ALASKA DIVISION OF GEOLOGICAL &
GEOPHYSICAL SURVEYS

ALASKA'S QUATERNARY FAULTS

MISCELLANEOUS PUBLICATION 141
Koehler and others, 2012
SHEET 1 OF 1
Report and digital data accompanies sheet

Overview of Quaternary faults in Alaska

Alaska is the most seismically active state in the country. Since 1900, Alaska has had an average of one M8+ (magnitude 8 or greater) earthquake every 13 years, one M7–8 earthquake every year, and five M6–7 earthquakes per year, representing 11% of earthquake occurrence worldwide (Alaska Earthquake Information Center, 2012). Primary hazards associated with earthquakes include strong ground motion, surface fault rupture, and dramatic uplift and subsidence. Secondary hazards include seismically induced liquefaction, landslides, rockfall, lateral spread, and tsunami, among others.

Quaternary deformation in Alaska is the result of oblique subduction of the Pacific plate and Yakutat microplate beneath the North American plate at a rate of ~5.5 cm/yr. This deformation is distributed over 900 km into interior Alaska. The Alaska–Aleutian subduction zone along the state's southern margin is the most active seismic feature in the state and has generated multiple great historic earthquakes including the 1938 M8.3 Alaska Peninsula earthquake, 1946 M7.8 Unimak earthquake, 1957 M8.6 Fox Islands earthquake, 1964 M9.2 Good Friday earthquake, and 1965 M8.7 Rat Islands earthquake (Johnson and Satake, 1994; Johnson and others, 1994; Plafker, 1969; Christensen and Beck, 1994; Beck and Christensen, 1991). The Chugach–Saint Elias fold and thrust belt extends east–west along the Chugach Mountains and northern Gulf of Alaska. The 1899 Yakutat Bay earthquakes occurred along the eastern part of this system and included three shocks: M8.1, M8.2, and M7.4 (Tarr and Martin, 1912; Plafker and Thatcher, 2008). In the southeastern part of the state, the Fairweather fault extends over 1,000 km along the continental margin and has generated three large strike-slip earthquakes during the last century including the 1949 M8.1 Queen Charlotte, the 1972 M7.3 Sitka, the 1958 M7.9 Lituya Bay, and the 2013 M7.5 Craig earthquakes (Sykes, 1971; Page, 1973; Tocher, 1960). To the north, the Denali fault extends along the southern margin of the Alaska Range in south-central Alaska and was the source of the 2002 M7.9 earthquake, one of the seven largest continental strike-slip earthquakes worldwide over the last century (Eberhart-Phillips and others, 2003; Haeussler and others, 2004; Schwartz, 2006).

The interior of Alaska north of the Alaska Range is an area of diffuse seismicity and few mapped surface faults. A north-directed component of compression related to the curvature of the Denali fault is accommodated along the Northern Foothills fold and thrust belt (Bemis and others, 2012), which extends over 500 km along the northern side of the Alaska Range. This system has generated multiple moderate magnitude earthquakes, although the locations of these events are poorly constrained (Ruppert and others, 2008). Paleoseismic data suggest this system is capable of generating earthquakes with large displacements (Carver and others, 2008; 2010). In the Fairbanks area, seismic zones defined by clusters of seismicity have been the source of multiple moderate to large magnitude earthquakes, the largest of which was the 1937 M7.3 earthquake centered in the Salcha seismic zone (Ruppert and others, 2008; Wickens and Hodgson, 1967).

