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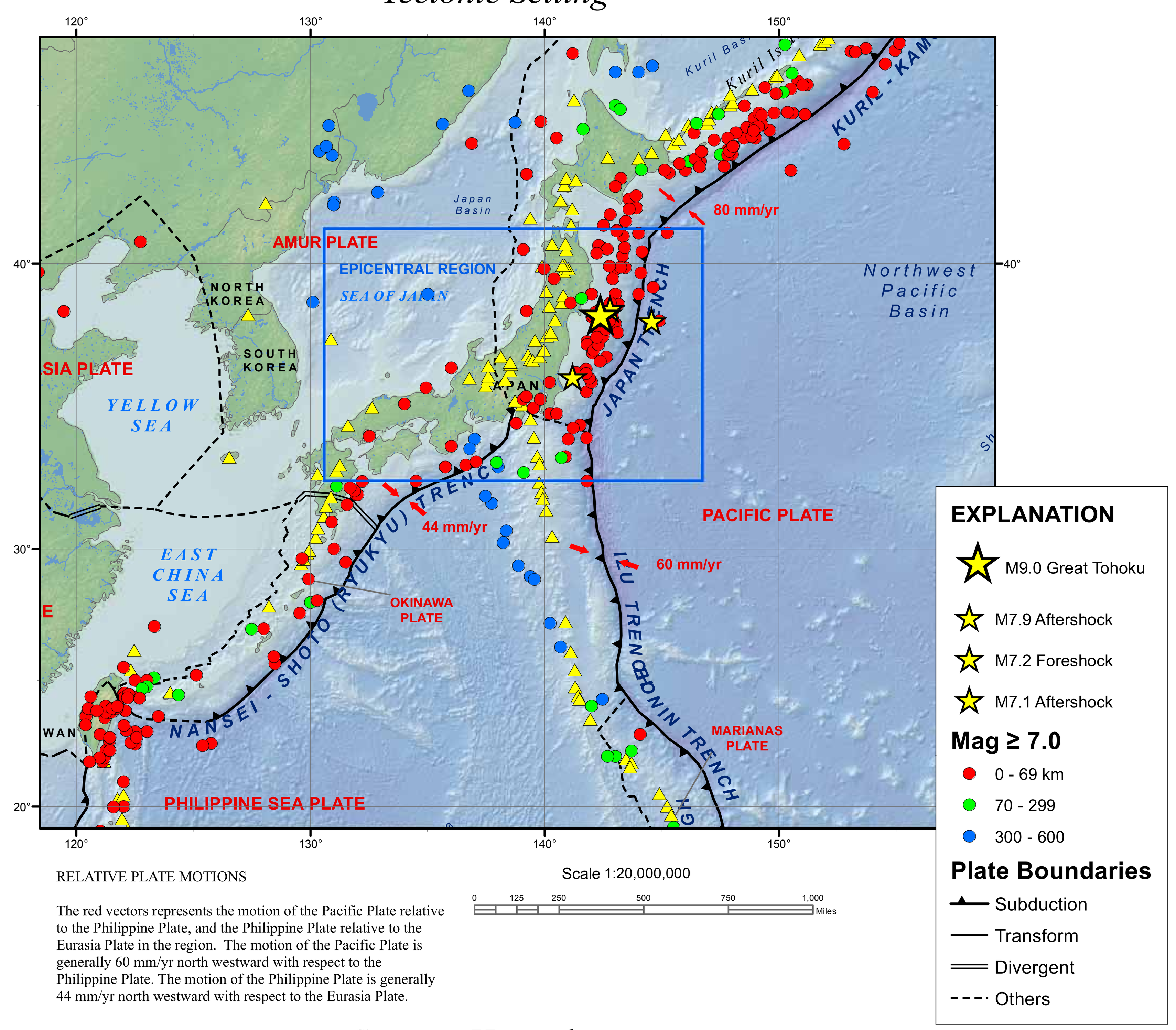
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

