FT2008

11th INTERNATIONAL CONFERENCE ON THERMOCHRONOMETRY

CONFERENCE FIELD-TRIP

FIELD EXCURSION FROM ANCHORAGE TO SEWARD, ALASKA

17 SEPTEMBER 2008

Colony Glacier, Inner Lake George, Chugach Mountains (Photo: J. Cockburn, June 2008)

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APPROXIMATE ITINERARY

Time	What	Plans
8:00 AM	Depart Captain Cook Hotel in Anchorage	
8:00 – 9:00	Drive along Turnagain Arm	Outcrops of accretionary prism rocks, drowned trees from 1964 earthquake, east-west oriented fiord of Turnagain Arm
9:00 – 9:30	**Stop 1**. Stop near Girdwood.	Overview of regional geology and 1964 earthquake.
10:00 – 11:00	**Stop 2**. Begich-Boggs Visitor's Center	Visit Begich-Boggs Visitors Center. Overview of Portage Lake at toe of Portage Glacier. **Chance to grab cup of coffee/tea** at the Portage Glacier Lodge.
11:00-12:30 PM	Drive to Exit Glacier near Seward.	Drive through the Kenai Mountains. Good exposures of Late Cretaceous Valdez Group accretionary rocks.
12:30-2:30 PM	**Stop 3**. Exit Glacier – just minutes from Seward.	Box lunch. Explore Exit Glacier – chance to stretch the legs.
3:00 – 6:30 PM	**Stop 4**. Seward – bay and glacier cruise	Cruise out of Seward around Resurrection Bay. Weather permitting, we will see some of the geology surrounding the bay and visit a tide-water glacier. Snacks will be served and drinks will be available for purchase.
6:30-8:30 PM	Dinner	There are several dinner options in the Seward harbor area – see map and list of restaurants at end of this guide.
8:30-10:30 PM	Return to Anchorage	

INTRODUCTION AND PURPOSE

The purpose of this excursion is to get us out of the meeting room of the Captain Cook Hotel and spend a day exploring some of the geology and history between Anchorage and Seward in south-cental Alaska. As part of this trip, we will drive along the Turnagain Arm of the Cook Inlet, visit a glacier, drive across the Kenai Mountains, and take a cruise in Resurrection Bay out of Seward. Given the size of the group and time constraints, we cannot visit many of the rocks. We will, however, make a stop en route to give a geologic overview of the area. We will also make a couple additional stops to explore visitor's centers and hike to one of the more accessible glaciers near Seward (Exit Glacier). This short and general field guide is based mostly on earlier field trip guides across the same region including a Union College field trip guide (which is based on information from many sources), an AGU Chapman Conference guidebook (Haeussler, 2006), a GSA/AAPG-sponsored field guide (Bradley and Miller, 2006), and earlier field guides for the Turnagain Arm and Resurrection Peninsula areas (Clark, 1981; Winkler et al., 1984; Miller, 1984; Nelson et al., 1987; Bradley et al., 1997).

As we drive along Turnagain Arm, starting about 20 minutes after leaving downtown Anchorage, we will cross through one of the most accessible parts of the Mesozoic accretionary complex in south-central Alaska. We will cross two of the main units of this complex – the McHugh Complex and the Valdez Group rocks. Turnagain Arm is an east-west oriented fiord that displays rapid and dramatic tidal changes and that partially splits the northeast-southwest trending Chugach and Kenai Mountains. We will stop along the fiord to have an overview discussion of the regional geology.

SOME GEOLOGY AND TECTONICS RELEVANT TO OUR EXCURSION

Our drive today will take us across part of one of the most well exposed accretionary complexes in the world. In terrane nomenclature, south-central Alaska is underlain primarily by two terranes (Plafker et al., 1994): (1) the Jurassic Wrangellia/Peninsular composite terrane and (2) the Cretaceous Chugach composite terrane. The Wrangellia/Peninsular is the more inboard (northern) terrane and has undergone extensive episodic volcanism and plutonism since Mississippian time. Farther outboard, the Chugach terrane is an accretionary complex that rims the southern Alaska margin (which we will drive through exclusively on our sojourn to Seward) and consists of two parts – the Permian to Middle Cretaceous McHugh Complex and the Late Cretaceous Valdez Group. A major crustal discontinuity – the Border Ranges fault system – separates the Peninsular and Chugach terranes. If one were to continue farther southeast and into Prince William Sound from our stop at Portage Glacier Visitors Center, another phase of the accretionary complex called the Prince William Terrane would be encountered. This terrane contains the Paleogene Orca Group, which includes turdidites, shale, and argillite similar to the Valdez Group. In Prince William Sound, the Chugach and Prince William terranes appear to be separated by the Contact fault. However, some argue that the distinction between these two terranes is artificial and that the rocks represent progressive accretion at one convergent margin (e.g., Dumoulin, 1988). The terrane concept does not apply well to this accretionary complex, but the terrane nomenclature has become entrenched in the literature.

Again, the McHugh Complex is the older, more inboard of the Chugach terrane accretionary complex rocks we will drive past today. The McHugh along Turnagain Arm includes a variety of rock types including a mélange of highly disrupted greywacke, mafic volcanic rocks, chert, argillite and tuff to the west and pebble to boulder conglomerate, greywacke, and argillite to the east. At about mile 15 of our road log, we will cross the Eagle River Thrust, which is the major regional structure that separates the McHugh Complex from the younger, more outboard Valdez Group rocks. The Valdez consists of thin to medium bedded, moderately well sorted greywacke turbidite sandstone and black argillite. The Valdez Group and McHugh Complex rocks were most likely deposited on the down-going plate at a trench, and then accreted to the North American plate shortly thereafter.

Subduction initiated along the southern Alaska margin with the development of the Talkeetna arc in latest Triassic – early Jurassic time. Accretion continued until Late Cretaceous time when voluminous turbidites of the Valdez Group were deposited, though this accretion was not always coincident with arc magmatism. In the early Cenozoic, the Border Ranges fault was reactivated as a backstop and the Orca Group the Prince William terrane was accreted shortly after its deposition. It was during this early Cenozoic time (~61 – 50 Ma) that near-trench intrusions were emplaced only a few million years after the turbidites that they intrude were deposited at the trench (Bradley et al., 2003). We won't see any of the large intrusions on our excursion, but a few dikes are briefly visible along the road. Also, if you were to turn left at Girdwood (mile 30.9 of our road guide) and drive about 8 miles up Crow Creek Road, then hike a couple miles to Crow Pass you could visit one of the near trench intrusions. These intrusions are thought to have formed above a slab window during ridge subduction and are responsible for all of the lode-gold mineralization in the area (Haeussler et al., 1995).