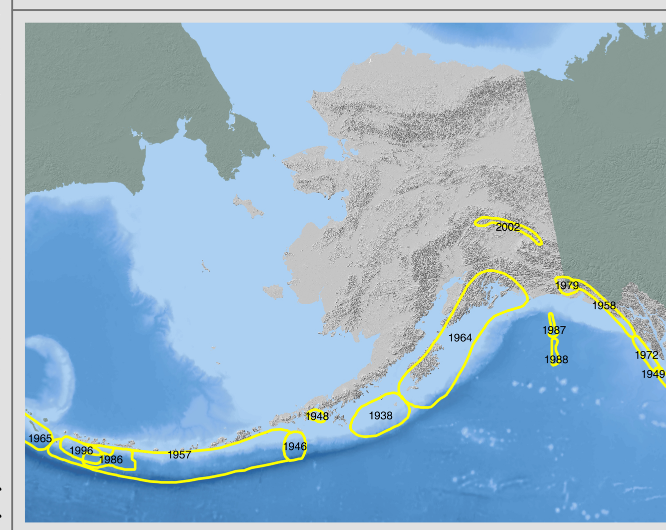
The high rate of large earthquakes, distribution of Quaternary active faults, and distributed seismicity throughout the state illustrate widespread earthquake hazards and the likely existence of additional undiscovered or unstudied Quaternary structures. Alaska's rugged terrain, extensive forests, and youthful glacially scoured surficial geology have presented challenges in the study of active faults and folds. Thus, the majority of Quaternary structures in Alaska remain poorly characterized. Particularly relevant to seismic hazards assessment, information on the location, style of deformation, and slip rates for most faults is generally lacking, and few site-specific paleoseismic studies have been conducted. Utilization of increasingly available lidar and other high-resolution imagery in future mapping and paleoseismic studies will likely contribute to the discovery of previously unknown active Quaternary structures and a better understanding of seismic hazards in Alaska.

Relative activity of Quaternary faults

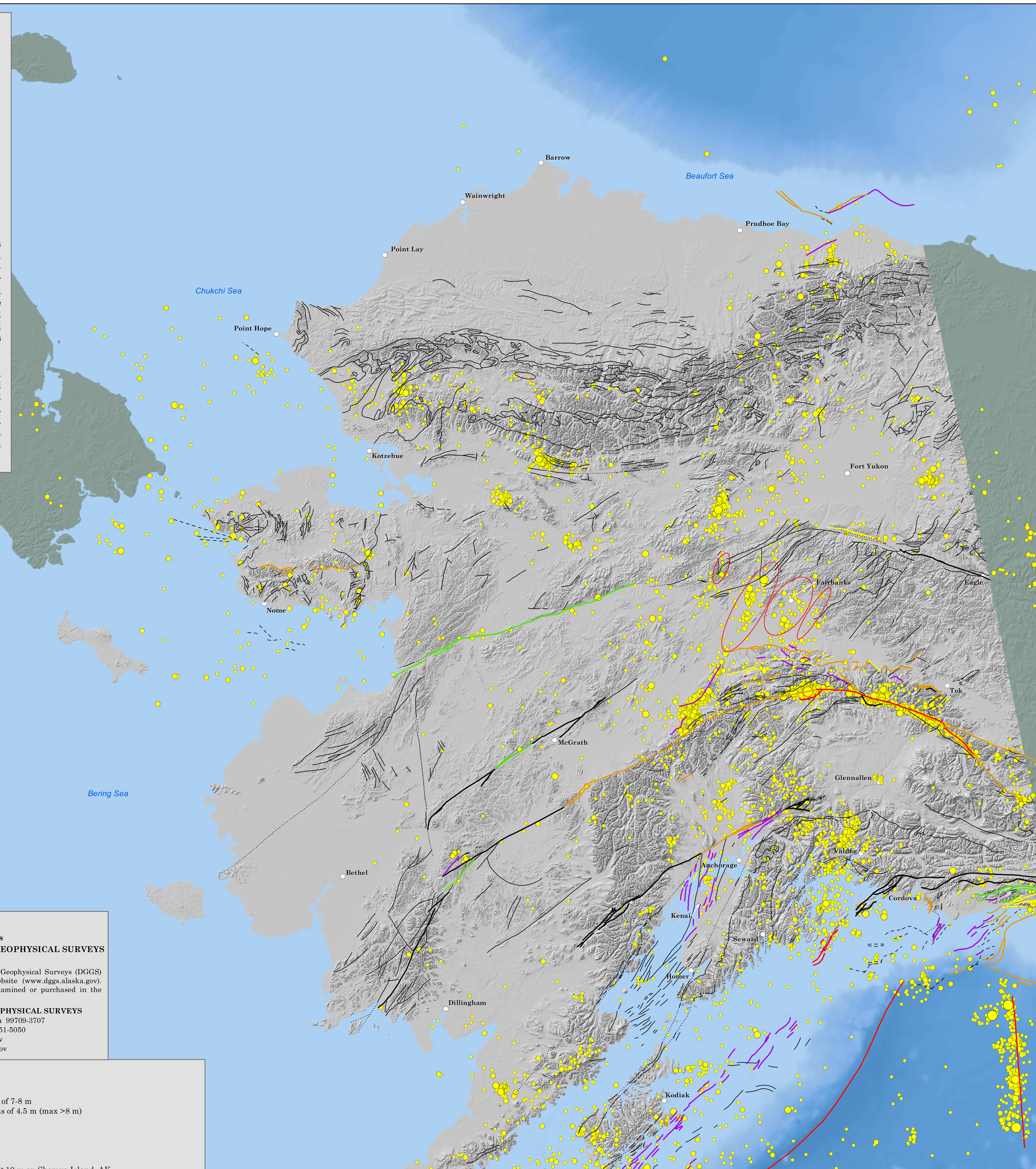
Age of most recent surface deformation	Earthquakes - Magnitude 1980 - 2011, M>3, depth <30 km
Historical, <150 yrs	3.0 - 3.9
Latest Pleistocene and Holocene, <15,000 yrs	4.0 - 4.9
Latest Quaternary, <130,000 yrs	5.0 - 5.9
Mid-Quaternary, <750,000 yrs	6.0 - 6.9
Quaternary, <1,600,000 yrs	≥ 7.0
Class B	
Pre-Quaternary	Named seismic zones