EARTHQUAKE SUMMARY MAP XXX

Prepared in cooperation with the Global Seismographic Network

The M9.0 Great Tohoku Earthquake (northeast Honshu, Japan) of March 11, 2011

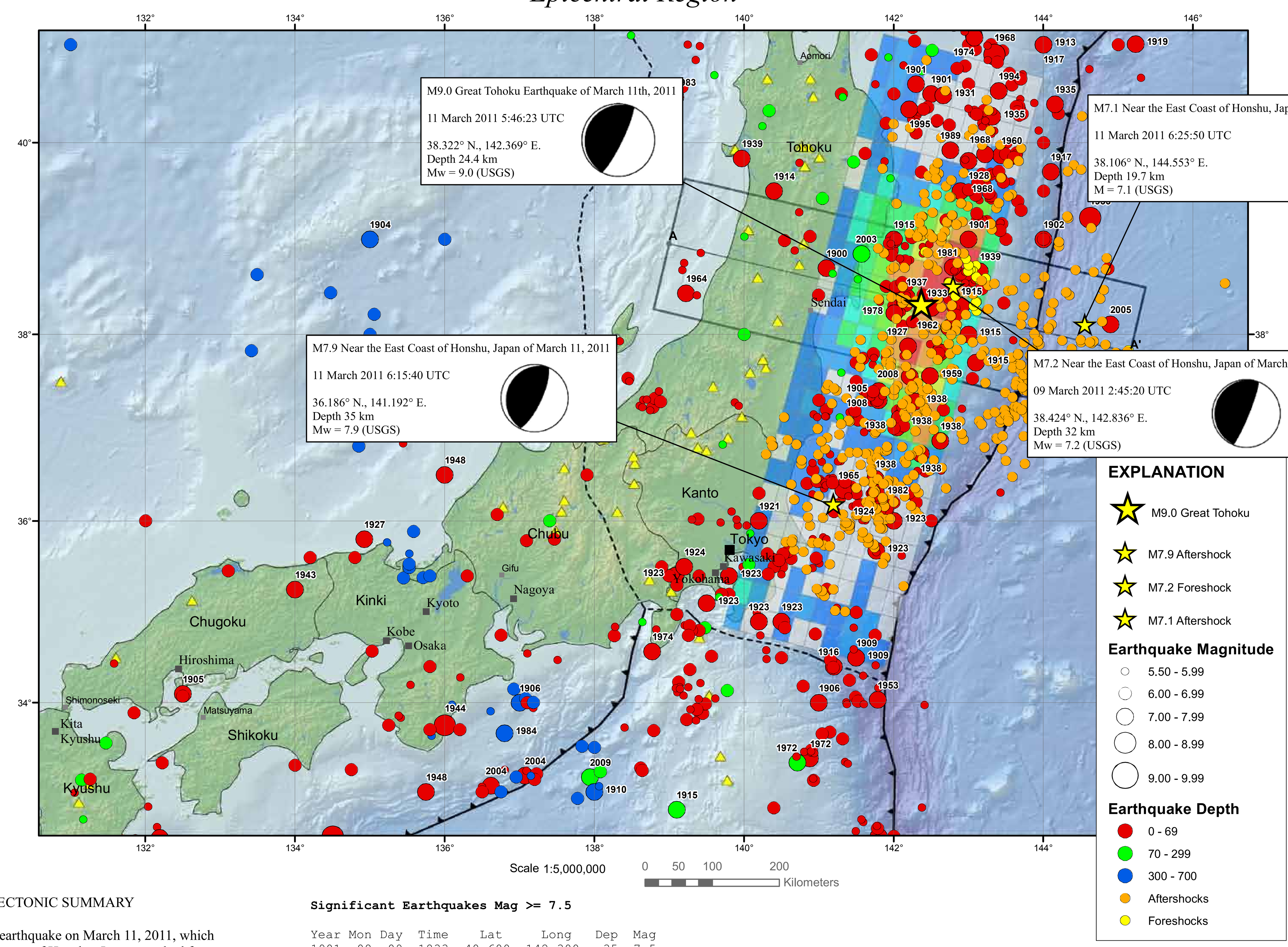
Tectonic Setting



RELATIVE PLATE MOTIONS

The red vectors represents the motion of the Pacific Plate relative to the Philippine Plate, and the Philippine Plate relative to the Eurasia Plate in the region. The motion of the Pacific Plate is generally 60 mm/yr north westward with respect to the Philippine Plate. The motion of the Philippine Plate is generally 44 mm/yr north westward with respect to the Eurasia Plate.

