

Geologic Resources Inventory Scoping Summary

Sitka National Historical Park, Alaska

Prepared by Katie KellerLynn
September 30, 2009

Geologic Resources Division
National Park Service
U.S. Department of the Interior



The Geologic Resources Inventory (GRI) Program provides each of 270 identified natural area National Park System units with a geologic scoping meeting, a digital geologic map, and a geologic resource inventory report. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity for discussion of park-specific geologic management issues and, if possible, include a site visit with local experts. The purpose of these meetings is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and potential monitoring and research needs. Outcomes of this scoping process are a scoping summary (this report), a digital geologic map, and a geologic resources inventory report.

The National Park Service held a GRI scoping meeting for Sitka National Historical Park on June 16, 2009, at the park headquarters of Klondike Gold Rush National Historical Park in Skagway, Alaska. Participants at the meeting included NPS staff from the park, Alaska Regional Office, Geologic Resources Division, and Southeast Alaska Network; and cooperators from Colorado State University and the U.S. Geological Survey (table 2). During the meeting, Tim Connors (Geologic Resources Division) facilitated the assessment of map coverage, and Bruce Heise (Geologic Resources Division) led the discussion regarding geologic processes, features, and issues at Sitka National Historical Park. Dave Brew (U.S. Geological Survey emeritus) presented the geologic story of southeast Alaska.

This scoping summary highlights the GRI scoping meeting for Sitka National Historical Park including the geologic setting; the plan for providing a digital geologic map; a list of geologic features, processes, and issues; and a record of meeting participants (table 2).

Park and Geologic Setting

Sitka National Historical Park is located on the western coast of Baranof Island, one of the most rugged of all the islands in southeast Alaska. Mount Edgecumbe, a distinctive feature in the national historical park's viewshed, is situated on Kruzof Island west of Sitka. Exemplified by a lack of roads to the mainland, islands are a dominant feature of the region's landscape. Marine waters, high mountains, and active glaciers serve as barriers to mainland areas (Moynahan and Johnson 2008).

At 46 ha (113 ac), Sitka National Historical Park is small, but it encompasses both culturally and physically significant landscapes. The national historical park commemorates the Battle of Sitka, which took place on the point of land where the Indian River flows into the Sitka Sound. This 1804 battle marks the last major Tlingit resistance to Russian colonization. Russian and Tlingit history and culture are displayed at the Russian Bishop's House, the park's visitor center museum, and the Southeast Alaska Indian Cultural Center (SEAIICC). The park's curatorial collections contain both Tlingit and Russian artifacts. Also numerous totem poles stand at the visitor center, fort site, and along the Totem Trail in the park. Most of the park's physical landscape is composed of elevated shore and delta deposits but some minor alluvial deposits, modern beach deposits, modern delta

deposits of the intertidal zone, and embankment fill also occur (Yehle 1974). The source areas for all these deposits are the steep mountain slopes and cirque walls that formed during local alpine glaciations (<http://www.nps.gov/sitk/naturescience/geologicformations.htm>; accessed September 30, 2009). The park contains only one consolidated (bedrock) unit—Sitka Graywacke (i.e., dark gray, coarse-grained sandstone, several hundred feet thick). Graywacke originated as offshore turbidites that were deposited by turbidity (density) currents, specifically bottom-flowing currents laden with suspended sediment. Turbidites are characterized by graded bedding, moderate sorting, and well-developed primary structures such as laminations.

Geologic Mapping for Sitka National Historical Park

During the scoping meeting, Tim Connors (Geologic Resources Division) showed some of the main features of the GRI Program’s digital geologic maps, which reproduce all aspects of paper maps, including notes, legend, and cross sections, with the added benefit of being GIS compatible. The NPS GRI Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRI Program and allows for rigorous quality control. Staff members digitize maps or convert digital data to the GRI digital geologic map model using ESRI ArcGIS software. Final digital geologic map products include data in geodatabase and shapefile format, layer files complete with feature symbology, Federal Geographic Data Committee (FGDC)–compliant metadata, a Windows HelpFile that captures ancillary map data, and a map document that displays the map and provides a tool to directly access the HelpFile. Final products are posted at <http://science.nature.nps.gov/nrdata/> (accessed September 30, 2009). The data model is available at <http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm> (accessed September 30, 2009).

Table 1. Source Maps for Sitka National Historical Park

GMAP ID ¹	References
75179	Brew, D. A. 1997. <i>Description and regional setting of the Silver Bay segment of the Sitka fault zone, southeastern Alaska, and evidence for possible sinistral separation</i> , 307–316. Professional Paper 1574. Reston, VA: U.S. Geological Survey.
15335	Gehrels, G. E., and H. C. Berg. 1992. <i>Geologic map of southeastern Alaska</i> . Miscellaneous Investigations Series Map I-1867. Scale 1:600,000. Reston, VA: U.S. Geological Survey. http://pubs.er.usgs.gov/usgspubs/i/i1867 (accessed September 30, 2009).
74502	Gehrels, G. E., H. C. Berg, N. Shew, C. S. Peterson, N. Grabman, S. Mohadjer, D. Grunwald, F. H. Wilson, and C. K. Hults. 2006. <i>Preliminary integrated geologic map databases for the United States: Digital data for the geology of southeast Alaska, Sitka sheet</i> . Scale 1:500,000. Open-File Report OF-2006-1290. Reston, VA: U.S. Geological Survey. http://pubs.usgs.gov/of/2006/1290/ (accessed September 30, 2009).
3636	Loney, R. A., D. A. Brew, L. J. P. Muffler, and J. S. Pomeroy. 1975. <i>Reconnaissance geology of Chichagof, Baranof, and Kruzof islands, southeastern Alaska</i> . Scale 1:250,000. Professional Paper 792. Reston, VA: U.S. Geological Survey.
3630	Riehle, J. R., D. A. Brew, and M. A. Lanphere. 1989. <i>Geologic map of the Mount Edgecumbe volcanic field, Kruzof Island, southeastern Alaska</i> . Scale 1:63,360. Miscellaneous Investigations Series Map I-1983. Reston, VA: U.S. Geological Survey.

