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

Open-File Report 2010–1083-H

Seismicity of the Earth 1900–2010
New Guinea and Vicinity

Compiled by Harley M. Benz,[1] Matthew Herman,[2] Arthur C. Tarr,[1] Gavin P. Hayes,[1] Kevin P. Furlong,[2] Antonio Villaseñor,[3] Richard L. Dart,[1] and Susan Rhea[1]

[1]U.S. Geological Survey
[2]Department of Geosciences, Pennsylvania State University, State College, PA 16802 USA
[3]Institute of Earth Sciences, CSIC, Barcelona, Spain

2011

TECTONIC SUMMARY

There have been 22 M7.5+ earthquakes recorded in the New Guinea region since 1900. The dominant earthquake mechanisms are thrust and strike slip, associated with the arc-continent collision and the relative motions between numerous local microplates. The largest earthquake in the region was a M8.2 shallow thrust fault event in the northern Papua province of Indonesia that killed 166 people in 1996.

The Australia-Pacific plate boundary is over 4,000 km long on the northern margin, from the Sunda (Java) trench in the west to the Solomon Islands in the east. The eastern section is over 2,300 km long, extending west from northeast of the Australian continent and the Coral Sea until it intersects the east coast of Papua New Guinea. The boundary is dominated by the general northward subduction of the Australia plate.

Along the South Solomon trench, the Australia plate converges with the Pacific plate at a rate of approximately 95 mm/yr towards the east-northeast. Seismicity along the trench is dominantly related to subduction tectonics and large earthquakes are common: there have been 13 M7.5+ earthquakes recorded since 1900. On April 1, 2007, a M8.1 interplate megathrust earthquake occurred at the western end of the trench, generating a tsunami and killing at least 40 people. This was the third M8.1 megathrust event associated with this subduction zone in the past century; the other two occurred in 1939 and 1977.

Further east at the New Britain trench, the relative motions of several microplates surrounding the Australia-Pacific boundary, including north-south oriented seafloor spreading in the Woodlark Basin south of the Solomon Islands, maintain the subduction of Australia-affiliated lithosphere beneath Pacific-affiliated lithosphere. Most of the large and great earthquakes east of New Guinea are related to this subduction; such earthquakes are particularly concentrated at the cusp of the trench south of New Ireland. 33 M7.5+ earthquakes have been recorded since 1900, including three shallow thrust fault M8.1 events in 1906, 1919, and 2007.

The western end of the Australia-Pacific plate boundary is perhaps the most complex portion of this boundary, extending 2,000 km from Indonesia and the Banda Sea to eastern New Guinea. The boundary is dominantly convergent along an arc-continent collision segment spanning the width of New Guinea, but the regions near the edges of the impinging Australia continental margin also include relatively short segments of extensional, strike-slip and convergent deformation. The dominant convergence is accommodated by shortening and uplift across a 250–350 km-wide band of northern New Guinea, as well as by slow southward-verging subduction of the Pacific plate north of New Guinea at the New Guinea trench. Here, the Australia-Pacific plate relative velocity is approximately 110 mm/yr towards the northeast, leading to the 2–8 mm/yr uplift of the New Guinea Highlands.

Whereas the northern band of deformation is relatively diffuse east of the Indonesia–Papua New Guinea border, in western New Guinea there are at least two small (<100,000 km^2) blocks of relatively undeformed lithosphere. The westernmost of these is the Birds Head Peninsula microplate in Indonesia's West Papua province, bounded on the south by the Seram trench. The Seram trench was originally interpreted as an extreme bend in the Sunda subduction zone, but is now thought to represent a southward-verging subduction zone between Birds Head and the Banda Sea.

The western portion of the northern Australia plate boundary extends approximately 4,800 km from New Guinea to Sumatra and primarily separates Australia from the Eurasia plate, including the Sunda block. This portion is dominantly convergent and includes subduction at the Sunda (Java) trench, and a young arc-continent collision.

