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

SCIENTIFIC INFORMATION MAP XXX

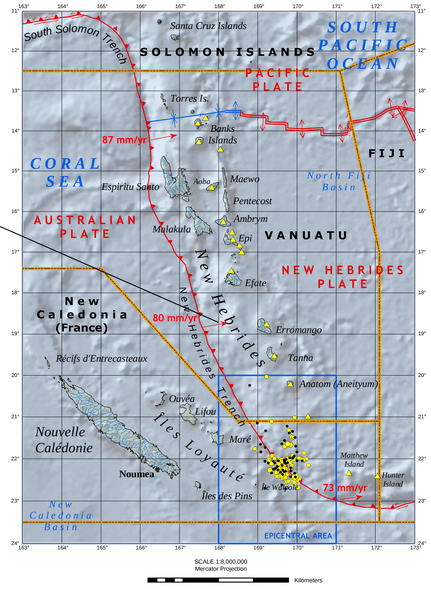
Loyalty Islands Earthquake Sequence of December 2003 and January 2004

RELATIVE PLATE MOTIONS

The relative motion of adjacent tectonic plates is depicted on the map by short vectors located at selected points on the plate boundary. In this presentation, one plate (the fixed reference plate) is assumed to be rigid. The vector therefore represents the direction of the moving plate relative to the reference plate. The rate of relative motion is labelled next to the vector. For this map, the relative motion vector and rate are computed assuming that the Pacific plate is the reference plate and that the Australian plate is the moving plate.

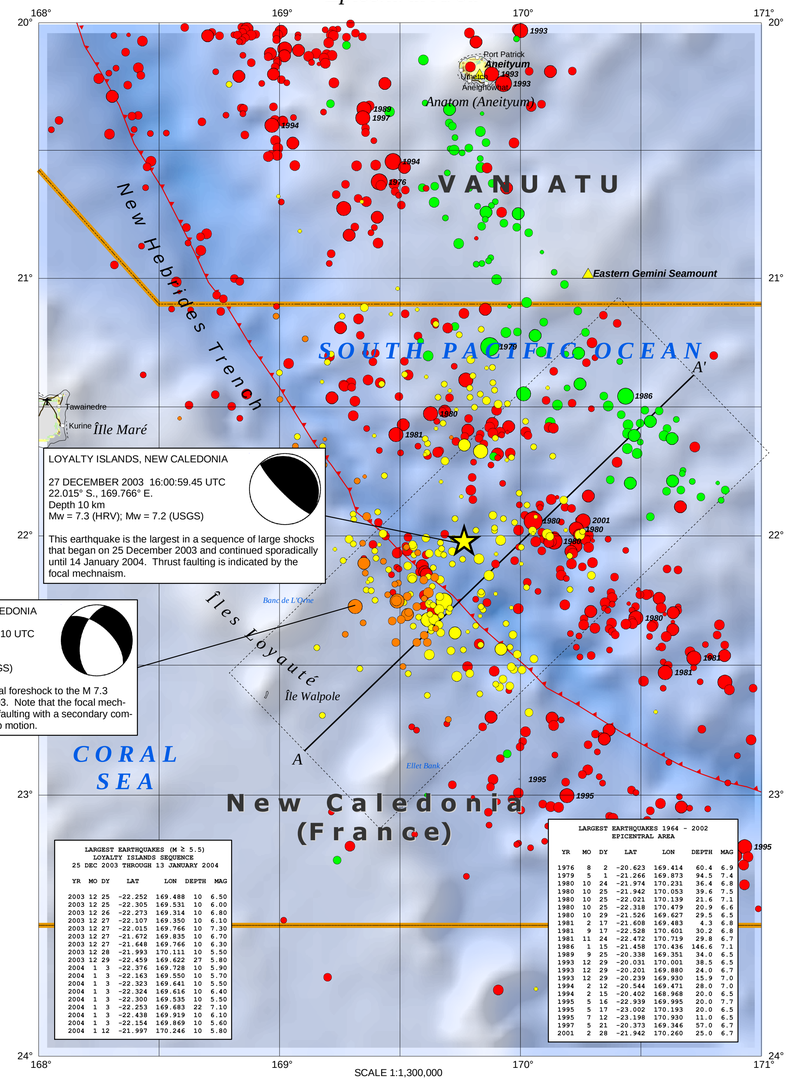
The components of the vector perpendicular and parallel to the plate margin approximate convergent/divergent and transverse direction of motion between the plates, respectively. As viewed from the reference plate, an inward directed component suggests convergence at and near the plate boundary that may 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 predominant vector component is parallel to the plate margin.

