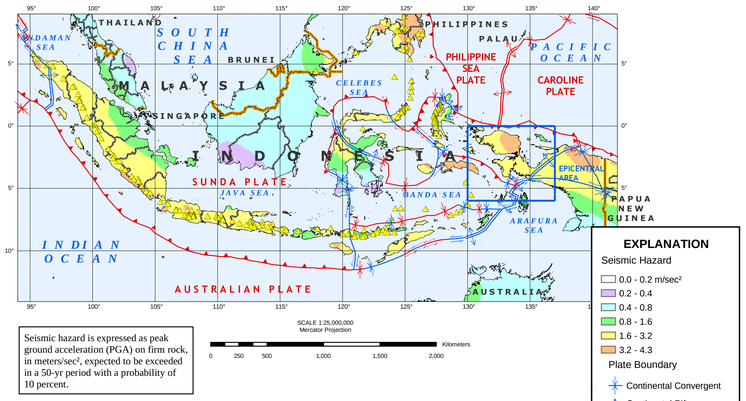
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY



# Papua, Indonesia Earthquake Sequence of February 2004

## Generalized Seismic Hazard of Indonesia




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.

**EXPLANATION**

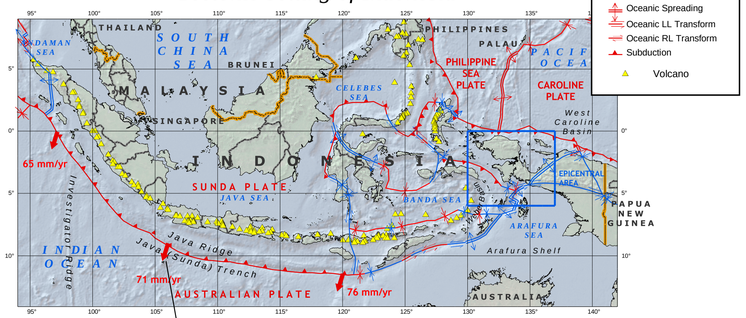
Seismic Hazard

- 0.0 - 0.2 m/sec²
- 0.2 - 0.4
- 0.4 - 0.8
- 0.8 - 1.6
- 1.6 - 3.2
- 3.2 - 4.3

Plate Boundary

- Continental Convergent
- Continental Rift
- Continental LL Transform
- Continental RL Transform
- Oceanic Convergent
- Oceanic Spreading
- Oceanic LL Transform
- Oceanic RL Transform
- Subduction
- Volcano

