THE QUATERNARY FAULT AND FOLD DATABASE OF ALASKA: GIS COVERAGES AND MAP COMPILATION TECHNIQUES

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Abstract

Alaska is the most seismically active region of the United States, however little information exists on the location, style of deformation, and slip rates of Quaternary faults. Historic earthquakes along the Denali fault (2002, M7.9), Aleutian subduction zone (1964, M9.2), and the Fairweather fault (1958, M7.9) attest to the importance of information related to Quaternary faults and their associated hazards. The Alaska Division of Geological & Geophysical Surveys (DGGS) has designed a Quaternary fault and fold database for Alaska in conformance with standards defined by the U.S. Geological Survey for the national Quaternary fault and fold database. The objective of the database is to produce an accurate, user-friendly and cohesive resource that provides summarized information on Quaternary faults, digital GIS files, and references for geologists, industry, and the public. The current GIS project includes thirty active faults which pose the greatest seismic hazard to Alaskans. Additional faults will be incorporated into the database as more information is developed.

Here we present the GIS data for the state of Alaska and discuss some of the problems that were encountered and resolved during its compilation. The Neotectonic Map of Alaska (Plafker et al., 1994) served as the starting point in the identification of Quaternary active structures. The mapped trace of each fault in the database was selected based on review of previously compiled literature (Craw et al., 2001). The majority of the faults included have been georegistered from 1:250,000-scale paper maps contained in 1970's vintage and earlier bedrock maps, however each fault is evaluated on a case-by-case basis, with paper map scales ranging from 1: 20,000 to 1: 500,000. GIS fault attributes are consistent with the national guidelines and include relevant information such as fault name, age, slip rate, slip sense, dip direction, fault line type (well constrained, moderately constrained, or inferred), and mapped scale. Each fault is assigned a three-integer CODE, based upon age, slip rate, and how well the fault is located. This CODE dictates the line-type for the GIS files. Due to the limited level of knowledge on Quaternary faults, Alaska-specific modifications to the attributes have been made pertaining to slip rate and mapped scale.

