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

Seismicity of the Earth 1900–2010

Aleutian Arc and Vicinity

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

2011

OPEN-FILE REPORT 2010–1083-B
Revised September, 2011

TECTONIC SUMMARY

This map shows details of the Aleutian arc not visible in an earlier publication (Tarr and others, 2010).The Aleutian arc extends about 3,000 km from the Gulf of Alaska to the Kamchatka Peninsula. It marks the region where the Pacific plate subducts into the mantle beneath the North America plate. This subduction is responsible for the generation of the Aleutian Islands and the deep offshore Aleutian Trench. Relative to a fixed North America plate, the Pacific plate is moving northwest at a rate that increases from about 55 mm per year at the arc's eastern edge to 75 mm per year near its western terminus. In the east, the convergence of the plates is nearly perpendicular to the plate boundary. However, because of the boundary's curvature, as one travels westward along the arc, the subduction becomes more and more oblique to the boundary until the relative plate motion becomes parallel to the arc at the Near Islands near its western edge.

Subduction zones such as the Aleutian arc are geologically complex and produce numerous earthquakes from multiple sources. Deformation of the overriding North America plate generates shallow crustal earthquakes, whereas slip at the interface of the plates generates interplate earthquakes that extend from near the base of the trench to depths of 40 to 60 km. At greater depths, Aleutian arc earthquakes occur within the subducting Pacific plate and can reach depths of 300 km. Since 1900, six great earthquakes have occurred along the Aleutian Trench, Alaska Peninsula, and Gulf of Alaska: M8.4 1906 Rat Islands (Okal, 2005); M8.6 1938 Shumagin Islands (Estabrook and others, 1994); M8.6 1946 Unimak Island (Lopez and Okal, 2006); M8.6 1957 Andreanof Islands (Johnson and Satake, 1993); M9.2 1964 Prince William Sound (Kanamori, 1970); and M8.7 1965 Rat Islands (Wu and Kanamori, 1973).

Several relevant tectonic elements (plate boundaries and active volcanoes) provide a context for the seismicity presented on the main map panel. The plate boundaries (Bird, 2003) are most accurate along the axis of the Aleutian Trench and more diffuse or speculative in extreme northeastern Russia. The active volcanoes (Siebert and Simkin, 2002) parallel the Aleutian Trench from the Gulf of Alaska to the Rat Islands.

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 commun., 2009.)

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 Seismic Hazard and Relative Plate Motion map displays the generalized seismic hazard of the region (Giardini and others, 1999) and representative relative plate motion vectors of the Pacific plate relative to the adjacent North America plate using the NUVEL–1A model (DeMets and others, 1994).

Pre-instrumental seismicity for the Aleutian arc 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 Intensity at least X, or tsunami generation.

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

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, International Association for Earthquake Engineering, v. 81(A), chap. 41, p. 1–26.
ESRI, 2002, ESRI data and maps: Redlands, Calif., ESRI. Available at *http://www.esri.com/data/data-maps/index.html.*
Estabrook, C.H., Jacob, K.H., and Sykes, L.R., 1994, Body wave and surface wave analysis of large and great earthquakes along the eastern Aleutian arc, 1923–1993, Implications for future events: Journal of Geophysical Research, v. 99, no. B6, p. 11643–11662.
GEBCO, 2008, The GEBCO_08_Grid, ver. 20091120: *http://www.gebco.net/*, last accessed January 8, 2010.
Giardini, D., Grünthal, G., Shedlock, K., Zhang, P., and Global Seismic Hazards Program, 1999, Global seismic hazards map: *http://seismo.ethz.ch/GSHAP*, last accessed January 9, 2007.
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/.*
Johnson, J.M. and Satake, Kenji, 1993, Source parameters of the 1957 Aleutian earthquake from tsunami waveforms: Geophysical Research Letters, v. 20, no. 14, p. 1487–1490.
Kanamori, Hiroo, 1970, The Alaska earthquake of 1964: Radiation of long-period surface waves and source mechanism: Journal of Geophysical Research, v. 75, no. 26, p. 5029–5040.
Lopez, A.M., and Okal, E.A., 2006, A seismological reassessment of the source of the 1946 Aleutian 'tsunami' earthquake: Geophysical Journal International, v. 165, no. 3, p. 835–849.
NOAA, 2010, National Geophysical Data Center: National Oceanic and Atmospheric Administration, accessed on March 31, 2010 at *http://www.ngdc.noaa.gov/hazards.*
Okal, E.A., 2005, A re-evaluation of the great Aleutian and Chilean earthquakes of 1906 August 17: Geophysical Journal International, v. 161, no. 2, p. 268–282.
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: *http://www.volcano.si.edu/world/*, last accessed January 9, 2007.
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.
Wu, F.T., and Kanamori, Hiroo, 1973, Source mechanism of February 4, 1965, Rat Island earthquake: Journal of Geophysical Research, v. 78, no. 26, p. 6082–6092.

