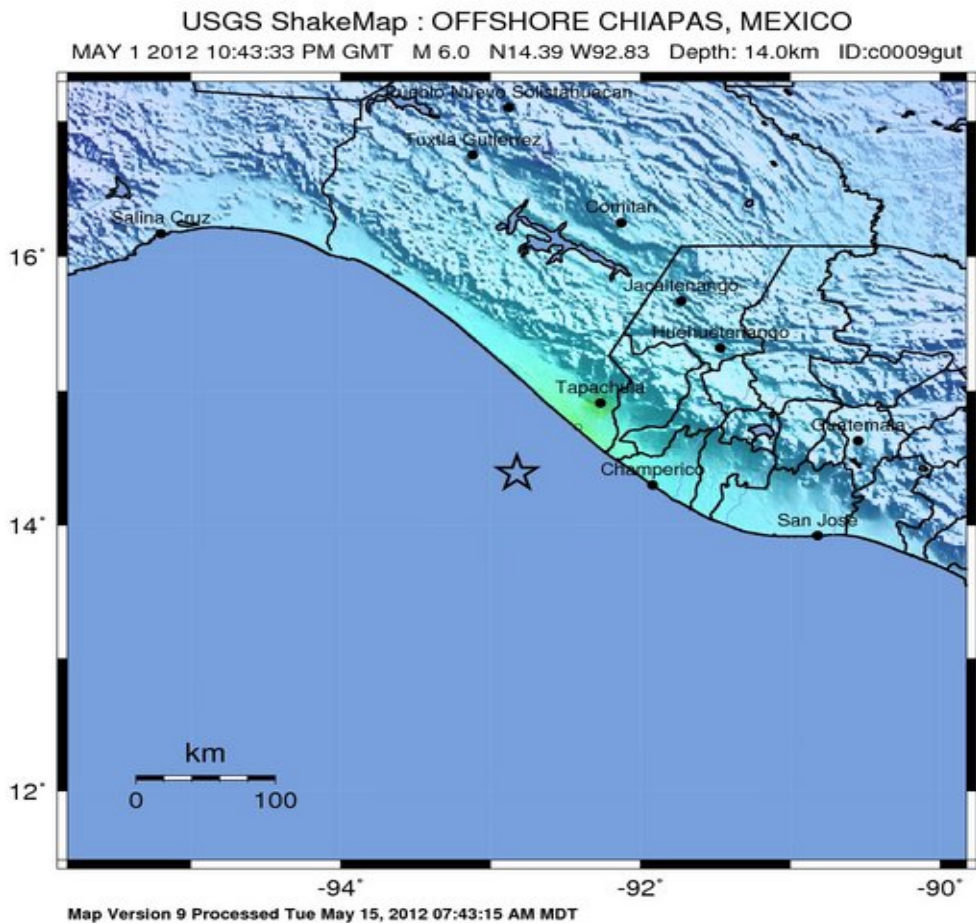
APR 2 2012 05:36:42 PM GMT M 6.0 N16.46 W98.30 Depth: 9.1km ID:c0008ui2



Map Version 23 Processed Mon Apr 16, 2012 08:39:22 AM 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)	<0.03	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	<0.01	0.1	1.4	4.7	9.6	20	41	86	>178
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

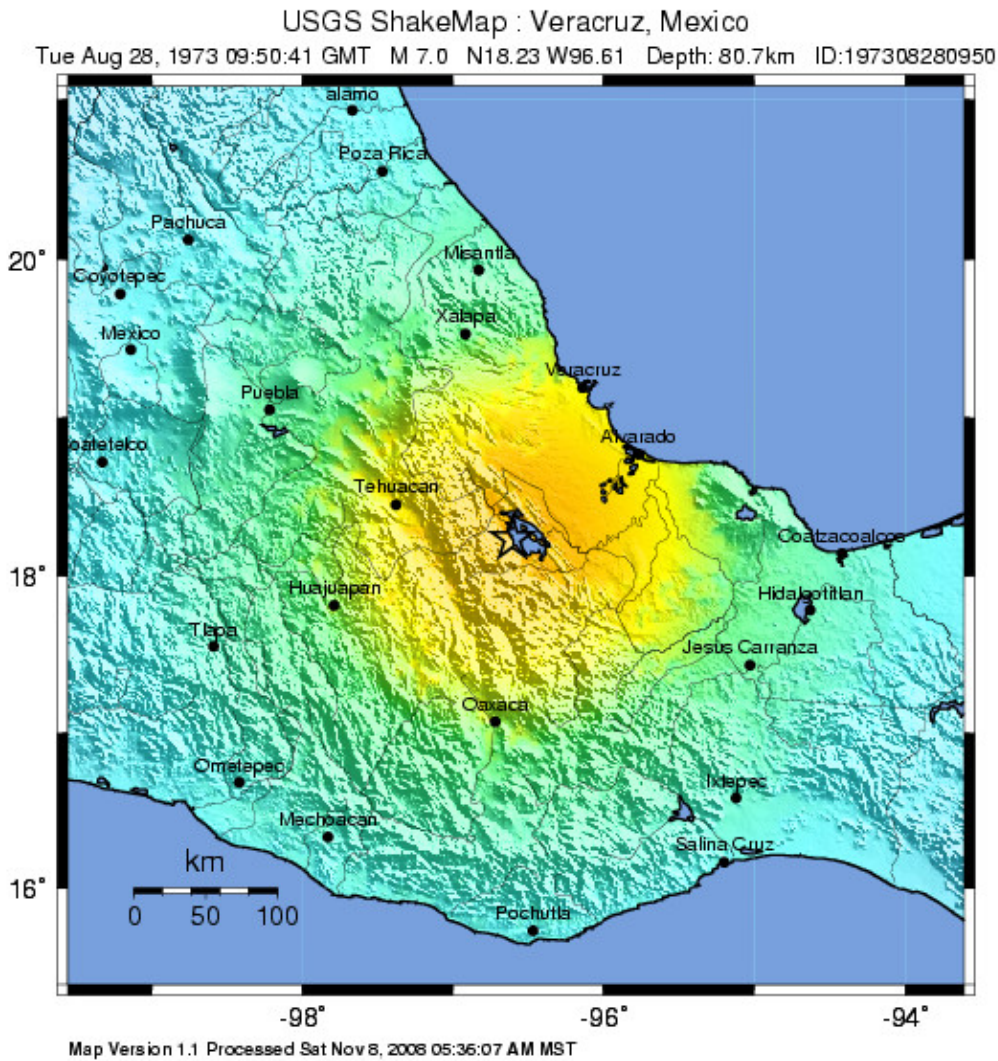
Scale based upon Worden et al. (2011)