The late Cenozoic tectonics of southern Alaska is dominated by collision of the Yakutat terrane, an allochthonous fragment of the North American continent (e.g., Plafker et al., 1994). The relatively buoyant Yakutat crust is subducting at a shallow angle of about 6 degrees beneath the Chugach-Kenai-Prince William Sound area, and over 400 kilometers from the trench the dip of the subducted slab steepens beneath the Alaska Range (Eberhart-Phillips et al., 2006). Many researchers now refer to this subducting fragment as the Yakutat "microplate" (e.g., Pavlis et al., 2004). The Yakutat microplate began subducting ~25 Ma and currently is moving north-northwest about 46 mm/yr (Fletcher and Freymueller, 1999), which is close to the velocity of the Pacific plate relative to North America. A change in the Pacific–North American relative motion ca 5 Ma may have partly or totally 'locked' the Transition Fault (the presumed western boundary of the Yakutat) and caused acceleration of the Yakutat microplate up to nearly the full velocity of the Pacific plate. This abrupt change coincided with rapid uplift of the coastal Saint Elias and eastern Chugach Mountains, and central Alaska Range. Very strong, but spatially varying, coupling exists currently between the Yakutat microplate and the North American plate – the strongest coupling is centered on Prince William Sound (Zweck et al., 2002) where the 1964 M9.2 earthquake initiated.

The rugged Chugach and Kenai Mountains may be result of upper plate convergence above the shallow-dipping Yakutat microplate. However, sparse low-T thermochronometer data suggest relatively low exhumation rates in this area. Apatite (U-Th)/He ages from Valdez Group turbidite deposits range from 19.9 Ma on the west side of the Kenai Mountains adjacent to the Border Ranges fault to 13.5 Ma near Seward (Buscher et al., in press). This same west to east decreasing trend is also seen in two samples along Turnagain Arm – Whittier area just north. AHe ages are 22.0 Ma near Beluga Point to the west and 14.9 Ma (felsic dike) in Whittier a few kilometers east of Portage Glacier. A granitic cobble from the McHugh Complex in this area yielded an apatite fission-track age of 38 ±3.7 Ma (P. Haeussler, P. O'Sullivan, unpublished data). These ages suggest relatively slow exhumation rates of ~0.1 mm/yr or less for the Kenai Mountains (Buscher et al., in press). Thus it appears that long-term shortening above the subducting Yakutat microplate is slow in the Kenai and westernmost Chugach region.

The long straight U-shaped valleys that we will see along Turnagain Arm and across the Kenai Mountains are the result of a long history of glaciations. Though glacier advances occurred regionally throughout much of the late Tertiary, the two most recent late Pleistocene advances probably have affected the landscape most dramatically. These glaciations include the Knik (>49 ka) and Naptowne (late Wisconsin) glaciations (Hamilton, 1994 and references therein) in the upper Cook Inlet-Kenai area. The Knik-age glaciers coalesced across the Anchorage area, but did not cover all of the Kenai Mountains. Later Naptowne glacier advances covered most of the lowland areas of the upper Cook Inlet and probably filled most of the valleys that we will drive through today. Look for evidence of the glaciers (prominent colluvial and erosional benches) as we drive past Upper Summit Lake about 35 minutes after we depart the Begich-Boggs Visitor's center. The Harding Icefield, from which many alpine and tide water glaciers radiate, is what remains of the Naptowne glaciation in the Kenai Mountains.

<u>Rocks of Resurrection Peninsula</u>

Hopefully, our cruise in Resurrection Bay will take us to the Resurrection Peninsula on the east side of the Bay where a nearly complete ophiolite section is exposed. The following general description of the ophiolite is summarized from Bradley and Miller (2006) and references therein. The ophiolite consists of [from bottom to top] (1) gabbro with local ultramafic pods; (2) plagioclase-rich granite; (3) sheeted dikes; (4) pillow basalt. Unfortunately, the gabbro and plagiogranite are not present along the west side of Resurrection Peninsula where we can view the rocks from Resurrection Bay during our cruise. In terms of a complete ophiolite section in the classic sense, the only part missing is tectonized peridotite. A sample from the plagiogranite yielded a U-Pb zircon age of 57 Ma. Note that this is the same time as ridge subduction and the same age as near-trench plutons in Resurrection Bay. Irregular pods of gabbro up to a few 10's of meters across occur within local ultramafic pods that are almost entirely serpentinized. Up-section, the gabbro consists of two main bodies in fault contact with the Valdez Group rocks. The gabbro grades upward and westward into sheeted dikes to form the rugged crest of Resurrection Peninsula. The sheeted dikes grade westward into pillow basalts and volcanic breccias. The pillows are spectacularly exposed along the southern shores of the Resurrection Peninsula, where white guano at sea-bird rookeries clearly outlines the pillow forms.

