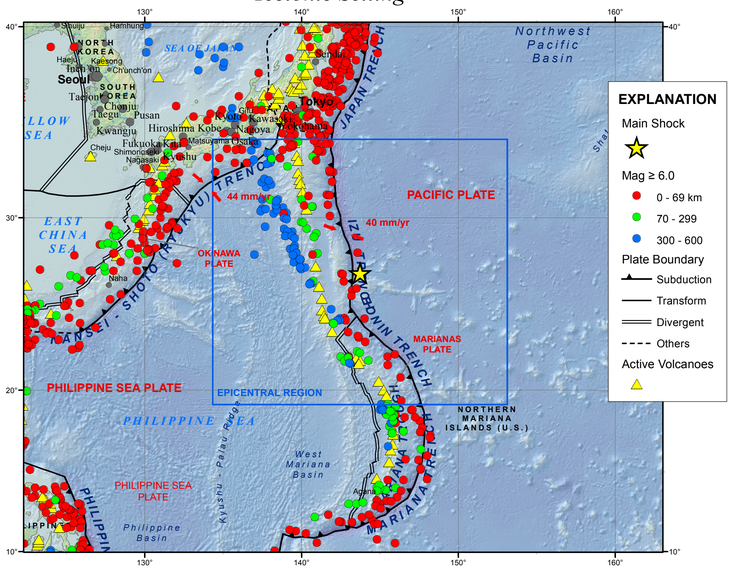
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the Global Seismographic Network
GSN