In the east, this boundary extends from the Kai Islands to Sumba along the Timor trough, offset from the Sunda trench by 250 km south of Sumba. Contrary to earlier tectonic models in which this trough was interpreted as a subduction feature continuous with the Sunda subduction zone, it is now thought to represent a subsiding deformational feature related to the collision of the Australia plate continental margin and the volcanic arc of the Eurasia plate, initiating in the last 5–8 Myr. Before collision began, the Sunda subduction zone extended eastward to at least the Kai Islands, evidenced by the presence of a northward-dipping zone of seismicity beneath Timor Leste. A more detailed examination of the seismic zone along its eastern segment reveals a gap in intermediate depth seismicity under Timor and seismic mechanisms that indicate an eastward propagating tear in the descending slab as the negatively buoyant oceanic lithosphere detaches from positively buoyant continental lithosphere. On the surface, GPS measurements indicate that the region around Timor is currently no longer connected to the Eurasia plate, but instead is moving at nearly the same velocity as the Australia plate, another consequence of collision.

Large earthquakes in eastern Indonesia occur frequently but interplate megathrust events related to subduction are rare; this is likely due to the disconnection of the descending oceanic slab from the continental margin. There have been nine M7.5+ earthquakes recorded from the Kai Islands to Sumba since 1900. The largest was the great Banda Sea earthquake of 1938 (M8.5) an intermediate depth thrust faulting event that did not cause significant loss of life.

DATA SOURCES

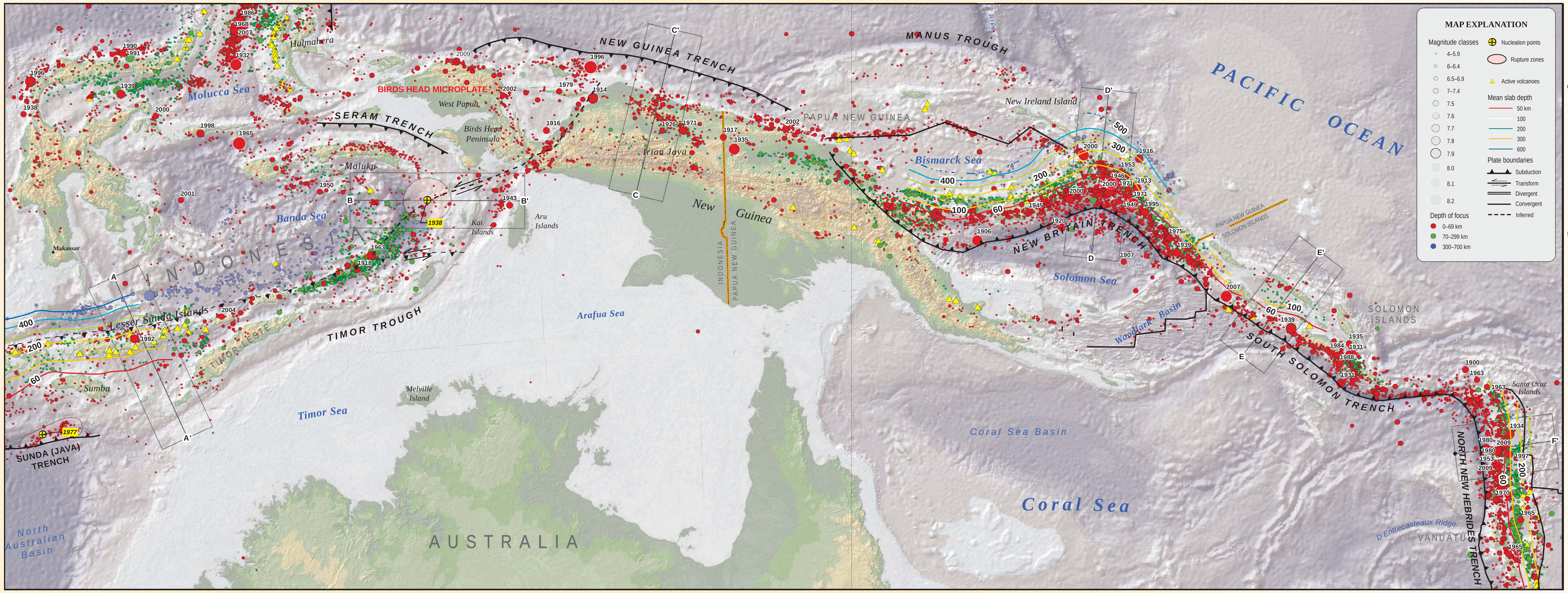
The earthquakes portrayed on the main map and the depth profiles are taken from two sources: (a) the Centennial earthquake catalog (Engdahl and Villaseñor, 2002) and annual supplements for the interval 1900–2007, where the magnitude floor is 5.5 globally, and (b) a catalog of earthquakes having high-quality depth determinations for the period 1964–2002 and a magnitude range of 5.0≤M≤5.4 (Engdahl, personal comm. 2003).