¹GMAP numbers are identification codes for the GRI Program’s database.

When possible, the GRI Program provides large scale (1:24,000) digital geologic map coverage for each unit’s area of interest, which is generally composed of the 7.5-minute quadrangles that contain NPS-managed lands. Maps of this scale (and larger) are useful to resource managers because they capture most geologic features of interest and are spatially accurate within 12 m (40 ft). The process

of selecting maps for management begins with the identification of existing geologic maps in the vicinity of the National Park System unit. Scoping session participants then discuss mapping needs and select appropriate source maps for the digital geologic data (table 1) or, if necessary, develop a plan to obtain new mapping. In Alaska, large-scale mapping is usually defined as “one inch to the mile” or quadrangles produced at a scale of 1:63,360.

Sitka National Historical Park has two “inch to the mile” quadrangles of interest: Sitka A-4 and Sitka A-5 (fig. 1). The park is situated entirely within the Sitka A-4 quadrangle. The Sitka A-5 does not contain parklands but is of interest to NPS staff for resource management and interpretation.

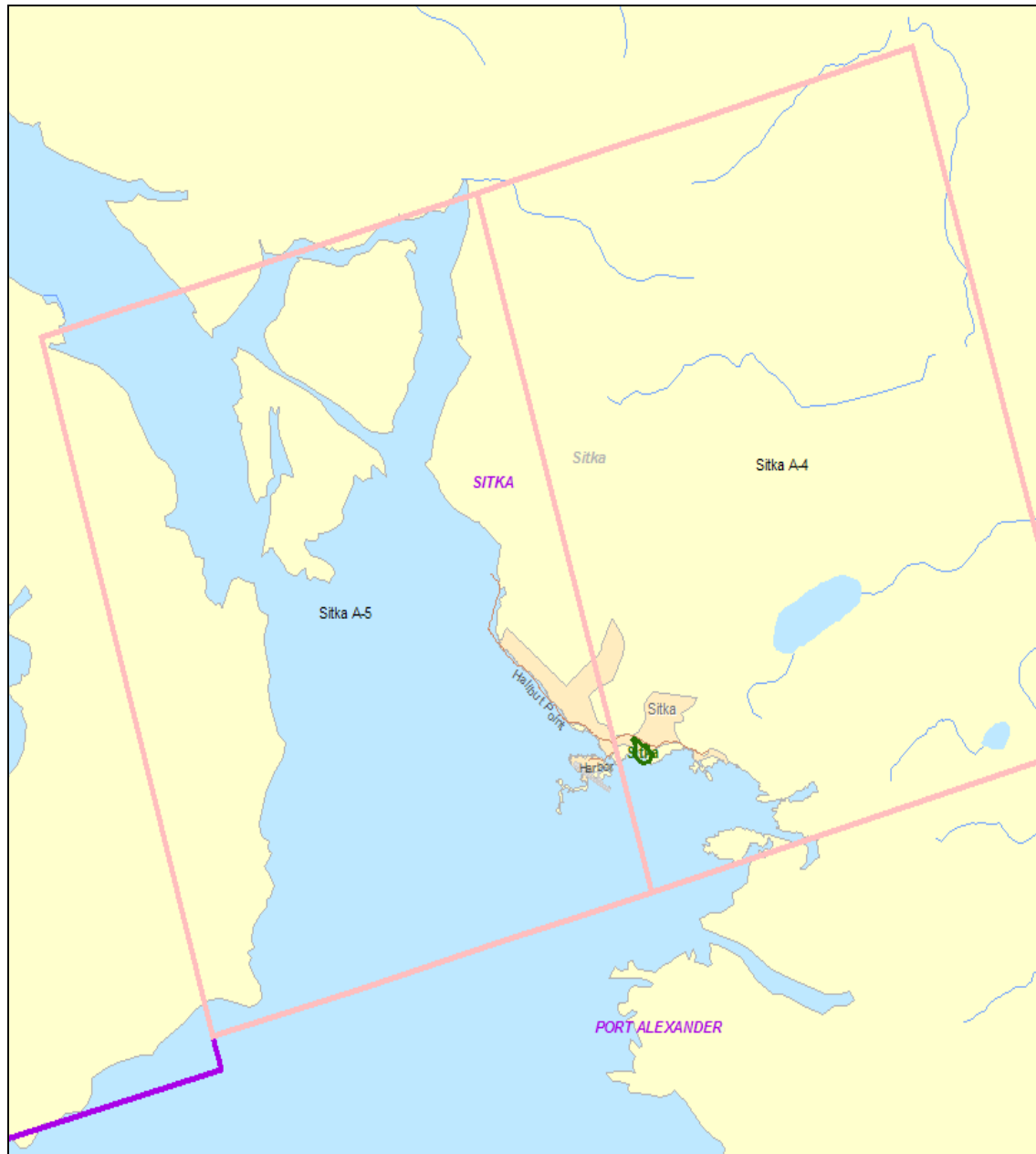


Figure 1. Area of Interest for Sitka National Historical Park. The national historical park boundaries are shown in green. The park is situated in the Sitka A-4 quadrangle. The “inch to a mile” (scale 1:63,360) quadrangles surrounding the park are outlined in pink.

During scoping, Dave Brew told the group that he has detailed mapping for the park's area of interest from figures in USGS Professional Paper 1574 (Brew 1997), specifically figure 2 (p. 311) (see fig. 2 below). This map is particularly useful for showing faults in the area. This figure/map is not currently digitized in a GIS format.