M7.4 Bonin Islands, Japan Earthquake of 21 December 2010

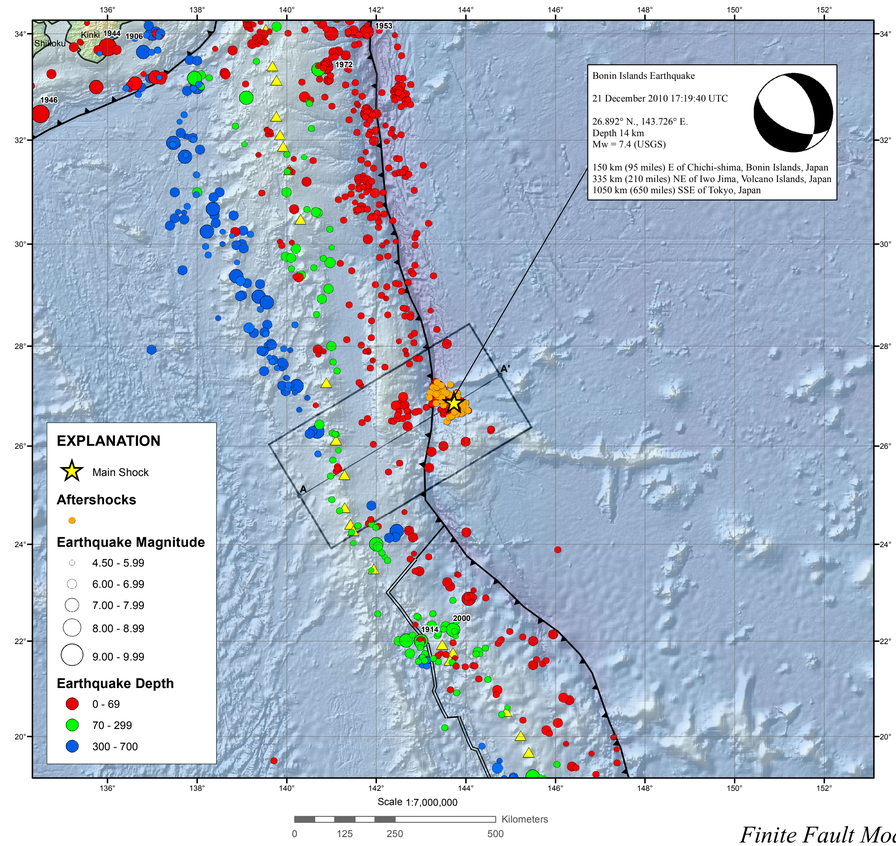
Tectonic Setting



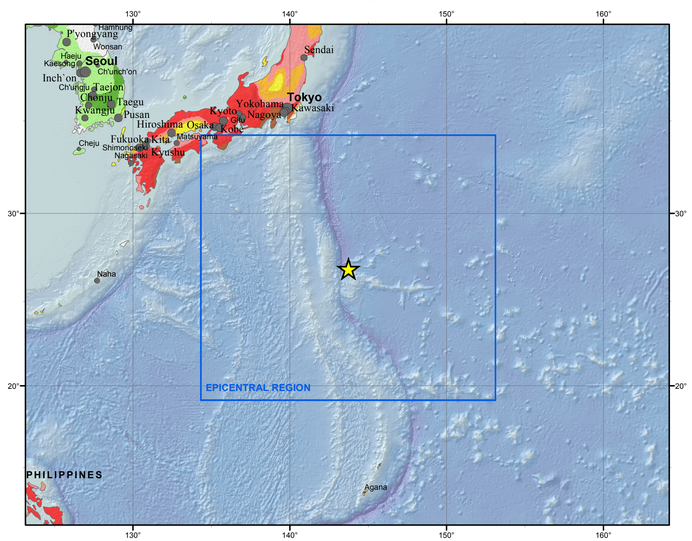
RELATIVE PLATE MOTIONS

The red vectors represents the motion of the Pacific plate relative to the Philippine Sea plate, and the Philippine Sea plate relative to the Eurasia plate in the region.

Epicentral Region



Seismic Hazard



Seismic hazard is expressed as peak ground acceleration (PGA) on firm rock, in meters/sec², expected to be exceeded in a 50-yr period with a probability of 10 percent.

Peak Ground Acceleration in m/sec**2

.2 .4 .8 1.6 2.4 3.2 4.0 4.8

USGS science for a changing world — Earthquake Shaking Green Alert — USAID FROM THE AMERICAN PEOPLE — ANSS

M 7.4, BONIN ISLANDS, JAPAN REGION
Origin Time: Tue 2010-12-21 17:19:40 UTC (03:19:40 local)
Location: 26.89°N 143.73°E Depth: 14 km
FOR TSUNAMI INFORMATION, SEE: tsunami.noaa.gov

PAGER Version 2
Created: 3 hours, 36 minutes after earthquake

Estimated Fatalities

Green alert for shaking-related fatalities and economic losses. There is a low likelihood of casualties and damage.

Estimated Economic Losses

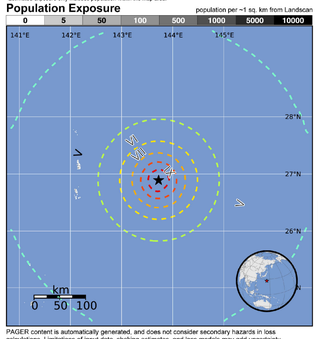
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	- -*	- -*	846*	2k	0	0	0	0	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
POTENTIAL DAMAGE: 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



Structures:
Overall, the population in this region resides in structures that are resistant to earthquake shaking, though some vulnerable structures exist.

Historical Earthquakes (with MMI levels):

There were no earthquakes with significant population exposure to shaking within a 400 km radius of this event.

Selected City Exposure
from GeoNames.org

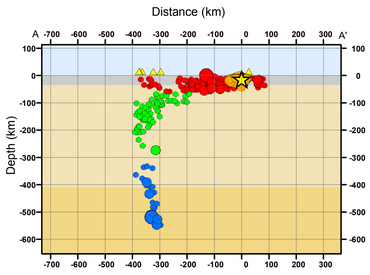
MMI	City	Population

bold cities appear on map (k = x1000)

PAGER content is automatically generated, and does not consider secondary hazards in loss calculations. Limitations of input data, shaking estimates, and loss models may add uncertainty.
http://earthquake.usgs.gov/pager