Epicentral Region



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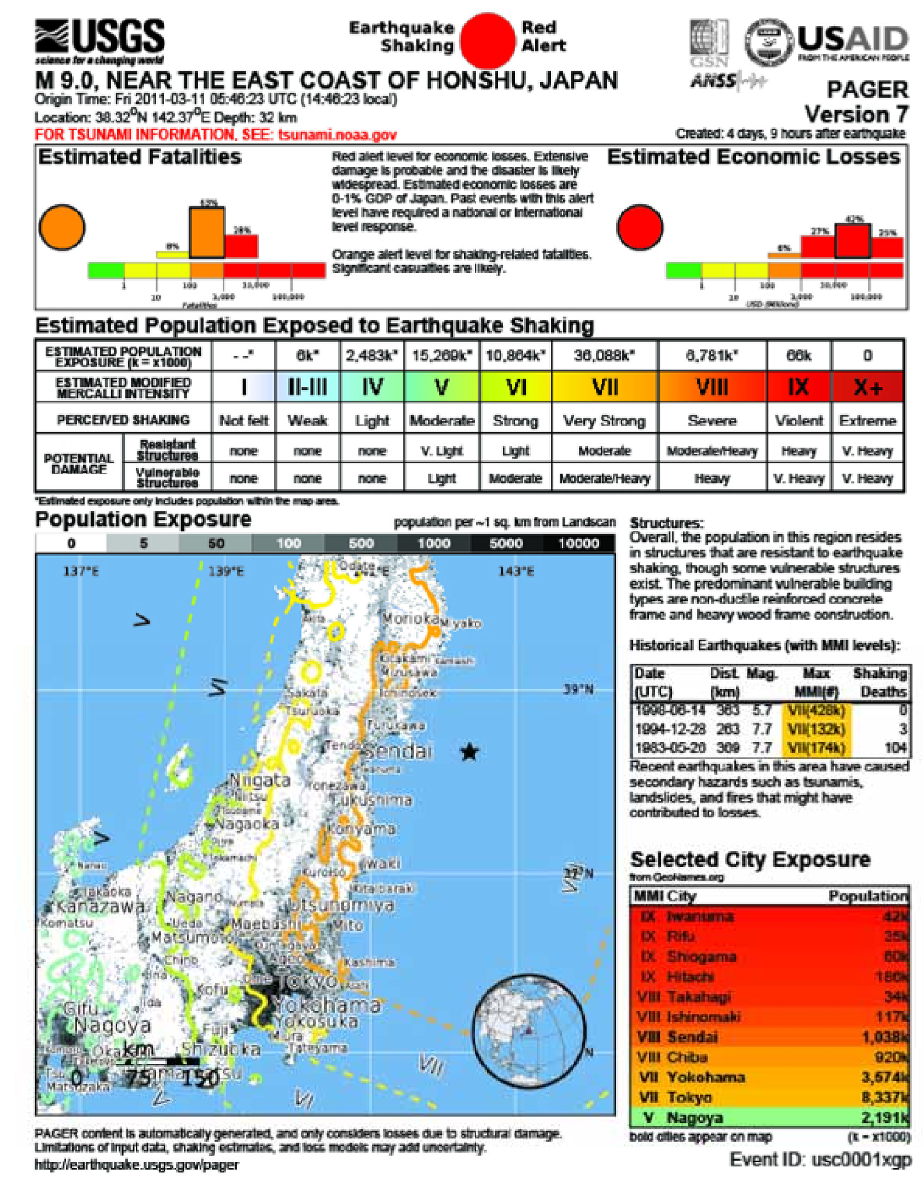
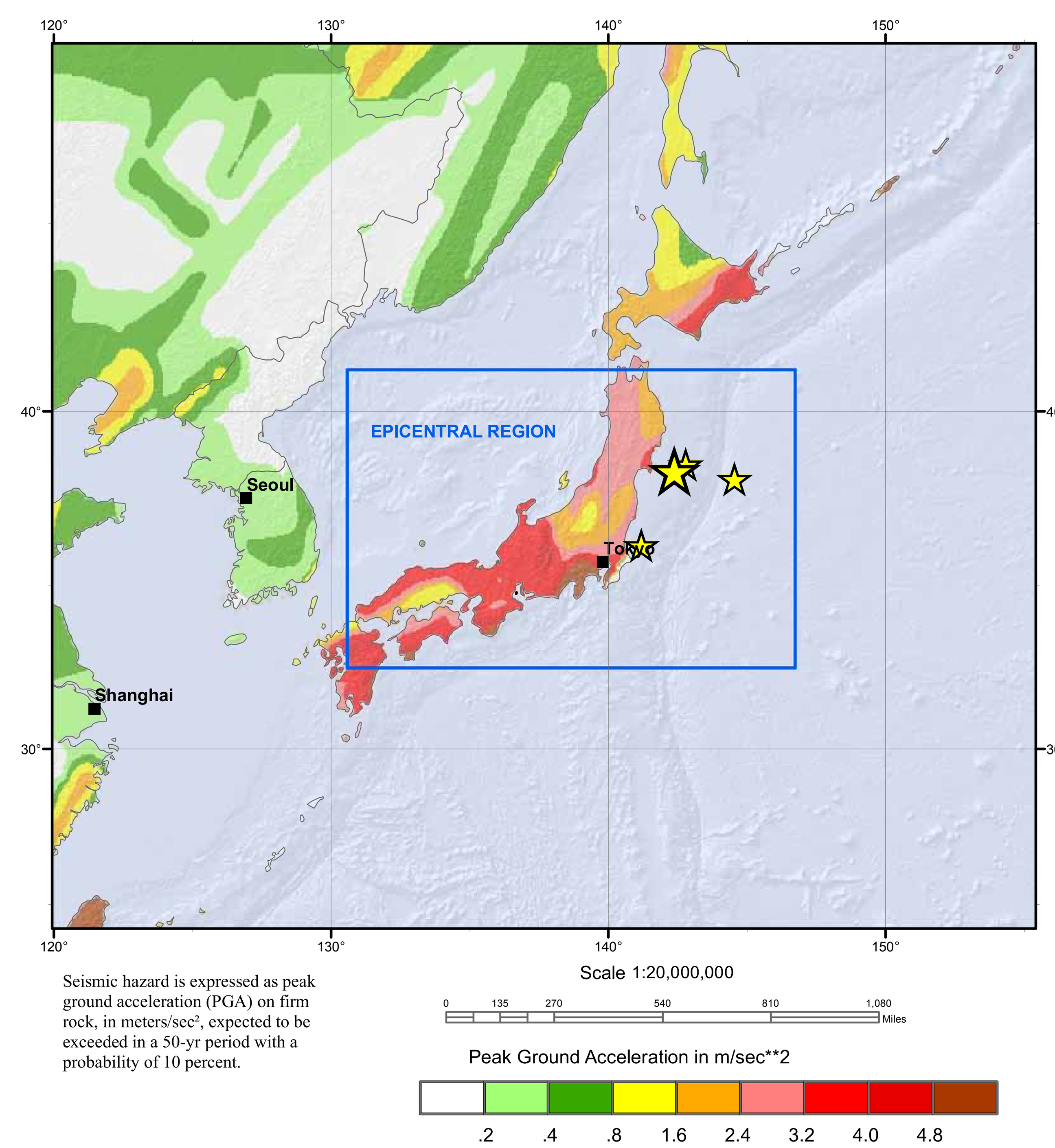