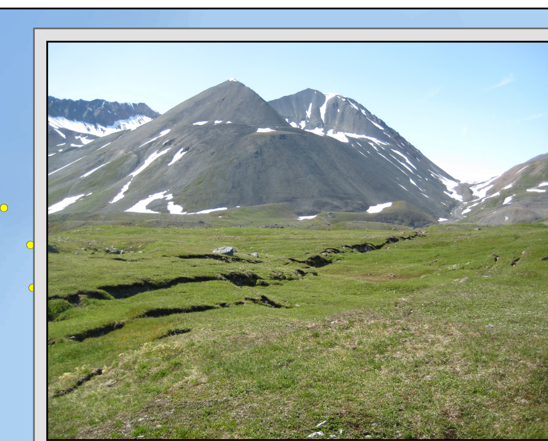
The age of the latest fault rupture is indicated by color on the map. The colors are based on the U.S. Geological Survey National Fault and Fold database. DGGS has modified the color scheme to include black lines that indicate pre-Quaternary faults (thin) and faults with questionable or suspected Quaternary movement (thick). The dates and locations of historical earthquakes are shown on the inset map below and additional information for some of these earthquakes is contained in Table 1. Identification of latest Pleistocene and Holocene fault movement is primarily based on displacement of widespread deposits left by the latest Wisconsin glacial advance, which reached its maximum extent around 15,000 years ago.

This pdf is a printable map that accompanies the report and digital data (shapefile) associated with this publication. Additional fault and fold parameters for each structure are contained in the attribute table associated with the shapefile. These parameters include fault name, slip rate, slip sense, dip direction, mapped scale, and mapping certainty (well constrained, moderately constrained, or inferred). As detailed investigations are undertaken along individual faults, significantly younger age of movement than shown on the current map may be determined.