Plate Tectonic Setting



EXPLANATION
Earthquake Sequence
4.7 - 4.9
5.0 - 5.9
6.0 - 6.9
7.0 - 7.3
Volcanoes
Plate Boundary
Continental Convergent
Continental Rift
Oceanic Spreading
Oceanic LL Transform
Oceanic RL Transform
Subduction

Epicentral Area



LOYALTY ISLANDS, NEW CALEDONIA

27 DECEMBER 2003 16:00:59.45 UTC
22.015° S., 169.766° E.
Depth 10 km
Mw = 7.3 (HRV); Mw = 7.2 (USGS)

This earthquake is the largest in a sequence of large shocks that began on 25 December 2003 and continued sporadically until 14 January 2004. Thrust faulting is indicated by the focal mechnaism.

LOYALTY ISLANDS, NEW CALEDONIA

26 DECEMBER 2003 21:26:04.10 UTC
22.273° S., 169.314° E.
Depth 10 km
Mw = 6.8 (HRV); Mw = 6.7 (USGS)

This earthquake was the principal foreshock to the M 7.3 earthquake of 27 December 2003. Note that the focal mechanism indicates primary normal faulting with a secondary component of right- lateral strike- slip motion.

LARGEST EARTHQUAKES (M ≥ 5.5)
LOYALTY ISLANDS SEQUENCE
25 DEC 2003 THROUGH 13 JANUARY 2004

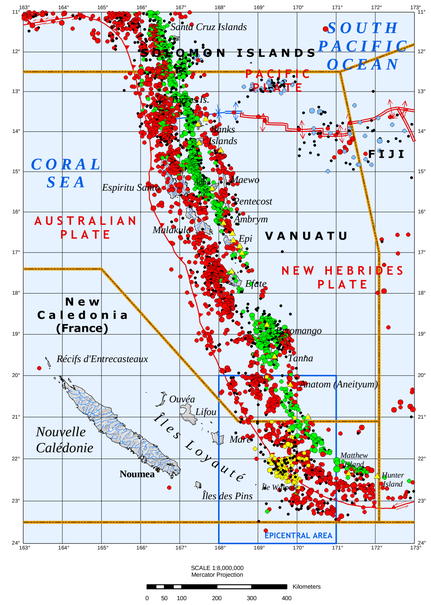
YR	MO	DY	LAT	LON	DEPTH	MAG
2003	12	25	-22.252	169.488	10	6.50
2003	12	25	-22.305	169.531	10	6.00
2003	12	26	-22.273	169.314	10	6.80
2003	12	27	-22.107	169.350	10	6.10
2003	12	27	-22.015	169.766	10	7.30
2003	12	27	-21.672	169.835	10	6.70
2003	12	27	-21.648	169.766	10	6.30
2003	12	28	-21.993	170.111	10	5.50
2003	12	29	-22.459	169.622	27	5.80
2004	1	3	-22.376	169.728	10	5.90
2004	1	3	-22.163	169.550	10	5.70
2004	1	3	-22.323	169.641	10	5.50
2004	1	3	-22.324	169.616	10	6.40
2004	1	3	-22.300	169.535	10	5.50
2004	1	3	-22.253	169.683	22	7.10
2004	1	3	-22.438	169.919	10	6.10
2004	1	3	-22.154	169.869	10	5.60
2004	1	12	-21.997	170.246	10	5.80