Seismic Hazard



Seismic hazard is expressed as peak ground acceleration (PGA) on firm rock, in meters/sec^2, expected to be exceeded in a 50-yr period with a probability of 10 percent.

M9.0 GREAT TOHOKU TECTONIC SUMMARY

The magnitude 9.0 Tohoku earthquake on March 11, 2011, which occurred near the northeast coast of Honshu, Japan, resulted from thrust faulting on or near the subduction zone plate boundary between the Pacific and North America plates. At the latitude of this earthquake, the Pacific plate moves approximately westwards with respect to the North America plate at a rate of 83 mm/yr, and begins its westward descent beneath Japan at the Japan Trench. Note that some authors divide this region into several microplates that together define the relative motions between the larger Pacific, North America and Eurasia plates; these include the Okhotsk and Amur microplates that are respectively part of North America and Eurasia.

The March 11 earthquake was preceded by a series of large foreshocks over the previous two days, beginning on March 9th with a M 7.2 event approximately 40 km from the epicenter of the March 11 earthquake, and continuing with another three earthquakes greater than M 6 on the same day.

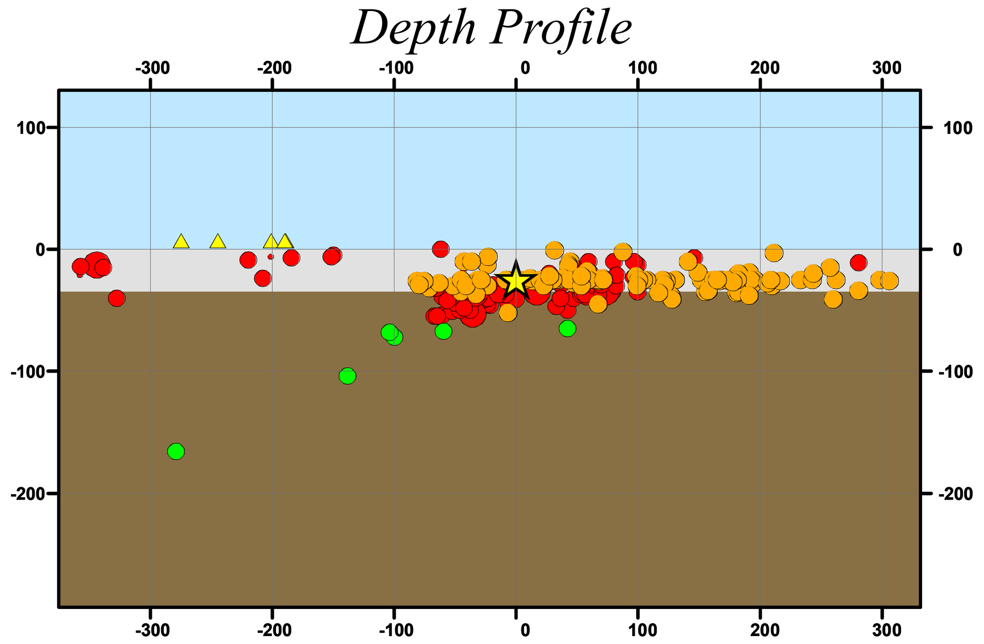
The Japan Trench subduction zone has hosted nine events of magnitude 7 or greater since 1973. The largest of these, a M 7.8 earthquake approximately 260 km to the north of the March 11 epicenter, caused 3 fatalities and almost 700 injuries in December 1994. In June of 1978, a M 7.7 earthquake 35 km to the southwest of the March 11 epicenter caused 22 fatalities and over 400 injuries. Large offshore earthquakes have occurred in the same subduction zone in 1611, 1896 and 1933 that each produced devastating tsunami waves on the Sanriku coast of Pacific NE Japan. That coastline is particularly vulnerable to tsunami waves because it has many deep coastal embayments that amplify tsunami waves and cause great wave inundations. The M 7.6 subduction earthquake of 1896 created tsunami waves as high 38 m and a reported death toll of 22,000. The M 8.6 earthquake of March 2, 1933 produced tsunami waves as high as 29 m on the Sanriku coast and caused more than 3000 fatalities.

The March 11, 2011 earthquake was an infrequent catastrophe. It far surpassed other earthquakes in the southern Japan Trench of the 20th century, none of which attained M8. A predecessor may have occurred on July 13, 869, when the Sendai area was swept by a large tsunami that Japanese scientists have identified from written records and a sand sheet.