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)	<0.03	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	<0.01	0.1	1.4	4.7	9.6	20	41	86	>178
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2011)

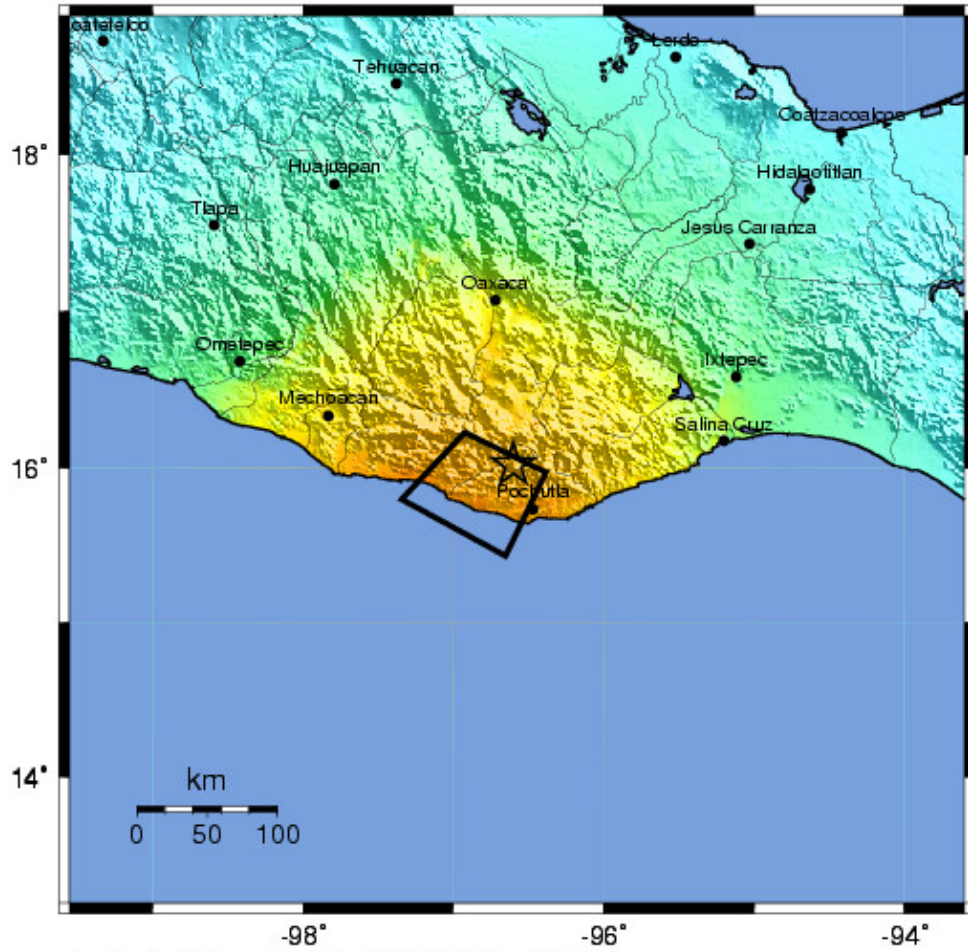
M_w7 and above Earthquakes



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+

USGS ShakeMap : Oaxaca, Mexico

Wed Nov 29, 1978 19:52:50 GMT M 7.8 N16.01 W96.60 Depth: 24.5km ID:197811291952

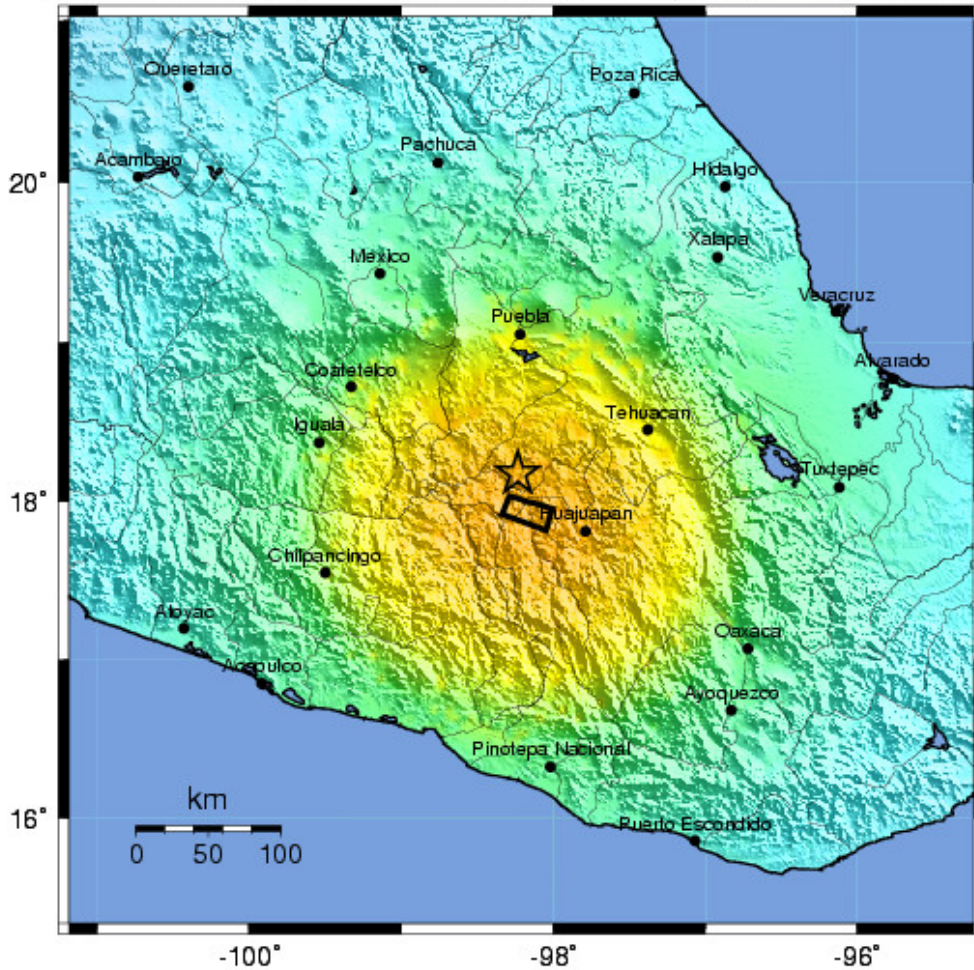


Map Version 1.1 Processed Sat Nov 8, 2008 07:50:46 AM MST