Introduction

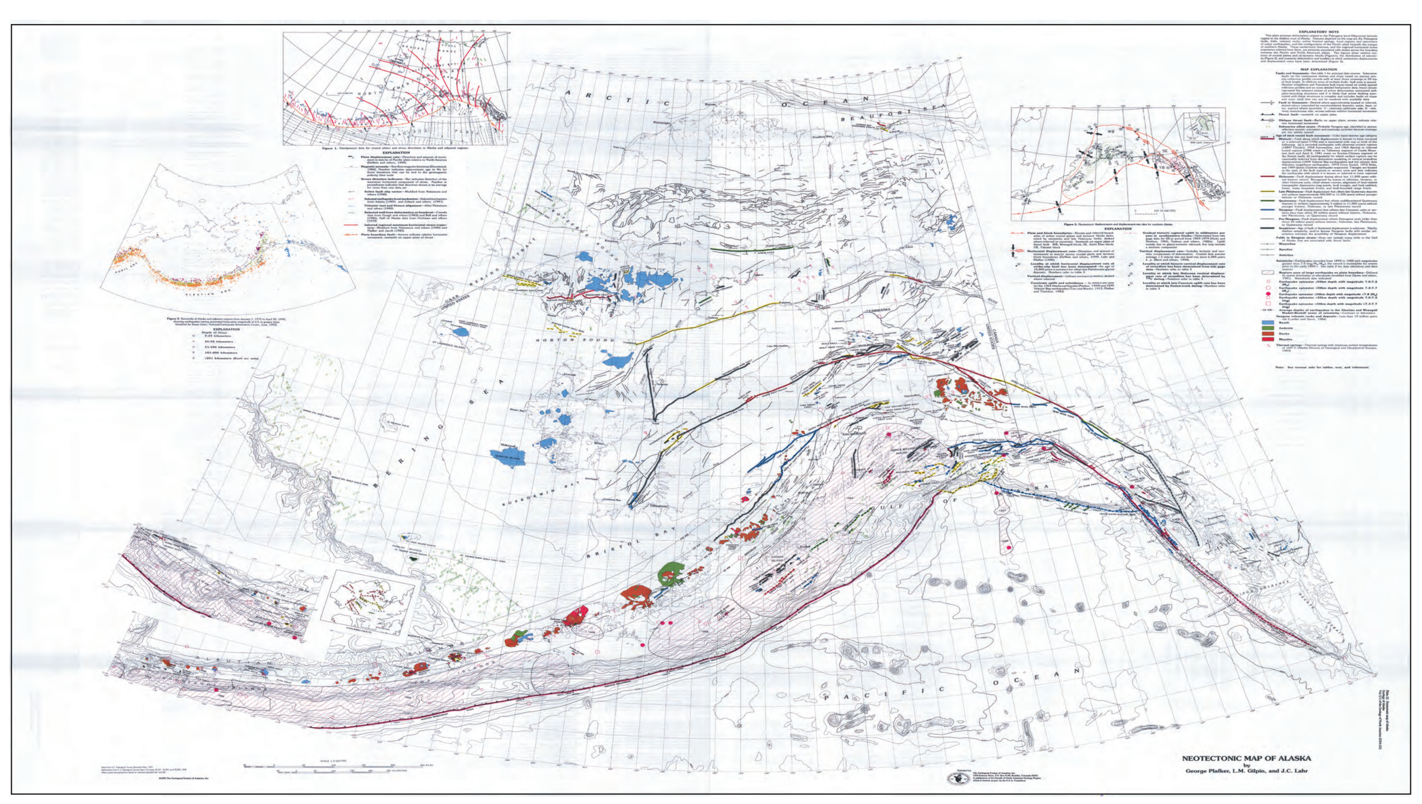
This poster summarizes the new Quaternary fault and fold database for Alaska. The database includes the first comprehensive collection of shapefiles digitized from original sources, as well as attribute tables for each fault trace that catalogue fault parameters such as length, slip rate, age of most recent rupture, among others. This information will be published as a digital database by the Alaska Division of Geological & Geophysical Surveys and eventually be incorporated in the U.S. Geological Surveys national fault and fold database.

The database is of critical importance for the assessment of seismic hazards, refinement of U.S. Geological Survey probabilistic seismic hazard maps, planning and public policy decisions, and engineering design of energy and water infrastructure. The database will also be of relevance to researchers, educators, and students in studies of Alaska neotectonics and paleoseismology.

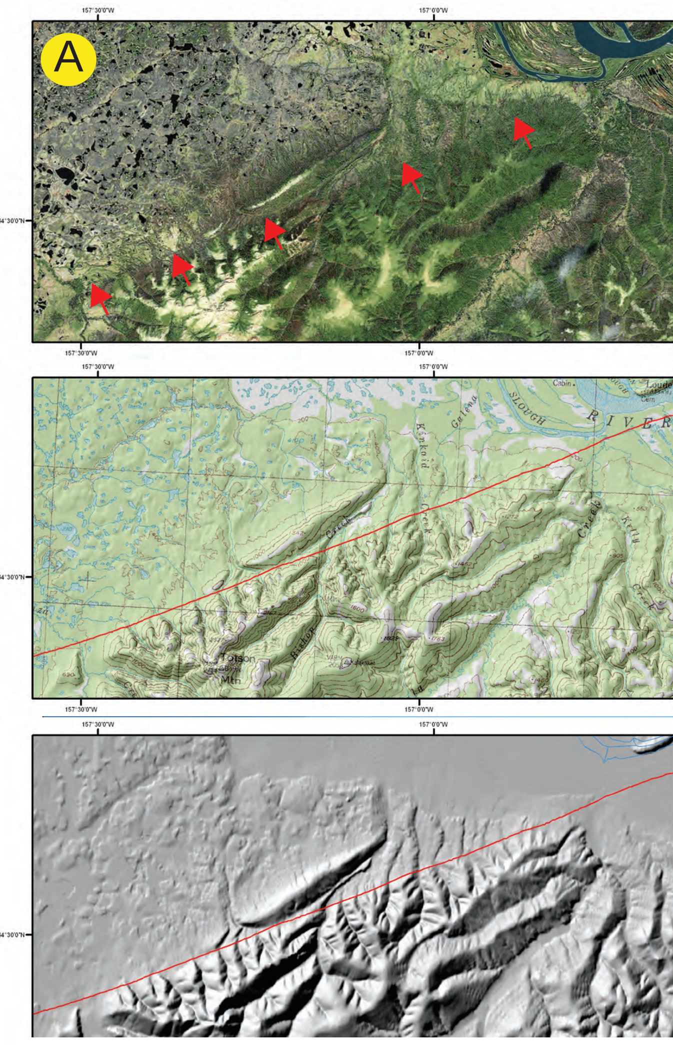
Alaska is not presently included in the U.S. Geological Survey national fault and fold database despite being one of the most seismically active states in the country. Earlier efforts to compile the Alaska database were interupted by the 2002 Denali fault earthquake which diverted staff attention to documenting the effects of the earthquake. However, maps and literature assembled at the beginning of the project provided an excellent resource for our digitizing and mapping efforts. A comprehensive literature collection searchable by fault name is archived in Craw et al. (2001), Preliminary Bibliographic Database of Quaternary Faults and Folds in Alaska, DGGS, Miscellaneous Publication 44.