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

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

Scale 1:5,000,000
0 100 200 300 400 500 600 700 800 KILOMETERS

MAP EXPLANATION

Magnitude classes: 4–5.9; 6–6.4; 6.5–6.9; 7–7.4; 7.5; 7.6; 7.7; 7.8; 7.9; 8.0; 8.1; 8.2
Nucleation points
Rupture zones
Active volcanoes
Mean slab depth: 50 km; 100; 200; 300; 600
Plate boundaries: Subduction; Transform; Divergent; Convergent; Inferred
Depth of focus: 0–69 km; 70–299 km; 300–700 km

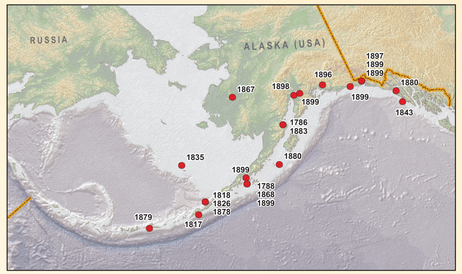
DEPTH PROFILE EXPLANATION

Magnitude classes: 4–5.9; 6–6.4; 6.5–6.9; 7–7.4; 7.5; 7.6; 7.7; 7.8; 7.9; 8.0; 8.1; 8.2
Depth of focus: 0–69 km; 70–299 km; 300–700 km
Nucleation points of M>8.3 events
Active volcanoes
Earth structure: Air; Crust; Upper mantle; Transition zone; Lower mantle

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 the profile. Length of the profile graphic is the same as on 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 magnitude, are visible on every profile.

PRE-INSTRUMENTAL SEISMICITY 1500–1899

Modified Mercalli Intensity (MMI) ≥ 4



Any use of trade, product or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this information product, for the most part, is in the public domain, it also contains copyrighted materials as noted in the text. Permission to reproduce copyrighted items for other than personal use must be secured from the copyright owner

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/b*

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., Tarr, A.C., Hayes, G.P., Villaseñor, Antonio, Hayes, G.P., Furlong, K.P., Dart, R.L., and Rhea, Susan, 2011, Seismicity of the Earth 1900–2010 Aleutian arc and vicinity: U.S. Geological Survey Open-File Report 2010–1083-B, scale 1:5,000,000.

SEISMIC HAZARD AND RELATIVE PLATE MOTION

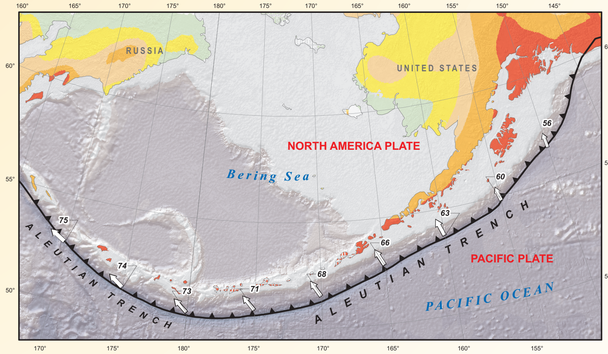


FIGURE EXPLANATION

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