## Tectonic Setting of Indonesia

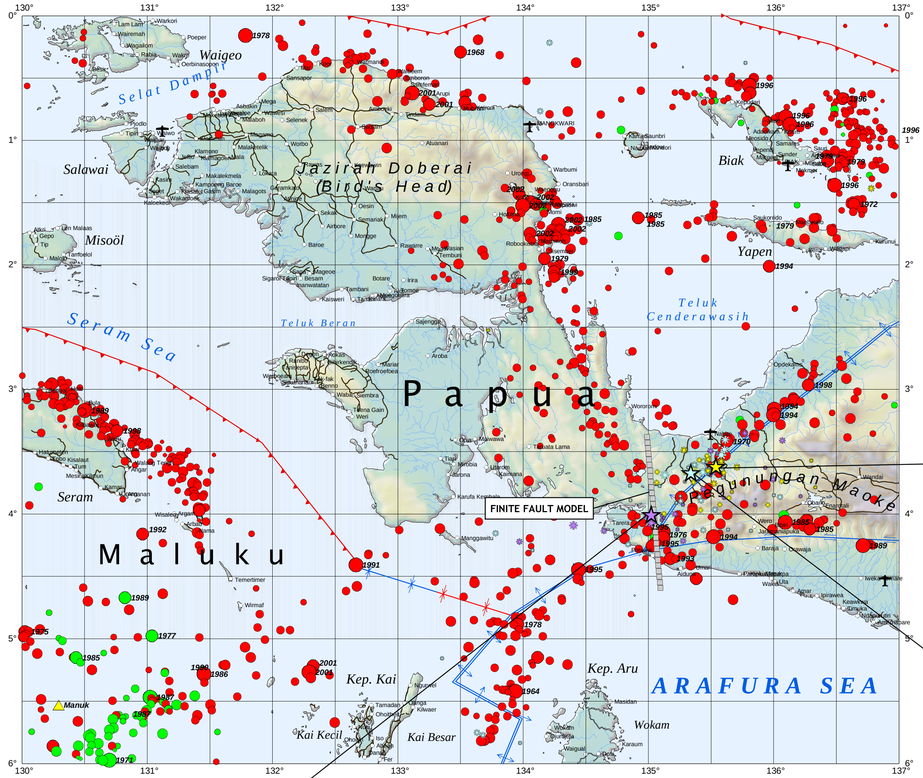



**LARGEST EARTHQUAKES IN THE EPICENTRAL AREA**
**1964 - 2002**

| YR | MO | DY | LAT | LON | DEPTH | MAG |
|---|---|---|---|---|---|---|
| 1964 | 4 | 23 | -5.420 | 133.939 | 6.1 | 6.4 |
| 1968 | 7 | 29 | -0.291 | 133.499 | 32.7 | 6.1 |
| 1970 | 11 | 8 | -3.418 | 135.624 | 2.3 | 6.2 |
| 1971 | 9 | 16 | -5.971 | 130.697 | 133.0 | 6.4 |
| 1972 | 12 | 4 | -1.513 | 136.639 | 1.4 | 6.1 |
| 1975 | 1 | 14 | -4.942 | 130.021 | 16.4 | 6.0 |
| 1976 | 11 | 18 | -4.193 | 135.116 | 3.6 | 6.5 |
| 1977 | 3 | 15 | -4.976 | 131.036 | 75.7 | 6.2 |
| 1978 | 4 | 3 | -4.884 | 133.956 | 6.4 | 6.3 |
| 1978 | 8 | 3 | -0.157 | 131.785 | 40.5 | 6.4 |
| 1979 | 9 | 12 | -1.686 | 135.969 | 18.5 | 7.6 |
| 1979 | 9 | 13 | -1.166 | 136.430 | 17.9 | 6.1 |
| 1979 | 10 | 17 | -1.171 | 136.535 | 18.4 | 6.1 |
| 1979 | 11 | 16 | -1.951 | 134.170 | 37.8 | 6.1 |
| 1985 | 4 | 8 | -4.050 | 136.259 | 18.3 | 6.0 |
| 1985 | 4 | 21 | -5.151 | 130.430 | 91.0 | 6.0 |
| 1985 | 9 | 15 | -4.005 | 136.093 | 4.4 | 6.4 |
| 1985 | 9 | 15 | -4.120 | 136.287 | 11.1 | 6.3 |
| 1985 | 11 | 17 | -1.634 | 134.434 | 26.5 | 6.0 |
| 1985 | 11 | 17 | -1.671 | 134.937 | 11.8 | 7.3 |
| 1985 | 12 | 6 | -1.623 | 134.918 | 19.9 | 6.0 |
| 1986 | 10 | 17 | -5.283 | 131.453 | 58.1 | 6.4 |
| 1987 | 6 | 17 | -5.599 | 130.835 | 67.0 | 7.1 |
| 1987 | 10 | 3 | -5.467 | 131.023 | 74.0 | 6.4 |
| 1989 | 1 | 10 | -3.170 | 130.500 | 32.0 | 6.7 |
| 1989 | 9 | 4 | -4.253 | 136.713 | 9.0 | 6.4 |
| 1989 | 12 | 12 | -4.671 | 130.821 | 74.2 | 6.1 |
| 1990 | 12 | 5 | -5.269 | 131.446 | 75.0 | 6.1 |
| 1991 | 12 | 29 | -4.407 | 132.665 | 42.5 | 6.4 |
| 1992 | 4 | 7 | -4.161 | 130.961 | 51.0 | 6.0 |
| 1993 | 6 | 12 | -4.357 | 135.175 | 10.0 | 6.1 |
| 1994 | 1 | 19 | -3.205 | 136.000 | 23.0 | 6.8 |
| 1994 | 4 | 13 | -3.159 | 136.005 | 29.0 | 6.5 |
| 1994 | 5 | 25 | -4.182 | 135.520 | 15.0 | 6.5 |
| 1994 | 11 | 20 | -2.011 | 135.962 | 16.0 | 6.3 |
| 1995 | 1 | 27 | -4.445 | 134.442 | 22.0 | 6.8 |
| 1995 | 3 | 19 | -4.143 | 135.118 | 26.5 | 6.9 |
| 1995 | 3 | 19 | -4.236 | 135.051 | 19.0 | 6.1 |
| 1996 | 2 | 17 | -0.558 | 135.804 | 19.0 | 6.5 |
| 1996 | 2 | 17 | -0.811 | 136.096 | 32.0 | 6.5 |
| 1996 | 2 | 17 | -0.871 | 136.128 | 32.0 | 6.5 |
| 1996 | 2 | 17 | -0.918 | 136.971 | 36.0 | 8.2 |
| 1996 | 2 | 18 | -0.665 | 136.550 | 20.2 | 6.3 |
| 1996 | 2 | 18 | -1.360 | 136.487 | 11.0 | 6.4 |
| 1998 | 4 | 27 | -2.965 | 136.275 | 24.0 | 6.1 |
| 1998 | 11 | 18 | -3.332 | 130.757 | 31.2 | 6.0 |
| 1999 | 10 | 10 | -2.056 | 134.245 | 10.0 | 6.1 |
| 2001 | 1 | 29 | -0.710 | 133.250 | 14.0 | 6.2 |
| 2001 | 4 | 4 | -5.265 | 132.290 | 17.0 | 6.4 |
| 2001 | 7 | 22 | -5.216 | 132.322 | 38.4 | 6.0 |
| 2001 | 9 | 11 | -0.618 | 133.115 | 31.1 | 6.5 |
| 2002 | 9 | 20 | -1.675 | 134.281 | 24.0 | 6.4 |
| 2002 | 9 | 20 | -1.747 | 134.054 | 9.0 | 6.0 |
| 2002 | 10 | 10 | -1.432 | 133.966 | 15.8 | 6.0 |
| 2002 | 10 | 10 | -1.493 | 134.056 | 48.8 | 6.0 |
| 2002 | 10 | 10 | -1.526 | 133.996 | 36.7 | 6.7 |
| 2002 | 10 | 10 | -1.711 | 134.311 | 16.0 | 7.7 |