Our new Quaternary fault and fold database is based on the literature compiled in Miscellaneous Publication 44 and the Neotectonic map of Alaska (Plafker et al., 1994) described below.

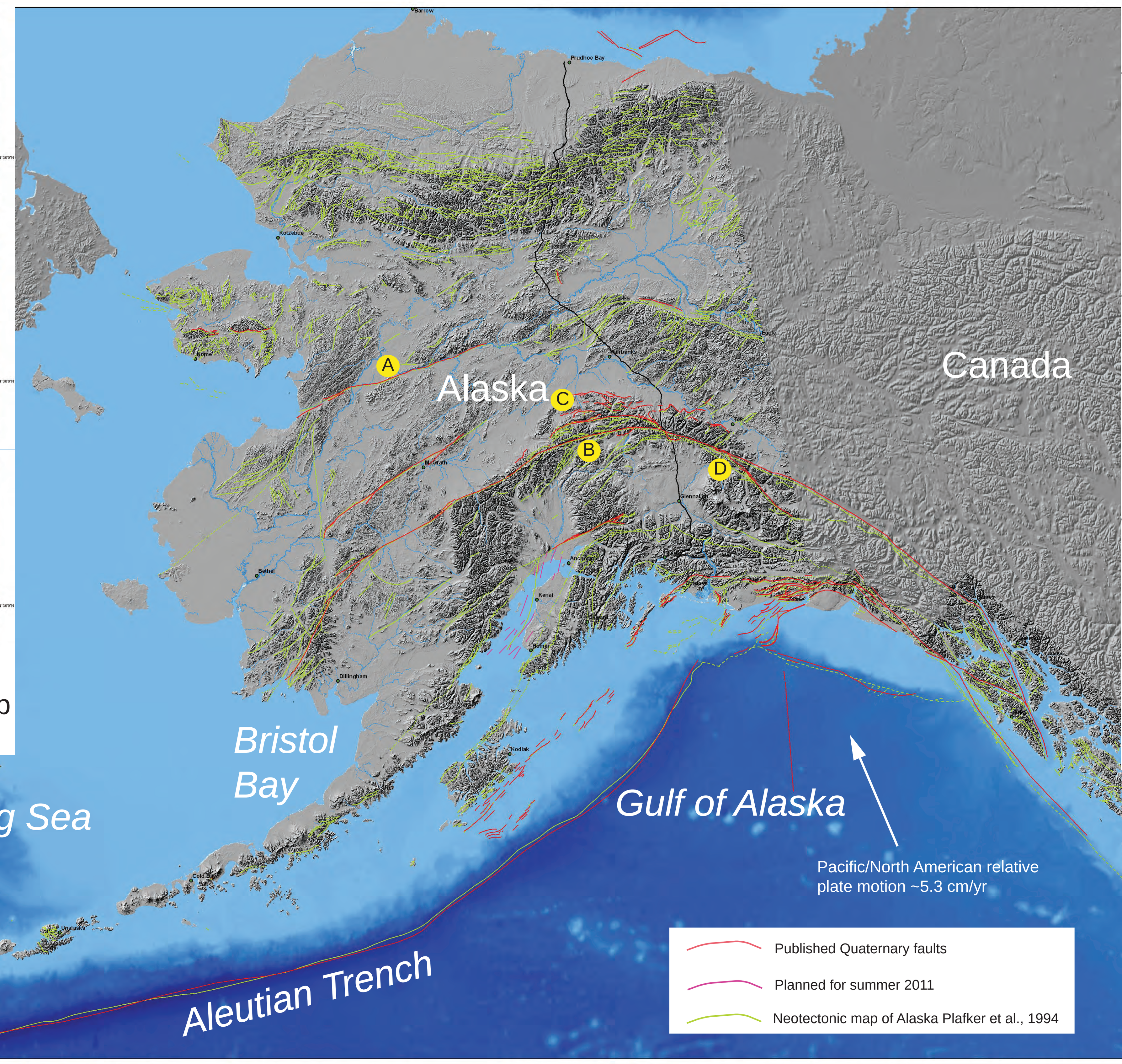
Previous Quaternary fault compilation (Plafker et al., 1994)