The nucleation points of great earthquakes (M≥8.3) are designated with a label showing the year of occurrence. Their rupture areas are shown as pale reddish polygons. Major earthquakes (7.5≥M≤8.2) are labeled with the year of occurrence, while earthquakes (8.0≥M≤8.2) are labeled with the year of occurrence and also denoted by a white outline. (Tarr and others, 2010). The aftershock rupture zone of the M8.4 1938 Banda Sea earthquake could not be determined. Consequently, a radial area comparable to the aftershock zone expected for such an event is shown.

The Seismic Hazard and Relative Plate Motion panel displays the generalized seismic hazard of the region (Giardini and others, 1999) and representative relative plate motion vectors using the NUVEL-1A model (DeMets, and others, 1994.)

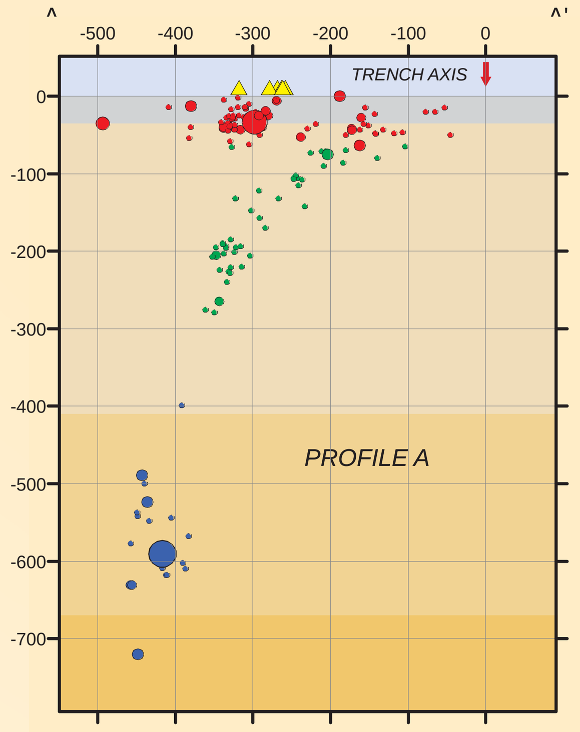
Pre-instrumental seismicity was obtained from the NOAA National Geophysical Data Center (2010) database of significant earthquakes; locations are approximate, based on macro-seismic reports and field investigations. We selected earthquakes with associated reports of moderate to major damage, 10 or more deaths, an estimated magnitude of 7.5 or greater (if known), Modified Mercalli Intensities X, or tsunami generation.

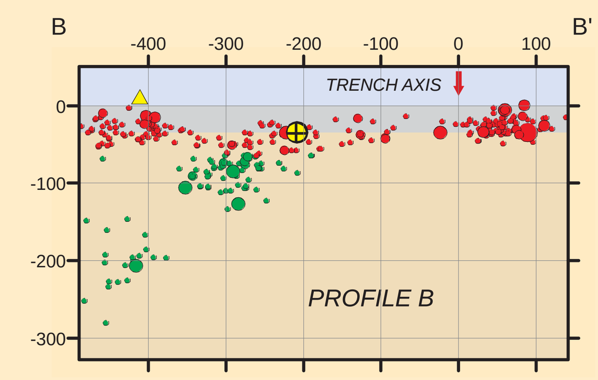
Base map data sources include GEBCO 2008, Volcanoes of the World Dataset (Siebert an Simkin (2002), plate boundaries (Bird, 2003), Digital Chart of the World (1992), and ESRI (2002). Slab contours from Hayes and Wald (2010).