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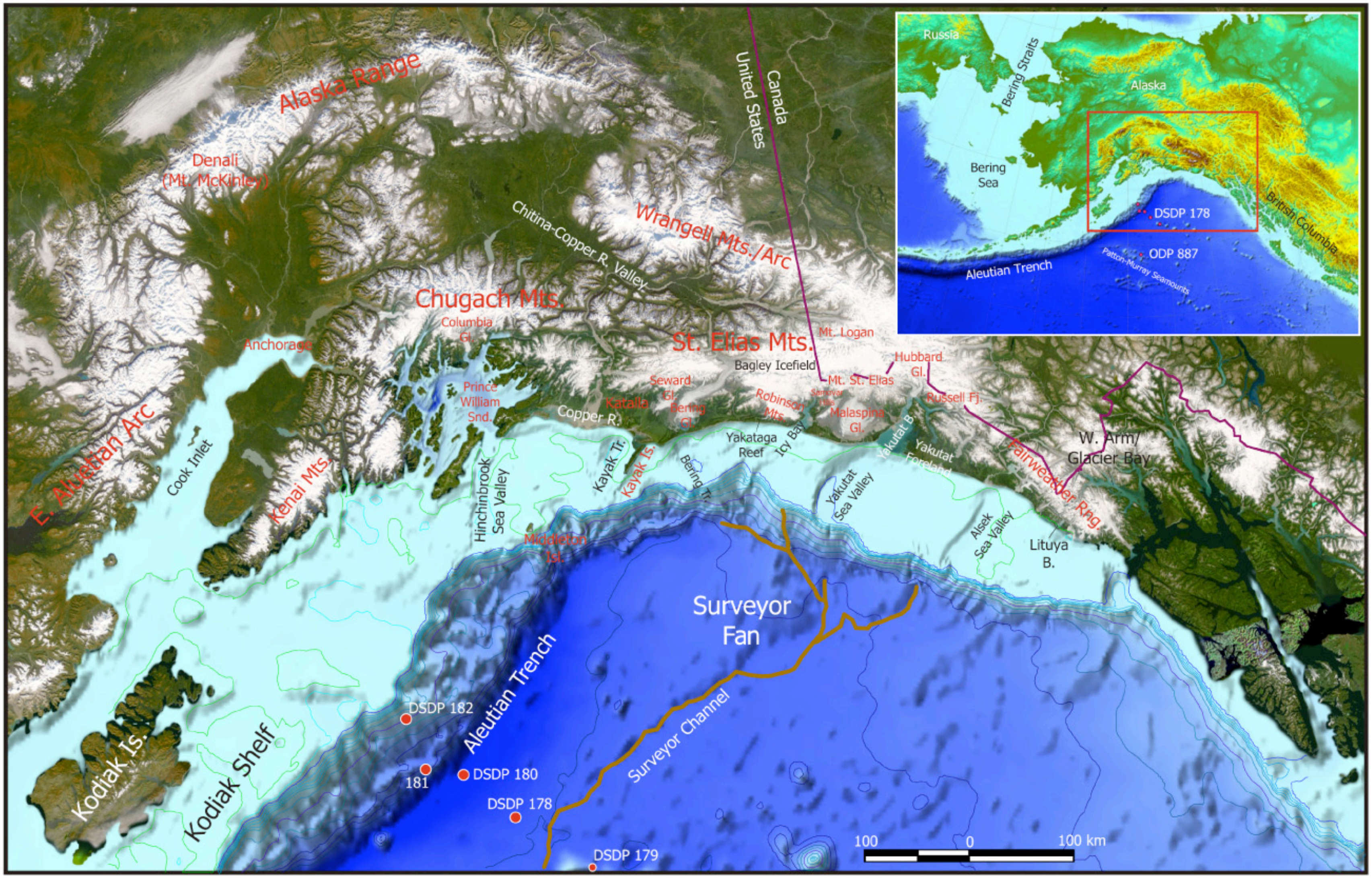
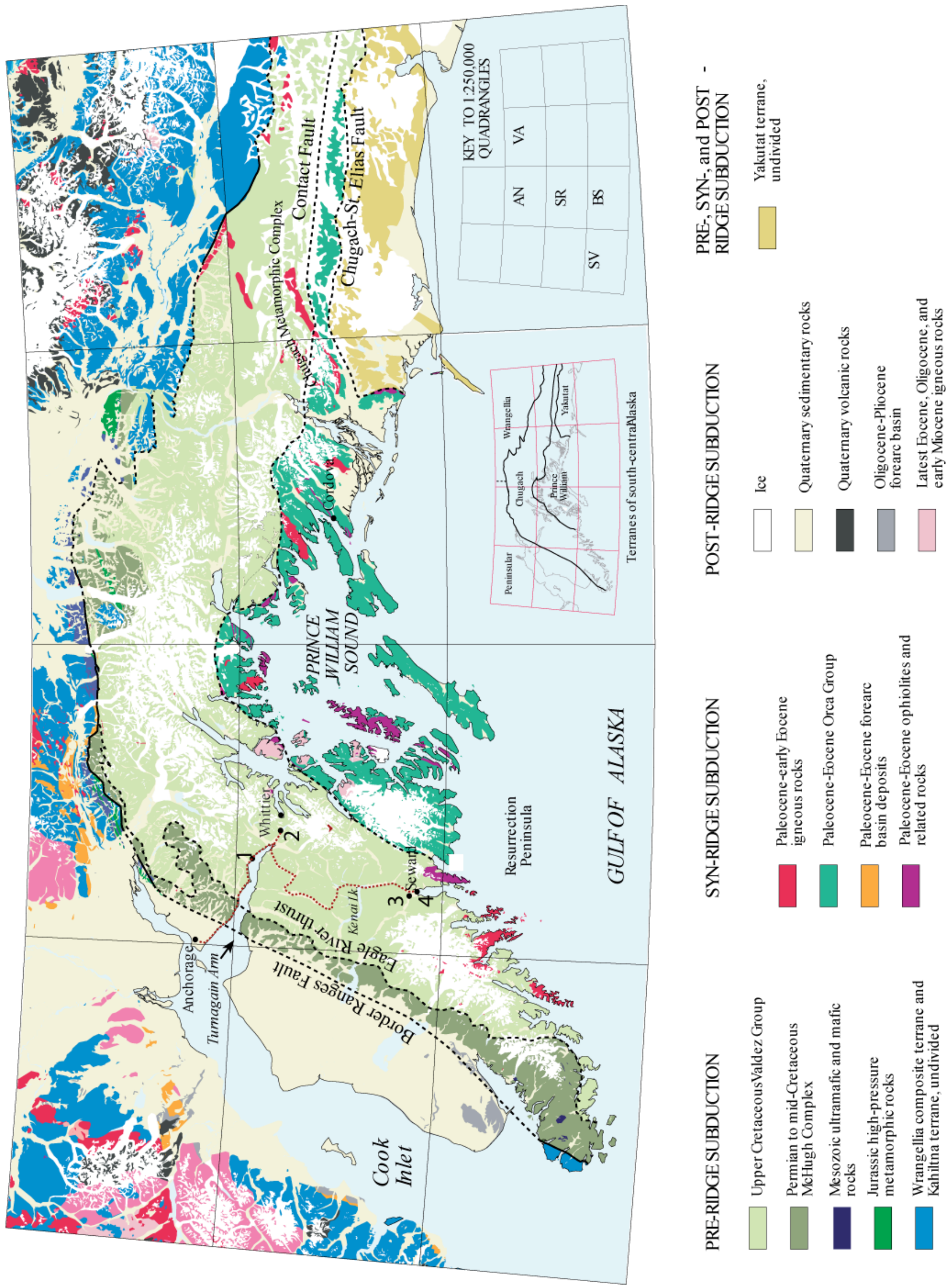


The Gulf of Alaska region: geography and location of DSDP and ODP drilling locations (see inset). Composite of MODIS images for southern Alaska courtesy of MODIS Rapid Response Project at NASA/GSFC. The figure is a composite of many separate images taken at different times. Note the inset map for overall location. Shaded bathymetry from ETOPO2 global elevation data set. (from STEEP Science Plan).