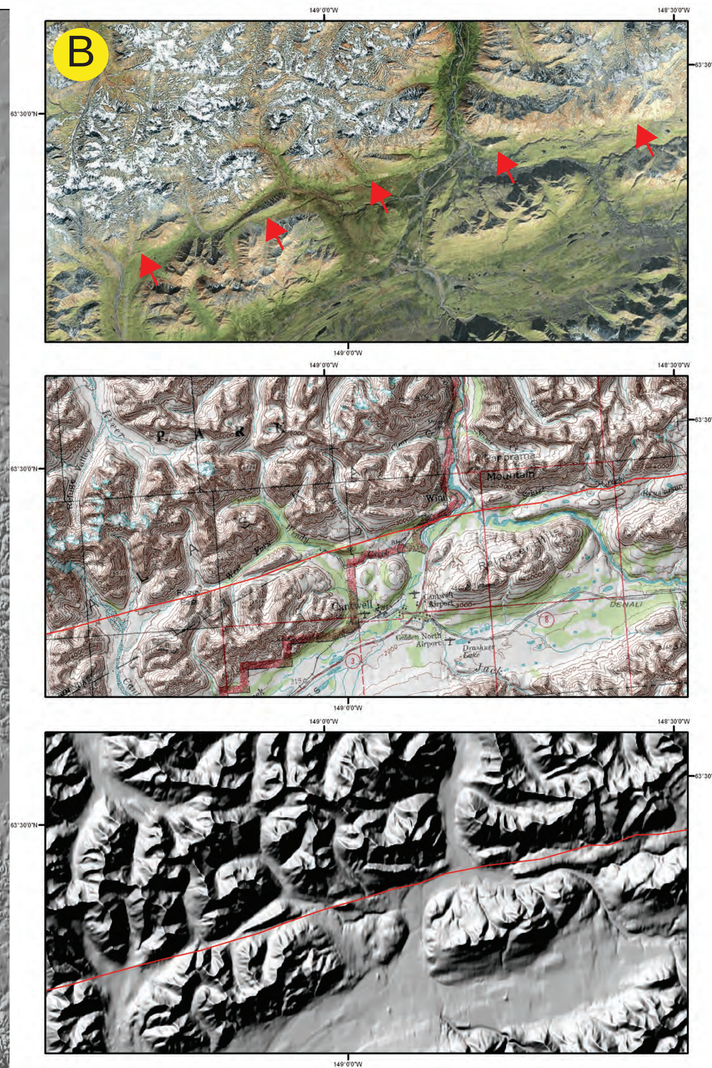


The Neotectonic Map of Alaska (Plafker et al., 1994) was the first comprehensive compilation of tectonic structures for the state of Alaska. Faults were color coded based on their relative activity including historic, Holocene, late Pleistocene, Quaternary, Neogene, pre-Neogene, and suspicious. Although a seminal contribution to earthquake hazard studies, this map is of limited use with modern GIS databases due to its scale (1:2,500,000). Quaternary faults from this map have now been digitized from original sources to a scale of 1:250,000 or better. The line work from the original sources (i.e. solid, dashed, dotted, querried) has been preserved to capture authors uncertainty.