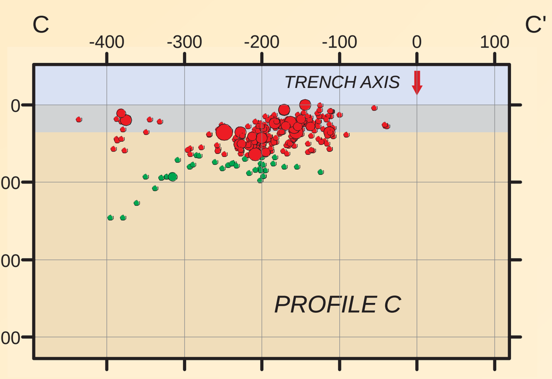


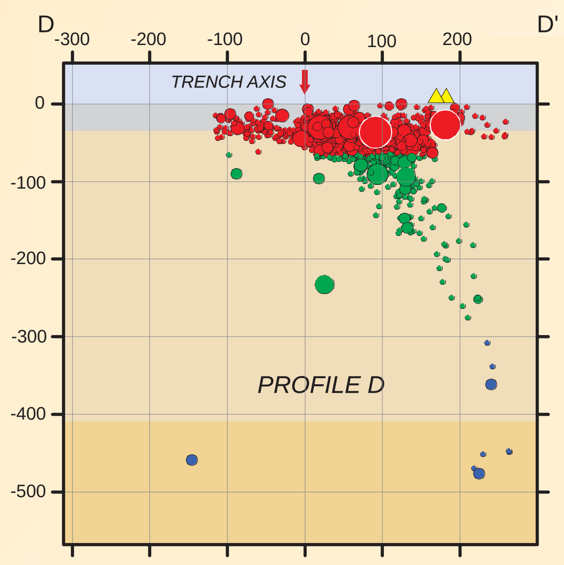
Albers Equal Area Conic Projection
Digital map database and cartography by Susan Rhea and Arthur Tarr
Manuscript approved for publication Nov. 16, 2011

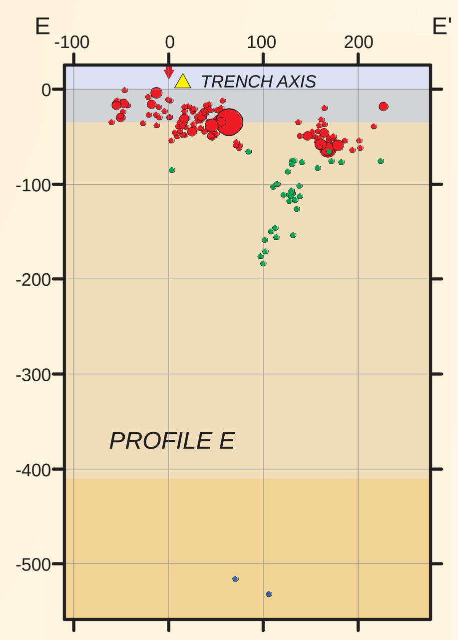
SCALE 1:8 000 000
0 100 200 400 600 KILOMETERS

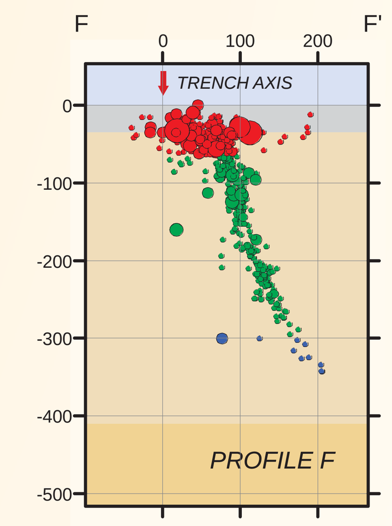












REFERENCES

Bird, Peter, 2003, An updated digital model of plate boundaries: Geochemistry Geophysics Geosystems, v. 4, no. 3, 52 p.

DeMets, Charles, Gordon, R.G., Argus, D.F., and Stein, Seth, 1994, Effects of recent revisions to the geomagnetic time scale on estimates of current plate motions: Geophysical Research Letters, v. 21, p. 2191–2194.

Digital Chart of the World, 1992: *http://earth-info.nga.mil/publications/specs/printed/89009/89009_DCW.pdf*, last accessed Mar. 9, 1996.

Engdahl, E.R., and Villaseñor, Antonio, 2002, Global seismicity 1900–1999, *in* Lee, W.H.K., Kanamori, Hiroo, Jennings, P.C., and Kisslinger, Carl, eds, International Handbook of Earthquake and Engineering Seismology, v. 81(A), chap. 41, p. 665–690.

ESRI, 2002, ESRI data and maps: Redlands, Calif., ESRI. Available at *http://www.esri.com/data/data-maps/index.html*.

GEBCO, 2008, The GEBCO_08_Grid, ver. 20091120, last accessed January 8, 2010 at *http://www.gebco.net/*.

Giardini, D., Grünthal, G., Shedlock, K., Zhang, P., and Global Seismic Hazards Program, 1999, Global Seismic Hazards Map, last accessed January 9, 2007, at *http://www.seismo.ethz.ch/GSHAP*.