This map show regional geology for south-central Alaska. From Bradley et al. (2003) and sources therein. The numbers show stops along our excursion from Anchorage to Seward along the red dashed line.

The Seward Highway crosses the Kenai Peninsula. Few roads in the United States can offer the diversity of scenic landscapes and unique natural features so concentrated in one area. This 127-mile road, linking Anchorage with Seward, passes through some of the most spectacular scenery in the country. The landscape varies from the muddy waters of Turnagain Arm to the icy blue glaciers that hang almost to the sea. Wildflowers and waterfalls brighten every corner of the road as it glides below rough mountains that pierce thick, heavy clouds. Only Alaska's Seward Highway can offer this particular mix created by climate, geography, and geology. From the reflective waters of Turnagain Arm, travelers rapidly ascend 1,000 feet above sea level to an alpine meadow. Within the hour, they find themselves back at sea level surrounded by fjords, having just passed through a district of rivers and lakes. (see: byways.org).

ROAD LOG

Mile markers start at the O'Malley Street overpass on Seward Highway – it's one of the last main highway exits as we are leaving the main Anchorage area. We've also listed approximate times between locations based on travelling at speeds of 60 MPH.

000.0 (0 min.) Cross over O'Malley overpass – departing Anchorage proper

005.8 (6 min.) East end of marsh (Potter Marsh). Approximate buried trace of the Border Ranges Fault system, which marks a major structural boundary between the Peninsular and Chugach terranes. Though it is not exposed, it is approximately located at the break in slope and extends SSW across Turnagain Arm to the Kenai Peninsula – if you look to the SSW (right side of bus) you may be able to see the fault as a major break in slope between the Kenai Mountains to the east and the Kenai coastal plane to the west.

010.2 (5 min.) Beluga Point – Deformed Sedimentary Rocks. McHugh Complex with cliffs of sandstone and conglomerate. Look for the obvious cobbles in the outcrops on the left side of the bus. A granitic cobble from this location yielded an apatite fission-track age of 38 Ma (P. Haeussler, and P. O'Sullivan, unpublished data). An apatite (U-Th)/He age from turbidite deposits near here yielded an age of 22.0 Ma (Buscher et al., in press). During the early summer months both beluga and orca whales can be seen following the salmon into Turnagain Arm.

014.9 (5 min.) Falls Creek – Cross the Eagle River Fault, which is a low-angle thrust. This thrust separates the older McHugh Complex in the hanging wall from the Valdez Group rocks in the footwall. The thrust is not obvious as we drive by, but the Valdez exposures for about the next kilometer display considerable deformation perhaps associated with shearing in the overturned limb of a footwall syncline.

Rocks for the rest of the drive are Valdez Group sandstone and shale. However, there are sparse felsic dikes; these are undated but are presumed to be part of the Sanak-Baronof near-trench intrusive suite and about 54 Ma. Similar dikes occur throughout the Chugach and Prince William Sound regions.

Turnagain Arm is one of only about 60 bodies of water worldwide to exhibit a tidal bore. The bore may be more than six feet high and travel at 15 miles per hour on high spring tides (see note above). On a typical day, Turnagain Arm sees tides of more than 30 feet, second in North America to Canada's Bay of Fundy. The ocean's natural 12-hour 25-minute tidal cycle is close to Turnagain Arm's natural resonant frequency, which then reinforces the tide similar to water sloshing in a bathtub. Tidal fluctuations in the main body of Cook Inlet, while not as extreme as the shallow and narrow Turnagain Arm, regularly reach 25 feet and exhibit currents in excess of 5 knots at full tidal flow. The inlet and its arms have been proposed as a potentially attractive site for the generation of tidal power.

A **tidal bore** is a tidal phenomenon in which the leading edge of the incoming tide forms a wave (or series of waves) of water that travel up a river or narrow bay against the direction of the current. As such, it is a true "tidal wave" (not to be confused with a tsunami). Bores occur in relatively few locations worldwide, usually in areas with a large tidal range (typically more than 20 feet between high and low water), and where incoming tides are funneled into a shallow, narrowing river via a broad bay. The funnel-like shape not only increases the height of the tide, but it can also decrease the duration of the flood tide down to a point where the flood appears as a sudden increase in the water level. Bores take on various forms, ranging from a single breaking wave front, to 'undular bores' made of a smooth wave front followed by a train of solitary waves. Larger bores can be particularly dangerous for shipping, but also present a challenge to surfers. Timing is the key to maximizing the tidal-bore experience. The tidal change on a typical day is about 30', but the bore that precedes it may not always be the 6-foot-tall wall preferred by surfers. It may even be difficult to see what sometimes appears like only an approaching ripple. The best time to view a large tidal bore is within the five-day window around a new or full moon, when there is the greatest difference between high and low tides. Check a tide chart for the low tides in Anchorage. The tidal bore usually reaches Beluga Point 1.5 hours after that time, and Bird Point 2.5 hours after low tide in Anchorage. Depending on wind and tide conditions, the timing may vary, so arrive early. It takes the bore about five hours to travel the entire length of Turnagain Arm, so observers can watch it once, drive south and catch it again (modified: Geotimes, July 05)

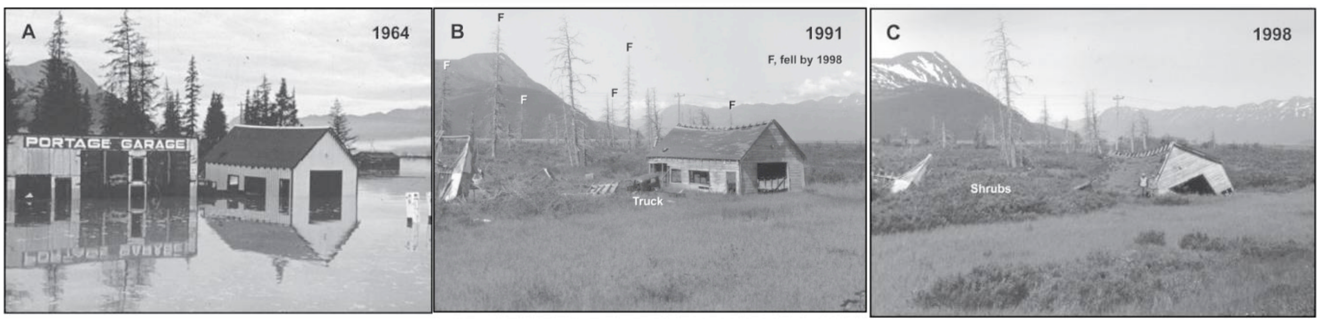
019.0 (4 min.) Bird Creek - exposures of recently excavated Valdez Group.