LARGEST EARTHQUAKES 1964 - 2002
EPICENTRAL AREA

YR	MO	DY	LAT	LON	DEPTH	MAG
1976	8	2	-20.623	169.414	60.4	6.9
1979	5	1	-21.266	169.873	94.5	7.4
1980	10	24	-21.974	170.231	36.4	6.8
1980	10	25	-21.942	170.053	39.6	7.5
1980	10	25	-22.021	170.139	21.6	7.1
1980	10	25	-22.318	170.479	20.9	6.6
1980	10	29	-21.526	169.627	29.5	6.5
1981	2	17	-21.608	169.483	4.3	6.8
1981	9	17	-22.528	170.601	30.2	6.8
1981	11	24	-22.472	170.719	29.8	6.7
1986	1	15	-21.458	170.436	146.6	7.1
1989	9	25	-20.338	169.351	34.0	6.5
1993	12	29	-20.031	170.001	38.5	6.5
1993	12	29	-20.201	169.880	24.0	6.7
1993	12	29	-20.239	169.930	15.9	7.0
1994	2	12	-20.544	169.471	28.0	7.0
1994	2	15	-20.402	168.968	20.0	6.5
1995	5	16	-22.939	169.995	20.0	7.7
1995	5	17	-23.002	170.193	20.0	6.5
1995	7	12	-23.198	170.930	11.0	6.5
1997	5	21	-20.373	169.346	57.0	6.7
2001	2	28	-21.942	170.260	25.0	6.7

EXPLANATION
Earthquake Sequence
25 - 27 Dec. 2003
27 Dec. 2003 - 14 Jan. 2004
Depth Classes 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
7.0 - 7.4
7.5 - 7.9
Plate Boundary
Subduction
Volcano
Populated Place
Road
Airport

Seismicity of the New Hebrides Arc



EXPLANATION
Earthquake Sequence
4.0 - 4.9
5.0 - 5.9
6.0 - 6.9
7.0 - 7.9
Depth Classes 1964 - 2002
0 - 69 km
70 - 299
300 - 700
Magnitude Classes
4.0 - 4.9
5.0 - 5.9
6.0 - 6.9
7.0 - 7.9
Volcanoes
Plate Boundary
Continental Convergent
Continental Rift
Oceanic Spreading
Oceanic LL Transform
Oceanic RL Transform
Subduction

LARGEST EARTHQUAKES 1964 - 2002
NEW HEBRIDES ARC AND VICINITY

YR	MO	DY	LAT	LON	DEPTH	MAG
1966	12	31	-11.893	166.445	82.9	7.5
1970	8	11	-14.093	166.571	38.3	7.5
1973	12	28	-14.500	166.784	23.3	7.8
1979	5	1	-21.266	169.873	94.5	7.4
1980	3	8	-22.639	171.453	40.1	7.2
1980	7	8	-12.487	166.483	56.6	7.5
1980	7	17	-12.505	166.010	31.9	7.8
1980	10	25	-21.942	170.053	39.6	7.5
1980	10	25	-22.021	170.139	21.6	7.1
1981	7	6	-22.251	171.814	30.0	7.6
1981	7	15	-17.263	167.695	13.2	7.1
1982	8	5	-12.454	166.201	9.4	7.1
1984	11	15	-22.044	171.018	131.6	7.1
1985	11	28	-13.983	166.284	51.1	7.0
1985	11	28	-14.051	166.324	41.3	7.0
1985	12	21	-14.010	166.633	43.1	7.2
1986	1	15	-21.458	170.436	146.6	7.1
1990	3	5	-18.318	168.157	21.0	7.0
1990	7	27	-15.329	167.539	126.0	7.2
1990	8	12	-19.440	169.237	140.0	7.1
1992	5	27	-11.076	165.290	19.0	7.0
1992	10	11	-19.253	169.036	129.0	7.4
1993	12	29	-20.239	169.930	15.9	7.0
1994	2	12	-20.544	169.471	28.0	7.0
1994	7	13	-16.600	167.538	33.4	7.3
1995	5	16	-22.939	169.995	20.0	7.7
1997	4	21	-12.570	166.799	28.0	7.9
1997	11	15	-15.101	167.450	113.0	7.0
1998	1	4	-22.242	171.019	97.2	7.5
1998	7	16	-11.033	166.266	93.0	7.0
1999	2	6	-12.805	166.783	76.0	7.3
1999	11	26	-16.320	168.241	33.0	7.4
2000	10	4	-15.341	167.006	23.0	7.0
2001	1	9	-14.945	167.298	103.0	7.0
2002	1	2	-17.607	167.952	23.0	7.5