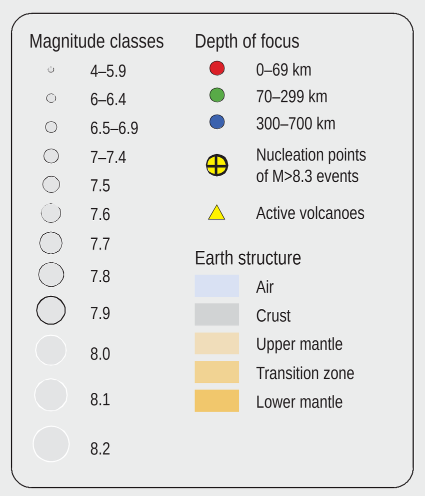
Hayes, Gavin., and Wald, David., 2010, Slab models for subduction zones: U.S. Geological Survey Earthquake Hazards Program, last accessed July 22, 2010 at *http://earthquake.usgs.gov/research/data/slab/*.

NOAA, 2010, National Geophysical Data Center: National Oceanic and Atmospheric Administration, accessed on March 31, 2010 at *http://www.ngdc.noaa.gov/hazards*.

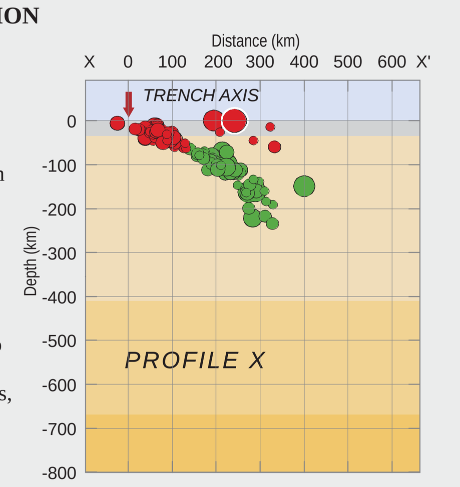
Siebert, Lee, and Simkin, Thomas, 2002, Volcanoes of the world: An illustrated catalog of Holocene volcanoes and their eruptions: Smithsonian Institution, Global Volcanism Program Digital Information series, GVP–3, last accessed January 9, 2007, at *http://www.volcano.si.edu/world/*.

Tarr, A.C., Villaseñor, Antonio, Furlong, K.P., Rhea, Susan, and Benz, H.M., 2010, Seismicity of the Earth 1900–2007: U.S. Geological Survey Scientific Investigations Map 3064, scale 1:25,000,000.