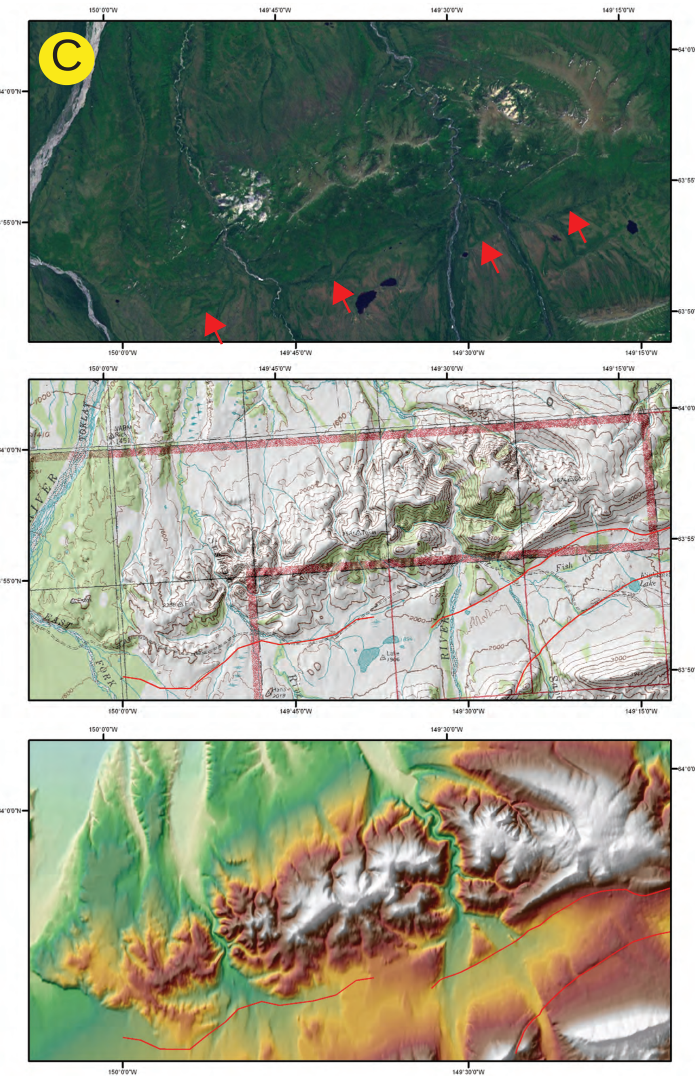


Kaltag fault shown at 1:250,000 scale on satellite image, topo map and hillshade.