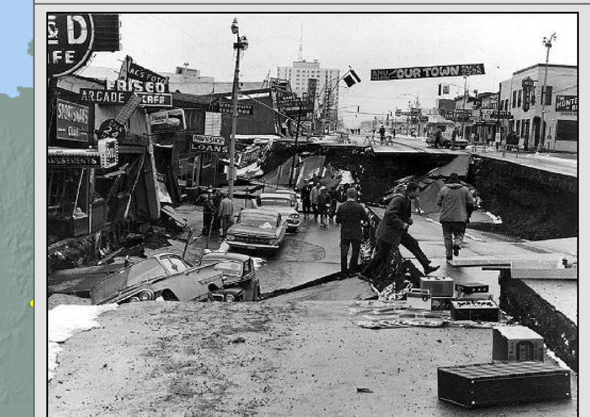


Map of historical rupture areas

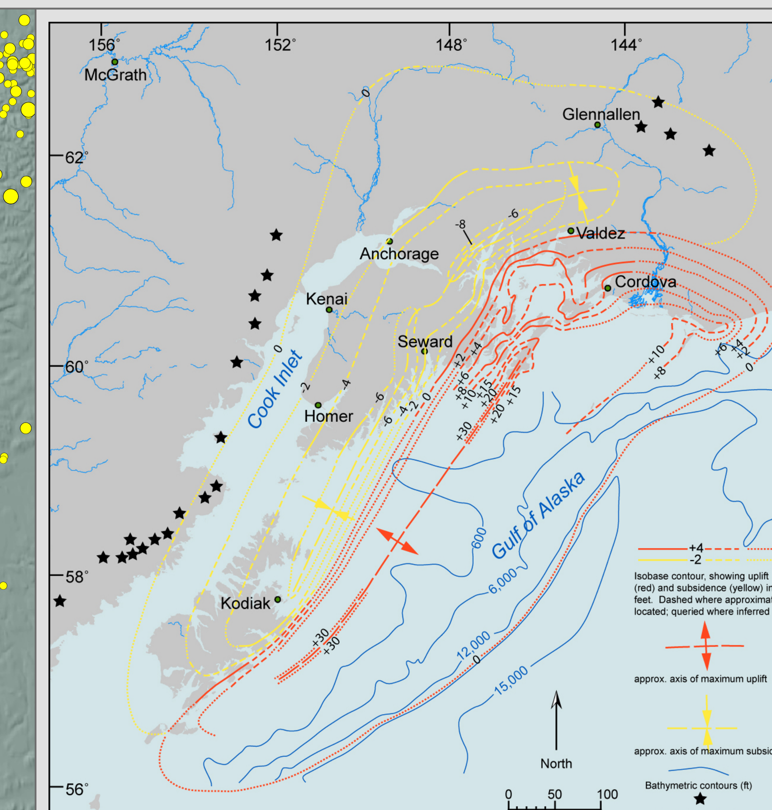



Trace of the 2002 Denali fault rupture in the vicinity of Chistochina Glacier. Photo credit: Rich Koehler, Alaska Division of Geological & Geophysical Surveys.


Trace of the 2002 Denali fault rupture along the northern margin of Canwell Glacier. Photo credit: Peter Haeussler, U.S. Geological Survey.


Damage along Fouth Avenue near C Street in Anchorage caused by an earthquake-induced landslide during the 1964 Good Friday earthquake. Photo Credit: J.K. McGregor and C. Abston, U.S. Geological Survey.


Photograph of seafloor (white platform) uplifted during the 1964 earthquake, Cape Cleare, Montague Island, Prince William Sound. Photo Credit: G. Plafker, U.S. Geological Survey



Map showing distribution of uplift and subsidence in south-central Alaska during the 1964 earthquake. Modified from Plafker, 1969.

Acknowledgments

The seminal work of George Plafker and colleagues provided the background information on the distribution of faults in Alaska. We are grateful for the opportunity this project provided to update and make this work available in the modern technological environment. The layout for this poster was inspired by dePolo (2008), Quaternary faults in Nevada, Map 167, Nevada Bureau of Mines and Geology. Regional seismicity data was provided by Natalia Ruppert of the Alaska Earthquake Information Center at the University of Alaska Fairbanks. Jim Weakland of the Alaska Division of Geological & Geophysical Surveys (DGGS) provided GIS expertise and patiently completed multiple map layout edits. We thank Peter Haeussler (U.S. Geological Survey) for map review.

References

Full text references and original map references for Quaternary fault strands are contained in Koehler and others (2012). Pre-Quaternary faults were digitized from Plafker and others (1994). A shapefile of the digital pre-Quaternary faults is contained in Koehler and others (2013).

Koehler, R.D., Farrell, R-E, Burns, P.A.C., and Combellick, R.A., 2012, Quaternary faults and folds of Alaska: A digital database: Alaska Division of Geological & Geophysical Surveys, Miscellaneous Publication 141, 31 p., 1 sheet, scale 1:3,700,000. http://www.dggs.alaska.gov/pubs/id/23944