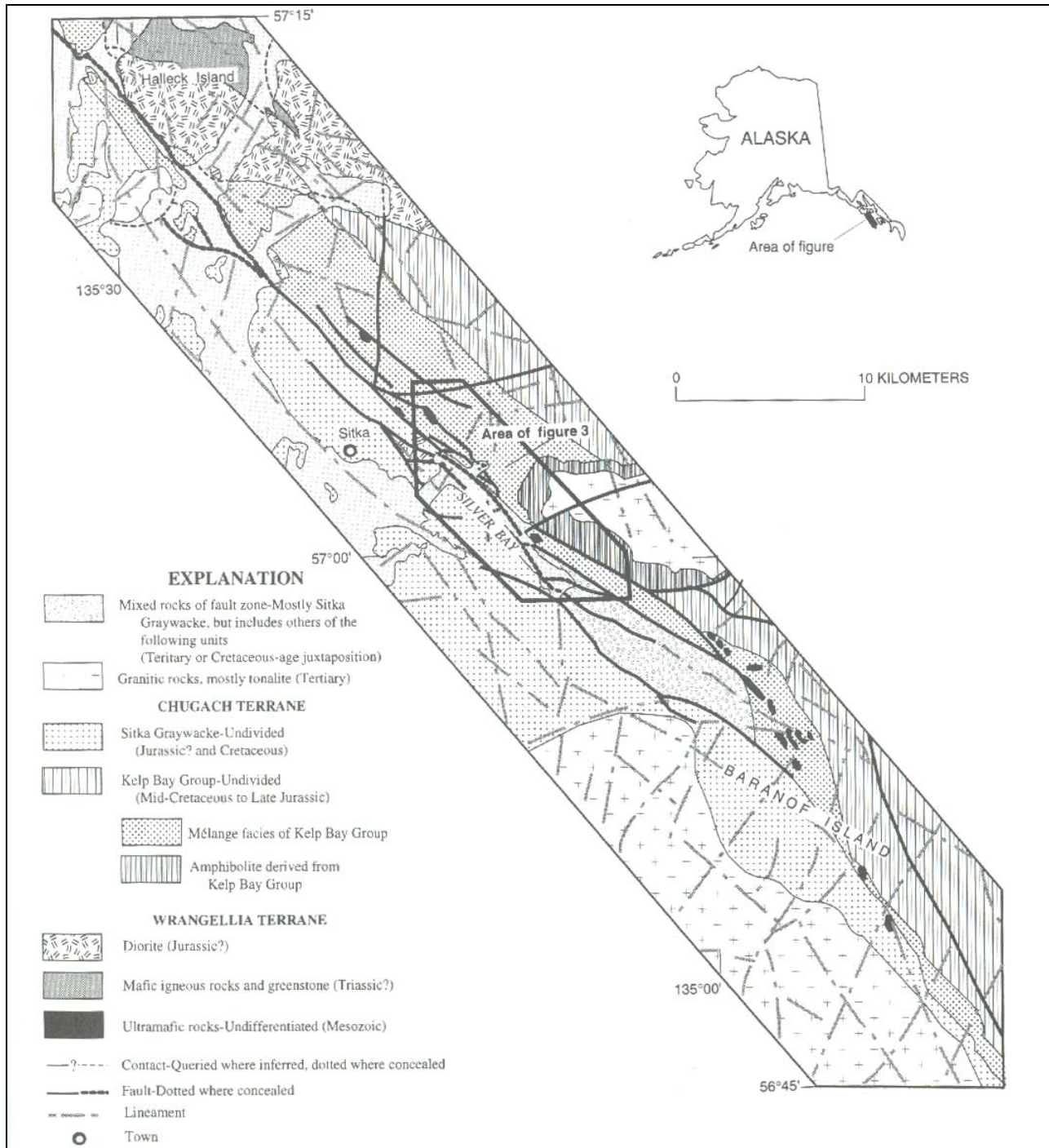


Figure 2. Sketch Map of the Sitka Area. This figure from USGS Professional Paper 1574 (Brew 1997) shows map units adjacent to the Silver Bay fault, its traces, and other fault segments and lineaments. The author modified the figure from Loney et al. (1975), Karl et al. (1990), and unpublished lineament maps. Surficial deposits are not shown. The base map was compiled from the Sitka and Port Alexander 1:250,000-scale topographic maps.

Another map of interest is part of USGS Professional Paper 792 (Loney et al. 1975), which shows detailed bedrock geology. According to Ric Wilson (U.S. Geological Survey) who is responsible for USGS mapping projects in the state of Alaska, this publication already exists in a digital format. Finally, Miscellaneous Investigations Series Map I-1983 (Riehle et al. 1989) shows the volcanic deposits and features of the area, which are important for Sitka National Historical Park's viewshed and interpretation of the geologic story. This map is large scale but not in a digital format.

A composite of these three maps (i.e., Loney et al. 1975, Riehle et al. 1989, and Brew 1997) compiled by Dave Brew and published by the U.S. Geological Survey would be an ideal dataset with multiple uses for Sitka National Historical Park. GRI and USGS staffs will have future discussions about how to get the aforementioned items into a digital GIS format to create the best large-scale dataset possible for Sitka National Historical Park.

Geologic Features, Processes, and Issues

The scoping session for Sitka National Historical Park provided the opportunity to develop a list of geologic features and processes at the park to be further explained in the final GRI report. Many of these features and processes have associated issues of resource management concern. Scoping participants did not prioritize the issues discussed during scoping, and the features and processes are listed in alphabetical order here.