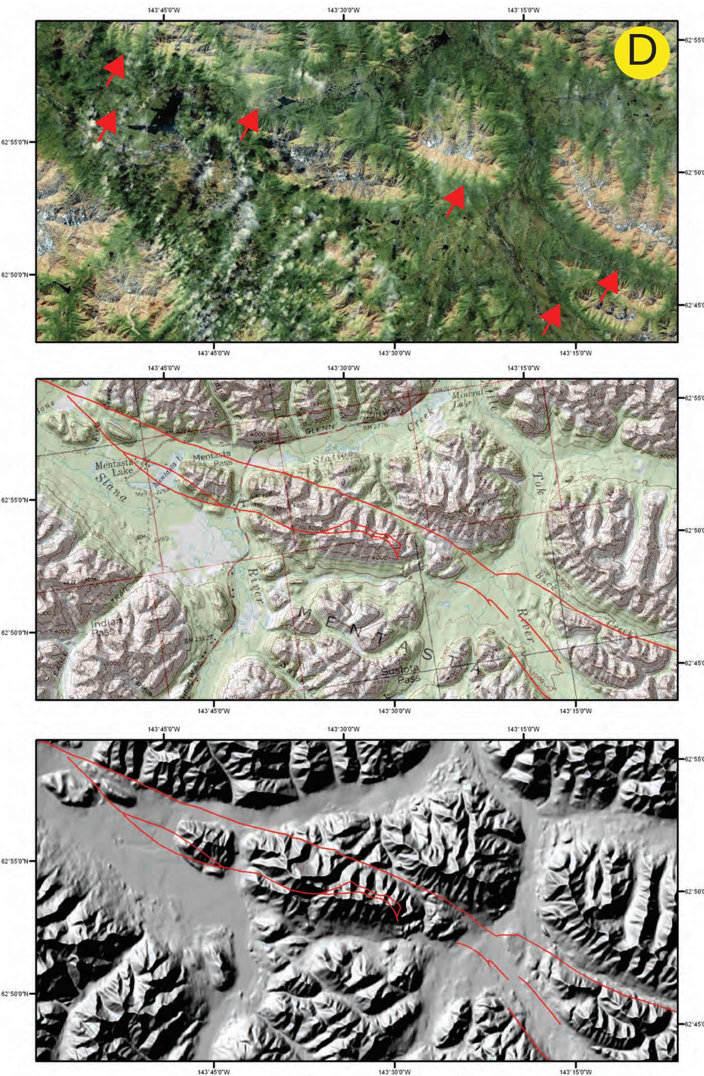




Denali fault shown at 1:250,000 scale on satellite image, topo map and hillshade.



Stampede fault shown at 1:250,000 scale on satellite image, topo map and hillshade.



Denali and Totschunda faults shown at 1:250,000 scale on satellite image, topo map and hillshade.

Methods and technical issues

The majority of the fault traces were digitized from published U.S.G.S. maps and reports. Many of these reports are available on-line at the DGGS library and digital maps were registered to our basemap. When digital maps were not available, paper maps were scanned using a large format scanner and the resulting tiff files georegistered in ArcMap. In some cases, the only available map trace was contained in published paper figures. These map traces were the most difficult to accurately register. This problem was aleviated by adding as many control points as possible to obtain the best fit to our topographic base map.

Issues with scale: Some reproduction source maps were identified as being at the 1:250,000 scale. Upon further examination of the maps (i.e. measuring with a ruler), it was determined that the scale was slightly off. This required "heads-up" digitizing of the fault traces based on terrain matching between source maps and the digital fault database.

Issues with projections: The source data was in a wide variety of projections common in Alaska. Thus, it was necessary to import the source data in its native projection and then reproject it to the database projection. For example, NAD 27 UTM to GCS WGS 1984.

Issues with attributes: Specific fault parameters were archived in ArcMap attribute tables linked to individual fault traces (See example attribute table below). Because so few faults have been studied in detail in Alaska, specific modifications were made for unknown attributes (i.e. slip rate).