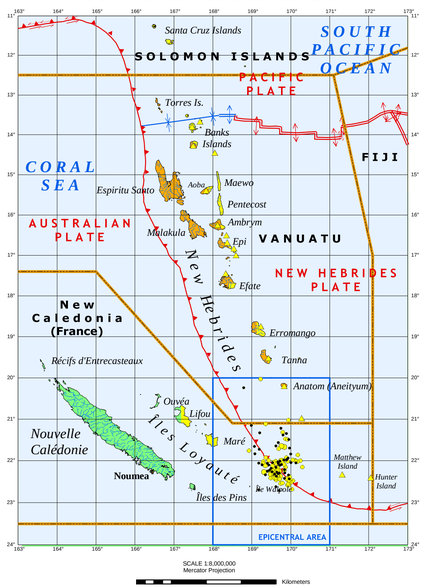
Generalized Seismic Hazard

DISCUSSION

On 25 December 2003, an extended sequence of some 270 earthquakes commenced in the Loyalty Islands, located in the southeastern corner of the French territory of New Caledonia. The sequence included three large shocks, an M 6.8 foreshock on 26 December, an M 7.3 main shock on 27 December, and an M 7.1 earthquake on 3 January 2004 that was part of an aftershock series that essentially terminated on 13 January (see diagram at lower right).

This earthquake sequence occurred within the broader zone of intense regional seismicity of the New Hebrides island arc. The arc gently curves to the SSE from the Santa Cruz Islands, across the island nation of Vanuatu, and terminates where the seismic zone curves sharply to the east near the Loyalty Islands (see Seismicity of the New Hebrides Arc map). The arc's islands, many of which are volcanic, lie parallel to the New Hebrides Trench. Bands of shallow depth (0 - 69 km) and intermediate depth (70 - 299 km) earthquakes are also parallel to the axes of the trench and island chain. A band of shallow seismicity clearly defines the extent of the outer ridge of the New Hebrides Trench. The foreshocks were located principally in this outer ridge band while the aftershocks were located principally under the inner arc (see Epicentral Area map).

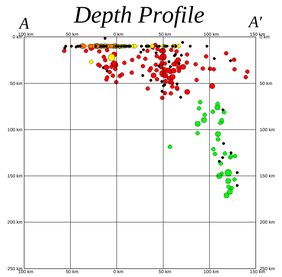
The shallow seismicity defines the zone of convergence of the Australian plate with the New Hebrides microplate (a segment of the much larger Pacific plate) and the intermediate seismicity defines the extent of the downgoing slab of Australian plate. The rate of convergence of the Australian plate is estimated to be about 75 mm/yr and the plate motion is ENE relative to the New Hebrides microplate (see Plate Tectonic Setting map). The focal mechanisms of the foreshock sequence were typical of normal faulting in a tensional horizontal stress regime while mechanisms of the main shock and the many aftershocks were characteristic of shallow thrust faulting.



EXPLANATION
Earthquake Sequence
4.0 - 4.9
5.0 - 5.9
6.0 - 6.9
7.0 - 7.9
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 - 5.9
Volcanoes
Plate Boundary
Continental Convergent
Continental Rift
Oceanic Spreading
Oceanic LL Transform
Oceanic RL Transform
Subduction

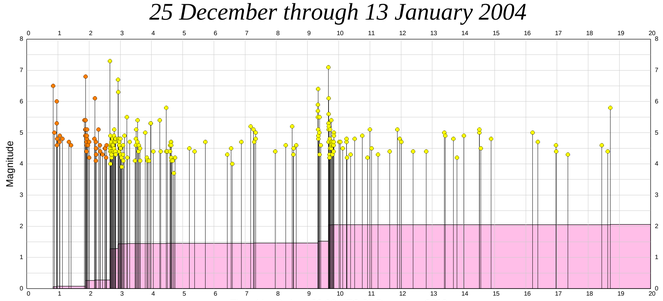
Seismic hazard is expressed as peak ground acceleration (PGA) on firm rock, in meters/sec², expected to be exceeded in a 50-yr period with a probability of 10 percent.

Depth Profile



EXPLANATION
Earthquake Sequence
25 - 27 Dec 2003
28 Dec 2003 - 13 Jan 2004
Depth Classes 1964 - 2002
0 - 69 km
70 - 299
Magnitude Classes
4.0 - 4.9
5.0 - 5.9
6.0 - 6.9
7.0 - 7.9

25 December through 13 January 2004



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

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.

REFERENCES

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

E.R. Engdahl, 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, pp. 722-743.

Engdahl, E.R. and Villaseñor, A., 2002, Global Seismicity: 1900-1999 in International Earthquake and Engineering Seismology, Part A: v. 81A, ch. 41, 26 p.

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