Climate Change

Dramatic melting of snow and ice in Alaska has been occurring over the last few decades as a result of warmer climate. Warming has caused thawing of many glaciers and permanent snowfields across the state, as well as reductions in seasonal snowfall and shorter seasons of river, lake, and sea ice (Moynahan and Johnson 2008). Impacts on park resources from climate change include isostatic rebound and sea-level rise. During scoping, park staff posed the question whether isostatic rebound will keep pace with sea-level rise. Dave Brew mentioned a study by Christopher F. Larsen and others that addressed this question. According to this study (i.e., Larsen et al. 2005), southeast Alaska has "the world's fastest present-day glacio-isostatic uplift yet documented." Larsen et al. (2005) used global positioning system (GPS) geodesy combined with studies of raised shorelines to determine that the rate of uplift is as much as 32 mm (1.6 in) per year in parts of southeast Alaska. Peak uplift is occurring at the Yakutat Icefield, situated in the Tongass National Forest northwest of Sitka. At 30 mm (1.2 in) per year, Glacier Bay has the second greatest area of uplift. The rate of uplift at Sitka National Historical Park is 3 mm (0.12 in) per year. Deglaciation in the coastal areas of Alaska began about 13,000 years ago (Hamilton 1994). Total rebound of the land surface since deglaciation in the Sitka area has been approximately 10 m (35 ft) (<http://www.nps.gov/sitk/naturescience/geologicformations.htm>; accessed September 30, 2009).

Investigators attribute the majority of uplift to viscoelastic rebound following the Little Ice Age deglaciation, with extreme uplift beginning about 1770 AD. The volume of ice lost in Glacier Bay alone since the end of the Little Ice Age is equivalent to a global rise in sea level of 8 mm (0.3 in). Other contributors to uplift are current ice thinning, tectonic forcing, and global glacial isostatic adjustment.

The Intergovernmental Panel on Climate Change determined that over the past 120 years, global relative sea-level rise has been 1.8 mm (0.07 in) per year (Houghton et al. 2001). Comparing this number to the rate of uplift determined by Larsen et al. (2005), sea-level rise is not a threat to national parks in southeast Alaska. However, isostatic rebound is resulting in other changes. In Sitka National Historical Park, uplift is causing changes in habitat, in particular, beach building. As a result, the park's terrestrial acreage is increasing. Isostatic rebound, coupled with local volcanic activity and earthquakes, has resulted in the uplift of the Indian River delta along with beaches, floodplains, and abandoned channels (Chaney et al. 1995). Rebound can also lead to increased erosion (Hallett et al. 1996; Jaeger et al. 2001) and affect fault stability (Arvidsson 1996; Stewart et al. 2000). According to Sauber and Molnia (2004), release of overburden stress caused by thinning glaciers has increased rates of seismicity in tectonically active southern Alaska. Larsen et al. (2005) concluded that the remarkably large amplitude and short timescale of uplift since the Little Ice Age deglaciation is evidence that recent changes of glacial systems triggered by climate can excite a very large solid earth response, much larger than investigators previously appreciated.

Coastal and Marine Features and Processes

Nearly half of the resources at Sitka National Historical Park are coastal or marine, including about a mile of shoreline. The park's intertidal zone and estuarine area comprise 20 ha (50 ac). Tidal flats are the primary coastal landform type. The tidal range is 3.7 m (12 ft). Although the State of Alaska owns the intertidal zone within the park boundary, the National Park Service has the authority to manage these intertidal lands from a state lease (Moynahan and Johnson 2008).

The marine intertidal area is unusually diverse and productive. Pink and chum salmon enter the intertidal and lower floodplain channel segments of the Indian River to spawn. In addition, coho and chinook salmon, Dolly Varden char, and steelhead trout migrate through the park. The shoreline supports a variety of migratory waterfowl and shorebirds. Bald eagles, gulls, northwest crows, and ravens scavenge along the tidal flats and the river, especially during herring spawning in the spring and salmon runs, which extend from mid-July to early October (Geof Smith, Sitka National Historical Park, written communication, September 15, 2009).

Currently, large cruise ships anchor in Sitka Sound, and tenders transport passengers to the docks at Sitka. Citizens have periodically put forth proposals to build docks adjacent to parklands, in particular a deepwater dock in Sitka Harbor to accommodate cruise ships. However, the majority of Sitka voters have never approved these proposals. If docks were ever to be developed, they would have the potential to alter longshore drift, thereby affecting the intertidal zone and sediment patterns in Sitka National Historical Park.

Disturbed Lands

Disturbed lands are those parklands where the natural conditions and processes have been impacted directly by mining, oil and gas production, development (e.g., facilities, roads, dams, abandoned campgrounds, and trails), agricultural practices (e.g., farming, grazing, timber harvest, and abandoned irrigation ditches), overuse, or inappropriate use. The NPS Disturbed Lands Restoration Program, administered by the Geologic Resources Division, usually does not consider lands disturbed by natural phenomena (e.g., landslides, earthquakes, floods, hurricanes, tornadoes, and fires) for restoration unless the areas are influenced by human activities.

The primary disturbance in the area is gravel mining. During World War II, a mining operation along the shoreline in Sitka Sound excavated gravel and created holes or pools in the intertidal area. These holes are visible in aerial photographs, particularly at low tide (fig. 3). No vertical recovery of the holes has occurred since they were created (Geoffrey Smith, Sitka National Historical Park, e-mail, July 16, 2009). In addition, state-approved gravel extraction from the Indian River continued until the 1970s.

The Alaska Resource Data File (ARDF) at <http://ardf.wr.usgs.gov/> (accessed September 30, 2009) is a statewide database on mines, prospects, and mineral occurrences throughout Alaska. The record for the Sitka 1:250,000-scale quadrangle documents 189 mineral occurrences (Berg and Grybeck 2005). Scoping participants did not identify any of these sites as disturbed lands needing restoration; however, ARDF numbers SI170 to SI181 would be the sites to consider for potential (though highly unlikely) impacts (Ric Wilson and Dave Brew, U.S. Geological Survey, e-mails, October 5 and 6, 2009).