Example attribute table exported from ArcMap

OBJECTID	NAME	CODE	NUM	AGE	ACODE	SLIPRATE	SLIPCODE	SLIPSENSE	DIPDIRECTI	FCODE	FTYPE	MAPPEDSCAL	SecondaryS	Shape_Leng
30	Denali fault, west Muldrow-Alsek section	311	5000f	<150	1	>5	1	RL	Vertical	3	Inferred	250	T	0.26691154305
32	Denali fault, west Muldrow-Alsek section	211	5000f	<150	1	>5	1	RL	Vertical	2	Moderately constrained	250	T	2.84583779362
33	Denali fault, west Muldrow-Alsek section	111	5000f	<150	1	>5	1	RL	Vertical	1	Well constrained	24	T	3.07125006835
34	Denali fault, central Muldrow-Alsek section	110	5000g	<150	1	Unknown	0	RL	Vertical	1	Well constrained	24	T	0.91282440189
48	Denali fault, central Muldrow-Alsek section	330	5000g	<750,000	3	Unknown	0	RL	Vertical	3	Inferred	250	T	0.81250380816
49	Denali fault, central Muldrow-Alsek section	130	5000g	<130,000	3	Unknown	0	RL	Vertical	1	Well constrained	250	T	0.85047700813
50	Denali fault, central Muldrow-Alsek section	230	5000g	<130,000	3	Unknown	0	RL	Vertical	2	Moderately constrained	250	T	0.09224411484
58	Kaltag fault	325	5134	<15,000	2	Unknown	5	RL	Unspecified	3	Inferred	250	Unk	0.06465187479
59	Kaltag fault	125	5134	<15,000	2	Unknown	5	RL	Unspecified	1	Well constrained	250	Unk	0.02074611706
60	Kaltag fault	325	5134	<15,000	2	Unknown	5	RL	Unspecified	3	Inferred	250	Unk	0.71609209923
63	Kaltag fault	125	5134	<15,000	2	Unknown	5	RL	Unspecified	1	Well constrained	250	Unk	0.13047548369
64	Kaltag fault	125	5134	<15,000	2	Unknown	5	RL	Unspecified	1	Well constrained	250	Unk	0.03892164153
74	Kaltag fault	225	5134	<15,000	2	Unknown	5	RL	Unspecified	2	Moderately constrained	250	Unk	0.12886176122
1255	Northern Foothills thrust (Stampede fault)	0		<15,000	2	Unknown	0	T	North	3	Inferred	100	Unk	0.37541660599
1256	Northern Foothills thrust (Stampede fault)	0		<15,000	2	Unknown	0	T	North	2	Moderately constrained	100	Unk	0.15484636741
1308	Northern Foothills thrust (Stampede fault)	0		<15,000	2	Unknown	0	T	North	1	Well constrained	100	Unk	0.10692221342

Fault summary sheets

Below is an example of part of a fault summary sheet. These sheets are being created for each fault in the database and contain descriptions of pertinent information and references. The sheets are intended to be included in the national database and will be digitally linked to the on-line maps.

5134, Kaltag fault

Structure Type

Fault Class A

Structure Number 5134

Comments: Fault number 134 in the Alaska Division of Geological & Geophysical Surveys Quaternary fault and fold database.

Structure Name Kaltag fault

Comments: The fault was called the Kaltag fault by Gates and Grye, 1963; Patton, 1964; Grantz, 1966; St. Amand, 1957). Patton and others (1978) mapped the Kaltag fault in the Melozitna Quadrangle at 1:250,000 scale and it was inferred in Chapman and others (1982) 1:250,000 scale geologic map of the Tanana Quadrangle. Yeend (1989, p. 55) describes Tertiary rocks associated with placer gold deposits in the vicinity of Kaltag fault in the eastern part of the Tanana Quadrangle and asserts that Kaltag fault has probably exerted strong control over the present position of the Yukon River in the area he describes. The Kaltag fault was not included in Cass' 1959 reconnaissance geologic map of the Melozitna or Ruby quadrangles. East of Tanana, the projection of the Kaltag fault has been shown as the Kaltag fault zone on 1:63,360 scale mapping by Reifenstuhl and others 1997. Here the fault has been variously called, "the Kaltag, Tozitna, and Victoria Creek fault" (Reifenstuhl and others 1997). The map of Wilson and others (1998) also shows the fault projecting to the east into the Livengood quadrangle where it appears to splay into northeast trending thrust faults eventually merging with the Victoria Creek fault.

Synopsis

The Kaltag fault extends east-northeast across west central Alaska for ~440 km, from Norton Sound to the vicinity of Tanana (Patton and Hoare, 1968). The fault controls a long reach of the Yukon river, and it is marked in places by rift valleys and Quaternary fault scarps (Grantz, 1966). East of Tanana, Patton and Hoare (1968) speculate that the Kaltag fault may continue along the aligned courses of the Yukon and Porcupine Rivers or up the Yukon River to Yukon flats. To the west offshore, geophysical studies indicate the the fault may continue for another 200 miles southwestward across the Bering Sea shelf (Scholl and others, 1970).