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+

USGS ShakeMap : Haujuapan de Leon, Mexico

Fri Oct 24, 1980 14:53:35 GMT M 7.1 N18.18 W98.23 Depth: 64.9km ID:198010241453

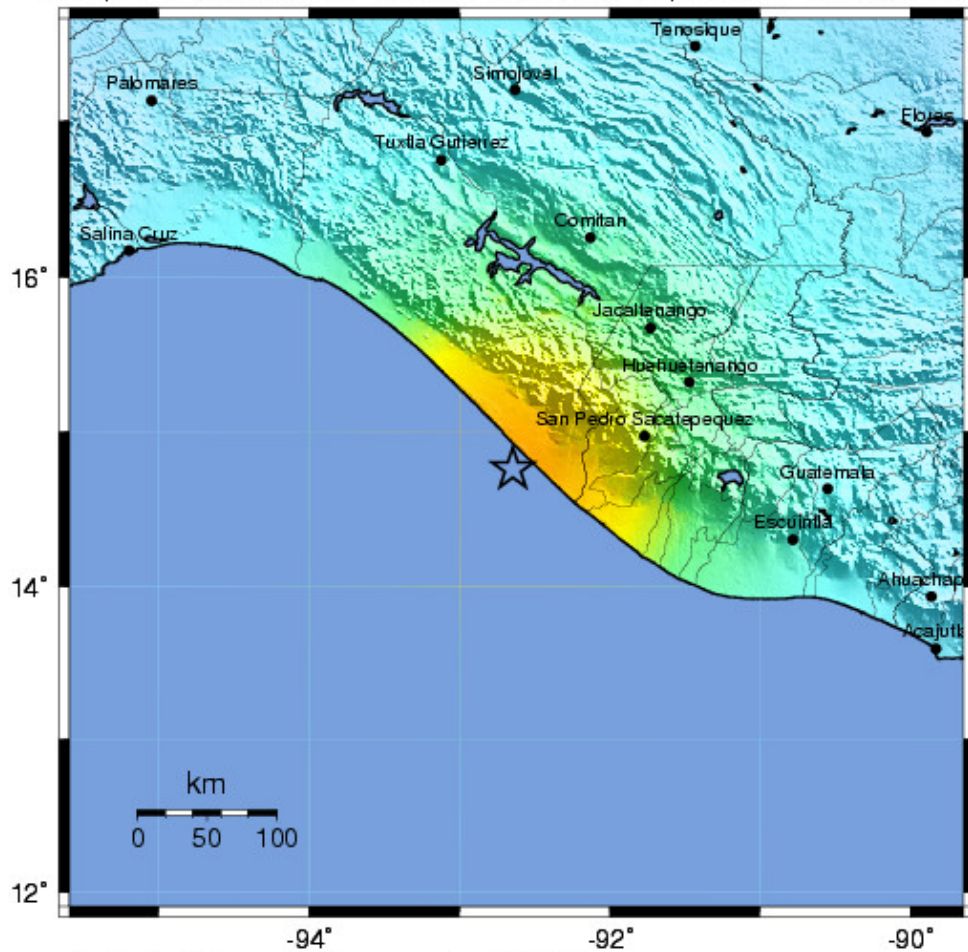


Map Version 1.1 Processed Sat Nov 8, 2008 09:06:34 AM MST

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+

USGS ShakeMap : MEXICO

Fri Sep 10, 1993 19:12:56 GMT M 7.2 N14.76 W92.65 Depth: 34.0km ID:199309101912

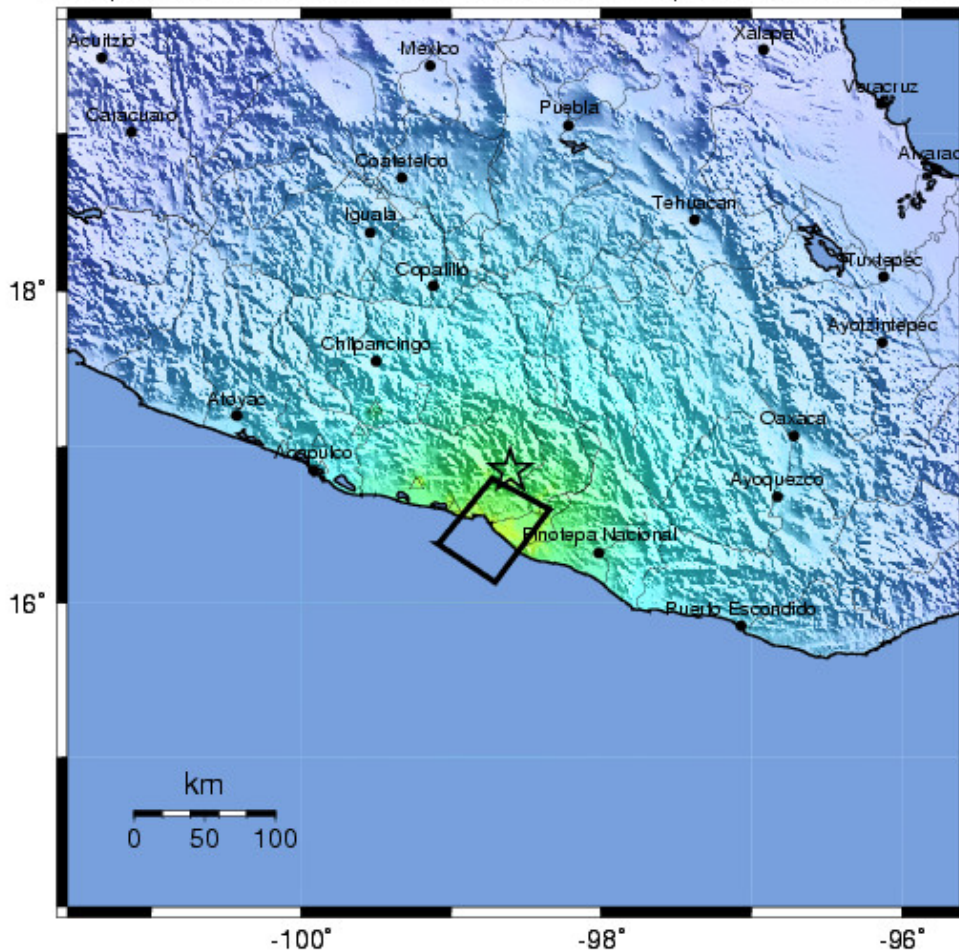