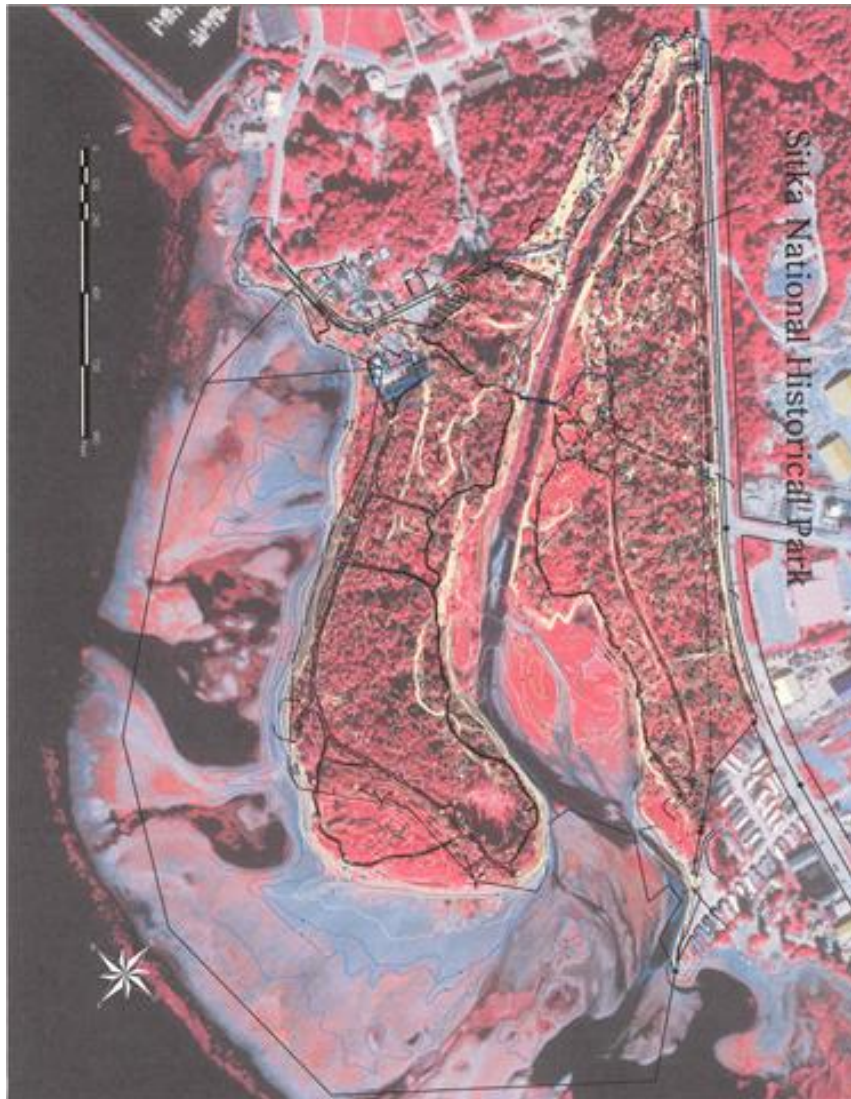


Figure 3. Infrared Imagery of the Sitka Area. World War II mining operations excavated gravel in Sitka Sound. These areas are shown on the image as dark-gray, bulbous polygons in the intertidal zone on the lefthand side of the landmass. NPS graphic.

The primary disturbance within the park was the Indian River Asphalt Site, located on the northeast bank of the Indian River off Sawmill Creek Road. In 1957, John C. Miller, under contract to the Morrison-Knudson Company, entered into an agreement with the U.S. Department of the Interior, Bureau of Land Management, to remove gravel from the mouth of the Indian River. An asphalt batch plant was set up at the same time. The gravel was used for asphalt to pave Halibut Point Road. Sometime between 1959 and 1961, the asphalt plant stopped operations. Plant operators buried much of the debris and left behind some at the surface (e.g., drums, cables, miscellaneous equipment, metal pipes, a crane on tracks, chunks of asphalt, and heavy timbers). As the bank of the Indian River eroded near the site, debris washed out of the bank. In addition, citizens began reporting “a sheen originating from exposed soils in the bank” to state and federal authorities as early as 1990 (Shannon & Wilson, Inc. 1995).

In 1995, the National Park Service contracted Shannon & Wilson, Inc., to conduct an environmental assessment (EA) of the site. Based on this EA, investigators did not recommend any remedial alternatives that involved removal and treatment or disposal of the contaminated soils at the site because alternatives would have been very disruptive to the park (and potentially to the marine environment), expensive, and difficult to implement. However, the EA recommended that the National Park Service be committed to respond as needed, including emergency removal of highly contaminated soils about to erode from the bank. Furthermore, investigators recommended that park staff regularly monitor erosion and beach conditions, particularly during the winter storm season (Shannon & Wilson, Inc. 1995, p. 33). Park staff monitored soil and water quality at the site until 2005.

Fluvial Features and Processes

The Indian River bisects Sitka National Historical Park. Stream terraces are the primary fluvial landform type. The river flows through a large U-shaped, post-glacial valley that encompasses 31 km² (12 mi²) and ranges in elevation between sea level and 1,158 m (3,800 ft). The river originates in the rugged mountains of central Baranof Island north of the park and enters Sitka Sound between Crescent and Jamestown bays, ending in an estuary. The Indian River flows through old-growth and mature secondary growth forests; these trees fall directly into and across the stream. This large woody debris creates relatively immobile log barriers, log jams, and root wads that stabilize the river channel, provide cover, and form pools, all of which are critical for juvenile salmonid survival (Naiman et al. 2000; Montgomery and Buffington 2001). In addition, many harvested logs have washed up on the park’s beaches, which have influenced the natural beach-forming process. These logs escaped from log rafts that barges were towing to the Sawmill Creek pulp mill.

