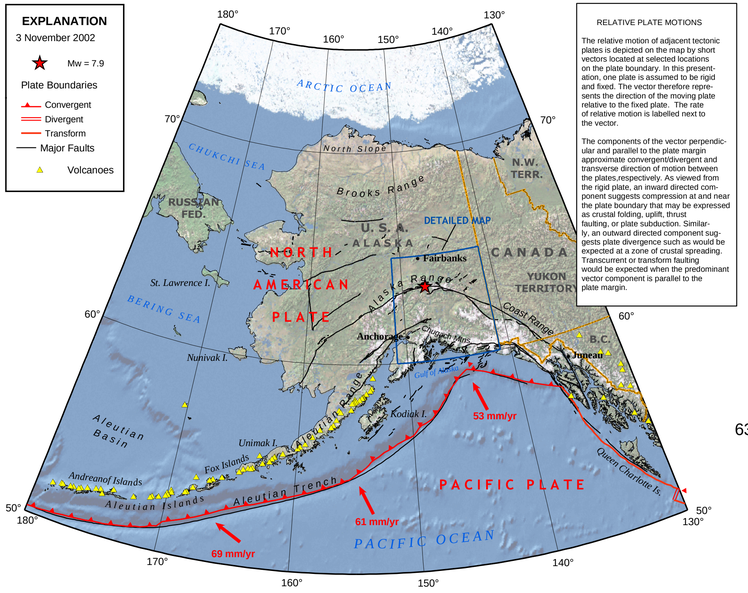
U.S. Department of the Interior
U.S. Geological Survey

General Interest Product xxx

Denali Park, Alaska Earthquake of 3 November, 2002

Plate Tectonic Setting



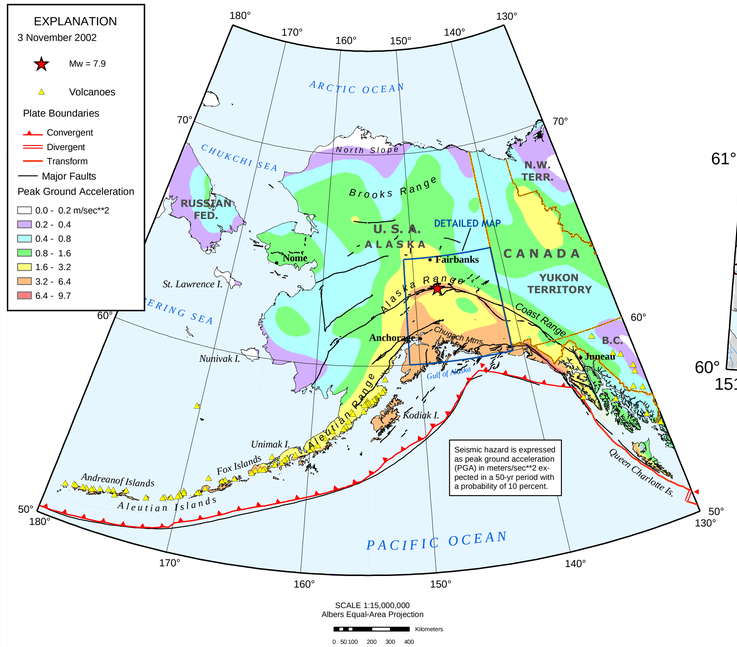
RELATIVE PLATE MOTIONS

The relative motion of adjacent tectonic plates is depicted on the map by short vectors located at selected locations on the plate boundary. In this presentation, one plate is assumed to be rigid and fixed. The vector therefore represents the direction of the moving plate relative to the fixed plate. The rate of relative motion is labelled next to the vector.