Significant Earthquakes Mag >= 7.5

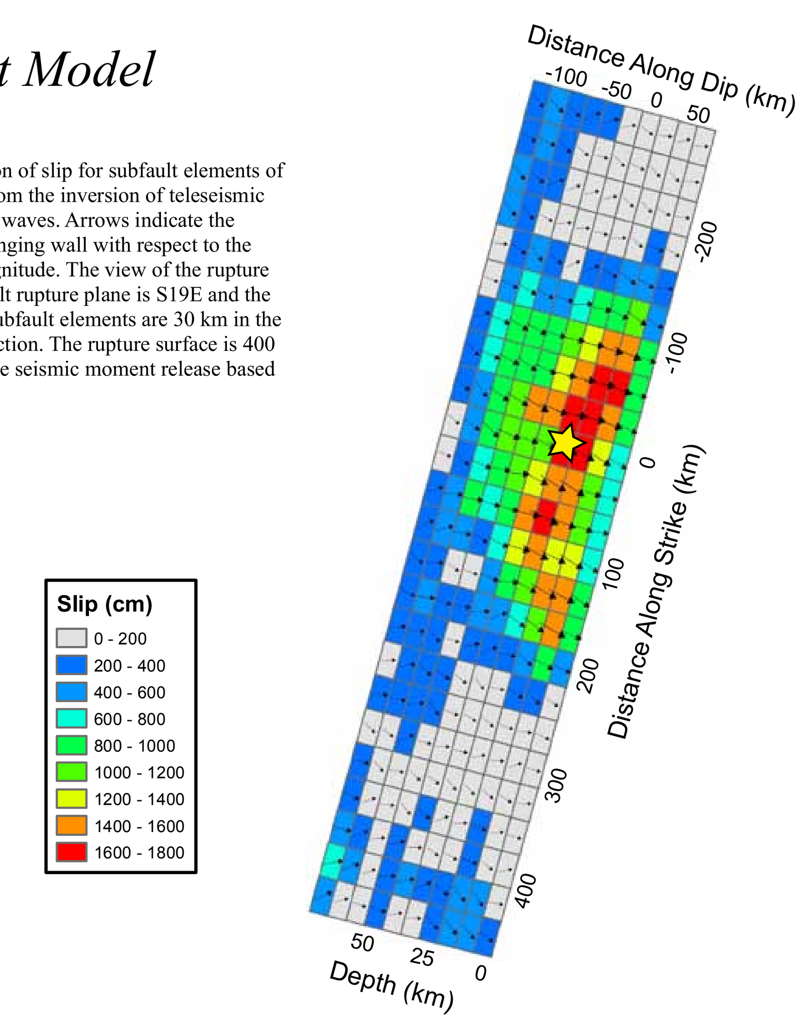
Year	Mon	Day	Time	Lat	Long	Dep	Mag
1901	08	09	1833	40.600	142.300	35	7.5
1906	01	21	1349	34.000	137.000	350	7.7
1909	03	13	1429	34.500	141.500	35	7.6
1915	11	01	0724	38.300	142.900	35	7.5
1923	09	01	0258	35.405	139.084	35	7.9
1923	09	02	0246	34.900	140.200	35	7.6
1927	03	07	0927	35.802	134.924	9.6	7.6
1931	03	09	0348	40.484	142.664	35	7.7
1933	03	02	1731	39.224	144.622	35	8.4
1938	05	23	0718	36.458	141.755	35	7.7
1938	11	05	0843	37.009	142.045	35	7.9
1938	11	05	1050	37.108	142.081	35	7.8
1938	11	06	0853	37.287	142.283	35	7.7
1944	12	07	0435	33.750	136.000	0	8.1
1953	11	25	1748	34.034	141.786	35	7.9
1960	03	20	1707	39.871	143.435	2.1	7.8
1964	06	16	0401	38.434	139.226	13.1	7.5
1968	05	16	0049	40.903	143.346	25.8	8.3
1972	02	29	0923	33.377	140.881	58.8	7.5
1978	06	12	0814	38.224	142.009	53.3	7.7
1983	05	26	0300	40.468	139.080	20	7.7
1994	12	28	1219	40.530	143.403	29.2	7.8
2011	03	11	0546	38.322	142.369	24.4	8.9