Map Version 1.1 Processed Sat Nov 8, 2008 04:26:43 PM MST

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+

USGS ShakeMap : Copala, Mexico

Thu Sep 14, 1995 14:04:33 GMT M 7.3 N16.85 W98.61 Depth: 23.0km ID:199509141404

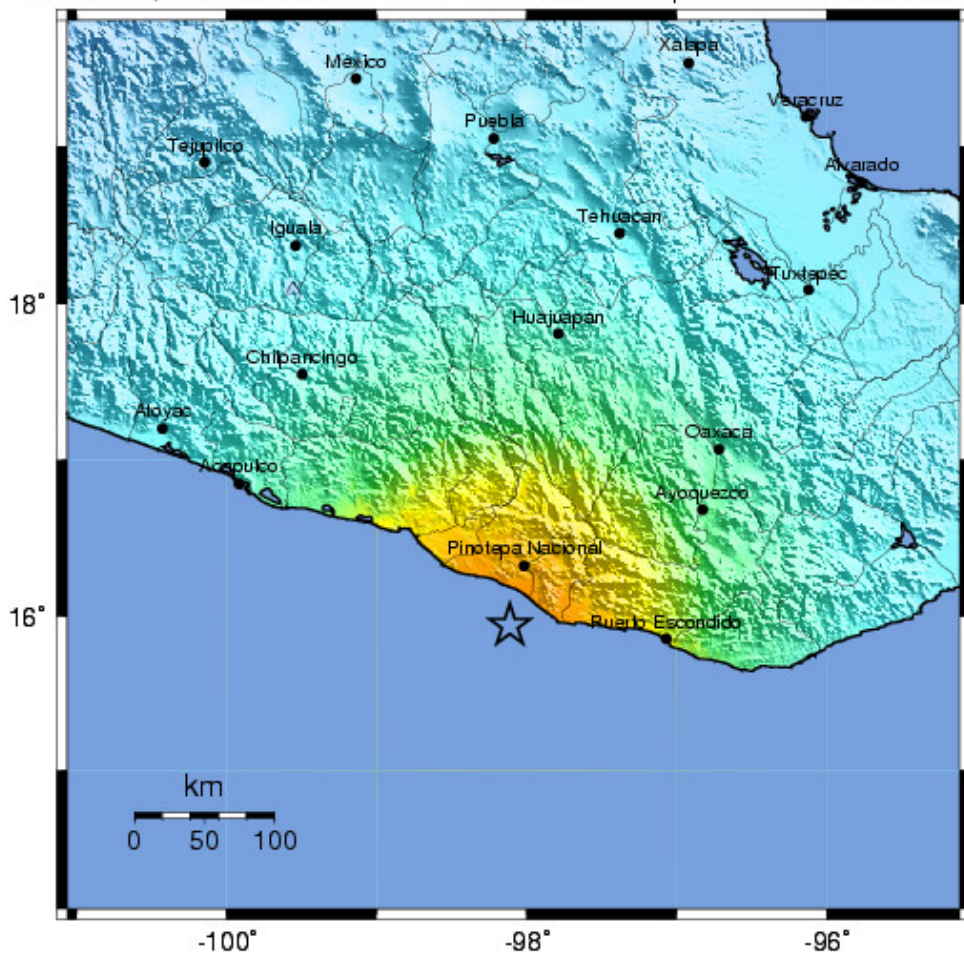


Map Version 1.1 Processed Sat Nov 8, 2008 05:46:41 PM MST

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+

USGS ShakeMap : Oaxaca, Mexico

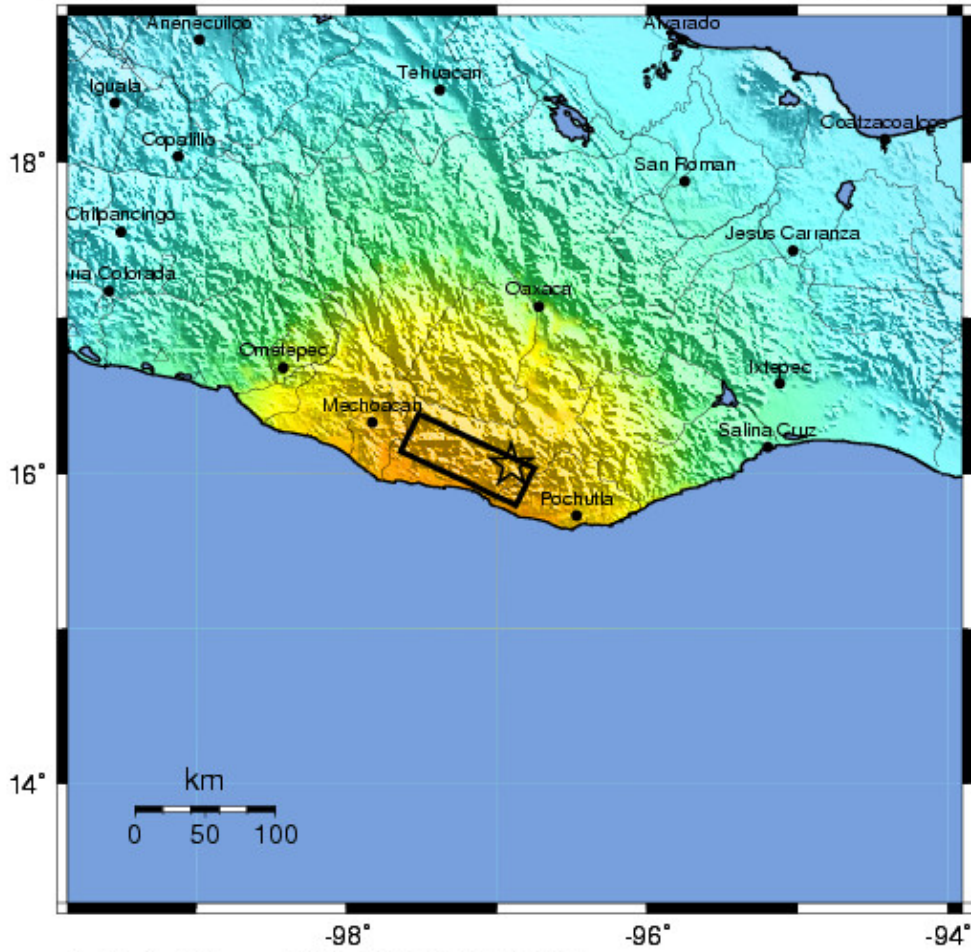
Sun Feb 25, 1996 03:08:17 GMT M 7.1 N15.94 W98.11 Depth: 21.0km ID:199602250308