Other anthropogenic changes to the fluvial system include a wing dam in the river to deflect flow from the fort site; segments of armored channel (i.e., riprap), which protects the fort site; and water diversion associated with Sheldon Jackson College. The college was granted a 30 cubic feet per second (cfs) (0.8 m³/s) water right (priority date 1914), primarily to produce hydroelectric power. However, power generation ceased in the 1980s. The diverted water now is used entirely to supply a fish hatchery that began operating in 1975. The diversion dam blocks coarse sediment from moving to the lower reaches of the river, thereby starving the river of spawning-size gravel and cobbles and affecting salmon productivity and aquatic ecosystem health. According to Geof Smith (Sitka National Historical Park):

Sheldon Jackson College (SJC) fish hatchery did some major repairs to their Indian River diversion dam and water intake facilities in the summer of 2003. ... Part of this process was removing gravel that had built up behind the dam (the dam stops the free-flow of gravel down river). This was necessary to clear the water intake structures upstream of the dam. A small amount of gravel was returned to the river but over 98% of the gravel was taken away from the river system and used as fill material for roads and development projects. SJC is now defunct (yet the college still owns the water right) but the hatchery continues to be operated by the Sitka Sound Science Center, a nonprofit organization intent on maintaining a science program in the Sitka area. Science professors out of work by the closing of the college organized the center and now run it. Just before the college closed, the hatchery contemplated another major repair and upgrade of their dam. Gravel was to be removed from behind the dam but instead of using it for other purposes, a compromise was worked out where the removed gravel would be lined up along the shore of the river below the dam and when high water occurred in the fall and winter, the gravel would be pushed into the river to continue its journey down stream. But before the repairs occurred, the college closed. This solution was brought up again as an EIS mitigating measure for expansion of the Sitka Airport. I talked to John Klutz of the Army Corp of Engineers who is responsible for issuing wetland permits. But apparently the proposal was not adopted. The hatchery and Science Center is in survival mode at present and work on the dam is not expected in the near future. But I am sure the Science Center wants to complete the dam repairs as soon as it is financially feasible for them to do so (Geof Smith, Sitka National Historical Park, e-mail, July 17, 2009).

Geothermal Features and Processes

Windy Passage fault, which lies several miles southwest of the park, is the source of heat for the only known geothermal features (i.e., hot springs) in the vicinity of Sitka National Historical Park. Entrepreneurs have exploited the thermal waters in areas such as Goddard and Baranof hot springs, but no development occurs within the park.

Glacial Features and Processes

In addition to isostatic rebound (see “Climate Change” section), features that illustrate the park’s glacial past include glacial till, glacially deposited gravels in the intertidal zone, and glacial erratics exposed at low tide. The park’s Web site suggests that the park has a lateral moraine (see <http://www.nps.gov/sitk/naturescience/geologicformations.htm>; accessed September 30, 2009); however, Chaney et al. (1995) found no clear evidence, and Geof Smith and Dave Brew think it unlikely (post-scoping correspondence, September 2009). It is possible that exposed bedrock within the park may have glacial striations; however, Chaney et al. (1995) did not observe any as a result of moss mantling, poor lighting conditions, and limited time devoted to the search of striations. Glacial features within the park would have formed around the time of the last glacial maximum (150,000–30,000 years ago). On portions of Baranof Island higher than 1,370 m (4,500 ft), cirque glaciers and small ice fields are still active (McMahan 1998).

Lacustrine Features and Processes

There are no true lakes in Sitka National Historical Park; however, intermittent ponds are seasonally present. These rainfall-dependant ponds can completely dry up in the summer (Moynahan and Johnson 2008).

As a result of isostatic rebound, nearby Redoubt Lake is no longer directly connected to the marine system and contains “fossil” saltwater at depth. McCoy (1977) speculated that Redoubt Lake is a meromictic lake and remnant fjord that became isolated from the sea by geological uplift between 650 and 800 years ago. A 4-m- (12-ft-) high waterfall now separates the lake from the ocean.

Occasionally during exceptionally high tides and strong storm surge, saltwater washes over the falls and into the lake (Geof Smith, Sitka National Historical Park, e-mail, July 16, 2009). Although this lake is 19 km (12 mi) south of the park's boundaries, it provides an interesting interpretive example of glacial isostasy in the vicinity of the park.

Tectonic and Seismic Features and Processes

For a small park, Sitka has a dynamic geologic setting and an impressive geologic history. The Queen Charlotte–Fairweather fault system runs nearby, primarily offshore. This fault system marks the eastern boundary of the Pacific plate and the western boundary of the North American plate. Sitka National Historical Park lies on the continental North American plate. Situated west of Sitka (and the Queen Charlotte–Fairweather fault system) are oceanic rocks of the Pacific plate. In Alaska, the boundary is also the site of accreted terranes—geologic “bits and pieces” that have shattered and smeared along the leading edge of the North American plate.

The Pacific plate moves in a northwestward direction relative to the North American plate, creating a transform boundary, the name given to the interface between two plates moving horizontally in opposite directions. The fault associated with a transform boundary is a strike-slip fault, in this case with right-lateral movement. The Fairweather fault marks the northern end of the Queen Charlotte–Fairweather fault system and is visible on land for about 280 km (174 mi)—from Cross Sound northwestward to its junction with the St. Elias fault in the vicinity of Yakutat Bay. Seismic exploration methods have projected the Fairweather fault just offshore of the Alexander Archipelago from Cross Sound to the mouth of Chatham Strait, where it likely connects with the Queen Charlotte fault. The Queen Charlotte fault comprises the southern segment of Queen Charlotte–Fairweather fault system. It extends southeastward from Chatham Strait past the Queen Charlotte Islands (http://www.aeic.alaska.edu/maps/QueenCharlotteFairweather_fault.html; accessed September 30, 2009).

East of the Queen Charlotte–Fairweather fault system is the Chugach terrane. Sitka National Historical Park is situated on this terrane, which extends for 2,000 km (1,243 mi) along the margin of the Gulf of Alaska. The terrane is a discrete, fault-bounded fragment of oceanic material. The seaward portion of the Chugach terrane represents the fill of a Late Cretaceous trench and consists of structurally deformed turbidites (graywacke) with some mafic volcanic rocks. Granitic plutons of early Tertiary age intruded the terrane (Nilsen and Zuffa 1982). The Chugach terrane is characterized by a geologic history different from contiguous terranes. Paleomagnetic data from the terrane and adjacent deposits indicate original deposition far to the south of the present latitude of Alaska (Nilsen and Zuffa 1982). According to Dave Brew, the terrane docked onto North America as a result of northwest-directed subduction during the Paleocene and Eocene epochs (65.5–33.9 million years ago).