The fault appears to offset all major lithologic and structural trends between Ruby and Unakleet with estimated right-lateral offset between 40 and 80 miles. "The major lateral displacement of Cretaceous and early Tertiary trends seems to have occurred before middle Tertiary time, but some movement has continued into Holocene time, as evidenced by local drainage offsets of as much as 1.5 miles (Patton and Hoare, 1968). The fault is characterized by prominent linear alignments of vegetation, scarps, and slivers of bedrock (Patton and Hoare, 1968) suggesting Quaternary activity. No detailed studies have been performed along the fault, thus, little is known about the timing of paleoearthquakes and slip rate. Information about the fault is primarily based on reconnaissance geological and geophysical surveys, reconnaissance geomorphic studies of aerial photos, and limited field observations.

Date of compilation 8/29/00; updated 5/2010

Compiler Patricia A. Craw, Alaska Division of Geological & Geophysical Survey; updated by Rich Koehler, Alaska Division of Geological & Geophysical Surveys

Number of sections 0

Comments: Insufficient data exist to divide the fault into sections.

Reliability of location Good

Comments: Patton and others (1978) map the main trace of Kaltag fault under cover through the Melozitna Quadrangle at 1:250,000 scale and state that the presence of the fault is "strongly suggested by a steep gradient linear gravity anomaly which parallels the north bank of the Yukon river (Barnes, 1976)".In the Nulato Quadrangle the fault trace is from Patton and Moll-Stalcup (2000). Wilson and others (1998) included the digital trace of Kaltag fault in the Nulato Quadrangle from Patton and Moll-Stalcup's draft map. In the Ruby Quadrangle the Trace of Kaltag fault is from Wilson and others (1998) compilation; however the metadata are unclear as to the original source of the data, it simply cites Patton. The trace of the Kaltag fault is from Patton and Moll-Stalcup's (1996) 1:250,000-scale map in the Unakleet Quadrangle. Faults that are along strike with the Kaltag fault are shown on the Norton Bay Quadrangle but are not labeled (Cass, 1959).

To the west offshore, Worrall (1991, p. 103 and figure104) describe the location of the terminus of Kaltag fault as uncertain due to water cover and poor seismic control southwest of Norton basin. Worral (1991, p. 104) suggests that the faults terminus must be south or southwest of Norton basin due to the fact that onshore Kaltag fault is perpendicular to the Bering Shelf faults. Based on the location of a magnetic lineament, Fisher (1982, p. 138) raises the possibility that the Kaltag fault, or a splay of the fault, extends from the mainland beyond Saint Lawrence Island.

State Alaska

quadrangles Norton Bay, Unalakleet, Nulato, Ruby, Melozitna, Tanana

Physiographic province Intermontane plateaus (Wahrhaftig, 1994).

Scale of digital trace 1:250,000

Conclusions and future activities

Digital map traces at a scale of 1:250,000 and attribute tables have been completed for 30 faults and a digital publication is planned for summer 2011 pending completion of metadata.

The database will serve as a platform to incorporate new data as more research is conducted.

We are continuing to write fault summary sheets which are intended to be integrated into the U.S. Geological Survey national fault and fold database.

By presenting the mapped fault traces on a variety of basemaps including topographic, hillshade, and satellite images, the database will provide an essential resource for planning and mitigating seismic hazards, and furthering the understanding of neotectonic deformation in Alaska. In particular, on-going geodetic modelling and the upcoming deployment of the USArray seismic monitoring program will benefit from our depiciton of the distribution of active faults.

References

Craw, P.A., Mayer, J.L., and Combellick, R.A., 2001, Preliminary Bibliographic Database of Quaternary Faults and Folds in Alaska, Division of Geological & Geophysical Surveys, Miscellaneous Publication 44.

Plafker, G., Gilpin, L.M., and Lahr, J.C., 1994, Neotectonic map of Alaska, in Plafker, G., and Berg, H.C., eds., Geology of Alaska, Geology of North America, in Decade of North American Geology: Boulder, Geological Society of America, v. G-1,, plate 12, 1 sheet, 1:2,500,000 scale.

Acknowledgements

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