030.9 (12 min.) Girdwood Turnoff. Note the dead trees. These are some of the dead spruce forests killed by salt water incursion soon after the March 27, 1964 earthquake.

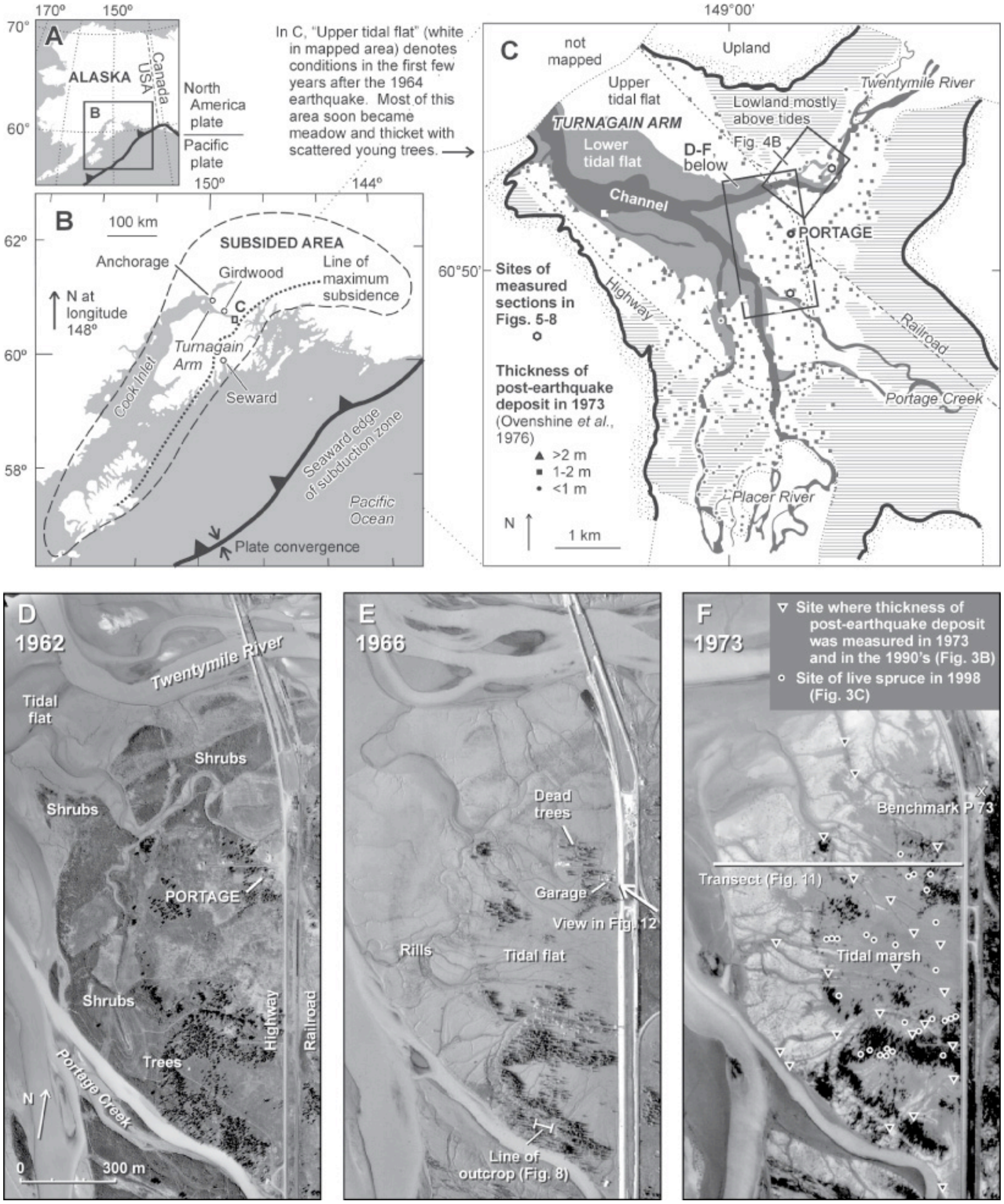
038.4 (8 min.) Turn left into "Kenai Peninsula Tourist

Informtion" kiosk and proceed east ¼ mile to train loading dock. Peter Haeussler (USGS – Anchorage) will give a geologic overview of the tectonics and the effects of the 1964 earthquake in the area. Across the road is the old Portage town site.

The M9.2 March 27, 1964 earthquake was centered approximately 100 km to the east, but caused significant subsidence in this area. The 1964 earthquake caused as much as 2.3 m of tectonic subsidence in a largely coastal belt 850 km long and 150 km wide. Seismic shaking locally added to the subsidence by causing unconsolidated deposits to settle. In Portage (where we're standing) and vicinity, the earthquake produced 1.5 m of tectonic subsidence and mostly unknown amounts of non-tectonic subsidence. Tectonic subsidence was measured at geodetic benchmarks on bedrock, the nearest of them 3.5 km northwest of town. Non-tectonic subsidence averaged about 1 m on a railroad embankment that probably settled more than did undeveloped land. The area at Portage lowered into the intertidal zone and this affected groves of spruce and cottonwood, thickets of alder and willow, marshes and bogs, hunting cabins, and a gas station (from Atwater et al., GSAB 2001), which you can see the dilapidated remnants of across the highway.



These are pictures of the same location in Portage Alaska taken over a number of years. You'll note that immediately following the earthquake this near coastal area was flooded with seawater due to rapid and dramatic co-seismic subsidence (1964). However as time passed (here 1991), inter-seismic uplift has risen the land level, and it has now drained. So, technically they could rebuild and start selling gas again (from Atwater et al., 2001).



This set of maps shows regional subsidence associated with the 1964 earthquake (B) and regions of new tidal flats (C). The photos at bottom are time series photos showing tidal flat formation due to subsidence during the 1964 earthquake and later rebound (1973 photo). From Atwater et al. (GSAB, 2001).