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+

USGS ShakeMap : Oaxaca, Mexico

Thu Sep 30, 1999 16:31:14 GMT M 7.4 N16.05 W96.91 Depth: 40.0km ID:199909301631

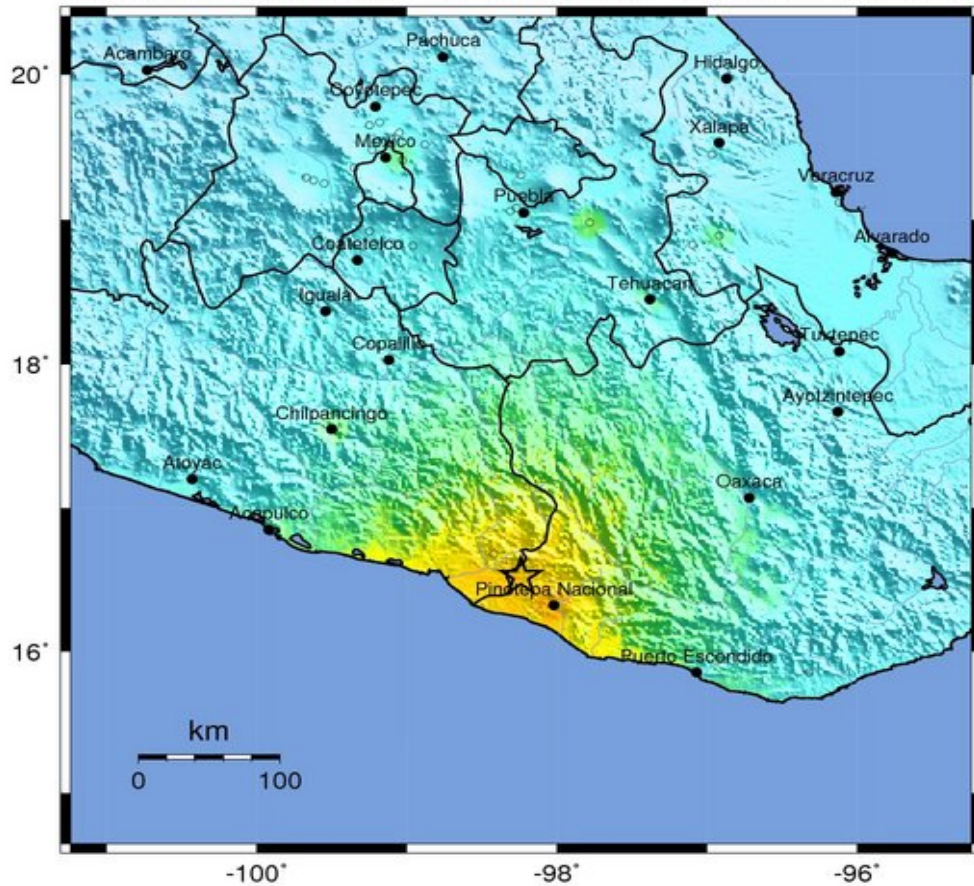


Map Version 1.1 Processed Sat Nov 8, 2008 08:37:50 PM MST

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+

USGS ShakeMap : OAXACA, MEXICO

MAR 20 2012 06:02:47 PM GMT M 7.4 N16.52 W98.24 Depth: 20.0km ID:c0008m6h

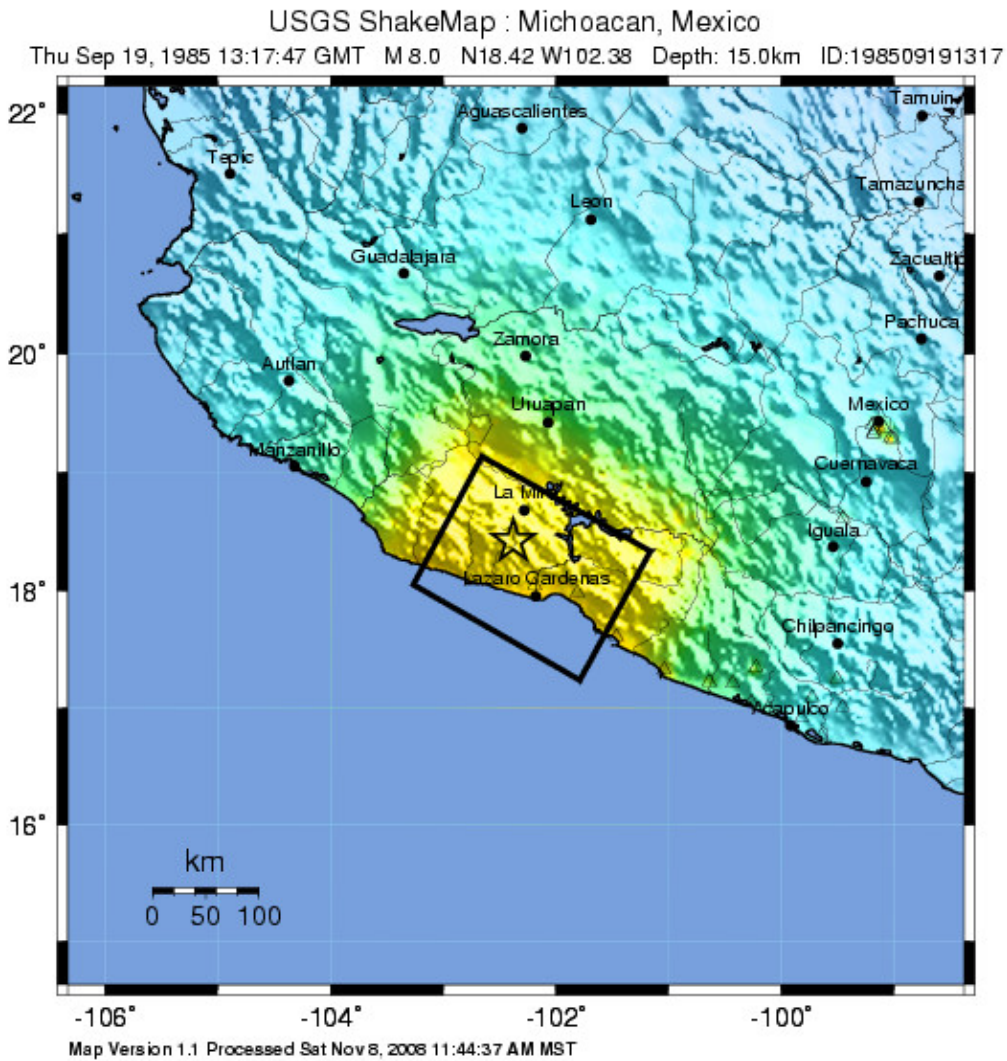


Map Version 31 Processed Mon Apr 16, 2012 06:53:15 AM MDT

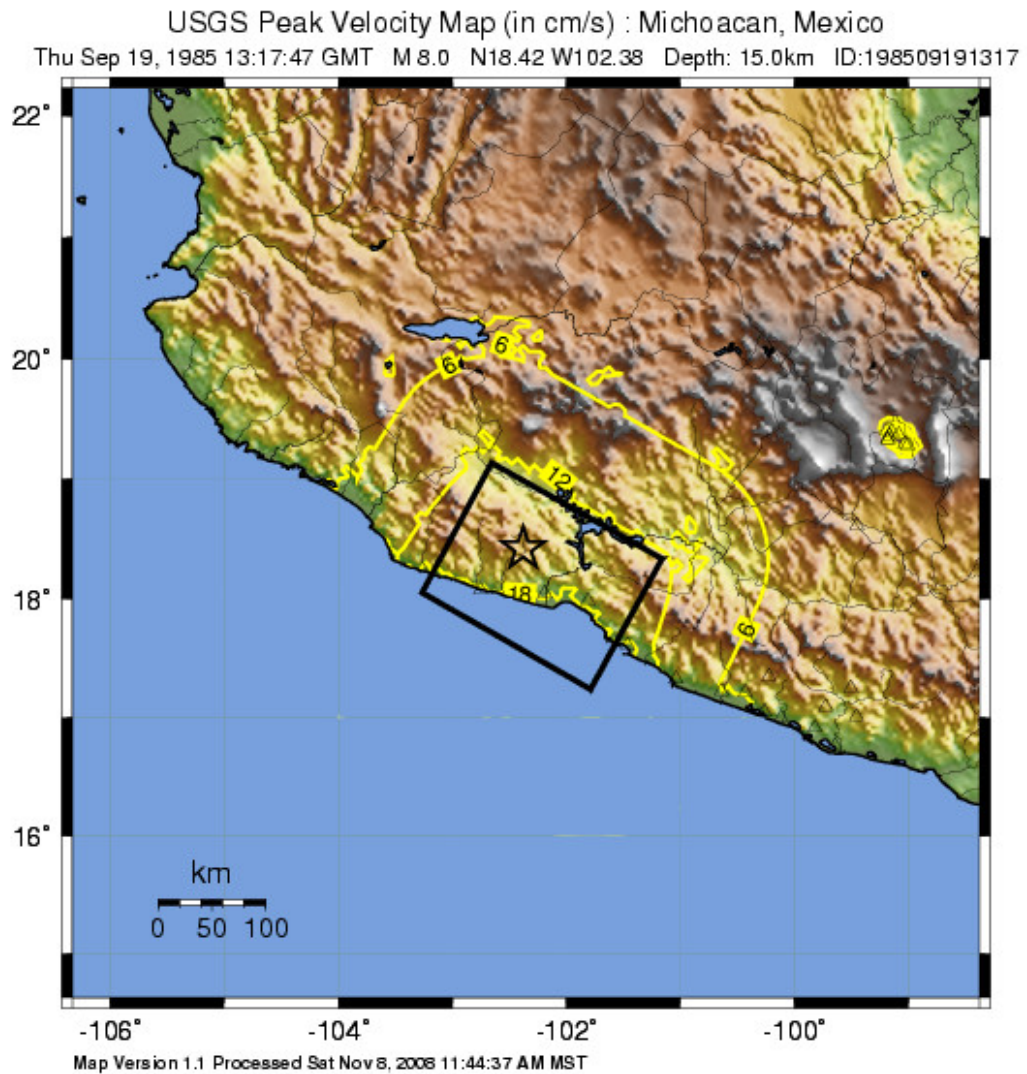
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.03	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	<0.01	0.1	1.4	4.7	9.6	20	41	86	>178
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2011)

Mexico City Earthquake



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+



As is apparent from the Shakemaps, earthquakes of similar magnitude as the strongest volcanic earthquakes only could cause damage on a very limited local scale. In order to account for the destruction described in 3rd Nephi, it is clear that a volcano and a regional earthquake are indicated.

Non-Volcanic Storm Events

Relying on two premises, Kowallis (1997) and Ball (1993) both assert that nothing beyond a volcanic event is necessary to explain the disaster described in 3rd Nephi, excluding a storm. The first premise is the reference to “exceedingly dry wood” in 3rd Nephi 8: 21 which states:

And there could be no light, because of the darkness, neither candles, neither torches; neither could there be fire kindled with their fine and exceedingly [exceeding] dry wood, so that there could not be any light at all;

The argument was that it would not be likely that wood would have been exceedingly dry if the wood had just been exposed to a hurricane or a large tropical storm. This argument does not seem at all consistent with the language in the verse itself, as the Book of Mormon author appears to be simply listing all the types of artificial light that inhabitants were capable of igniting, and pointing out that they could not ignite any of them. If anything, it would seem to indicate that the author is trying to emphasize that the wood they were trying to ignite was indeed dry, not the wet wood that would be ubiquitous in light of a large storm.