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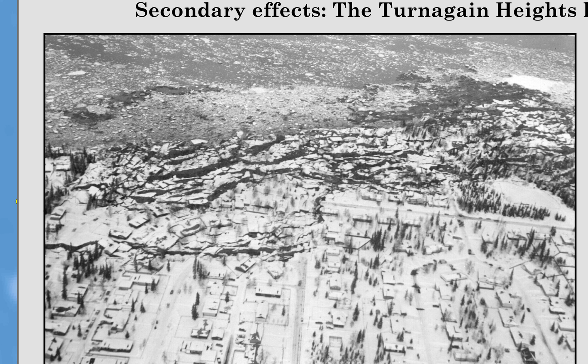
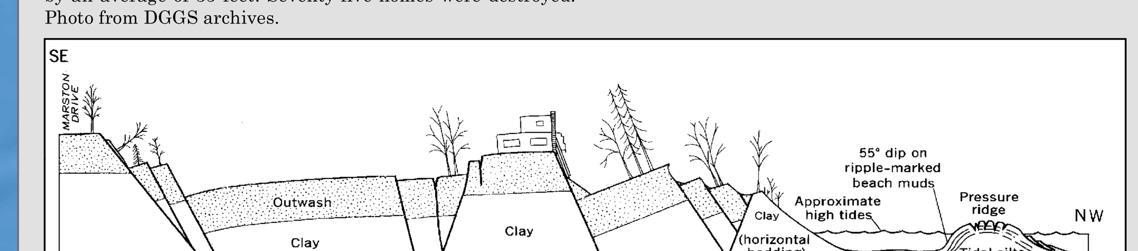
Table 1. Significant historical earthquake ruptures in Alaska

Date	Earthquake Magnitude	Fault	Earthquake Name	Notes
2013	7.5	Queen Charlotte fault	Craig earthquake	Surface rupture length approx. 120 km, maximum right-lateral displacements of 7-8 m
2002	7.9	Susitna Glacier, Denali, and Totschunda faults	Denali fault earthquake sequence	Surface rupture 340 km (east propagating), average right-lateral displacements of 4.5 m (max >8 m)
1995	6	Northern Minto Flats seismic zone	no official name	Surface rupture unknown
1986	8	Alaska-Aleutian megathrust	Andreanof earthquake	260-km-long bilateral rupture, partial re-rupture of 1957 rupture patch
1972	7.3	Fairweather fault	Sitka earthquake	Surface rupture offshore (?), rupture length 190 km based on seismicity
1968	7.1	Rampart seismic zone	no official name	Surface rupture unknown
1967	5.4	Fairbanks seismic zone	no official name	Surface rupture unknown
1965	8.7	Aleutian megathrust	Rat Islands earthquake	West-northwest propagating rupture, ≥420 km long, tsunami run-up height of >10 m on Shemya Island, AK
1964	9.2	Alaska-Aleutian megathrust	Good Friday earthquake	Rupture length 800 km, megathrust slip 25 m, contemporaneous rupture with Patton Bay & Hanning Bay faults, Montague Island
1958	7.9	Fairweather fault	Lituya Bay earthquake	Surface rupture length 280 km, maximum right-lateral displacements of 6.5 m
1957	8.6	Alaska-Aleutian megathrust	Fox Islands earthquake	Rupture length of ~1,200 km based on aftershocks, tsunami run-up height of 13 m on Adak and Unimak Islands, AK
1949	8.1	Fairweather fault	Queen Charlotte earthquake	Surface rupture offshore (?)
1946	7.8	Alaska-Aleutian megathrust	Unimak earthquake	181-km-long bilateral rupture, tsunami run-up heights up to 42 m on Unimak Island, AK
1938	8.3	Alaska-Aleutian megathrust	Alaska Peninsula earthquake	300-km-long rupture length based on aftershocks, moment release concentrated in the east
1937	7.3	Salcha seismic zone	no official name	Surface rupture unknown
1899	8.1, 8.2, 7.4	Yakutat, Boundary, Bancas Point, Esker, and Otmeloi faults	Yakutat Bay earthquake sequence	Faults listed are inferred to be involved based on uplift patterns distributed over 1,500 km, max uplift 14.4 m

Secondary effects: The Turnagain Heights landslide triggered by the 1964 earthquake


Aerial photograph. Dark shadows parallel to the coast are fissures and grabens associated with the slide. The slide was 8,500 feet long and lowered an approximately 130 acre area by an average of 35 feet. Seventy-five homes were destroyed. Photo from DGGS archives.


Demolished houses within a graben associated with the Turnagain landslide. Note back-tilted trees. Photo from DGGS archives.



Schematic cross section of the Turnagain Heights landslide showing grabens and rotated blocks. Hansen, 1965.

Cartography by: James R. Weakland, GISP