040.5 (2 minutes) Turn left and head about 6 miles to the Begich-Boggs Visitor's Center. **<u>We will spend one hour at this location.</u> Feel free to explore the Visitor's Center and/or pick up a cup of coffee/tea at the Portage Glacier Lodge located a few hundred meters south of the visitor's center.**

Portage Lake east of the visitor's center highlights the recent deglaciation in the Chugach Mountains. The actual glacier has receded far enough that it is no longer visible from the visitor's center; it presently is located at the head of the lake and around a ridge on the right (south) side of the lake. The toe of the glacier was at the visitor's center location around 1900. The visitor's center was named after two politicians Thomas Hale Boggs and Nick Begich, both of whom disappeared during a plane trip from Juneau to Anchorage in 1972 – the men and their plane were never found. Boggs was a U.S. Congressman from Louisiana and House Majority Leader and Begich was a Congressman from Alaska. The disappearance during a flight led to legislation requiring the use of aircraft emergency locator transmitters.

052.0 Return to Seward Highway. Turn left and proceed toward the Kenai Mountains. We will now be driving through the impressively glaciated Kenai Mountains. All bedrock here is Valdez Group accretionary prism rock. Apatite (U-Th)/He ages turbidite deposits of the Valdez Group range from 19.9 Ma on the west side of the Kenai Mountains adjacent to the Border Ranges fault to 13.5 Ma near Seward (Buscher et al., in press). This same west to east decreasing trend is also seen in two samples along Turnagain Arm – Whittier area just north. In west AHe age is 22.0 Ma near Beluga Point and 14.9 Ma (felsic dike) in Whittier a few kilometers east of Portage Glacier. These ages suggest relatively slow exhumation rates of ~0.1 mm/yr or less for the Kenai Mountains (Buscher et al., in press).

074.0 (22 min.) Junction with the Hope Cutoff. The Hope Road heads northwest into the communities of Sunrise Alaska and Hope Alaska, boom towns when gold was discovered.

084.5 (10 min.) Upper Summit Lake - east of the highway. This lake is deep and fishing is near the shores. The prominent bench 24 m (~80 ft) above the shore across the lake developed late in the Naptowne glaciation when colluvium from the slopes above accumulated against stagnant glacial ice that then occupied the floor of the valley. Subsequent melting of this ice mass left the bench scarps on either side of the lake and the basin now occupied by Summit Lake.

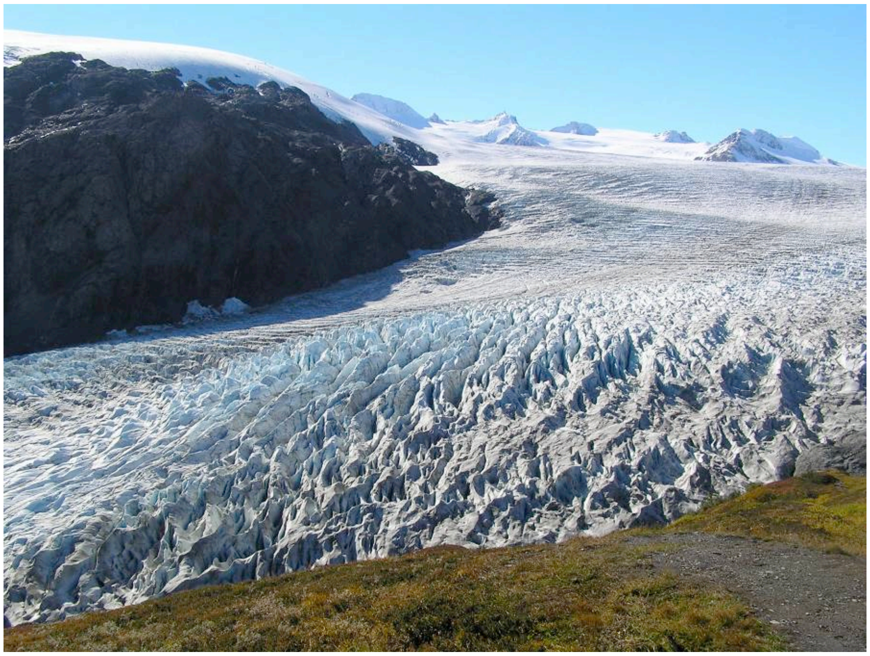
092.5 (8 min.) Junction with Sterling Highway Alaska Highway 1. Sterling Highway turns to the east. At this junction lies Tern Lake, a wildlife refuge area. Migratory birds, terns, gulls, geese, duck, and trumpeter swans can be seen here in the late spring and early fall.

106.0 (14 min.) Views of Kenai Lake on right side. This long S-shaped glacial lake is drained by the Kenai River which empties into Cook Inlet to the west.

125.2 (19 min.) Exit Glacier Road. An 8.6-mile paved road leading to Exit Glacier, the only land access to the Kenai Fjords National Park. A ranger station, parking and interpretive signs lead to an easy walk to the face of the glacier. **We will spend two hours at this stop to allow you time to eat a boxed lunch and explore the glacier.** It is about a 1.2 mile walk from the visitor's center to the toe of the Exit Glacier.

Kenai Fjords National Park encompasses 607,805 acres of unspoiled wilderness on the southeast coast of Alaska's Kenai Peninsula. The park is capped by the Harding Icefield, a relic from past ice-ages and the largest icefield entirely within U.S. borders. Orcas, otters, puffins, bear, moose and mountain goats are just a few of the numerous animals that make their home in this ever-changing place where mountains, ice and ocean meet.

Exit Glacier is a glacier that has its origins in the Harding Icefield in the Kenai Mountains. The name is from the fact that it served as the "exit" for the first recorded crossing of the Harding Icefield. Exit Glacier is notable for being a "drive up" glacier, and the road off the Seward Highway takes visitors to the only road-accessible part of the Kenai Fjords National Park. Although this is one of the smaller glaciers of the Harding Icefield, the easy access makes it one of the more visited glaciers in Alaska.



Exit Glacier originates in the Harding Icefield, which covers over 483 km², but if all the glaciers that descend to low elevations are includes, the area is 1,771 km². Some of the well known glaciers include the Tustumena Glacier, Exit Glacier, and McCarty Glacier. The icefield is also one of the four remaining icefields in the United States that receive over 400 inches of snow each year (modified; Wikipedia PD photo)

142.4 Return to Seward Highway – turn right and proceed to Seward.

144.4 (15 min. from Exit Glacier) City of Seward Alaska Historic city of Seward, Gateway to the Interior and Kenai Fjords Alaska National Park and southern terminus of the Alaska Railroad. The historic Iditarod Trail begins at the waterfront in the downtown district where the city docks stood prior to the catastrophic 1964 earthquake. From this terminal was also the beginning of the privately-owned Central Alaska Railroad which eventually was owned by the federal government and now a corporation owned by the State of Alaska and named the Alaska Railroad.