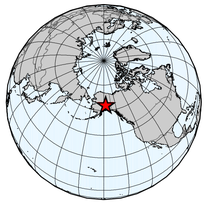
The components of the vector perpendicular and parallel to the plate margin approximate convergent/divergent and transverse direction of motion between the plates,respectively. As viewed from the rigid plate, an inward directed component suggests compression at and near the plate boundary that may be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

SCALE 1:15,000,000
Albers Equal-Area Projection
Kilometers
0 50 100 200 300 400

Generalized Seismic Hazard

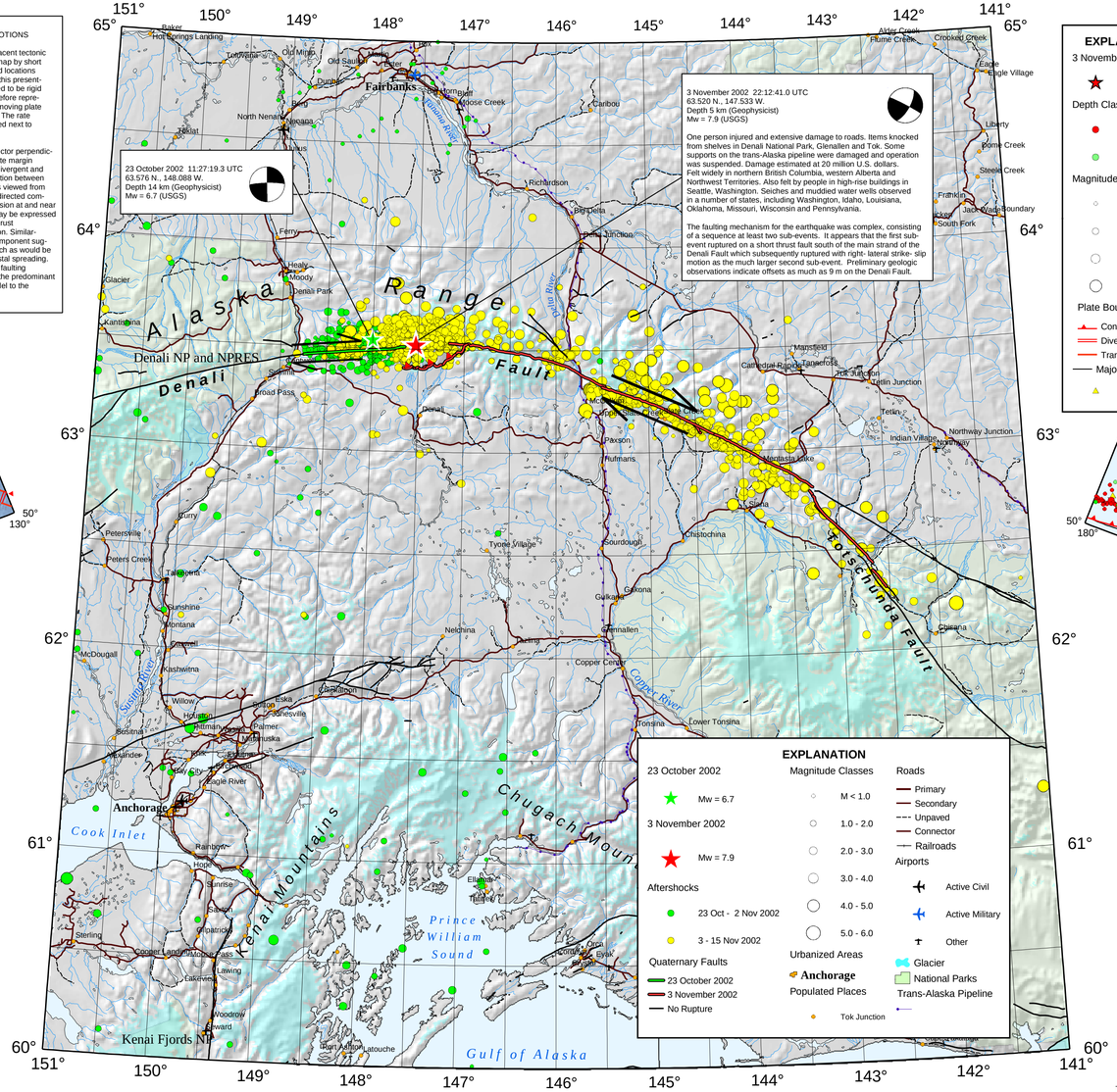


SCALE 1:15,000,000
Albers Equal-Area Projection
Kilometers
0 50 100 200 300 400



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.