Recent seismic activity in the region is concentrated along this fault system and occurs almost exclusively in large earthquakes (Brew et al. 1991); that is, relative seismic quiescence and very few small-magnitude earthquakes occur between large-magnitude events. According to the Alaska Earthquake Information Center, investigators have linked four major earthquakes to the Queen Charlotte–Fairweather fault system in the last century: In 1927 a magnitude (M)=7.1 earthquake occurred in the northern part of Chichagof Island. In 1949 a M=8.1 earthquake occurred along the

Queen Charlotte fault near the Queen Charlotte Islands. In 1958 movement along the Fairweather fault near Lituya Bay created a $M=7.9$ earthquake. In 1972 a $M=7.4$ earthquake occurred near Sitka (http://www.aeic.alaska.edu/maps/QueenCharlotteFairweather_fault.html; accessed September 30, 2009). Yehle (1974) provided a detailed analysis of the earthquake potential, as known at that time, as well as information on the likely response of different earth materials to seismic events.

Volcanic Features and Processes

On a clear day, Mount Edgecumbe is a site to behold and significant for the viewshed of Sitka National Historical Park. Dormant volcanoes surround the park, and Mount Edgecumbe—elevation 976 m (3,202 ft) above sea level—is the highest. The volcano is located at the southern end of Kruzof Island and is its highest point.

Mount Edgecumbe is a local landmark and tourist attraction. Hikers can easily ascend the volcano in a day; the greatest obstacle to a successful climb probably is finding marine transportation from Sitka to Kruzof Island. On April 1, 1974, a local prankster named Porky Bickar flew into the crater and ignited 100 old tires, convincing Sitka residents that the volcano was erupting. Nevertheless, according to Dave Brew, the most recent (authentic) eruptions were about 4,000 years ago; these eruptions were small and occurred mostly in a remote place on the southwest part of Kruzof Island (Riehle and Brew 1984). The vents of these eruptions are not known.

The Mount Edgecumbe volcanic field became active about 611,000 years ago (Riehle et al. 1992), with its greatest activity in the late Pleistocene about 11,250 years ago (Begét and Motyka 1998). Ash from this major eruptive period originally blanketed all of the Sitka area (Yehle 1974) and reached Juneau (Heusser 1960) and Glacier Bay (McKenzie 1970). This layer serves as a time-stratigraphic marker that helps put geologic events in sequence on a regional scale. Recent investigations have not found evidence of this layer in Sitka National Historical Park (Chaney et al. 1995), and it appears to have been removed by natural and anthropogenic processes. However, a 4,000-year-old layer, corresponding to the most recent eruptions, provides an important tephrochronologic marker horizon for geomorphic (and archaeological) investigation at Sitka National Historical Park (Chaney et al. 1995).

In 1995 during the park's "physical and cultural landscapes" study, investigators identified this recent ash layer (tephra) in test pits and soil probes. Radiocarbon dates of $4,000 \pm 70$ years before present (BP) and $4,290 \pm 70$ years BP bracket the layer (Chaney et al. 1995). Gene Griffin (retired park archaeologist) originally discovered this layer in a soil profile exposed along the southeast side of the park maintenance shed and in the root wads of tree throws near the Russian Memorial on the east side of Indian River. Geof Smith described this layer as "light colored and gritty but finer than sand" (Geof Smith, Sitka National Historical Park, e-mail, September 30, 2009).

References

- Arvidsson, R. 1996. Fennoscandian earthquakes: Whole crustal rupturing related to postglacial rebound. *Science* 274:744–746.
- Begét, J. E., and R. J. Motyka, 1998. New dates on late Pleistocene dacitic tephra from Mount Edgecumbe volcanic field, southeastern Alaska. *Quaternary Research* 49:123–125.

- Berg, H. C., and D. J. Grybeck. 2005. *Alaska resource data file: Sitka quadrangle*. Open-File Report 2005-1376. Anchorage, AK: U.S. Geological Survey.
<http://ardf.wr.usgs.gov/quads/html/Sitka.html> (accessed September 30, 2009).
- Brew, D. A. 1997. *Description and regional setting of the Silver Bay segment of the Sitka fault zone, southeastern Alaska, and evidence for possible sinistral separation*. Professional Paper 1574. Reston, VA: U.S. Geological Survey.
- Brew, D. A., S. M. Karl, D. F. Barnes, R. C. Jachens, A. B. Ford, and R. Horner. 1991. A northern Cordilleran ocean-continent transect: Sitka Sound, Alaska, to Atlin Lake, British Columbia. *Canadian Journal of Earth Sciences* 28(6):840–853.
- Chaney, G. P., R. C. Betts, and D. Longenbaugh. 1995. *Physical and cultural landscapes of Sitka National Historical Park, Sitka, Alaska*. Douglas, AK: Vanguard Research.
<http://www.nps.gov/sitk/historyculture/publications-on-line.htm> (accessed September 30, 2009).
- Hallet, B., L. E. Hunter, and J. Bogen. 1996. Rates of erosion and sediment evacuation by glaciers: A review of the evidence. *Global Planetary Change* 12:213–235.
- Hamilton, T. D. 1994. Late Cenozoic glaciations of Alaska. In *The Geology of Alaska*, ed. G. Plafker and H. C. Berg, 813–844. The Geology of North America. Volume G-1. Boulder, CO: The Geological Society of America.
- Heusser, C. J. 1960. *Late-Pleistocene environments of North Pacific North America*. Special Publication 35. New York: American Geographical Society.
- Houghton, J. T., Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, and D. Xiaosu. 2001. *Climate change 2001: The scientific basis. Contribution of Working Group I to the third assessment report of the Intergovernmental Panel on Climate Change (IPCC)*. Cambridge, UK, and New York, NY: Cambridge University Press.
- Jaeger, J., B. Hallet, T. Pavlis, J. Sauber, D. Lawson, J. Milliman, R. Powell, S. P. Anderson, and R. Anderson. 2001. Orogenic and glacial research in pristine southern Alaska. American Geophysical Union (AGU) Transactions. *Eos* 82(19):213–216.
- Karl, S. M., D. A. Brew, and B. R. Wardlaw. 1990. Significance of Triassic marble at Nakwasina Sound, southeastern Alaska. In *Geologic Studies in Alaska by the U.S. Geological Survey, 1989*, ed. J. H. Dover, and J. B. Galloway, 21–28. Bulletin 1946. Reston, VA: U.S. Geological Survey.
http://pubs.er.usgs.gov/djvu/B/bull_1946.djvu (accessed September 30, 2009).
- Larsen, C. F., R. J. Motyka, J. T. Freymueller, K. A. Echelmeyer, and E. R. Ivins. 2005. Rapid viscoelastic uplift in southeast Alaska caused by post-Little Ice Age glacial retreat. *Earth and Planetary Science Letters* 237:548–560.