Seward is situated at the head of Resurrection Bay on the Kenai Peninsula and is one of Alaska's oldest and most scenic communities. Known as the 'Gateway to Kenai Fjords National Park' Seward is a picturesque town located 126 miles south of Anchorage. In 1792 the bay was named on Resurrection Day, Easter Sunday, by Alexander Baranof, a famous early Russian explorer.

The city of Seward was named for President Lincoln's Secretary of State, William Henry Seward, the man who engineered the Purchase of Alaska from Russia in 1867. Seward was born in Florida, New York. He attended Union College (a famous fission-track destination), studying law, and graduated in 1820, with high honors. On April 14, 1865, Lewis Powell, an associate of John Wilkes Booth, attempted to assassinate Seward, the same night and at the same moment Abraham Lincoln was shot.

The city of Seward was officially founded in 1903 on a long-abandoned Native village site, but the town had already been a Gold Rush encampment for at least a decade. Optimistic prospectors heard tales of a trail that led from Seward to riches-to-be, and on to Cook Inlet. That dogsled trail would indeed lead to the rich strikes at Hope and Sunrise and later to the bonanza at Iditarod, a place name commemorated in today's Iditarod Sled Dog Race, and on to Nome.

Seward was damaged by shaking from the earthquake and then the tsunami. The earthquake caused significant subsidence and failure of the shorefront. Here the rail track can be seen diving into the slumped ground. View of damage to waterfront, Seward, Alaska, after March 27, 1964 earthquake. March 1964. Photographer: U.S. Army (Alaska Digital Archives)

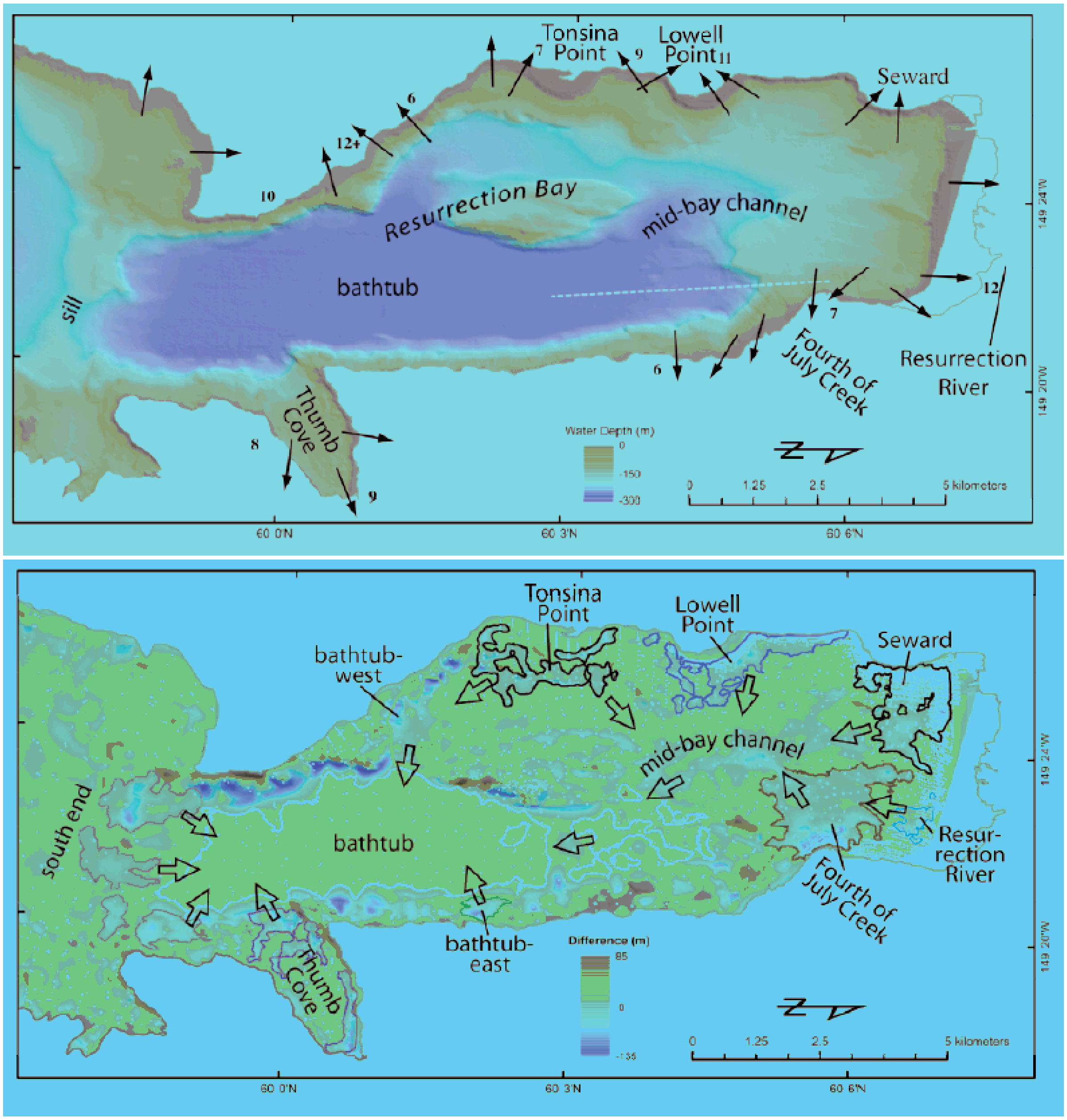
Seward was the only community in Alaska hit by both a far-traveled tsunami and a locally generated tsunami during the 1964 earthquake. Twenty one people died in Alaska due to the far-traveled tsunami. In Seward though, 13 people died from underwater landslides that generated local tsunamis. The major damage to the city occurred along a 1070 m long part of the waterfront that failed. Tanks at a fuel yard slid into the water and oil caught fire. Later tsunami waves pushed the burning oil back on shore causing extensive fire damage.