The Book of Mormon peoples were no doubt aware of local precipitation cycles, namely that there is an annual rainy season that typically lasts from May to November that includes heavy tropical rains. It would be unreasonable to assume that they did not have methods and locations to protect their firewood from tropical precipitation.

The second premise presented by Kowallis and Ball is that the word “rain” is never specifically mentioned as part of the “great storm.” This argument seems to assert that the definition of the word “storm” would not normally include precipitation unless the word rain was somehow used as a descriptor.

At this point, while meteorological analysis is not the primary purpose of this book, it will be useful to evaluate some of the meteorological terminology found in the Book of Mormon.

All of the verses in the Book of Mormon that contain the word (or a derivate of the word) “storm,” “tempest,” “rain,” “flood,” “wind,” “whirlwind,” “thunder,” “lightning,” and “tumultuous noise” were examined. In examining the verses related to these terms, the primary purpose is to determine if a phrase, verse, or series of verses is so structured that it identifies individual terms as being more or less mutually exclusive, meaning that they are different and distinct events or items. Additionally, the verses can also determine if these terms are related or otherwise described sufficient to further differentiate between their meanings.

The following verses, although containing one or more of these terms, were not considered in the analysis because they were not relating to weather or natural hazard terminology, or were derived from external records or implied other non-Mesoamerican sources (i.e., Old Testament scriptural references, teachings of Jesus, etc.): 1 Nephi 17:45, 2 Nephi 14:6, 2 Nephi 15:6, 2 Nephi 15:28, 2 Nephi 17:2, 2 Nephi 21:15, 2 Nephi 23:4, Mosiah 27:11, Mosiah 27:18, Alma 10:22, Alma 29:2, Alma 36:7, Alma 38:7, 3 Nephi 11:40, 3 Nephi 14:25, 3 Nephi 14:27, 3 Nephi 18:13, and 3 Nephi 22:11.

The following verses indicated the presence of the terms, but did not provide any further description or comparisons: 1 Nephi 18:8–9, Mosiah 12:12 (wind); Mosiah 7:30 (whirlwind); Helaman 11:13, 17, Ether 9:30, 35 (rain); Mormon 8:29 (tempests); Ether 2:20, Ether 3:2 (floods).

The following remaining verses are useful for comparisons of the various weather and/or hazard terminologies:

1 Nephi 12:4

And it came to pass that I saw a mist of darkness on the face of the land of promise; and I saw **lightnings**, and I heard **thunderings**, and earthquakes, and all manner of **tumultuous noises**; and I saw the earth ~~and the rocks, that they rent~~ [that it rent the rocks] ; and I saw mountains tumbling into pieces; and I saw the plains of the earth, that they were broken up; and I saw many cities that they were sunk; and I saw many that they were ~~burned~~ [burnt] with fire; and I saw many that did tumble to the earth, because of the quaking thereof.

1 Nephi 18:13–14

Wherefore, they knew not whither they should steer the ship, insomuch that there arose a **great storm**, yea, **a great and terrible tempest**, and we were driven back upon the waters for the space of three days; and they began to be frightened exceedingly lest they should be drowned in the sea; nevertheless they did ~~not~~ loose me [not].

And on the fourth day, which we had been driven back, **the tempest** began to be exceedingly sore.

1 Nephi 18:21

And it came to pass after they had loosed me, behold, I took the compass, and it did work whither I desired it. And it came to pass that I prayed unto the Lord; and after I had prayed **the winds** did cease, and **the storm** did cease, and there was a great calm.

1 Nephi 19:11

For thus spake the prophet: The Lord God surely shall visit all the house of Israel at that day, some with his voice, because of their righteousness, unto their great joy and salvation, and others with the **thunderings** and the **lightnings** of his power, by **tempest**, by fire, and by smoke, and vapor of darkness, and by the opening of the earth, and by mountains which shall be carried up.

2 Nephi 6:15

And they that believe not in him shall be destroyed, both by fire, and by **tempest**, and by earthquakes, and by bloodsheds, and by pestilence, and by famine. And they shall know that the Lord is God, the Holy One of Israel.

2 Nephi 26:5

And they that kill the prophets, and the saints, the depths of the earth shall swallow them up, saith the Lord of Hosts; and mountains shall cover them, and **whirlwinds** shall carry them away, and buildings shall fall upon them and crush them to pieces and grind them to powder.

2 Nephi 26:6

And they shall be visited with **thunderings**, and **lightnings**, and earthquakes, and all manner of destructions, for the fire of the anger of the Lord shall be kindled against them, and they shall be as stubble, and the day that cometh shall consume them, saith the Lord of Hosts.

2 Nephi 27:2

And when that day shall come they shall be visited of the Lord of Hosts, with **thunder** and with earthquake, and with a great noise, and with **storm**, and with **tempest**, and with the flame of devouring fire.

Mosiah 7:31

And again he saith: If my people shall sow filthiness they shall reap the **east wind**, which bringeth immediate destruction.

Mosiah 12:6

And it shall come to pass that I will send forth **hail** among them, and it shall smite them; and they shall also be smitten with the **east wind**; and insects shall pester their land also, and devour their grain.

Alma 26:6

Yea, they shall not be beaten down by the storm at the last day; yea, neither shall they be harrowed up by the **whirlwinds**; but when **the storm** cometh they shall be gathered together in their place, that **the storm** cannot penetrate to them; yea, neither shall they be driven with **fierce winds** whithersoever the enemy listeth to carry them.

Helaman 5:12

And now, my sons, remember, remember that it is upon the rock of our Redeemer, who is Christ, the Son of God, that ye must build your foundation; that when the devil shall send forth his **mighty winds**, yea, his shafts in **the whirlwind**, yea, when all his **hail and his mighty storm** shall beat upon you, it shall have no power over you to drag you down to the gulf of misery and endless wo, because of the rock upon which ye are built, which is a sure foundation, a foundation whereon if men build they cannot fall.