Event ID: usc0000rxc

Depth Profile



Cross-section defined by profile boundaries shown on the Epicenter Map

TECTONIC SUMMARY

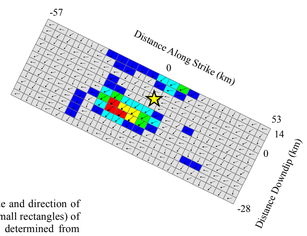
The Bonin Islands earthquake of December 21, 2010, occurred as the result of normal-faulting within the Pacific plate, in the region of the boundary between the Pacific plate and the Philippine Sea plate. In the epicentral region of the earthquake, the Pacific plate moves west relative to the Philippine Sea plate with a velocity of about 4 cm/yr. The Pacific plate subducts beneath the Philippine plate at the Izu trench and is seismically active west of the epicenter of the December 21 earthquake to a depth of about 560 km. The stresses that generated the December 21 earthquake result from the bending of the Pacific plate as it subducts beneath the Philippine Sea plate.

The Izu-Bonin and Mariana arcs of the Pacific/Philippine Sea plate-boundary region experience frequent moderate and strong earthquakes. In the past quarter century, the thousand kilometer section of the plate boundary centered on the epicenter of the December 21 earthquake has produced 27 earthquakes of magnitude 6 or greater, with 3 having magnitudes larger than 7.0. Roughly half of the moderate and large shocks in this region occur as intermediate-depth earthquakes (70 – 300 km below the earth's surface) or deep-focus earthquakes (greater than 300 km below the earth's surface). The December 21 earthquake, however, occurred within several tens of kilometers of the earth's surface and would be classified as a "shallow-focus" earthquake.

Significant Earthquakes Mag >= 7.5

Year	Mon	Day	Time	Lat	Long	Dep	Mag
1906	01	21	1349	34.000	137.000	350	7.7
1914	11	24	1153	22.000	143.000	110	7.9
1944	12	07	0435	33.750	136.000	0	8.1
1953	11	25	1748	34.034	141.786	35	7.9
1972	02	29	0923	33.377	140.881	58.8	7.5
2000	03	28	1100	22.232	143.711	105	7.6
2007	09	28	1338	22.013	142.668	260	7.5

Finite Fault Model for M7.4 Earthquake



FINITE FAULT MODEL
Contributed by
Gavin Hayes (NEIC)

Distribution of the amplitude and direction of slip for subfault elements (small rectangles) of the fault rupture model are determined from the inversion of teleseismic body waves and long period surface waves. A W-phase moment tensor solution was used. Arrows indicate the amplitude and direction of slip (of the hanging wall with respect to the foot wall); the slip amount is also color-coded as shown. The view of the rupture plane is from above.

The strike of the fault rupture plane is N72°W and the dip is 34°SW. The dimensions of the subfault elements are 5 km in the strike direction and 3.5 km in the dip direction. The seismic moment release based on this plane is 1.5e+27 dyne. cm.

Slip (cm)

0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600

DATA SOURCES and REFERENCES

EARTHQUAKES
USGS, National Earthquake Information Center
NOAA, National Geophysical Data Center
IASPEI, Centennial Catalog (1900 - 1999) and Engdahl, E.R. and Villaseñor, A., 2002, Global Seismicity: 1900 - 1999, chap. 41 of Lee, W.H.K., and others,eds., International Earthquake and Engineering Seismology, Part A: New York, N.Y., Elsevier Academic Press, 932 p.
EHB catalog (Engdahl, E.R., Van der Hilst, R.D., and Buland, R.P., 1998, Global teleseismic earthquake relocation with improved travel times and procedures for depth determination: Bull. Seism. Soc. Amer., v. 88, p. 722-743.)
HDF (unpublished earthquake catalog, Engdahl, 2003)

SEISMIC HAZARD
Global Seismic Hazard Assessment Program, http://www.seismo.ethz.ch/GSHAP/

PLATE TECTONICS
Bird, P., 2003, An updated digital model of plate boundaries: Geochem. Geophys. Geosyst., v. 4, no. 3, pp. 1027- 80.

BASE MAP
NIMA and ESRI, Digital Chart of the World
USGS, EROS Data Center
NOAA GEBCO and GLOBE Elevation Models

Map prepared by U.S. Geological Survey
National Earthquake Information Center
26 December 2010
Map not approved for release by Director USGS