SCALE 1:1,500,000
Albers Equal-Area Projection
Kilometers
0 10 20 40 60 80
Miles
0 10 20 40 60 80

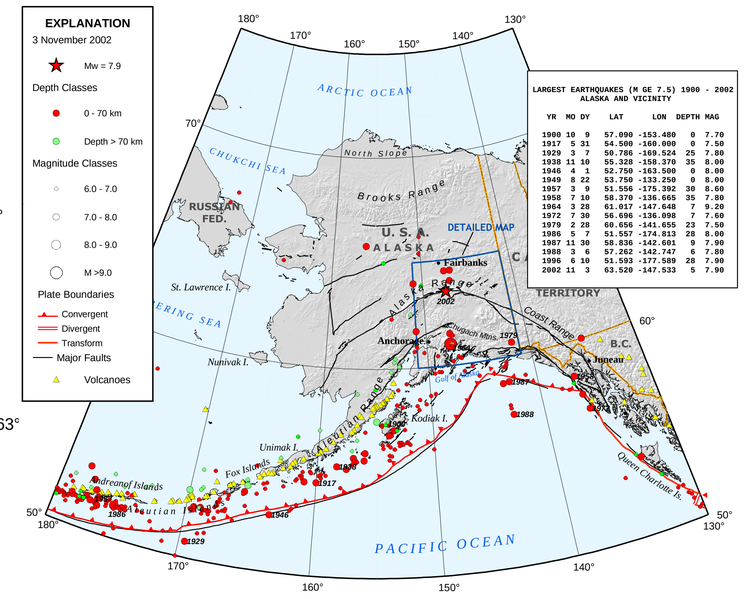
EXPLANATION

23 October 2002
Mw = 6.7
3 November 2002
Mw = 7.9
Aftershocks
23 Oct - 2 Nov 2002
3 - 15 Nov 2002
Quaternary Faults
23 October 2002
3 November 2002
No Rupture

Magnitude Classes
M < 1.0
1.0 - 2.0
2.0 - 3.0
3.0 - 4.0
4.0 - 5.0
5.0 - 6.0
Urbanized Areas
Anchorage
Populated Places
Tok Junction

Roads
Primary
Secondary
Unpaved
Connector
Railroads
Airports
Active Civil
Active Military
Other
Glacier
National Parks
Trans-Alaska Pipeline

Seismic History 1900 - 2002

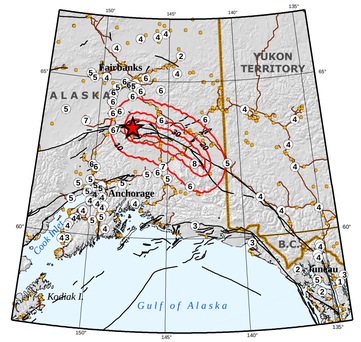


LARGEST EARTHQUAKES (M GE 7.5) 1900 - 2002
ALASKA AND VICINITY

YR	MO	DY	LAT	LON	DEPTH	MAG
1900	10	9	57.090	-153.480	0	7.70
1917	5	31	54.500	-160.000	0	7.50
1929	3	7	50.786	-169.524	25	7.80
1938	11	10	55.328	-158.370	35	8.00
1946	4	1	52.750	-163.500	0	8.00
1949	8	22	53.750	-133.250	0	8.00
1957	3	9	51.556	-175.392	30	8.60
1958	7	10	58.370	-136.665	35	7.80
1964	3	28	61.017	-147.648	7	9.20
1972	7	30	56.696	-136.098	7	7.60
1979	2	28	60.656	-141.655	23	7.50
1986	5	7	51.557	-174.813	28	8.00
1987	11	30	58.836	-142.601	9	7.90
1988	3	6	57.262	-142.747	6	7.80
1996	6	10	51.593	-177.589	28	7.90
2002	11	3	63.520	-147.533	5	7.90