Helaman 5:30

And it came to pass when they heard this voice, and beheld that it was not a voice of **thunder**, neither was it a voice of a **great tumultuous noise**, but behold, it was a still voice of perfect mildness, as if it had been a whisper, and it did pierce even to the very soul--

Helaman 14:21

Yea, at the time that he shall yield up the ghost there shall be **thunderings** and **lightnings** for the space of many hours, and the earth shall shake and tremble; and the rocks which ~~are~~ [is] upon the face of this earth, which ~~are~~ [is] both above the earth and beneath, which ye know at this time ~~are~~ [is] solid, or the more part of it is one solid mass, shall be broken up;

Helaman 14:23

And behold, there shall be **great tempests**, and there shall be many mountains laid low, like unto a valley, and there shall be many places which are now called valleys which shall become mountains, whose height [thereof] is great.

Helaman 14:26-27

And behold, thus hath the angel spoken unto me; for he said unto me that there should be **thunderings** and **lightnings** for the space of many hours.

And he said unto me that while **the thunder** and **the lightning** lasted, and **the tempest**, that these things should be, and that darkness should cover the face of the whole earth for the space of three days.

3 Nephi 8:5-7

And it came to pass in the thirty and fourth year, in the first month, ~~on~~ [in] the fourth day of the month, there arose a **great storm**, such an one as never had been known in all the land.

And there was also a **great and terrible tempest**; and there was **terrible thunder**, insomuch that it did shake the whole earth as if it was about to divide asunder.

And there were **exceedingly sharp lightnings**, such as never had been known in all the land.

3 Nephi 8:12

But behold, there was a more great and terrible destruction in the land northward; for behold, the whole face of the land was changed, because of **the tempest** and **the whirlwinds** and **the thundering** and **the lightnings**, and the exceedingly great quaking of the whole earth;

3 Nephi 8:16–17

And there were some ~~who~~ [which] were carried away in **the whirlwind**; and whither they went no man knoweth, save they know that they were carried away.

And thus the face of the whole earth became deformed, because of the **tempests**, and **the thunderings**, and **the lightnings**, and the quaking of the earth.

3 Nephi 8:19

And it came to pass that when **the thunderings**, and **the lightnings**, and **the storm**, and **the tempest**, and the quakings of the earth did cease--for behold, they did last for about the space of three hours; and it was said by some that the time was greater; nevertheless, all these great and terrible things were done in about the space of three hours--and then behold, there was darkness upon the face of the land.

3 Nephi 10:9

And it came to pass that thus did the three days pass away. And it was in the morning, and the darkness dispersed from off the face of the land, and the earth did cease to tremble, and the rocks did cease to rend, and the dreadful groanings did cease, and all **the tumultuous noises** did pass away.

3 Nephi 10:13–14

And they were spared and were not sunk and buried up in the earth; and they were not drowned in the depths of the sea; and they were not burned by fire, neither were they fallen upon and crushed to death; and they were not carried away in **the whirlwind**; neither were they overpowered by the vapor of smoke and of darkness.

And now, whoso readeth, let him understand; he that hath the scriptures, let him search them, and see and behold if all these deaths and destructions by fire, and by smoke, and by **tempests**, and by **whirlwinds**, and by the opening of the earth to receive them, and all these things are not unto the fulfilling of the prophecies of many of the holy prophets.

Ether 2:24–25

For behold, ye shall be as a whale in the midst of the sea; for the mountain waves shall dash upon you. Nevertheless, I will bring you up again out of the depths of the sea; for **the winds** have gone forth out of my mouth, and also **the rains** and **the floods** have I sent forth.

And behold, I prepare you against these things; for ye cannot cross this great deep save I prepare you against the waves of the sea, and **the winds** which have gone forth, and **the floods** which shall come. Therefore what will ye that I should prepare for you that ye may have light when ye are swallowed up in the depths of the sea?

Ether 6:6

And it came to pass that they were many times buried in the depths of the sea, because of the mountain waves which broke upon them, and also **the great and terrible tempests** which were caused by the fierceness of **the wind**.

The events or items that are obviously mutually exclusive throughout are thunder and lightning with each other and everything else. One important distinction clear from the passages is that thunder and “tumultuous noises” are clearly not the same thing. Whirlwinds are also essentially exclusive except that they occur in conjunction with mighty or fierce winds, which of course is not surprising. The principal reason for this analysis is to get a better delineation of the terms ‘storm’ and ‘tempest.’ When reading the Book of Mormon description of the destruction, it identifies both a storm and a tempest. It is important to verify that they were separate events, as they may delineate separately generated hazards. The principal questions that need to be considered from the Book of Mormon textual language are:

1. Does the term “storm” inherently include rain?
2. What are the apparent definitions of “storm” and “tempest”?

Webster’s Dictionary (2013) defines a “storm” as “a disturbance of the atmosphere marked by wind and usually by rain, snow, hail, sleet, or thunder and lightning” and defines “tempest” as “a violent storm.” Webster’s Dictionary (1828) defines a “storm” as a “violent wind. It has primarily no reference to a fall of rain or snow. But as a violent wind is often attended with rain or snow, the word ‘storm’ has come to be used, most improperly, for a fall of rain or snow without wind.” There is nothing in the text of the Book of Mormon that is inconsistent with the definitions found in Webster’s. A ‘storm’ is implied to include rain, as rain is never used in conjunction with or in addition to the word ‘storm’ in the Book of Mormon. It is only apparently clarified when hail is involved, which would be reasonable considering that hail is probably not a common event. In the Book of Mormon, use of the term ‘tempest’ is also consistent with Webster’s as ‘tempest’ is often associated with those items consistent with a violent storm such as thunder, lightning, and fierce wind (ships “driven” back, etc.).

Conclusion

A volcano-only scenario for the 3rd Nephi disaster is not viable to account for the description given in the Book of Mormon as volcanic earthquakes are simply not of the magnitudes necessary to account for the events and level of damage described in the Book of Mormon. In addition to a volcano, a large regional earthquake will be necessary to account for the level of damage described.

A storm involving precipitation cannot be ruled out based on the descriptions and text of the Book of Mormon. The usage of the term “storm” is not inconsistent with the current usage of the term, which typically involves precipitation.