Submarine slope failures near Seward. The 1964 M9.2 great Alaska earthquake is the second or third largest ever recorded. Shaking lasted about 4.5 minutes and the rupture area was about 800 km long by 250 km wide. The earthquake produced both tectonic and submarine-landslide-generated tsunamis. In Alaska, 106 of 115 deaths were tsunami related, but 83 of these 106 deaths were related to submarine landslide-generated tsunamis. The fiords and glacial landscapes of coastal Alaska are an ideal geologic environment for producing submarine landslides, because they deposit sediment on the steep walls of fiords, which can subsequently fail.

Soon after the earthquake began, a >1 km section of the Seward waterfront started sliding toward the bay and tsunami waves as high as 8 m ran back up into the town. Wave run-up heights from the tsunamis around Resurrection Bay were 10+ m (Plafker et al., 1969) (see following figure).

Recently, Haeussler et al. (2007) used bathymetric data analysis and high-resolution seismic data to evaluate the distribution, sizes, and run out directions of submarine landslides during and after the 1964 earthquake. They were able to map out several regions of submarine slope failure and sediment flow directions toward a sediment collection "bathtub" near the south end of Resurrection Bay. These submarine slides are up to about 4 km wide and illustrate the potential for large slide-generated tsunamis in confined bays, like Resurrection Bay. The following abstract and figure are from Haeussler et al. (2007).

Following the 1964 M9.2 megathrust earthquake in southern Alaska, Seward was the only town hit by tsunamis generated from both submarine landslides and tectonic sources. Within 45 seconds of the start of the earthquake, a 1.2-km-long section of waterfront began sliding seaward, and soon after, ~6-8-m high waves inundated the town. Studies soon after the earthquake concluded that submarine landslides along the Seward waterfront generated the tsunamis that occurred immediately after the earthquake. We analyze pre- and post-earthquake bathymetry data to assess the location and extent of submarine mass failures and sediment transport. New NOAA multibeam bathymetry shows the morphology of the entire fjord at 15 m resolution. We also assembled all older soundings from smooth sheets for comparison to the multibeam dataset. We gridded the sounding data, applied corrections for coseismic subsidence, post-seismic rebound, unrecovered co-seismic subsidence, sea-level rise (vertical datum shift), and measurement errors. The difference grids show changes resulting from the 1964 earthquake. We estimate the total volume of slide material to be about 211 million m^3. Most of this material was transported to a deep, flat area, which we refer to as "the bathtub", about 6 to 13 km south of Seward. Sub-bottom profiling of the bathtub shows an acoustically transparent unit, which we interpret as a sediment flow deposit resulting from the submarine landslides. The scale of the submarine landslides and the distance over which sediment was transported is much larger than previously appreciated.



Upper figure shows multibeam imagery of Resurrection Bay. Numbers and arrows show measured tsunami wave run-up height (m) and direction. The bottom figure shows the difference between pre and post 1964 bathymetric depths. Named and outlined areas show inferred landslide areas. Arrows in lower figure represent inferred sediment flow directions. From Haeussler et al. (2007).

Cruise on Resurrection Bay. This cruise should last about 3 hours. Snacks will be available and you can purchase drinks. Logistics of the cruise will depend on weather conditions. Hopefully, we will be able to see some of the ophiolite deposits along the east side of Resurrection Bay (see earlier discussion of the geology) and get some good views of a Harding Icefield tidal glacier – see earlier discussion of the Exit Glacier and Harding Icefield.

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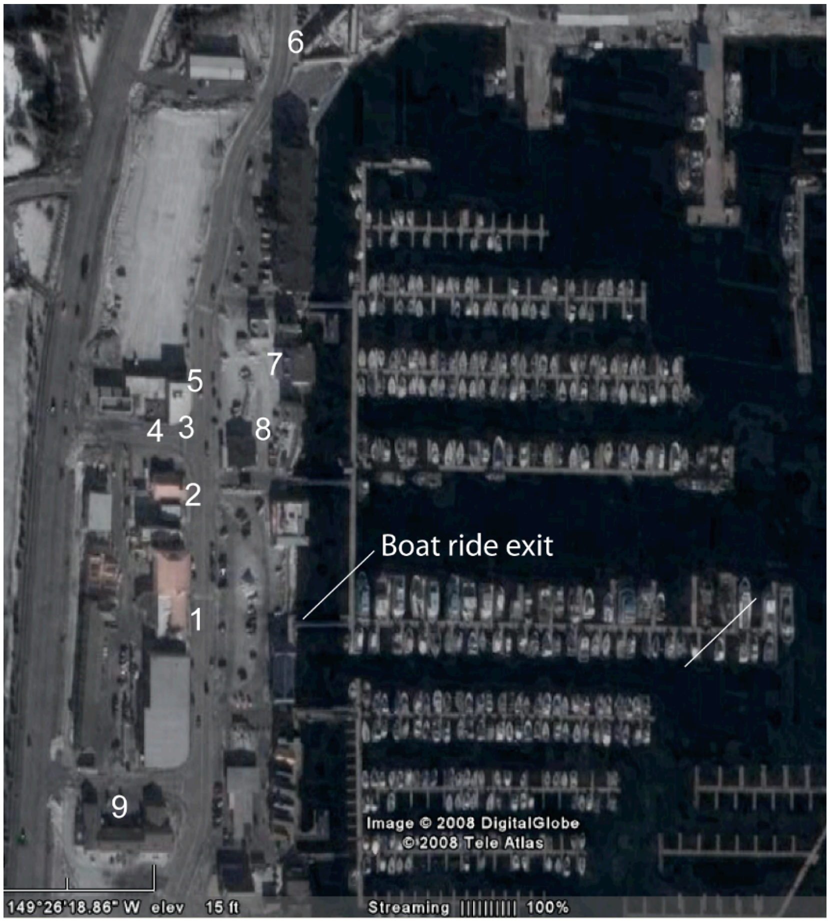
Map showing some of the places to eat in the Seward harbor area.



1. Breeze Inn. Burgers and sea food. $9-20.
2. Marina Restaurant. Fish & chips. $10-20
3. Terry's Fish and Chowder. Fish & chips, chowder. $10-20
4. Lombardos Eatery. Pizza and pasta. $10-15.
5. Railway Cantina. Burritos and tacos. $10
6. Train Wreck – Smoke Shack. BBQ ribs and sandwiches. $10-15
7. Chinook Waterfront. Sea Food. $20-30.
8. Rays Waterfront. Sea food and steaks. $20-30
9. Subway. Sandwiches. $5-10