DEPTH PROFILE EXPLANATION

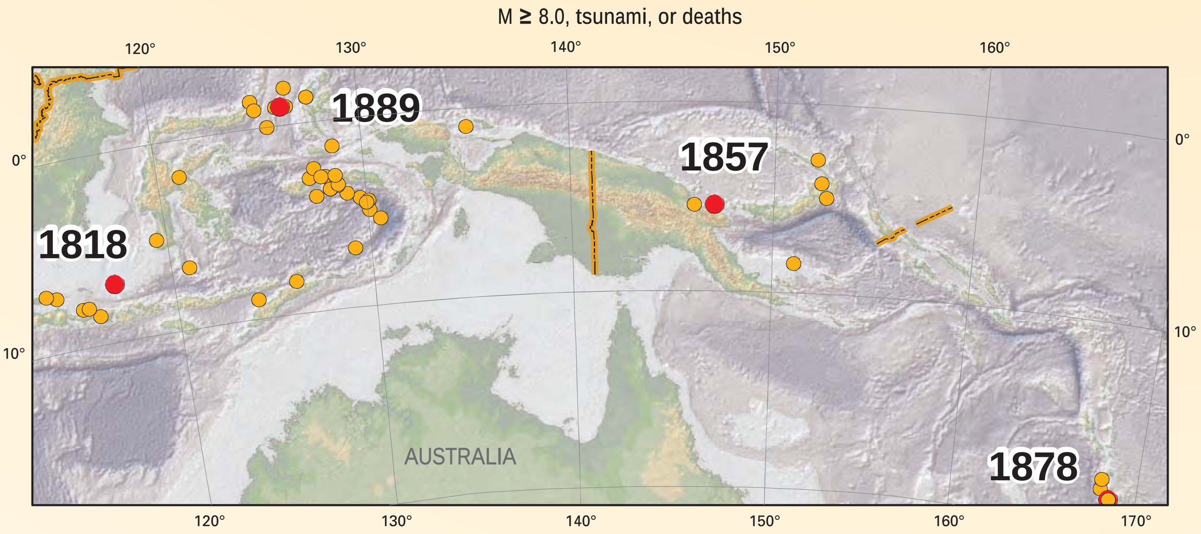


Profiles of earthquake and volcano locations are constructed from the mapped data. Locations of the profile intersection with the surface are drawn on the map and labeled to coincide with the profile label. Box defines extent of earthquakes included in profile. Length of the profile graphic is the same as in the map. Distance in kilometers from the trench axis is indicated in the X direction. Depth, in kilometers is indicated in the Y direction. There is no vertical exaggeration. See Explanation at side for color key. Not all earth layers, earthquake depths or magnitudes, are visible on every map.



PRE-INSTRUMENTAL SEISMICITY 1500–1899

M ≥ 8.0, tsunami, or deaths



This and other USGS information products are available at http://store.usgs.gov/
U.S. Geological Survey
Box 25286, Denver Federal Center
Denver, CO 80225

To learn about the USGS and its information products visit http://www.usgs.gov/
1-888-ASK-USGS

This report is available at:
http://pubs.usgs.gov/of/2010/1083/h

For more information concerning this publication, contact:
Center Director, USGS Geologic Hazards Science Center
Box 25046, Mail Stop 966
Denver, CO 80225
(303) 273-8579

Or visit Geologic Hazards Science Center Web site at:
http://geohazards.cr.usgs.gov/

Suggested citation:
Benz, H.M., Herman, Matthew, Tarr, A.C., Hayes, G.P., Furlong, K.P., Villaseñor, Antonio, Dart, R.L., and Rhea, Susan, 2011, Seismicity of the Earth 1900–2010 New Guinea and vicinity: U.S. Geological Survey Open-File Report 2010–1083-H, scale 1:8,000,000.

SEISMIC HAZARD AND RELATIVE PLATE MOTION

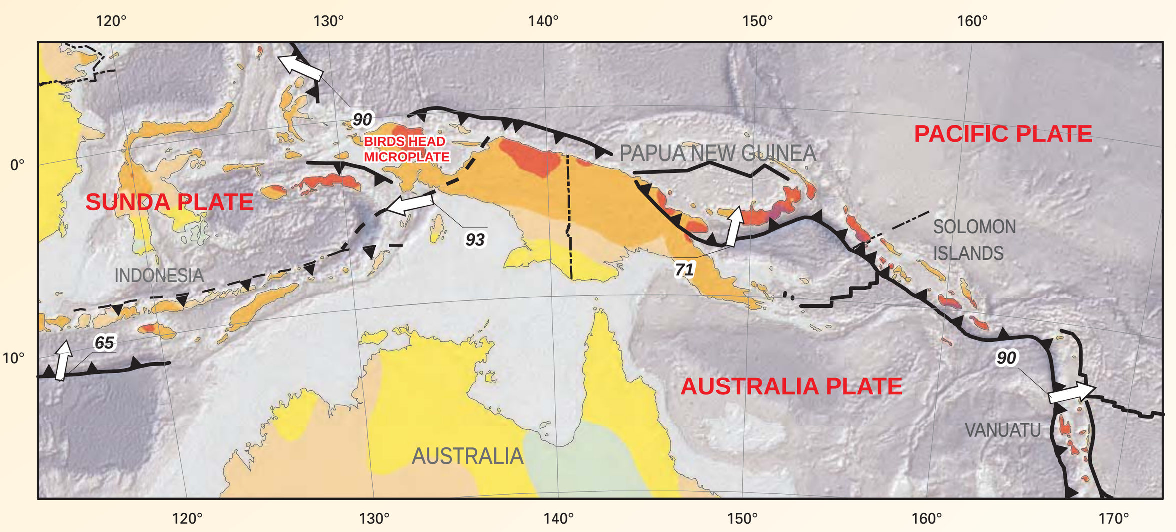


FIGURE EXPLANATION

Peak ground acceleration
- 0–0.2 m/s²
- 0.2–0.4
- 0.4–0.8
- 0.8–1.6
- 1.6–3.2
- 3.2–6.4
- 6.4–9.8

Relative plate motion
- 11.0–19.9 mm/yr
- 20.0–39.9
- 40.0–59.9
- 60.0–79.9
- 80.0–100.0

Plate boundaries
- Subduction
- Transform
- Divergent
- Convergent
- Inferred