Depth Profile

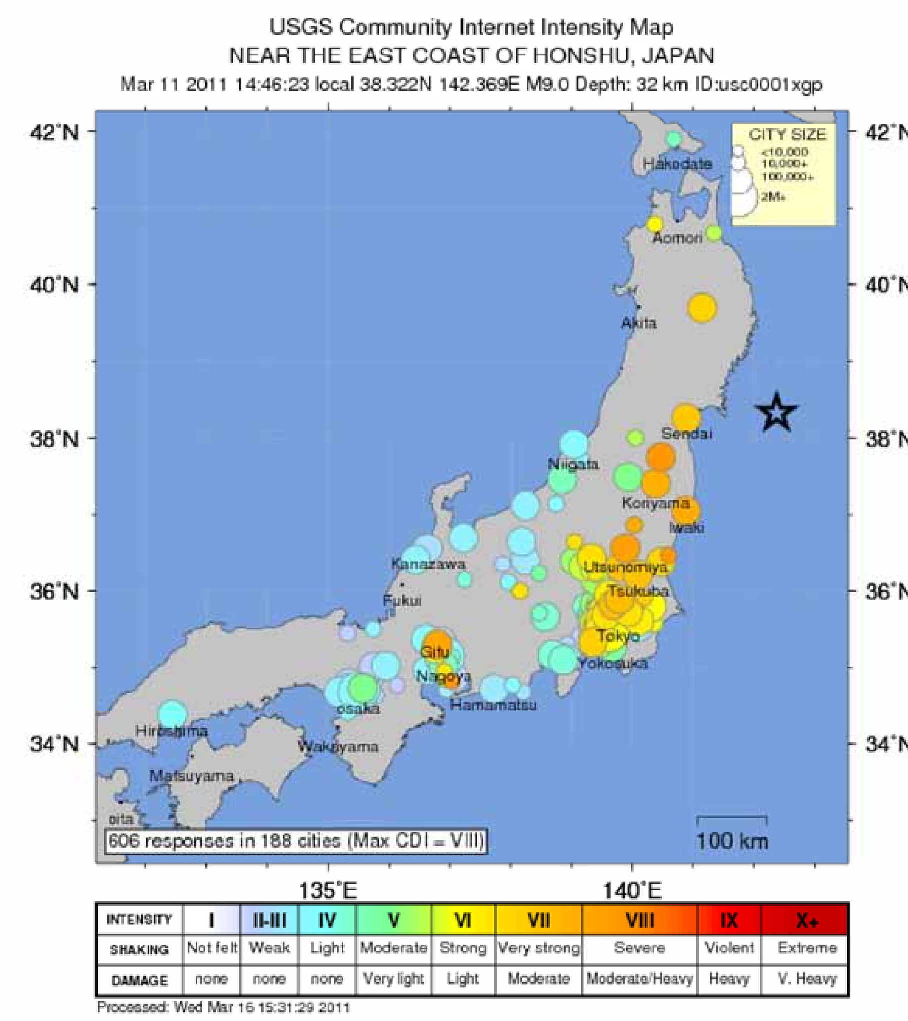


Finite Fault Model

Distribution of the amplitude and direction of slip for subfault elements of the fault rupture model are determined from the inversion of teleseismic body waveforms and long period surface waves. Arrows indicate the amplitude and direction of slip (of the hanging wall with respect to the foot wall); the slip is also colored by magnitude. The view of the rupture plane is from above. The strike of the fault rupture plane is S19E and the dip is 14 WNW. The dimensions of the subfault elements are 30 km in the strike direction and 20 km in the dip direction. The rupture surface is 400 km along strike and 150 km downdip. The seismic moment release based upon this plane is 4.04e+29 dyne.cm.



Did You Feel It?



DISCLAIMER

Base map data, such as place names and political boundaries, are the best available but may not be current or may contain inaccuracies and therefore should not be regarded as having official significance.

DATA SOURCES

EARTHQUAKES AND SEISMIC HAZARD
USGS, National Earthquake Information Center
NOAA, National Geophysical Data Center
IASPEI, Centennial Catalog (1900 - 1999) and extensions (Engdahl and Villaseñor, 2002)
HDF (unpublished earthquake catalog) (Engdahl, 2003)
Global Seismic Hazard Assessment Program

PLATE TECTONICS AND FAULT MODEL
PB2002 (Bird, 2003)
Finite Fault Model, Gavin Hayes, USGS (2011)

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

REFERENCES

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

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 Academeic Press, 932 p.

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.

The GEBCO_08 Grid, version 20090202, http://www.gebco.net

Map prepared by U.S. Geological Survey
National Earthquake Information Center
14 March 2011
Map not approved for release by Director USGS