From: Engdahl (2003, unpublished catalog)

## Epicentral Area




PAPUA, INDONESIA

7 February 2004 02:42:35.43 UTC
4.003° S., 135.023° E.
Depth 10 km
Mw = 7.3 (USGS)

This earthquake occurred approximately 30 hours after and about 70 km southwest of an M7.0 shock on 5 February 2004 that killed at least 37 people in and near the town of Nabire. The epicenter of this latest earthquake is in a particularly remote area; consequently, reports of casualties and damage emerging from the region are expected to be incomplete; however, additional damage was reported in Nabire.

### DISCUSSION

These earthquakes occurred in a region considered to have the most complex present-day tectonics on Earth. In the area surrounding Irian Jaya (the western half of New Guinea), four major tectonic plates, the Australian, Sunda, Philippine Sea, and Caroline plates, sandwich half a dozen proposed microplates. The interactions between these microplates produce all possible styles of faulting. These particular earthquakes ruptured strike-slip faults near the boundary of the Bird's Head plate and the recently proposed Maoke plate.

### RELATIVE PLATE MOTIONS

The relative motion of adjacent tectonic plates is depicted on the map by short vectors shown at selected locations on the plate boundary. In this presentation, one of the plates is defined as the reference plate. The vector therefore represents the direction of motion of the adjacent plate relative to the reference plate. The rate of relative motion is labeled next to the vector.

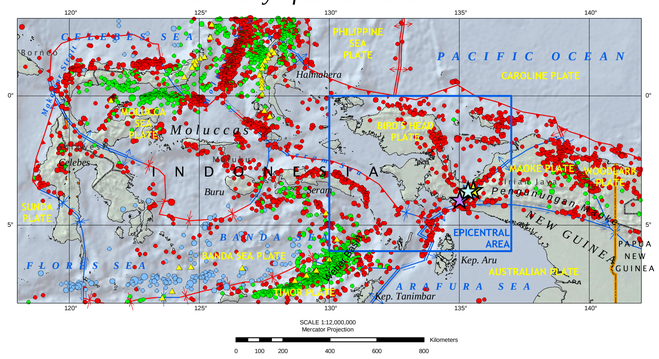
The components of the vector perpendicular and parallel to the plate margin approximate convergent/divergent and transverse direction of motion between the plates, respectively. As viewed from the reference plate, an inward directed component suggests convergence at and near the plate boundary that may be expressed as crustal folding, uplift, thrust faulting, or plate subduction. Similarly, an outward directed component suggests plate divergence such as would be expected at a zone of crustal spreading. Transcurrent or transform faulting would be expected when the dominant vector component is parallel to the plate margin.

In the Tectonic Setting map, the reference plate is the Australian plate and the adjacent plate is the Sunda plate. The vectors indicate that the Sunda plate is moving roughly south-southwest relative to the Australian plate at a rate that varies from about 65 mm/yr to 76 mm/yr. The Java (Sunda) Trench, deep earthquake foci, and line of volcanoes parallel to the plate boundary are characteristic of typical subduction zones.