- Loney, R. A., D. A. Brew, L. J. P. Muffler, and J. S. Pomeroy. 1975. *Reconnaissance geology of Chichagof, Baranof, and Kruzof islands, southeastern Alaska*. Scale 1:250,000. Professional Paper 792. Reston, VA: U.S. Geological Survey.
- McCoy, G. A. 1977. A reconnaissance investigation of a large meromictic lake in southeastern Alaska. *U.S. Geological Survey Journal of Research* 5(3):319–324.
- McKenzie, G. D. 1970. Some properties and age of volcanic ash in Glacier Bay National Monument. *Arctic* 23:46–49.
- McMahan, J. D. 1998. (Updated April 2, 2009.) Chapter two: Environmental setting. Castle Hill Archaeological Project. Anchorage, AK: Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation, Office of History and Archaeology.
<http://dnr.alaska.gov/parks/oha/castlehill/chpttwo.htm> (accessed September 30, 2009).
- Montgomery, D. R., and J. M. Buffington. 2001. Channel processes, classification and response. In *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion*, ed. R. J. Naiman and R. E. Bilby, 13–42. New York, NY: Springer-Verlag.
- Moynahan, B. J., and W. F. Johnson. 2008. *Vital Signs monitoring plan, Southeast Alaska Network, phase III report*. Juneau, AK: National Park Service.
- Naiman, R. J., R. E. Bilby, and P. A. Bisson. 2000. Riparian ecology and management in the Pacific coastal rain forest. *Bioscience* 50:996–1011.
- Nilsen, T. H., and G. G. Zuffa. 1982. The Chugach terrane, a Cretaceous trench-fill deposit, southern Alaska. *Geological Society of London Special Publications* 10:213–227.
- Riehle, J. R., and D. A. Brew. 1984. Explosive latest Pleistocene(?) and Holocene activity of the Mount Edgumbe volcanic field, Alaska. In *The United States Geological Survey in Alaska: Accomplishments during 1982*, ed. K. M. Reed and S. Bartsch-Winkler, 111–115. Circular C-0939. Reston, VA: U.S. Geological Survey.
- Riehle, J. R., D. A. Brew, and M. A. Lanphere. 1989. *Geologic map of the Mount Edgumbe volcanic field, Kruzof Island, southeastern Alaska*. Scale 1:63,360. Miscellaneous Investigations Series Map I-1983. Reston, VA: U.S. Geological Survey.
- Riehle, J. R., D. H. Mann, D. M. Peteet, D. M. Engstrom, D. A. Brew, and C.E. Meyer. 1992. The Mount Edgumbe tephra deposits, a marker horizon in southeastern Alaska near the Pleistocene-Holocene boundary. *Quaternary Research* 37:183–202.
- Sauber, J. S., and B. F. Molnia. 2004. Glacial ice mass fluctuations and fault instability in tectonically active southern Alaska. *Global Planetary Change* 42:279–293.
- Shannon & Wilson, Inc. 1995. Environmental site assessment, Indian River Asphalt Plant Site, Sitka National Historical Park, Sitka, Alaska. Fairbanks, AK: Shannon & Wilson, Inc.

Stewart, I. S., J. Sauber, and J. Rose. 2000. Glacio-seismotectonics: Ice sheets, crustal deformation and seismicity. *Quaternary Science Review* 19:1367–1389.

Yehle, L. A. 1974. *Reconnaissance engineering geology of Sitka and vicinity, Alaska, with emphasis on evaluation of earthquake and other geologic hazards*. Open-File Report 74-53. Reston, VA: U.S. Geological Survey.

Table 2. Scoping Meeting Participants

Name	Affiliation	Position	Phone	E-Mail
Dave Brew	U.S. Geological Survey	Geologist	650-941-6485	dbrew@usgs.gov
Tim Connors	Geologic Resources Division	Geologist	303-969-2093	tim_connors@nps.gov
Bruce Giffen	Alaska Regional Office	Geologist	907-644-3572	bruce_giffen@nps.gov
Bruce Heise	Geologic Resources Division	Geologist/GRI program coordinator	303-969-2017	bruce_heise@nps.gov
Ron Karpilo	Colorado State University	Research associate	253-777-2033	ron_karpilo@partner.nps.gov
Katie KellerLynn	Colorado State University	Research associate	801-608-7114	katiekellerlynn@msn.com
Brendan Moynahan	Southeast Alaska Network	Network coordinator	907-364-2621	brendan_moynahan@nps.gov
Geof Smith	Sitka National Historical Park	Natural resource specialist	907-747-0182	geoffrey_smith@nps.gov
Ric Wilson	U.S. Geological Survey	Geologist	907-786-7448	fwilson@usgs.gov