SCALE 1:15,000,000
Albers Equal-Area Projection
Kilometers
0 50 100 200 300 400

ShakeMap Acceleration and Observed Intensity



EXPLANATION
3 November 2002
ShakeMap Acceleration (%g)
Major Faults
Highways and Roads
Populated Places
Intensity (MMI)

SCALE 1:10,000,000
Albers Equal-Area Projection
Kilometers
0 50 100 200 300 400

DISCUSSION

This M7.9 shock, one of the largest ever recorded on U.S. soil, occurred on the Denali-Totschunda fault system, which is one of the longest strike- slip fault systems in the world and rivals in size California's famed San Andreas strike- slip fault system that spawned the destructive M7.8 "San Francisco" earthquake in 1906.

Most of the seismic activity in Alaska results from interaction of the northwestward- moving Pacific plate with the corner of the North American plate that includes Alaska. Along the southeastern panhandle of Alaska, this motion is accommodated by right- lateral strike- slip faulting, but from Yakutat Bay westward along the southern coast of Alaska and the Aleutian Islands, the Pacific plate is colliding with Alaska. West of Kayak Island, this collision results in subduction of the Pacific plate beneath continental Alaska and the Aleutian Islands. This underthrusting motion was the cause of the M9.2 Alaska earthquake of 1964. Between Kayak Island and Yakutat Bay, the Pacific plate is mostly coupled to southern Alaska. This coupling has resulted in the rapid, geologically- recent building of the coastal St. Elias Mountains and produces northwest- southeast oriented compressive stress that extends inland through the Alaskan crust to Fairbanks and seaward into the Gulf of Alaska. This compressive stress drives the right- lateral slip witnessed on the Denali-Totschunda fault system.

DISCUSSION (Continued)

The Denali fault is a prominent topographic scar on the Alaskan landscape. Prior to the recent earthquake, the fault scarp between Denali National Park on the west and the Richardson Highway on the east appeared degraded, indicating that the last major earthquake was a few hundred years ago. In the epicentral area of the recent quake, USGS geologist George Plafker observed that the last major earthquake had 6-8 m of right- lateral offset. Slip rate on the Denali fault since the last glaciation (10,000 years before present) has averaged about 1 cm/year. Accordingly, a 6- m displacement would require 600 years of strain accumulation.

This is the largest earthquake on the Denali fault since at least 1912, when a M 7.2 earthquake occurred in the general vicinity of the fault, more than 50 miles to the east of the 3 November epicenter. Since there were no seismographs operating in Alaska at that time and no reports of surface faulting in the remote Alaska Range, the location of the 1912 shock is not well-constrained. Fault rupture initiated about 25 km east of the M6.7 23 October foreshock and continued eastward and southeastward for about 300 km, crossing the Richardson and Glenn (Tok Cutoff) highways. Near Mentasta Lake the rupture branched from the Denali fault and continued for about 75 km along the Totschunda fault. This branching from the Denali to the Totschunda was expected based on earlier geologic fault investigations and is reflected in the USGS seismic hazard map of Alaska. The seismic radiation pattern determined by Harvard University seismologists is consistent with the observed right- lateral slip. Preliminary measurements of fault displacements in the field by geologists range from under a meter in some locations in the west to nearly 9 meters near Mentasta Lake.

DATA SOURCES

EARTHQUAKES AND SEISMIC HAZARD
USGS, National Earthquake Information Center
Alaska Earthquake Information Center
IASPEI, Centennial Catalog (1900 - 1999)
Handbook of Seismology and Earthquake Engineering
Global Seismic Hazard Assessment Program

FAULTS
USGS, Anchorage and Denver

PLATE TECTONICS
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
21 November 2002
Map not approved for release by Director