### 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.

## Seismicity of Eastern Indonesia



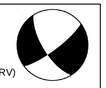

PAPUA, INDONESIA

5 February 2004 21:05:04.76 UTC
3.615° S., 135.538°E.
Depth 17 km
Mw = 7.0 (HRV)

This earthquake occurred in the sparsely populated eastern Indonesian province of Papua, a mountainous and jungle- clad area of western New Guinea. The epicenter of this earthquake was located approximately 25 km from Nabire, a coastal town of about 26,000 people. Unofficial reports placed the death toll at 37, with 682 injured and 2,678 structures damaged. Local roads, an airport runway, and nine bridges were damaged as well as two pipelines at an oil refinery nearby. The earthquake also caused minor injuries and damage at two other towns, Enarotali and Manokwari.

PAPUA, INDONESIA

8 February 2004 08:58:51.80 UTC
3.665° S., 135.339° E.
Depth 26 km
Ms = 6.9 (USGS); Mw = 6.5 (USGS), 6.7 (HRV)



This was the third large earthquake of the sequence that began on 5 February 2004 approximately 20 km to the northeast. The two events are notable because they had similar magnitudes and focal mechanisms. Felt (MMI VI) in Nabire.

**EXPLANATION**

Main Shock #1
5 February 2004
Main Shock #2
7 February 2004
Main Shock #3
8 February 2004

Post-Mainshock Activity
- 5 - 6 February 2004
- 7 February 2004
- 8 February - 20 March 2004

Aftershock Magnitude Classes
- M < 3.5
- 3.5 - 3.9
- 4.0 - 4.4
- 4.5 - 4.9
- 5.0 - 5.4
- 5.5 - 5.9

Earthquakes 1964 - 2002
- 0 - 69 km
- 70 - 299

Magnitude Classes
- 4.0 - 4.4
- 4.5 - 4.9
- 5.0 - 5.4
- 5.5 - 5.9
- 6.0 - 6.4
- 6.5 - 6.9

Generalized Plate Boundaries
- Continental Convergent
- Continental Rift
- Continental LL Transform
- Oceanic Convergent
- Subduction
- Volcano

**EXPLANATION**

Main Shock #1
5 February 2004
Main Shock #2
7 February 2004
Main Shock #3
8 February 2004

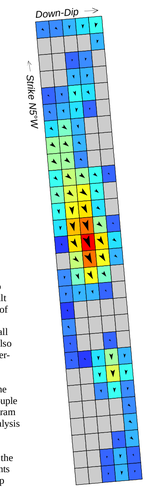
Magnitude Classes
- 5.0 - 5.9
- 6.0 - 6.9
- 7.0 - 7.9
- 8.0 - 8.9

Plate Boundaries
- Continental Convergent
- Continental Rift
- Continental LL Transform
- Continental RL Transform

Earthquakes 1964 - 2002
- 0 - 69 km
- 70 - 299
- 300 - 700

- Oceanic Convergent
- Oceanic Spreading
- Oceanic LL Transform
- Oceanic RL Transform
- Subduction
- Volcano

## Finite Fault Model




**EXPLANATION**

Amount of Slip
- 0 cm
- 30
- 60
- 90
- 120
- 150
- 180
- 210
- 240 cm
- 270
- 300
- 330
- 360
- 390
- 420
- 450
- 480
- 510

FINITE FAULT MODEL
(C. Ji, California Institute of Technology)

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 waveforms. 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 is from above, perpendicular to the fault plane.

The fact that the orientation of the finite fault plane may differ from the corresponding best double couple nodal plane depicted in the focal mechanism diagram on the main map reflects differing methods of analysis and data sets.

The strike of the fault rupture plane is N5°W and the dip is 80°. The dimensions of the subfault elements are 5 km in the strike direction and 4 km in the dip direction.

### 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.

### ON-LINE NEWS RESOURCES

ABC News http://abcnews.go.com/wire/World/
Arizona Central News http://www/azcentral/com/news/
Channel News Asia http://www.channelnewsasia.com/stories/
Radio Australia http://www.abc.net.au/ra/

### 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
PB2003 (Bird, 2003)

VOLCANOES
Smithsonian Institution, Global Volcano Program

BASE MAP
NIMA and ESRI, Digital Chart of the World
USGS, EROS Data Center

Map prepared by U.S. Geological Survey
National Earthquake Information Center
25 May 2004
Map not approved for release by Director USGS